Update on Light Gas Cherenkov

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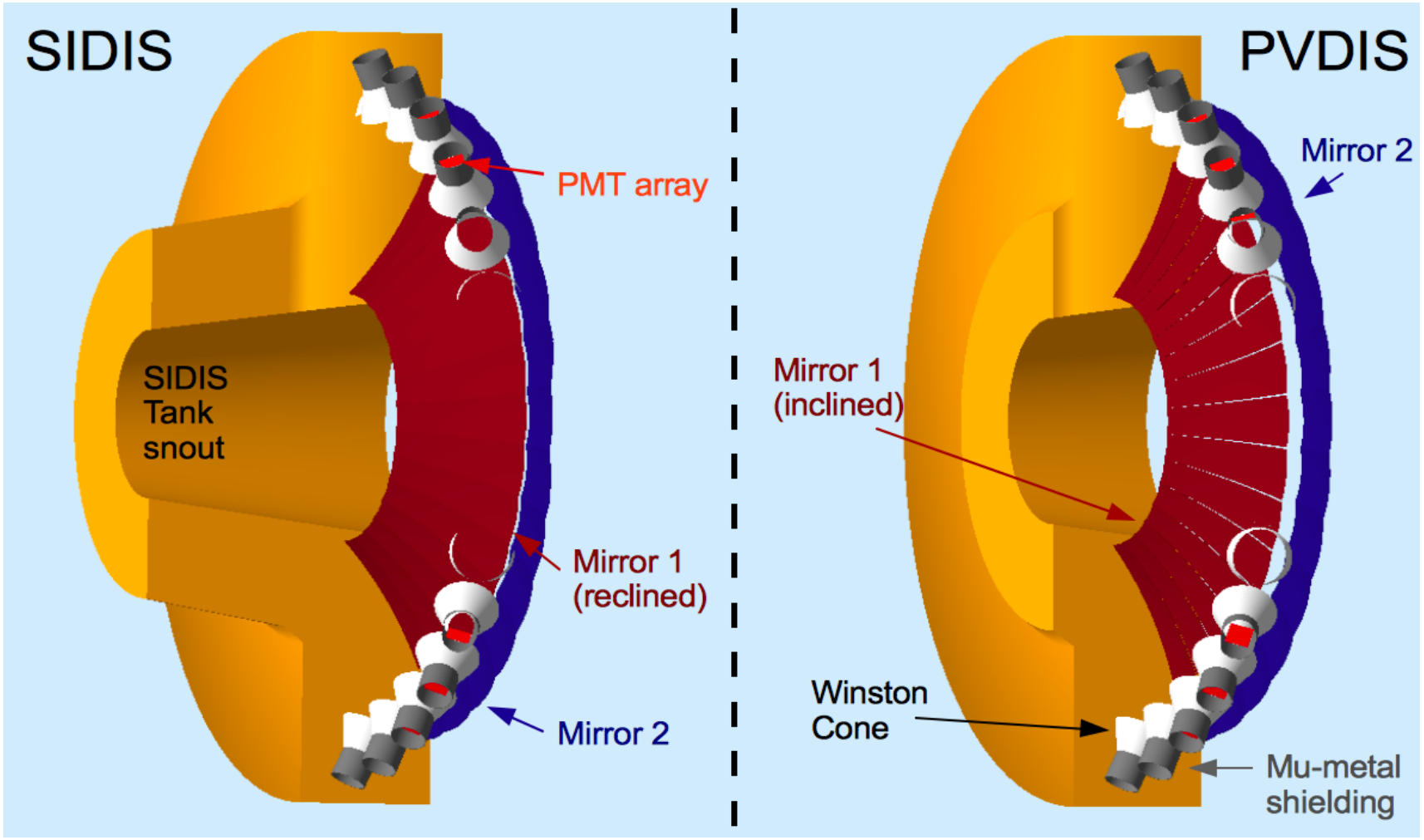
Temple University

For the SoLID Collaboration

March 22nd 2013

Review + Updates

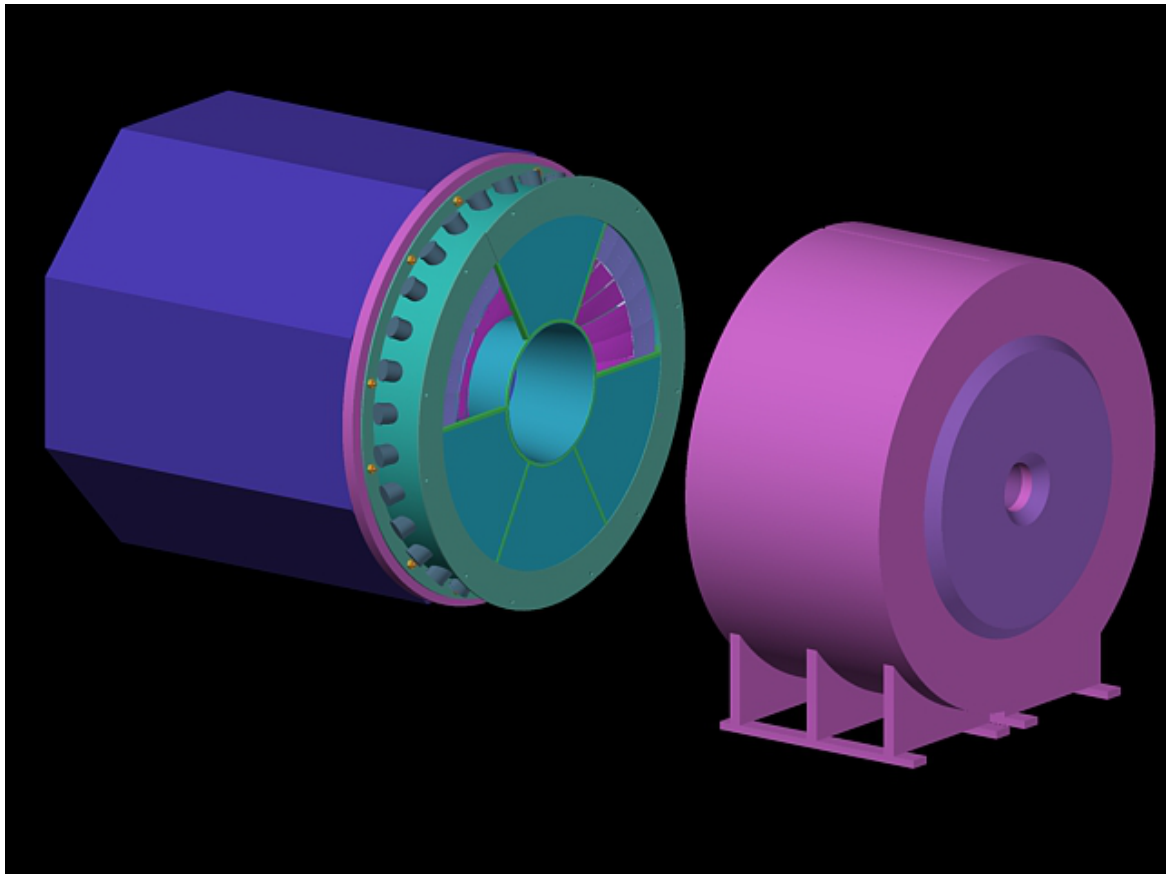
Consolidated Design



- The same mirror-1 is used in both SIDIS and PVDIS configurations, with an adjustment in orientation.
- The same PMTs and cones are used for both configurations with no adjustments.

Update on Tank and Support

- Latest design will have 6 separate sectors that create the entire tank.
- Each sector to be mounted on back of magnet housing (as opposed to the enclosure wall or snout).



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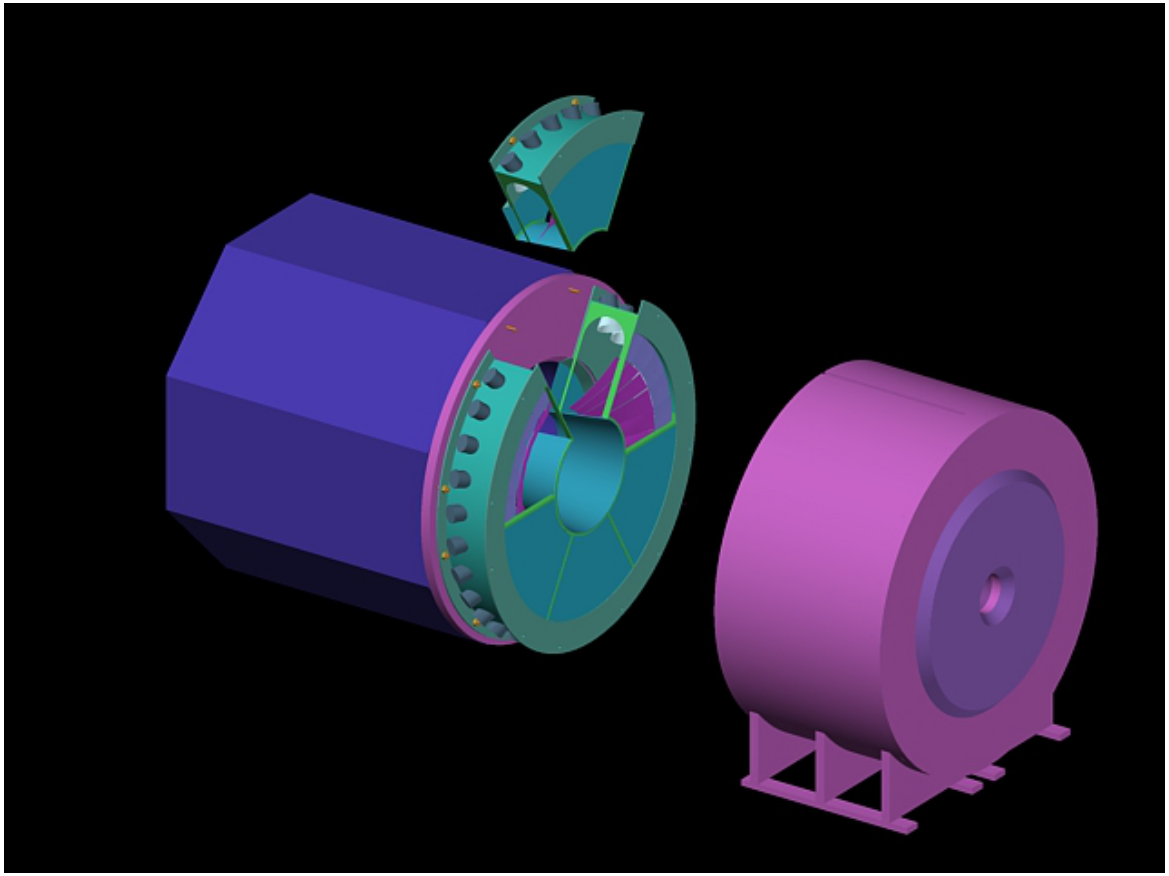

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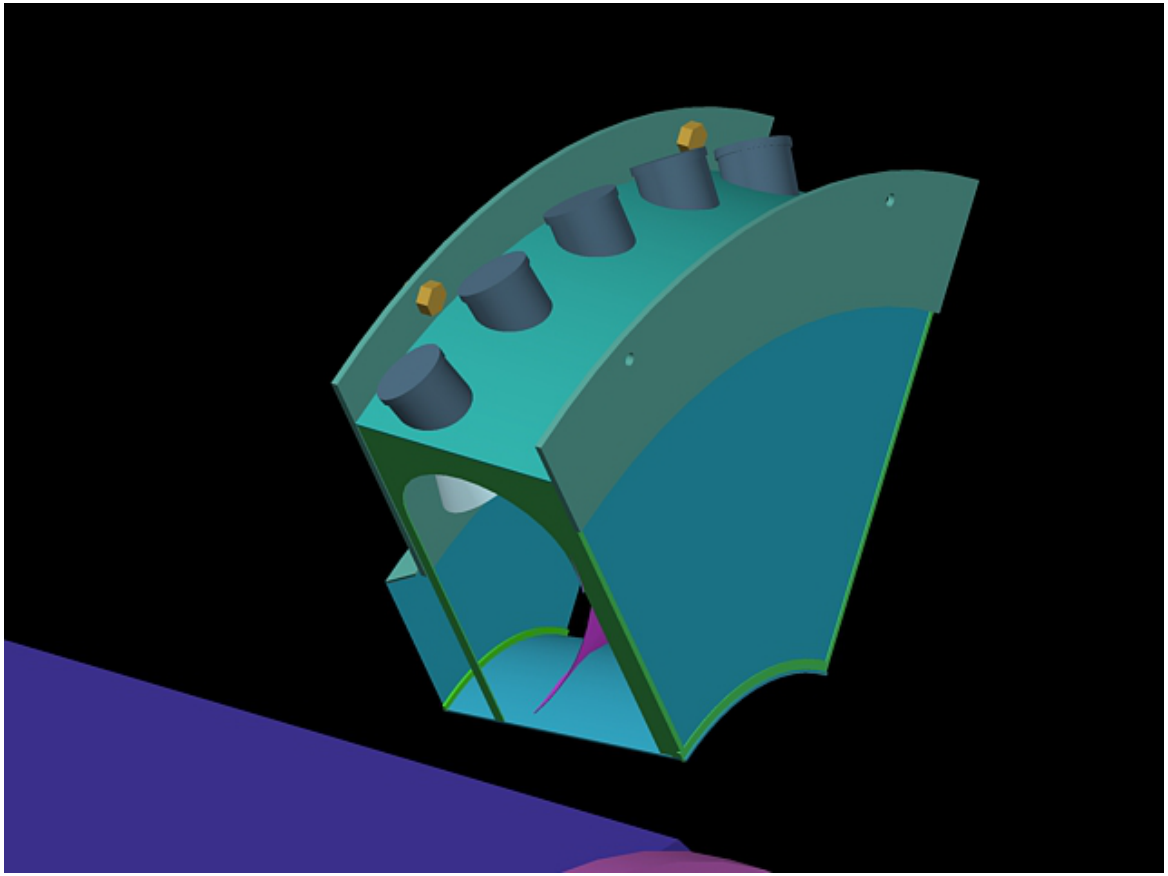

