SIDIS Cerenkov Update

S. Malace (JLab), H. Gao (Duke) *et al.*

Outline:

→ **reply to reviewers comments: study effect of NH3 target field on the focusing in the Cerenkov detectors**

→ **reply to reviewers comments: non-uniformity in pixel output for H8500C-03; resolution could be improved by matching pixels output**

→ **measurements of SPE with 10x; extract SPE characteristics using a well established PMT response function (***S.P. Malace, B.D. Sawatzky, H. Gao, to be submitted to NIM A***)**

→ **~ Manpower cost estimate for the electron and pion Cerenkov: 983.7 K$ (from Al Gavalya)**

Acknowledgements: Brad Sawatzky, Jack McKisson, Drew Weisenberger, Carl Zorn, Chris Cuevas

NH_3 Target Field: Effect on Cerenkov Performance

Reviewers comments

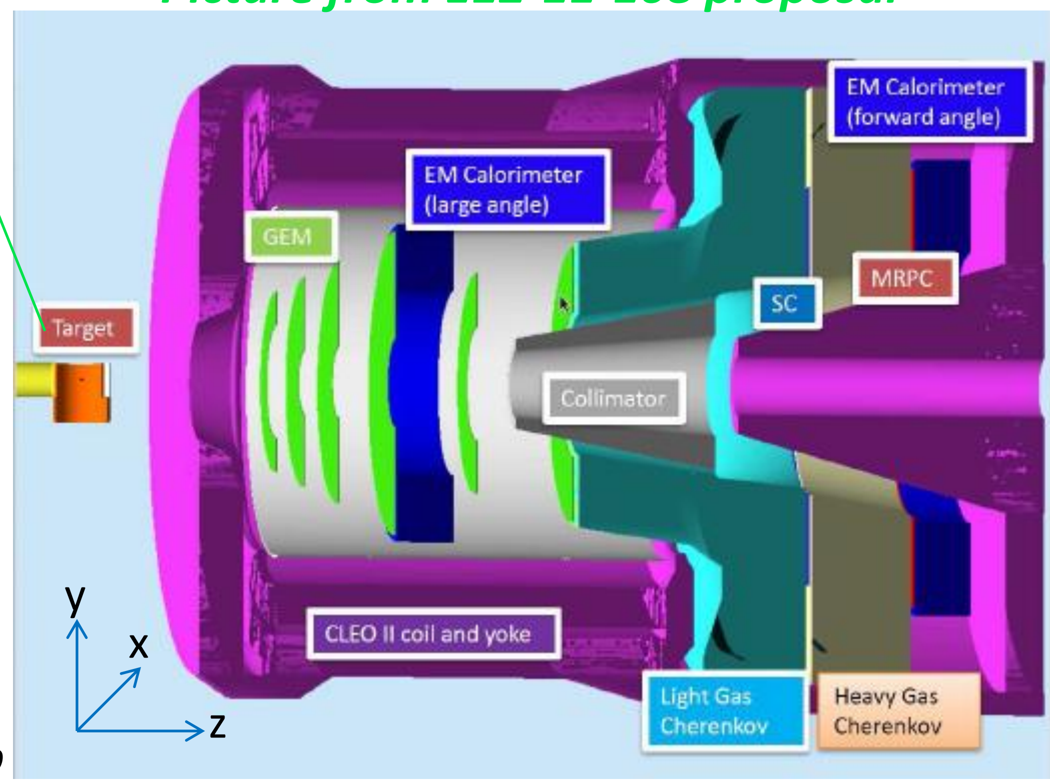
"The Gas Cerenkov simulations for PVDIS and SIDIS appear very complete.

Some additional simulations for the polarized Hydrogen target (which appears in a separate SOLID proposal to the current PAC) need to be done to see if the additional dispersion and larger raster size present problems."

→ Transversely polarized NH_3 target: magnetic field up to 5 Tesla; symmetry in yz plane (SoLID field symmetry in yx plane)

→ We implemented the target magnetic field in the GEANT4 Cerenkov simulation and **checked the focusing in the pion Cerenkov detector**

