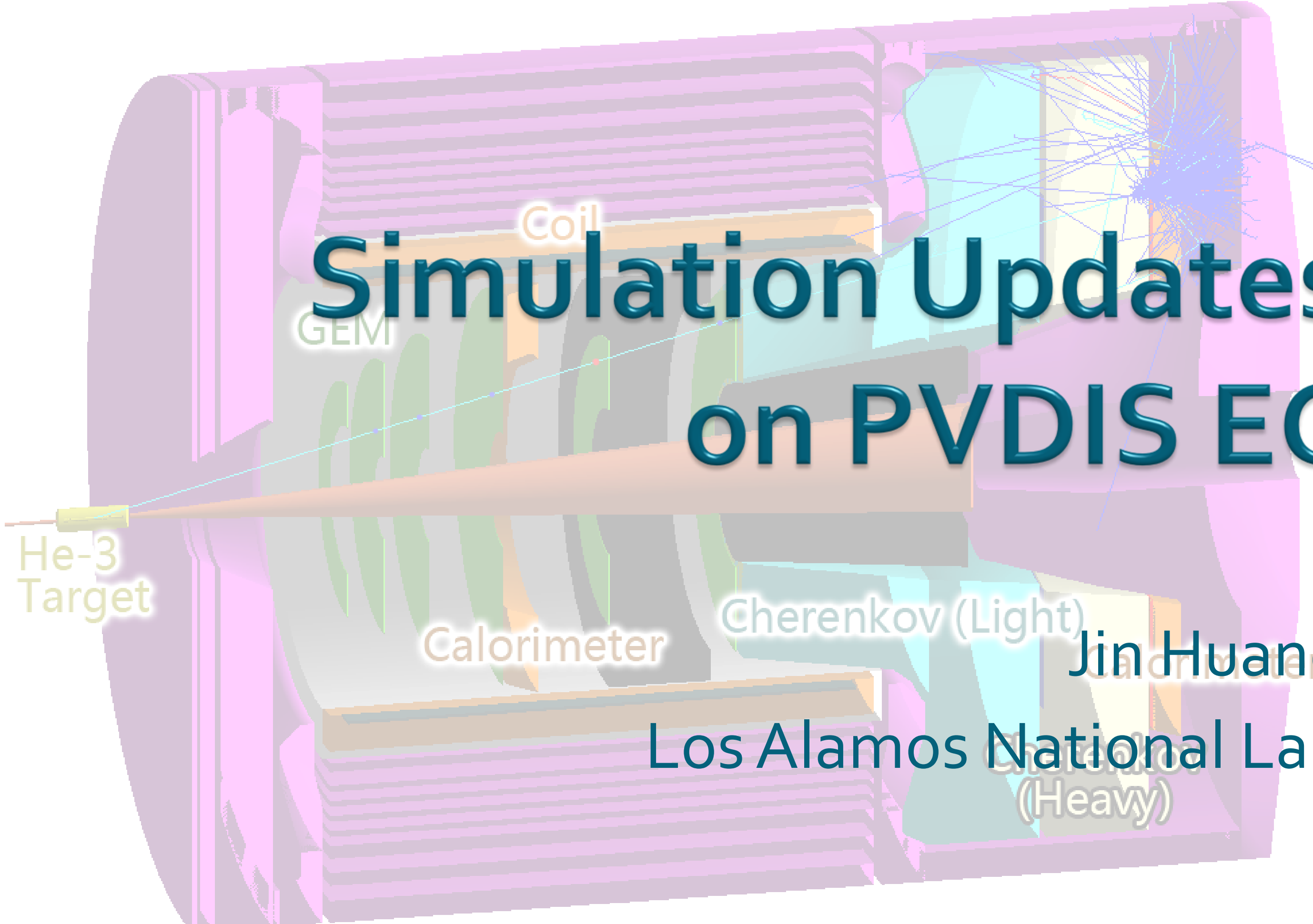
Simulation Updates on PVDIS EC

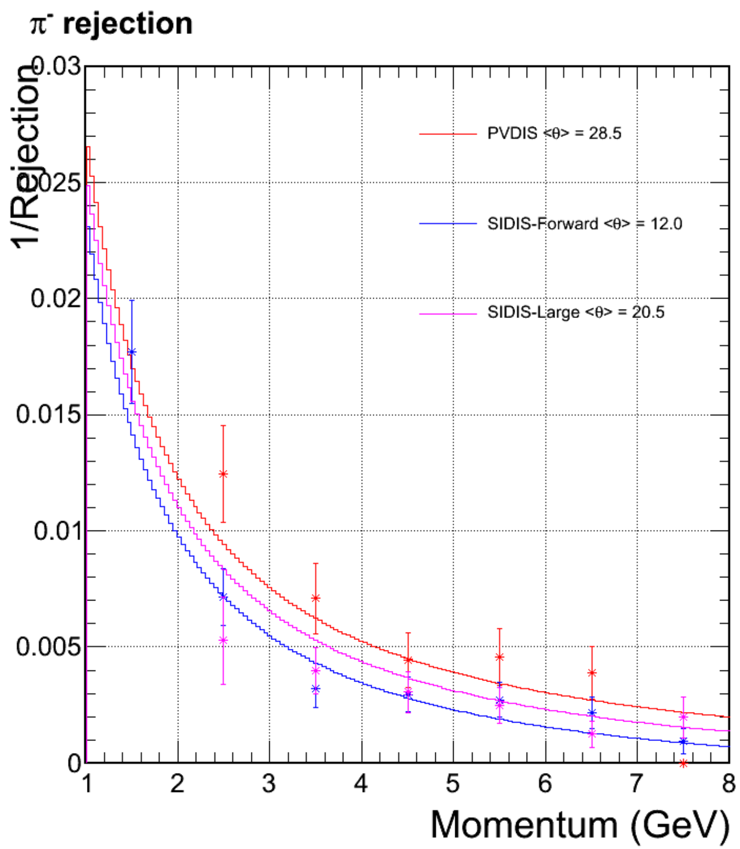
Jin Huang
Los Alamos National Lab

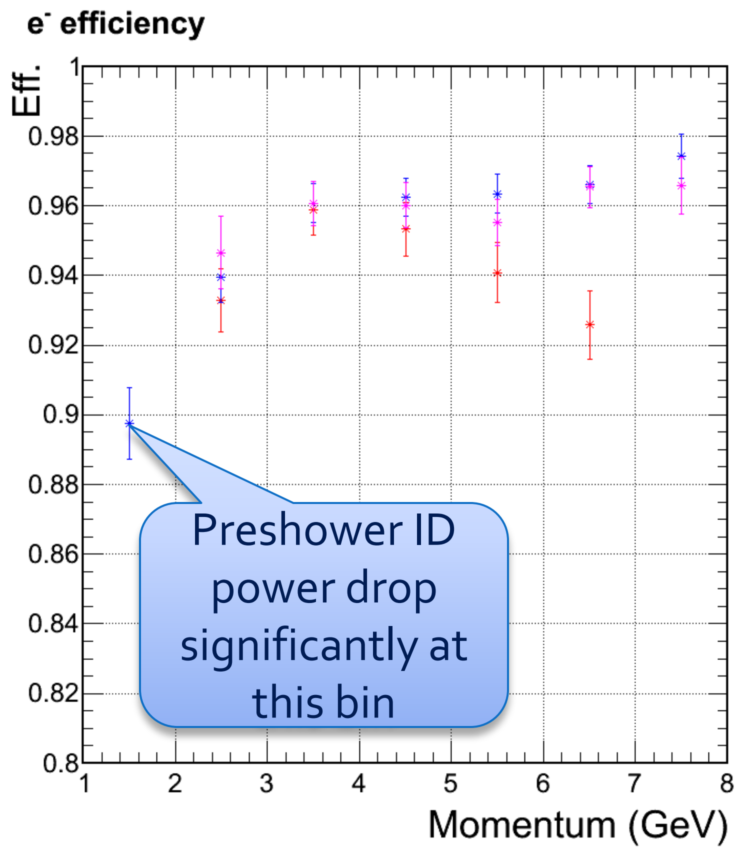


Jefferson Lab

EC performance w/o background

- Cited from March collaboration Meeting



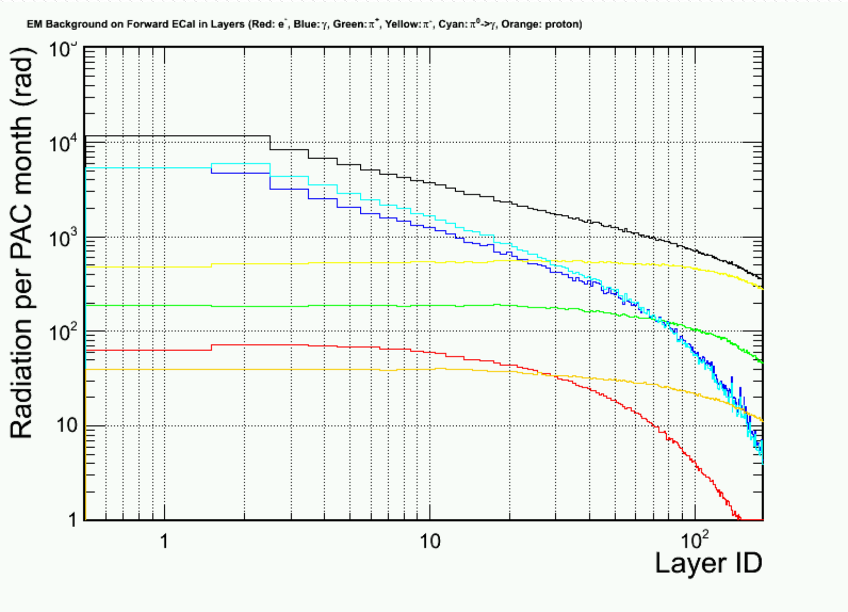


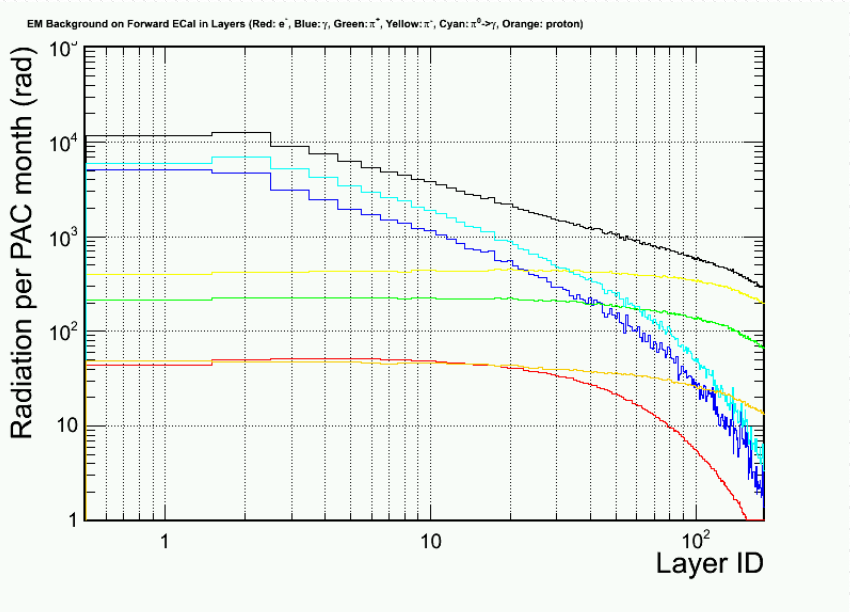
Sixth update of CLEO background

- A.K.A. **Babar More1 Block** in Zhiwen's notes
  - Significant improvement observed

Updated radiation dose VS layers

Lead baffle



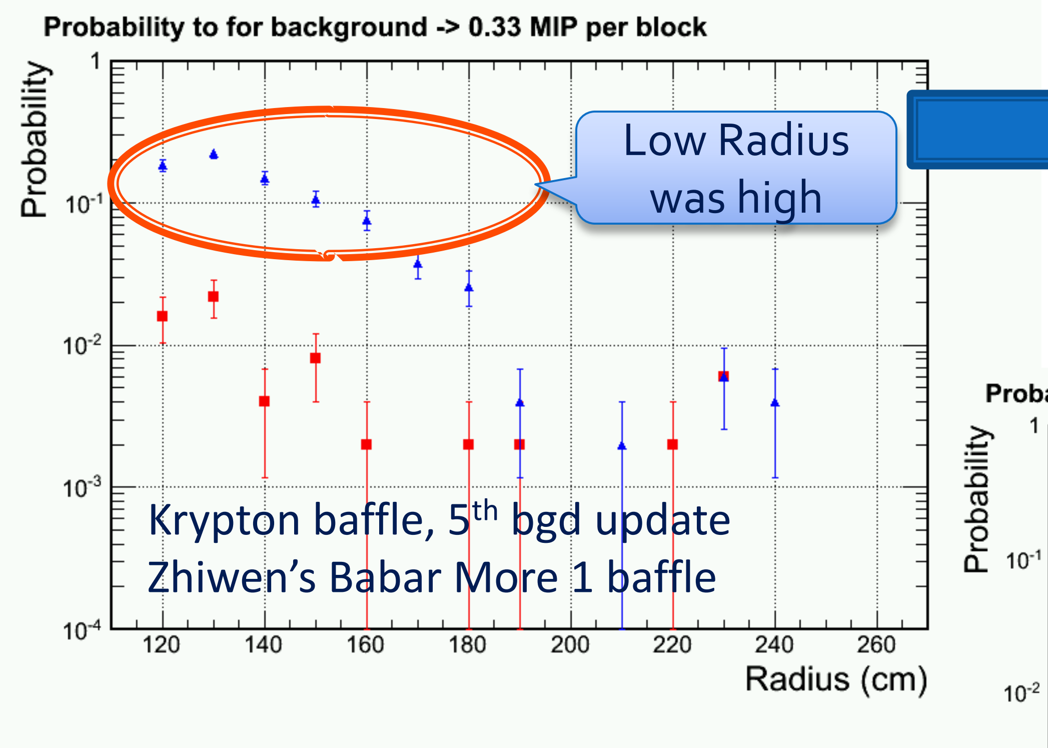


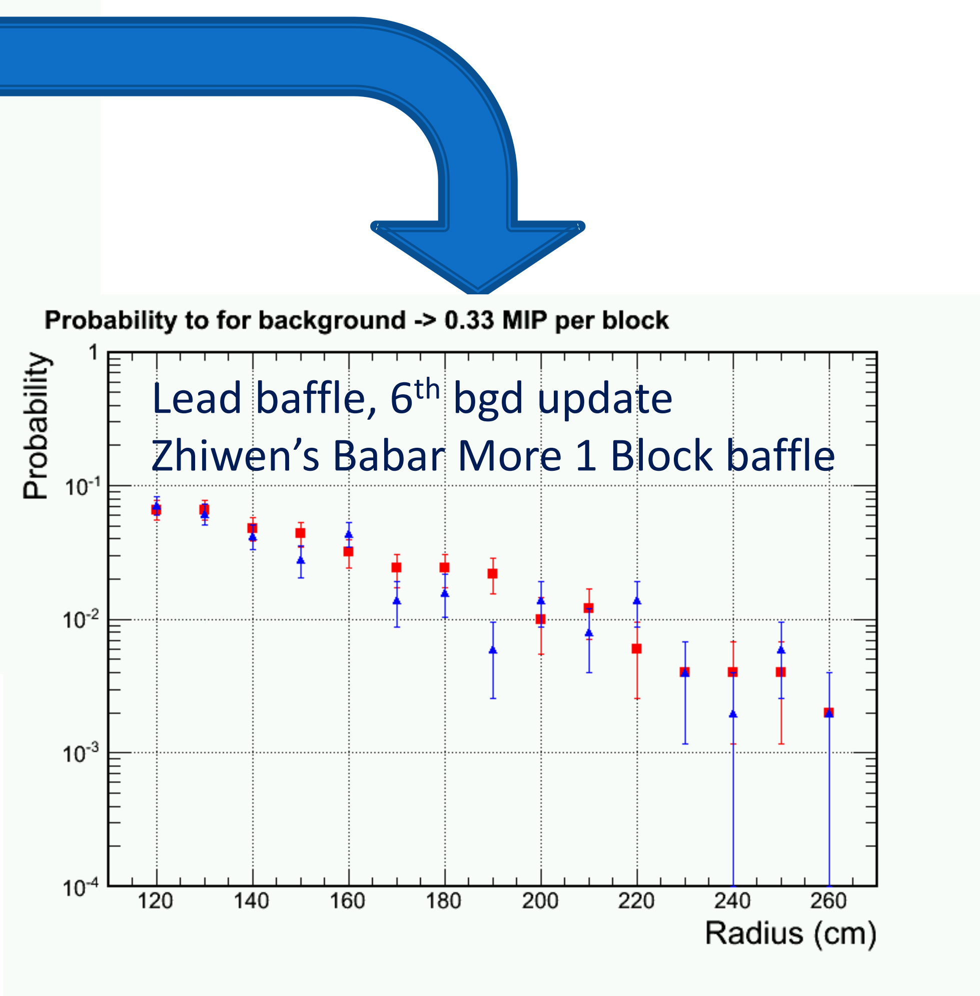
~ 11 layers per radiation length

High radiation ϕ slice

Low radiation ϕ slice

Readout occupancy per shower channel for ~75MeV zero suppression





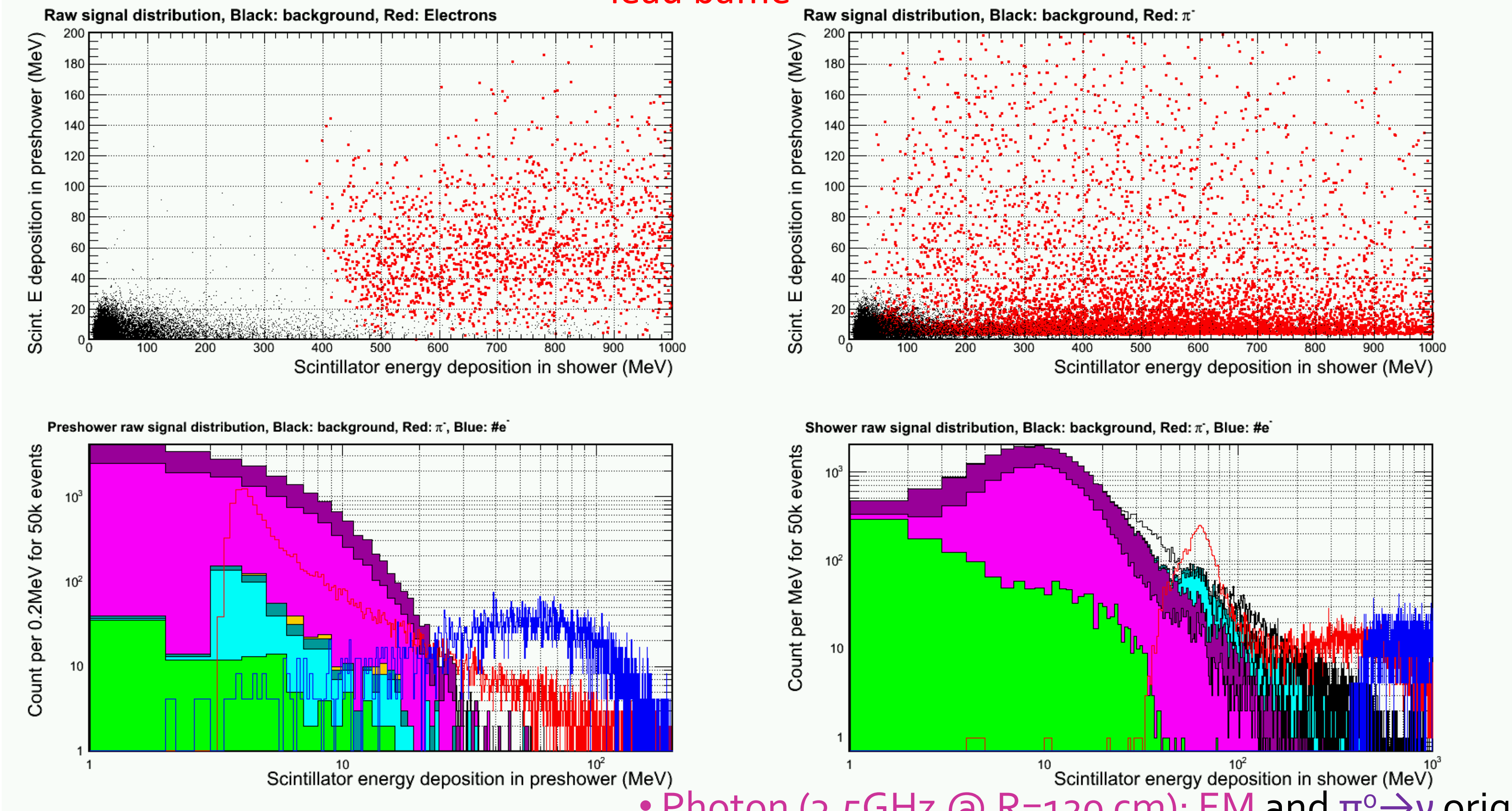
- High radiation phi slice
- Low radiation phi slice

Composition of background

inner radius region within the high-radiation azimuthal sectors

→Photon dominated

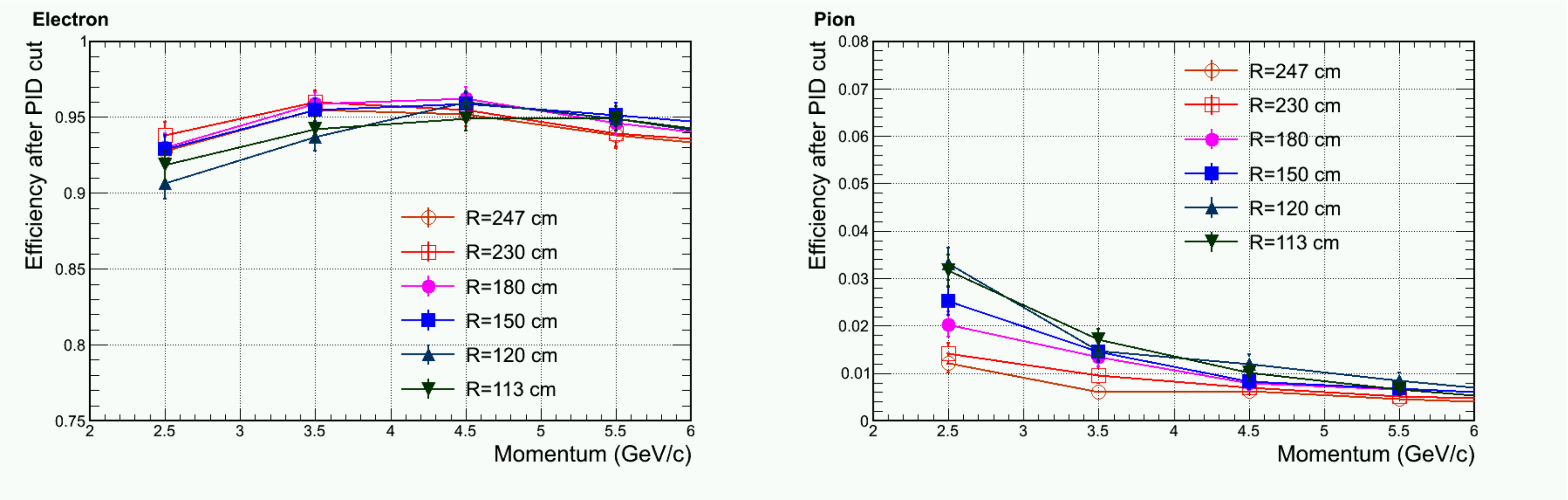
lead baffle



- Photon (3.5GHz @ R=120 cm): EM and $\pi^0 \to \gamma$ origin
- Electron
- Pion- Pion+ Proton

PID performance
– low radiation phi slice

Lead baffle



PID performance
– high radiation phi slice

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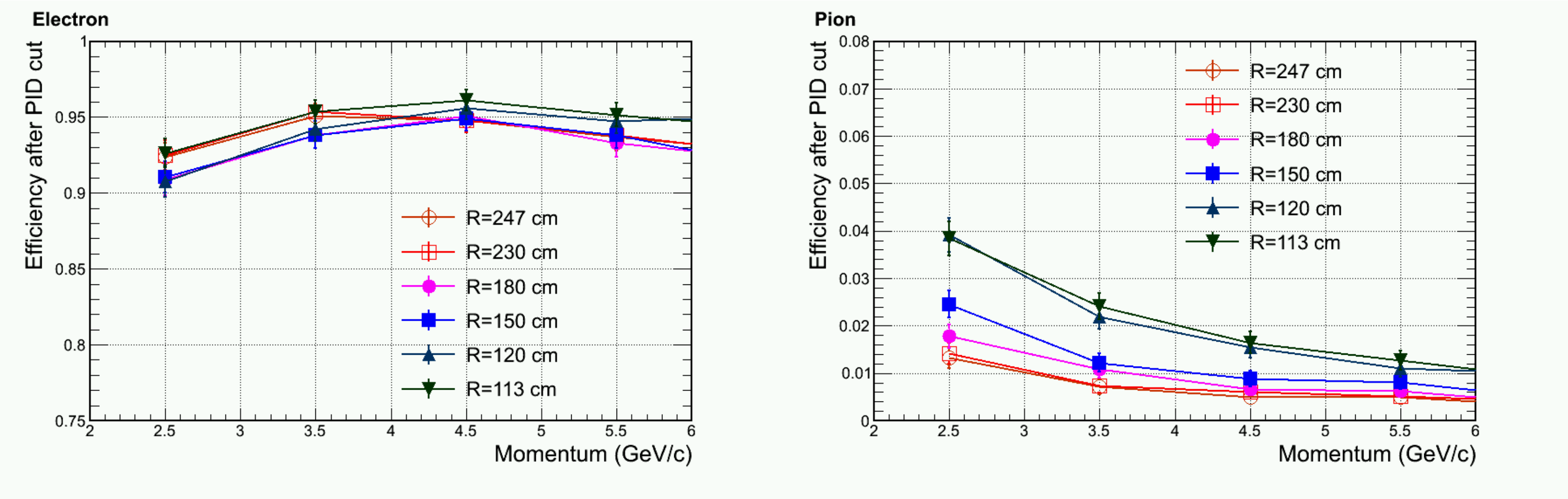
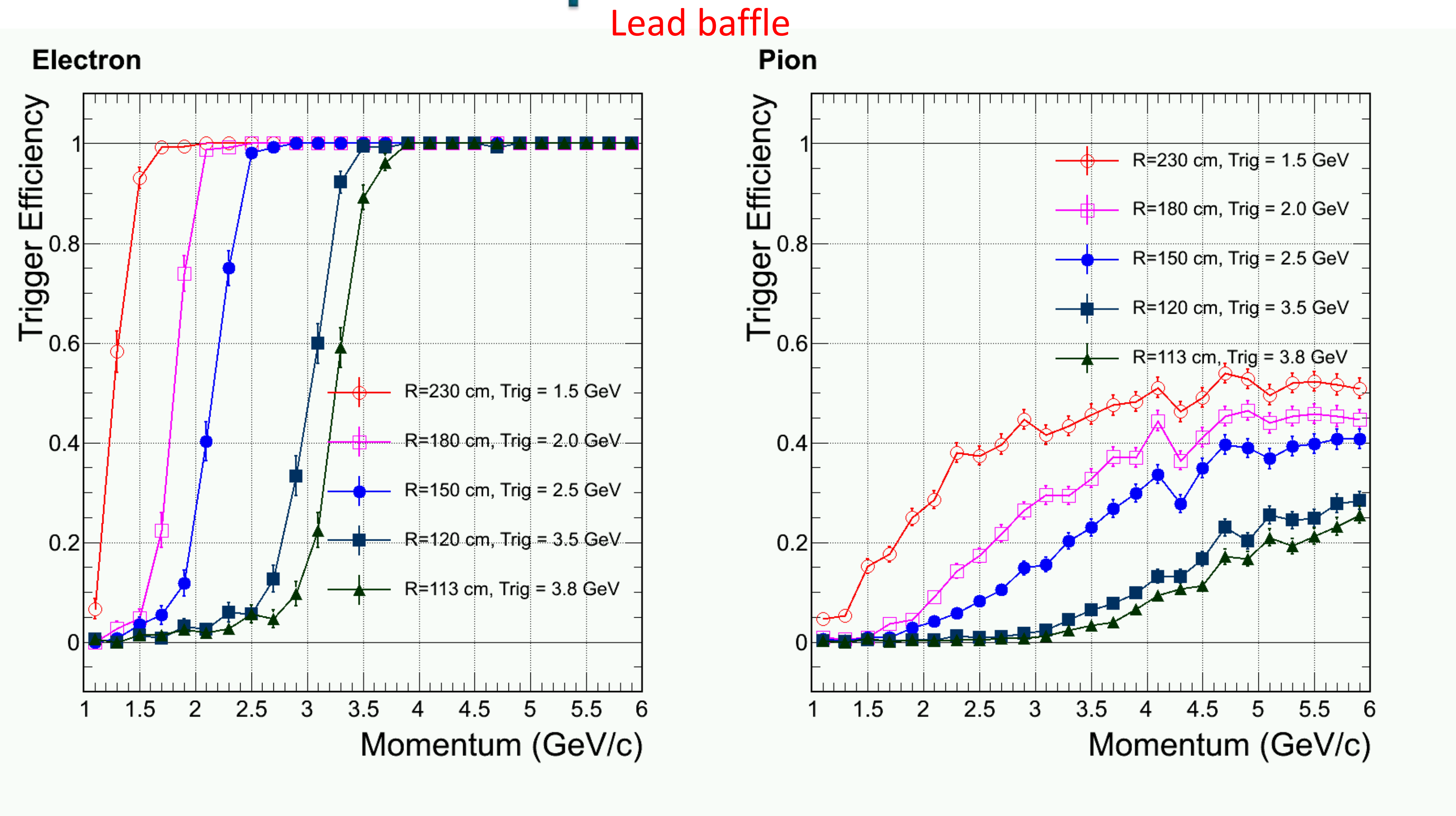
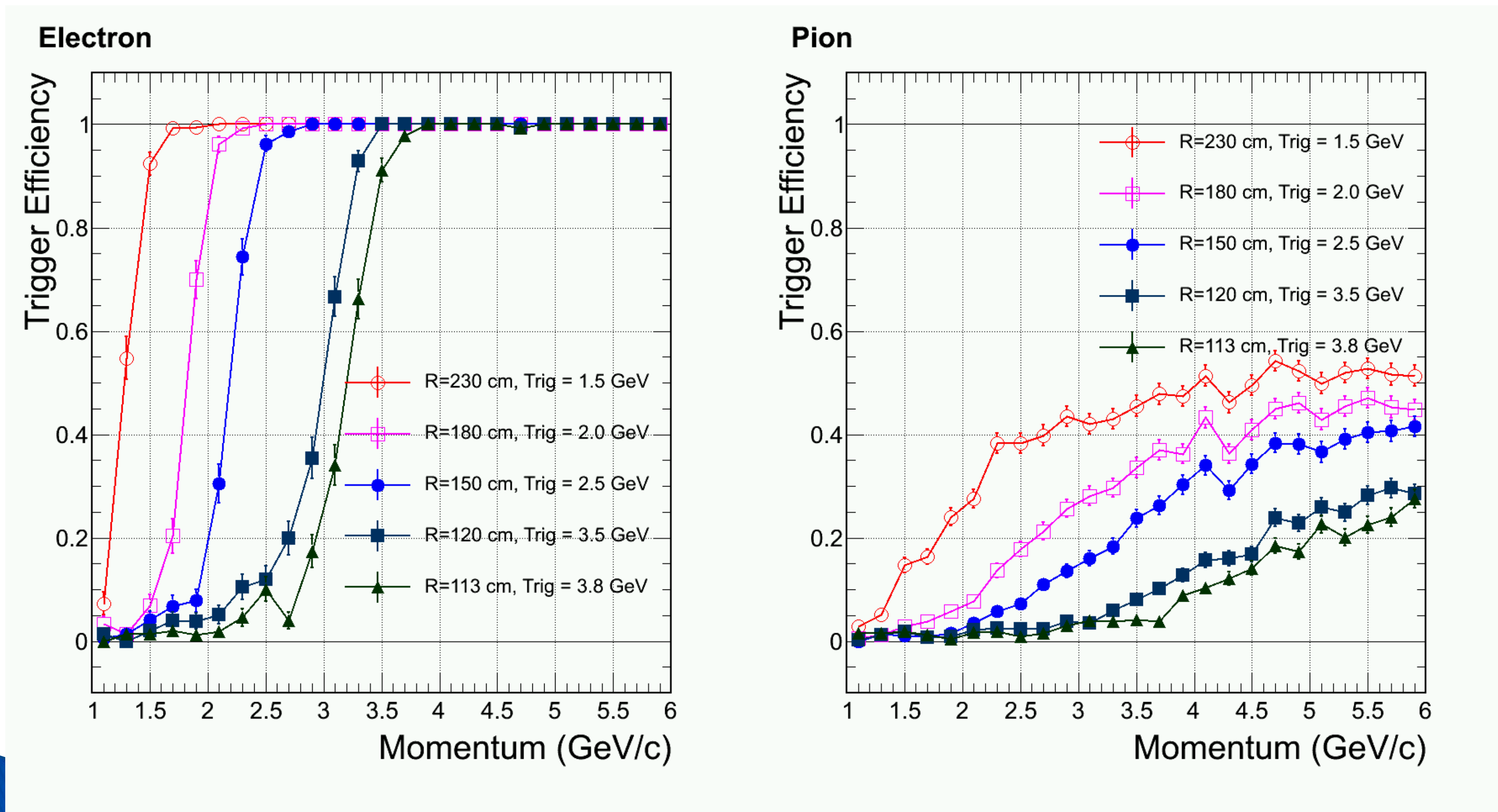


