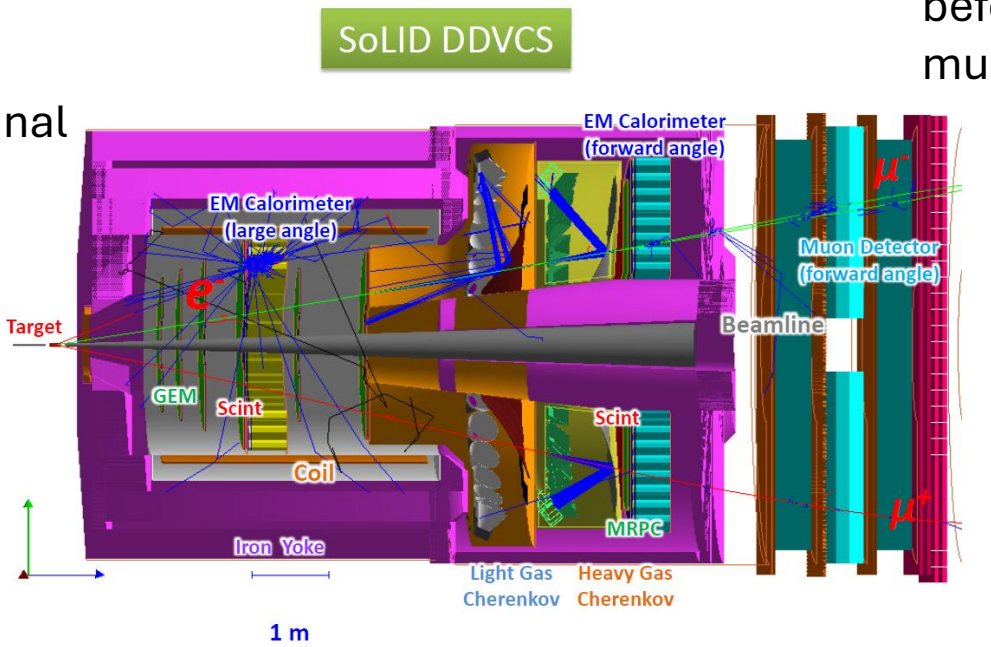
SoLID DDVCS Update 2025

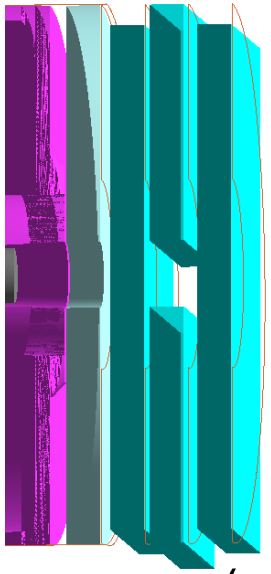
Zhiwen Zhao

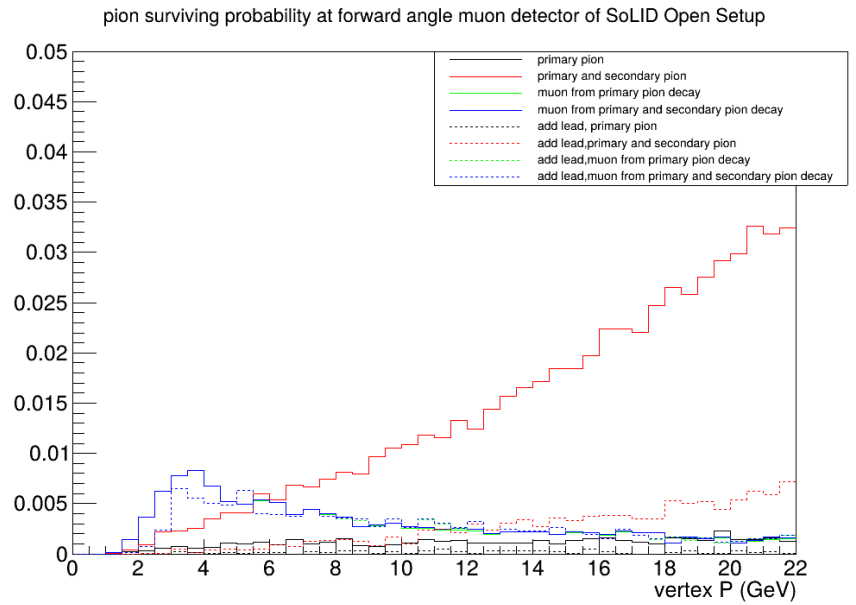
SoLID DDVCS Setup (add one layer of lead before FAMD)

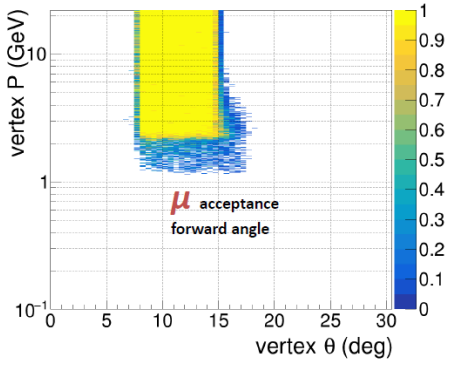
Original

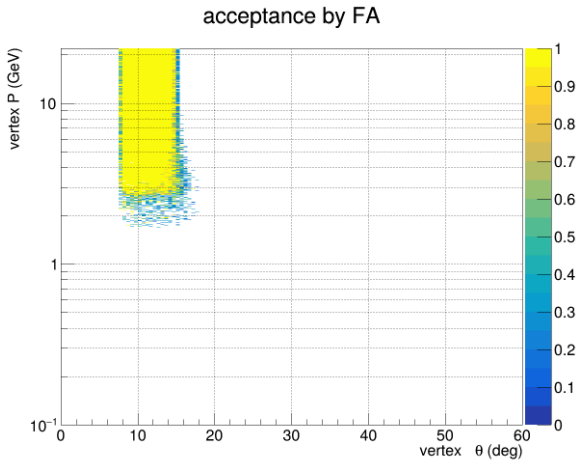


Add one layer of lead before the forward muon detector (FAMD)

