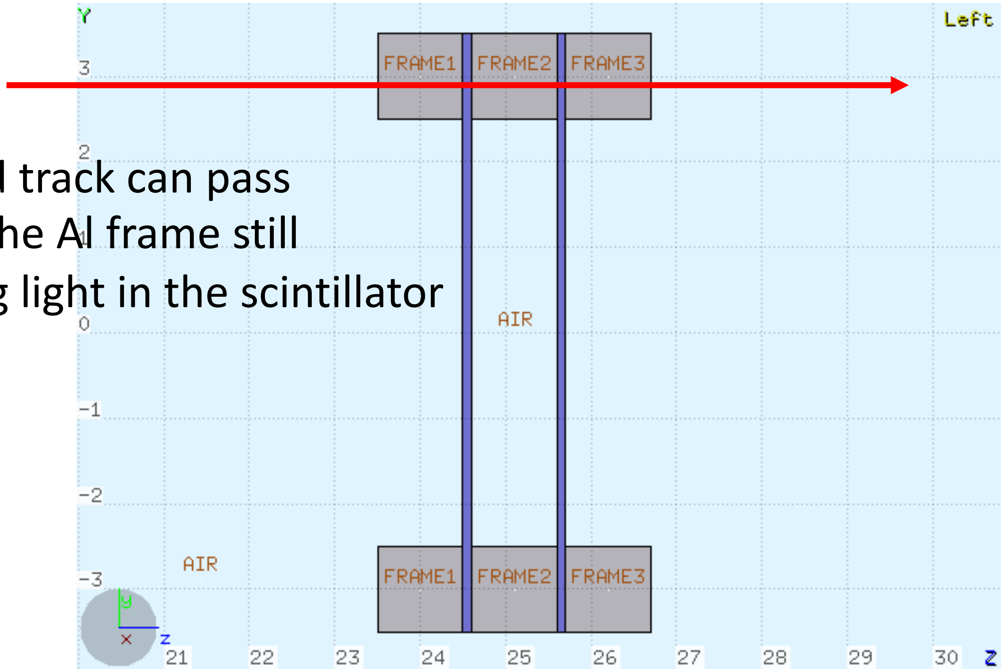
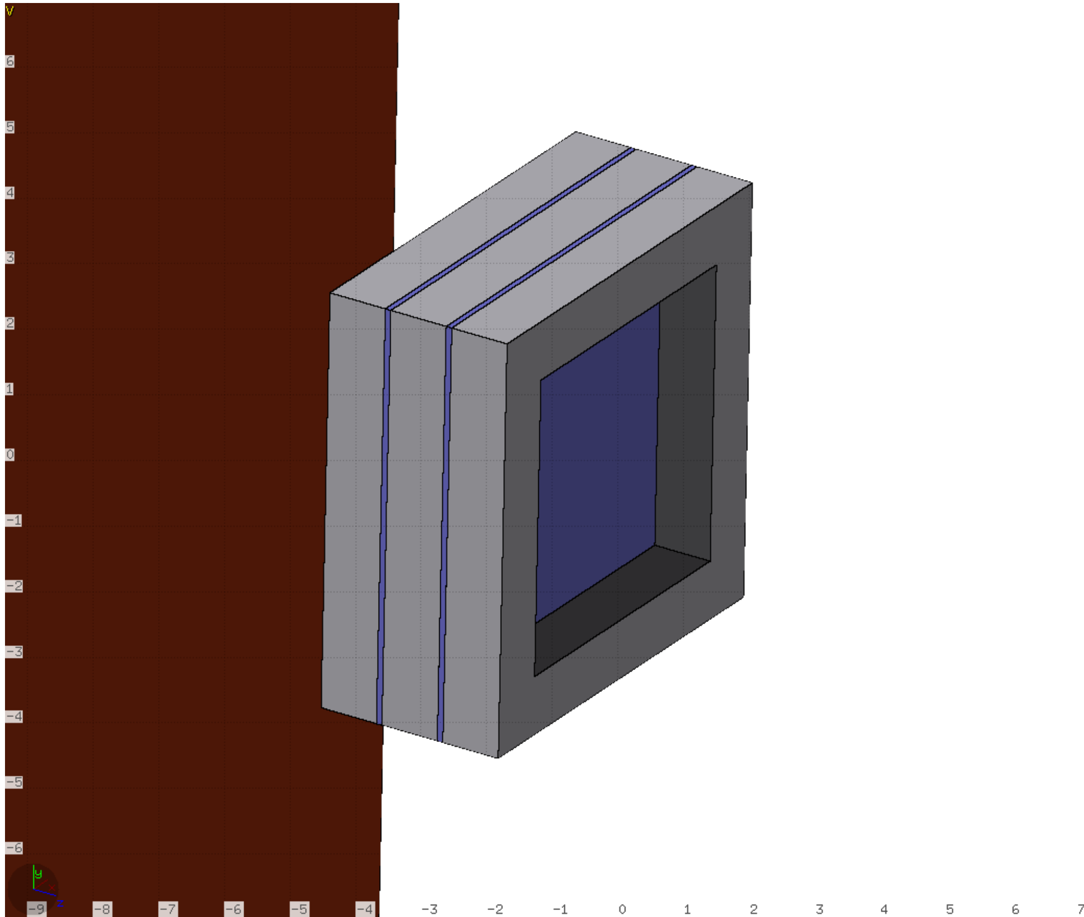
MC Simulation Update

Geometry improvements

- Latest coordinates and distances of different components
- Addition of passive material on Start Counter (Al frame)

