Isolated photon analysis in pp collisions at 13 TeV analysis status

--- analysis further check

ranxu

LPSC regular meeting
26/11/2021

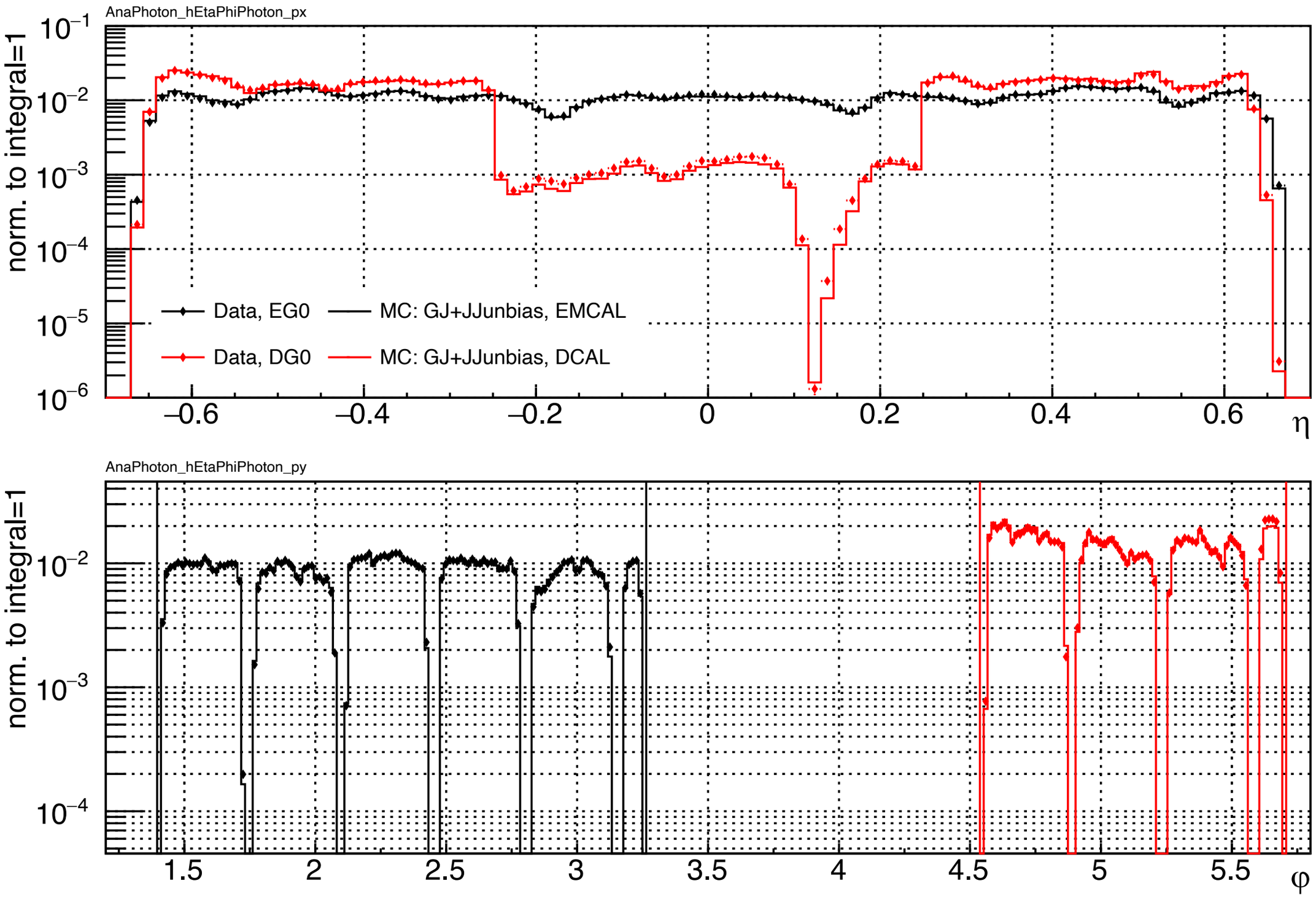
Last presentation

- 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

Outline

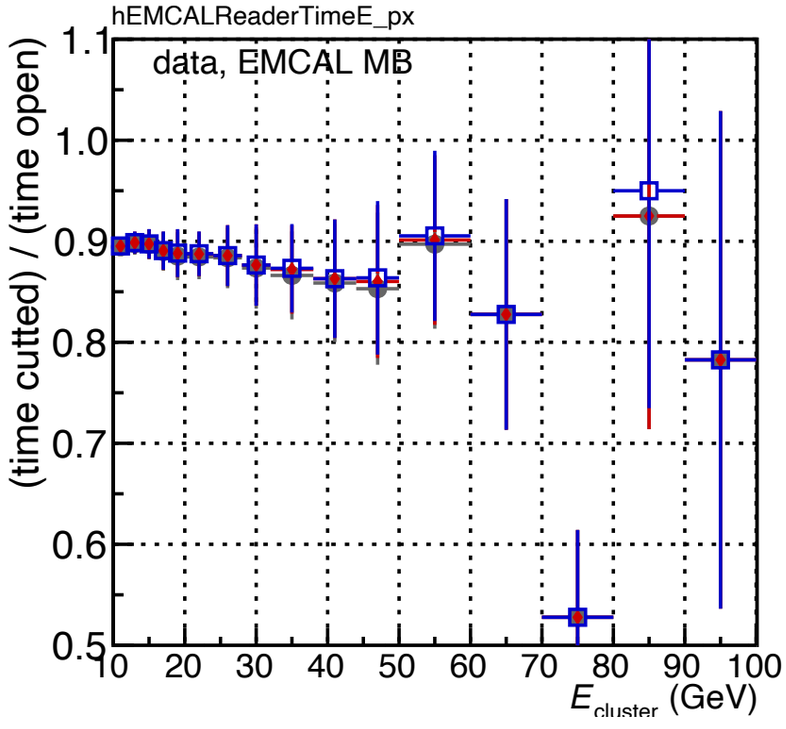
- dead/bad region mask
- effect of time cut
- Sum pt in isolation cone distribution
- Shower shape parameter for signal

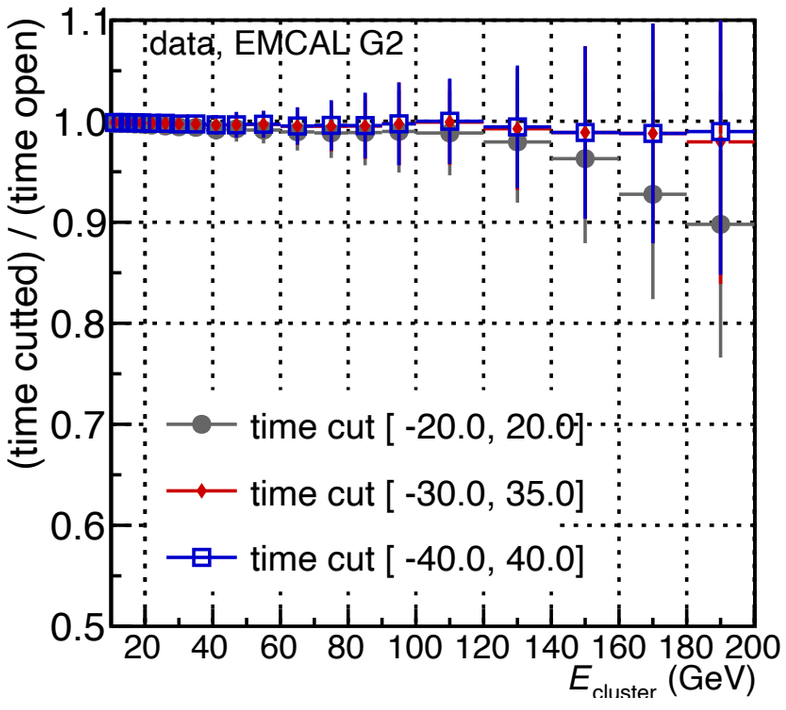
Eta(Phi) distribution, combined MB V.S. GJ+JJunb

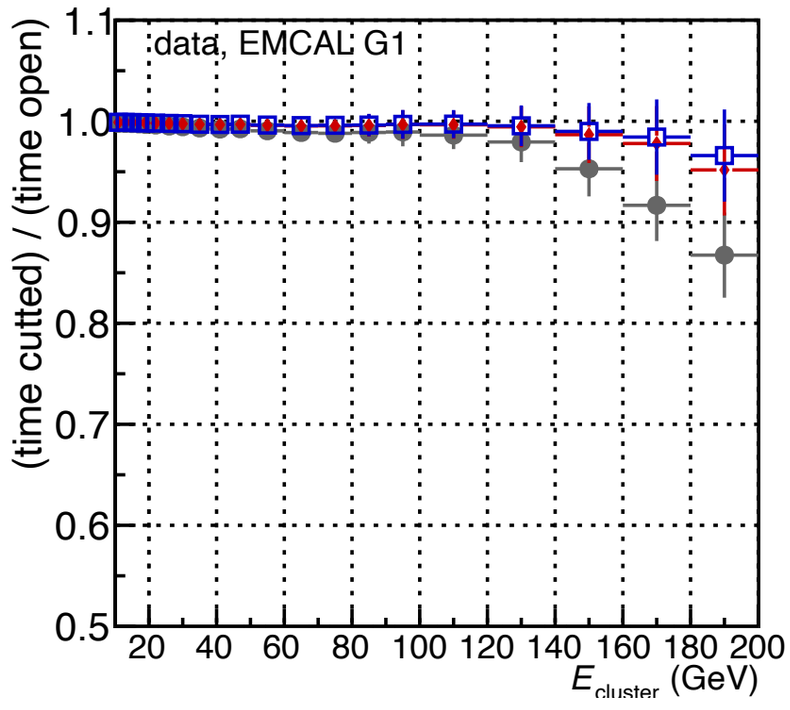


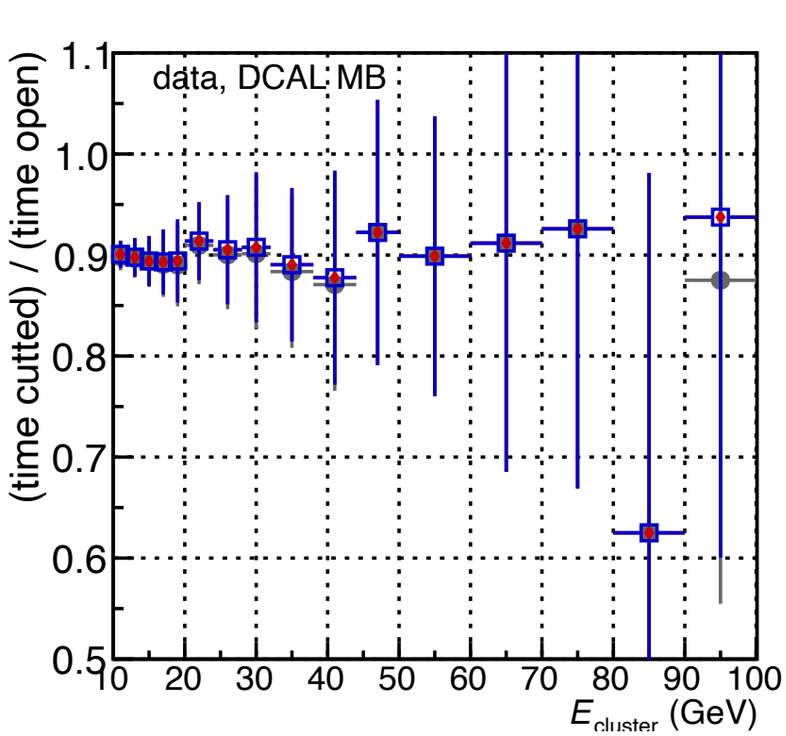
MC has similar distribution with data in η and φ distribution

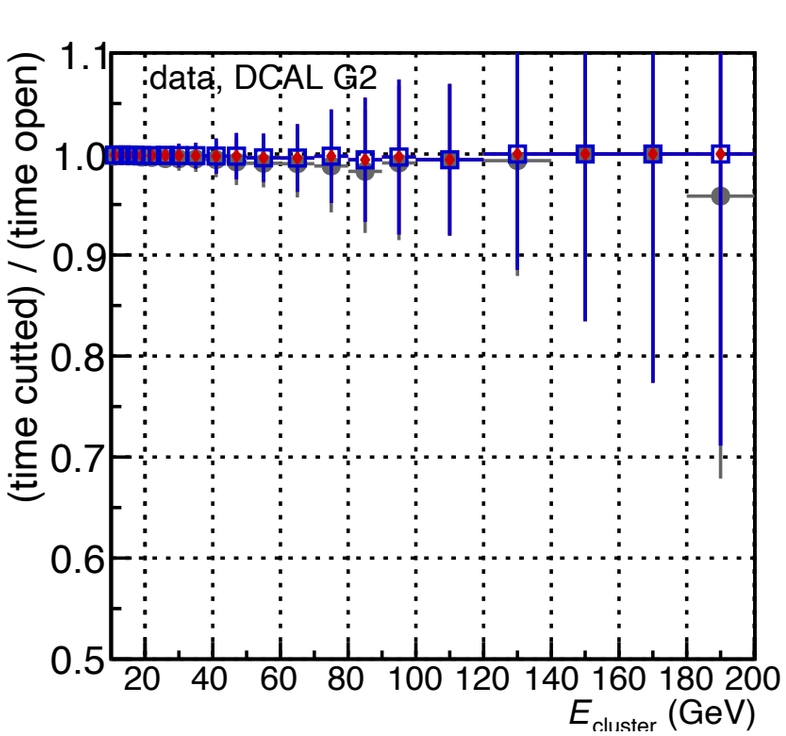
Time cut fraction

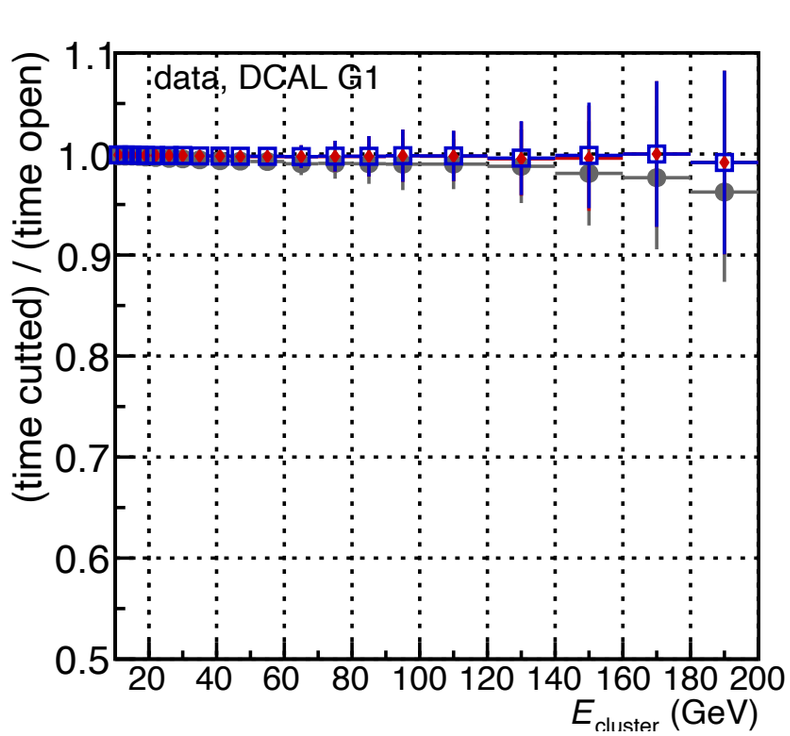








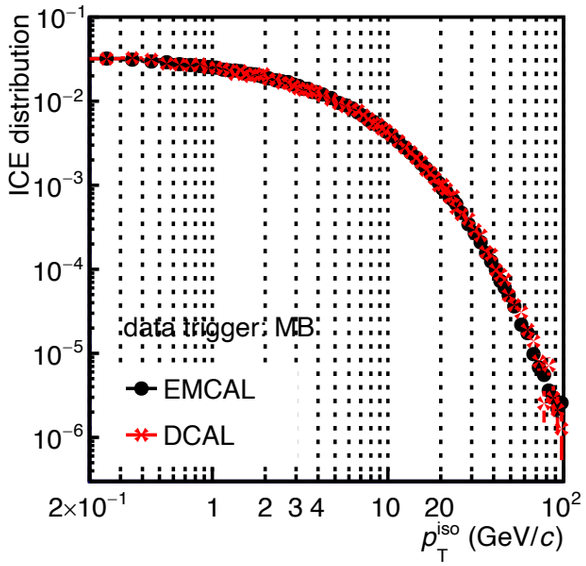




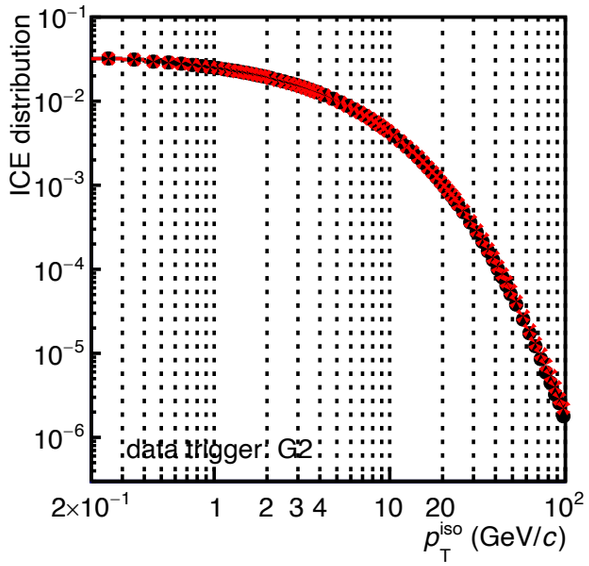
- No large impact (~1% when decreasing to +-20 ns), might need to open it at very high p_T (>100 GeV)

$\Sigma p_{T,incone}^{iso}$ distribution in data and MC

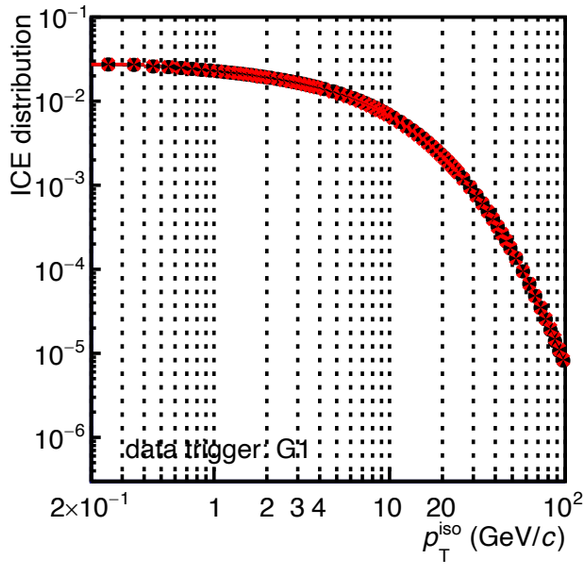
MB



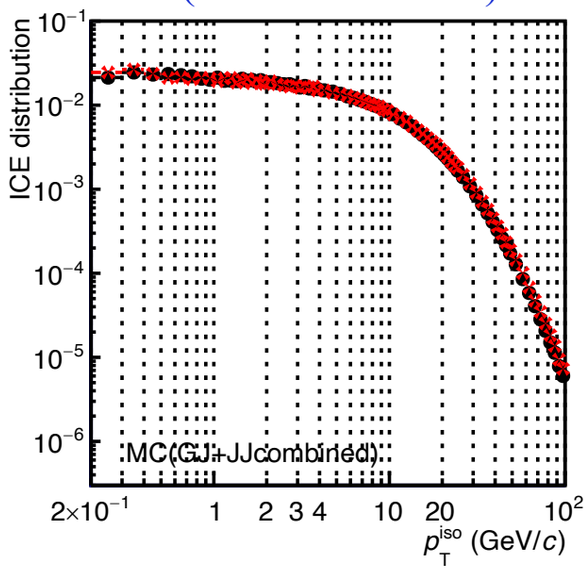
G2

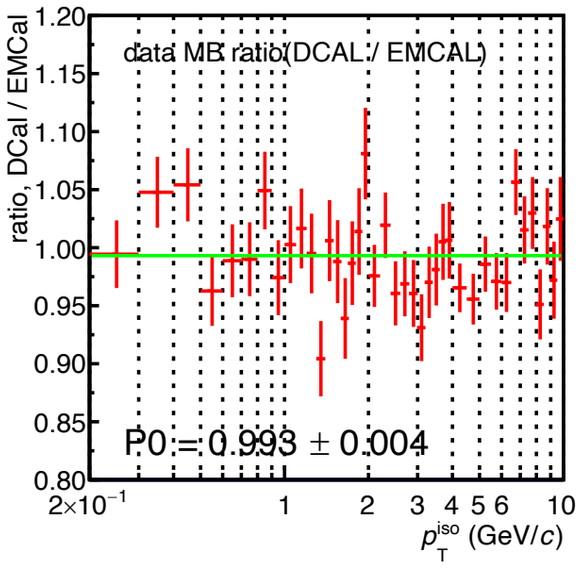


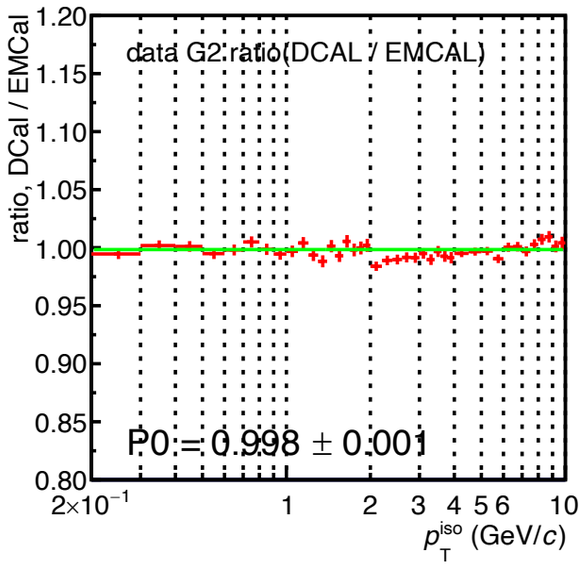
G1

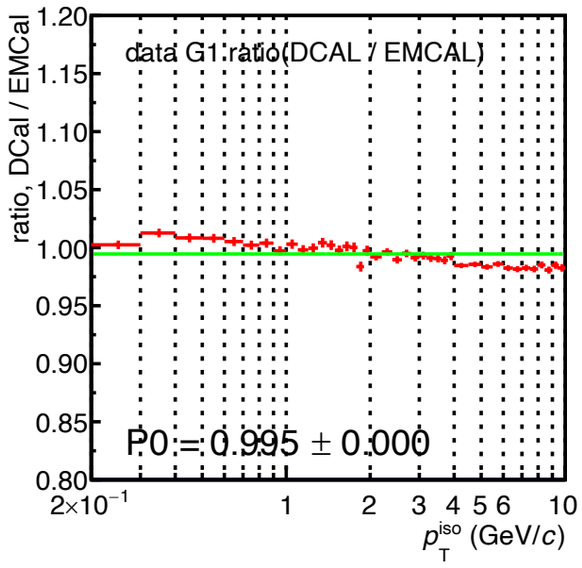


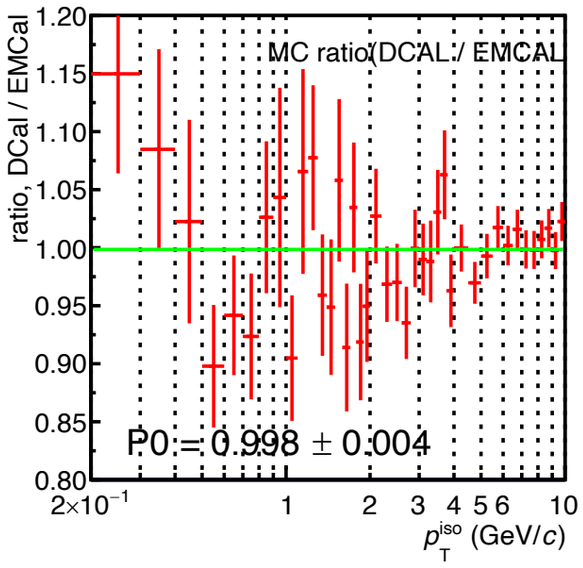
MC(GJ+JJcombined)







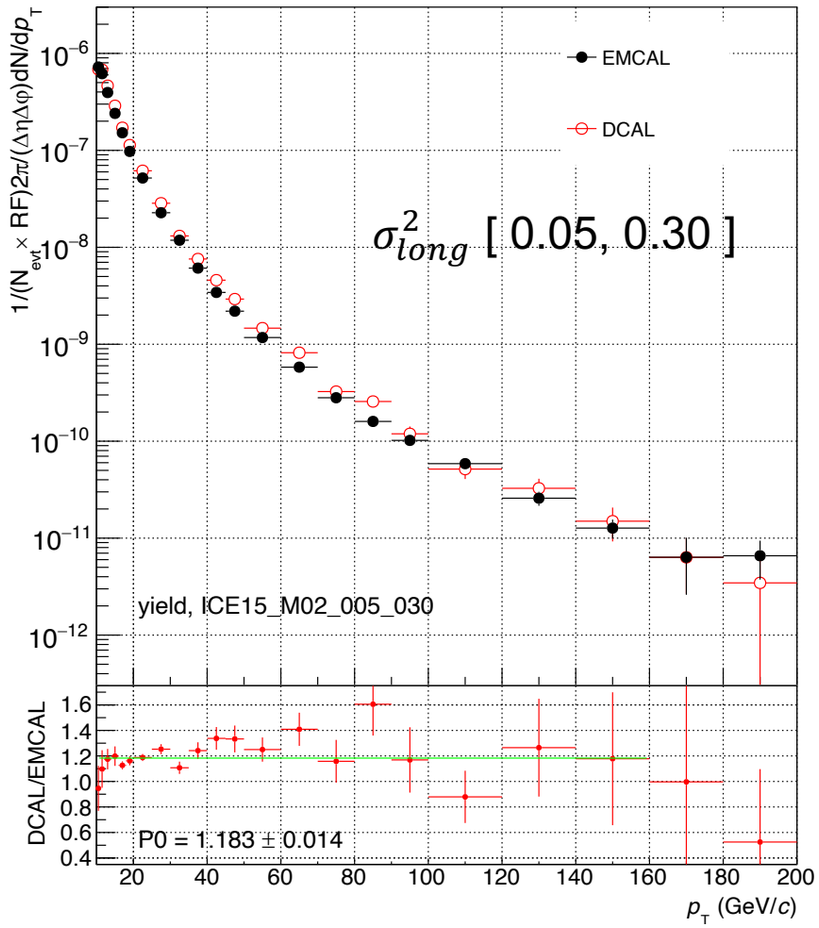


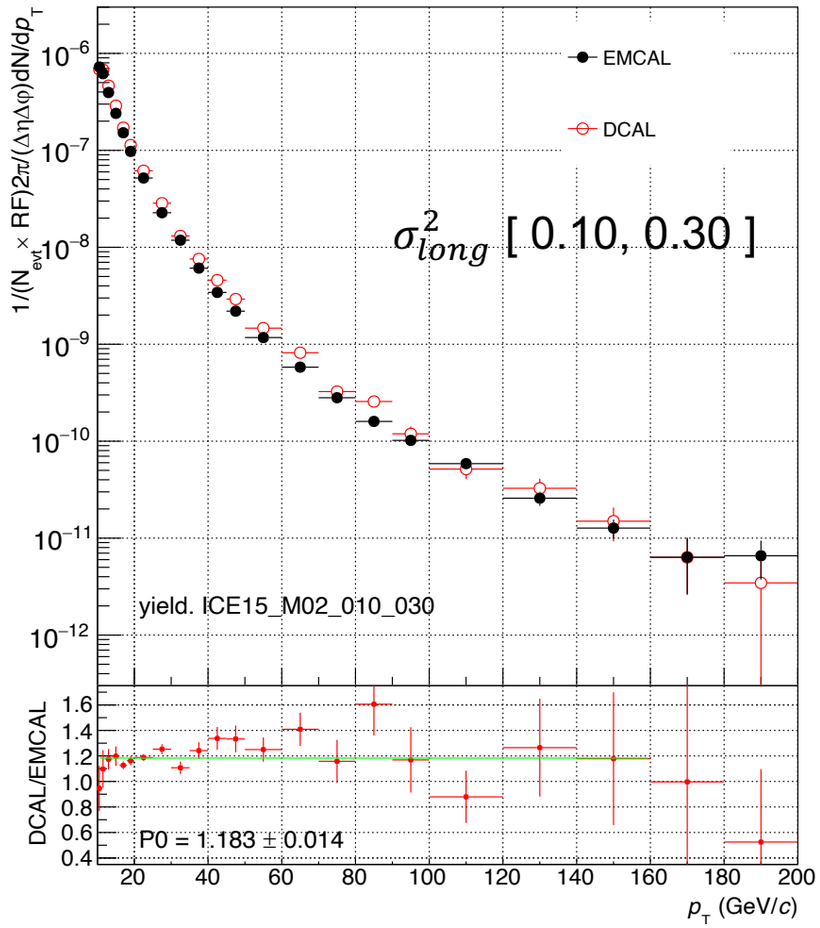


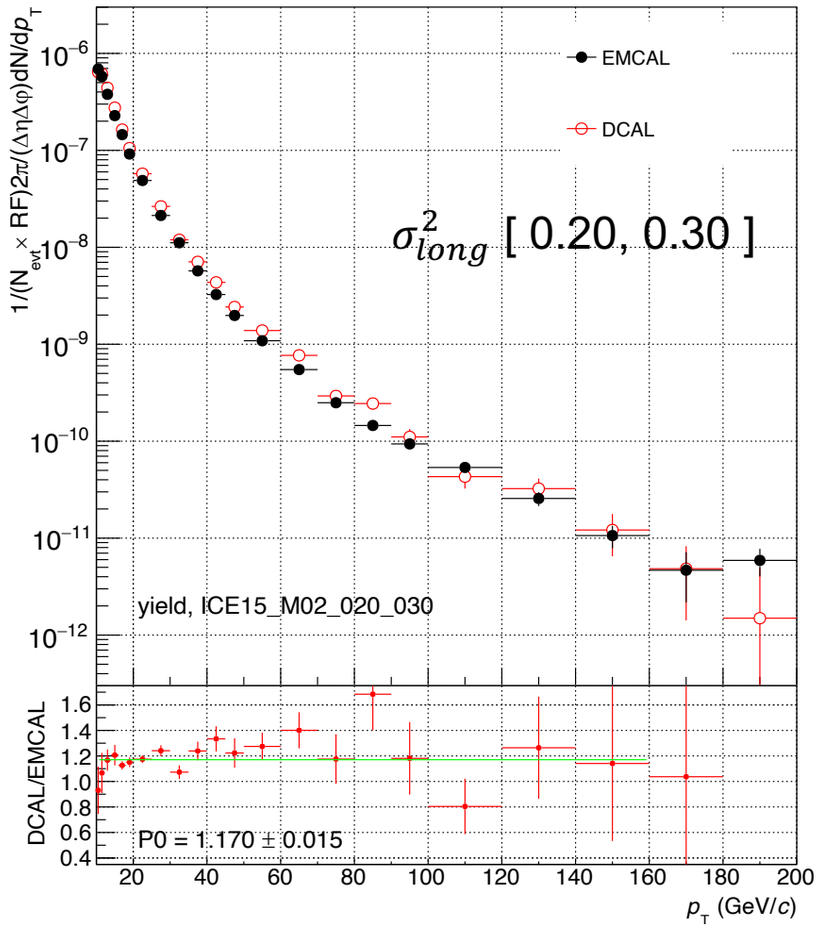
	MB	data(G2)	data(G2)	MC
Pol0	P0 = 0.993±0.004	P0 = 0.998±0.001	P0=0.995±0.000	P0=0.998±0.004

- MC and data have similar Σp_T distribution in isolation cone

Shower shape minimum cut variation



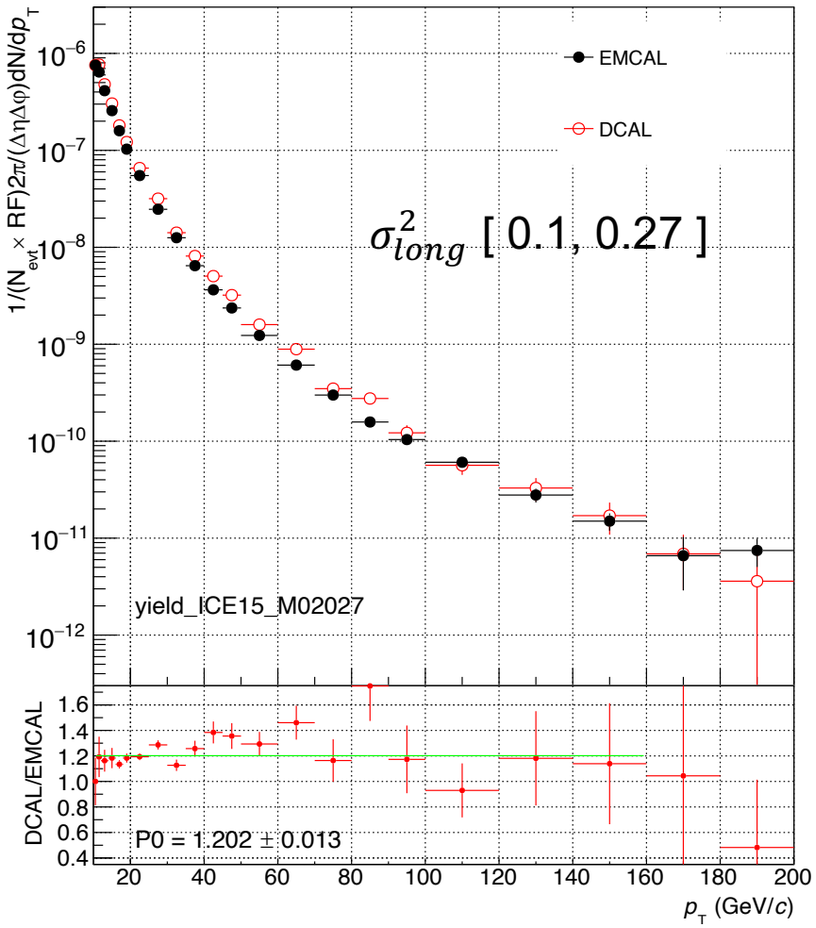


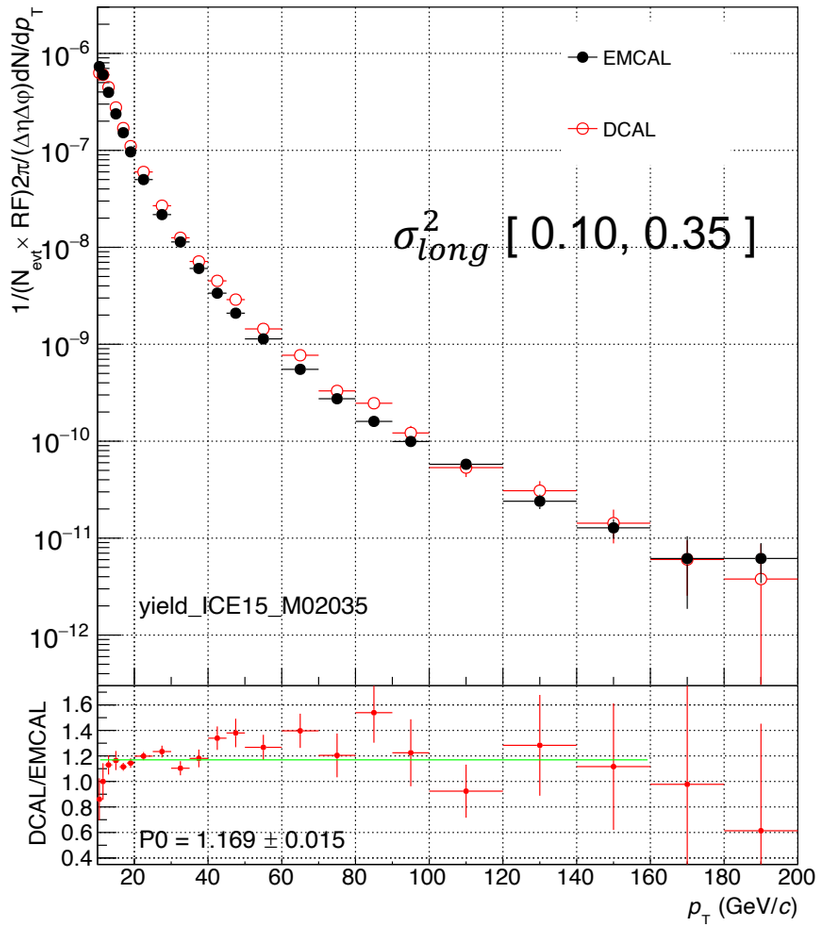


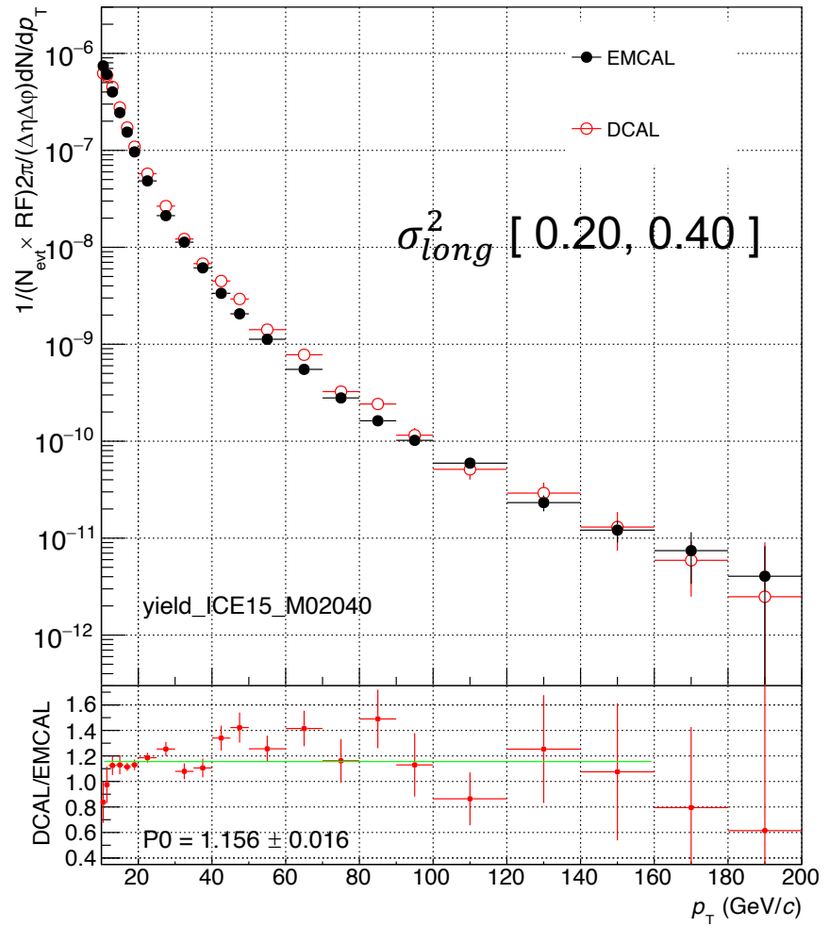
σ^2_{long}	[0.05, 0.30]	[0.1, 0.30]	[0.2, 0.30]
Pol0 fit value	1.183±0.014	1.183±0.014	1.17±0.015

- No obvious change when signal σ^2_{long} minimum parameter change

Shower shape maximum cut variation







σ^2_{long}	[0.1, 0.27]	[0.1, 0.30]	[0.1, 0.35]	[0.1, 0.40]
Pol0 fit value	1.202 $\pm$0.013	1.183$\pm$0.014	1.169 $\pm$0.015	1.156 $\pm$0.016

- No obvious change when signal σ^2_{long} maximum parameter change

Summary

✢ check distribution between EMCal and Dcal

→dead/bad regions mask: MC can reproduce data

→ $\Sigma p_{T,incone}^{iso}$: MC can reproduce data

→effect of time cut: No large impact (~1% when decreasing to +-20 ns), might need to open it at very high p_T (>100 GeV)

→shower shape cut for signal: not sensitive to shower shape parameter

Next step:

- check EMCal/DCal ratio with other cluster selection cut variations:
  - ▻ using different cross talk parameters
  - ▻ using different EMCal and DCal subregions
  - ▻ without distance to bad channel applied
  - ▻ with different track matching cuts
  - ▻ with different NLM cut
  - ▻ with different exoticity cut
  - ▻ …