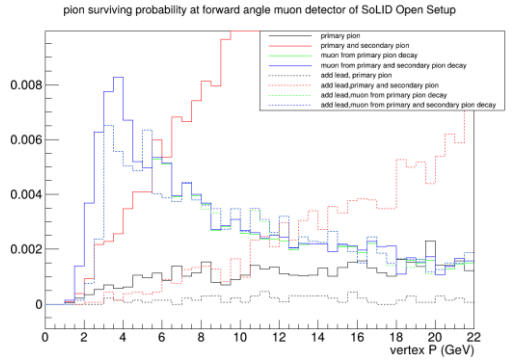






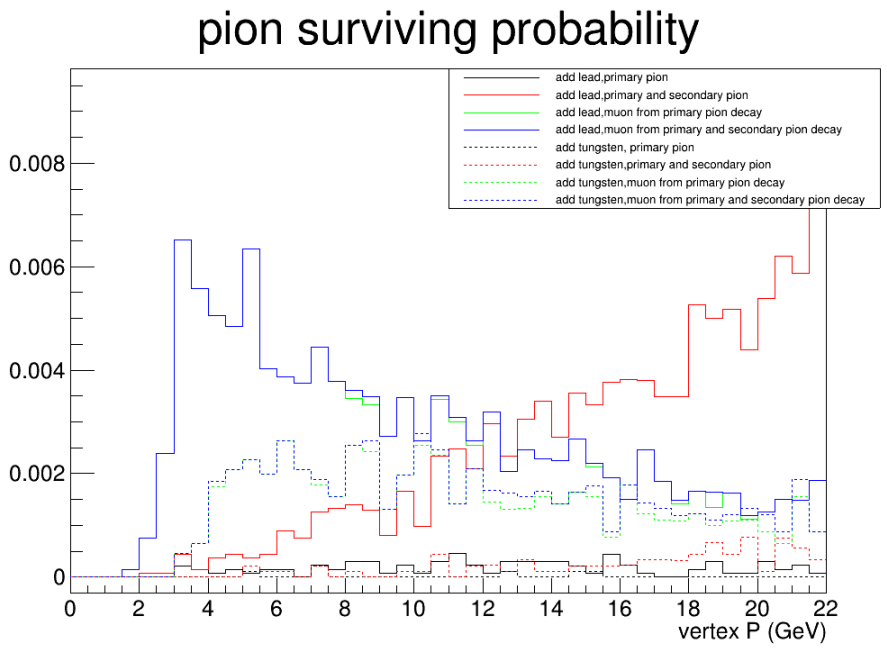


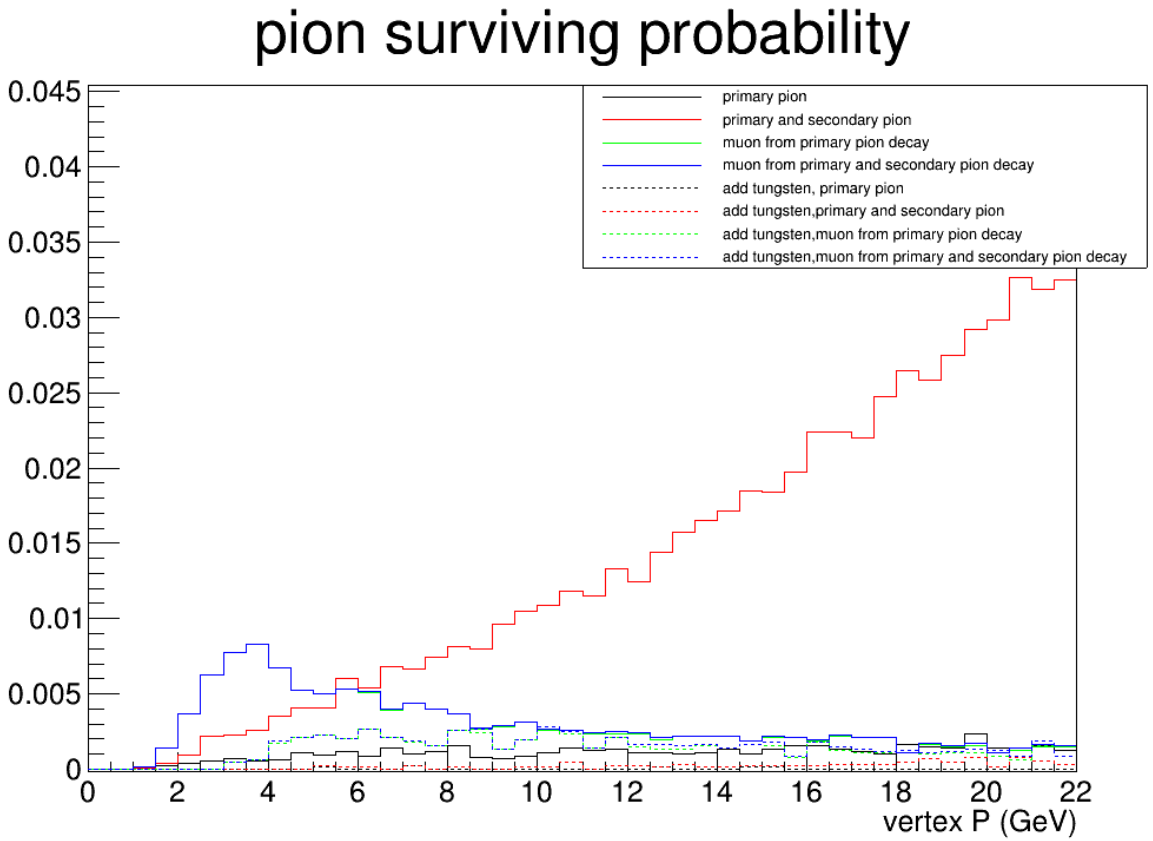
- (original) Single pi-/pi+ rate 9khz, mu-/mu+ rate 26khz, total 70khz
- Adding lead would reduce pion 18khz to maybe 3khz, but not muon 52khz much



SoLID DDVCS Setup (add tungsten cone near target)

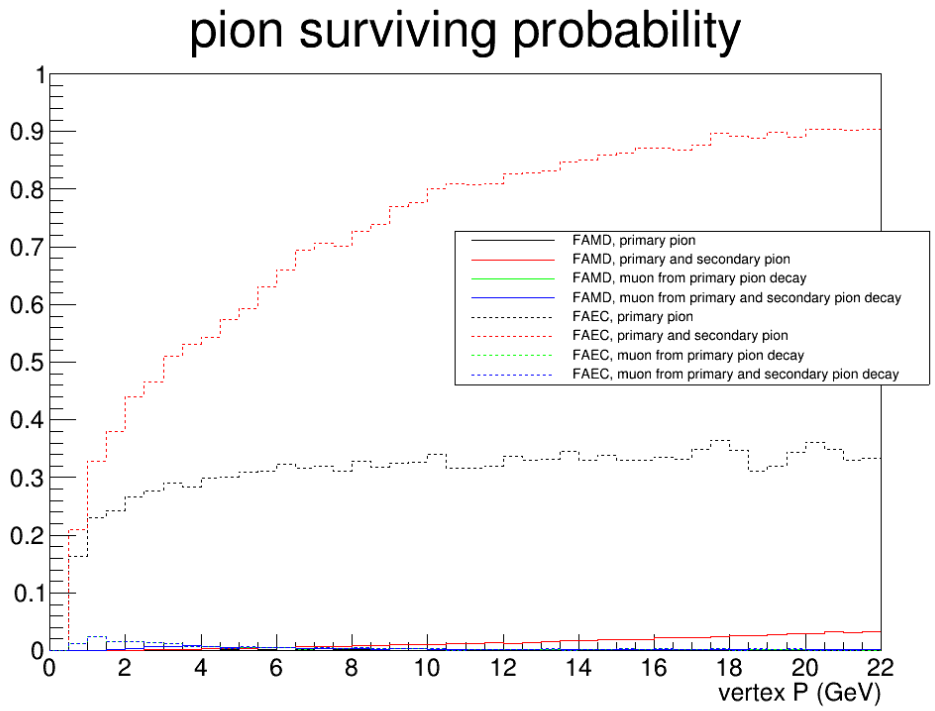
- Add 50cm thickness tungsten cone near target as uCLAS12 shows it can effectively block pion and muon decay from pion, and the result confirm it
- It's even better than a layer of lead before FAMD because it block pion before it decays to muon

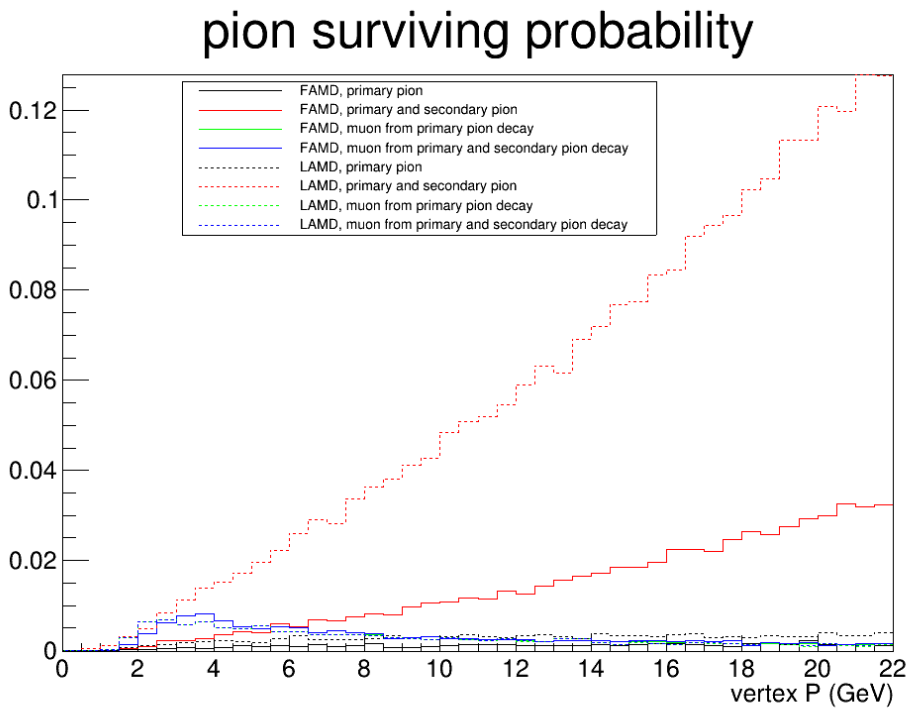




SoLID DDVCS Setup (FAEC and LAMD)

- Primary pion passing FAEC is 30%, and if including secondary pion, it would be 70% or more
- Comparing to FAMD, large angle muon detector (LAMD) has similar result of muon from pion decay, but secondary pion result is higher

