dRICh Update

Christopher Dilks
ATHENA PID Meeting
21 June 2021

Current Status

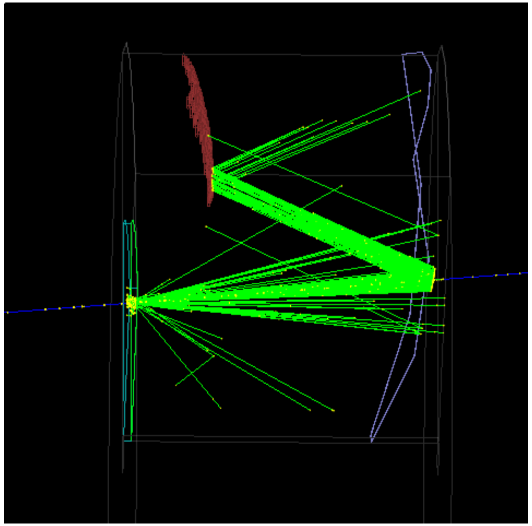
- Standalone GEMC implementation → AI Optimization studies
- G4E and Fun4All Ports in progress
  - Substantial progress in Fun4all port → support ECCE and CORE
  - Geant4 Text File geometry
  - Optics and material properties class
  - Hits readout and classification

attempt to be framework agnostic

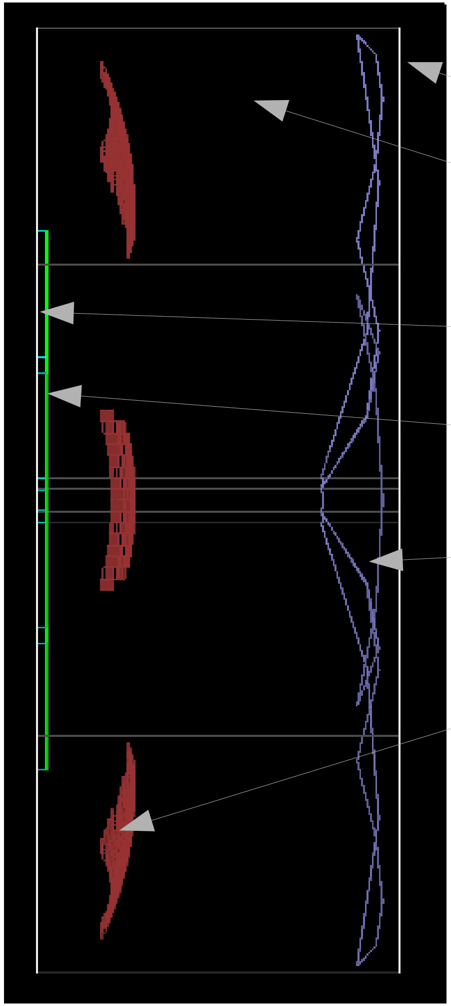
- Migration to DD4hep
  - ATHENA Software group contacted for help/guidance

dRICh Geometry

Incident pion



Volume Hierarchy



Vessel (white) – Aluminum volume

Petal (grey) [x6] – Gas volume

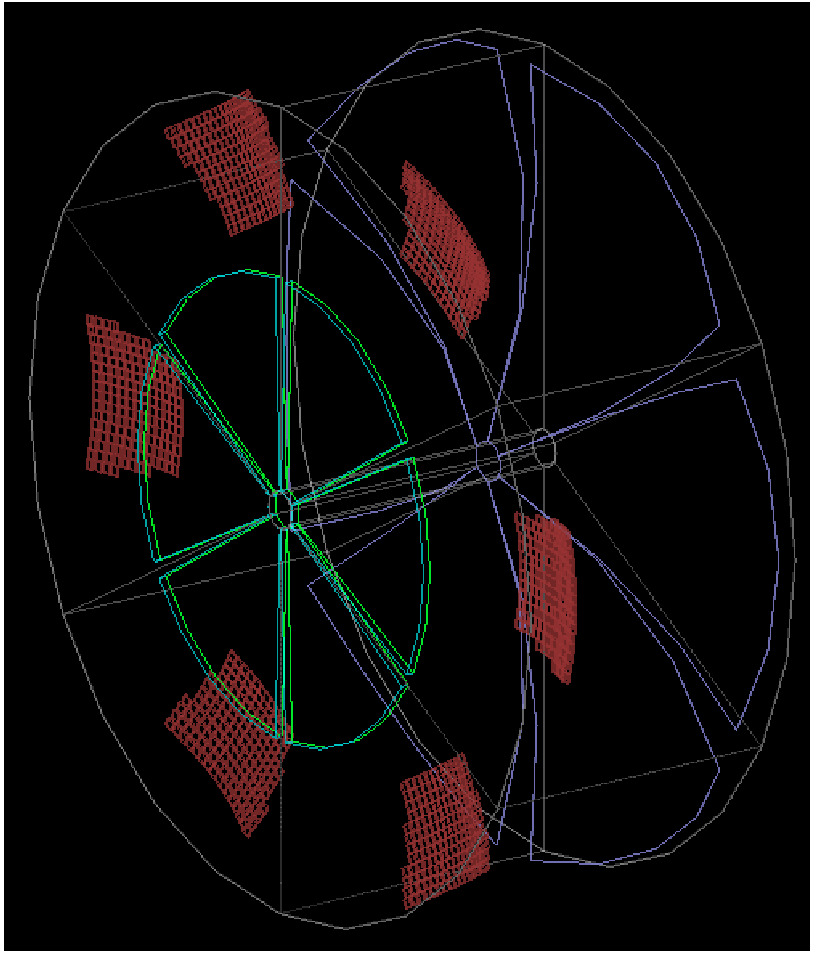
Aerogel (blue)

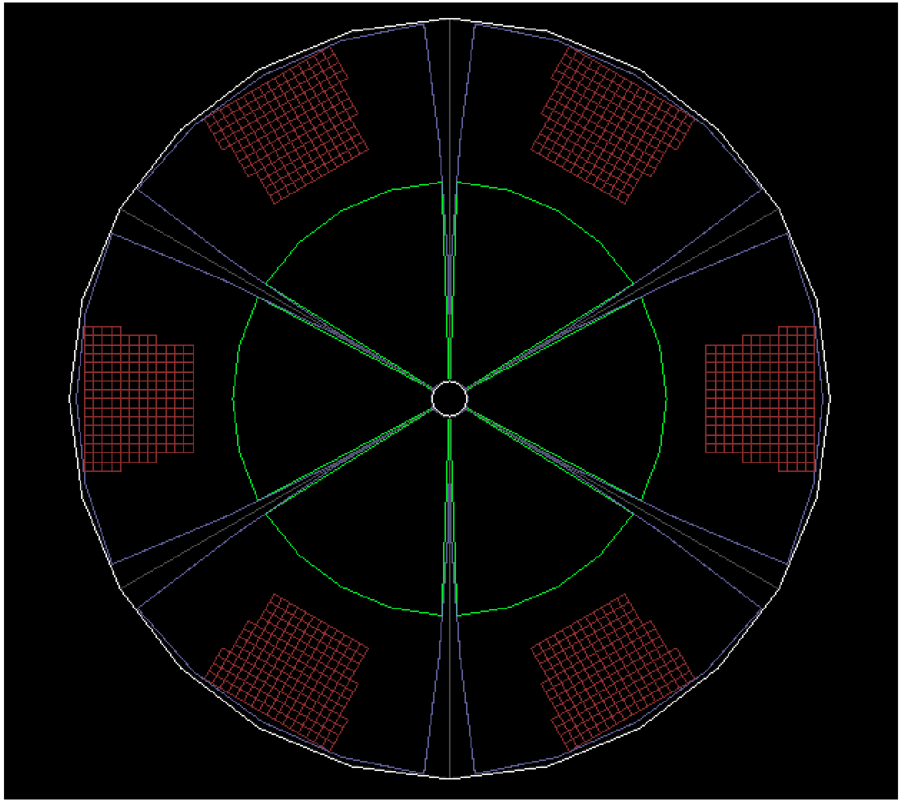
Filter (green)

Spherical Mirror (purple)

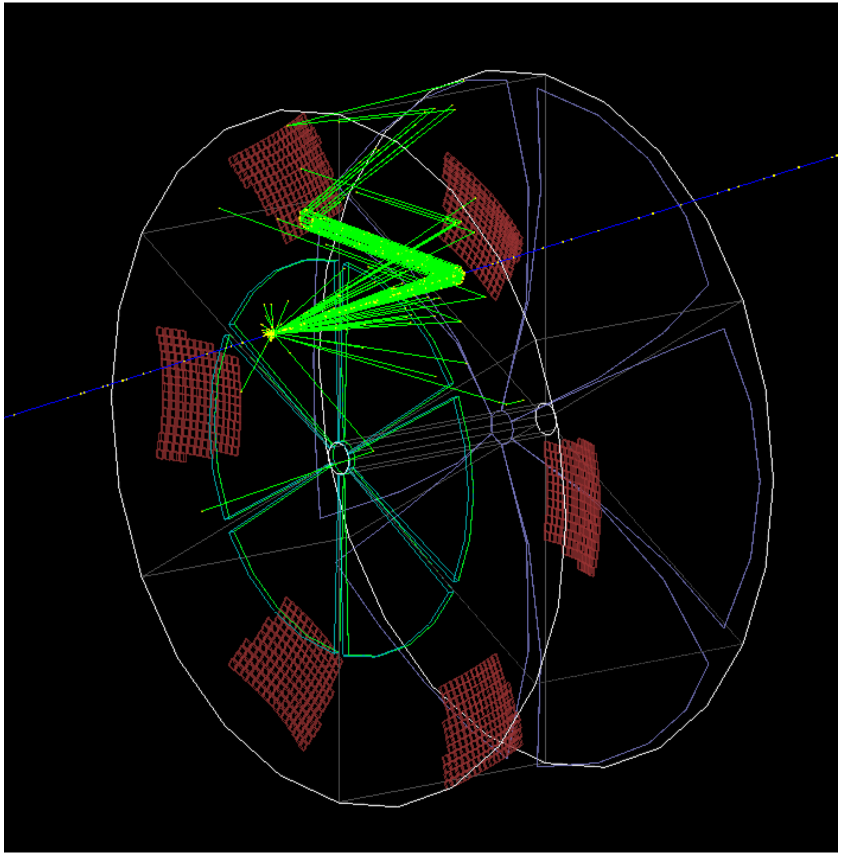
Photosensors (PSST) (red)

Geometry Pictures (Fun4all)

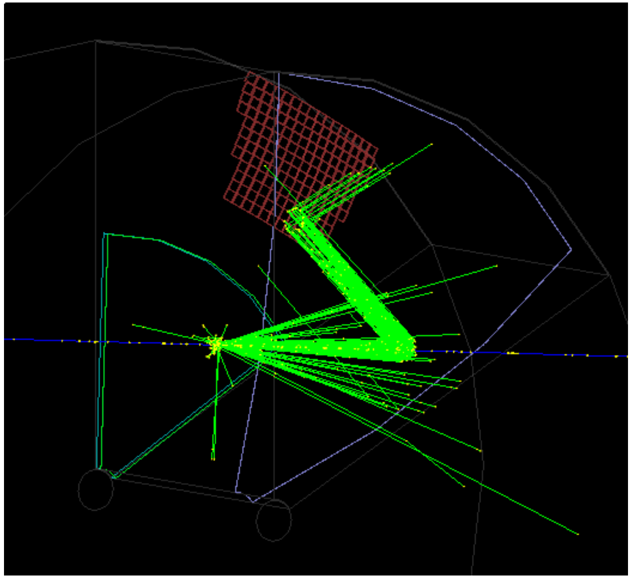


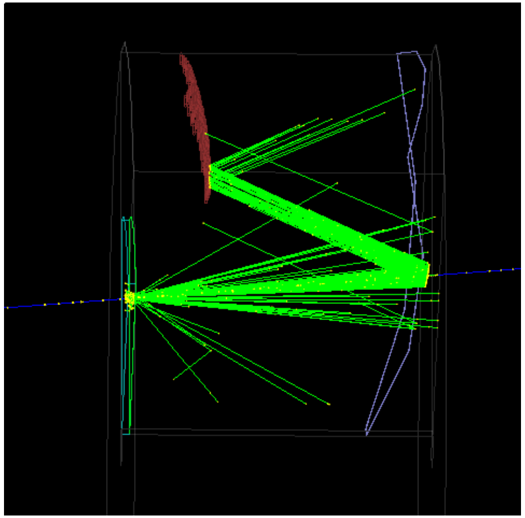


Single Event (pi+)

