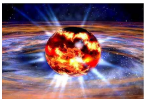


Main Detectors for PREX and CREX

Dustin McNulty
Idaho State University
mcnulty@jlab.org

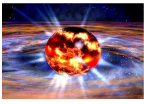
February 27, 2016



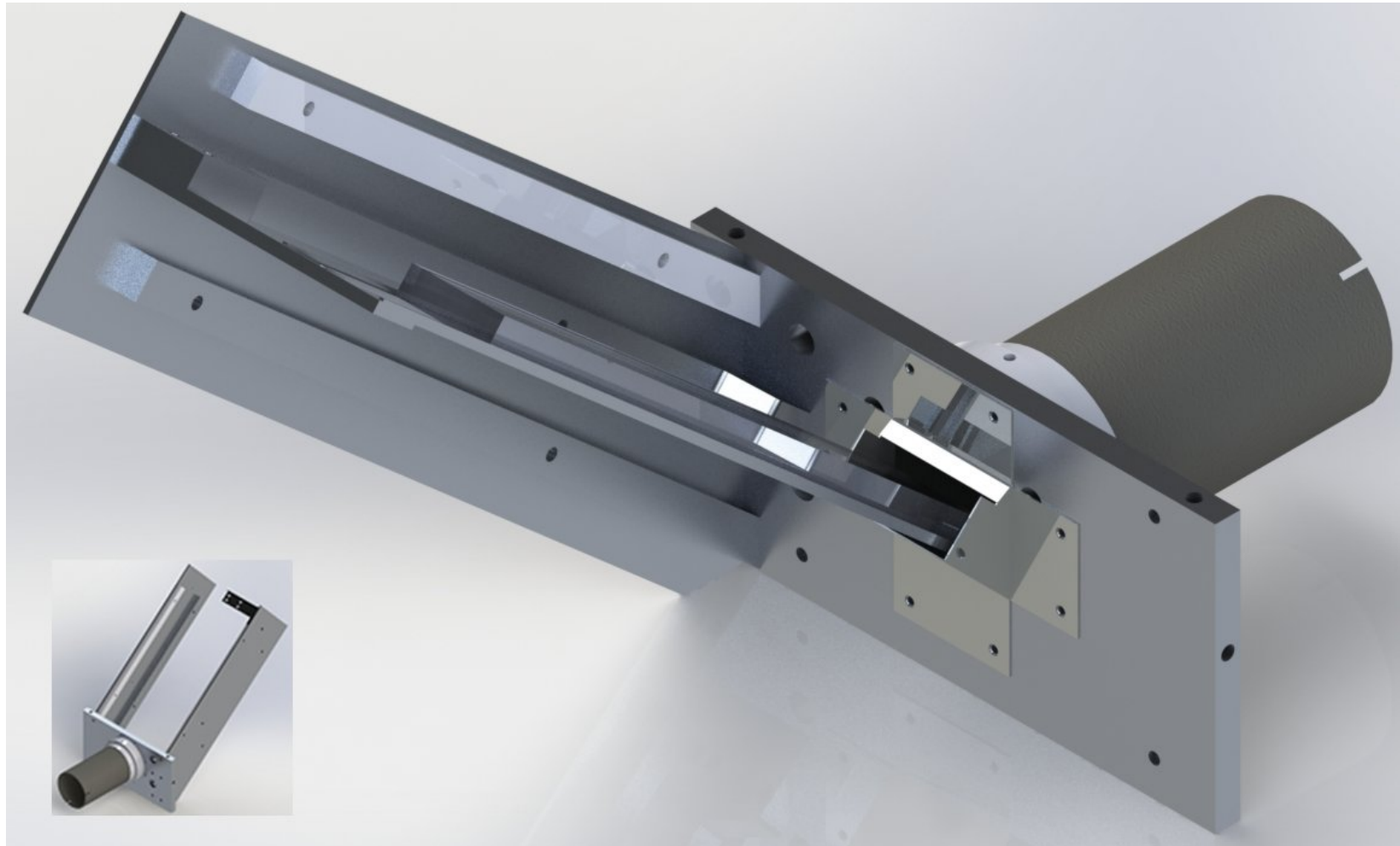
Main Detectors for PREX and CREX

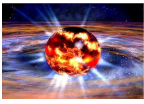
Outline

- Detector design (\sim finalized)
- Optical simulation (\sim benchmarked)
- Results from 2015 MAMI testbeam
- Plans for upcoming testbeam
- GEM trackers (very brief)
- Summary and Plans

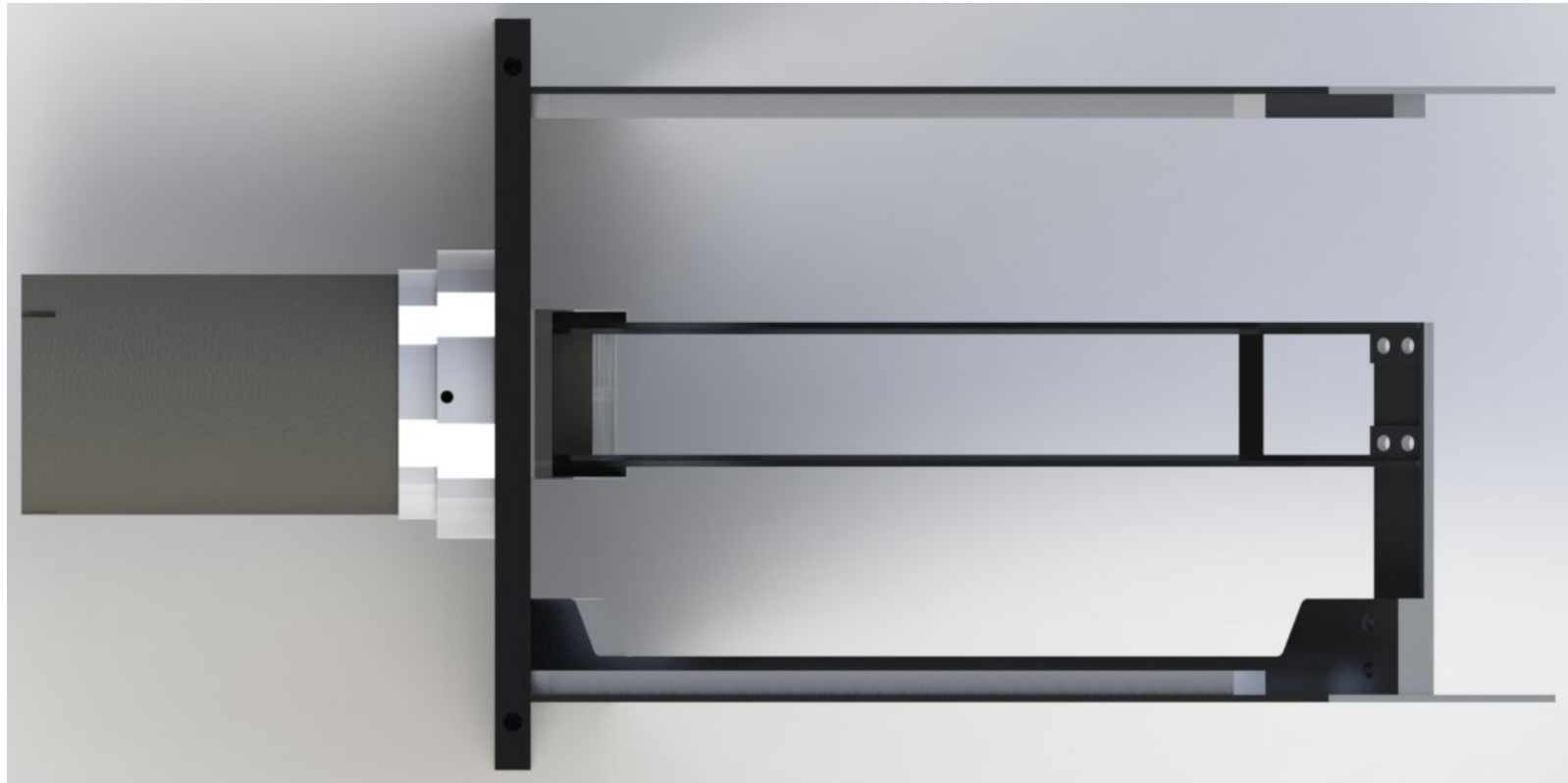


PREX/CREX Detector Design





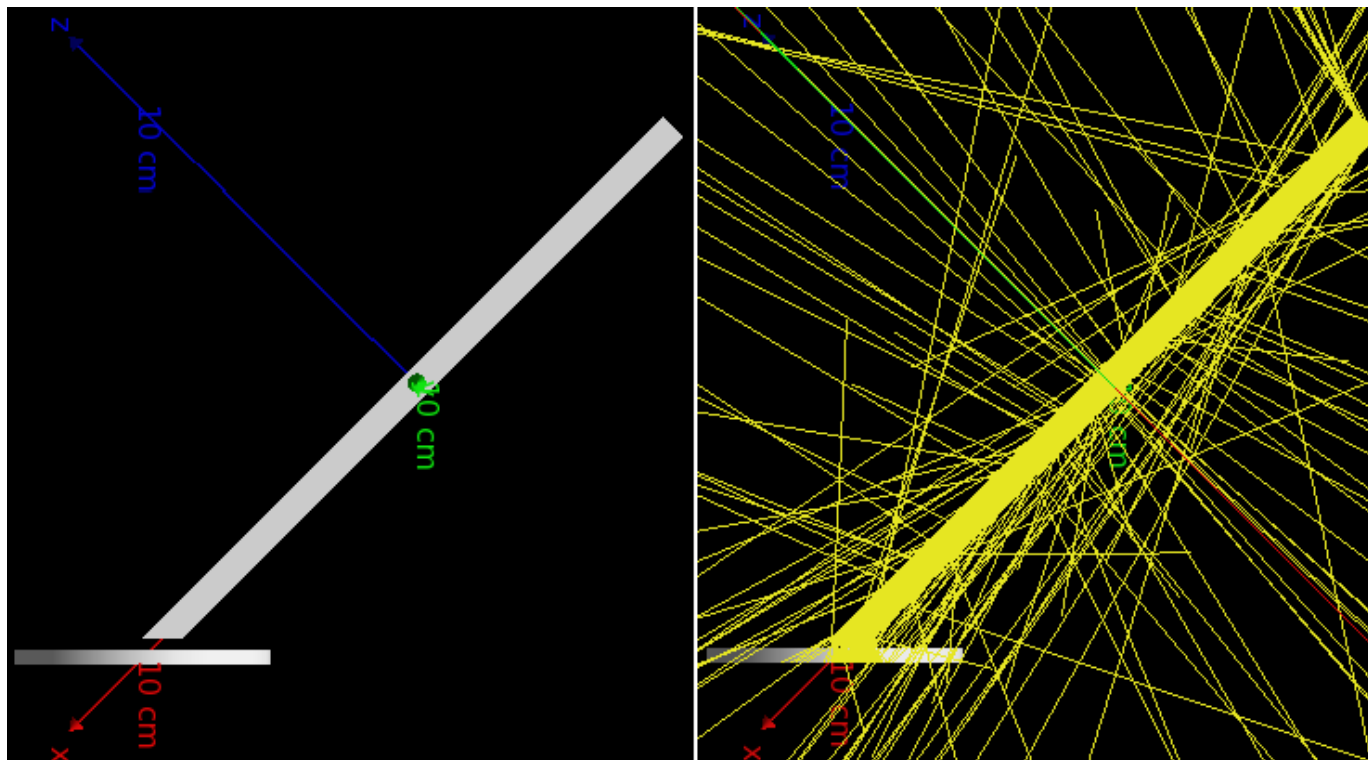
PREX/CREX Detector Design



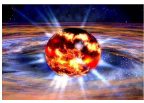
Scattered electron's view



Optical Simulations: Geometry and Event vis.

