SoLID Collaboration Meeting

Heavy gas Cerenkov

July 9th, 2014

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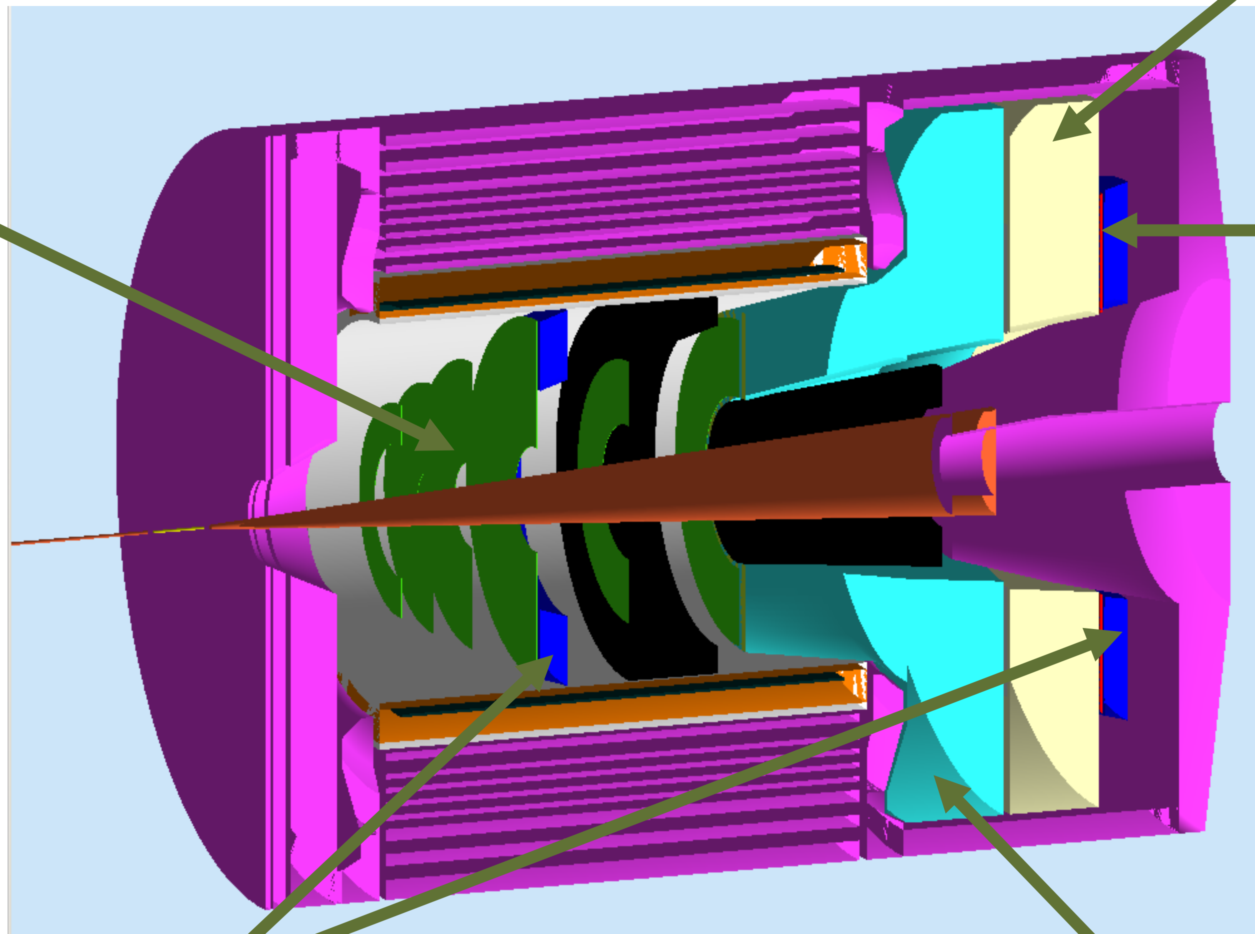
OUTLINE

- ❖SIDIS Configuration
- ❖Design
- ❖Performances
- ❖Multi-Anodes PMTs, field tests
- ❖Budget Estimate

SoLID SIDIS configuration

CLEO II Geometry



SIDIS Heavy Gas Cherenkov

- **Useful momentum range: 2.5-7.6 GeV/c**
- **Cover 8° - 14.8° angular range**
- **Kaon contamination goal <1%**

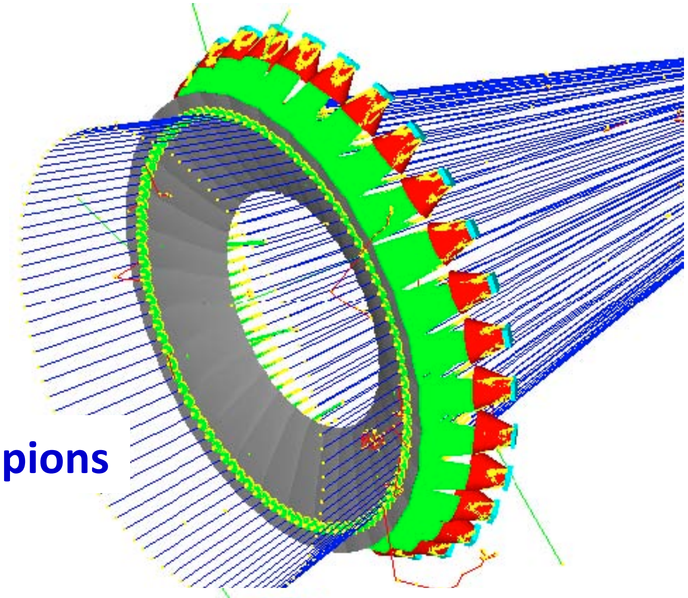
- Radiator: C_4F_8O at 1 .5 atm at 20 ^{0}C, n=1.002, 1m thick

- Mirrors: one spherical mirror per sector. Al+MgF_2 reflective coating

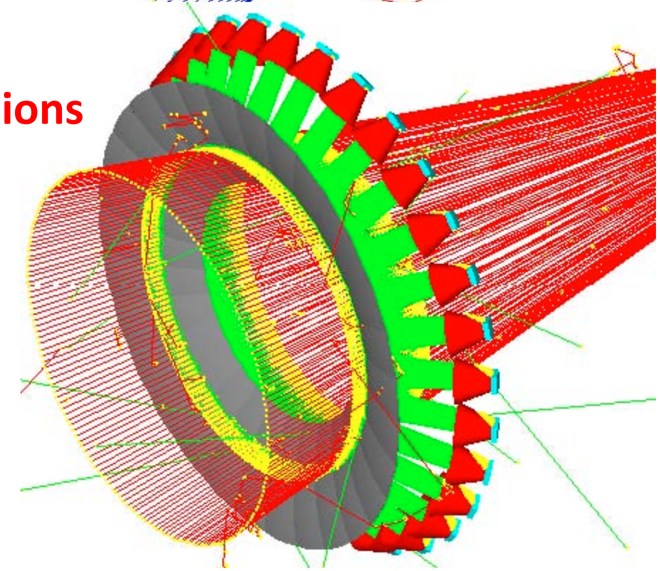
- Photodetectors: maPMTs tiled 4x4=16 per sector with a total of 30 sectors

- maPMTs array shielded with a mu-metal cone, and embedded mirror to enhance the angular acceptance