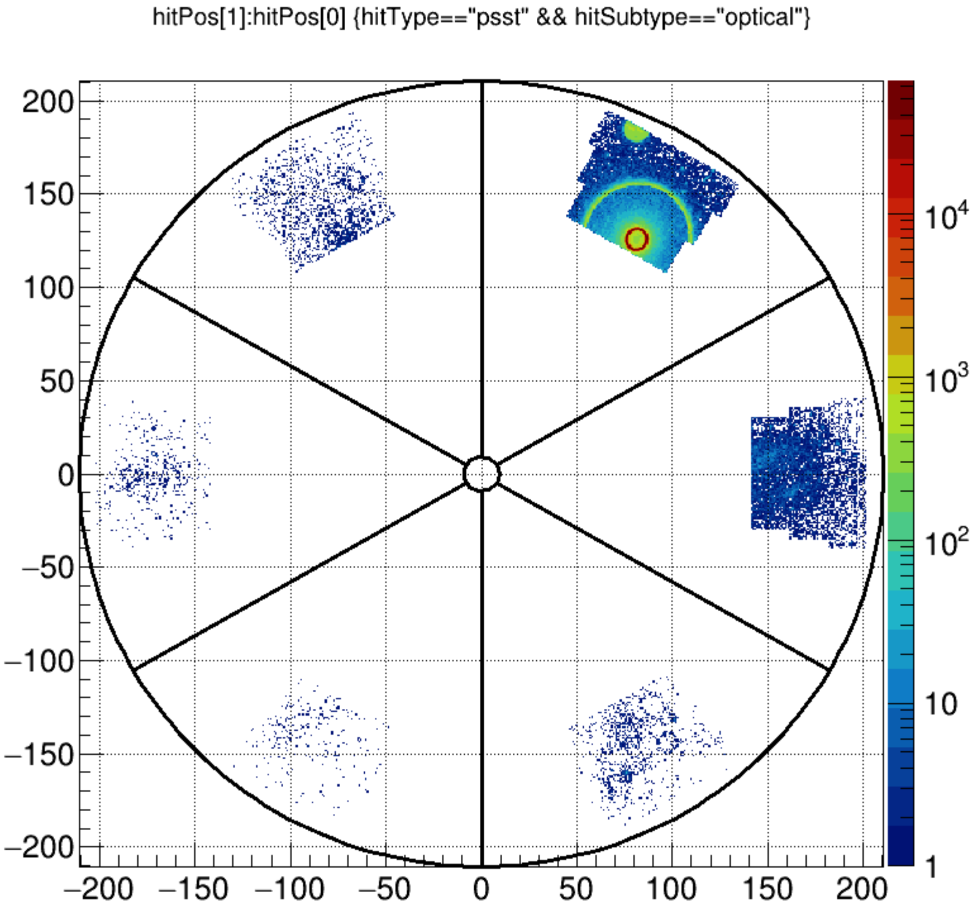


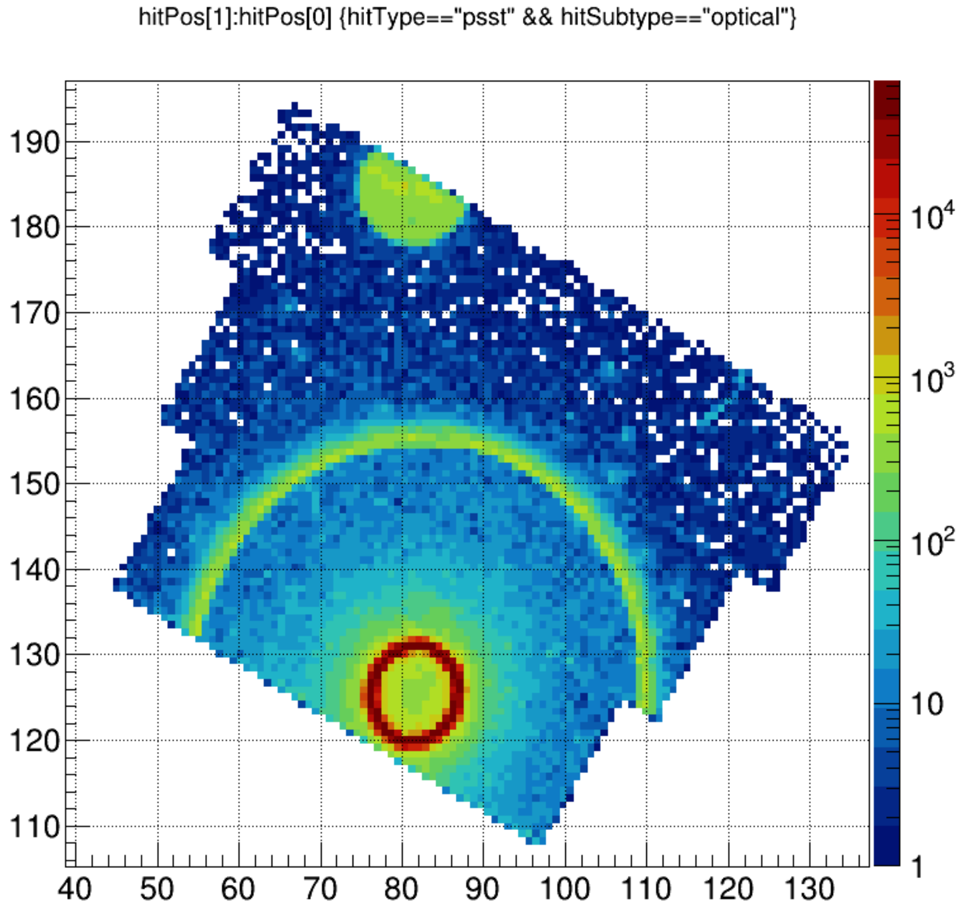
front view





Photosensor opticalphoton hit positions





shown with vessel geometry outline

zoom in of primary petal

Fun4all Hits Readout

Custom hit class → streamable to DST

Also streaming to TTree, with the following branches:

indices

- **evnum** – event number
- **trackID** – unique ID for the track
- **parentID** – trackID of the parent particle

hit classification

- **hitType** – string classifying the hit type
- **hitSubtype** – further hit type classification

unique ID for photosensor

- **petal** – which petal the hit is in
- **psst** – which photosensor (from copy number)

particle type and production process

- **pdg** – PDG encoding
- **particleName** – string for particle name
- **process** – physics process that produced the particle

kinematics

- **hitPos[3]** – hit position [x,y,z] (cm)
- **hitP[3]** – hit momentum [px,py,pz] (GeV)
- **hitPdir[3]** – hit momentum direction [x,y,z]
- **hitVtxPos[3]** – vertex position [x,y,z] (cm)
- **hitVtxPdir[3]** – vertex momentum direction [x,y,z]

integrated values

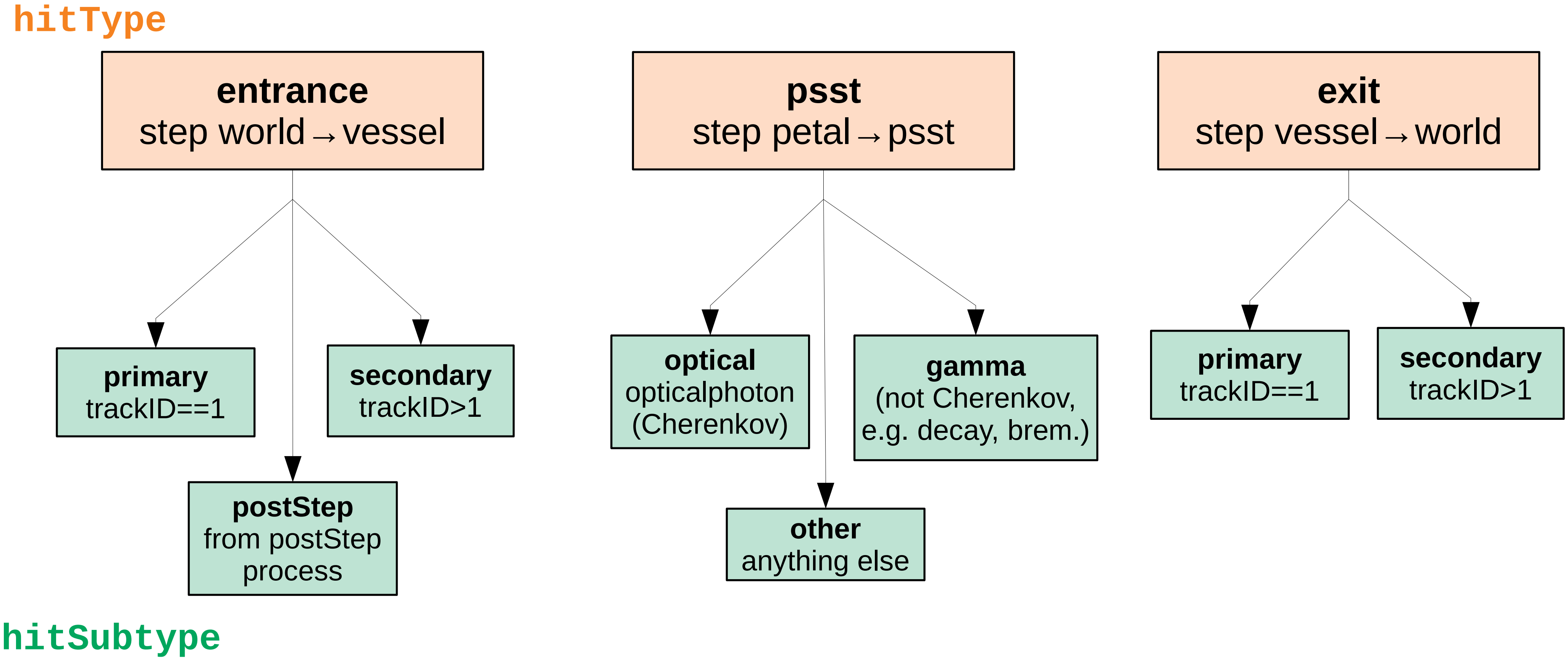
- **deltaT** – global time difference (ns)
- **edep** – energy deposition (GeV)

Outlook and Plans

- **Much development in the hits readout**
  - 3 hit types, further classified into subtypes
- **Short term tasks for fun4all:**
  - Analysis code is in progress
  - Cross checks with GEMC implementation (geometry has been kept the same)
  - Other tasks:
    - Very slow memory leak – need to fix
    - Mirror geometry → would mirror hits be useful?
    - Consider splitting PSST optical hits to “opticalGas” and “opticalAerogel”
- **Integration with Full Simulations**
  - **ATHENA**
    - Need to port to dd4hep → ATHENA Software Group contacted
    - Better to do this sooner rather than later…
  - CORE and ECCE
    - We have the f4a implementation in a prototype state, but to continue development, it would be more efficient to have help from someone in CORE / ECCE

