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Neutral Pion DIS Multiplicity with CLAS12 Data

CLAS collaboration Meeting - March 7 2019

Giovanni Angelini (GWU), PhD candidate

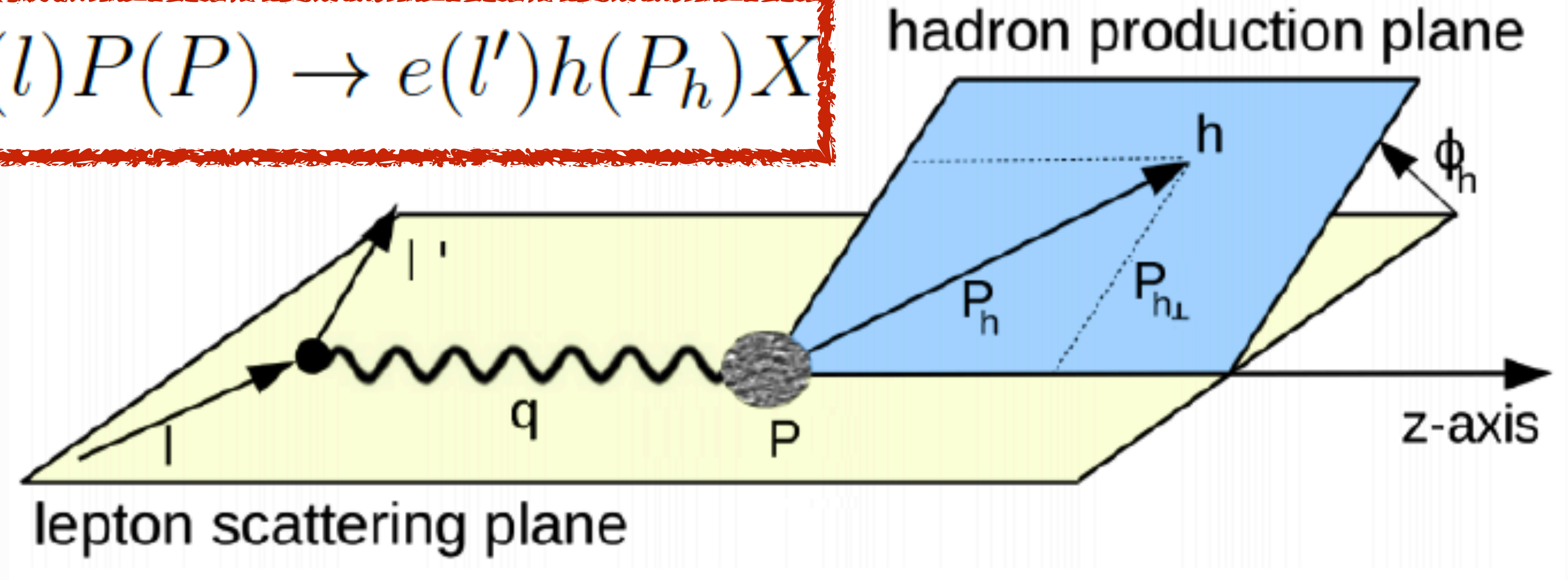
Observable: Multiplicity

Multiplicity:

$$\boxed{m^h(x, z, dP_{hT}^2, Q^2) = \frac{d\sigma_{SIDIS}^h / dx\, dz\, dP_{hT}^2\, dQ^2}{d\sigma_{DIS} / dx\, dQ^2}}$$

SDIS:

$$\boxed{e(l)P(P) \to e(l')h(P_h)X}$$



$$\boxed{m_N^h(x, z, P_{hT}^2, Q^2) = \frac{\pi F_{UU,T}(x, z, P_{hT}^2, Q^2) + \pi \varepsilon F_{UU,L}(x, z, P_{hT}^2, Q^2)}{F_T(x, Q^2) + \varepsilon F_L(x, Q^2)}}$$

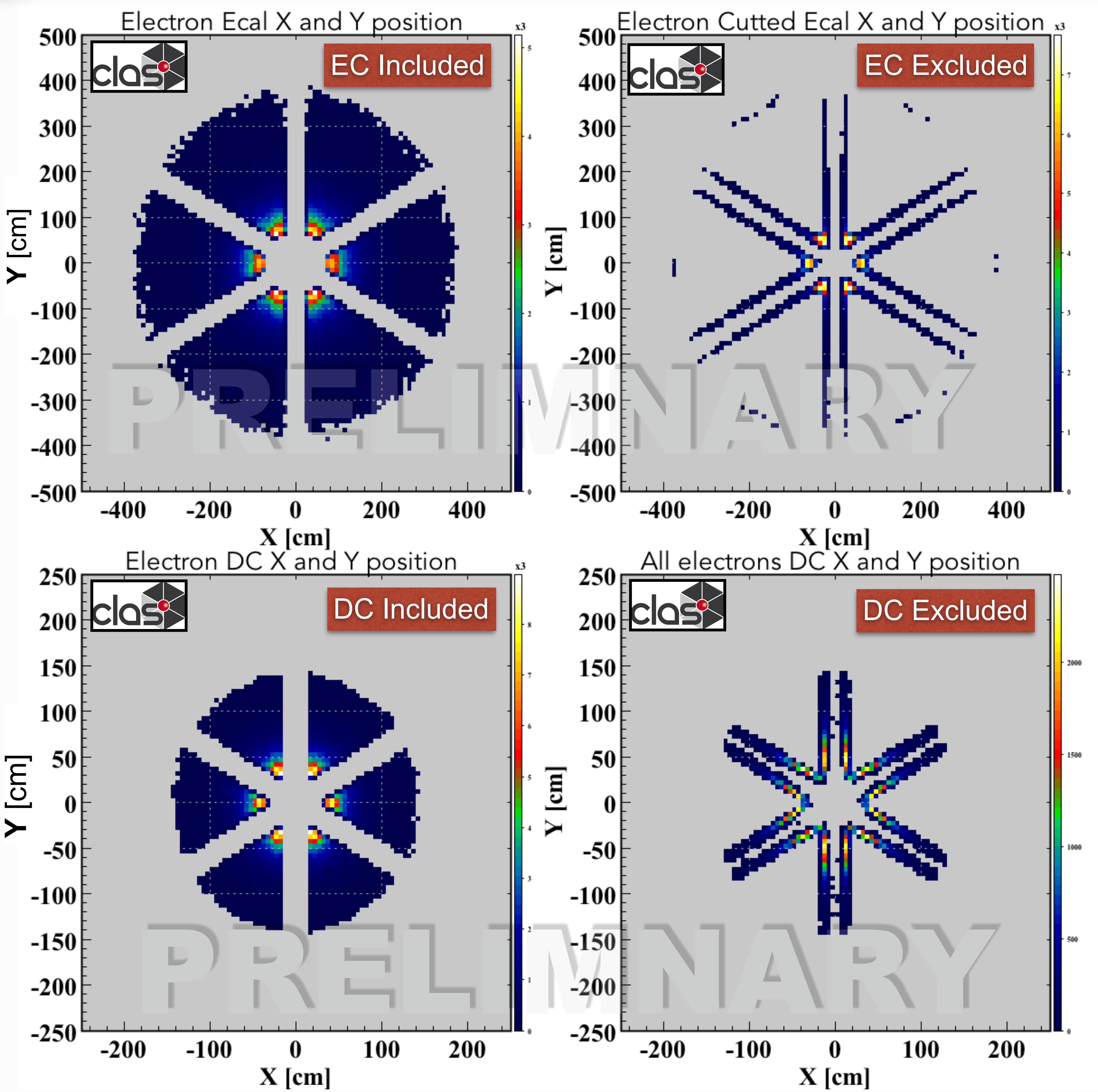
Kinematics factors drops in the ratio. Information on the FF can be extracted from it.

Assuming Gaussian distributions in k_T and p_T

$$m_N^h(x, z, P_{hT}^2) = \frac{\pi}{\sum_a e_a^2 f_1^a(x)} \times \sum_a e_a^2\, f_1^a(x) \underbrace{\boxed{D_1^{a\to h}(z)}}_{\text{FF}} \frac{e^{-P_{hT}^2 / \left(z^2 \langle k_{\perp,a}^2 \rangle + \langle P_{\perp,a\to h}^2 \rangle\right)}}{\pi\left(z^2 \langle k_{\perp,a}^2 \rangle + \langle P_{\perp,a\to h}^2 \rangle\right)}$$