- Optics optimized for both positive and negative pions

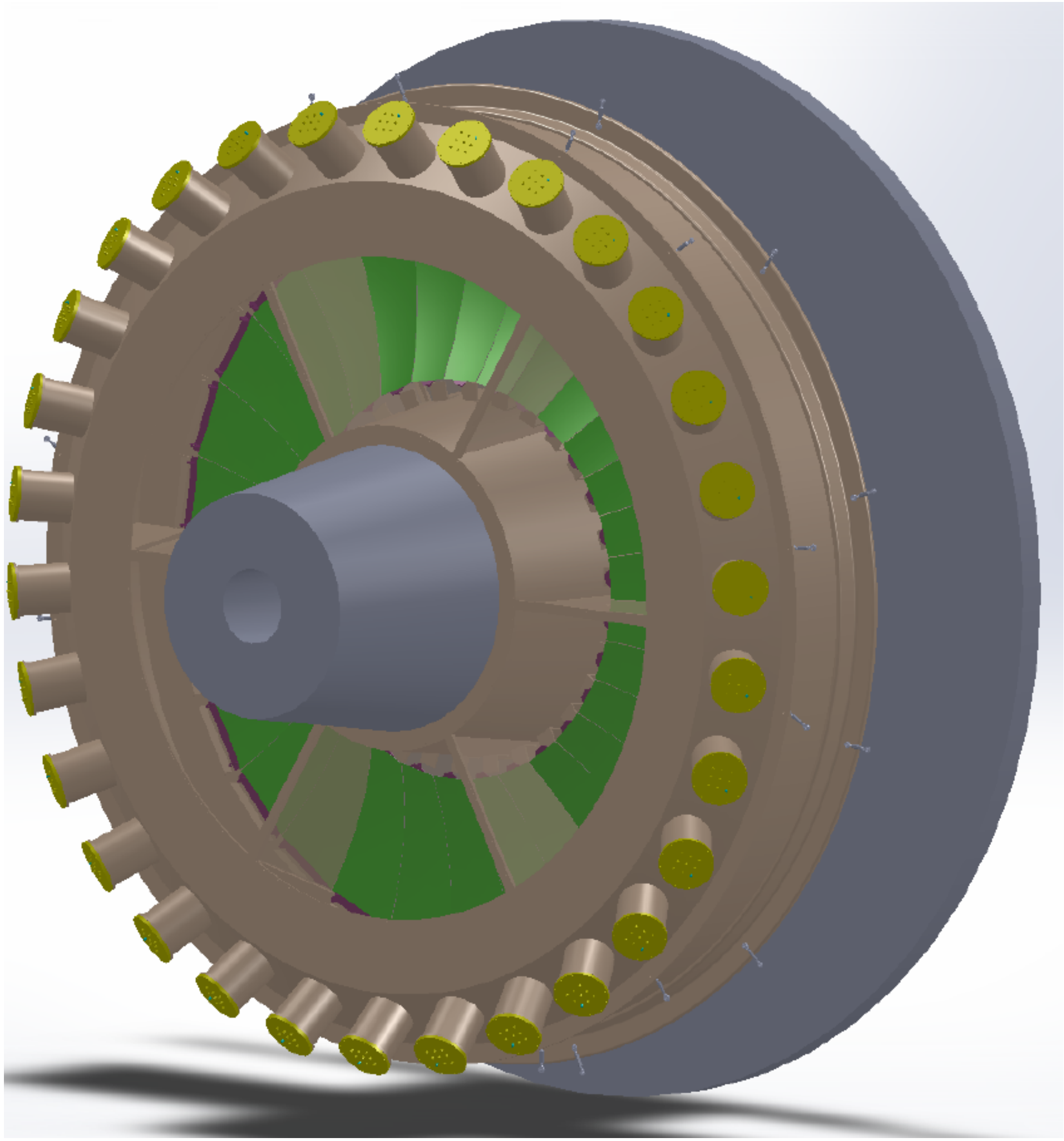


Positive pions

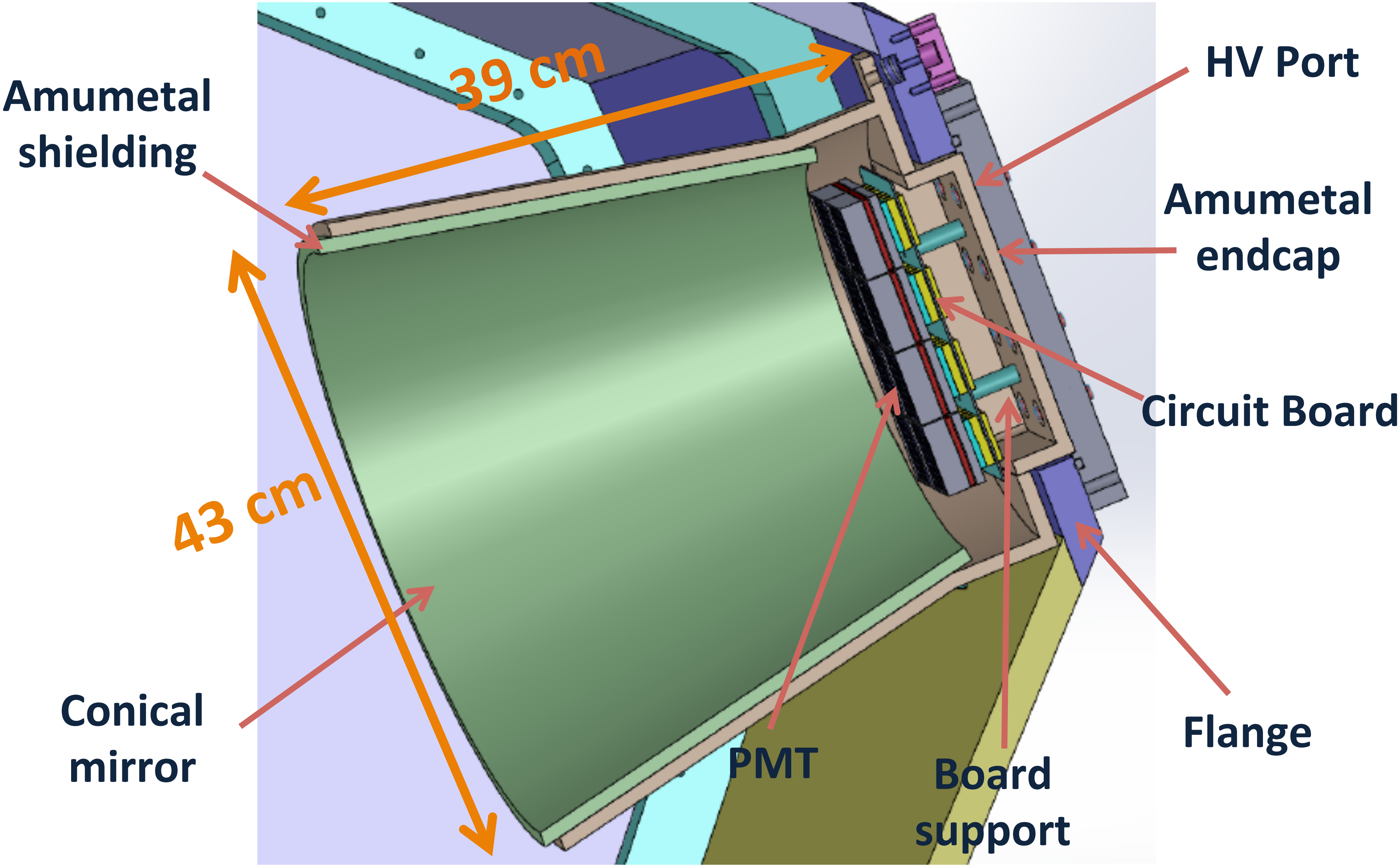


Negative pions

Heavy Gas Cherenkov Design



Heavy Gas Cherenkov Design

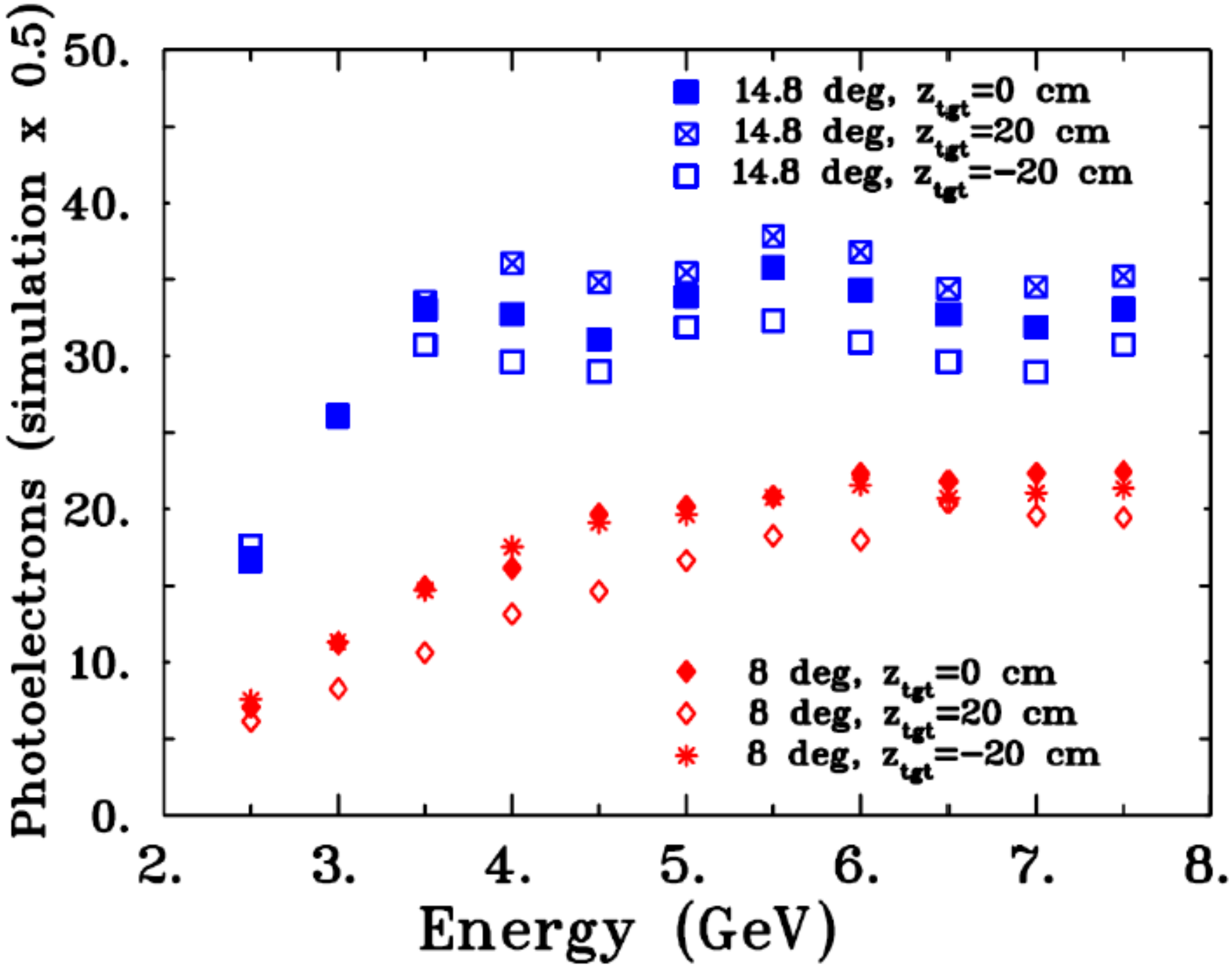


Simulation of the Heavy gas Cherenkov

- **GEANT4 Optics Simulations**

  - CLEO II Magnet Geometry
  - Target length and beam raster included
  - Gas transparency, mirror and cone reflectivity, photocathode response are all included
  - Optimization was performed to favored small scattering angles
  - Keep max number of reflection on cone to 1

