PREx Detector Test Run Analysis

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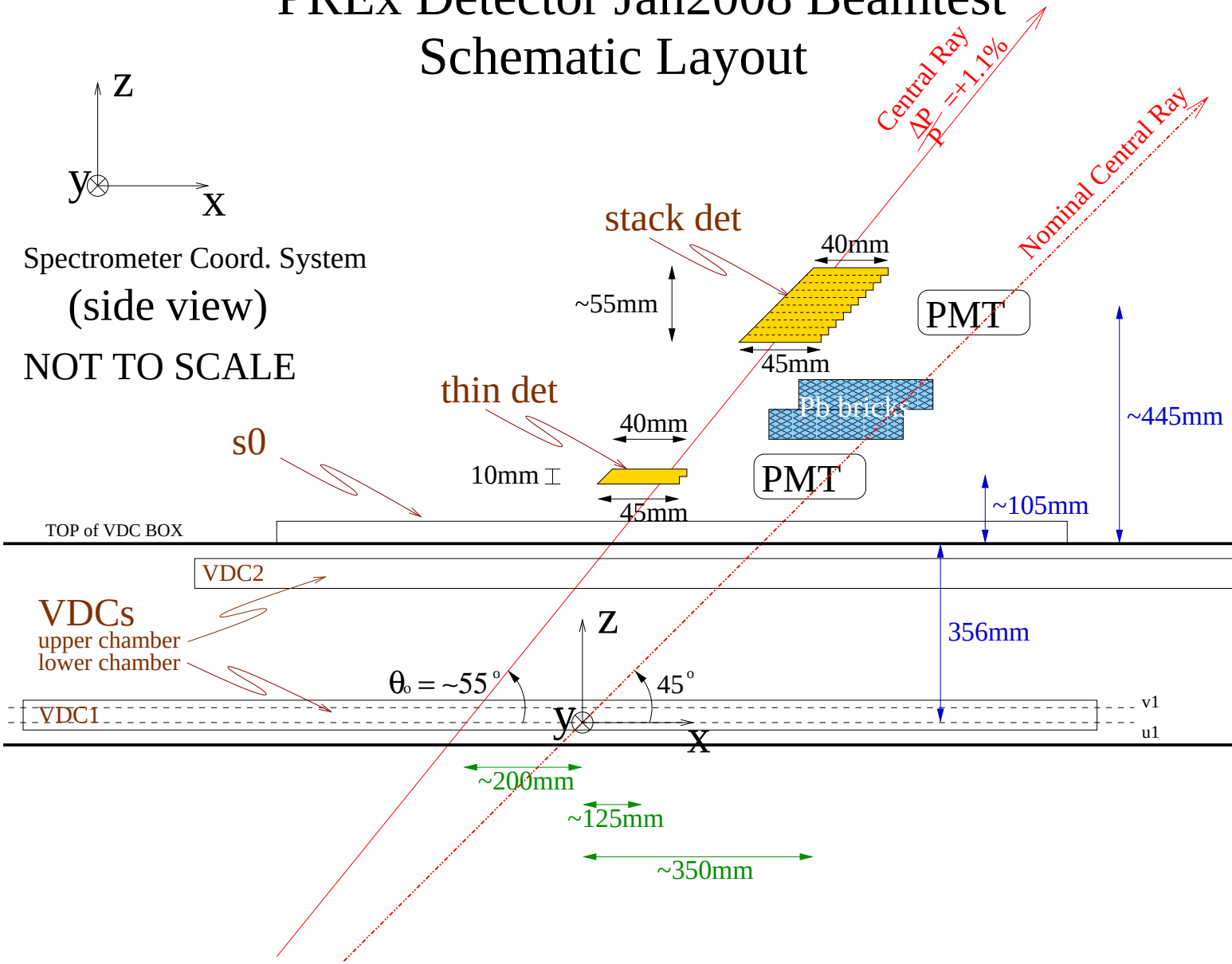
Outline

- Review Jan 2008 Beamtest Results
- Review Detector Design and Status
- Introduce new Hall A MC (HAMC) and Explore its ability to reproduce 2005 test run data
- Results: Detector Dimensions for Default and Tweaked HRS Optics Setup
- Summary and Outlook

PREx Detector Jan2008 Beamtest Schematic Layout



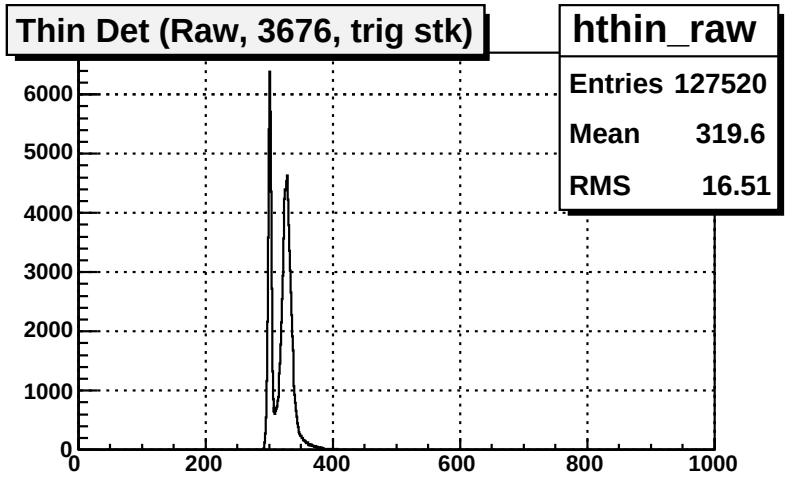
Review: Detector Pulse-height Analysis from Jan 2008 Beamtest

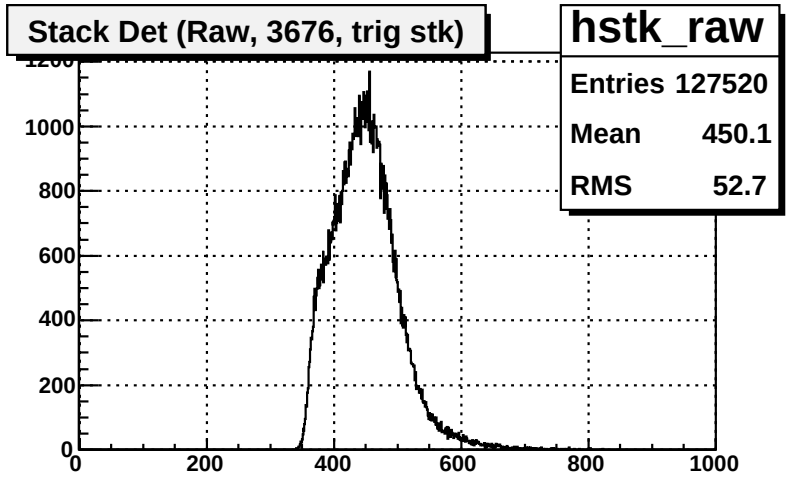
- Want to quantify the peak and tails–Fit ADC distributions with Landau function convoluted with a Gaussian.
  - -4 parameters: Landau width, MPV, width of Gaussian, and normalization.

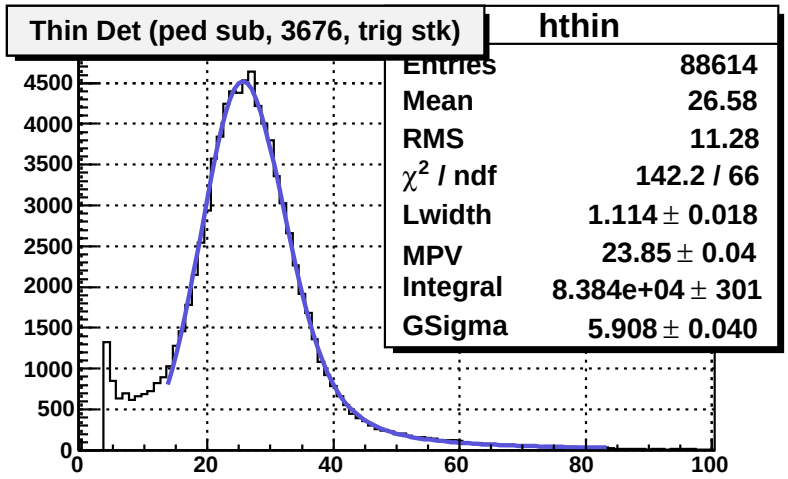
- Landau tail results from low-probability hard-scatters (usually in first few radiation lengths).

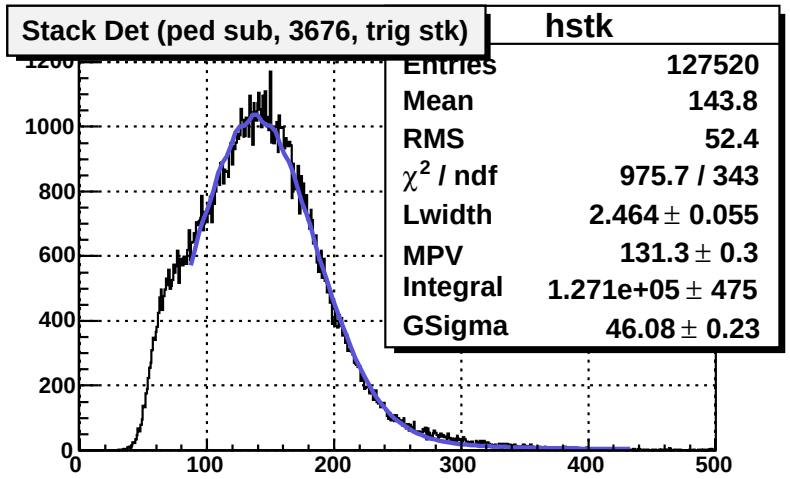
- Tails are exacerbated by too much upstream material (which acts as a preshower).
  - For Quartz, $X_o \approx 27$ g/cm^2, =>10mm thin det is ~ 0.1 X_o
  - The S0 detector is ? X_o
  - Upstream VDC material is ? X_o

Pulse-height Anal: Sample from run 3676 (s0 in, 10mm)