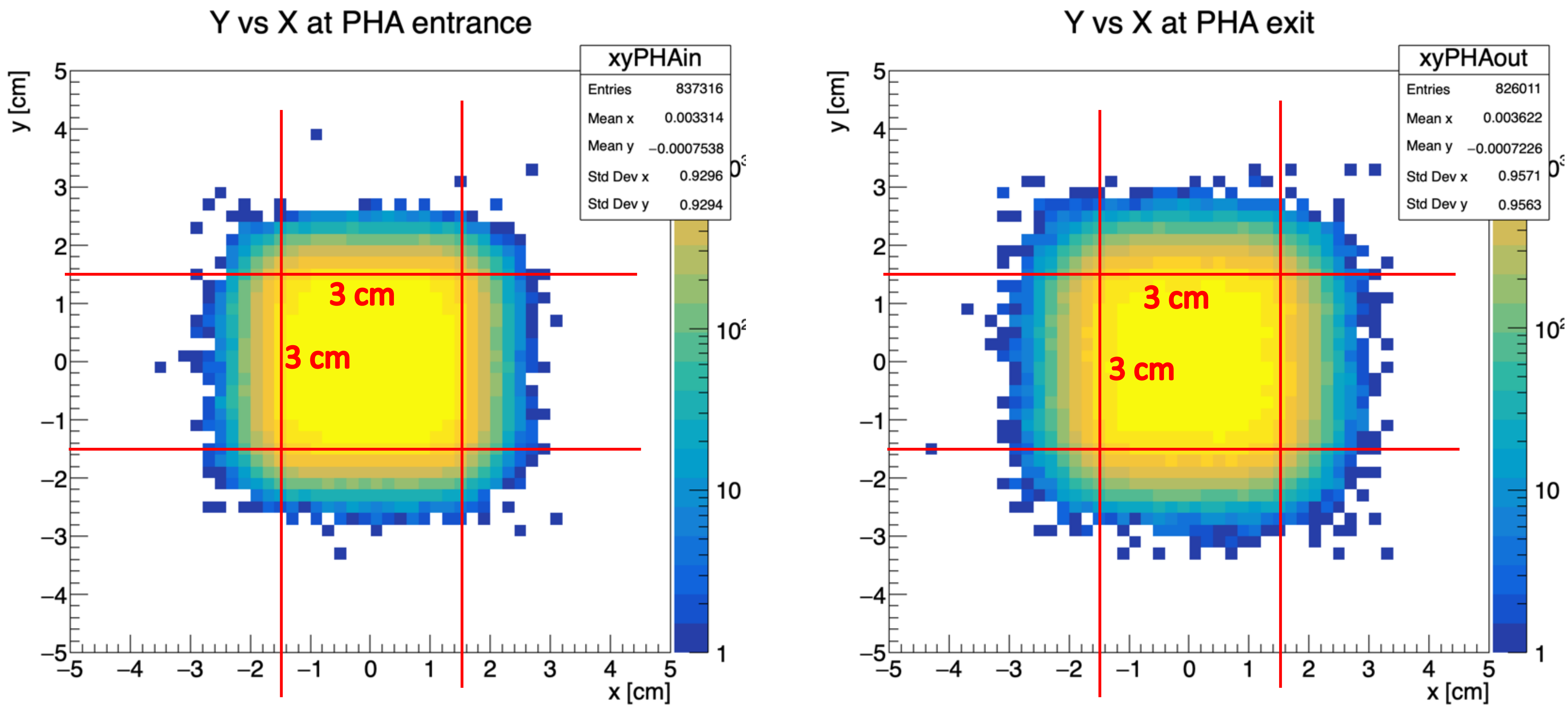
A charged track can pass through the Al frame still producing light in the scintillator





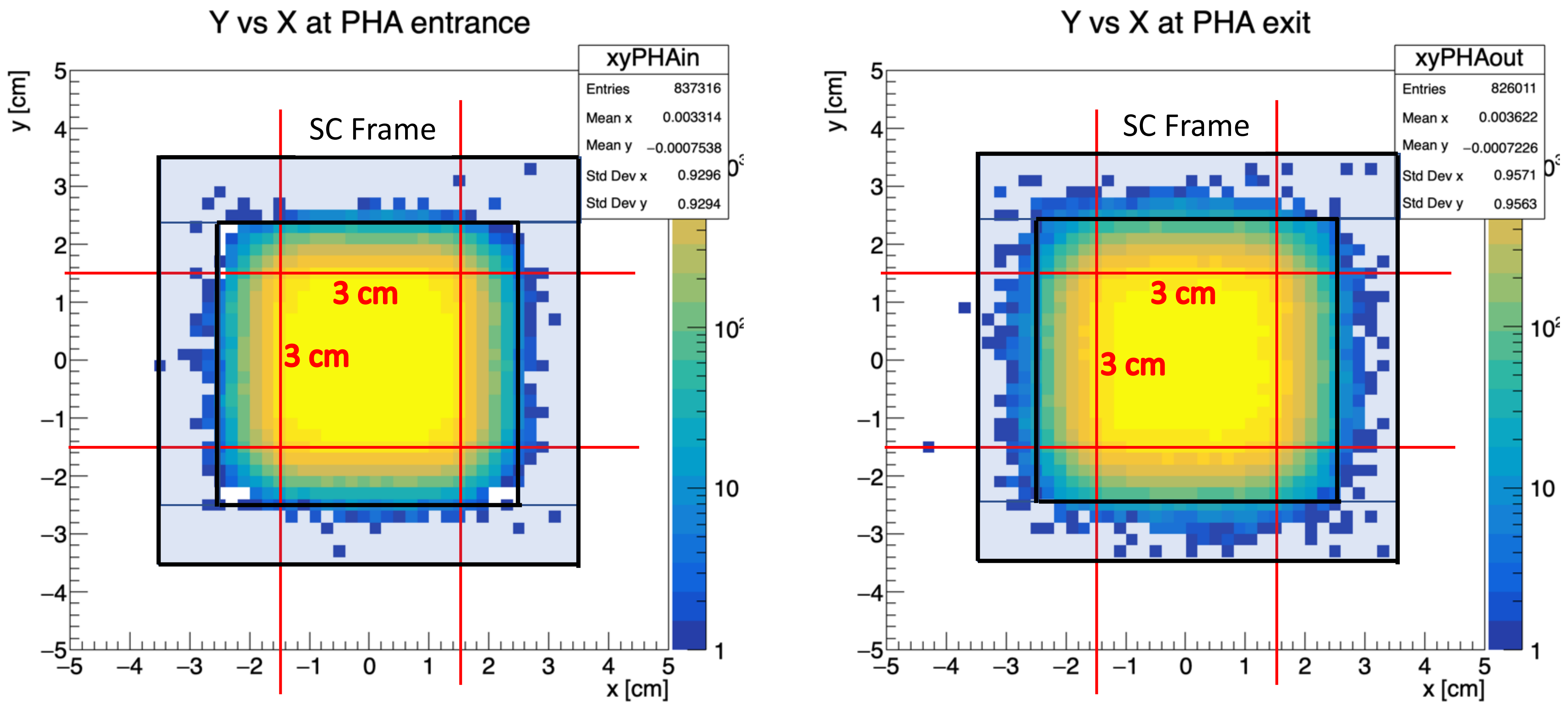
Widening of the field in passing through the phantom

