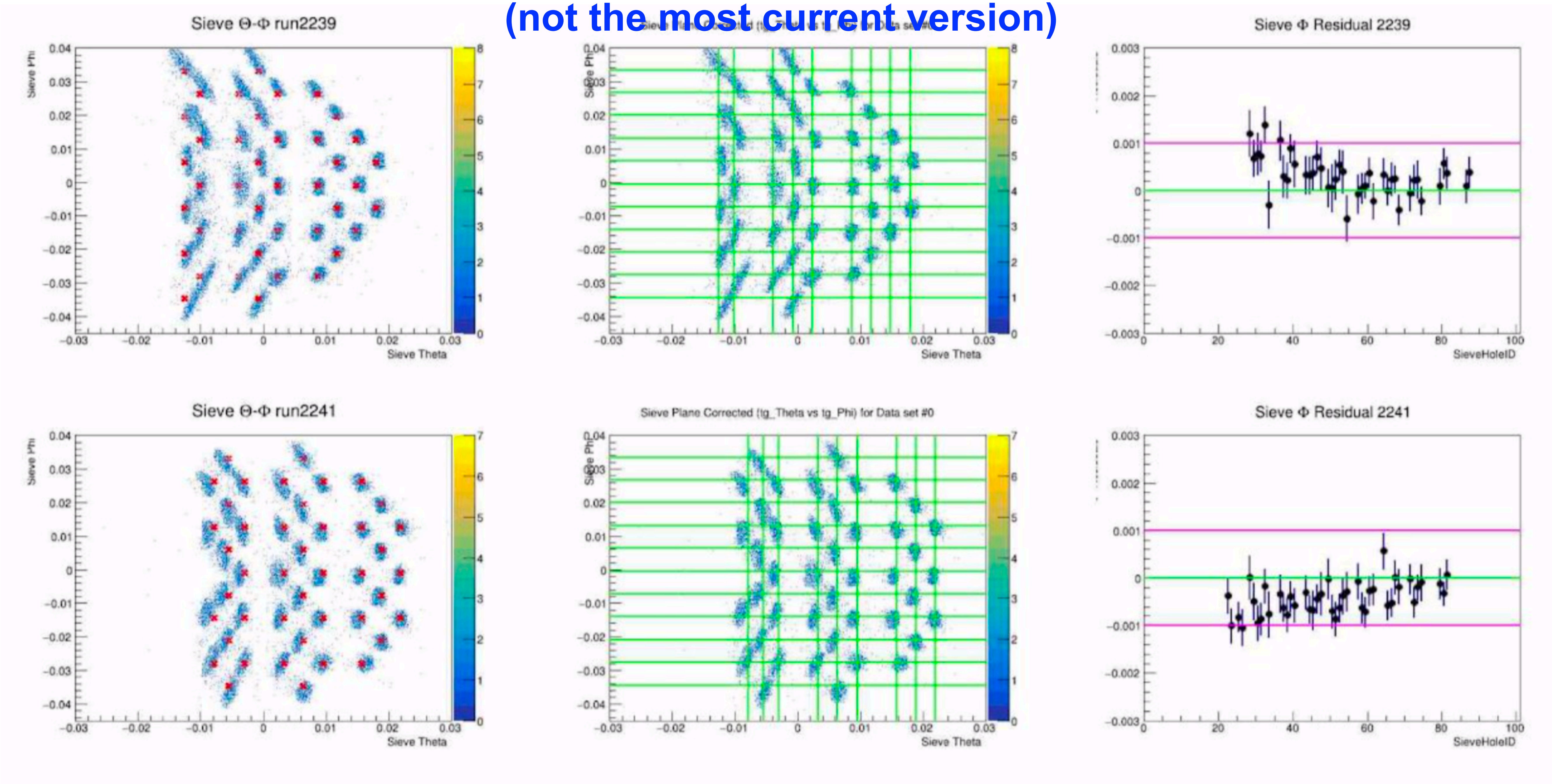
example residuals from Siyu’s studies (not the most current version)



As an example: In any specific run, the reconstructed angle φ_{tg} doesn’t match the sieve angle φ_{sv}.

We should interpolate in the φ_{tg}-θ_{tg} plane, to create “reconstructed” variables that mimic these residuals.

This 2-D interpolation (φ θ) would depend on y_{tg}, so in total this is a 3D interpolation table, with the binning of the lookup table set by the sieve holes.

after target with post-scattering radiation + MS	*"Apparent"*	*Counting measurement*
radiated, multiple-scattered beam	*"Vertex"*	*Integrating measurement*
point-like, mono-energetic scattering, over a range of angles	*"Elemental"*	*Ties to theory*

The asymmetry in the data we measure is baked in at the hard-scattering vertex, and corresponds to $\langle A_v \rangle$. To interpret it, we need to be able to take an integral over any physics model $A_e(\theta, p)$ to compare to $\langle A_e \rangle$:

$$\langle A_e \rangle = \frac{\int d\theta \sin\theta \, A_e \frac{d\sigma}{d\Omega} \epsilon(\theta)}{\int d\theta \sin\theta \, \frac{d\sigma}{d\Omega} \epsilon(\theta)}$$

ε as a function of scattering angle θ

A(θ) is not linear, so the acceptance function distribution matters! This function and the beam energy are THE normalization of our experiment!