Trigger curve – low radiation phi slice



Trigger curve
– high radiation phi slice

Lead baffle



New trigger strategy

- Embedding bgd stochastically according to its 3D distribution
- Look for percentage of 30ns trigger window that pass trigger threshold
- Good for low energy background pile ups
- Can not handle rare events due to stat. limit
- Handle p<1GeV background particle trigger

From background embedding

- Embedding bgd stochastically according to its 3D distribution
- Produce trigger turn on curve for high energy particle
- Good for rare events, e.g. DIS
- Can not handle low energy particle dominated trigger, which is non-linear
- Handle p>1GeV particle dominated trigger

From trigger turn on curve

Low energy (P<1GeV) particle trigger

- Place a calorimeter 6+1 cluster at given reference radius location
- Assume a 30ns trigger integration window, stochastically simulate which bgd particle would fly into calorimeter
  - including e/gamma/pi+/-/0/proton, 1keV – 1GeV
  - Particle with P>1GeV is ignored in this case, since their trigger rate should be counted in high energy trigger curve x rate study
- Simulate scintillator energy deposition in the shower part for all these particle and sum to give a trigger signal
- Repeat for 60k times, check the probability to produce a trigger. Trigger threshold set according to the radius
- Multiply by number of trigger channels and get the total low energy trigger rate

Inspect on few triggered case

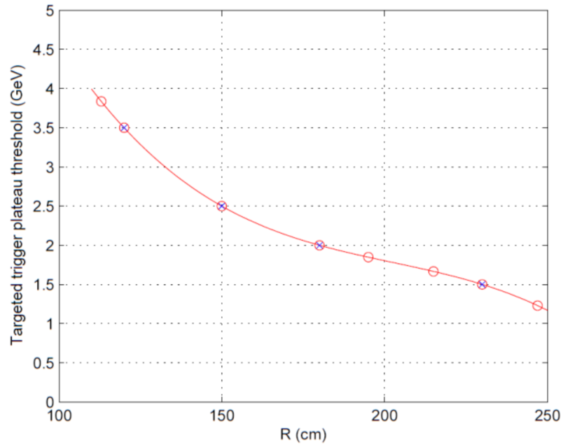
- For low radiation slice at R=230 cm, trigger threshold is
  - scintillator energy > 283 MeV
  - targeted high trigger efficiency for electron with E>1.5 GeV
- 9 out of 60k simulations produced a trigger

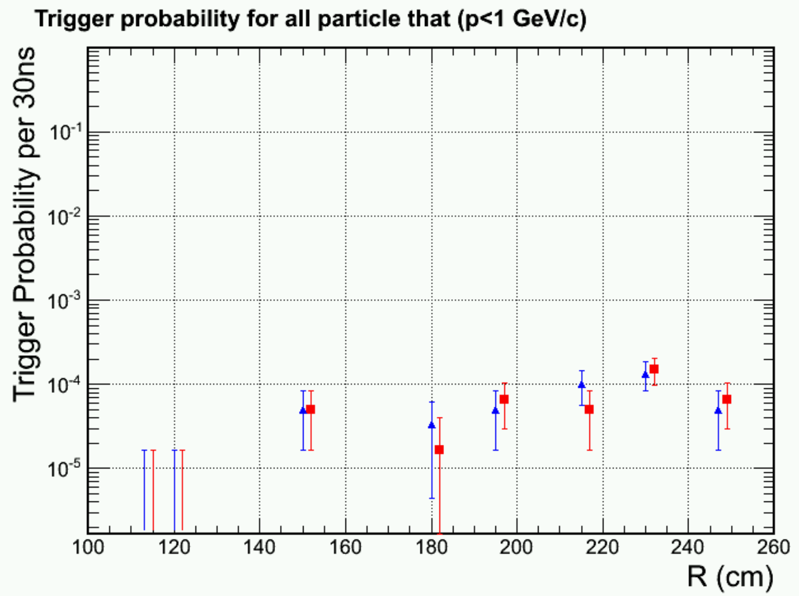
n_* : number of that particle for 30ns window
sh_*: shower scintillator energy deposition for that particle species

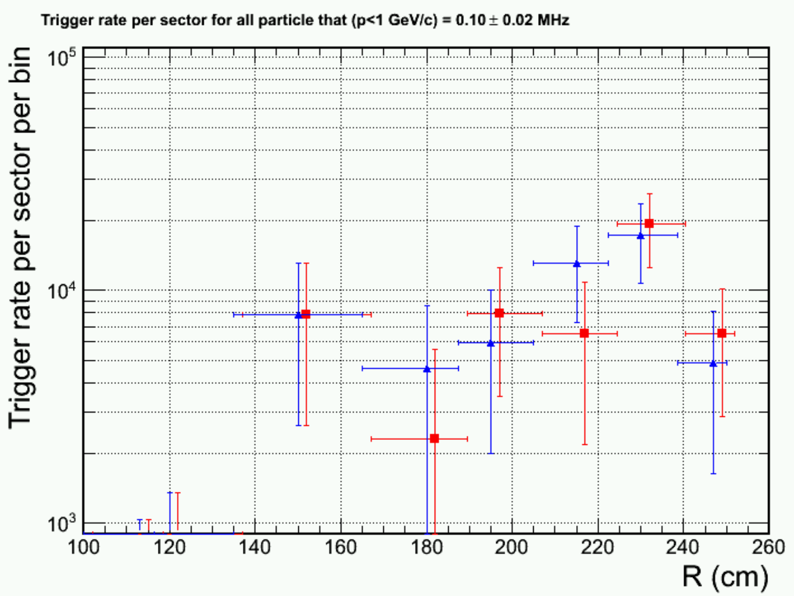
Row	n_elec	sh_elec	n_gamma	sh_gamma	n_gamma_p	sh_gamma_	n_pip	sh_pip	n_pim	sh_pim	comment
5116	0	0	11	1.4133610	4	0.8096210	0	0	1	287.67065	<- Pi- dominated
10508	0	0	13	0	10	17.858110	0	0	1	272.90136	
12082	0	0	13	1.1497589	5	3.1542911	1	328.03814	0	0	<- Pi+ dominated
26961	0	0	15	0	9	13.370458	0	0	1	277.56695	
31170	0	0	18	3.771492	4	3.6389594	0	0	1	301.99948	
37962	0	0	12	0	2	0	0	0	2	315.43313	
40813	0	0	20	10.953822	6	12.016947	0	0	1	266.20440	
42284	1	0	13	1.1786102	5	1.1385887	1	82.557189	1	216.75323	<- two pion pile up
42872	0	0	16	0.9754827	4	0	0	0	1	285.33731	

Total rate from P<1GeV particle

- Sum = 0.10 ± 0.2 MHz per sector
  - Statistical precision can be improved with more simulation
  - Ignored correlation between neighboring trigger channels -> over estimate
- Dominated by radius region R~230cm, where trigger threshold is low (E_{target}=1.5GeV)







- High radiation phi slice
- Low radiation phi slice

Fifth update of CLEO background

- * A.K.A. Babar More1 in Zhiwen’s notes
  * Inputs received on Friday Sept 6

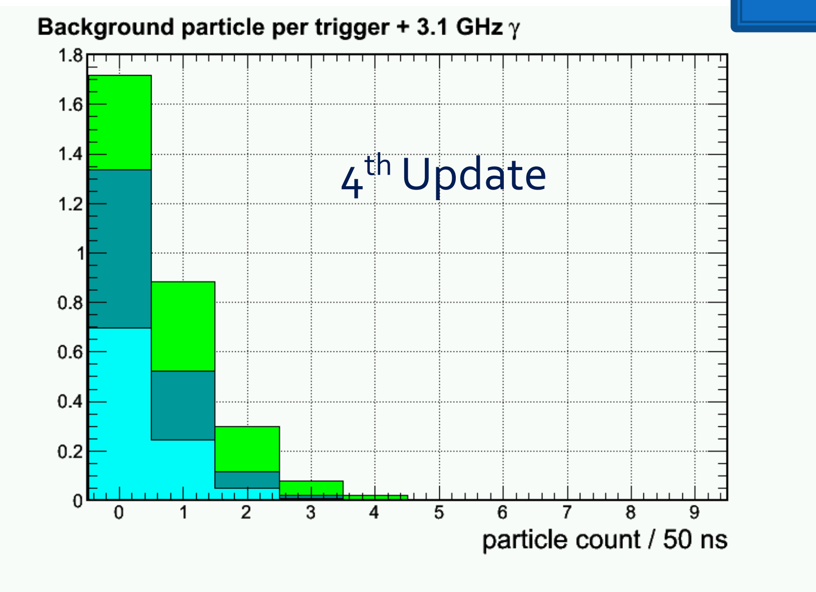
Data points saved to ROOT format and uploaded to SVN:
https://solid.physics.umass.edu/svn/solid/solidtech/calorimeter/figs

Comments on this update

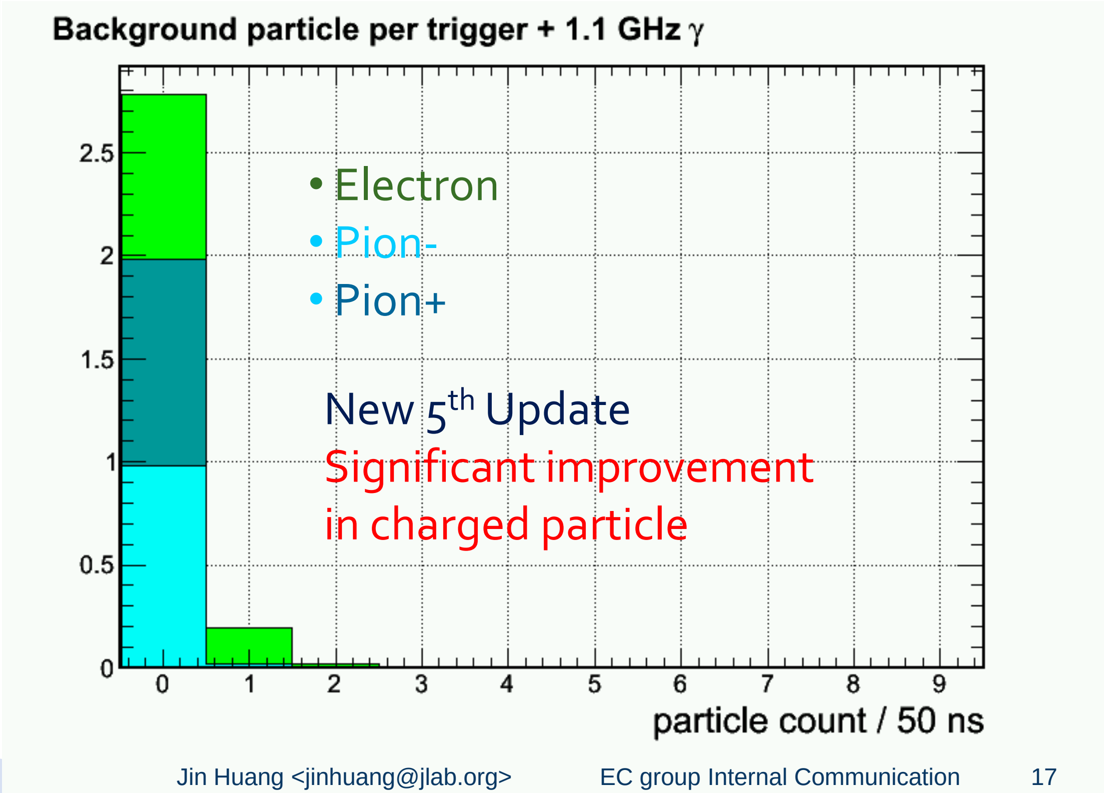
- Use Babar More1 baffle in Zhiwen's notes
- Two version background are generated:
  - With krypton baffle for hadron background and that with lead baffle
- Now only one region show significant radiation effect: inner radius in the higher-radiation phi slice
- The updated dominate background is photons, which can be attenuated by x10 with 4 radiation length of absorbing material (~2cm lead)
- Updated to use 30 ns-equivalent ADC integration window instead of 50 ns
  - Suggested in previous meetings
  - Confirmed again with Alex
- Simulated assuming NO supporting structure between preshower and shower
  - Supporting structure could be before the Pb absorber or between Pb and the preshower scintillator
- Updated plots and data points uploaded to SVN https://solid.physics.umass.edu/svn/solid/solidtech/calorimeter/figs

Updated: Per-event pion rate

for 1+6 hexagon cluster at Mid radius, high radiation ϕ-slice



Krypton baffle



Updated radiation dose VS layers (High radiation ϕ slice)

- Photon (EM) <- dominant!
- Photon (Pi⁰)
- Electron
- Pion- Pion+ Proton

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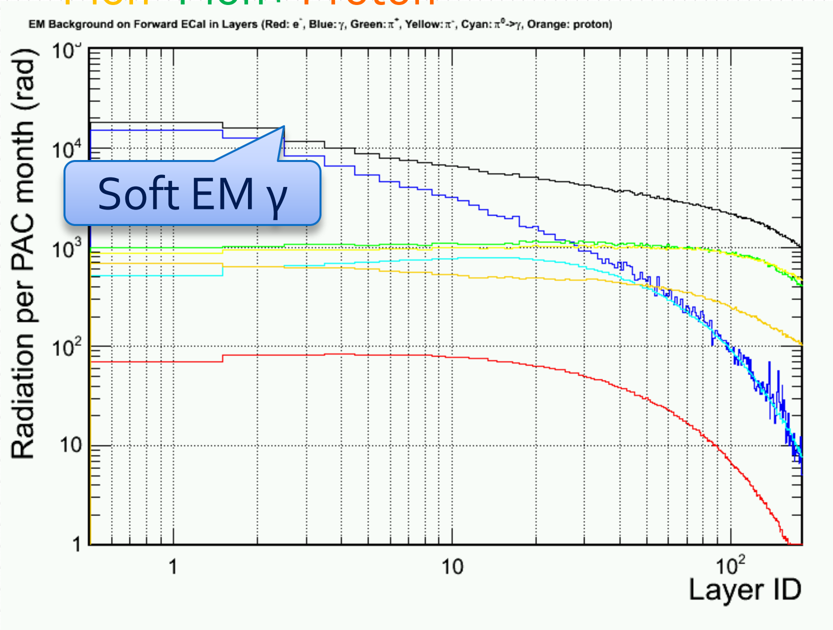
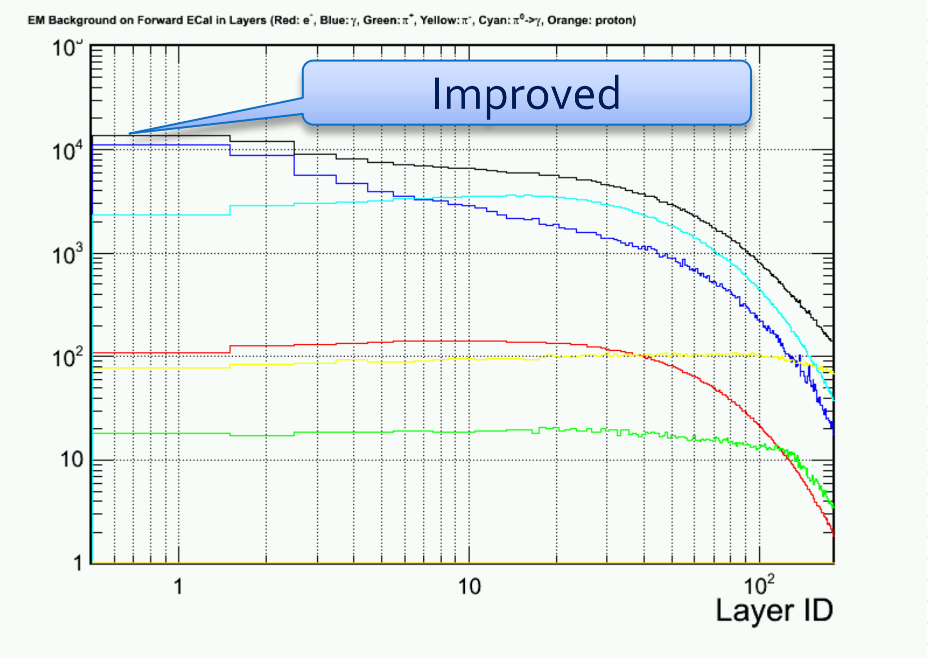


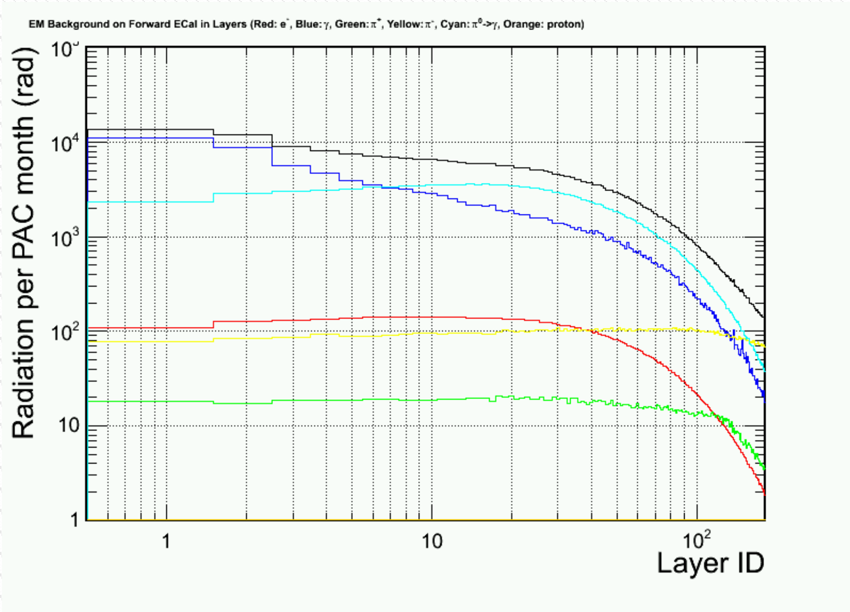


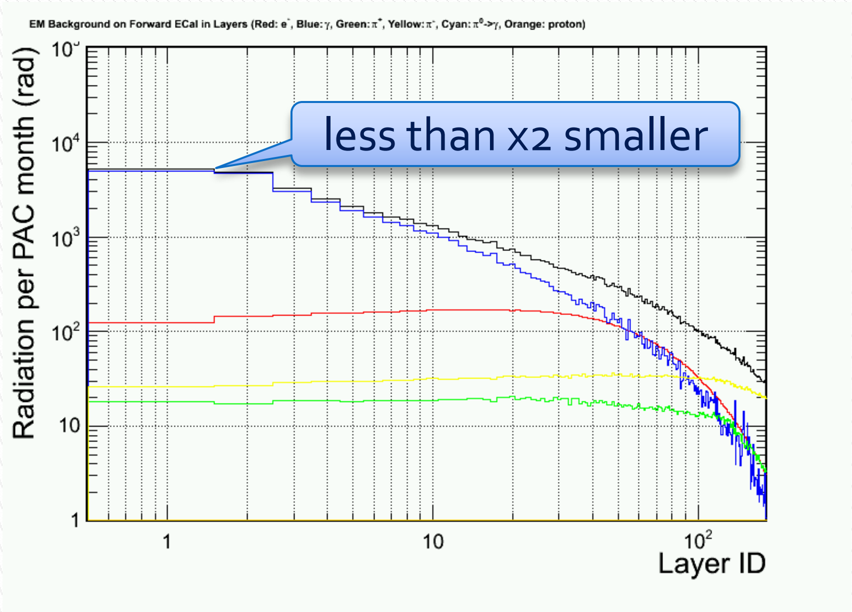
4^{th} Update

New: 5^{th} Update

Updated radiation dose VS layers

Krypton baffle





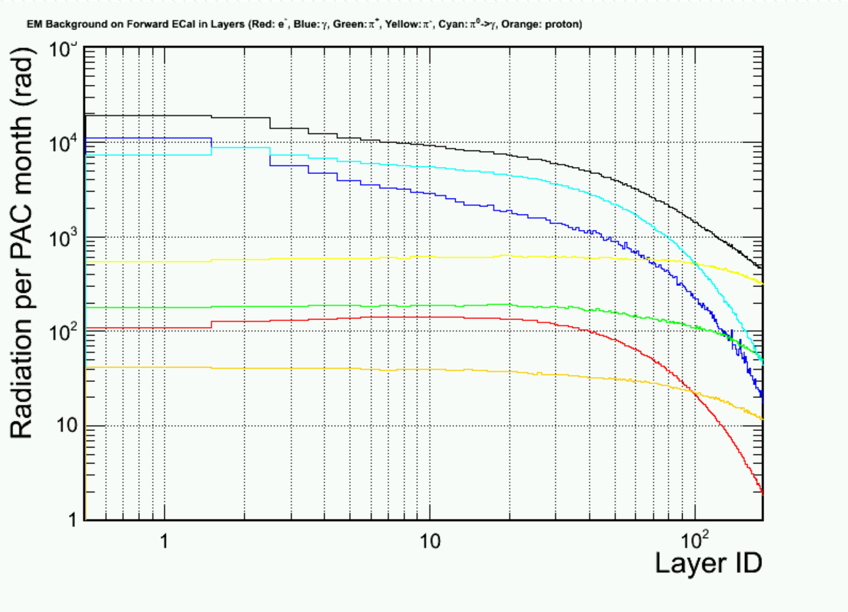
~ 11 layers per radiation length

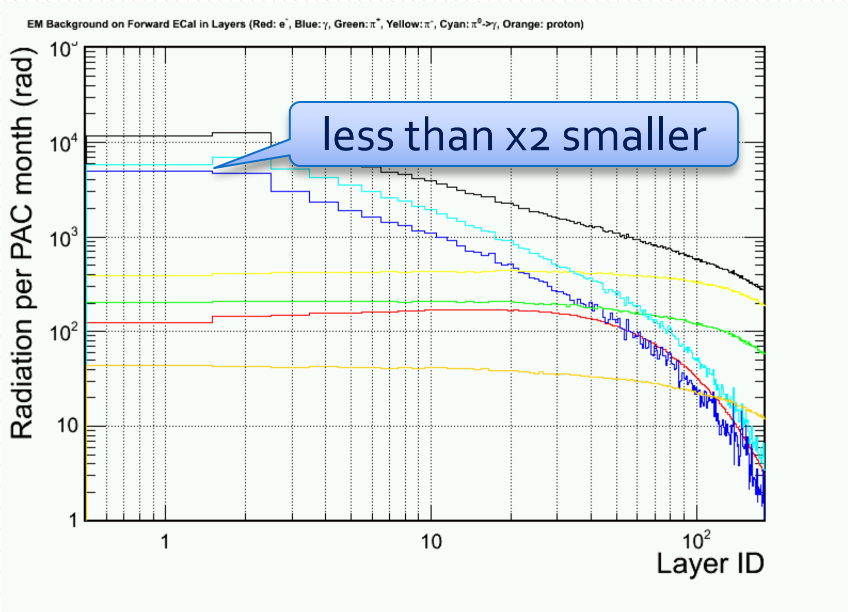
High radiation ϕ slice

Low radiation ϕ slice

Updated radiation dose VS layers

Lead baffle





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High radiation ϕ slice

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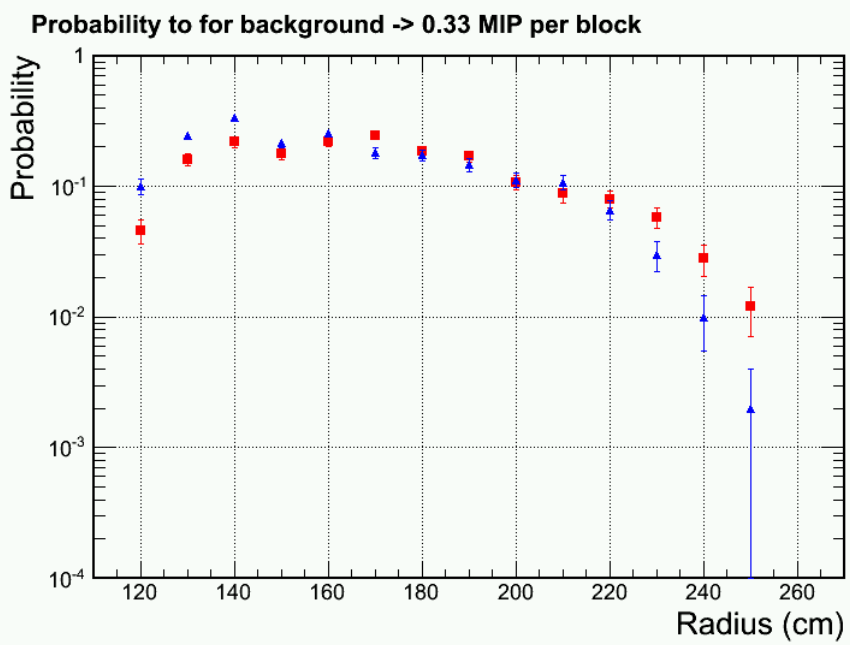