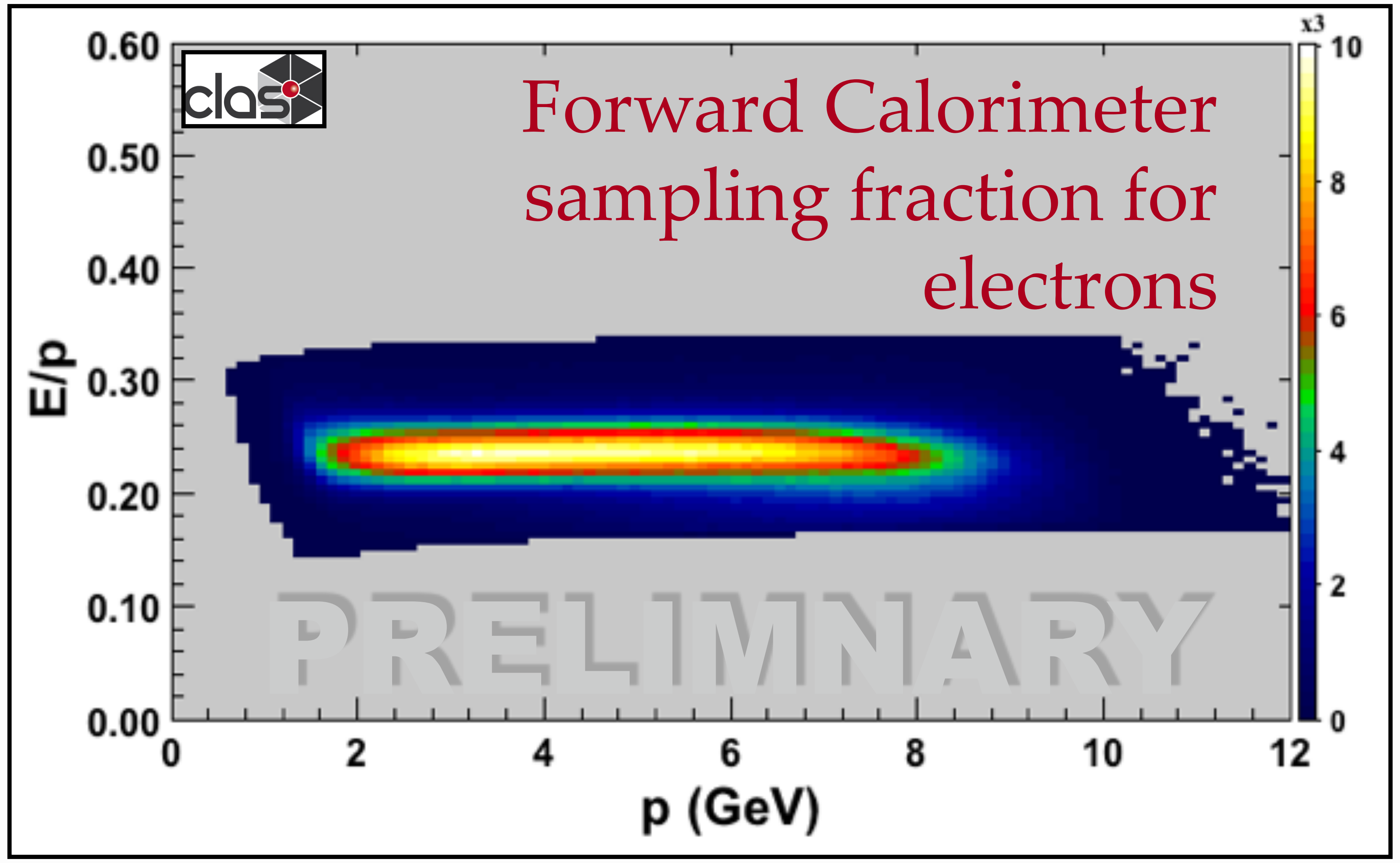
Data Selection: Scattered Electron Cuts

FIDUCIAL CUTS:

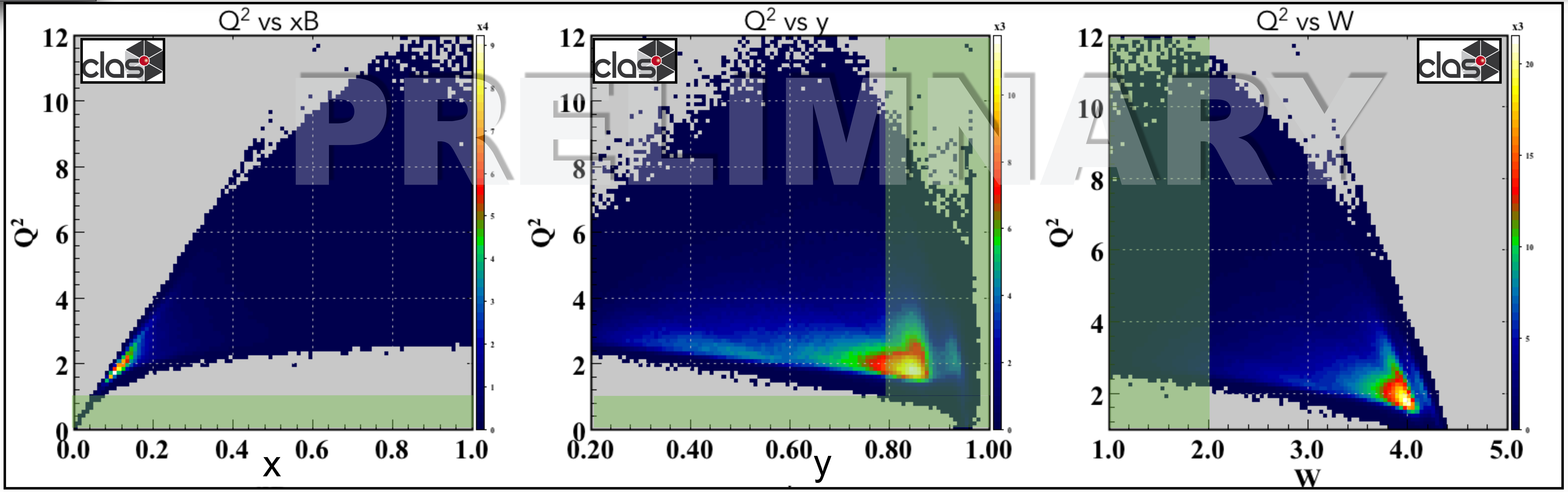


Data Sample:

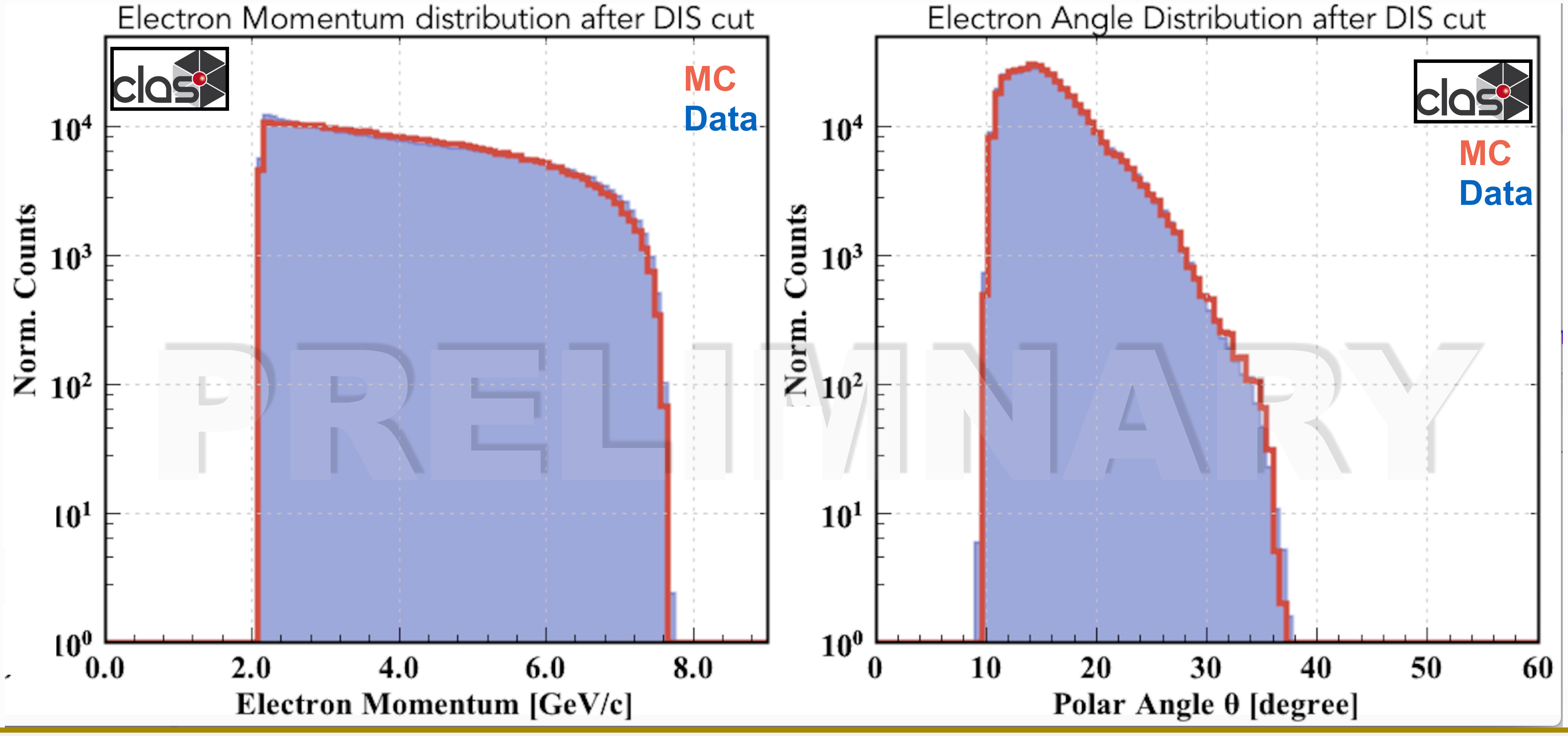
SIDIS:	$e\,P \longrightarrow e'\,\pi^0\,X$
DIS:	$e\,P \longrightarrow e'\,X$