Simulation:

1) calculate the acceptance over the kinematics at the vertex: θ
2) calculate $\langle A_e^s \rangle$ and $\langle A_v^s \rangle$, and use this to correct A_M . This provides a correction to our measurement, corresponding to the change in the asymmetry from measuring with a mono-energetic incident beam

$$\langle A_e \rangle = A_M \frac{\langle A_e^s \rangle}{\langle A_v^s \rangle}$$

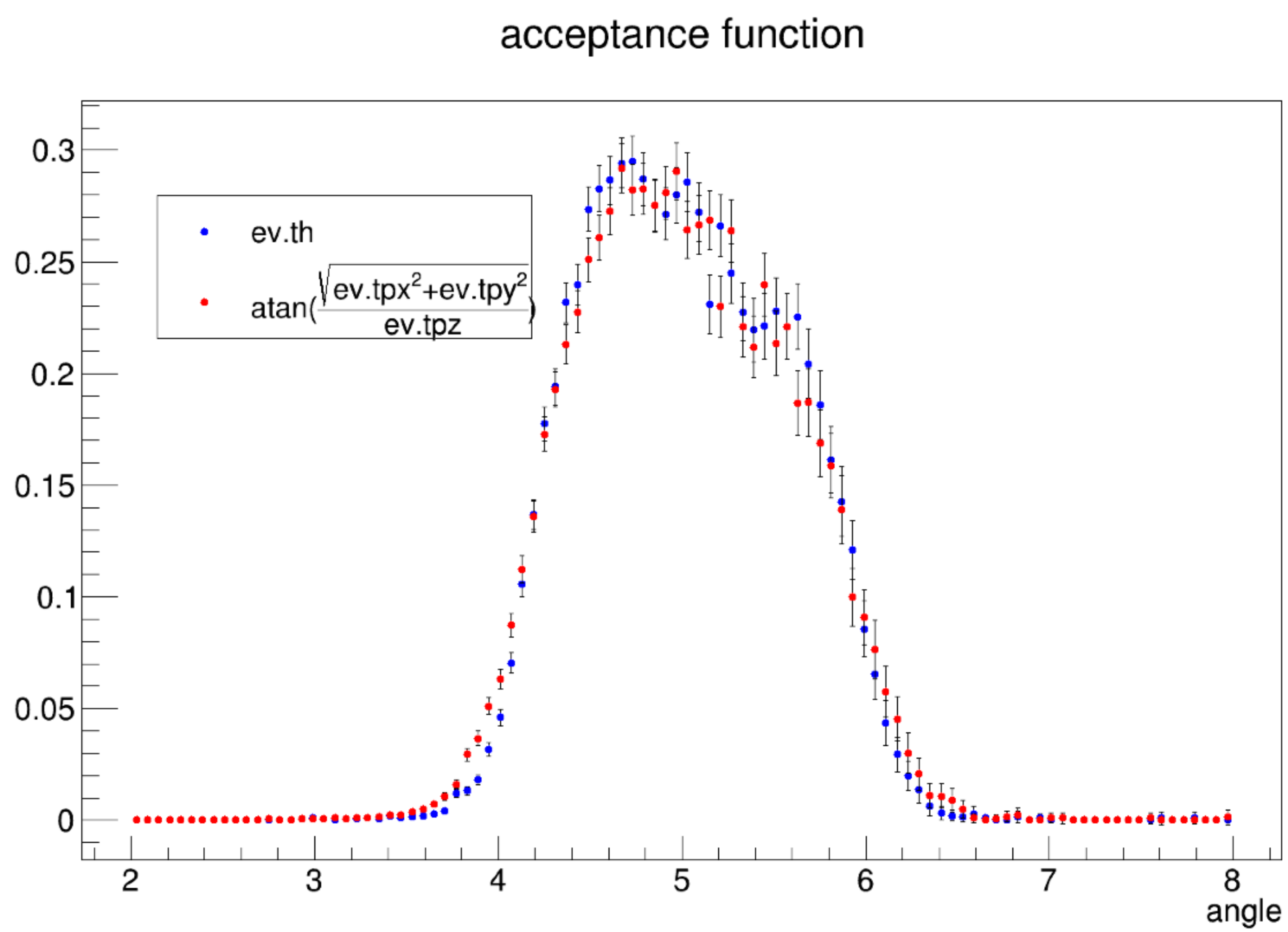
Acceptance function

The asymmetry measured by the integrating experiment is from the vertex: with an incident energy after radiation and ionizaton losses in the target plus external brem from the target nucleus, and a direction spread out by multiple scattering on the way in.

What is seen in the detector is additionally radiated (final state radiation + passage through the target), loses energy to ionization, and multiple scattered

$$\langle A_e \rangle = \frac{\int d\theta \sin\theta \, A_e \frac{d\sigma}{d\Omega} \epsilon(\theta)}{\int d\theta \sin\theta \frac{d\sigma}{d\Omega} \epsilon(\theta)}$$

