PREX-II/CREX detectors & SAMs

Test Beam and Simulation Benchmarking

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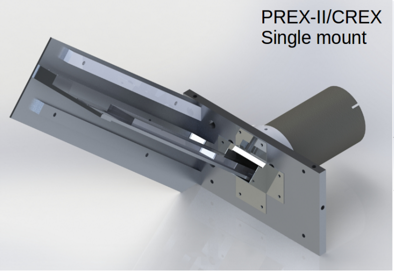
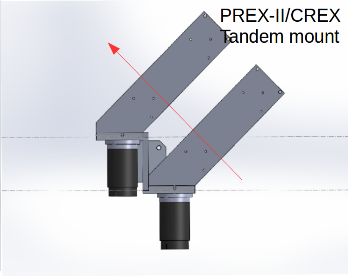
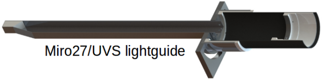
Overview

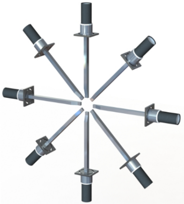
1. PREX-II/CREX prototypes and Hall A's SAMs
2. 2015 and 2016 Mainz beam tests
3. Geant4 and QSIM
4. Benchmarked Parameters and Procedure
5. Comparison of Data and Simulation
6. Conclusions
7. Future Work

PREX-II/CREX prototypes and Hall A’s SAMs

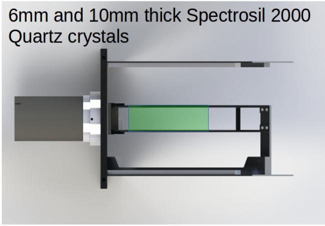






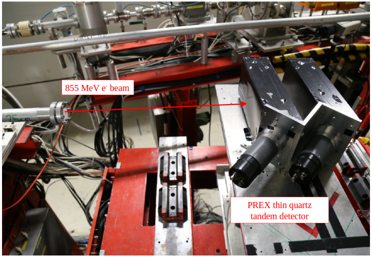


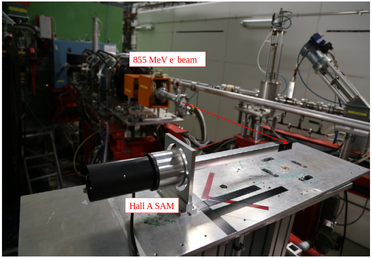
SAMs
Assembly



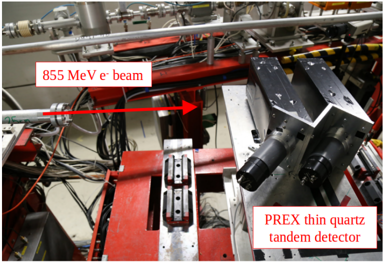
2015 and 2016 Mainz beam tests

- 855MeV MAMI electron testbeam (pinpoint).
- 2015 testbeam: PREX-II/CREX single thin quartz mount without wrapping, angle scan.
- 2016 testbeam: PREX-II/CREX tandem mount with Al. mylar wrapped quartz, 16cm separation between quartz pieces. SAM with wrapping, UVS and MIRO 27 lightguides, and with and without 10mm tungsten pre-radiator.





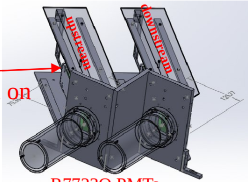
PREX-II/CREX Tandem Mount Test



Spectrosil2000 thicknesses: 10mm and 6mm, 6mm and 10mm

e^- beam

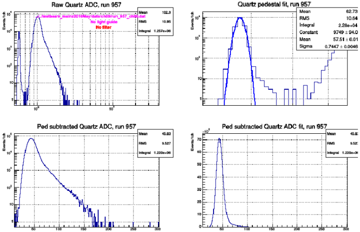
Centered on quartz at ~90°



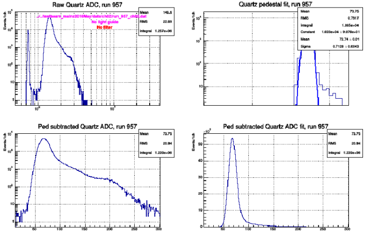
R7723Q PMTs

Raw data, pedestal fit and ped-corrected ADC distributions.