Data Selection: Scattered Electron



$Q^2 > 1$ GeV^2
W > 2 GeV
y < 0.80



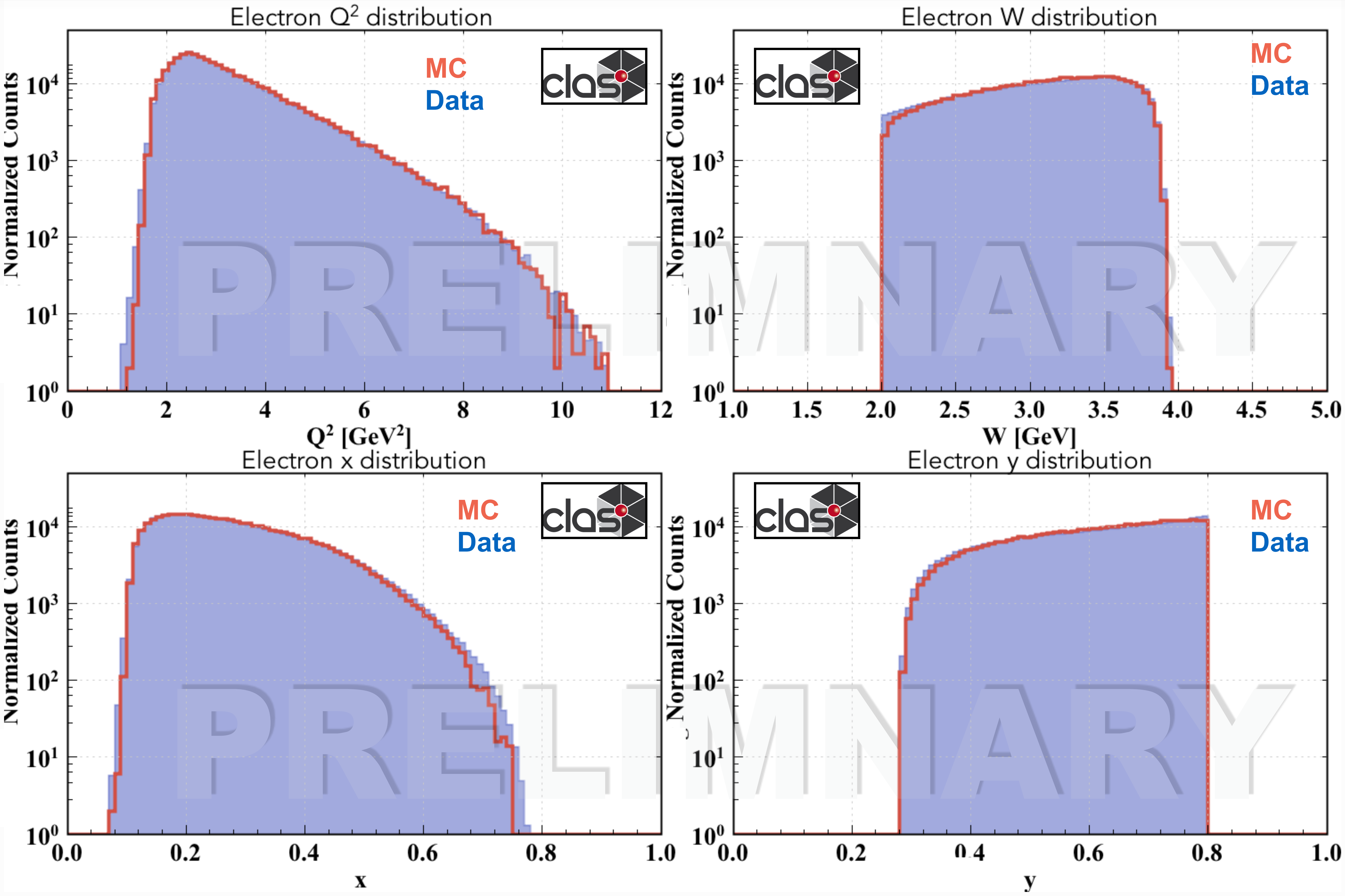
Reconstructed electrons kinematics

MC:

CLASDIS LUND Generator
Based on LEPTO-PEPSI

Hadronization:
Lund String Model

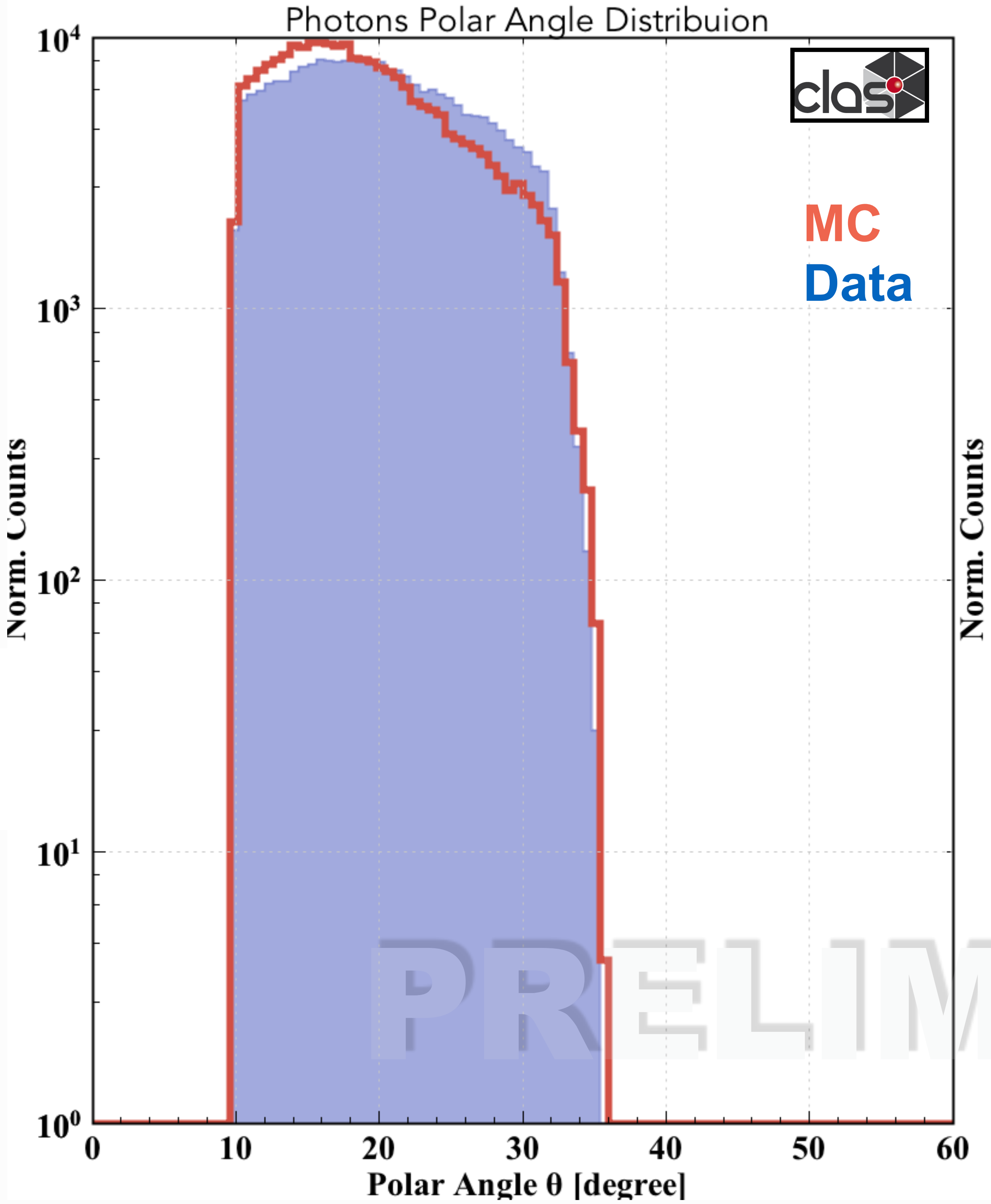
Data vs MC Kinematics

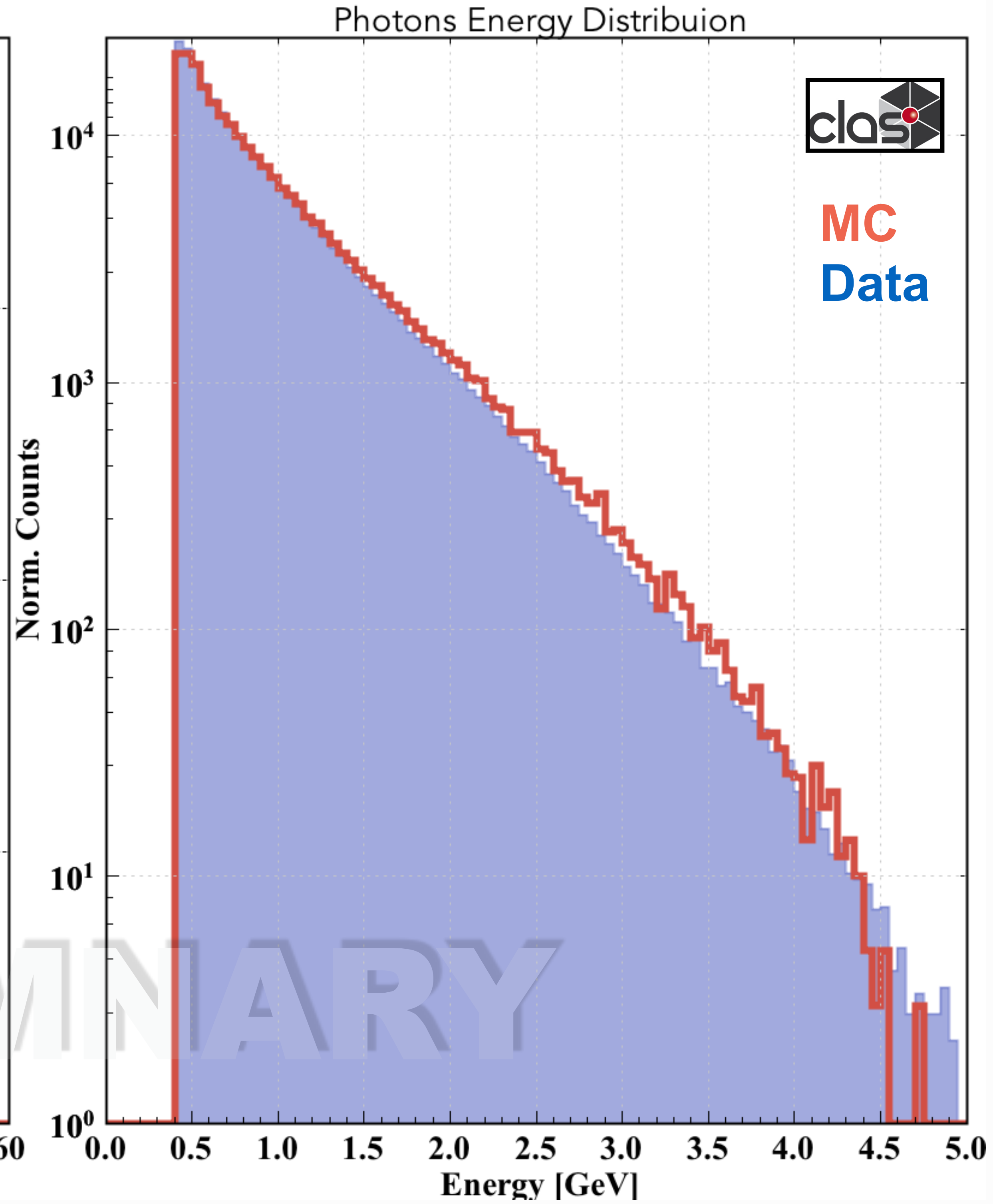


Reconstructed photons

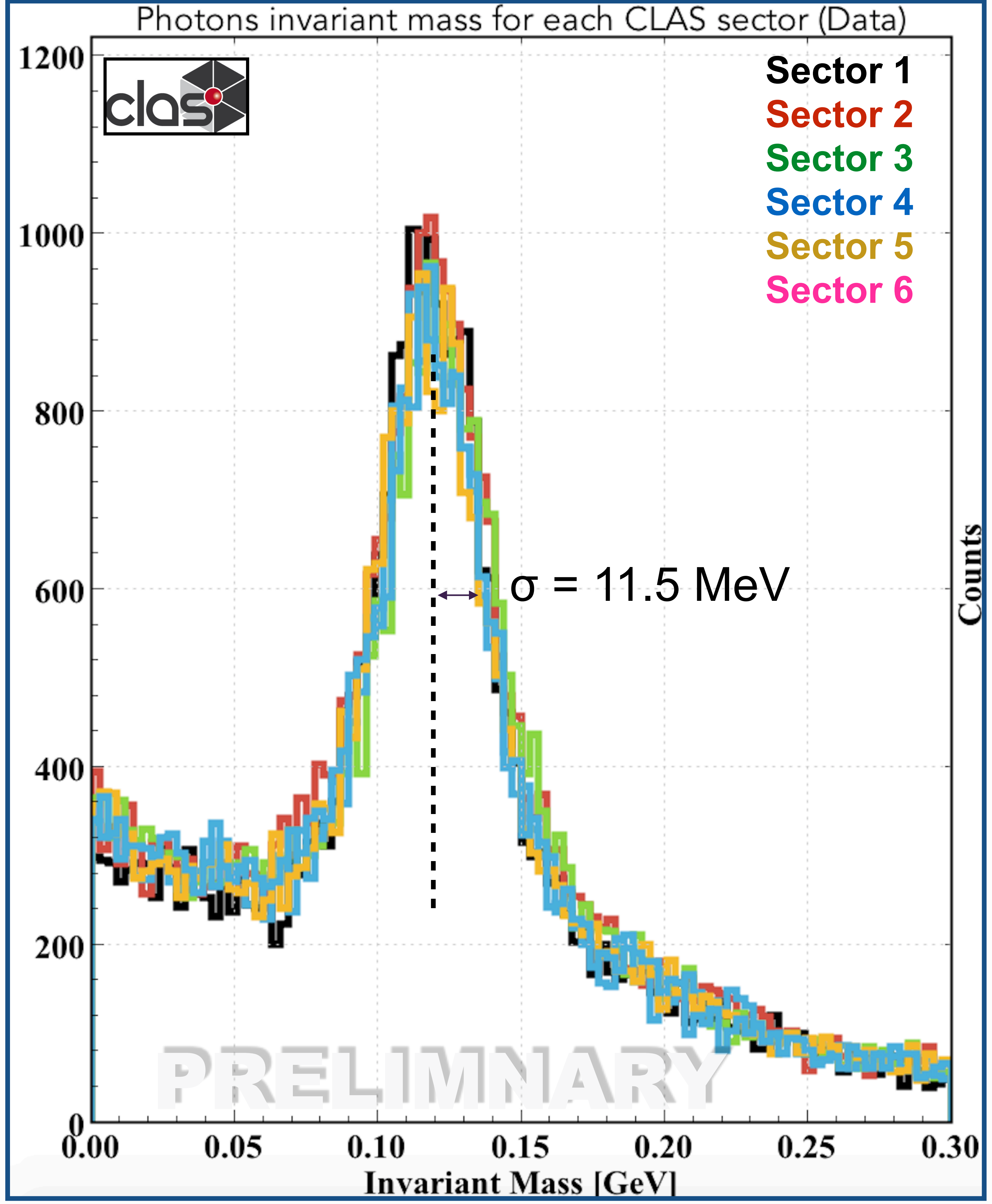
Photon selections

Photon Energy > 400 MeV
Photon with angle > 2 ° with respect e'





Cal. Sector Uniformity



$\pi 0$ Reconstruction in Z bins

Data divided in z bin (size 0.1)

$0.2 < z \leqslant 0.9$

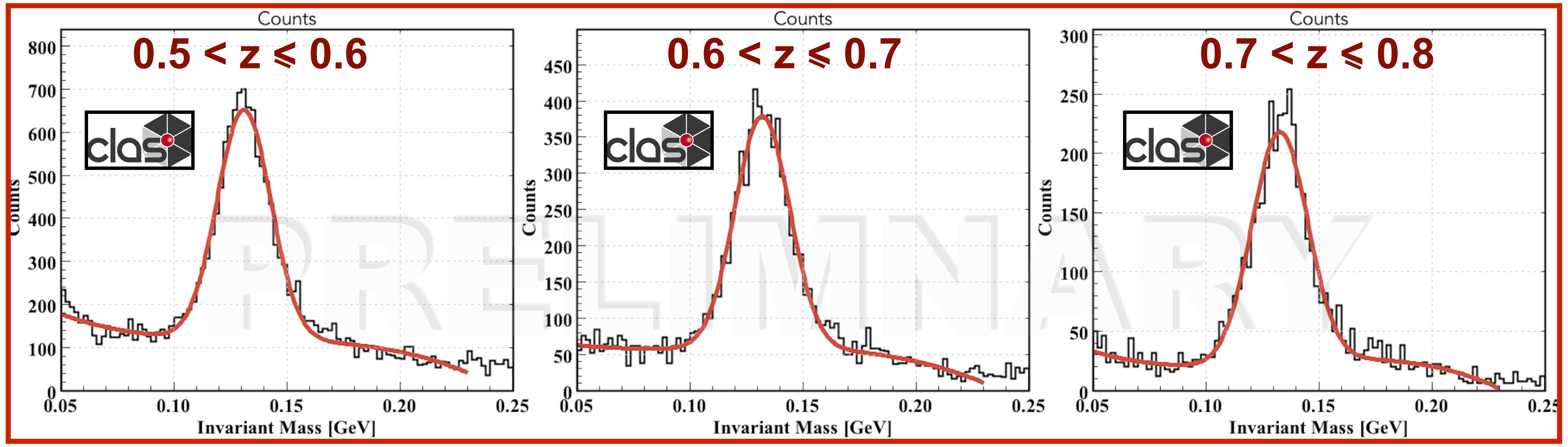
Each bin has been fitted with : Gauss + Poly 3rd