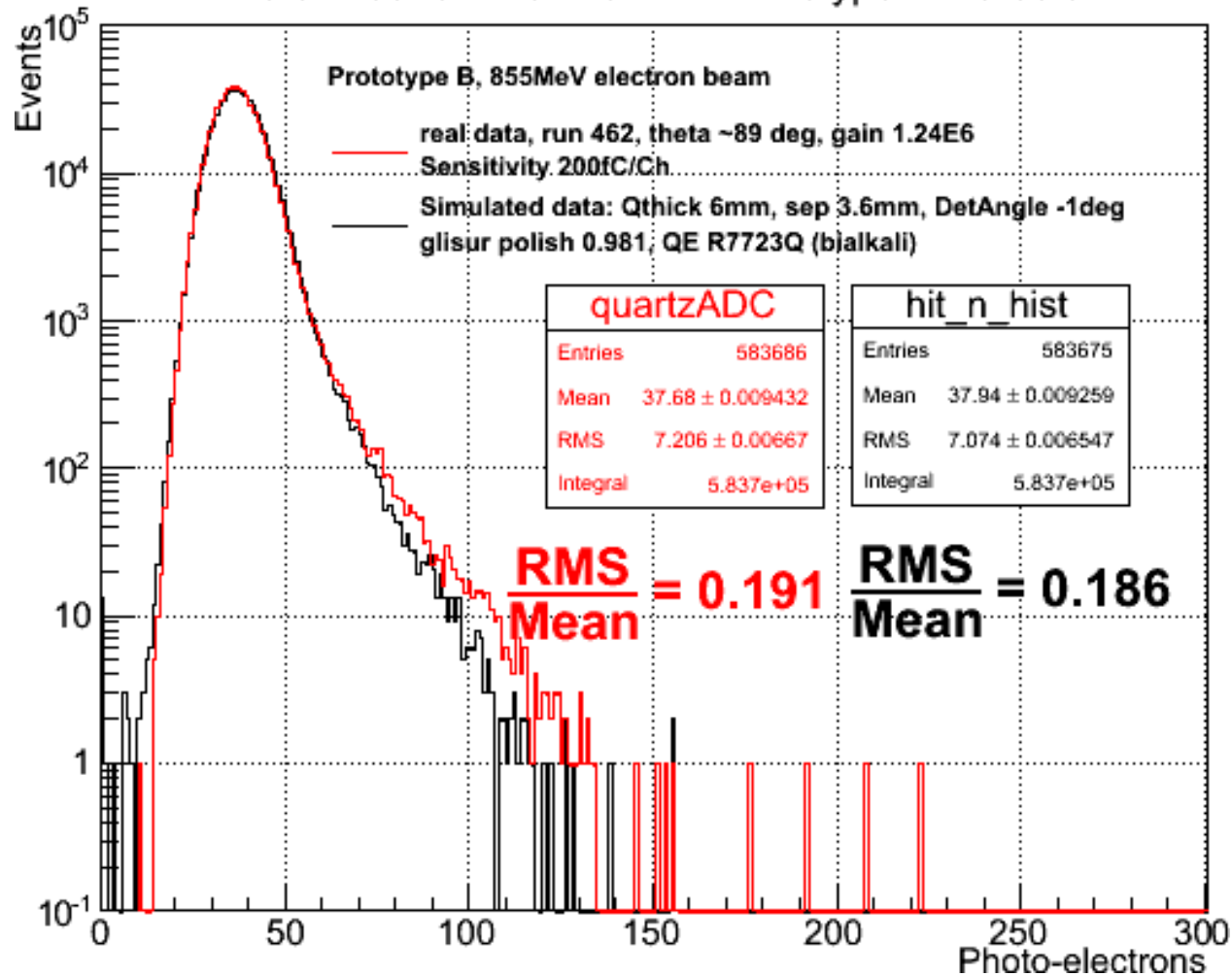


- Electron enters quartz at 90 deg (coming from below quartz)
- Showing 6 mm thick PREX-I quartz geometry
- Quartz is 3.6 mm from pmt window (no light guides used)
- Using 2 inch R7723Q pmt
- Simulating MAMI testbeam: 855 MeV pin-point electron beam

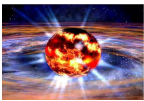


Optical Simulations: Comparison with Data

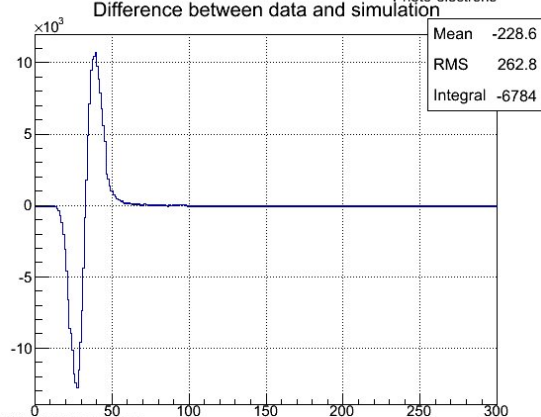
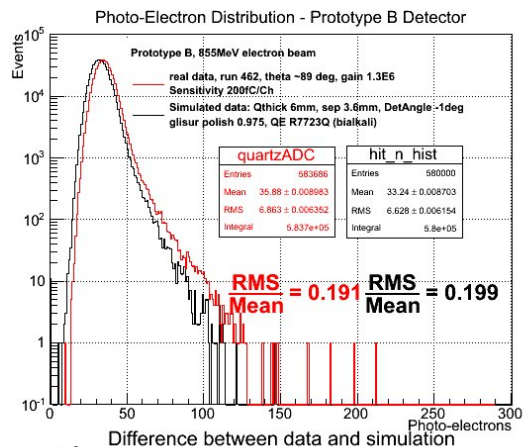
Photo-Electron Distribution - Prototype B Detector



No light guides used; quartz properties ~benchmarked

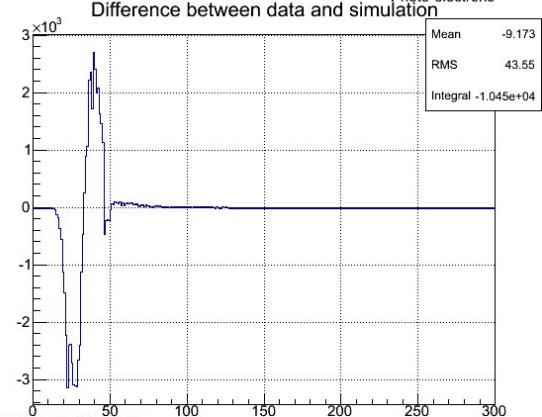
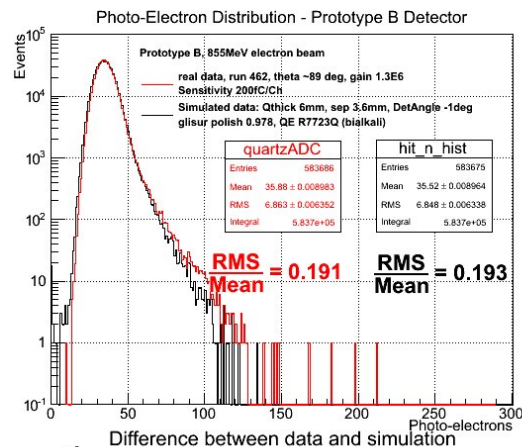


Optical Simulations: Tuning quartz properties



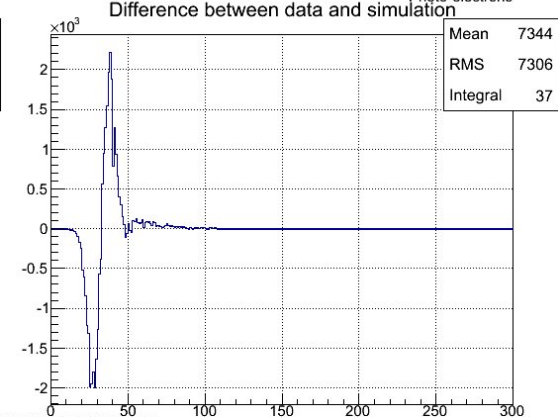
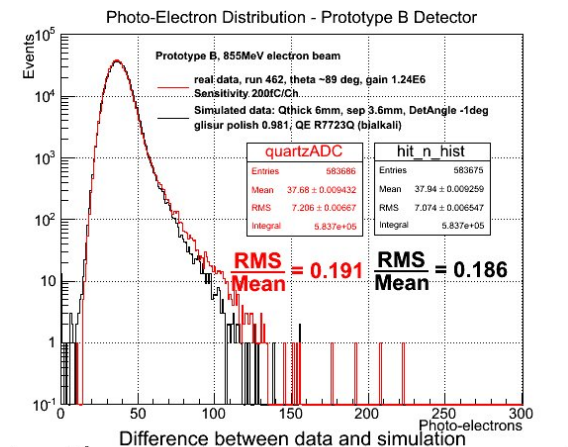
Polish: 0.975
gain: 1.3E+6