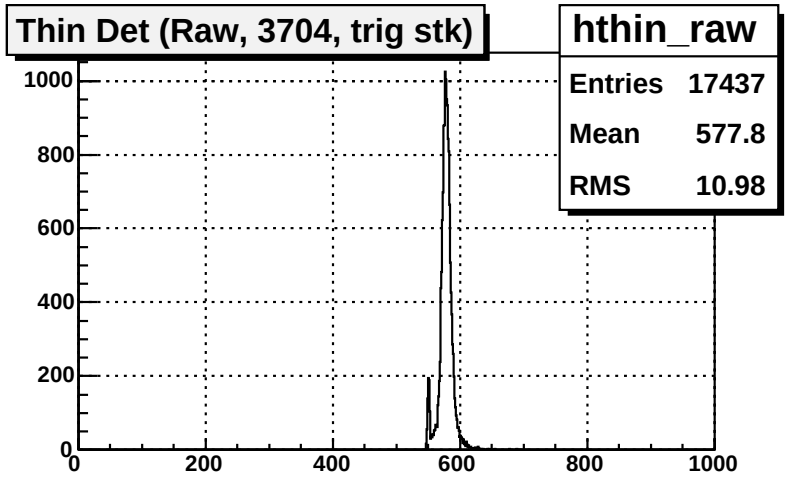


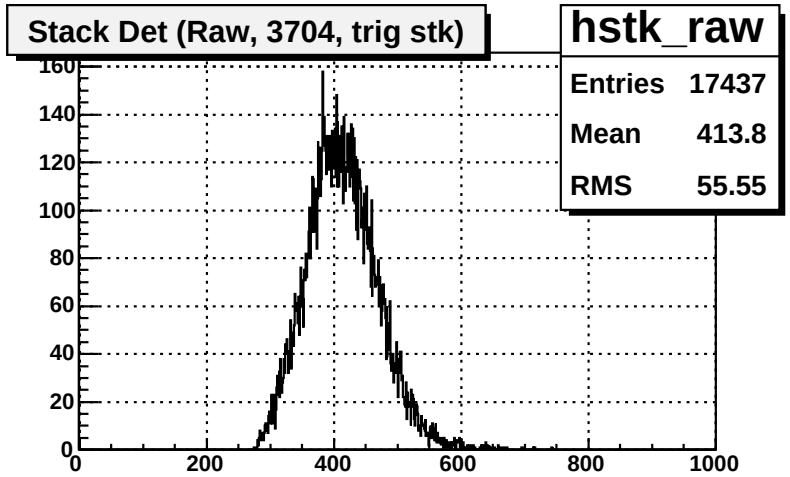


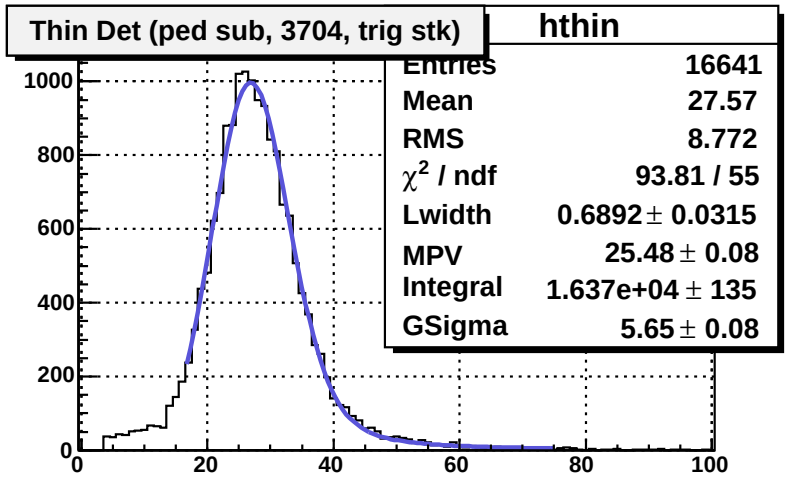


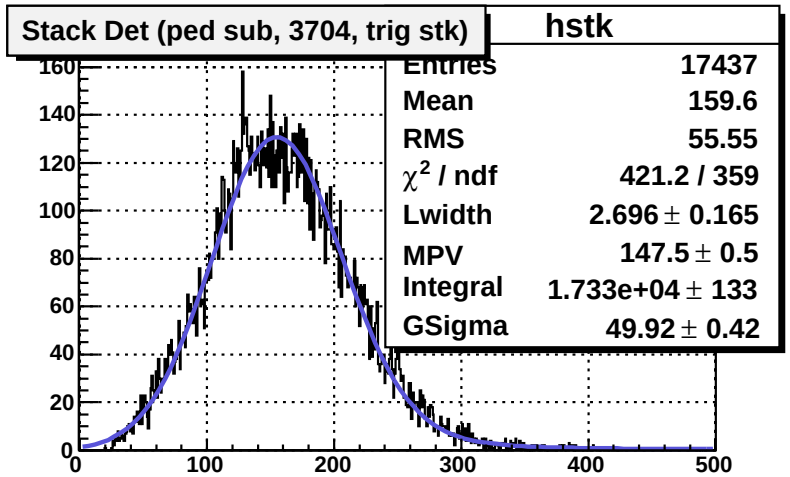


Pulse-height Anal: Sample from run 3704 (s0 out, 10mm)

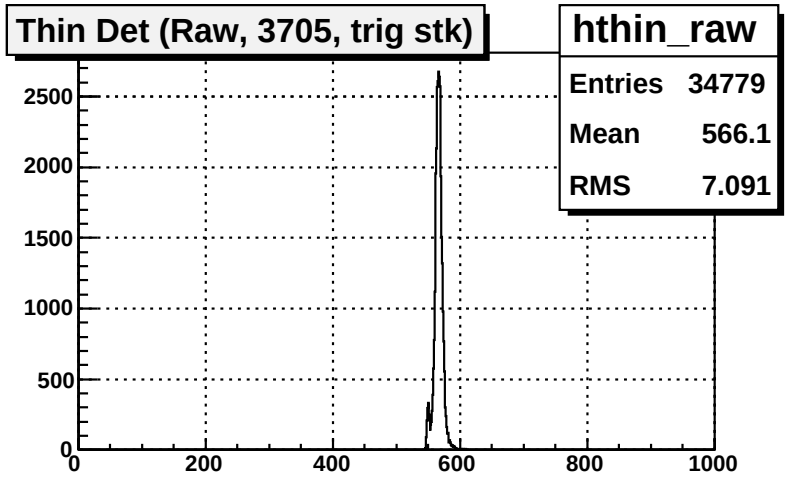


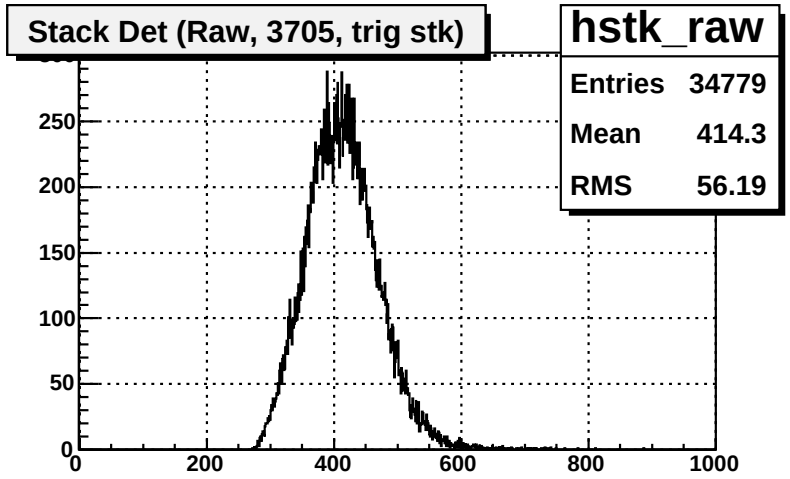


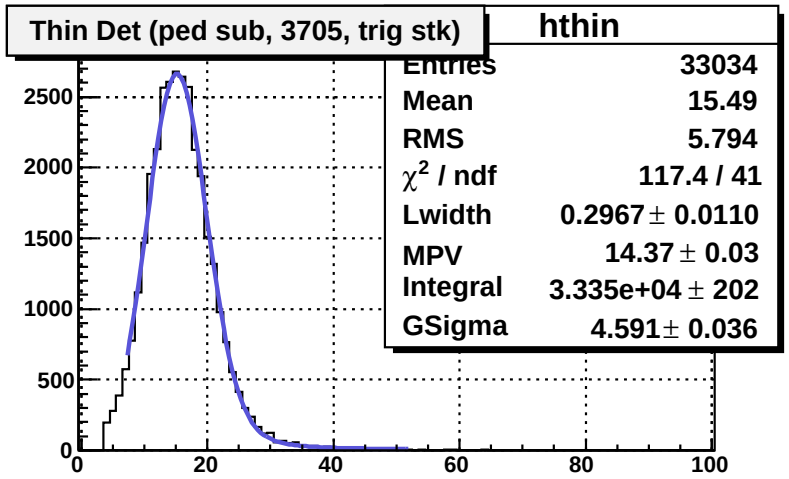


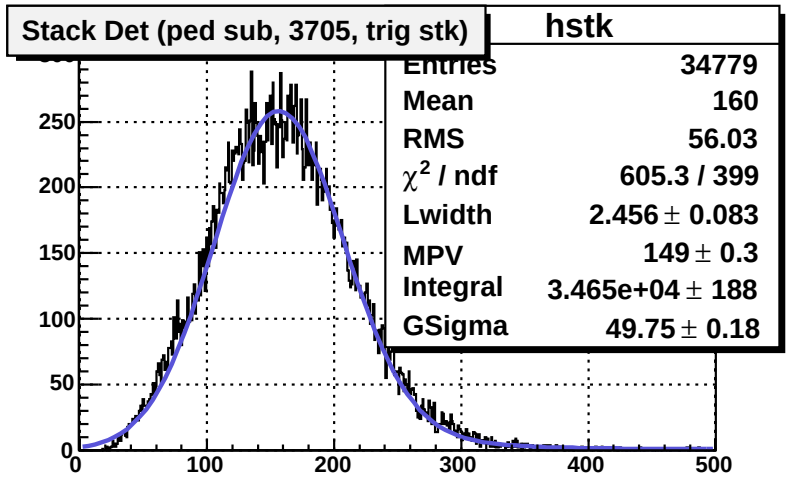


Pulse-height Anal: Sample from run 3705 (s0 out, 5mm)