Input beam size 3x3 cm^2: -1.5<x<1.5 cm; -1.5<y<1.5 cm



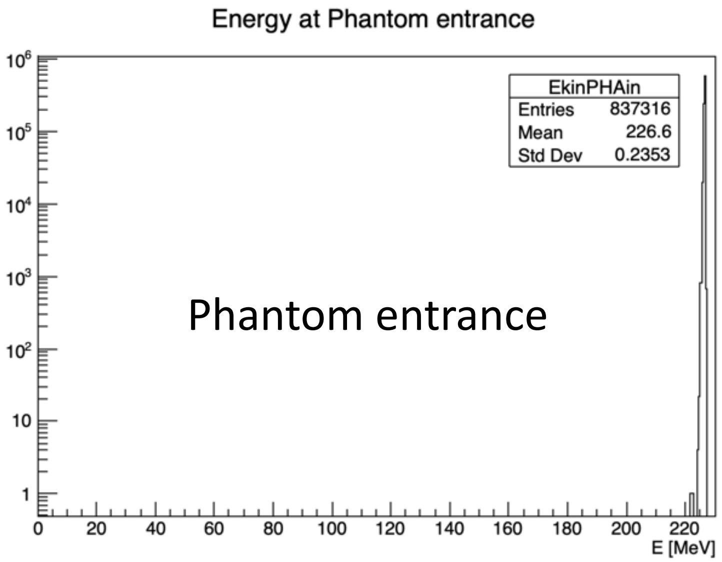
Widening of the field in passing through the phantom

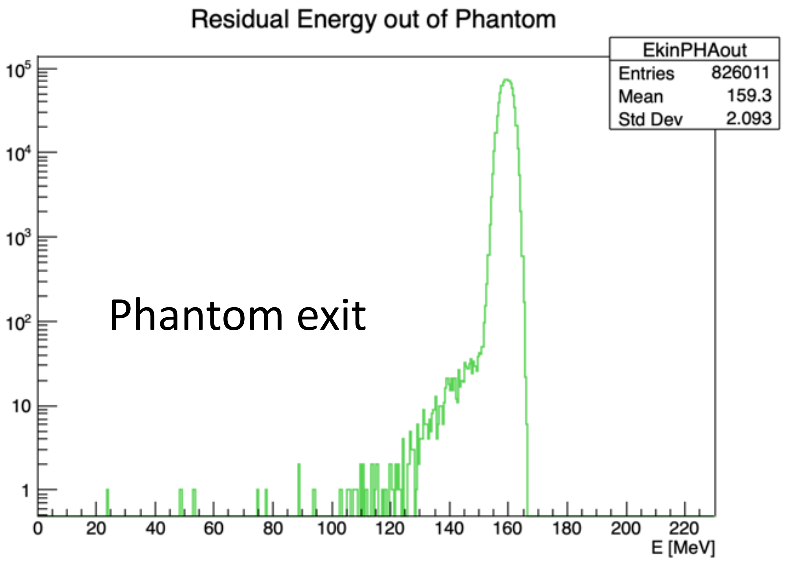
Input beam size 3x3 cm^2: -1.5<x<1.5 cm; -1.5<y<1.5 cm



There are tails in the space distribution hitting the SC frame

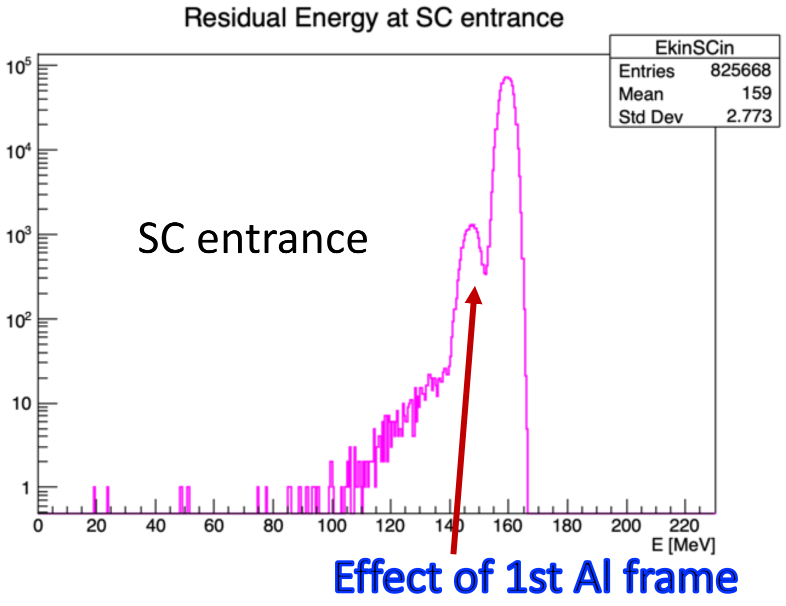
Energy of protons at different depths

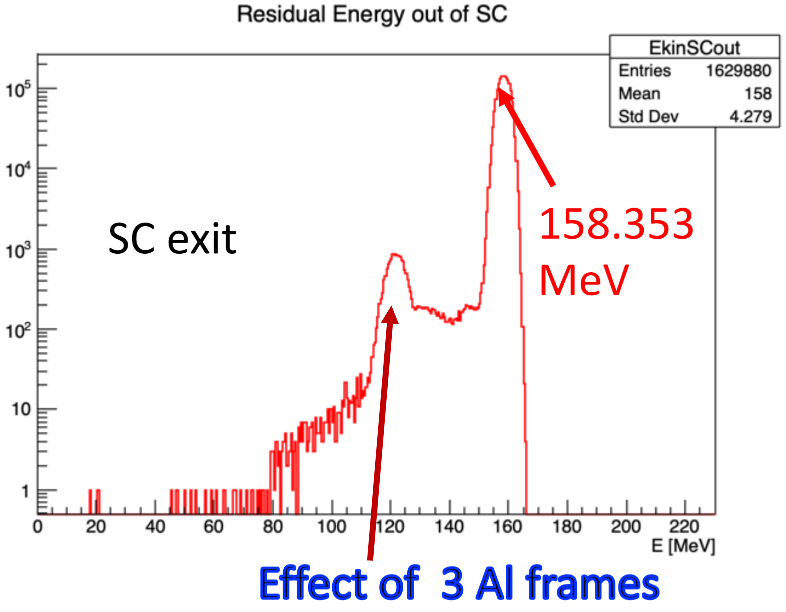


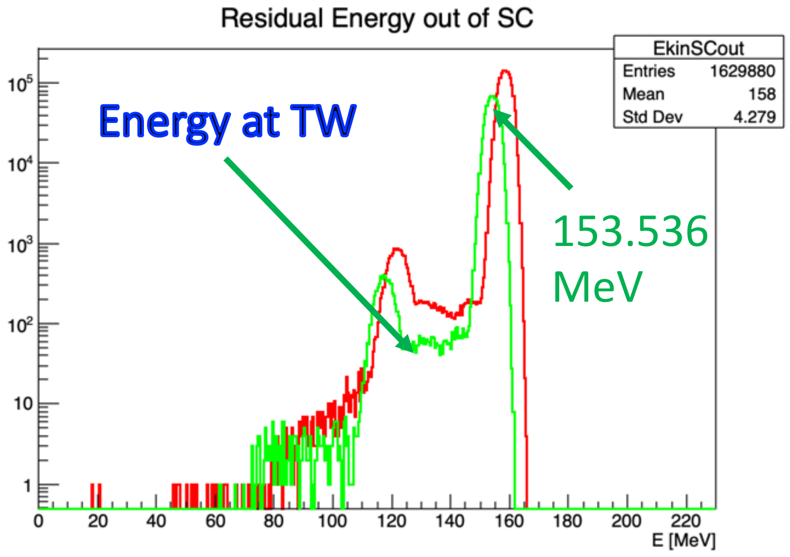


Input beam size:

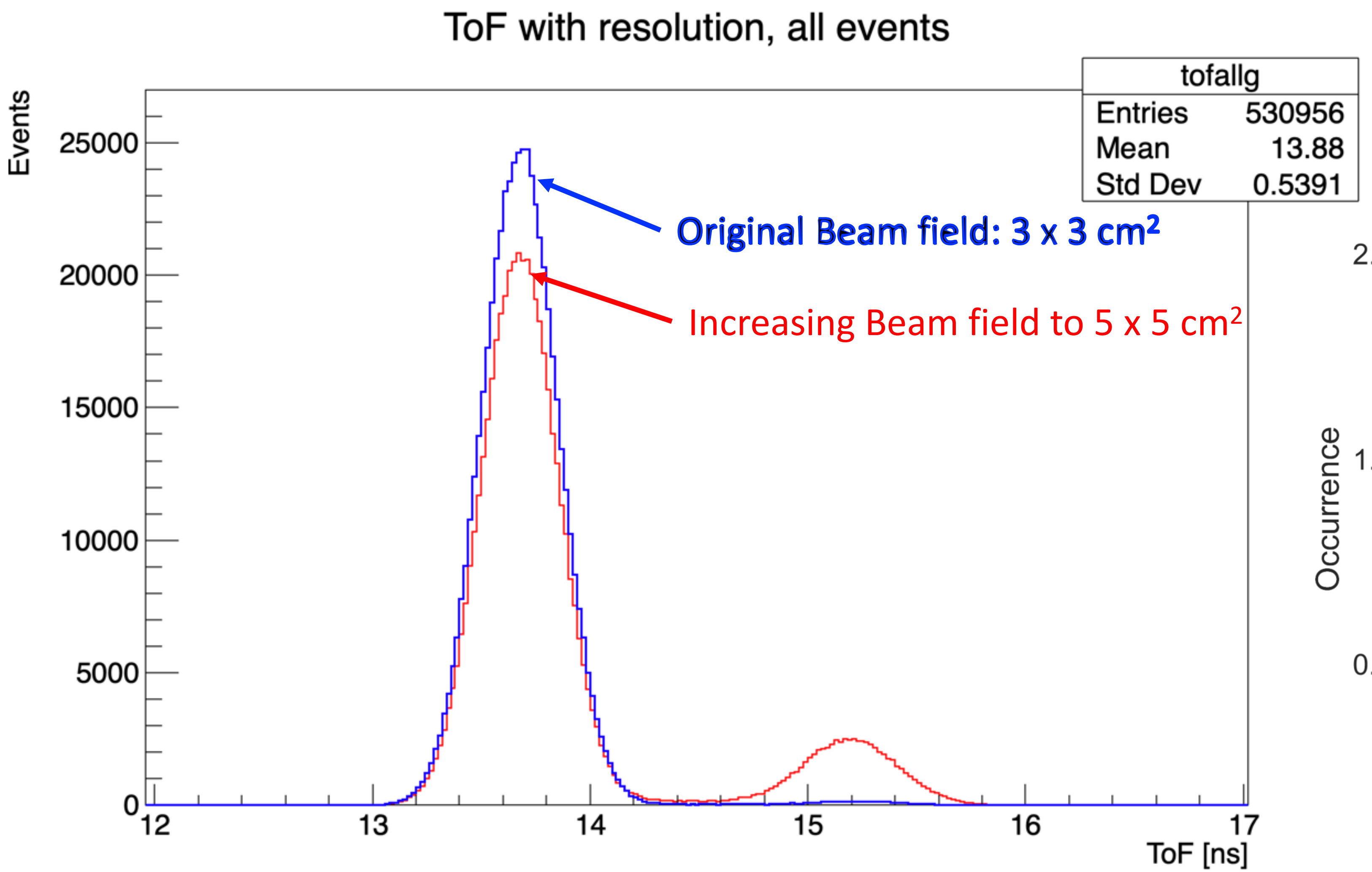
-1.5<x<1.5 cm; -1.5<y<1.5 cm

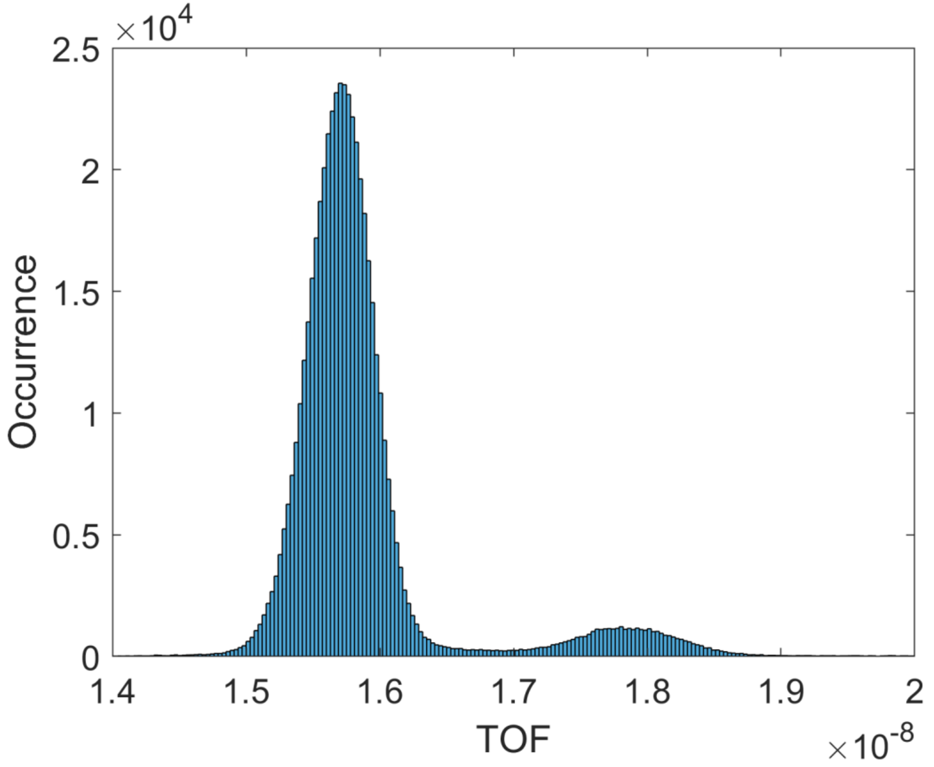