backup

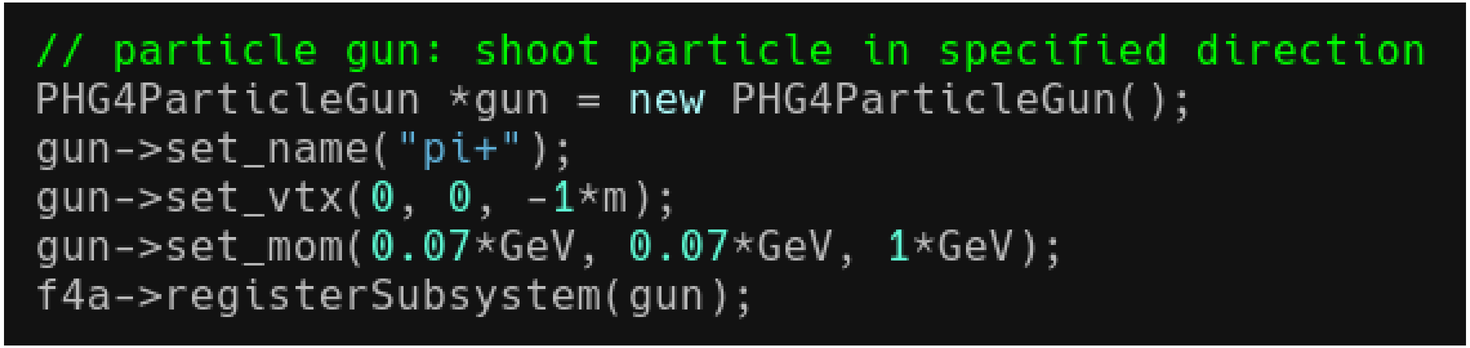
Hits Classification



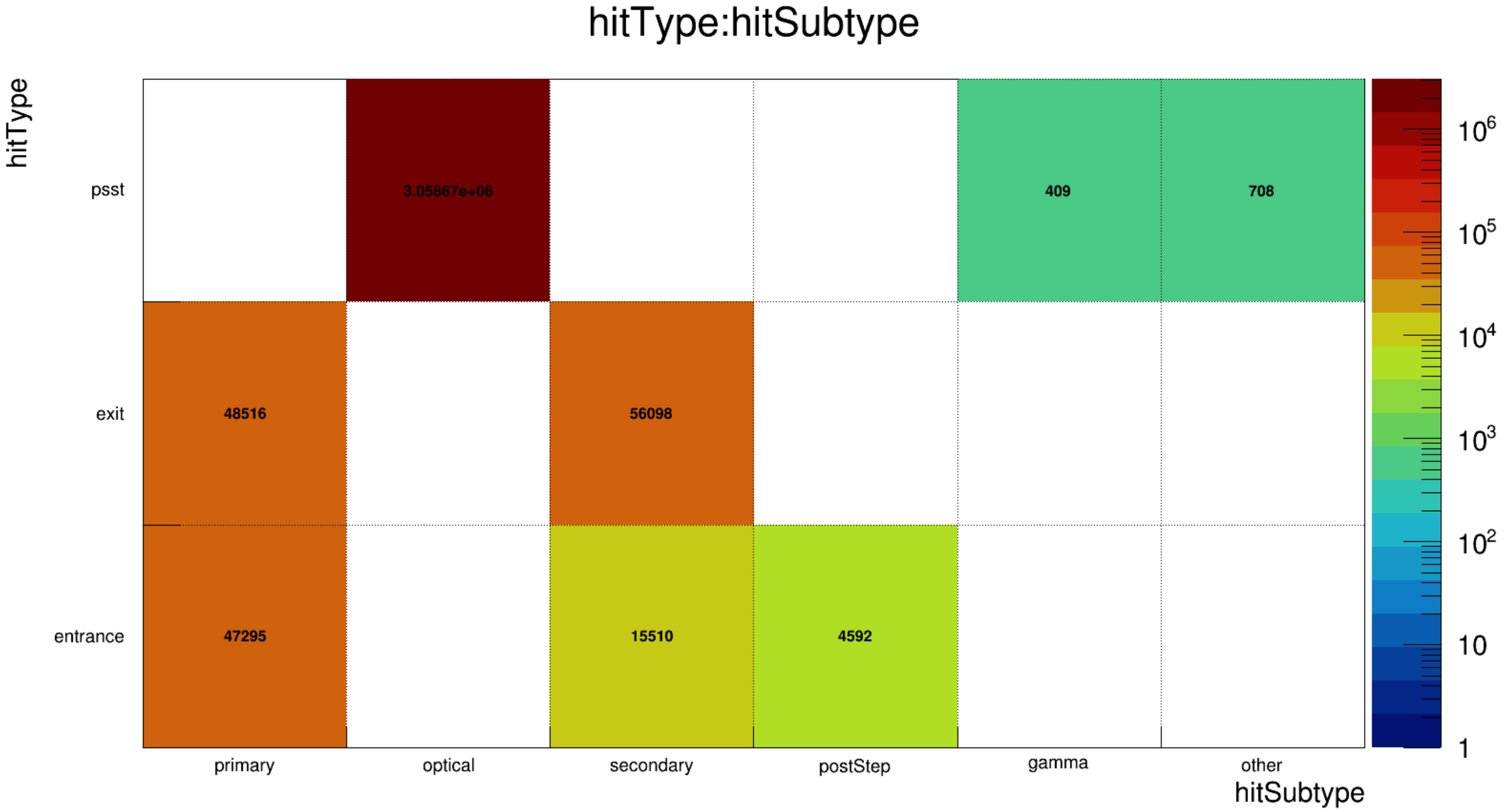
Simulation for Hits Readout Testing

Simulation test: throw 50k π^+s at the dRICh

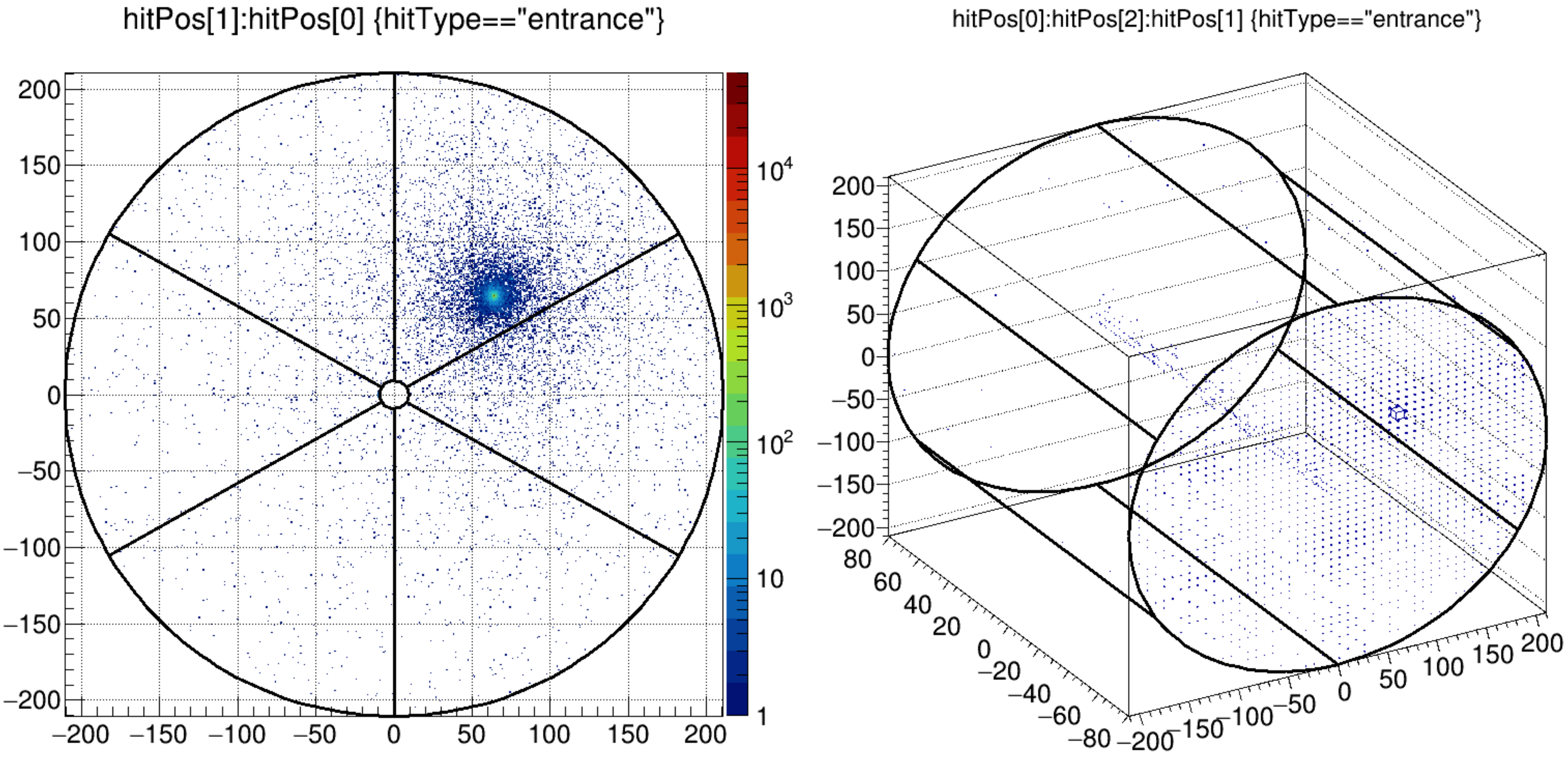
- each pion thrown with the same momentum and direction, to accumulate statistics for a single type of event
- different things happen in each event, but in general we get 2 rings of Cherenkov photons on the photosensors
- some pions interact with the world volume prior to hitting the dRICh, causing secondary hits



```
// particle gun: shoot particle in specified direction
PHG4ParticleGun *gun = new PHG4ParticleGun();
gun->set_name("pi+");
gun->set_vtx(0, 0, -1*m);
gun->set_mom(0.07*GeV, 0.07*GeV, 1*GeV);
f4a->registerSubsystem(gun);
```

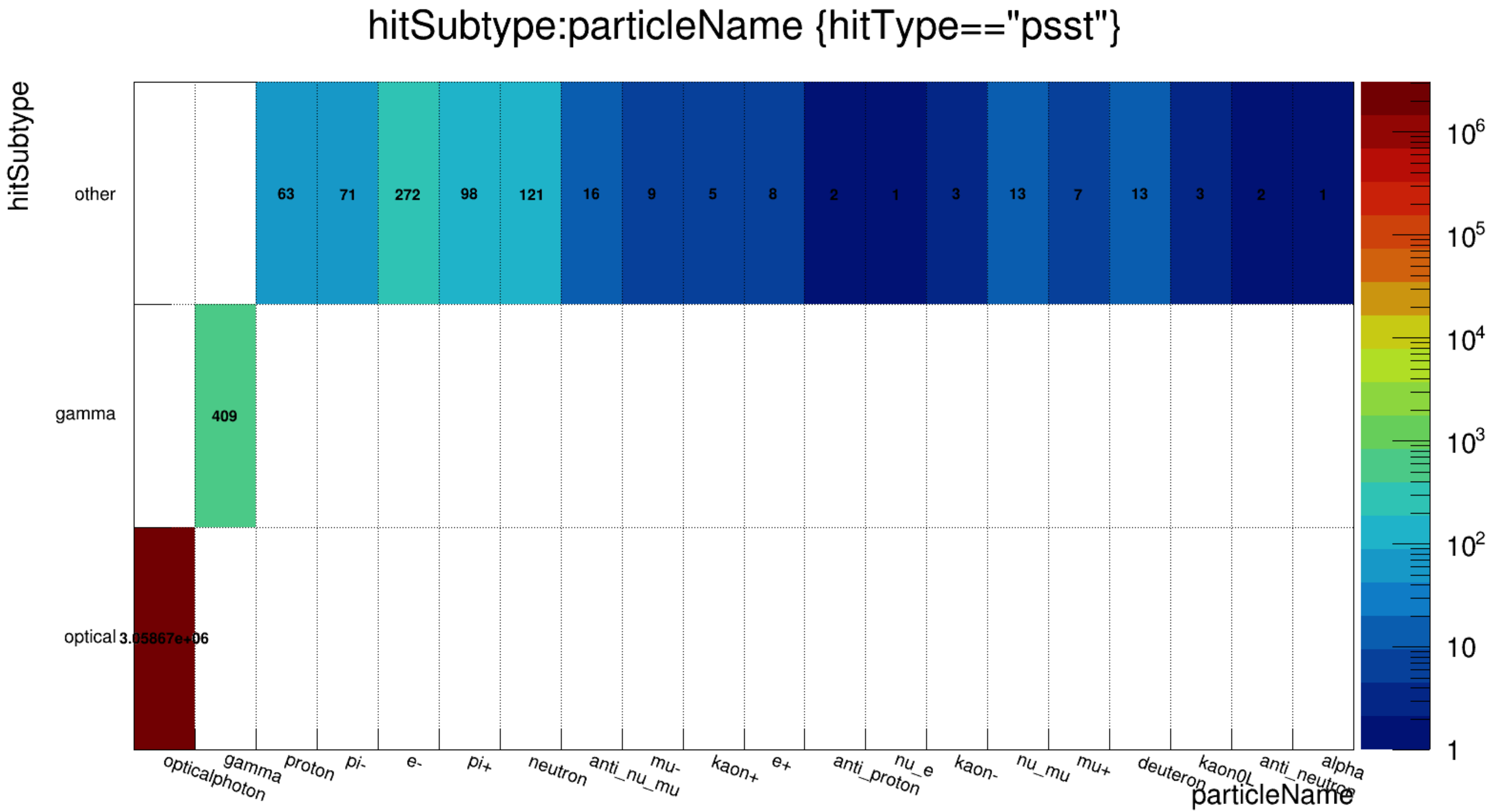

hitType:hitSubtype
hitType
psst
exit
entrance
3.05867e+06
409
708
48516
56098
47295
15510
4592
primary
optical
secondary
postStep
gamma
other
hitSubtype
10^6
10^5
10^4
10^3
10^2
10
1

