Isolated photons Purity in Pb-Pb Study and comparison of different methods: ABCD ALICE vs ATLAS, vs template

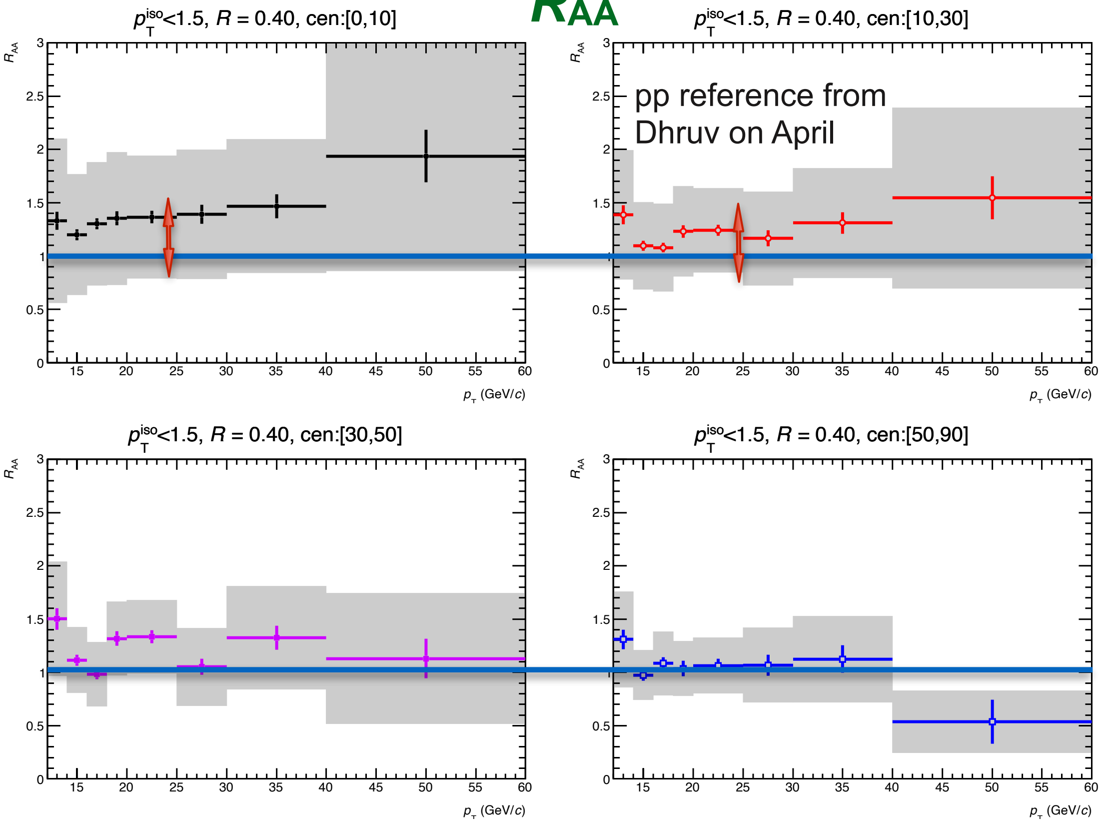
Previous presentations:

- PWG-GA 02/03/21
- PWG-GA 06/04/21 (UE)
- PWG-GA 20/04/21 (UE)
- PWG-GA/JE 20/07/21
- PWG-PAG-JP 13/12/21
- PWG-JE 24/01/23

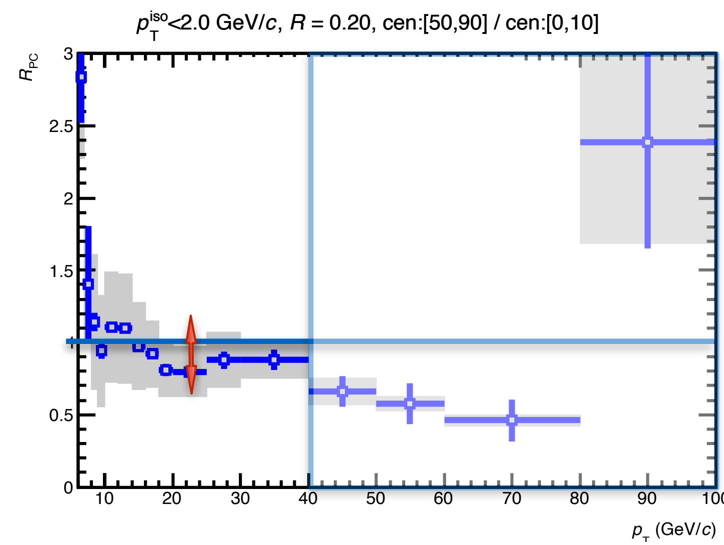
Gustavo Conesa Balbastre

Outstanding issue: Purity in central collisions likely too high

R_{AA}

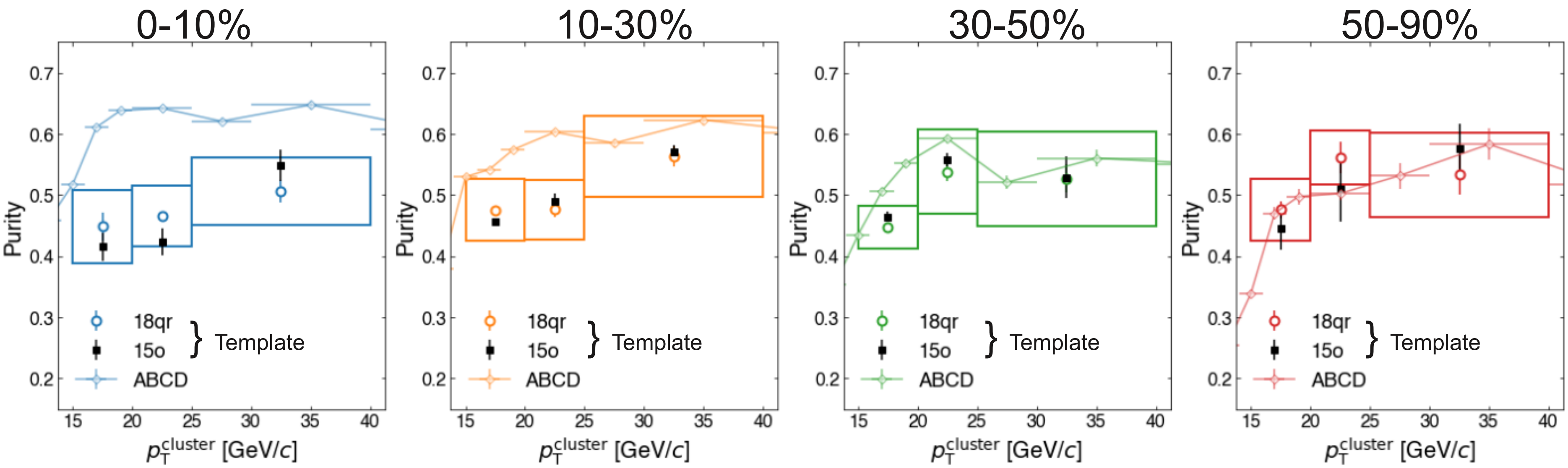


Peripheral / Central



- From previous presentations
- Systematic uncertainty blown up on purpose here to cover the shift

Outstanding issue: Purity ABCD vs Alwina's Template



- Non central purities are compatible between the 2 analysis but central are rather clearly different
- Today, reanalyse and study different methods

What's changed since last report

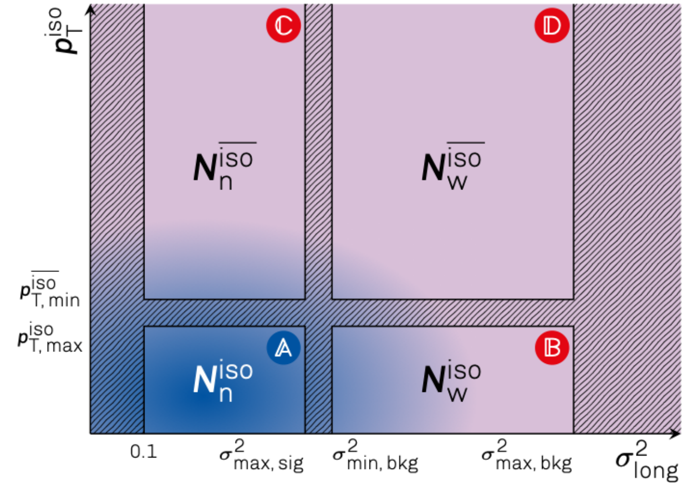
- Bug in embedding gamma-jet events fixed:
  - embedded data clusters were not rejected
  - effect in the end is not that large in the final result

- Analysis cuts:
  - Distance to bad channel cut not applied, previously observed no impact and important reduction on acceptance
  - Exclusion zone on the center of the isolation cone not considered anymore, it did not show any improvement

- R_{AA} weight applied
  - Before, Jet-Jet spectra directly scaled down by published charged particles R_{AA}
  - Now, R_{AA} weight applied when filling the histograms based on the meson mother p_T and not the cluster p_T
    - In case of the clusters originated from decay photons, else the generated particle p_T
  - Anyway, today comparison of the two approaches done in some plots
  - R_{AA} points used are in back-up

- **Study the purity with different methods**
  - **ABCD-ALICE**: What was used so far in this analysis, the approach of the pp@7 TeV paper
  - **ABCD-ATLAS**: Similar approach, but different treatment of the signal leaking the bkg regions
  - **Template**: Tried Alwina's approach, but found some problems, I used new modified approach to handle the signal contribution to the bkg template

Purity estimation with ABCD method: ALICE (pp@7TeV like)

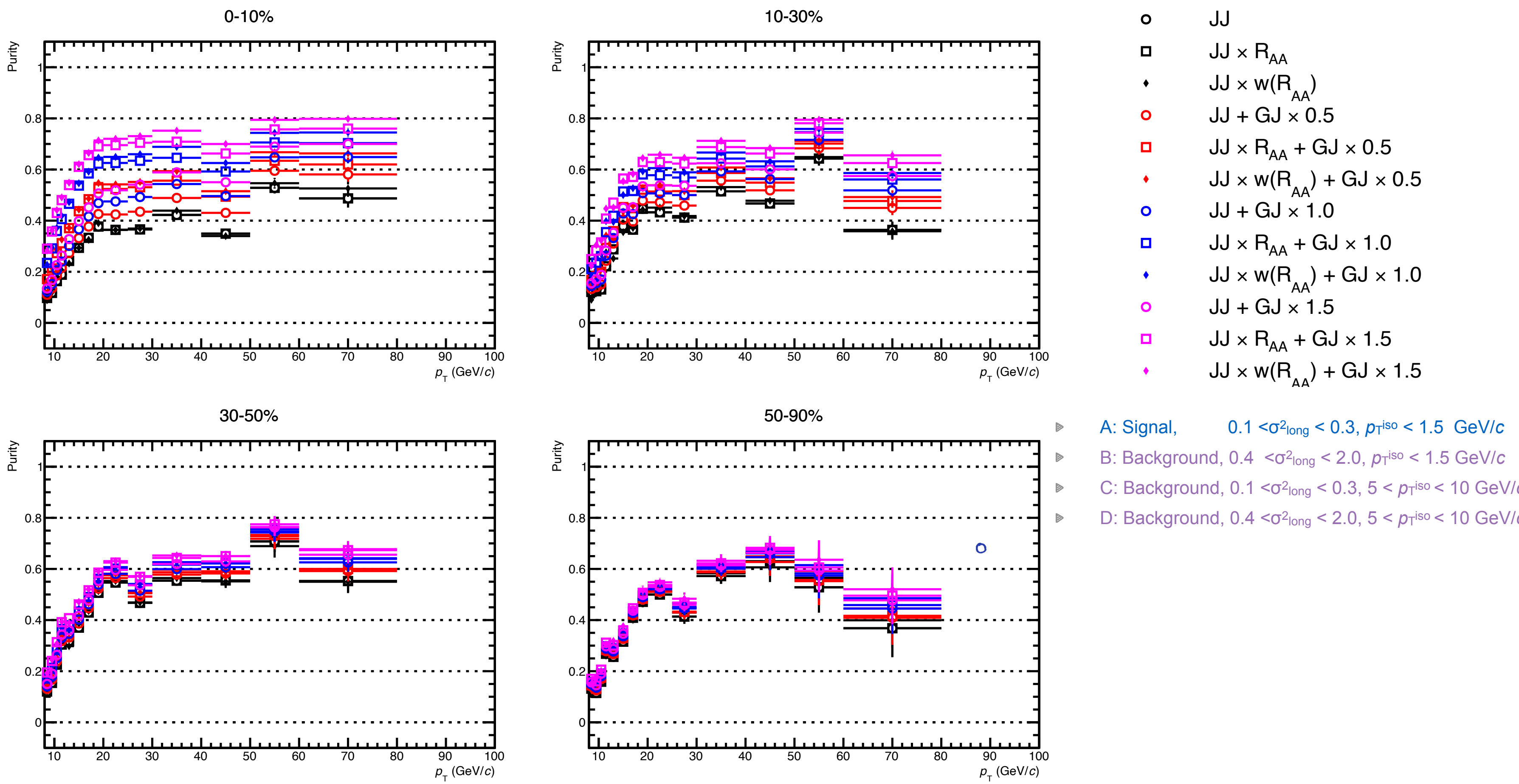


- Purity in A region extracted as

$$P = \boxed{1 - \left(\frac{N_{n}^{\overline{iso}}/N_{n}^{iso}}{N_{w}^{\overline{iso}}/N_{w}^{iso}}\right)_{data}}_{P_{dd}} \times \boxed{\left(\frac{B_{n}^{iso}/N_{n}^{\overline{iso}}}{N_{w}^{iso}/N_{w}^{\overline{iso}}}\right)_{MC}}_{\alpha_{MC}}$$

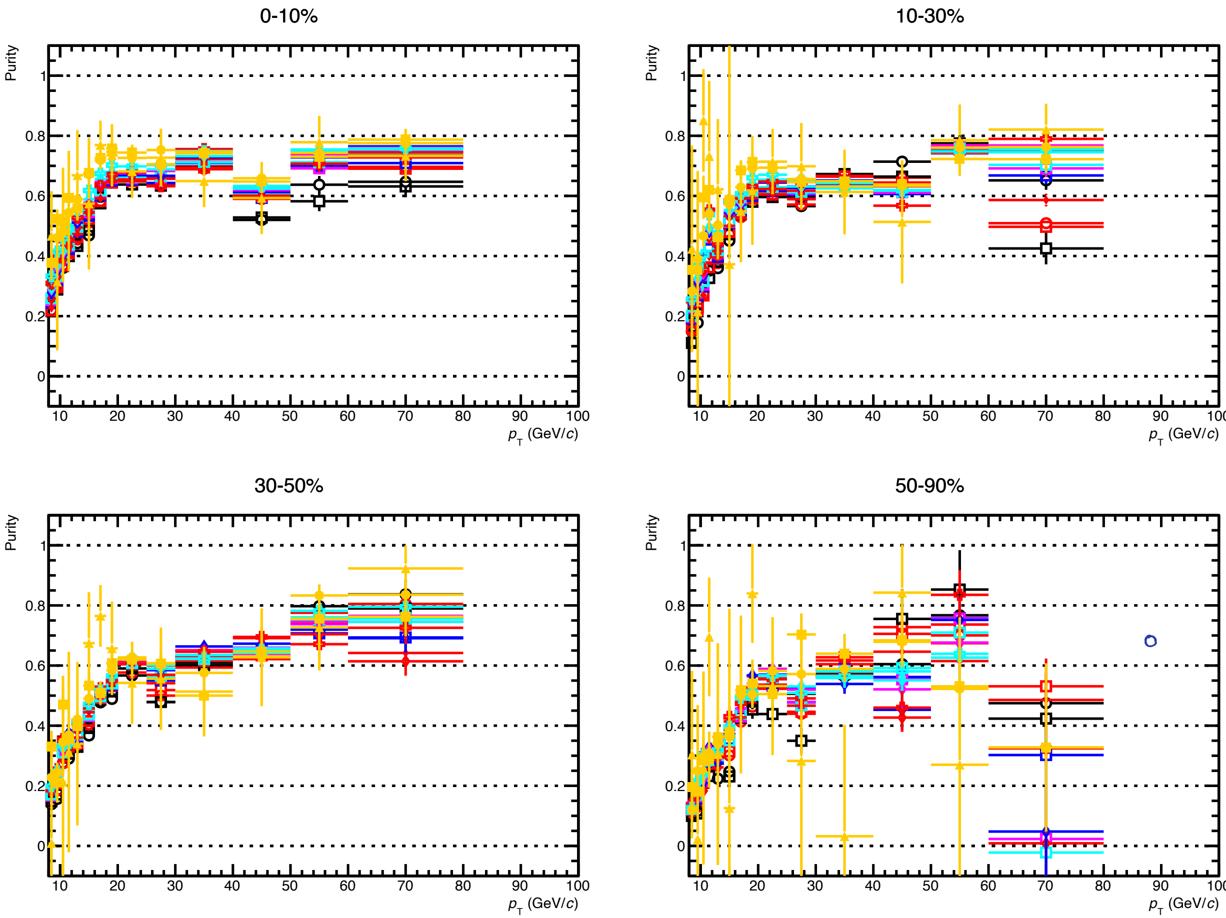
- α_{MC}: correction term needed due to the non perfect proportionality in the different regions, jet-jet MC are the main ingredient for this correction factor combined with γ-jet MC: ***N*** = ***B*** (jet-jet) + ***S*** (γ-jet)
  - $\mathrm{MC} = \mathbf{k} \times (\gamma - \mathrm{jet})_{\mathrm{MC}} + R_{\mathrm{AA}} \times (\mathrm{jet} - \mathrm{jet})_{\mathrm{MC}} = \mathbf{k} \times \mathrm{GJ} + R_{\mathrm{AA}} \times \mathrm{JJ}$
    - k = 0, 0.5, 1 and 1.5, arbitrary γ-jet scale to check result stability with the scale
    - R_{AA}: measured one for charged particles, applied directly on spectra or histograms weight based on the mother neutral mesons generated p_T
- Remarks:
  - **Pros:** If regions are not too narrow, good statistic for estimation, result rather stable with bkg region ranges variation
  - **Cons:** Dependence of the scale in MC between signal (γ-jet) and bkg (jet-jet)

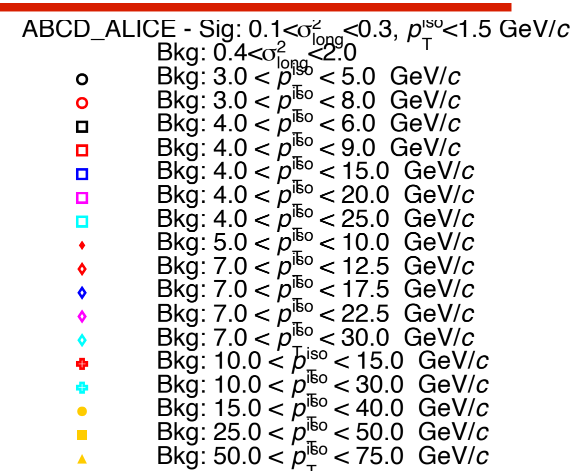
ABCD-ALICE Purity: different MC scales



- In central collisions, inclusion of signal in background regions has an important effect on the correction
- Purity is a bit larger using R_{AA} as weight at high p_T
- No large dependence in peripheral collisions, like observed in pp

ABCD-ALICE Purity for different isolation bkg regions — MC=JJ x w(R_{AA}) + GJ

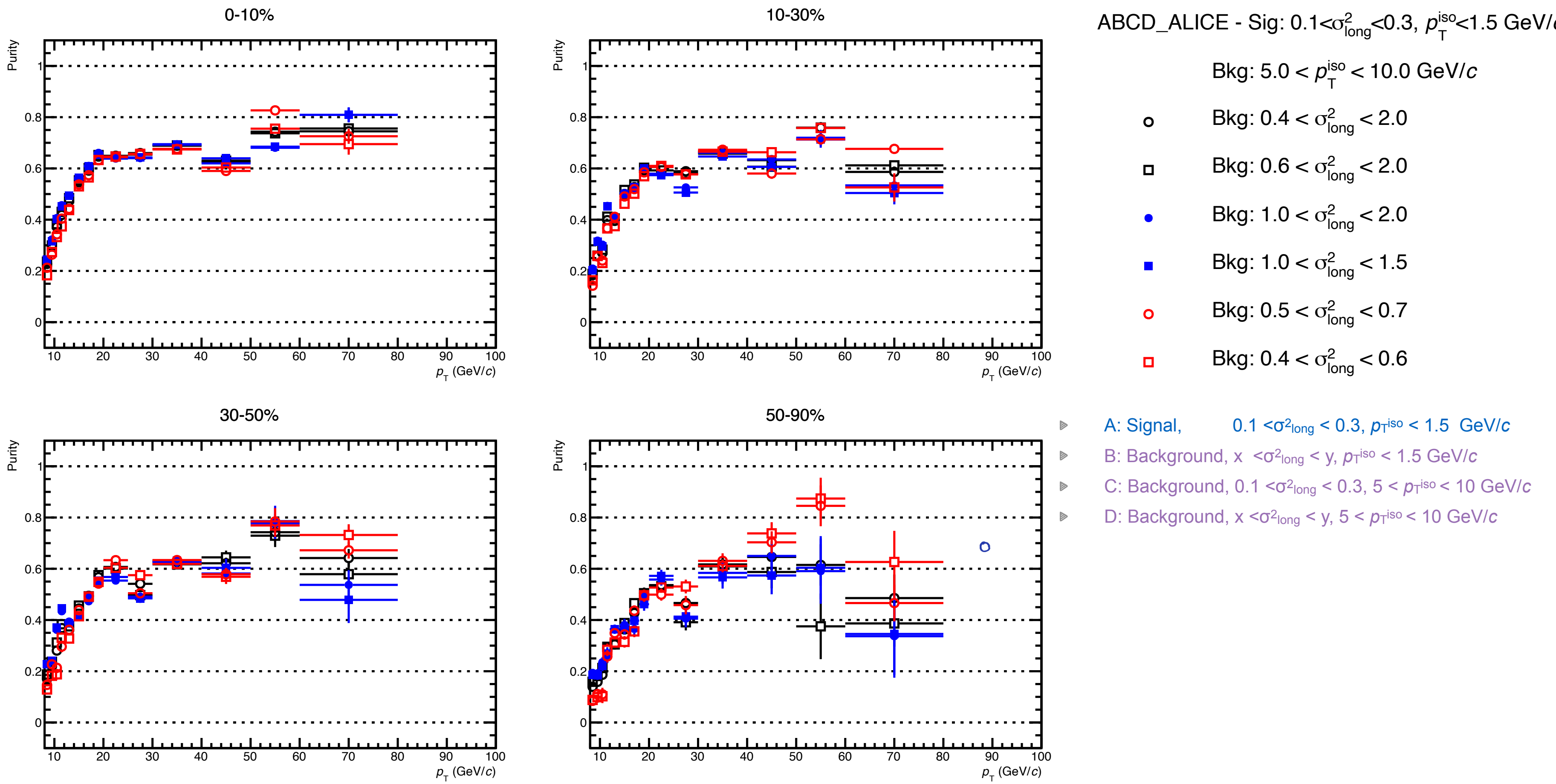




- A: Signal, $0.1 < \sigma^2_{long} < 0.3$, $p_T^{iso} < 1.5$ GeV/c
- B: Background, $0.4 < \sigma^2_{long} < 2.0$, $p_T^{iso} < 1.5$ GeV/c
- C: Background, $0.1 < \sigma^2_{long} < 0.3$, $x < p_T^{iso} < y$ GeV/c
- D: Background, $0.4 < \sigma^2_{long} < 2.0$, $y < p_T^{iso} < y$ GeV/c

- Rather independent of the variations done,
  - If not very high bkg p_T^{iso} range in central,
  - Low signal statistics for high bkg p_T^{iso} range seems to cause large error bars
  - More variation as soon as GJ is removed from the MC correction (back-up)
  - In back-up, variation of P_{dd}, 91, and α_{MC}, 92 to 94 (different k)

ABCD-ALICE Purity for different shower shape bkg regions — MC=JJ x w(R_{AA}) + GJ



- A: Signal, $0.1 < \sigma^2_{long} < 0.3$, $p_T^{iso} < 1.5$ GeV/c
- B: Background, $x < \sigma^2_{long} < y$, $p_T^{iso} < 1.5$ GeV/c
- C: Background, $0.1 < \sigma^2_{long} < 0.3$, $5 < p_T^{iso} < 10$ GeV/c
- D: Background, $x < \sigma^2_{long} < y$, $5 < p_T^{iso} < 10$ GeV/c

- Rather independent of the bkg shower shape variations done
  - A bit more variation as soon as GJ is removed from the MC correction (back-up)
  - In back-up, variation of P_{dd}, 95, and α_{MC}, 96 to 98 (different k)

- Same 4 regions as ABCD-ALICE, N_i measured in region i = A, B, C, D
- Similar approach but signal leak into bkg regions treated out of α_{MC}
  - $\alpha_{MC} = R^{MC}_{Bkg} = \frac{N_A^{MC,bkg} N_D^{MC,bkg}}{N_B^{MC,bkg} N_C^{MC,bkg}}$ when MC = JJ and not a combination of JJ and GJ
  - Replace in ABCD-ALICE, in the $P_{\rm dd}$ term N_i by $N_i' = N_i - c_i N_{\rm A}^{\rm signal}$, where $c_i = \frac{N_i^{MC,\ signal}}{N_A^{MC,\ signal}}$ and $N_A^{\rm signal}$ is the isolated photons measured without background
- Then the purity is extracted as $P = N_A^{\rm signal}/N_A$, where

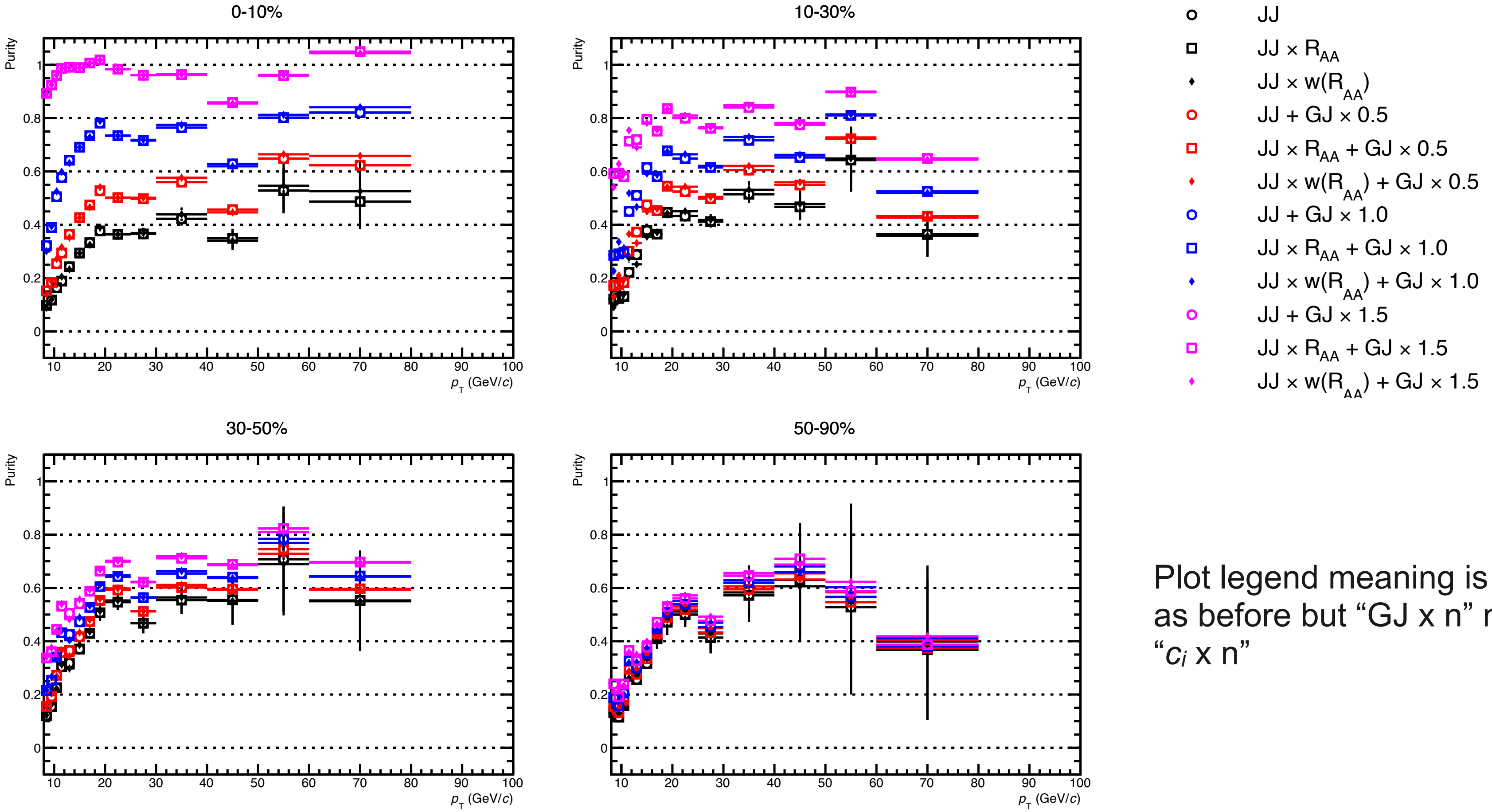
$$\boxed{N_A^{\rm signal} = N_A - R^{\rm MC}_{\rm Bkg}(N_B - \mathbf{k}c_B N_A^{\rm signal})\frac{(N_C - \mathbf{k}c_C N_A^{\rm signal})}{(N_D - \mathbf{k}c_D N_A^{\rm signal})}}$$

  - k = 0, 0.5, 1 and 1.5, arbitrary scale γ-jet to check result stability with the scale
  - Solving the equation (for k=1, check in back-up)

$$\boxed{\begin{aligned} X &= c_B c_C R^{MC}_{Bkg} - c_D \\ Y &= N_D + c_D N_A - N_B c_C R^{MC}_{Bkg} - c_B N_C R^{MC}_{Bkg} \\ Z &= N_B N_C R^{MC}_{Bkg} - N_D N_A \end{aligned} \qquad N_A^{signal} = \frac{-Y + \sqrt{Y^2 - 4XZ}}{2X}}$$

- Remarks:
  - **Pros:** If regions are not too narrow, good statistic for estimation
  - **Pros: No** dependence of the scale in MC between signal (γ-jet) and bkg (jet-jet),
    - except the arbitrary k factor in c_i that can induce large variations

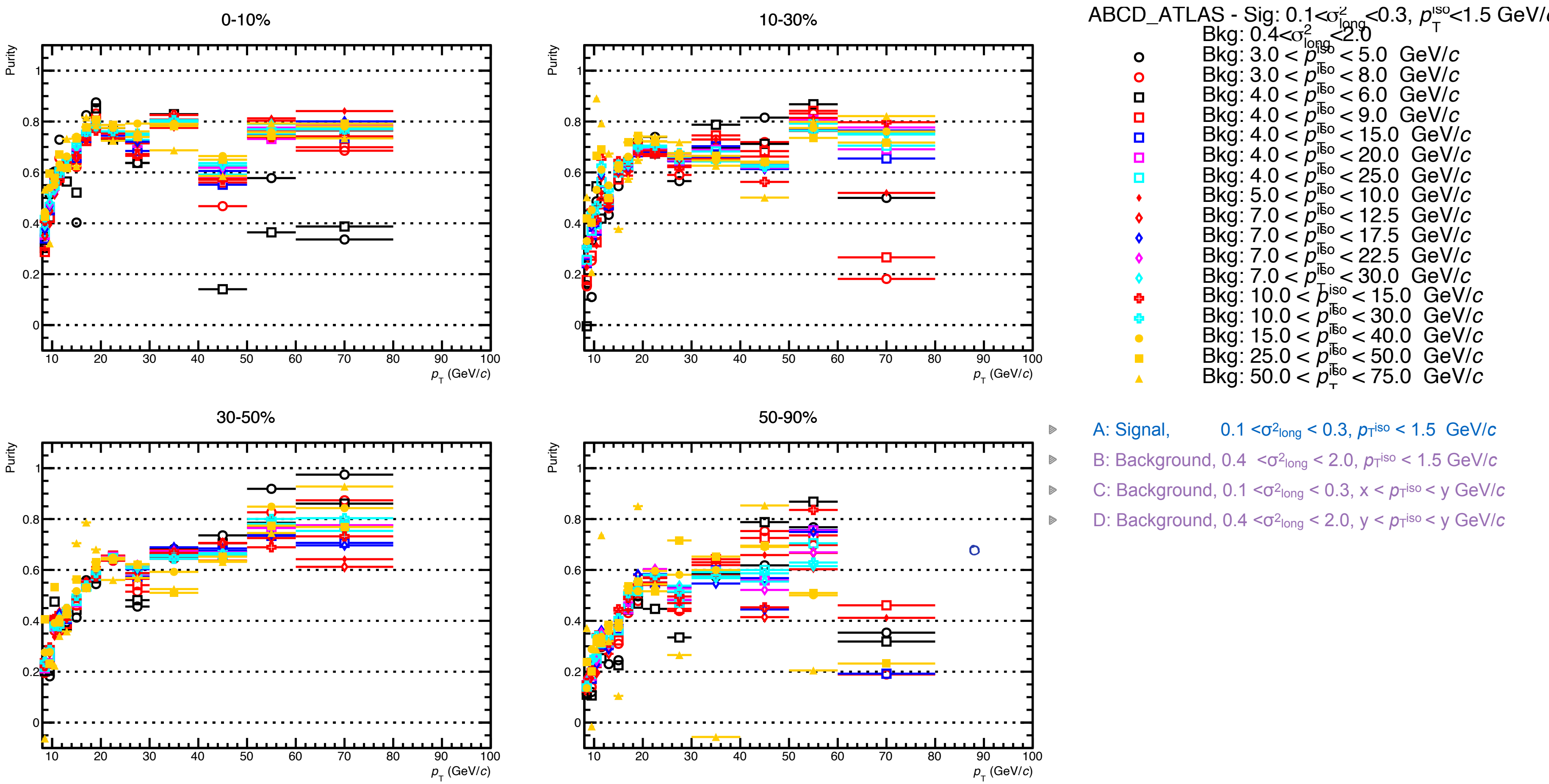
ABCD-ATLAS Purity: Different scales, arbitrary c_i factor scale



Plot legend meaning is same as before but “GJ x n” means “c_i x n”

- Apply the same scale factor 0, 0.5, 1 or 1.5 to the fraction c_i
  - A particular extreme case, one should do pseudo experiments varying each independently
- Result is quite sensitive to the c_i scale
- No effect on the scale applied to the JJ bkg (as expected)
- Agreement with “ALICE” in 30-90%, in central it is too high (1 x c_i), although 0.5 x c_i seems reasonable

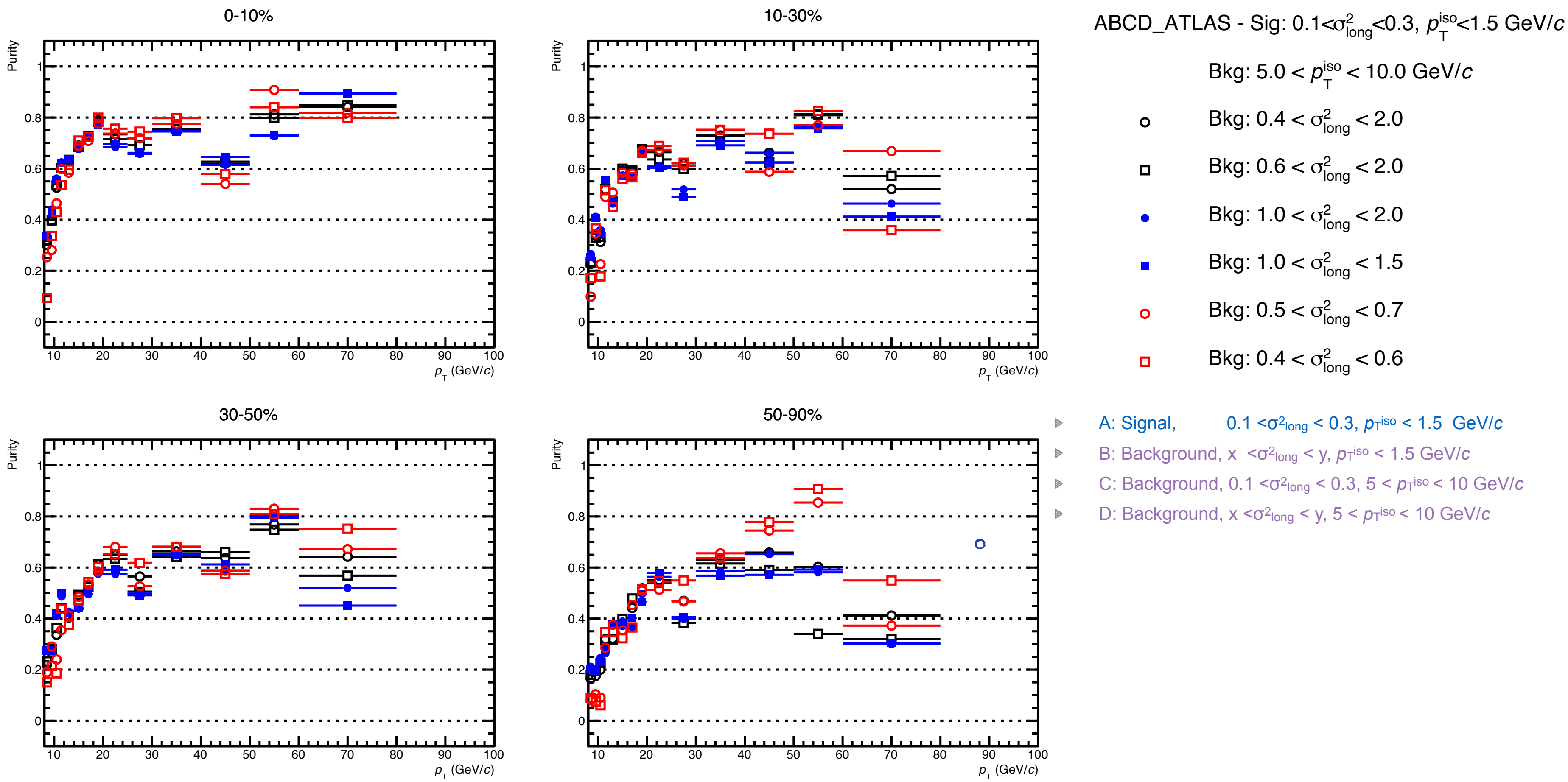
ABCD-ATLAS Purity for different isolation bkg regions — MC=JJ x w(R_{AA}) + GJ



- A: Signal, 0.1 <σ^2_{long} < 0.3, p_T^{iso} < 1.5 GeV/c
- B: Background, 0.4 <σ^2_{long} < 2.0, p_T^{iso} < 1.5 GeV/c
- C: Background, 0.1 <σ^2_{long} < 0.3, x < p_T^{iso} < y GeV/c
- D: Background, 0.4 <σ^2_{long} < 2.0, y < p_T^{iso} < y GeV/c

- Purity tends to be very high in central
- Rather independent of the p_T^{iso} bkg variations done
  - Avoid narrow ranges
  - More variation as soon as GJ is removed from the MC correction (back-up)

ABCD-ATLAS Purity for different shower shape bkg regions — MC=JJ x w(R_{AA}) + GJ



- A: Signal, $0.1 < \sigma^2_{long} < 0.3$, $p_T^{iso} < 1.5$ GeV/c
- B: Background, $x < \sigma^2_{long} < y$, $p_T^{iso} < 1.5$ GeV/c
- C: Background, $0.1 < \sigma^2_{long} < 0.3$, $5 < p_T^{iso} < 10$ GeV/c
- D: Background, $x < \sigma^2_{long} < y$, $5 < p_T^{iso} < 10$ GeV/c

- Rather independent of the bkg shower shape variations done
  - More variation as soon as GJ is removed from the MC correction (back-up)

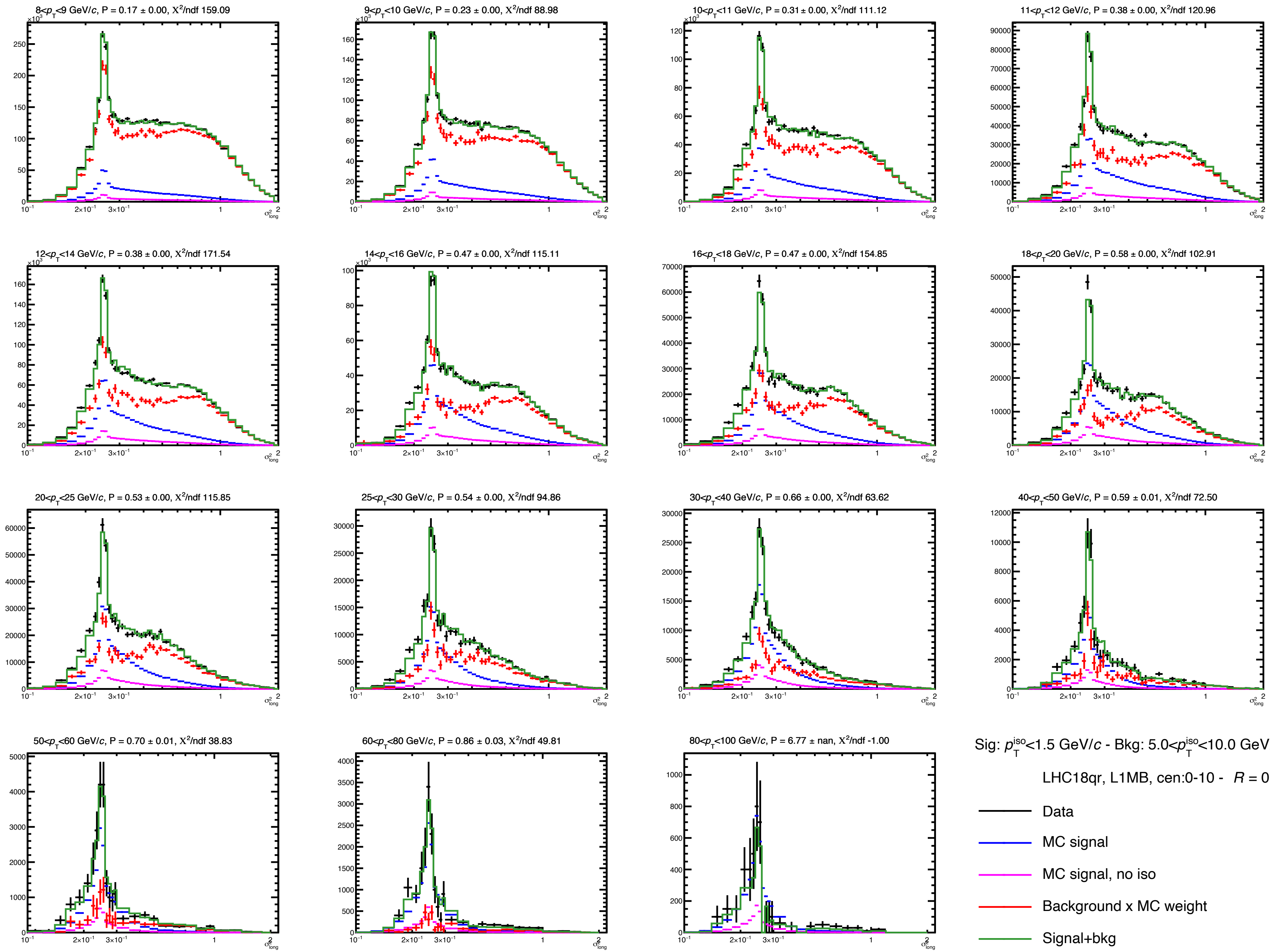
Purity estimation with Template fit method (pp-pPb hadron, pp-PbPb jet, like)

- Fit the shower shape distribution of isolated clusters to a linear combination of background and signal templates :

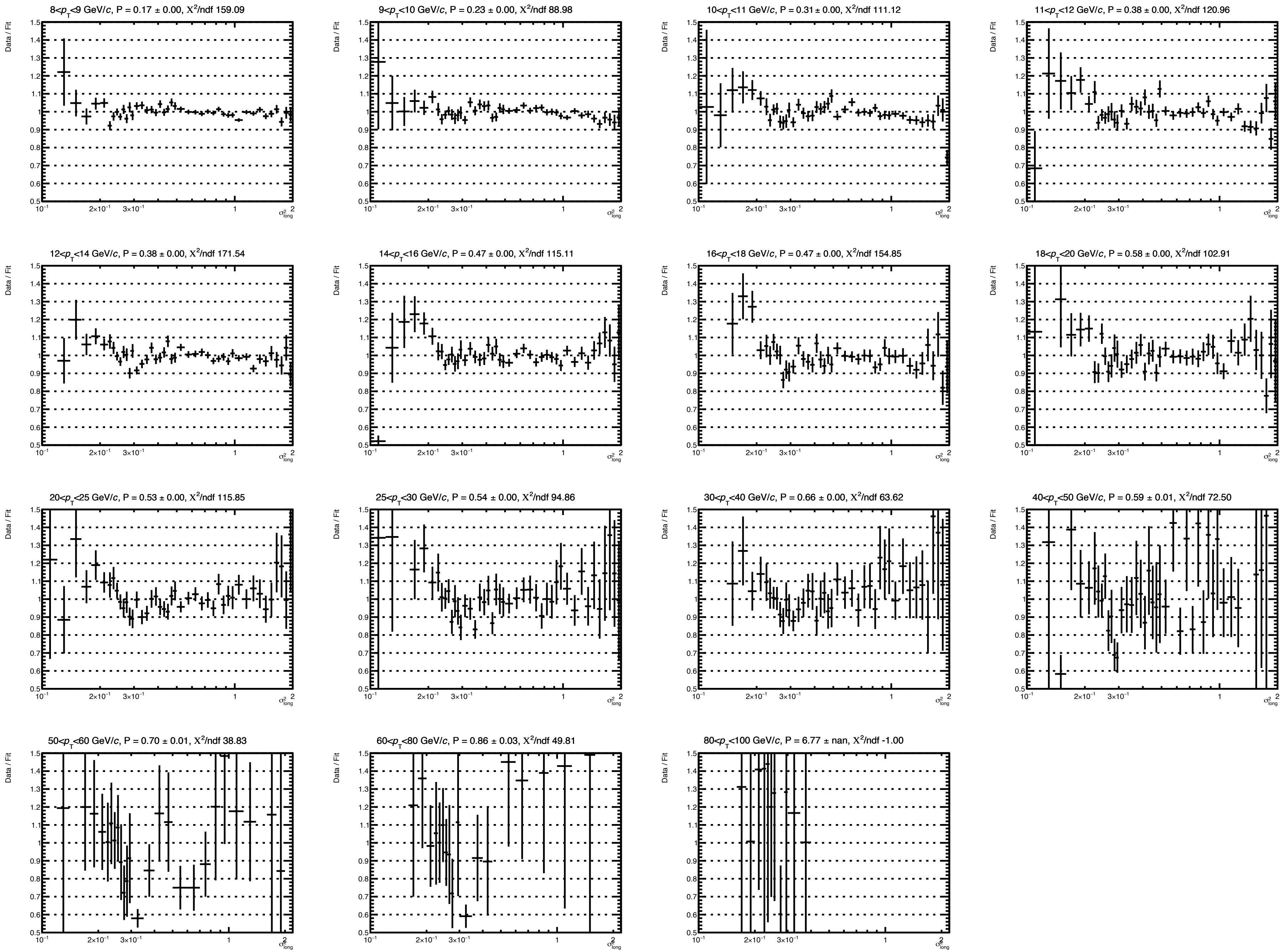
$$\boxed{N^{observed}(\sigma_{long}^{2}) = N_{sig} \times S(\sigma_{long}^{2}) + (N - N_{sig}) \times B(\sigma_{long}^{2})}$$

- Since shower shape distribution of the background is different for isolated and not isolated background, a **correction to the background template** is needed:
  - Calculate the bkg template without using the signal in the weight (like ABCD-ATLAS), subtract the signal contribution to the bkg template iteratively
    - $N_{\mathrm{bkg}}(\sigma_{\mathrm{long}}^{2}) = (N_{\mathrm{bkg}}^{\mathrm{meas}} - \mathbf{k} N_{\mathrm{MC\ GJ,\ scaled}}^{\mathrm{anti\ iso}}) \times Weight = (N_{\mathrm{bkg}}^{\mathrm{meas}} - \mathbf{k} N_{\mathrm{MC\ GJ,\ scaled}}^{\mathrm{anti\ iso}}) \times \frac{N_{\mathrm{MC\ JJ}}^{\mathrm{iso}}}{N_{\mathrm{MC\ JJ}}^{\mathrm{anti\ iso}}}$
    - Where the anti-isolated signal scaled $N_{\mathrm{MC\ GJ,\ scaled}}^{\mathrm{anti\ iso}}$, is obtained scaling the MC anti-iso signal with the template fit scale obtained previously without subtraction (k=0). No need for iteration.
  - k = 0, 0.5, 1 and 1.5, arbitrary scale to signal γ-jet (iso and anti-iso) to check result stability with the scale
- Remark:
  - **Cons:** Need of good statistics in full shower shape and good shape in MC for stable fit. Depends on binning.
  - **Pros: No** dependence of the scale in MC between signal (γ-jet) and bkg (jet-jet)
    - Unless the k factor is not applied to the signal template but just to the anti-iso correction, then small variation

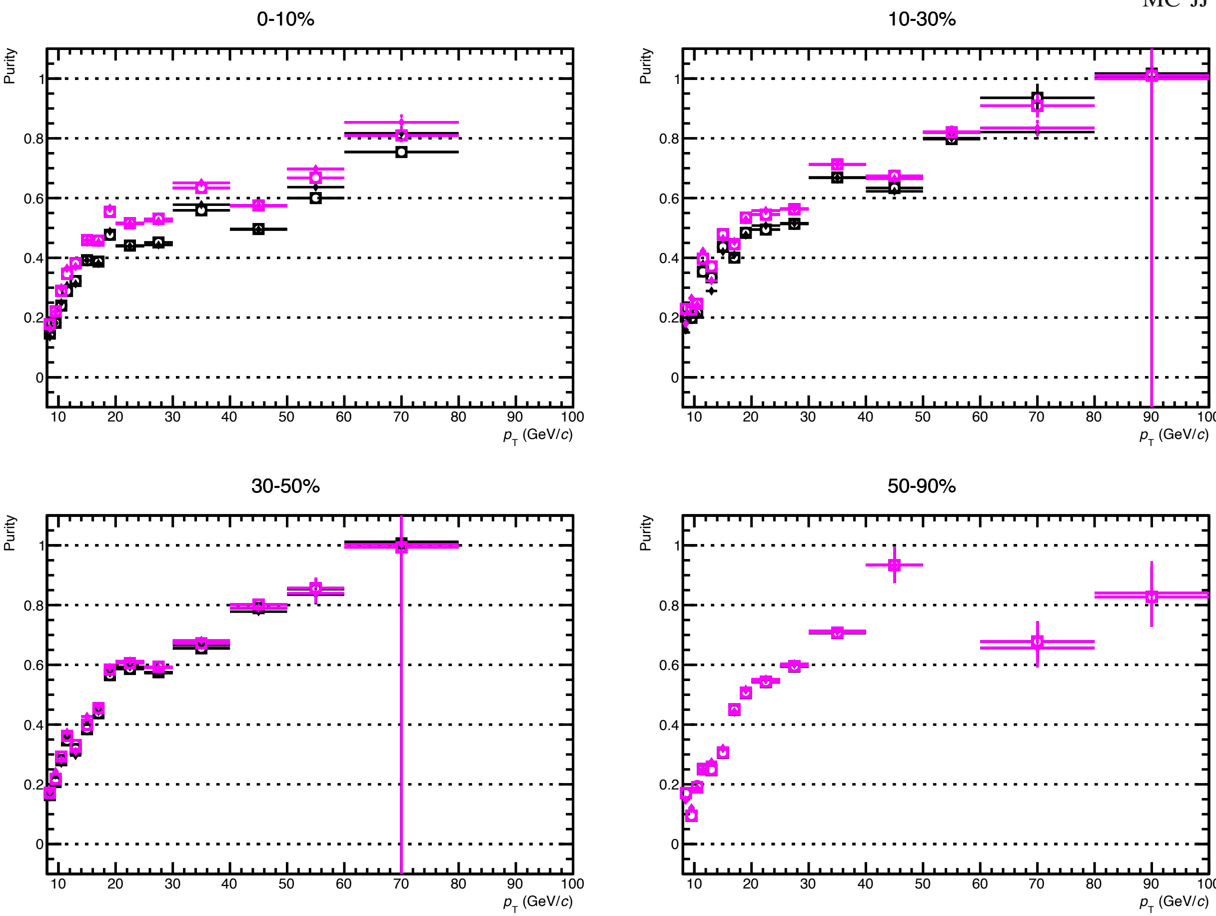
Template shower shape distributions: 0-10% (other cent in back-up 58, 60 & 62)



Shower shape data / template fit signal+bkg: 0-10% (other cent in back-up 59, 61 & 63)



Template Purity with $N_{\mathrm{bkg}} = (N^{\mathrm{meas}}_{\mathrm{bkg}} - \mathbf{k} N^{\mathrm{anti\ iso}}_{\mathrm{MC\ GJ,\ scaled}}) \frac{N^{\mathrm{iso}}_{\mathrm{MC\ JJ}}}{N^{\mathrm{anti\ iso}}_{\mathrm{MC\ JJ}}}$ k = 0, 0.5, 1, 1.5



- JJ
- JJ × R_{AA}
- JJ × w(R_{AA})
- JJ + GJ × 0.5
- JJ × R_{AA} + GJ × 0.5
- JJ × w(R_{AA}) + GJ × 0.5
- JJ + GJ × 1.0
- JJ × R_{AA} + GJ × 1.0
- JJ × w(R_{AA}) + GJ × 1.0
- JJ + GJ × 1.5
- JJ × R_{AA} + GJ × 1.5
- JJ × w(R_{AA}) + GJ × 1.5

No subtraction of $N^{\mathrm{anti\ iso}}_{\mathrm{MC\ GJ,\ scaled}}$

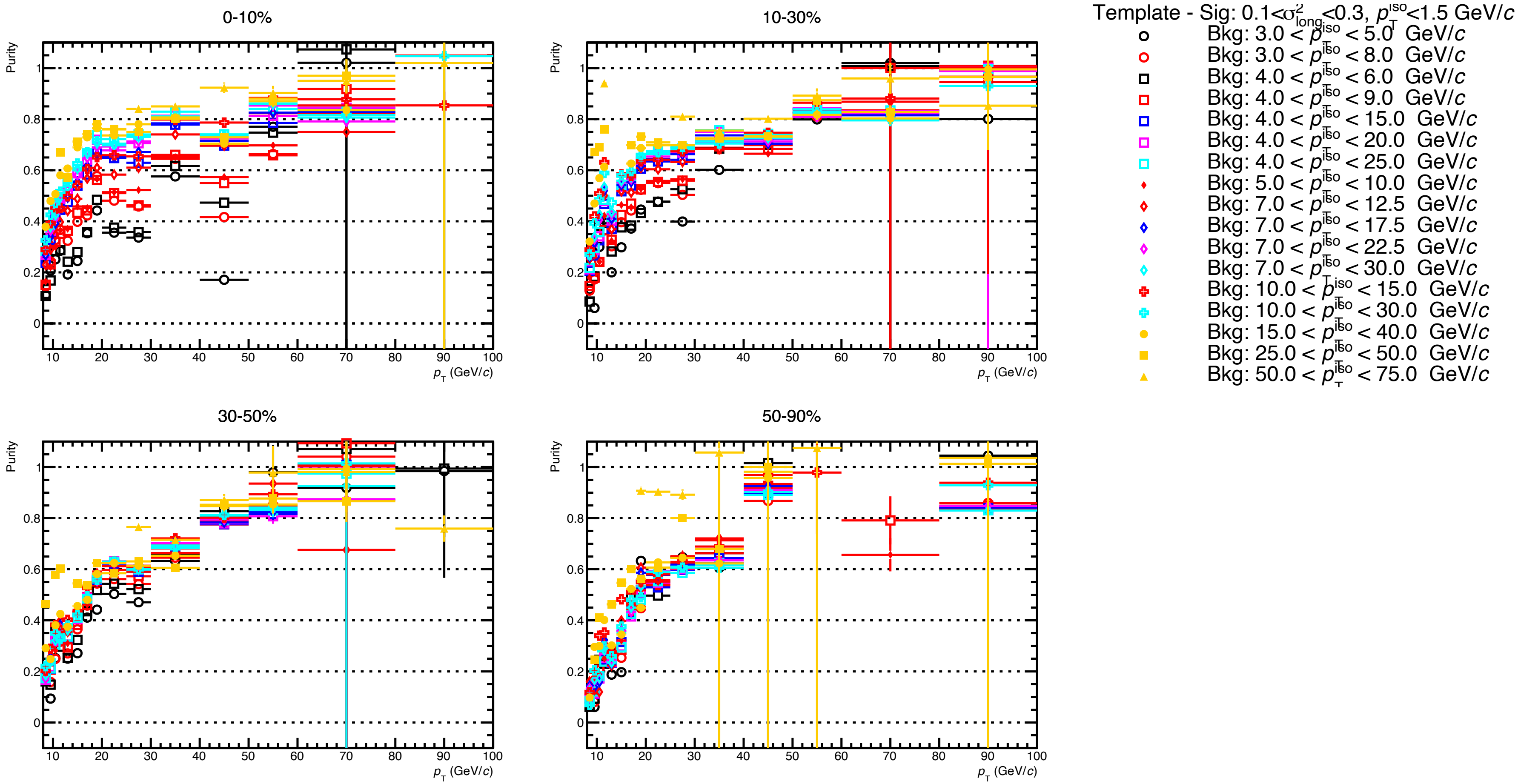
Subtraction of $k\,N^{\mathrm{anti\ iso}}_{\mathrm{MC\ GJ,\ scaled}}$

Scale obtained from black points template

- $0.1 < \sigma^2_{long} < 0.3$
- Signal, $p_T^{iso} < 1.5$ GeV/c
- Background, $5 < p_T^{iso} < 10$ GeV/c

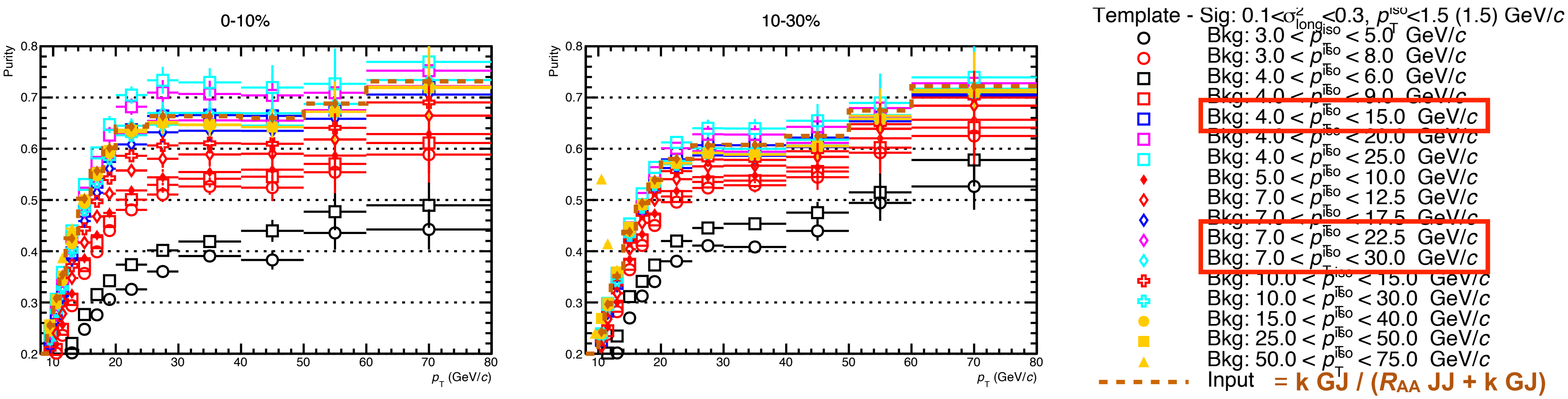
- Closer to what reports Alwina, specially when $N^{\mathrm{anti\ iso}}_{\mathrm{MC\ GJ,\ scaled}}$ is not subtracted from bkg template
- No effect of use of R_{AA} scaling JJ
- Subtracting $N^{\mathrm{anti\ iso}}_{\mathrm{MC\ GJ,\ scaled}}$ in central collisions moves up purity
  - But shift independent of the k signal arbitrary scale.
    - If k applied only to ant-iso, but not on both iso and anti-iso, small variation, k=0.5 between k=1 and k=0 (not done in slides)
  - Recalculation with the template scale $N^{\mathrm{anti\ iso}}_{\mathrm{MC\ GJ,\ scaled}}$ obtained with a first subtraction does not change the result
  - Depending the bkg range, the shift between no subtraction and subtraction can change
- Peripheral and semi-central seem to go too up at hight p_T likely due to low statistics

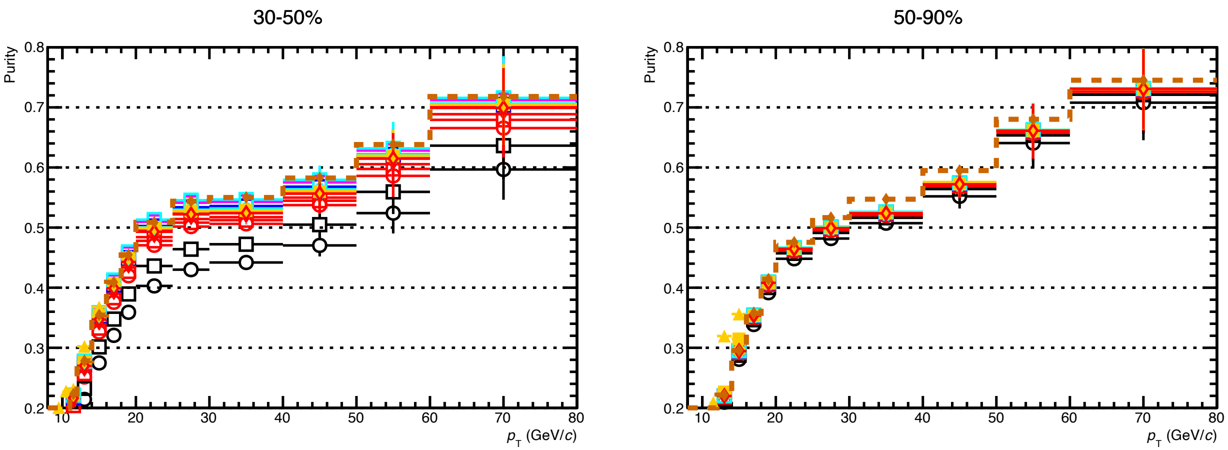
Template Purity for different isolation bkg regions — MC = JJ x w(R_{AA}) + GJ



- Result varies more than other methods with the p_T^{iso} bkg ranges selected here, specially in central
  - The higher the range lower limit the higher the purity
  - Even more variation as soon as GJ anti-iso is not removed from template ([back-up](#))