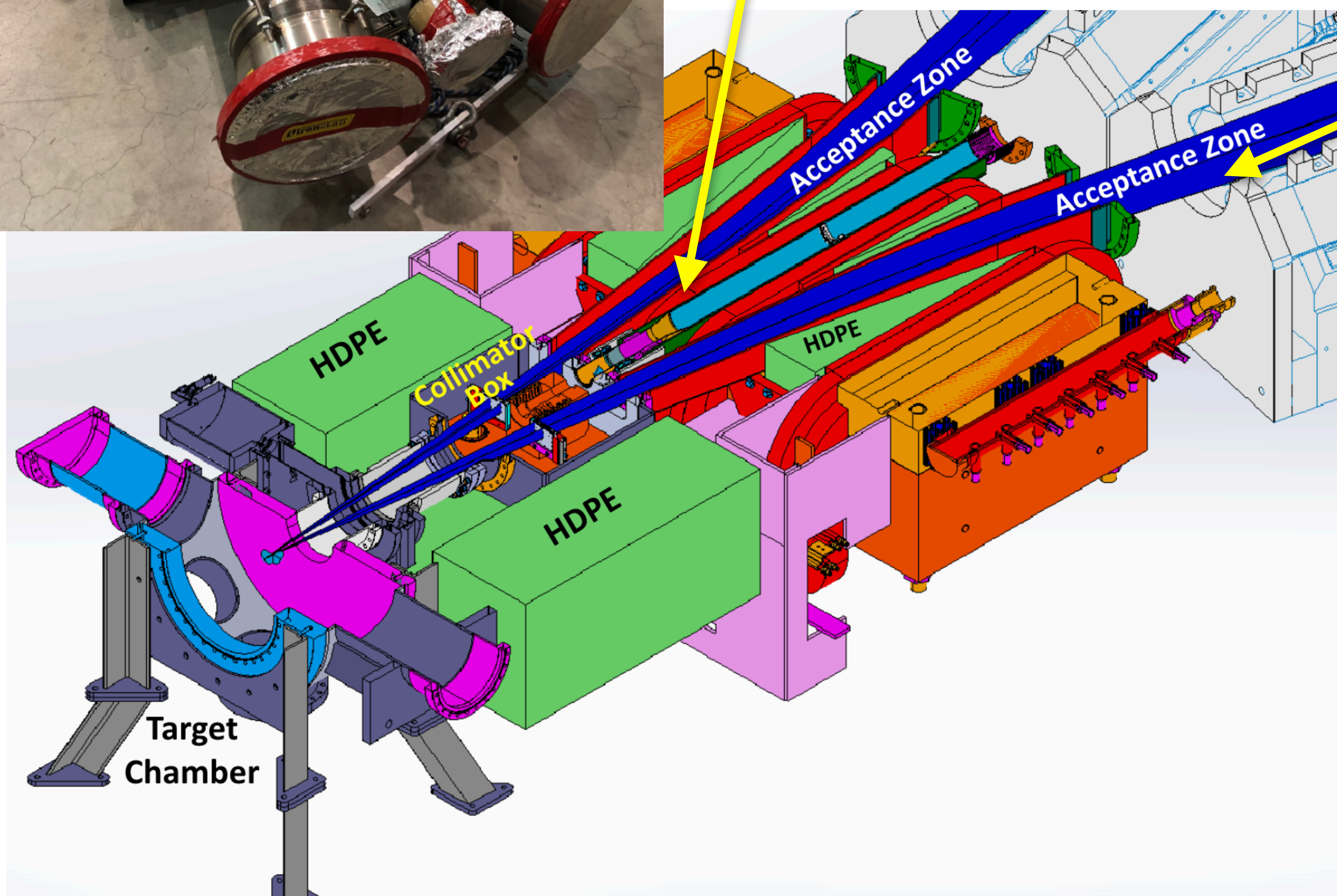
Every physics model (including our reference from Chuck) will evaluate its agreement with our measurement by evaluating this average over the acceptance function

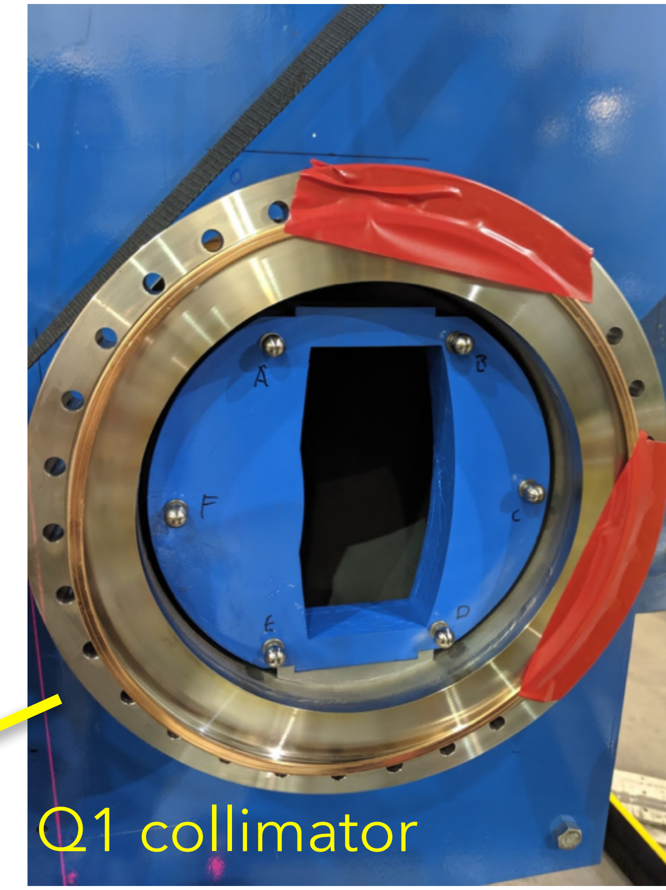


what might limit acceptance

pinch point

Not in spec, forced target move, “floppy”, difficult to align. Did the best we could.





