2015 Vertex Analysis Update
L1L1

Holly Szumila-Vance

23 May 2018

HPS Collaboration Meeting, JLab

Outline:

- Key updates since last time
  - Pass 8
  - Large sample Monte Carlo (thanks Takashi!)
  - Detailed Monte Carlo and track state information (Matt S and Miriam)
  - Vertexer fixed for downstream vertices (Matt G)

- Vertex analysis outline
  - To do list: https://confluence.slac.stanford.edu/pages/viewpage.action?spaceKey=hpsg&title=Things-to-do%3A++Vertexing
  - Goal is a preliminary result by ICHEP (July 4): handle backgrounds/cuts, background rejection/fitting, general estimate of systematics
  - Cut optimization and systematics, specifics, can be done after ICHEP

- Basic cuts

- Comparison of L1L1 with Monte Carlo

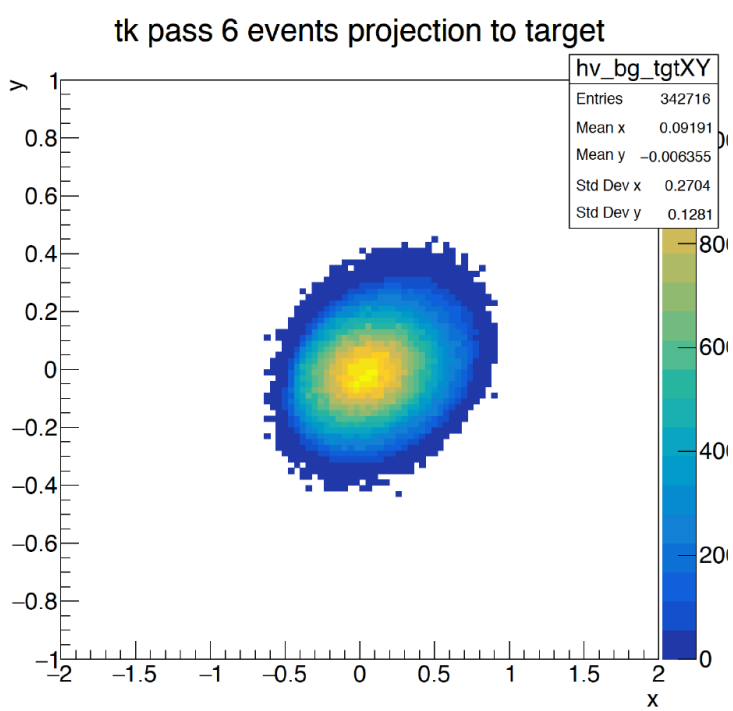
Cuts selecting the L1L1 dataset:

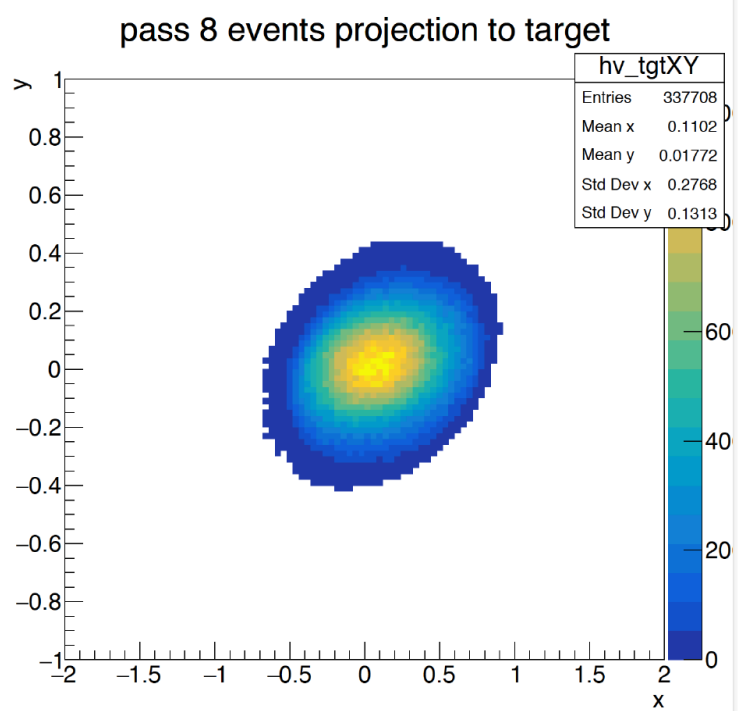
Core: |zVtx| < 10
Tails: zVtx > 30

			% removed core		% removed tails	
Cut type	**Cut**	**Value**	**data**	**MC**	**data**	**MC**
Basic selection	Pairs1					
Radiative	P sum	> 80% Ebeam				
Quality	Track-cluster matching chi2	<10				
Layer	L1L1 and L2L2		23%	4%	90%	70%
Quality	Track chi2/dof	<12	0%	0%	2%	1%
Quality	e-, e+ cluster time difference	<2 ns	1%	1%	3%	2%
Quality	Isolation		0%	0%	13%	31%
Vertex	beamspot constrained chi2	<10	13%	5%	40%	34%
Vertex	beamspot - unconstrained chi2	<5	22%	11%	48%	52%
Physics	P asymmetry	<0.5	5%	4%	19%	11%
Physics	Projection to beamspot at target	3 sigma, tilted	22%	11%	91%	89%
Physics	Max P, single track	<0.8	2%	0%	8%	0%

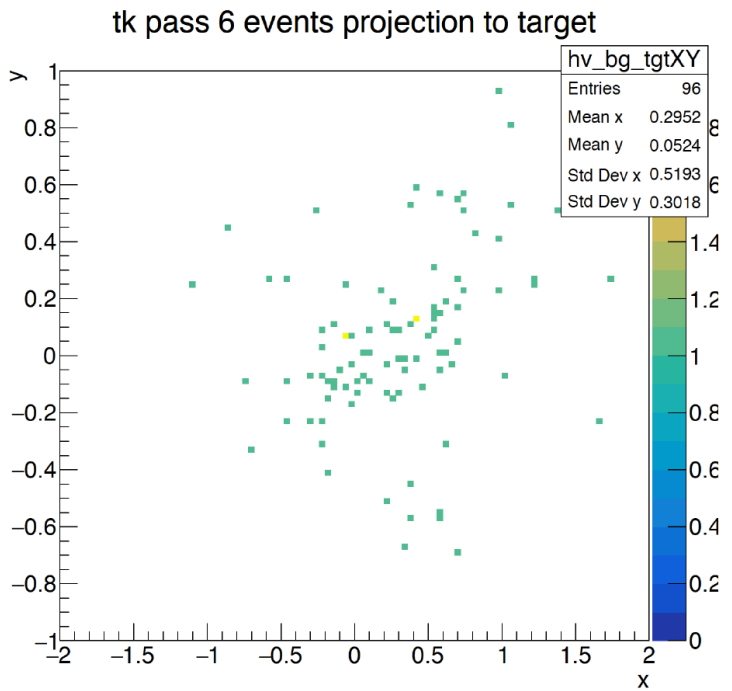
Debatable extra cuts: kink cuts, beam spot constrained vertex projection to target

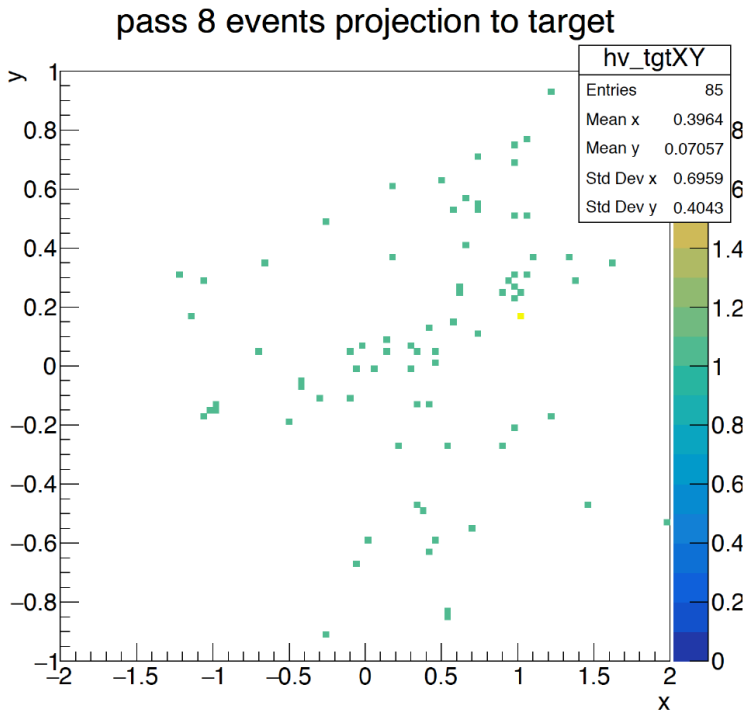
Projecting the unconstrained z vertex back to beamspot at target is useful now!