Picture from E12-11-108 proposal

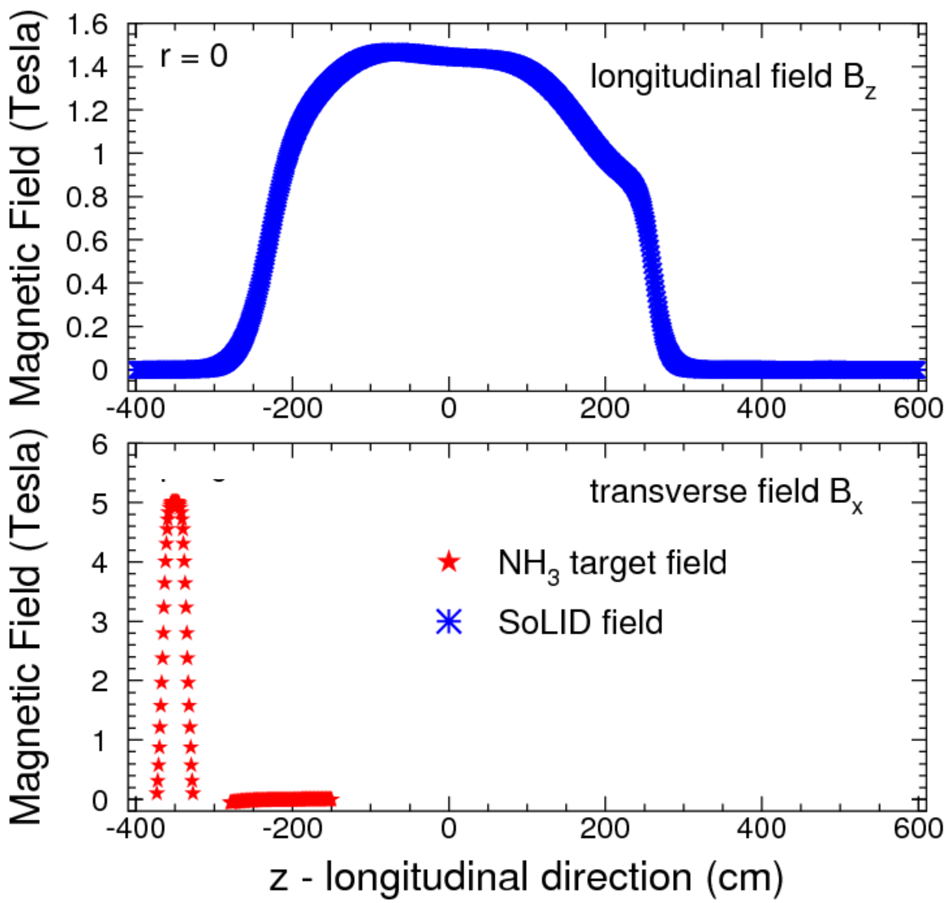


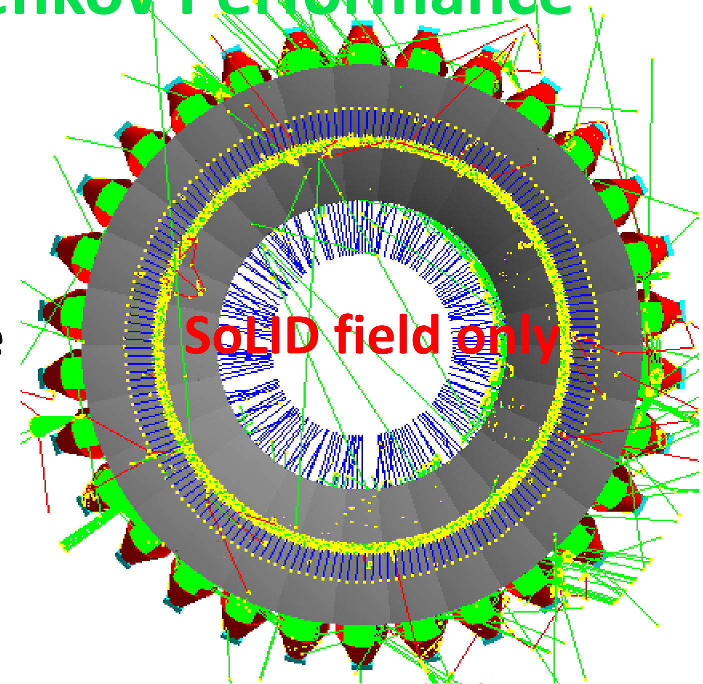
Thx to Kalyan for providing the field map

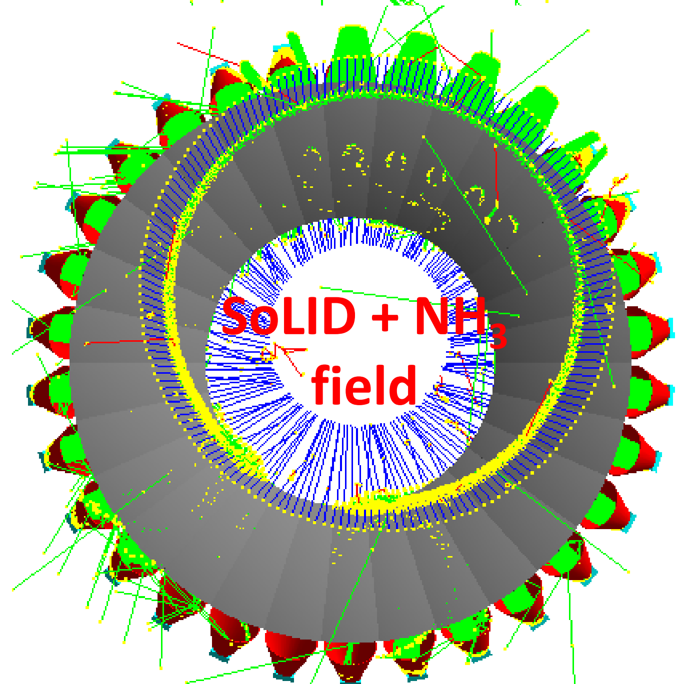
NH_3 Target Field: Effect on Cerenkov Performance