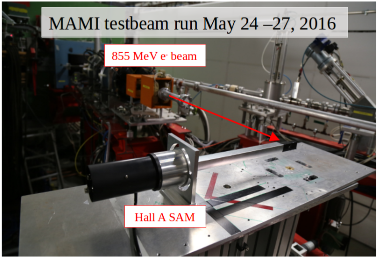
6mm Upstream
Mylar wrapping



10mm Downstream
Mylar Wrapping



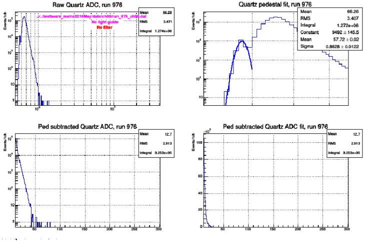
SAM Test with MIRO27 Lightguide



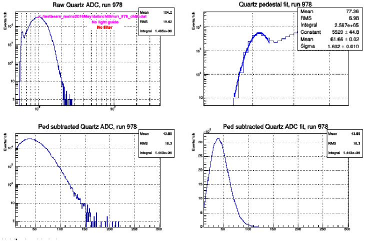
- Final SAM detector PE yield studies:
    - MiroSilver27 and UVS light-guides
    - With and without 1cm tungsten pre-radiator

Raw data, pedestal fit, and ped-corrected ADC distributions.

SAM with MIRO27 Lightguide
Without pre-radiator



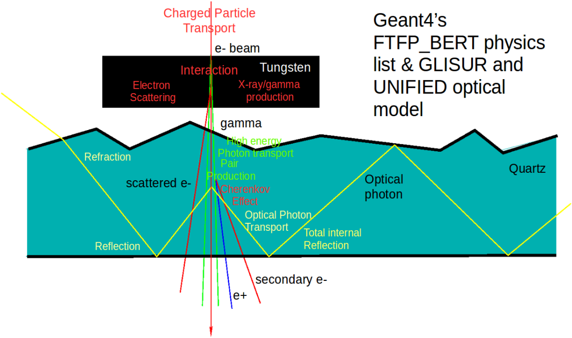
SAM with MIRO27 Lightguide
With 10mm pre-radiator



Geant4 and QSIM

GLISUR (quartz polish and reflectance) and **UNIFIED** (lightguide, dielectric-metal interface) optical models.

- QSIM uses the GLISUR model for the quartz pieces. A single *ground polish parameter* models the surface roughness.
- QSIM uses UNIFIED model for the SAM light-guide materials. The lightguides and the wrapping have a metal-dielectric interface with a given *reflectivity*.



Geant4's FTFP_BERT physics list & GLISUR and UNIFIED optical model

Benchmarked Parameters

Apart of the geometry, the PE yield depends on certain parameters that need to be benchmarked with real data.

QSIM's parameters to be benchmarked in this study

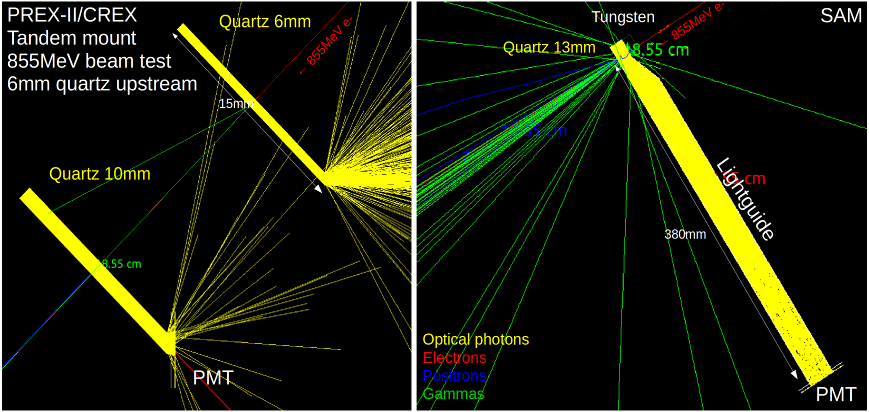
- Quartz polish.
- Aluminized mylar reflectivity.
- SAM lightguide reflectivity as a function of photon wavelength.

