SIDIS Gas CherenkovS

S. Malace, H. Gao *et al.*

SoLID Collaboration Meeting, Feb. 3-4 2012

Outline

Update on the simulation:

→ the electron Cherenkov: GEMs+CsI

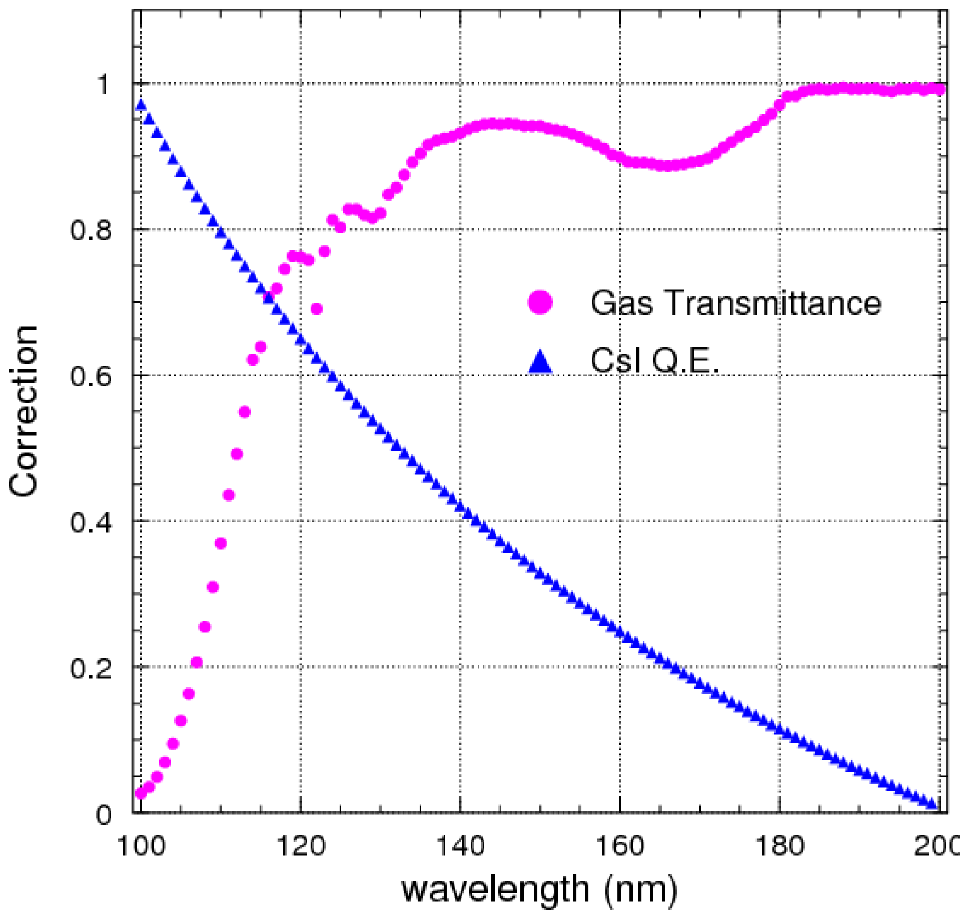
→ the pion Cherenkov: maPMTs

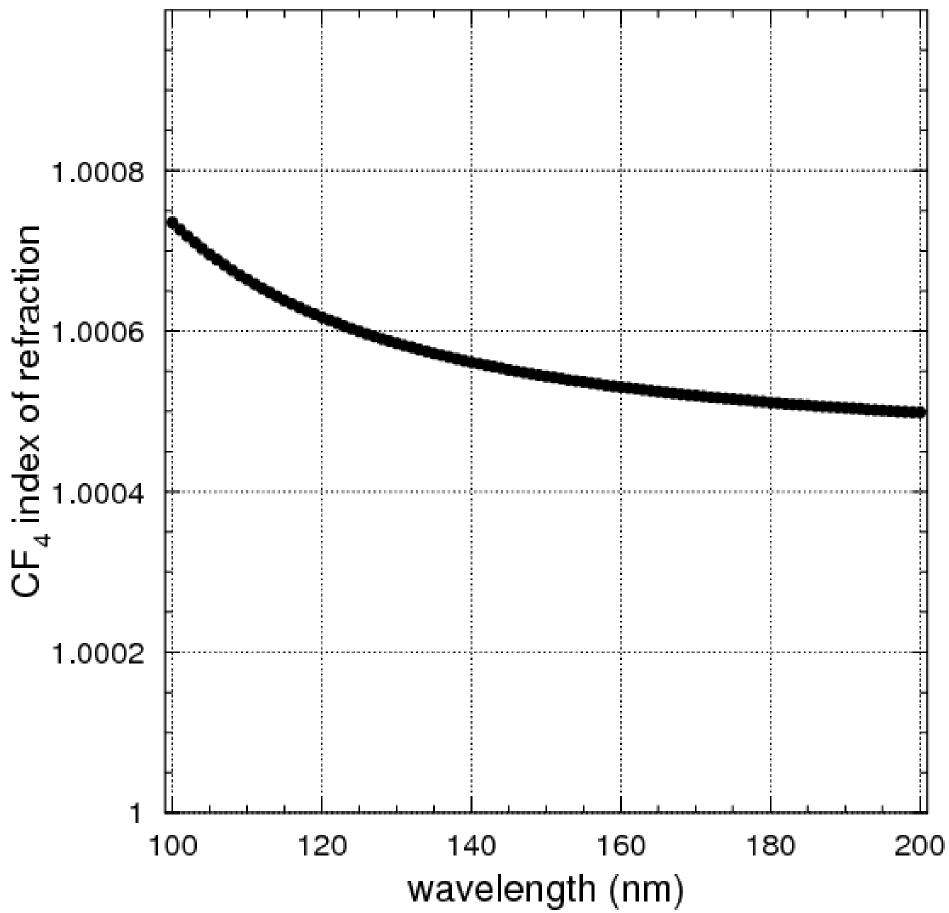
→ Hardware tests: maPMT H8500C-03

SIDIS Electron Cherenkov: GEMs + CsI

SIDIS Electron Cherenkov: GEMs + CsI

Cherenkov yield outputted by the simulation depends on: gas density, index of refraction, gas absorption length, photocathode Q.E. + …

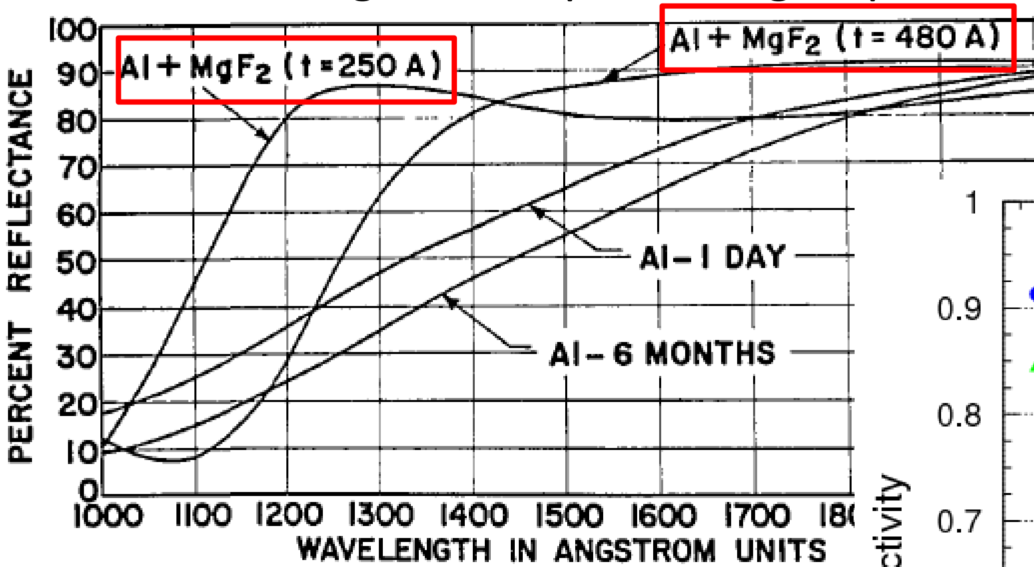




Many thanks to Bob Azmoun (BNL) for providing me with very detailed information on the PHENIX corrections to the Cherenkov photon yield and on the N_{pe} calculation

SIDIS Electron Cherenkov: GEMs + CsI

Cherenkov yield outputted by the simulation depends on: gas density, index of refraction, gas absorption length, photocathode Q.E. + mirror reflectivity



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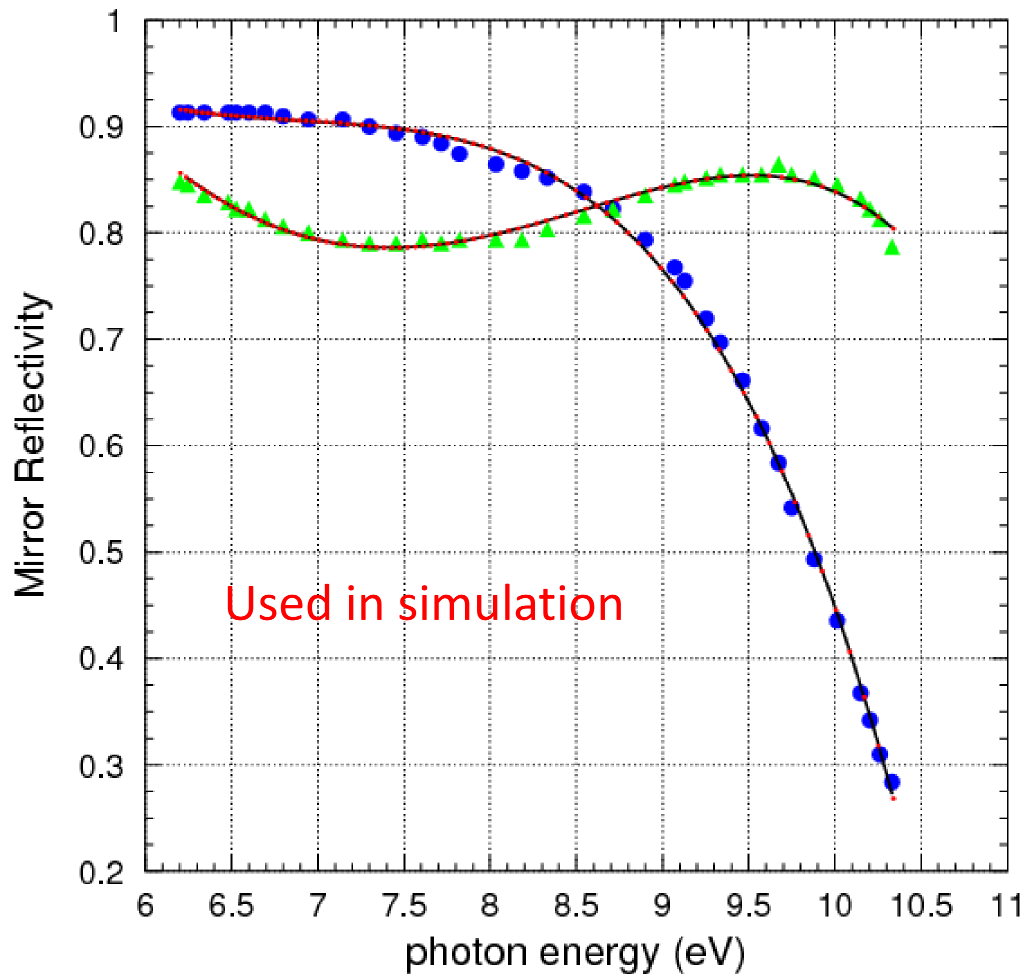
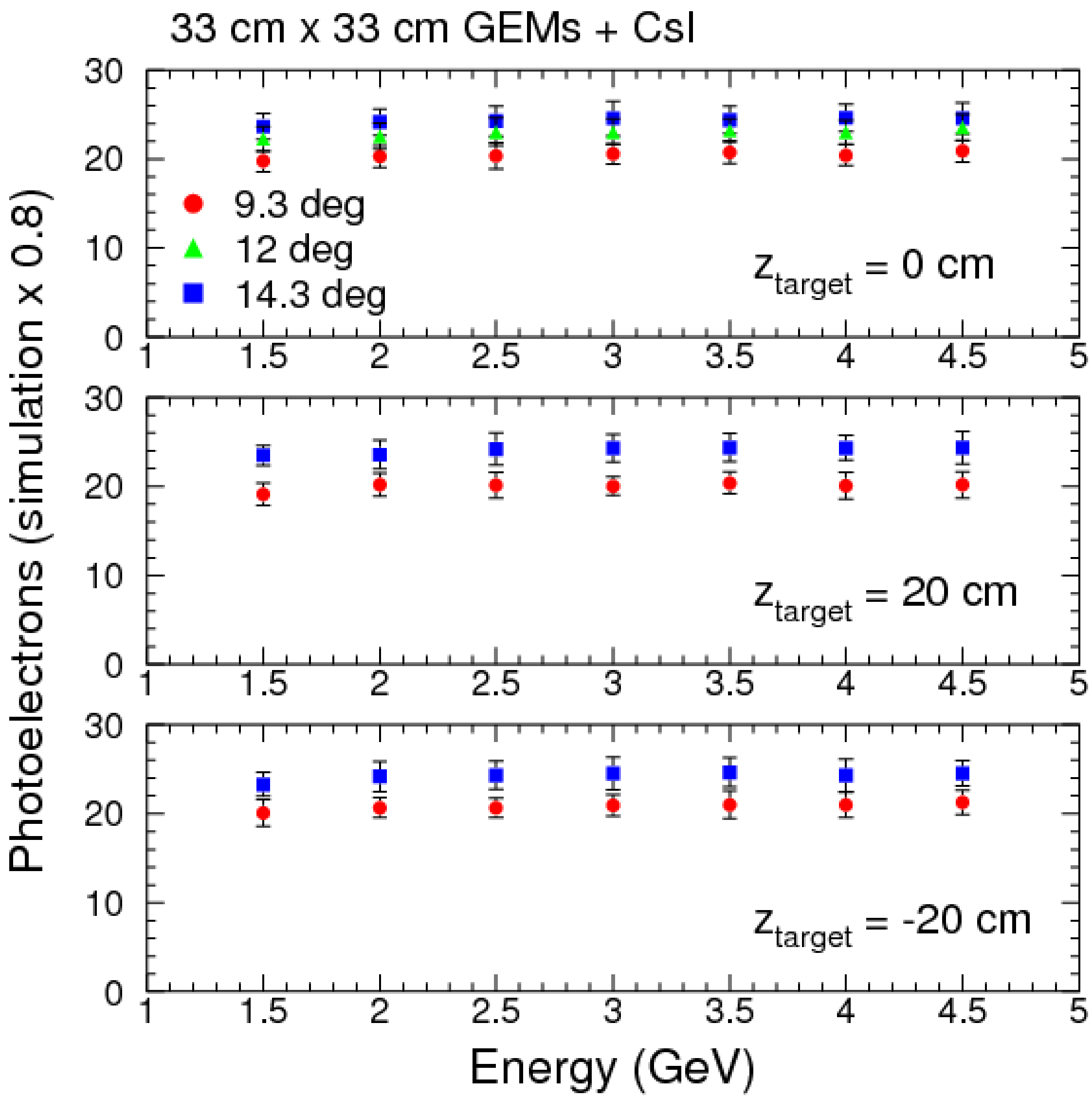


Mirror performance (reflectivity) in UV could be an issue: systematic study of photoelectron yield as function of possible mirror performance

SIDIS Electron Cherenkov: GEMs + CsI

→Expected photoelectrons yield



Two parametrizations for mirror reflectivity used (gives the uncertainty)

PHENIX factor: 0.516 (mesh and photocathode transparency, transport efficiency)

Safety factor: 0.8

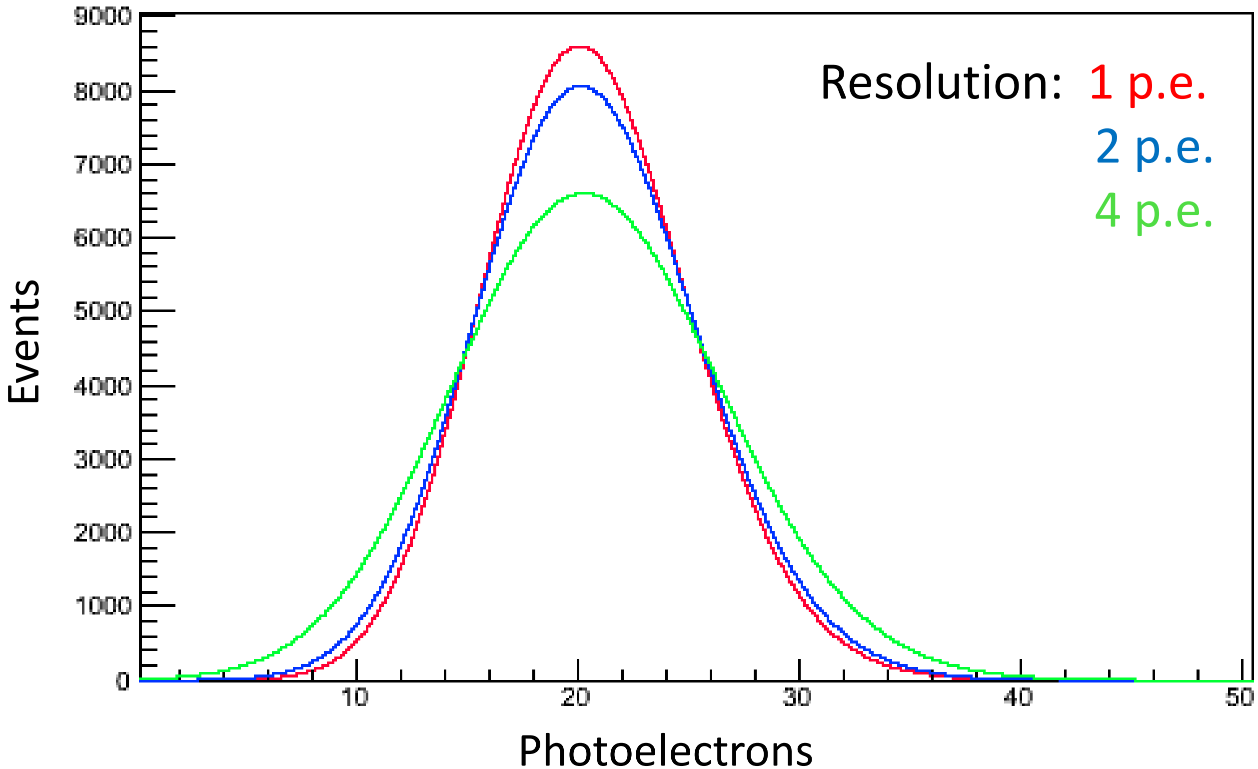
Work in progress

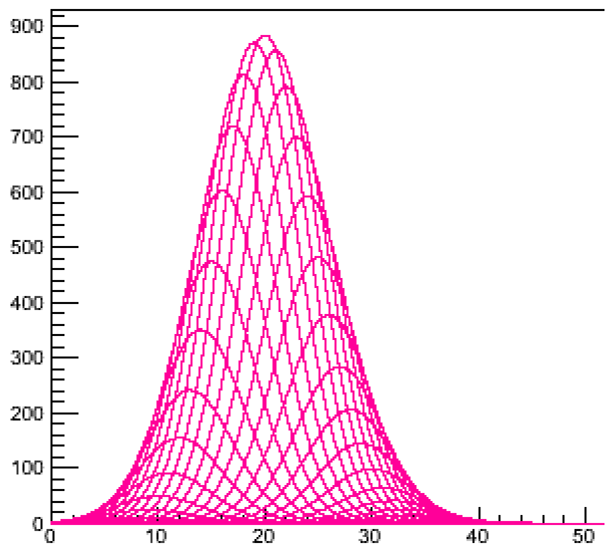
→Study electron cut efficiency as a function of detector resolution (GEMs+CsI)

→ Study pion contamination (GEMs+CsI option)

