Light Gas Cherenkov Detector for SoLID

Update: May 2015

Michael Paolone
Edward Kaczanowicz
Zein-Eddine Mezziani

Temple University

pi0 rate comparison

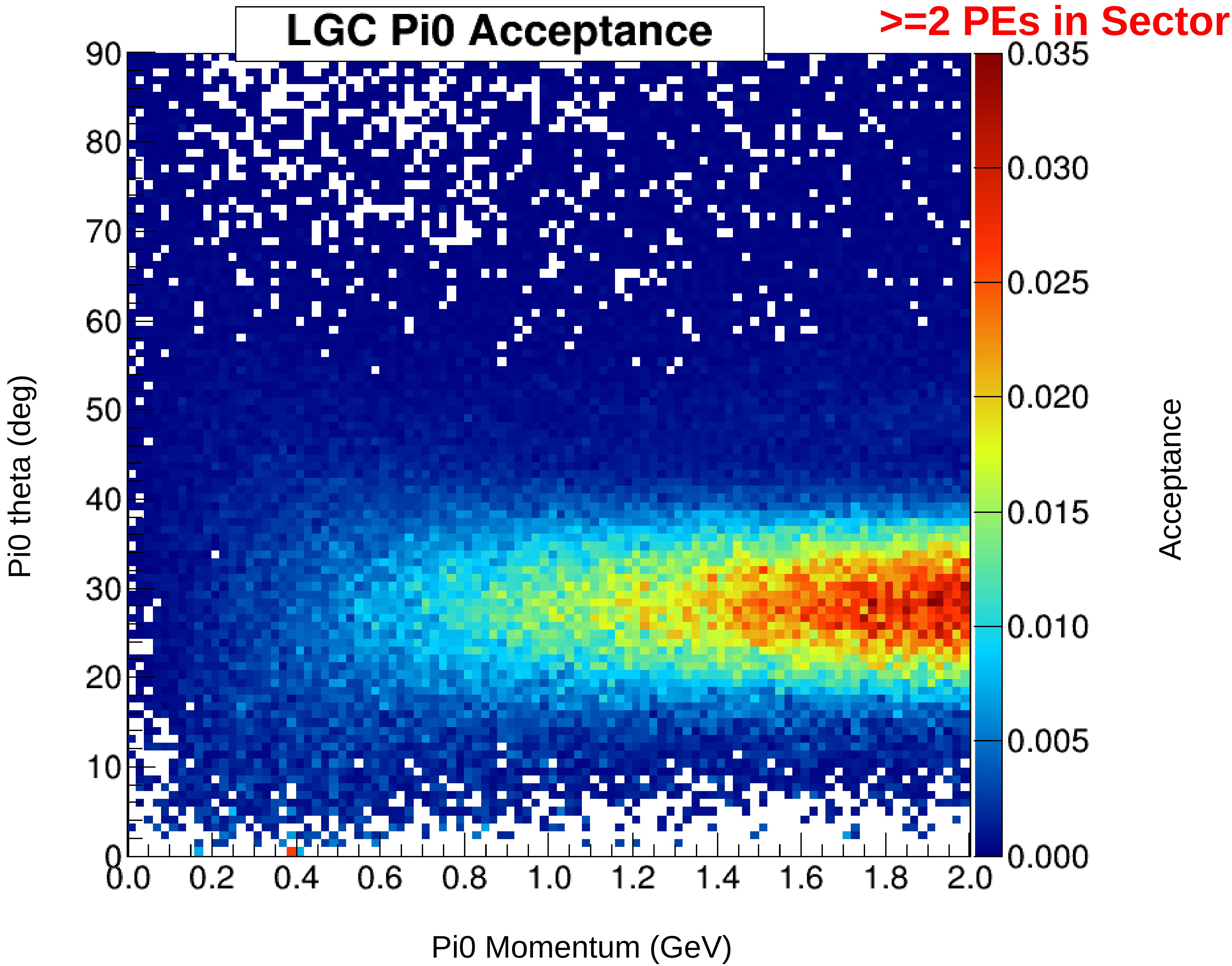
- Director's review talk quoted a rate of about 2 Mhz/sec for backgrounds in LGC for PVDIS configuration.
  - From the most conservative estimate.

