Isolated photon analysis in pp collisions at 13 TeV analysis status

--- preliminary result update

ranxu

LPSC regular meeting
12/10/2022

Last presentation

- preliminary results
  - → using EMCal+DCal as input
  - → keep default XTalk as main setting

Outline

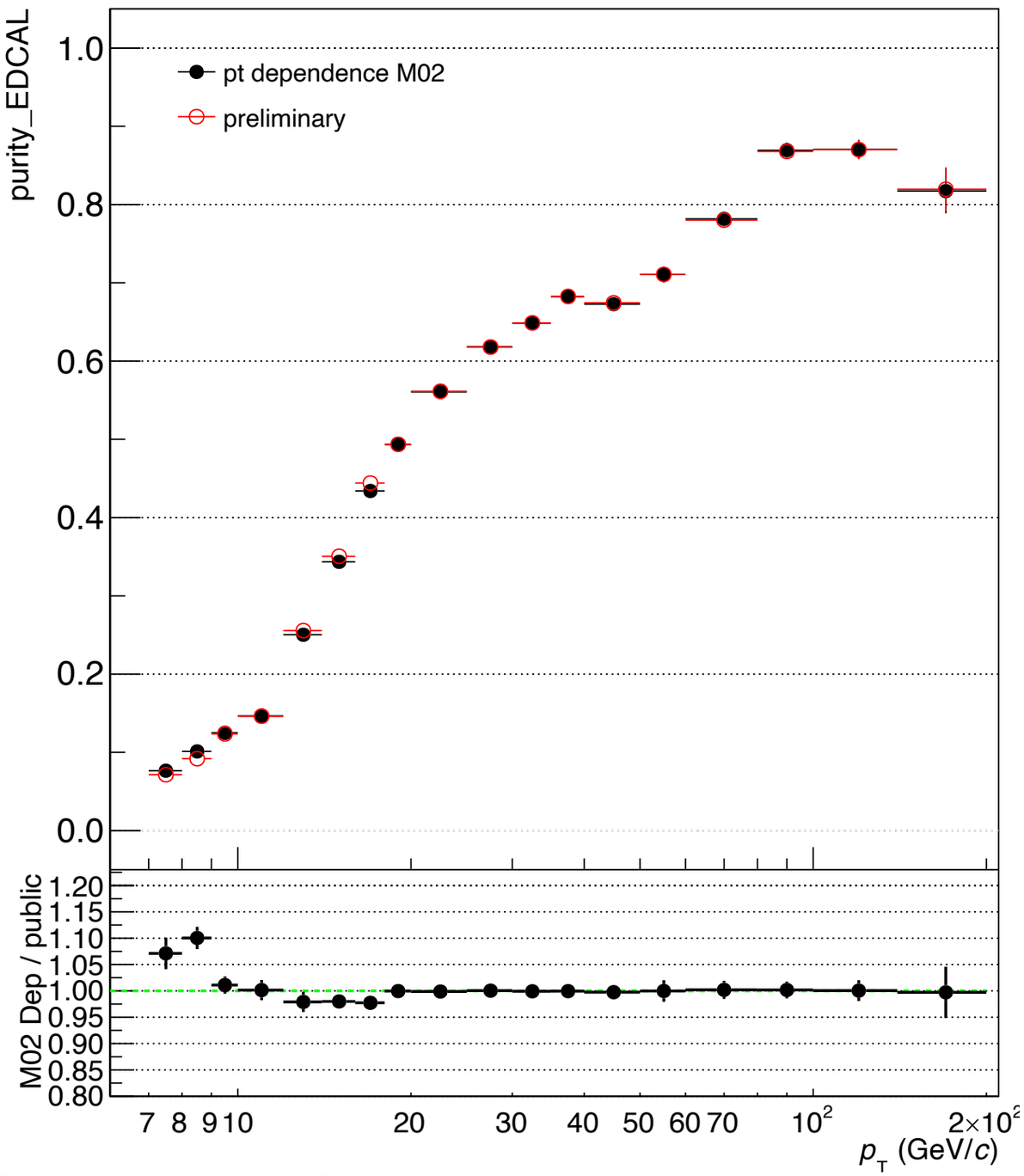
- update pt dependence shower shape cut
- SM group check

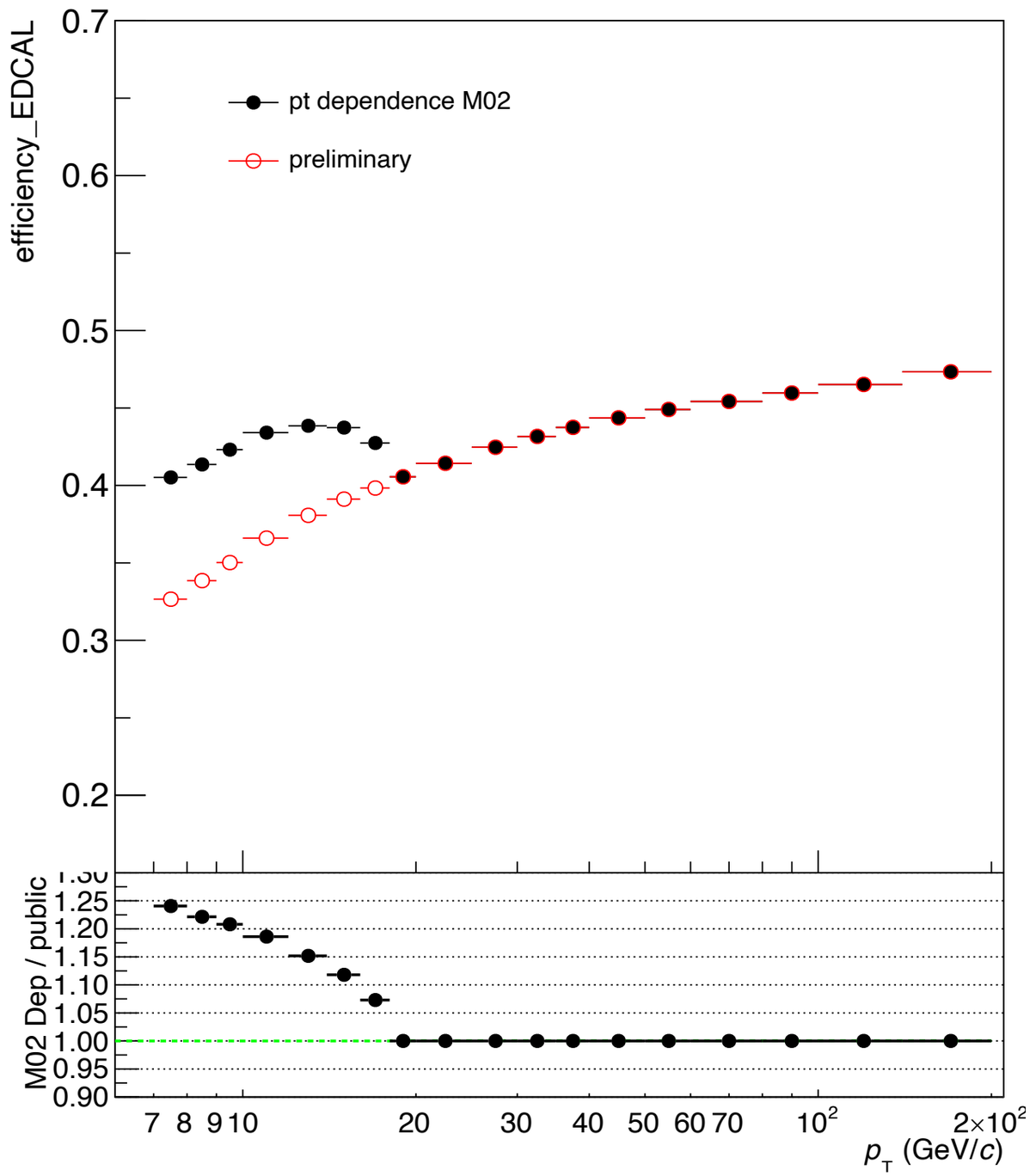
Part 1: p_{T} dependence shower shape cut

Why we want to do this?

To gain statistics at low p_{T}, check effect on 10-12 GeV/c final spectrum were there was tension with theory

Correction factor, compare to preliminary

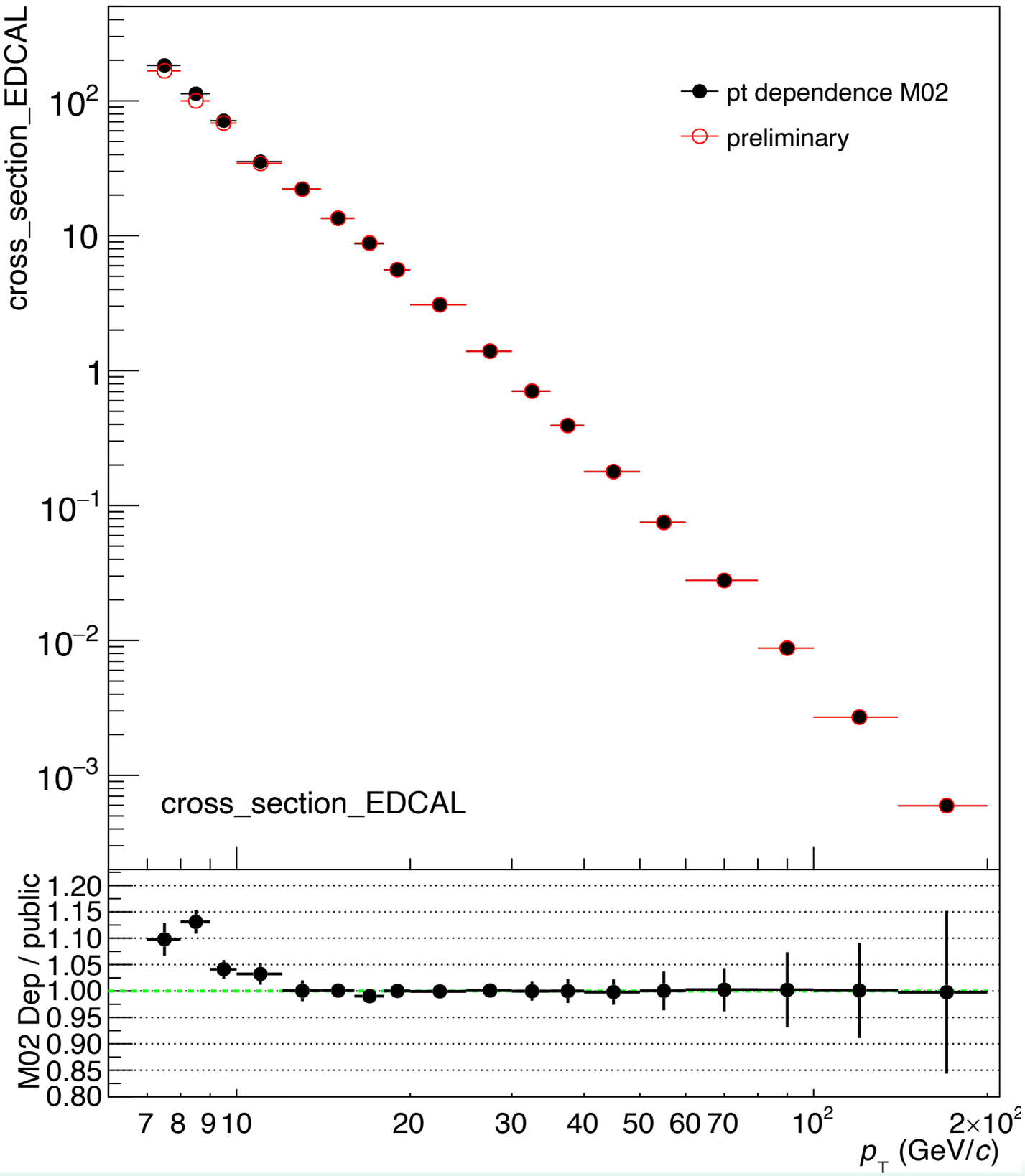




Shower shape cut func:

$$\sigma_{\gamma,min} = 0.1; \sigma_{\gamma,max} = 0.6 - 0.016 * pt \; ; pt < 20$$
$$\sigma_{\gamma,max} = 0.3 \qquad ; pt \geq 20$$
$$\sigma_{\pi^0,min} = 0.6 - 0.016 * pt + 0.1 \; ; pt < 20; \; \sigma_{\pi^0,max} = 2.0$$
$$\sigma_{\pi^0,min} = 0.3 + 0.1 \qquad ; pt \geq 20;$$

Cross section, compare to preliminary



Part 2: SMs group validation update

What update

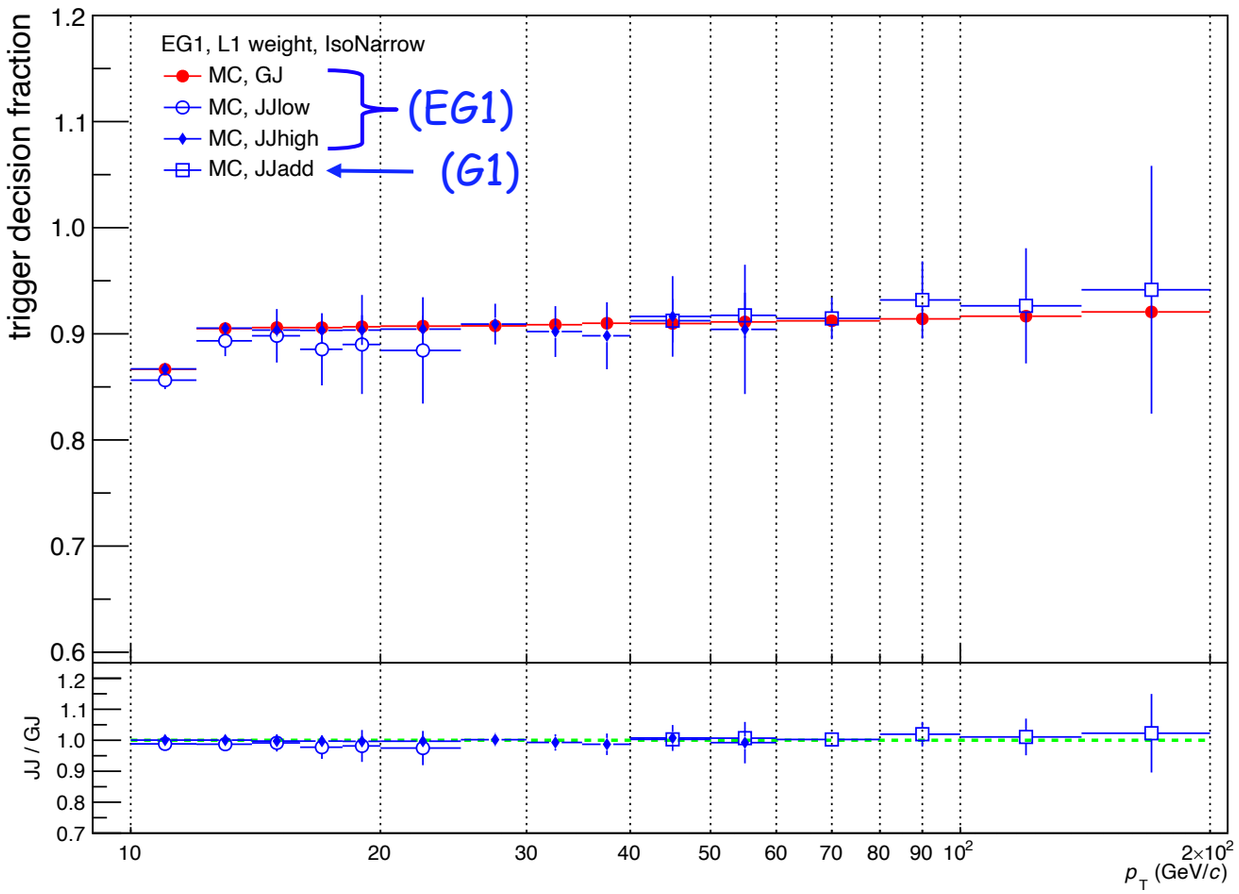
- SM group difference due to simulation respond not well. more detail here.
- 2 kind of combination scale weight:
  - Nevt from MB case, NO trigger
  - Nevt from triggered sample, trigger applied
- Decision applied in detail analysis
  - Results with final masks and weights from Gustavo → need redo analysis with this results

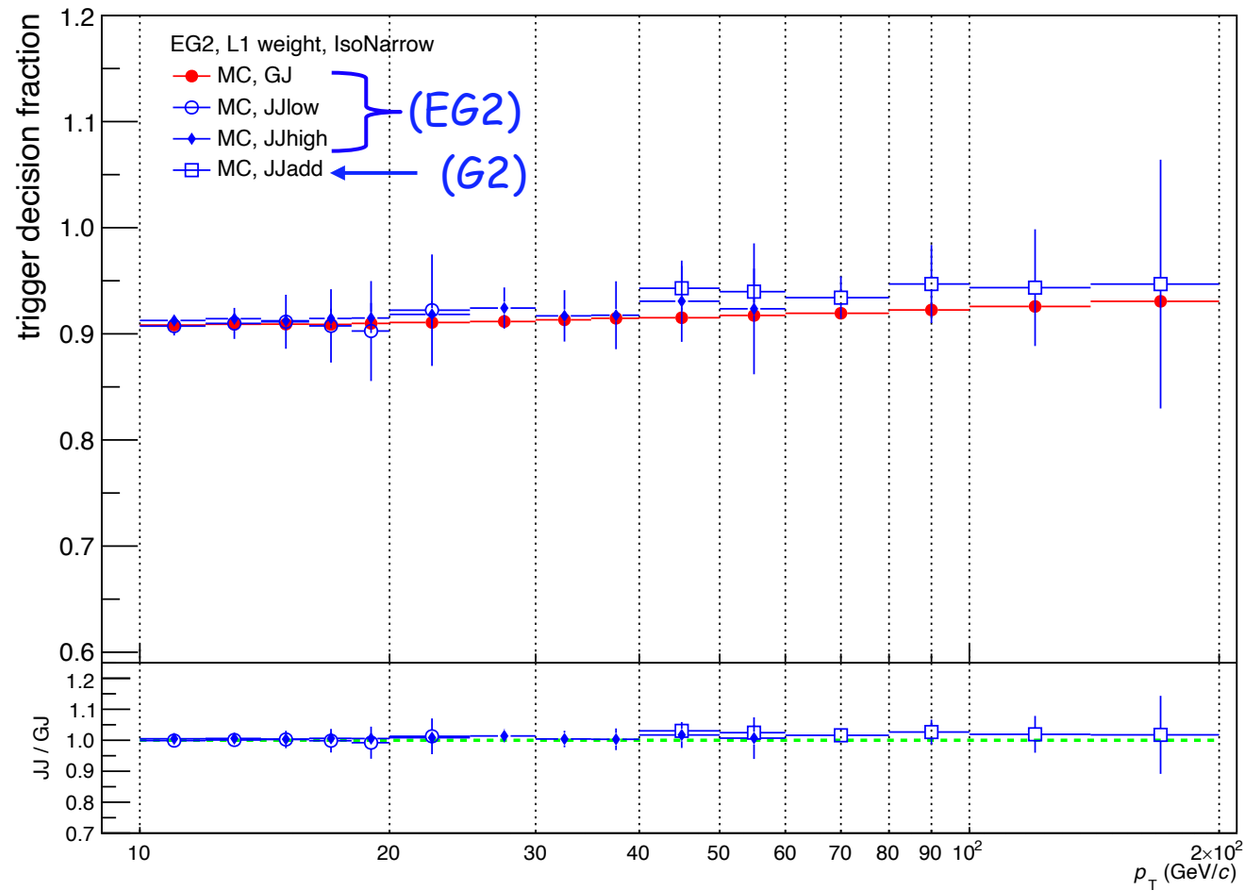
1. Check the trigger decision task works ✓
2. Apply new correction factor and compare to preliminary result
   a) correction for raw spectrum and efficiency
   b) correction effect on purity may cancelled by double ratio
   c) correction only works for trigger exist sample

Trigger decision factor, EMCal, L1 weight

EG trigger, **L1** trigger decision weight

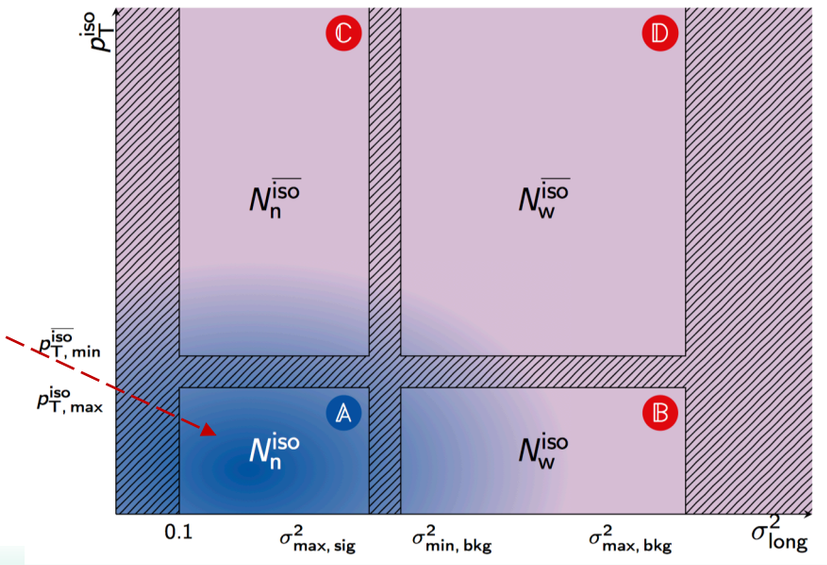
! JJadd not separate EMCal and DCal, take G1 or G2





signal region, isolated narrow cluster

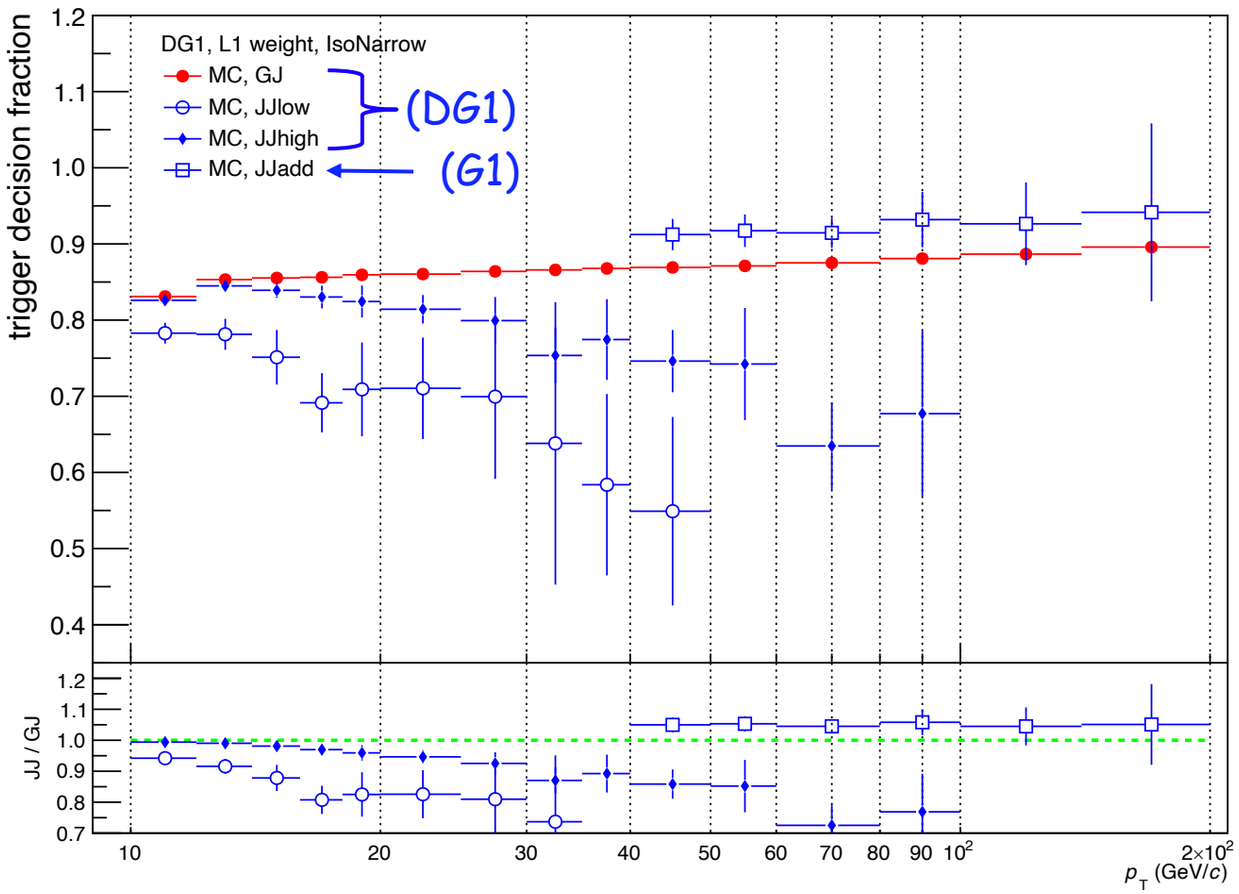
(A region)

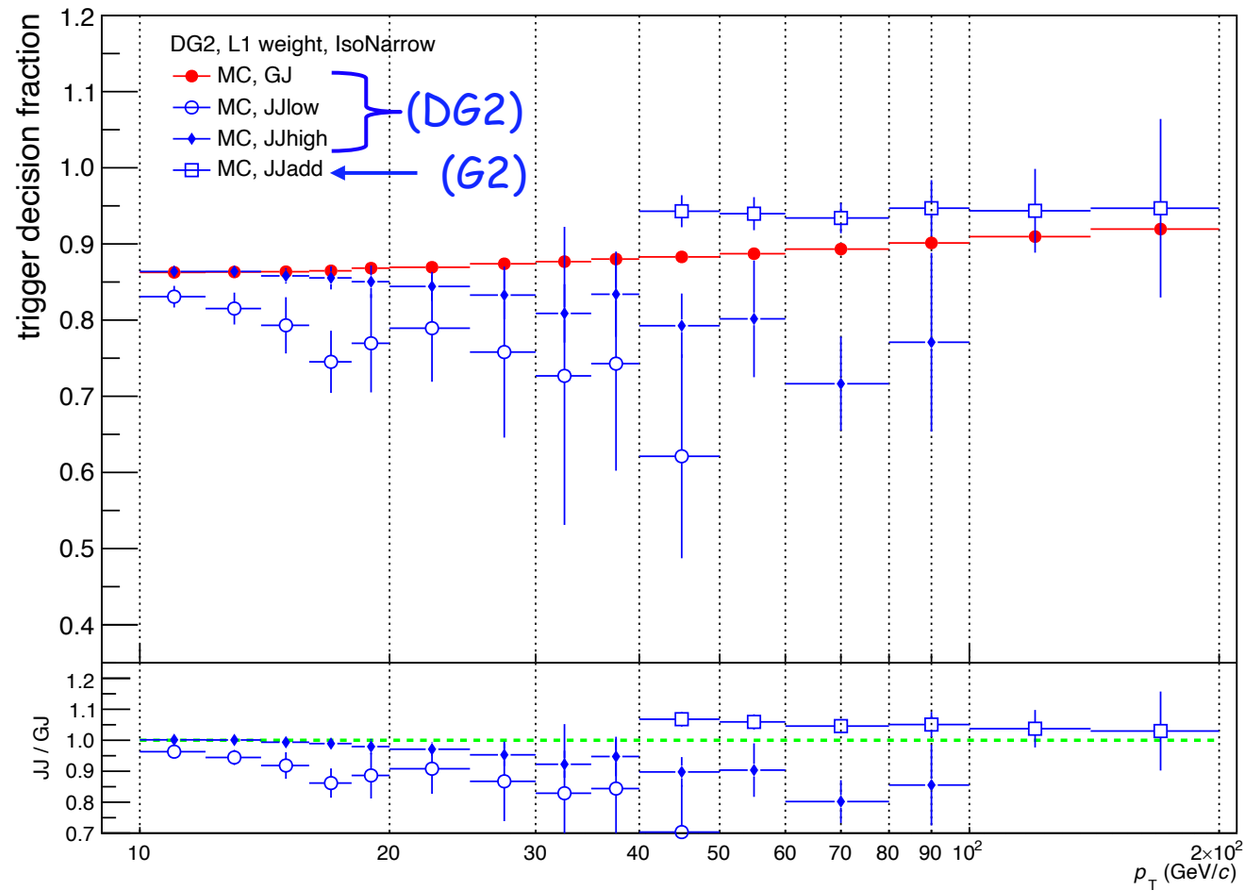


Trigger decision factor, DCal, L1 weight

DG trigger, **LI** trigger decision weight

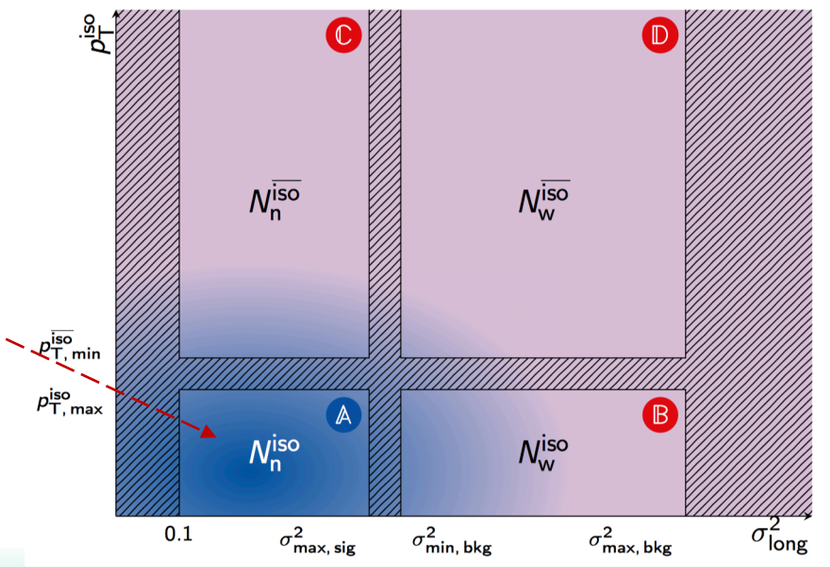
! JJadd not separate EMCal and DCal, take G1 or G2



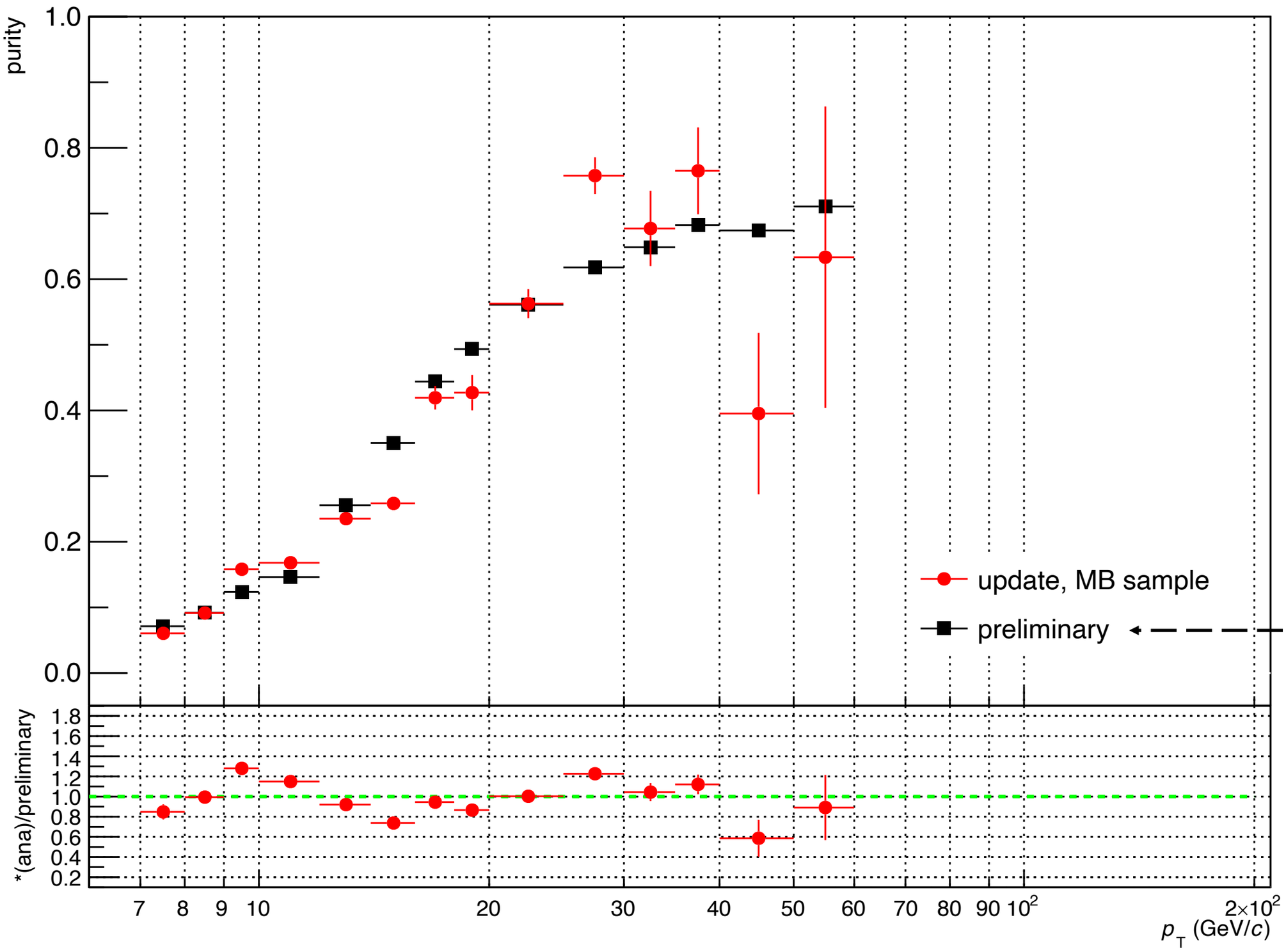


signal region, isolated narrow cluster

(A region)



Purity, compare to preliminary



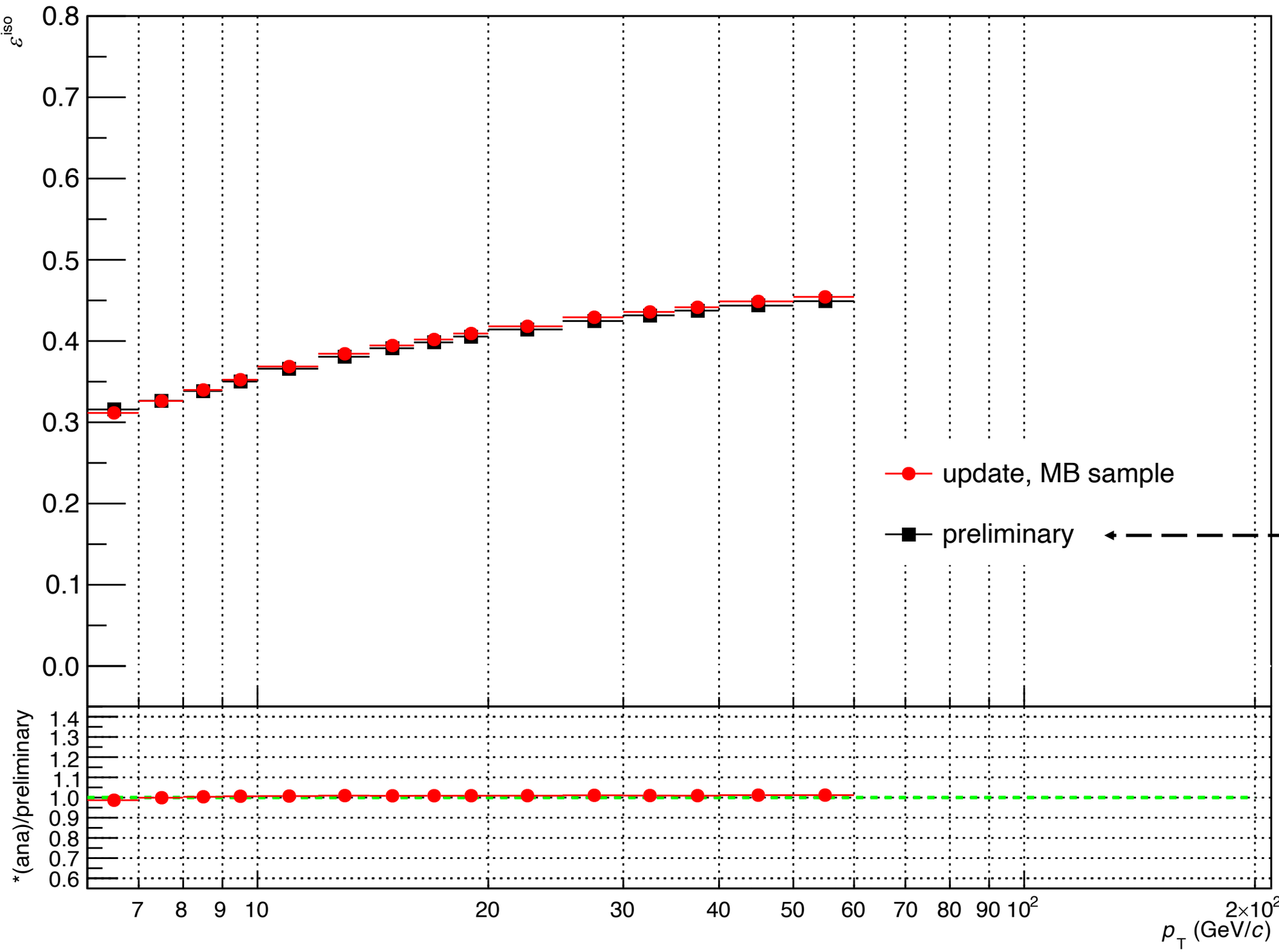
Data: full statistic

MB sample

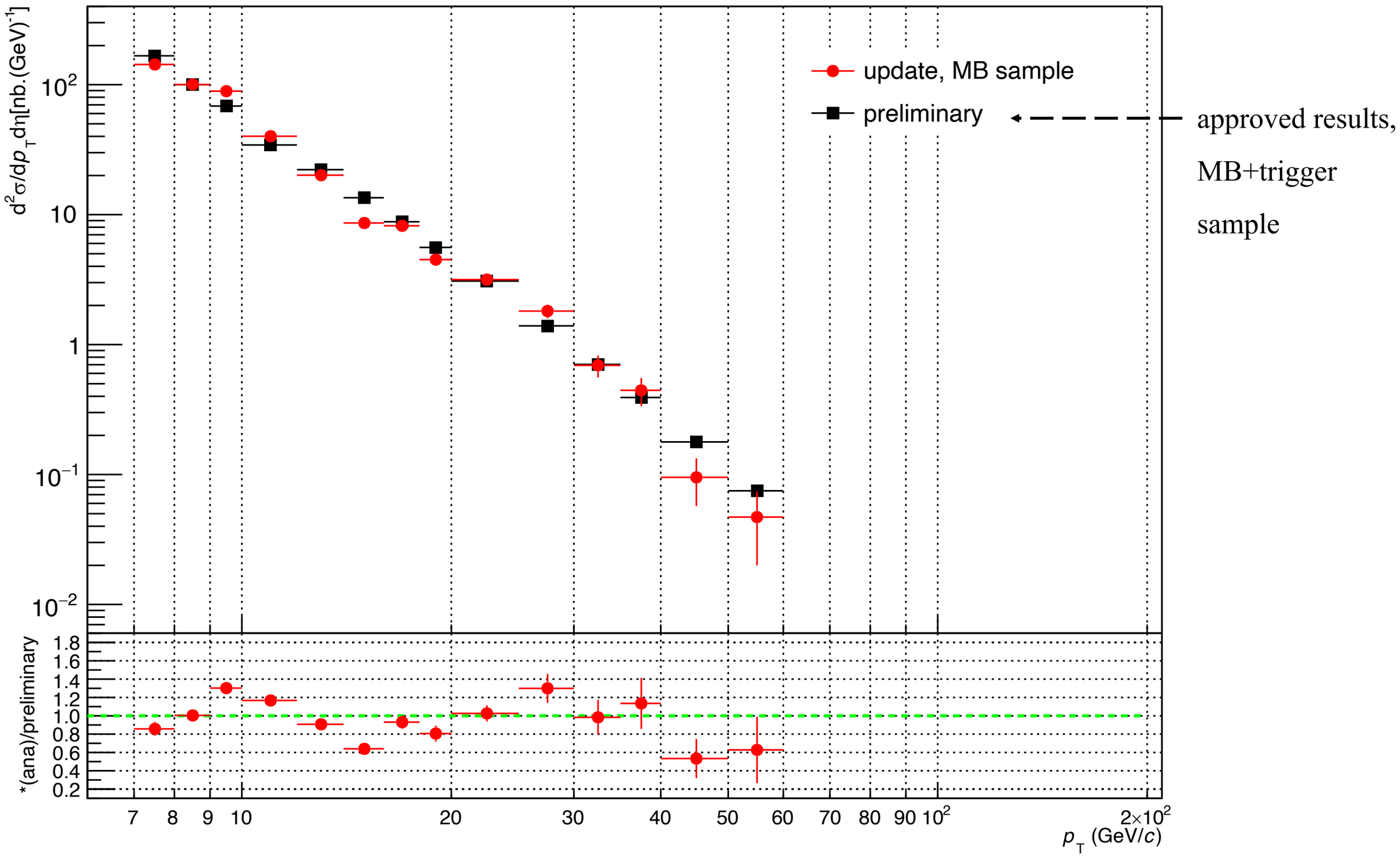
approved results, MB+trigger sample

fluctuation need more check and understand

efficiency, compare to preliminary



Cross section



fluctuation comes from purity

summary

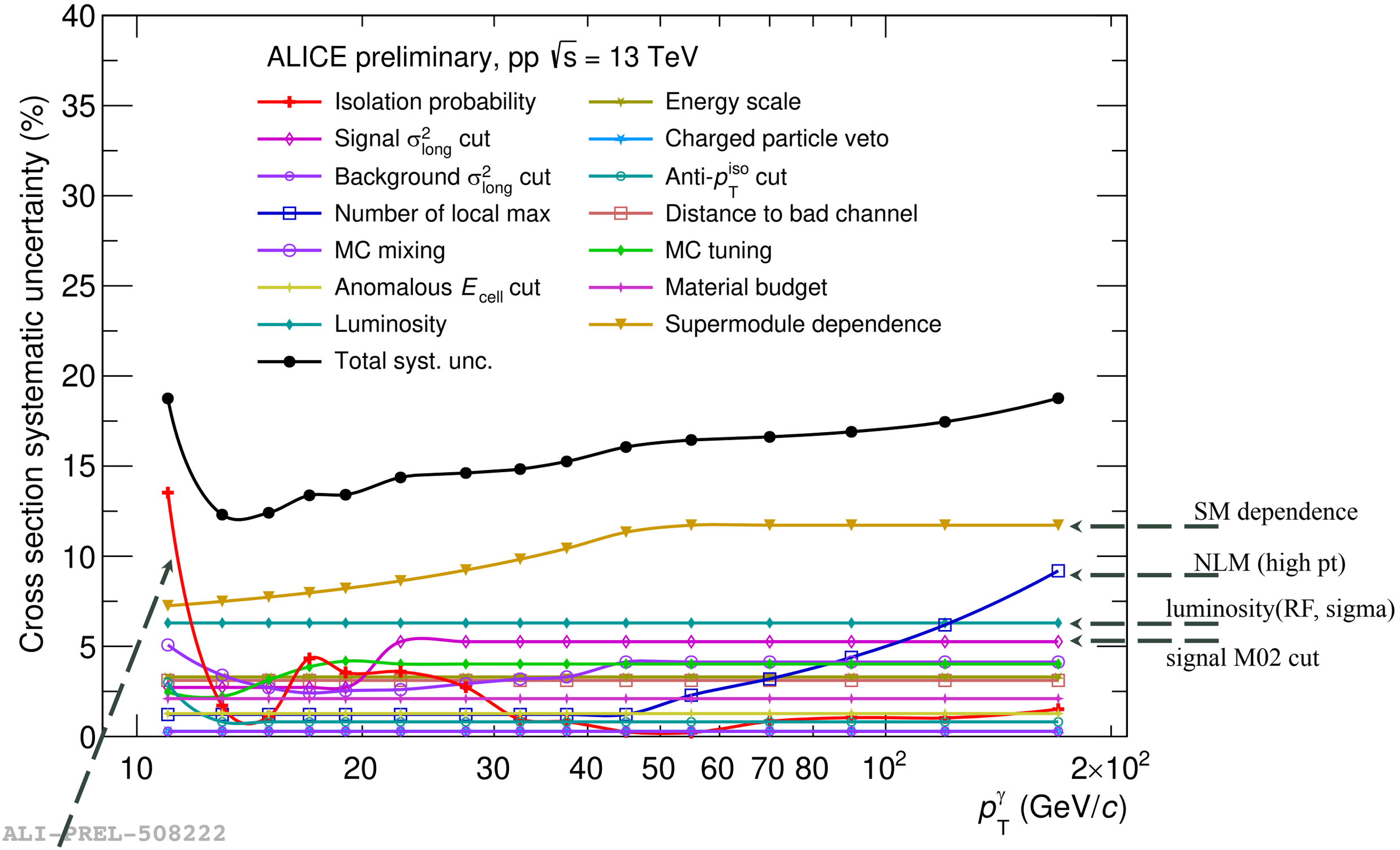
- p_T dependence shower shape cut
  - → no obviously change in purity
  - → obviously changed in efficiency due to shower shape cut change
  - → not changed in final cross section
- SM group applied
  - → the MB results has fluctuation which comes from purity, need further check and understand.