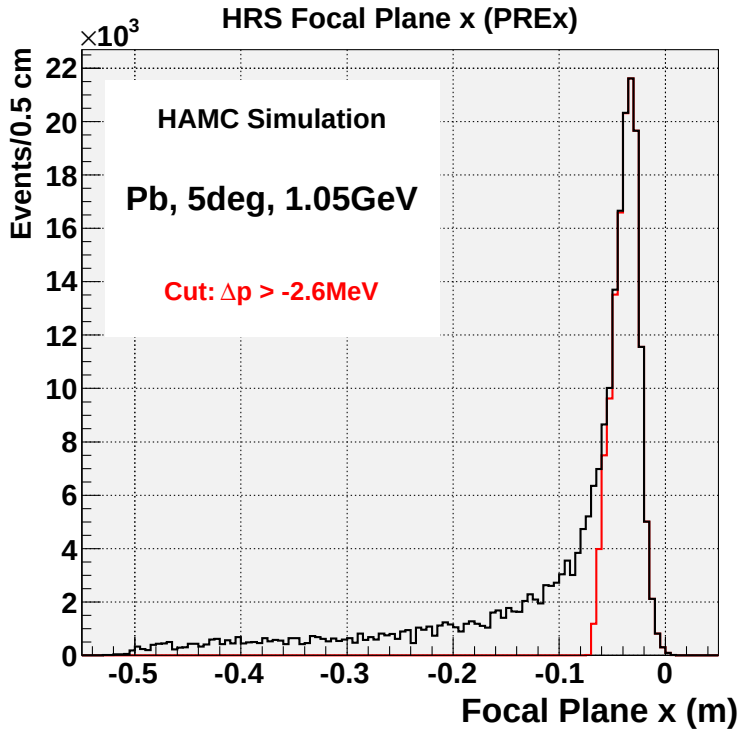
Pulse-height Analysis Summary for Thin Dets

Run	5mm Thin Det			10mm Thin Det		
	Lwidth	MPV±GSigma	Res	Lwidth	MPV±GSigma	Res
3512	N/A	N/A	N/A	1.0	22.5 ± 5.5	24.4%
3676	N/A	N/A	N/A	1.1	23.4 ± 5.9	25.3%
3681	N/A	N/A	N/A	1.1	23.5 ± 6.0	25.5%
3686	N/A	N/A	N/A	1.9	24.8 ± 5.9	24.0%
3704	N/A	N/A	N/A	0.69*	25.5 ± 5.7	22.4%
3705	0.30*	15.9 ± 4.6	28.9%	N/A	N/A	N/A
3720	0.31*	16.1 ± 4.6	28.7%	N/A	N/A	N/A
Avg			28.8%			24.3%

* – s0 removed from detector acceptance.

- For 10mm, tail width reduced by factor ~ 2 when s0 removed.
- Tail width reduced by additional factor of ~ 2 for 5mm thin det.

Review Detector Design and Status



- Will use 2 separate, single thin quartz detectors in tandem.
- For dispersive x, must exclude first excited state and beyond.
- For y, must cover entire signal, but not more than necessary.

- Detectors employ well understood 2in phototubes. Monte Carlo optimization of light guides and quartz thickness at UMass and Smith.
- The x,y dimensions of the quartz determined from beam test data and new Hall A Monte Carlo (HAMC).

Detector x,y Dimensions Study: The Plan

- Establish reliability of new Monte Carlo:
  - Compare HAMC with real data from 2005 beamtest (6°cold septum, 3-pass H and 1-pass Pb)
  - Try to understand discrepancies
- Run HAMC using PREx conditions, determine optimal detector sizes using the default HRS optics setup.
- Tweak HRS optics (Q2 and Q3) to provide elastic peak focus at the detector location–LeRose provided.
- Incorporate new optics in HAMC and use to determine optimal detector sizes using the tweaked HRS optics setup – in principle, this should be the optics used for the run.

Hall A Monte Carlo: HAMC

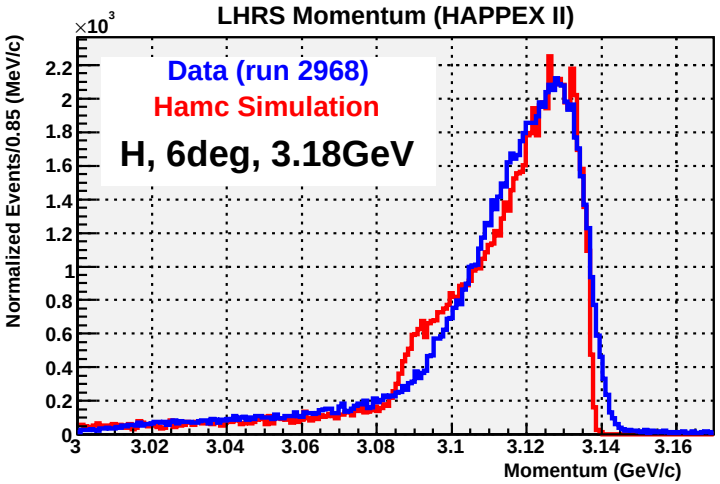
- C++ based MC developed by Bob Michaels to support the three upcoming parity experiments.
- Incorporates LeRose transport functions to provide focal plane distributions with realistic acceptance definitions at all apertures.
- Includes cold, warm, or no septum configurations with extended Hydrogen and PREx Pb targets.
- Uniform target sampling (vertex and scattering angles) with precision cross section weighting; includes external radiation, multiple scattering and resolution smearing.

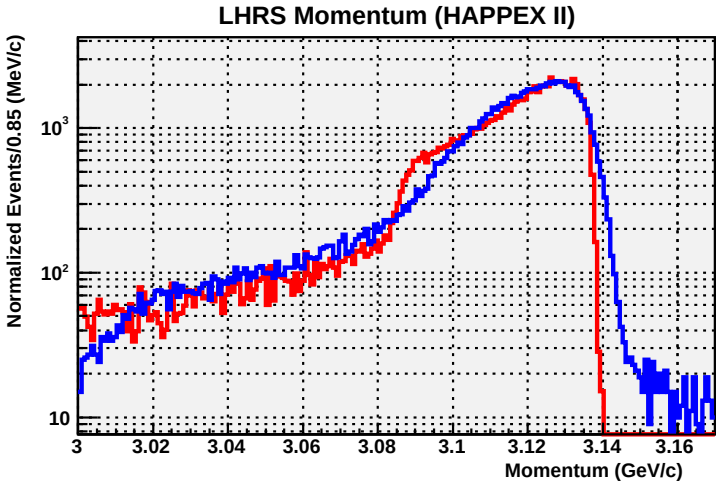
2005 Beamtest Data

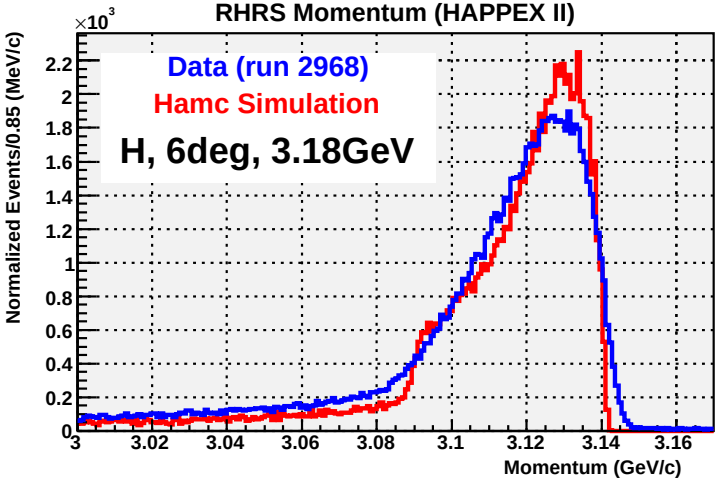
- HAPPEX-II Run: 2968, Nov 2, 2005
  - Hydrogen target with 2mm x 4mm raster
  - Beam energy 3.18GeV, current 0.5μA
  - 6°scattering with cold septum, p0 = 3.12GeV

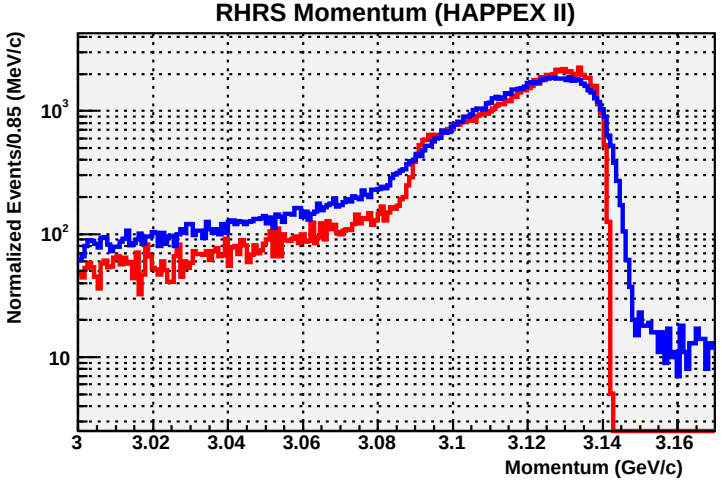
- HAPPEX-II Run: 3131, Nov 21, 2005
  - Pb-Diamond target with 3mm x 3mm raster
  - Beam energy 1.1GeV, current 0.1μA
  - 6°scattering with cold septum, p0 = 1.1GeV