ADC Sens: 200 fC/ch



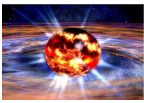
Polish: 0.978
gain: 1.3E+6

ADC Sens: 200 fC/ch

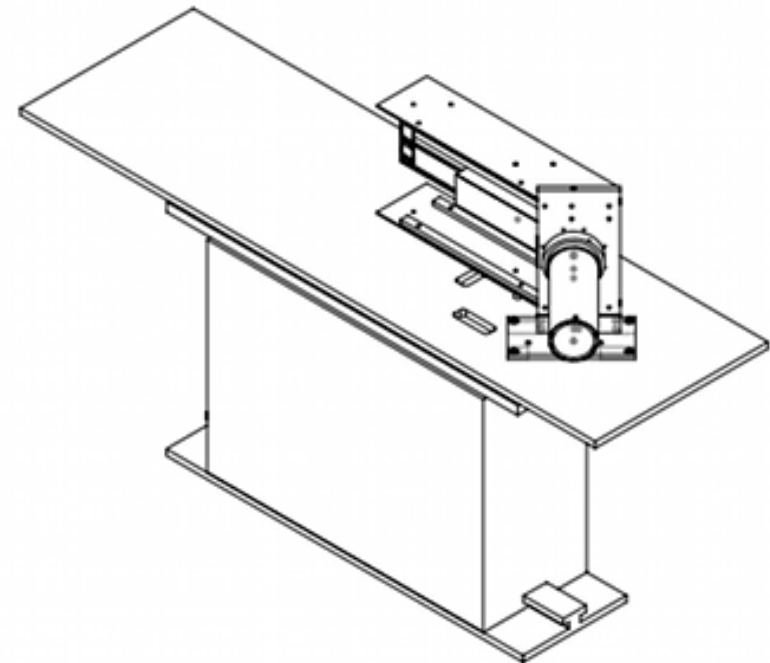
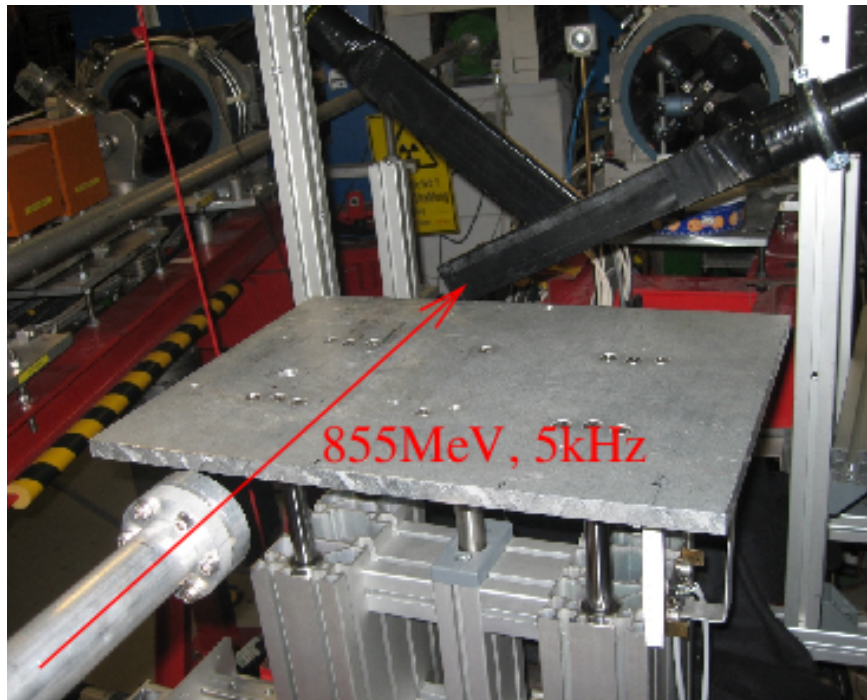


Polish: 0.981
gain: 1.24E+6 ± 5%

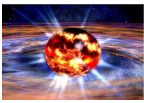
ADC Sens: 200 fC/ch



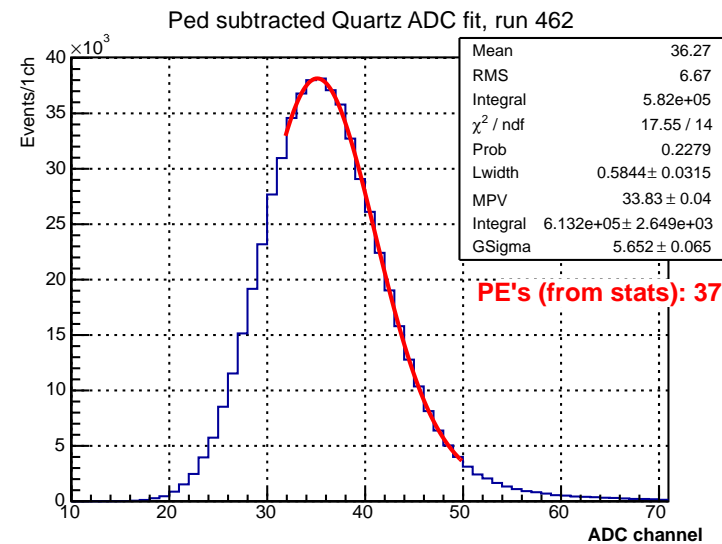
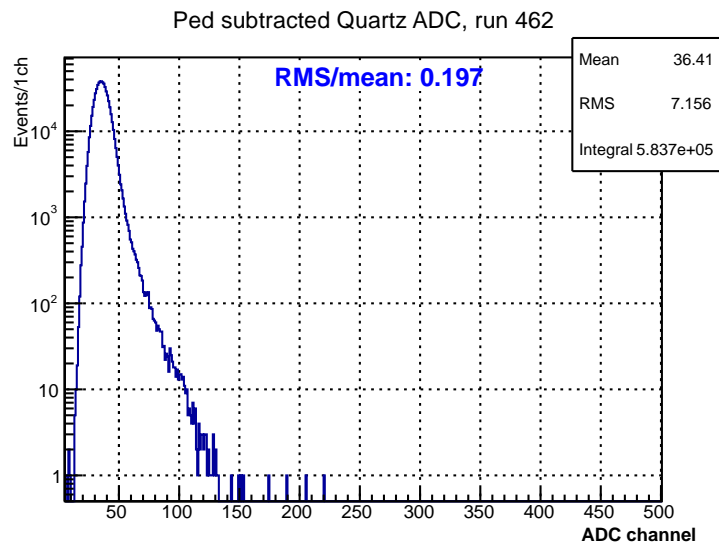
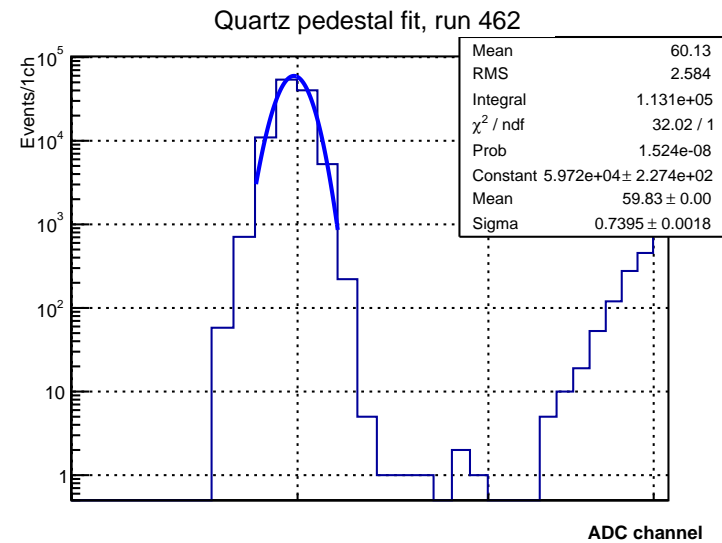
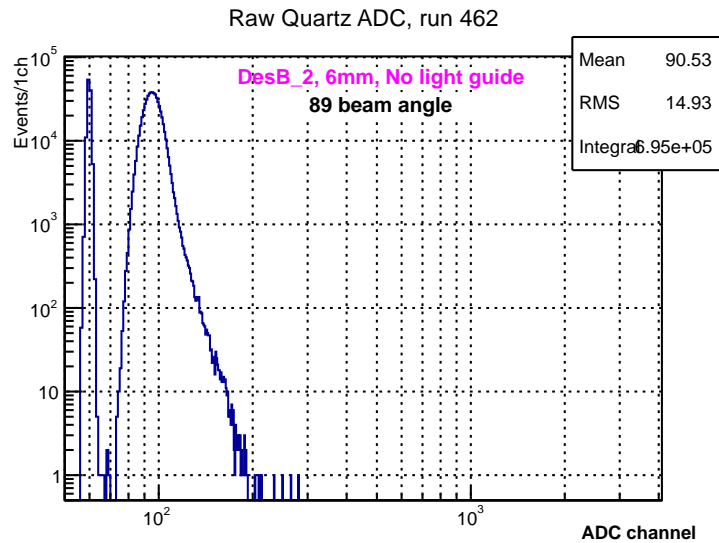
MAMI Testbeam (PREX/CREX Detector Tests)



- Last testbeam: May 29 - June 1, 2015: MOLLER, PREX/CREX
- About 1.5 shift for PREX/CREX prototype tests:
 - 2 prototypes tested: Angle scans with and without LG (6 mm)
 - Longpass filter study with no-LG 6mm
 - Angle scan for no-LG with 10 mm thick quartz



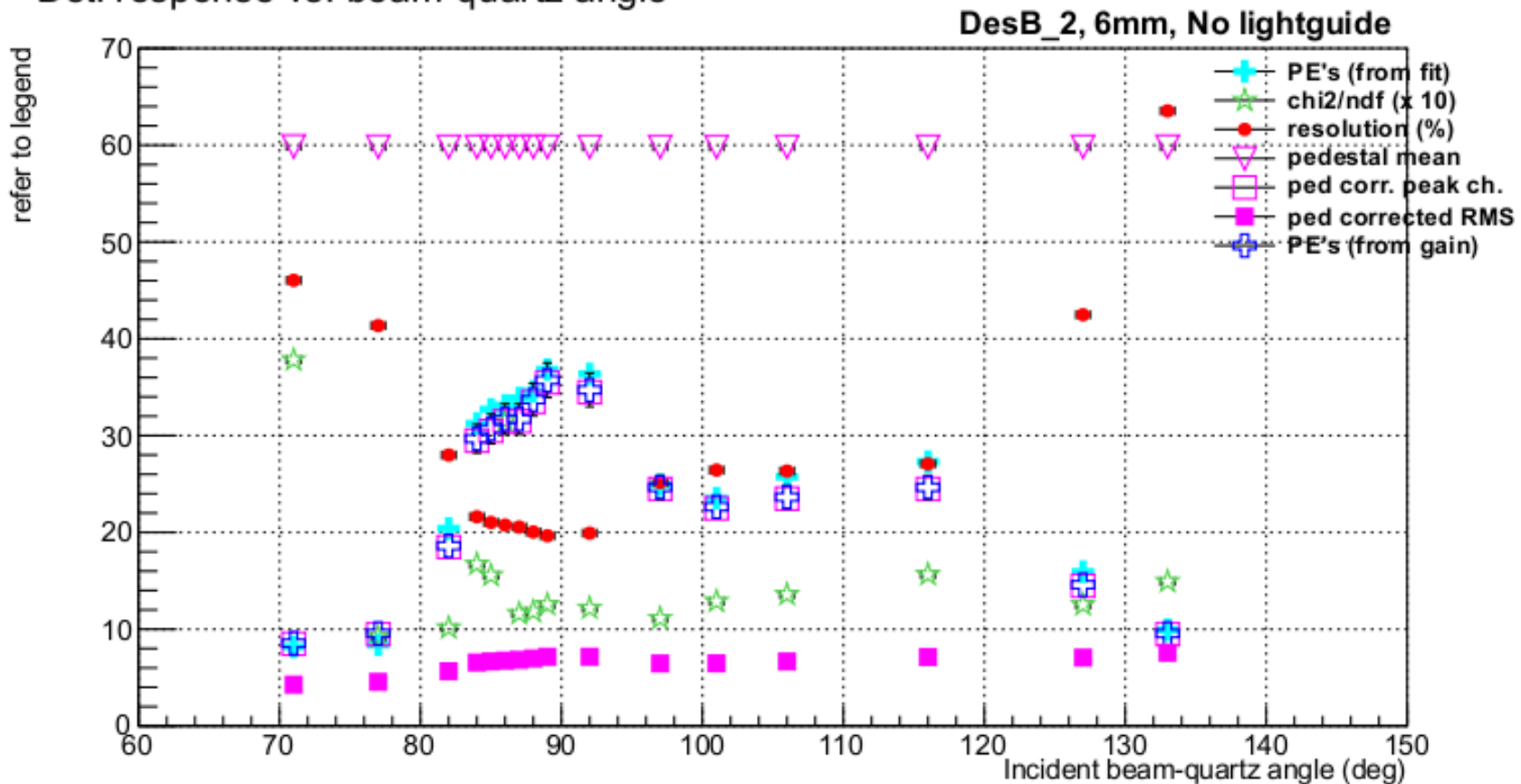
Testbeam Data: 6mm, no-LG, 89deg incidence