BACK UP

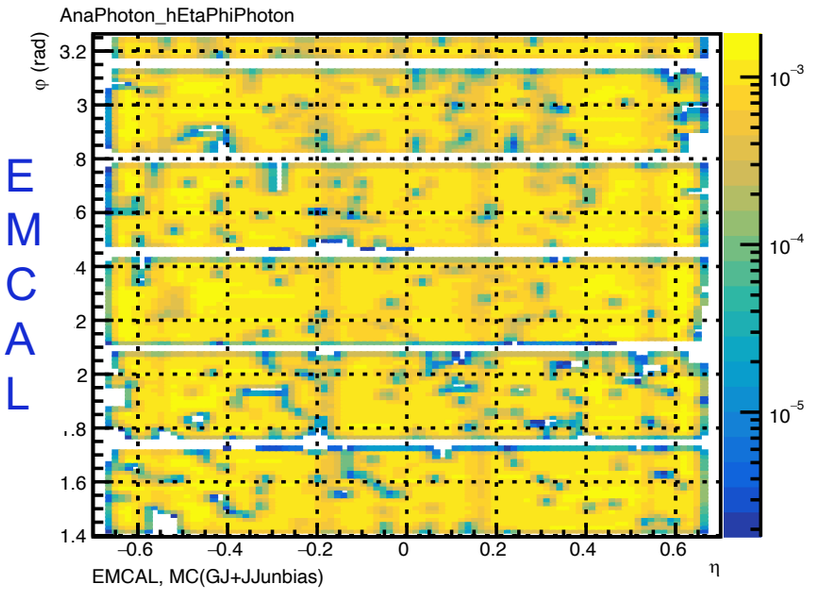
Eta-Phi map, combined G1 V.S. GJ+JJunb

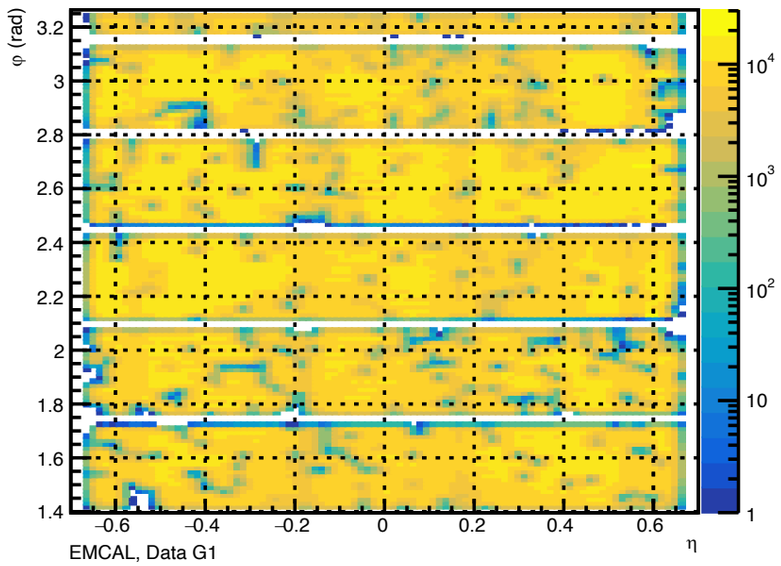
GJ+JJunb

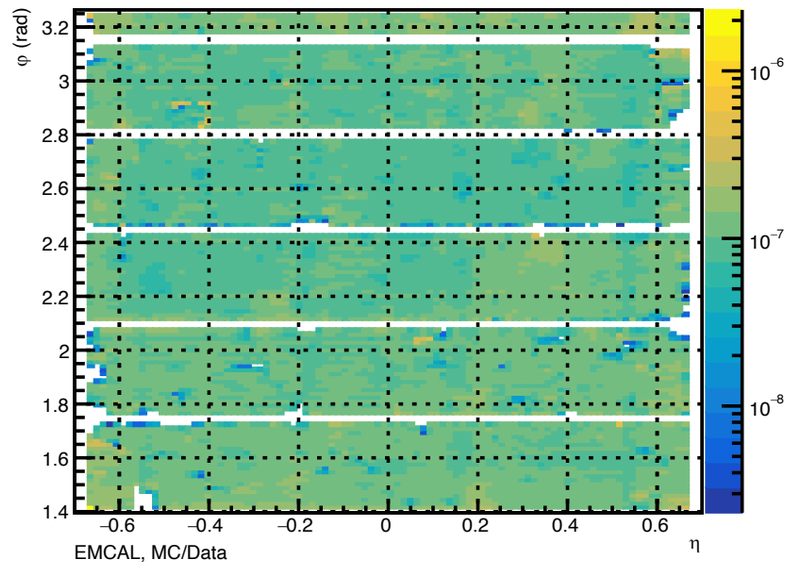
Data

MC / Data

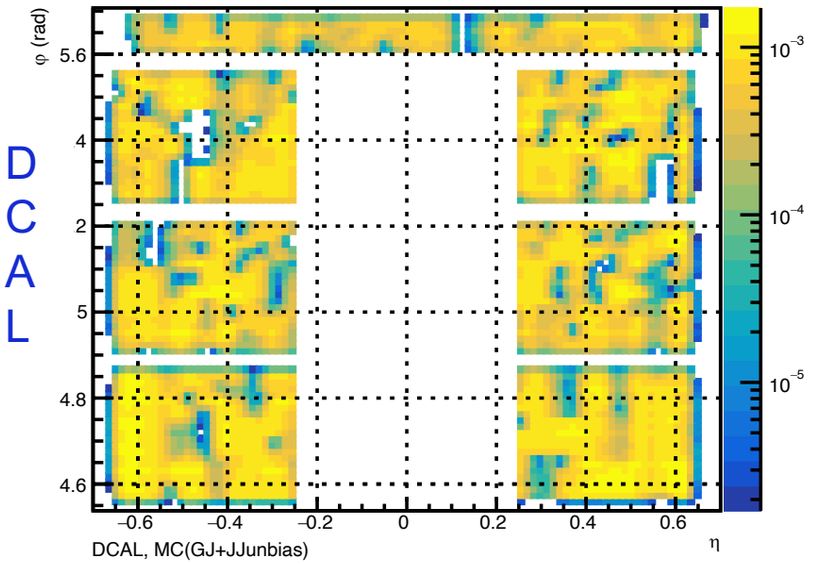
EMCAL

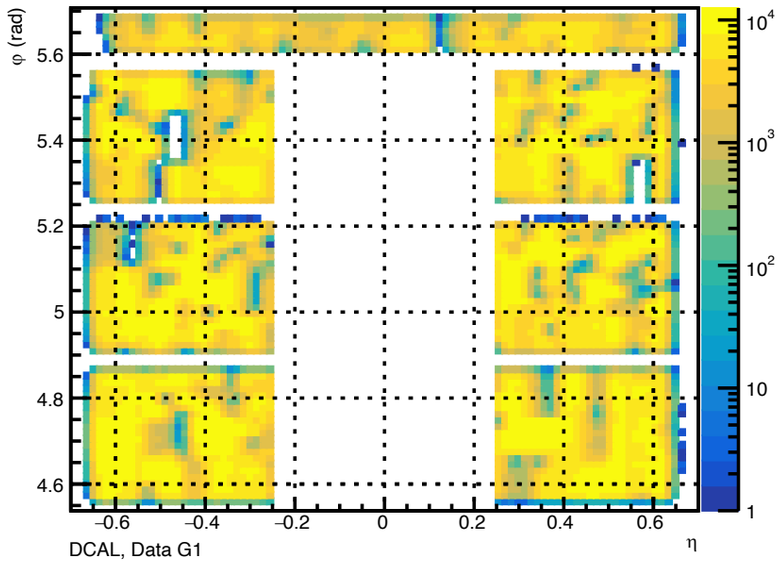


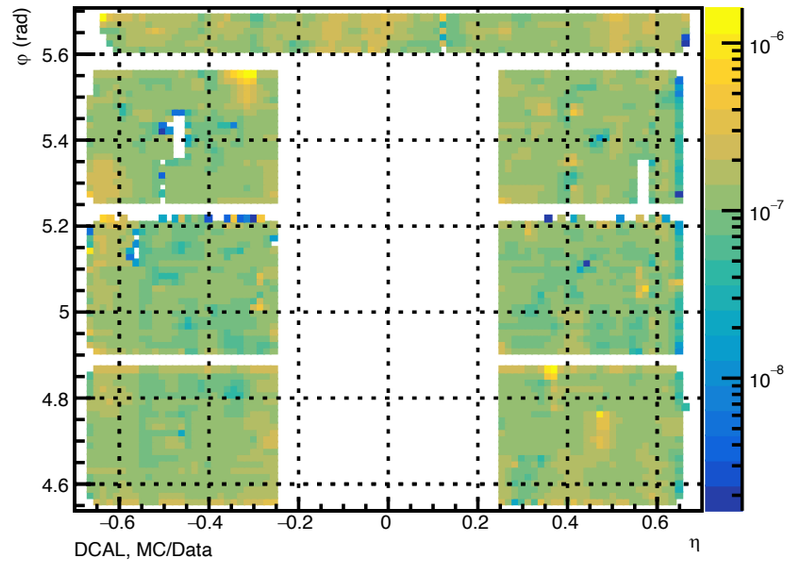




DCAL







Histo_name: AnaPhoton_hEtaPhiPhoton

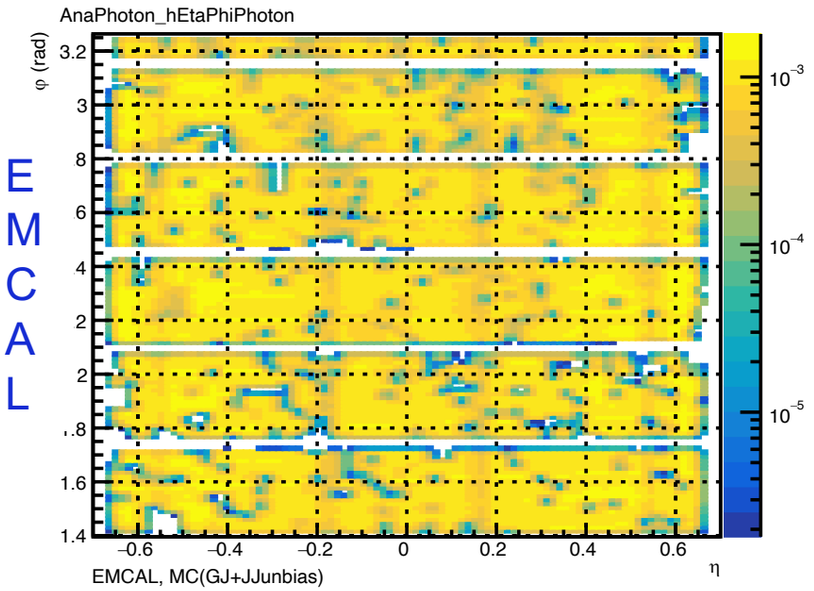
Eta-Phi map, combined G2 V.S. GJ+JJunb

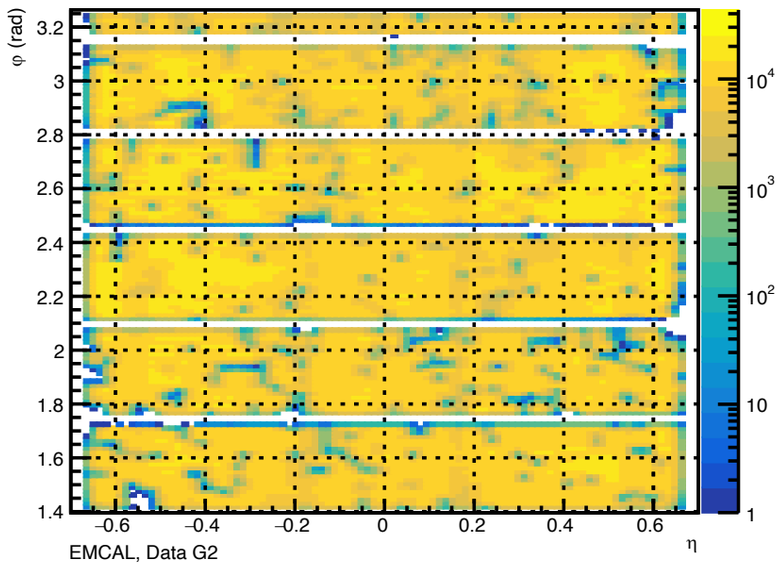
GJ+JJunb

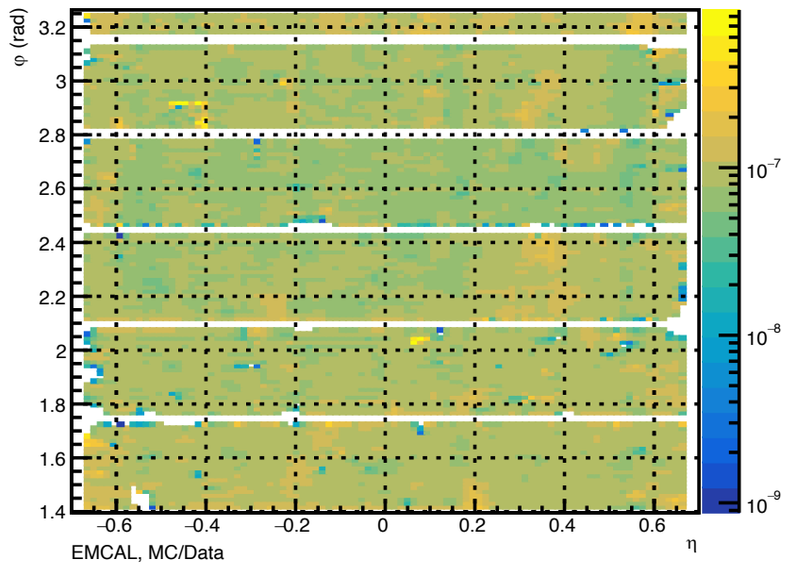
Data

MC / Data

EMCAL







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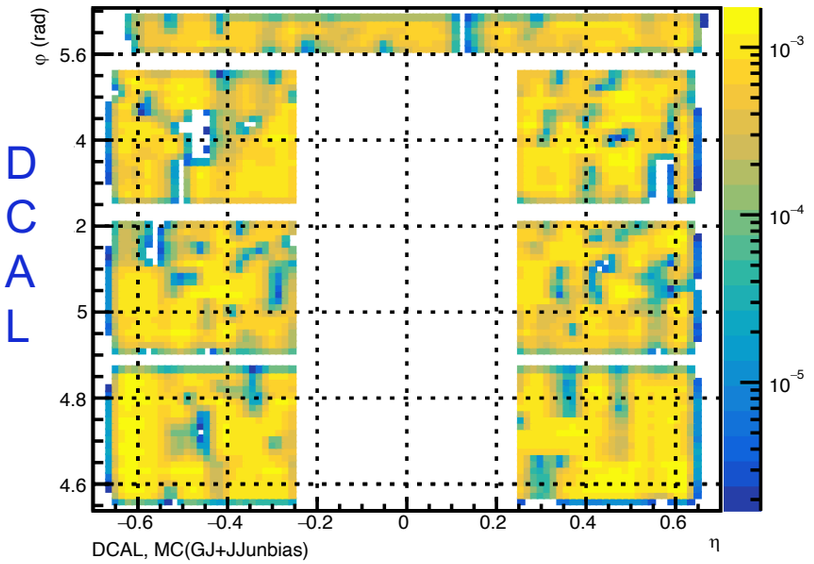
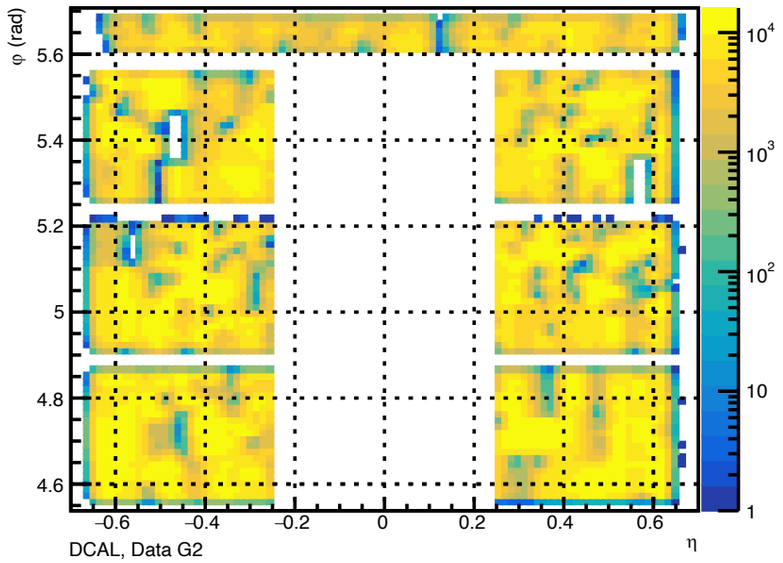
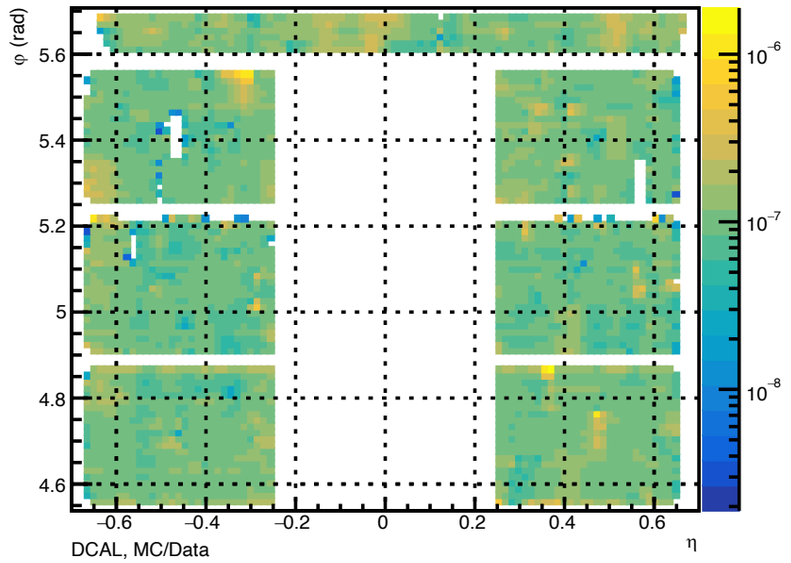






Histo_name: AnaPhoton_hEtaPhiPhoton

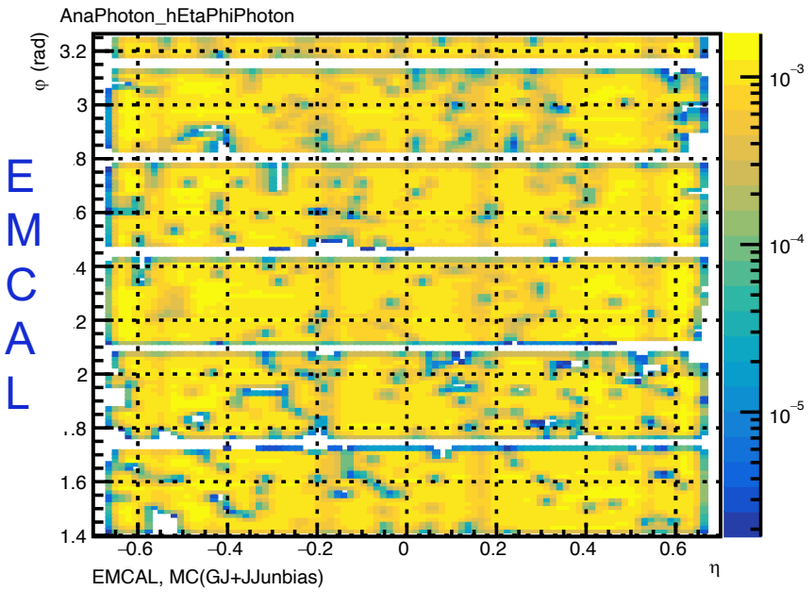
Eta-Phi map, combined MB V.S. GJ+JJunb

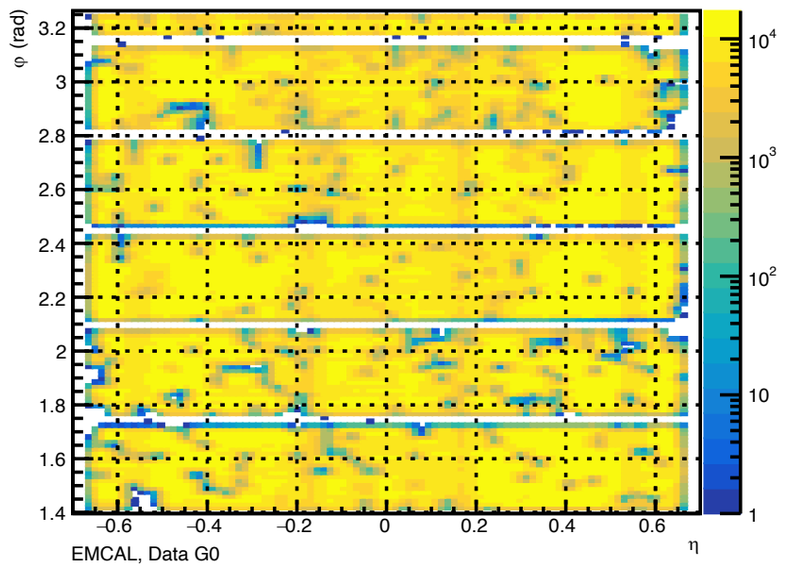
GJ+JJunb

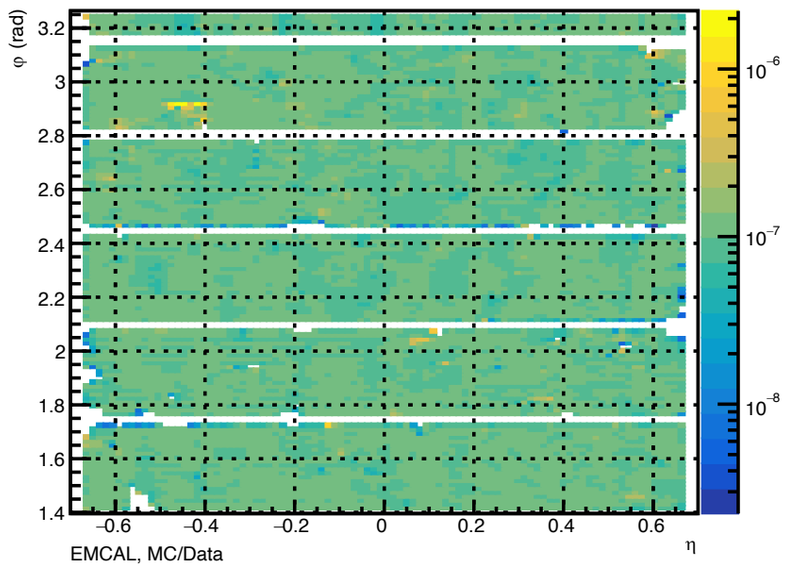
Data

MC / Data

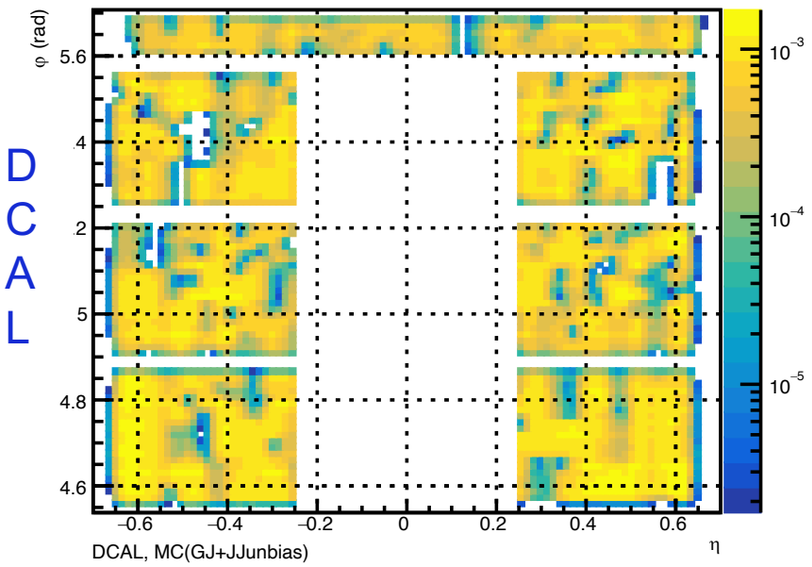
EMCAL

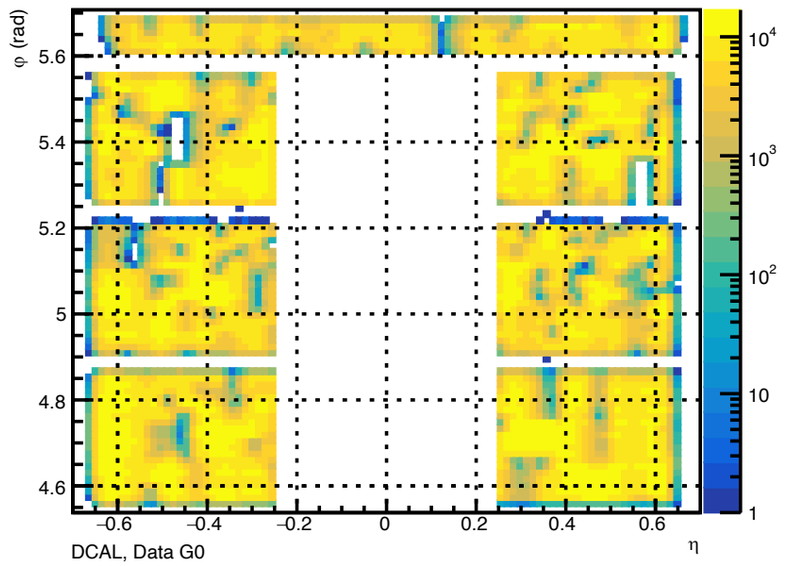


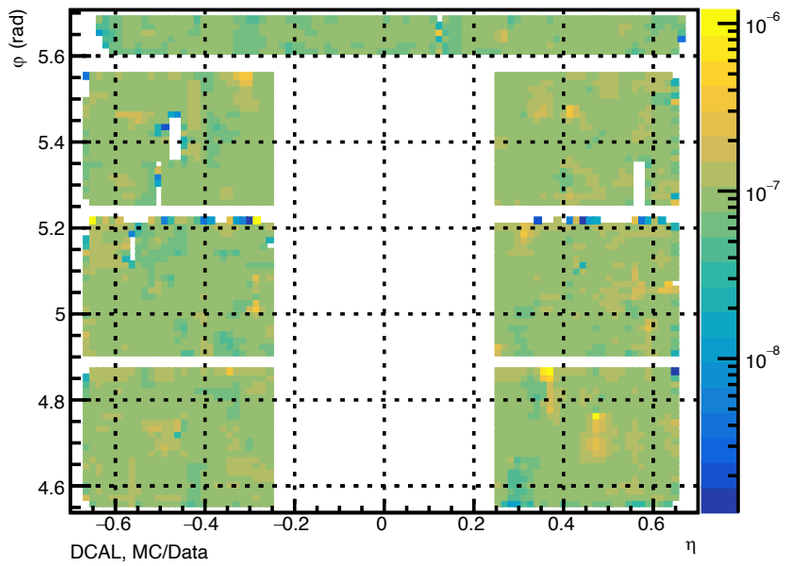




DCAL

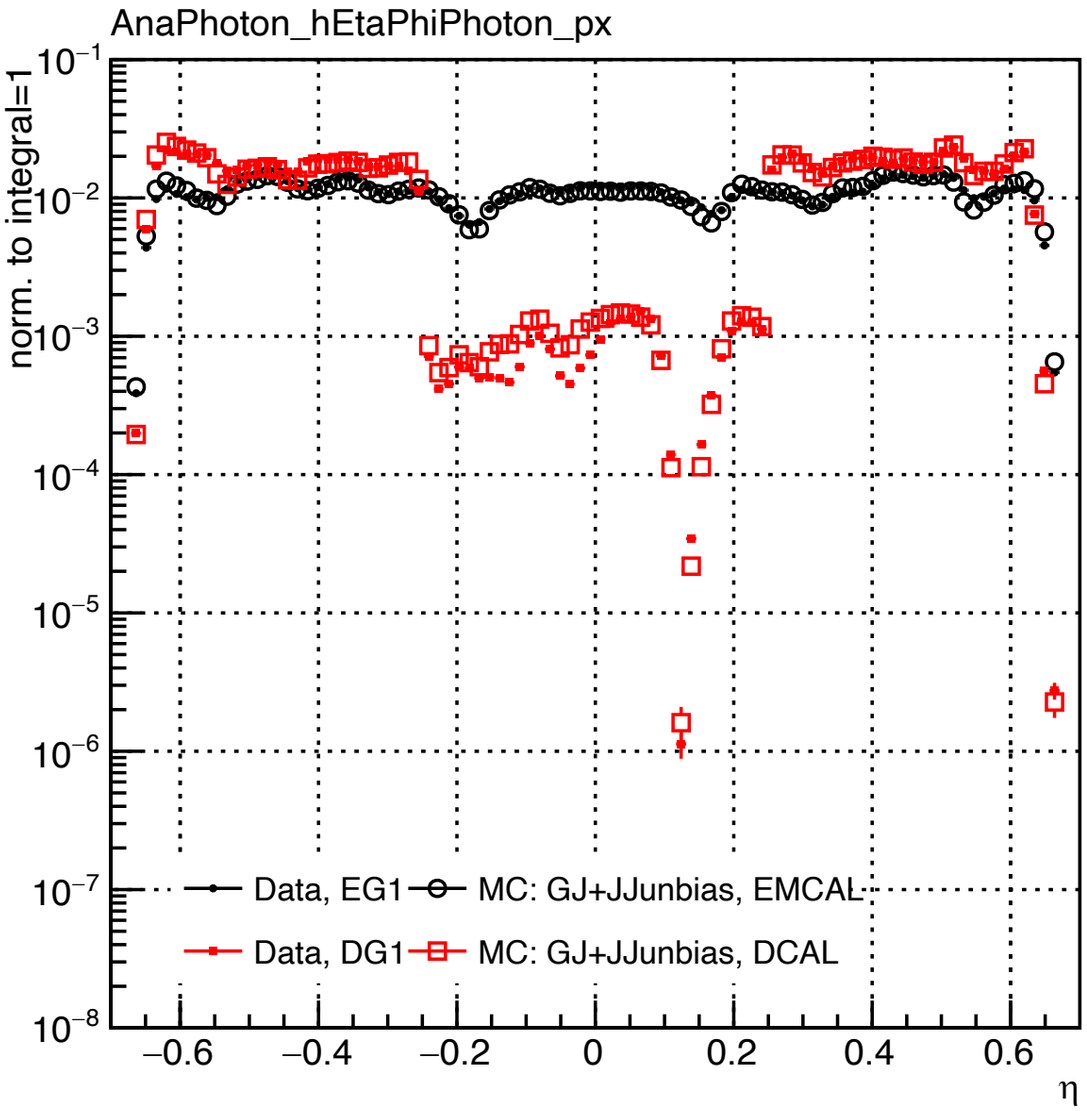


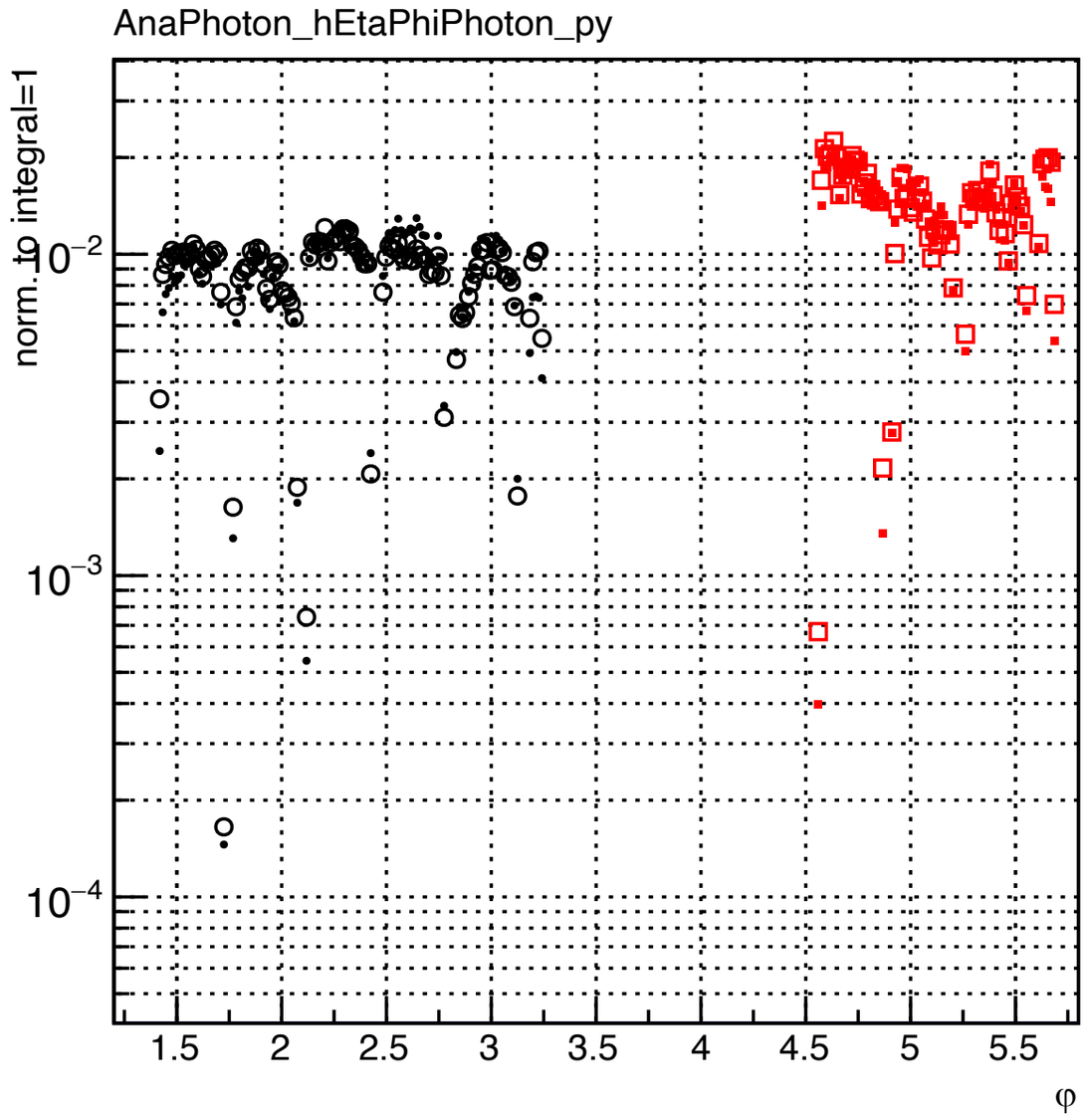




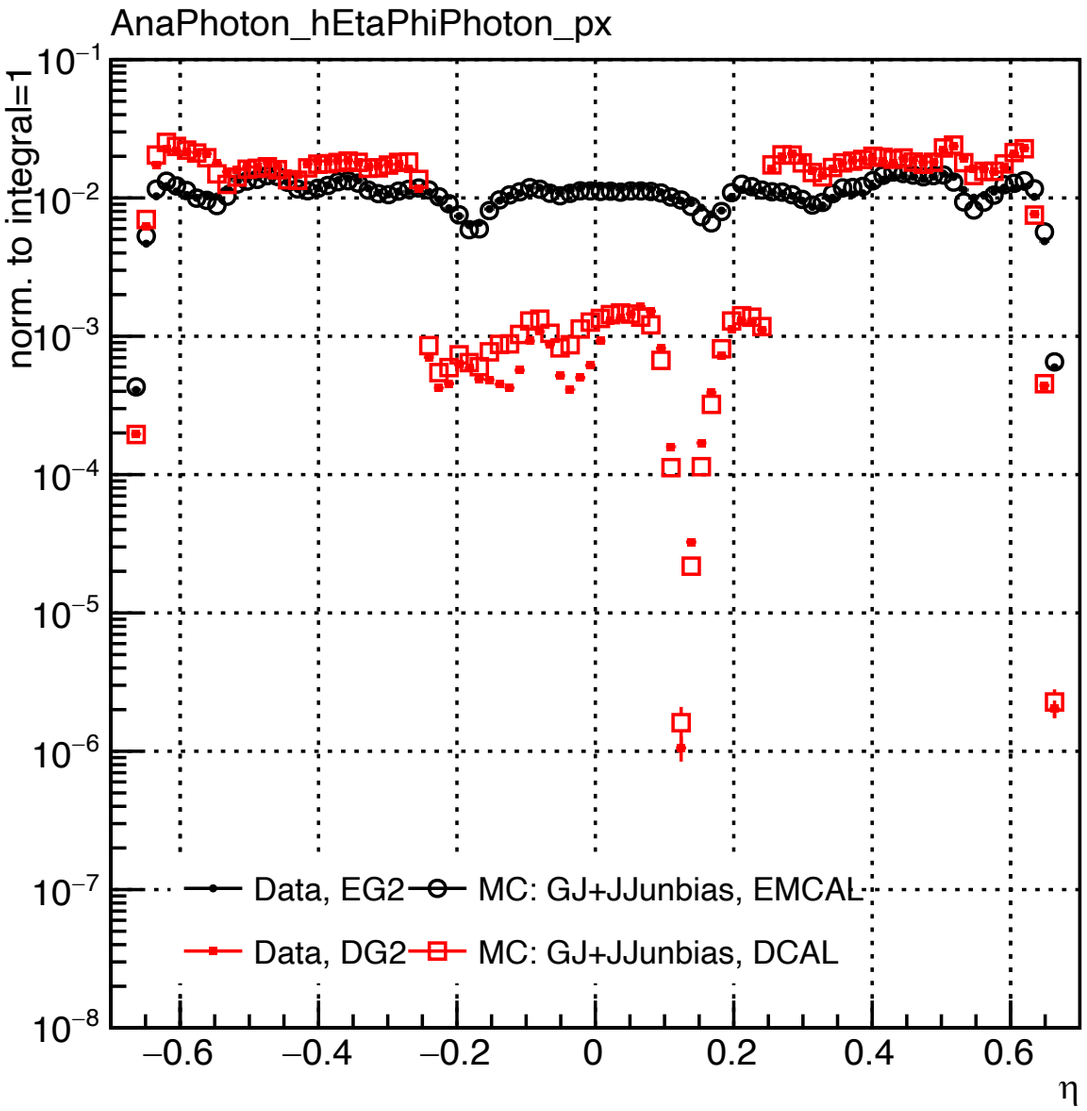
Histo_name: AnaPhoton_hEtaPhiPhoton

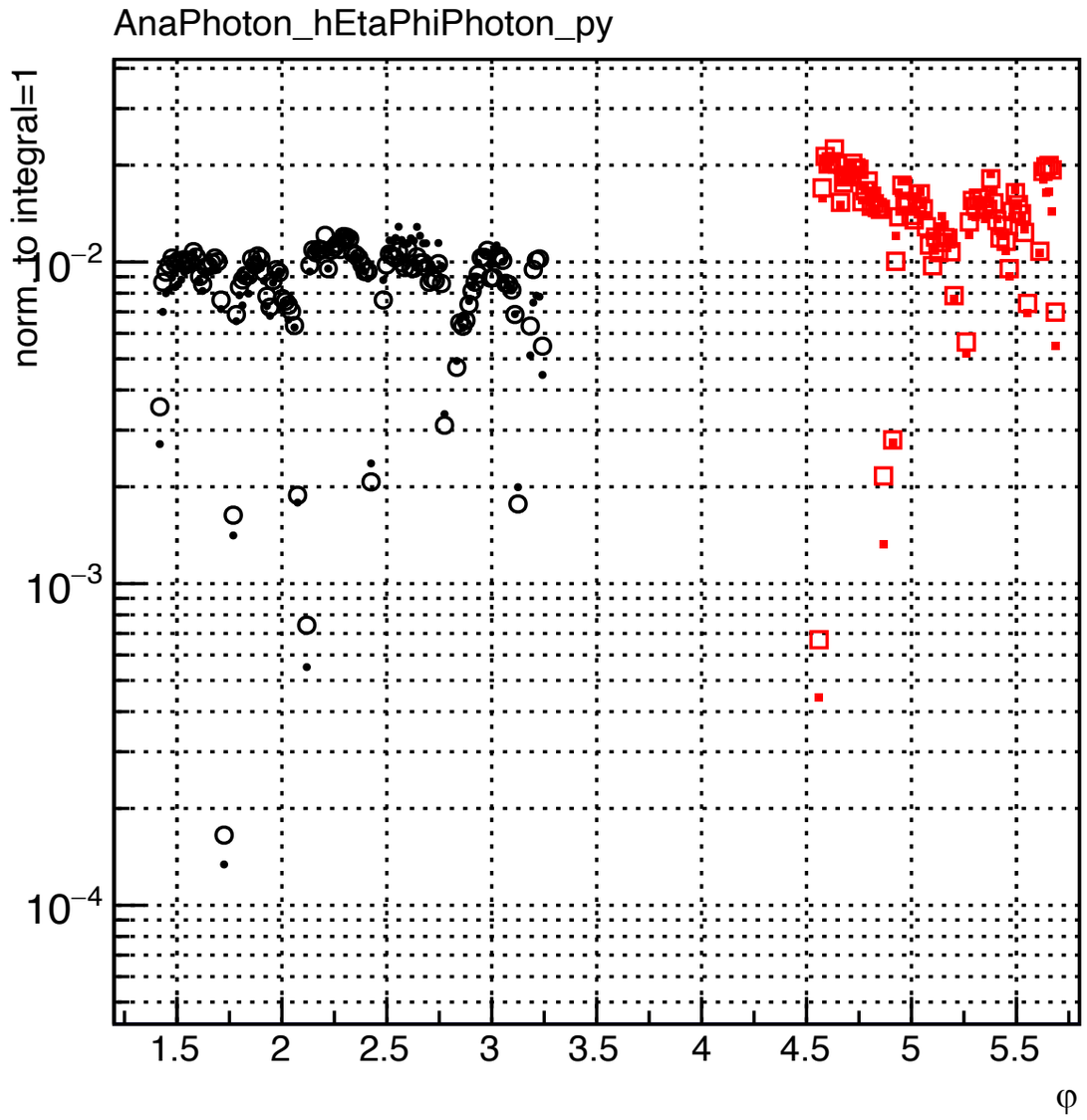
Eta(Phi) distribution, combined G1 V.S. GJ+JJunb



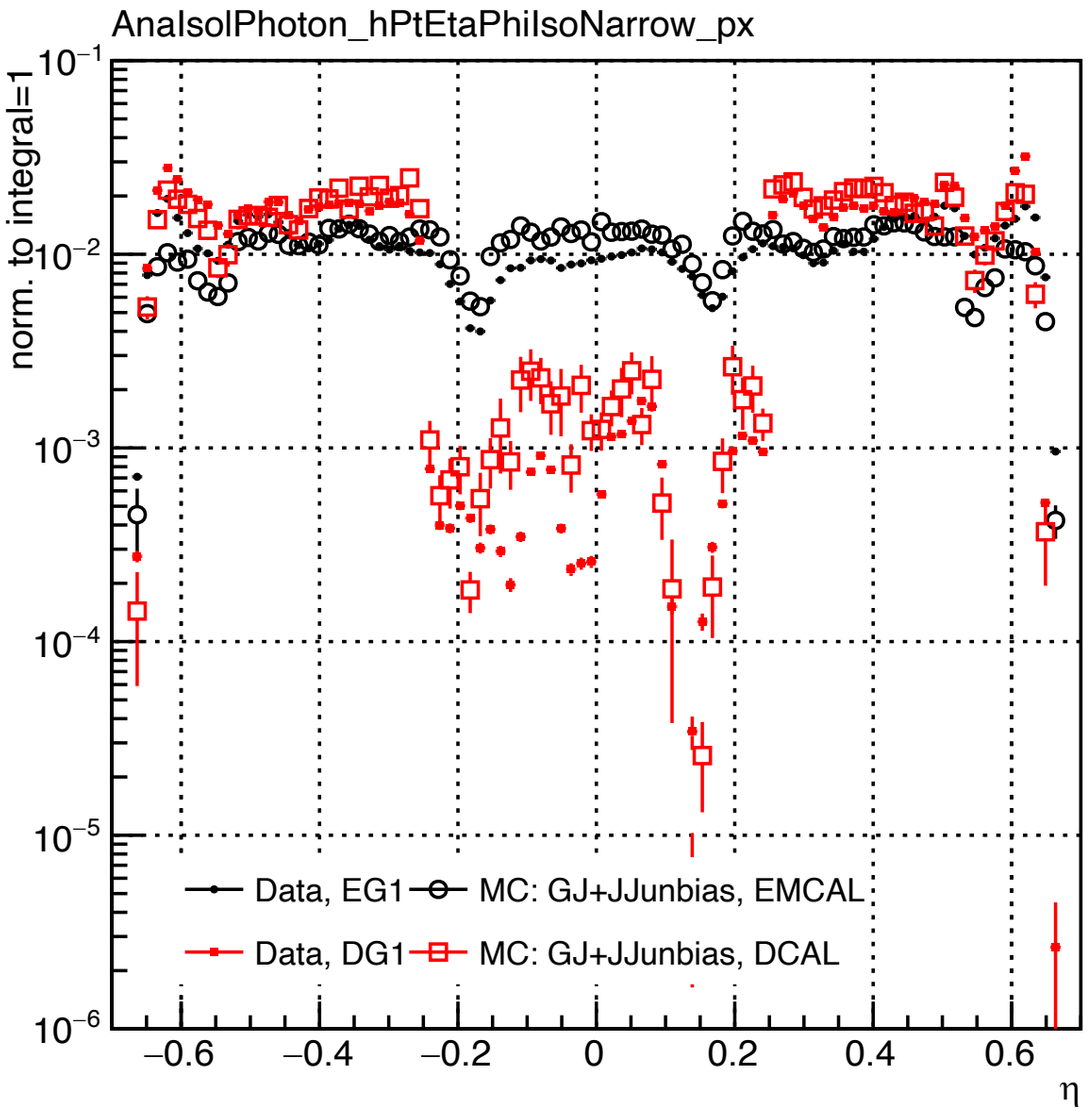


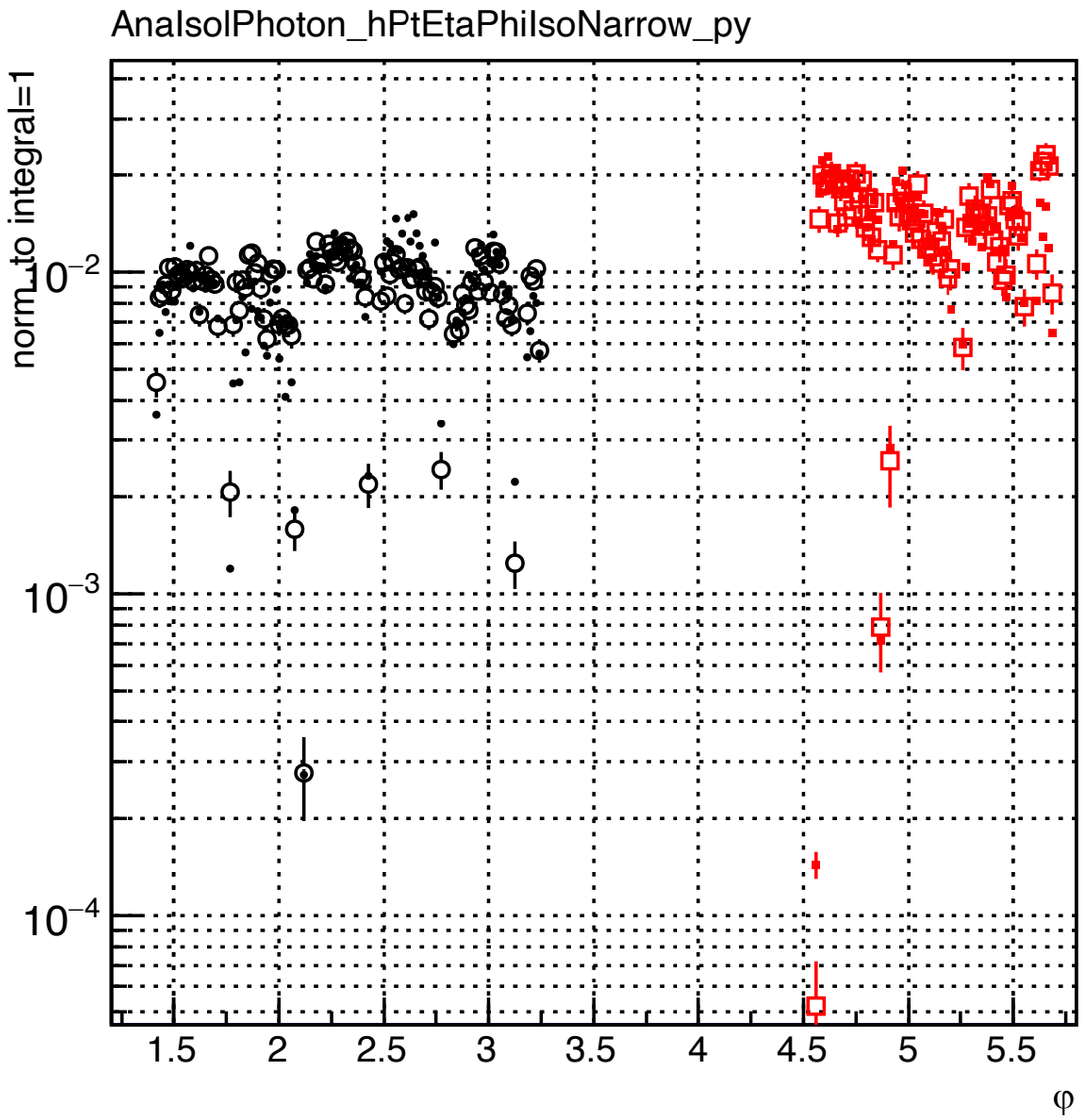
Eta(Phi) distribution, combined G2 V.S. GJ+JJunb



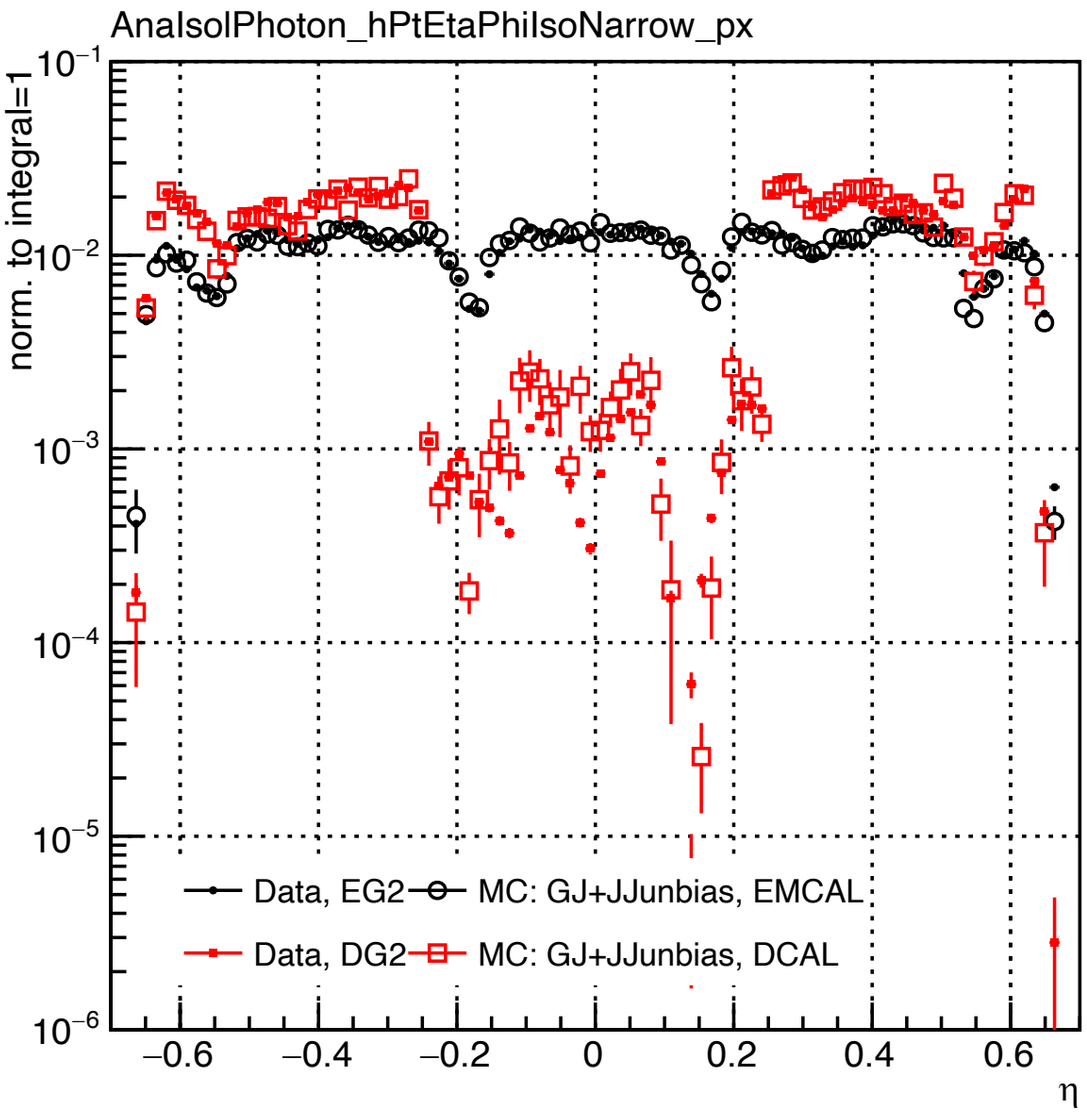


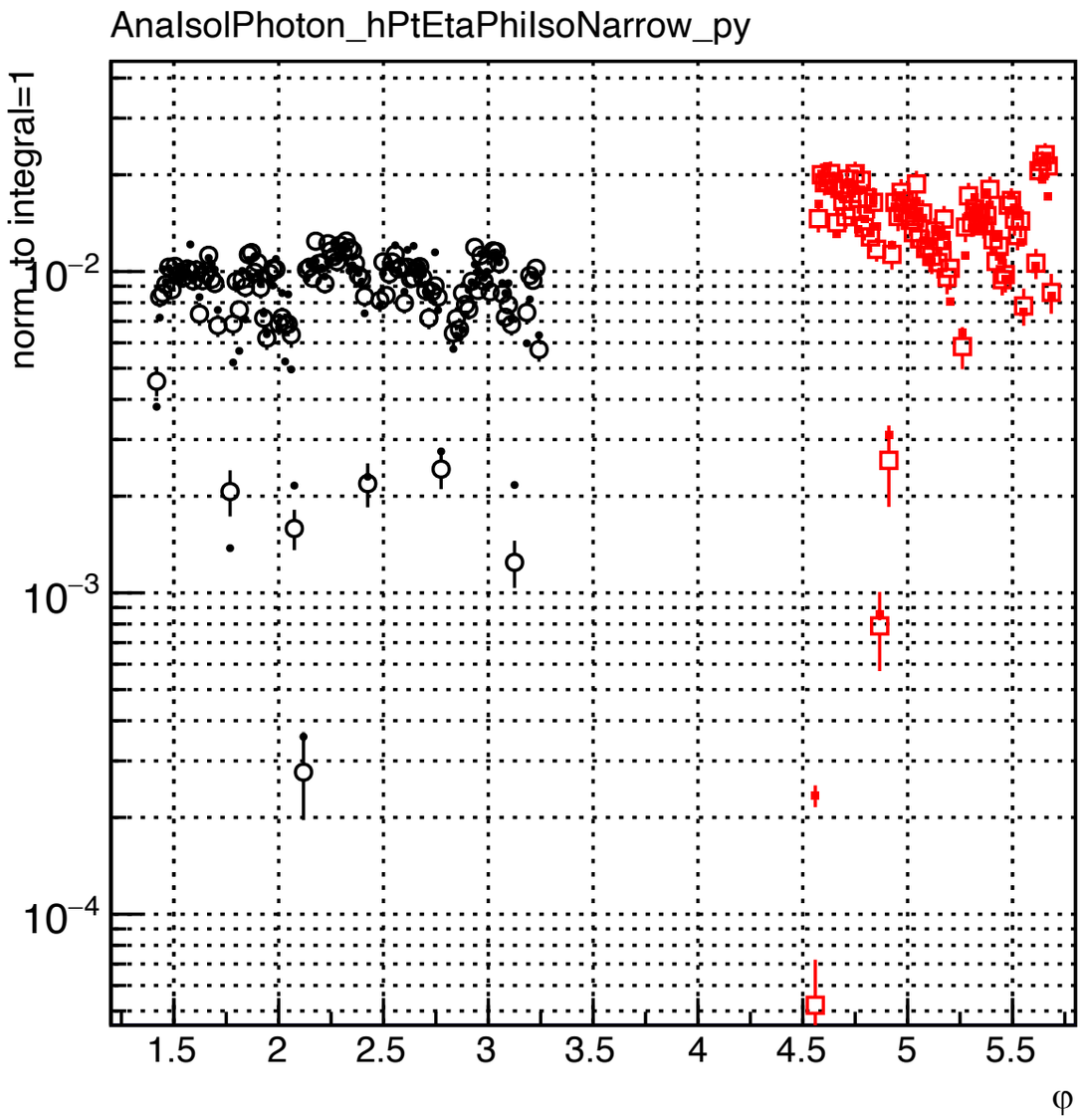
Eta(Phi) distribution, combined G1 V.S. GJ+JJunb



