PREx detector test-run analysis

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PREx Detector Test-run Analysis

Outline

- Review: Detector Setup and Beamtest Goals
- Beamtest Analysis Results

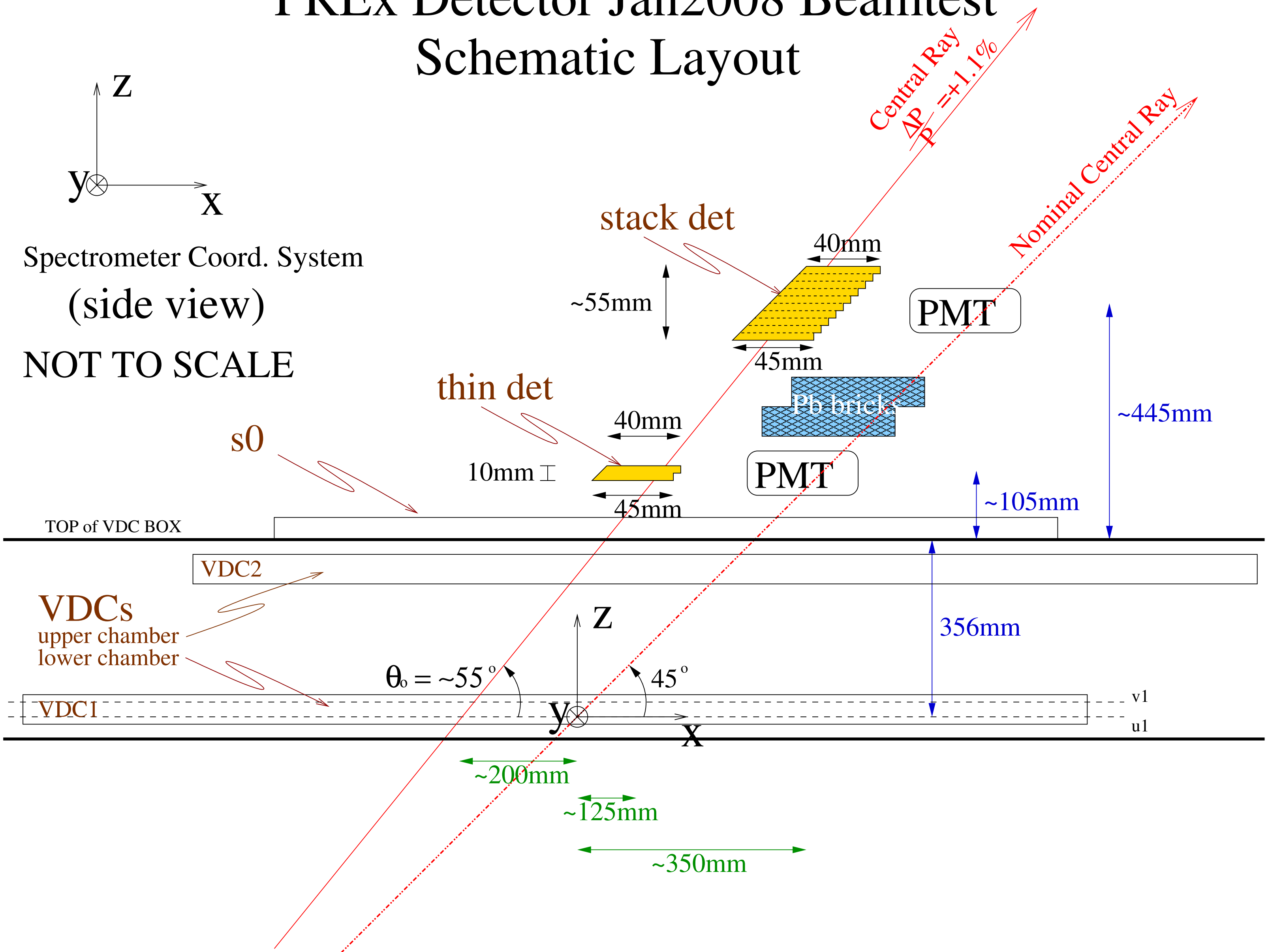
  Tantalum Spectra

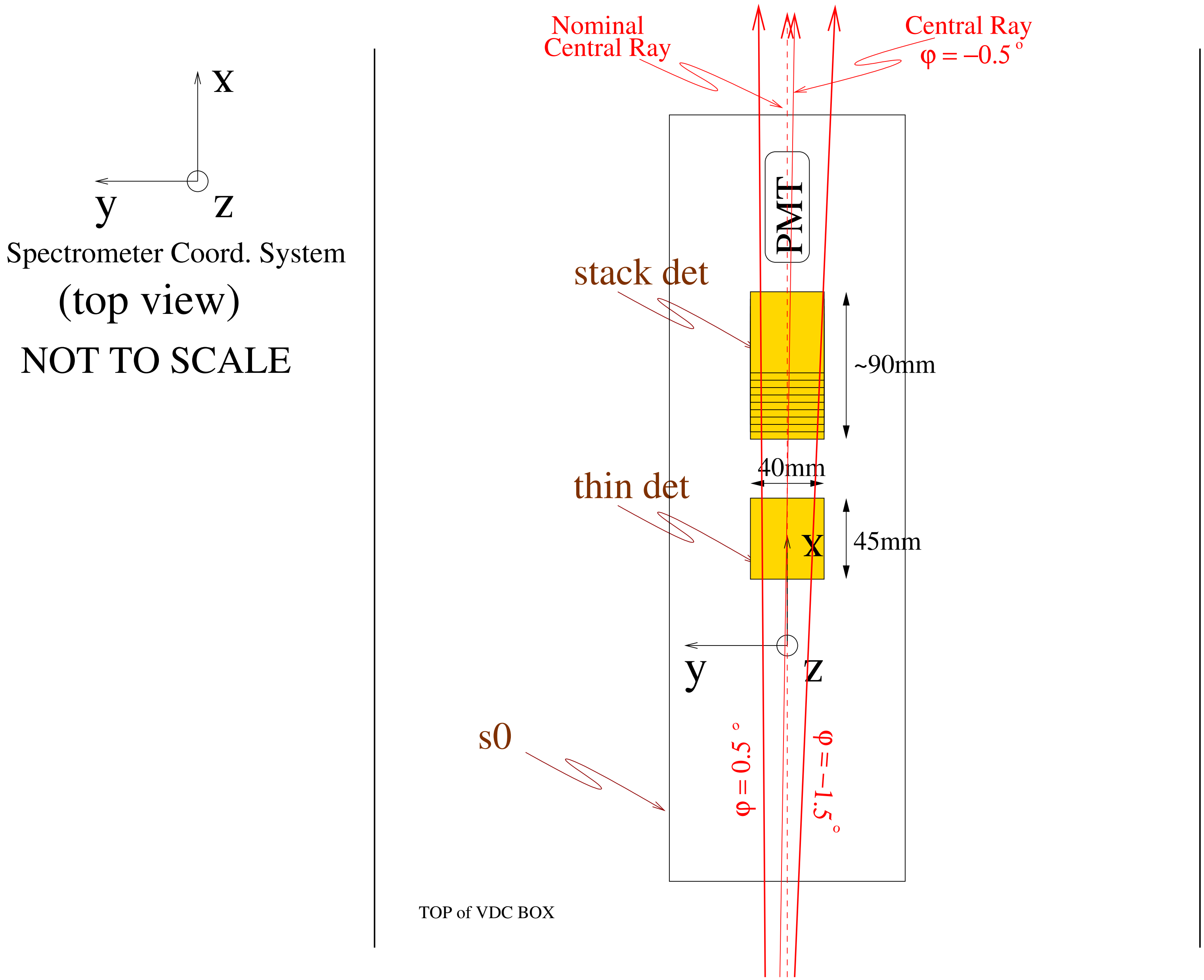
  Pulse-height distributions & Landau tail assessment
  Detection efficiencies vs. x,y
- HRS Beamtest Optics Review/Discussion
- Summary and Outlook

PREx Detector Setup and Beamtest Goals

- Examine Tantalum spectrum at 19 $^\circ$ and 12.5 $^\circ$ using Sampling DAQ
  - -Adjust HRS momentum to position elastic peak on dets
  - -Question: Does detector encompass entire elastic peak?
- Analyze detector pulse-height distributions and Landau tails
- Verify near 100% detection efficiency in thin quartz
- Determine stack and thin detector rates (not finished)
- At 12.5 $^\circ$, switch to Integrating DAQ, take 30 Hz data at 50 μA
  - -Relate integrated signal statistics with expectations based on scattering rates, quartz Čerenkov multiplicity, and PMT gain