➢ **Large transverse magnetic field at the NH3 target: up to 5 Tesla**

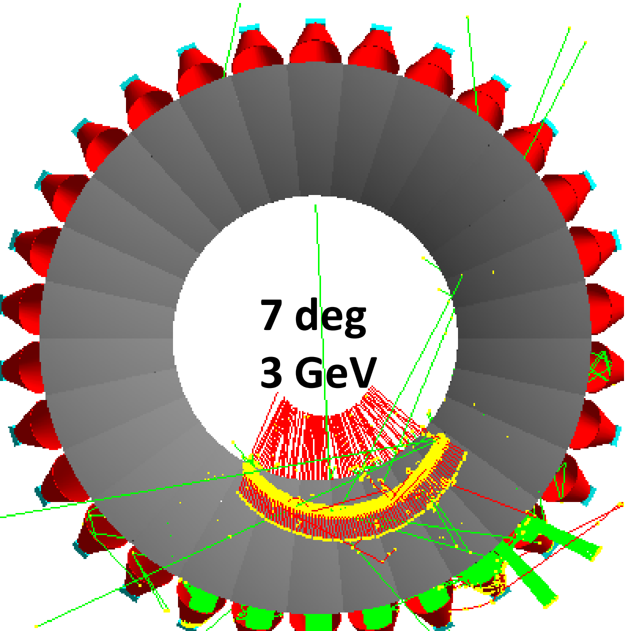
➢ **It strongly distorts the charged particles trajectory changing the kinematic acceptance**