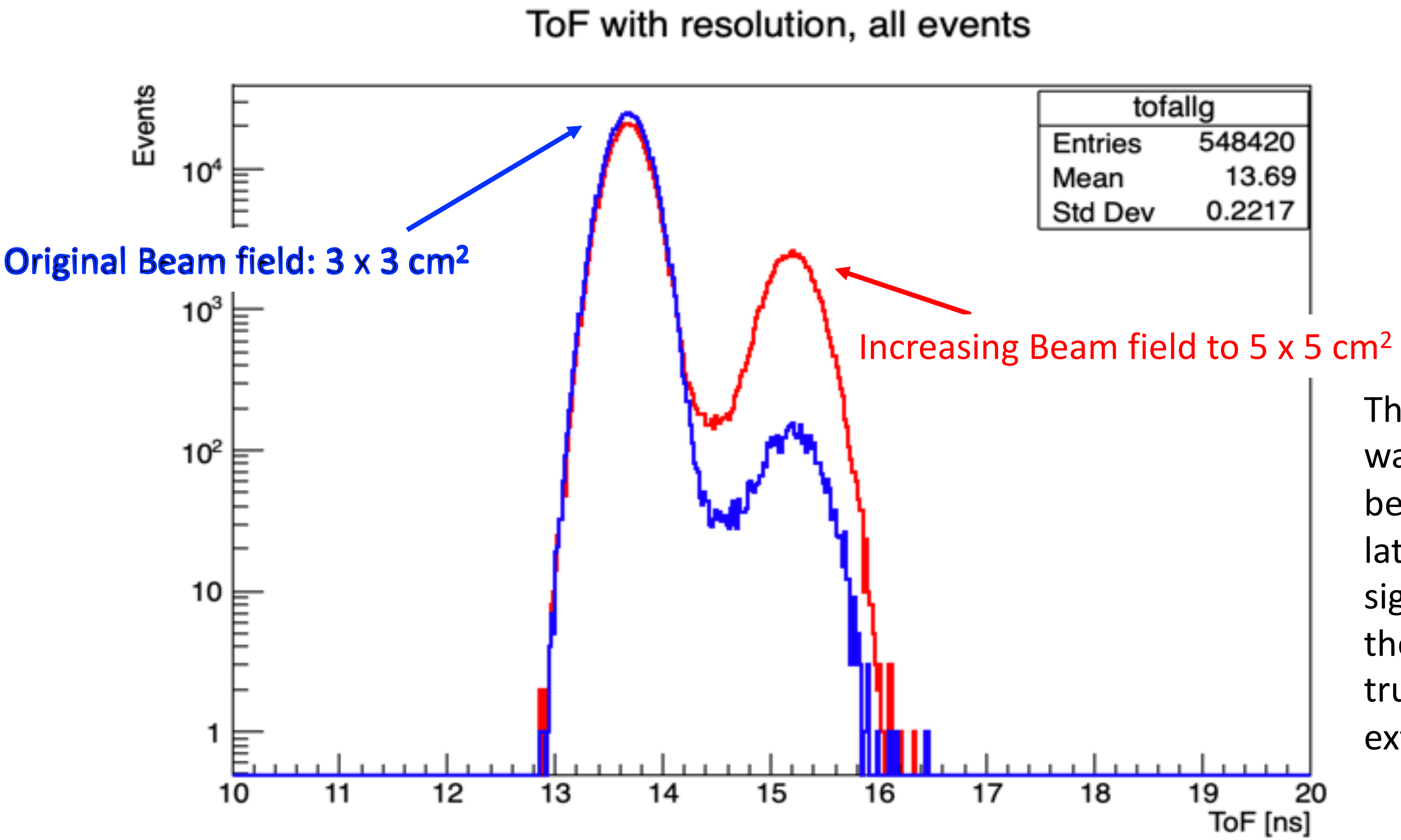


Effect on TOF distribution (using 160 ps resolution)