PREx Detector Jan2008 Beamtest Schematic Layout

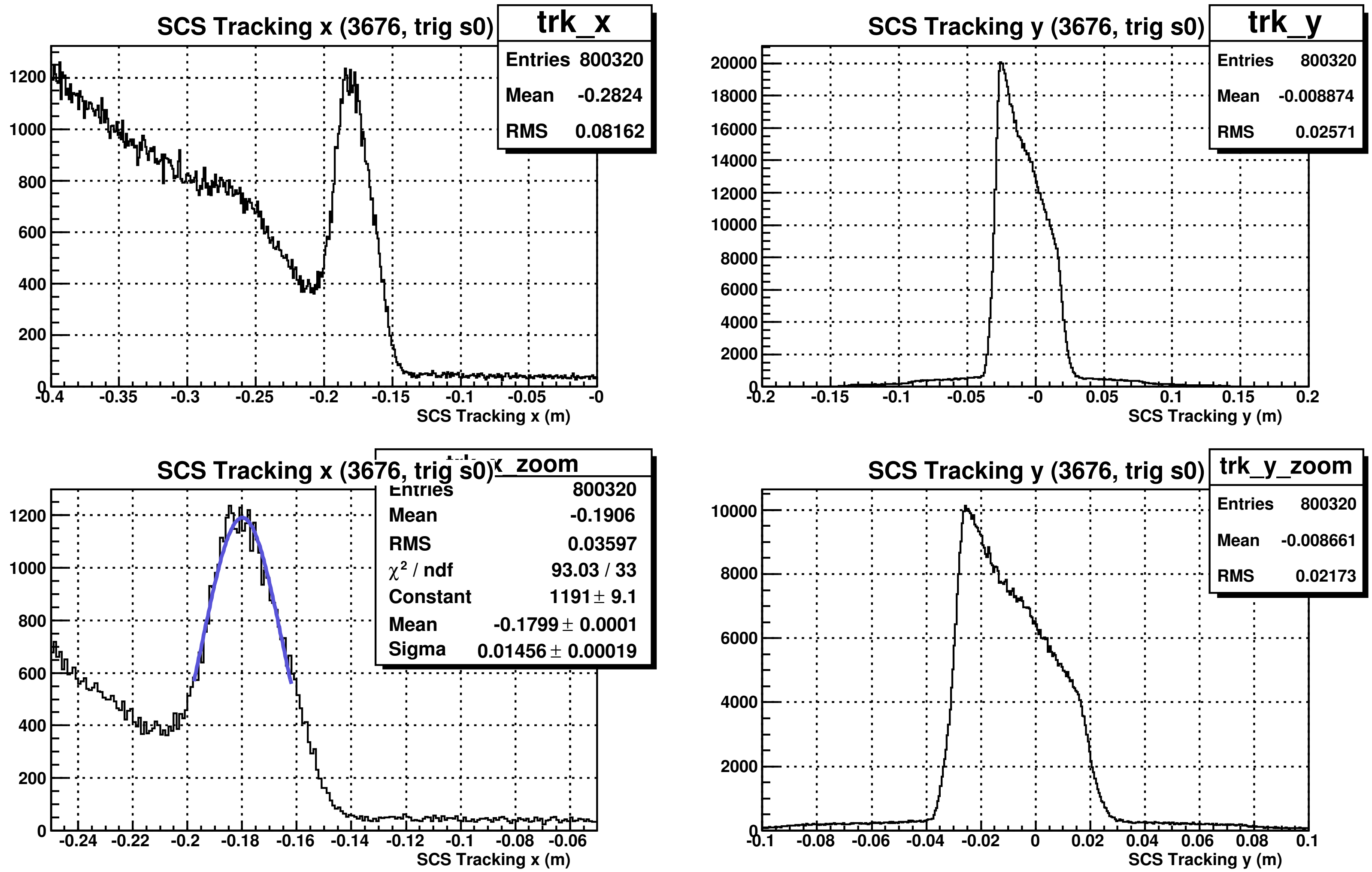



x
y
z
Spectrometer Coord. System
(top view)
NOT TO SCALE
Nominal
Central Ray
Central Ray
φ = −0.5°
PMT
stack det
~90mm
40mm
thin det
45mm
x
y
z
s0
φ = 0.5°
φ = −1.5°
TOP of VDC BOX

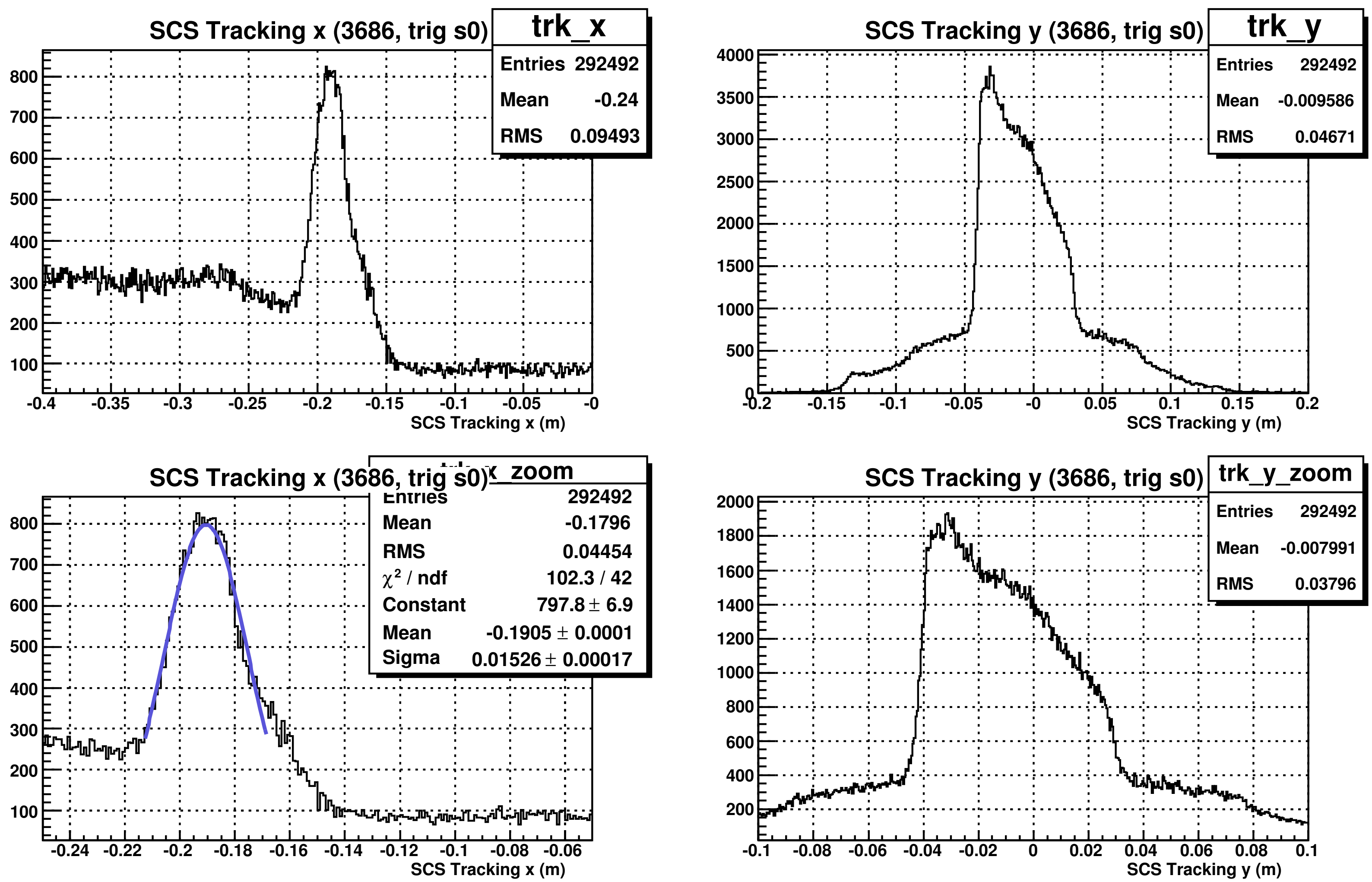
Run Summary Highlights

Run	Beam E (GeV)	rHRS angle	Targ	I_{beam} (μA)	Q3 Tweak	s0	Thin Det	ADC Change
3512	2.77	19 $^\circ$	Pb	60	Before	IN	10mm	Before
3676	0.956	19 $^\circ$	Ta	50	Before	IN	10mm	Before
3681	0.956	19 $^\circ$	Ta	50	After	IN	10mm	After
3686	0.956	19 $^\circ$	Ta	50	After	IN	10mm	Before
3704	0.956	19 $^\circ$	Ta	8	After	OUT	10mm	After
3705	0.956	19 $^\circ$	Ta	8	After	OUT	5mm	After
3720	0.956	12.5 $^\circ$	Ta	5	After	OUT	5mm	After

