Main Detectors for PREX and CREX

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Main Detectors for PREX and CREX

Outline

• Detector design (∼finalized)
• Optical simulation (∼benchmark)
• 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

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

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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

Raw Quartz ADC, run 462

- Mean: 90.53
- RMS: 14.93
- Integral: 95e+05

Quartz pedestal fit, run 462

- Mean: 60.13
- RMS: 2.584
- Integral: 1.131e+05
- χ² / ndf: 32.02 / 1
- Prob: 1.524e-08
- Constant: 5.972e+04 ± 2.724e+02
- Mean: 59.83 ± 0.00
- Sigma: 0.7985 ± 0.0018

Ped subtracted Quartz ADC, run 462

- Mean: 36.41
- RMS: 7.156
- Integral: 5.837e+05
- RMS/mean: 0.197

Ped subtracted Quartz ADC fit, run 462

- Mean: 36.27
- RMS: 6.67
- Integral: 5.82e+05
- χ² / ndf: 17.55 / 14
- Prob: 0.2279
- Lwidth: 0.5844 ± 0.0315
- MPV: 33.83 ± 0.04
- Integral: 2.649e+03 ± 6.132e+05
- GSigma: 0.065 ± 5.652

PE's (from stats): 37
MAMI Testbeam: no-LG, 6mm angle scan
6mm, no-LG angle scan PE comparisons: 
Gain vs. Stat widths

![Graph showing PE comparisons and statistical parameters]

- $\chi^2$/ndf = 2.97/11
- Prob = 0.9911
- $p0$ = $-1.207 \pm 1.305$
- $p1$ = $0.9879 \pm 0.04984$

Fri Feb 26 13:54:43 2016
6mm, no-LG angle scan PE comparisons: Gain vs. Stat widths
Comparison: 6mm, no-LG, 92deg incidence

Photo-Electron Distribution - Prototype B Detector

**Prototype B, 855MeV electron beam**
- real data, run 461, theta ~92 deg, gain 1.24E6
- Sensitivity 200fC/Ch
- Simulated data: Qthick 6mm, sep 3.6mm, DetAngle 2deg
glisur polish 0.981, QE R7723Q (bialkali)

**quartzADC**
- Entries: 579986
- Mean: 37.2 ± 0.009464
- RMS: 7.207 ± 0.006692
- Integral: 5.8e+05

**hit_n_hist**
- Entries: 580000
- Mean: 37.22 ± 0.009283
- RMS: 7.07 ± 0.006564
- Integral: 5.8e+05

**RMS**
- Mean = 0.194

**RMS**
- Mean = 0.19
Comparison: 6mm, no-LG, 88deg incidence

Photo-Electron Distribution - Prototype B Detector

Prototype B, 855MeV electron beam
- real data, run 472, theta ~88 deg, gain 1.24E6
- Sensitivity 200fC/Ch

Simulated data: Q thick 6mm, sep 3.6mm, DetAngle -2deg
glisor polish 0.981, QE R7723Q (biaxial)

<table>
<thead>
<tr>
<th></th>
<th>quartzADC</th>
<th>hit_n_hist</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entries</td>
<td>580077</td>
<td>580000</td>
</tr>
<tr>
<td>Mean</td>
<td>36.08 ± 0.009226</td>
<td>36.92 ± 0.009172</td>
</tr>
<tr>
<td>RMS</td>
<td>7.027 ± 0.006524</td>
<td>6.985 ± 0.006486</td>
</tr>
<tr>
<td>Integral</td>
<td>5.801e+05</td>
<td>5.8e+05</td>
</tr>
</tbody>
</table>

RMS
---

\[
\frac{\text{RMS}}{\text{Mean}} = 0.195
\]

Fri Feb 26 15:13:28 2016
Comparison: 6mm, no-LG, 86deg incidence

Photo-Electron Distribution - Prototype B Detector

Prototype B, 885MeV electron beam

- real data, run 473, theta ~86 deg, gain: 1.24E6
- Sensitivity 200fC/Ch

Simulated data: Qthick 6mm, sep 3.6mm, DetAngle ~4deg
glisur polish 0.981, QE R7723Q (biaxial)

