PCAL/ECAL reconstruction studies With neutral pions

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Current knowledge

- We are already aware that there are some limitations in PCAL/ECAL reconstruction to detect high energy pi0's
  (Talk of Cole yesteday !)

- When the opening angle gets below 3 degrees, the energy of the two photons is not correctly shared.

- A possible solution is to compare the opening angle with the energy asymetry with the two photons when they are both detected.

DVCS and neutral pions

- The final state for the deeply virtual compton scattering (DVCS) consists of
  - the scattered electron,
  - the recoil proton,
  - a multi-GeV photon.

- To ensure the exclusivity, several cuts can be performed on monentum/energy balance :
  - Missing transverse momentum,
  - angle between expected photon and detected photon,
  - Missing energy,
  -…

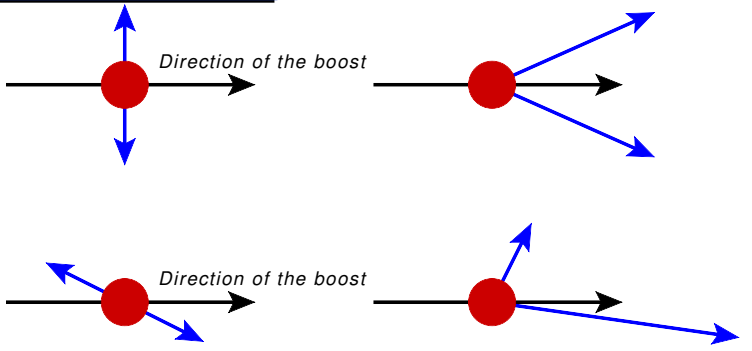
- However, inspite of the cuts on all these variables, high-energy pi0’s will induce some comtamination which must be subtracted

The pi0 contamination

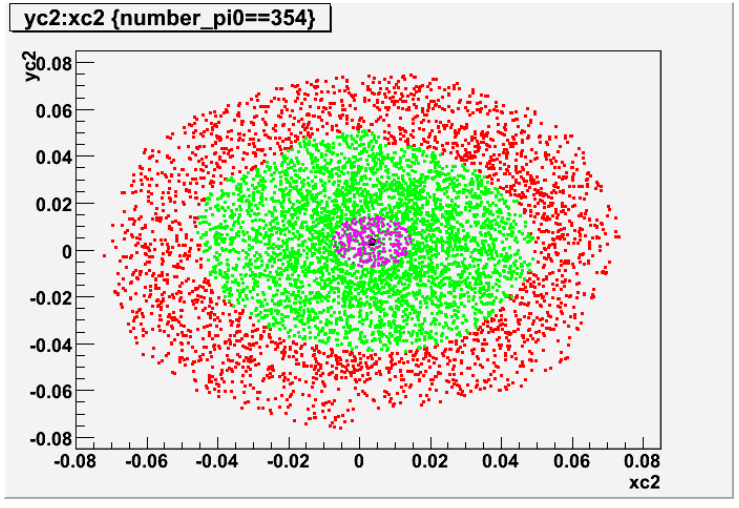
- Pi0 contamination arises from asymmetric decay of pi0 (one photon inherits all the pi0 energy).

- **Black dot** = impact point of 2-GeV pi0 at 1 m,
  Red dots = 2 detected photons,
  Green dots = 1 photon but no DVCS,
  Purple dots = 1 photon id as dvcs.

- For a pi0 at a higher energy, the distance between 2 detected photons decreased.