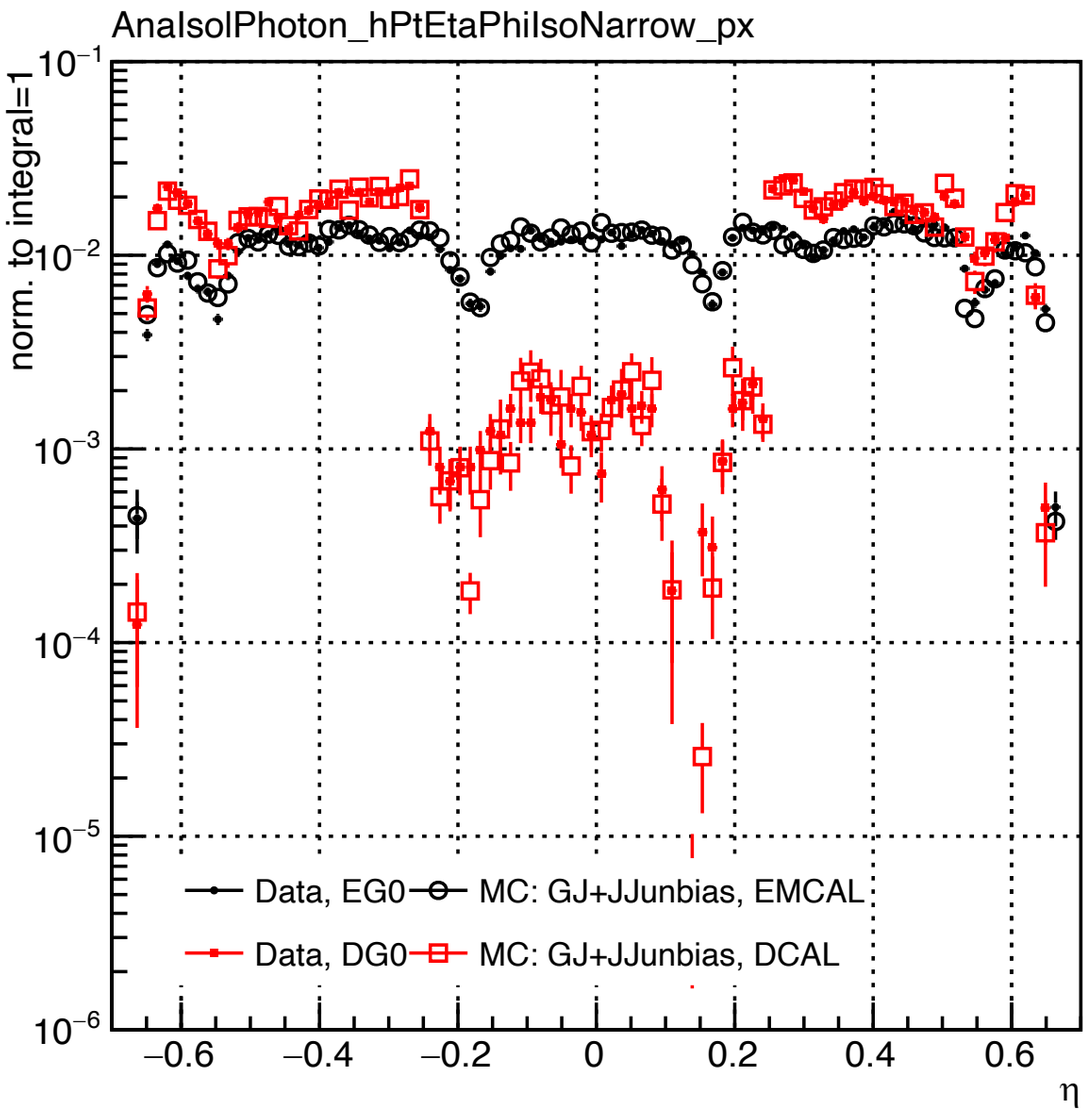


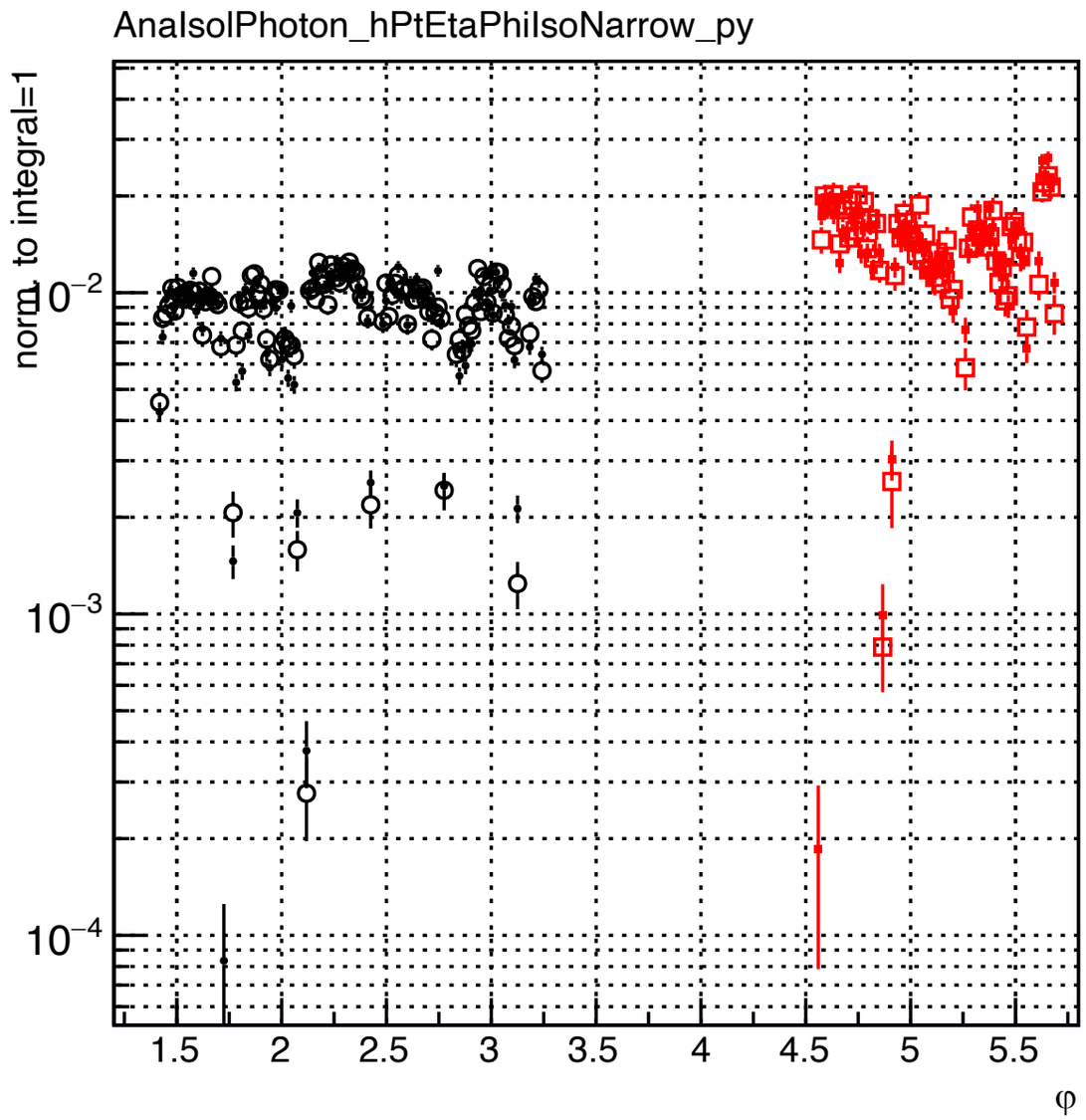
Eta(Phi) distribution, combined G2 V.S. GJ+JJunb



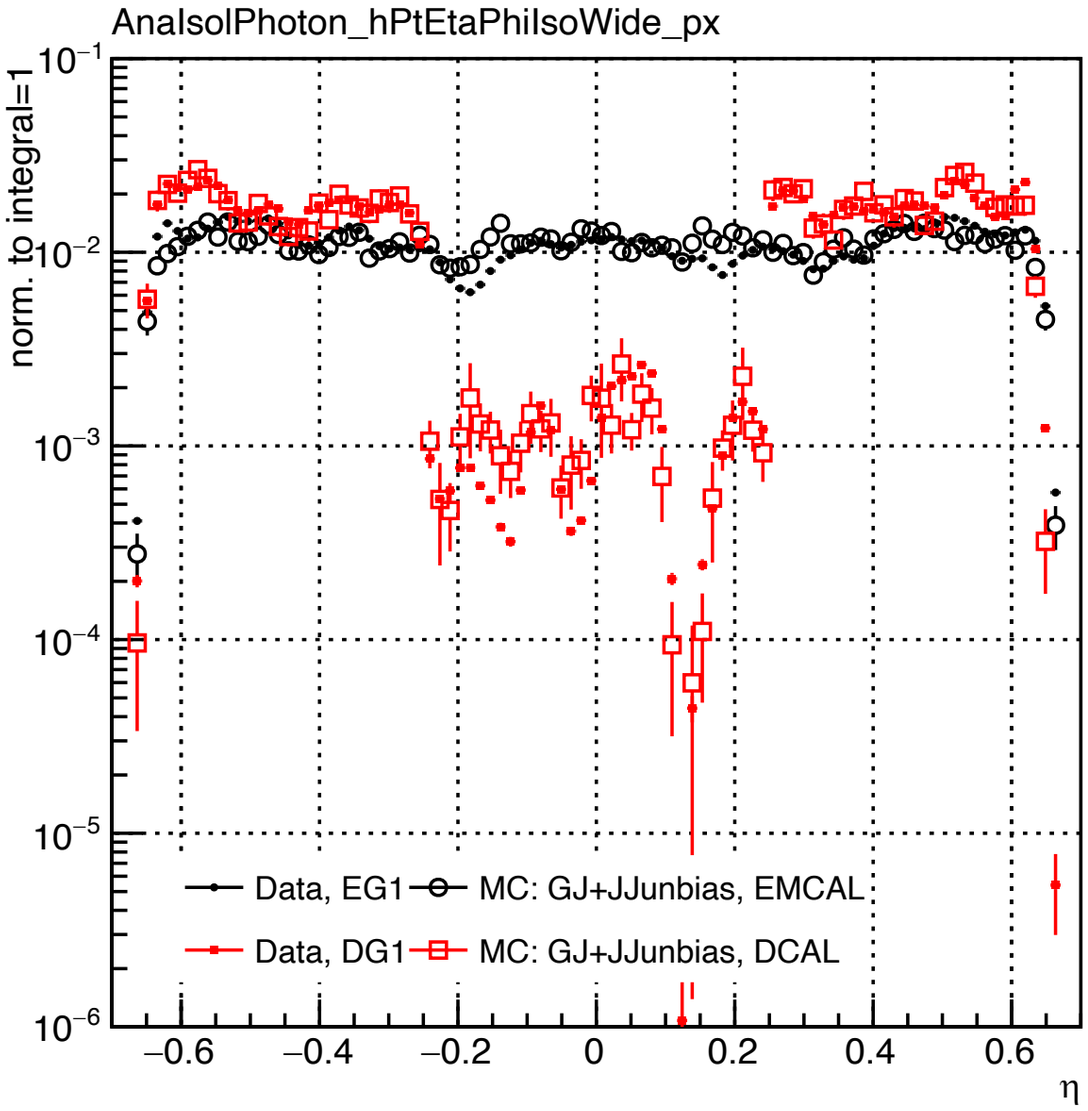


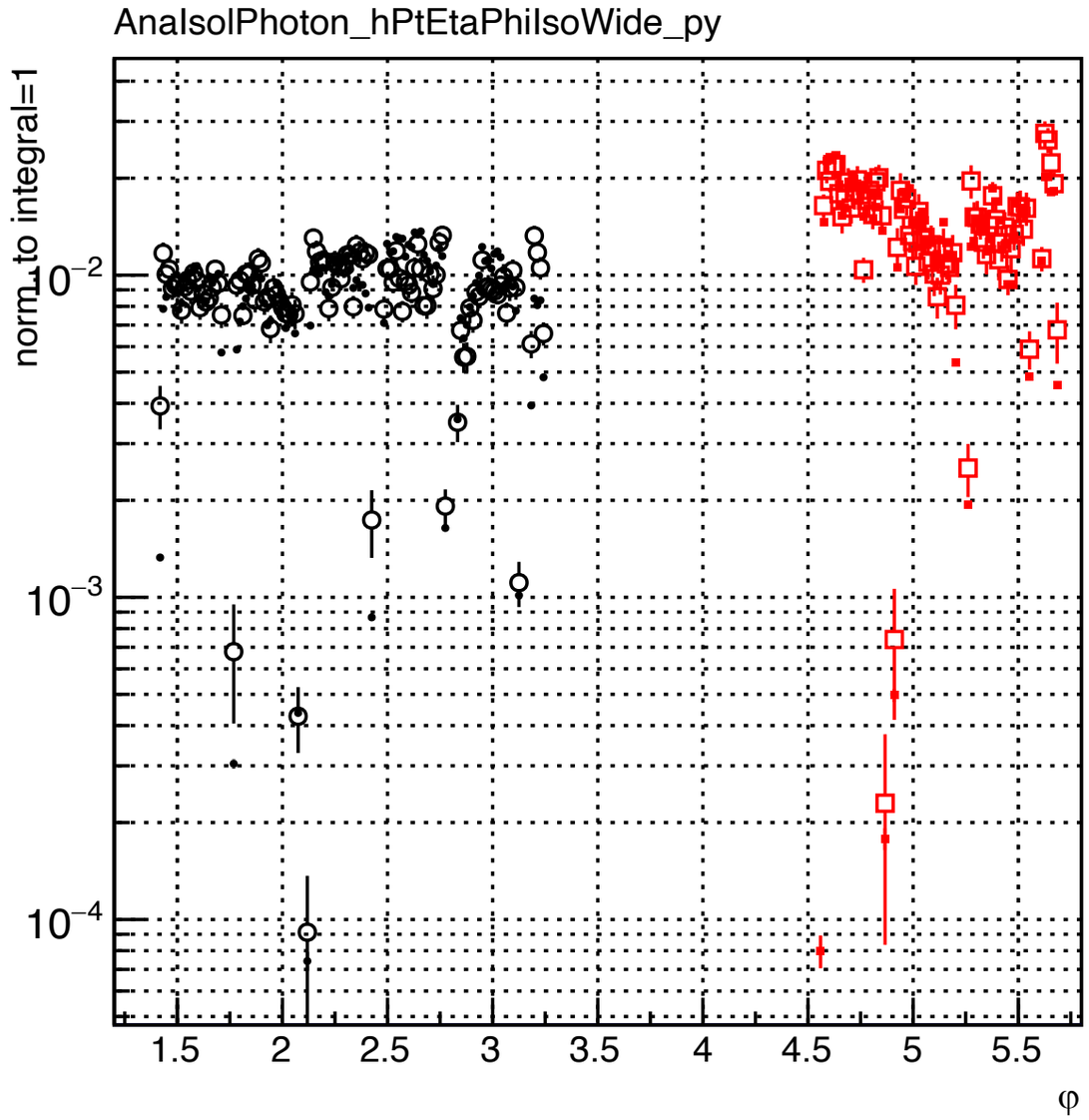
Eta(Phi) distribution, combined MB V.S. GJ+JJunb



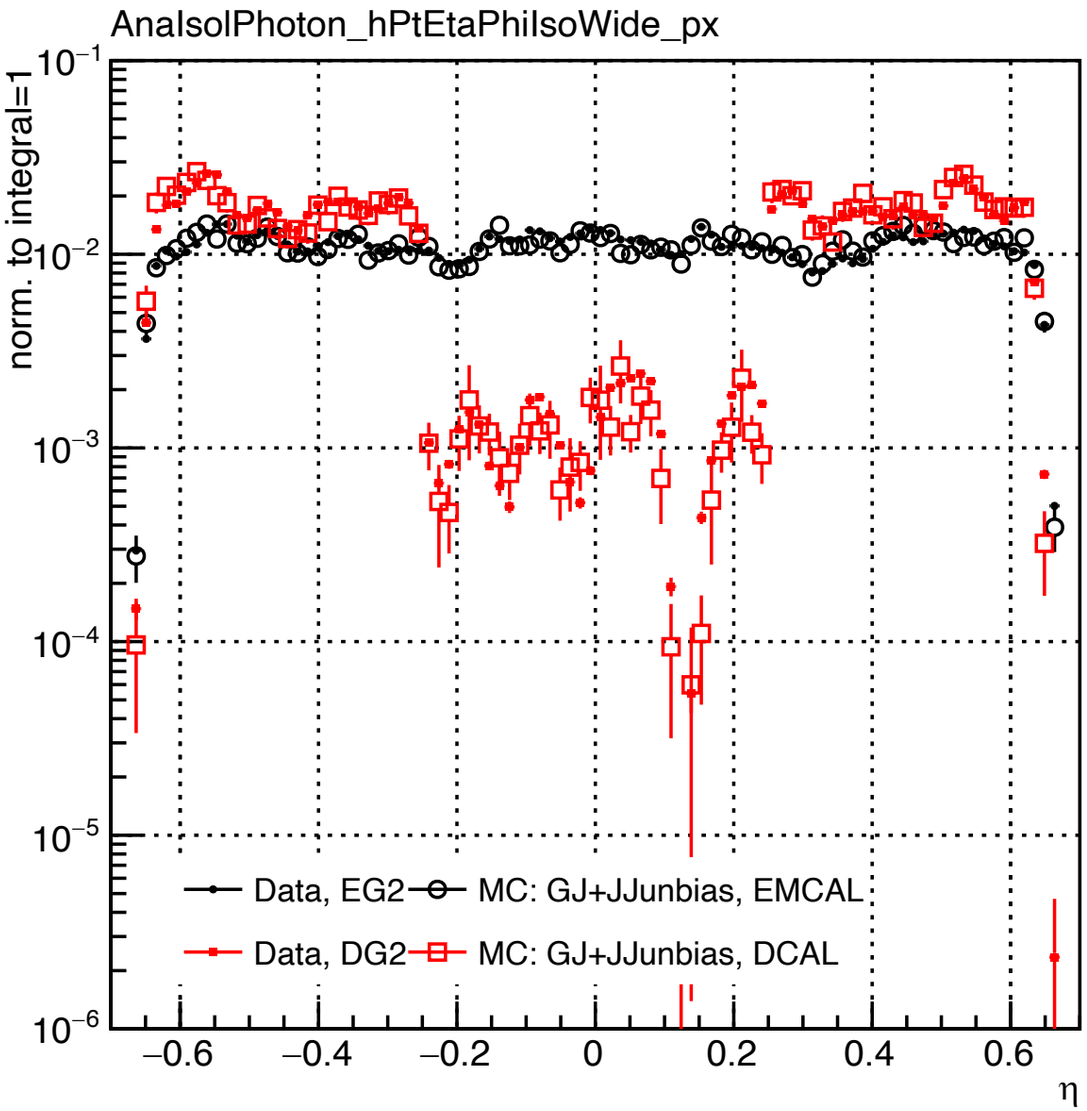


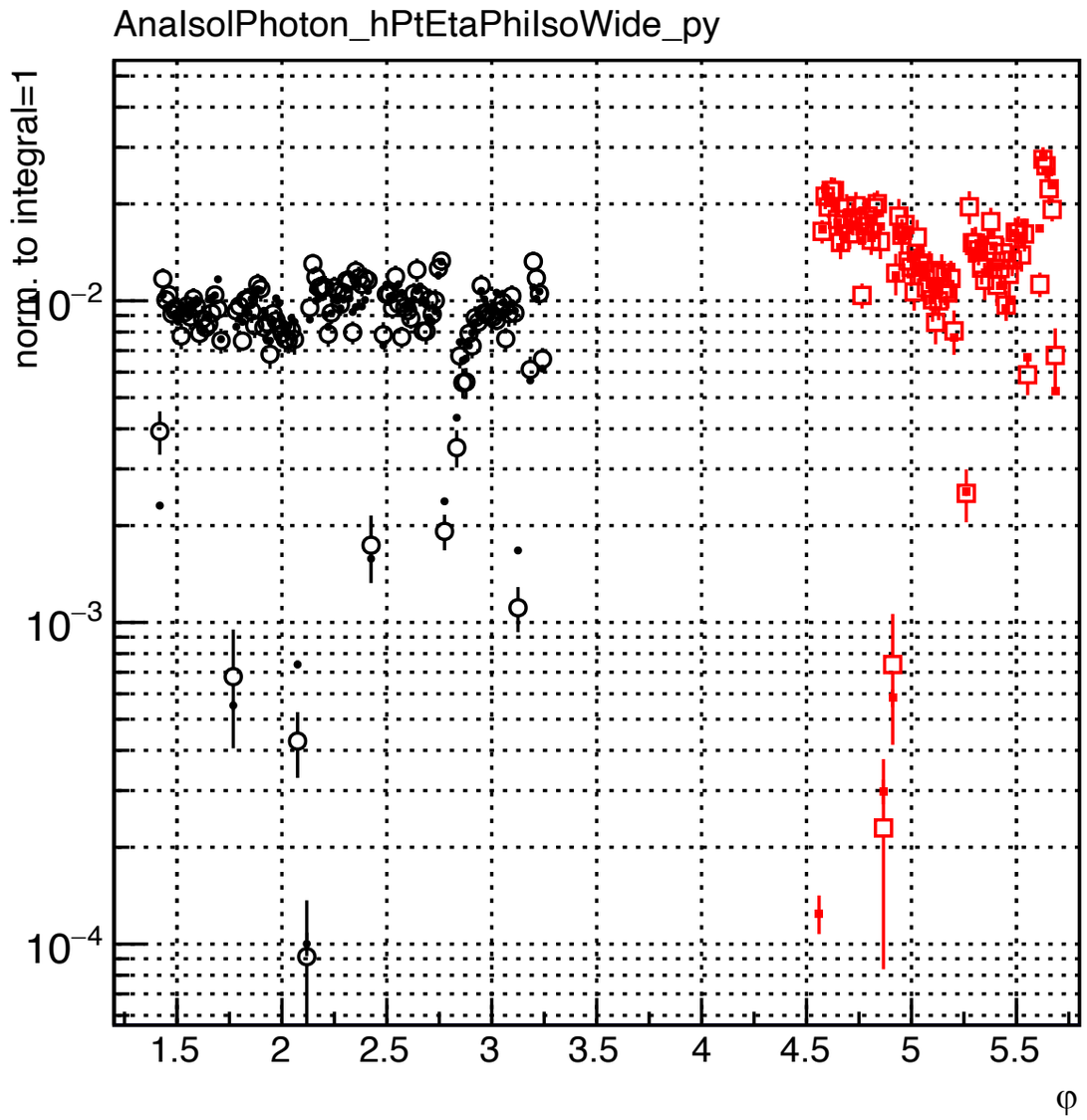
Eta(Phi) distribution, combined G1 V.S. GJ+JJunb



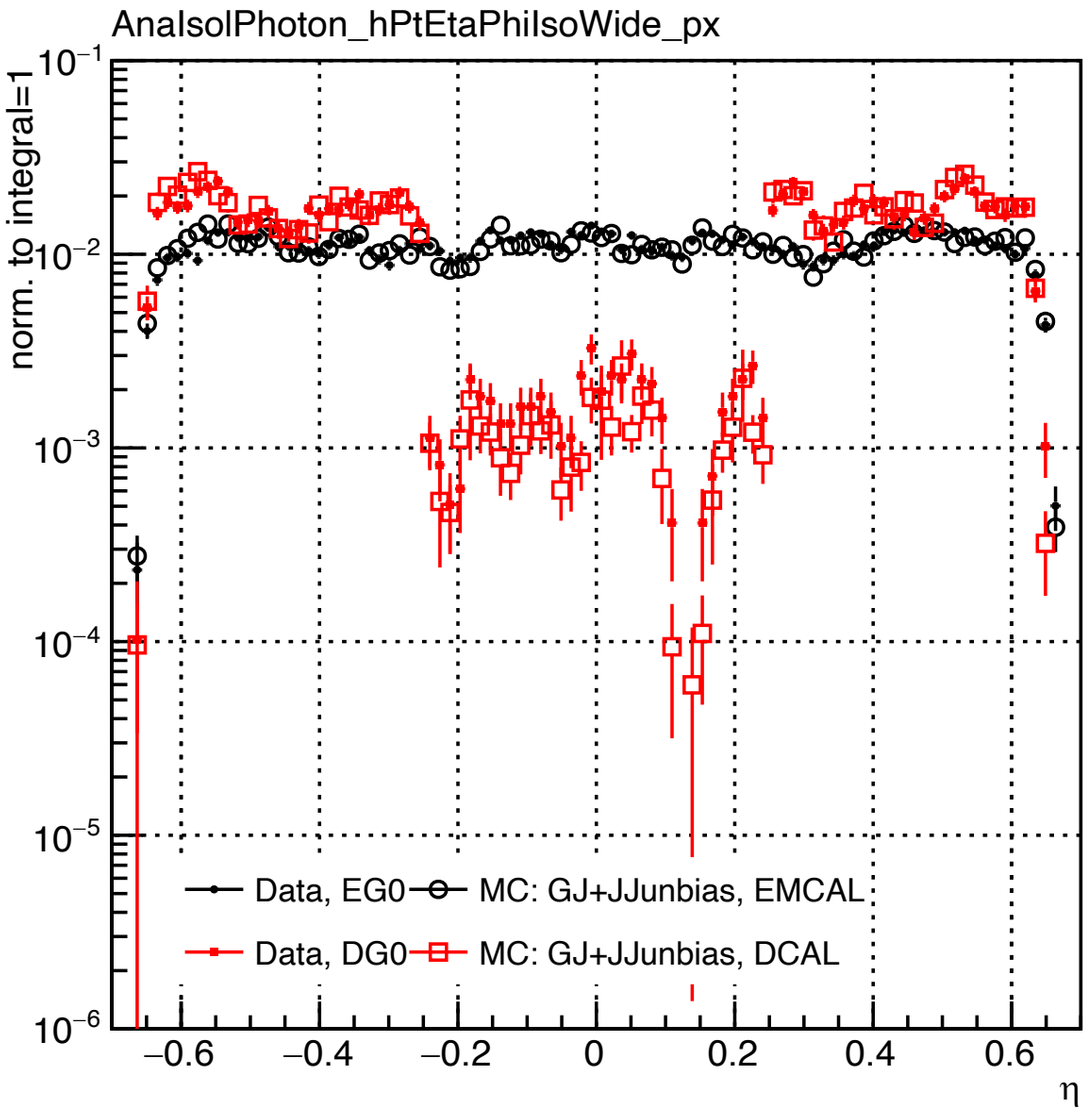


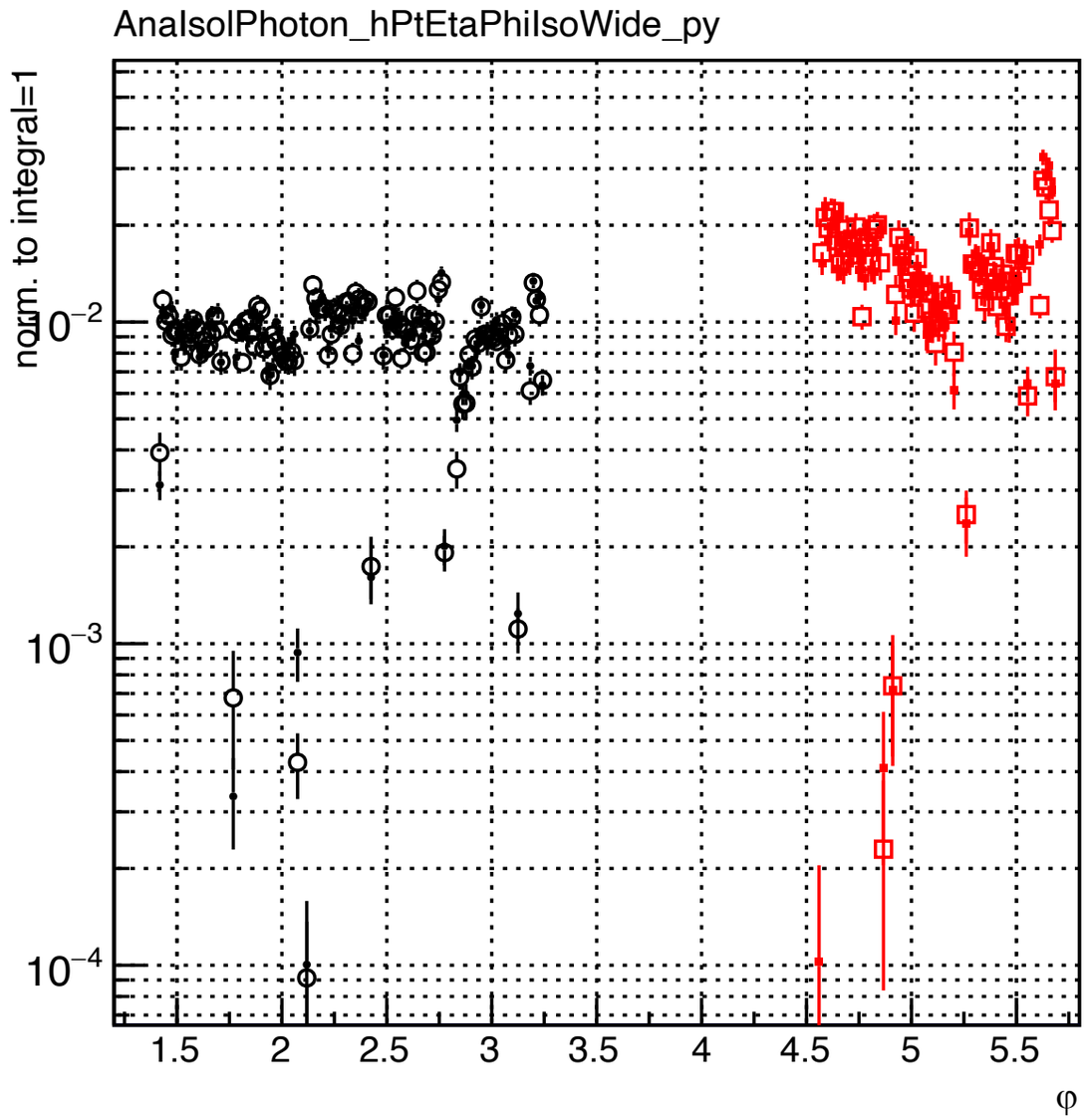
Eta(Phi) distribution, combined G2 V.S. GJ



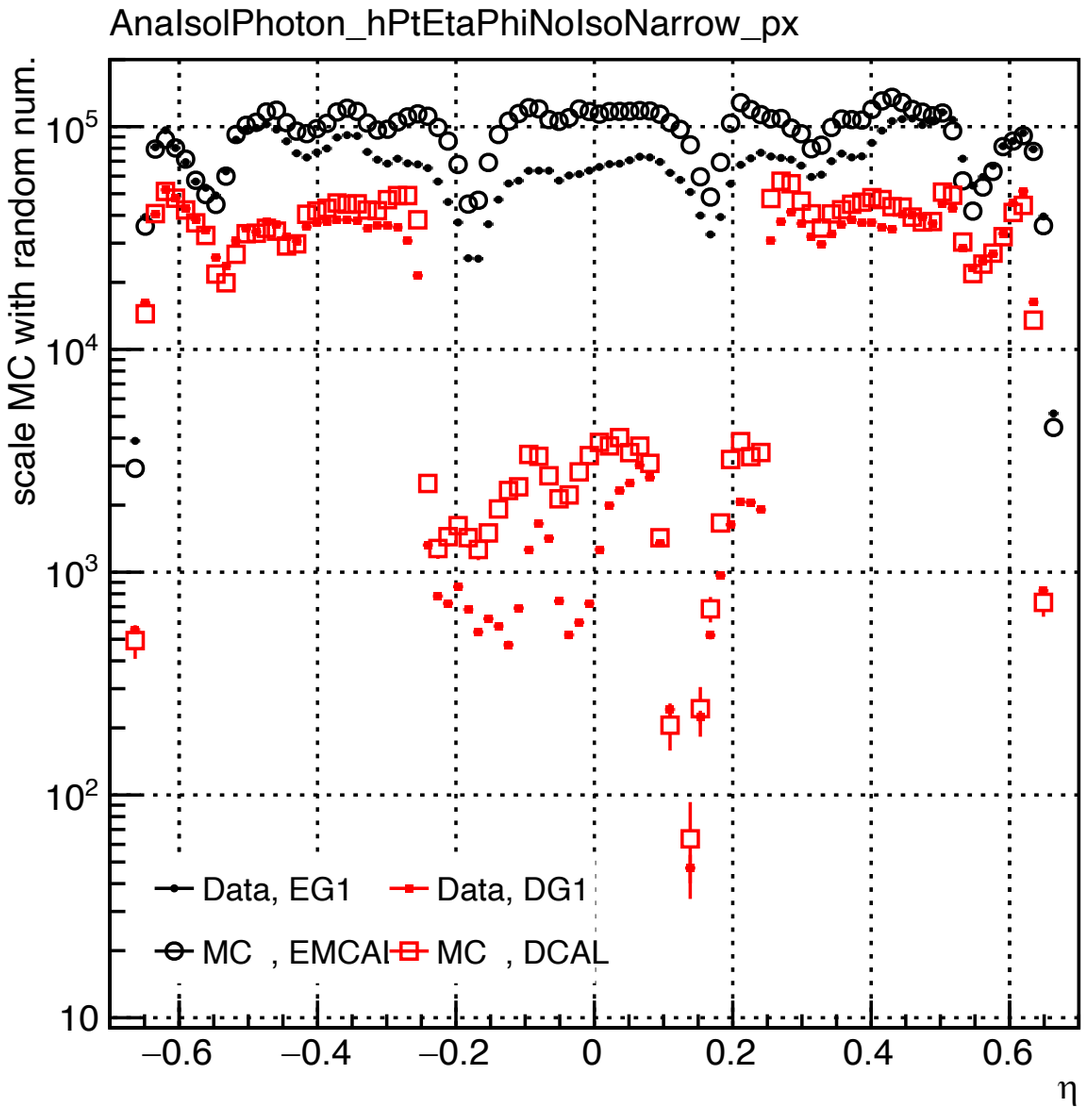


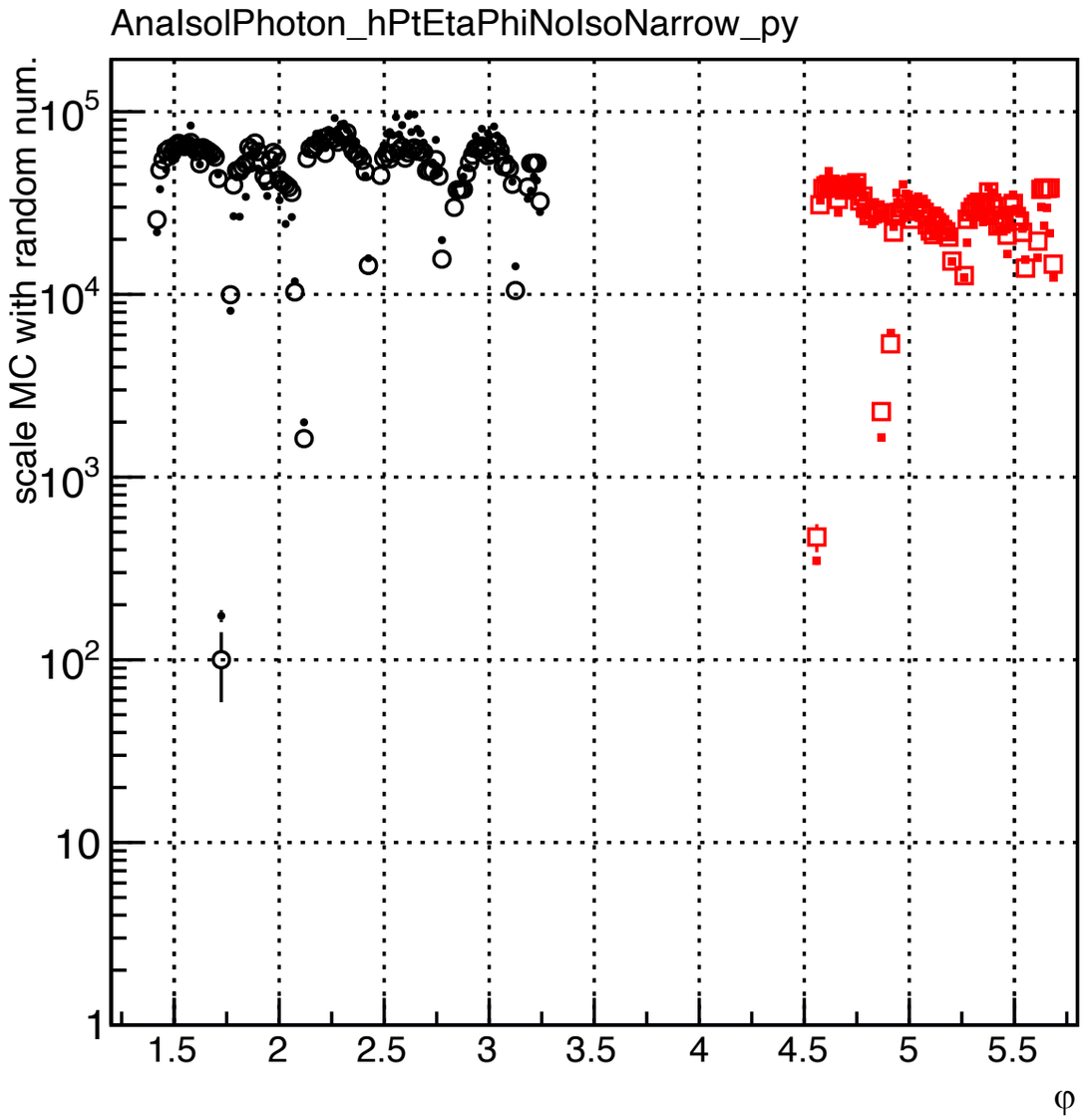
Eta(Phi) distribution, combined MB V.S. GJ



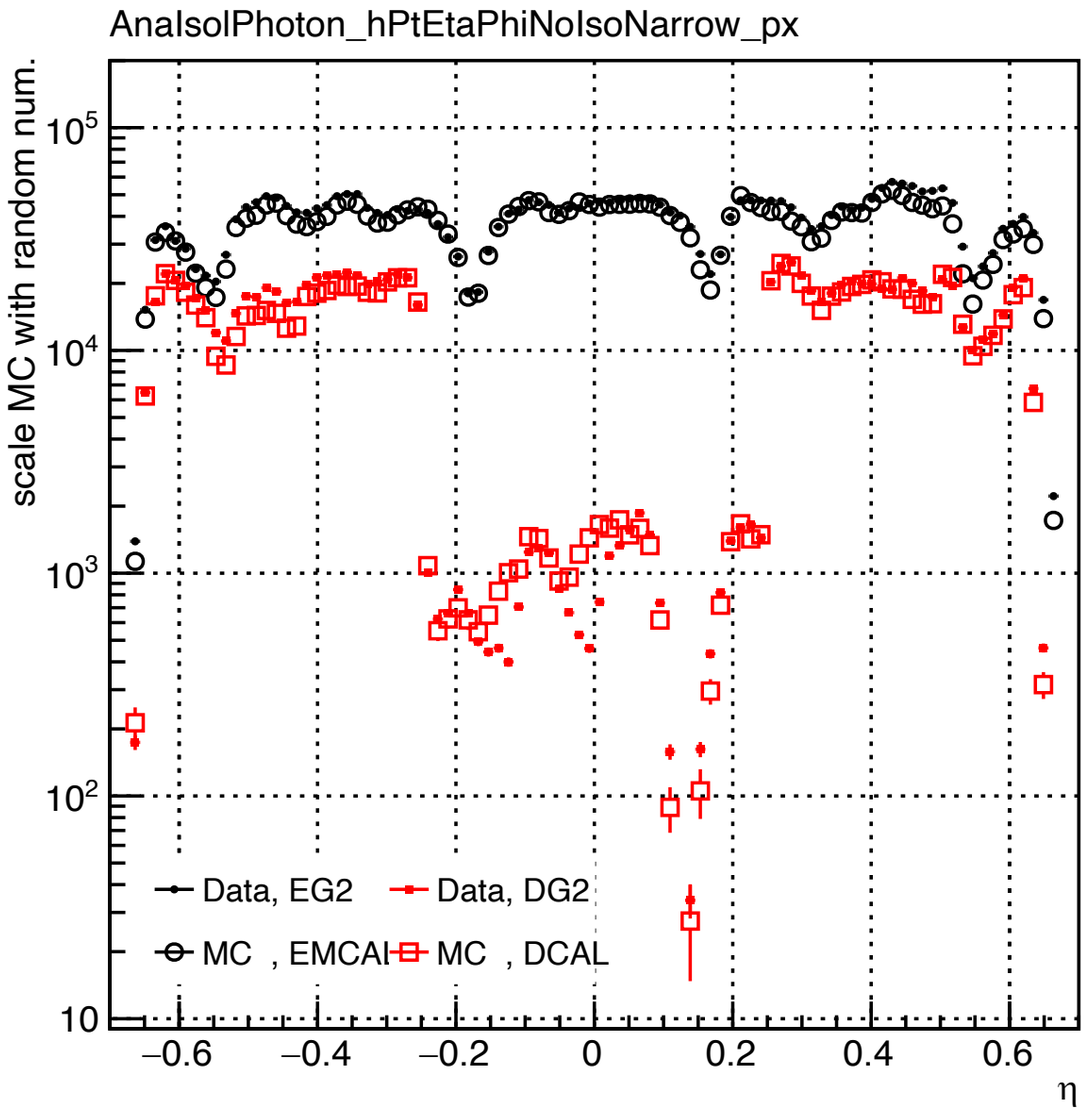


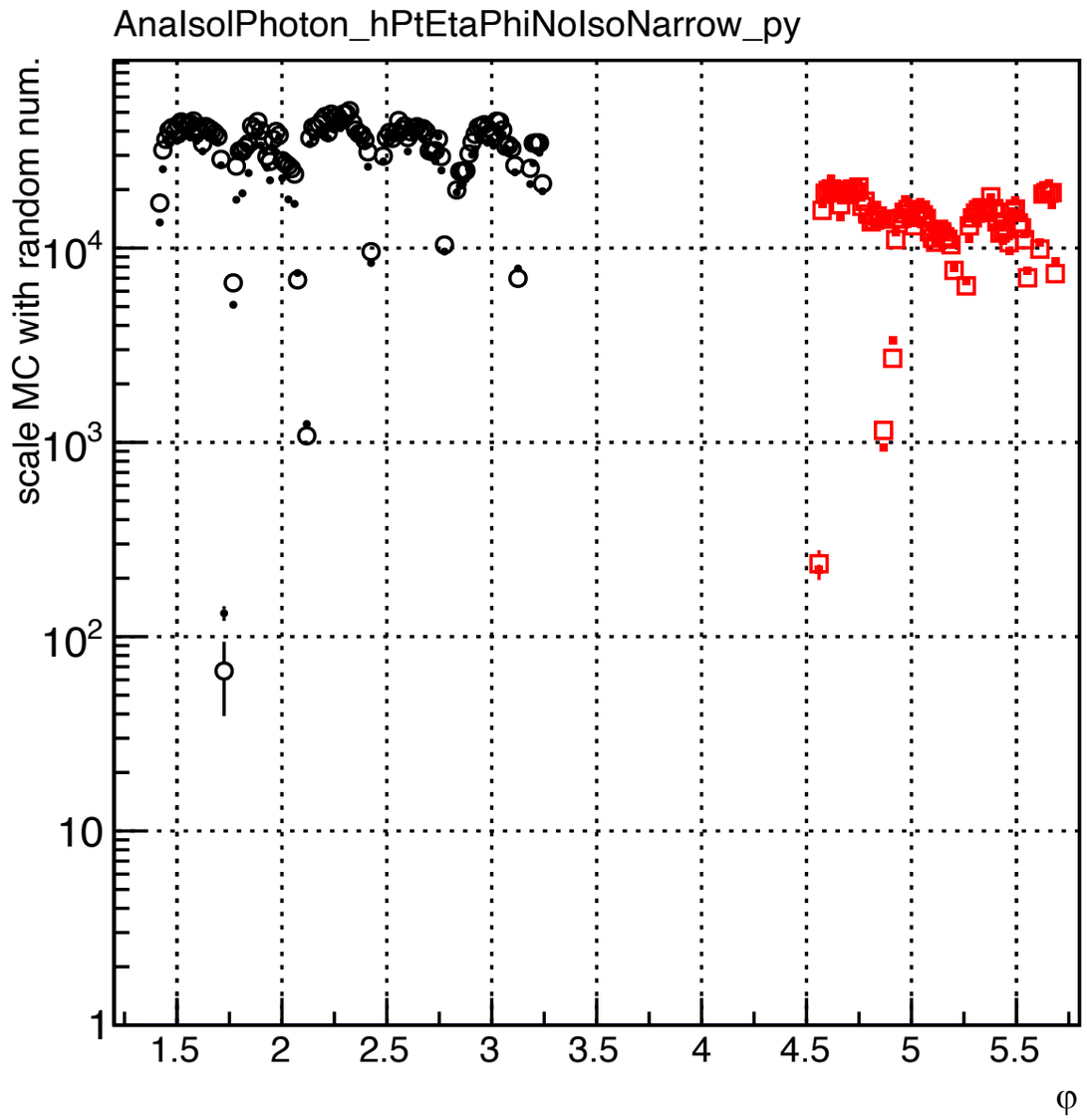
Eta(Phi) distribution, combined G1 V.S. GJ