Next step

- Applied trigger decision factor for triggered case
- Update analysis result uncertainty
- Prepare paper proposal, need a published paper to defense in China
- Thesis preparation
  - thesis plan
  - thesis outline

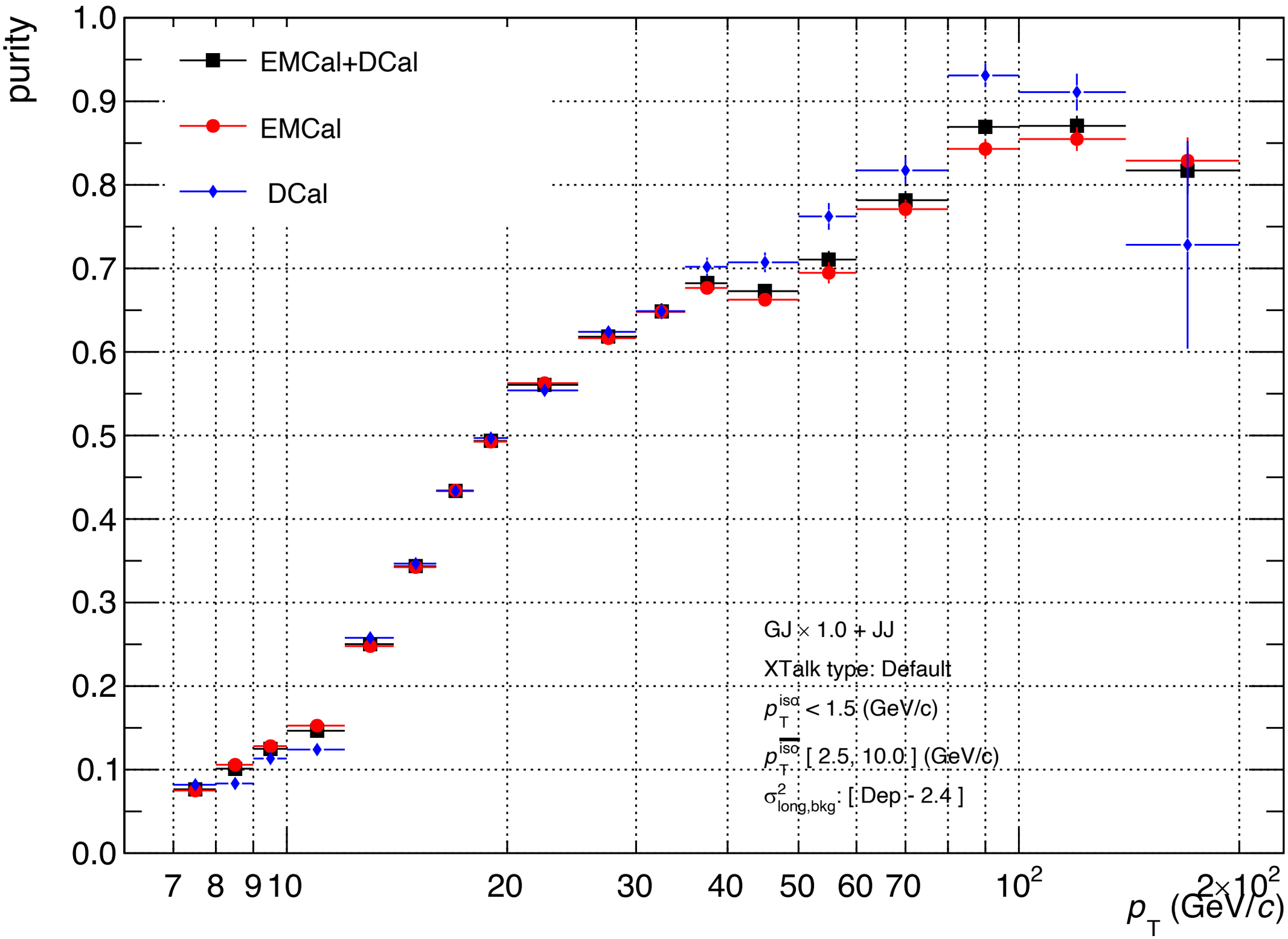
Back up

Systematic uncertainty

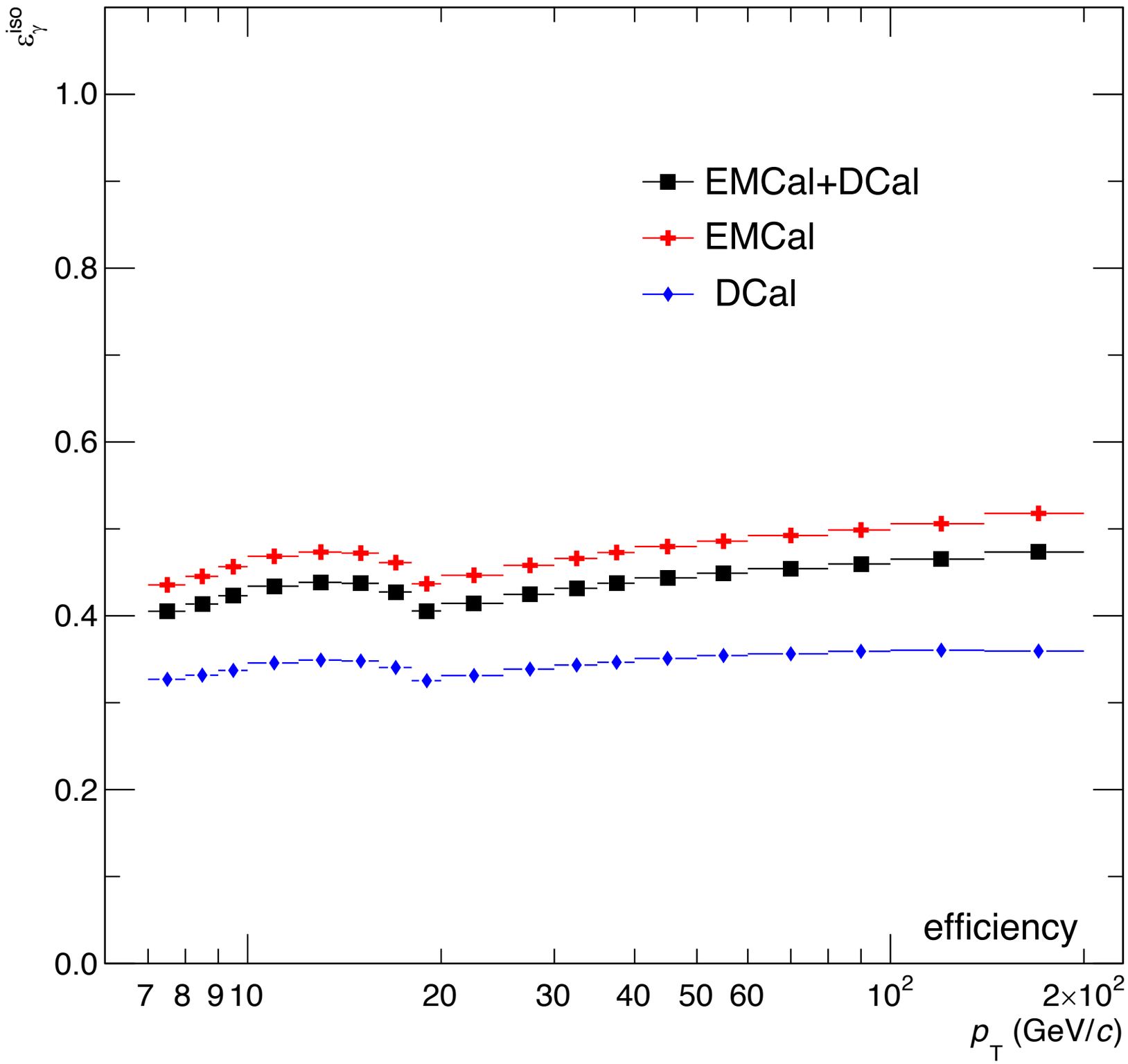


Isolation probability (alpha factor)

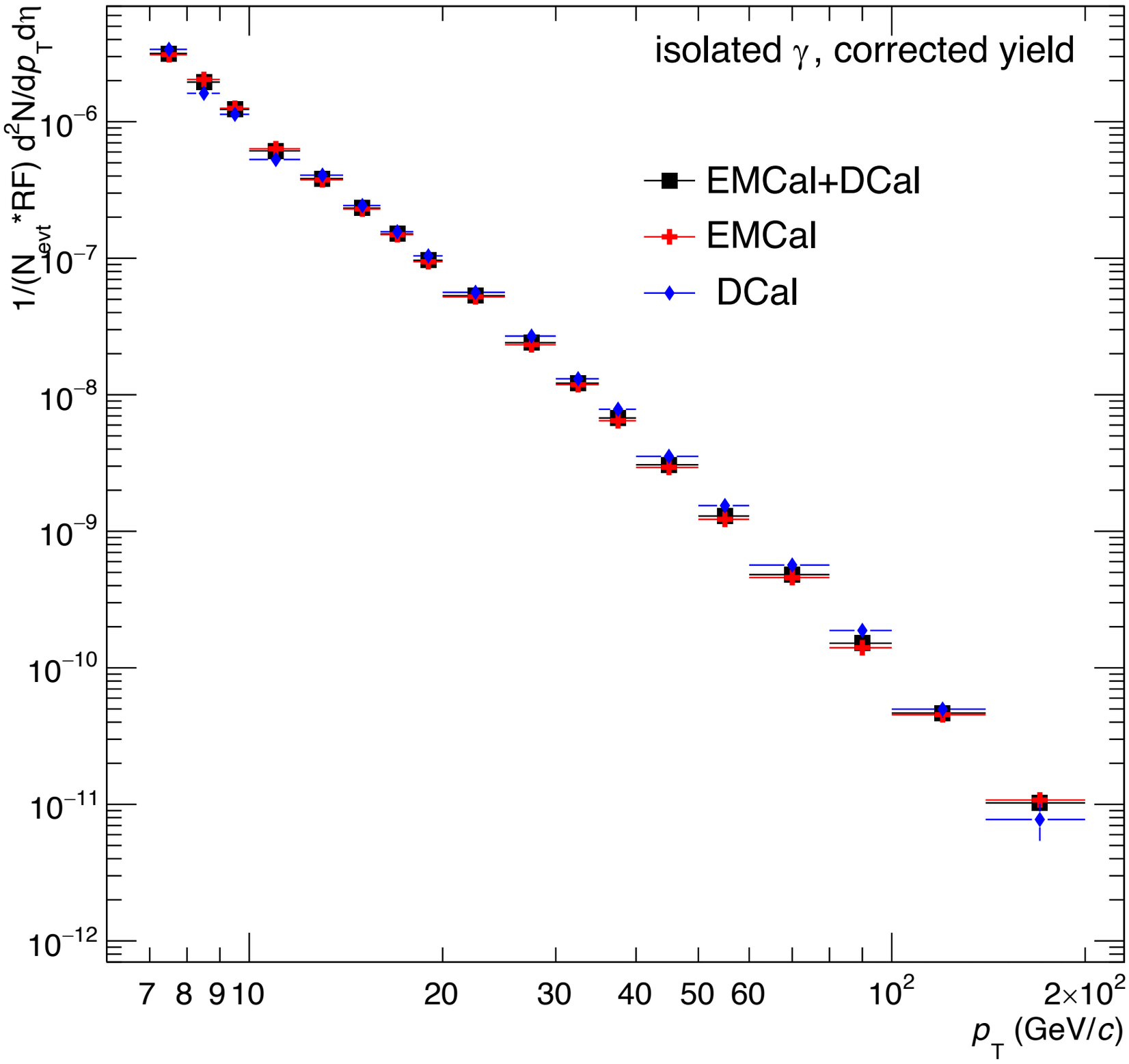
P_T dependence M02 cut: purity



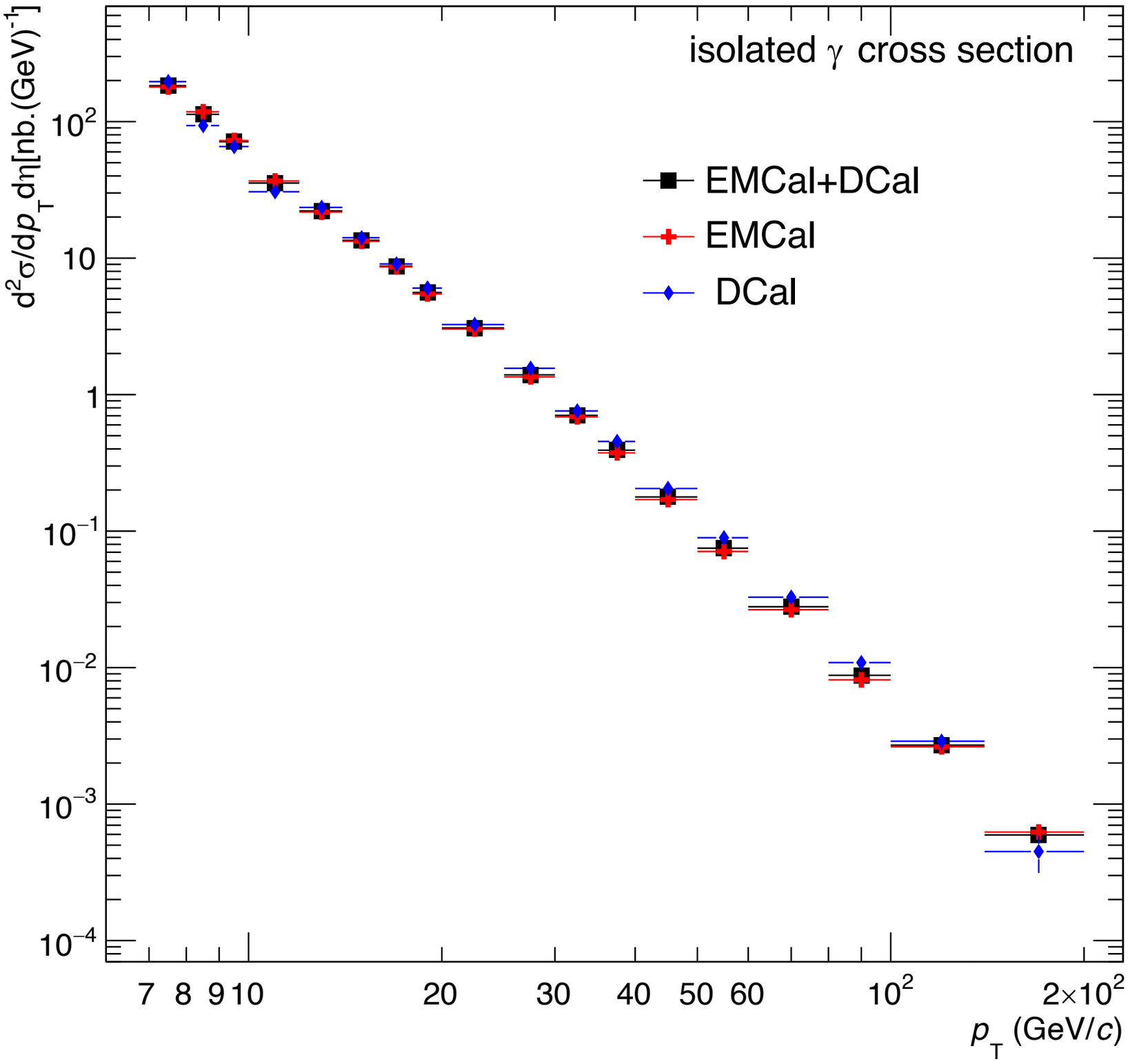
P_T dependence M02 cut: efficiency



P_T dependence M02 cut: yield



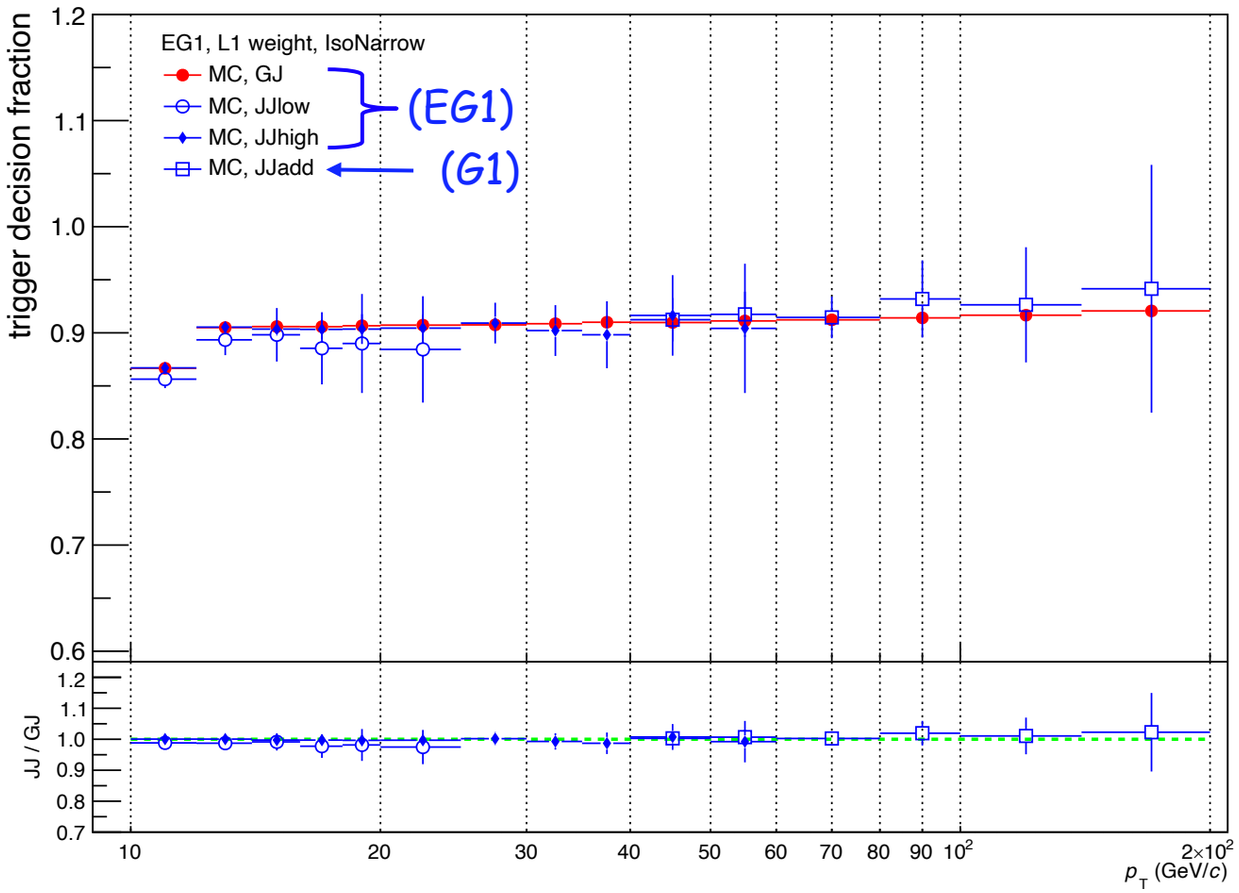
P_T dependence M02 cut: cross section

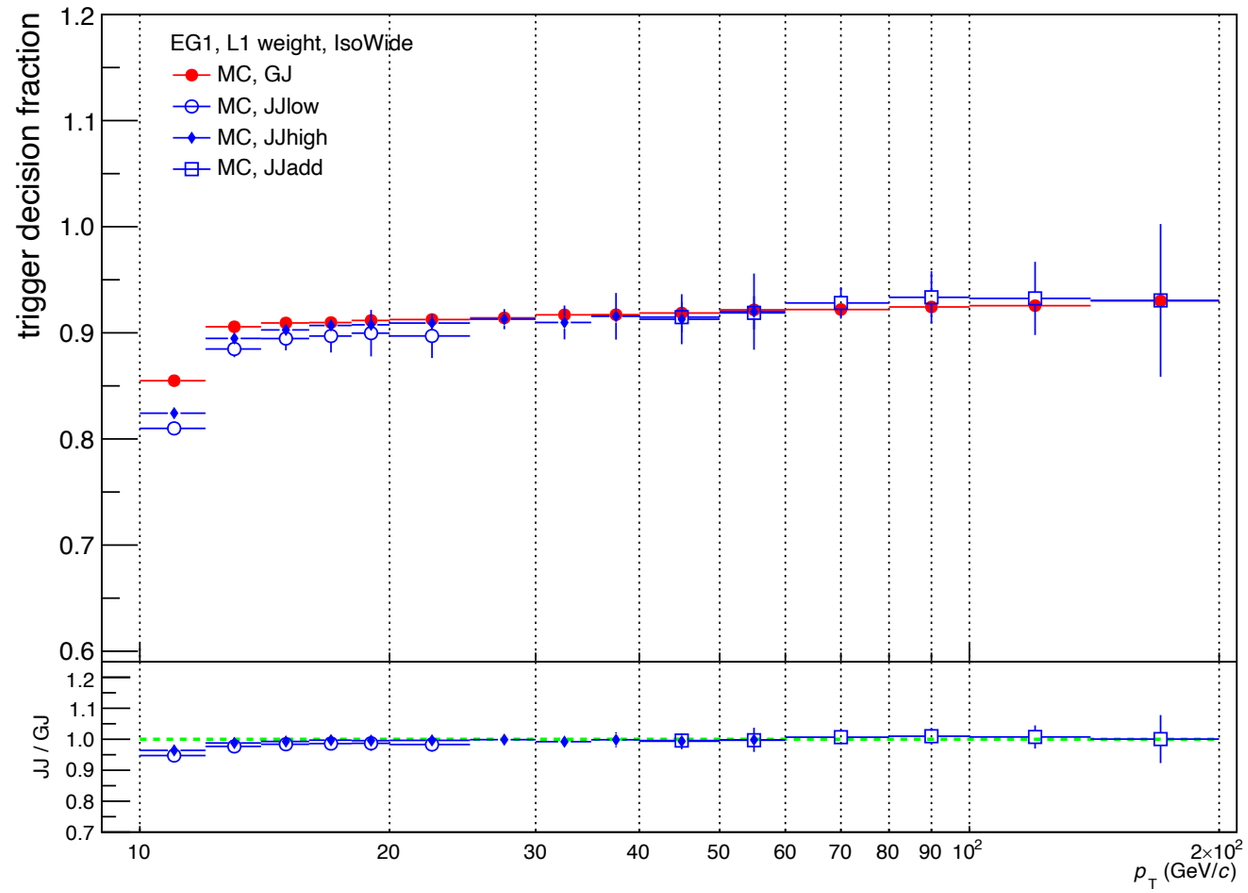


Trigger decision factor, EG1, L1 weight, isolated part

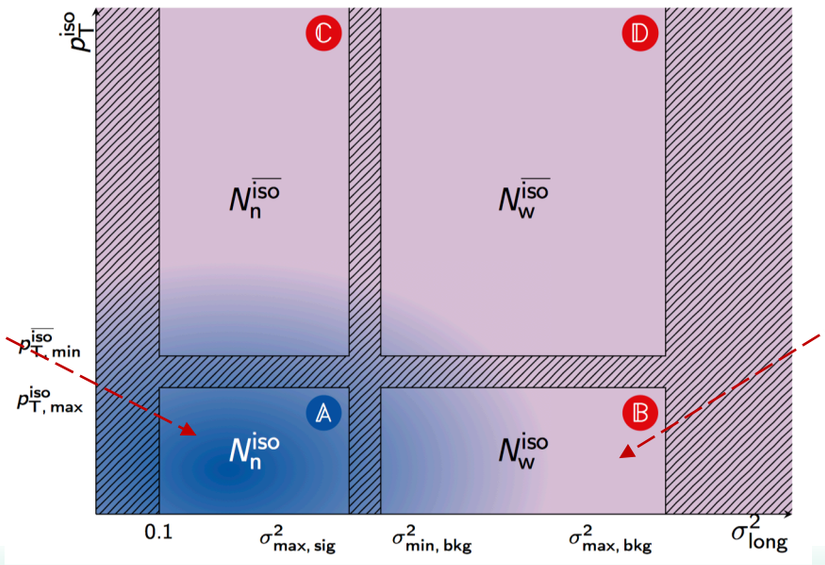
EG1 trigger, **L1** trigger decision weight

! JJadd not separate EMCal and DCal, take G1





A region, isolated narrow cluster
(signal region)

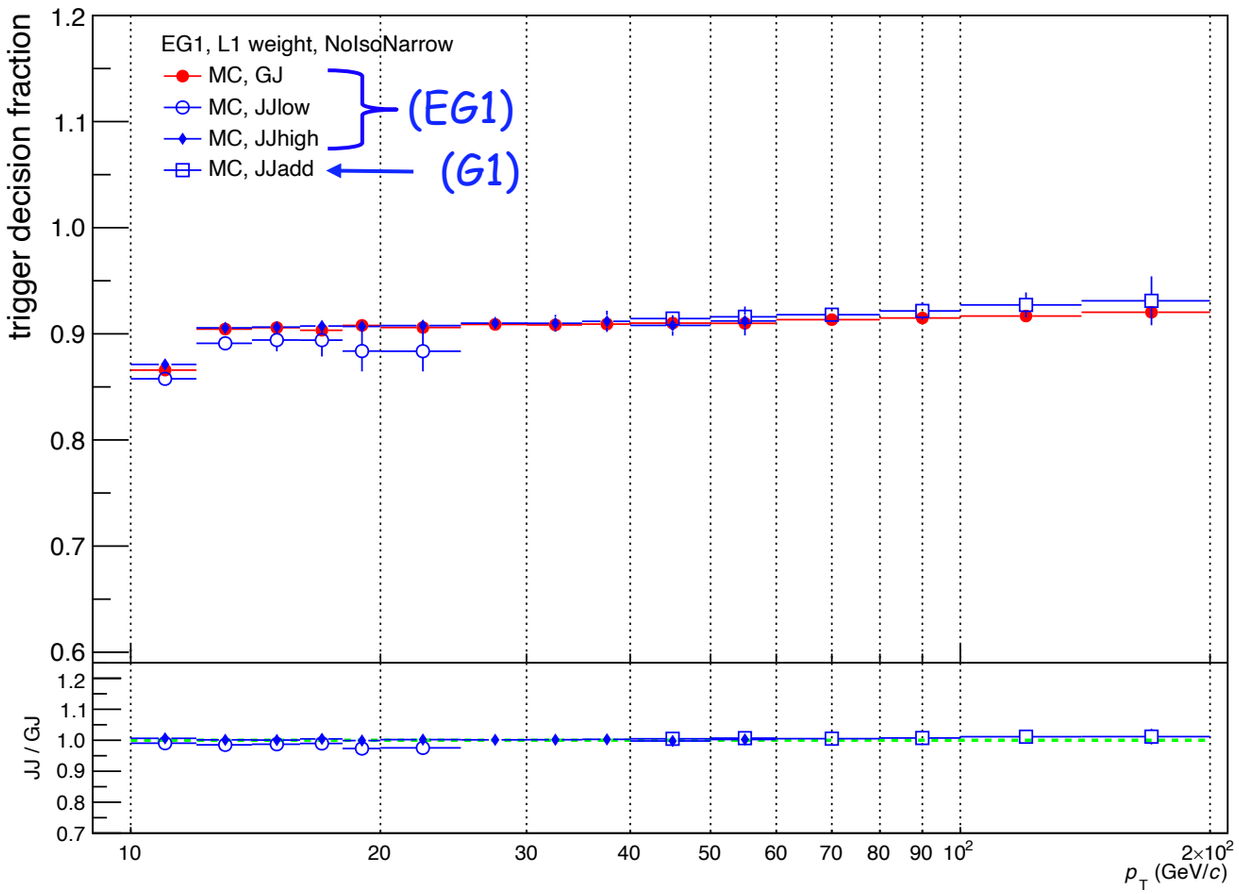


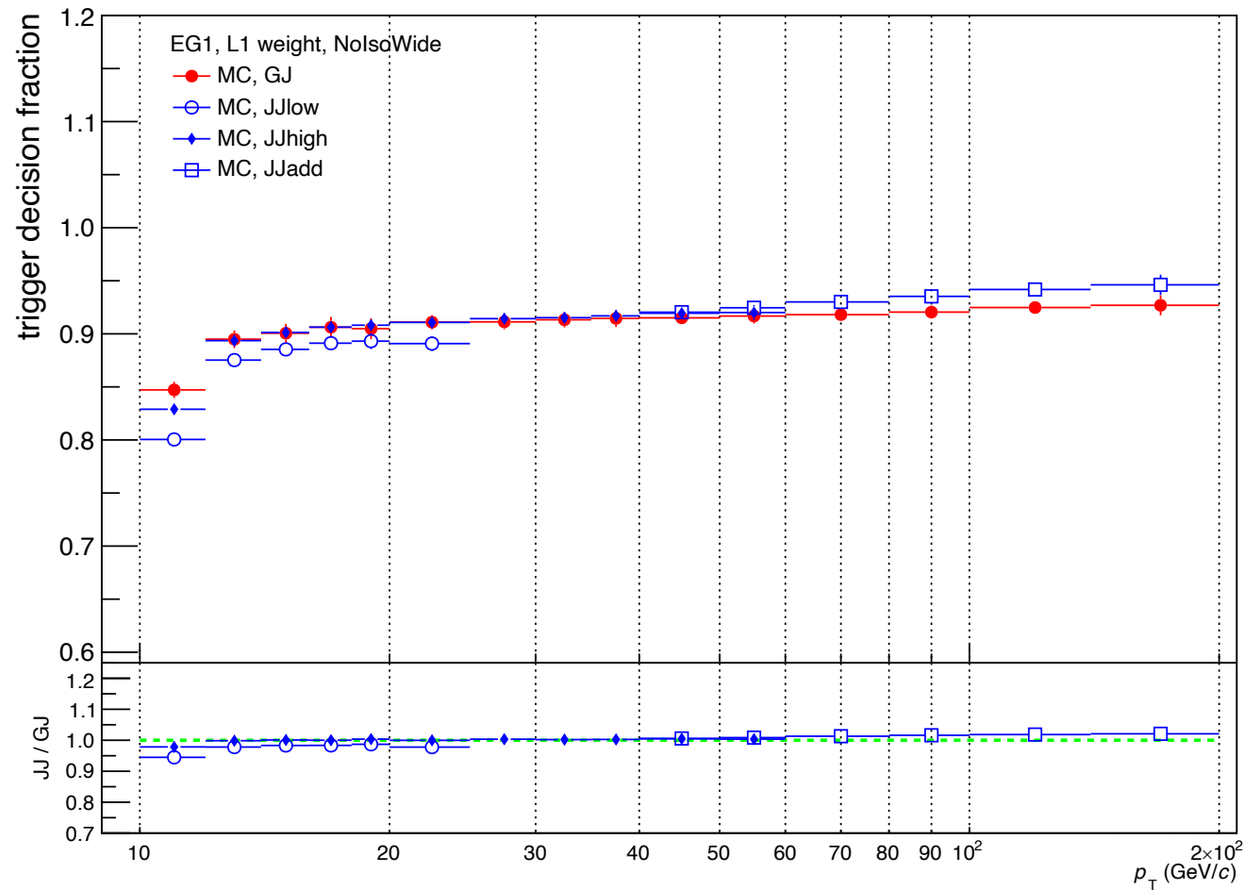
B region, isolated wide cluster
(background region)

Trigger decision factor, EG1, L1 weight, no-isolated part

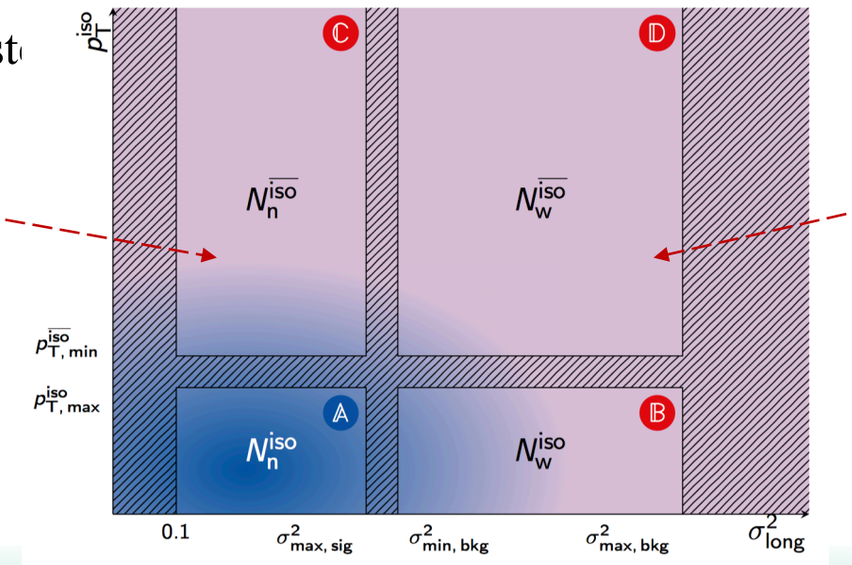
EG1 trigger, **L1** trigger decision weight

! JJadd not separate EMCal and DCal, take G1





C region, no-isolated narrow clust
(background region)

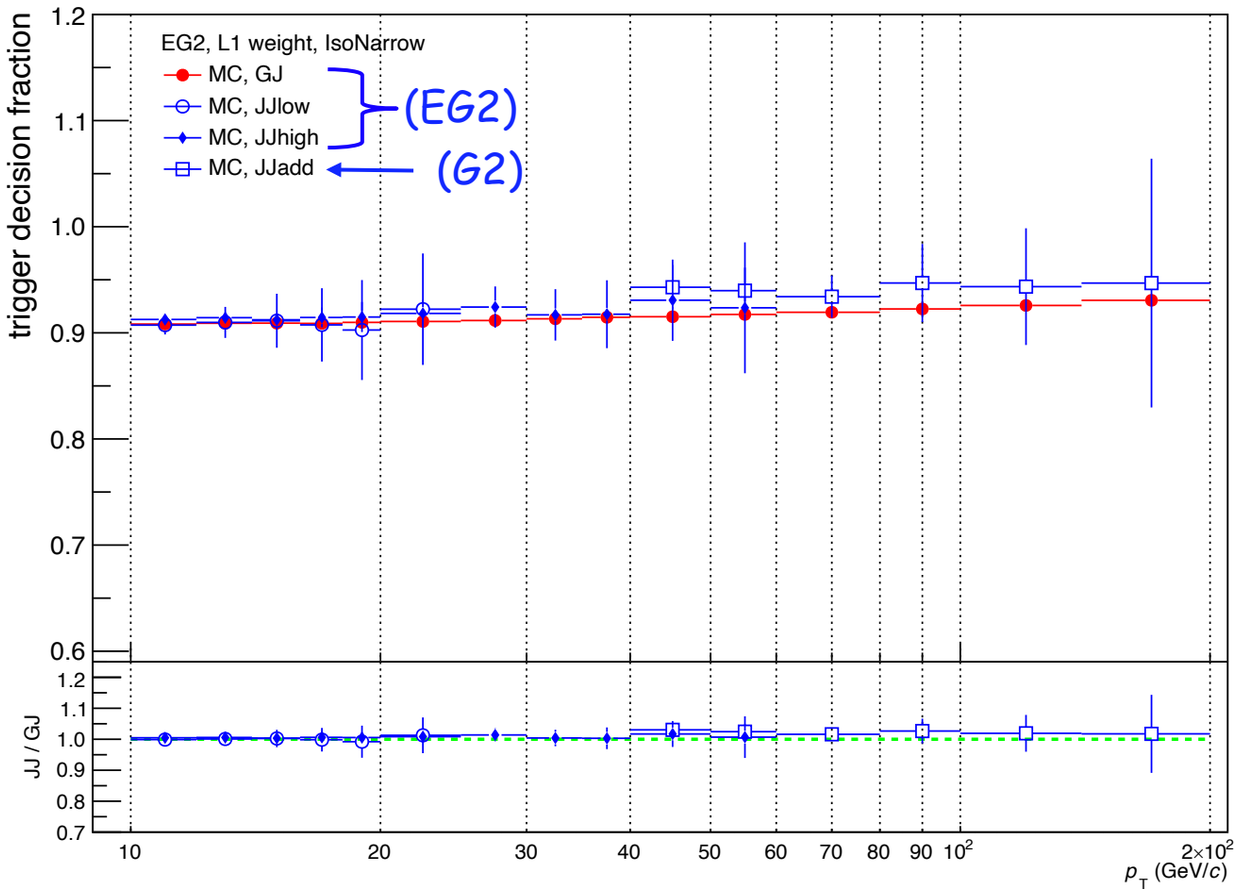


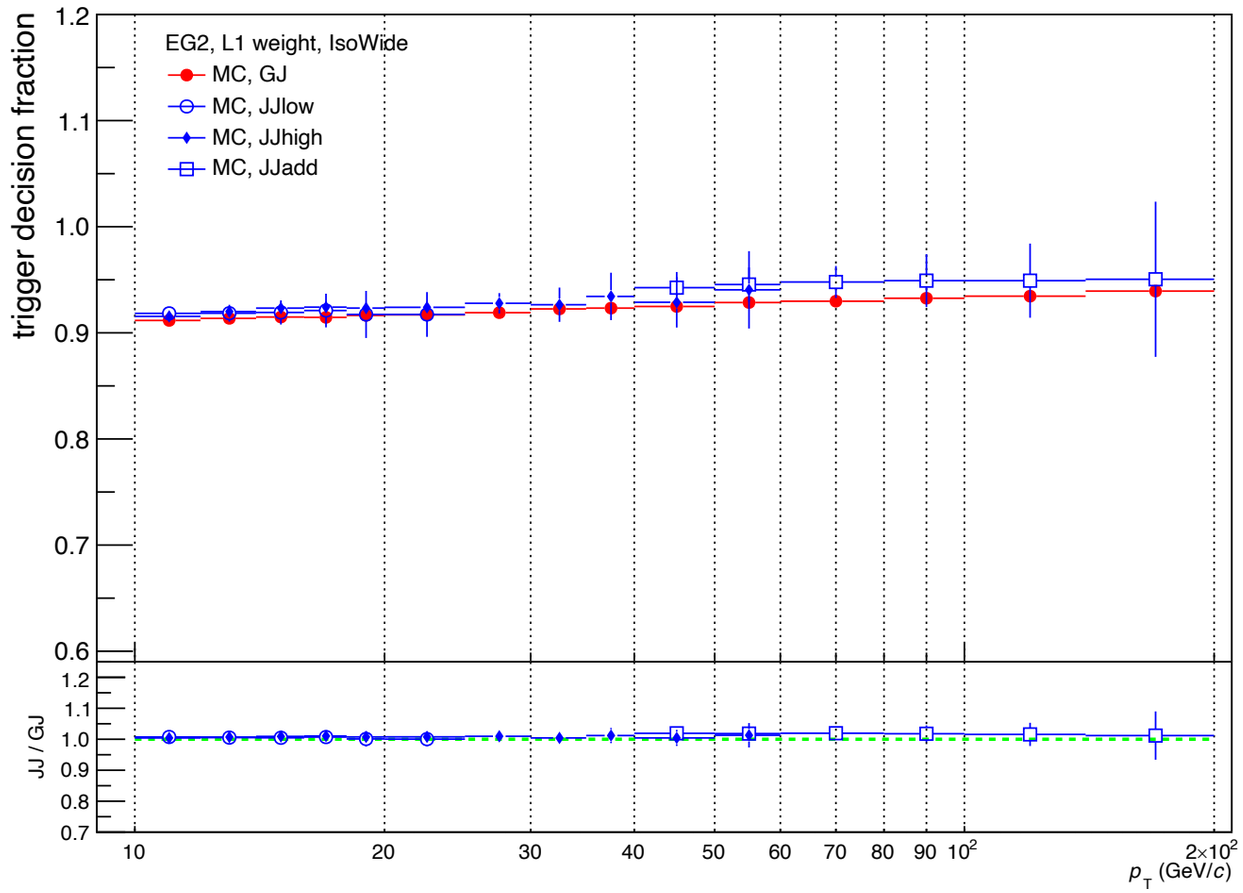
D region, no-isolated wide cluster
(background region)