Pion rest frame Laboratory frame



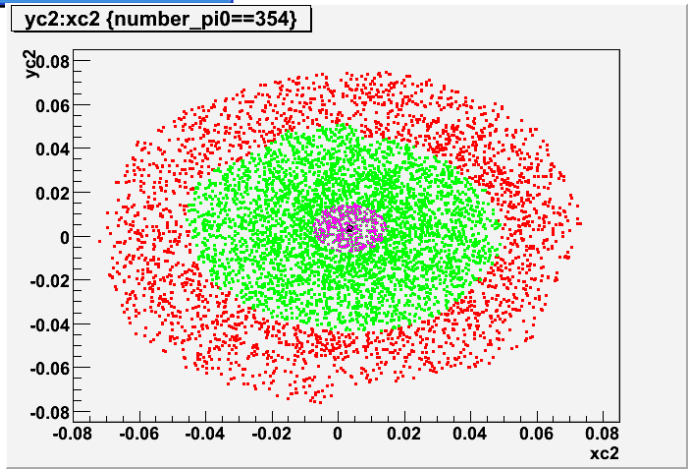
Pi0 subtraction principle

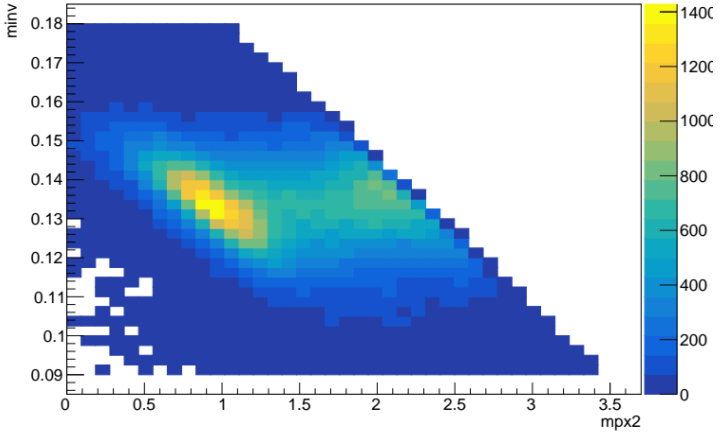
Black dot = impact point of 2-GeV pi0 at 1 m,
Red dots = 2 detected photons,
Green dots = 1 photon but no DVCS,
Purple dots = 1 photon id as dvcs.

« DVCS-contamination » given by **Purple dots / Red dots**.

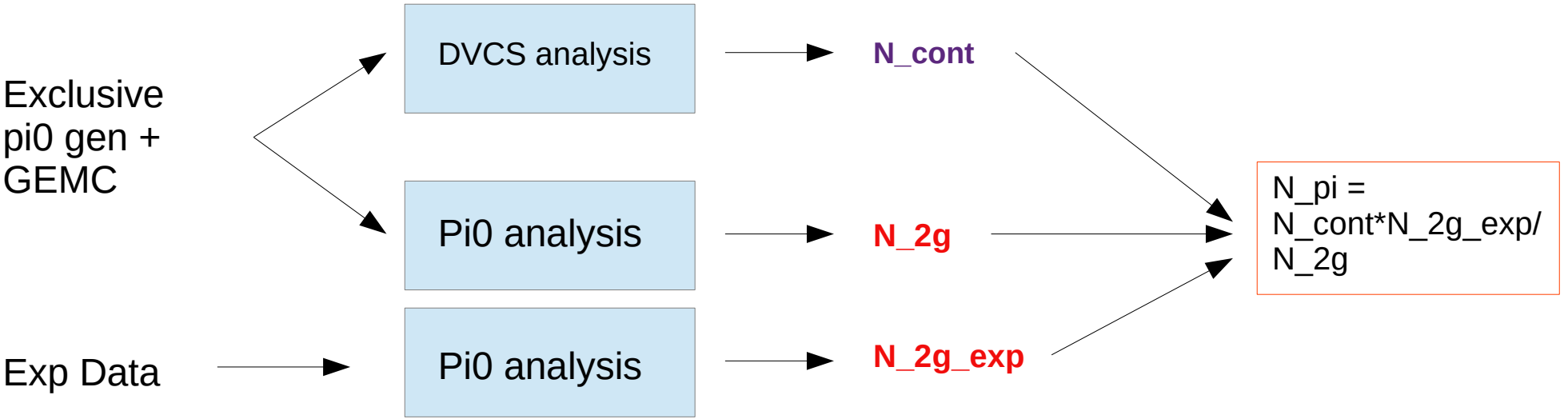
The ratio is derived using Monte-Carlo simulation.