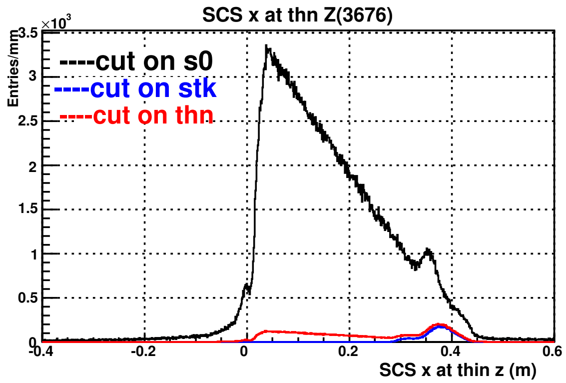
Tantalum Spectrum in Spectrometer Coord System (SCS) x,y plane (at z=0): Run 3676 (before Q3+)

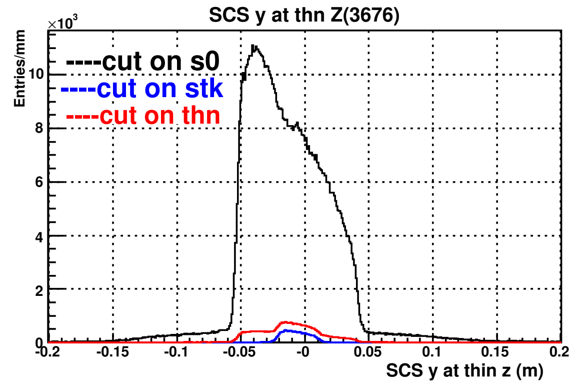


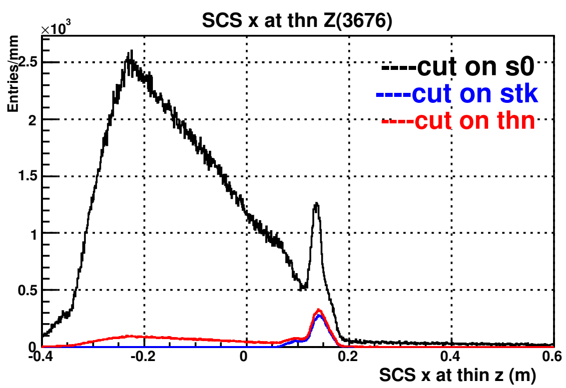
Tantalum Spectrum in Spectrometer Coord System (SCS)
x,y plane (at z=0): Run 3686 (after Q3+)

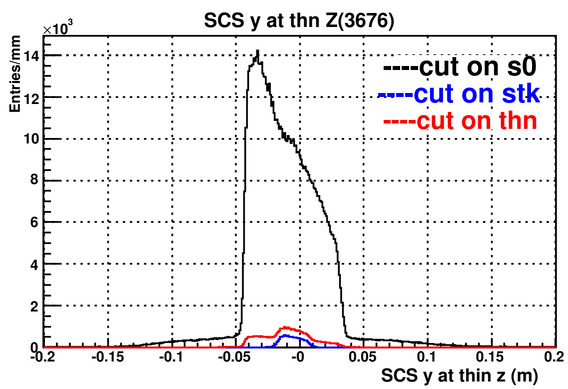


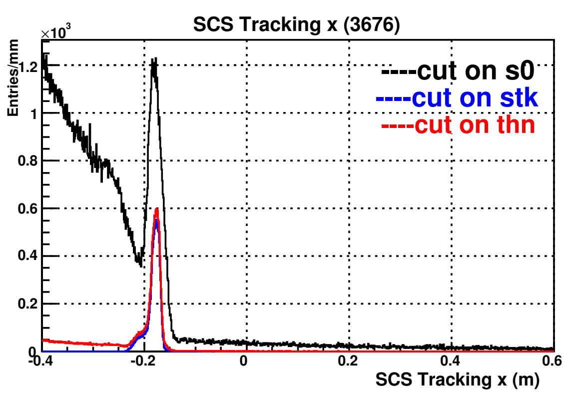
Ta Spectrum at SCS z=0,thin;stack (before Q3+)