Trigger decision factor, EG2, L1 weight, isolated part

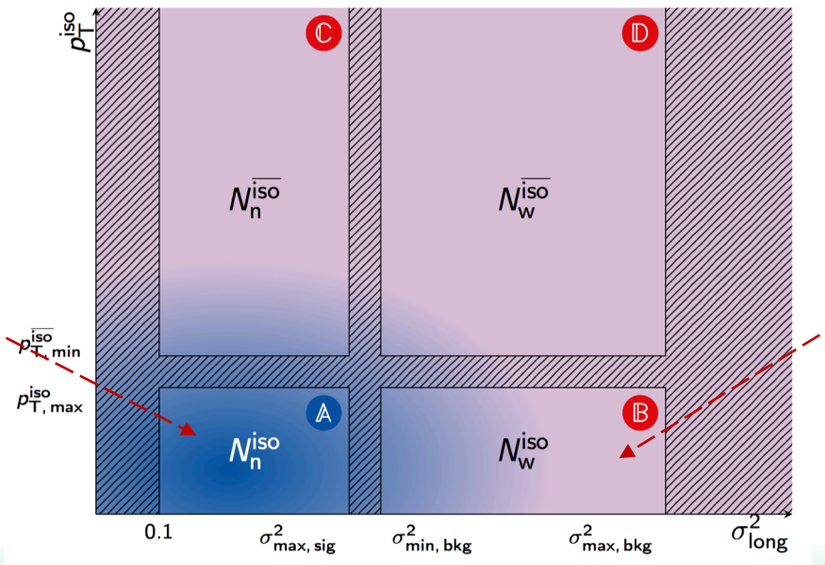
EG2 trigger, **L1** trigger decision weight

! JJadd not separate EMCal and DCal, take G2





A region, isolated narrow cluster
(signal region)

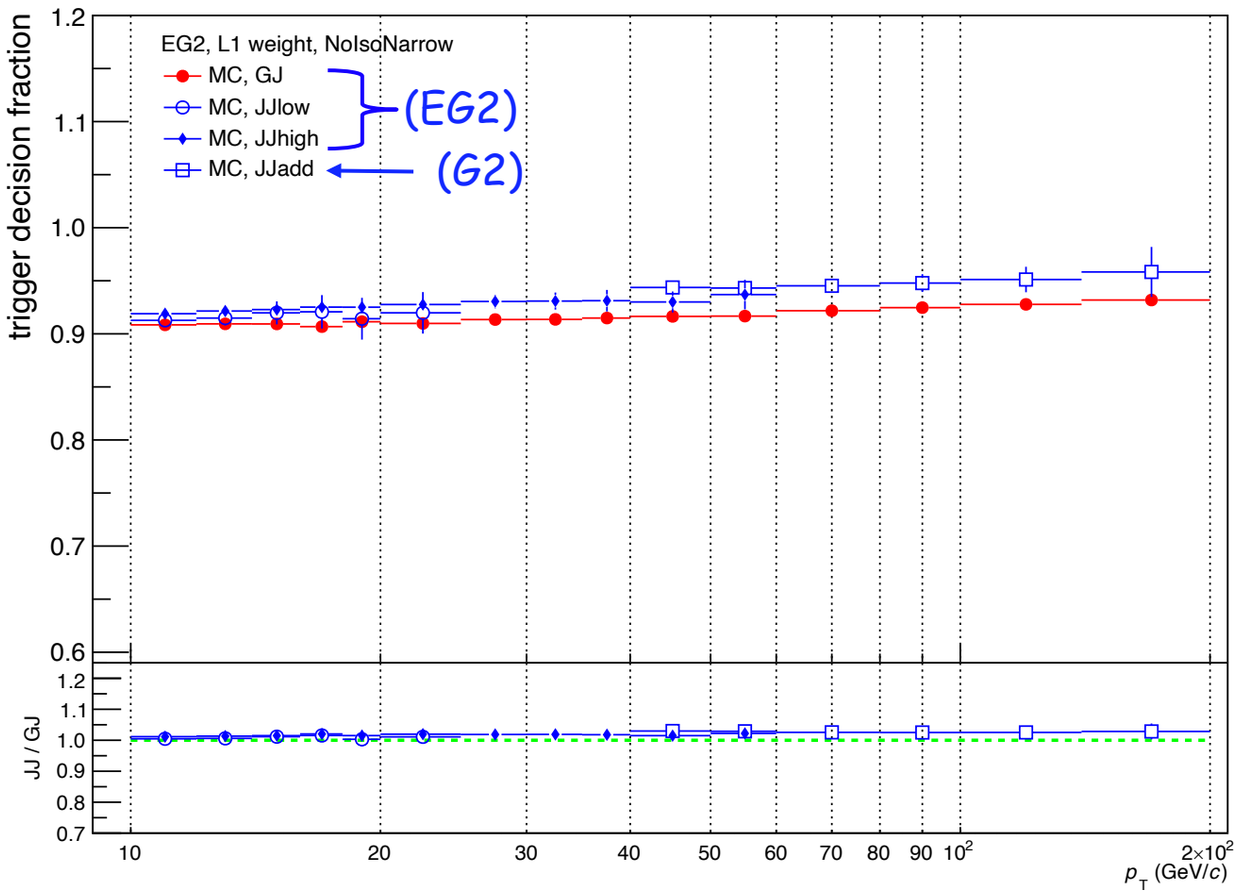


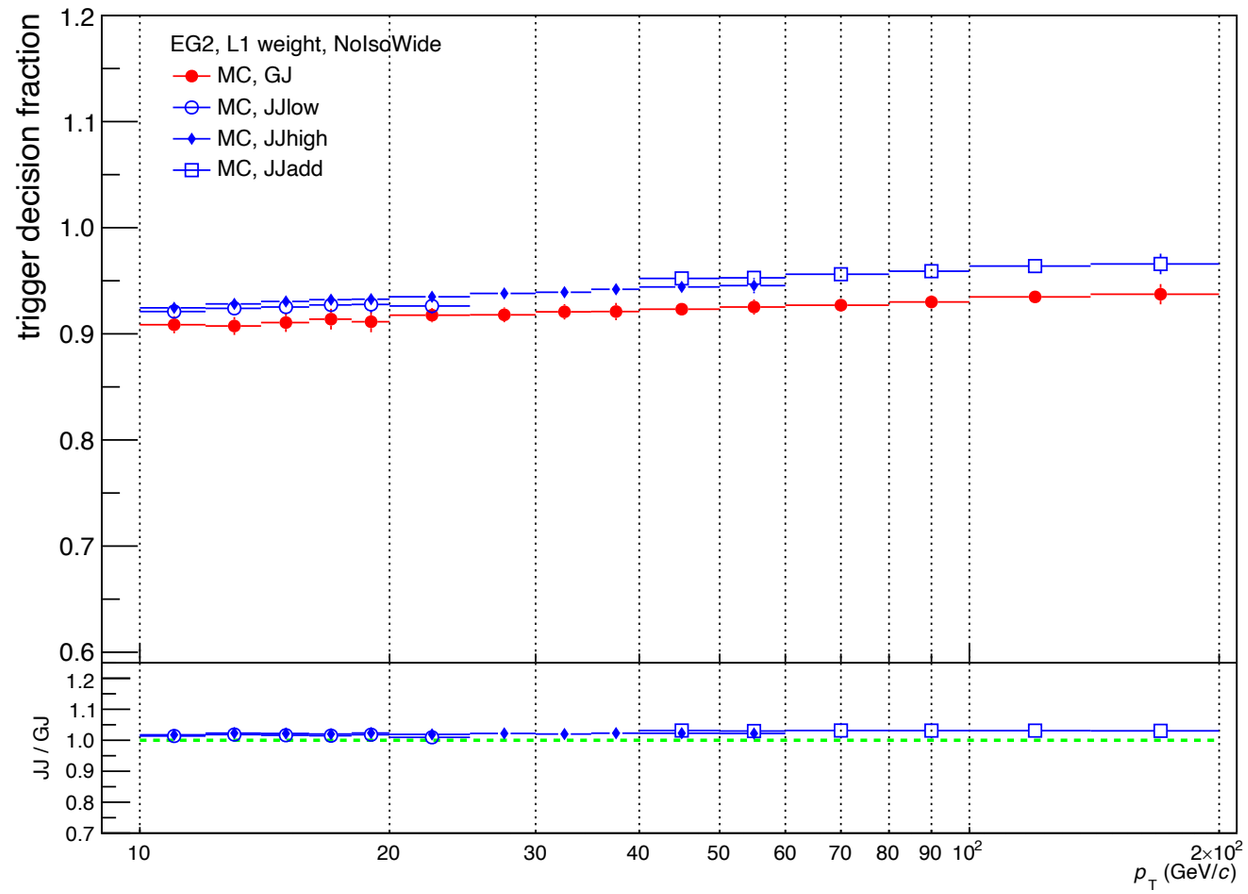
B region, isolated wide cluster
(background region)

Trigger decision factor, EG2, L1 weight, no-isolated part

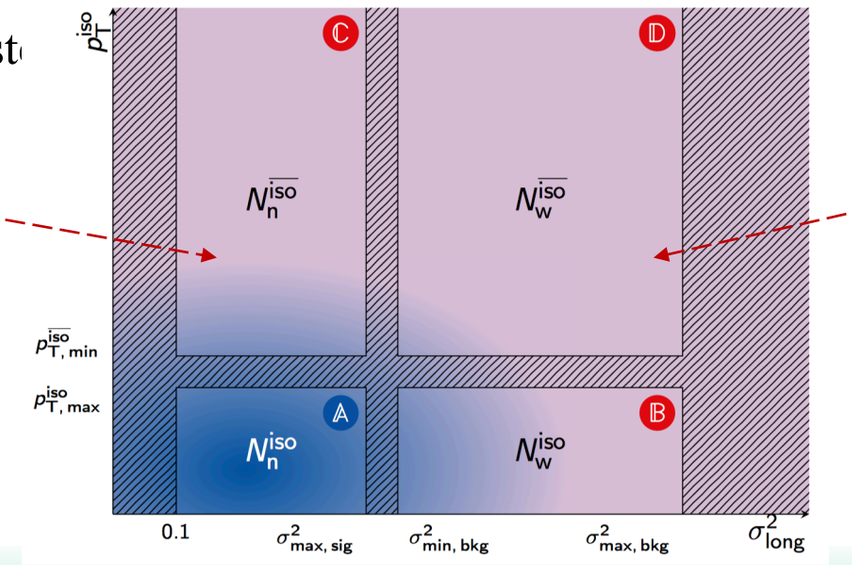
EG2 trigger, **L1** trigger decision weight

! JJadd not separate EMCal and DCal, take G2





C region, no-isolated narrow clust
(background region)

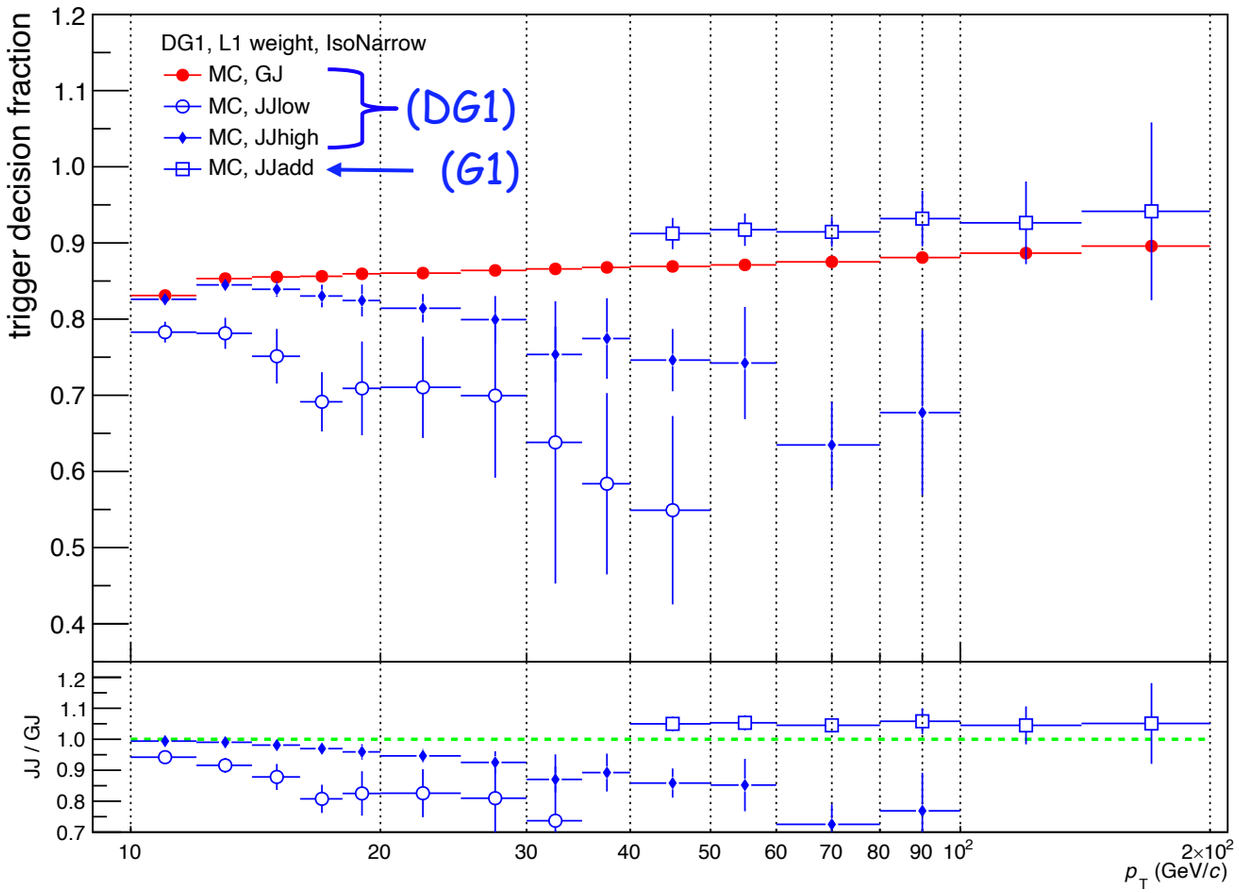


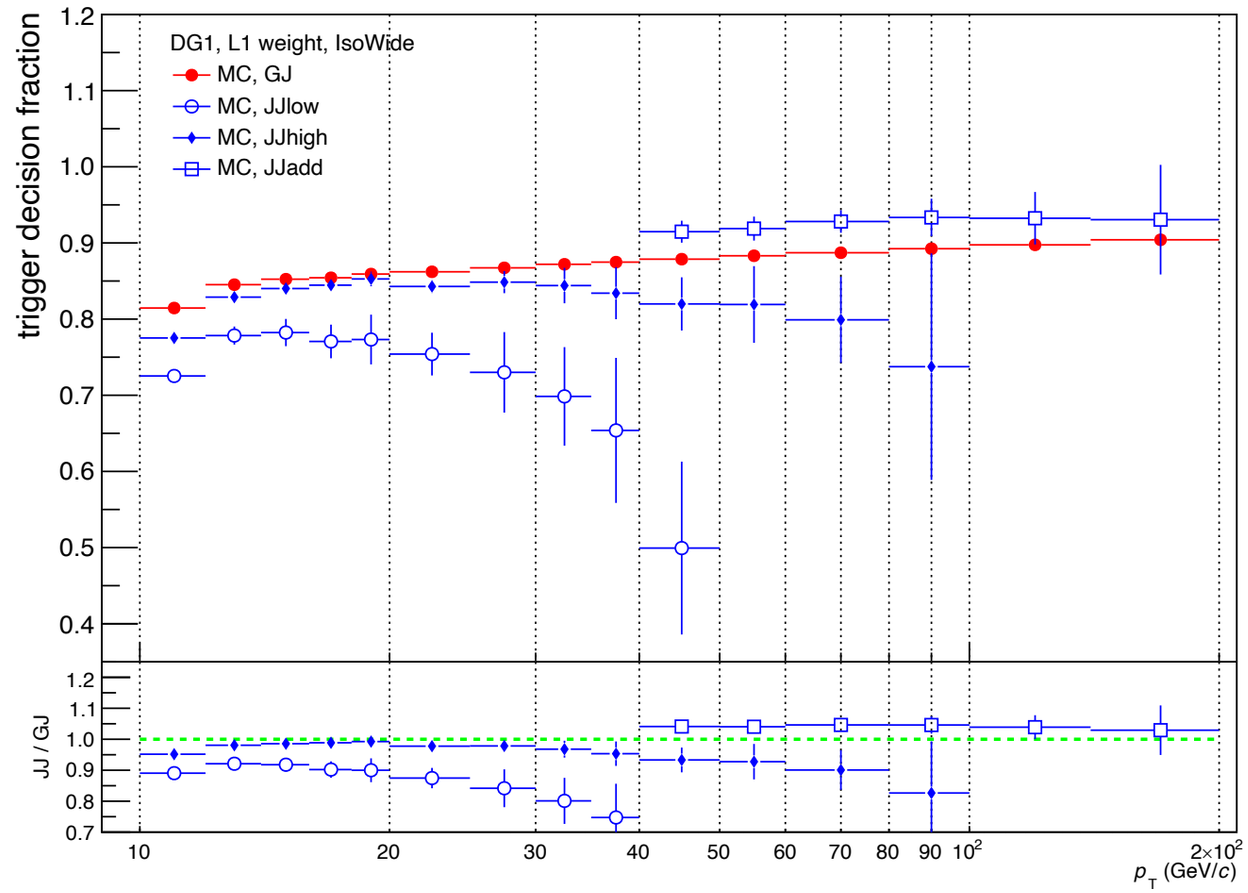
D region, no-isolated wide cluster
(background region)

Trigger decision factor, DG1, L1 weight, isolated part

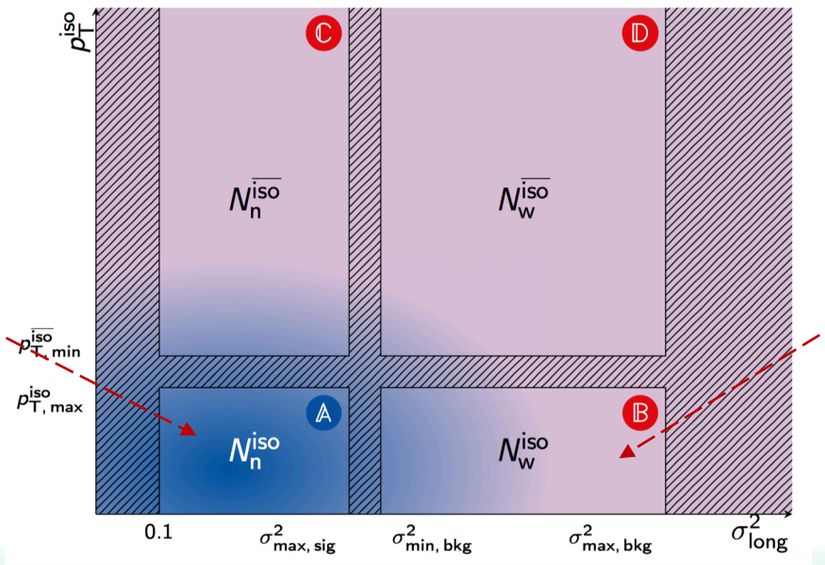
DG1 trigger, **L1** trigger decision weight

! JJadd not separate EMCal and DCal, take G1





A region, isolated narrow cluster
(signal region)

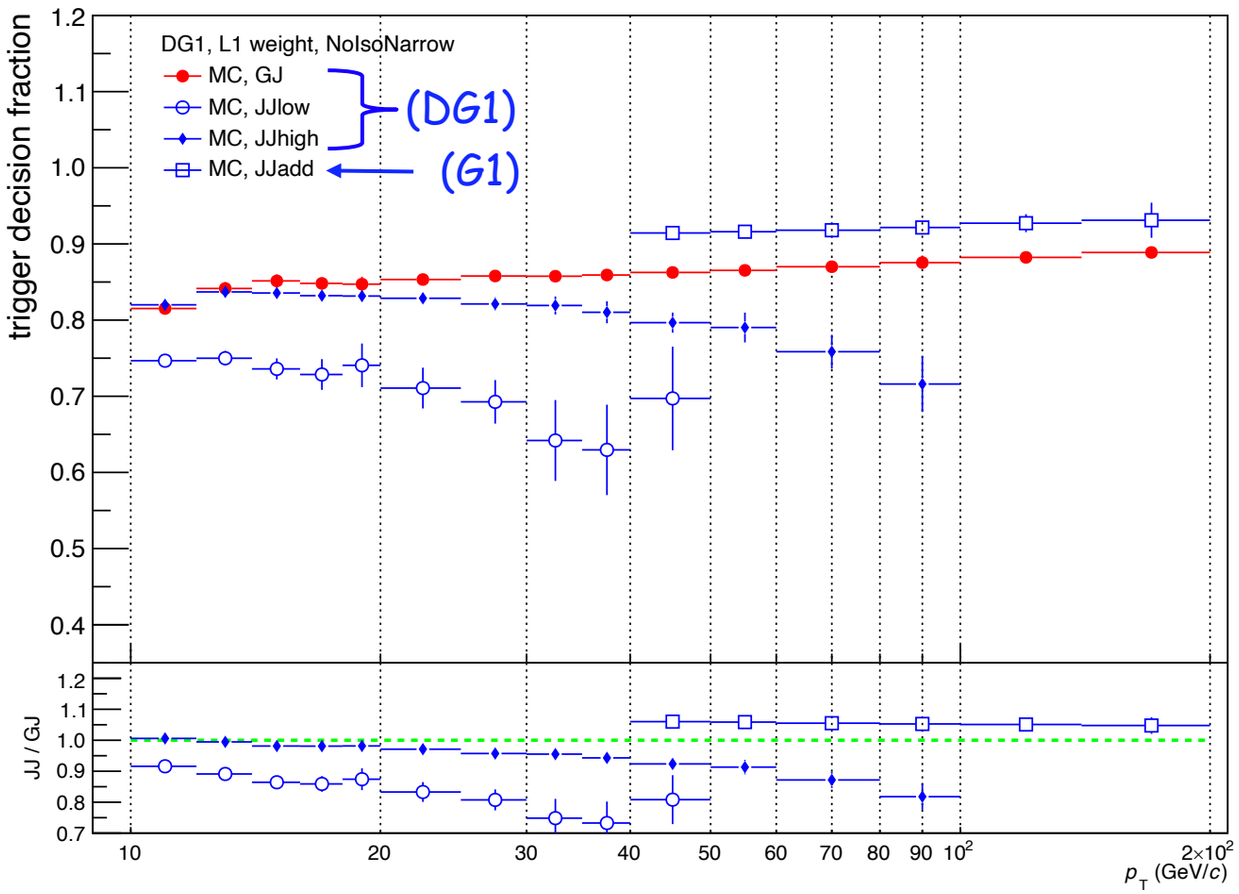


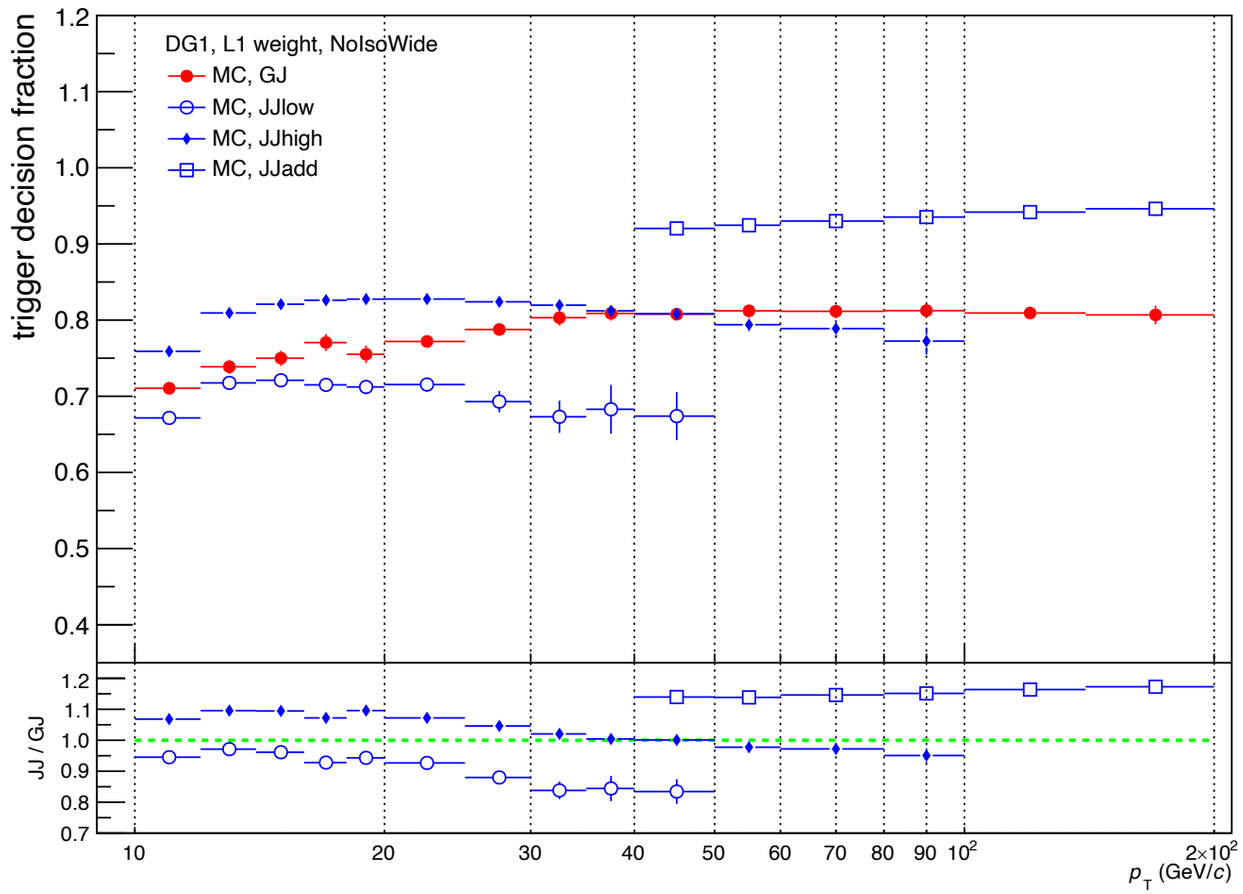
B region, isolated wide cluster
(background region)

Trigger decision factor, DG1, L1 weight, no-isolated part

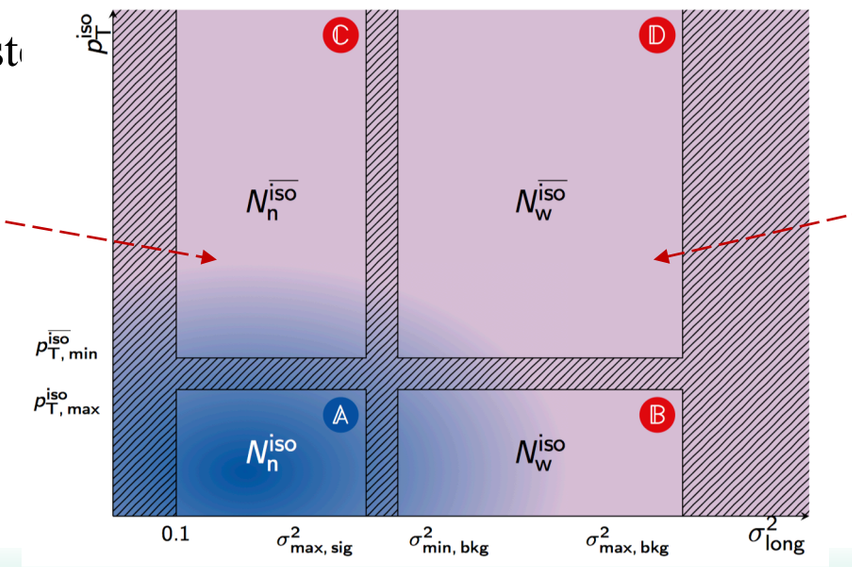
DG1 trigger, **L1** trigger decision weight

! JJadd not separate EMCal and DCal, take G1





C region, no-isolated narrow clust
(background region)

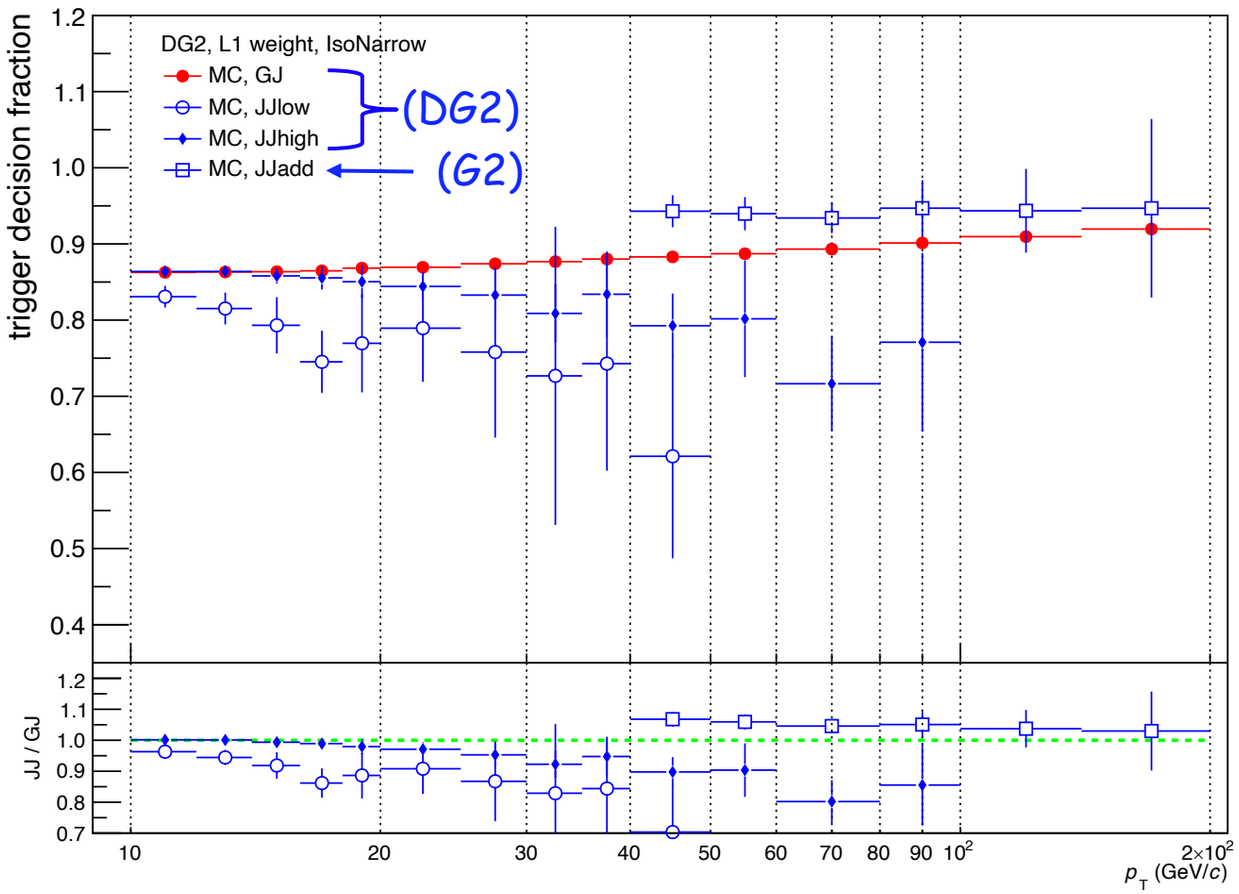


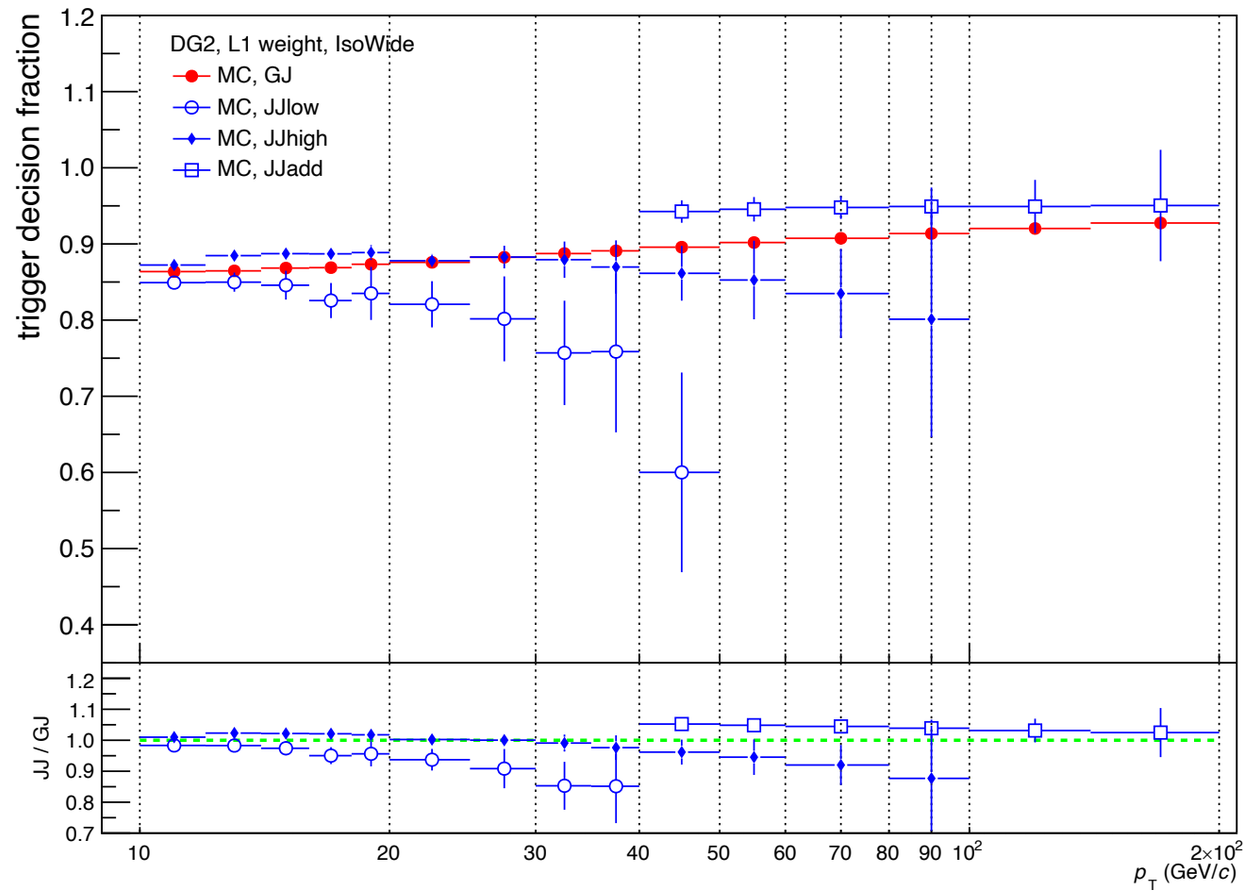
D region, no-isolated wide cluster
(background region)

Trigger decision factor, DG2, L1 weight, isolated part

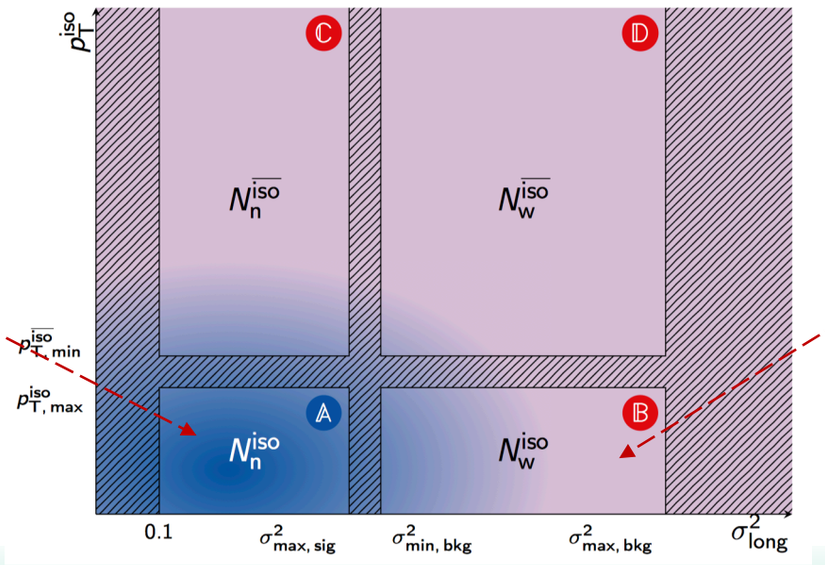
DG2 trigger, **L1** trigger decision weight

! JJadd not separate EMCal and DCal, take G2





A region, isolated narrow cluster
(signal region)

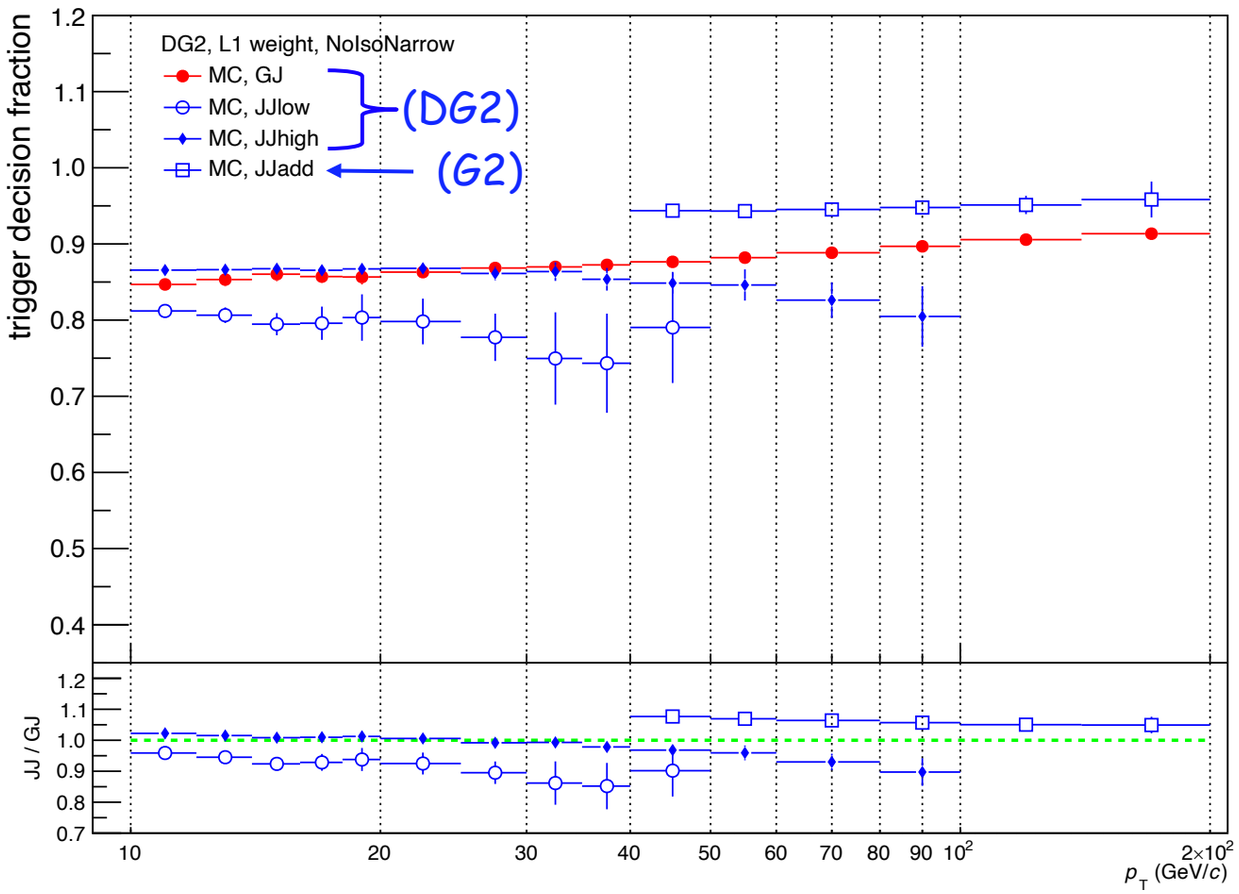


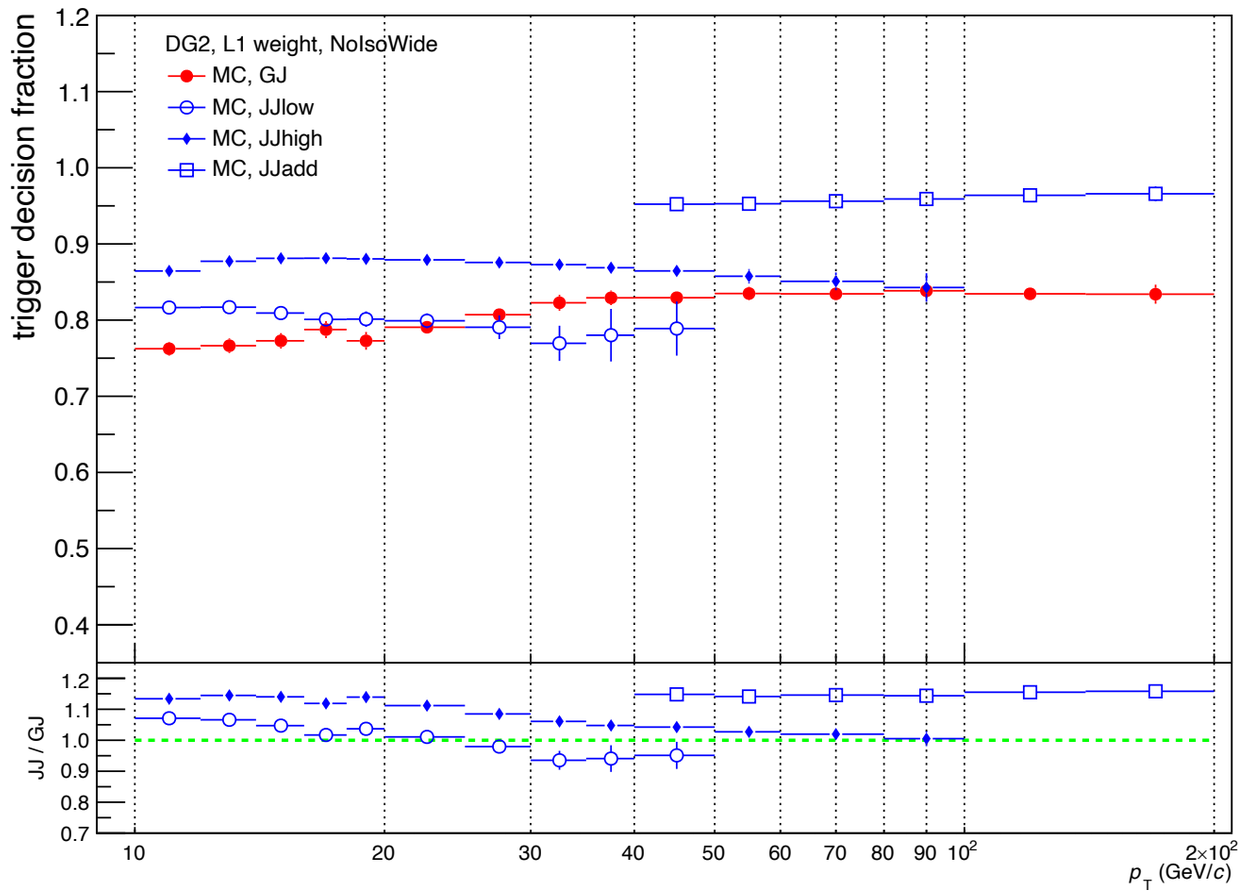
B region, isolated wide cluster
(background region)