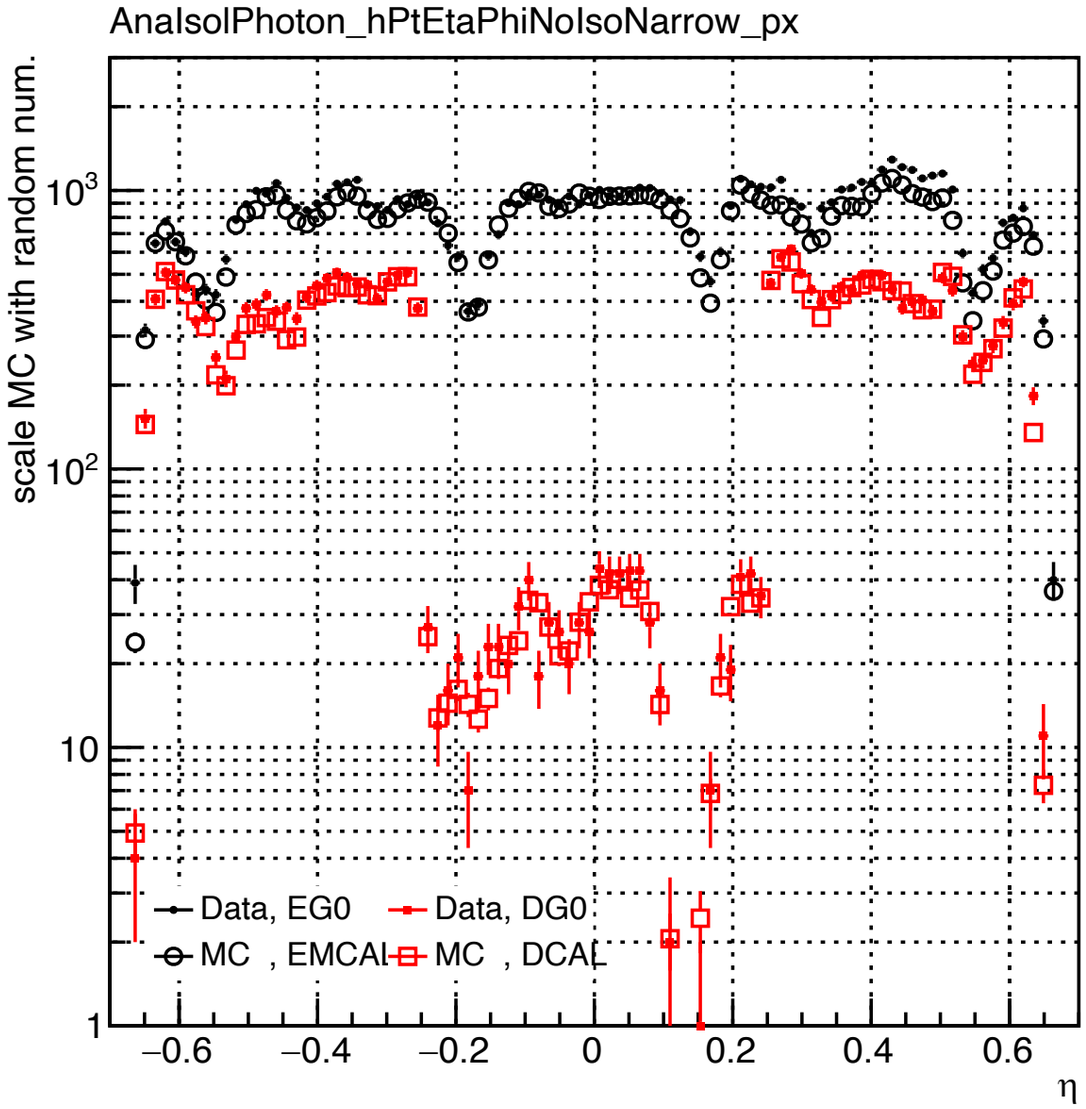


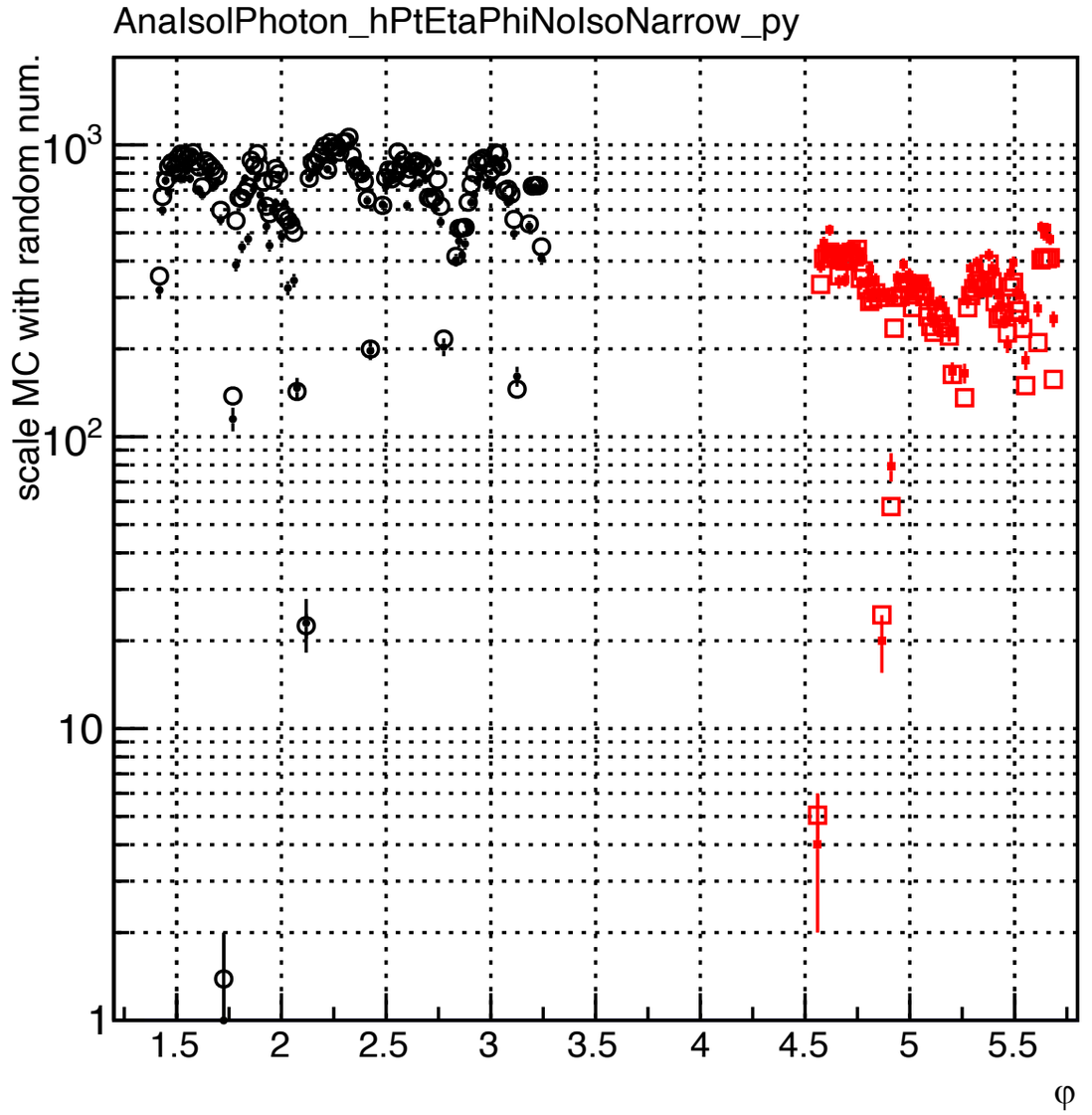
Eta(Phi) distribution, combined G2 V.S. GJ



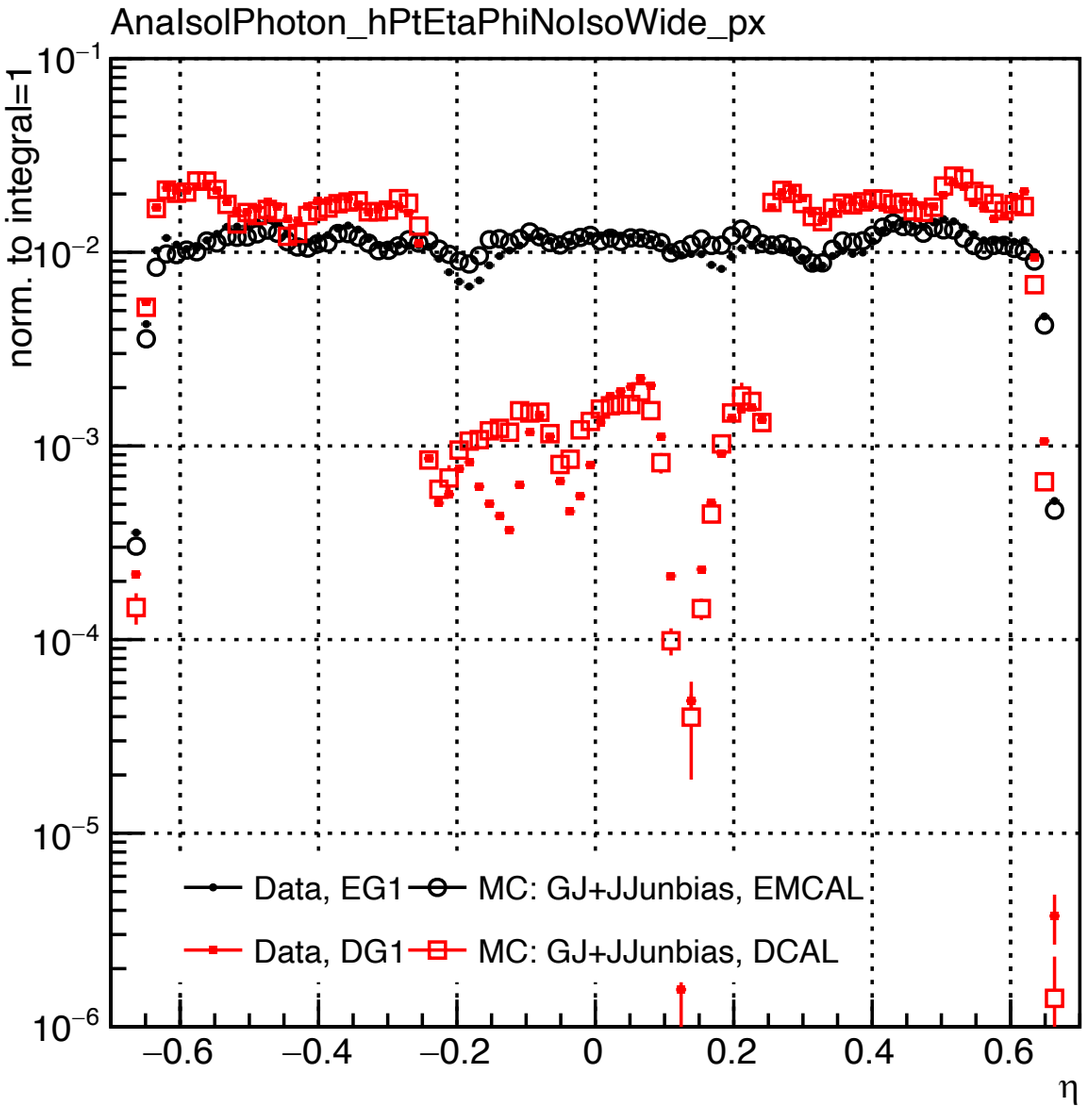


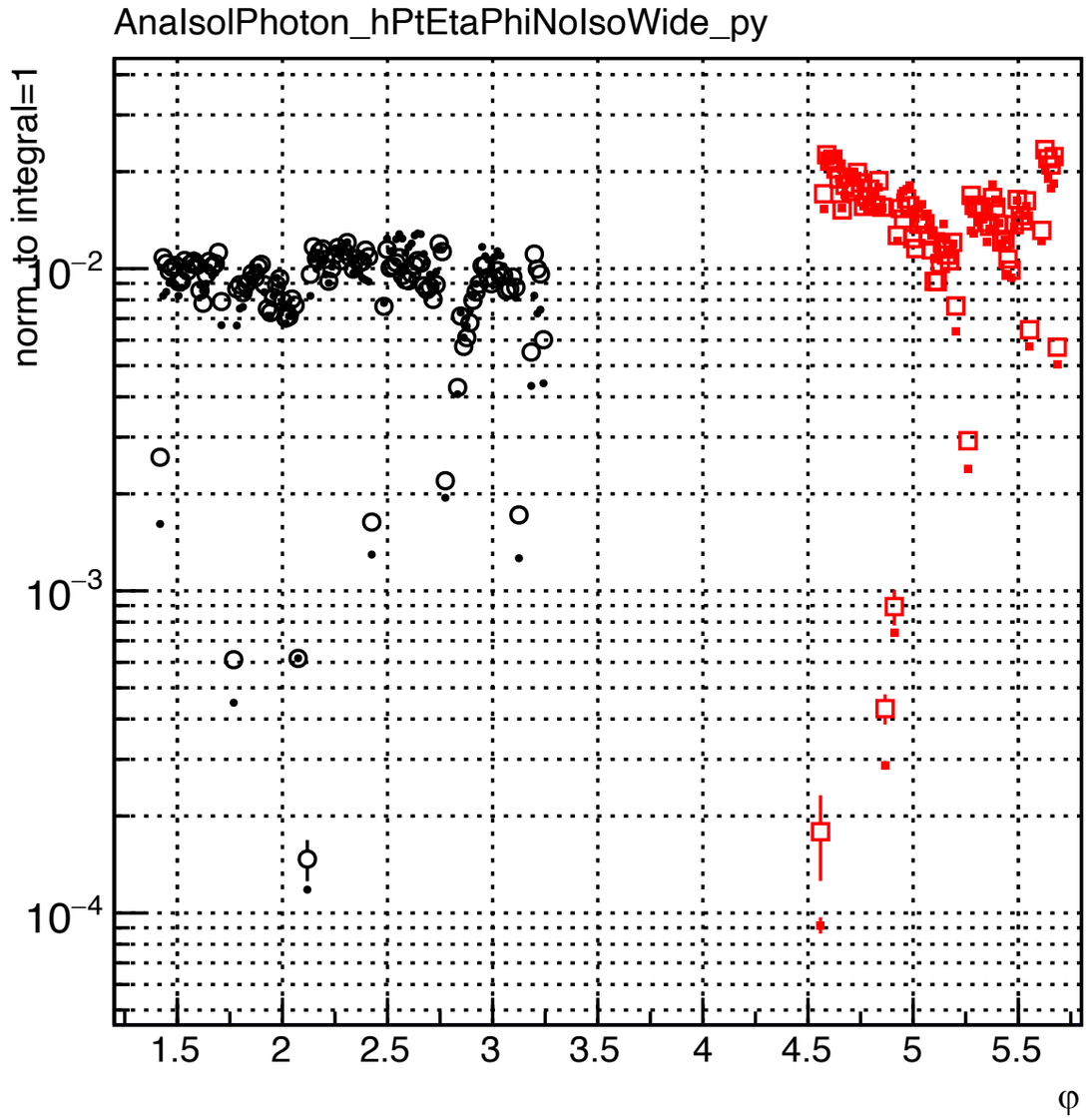
Eta(Phi) distribution, combined MB V.S. GJ



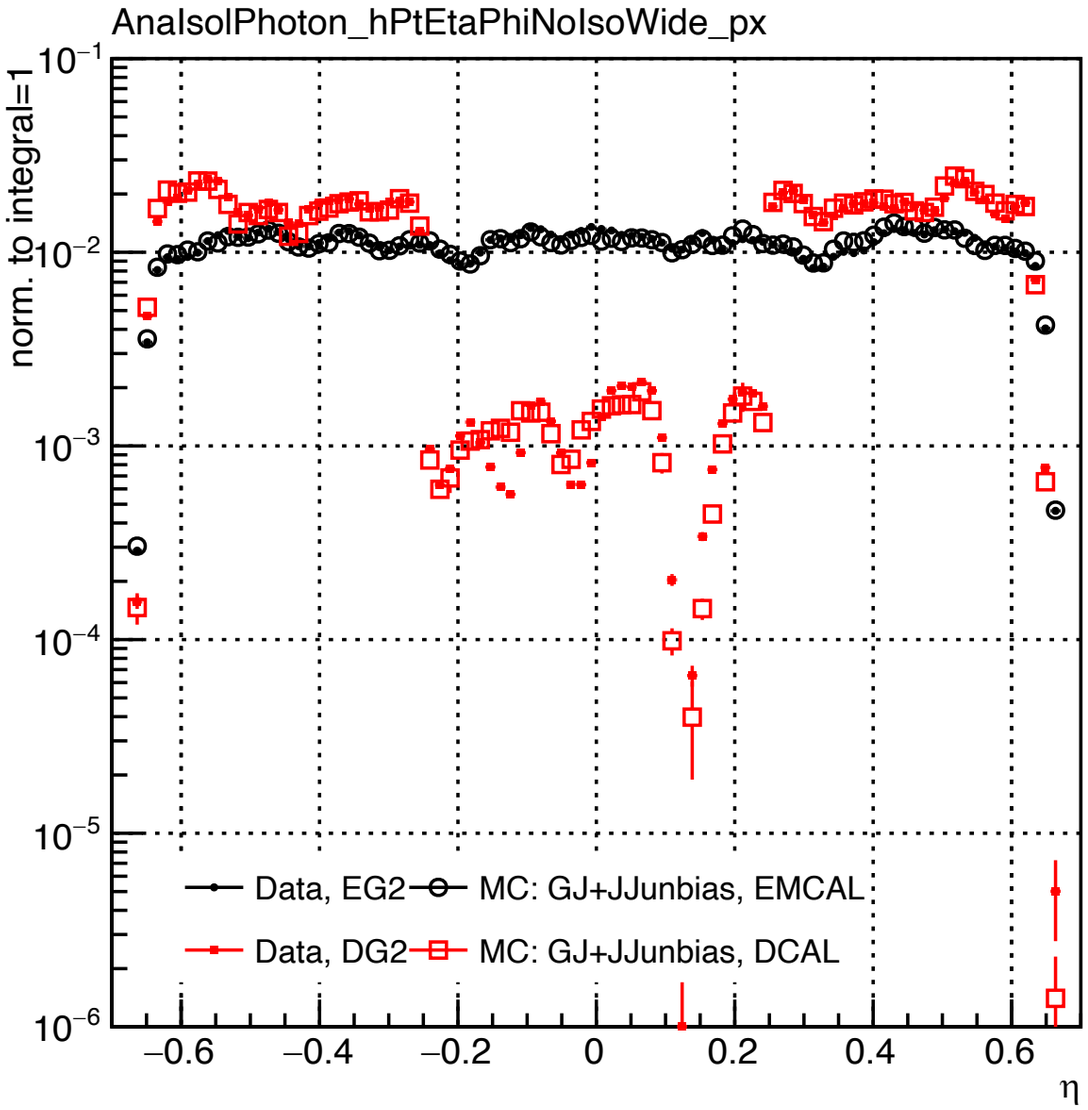


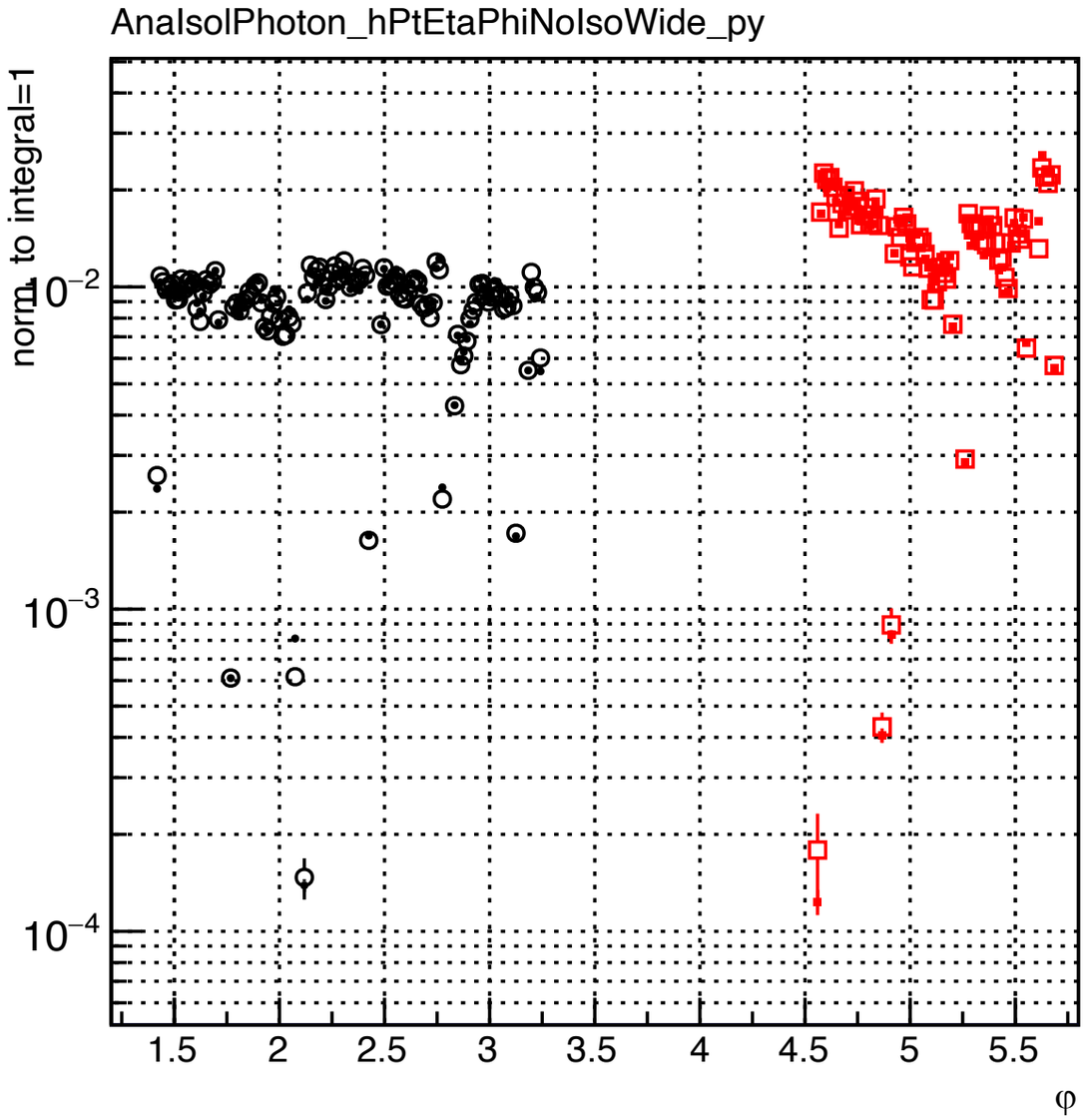
Eta(Phi) distribution, combined G1 V.S. GJ+JJunb



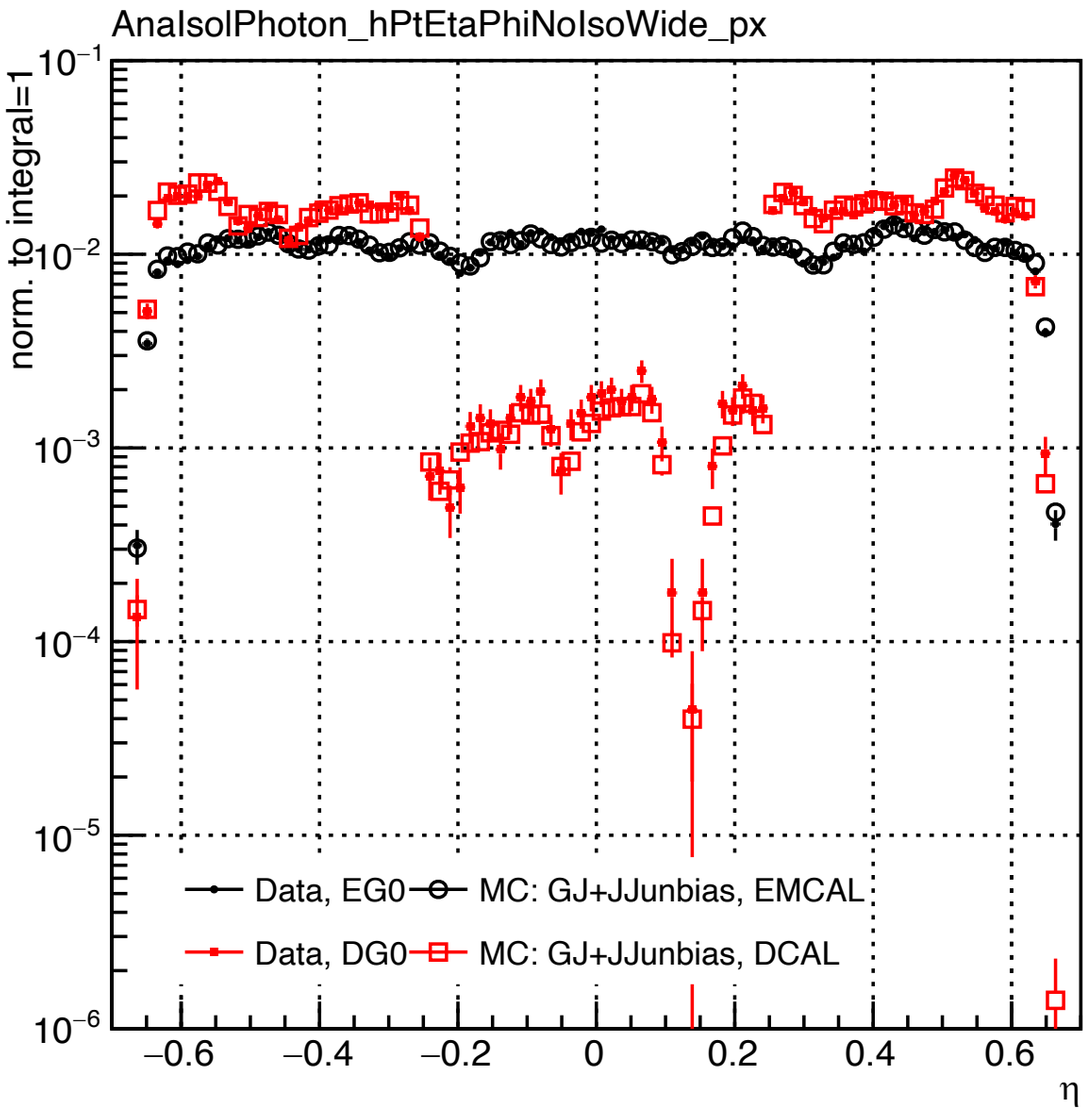


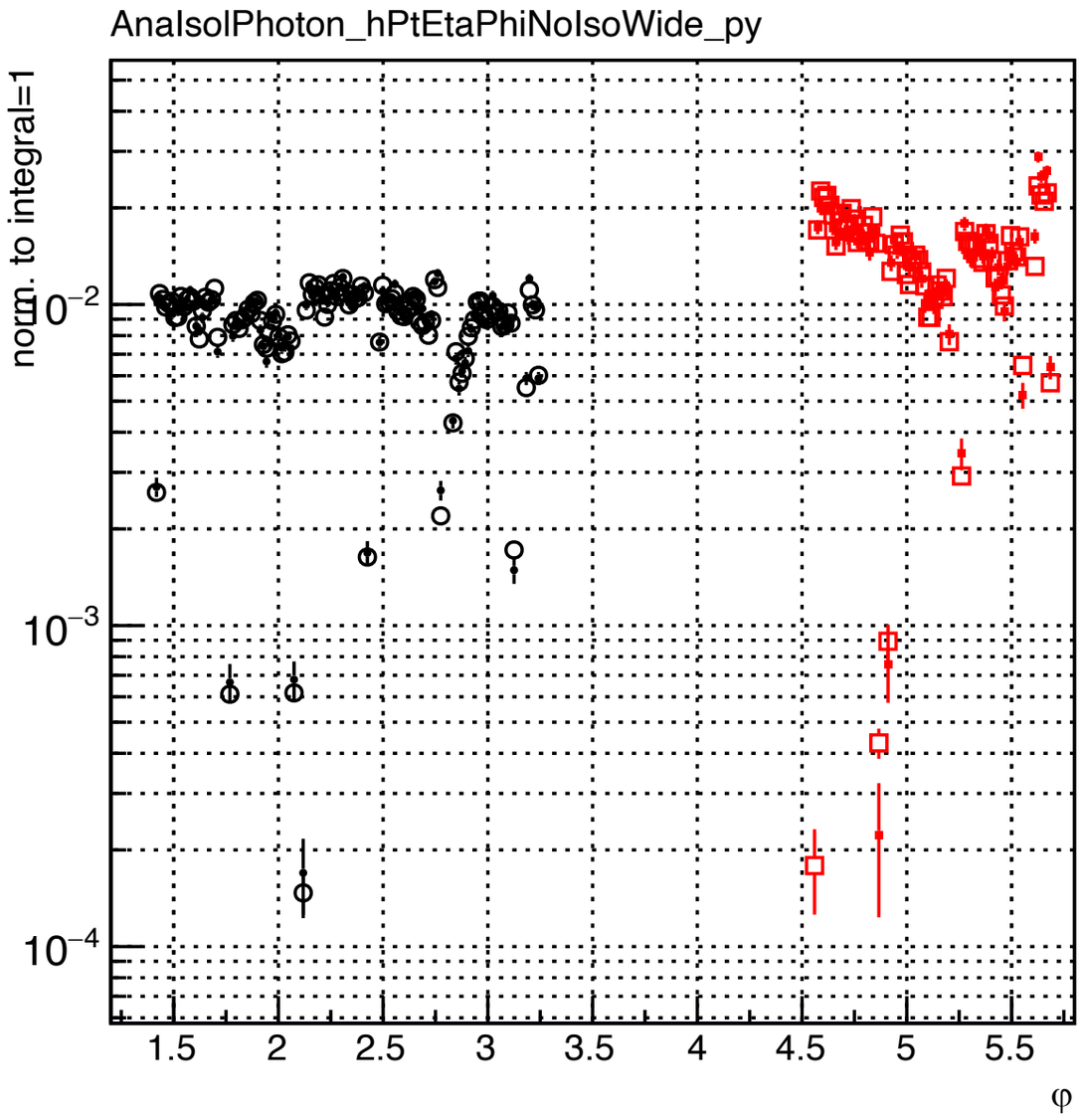
Eta(Phi) distribution, combined G2 V.S. GJ+JJunb





Eta(Phi) distribution, combined MB V.S. GJ



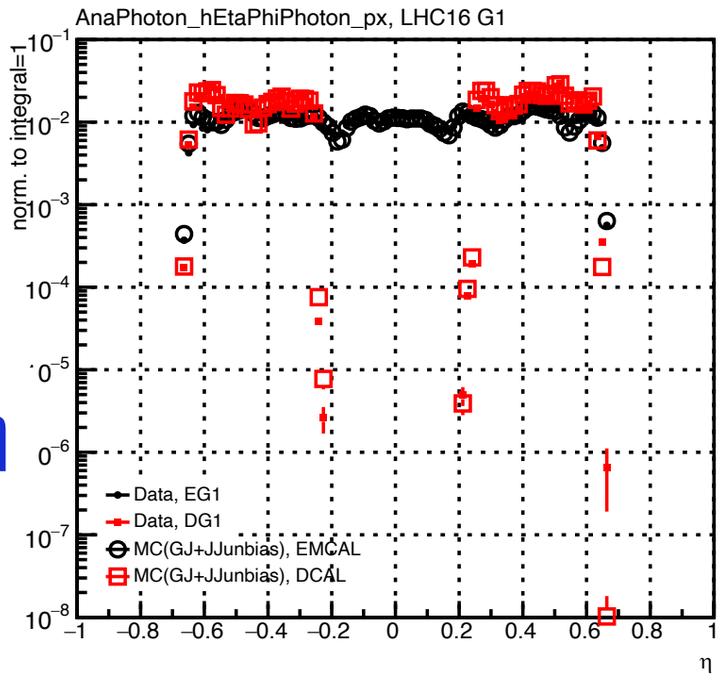


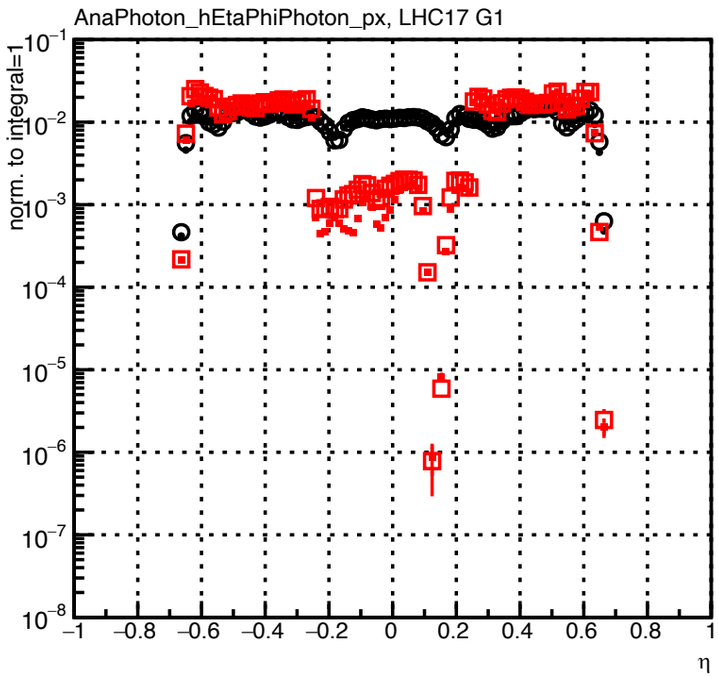
Eta(Phi) distribution, per year G1 V.S. GJ+JJunb