Purity Template — MC closure test — MC = JJ x w(R_{AA}) + GJ

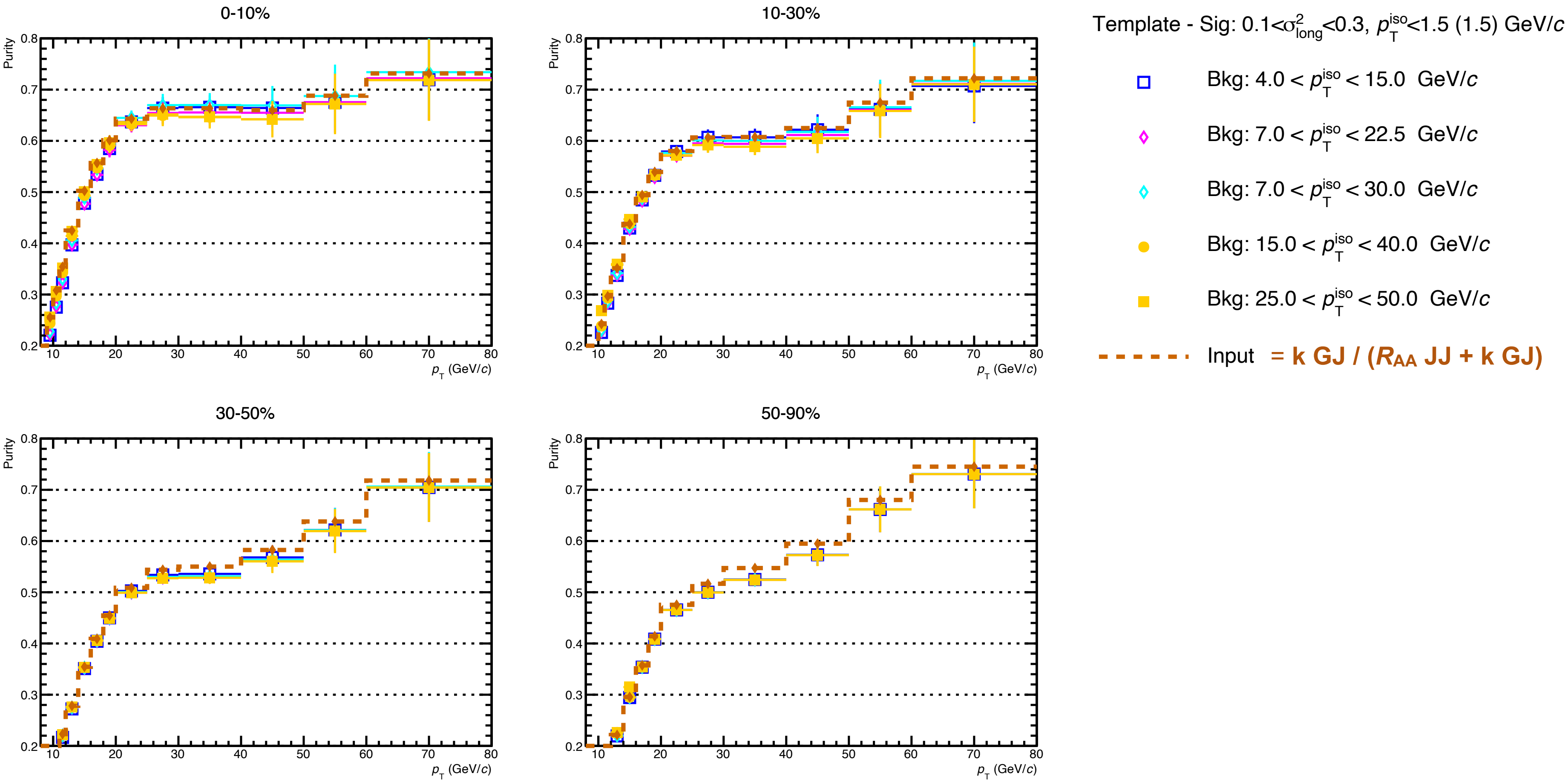




Shower shape distributions in back-up

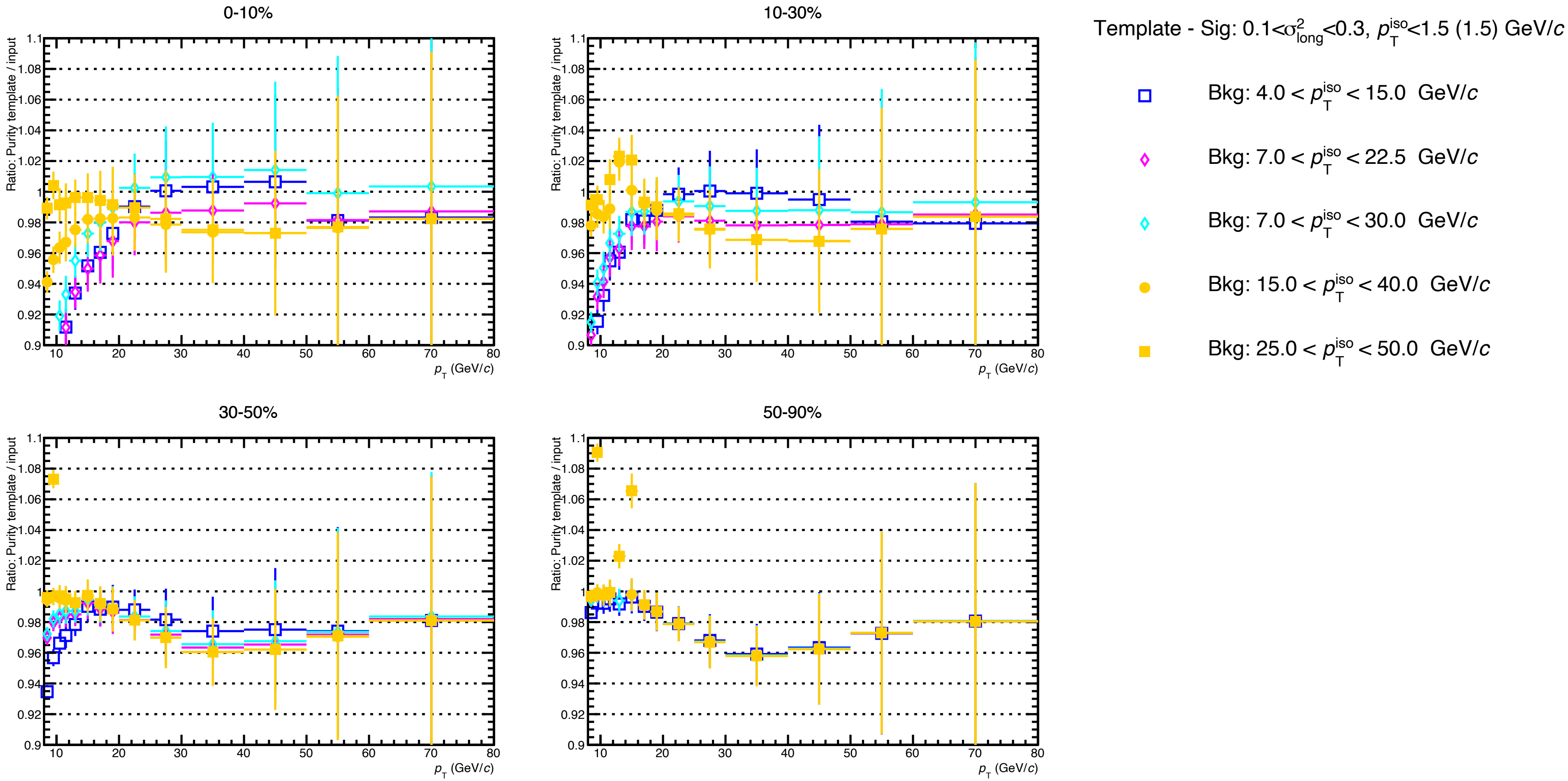
- Replace real data by MC and apply the same purity estimation procedure, compare to the injected purity, discontinuous histogram ***Input purity*** **= k GJ / (R_{AA} JJ + k GJ)**
  - Fitted shower shape distributions per p_T bin in back-up from 64 to 71
  - ABCD methods give the input purity by construction
    - See back-up 72 to 75 for direct comparison of the 3 methods, each slide for different p_T^{iso} bkg ranges
- Changing the p_T^{iso} bkg range changes the purity with the template,
  - but much more than in data in central collisions
  - Higher p_T^{iso} bkg range lower limit or window reproduce better the input purity

Purity Template — MC closure test — MC = JJ x w(R_{AA}) + GJ



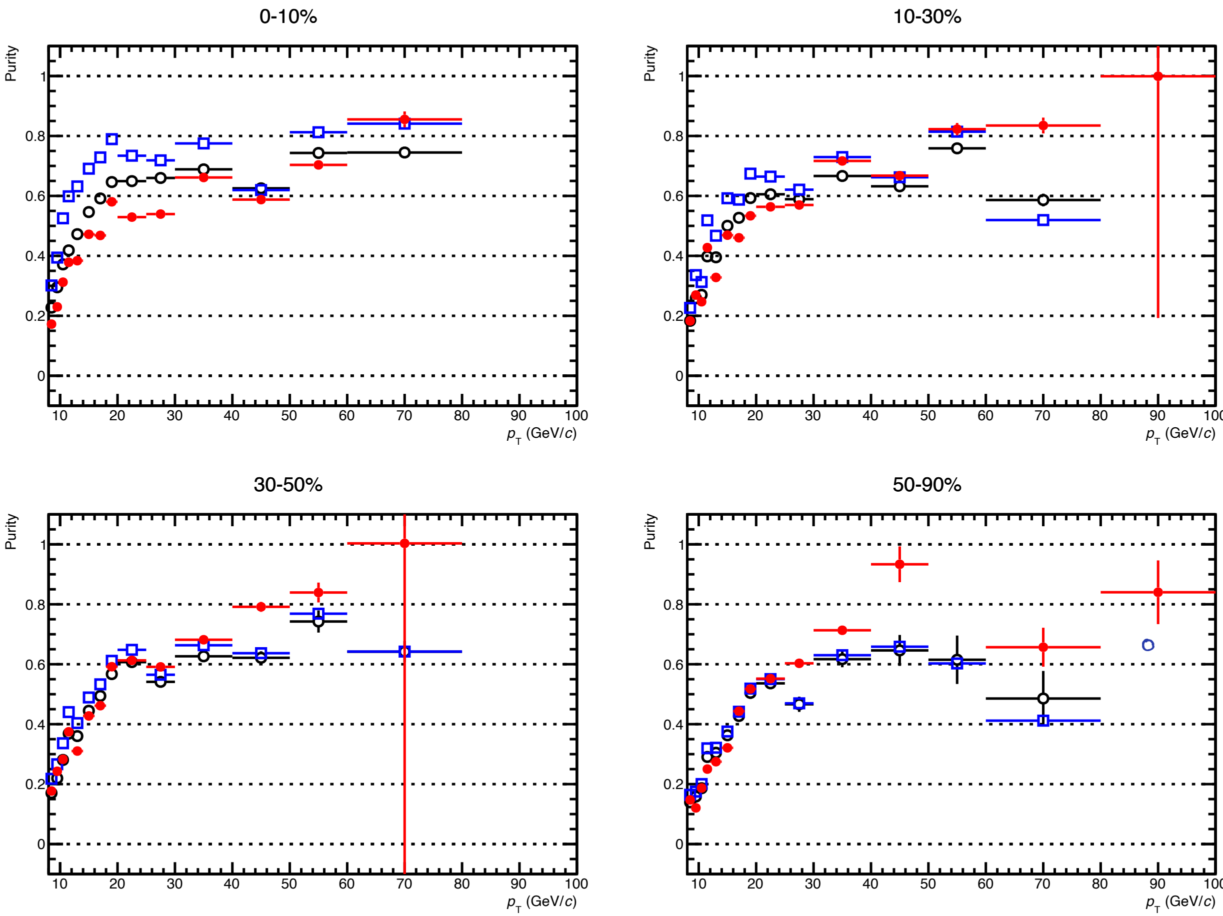
- Selection of "best" p_T^{iso} bkg ranges found of previous slide
- With k=0.5, the agreement is not so good, but not far: back-up 76 to 79
- With k=0, only ranges far away from the signal range (>15 GeV/c) manage to get close to the input purity (which makes sense): back-up 80 & 81

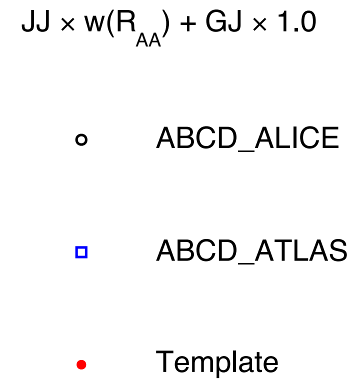
Purity Template — MC closure test — MC=JJ x w(R_{AA}) + GJ



- Selection of “best” p_T^{iso} bkg ranges found of previous plot
  - In central, higher ranges have better agreement at low p_T, but lower ranges at high pT
  - In not central, not perfect agreement at high p_T, some 2-4% offset (like for high range in central)
- Changing the scale to k=0.5, the agreement is not so good, but not far (back-up 76 to 79)

Purity methods comparison — MC =JJ x w(R_{AA}) + GJ



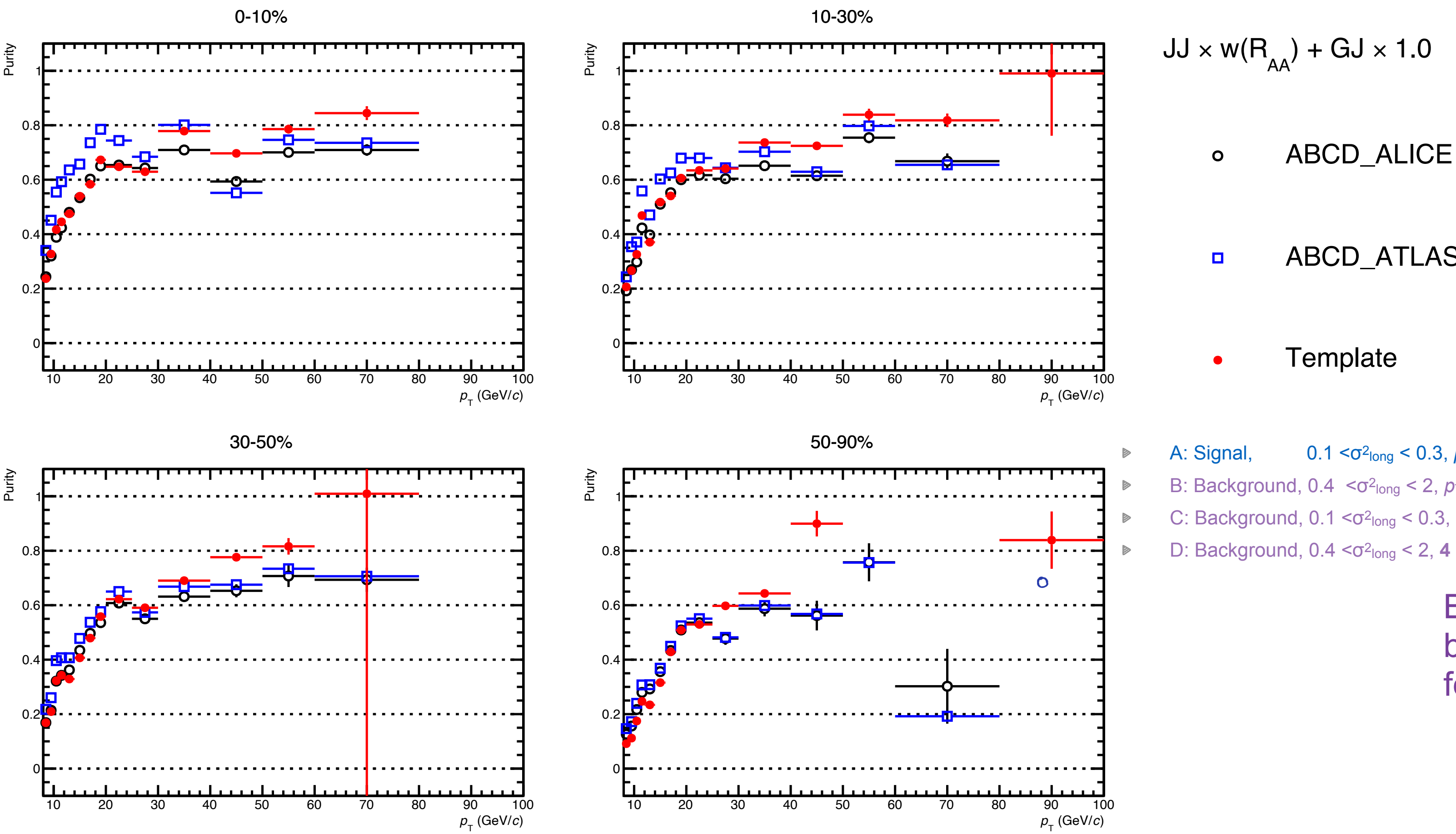


- A: Signal, $0.1 < \sigma^2_{long} < 0.3$, $p_T^{iso} < 1.5$ GeV/c
- B: Background, $0.4 < \sigma^2_{long} < 2$, $p_T^{iso} < 1.5$ GeV/c
- C: Background, $0.1 < \sigma^2_{long} < 0.3$, **$5 < p_T^{iso} < 10$ GeV/c**
- D: Background, $0.4 < \sigma^2_{long} < 2$, **$5 < p_T^{iso} < 10$ GeV/c**

Not blessed region by MC closure for template

- 50-90%: Very good agreement between methods.
  - ATLAS=ALICE
    - Bin 25-30 GeV problematic
  - Template tends to go up at high p_T (maybe statistics problem)
- 30-50%: Rather good agreement between methods
- 0-30%: ATLAS higher, Template lower than ABCD-ALICE

Purity methods comparison — JJ x w(R_{AA}) + GJ

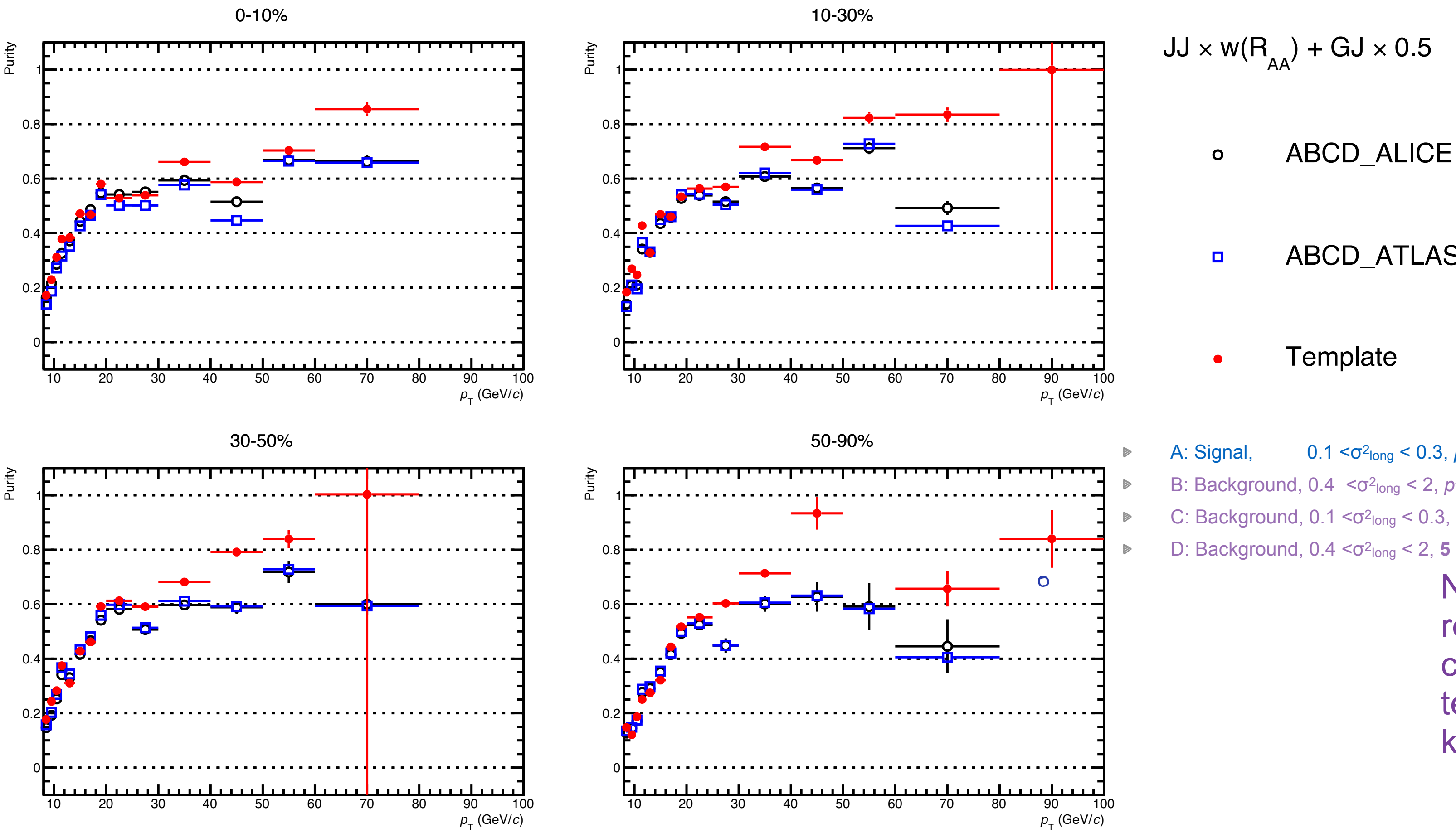


- A: Signal, 0.1 < σ^2_{long} < 0.3, p_T^{iso} < 1.5 GeV/c
- B: Background, 0.4 < σ^2_{long} < 2, p_T^{iso} < 1.5 GeV/c
- C: Background, 0.1 < σ^2_{long} < 0.3, **4 < p_T^{iso} < 15 GeV/c**
- D: Background, 0.4 < σ^2_{long} < 2, **4 < p_T^{iso} < 15 GeV/c**

Blessed region by MC closure for template

- Using the p_T^{iso} bkg range that the template MC closure suggests, ABCD-ALICE and template tend to agree in central collisions, very well at low p_T
  - Similar agreement with 7-22 GeV/c and 7-30 GeV/c p_T^{iso} bkg ranges (back-up 82 & 83)
- ABCD-ATLAS still does not match the other in central

Purity methods comparison — JJ x w(R_{AA}) + 0.5 x GJ

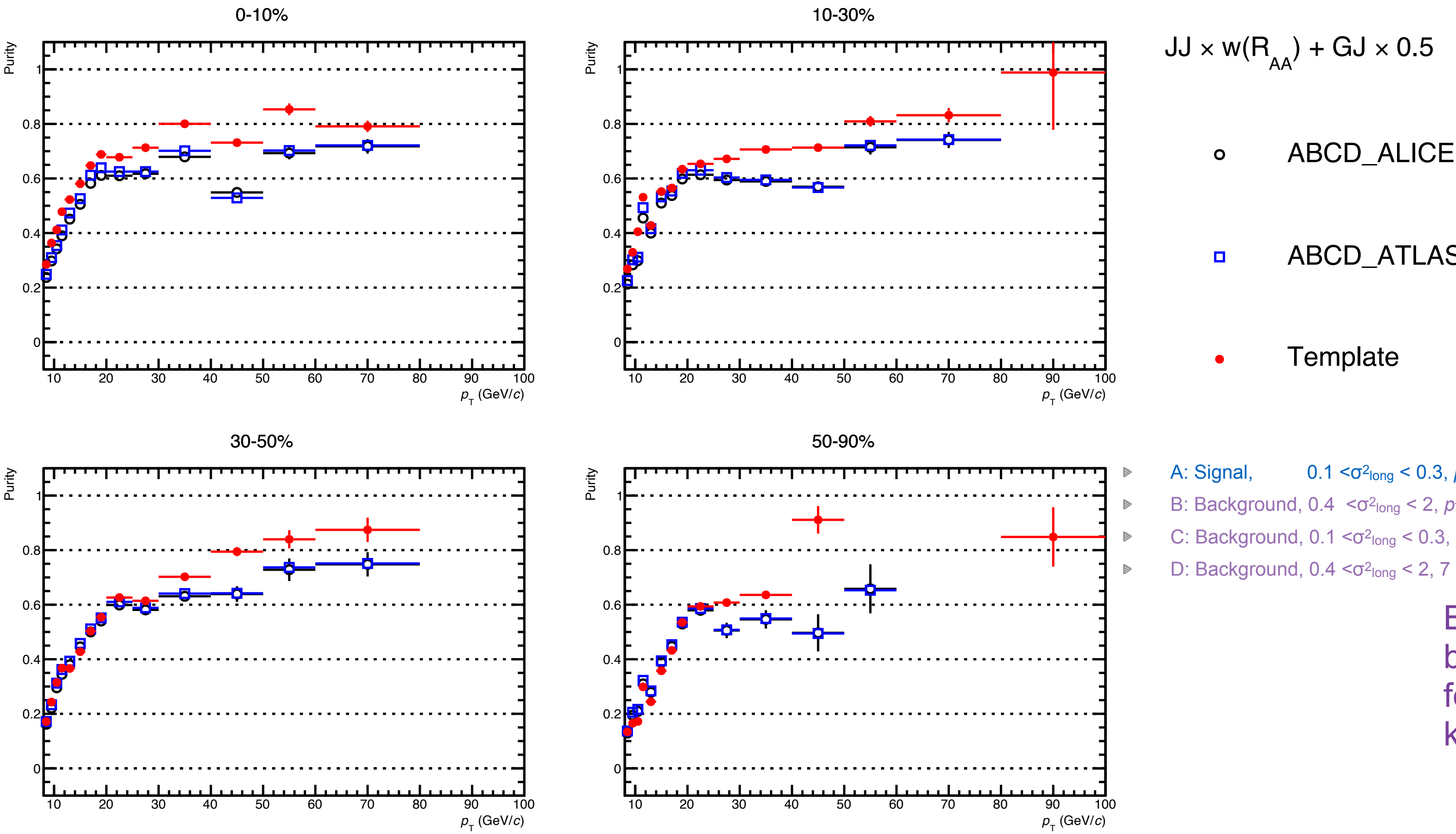


- A: Signal, $0.1 < \sigma^2_{long} < 0.3$, $p_T^{iso} < 1.5$ GeV/c
- B: Background, $0.4 < \sigma^2_{long} < 2$, $p_T^{iso} < 1.5$ GeV/c
- C: Background, $0.1 < \sigma^2_{long} < 0.3$, **$5 < p_T^{iso} < 10$ GeV/c**
- D: Background, $0.4 < \sigma^2_{long} < 2$, **$5 < p_T^{iso} < 10$ GeV/c**

Not blessed region by MC closure for template for k=1

- Funny observation or accident?
  - Changing GJ scale a factor k=0.5, template and ABCD-ALICE decrease, more or less to where we would like and tend to agree.
  - Now ABCD-ATLAS agrees with the other, when applying a k=0.5 factor to the c_i GJ fractions
  - Could this mean that the photon shape is not well reproduced and we are giving too much weight to the bkg regions?

Purity methods comparison — JJ x w(R_{AA}) + 0.5 x GJ



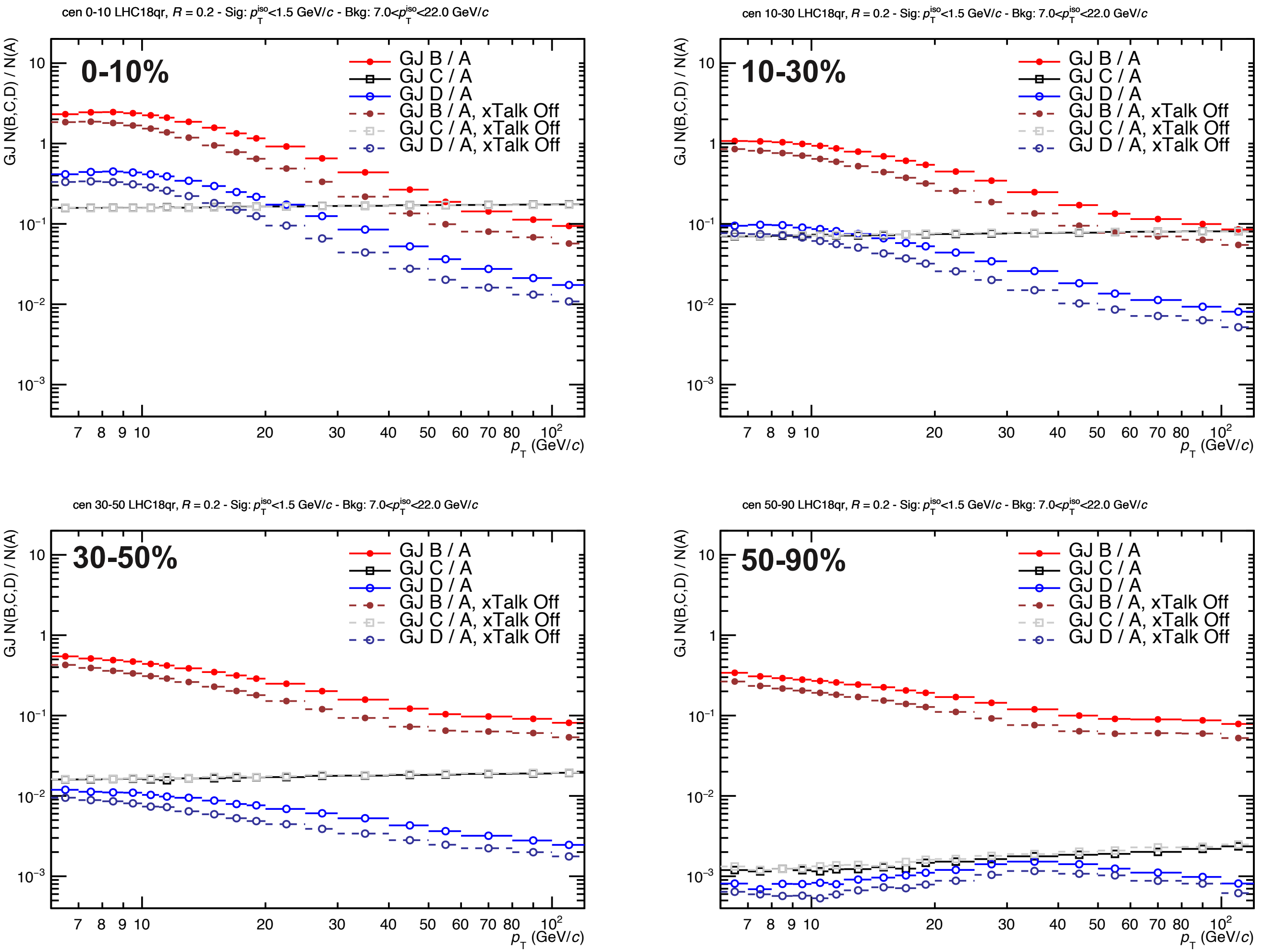
- A: Signal, $0.1 < \sigma^2_{long} < 0.3$, $p_T^{iso} < 1.5$ GeV/c
- B: Background, $0.4 < \sigma^2_{long} < 2$, $p_T^{iso} < 1.5$ GeV/c
- C: Background, $0.1 < \sigma^2_{long} < 0.3$, **$7 < p_T^{iso} < 22$ GeV/c**
- D: Background, $0.4 < \sigma^2_{long} < 2$, **$7 < p_T^{iso} < 22$ GeV/c**

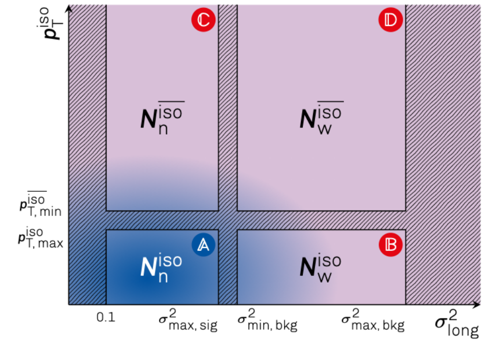
Blessed region by MC closure for template for k=0.5

Funny observation or accident?

- Changing GJ scale a factor k=0.5, template and ABCD-ALICE decrease, more or less to where we would like and tend to agree.
- Now ABCD-ATLAS agrees with the other, when applying a k=0.5 factor to the c_i GJ fractions
- But now template doesn't agree as good as before with p_T^{iso} range 7-22 GeV/c
  - If only anti-iso was scaled by k=0.5 in the template, better agreement would be found

γ-jet MC c_i fraction B,C,D / A, with cross talk on or off



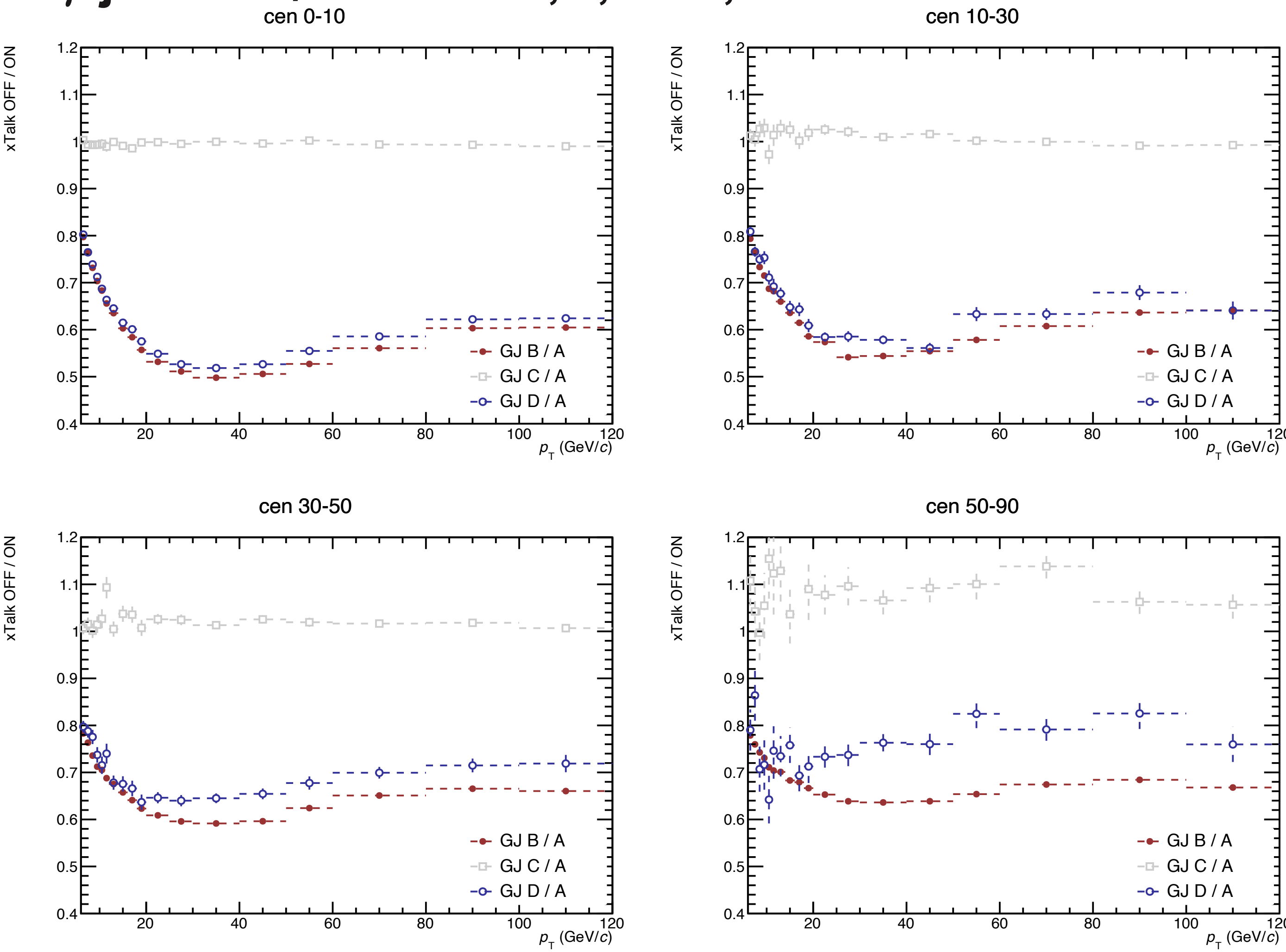


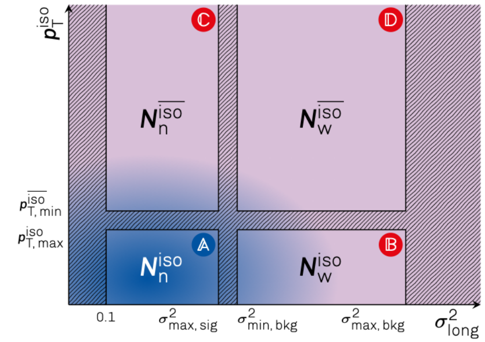
A: Signal, $0.1 < \sigma^2_{long} < 0.3$, $p_T^{iso} < 1.5$ GeV/c
B: Background, $0.4 < \sigma^2_{long} < 2.0$, $p_T^{iso} < 1.5$ GeV/c
C: Background, $0.1 < \sigma^2_{long} < 0.3$, $7 < p_T^{iso} < 22$ GeV/c
D: Background, $0.4 < \sigma^2_{long} < 2.0$, $7 < p_T^{iso} < 22$ GeV/c

- B /A (isolated wide clusters) is large at low p_T, it decreases decreasing the window or moving it to higher values, but is the highest fraction of the 3 in any case
- C / A is constant with p_T, smaller than 20%
- All fractions can be reduced decreasing the background regions windows or moving to higher values (back-up 53 and 54) but the impact in the purity is not large.

What can change the GJ contribution in Bkg to affect the purity? Cross talk

γ-jet MC c_i fraction B,C,D / A, with cross talk on or off





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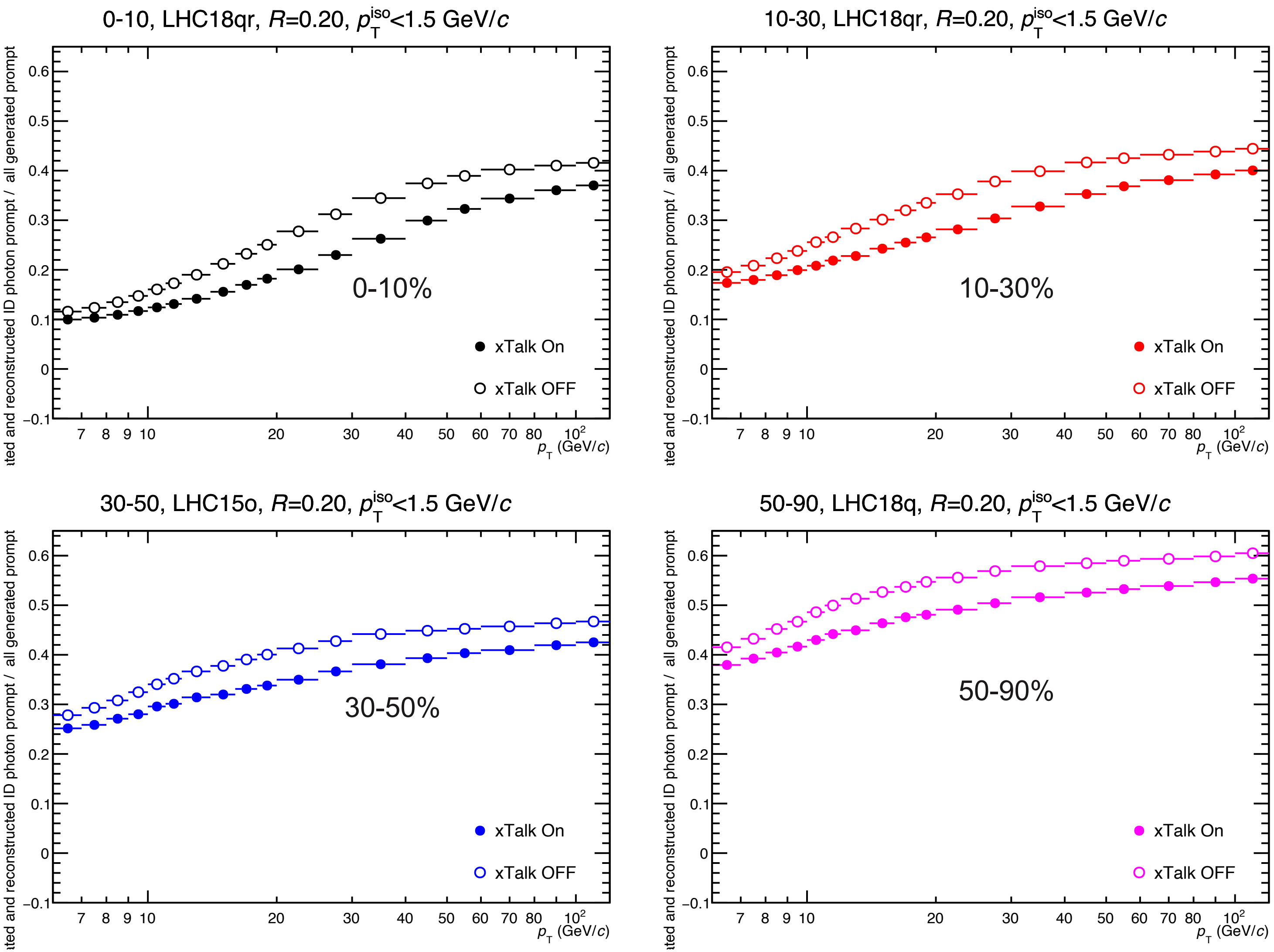
C: Background, $0.1 < \sigma^2_{long} < 0.3$, $7 < p_T^{iso} < 22$ GeV/c

D: Background, $0.4 < \sigma^2_{long} < 2.0$, $7 < p_T^{iso} < 22$ GeV/c

- c_B and c_D are smaller by close to 0.5 over most of the p_T range when no cross talk is used
- c_C is mostly unchanged, normal since here the shower shape region is the same in A and C

Effect of cross talk on the efficiency

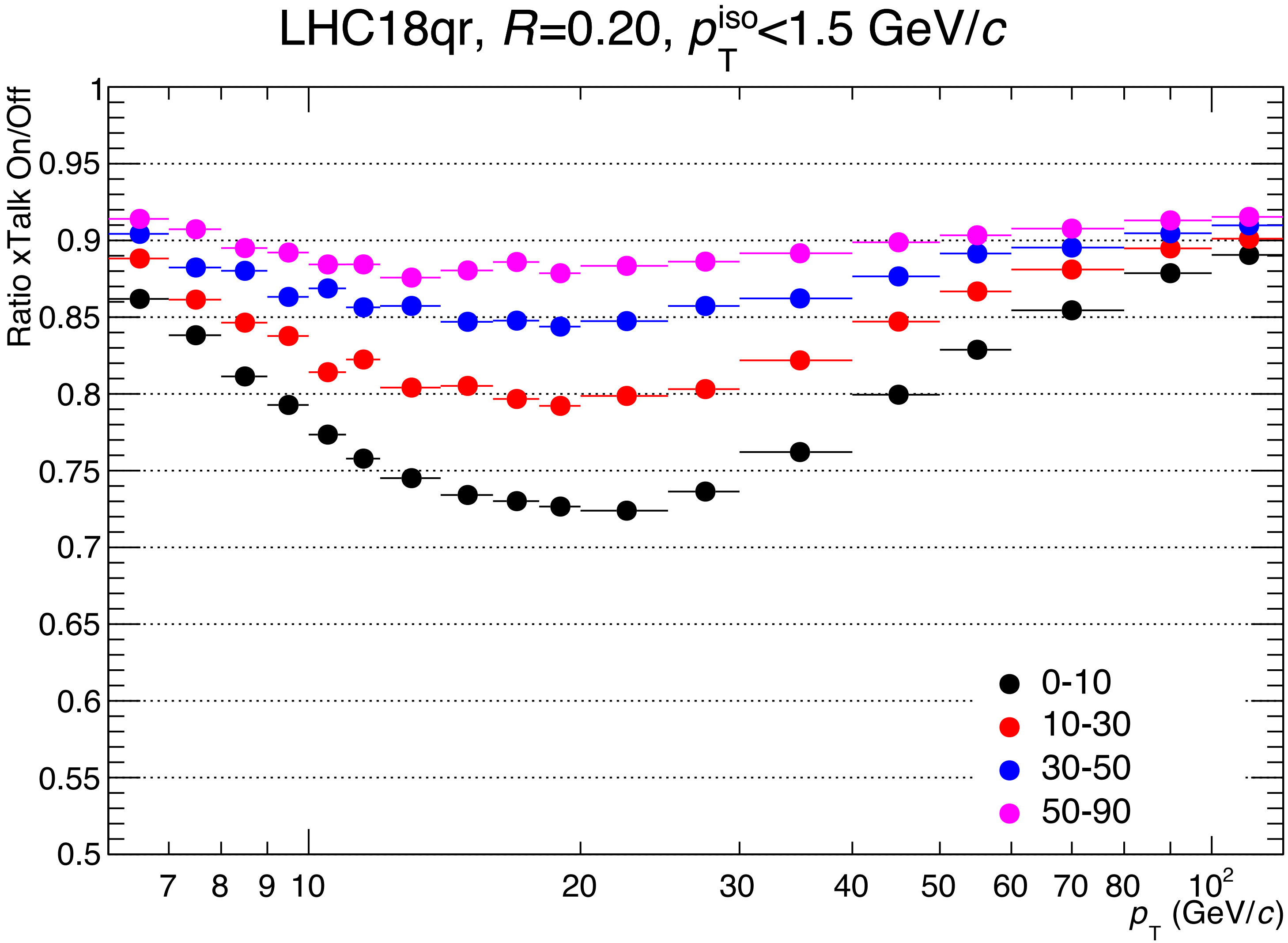
A: Signal, 0.1 < σ^2_{long} < 0.3, p_T^{iso} < 1.5 GeV/c



- Non negligible effect of cross talk in efficiency

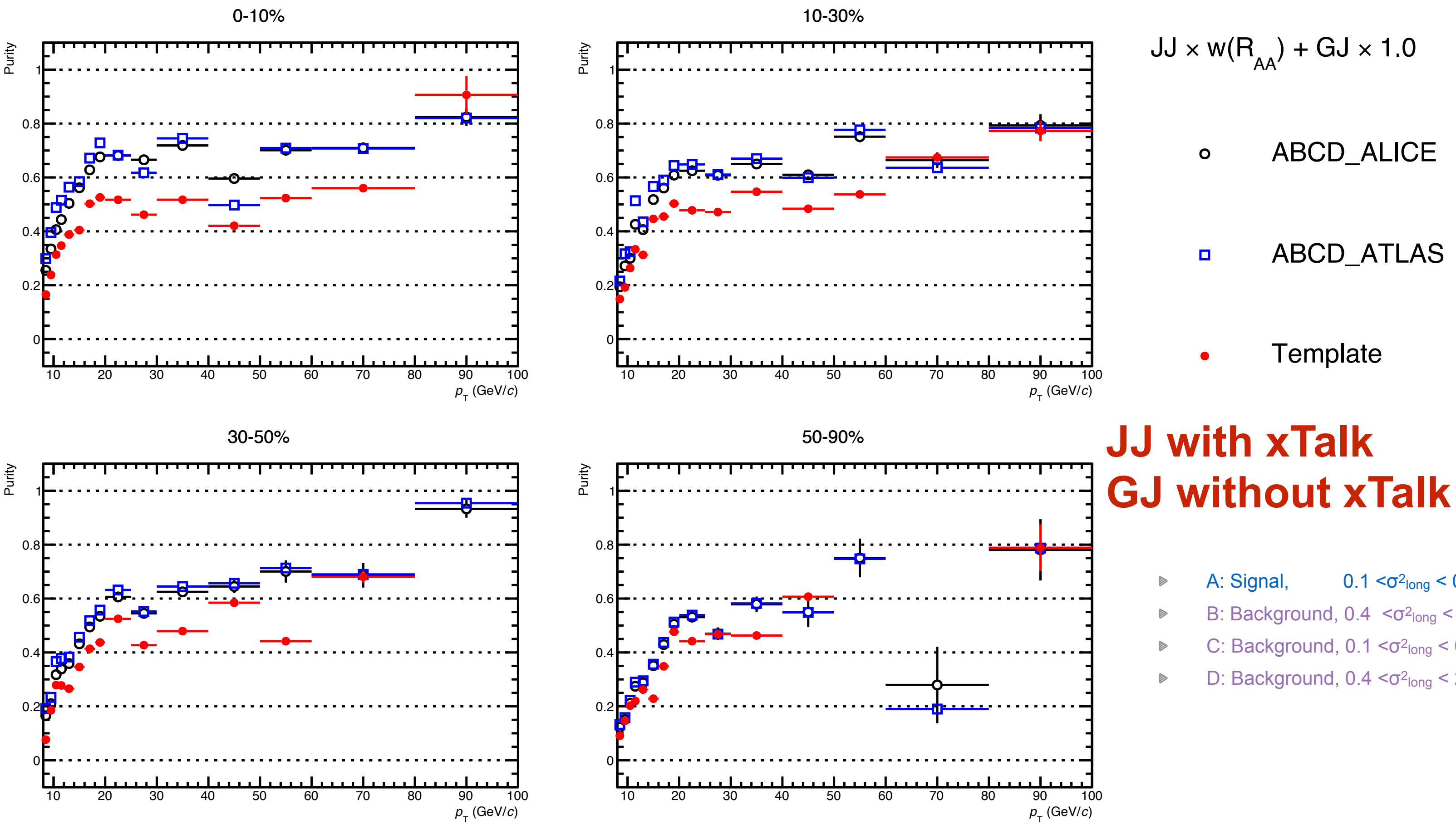
Effect of cross talk on the efficiency

A: Signal, $0.1 < \sigma^2_{long} < 0.3$, $p_T^{iso} < 1.5$ GeV/c



- In more central events, between 10 and 30 GeV effect of cross talk on efficiency is significantly larger

Purity methods comparison — JJ x w(R$_{AA}$) + GJ (xTalk Off)



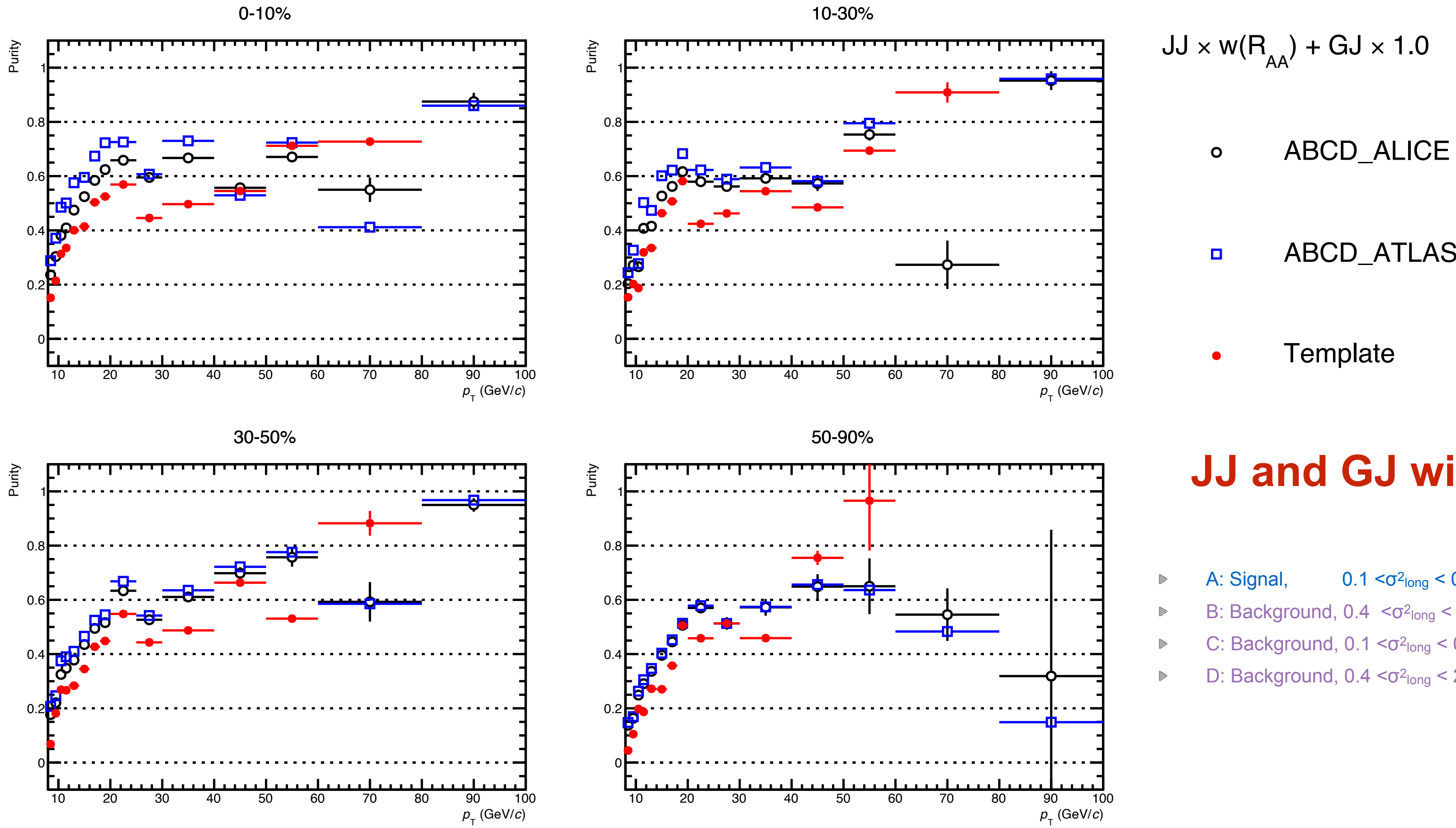
JJ with xTalk
GJ without xTalk

- A: Signal, $0.1 < \sigma^2_{long} < 0.3$, $p_T^{iso} < 1.5$ GeV/c
- B: Background, $0.4 < \sigma^2_{long} < 2$, $p_T^{iso} < 1.5$ GeV/c
- C: Background, $0.1 < \sigma^2_{long} < 0.3$, **$7 < p_T^{iso} < 22$ GeV/c**
- D: Background, $0.4 < \sigma^2_{long} < 2$, **$7 < p_T^{iso} < 22$ GeV/c**

Blessed region by MC closure for template

- Removing the cross talk from the signal MC moves down the ABCD-ATLAS purity and tends to agree with ALICE
- Now template gives lower than ALICE, need to check with closure test what are now the best bkg ranges

Purity methods comparison — JJ (xTalk Off) x w(R$_{AA}$) + GJ (xTalk Off)



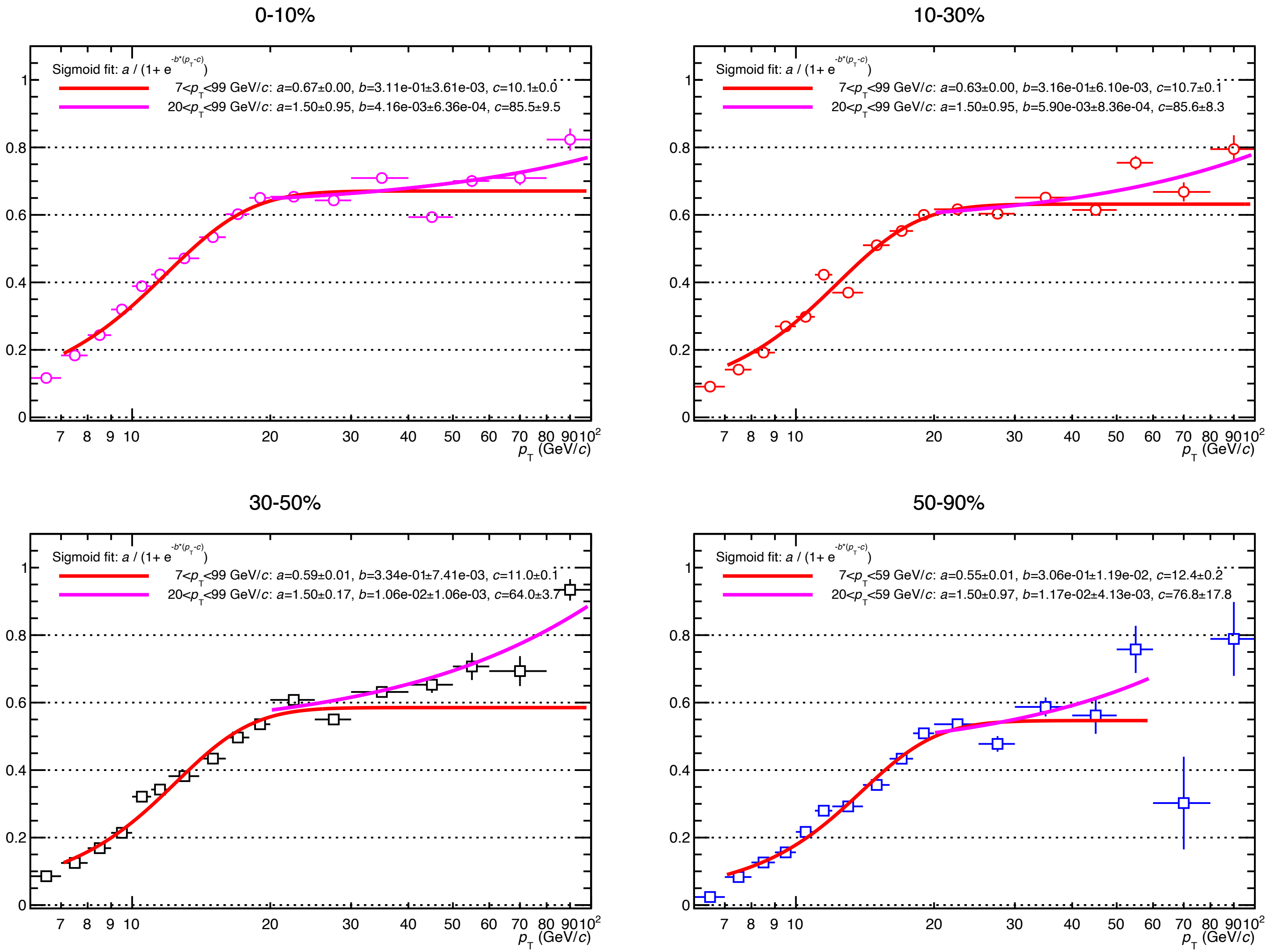
JJ and GJ without xTalk

- A: Signal, 0.1 <σ^2_{long} < 0.3, p_T^{iso} < 1.5 GeV/c
- B: Background, 0.4 <σ^2_{long} < 2, p_T^{iso} < 1.5 GeV/c
- C: Background, 0.1 <σ^2_{long} < 0.3, **7 < p_T^{iso} < 22 GeV/c**
- D: Background, 0.4 <σ^2_{long} < 2, 7 **< p_T^{iso} < 22 GeV/c**

Blessed region by MC closure for template

- Removing the cross talk from the signal and bkg MC moves down ABCD-ALICE, not so good agreement with ATLAS now (although mostly below 20 GeV?, see later)
- Template is lower than ALICE need to check with closure test what are now the best bkg ranges

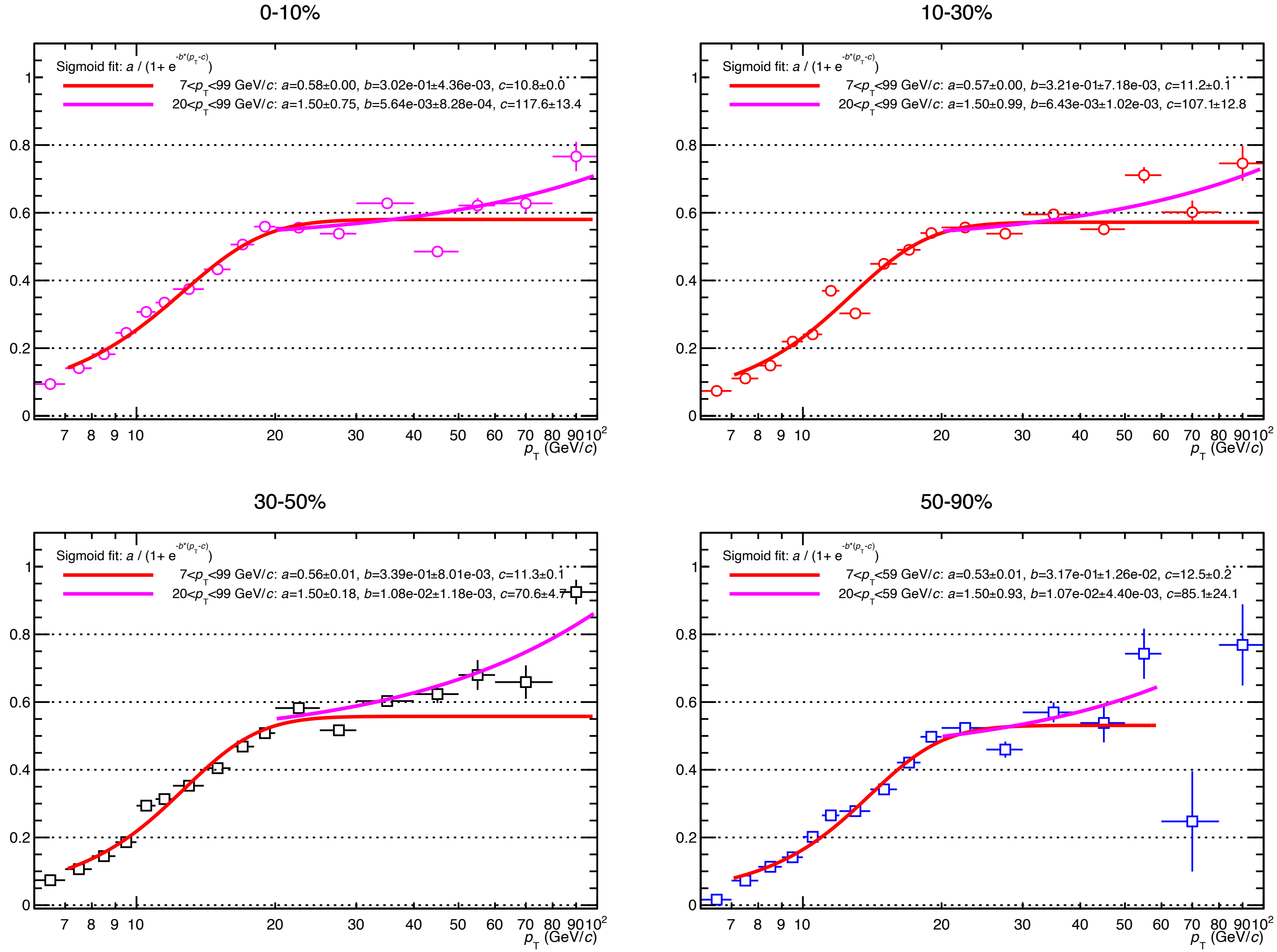
ABCD-ALICE Purity fit with sigmoid function — MC=JJ x w(R_{AA}) + GJ



- This kind of fit seems to work quite well
- Not obvious what to do at high pT, try single or 2 range fits

- A: Signal, 0.1 < σ^2_{long} < 0.3, p_T^{iso} < 1.5 GeV/c
- B: Background, x < σ^2_{long} < y, p_T^{iso} < 1.5 GeV/c
- C: Background, 0.1 < σ^2_{long} < 0.3, 4 < p_T^{iso} < 15 GeV/c
- D: Background, x < σ^2_{long} < y, 4 < p_T^{iso} < 15 GeV/c

ABCD-ALICE Purity fit with sigmoid function — MC=JJ x w(R_{AA}) + 0.5xGJ



- This kind of fit seems to work quite well
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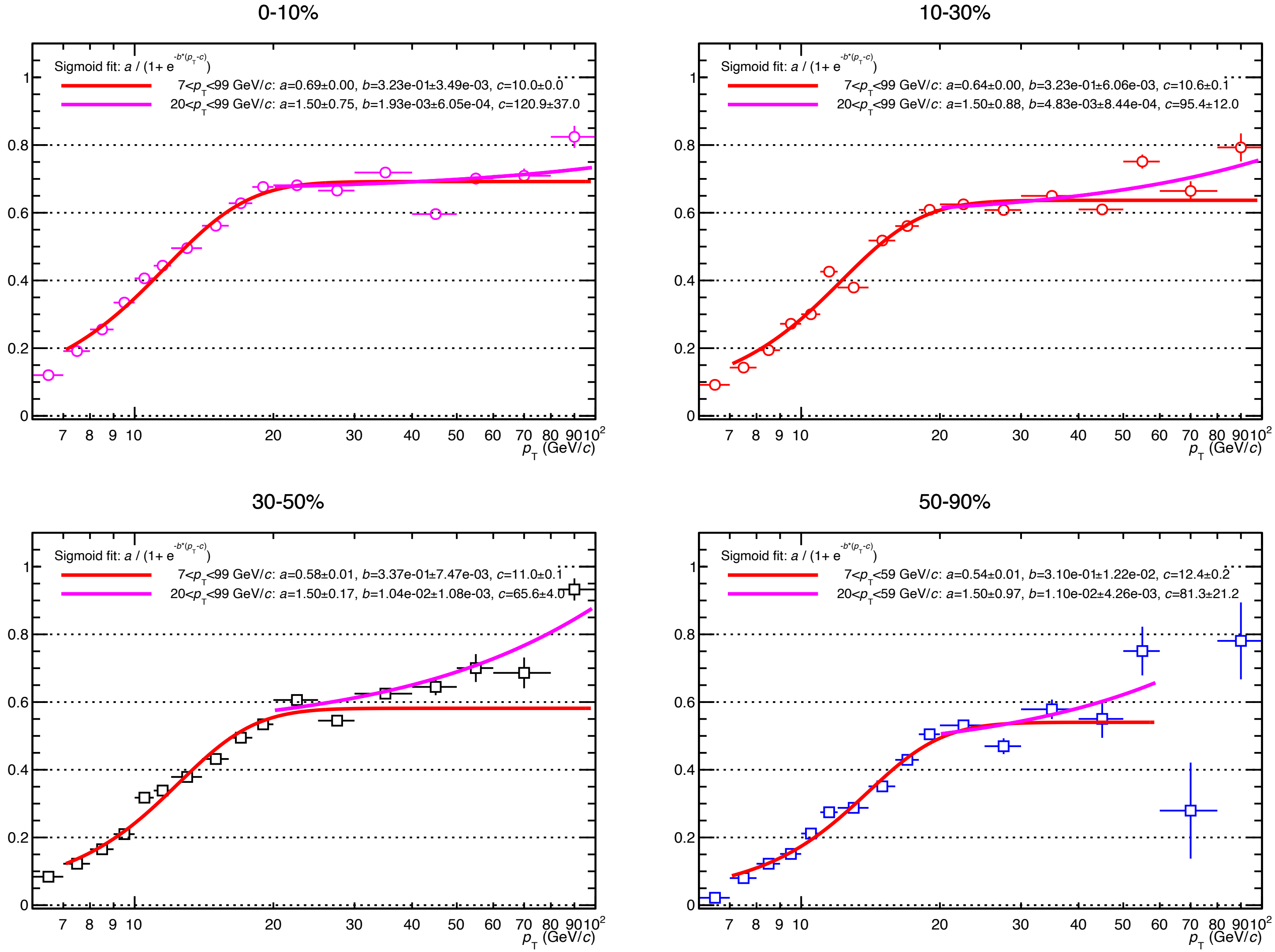
- D: Background, $x < \sigma^2_{long} < y$, $4 < p_T^{iso} < 15$ GeV/c

ABCD-ALICE Purity fit with sigmoid function — MC=JJ x w(R_{AA}) + GJ(xTalk Off)



