

dRICH Simulation Meeting : 07/05/2026

**Understanding the time distribution of dRICH Hits:
Generator and full detector level checks of the dRICH Hit
Time Tail**

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INFN Trieste

Recap (dRICH Simulation Meeting-26/03/2026) :

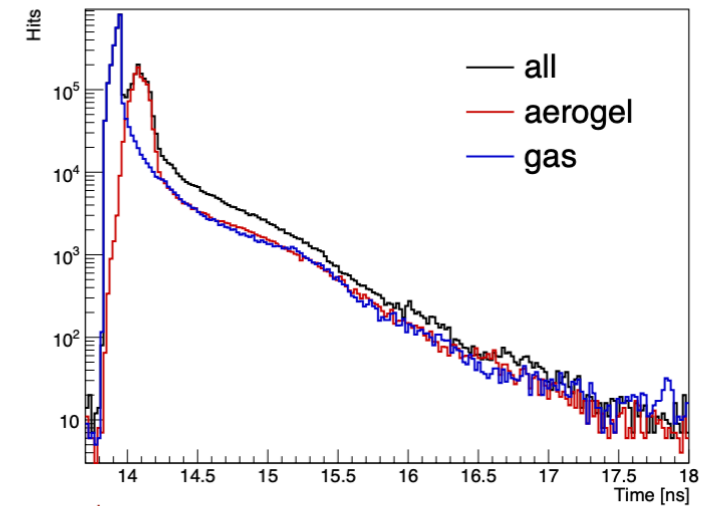
Previous observations

- A clear late-time component appears beyond the prompt photon-hit peaks.
- The tail is not only a gas effect or only an aerogel effect; both radiator configurations contribute.
- Late-time photon hits are dominated by photons whose immediate parent is a secondary particle; among those secondary parents, electrons/positrons are a major component.

Open question for this talk

- Is this tail sensitive to the event-generation method:
Particle Gun vs HepMC?
- Does the **full-detector setup** enhance the secondary-induced late tail?

TAIL ?

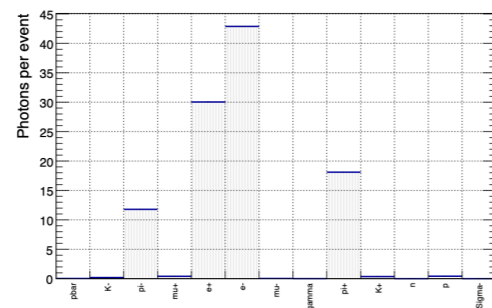
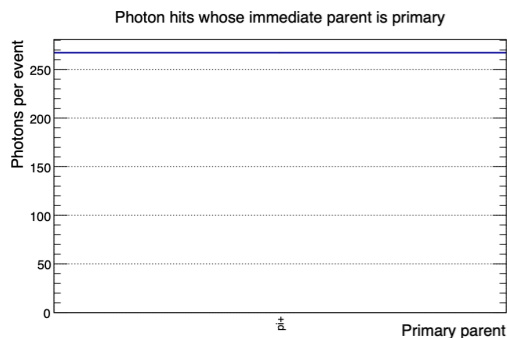
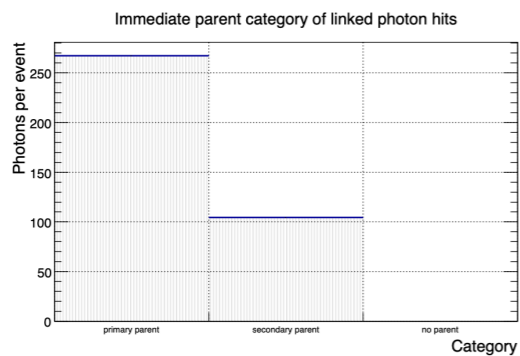
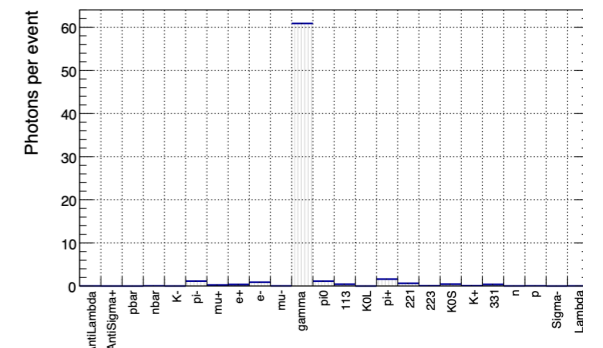
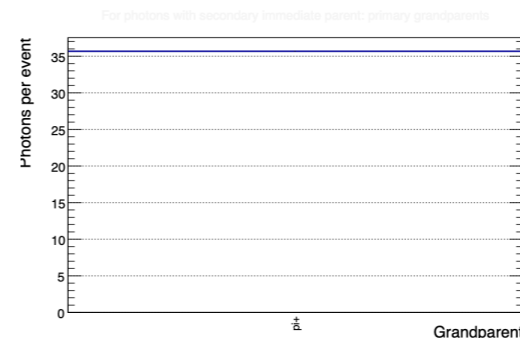
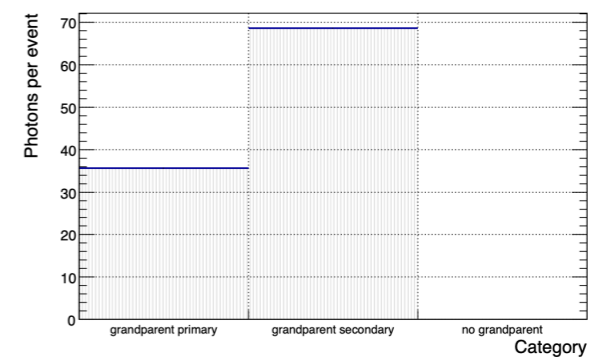


* legends' meaning : "all" means aerogel and gas;
: "gas" means gas and vacuum;
: "aerogel" means vacuum and aerogel;

❖ The observed tail is a combined effect of both radiators rather than a feature of only one radiator.

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Grand-Parent Particle Type :



*Y-axis shows the number of hits per event.

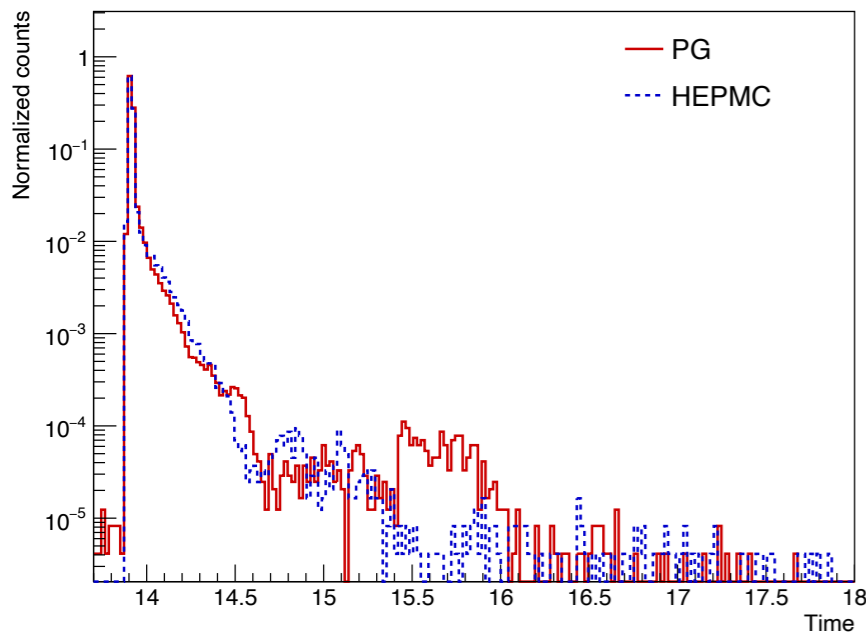
Simulation setup:

Quantity	Particle Gun	HepMC
Particle	π^+	π^+
PDG	211	211
Energy / momentum scale	30 GeV	30 GeV/c
ϕ	90°	90°
η values	1.5, 2.0, 2.5, 3.0, 3.5	same
Events	same per η (1000)	same per η (1000)
Detector setup	dRICH-only and Full Detector	same

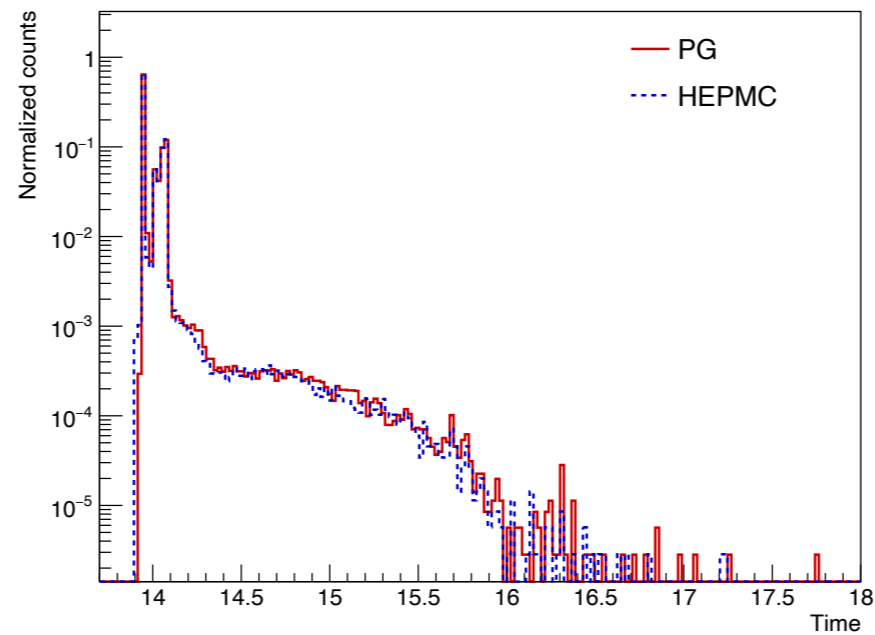
Normalized time distribution for PION generated from *Particle Gun* (*PG*) & *HepMC* for different η (no. of events, p , ϕ are same)

Simulation : dRICH Only

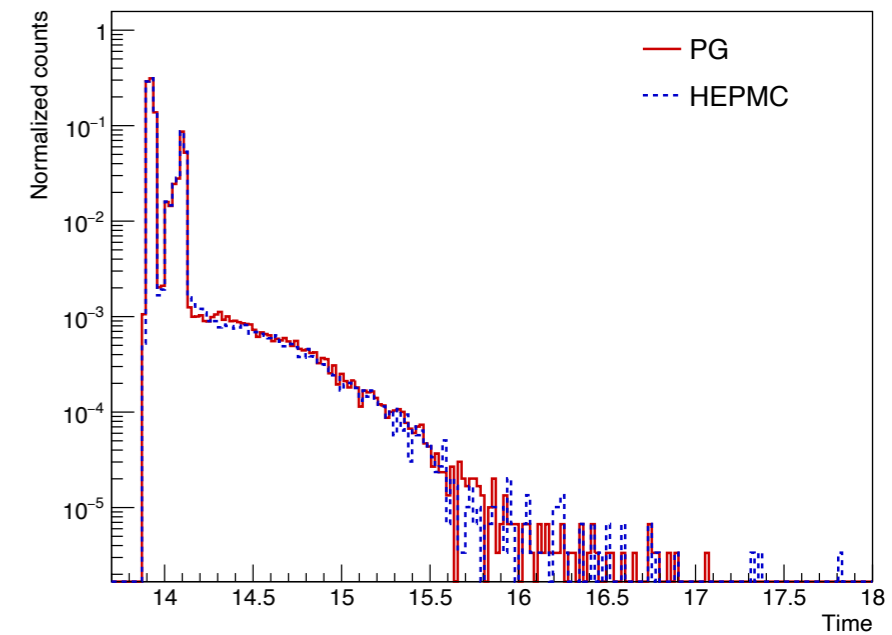
Normalized time distribution, $\eta = 1.5$



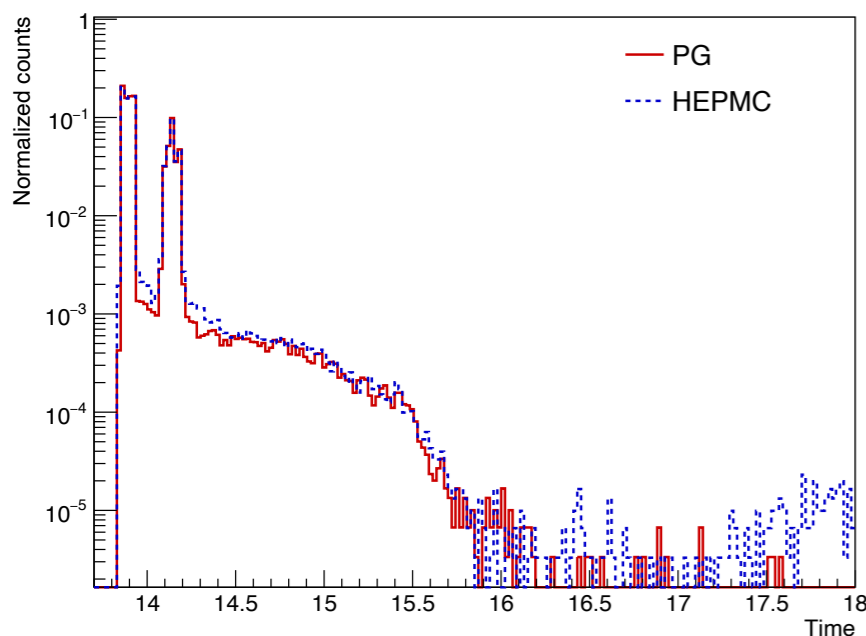
Normalized time distribution, $\eta = 2.0$



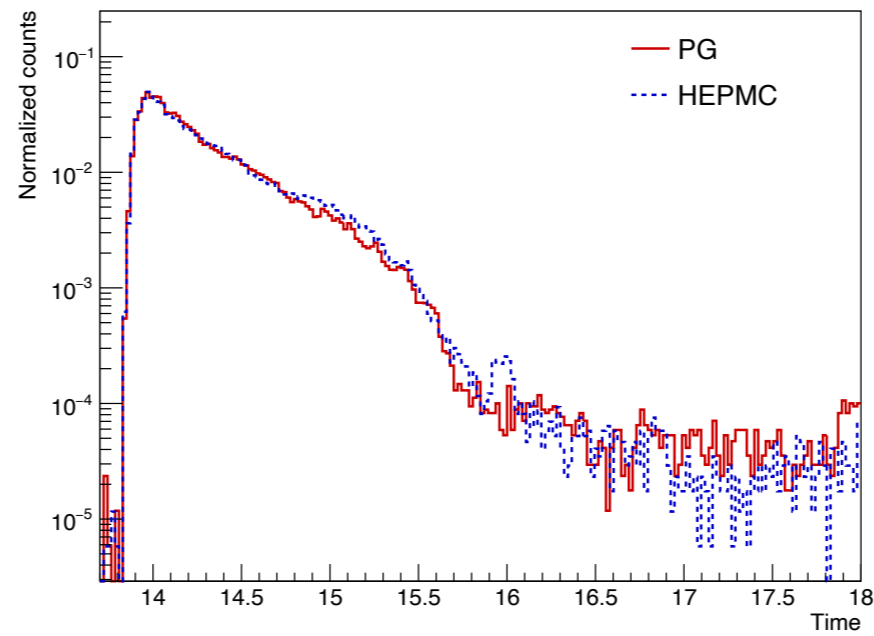
Normalized time distribution, $\eta = 2.5$



Normalized time distribution, $\eta = 3.0$



Normalized time distribution, $\eta = 3.5$



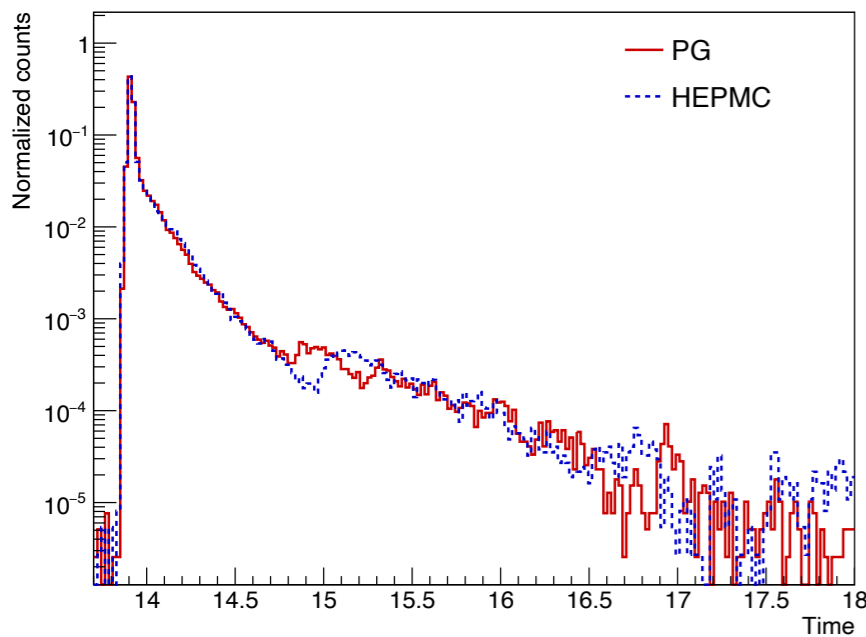
PG and HepMC show broadly consistent photon-hit time distributions in the dRICH only setup.