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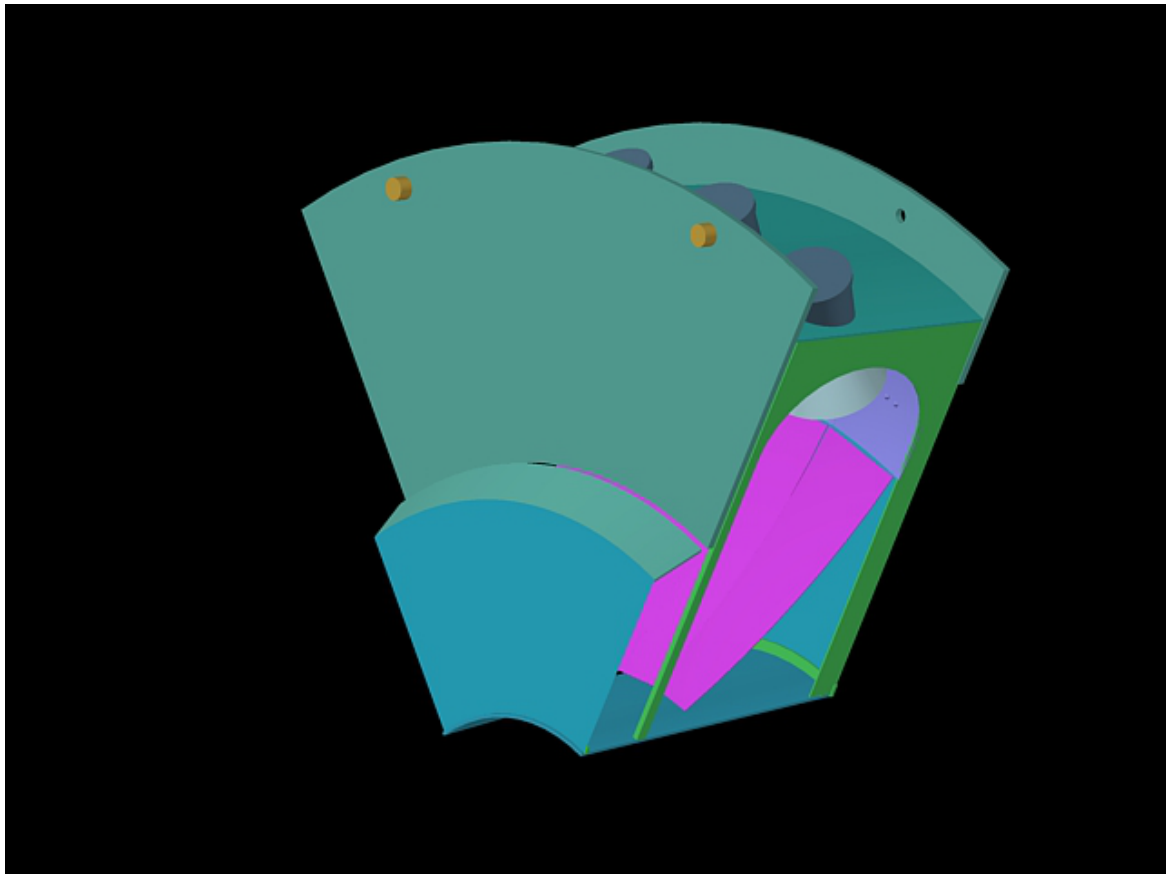

Windows In

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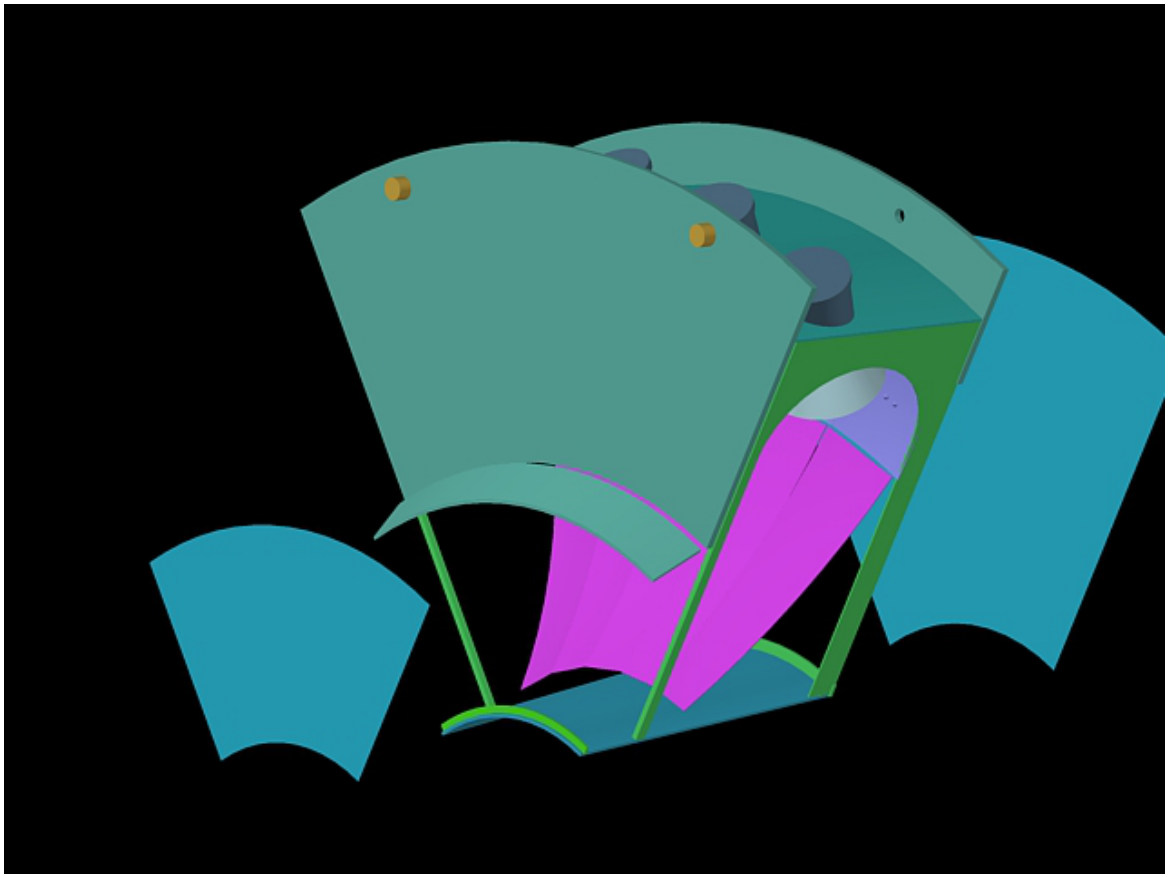

Windows Out

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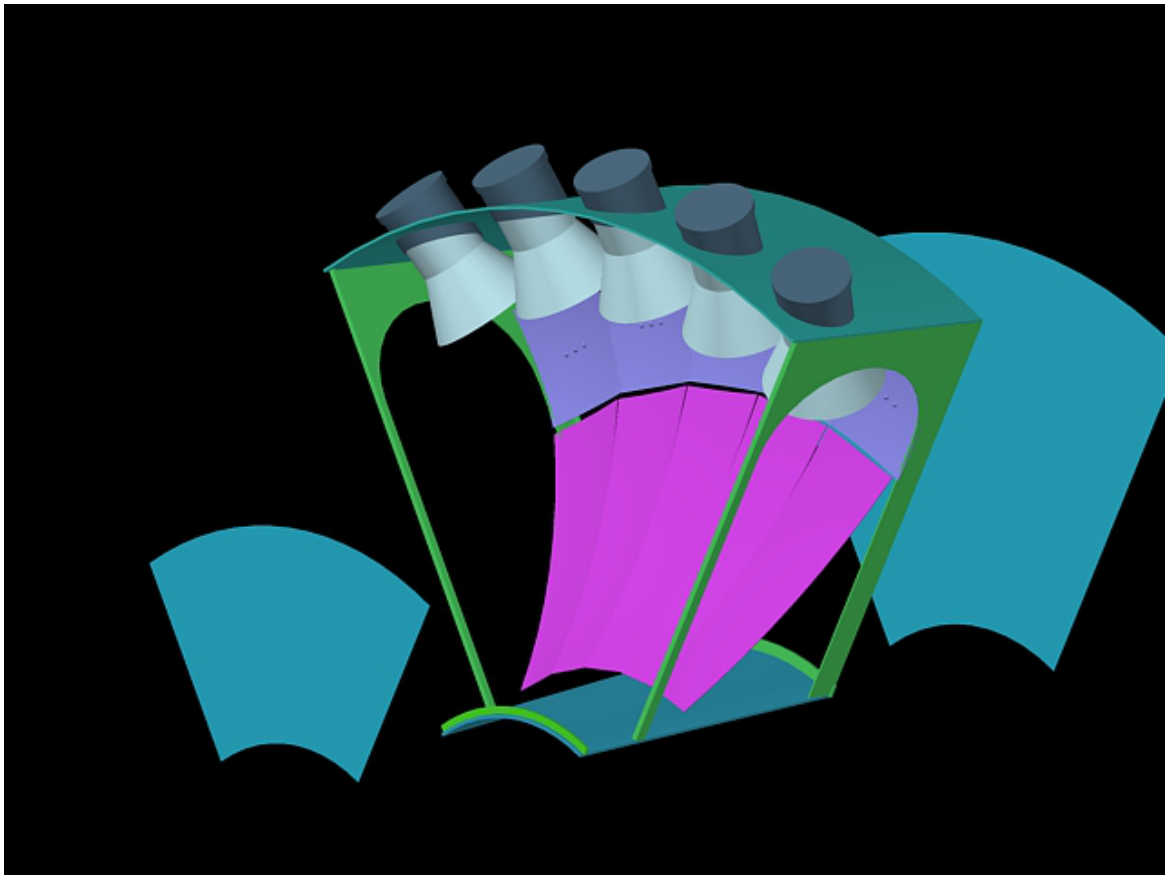
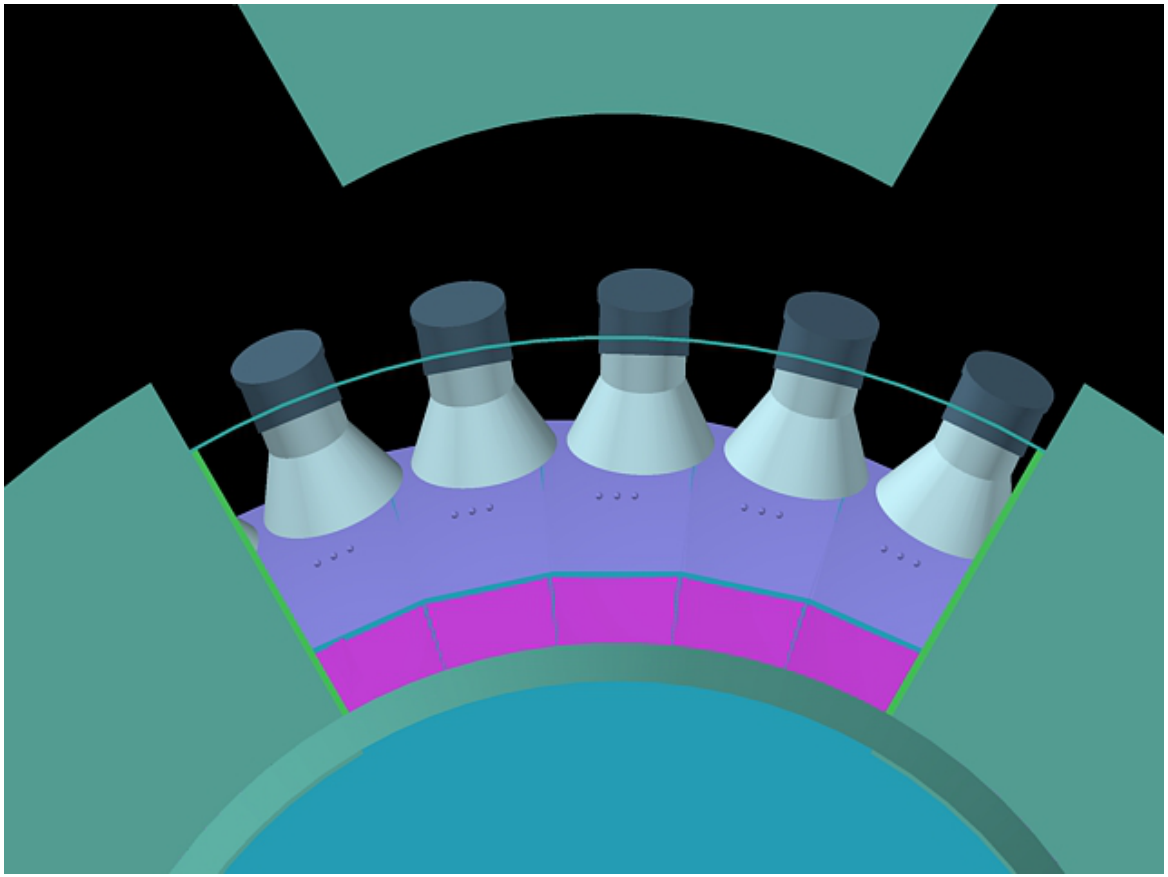


Update on Tank and Support

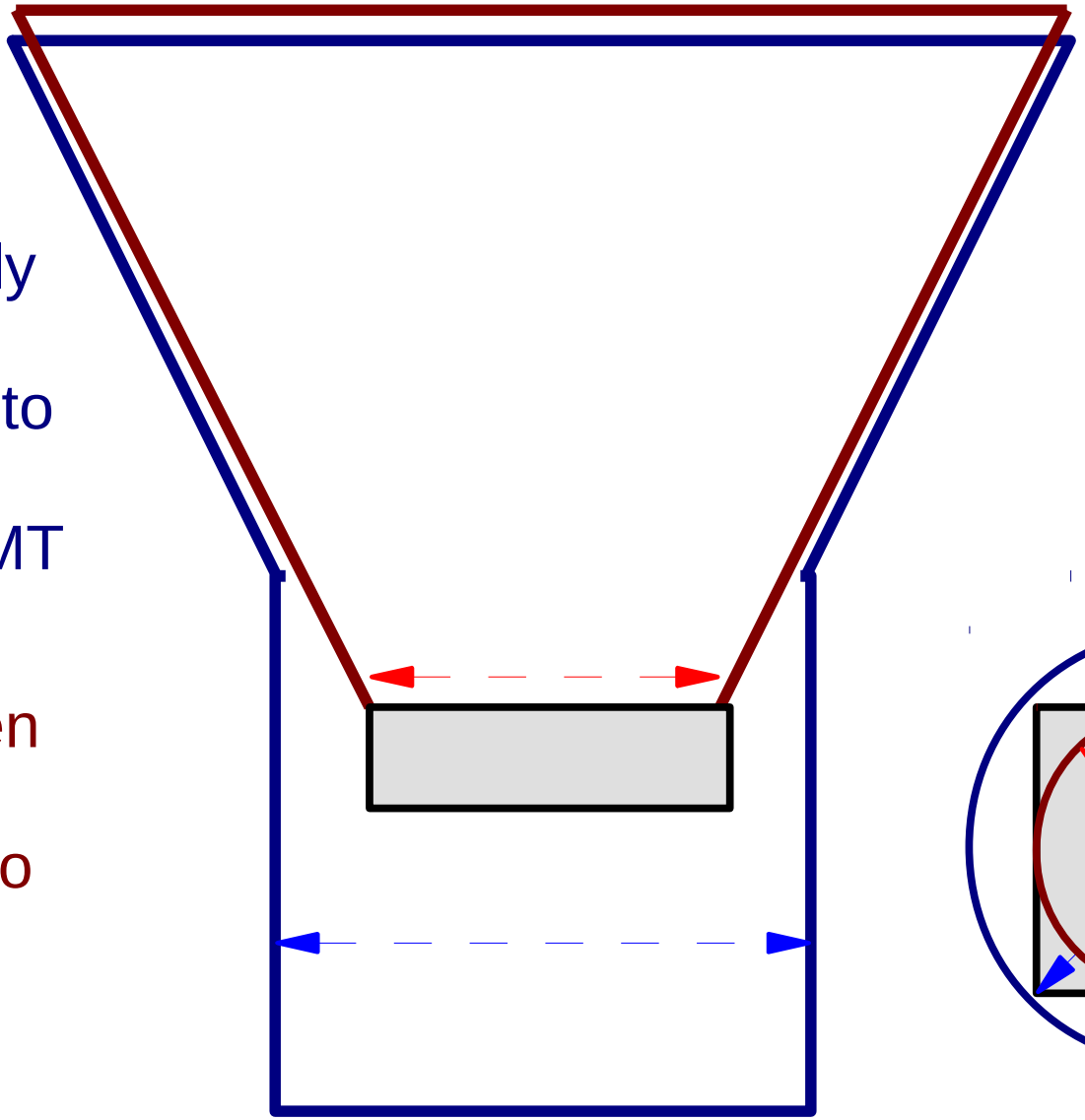
- Latest design will have 6 separate sectors that create the entire tank.
- No “walls” between sectors.
  - Needed to accommodate rotation of pmts/cones
- Each sector to be mounted on back of magnet housing (as opposed to the enclosure wall or snout).