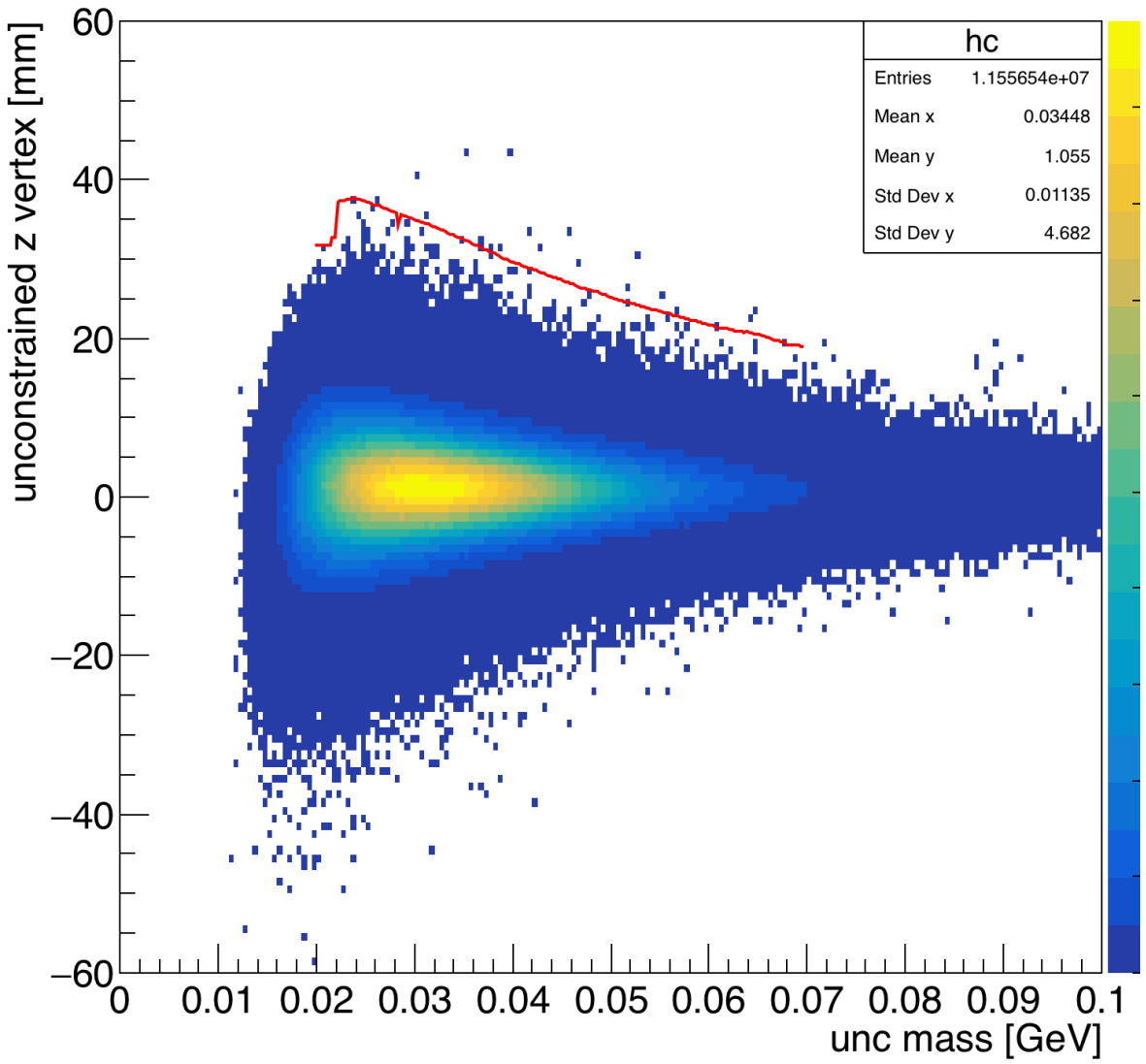
High z type events



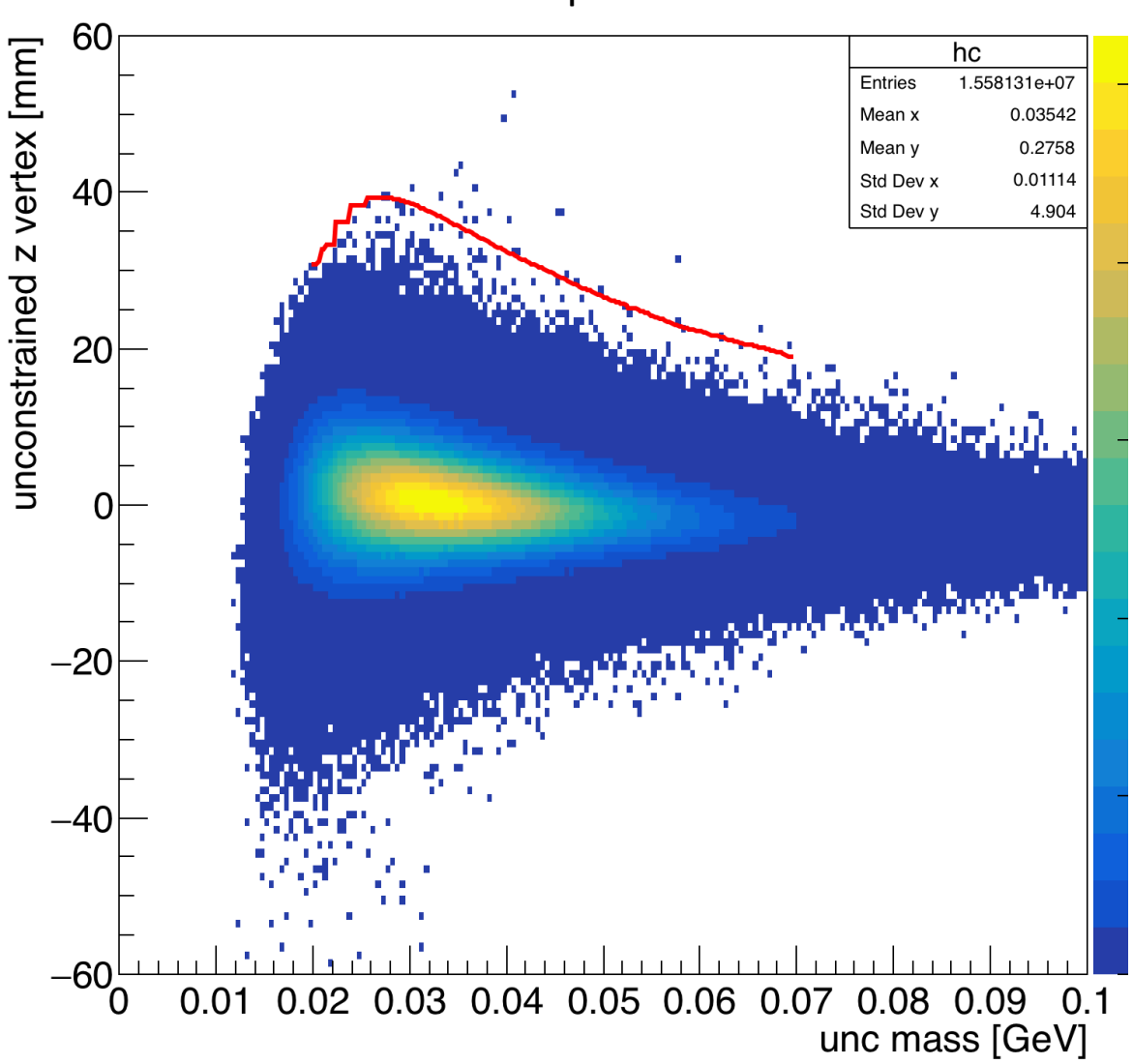


Ideally, we should use the errors, but Matt G is working on getting this information!!

100% Monte Carlo (TTWB)



100% L1L1 pass 8 data

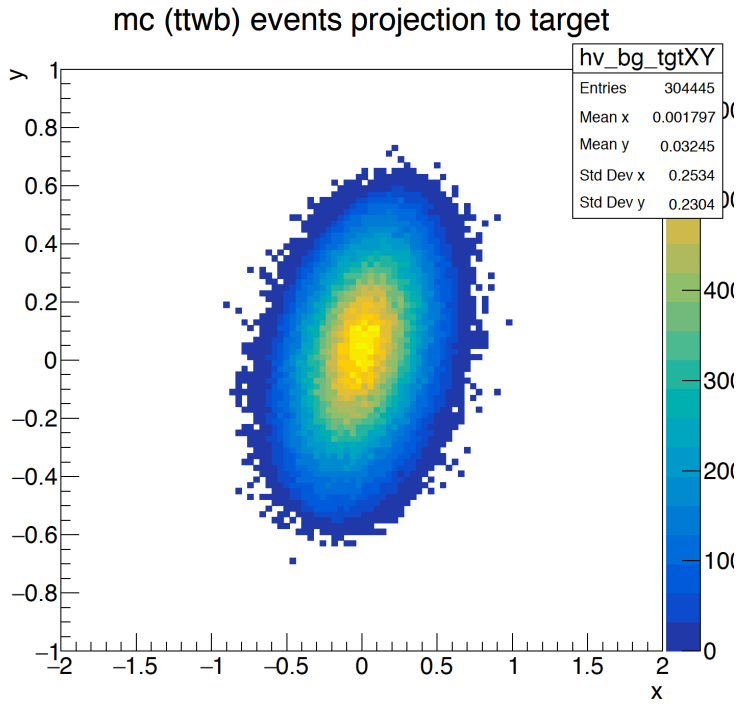


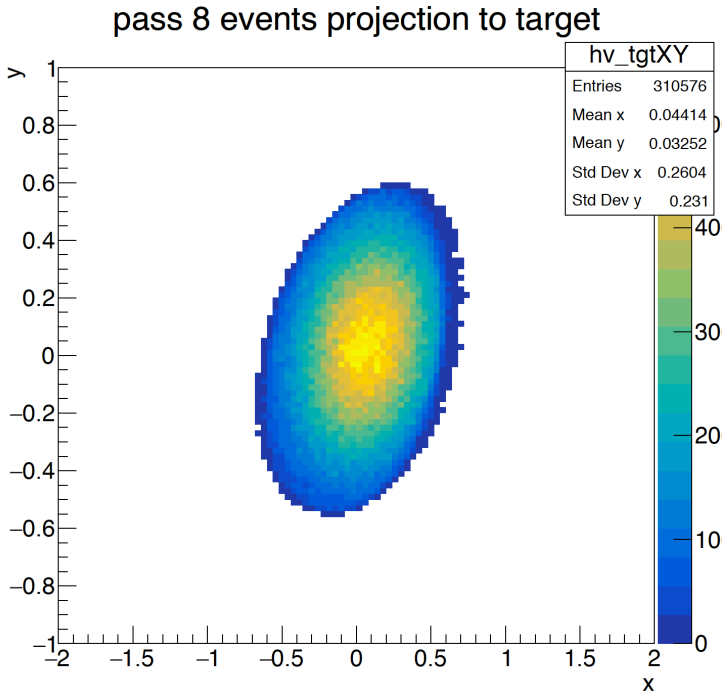
MC: 12 high z, 1.1556540 events

data: 16, 1.5581310 events

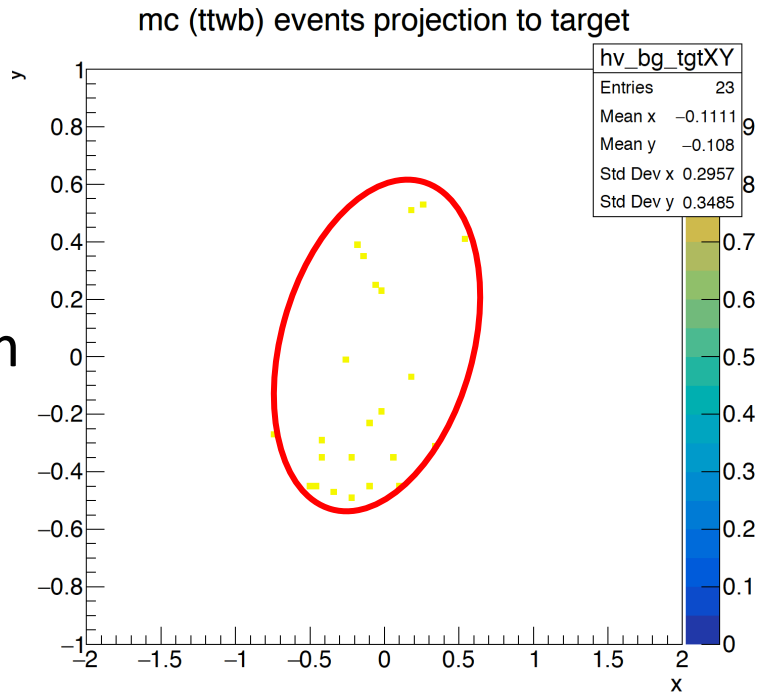
MC has overall 5% less statistics in L1L1 than data (had about 20% failed jobs)