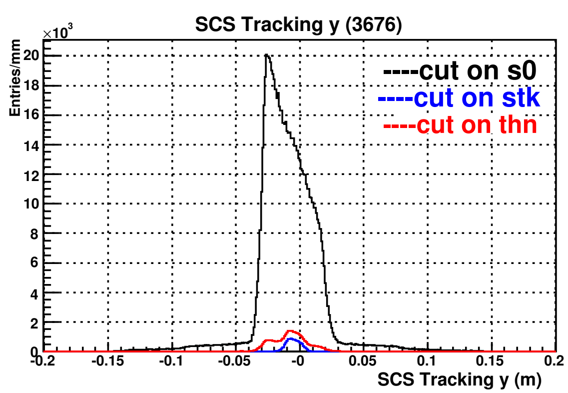




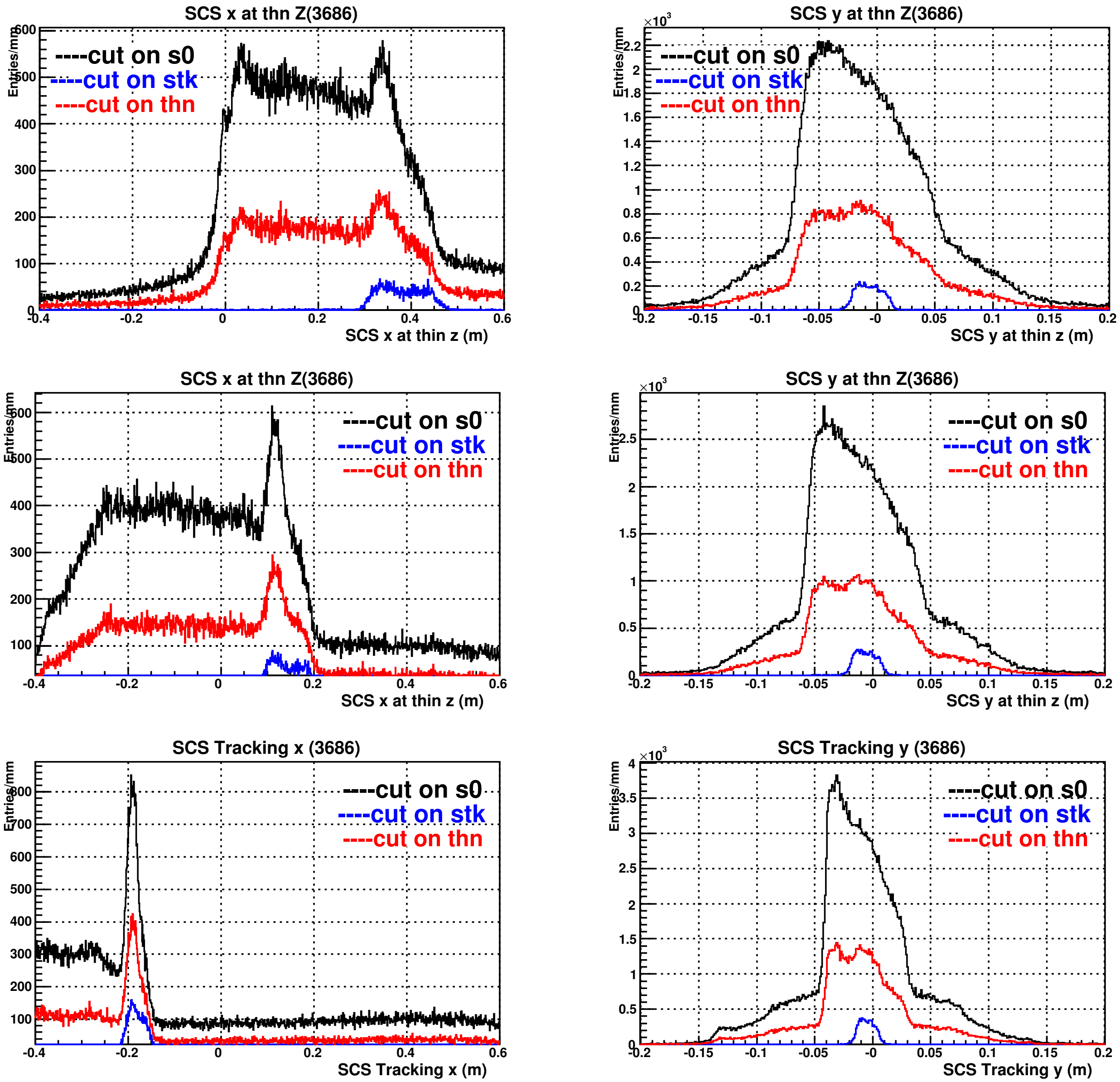




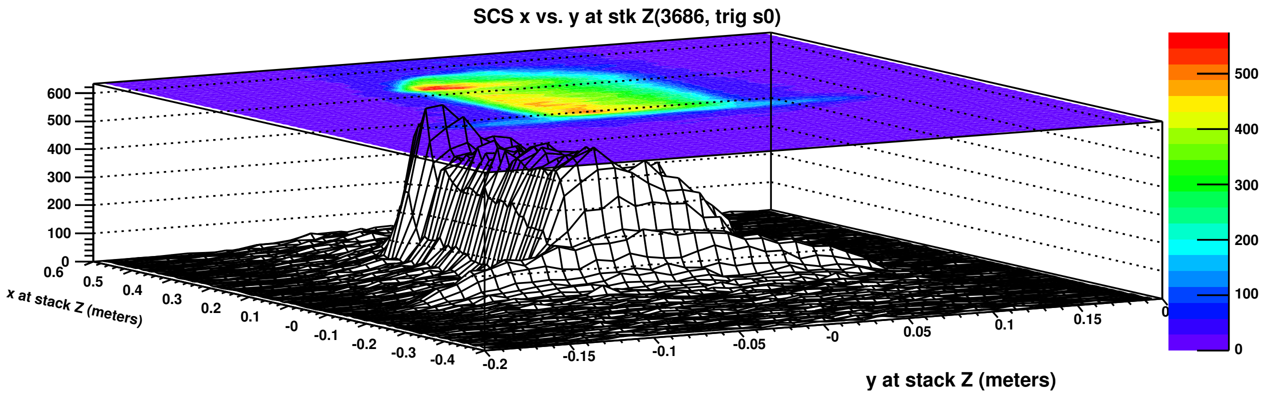


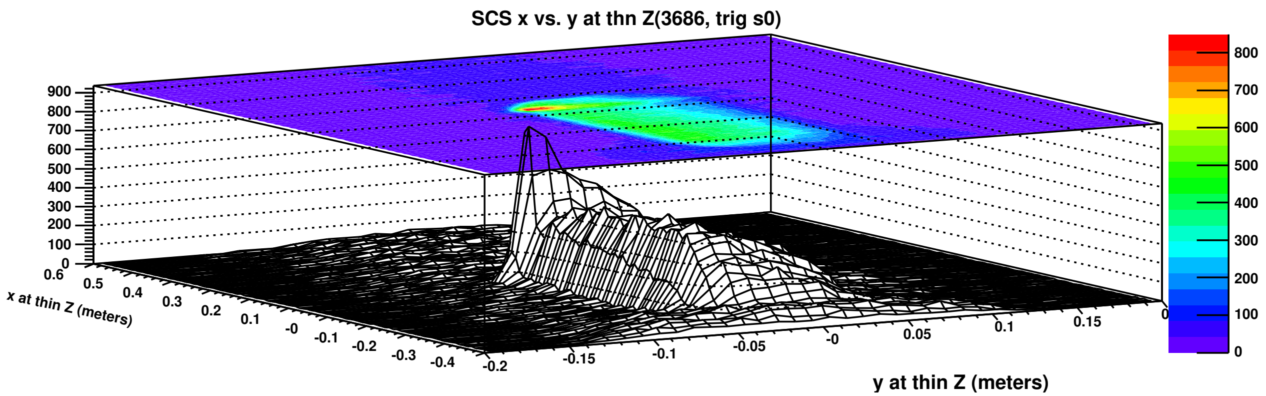


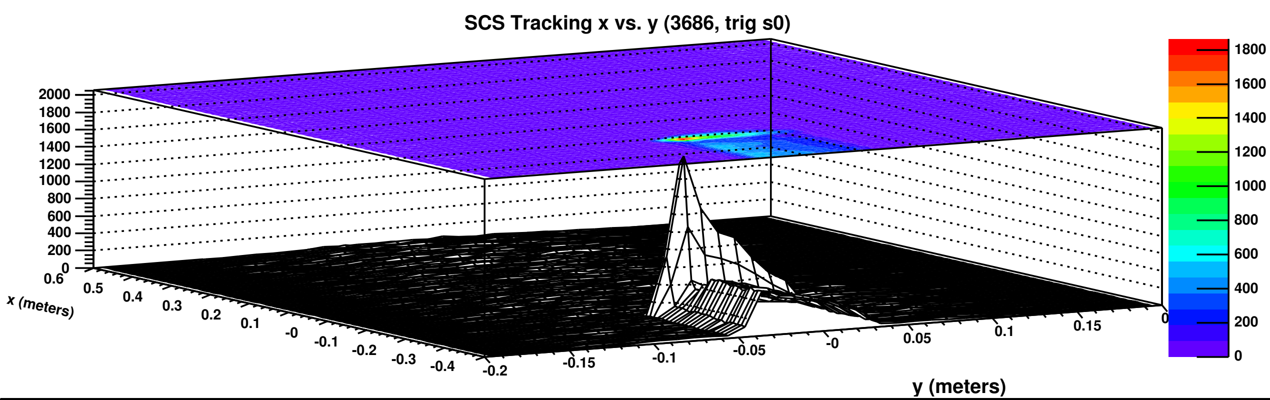
Ta Spectrum at SCS z=0,thin;stack (after Q3+)



Ta Spectrum at SCS z=0,thin;stack (after Q3+)