Trigger decision factor, DG2, L1 weight, no-isolated part

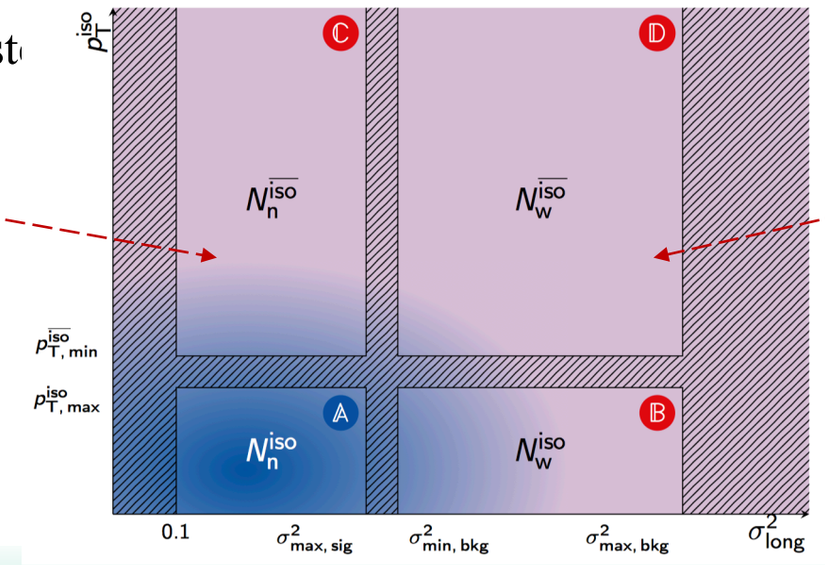
DG2 trigger, **L1** trigger decision weight

! JJadd not separate EMCal and DCal, take G2





C region, no-isolated narrow clust
(background region)



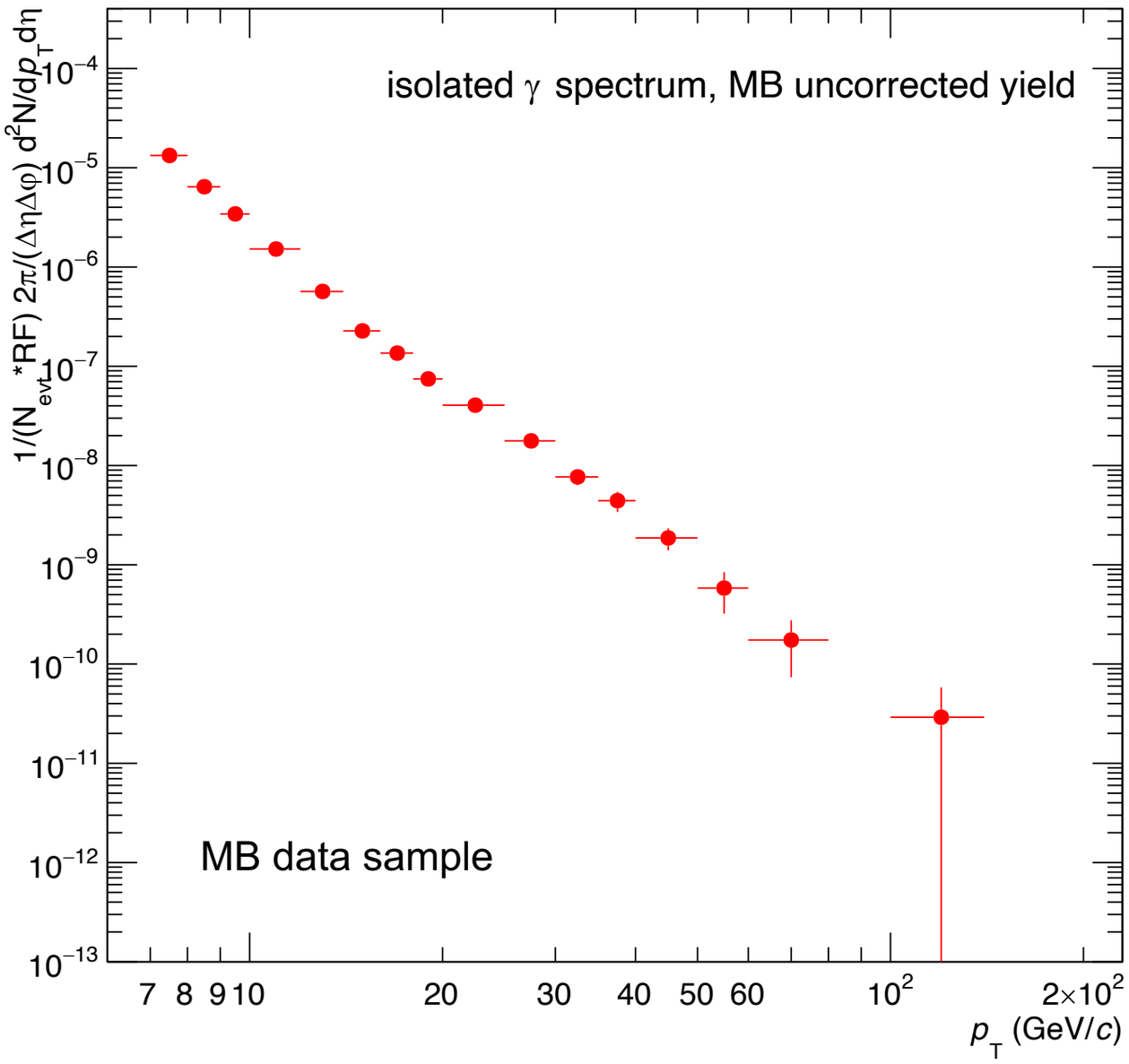
D region, no-isolated wide cluster
(background region)

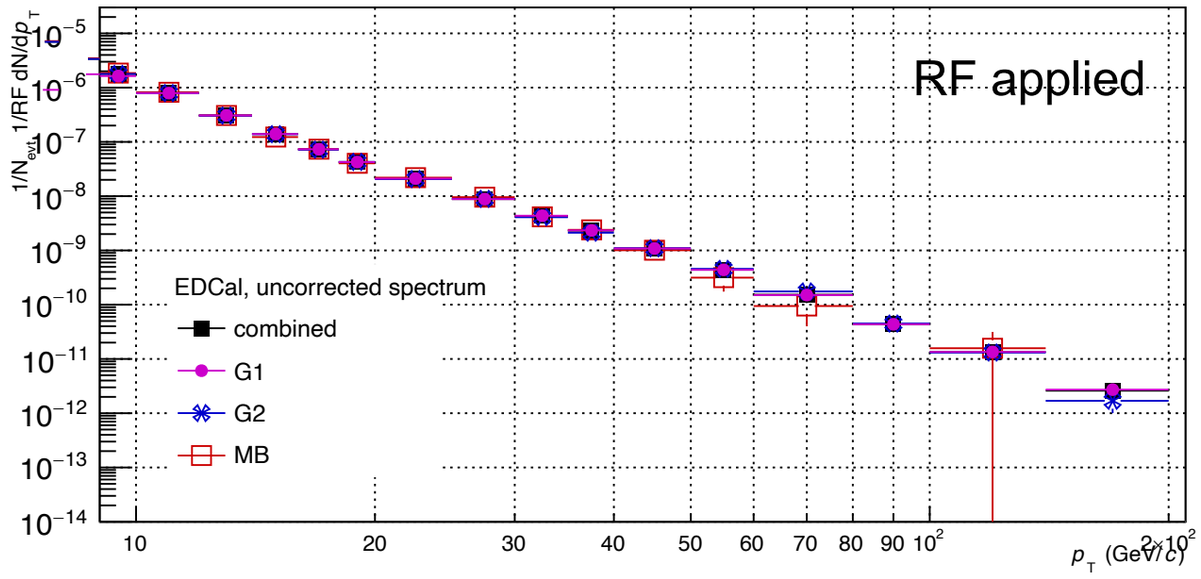
Plo0 fit result, EMCal trigger

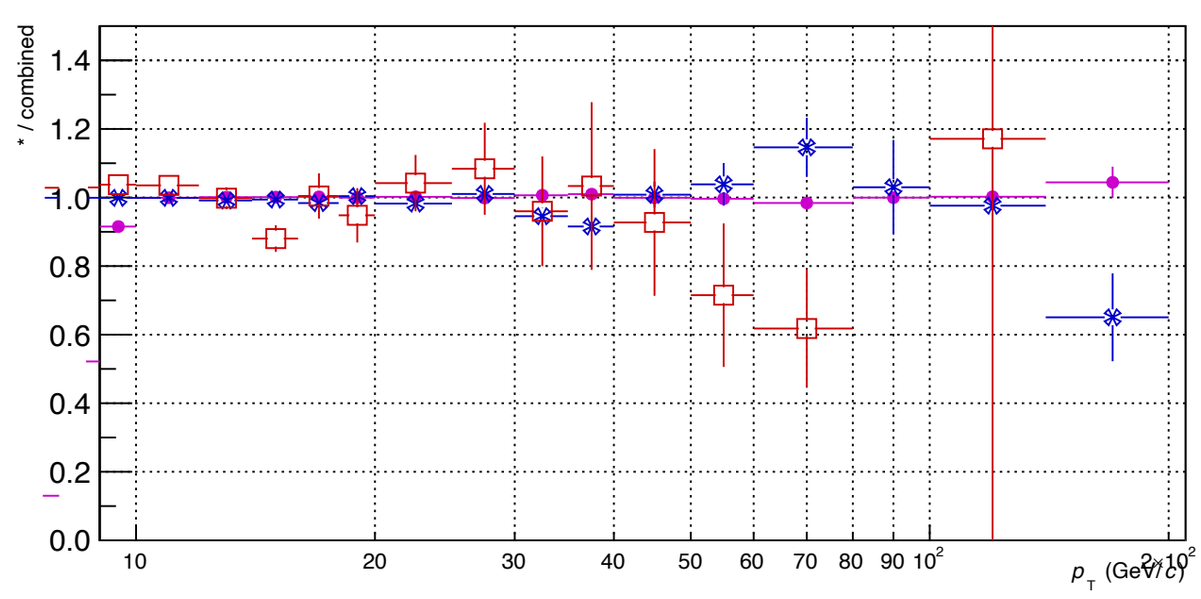
	fit range	MC sample	IsoNarrow	IsoWide	No IsoNarrow	No IsoWide
EG1	[12, 200]	GJ	0.910	0.917	0.910	0.913
	[12, 24]	JJ low	0.890	0.895	0.889	0.887
	[12, 59]	JJ high	0.905	0.909	0.909	0.911
	[40, 200]	JJ add	0.923	0.926	0.921	0.933
EG2	[12, 200]	GJ	0.915	0.924	0.916	0.921
	[12, 24]	JJ low	0.911	0.919	0.918	0.926
	[12, 59]	JJ high	0.919	0.927	0.928	0.937
	[40, 200]	JJ add	0.942	0.947	0.948	0.958

Raw spectrum, MB sample

16,17,18 data, Std case

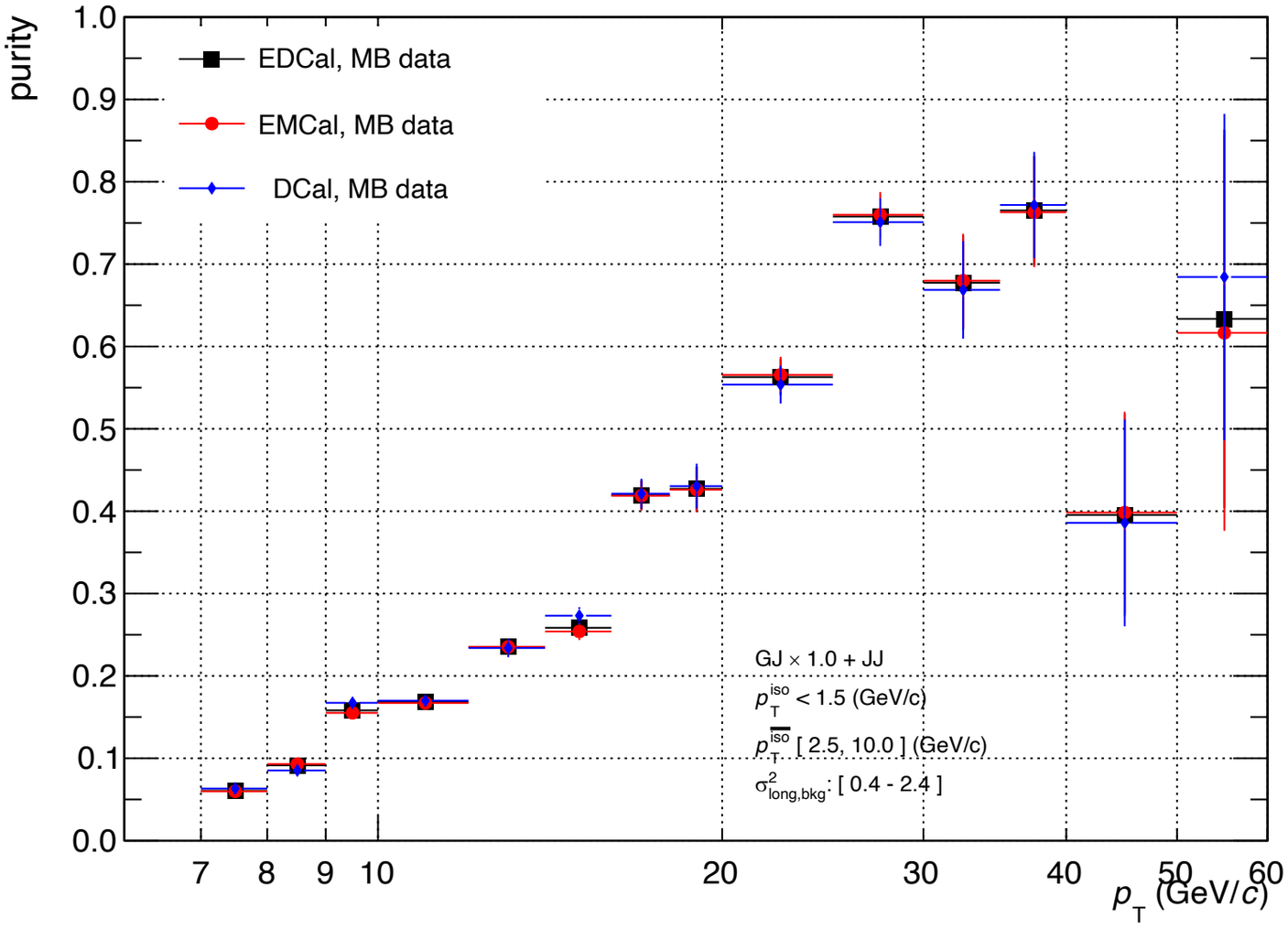


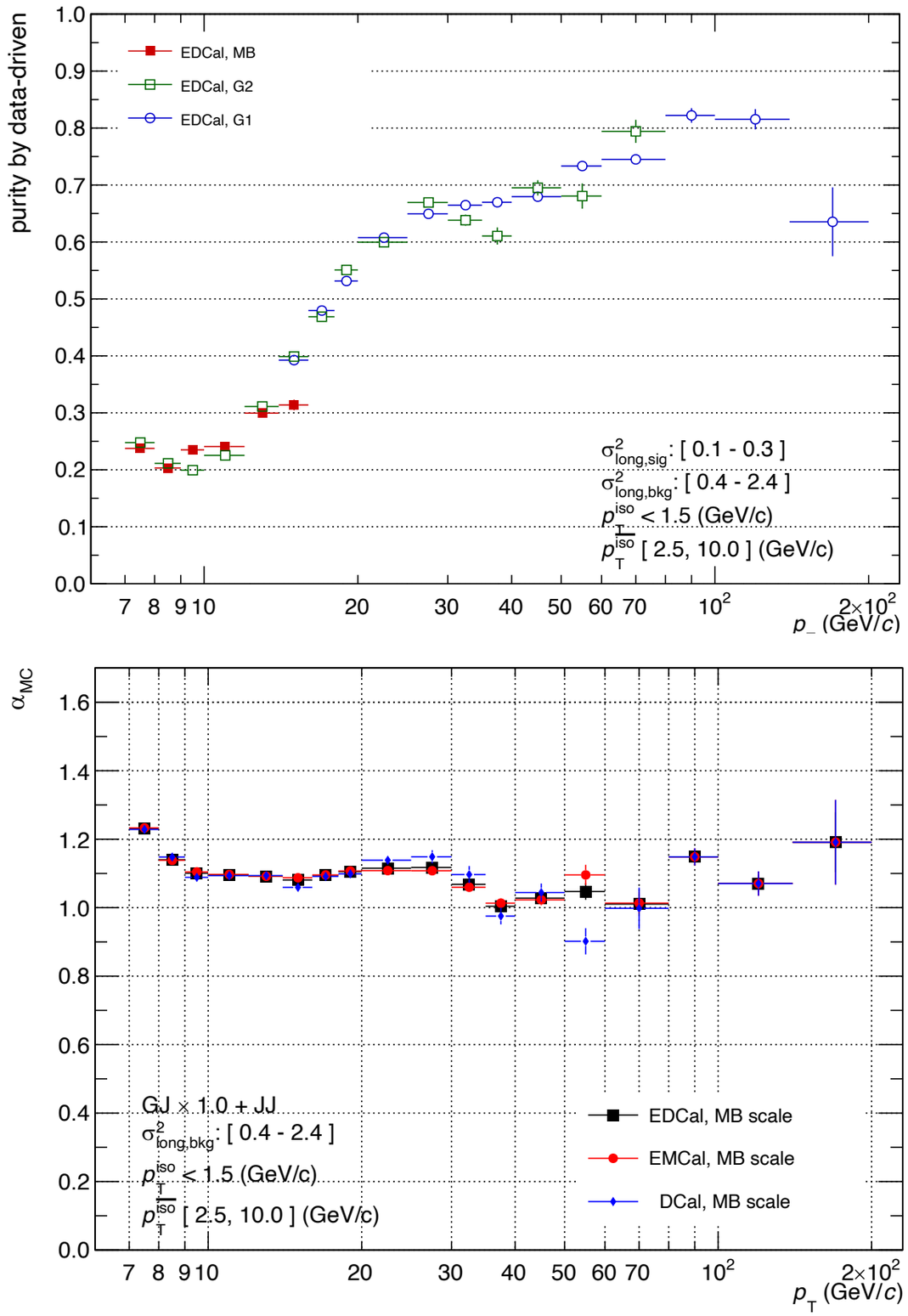




Purity, MB case

161718 MB data, **Std** case





Last presentation

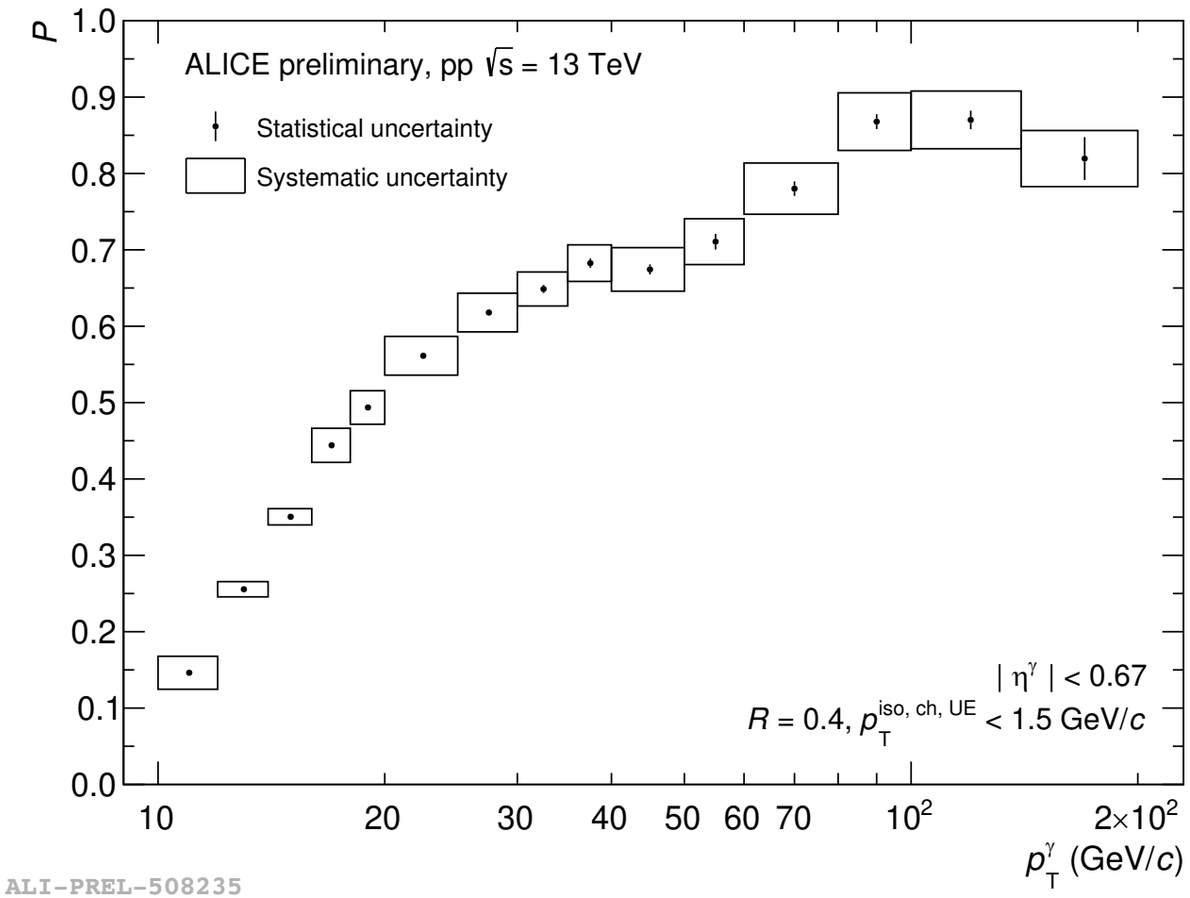
Last presentation

- update configure and xtalk
  - → remove cut on GJ evt with $p_{T,cluster}/p_{T,hard} > 2$.
  - → add a new type xtalk (more center eta).

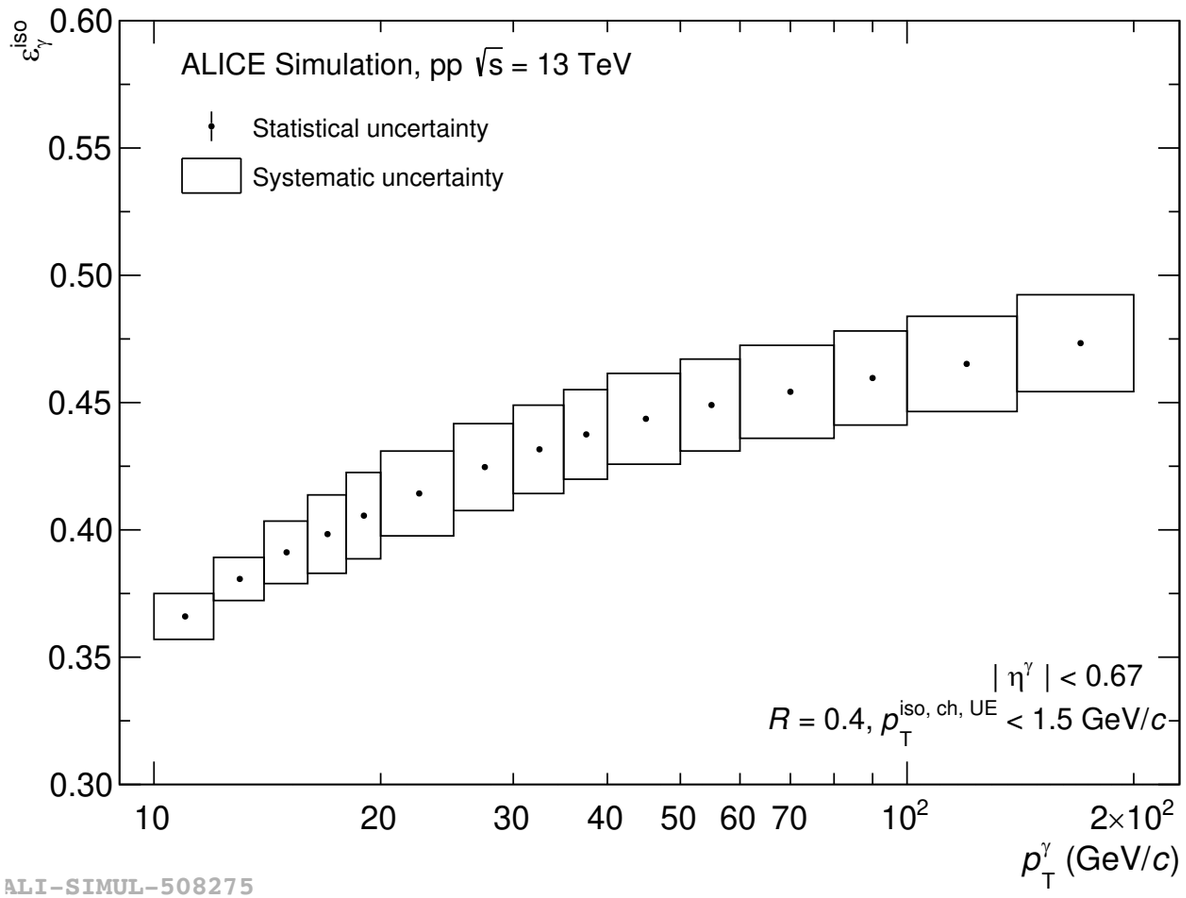
Outline

- approved preliminary result
  - using EMCAL+DCAL as input
  - keep default XTalk as main setting
- next step
  - understand the reason for difference between EMCAL and DCAL SMs
  - factors to decrease sys uncertainty

Correction factor, preliminary results

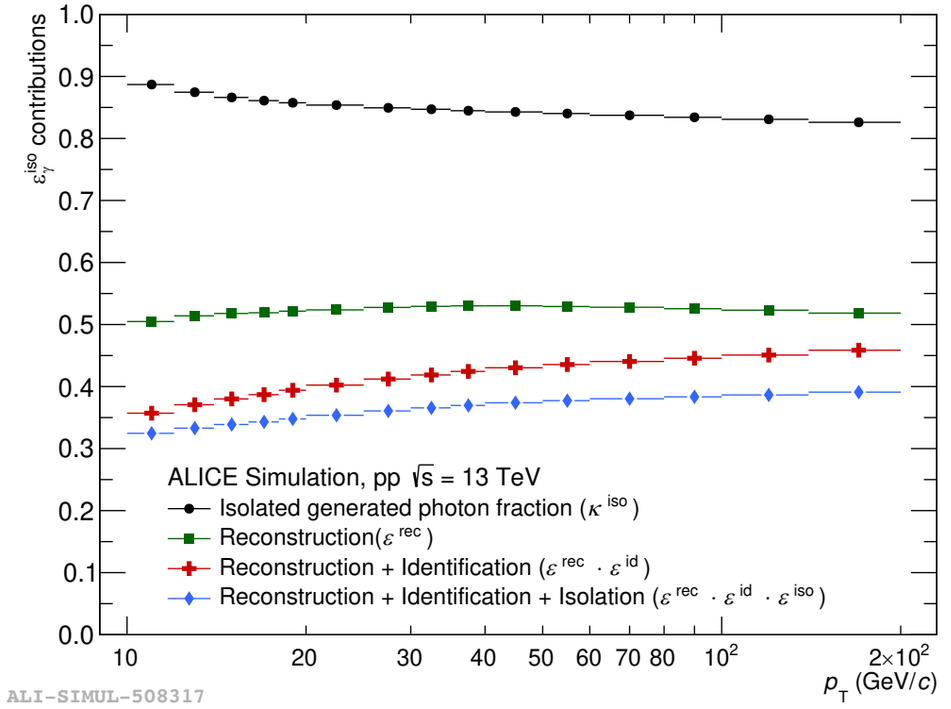


ALI-PREL-508235



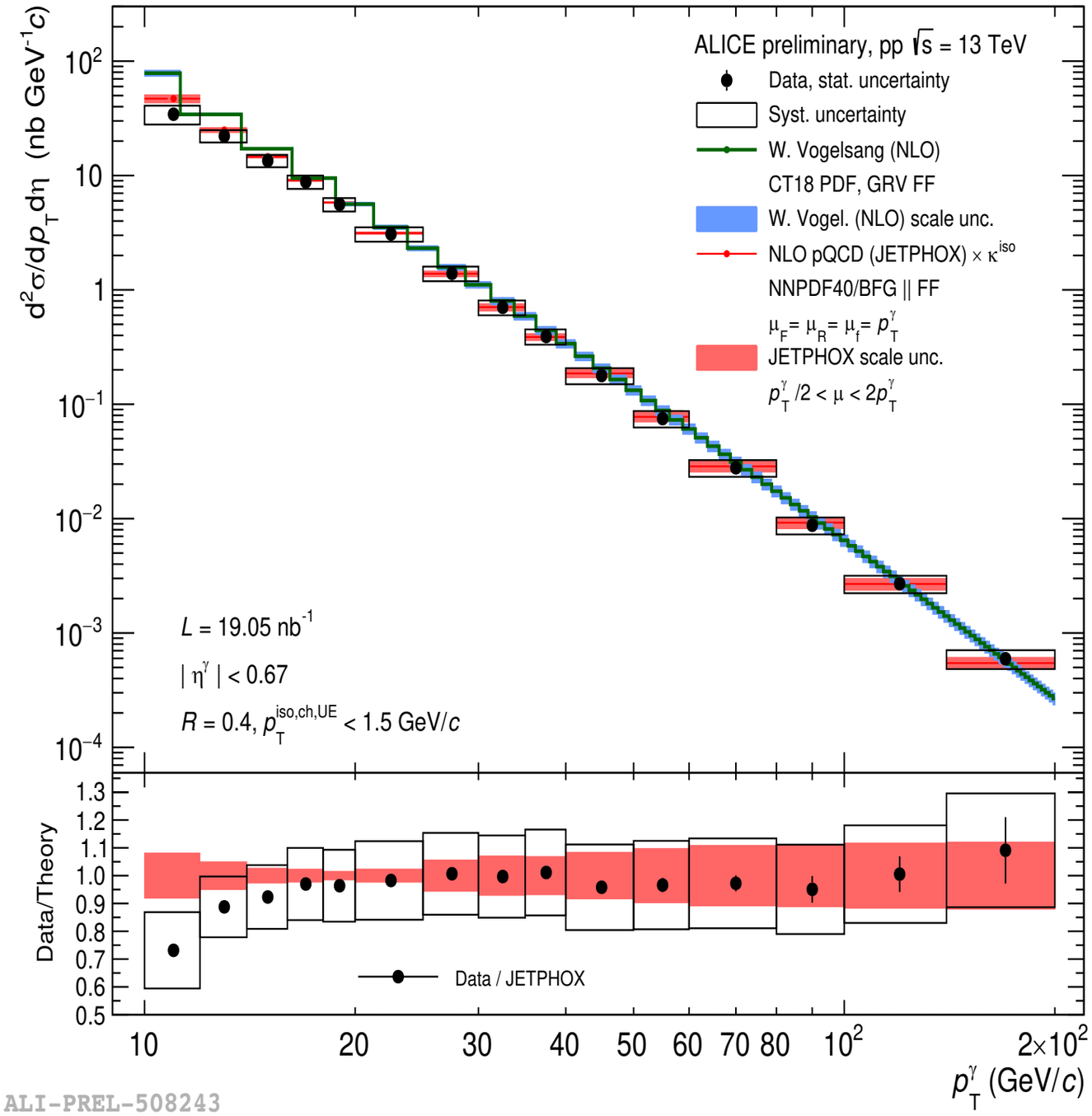
ALI-SIMUL-508275

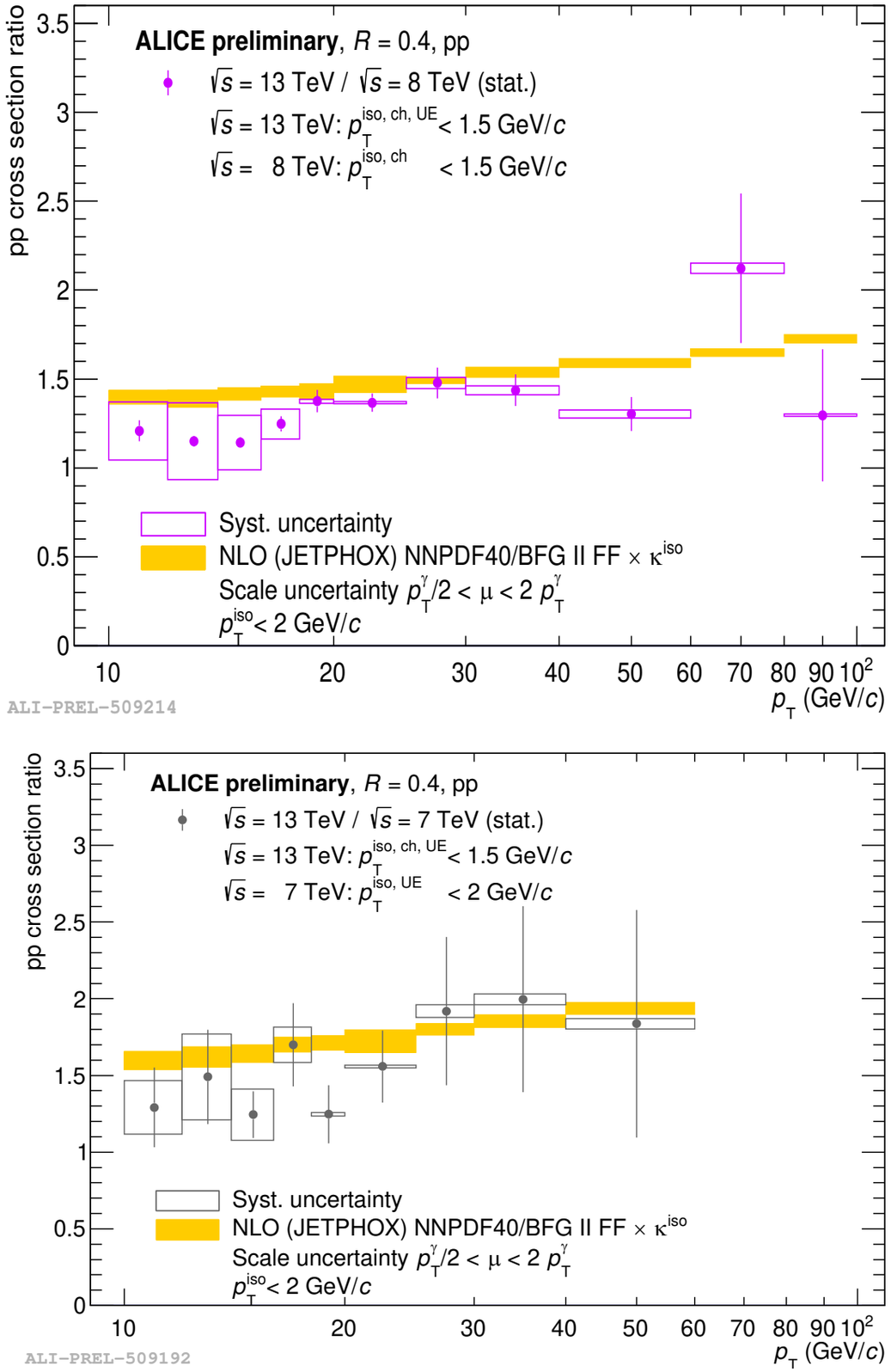
- Analysis pt range for preliminary is 10 to 200 GeV/c
- Efficiency decrease much after shower shape applied at low pt
- comments from PF approval:
  - It would be nice if we can start below 10 GeV/c



ALI-SIMUL-508317

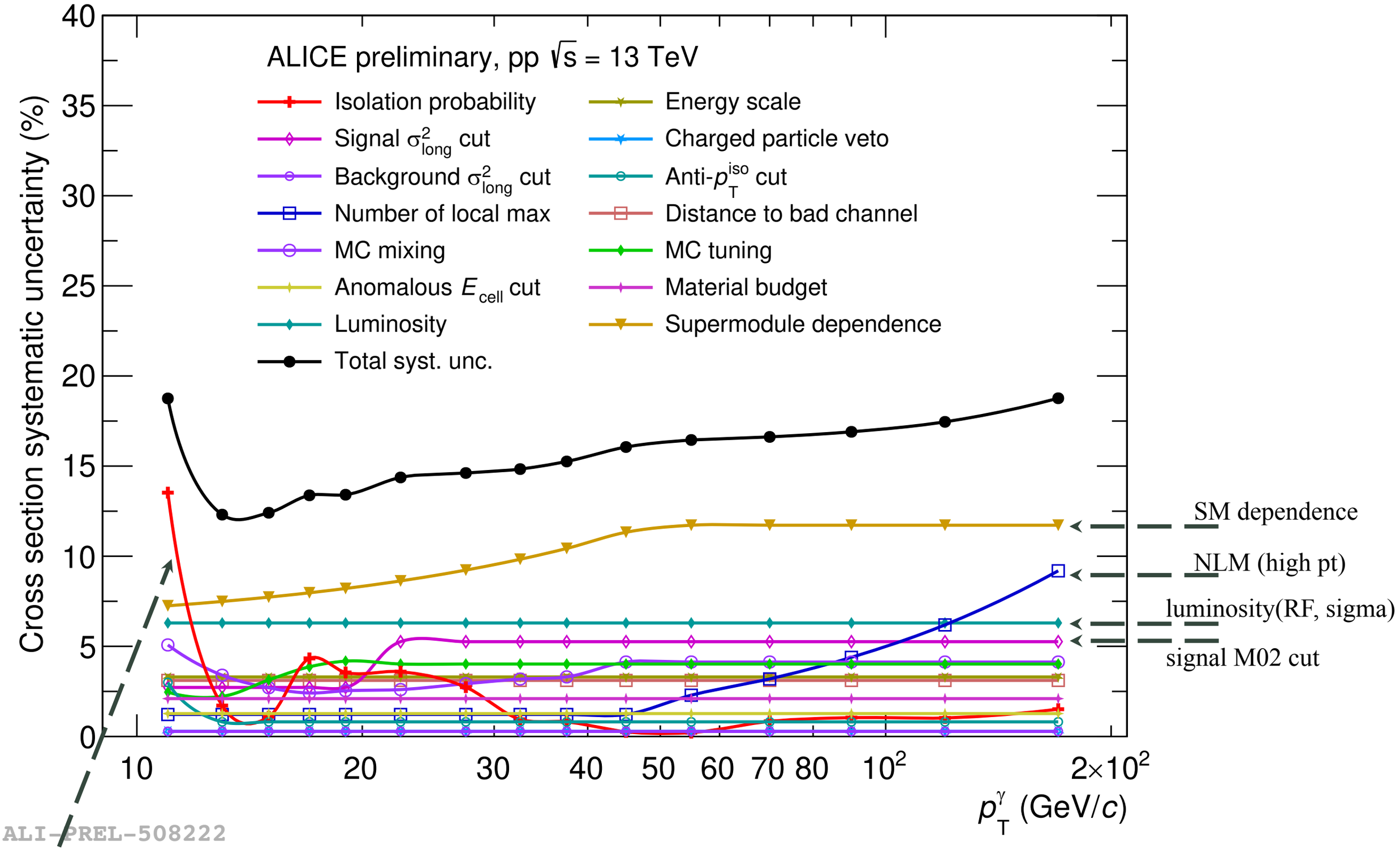
Cross section, preliminary results





- Cross section agree with model (JETPHOX) within uncertainty
- Similar shape as model when comparing different energy system