Normalization is given by pi0's in dataset





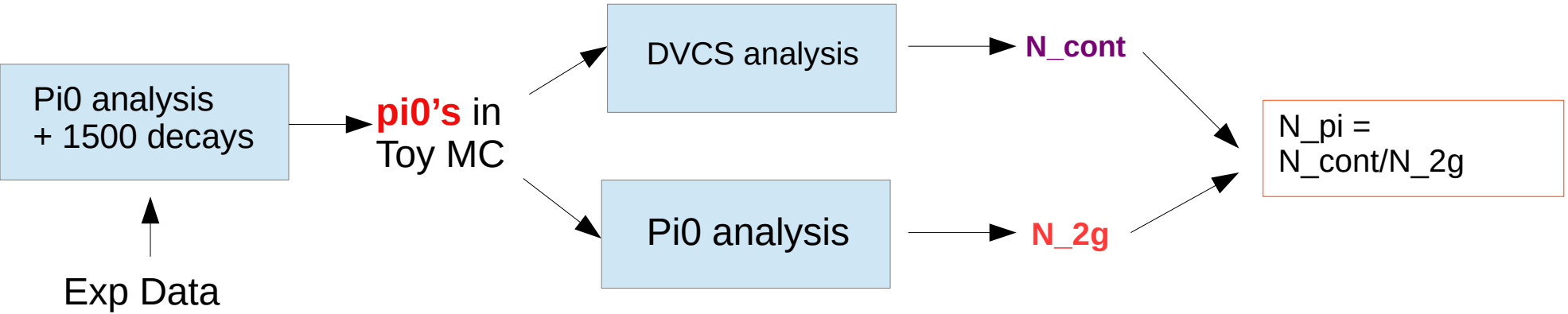
Method 1 : The MC-driven method



- Advantage : Faithful geometrical description of CLAS12

- Drawback : Is it only exclusive pi0 ?
  Absolute yield required for pi0 ~ Cross section !!

Method 2 : The data-driven method

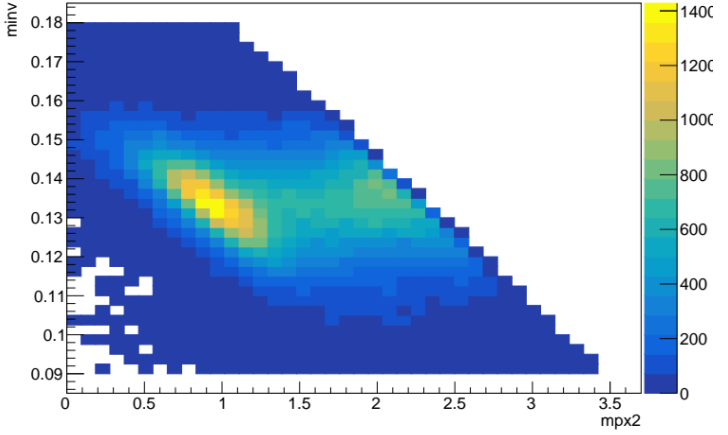


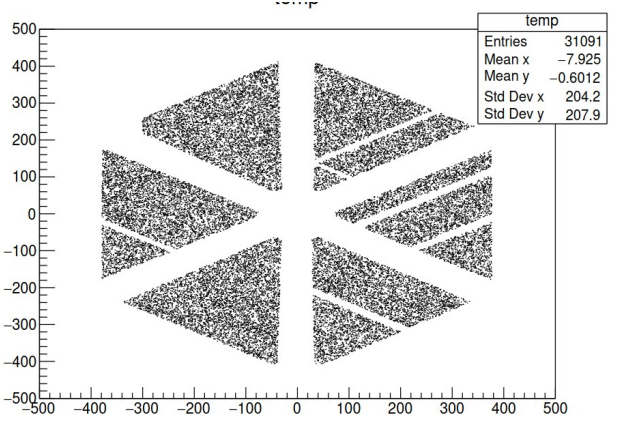
- Advantage : Faithful electron + proton shapes from data
  Exclusive + SIDIS pi0's
  Drawback : DVCS analysis must include pi0 acceptance check
  Toy MC assumes ideal reconstruction for cal.