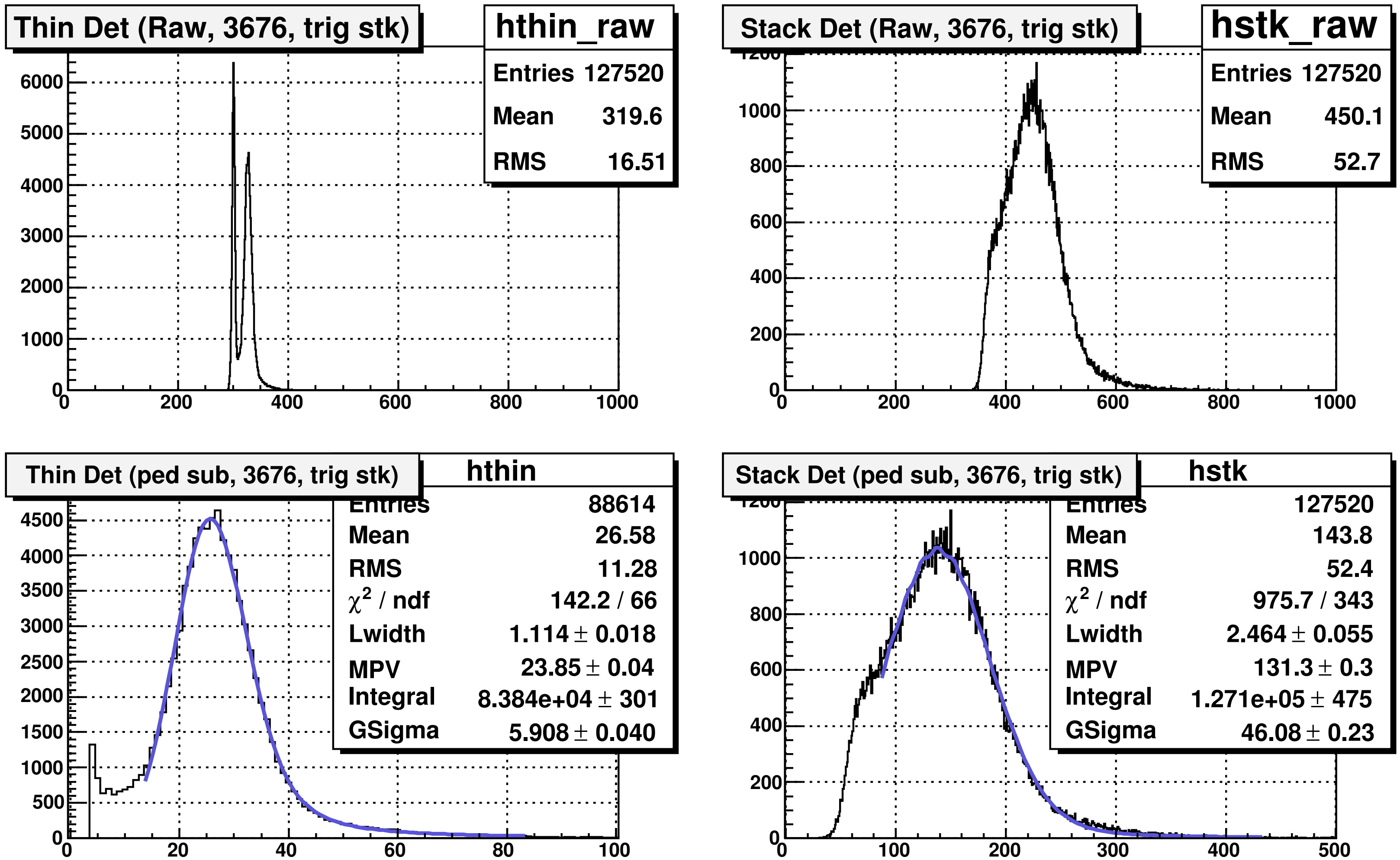




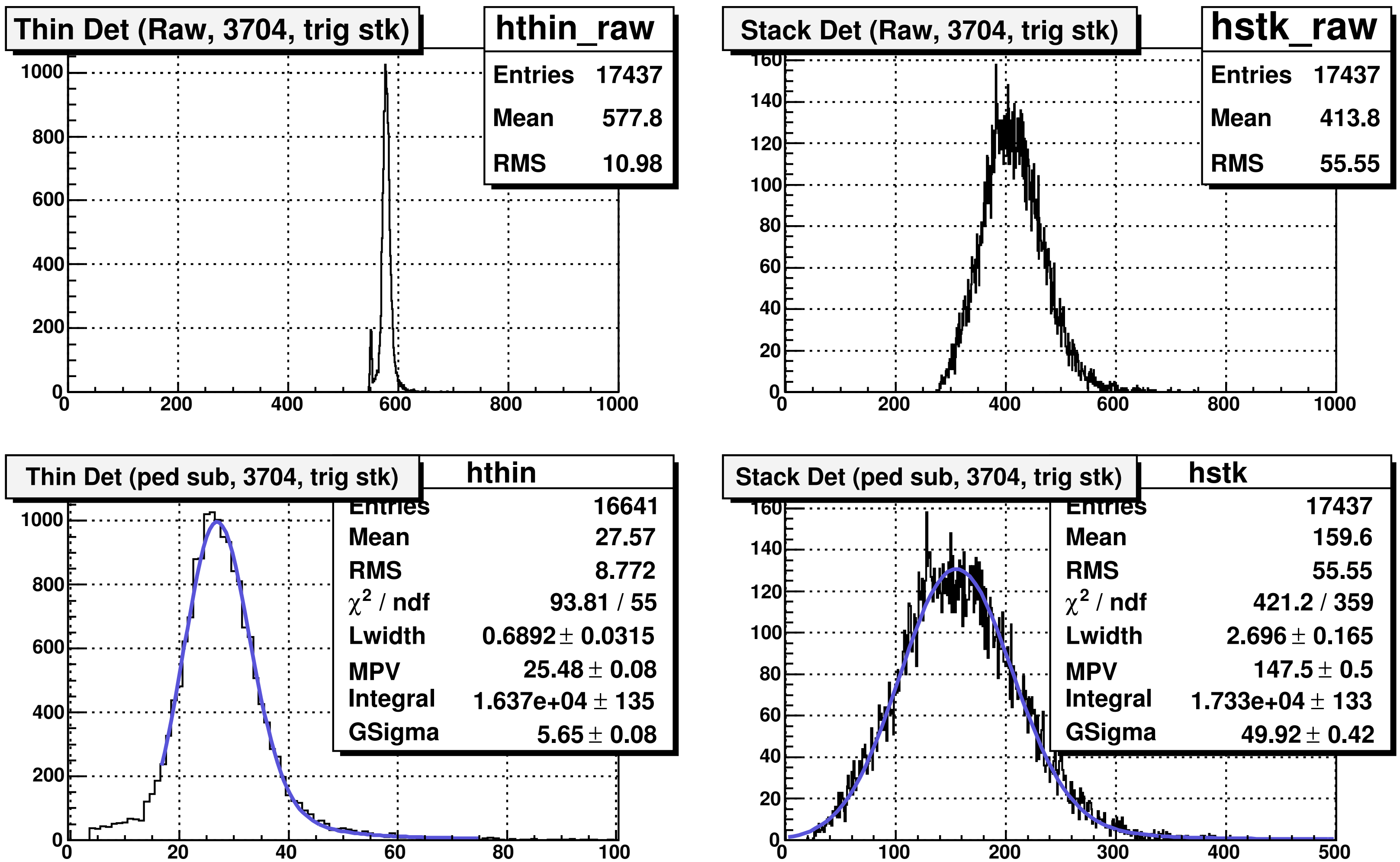
Pulse-height Analysis and Landau Tail Quantification

- To do this, fit ADC distributions with Landau function convoluted with a Gaussian
  -parameters: Landau width, Landau MPV, width of Gaussian, and normalization
- Landau tail results from low-probability hard-scatters (usually in first few radiation lengths)
- These tails are exacerbated by too much upstream material (which acts as a preshower)
- For Quartz, $X_o \approx 27.05$ g/cm^2, =>10mm thin det is ~ 0.1 X_o
- The S0 detector is ? X_o

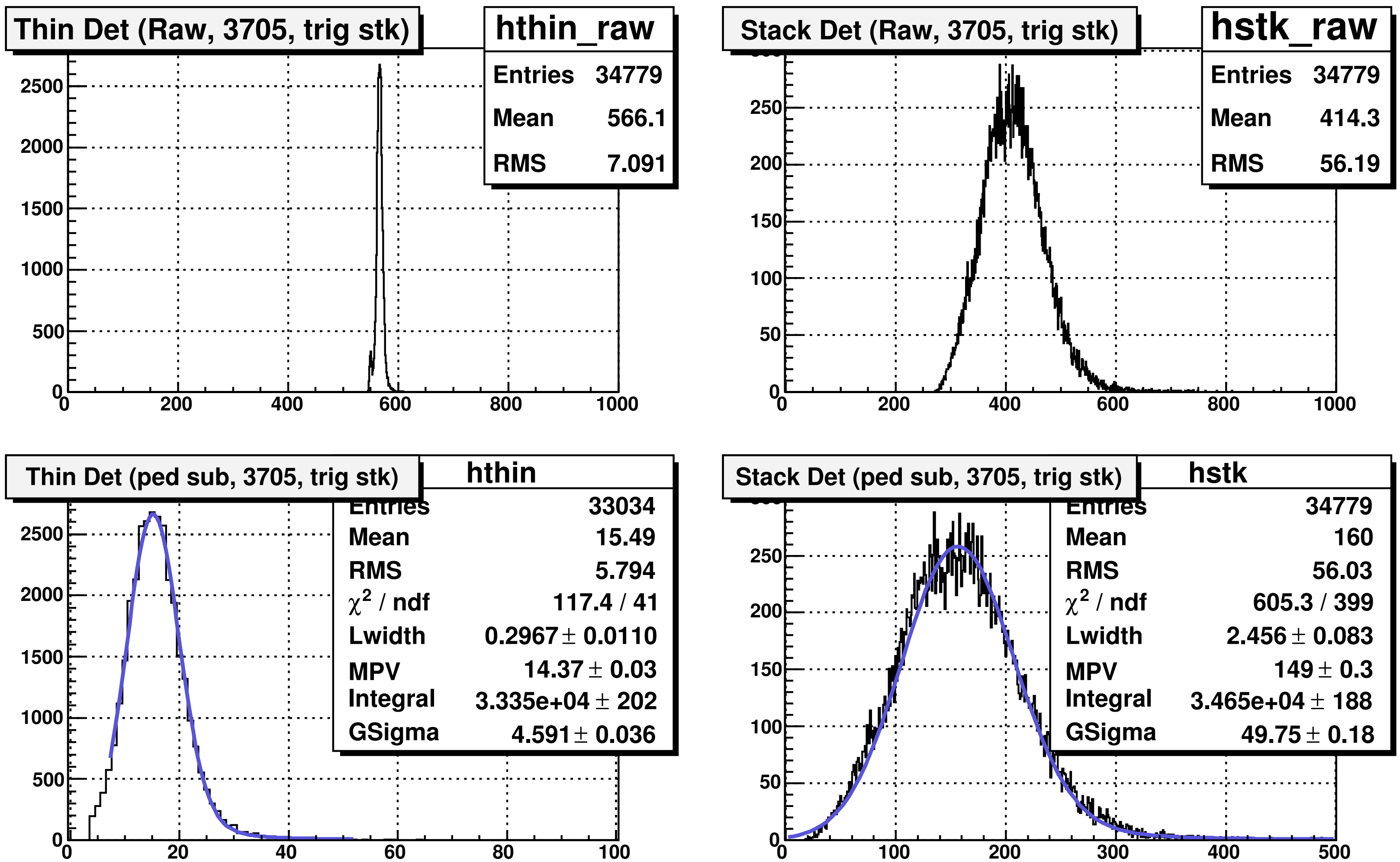
Pulse-height Anal: Sample from run 3676 (s0 in, 10mm)