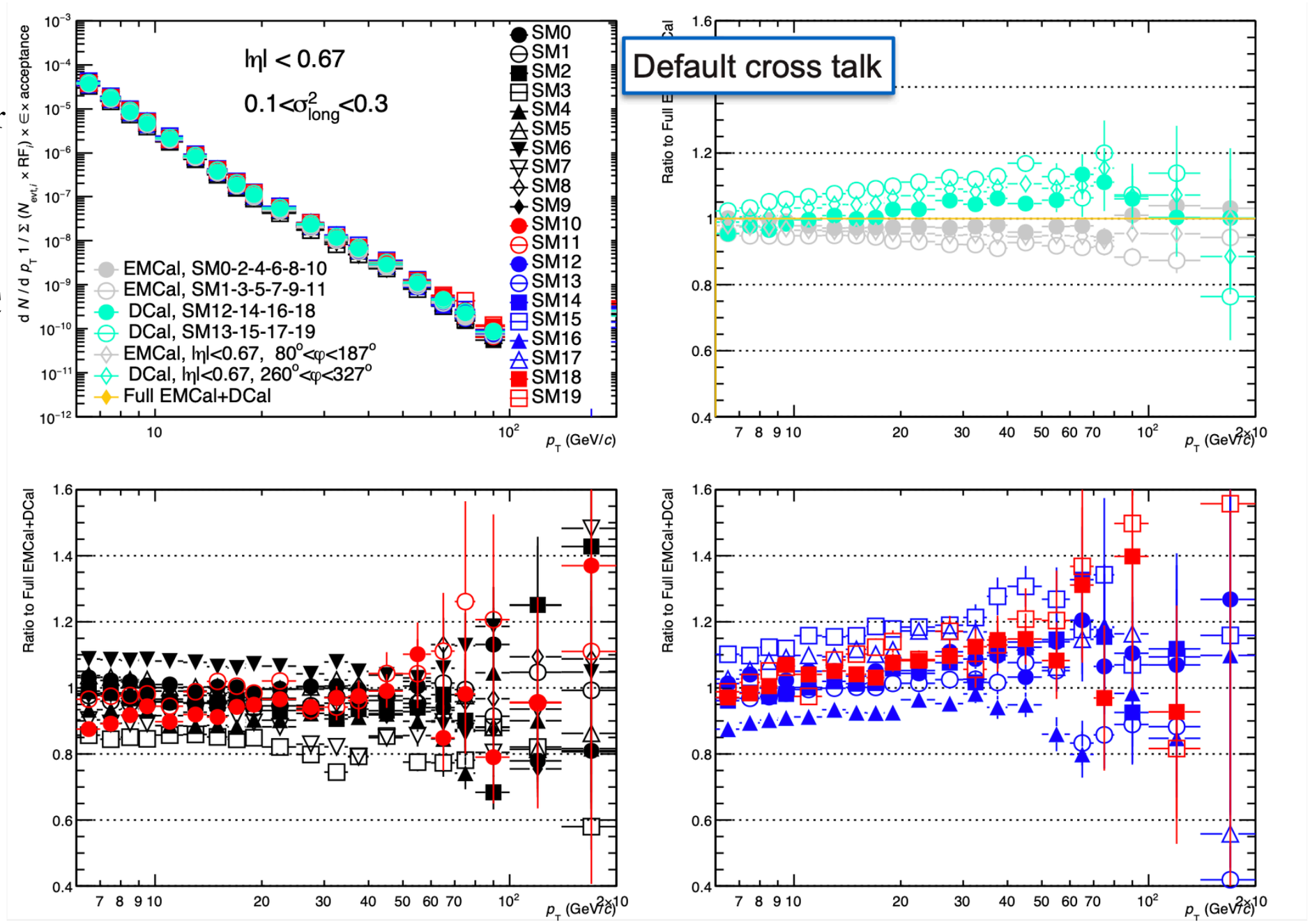
Systematic uncertainty



Isolation probability (alpha factor)

SuperModule dependence

- Spectra of narrow cluster just by prompt photon efficiency (no isolation)
- All data triggers and MC combined



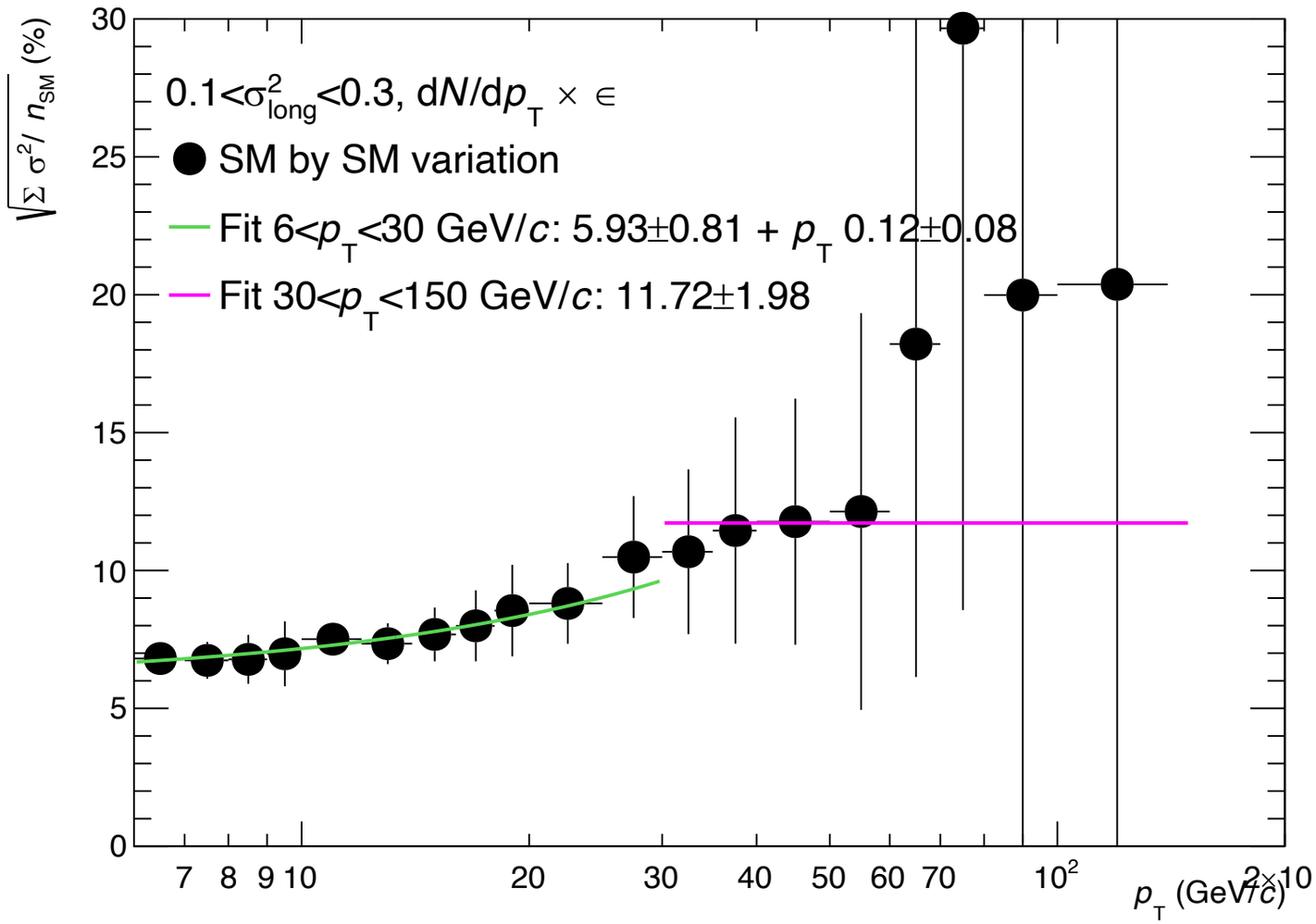
PHYSICS FORM, QM2022 APPROVAL

SuperModule dependence

- Average fractional variation with respect EMCal+DCal clusters

→ $p_T < 40$ GeV/c : 5.93 + 0.12 p_T (%)

$p_T > 40$ GeV/c: 11.72%



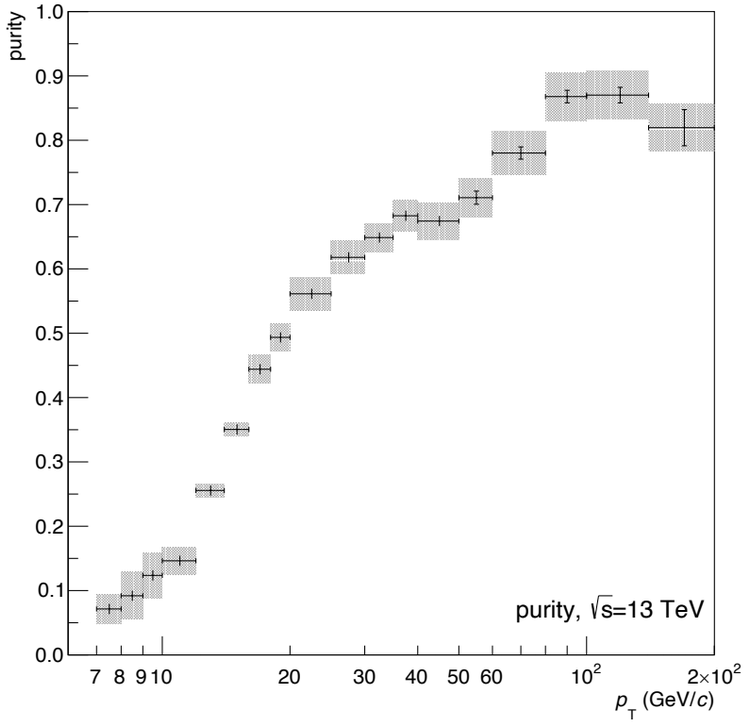
Status table for each uncertainty source

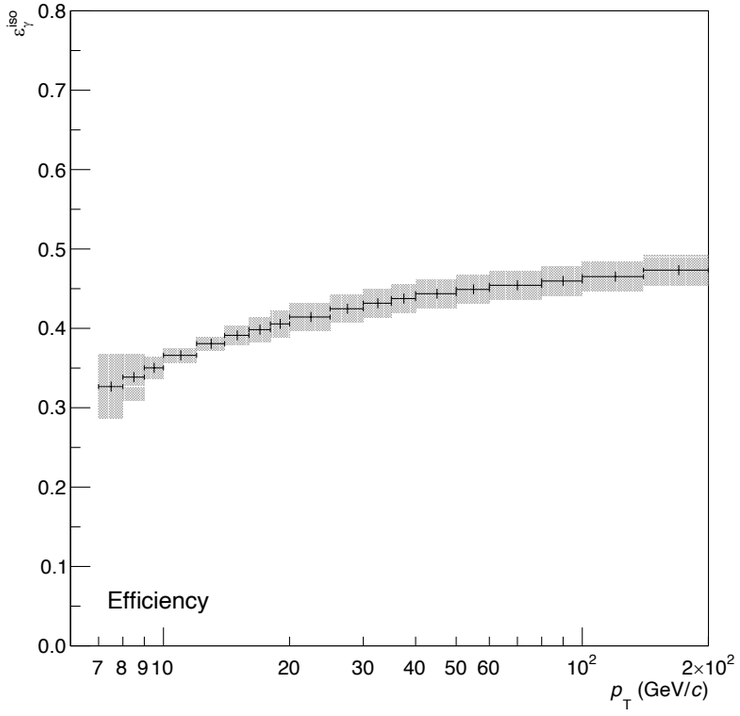
source			state	comments
signal M02 max				>20 GeV/c enhance, from shower shape?
purity	bkg M02	min		use pt dependence shower shape cut to avoid low pt uncertainty contribution
		max		
	anti ptIso		✓	maybe change if M02 change
	alpha factor (C term)			main contribution for purity
	GJ/(GJ+JJ)		✓	Final maybe change, GJ=1(default), 0.5, 1.5
distance to bad channel			✓	too small, may consider ignore ?
NLM			✓	
TM			✓	
exotic cluster remove			✓	
cross talk				off / 2
luminosity	RF			Need decrease, change to evt counter scale
	sigma total		✓	Taken from twiki,
SM group variation				Should not appear in final
Energy scale			?	Taken from 7TeV
Material budget			?	Taken from 7TeV

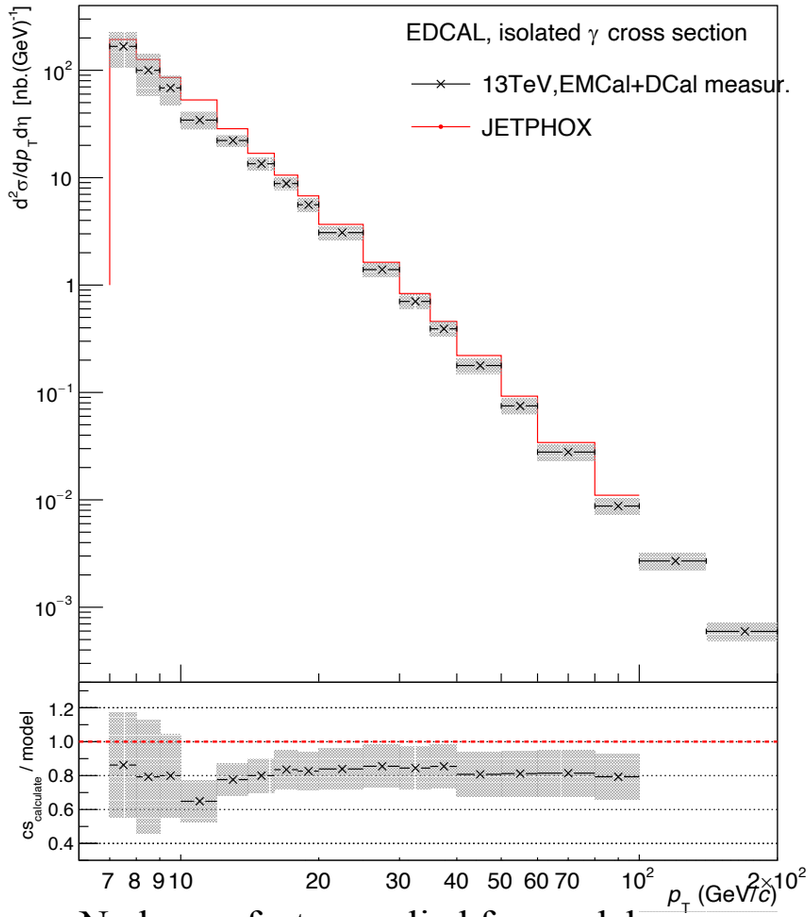
To do list

1. check and find the further information to understand the difference between SMs
2. apply pt dependence shower shape cut for signal and background part

   → reduce uncertainty for isolation probability
3. use event counter→ reduce RF uncertainty
4. use NevtIn instead of Nevt normalize for MC pt hard bin normalization
5. ……



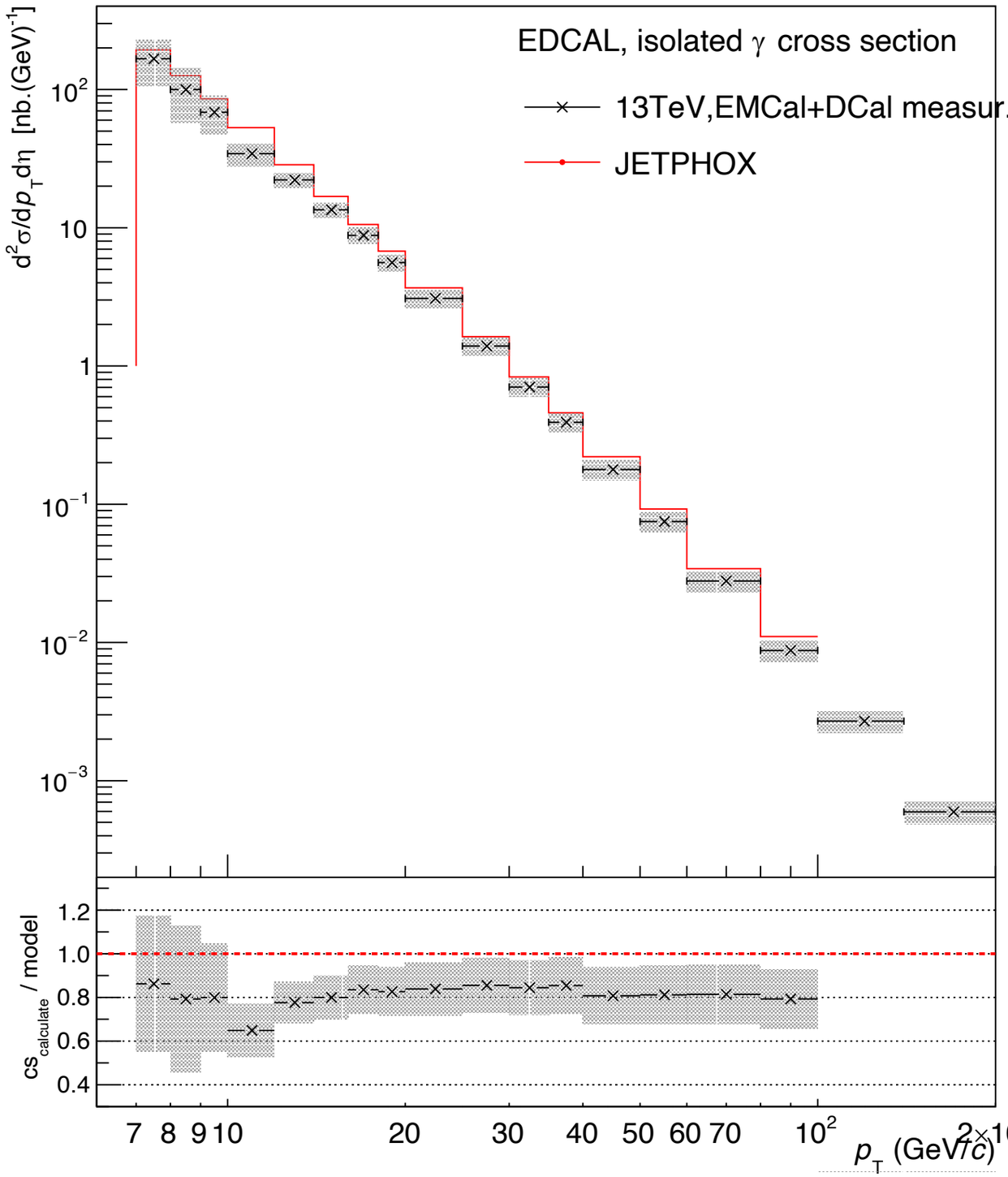


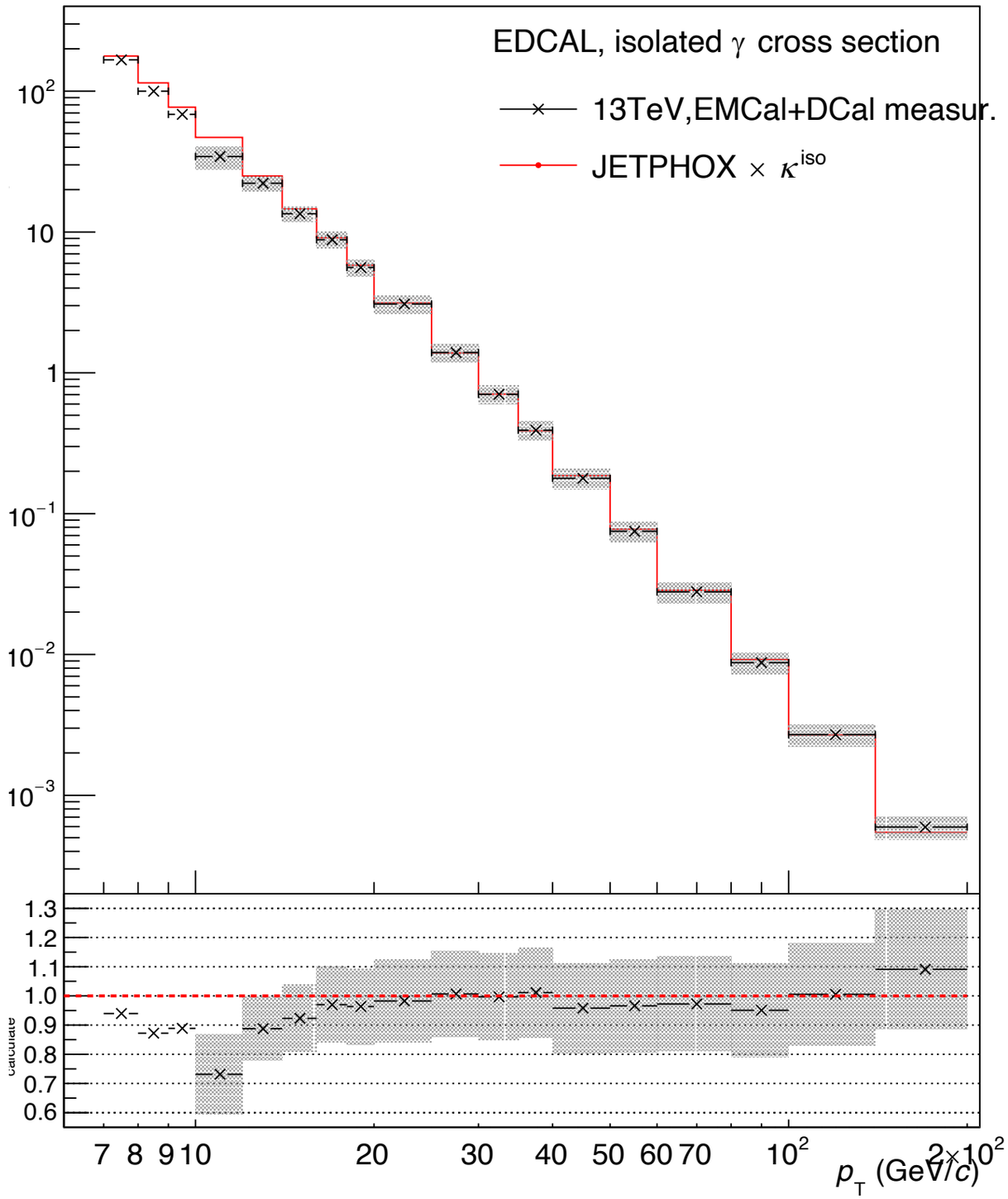


No kappa factor applied for model

Back up

uncertainties source

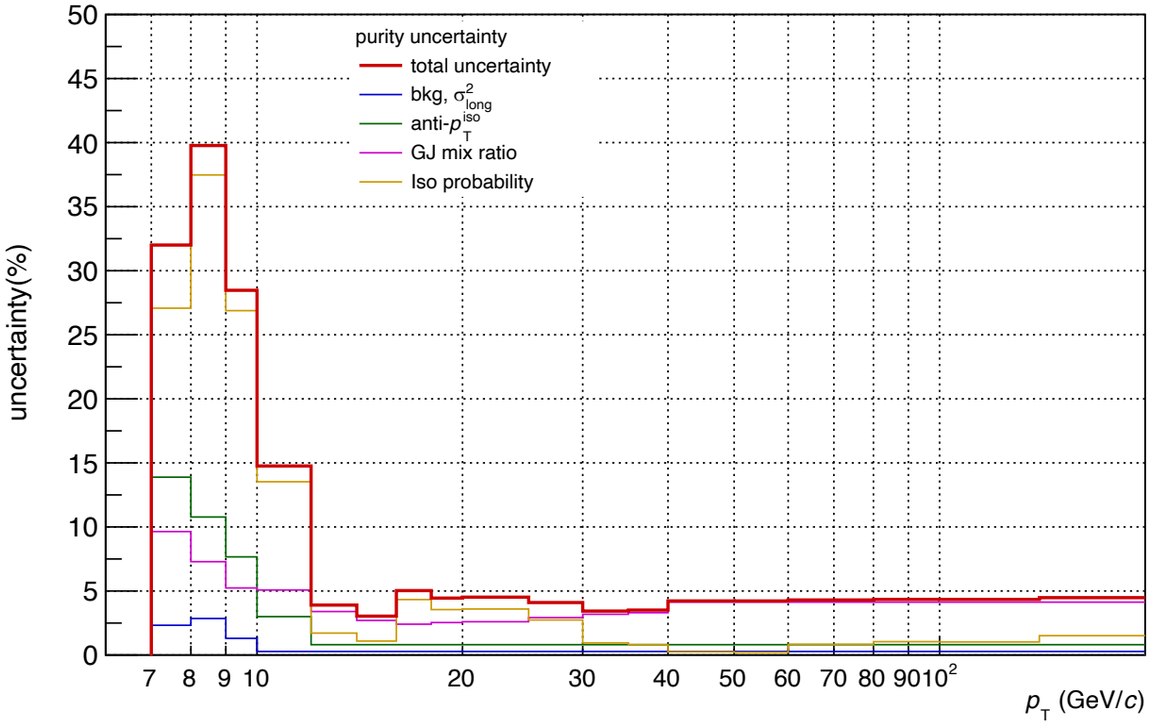




uncertainties source

Purity
background σ^2_{long}
anti-p_T^{iso}
Isolation probability
MC mix ratio (GJ / GJ+JJ)

cross section	
signal σ^2_{long} maximum	
purity	
distance to bad channel	
Number of local maximum	
track match	
exotic cluster removal	
cross talk	
luminosity	rejection factor
	cross section
SM group variations	
Energy scale	
Material budget	



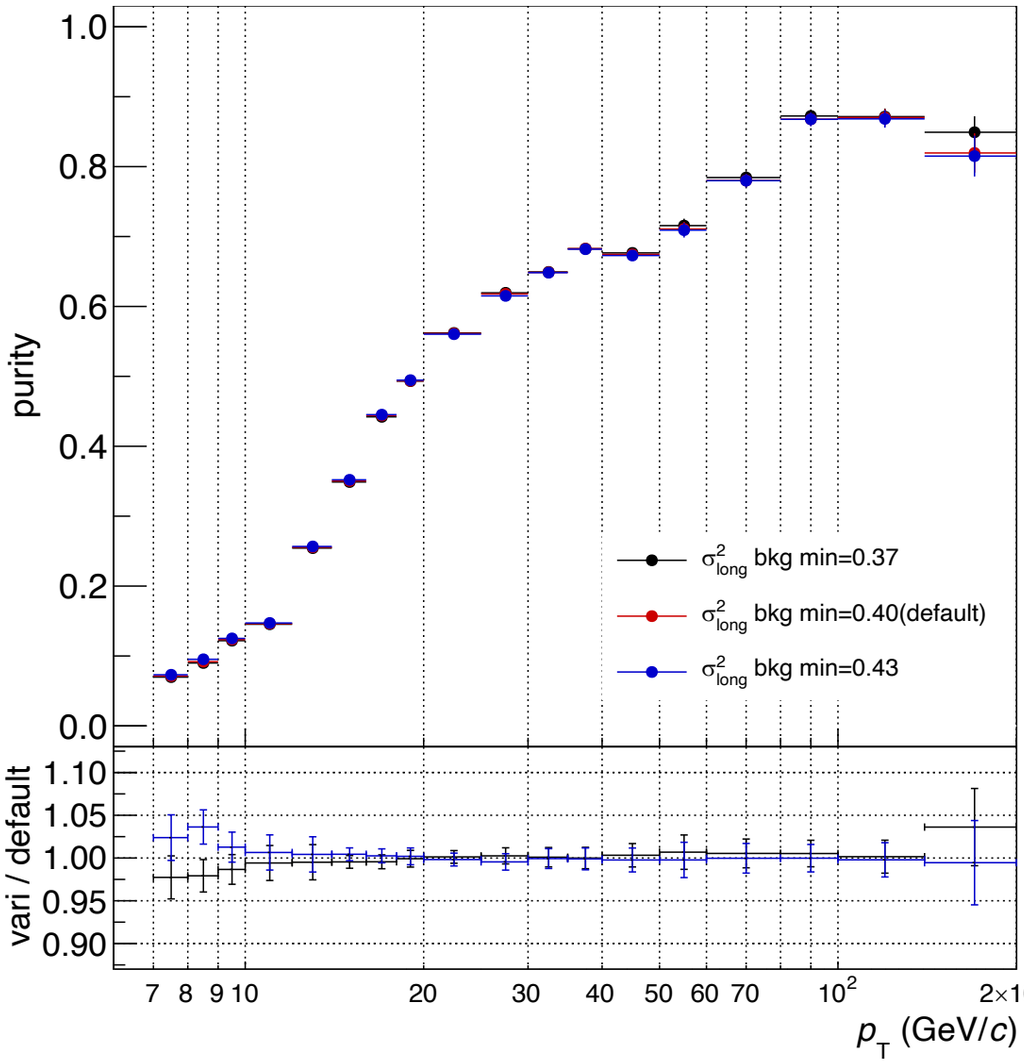
Purity systematic uncertainties estimation

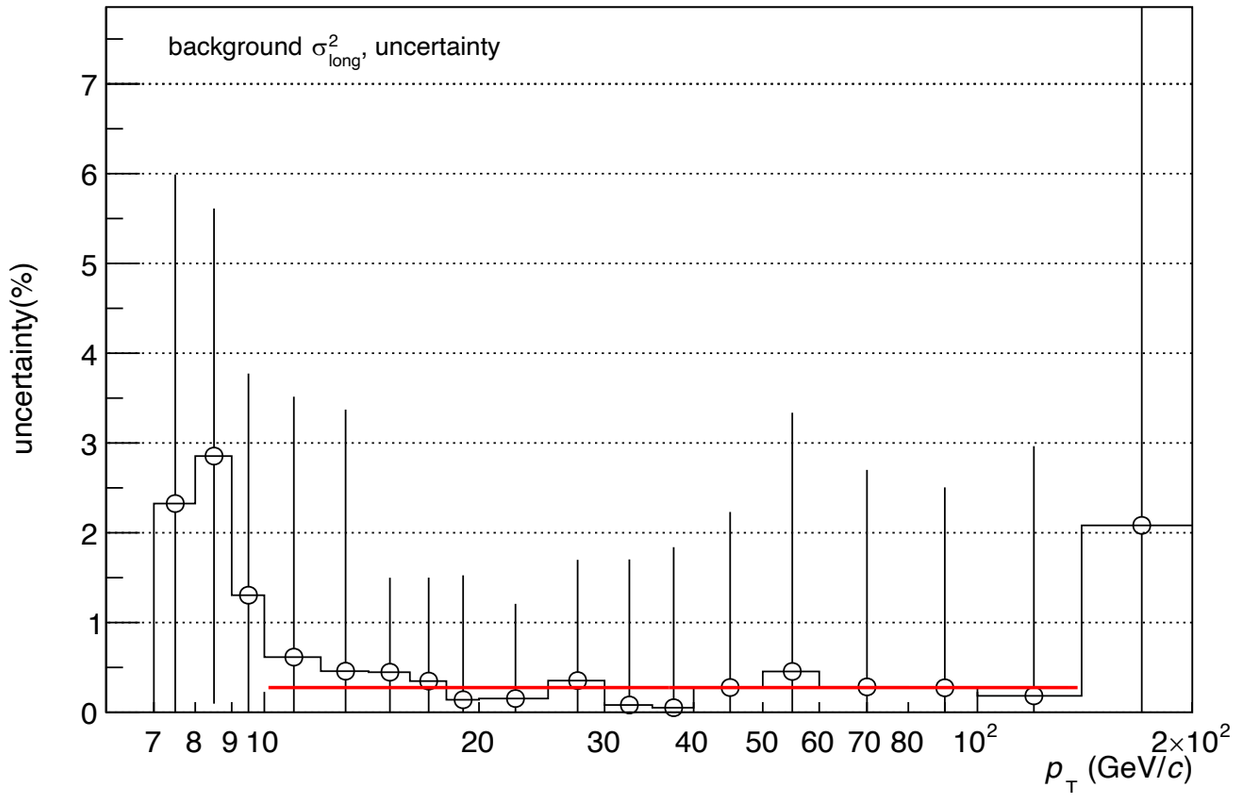
		default	varies	
background σ^2_{long}	min	0.4	0.37, 0.43	p_T < 10 GeV/c : value from plot p_T > 10 GeV/c : 0.28 (%)
	max	2.4	2.37, 2.43	
anti-p_T^{iso}	min	2.5	2.0, 3.0, 4.0, 5.0	p_T < 12 GeV/c : 37.21 - 3.11*p_T (%) p_T > 12 GeV/c : 0.81 (%)
	max	10	6.0, 8.0, 12.0, 15.0, 20.0	
Isolation probability				
MC mix ratio (GJ / GJ+JJ)		0.5	0.33, 0.67	p_T < 40 GeV/c : value from plot p_T > 40 GeV/c : 4.13 (%)

Systematic uncertainties estimation

		default	varies	
	signal σ^2_{long} maximum	0.3	0.27, 0.35	p_T < 20 GeV/c : 2.72% p_T > 20 GeV/c : 5.26%
purity				
cluster selection	distance to bad channel	2	off	3.11%
	Number of local maximum	2	3	p_T < 50 GeV/c : 1.22 (%) p_T > 50 GeV/c : 0.06*p_T-1.01 (%)
	track match	2	loose	0.29%
	exotic cluster removal	0.97	0.95	1.27%
	cross talk	default	off	p_T < 20 GeV/c : value from plots p_T > 20 GeV/c : 4.02 (%)
luminosity	rejection factor			6.02%
	cross section	taken from twiki page		1.85%
	SM group variations			p_T < 30 GeV/c : 5.93 + 0.12*p_T (%) p_T > 30 GeV/c : 11.72%
	Energy scale			3.3%
	Material budget			2.1%

Systematic – bkg shower shape variation

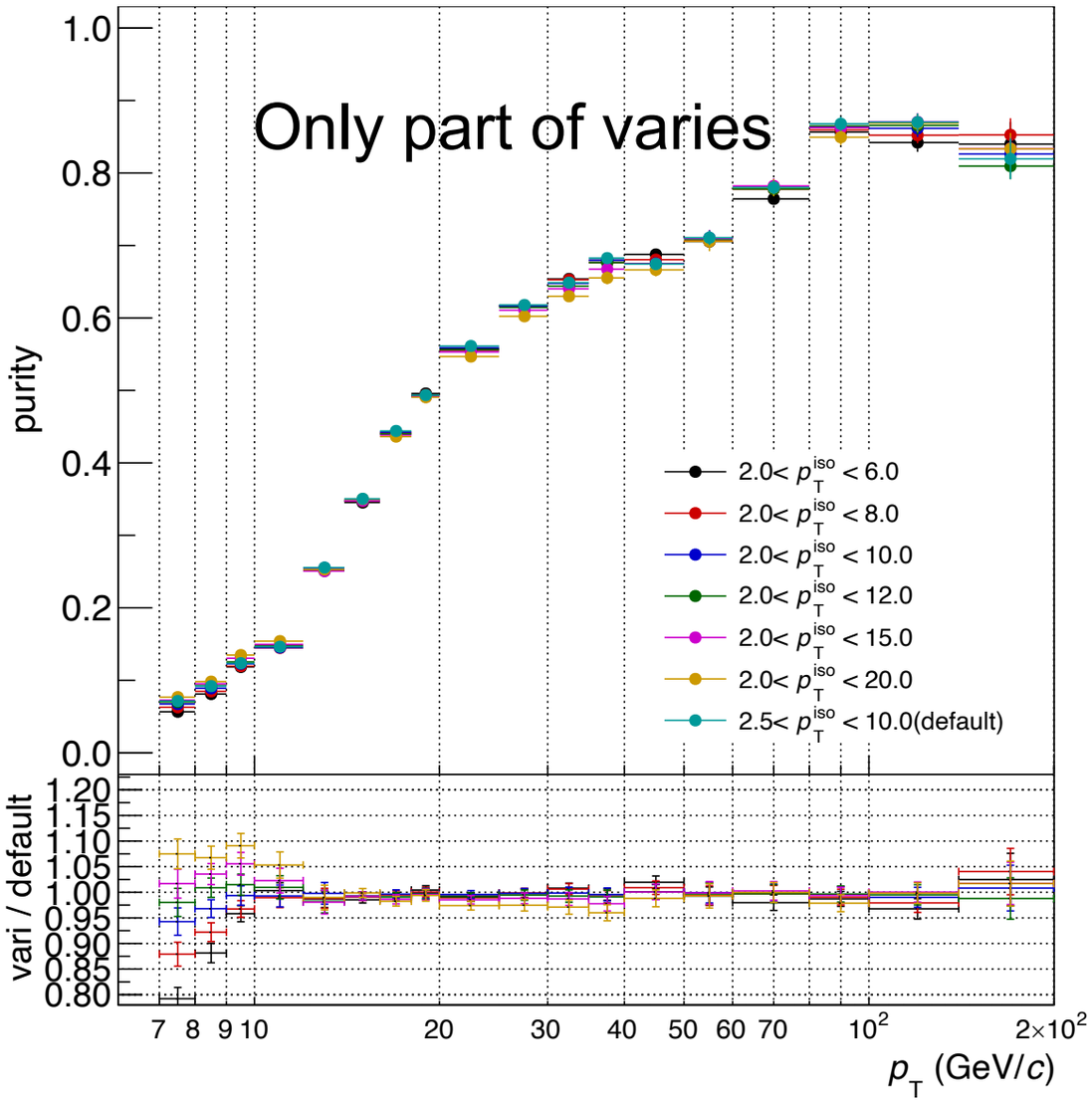


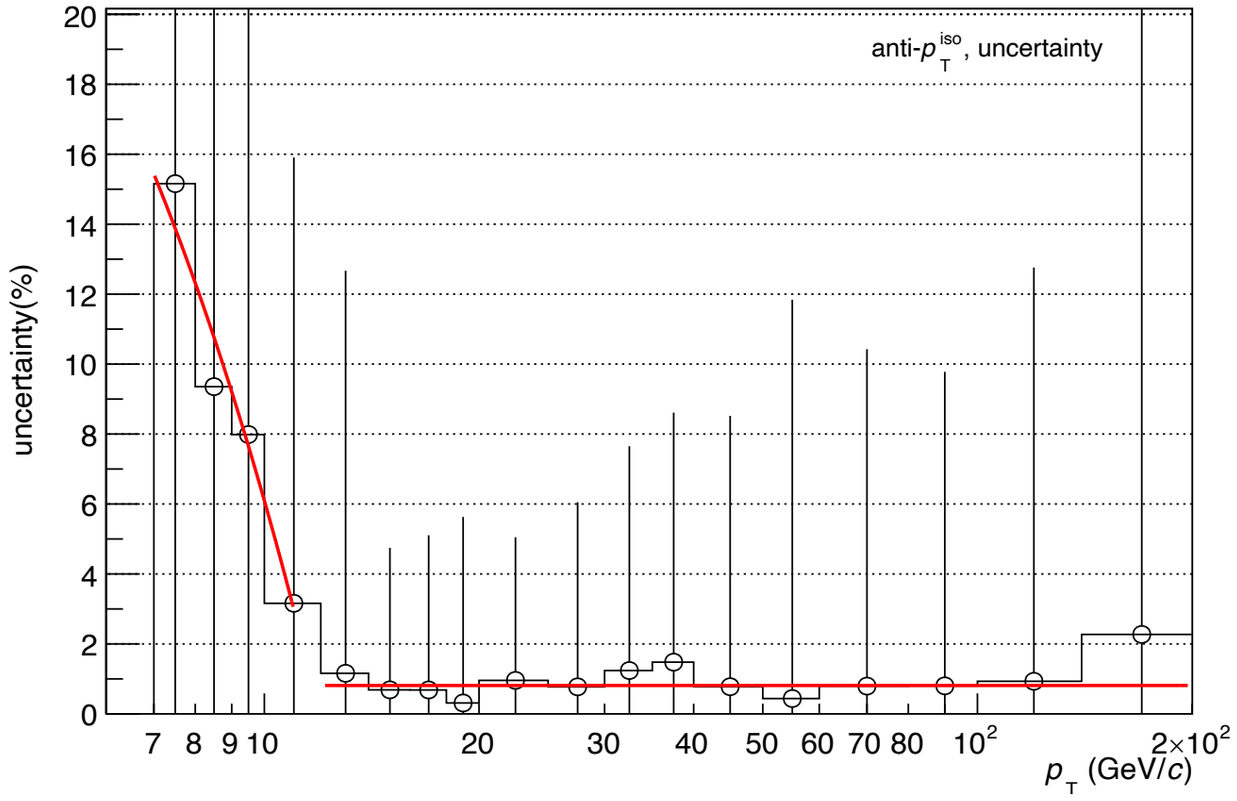


Take 0.37 and 0.43 as varies to estimate the uncertainty from background shower shape the ratios, varies / default

	default	varies	uncertainty
bkg σ^2_{long}	0.40	0.37 ; 0.43	[7 , 10]: value from plot [10, 100]: 0.28 (%)