well aligned and surveyed

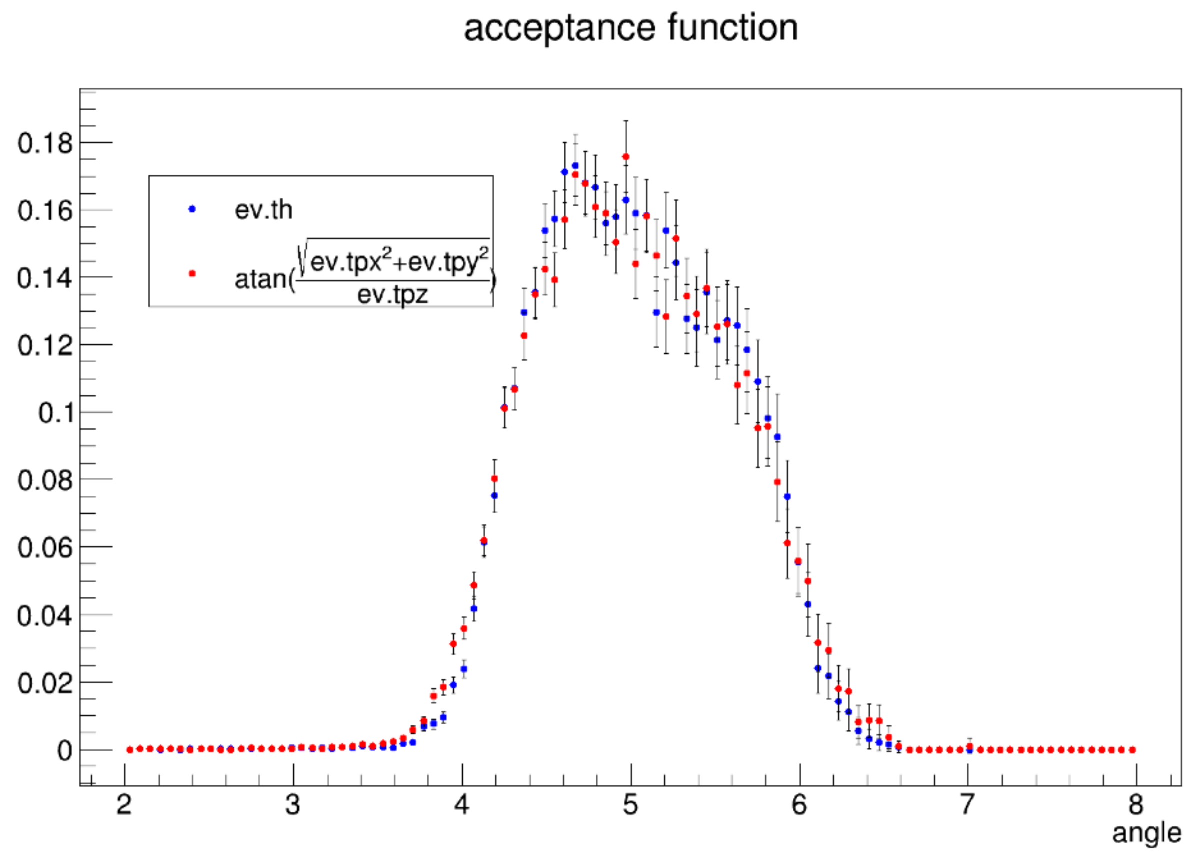
How to find an acceptance function that matches reality

To determine an acceptance model that is correct (within estimated variation):

- use models of varying acceptance (Q1 collimator, pinch point, Z_{targ}) to find configurations with reasonable matches to average θ, Q^2, and A_a. Experience suggests we will find more than one, perhaps, 4 or 5, for each arm.
- Choose one of these models, preferring versions that remain close to original survey expectation and which appear to agree qualitatively with the plots of the theta, Q^2, and A_a distributions. This model will be the basis for the acceptance function.
- We will end up with a range of 0.2-0.5% deviations from comparing the models. This uncertainty will be added our CREX result, to represent the uncertainty of the acceptance function when other F_W physics models are compared.

- We have enough experience to say that we will not see large (>0.5%) discrepancies.
- Some cross-checks or tests can be deferred until after unblinding

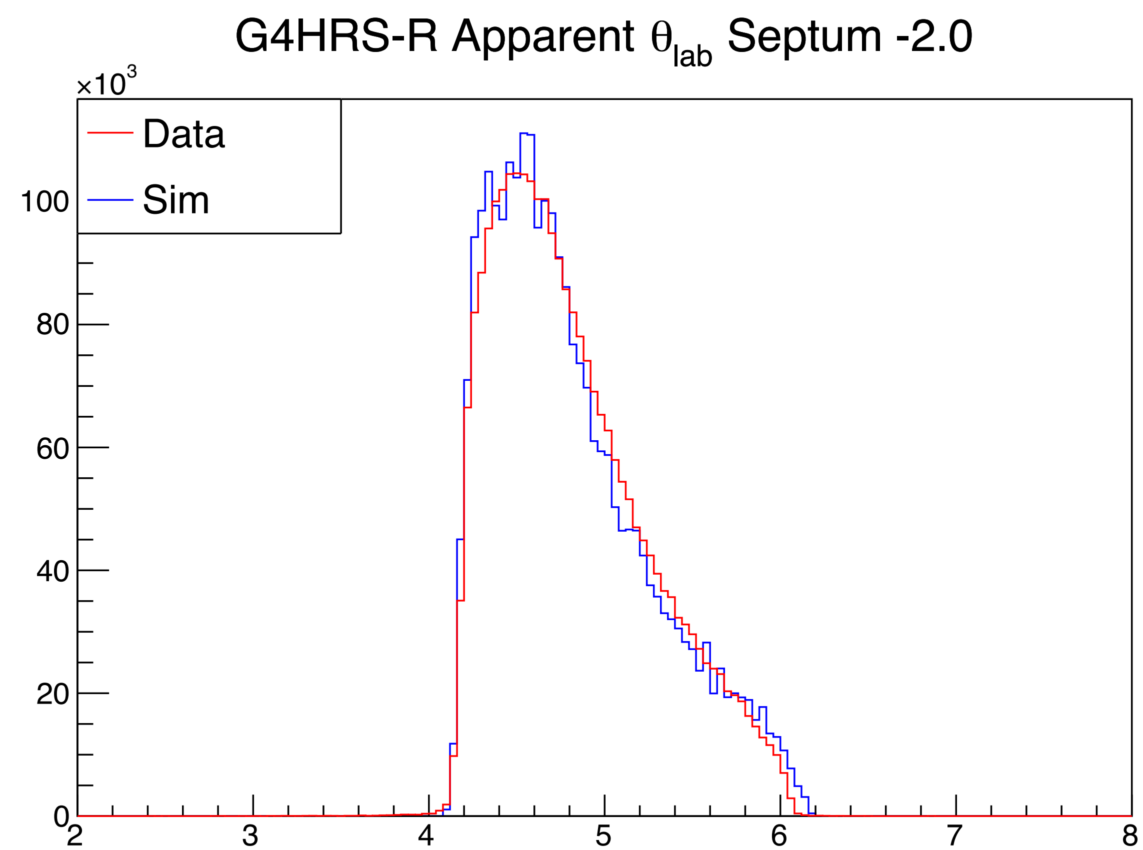
$$\langle A_e \rangle = \frac{\int d\theta \sin\theta \, A_e \, \frac{d\sigma}{d\Omega} \, \epsilon(\theta)}{\int d\theta \sin\theta \, \frac{d\sigma}{d\Omega} \, \epsilon(\theta)}$$