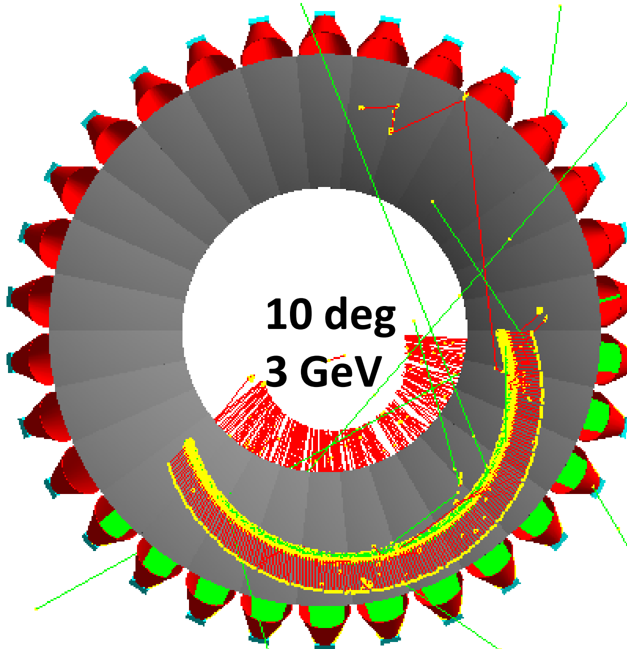


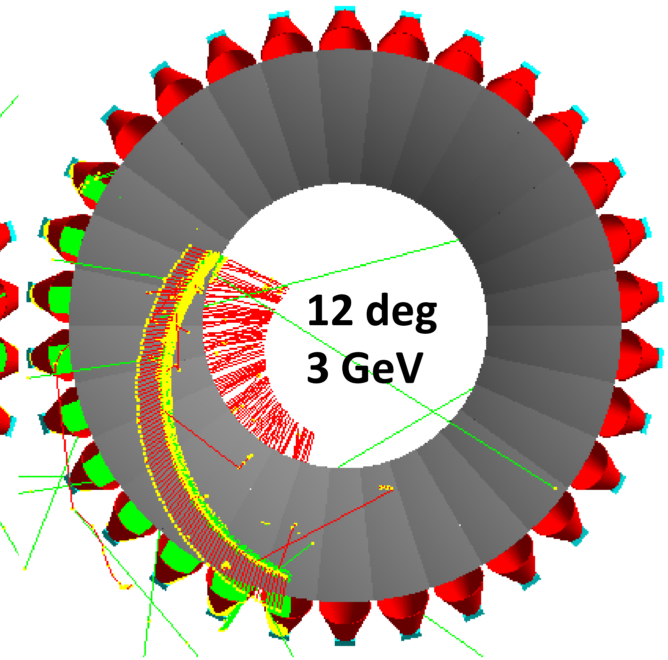


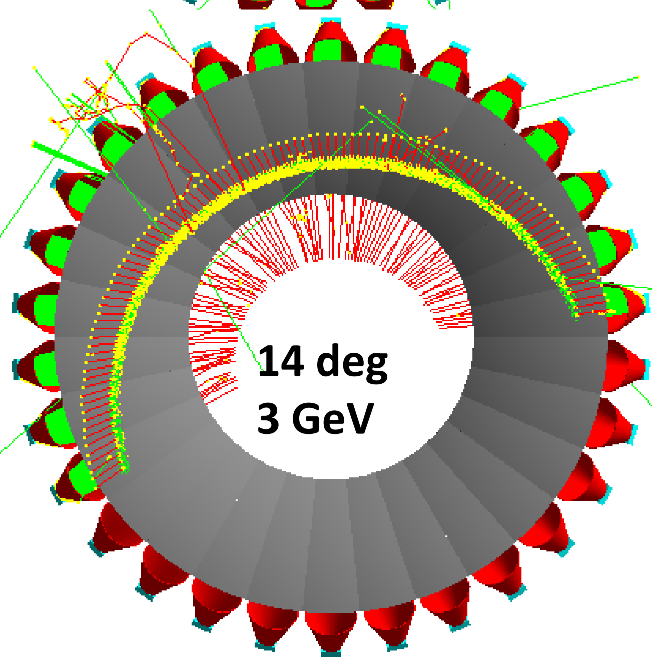


NH_3 Target Field: Effect on Cerenkov Performance → π^-





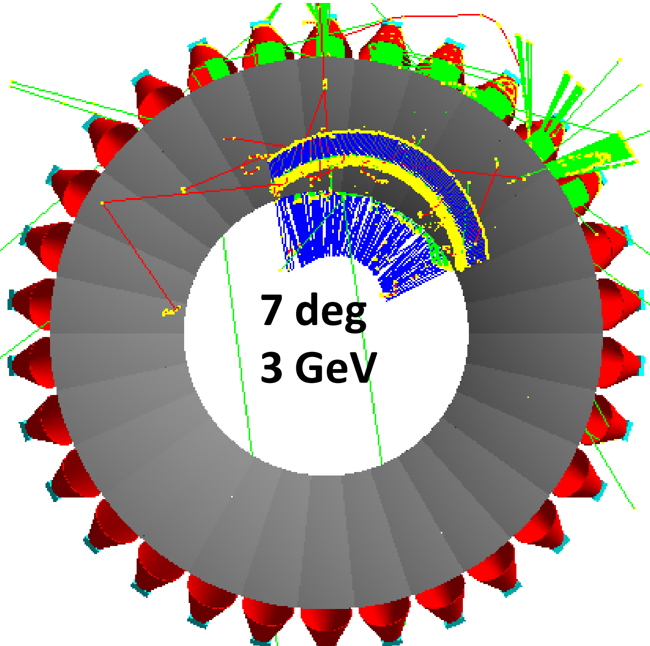


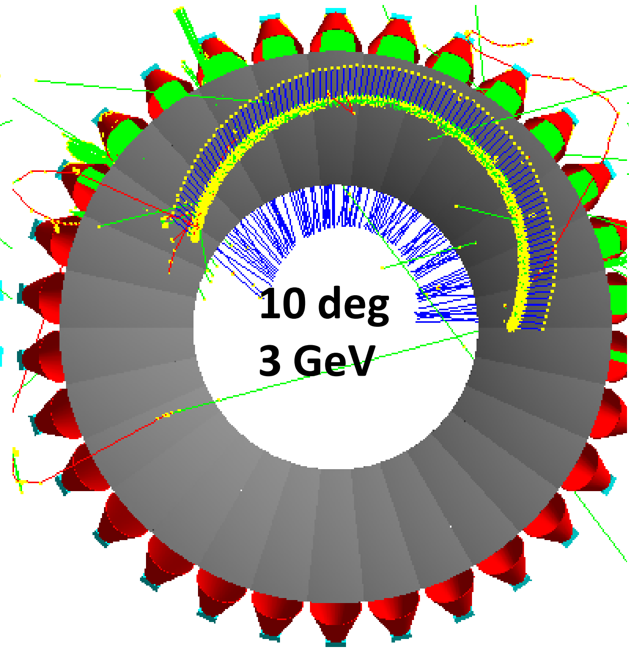


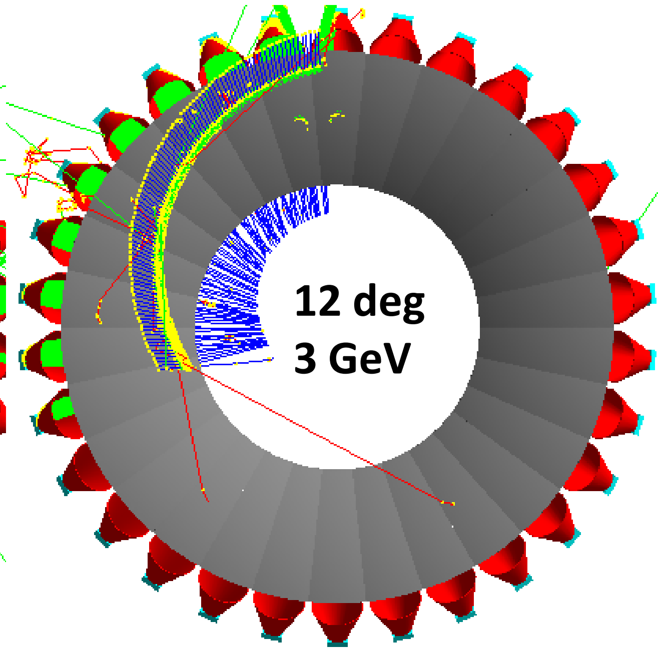
Polar angle/phi	efficiency
7 /(200,320) deg	0.9816
10/(180,360) deg	1
12/(120,230) deg	0.9906
14/(0,180) deg	0.999