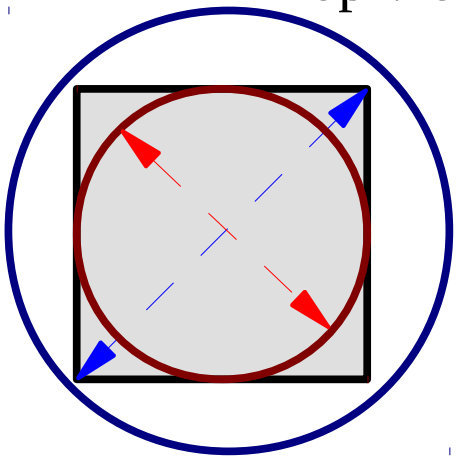
- Estimated total cost per sector: ~ $60,000.00

Update on Magnetic Shielding / Cones

- Mu-metal cone connects directly to tube with a diameter equal to the diagonal length of the PMT face.
- Glass cone then is mirror coated and inserted into cone opening.



Side view

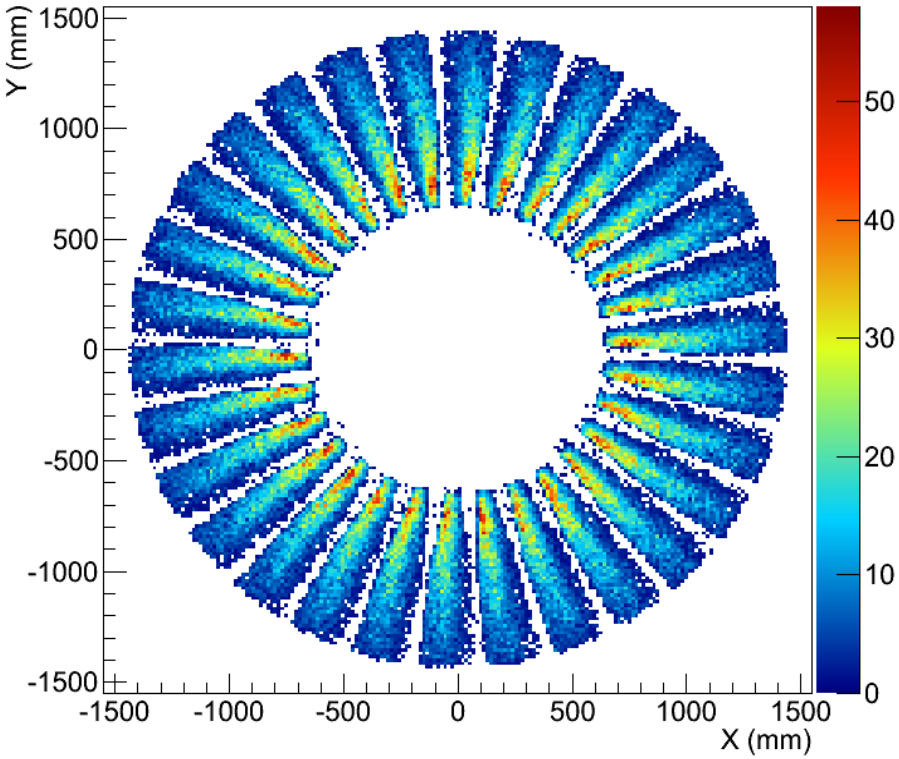


Top view

Simulation Parameters

- DIS electron event generation (eicRate) for 11 GeV electrons off of H or 3He for PVDIS and SIDIS respectively.
- Pions are generated using the pion/electron rate tables (in theta vs momentum) **[Update: new PVDIS ratio tables]**
- Baffle acceptance is taken into account in the PVDIS simulations. **[Update: latest baffle design & bug fix]**
- Events are distributed over the 40cm target. **[Update: data at wider theta]**
- Interactions with Cherenkov window generate knock-ons / pair creation.

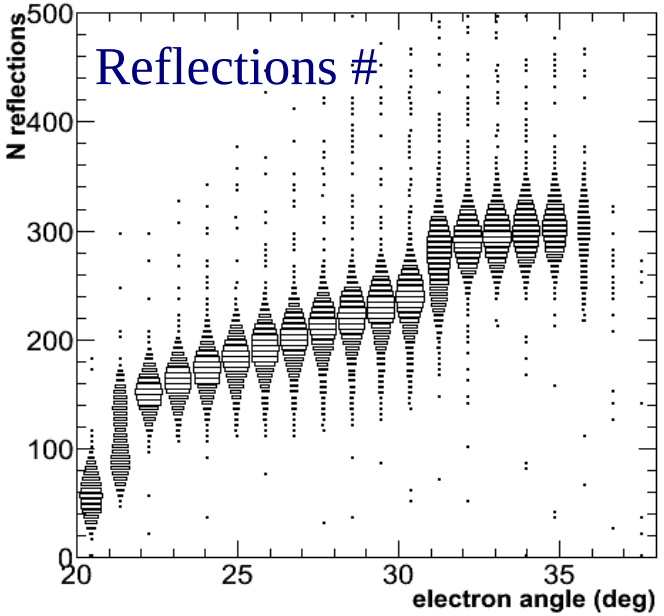
PVDIS electron acceptance post-baffle



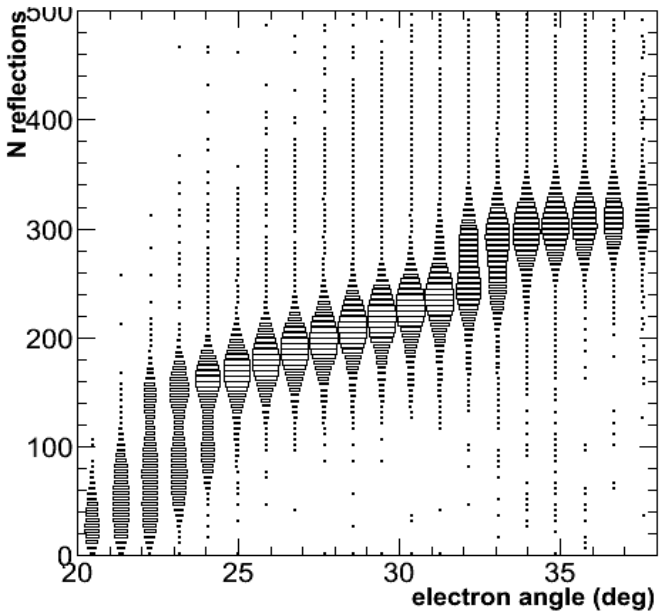
Simulations: Collection + Optical Efficiencies

- The efficiencies include the following possible loss of optical photons:
  - Geometric acceptance
  - Primary (off mirror) and secondary reflections (off cones)
  - PMT window optical properties
  - PMT quantum efficiency
  - PMT dead-area
- Interactions with the primary mirrors are summed to give the number of reflections.
  - Simulated mirrors have 90% reflection efficiency over all energies.
- Summed photoelectrons are over all PMT assemblies and are after the losses listed above.

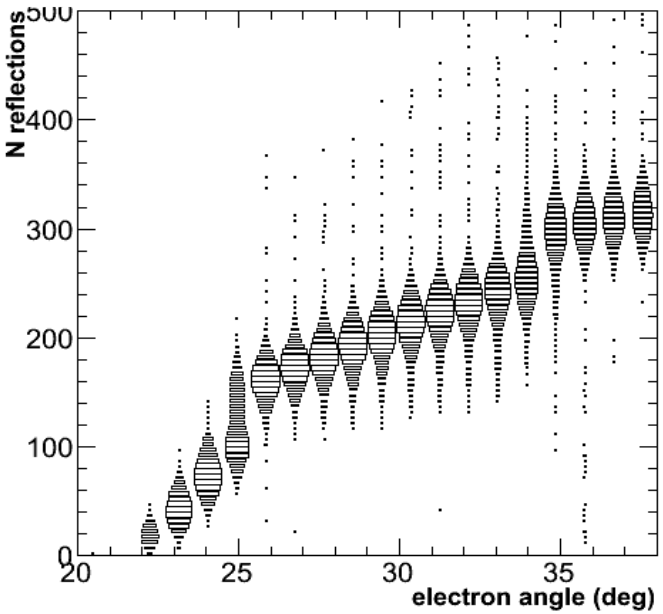
PVDIS



Z < -15cm



Z mid 30 cm



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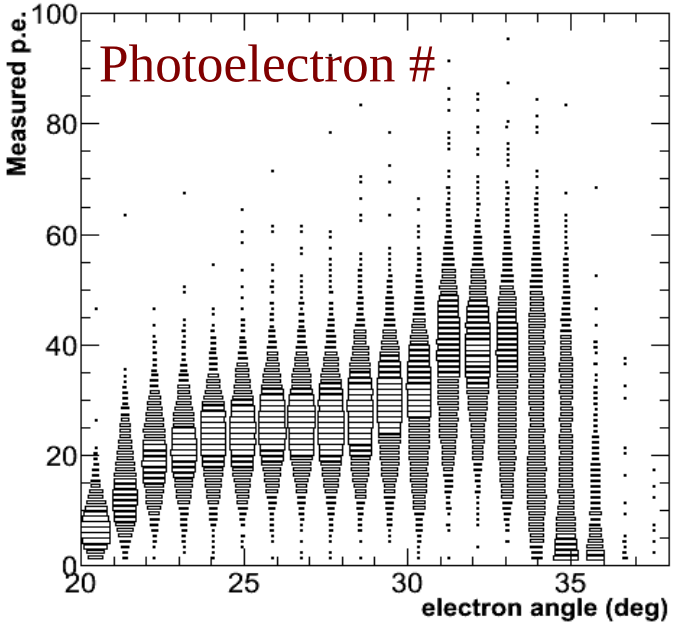
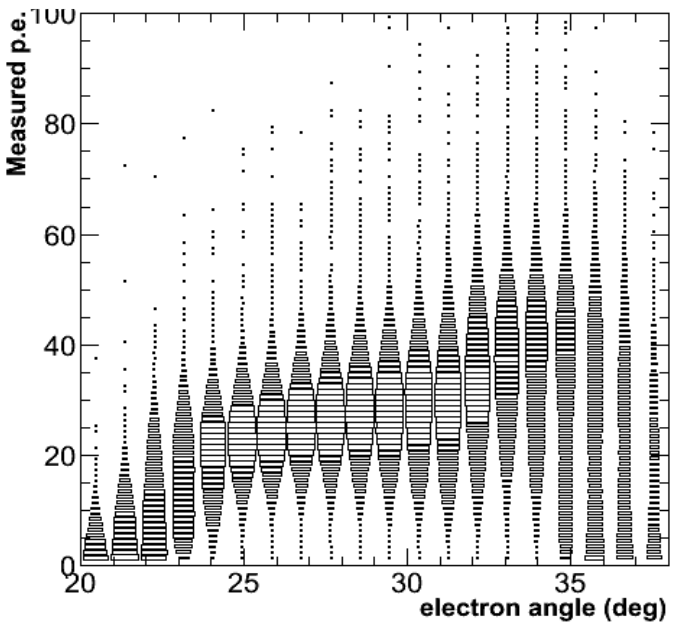
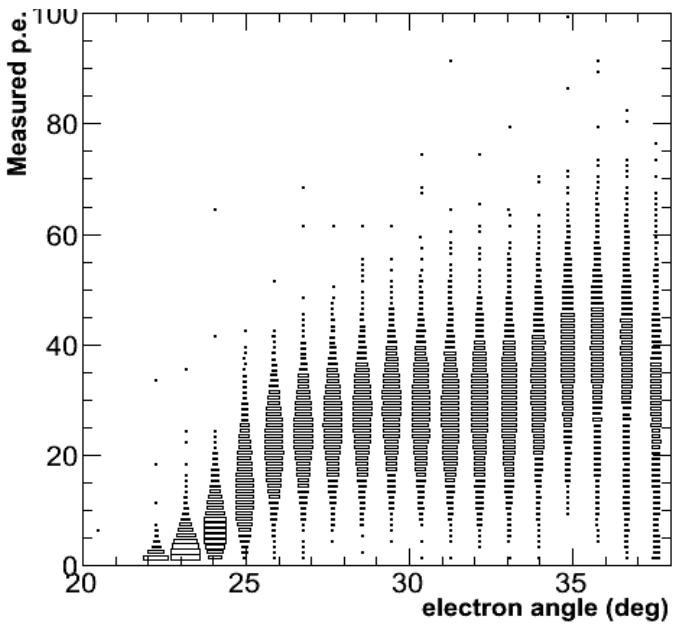
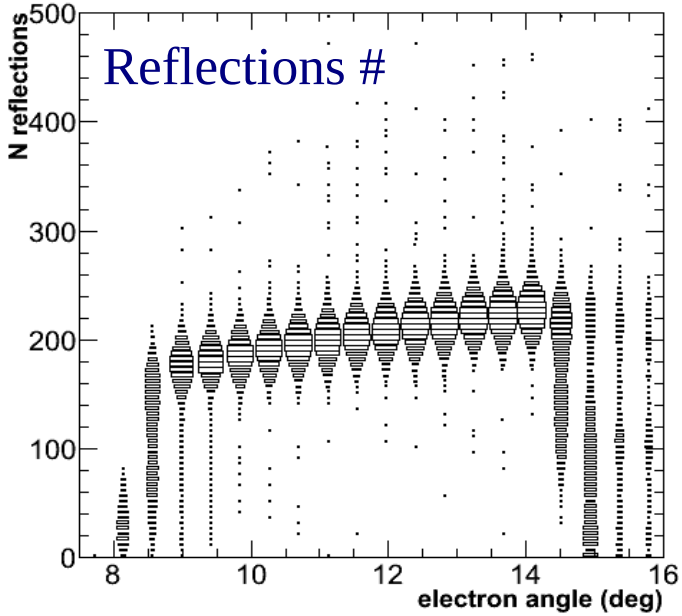
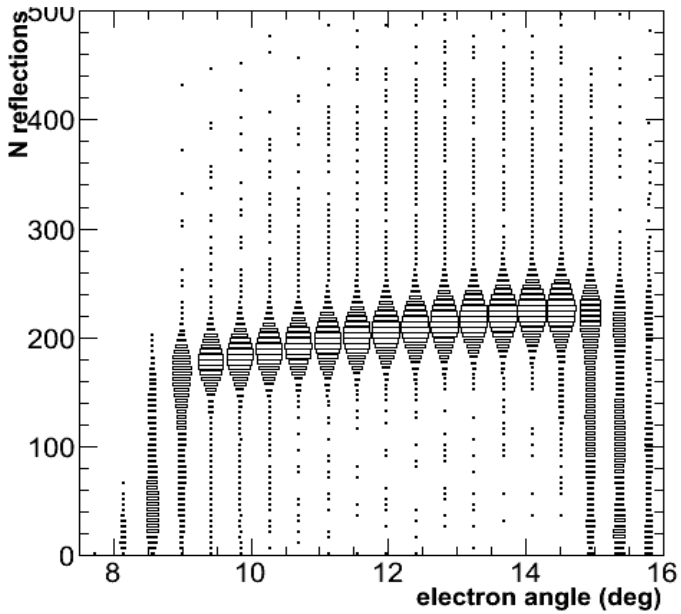