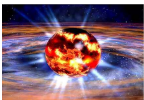




MAMI Testbeam: no-LG, 6mm angle scan

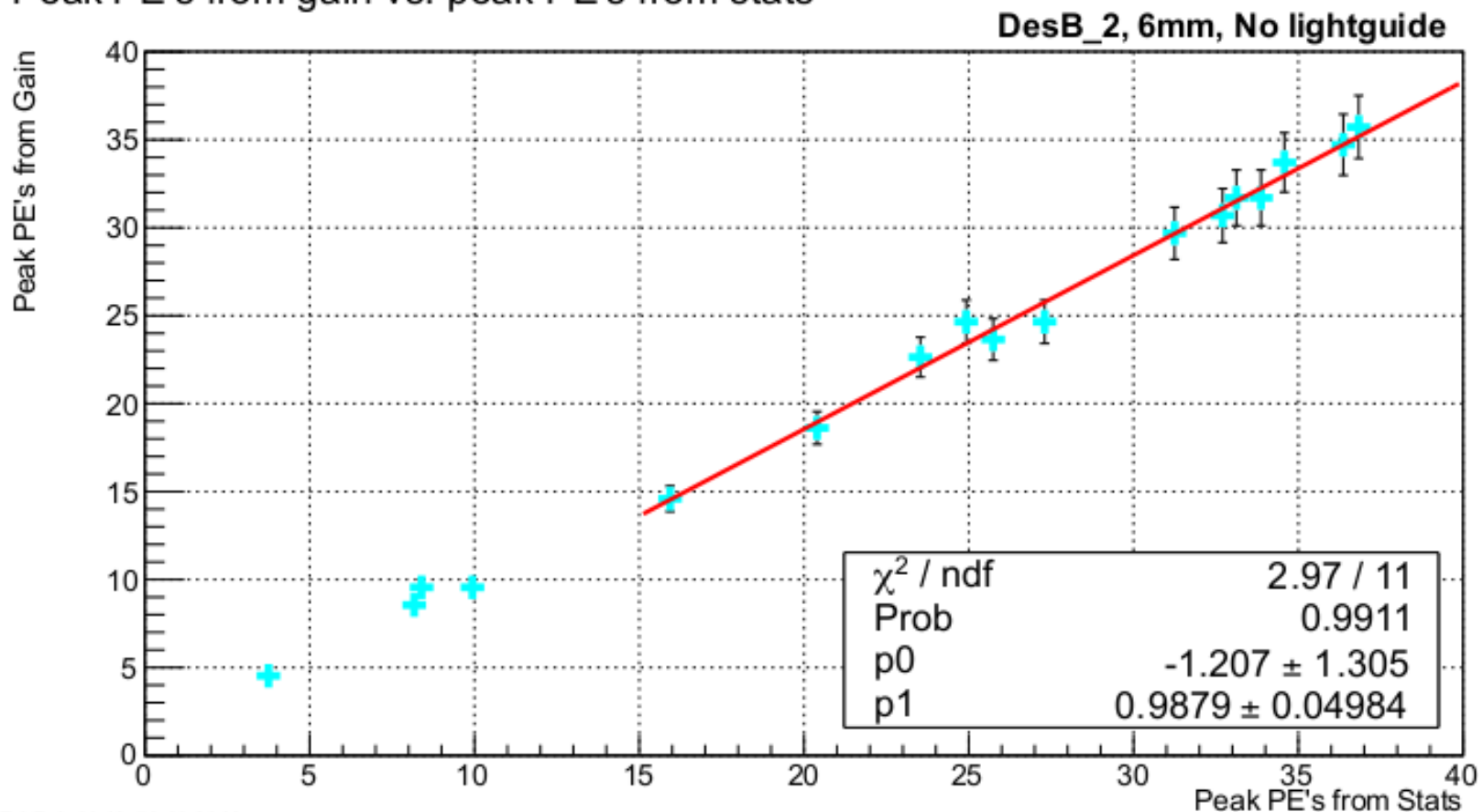
Det. response vs. beam-quartz angle



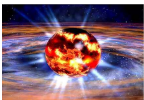


6mm, no-LG angle scan PE comparisons: Gain vs. Stat widths

Peak PE's from gain vs. peak PE's from stats

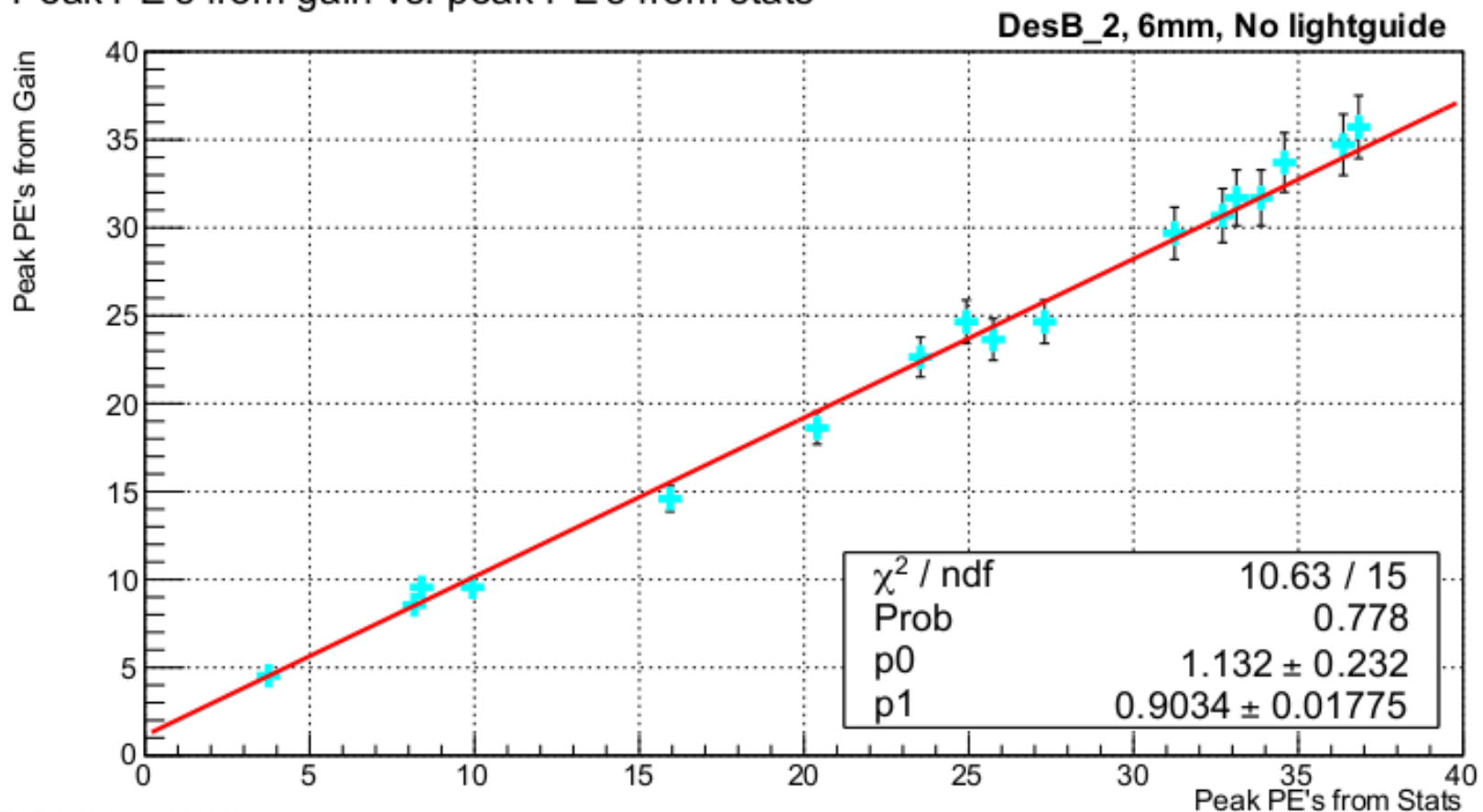


Fri Feb 26 13:54:43 2016

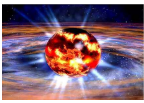


6mm, no-LG angle scan PE comparisons: Gain vs. Stat widths

Peak PE's from gain vs. peak PE's from stats

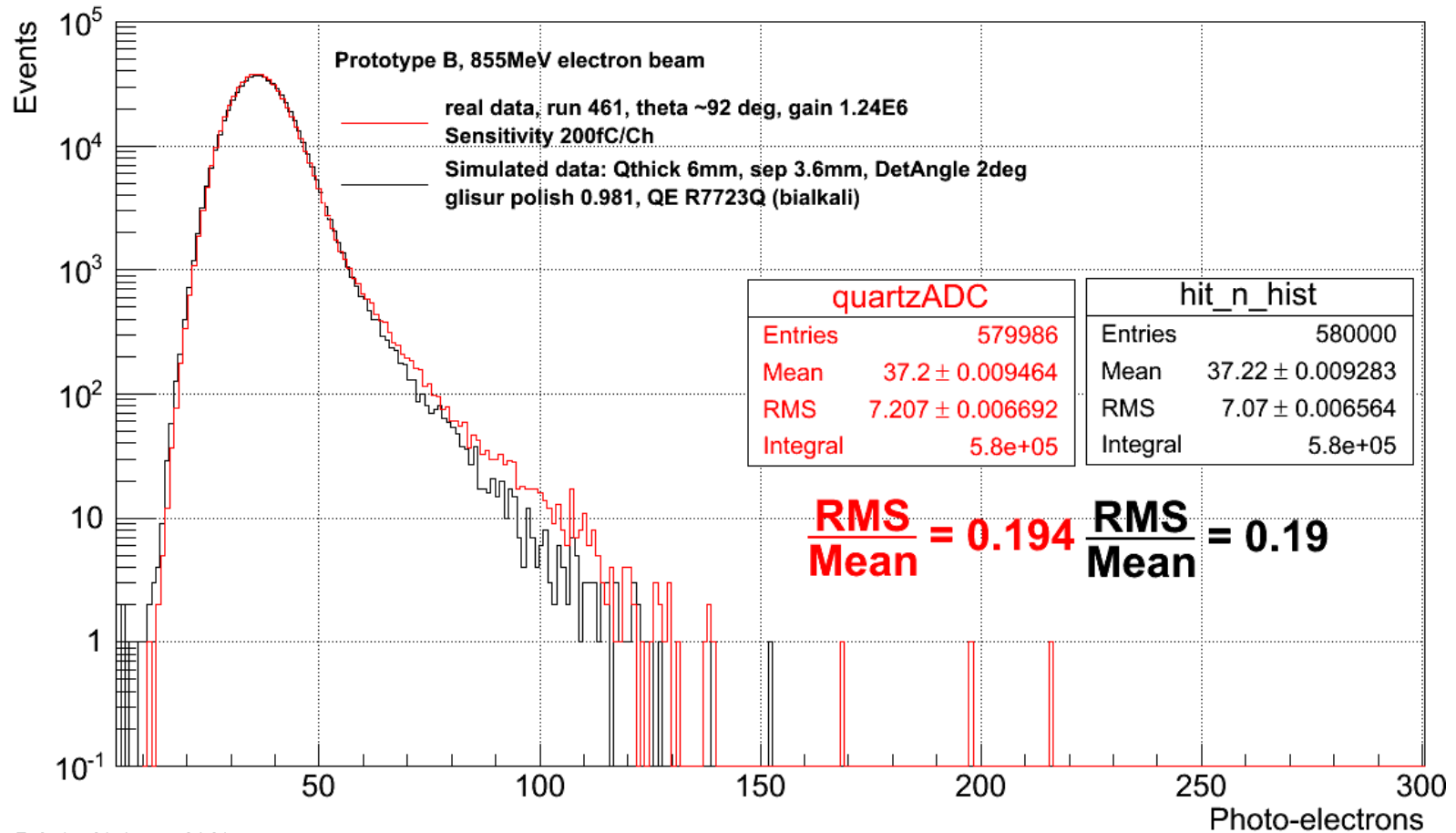