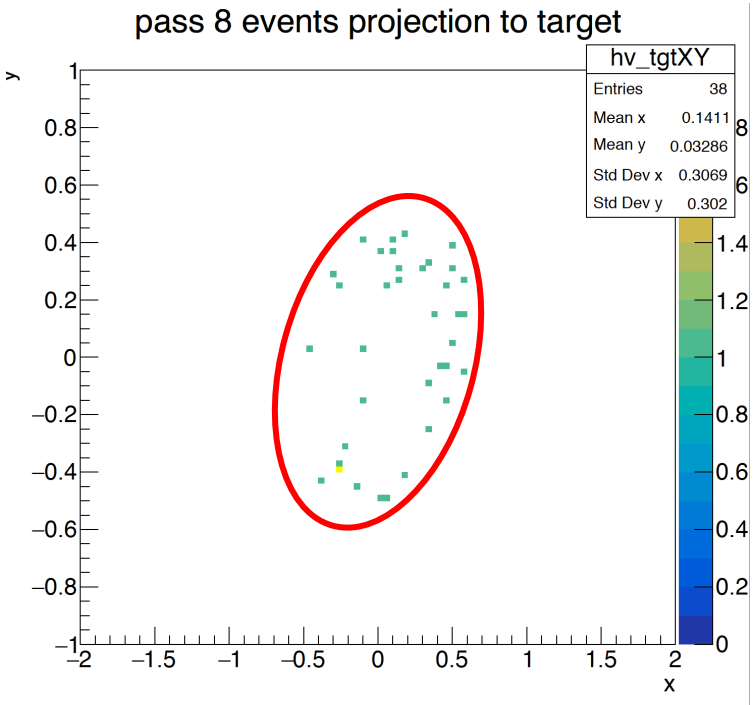
100% of data sets:



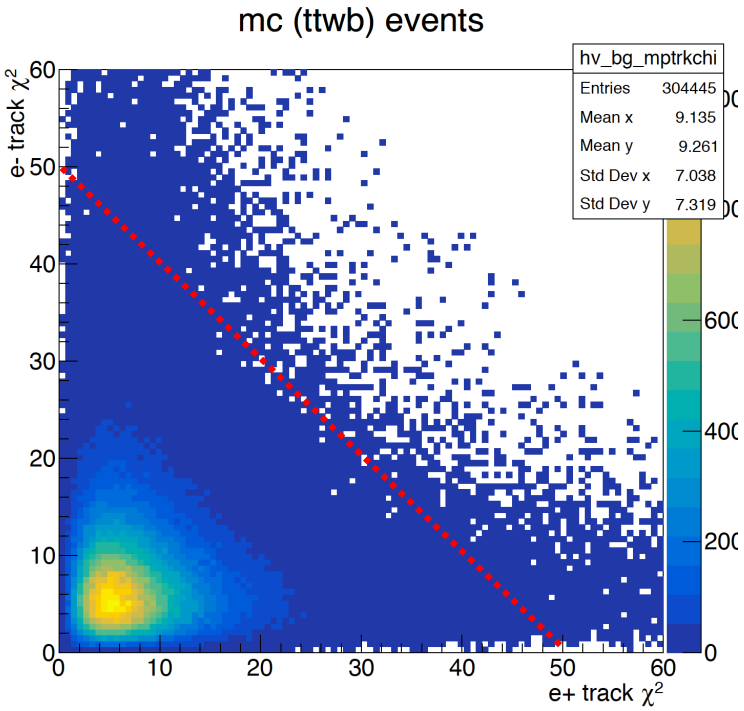


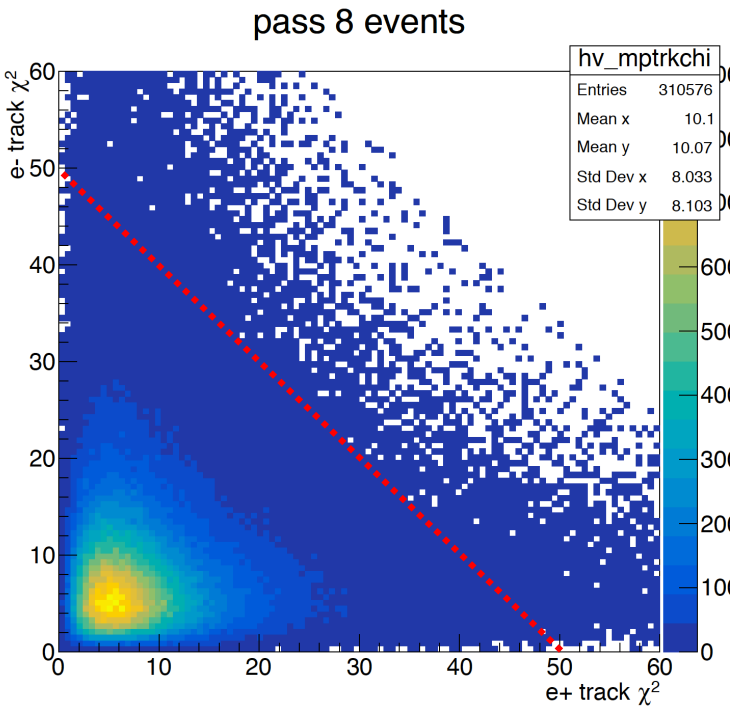
High z events from data sets:



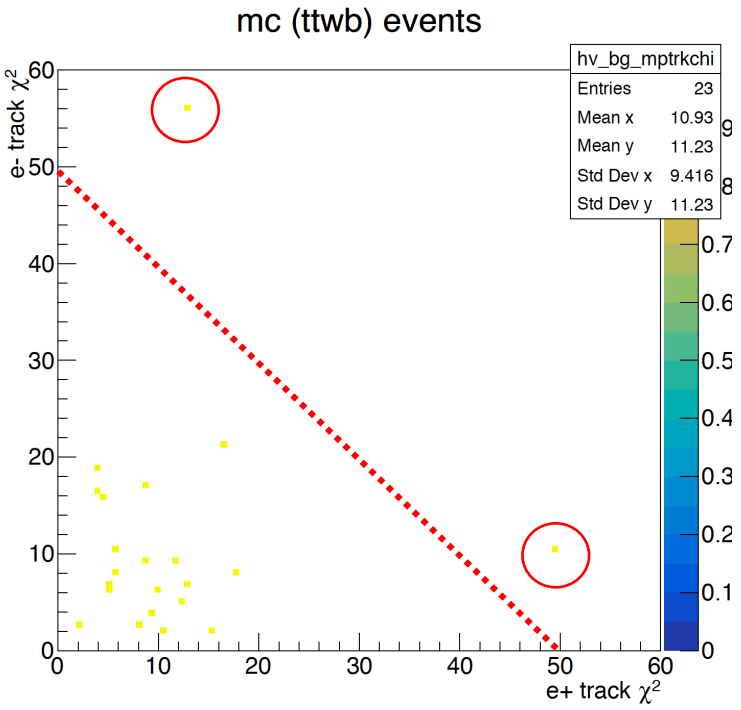


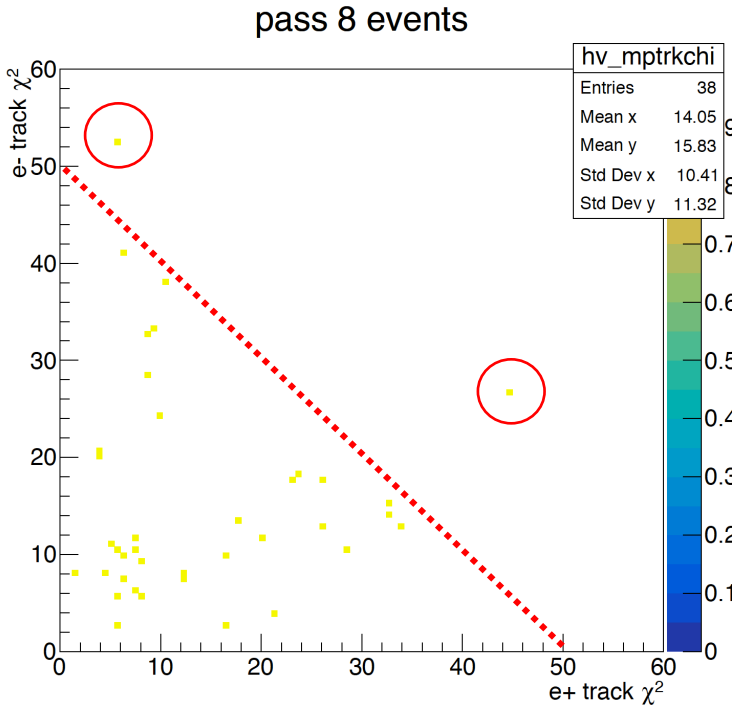
100% of data sets:

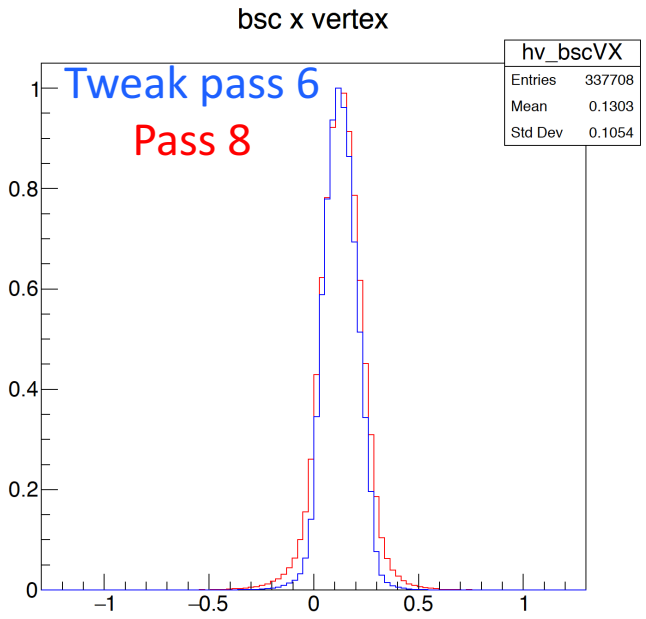


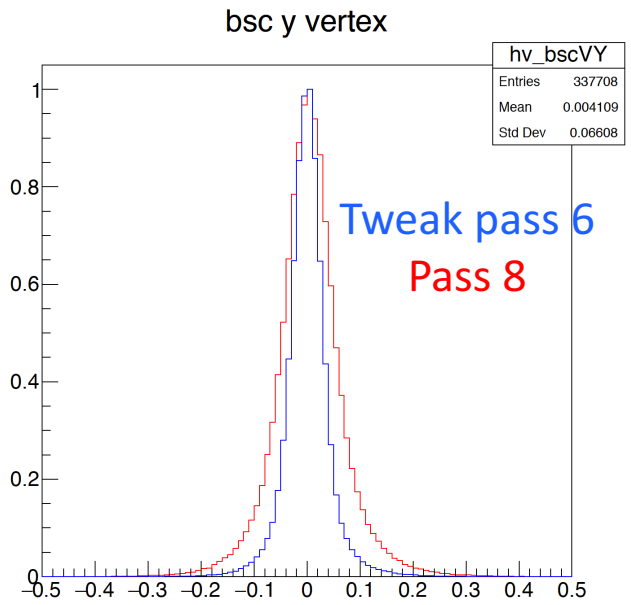


High z events from data sets:

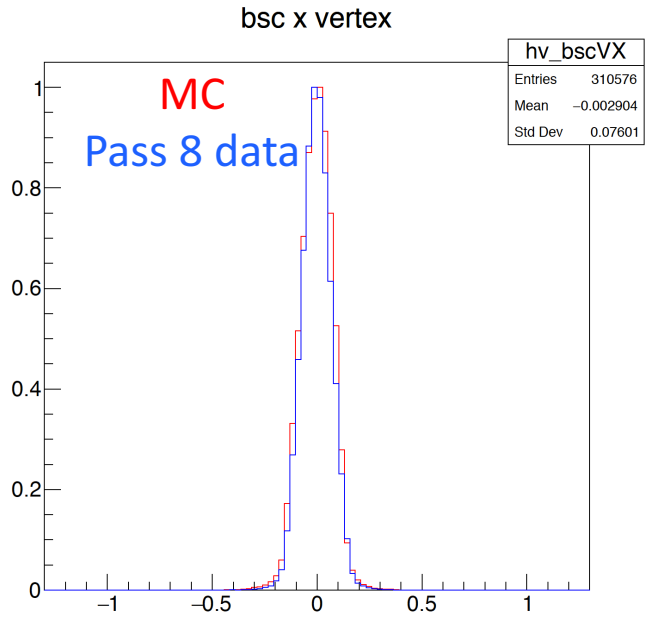


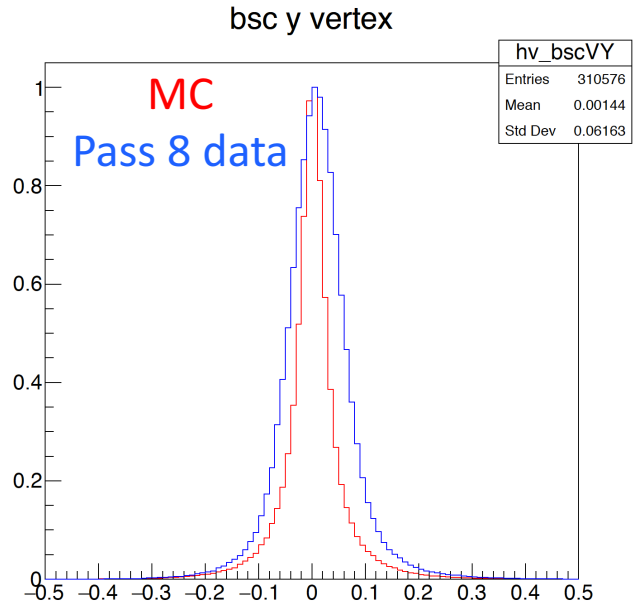






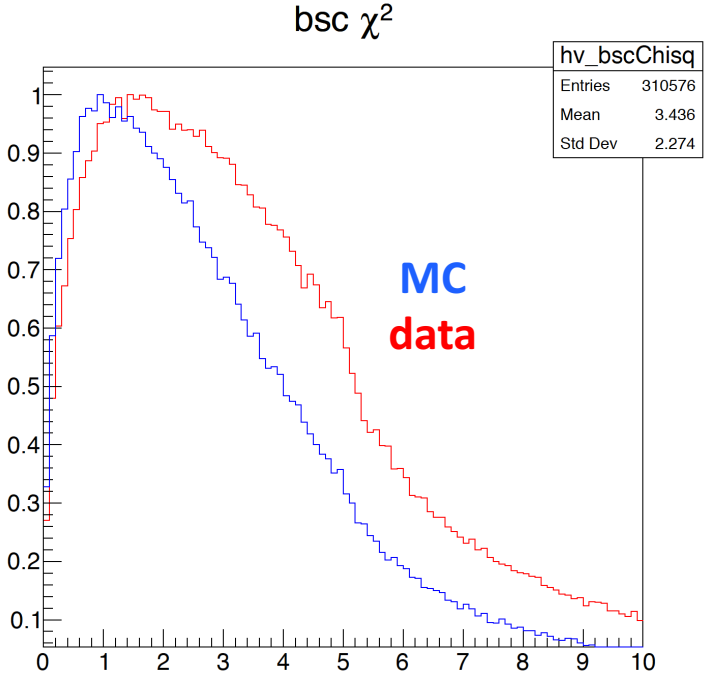
Is there a cut here? On the projection? Do we trust it?

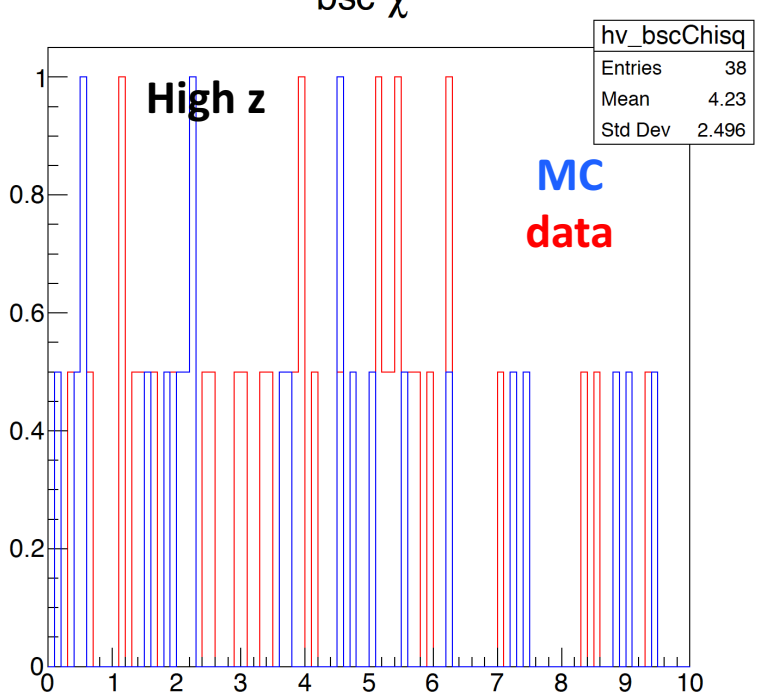


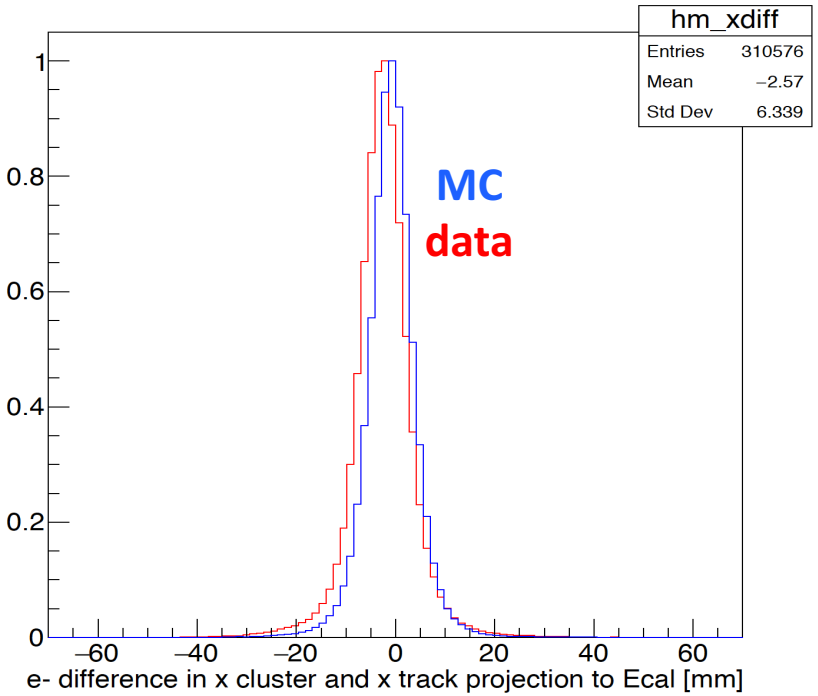


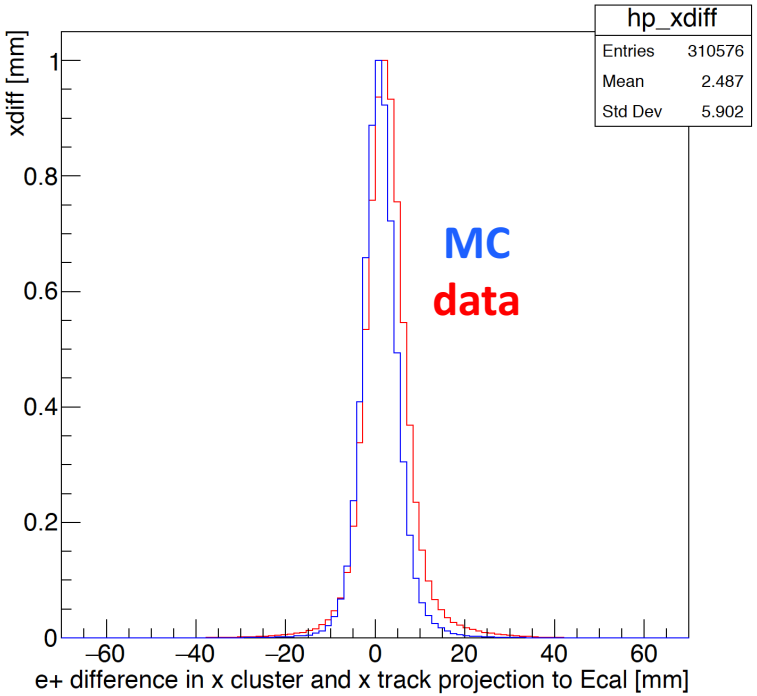
Sigh…. Why is this so different?

The pulls are the same!