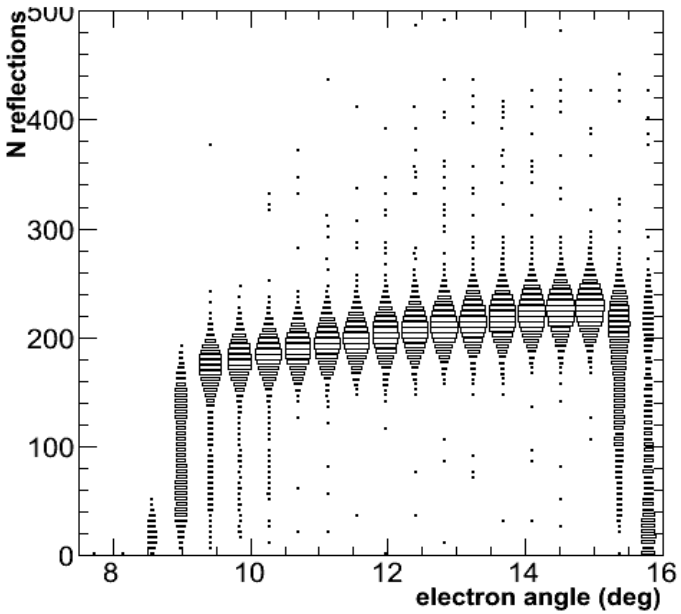




SIDIS







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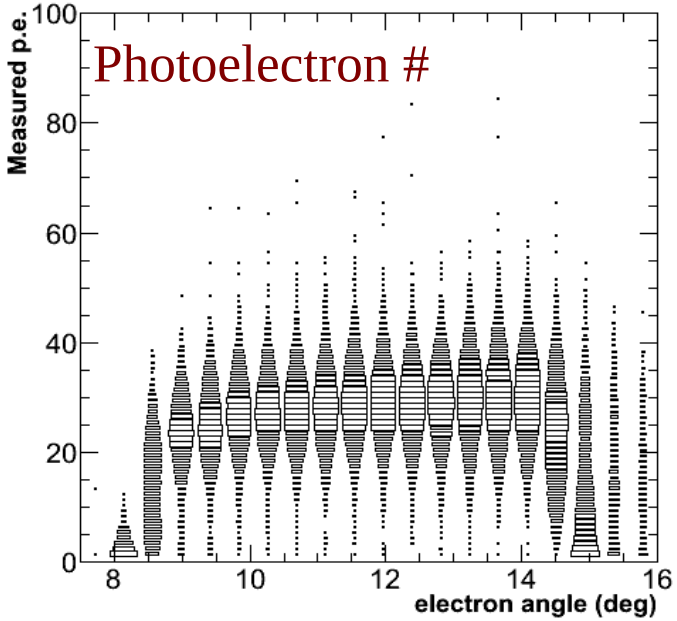
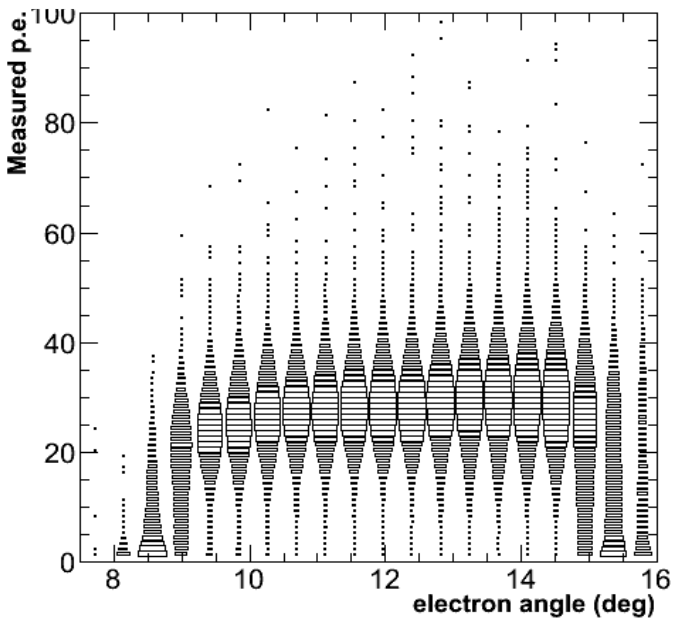
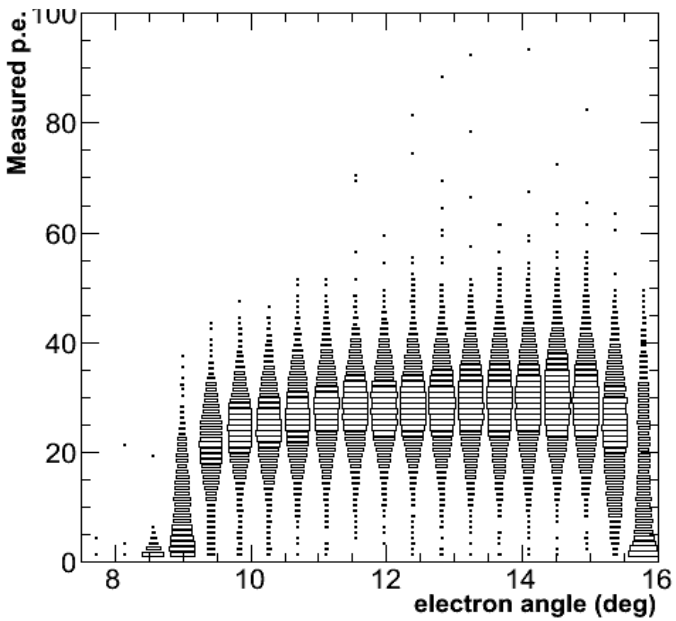
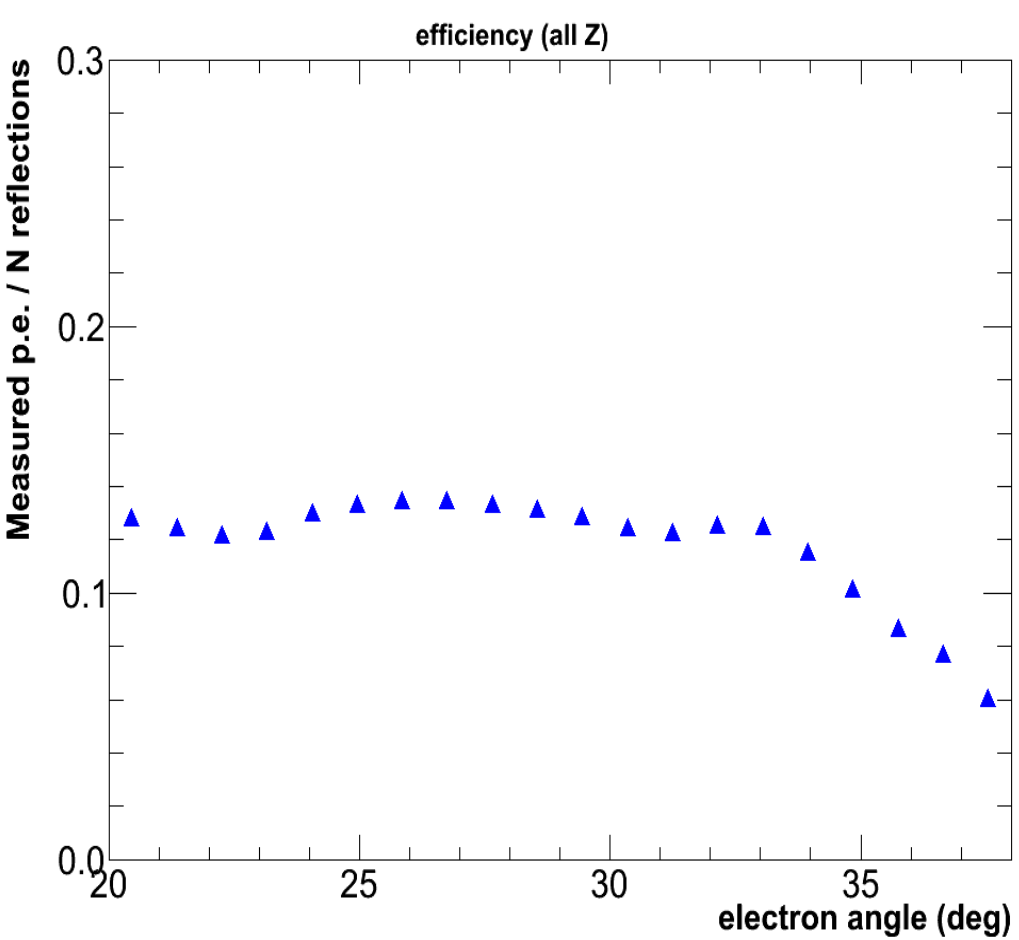
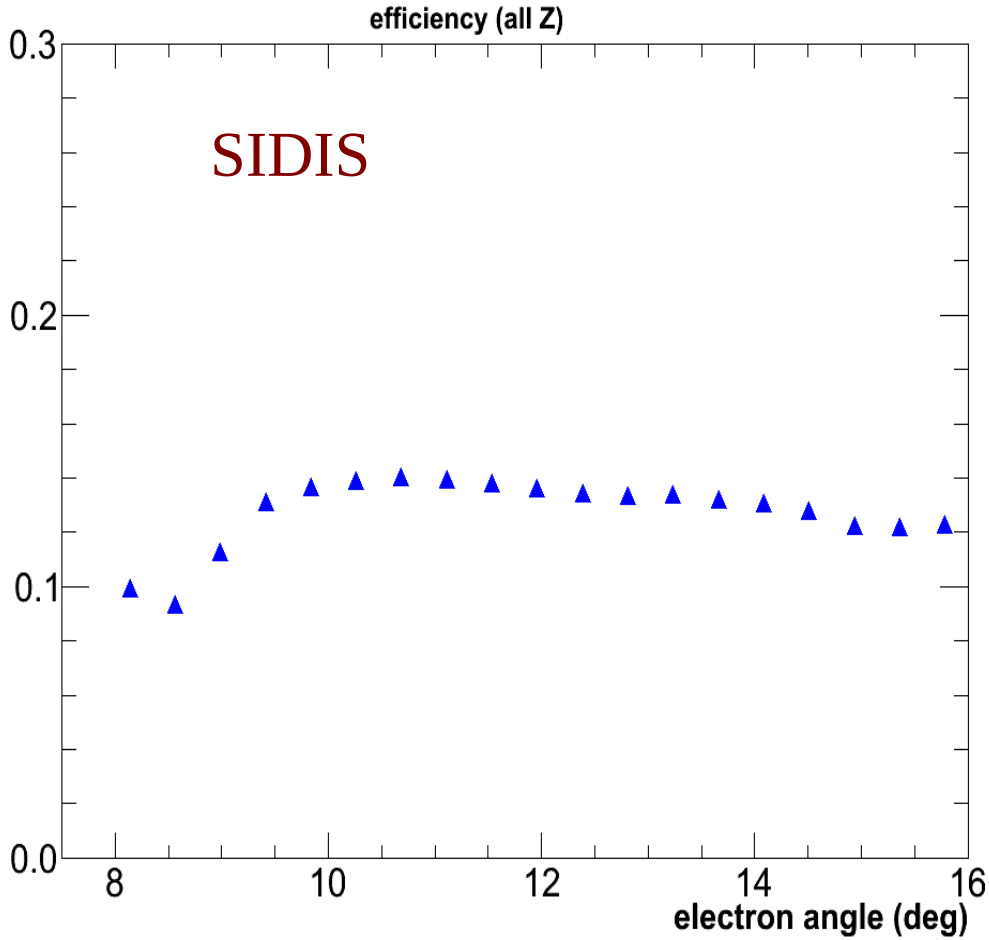