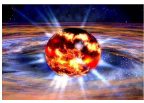
Fri Feb 26 13:55:14 2016



Comparison: 6mm, no-LG, 92deg incidence

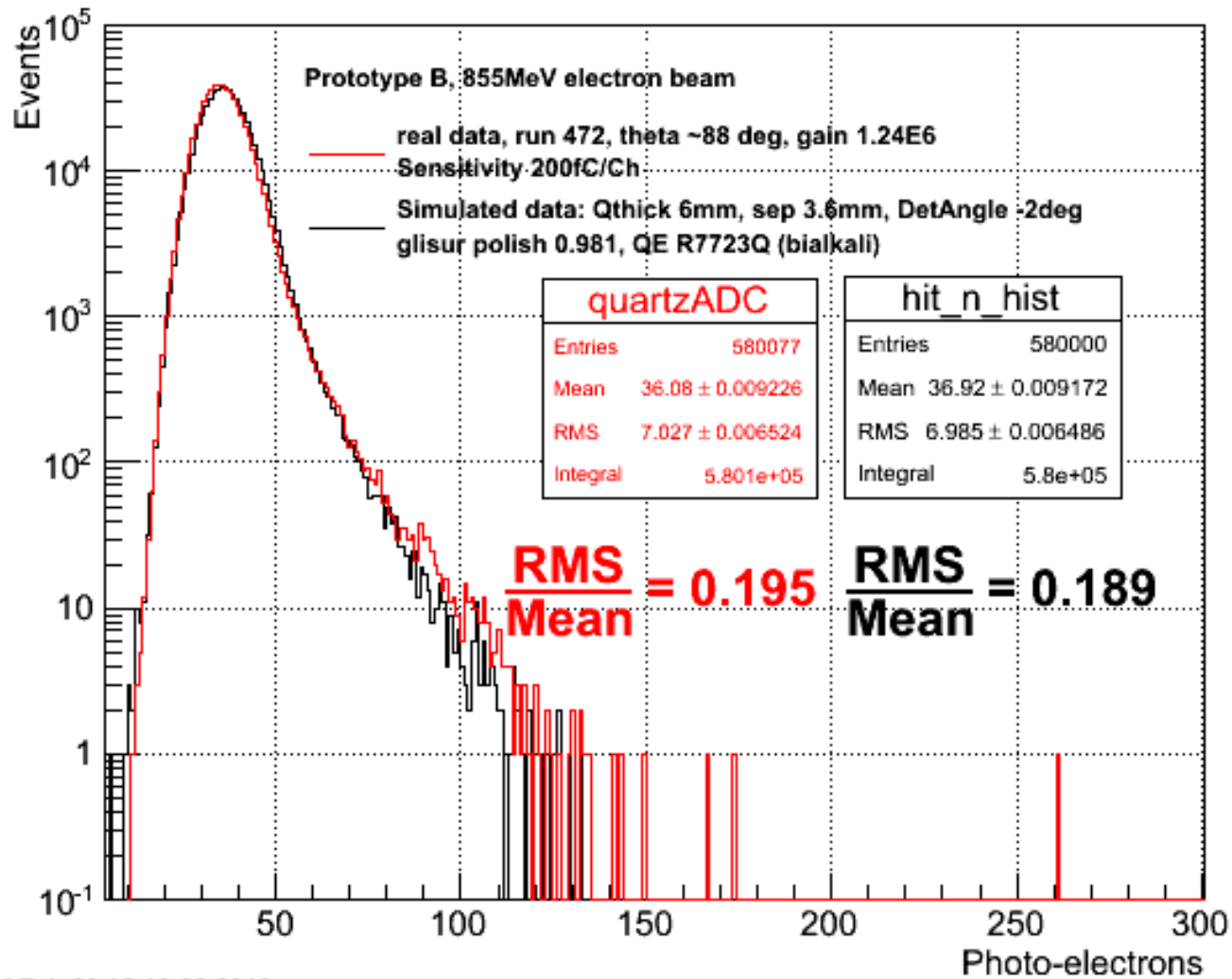
Photo-Electron Distribution - Prototype B Detector

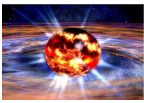




Comparison: 6mm, no-LG, 88deg incidence

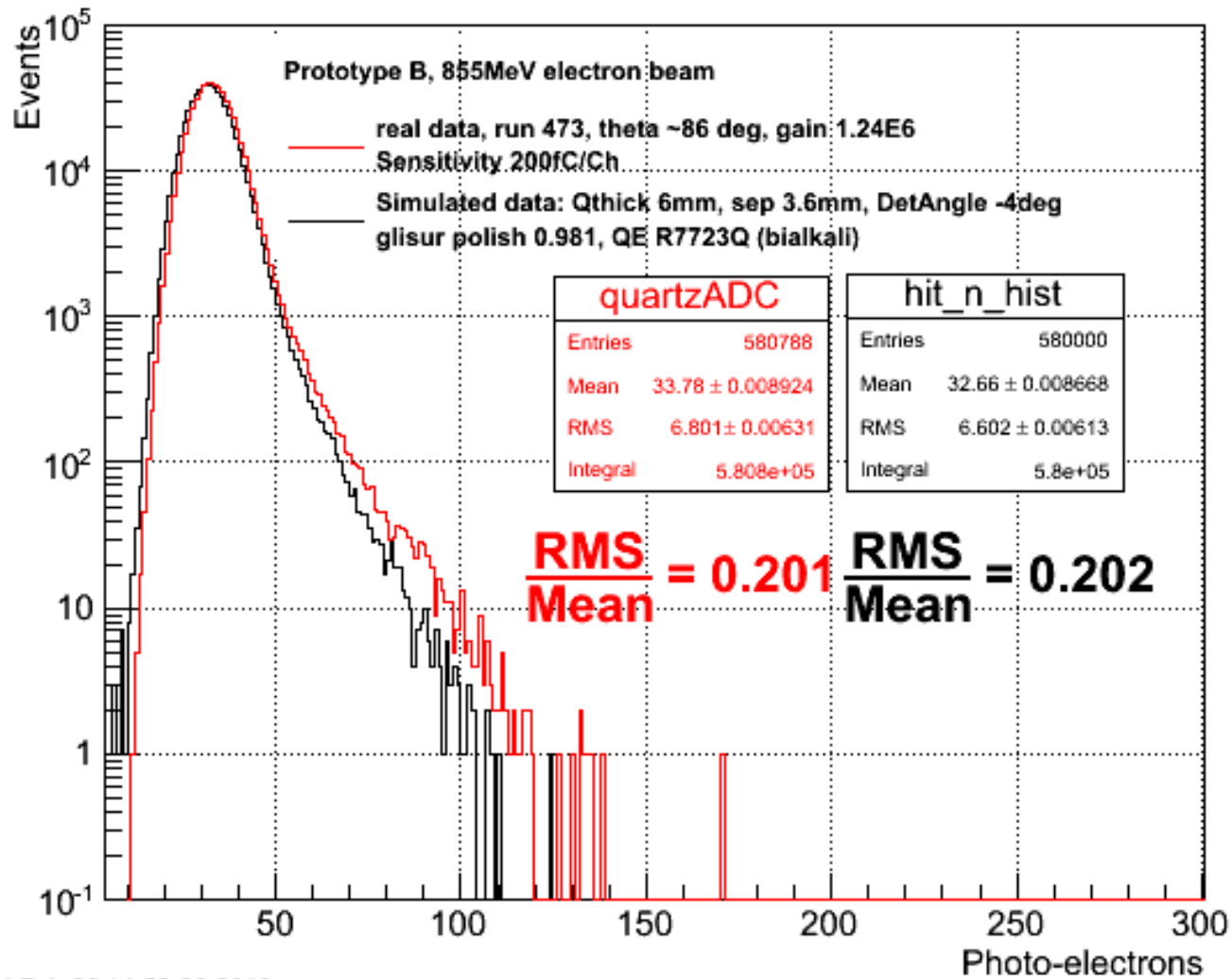
Photo-Electron Distribution - Prototype B Detector

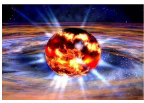




Comparison: 6mm, no-LG, 86deg incidence

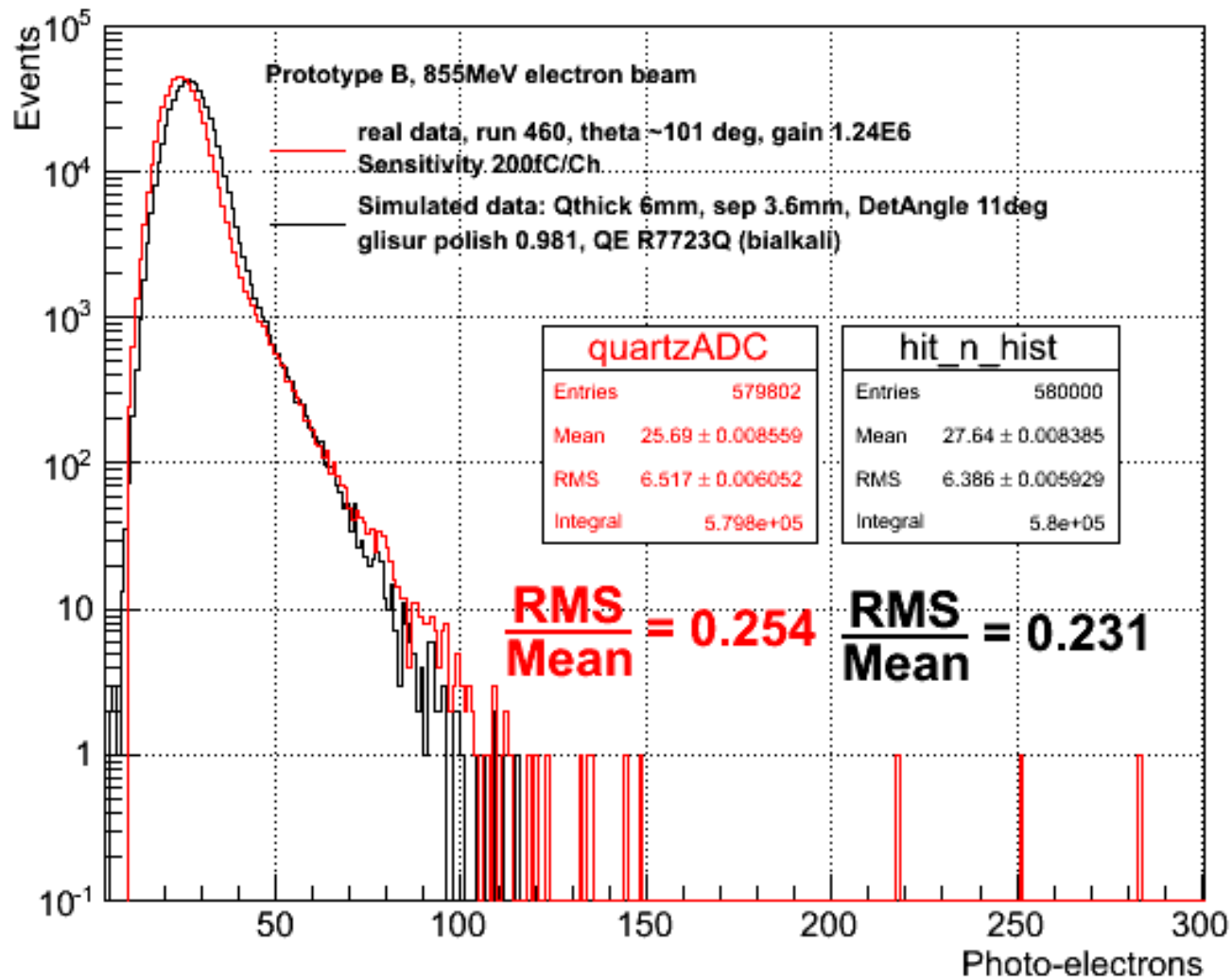
Photo-Electron Distribution - Prototype B Detector