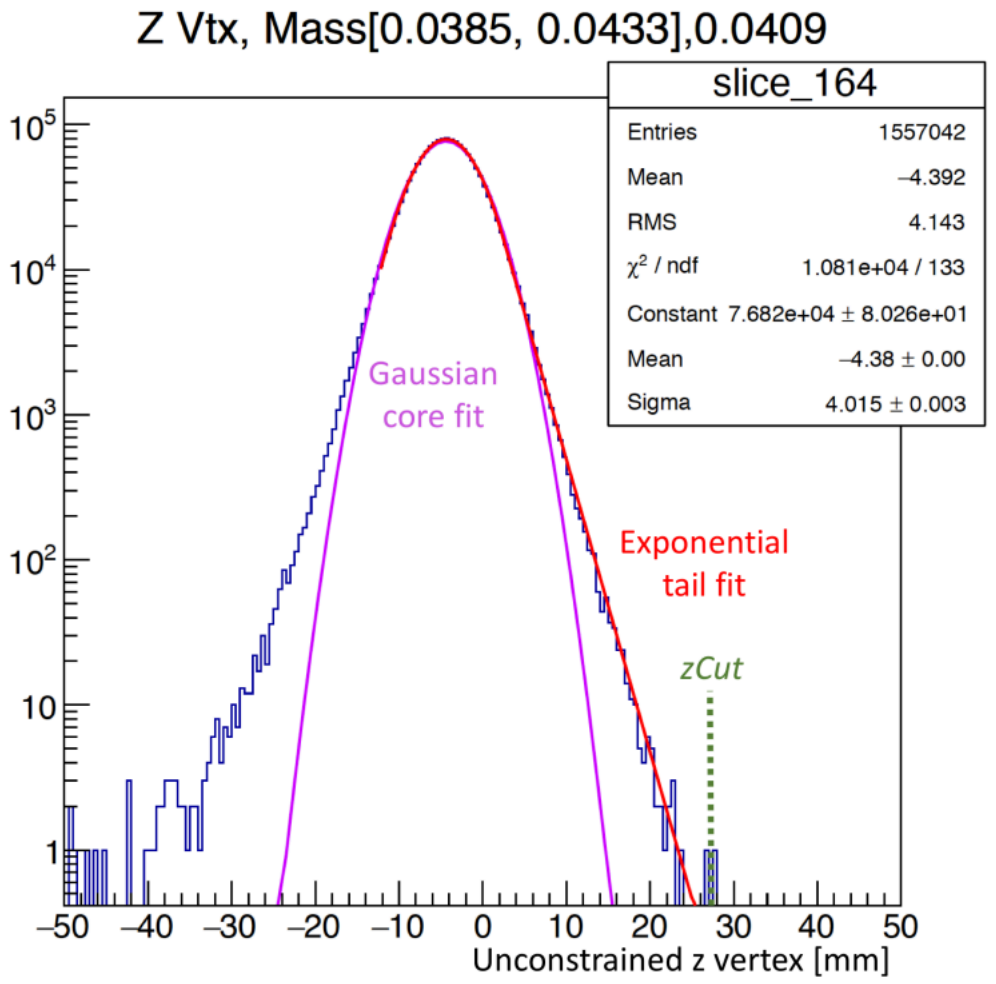
Some funny offsets between cluster position and track projection to Ecal. Is this related to the alignment?

Fitting the distributions

Do we trust the fit model?

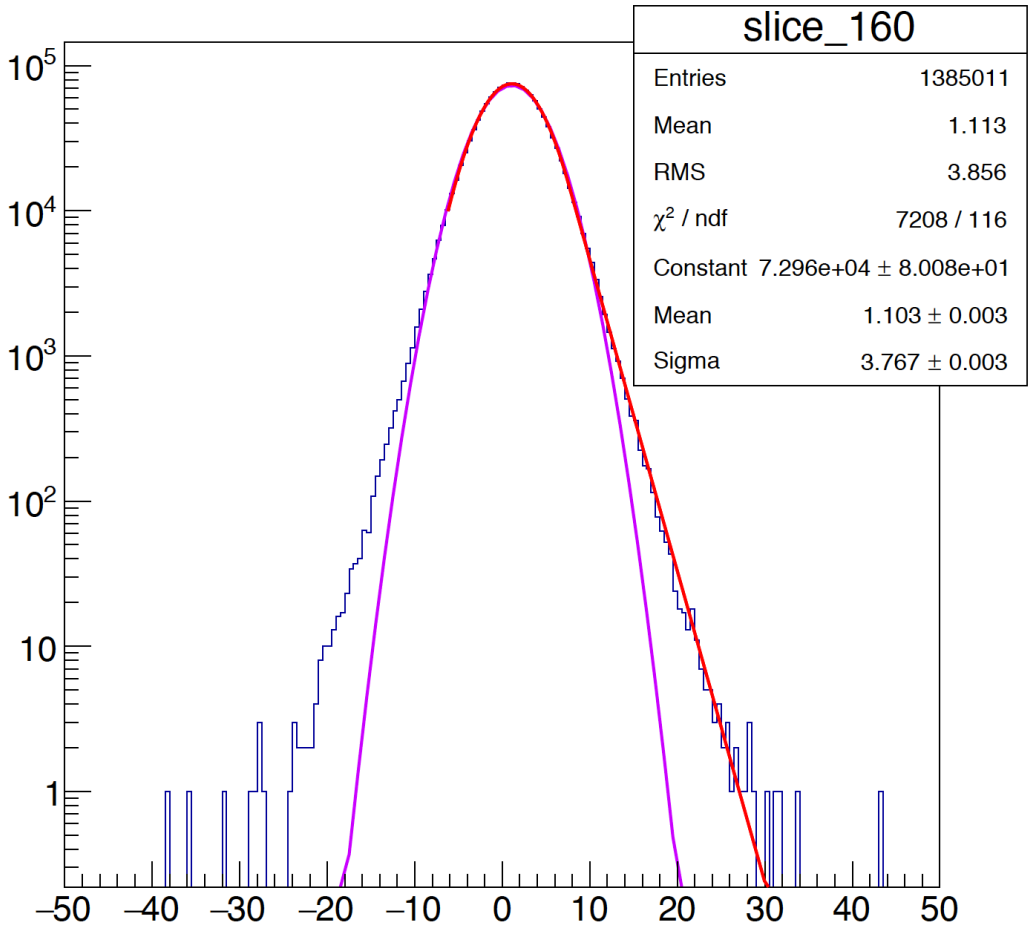
$$F(z < b) = Ae^{-\frac{(z - z_{mean})^2}{2\sigma^2}}$$

$$F(z > b) = Ae^{-\frac{b^2}{2\sigma^2} - \frac{z - z_{mean} - b}{l}}$$



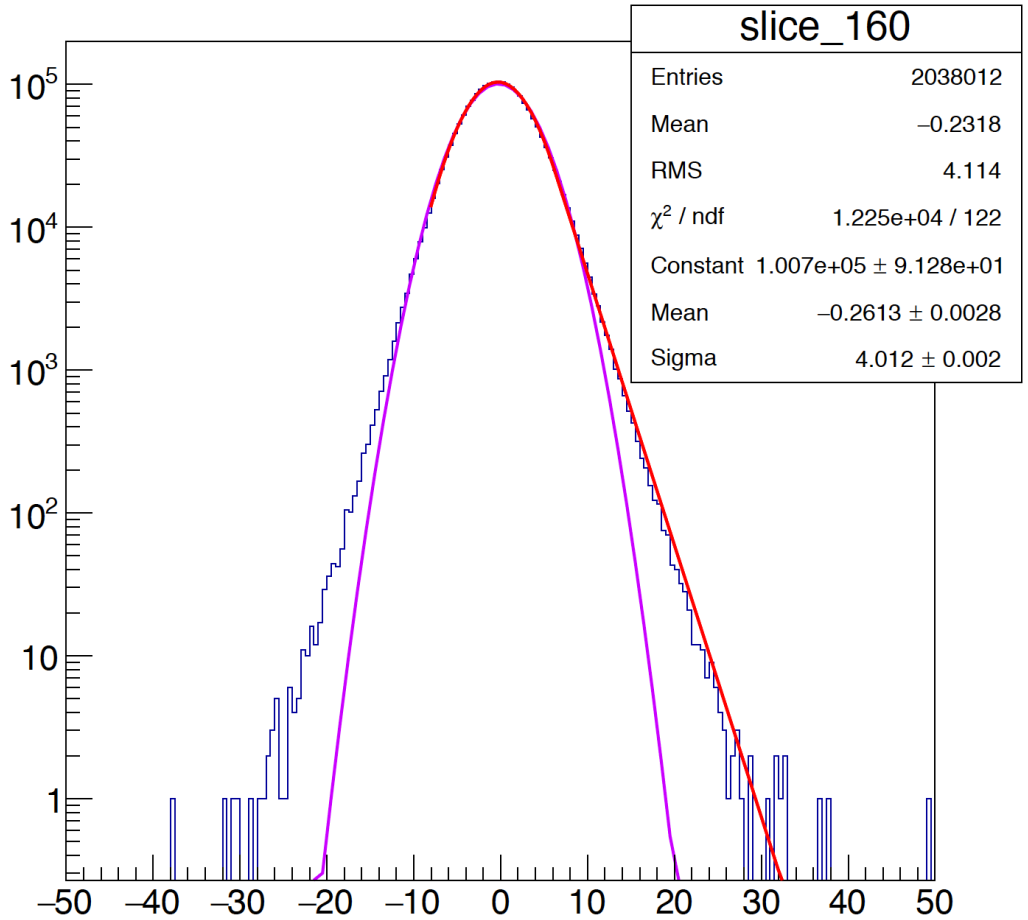
100% Monte Carlo (TTWB)