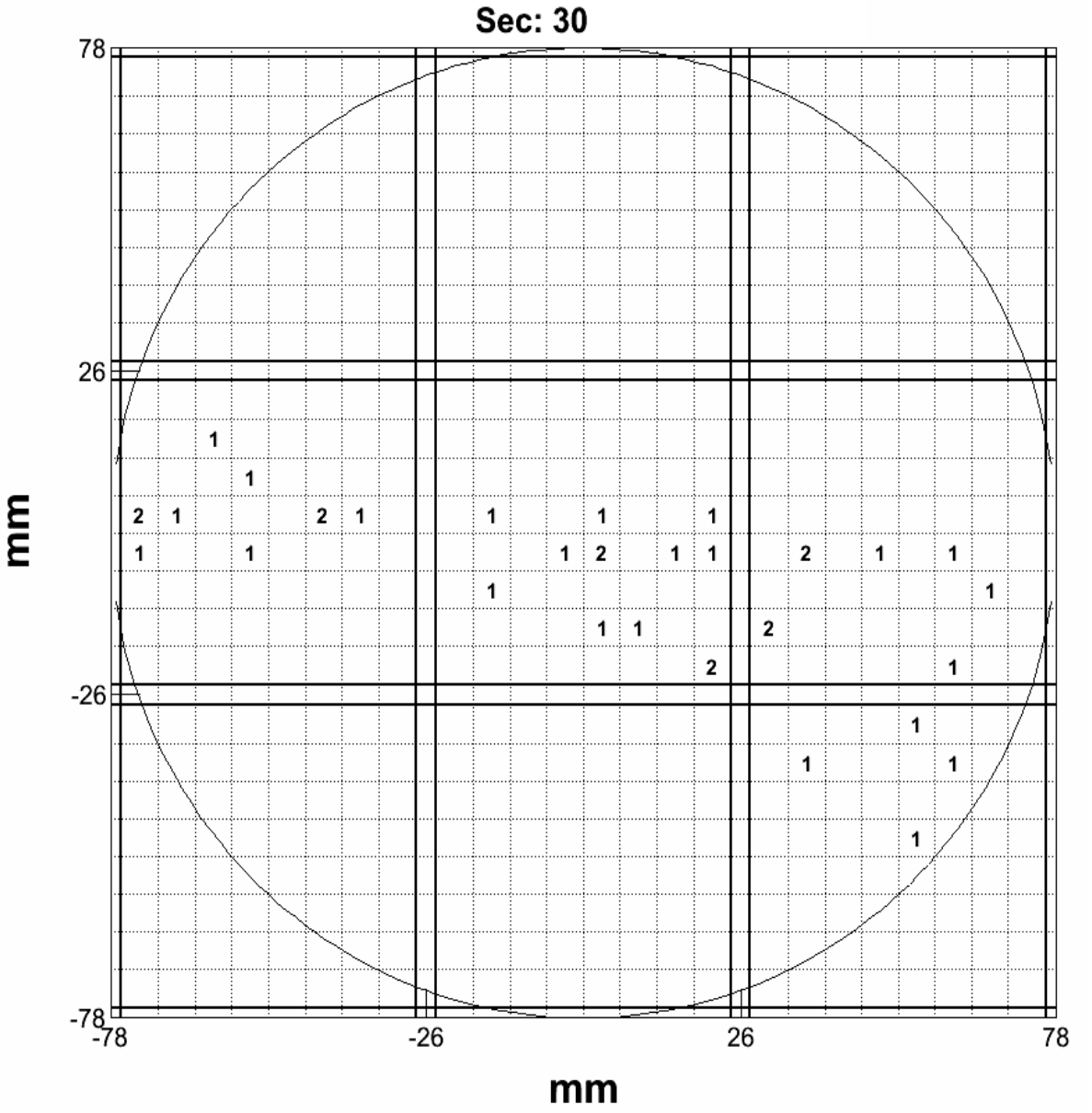


PVDIS / SIDIS Collection Efficiency



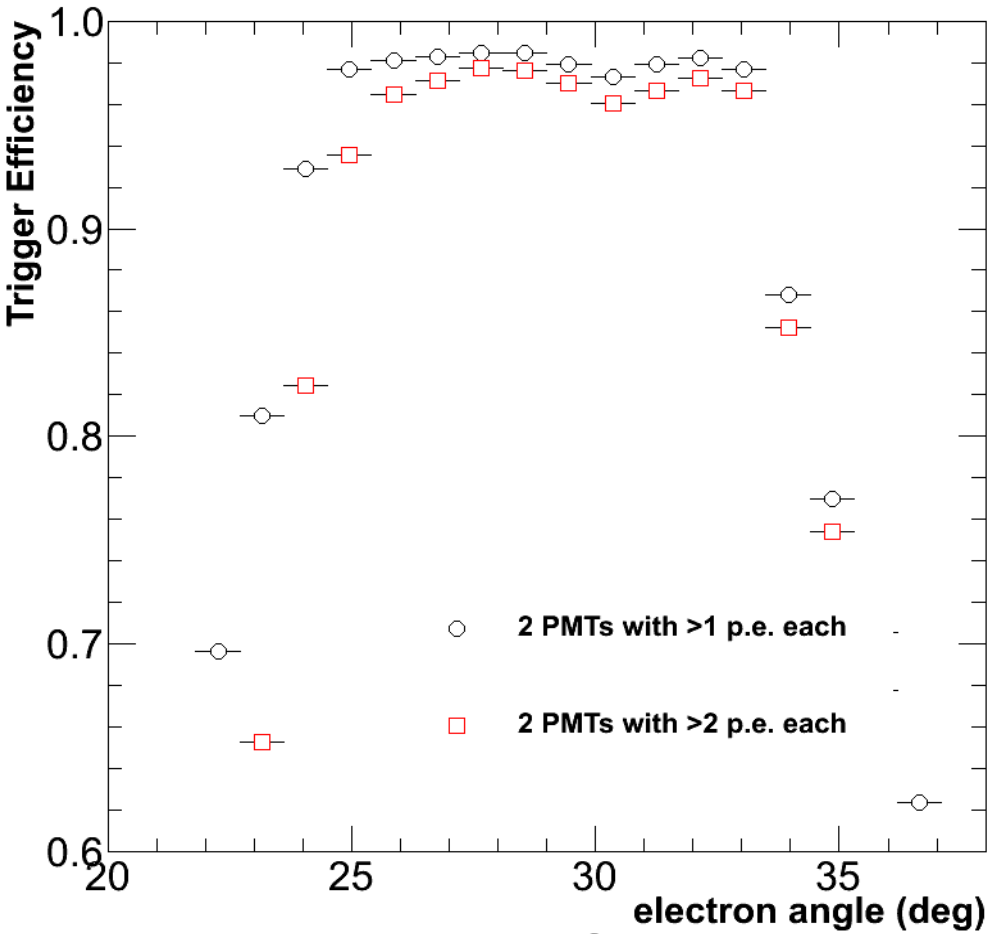


PMT Cherenkov trigger

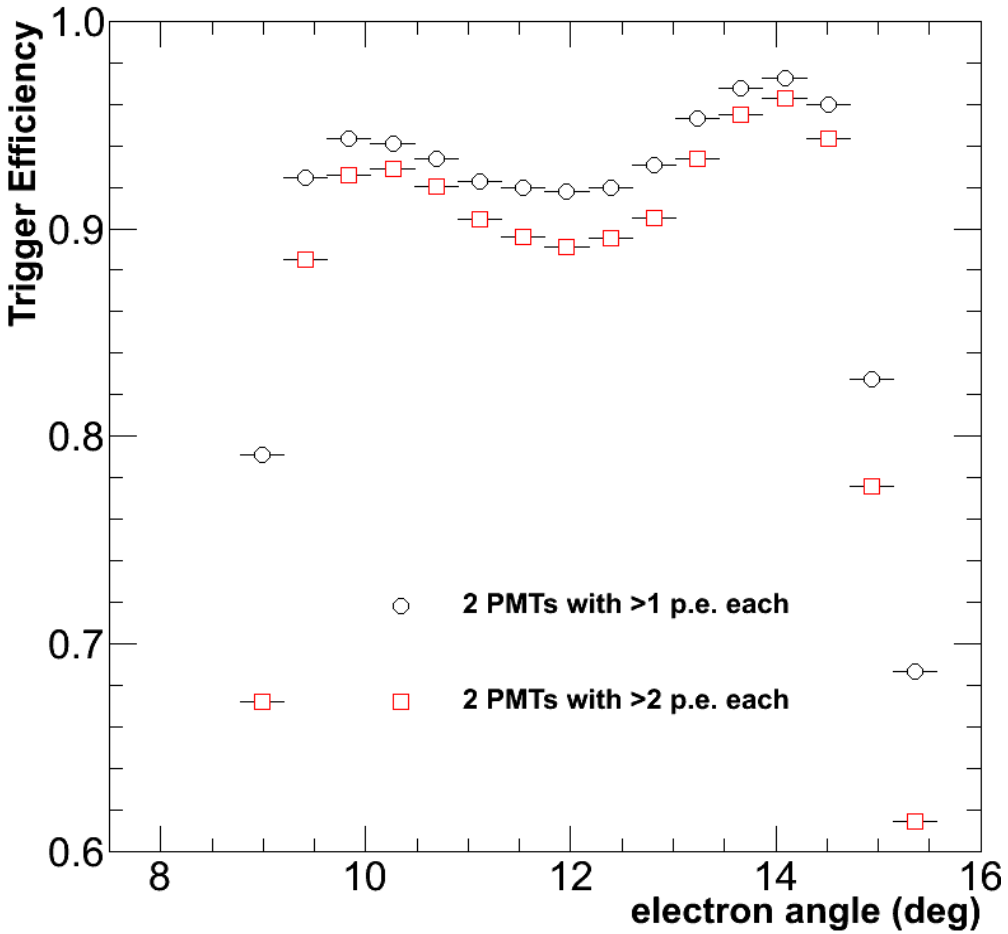


- 3 by 3 array of PMT assemblies (H8500C).
  - Each assembly is 8 by 8 array of pixel PMTs
- All photoelectrons from a single assembly will be summed.
- Then a coincidence circuit can be formed between assemblies with greater than 'X' p.e.'s.
  - 36 total ANDs (or only 18 if you only use adjacent assemblies)