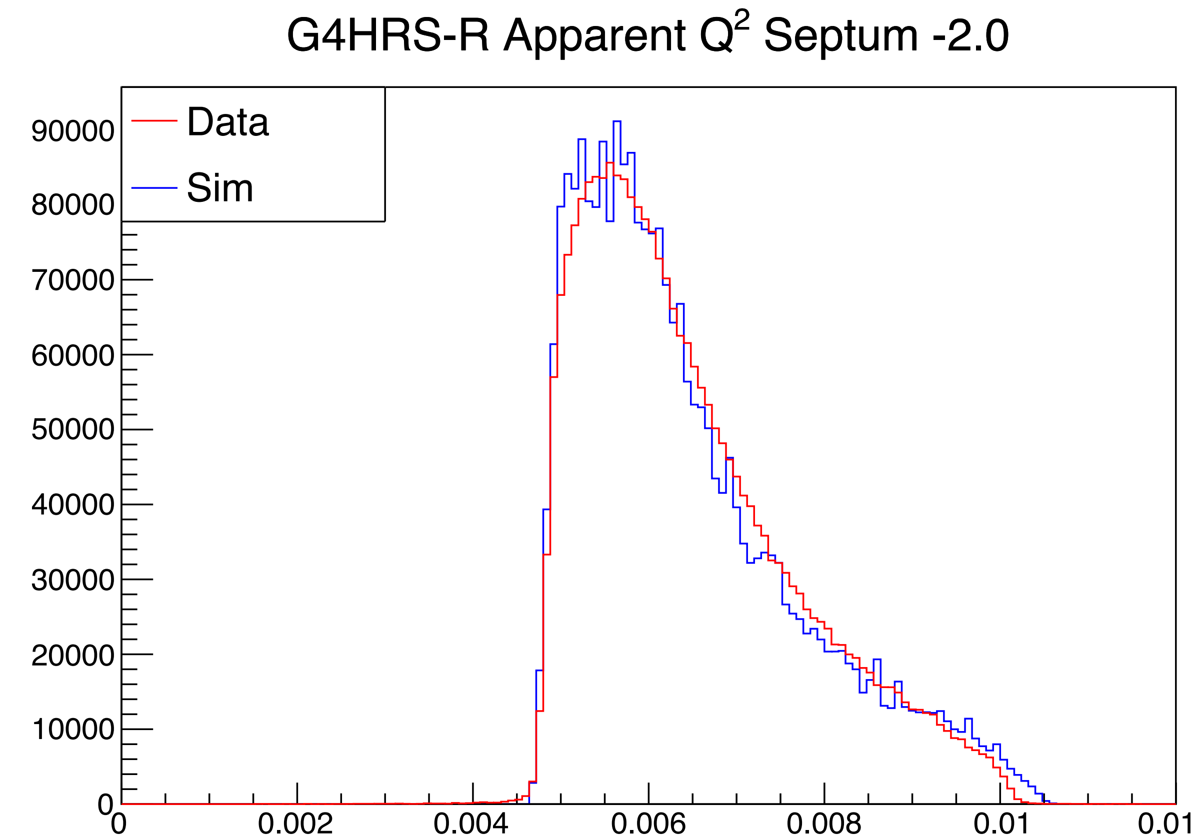


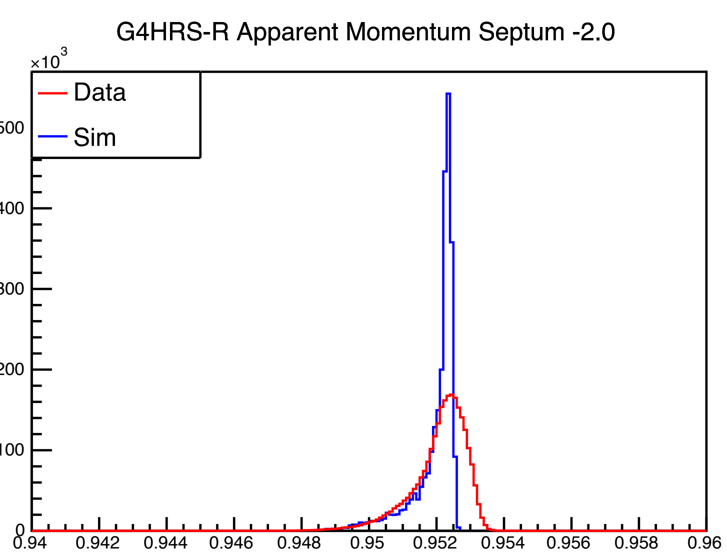
Example “good” PREX match - R21185

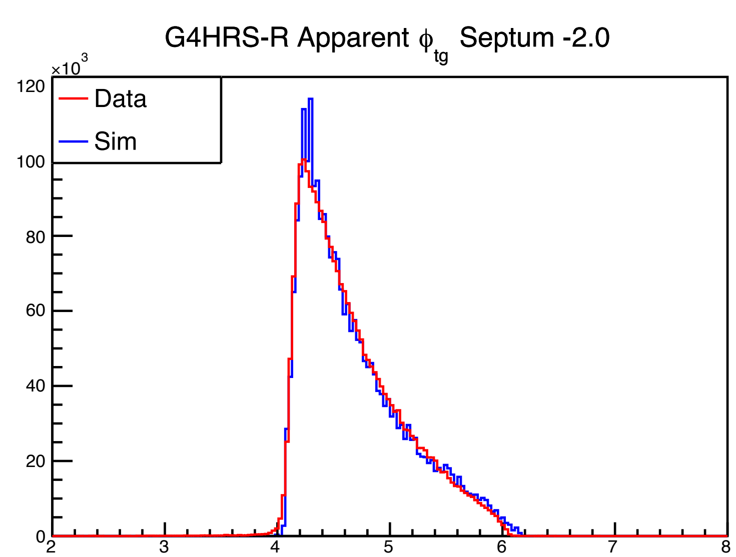
theta	q2	asym