SIDIS Electron Cherenkov: GEMs + CsI

→Study photoelectron cut efficiency as a function of detector resolution





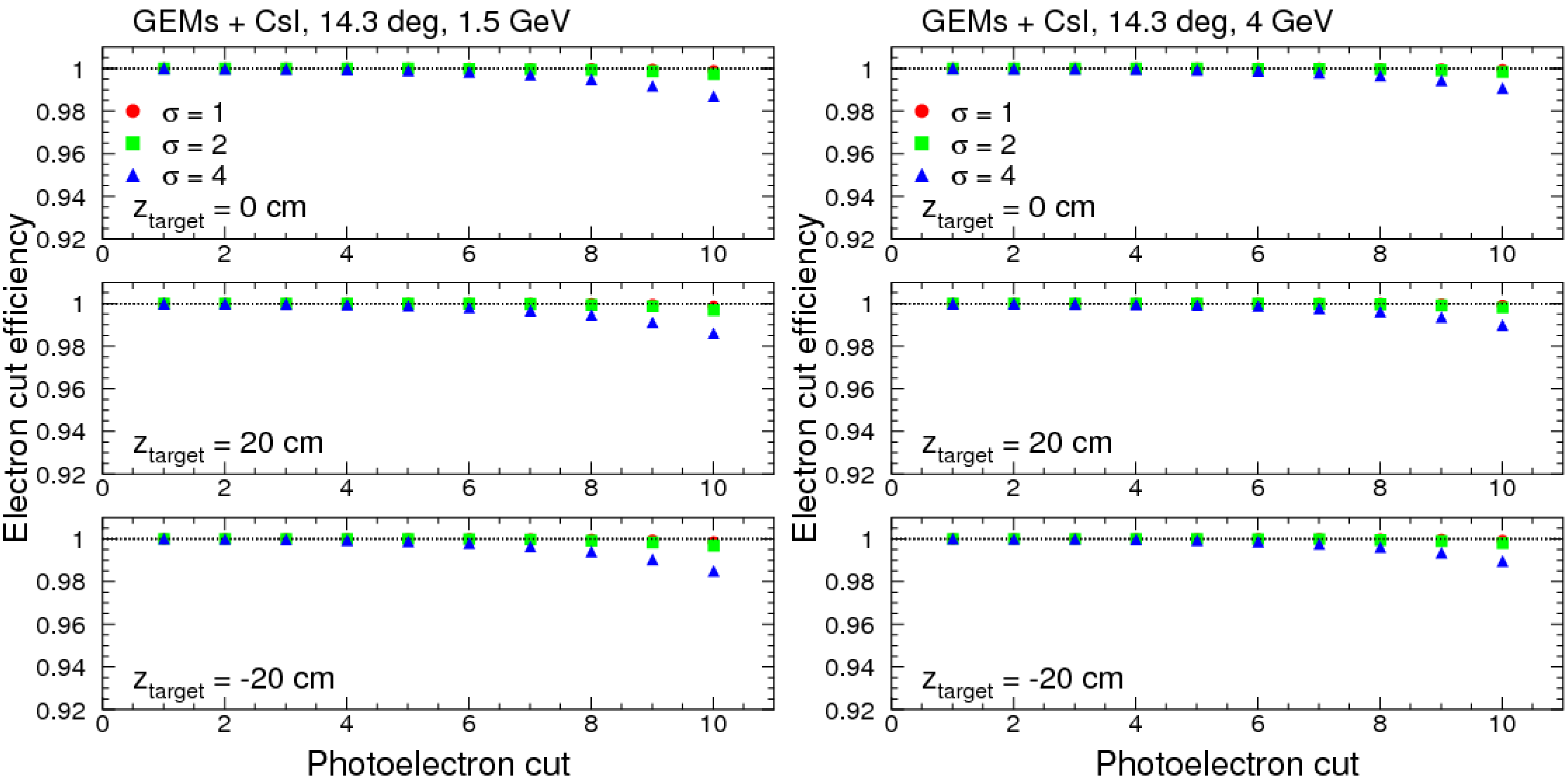
→ The distributions are obtained from the convolution of Poisson and Gauss functions

→The "assumed" detector resolution enters as the σ of the Gauss distribution

→ The GEMs+CsI p.e. resolution not readily available; will probably have to extract it from the HBD distribution

SIDIS Electron Cherenkov: GEMs + CsI

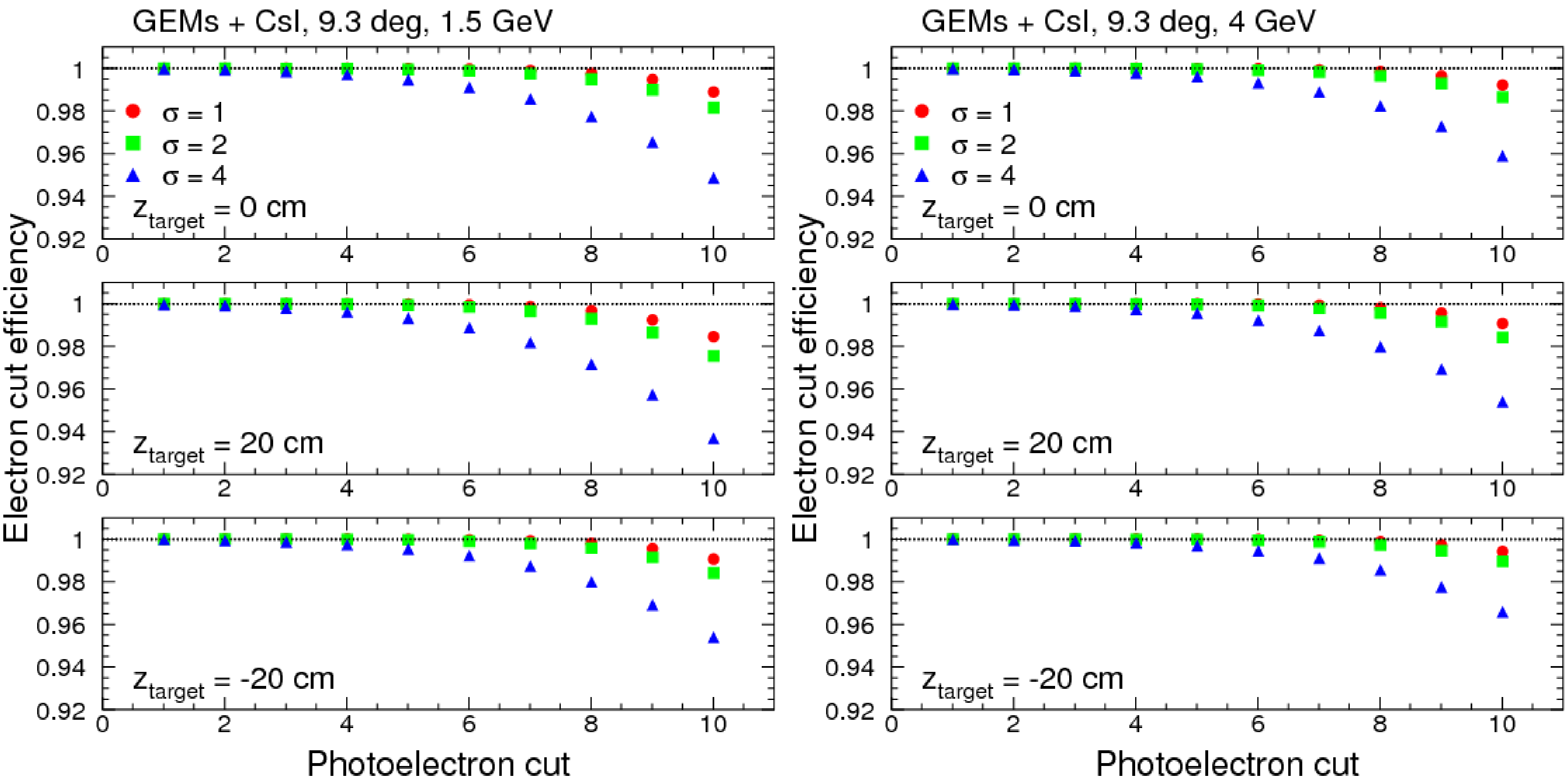
→Study photoelectron cut efficiency as a function of detector resolution



→Mean number of photoelectrons: ~ 25

SIDIS Electron Cherenkov: GEMs + CsI

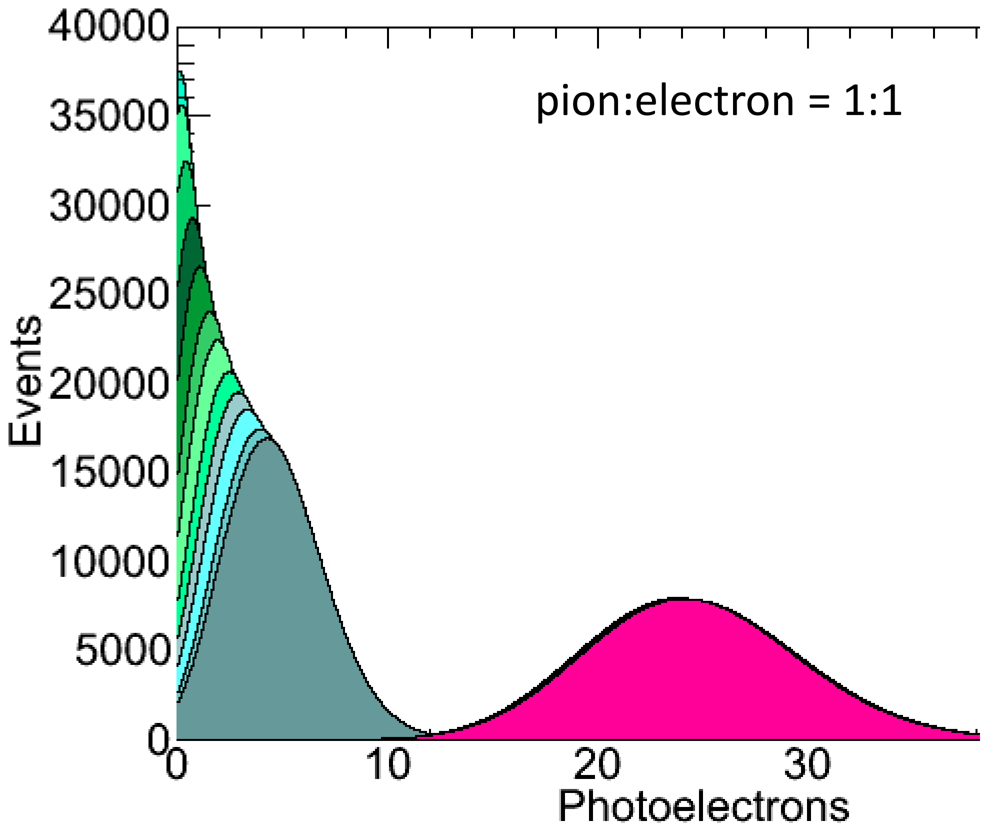
→Study photoelectron cut efficiency as a function of detector resolution

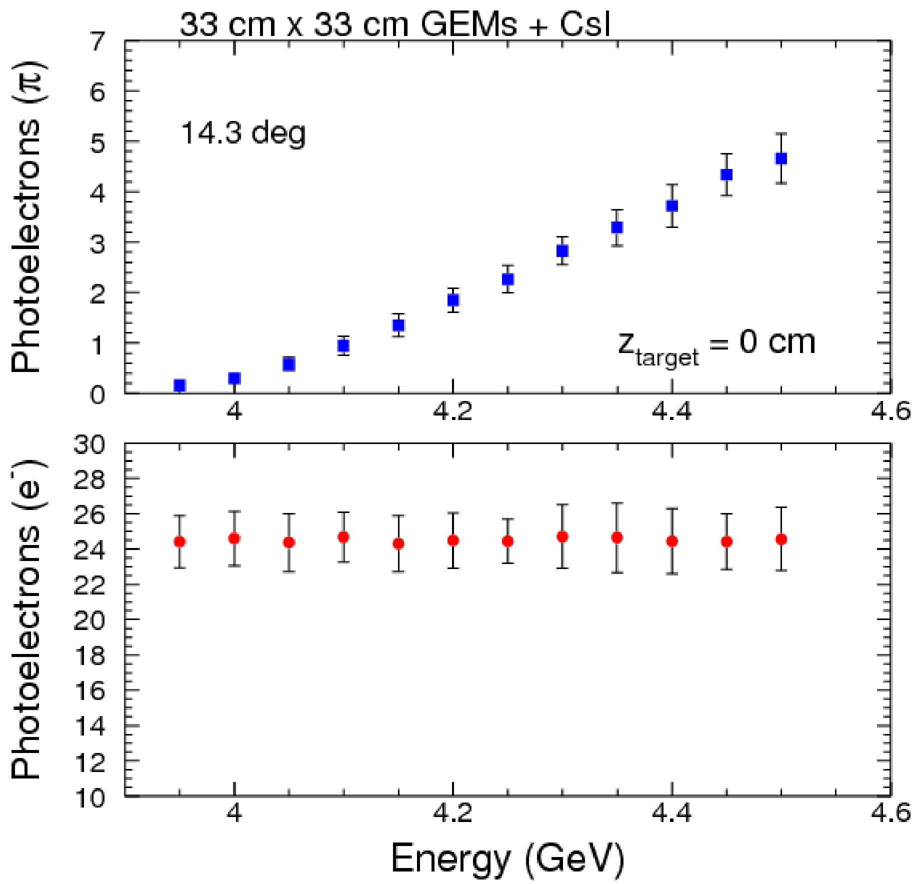


→Mean number of photoelectrons: ~ 20

SIDIS Electron Cherenkov: GEMs + CsI

→Study electron-pion separation for electrons with a momentum larger than the typical pion threshold in CF_4 (~3.95 GeV/c)



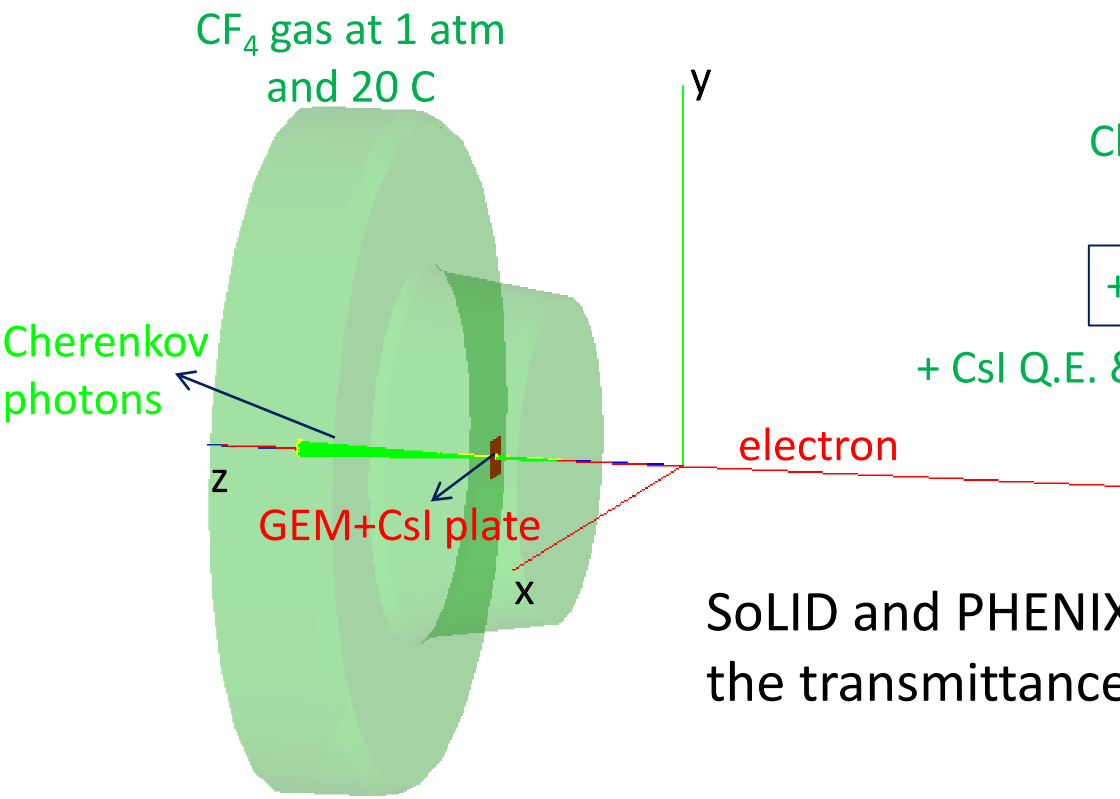


→To do: scale the pion distribution with the pion:electron ratio and calculate the pion contamination for a given cut on number of photoelectrons

SoLID vs PHENIX

Gas length: 0.515 m

Index of refraction n, CsI Q.E., CF_4 transmittance corrections: same as PHENIX



141.29

	SoLID	PHENIX
Cherenkov yield	139.33	141.14
+ CsI Q.E. corr.	72.46	74.17
+ transmt. corr.	112.35	96.25
+ CsI Q.E. & transmt. corr.	51.17	39.27
+ all corr.	26.4	20.3

SoLID and PHENIX in very good agreement <u>until</u> the transmittance correction is applied

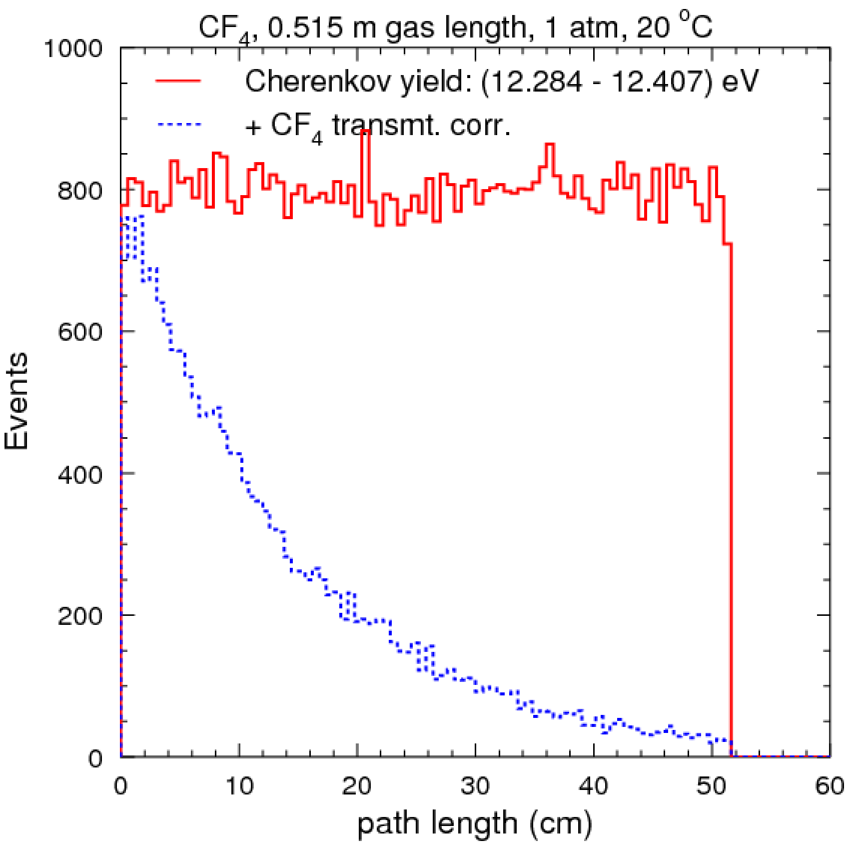
Note: In the excel table sent by Bob the integration is actually done between 99.5 nm and 200.5 nm; if I use these limits in GEANT4 (instead of 100 nm to 200 nm as above) I would get an yield of 141.29 in very …. very good agreement with the PHENIX number

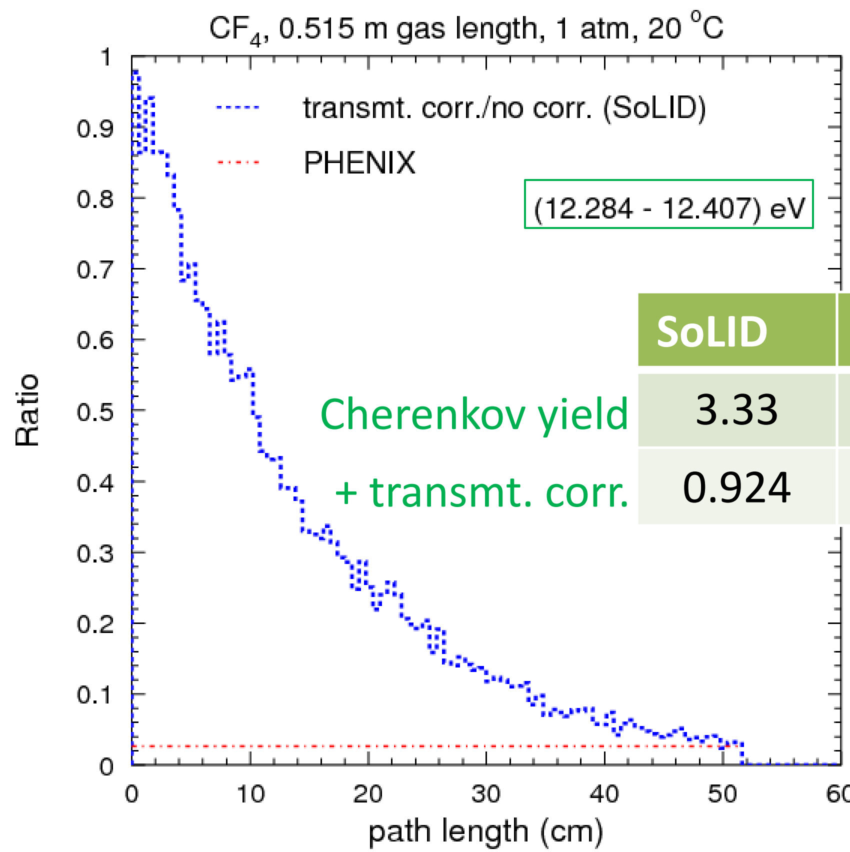
SoLID: GEANT4-based simulation

<u>Example: Cherenkov yield in one energy bin</u>

SoLID Geant4: uses the convolution of the gas transparency with the photon path length (not all Cherenkov photons are created at the entrance in the gas)