Entrance hit positions

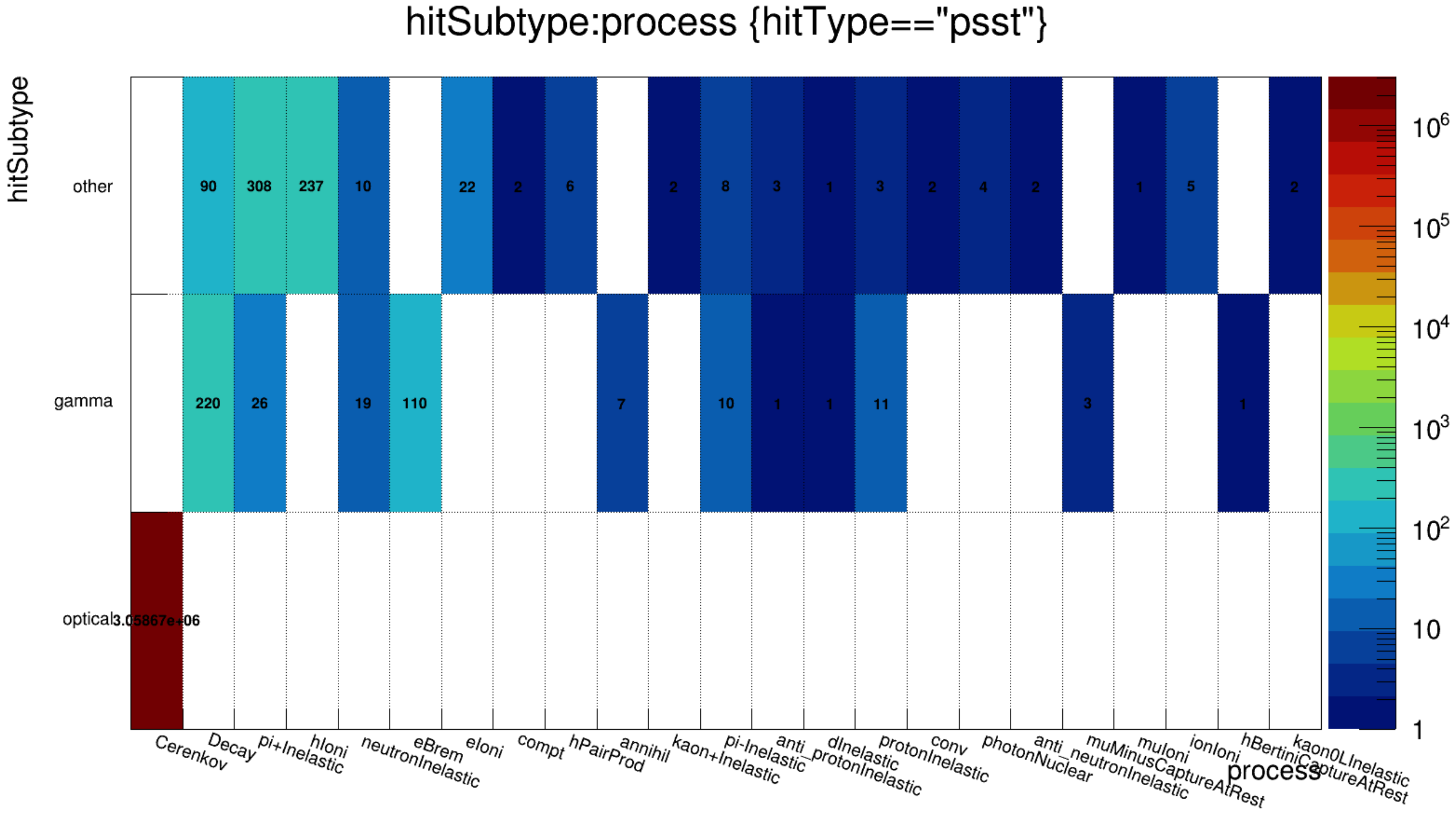


shown with vessel geometry outline

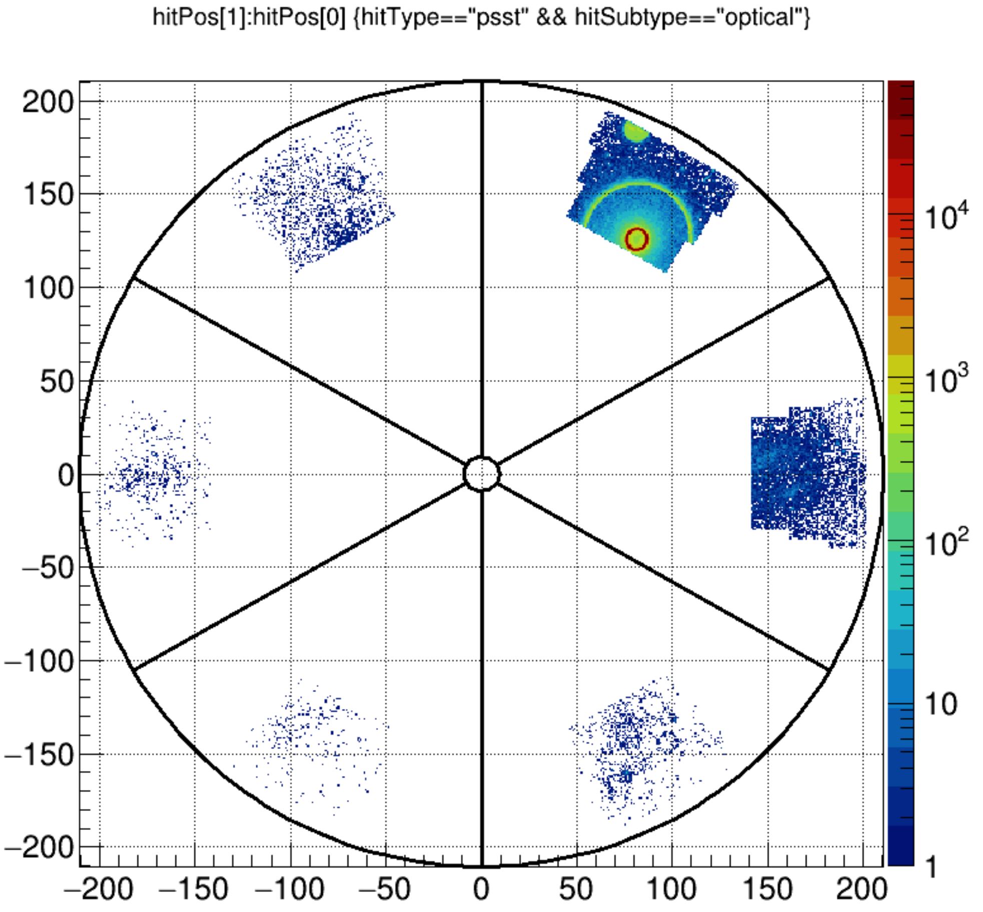
Photosensor hits: sub-type vs. particle



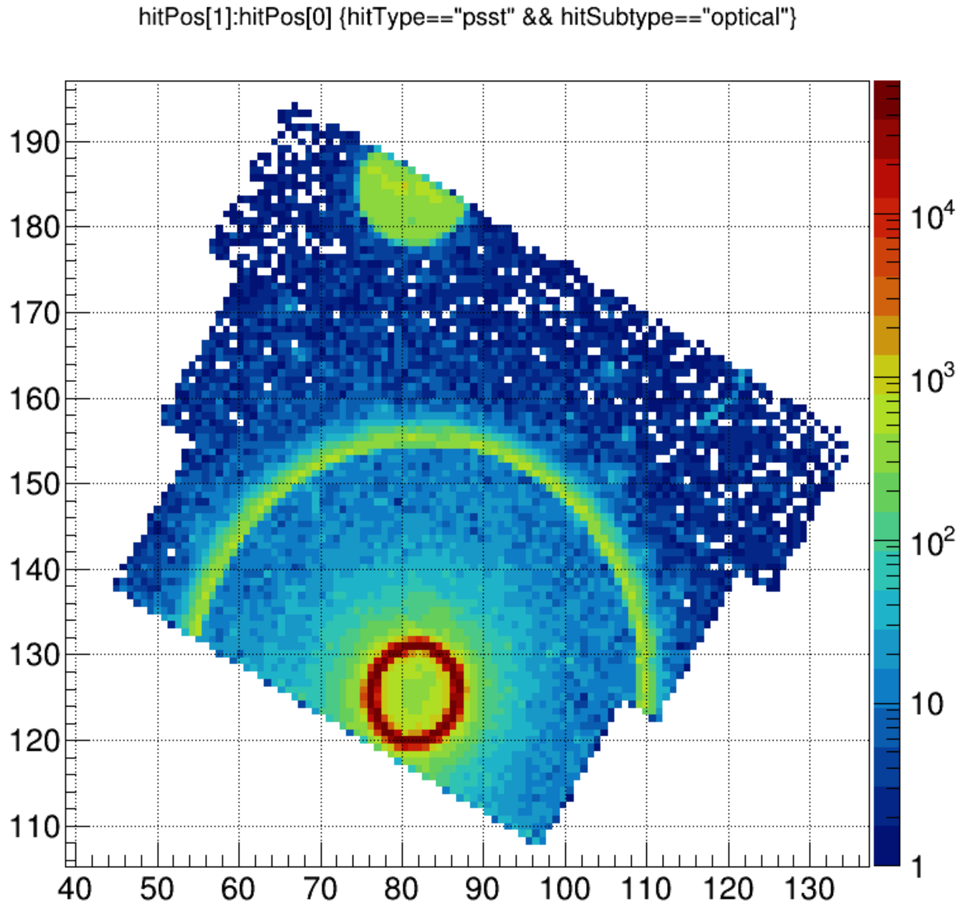
Photosensor hits: sub-type vs. process



Photosensor opticalphoton hit positions

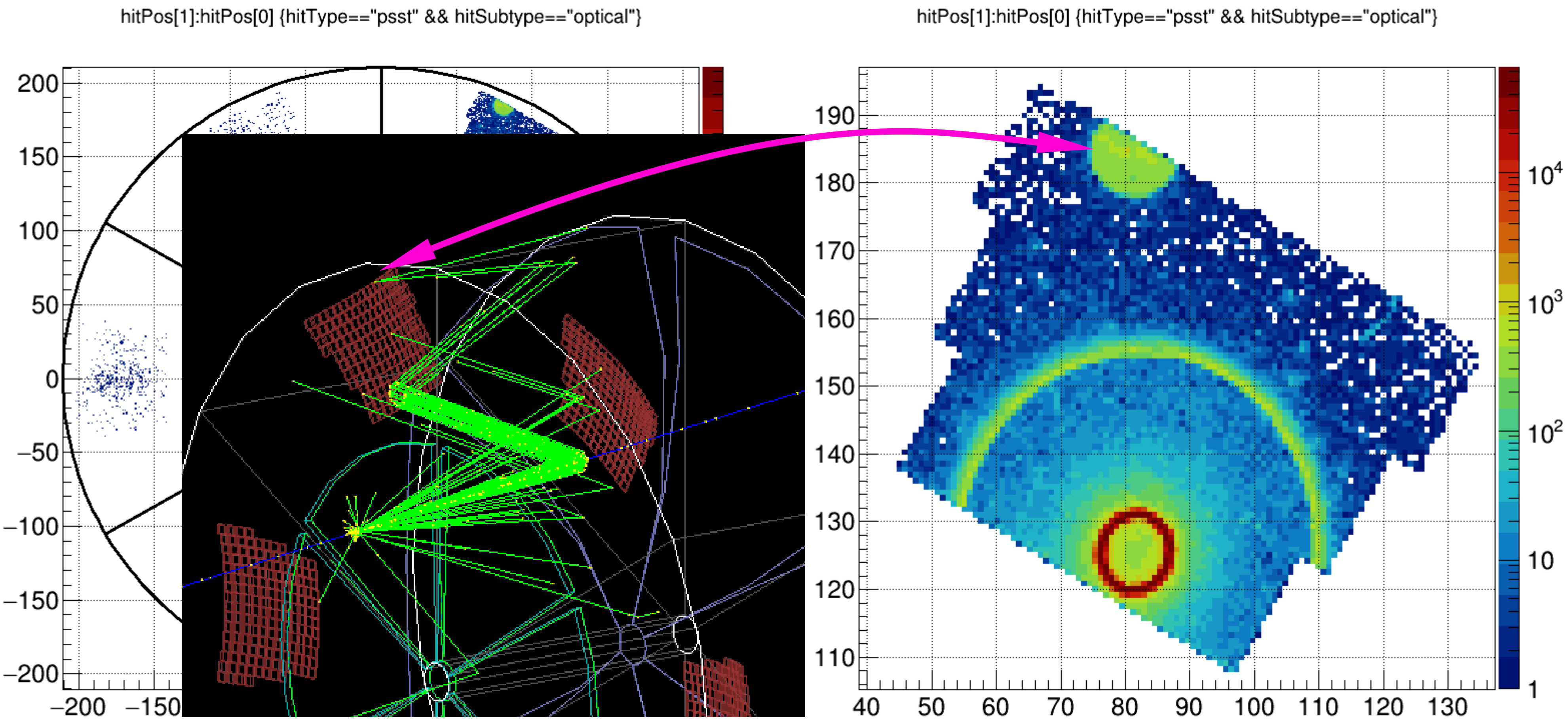


shown with vessel geometry outline



zoom in of primary petal

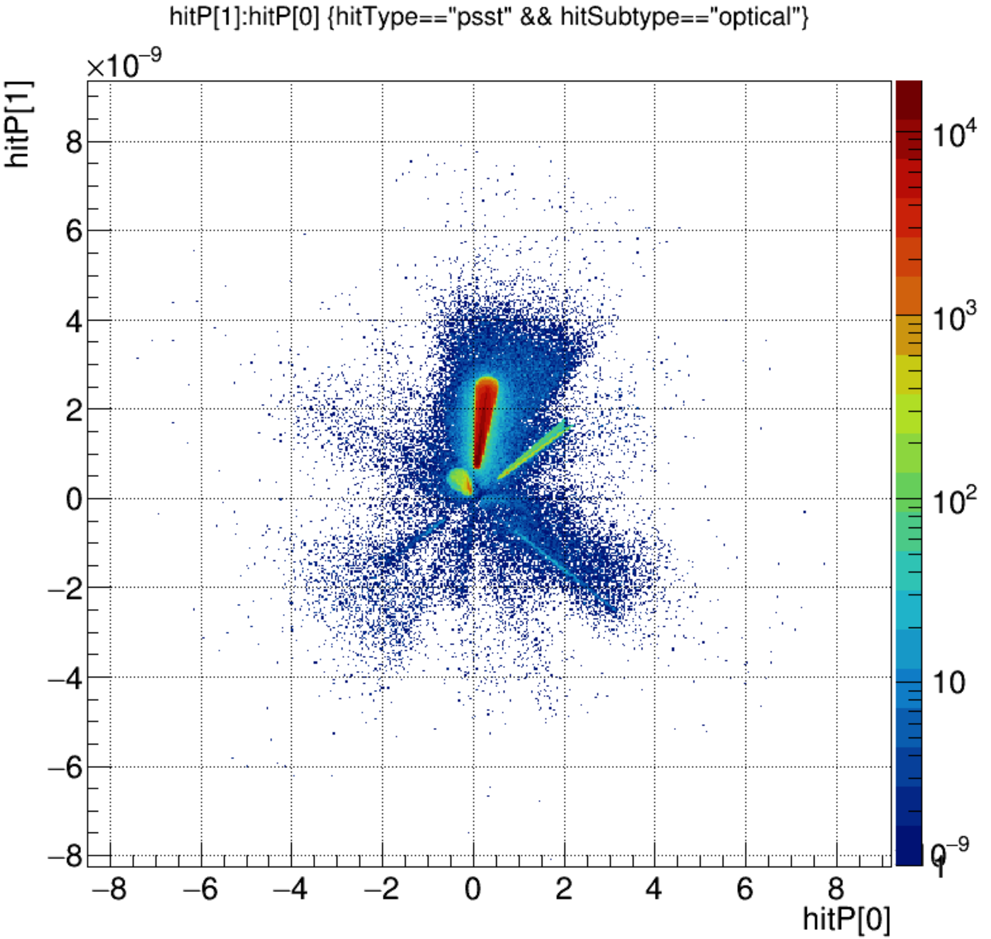