Normalized time distribution for PION generated from *Particle Gun*

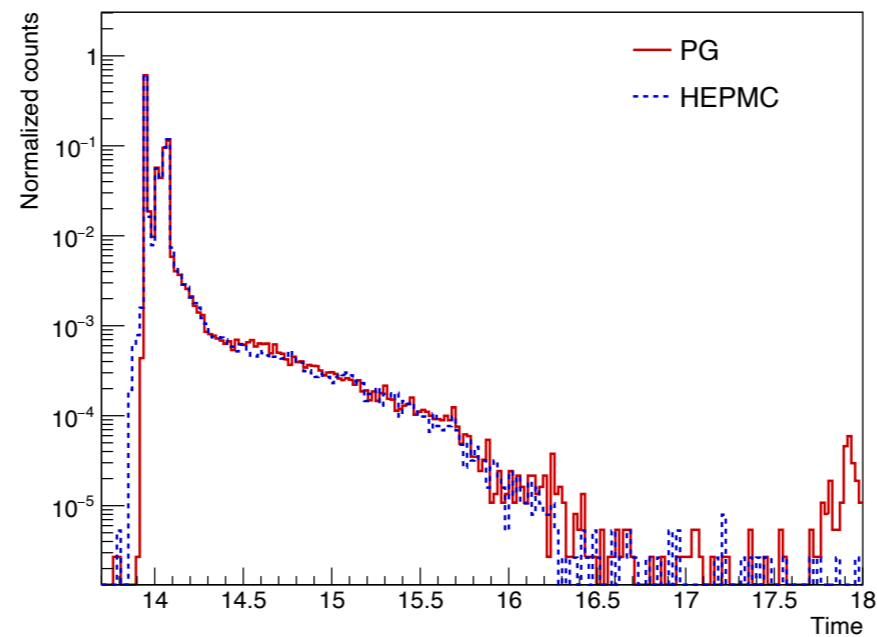
(PG) & HepMC for different η (no. of events, p , ϕ are same)

Simulation : full detector setup

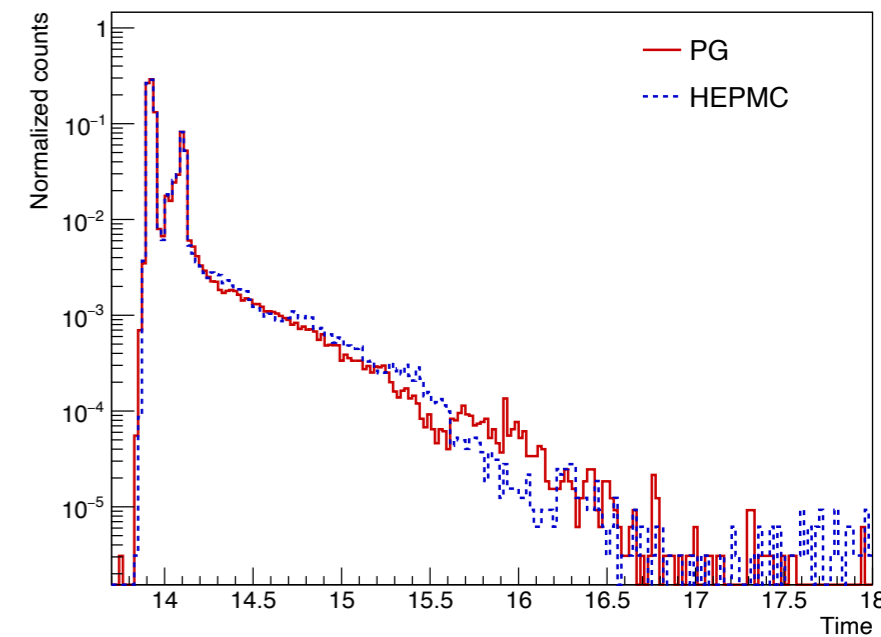
Normalized time distribution, $\eta = 1.5$



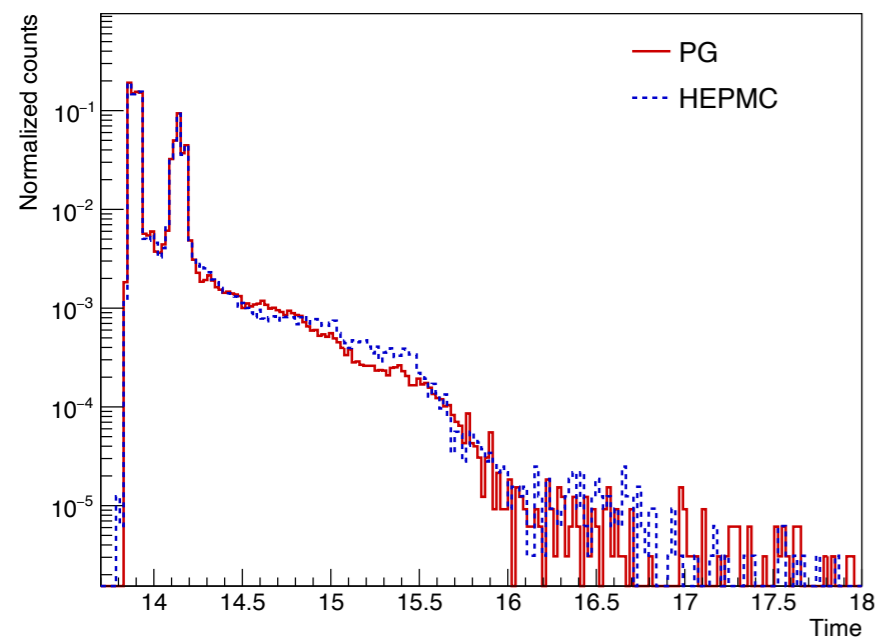
Normalized time distribution, $\eta = 2.0$



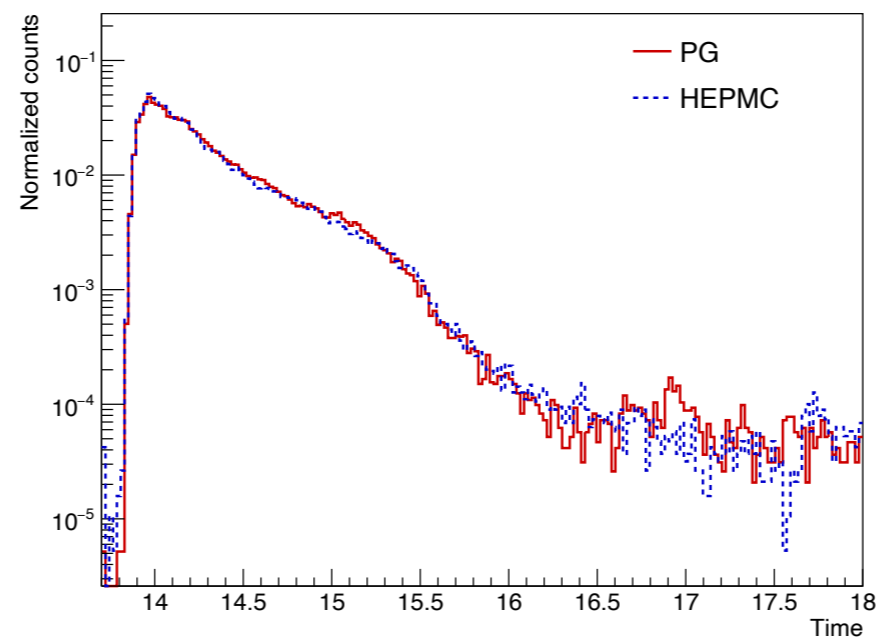
Normalized time distribution, $\eta = 2.5$



Normalized time distribution, $\eta = 3.0$



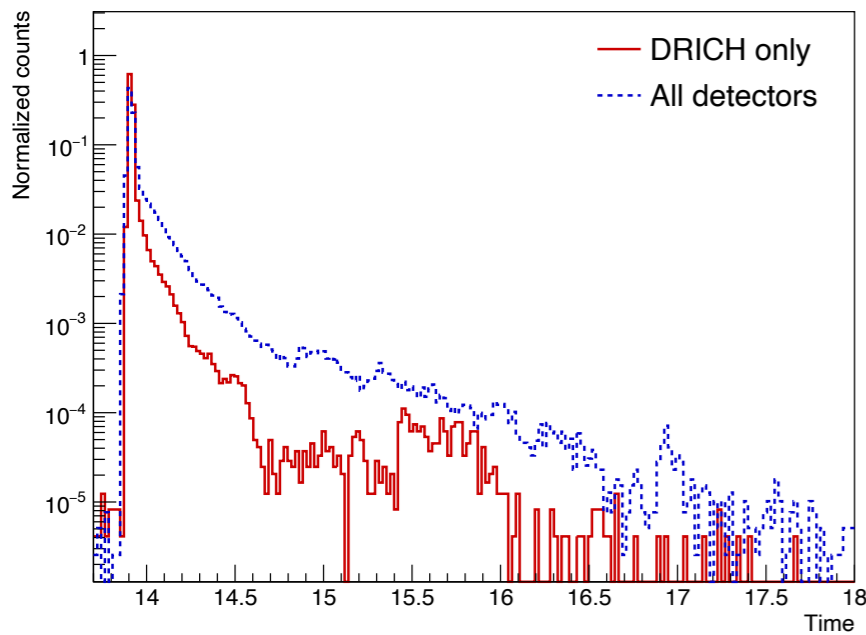
Normalized time distribution, $\eta = 3.5$



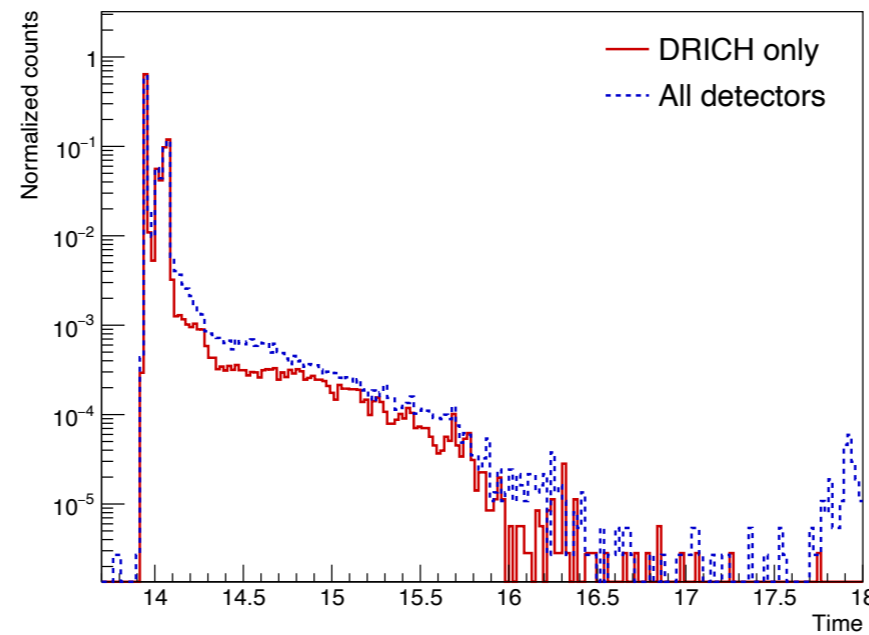
The full-detector simulation changes the late-time population, but PG and HepMC remain consistent.

Normalized time distribution for PION generated from *Particle Gun* for *dRICH only* & *full detector* sim setup for different η (no. of events, ρ, ϕ are same)

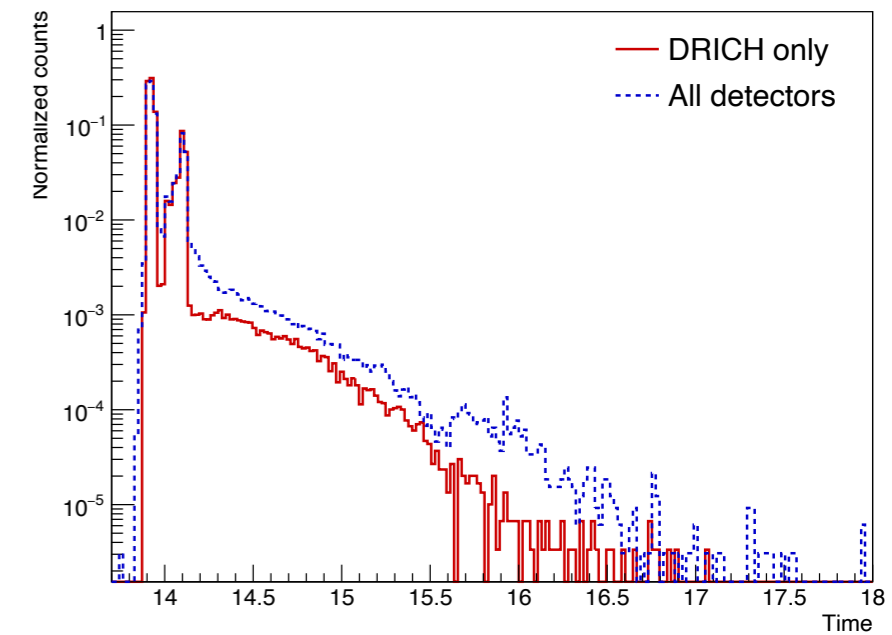
Normalized time distribution, $\eta = 1.5$



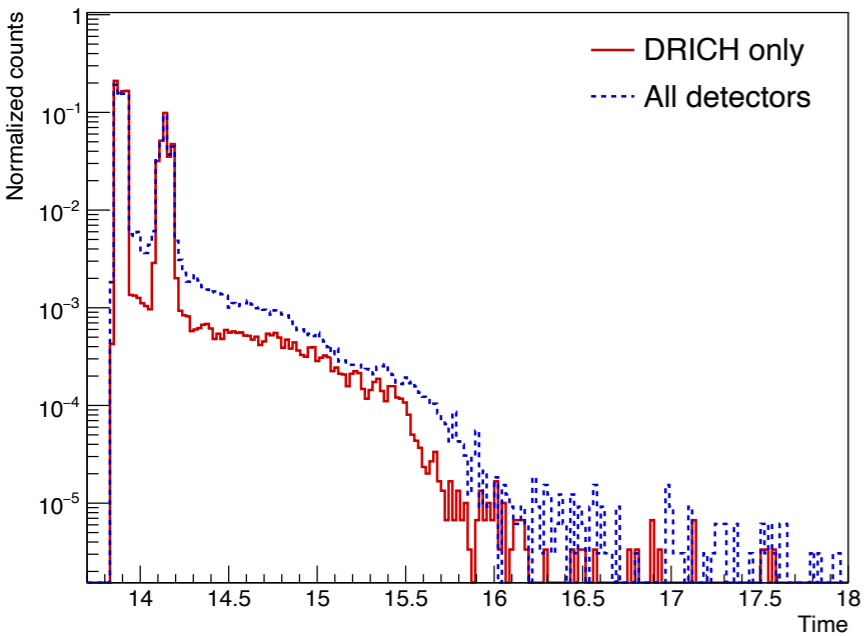
Normalized time distribution, $\eta = 2.0$



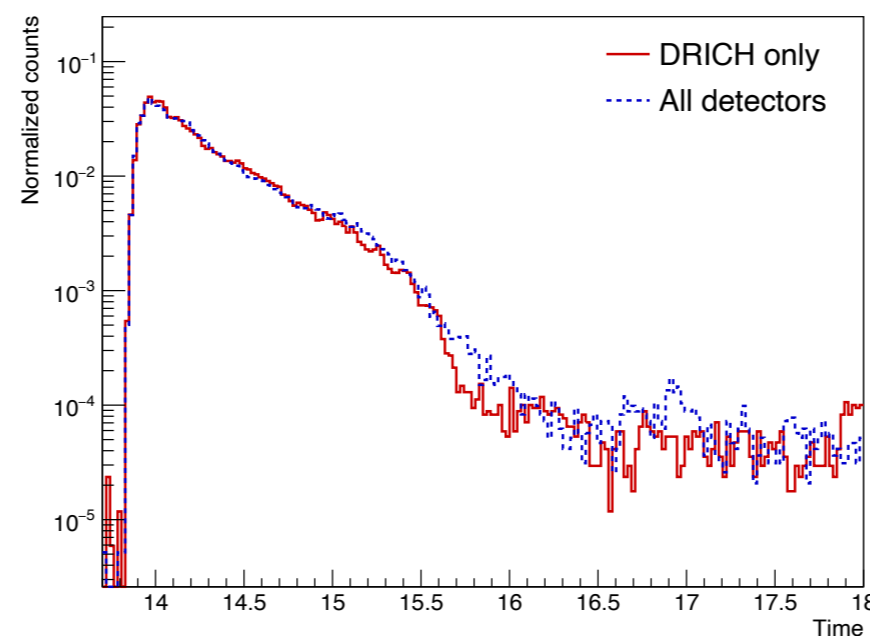
Normalized time distribution, $\eta = 2.5$