Pulse-height Anal: Sample from run 3704 (s0 in, 5mm)



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



Pulse-height Analysis Summary for Thin Dets

	5mm Thin Det			10mm Thin Det		
Run	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

Pulse-height Analysis Summary for Stack Det

	Stack Det		
Run	Lwidth	MPV±GSigma	Res
3512	3.5	396.8 ± 94.4	23.8%
3676	2.4	130.7 ± 46.2	35.3%
3681	2.3	136.1 ± 42.3	31.1%
3686	1.7	134.6 ± 43.7	32.4%
3704	2.7*	147.0 ± 49.9	34.0%
3705	2.5*	148.5 ± 49.8	33.5%
3720	1.9*	119.8 ± 56.0	46.7%†
Avg			33.3%

* – s0 removed from detector acceptance.

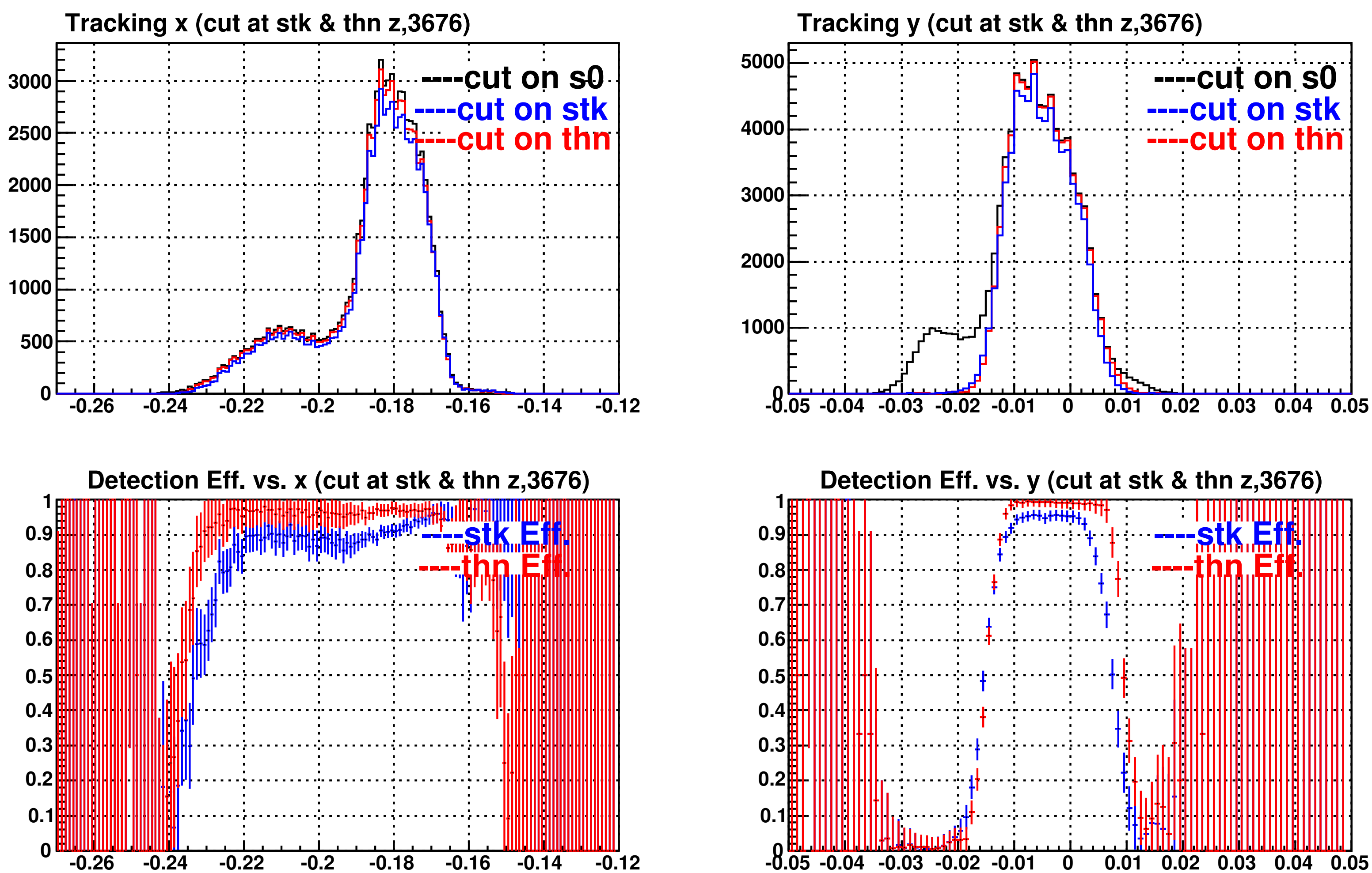
† – Not included in average.

- For stack, Landau tail dominated by shower development fluctuations and ∼insensitive to whether s0 is in or out

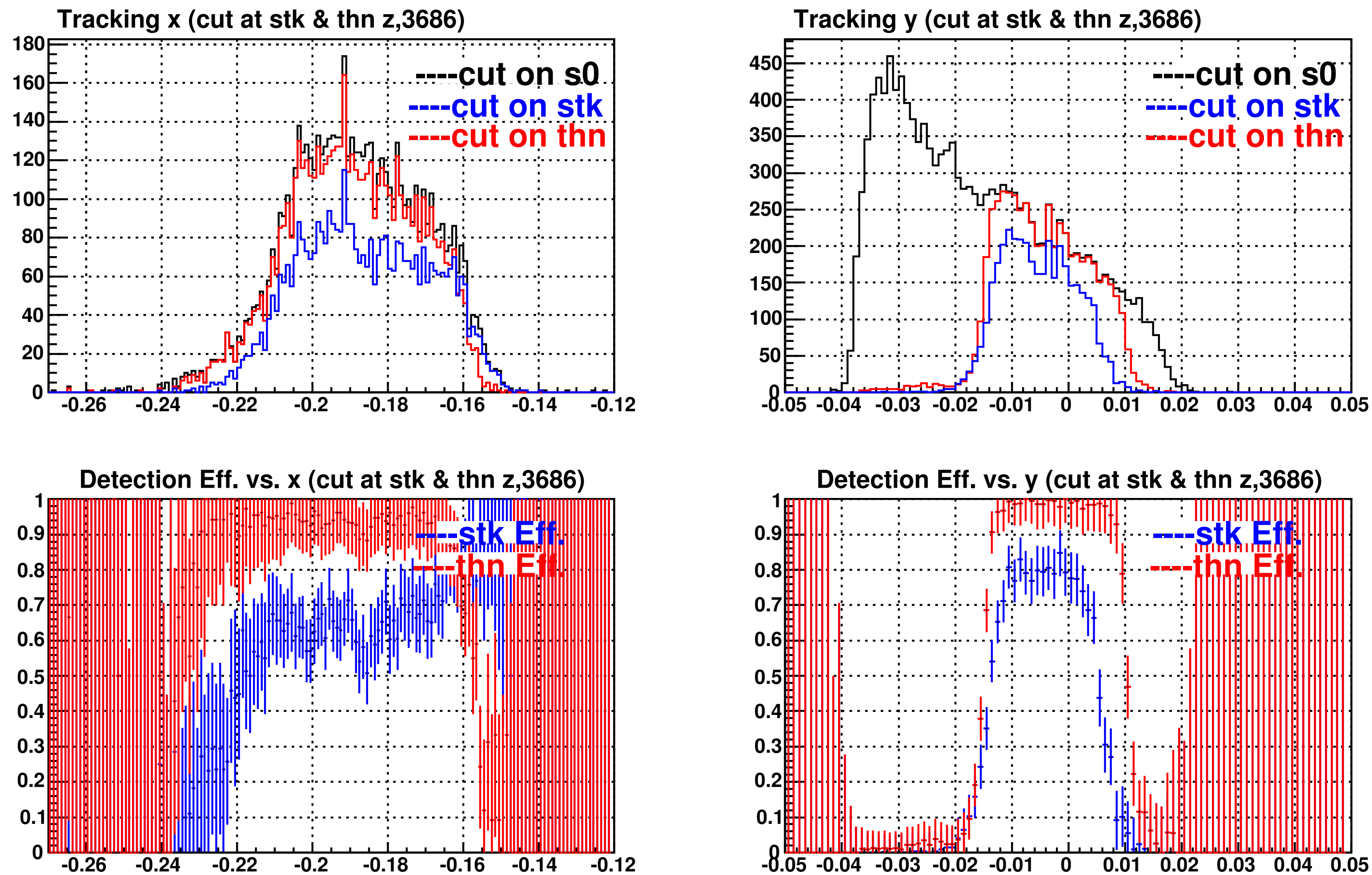
Thin Detectors: Landau RMS factor = RMS/Gsigma