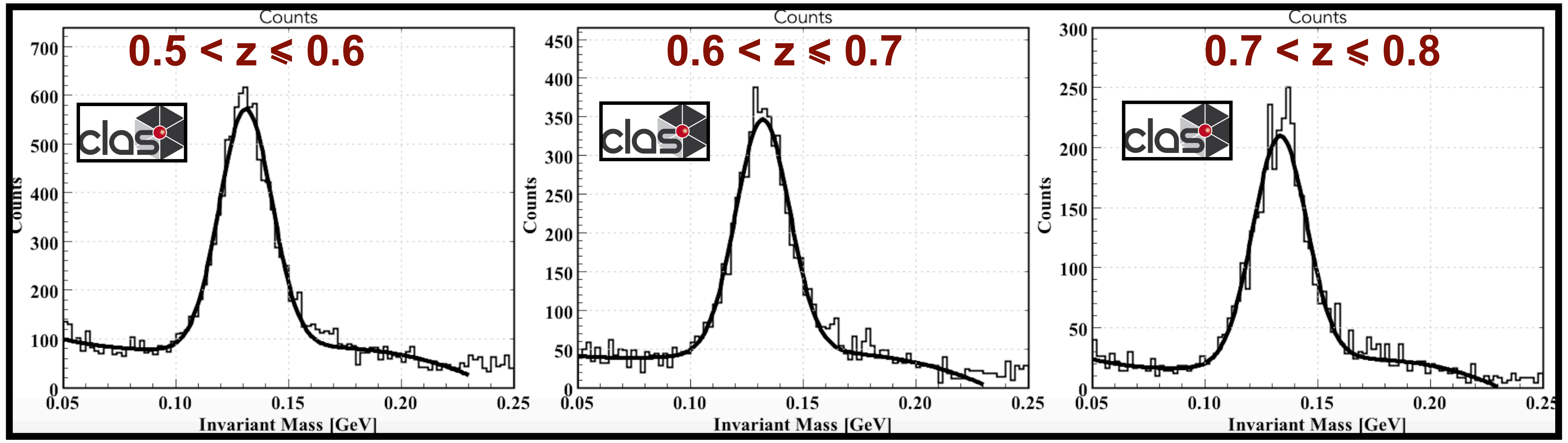
$\pi 0$ s obtained from the gaussian integral

Two methods:

-) Combination of all photons pair in event

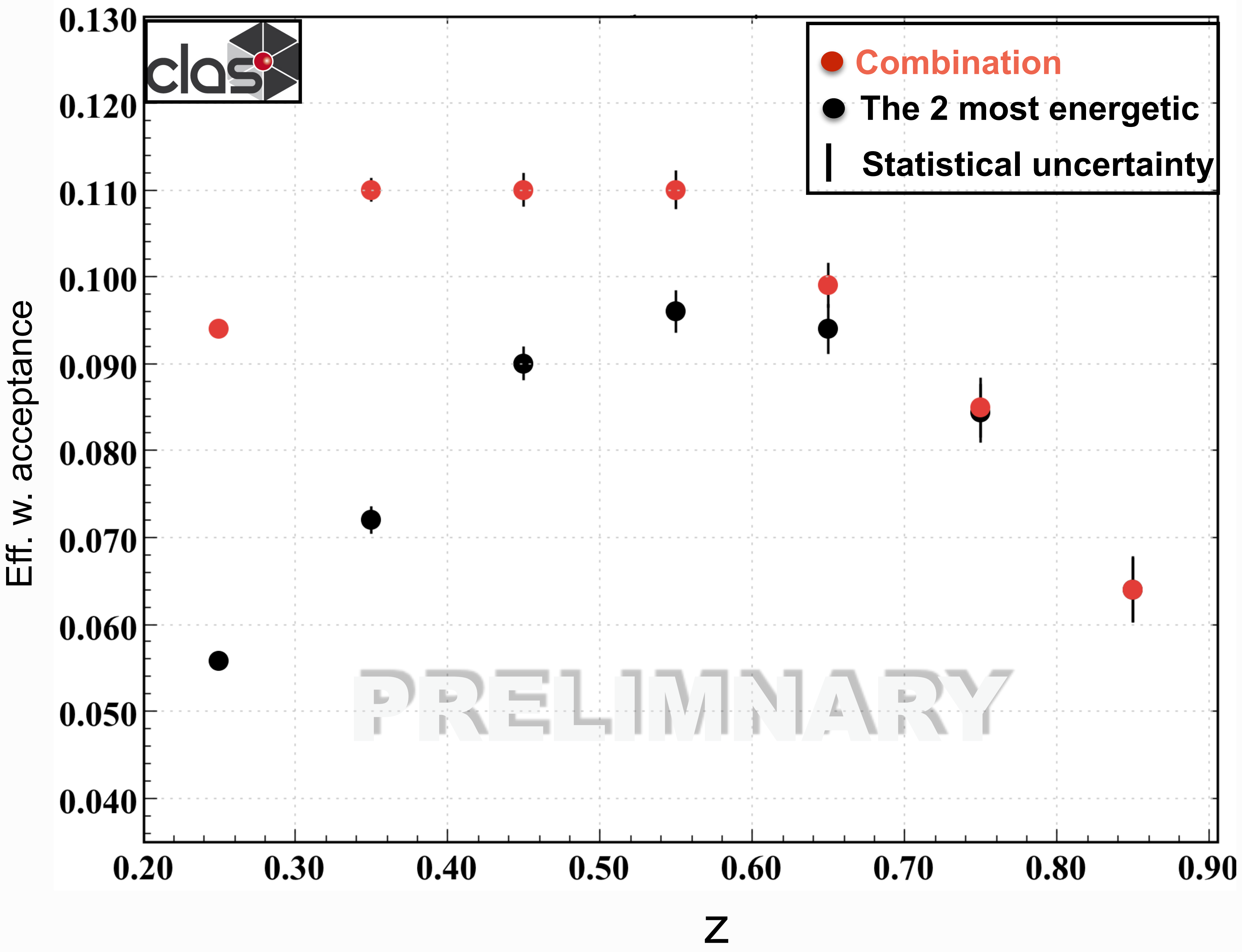
-) The 2 most energetic photons of the event





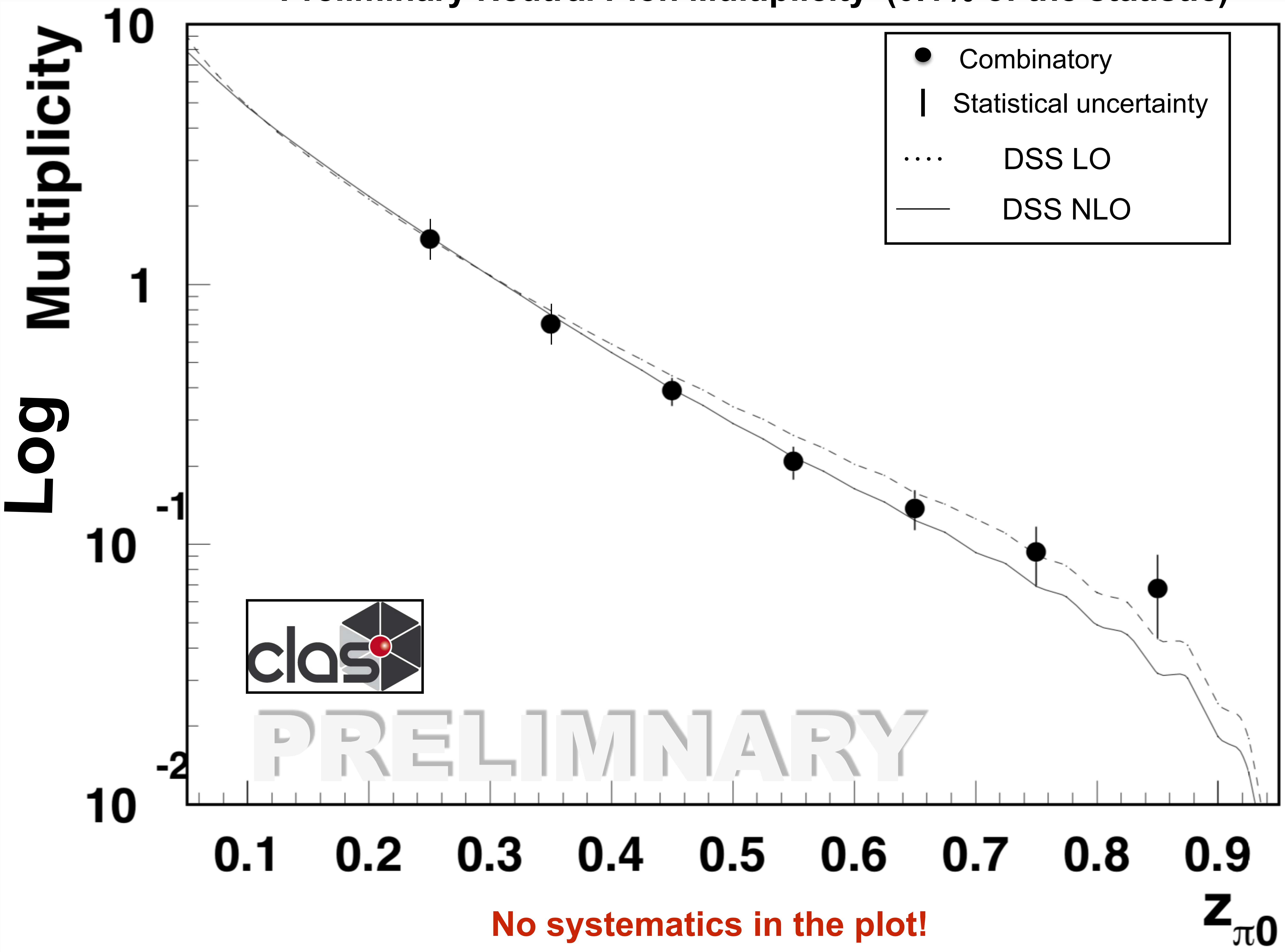
Efficiency w. Acceptance:

$$\frac{\pi 0\text{s reconstructed from MC (within the cuts)}}{\pi 0\text{s generated } (4\pi)}$$



Multiplicity of Neutral Pions Electroproduction

Preliminary Neutral Pion Multiplicity (0.1% of the statistic)



DSS: FF obtained from global fits.