Comparison of Momentum Distributions: Hydrogen

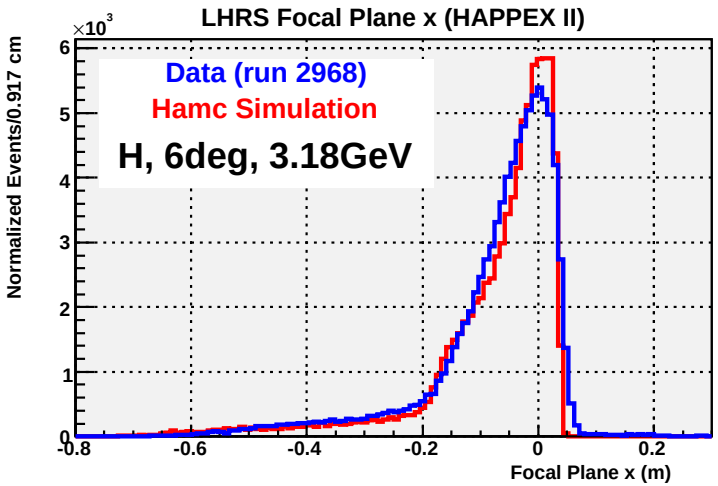


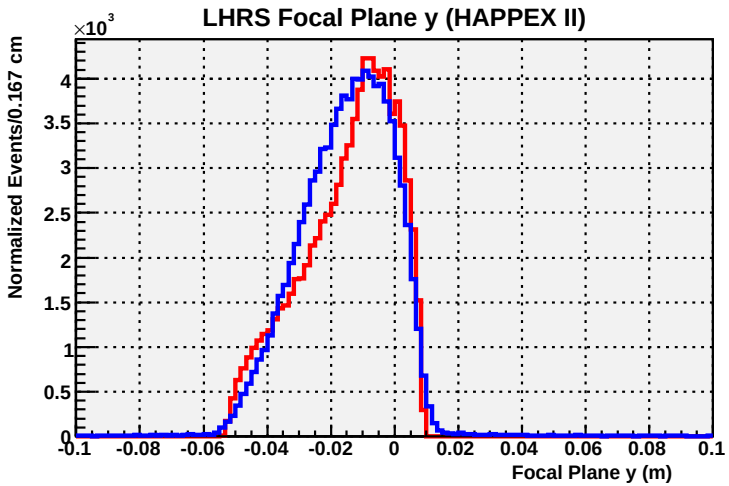


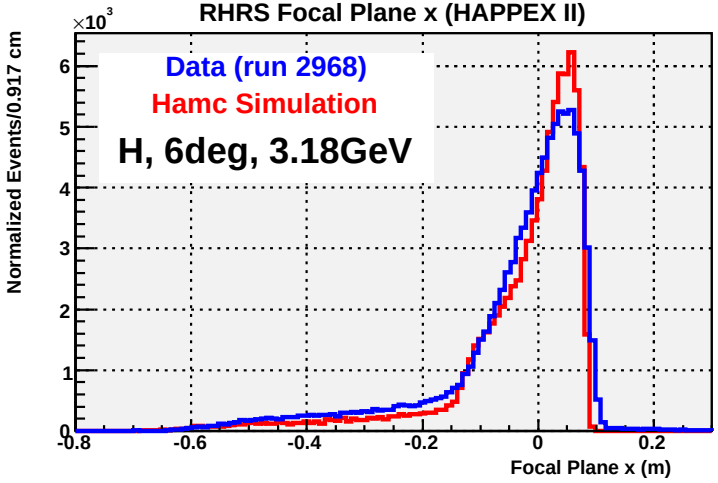


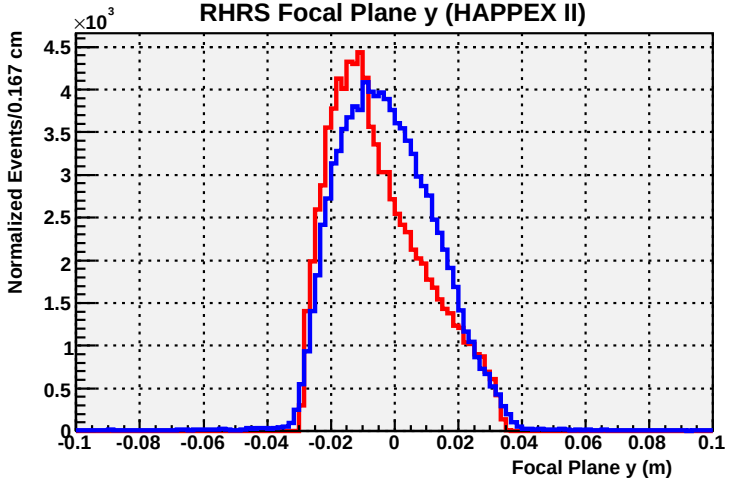


Comparison of Focal Plane x,y: Hydrogen

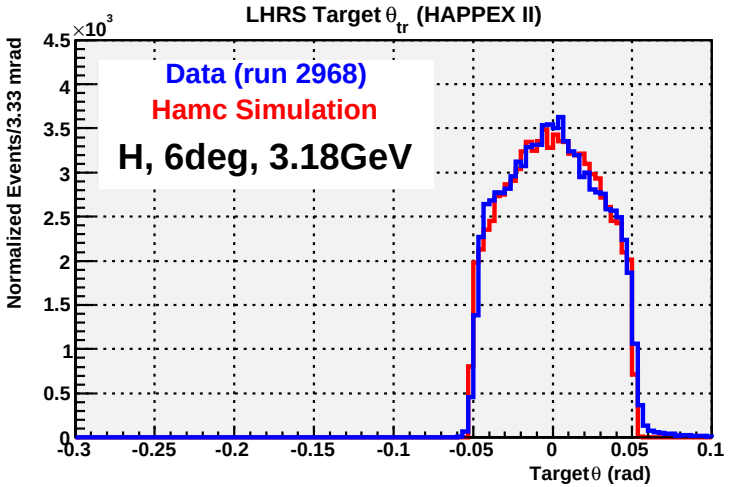


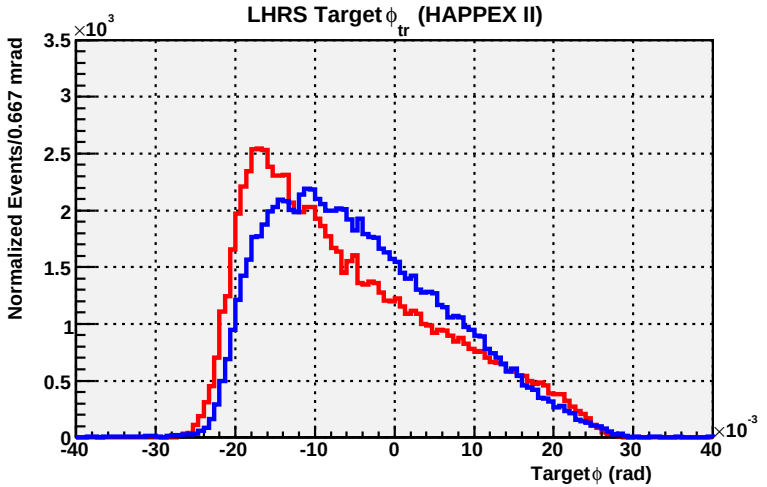


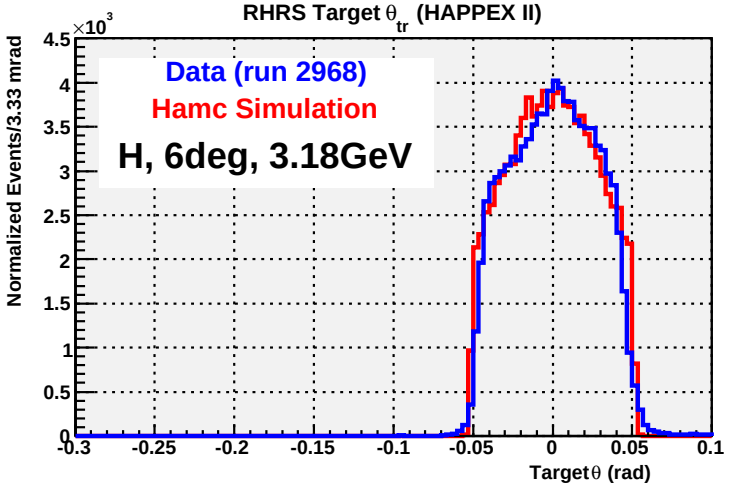


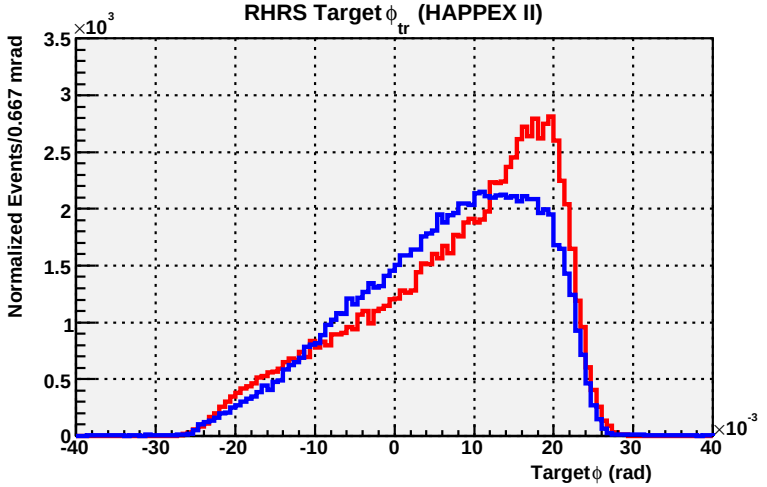


Comparison of Transport Angles at Target: Hydrogen

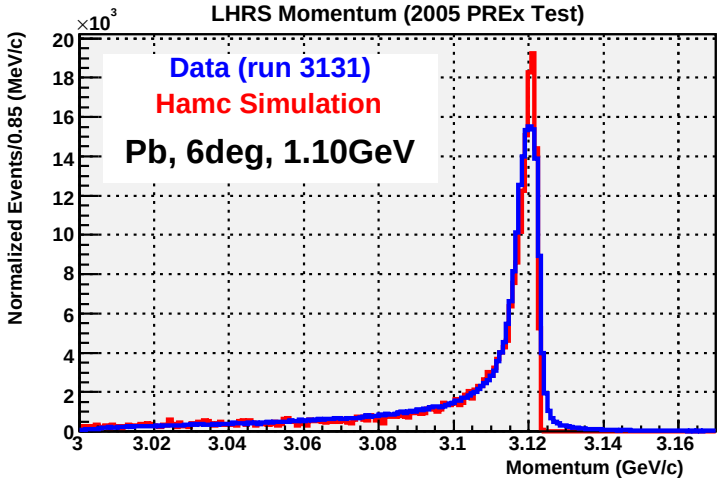


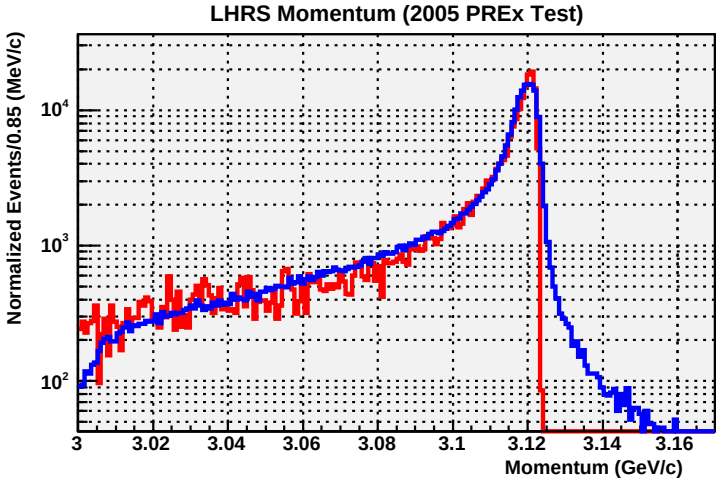


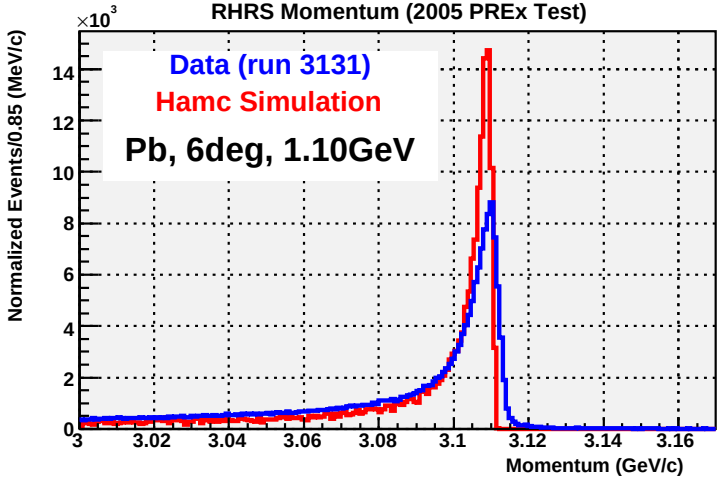


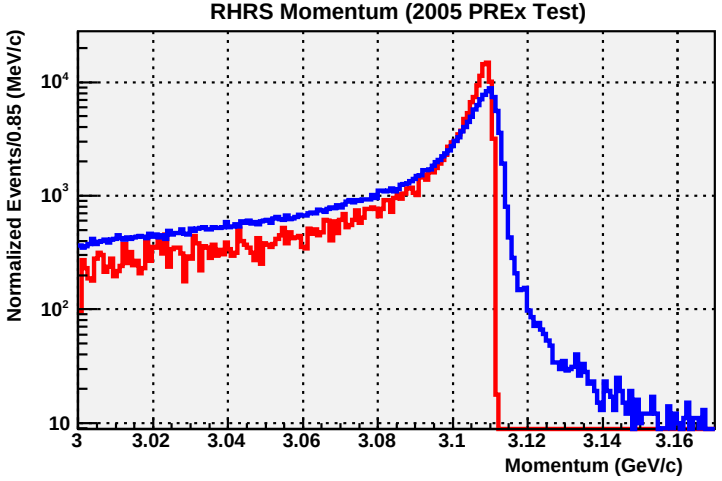