Trigger Efficiencies

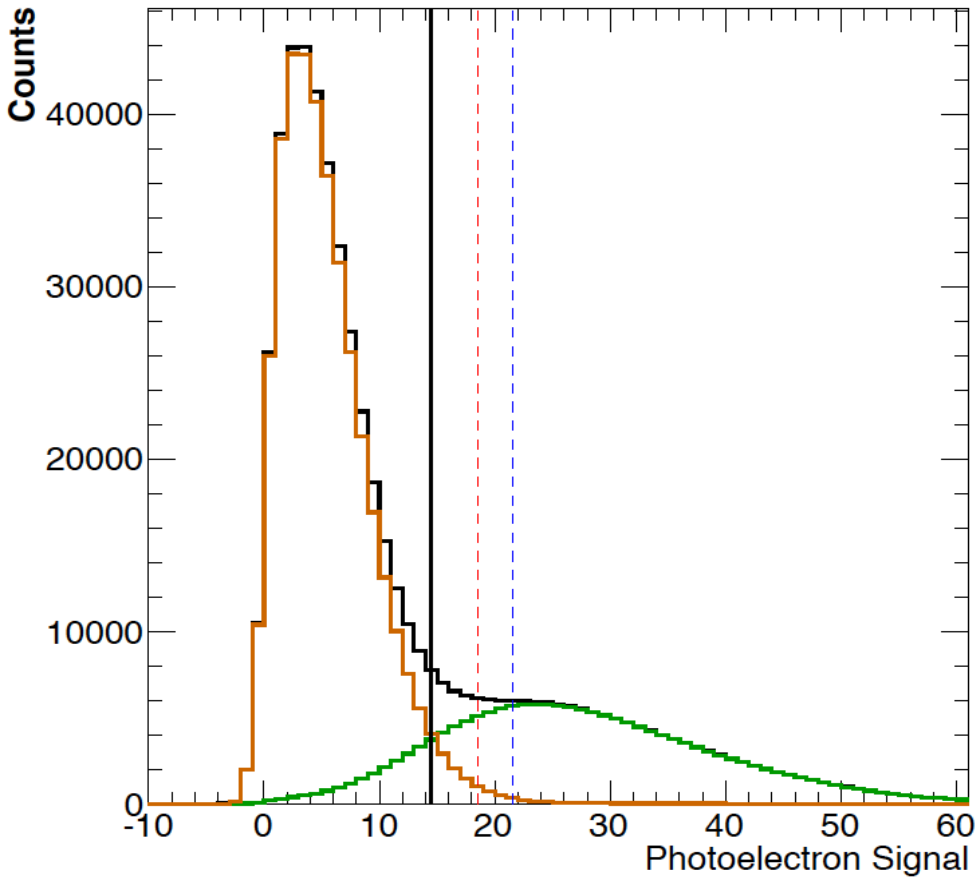


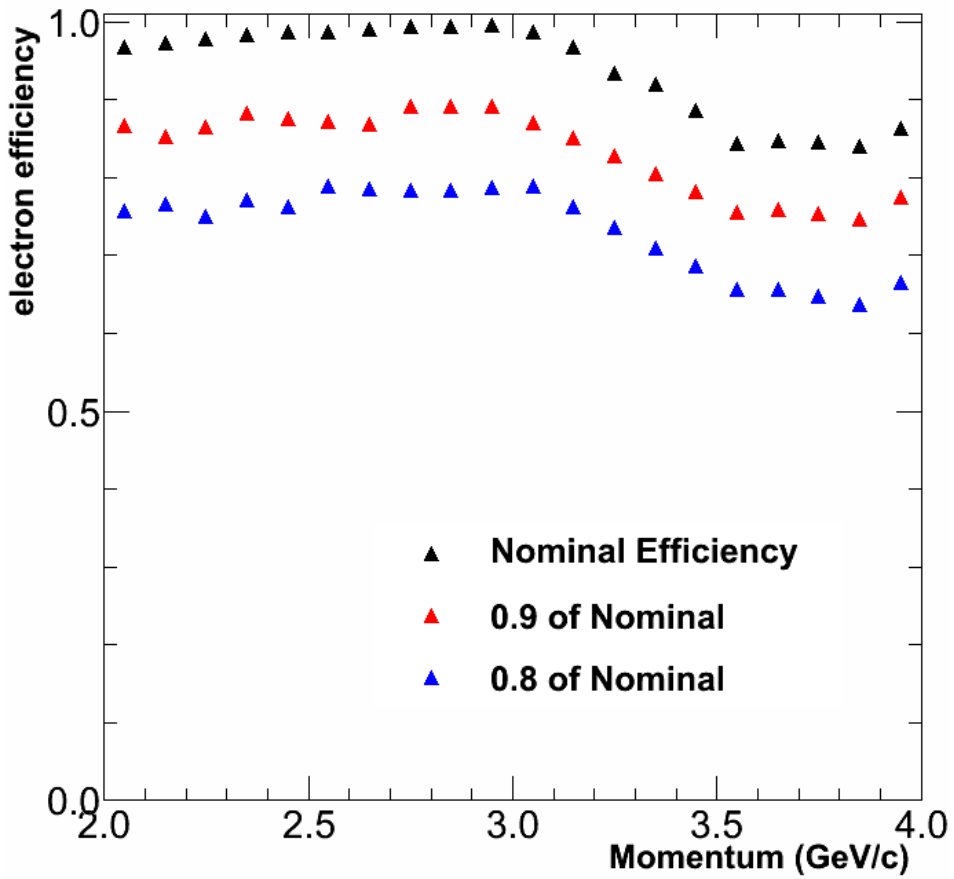
PVDIS



SIDIS

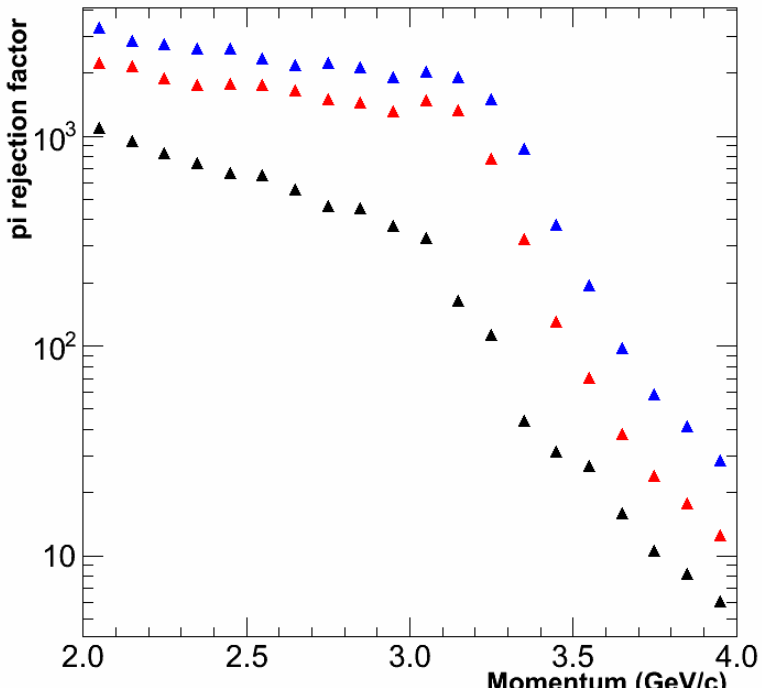
Pion Rejection - PVDIS

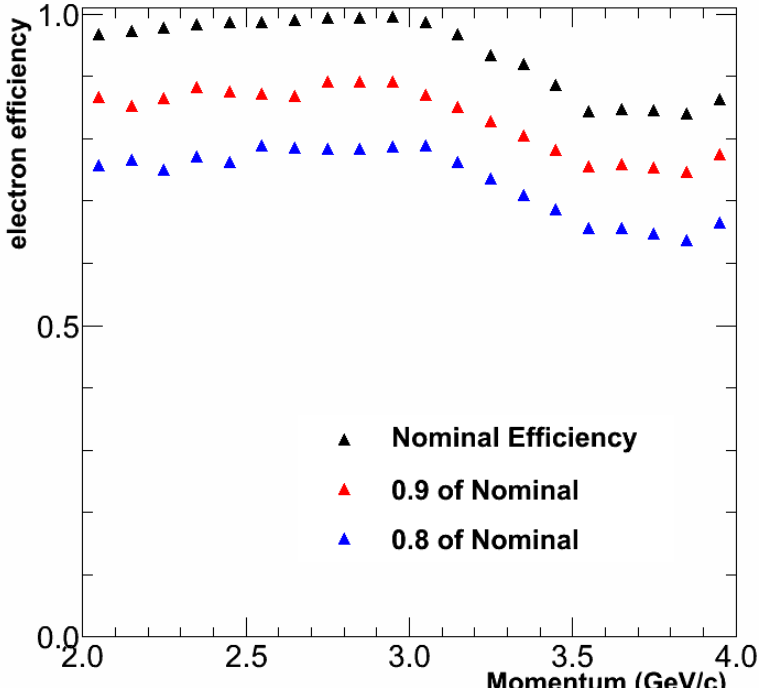


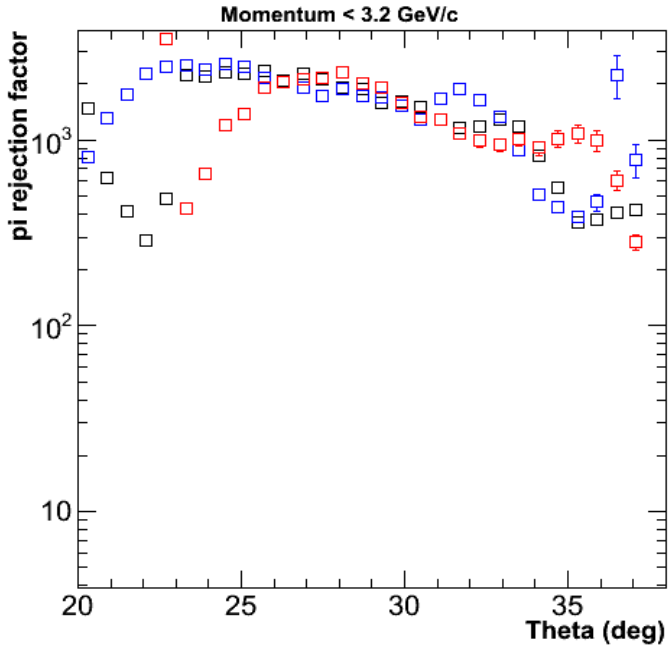


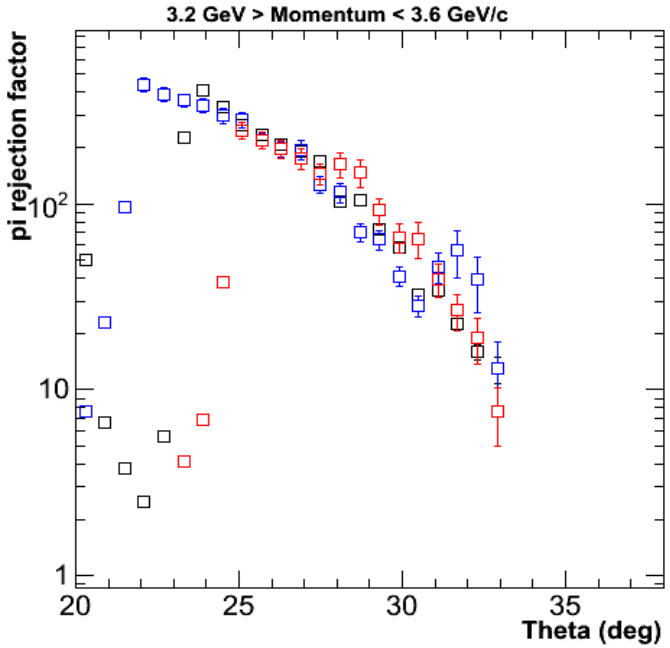
- Rejection per bin in momentum is shown at nominal efficiency (black line), 90% of nominal electron efficiency (red dashed) and 80% (blue dashed).