Photocathode reflectivity and attenuation is not yet considered in the study.

Benchmarking Procedure

- PREX-II/CREX data without wrapping is used to benchmark the quartz polish.
- With the benchmarked polish value, PREX-II/CREX data with wrapping is used to benchmark reflectivity.
- With benchmarked polish, and wrapping reflectivity, SAM lightguide reflectivity is bechmarked. There is a complication: lightguide reflectivity is not only function of photon wavelengths but function of incident angle.

QSIM Visualization



Determination of the number of PEs using PMT gain

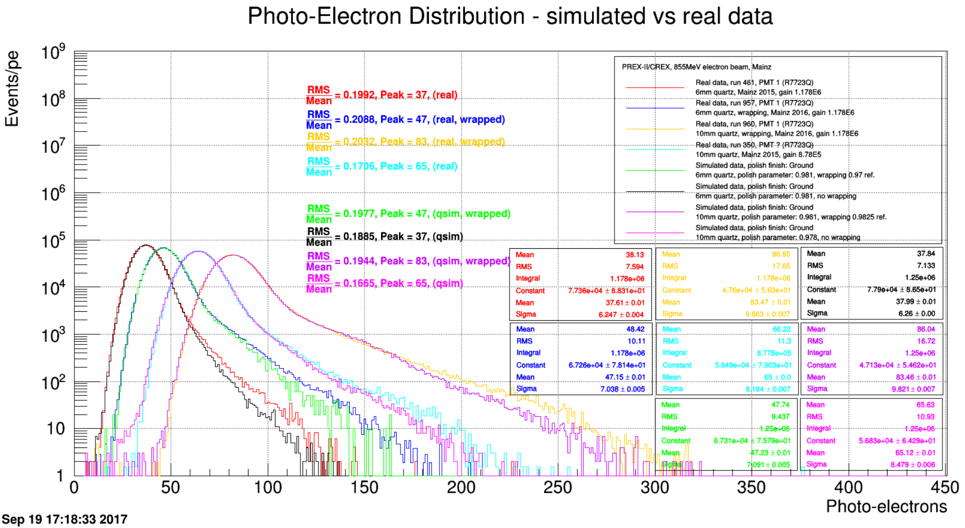
$$\#PEs \times (1.602 \times 10^{-4} fC) \times Gain = \#ADC \times 200 fC/Ch$$

$$Gain(PMT1) = 1.24 \times 10^{6} \pm 5\%$$
$$Gain(PMT2) = 1.10 \times 10^{6} \pm 5\%$$