Method 2-a : Pi0 selection

- Cuts on :
  - photon + electron + proton fiducial cuts
  - Invariant mass of photons
  - Missing mass ep → e \gamma \gamma X

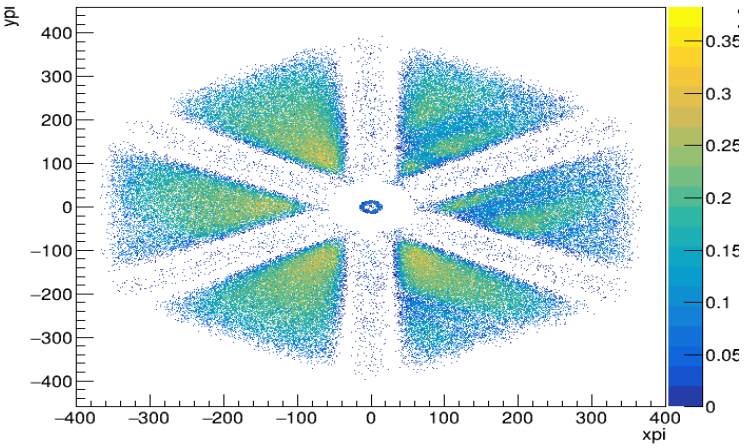
- For each pi0 selected, create 1500 MC events :
  → Electron from exp event,
  → Proton from exp event,
  → Two photons from a MC decay of the pi0.



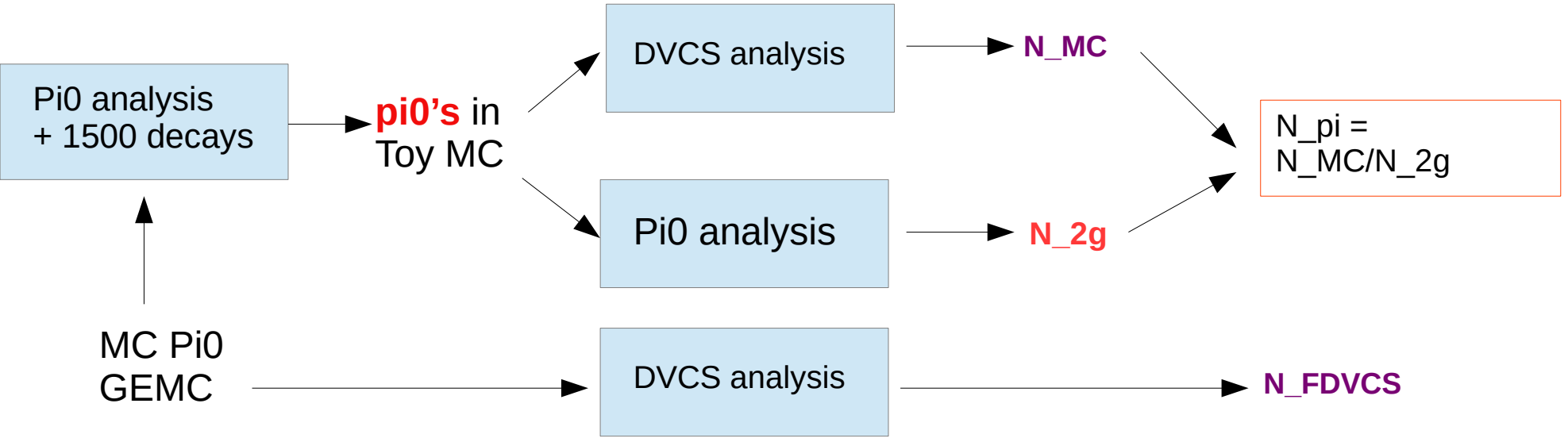


Method 2-b : Photon in Toy-MC

- Electron and proton are known to be detected since form the data.
- If the photons reaches PCAL/ECAL, there are considered detected => Fiducial cuts
- But they may undergo pair conversion
  F(X)= F0*Exp(-7/9*X/X0)



Method 2 : Validation...