Z Vtx, Mass[0.0375, 0.0423],0.0399

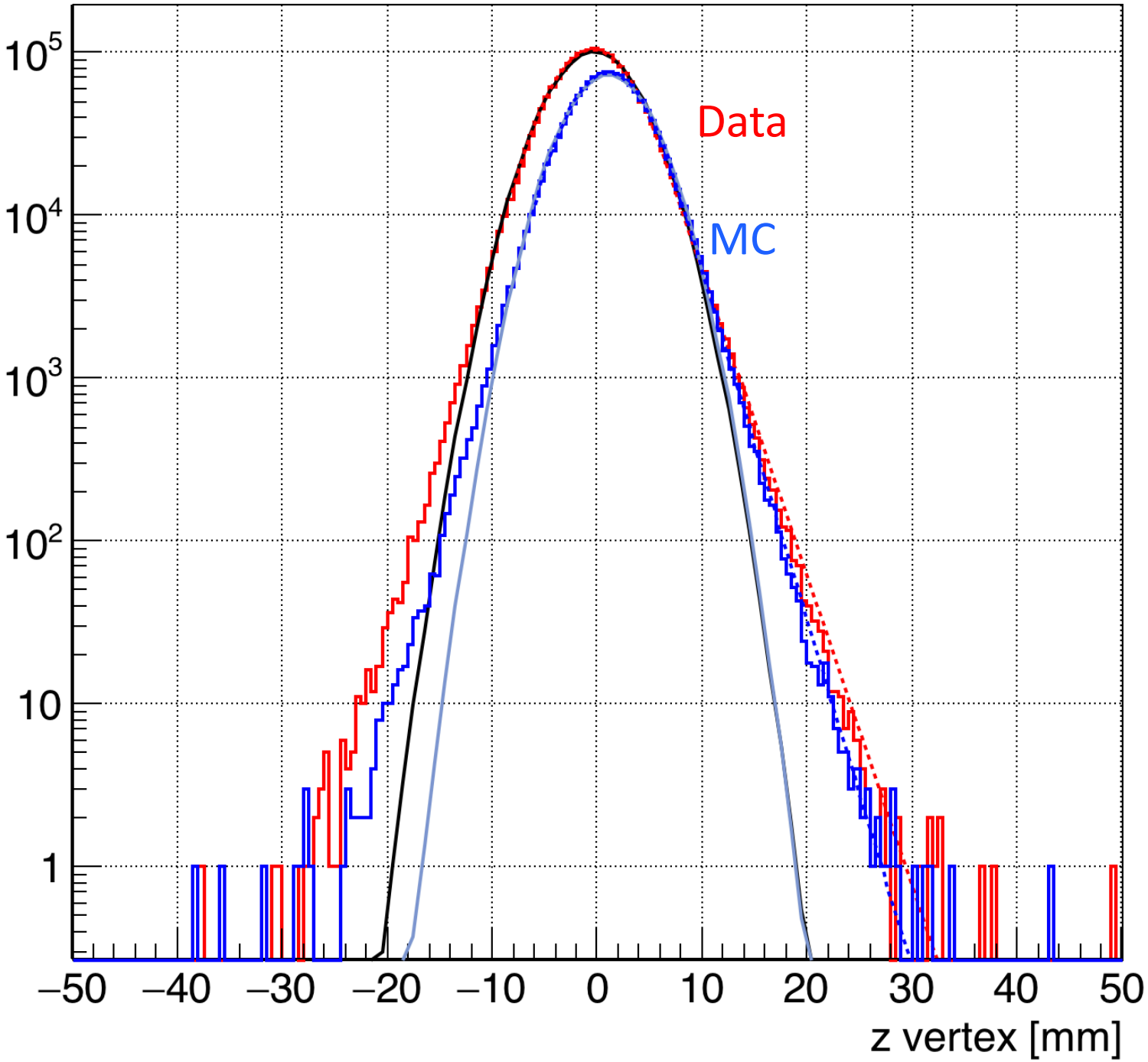


100% L1L1 pass 8 data

Z Vtx, Mass[0.0375, 0.0423],0.0399



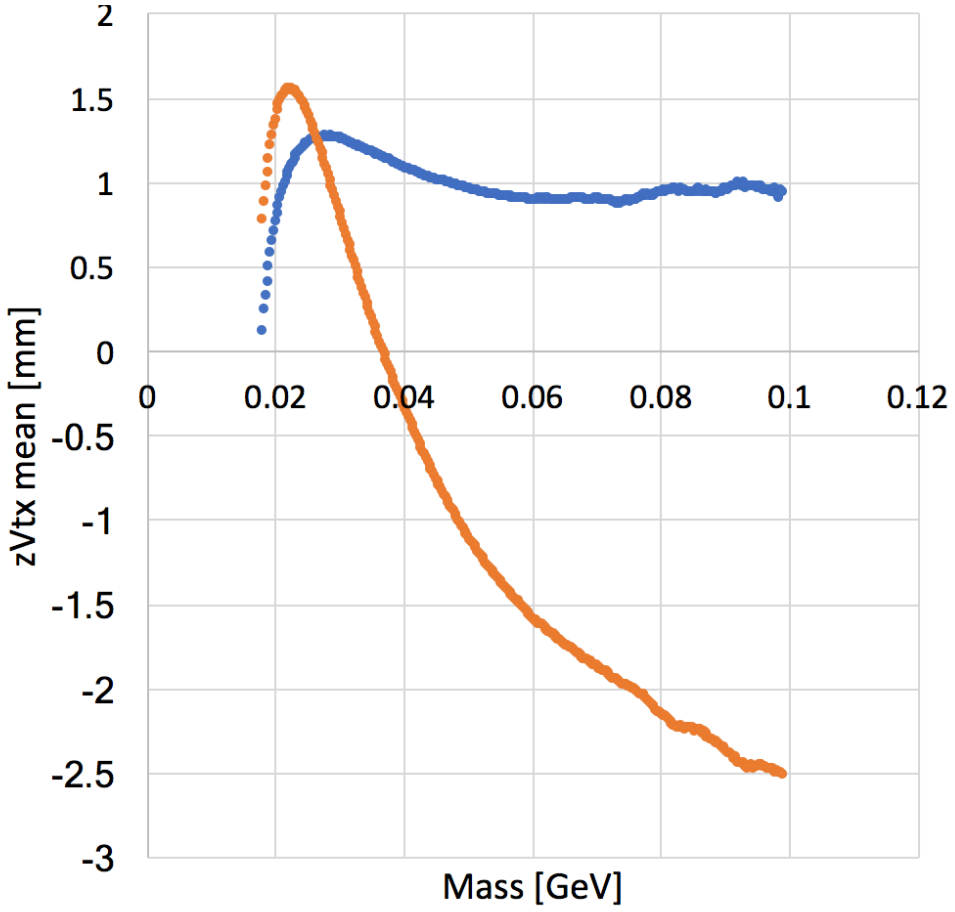
Same slice, superimposed:

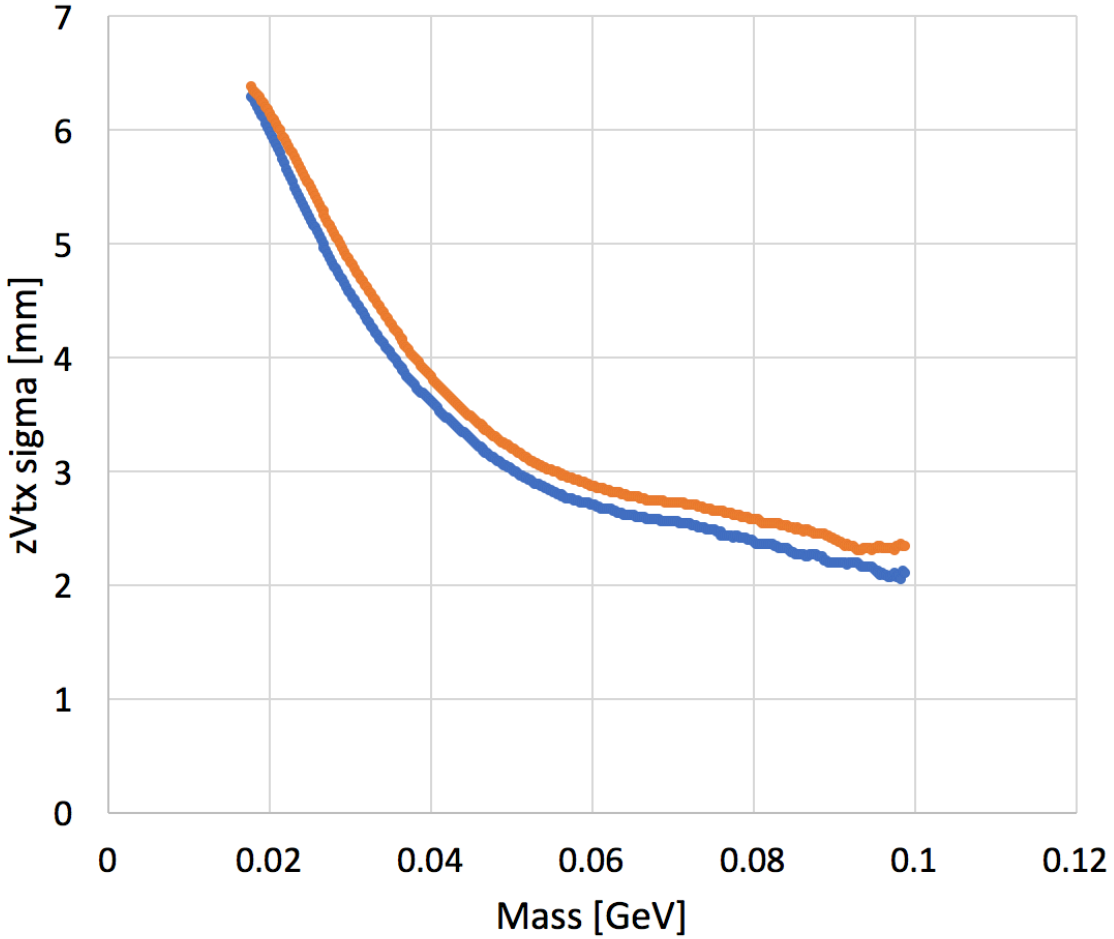


MC z vertex has constant offset

Data z vertex offset varies with mass (-> alignment!)