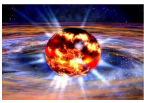


Comparison: 6mm, no-LG, 101deg incidence

Photo-Electron Distribution - Prototype B Detector

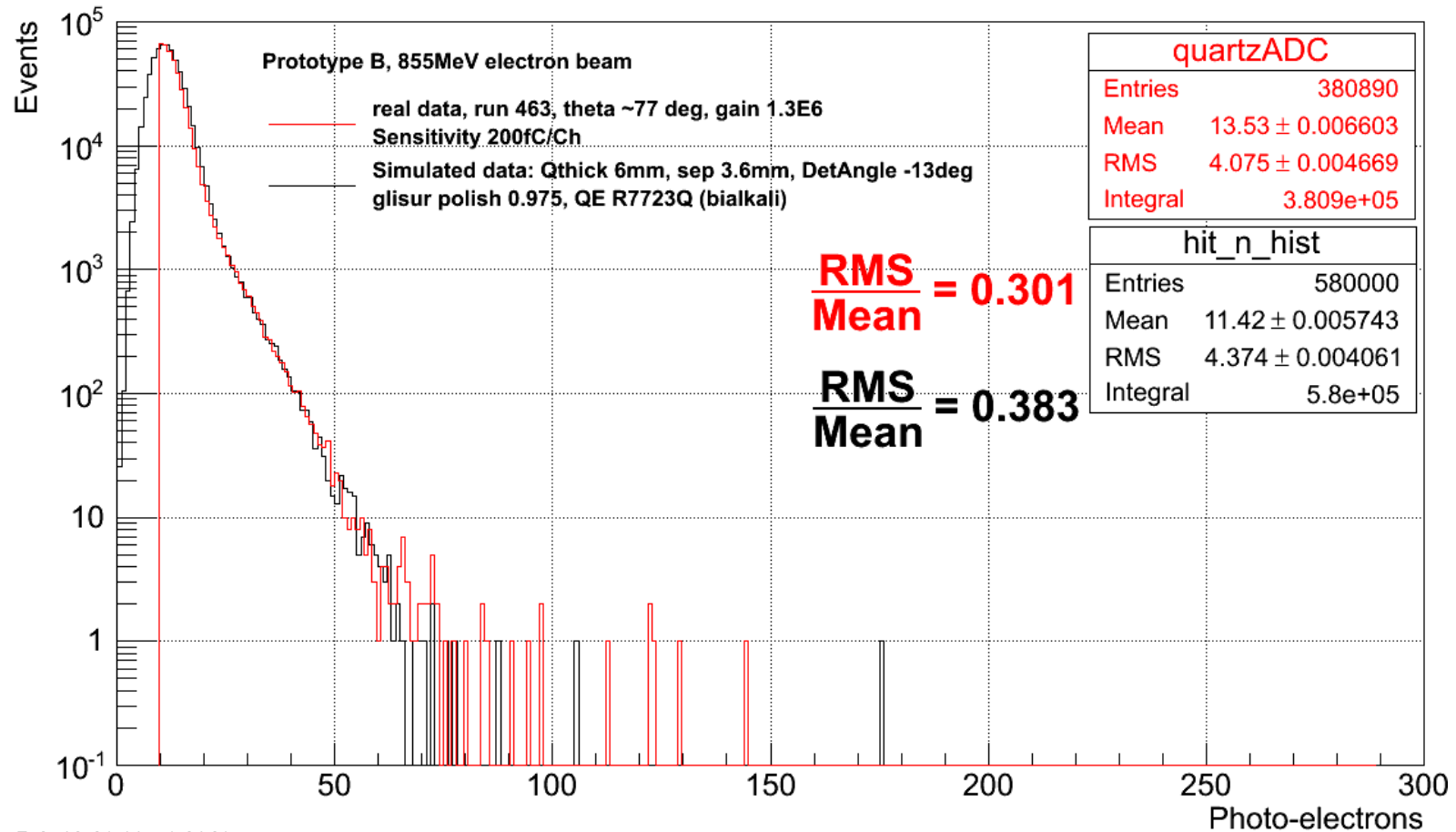


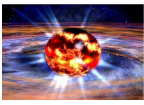
Fri Feb 26 15:31:53 2016



Comparison: 6mm, no-LG, 77deg incidence

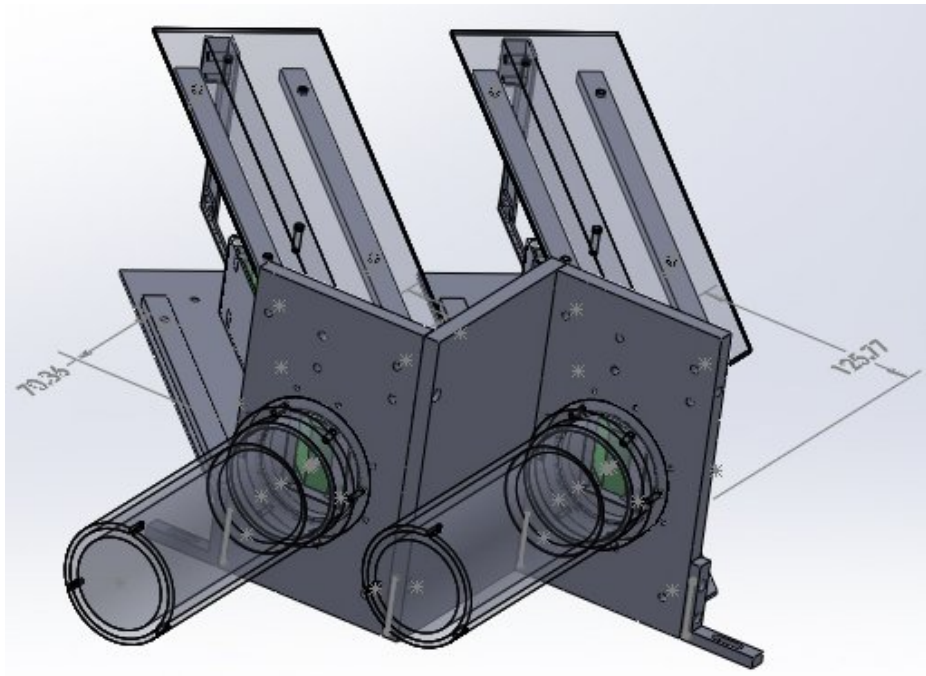
Photo-Electron Distribution - Prototype B Detector



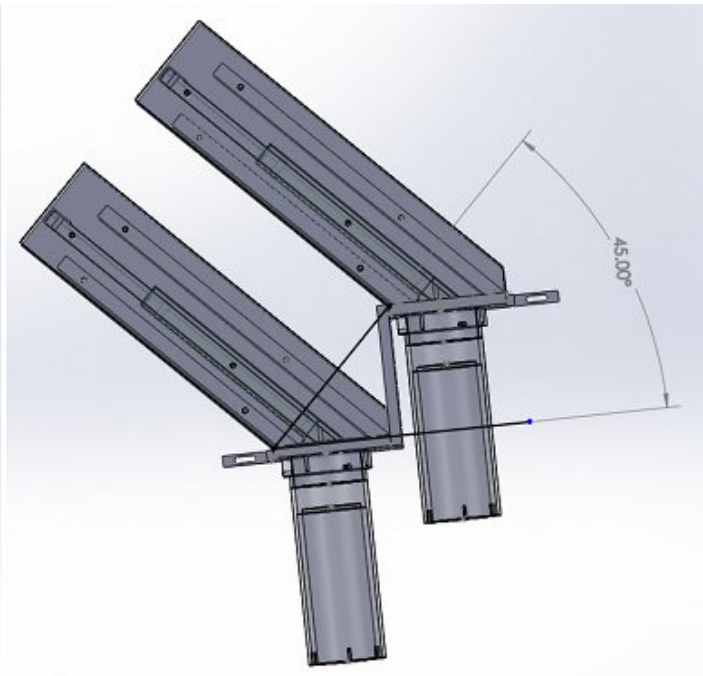


Plans for next MAMI Testbeam (May 2016)

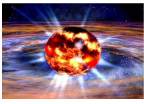
Side-angled view



Top view

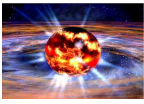


Will test PREX tandem detector mount using "thin" 6 mm quartz upstream and "thick" 10 mm quartz downstream



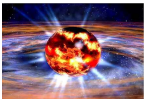
GEM Trackers for PREX/CREX

- Contacted Rui De Oliveira at CERN last November to discuss possibility of purchasing custom (10 by 20 cm²) complete CERN GEM chamber kits
- A couple weeks later he sent me a rough cost estimate and I asked for a formal quote for:
 - 5 triple gem chambers assembled and tested
 - 5 spare framed foils
- Placed the order last month – 12 weeks lead-time
- Also joined Nilanga's big electronics order: We're getting 6 MPD VME modules and 55 UVA-style APV FE cards
- Complication is mostly in the readout. Still need to design and build custom APV FE bussing PCB and HV distribution scheme (will modify UVA design for our system)

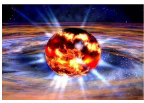


Summary and Plans

- PREX II det design near final: no-LG / uses quartz TIR as LG
- Final CREX design waiting for focal plane footprint—for quartz (and pmt) size—but will also use no-LG design
- G4 optical simulations for no-LG, 6mm configuration in very good agreement; continuing to refine and study
- Simulations for designs with LG's require additional tuning (need to sample reflectivities as function of angle and λ)
- Working to simulate complete angle scans for 6mm and 10mm quartz as well as long pass filter study (and compare with data)
- Planning to test 6 mm/10 mm tandem PREX detector at MAMI this May
- 10 by 20 cm² GEM tracker system under development...more next time