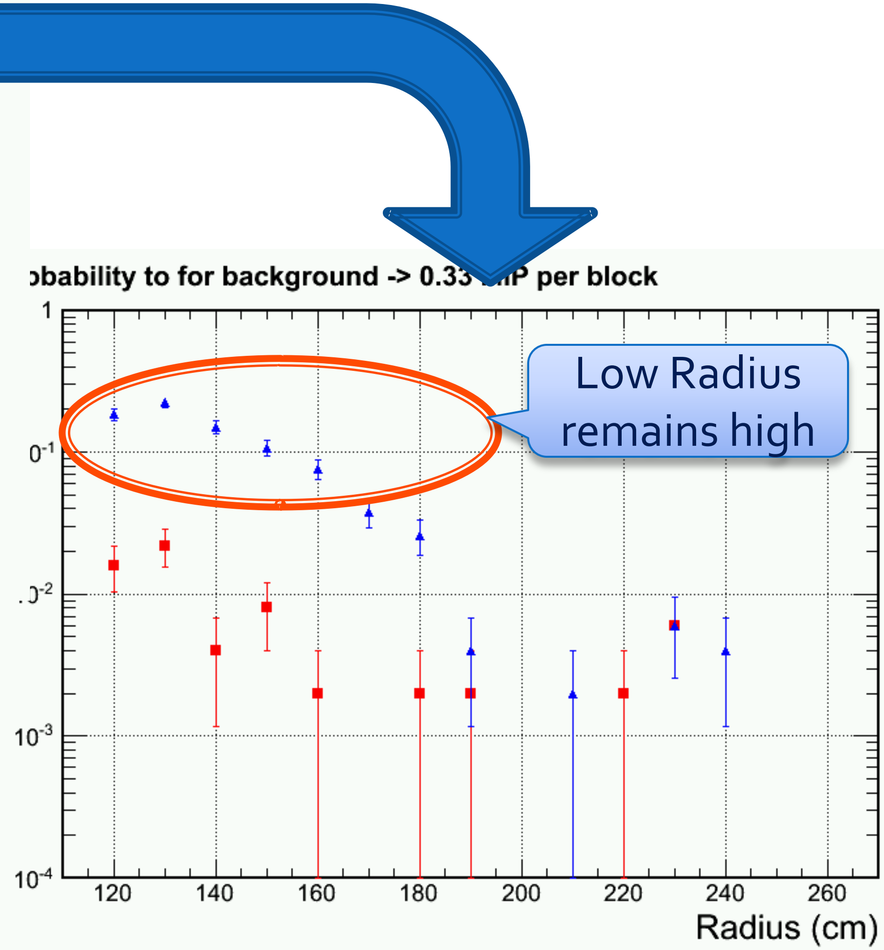

Krypton baffle

- High radiation phi slice
- Low radiation phi slice

Composition of background

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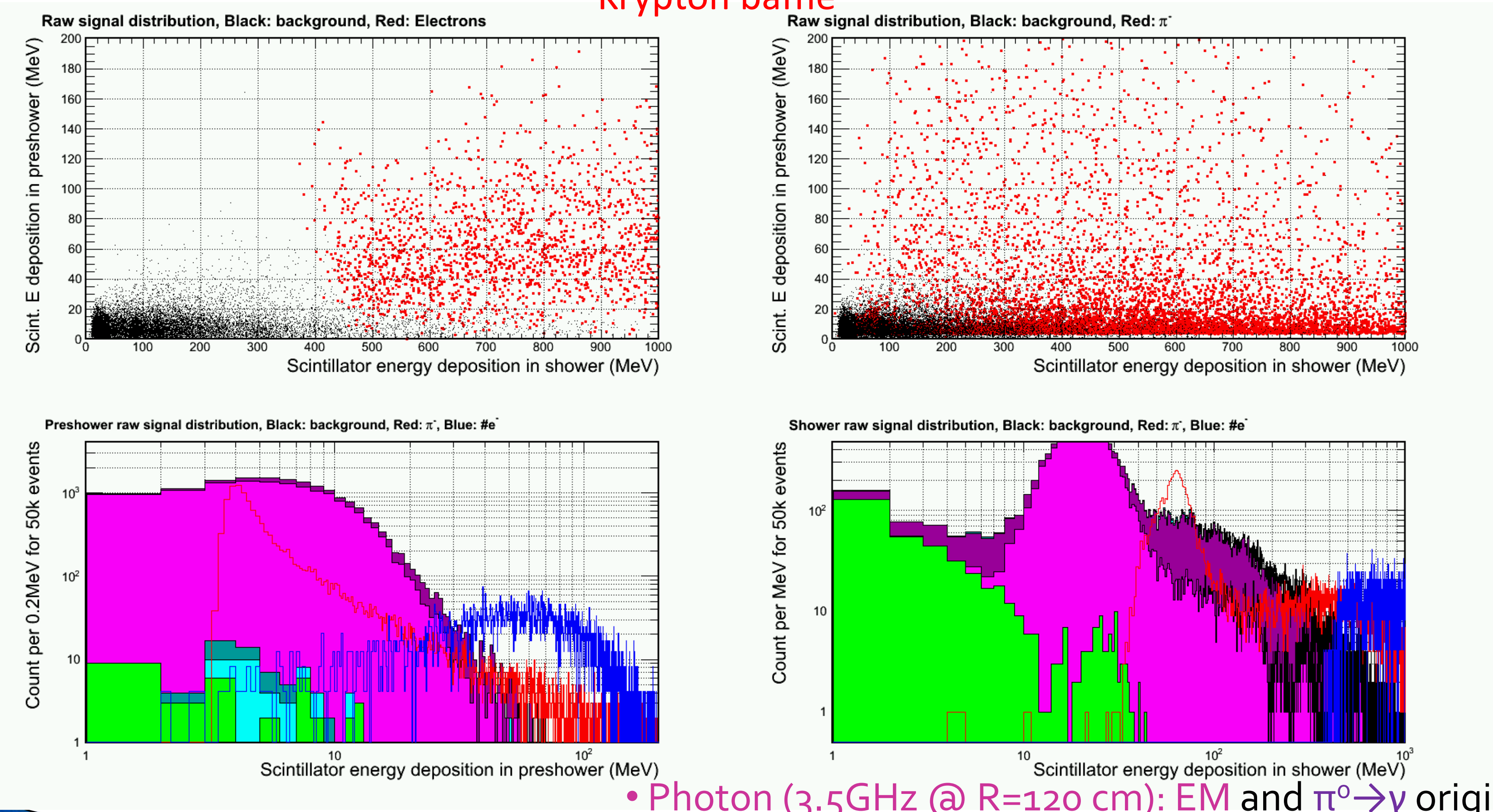
→Photon dominated

Krypton baffle



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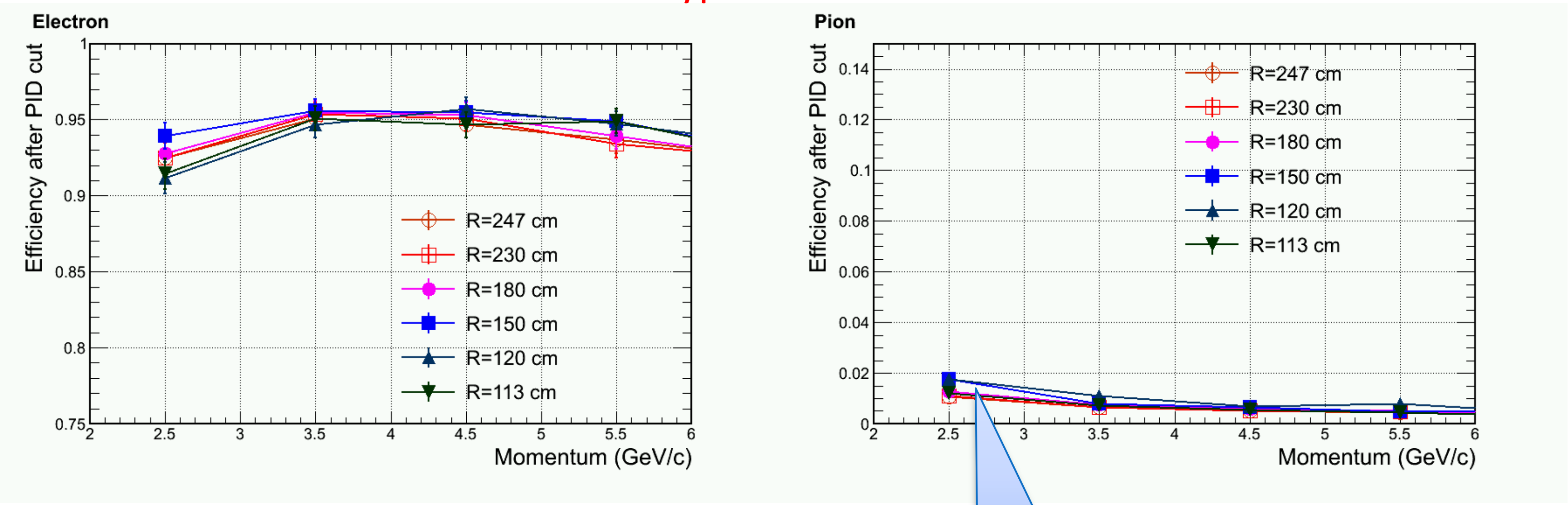
PID performance – low radiation phi slice

Krypton baffle

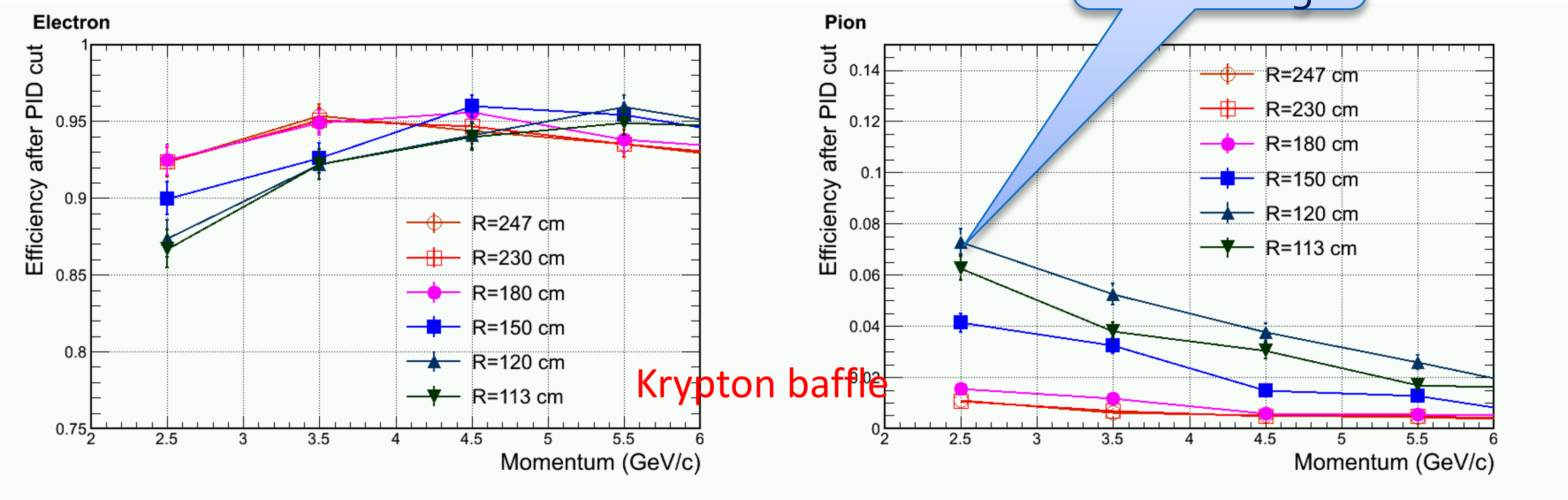


Significantly improved

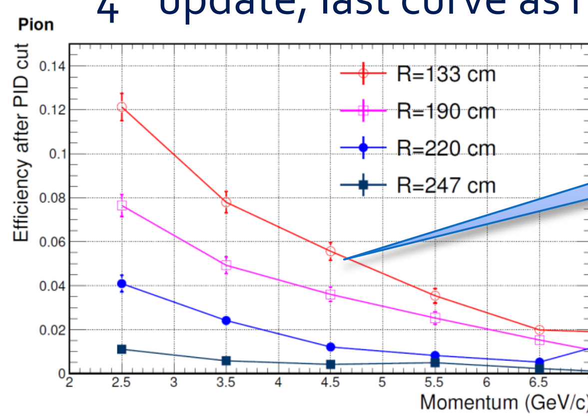
Jefferson Lab

PID performance
– high radiation phi slice

Lower radius remains high

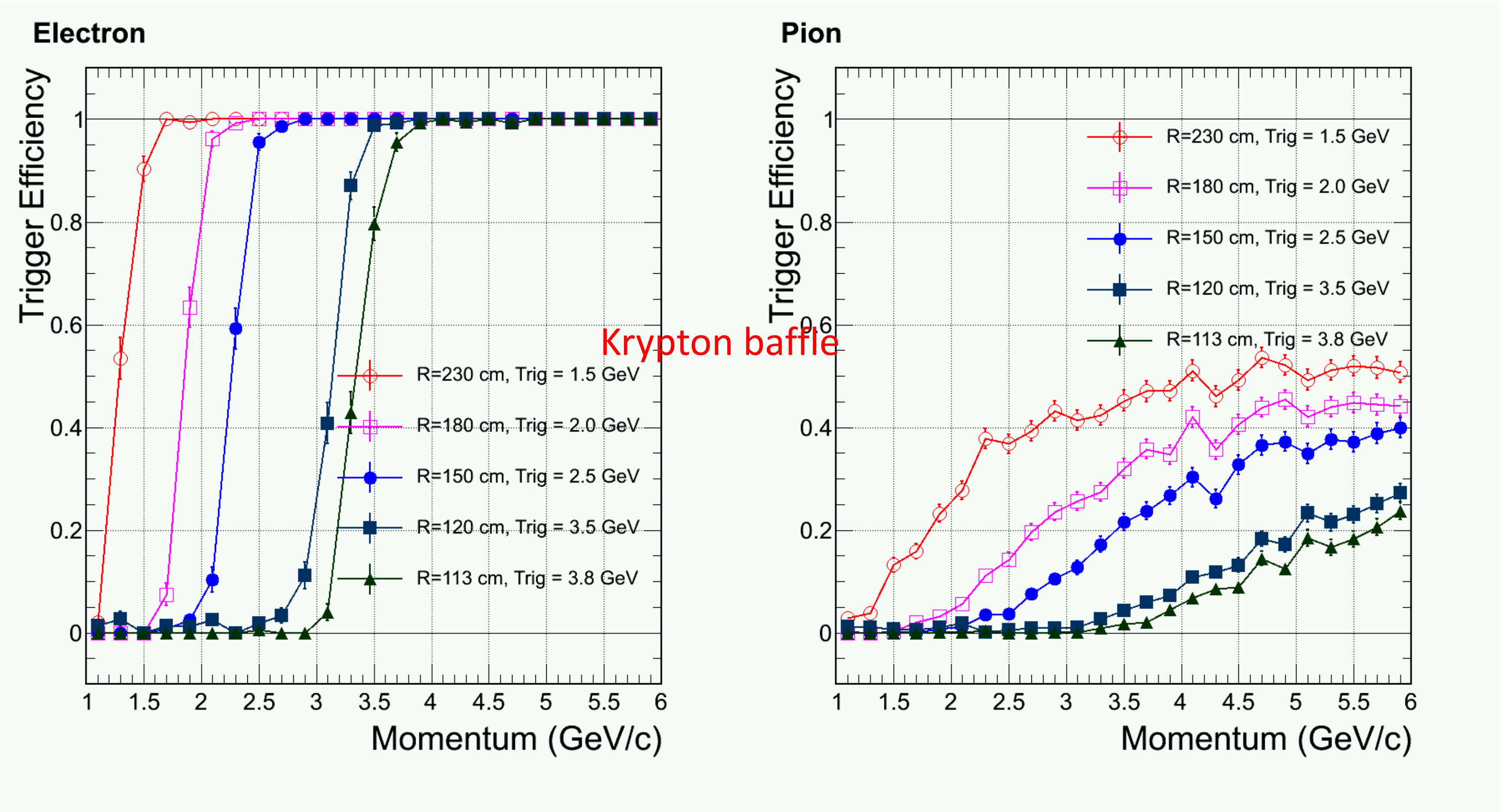


4th update, last curve as reference

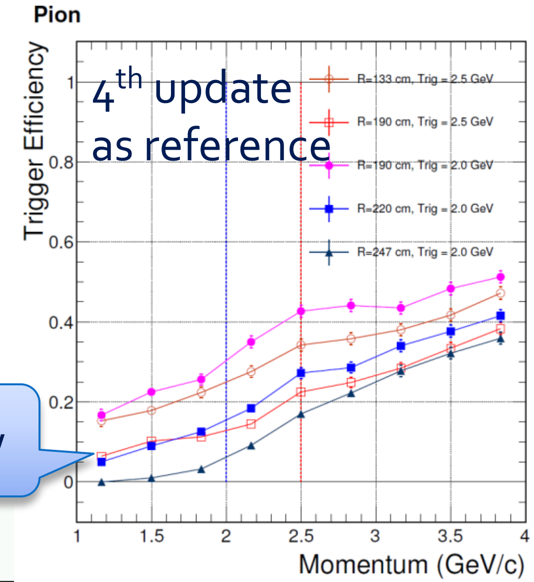


improved now

Trigger curve – low radiation phi slice



Trigger curve – high radiation phi slice



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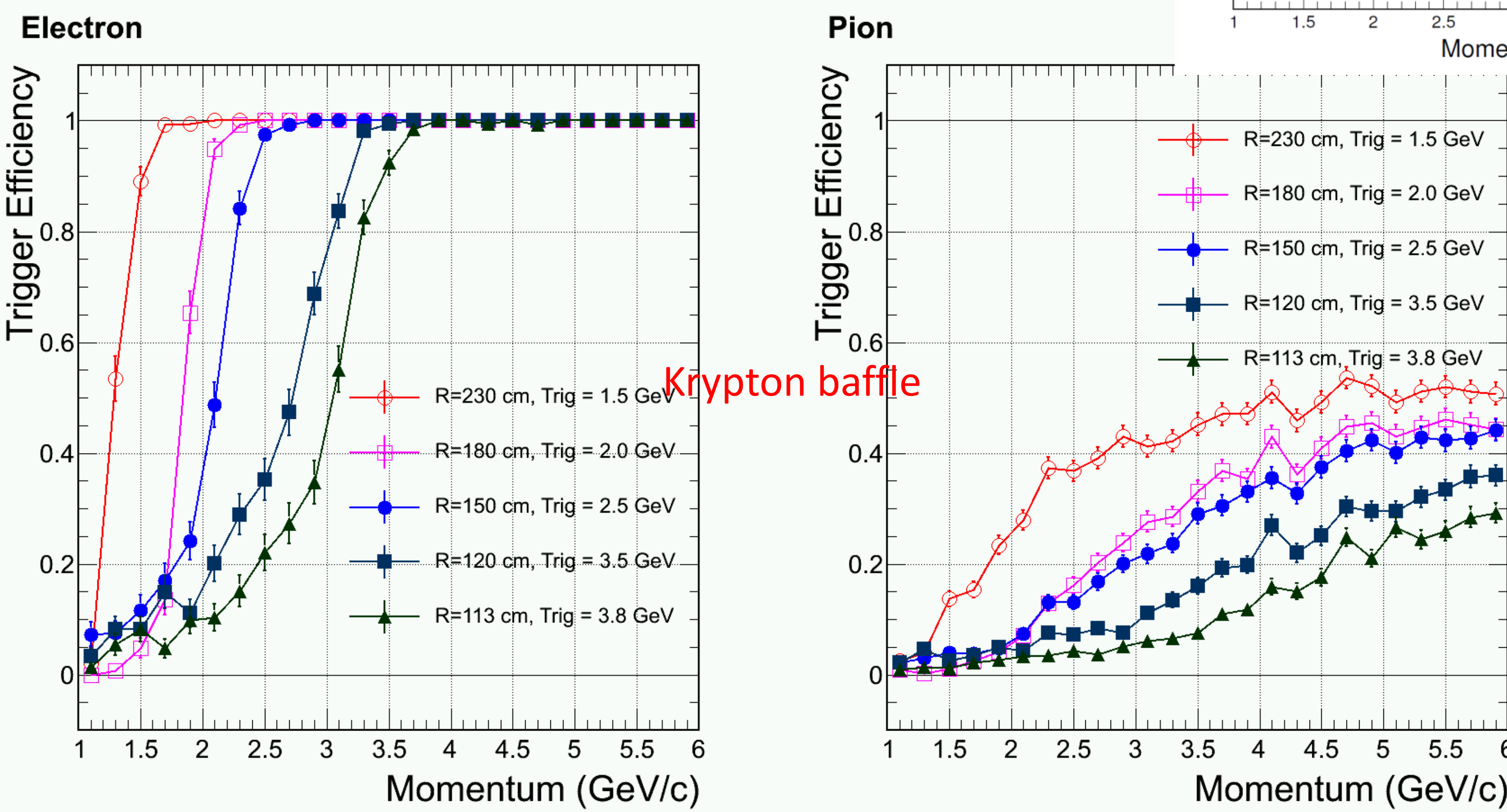
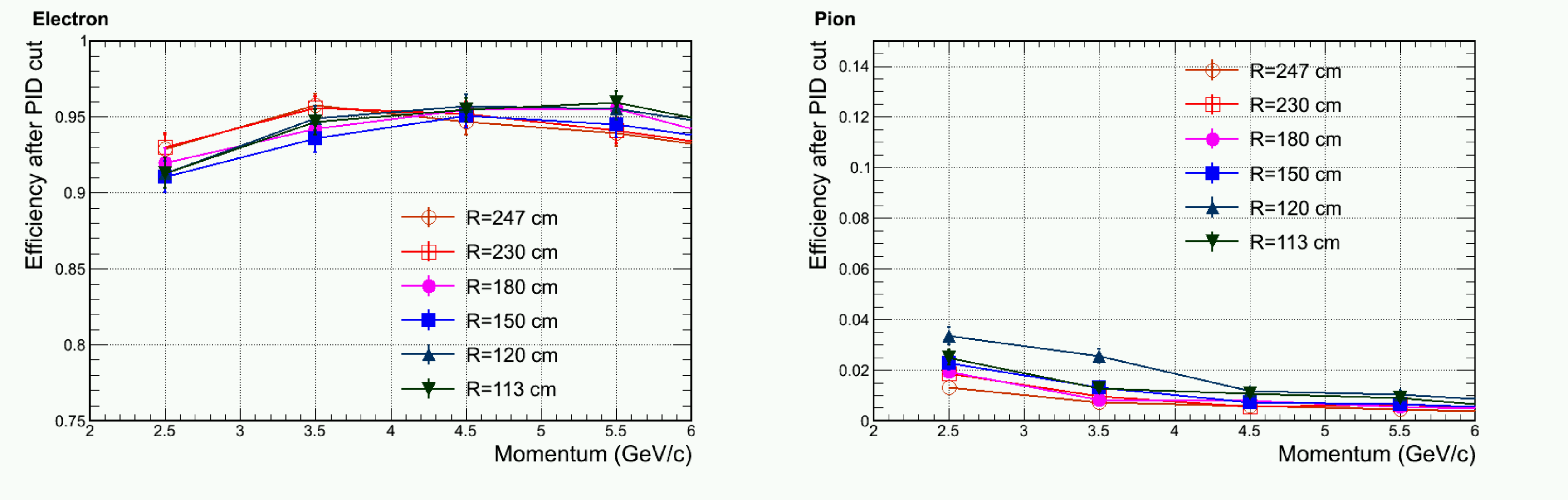


Krypton baffle

PID performance – low radiation phi slice

Lead baffle



PID performance – high radiation phi slice

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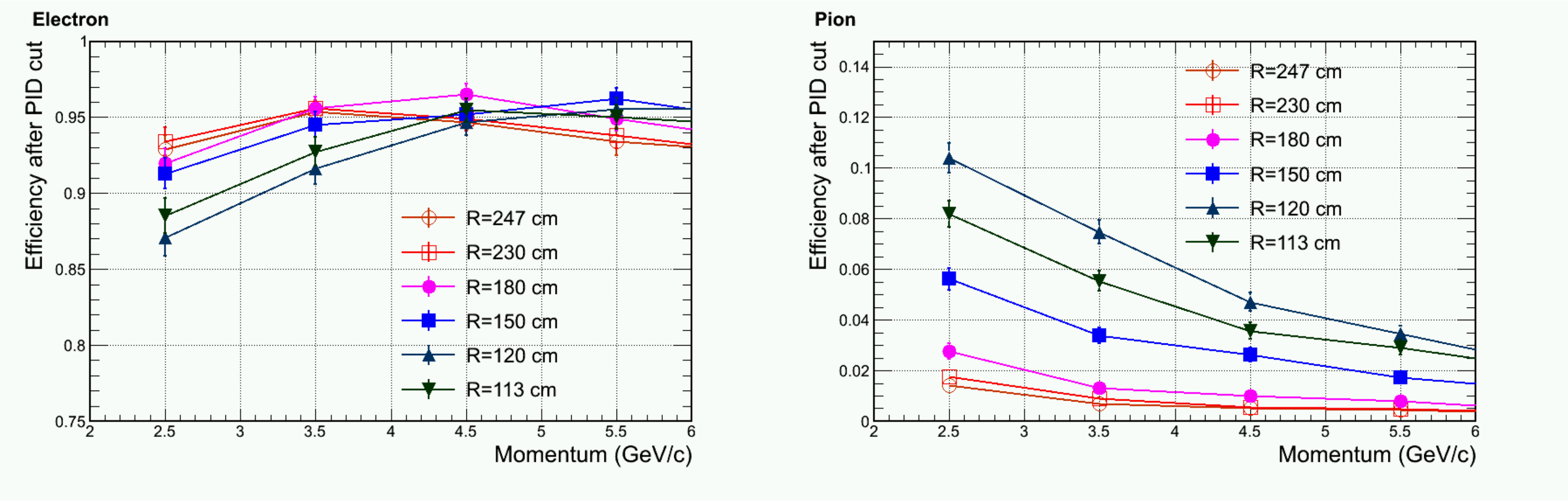
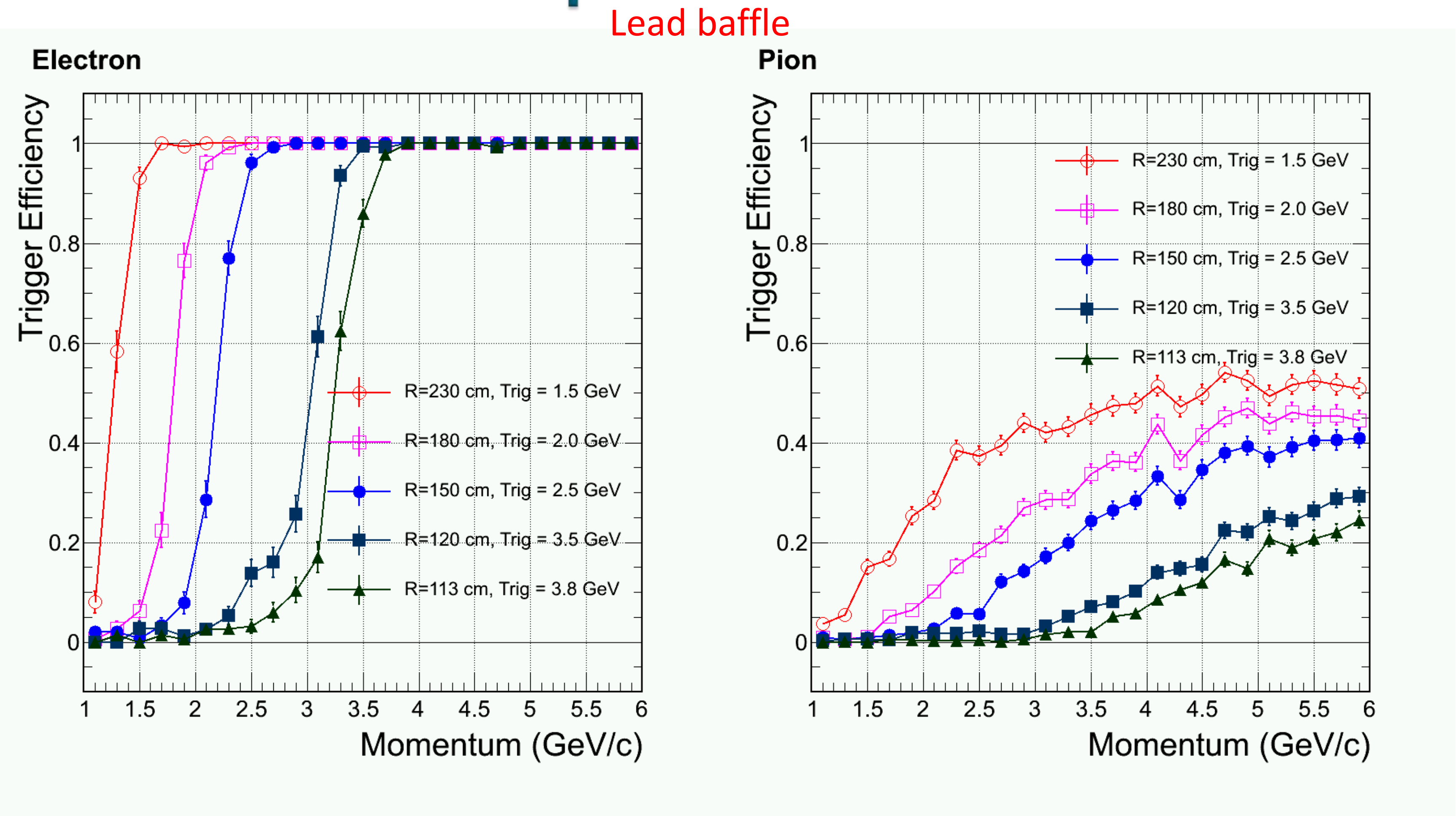


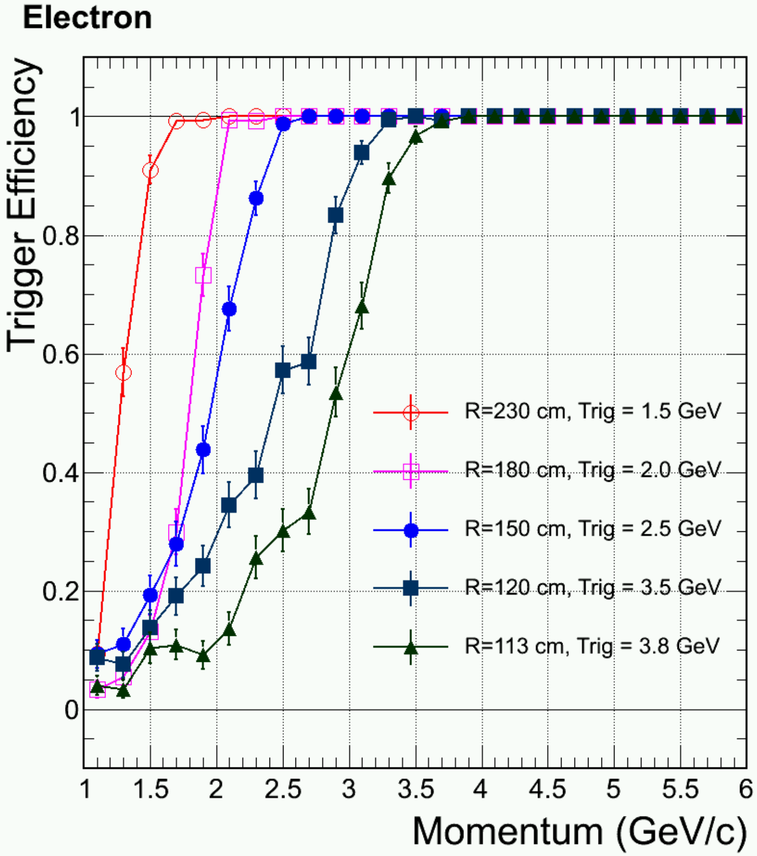
Trigger curve – low radiation phi slice

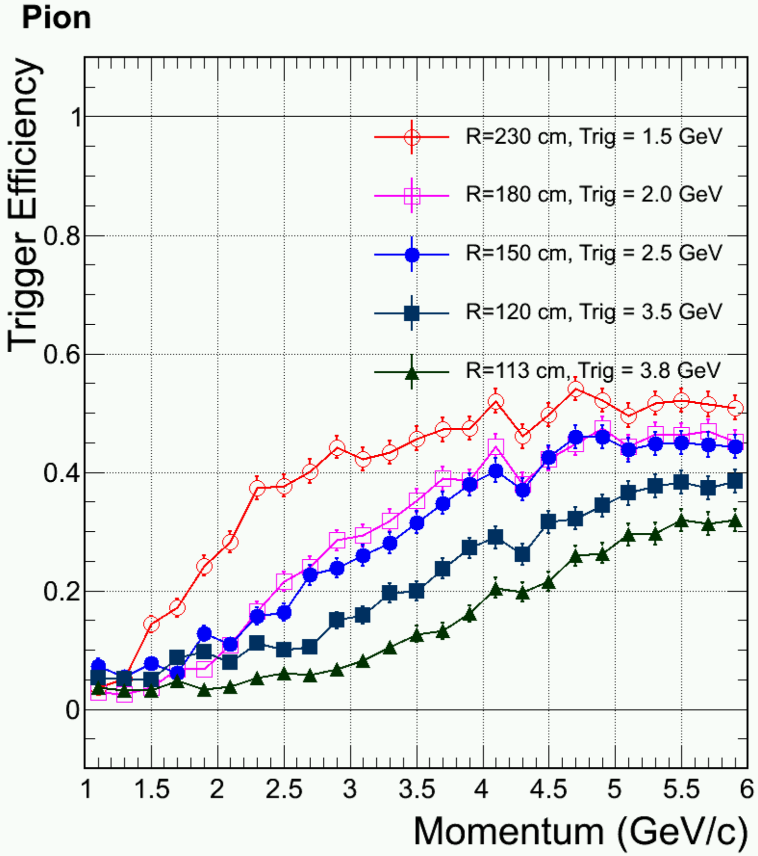


Trigger curve – high radiation phi slice

4th update
as reference

Lead baffle





New trigger strategy

From background embedding

- Embedding bgd stochastically according to its 3D distribution
- Look for percentage of 30ns trigger window that pass trigger threshold
- Good for low energy background pile ups
- Can not handle rare events due to stat. limit
- Handle p<1GeV background particle trigger