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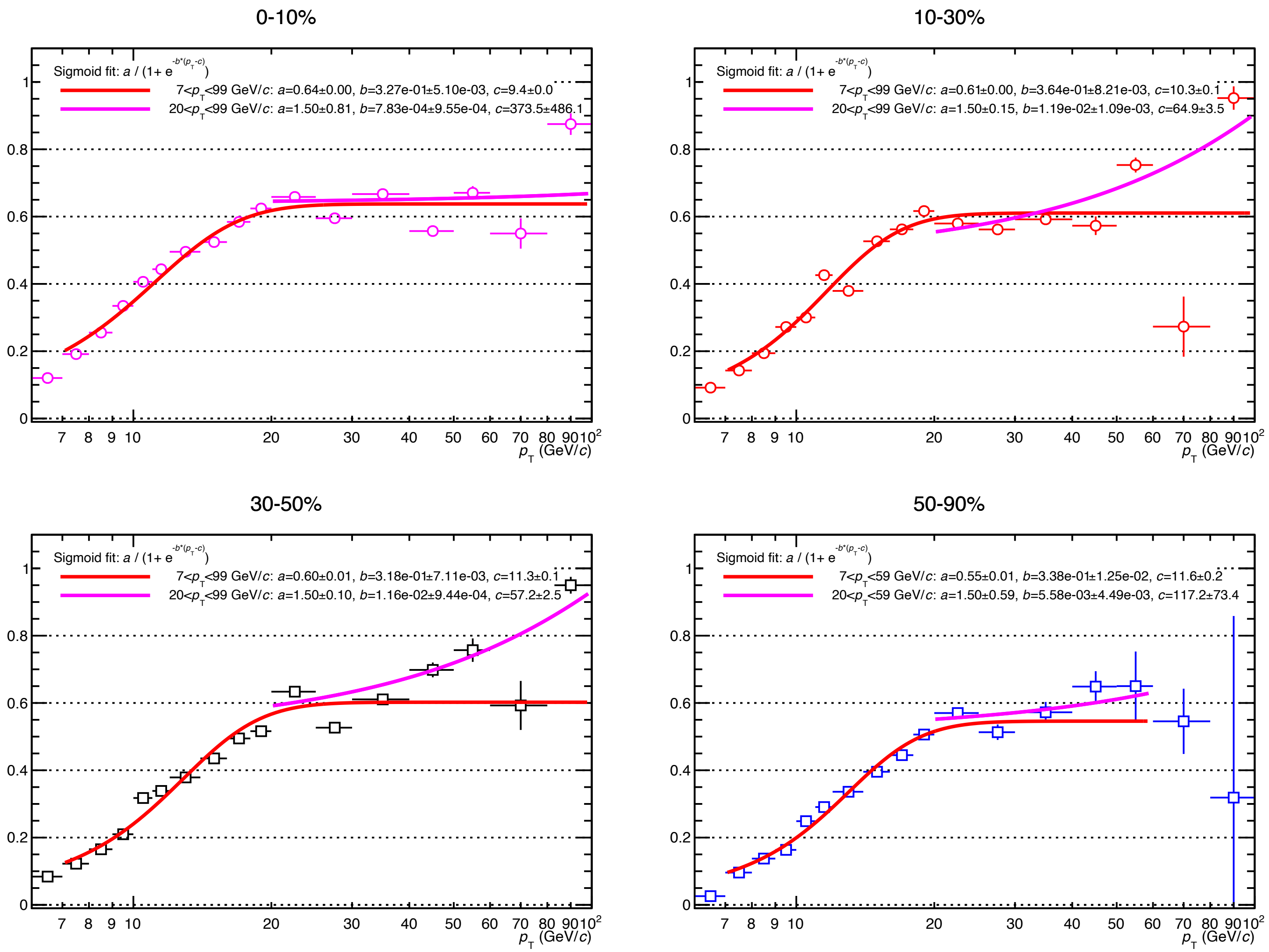
- D: Background, x <σ^2_{long} < y, 4 < p_T^{iso} < 15 GeV/c

ABCD-ALICE Purity fit with sigmoid function — MC=JJ (xTalkOff)x w(R_{AA}) + GJ(xTalk Off)



- This kind of fit seems to work quite well
- Not obvious what to do at high pT, try single or 2 range fits

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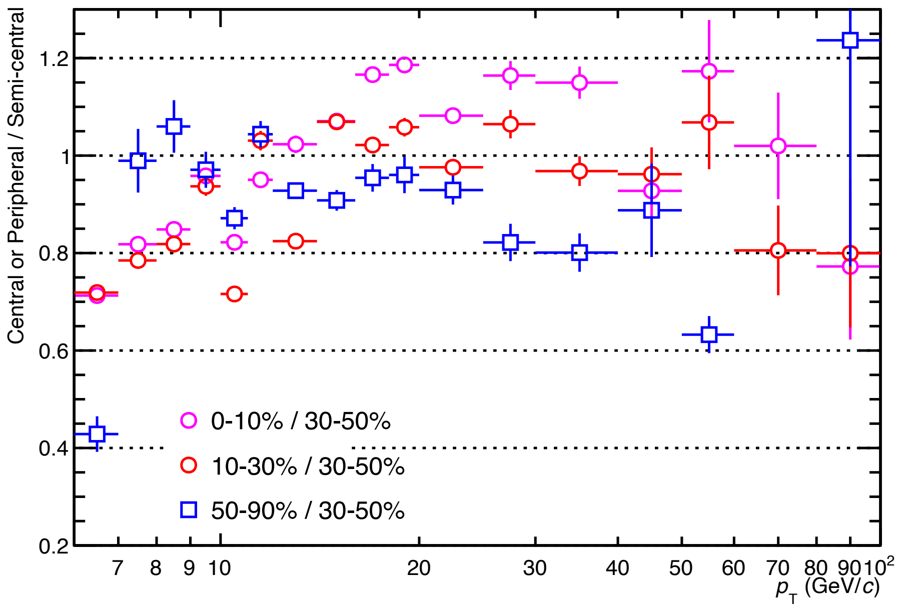
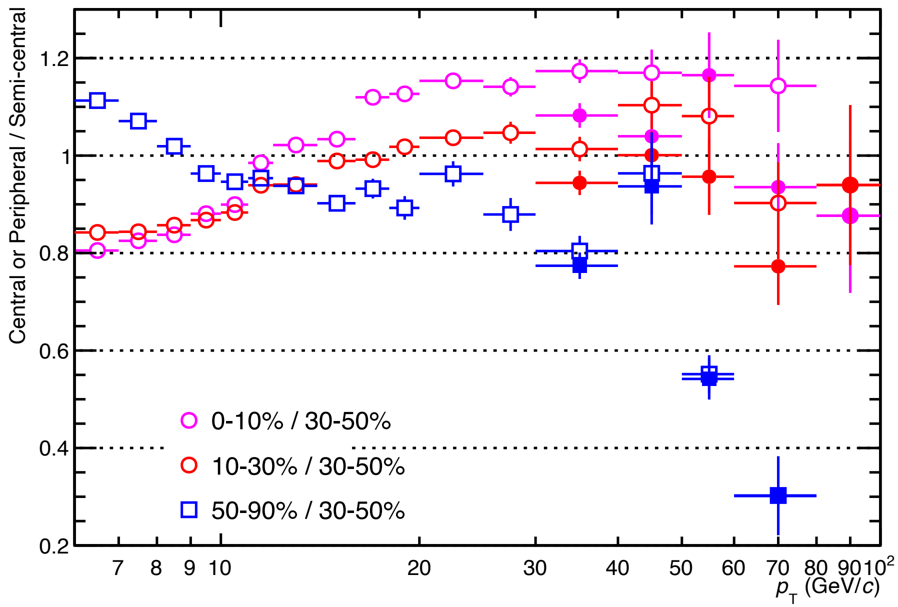
- D: Background, $x < \sigma^2_{long} < y$, $4 < p_T^{iso} < 15$ GeV/c

ABCD-ALICE Corrected spectra ratio to 30-50% — MC=JJ x w(R_{AA}) + GJ

Purity Points



Purity FIT



- Fluctuations highly reduced using fit (as expected)
- **Above 10 GeV, 50-90% and 10-30% close to 30-50% but 0-10% clearly different**
- Behaviour below ~15 GeV artefact of fit? maybe physics (nPDF?), I would not pay too much attention
- Full points above 30 GeV/c fit in second range

- A: Signal, 0.1 <σ^2_{long} < 0.3, p_T^{iso} < 1.5 GeV/c
- B: Background, x <σ^2_{long} < y, p_T^{iso} < 1.5 GeV/c
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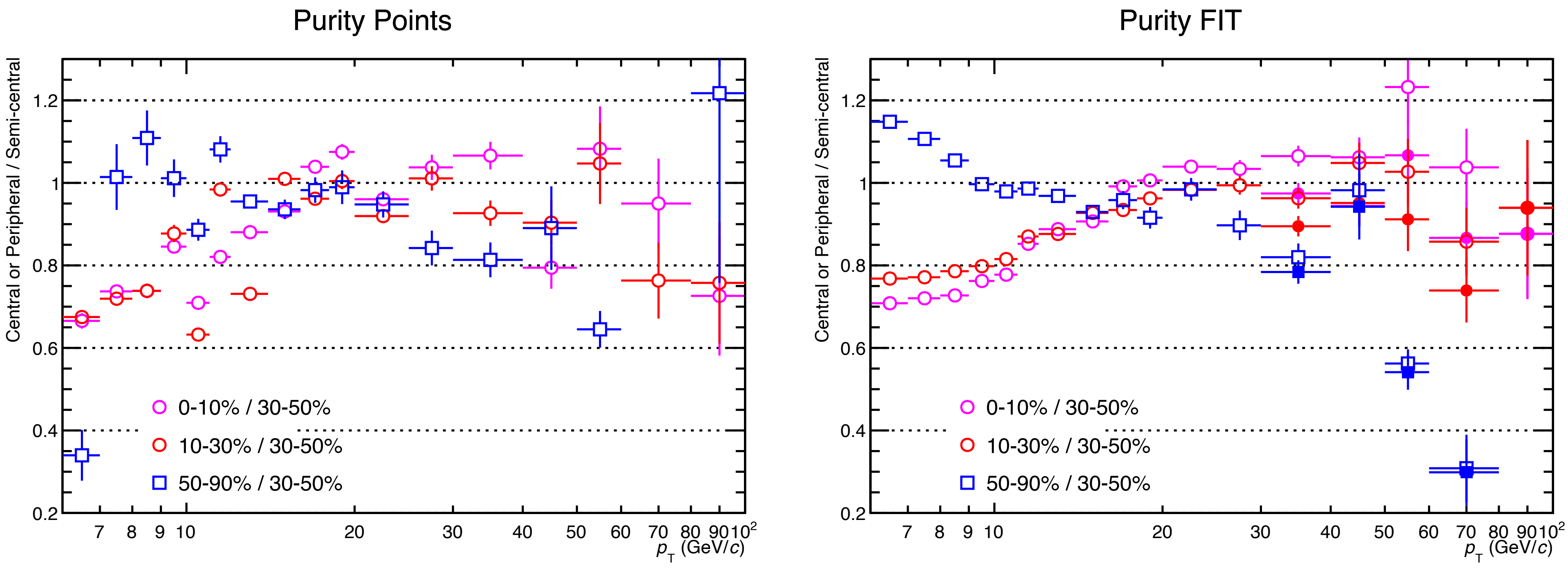
ABCD-ALICE Corrected spectra ratio to 30-50% — MC=JJ x w(R_{AA}) + 0.5xGJ



- Fluctuations highly reduced using fit (as expected)
- **At high p_T, better agreement between the different centralities when scale 0.5 is used**
- Behaviour below ~15 GeV artefact of fit? maybe physics (nPDF?), I would not pay too much attention
- Full points above 30 GeV/c fit in second range

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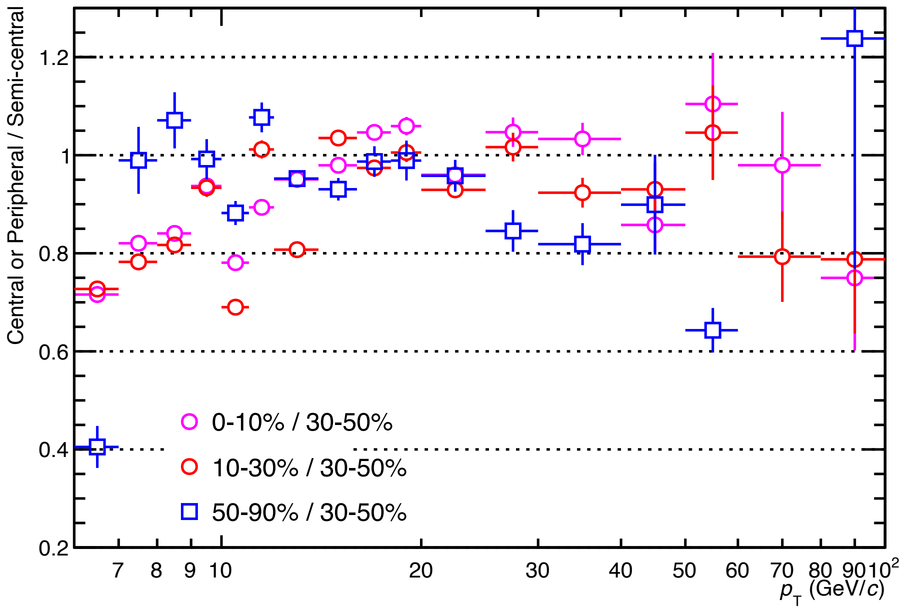
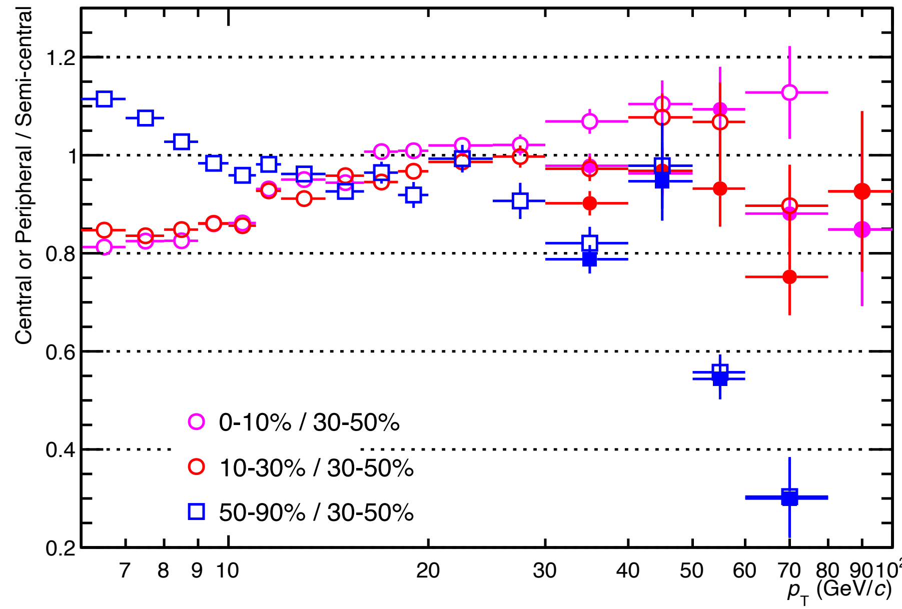
- B: Background, x <σ^2_{long} < y, p_T^{iso} < 1.5 GeV/c
- C: Background, 0.1 <σ^2_{long} < 0.3, 4 < p_T^{iso} < 15 GeV/c
- D: Background, x <σ^2_{long} < y, 4 < p_T^{iso} < 15 GeV/c

ABCD-ALICE Corrected spectra ratio to 30-50% — MC=JJ x w(R_{AA}) + GJ (xTalk Off)

Purity Points



Purity FIT

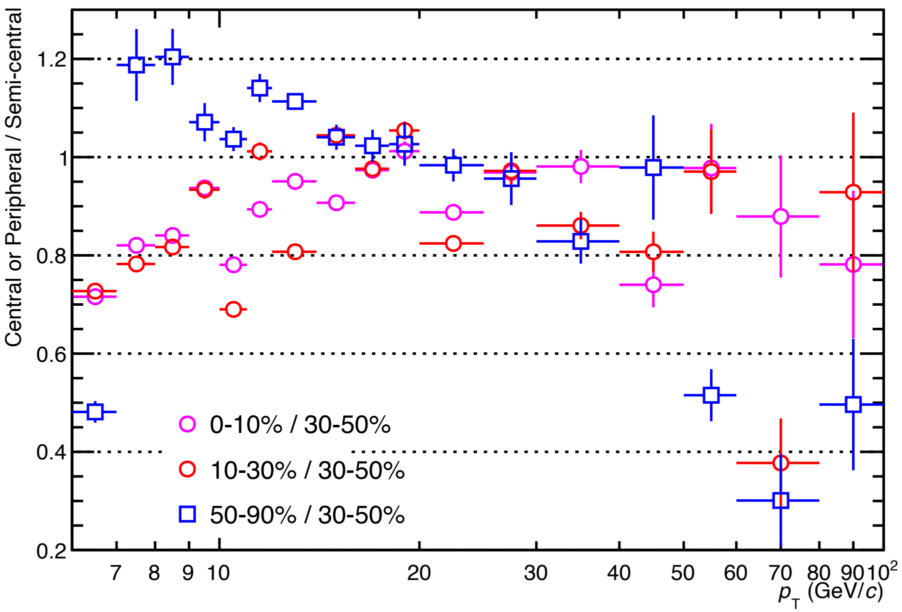


- Fluctuations highly reduced using fit (as expected)
- **At high p_T, better agreement between the different centralities when cross talk is off in signal MC GJ**
- Behaviour below ~15 GeV artefact of fit? maybe physics (nPDF?), I would not pay too much attention
- Full points above 30 GeV/c fit in second range

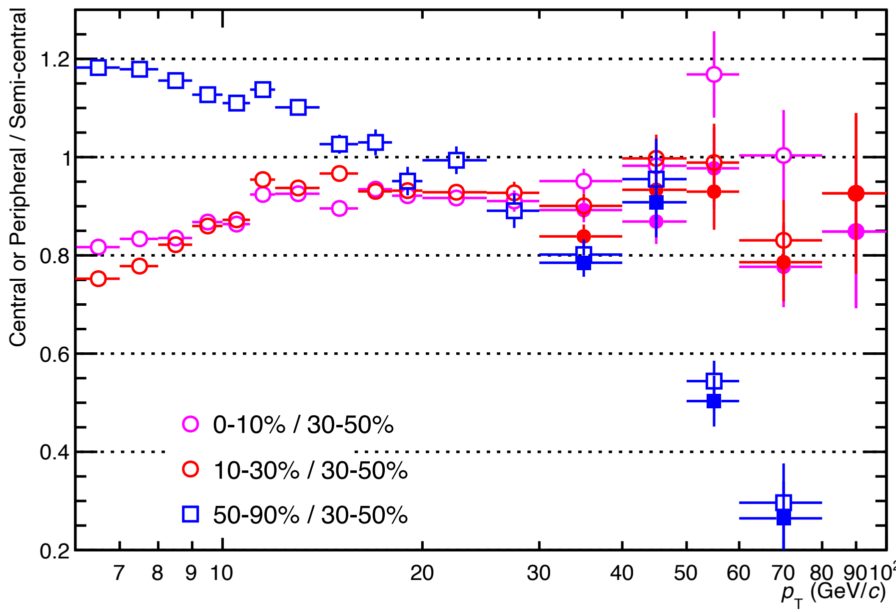
- A: Signal, $0.1 < \sigma^2_{long} < 0.3$, $p_T^{iso} < 1.5$ GeV/c
- B: Background, $x < \sigma^2_{long} < y$, $p_T^{iso} < 1.5$ GeV/c
- C: Background, $0.1 < \sigma^2_{long} < 0.3$, $4 < p_T^{iso} < 15$ GeV/c
- D: Background, $x < \sigma^2_{long} < y$, $4 < p_T^{iso} < 15$ GeV/c

ABCD-ALICE Corrected spectra ratio to 30-50% — MC=JJ (xTalk Off) x w(R_{AA}) + GJ (xTalk Off)

Purity Points



Purity FIT



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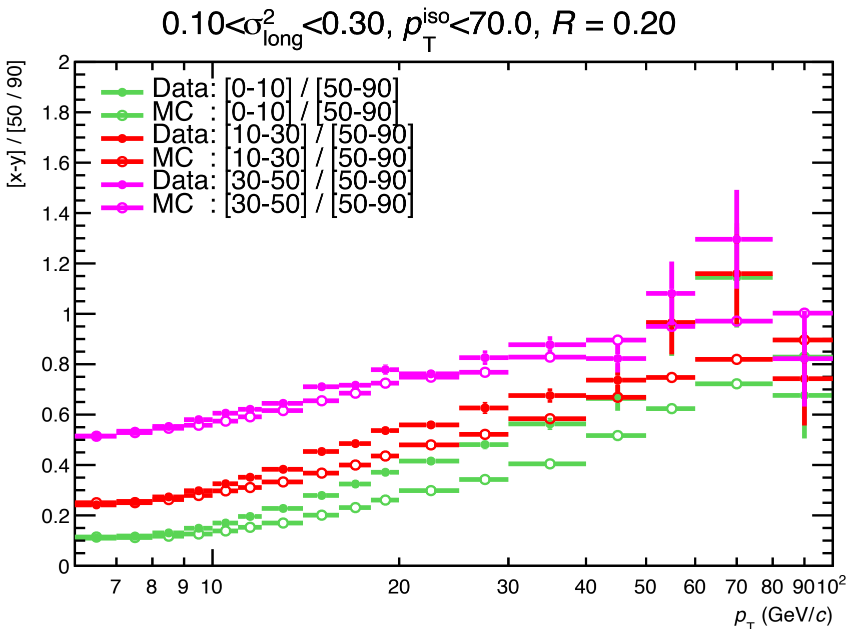
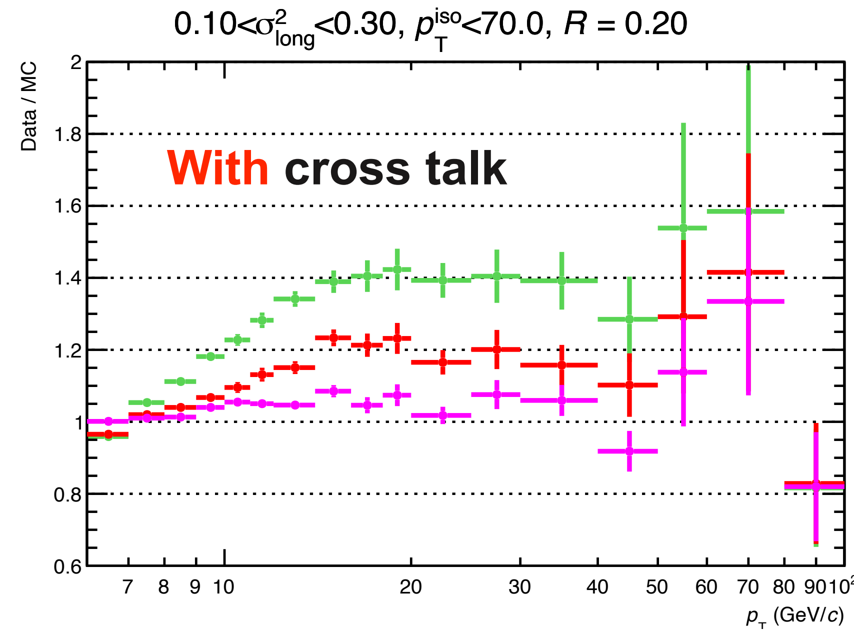
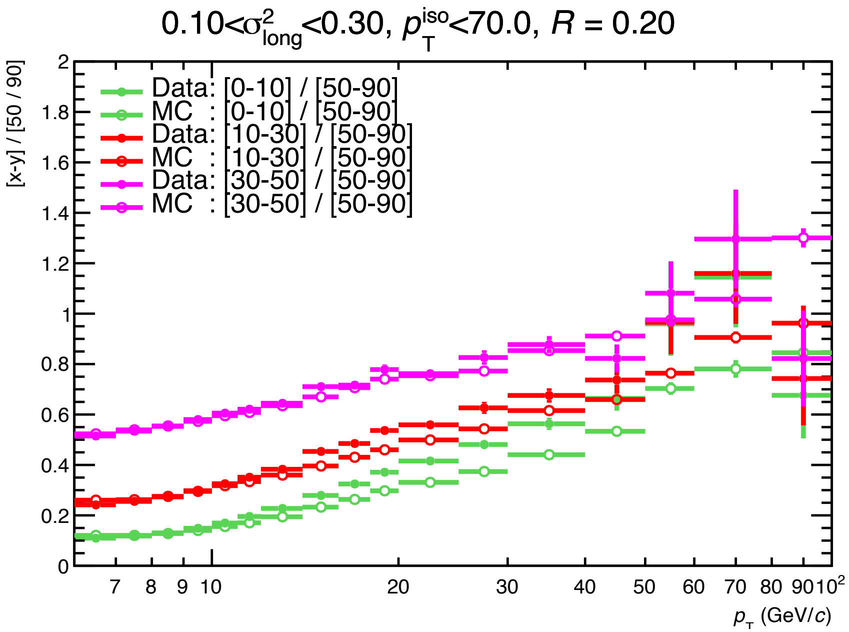
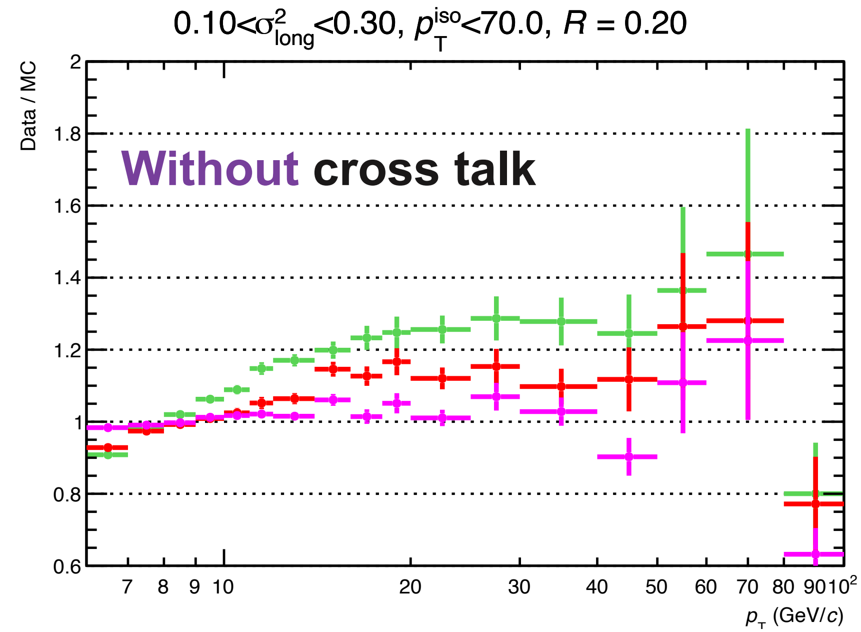
Uncorrected spectra ratio Data/MC: Signal, $0.1 < \sigma^2_{long} < 0.3$



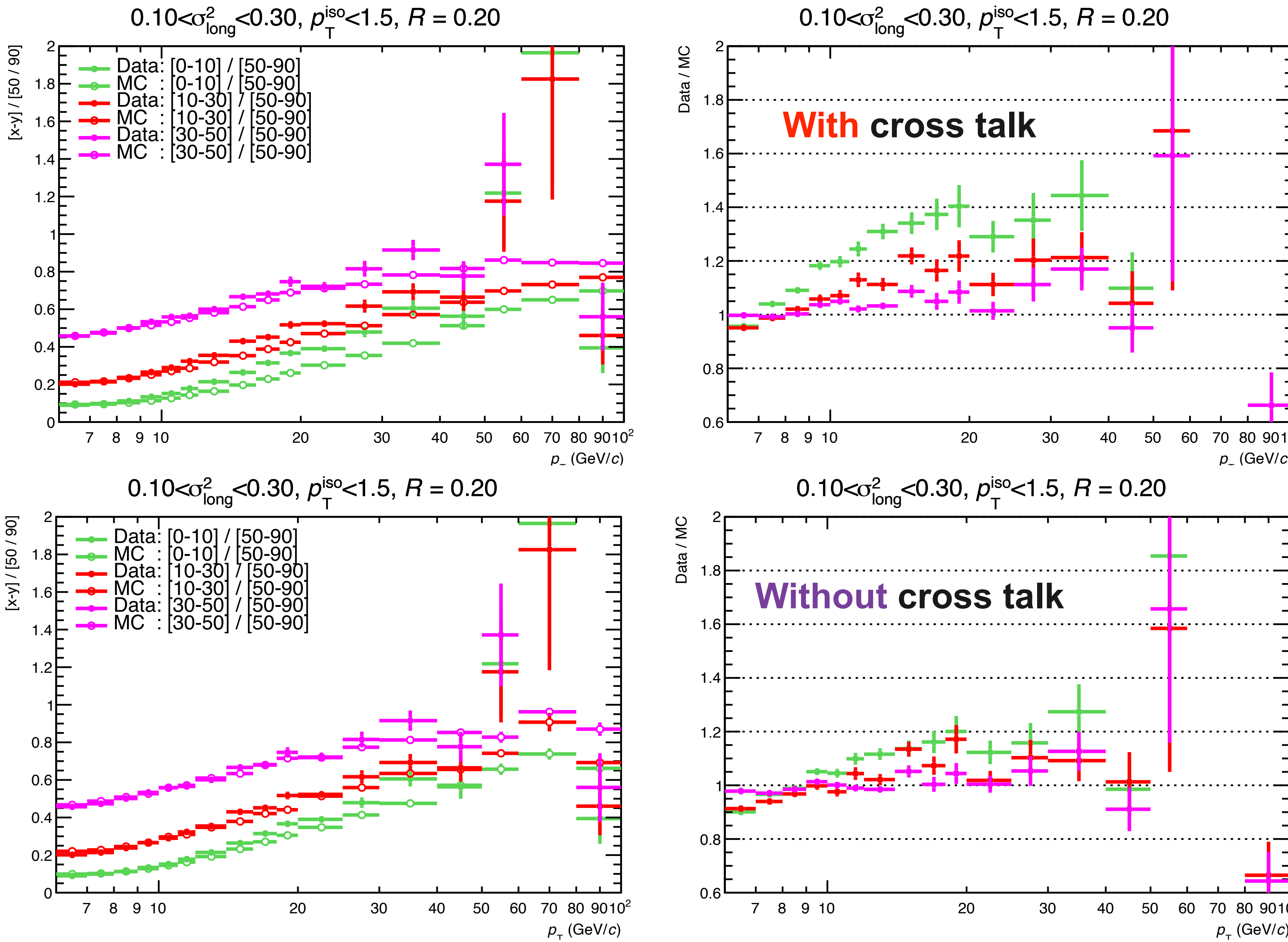






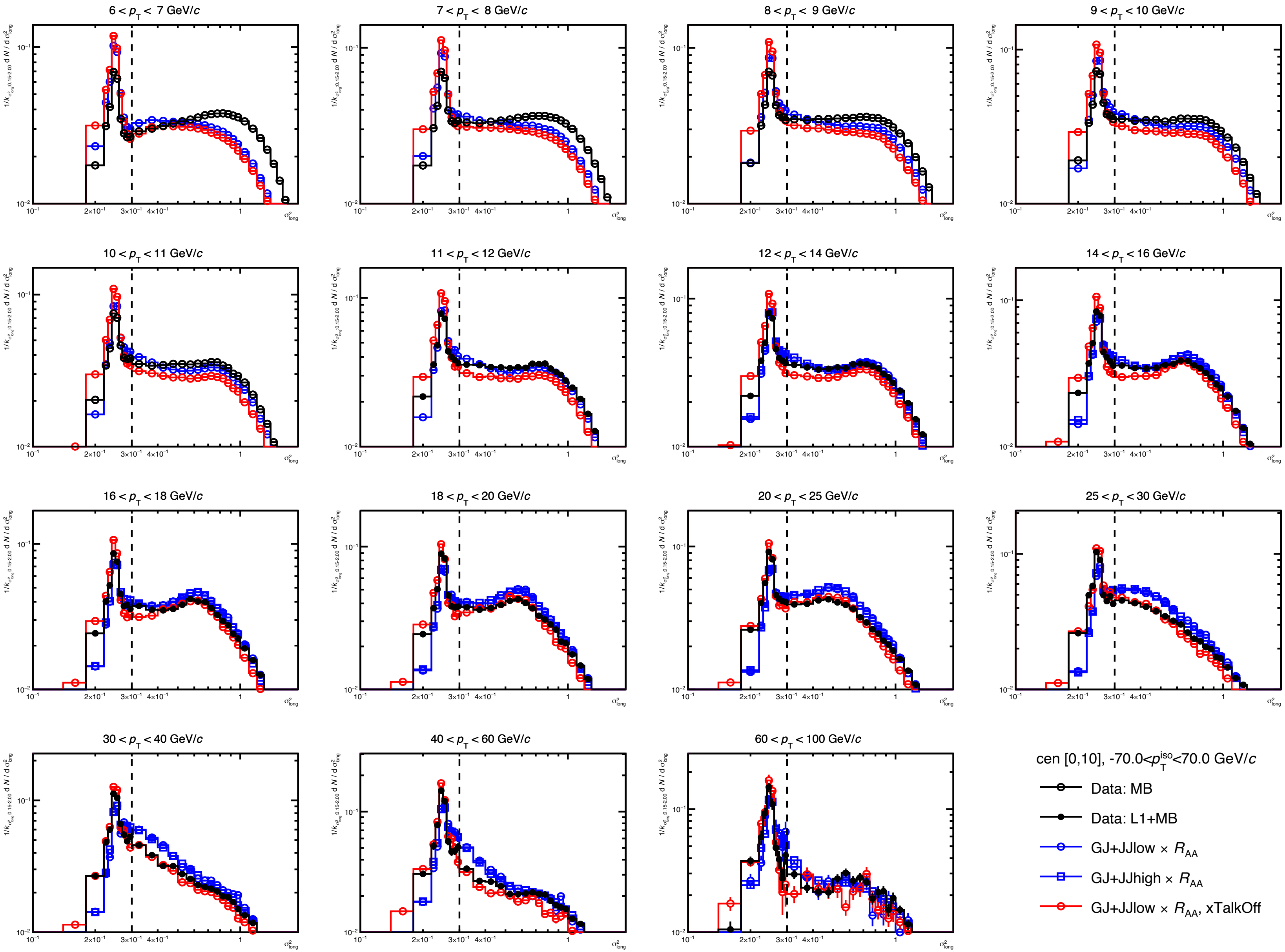
- Clearly, description with cross talk is worse

Uncorrected spectra ratio Data/MC: Signal, 0.1 < σ^2_{long} < 0.3, p_T^{iso} < 1.5 GeV/c



- Clearly, description with cross talk is worse

Comparison Data-MC w/out xTalk of shower shape, 0-10%, inclusive clusters

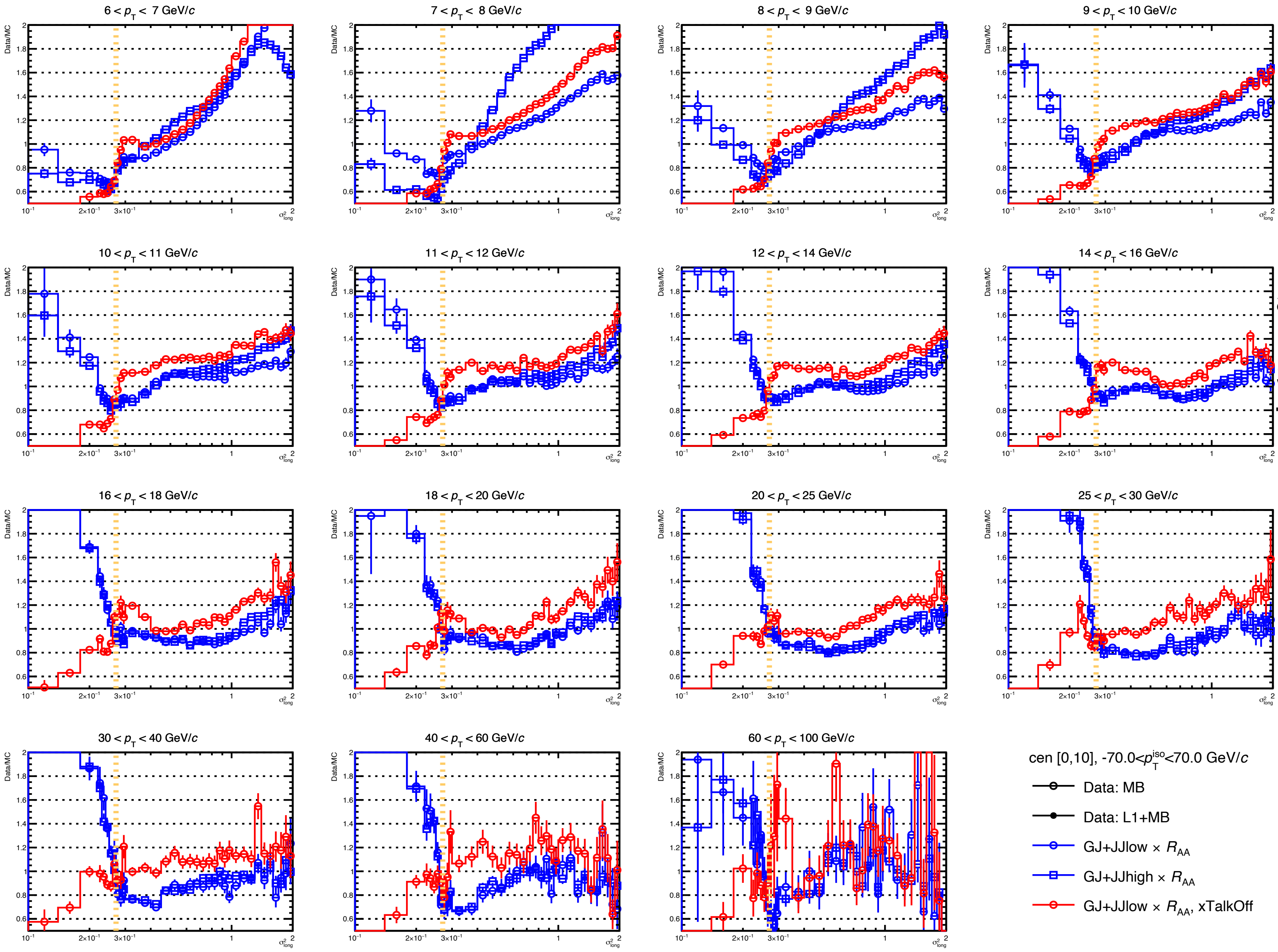


No isolation applied

Same plots for different isolation cuts in back-up

- Cross talk emulation better below 18-20 GeV/c, not above 20 GeV

Comparison Data-MC w/out xTalk of shower shape, 0-10%, inclusive clusters



No isolation applied

Same plots for different isolation cuts in back-up

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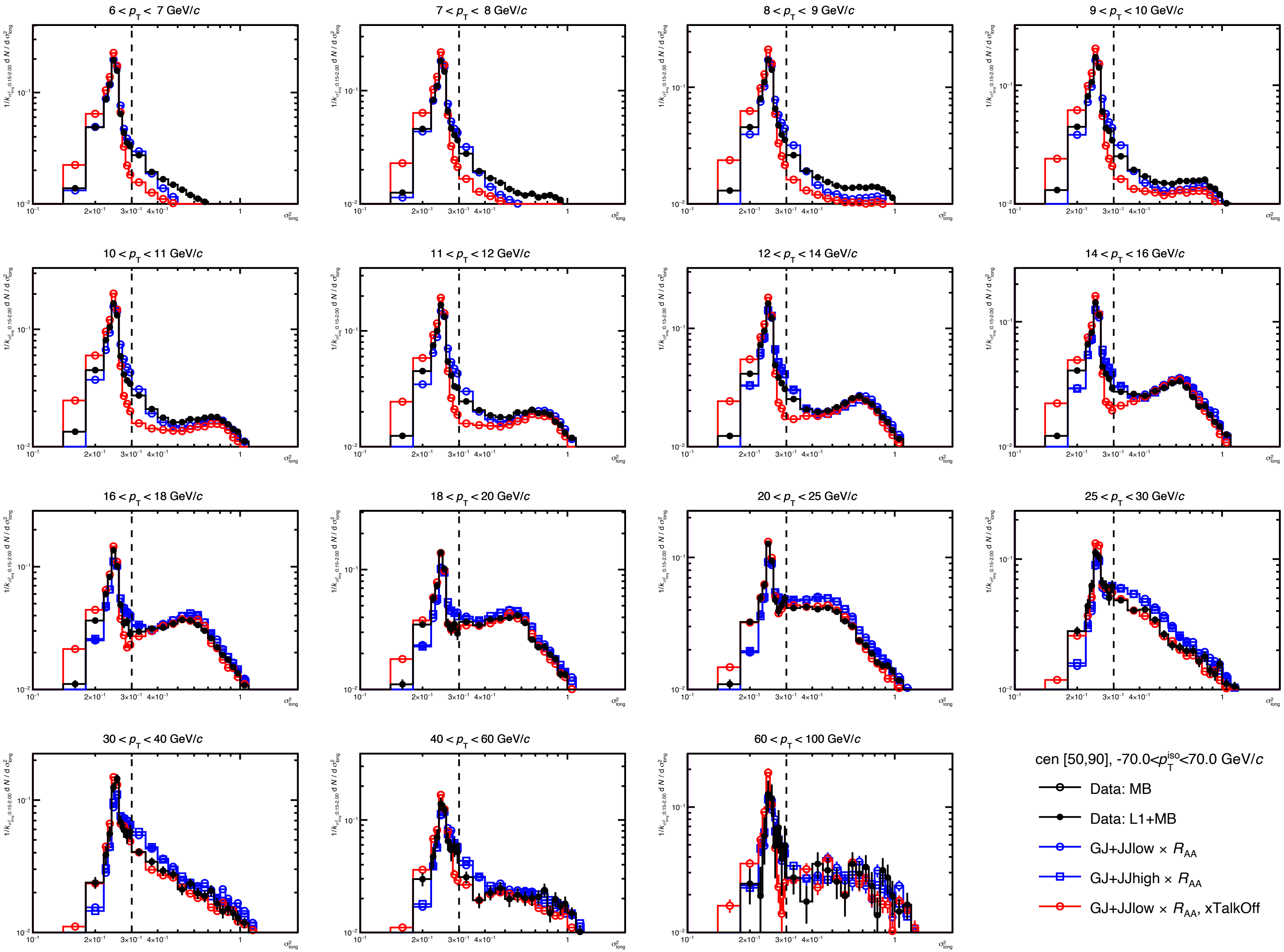
Comparison Data-MC w/out xTalk of shower shape, 50-90%, inclusive clusters



No isolation applied

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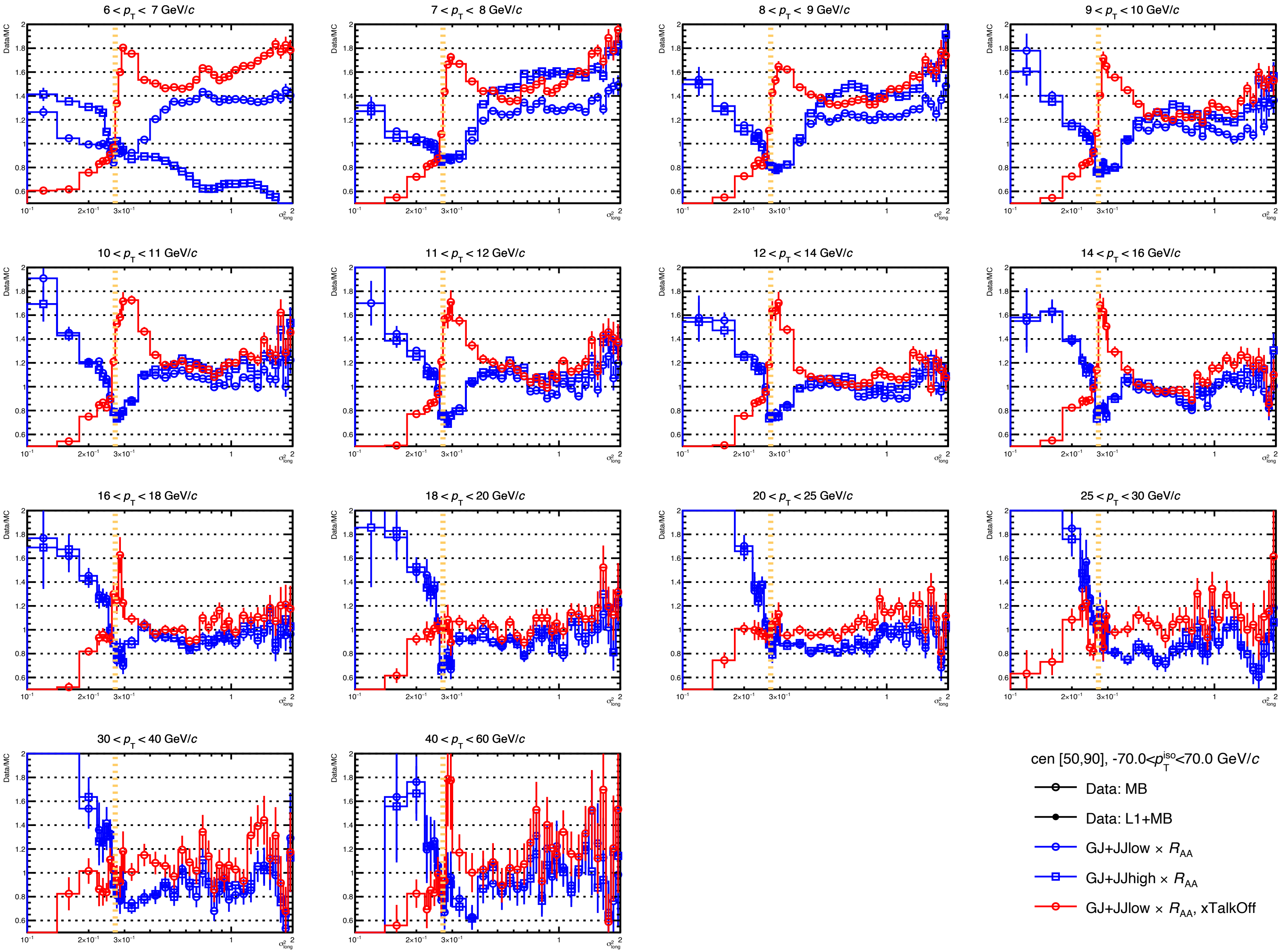

No isolation applied

Same plots for different isolation cuts in back-up

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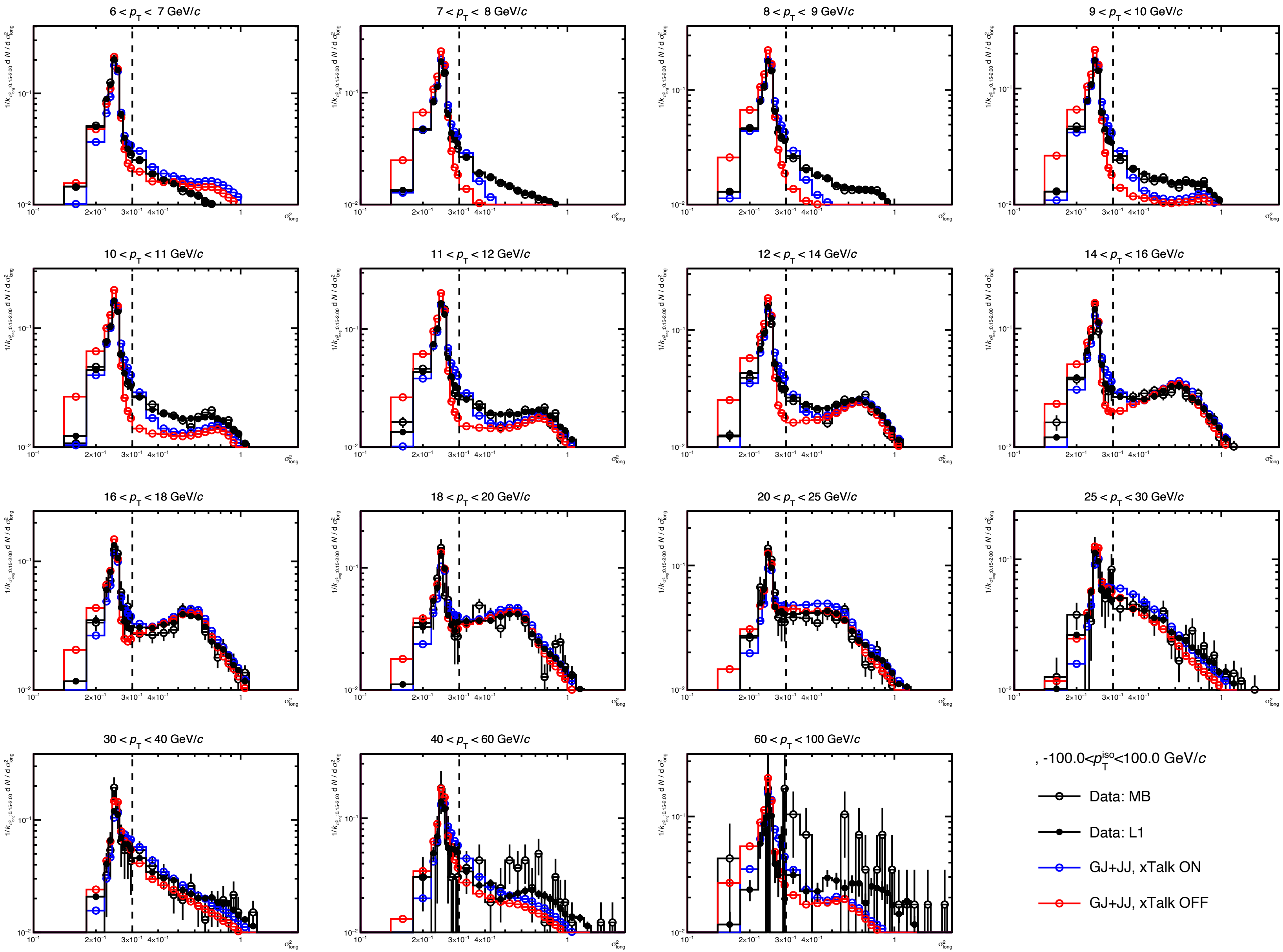
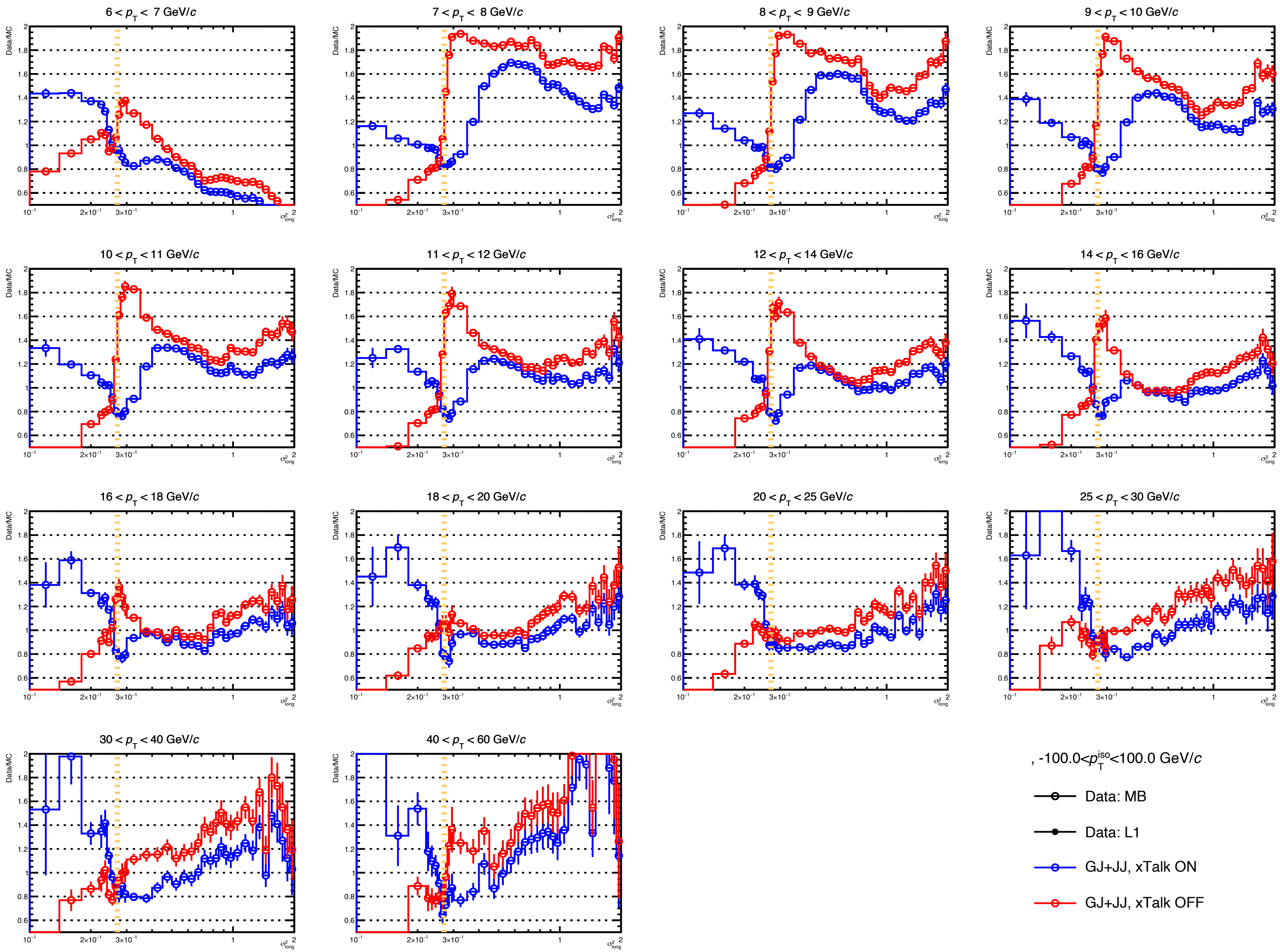
Comparison Data-MC w/out xTalk of shower shape, pp, inclusive clusters



No isolation applied

- Cross talk emulation better below 18-20 GeV/c, not above 20 GeV

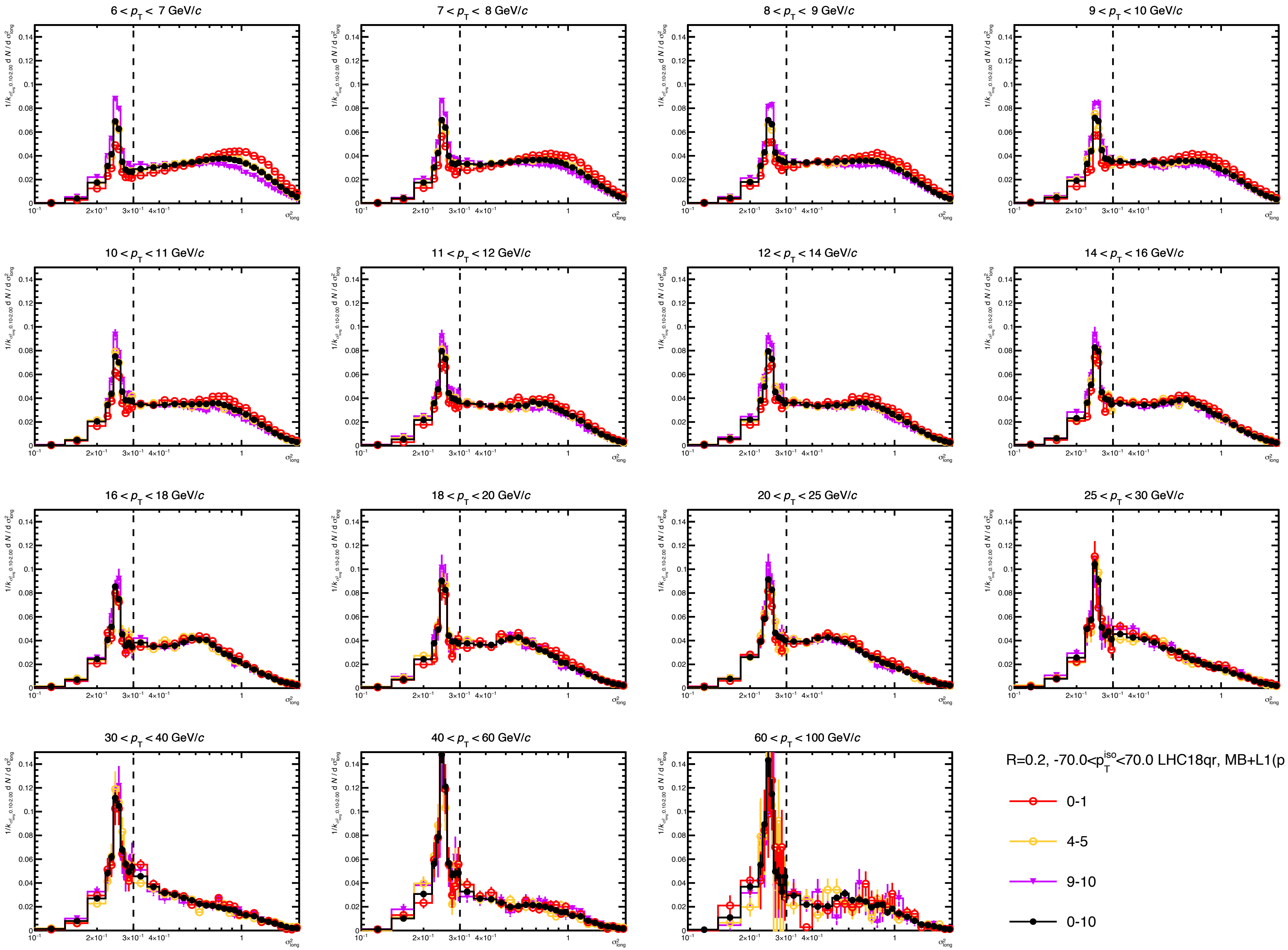
Comparison Data-MC w/out xTalk of shower shape, pp, inclusive clusters



No isolation applied

- Cross talk emulation better below 18-20 GeV/c, not above 20 GeV

Can we make the analysis in super-central events?



Data in fine centrality bins

No isolation applied

Same plots for different isolation cut in back-up

- In 0-1% the photon peak does not disappear completely and pi0 bump is visible, so a priory no need to exclude very central events

Summary

- ***ABCD-ALICE:***
  - *MC scales dependence:* Rather strong
  - *Bkg ranges dependence*: Low, rather stable
  - *Purity:* suspiciously high in central collisions (k=1)
- ***ABCD-ATLAS:***
  - *MC scales dependence:* Low but strong variations of c_i have strong effect
  - *Bkg ranges dependence*: Low, but more than ABCD-ALICE
  - *Purity:* Too high in central collisions (k=1)
- ***Template,*** I have problems in case of Alwina's correction approach, using a new approach that attempts to subtract signal contribution for the bkg template
  - *MC scales dependence:* No dependence
  - *Bkg ranges dependence*: Not so stable
  - *Purity:* Better agreement with ABCD-ALICE if Bkg range selected looking to MC closure
- Methods tend to agree in 30-90% but tend to differ in 0-30%
  - With the guidance of the MC closure to select bkg regions for the template, agreement between template and ABCD-ALICE (and thus high purity) in central
  - Using scale k=0.5, or no cross talk in signal MC, agreement ATLAS and ALICE, tension with template, depending bkg range
  - Switching off the cross talk, Rcp improve, Raa?