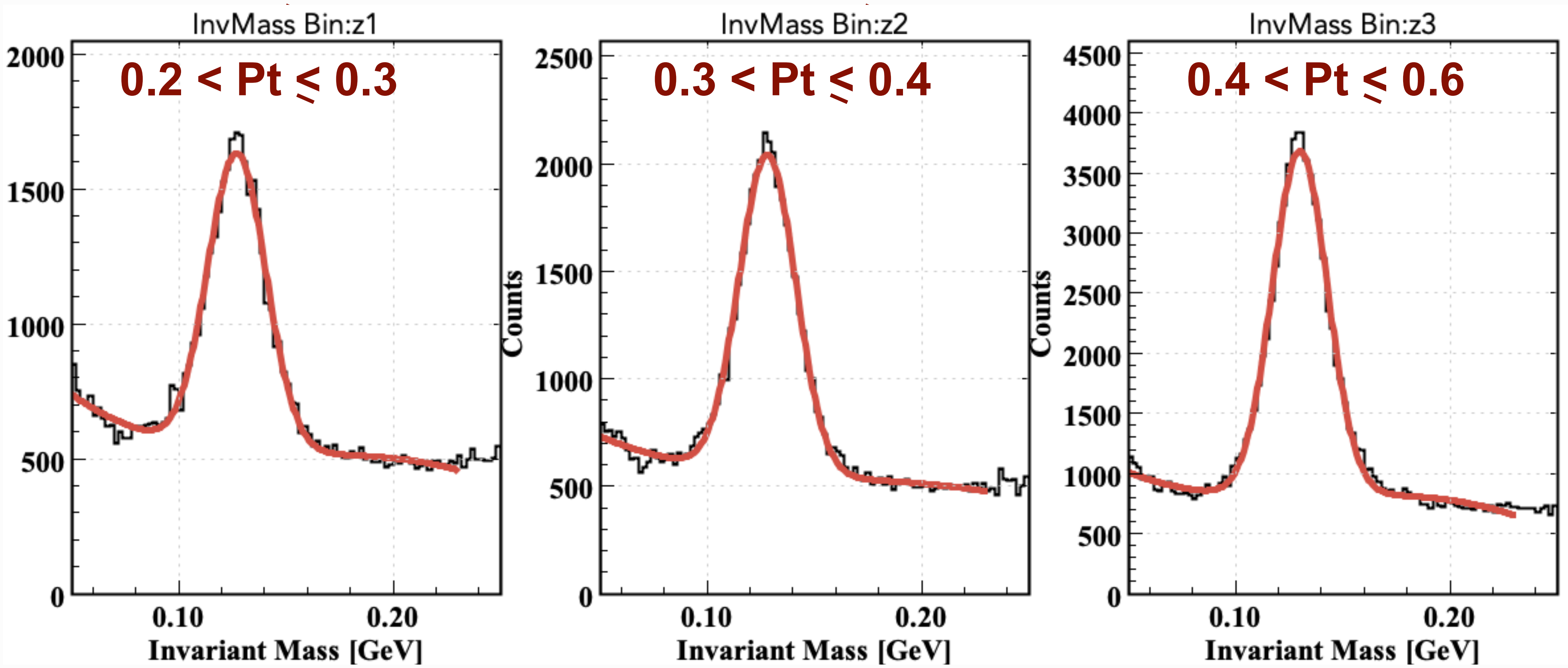
No systematics in the plot!

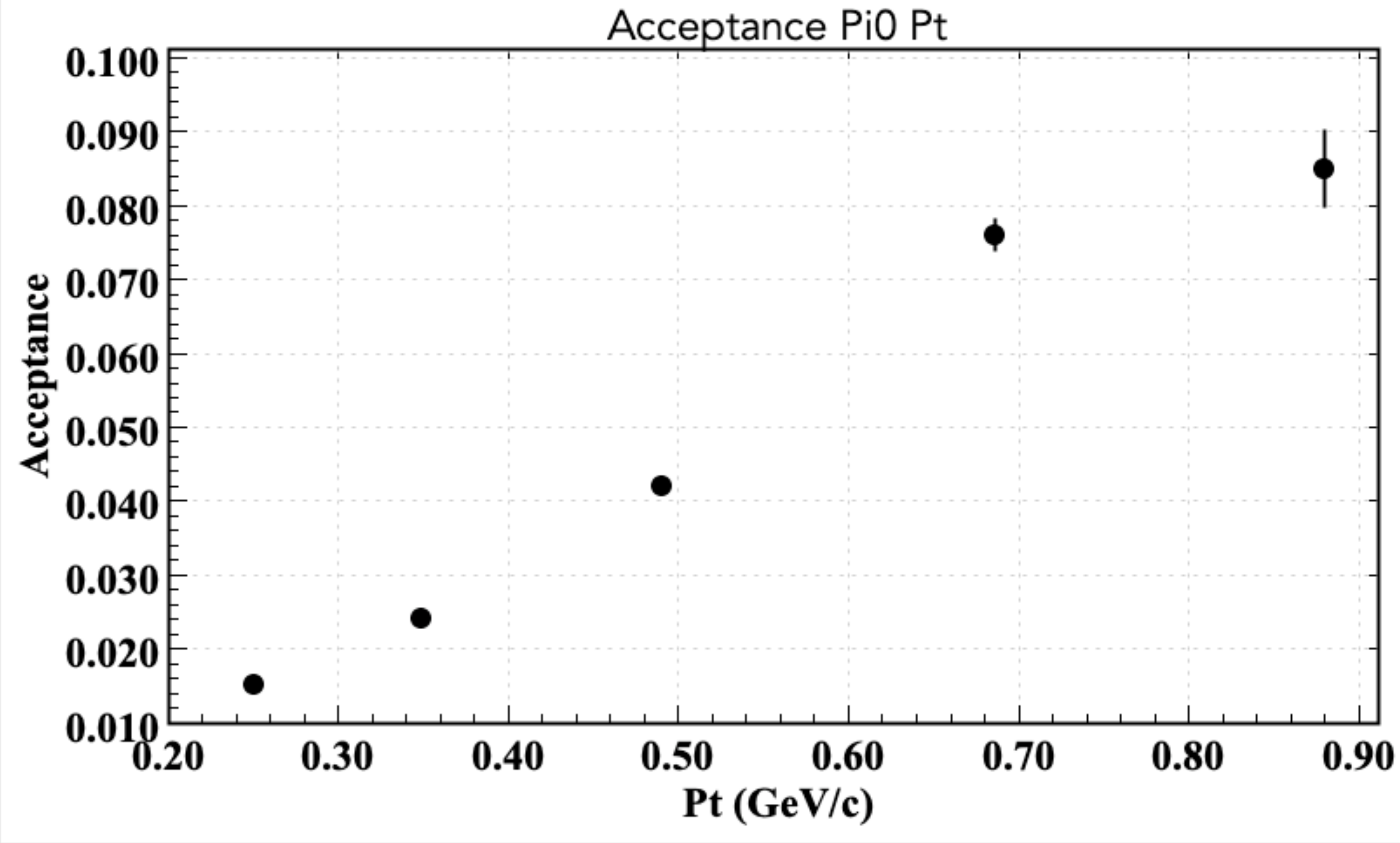
π0 Reconstruction in Pt bins

Data divided in Pt bin from 0.2 to 1GeV/c
Each bin has been fitted with : Gauss + Poly 3rd
π0 s obtained from the gaussian integral