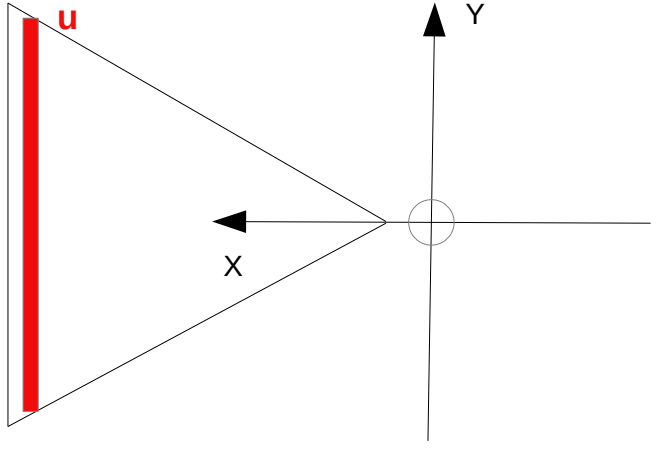


- As input, a pi0 simulation with GEMC and I must obtain N_FDVCS = N_pi.

- Obviously I would not be talking if it was found...

Method 2 : Toy MC vs GEMC

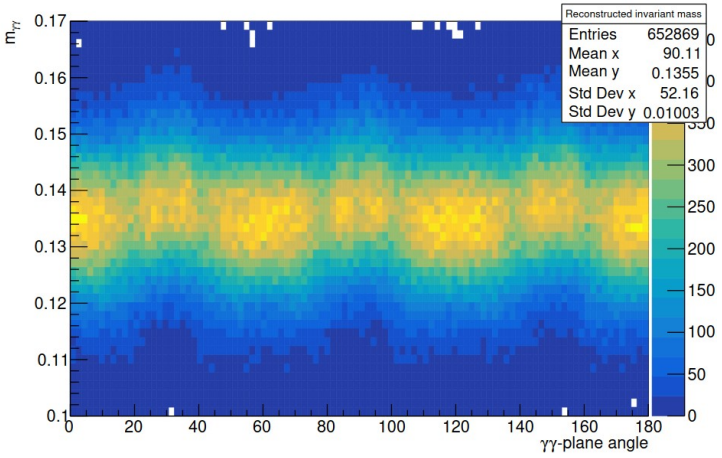
- To study the pi0 reconstruction, this method is quite convenience since it will highlight differences from a ideal behaviour.
- But before let’s check the reconstructed pi0s.
- Definition of the gg-plane angle : atan2(ny,nx) with n=g1*g2
- U= 90 degrees / V= 30 degrees

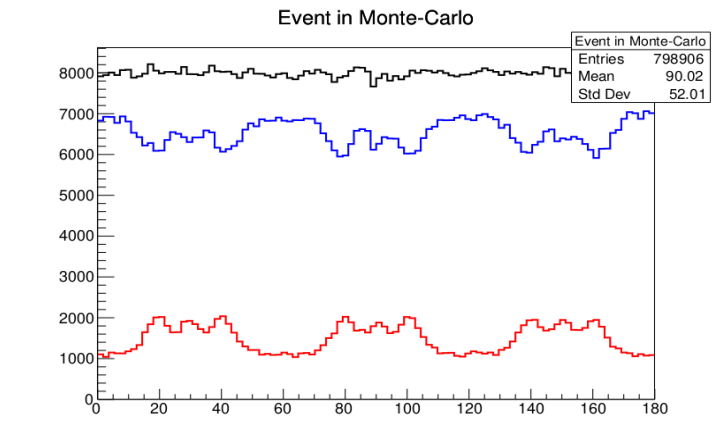


A few subtleties with MC

- Slight but definitely there, correlation between invariant mass and the gg-plane angle.
- Reduced 2-photons acceptance when hit on same U/V/W
- Increase of « 1-photon » decays at the expense of « 2-photon » decays

  => Does 10 % 2-photon loss induce 10 % additional contamination ?