Highest energy bin: transmittance correction very large





	SoLID	PHENIX
Cherenkov yield	3.33	3.46
+ transmt. corr.	0.924	0.093

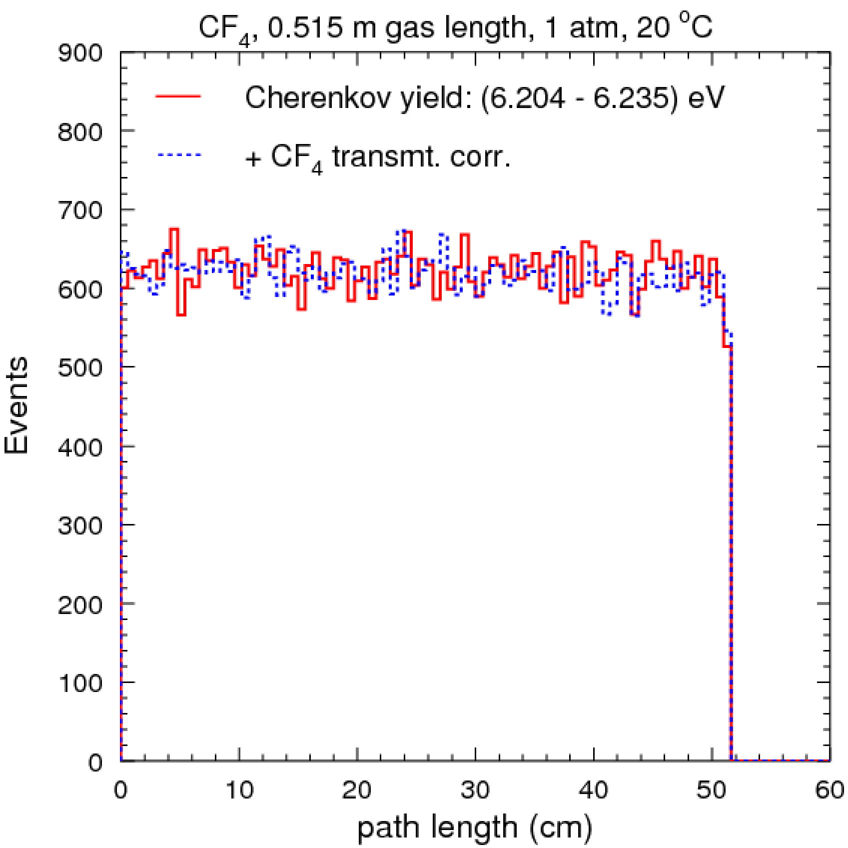
PHENIX: applies an **overall correction** to all photons created in **a given energy bin regardless of their path length**

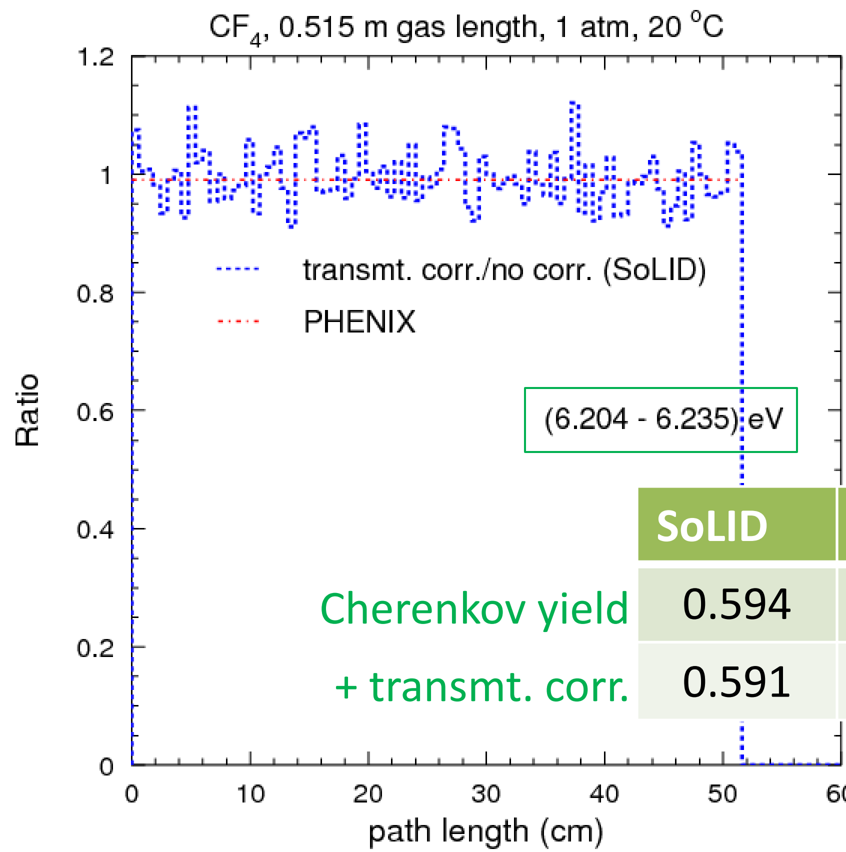
SoLID: GEANT4-based simulation

<u>Example: Cherenkov yield in one energy bin</u>

SoLID Geant4: uses the convolution of the gas transparency with the photon path length (not all Cherenkov photons are created at the entrance in the gas)

Lowest energy bin: transmittance correction very small





	SoLID	PHENIX
Cherenkov yield	0.594	0.588
+ transmt. corr.	0.591	0.582

PHENIX: applies an **overall correction** to all photons created in **a given energy bin regardless of their path length**

SIDIS Pion Cherenkov: maPMTs

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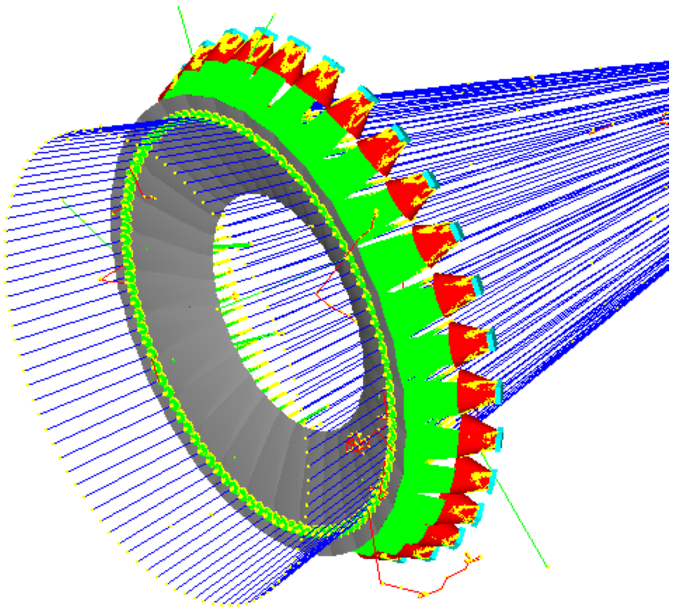
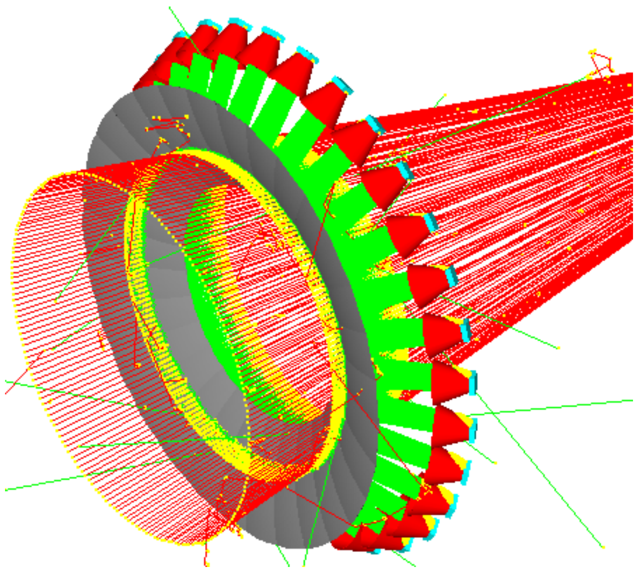
Design: one ring of spherical mirrors + 9 H8500C-03 PMTs per sector + straight cones + C_4F_8O at 1.5 atm and 20 C (pion threshold ~ 2 GeV)





Couldn't make the photon detector smaller:

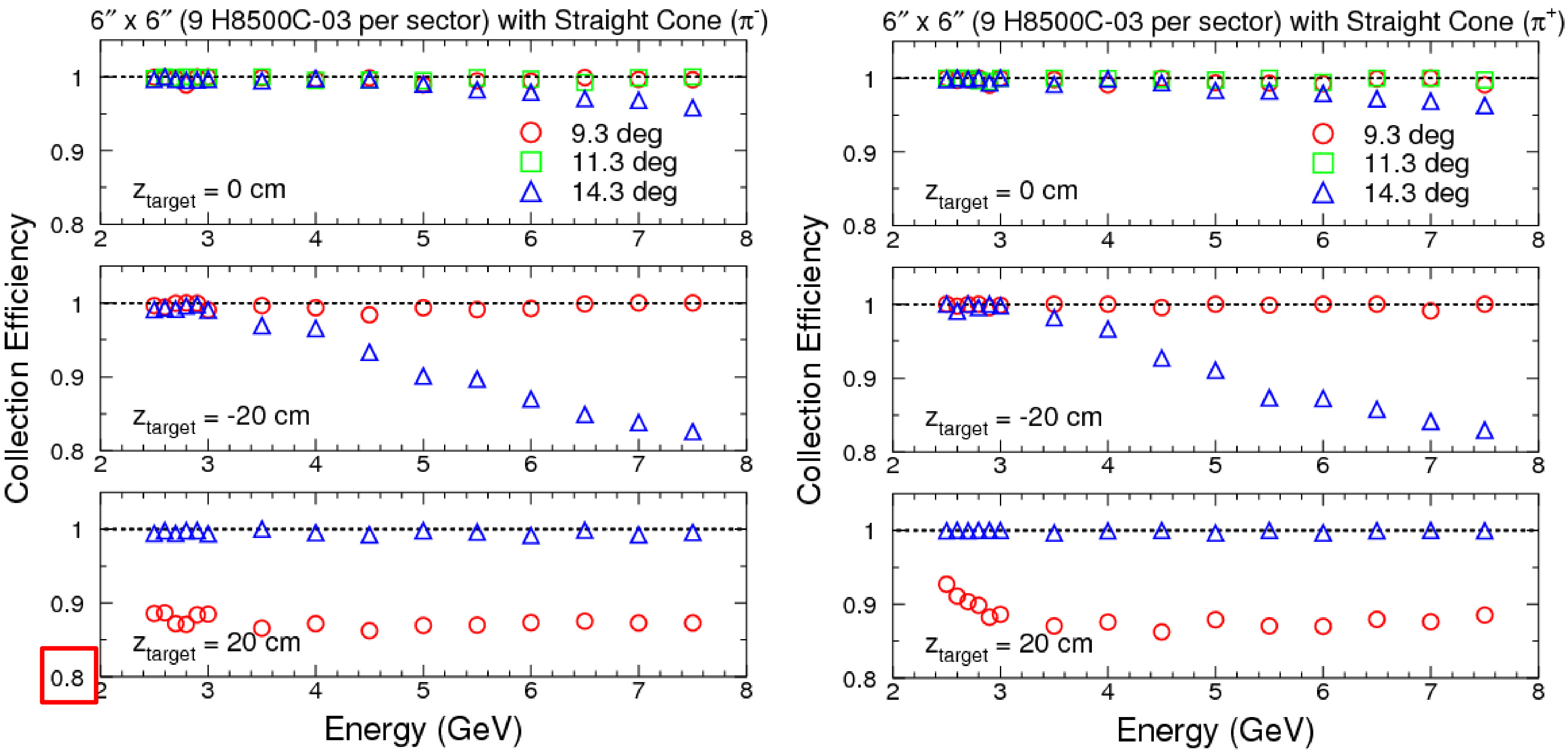
→ constraints on PMT position in the tank

→ gas with high index of refraction: large enough Cherenkov cone to impose constraints on the photon detector size given the wide kinematic range to be covered

Mirrors will be kept in one piece per sector

SIDIS Pion Cherenkov: maPMTs

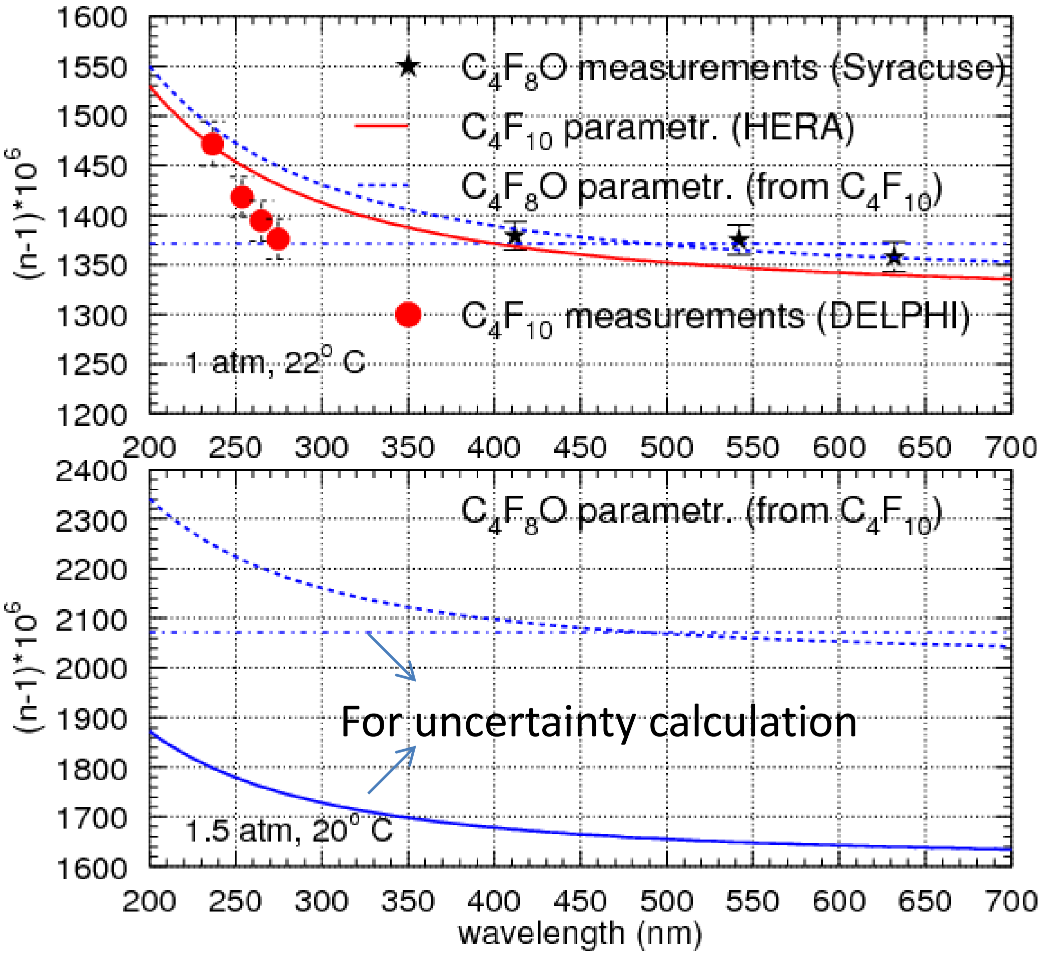
Design: one ring of spherical mirrors + 9 H8500C-03 PMTs per sector + straight cones + C_4F_8O at 1.5 atm and 20 C (pion threshold ~ 2 GeV)

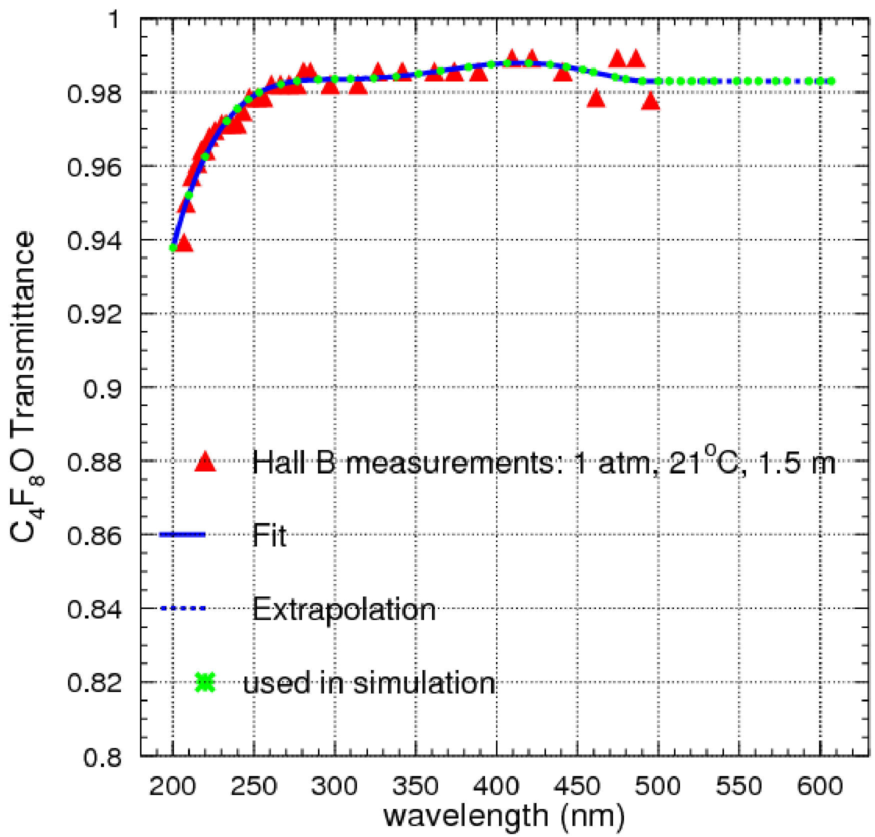


Design: optimized to get uniform photoelectron yield across kinematic range of interest (if possible)

SIDIS Pion Cherenkov: maPMTs

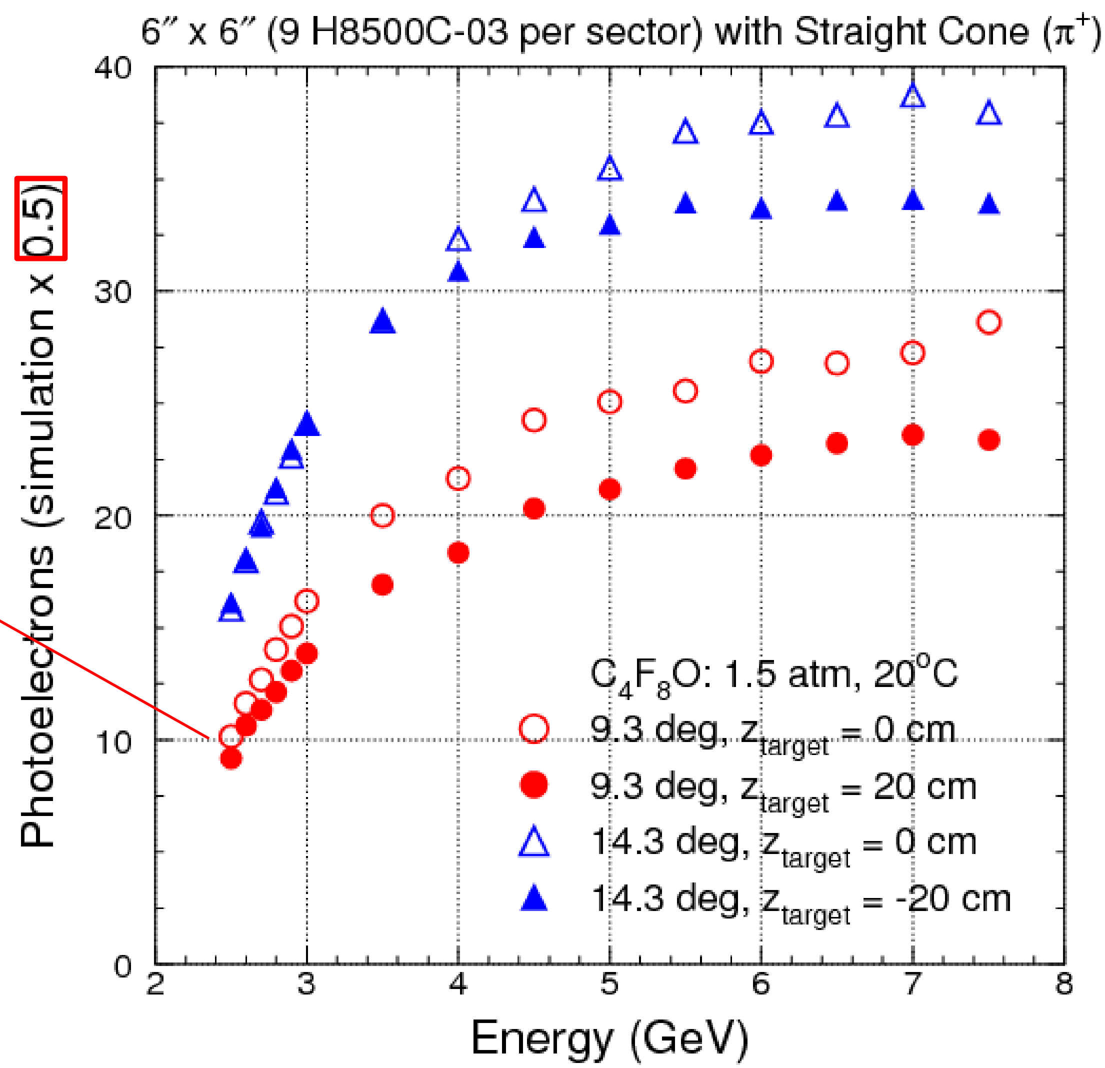
→Parametrizations, corrections for simulation