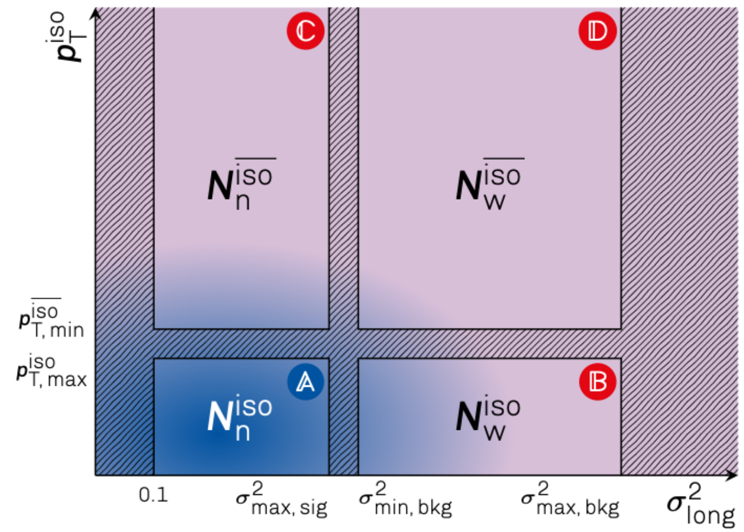
Outlook

- What is the real purity of central collisions?
  - R_{AA} and R_{PC} suggest that lower purity than ABCD-ALICE in central collisions is more reasonable
  - How to validate current methods for central or if the k=0.5 scale should be used or if cross talk emulation is ok?
    - **Cross talk modifies the shape, specially in the tail, it changes the modelling of the signal leak into different regions.**
    - **Plots could suggest that cross-talk emulation is not good specially for p_T > 18-20 GeV**
- If we manage to understand the behaviour in central events, analysis in super-central events seems feasible, not worth yet spending time on this, not sure also if it is useful
- Ongoing:
  - Run MC embedding without cross-talk for the JJ high MC and recheck the effect on the purity at high pT with better statistics, analysis trains running
  - Analyse pp at 5 TeV and reproduce published purity and preliminary spectra (it is becoming quite difficult)
    - So far analyzed wrong data sample “reconstruction without SDD” that gives very low purity (which might be right) and large fluctuations. One should have a look to reconstruction “with SDD”, analysis trains running.

back-up

Main analysis cuts and data

- R = 0.2 and $p_{\mathrm{T}}^{\mathrm{iso}} = \Sigma p_{\mathrm{T}}^{\mathrm{track}} - \pi\rho_{\mathrm{UE}}R^2$, UE density calculation using the **η-band method**
  - see back-up for definition of band and previous presentation
- Shower shape calculated in a window 5x5 around the highest energy cell of V3 clusters (only one local energy maxima in the cluster, highest energy cell), $\sigma^2_{\mathrm{long\ (5\times5)}}$
  - see back-up for full definition and previous presentations
  - for simplicity still refers just as σ^2_{long}
- Phase space of EMCal+DCal clusters divided in 4 regions
  - A: Signal, 0.1 $< \sigma^2_{\mathrm{long}} <$ 0.3, $p_{\mathrm{T}}^{\mathrm{iso}} <$ 1.5 GeV/c
  - B: Background, 0.4 $< \sigma^2_{\mathrm{long}} <$ 2.0, $p_{\mathrm{T}}^{\mathrm{iso}} <$ 1.5 GeV/c
  - C: Background, 0.1 $< \sigma^2_{\mathrm{long}} <$ 0.3, $p_{\mathrm{T}}^{\mathrm{iso}} <$ 10 GeV/c
  - D: Background, 0.4 $< \sigma^2_{\mathrm{long}} <$ 2.0, 5 $< p_{\mathrm{T}}^{\mathrm{iso}} <$ 10 GeV/c
    - *Reference values used in other analysis or close*
    - *Variations of bkg region ranges also studied and shown*
    - *In case of* **σ^2_{long}** *template only 2 regions depending* $p_{\mathrm{T}}^{\mathrm{iso}}$



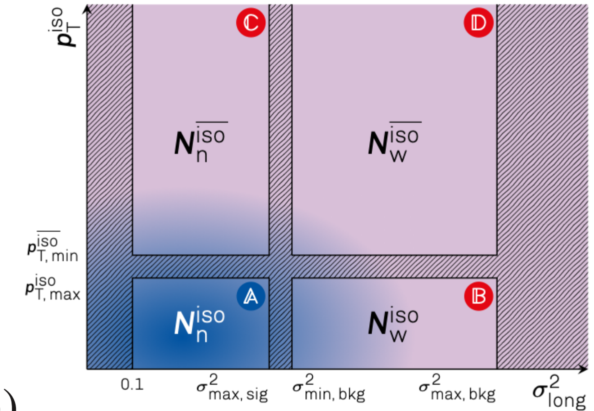
- Data: LHC18q+r, MB and L1 triggers
  - (LHC15o analyzed but not shown for simplicity)
  - 00-50% MB for 8 $< p_{\mathrm{T}} <$ 12 GeV/c and MB+L1 for 12 $< p_{\mathrm{T}} <$ 100 GeV/c
  - 50-90% MB+L1 for 8 $< p_{\mathrm{T}} <$ 100 GeV/c
- MC: pp @ 5.02 TeV, PYTHIA8 γ-jet and jet-jet with trigger on decay photons (p_{T} >3.5 and 7 GeV/c), **embedded** on MB data
  - Cross talk ON

Purity considering GJ leak, k=1

N_i measured in region $\mathrm{i = A, B, C, D}$ $\qquad x = N_A^{signal}$ measured without bkg,

$$c_i = \frac{N_i^{MC,\ signal}}{N_A^{MC,\ signal}} \qquad R_{Bkg}^{MC} = \frac{N_A^{MC,bkg} N_D^{MC,bkg}}{N_B^{MC,bkg} N_C^{MC,bkg}}$$

$$x = N_A - R_{Bkg}^{MC}(N_B - c_B x)\frac{(N_C - c_C x)}{(N_D - c_D x)}$$



$$x(N_D - c_D x) = N_A(N_D - c_D x) - R_{Bkg}^{MC}(N_B - c_B x)(N_C - c_C x)$$

$$N_D x - c_D x^2 = N_D N_A - c_D N_A x - R(N_B - c_B x)(N_C - c_C x)$$

$$N_D x - c_D x^2 = N_D N_A - c_D N_A x - R(N_B(N_C - c_C x) - c_B x(N_C - c_C x))$$

$$N_D x - c_D x^2 = N_D N_A - c_D N_A x - R(N_B N_C - N_B c_C x - c_B N_C x + c_B c_C x^2)$$

$$N_D x - c_D x^2 = N_D N_A - c_D N_A x - N_B N_C R + N_B c_C R x + c_B N_C R x - c_B c_C R x^2$$

$$N_D x + c_D N_A x - N_B c_C R x - c_B N_C R x - c_D x^2 + c_B c_C R x^2 = N_D N_A - N_B N_C R$$

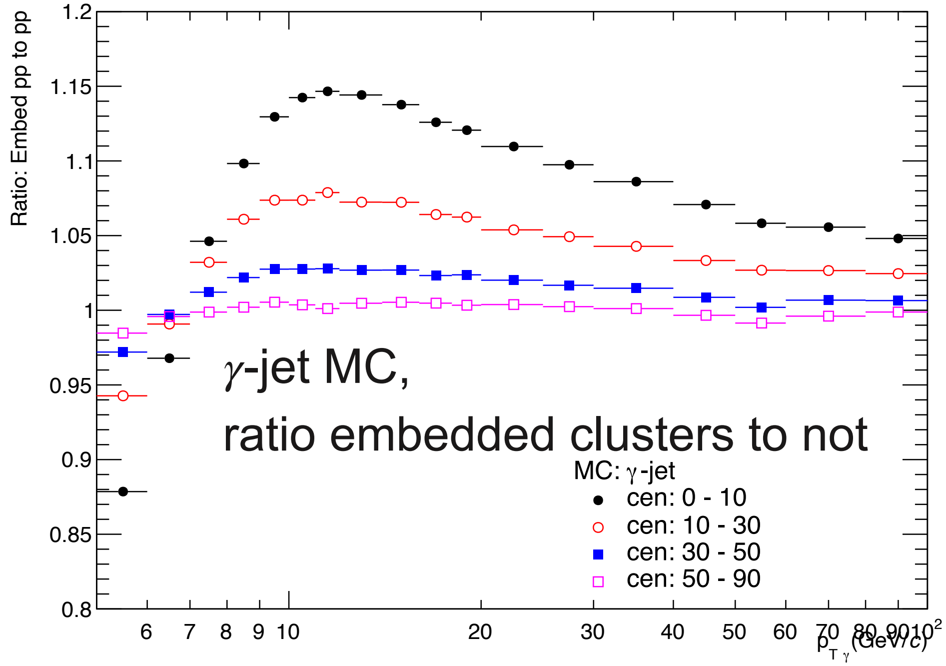
$$(c_B c_C R - c_D)x^2 + (N_D + c_D N_A - N_B c_C R - c_B N_C R)x = N_D N_A - N_B N_C R$$

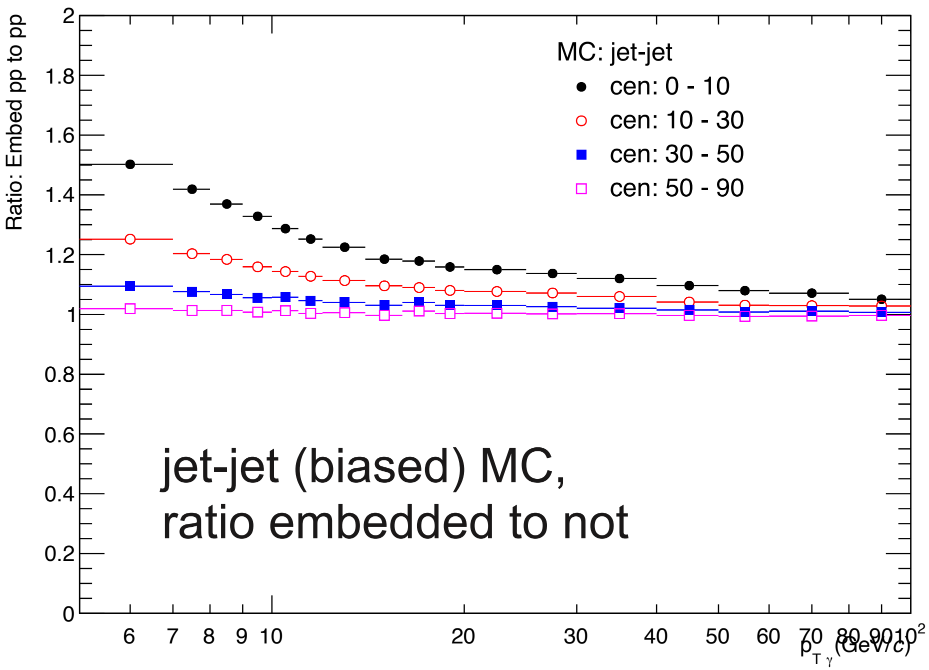
$$A = c_B c_C R_{Bkg}^{MC} - c_D$$
$$B = N_D + c_D N_A - N_B c_C R_{Bkg}^{MC} - c_B N_C R_{Bkg}^{MC}$$
$$C = N_B N_C R_{Bkg}^{MC} - N_D N_A$$

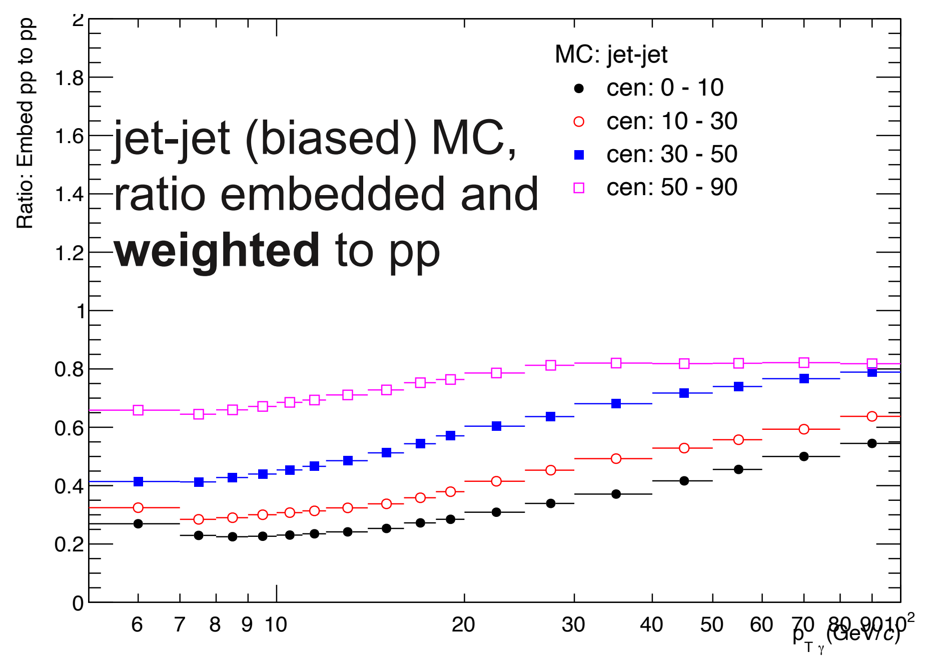
$$x = \frac{-B \pm \sqrt{B^2 - 4AC}}{2A} \qquad P = \frac{N_A^{signal}}{N_A} = \frac{x}{N_A}$$

Sanity check: Comparison of embedded and un-embedded MC

- Ratio embedded w/out weight to not embedded clusters
  - Weighted jet-jet do not reach 0.1 for central because of the UE cluster energy shift, specially in wide clusters

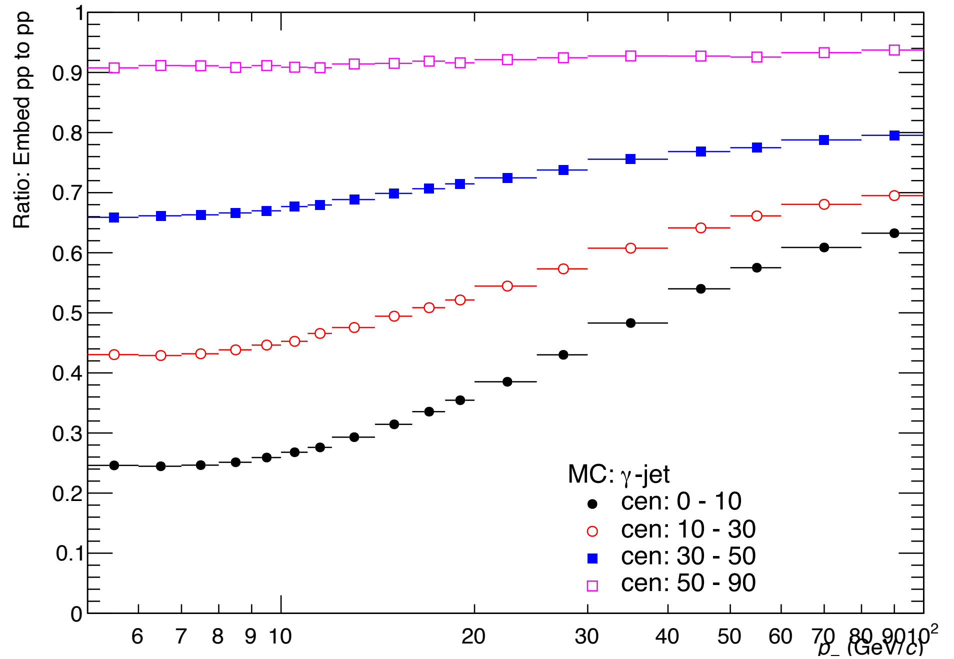


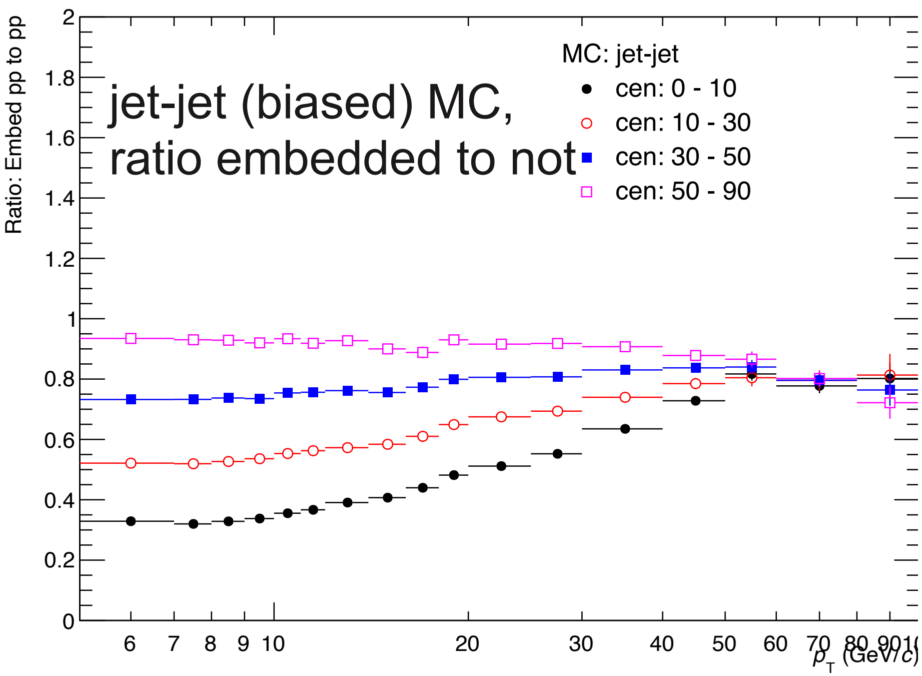


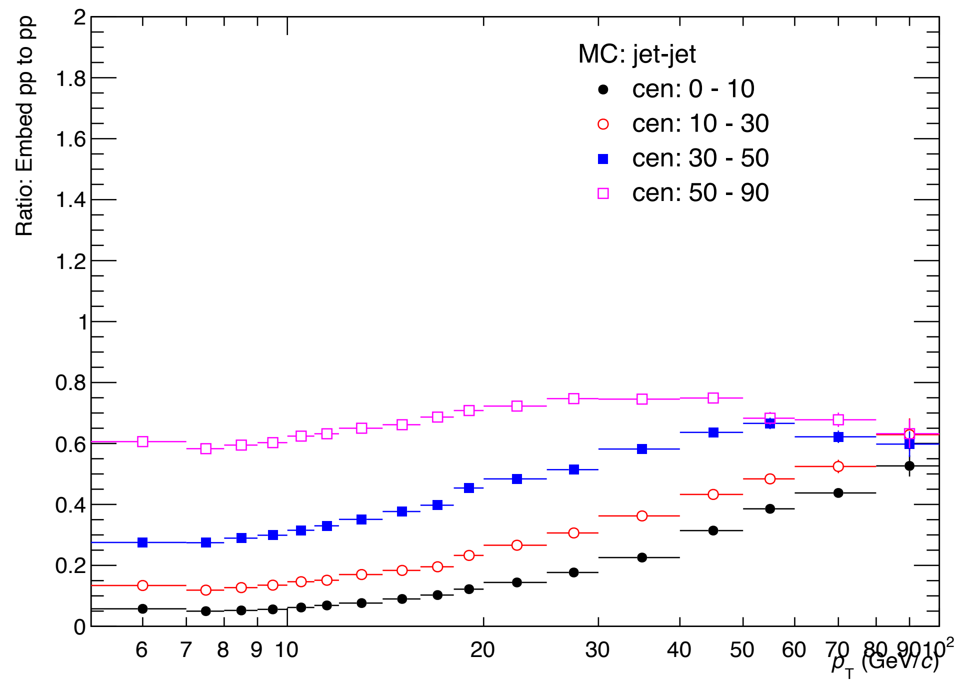


Isolated narrow clusters (signal A region) embedded to not embedded ratio

- $p_T^{iso} < 2$ GeV/c, $0.1 < \sigma^2_{long} < 0.3$
- The ratio embedded to not, is different for each of the ABCD regions, as to be expected
  - Not in previous report when constant scale factor applied per centrality and region
- In back up for isolated wide and narrow but not isolated bkg clusters

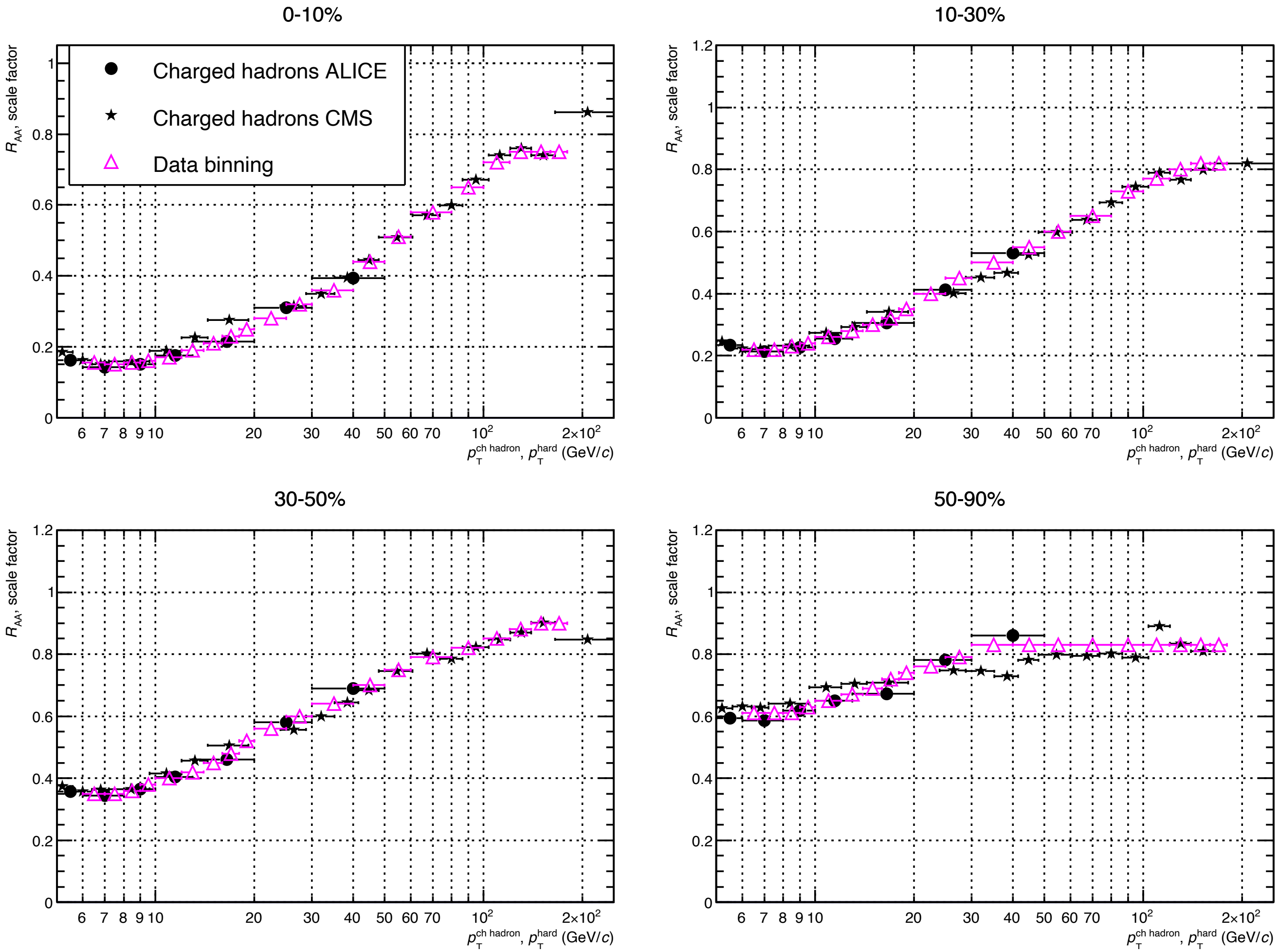






Jet-jet MCs weighted by particle R_{AA}

- Jet-jet MC need to be scaled down to account for jet-quenching.
- As a first approximation, use the charged particles R_{AA} and scale down the clusters p_T with this factor

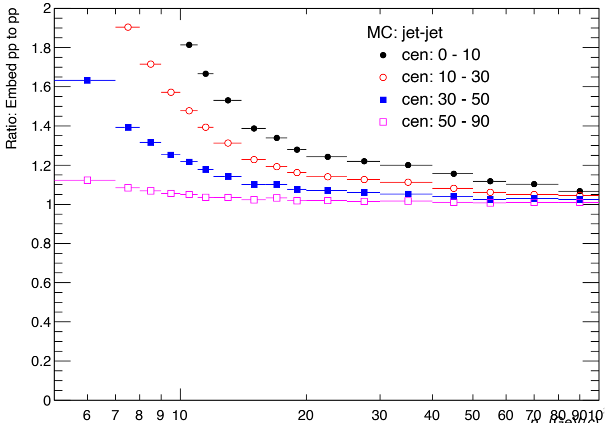


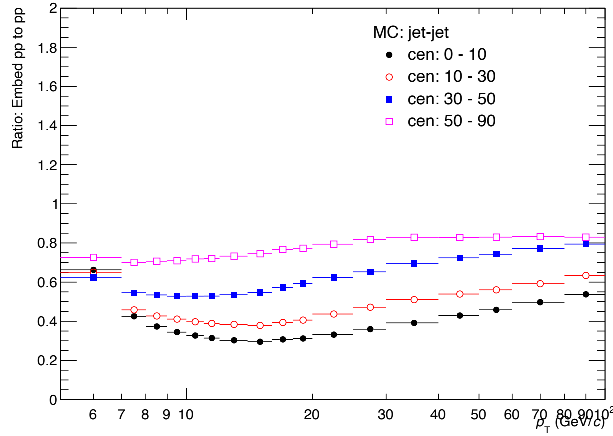
ALICE 0-80%:
https://www.hepdata.net/record/86210

CMS 0-90%:
https://www.hepdata.net/record/77101

Background jet-jet clusters embedded to not embedded ratio

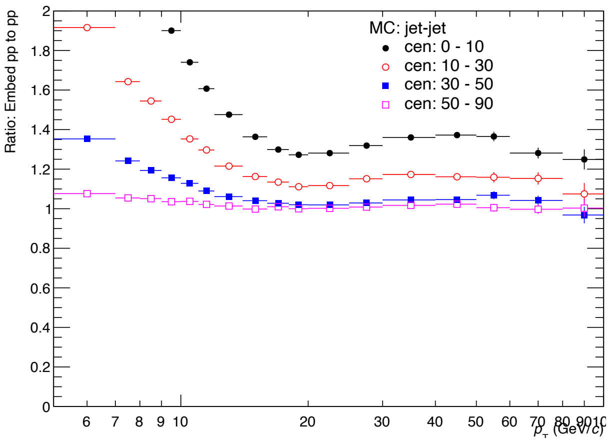
Embedded to pp | **Embedded & weighted to pp**

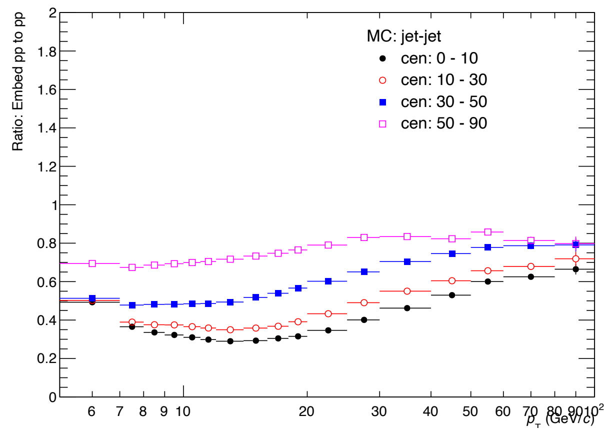




Not isolated, wide clusters

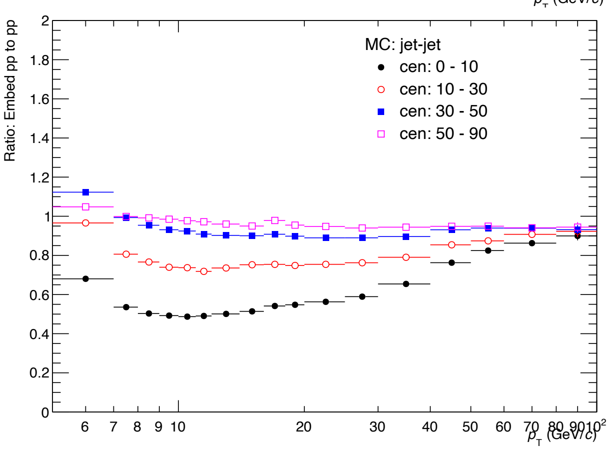
$p_T^{iso} > 2$ GeV/c, $\sigma^2_{long} > 0.3$

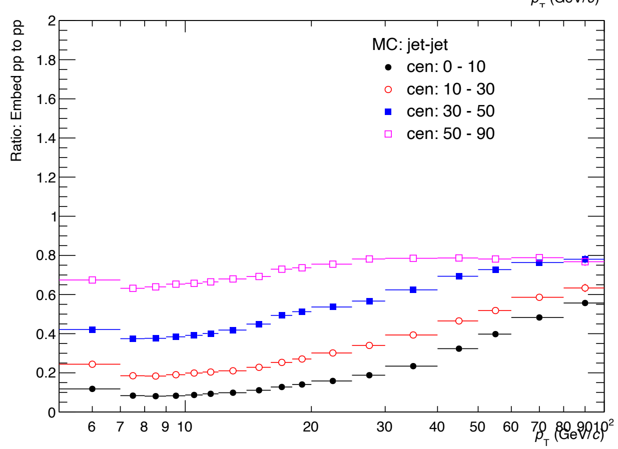




Isolated, wide clusters

$p_T^{iso} < 2$ GeV/c, $\sigma^2_{long} > 0.3$

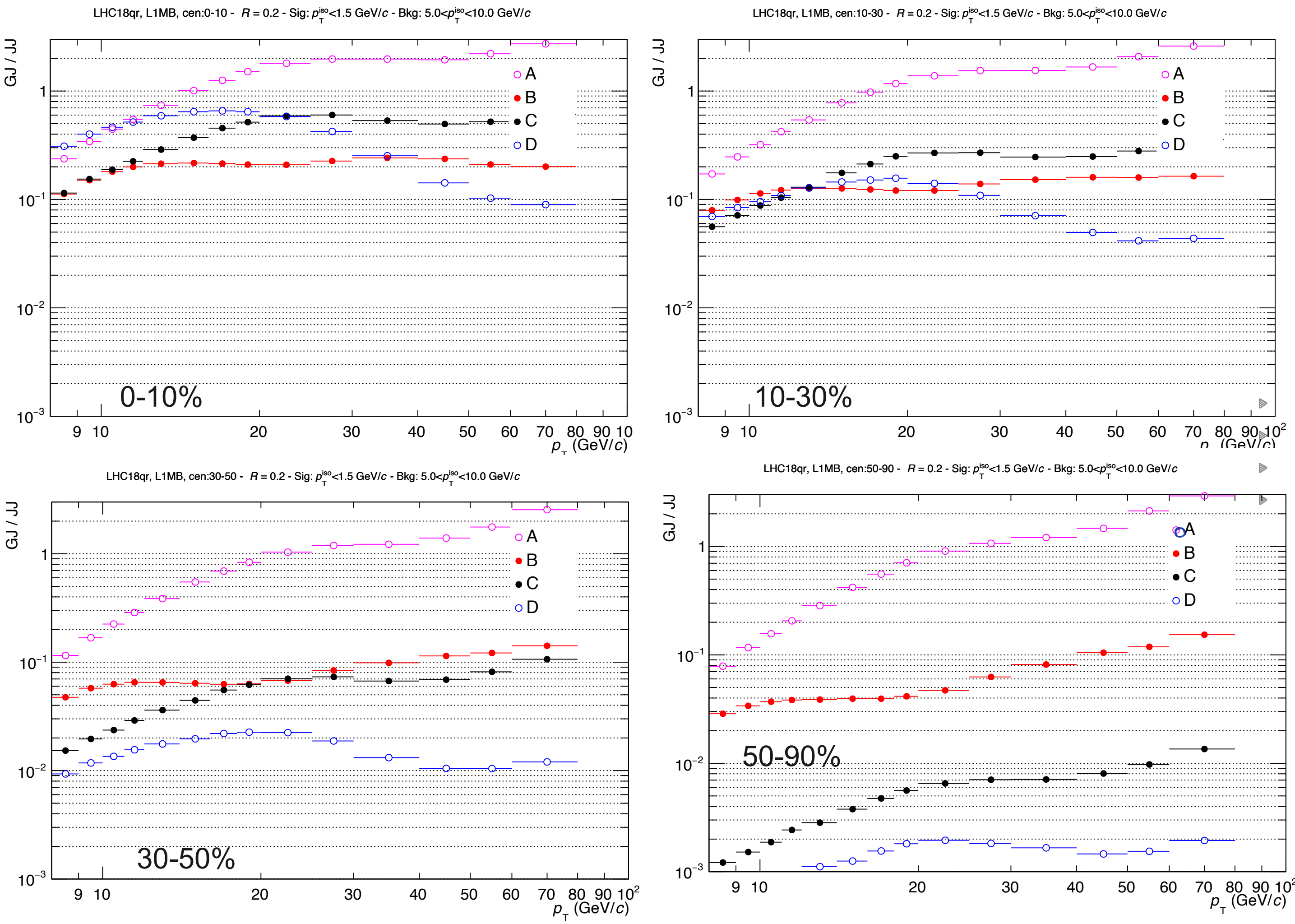




Not isolated, narrow clusters

$p_T^{iso} < 2$ GeV/c, $0.1 < \sigma^2_{long} < 0.3$

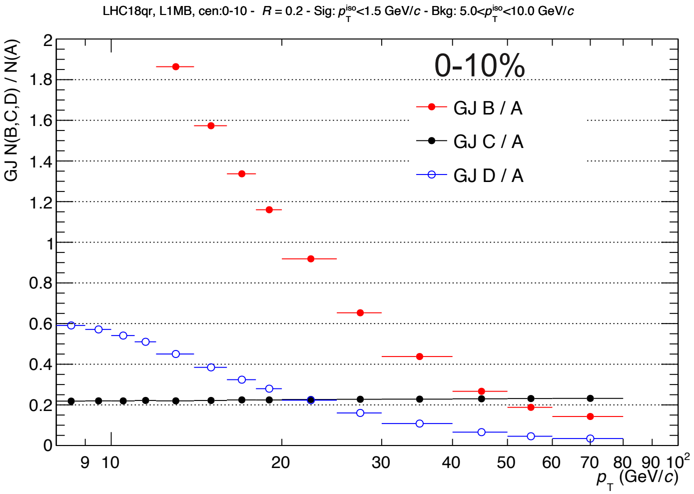
MC Signal over background (GJ/JJ) in ABCD

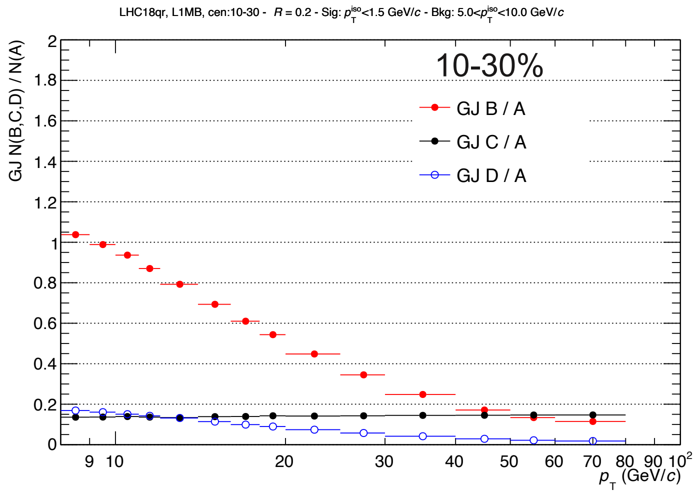


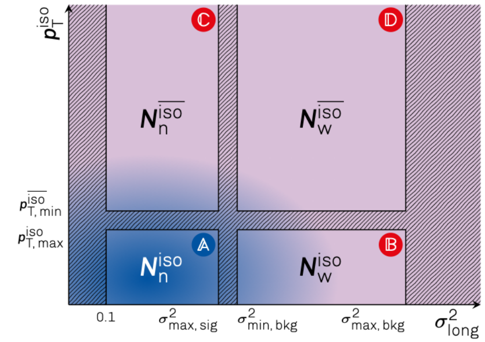
A: 0.1 <σ^2_{long} < 0.3, p_T^{iso} < 1.5 GeV/c
B: 0.4 <σ^2_{long} < 2.0, p_T^{iso} < 1.5 GeV/c
C: 0.1 <σ^2_{long} < 0.3, 5 < p_T^{iso} < 10 GeV/c
D: 0.4 <σ^2_{long} < 2.0, 5 < p_T^{iso} < 10 GeV/c

- Central collisions have a significant contribution of signal in bkg regions compared to peripheral
- This can be reduced moving the bkg ranges up and reducing the window, but the purity obtained with the ABCD method seems not to be too sensitive to the bkg range (next slides)
- See back-up 51, 52 for different bkg ranges

γ-jet MC c_i fraction B,C,D / A





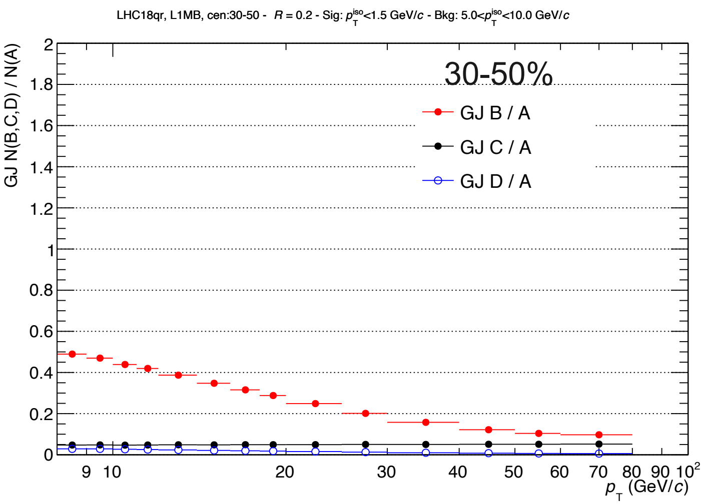


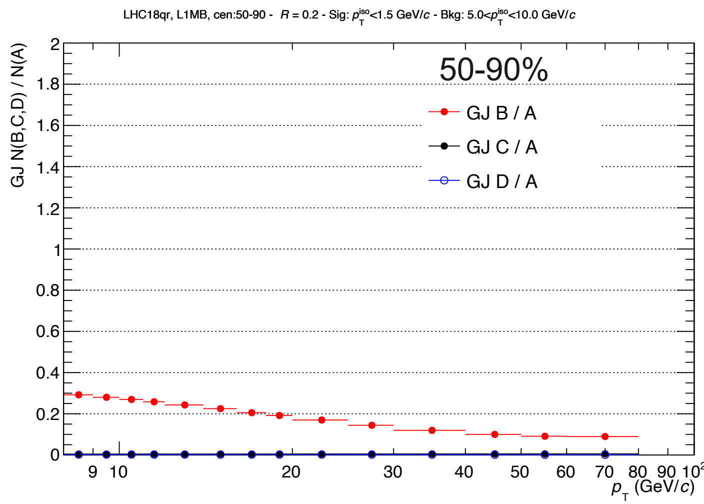
A: Signal, 0.1 <σ^2_{long} < 0.3, p_T^{iso} < 1.5 GeV/c

B: Background, 0.4 <σ^2_{long} < 2.0, p_T^{iso} < 1.5 GeV/c

C: Background, 0.1 <σ^2_{long} < 0.3, 5 < p_T^{iso} < 10 GeV/c

D: Background, 0.4 <σ^2_{long} < 2.0, 5 < p_T^{iso} < 10 GeV/c

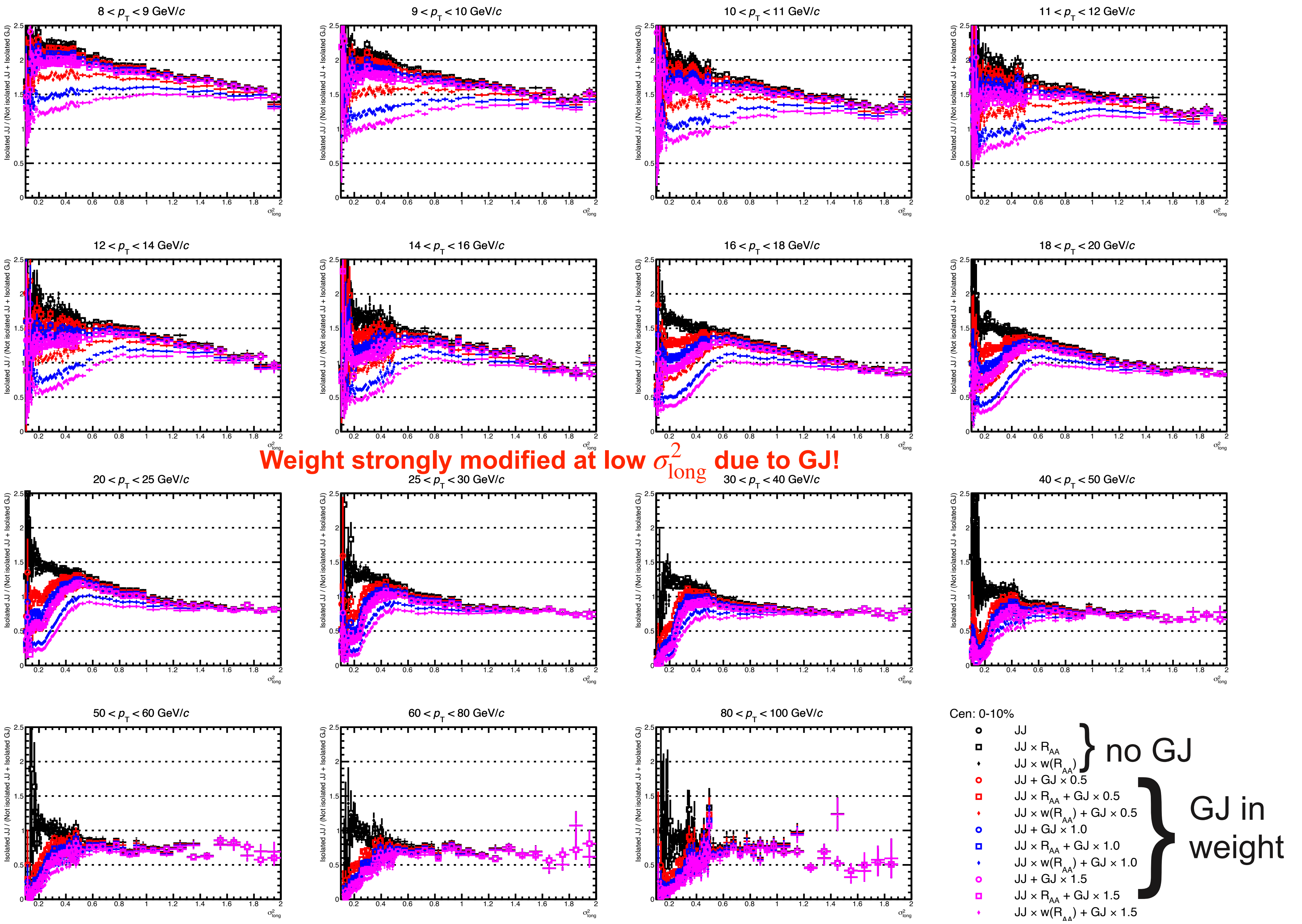




- B /A (isolated wide clusters) is large at low p_T, it decreases decreasing the window or moving it to higher values, but is the highest fraction of the 3 in any case
- C / A is constant with p_T, smaller than 20%
- All fractions can be reduced decreasing the background regions windows or moving to higher values (back-up 53 and 54) but the impact in the purity is not large.

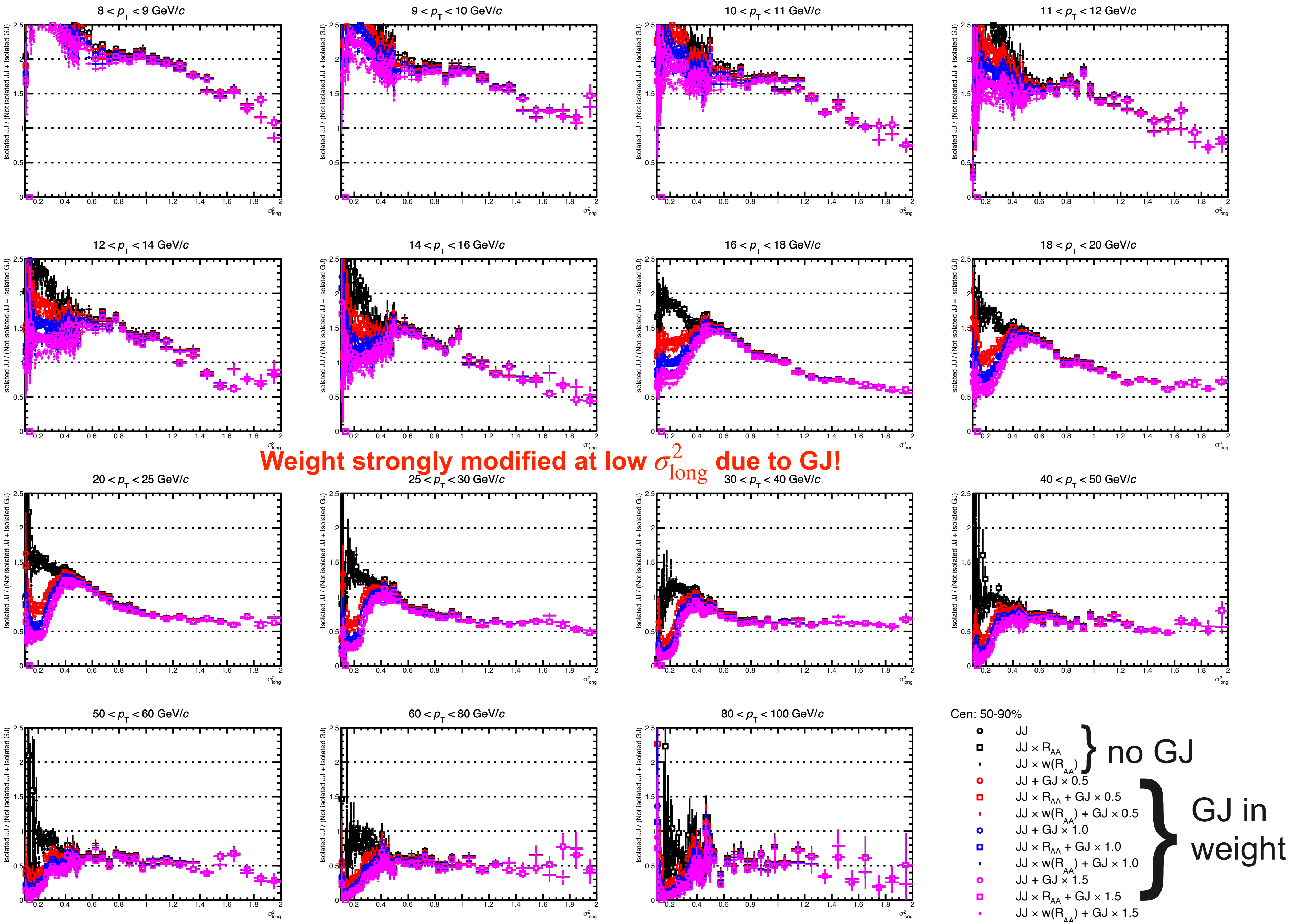
Template weight correction, 0-10%

$$Weight = \frac{R_{AA} N^{iso}_{MC\ JJ}}{R_{AA} N^{anti\ iso}_{MC\ JJ} + \mathbf{k} N^{iso}_{MC\ GJ}}$$ k = 0, 0.5, 1, 1.5



Template weight correction, 50-90%

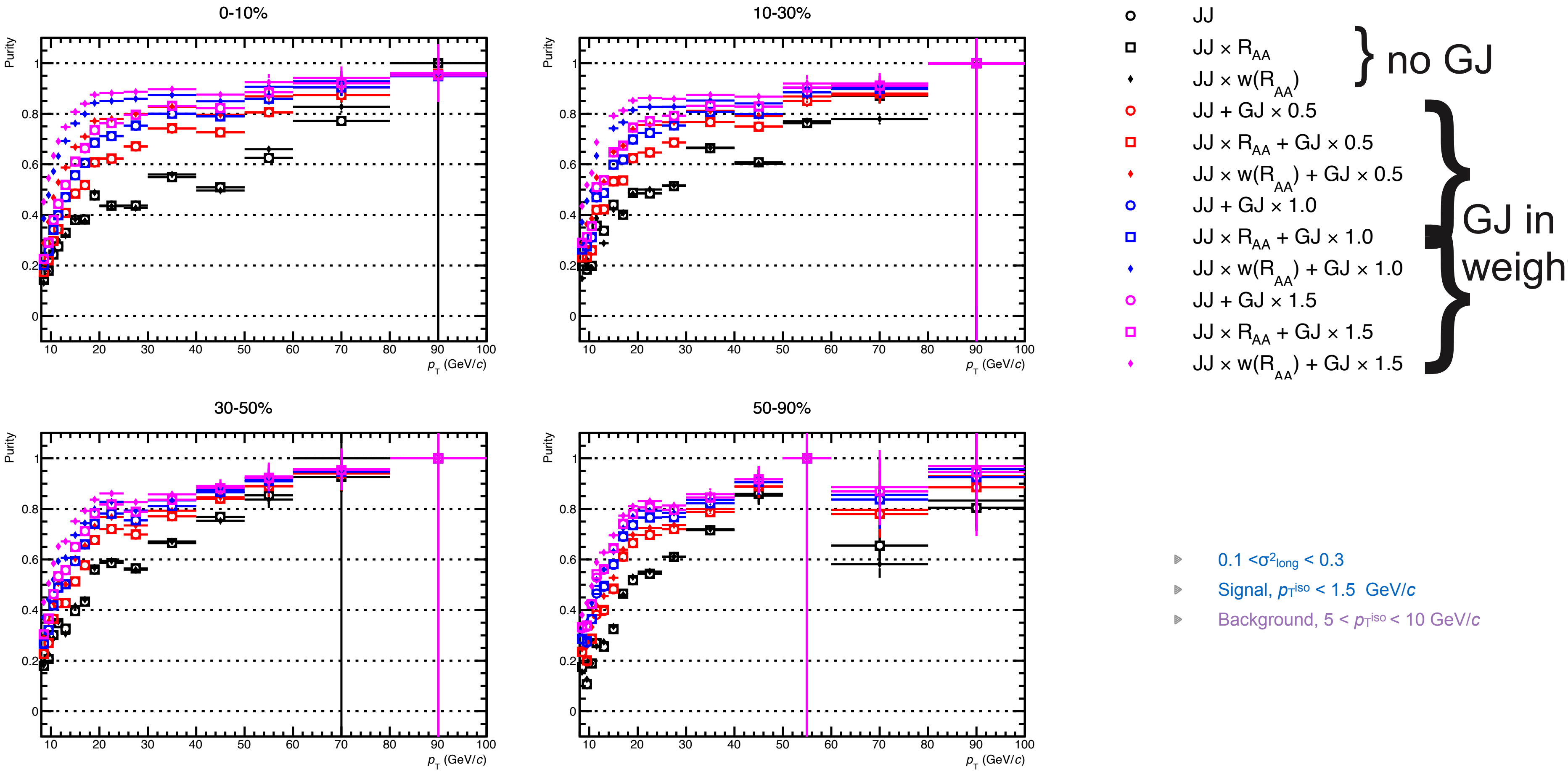
$$Weight = \frac{R_{AA} N^{iso}_{MC\ JJ}}{R_{AA} N^{anti\ iso}_{MC\ JJ} \times \mathbf{k} N^{iso}_{MC\ GJ}}$$ k = 0, 0.5, 1, 1.5



Weight strongly modified at low σ^2_{long} due to GJ!

Template Purity: GJ in weight

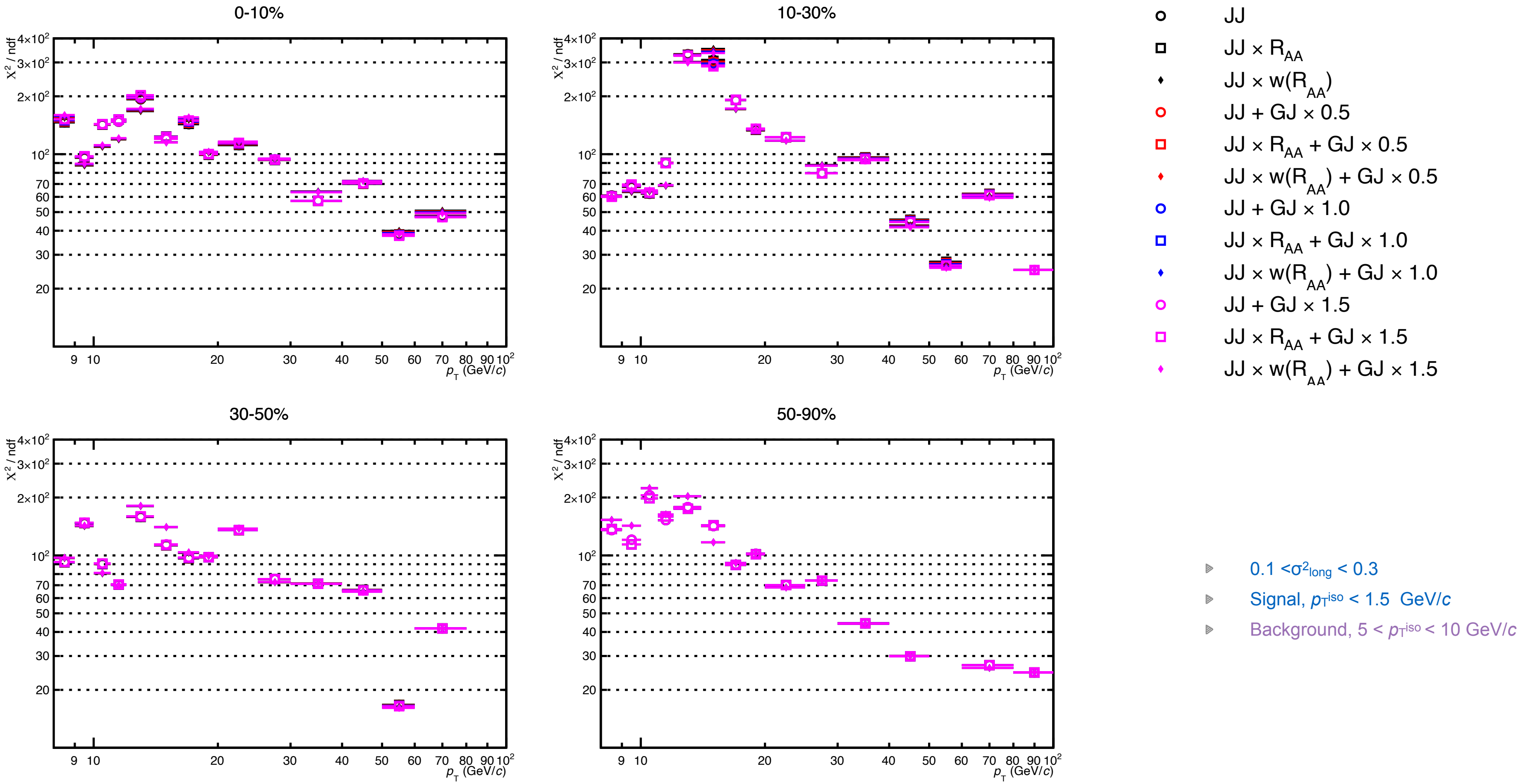
$$Weight = \frac{R_{AA} N^{iso}_{MC\ JJ}}{R_{AA} N^{anti\ iso}_{MC\ JJ} \times \mathbf{k} N^{iso}_{MC\ GJ}}$$ k = 0, 0.5, 1, 1.5



- $0.1 < \sigma^2_{long} < 0.3$
- Signal, $p_T^{iso} < 1.5$ GeV/c
- Background, $5 < p_T^{iso} < 10$ GeV/c

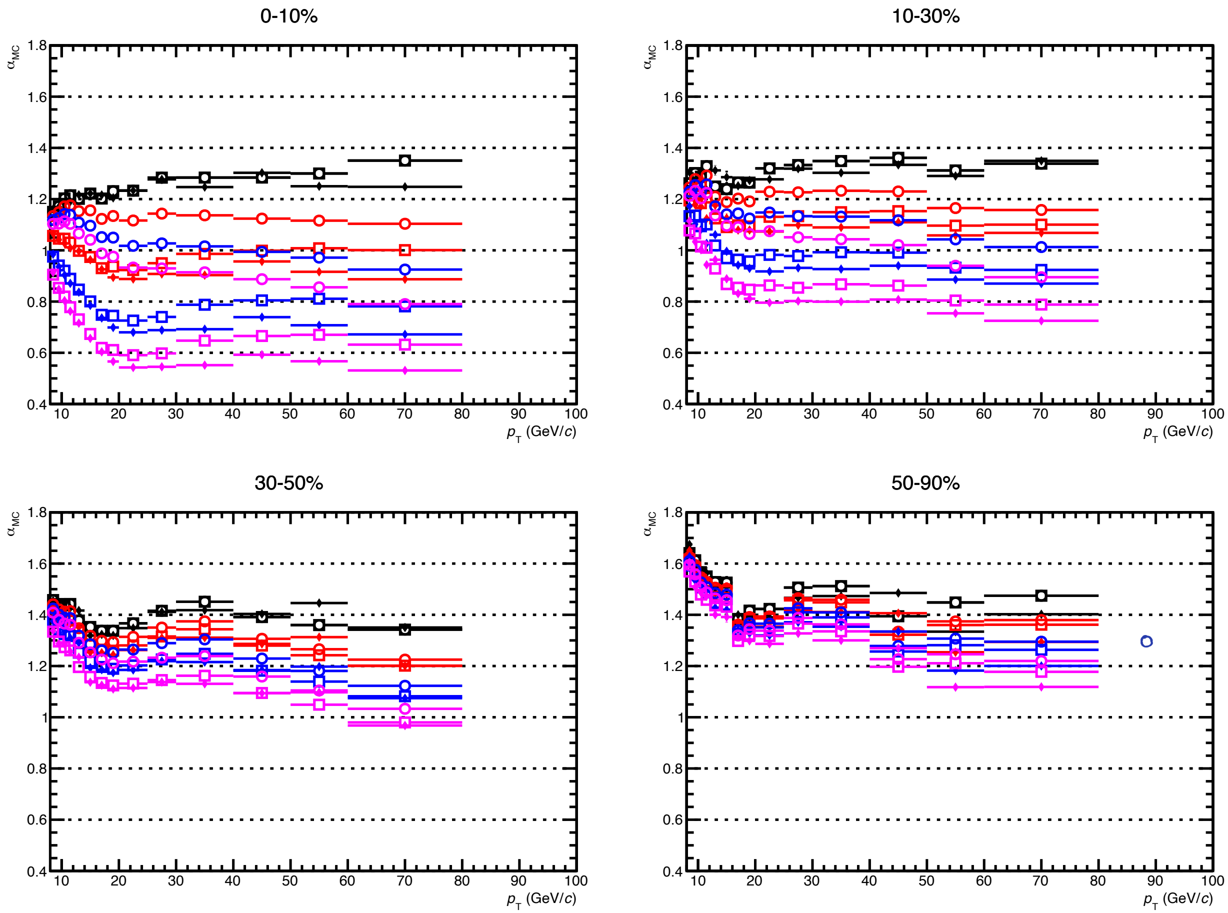
- Black points (no gamma-jet in weight), closer to what reports Alwina
- Including the GJ in the weight moves purity up too much in all centralities
  - Is this what was done or I am doing something wrong?
  - I am not using this correction from now on

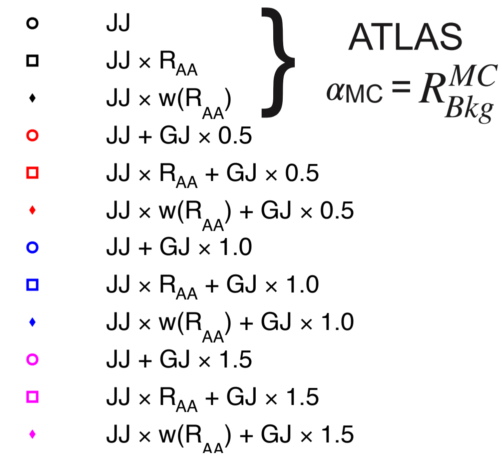
Template Chi2/ndf



- Fit quality not very good, not sure how to improve it, I have been playing with binning, or bkg regions (back-up 56 & 57), but no significant help.

ABCD-ALICE Correction factor α_{MC} for different MC scales



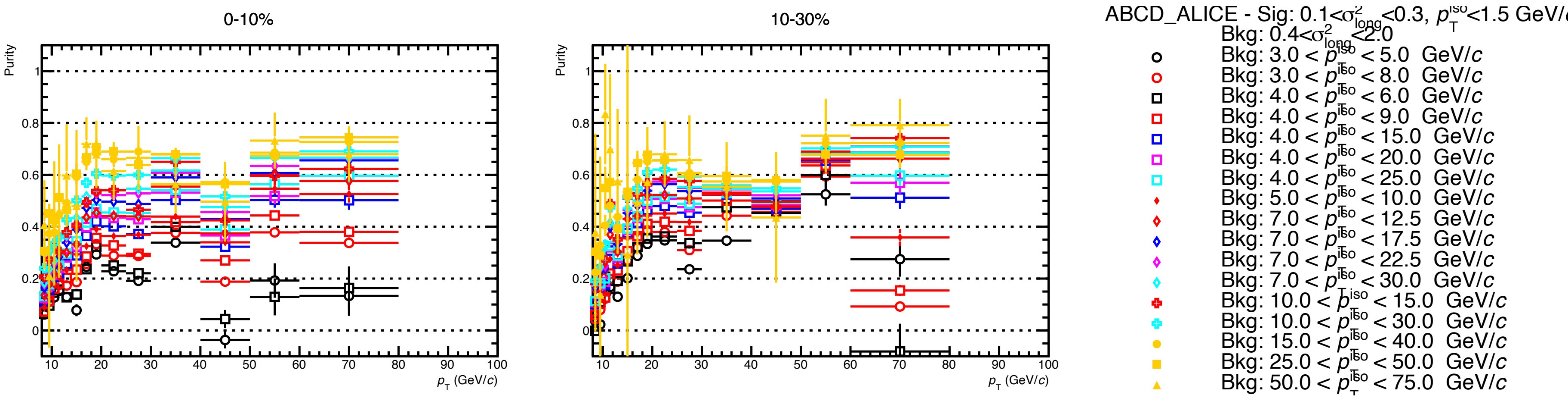


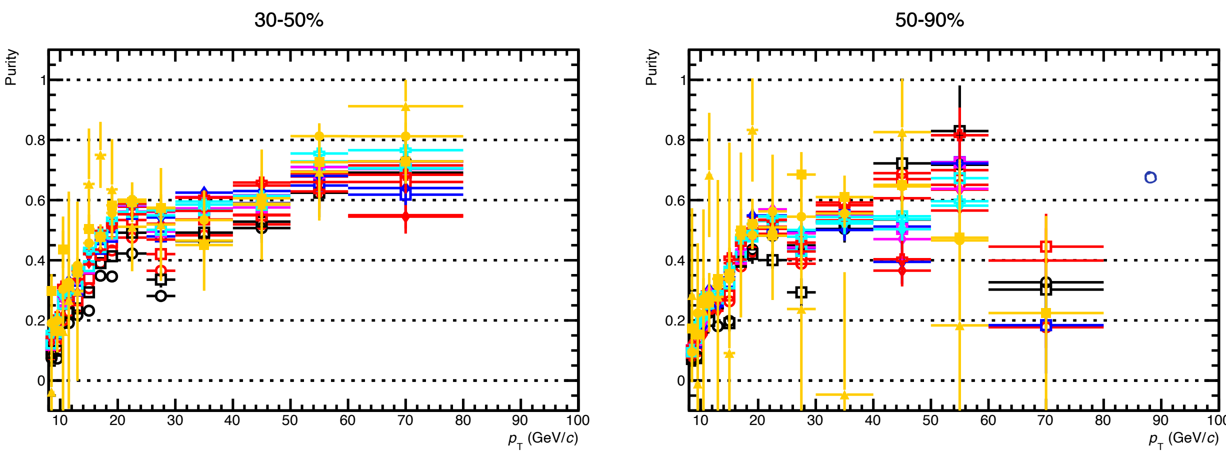
- A: Signal, $0.1 < \sigma^2_{long} < 0.3$, $p_T^{iso} < 1.5$ GeV/c
- B: Background, $0.4 < \sigma^2_{long} < 2.0$, $p_T^{iso} < 1.5$ GeV/c
- C: Background, $0.1 < \sigma^2_{long} < 0.3$, $5 < p_T^{iso} < 10$ GeV/c
- D: Background, $0.4 < \sigma^2_{long} < 2.0$, $5 < p_T^{iso} < 10$ GeV/c

Legend nomenclature:
JJ x R_{AA}: Simple scale
JJ x w(R_{AA}): Weighted scale

- Inclusion of signal in background regions has an important effect on the correction when jet-jet is strongly scaled down in central collisions, due to the strong contribution of signal in bkg regions
- The R_{AA} simple scale or weight on jet-jet MC has almost no difference at low p_T but in central collisions high p_T clusters the correction seems a bit lower with the weight

ABCD-ALICE Purity for different isolation bkg regions — MC = JJ x w(R_{AA})

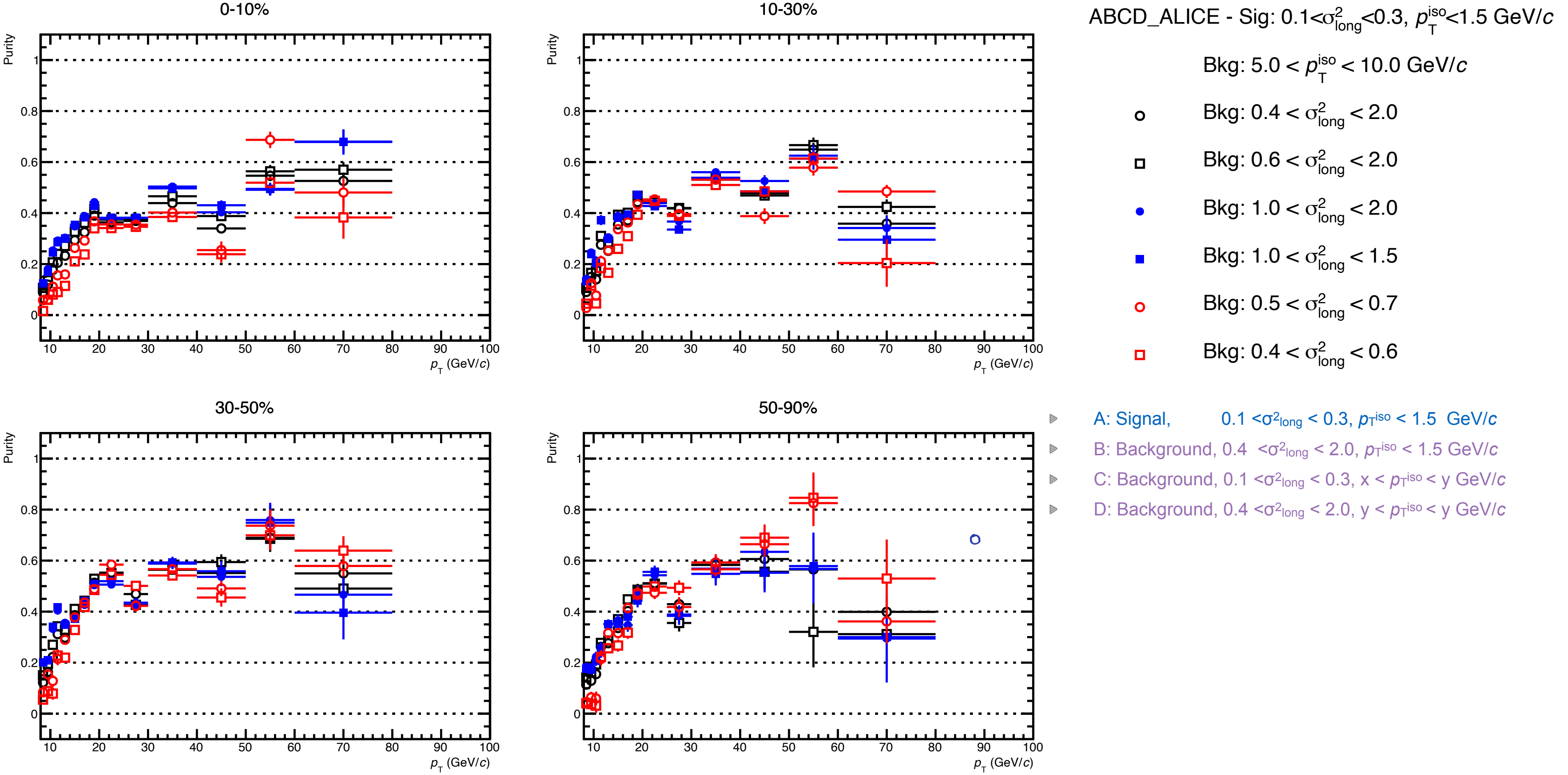




- A: Signal, 0.1 <σ^2_{long} < 0.3, p_T^{iso} < 1.5 GeV/c
- B: Background, 0.4 <σ^2_{long} < 2.0, p_T^{iso} < 1.5 GeV/c
- C: Background, 0.1 <σ^2_{long} < 0.3, x < p_T^{iso} < y GeV/c
- D: Background, 0.4 <σ^2_{long} < 2.0, y < p_T^{iso} < y GeV/c

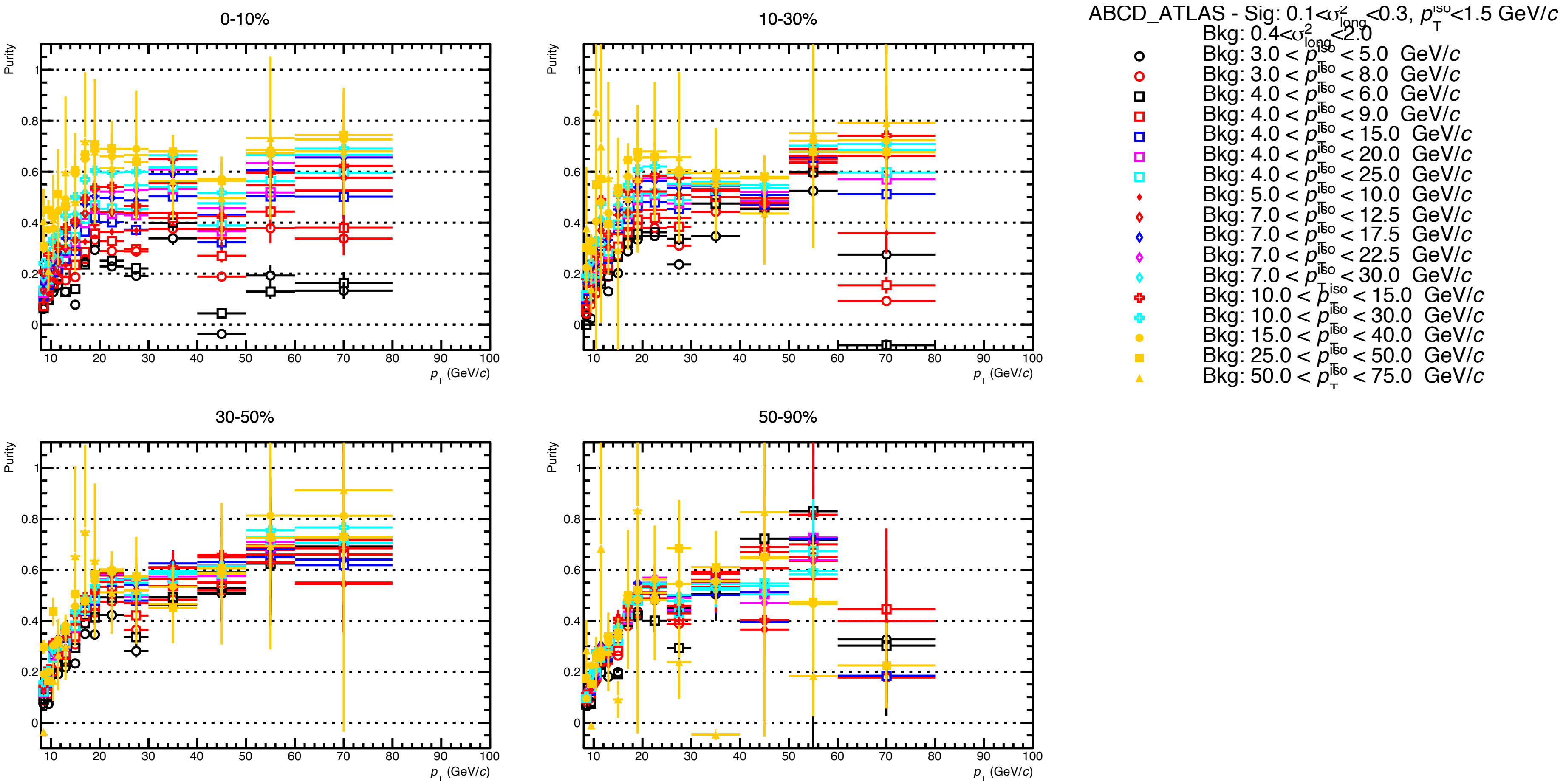
- Significant variation when k=0

ABCD-ALICE Purity for different shower shape bkg regions — MC =JJ x w(R_{AA})