Comparison of Momentum Distributions: Lead Test

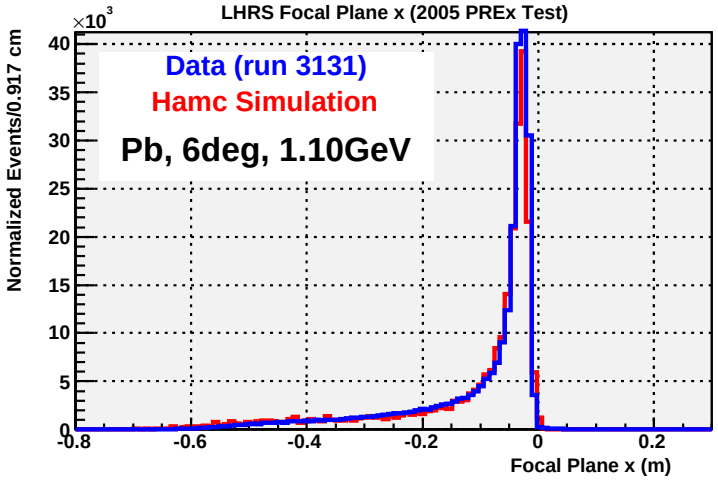


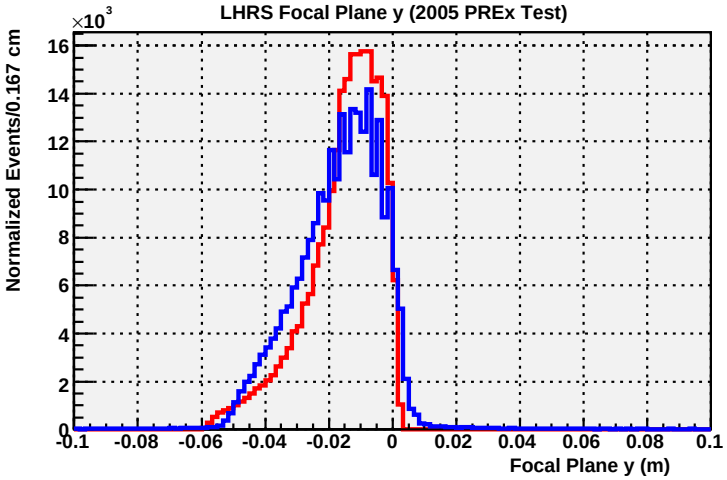


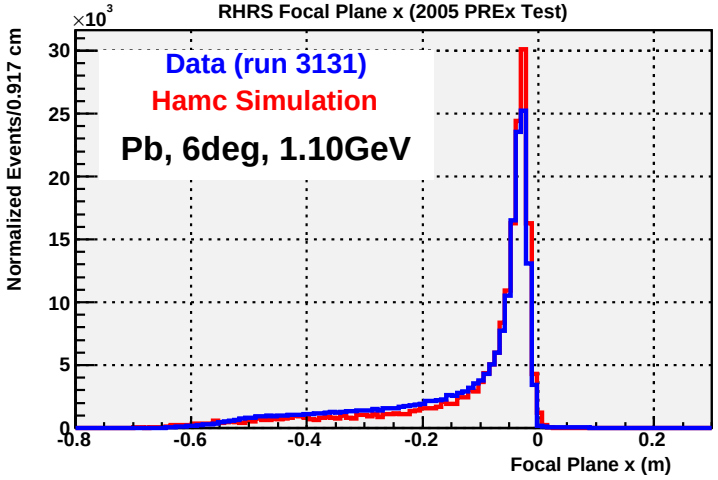


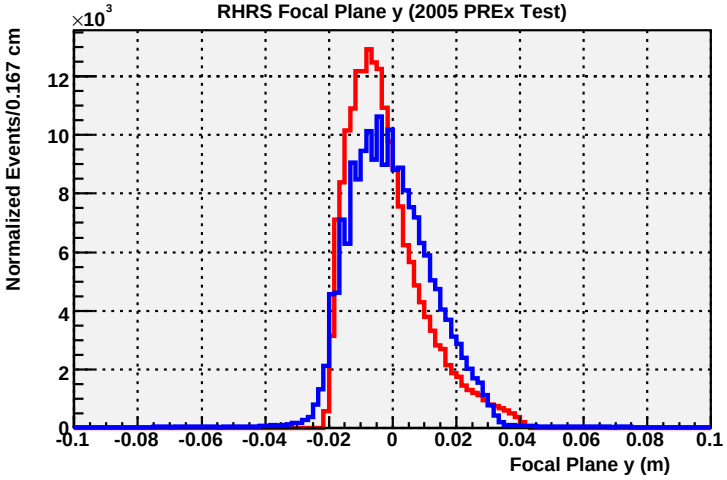


Comparison of Focal Plane x,y: Lead Test

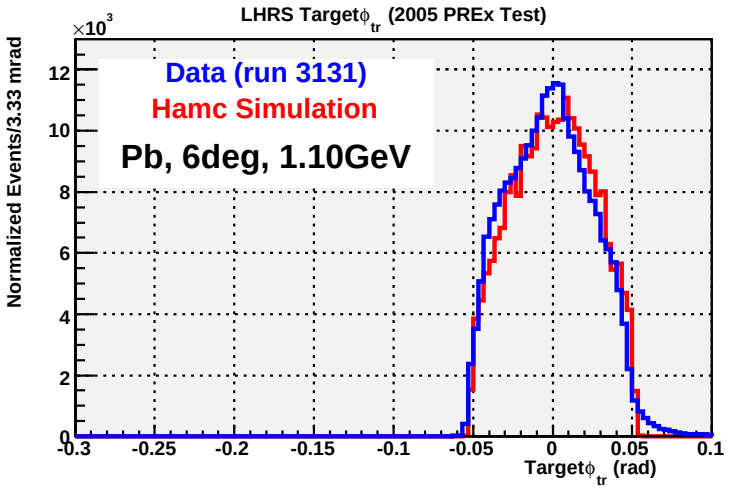


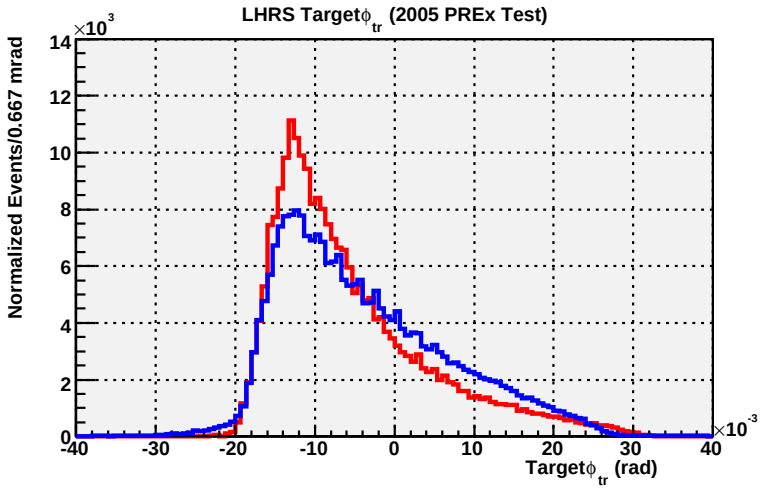


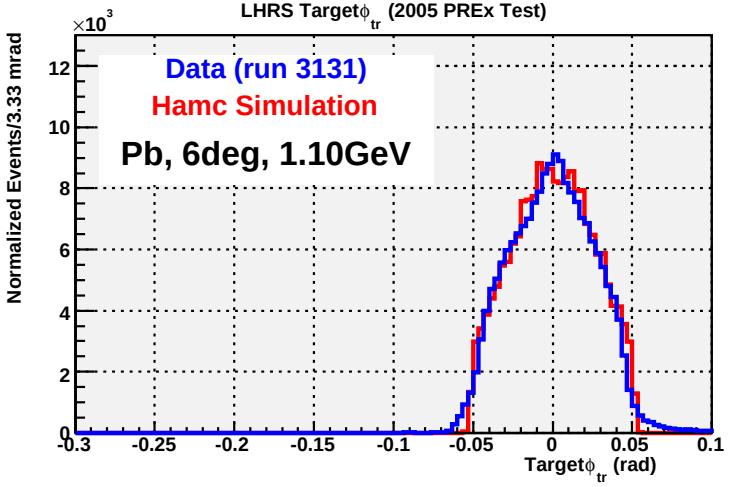


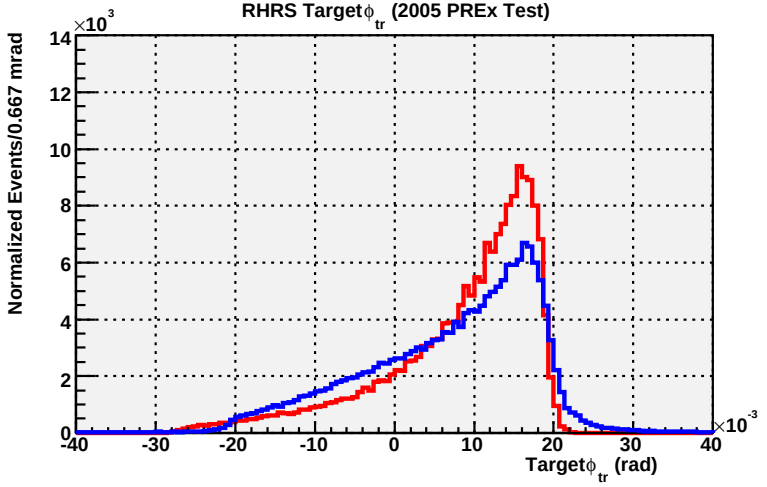


Comparison of Transport Angles at Target: Lead Test





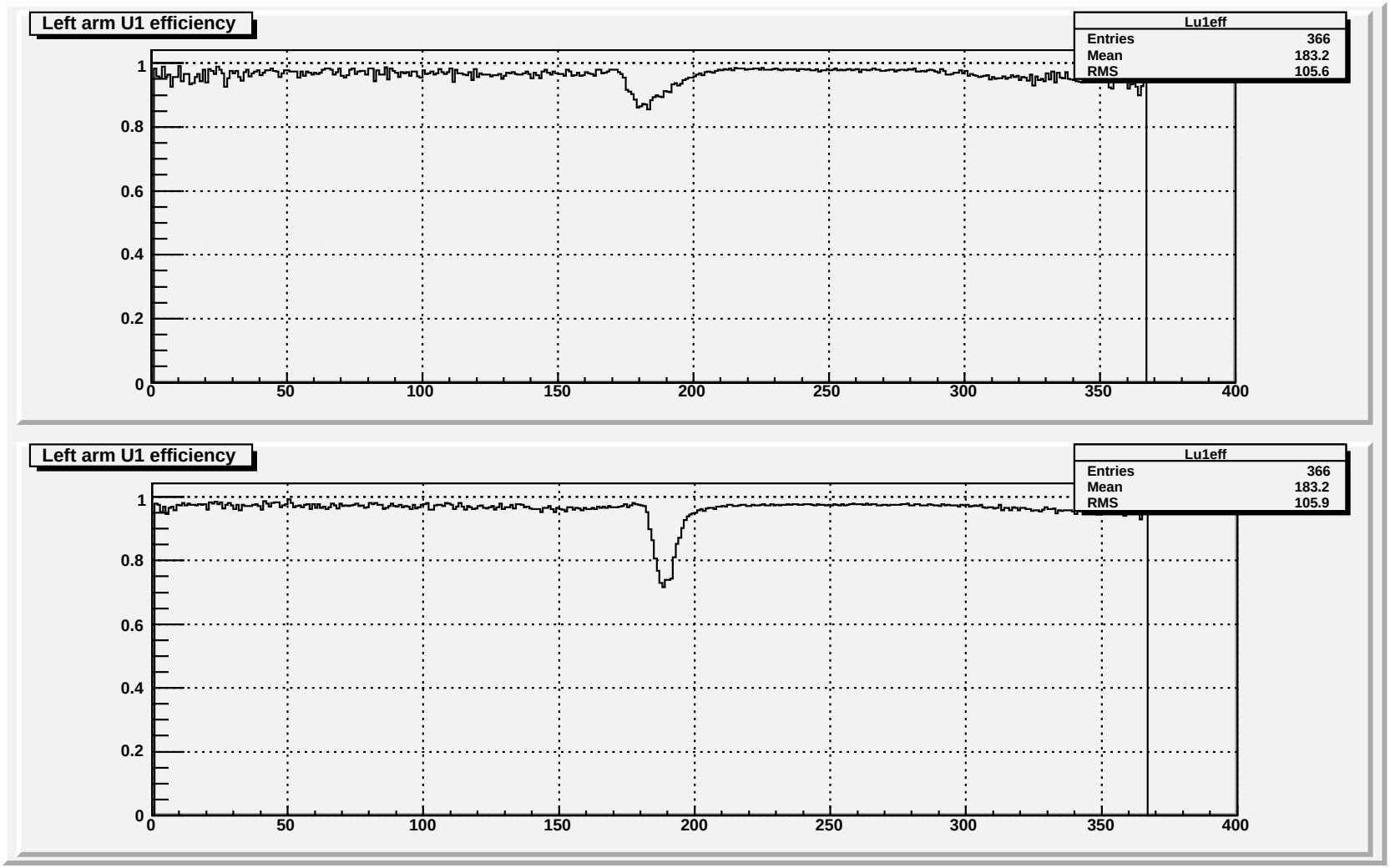


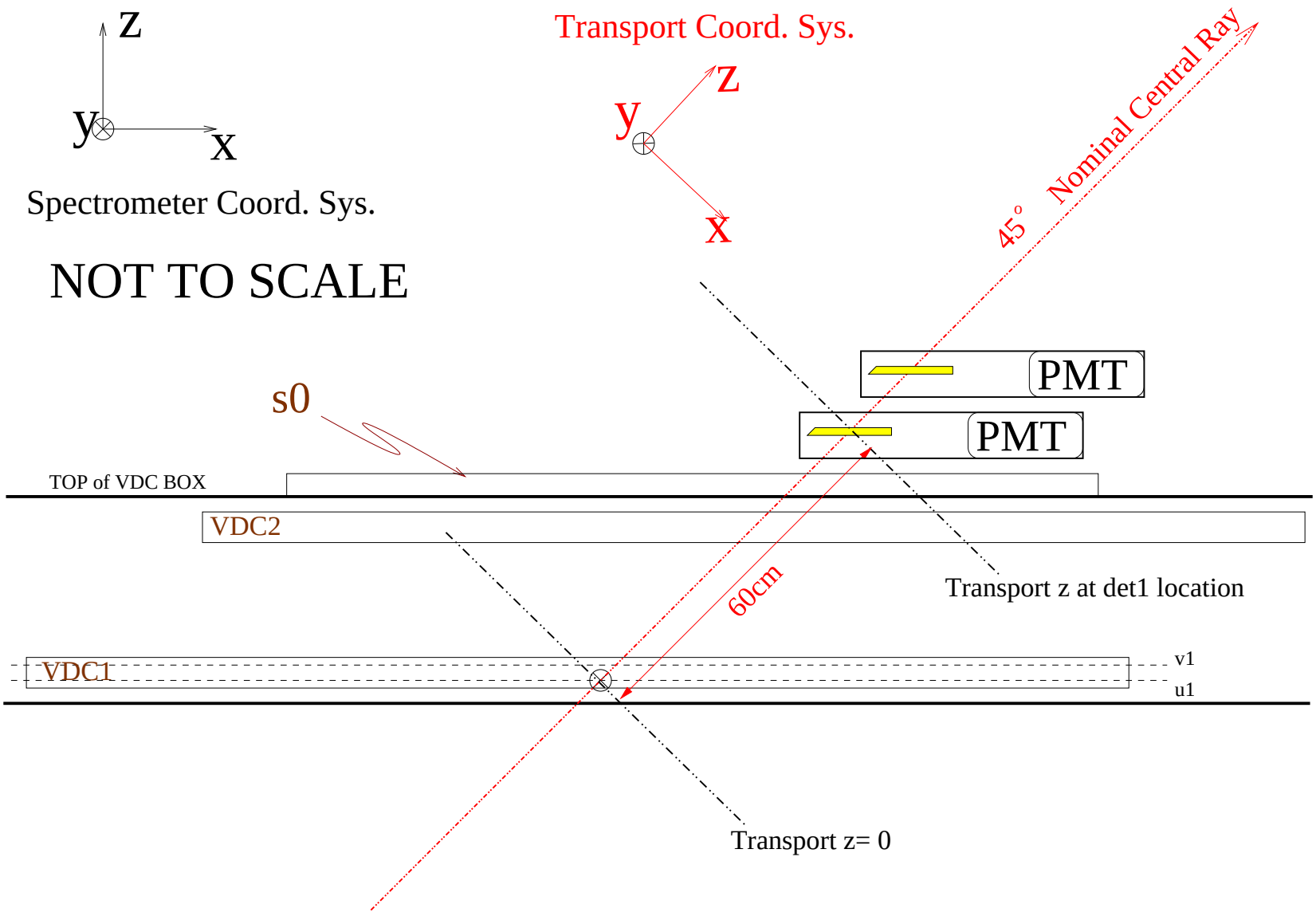


Comparison Comments and Understanding Discrepancies