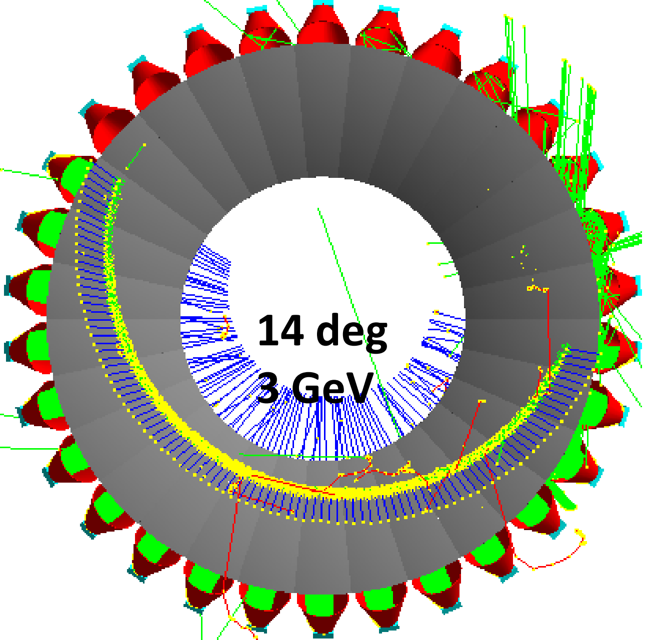
- **Limited phi coverage**
- **Good efficiency where photons scatter off the mirrors**

NH_3 Target Field: Effect on Cerenkov Performance → π^+







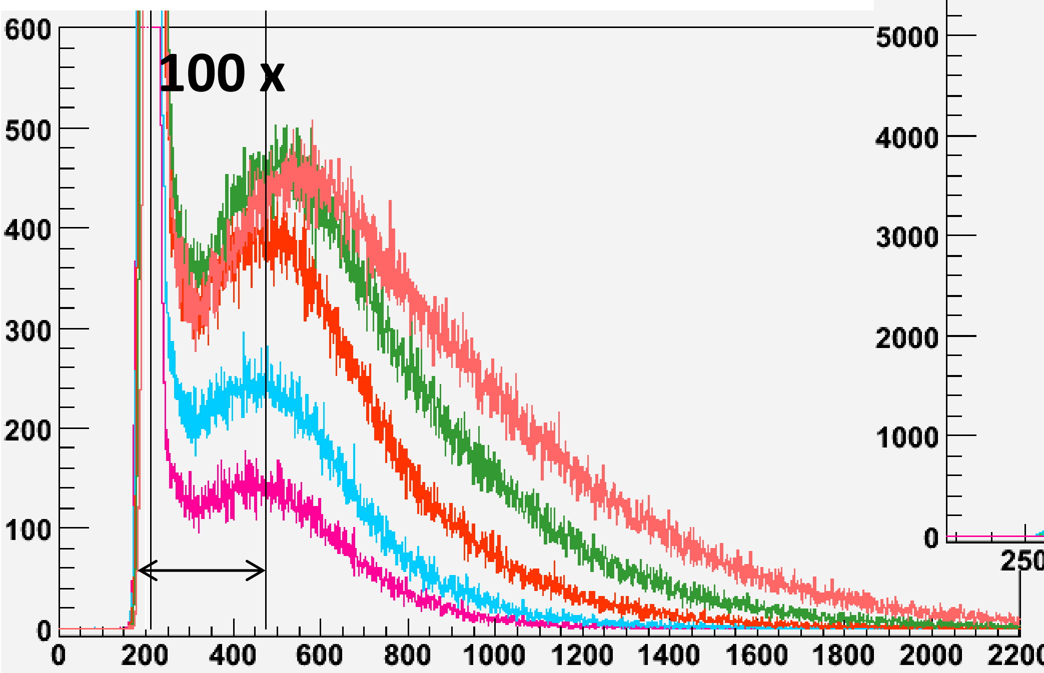


Polar angle/phi	efficiency
7 /(200,320) deg	0.987
10/(180,360) deg	0.9889
12/(120,230) deg	0.9826
14/(0,180) deg	0.991

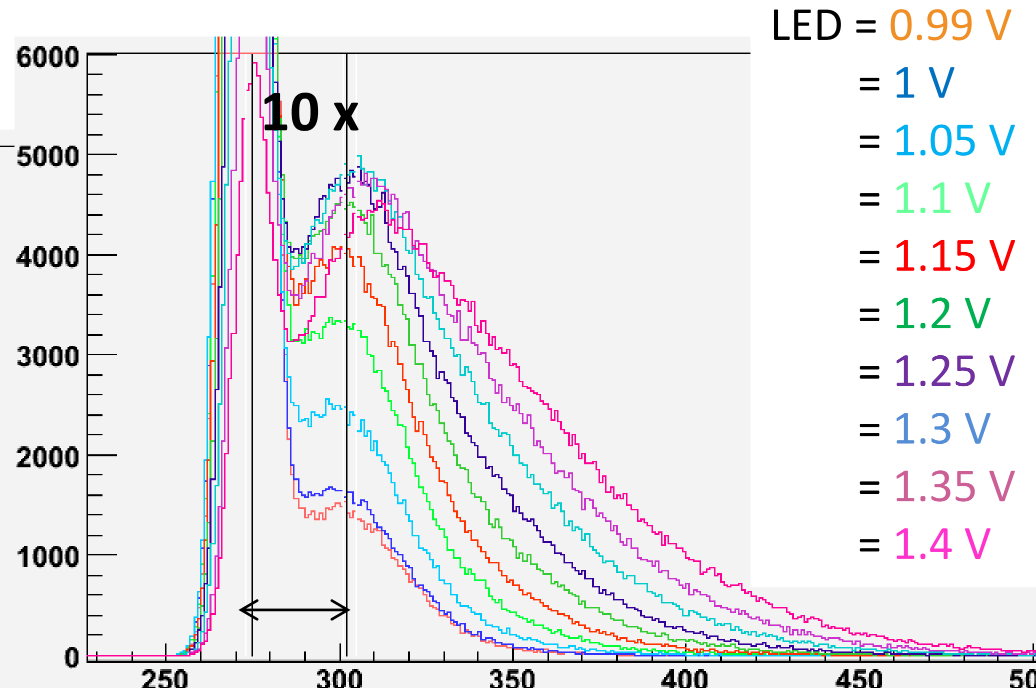
- **Limited phi coverage**
- **Good efficiency where photons scatter off the mirrors**