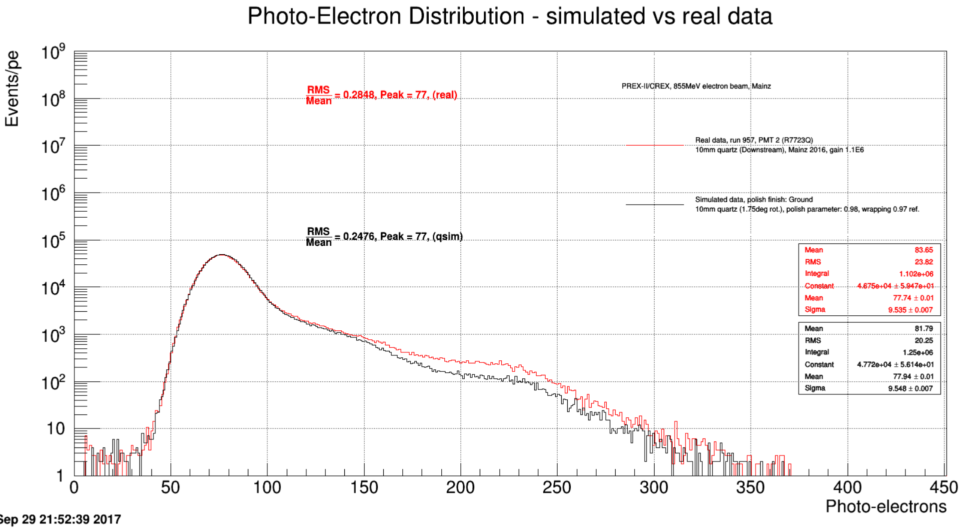
$$\#PEs = 1.068 \times \#ADC(PMT1)$$

$$\#PEs = 1.134 \times \#ADC(PMT2)$$

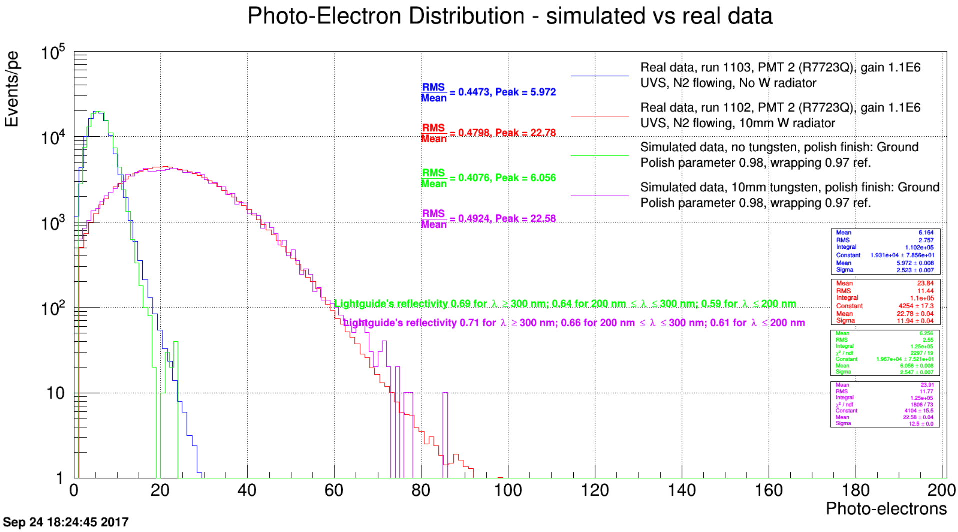
2015 & 2016 (upstream) PREX-II/CREX's PE distributions



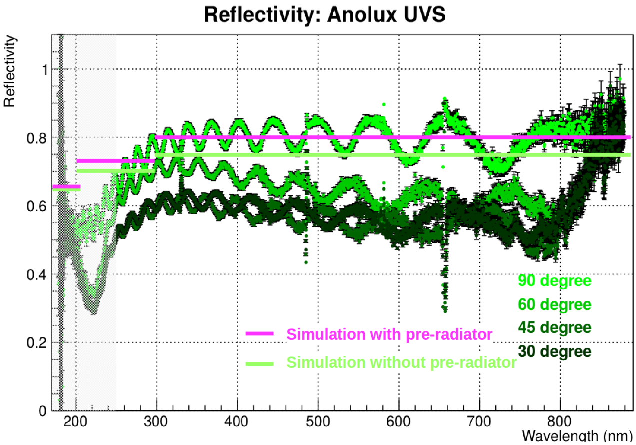
2016 (downstream) PREX-II/CREX's PE distributions