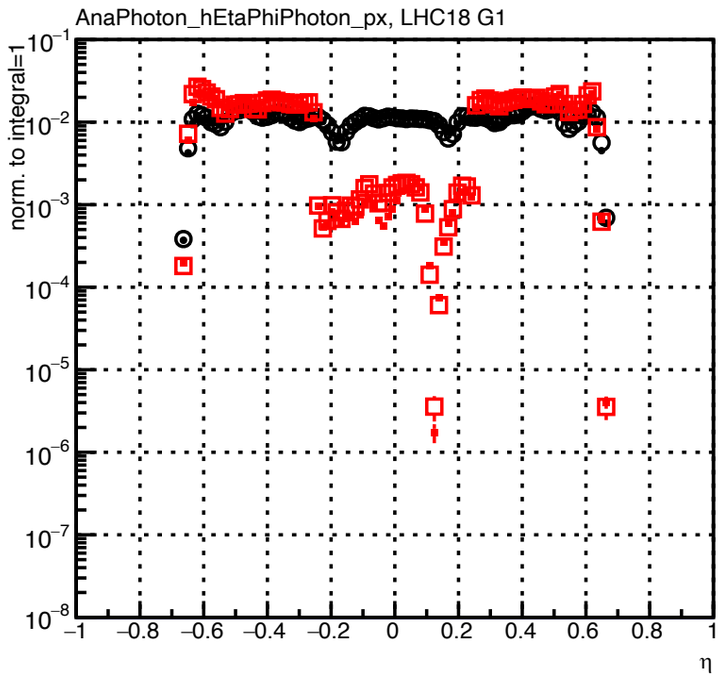
LHC16

LHC17

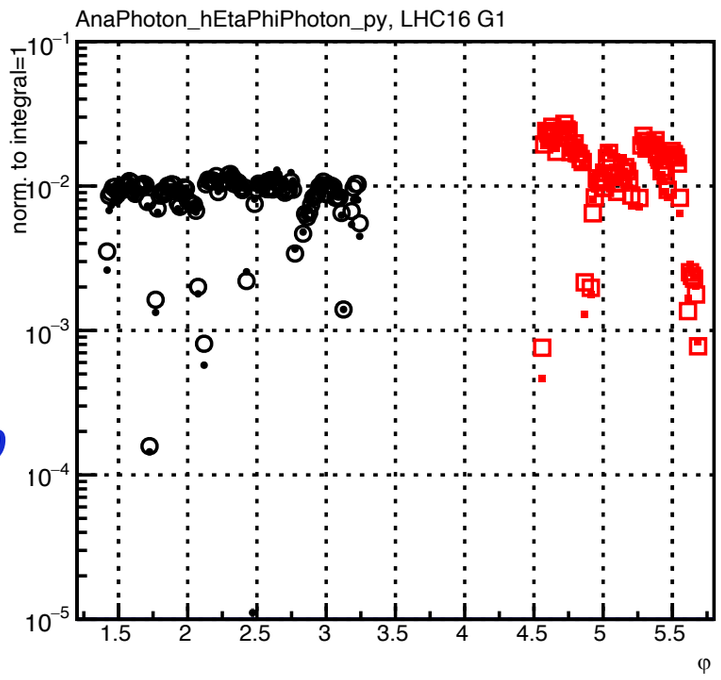
LHC18

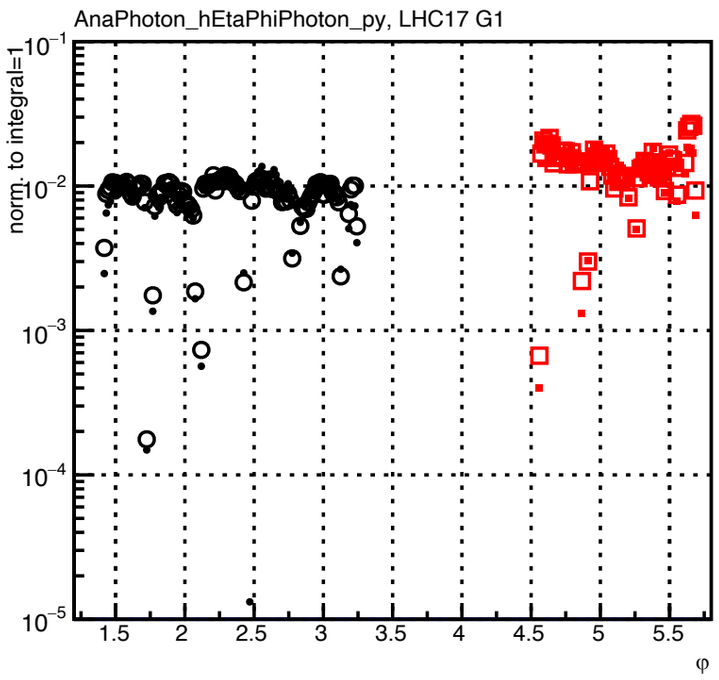


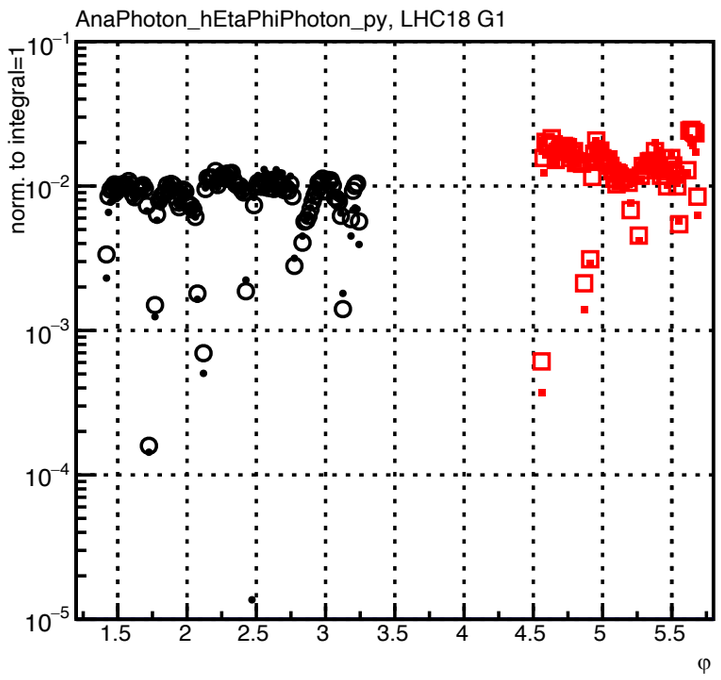




φ



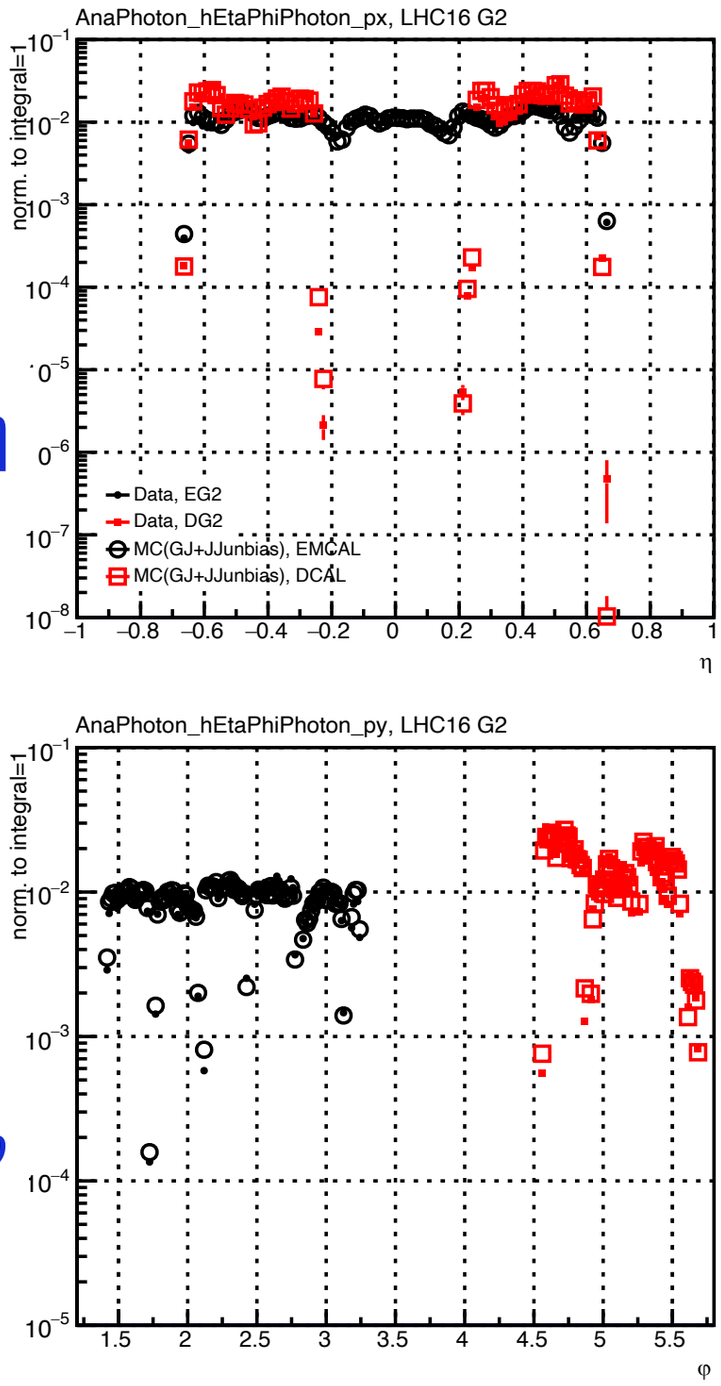




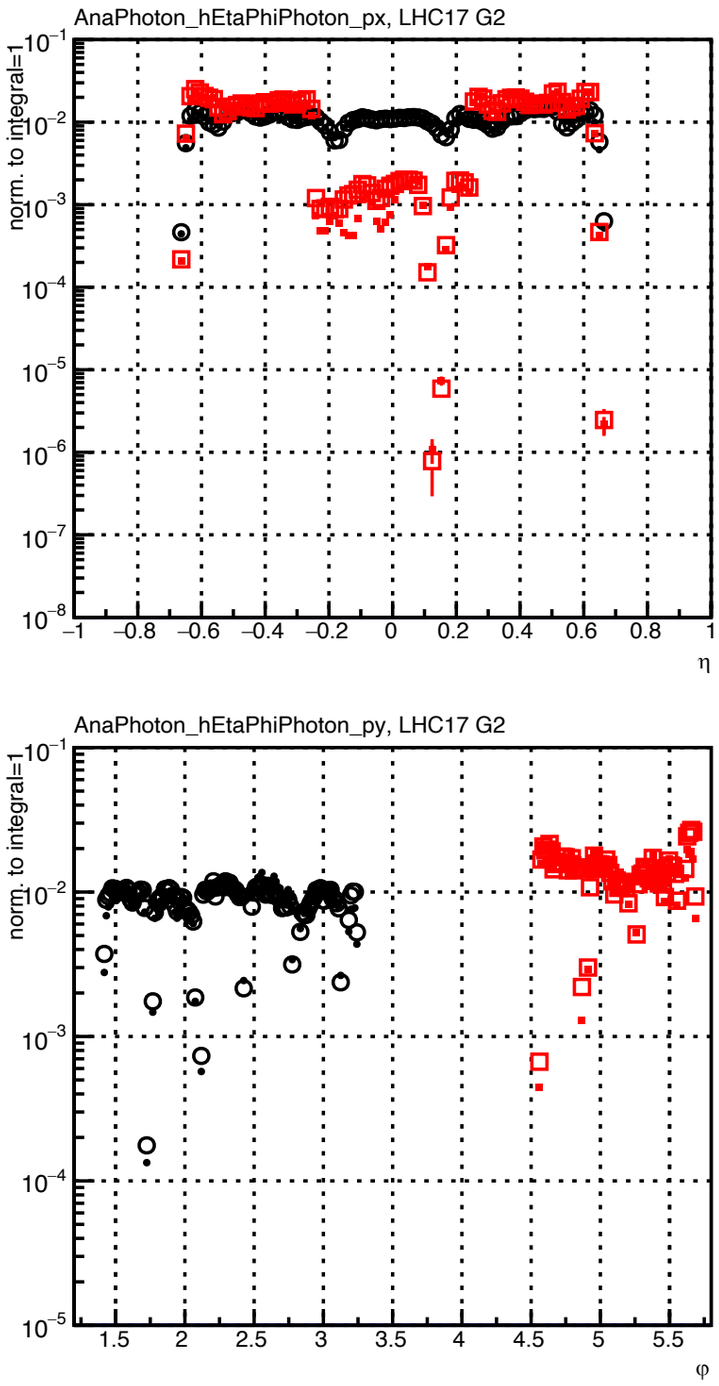
Histo_name: AnaPhoton_hEtaPhiPhoton

Eta(Phi) distribution, per year G2 V.S. GJ+JJunb

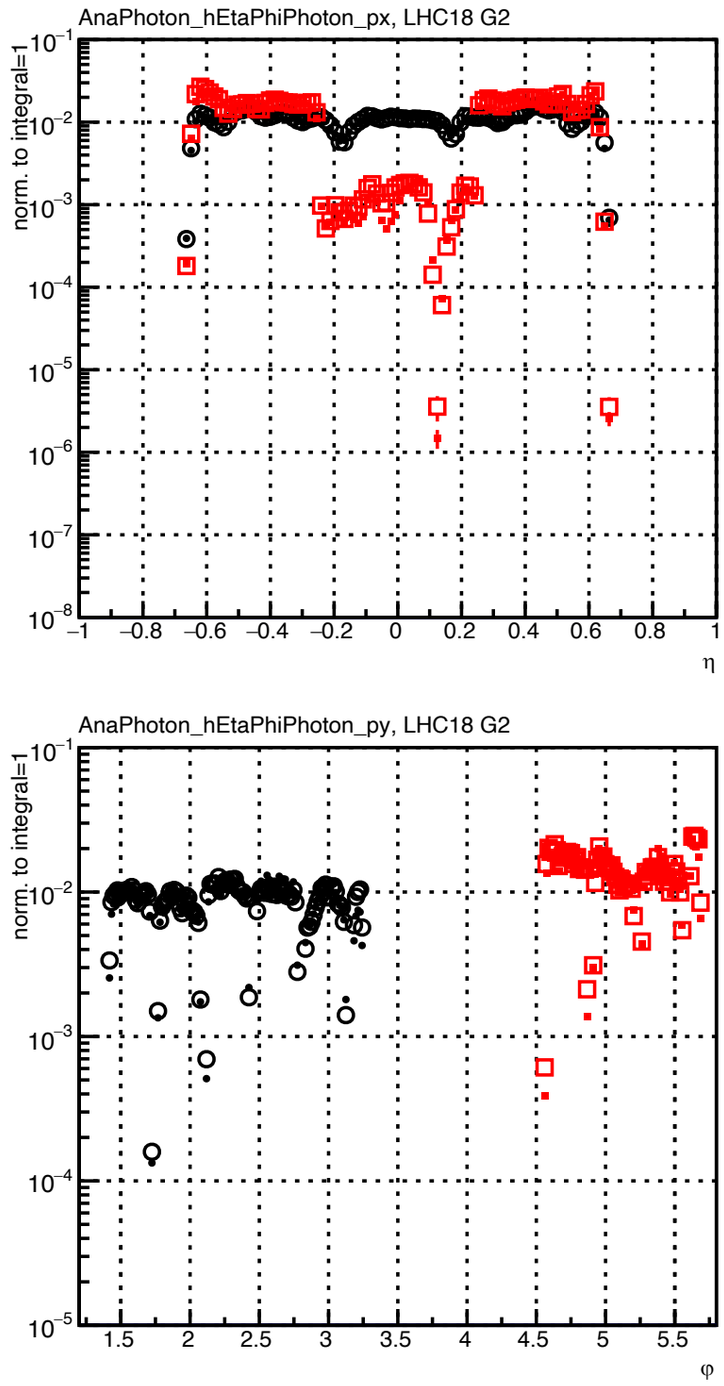
LHC16



LHC17



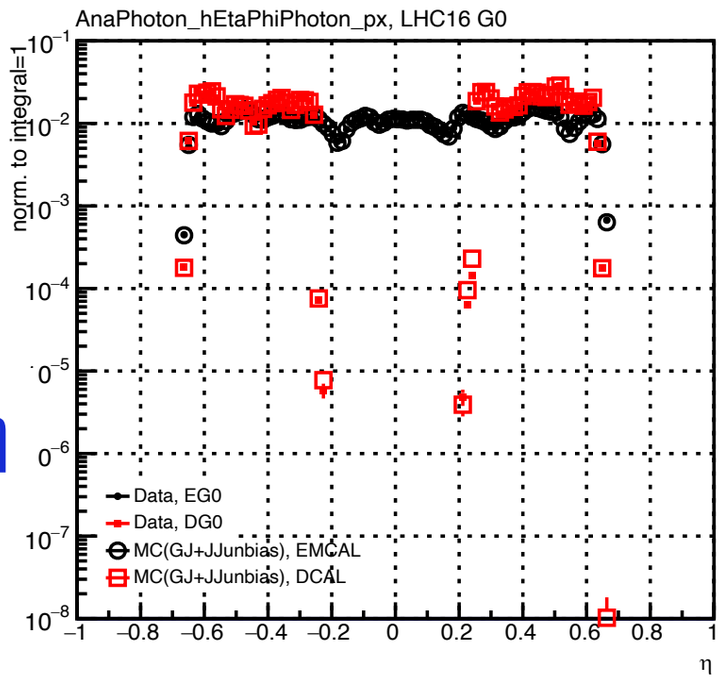
LHC18

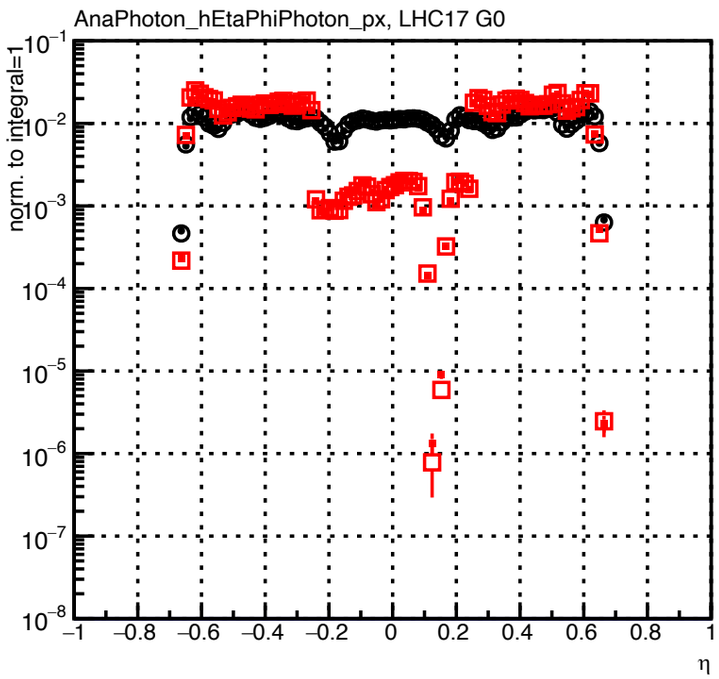


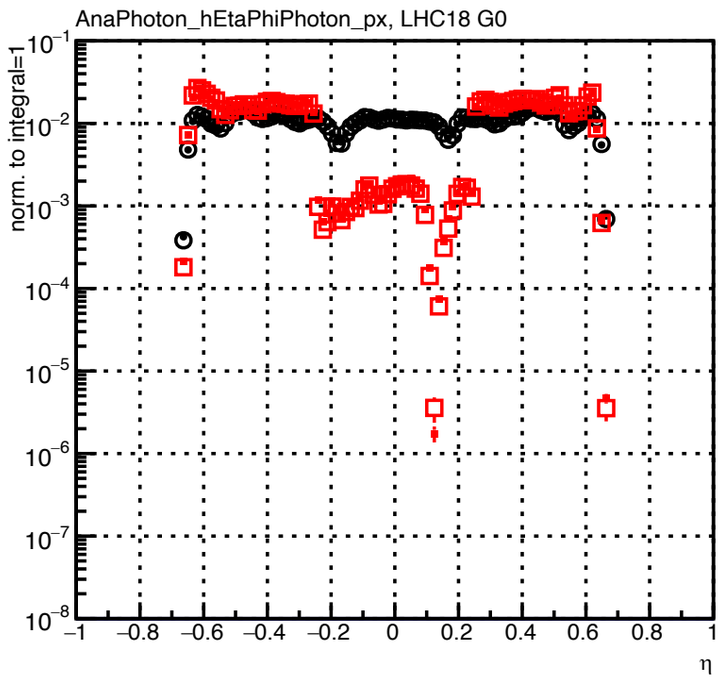
Histo_name: AnaPhoton_hEtaPhiPhoton

Eta(Phi) distribution, per year MB V.S. GJ+JJunb

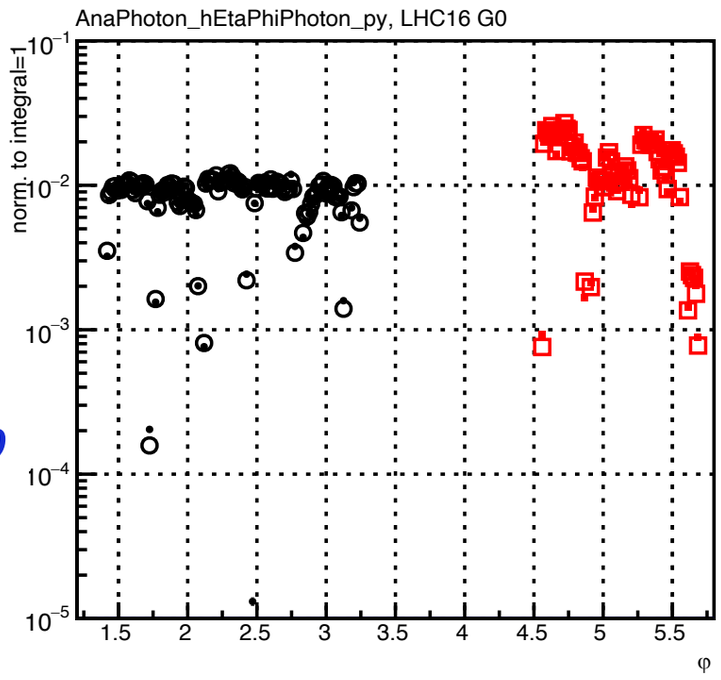
LHC16 | LHC17 | LHC18

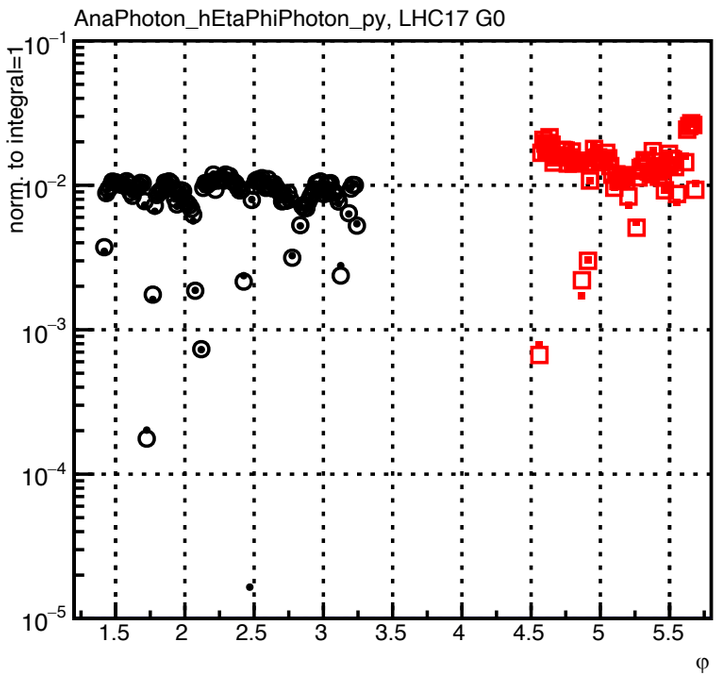


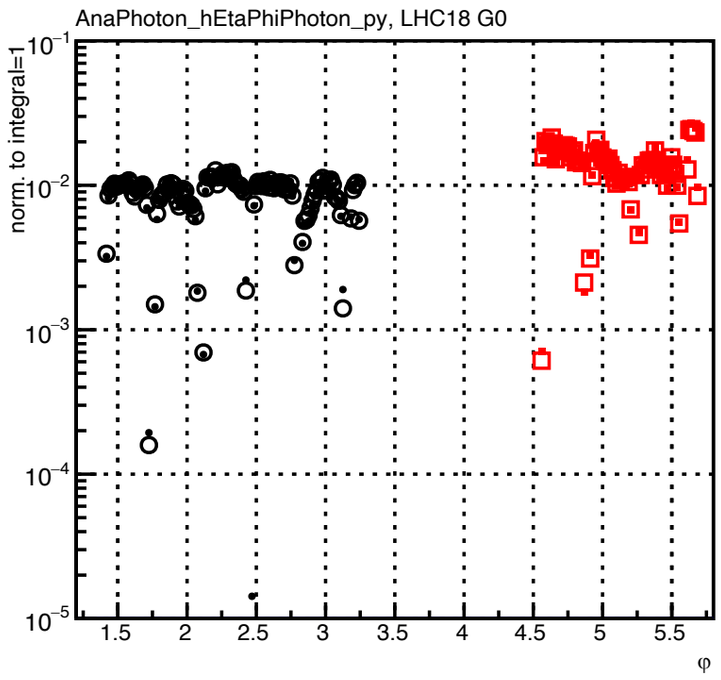




η





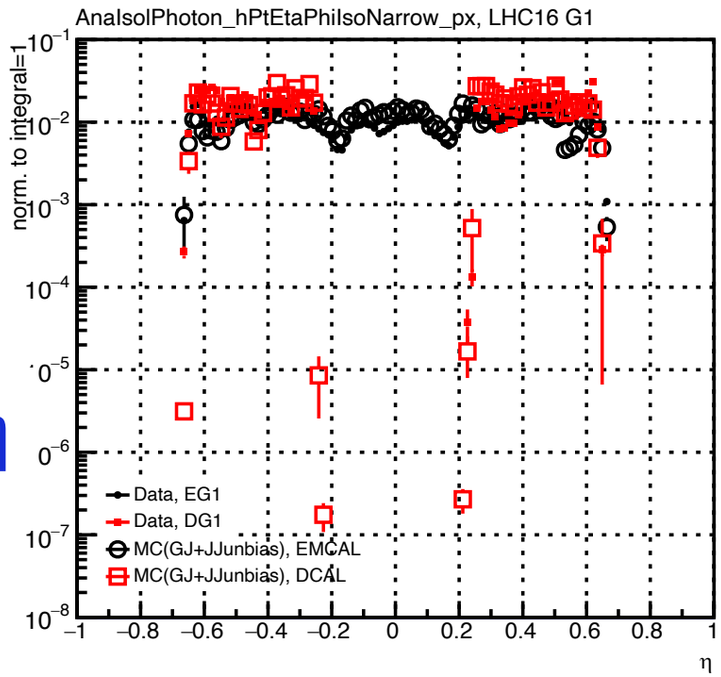


φ

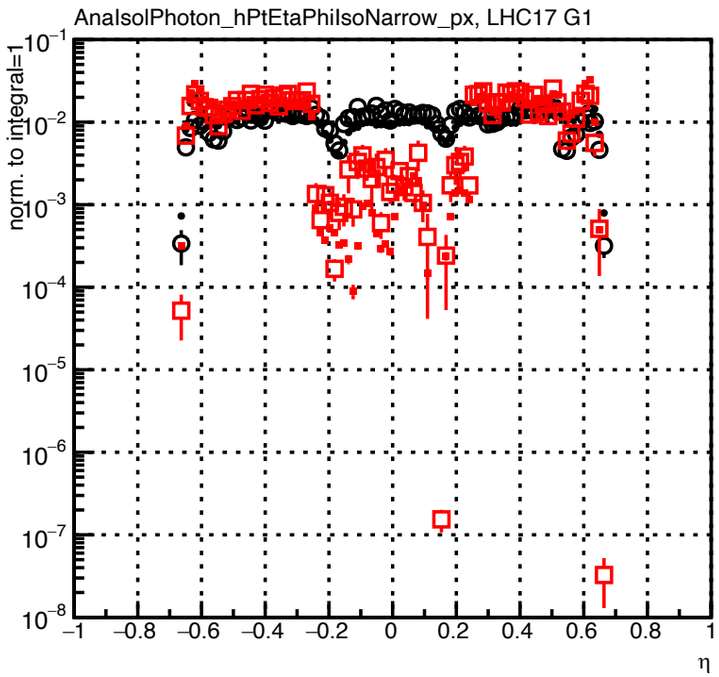
MC has similar distribution with data in η and φ distribution each year

Eta(Phi) distribution, per year G1 V.S. GJ

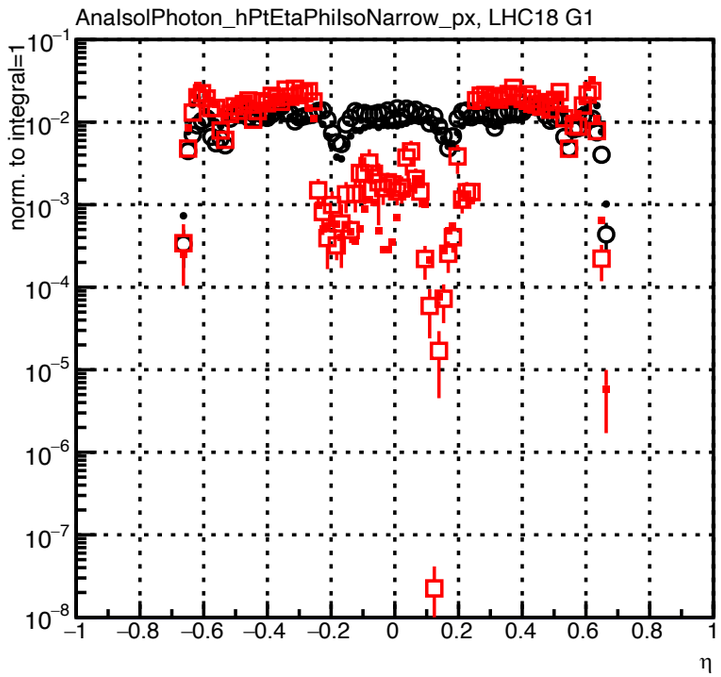
LHC16



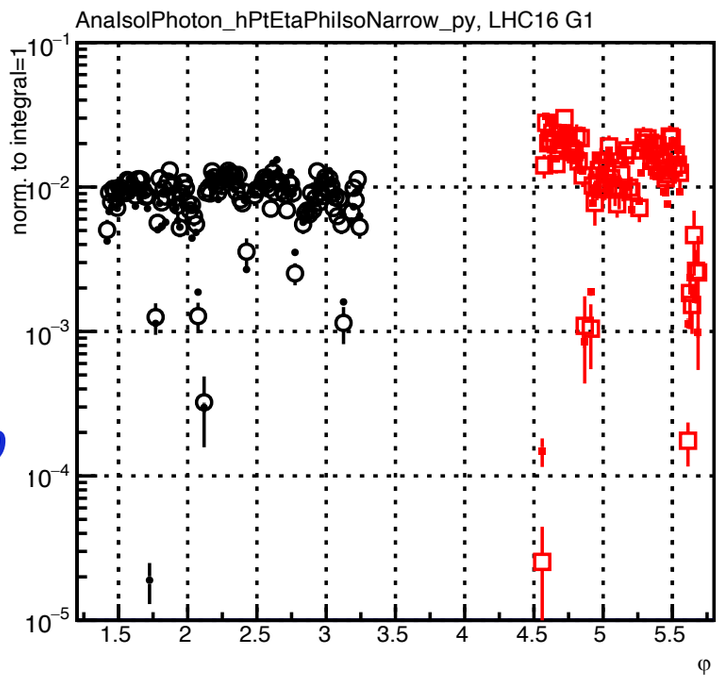
LHC17

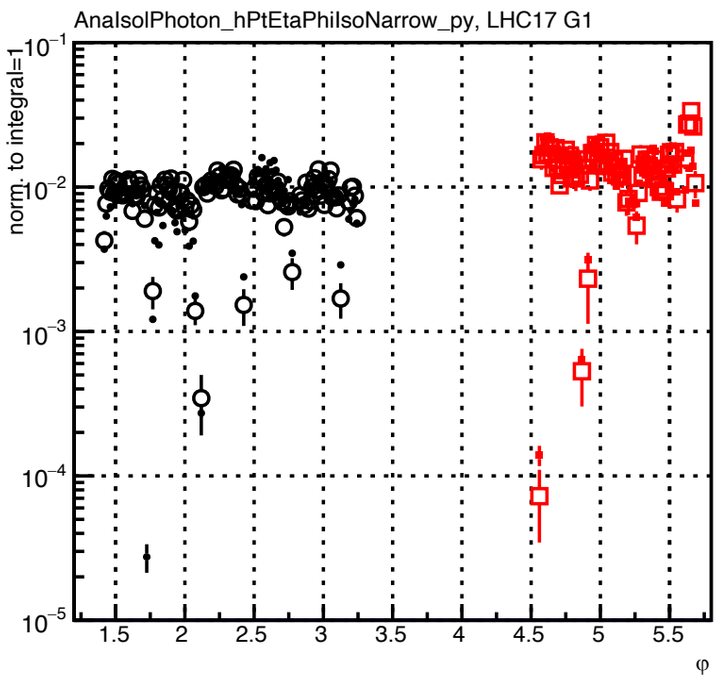


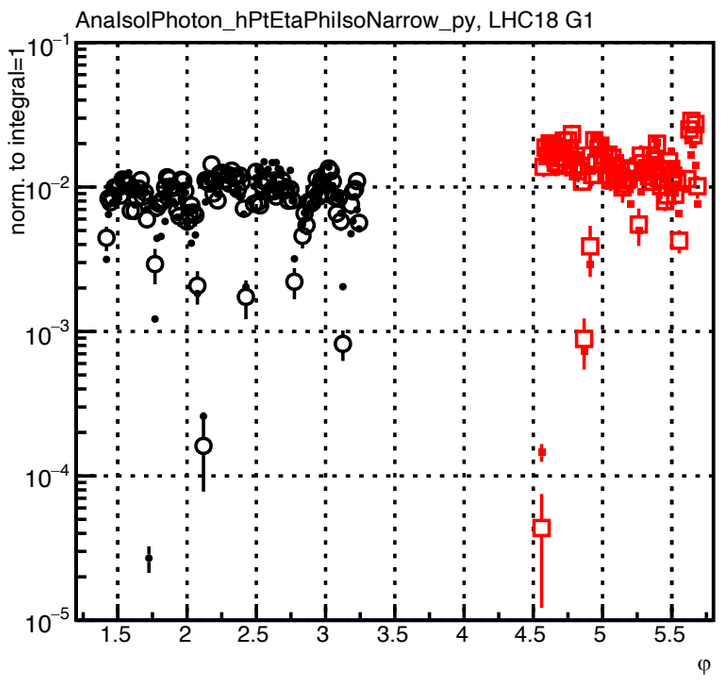
LHC18



φ



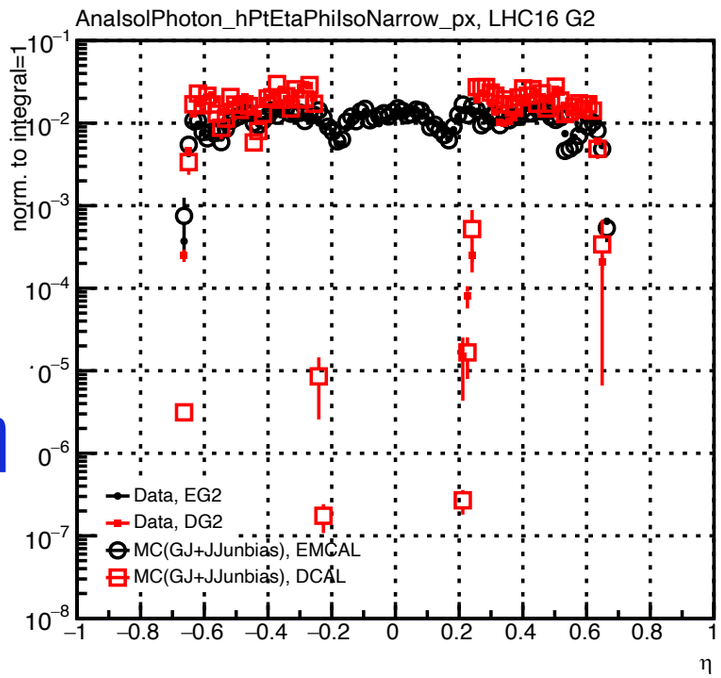




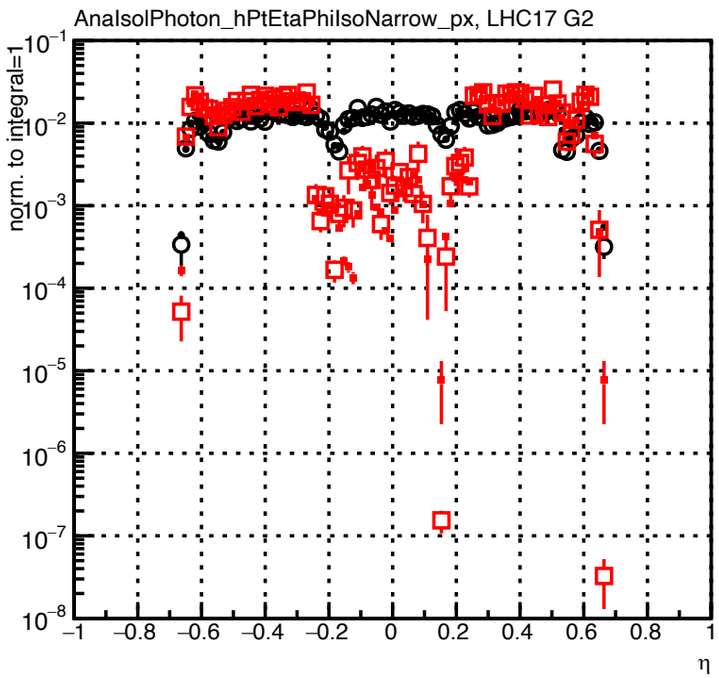
Histo_name: AnaIsolPhoton_hEtaPhiIsoNarrow

Eta(Phi) distribution, per year G2 V.S. GJ

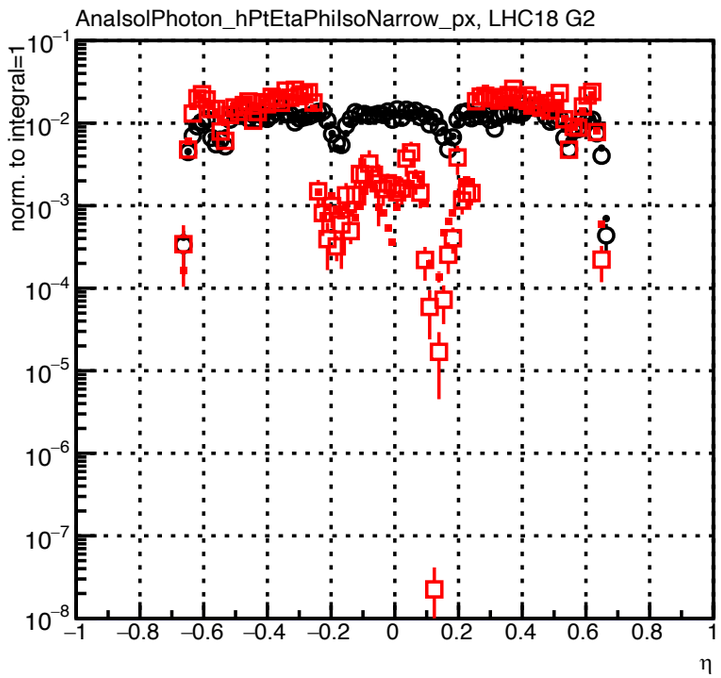
LHC16



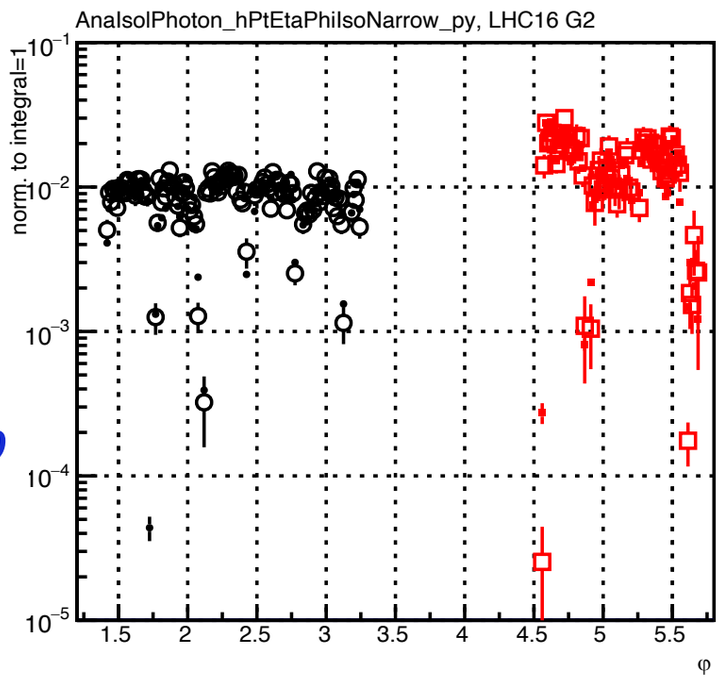
LHC17

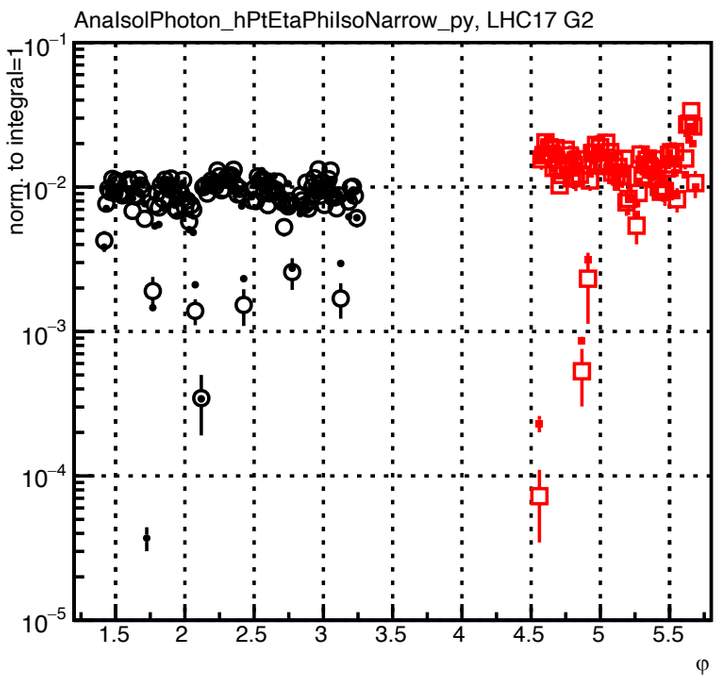


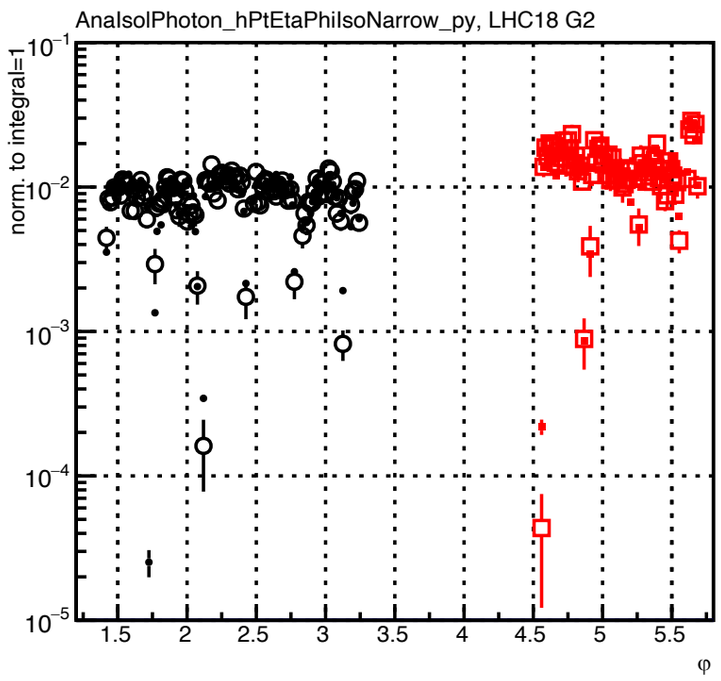
LHC18



φ







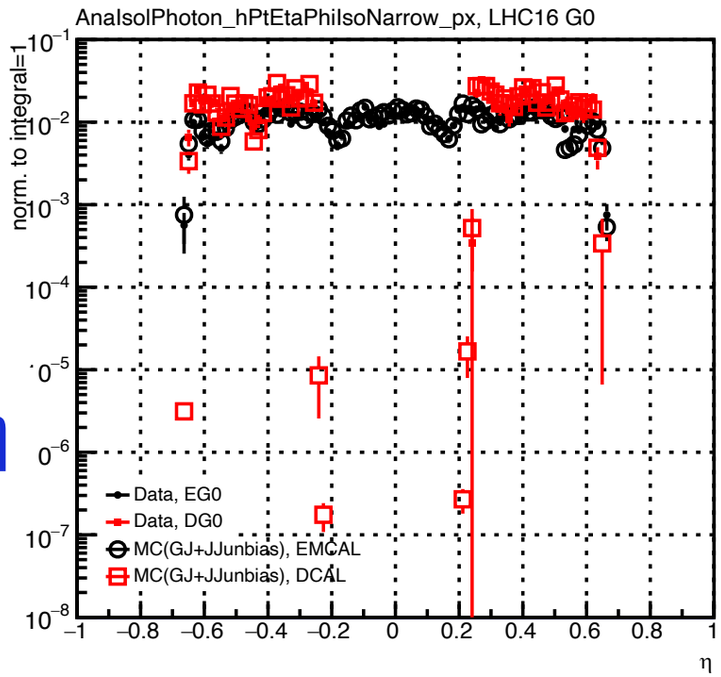
Histo_name: AnaIsolPhoton_hEtaPhiIsoNarrow

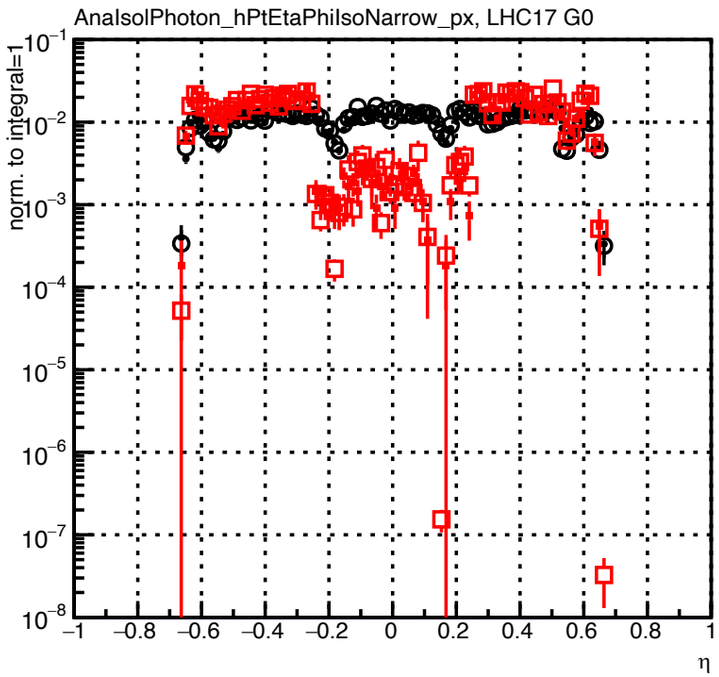
Eta(Phi) distribution, per year MB V.S. GJ

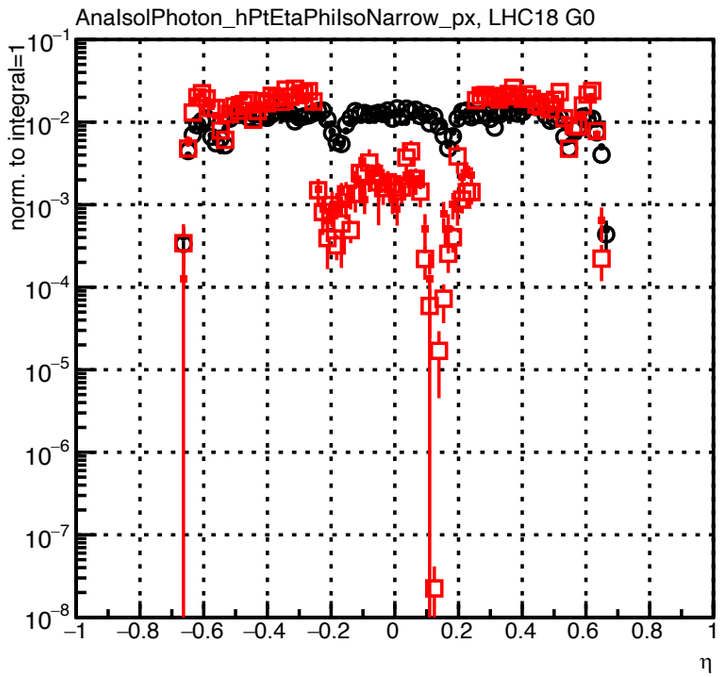
LHC16

LHC17

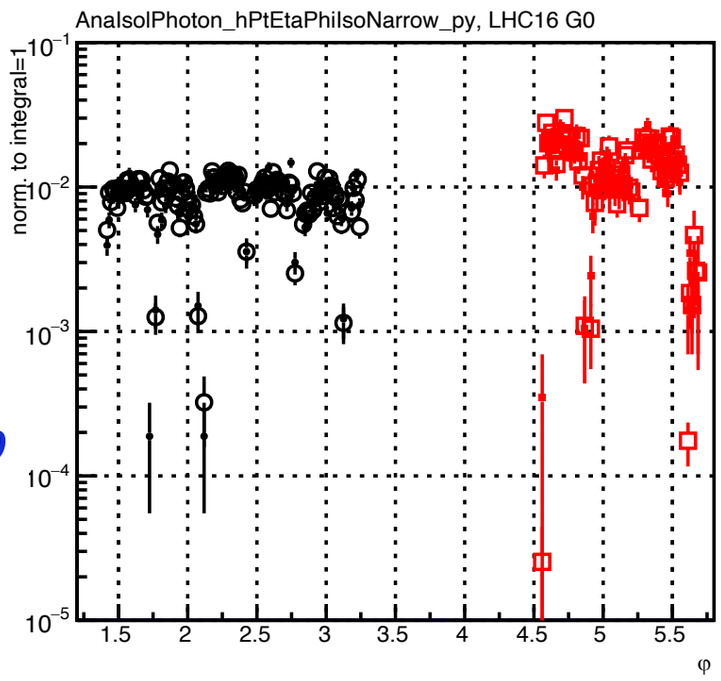
LHC18

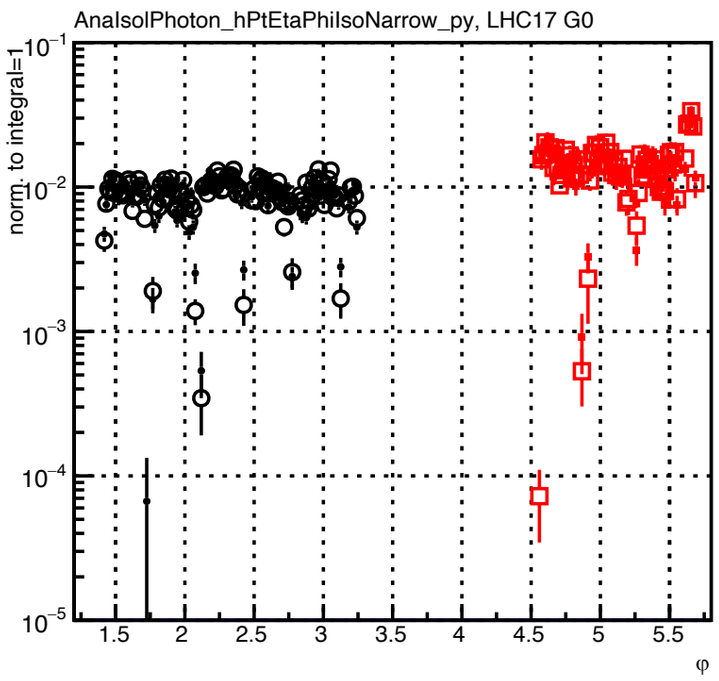


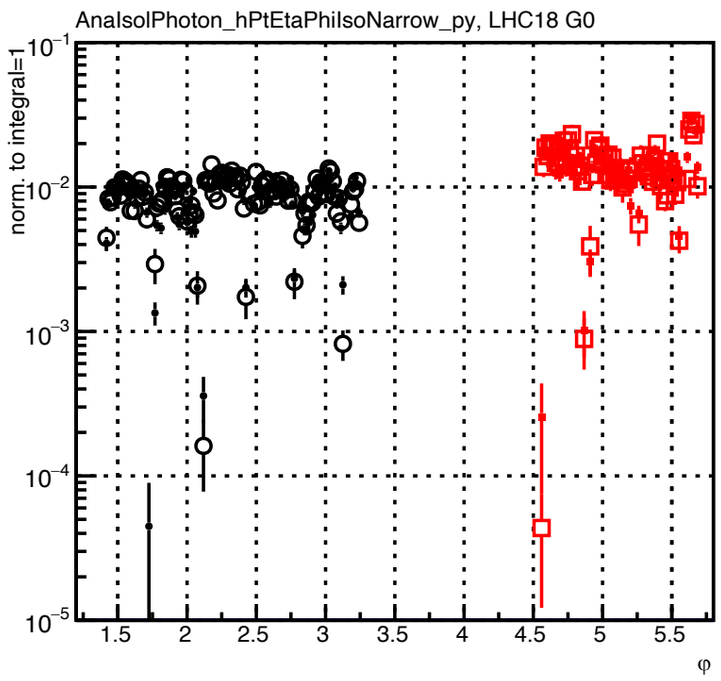




φ







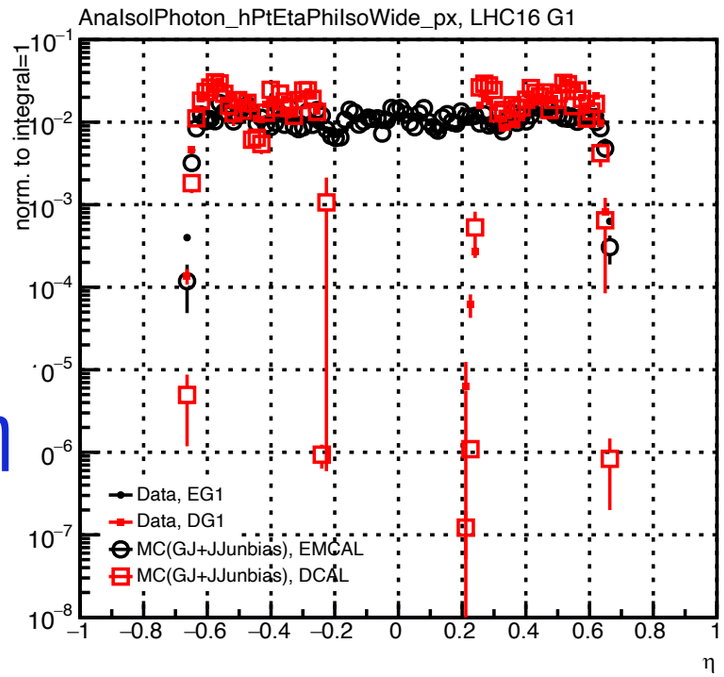
Histo_name: AnaIsolPhoton_hEtaPhiIsoNarrow

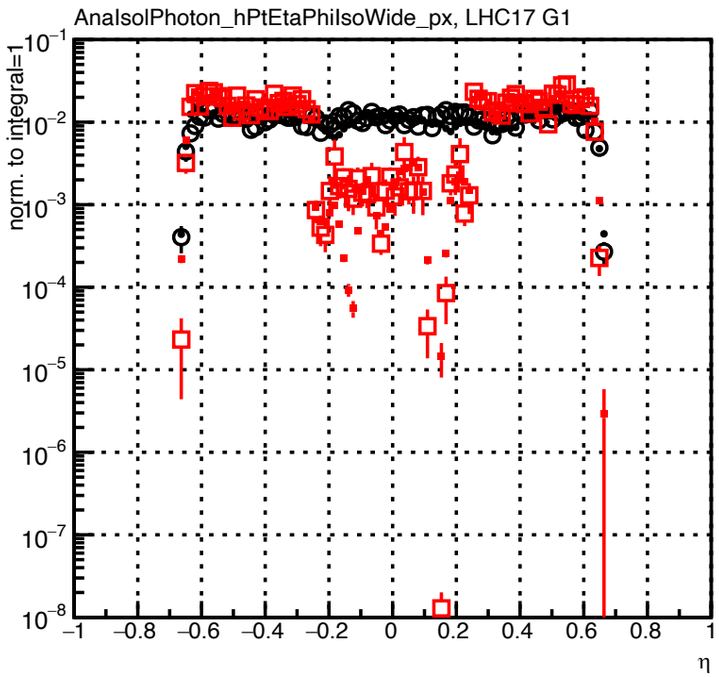
Eta(Phi) distribution, per year G1 V.S. GJ

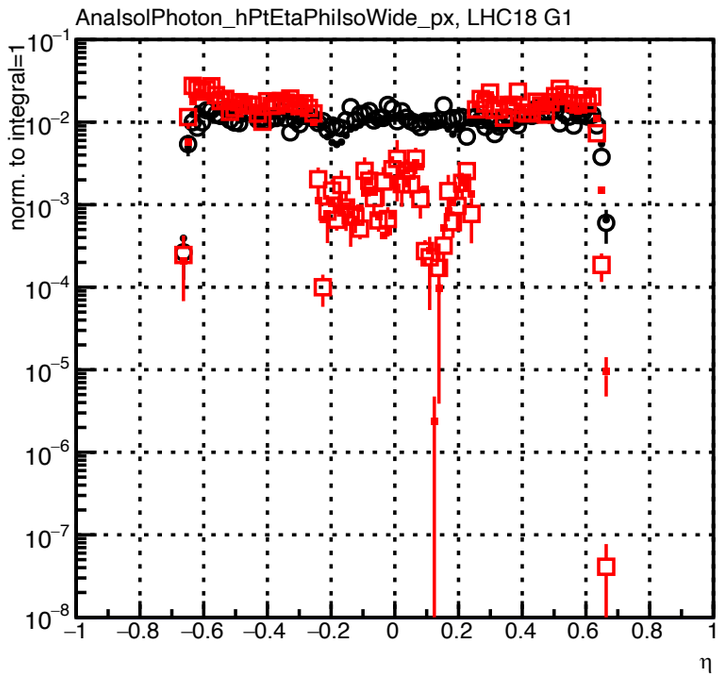
LHC16

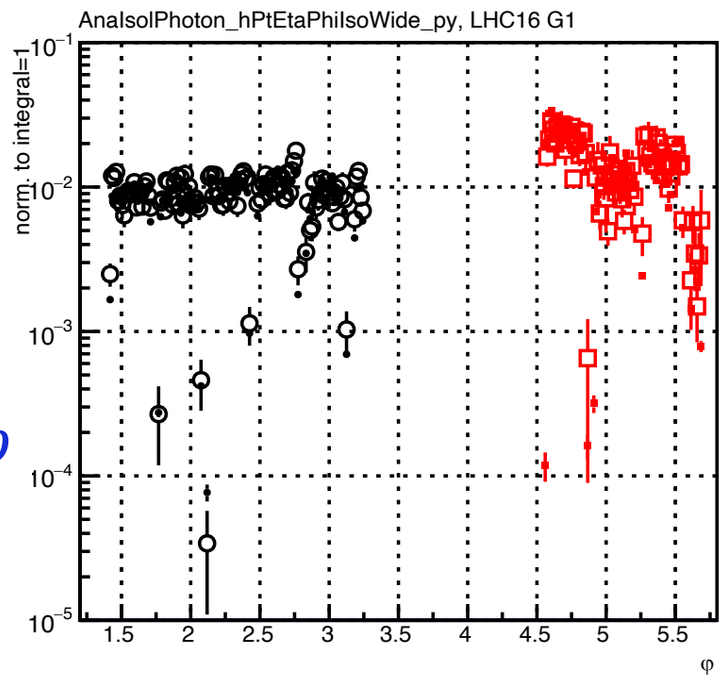
LHC17

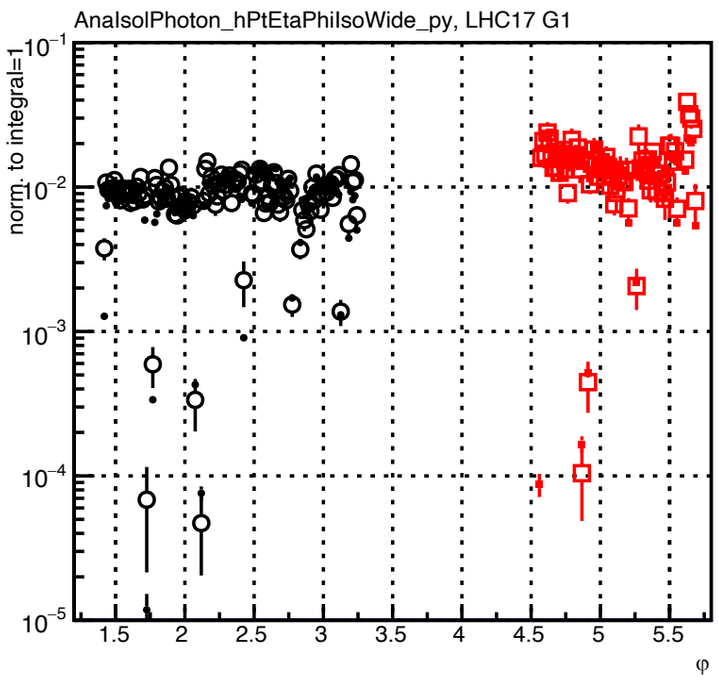
LHC18

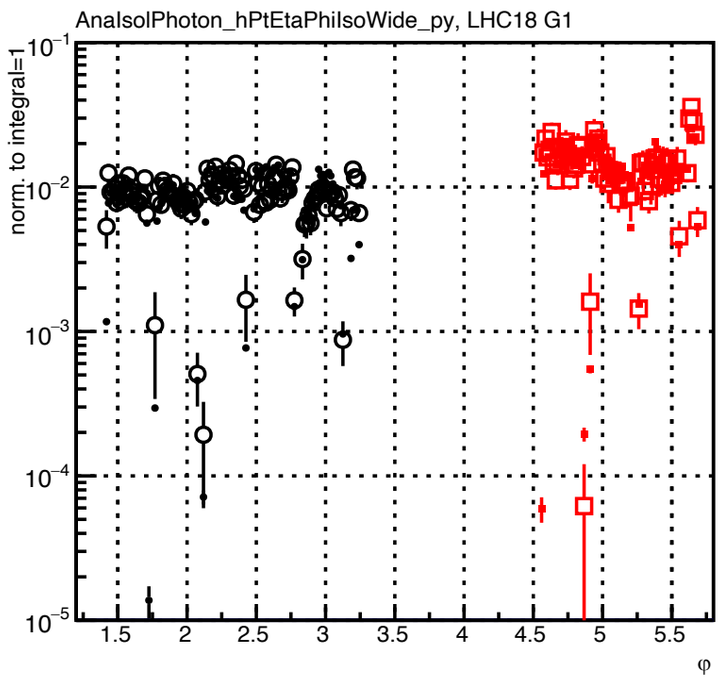












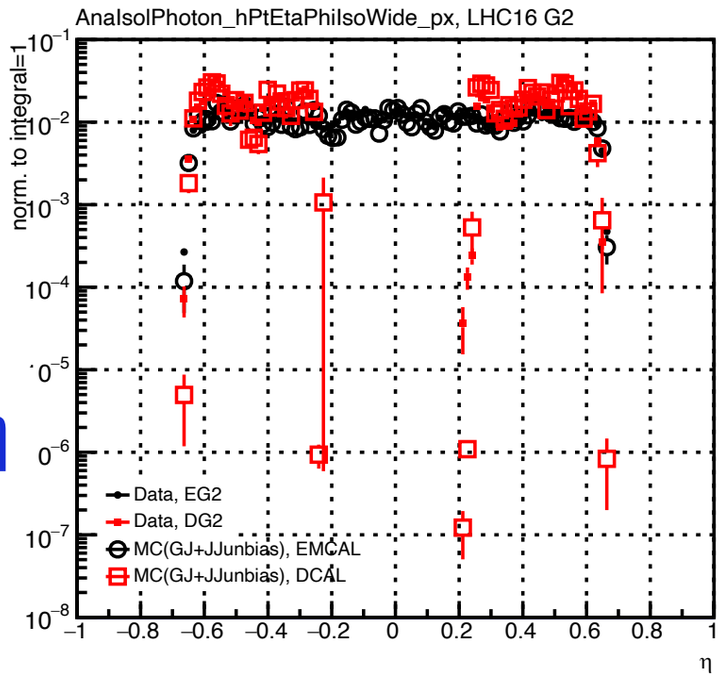
Histo_name: AnaIsolPhoton_hEtaPhiIsoWide