Run	Beam E (GeV)	Targ	I_{beam} (μA)	Q3 Tweak	s0	Thin Det	Landau factor
3512	2.77	Pb	60	Before	IN	10mm	1.7
3676	0.956	Ta	50	Before	IN	10mm	1.9
3681	0.956	Ta	50	After	IN	10mm	1.9
3686	0.956	Ta	50	After	IN	10mm	2.7
3704	0.956	Ta	8	After	OUT	10m	1.5
3705	0.956	Ta	8	After	OUT	5mm	1.2
3720	0.956	Ta	5	After	OUT	5mm	1.3

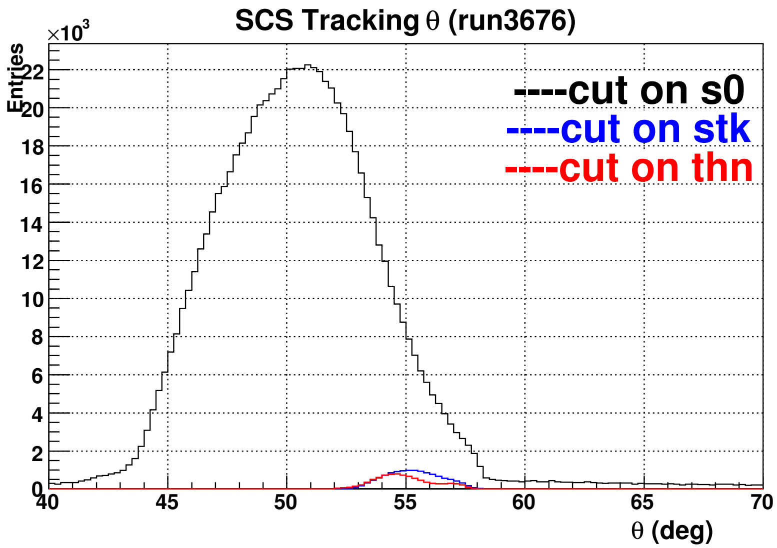
Thn and Stk x,y Efficiency profiles: run 3676 (before Q3+)

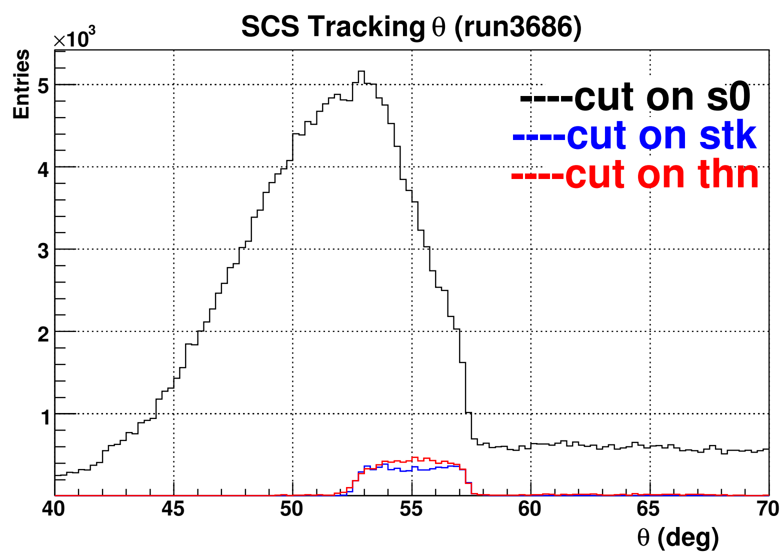


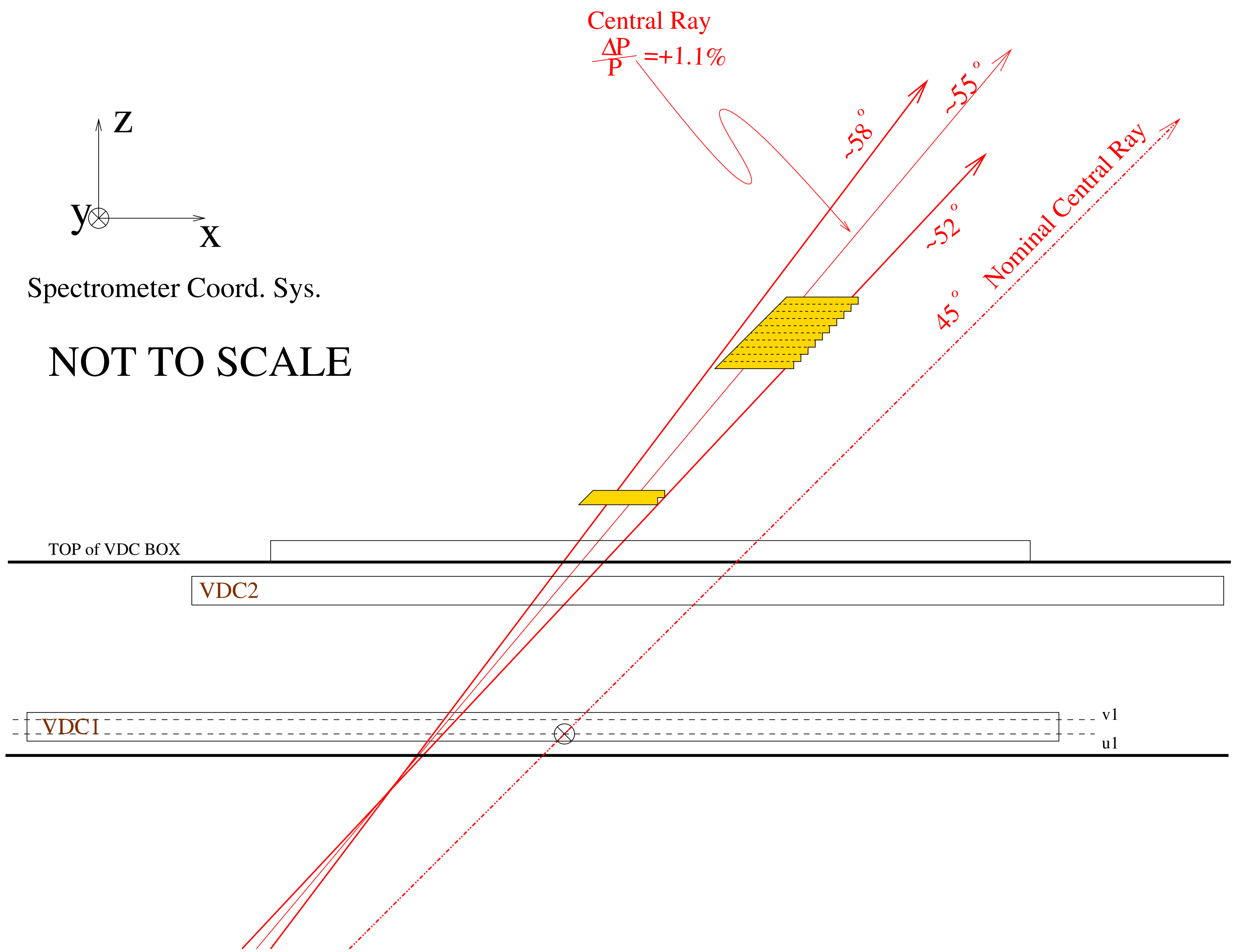
Thn and Stk x,y Efficiency profiles: run 3686 (after Q3+)