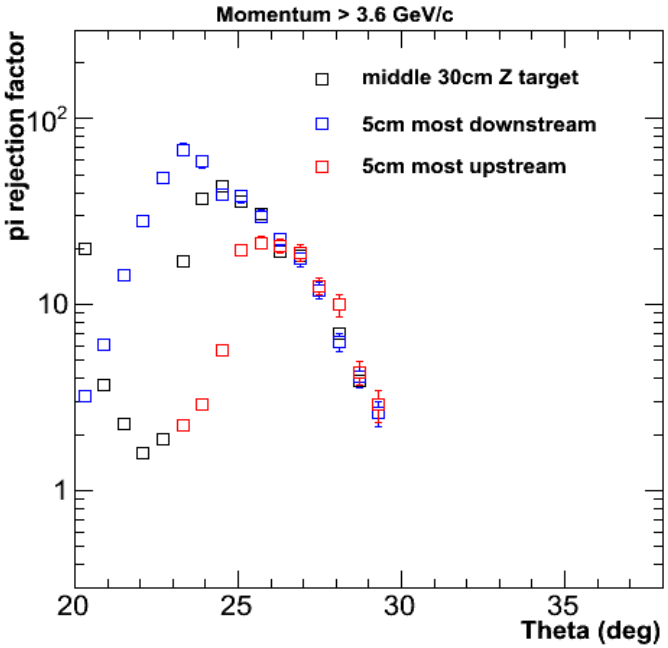
Pion Rejection - PVDIS





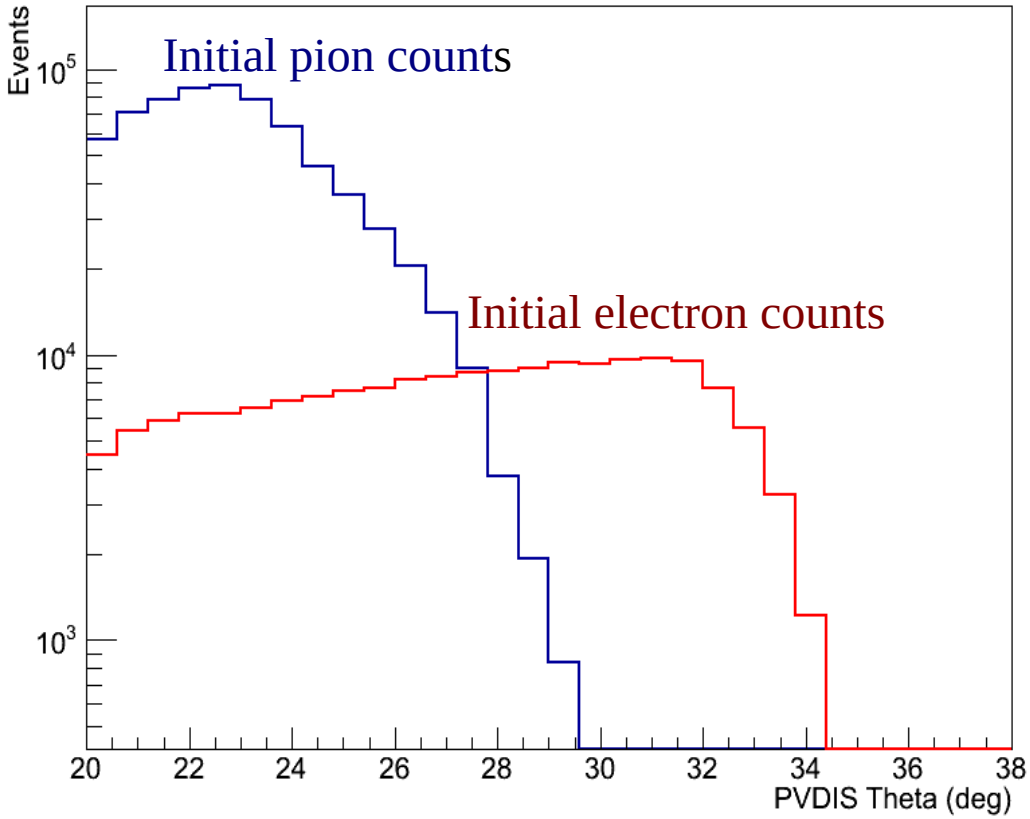




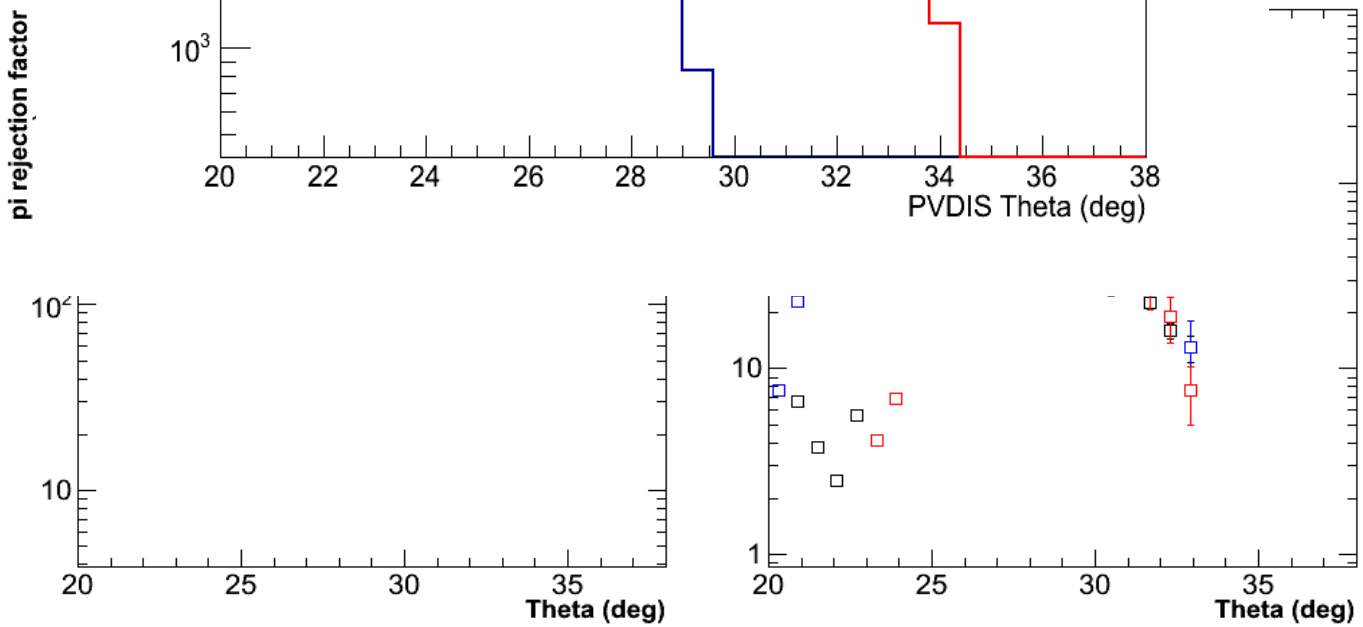


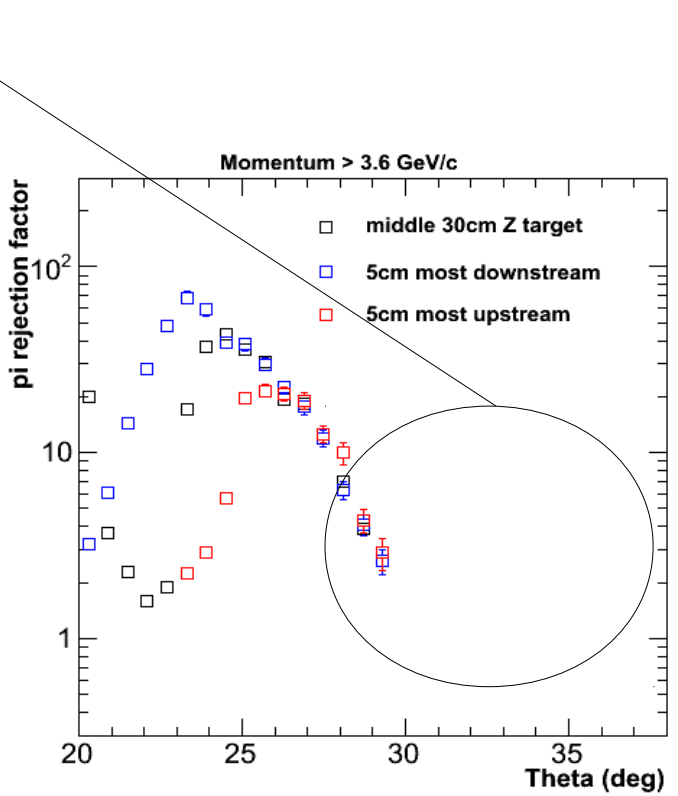
Pion Rejection - PVDIS

central Z vertex and p > 3.6 GeV

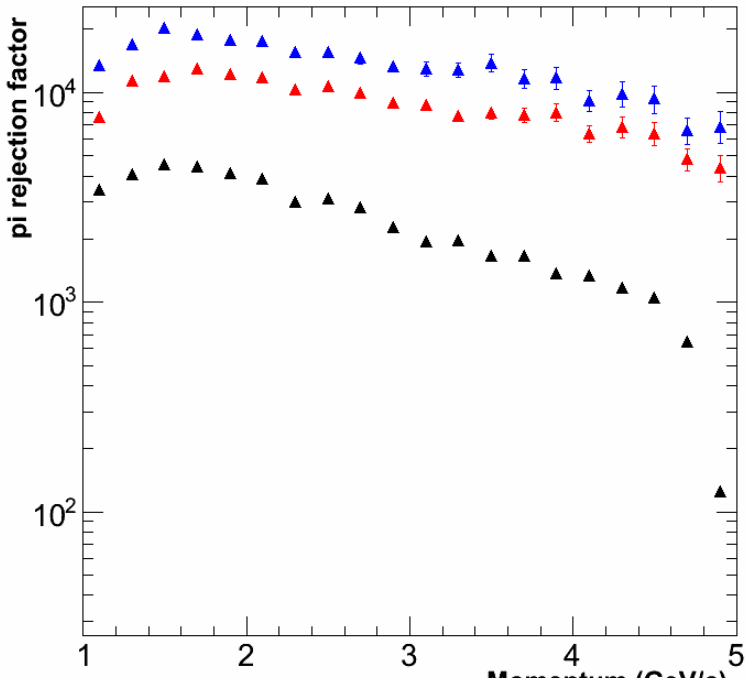


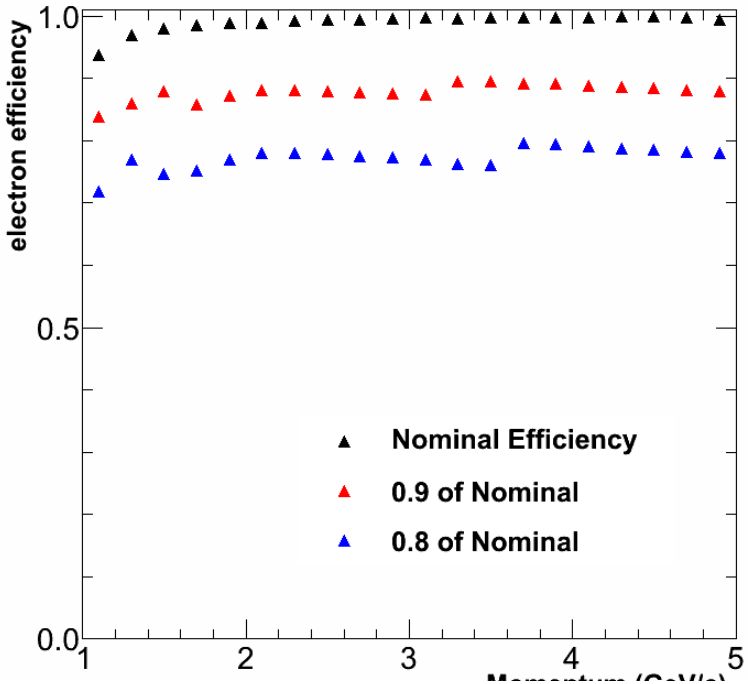
- Pion rejection factor not the whole story. Effectively no pion signal at large theta / momentum.

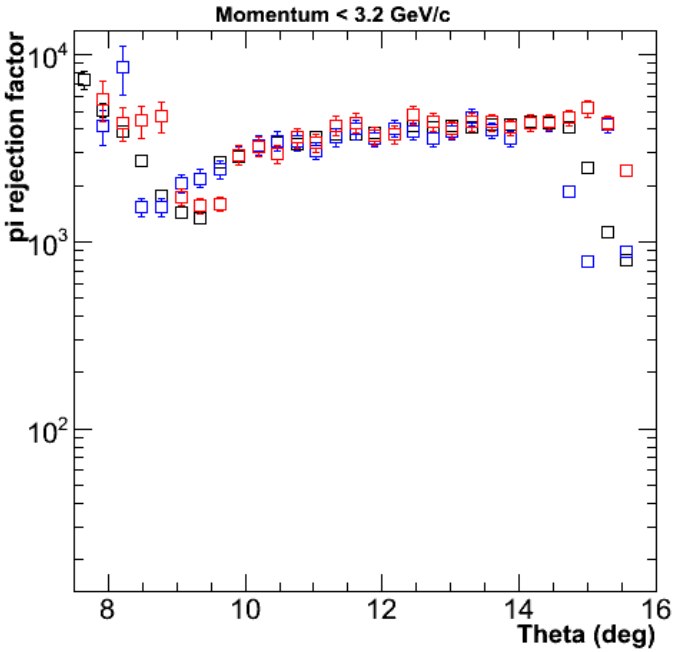


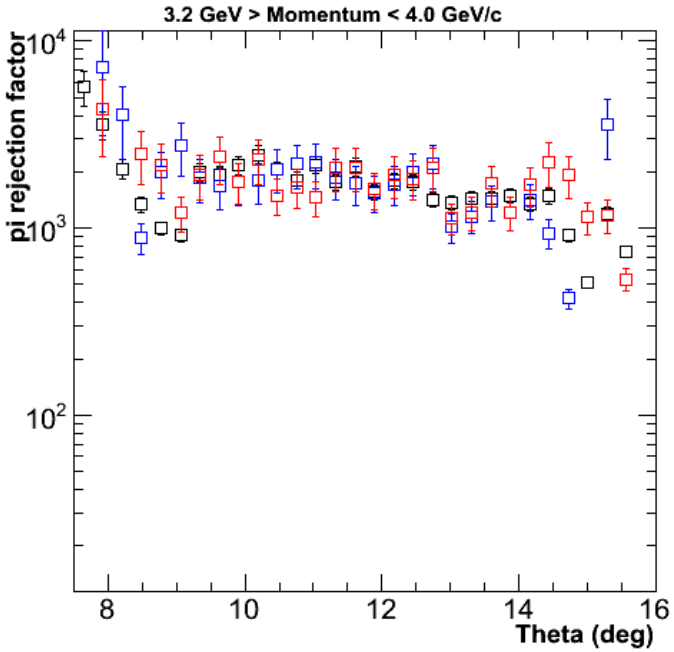


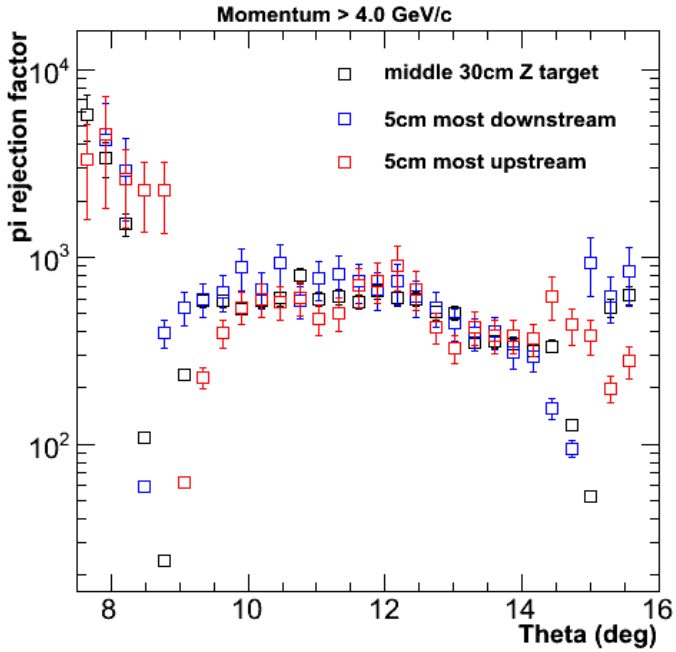
Pion Rejection – SIDIS – Wider Angles











Initial Pile-Up Considerations

- Want to calculate a probability that pions may pile-up to masquerade as an electron signal.
- Plan is to use simple dead-time like calculation.
- Using an ADC gate time of 10 ns.
  - PMT literature says a 0.6 ns rise time
- Total PVDIS π^- rate per TWO sectors in LG cherenkov acceptance ~ 1.5 MHz
- Total PVDIS electron rate per ONE sector ~ 0.5 kHz
- Pion pile-up “candidates” probability is 1.5% (duet) or 0.01% (triplet) over all theta and momenta.
  - Pion pile-up candidate rate is ~ 22 kHz.
- Still need to fold into actual pion signal to find true pile-up probability.

Updated Budget Considerations

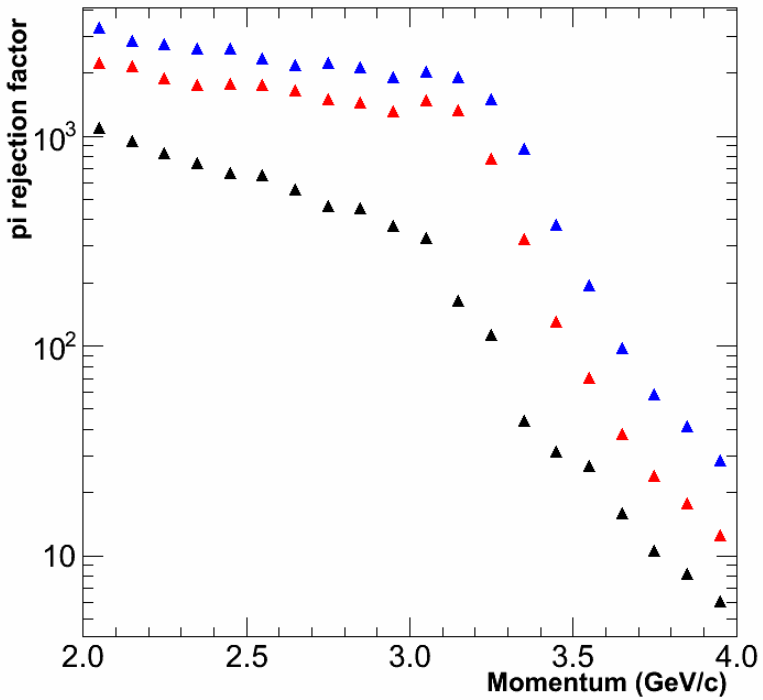
- Design was implemented with a strong desire to minimize costs through re-use of components between SIDIS and PVDIS without significant loss of efficiency for either configuration.
- Mirror cost (all + spares): $350,000
- PMTs (30 x 9 + 10 (spares) H850C0-03): $980,000
- 30 mu-metal cylinder / cones: $50,000
- Mirror coating: eff $0
- Tank / gas system: $350,000
- Total: $ 1,730,000

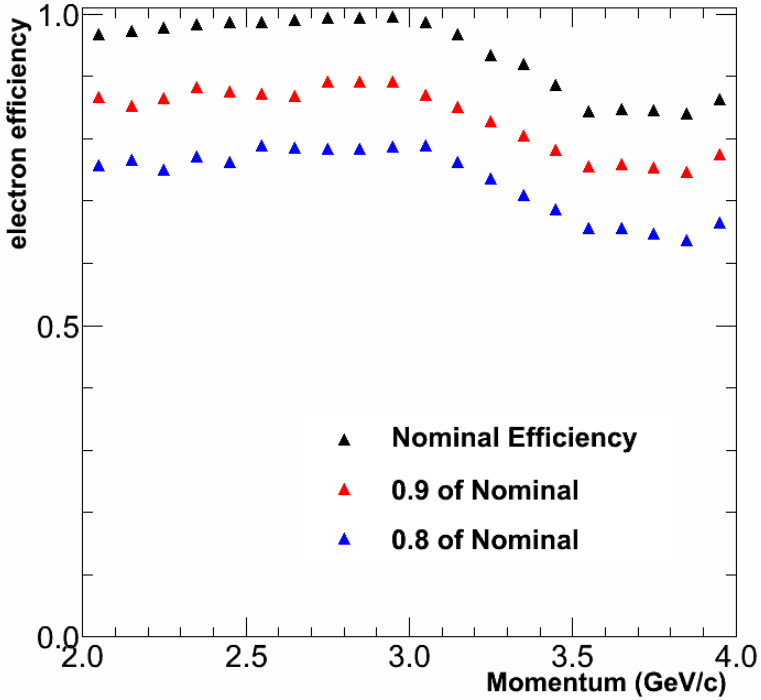
To-Do

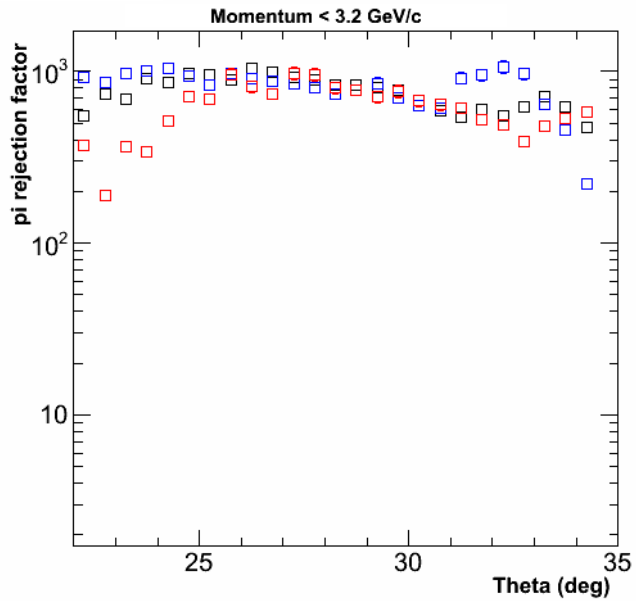
- Simulation:
  - Complete pile-up estimate.
  - Effect of secondaries produced off of baffles.
  - Second look at upstream z target optimization for PVDIS.
  - Track info from PMT pattern matching?
- Engineering / practical:
  - Finalize designs (in concert with other subsystem/structure designs)
  - Prototyping / tests.