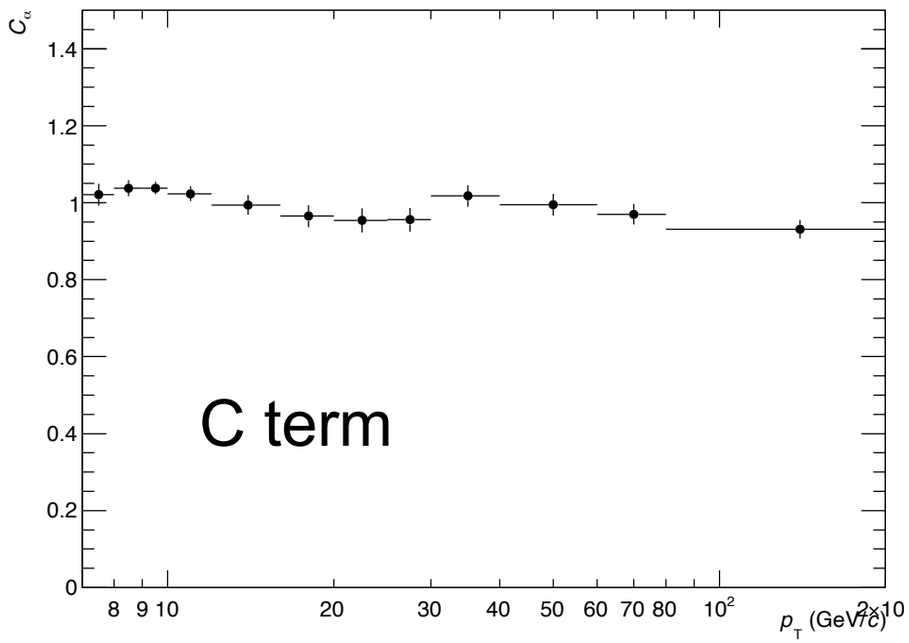
Systematic – anti – p_T^{iso}

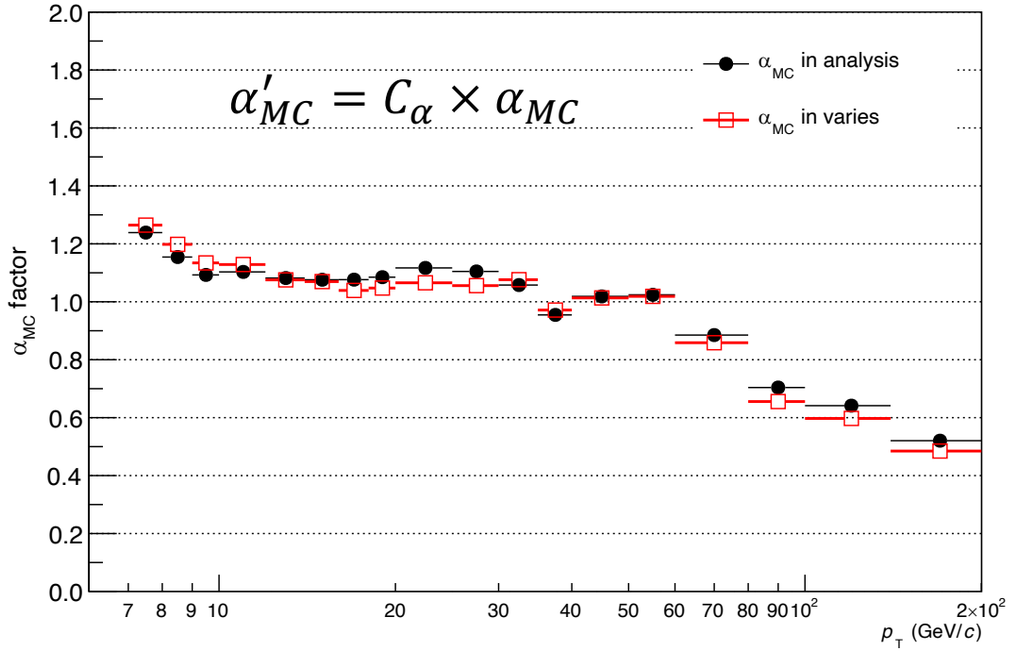


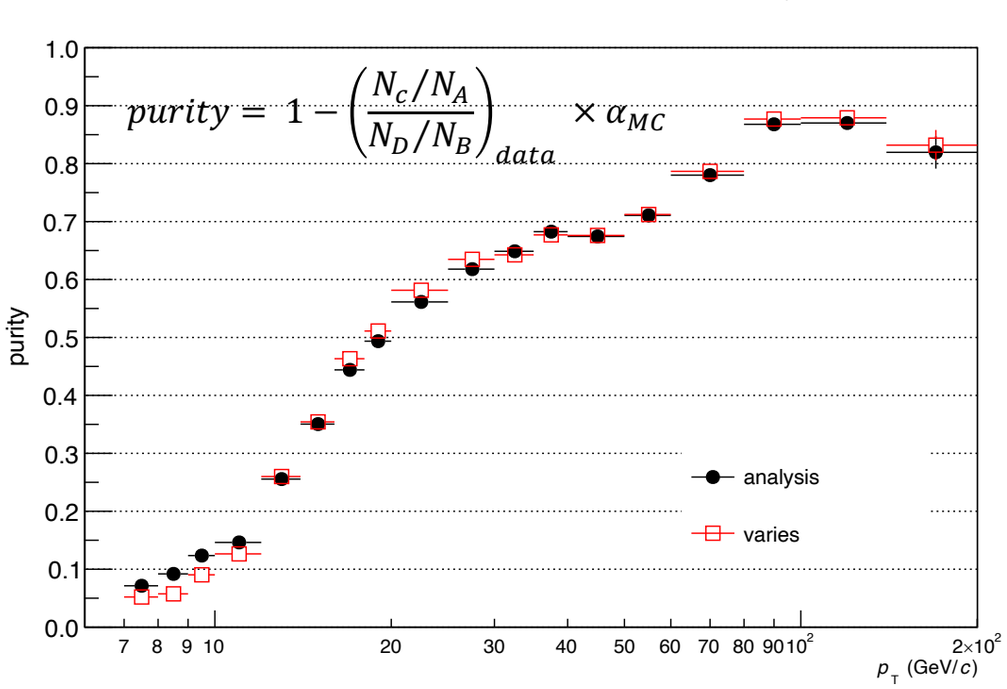


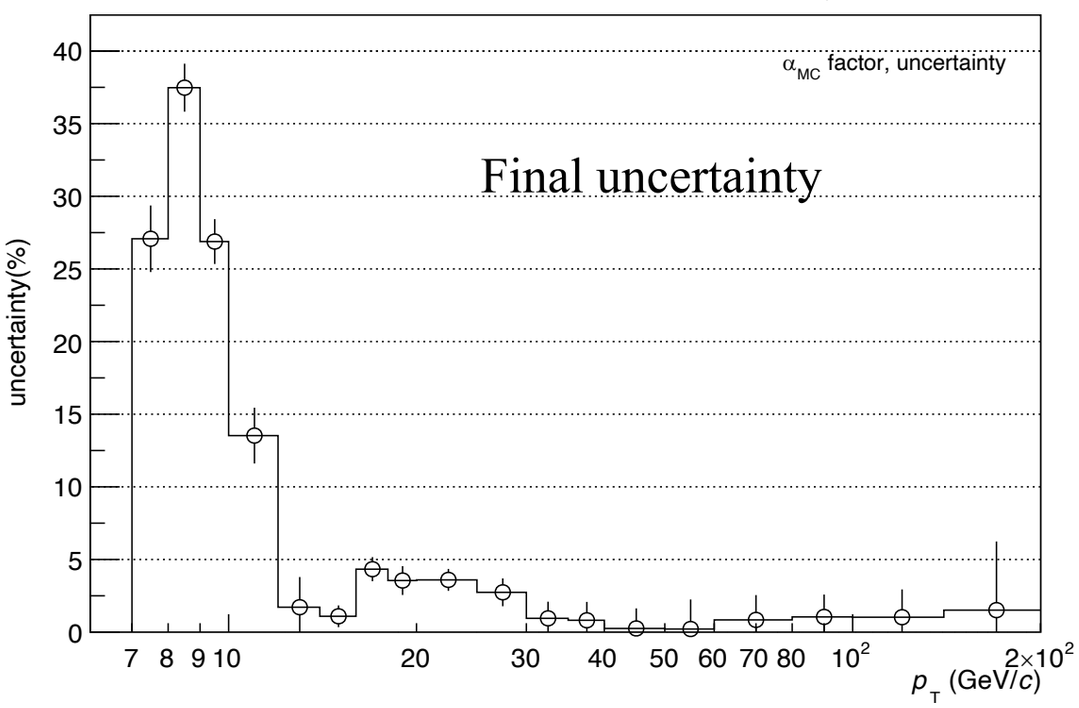
$\boldsymbol{anti - p_T^{iso}\ min}\ (GeV/c)$	2, 2.5(default), 3, 4, 5
$\boldsymbol{anti - p_T^{iso}\ max}\ (GeV/c)$	6, 8, 10(default), 12, 15, 20
uncertainty	[7 , 12]: 37.21 - 3.11*p_T (%) [12, 100]: 0.81 (%)

Systematic – Isolation probability,

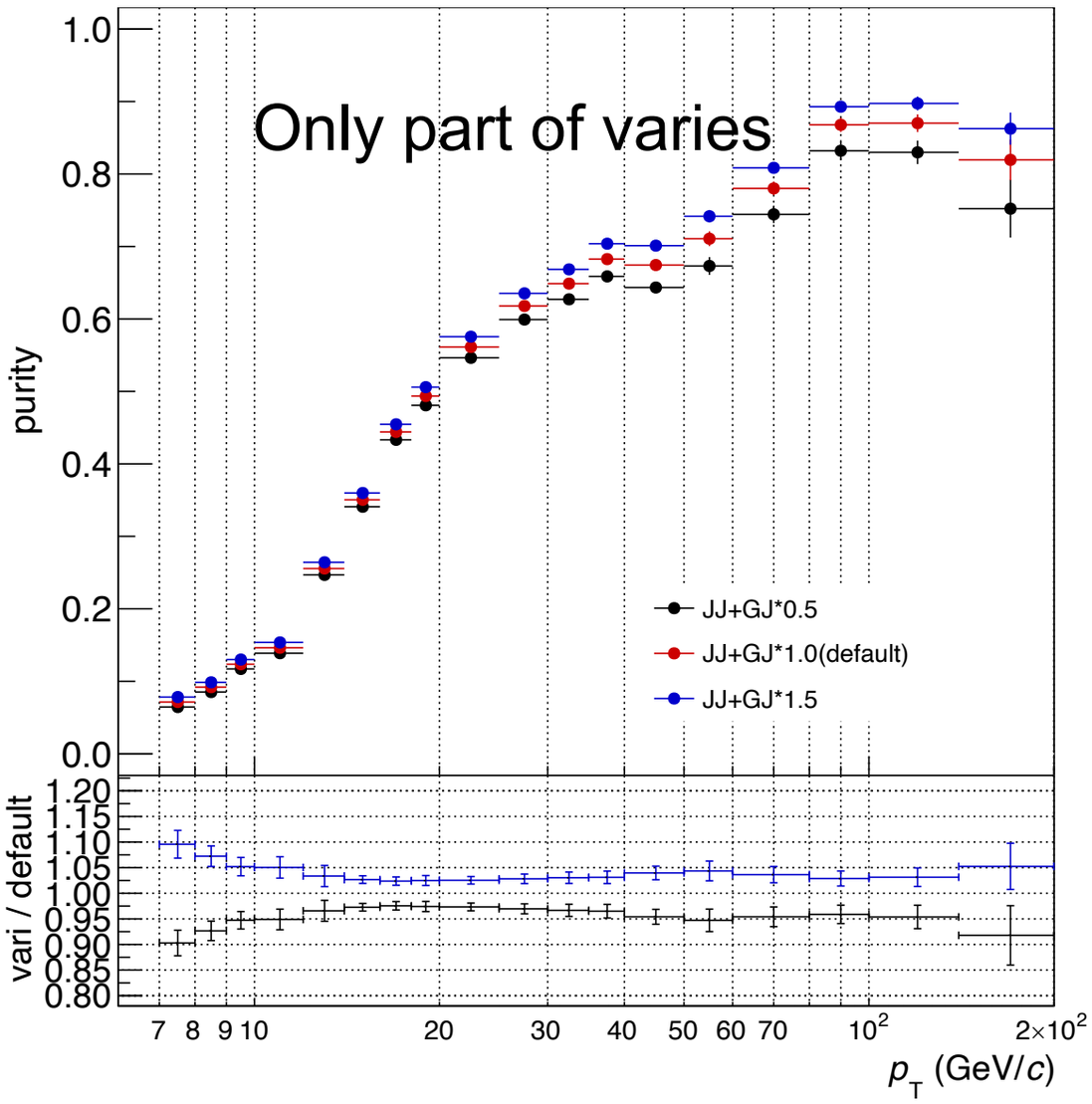


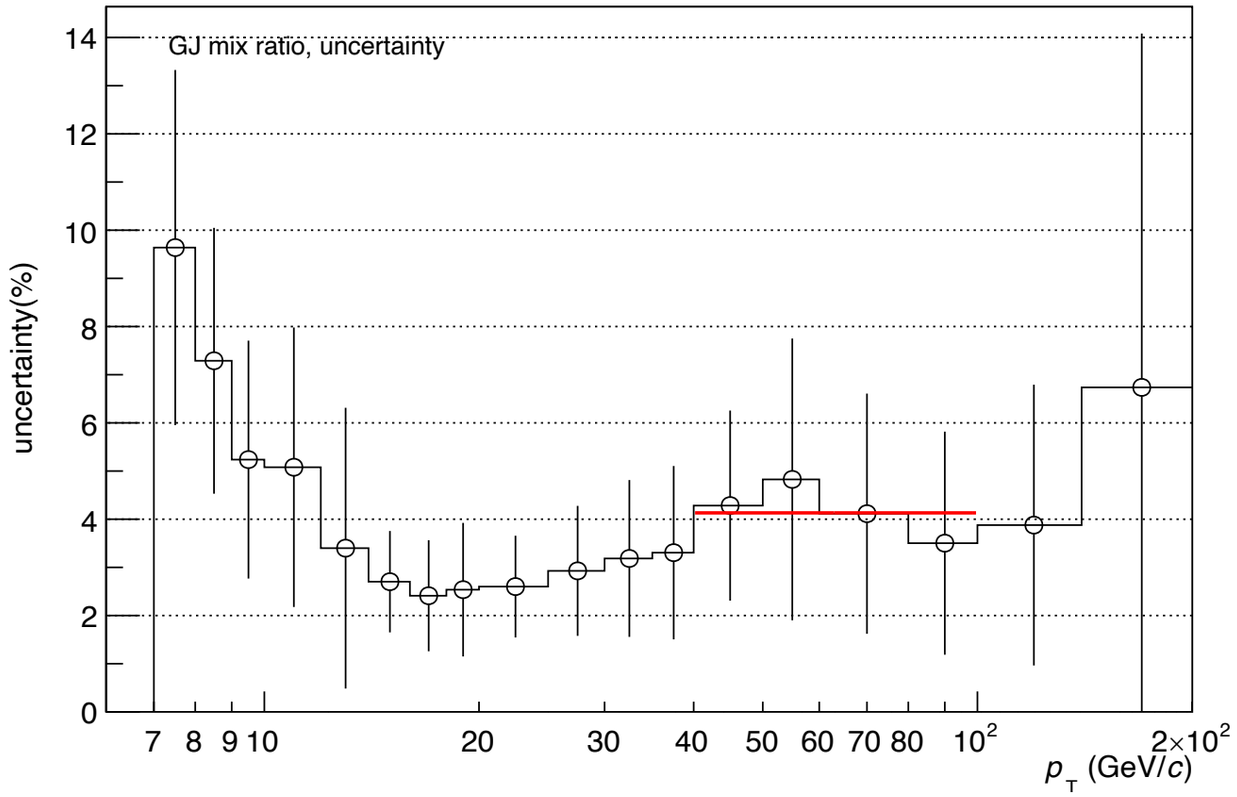






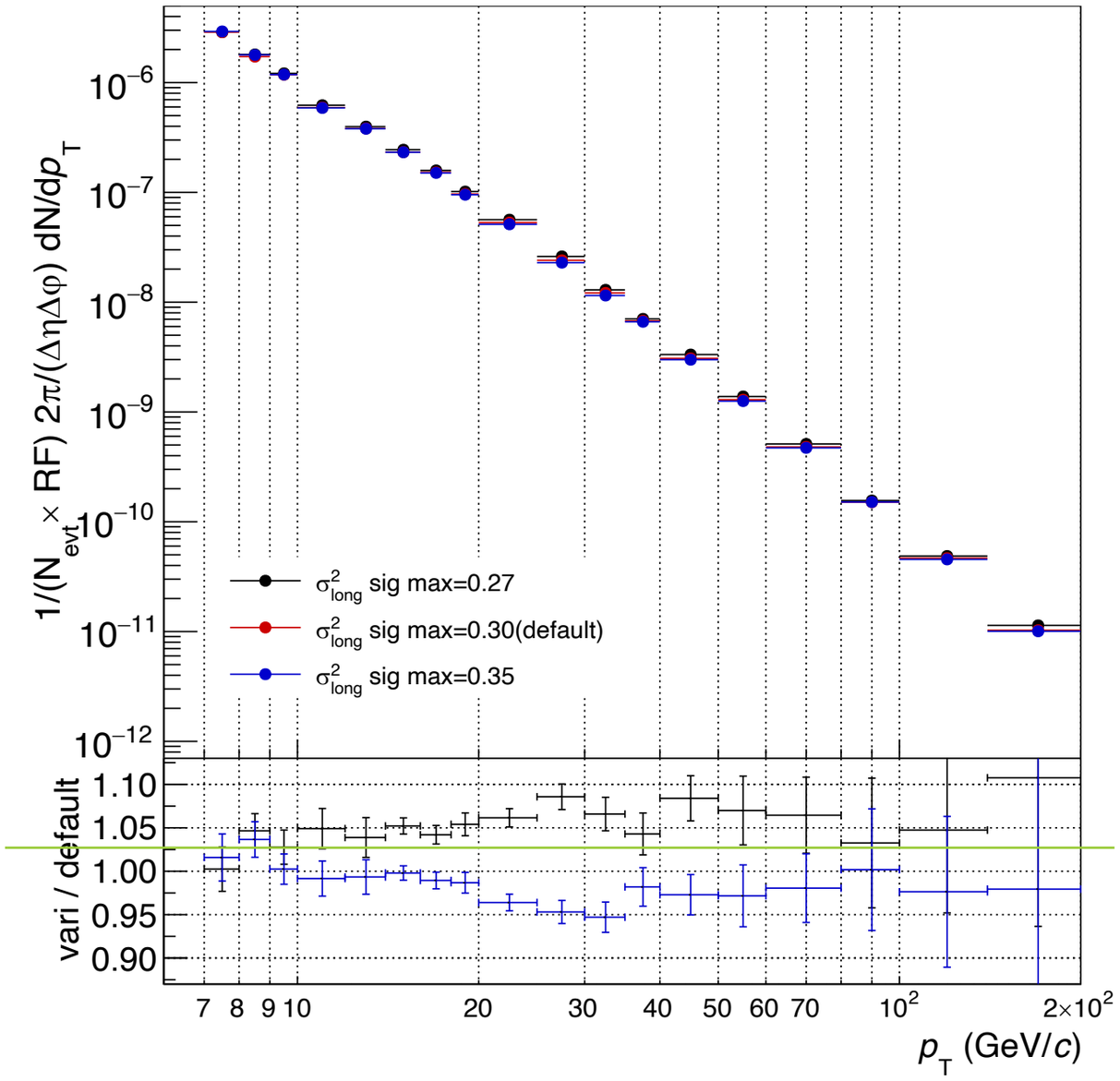
Systematic – GJ mix ratio

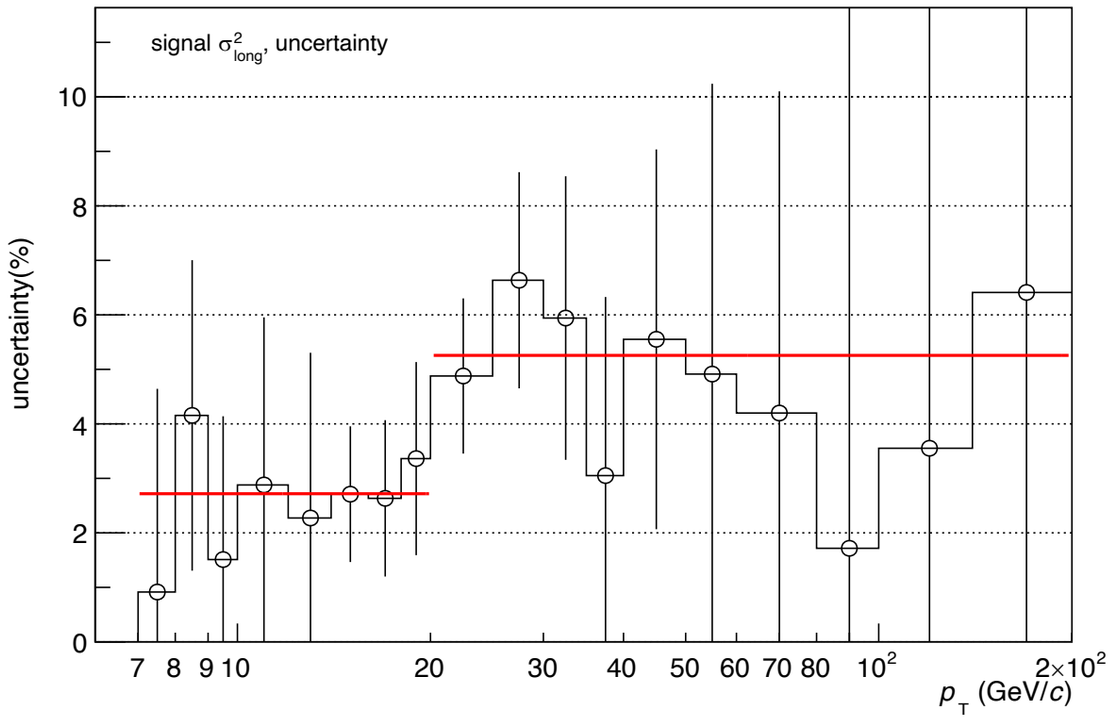




GJ combine factor	default	varies	Pol0 fit [10,100]
	1.0	0.5 ; 1.5	[7 , 40]: value from plot [40, 200]: 4.13 (%)

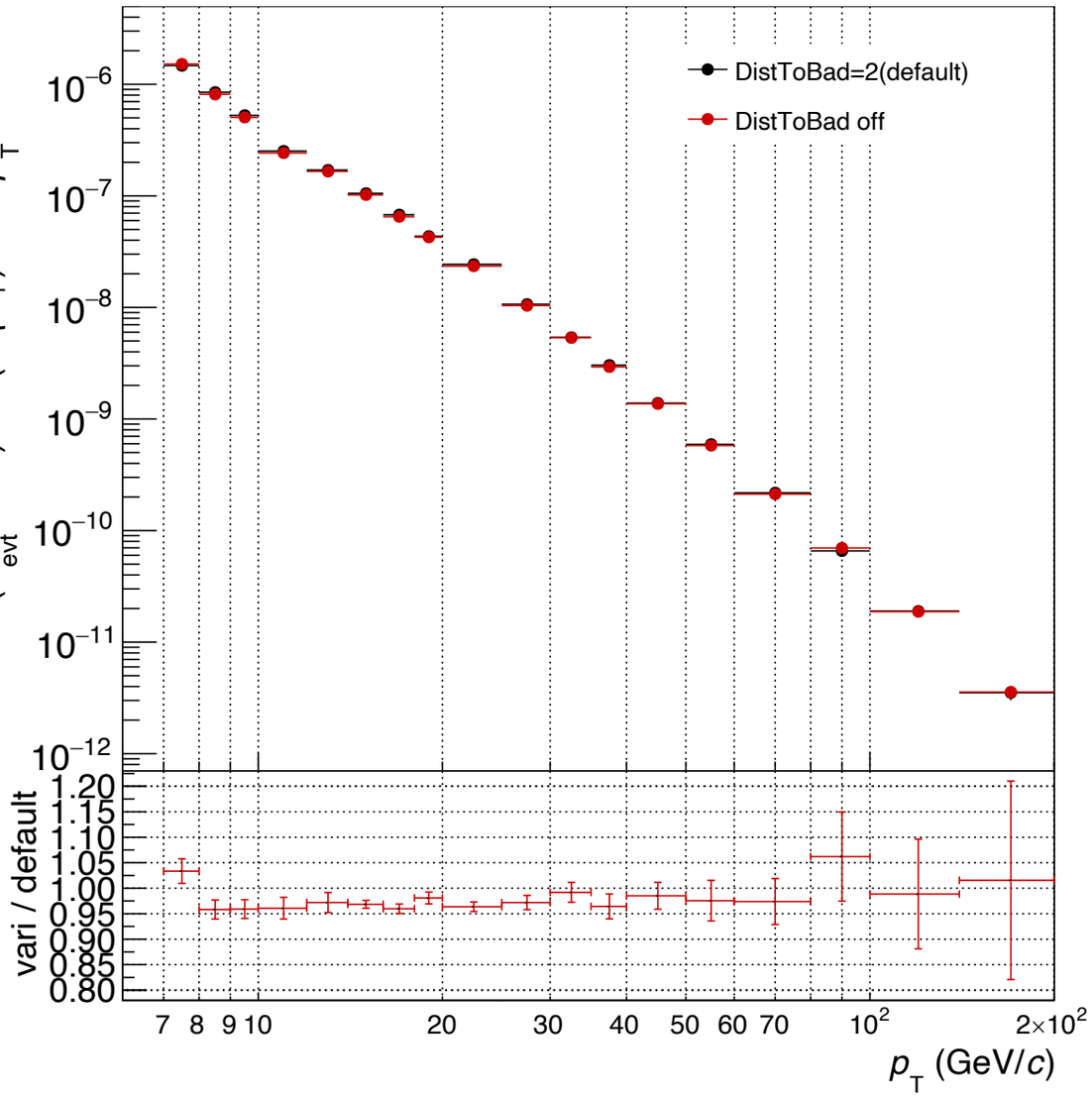
Systematic – signal σ^2_{long} max

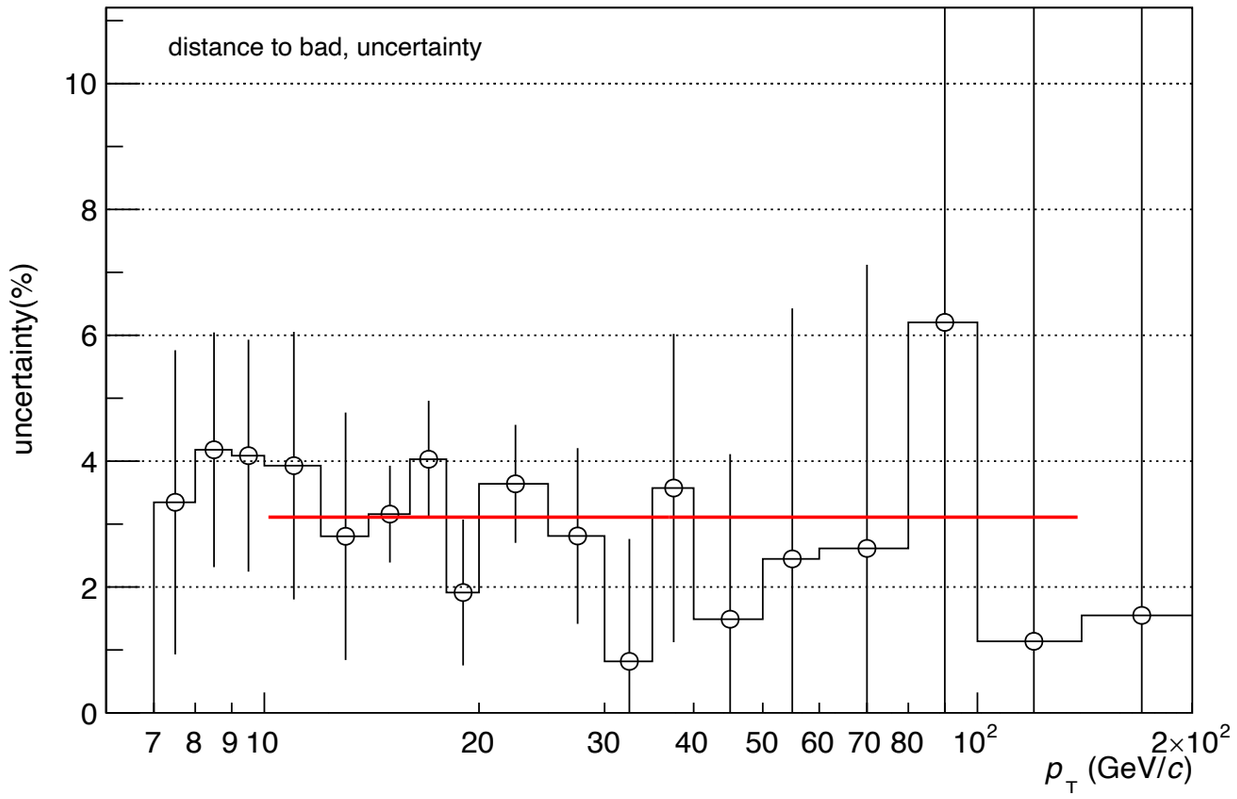




	default	varies	uncertainty
Signal σ^2_{long}	0.40	0.27 0.35	[7 , 20]: 2.72 (%) [20, 100]: 5.26 (%)

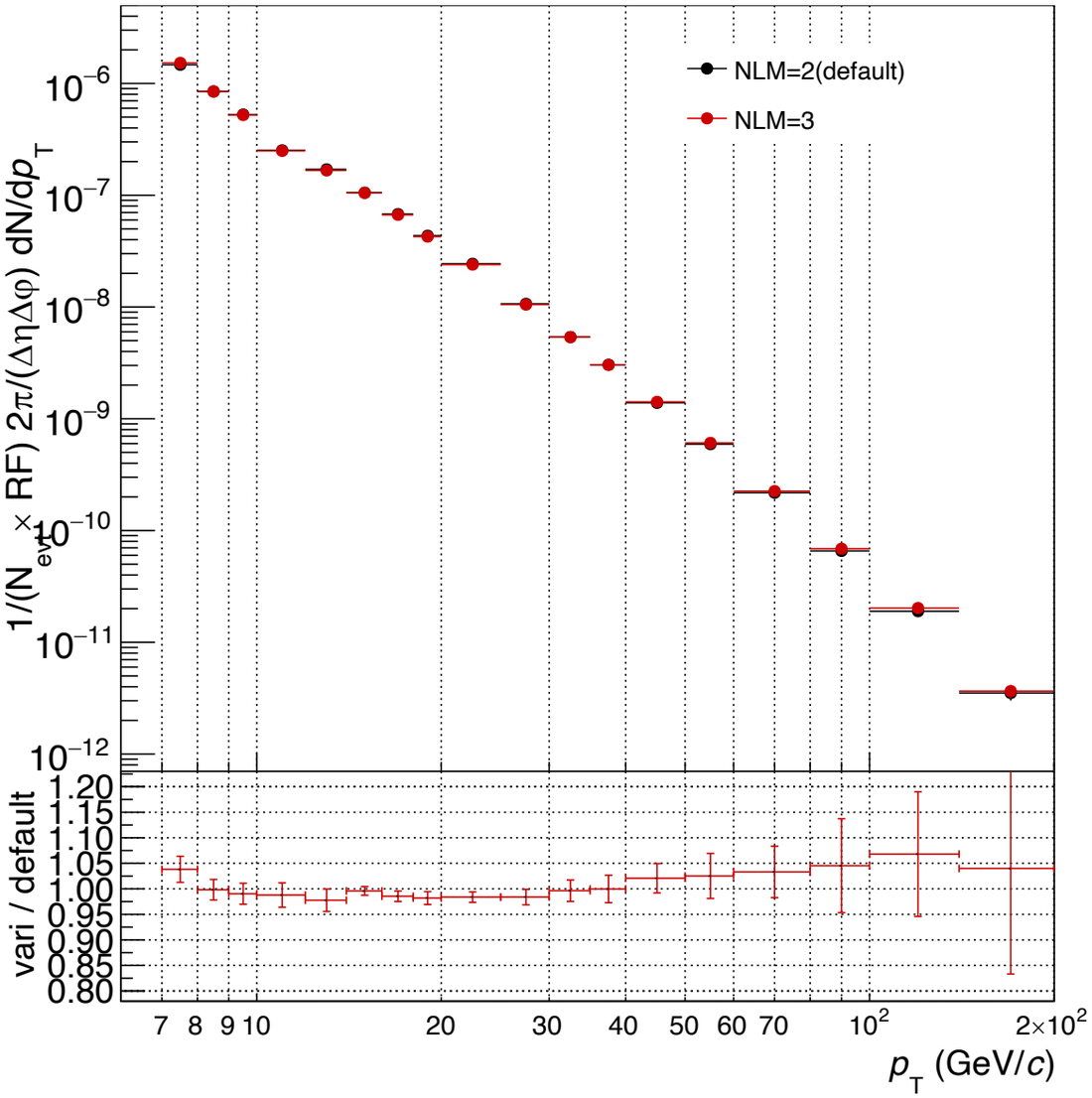
Systematic – Distance to bad

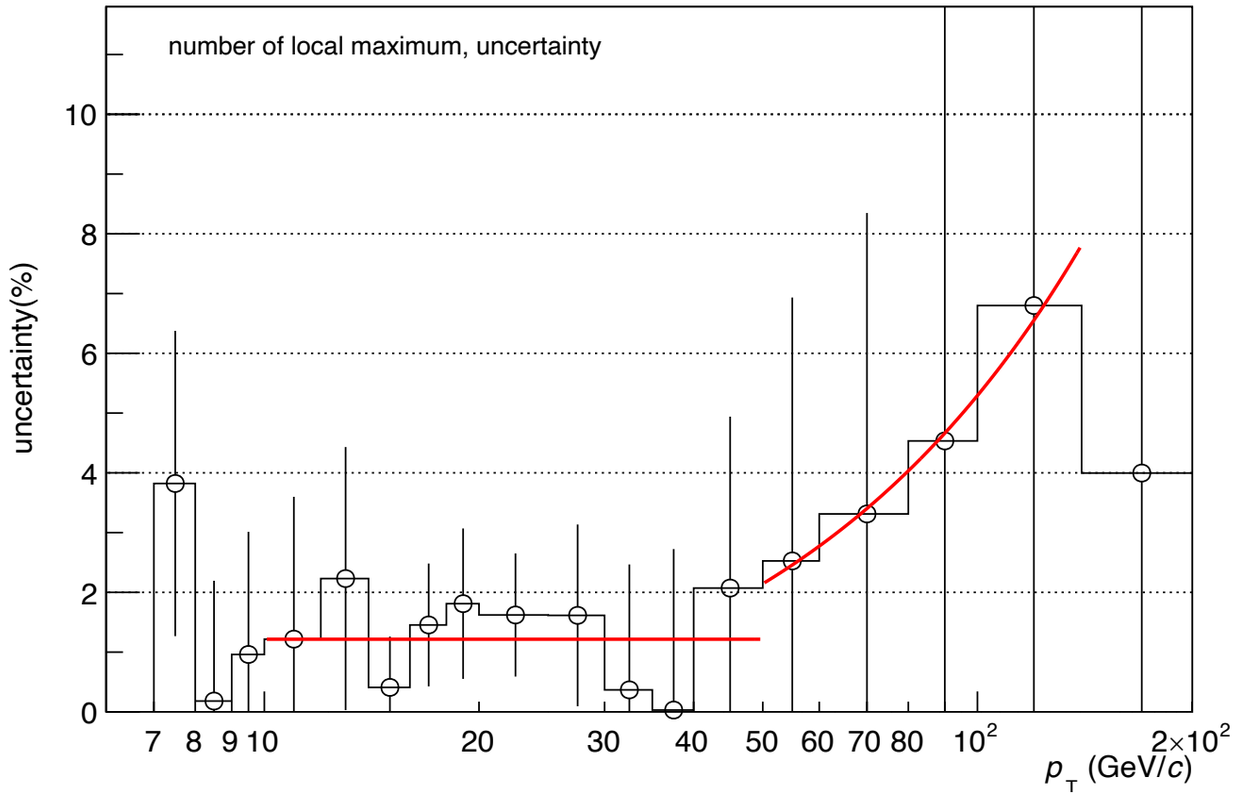




	default	varies	uncertainty
Distance to bad	2	off	3.11 (%)

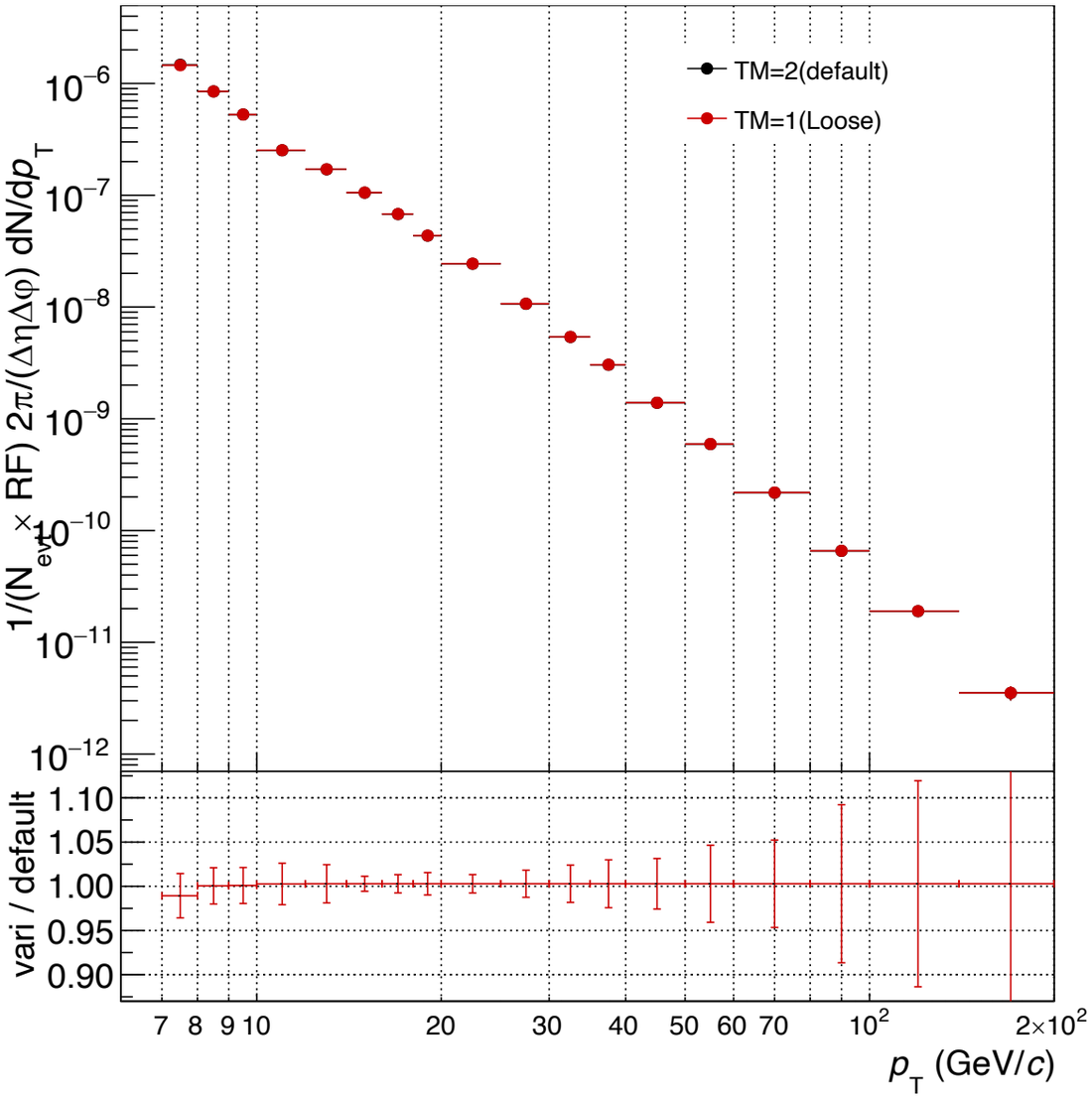
Systematic – Number of local maximum

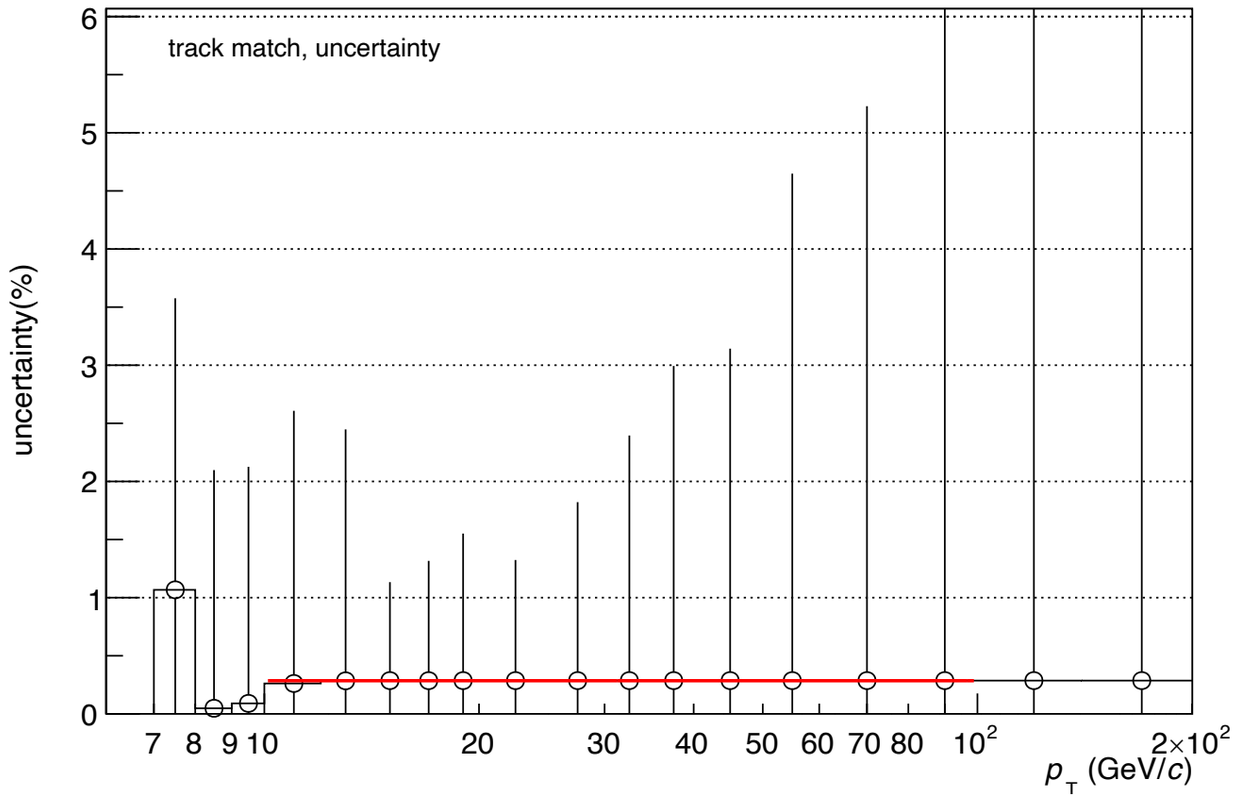




	default	varies	uncertainty
NLM	2	3	[10,50] 1.22 (%) [50,200] 0.06*p_T-1.01 (%)