From trigger turn on curve

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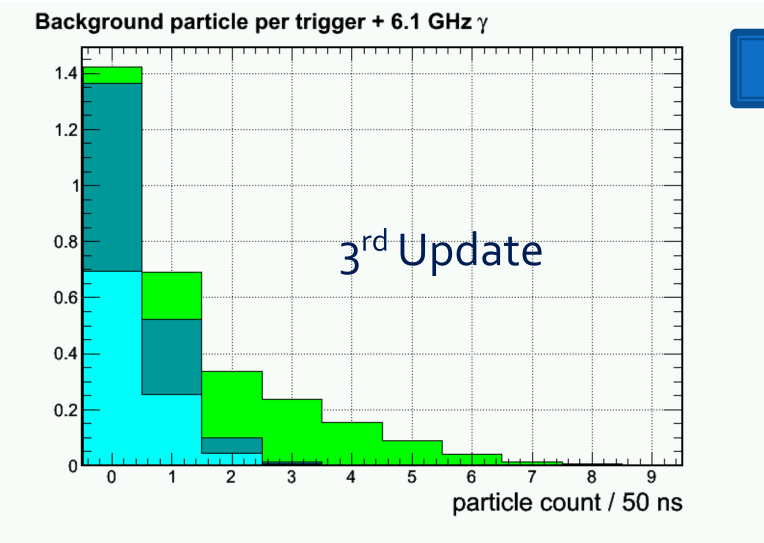
- Produce trigger turn on curve for high energy particle
- Good for rare events, e.g. DIS
- Can not handle low energy particle dominated trigger, which is non-linear
- Handle p>1GeV particle dominated trigger

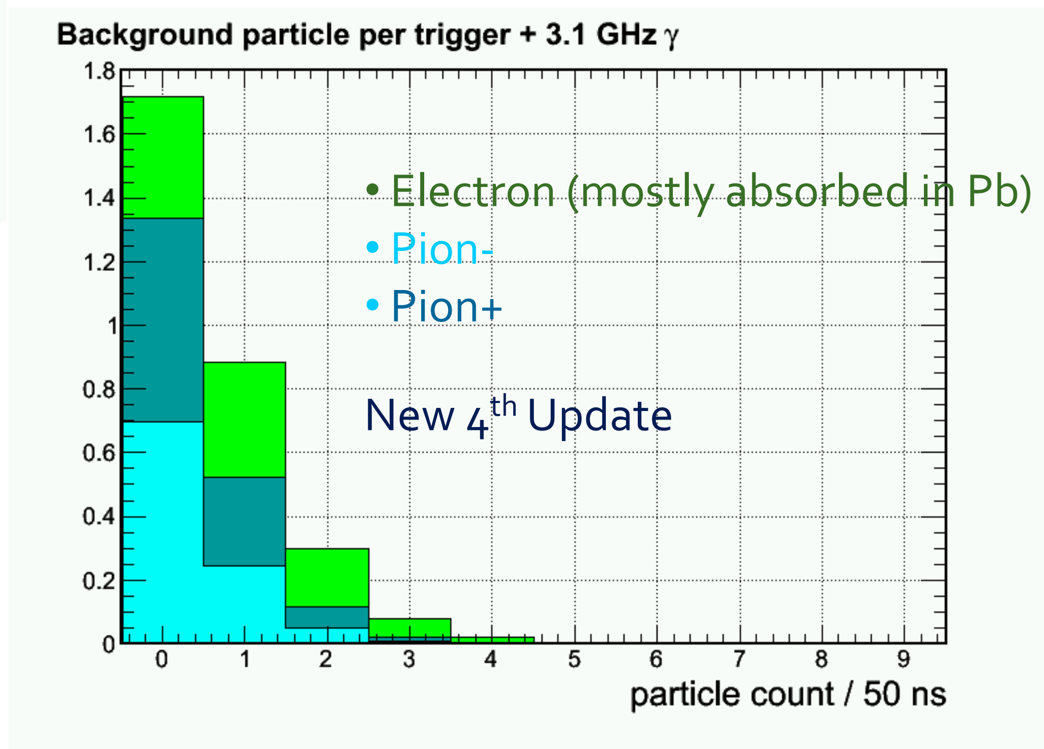
Forth update of CLEO background

- Cutting 2cm away on 1st baffle inner radius
- Received background simulation from Zhiwen on May 24

Updated: Per-event pion rate

for 1+6 hexagon cluster at Mid radius, high radiation ϕ-slice





Updated radiation dose VS layers (High radiation ϕ slice)

- Photon (EM) <- dominant!
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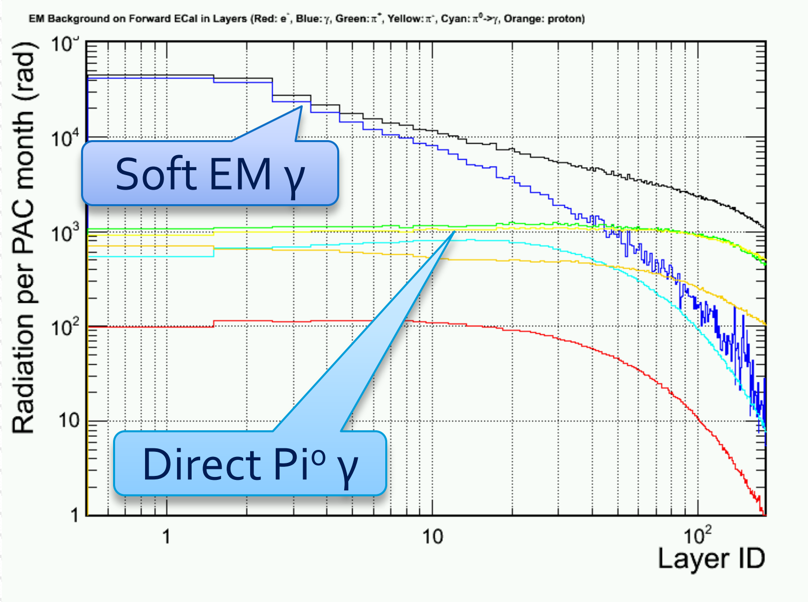
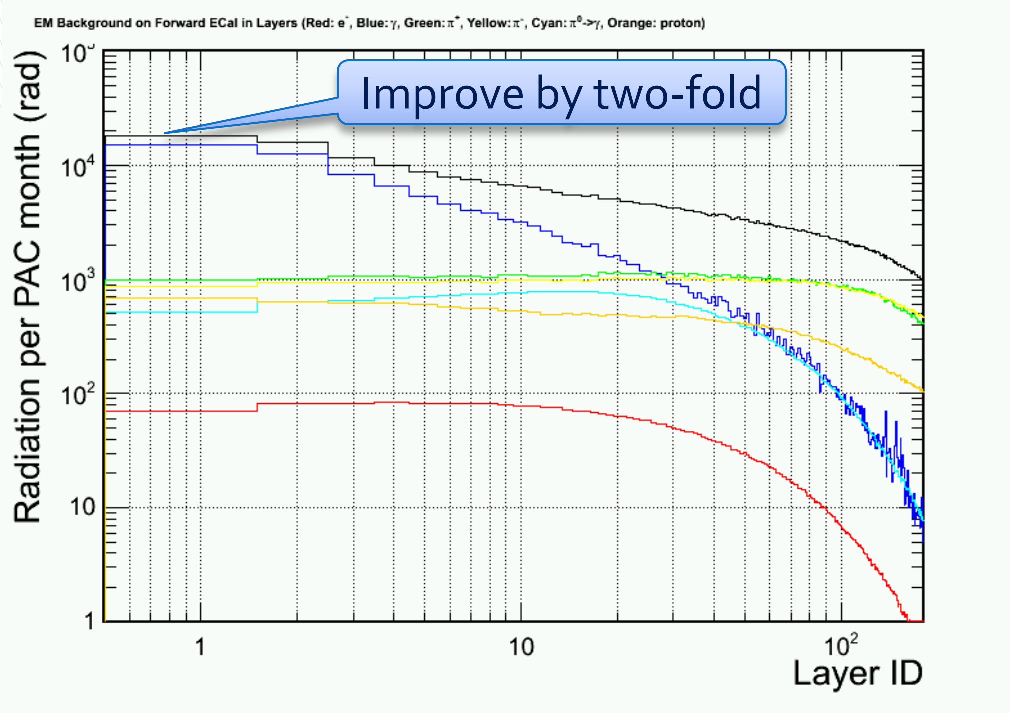
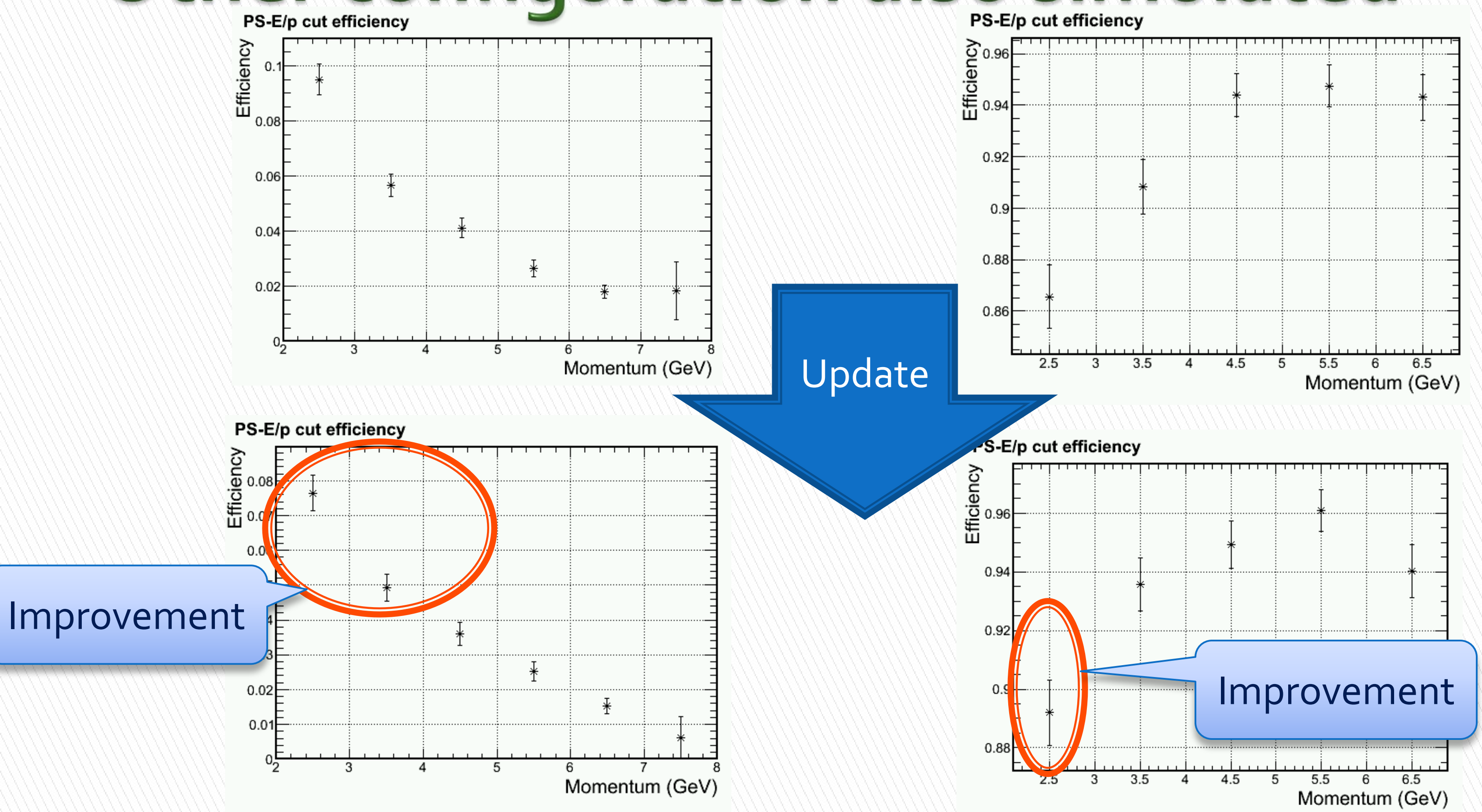




3rd Update	New: 4th Update

Update on PID
Mid radius, higher γ ϕ-band shown
Other configuration also simulated

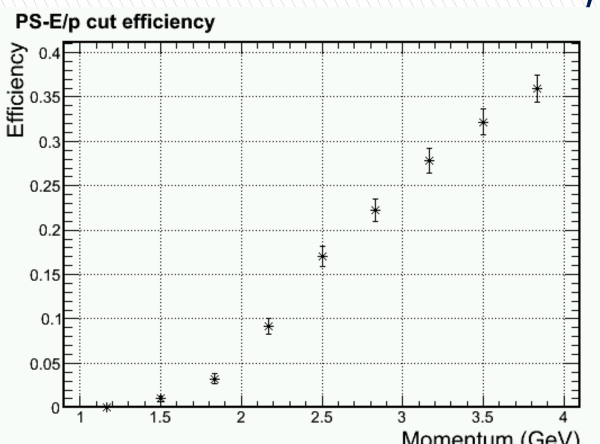


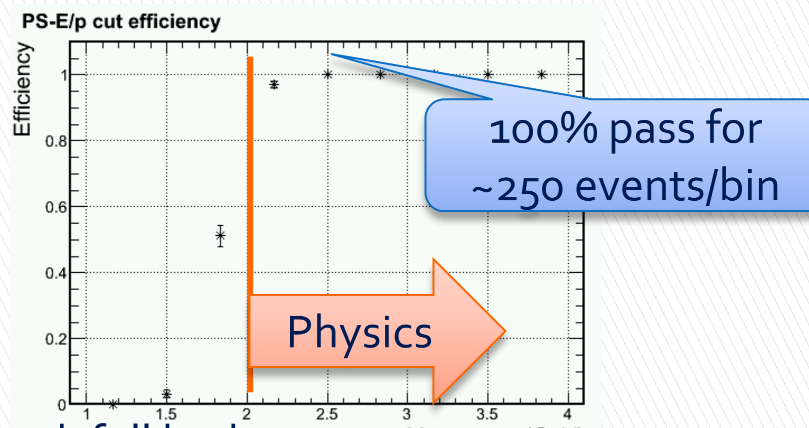
Pion Efficiency

Electron Efficiency

Trigger turn on curve for 2 GeV electron Shower Hex 1+6 trigger > 1.6 GeV

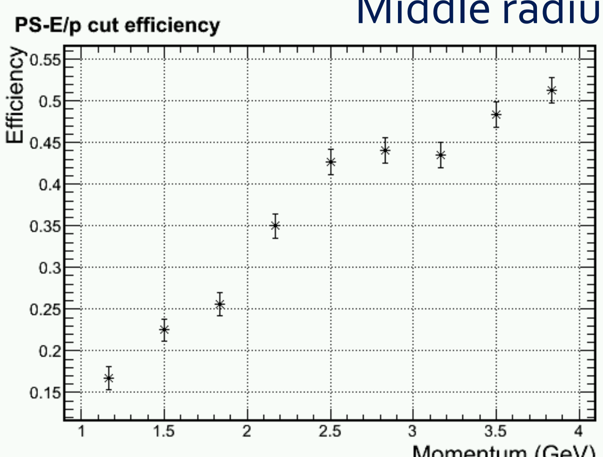
Outer radius, higher γ ϕ-band, full bgd

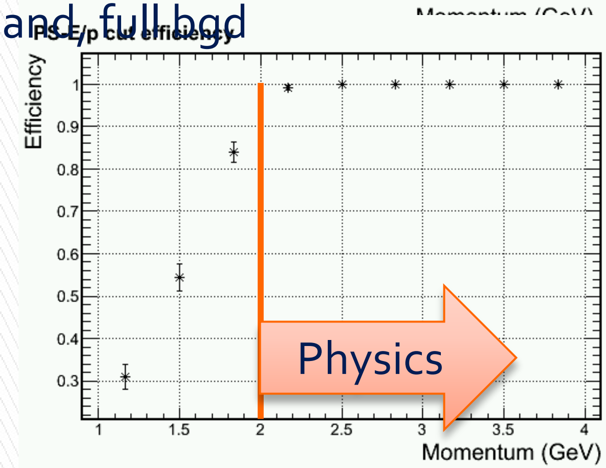




, full bgd

Middle radius, higer γ ϕ-band, full bgd



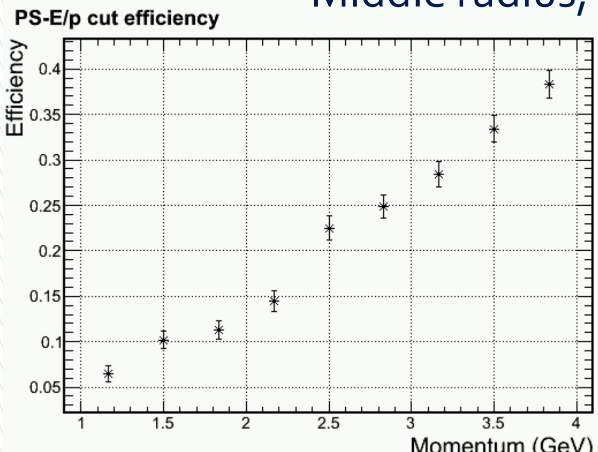


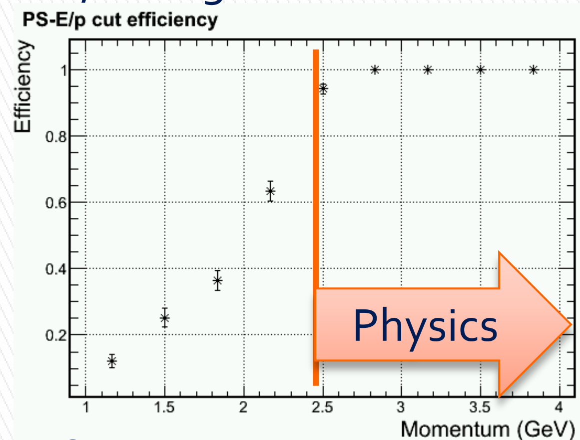
Pion Efficiency

Electron Efficiency

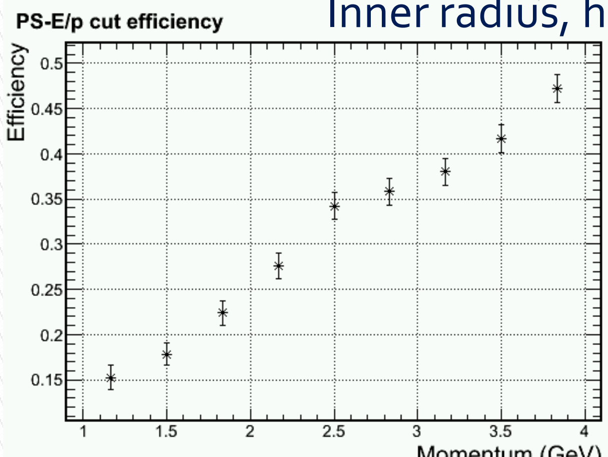
Trigger turn on curve for 2.5 GeV electron Shower Hex 1+6 trigger > 2.1 GeV

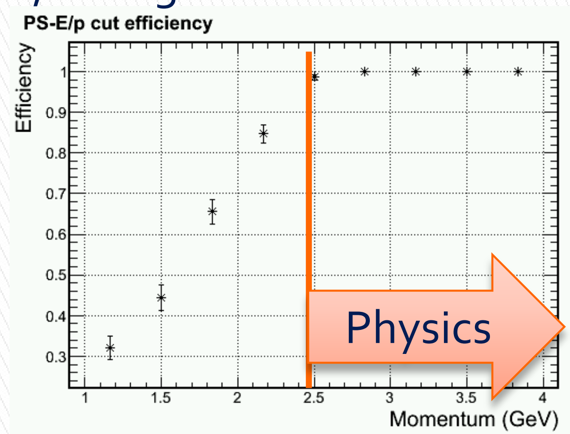
Middle radius, higher γ ϕ-band, full bgd





Inner radius, higer γ ϕ-band, full bgd

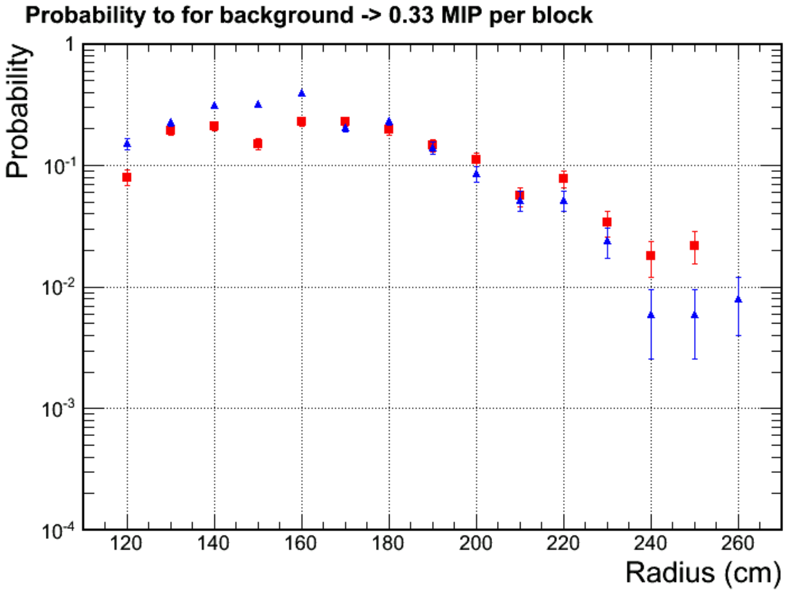


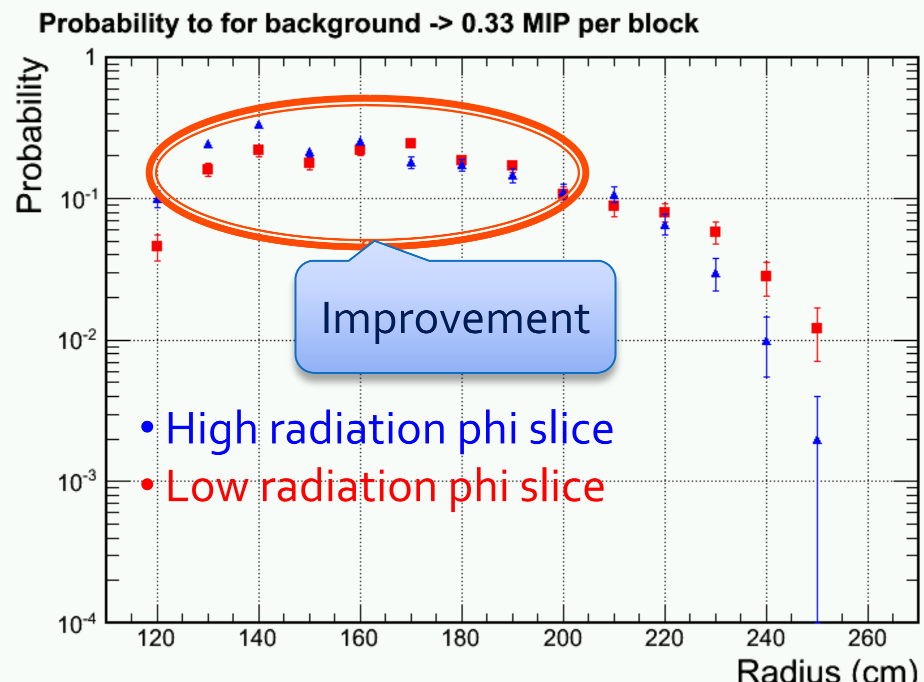


Pion Efficiency

Electron Efficiency

Readout occupancy per shower channel for ~75MeV zero suppression



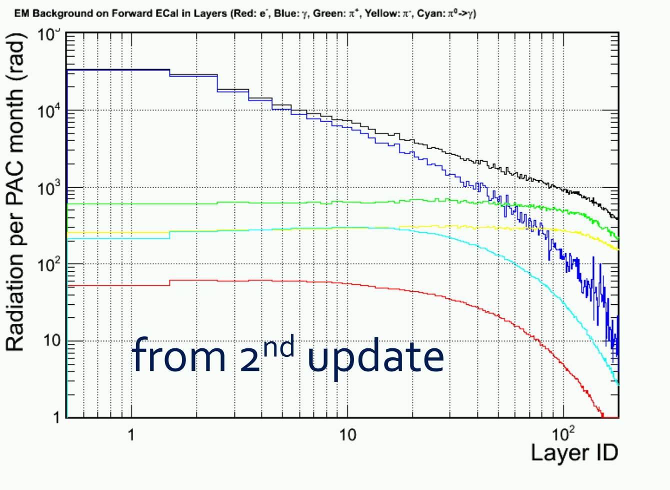


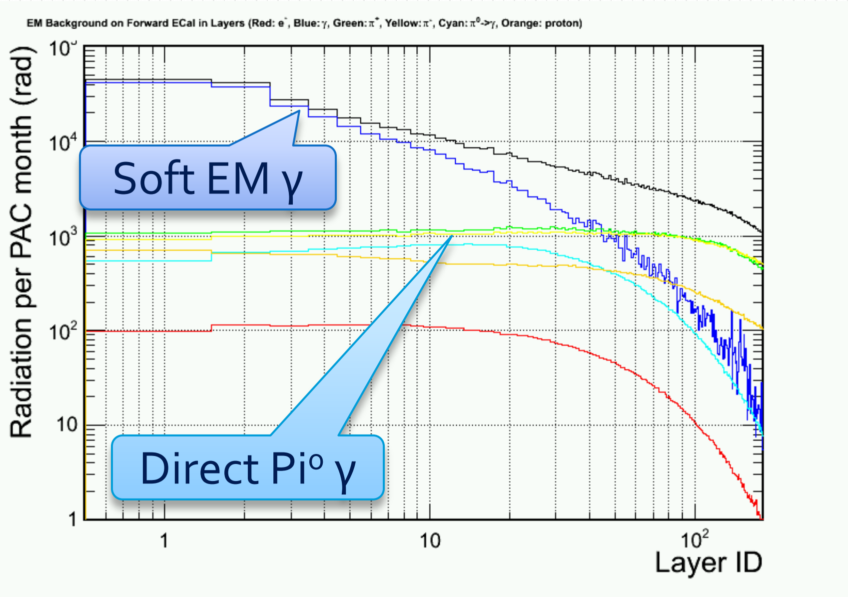
Third update of CLEO background

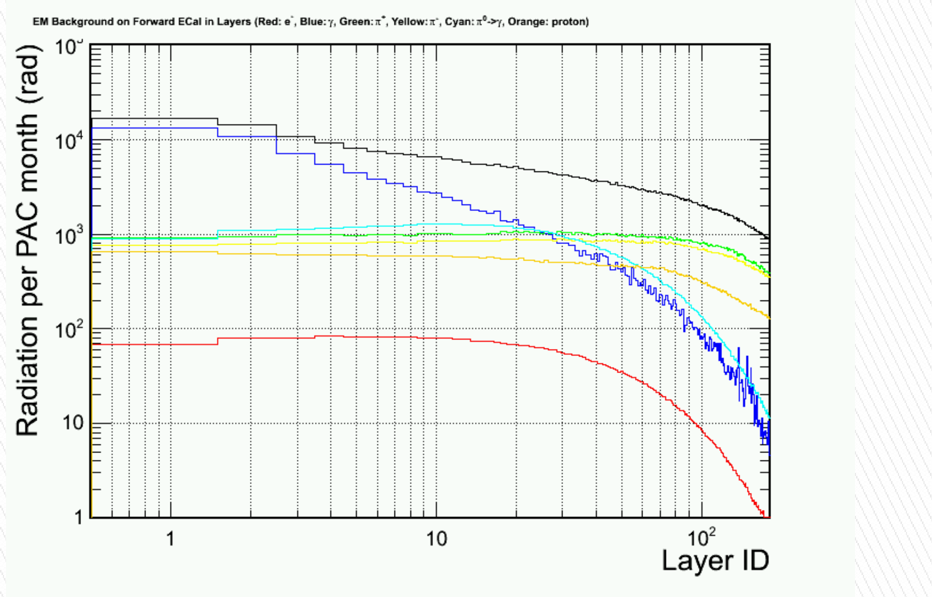
- Received background simulation from Zhiwen on May 19
  Running background imbedding