Method to compare rates

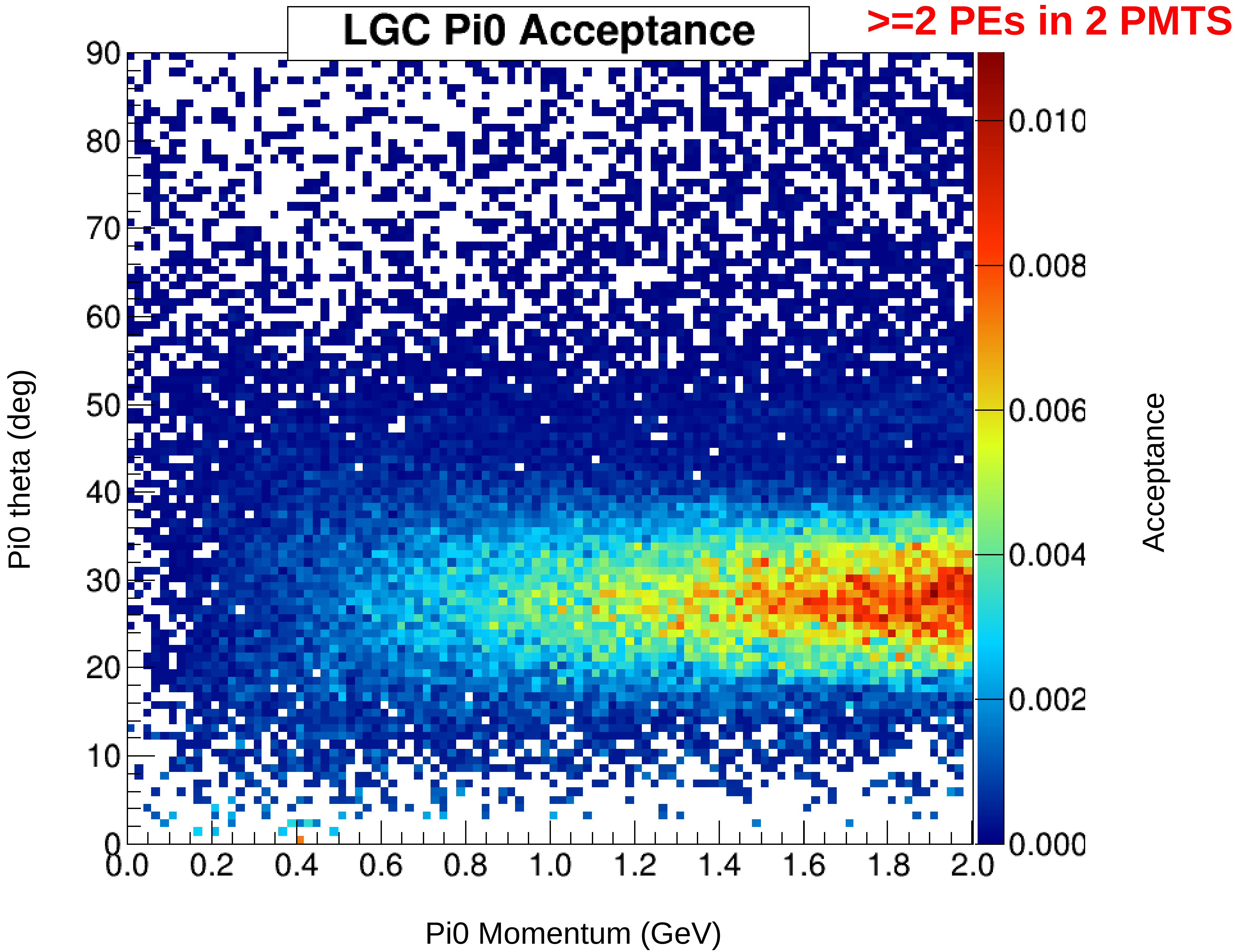
- First: LGC π^0 acceptance is simulated in the PVDIS configuration.
- Second: pi0 models are compared, and rates are calculated as Lum*X-sec*Acc.

Generate LGC pi0 Acceptance

- Generate random pi0's over a flat phase-space.
  - Decay ALL pi0's to 2-gamma immediately
- Propagate those gammas through SoLID geometry using GEMC, ar record everything that passes into the LGC window.
- Run GEMC with those particles in the LGC and record PMT photo-electrons.
- Apply very simple trigger logic to output.
  - No timing information.
  - All pi0s are assumed to have a multiplicity of 1 from target.
  - Each pi0 is considered a single “event” and all photoelectrons fro that event are considered inside the timing window (per sector).



LGC Pi0 Acceptance
>=2 PEs in Sector
Pi0 theta (deg)
Pi0 Momentum (GeV)
Acceptance
0
10
20
30
40
50
60
70
80
90
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035