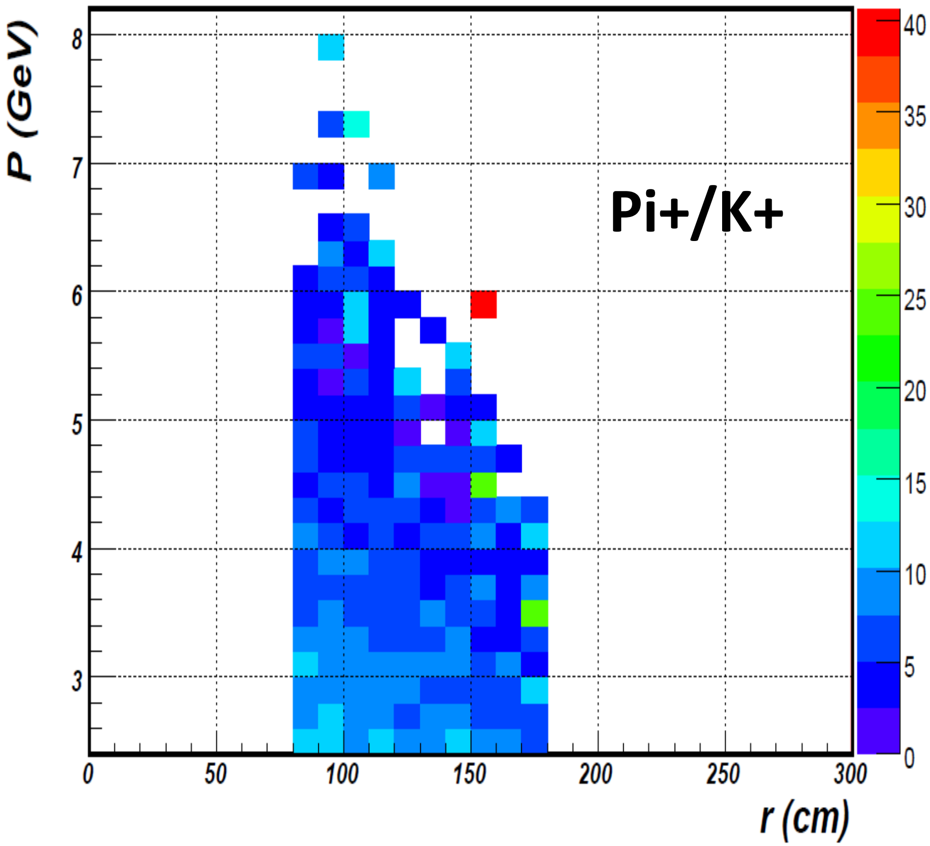
Photoelectron Yield

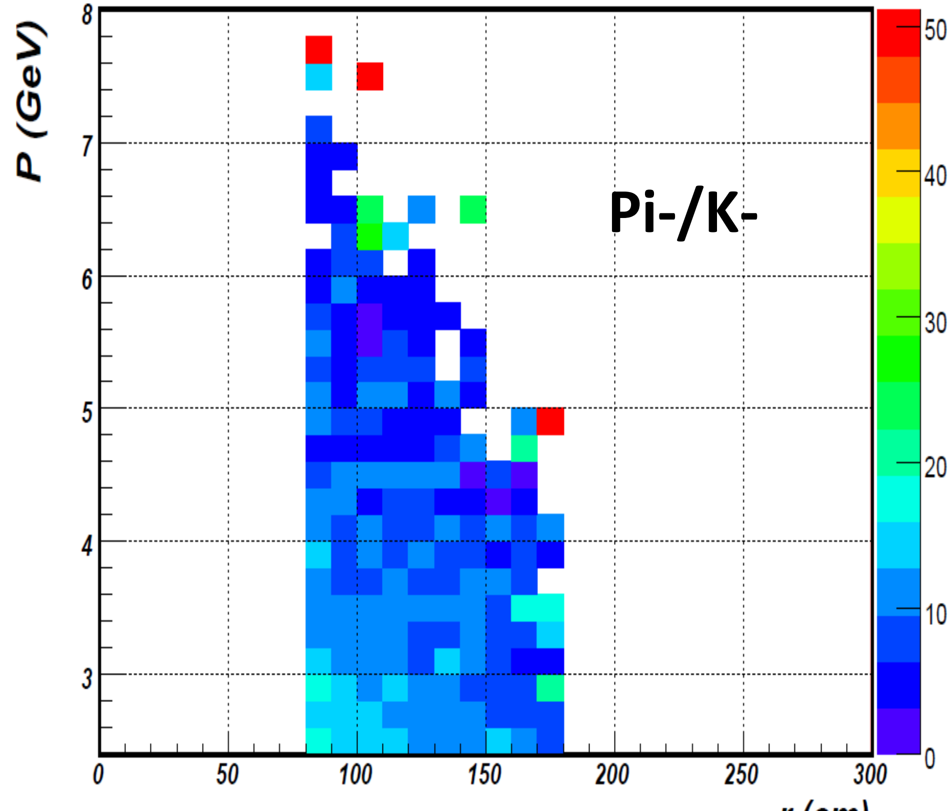


- Response for positive pions simulated with a safety factor of 0.5.

- Similar results obtained for negative pions

Pion/Kaon ratio





Radial dimension of the Cerenkov

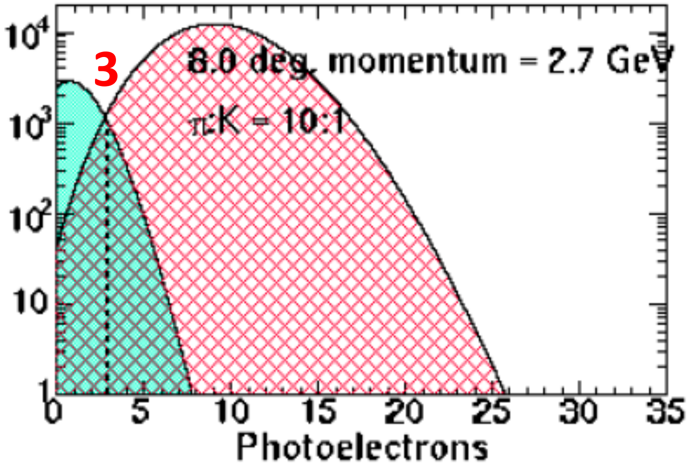
Ratio around 10 up to P~5 GeV/c and <10 above ~5GeV

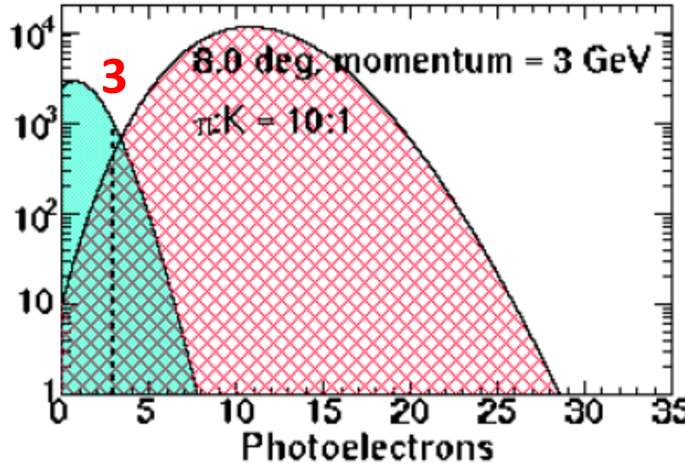
But yield is at least 15 above 5 GeV in the worst case (8deg)

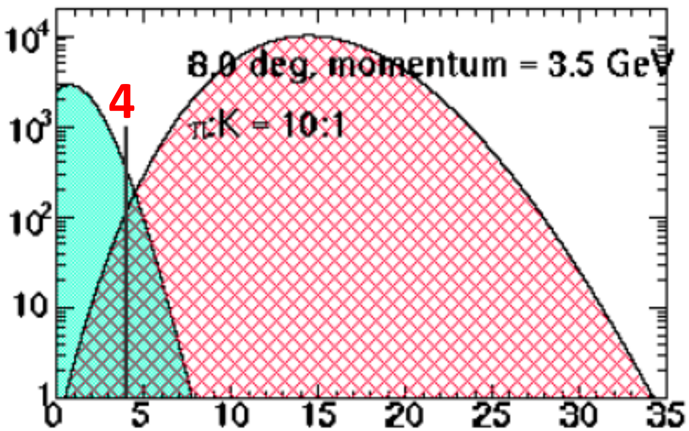
Pion efficiency

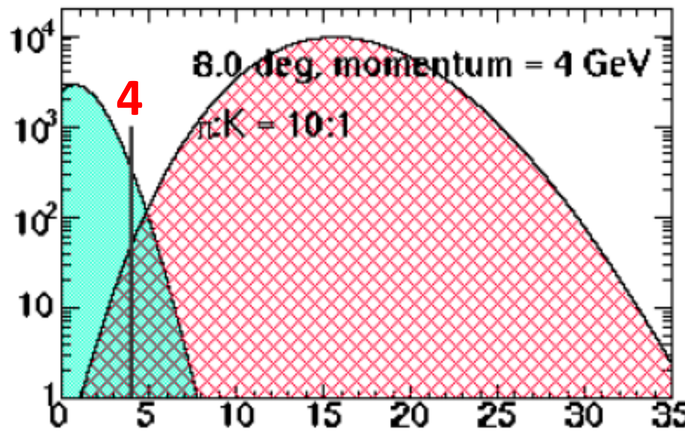
pion efficiency: 99.0%
kaon contamination: 0.8%

pion efficiency: 99.6%
kaon contamination: 0.8%









Pion distributions
Kaon distributions

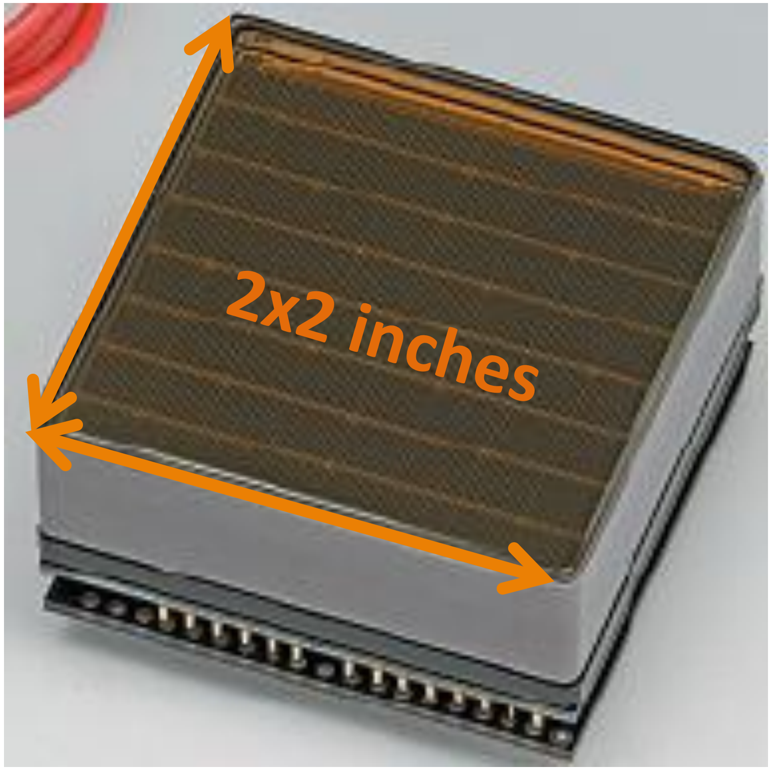
Hypothesis:

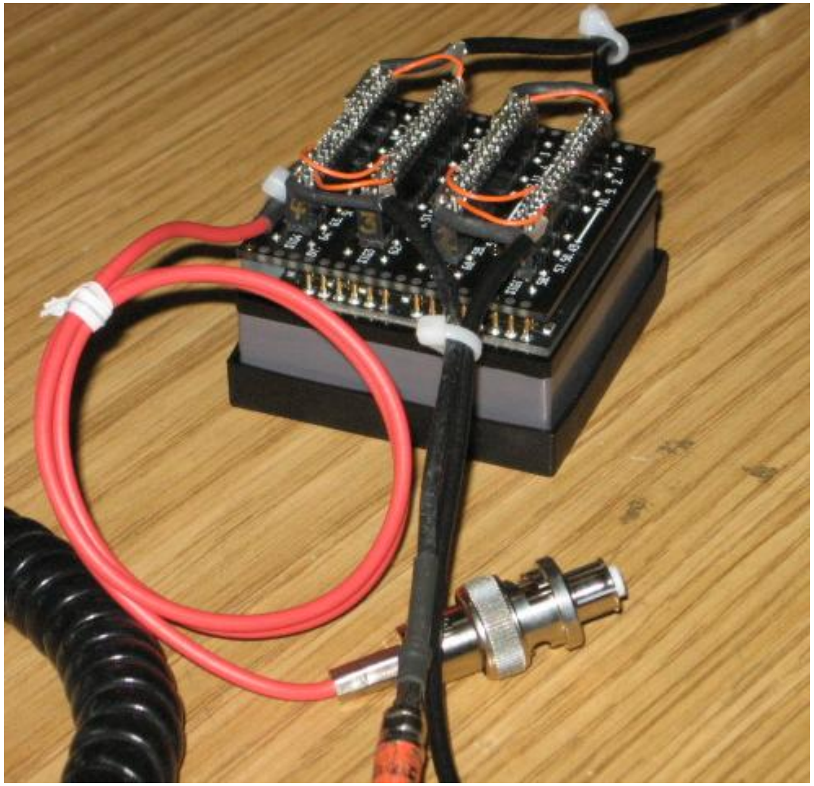
- **kaon:pion = 1:10**
- **PMT resolution: 1 p.e. (from measurements)**
- **kaons give at most 1 p.e. below threshold**

pion efficiency: 99.7%
kaon contamination: 0.3%

pion efficiency: 99.8%
kaon contamination: 0.3%

Hamamatsu H8500C





Readout Option: Multi-anode PMT

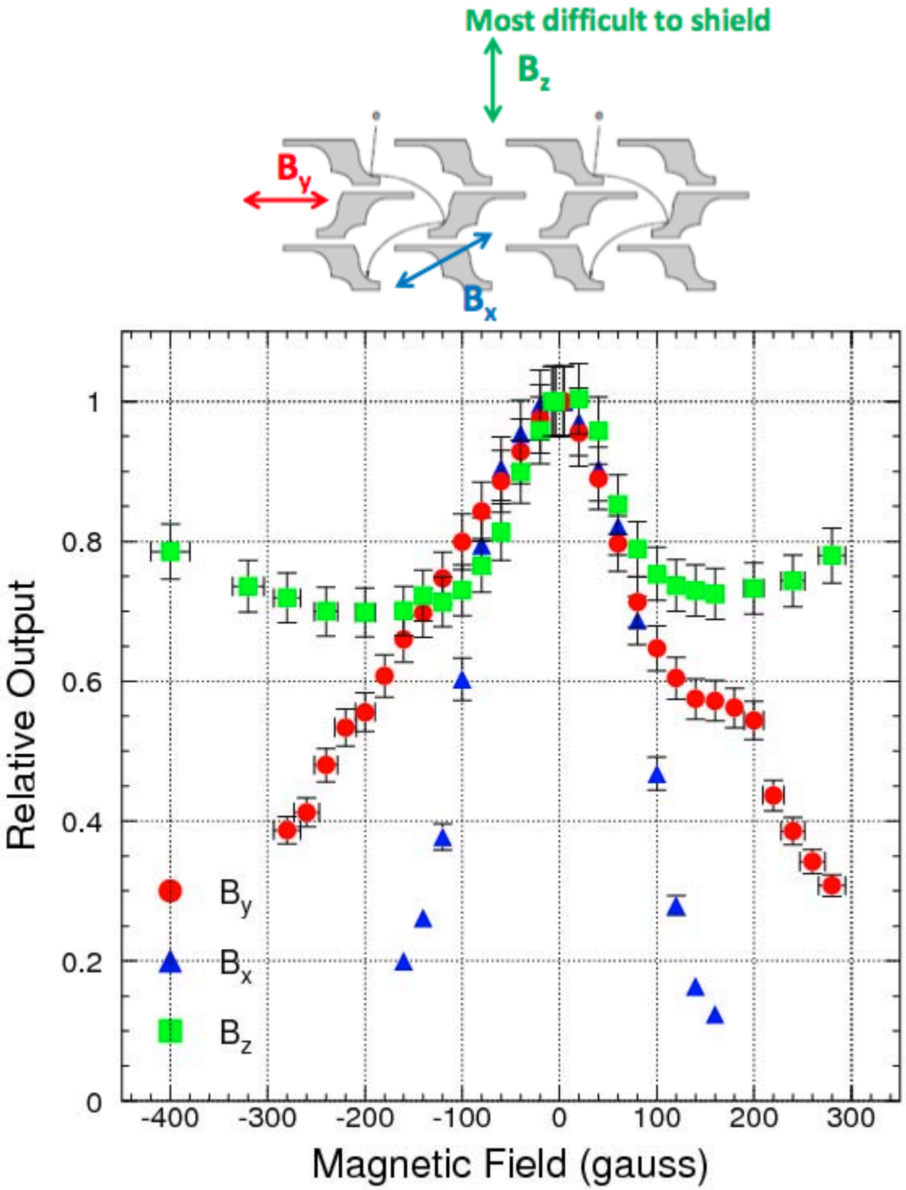
- Single photoelectron resolution: 1 pe or better (measured)
- Resistant to magnetic fields

PMT magnetic field test

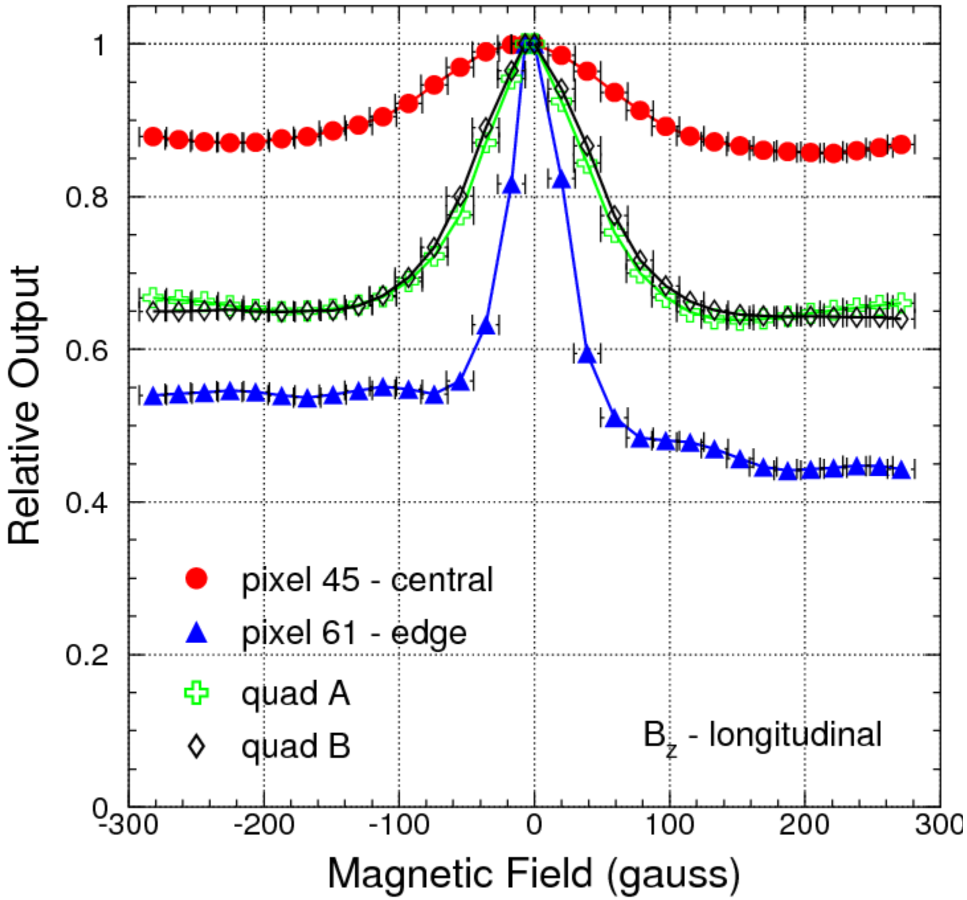
❖ Loss due to magnetic field mainly due to gain loss in the multiplication chain not at the first dynode for the longitudinal field