Normalized time distribution, $\eta = 3.0$

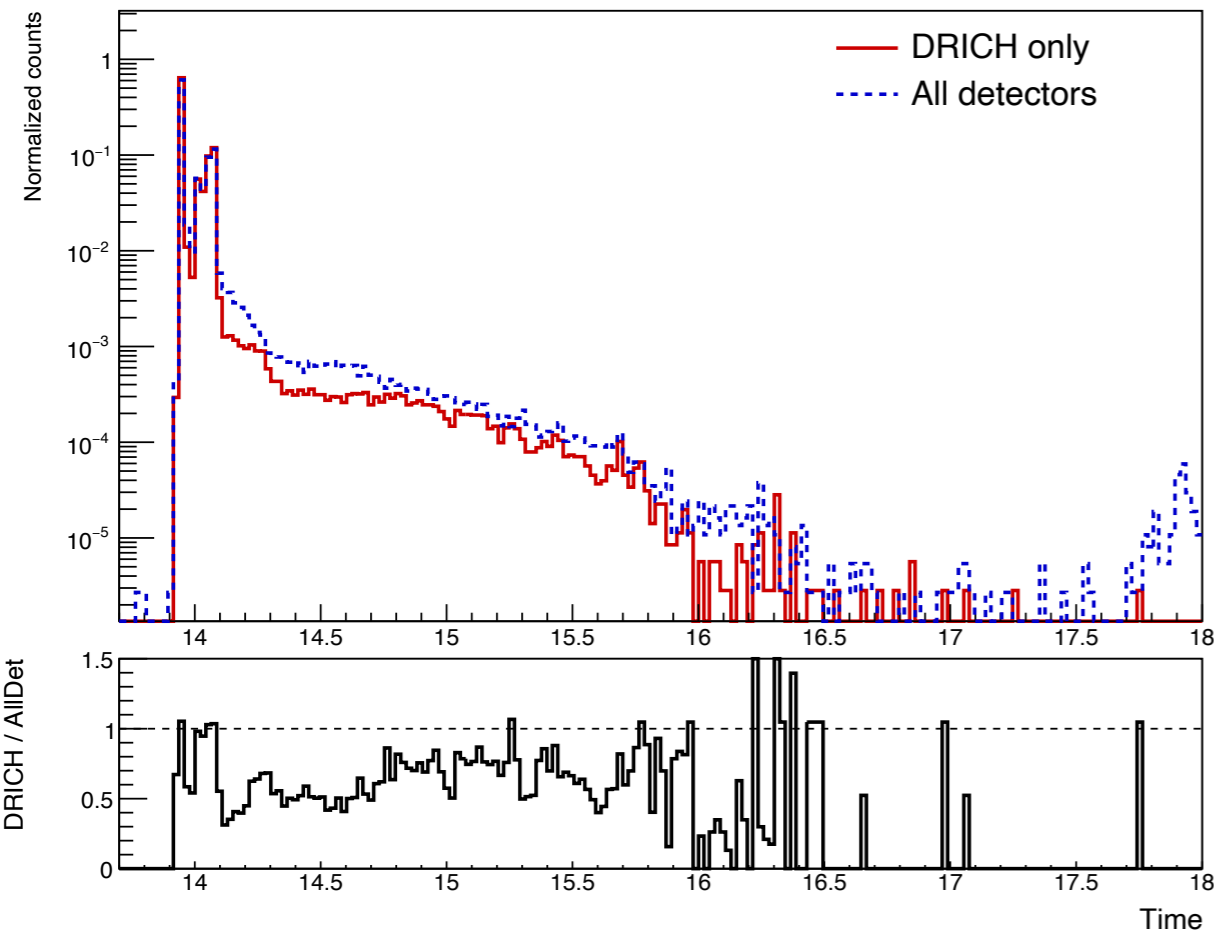


Normalized time distribution, $\eta = 3.5$

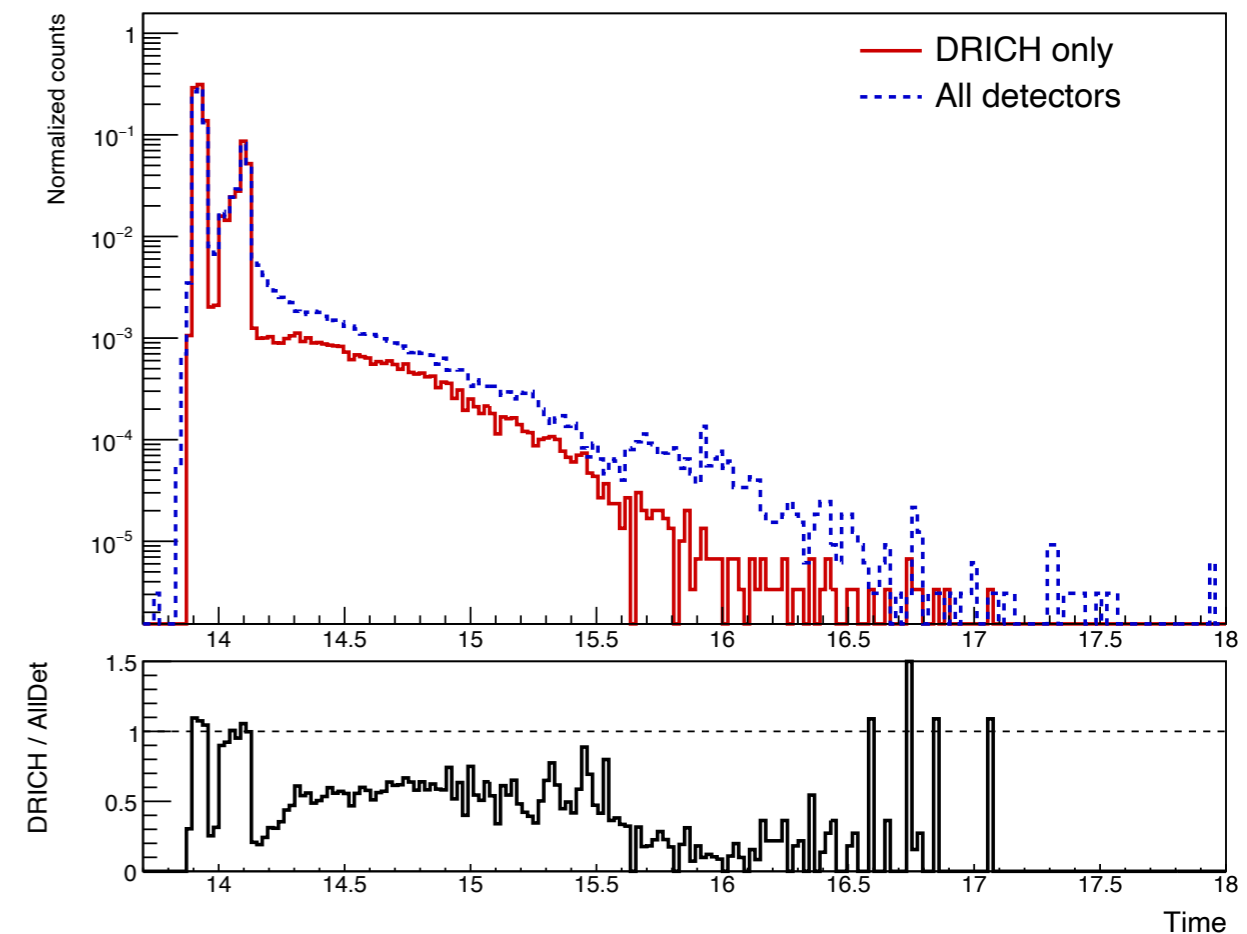


Compared with dRICH only simulation, the full-detector setup increases the late-time photon-hit population.

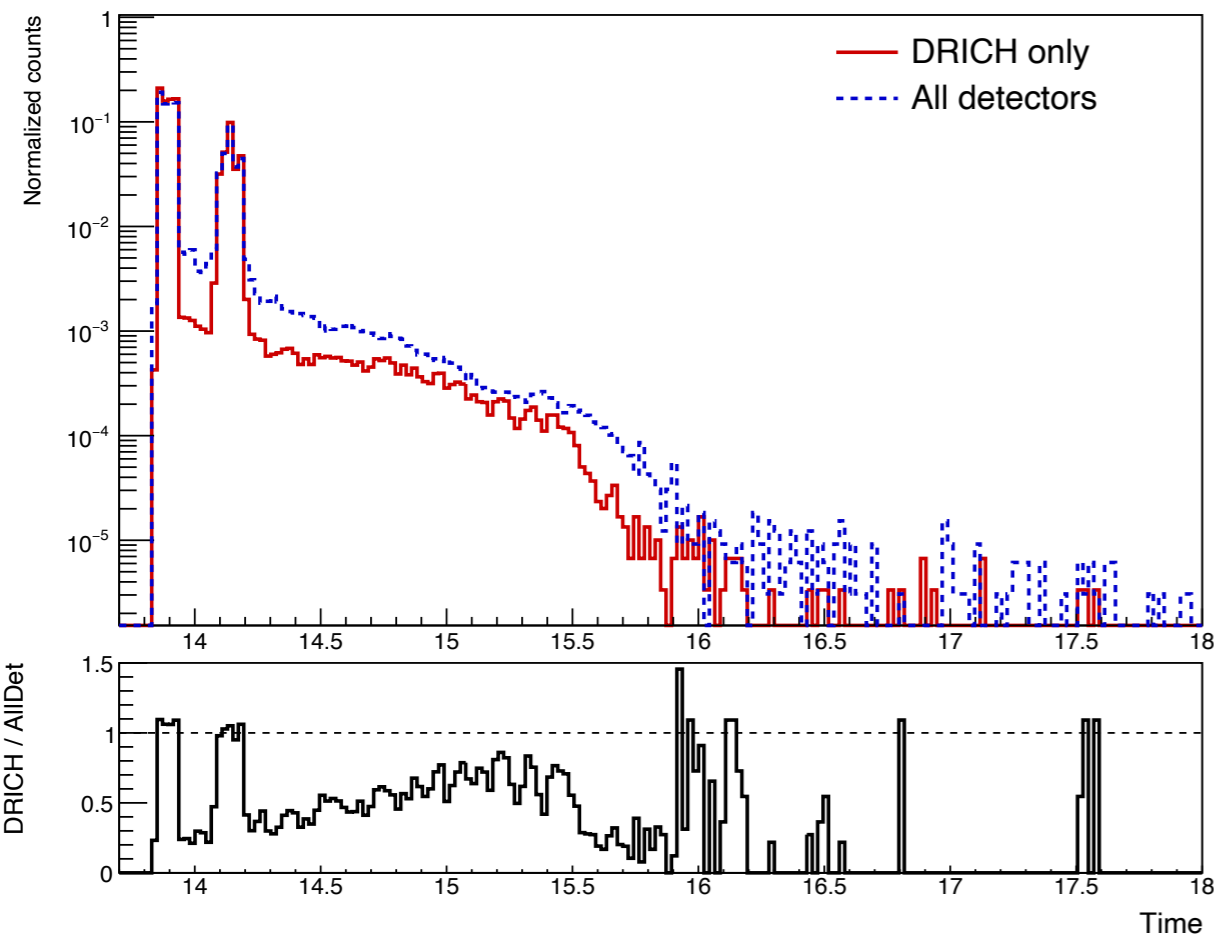
Normalized time distribution, $\eta = 2.0$



Normalized time distribution, $\eta = 2.5$



Normalized time distribution, $\eta = 3.0$



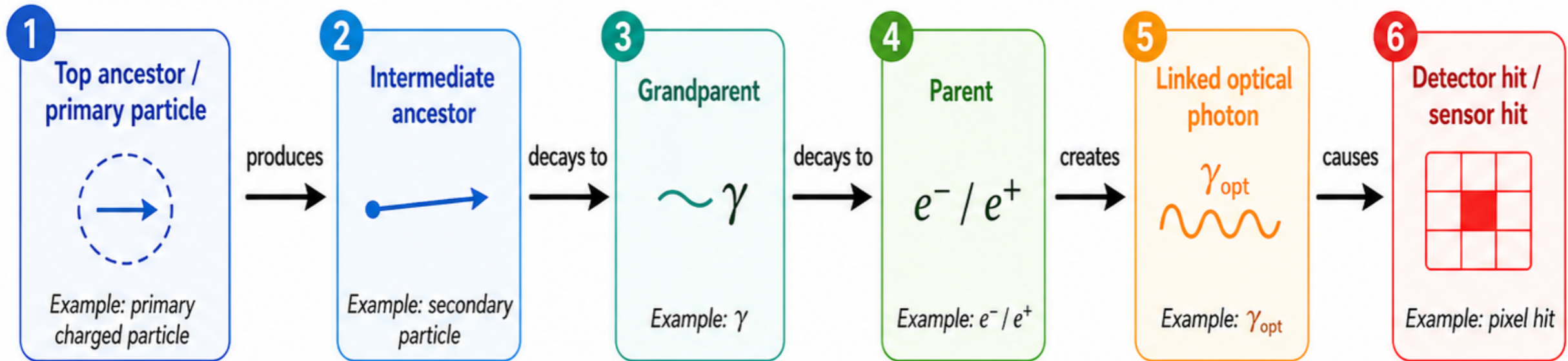
Timing result

- PG and HepMC are broadly consistent.
- FullDet enhances the late-time region.

Interpretation

- Full-detector material likely increases secondary production.
- Therefore, we study the **parent, grandparent, and production vertex** of photons linked to dRICH hits.

Understanding Parent, Grandparent, and Ancestor Relations



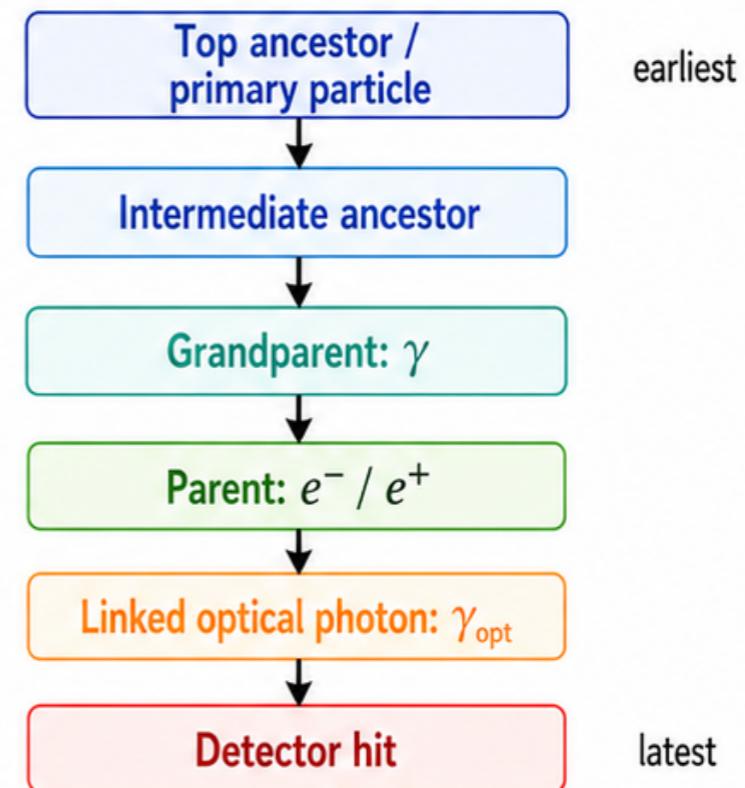
What these terms mean

- **Parent:** the particle directly responsible for the current particle.
- **Grandparent:** the parent of the parent.
- **Ancestor / top ancestor:** an earlier particle upstream in the chain.

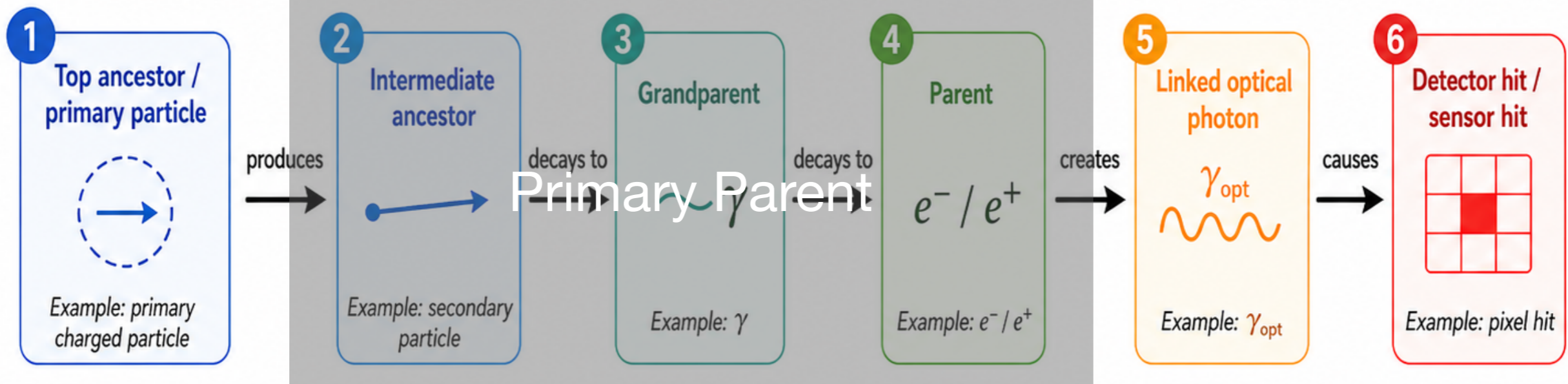


For a detector hit, the linked optical photon is the direct particle associated with the hit.