Data-pass 8, 100% L1L1
MC-TTWB, 100%

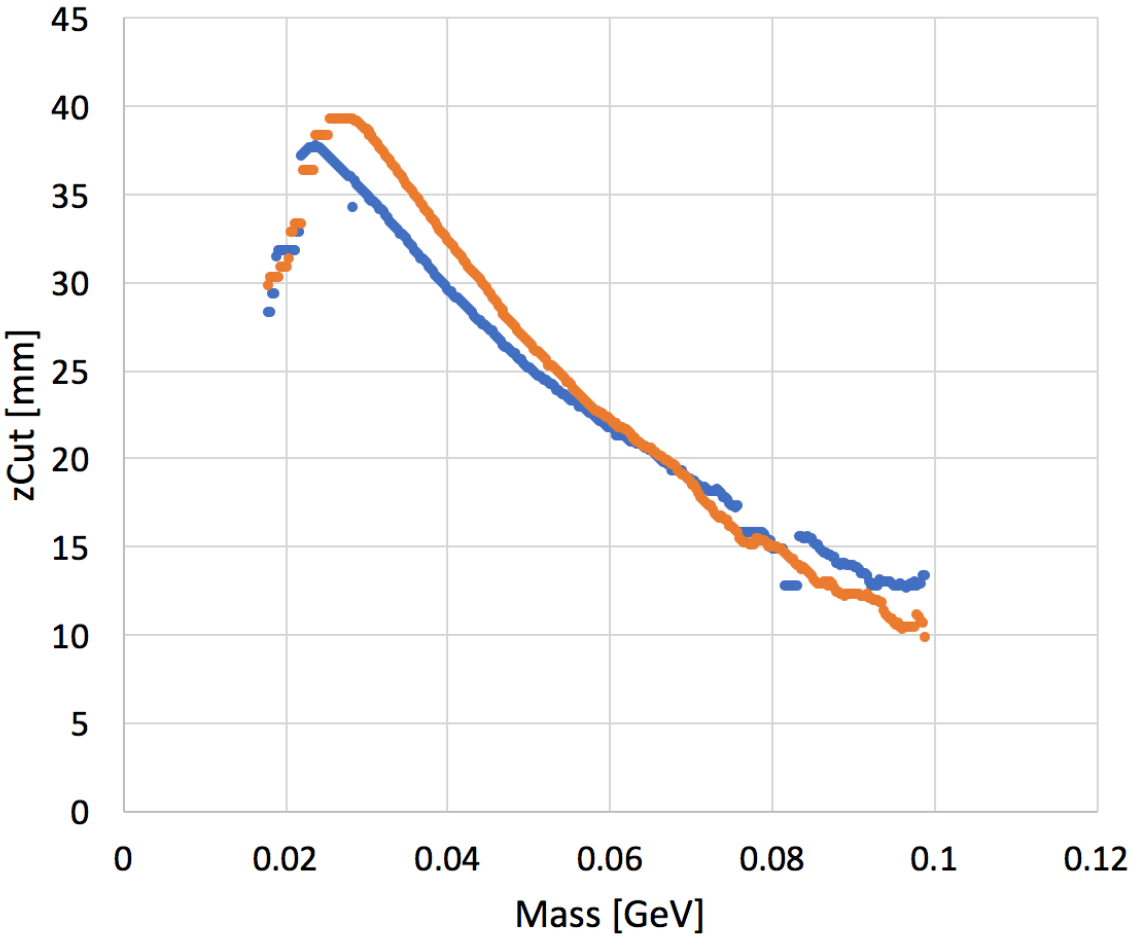


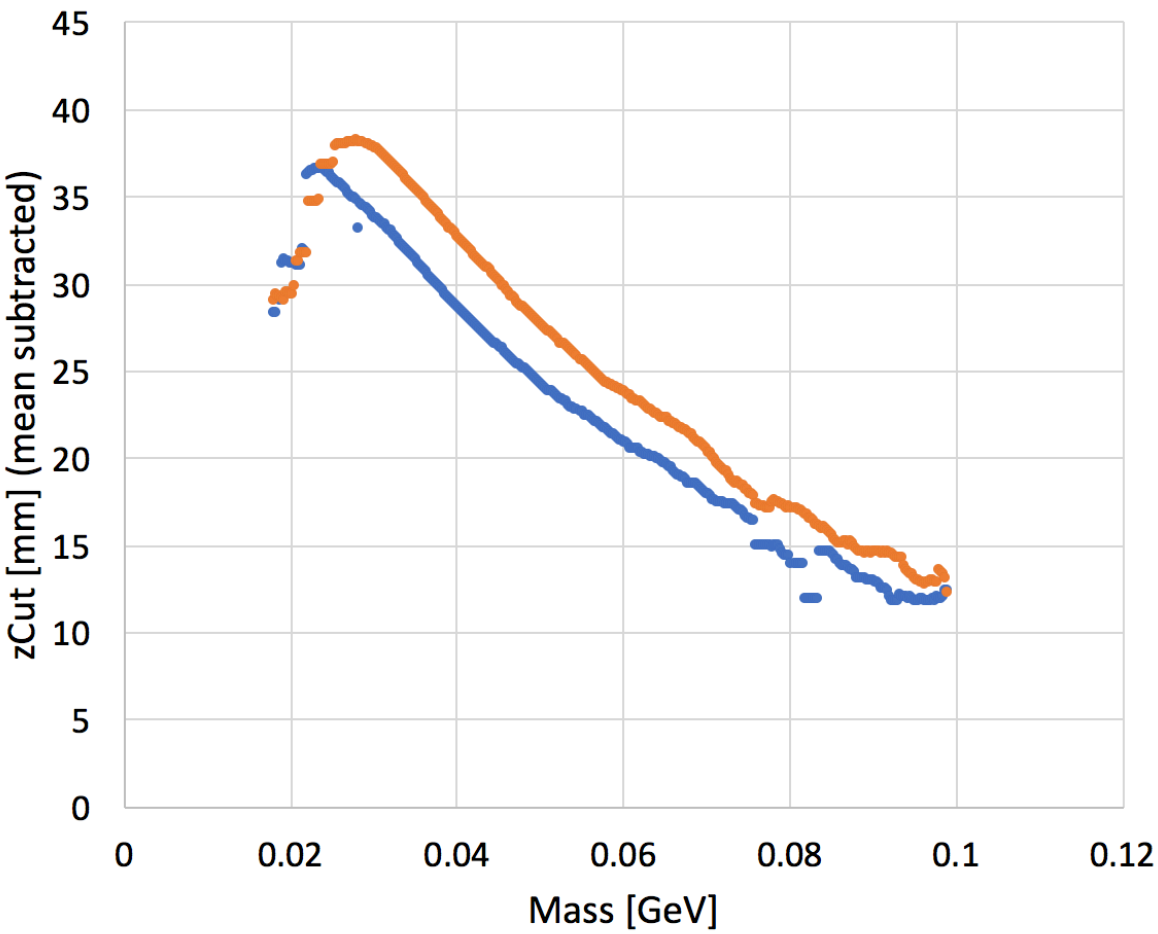


The mean was flat for tweak pass 6 (moved target to -5 mm to fix this effect)