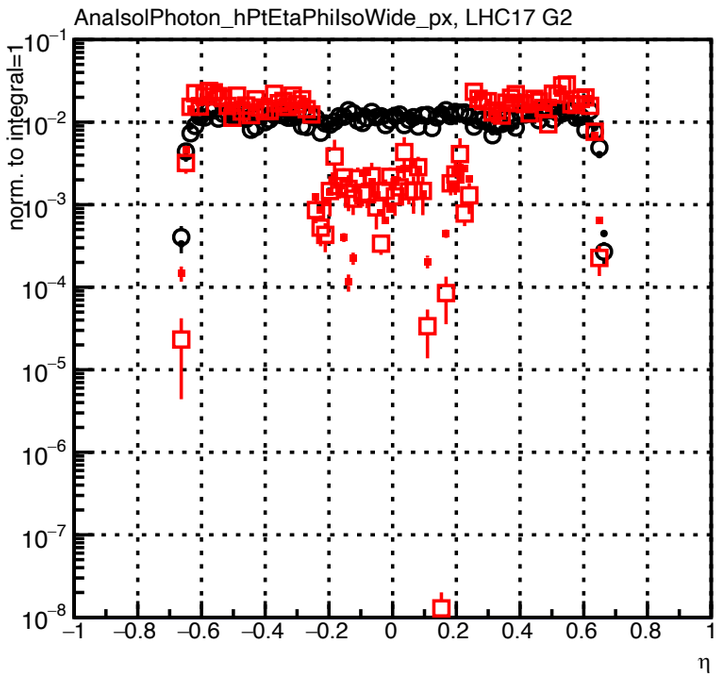
Eta(Phi) distribution, per year G2 V.S. GJ

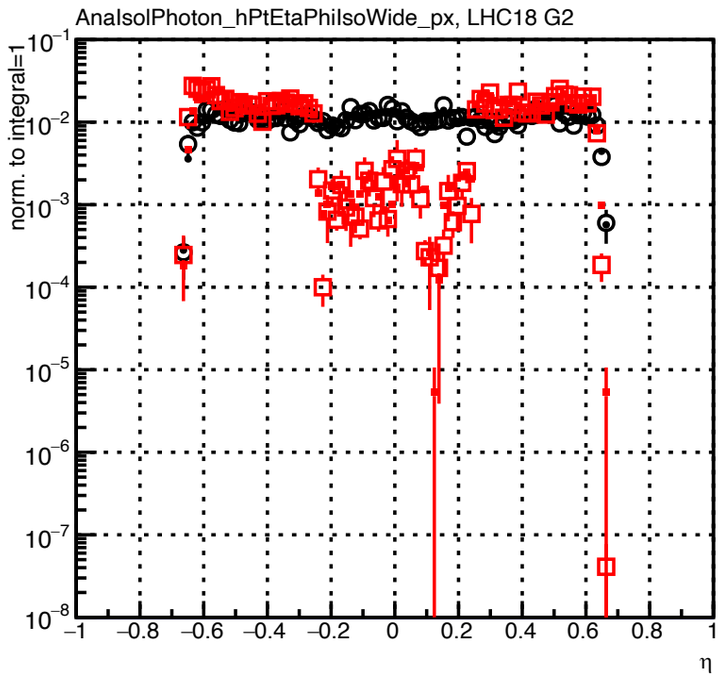
LHC16

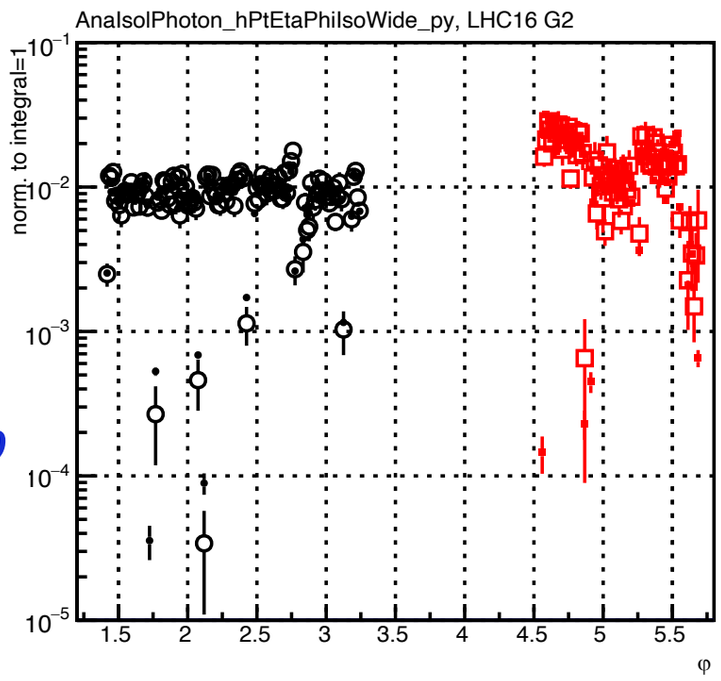
LHC17

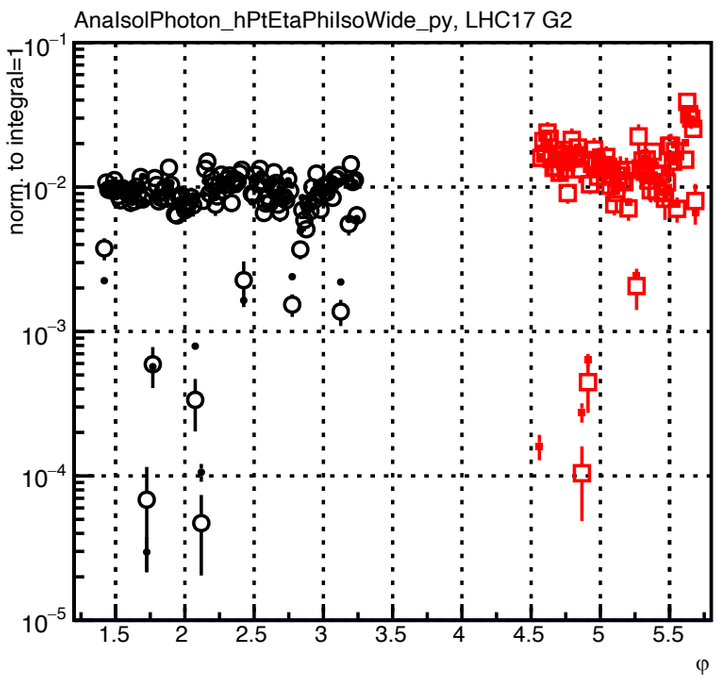
LHC18

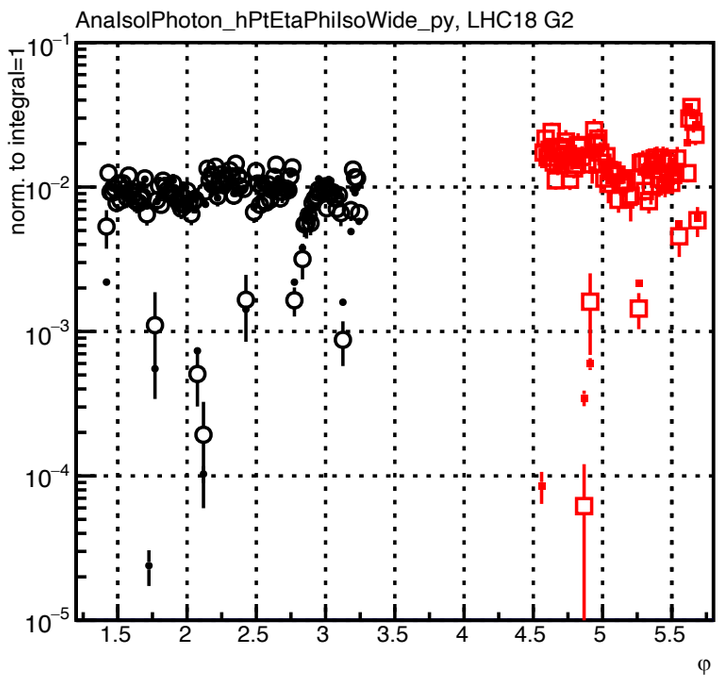








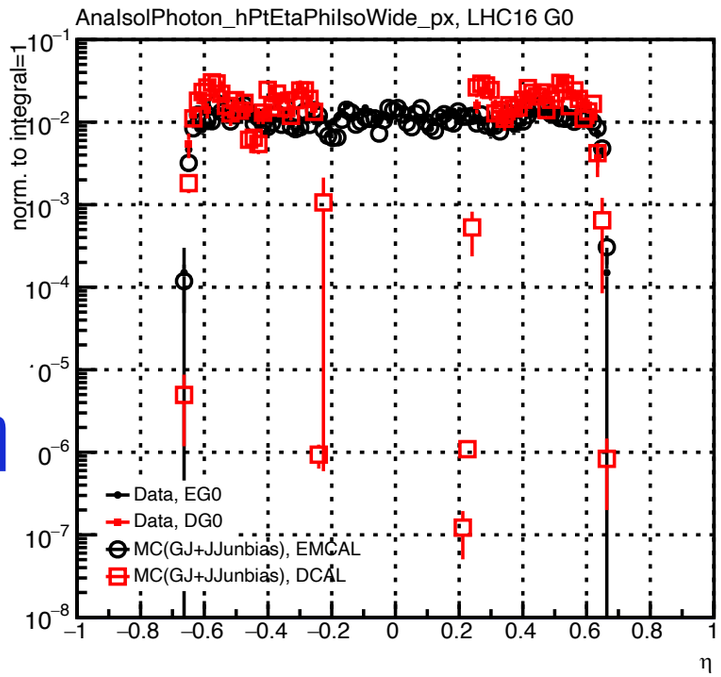




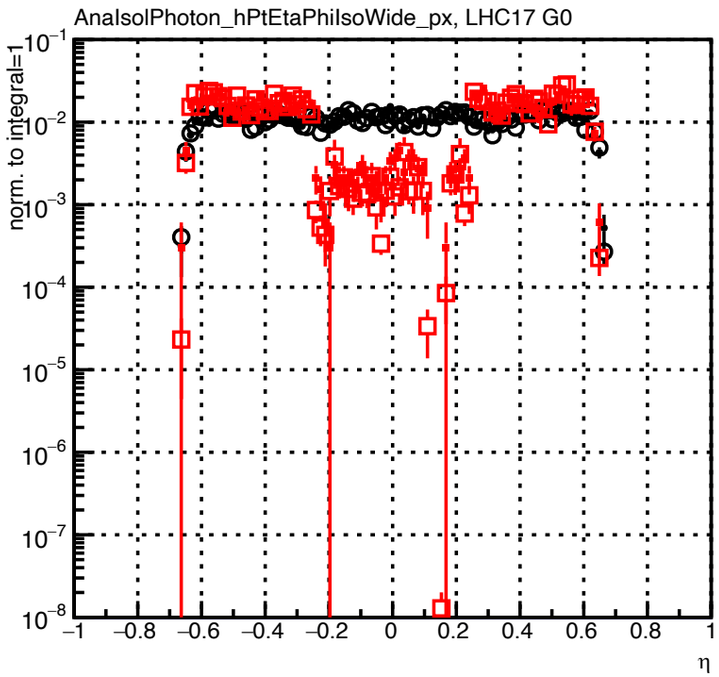
Histo_name: AnaIsolPhoton_hEtaPhiIsoWide

Eta(Phi) distribution, per year MB V.S. GJ

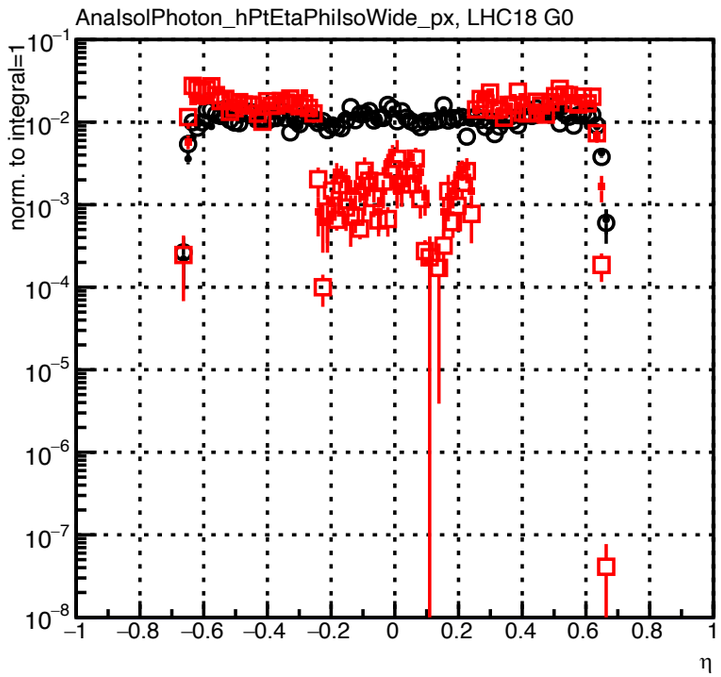
LHC16

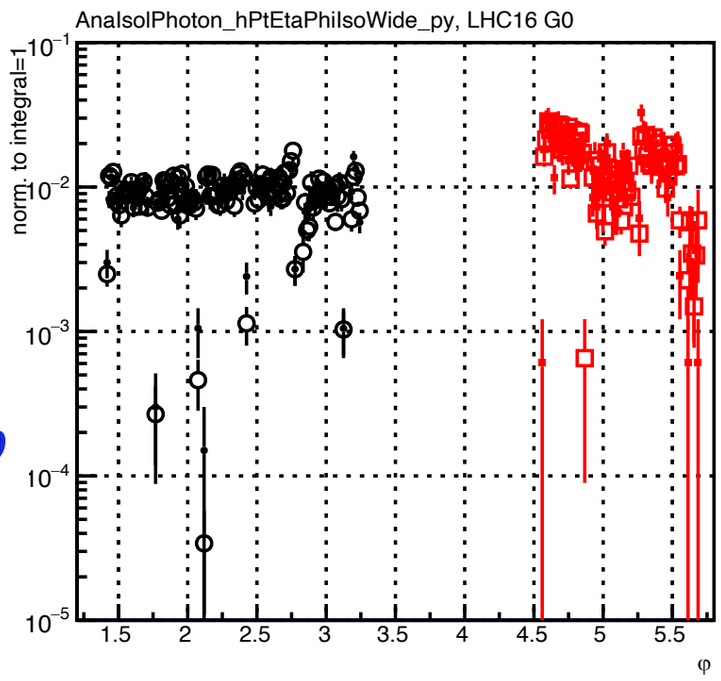


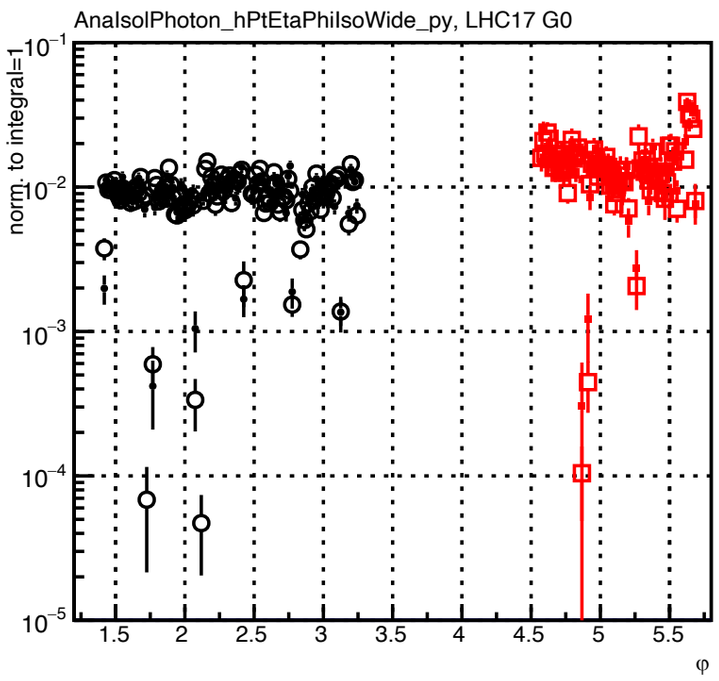
LHC17

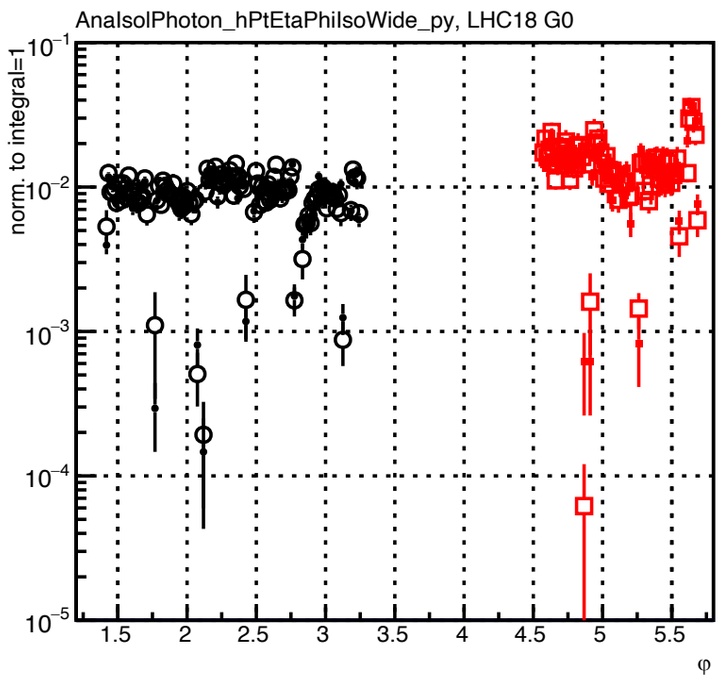


LHC18









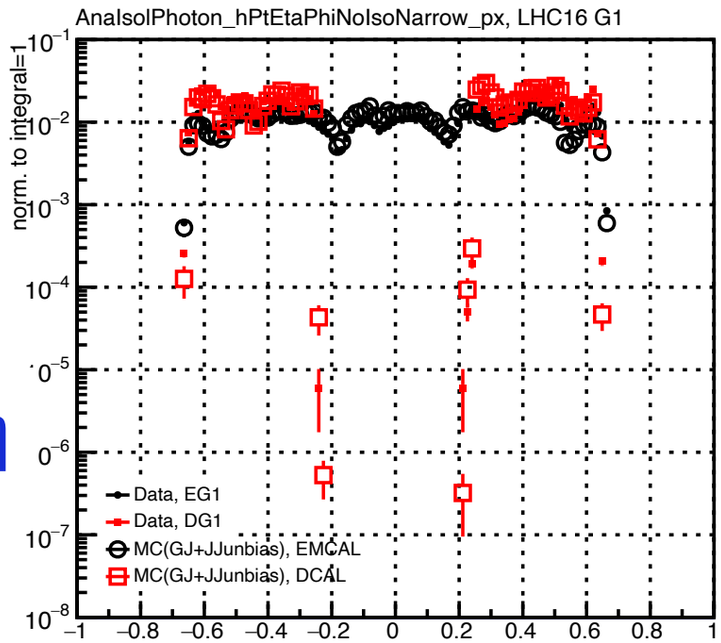
Histo_name: AnaIsolPhoton_hEtaPhiIsoWide

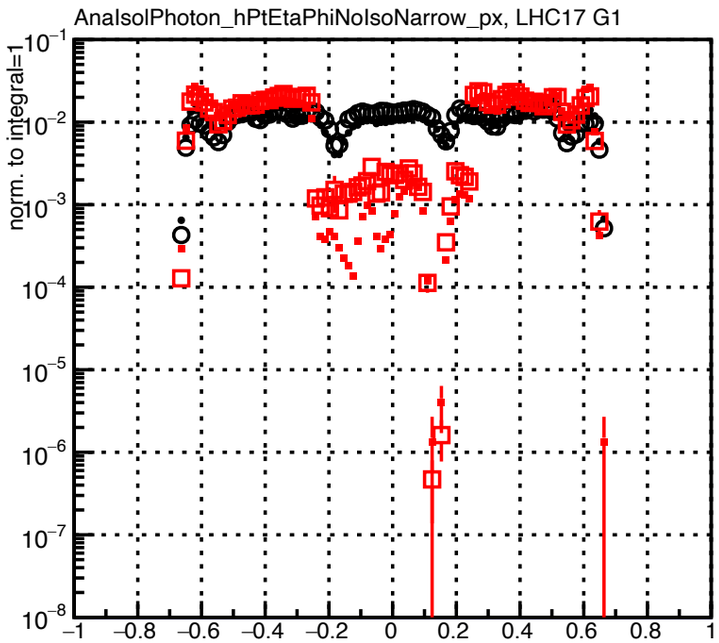
Eta(Phi) distribution, per year G1 V.S. GJ

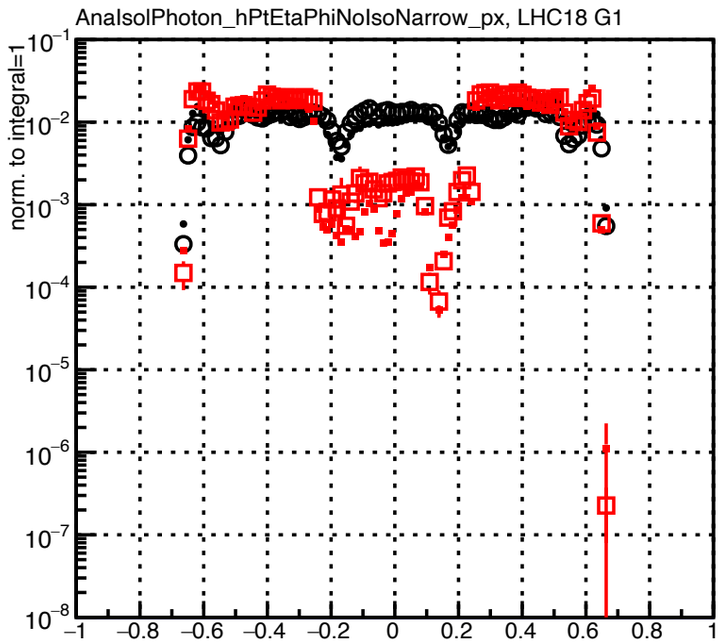
LHC16

LHC17

LHC18







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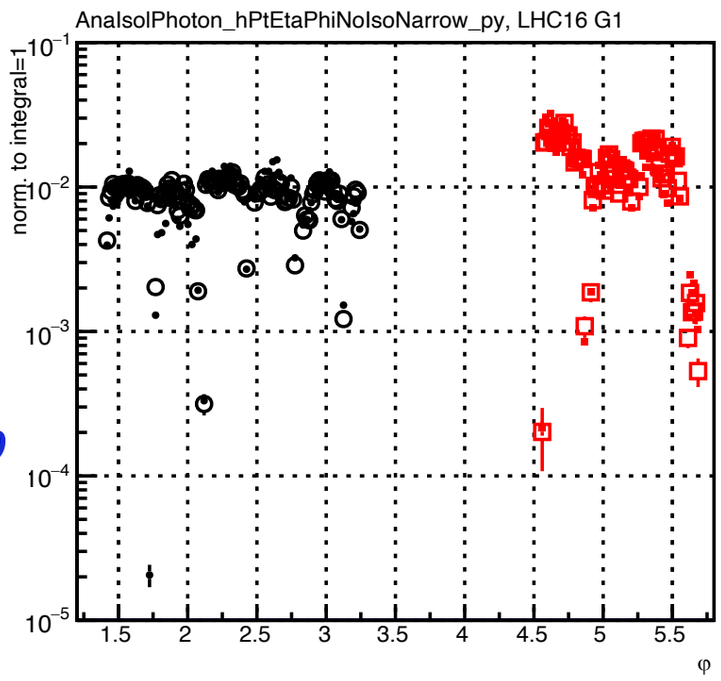
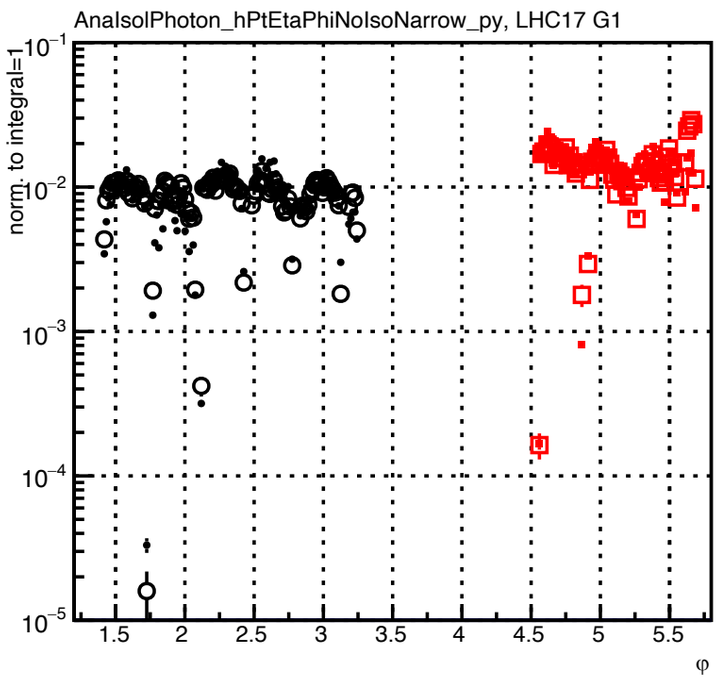
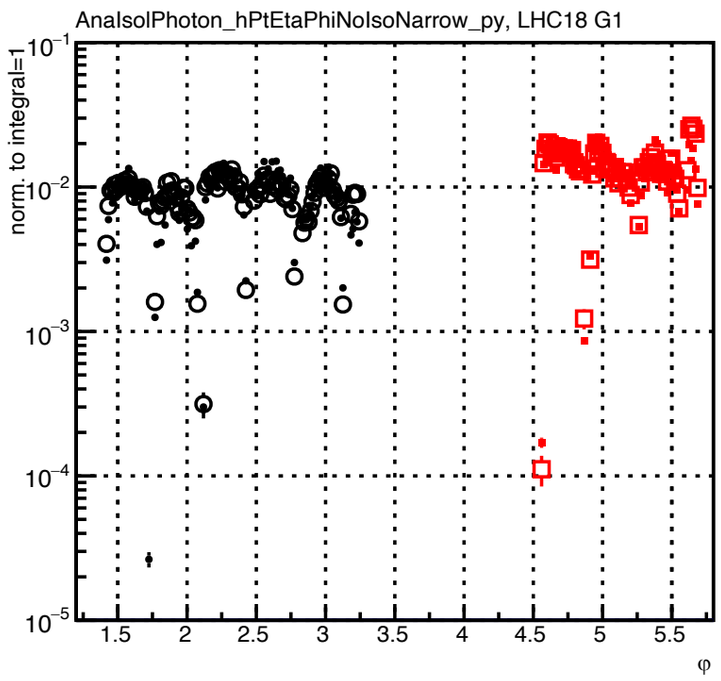


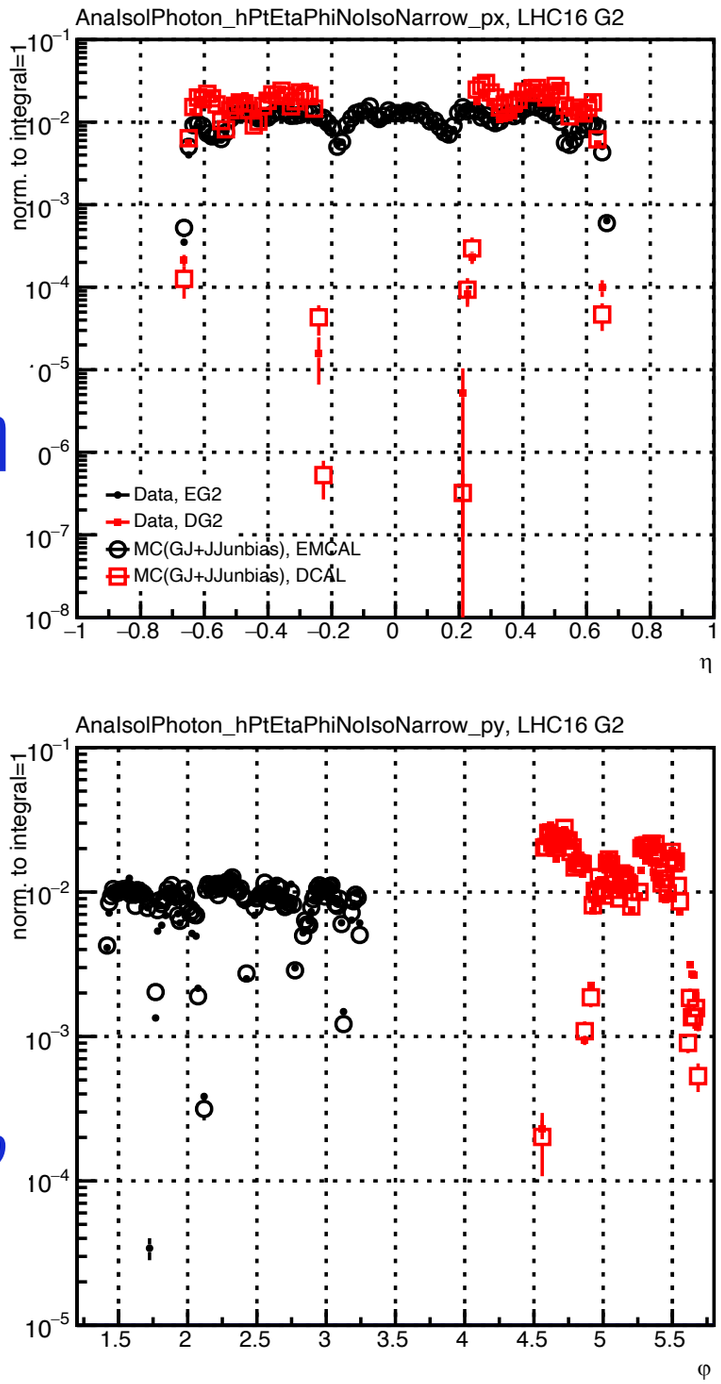




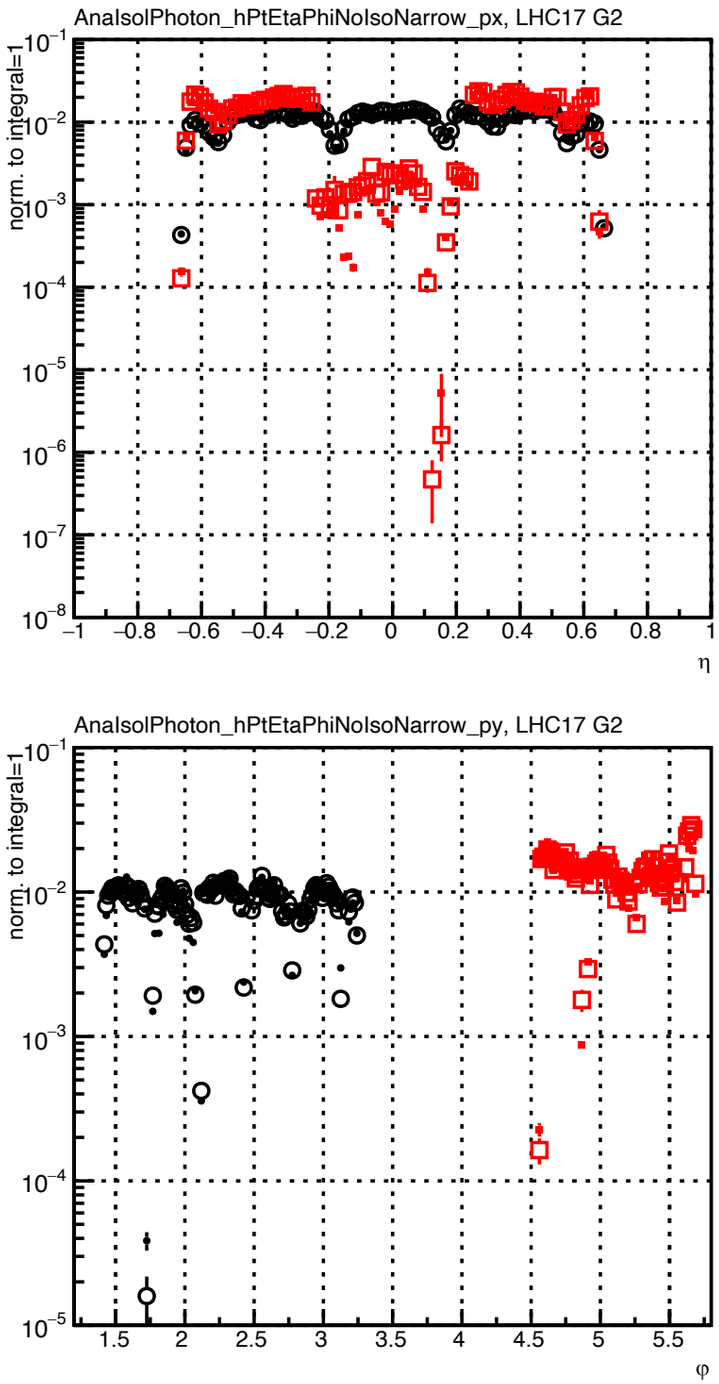
Histo_name: AnaIsolPhoton_hEtaPhiNoIsoNarrow

Eta(Phi) distribution, per year G2 V.S. GJ

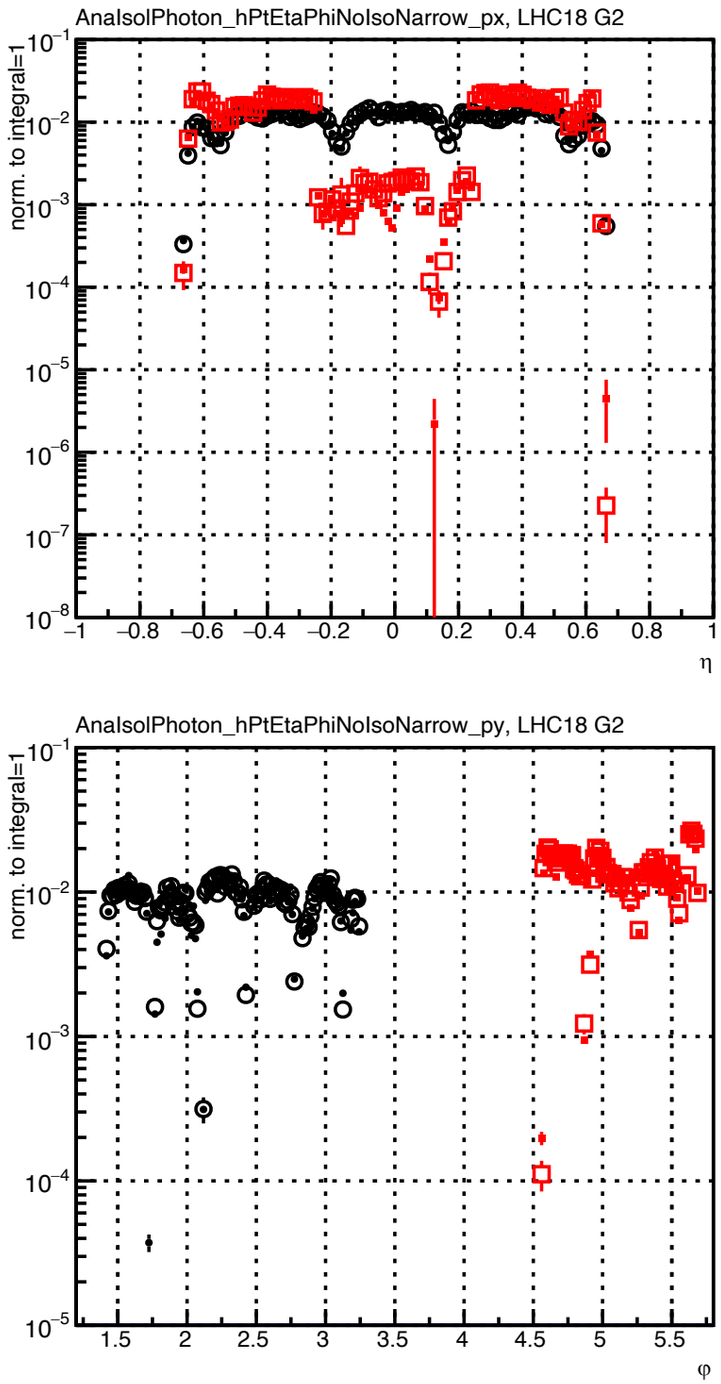
LHC16



LHC17



LHC18



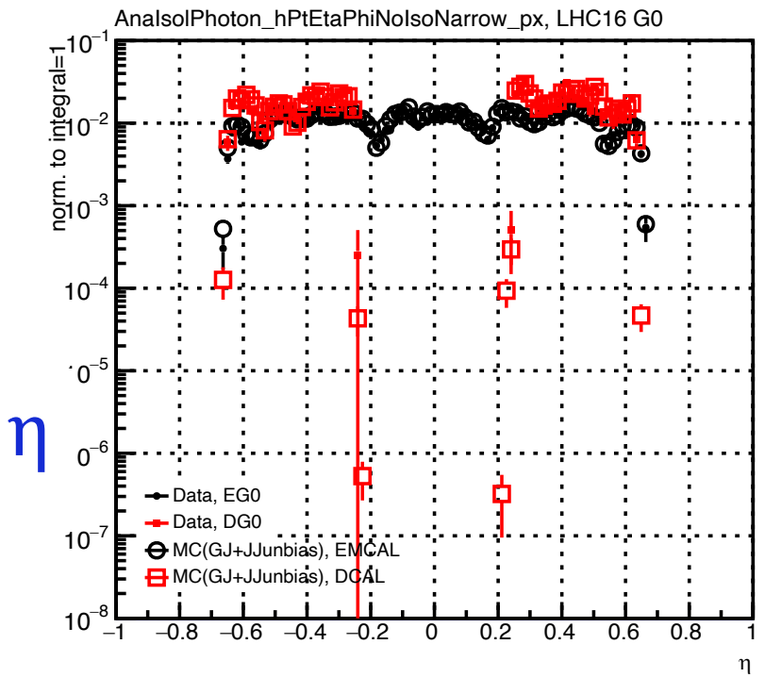
Histo_name: AnaIsolPhoton_hEtaPhiNoIsoNarrow

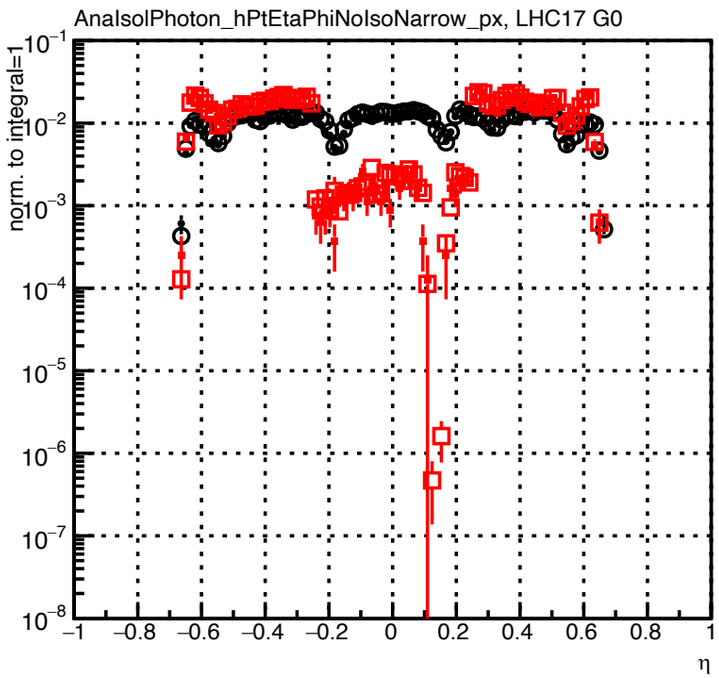
Eta(Phi) distribution, per year MB V.S. GJ

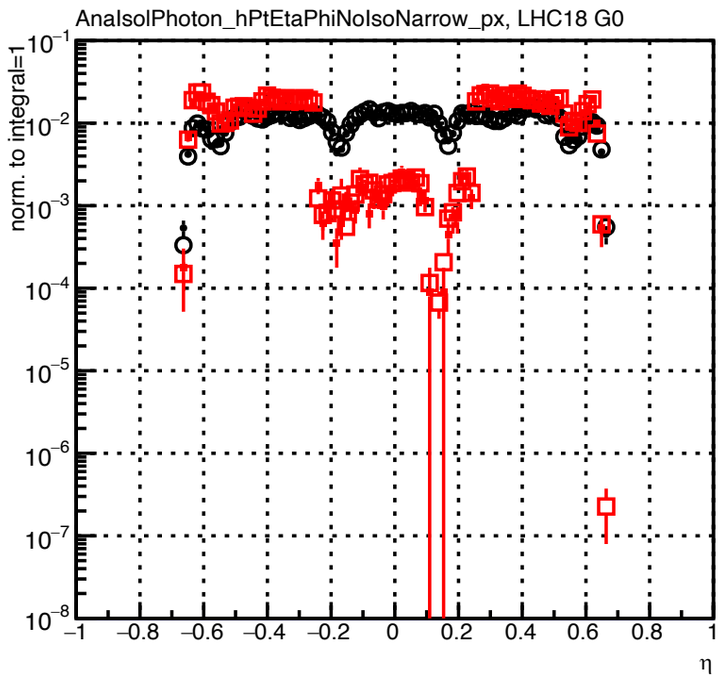
LHC16

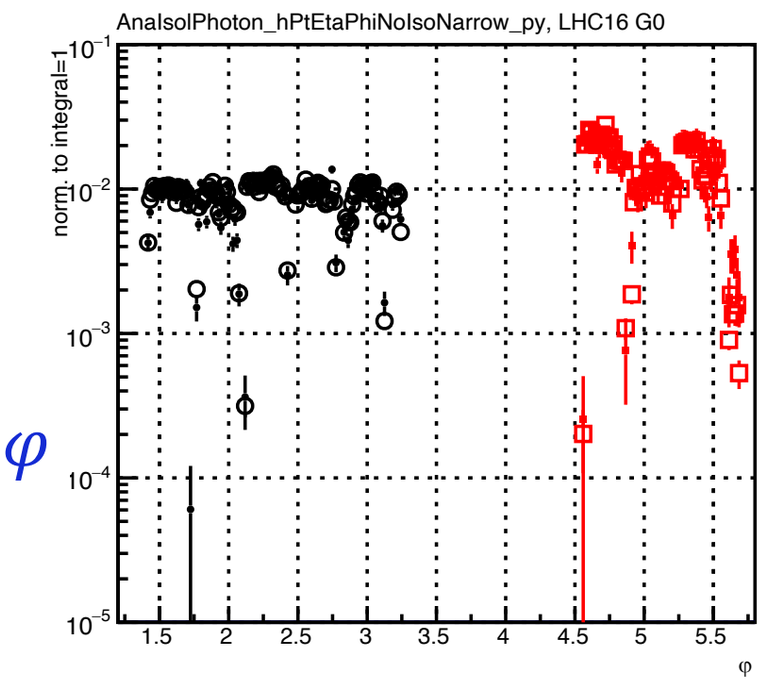
LHC17

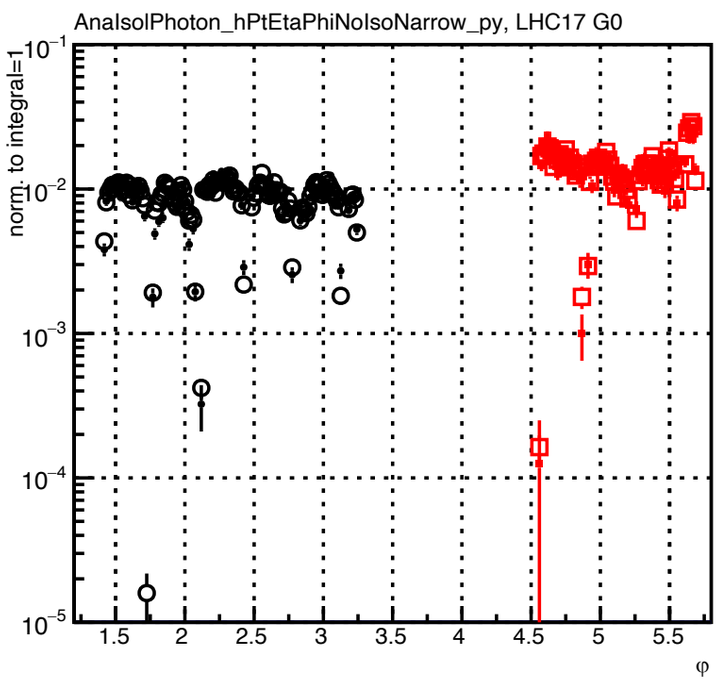
LHC18

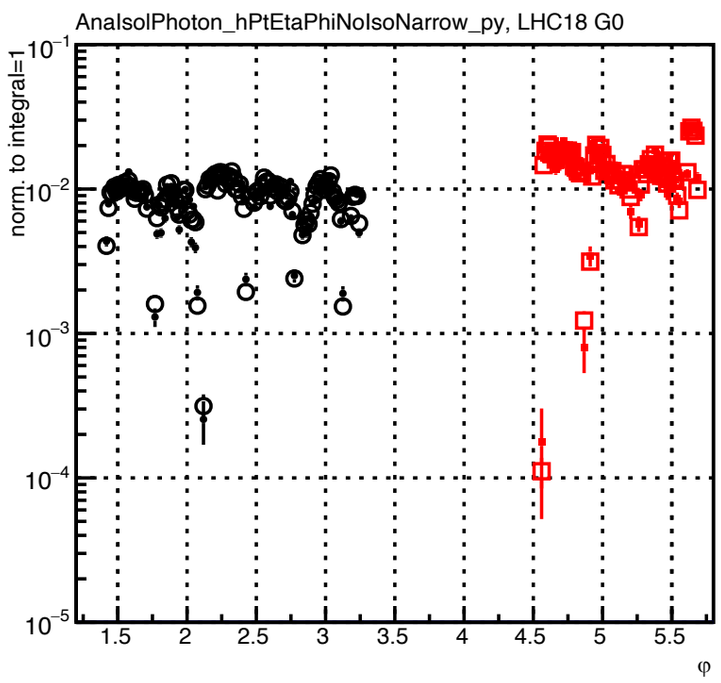












Histo_name: AnaIsolPhoton_hEtaPhiNoIsoNarrow

Eta(Phi) distribution, per year G1 V.S. GJ

LHC16

LHC17

LHC18

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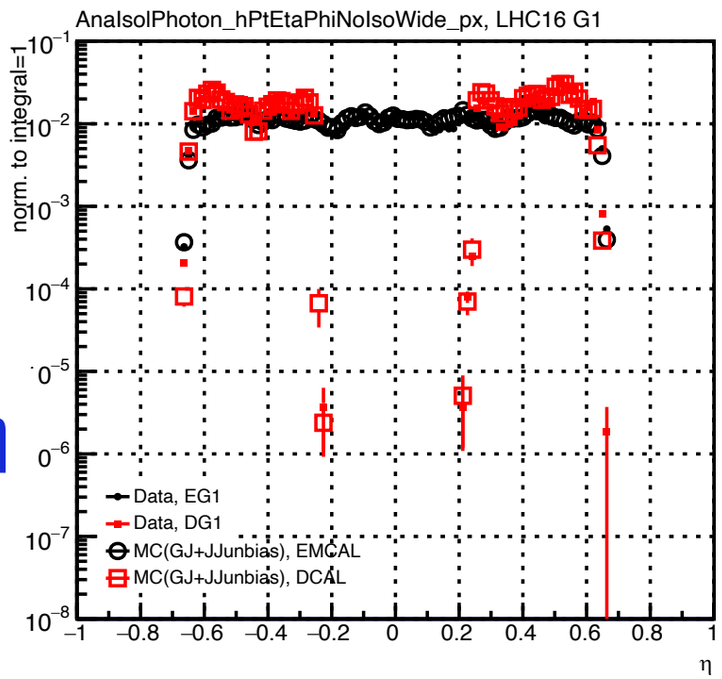