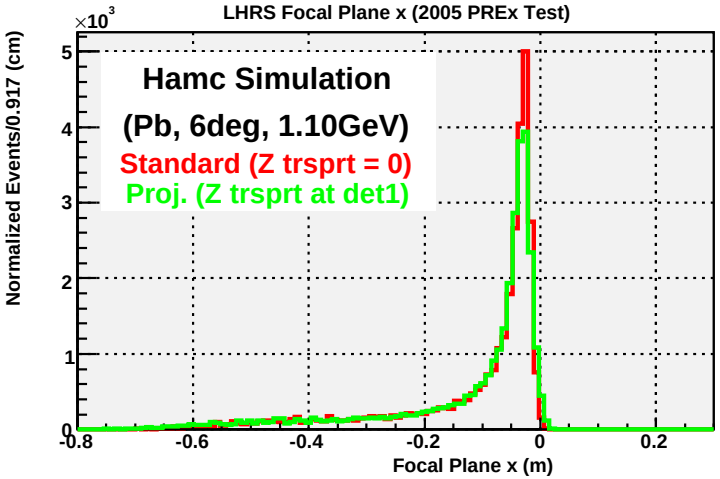
- In general, HAMC target θ_{tr} and subsequently focal plane x are in good agreement with real data.
- In general, shape of HAMC target ϕ_{tr} and focal plane y are not in good agreement with real data.
  - Distributions are more sharply peaked (resolution effect?) and significant curvature differences on the slow-falling side (???).
  - However, overall extent of y distributions are consistent.
- Perhaps very high rates in VDCs are distorting real data distributions. At 0.1μA and 0.5mm Pb target, rates are 500kHz. Tried simple correction to data without much improvement.