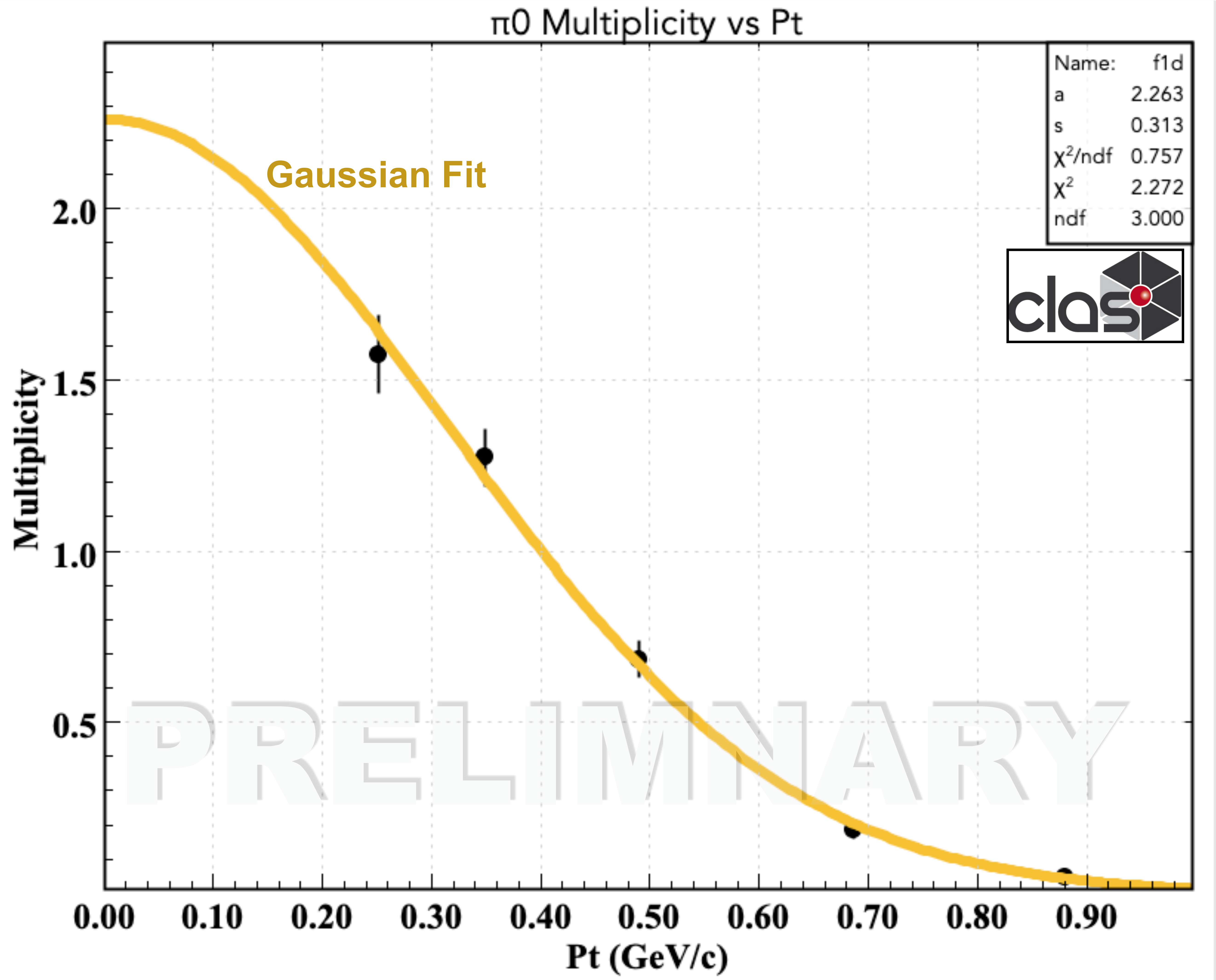
Efficiency w. Acceptance:

$$\frac{\pi0\text{s reconstructed from MC (within the cuts)}}{\pi0\text{s generated } (4\pi)}$$