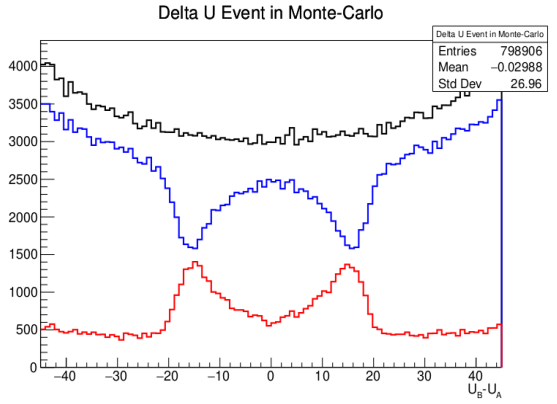


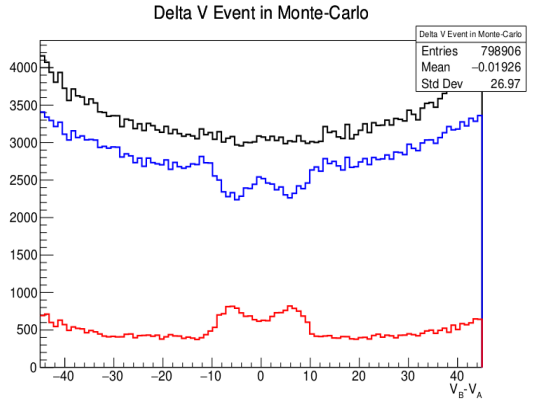
Looking at U/V/W specifically...

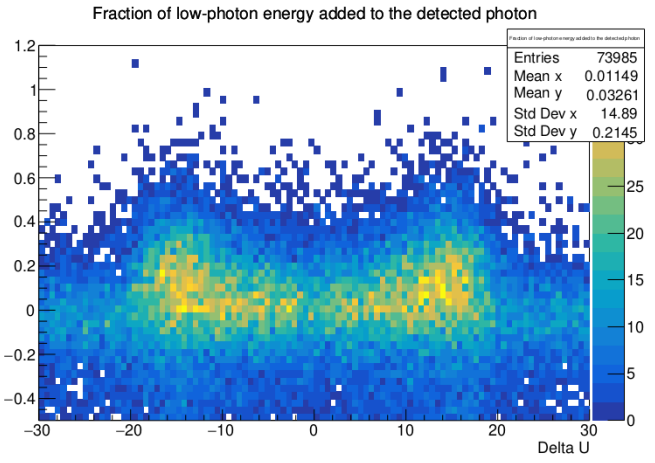
- Looking at dU=U2-U1, or dV/dW, the picture is clearer.
  Black = Generated
  Blue = 2 detected
  Red = 1 detected.

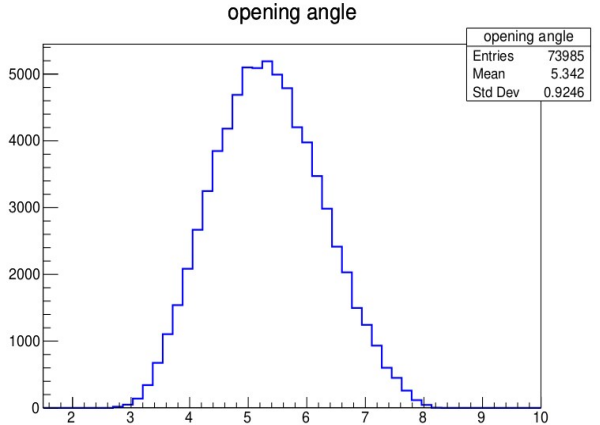
- Fraction of energy merged the high energy photon.

- Not only for small opening angle pi0.