**quartzADC**
- Entries: 580788
- Mean: 33.78 ± 0.008924
- RMS: 6.801 ± 0.00631
- Integral: 5.808e+05

**hit_n_hist**
- Entries: 580000
- Mean: 32.66 ± 0.008668
- RMS: 6.602 ± 0.00613
- Integral: 5.8e+05

\[
\frac{\text{RMS}}{\text{Mean}} = 0.201
\]

Fri Feb 26 14:58:30 2016
Comparison: 6mm, no-LG, 101deg incidence

Photo-Electron Distribution - Prototype B Detector

Prototype B, 855MeV electron beam
real data, run 460, theta ~101 deg, gain 1.24E6
Sensitivity 200fC/Ch
Simulated data: Qthick 6mm, sep 3.6mm, DetAngle 11deg
glisur polish 0.981, QE R7723Q (blakaki)

quartzADC
Entries 579802
Mean 25.69 ± 0.008559
RMS 6.517 ± 0.006052
Integral 5.798e+05

hit_n_hist
Entries 580000
Mean 27.64 ± 0.008385
RMS 6.386 ± 0.005929
Integral 5.8e+05

\[
\frac{\text{RMS}}{\text{Mean}} = 0.254
\]

Fri Feb 26 15:31:53 2016
Comparison: 6mm, no-LG, 92deg incidence

Photo-Electron Distribution - Prototype B Detector

Prototype B, 855MeV electron beam
- real data, run 463, theta ~77 deg, gain 1.3E6
- Sensitivity 200fC/Ch
- Simulated data: Qthick 6mm, sep 3.6mm, DetAngle -13deg
- glisur polish 0.975, QE R7723Q (bialekali)

RMS Mean = 0.301

**quartzADC**
- Entries 380890
- Mean 13.53 ± 0.006603
- RMS 4.075 ± 0.004669
- Integral 3.809e+05

**hit_n_hist**
- Entries 580000
- Mean 11.42 ± 0.005743
- RMS 4.374 ± 0.004061
- Integral 5.8e+05

Thu Feb 18 16:39:51 2016
Plans for next MAMI Testbeam (May 2016)

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 cm$^2$) 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 pmf) 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 $\lambda$)
- Working to simulate complete angle scans for 6mm and 10mm quartz as well as long pass filter study (and compare with data)
- Planing to test 6 mm/10 mm tandem PREX detector at MAMI this May
- 10 by 20 cm$^2$ GEM tracker system under development...more next time
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 $\sim 28.6$ and $\sim 230$ fC/ch with about $\sim 3\%$ uncertainty
PMT Gain Measurements

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

```
Entries 10329
Mean 1040
RMS 5.107
norm 1125 ± 24.7
lambda 0.24 ± 0.01
pedMean 1038 ± 0.1
pedSigma 3.442 ± 0.052
1PEMean 1044 ± 0.0
1PESigma 4.229 ± 0.209
```

```
Entries 10364
Mean 2044
RMS 36.77
norm 256.8 ± 3.3
lambda 0.1531 ± 0.0046
pedMean 2028 ± 0.2
pedSigma 14.31 ± 0.14
1PEMean 2094 ± 1.0
1PESigma 24.04 ± 1.97
```
PMT Gain Measurements

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

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<table>
<thead>
<tr>
<th>RUN</th>
<th>LED amplitude</th>
<th>PMT</th>
<th>Amp</th>
<th>Gain ($\times 10^6$)</th>
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<tr>
<td>1410</td>
<td>4,50</td>
<td>1</td>
<td>No</td>
<td>1.33</td>
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<td>1.23</td>
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<td>1419</td>
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<td>1.16</td>
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<tr>
<td>1433</td>
<td>5,50</td>
<td>2</td>
<td>Yes</td>
<td>0.99</td>
</tr>
</tbody>
</table>

Table 1: Table of gain measurements at -2000 V. Estimated uncertainty is about ±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