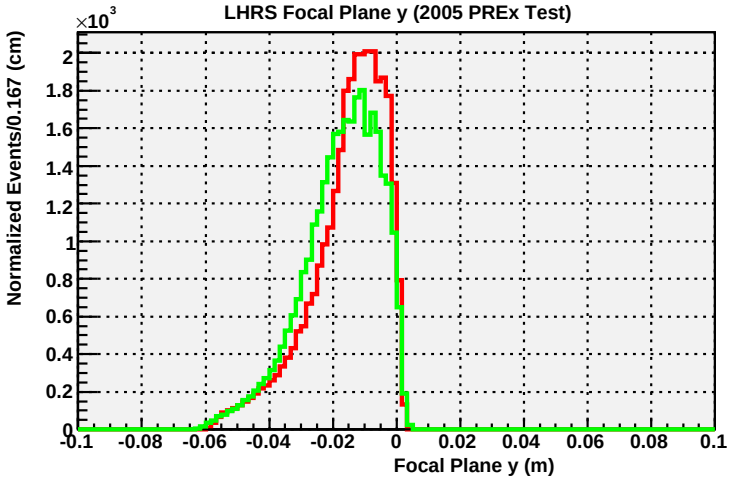
VDC Wire Efficiencies during 2005 data

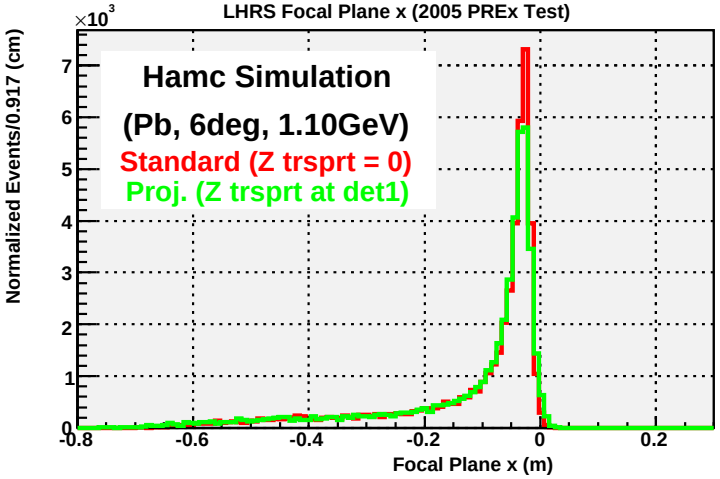


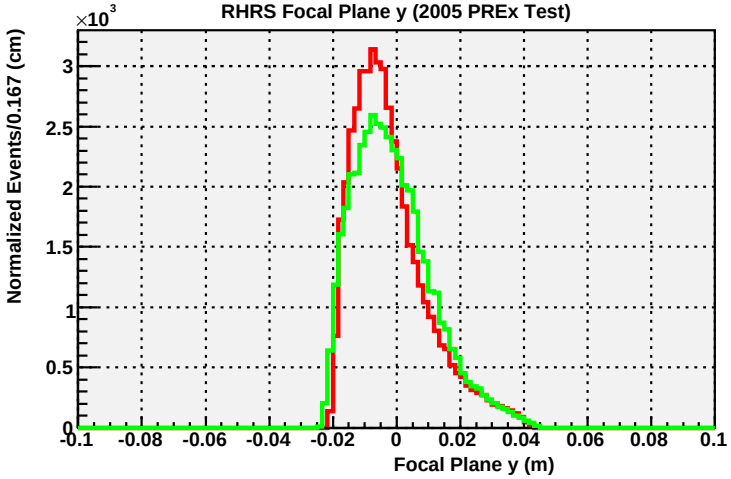

z
y
x
Spectrometer Coord. Sys.
Transport Coord. Sys.
z
y
x
NOT TO SCALE
45°
Nominal Central Ray
PMT
PMT
s0
TOP of VDC BOX
VDC2
60cm
Transport z at det1 location
VDC1
v1
u1
Transport z= 0