Family-tree view (one detector hit)



Understanding Parent, Grandparent, and Ancestor Relations



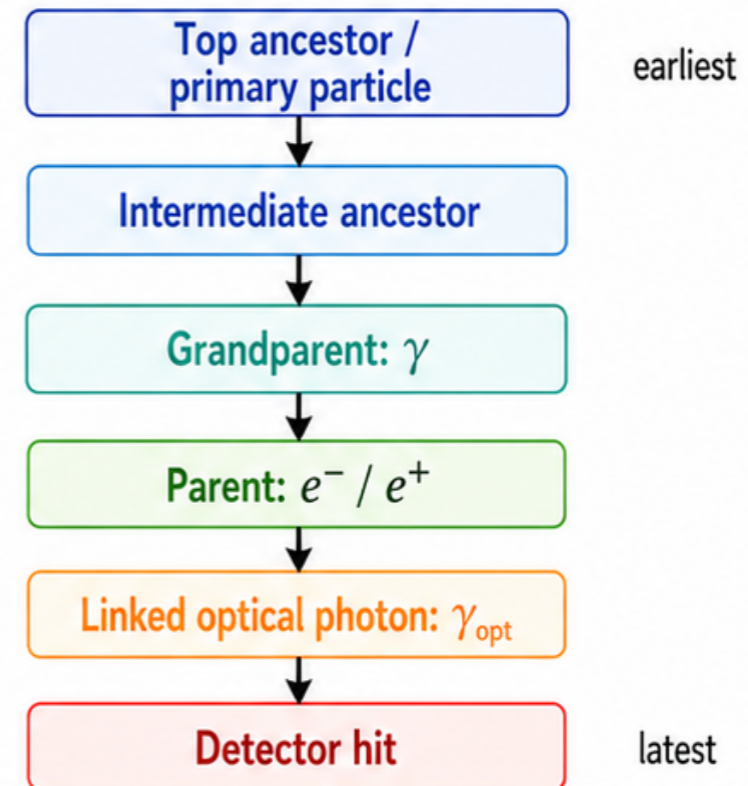
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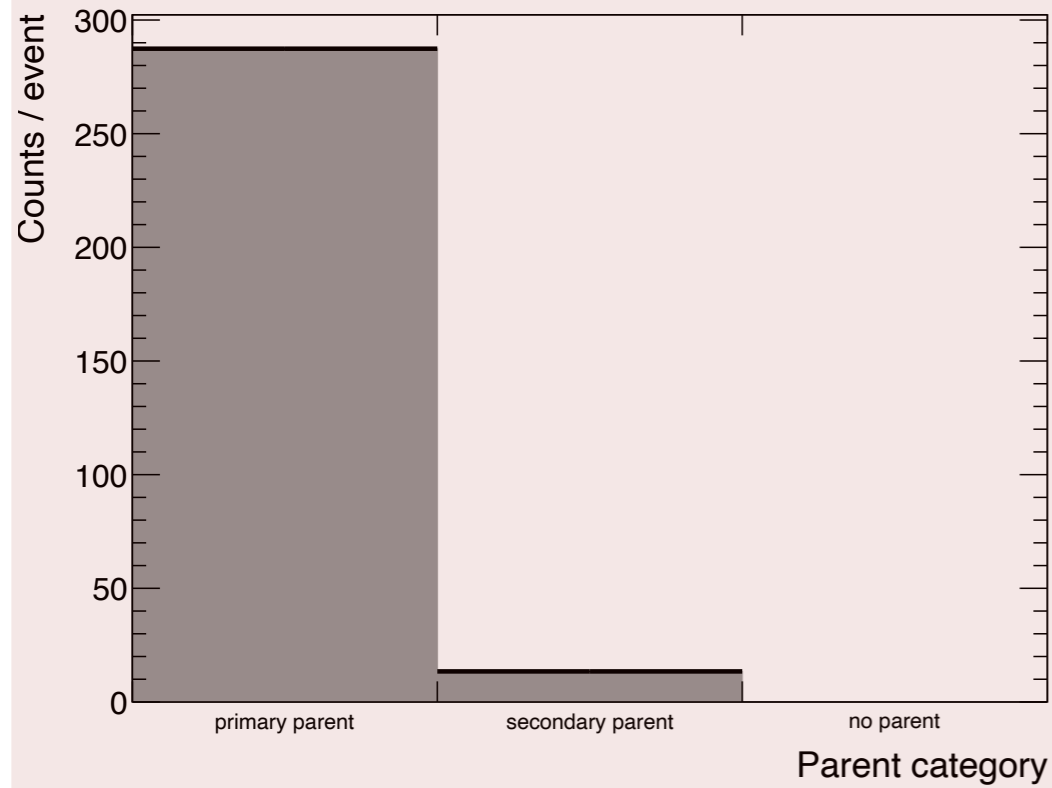
Family-tree view (one detector hit)



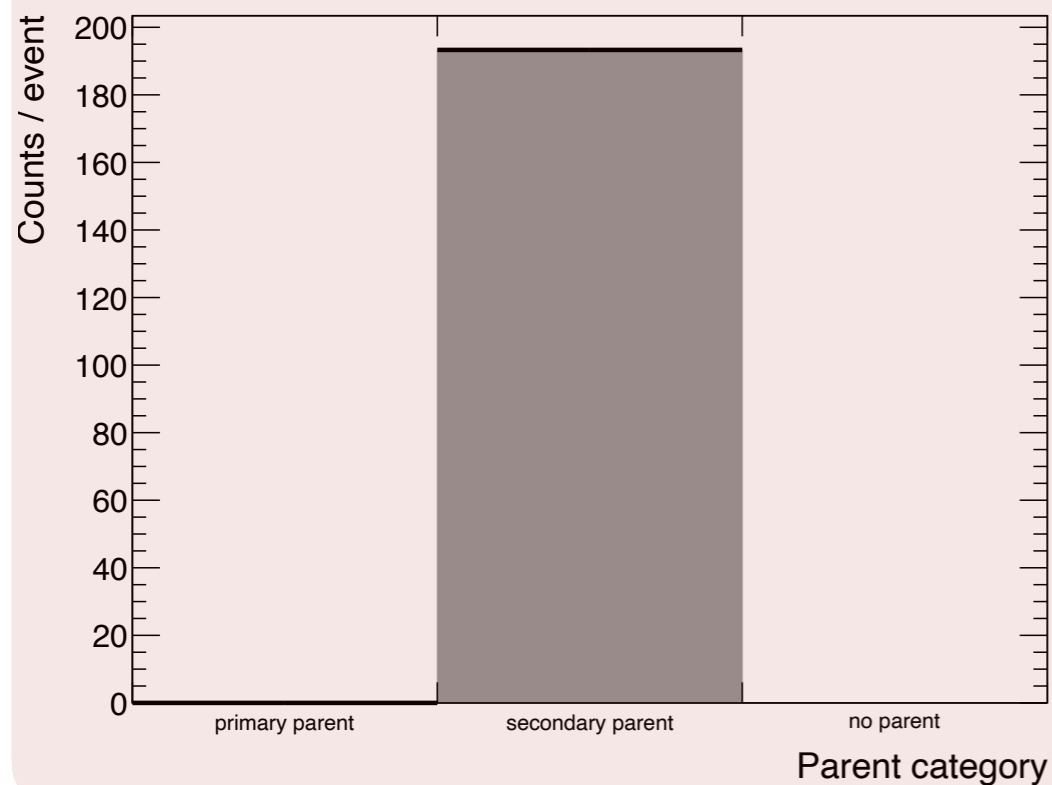
Immediate parent category of dRICH hits:

dRICH Only

Immediate parent category of DRICH photon hits



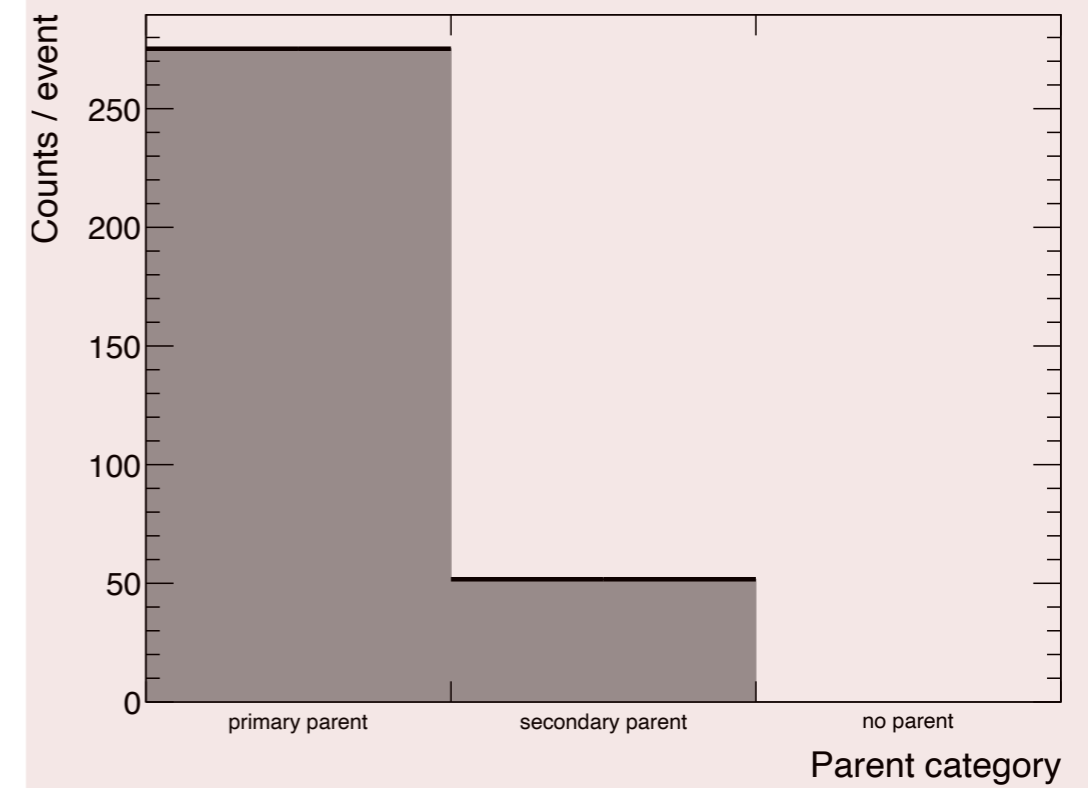
Immediate parent category of DRICH photon hits



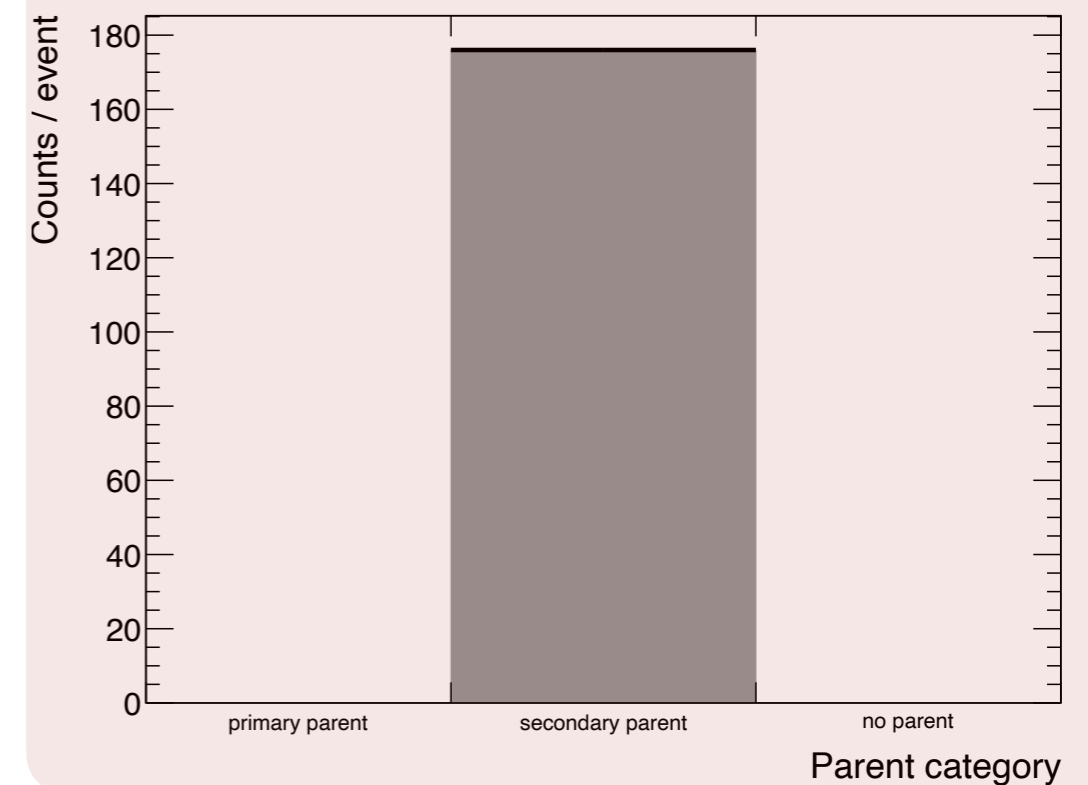
eta=2.5

Full Detector

Immediate parent category of DRICH photon hits



Immediate parent category of DRICH photon hits

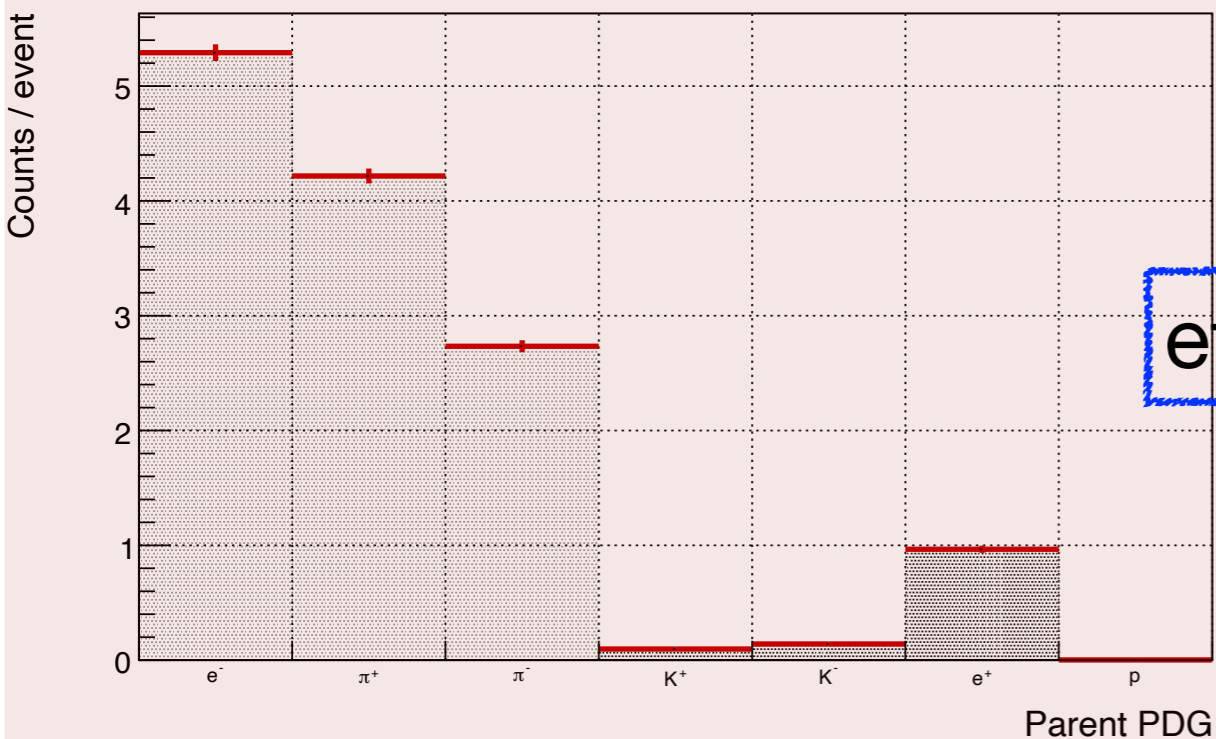


eta=3.5

Secondary-parent PDGs of dRICH hits:

dRICH Only

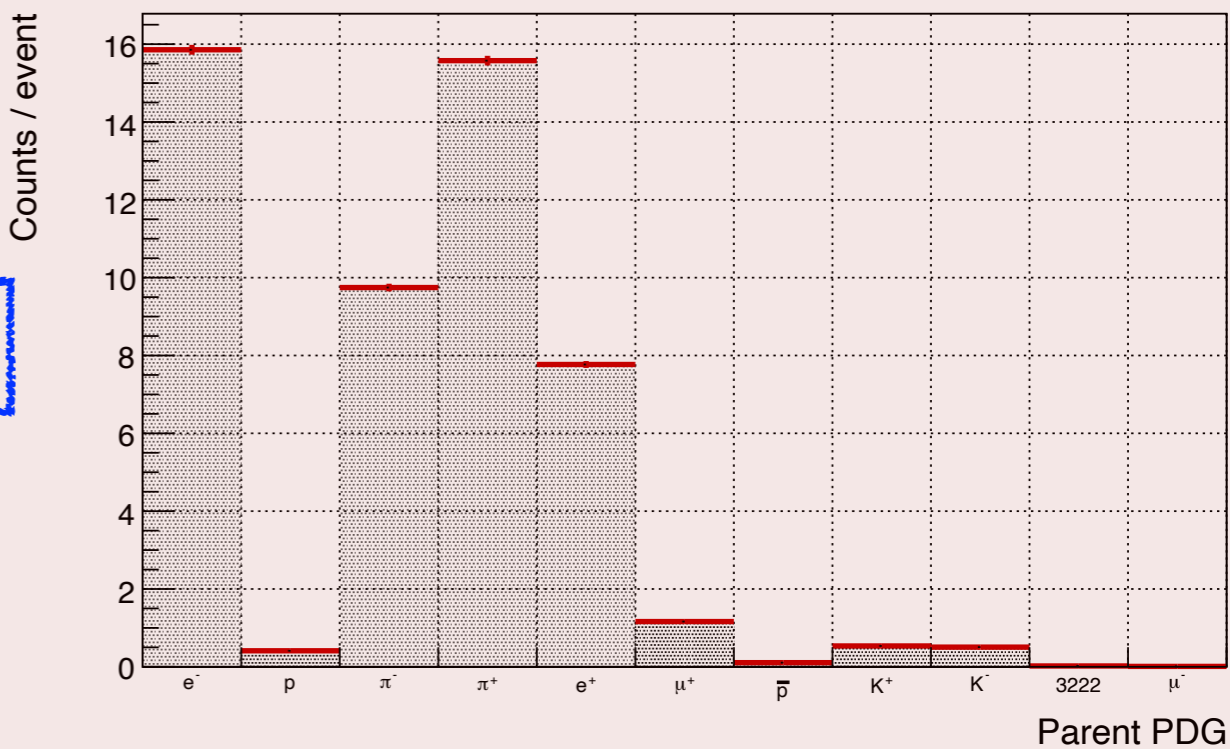
Secondary immediate parent PDG of DRICH photon hits