Updated radiation dose VS layers

- Photon (EM) <- dominant!
- Photon (Pi^o)
- Electron
- Pion- Pion+ Proton





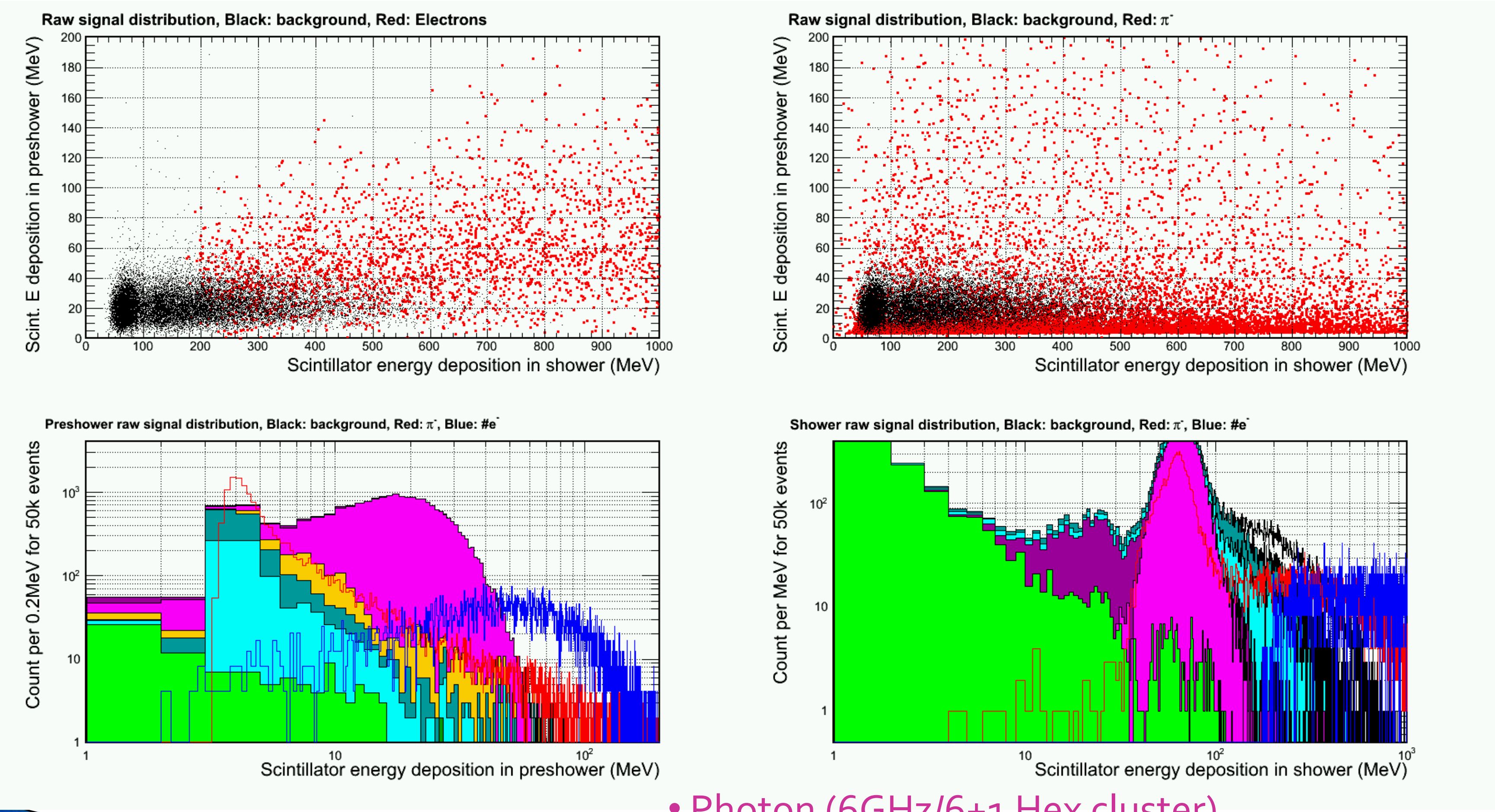


High radiation azimuthal region

Low radiation azimuthal region

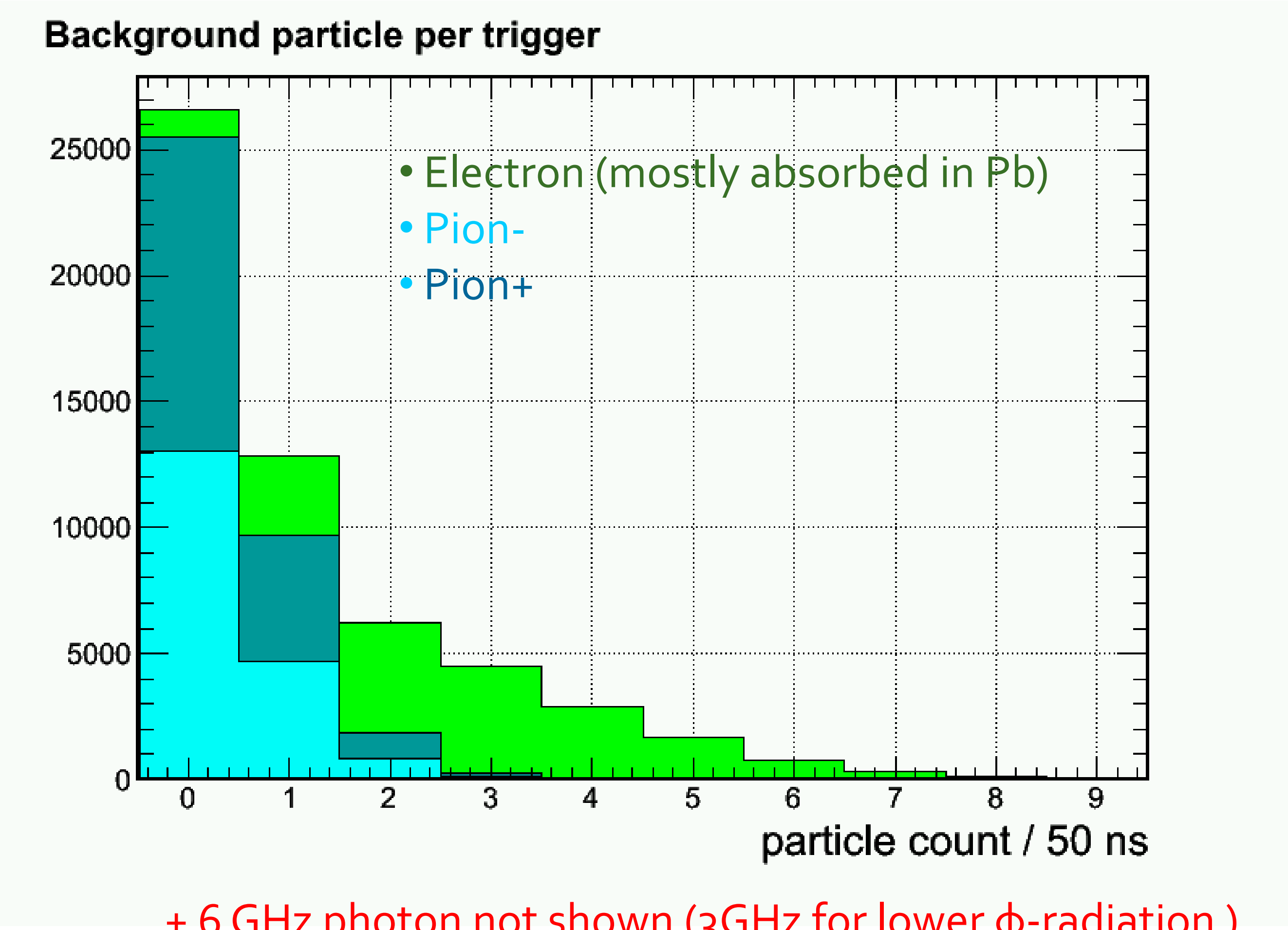
Background imbedding and distribution

Mid-R, High Radiation phi slice



- Photon (6GHz/6+1 Hex cluster)
- Electron
- Pion- Pion+ Proton

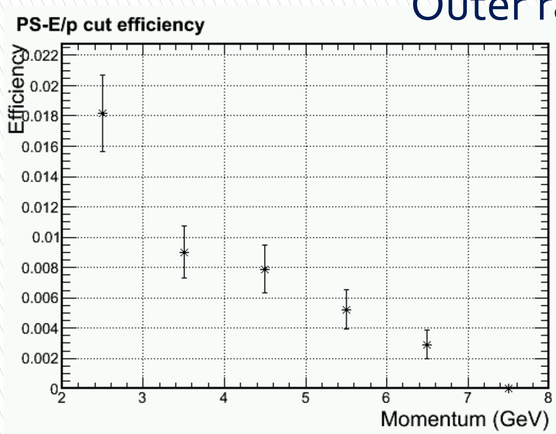
Updated: Per-event pion rate
for 1+6 hexagon cluster at Mid radius, high radiation ϕ-slice

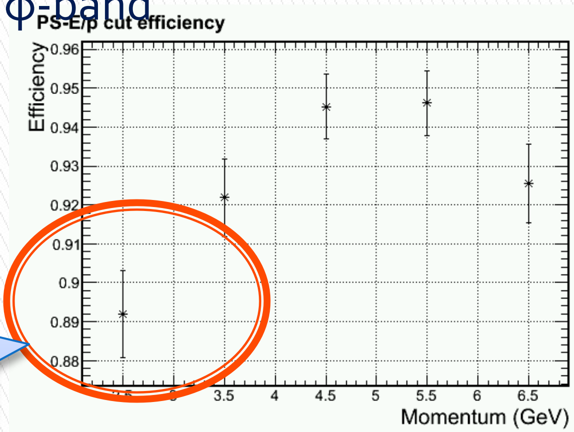


+ 6 GHz photon not shown (3GHz for lower ϕ-radiation)

Update on PID with DC component removal (PS > MIP + Bgd + (2-3) σ)

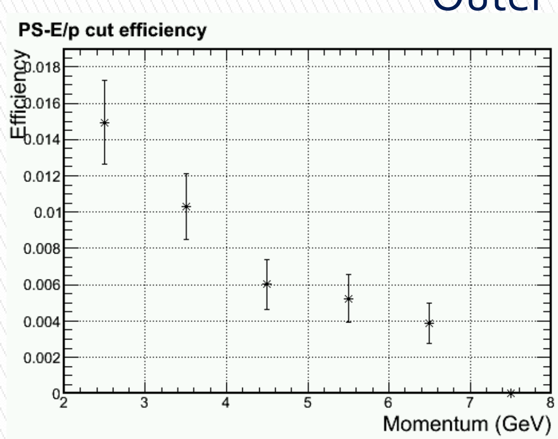
Outer radius, higher γ ϕ-band

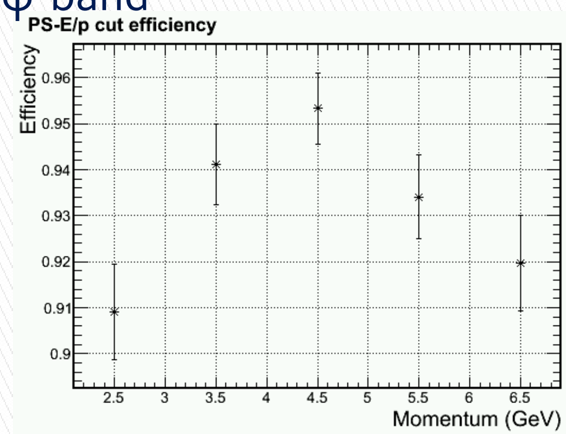




Due to Soft EM γ

Outer radius, lower γ ϕ-band



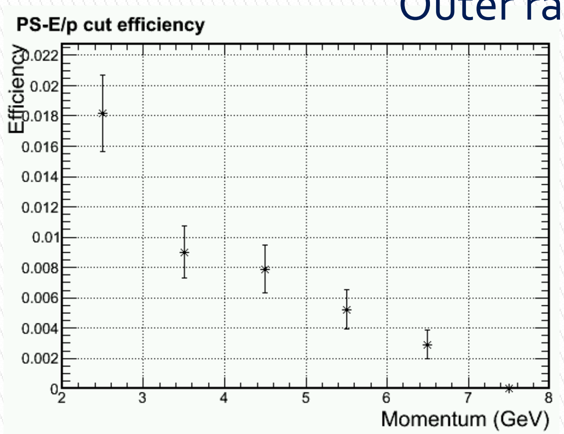


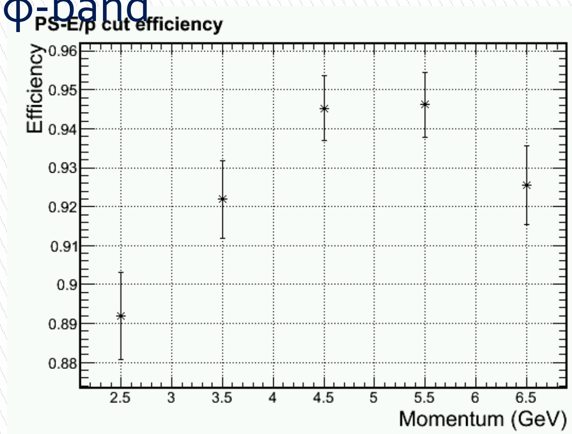
Pion Efficiency

Electron Efficiency

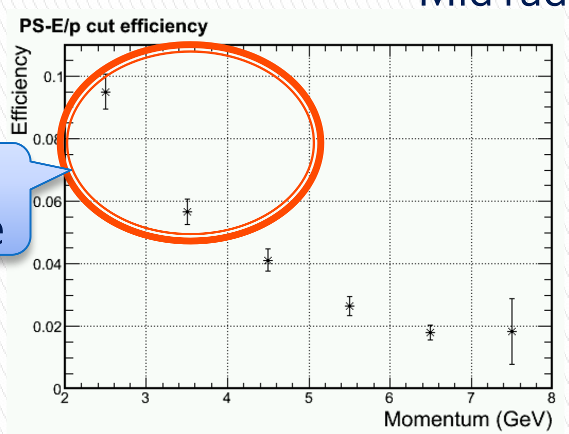
Update on PID with DC component removal (PS > MIP + Bgd + (2-3) σ)

Outer radius, higher γ ϕ-band

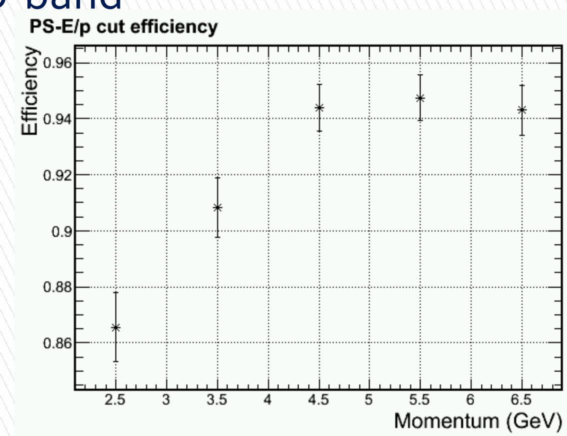




Mid radius, higher γ ϕ-band



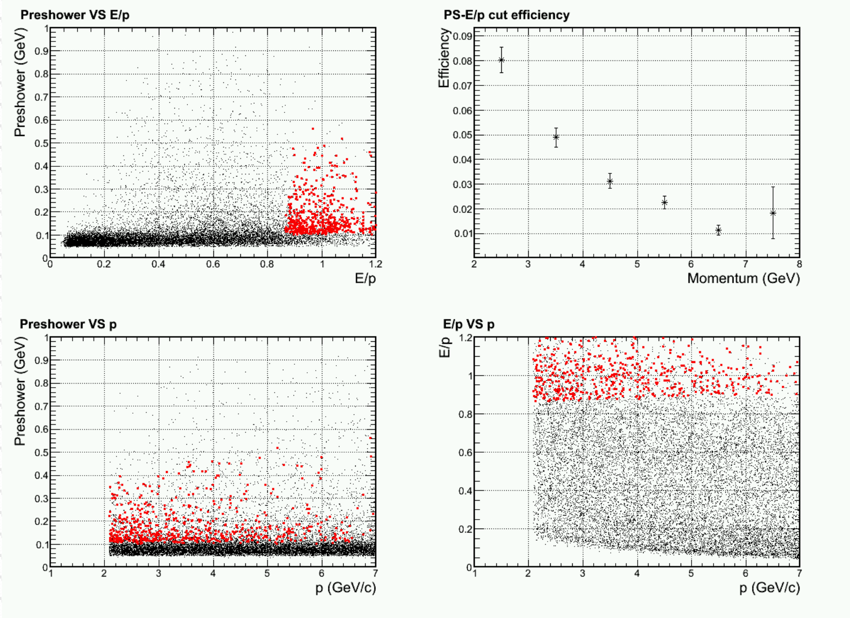
Due to Hadron rate

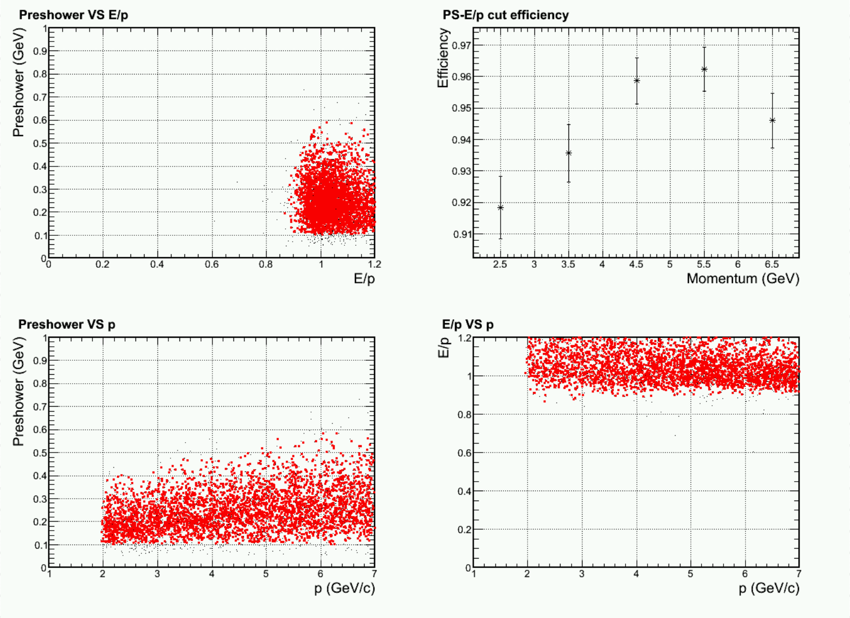


Pion Efficiency | Electron Efficiency

More detail in PID cut

Middle radius, lower γ ϕ-band, full bgd



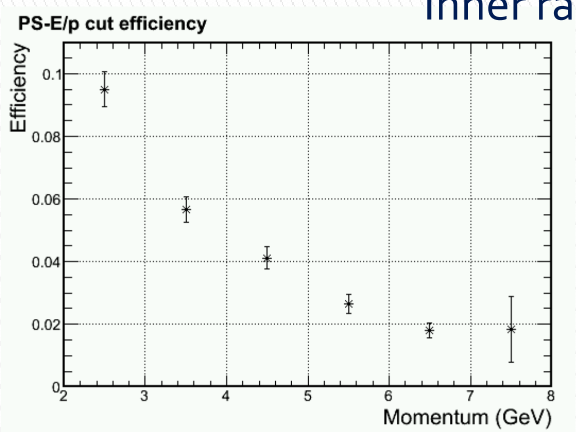


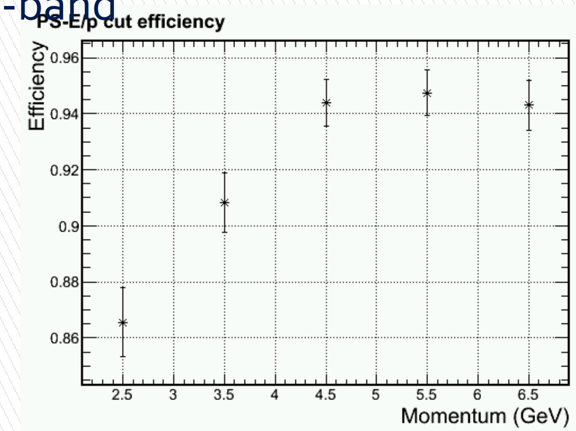
Pion Efficiency

Electron Efficiency

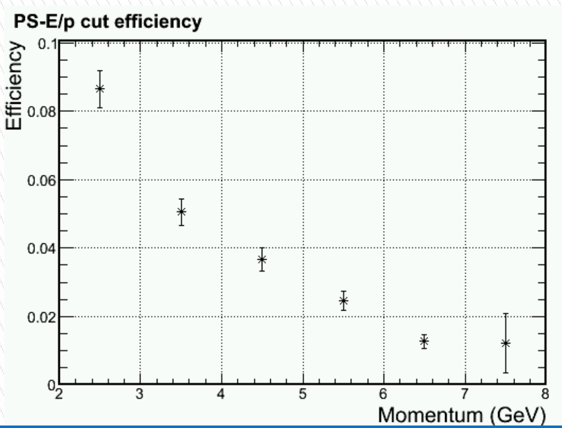
Update on PID with DC component removal (PS > MIP + Bgd + (2-3) σ)

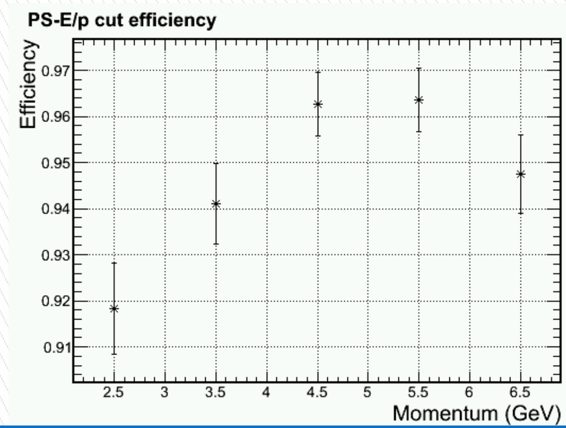
Inner radius, higher γ ϕ-band





Inner radius, lower γ ϕ-band



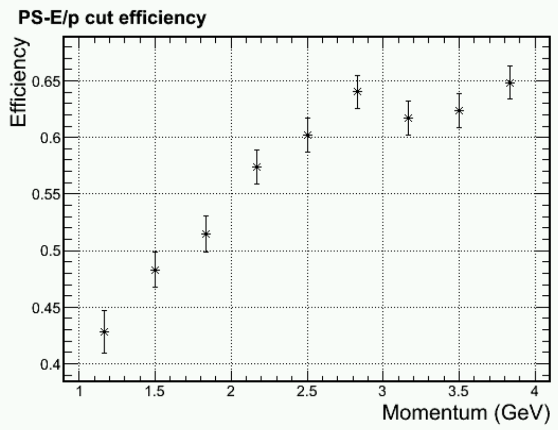


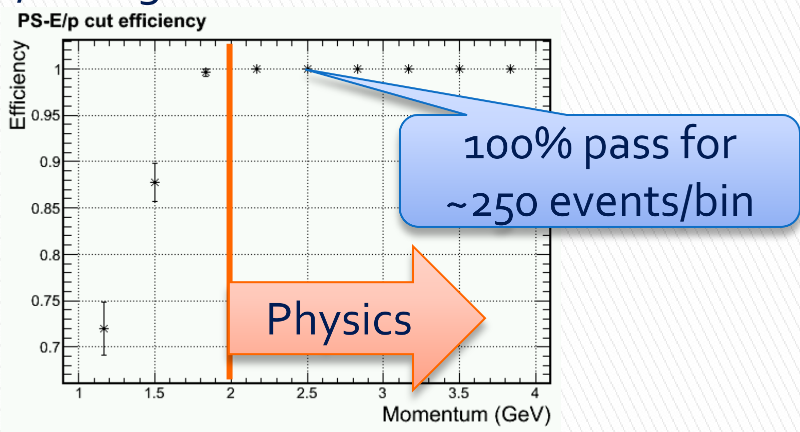
Pion Efficiency

Electron Efficiency

Trigger turn on curve for 2 GeV electron
Shower Hex 1+6 trigger > 1.6 GeV

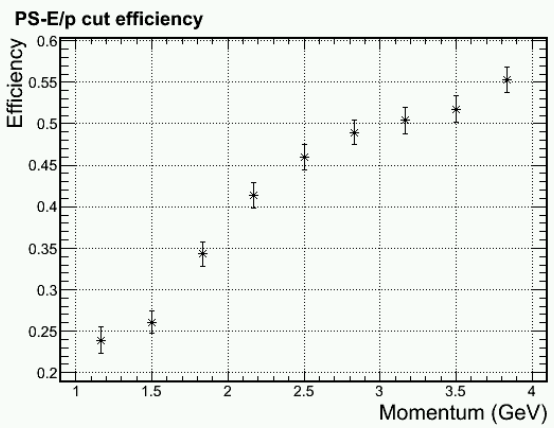
Inner radius, higher γ ϕ-band, full bgd

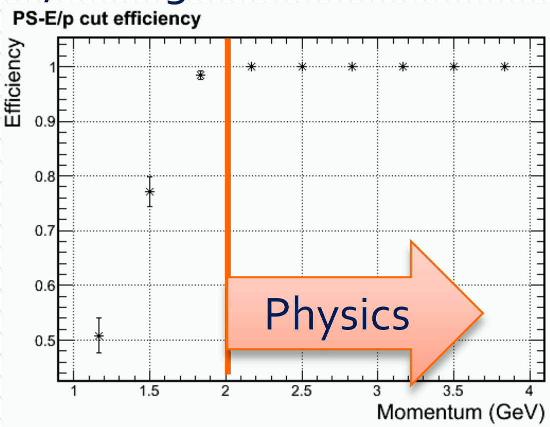




, full bgd

Middle radius, higer γ ϕ-band, full bgd



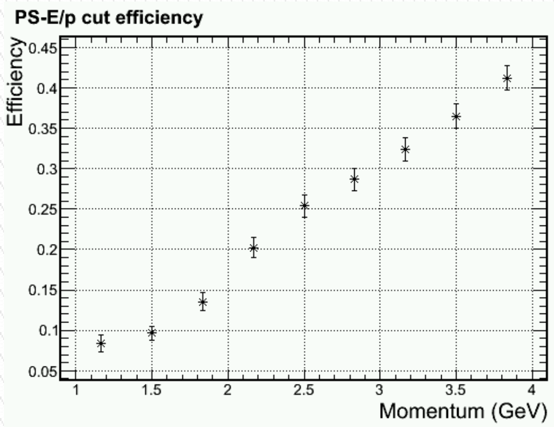


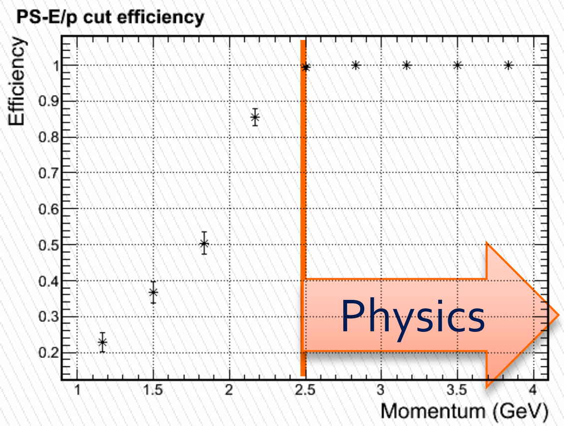
Pion Efficiency

Electron Efficiency

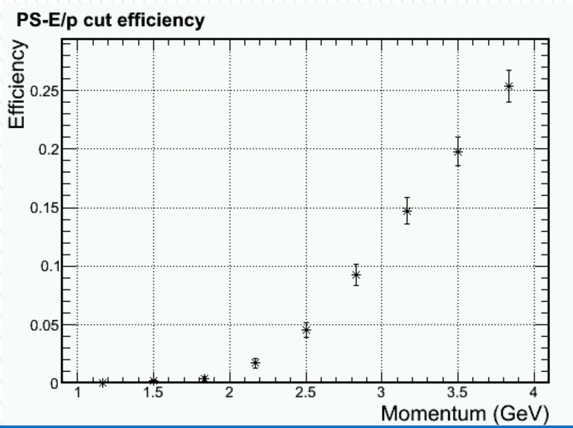
Trigger turn on curve for 2.5 GeV electron Shower Hex 1+6 trigger > 2.1 GeV

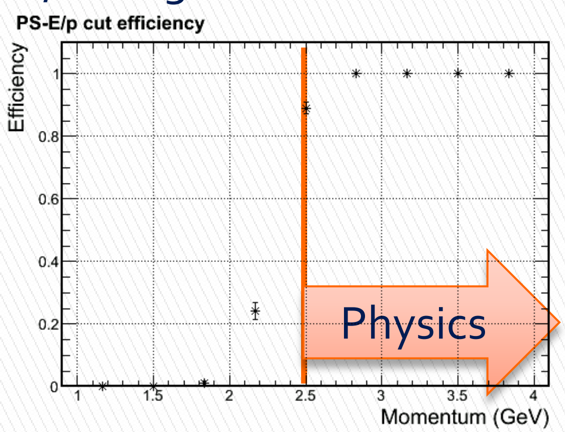
Middle radius, higher γ ϕ-band, full bgd