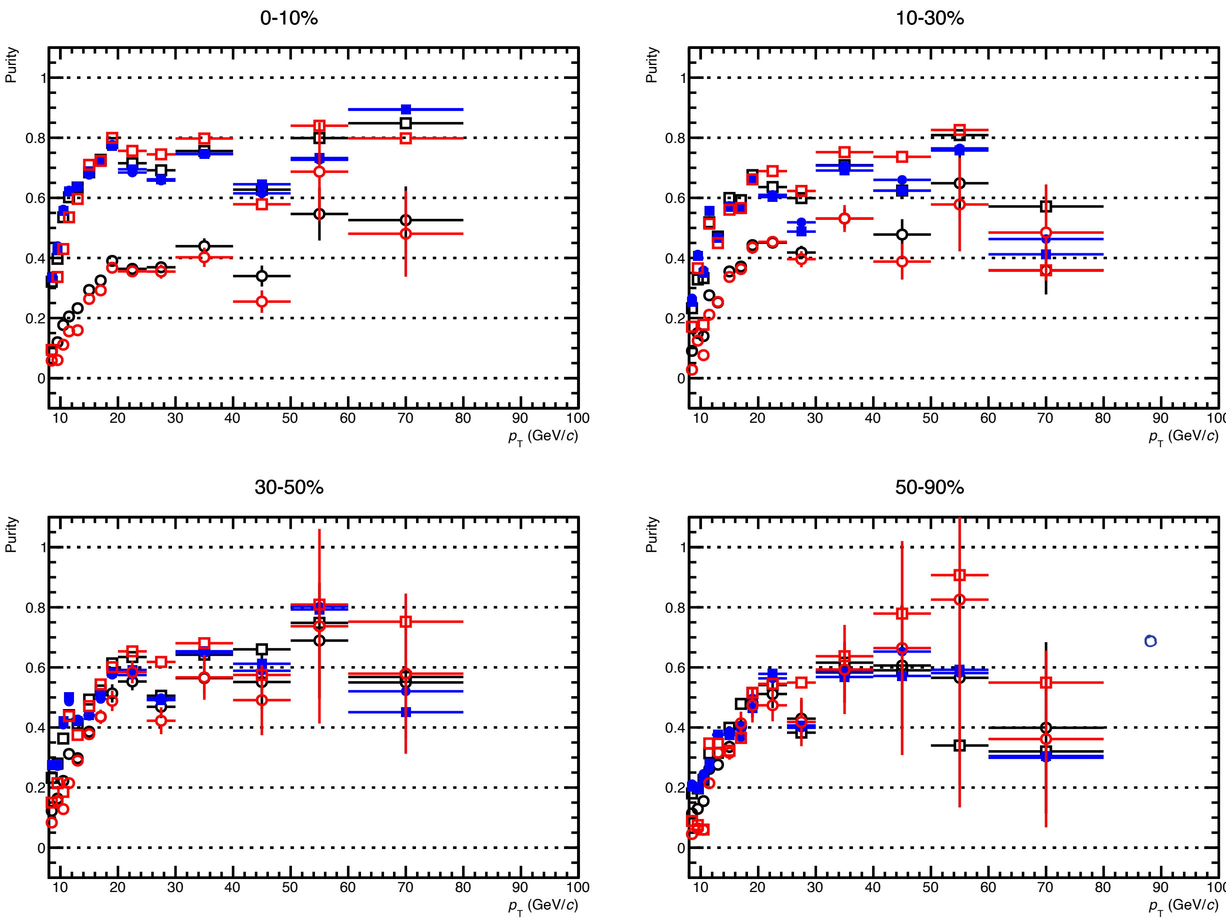
- A: Signal, $0.1 < \sigma^2_{long} < 0.3$, $p_T^{iso} < 1.5$ GeV/c
- B: Background, $0.4 < \sigma^2_{long} < 2.0$, $p_T^{iso} < 1.5$ GeV/c
- C: Background, $0.1 < \sigma^2_{long} < 0.3$, $x < p_T^{iso} < y$ GeV/c
- D: Background, $0.4 < \sigma^2_{long} < 2.0$, $y < p_T^{iso} < y$ GeV/c

ABCD-ATLAS Purity for different isolation bkg regions — MC = JJ x w(R_{AA})



- Significant variation when k=0

ABCD-ATLAS Purity for different shower shape bkg regions — MC =JJ x w(R_{AA})



ABCD_ATLAS - Sig: $0.1<\sigma^2_{long}<0.3$, $p_T^{iso}<1.5$ GeV/c

Bkg: $5.0 < p_T^{iso} < 10.0$ GeV/c

Bkg: $0.4 < \sigma^2_{long} < 2.0$

Bkg: $0.6 < \sigma^2_{long} < 2.0$

Bkg: $1.0 < \sigma^2_{long} < 2.0$

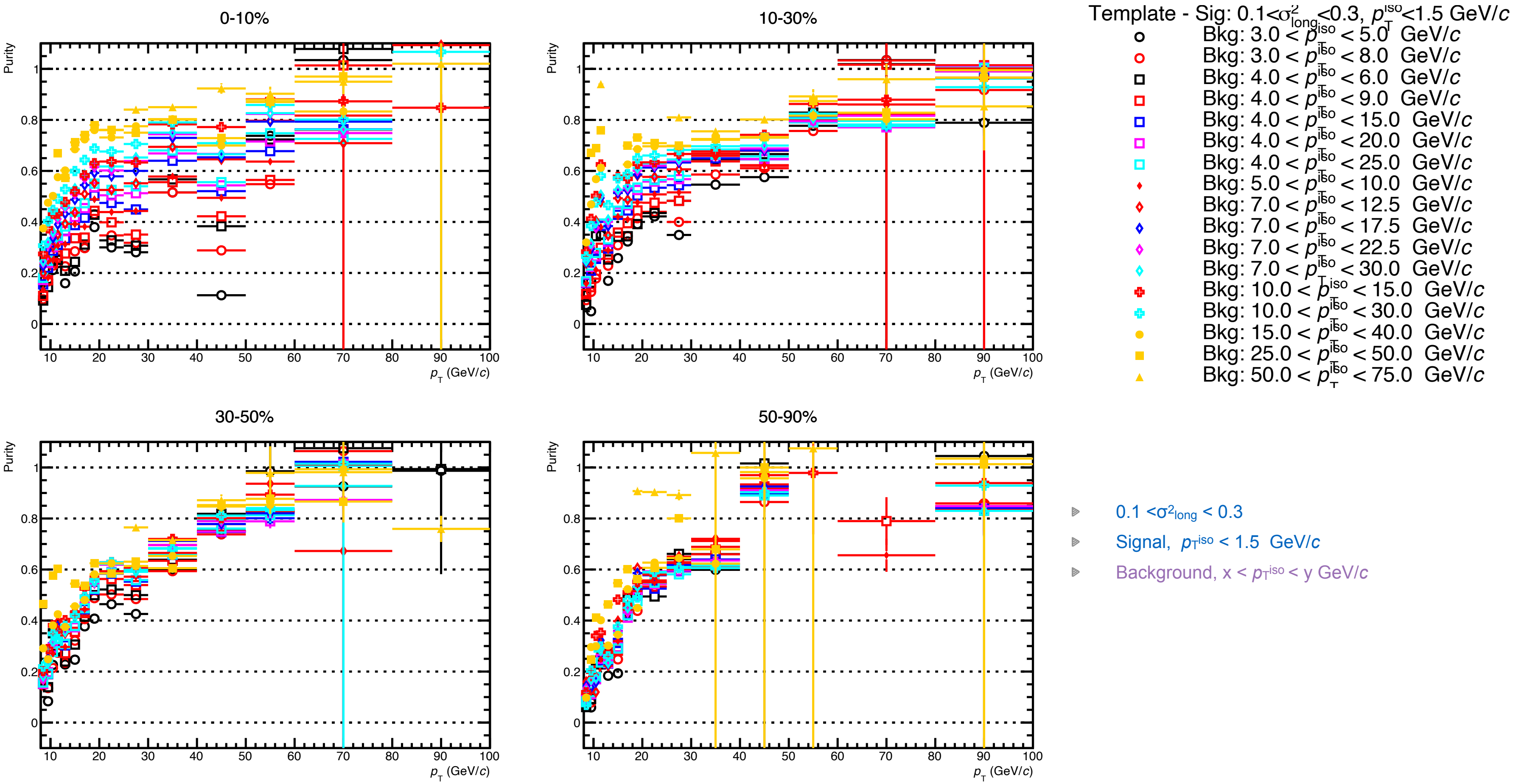
Bkg: $1.0 < \sigma^2_{long} < 1.5$

Bkg: $0.5 < \sigma^2_{long} < 0.7$

Bkg: $0.4 < \sigma^2_{long} < 0.6$

- A: Signal, $0.1 < \sigma^2_{long} < 0.3$, $p_T^{iso} < 1.5$ GeV/c
- B: Background, $0.4 < \sigma^2_{long} < 2.0$, $p_T^{iso} < 1.5$ GeV/c
- C: Background, $0.1 < \sigma^2_{long} < 0.3$, $x < p_T^{iso} < y$ GeV/c
- D: Background, $0.4 < \sigma^2_{long} < 2.0$, $y < p_T^{iso} < y$ GeV/c

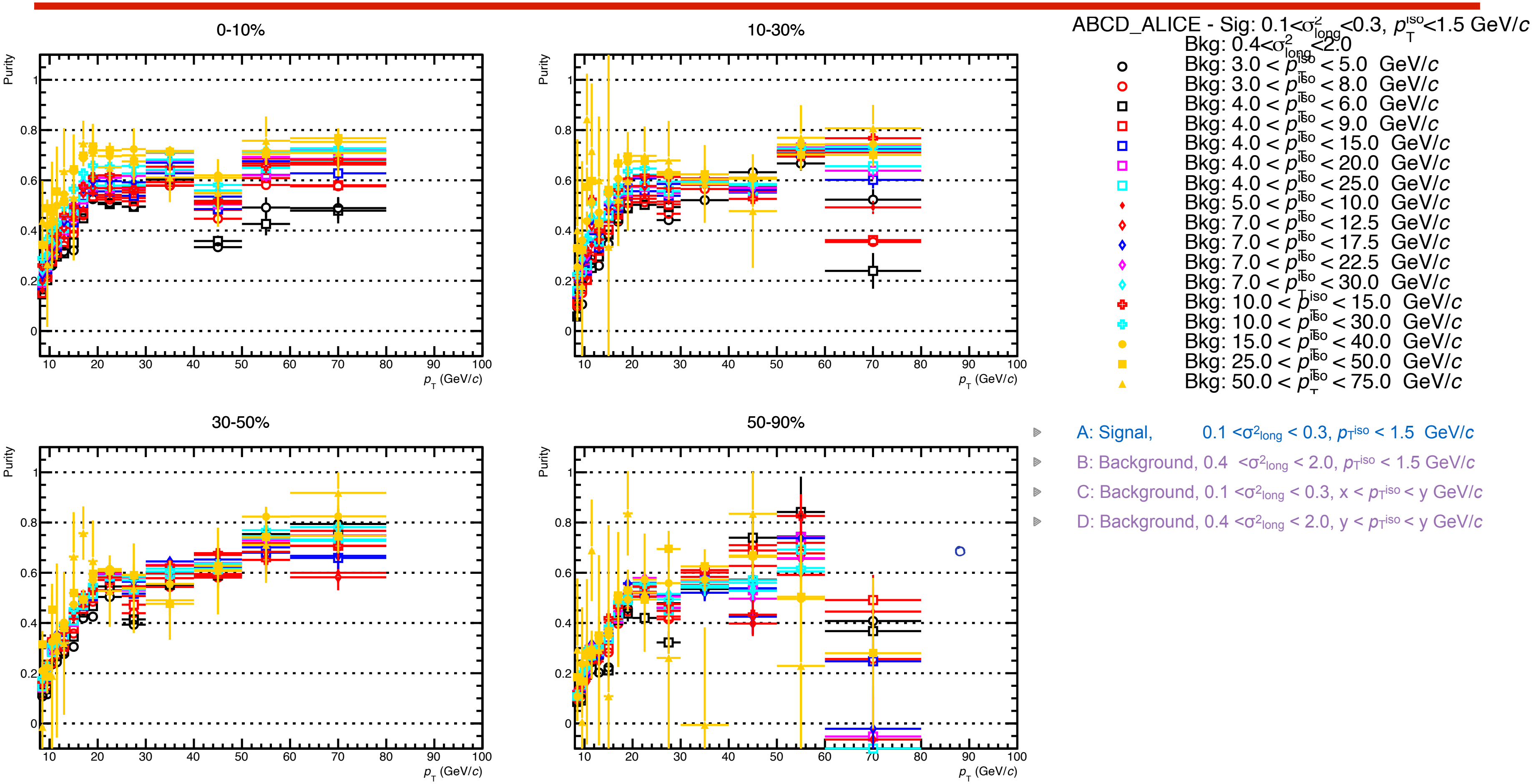
Template Purity for different isolation bkg regions — MC = JJ x w(R_{AA})



- 0.1 <σ^2_{long} < 0.3
- Signal, p_T^{iso} < 1.5 GeV/c
- Background, x < p_T^{iso} < y GeV/c

- Significant variation when k=0

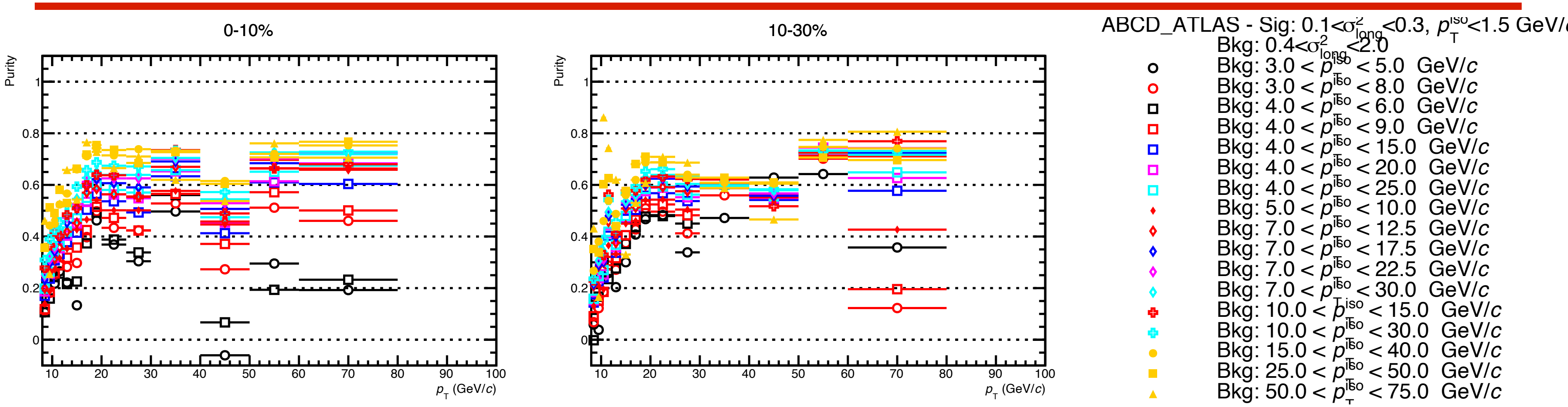
ABCD0ALICE Purity for different isolation bkg regions — MC = JJ x w(R_{AA}) + 0.5xGJ

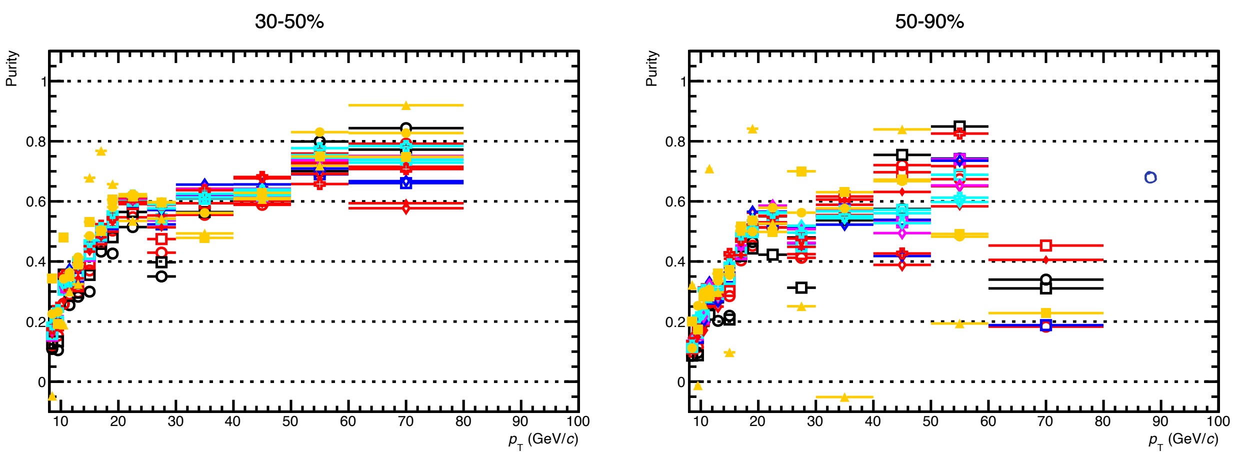


- A: Signal, $0.1 < \sigma^2_{long} < 0.3$, $p_T^{iso} < 1.5$ GeV/c
- B: Background, $0.4 < \sigma^2_{long} < 2.0$, $p_T^{iso} < 1.5$ GeV/c
- C: Background, $0.1 < \sigma^2_{long} < 0.3$, $x < p_T^{iso} < y$ GeV/c
- D: Background, $0.4 < \sigma^2_{long} < 2.0$, $y < p_T^{iso} < y$ GeV/c

- Rather independent of the variations done but a bit more than with k=1

ABCD-ATLAS Purity for different isolation bkg regions — MC = JJ x w(R_{AA}) + 0.5xGJ

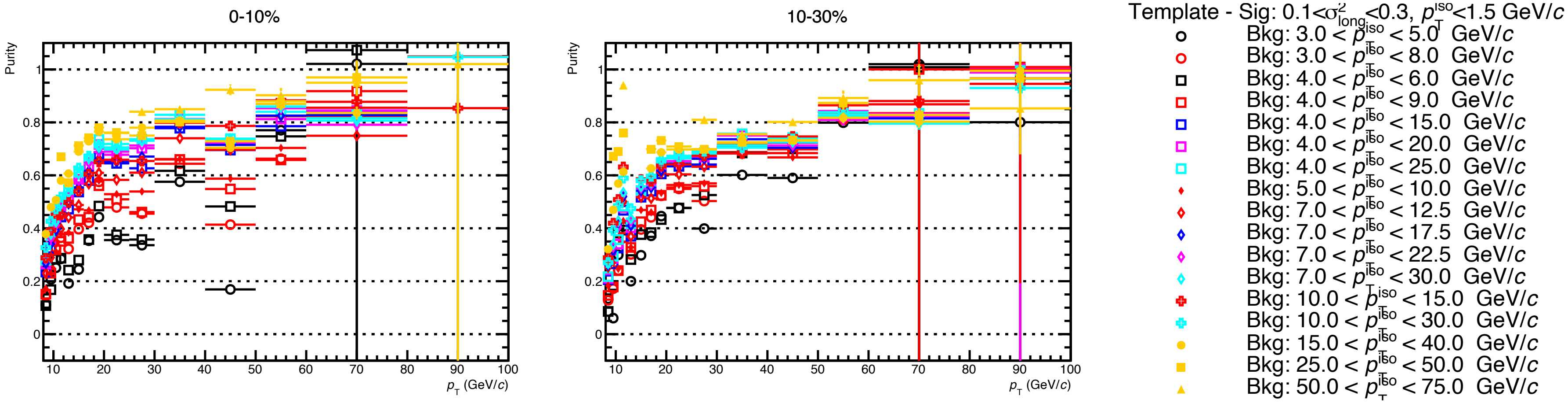


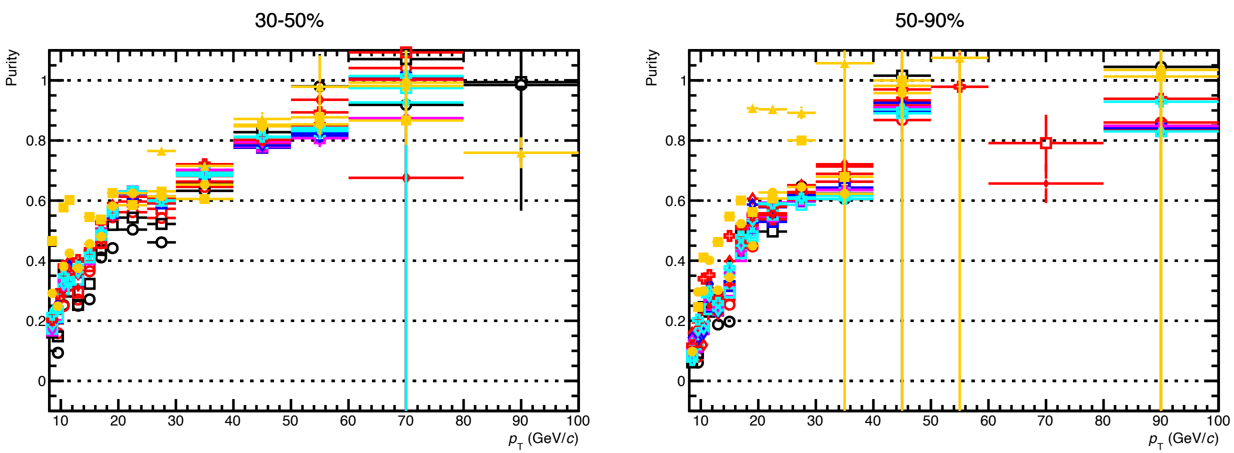


- A: Signal, $0.1 < \sigma^2_{long} < 0.3$, $p_T^{iso} < 1.5$ GeV/c
- B: Background, $0.4 < \sigma^2_{long} < 2.0$, $p_T^{iso} < 1.5$ GeV/c
- C: Background, $0.1 < \sigma^2_{long} < 0.3$, $x < p_T^{iso} < y$ GeV/c
- D: Background, $0.4 < \sigma^2_{long} < 2.0$, $y < p_T^{iso} < y$ GeV/c

- Significantly more variation than with k=1

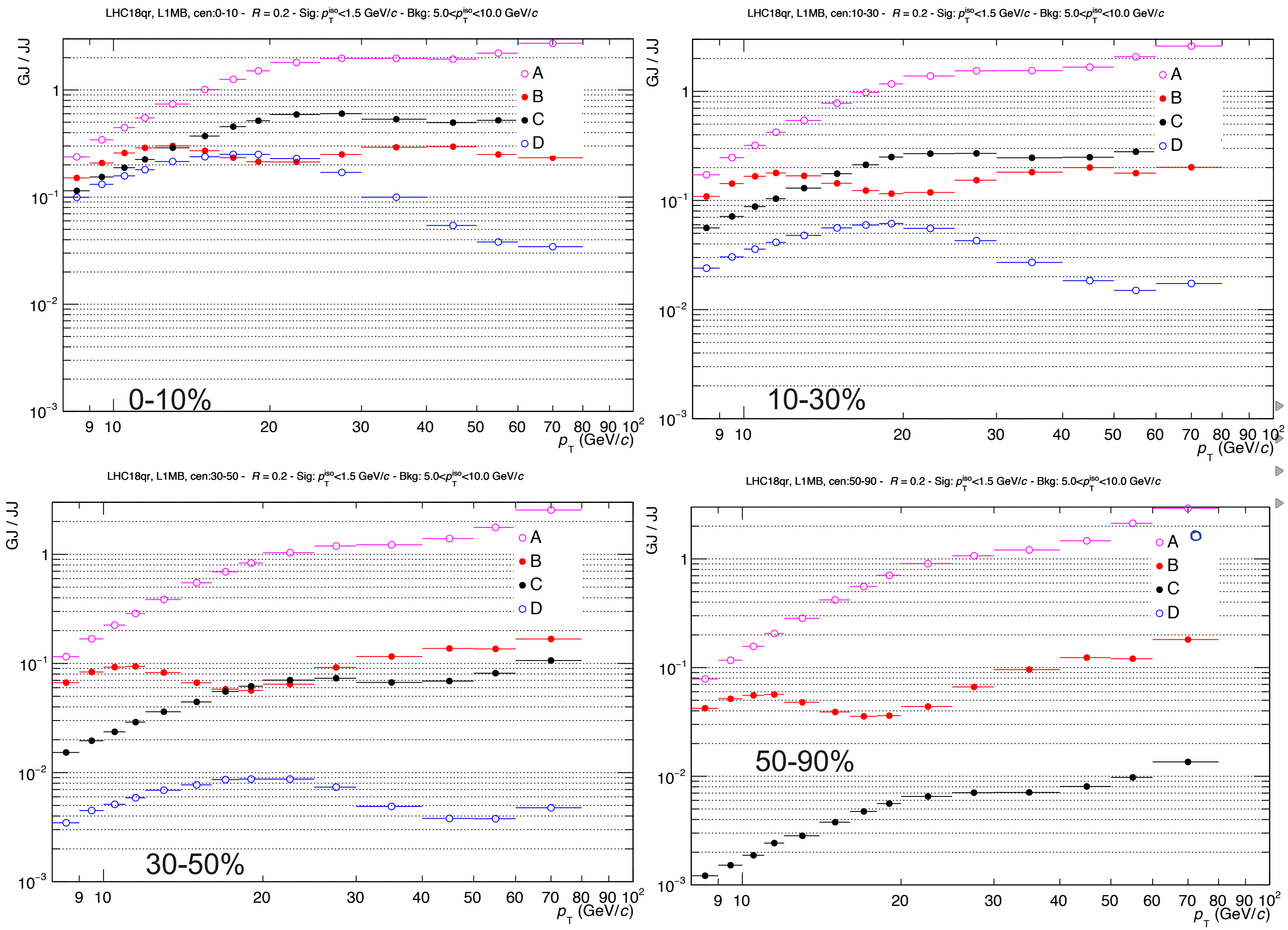
Template Purity for different isolation bkg regions — MC =JJ x w(R$_{AA}$) + 0.5xGJ





- $0.1 < \sigma^2_{long} < 0.3$
- Signal, $p_T^{iso} < 1.5$ GeV/c
- Background, x < p_T^{iso} < y GeV/c

MC Signal over background (GJ/JJ) in ABCD, Bkg 0.5< σ^2_{long} < 0.7



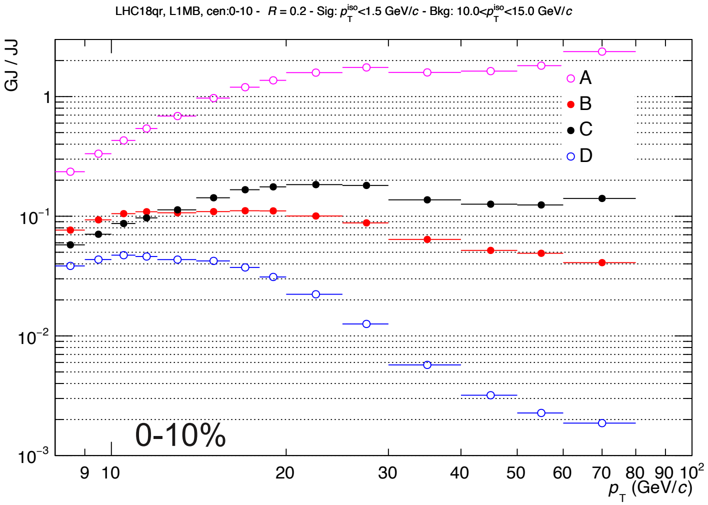
A: 0.1 <σ^2_{long} < 0.3, p_T^{iso} < 1.5 GeV/c

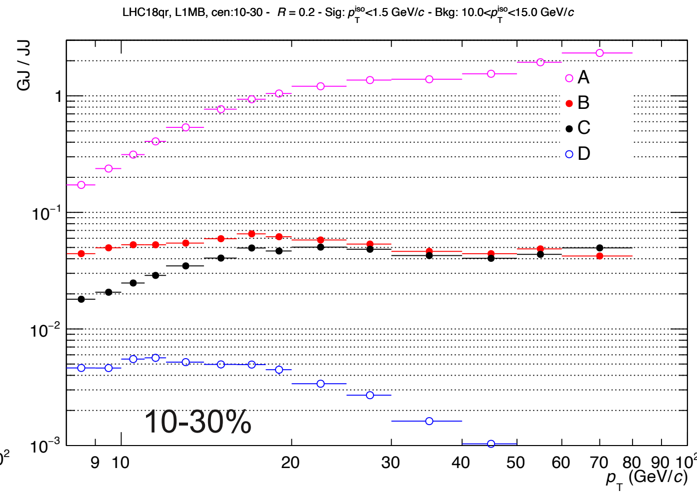
B: 0.5 <σ^2_{long} < 0.7, p_T^{iso} < 1.5 GeV/c

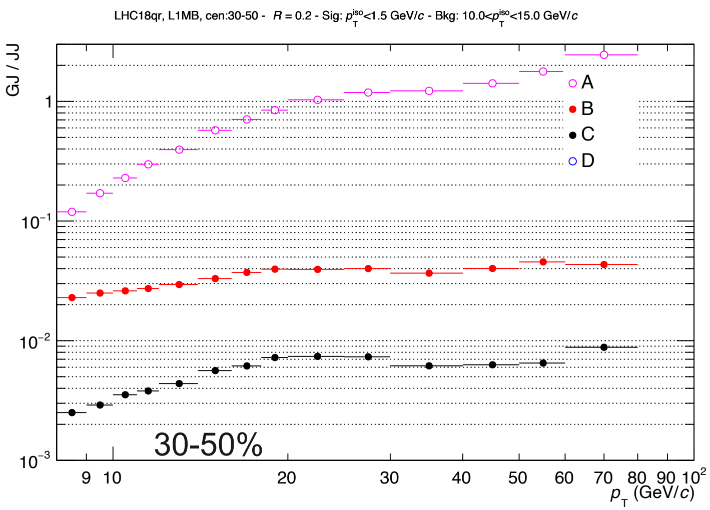
C: 0.1 <σ^2_{long} < 0.3, 5 < p_T^{iso} < 10 GeV/c

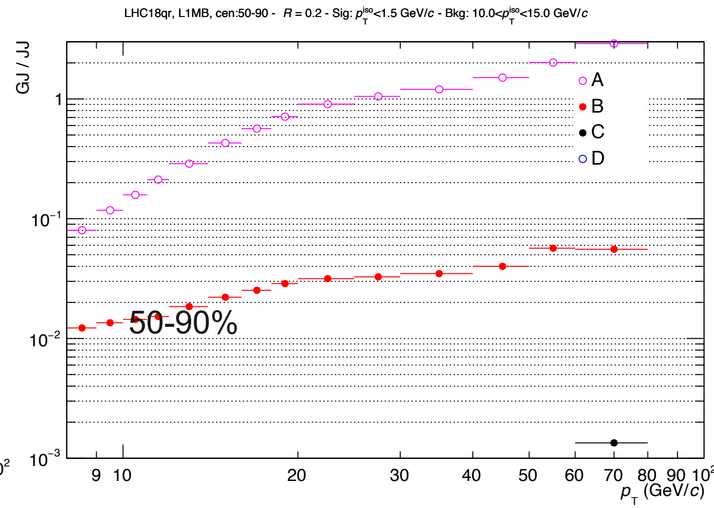
D: 0.5 <σ^2_{long} < 0.7, 5 < p_T^{iso} < 10 GeV/c

MC Signal over background (GJ/JJ) in ABCD, Bkg: $1.0 < \sigma^2_{long} < 1.5$, $10 < p_T^{iso} < 15$ GeV/c









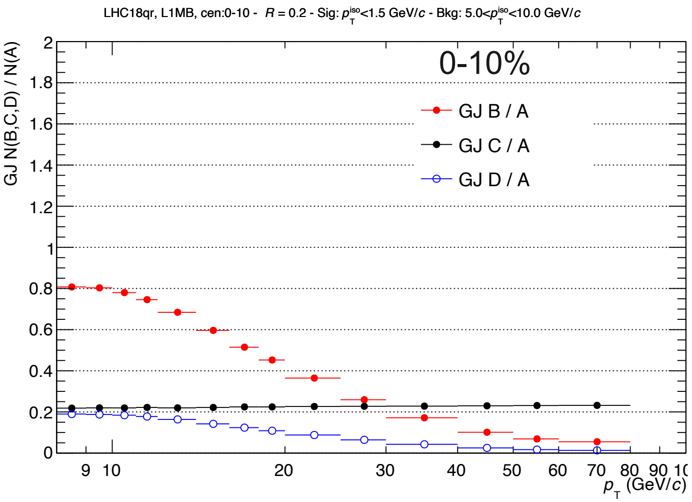
A: Signal, $0.1 < \sigma^2_{long} < 0.3$, $p_T^{iso} < 1.5$ GeV/c

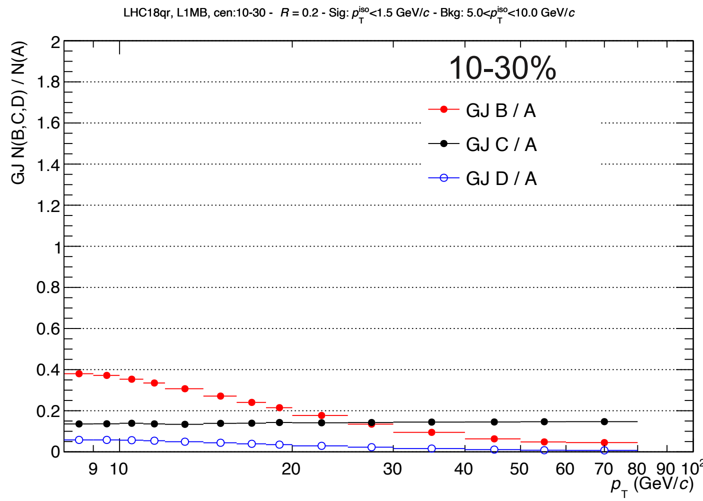
B: Background, $1.0 < \sigma^2_{long} < 1.5$, $p_T^{iso} < 1.5$ GeV/c

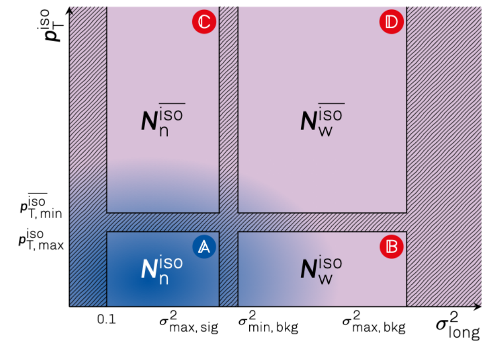
C: Background, $0.1 < \sigma^2_{long} < 0.3$, $10 < p_T^{iso} < 15$ GeV/c

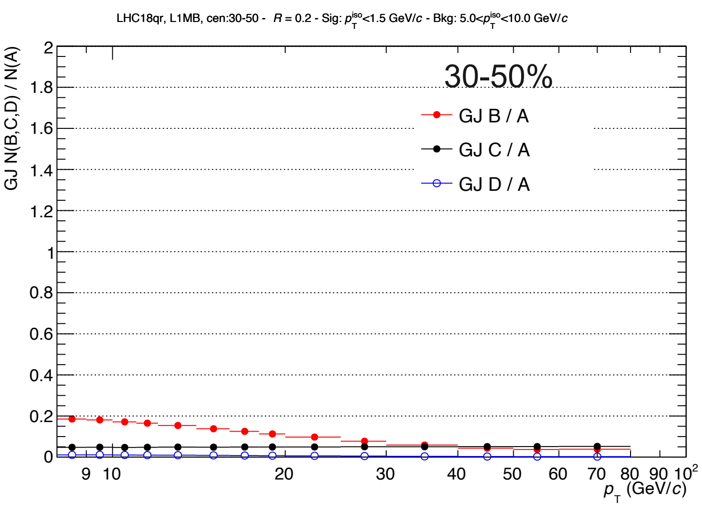
D: Background, $1.0 < \sigma^2_{long} < 1.5$, $10 < p_T^{iso} < 15$ GeV/c

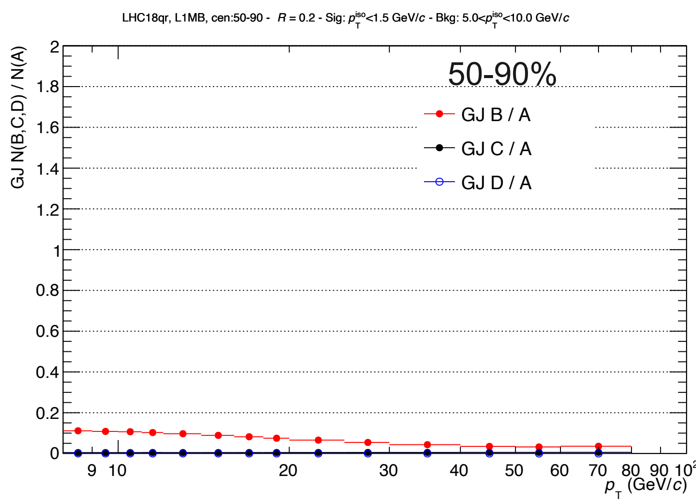
γ-jet MC fraction B,C,D / A (Bkg 0.5< σ^2_{long} < 0.7)











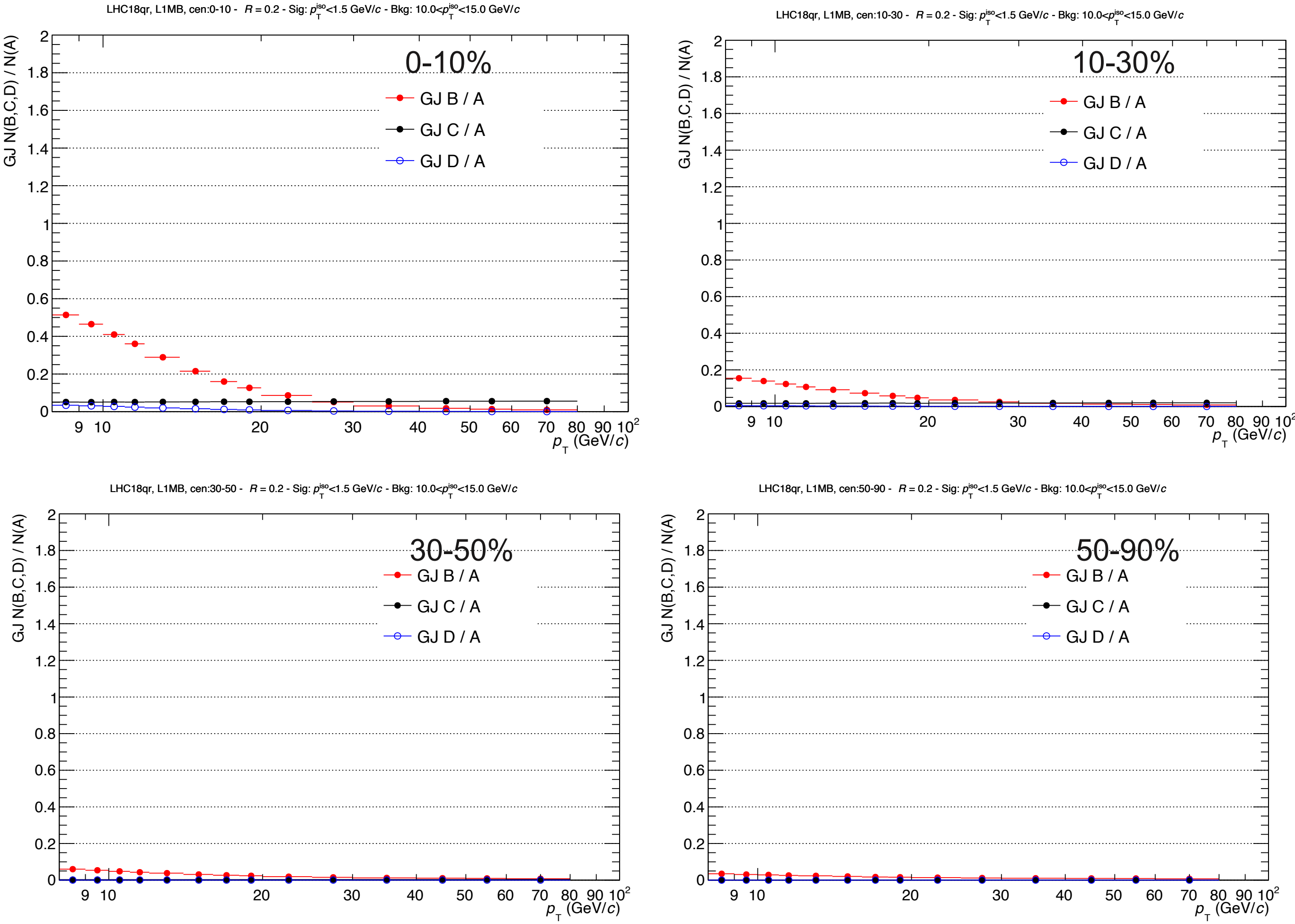
A: Signal, 0.1 < σ^2_{long} < 0.3, p_T^{iso} < 1.5 GeV/c

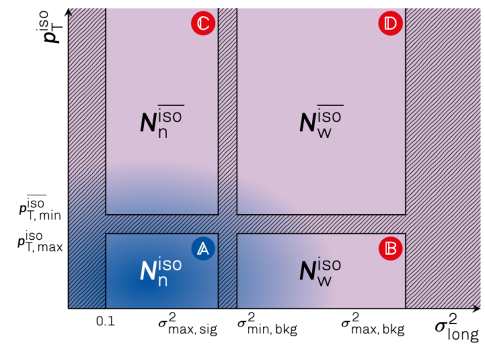
B: Background, 0.5 < σ^2_{long} < 0.7, p_T^{iso} < 1.5 GeV/c

C: Background, 0.1 < σ^2_{long} < 0.3, 5 < p_T^{iso} < 10 GeV/c

D: Background, 0.5 < σ^2_{long} < 0.7, 5 < p_T^{iso} < 10 GeV/c

γ-jet MC fraction B,C,D / A, Bkg: 1.0 < σ^2_{long} < 1.5, 10 < p_T^{iso} < 15 GeV/c





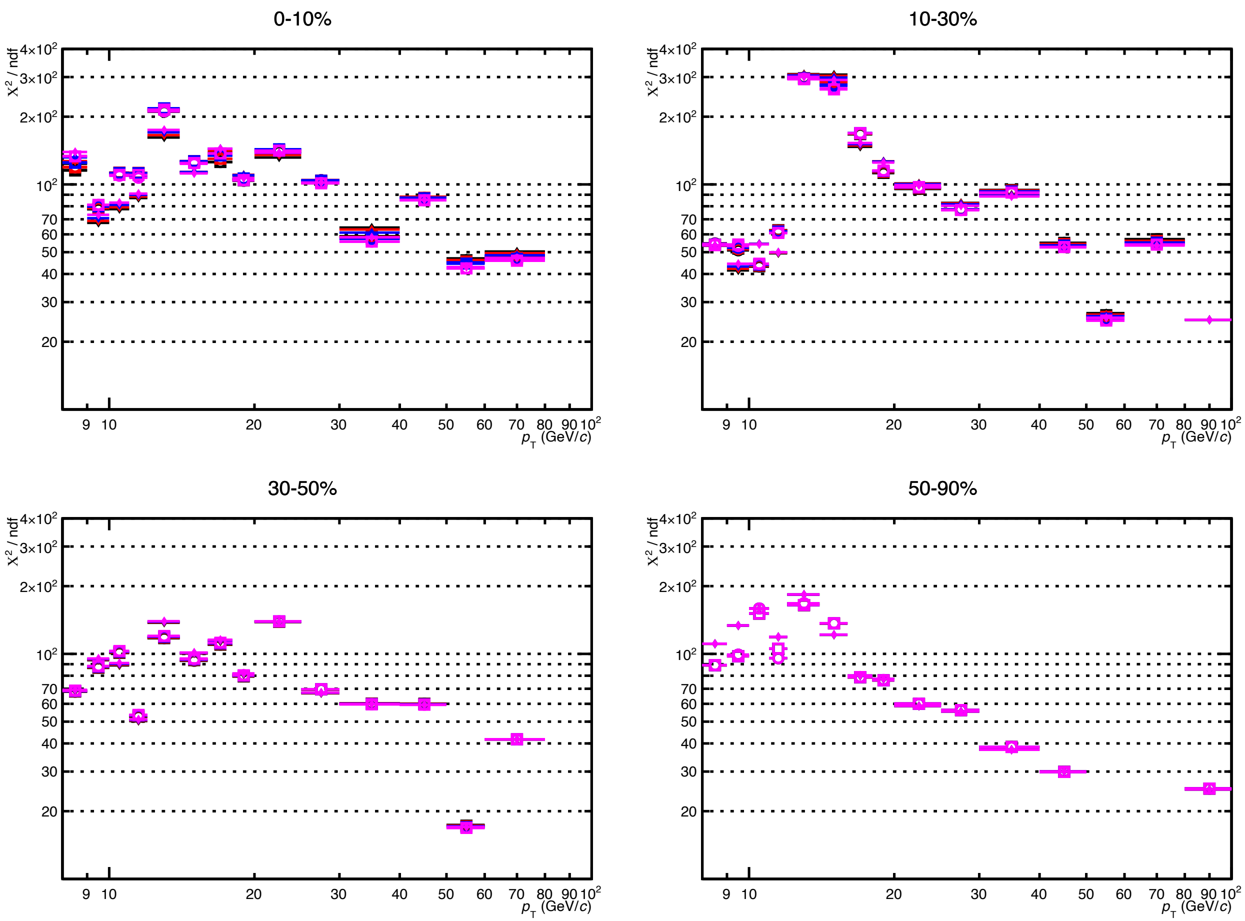
A: Signal, 0.1 < σ^2_{long} < 0.3, p_T^{iso} < 1.5 GeV/c

B: Background, 1.0 < σ^2_{long} < 1.5, p_T^{iso} < 1.5 GeV/c

C: Background, 0.1 < σ^2_{long} < 0.3, 10 < p_T^{iso} < 15 GeV/c

D: Background, 1.0 < σ^2_{long} < 1.5, 10 < p_T^{iso} < 15 GeV/c

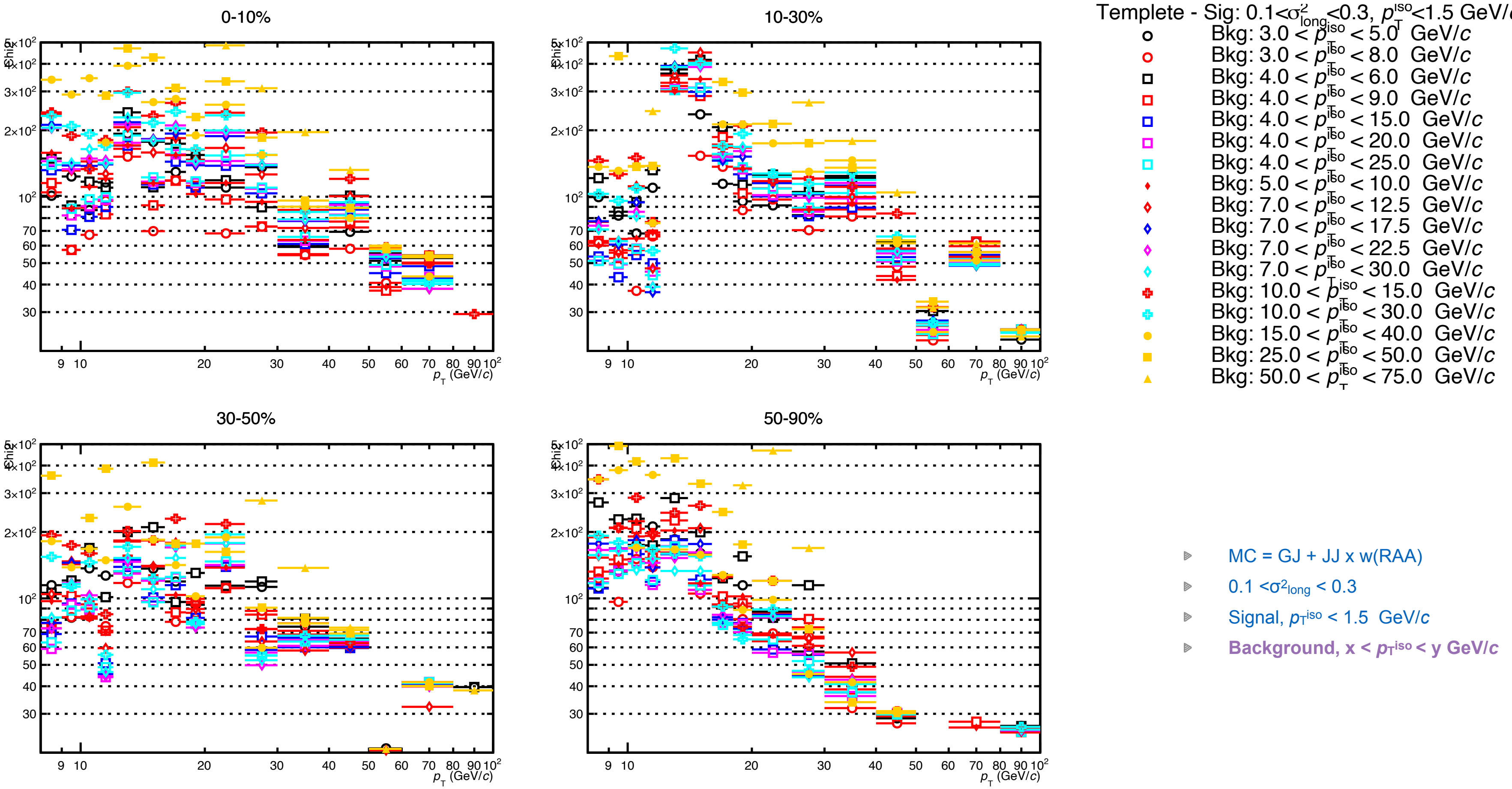
Template Chi2/ndf for different scales



- $0.1 < \sigma^2_{long} < 0.3$
- Signal, $p_T^{iso} < 1.5$ GeV/c
- **Background, $4 < p_T^{iso} < 14$ GeV/c**

- Fit quality not very good, not sure how to improve it, I have been playing with binning, but no significant help.

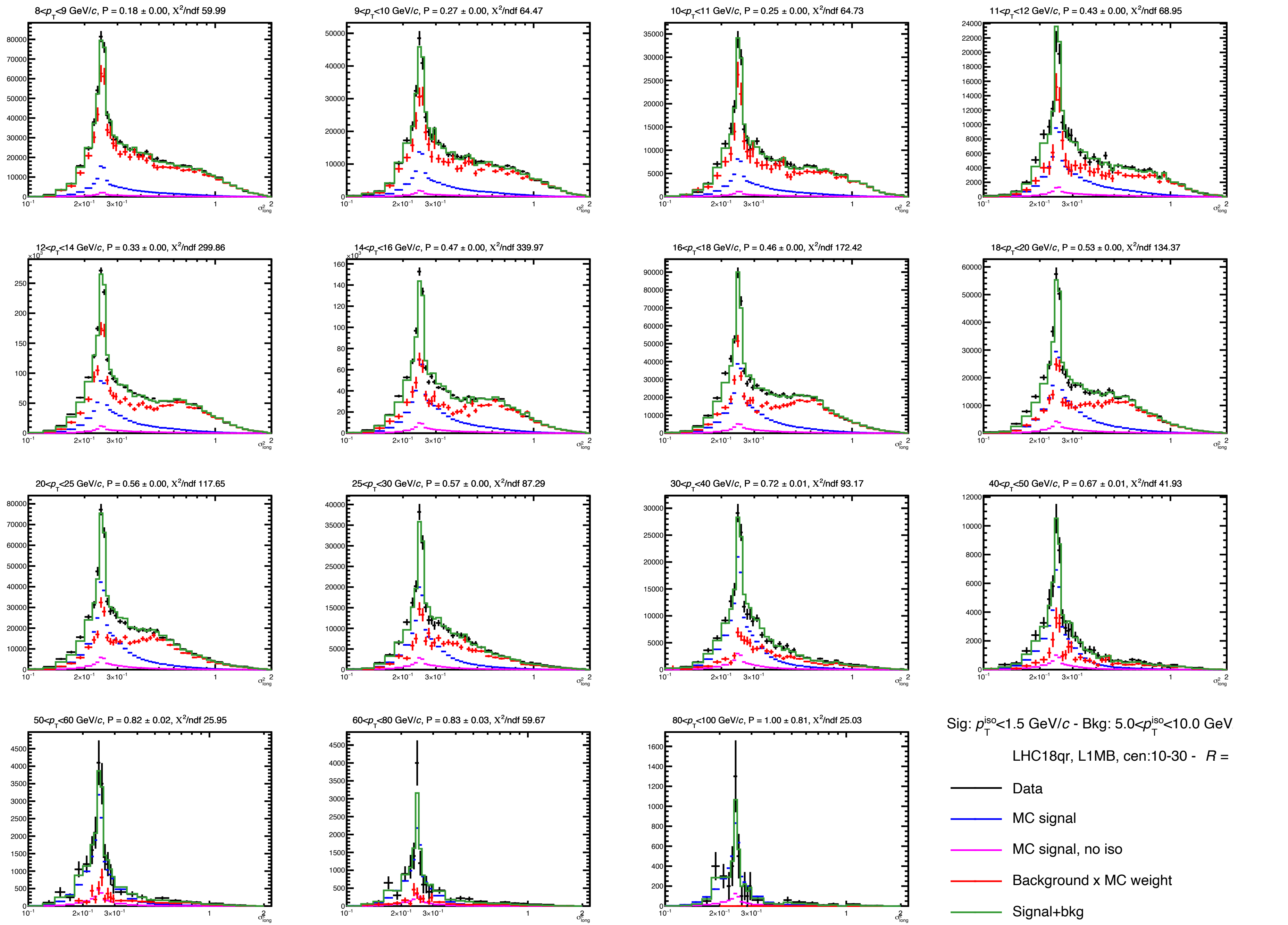
Template Chi2/ndf, for different bkg ranges



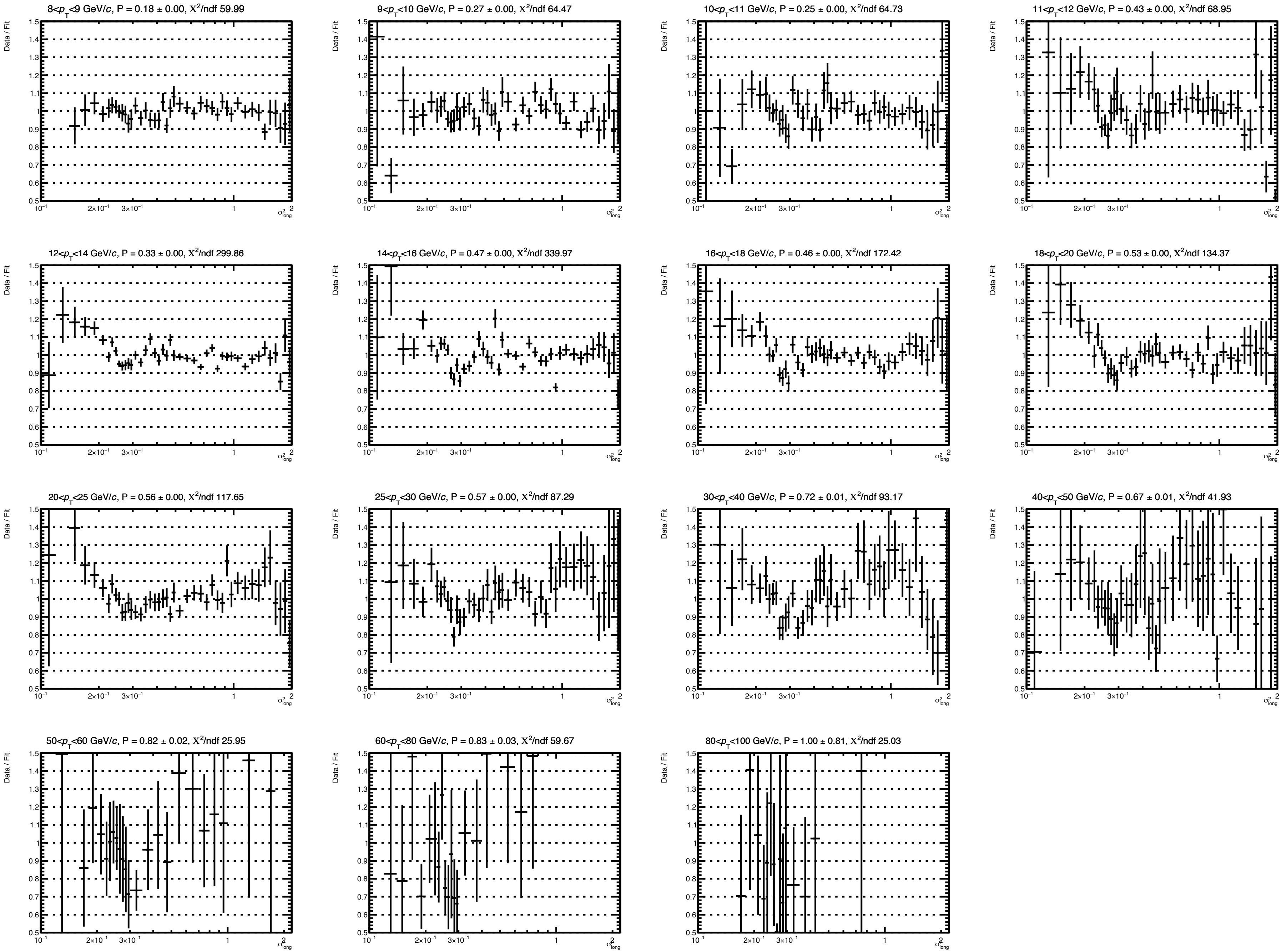
- MC = GJ + JJ x w(RAA)
- $0.1 < \sigma^2_{long} < 0.3$
- Signal, $p_T^{iso} < 1.5$ GeV/c
- **Background, $x < p_T^{iso} < y$ GeV/c**

- Fit quality not very good, not sure how to improve it, I have been playing with binning, but no significant help.