SIDIS Pion Cherenkov: maPMTs

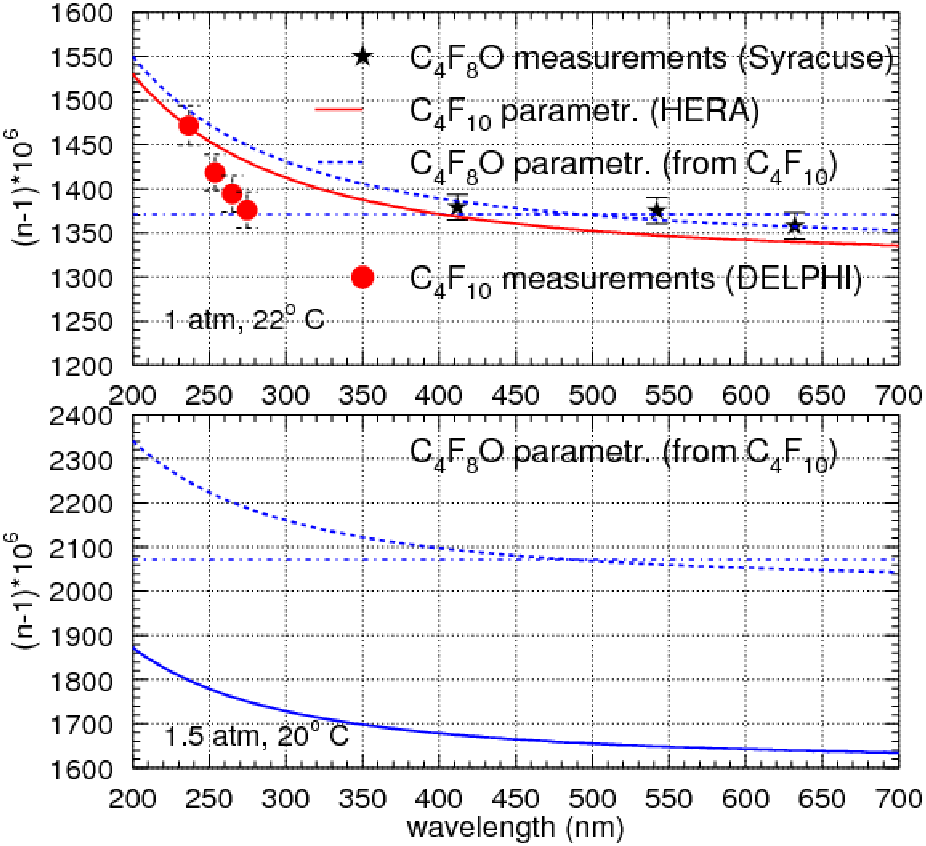
Design: one ring of spherical mirrors + 9 H8500C-03 PMTs per sector + straight cones + C_4F_8O at 1.5 atm and 20 C (pion threshold ~ 2 GeV)

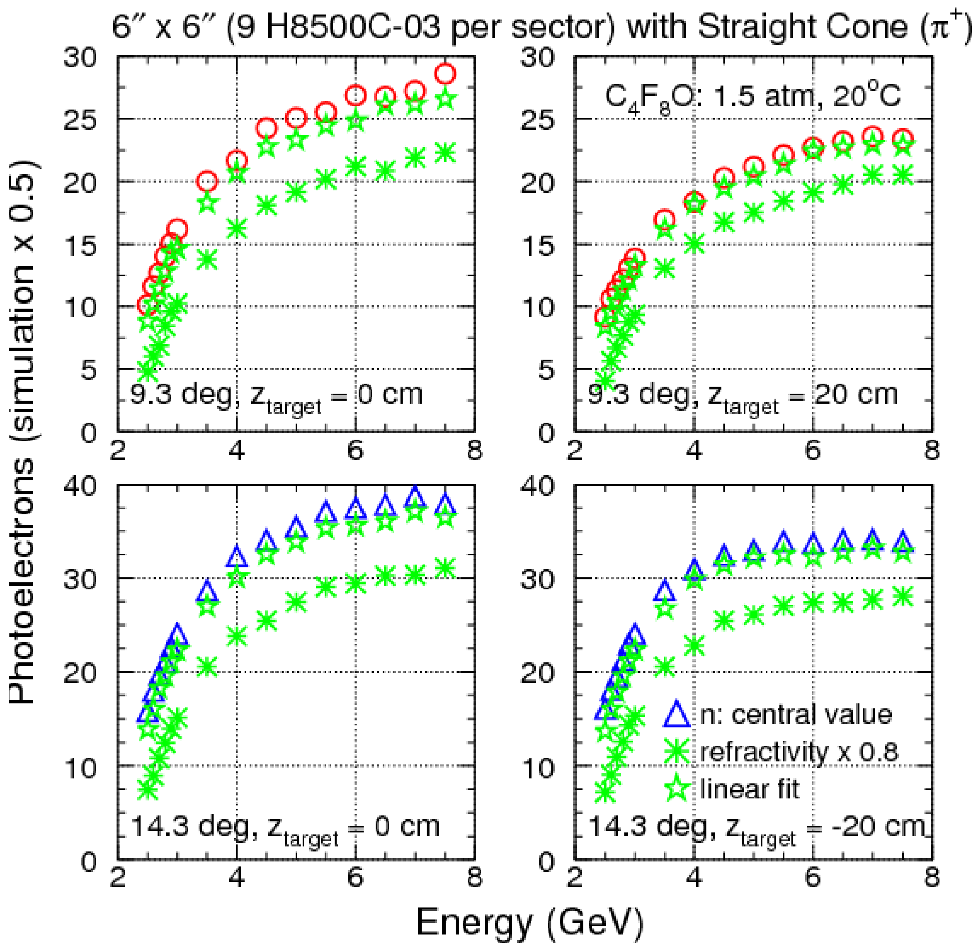


Smaller than at higher momentum because of proximity to threshold

SIDIS Pion Cherenkov: maPMTs

Index of refraction not well measured: study sensitivity of photoelectron yield to the value of n “plugged” in the simulation





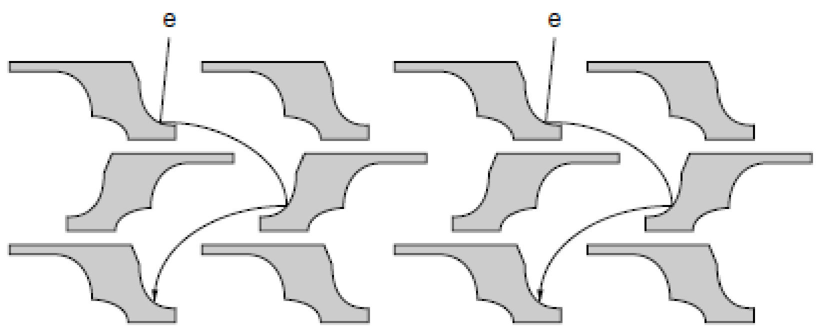
Hardware Tests: H8500C-03

Photon Detector: H8500C-03

Why this one over other PMTs?

→ Field resistant

→ Suitable for tiling



Parameter		H8500C	H8500D	H8500C-03	H8500D-0
Spectral Response		300 to 650		185 to 650	
Peak Wavelength		400			
Photocathode Material		Bialkali			
Window	Material	Borosilicate glass		UV glass	
	Thickness	1.5			
Dynode	Structure	Metal channel dynode			
	Number of Stages	12			
Number of Anode Pixels		64 (8 × 8 matrix)			
Pixel Size / Pitch at Center		5.8 × 5.8 / 6.08			
Effective Area		49 × 49			
Dimensional Outline (W × H × D)		52 × 52 × 27.4			
Packing Density (Effective Area / External Size)		89			

H8500C-03:Tests for SoLID

Bench tests:

→ measure the single photoelectron response

→ started tests of a new device purchased by Duke U. in November 2011

→ field measurements

→ did some at Temple in July 2011 (shown before, not covered here)

→ did some more this week

→ to do: field test with shielding specially designed for SoLID (?)

In beam test:

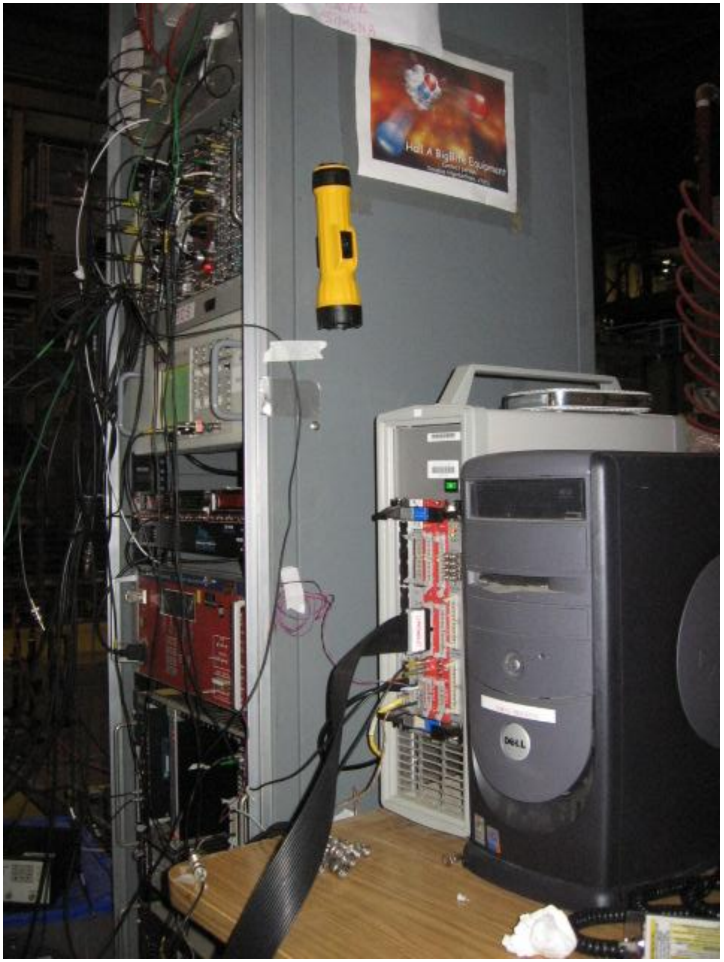
→ measure response of device to background

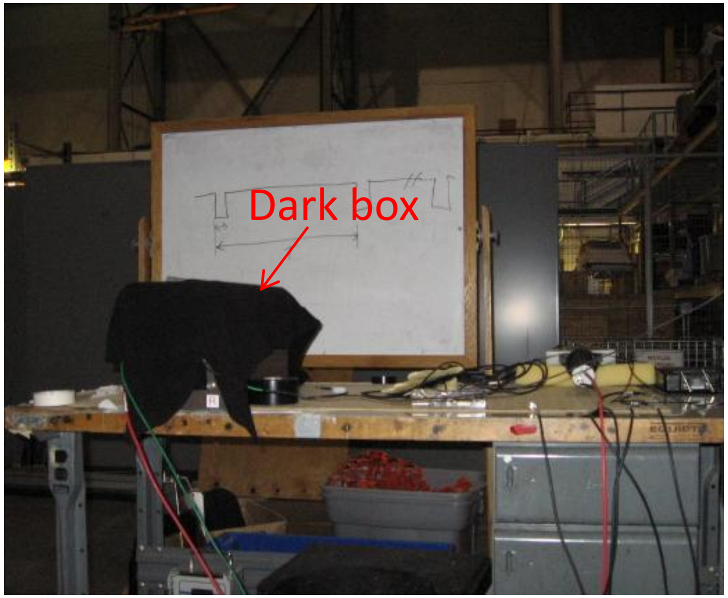
Many-many-many thanks to **Brad Sawatzky** for his guidance/support/help

H8500C-03: Single Photoelectron Response

2 test runs:

→ first: November 2011 (testlab)





pulser

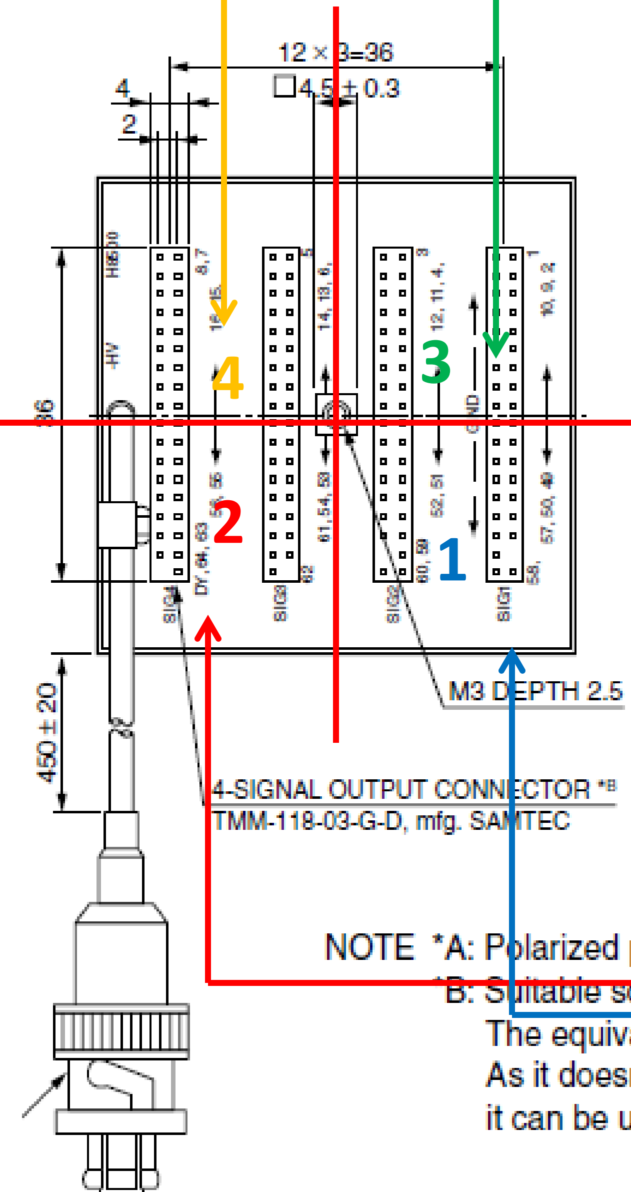
PMT has low gain: 1.5×10^6

It needs amplification of 100

Amplifier induced noise can be an issue

amplifier

H8500C-03: Single Photoelectron Response

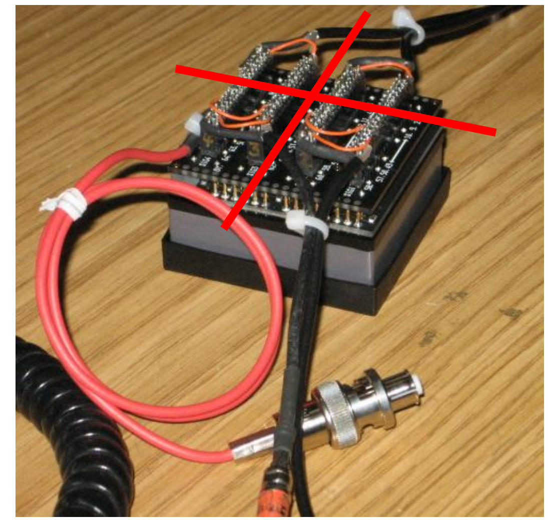


BOTTOM VIEW

CONNECTION FOR SIGNAL CONNECTORS
(BOTTOM VIEW)

SIG4		SIG3		SIG2		SIG1	
GND	P7	GND	P5	GND	P3	GND	P1
GND	P8	GND	P6	GND	P4	GND	P2
GND	P15	GND	P13	GND	P11	GND	P9
GND	P16	GND	P14	GND	P12	GND	P10
GND	P23	GND	P21	GND	P19	GND	P17
GND	P24	GND	P22	GND	P20	GND	P18
GND	P31	GND	P29	GND	P27	GND	P25
GND	P32	GND	P30	GND	P28	GND	P26
GND	P39	GND	P37	GND	P35	GND	P33
GND	P40	GND	P38	GND	P36	GND	P34
GND	P47	GND	P45	GND	P43	GND	P41
GND	P48	GND	P46	GND	P44	GND	P42
GND	P55	GND	P53	GND	P51	GND	P49
GND	P56	GND	P54	GND	P52	GND	P50
GND	P63	GND	P61	GND	P59	GND	P57
GND	P64	GND	P62	GND	P60	GND	P58
GND	DY12	GND	GND	*A	GND	GND	*A
*A	GND	GND	*A	GND	GND	GND	GND

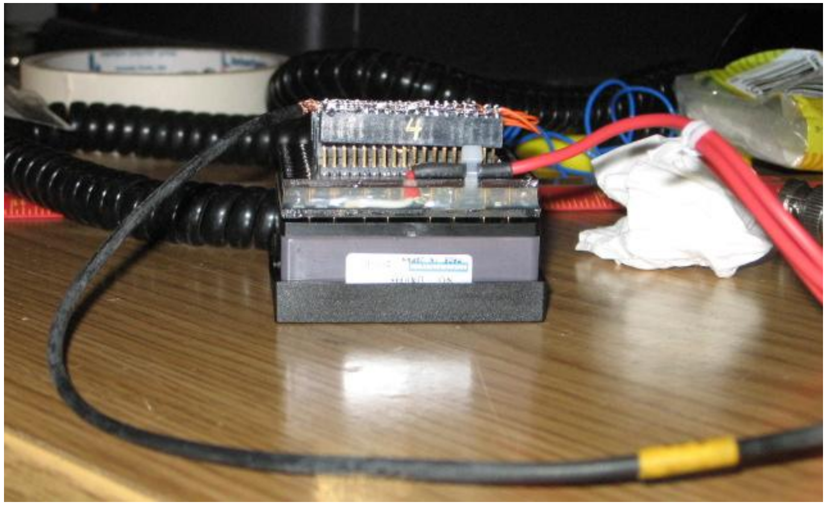
NOTE *A: Polarized position of omitted pin
*B: Suitable sockets for the signal connectors will be attache
The equivalent socket is SQT-118-01-L-D (SAMTEC).
As it doesn't have a polarized position marker,
it can be used at any positions.

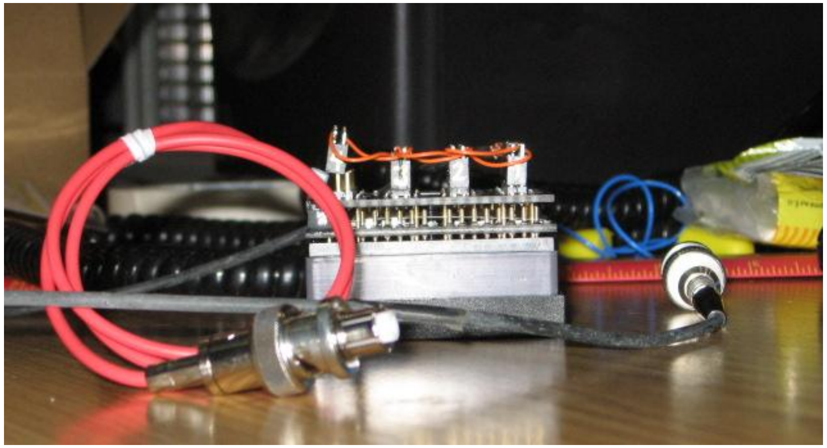


Quad division

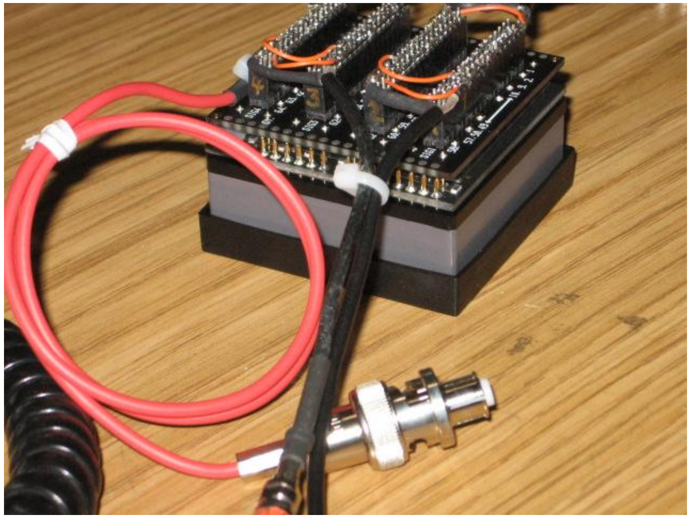
H8500C-03: Single Photoelectron Response