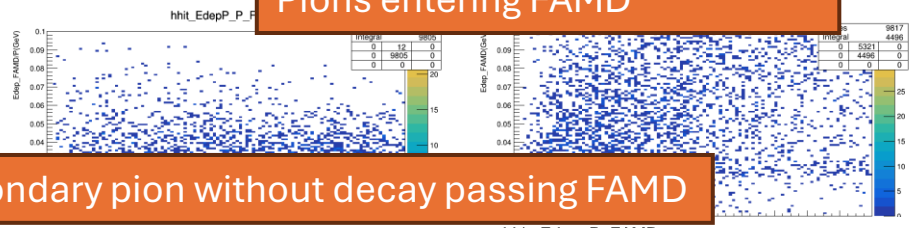




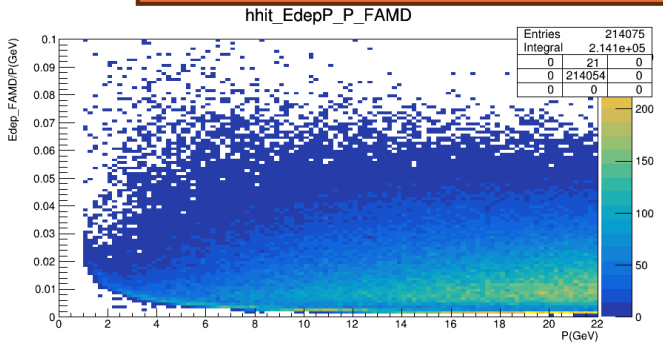
Testing pion and muon in FAMD

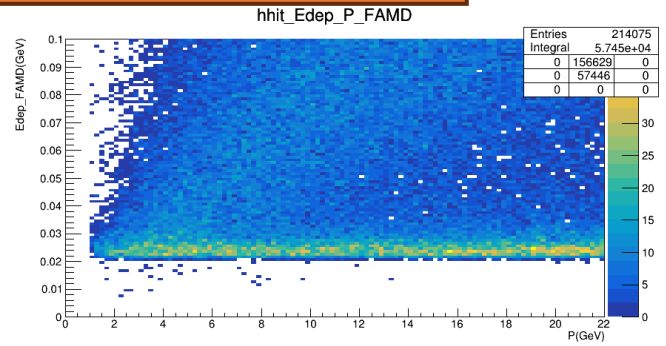
- Muon entering FAMD, primary pions decay muon passing FAMD, primary pion without decay passing FAMD are all behaves as MIP
- But secondary pion without decay passing through have a long tail in energy deposition and transverse energy spread
- My “pion surviving probability” plot looking at muon and pion passing through FAMD. So it hasn’t taken this cut on the secondary pion yet. A conservative estimation is the cut can have a factor 2 reduction.
- Better pion rejection from FAMD needs better algorithm like AIML and smarter design.