❖ Largest losses experienced when the magnetic field is parallel to the face of the PMT but can be easily shielded

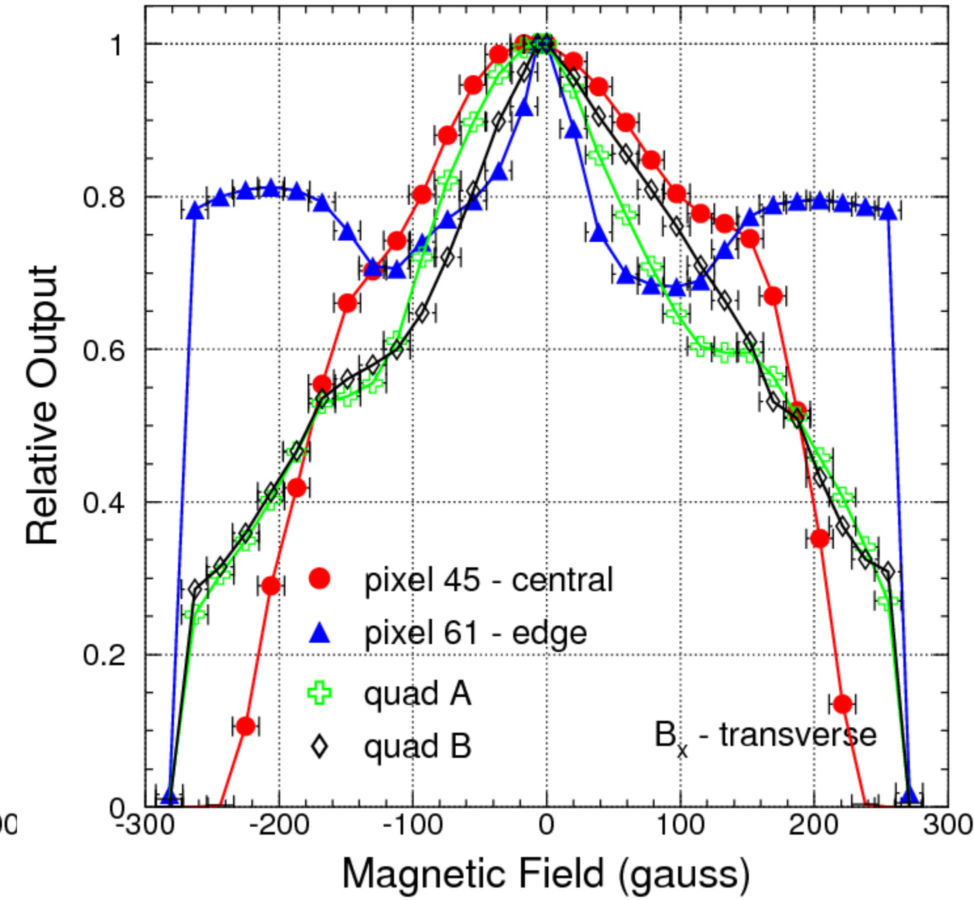
S P Malace, B. Sawatzky, H. Gao
2013 *JINST* 8 P09004