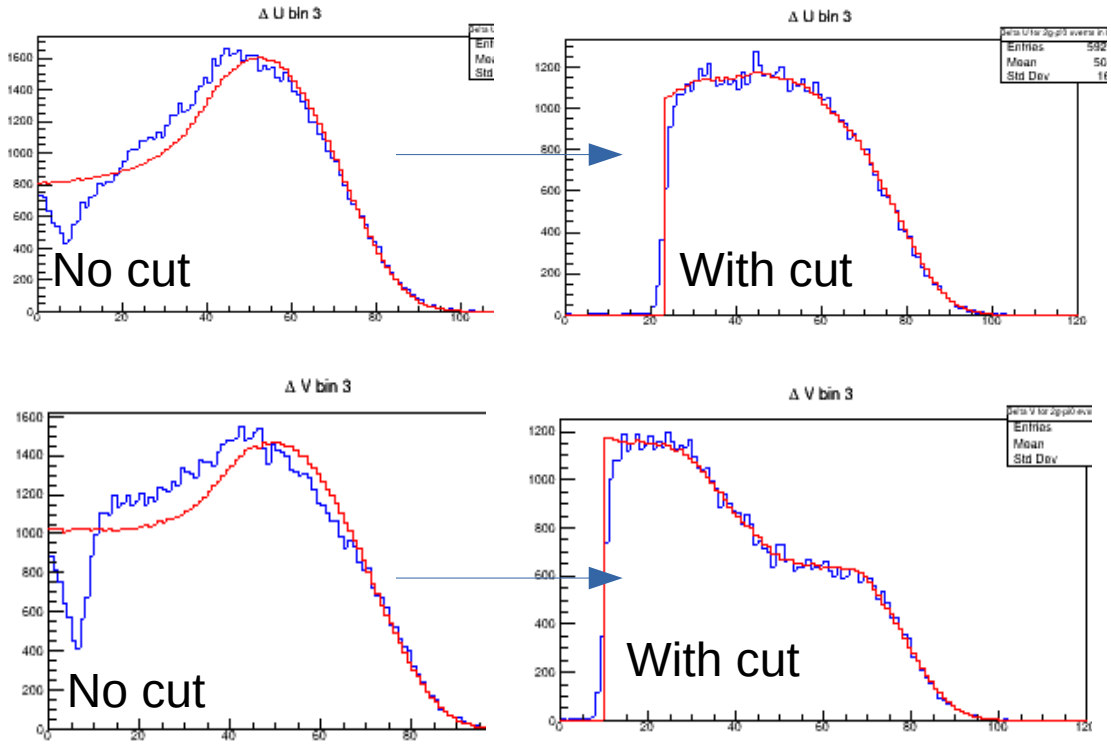




GEMC vs Toy MC

- Now, if we compare the reconstructed distributions from GEMC, and the one from my Toy-MC, we clearly see the dip at small dU/dV in 2 photons => Wrong normalization !!

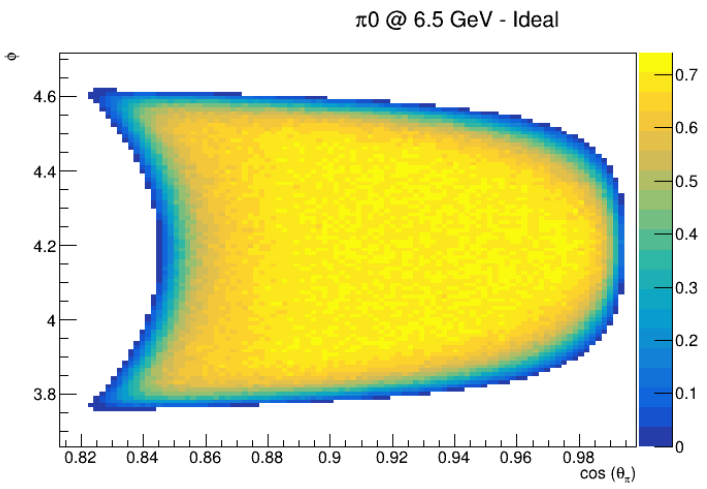
- But requiring dU > 20 cm and dV/dW> 10 cm definitely improve the agreement between Toy MC and GEMC-COATJAVA reconstruction.

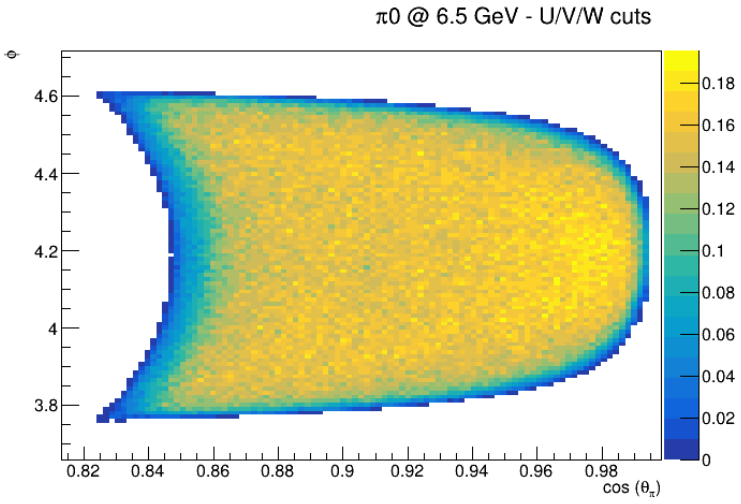


Blue = Generated distribution when the 2 photons are reconstructed
Red = Toy-MC reconstructed

At what cost ?