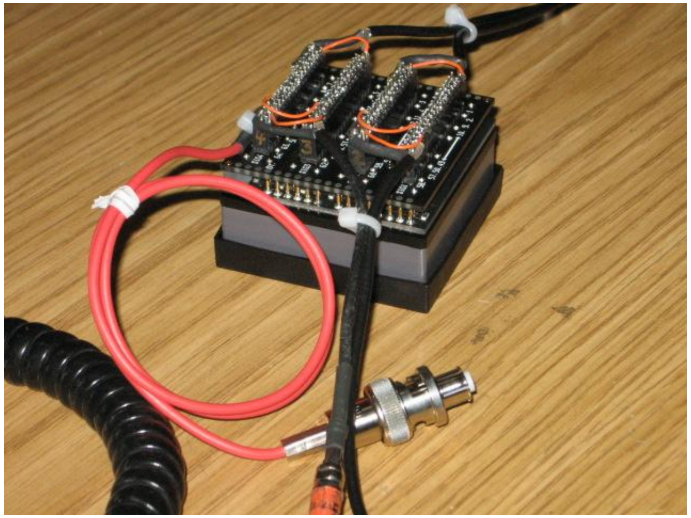
→ Connectors for sum output



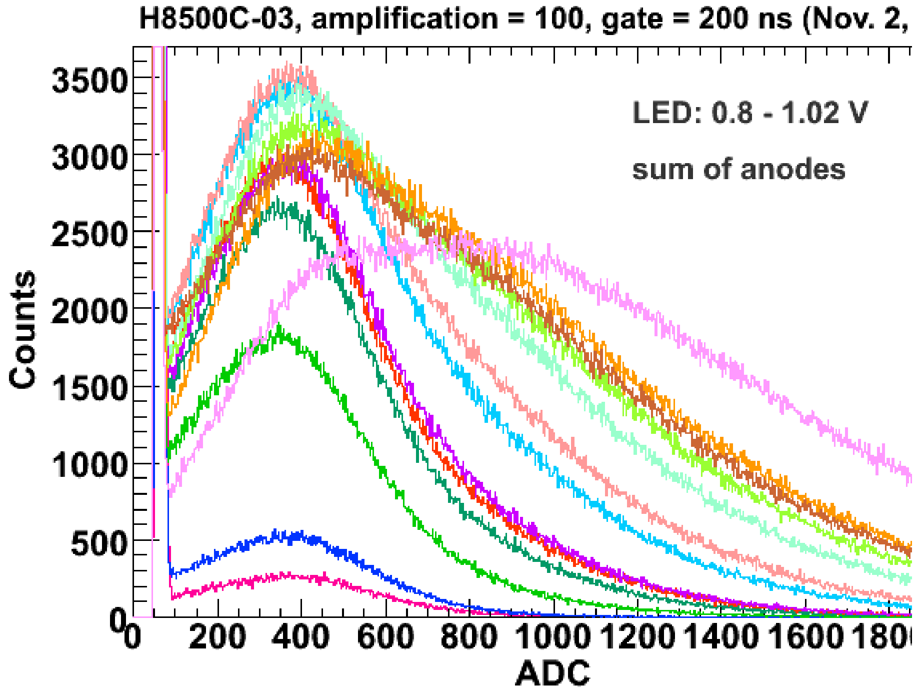


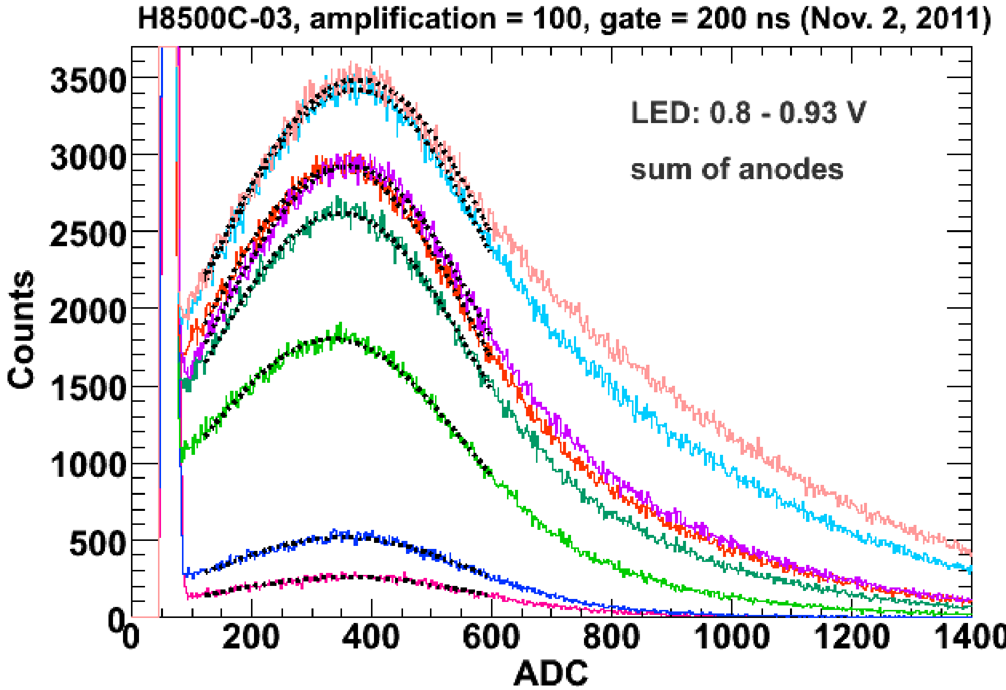
→ Connectors for quad output

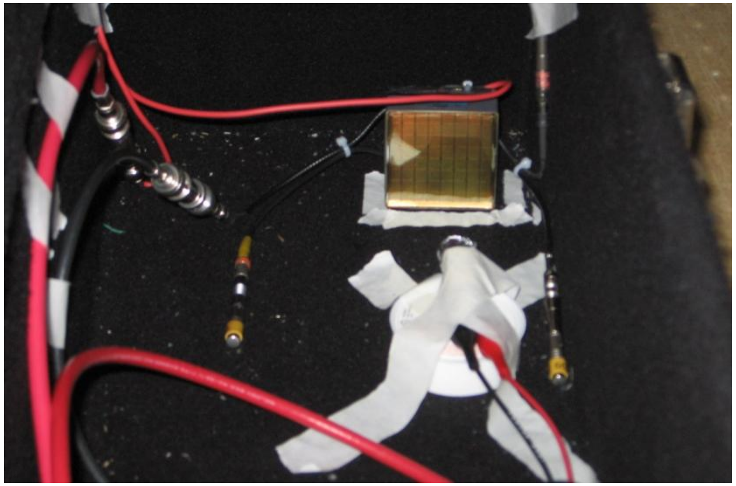


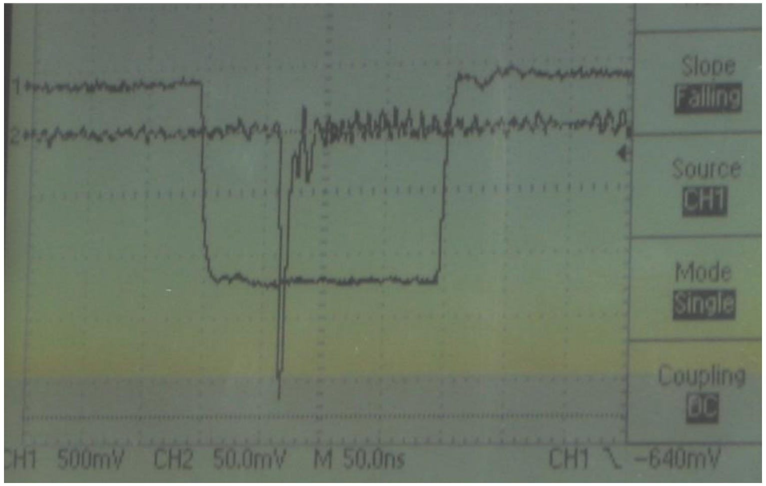


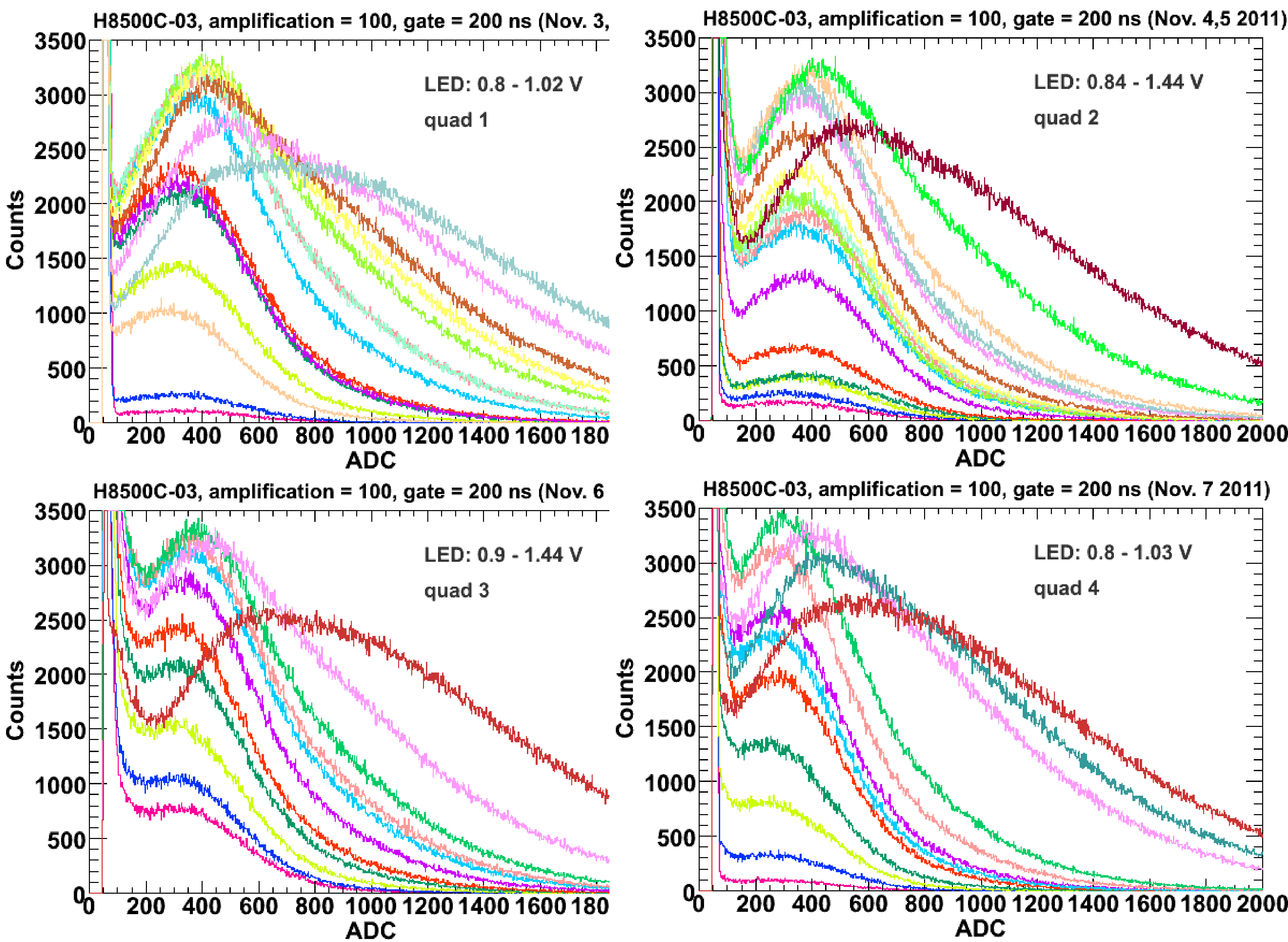
H8500C-03: Single Photoelectron Response

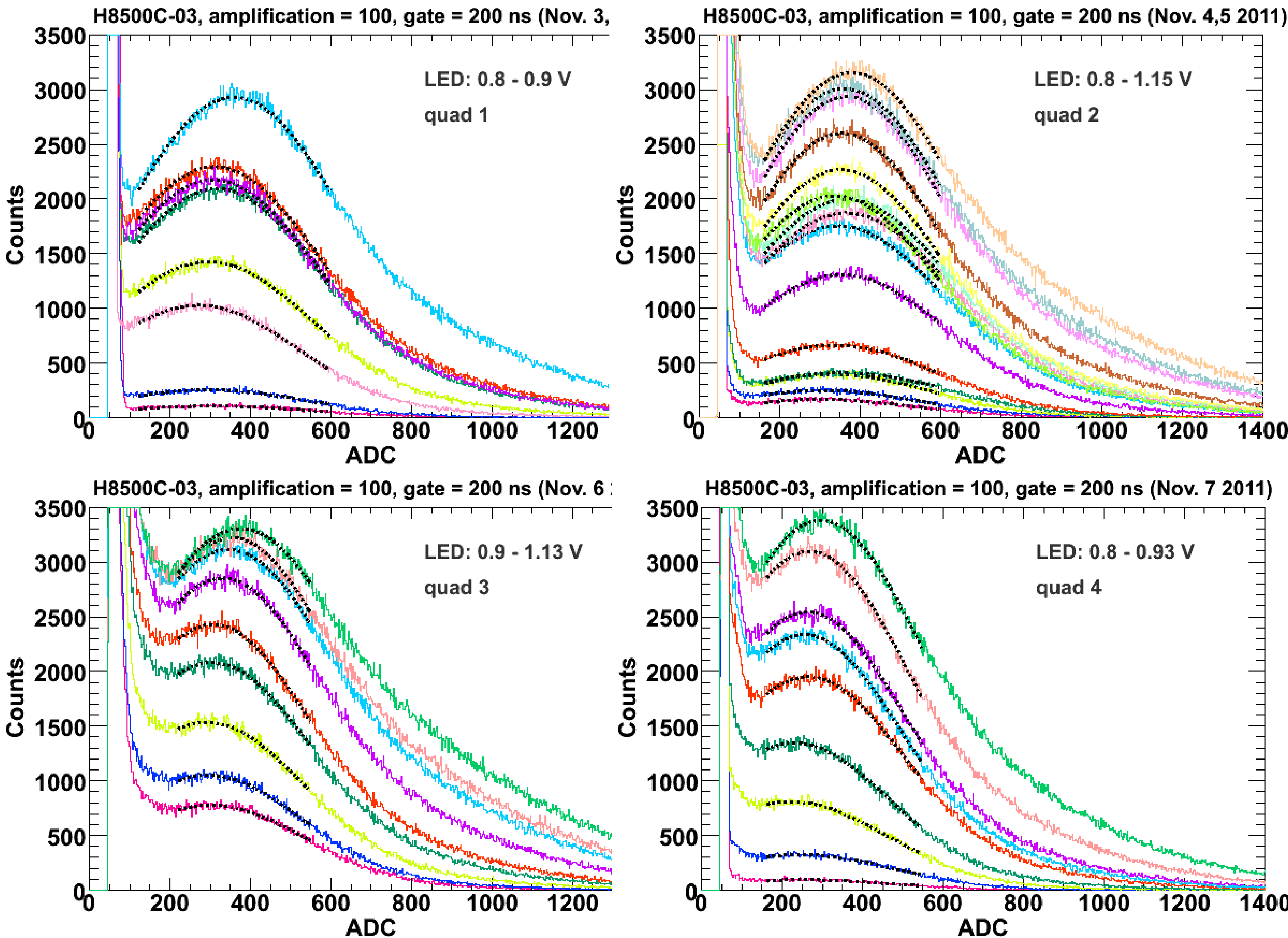









H8500C-03, amplification = 100, gate = 200 ns (Nov. 3,
LED: 0.8 - 1.02 V
quad 1
Counts
ADC
H8500C-03, amplification = 100, gate = 200 ns (Nov. 4,5 2011)
LED: 0.84 - 1.44 V
quad 2
Counts
ADC
H8500C-03, amplification = 100, gate = 200 ns (Nov. 6
LED: 0.9 - 1.44 V
quad 3
Counts
ADC
H8500C-03, amplification = 100, gate = 200 ns (Nov. 7 2011)
LED: 0.8 - 1.03 V
quad 4
Counts
ADC

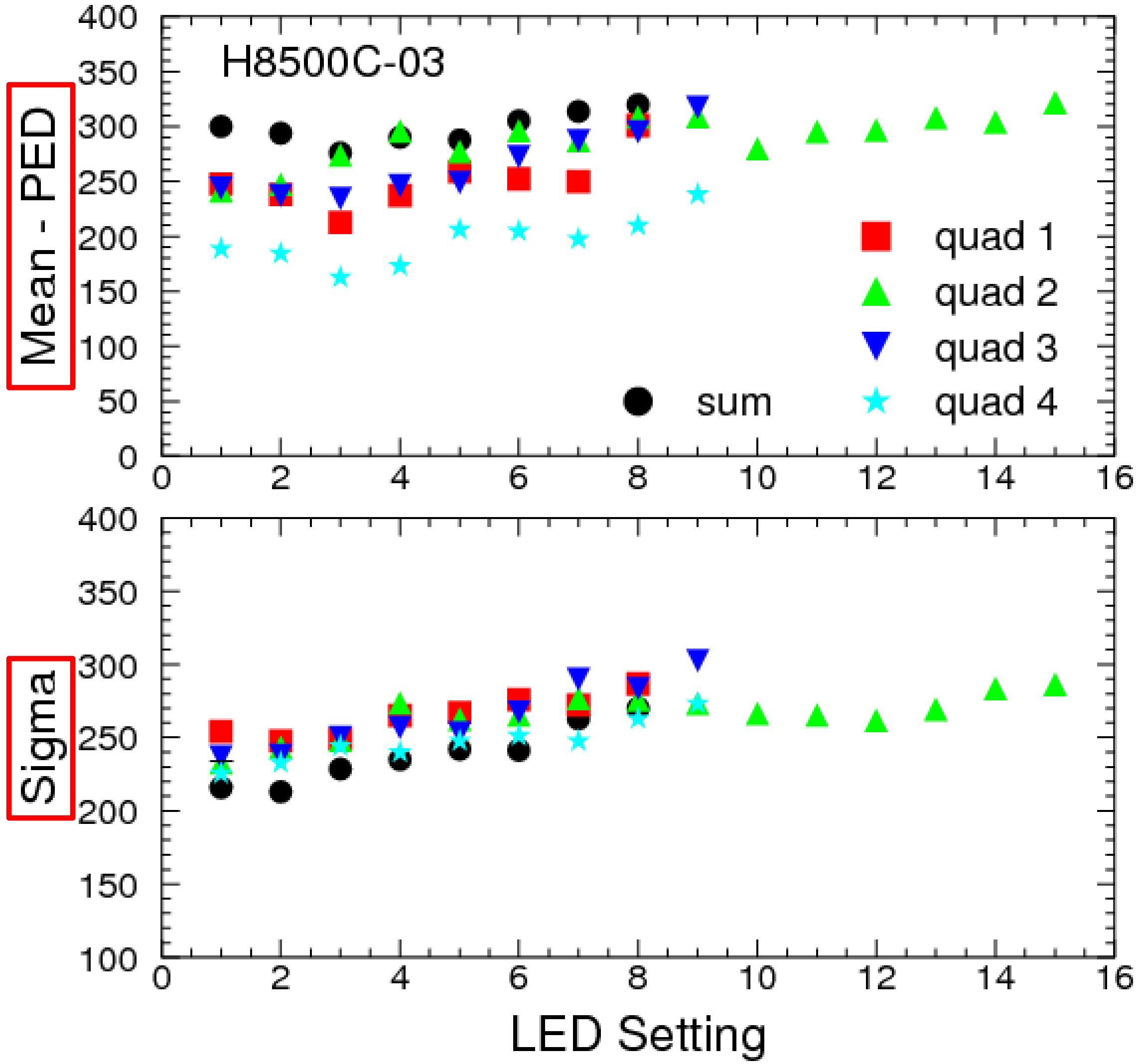


H8500C-03, amplification = 100, gate = 200 ns (Nov. 3,
LED: 0.8 - 0.9 V
quad 1
H8500C-03, amplification = 100, gate = 200 ns (Nov. 4,5 2011)
LED: 0.8 - 1.15 V
quad 2
H8500C-03, amplification = 100, gate = 200 ns (Nov. 6
LED: 0.9 - 1.13 V
quad 3
H8500C-03, amplification = 100, gate = 200 ns (Nov. 7 2011)
LED: 0.8 - 0.93 V
quad 4
Counts
ADC