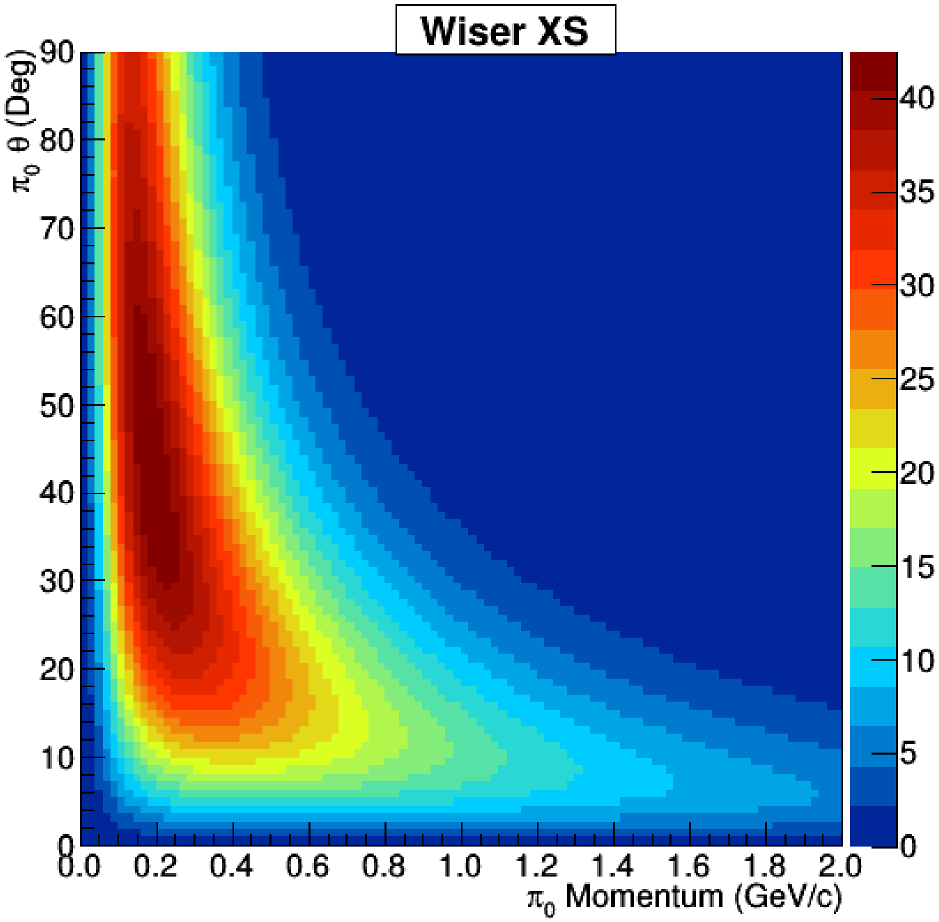


LGC Pi0 Acceptance
>=2 PEs in 2 PMTS
Pi0 theta (deg)
Pi0 Momentum (GeV)
Acceptance
0
10
20
30
40
50
60
70
80
90
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
0.000
0.002
0.004
0.006
0.008
0.010

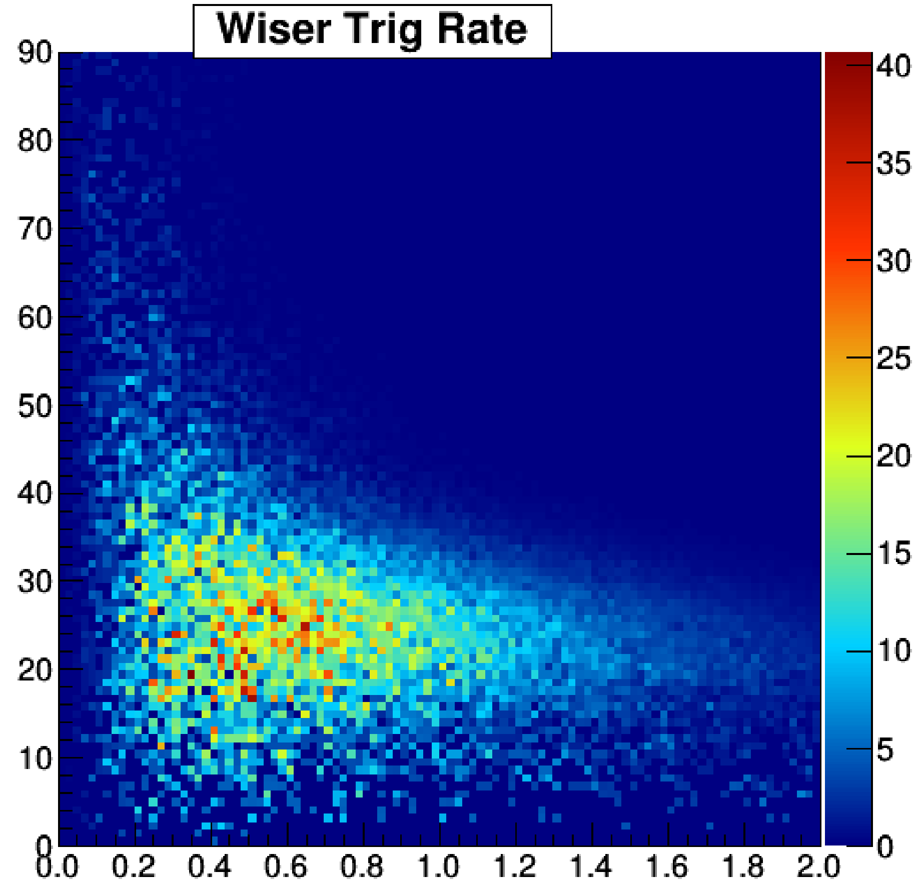
On Simulations:

- **Wiser – standard**
  - Use Wiser's standard photoproduction fit for charged pions
  - For electro-production, treat material before vertex as a radiator to make real photons.
- **EPC**
  - Takes into account kinematics of recoiling nucleon. (Taitor-Wright)
  - Use a forward peaking approximation (FPA, electron scattering angle = 0, photons are quasi-real) to directly calculate the photon flux for a given recoiling pion.
- **Wiser – FPA**
  - Use Taitor-Wright/FPA with wiser photo-production fit.
- LH2 Luminosity used: 5.34×10^{5} nb^{-1}

Wiser-standard (LH2)

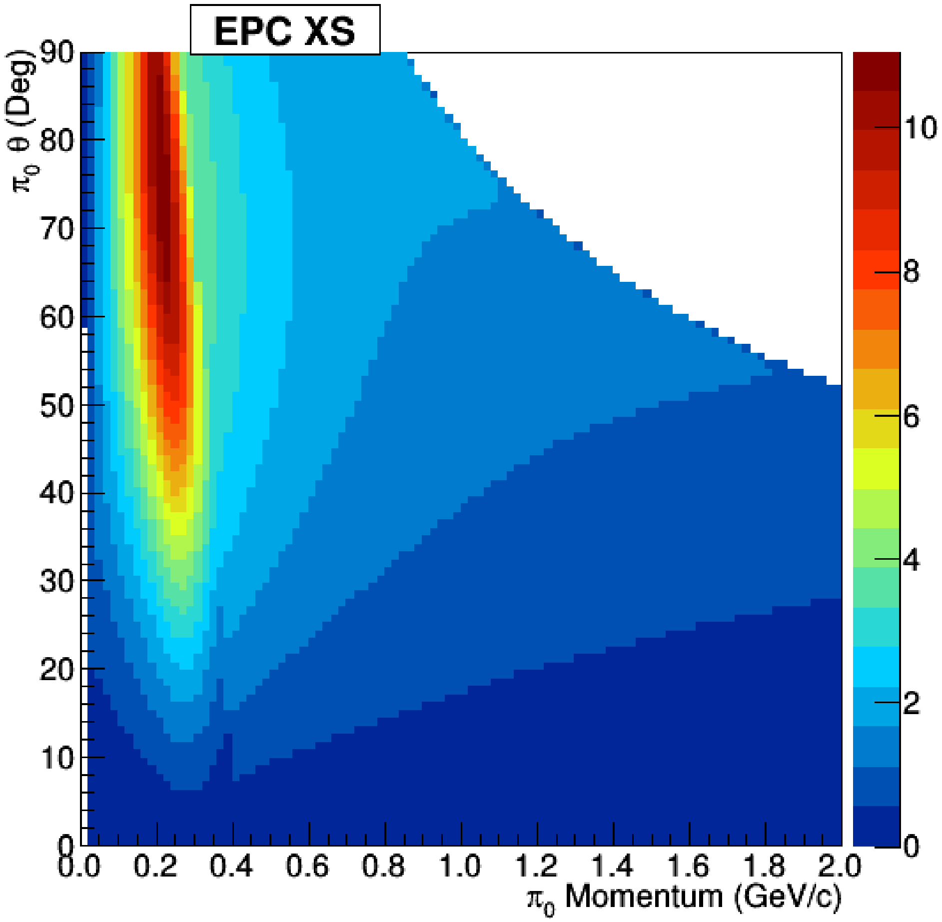


Wiser: ~ 80.0 ub

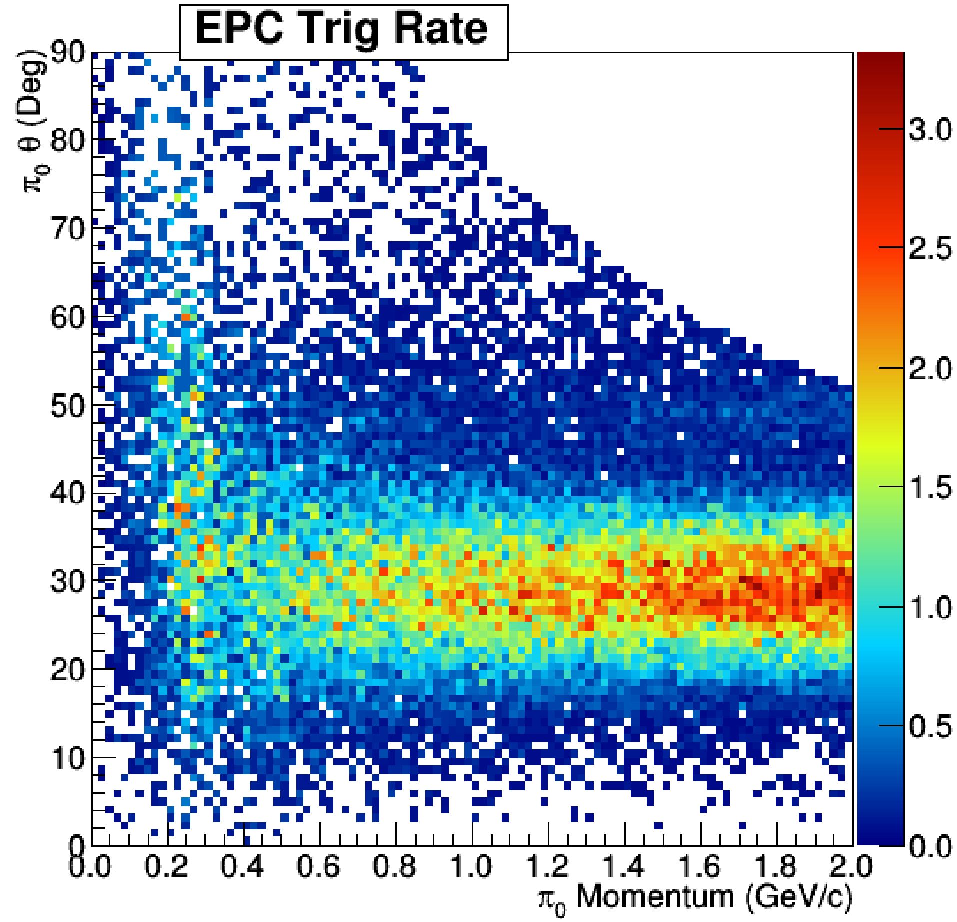


2x2 trigger:
Wiser: total rate: 24.6 MHz
rate/sec = 820 kHz
rate/PMT = 91 kHz

EPC (LH2)