PMT magnetic field test

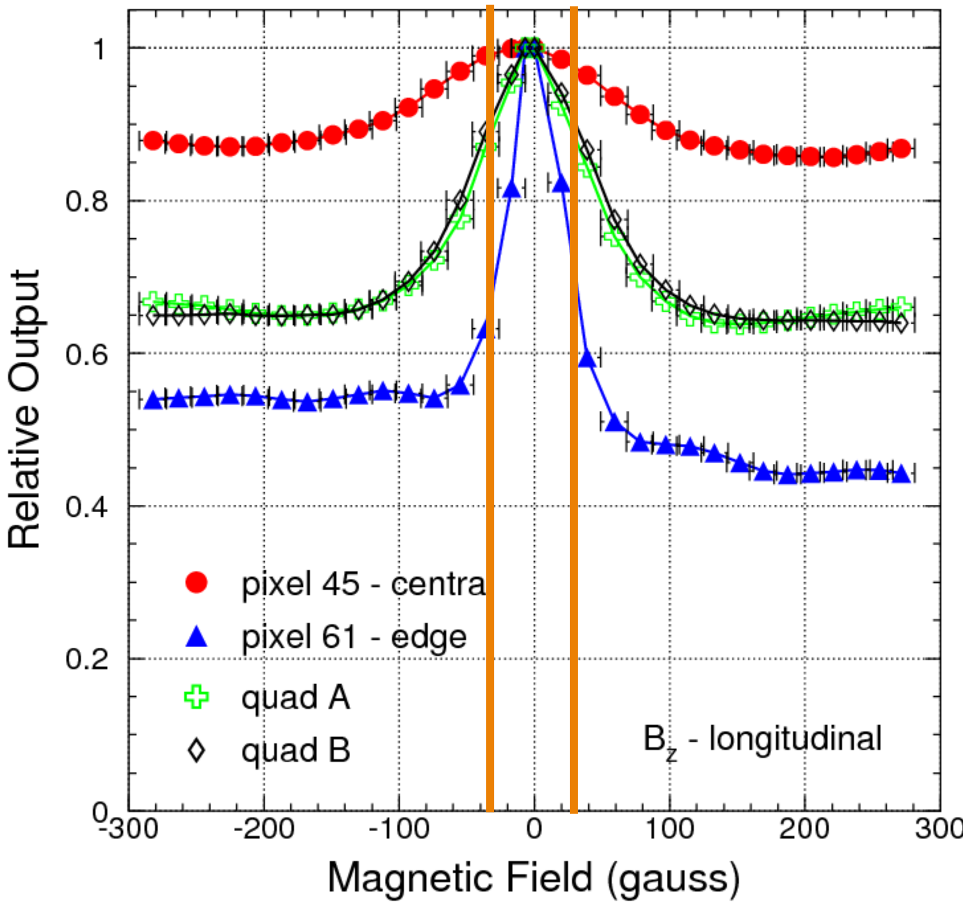


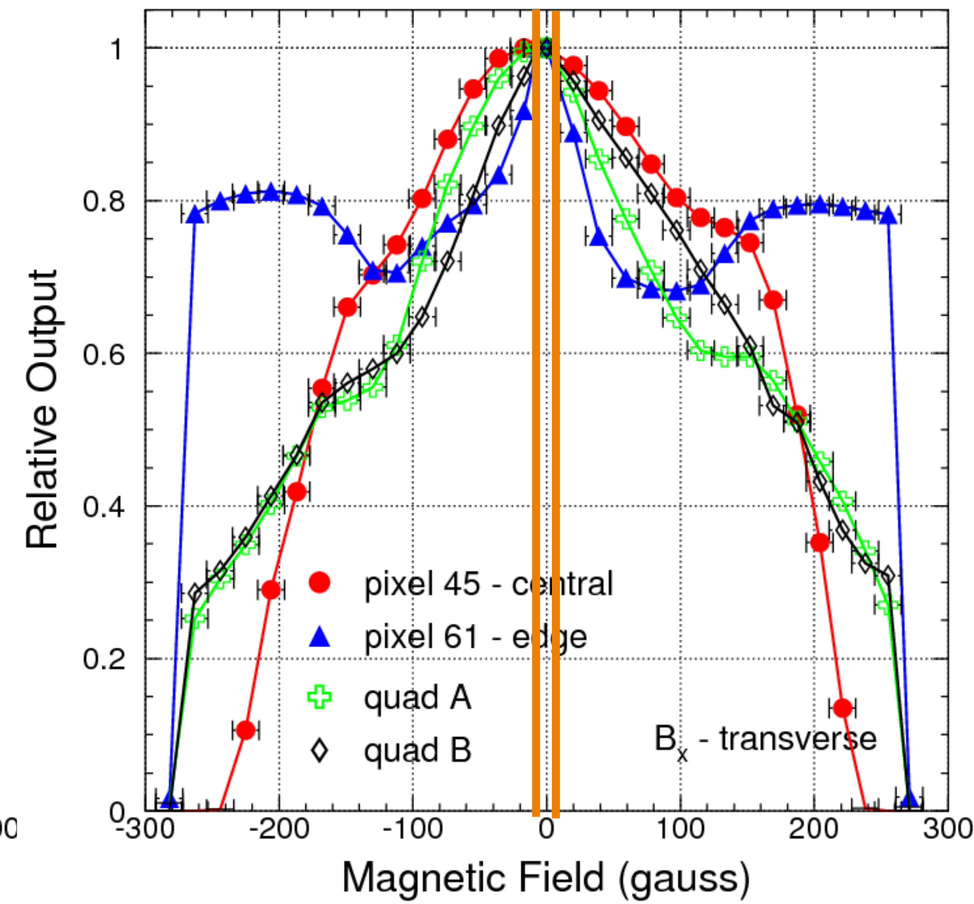
Longitudinal



Transverse

PMT magnetic field test



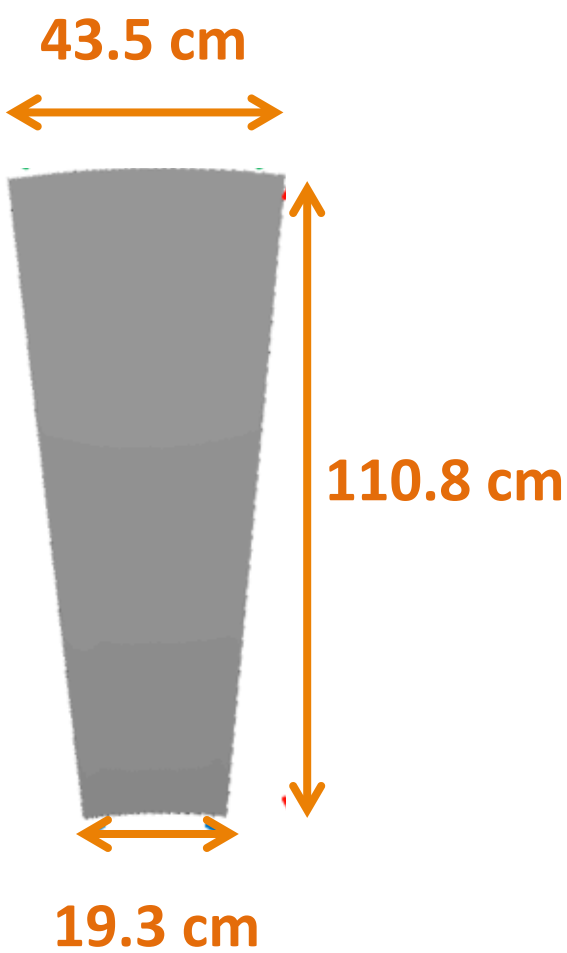


Longitudinal **Transverse**

Mu-metal can shield in
- **longitudinal direction: from 200 G to 15-30 G**
- **transverse direction: from 100 G to 3-5 G**

Spherical Mirror

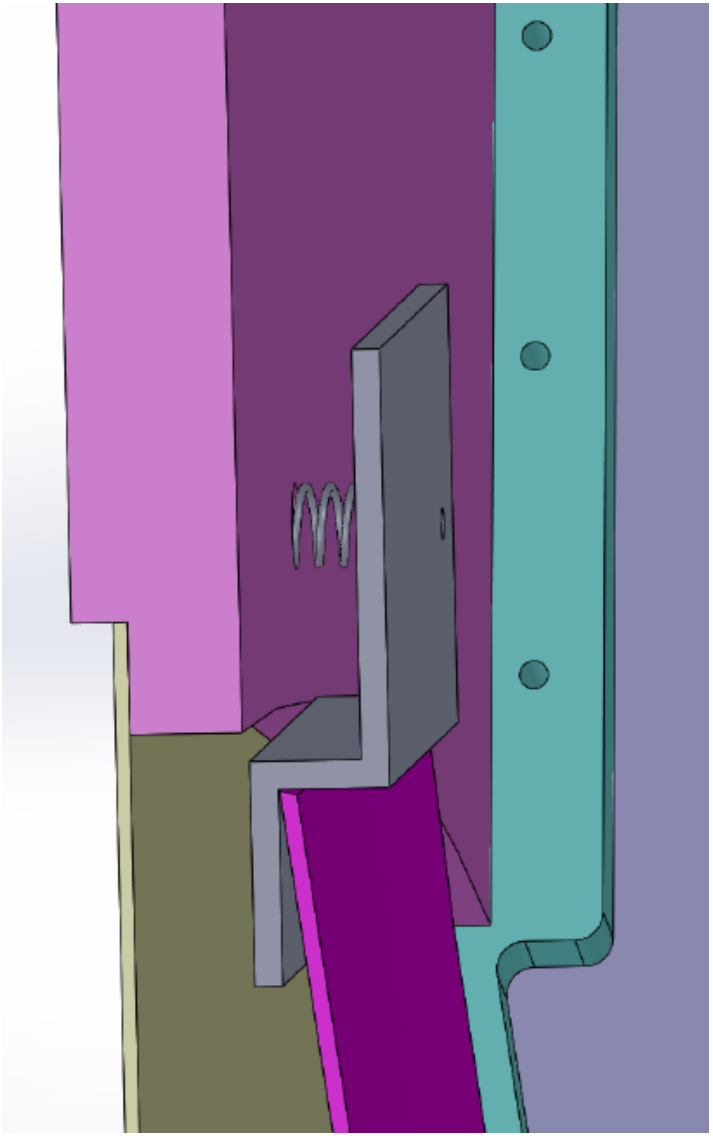
- 30 Spherical composite mirrors from CMA USA (carbon fiber reinforce polymer)
- Radius of curvature: 228.5 cm
- Light weight 6 kg/m^2
- 5mm thick (mirror + structure)
- Al + MgF_2 coating: >85% reflectance
- Mounted at 3 points on both inner and outer ends
- Successfully used in the CMS experiment