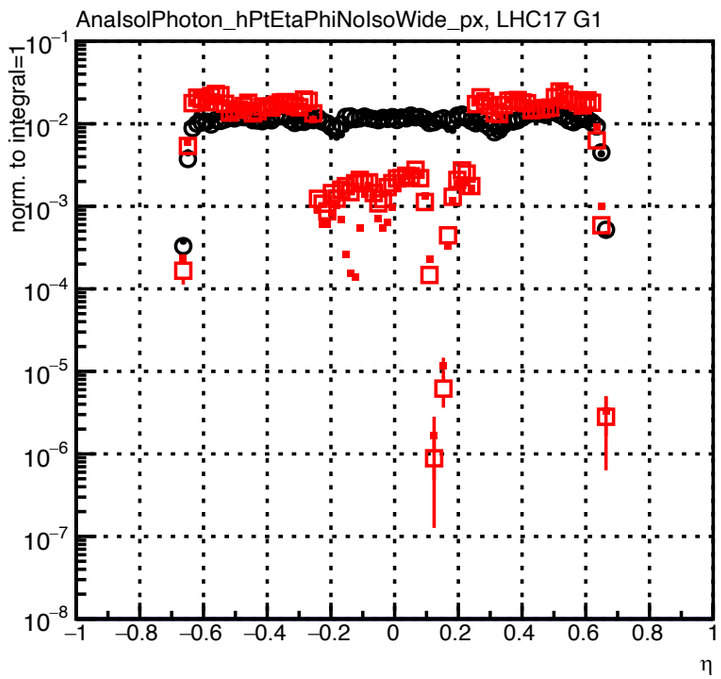

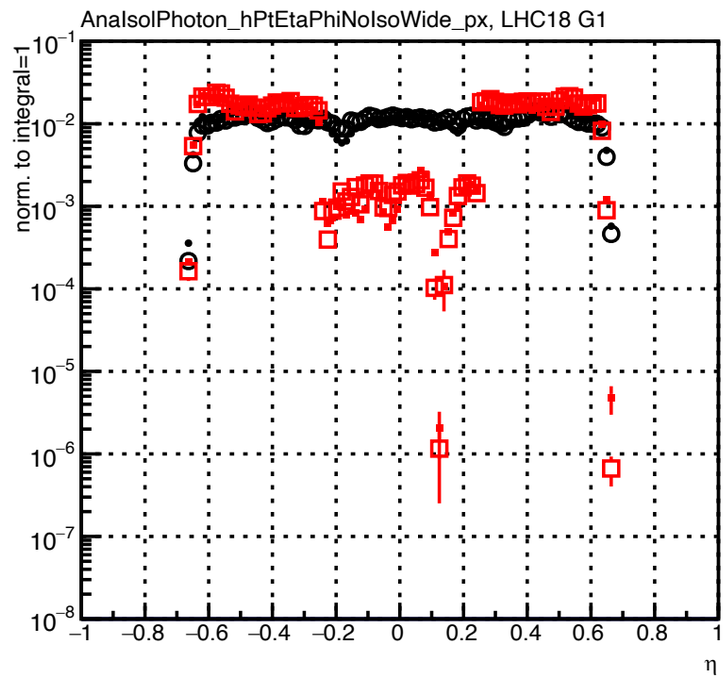

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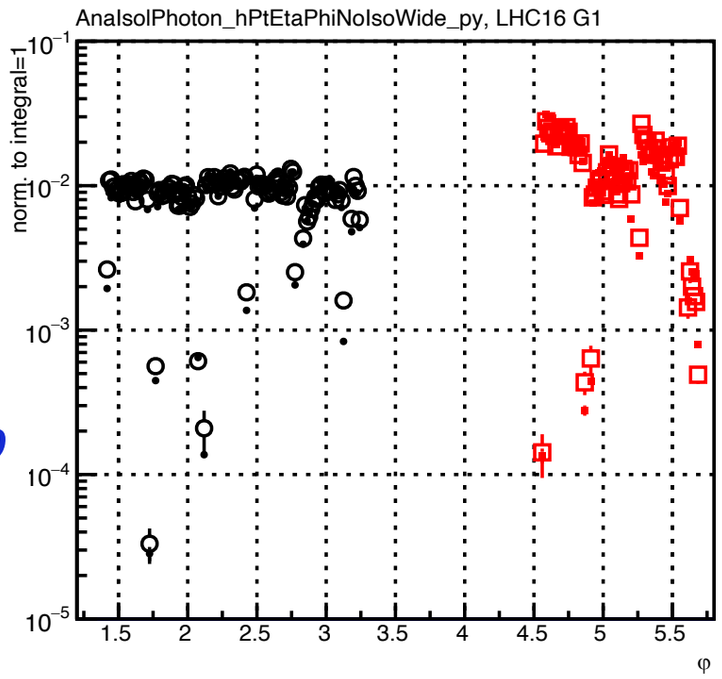
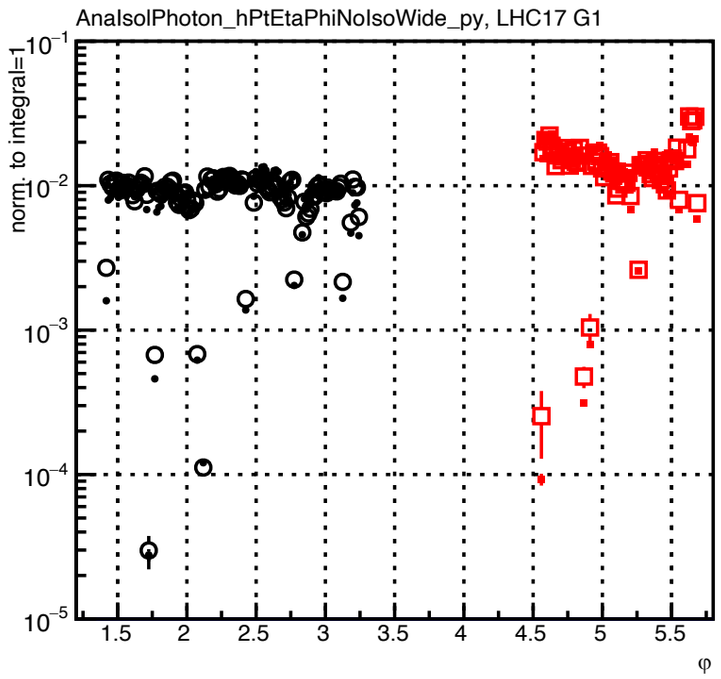
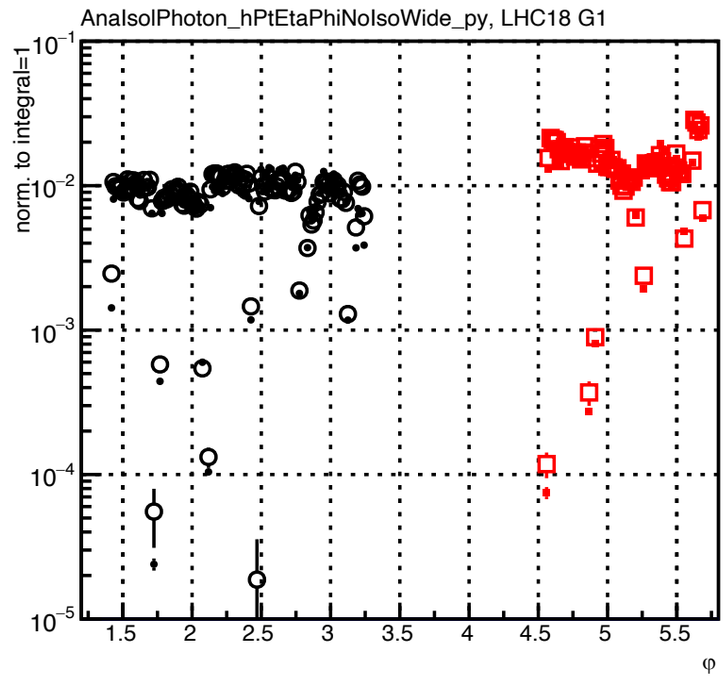


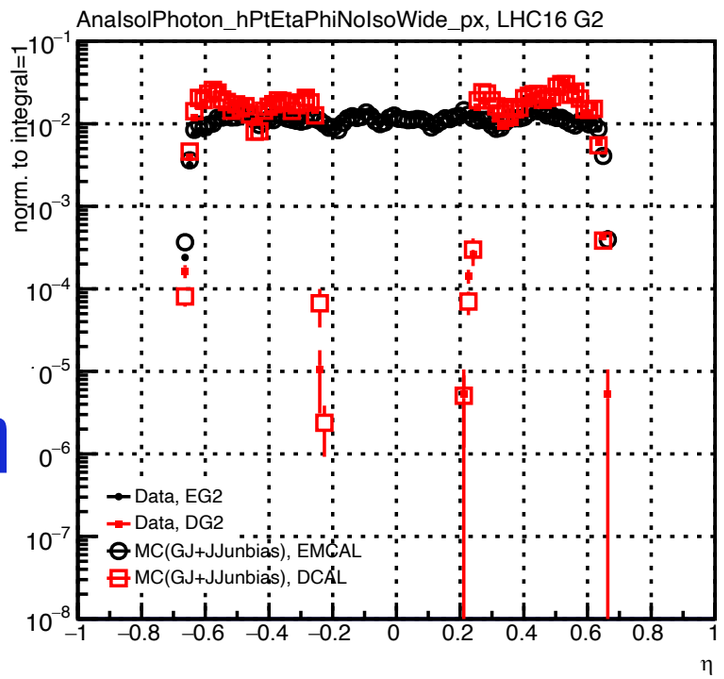




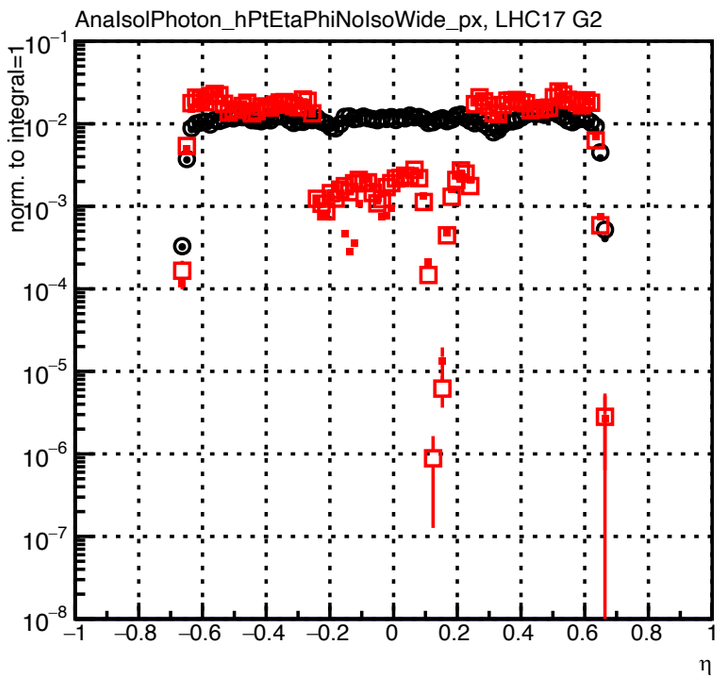
Histo_name: AnaIsolPhoton_hEtaPhiNoIsoWide

Eta(Phi) distribution, per year G2 V.S. GJ

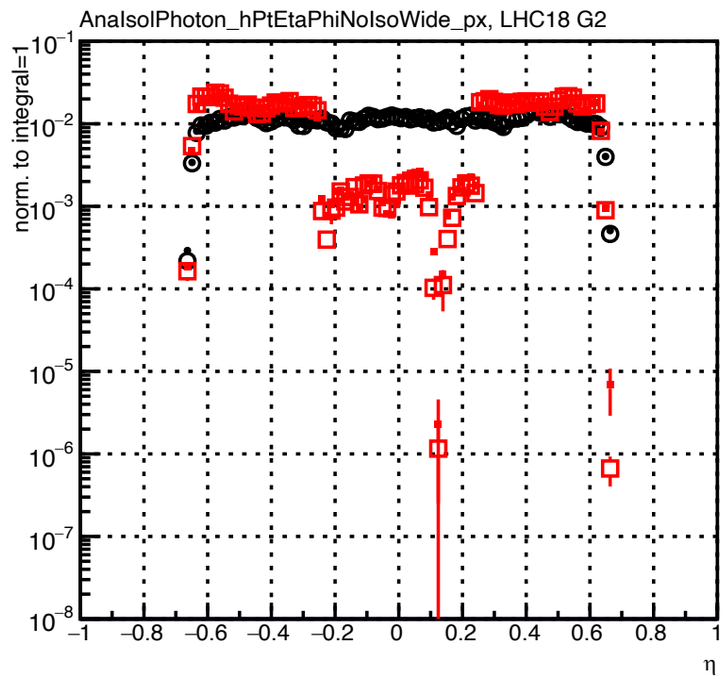
LHC16

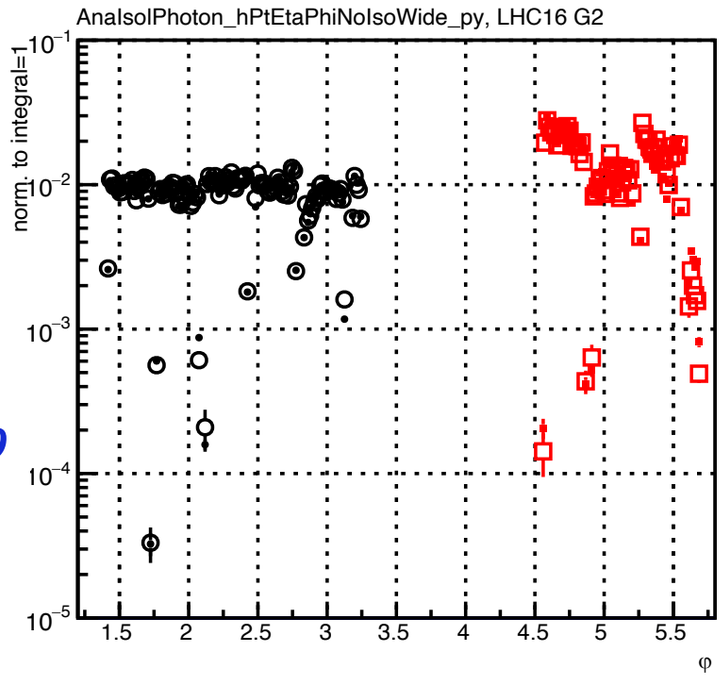


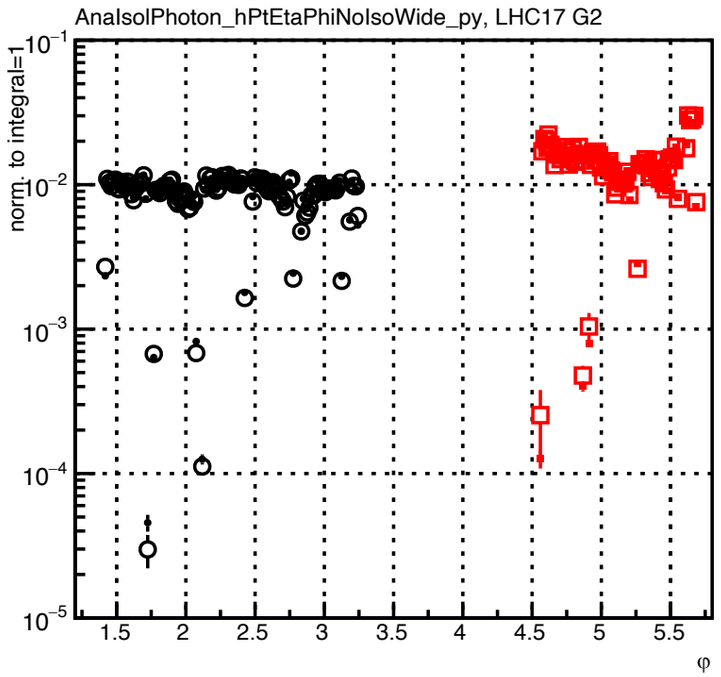
LHC17

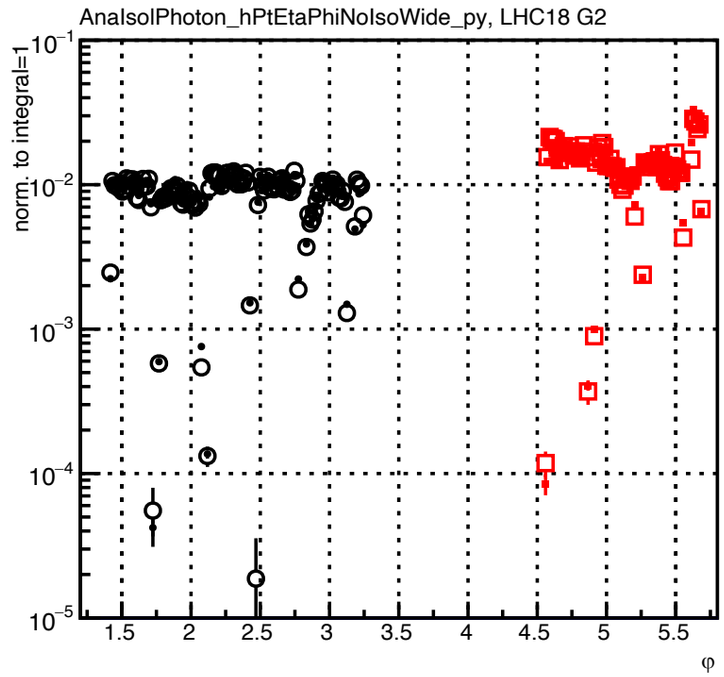


LHC18









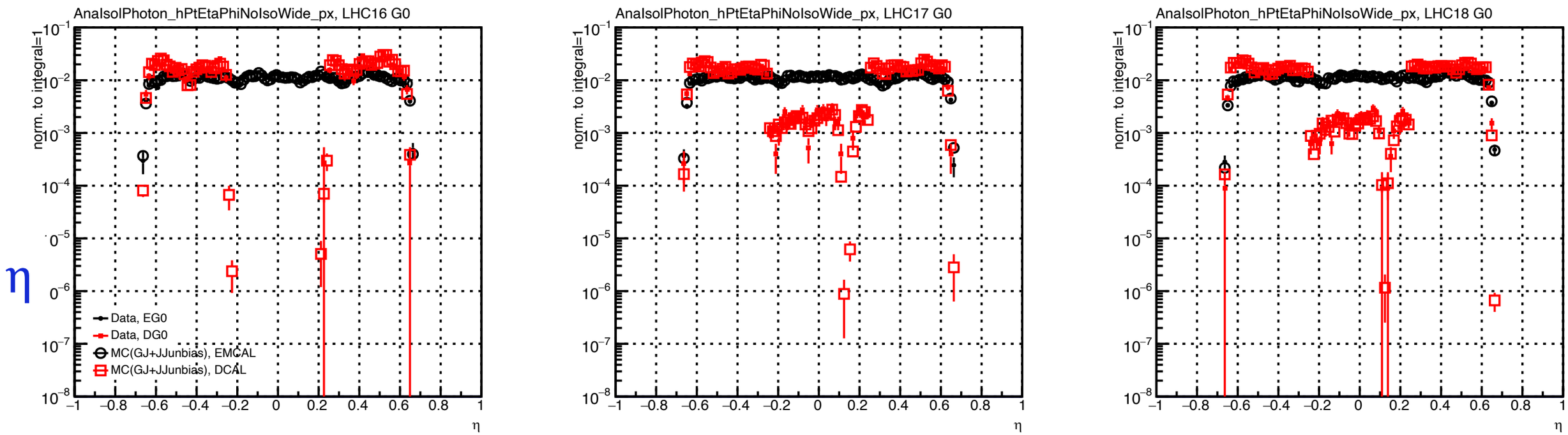
Histo_name: AnaIsolPhoton_hEtaPhiNoIsoWide

Eta(Phi) distribution, per year MB V.S. GJ

LHC16

LHC17

LHC18



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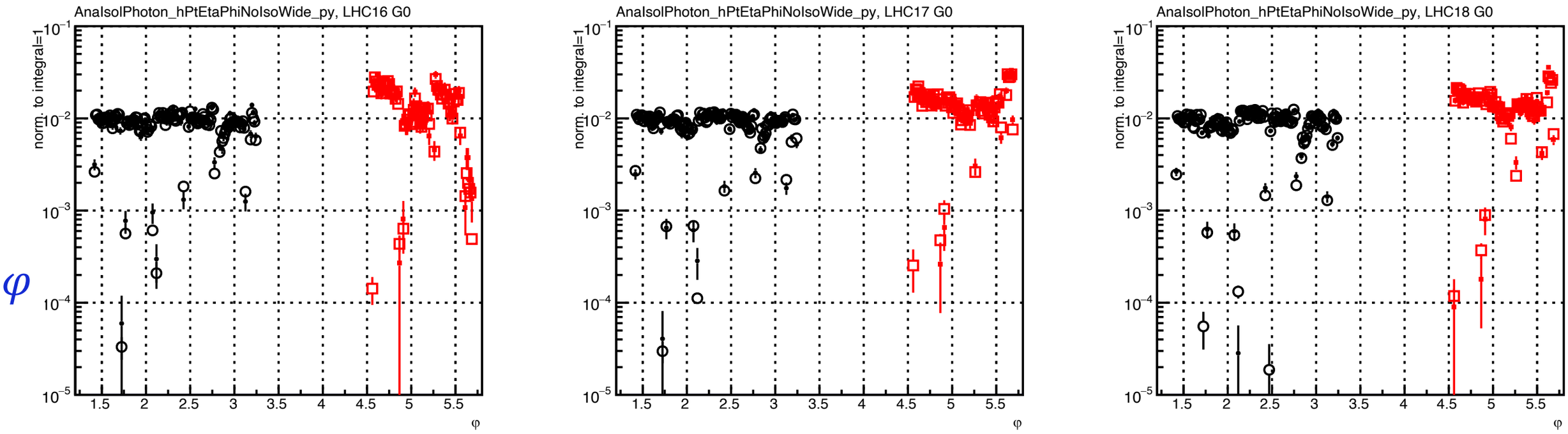
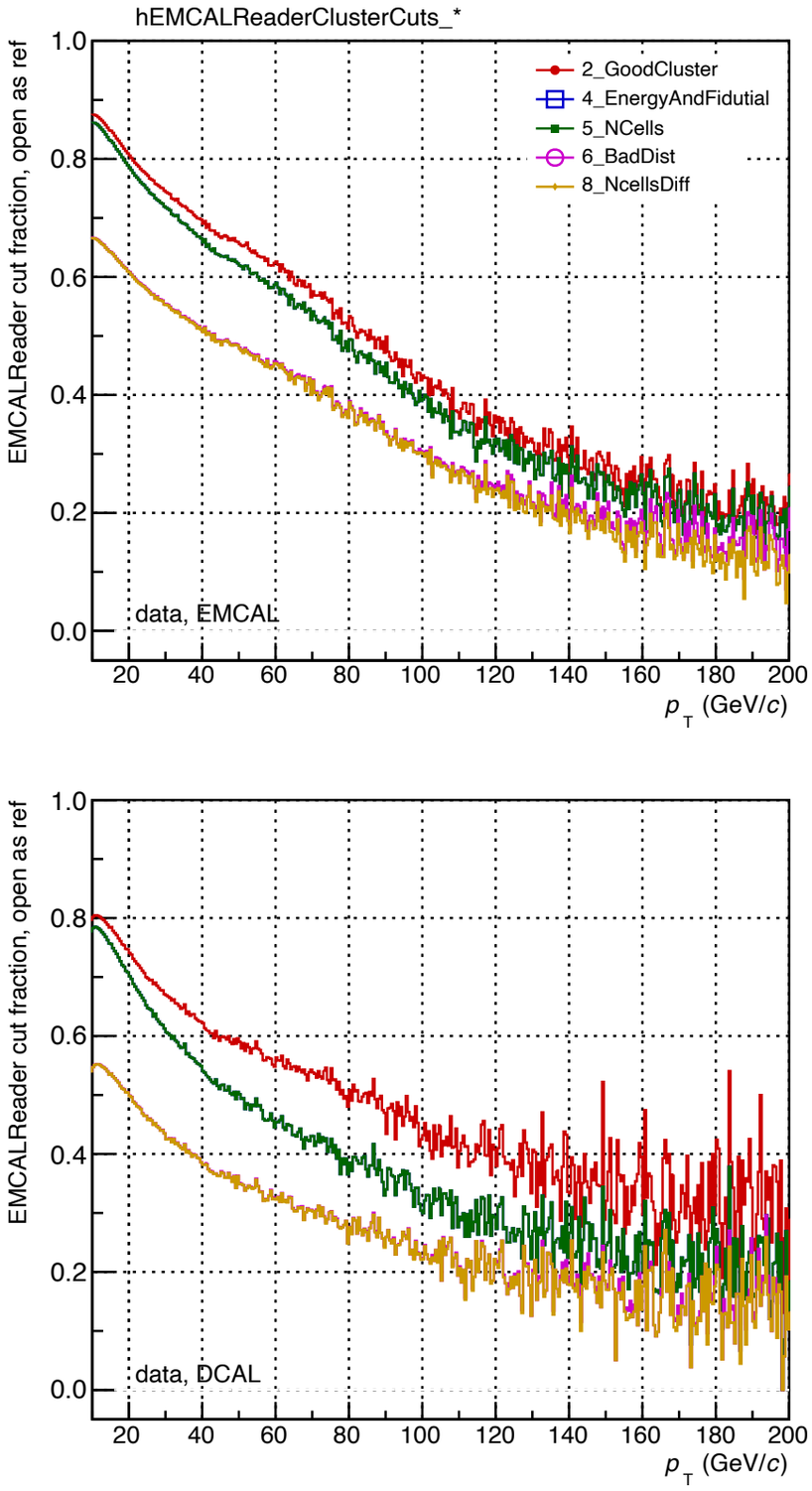
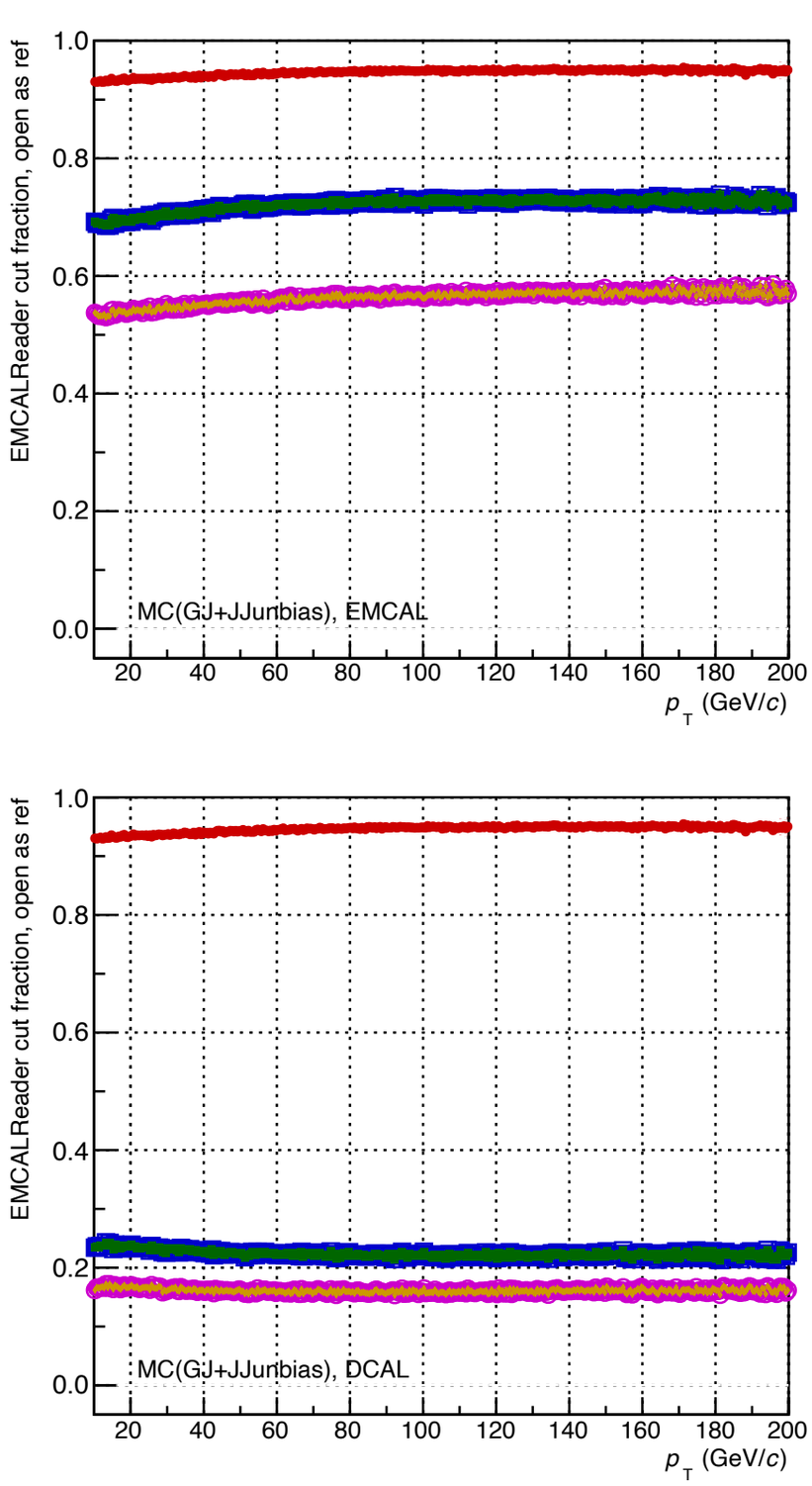


φ

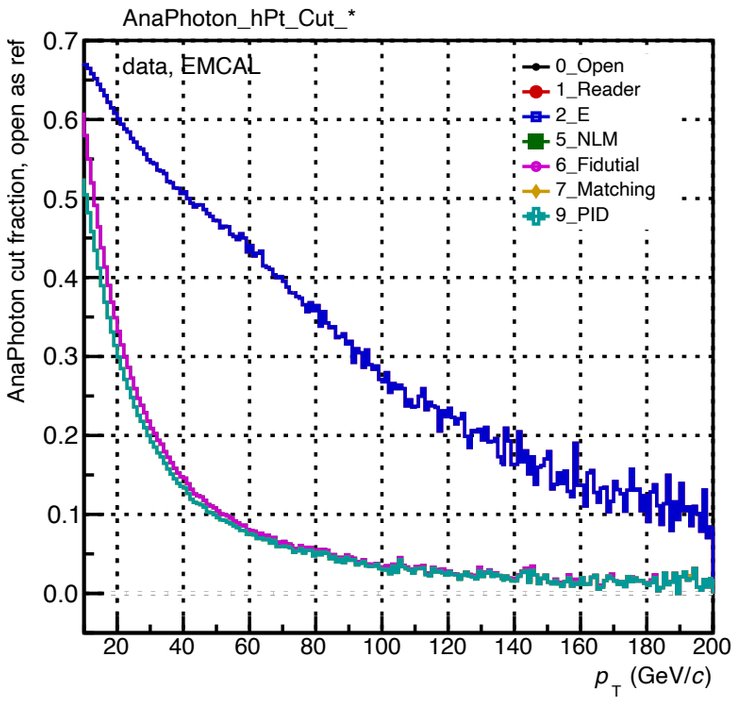
Histo_name: AnaIsolPhoton_hEtaPhiNoIsoWide

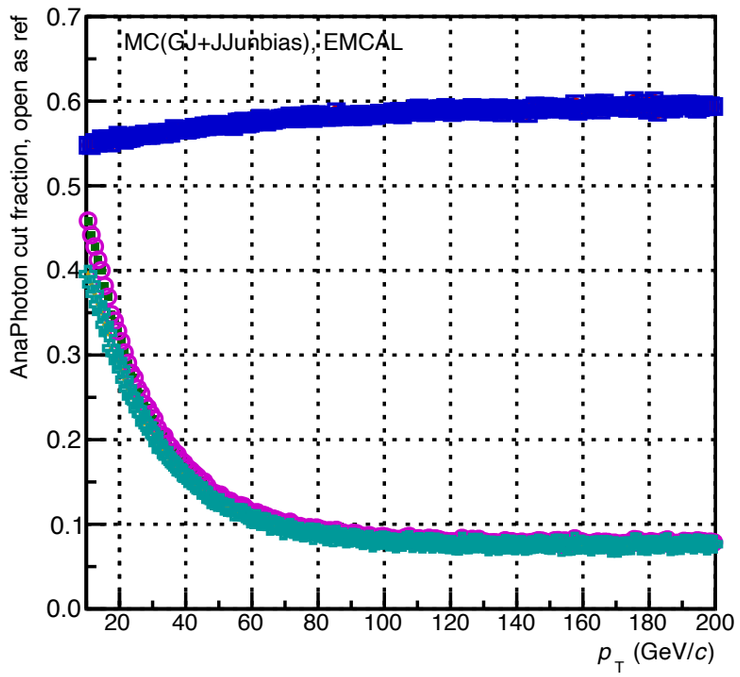
EMCALReader Cut fraction

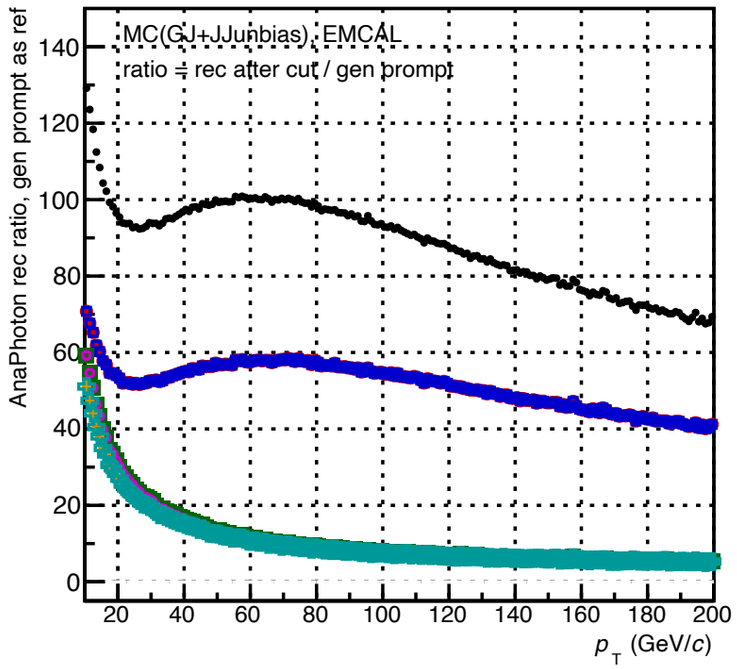


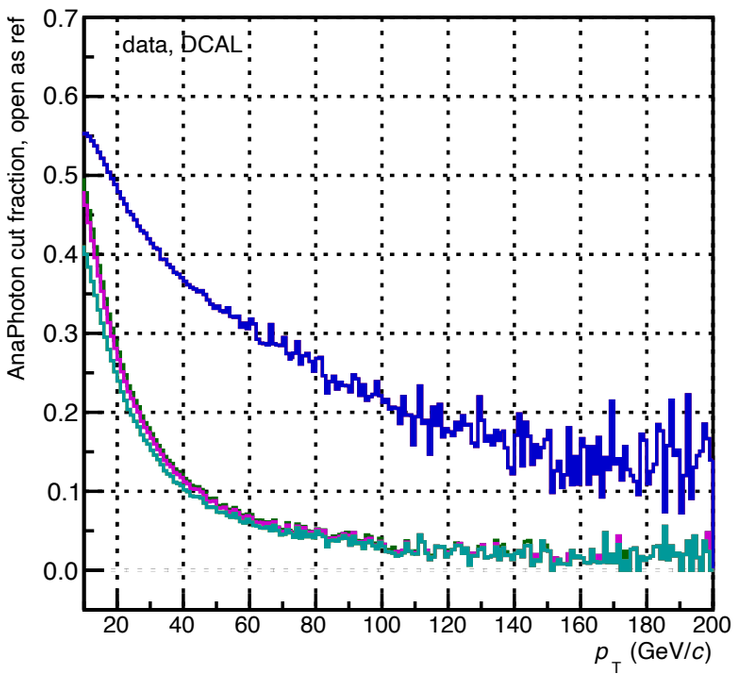


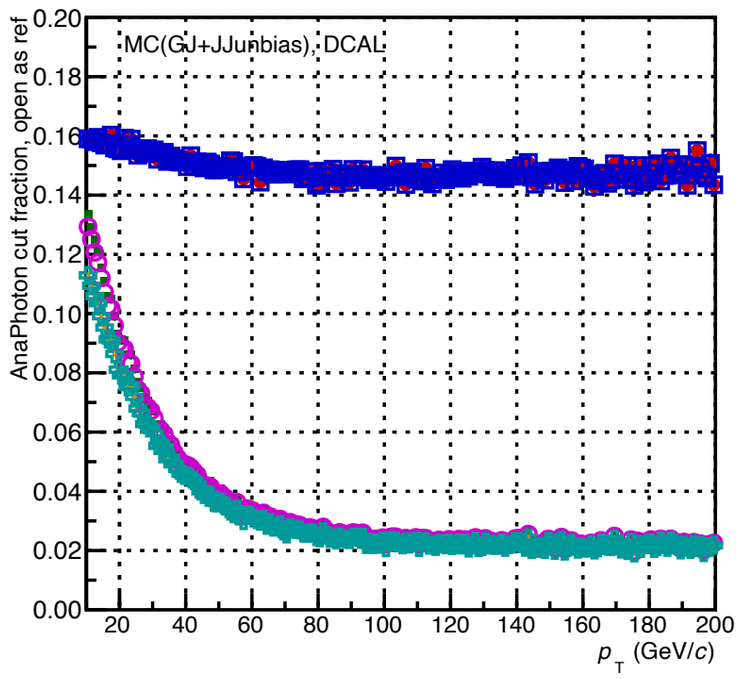
Cluster Cut fraction

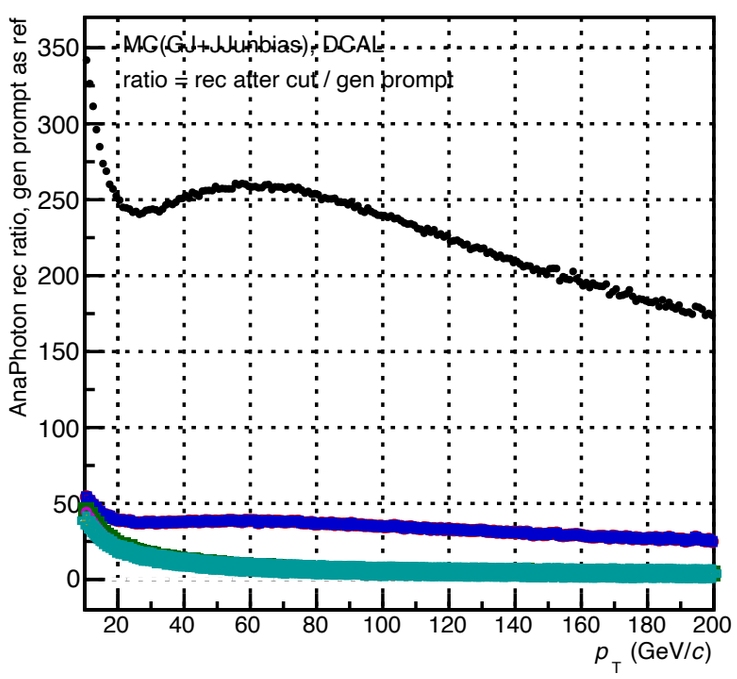












Last presentation

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

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

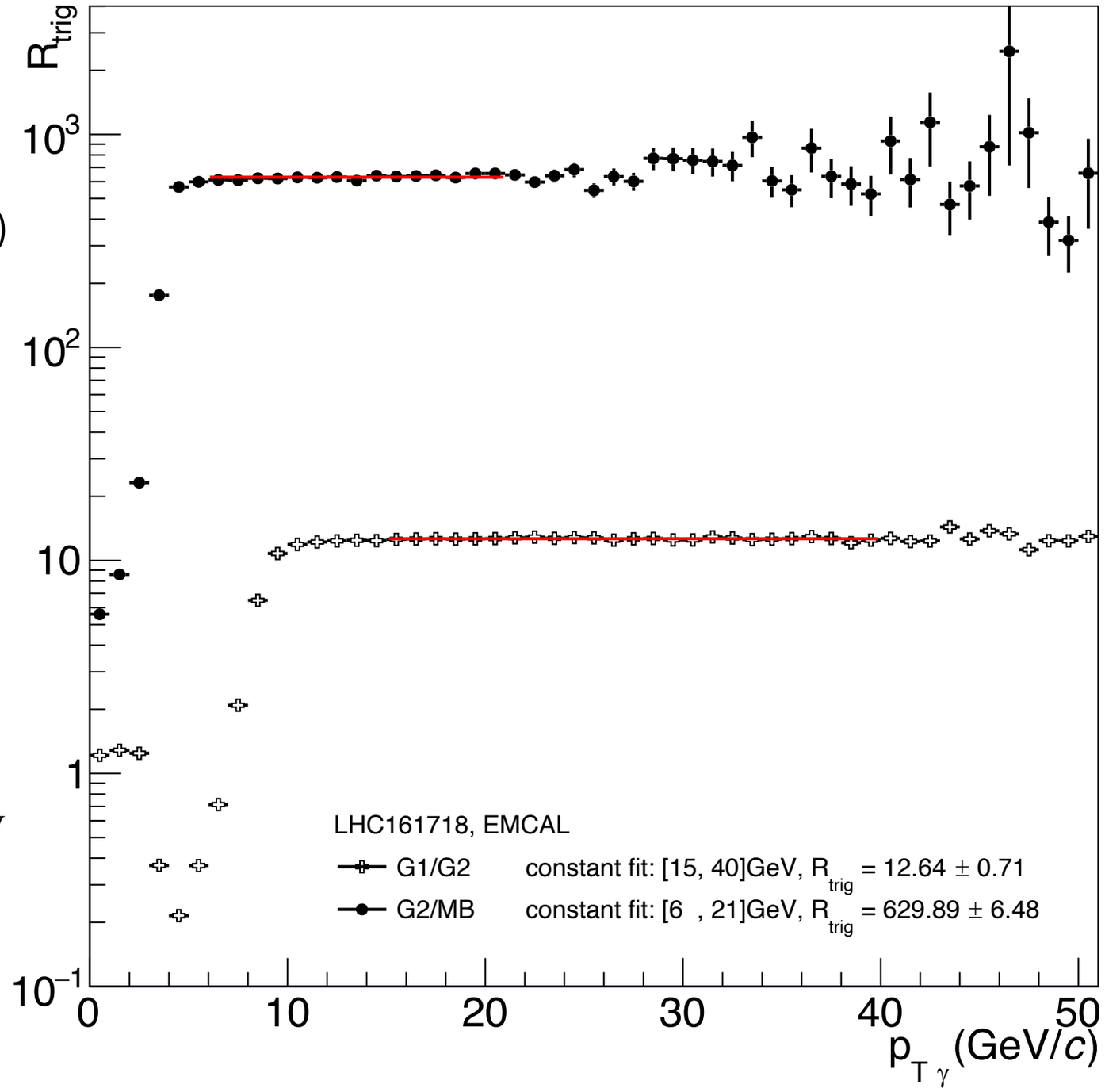
$$p_T^{\overline{iso}} \equiv \Sigma p_{T,track} > E_T^{th} = 2.5 GeV/c$$

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)

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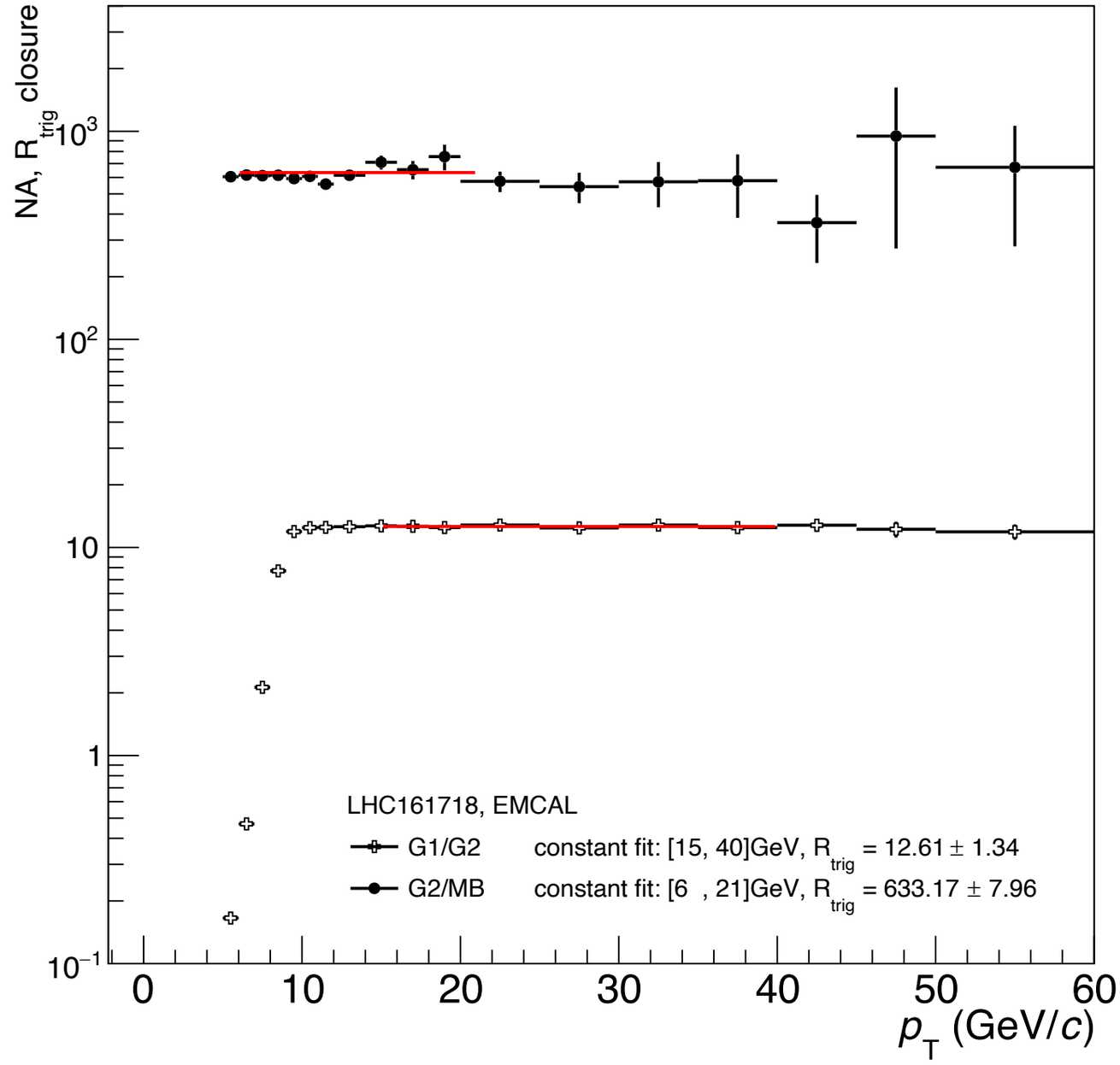
- Ncells/cluster >= 2
- distance to bad channel > 2 cell
- time cut: [-30, 30]ns
- NLM <= 2
- Trackmactch: : p_T dependent
- Emulation of cross-talk T-Card in MC applied

Isolated photon rejection factor

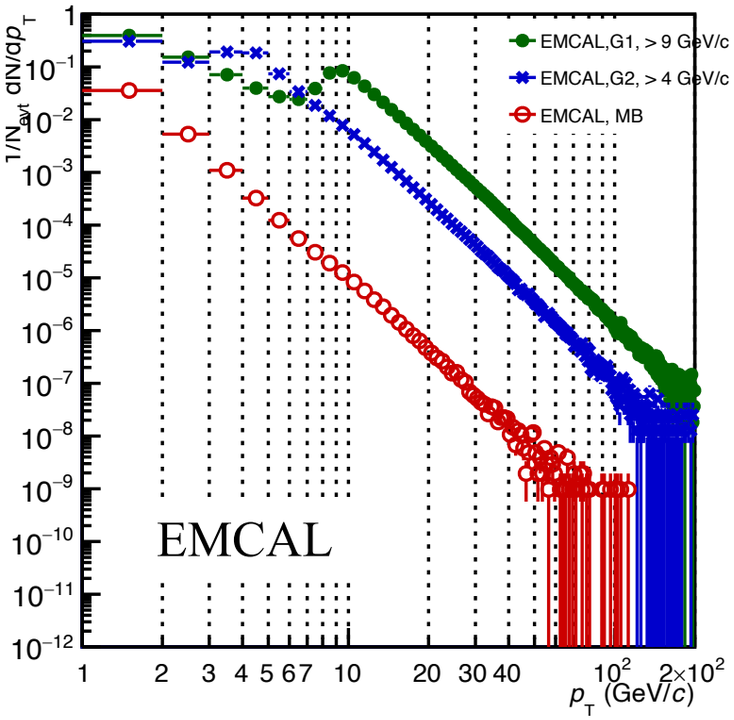
$$RF = \left(\frac{1}{N_{evt}}\frac{dN}{dP_T}\right)_{trigger} \Big/ \left(\frac{1}{N_{evt}}\frac{dN}{dP_T}\right)_{MB}$$

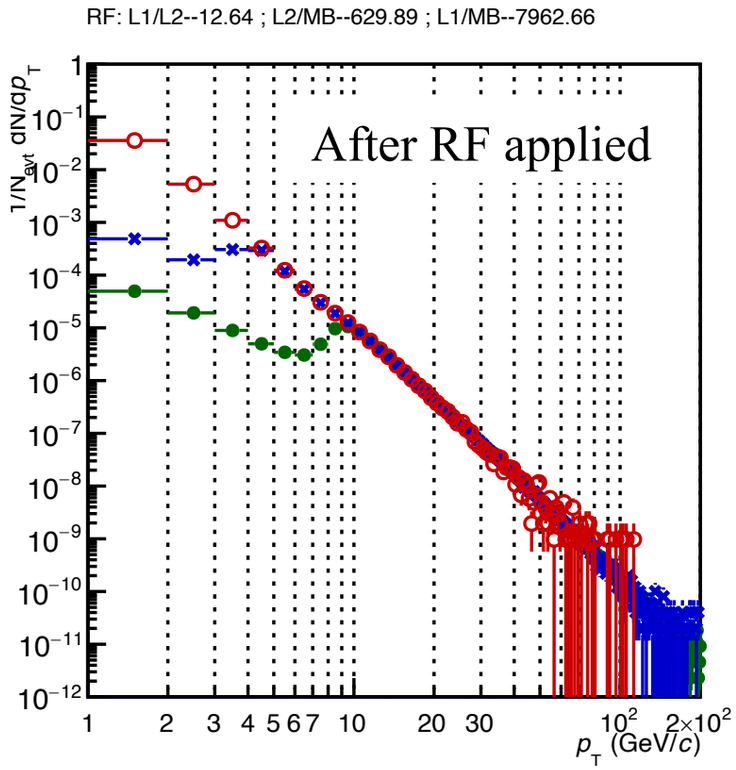
		cluster RF	Iso photon RF	Cluster/ IsoPhoton
EMCAL	G1 / G2	12.64±0.71	12.61±1.34	1.002
	G2 / MB	629.89±6.48	633.17±7.96	0.995
	G1 / MB	7962.73		
DCAL	G1 / G2	12.04±0.69	12.49±1.34	0.964
	G2 / MB	1280.87±9.24	1229.58±11.09	1.042
	G1 / MB	15427.31		

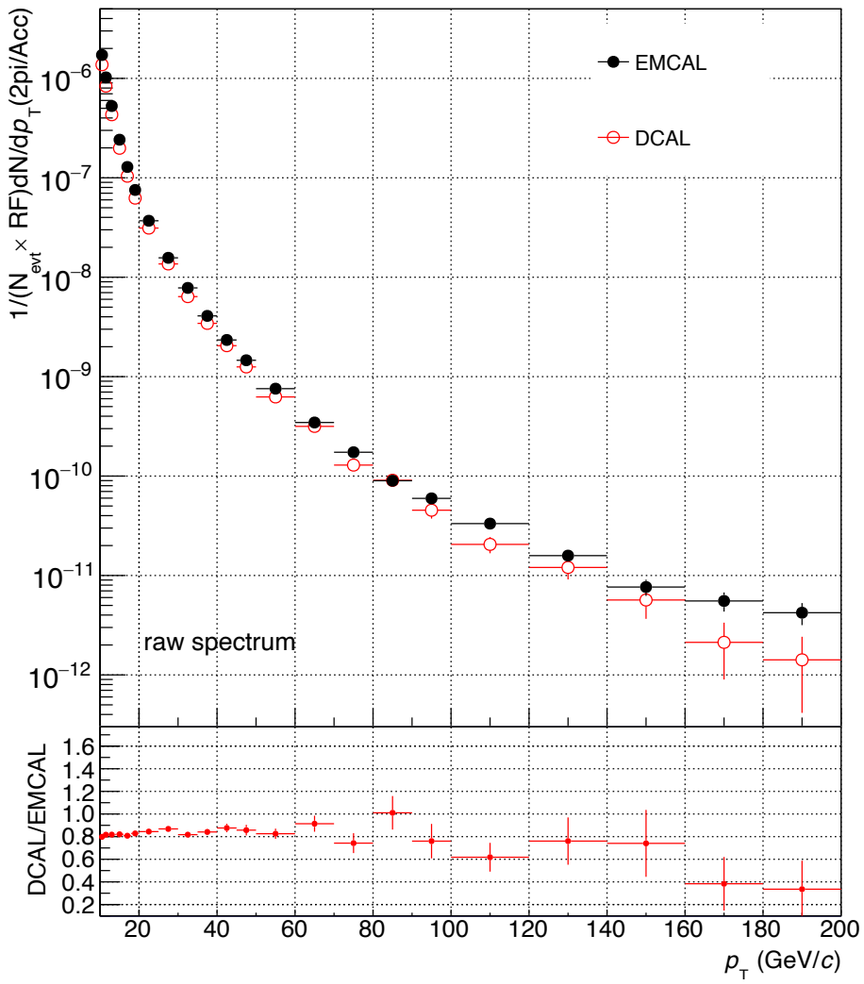
The rejection factor works equivalent in cluster and isolated photon.