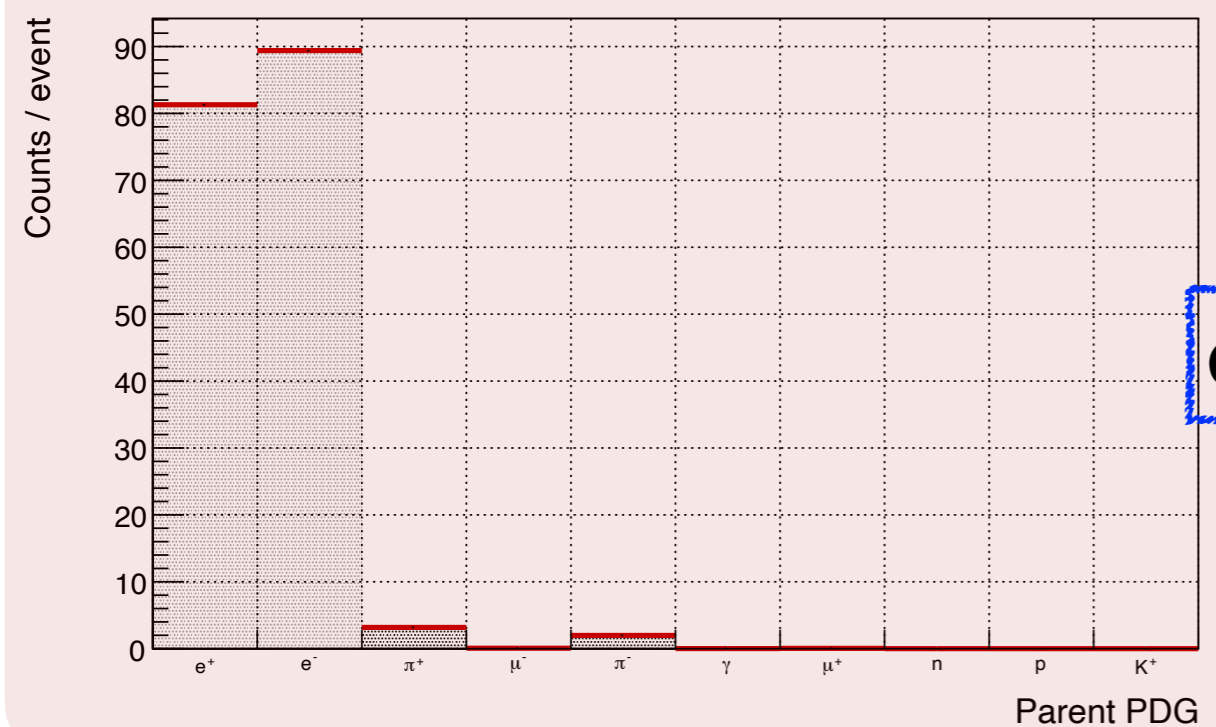
eta=2.5

Full Detector

Secondary immediate parent PDG of DRICH photon hits

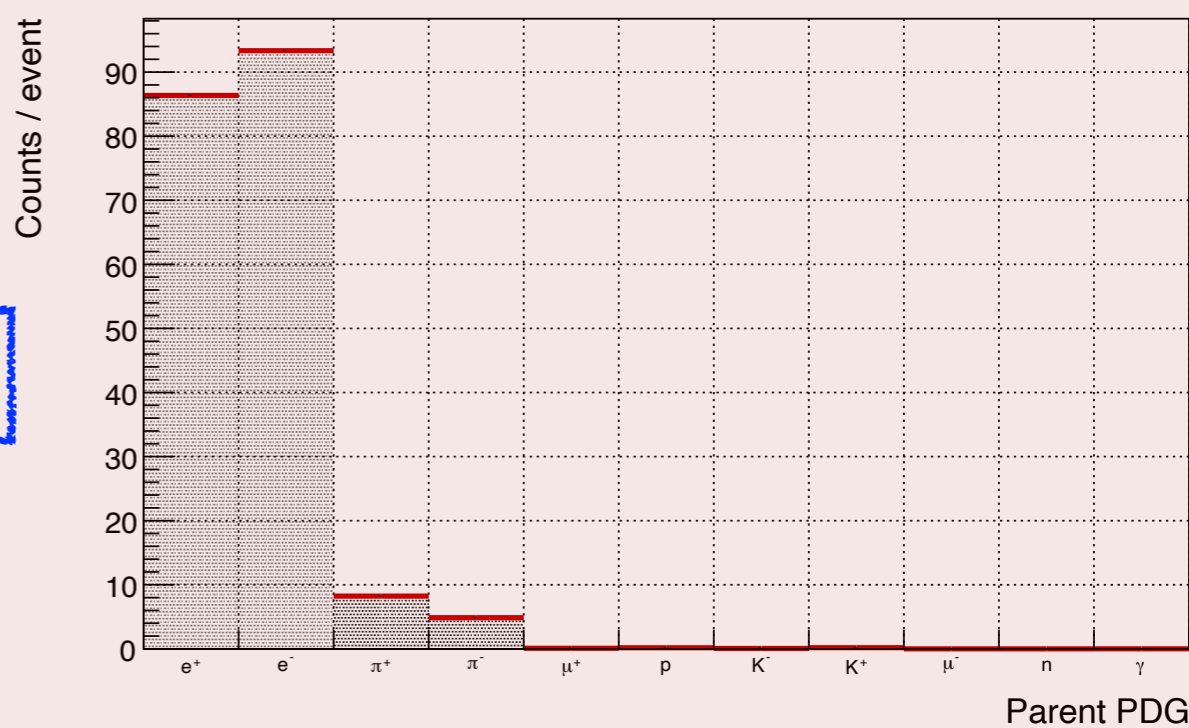


Secondary immediate parent PDG of DRICH photon hits



eta=3.5

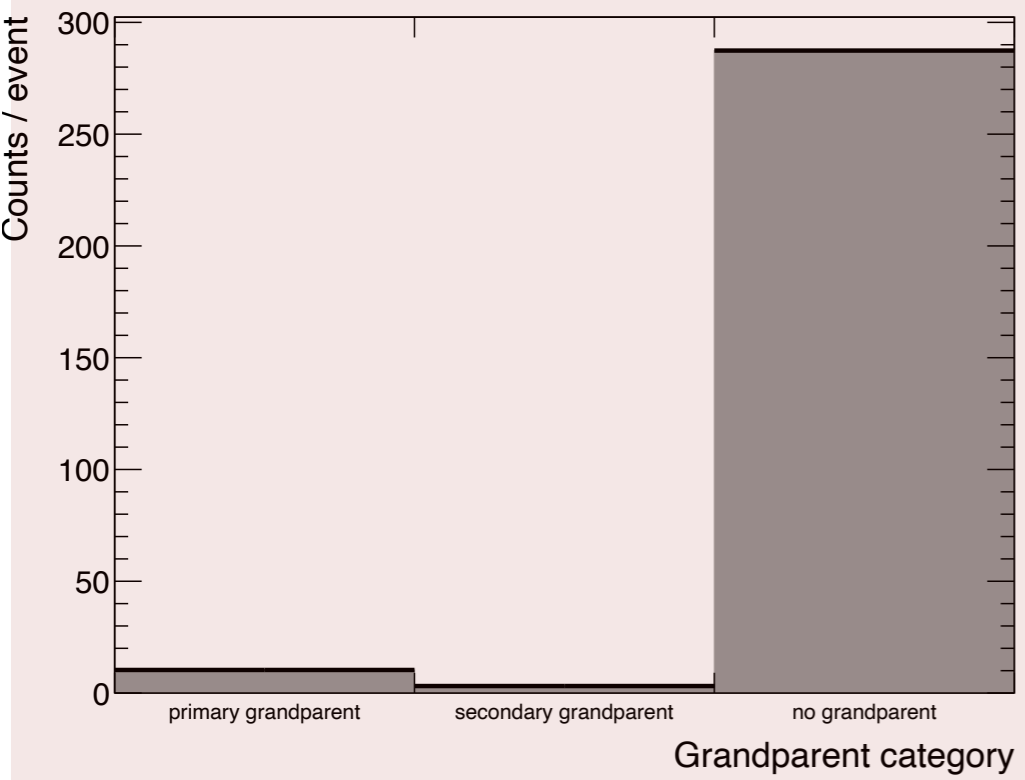
Secondary immediate parent PDG of DRICH photon hits



Grand-parent category of dRICH hits:

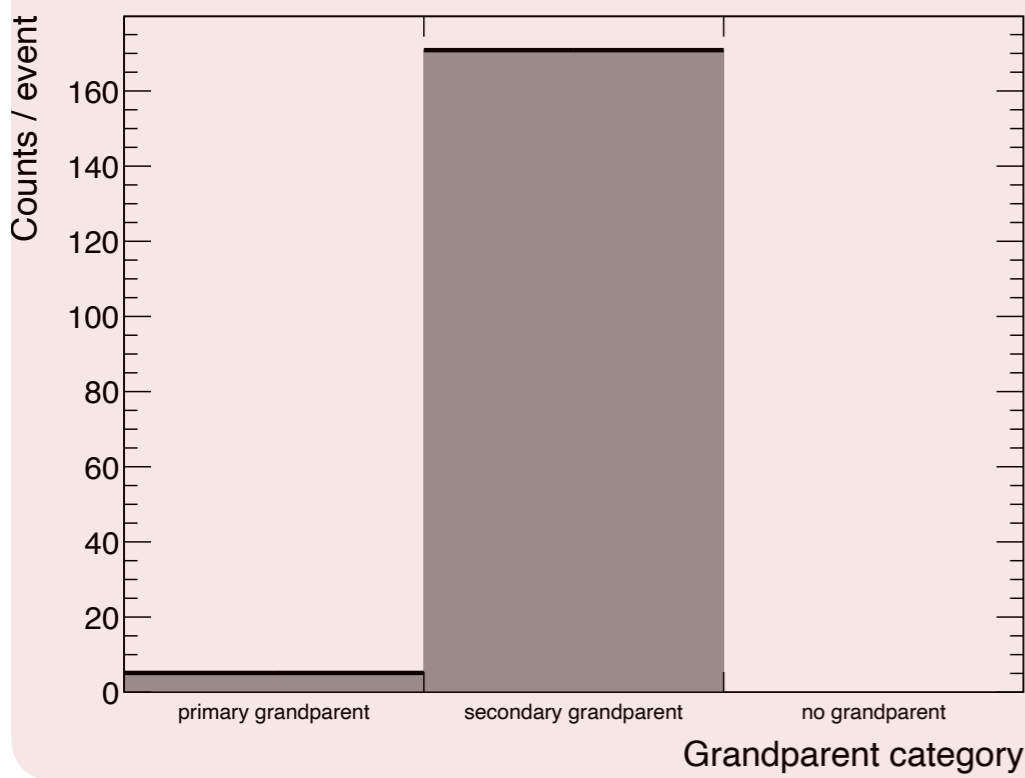
dRICH Only

Grandparent category of DRICH photon hits



eta=2.5

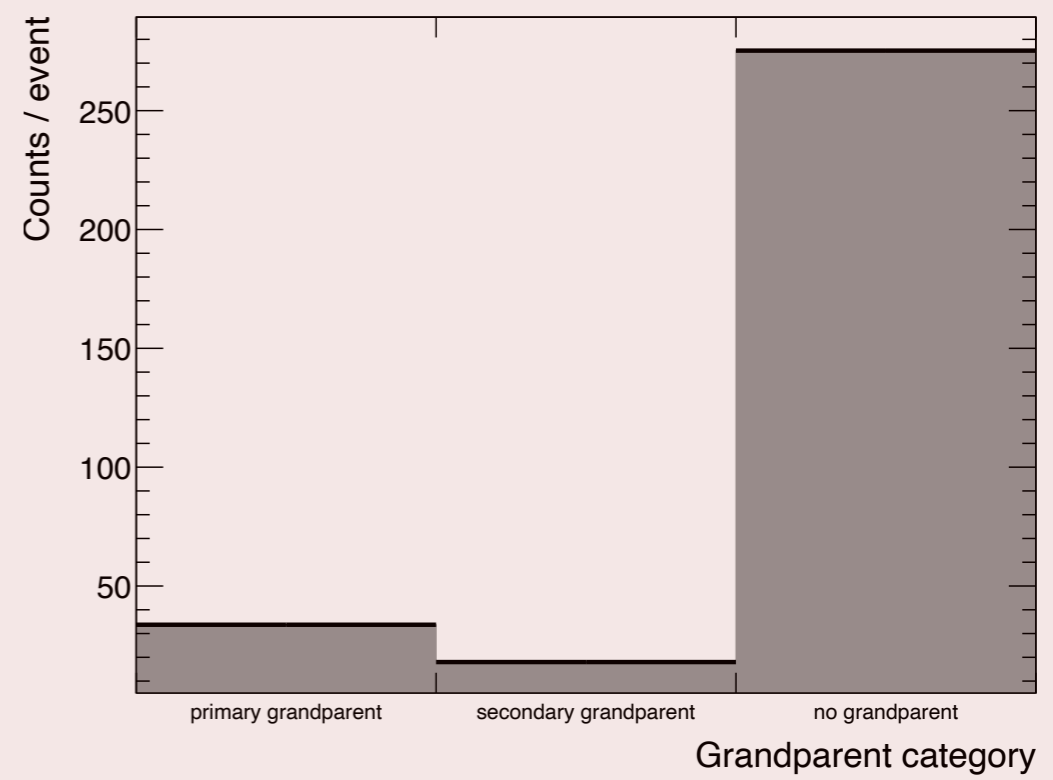
Grandparent category of DRICH photon hits