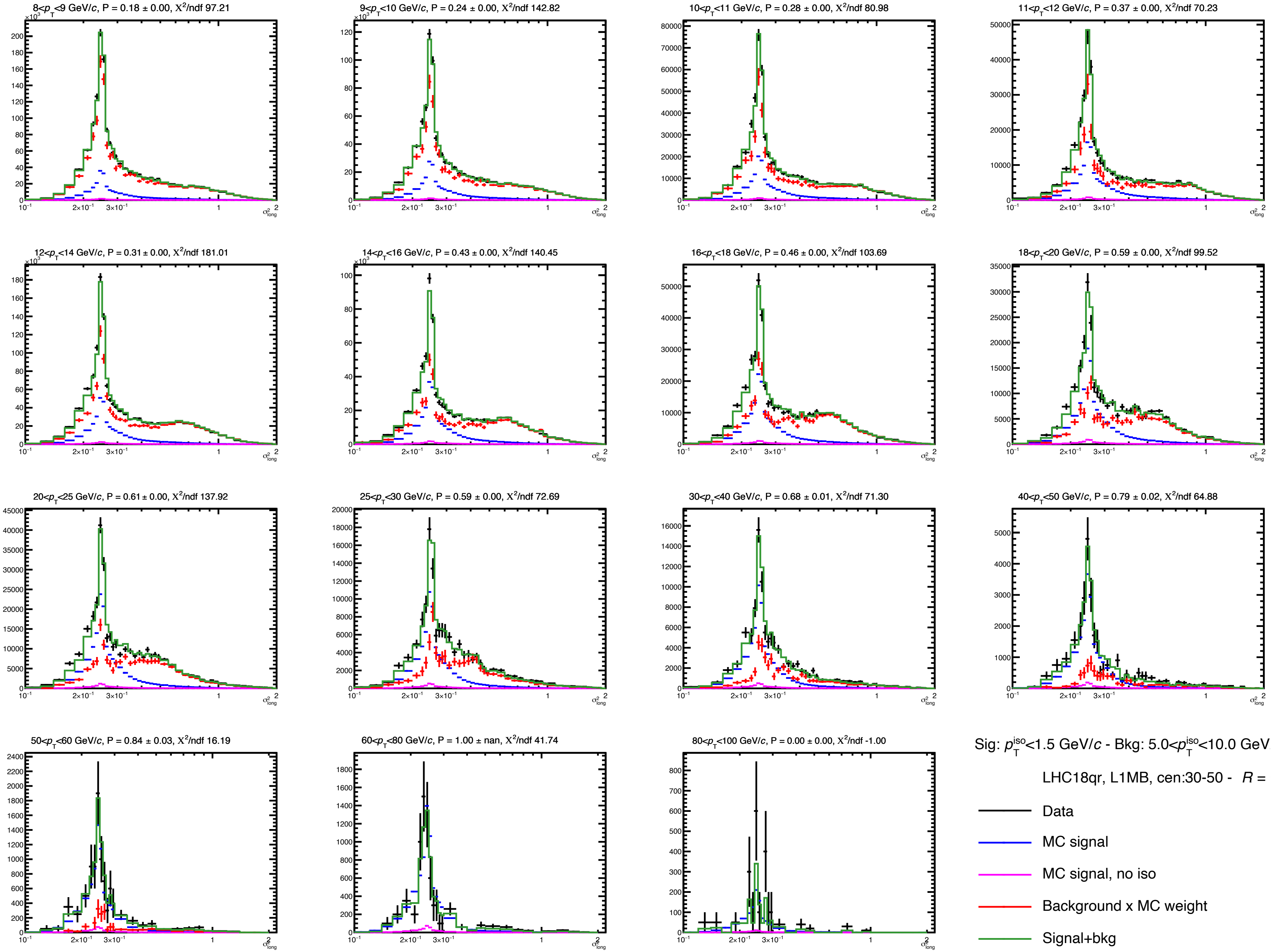
Template shower shape distributions: 10-30%



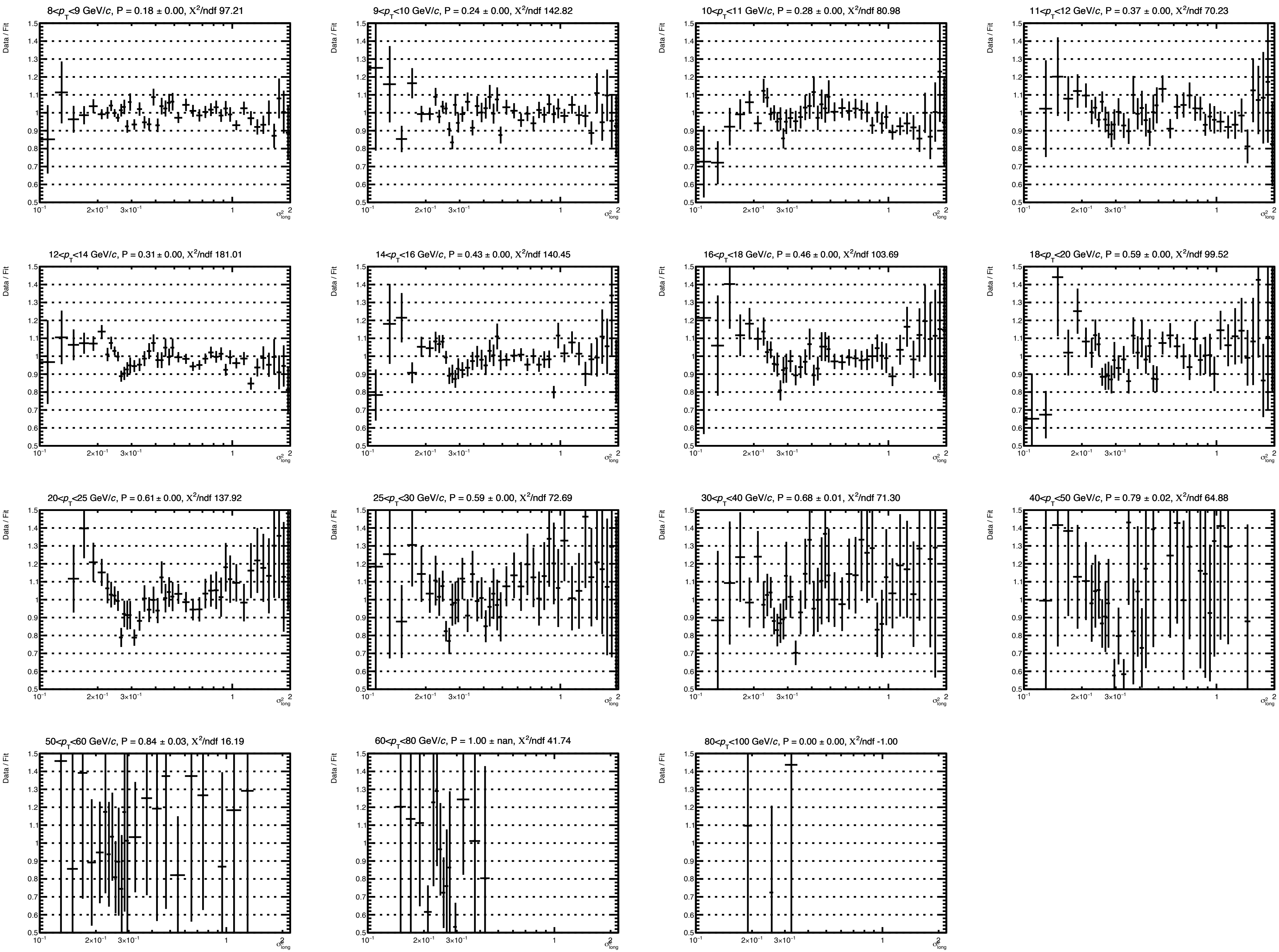
Shower shape data / template fit signal+bkg: 10-30%



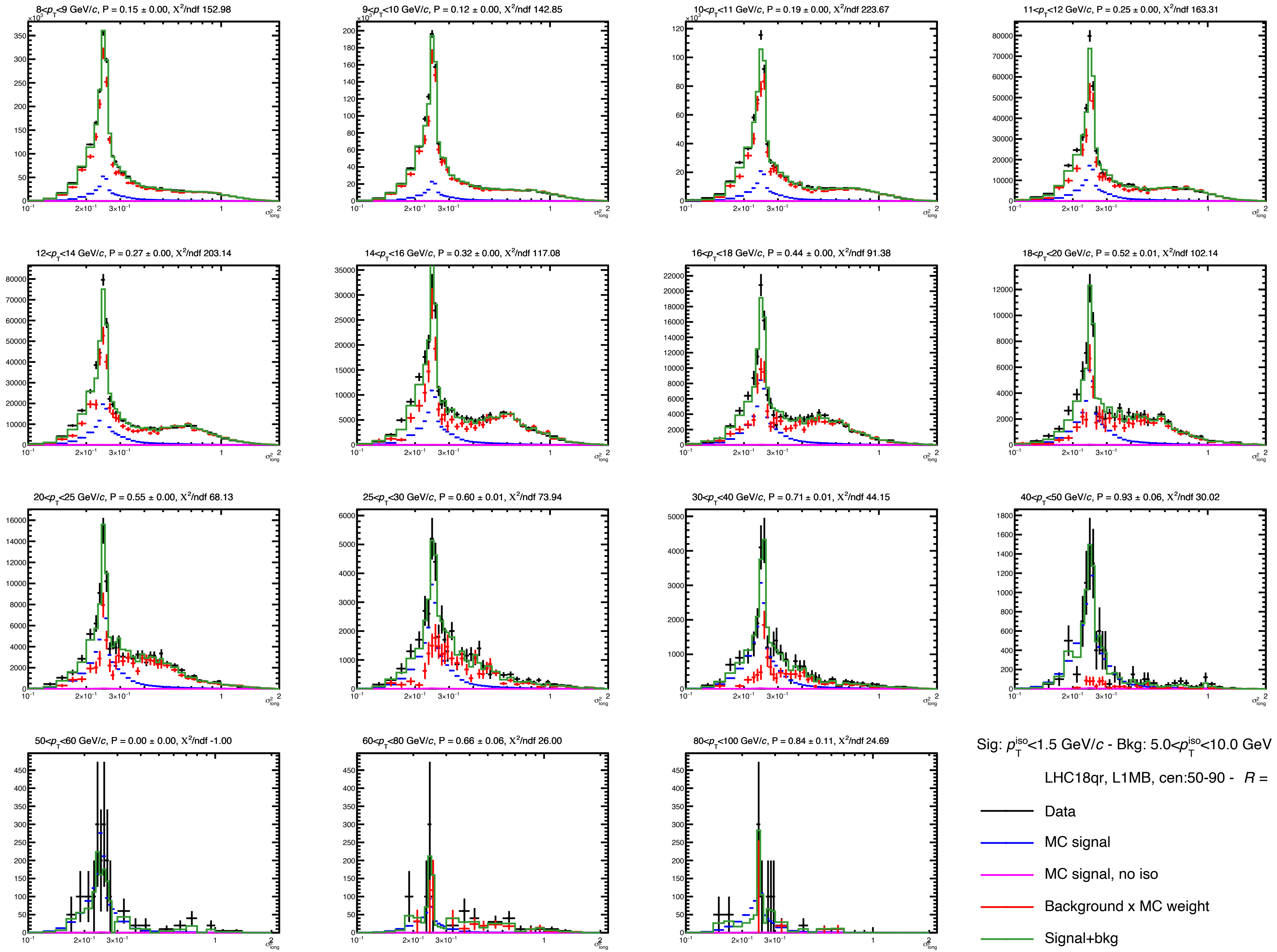
Template shower shape distributions: 30-50%



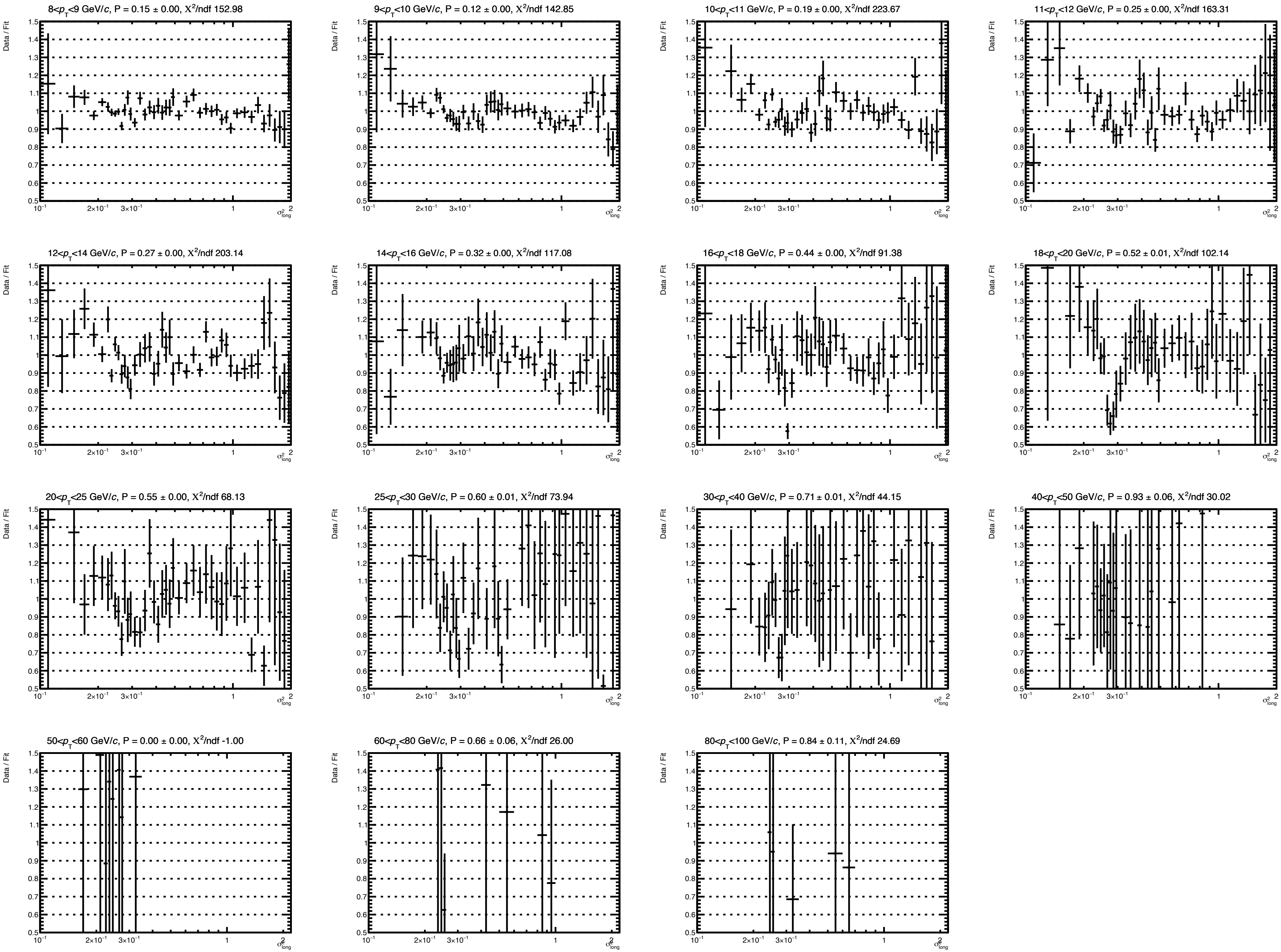
Shower shape data / template fit signal+bkg: 30-50%



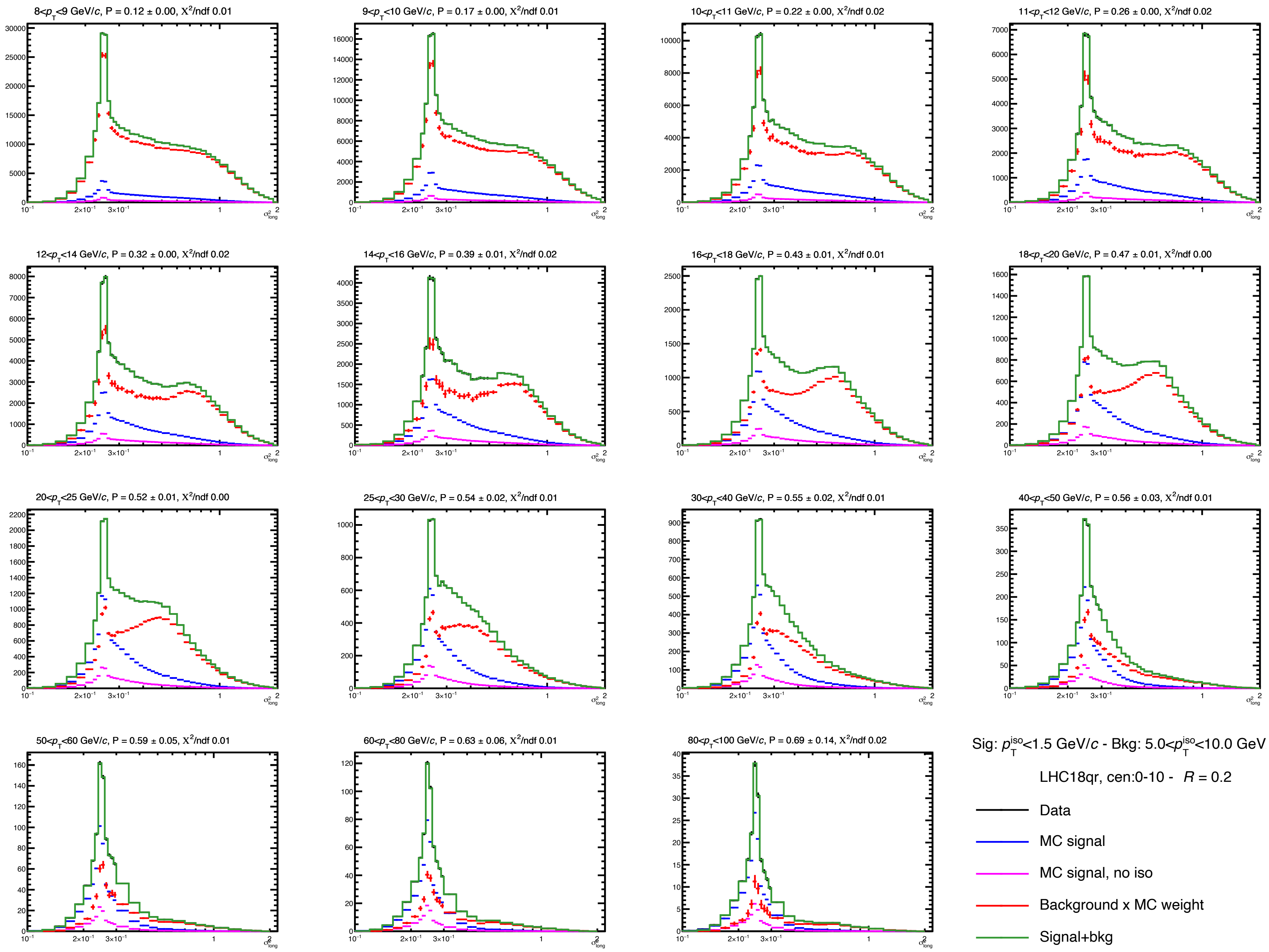
Template shower shape distributions: 50-90%



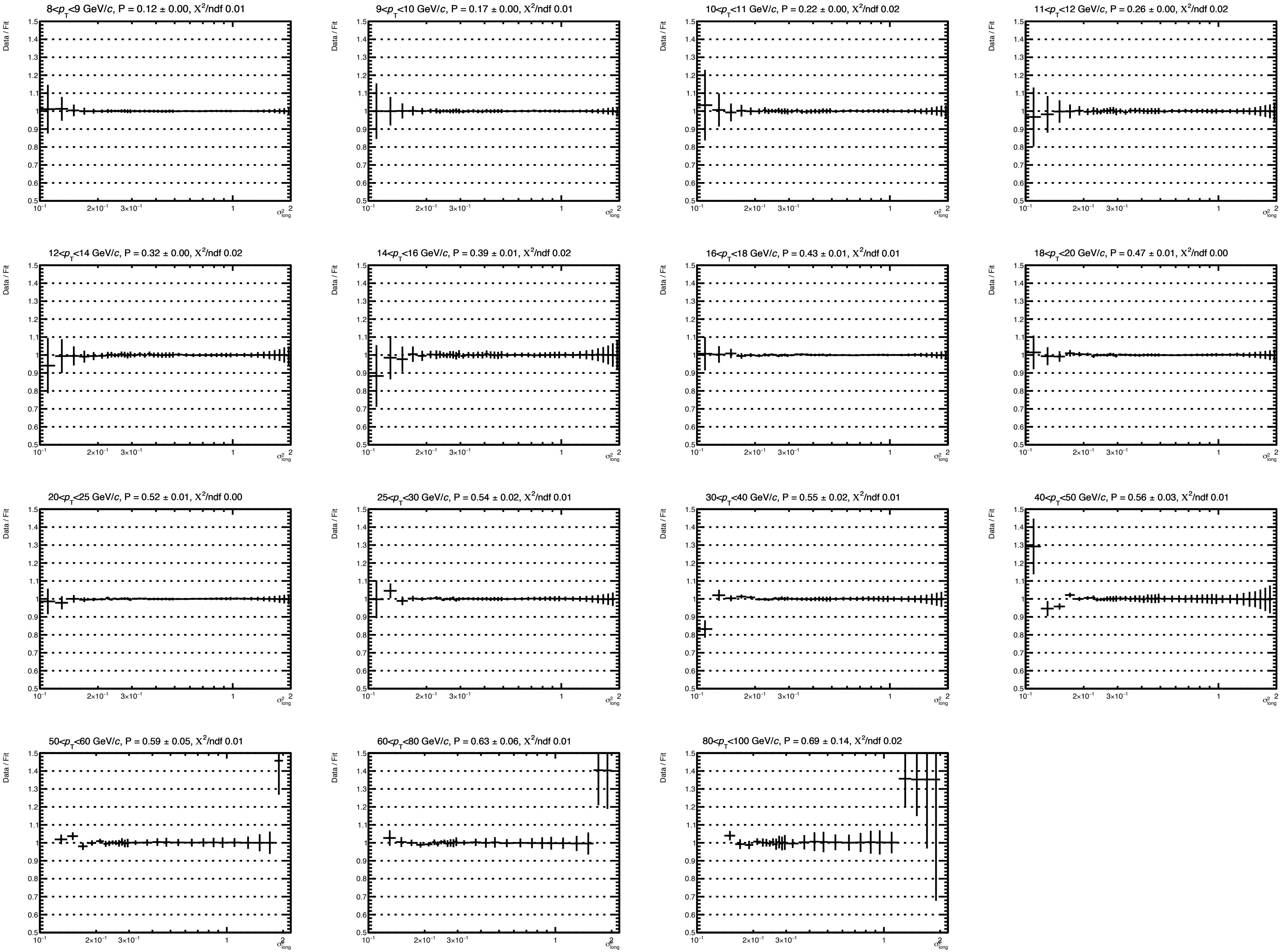
Shower shape data / template fit signal+bkg: 50-90%



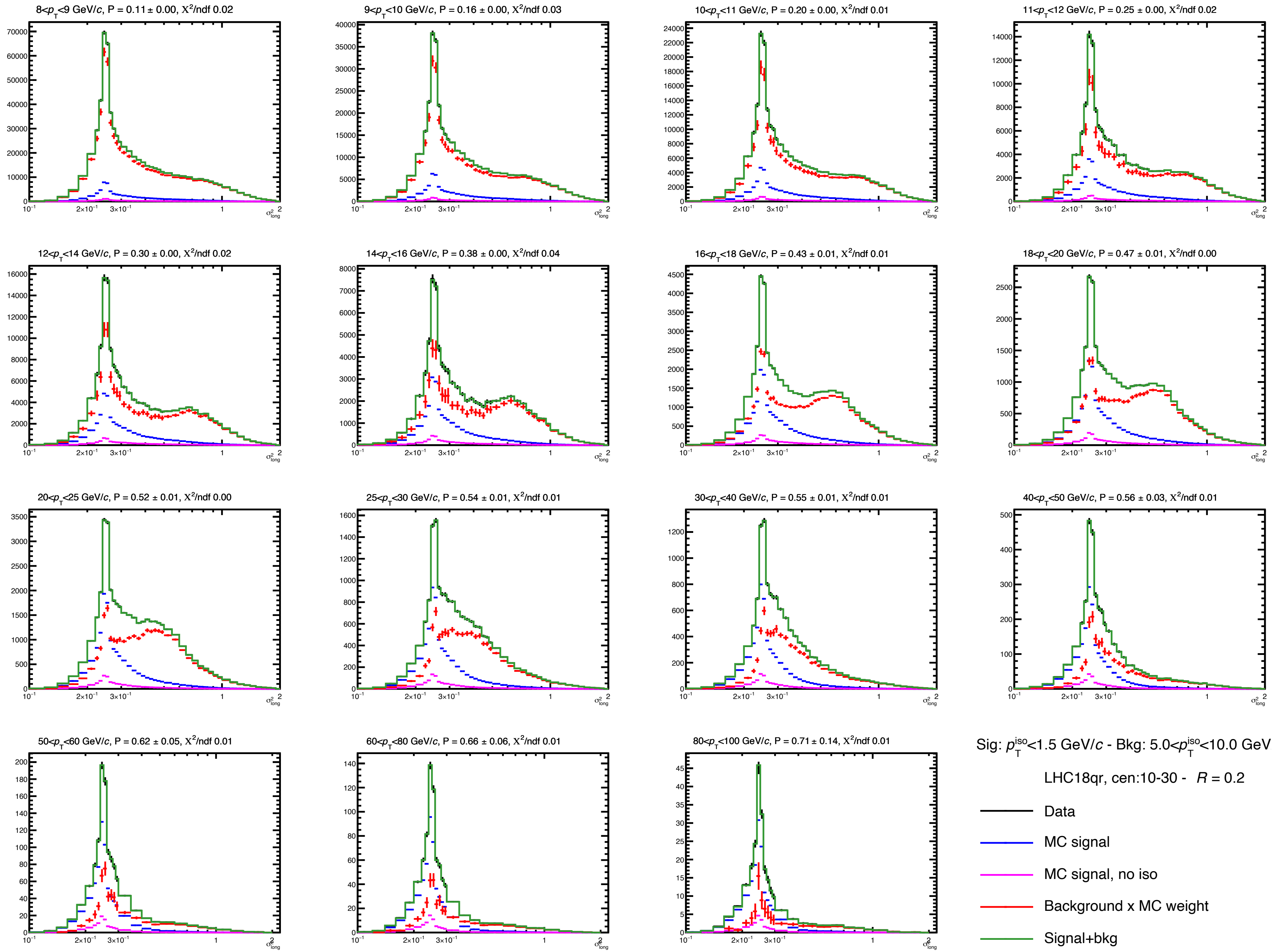
MC closure: Template shower shape distributions: 0-10%



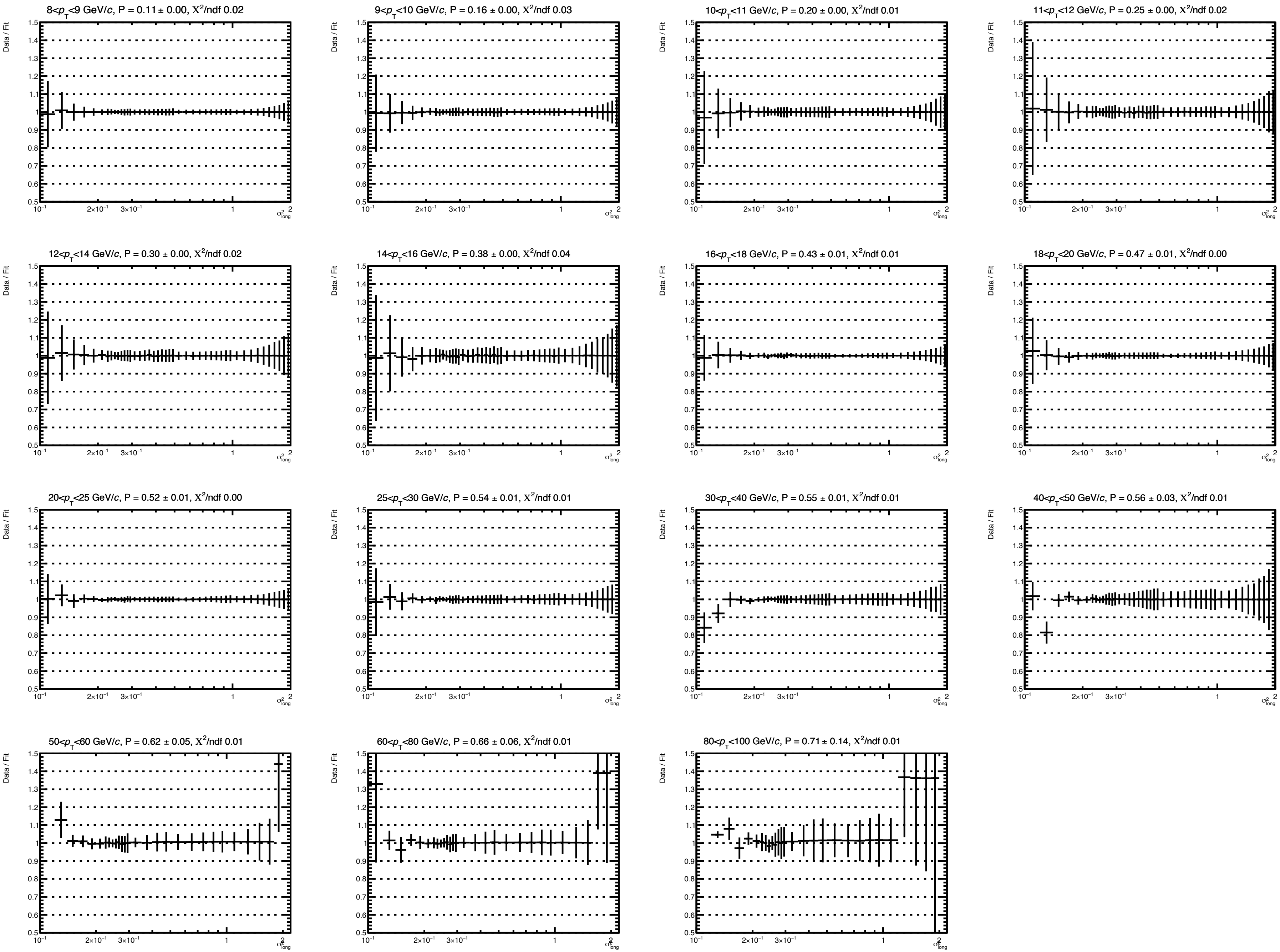
MC closure: Shower shape data / template fit signal+bkg: 0-10%



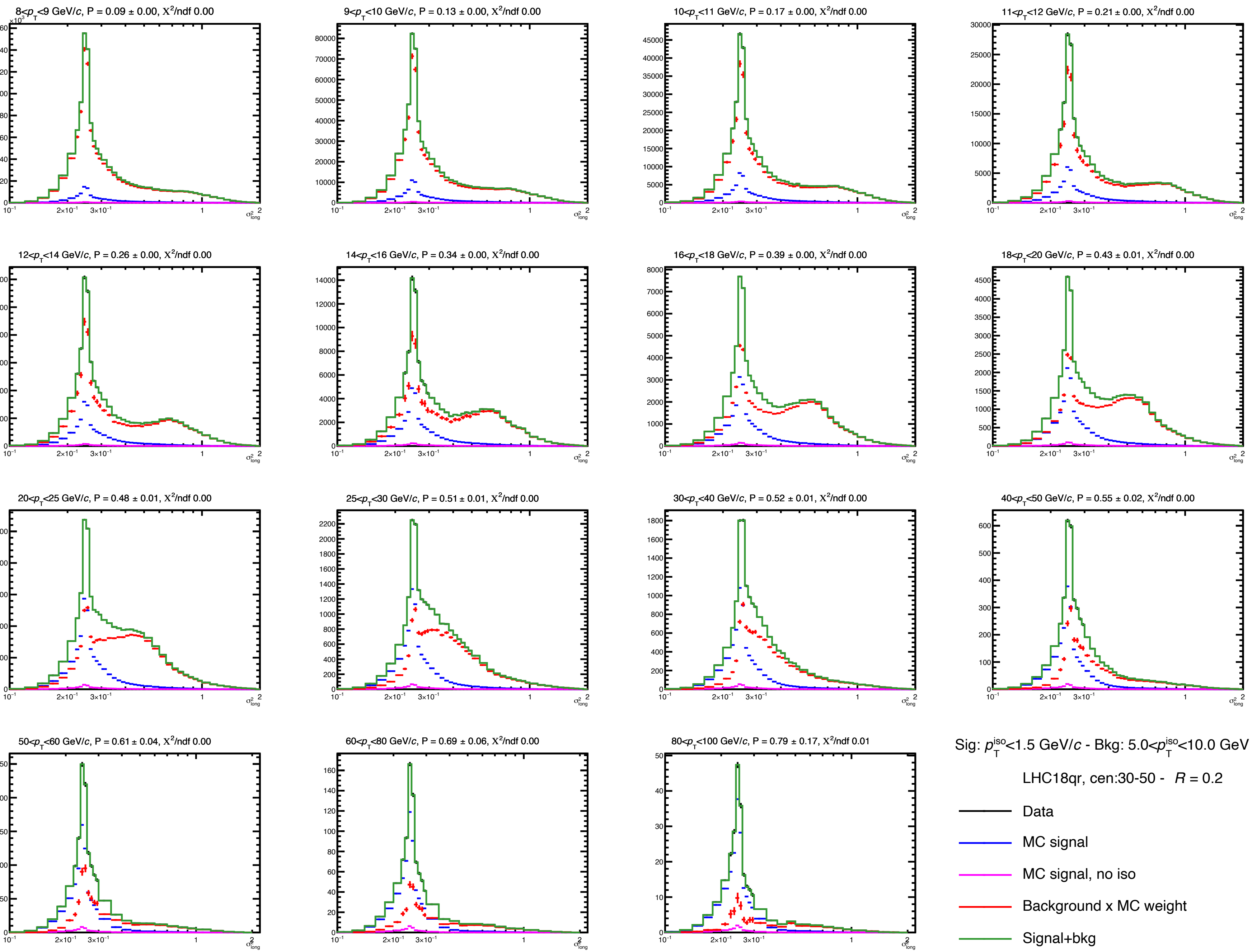
MC closure: Template shower shape distributions: 10-30%



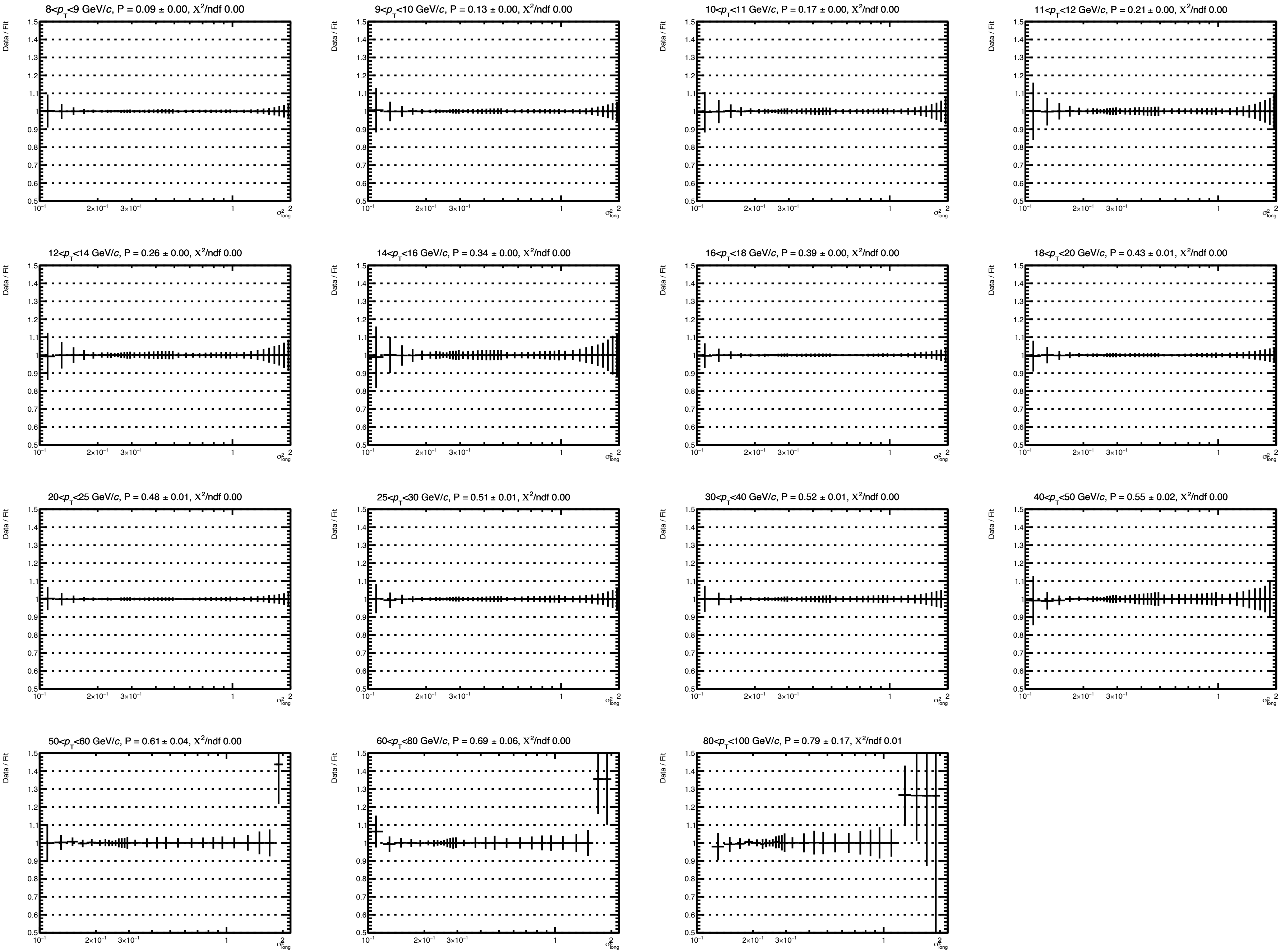
MC closure: Shower shape data / template fit signal+bkg: 10-30%



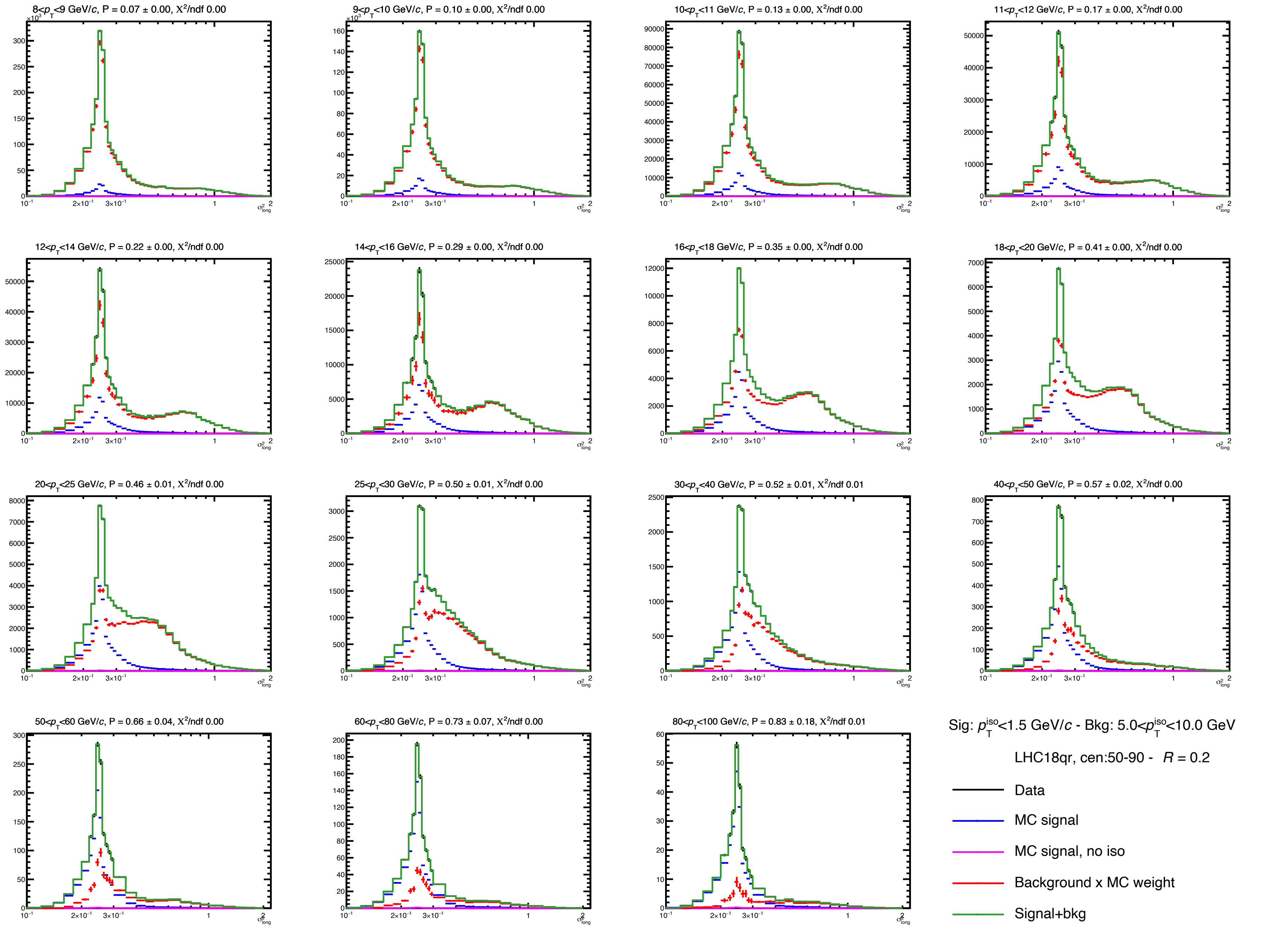
MC closure: Template shower shape distributions: 30-50%



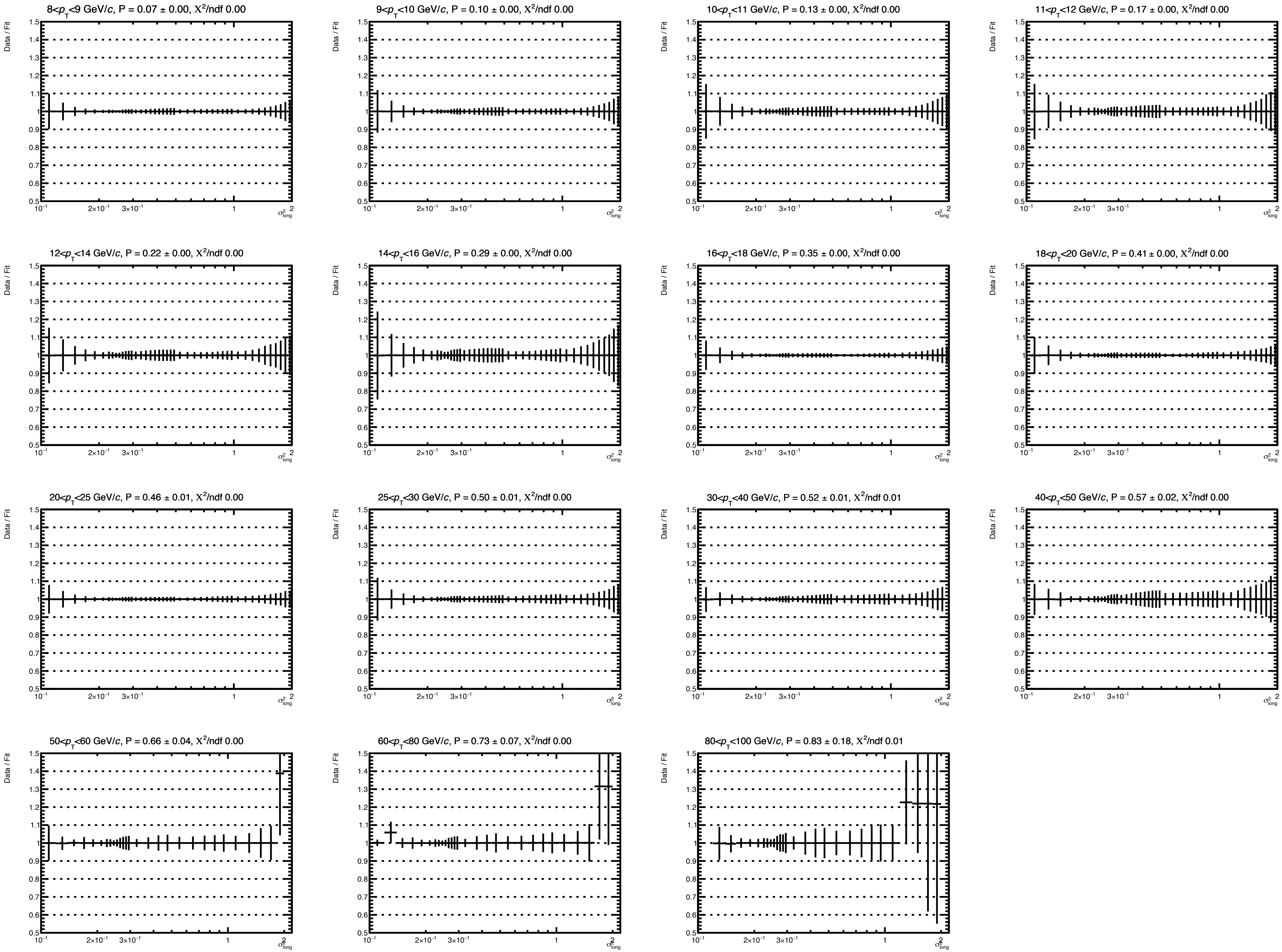
MC closure: Shower shape data / template fit signal+bkg: 30-50%



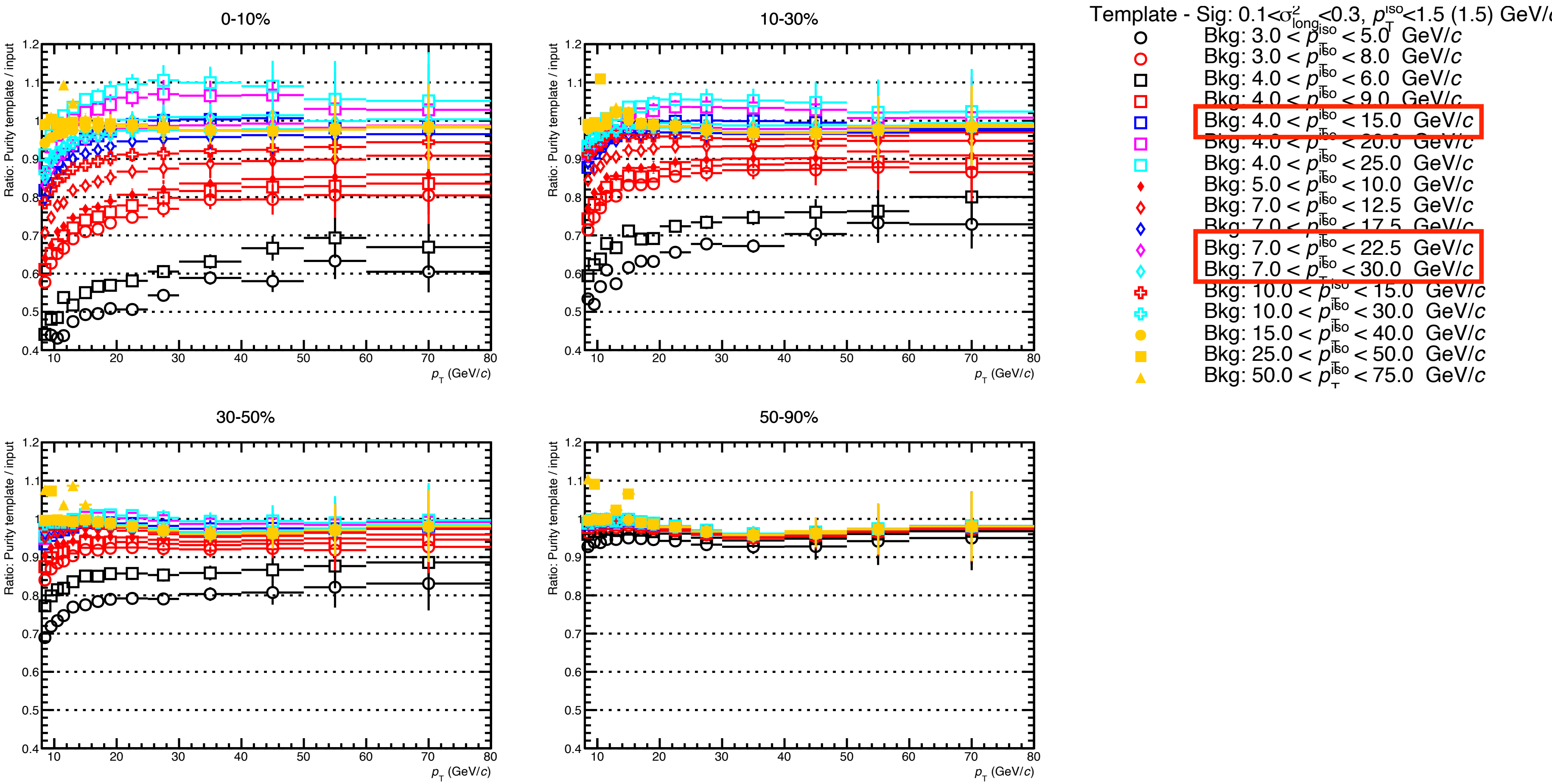
MC closure: Template shower shape distributions: 50-90%



MC closure: Shower shape data / template fit signal+bkg: 50-90%

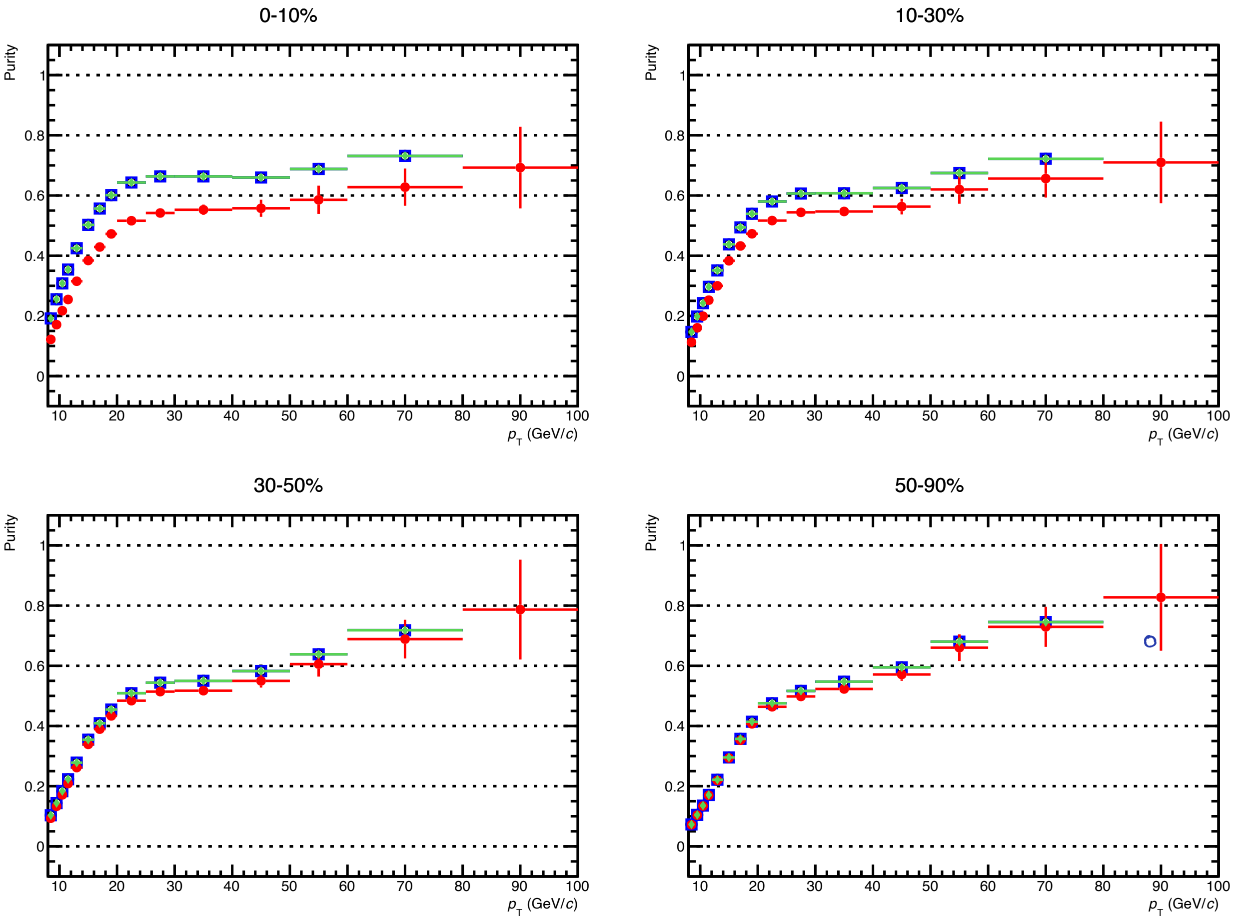


Purity Template — MC closure test — MC=JJ x w(R_{AA}) + GJ



- At high photon p_T > 20 GeV/c, p_T^{iso} ranges 4-15, 7-22 and 7-30 GeV/c seem optimal. In general high p_T^{iso} bkg range lower limit seems ok.
- At low photon p_T, for most p_T^{iso} range, p_T dependence is not super well reproduced. Only high p_T^{iso} bkg range lower limit seem to get it

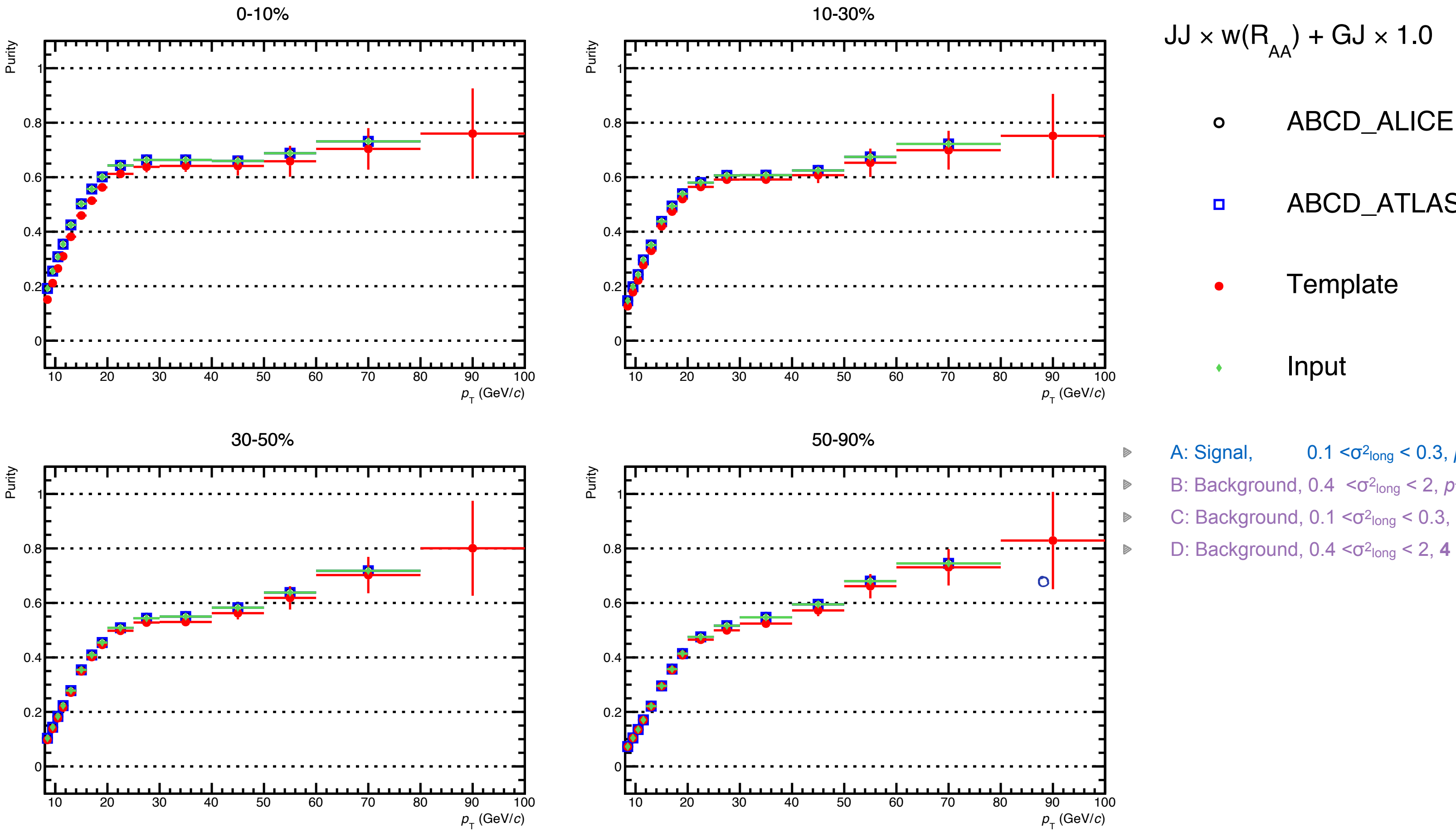
Purity methods comparison— MC closure test — JJ x w(R_{AA}) + GJ



- A: Signal, 0.1 < σ^2_{long} < 0.3, p_T^{iso} < 1.5 GeV/c
- B: Background, 0.4 < σ^2_{long} < 2, p_T^{iso} < 1.5 GeV/c
- C: Background, 0.1 < σ^2_{long} < 0.3, **5 < p_T^{iso} < 10 GeV/c**
- D: Background, 0.4 < σ^2_{long} < 2, **5 < p_T^{iso} < 10 GeV/c**

- Replace real data by MC and apply the same purity calculation estimation, compare to the injected purity
- ABCD methods give the input purity by construction
- Template lower than ABCDs with this p_T^{iso} bkg range

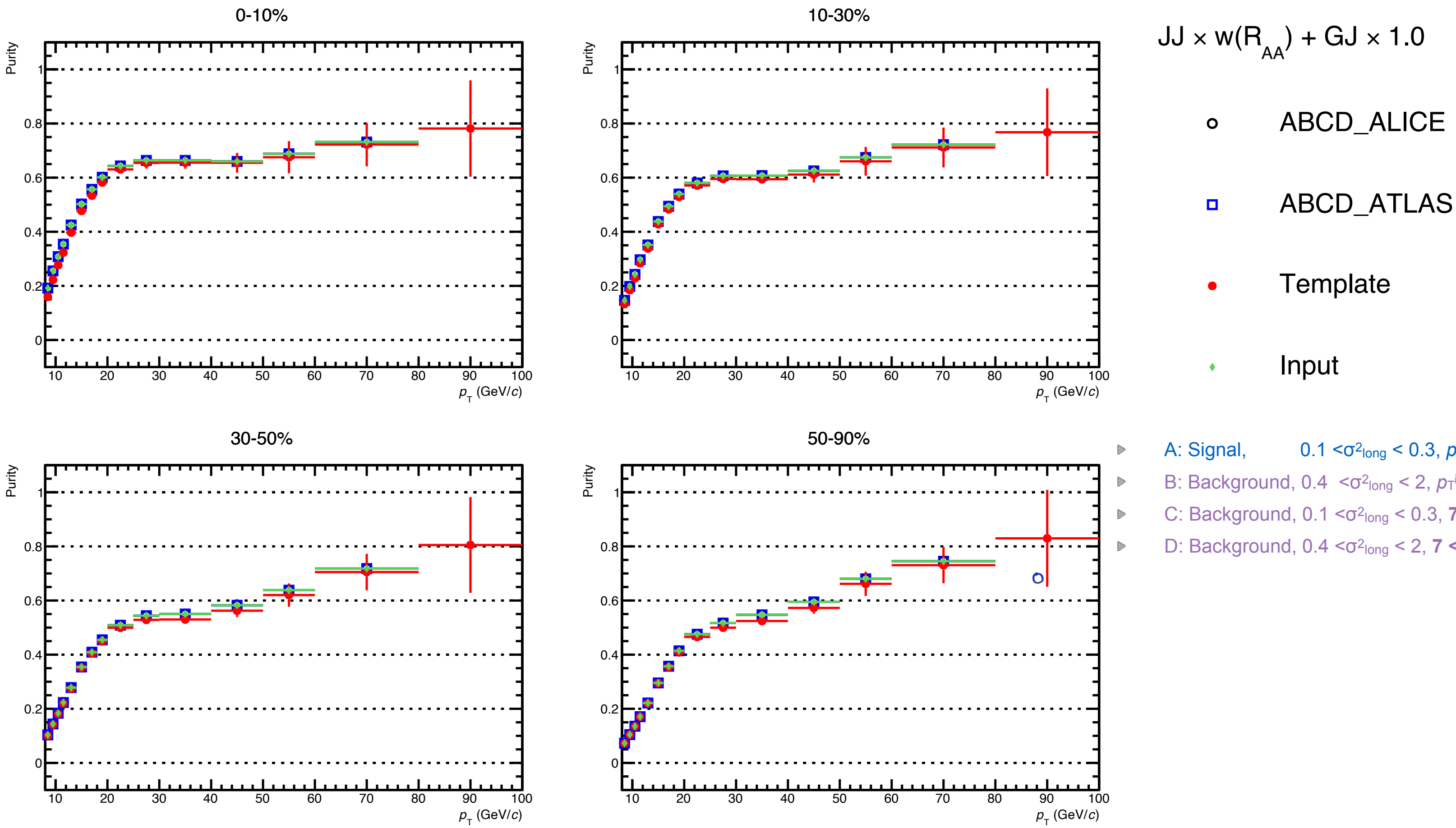
Purity methods comparison— MC closure test — JJ x w(R_{AA}) + GJ



- A: Signal, $0.1 < \sigma^2_{long} < 0.3$, $p_T^{iso} < 1.5$ GeV/c
- B: Background, $0.4 < \sigma^2_{long} < 2$, $p_T^{iso} < 1.5$ GeV/c
- C: Background, $0.1 < \sigma^2_{long} < 0.3$, **$4 < p_T^{iso} < 15$ GeV/c**
- D: Background, $0.4 < \sigma^2_{long} < 2$, **$4 < p_T^{iso} < 15$ GeV/c**

- Replace real data by MC and apply the same purity calculation estimation, compare to the injected purity
- ABCD methods give the input purity by construction
- Almost agreement between methods with this p_T^{iso} bkg range, template a bit lower

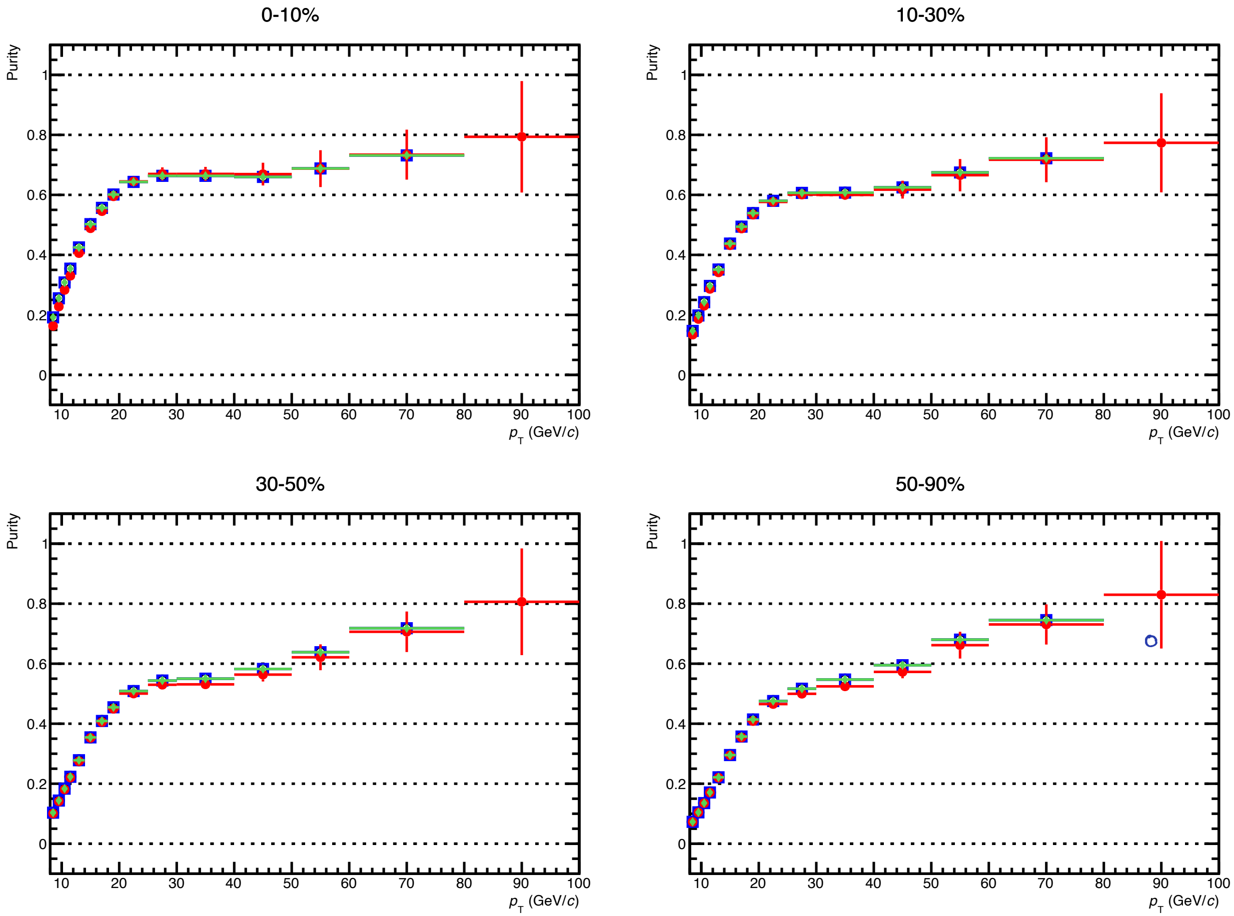
Purity methods comparison— MC closure test — JJ x w(R_{AA}) + GJ

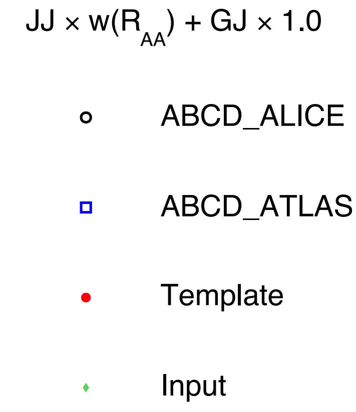


- A: Signal, 0.1 <σ^2_{long} < 0.3, p_T^{iso} < 1.5 GeV/c
- B: Background, 0.4 <σ^2_{long} < 2, p_T^{iso} < 1.5 GeV/c
- C: Background, 0.1 <σ^2_{long} < 0.3, **7 < p_T^{iso} < 22 GeV/c**
- D: Background, 0.4 <σ^2_{long} < 2, **7 < p_T^{iso} < 22 GeV/c**

- Replace real data by MC and apply the same purity calculation estimation, compare to the injected purity
- ABCD methods give the input purity by construction
- Agreement between methods with this p_T^{iso} bkg range

Purity methods comparison— MC closure test — JJ x w(R_{AA}) + GJ

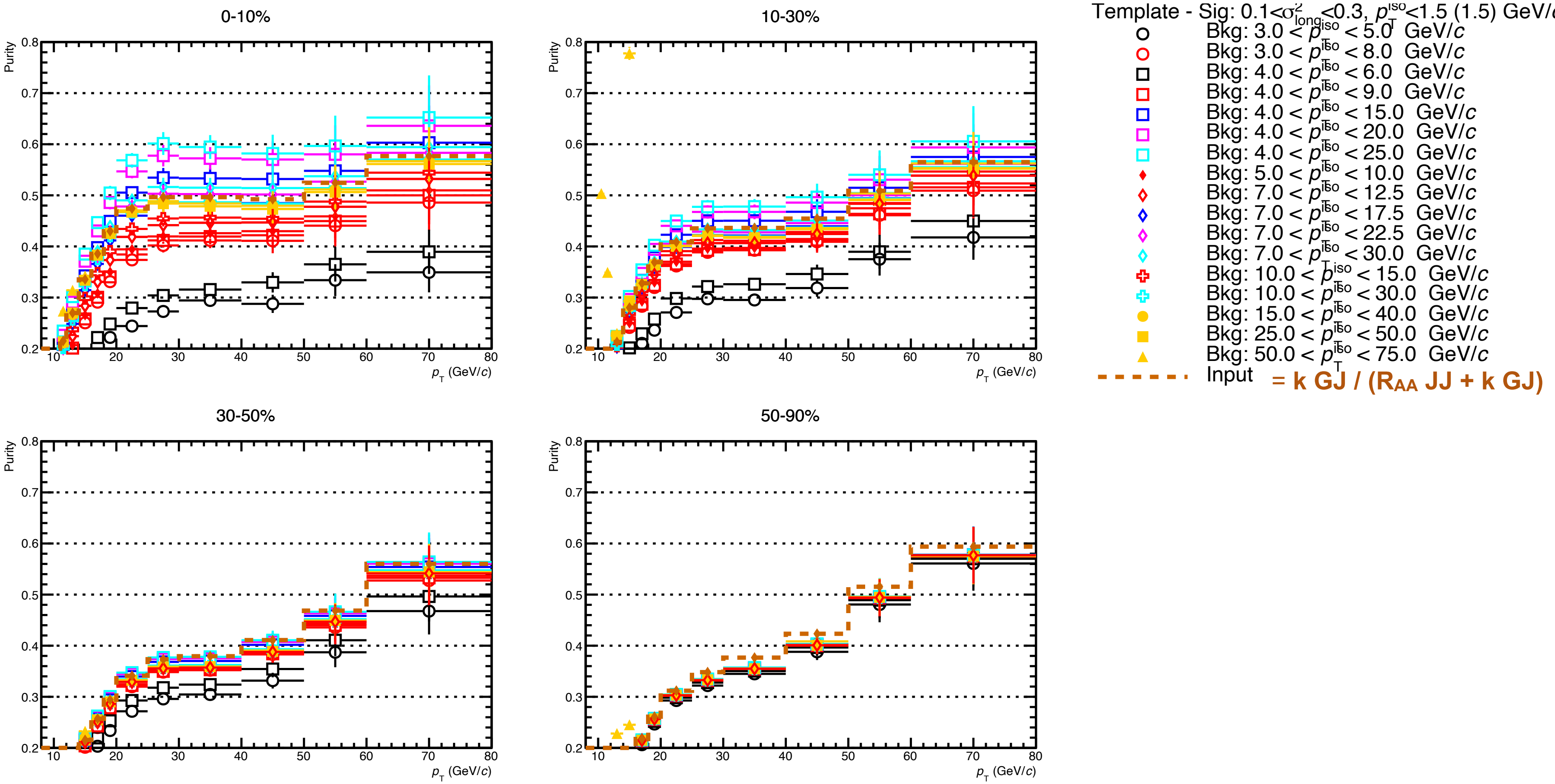




- A: Signal, $0.1 < \sigma^2_{long} < 0.3$, $p_T^{iso} < 1.5$ GeV/c
- B: Background, $0.4 < \sigma^2_{long} < 2$, $p_T^{iso} < 1.5$ GeV/c
- C: Background, $0.1 < \sigma^2_{long} < 0.3$, **$7 < p_T^{iso} < 30$ GeV/c**
- D: Background, $0.4 < \sigma^2_{long} < 2$, **$7 < p_T^{iso} < 30$ GeV/c**

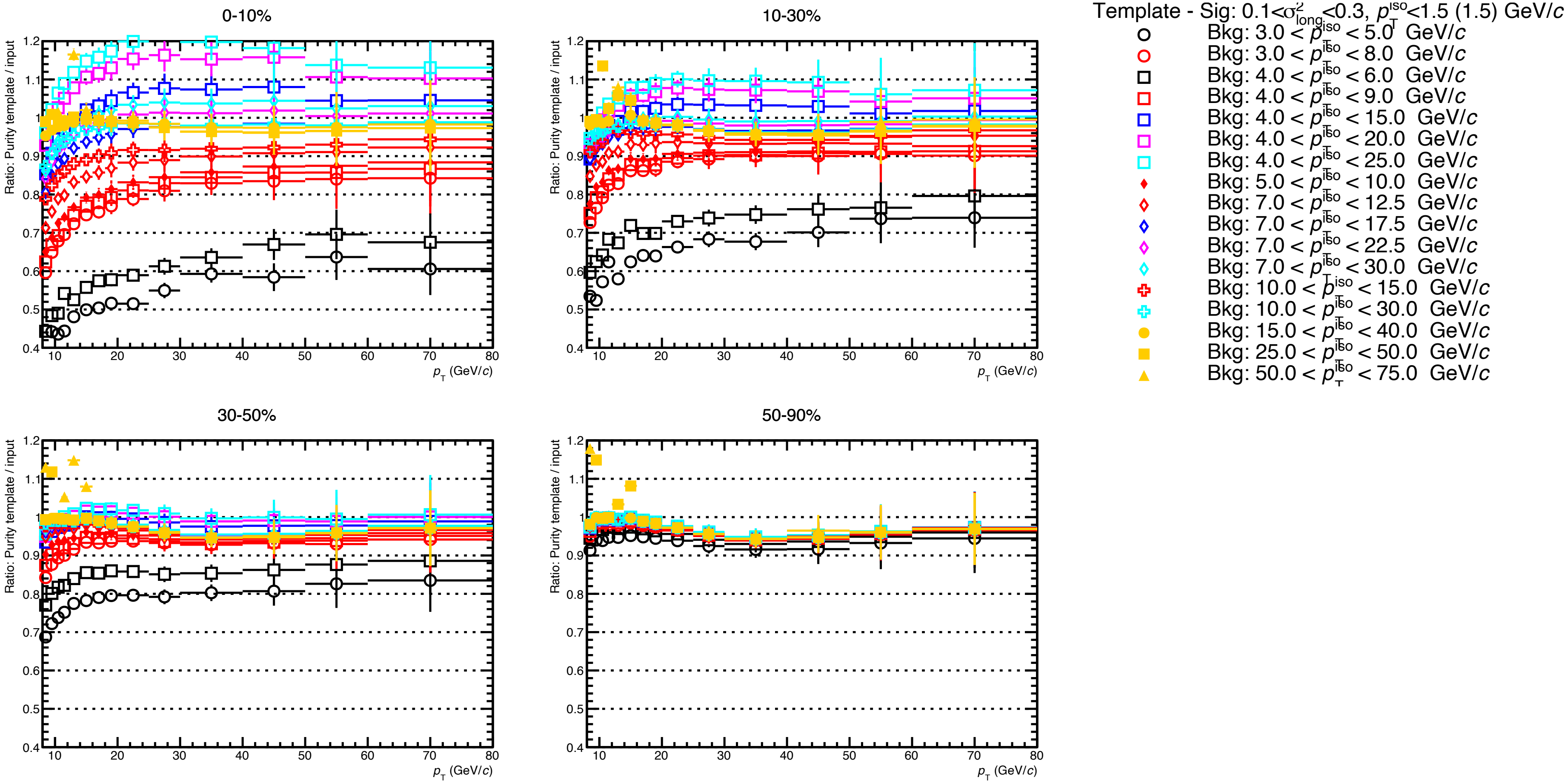
- Replace real data by MC and apply the same purity calculation estimation, compare to the injected purity
- ABCD methods give the input purity by construction
- Agreement between methods with this p_T^{iso} bkg range