- By cutting on dU/dV/dW the normalization is restored but it dramatically decreases the acceptance for pi0 as its energy is high.





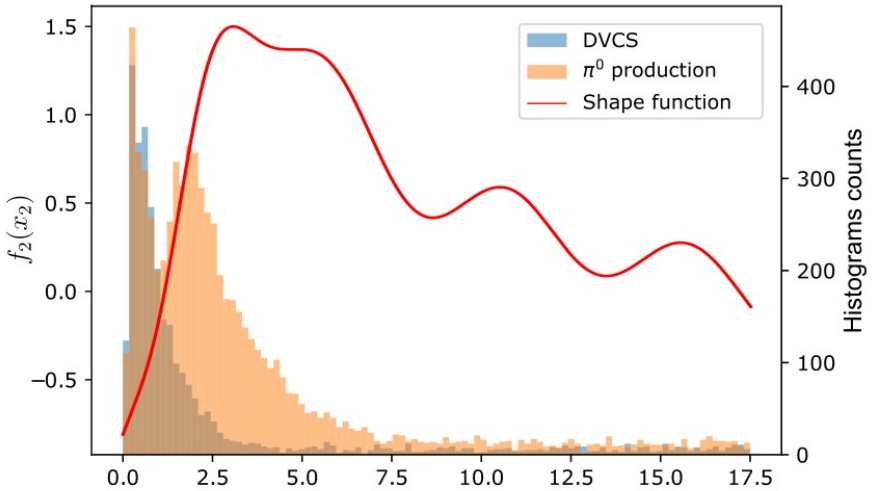
Next question to be answered : Do we have additional contamination in DVCS ?
Stay tuned !

Splitted photons

Need to be characterized but does not seem too be much of an issue.

Probably must merge all photons/neutrons with angle smaller than 1 degree.

Need to be quantified.



$$x_2 = \text{angle}\left(\overrightarrow{p^{\gamma_1}}, \overrightarrow{p^{\gamma_1}} + \overrightarrow{p^{\gamma_2}}\right)$$

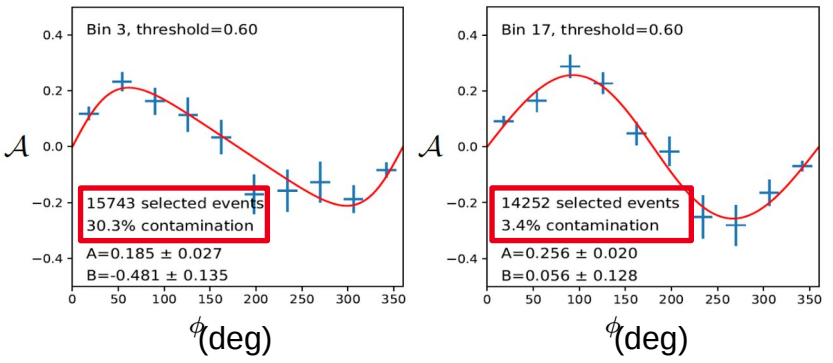
Conclusion

- No matter the opening angle between the photons, they partially merge when they hit same U/V/W.
- Ideal reconstruction otherwise.
- Need to investigate the environment of the photon (close fake photons/neutrons).
- I'll keep reporting to understand better the current reconstruction (we want to write the analysis note for June).

Thank you collaborators !

- Thank you very much for your participation to the ML survey => Very rare !
- Noelie defended on Monday and obtained her PhD with congratulations !
- The thesis will be soon uploaded to CLAS database.

GAM



Cuts