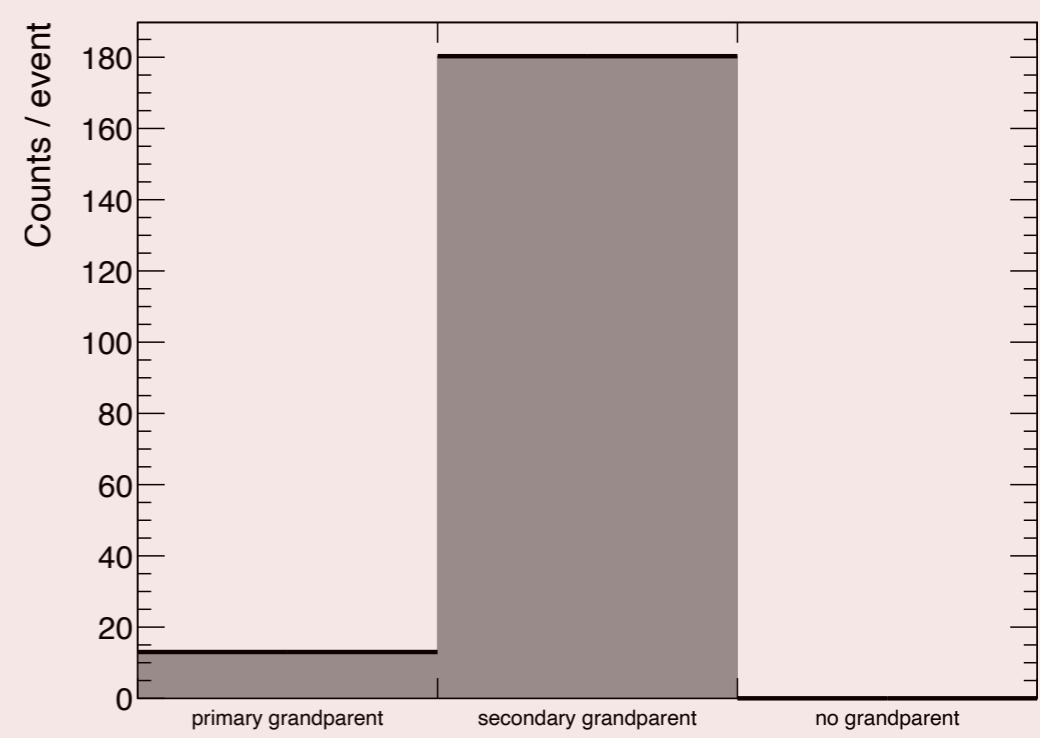
eta=3.5

Full Detector

Grandparent category of DRICH photon hits



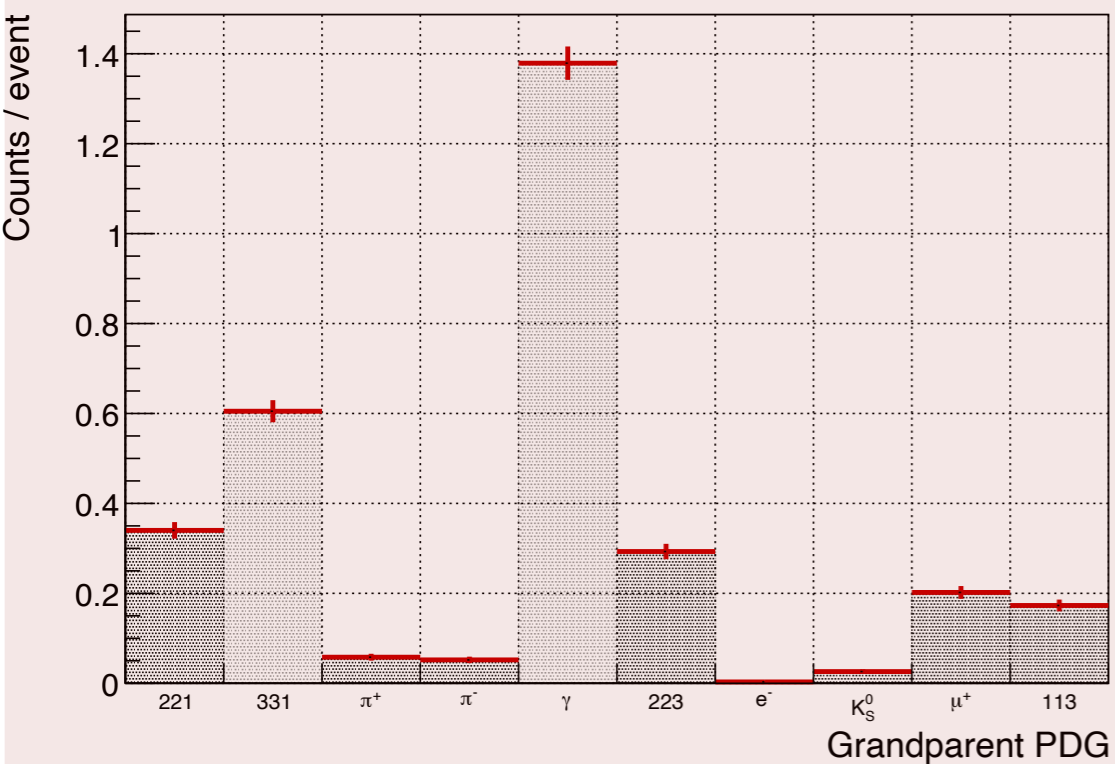
Grandparent category of DRICH photon hits



Secondary-Grandparent PDGs of dRICH hits:

dRICH Only

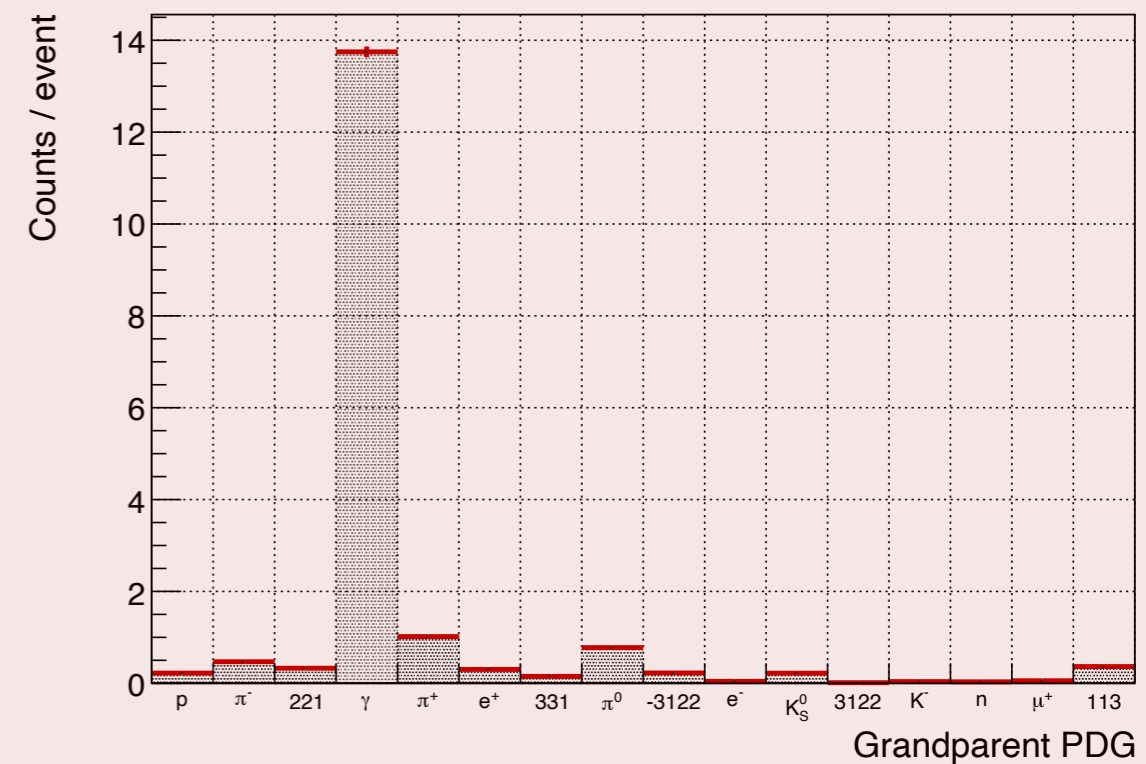
Secondary grandparent PDG of DRICH photon hits



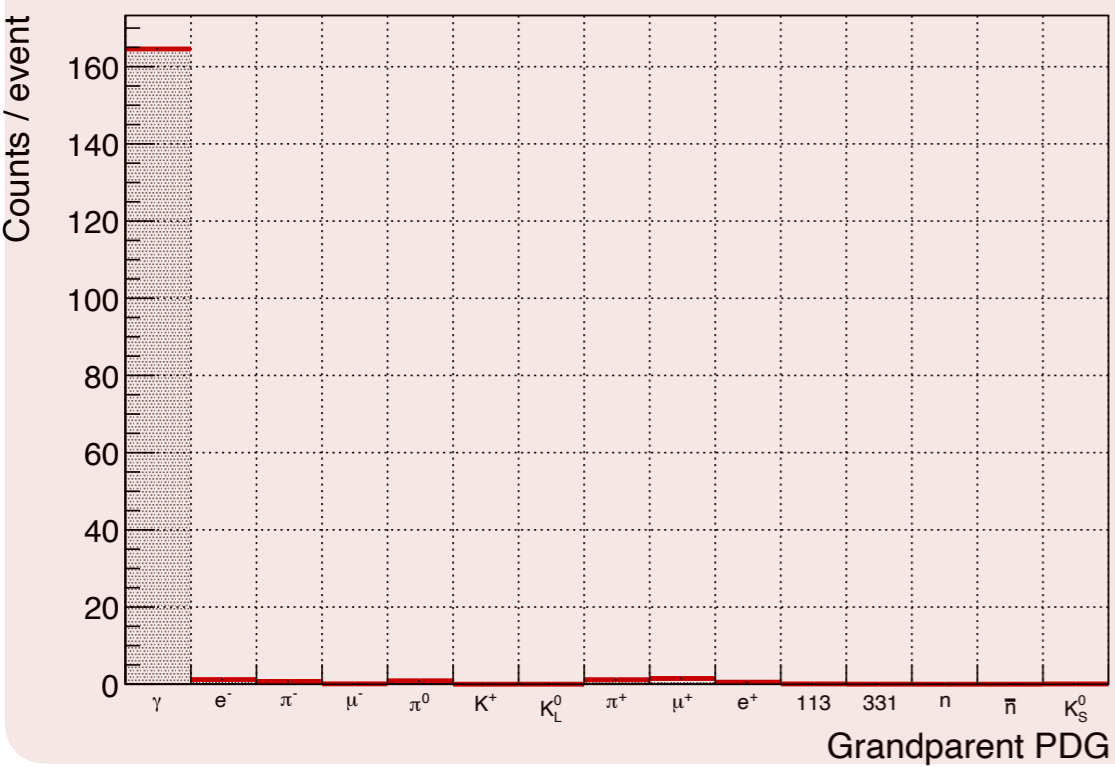
eta=2.5

Full Detector

Secondary grandparent PDG of DRICH photon hits

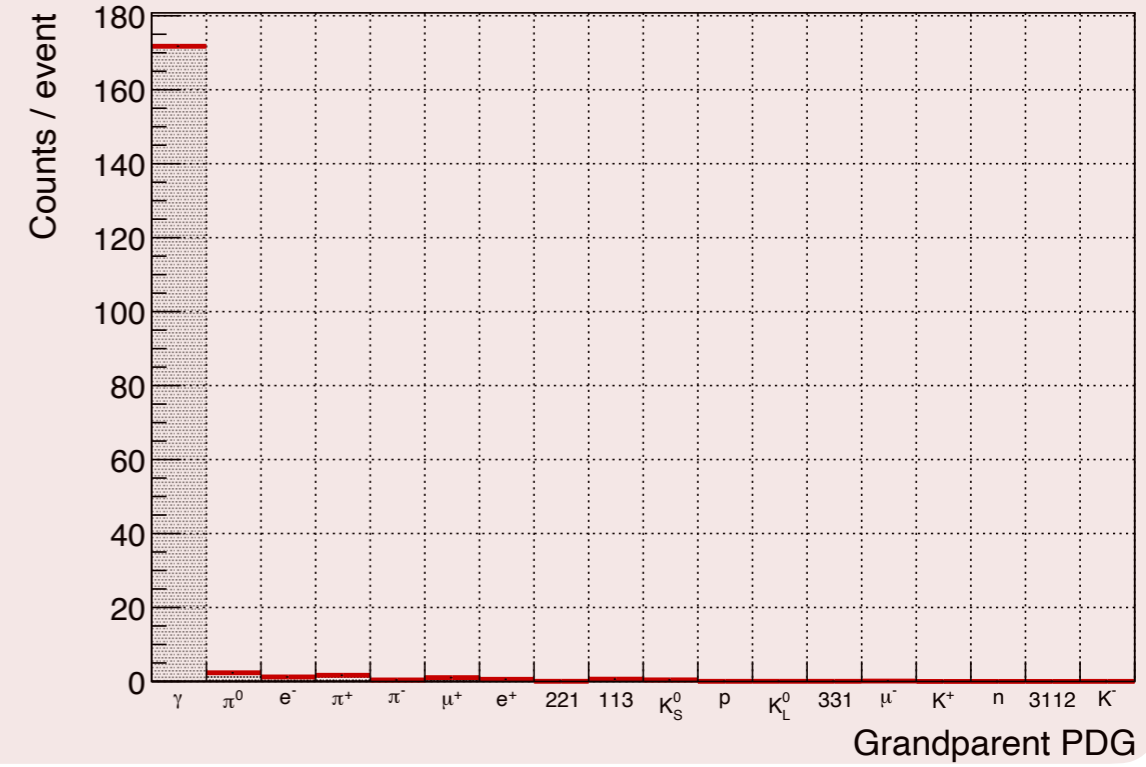


Secondary grandparent PDG of DRICH photon hits



eta=3.5

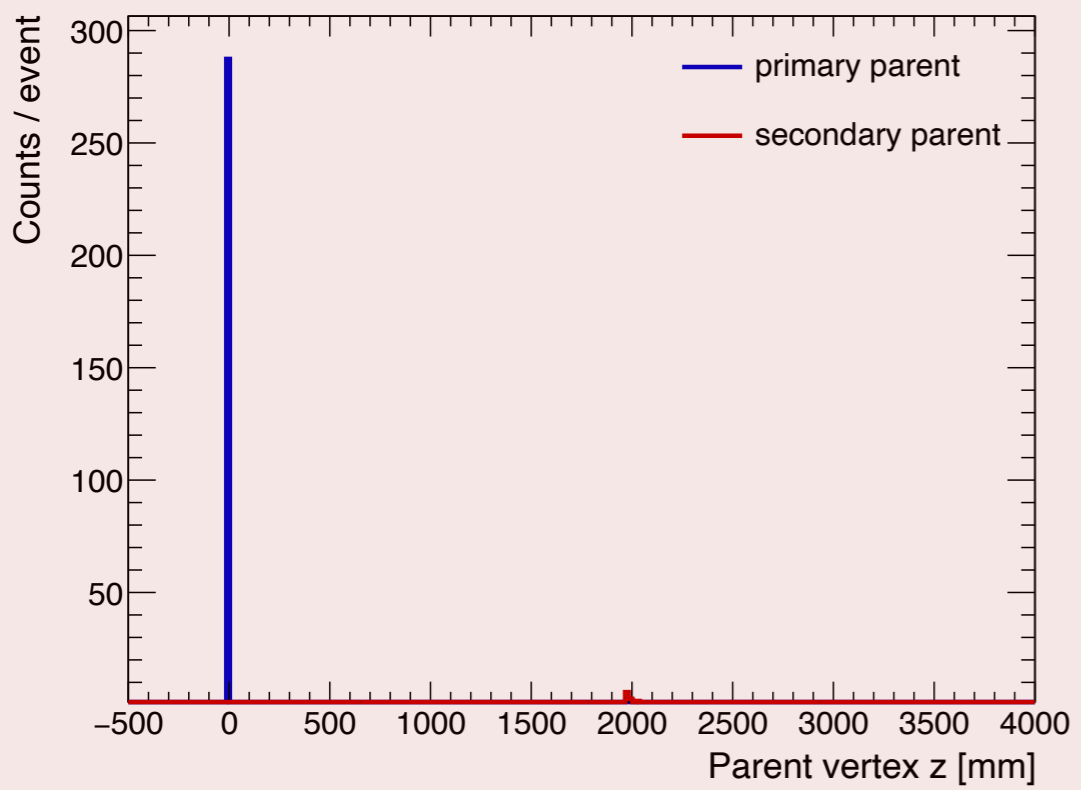
Secondary grandparent PDG of DRICH photon hits