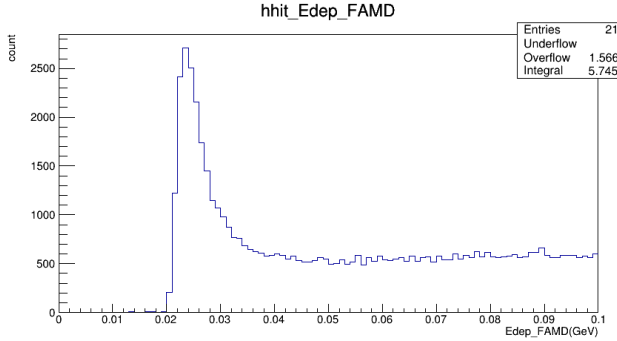
Pions entering FAMD

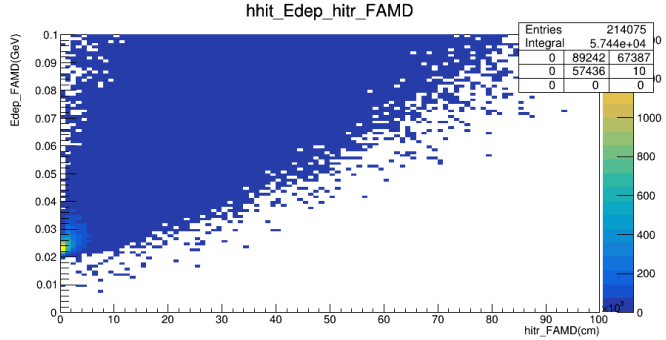


primary and secondary pion without decay passing FAMD

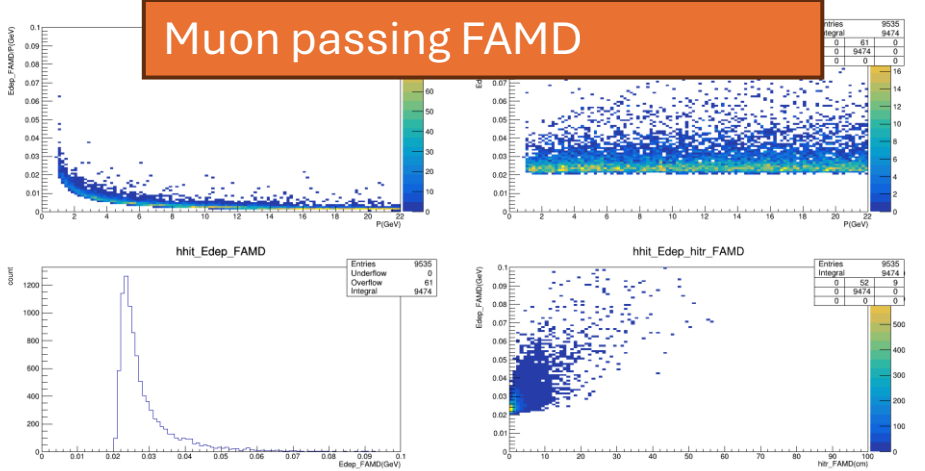




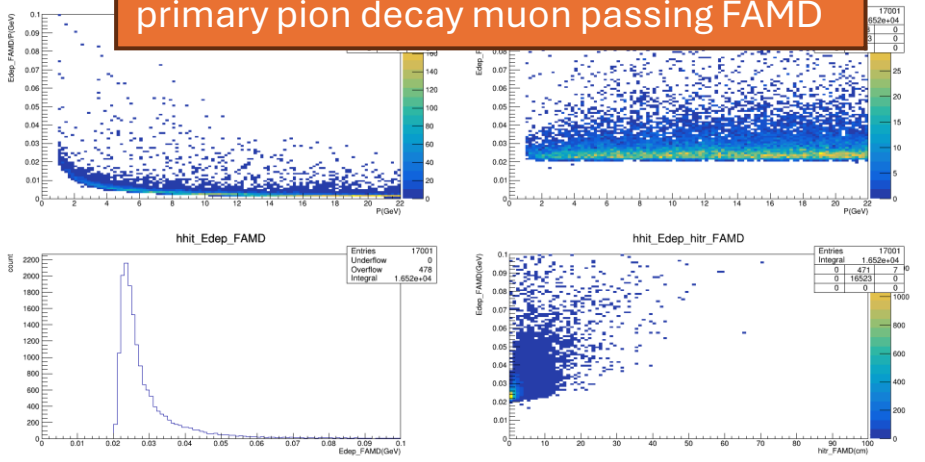




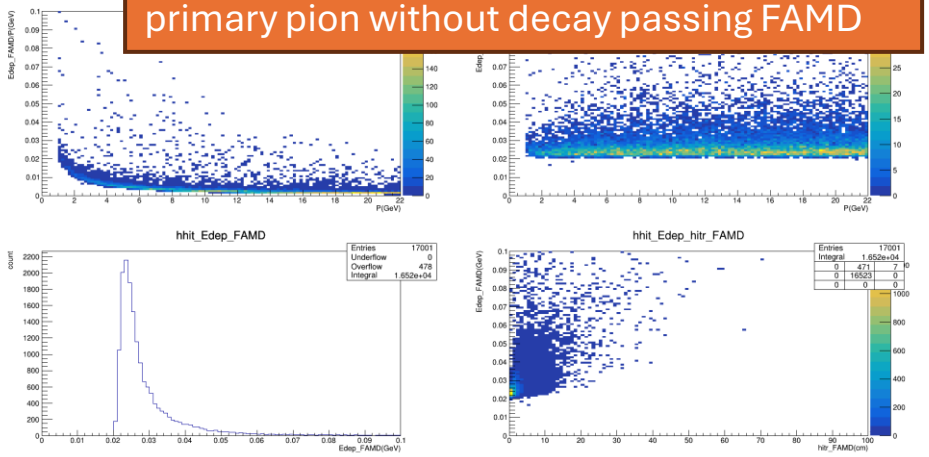
Muon passing FAMD



primary pion decay muon passing FAMD



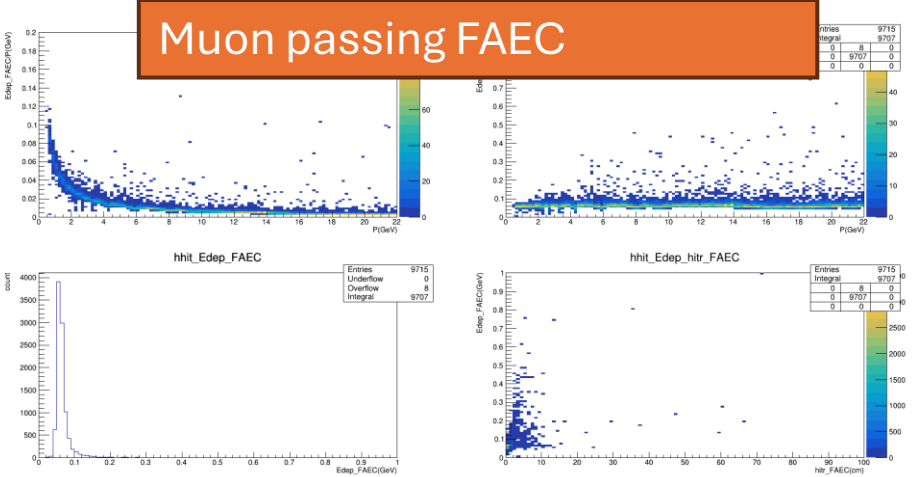
primary pion without decay passing FAMD



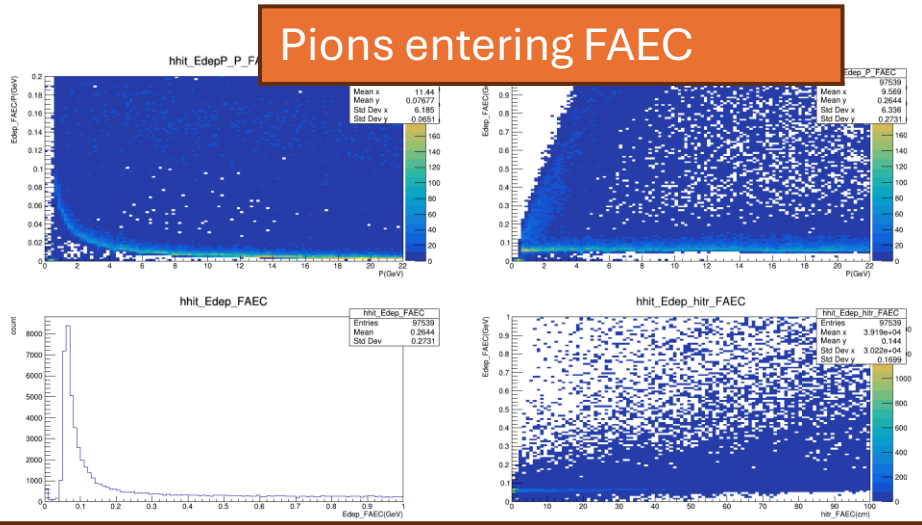
Testing pion and muon in FAEC

- Muon entering FAEC, primary pions decay muon passing FAEC, primary pion without decay passing FAEC are all behaves as MIP, which is similar to them in FAMD
- But secondary pion without decay passing through have a long tail in energy deposition and transverse energy spread, but it has different shape comparing to FAMD
- FAEC will have some pion rejection power but pion/muon ration is still too high at its location

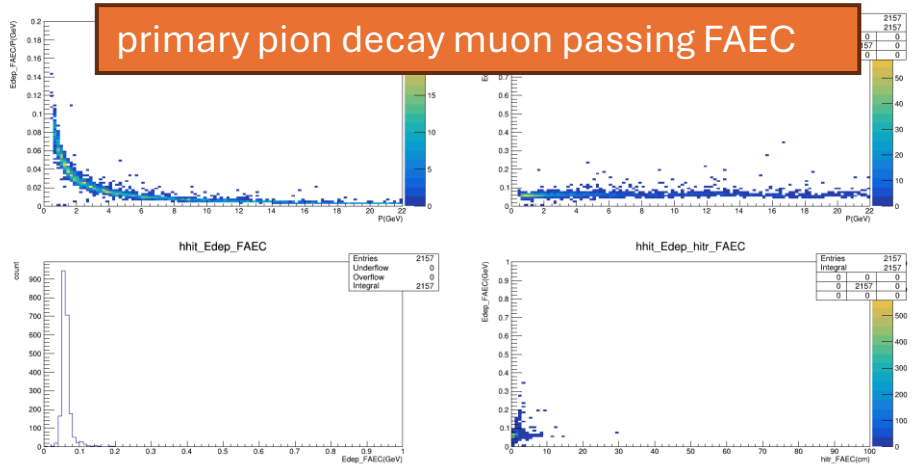
Muon passing FAEC



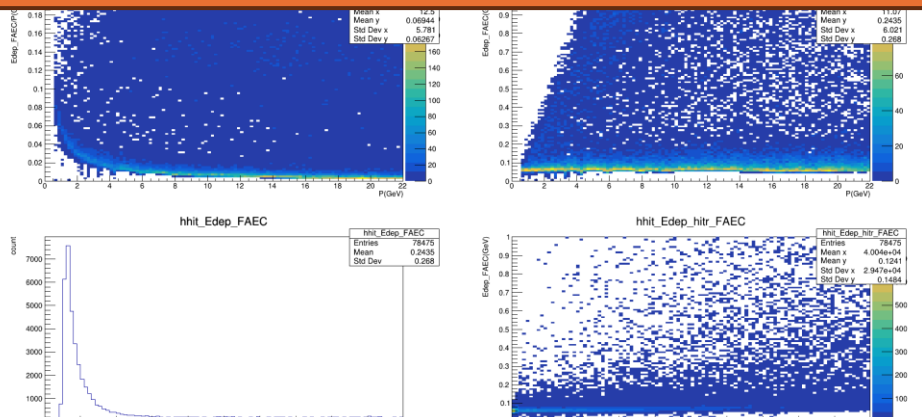
Pions entering FAEC



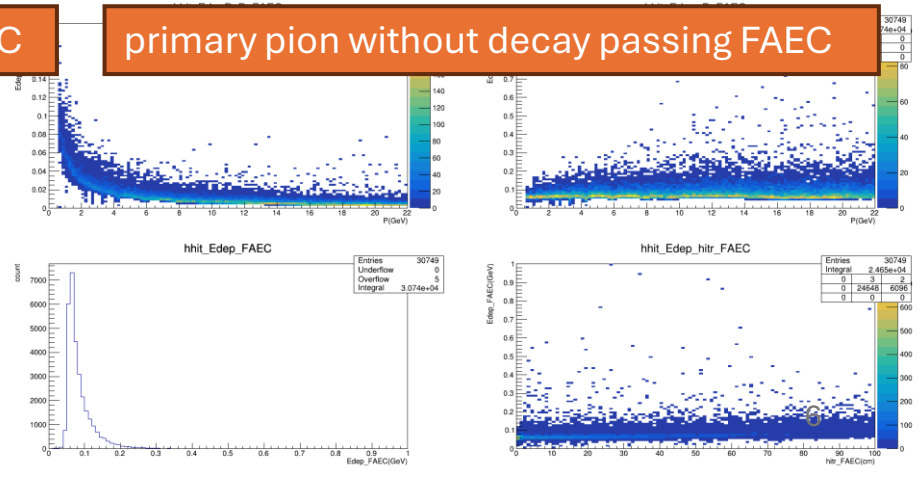
primary pion decay muon passing FAEC



primary and secondary pion without decay passing FAEC



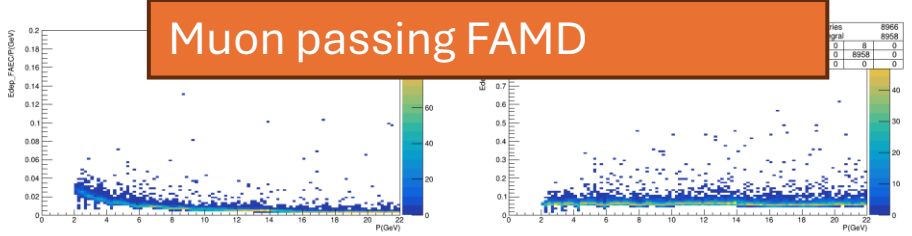
primary pion without decay passing FAEC

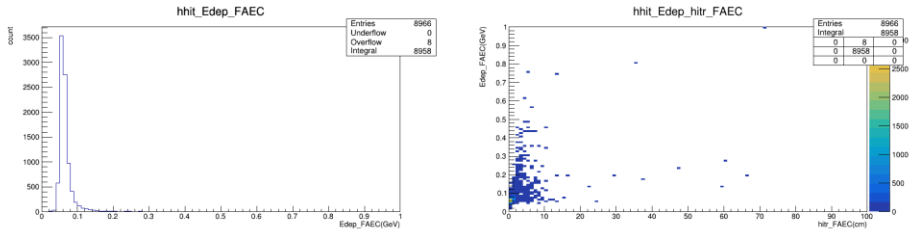


Testing pion and muon in FAEC when they passing FAMD

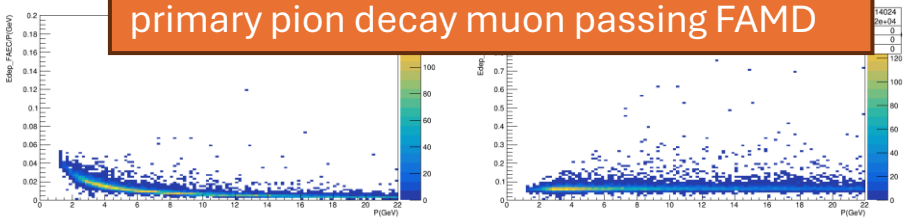
- All of them behaves like MIP in FAEC when passing FAMD
- I am not sure how to use FAEC to suppress pion if it pass FAMD yet