H8500C-03 Tests: Single Photoelectron Measurements

- **We detected the single photoelectron signal with 10 X amplification (we used 100 X before)!**



~263 channels above PED



~27 channels above PED

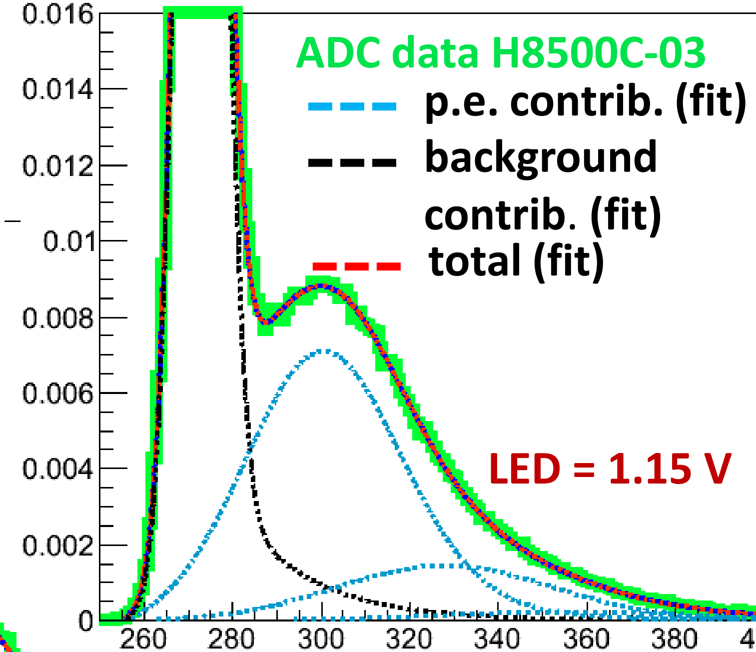
- **We found a problem with V792 being non-linear at low channel count (got around that by moving the PED above channel 100; *conclusions drawn from previous (field) measurements remain true!!*)**
- **10 x amplification preferable during experiments**

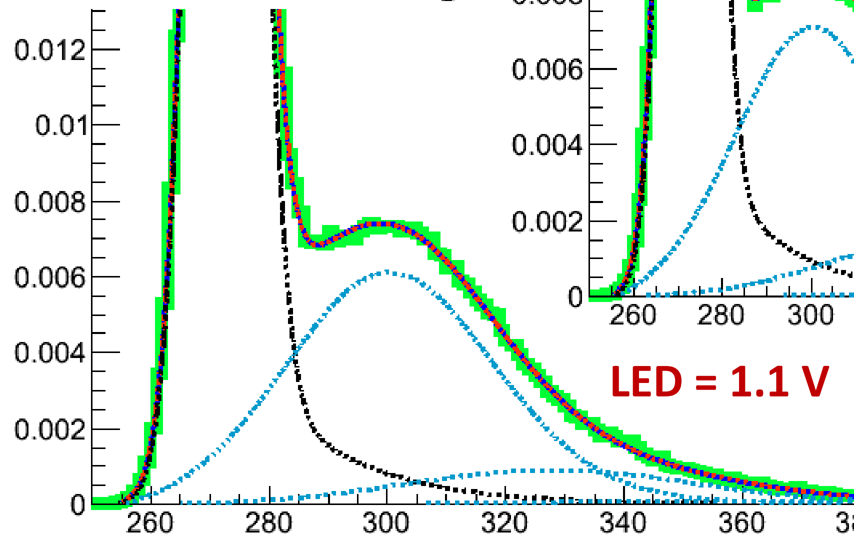
H8500C-03 Tests: Single Photoelectron Fitting