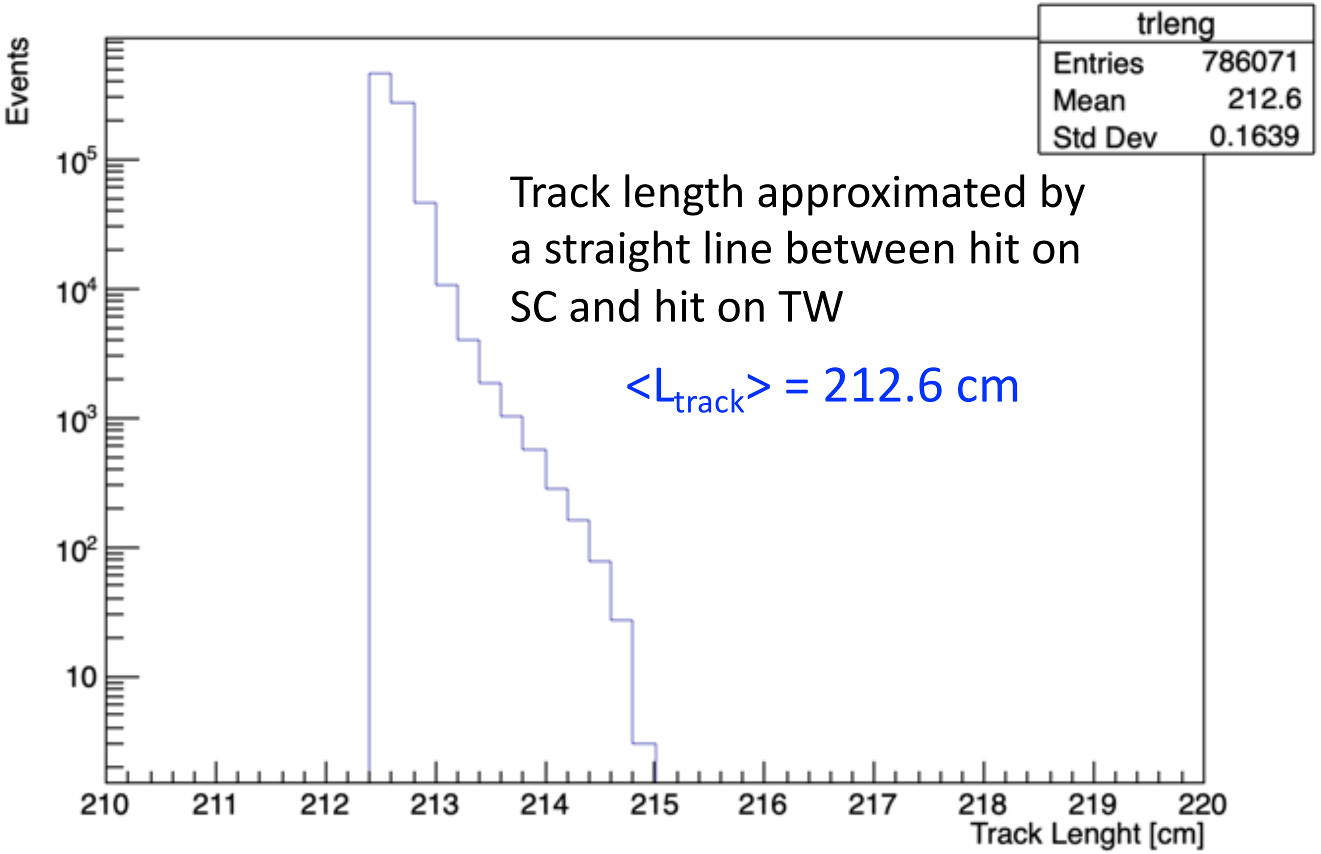


Effect on TOF distribution (using 160 ps resolution)



The actual experimental situation was somehting intermediate between these 2 cases, or the lateral spread of the beam was significantly larger with respect to the expectations (this could be true in the case of low-intensity extraction)

Justification of ToF value



Track length approximated by a straight line between hit on SC and hit on TW

$\langle L_{track} \rangle = 212.6$ cm

In the path from SC to TW:

$\langle E_{kin} \rangle = 155.9445$ MeV → $\beta = 0.5145$

ToF = $\langle L_{track} \rangle / (\beta * 29.979246) = 13.78$ ns

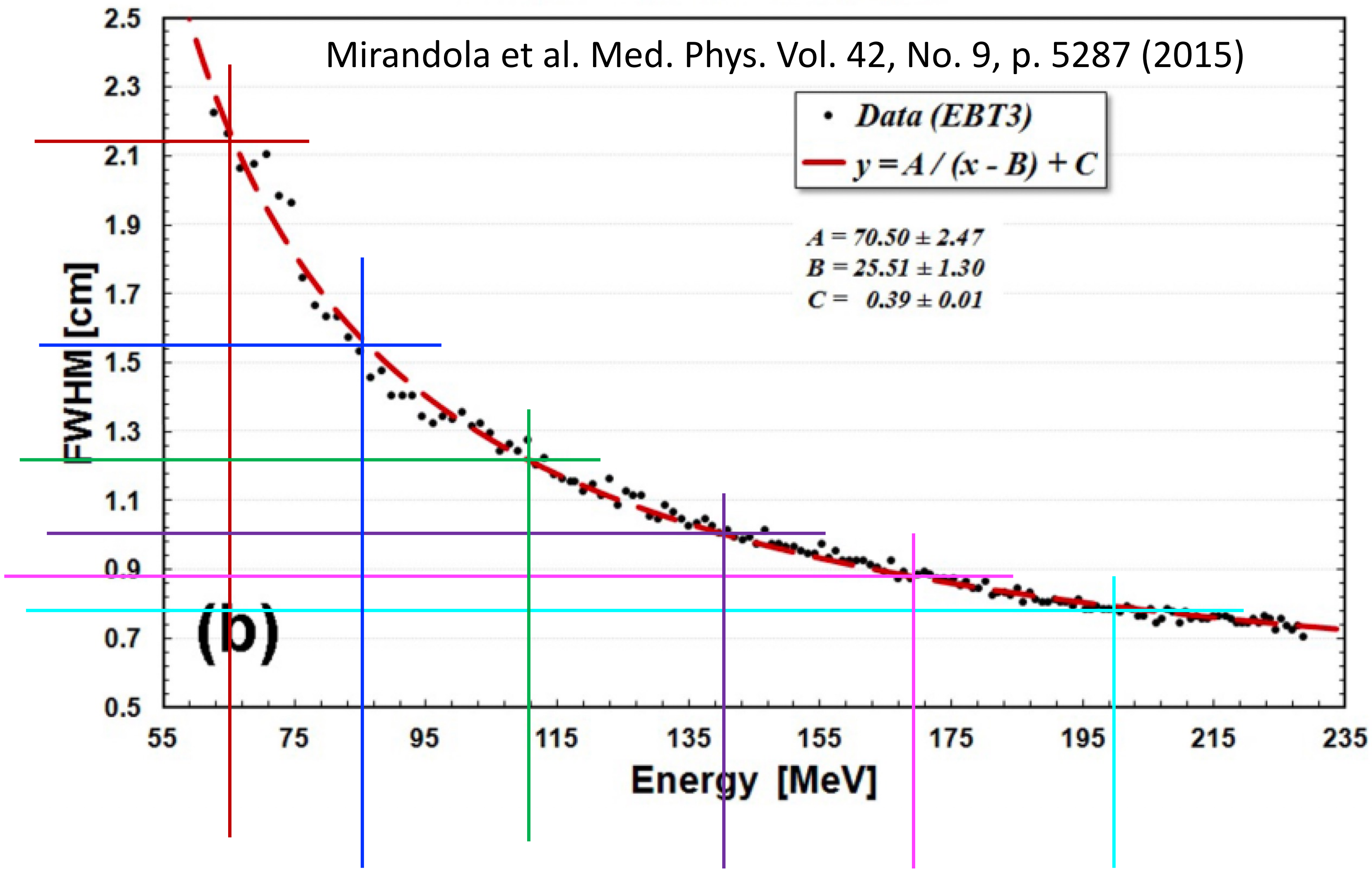
In order to get the measured <ToF> ~ 15.4 ns we would need to evaluate the Δt due to cables, etc.