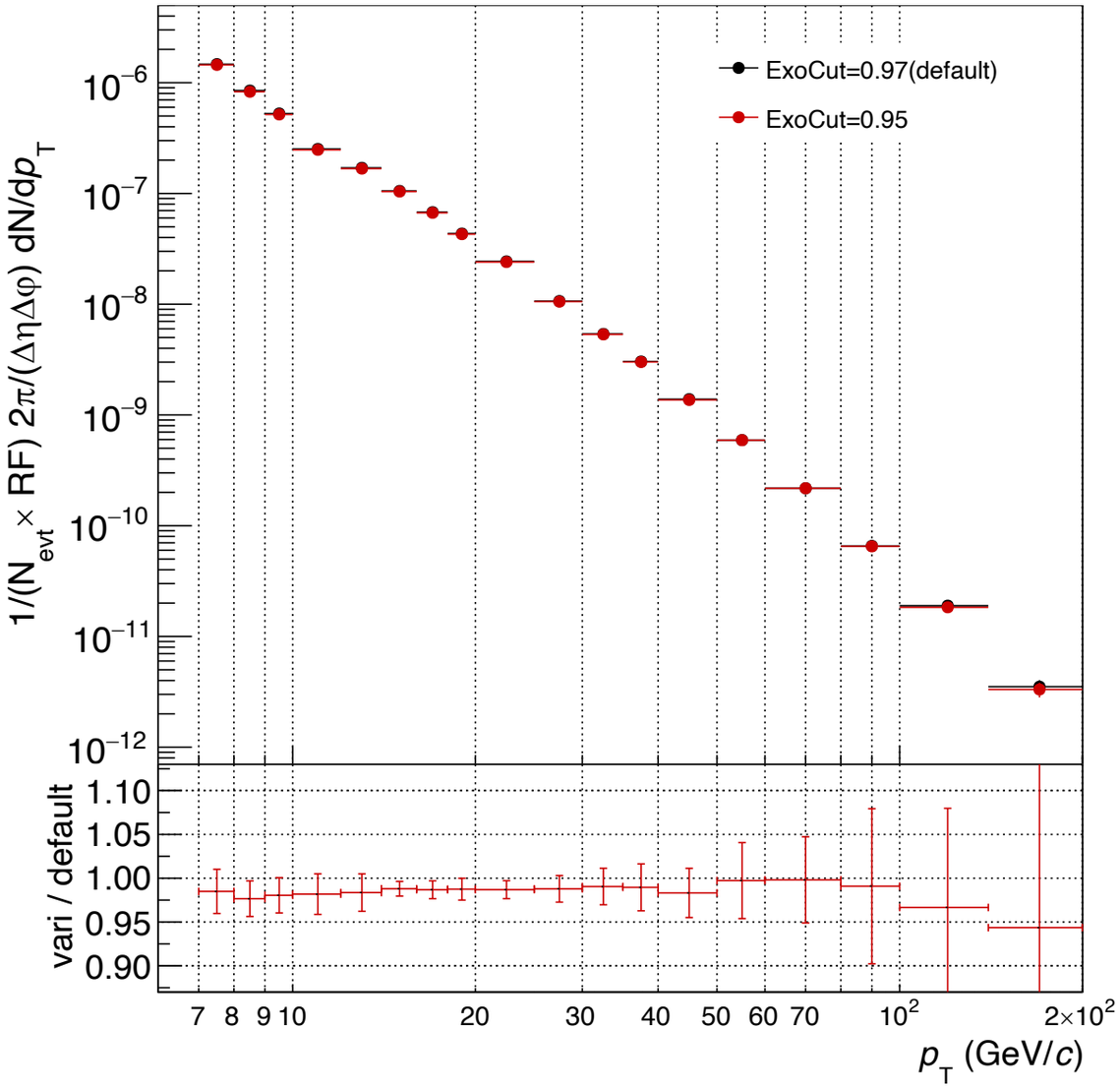
Systematic – Track match

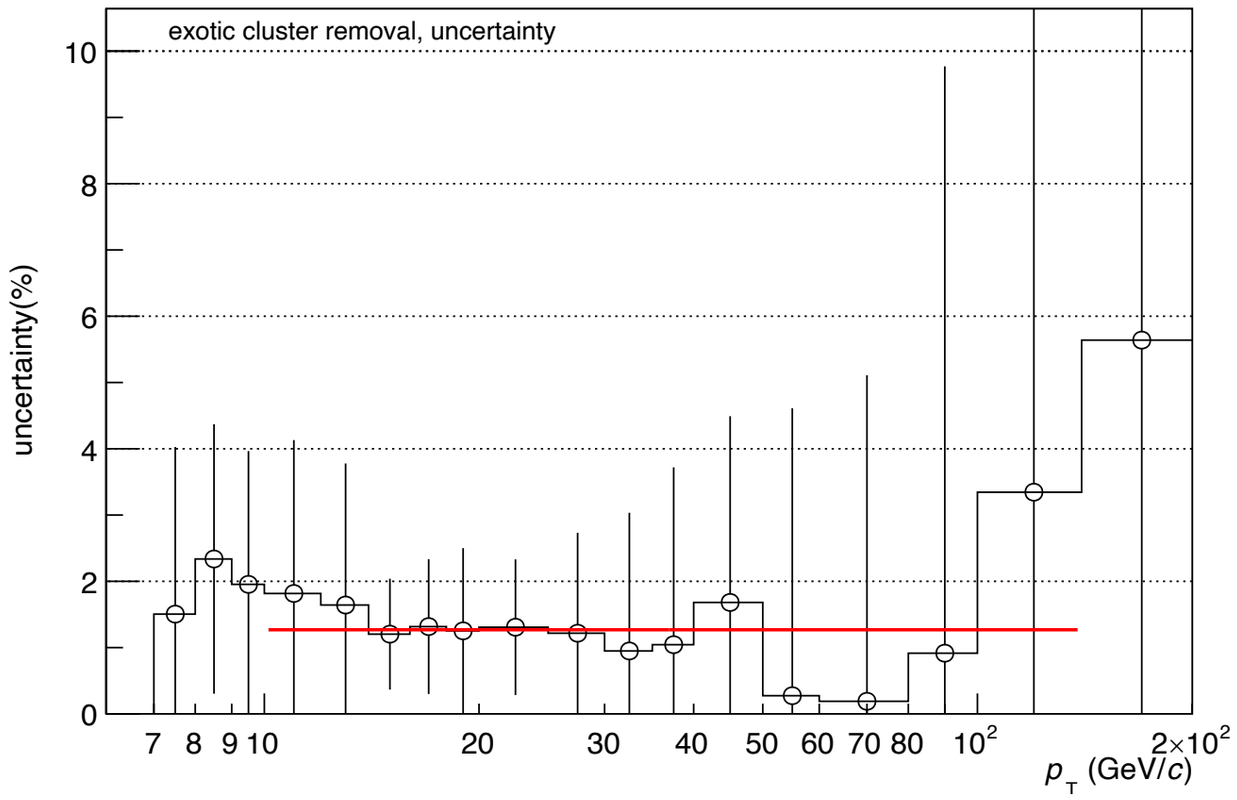




	default	varies	uncertainty
TM	2	1	0.29 (%)

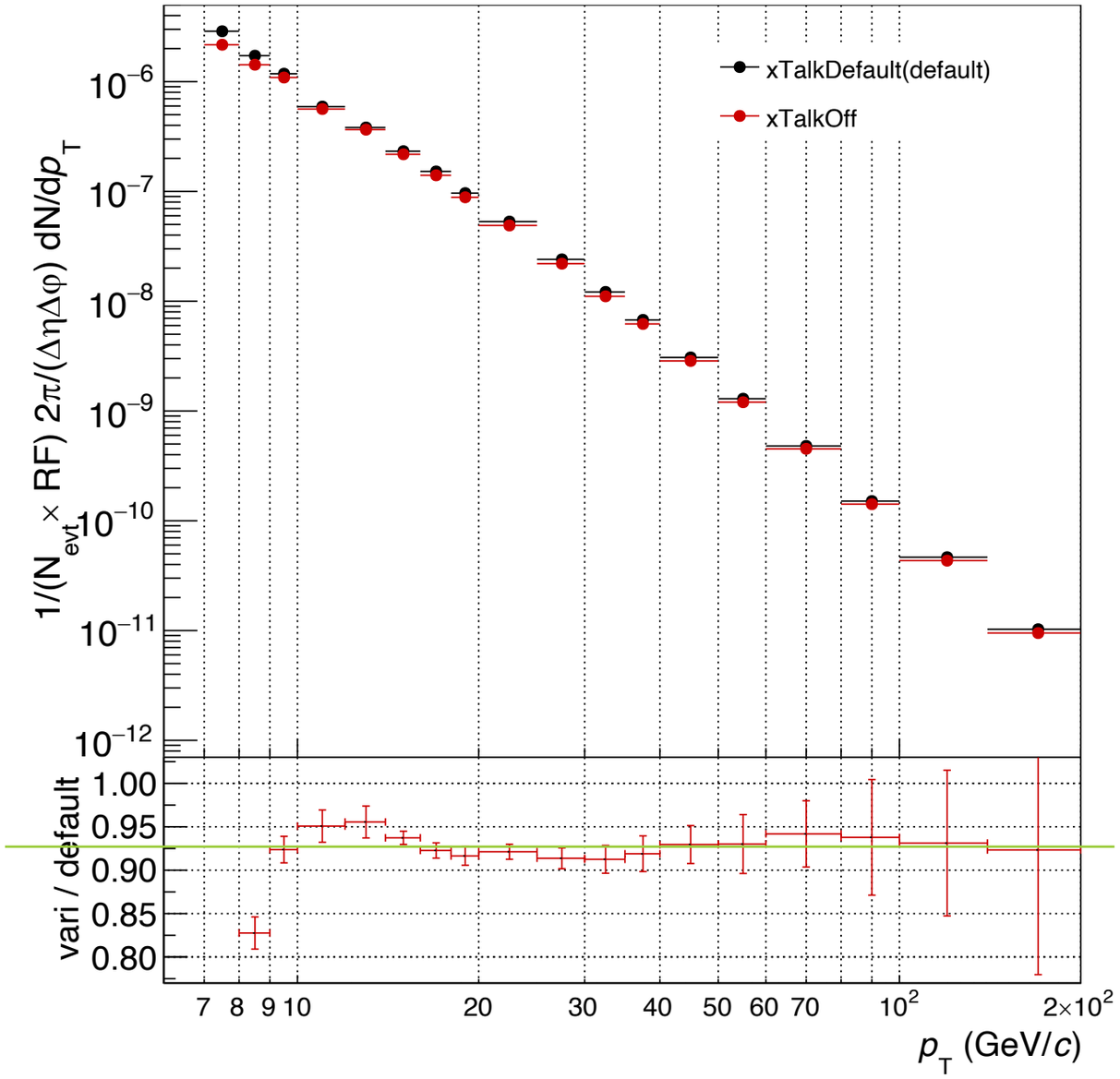
Systematic – Exotic cluster removal

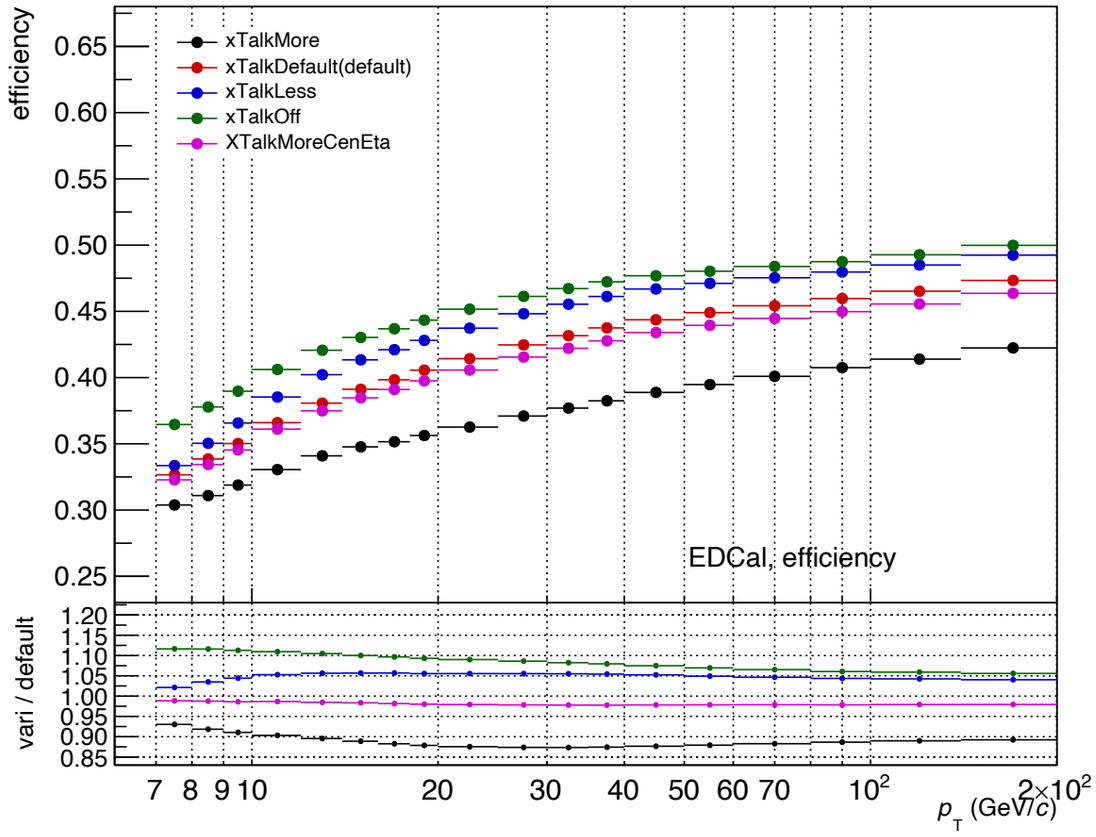




	default	varies	uncertainty
Exotic cut	0.97	0.95	1.27 (%)

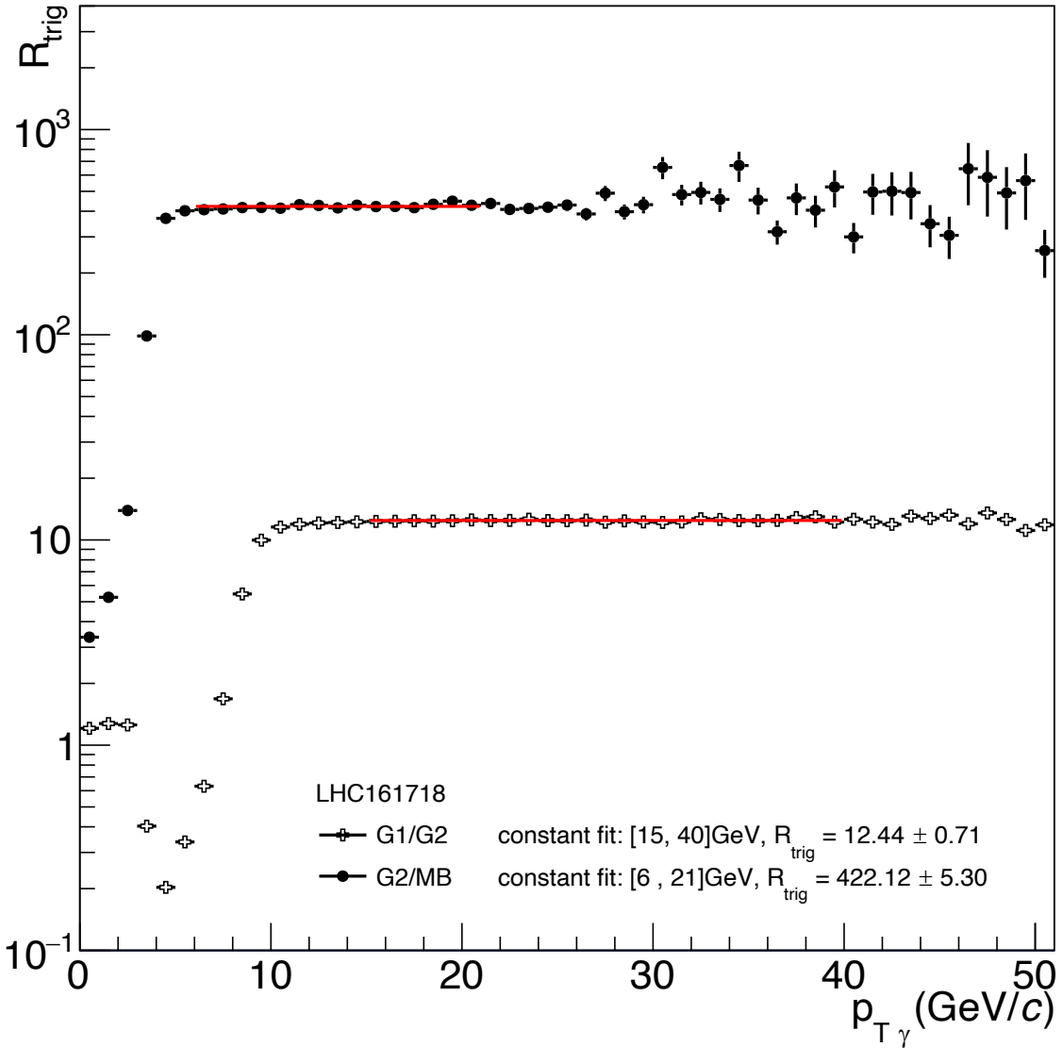
Systematic – different XTalk

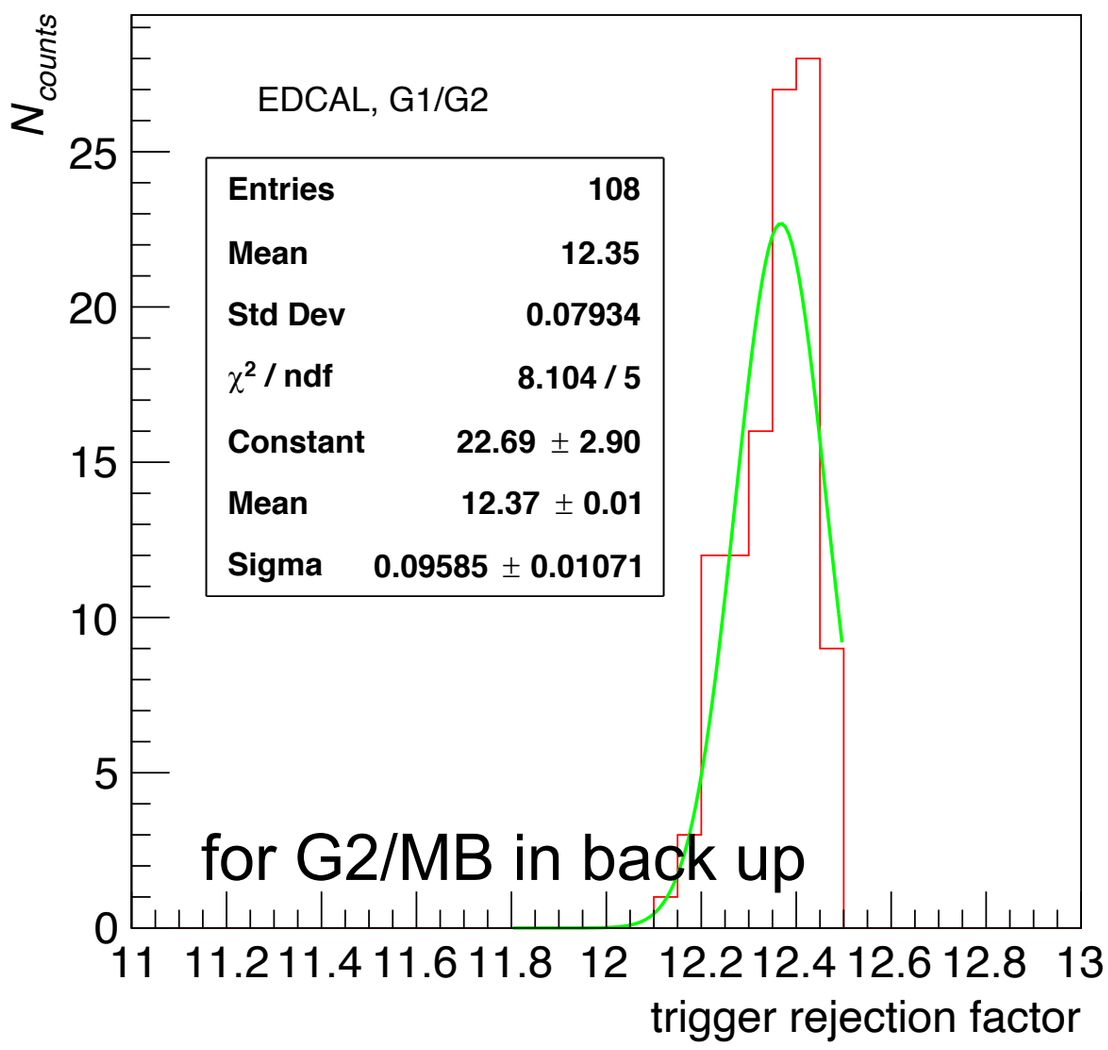




	uncertainty $(\lvert \text{ratio} - 1 \rvert)/2$	
XTalk	[7 , 20]	value from plots
	[20, 200]	4.02 (%)

Systematic – rejection factor





$$RF\ (G1/G2)\ = 12.44 \pm 0.71(stat) \pm 0.08(fit)$$

$$RF\ (G2/MB)\ = 422.12 \pm 5.30(stat) \pm 5.56(fit)$$

RF uncertainty: 6.02%

Mainly ana results presentation

Data set and analysis mainly cut

Analysis dataset:

- Data: ALICE data taken from 2016,17,18
  - MB: EMCAL ~ 1023.9M / 1066.6M ; DCAL ~ 1027.0M / 1066.7M
  - G2 : EMCAL ~ 79.0M / 204.3M ; DCAL ~ 36.6M / 204.3M
  - G1 : EMCAL ~ 54.7M / 204.3M ; DCAL ~ 26.7M / 204.3M
- Simulation: Gamma-Jet event + Jet-Jet events

Cluster selection: (clusterizer V1)

- Ncells/cluster >= 2
- distance to bad channel > 2 cell
- time cut: [-30, 30]ns
- cells energy: Eseed = 500 MeV , Ecell = 100 MeV
- NLM <= 2
- Trackmactch: : p_T dependent
- Emulation of cross-talk T-Card in MC applied

Photon selection:

- Showershape: $\sigma^2_{long} < 0.3$

Isolation criterion:

- particle in cone: charg+neutral
- track p_T in lsolation cone: p_T,track > 0.2 GeV
- $|\eta| < 0.52$, φ (1.57,3.11)
- isolation crite: R = 0.4

$$p_T^{iso} \equiv \Sigma p_{T,track} < E_T^{th} = 1.5 GeV/c$$

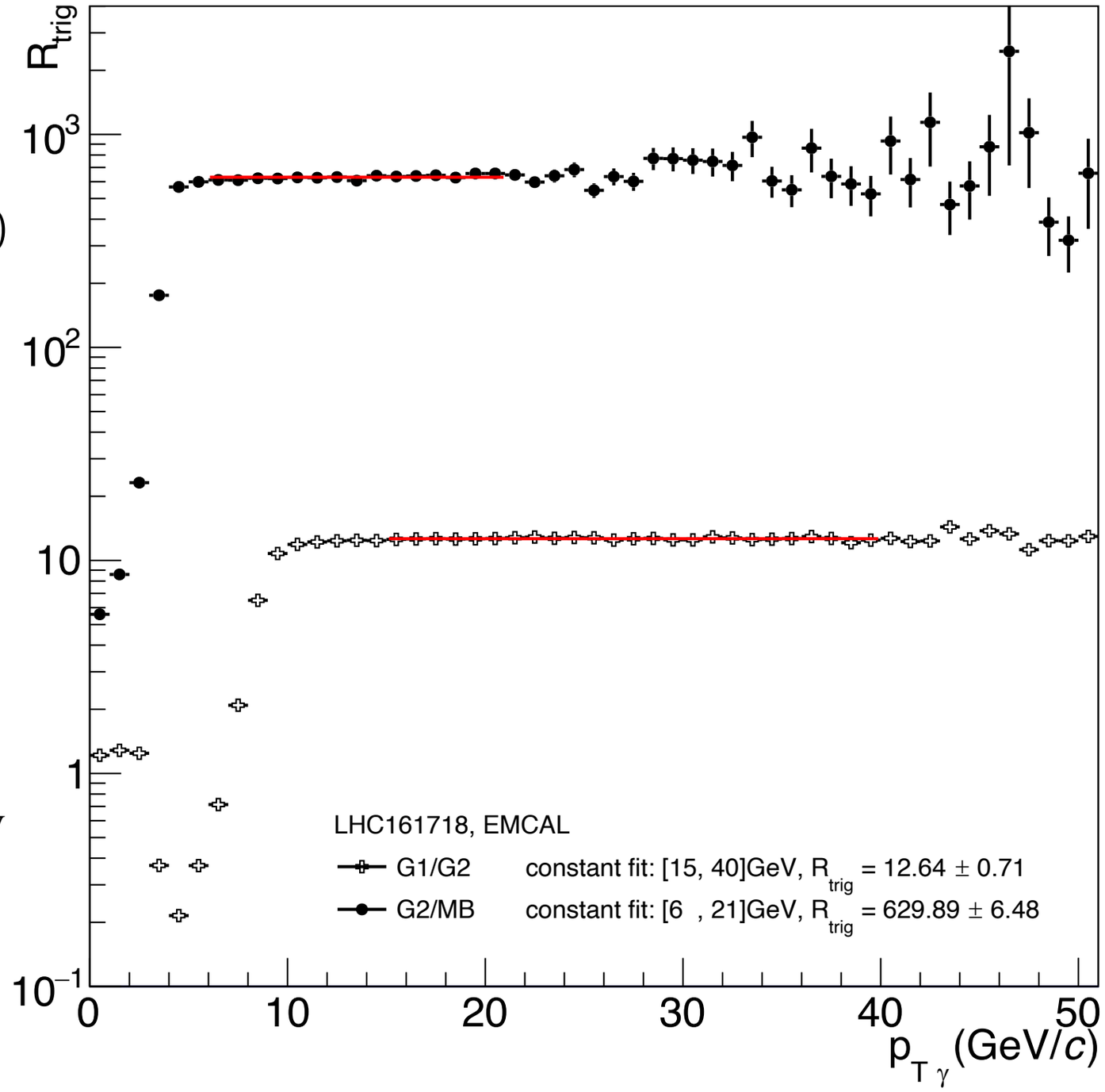
$$p_T^{\overline{iso}} \equiv \Sigma p_{T,track} > E_T^{th} = 2.5 GeV/c$$

Cluster rejection factor

- $RF = \left(\frac{1}{N_{evt}}\frac{dN_{cluster}}{dP_T}\right)_{trigger} \Big/ \left(\frac{1}{N_{evt}}\frac{dN_{cluster}}{dP_T}\right)_{MB}$
- Trigger sample normalize:

$$\left(\frac{1}{N_{evt}}\frac{dN}{dp_T}\right)_{norm.} = \left(\frac{dN}{dp_T}\right)_{trigger} / \left(N_{evt,trig} * RF\right)$$

	EMCAL	DCAL
G2/MB	629.89±6.48	1280.87±9.24
G1/G2	12.64±0.71	12.04±0.69
G1/MB	7962.73	15427.31



DCal RF plots in backup

Cluster selection: (clusterizer V1)

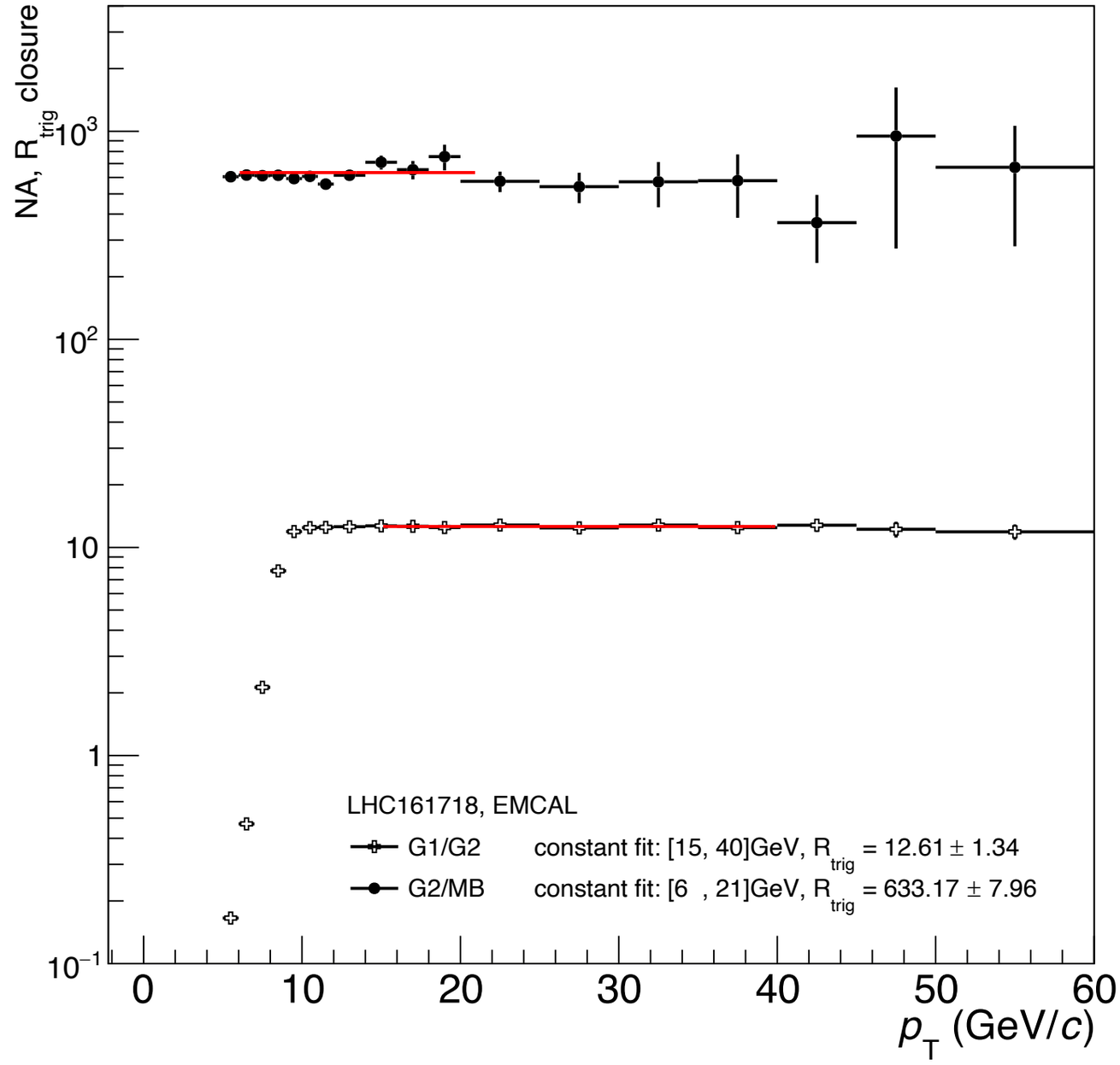
- cells energy: Eseed = 500 MeV , Ecell = 100 MeV
- Ncells/cluster >= 2
- distance to bad channel > 2 cell
- time cut: [-30, 30]ns
- NLM <= 2
- Trackmactch: : p_T dependent
- Emulation of cross-talk T-Card in MC applied

Isolated photon rejection factor

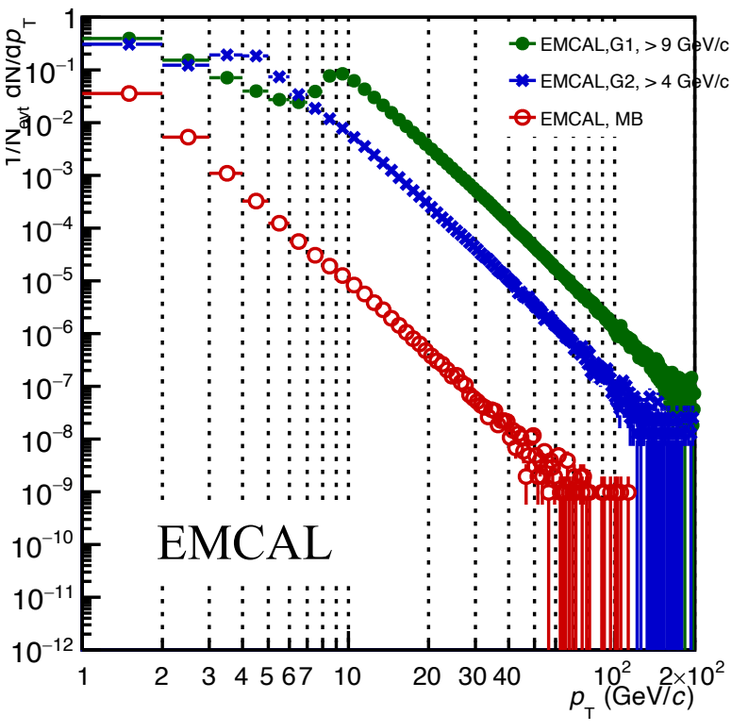
$$RF = \left(\frac{1}{N_{evt}}\frac{dN}{dP_T}\right)_{trigger} \Big/ \left(\frac{1}{N_{evt}}\frac{dN}{dP_T}\right)_{MB}$$

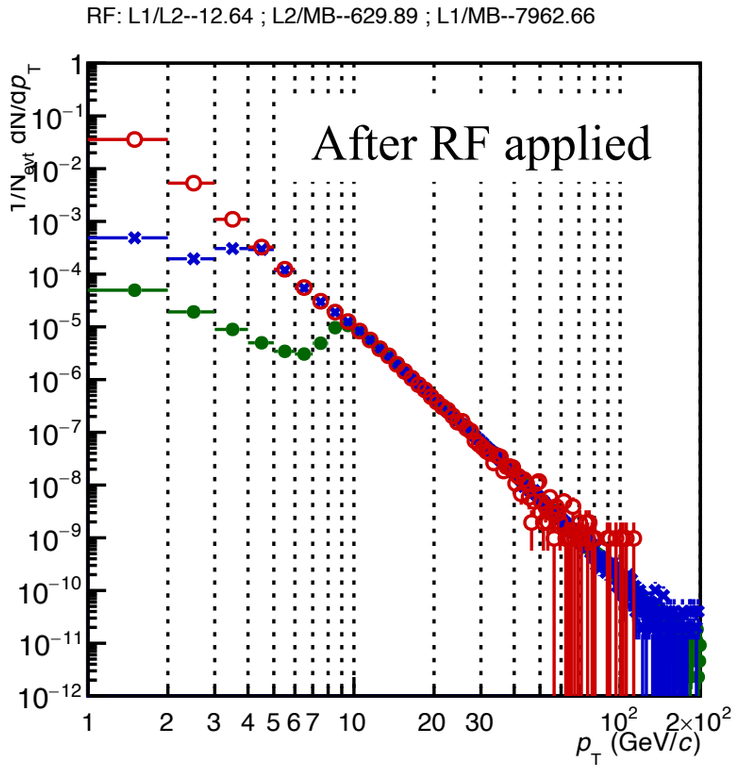
		cluster RF	Iso photon RF	Cluster/ IsoPhoton
EMCAL	G1 / G2	12.64±0.71	12.61±1.34	1.002
	G2 / MB	629.89±6.48	633.17±7.96	0.995
	G1 / MB	7962.73		
DCAL	G1 / G2	12.04±0.69	12.49±1.34	0.964
	G2 / MB	1280.87±9.24	1229.58±11.09	1.042
	G1 / MB	15427.31		

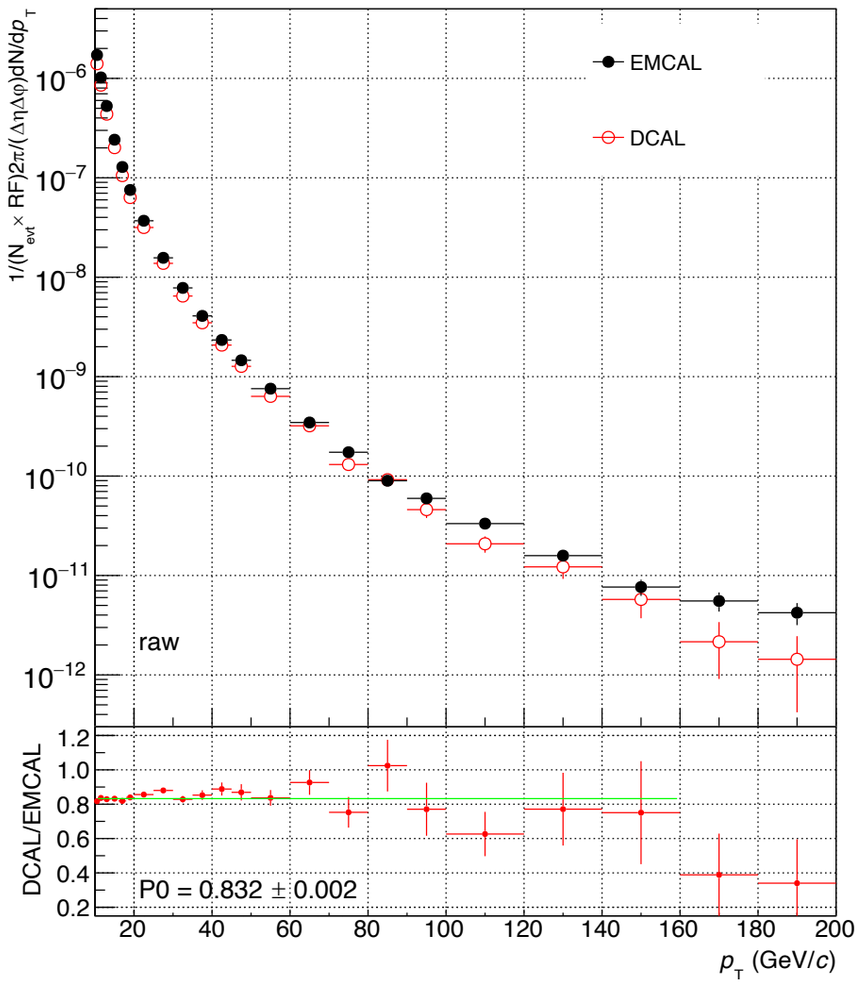
The rejection factor works equivalent in cluster and isolated photon.