99.89%	99.84%	99.77%

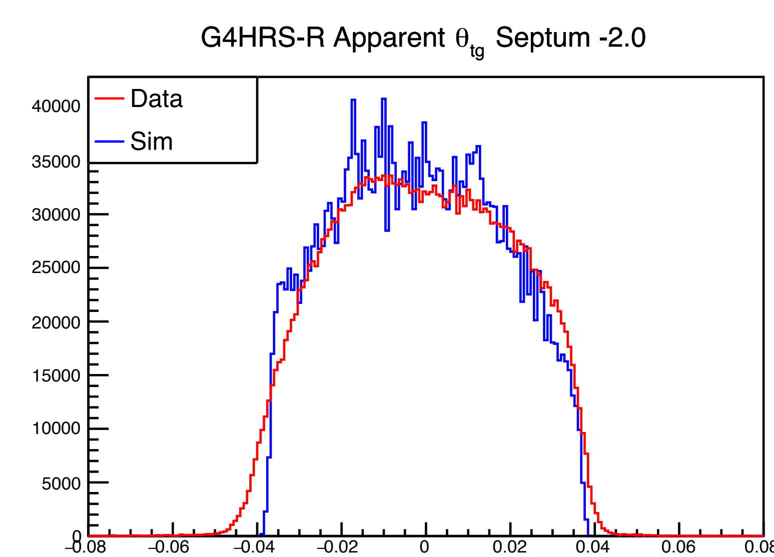
stat error from simulation





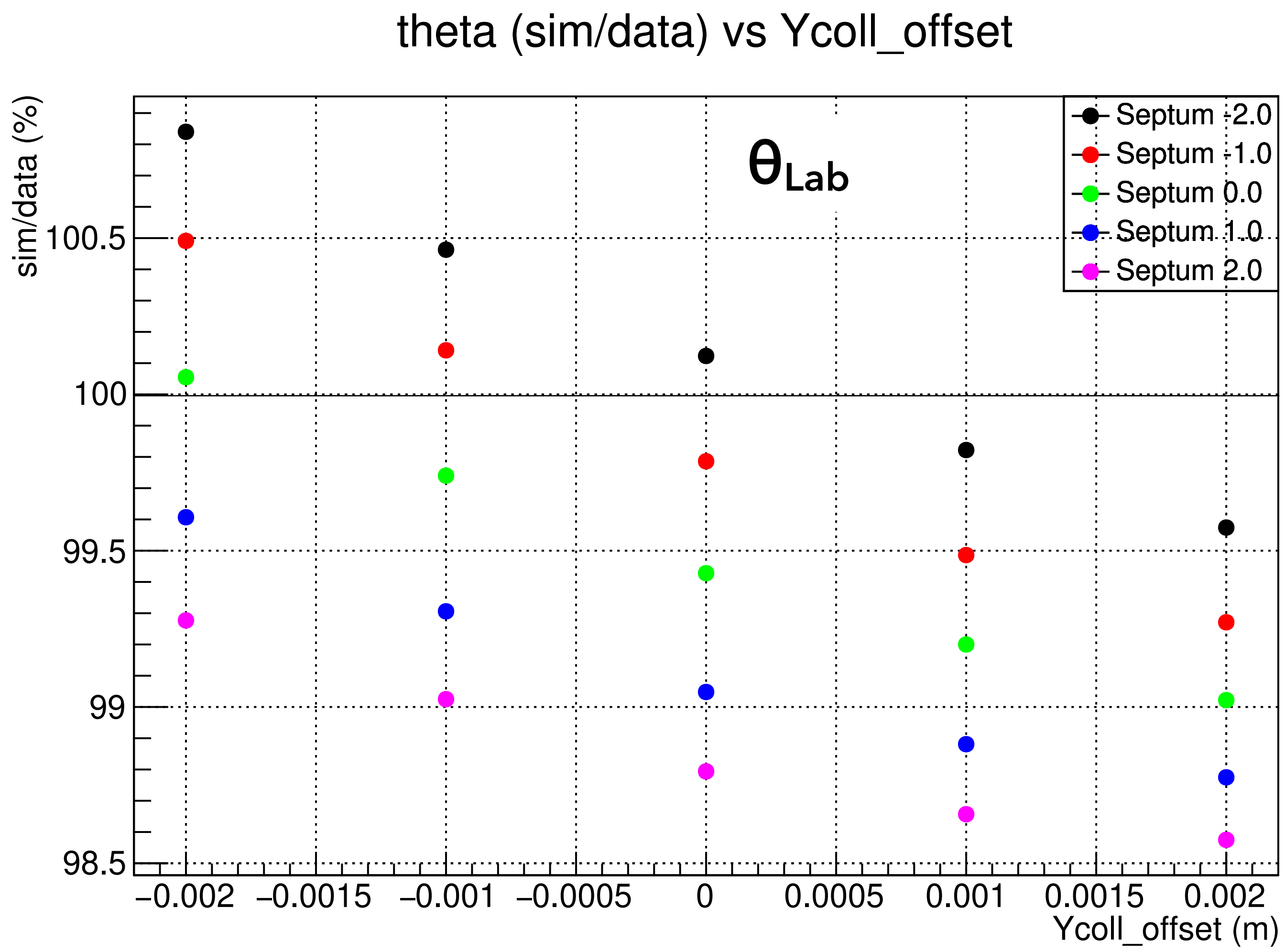






Multiple matches, give some sense of precision of the match