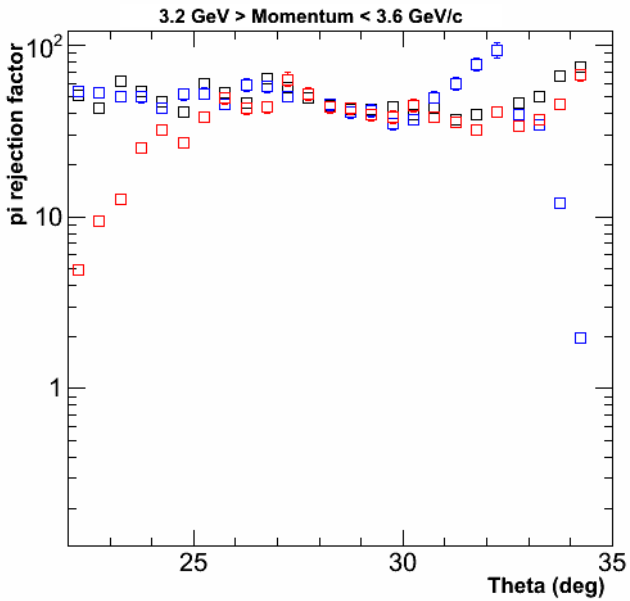
Backups

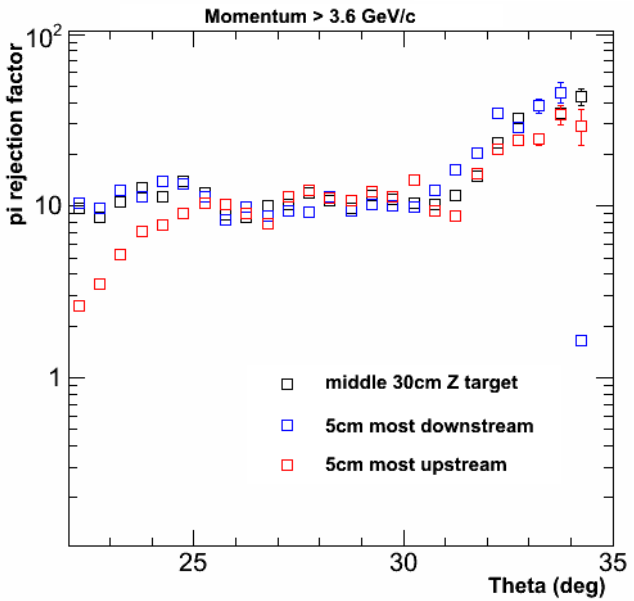
Pion Rejection - PVDIS



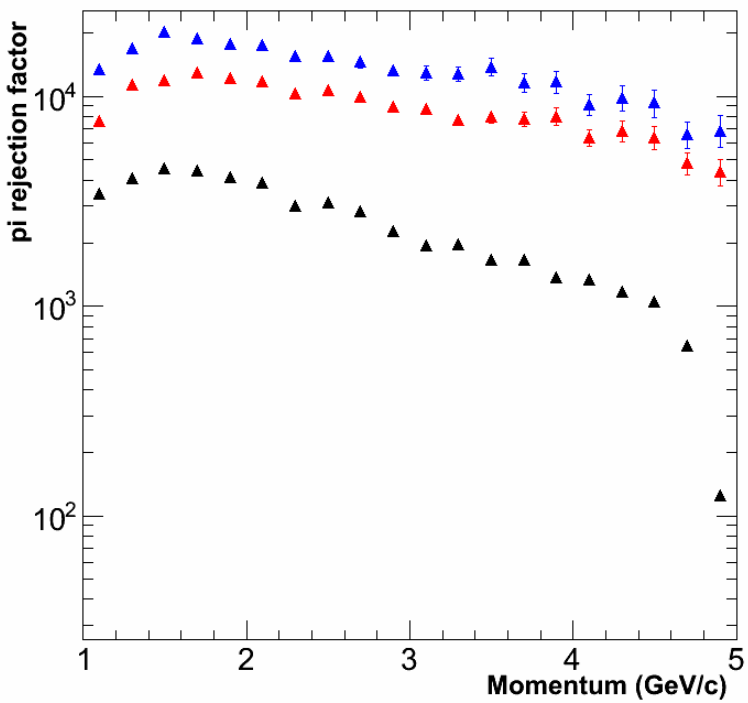


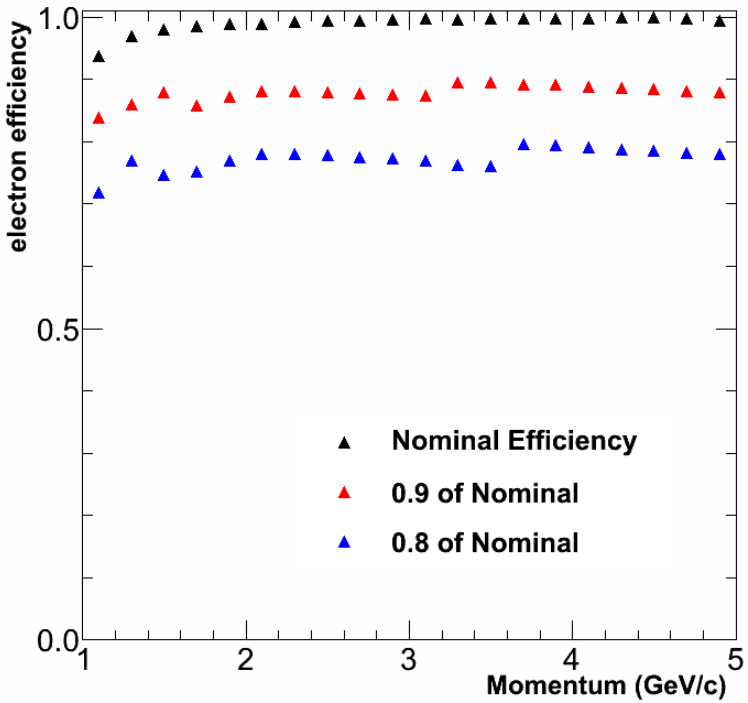


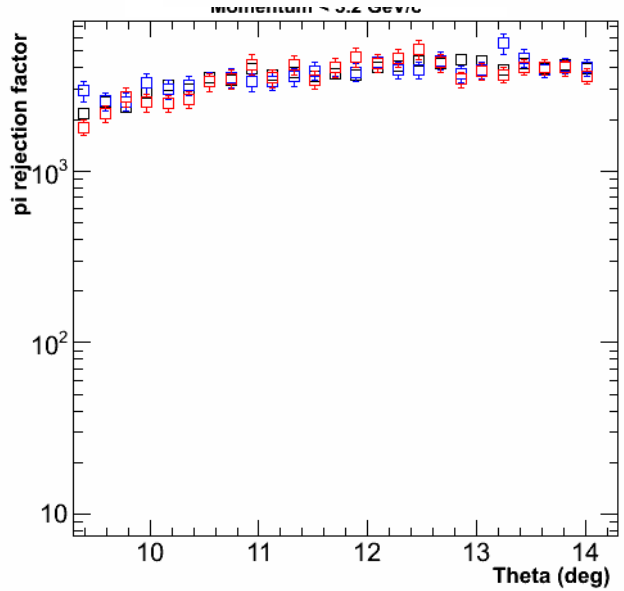


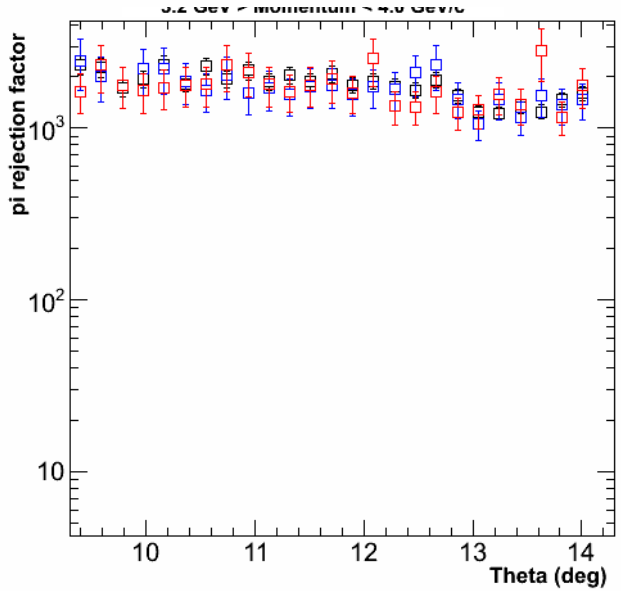


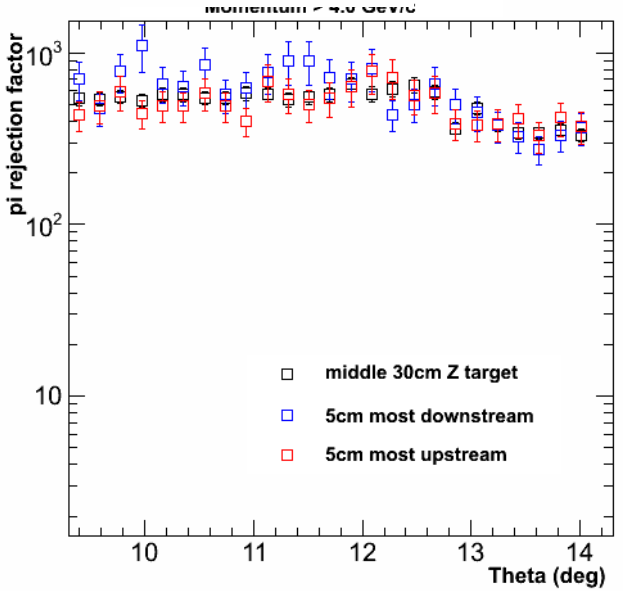
Pion Rejection - SIDIS

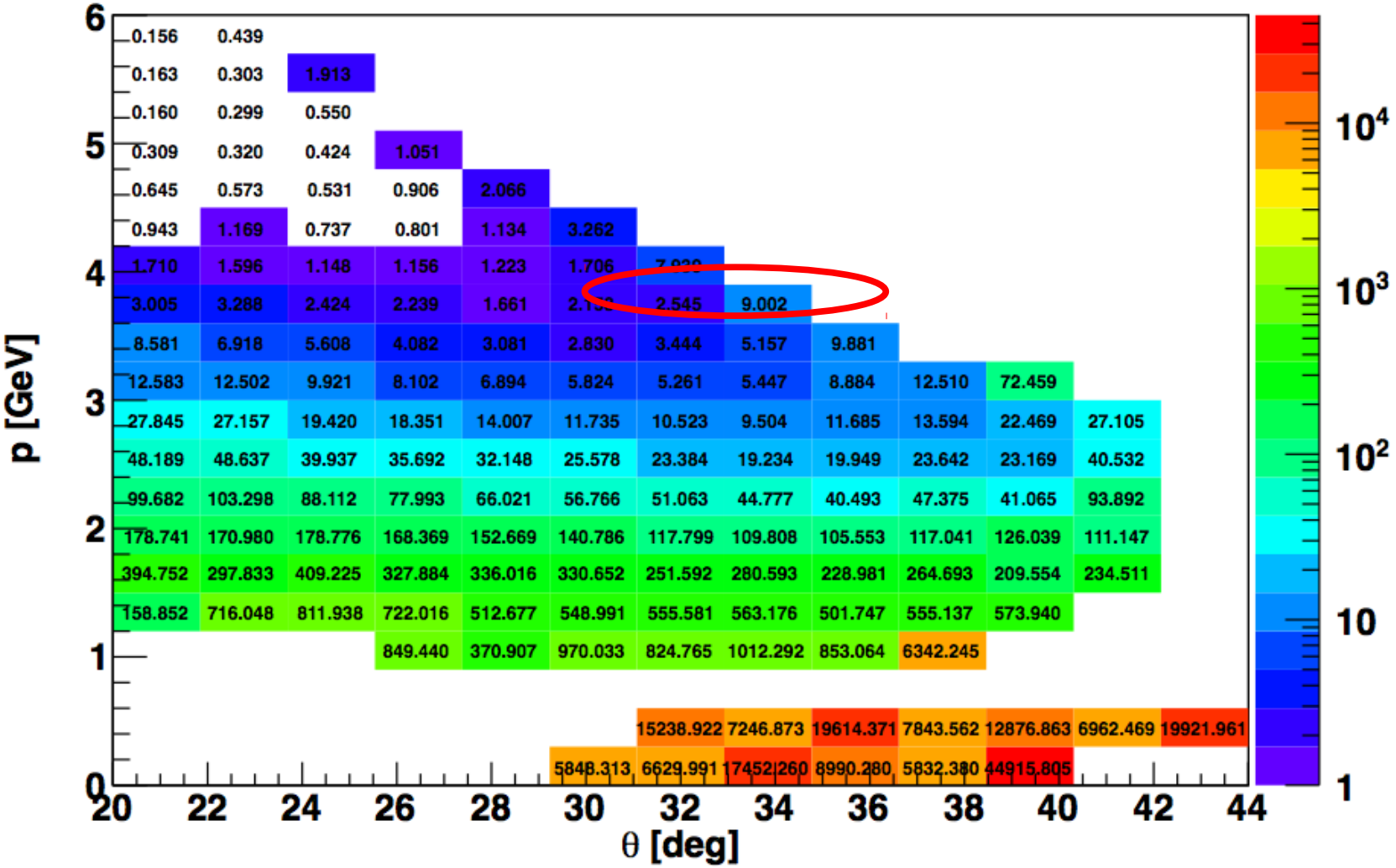








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0.160 0.299 0.550
0.309 0.320 0.424 1.051
0.645 0.573 0.531 0.906 2.066
0.943 1.169 0.737 0.801 1.134 3.262
1.710 1.596 1.148 1.156 1.223 1.706
3.005 3.288 2.424 2.239 1.661 2.545 9.002
8.581 6.918 5.608 4.082 3.081 2.830 3.444 5.157 9.881
12.583 12.502 9.921 8.102 6.894 5.824 5.261 5.447 8.884 12.510 72.459
27.845 27.157 19.420 18.351 14.007 11.735 10.523 9.504 11.685 13.594 22.469 27.105
48.189 48.637 39.937 35.692 32.148 25.578 23.384 19.234 19.949 23.642 23.169 40.532
99.682 103.298 88.112 77.993 66.021 56.766 51.063 44.777 40.493 47.375 41.065 93.892
178.741 170.980 178.776 168.369 152.669 140.786 117.799 109.808 105.553 117.041 126.039 111.147
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