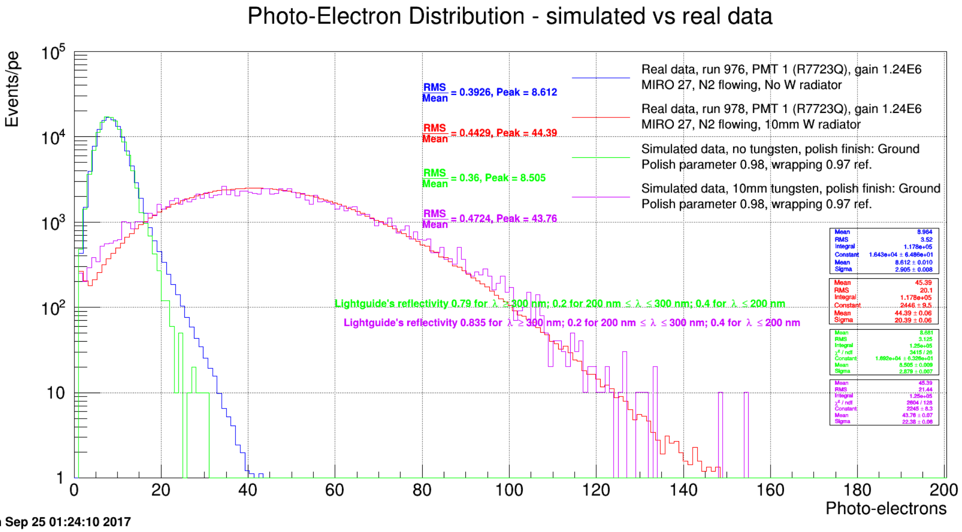
2016 SAMs' PE distributions, UVS lightguide



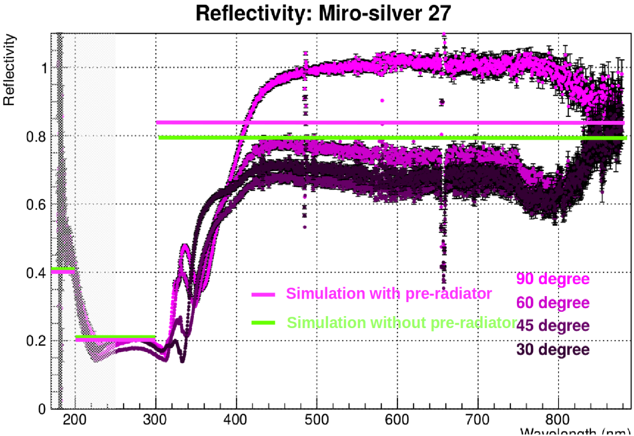
UVS reflectivity



2016 SAMs' PE distributions, MIRO27 lightguide



MIRO27 reflectivity



Benchmarked Parameters

PREX-II/CREX Prototype Benchmarked Parameters

Thickness [mm]	Polish Parameter	wrapping ref.	PEs (peak)	RMS/Mean
6	0.981	n/a (2015)	37	0.1885
6	0.981	0.97 (2016)	47	0.1977
10	0.978	n/a (2015)	65	0.1665
10	0.981	0.97 (2016)	83	0.1944

SAMs' Benchmarked Parameters, UVS Lightguide

Thickness [mm] Quartz/Tungsten	Polish Parameter	wrapping ref.	Mirror's ref. $\lambda > 300nm$	Mirror's ref. $200nm \leq \lambda \leq 300nm$	Mirror's ref. $\lambda < 200nm$	PEs (peak)	RMS/Mean
13/-	0.98	0.97	0.69	0.59	0.49	6	0.4076
13/10	0.98	0.97	0.71	0.66	0.61	22	0.4924

SAMs' Benchmarked Parameters, MIRO27 Lightguide

Thickness [mm] Quartz/Tungsten	Polish Parameter	wrapping ref.	Mirror's ref. $\lambda > 300nm$	Mirror's ref. $200nm \leq \lambda \leq 300nm$	Mirror's ref. $\lambda < 200nm$	PEs (peak)	RMS/Mean
13/-	0.98	0.97	0.79	0.2	0.4	9	0.36
13/10	0.98	0.97	0.835	0.2	0.4	44	0.4724

Summary

- Successful testing of PREX-II/CREX during 2015 & 2016.
- The simulation benchmarking is a difficult puzzle in which many pieces have to fit together consistently. We are making steady progress.
- QSIM works fine for thin quartz detectors like PREX-II/CREX in the PE peak region.
- QSIM simulation benchmarked parameters: 0.98 for GLISUR polish parameter and 0.97 for wrapping reflectivity.
- The lightguide reflectivity has yet to be understood.

Future Work

- Add MAMI beam exit window to simulation to help improve agreement in the tail region.
- Investigate the specular and diffuse reflectivity parameters in the UNIFIED optical model.
- Redo reflectivity measurements (include more angles and improve calibration).