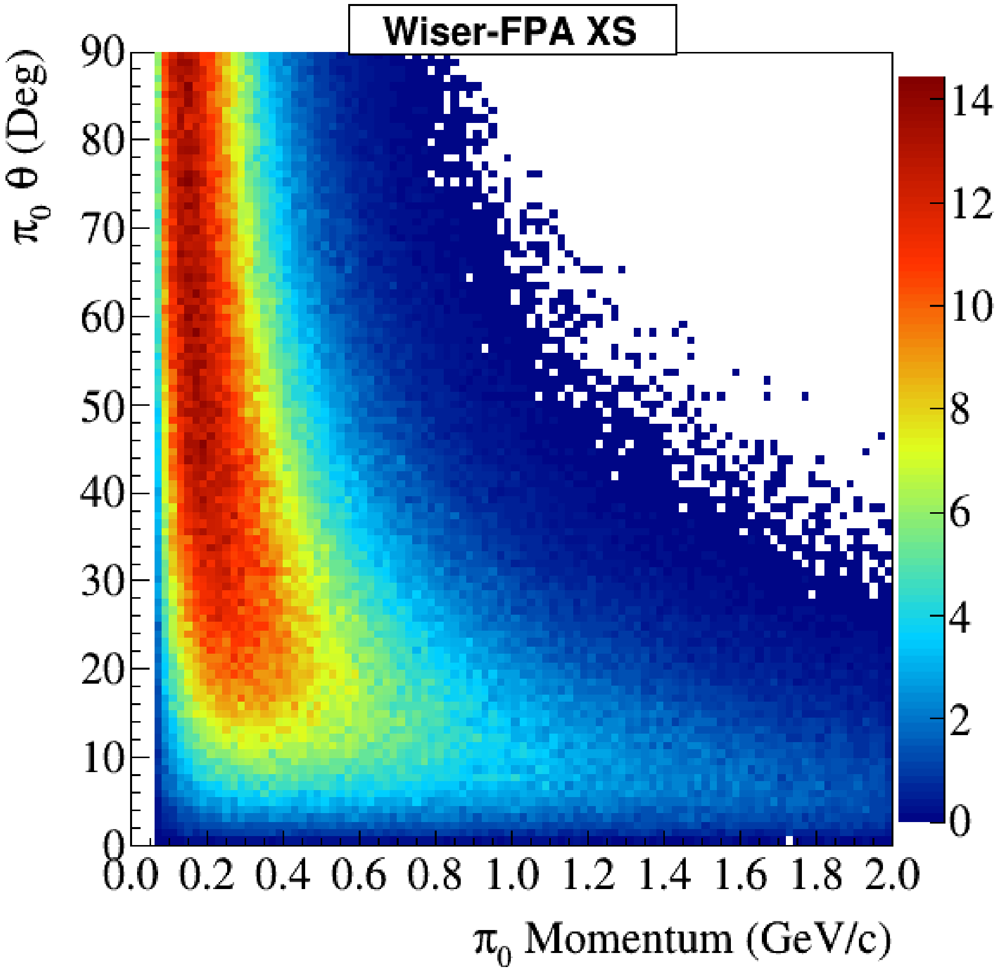


EPC: ~ 13.5 ub

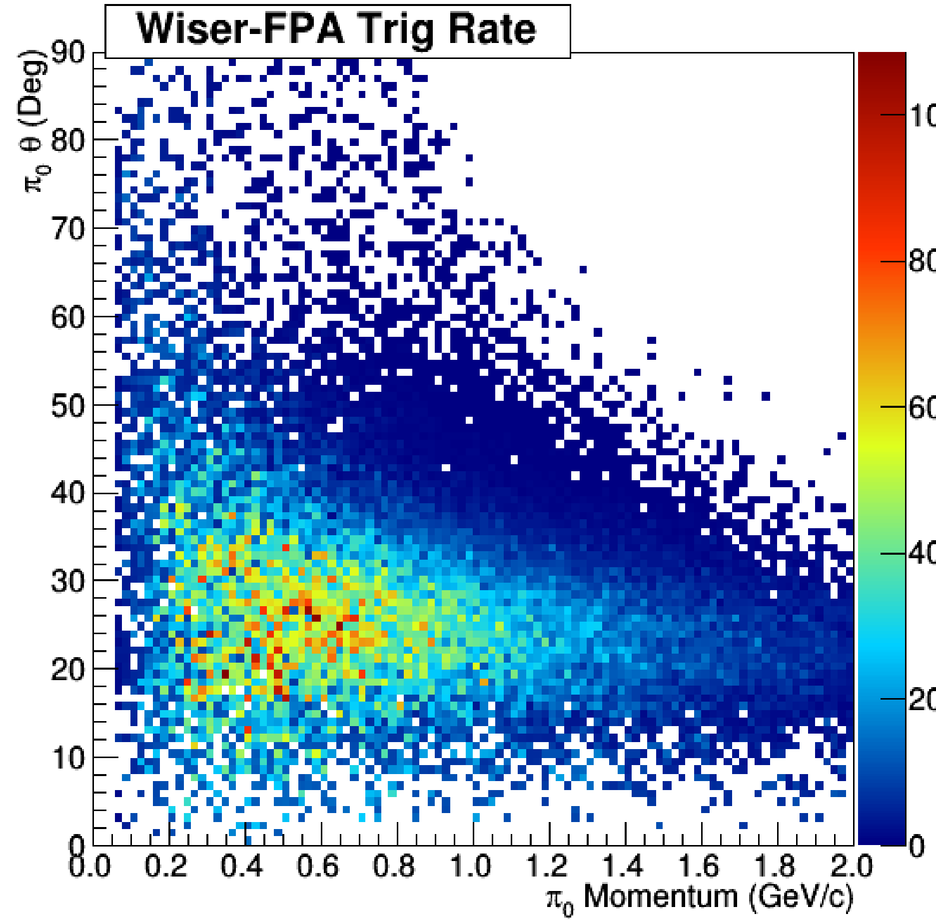


2x2 trigger:
EPC total rate: 3.7 MHz
rate/sec = 123 kHz
rate/PMT = 14 kHz

Wiser – FPA (LH2)