H8500C-03: Single Photoelectron Response

SPE peak location on ADC - pedestal

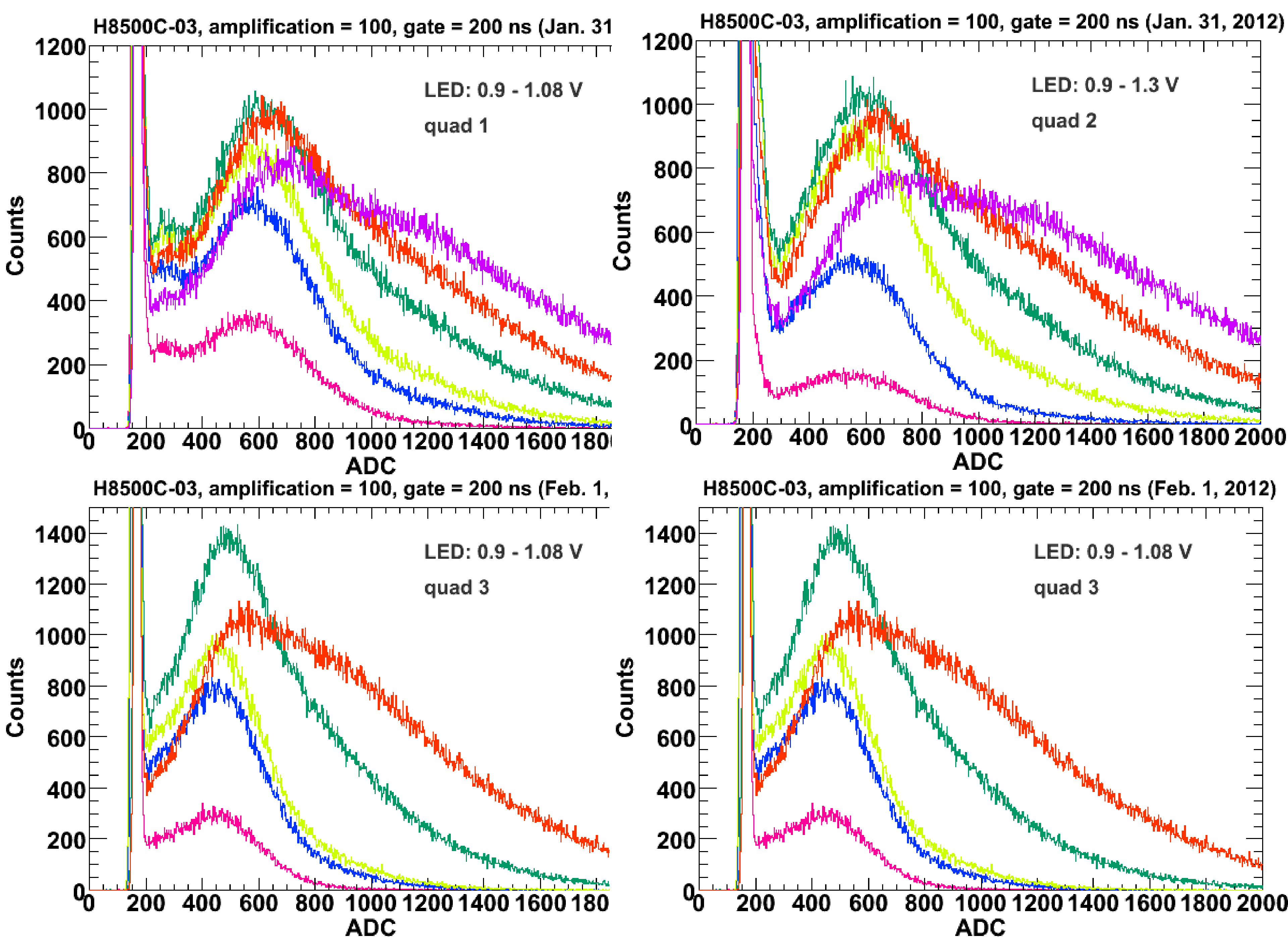
Width of SPE distribution

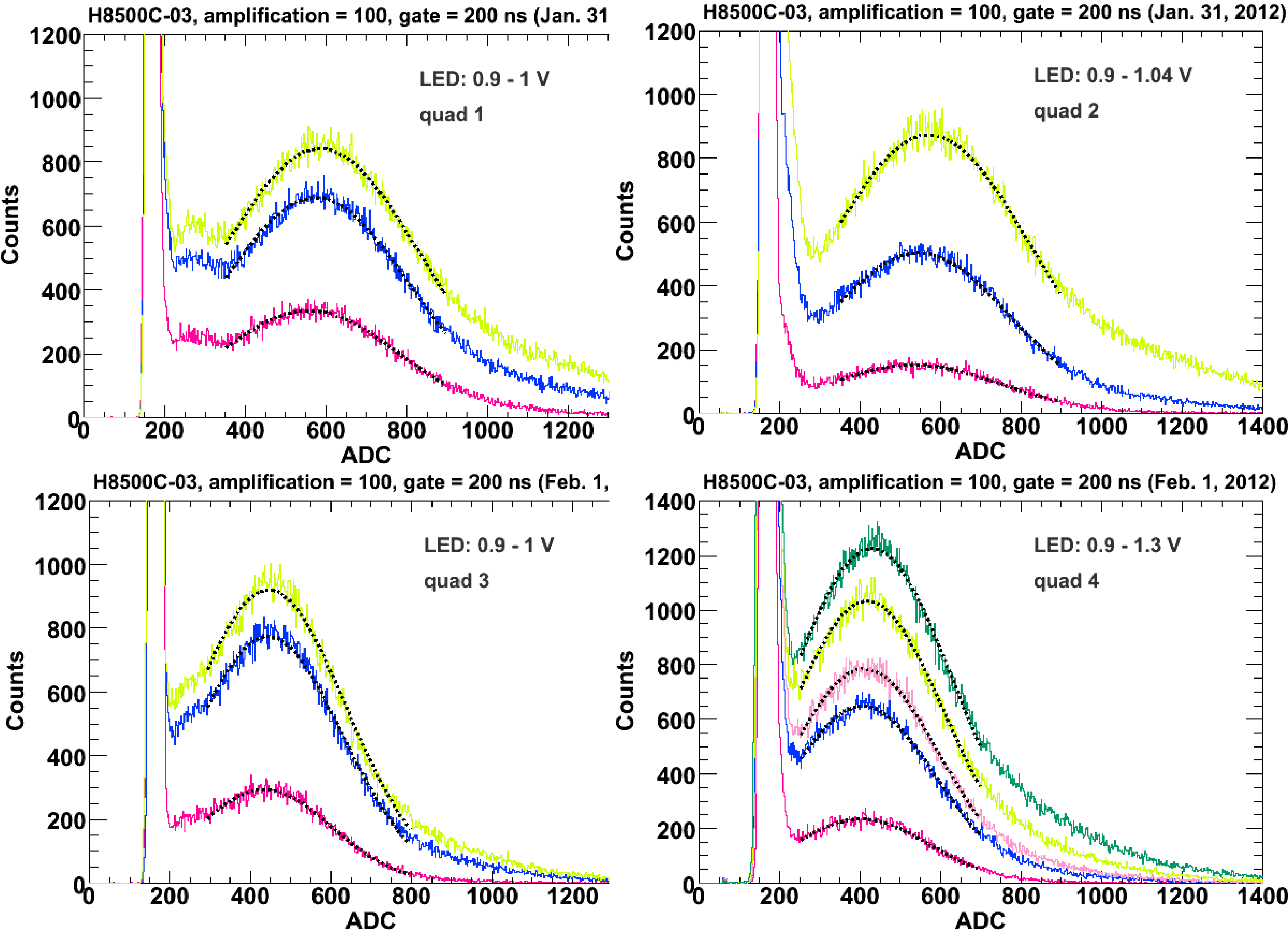


Resolution ~ 1 p.e.

H8500C-03: Single Photoelectron Response

→ second: Jan.-Feb. 2012 (2^{nd} floor, counting house)

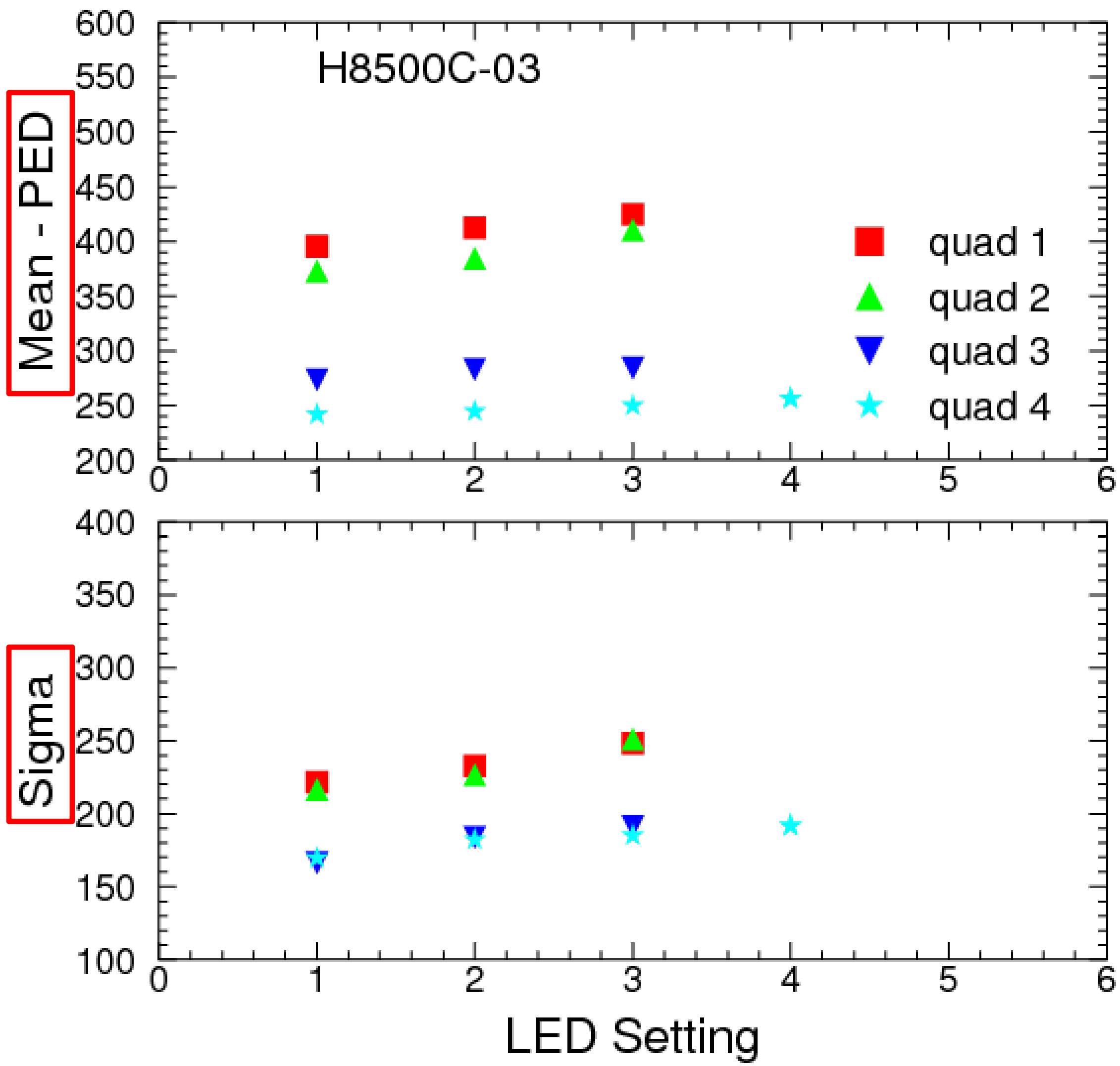

H8500C-03, amplification = 100, gate = 200 ns (Jan. 31
LED: 0.9 - 1.08 V
quad 1
Counts
ADC
H8500C-03, amplification = 100, gate = 200 ns (Jan. 31, 2012)
LED: 0.9 - 1.3 V
quad 2
Counts
ADC
H8500C-03, amplification = 100, gate = 200 ns (Feb. 1,
LED: 0.9 - 1.08 V
quad 3
Counts
ADC
H8500C-03, amplification = 100, gate = 200 ns (Feb. 1, 2012)
LED: 0.9 - 1.08 V
quad 3
Counts
ADC


H8500C-03, amplification = 100, gate = 200 ns (Jan. 31
LED: 0.9 - 1 V
quad 1
Counts
ADC
H8500C-03, amplification = 100, gate = 200 ns (Jan. 31, 2012)
LED: 0.9 - 1.04 V
quad 2
Counts
ADC
H8500C-03, amplification = 100, gate = 200 ns (Feb. 1,
LED: 0.9 - 1 V
quad 3
Counts
ADC
H8500C-03, amplification = 100, gate = 200 ns (Feb. 1, 2012)
LED: 0.9 - 1.3 V
quad 4
Counts
ADC

H8500C-03: Single Photoelectron Response

SPE peak location on ADC - pedestal

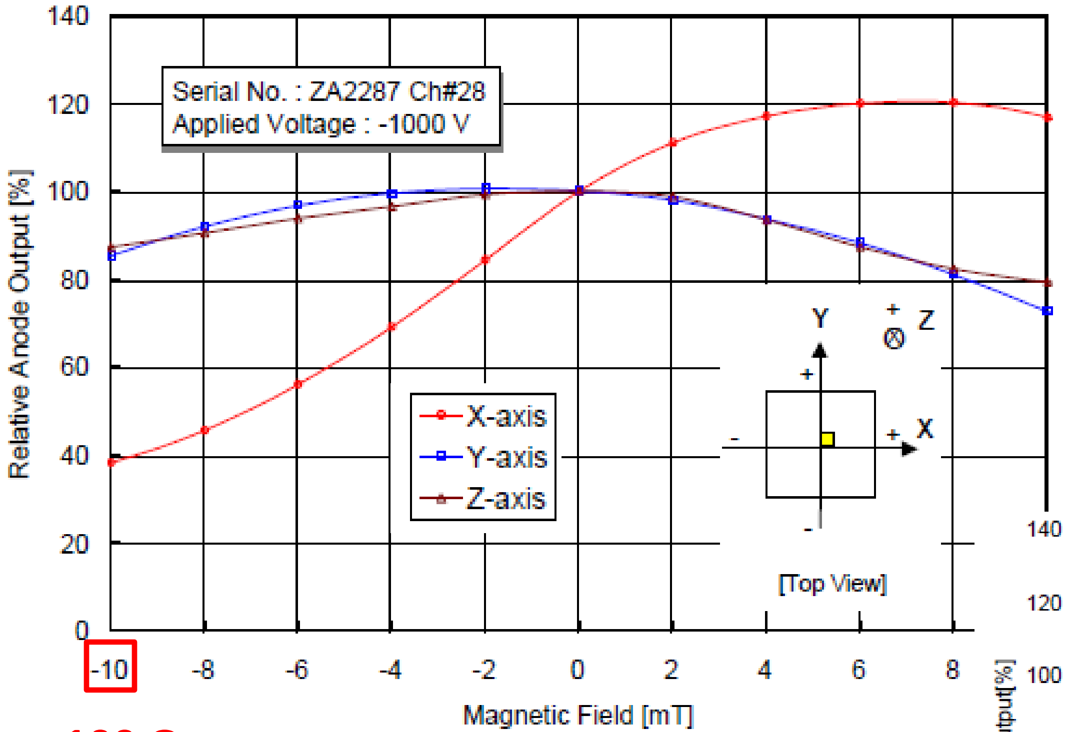
Width of SPE distribution



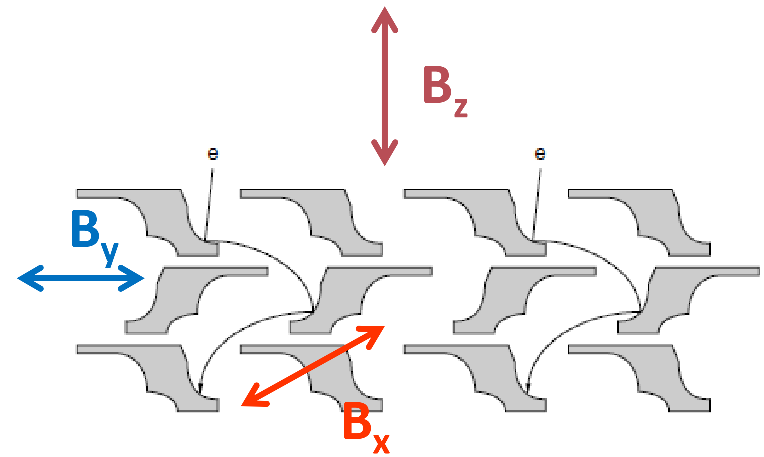
Resolution ~ 1 p.e. (or better?)

H8500C-03: Magnetic Field Response

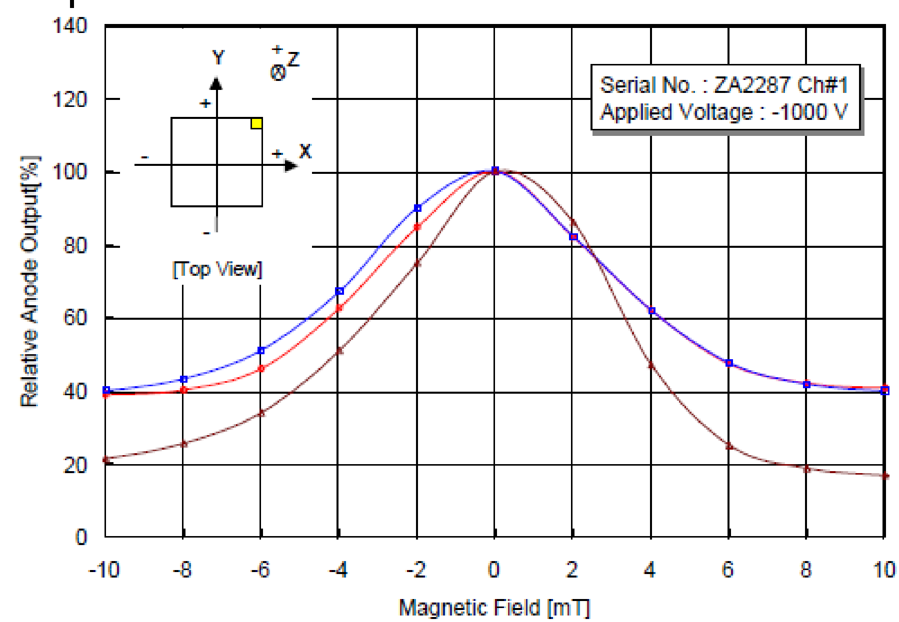
→ Data from Hamamatsu (PMT unshielded)



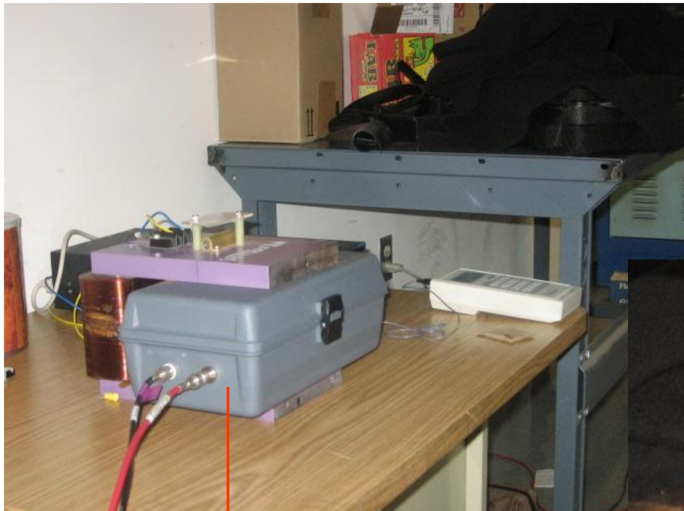
100 G



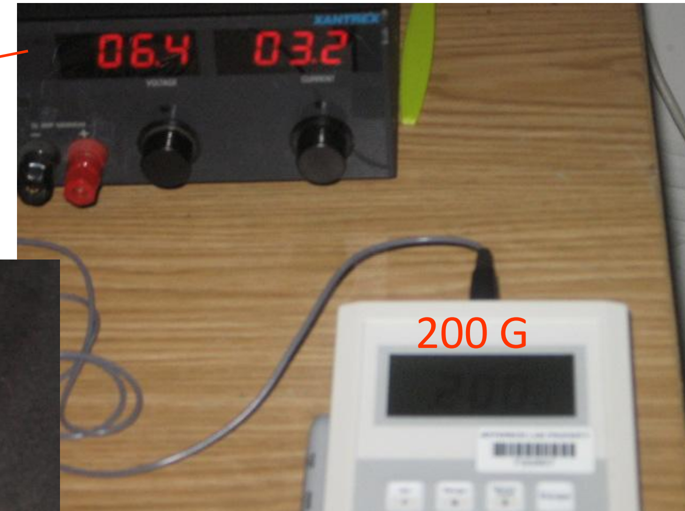
→ a 5” PMT would experience at 4 G same gain reduction as the maPMT at 100 G