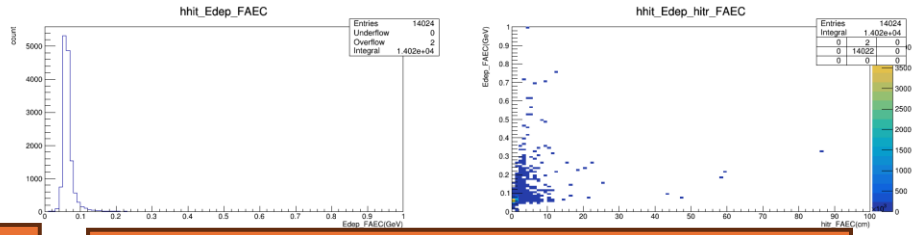
Muon passing FAMD



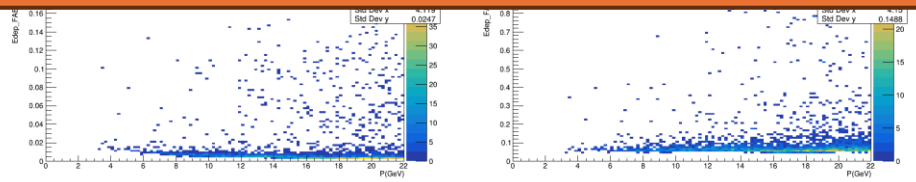


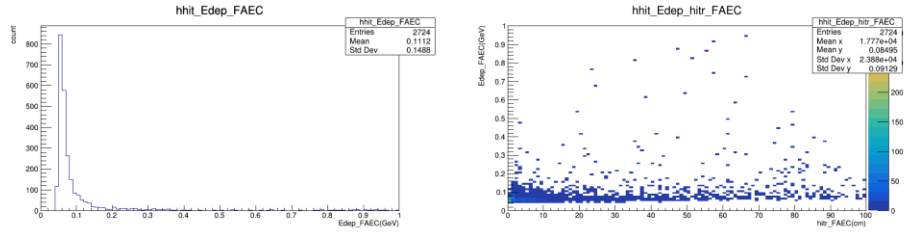
primary pion decay muon passing FAMD



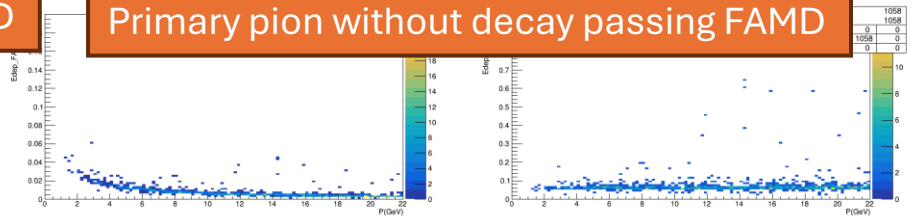


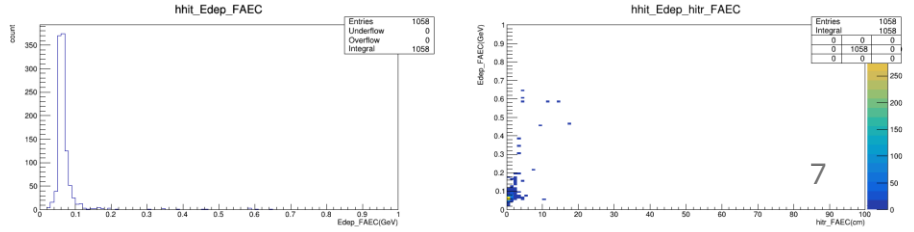
primary and secondary pion without decay passing FAMD