Wiser-FPA: ~ 23.1 ub



2x2 trigger:
Wiser-FPA total rate: 6.8 MHz
rate/sec = 226 kHz
rate/PMT = 25 kHz

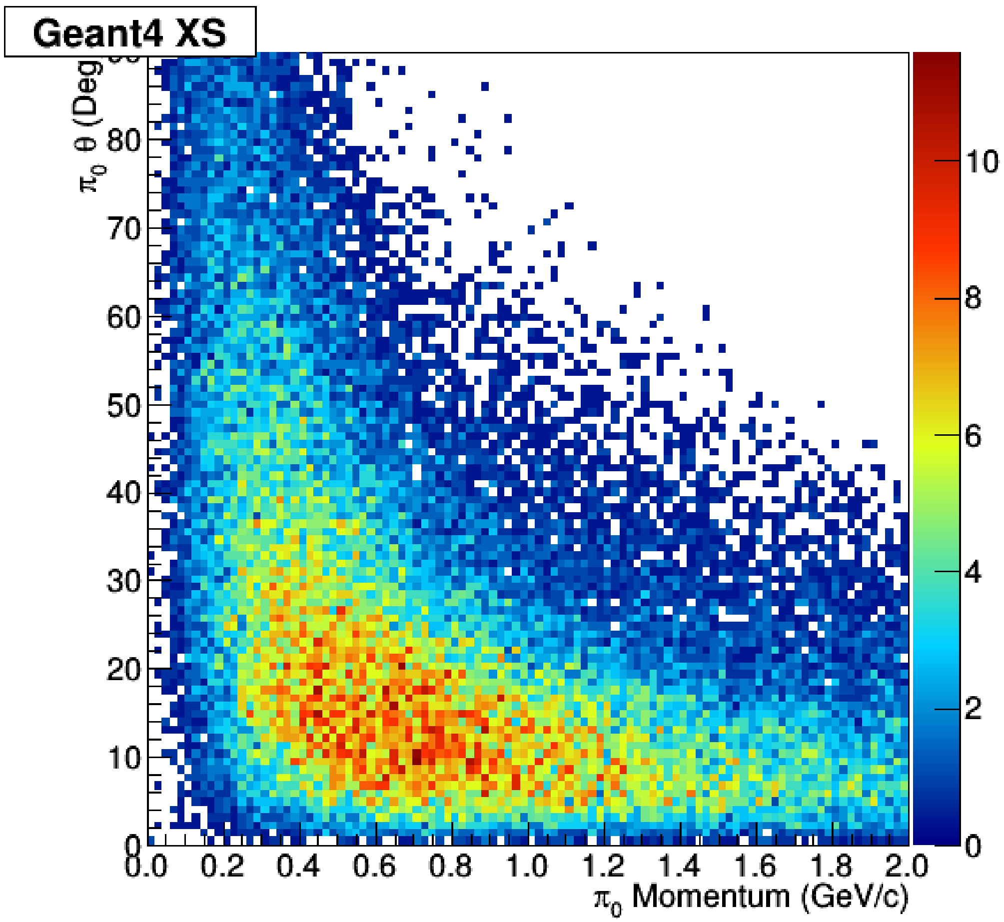
LH2 → LD2

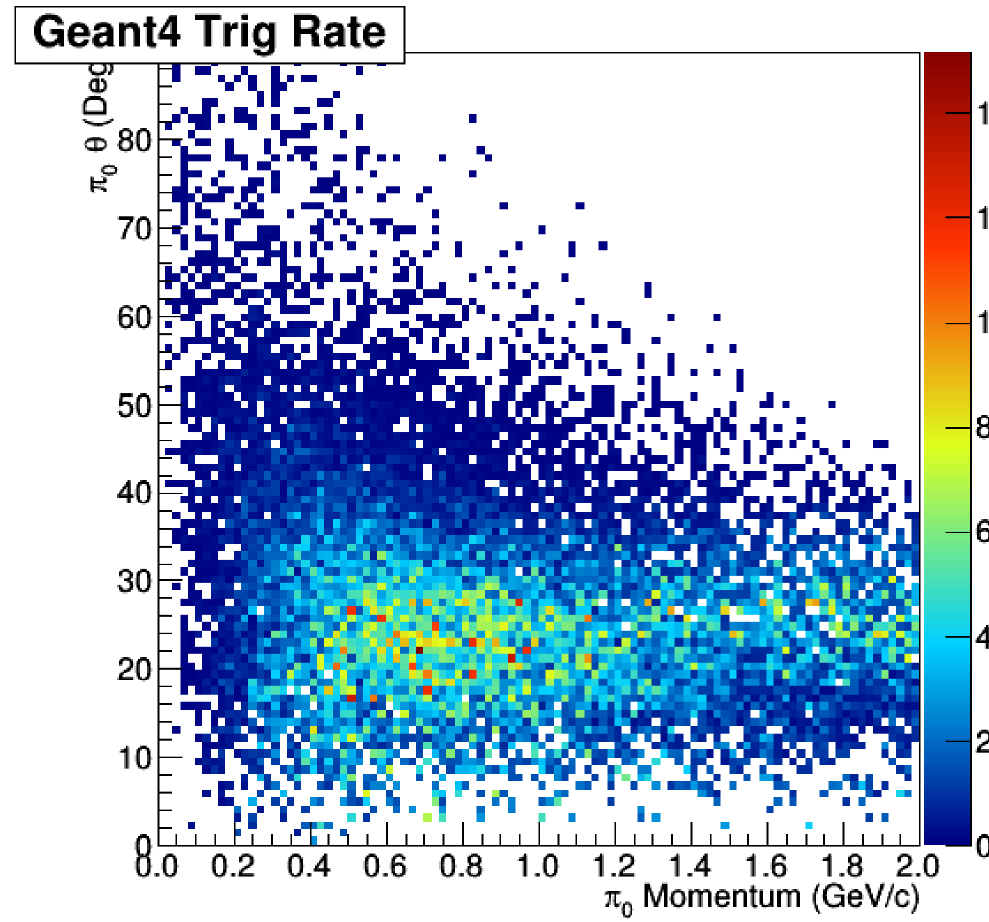
- Luminosity increase by a factor of ~1.2
  - Wiser radiator increase by a factor of 1.1
- Cross-section for Deuterium pi0 is just x2 Hydrogen for both Wiser and EPC
- So for LD2 (2x2 trigger):
  - Wiser-standard rate = 2,164 kHz/sec
  - EPC = 295 kHz/sec
  - Wiser-FPA = 542 kHz/sec