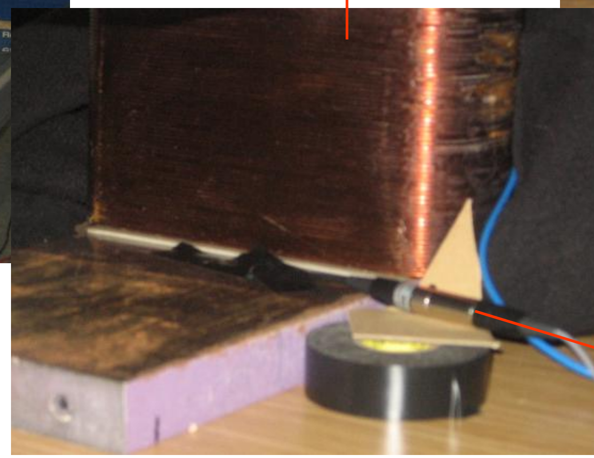
H8500C-03: Field Measurements



Power supply

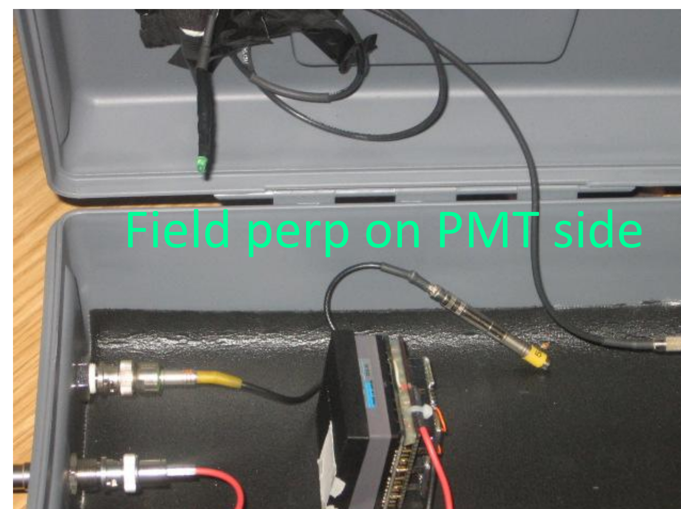


Coil



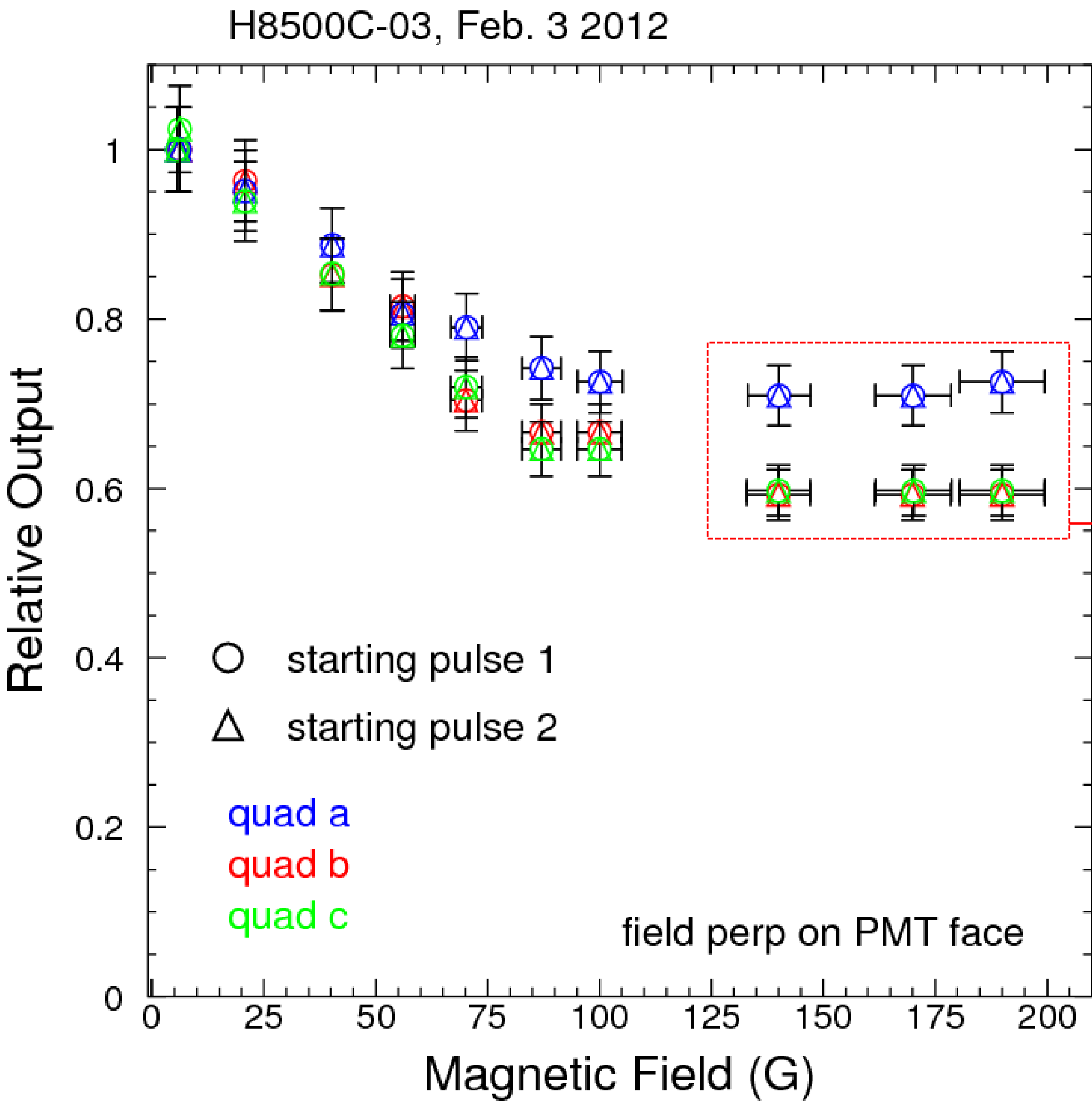
Tinny dark box inside the magnet

Magnetic field probe in position for field measurement

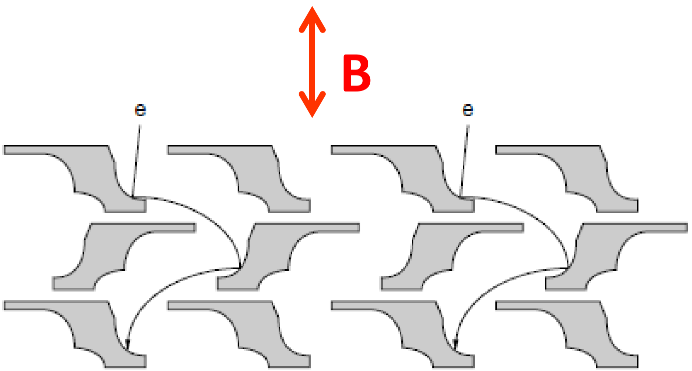


H8500C-03: Magnetic Field Response

→ Field perp on PMT "side" measurement



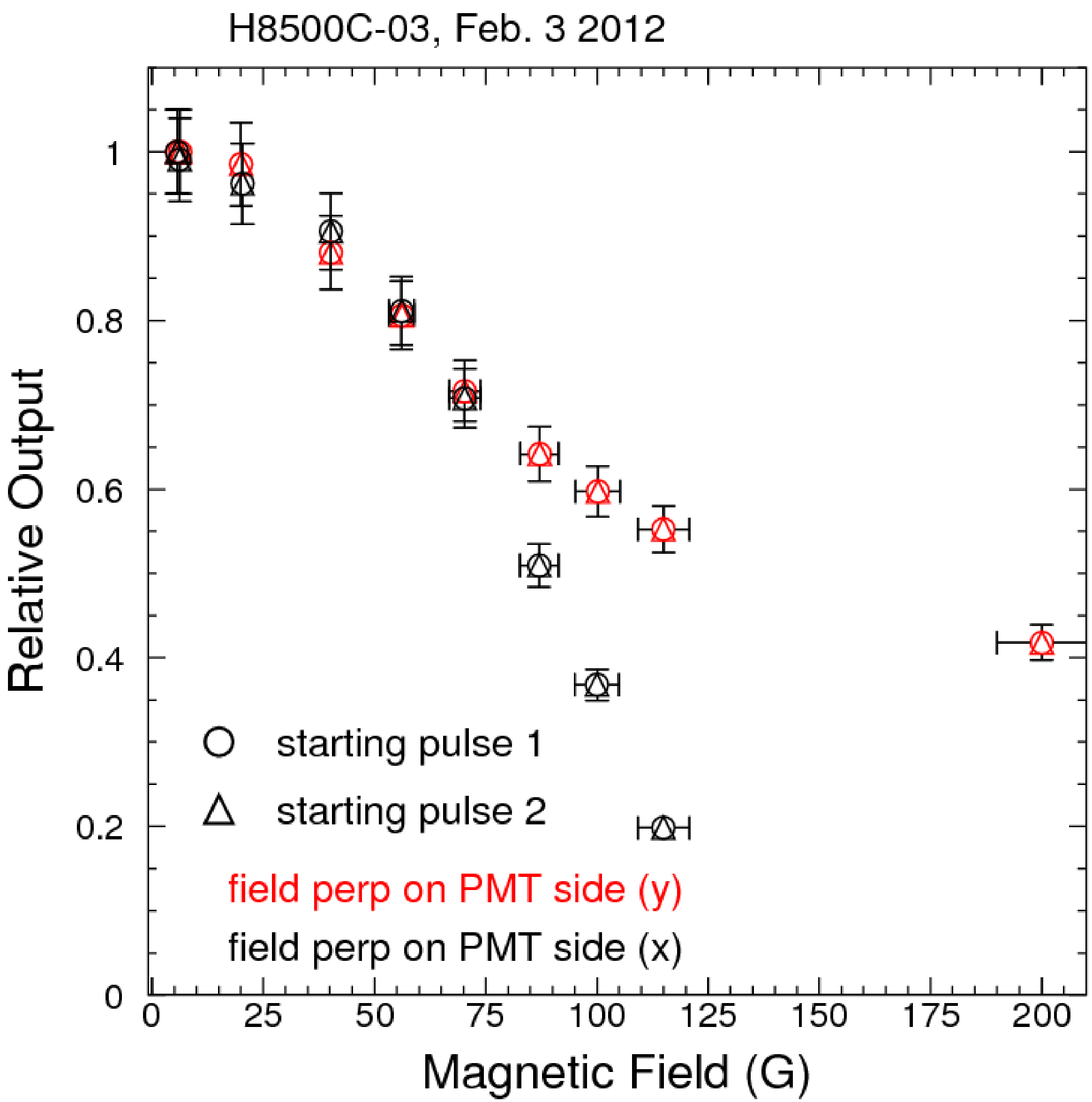
It saturates!!!

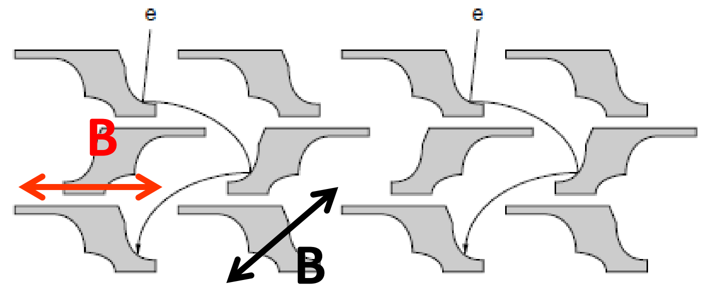


Monday I'll try to push it to higher field

H8500C-03: Magnetic Field Response

→ Field perp on PMT "face" measurement



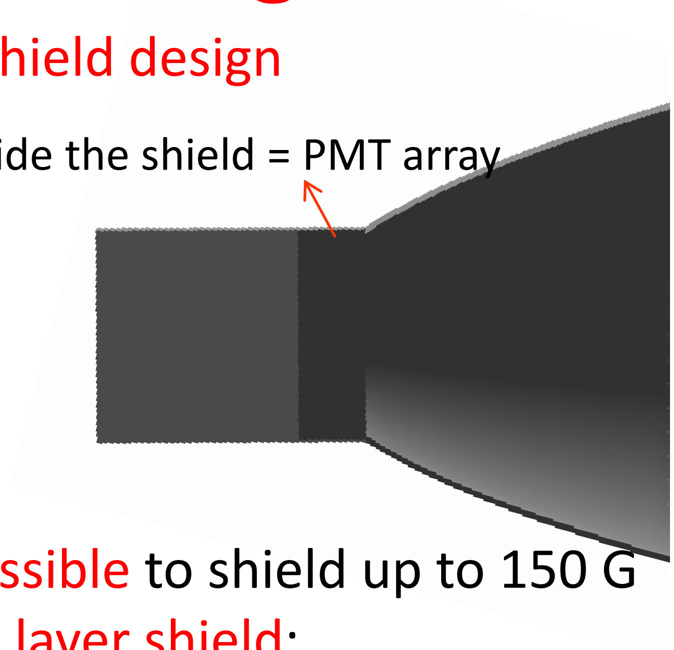


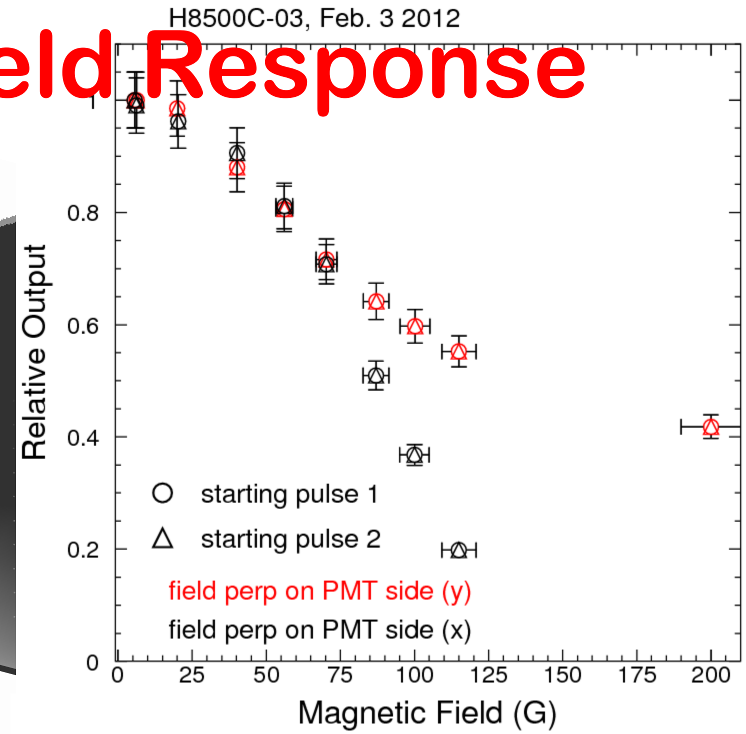
Monday I'll try to flip polarity ("field perp on PMT side (x)" should show a gain and not reduction) and go to higher field for "field perp on PMT side (y)"

H8500C-03: Magnetic Field Response

→ Implications for shield design

Dark area inside the shield = PMT array location



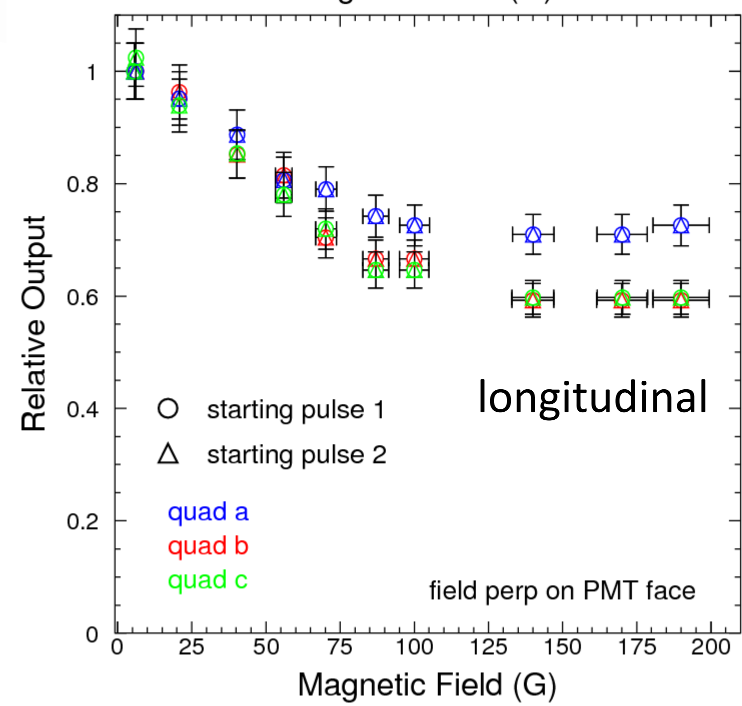


Amuneal says it's possible to shield up to 150 G longitudinal with a 2 layer shield:

- → inner: Amumetal 0.04"
- → outer: 1008 carbon steel 1/8"
- → mylar in between 0.062"

But this would make it heavy!

→ Because the field induced PMT gain reduction appears to saturate above ~ 125 G we could try to recover the ~ 50% loss by amplification of signal and focus to shield the transverse field component (much easier)



H8500C-03: Test in Beam

→ Purpose: get an idea of the maPMT response to background by comparison to a 5" PMT (more commonly used) and to a HBD

→Data taken:

→ scaler rates on a 5 inch Photonis and H8500C-03 maPMT on a Carbon target at a beam energy of 1.717 GeV and beam current of 0.15, 0.5 and 1 μA with the dark box placed at 45 deg on the rhs of the beam line, concrete shielding only under the box

→ scaler rates on both PMTs on a Carbon target at 1 μA with the box placed at 35 deg next to the HBD on table, no shielding

→ ADC data for most settings

→ 2-quad coincidence rates → ***not shown***

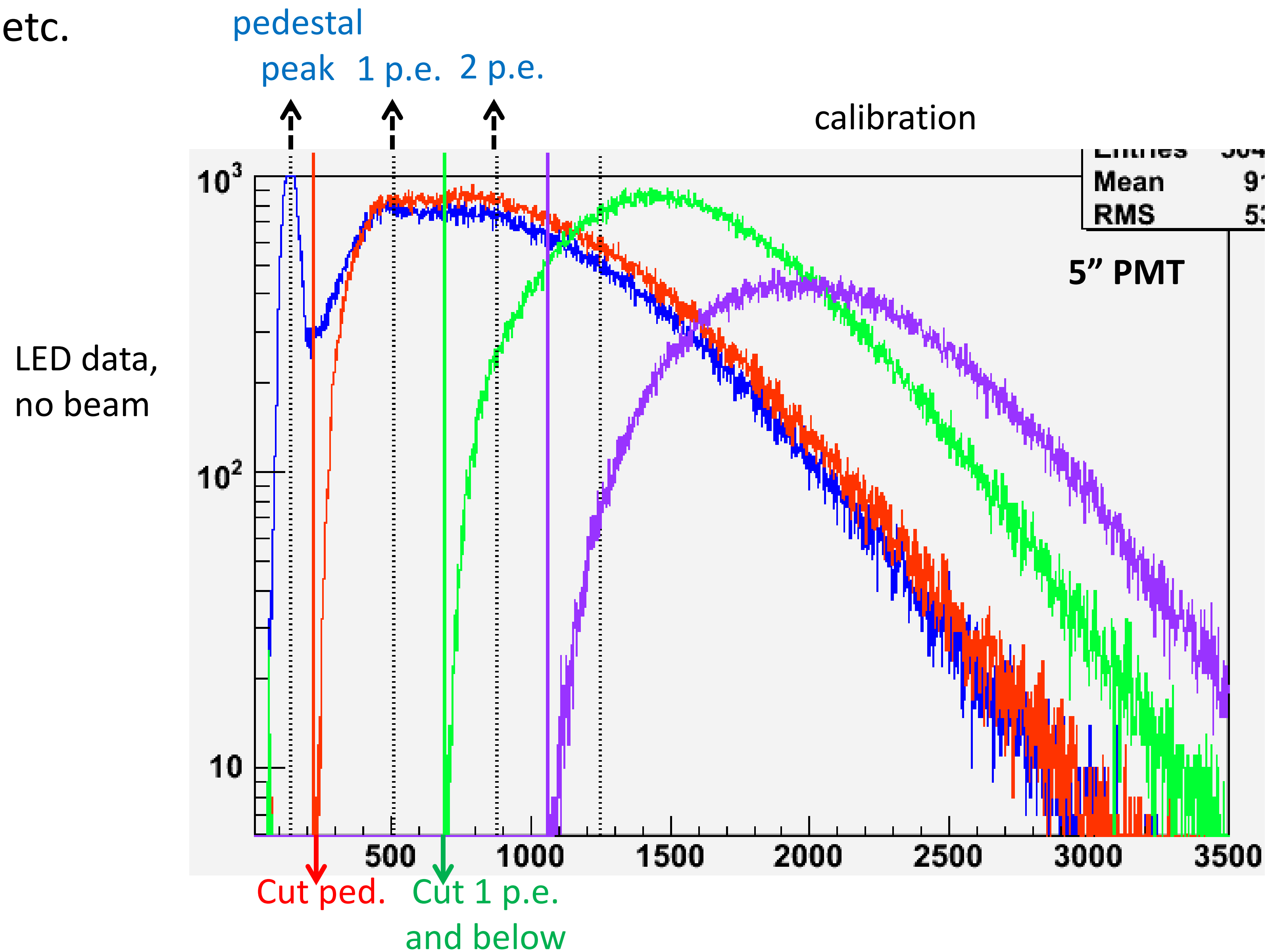
H8500C-03: Test in Beam

45 deg location
dark box sat on concrete blocks

35 deg location
dark box sat on GEM table

H8500C-03: Test in Beam

→ Set appropriate discriminator threshold to cut out: pedestal, 1 p.e., 2 p.e. etc.