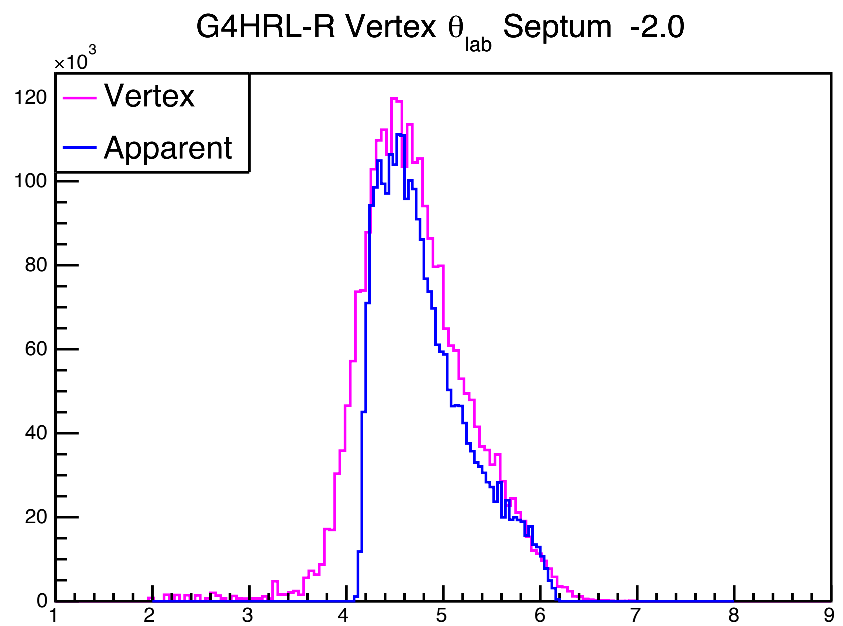
Will examine several "acceptance models" (collimator or target position + septum), and choose one as a central acceptance model.