Outer radius, higer γ ϕ-band, full bgd





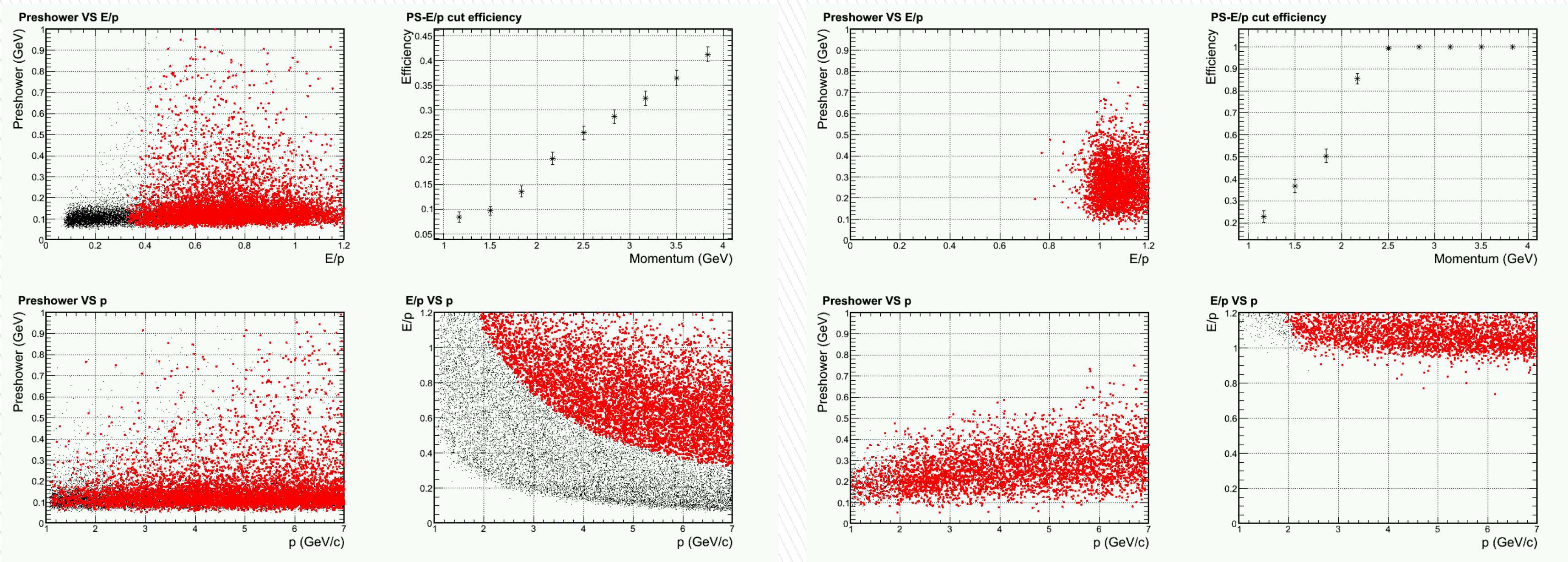
Pion Efficiency

Electron Efficiency

More detail in trigger cut

Middle radius, higher γ ϕ-band, full bgd

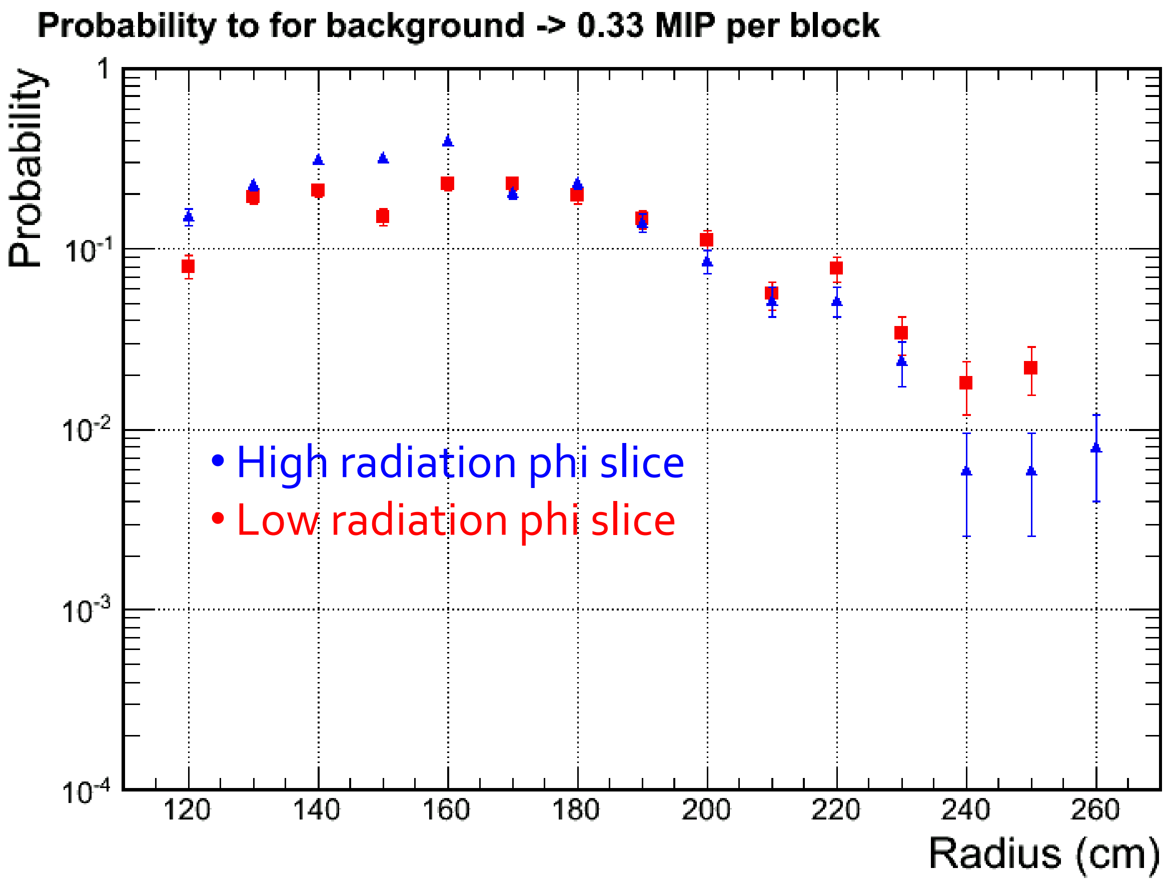
Shower Hex 1+6 trigger > 2.1 GeV



Pion Efficiency

Electron Efficiency

Readout occupancy per shower channel for ~75MeV zero suppression

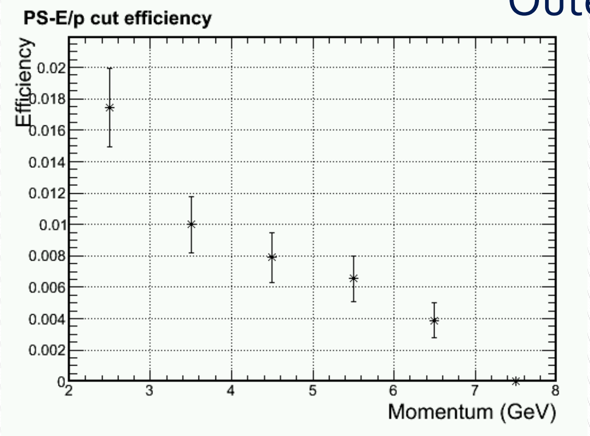


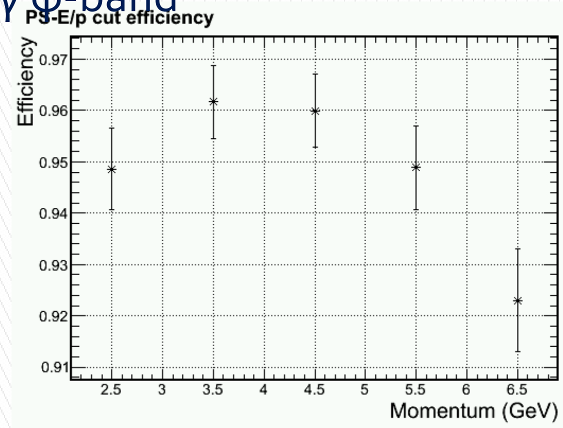
Trigger Study for Second update of CLEO background

- Reported May 7 Calorimeter Meeting

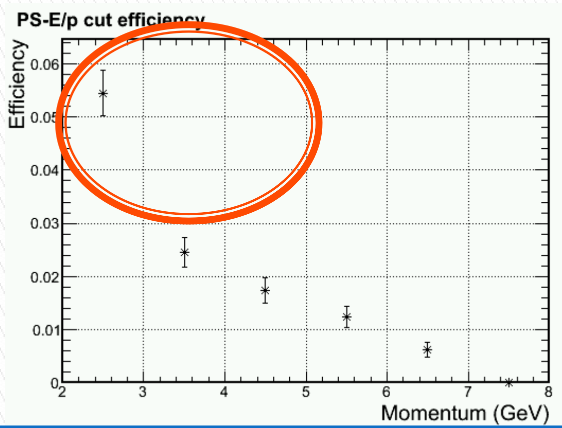
Update on PID with DC component removal (MIP + 2.5 σ)

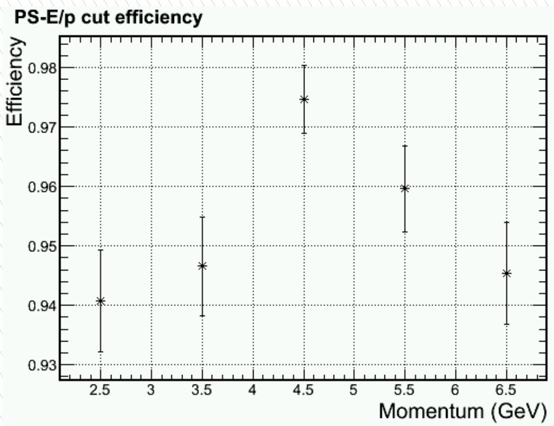
Outer radius, higher γ ϕ-band





Mid radius, higher γ ϕ-band



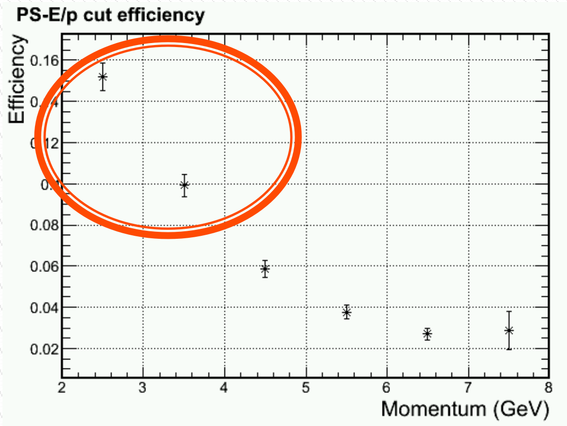


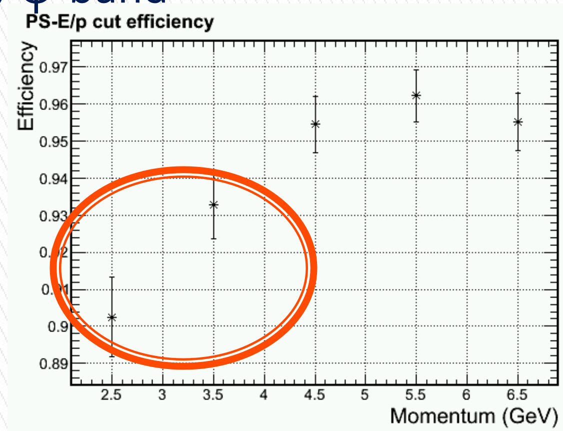
Pion Efficiency

Electron Efficiency

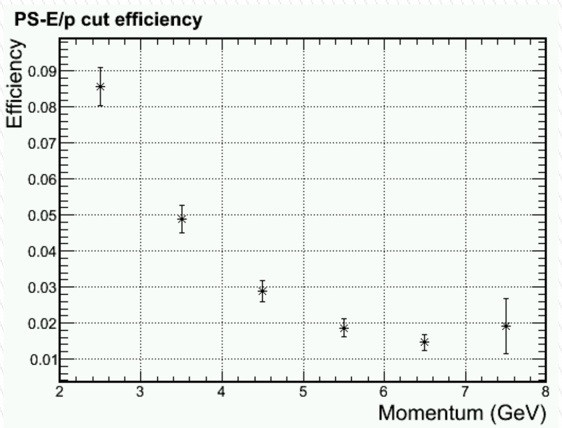
Update on PID with DC component removal (MIP + 2.5 σ)

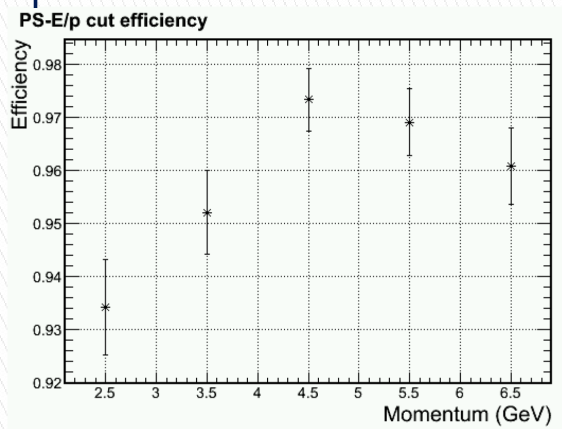
Inner radius, higher γ ϕ-band





Inner radius, lower γ ϕ-band

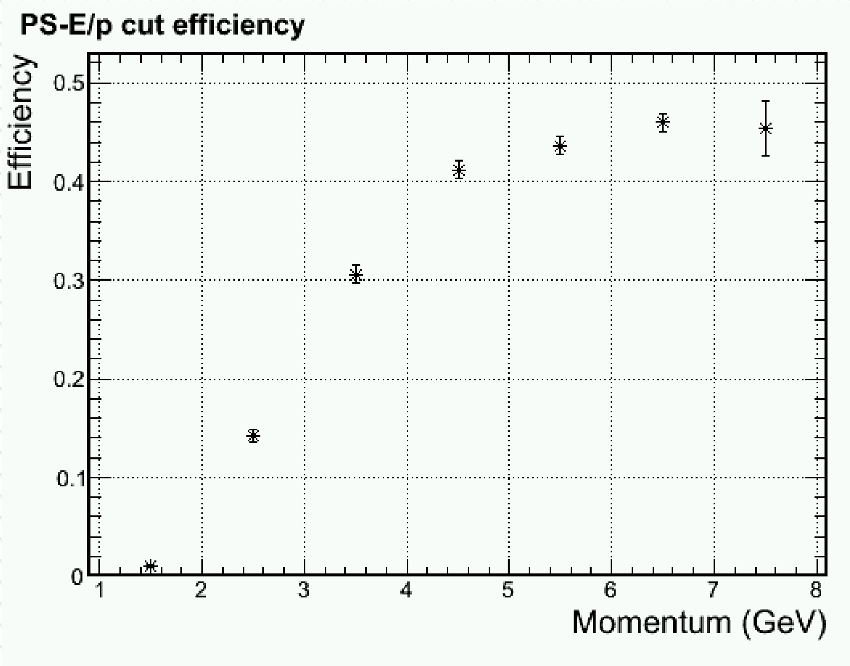


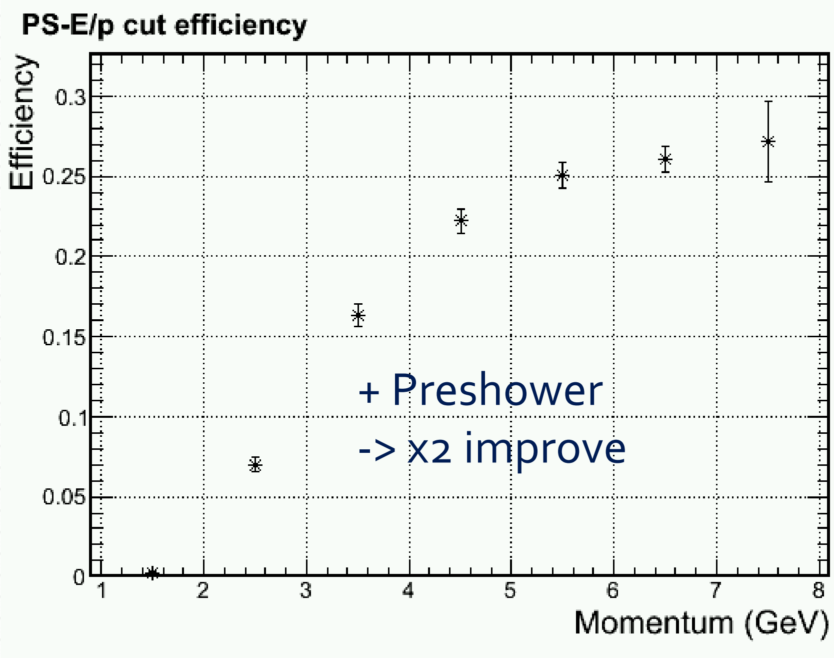


Pion Efficiency

Electron Efficiency

Pion Trigger Turn-On Curve (No background), Electron Eff. > 97%



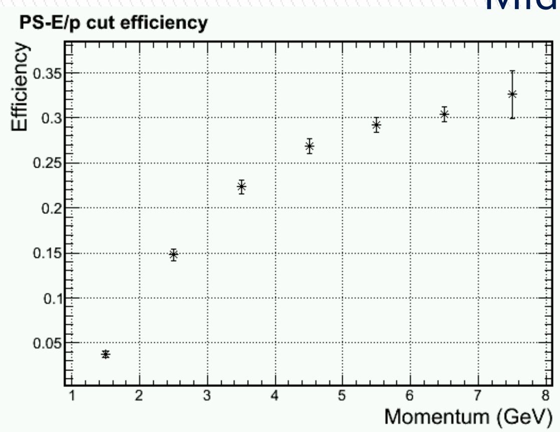


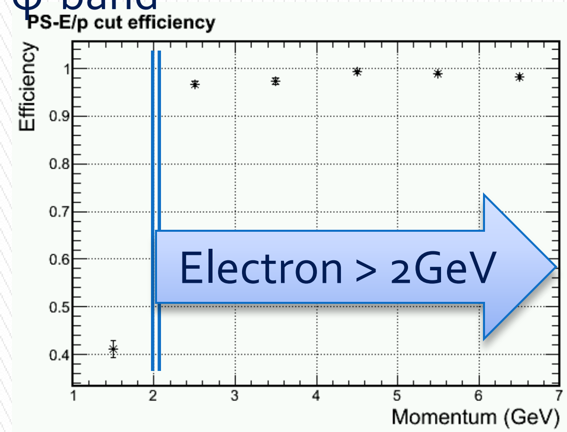
Hex 1+6 Shower Trigger > 1.6GeV (for 2GeV electron)

+ Preshower Pad on top of central shower block > MIP + 1σ

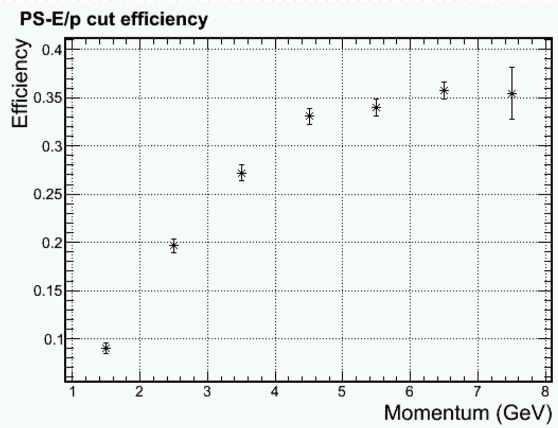
Trigger turn on curve with background

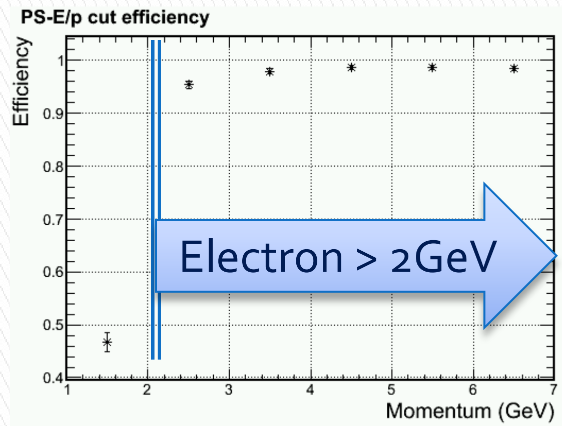
Middle radius, higher γ ϕ-band





Inner radius, higher γ ϕ-band





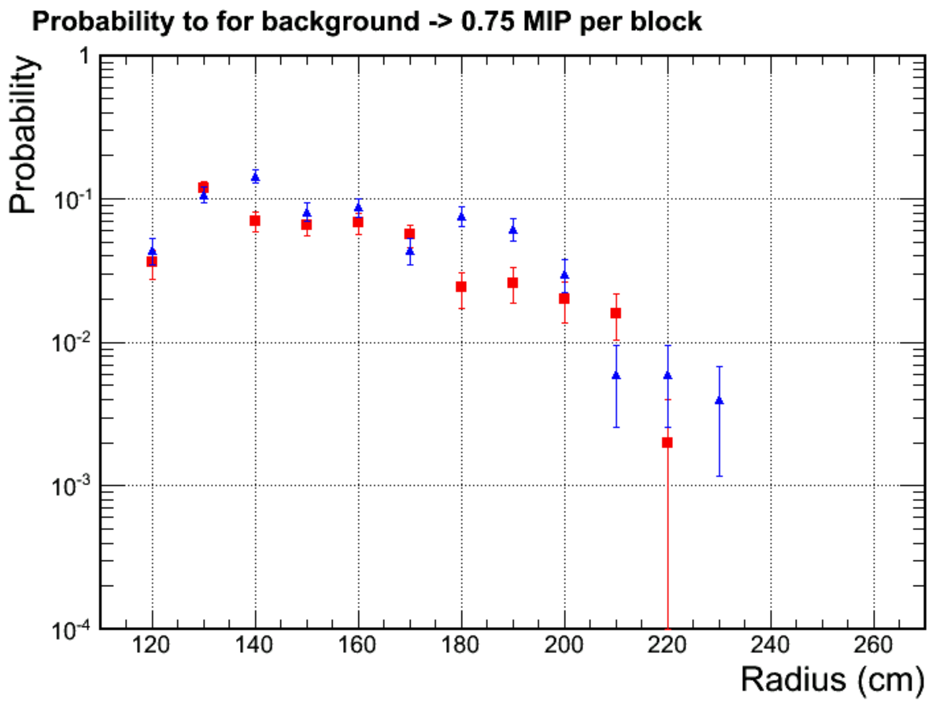
Pion Efficiency

Electron Efficiency

All background particle pile ups

- Look at single Hexagon shower blocks which passed 0.75 MIP cut.
  - Full background spectrum used
  - ADC integration window = 50ns
- ~10% blocks will produce a 0.75MIP signal for clock trigger
  - Data readout is least 10% of modules
  - A shower MIP trigger is likely just trigger on lower energy particles

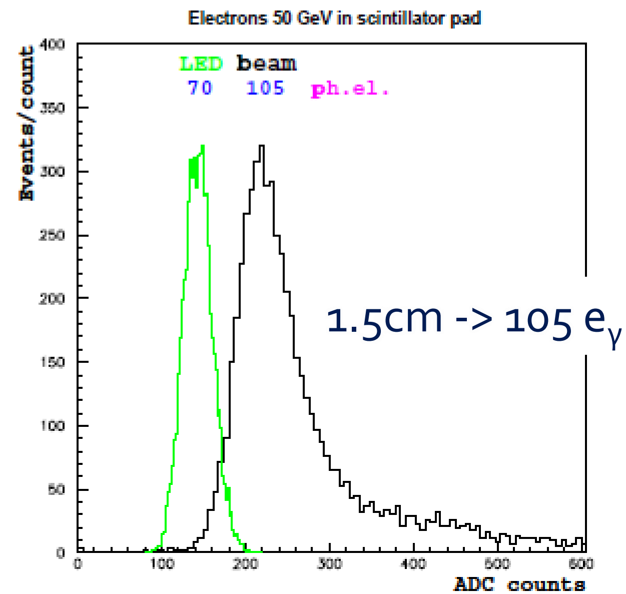
- higher γ ϕ-band
- lower γ ϕ-band



Quick estimation on impact of preshower radiation damage

- Radiation on preshower is high for PVDIS
  - Last meeting we showed that preshower will show radiation damage in a few months run in PVDIS configuration (assuming no cure for photon bgd)
  - Estimated light loss is a fraction depending on the choice of scintillator and fibers
- Our preshower was designed to produce high photon yield
  - Scint . thickness = 2cm with WLS imbedding
  - Expected photon / MIP = 140 e_γ
  - After 50% radiation damage (70 e_γ), MIP resolution from photon fluctuation = 12%
  - Intrinsic fluctuation on MIP sampling = 23%, PID cut on MIP + 2.5 σ
  - Therefore, effect on radiation damage to MIP resolution is expected to be minimal, as long as we calibrate the photon yield online

Beam test for LHCb pad (1.5cm thick)
From LHCb technical design report



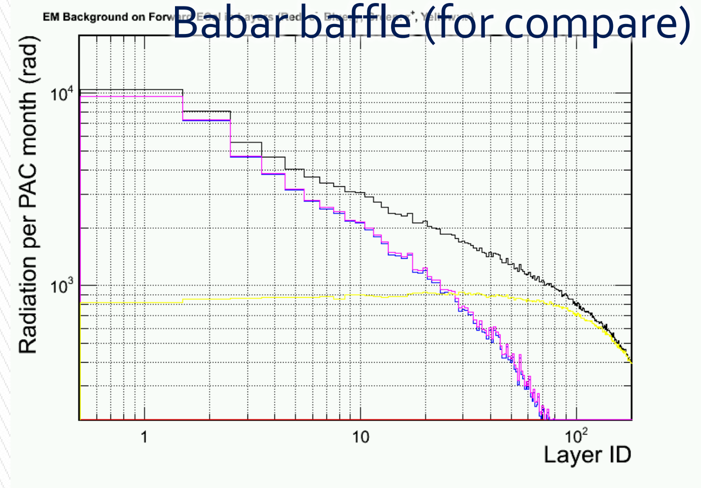
Second update of CLEO background

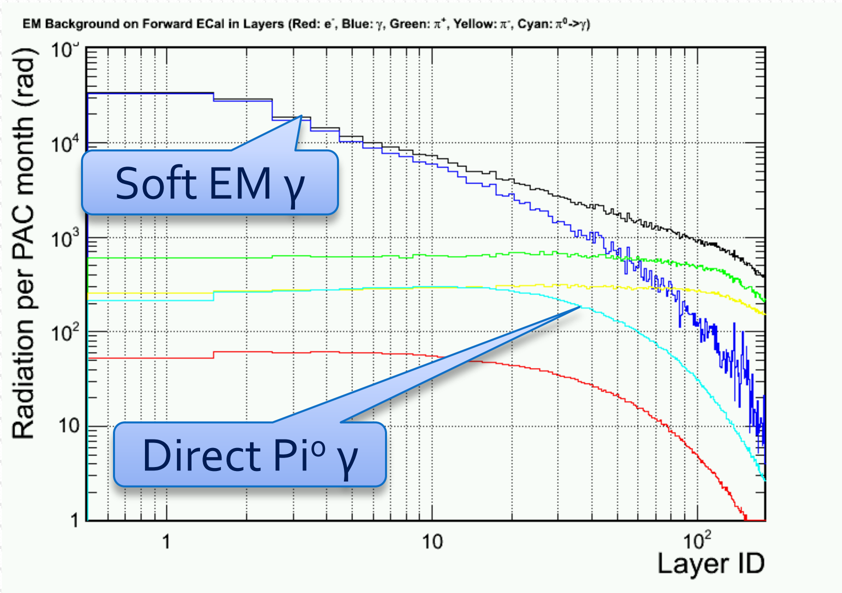
- Reported Apr 30 Calorimeter Meeting

For each sector, background rate were calculated in high and low regions in phi

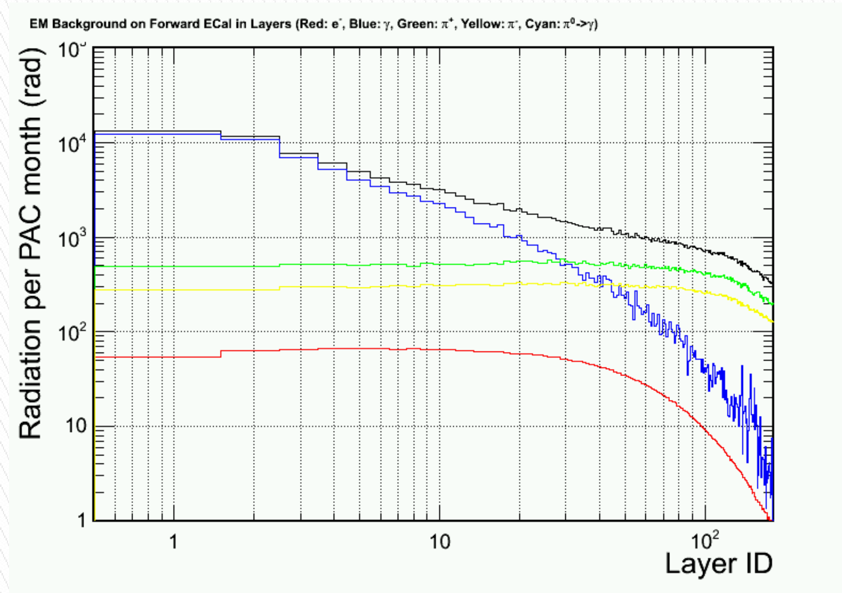
- Photon (EM) <- dominant!
- Photon (Pi°)
- Electron
- Pion- Pion+

Babar baffle (for compare)