Simulation of ToF calibration runs

Fixed beam, no phantom

Simulation repeated also in vacuum

x,y FWHM of beam vs energy



Summary of results

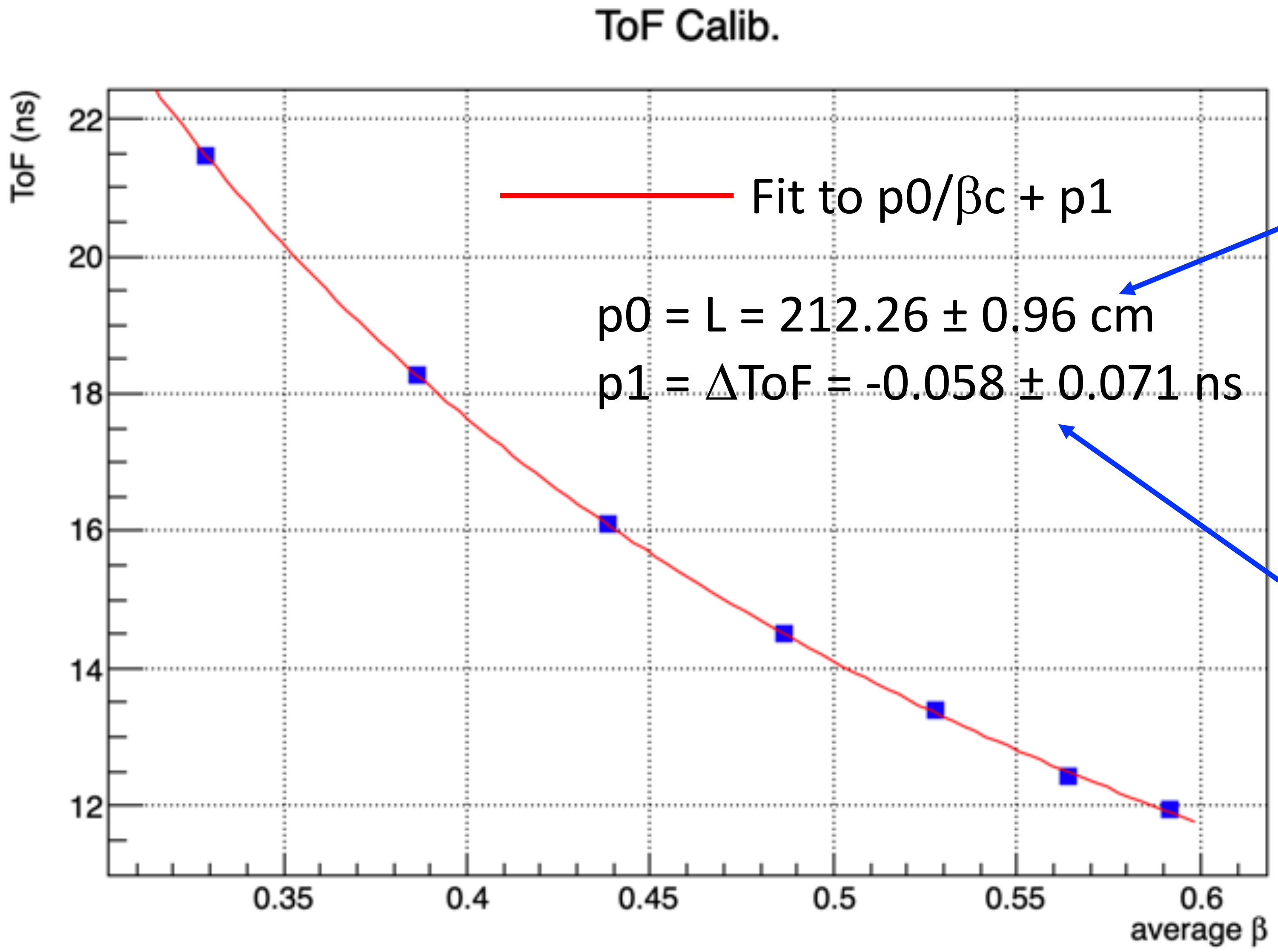
Beam Energy	$\langle\beta_{beam}\rangle$	<Energy> out of SC (MeV)	<Energy> at TW (MeV)	ΔE in Air (MeV)	$\langle\beta_{true}\rangle$	ToF in Air (ns)	Tof in Vacuum (ns)
62.73	0.3484	57.09	53.95	3.14	0.3287	21.47	21.14
84.94	0.3989	80.57	78.18	2.39	0.3867	18.26	18.12
110.41	0.4466	106.74	104.78	1.96	0.4382	16.11	16.04
139.77	0.4924	136.65	135.00	1.65	0.4865	14.51	14.47
169.88	0.5320	167.17	165.74	1.43	0.5277	13.38	13.36
200.84	0.5670	198.41	197.14	1.27	0.5637	12.43	12.51
228.57	0.5945	226.33	225.16	1.17	0.5917	11.94	11.92

Effective $\langle E_{kin}\rangle$ is lower than nominal E_{kin} of beam.
Energy loss in Nozzle, Beam Monitor, SC and air is important