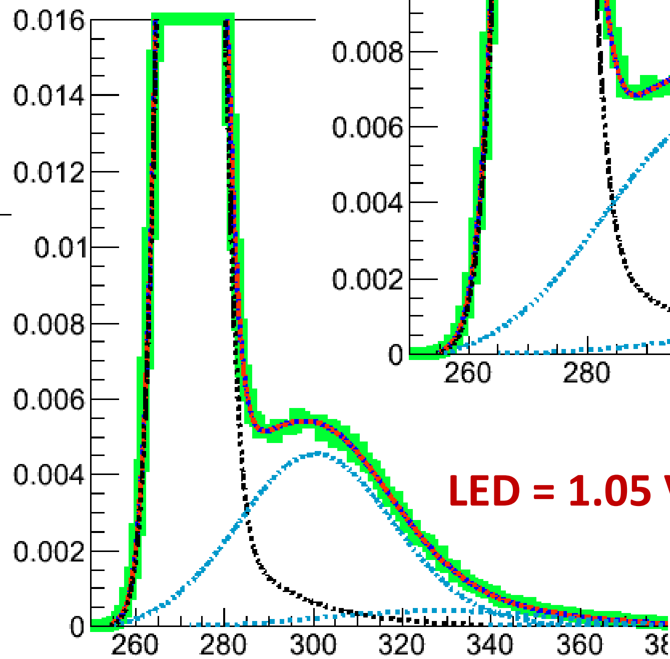
- **PMT response function:**

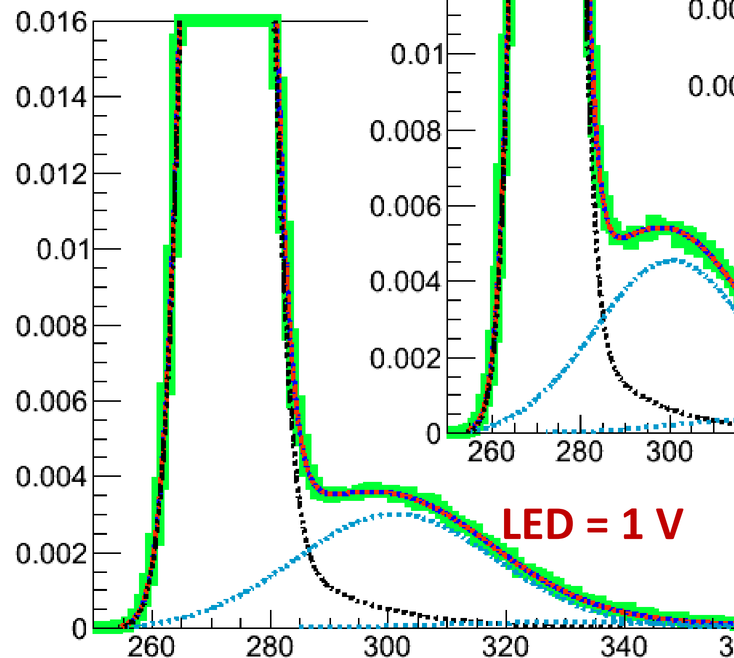
$$S_{\mathrm{real}}(x) = \int S_{\mathrm{ideal}}(x')B(x-x')\,\mathrm{d}x' = \sum_{n=0}^{\infty} \frac{\mu^n e^{-\mu}}{n!} \times \left[(1-w)G_n(x-Q_0) + wI_{G_n \otimes E}(x-Q_0)\right],$$

My precious!
(to mirror Tom's 2nd slide ;-)









From fit:
→ SPE peak ~ **27** channels above PED (with 10x)
→ SPE width ~ **16** channels
(*resolution ~ 1.6 p.e.)*

H8500C-03 Tests: Single Photoelectron Measurements

Reviewers comments

“Multiple outputs from the multianode H8500 PMTs … are planned to be electrically joined to provide the signal "sum" of all 576 anodes. *While it is possible to make the unit work like that, the performance may be improved by using the method of matrix gain balancing, patented by Vladimir Popov here at JLAB (US Patent 6,747,263 "Matrix output device readout system").*

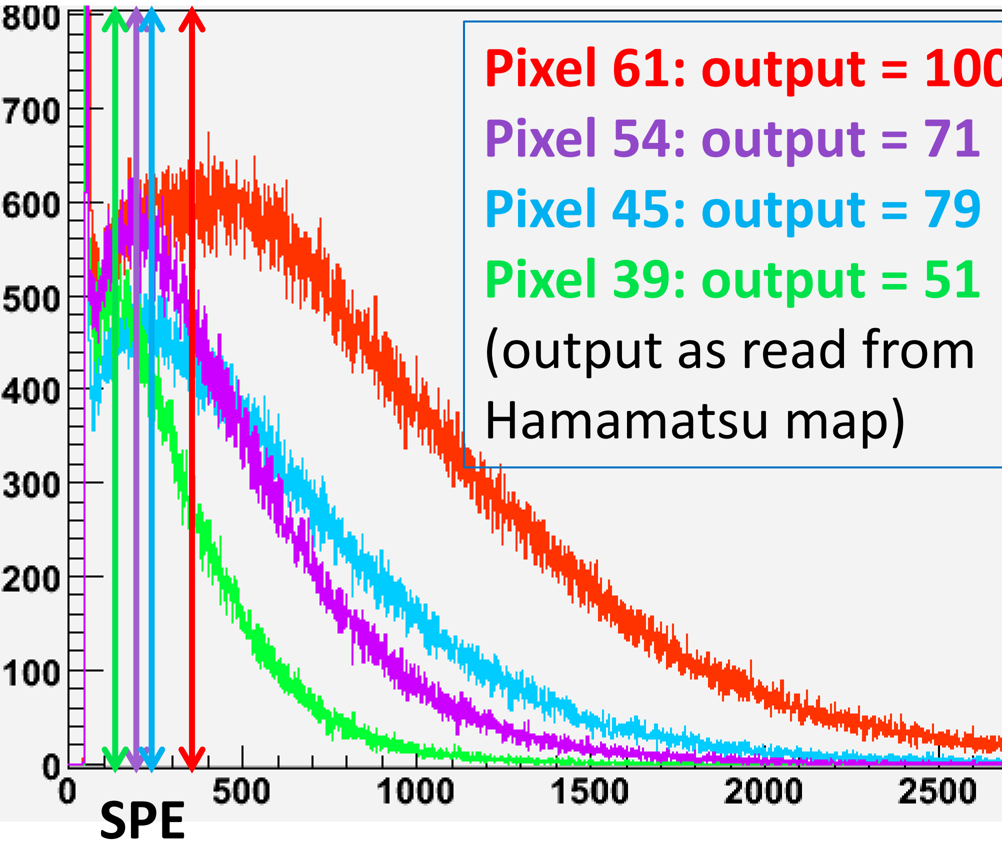
Individual channels in a H8500 PMT have different gains, with the anode-to-anode gain spread of factor 1.5 (best tubes) to 2.5-4 (average). Correspondingly, amplitudes of 1 ph.e. signals differ by these factors if detected by different anodes, and make the task of selecting a proper threshold difficult.