Focal Plane Distributions Projected to Det1: Lead Test

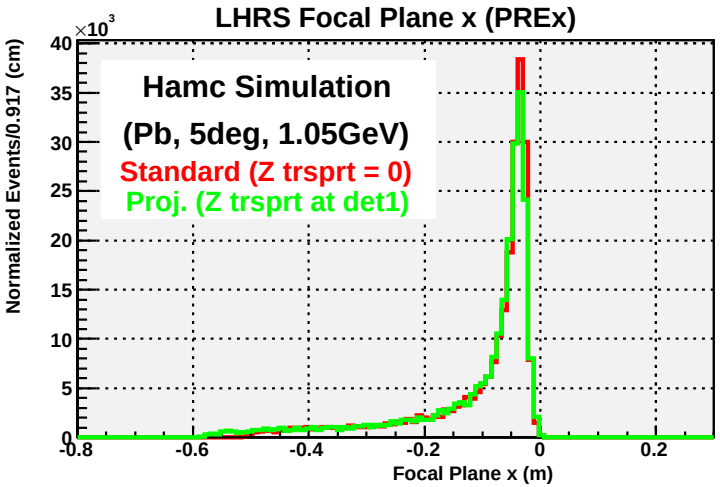


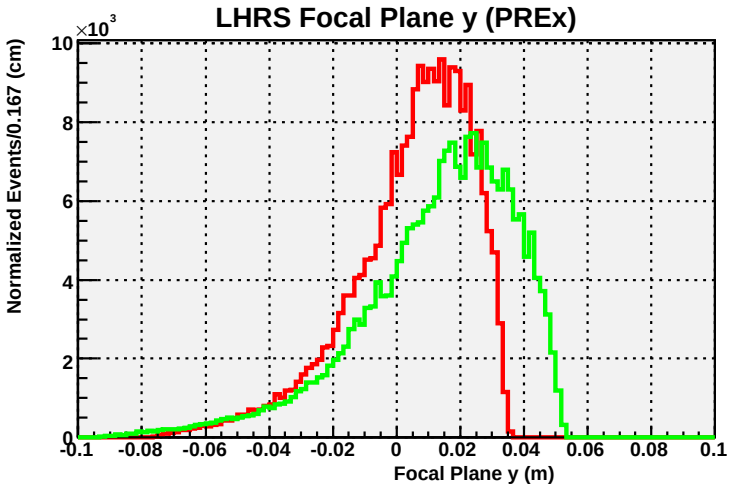


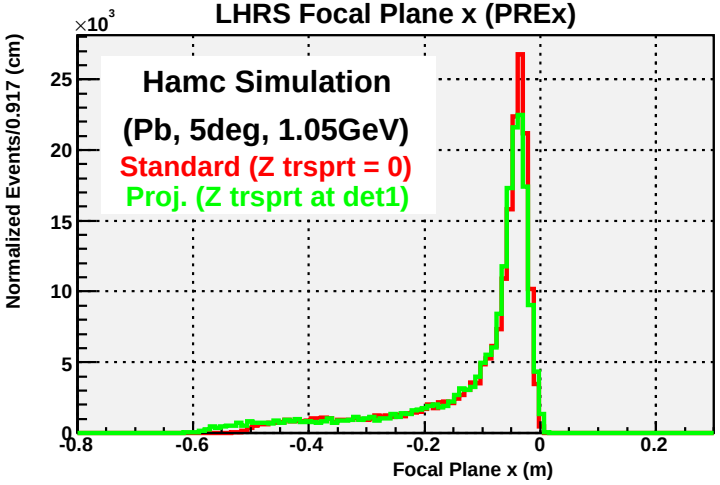


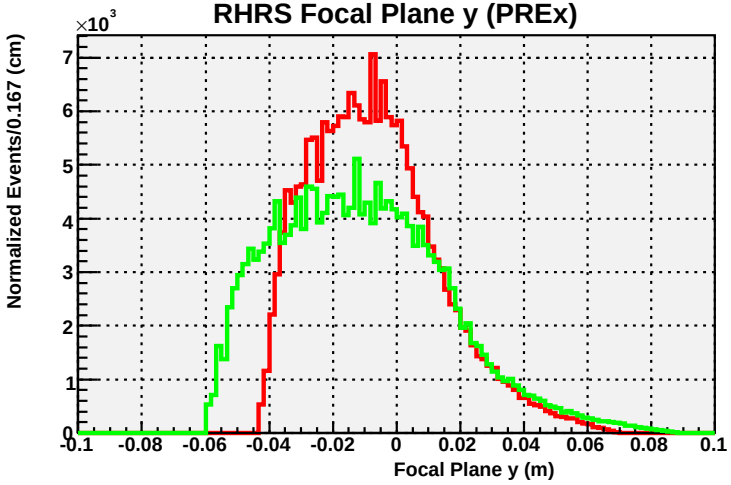


Focal Plane Distributions Projected to Det1: PREx

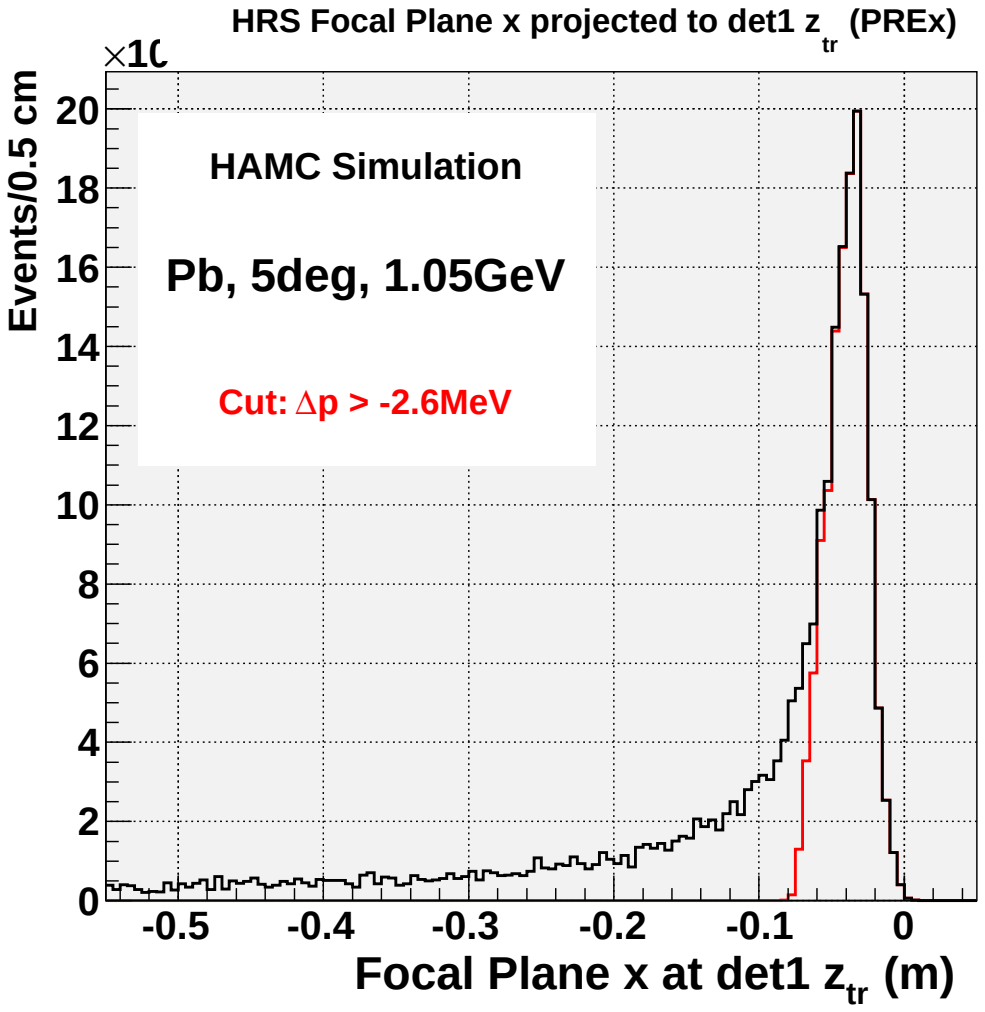




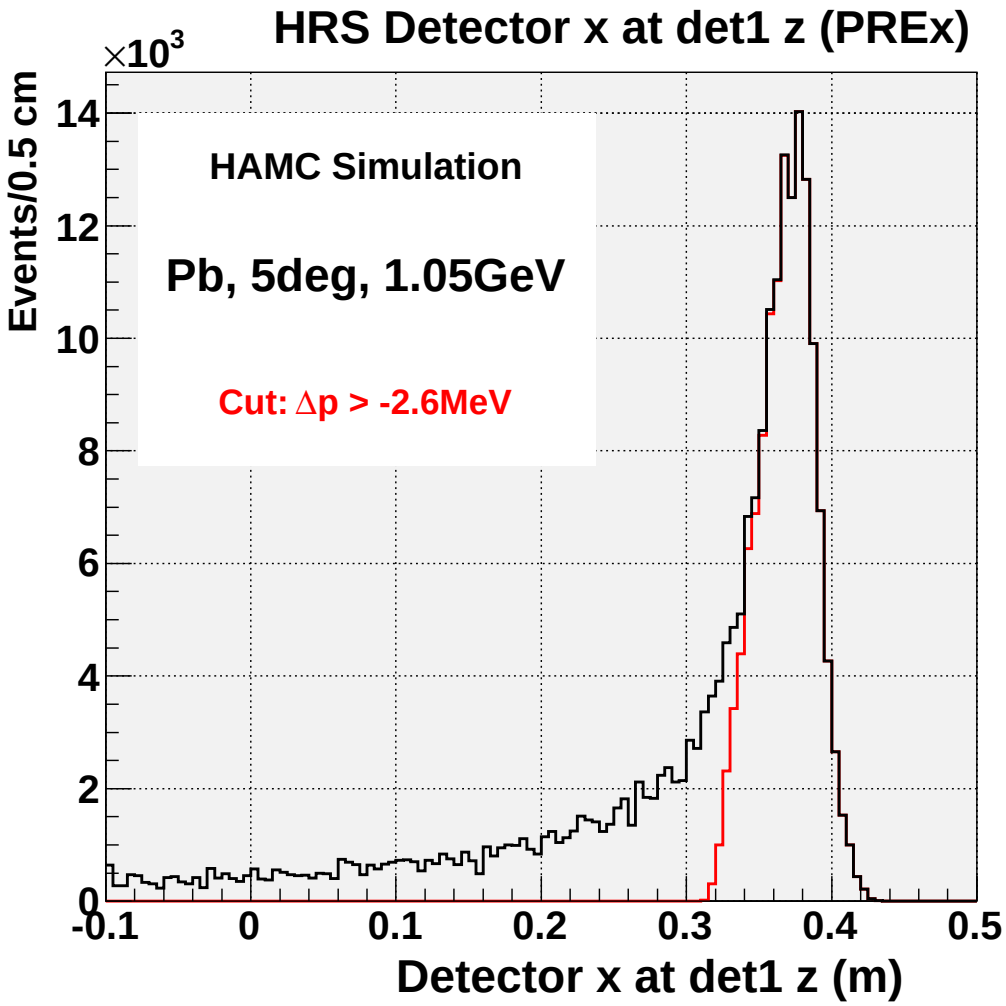




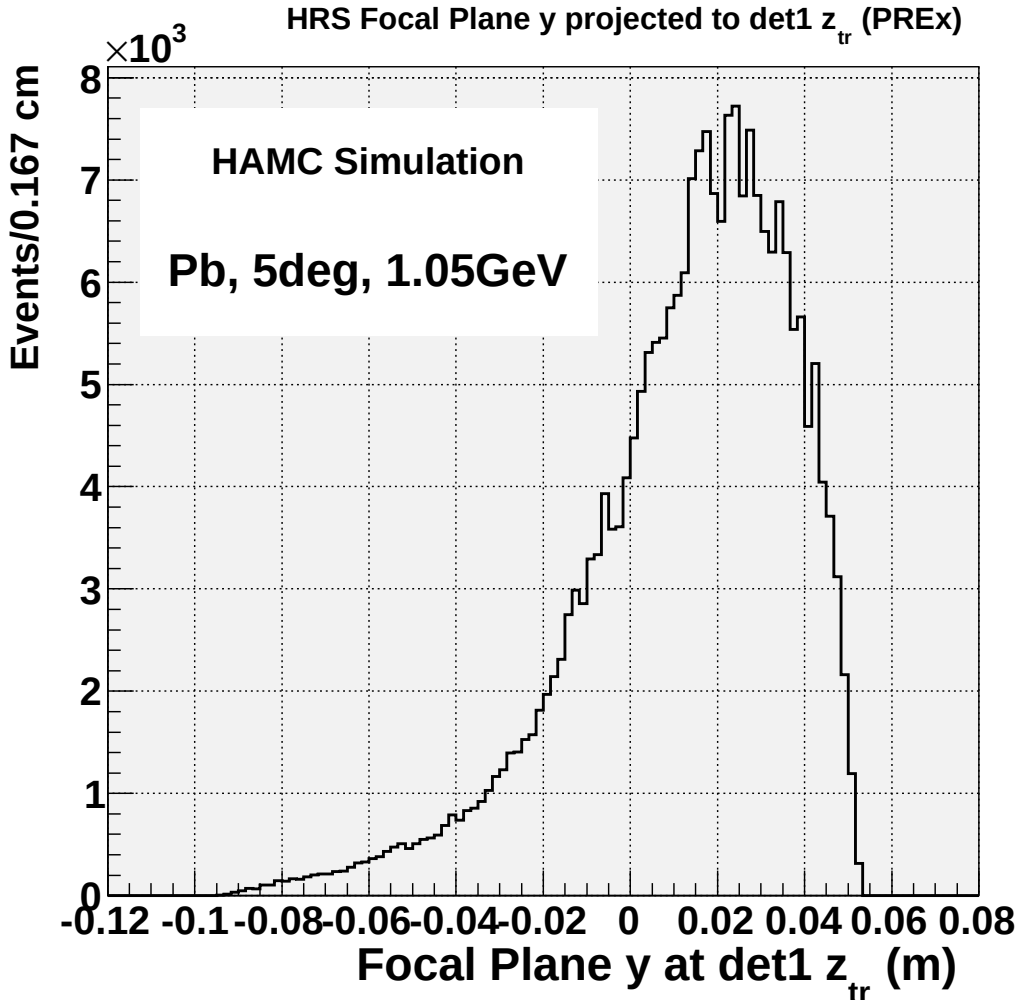
Focal Plane x Projected to Det1: PREx



x Distribution at Det1 Location: PREx



y Distribution at Det1 Location: PREx



PREx Detector Size Summary: Default Optics Setup

- x distribution does not change much with different configurations (by design) and detector plane projections (since transport angles are shallow).
  - Along transport x at det1: 8cm spacial extent
  - Along Spectrometer x at det1: 11cm extent

- y distribution shows significant changes with varying configurations and is more sensitive to detector plane projections
  - Along y at VDC1: 11cm spacial extent
  - Along y at det1: 14cm extent

Tweaked Optics Setup

- New transport functions not yet ready (LeRose says soon)
- Preliminary assessment: Elastic peak in both x_{tr} and y_{tr} can be focused at det1 location at 3 - 4cm level using small tweaks in Q2 and Q3 settings
- HAMC results to come soon

Summary and Outlook

- Based on 2008 beamtest, 2 thin detectors to be used for main Pb-elastic signal. These give best detection efficiency and pulse-height distributions with adequate resolution and minimal tails.
  - Replace Alzak reflectors with Al for more light collection.
  - Increased resolution of 10mm det is offset by its larger Landau tail. Quartz thickness to be optimized with MC.
- For standard HRS optics: Quartz needs to be 11cm (x) by 14cm (y) – requiring more than 1 pmt for each detector.
- More desirable to use tweaked optics setup which may need only 1 pmt/detector. HAMC results coming soon.
- Planning another PREx detector test during H-III commissioning – examine pulse-height-dists and integration test. Which target? Issues with max rate?
- Specs of satellite detectors (for A^T hole) under investigation.