H8500C-03: Test in Beam

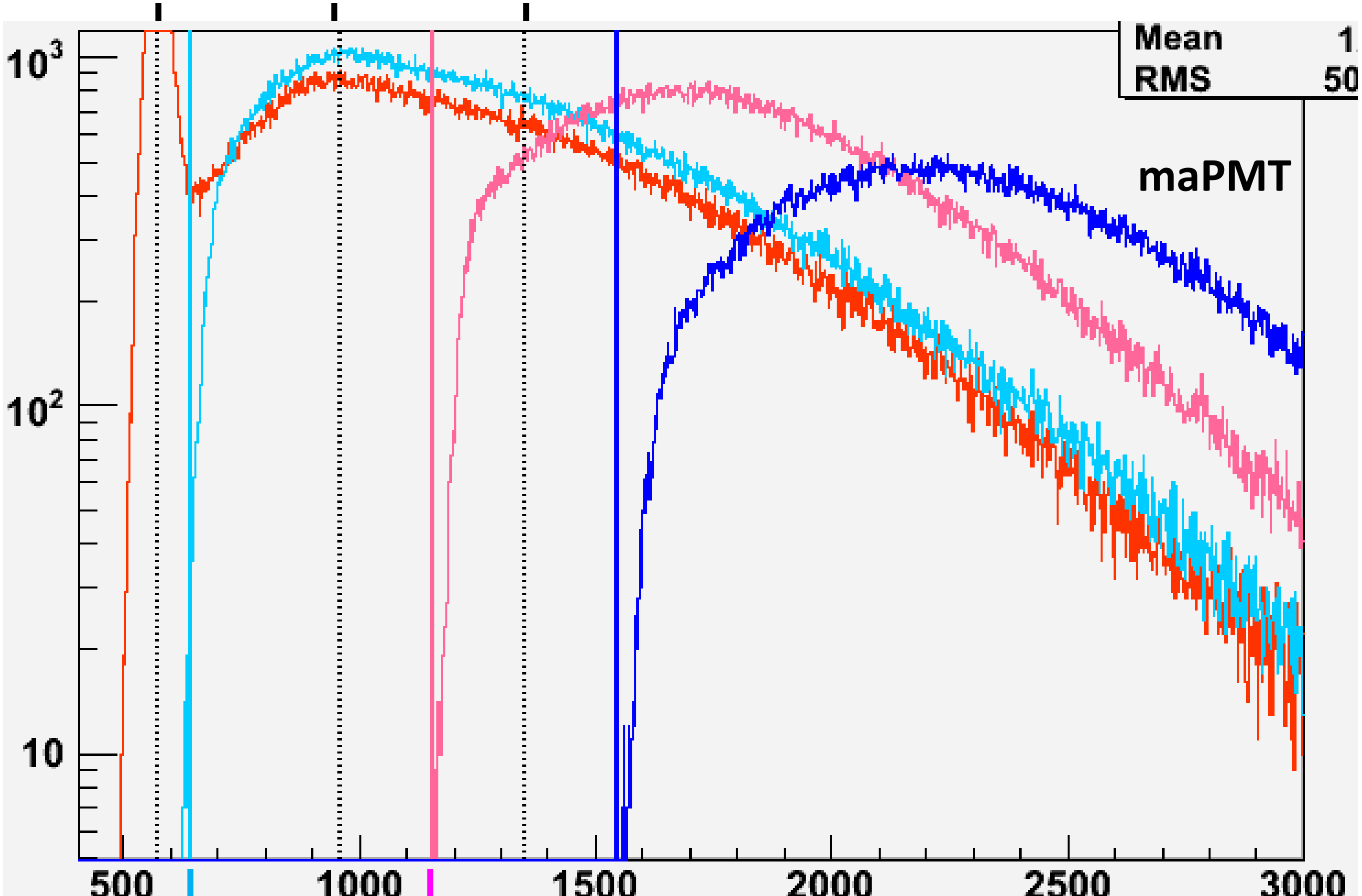
→ Set appropriate discriminator threshold to cut out: pedestal, 1 p.e., 2 p.e. etc.

pedestal peak

1 p.e.

2 p.e.

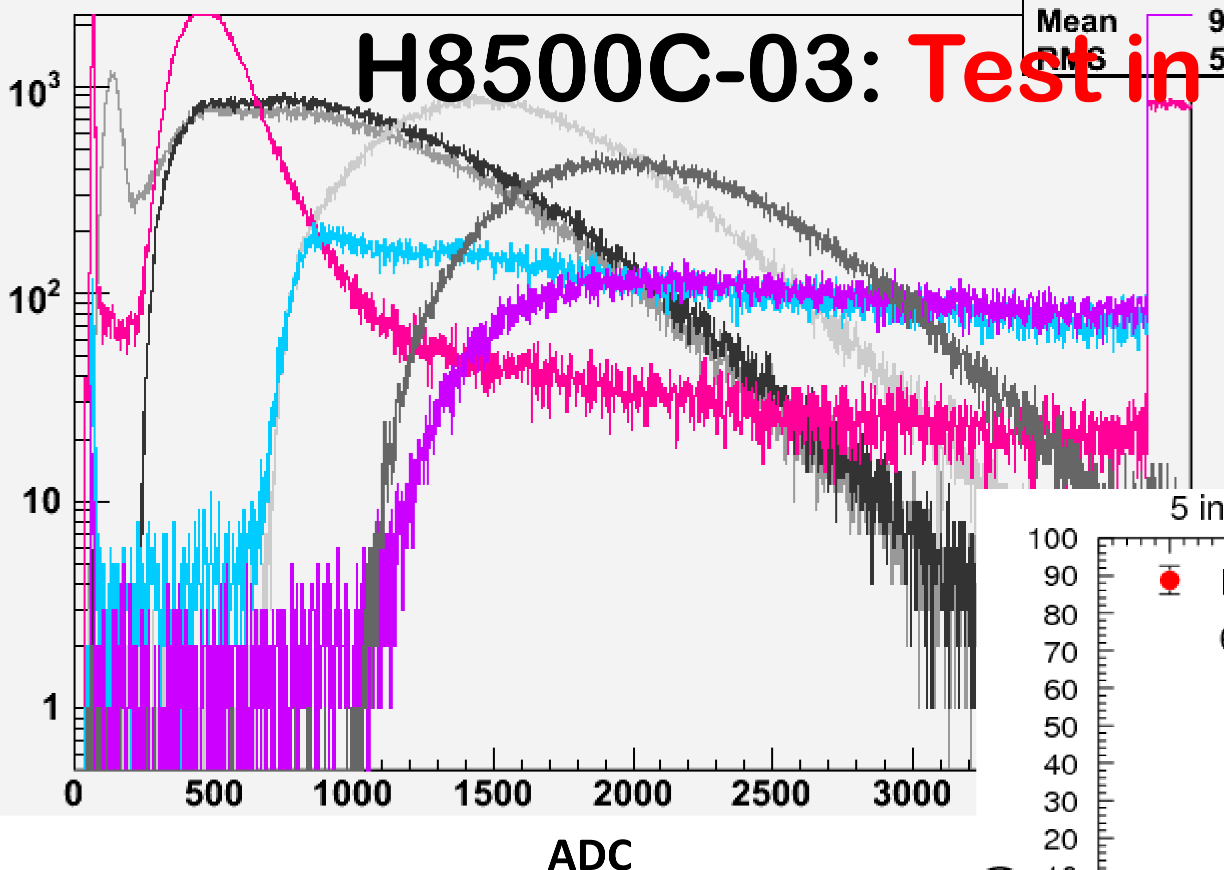
LED data, no beam



Cut ped.

Cut 1 p.e. and below

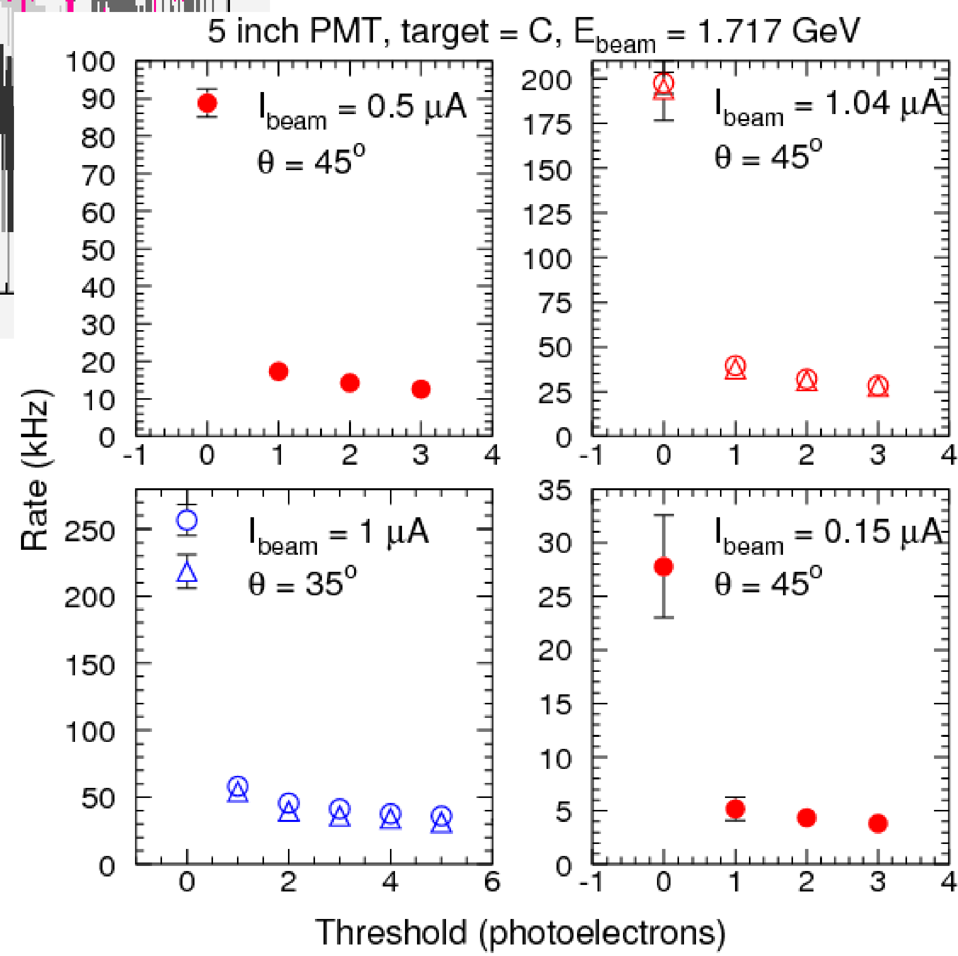
H8500C-03: Test in Beam



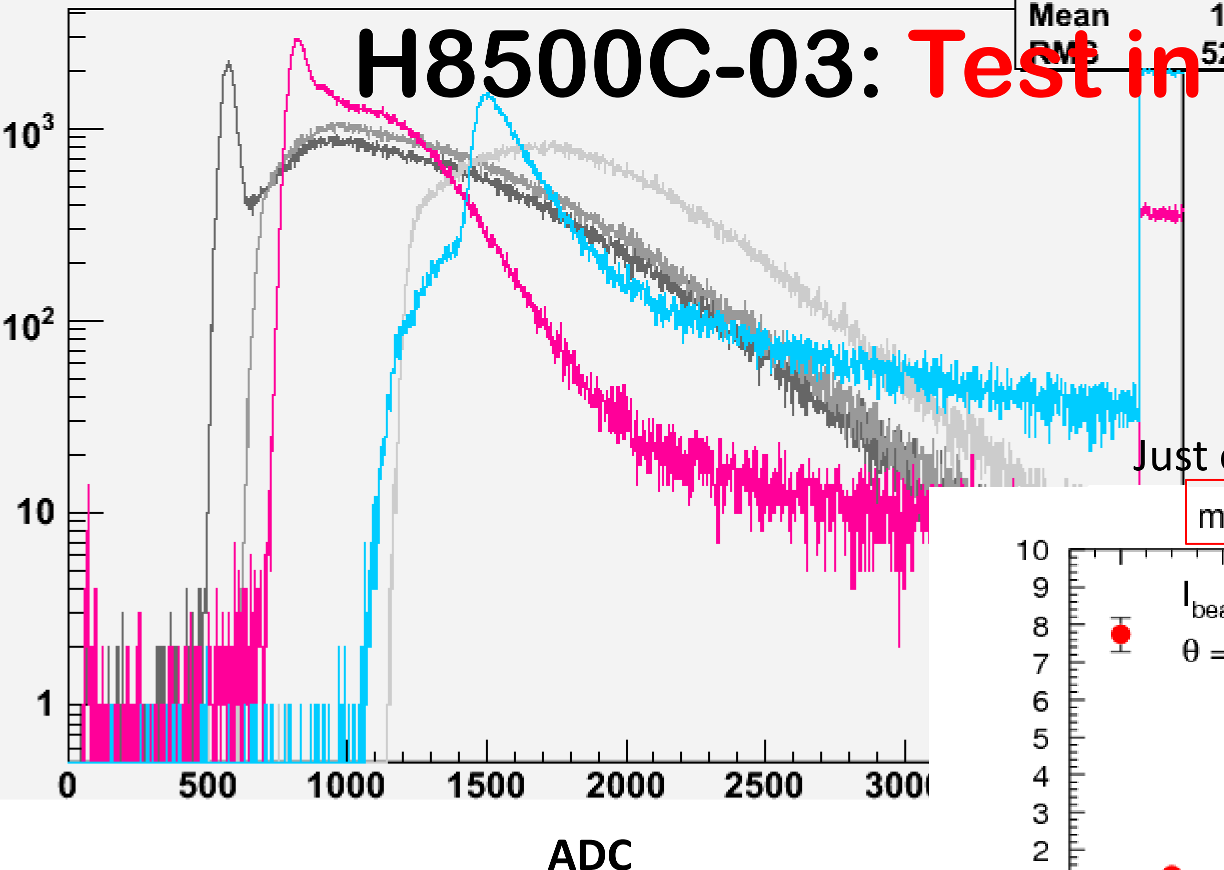
Gray: LED data shown for comparison

Pink, blue, violet beam data with discriminator threshold set to cut out ped., 1 p.e., 2 p.e., respectively

Scaler rates
5” PMT



H8500C-03: Test in Beam

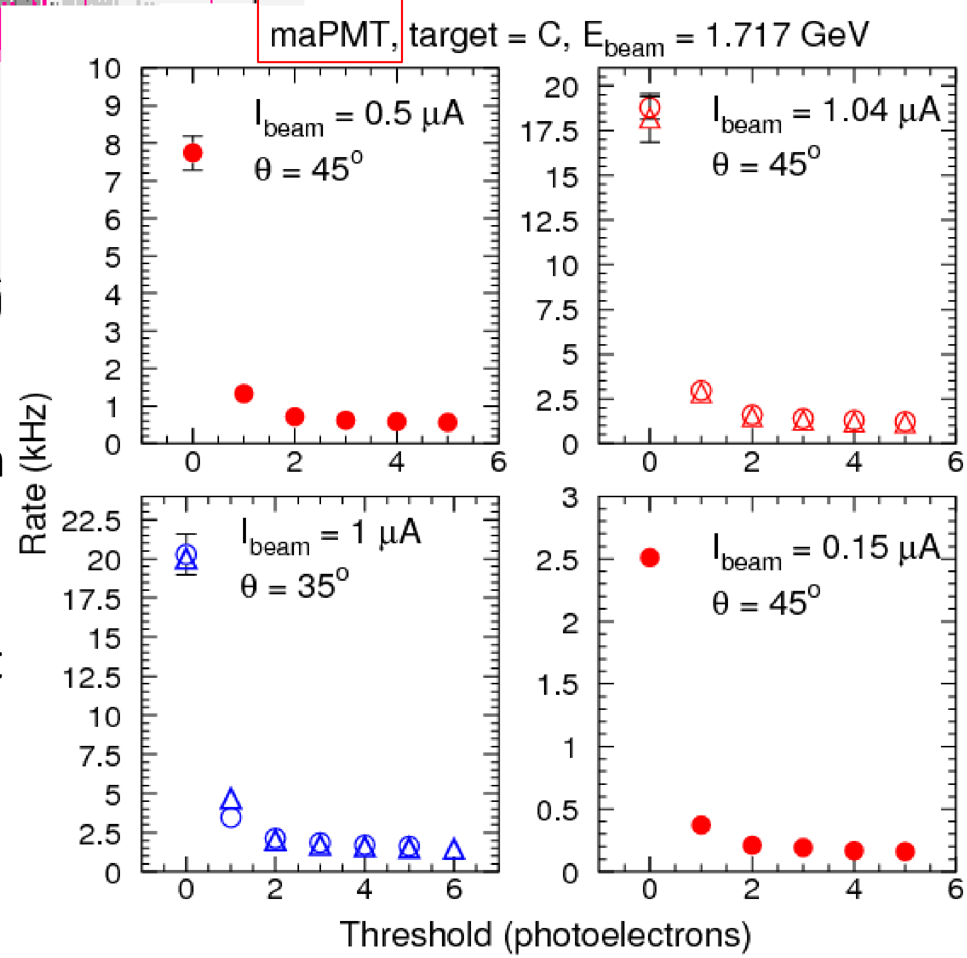


Gray: LED data shown for comparison

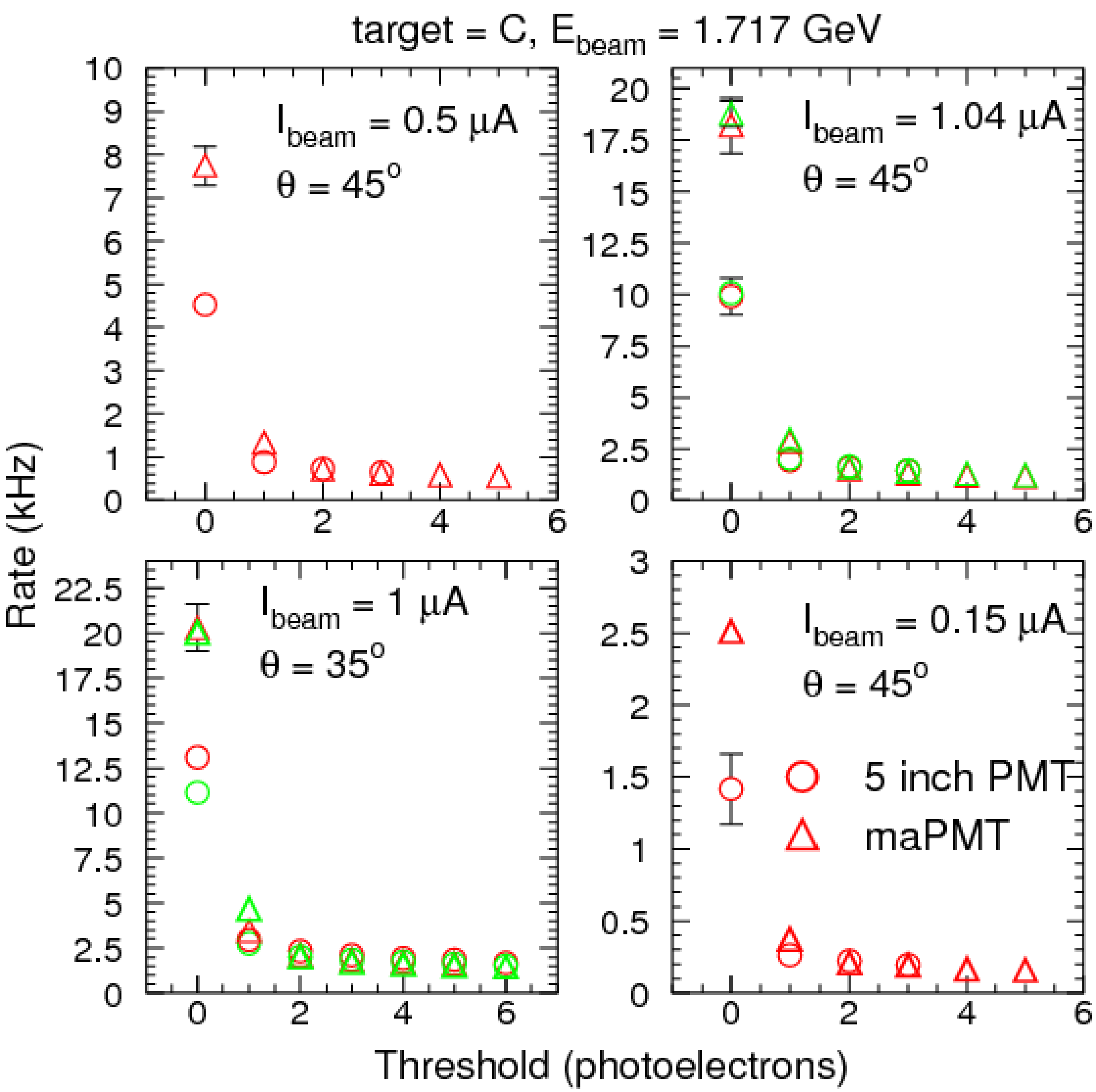
Pink, blue beam data with discriminator threshold set to cut out ped., 1 p.e., respectively

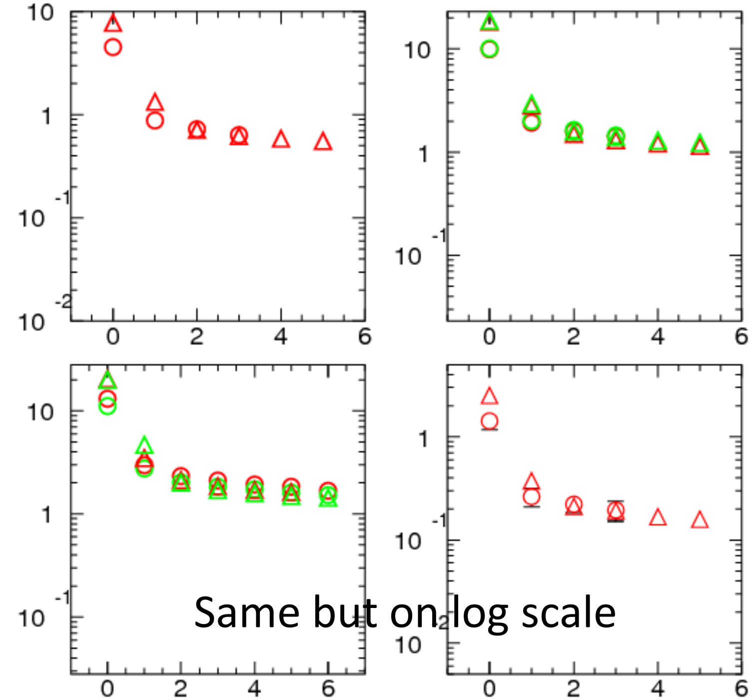
Scaler rates maPMT

Just one quad



H8500C-03: Test in Beam





The 5 inch PMT rates have been scaled by a factor of 19.63 to account for its larger area when compared to the maPMT

→The 2 PMTs respond similarly to background