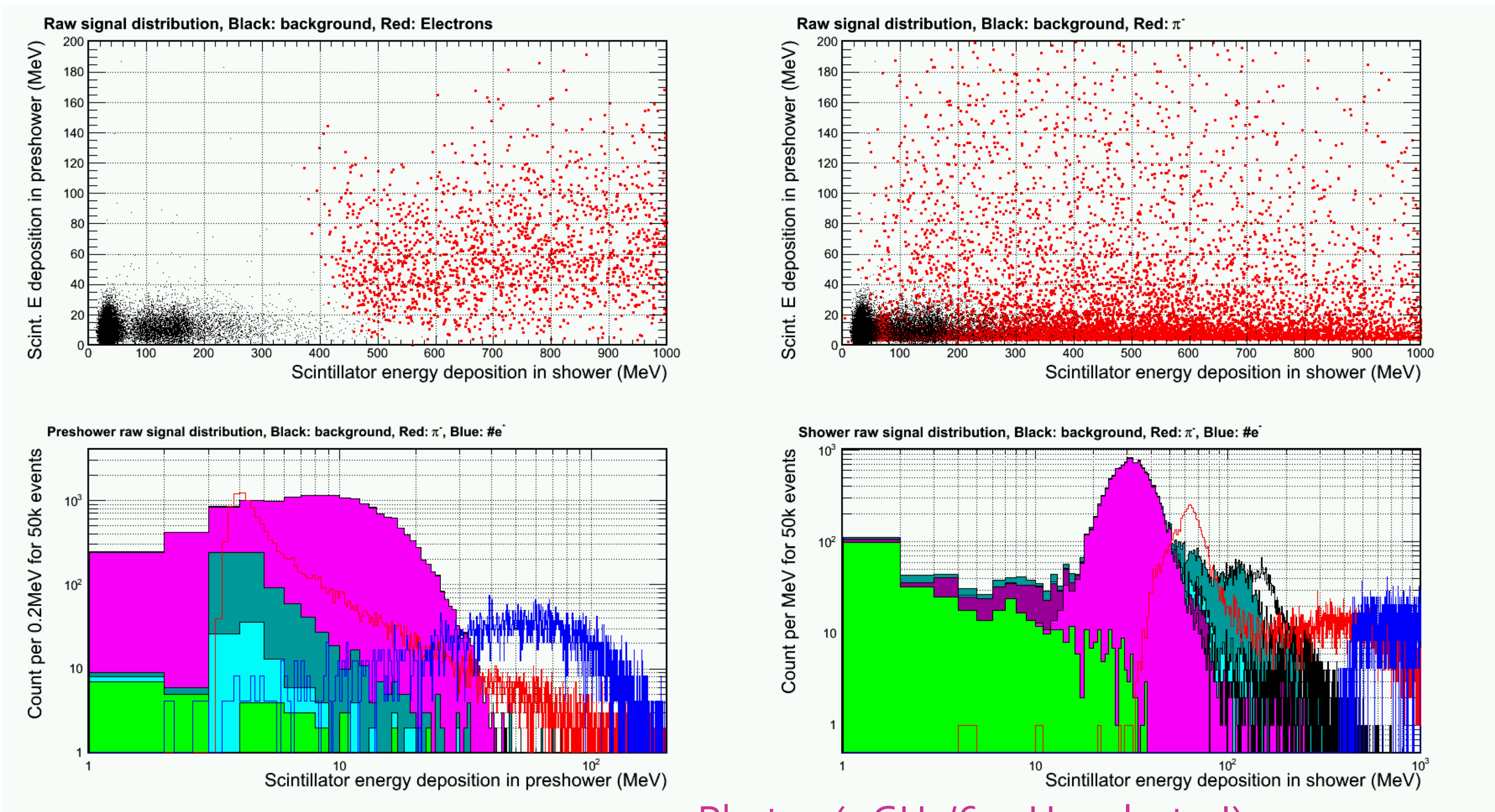
High radiation azimuthal region



Low radiation azimuthal region

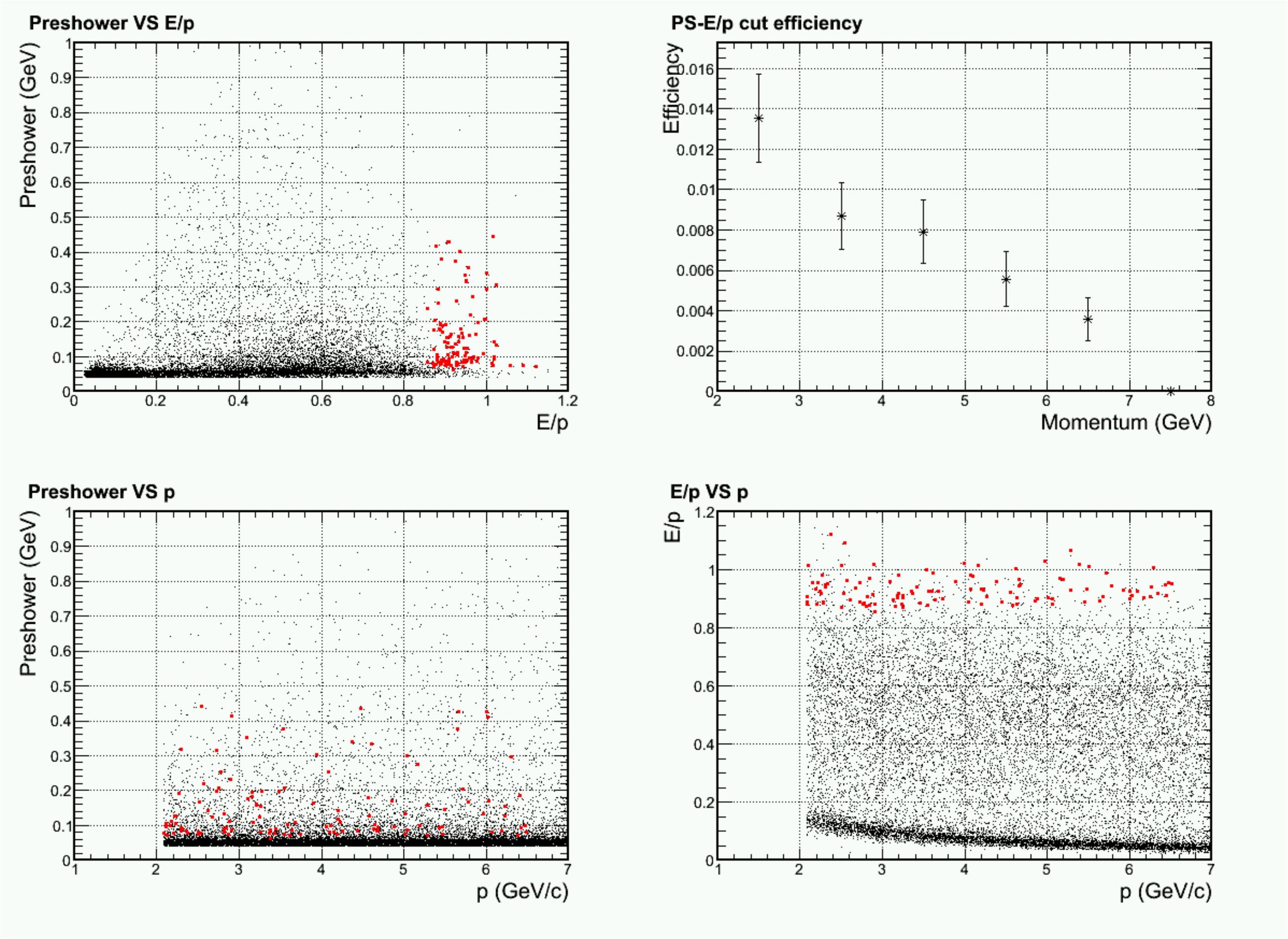
Background distribution

New: with photon and pi+, Mid R, High Rad phi slice

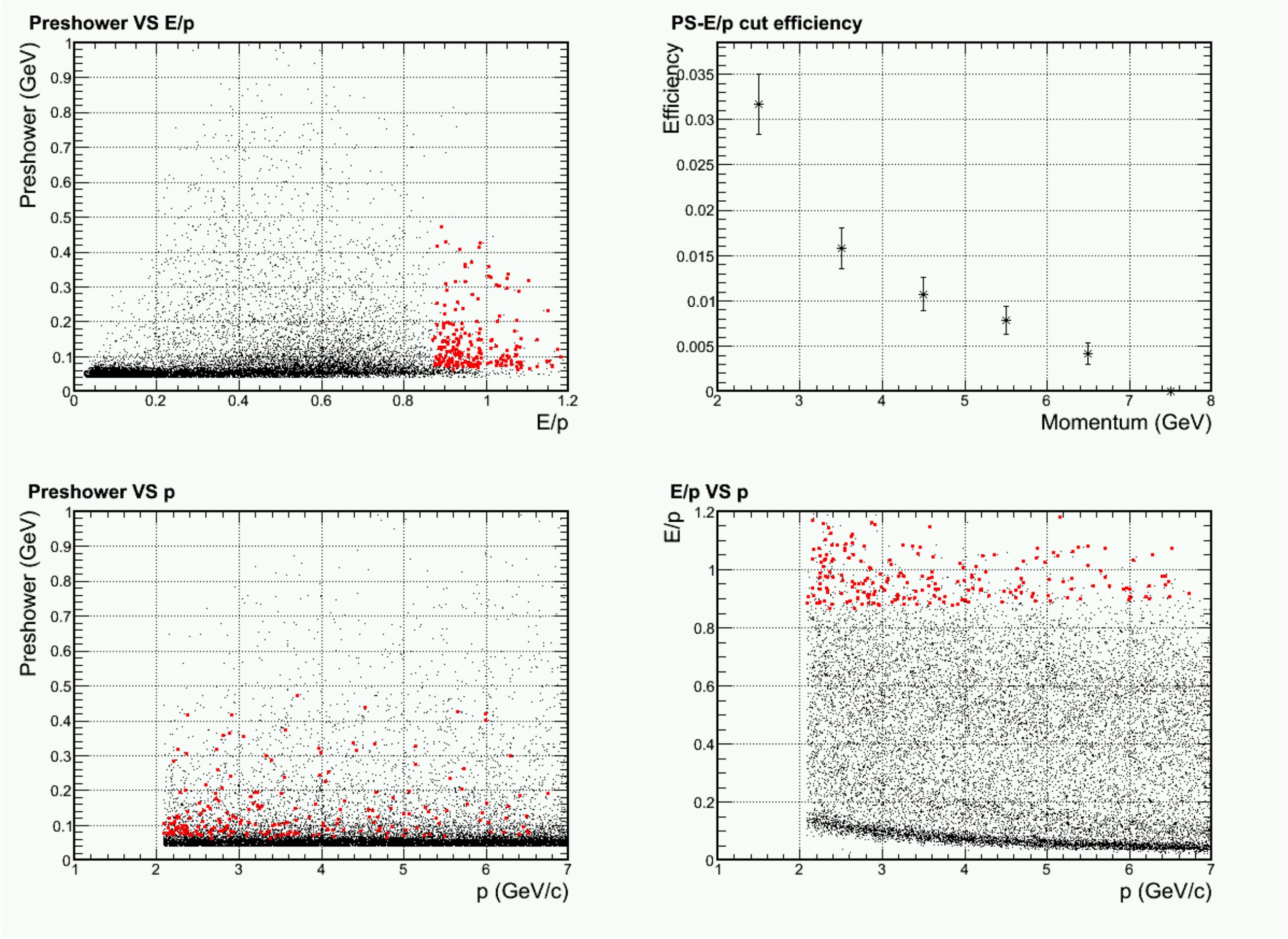


- Photon (7 GHz/6+1 Hex cluster!)
- Electron
- Pion- Pion+

PID Performance (pion eff. w/ 94% elec. eff)
w/o photon and pi+, Mid R, High Rad phi slice

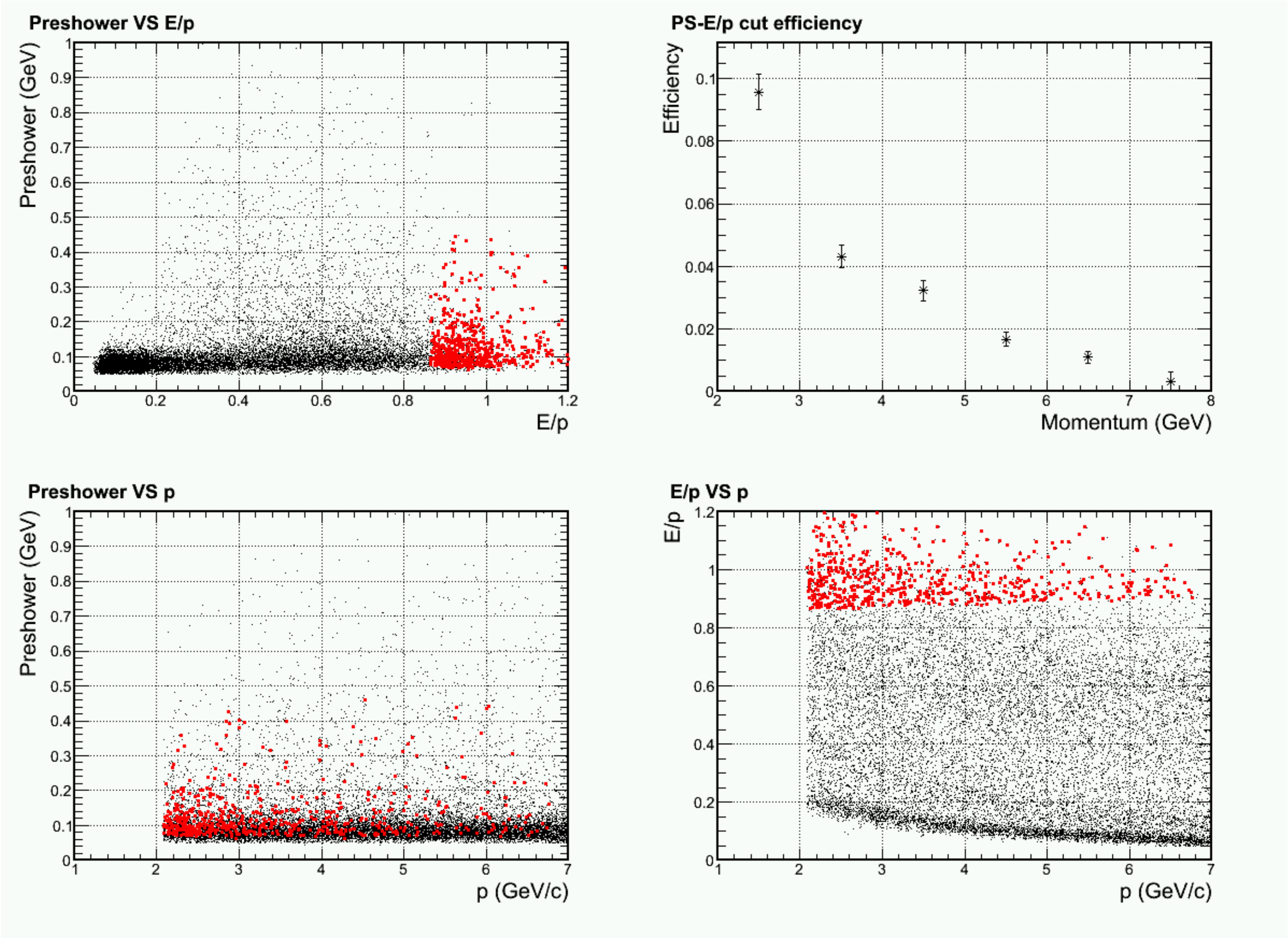


PID Performance (pion eff. w/ 94% elec. eff)
w/o photon, w/ pi+, Mid R, High Rad phi slice



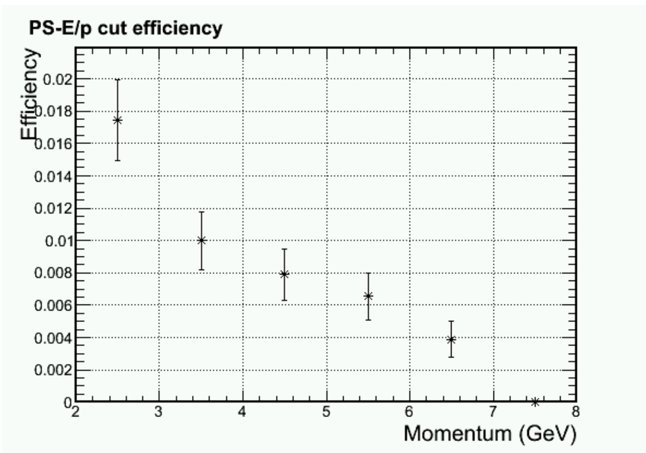
Jefferson Lab

PID Performance (pion eff. w/ 94% elec. eff) w/ photon, w/ pi+, Mid R, High Rad phi slice

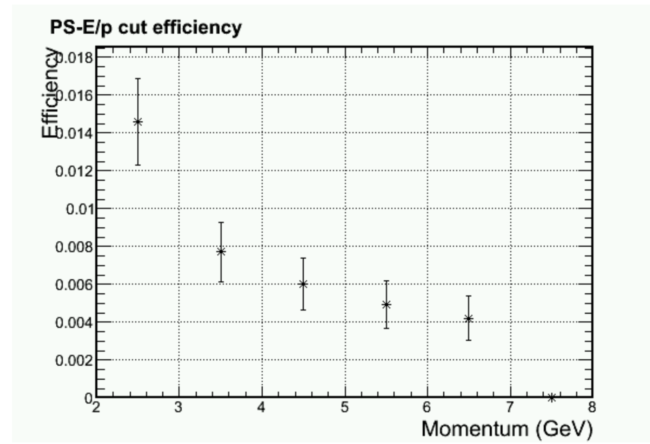


Look elsewhere, Outer/Inner R
PID Performance (pion eff. w/ 94% elec. eff)

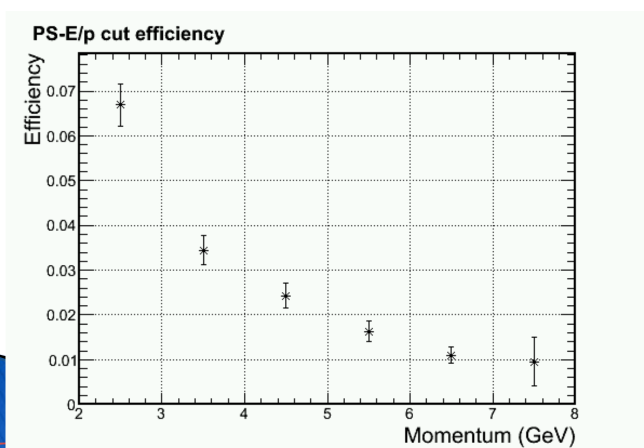
w/ photon, w/ pi+, Outer R, High Rad phi slice



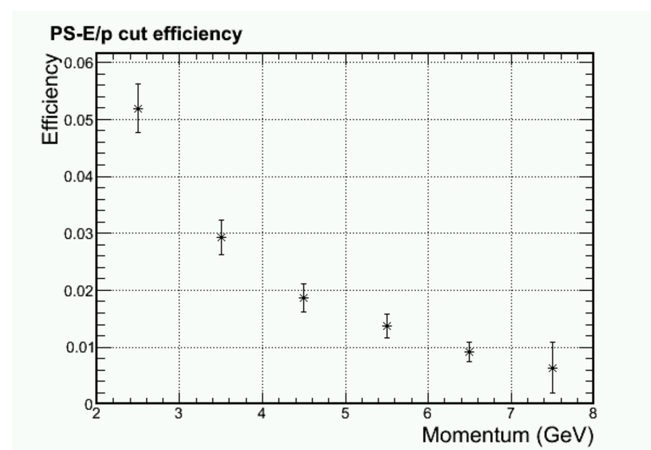
w/ photon, w/ pi+, Outer R, Low Rad phi slice



w/ o photon, w/ pi+, Inner R, High Rad phi slice



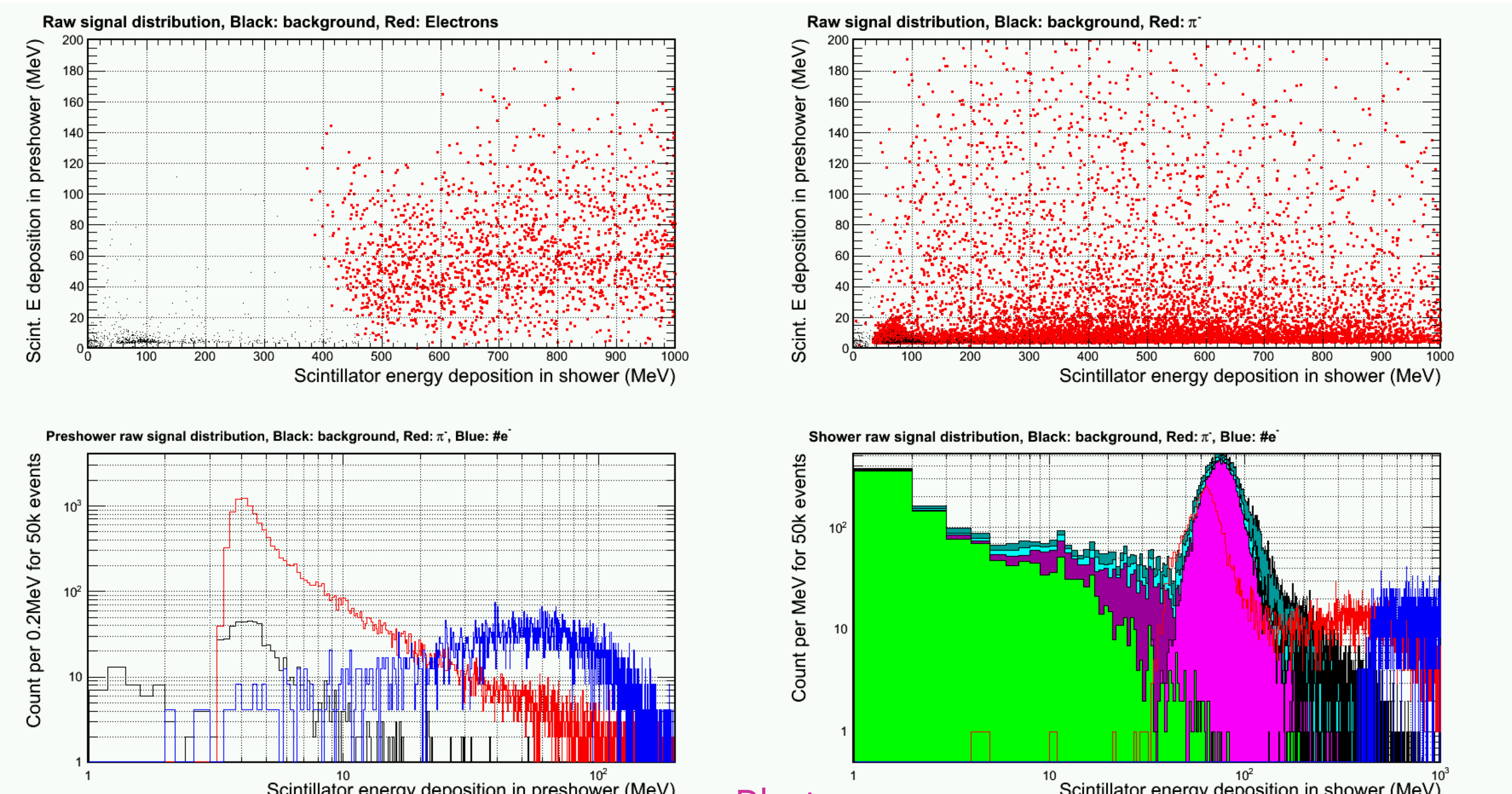
w/ o photon, w/ pi+, Inner R, Low Rad phi slice



First update of CLEO background

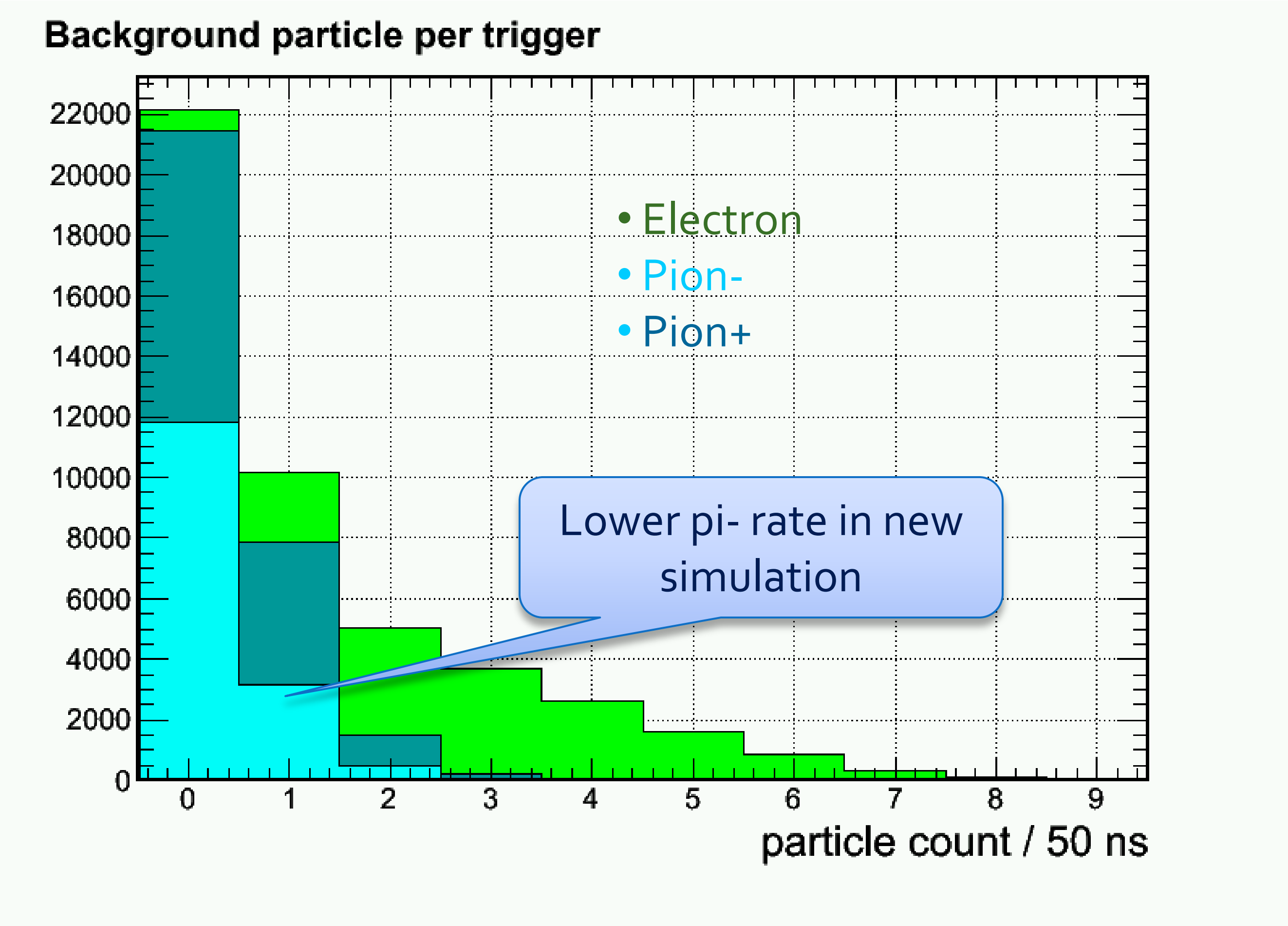
- Reported Apr 23 Calorimeter Meeting

Zhiwen Updated background contribution for all configurations. PVDIS shown here:

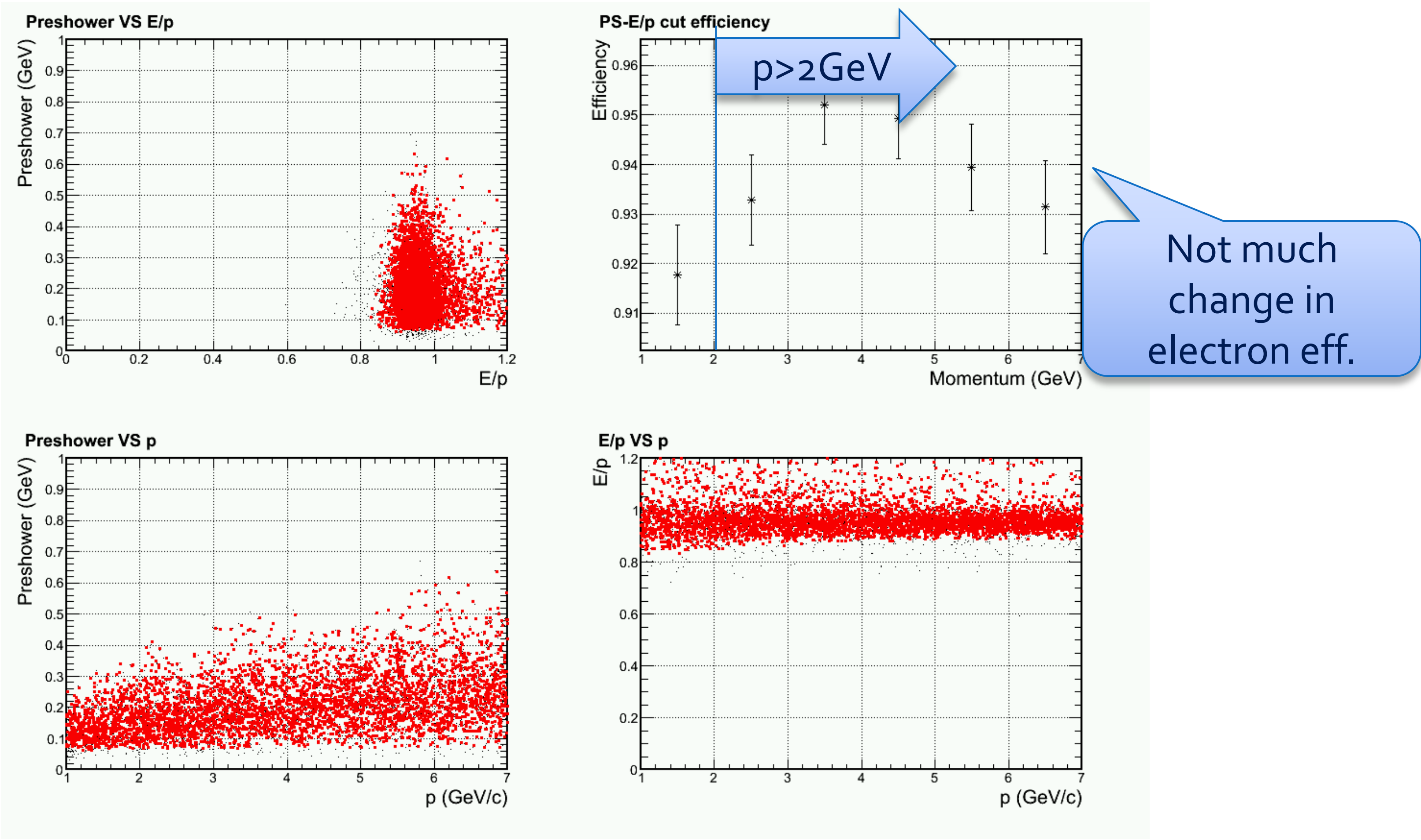


- Photon
- Electron
- Pion- Pion+

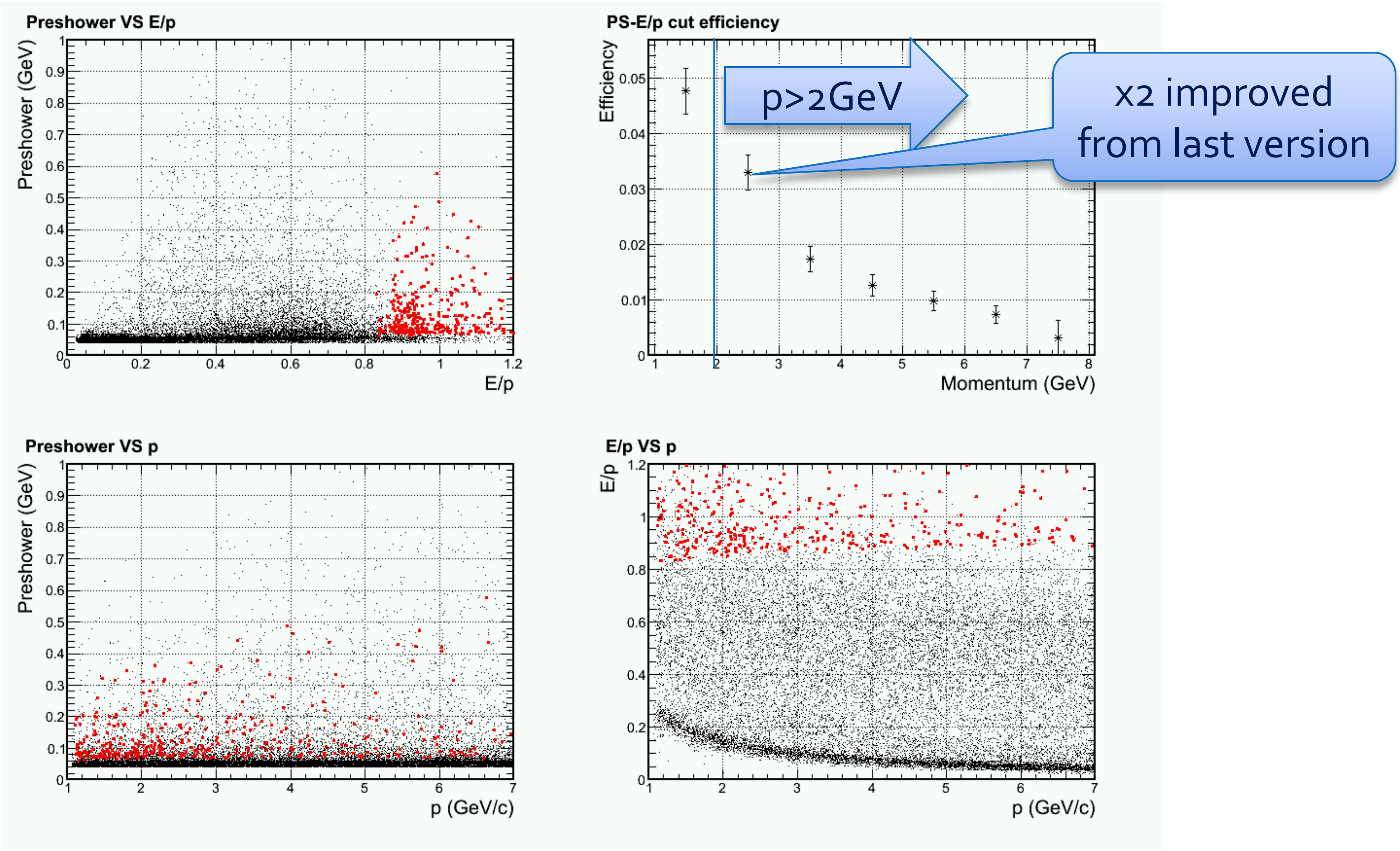
Updated: Per-event pion rate for 1+6 hexagon cluster at inner radius