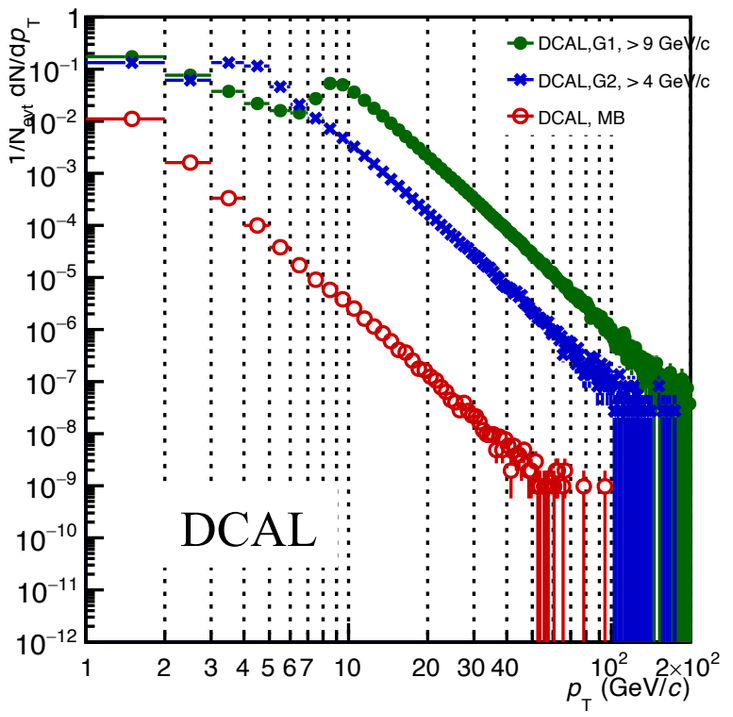


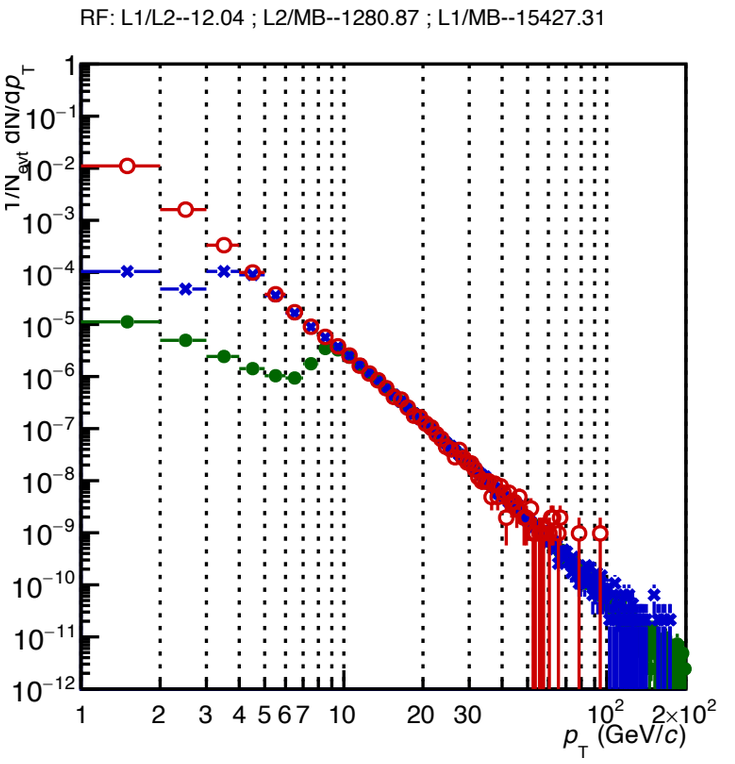
Isolated photon pt distribution





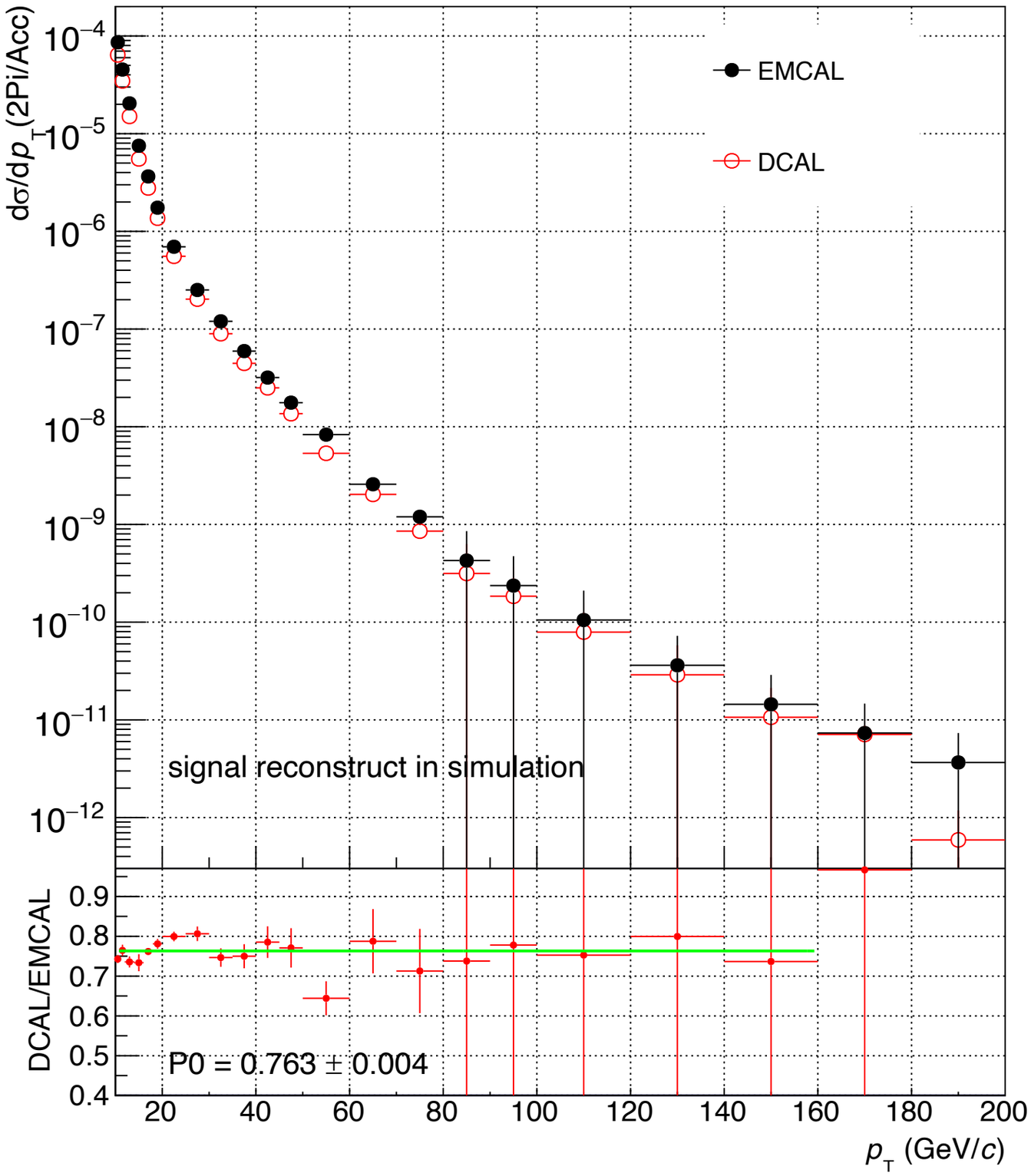






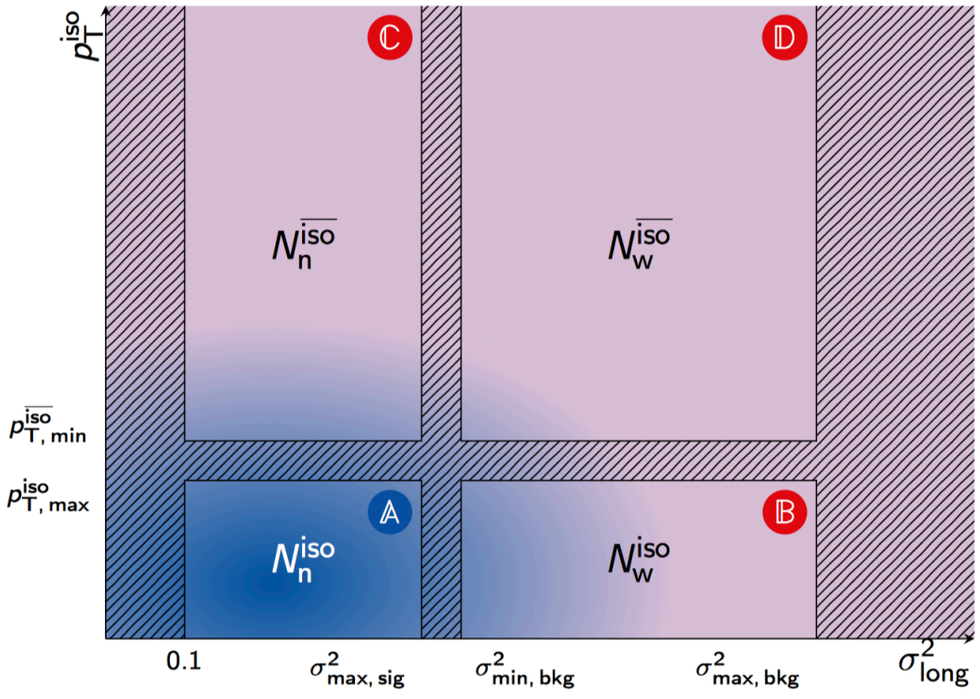
- After the cluster rejection factor applied, different samples similar to each other.
- Combined sample after acceptance normalized, DCAL/EMCAL around 0.83. because different masked regions not considered in acceptance correction factor.

Isolated photon pt distribution in MC



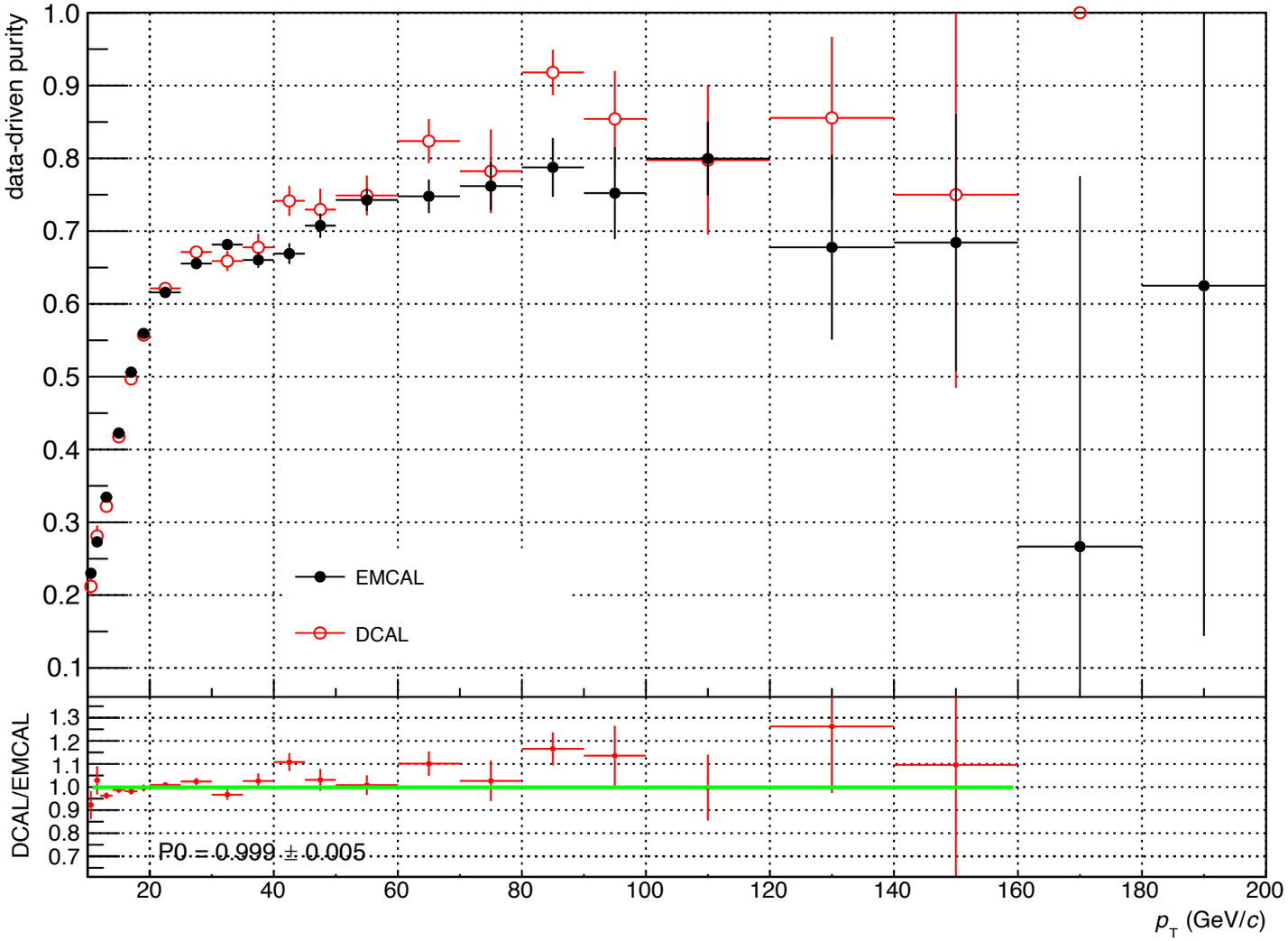
- In MC, the reconstructed signal in different calorimeters are close to each other after acceptance Combined sample after acceptance normalized.
- Ratio, DCAL/EMCAL is 0.76 in GJ but in data is 0.83.

Data driven purity in different detector



$$purity = \boxed{1 - \left(\frac{N_c/N_A}{N_D/N_B}\right)_{data}} \times \left(\frac{B_A/N_C}{N_B/N_D}\right)_{M}$$

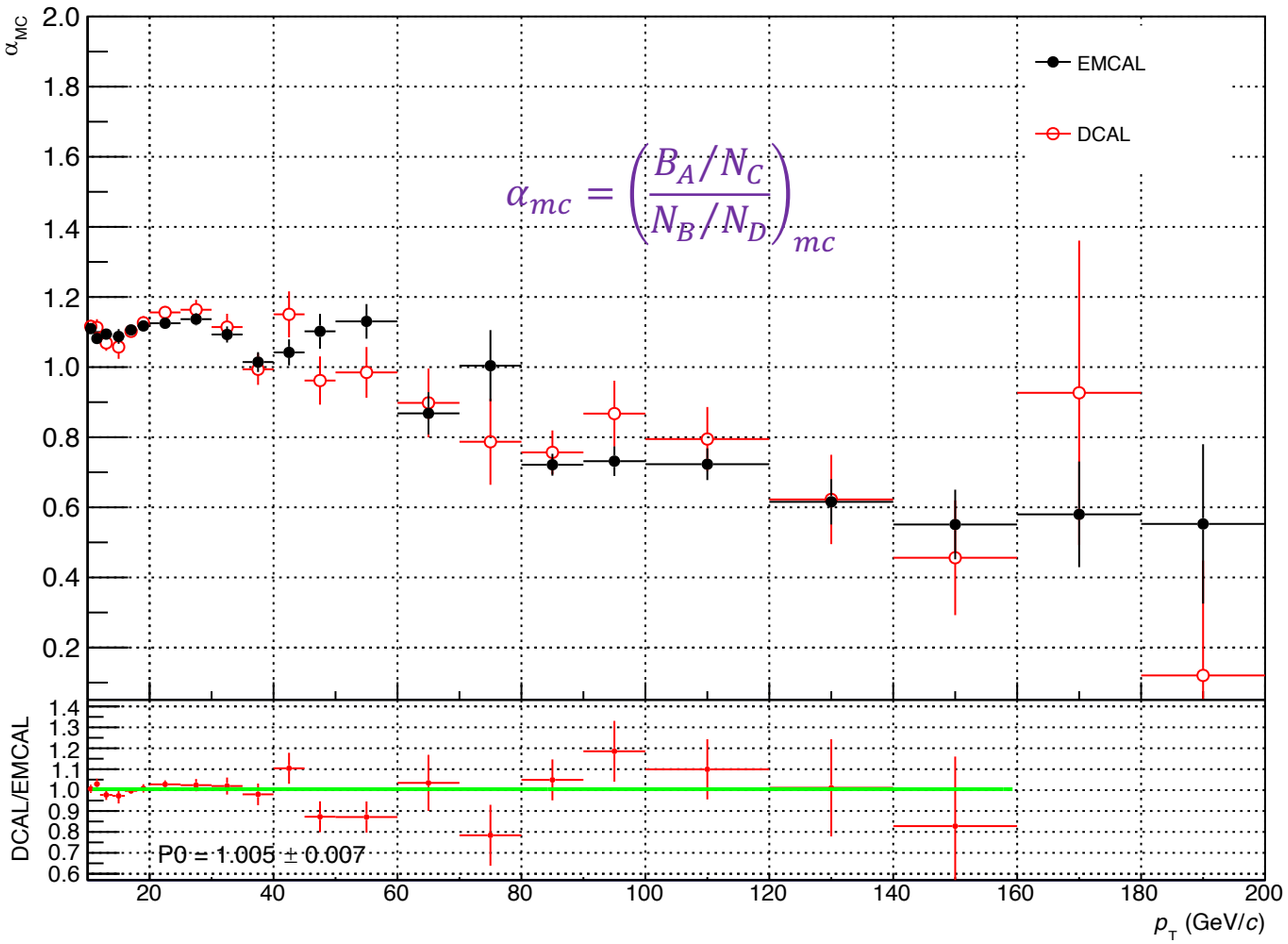
purity by data-driven

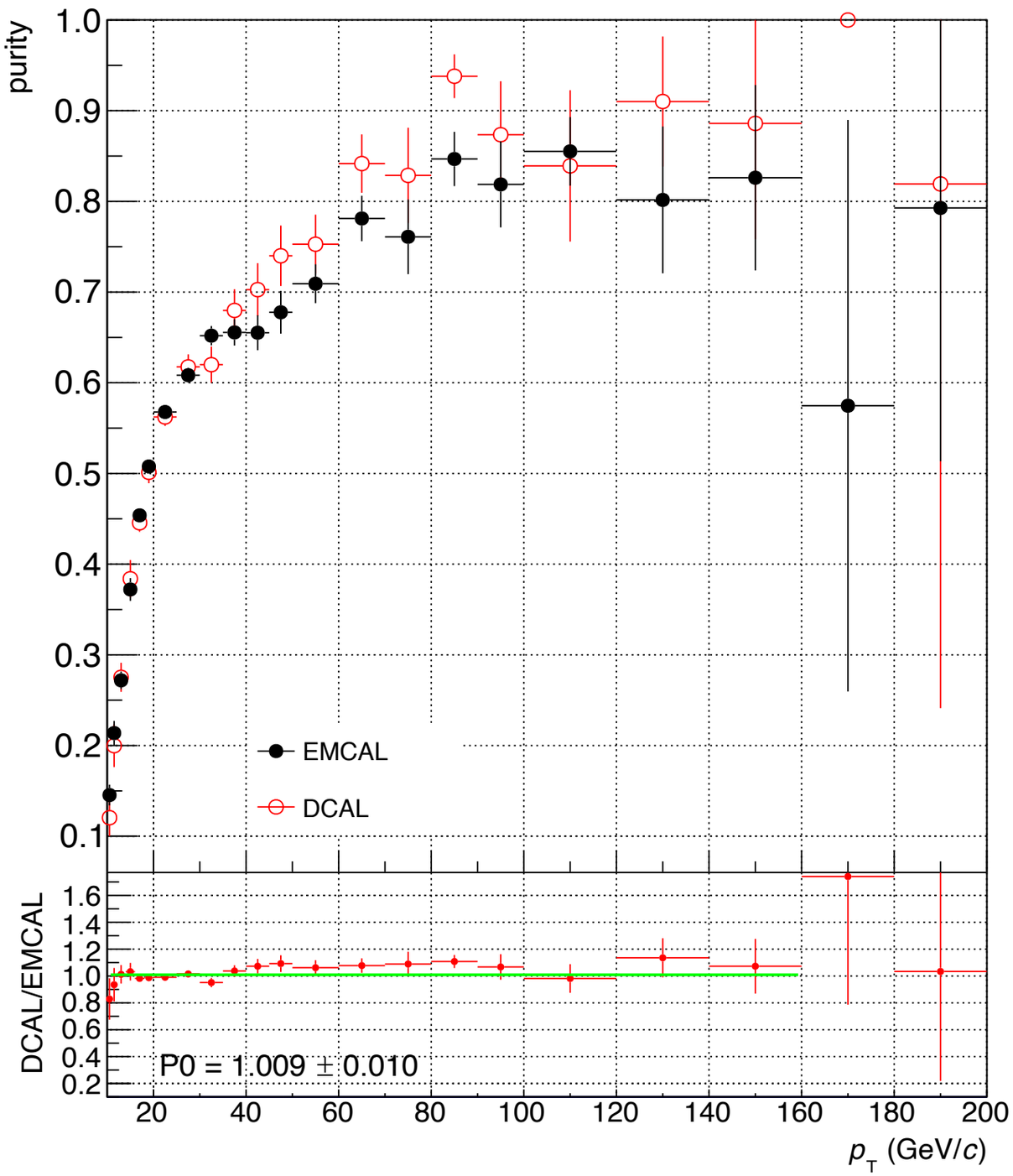


✢ Data-driven purity is equivalent between EMCal and DCal.

✢ Data-driven purity DCAL/EMCAL pol0 fit value: 0.999 ± 0.006.

MC correction factor and final purity



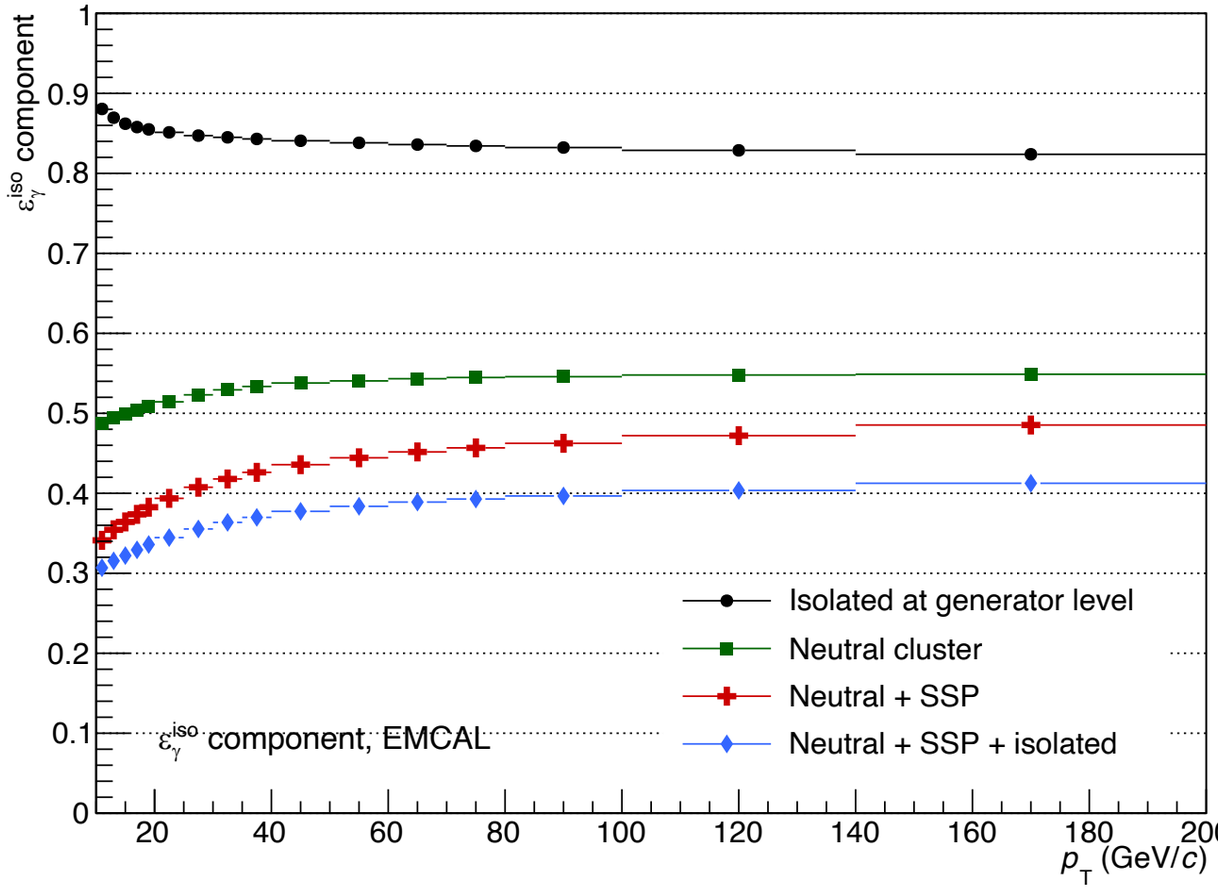


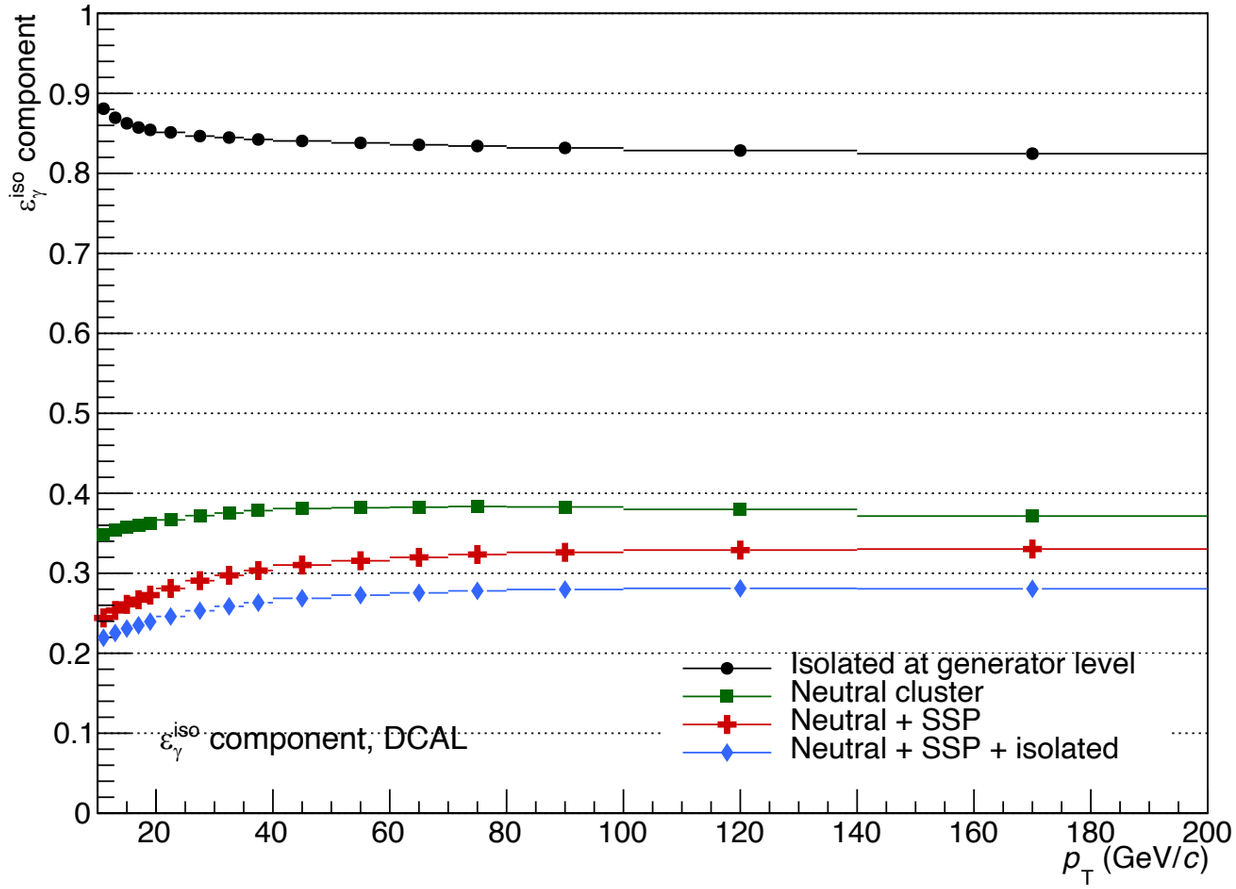
$$purity = 1 - \left(\frac{N_c/N_A}{N_D/N_B}\right)_{data} \times \left(\frac{B_A/N_C}{N_B/N_D}\right)_{mc} \alpha_{mc}$$

✢ MC correction factor is similar between EMCal and DCal. Pol0 fit: 1.005 ± 0.007

✢ Purity ~1 after 160 GeV/c in DCal due to data having less statistic.

Efficiency component





- Less neutral cluster can be reconstructed in DCal, because the different masked regions

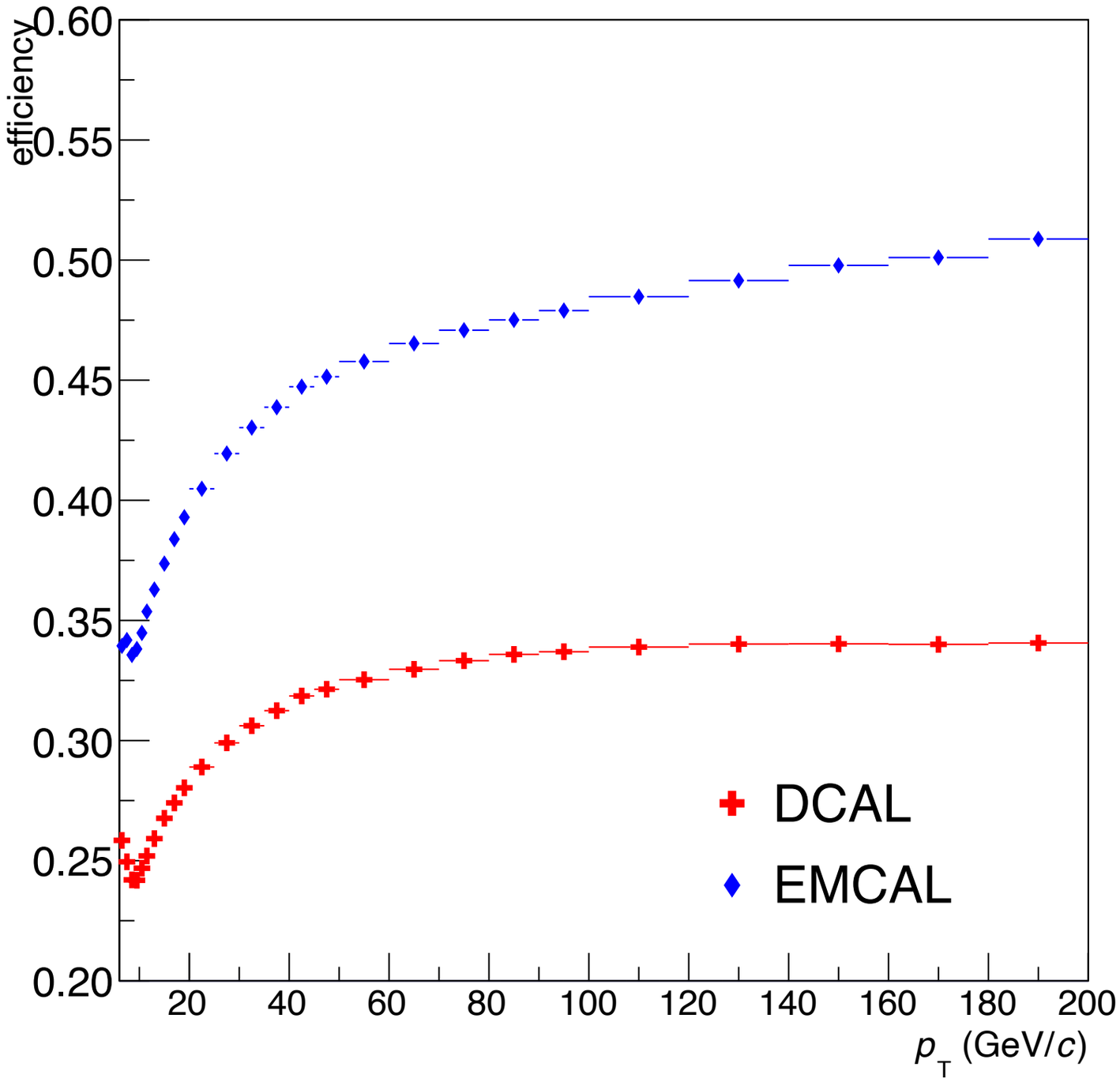
Efficiency comparison

- Efficiency correction:

$$\varepsilon_{\gamma}^{iso}(p_T) = \frac{dN_{\gamma_{iso}}^{reco}}{dp_T^{gen}} \Big/ \frac{dN_{\gamma_{iso}}^{gen}}{dp_T^{gen}}$$

Photon reconstruction, identification and isolation.

- Efficiency on EMCal is around 0.5 and DCal is 0.35.
  - — due to the less neutral cluster can be reconstructed in DCal.



Cross section comparison

cross section =

$$\sigma_{total} \times \frac{2\pi}{\Delta\eta\Delta\phi} \cdot \frac{1}{\sum(N_{evt,i} \times RF_i)} \sum \frac{dN}{dp_T} \times \frac{purity}{efficienc}$$

– $\frac{2\pi}{\Delta\eta\Delta\phi} \cdot \frac{1}{\sum(N_{evt,i} \times RF_i)} \sum \frac{dN}{dp_T}$ is raw spectrum

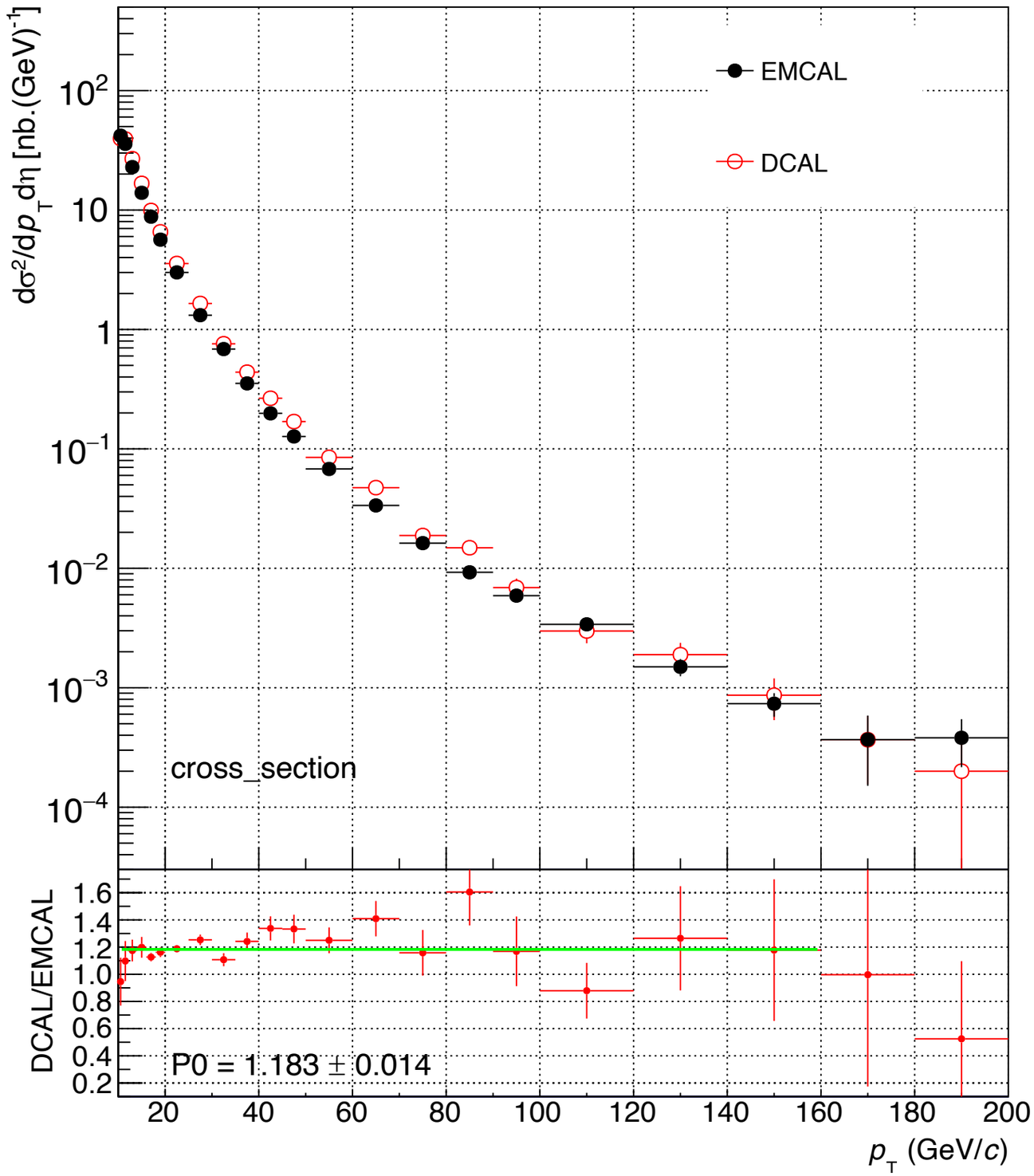
- Ratio DCAL / EMCAL around 1.18

  ratio fit information:

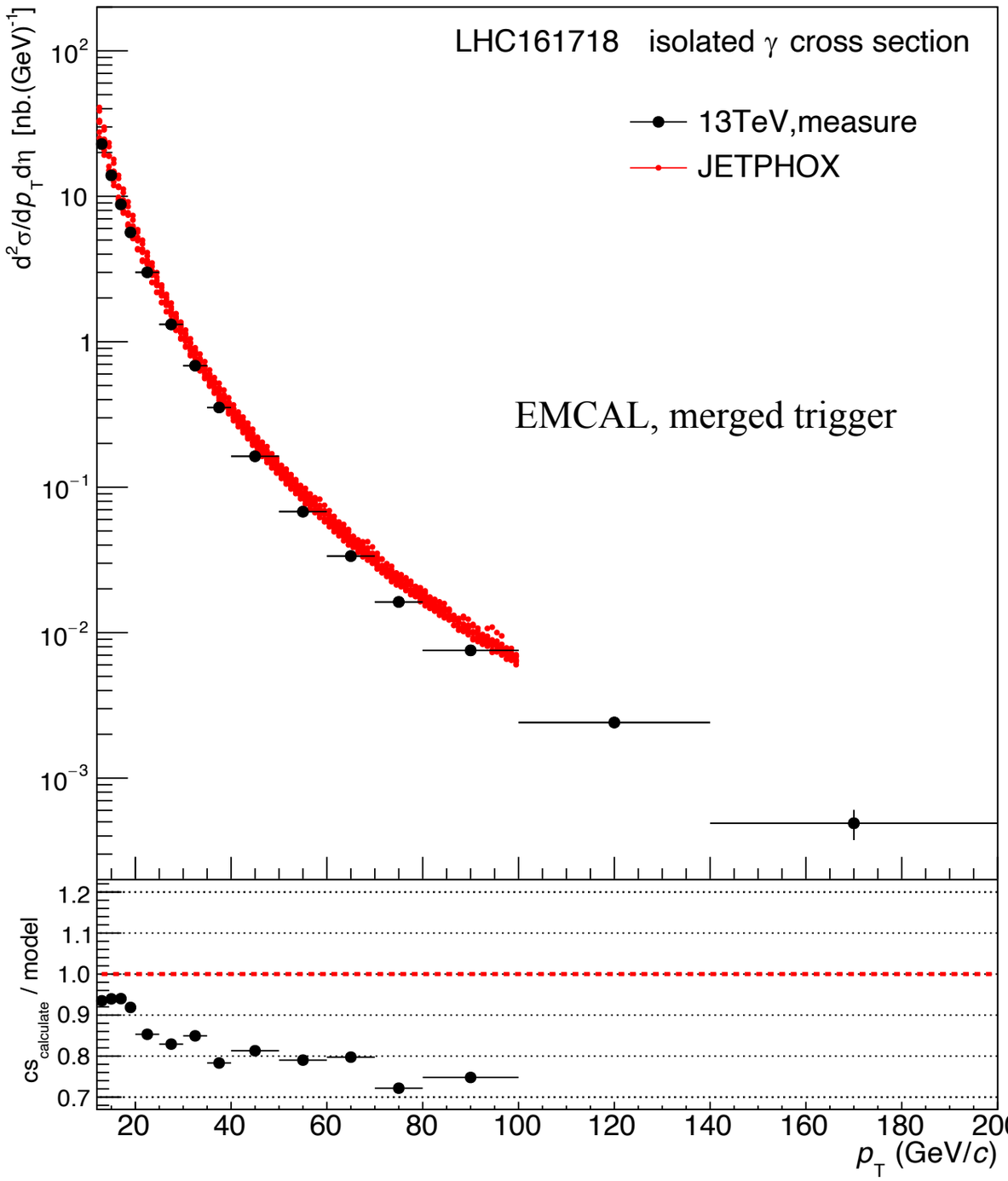
  -- fit function: pol0

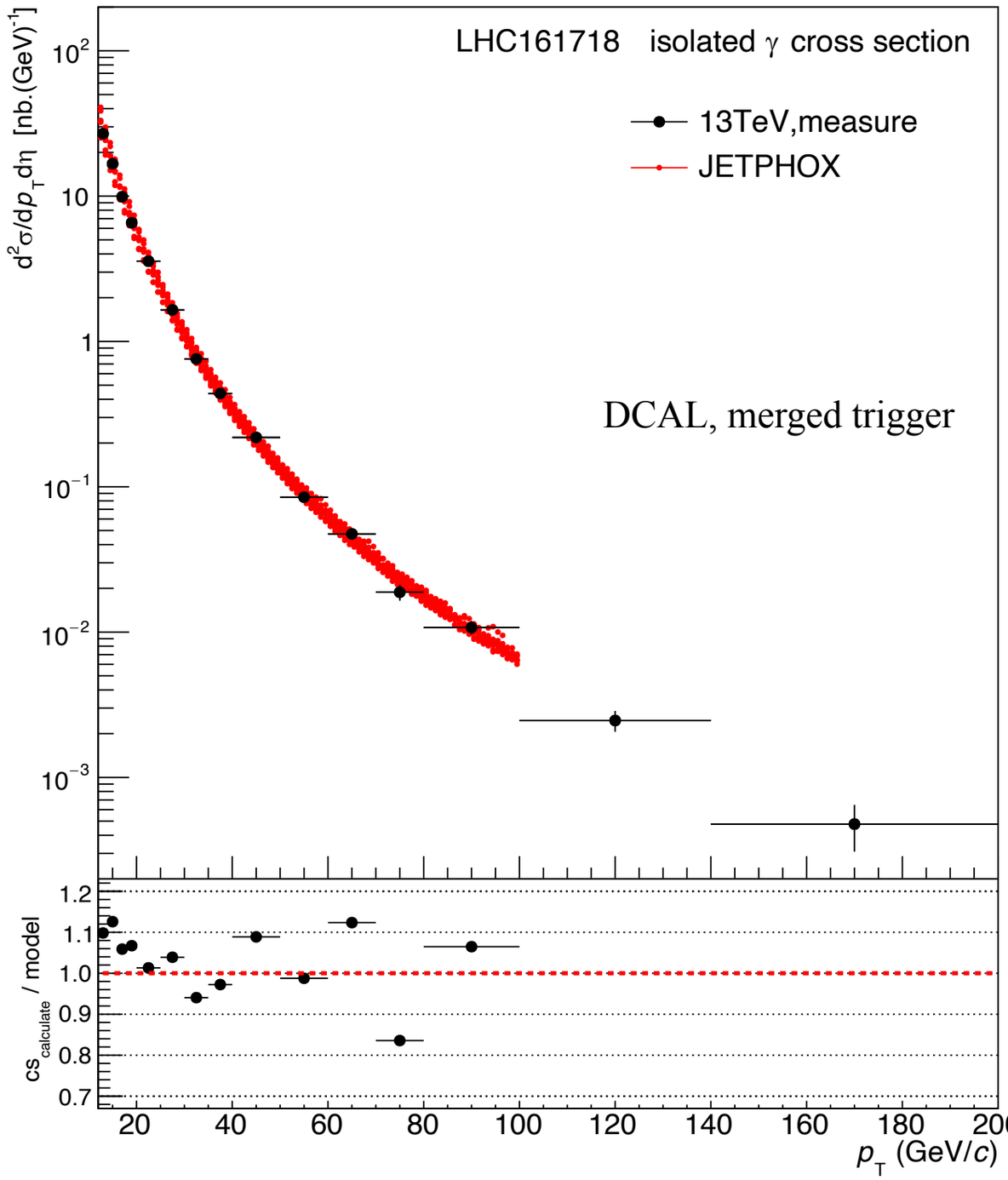
  -- fit range: [10. , 160.]

  -- fitted para: 1.183±0.014.



Cross section, EMCAL && DCAL





- Not sure the settings of the jetphox configuration settings, I will try to run jetphox and produce the theory points

Summary

✢ comparing mainly analysis result between EMCal and DCal

→ after acceptance normalization, combined spectrum ratio ~ 0.8 (DCal / EMCal).

→ purity has similar distribution between EMCal and DCal.

→ efficiency ratio around 0.7 which comes from reconstruct level.

→ yield and cross section ratio around 1.17 which equal to ratios from each analysis procedures

$$\text{cross section} = \sigma_{total} \times \underbrace{\frac{2\pi}{\Delta\eta\Delta\phi} \cdot \frac{1}{\sum(N_{evt,i} \times RF_i)} \sum \frac{dN}{dp_T}}_{\text{raw, ratio} \sim 0.8} \times \underbrace{\frac{purity}{efficiency}}_{\substack{\leftarrow \text{ ratio} \sim 1.0 \\ \leftarrow \text{ ratio} \sim 0.7}}$$

yield, ratio ~ 1.17

Next step:

1. check closely all the steps of the analysis to understand difference between EMCal and DCal
2. obtain theory curve running jetphox
3. prepare analysis note

luminosity

	Twiki	L1		L1 effective		L2		L2 effective	
	Sigma_total (mb^{-1})	value (pb^{-1})	Ratio to twiki	value (pb^{-1})	Ratio to twiki	value (pb^{-1})	Ratio to twiki	value (pb^{-1})	Ratio to twiki
16	58.44±1.9%	2.970057 ±0.16453 46		3.458734 ±0.16453 46		0.329282 4 ±0.14508 41		0.377056 0 ±0.14508 41	
17	58.10±2.7%	3.880987 ±0.00431 6249		3.897738 ±0.00431 6249		0.395848 7±0.0062 59196		0.398326 4±0.0062 59196	
18	57.52±2.1%	3.567375 ±0.00637 0571		3.590101 ±0.00637 0571		0.355981 3 ±0.00620 5869		0.358190 5 ±0.00620 5869	

	16	17	18
Sigma_total (mb^{-1})	58.44±1.9%	58.10±2.7%	57.52±2.1%