G4 pi0's on LD2

- Geant4 QGSC_BERT pi0s:
  - A GEMC detector completely surrounding the target measures all photons.
    - Photon pairs that reconstruct to pi0s are counted.
    - Does not take into account pi0 absorption and will miss any photon that scatters.
    - about 40 pi0s per million incident electrons.

Geant4 (LD2)





Geant4: ~ 13.75 ub

2x2 trigger:
g4 total rate: 8.0 MHz
rate/sec = 266 kHz
rate/PMT = 29.6 kHz

LD2 pi0s (2x2 trigger)

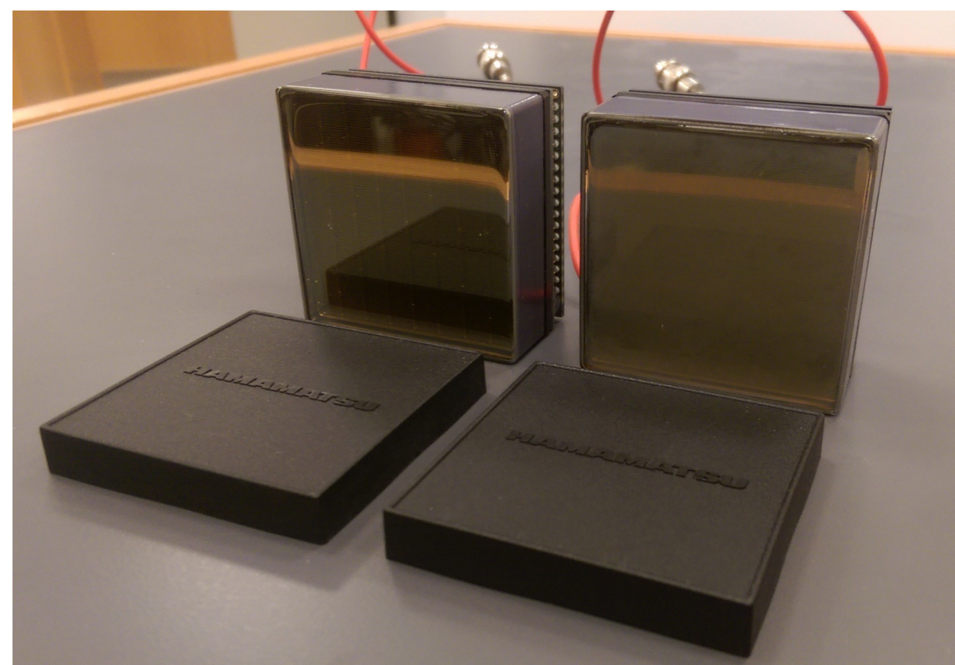
	Rate Total (MHz)	Rate/sector (kHz)
Wiser (Traditional)	64.92	2,164
Wiser - FPA	16.26	542
EPC	8.85	295
Geant4	8.00	266

Possible modifications to bring down background rate.

- Current Cherenkov is designed to maximize optical photon detection.
- Pi0 decays that create background Cherenkov radiation do not have the same trajectory as signal electrons.
  - Design still has some efficiency picking up non-signal electrons from secondary interactions.
- Possible solution: Limit acceptance to a tighter region around desired signal electrons.
  - Blinders between sectors?
  - Reduce size (or remove) reflective cones?
- Acceptance studies need to be performed for both signal and background with these modifications (work in progress).

Wavelength Shifting on MAPMTS

- Another way to increase signal-to-background is to upscale the photo-electron gain and then set a higher trigger threshold.
- Melanie Reyfuss (Student) and Sylvester Joosten (Post-Doc) at Temple have been testing the Hammamatsu 8500C PMTs coated with p-Terphenyl.
- **Very Preliminary** results show the following gains:
  - 245nm → 42%
  - 260nm → 16%
  - 275nm → 16%
  - 370nm → 3%
- A new study is underway with a better coating thickness and more wavelength data points.



Telescope Cherenkov for testing MAPMTs under high rate.