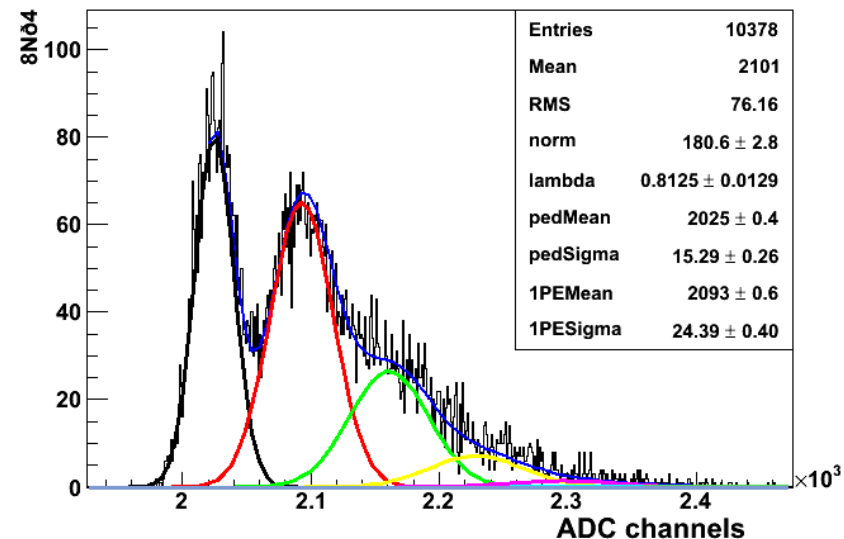
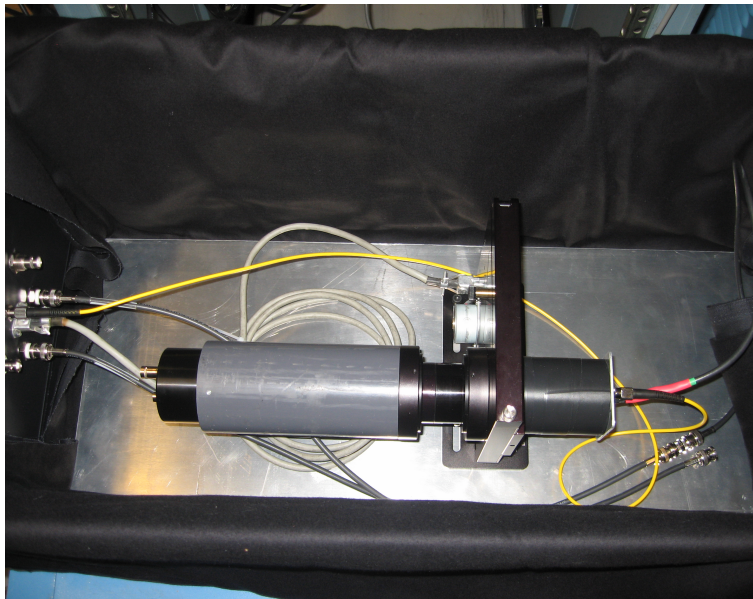


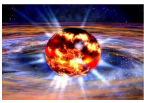
Extra Slides



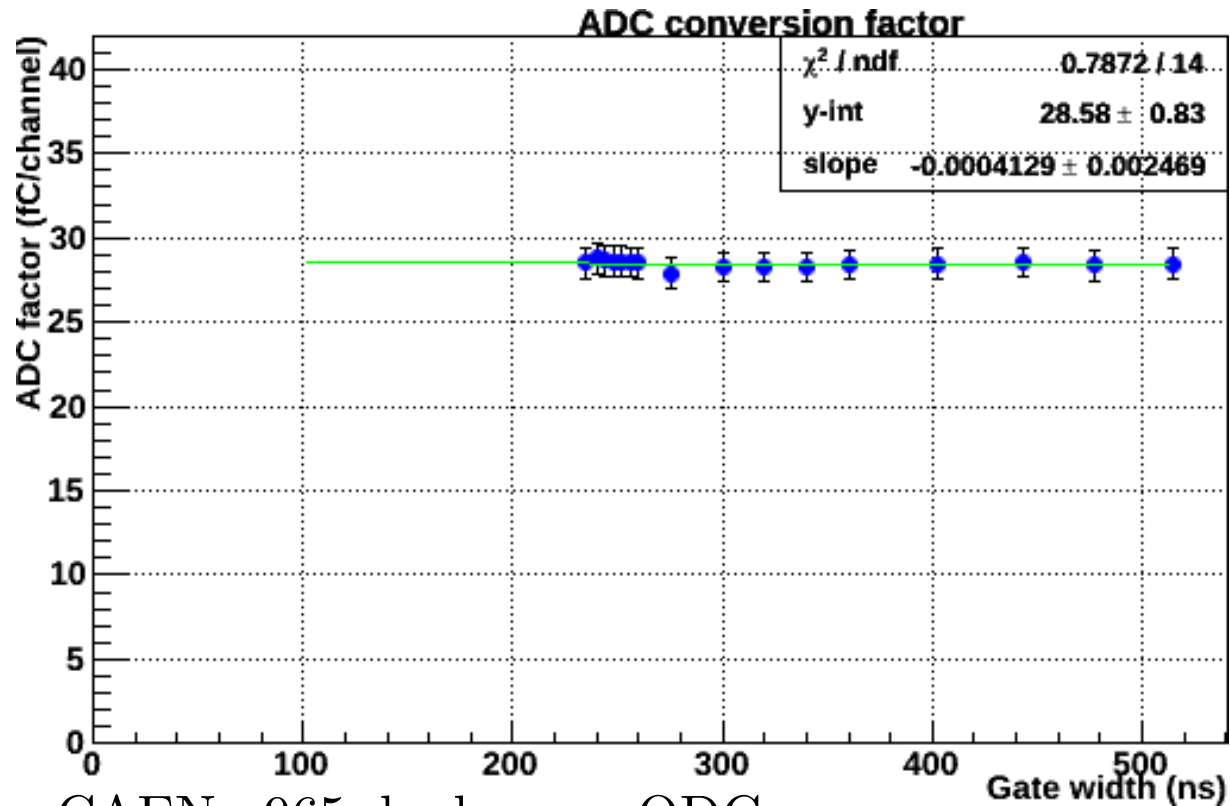
PMT Gain Measurements

- ADC charge sensitivity calibrated
- Gains measured using linearity apparatus with CAEN LED driver, ND filter wheel, and CAEN fast amplifier
- PE peaks extracted using multi-Poisson fit algorithm
- Purchased 4 new R7723Q pmts (with Mod. base); also have two pmts on loan from Jlab

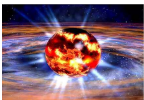




PMT Gain Measurements (ADC Charge Sensitivity)

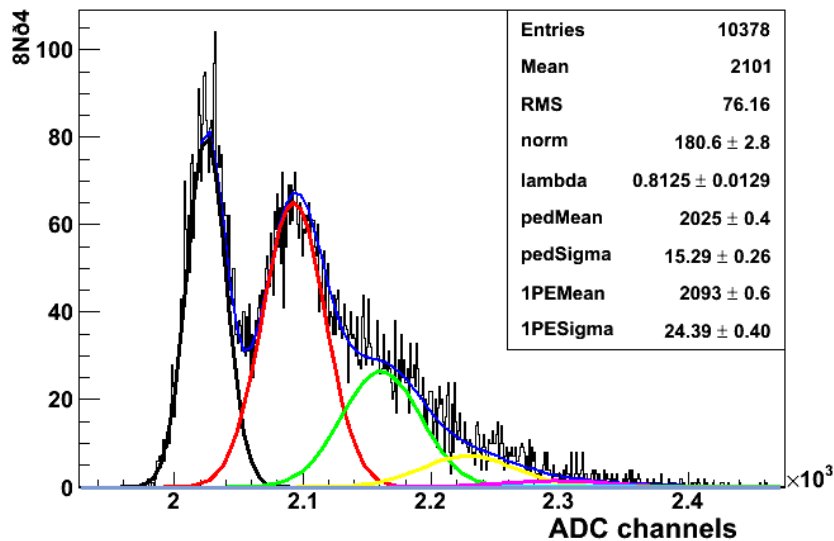
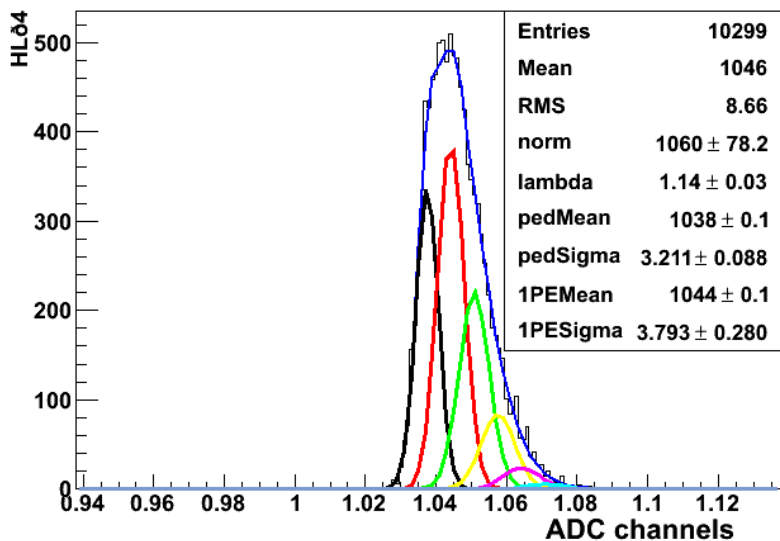
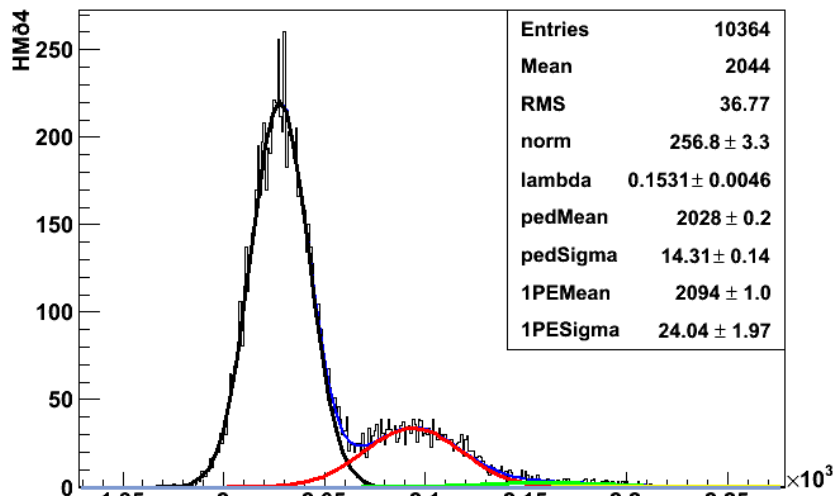
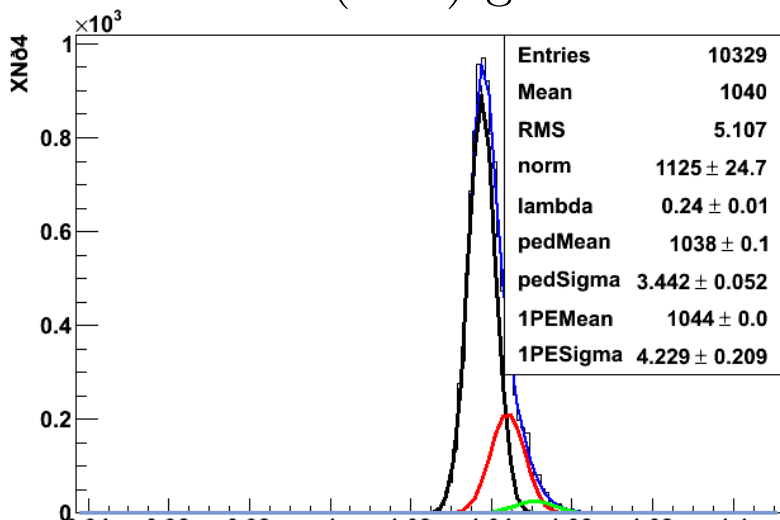