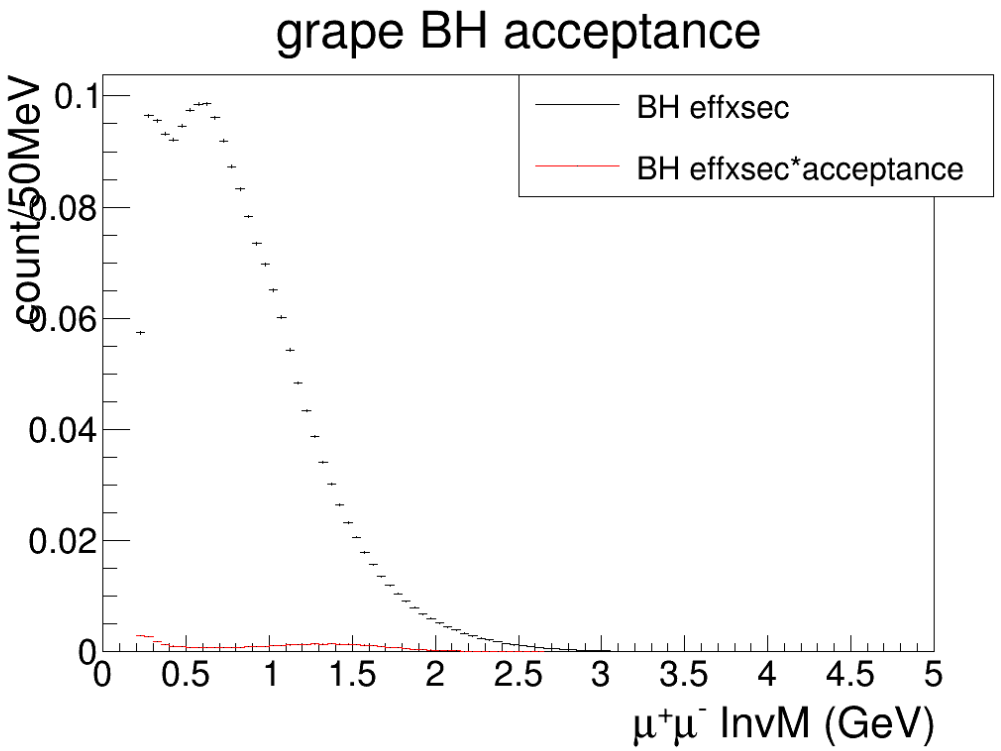
Primary pion without decay passing FAMD

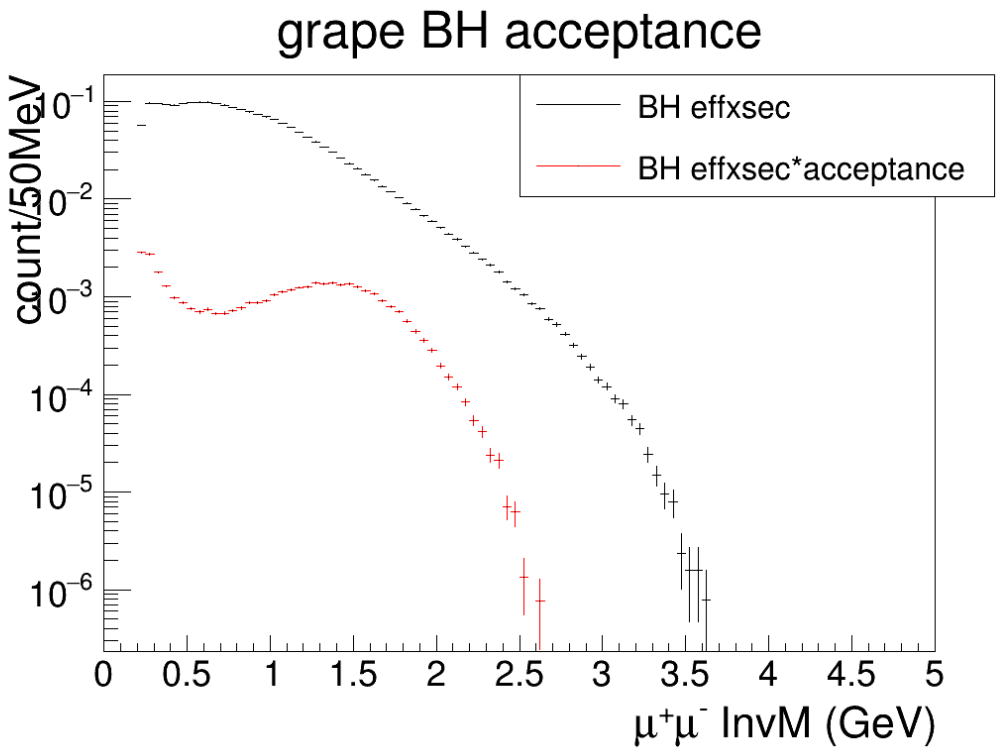




BH shape

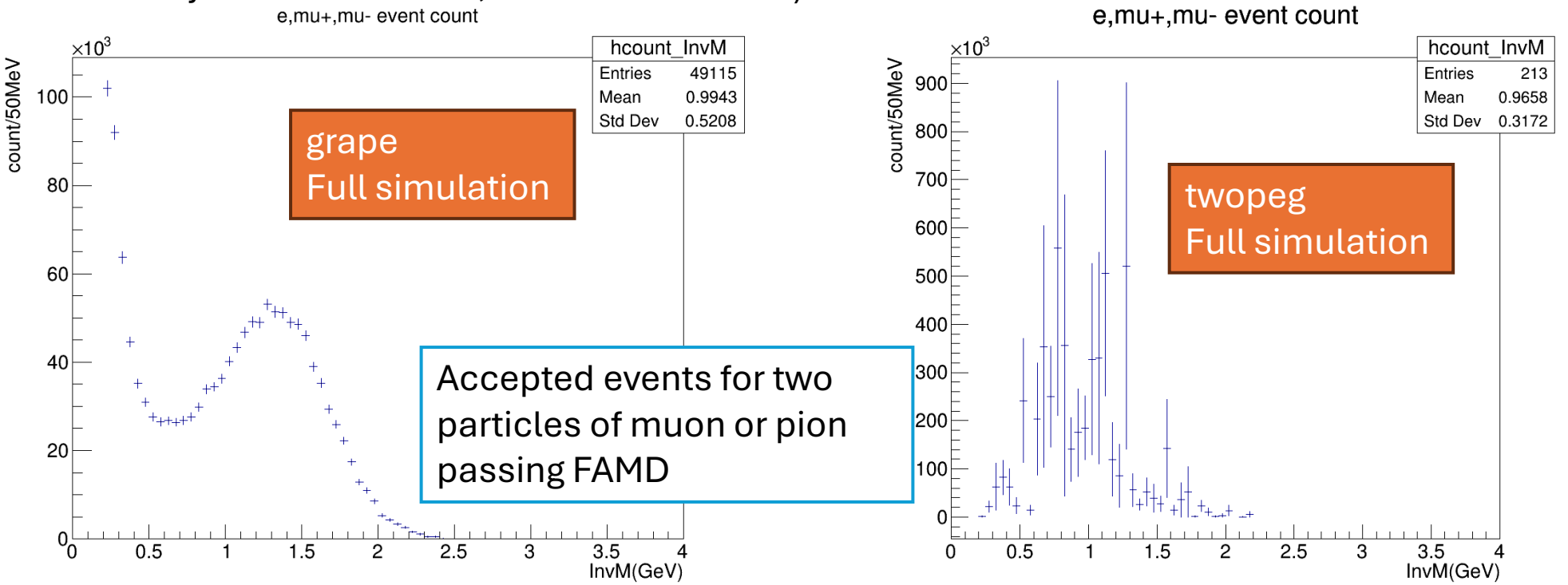
- The crosssection has a dip near 0.6 and peak near 0.8 which is BH1 and BH2 overlapping area
- acceptance events have a peak near 1.5 purely due to acceptance





Full simulation and fast simulation

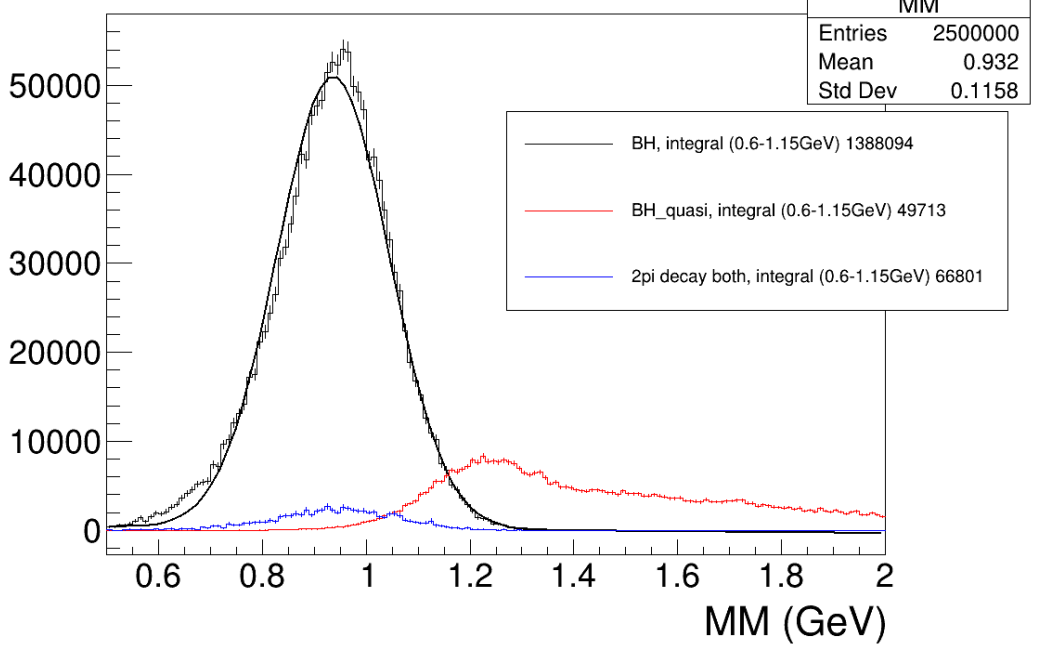
- all plots are done with “fast simulation” in 3 steps
  - event generator (BH from grape and 2pion exclusive from twopeg) generate outputs
  - Run single muon and pion into SoLID geant4 simulation to obtain muon acceptance histogram and pion surviving probability curve.
  - Combine those two to obtain plots like accepted BH (signal) and 2pi (background) events
- To check the fast simulation result, we do full simulation to run event generator output into SoLID geant4 simulation directly and look at events detected at FAMD
  - grape results from full and fast simulation are basically same
  - twopeg results from full simulation is not reliable due to too few events accepted due to <1% single pion surviving probability. (this plot is from 1.1e8 events entering Geant4 simulation for a week to run. I can try to run 1e9 events, but not much more)



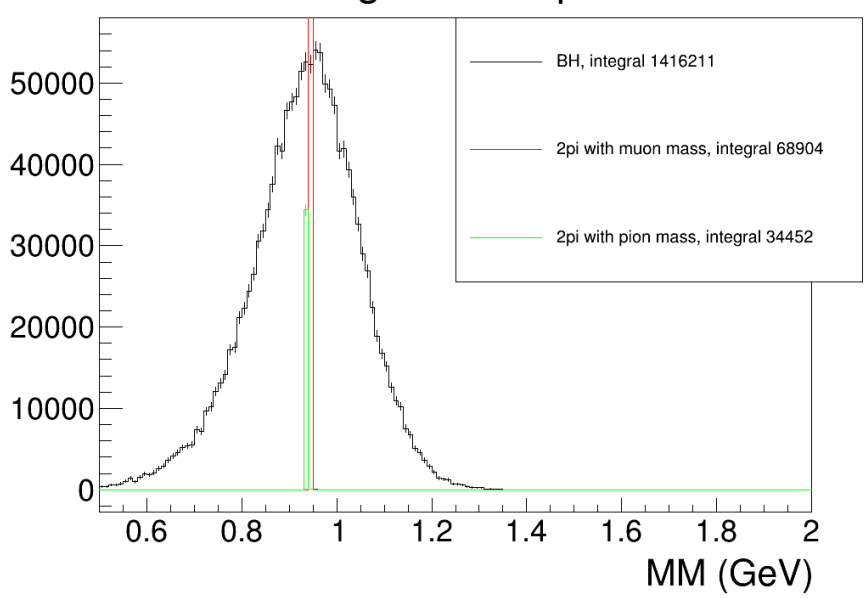
Missing mass of 2pi

- BH and BH_quasi are smeared by SoLID momentum vector resolution.
- “2pi decay both” exclusive events from twopeg
  - (right plot) when not smeared, show treating the two pion with muon mass or pion mass have very small shift on missing mass plot
  - (left plot) when smeared and with two muon mass, it won’t be cut out by missing mass cut at all