Photosensor opticalphoton hit positions

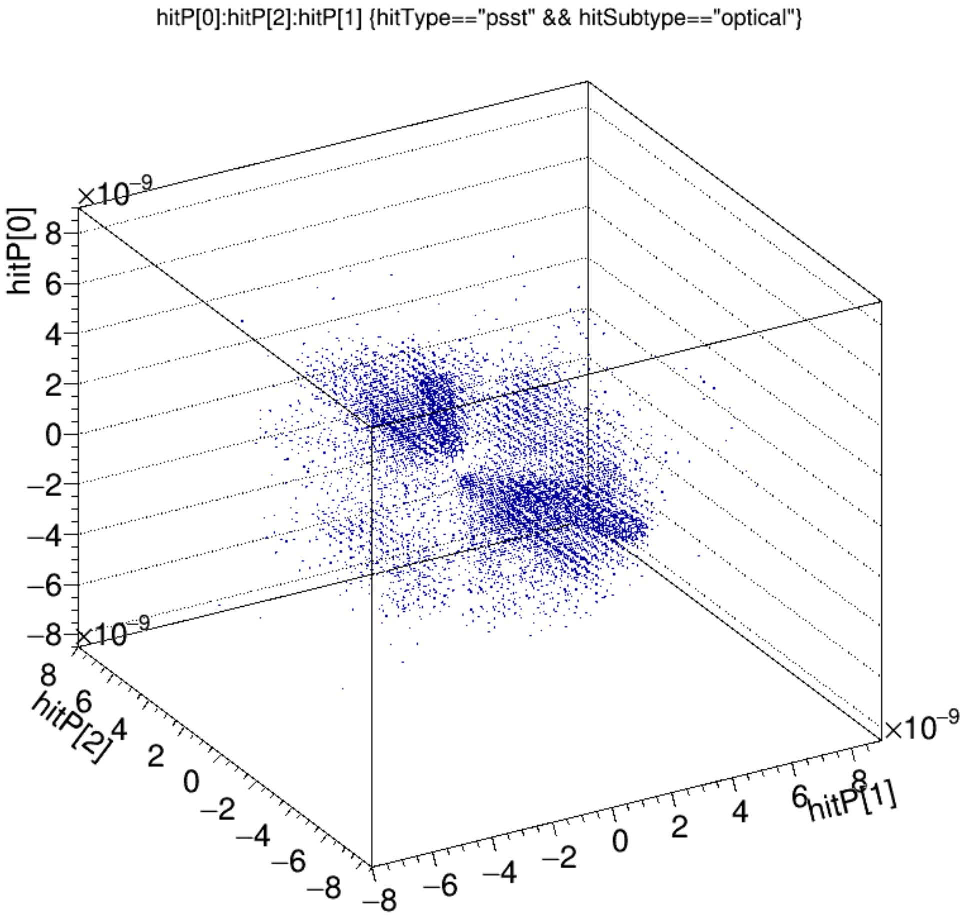


shown with vessel geometry outline

zoom in of primary petal

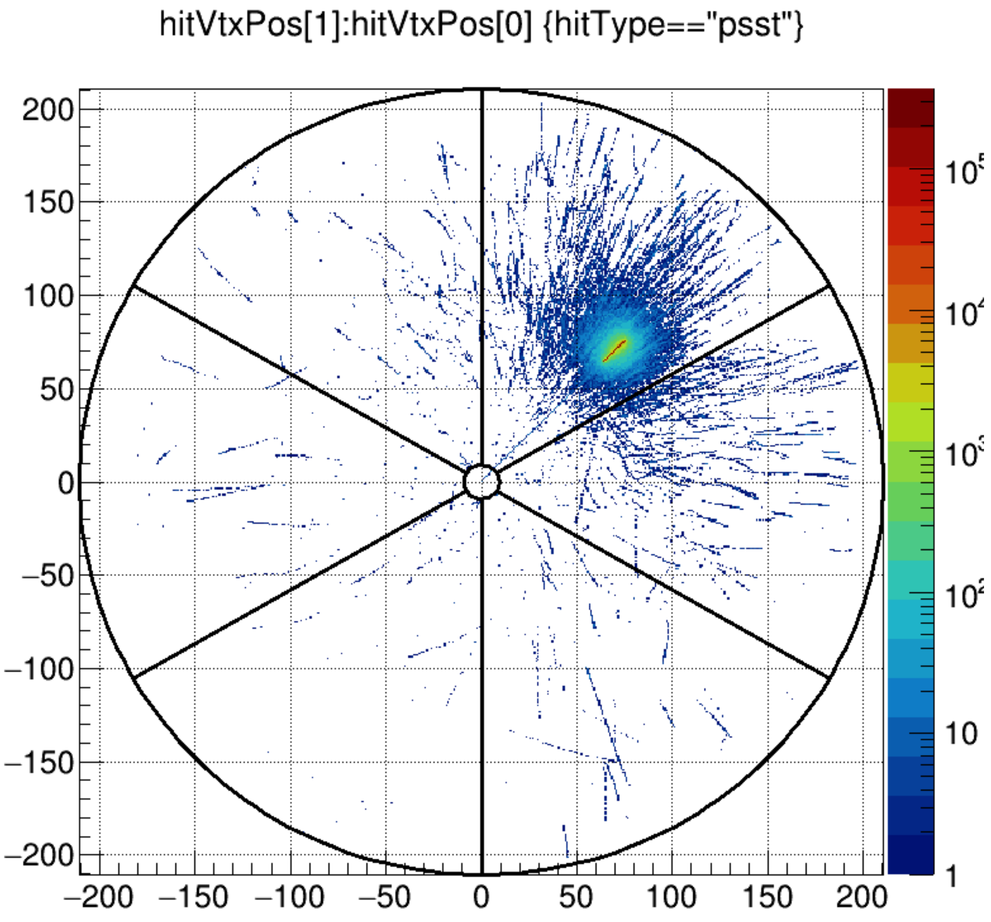
Photosensor opticalphoton hit momentum

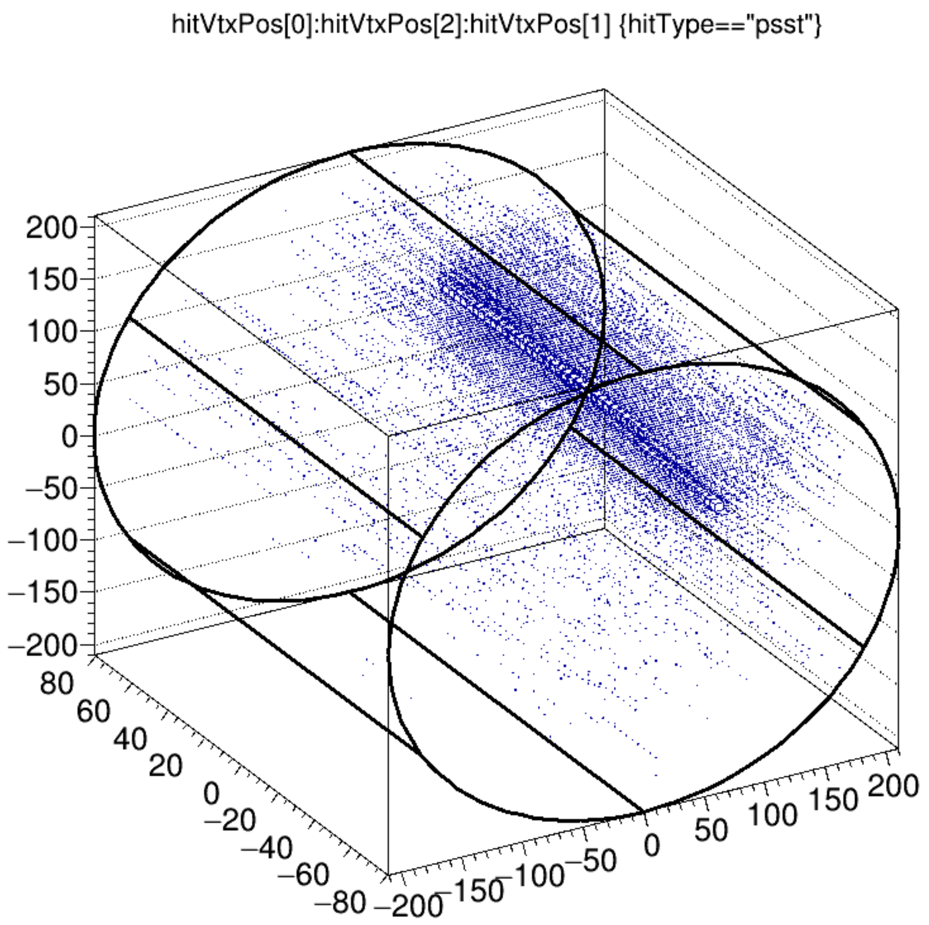




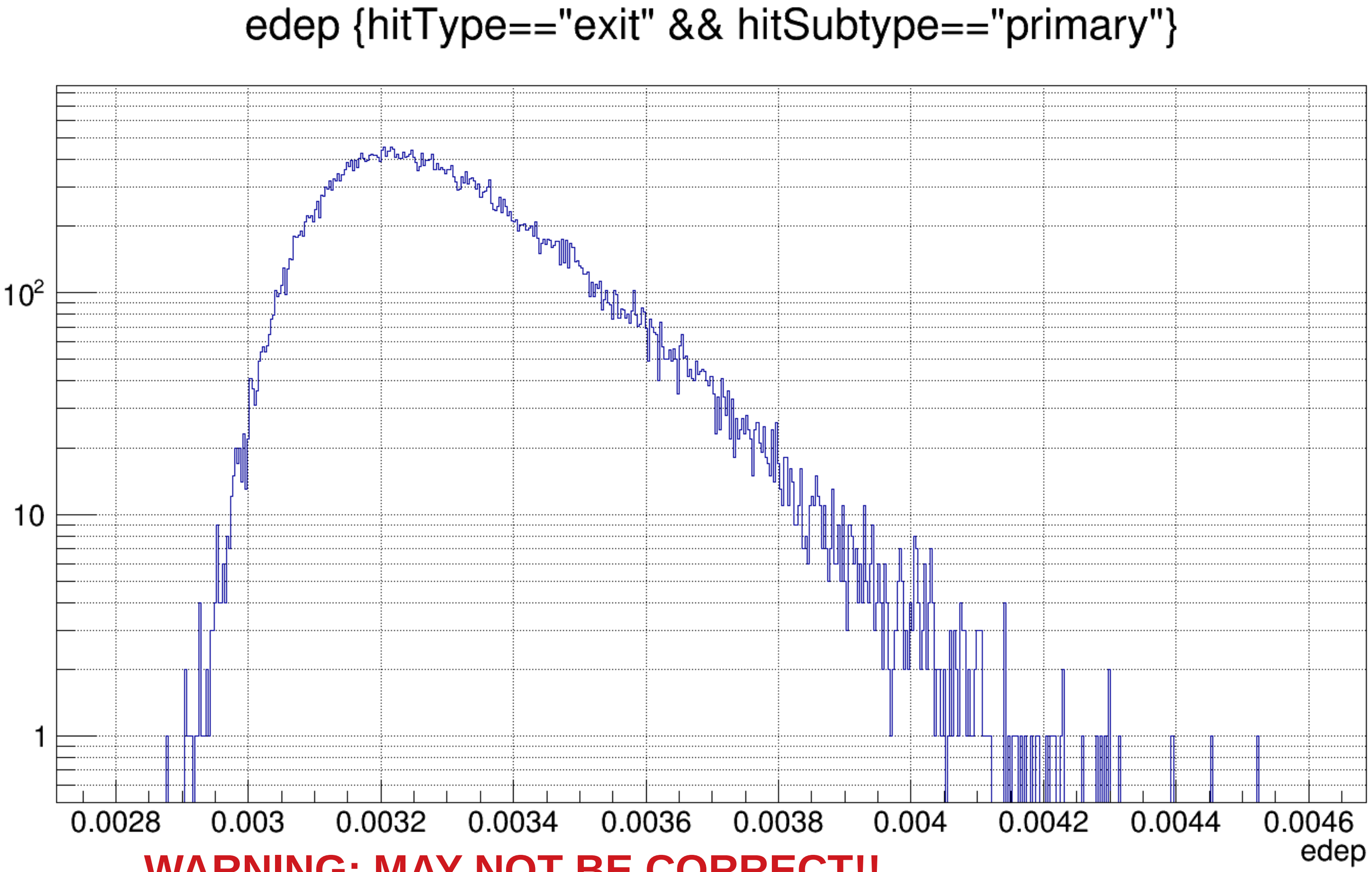
some PSST hits are from the “wrong” side – need some sort of shielding / electronics base in the geometry