π0 Reconstruction in PT bins

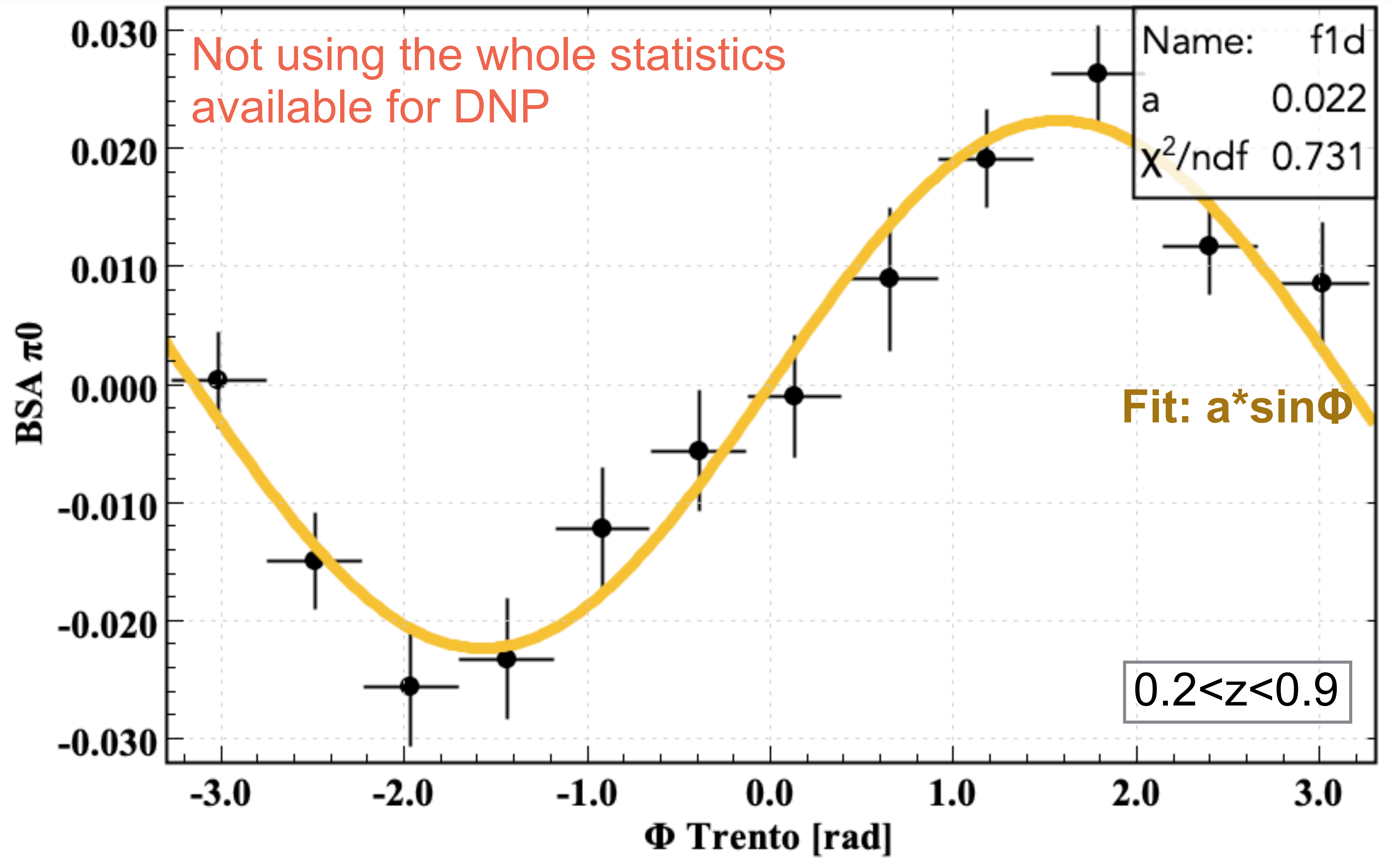


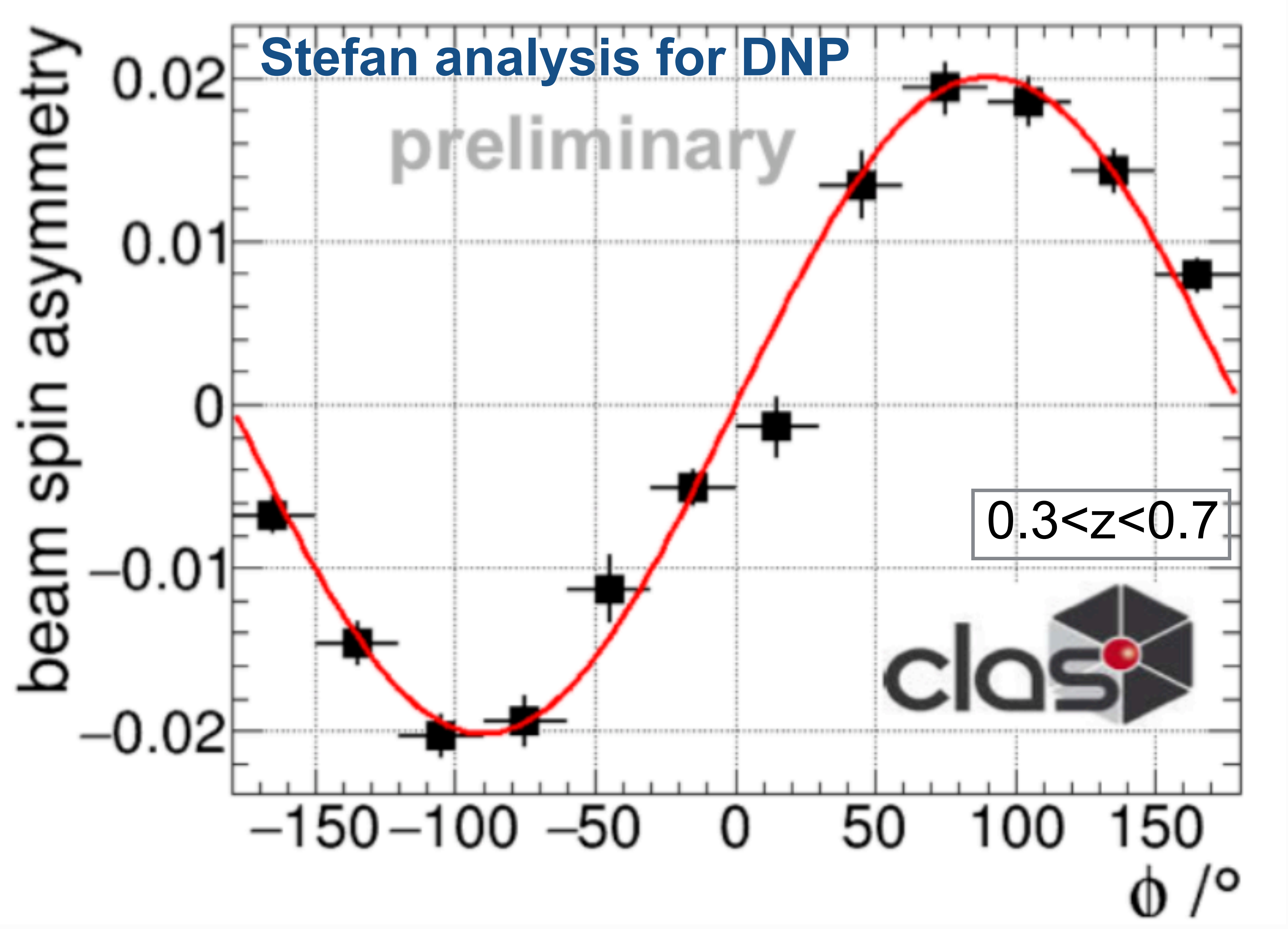
Beam Single Spin Asymmetry

Calculating nr of particle produced in SIDIS (multi dimensional bins) is a necessary step for multiplicity analysis.

BSA can be extracted from the same sample

$$BSA^{\pi 0} = \frac{1}{P} \frac{\overrightarrow{\pi^0} - \overleftarrow{\pi^0}}{\pi^0_{Total}}$$





MC, acceptances studies, fiducial cuts, etc. can be cross checked and used in both analysis

Independent cross checking with UCONN analysis

Conclusions

The multiplicity extracted as Z function follows global data.

The Pt distribution is in a good approximation gaussian with a sigma comparable with what expected by literature.

Next:
1)Production of 500M simulation for studying acceptances in multi-dimensional bins.
2) Multiplicity and BSA of Pi0

My Goal: Produce an Analysis note by the end of the year, PhD defense and publication in 2020

Extra Slides

π0 Advantages

For p0 at large x, when sea contribution can be neglected the ratio e'π^0X/ e'X should follow z-dependence of the fragmentation function (after integration over P_T)

$$\sigma_p^{eX} \propto 4u + d + \dots$$
$$\sigma_p^{\pi^0} \propto 4uD^{u\to\pi^0} + dD^{d\to\pi^0} + \dots$$
$$D^{u\to\pi^0} \approx D^{d\to\pi^0}$$

1) suppression of higher-twist contributions at large hadron energy fraction (particularly important at JLab energies where small z events are contaminated by target fragmentation)

2) the absence of ρ0 production which complicates the interpretation of the charged single-pion data

3) the fragmentation functions for u and d quarks to π0 are the same in first approximation

4) suppression of spin-dependent fragmentation for π0 s, due to the roughly equal magnitude and opposite sign of the Collins fragmentation functions for up and down

5) longitudinal photon contribution, is suppressed in exclusive neutral pions production with respect to the transverse photon contribution, which is higher twist, suggesting that longitudinal photon contribution to SIDIS π0 will also be suppressed.

6) at large x , where the sea contribution is negligible, π0 multiplicities and double spin asymmetries will provide direct info on the fragmentation function of u and d -quarks to pπ0 .

7) π0 data has better uniformity and smaller variations of averages of $\mathbf{P_T}$ with **x** due to correlations between longitudinal and transverse momentum of quarks and hadrons

MC Needs

1st (Now up to May) :
500 M DIS eP processes in Spring 2018 configuration (10% of it already produced in DST format)
-Generator: CLASDIS with no radiative processes.
- To be ready in about 1.5 months
- Disk space: 1.4 Tb
- **Need another use**r to lunch simulation to have them completed in 1.5 months.

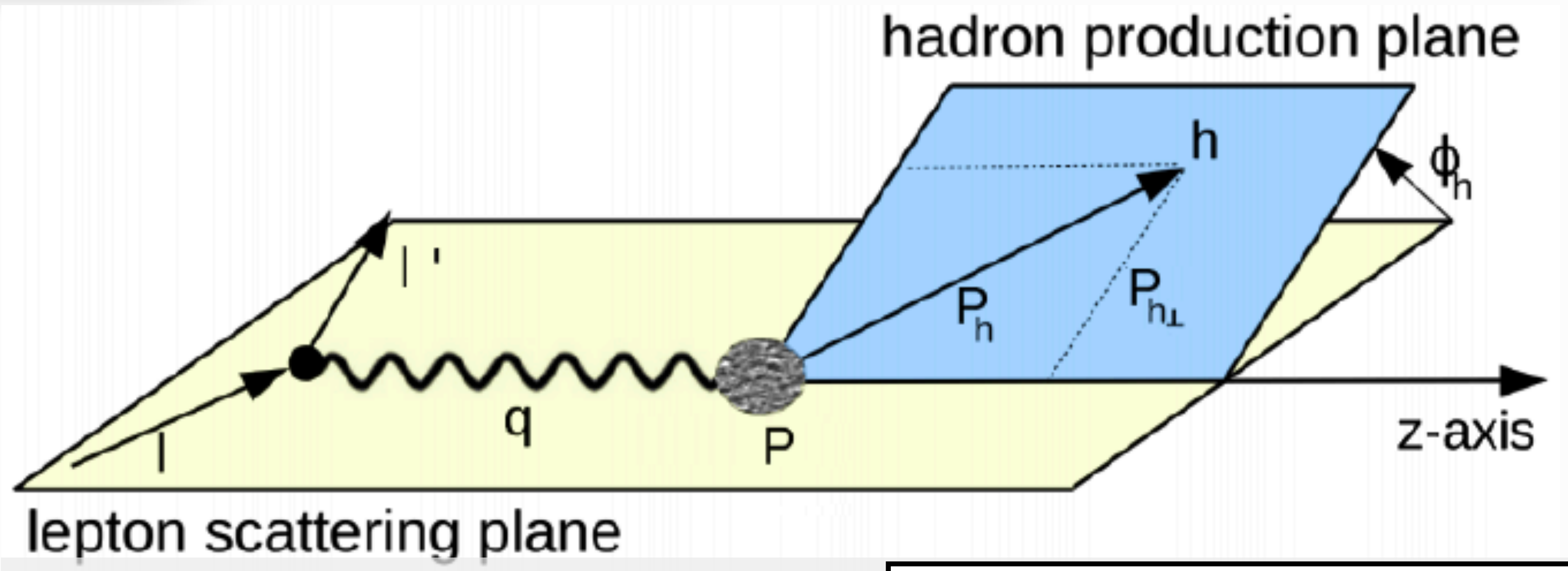
June to be spent to compare data and Montecarlo of 1st production.

2nd (Summer 2019):
- 500 M to 1000 M DIS eP process with radiative effects. CLASDIS + radiative processes (maybe)
- Produce them July-August.
- Disk Space: <4 Tb
- **Need 1 or 2 users to submit jobs** and have them completed in 2 months.

September for study in 2nd production.

If everything is ok, producing analysis note October-November.

Beam Single Spin Asymmetry



$$\boxed{e(l)P(P) \rightarrow e(l')h(P_h)X}$$

$$d\sigma = d\sigma_0(1 + A_{UU}^{cos\phi} cos\phi + A_{UU}^{cos2\phi} cos2\phi + \lambda_e A_{LU}^{sin\phi} sin\phi).$$

$$A_{LU}^{sin\phi} = \frac{\sqrt{2\epsilon(1-\epsilon)}F_{LU}^{sin\phi}}{F_{UU,T} + \epsilon F_{UU,L}}, \quad A_{UU}^{cos\phi} = \frac{\sqrt{2\epsilon(1+\epsilon)}F_{UU}^{cos\phi}}{F_{UU,T} + \epsilon F_{UU,L}}, \quad A_{UU}^{cos2\phi} = \frac{\epsilon F_{UU}^{cos2\phi}}{F_{UU,T} + \epsilon F_{UU,L}}.$$

$$BSA = \frac{d\sigma^+ - d\sigma^-}{d\sigma^+ + d\sigma^-} = \frac{A_{LU}^{\sin\phi} \sin\phi}{1 + A_{UU}^{\cos\phi} \cos\phi + A_{UU}^{\cos(2\phi)} \cos(2\phi)}$$

Measured in Hermes, Compass and CLAS6

Clas12 will have significant higher statistics and extended kinematic coverage.

Dominated by the sinφ term (often referred as : sinφ moment)