Data-pass 8, 100% L1L1

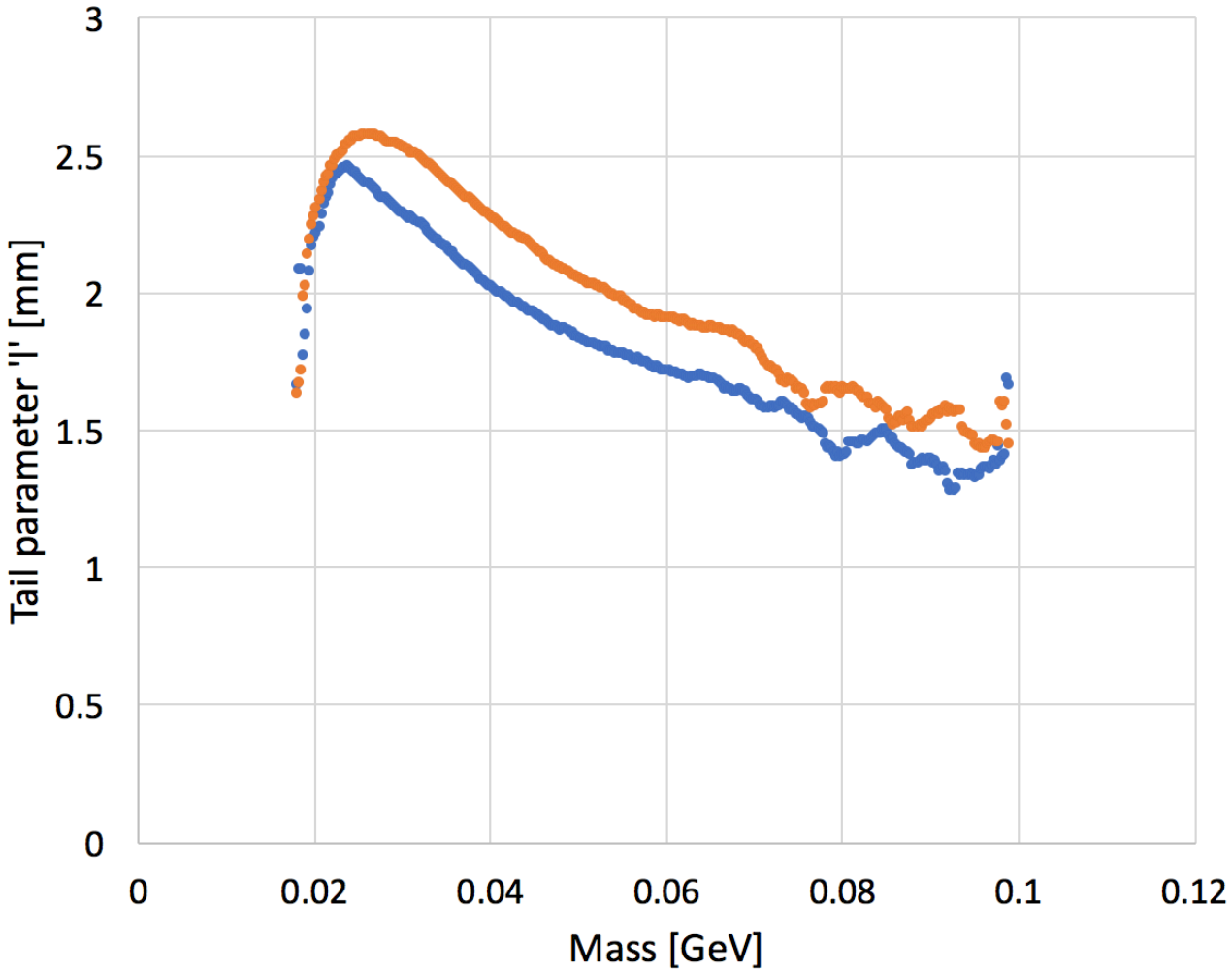
MC-TTWB, 100%

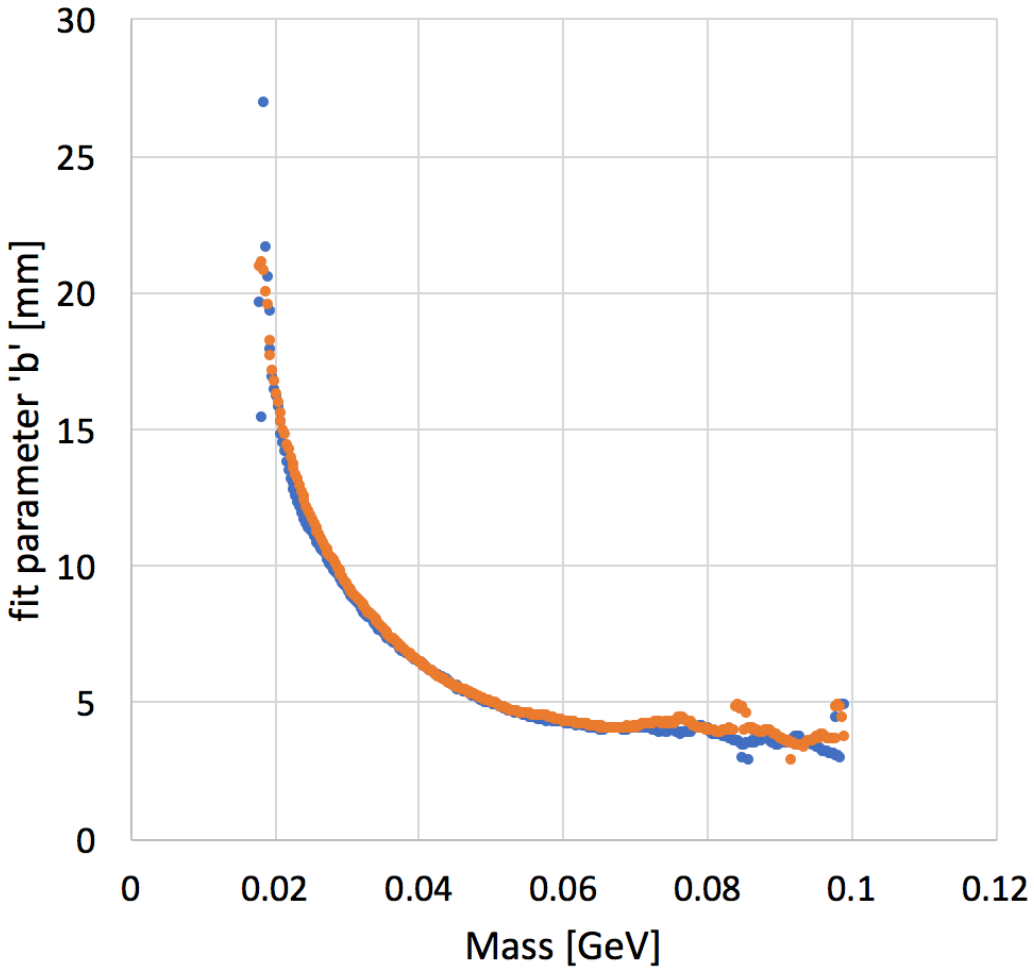




Data-pass 8, 100% L1L1

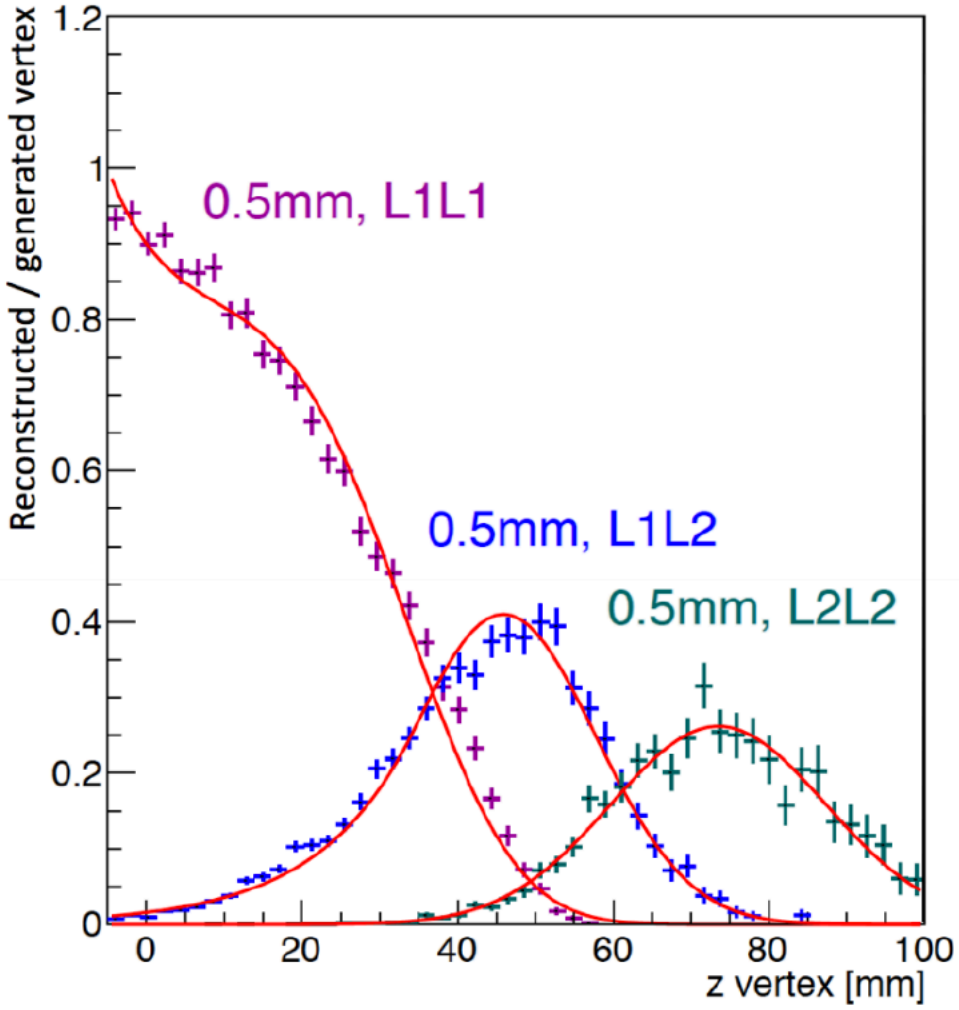
MC-TTWB, 100%





Systematics:

- Mass resolution/binning (Holly, Matt S, Matt G)
- Target position/alignment:
  - Rolls into mass resolution, mostly
  - Vertex zCuts are data-driven, relative to core
  - How does alignment shift high z events between bins?
- Radiative fraction (Brad)
- Fit model: (Matt G/Holly)
  - How does this affect zCut/backgrounds and reach?
- Vertex efficiency: (Matt S)
  - From MC
  - How to justify?



Number of A’ we expect to measure

84% A’ signal in mass bin

Historically, we chose $\delta_{mA} = +/- 1.4\sigma_m$, $\epsilon_{bin} = 84\%$

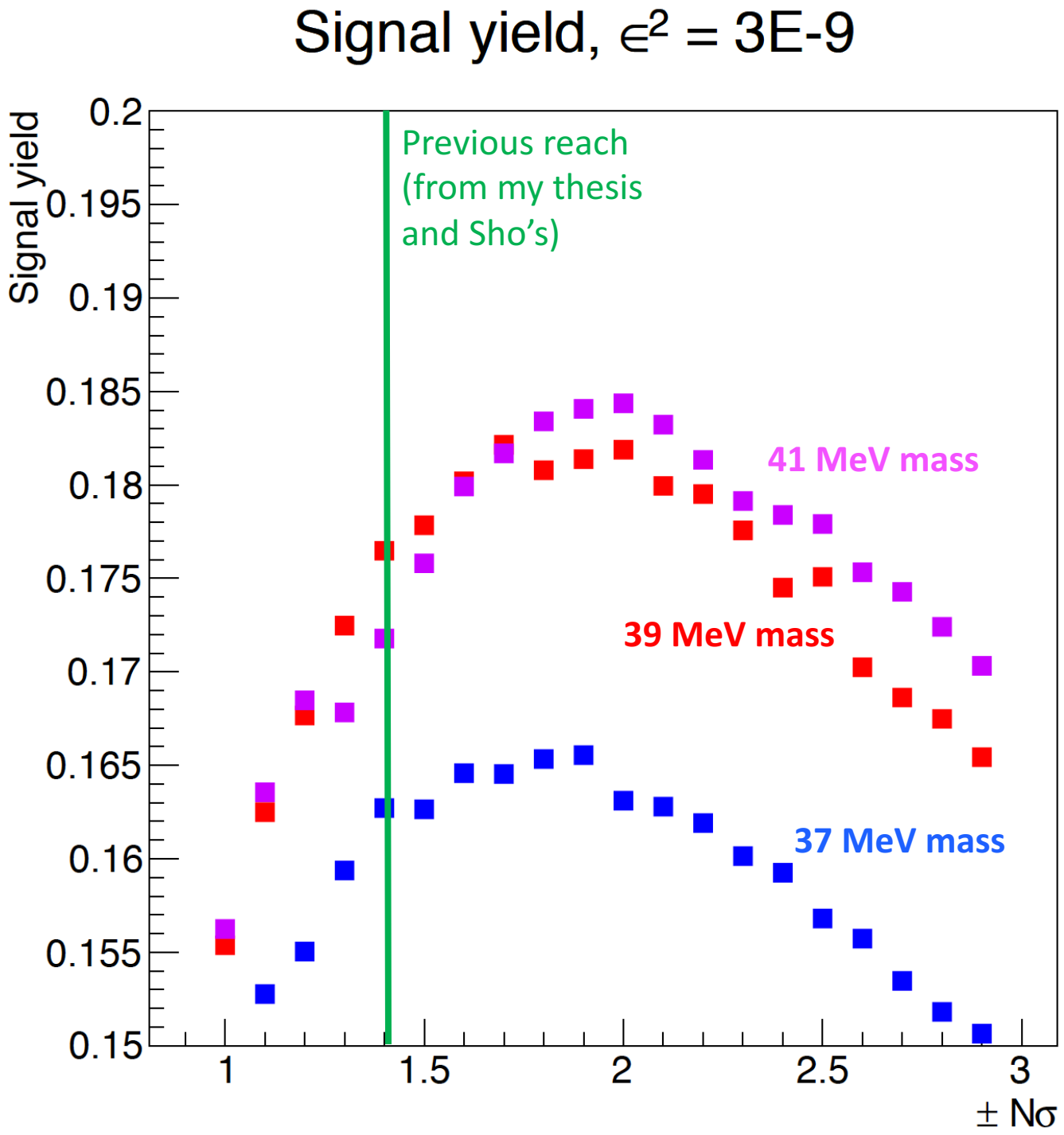
$$S_{bin,zCut} = \left(\frac{N_{rad}}{N_{tot}}\right) N_{bin} \left(\frac{3\pi\epsilon^2}{2N_{eff}\alpha}\right) \left(\frac{m_{A'}}{\delta m_{A'}}\right) \epsilon_{bin} \int_{zCut}^{zMax} \frac{e^{-ztgt - z/\gamma c\tau}}{\gamma c\tau} \epsilon_{vtx}(z, m_{A'}) dz$$

A’ yield in mass bin

Fraction of events beyond zCut we can reconstruct (includes inefficiencies and acceptance effects)

By choosing a coupling with high yield of A’, and various masses, we can optimize signal yield

Pretty significant!



Optimal bin width:
+/- 1.9σ_m

Summary:

- Pass 8 alignment incorrect- vertex position?
- Large sample MC generally produces the high z backgrounds
- Errors on vertex projection may be key (check correlations)
- Does the mis-alignment hurt the mass resolution? Can we roll with it to get a result? Probably.
  - Tweak pass 8?
- Lots of tools in place to analyze the backgrounds and Monte Carlo

- If we want result for ICHEP: either remove final background events or incorporate them in S/sqrt(B), lots to talk about backgrounds and vertex technique for future analyses

Lots of work, thanks Norman, Takashi, Matt G, and Matt S!