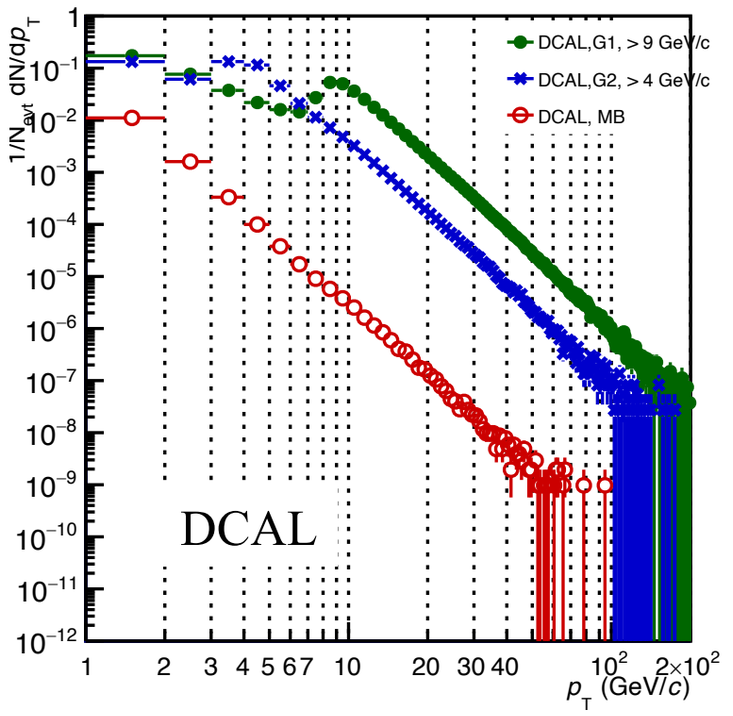


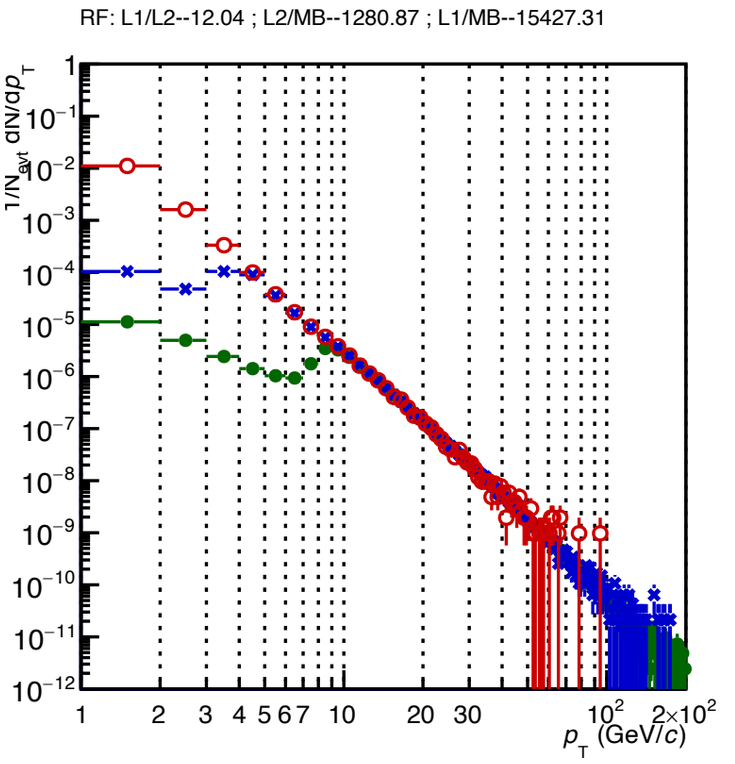
Isolated photon pt distribution





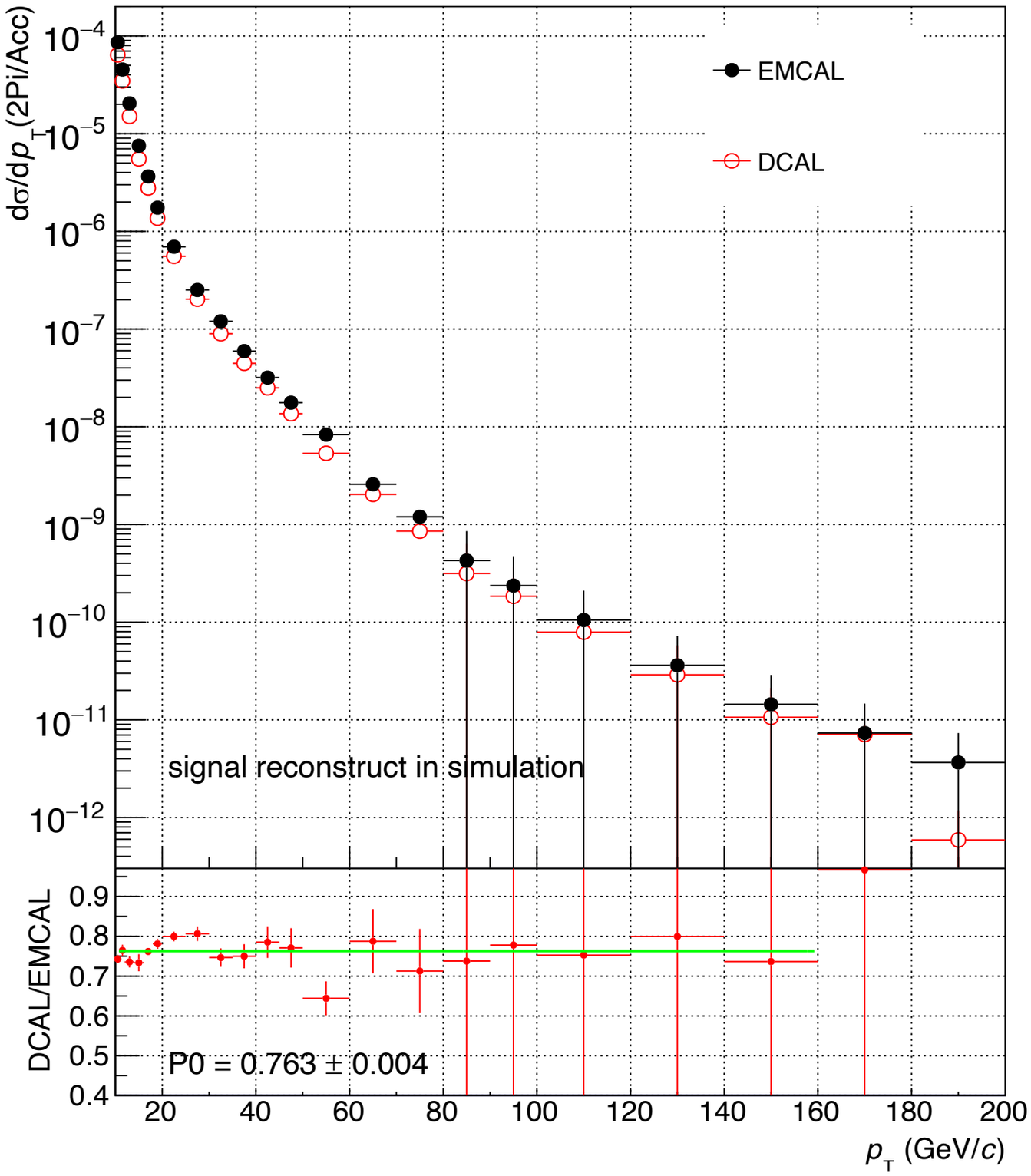






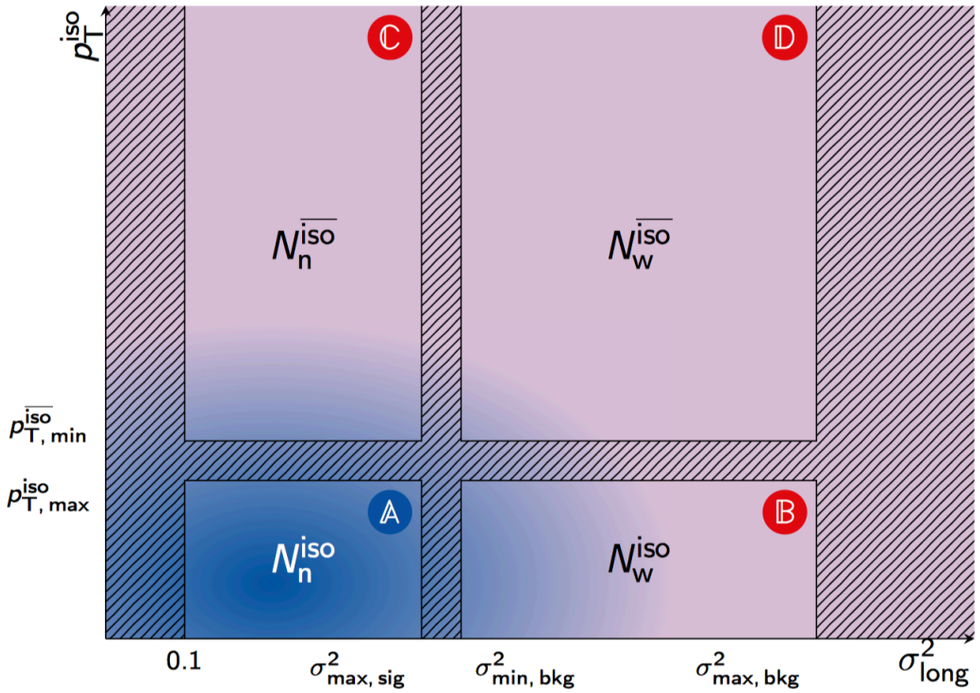
- After the cluster rejection factor applied, different samples similar to each other.
- Combined sample after acceptance normalized, DCAL/EMCAL around 0.83. because different masked regions not considered in acceptance correction factor.

Isolated photon pt distribution in MC



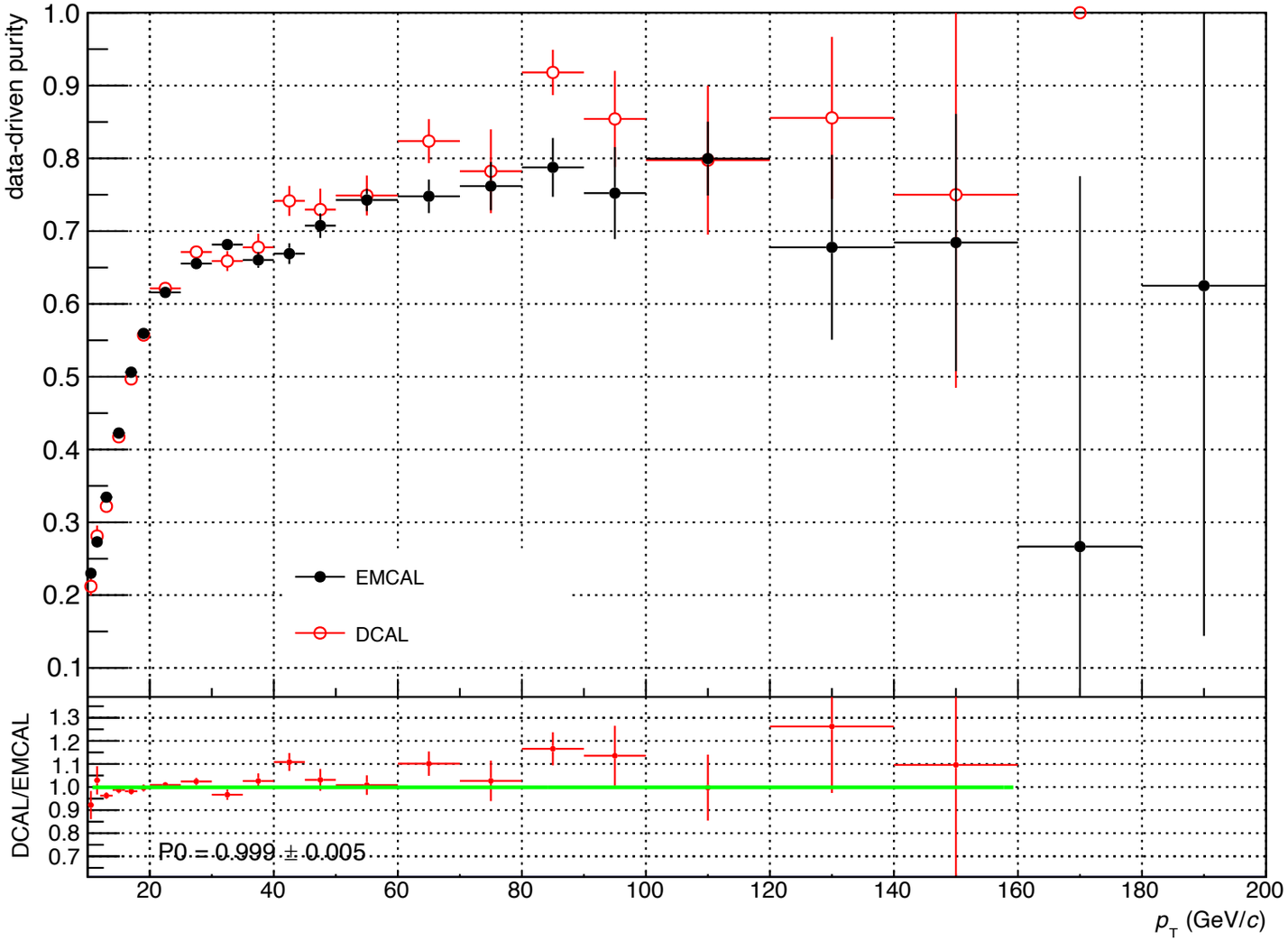
- In MC, the reconstructed signal in different calorimeters are close to each other after acceptance Combined sample after acceptance normalized.
- Ratio, DCAL/EMCAL is 0.76 in GJ but in data is 0.83.

Data driven purity in different detector



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

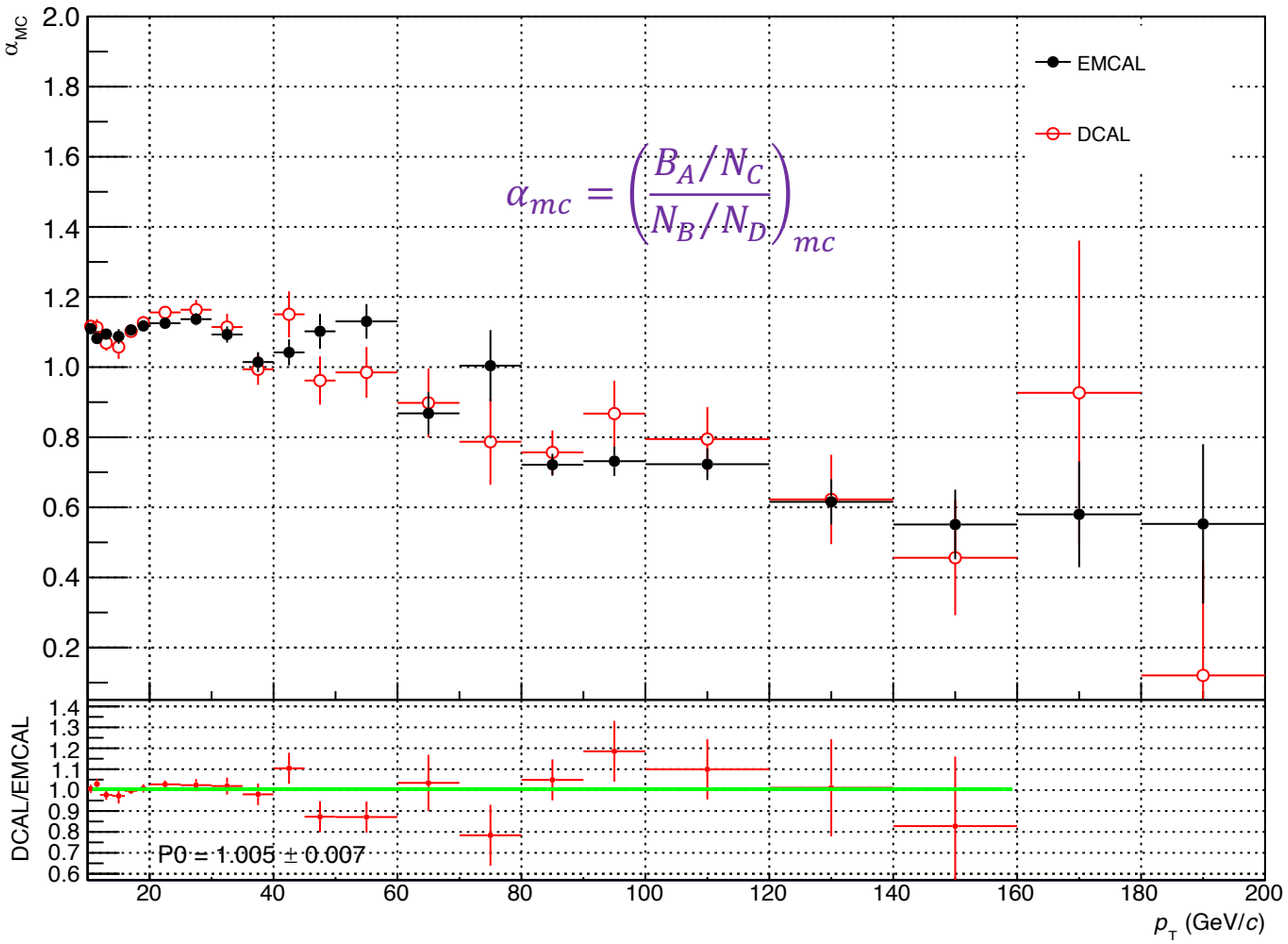
purity by data-driven

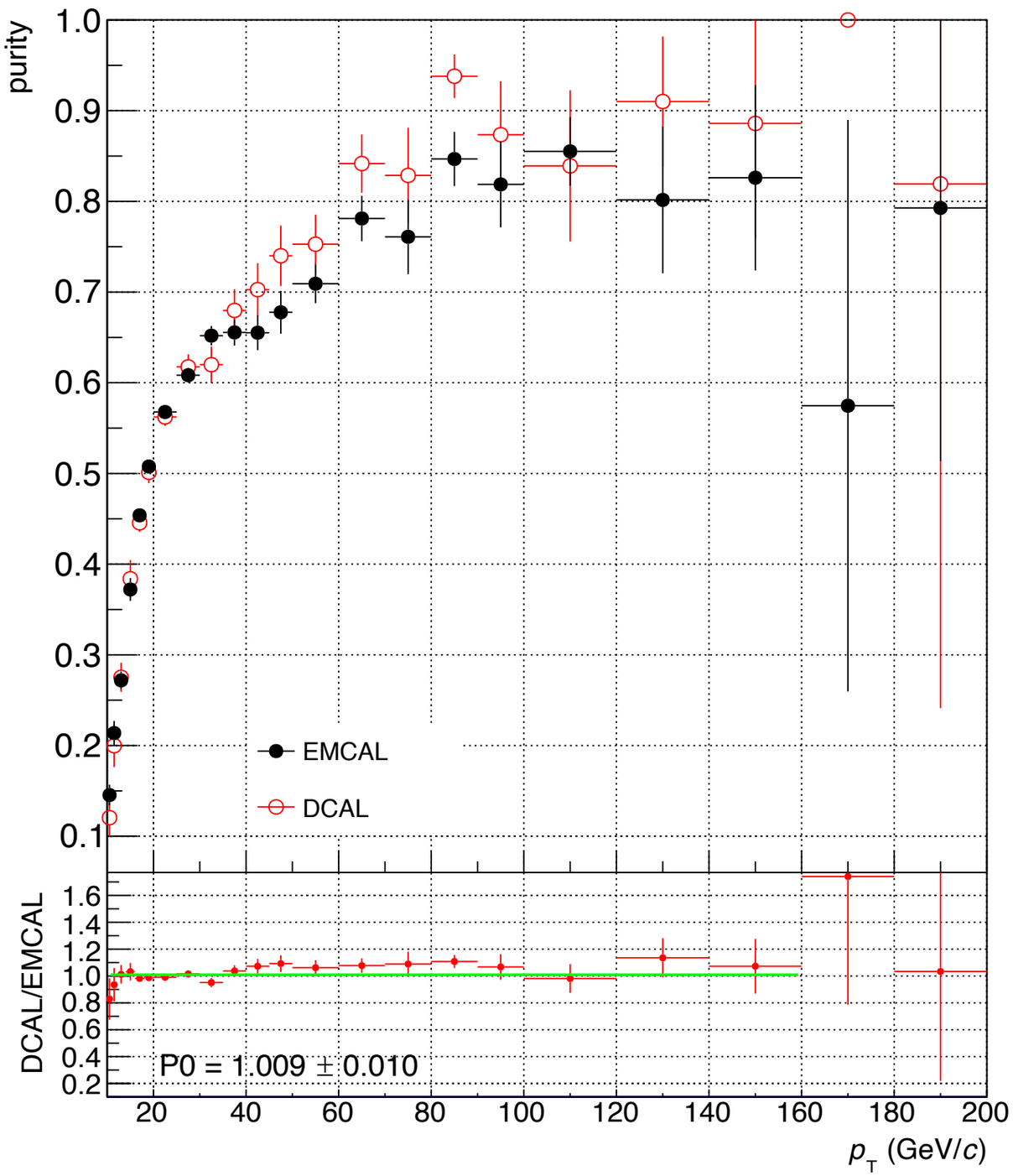


✢ Data-driven purity is equivalent between EMCal and DCal.

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

MC correction factor and final purity



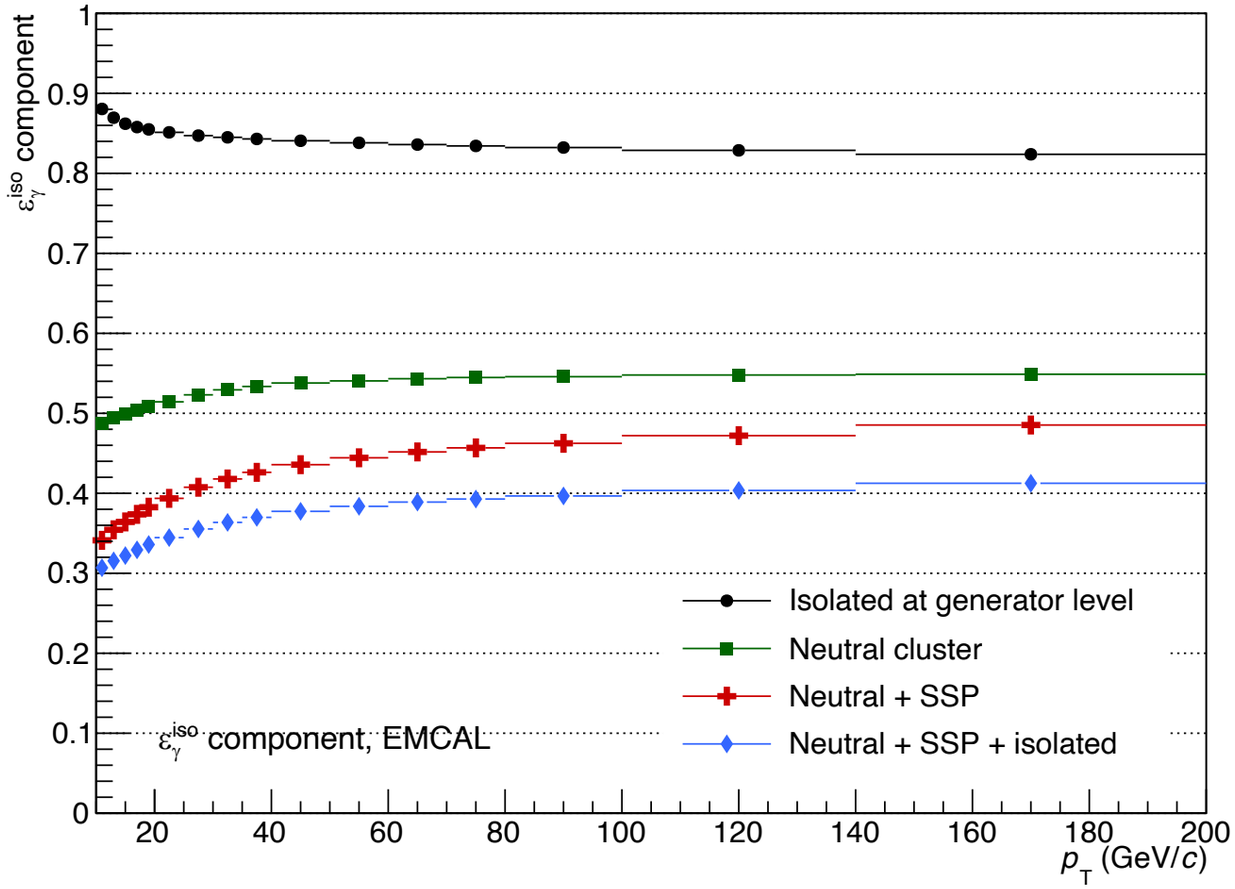


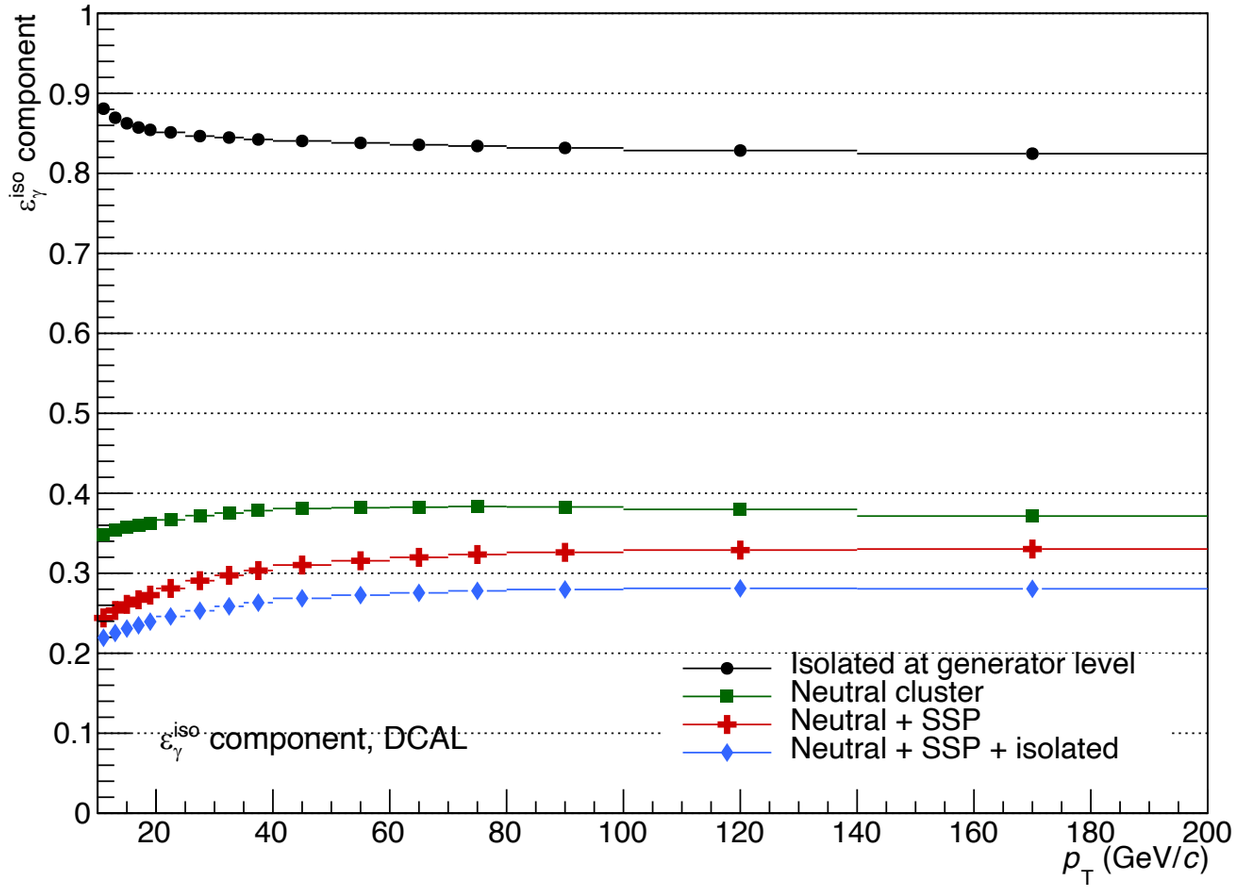
$$purity = 1 - \left(\frac{N_c/N_A}{N_D/N_B}\right)_{data} \times \left(\frac{B_A/N_C}{N_B/N_D}\right)_{mc} \alpha_{mc}$$

✢ 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

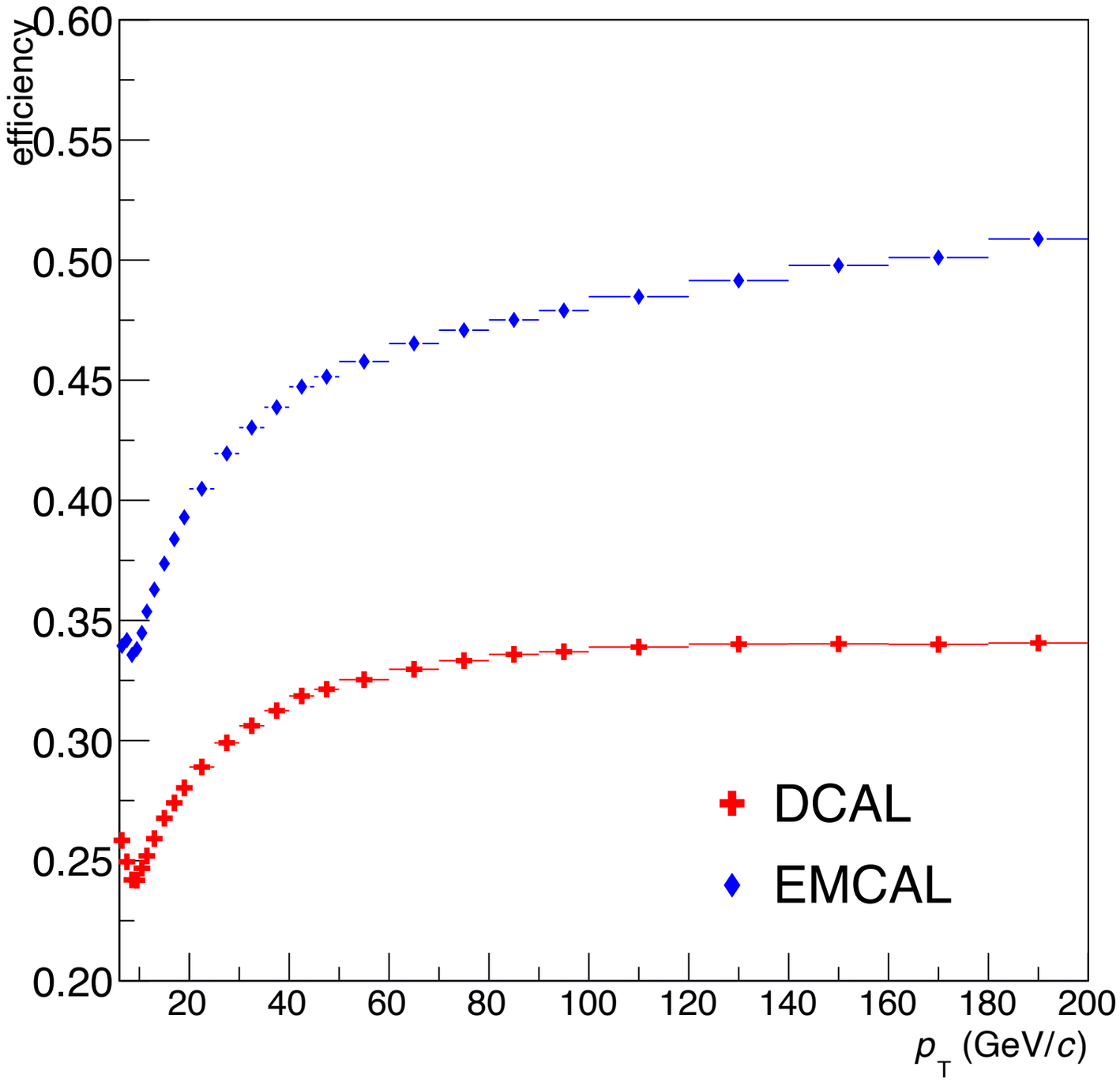
Efficiency comparison

- 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 =

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

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

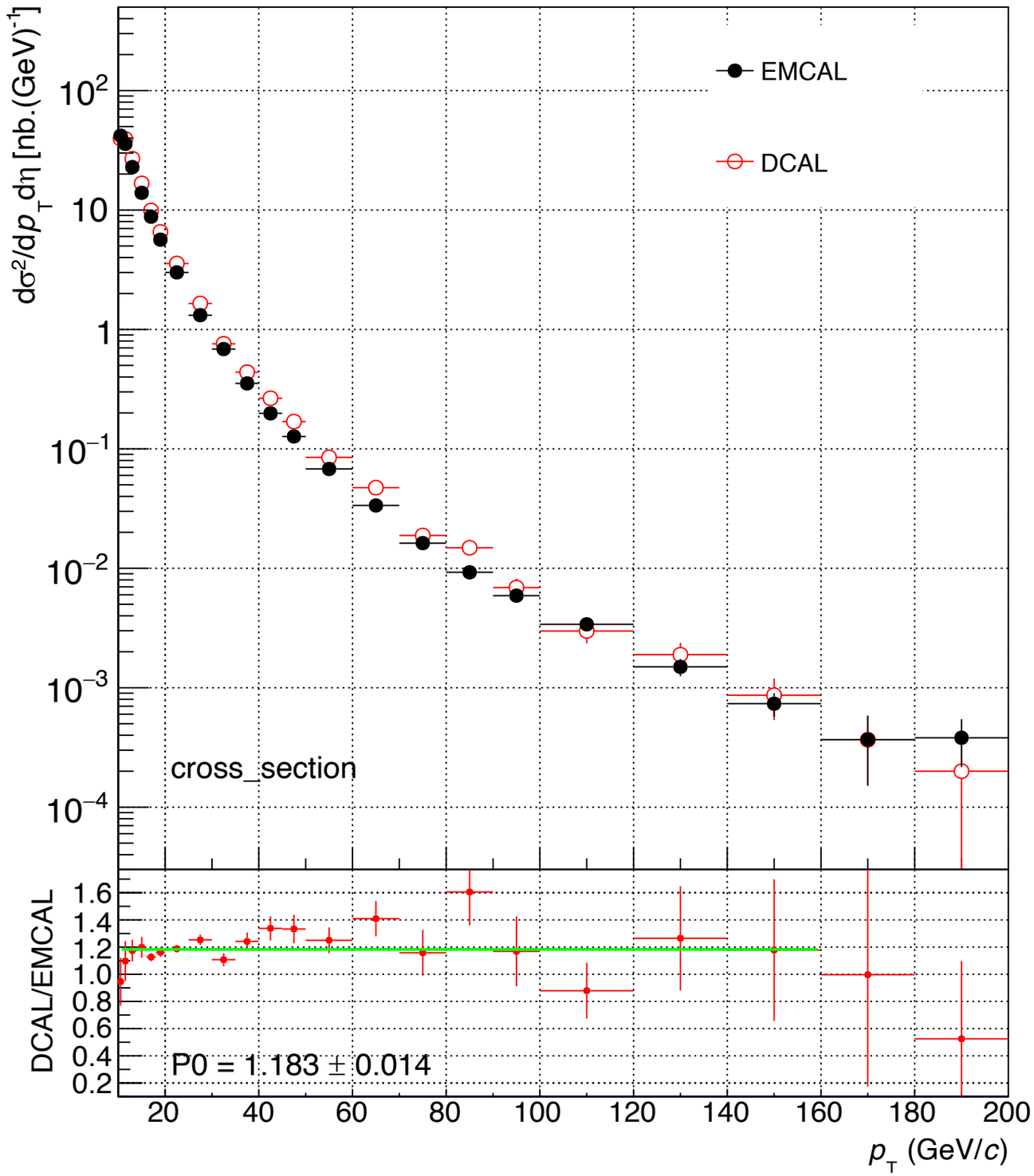
- Ratio DCAL / EMCAL around 1.18

  ratio fit information:

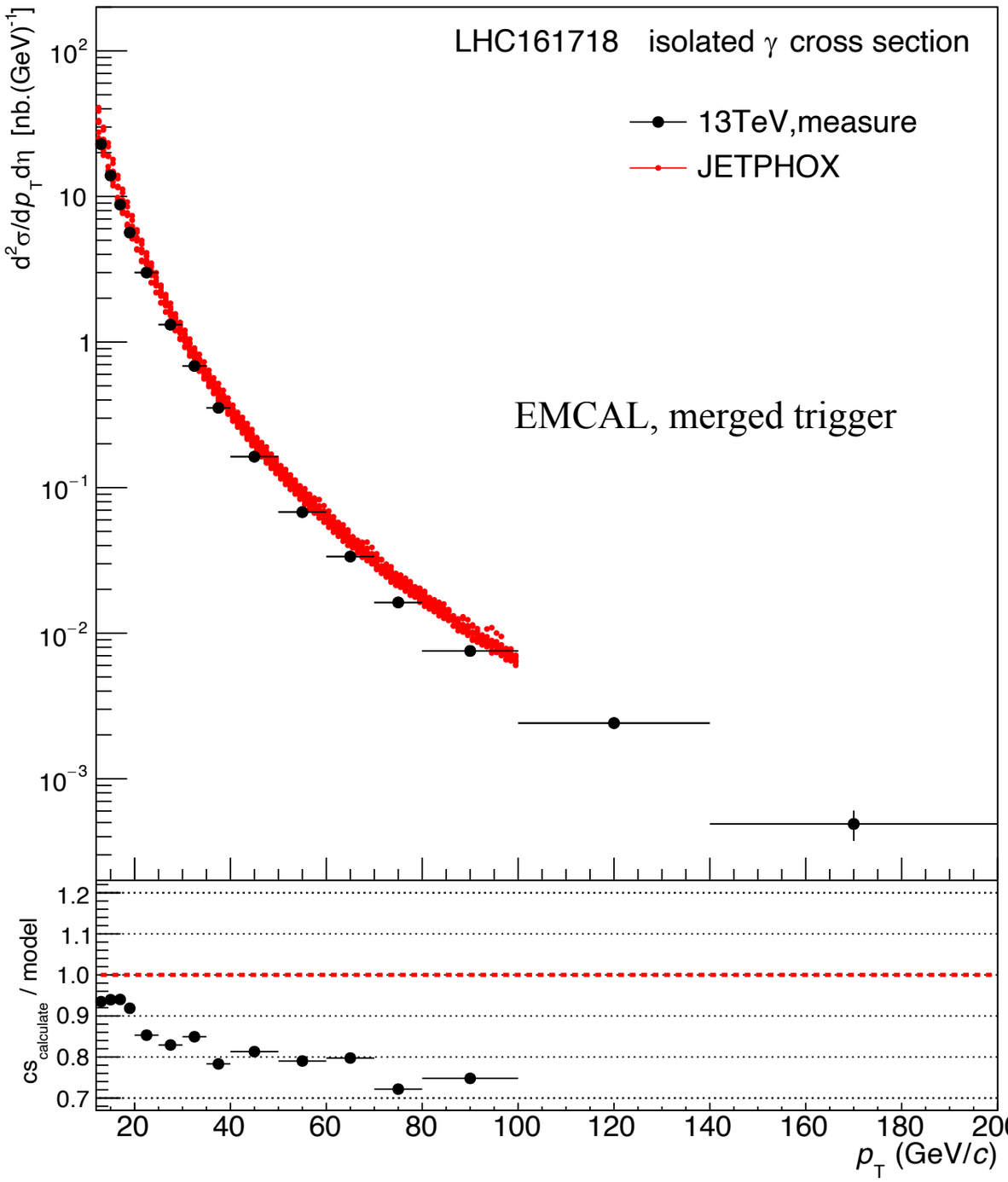
  -- fit function: pol0

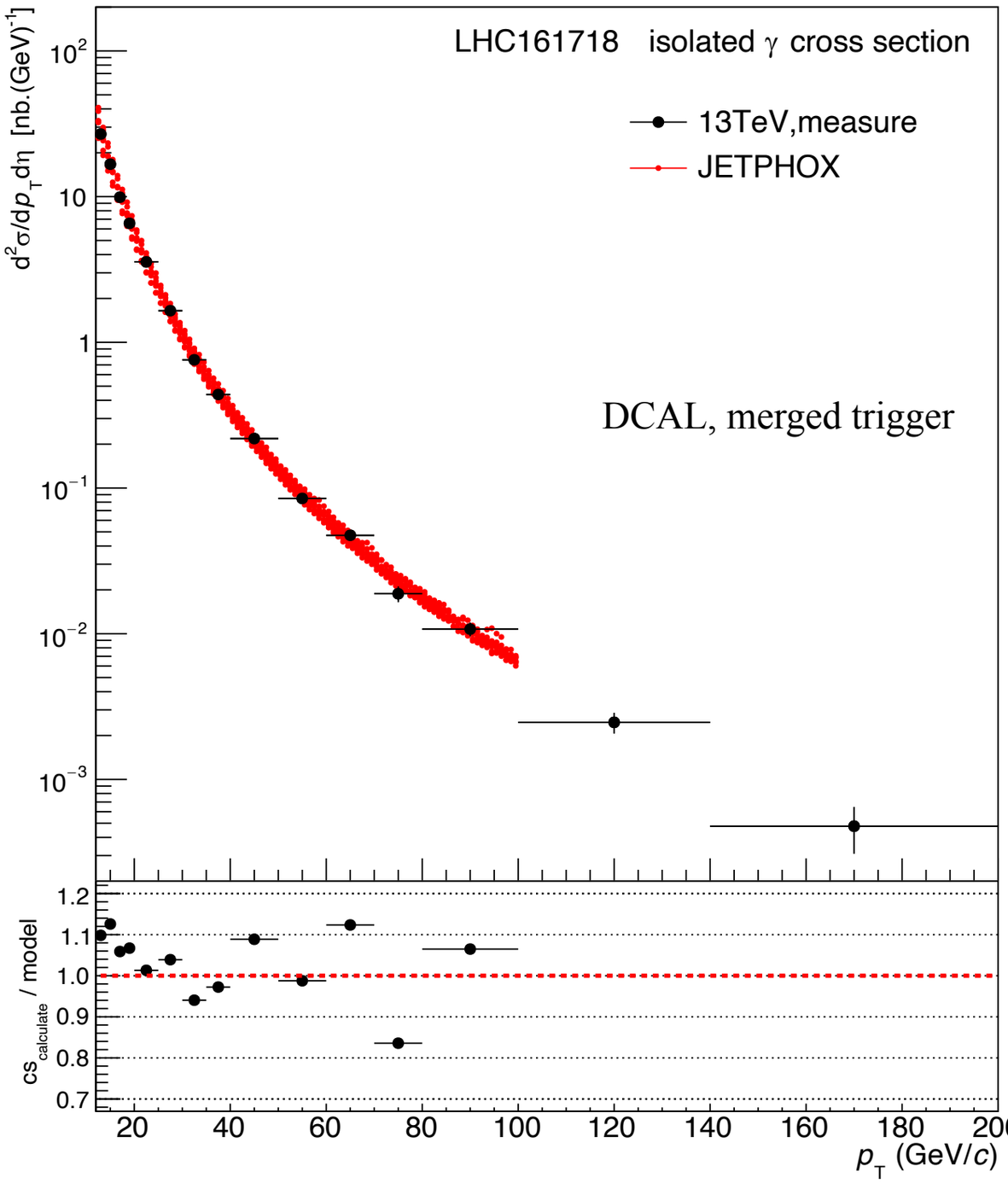
  -- fit range: [10. , 160.]

  -- 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

$$\text{cross section} = \sigma_{total} \times \underbrace{\underbrace{\frac{2\pi}{\Delta\eta\Delta\phi} \cdot \frac{1}{\sum(N_{evt,i} \times RF_i)} \sum \frac{dN}{dp_T}}_{\text{raw, ratio} \sim 0.8} \times \frac{purity}{efficiency}}_{\text{yield, ratio} \sim 1.17} \begin{array}{l} \longleftarrow \text{ratio} \sim 1.0 \\ \longleftarrow \text{ratio} \sim 0.7 \end{array}$$

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