Parent Particles: Production Vertex of immediate parent

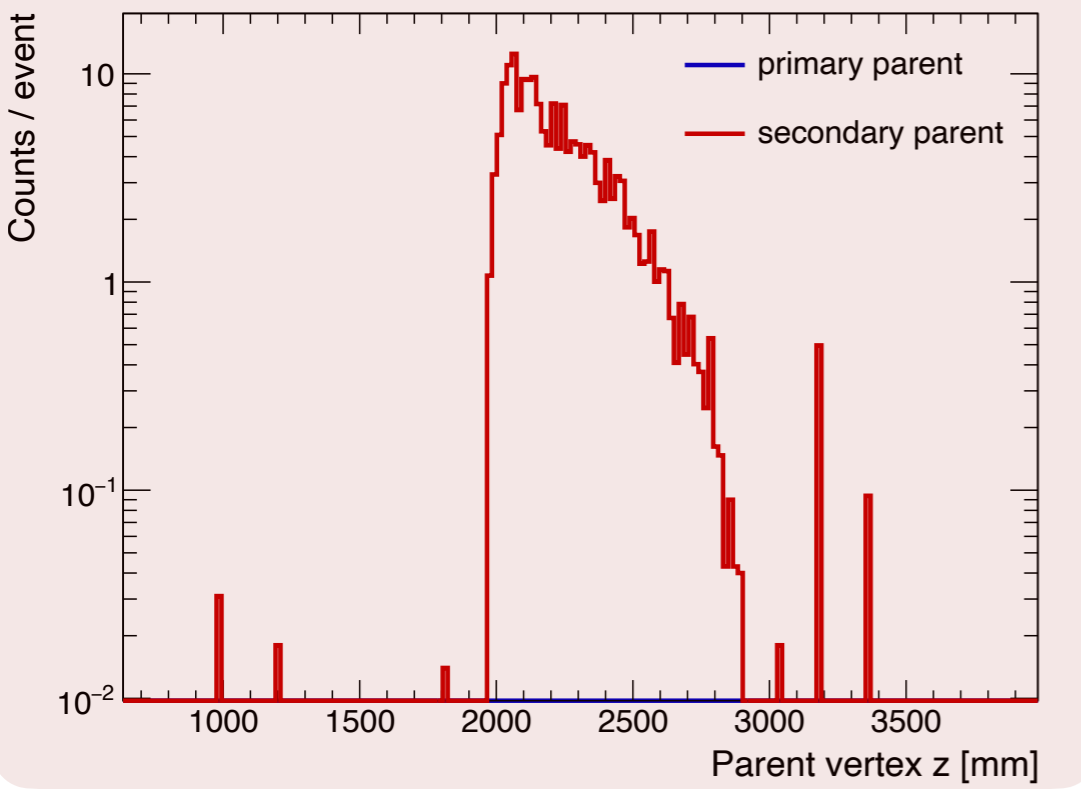
dRICH Only

Immediate parent vertex z



eta=2.5

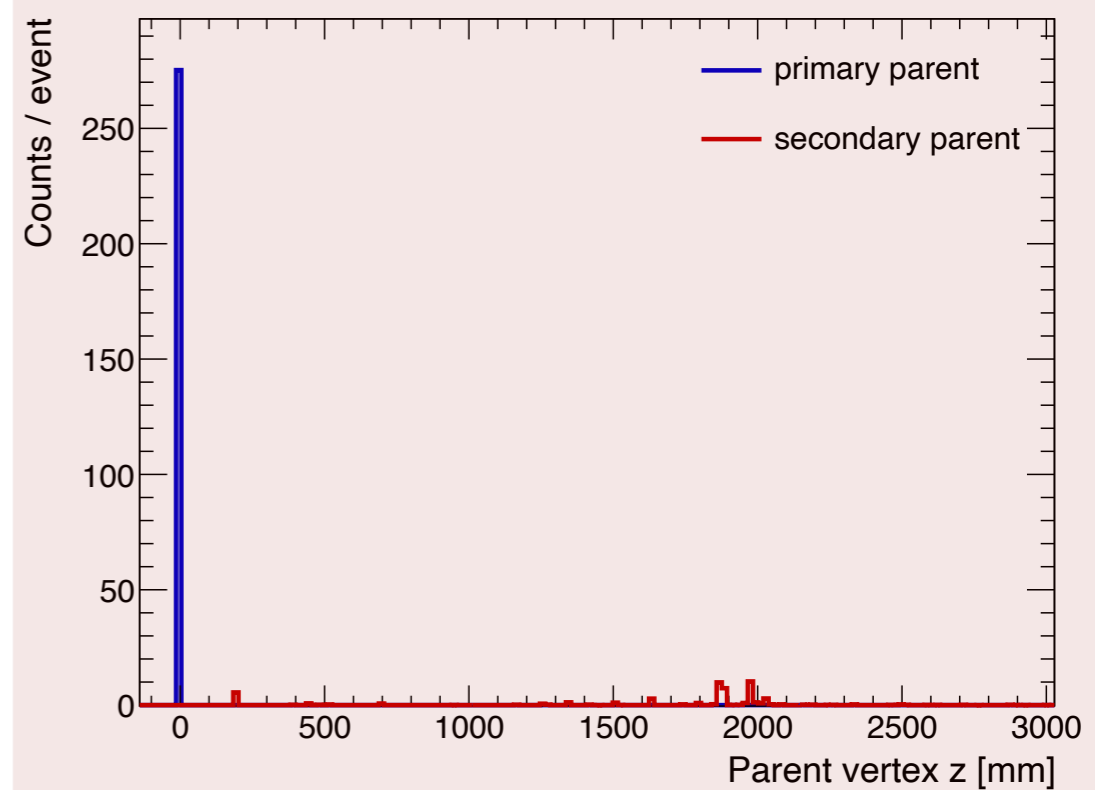
Immediate parent vertex z



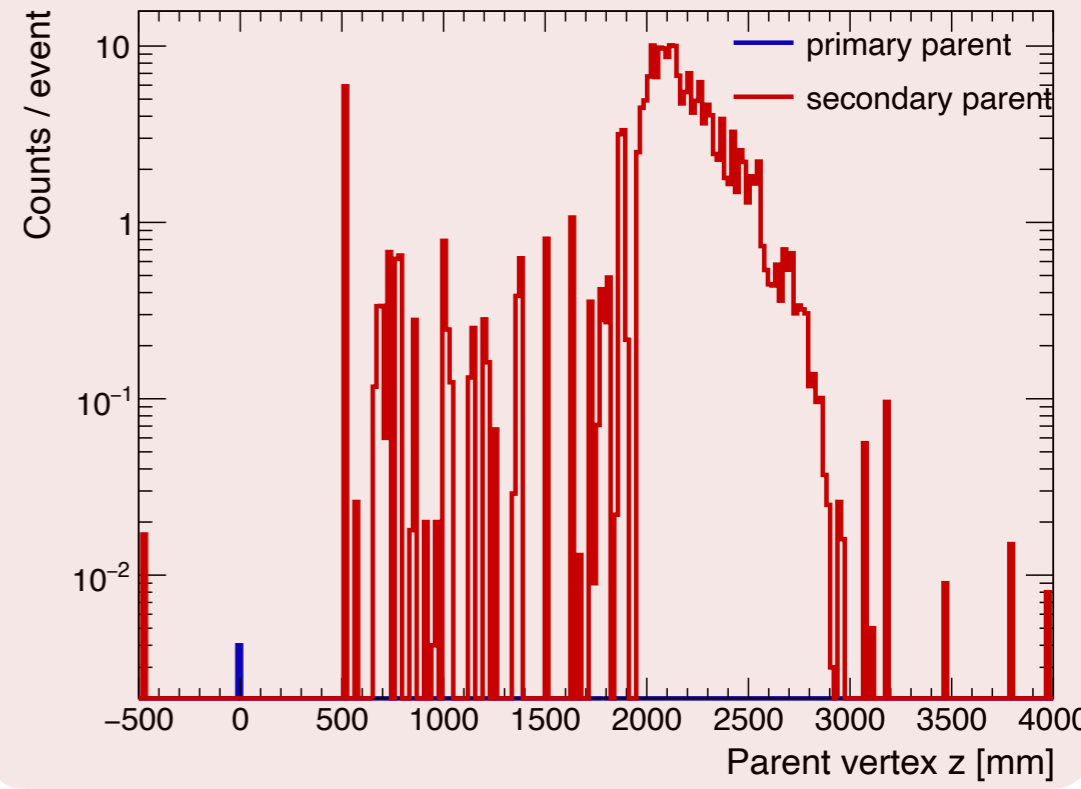
eta=3.5

Full Detector

Immediate parent vertex z

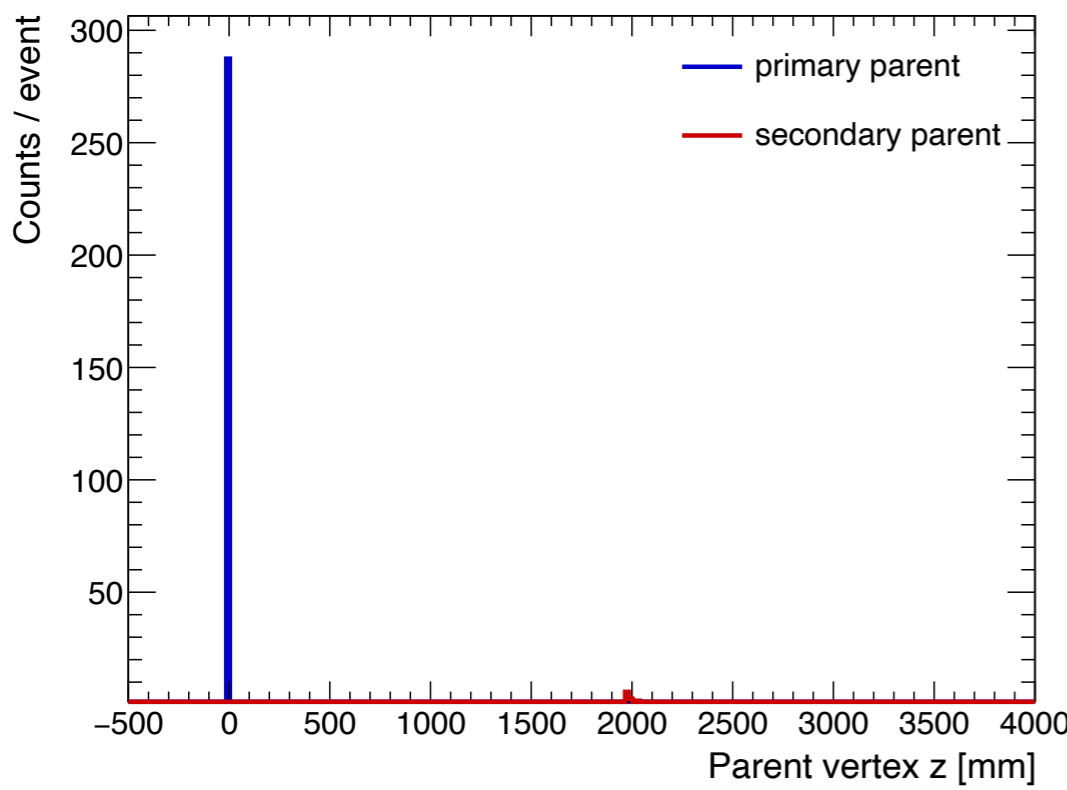


Immediate parent vertex z



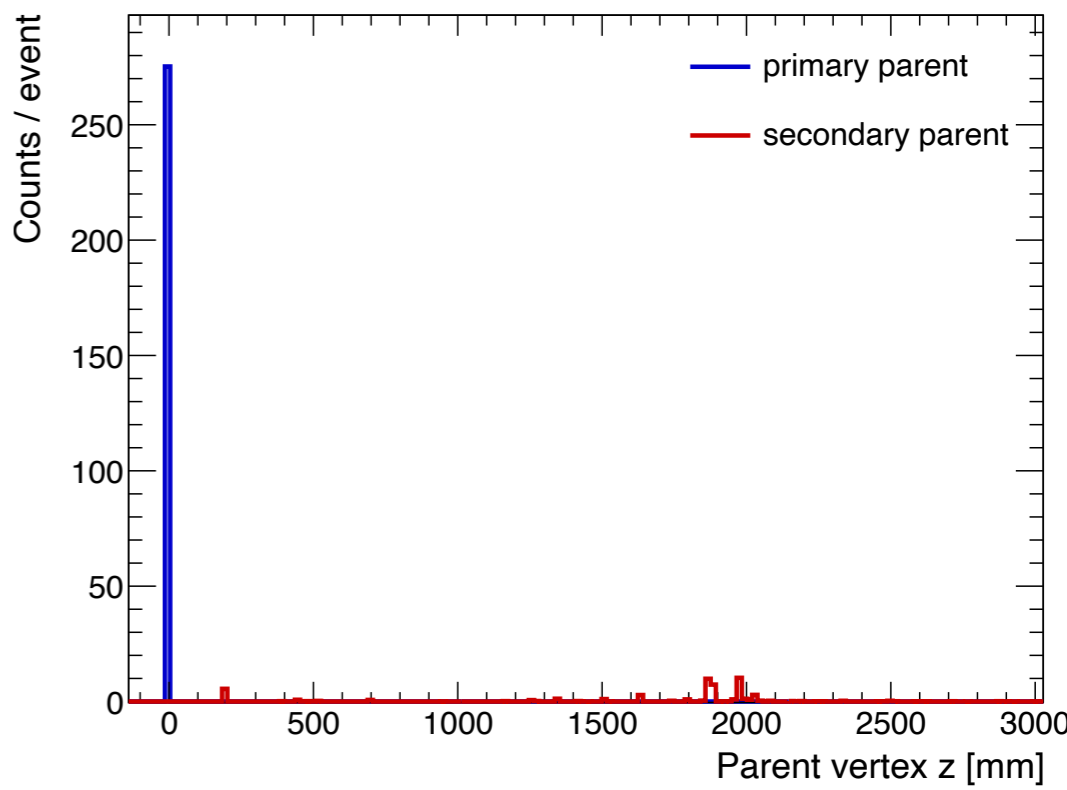
Parent Particles: Production Vertex of immediate parent