Purity Template — MC closure test — MC = JJ x w(R_{AA}) + 0.5xGJ



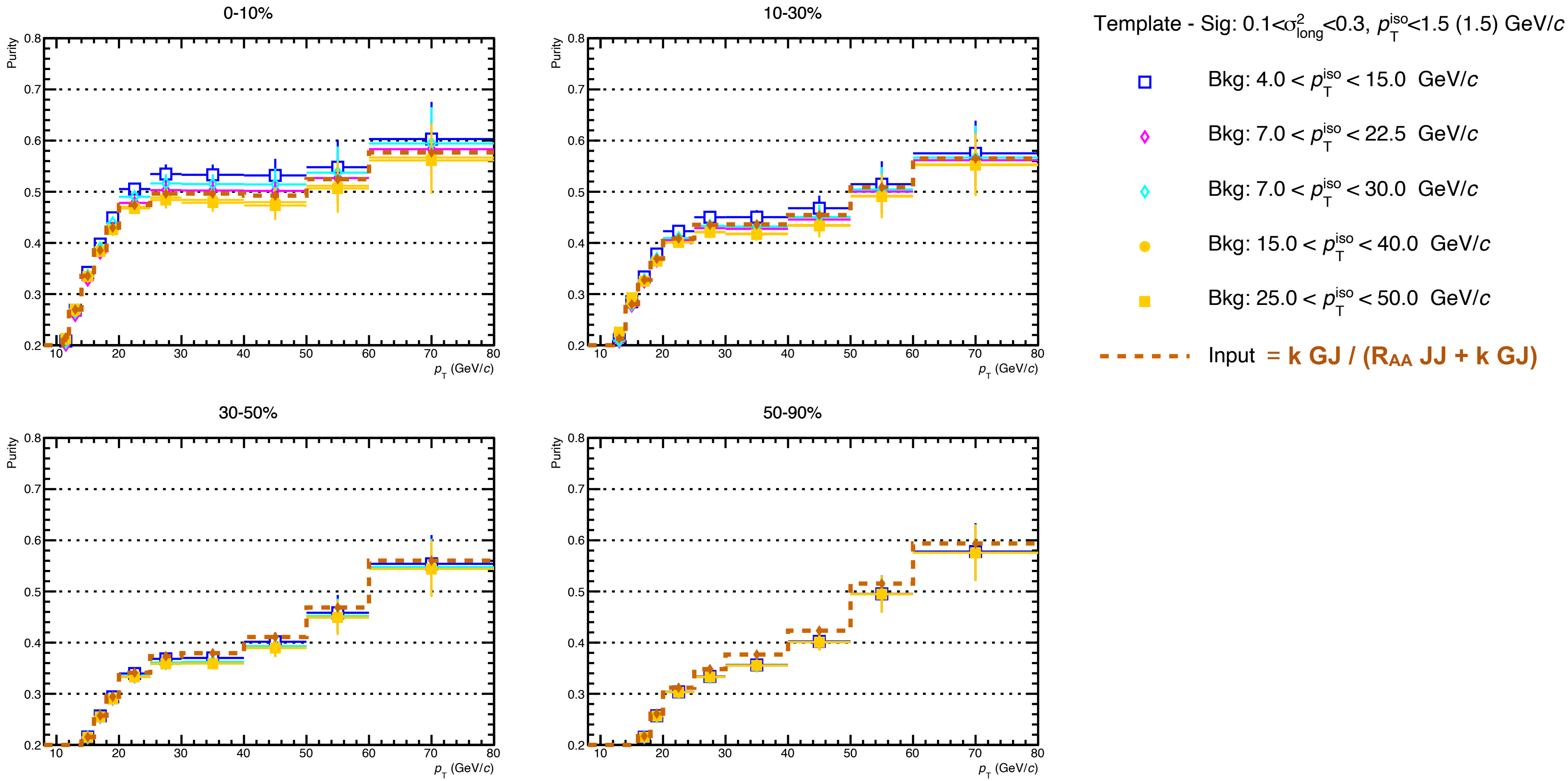
- Changing the scale from k=1 to k=0.5, the agreement in central worsens with the previous ranges, although p_T^{iso} bkg range 7-22 GeV/c seems rather good

Purity Template — MC closure test — MC=JJ x w(R_{AA}) + 0.5xGJ



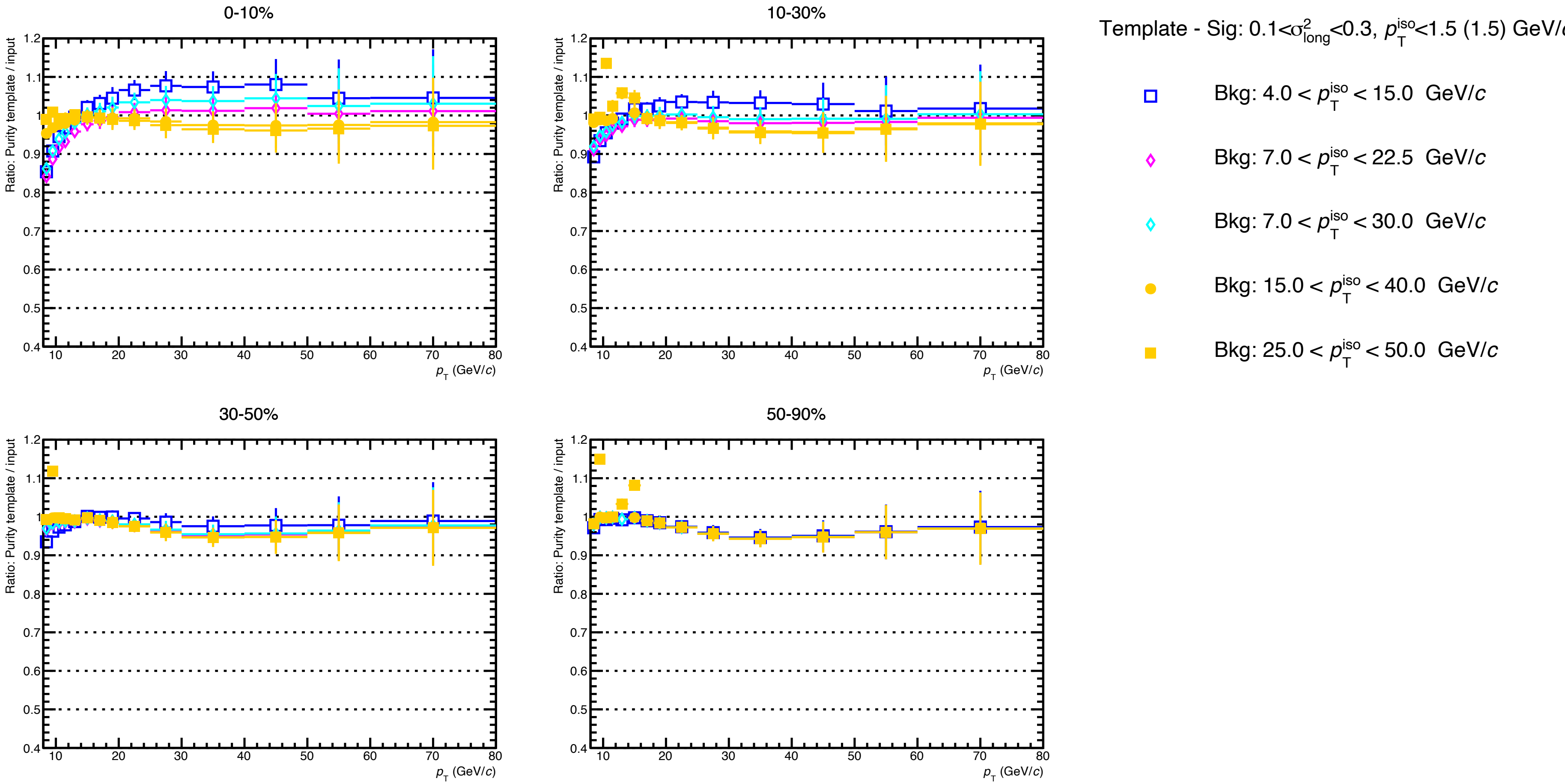
- Changing the scale from k=1 to k=0.5, the agreement in central worsens with the previous ranges, although p_T^{iso} bkg range 7-22 GeV/c seems rather good

Purity Template — MC closure test — MC = JJ x w(R$_{AA}$) + 0.5xGJ



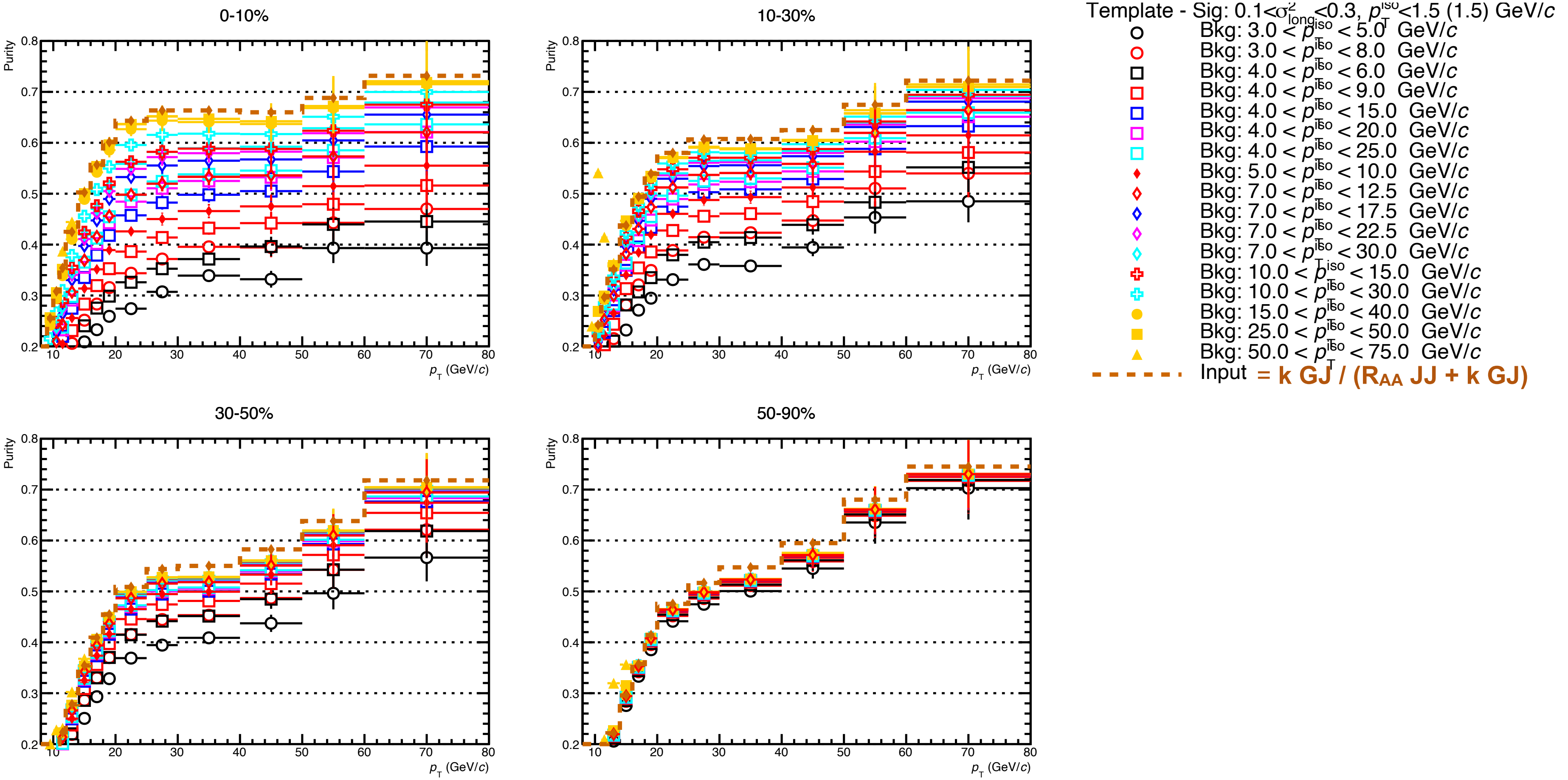
- Changing the scale from k=1 to k = 0.5, the agreement in central worsens with the previous ranges, although p_T^{iso} bkg range 7-22 GeV/c seems rather good

Purity Template — MC closure test — MC=JJ x w(R_{AA}) + 0.5xGJ



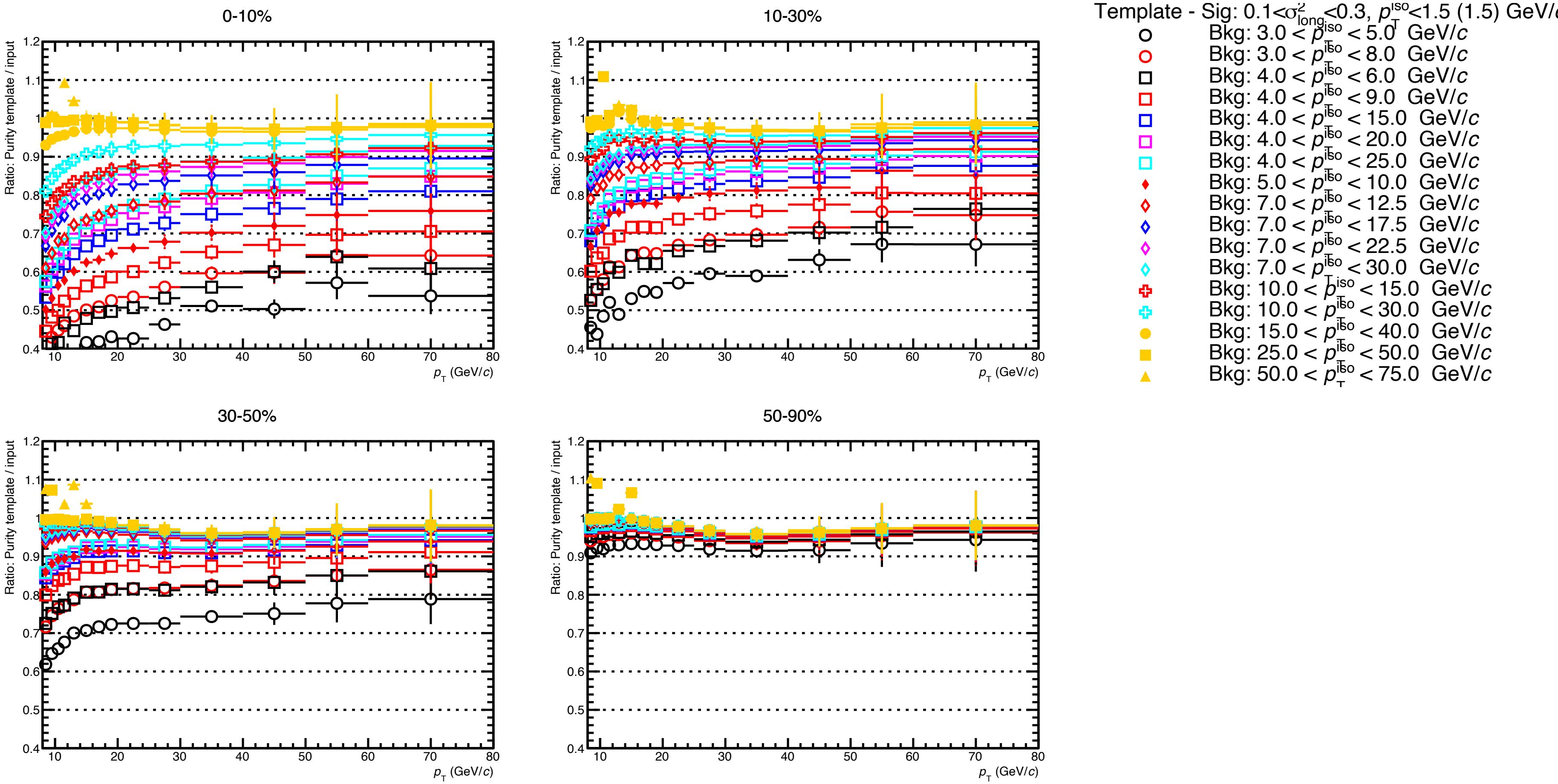
- Changing the scale from k=1 to k=0.5, the agreement in central worsens with the previous ranges, although p_T^{iso} bkg range 7-22 GeV/c seems rather good

Purity Template — MC closure test — MC = JJ x w(R_{AA})



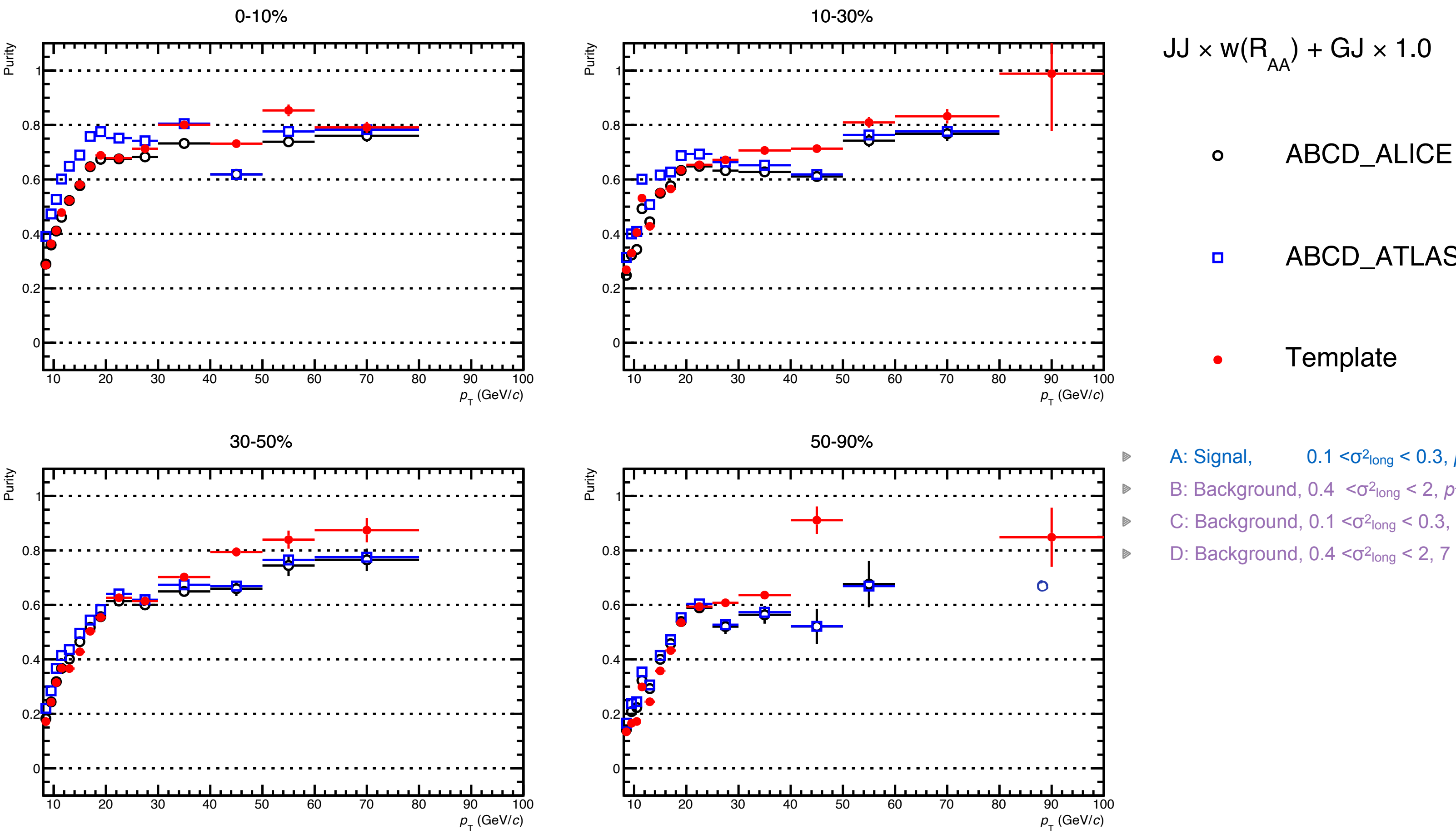
- Without signal leak correction, one has to place the reference to high isolation value, at least p_T^{iso} bkg range lower limit >15 GeV/c

Purity Template — MC closure test — MC = JJ x w(R_{AA})



- Without signal leak correction, one has to place the reference to high isolation value, at least p_T^{iso} bkg range lower limit > 15 GeV

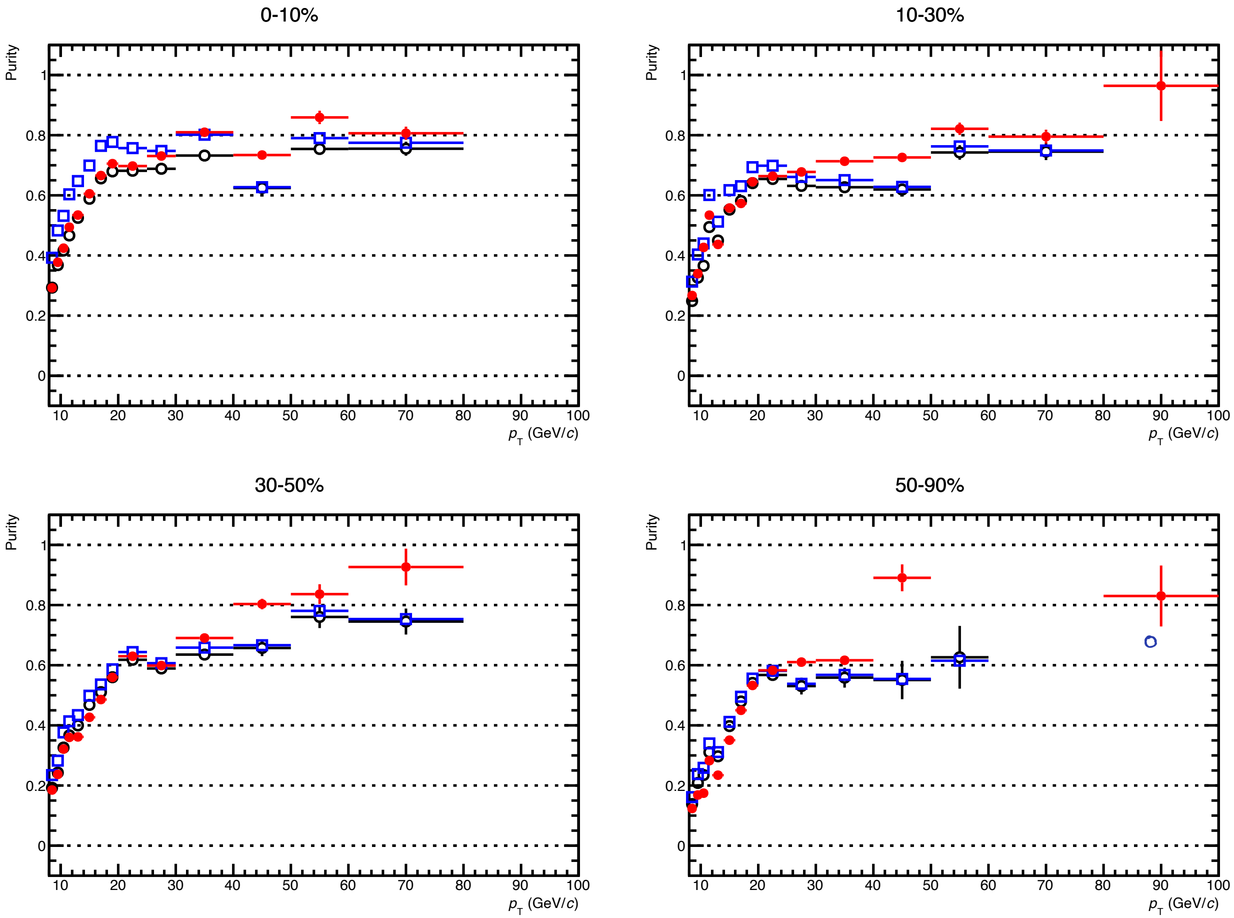
Purity methods comparison — JJ x w(R_{AA}) + GJ



- A: Signal, $0.1 < \sigma^2_{long} < 0.3$, $p_T^{iso} < 1.5$ GeV/c
- B: Background, $0.4 < \sigma^2_{long} < 2$, $p_T^{iso} < 1.5$ GeV/c
- C: Background, $0.1 < \sigma^2_{long} < 0.3$, **$7 < p_T^{iso} < 22$ GeV/c**
- D: Background, $0.4 < \sigma^2_{long} < 2$, **$7 < p_T^{iso} < 22$ GeV/c**

- Using the p_T^{iso} bkg range that the template MC closure suggest, ABCD-ALICE and template tend to agree in central collisions, in central collisions very well at low p_T
- ABCD-ATLAS still does not match the other in central

Purity methods comparison — JJ x w(R_{AA}) + GJ



JJ × w(R_{AA}) + GJ × 1.0

ABCD_ALICE

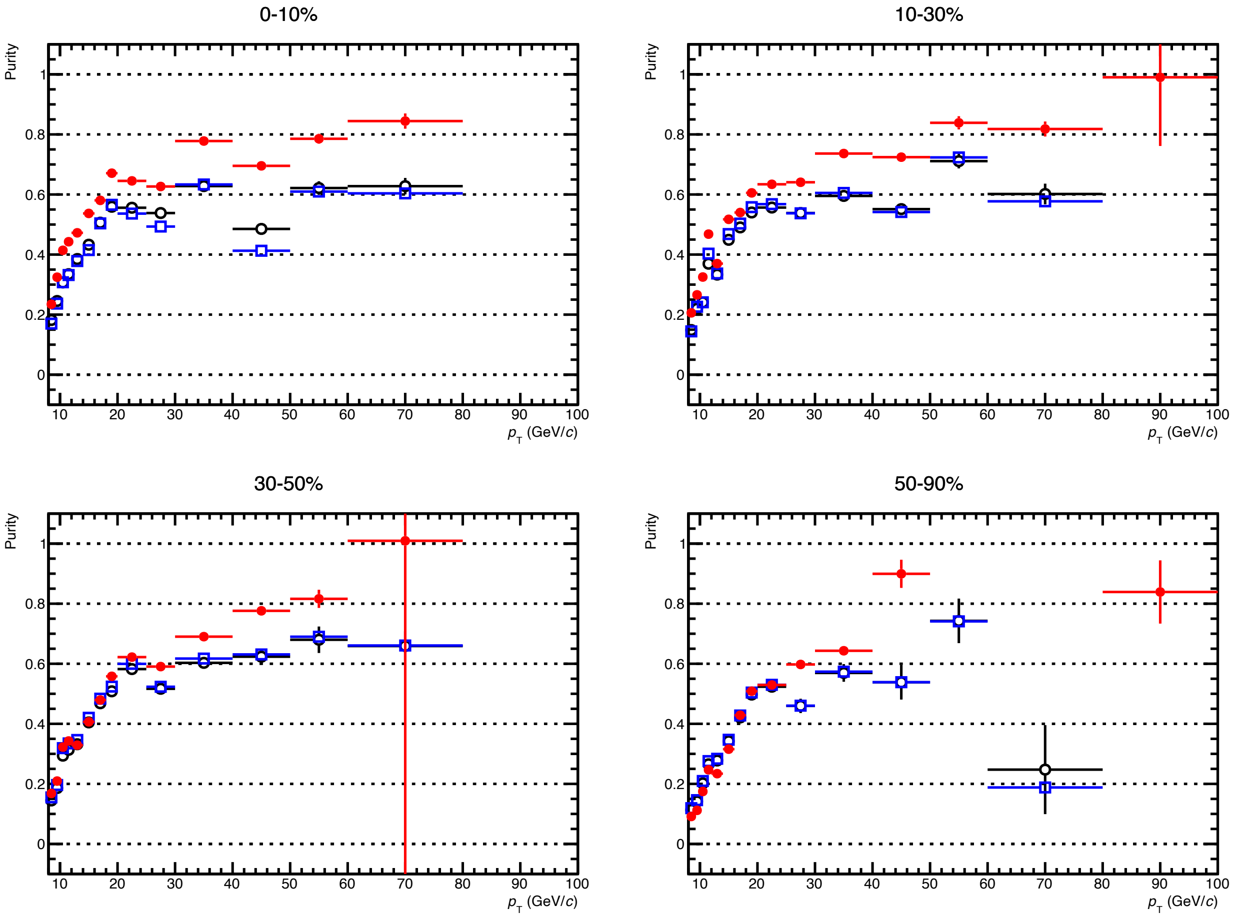
ABCD_ATLAS

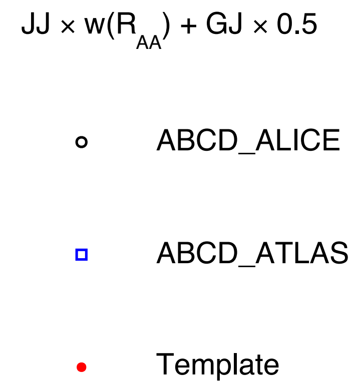
Template

- A: Signal, 0.1 <σ^2_{long} < 0.3, p_T^{iso} < 1.5 GeV/c
- B: Background, 0.4 <σ^2_{long} < 2, p_T^{iso} < 1.5 GeV/c
- C: Background, 0.1 <σ^2_{long} < 0.3, **7 < p_T^{iso} < 30 GeV/c**
- D: Background, 0.4 <σ^2_{long} < 2, 7 **< p_T^{iso} < 30 GeV/c**

- Using the p_T^{iso} bkg range that the template MC closure suggest, ABCD-ALICE and template tend to agree in central collisions, in central collisions very well at low p_T
- ABCD-ATLAS still does not match the other in central

Purity methods comparison — JJ x w(R_{AA}) + 0.5 x GJ



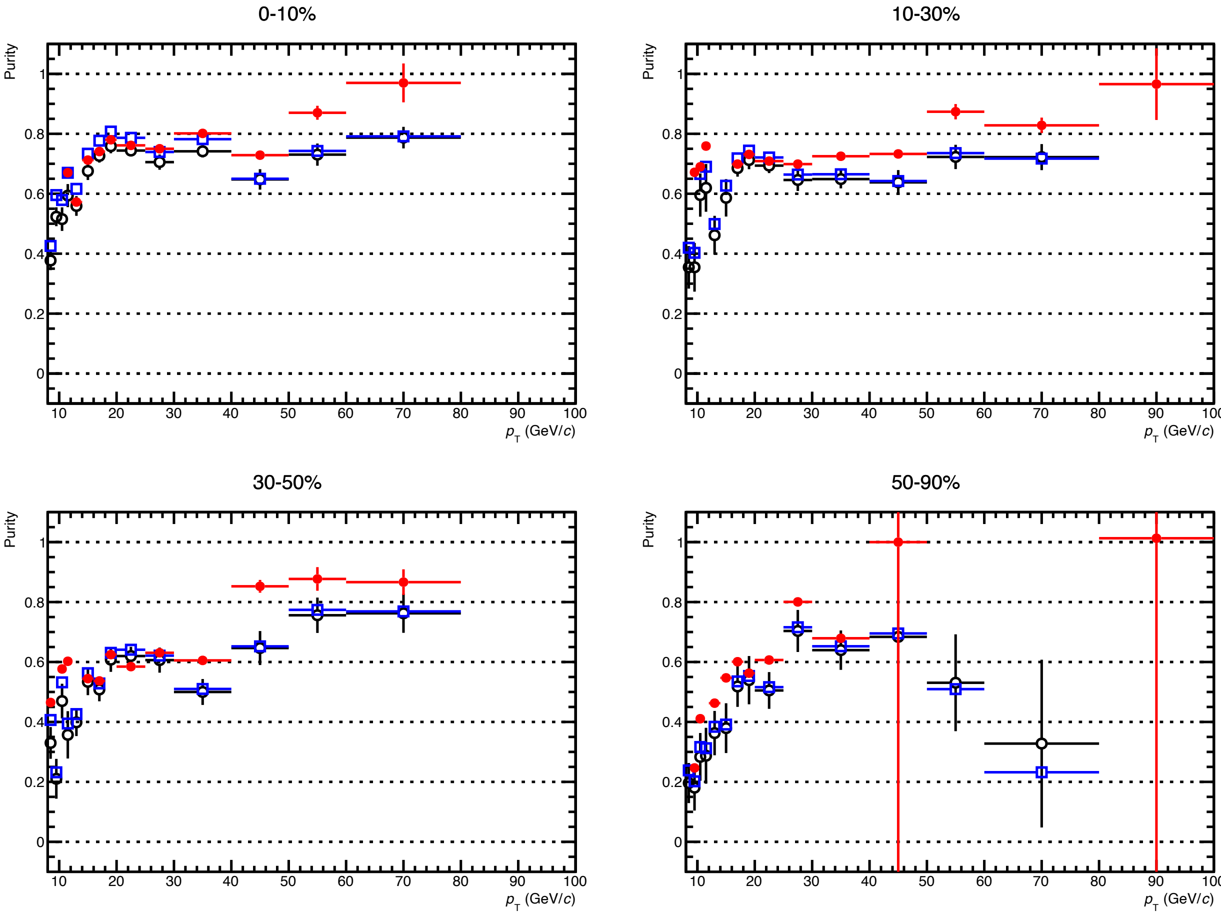


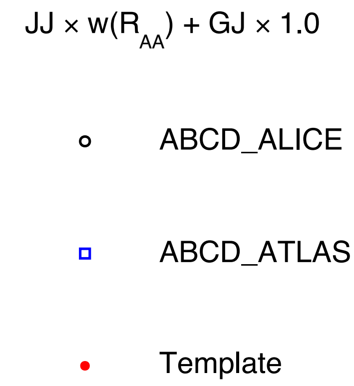
- A: Signal, $0.1 < \sigma^2_{long} < 0.3$, $p_T^{iso} < 1.5$ GeV/c
- B: Background, $0.4 < \sigma^2_{long} < 2$, $p_T^{iso} < 1.5$ GeV/c
- C: Background, $0.1 < \sigma^2_{long} < 0.3$, **$4 < p_T^{iso} < 15$ GeV/c**
- D: Background, $0.4 < \sigma^2_{long} < 2$, **$4 < p_T^{iso} < 15$ GeV/c**

Blessed region by MC closure for template for k=1

- Funny observation or accident?
  - Changing GJ scale a factor k=0.5, template and ABCD-ALICE decrease, more or less to where we would like and tend to agree.
  - Now ABCD-ATLAS agrees with the other, when applying a k=0.5 factor to the c_i GJ fractions
  - But now template doesn't with range p_T^{iso} bkg range 4-14 GeV/c, not too good in MC closure for k=0.5

Purity methods comparison — JJ x w(R_{AA}) + 1 x GJ

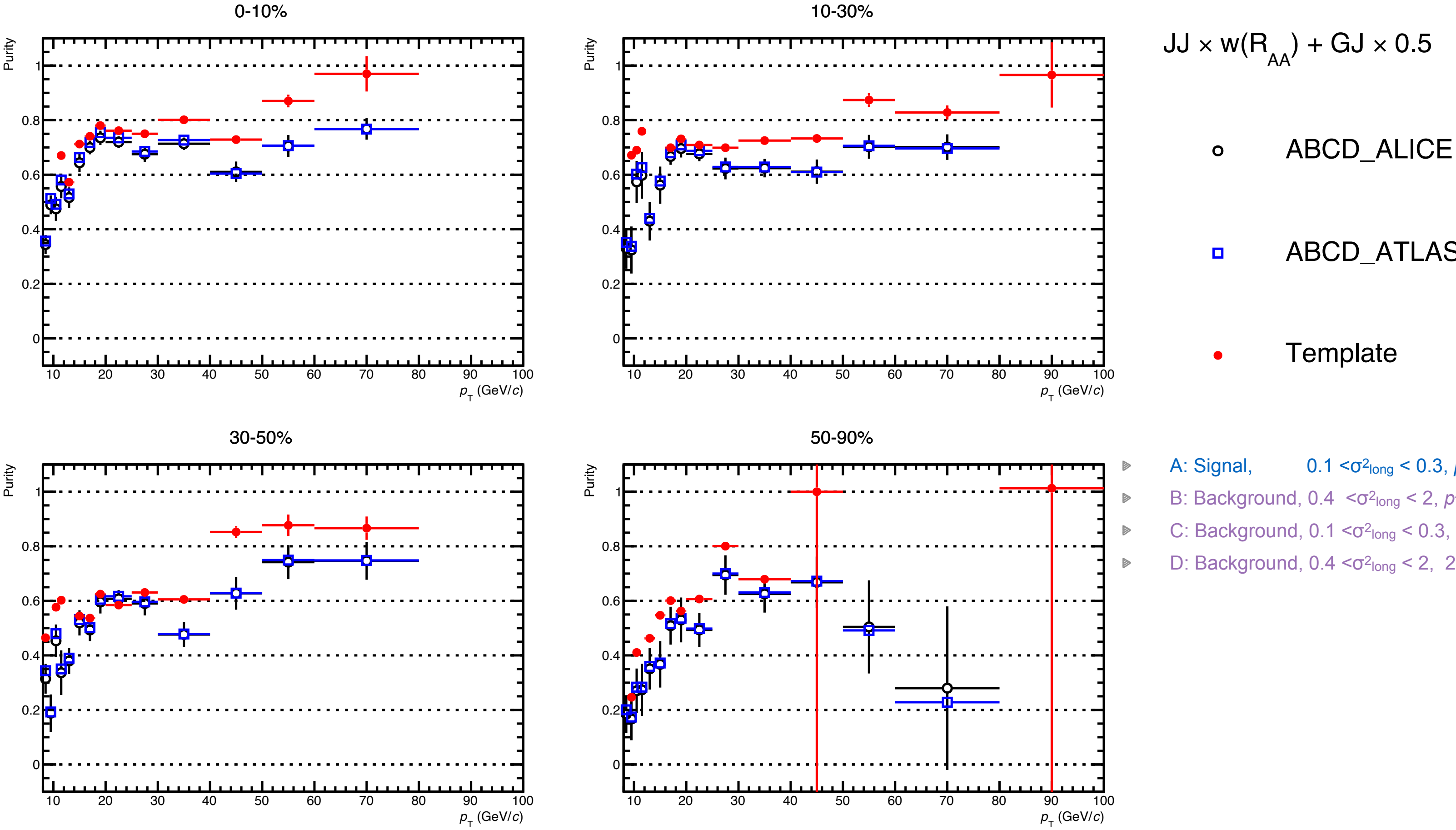




- A: Signal, 0.1 < σ^2_{long} < 0.3, p_T^{iso} < 1.5 GeV/c
- B: Background, 0.4 < σ^2_{long} < 2, p_T^{iso} < 1.5 GeV/c
- C: Background, 0.1 < σ^2_{long} < 0.3, **25 < p_T^{iso} < 50 GeV/c**
- D: Background, 0.4 < σ^2_{long} < 2, 25 **< p_T^{iso} < 50 GeV/c**

- Rather good agreement of all methods in central, not so much in peripheral with template

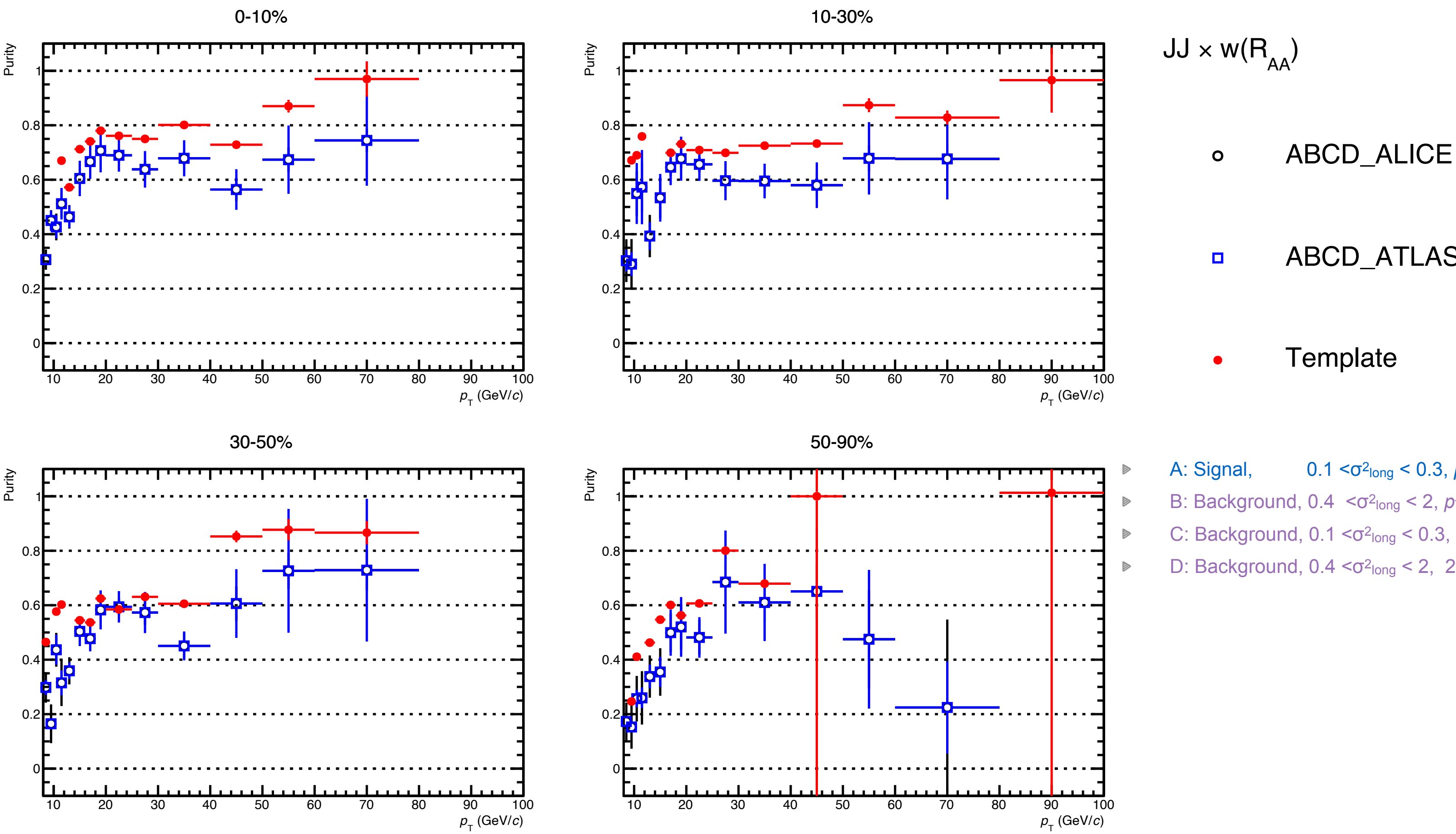
Purity methods comparison — JJ x w(R_{AA}) + 0.5 x GJ



- A: Signal, $0.1 < \sigma^2_{long} < 0.3$, $p_T^{iso} < 1.5$ GeV/c
- B: Background, $0.4 < \sigma^2_{long} < 2$, $p_T^{iso} < 1.5$ GeV/c
- C: Background, $0.1 < \sigma^2_{long} < 0.3$, $25 < p_T^{iso} < 50$ GeV/c
- D: Background, $0.4 < \sigma^2_{long} < 2$, $25 < p_T^{iso} < 50$ GeV/c

- A bit less agreement of template and ABCDs

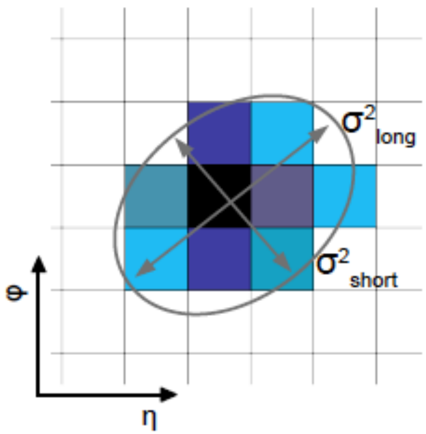
Purity methods comparison — JJ x w(R_{AA})



- A: Signal, $0.1 < \sigma^2_{long} < 0.3$, $p_T^{iso} < 1.5$ GeV/c
- B: Background, $0.4 < \sigma^2_{long} < 2$, $p_T^{iso} < 1.5$ GeV/c
- C: Background, $0.1 < \sigma^2_{long} < 0.3$, **$25 < p_T^{iso} < 50$ GeV/c**
- D: Background, $0.4 < \sigma^2_{long} < 2$, **$25 < p_T^{iso} < 50$ GeV/c**

- Even less agreement of template and ABCDs

Shower shape with fixed size



- Shower shape parameter σ^2_{long} is related to the longer axis of the cluster ellipse
- Parameter depends on cluster cells location and its energy

$$\sigma^2_{\alpha\beta} = \sum_i \frac{w_i \alpha_i \beta_i}{w_{tot}} - \sum_i \frac{w_i \alpha_i}{w_{tot}} \sum_i \frac{w_i \beta_i}{w_{tot}}$$

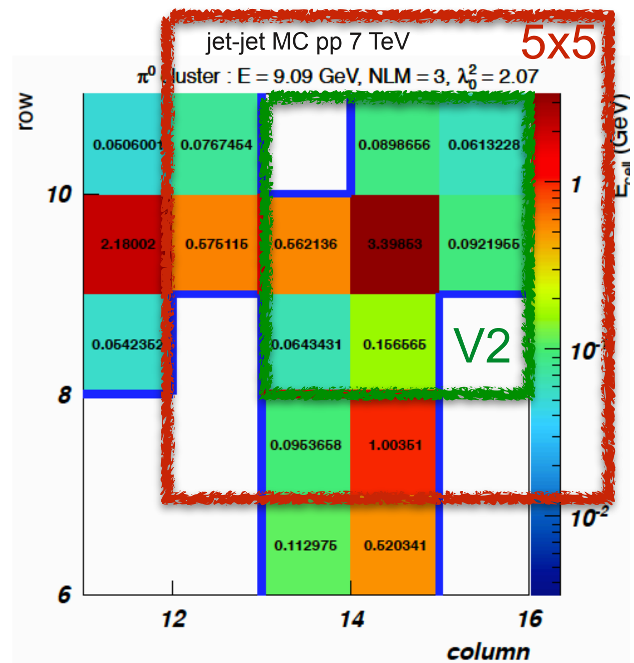
$$w_i = \mathrm{Maximum}(0, w_0 + \ln(E_{\mathrm{cell},\ i}/E))$$

$$w_{tot} = \sum_i w_i,$$

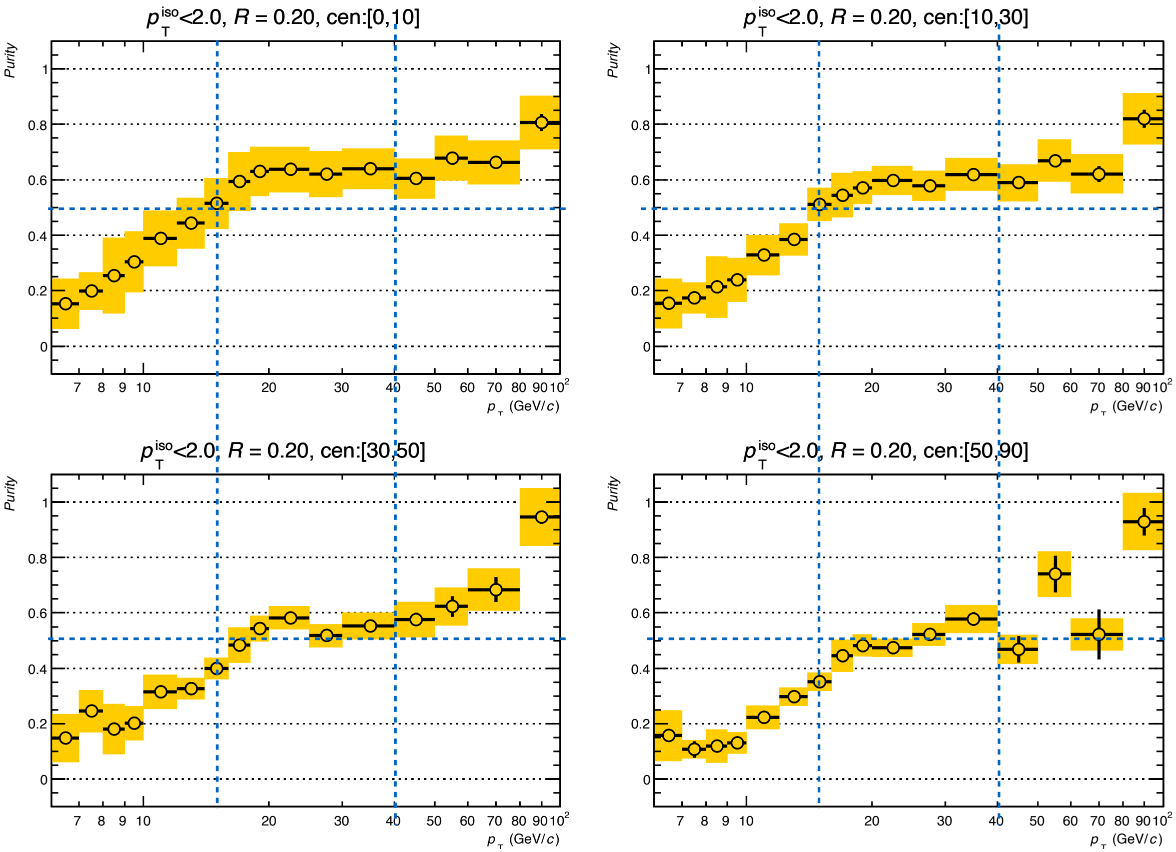
$$\sigma^2_{\mathrm{long}} = 0.5(\sigma^2_{\varphi\varphi} + \sigma^2_{\eta\eta}) + \sqrt{0.25(\sigma^2_{\varphi\varphi} - \sigma^2_{\eta\eta})^2 + \sigma^2_{\eta\varphi}},$$

$$\sigma^2_{\mathrm{short}} = 0.5(\sigma^2_{\varphi\varphi} + \sigma^2_{\eta\eta}) - \sqrt{0.25(\sigma^2_{\varphi\varphi} - \sigma^2_{\eta\eta})^2 + \sigma^2_{\eta\varphi}},$$

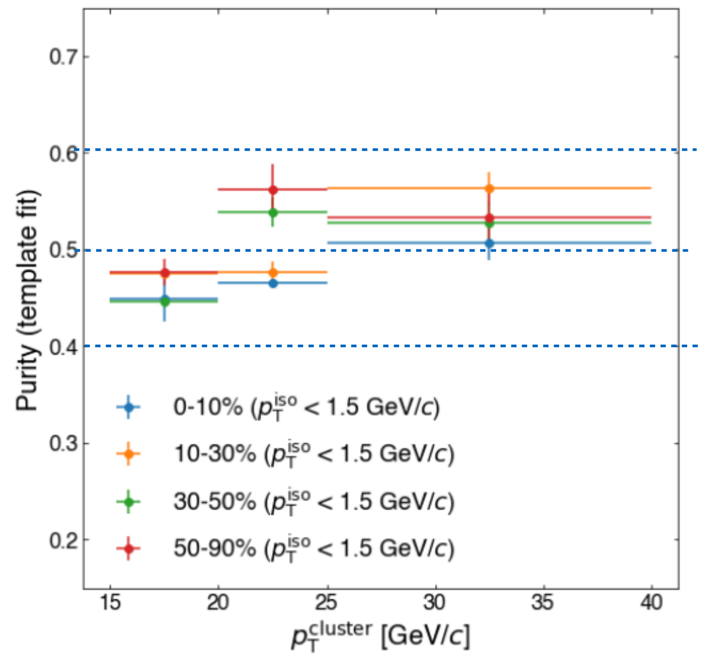
- For Pb-Pb, let's just consider the cells around the highest energy cell in a 5x5 fixed window in the σ^2_{long} calculation, independently if cells were assigned to the original V2 cluster
- Those cells must be all neighbours
- **The cluster energy and position remains the same as the V3 (V2) cluster**



Outstanding issue: Purity ABCD vs Template



Alwina's template

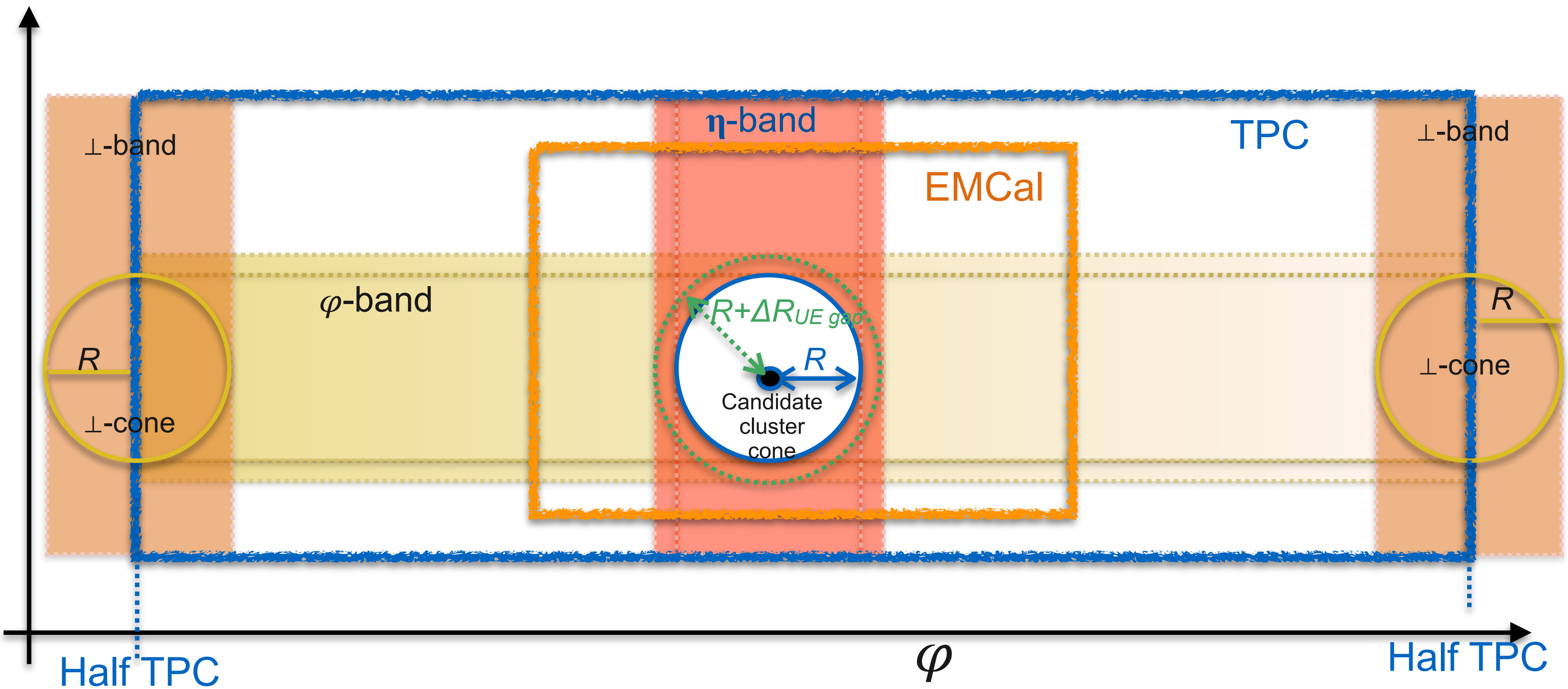


- Non central purities are compatible between the 2 analysis but central are rather clearly different
  - Cut is a bit different, but it should not differ much
- Today, reanalyse and study different methods

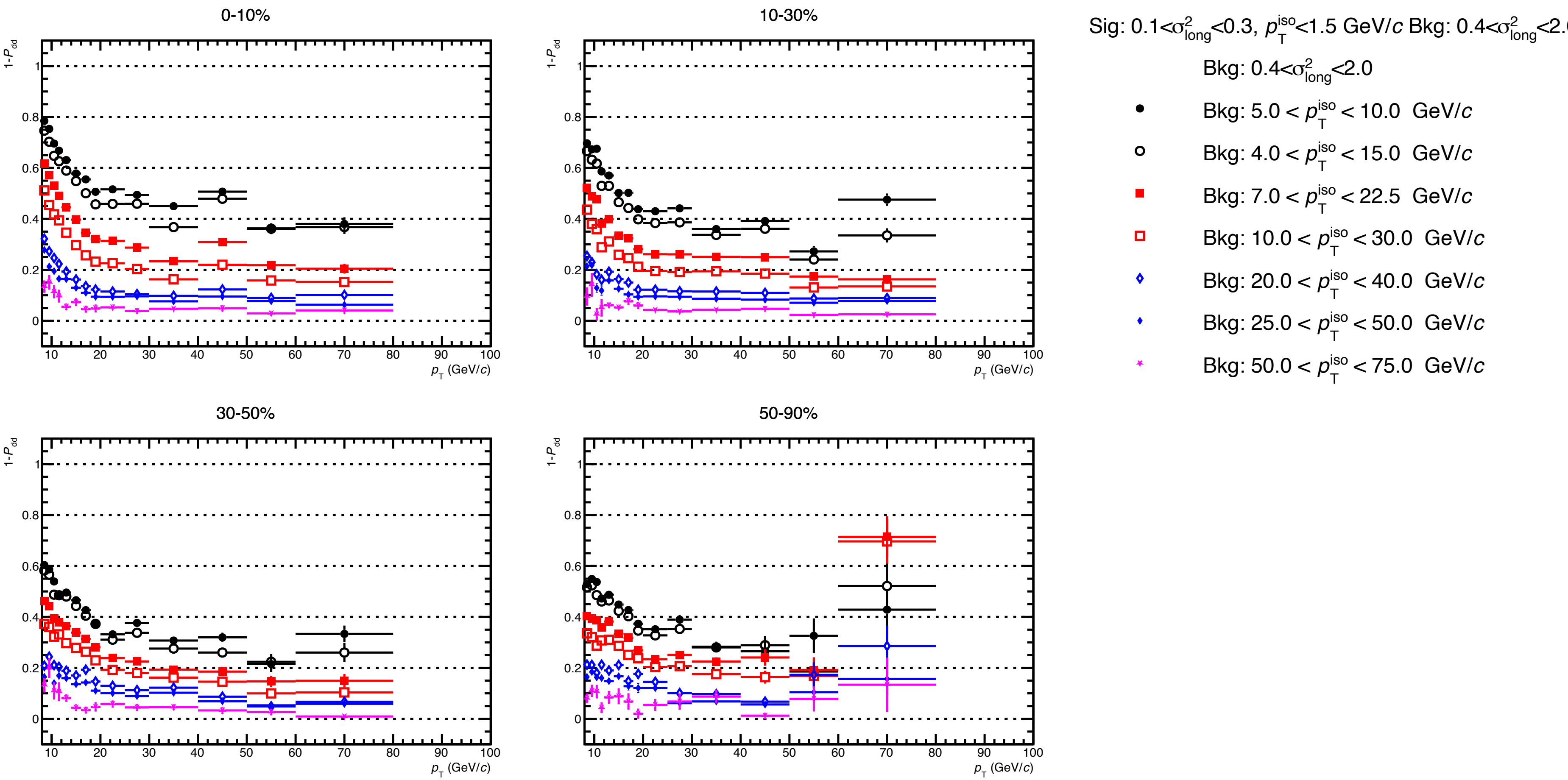
Isolation: UE energy estimation methods in isolation cone

- Tried different UE energy density (ρ) in cone estimators (also standard jet analysis ρ):

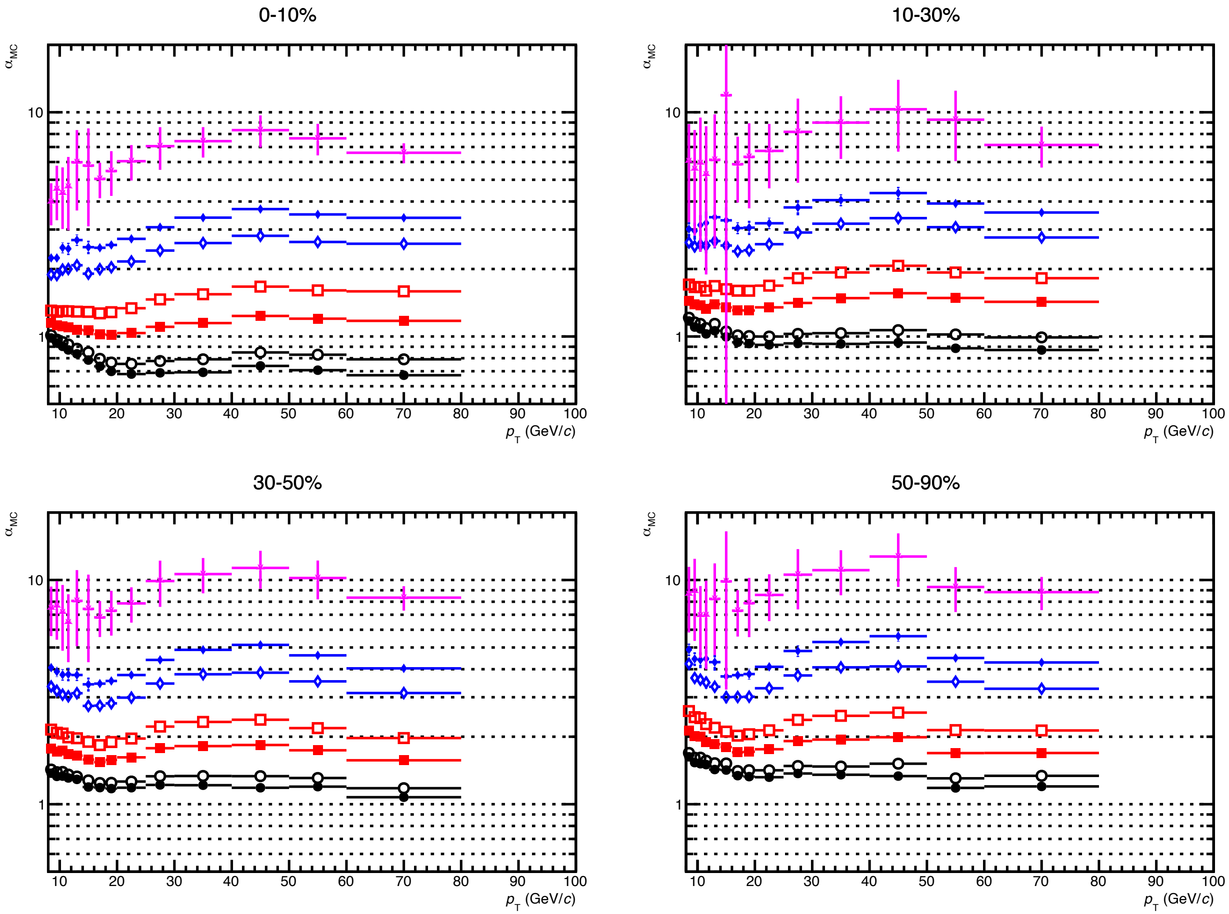
$$R = \sqrt{(\eta_{track}-\eta_{\gamma})^2+(\varphi_{track}-\varphi_{\gamma})^2}$$