Twopeg smeared



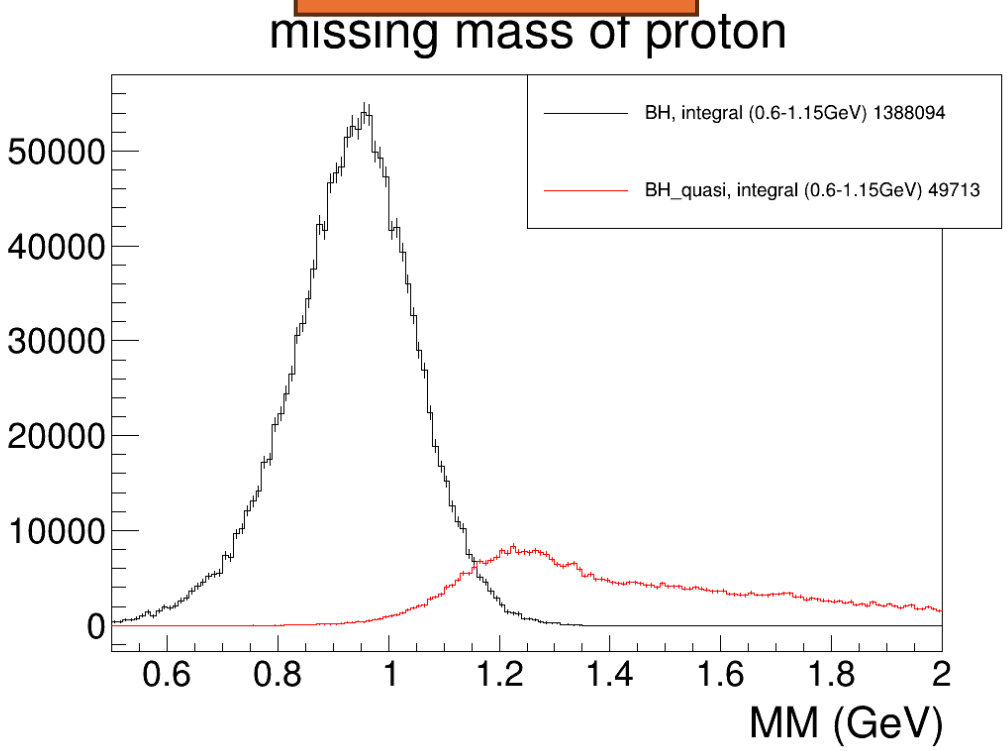
Twopeg not smeared



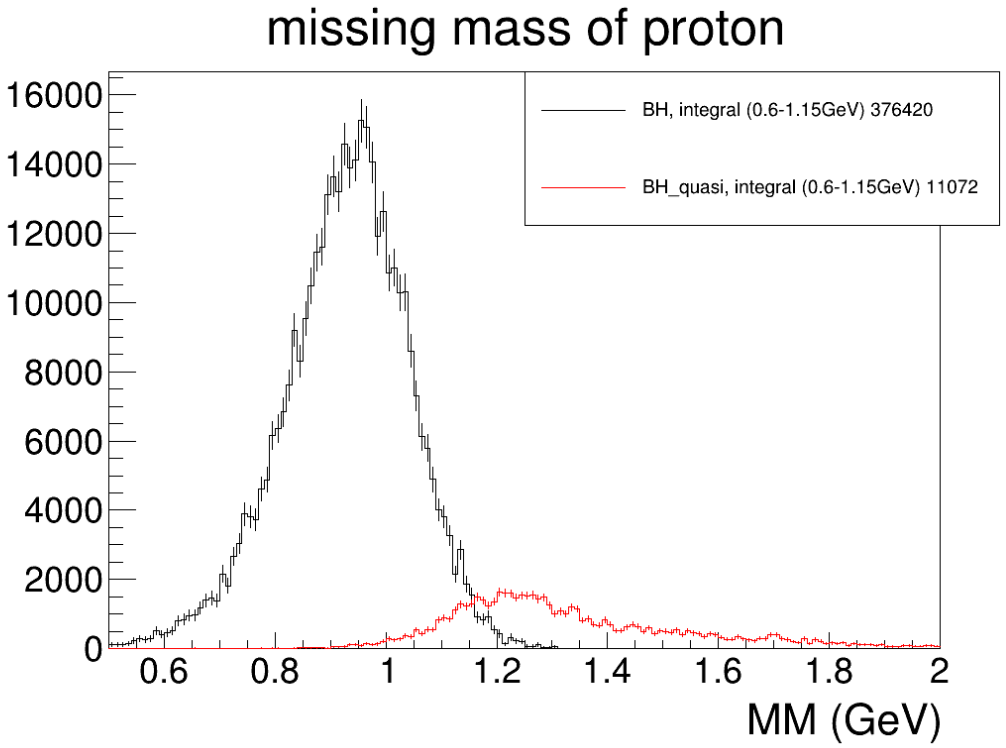
Missing mass of BH

- BH and BH_quasi are smeared by SoLID momentum vector resolution.
- With MM range of 0.6-1.15GeV, those accepted BH events has background from BH_quasi at level of 3%
  - 49713/1388094=0.04 with no cut
  - 11072/376420=0.03 with Qp2>2 cut

With no cut



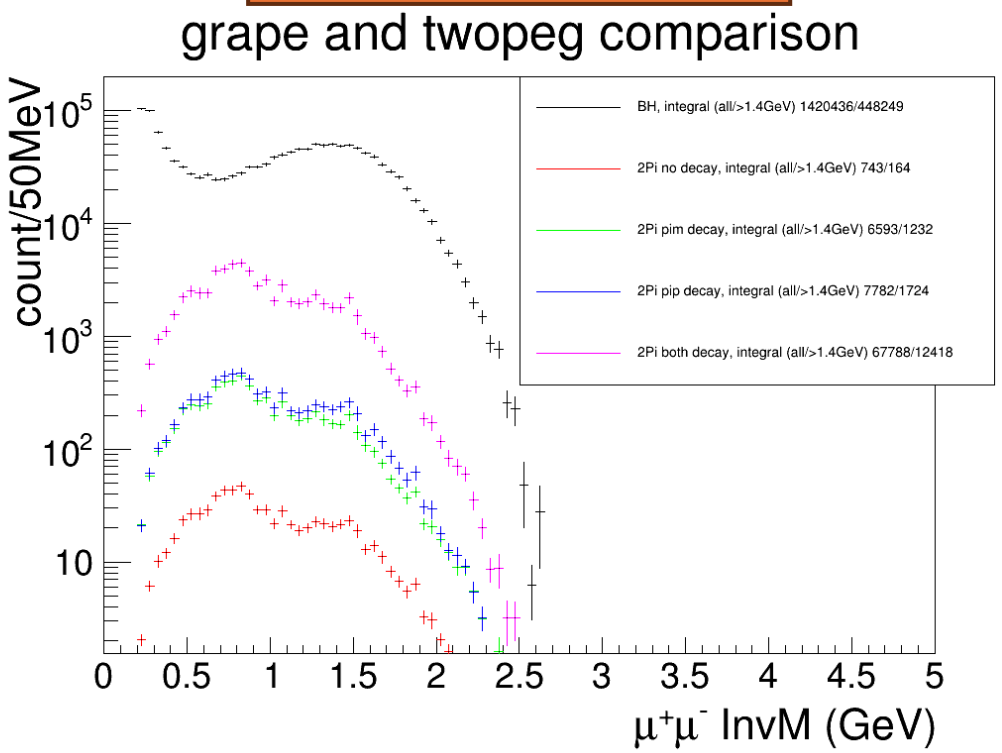
With cut Qp2>2GeV



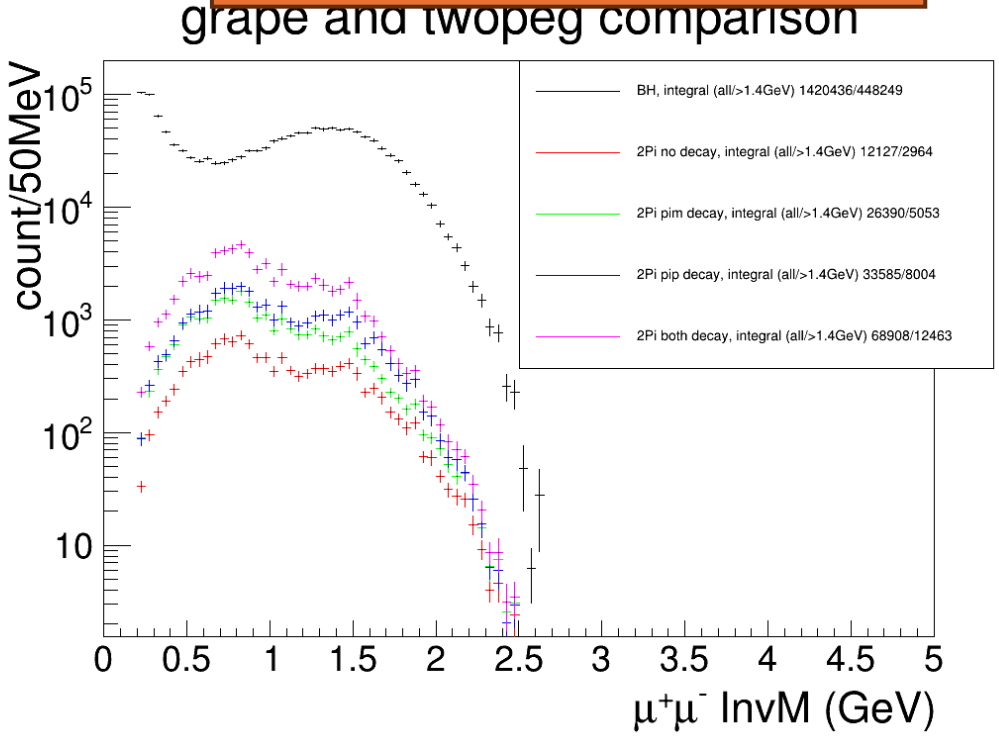
2pi/BH ratio

- In the previous draft, I used primary pion surviving probability curve to estimation 2pi background, while I should primary and secondary pion
- 2pi/BH ratio at level of 6.4%
  - (743+6593+7782+67788)/1420436 =0.058 with primary pion only, for events with no cut
  - (12127+26390+33585+68908)/1420436 =0.10 with primary pion only, for events with no cut
  - (164+1232+1724+12418)/448249=0.035 with primary pion only, for events after cut Qp2>2
  - (2964+5053+8004+12418)/448249=0.064 with primary and secondary pion,for events after cut Qp2>2