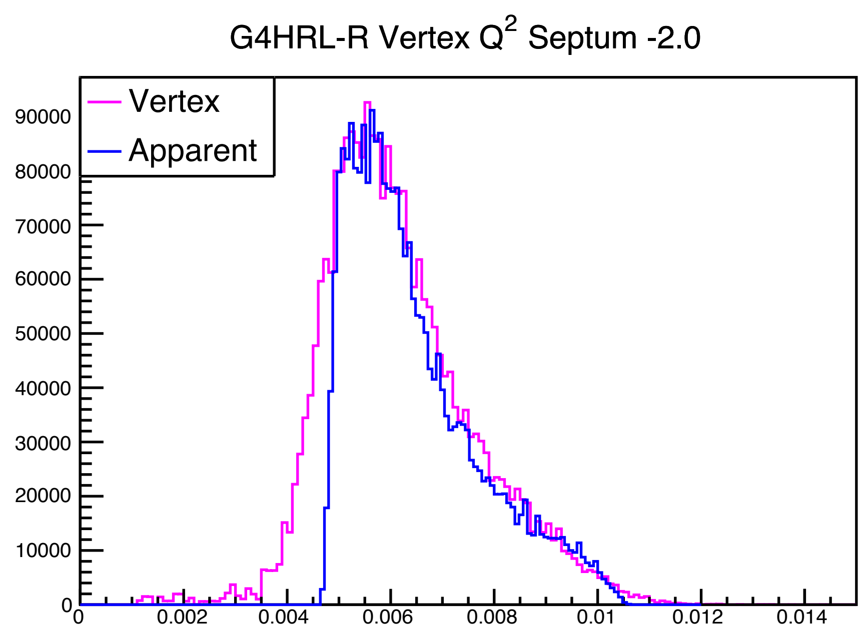


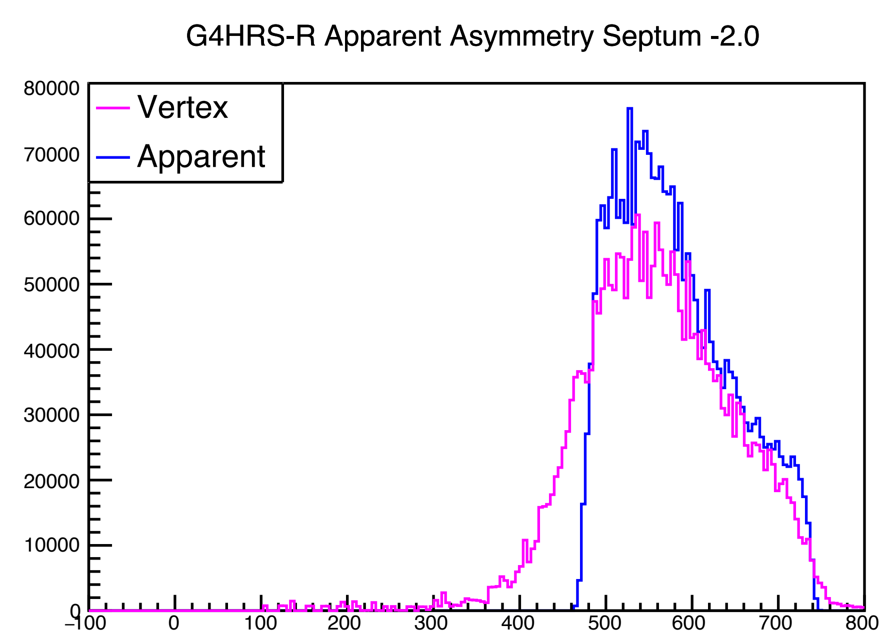
A_v vs Aa

3.0%, varies by 0.2% over configurations

Variation over the varieties of “acceptance model” configurations gives a sense of precision







	A_a	A_v	A_v / A_a
Left	581.8	563.7	97.0%
	582.4	564.5	97.0%
	583.2	566.1	97.0%
	582.0	563.9	97.0%
	583.1	564.9	97.0%
	581.6	563.8	97.0%
	581.8	564.4	97.0%
	A_a	A_v	A_v / A_a
Right	577.1	558.9	96.8%
	576.9	558.6	96.8%
	577.5	559.7	96.9%
	577.2	559.1	96.9%
	576.9	558.5	96.8%
	576.5	558.7	96.9%
	578.7	560.0	96.8%
	579.4	560.6	96.8%

PREX

	Models	Theta	Q2	A_a	A_v	A_v/A_a	dT/T	Aa(Cor)	dA(cor)/A	dAa/A	A_v(Cor)
	Septum -1%, pinch 1.5mm	4.8114	0.0064518	581.837	563.664	97.0%	-0.14%	583.03	0.2%	0.0%	564.8
	Septum nominal, pinch 2.3mm	4.8141	0.0064578	582.413	564.469	97.0%	-0.08%	583.12	0.2%	0.1%	565.2
L											
E	Septum -2%	4.822	0.006482	583.2	566.1	97.0%	0.08%	582.49	0.1%	0.2%	565.4
F	Septum nominal, Collimator -2mm	4.811	0.006448	582.0	563.9	97.0%	-0.15%	583.26	0.2%	0.0%	565.1
T	Septum -1%, Collimator -1mm	4.819	0.006471	583.1	564.9	97.0%	0.02%	582.91	0.2%	0.2%	564.7
	Target +5mm (DS), Septum -1%	4.810	0.006448	581.56	563.83	97.0%	-0.17%	583.02	0.2%	-0.1%	565.2
	Target -5mm (US), Septum -2%	4.812	0.006455	581.809	564.389	97.0%	-0.12%	582.85	0.2%	0.0%	565.4
										Average	565.1
										RMS	0.27

	Models	Theta	Q2	A_a	A_v	A_v/A_a	dT/T	Aa(Cor)	dA(cor)/A	dAa/A	A_v(Cor)
R	Septum Nominal	4.781	0.006370	577.1	558.9	96.8%	0.01%	576.96	0.0%	0.0%	558.8
I	Septum 1%, pinch 1mm	4.779	0.006364	576.9	558.6	96.8%	-0.03%	577.10	0.0%	0.0%	558.8
G	Septum 2%, pinch 1.5mm	4.781	0.006368	577.5	559.7	96.9%	0.03%	577.30	0.1%	0.1%	559.5
H											
T	Septum -1%, Collimator -1mm	4.783	0.006379	577.18	559.05	96.9%	0.06%	576.64	-0.1%	0.0%	558.5
	Septum 1%, Collimator 1mm	4.779	0.006363	576.88	558.54	96.8%	-0.03%	577.13	0.0%	0.0%	558.8
	Septum 2%, Collimator 2mm	4.774	0.006350	576.47	558.73	96.9%	-0.13%	577.56	0.1%	-0.1%	559.8
	Target +5mm (DS), Septum nominal	4.791	0.006398	578.72	560	96.8%	0.23%	576.69	0.0%	0.3%	558.0
	Target -5mm (US), Septum -1%	4.796	0.006411	579.37	560.55	96.8%	0.33%	576.49	-0.1%	0.4%	557.8
										Average	558.7
										RMS	0.67