Immediate parent vertex z

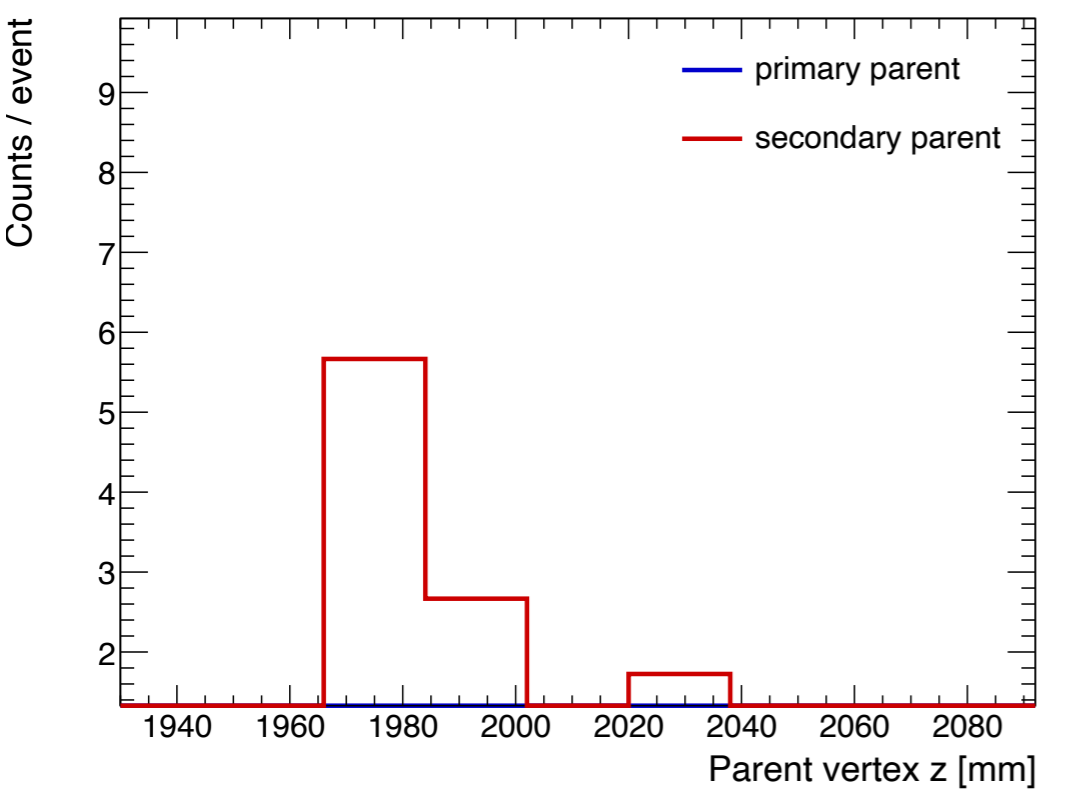


eta=2.5

Immediate parent vertex z



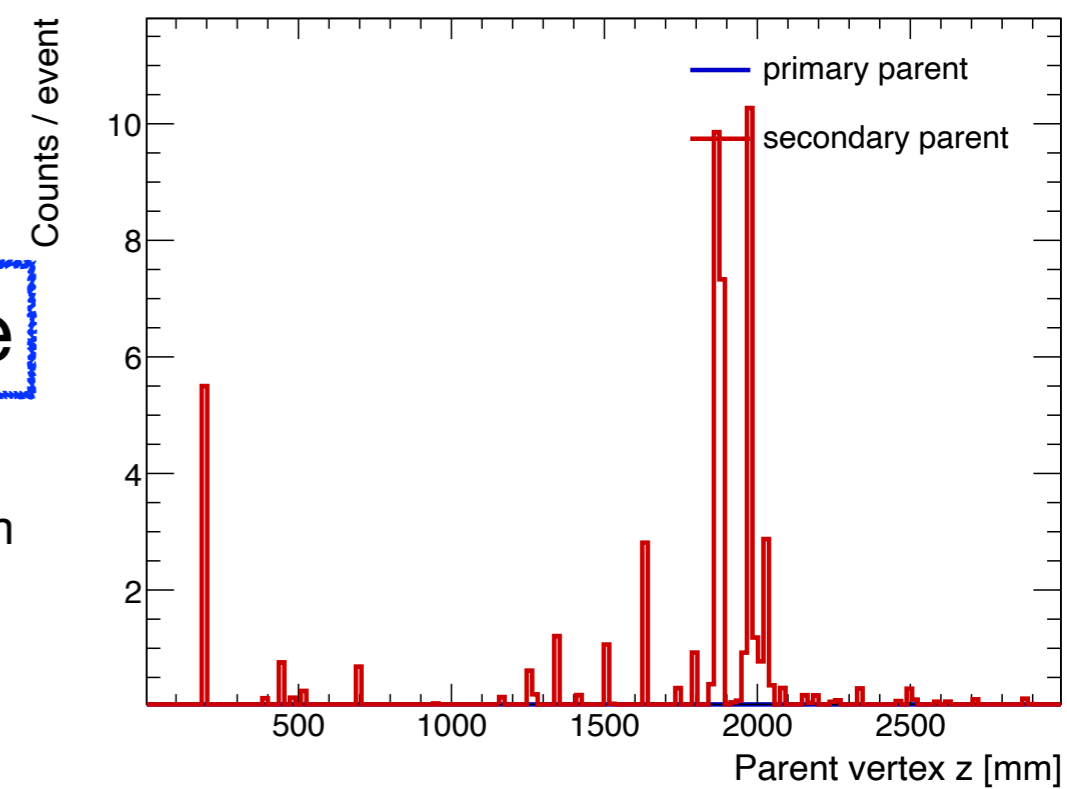
Immediate parent vertex z



zoomed scale

TOF ~ 1800–1980 mm,
dRICH ~1980–3250 mm

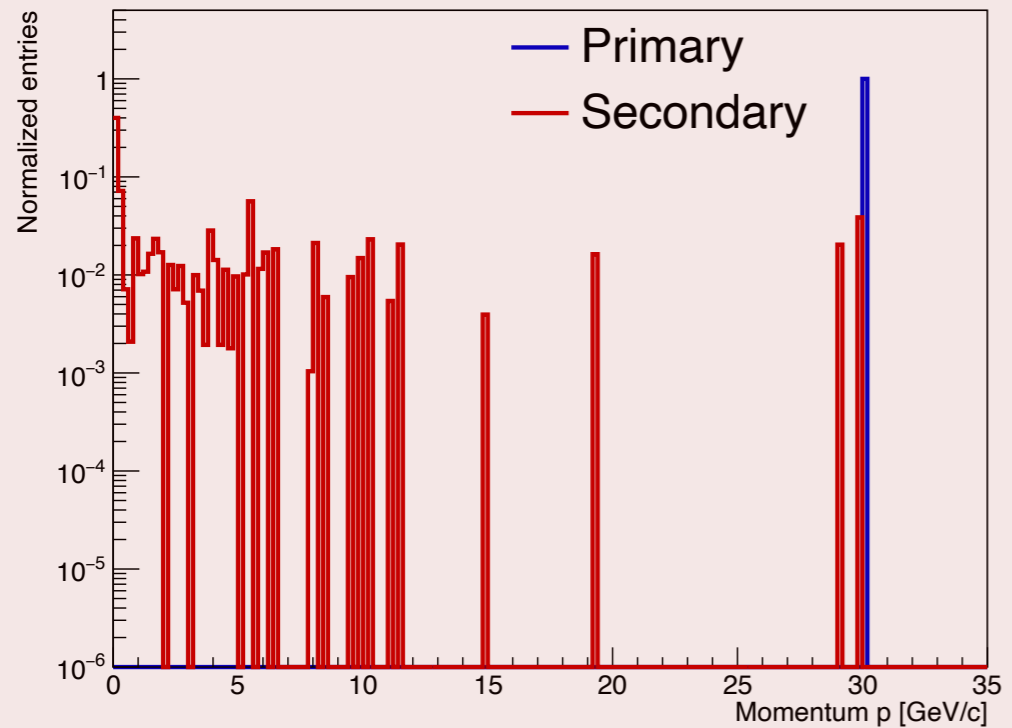
Immediate parent vertex z



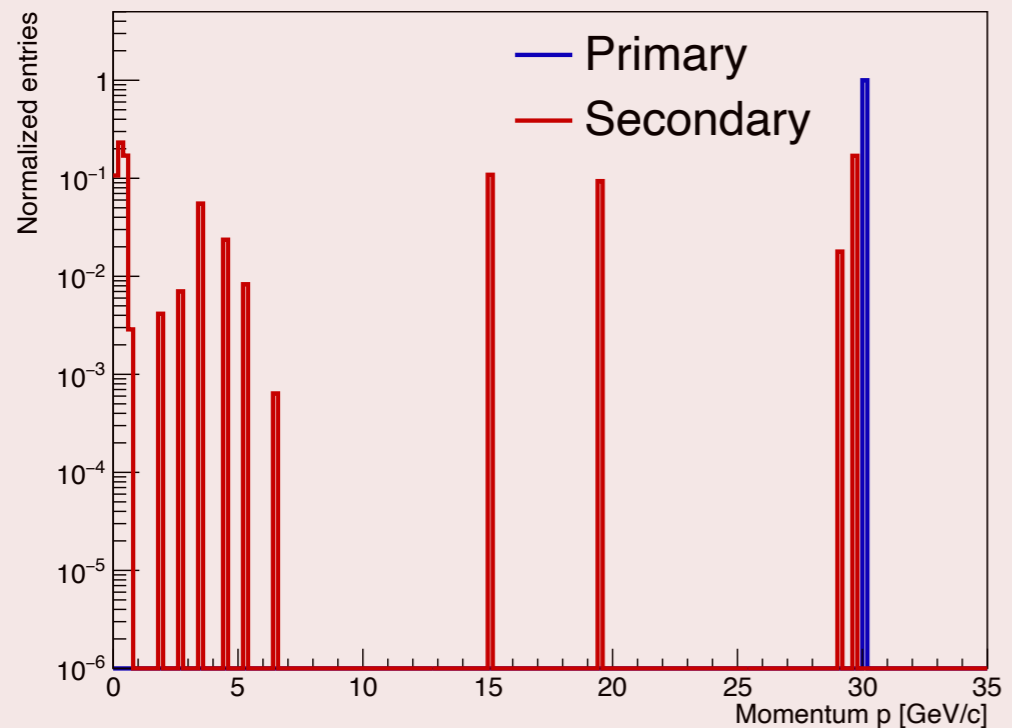
Momentum distribution of parent and grand-parent :

dRICH Only

Immediate parent momentum: primary vs secondary, normalized



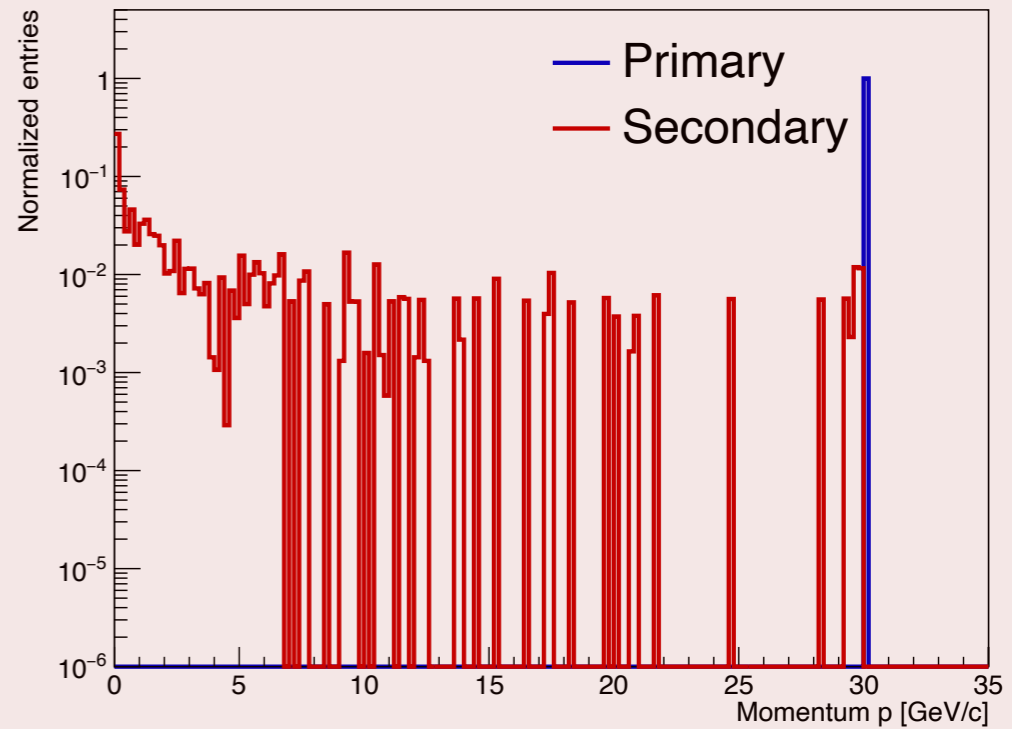
Grandparent momentum: primary vs secondary, normalized



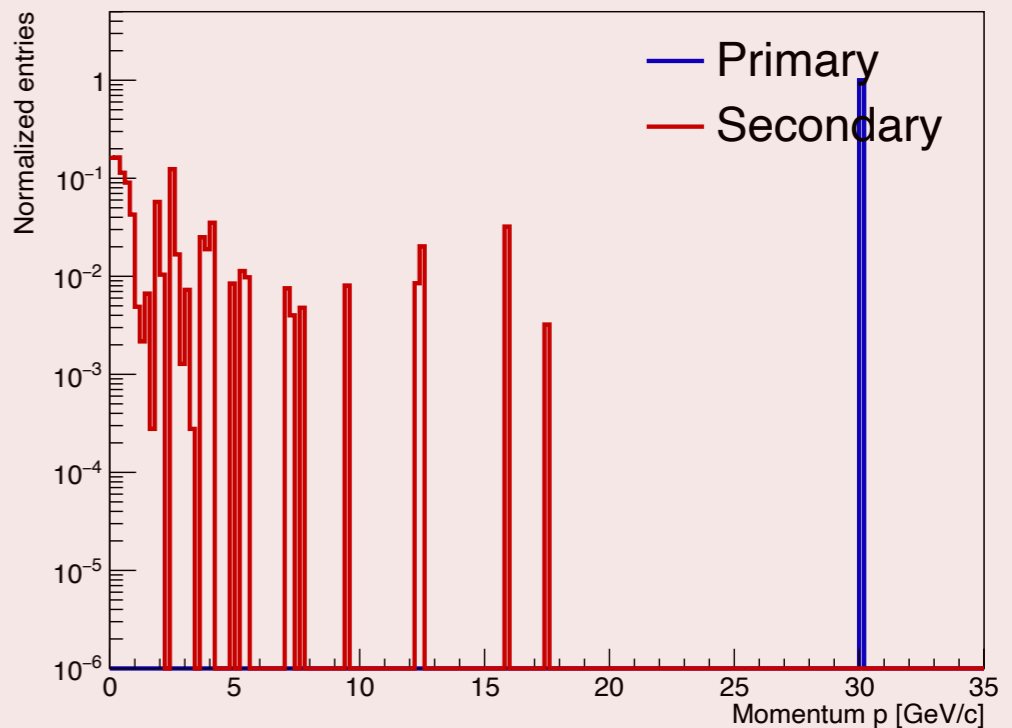
eta=2.5

Full Detector

Immediate parent momentum: primary vs secondary, normalized

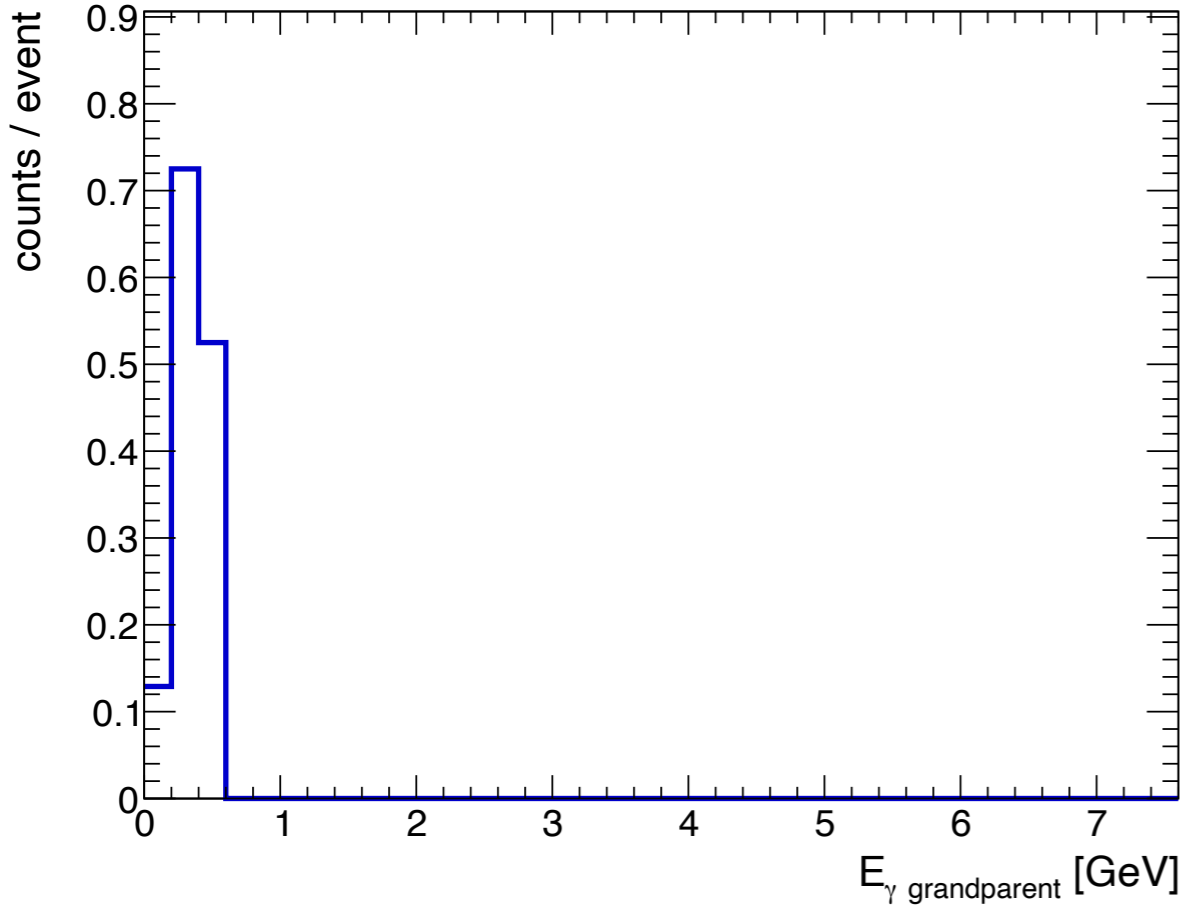


Grandparent momentum: primary vs secondary, normalized



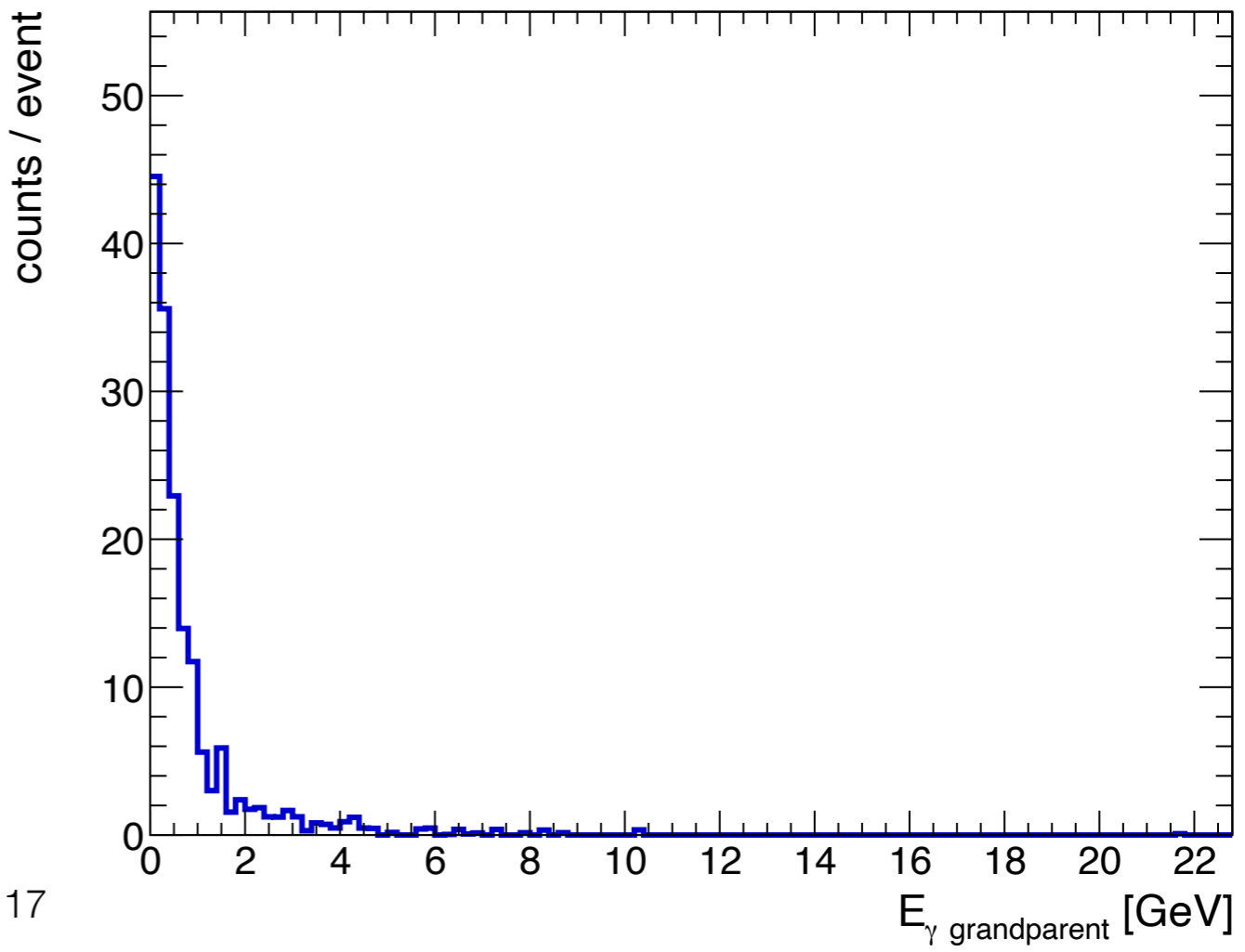
Only Grand-parent Photon Energy distribution:

Gamma grandparent energy



eta=2.5

Gamma grandparent energy



eta=3.5

Summary :

Previous tail study

- A clear late-time component is observed in the dRICH photon-hit time distribution.
- Both radiator configurations contribute to the tail.
- Late-time hits are dominated by photons whose immediate parent is a secondary particle.

Current study

- PG and HepMC give broadly consistent photon-hit time distributions for matched single-pion kinematics.
- Full detector enhances the late-time region relative to dRICH-only simulation.
- The enhanced tail is consistent with additional secondary-parent photon production from detector/material interactions.

Next steps

- Checking the dependence of momentum, Charge, species of primary particle.

Thank you !

Back-up

For particle Gun :

```
npsim --runType run \  
--compactFile $EIC_SHELL_PREFIX/share/epic/epic_drch_only.xml \  
--outputFile sim_piPlus_eta1p5_phi90.root \  
--enableGun \  
--gun.particle "pi+" \  
--gun.energy 30*GeV \  
--gun.direction "0.0 0.425 0.905" \  
--gun.position "0 0 0*cm" \  
.....
```

For HepMC :

```
root -l 'hepmc-writer-single-track.C(  
"hadron-going-endcap.calibration.hepmc",  
1000,  
211,  
30.0, 30.0,  
1.5, 1.5,  
M_PI/2, M_PI/2)'
```

and then pass through npsim