Photosensor hit track vertices





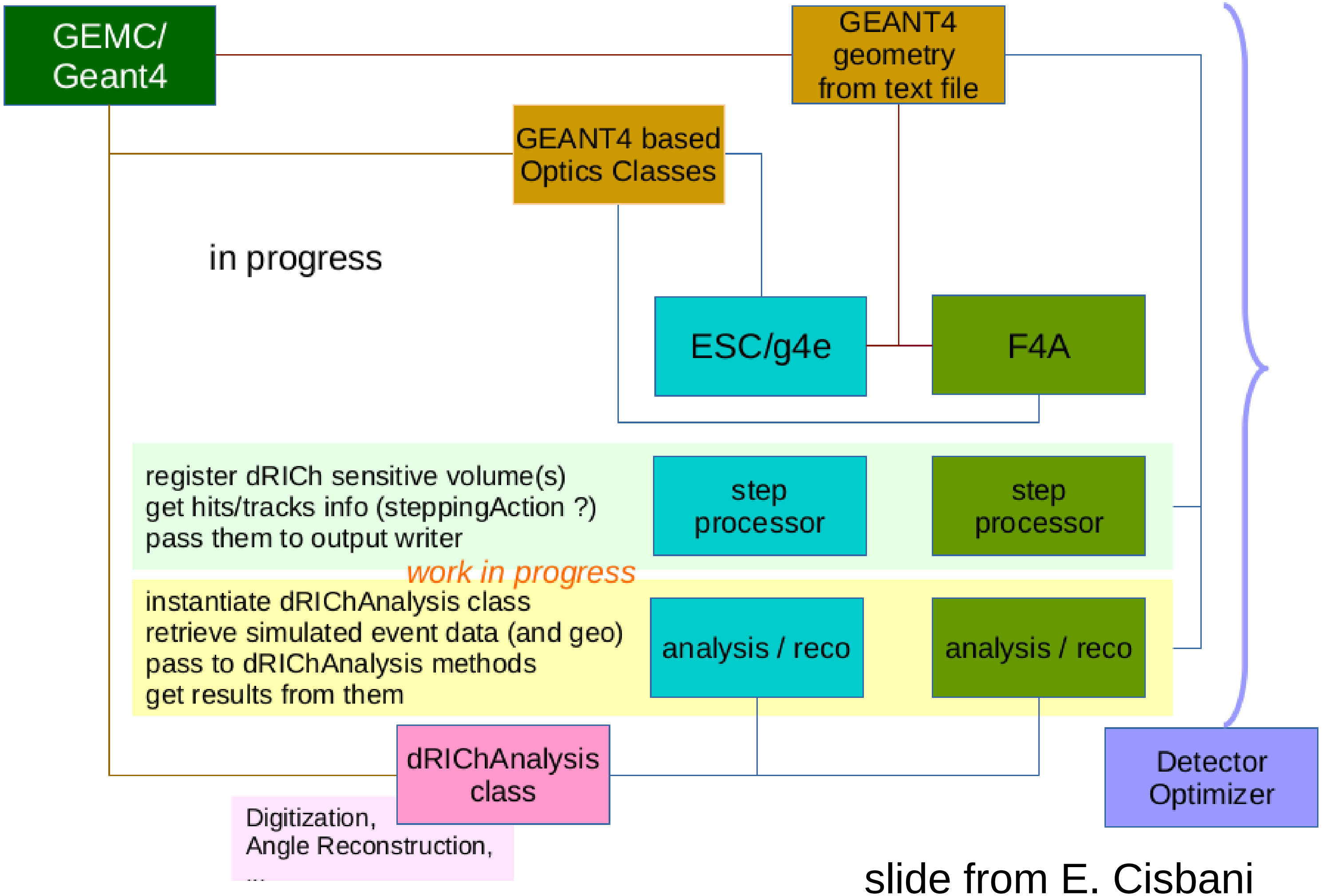
Exit hit Edep, from primary pions (units=GeV)



WARNING: MAY NOT BE CORRECT!!

Software Status

Overall



GEMC/ Geant4

GEANT4 geometry from text file

GEANT4 based Optics Classes

in progress

ESC/g4e

F4A

register dRICh sensitive volume(s)
get hits/tracks info (steppingAction ?)
pass them to output writer

step processor

step processor

work in progress

instantiate dRIChAnalysis class
retrieve simulated event data (and geo)
pass to dRIChAnalysis methods
get results from them

analysis / reco

analysis / reco

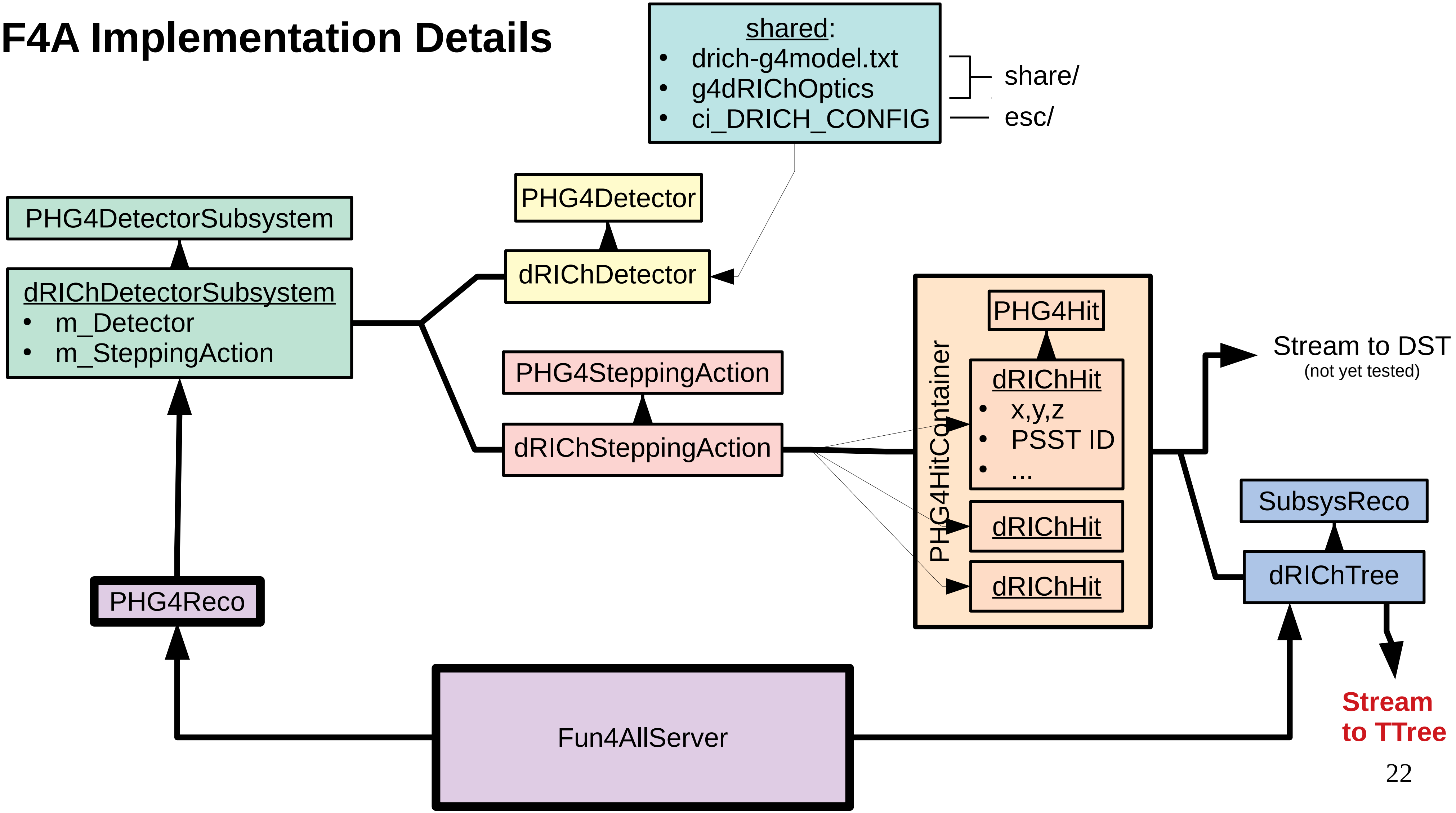
dRIChAnalysis class

Digitization,
Angle Reconstruction,
...