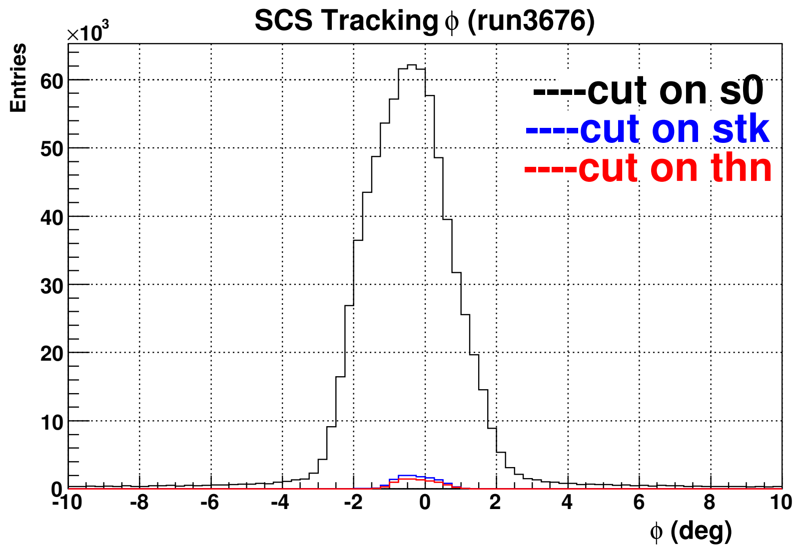
Beamtest Optics Review: Theta before and after Q3+

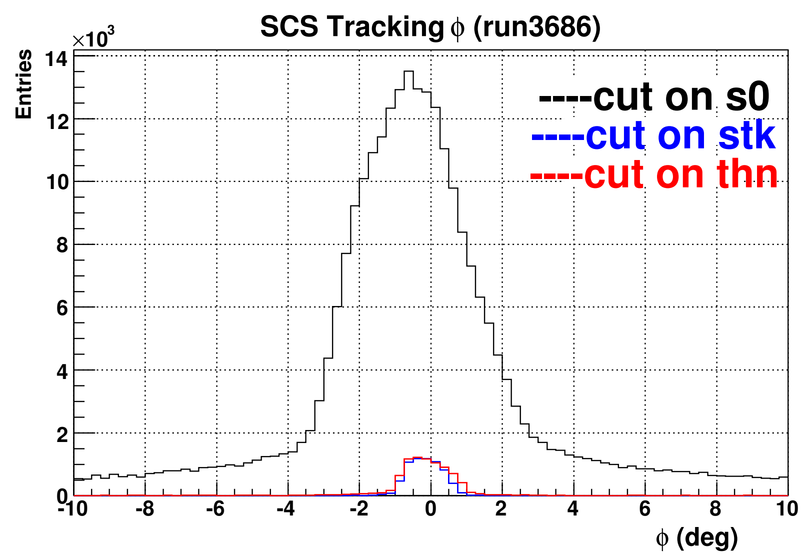


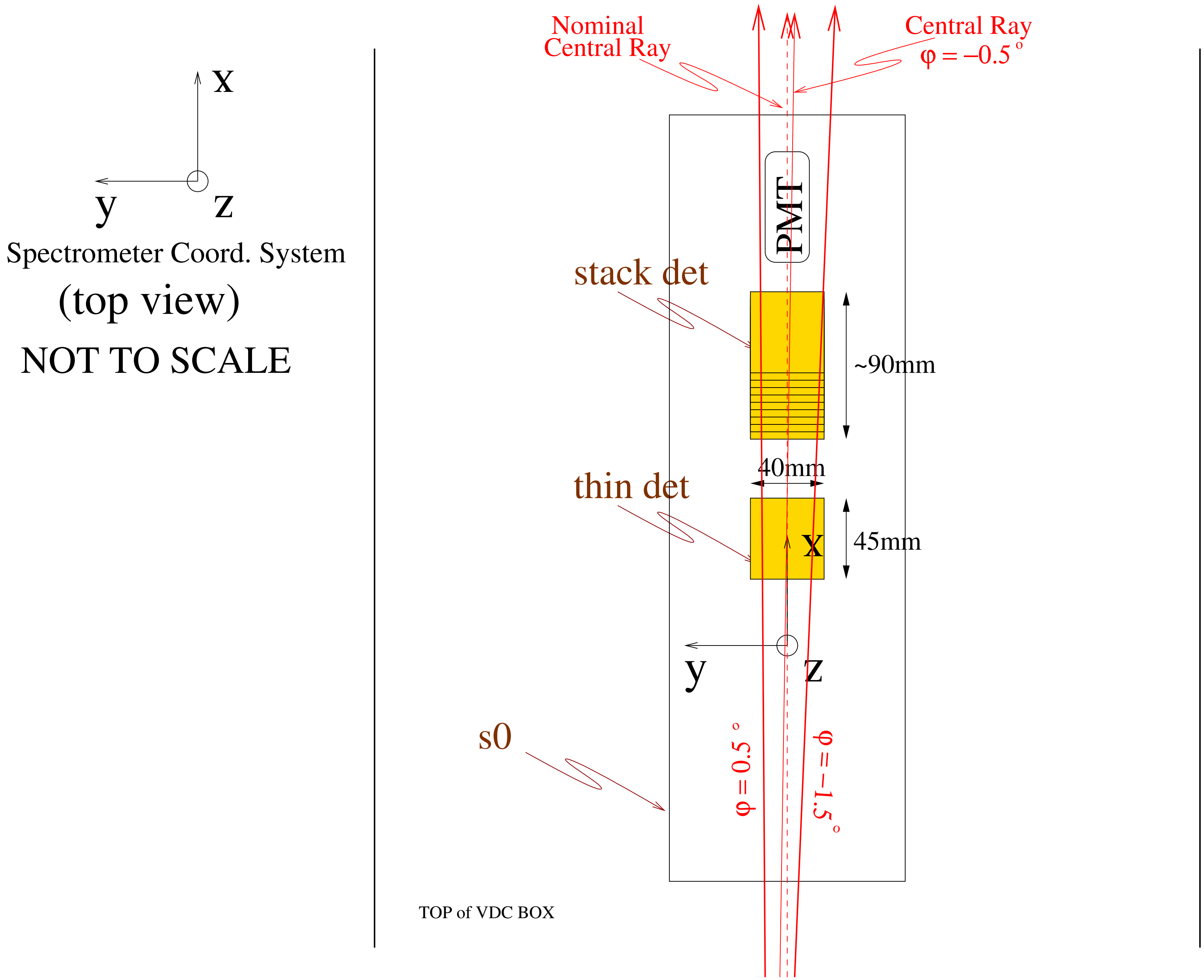



Central Ray
$\frac{\Delta P}{P}$ =+1.1%
-55°
-58°
-52°
45°
Nominal Central Ray
z
y
x
Spectrometer Coord. Sys.
NOT TO SCALE
TOP of VDC BOX
VDC2
VDC1
v1
u1

Beamtest Optics Review: Phi before and after Q3+






x
y
z
Spectrometer Coord. System
(top view)
NOT TO SCALE
Nominal
Central Ray
Central Ray
φ = −0.5 °
PMT
stack det
~90mm
40mm
thin det
45mm
x
y
z
s0
φ = 0.5 °
φ = −1.5 °
TOP of VDC BOX

Summary and Outlook

- Goal of the Jan beamtest–shore-up final design for PREx dets
- Ta elastic peak had $\sigma \sim 1.5$ cm in the dispersive direction and extended ~ 6 cm in the transverse
  - -Above numbers are for 19 $^\circ$ and at z=0 in the SCS
  - -For Pb target at 5 $^\circ$ and z=det_z, peak size likely different–need robust simulation for finalizing optimal detector size
- Thin det resolutions (24% and 29%) agreed well with simulation and are deemed adequate for PREx
  - -Could improve res. by replacing alzak mirrors with anodized Al or Silver
  - -Increased resolution of 10mm det is offset by its larger Landau tail
  - -s0 upstream of detector causes large and unnecessary Landau tails
- Usefulness of Stack detector in question
  - As expected, it's resolution is worse but more importantly, it stops the electron thus not allowing s0 to be downstream of dets (where it should be)

Summary and Outlook continued

- Preliminary results show flat and near 100% detection efficiencies in both x and y for thin det
  -Still need more work here to understand strangeness in spacial extent of the detection efficiency
- Need further investigation into stack and thin rates observed immediately following the integrating DAQ runs
- In order to finalize PREx detector design, need optics simulation which reproduces observed Ta spectra–both before and after Q3 change. After tuning simulation to match observed spectra, replace Ta target at 19 $^\circ$ with Pb target at 5 $^\circ$ and see what we see.
- Goal is to finalize design by end of this year

Lessons learned for future beamtest

- Need s0 (unbiased) triggers for all test configurations
- If plan to shift ΔP/P, need appropriate central ray alignment of two dets
- 10% increase in Q3 was probably too much
-