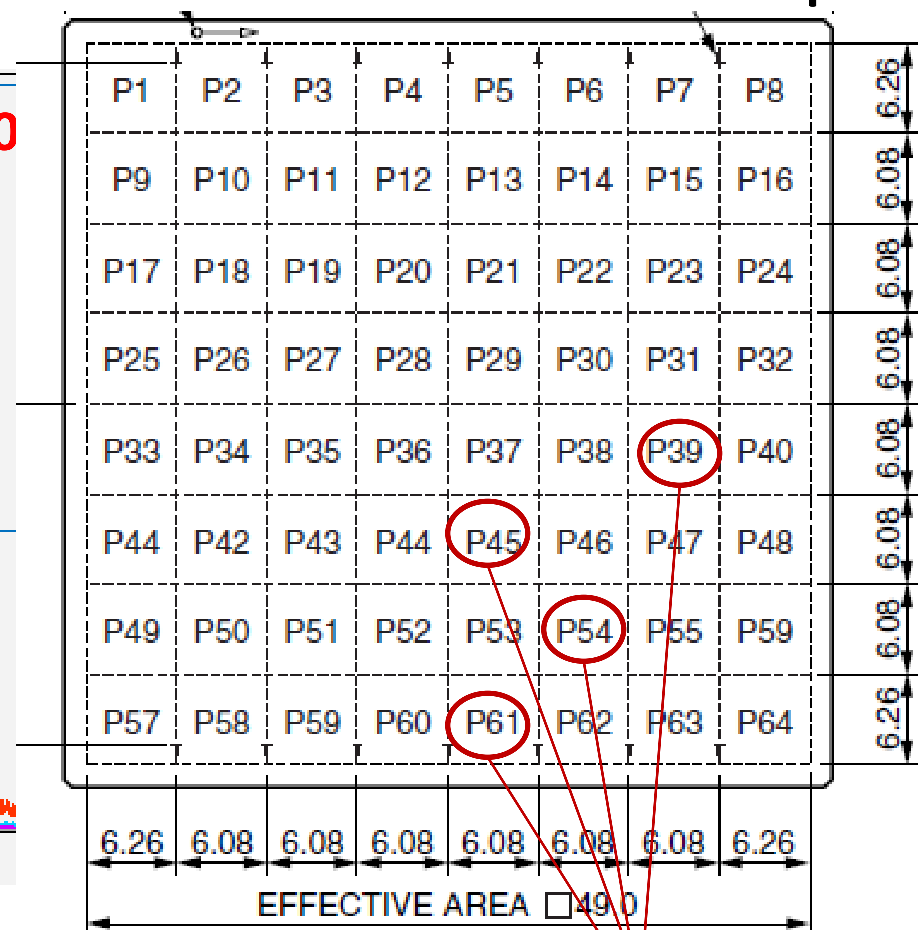
Hamamatsu provides the anode gain maps for every tube. As a first approximation, their data may be used to calculate the correction.

I believe that such measurements of the "average 1 ph.e. amplitude" from each anode can be done in a relatively straightforward fashion using the position information from the detected 1 ph.e. events.”

H8500C-03 Tests: Single Photoelectron Measurements

➢ **We verify that different pixels give different outputs; our measurements follow the expectation we had based on Hamamatsu map**





We read output from these pixels individually (thx Jack M. for re-wiring the maPMT)

➢ **Gain matching and a detailed study of possible improvements in the resolution coming up**

Summary

➢ **We verified that good collection efficiency is maintained for the pion Cerenkov with the existing configuration when including the NH_3 target magnetic field**

➢ **Hardware tests, working on** (will be summarized in a paper to be submitted to NIM A, *S. Malace, B. Sawatzky, H. Gao*):

*** SPE measurements, extract PMT resolution (use 10 x amplification, configuration likely to be used during experiments)**

→ use output from all 64 pixels

→ use output from 16 pixels (quad division)

→ use output from individual pixels

*** show difference in pixel output**

*** match gain (the easy way, by using an attenuator)**

*** show improvement in resolution after gain matching (if any)**

*** Magnetic field measurements**

→ on large number of photoelectrons: use output from all 64 pixels, 16 pixels, individual pixels

→ on SPE: use out put from all 64 pixels, 16 pixels, individual pixels

Having a PMT response function that describes the ADC data very well (see previous slides) will allow us to extract a wealth of information from these measurements