With primary pion only



With primary and seconday pion



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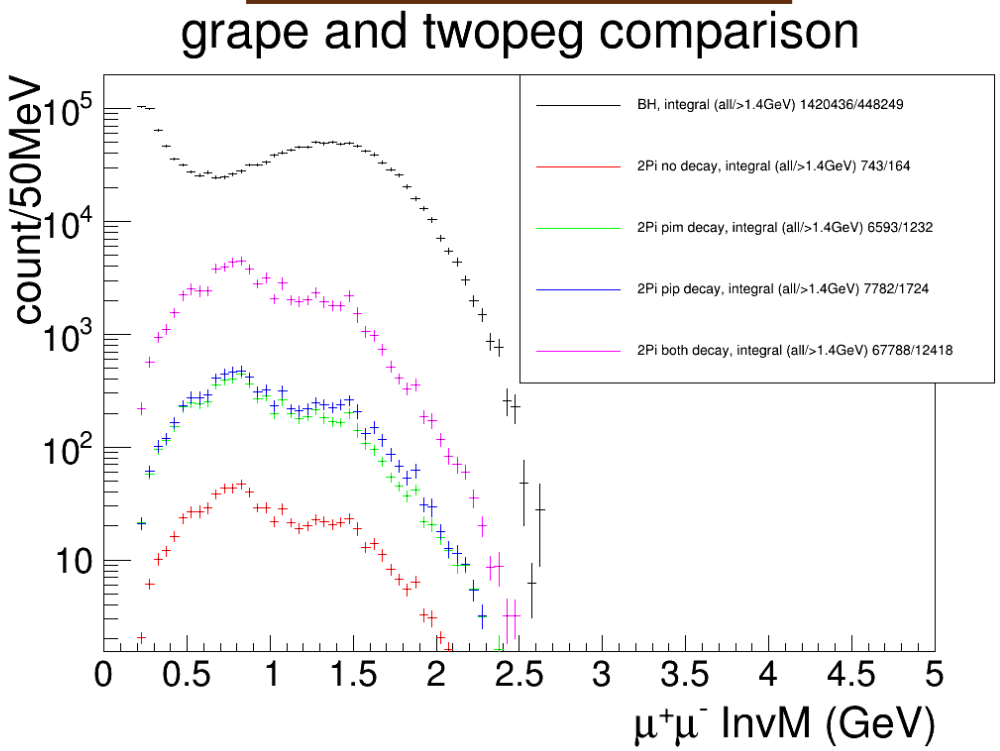
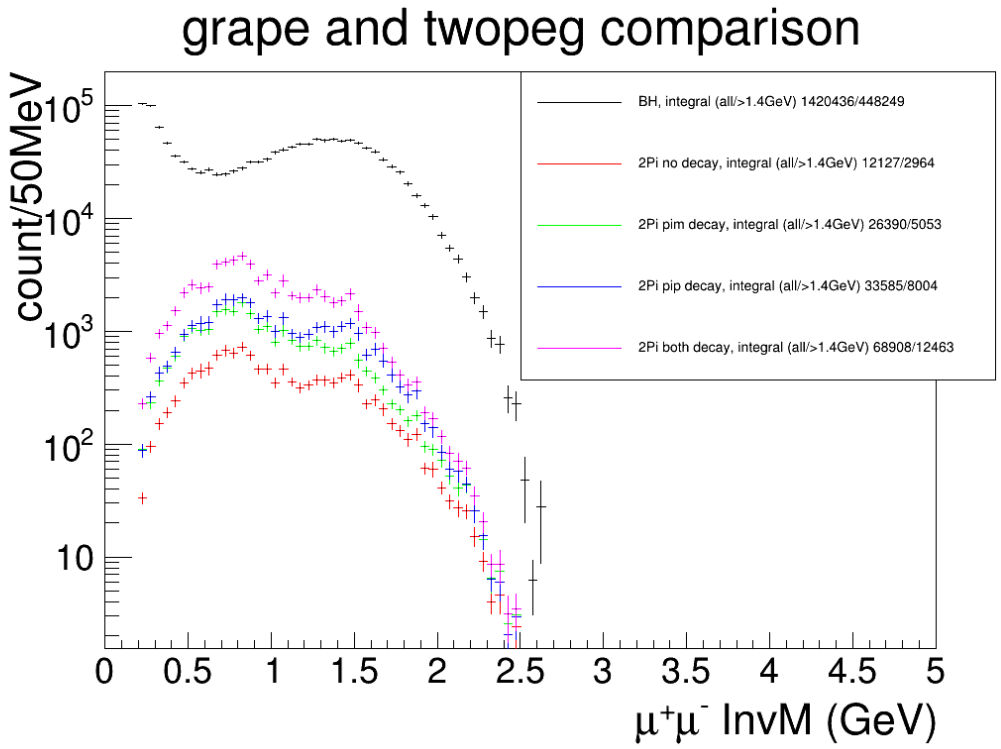
With primary pion only

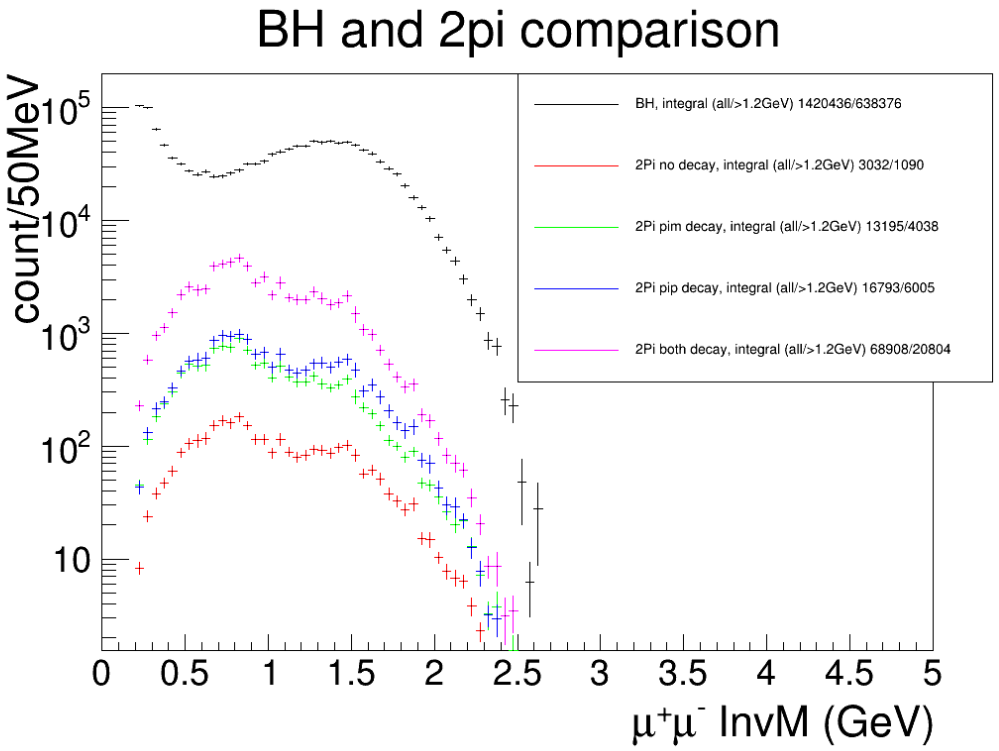


With primary and seconday pion



2pi/BH ratio after pion suppression

- After assuming a factor 2 suppression of primary and secondary pion without decay
- 2pi/BH ratio at level of 5%
  - (68908+16793+13195+3032)/1420436 =0.072, for events with no cut
  - (20804+6005+4038+1090)/638386=0.05,for events after cut Qp>1.2



With primary and seconday pion