- Using CAEN v965 dual range QDC
- Spec. gives 25 and 200 fC/ch sensitivities
- We found ~ 28.6 and ~ 230 fC/ch with about $\sim 3\%$ uncertainty



PMT Gain Measurements

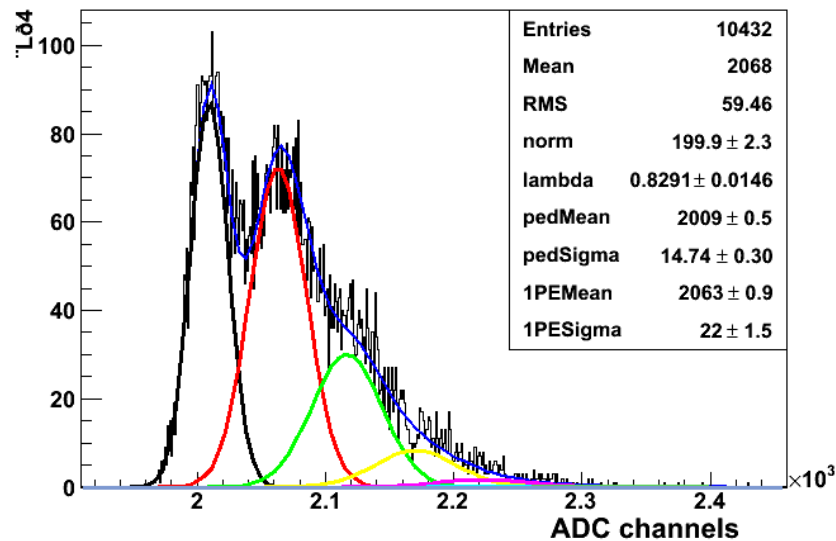
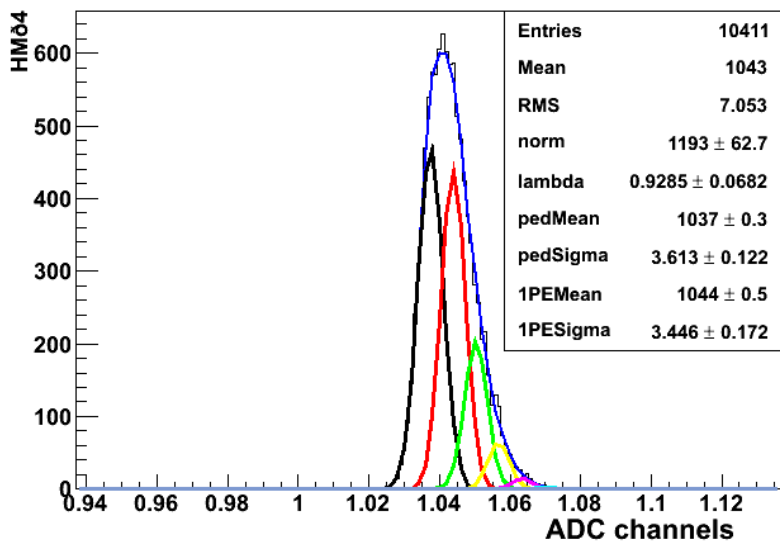
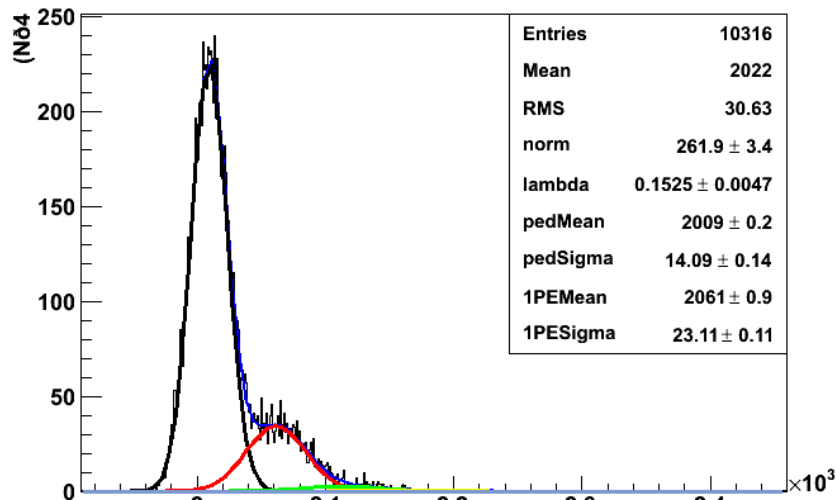
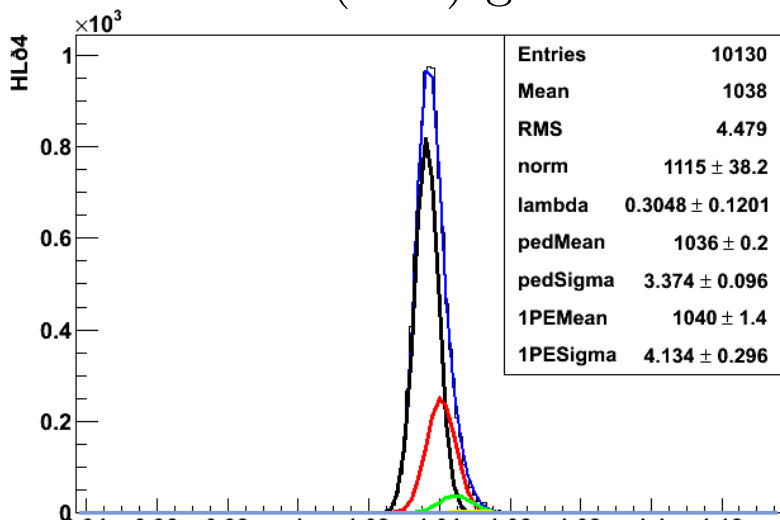
- PMT 1 (new) gain at -2000 V for two different light levels:

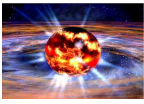




PMT Gain Measurements

- PMT 2 (new) gain at -2000 V for two different light levels:

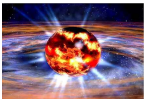




PMT Gain Measurements

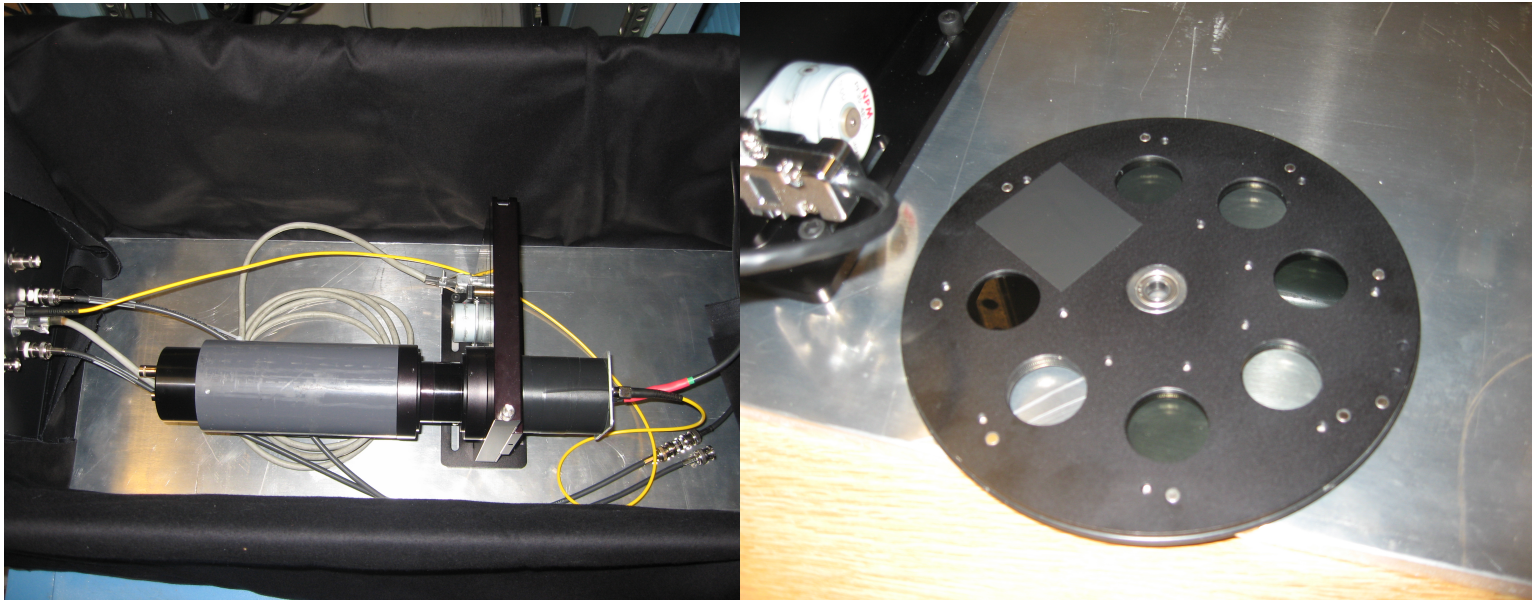
RUN	LED amplitude	PMT	Amp	Gain ($\times 10^6$)
1410	4,50	1	No	1.33
1412	5,50	1	No	1.16
1417	4,50	1	Yes	1.23
1419	5,50	1	Yes	1.25
1424	4,50	2	No	0.75
1426	5,50	2	No	1.16
1431	4,50	2	Yes	0.96
1433	5,50	2	Yes	0.99

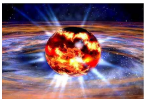
Table 1: Table of gain measurements at -2000 V. Estimated uncertainty is about $\pm 5\%$. Gains measured without amplifier are somewhat sensitive to fitting, while gains measured with amplifier are have uncertain amplification.



Path to Linearity Measurements

- Test apparatus constructed (based on Luis' setup):
 - Two LEDs (one steady, one flashing) → filter wheel → diffuser → pmt
 - Integrating DAQ using Qweak ADC: have HAPPEX timer and ported drivers for linuxROC, **NEED help porting drivers for Qweak ADC!!!** – Paul King volunteered to help





Linearity Study Strategy

- Using apparatus to map out pmt gains over large range of HV
- Will use these gains to calibrate PE's from real data tests. Can then use estimated e^- flux combined with PE's/ e^- to estimate anticipated pmt anode currents during PREX II and CREX
- LED light level is then adjusted to yield those anticipated PE rates
- For various HV's, LED asymmetries are measured for each filter setting and the degree of non-linearity is extracted from fits to the data.
- Choose HV setting that gives best linearity while utilizing \sim full range of 18-bit ADCs