Detector Optimizer

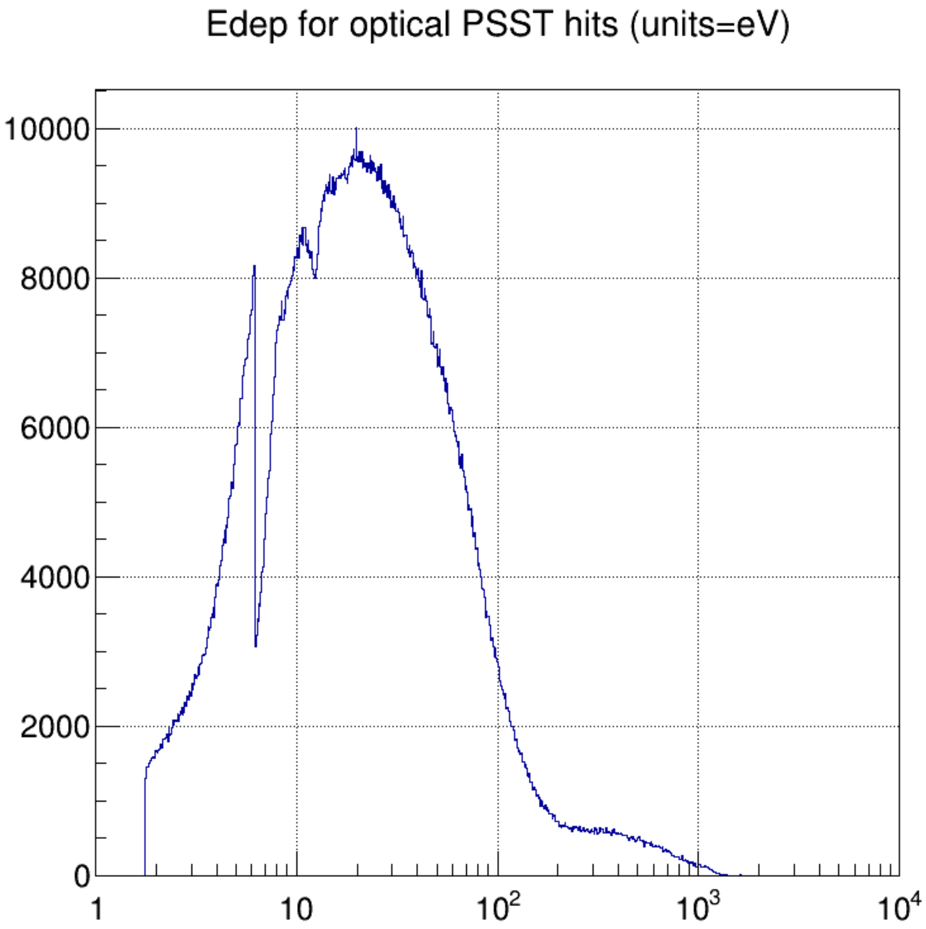
slide from E. Cisbani

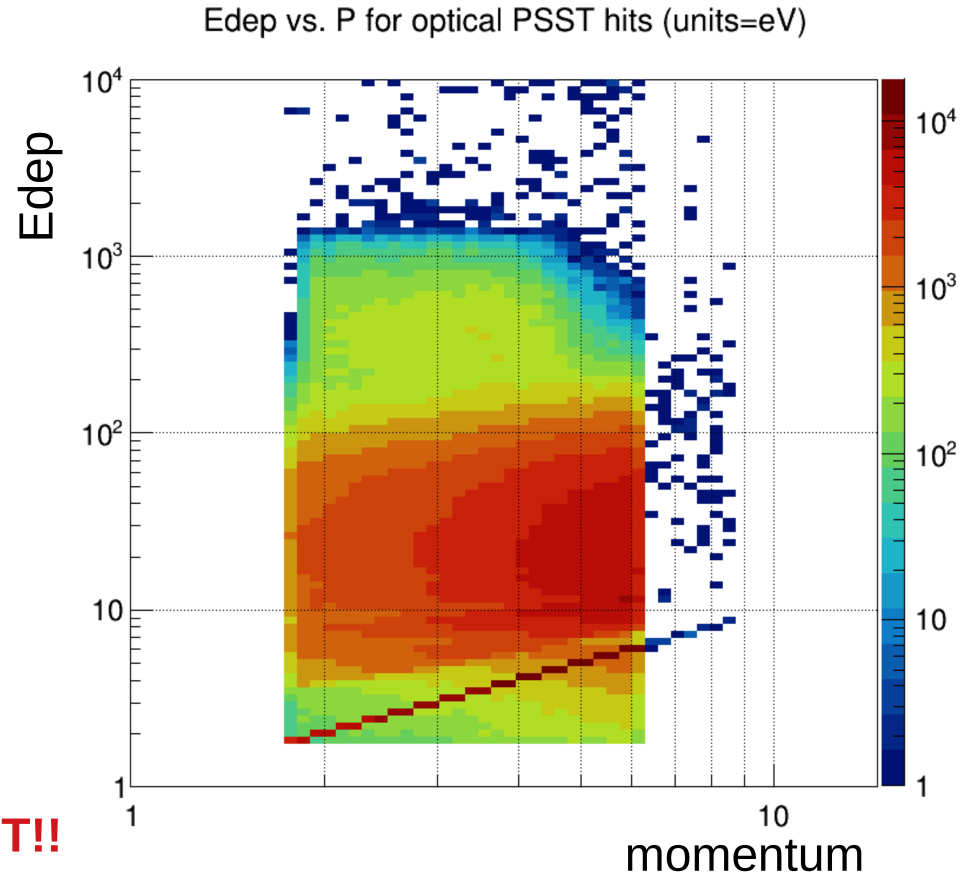
F4A Implementation Details



Edep from opticalphoton PSST hits

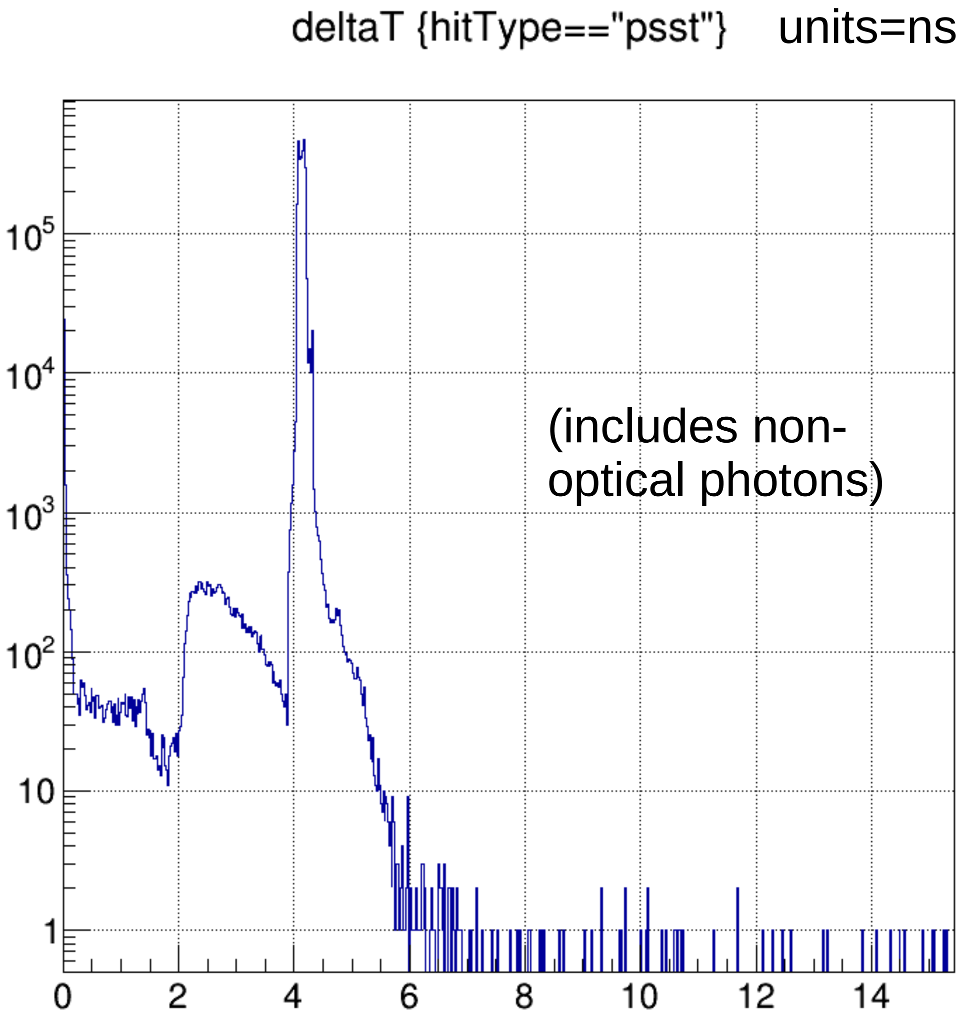
Consider splitting "optical" subtype to:
– opticalGas
– opticalAerogel





WARNING: MAY NOT BE CORRECT!!

Δtime from PSST hits

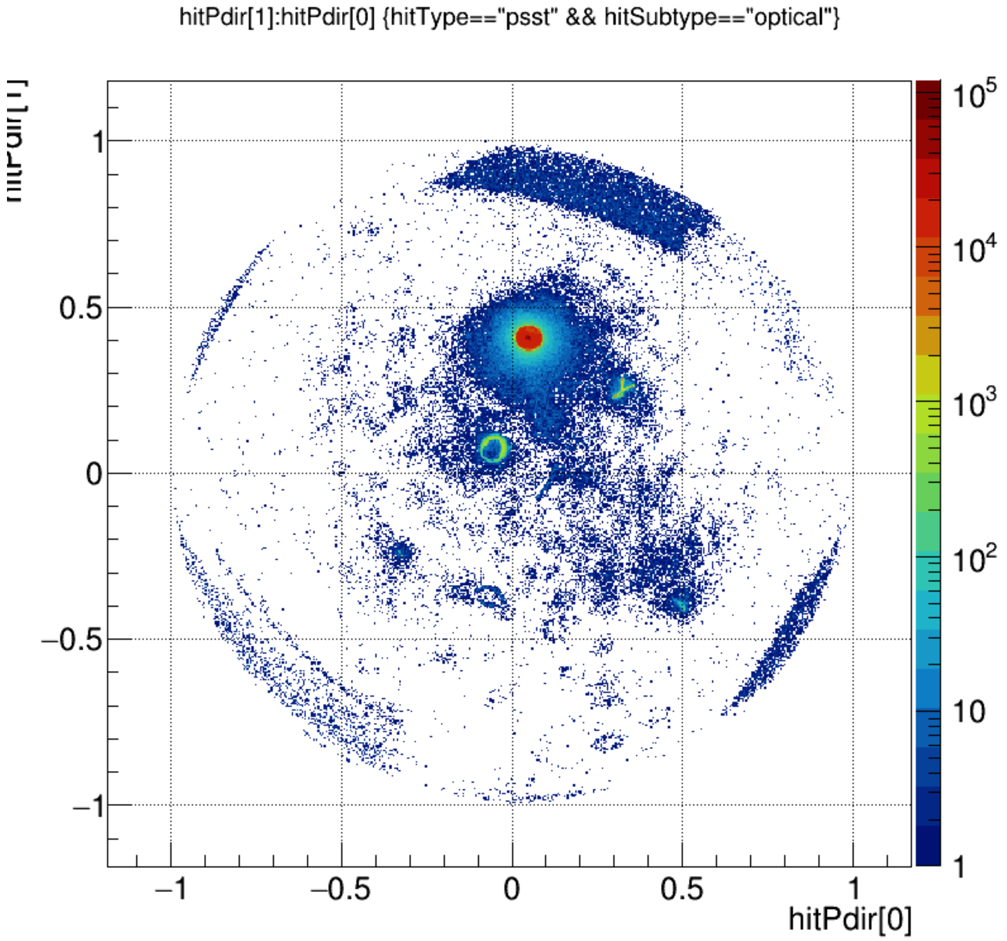


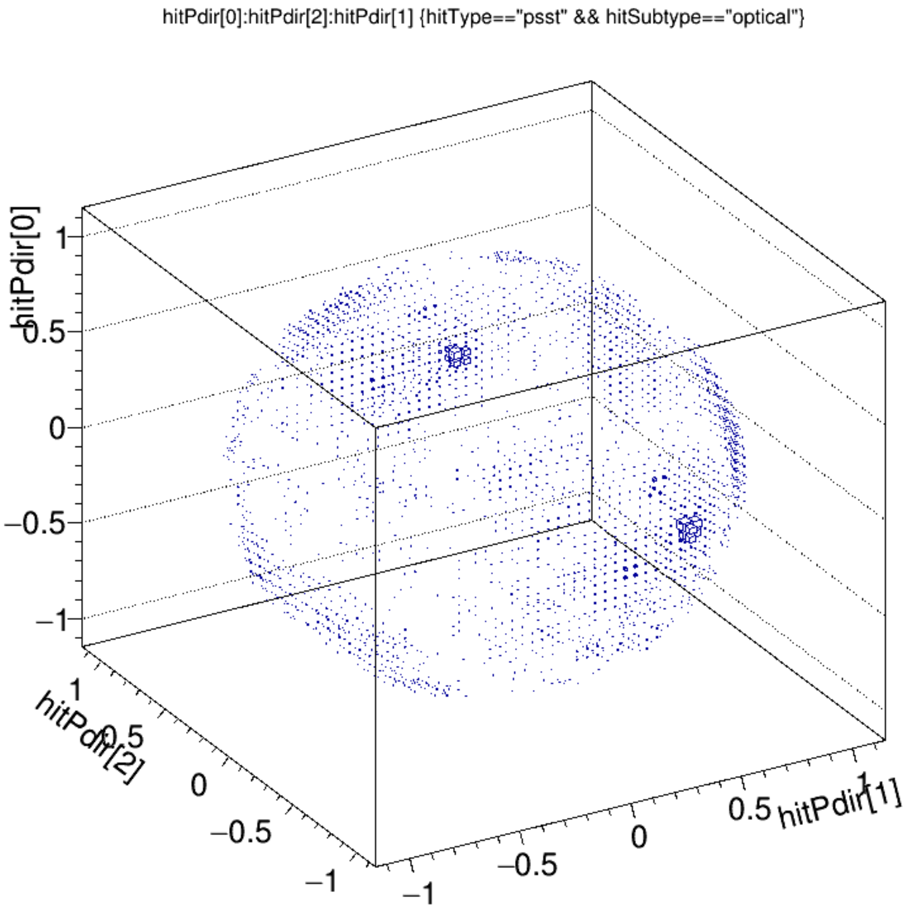
units=ns

(includes non-optical photons)

WARNING: MAY NOT BE CORRECT!!

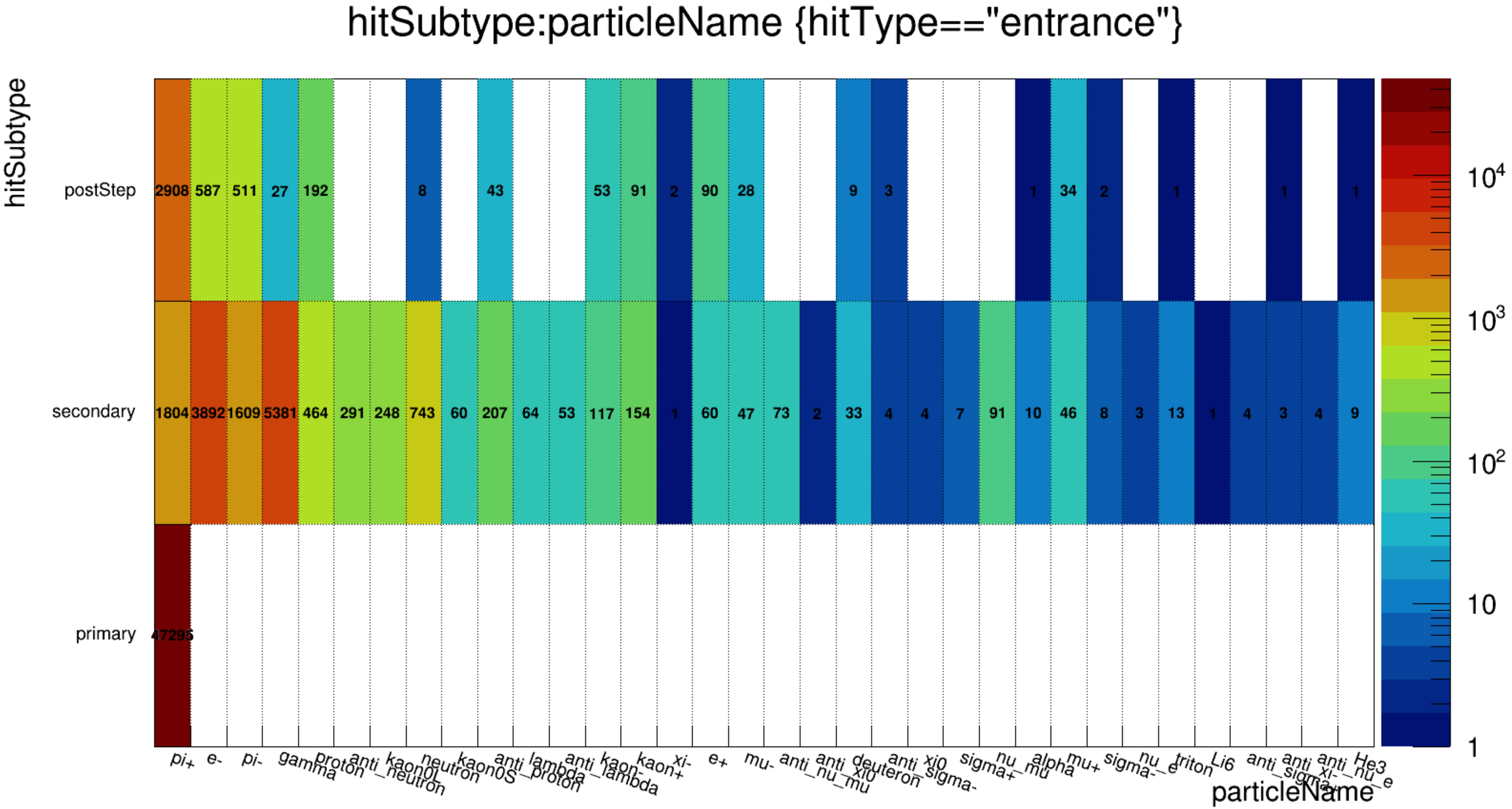
Photosensor opticalphoton hit momentum direction