ABCD-ALICE: 1 - P_{dd} for different isolation bkg regions



ABCD-ALICE: α_{MC} for different isolation bkg regions — MC = w(R_{AA})xJJ + GJ

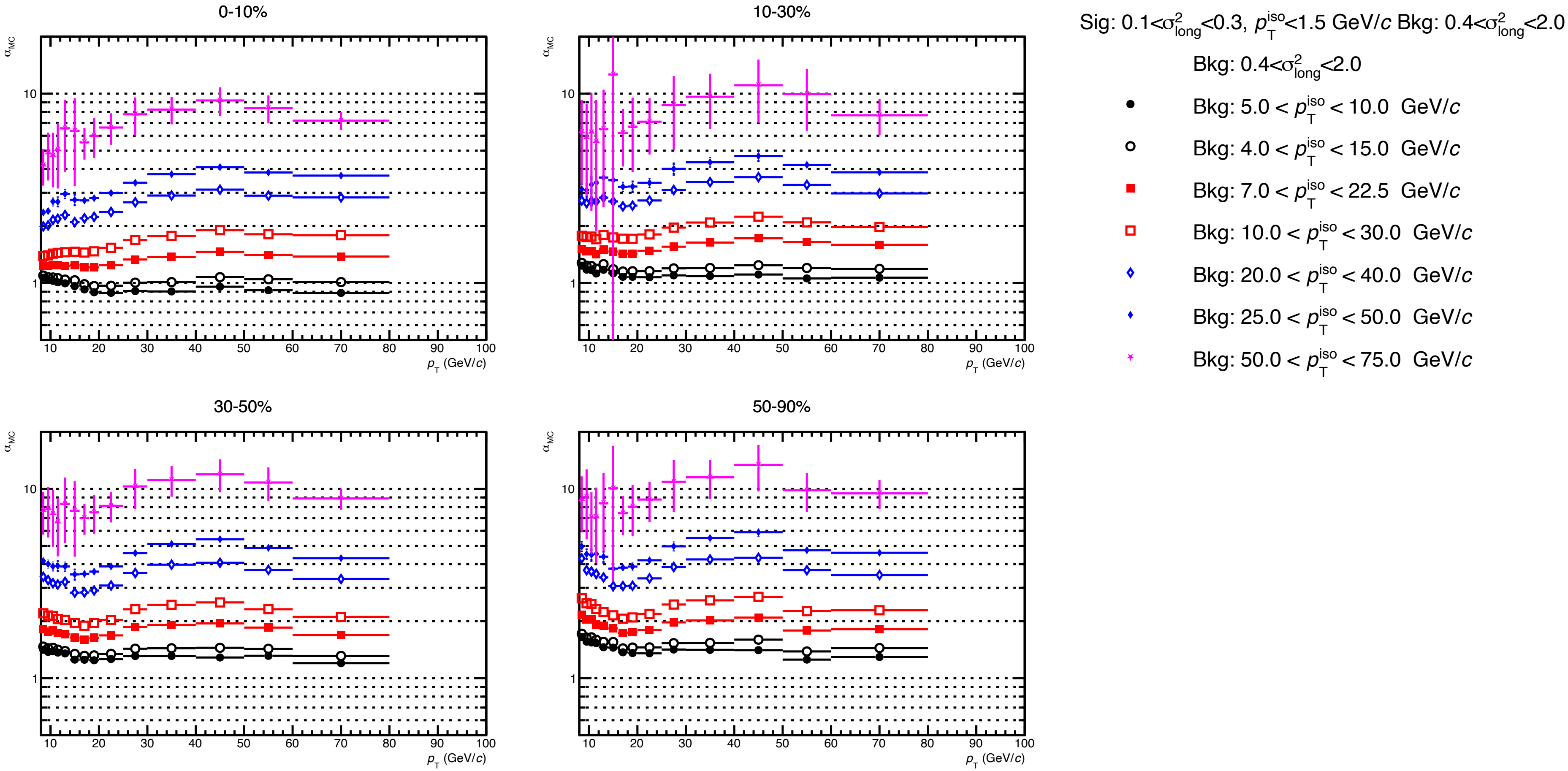


Sig: $0.1<\sigma^2_{long}<0.3$, $p_T^{iso}<1.5$ GeV/c Bkg: $0.4<\sigma^2_{long}<2.0$

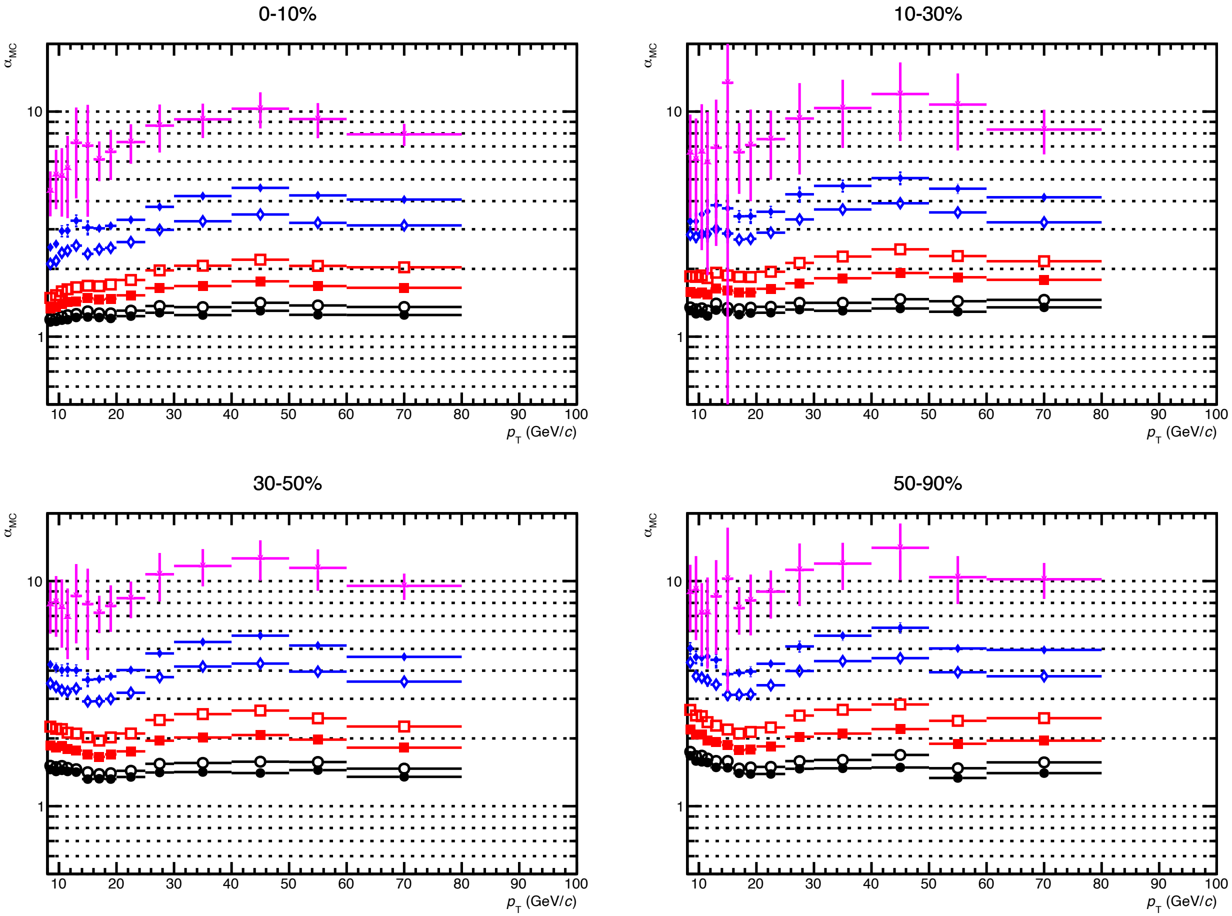
Bkg: $0.4<\sigma^2_{long}<2.0$

- Bkg: $5.0 < p_T^{iso} < 10.0$ GeV/c
- Bkg: $4.0 < p_T^{iso} < 15.0$ GeV/c
- Bkg: $7.0 < p_T^{iso} < 22.5$ GeV/c
- Bkg: $10.0 < p_T^{iso} < 30.0$ GeV/c
- Bkg: $20.0 < p_T^{iso} < 40.0$ GeV/c
- Bkg: $25.0 < p_T^{iso} < 50.0$ GeV/c
- Bkg: $50.0 < p_T^{iso} < 75.0$ GeV/c

ABCD-ALICE: α_{MC} for different isolation bkg regions — MC = w(R_{AA})xJJ + 0.5 x GJ



ABCD-ALICE: α_{MC} for different isolation bkg regions — MC = w(R_{AA})xJJ



Sig: $0.1<\sigma^2_{long}<0.3$, $p_T^{iso}<1.5$ GeV/c Bkg: $0.4<\sigma^2_{long}<2.0$

Bkg: $0.4<\sigma^2_{long}<2.0$

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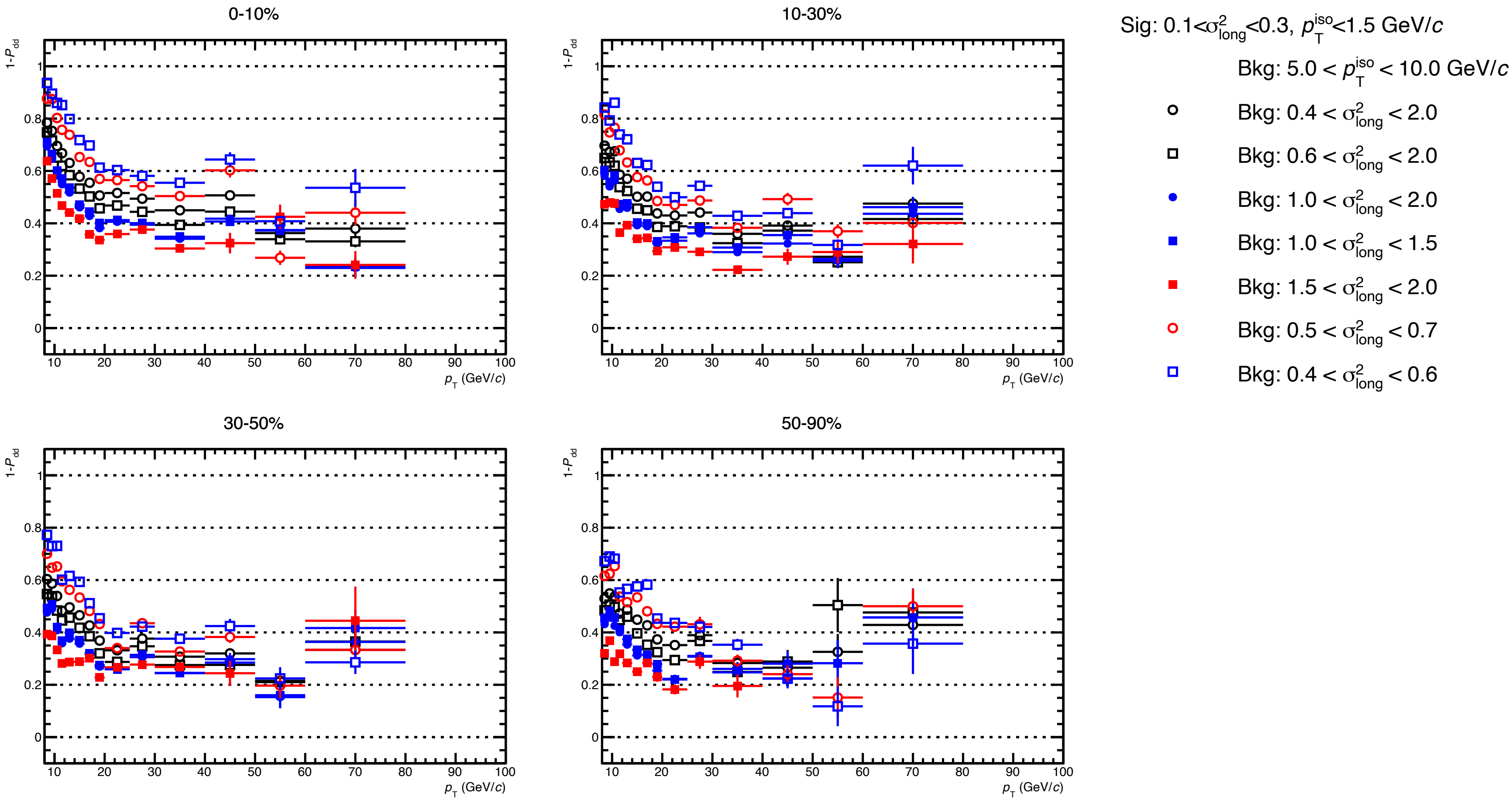
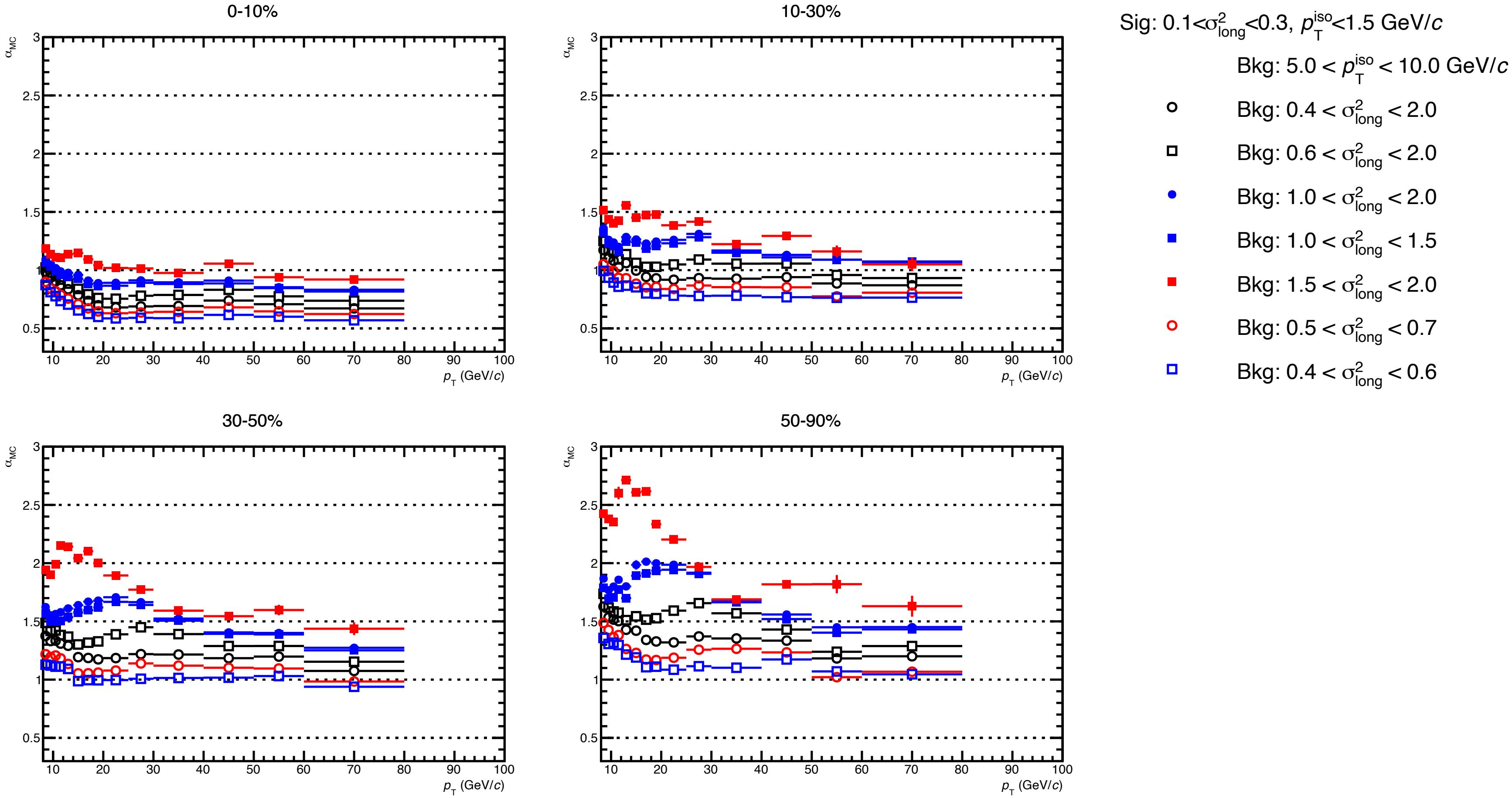
- Bkg: $20.0 < p_T^{iso} < 40.0$ GeV/c
- Bkg: $25.0 < p_T^{iso} < 50.0$ GeV/c
- Bkg: $50.0 < p_T^{iso} < 75.0$ GeV/c

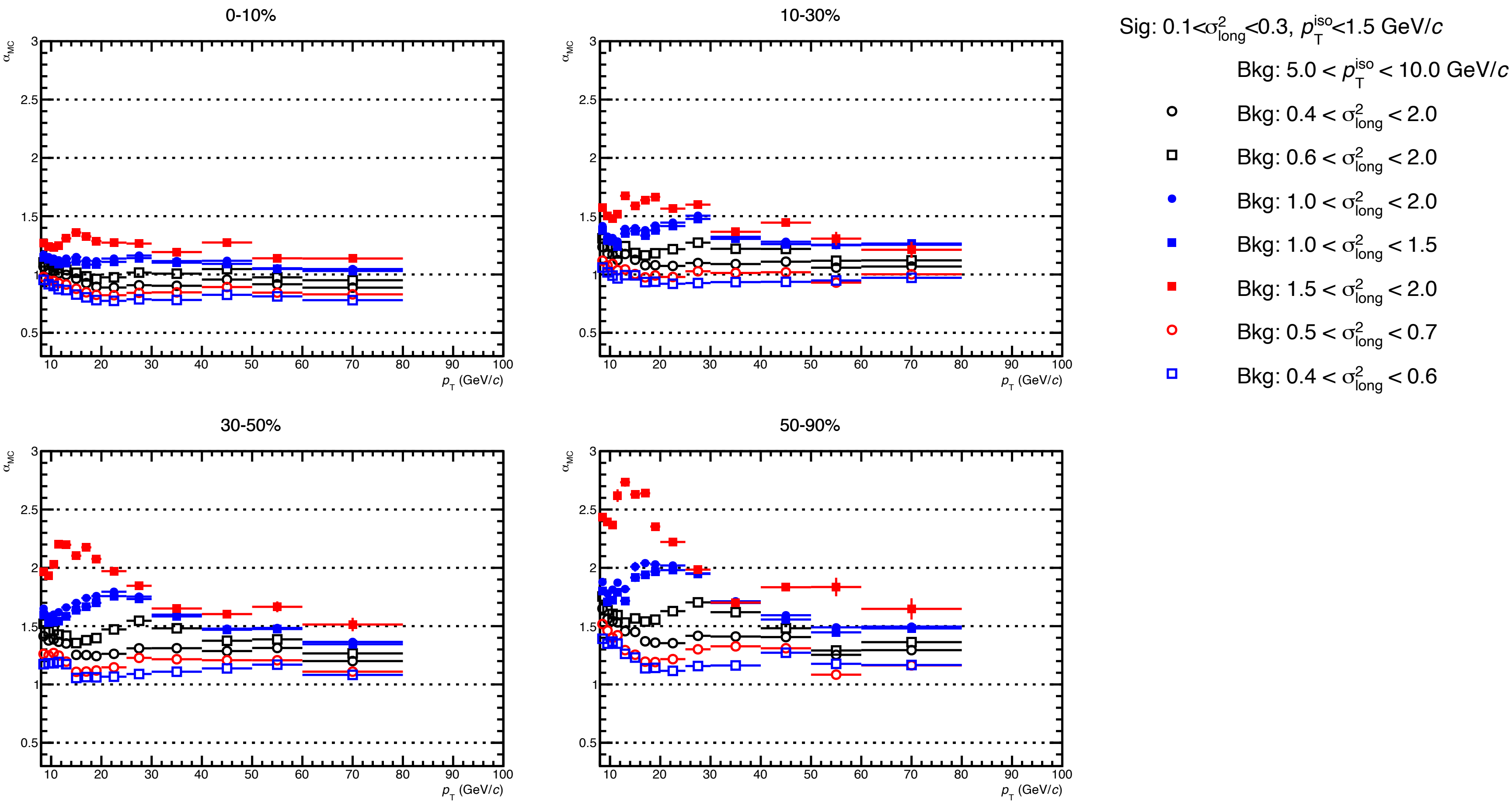
ABCD-ALICE: 1 - P_{dd} for different σ^2_{long} bkg regions



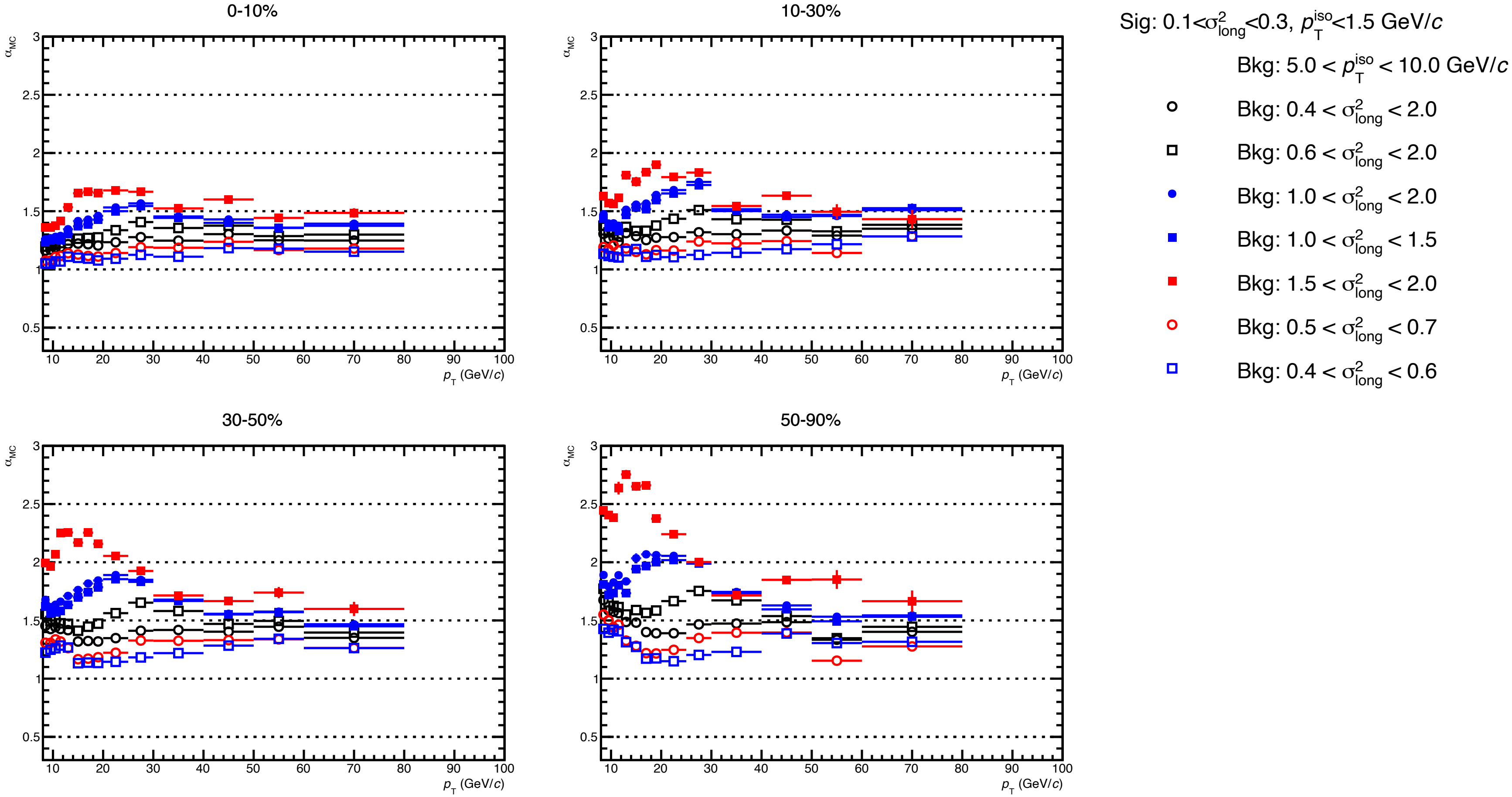
ABCD-ALICE: α_{MC} for different σ^2_{long} bkg regions — MC = w(R_{AA})xJJ + GJ



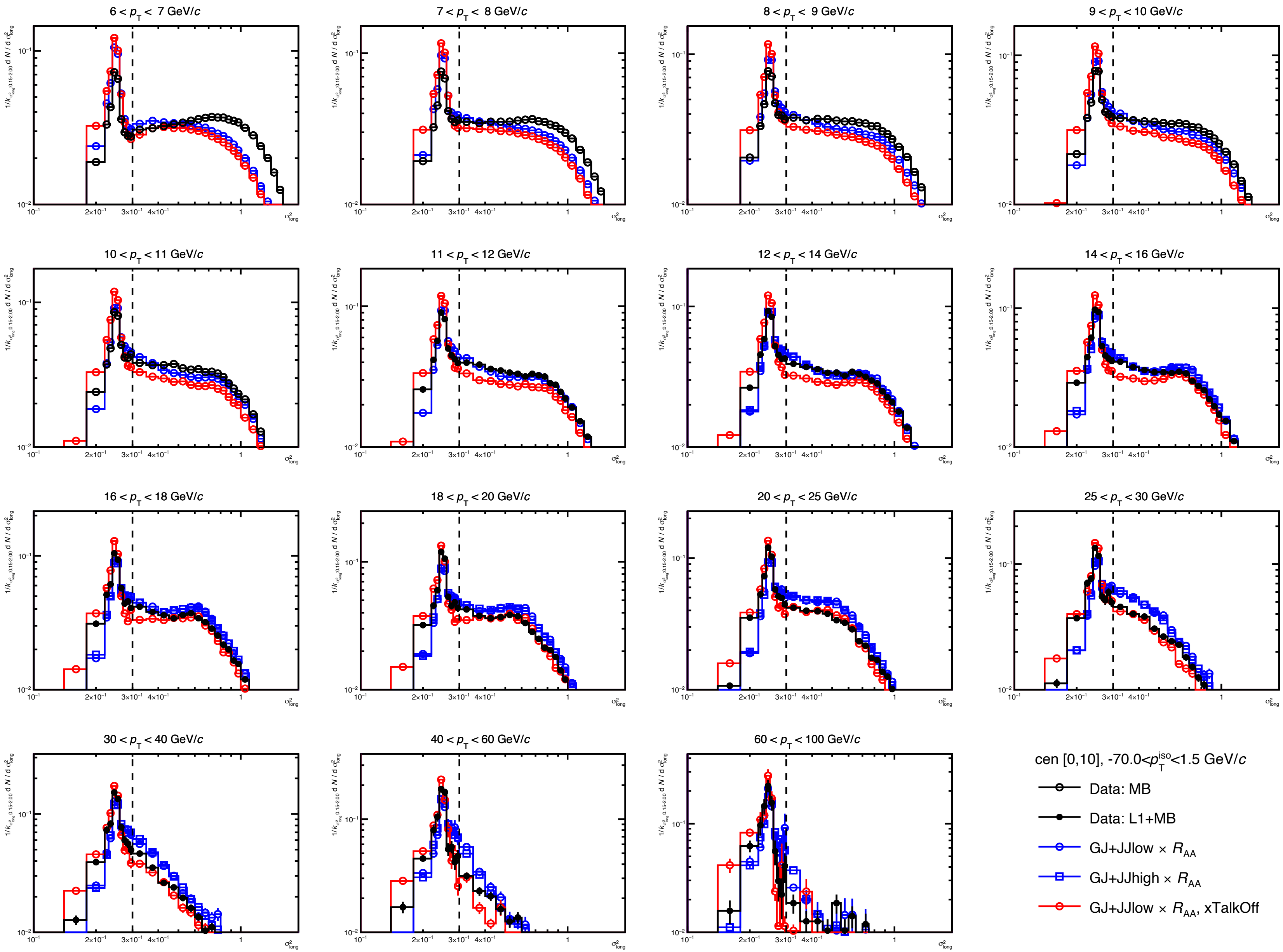
ABCD-ALICE: α_{MC} for different σ^2_{long} bkg regions — MC = w(R_{AA})xJJ + 0.5 x GJ



ABCD-ALICE: α_{MC} for different σ^2_{long} bkg regions — MC = w(R_{AA})xJJ

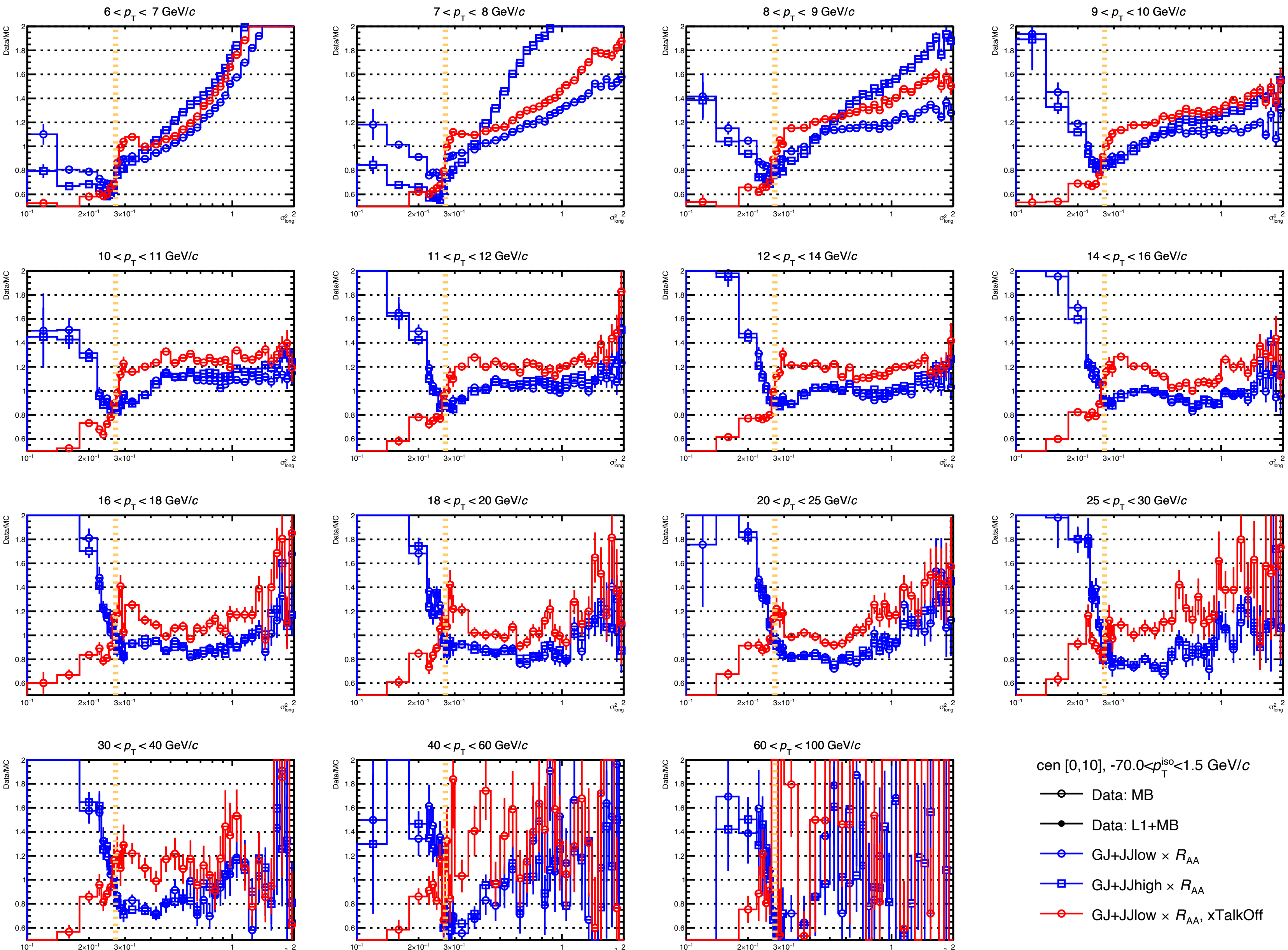


Comparison Data-MC w/out xTalk of shower shape, 0-10%, isolated clusters



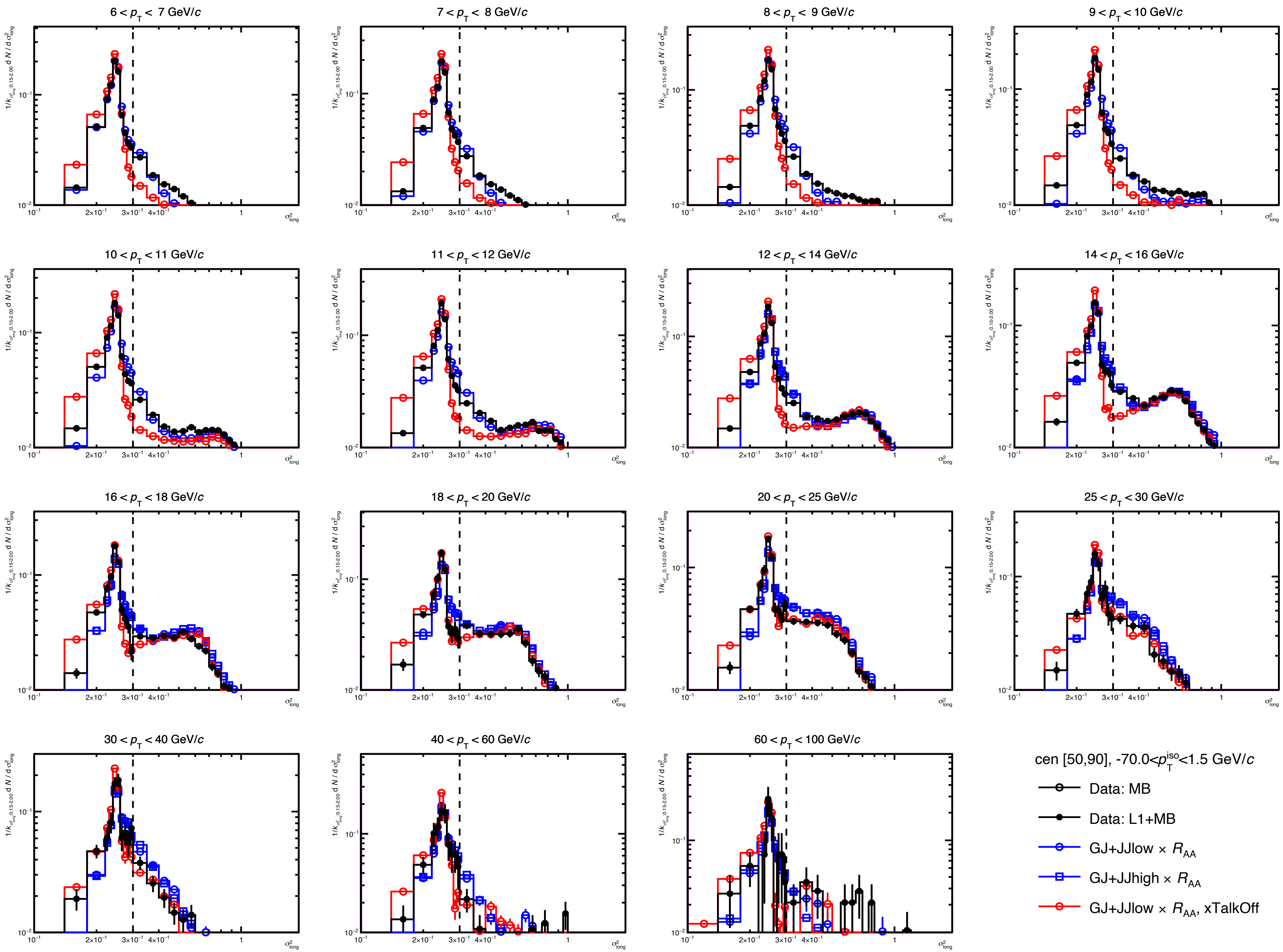
- Cross talk emulation better below 18-20 GeV/c, not above 20 GeV

Comparison Data-MC w/out xTalk of shower shape, 0-10%, isolated clusters



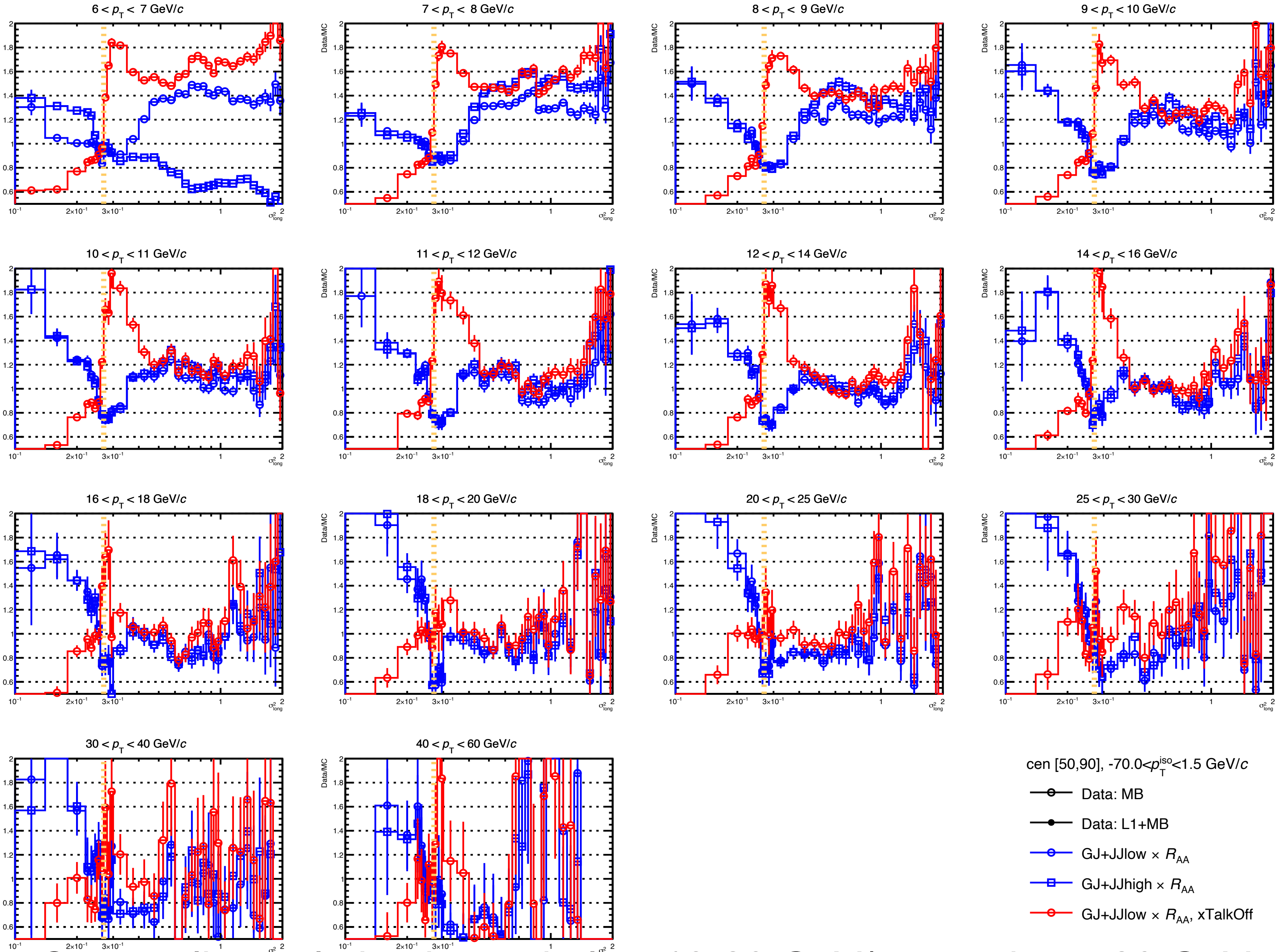
- Cross talk emulation better below 18-20 GeV/c, not above 20 GeV

Comparison Data-MC w/out xTalk of shower shape, 50-90%, isolated clusters



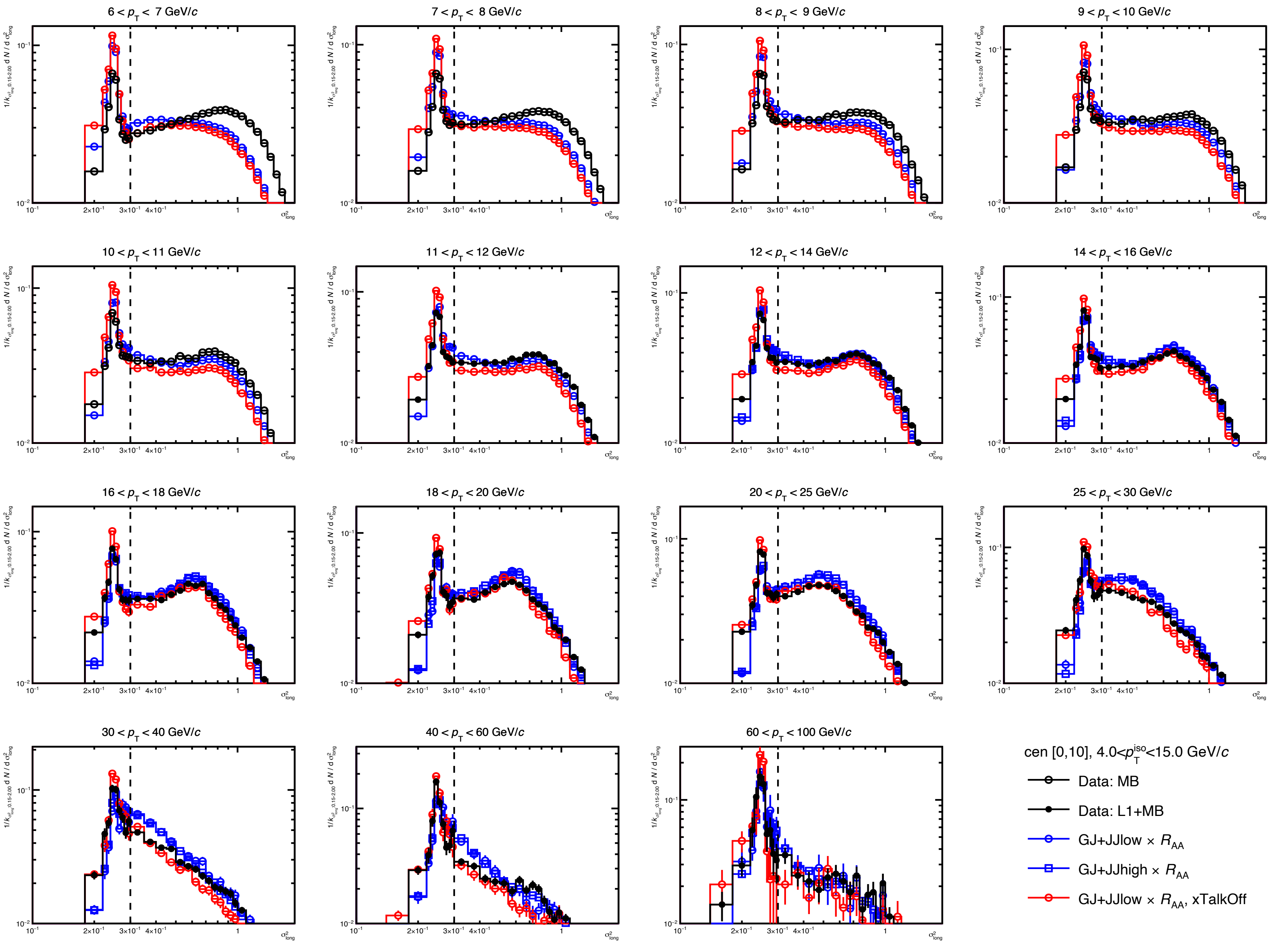
- Cross talk emulation better below 18-20 GeV/c, not above 20 GeV

Comparison Data-MC w/out xTalk of shower shape, 50-90%, isolated clusters



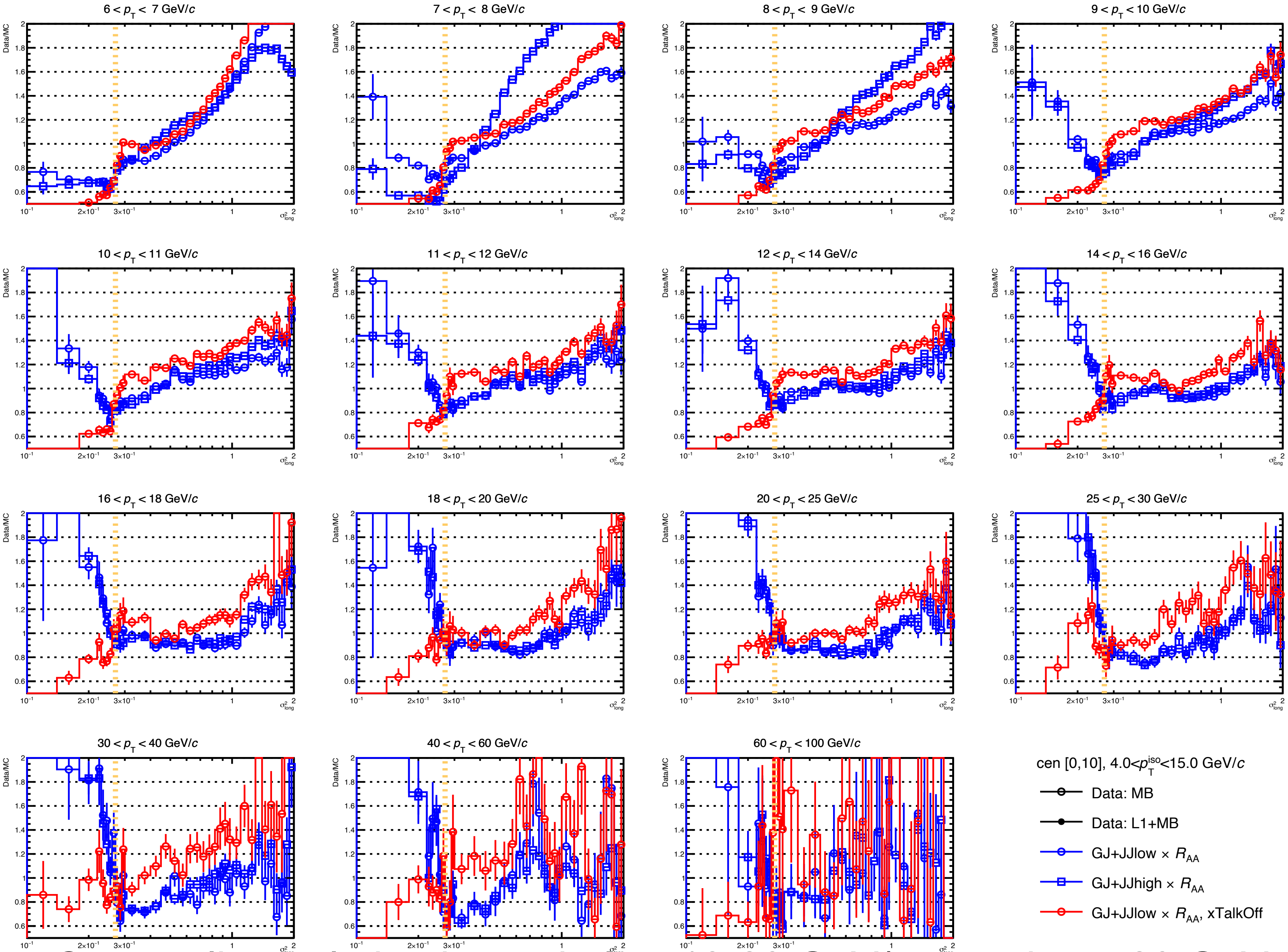
- Cross talk emulation better below 18-20 GeV/c, not above 20 GeV

Comparison Data-MC w/out xTalk of shower shape, 0-10%, NOT isolated clusters



- Cross talk emulation better below 18-20 GeV/c, not above 20 GeV

Comparison Data-MC w/out xTalk of shower shape, 0-10%, NOT isolated clusters



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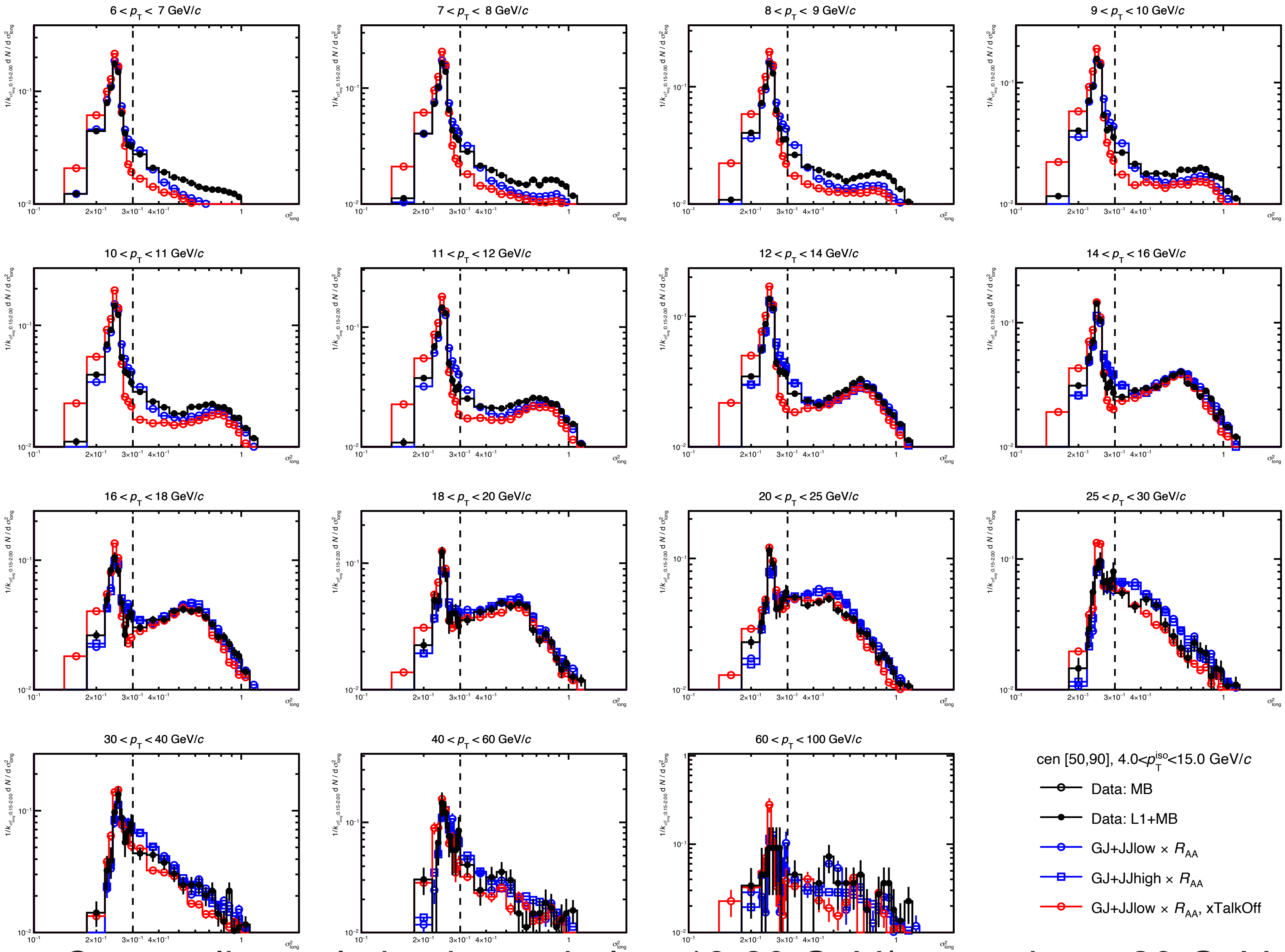
Comparison Data-MC w/out xTalk of shower shape, 50-90%, NOT isolated clusters



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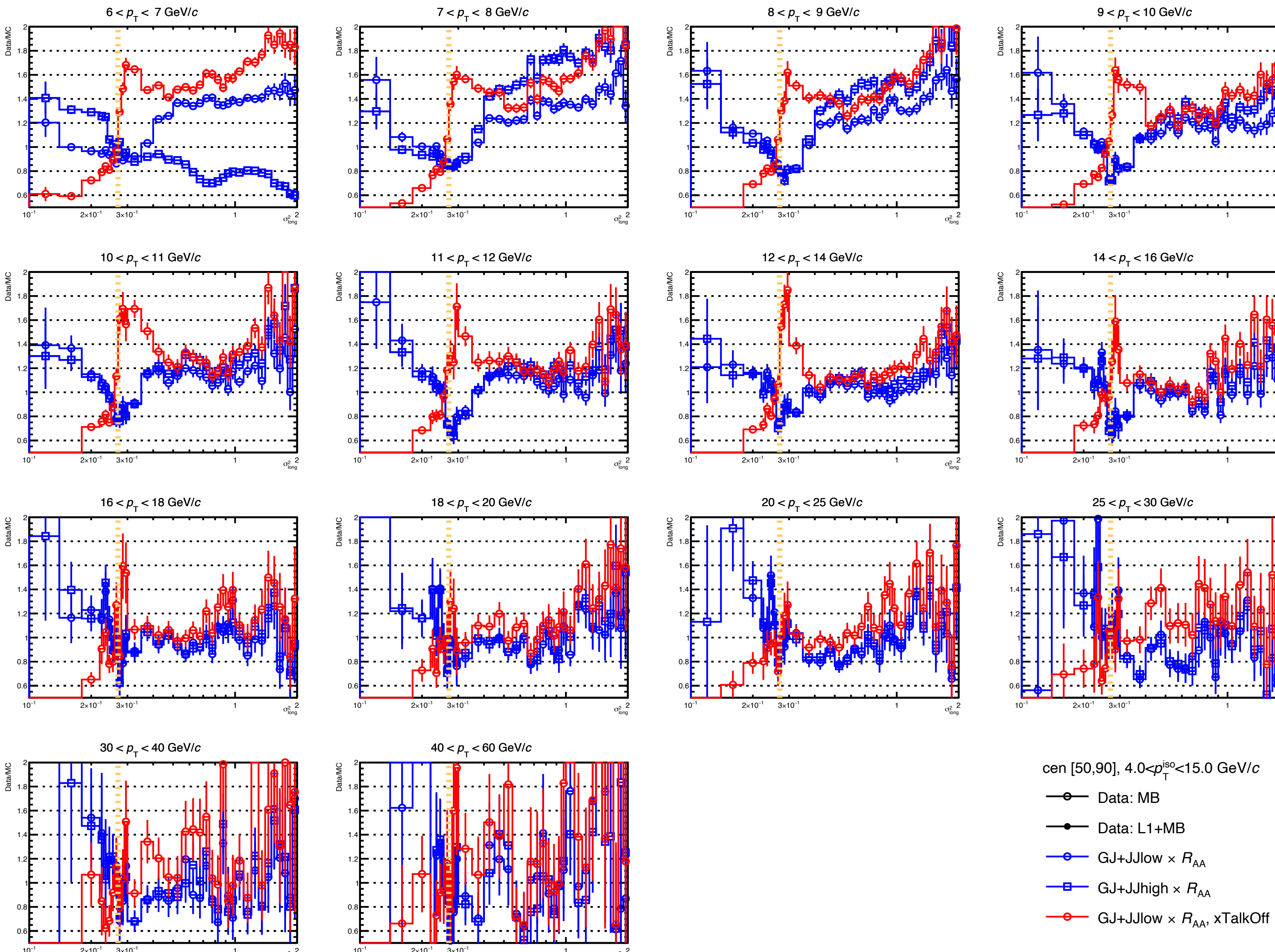
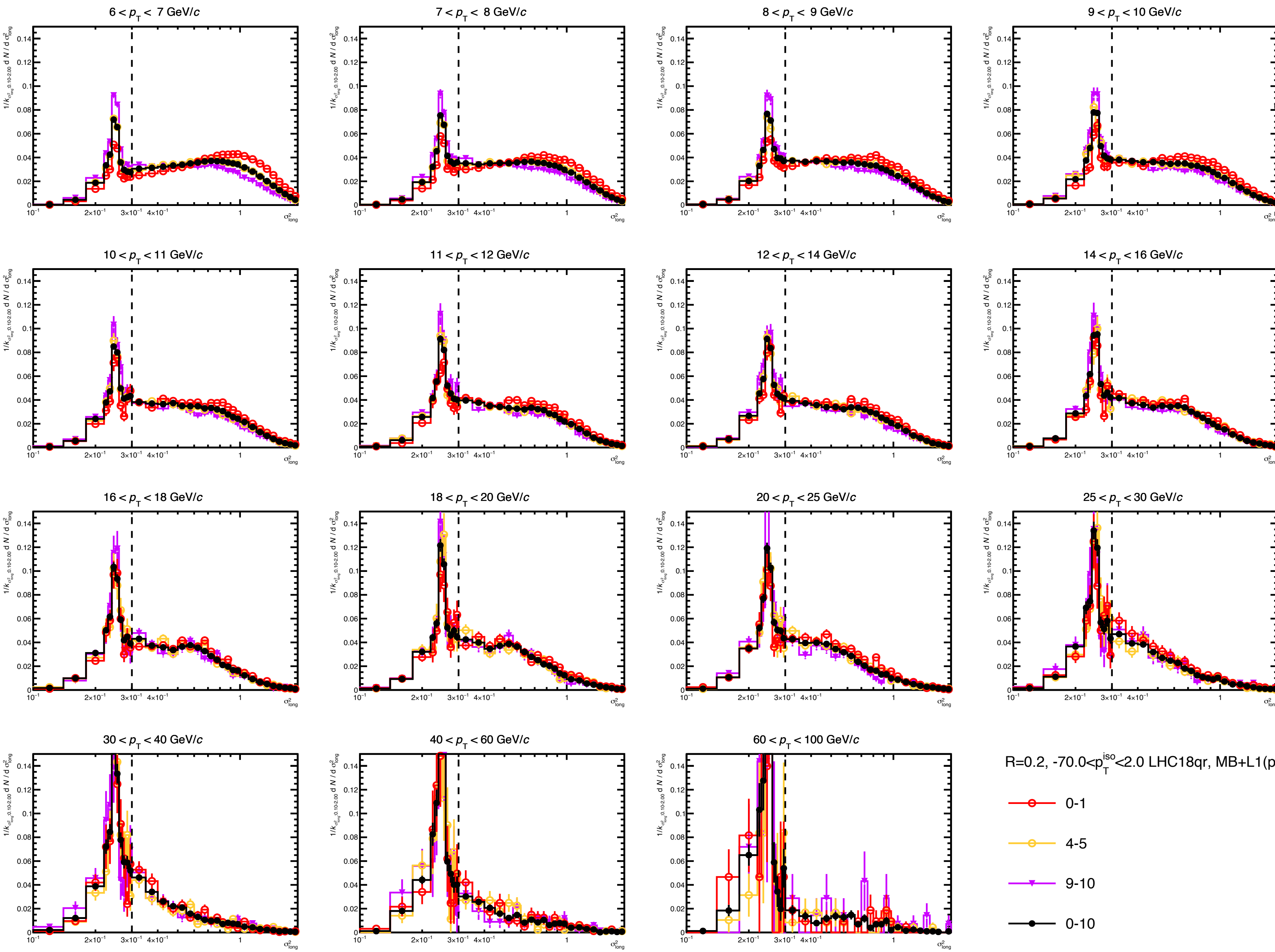
Comparison Data-MC w/out xTalk of shower shape, 50-90%, NOT isolated clusters



- Cross talk emulation better below 18-20 GeV/c, not above 20 GeV

Can we make the analysis in super-central events?

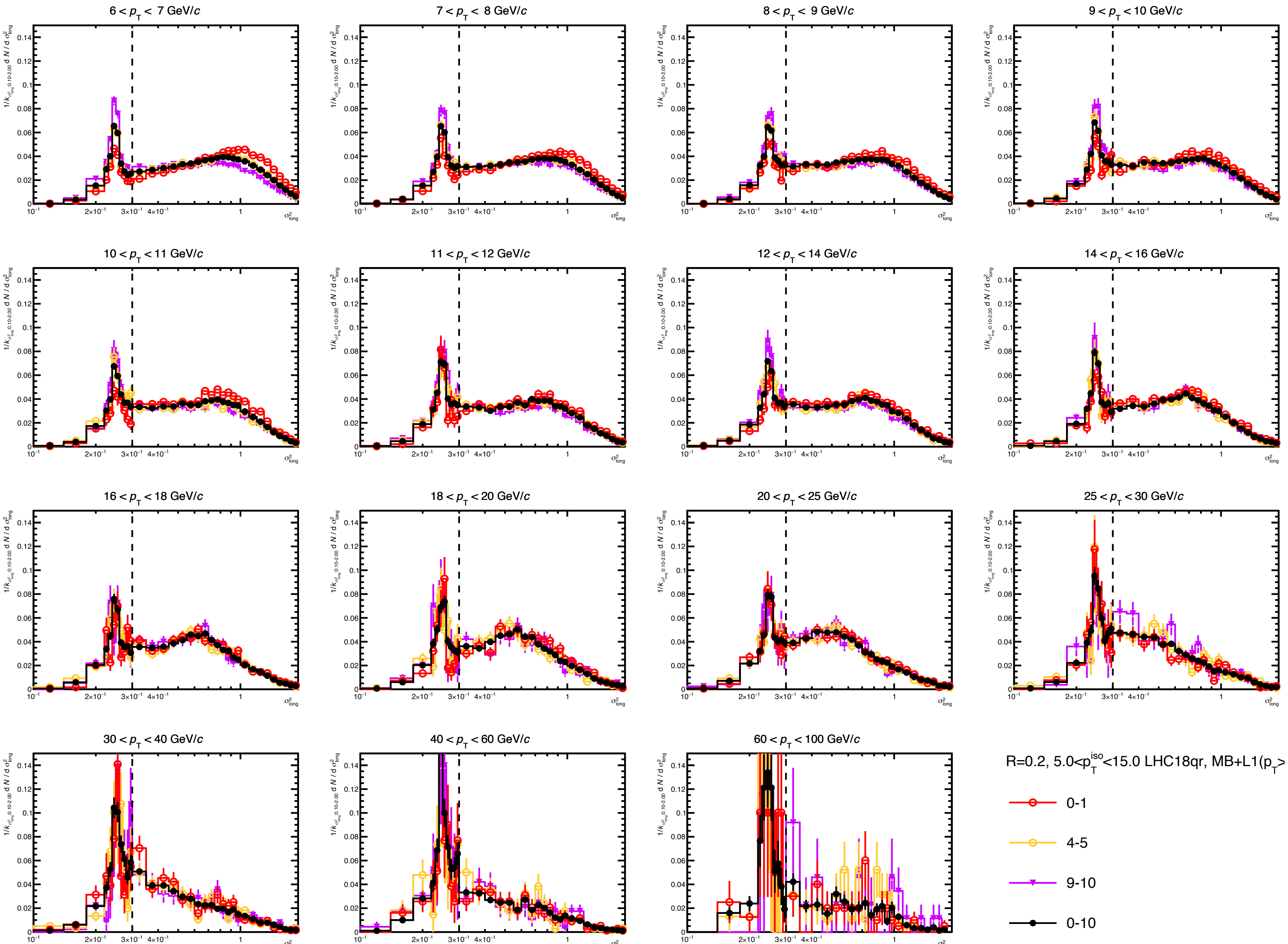


Data in fine centrality bins

<2 GeV/c isolation cut

- In 0-1% the photon peak does not disappear completely and pi0 bump is visible, so a priory no need to exclude very central events

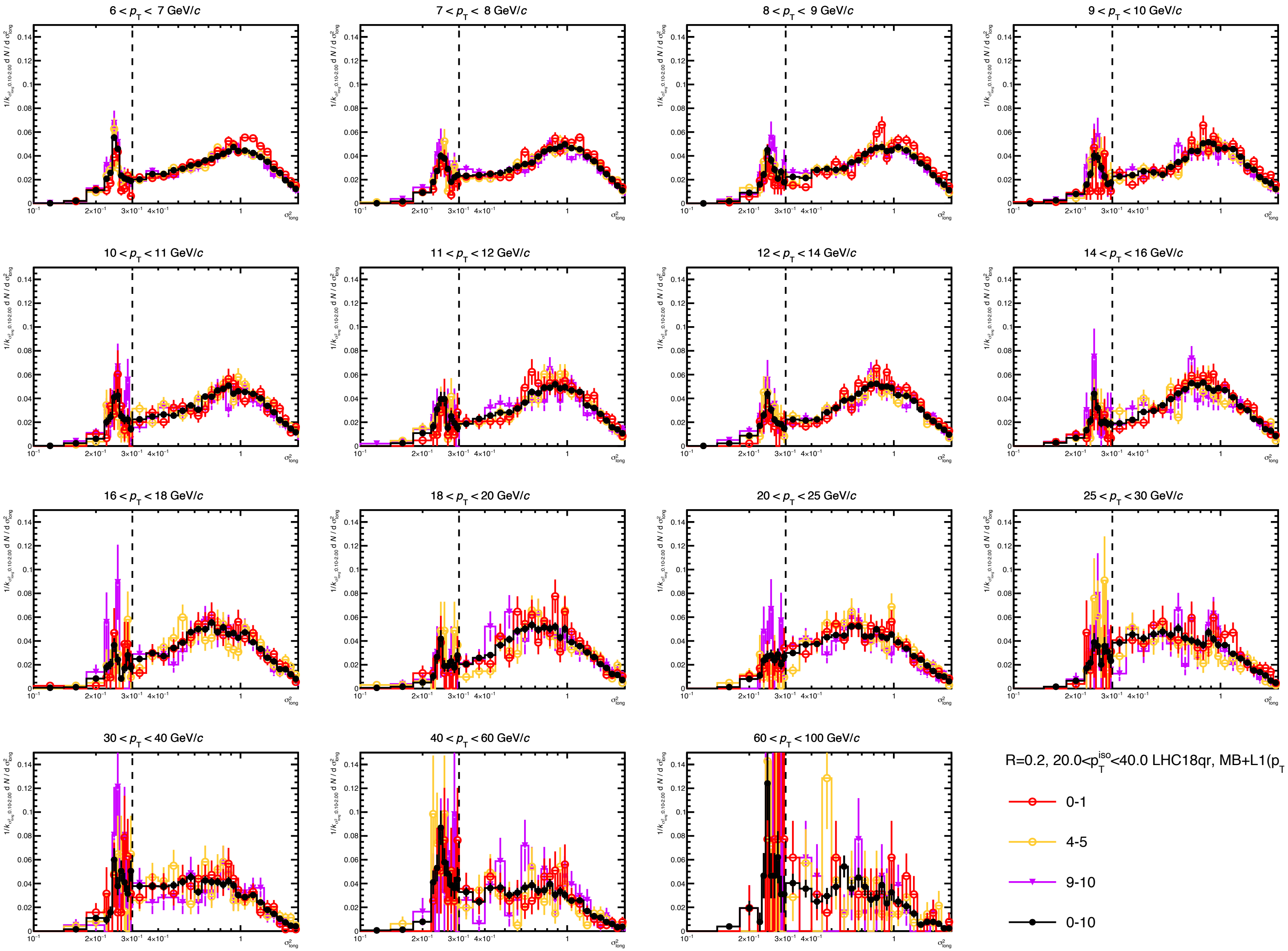
Can we make the analysis in super-central events?



5-15 GeV/c isolation cut

- In 0-1% the photon peak does not disappear completely and pi0 bump is visible, so a priory no need to exclude very central events

Can we make the analysis in super-central events?



20-40 GeV/c isolation cut

- In 0-1% the photon peak does not disappear completely and pi0 bump is visible, so a priory no need to exclude very central events