Updated: electron efficiency
Only electron and pi- background used

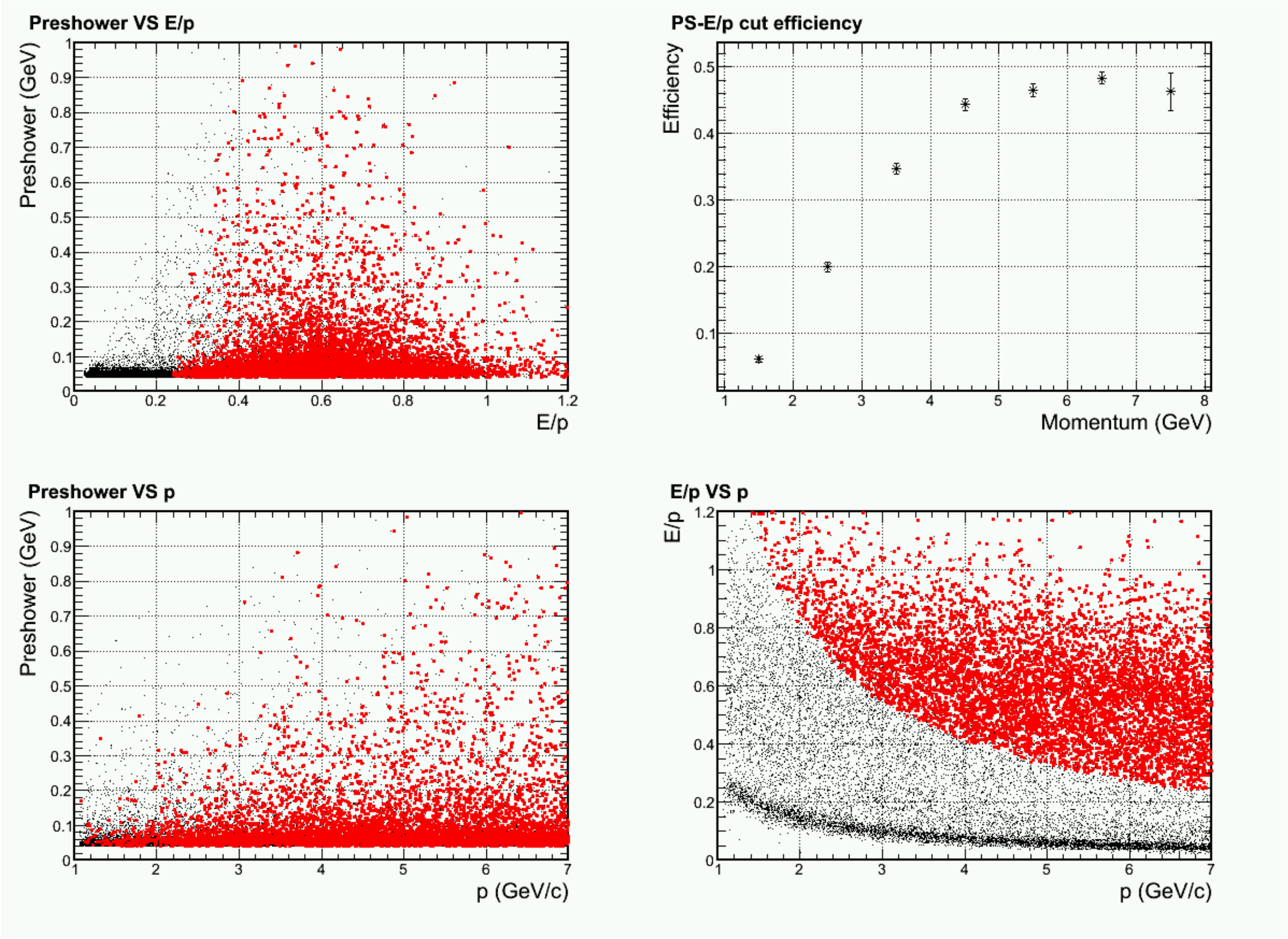


Updated: pion rejection
Only electron and pi- background used



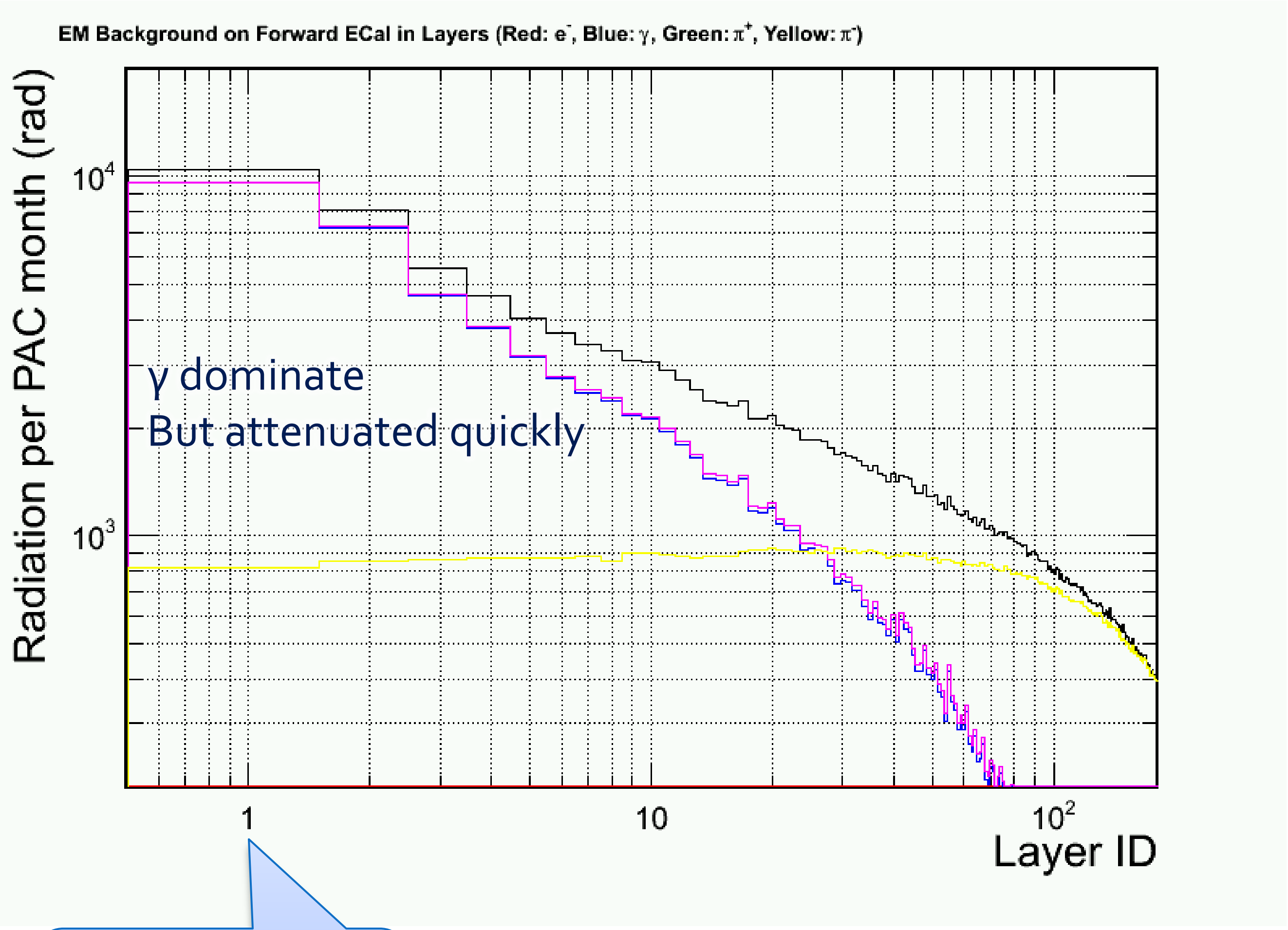
PVDIS trigger turn on curve

2GeV electron cut based on shower Hex1+6 cluster only



PVDIS – current baffle (with direct γ)

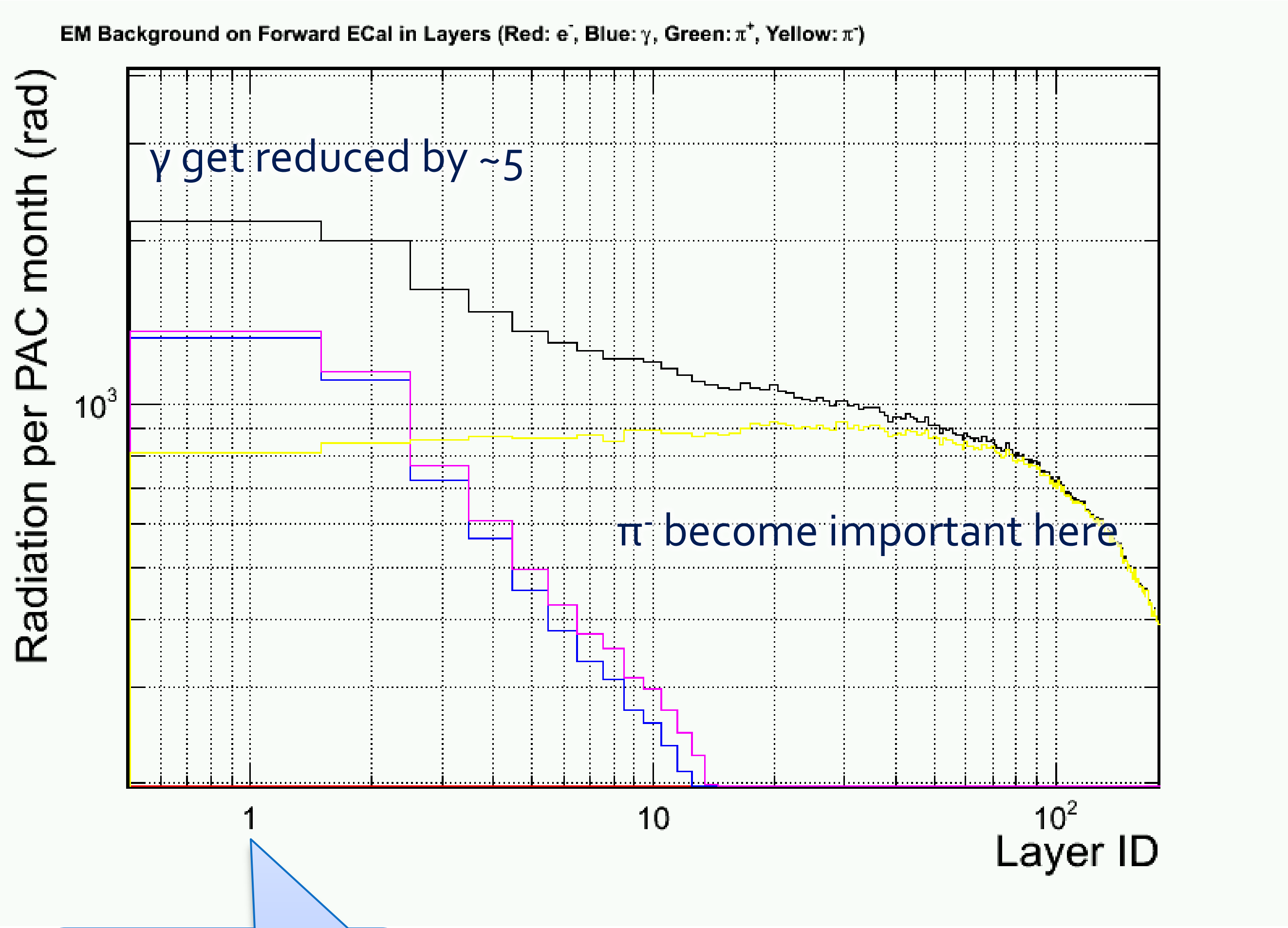
From Dec Collaboration Meeting



Layer #1 is 2cm preshower scint.

PVDIS – preview for a baffle w/o direct γ

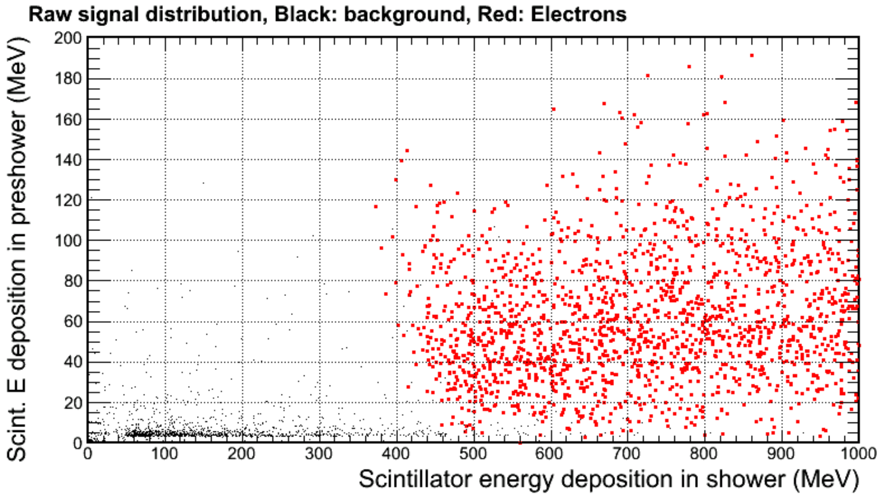
From Dec Collaboration Meeting

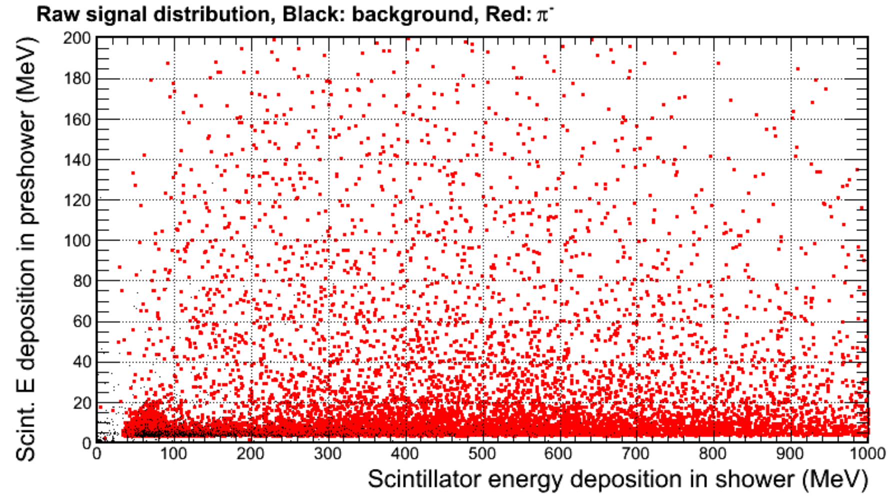


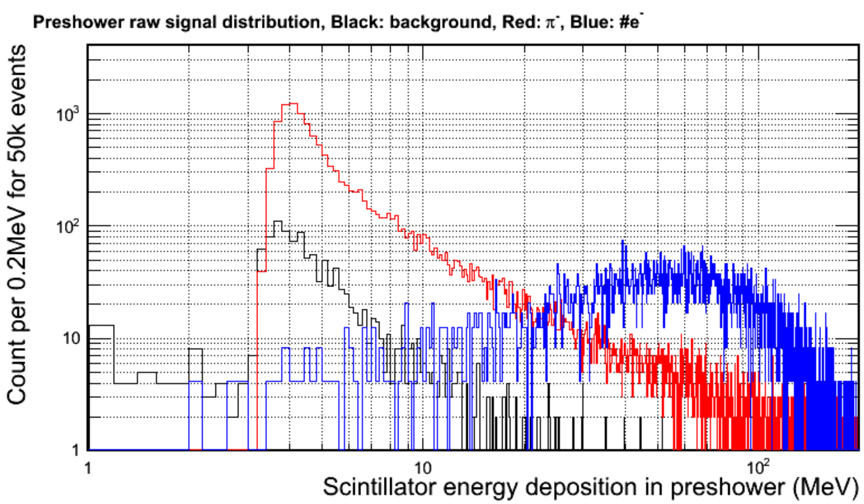
Layer #1 is 2cm preshower scint.

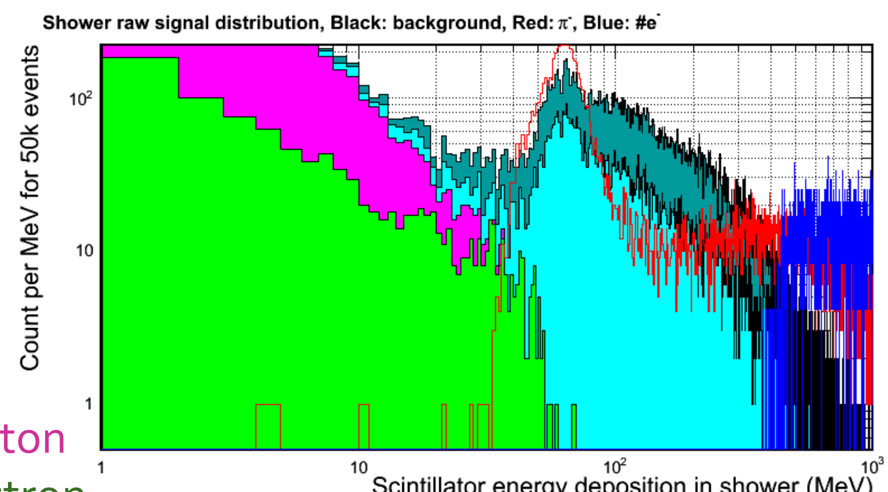
Last Version of Background Simulation (reported last week)

Why it is hard – lots of deep pions



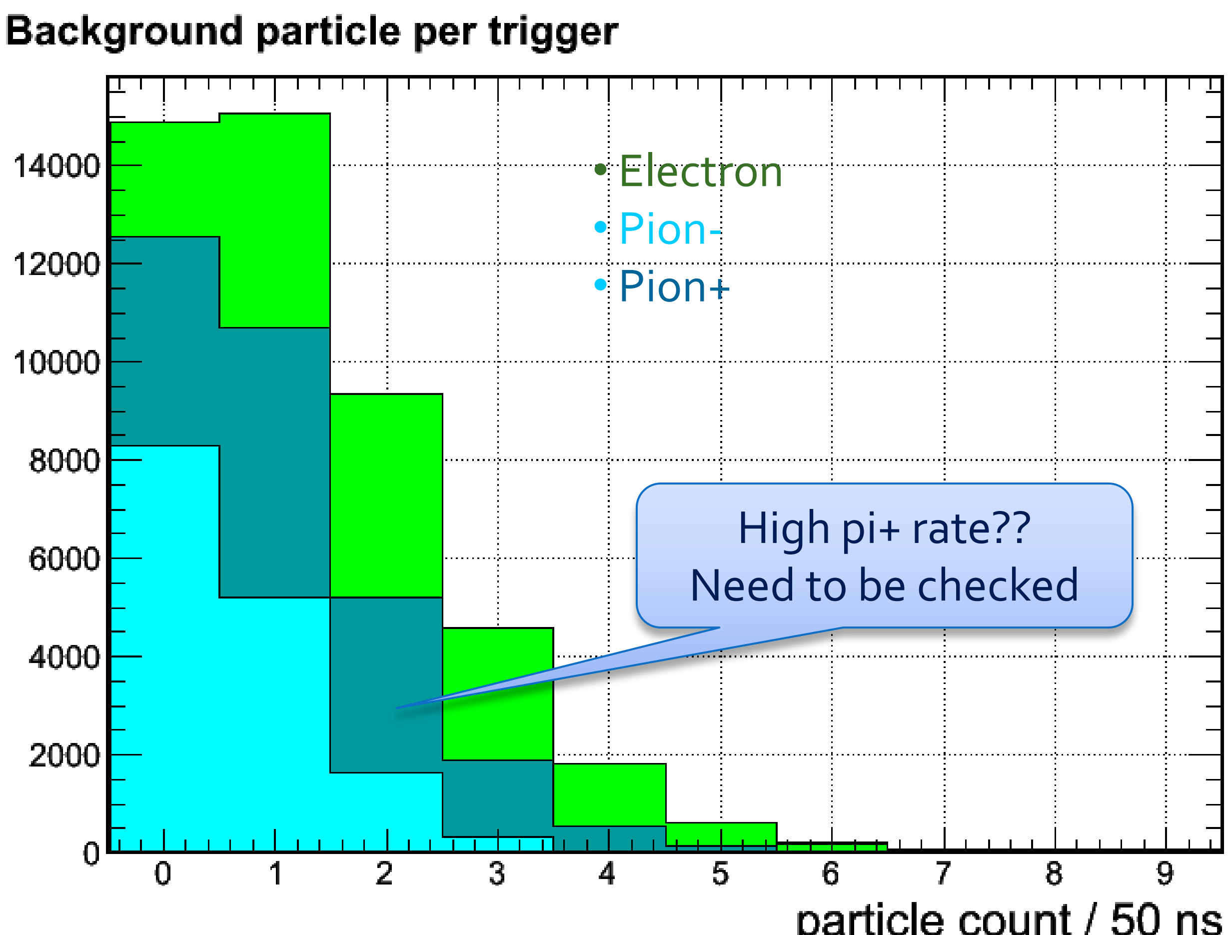




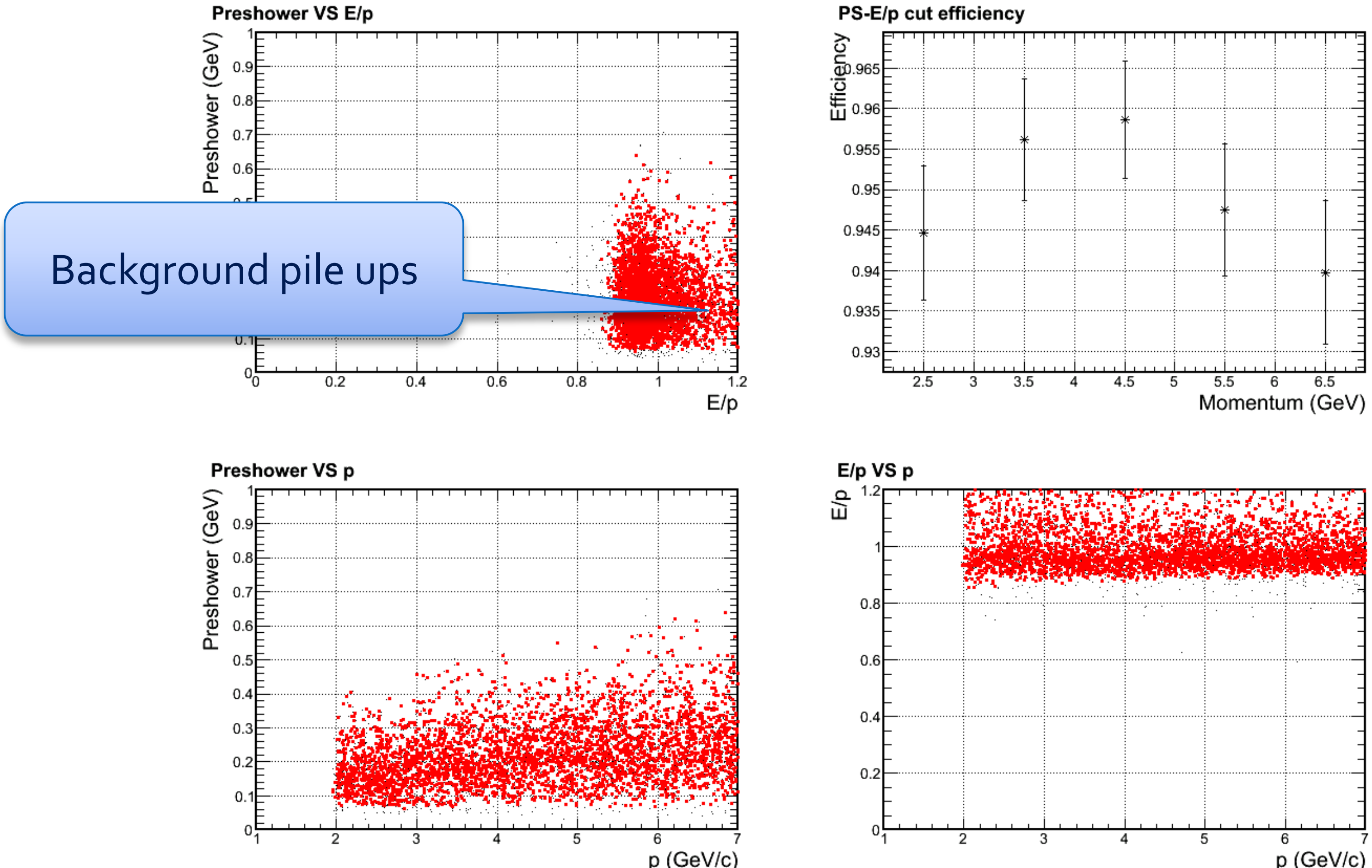


- Photon
- Electron
- Pion- Pion+

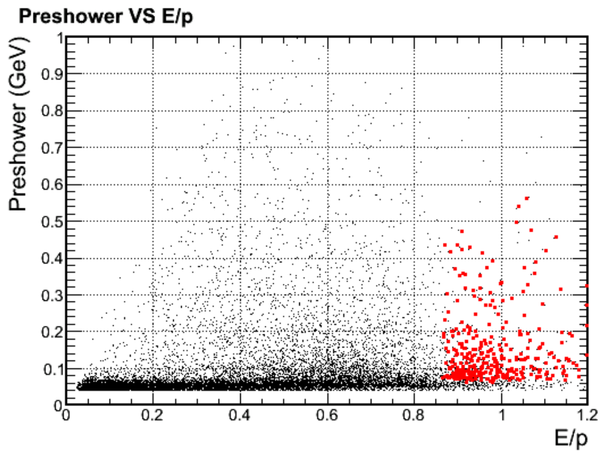
Per-event pion rate for 1+6 hexagon cluster at inner radius

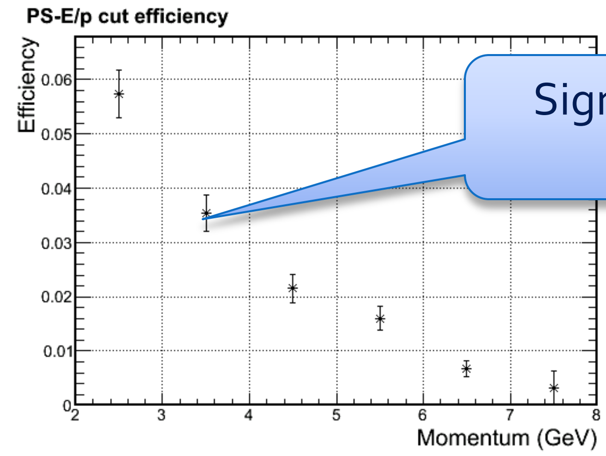


Electron efficiency w/ background at inner radius. Ignore gamma and pi+ bgd

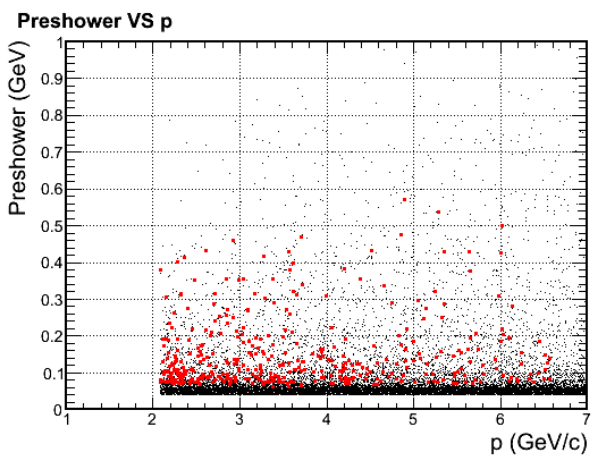


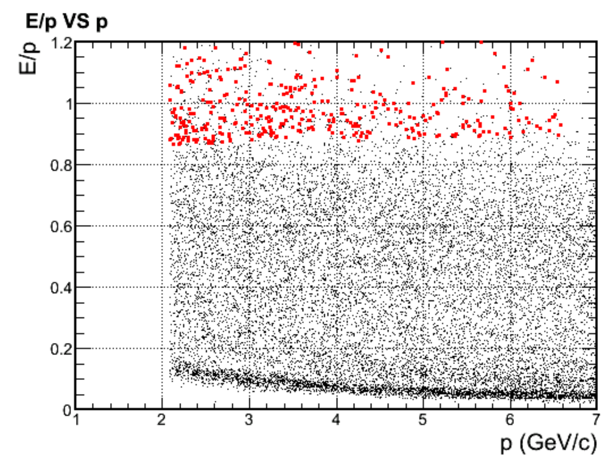
Pion efficiency w/ background at inner radius. Ignore gamma and pi+ bgd





Significant drop in rejection





What we can further try

- Position or kinematic dependent trigger threshold and cut threshold
- Use track multiplicity to assist calorimeter cuts