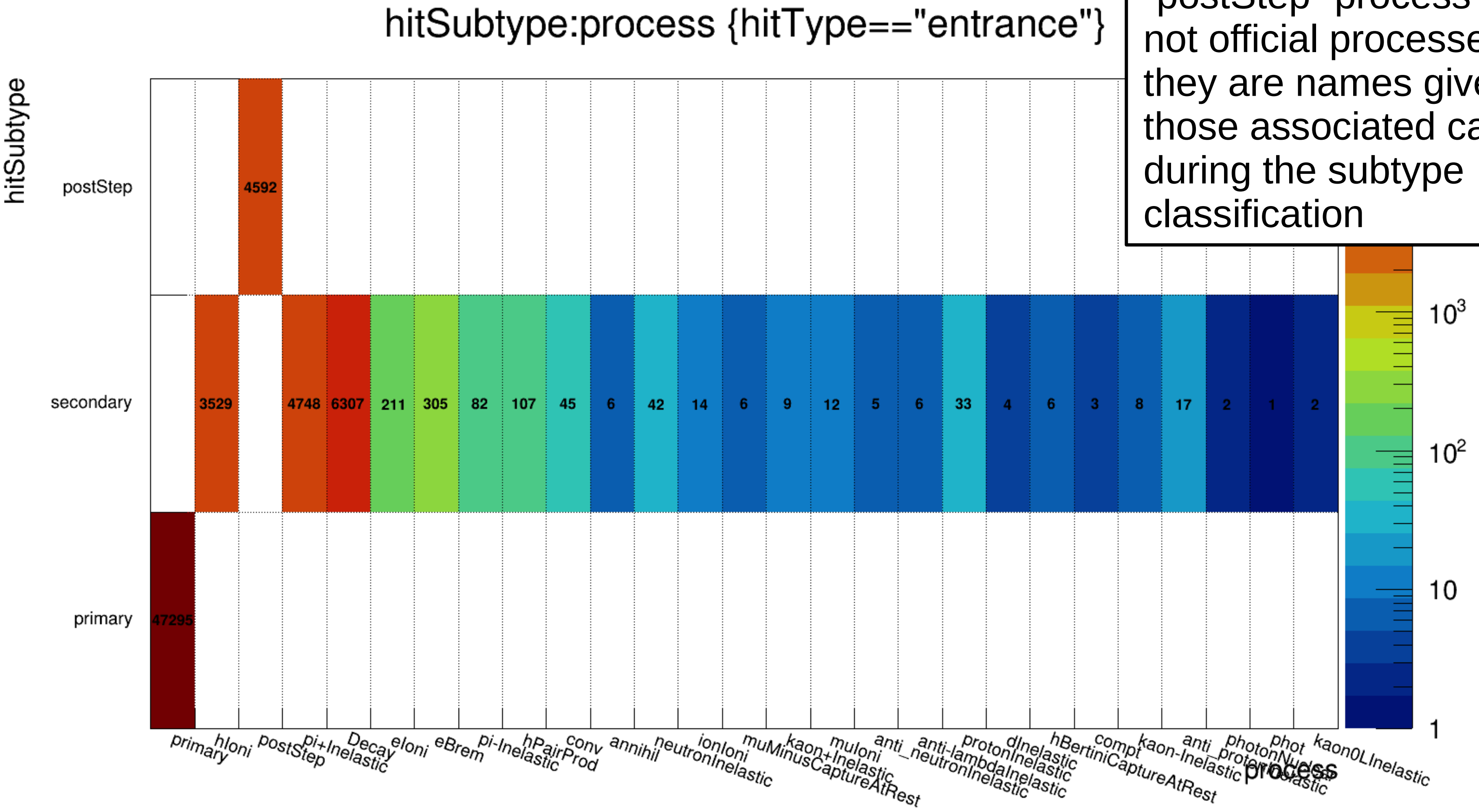
some PSST hits are from the “wrong” side – need some sort of shielding / electronics base in the geometry

Entrance hits: sub-type vs. particle

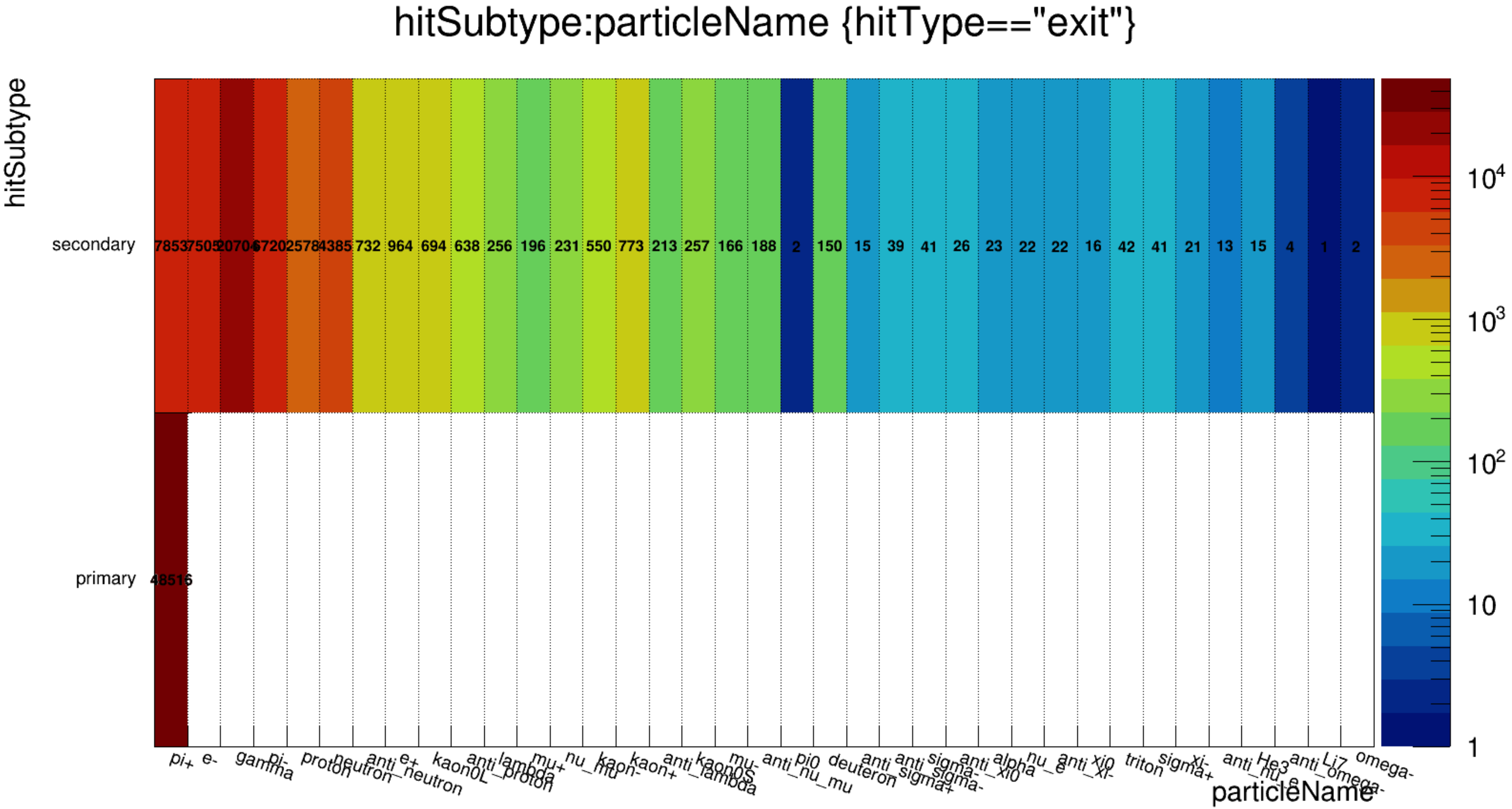


Entrance hits: sub-type vs. process

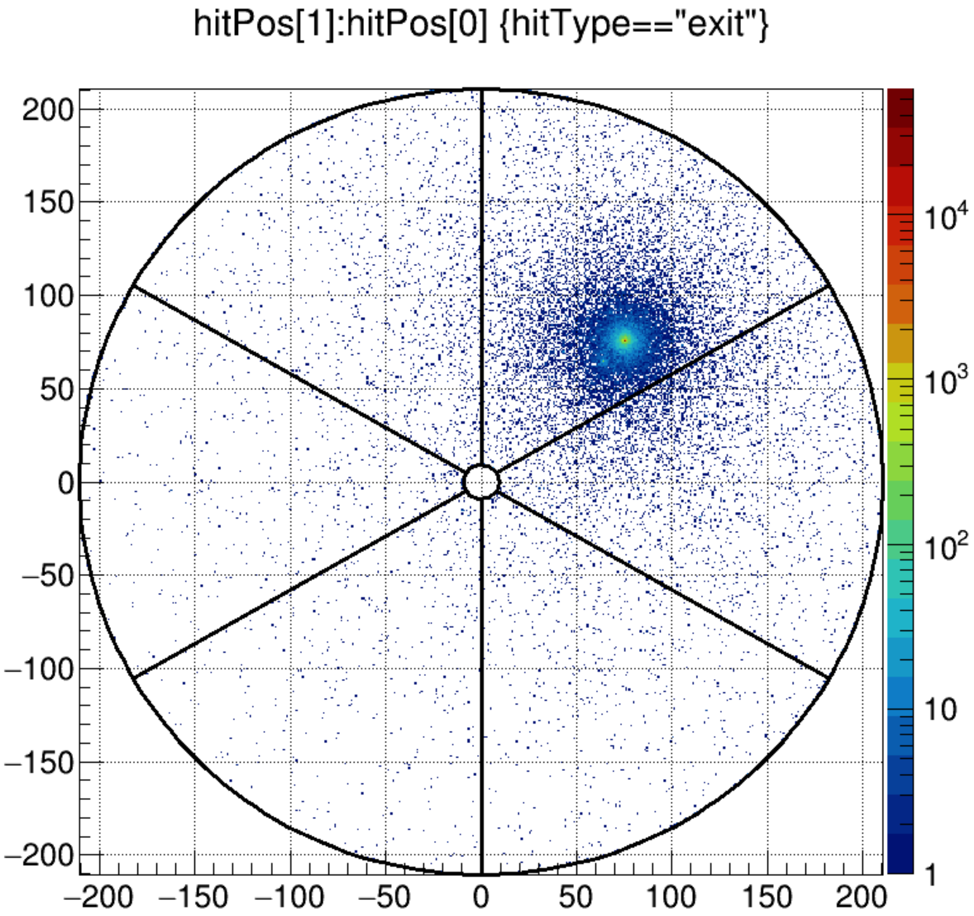
Note: “primary” and “postStep” process are not official processes; they are names given to those associated cases during the subtype classification

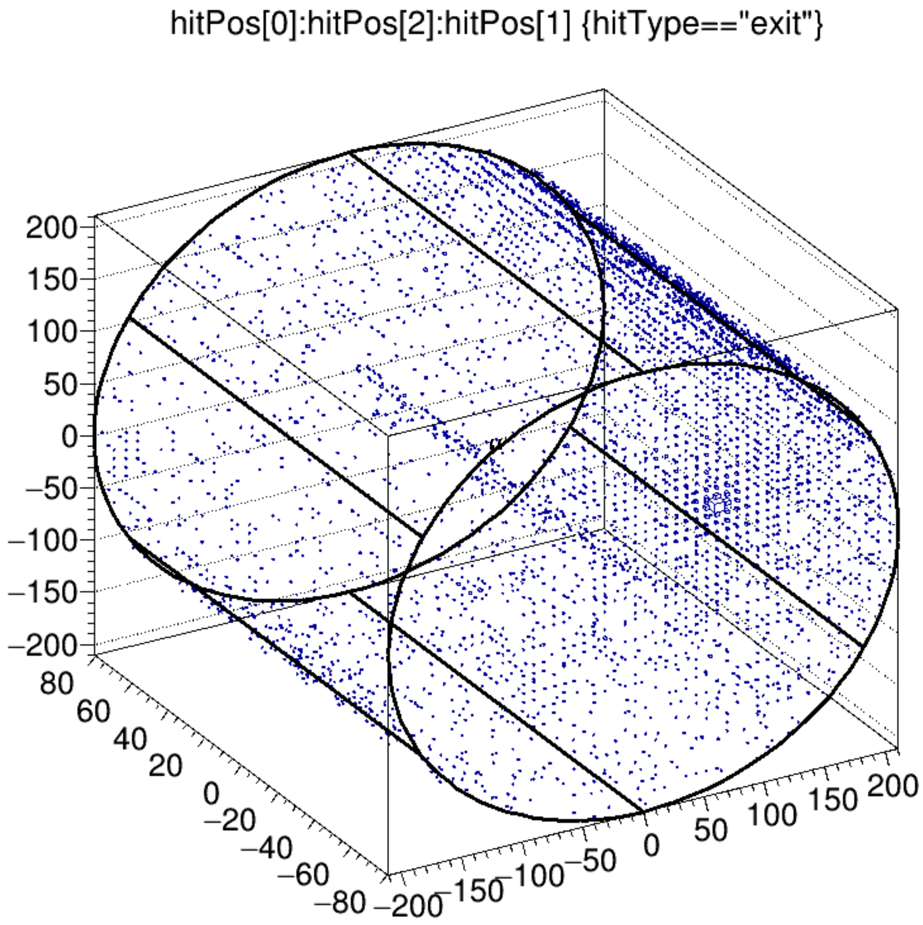


Exit hits: sub-type vs. particle



Exit hit positions





shown with vessel geometry outline