Spherical Mirror

TOP

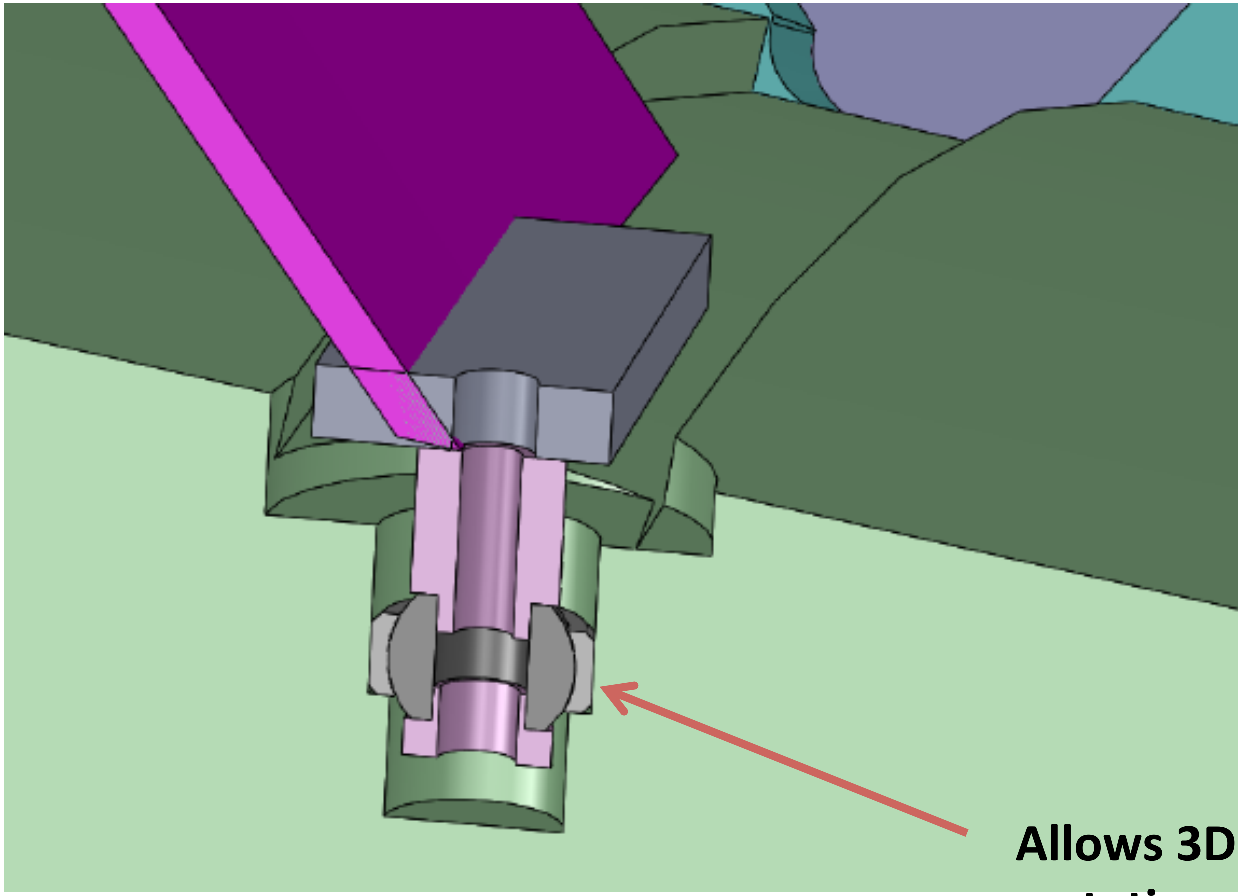
Bottom



Spherical Mirror

TOP

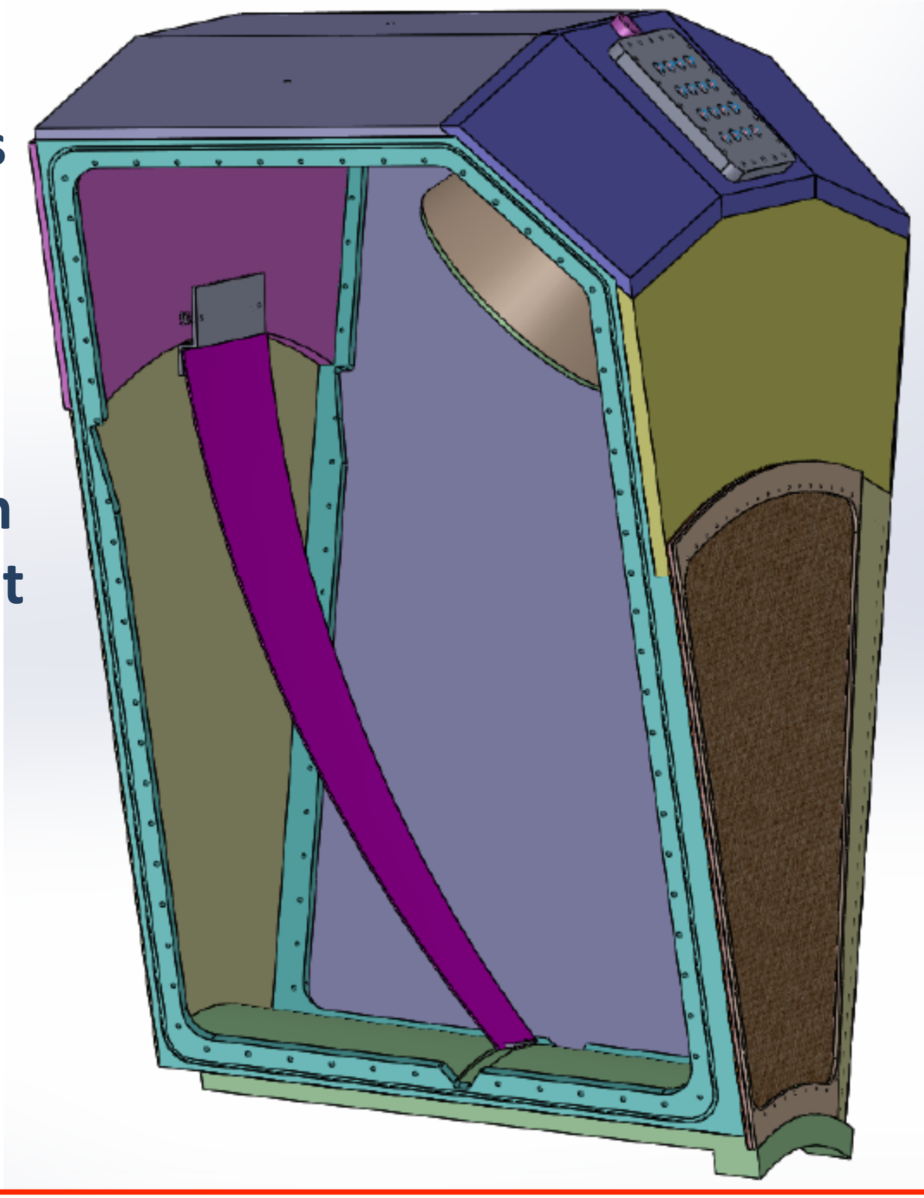
Bottom



Allows 3D rotation

Heavy gas Cherenkov Prototype

- Goal test the optical components, the thin window and gas tightness
- 1 cone, 1 mirror and 1 PMT array
- Building and assembly will happen at Duke University (thin window at JLab)
- Check the mirror reflectivity, curvature and uniformity,
- Tune the alignment



Cost Estimate

ITEM	COST (k$) / FTE
Prototype	50 / 2.5
Full Tank	300 / 4.5
Mirrors	300
Cones	120
PMTs	1680
Gas System	85 / 0.5
Gas	154
Total	$2,689 / 7.5

Summary

- Good reference design for the pion Cherenkov detectors of SoLID
- Full Geant4 simulation, very good projected performances
- Extensive studies of resistance of PMT to magnetic field
- Mu-metal from Amuneal will satisfy the shielding requirements
- Composite Mirrors from CMA USA
- Need to build a prototype