The lower is E_{kin}, the higher is energy loss

Effective $\langle\beta\rangle$ is lower than nominal β

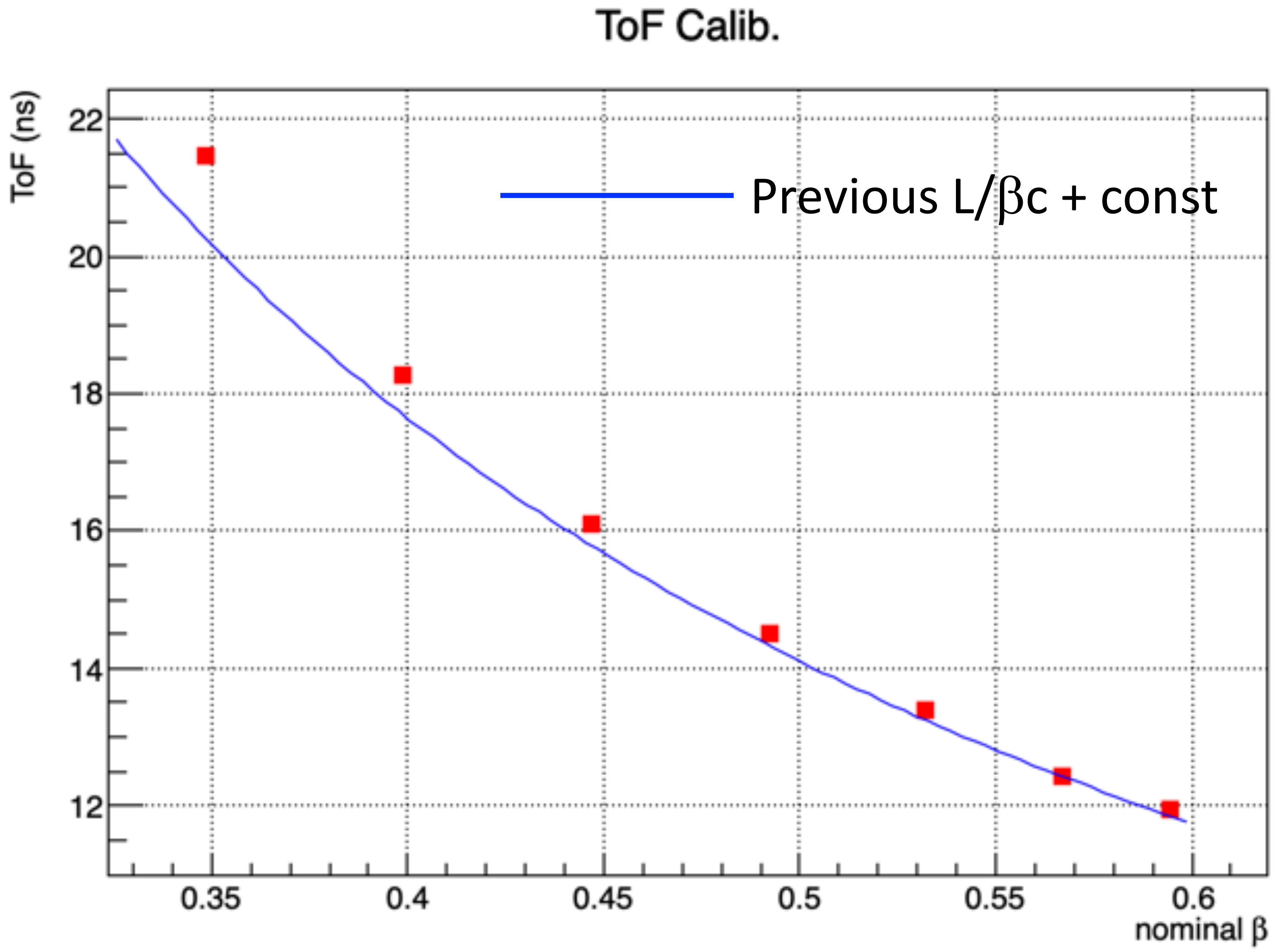
Fit using effective average β



$\langle L_{track} \rangle$ = 212.6 cm

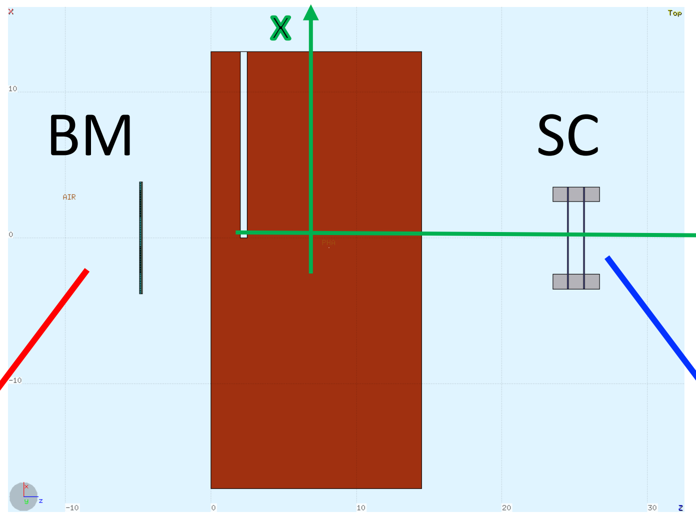
Compatible with 0, as it should be in a simulation

When using nominal β of beam

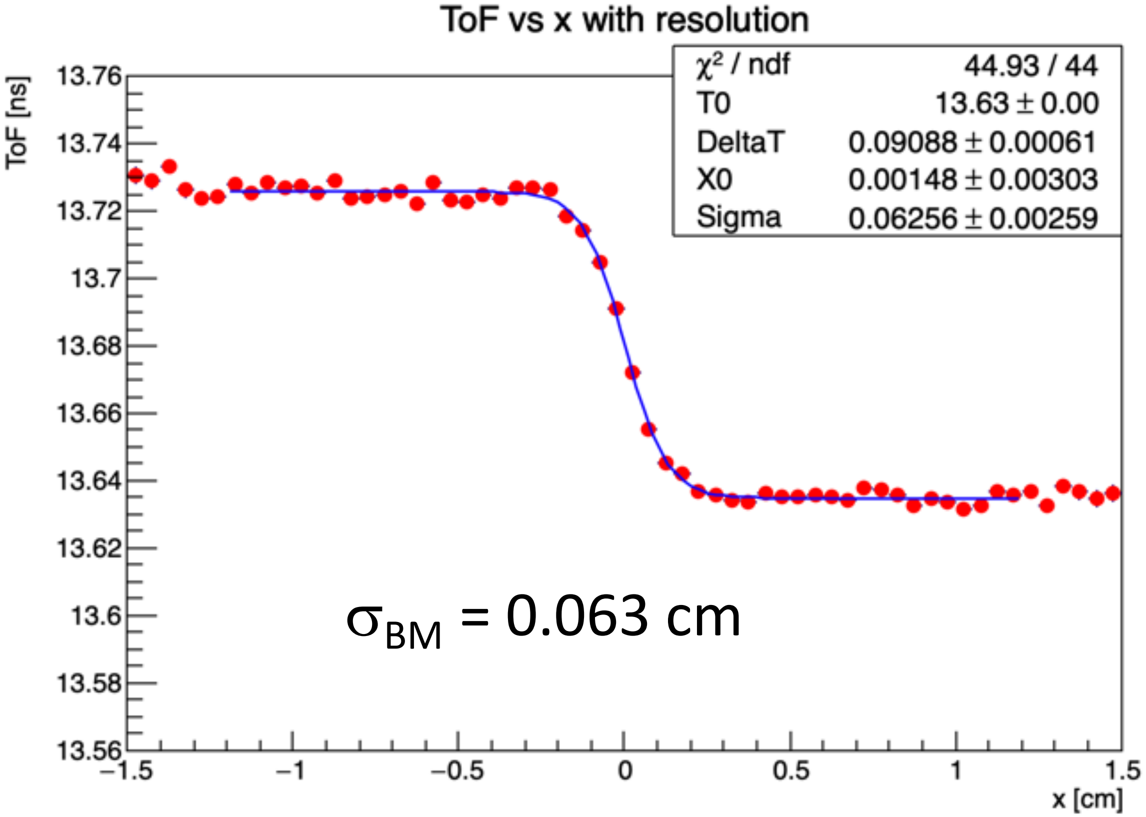


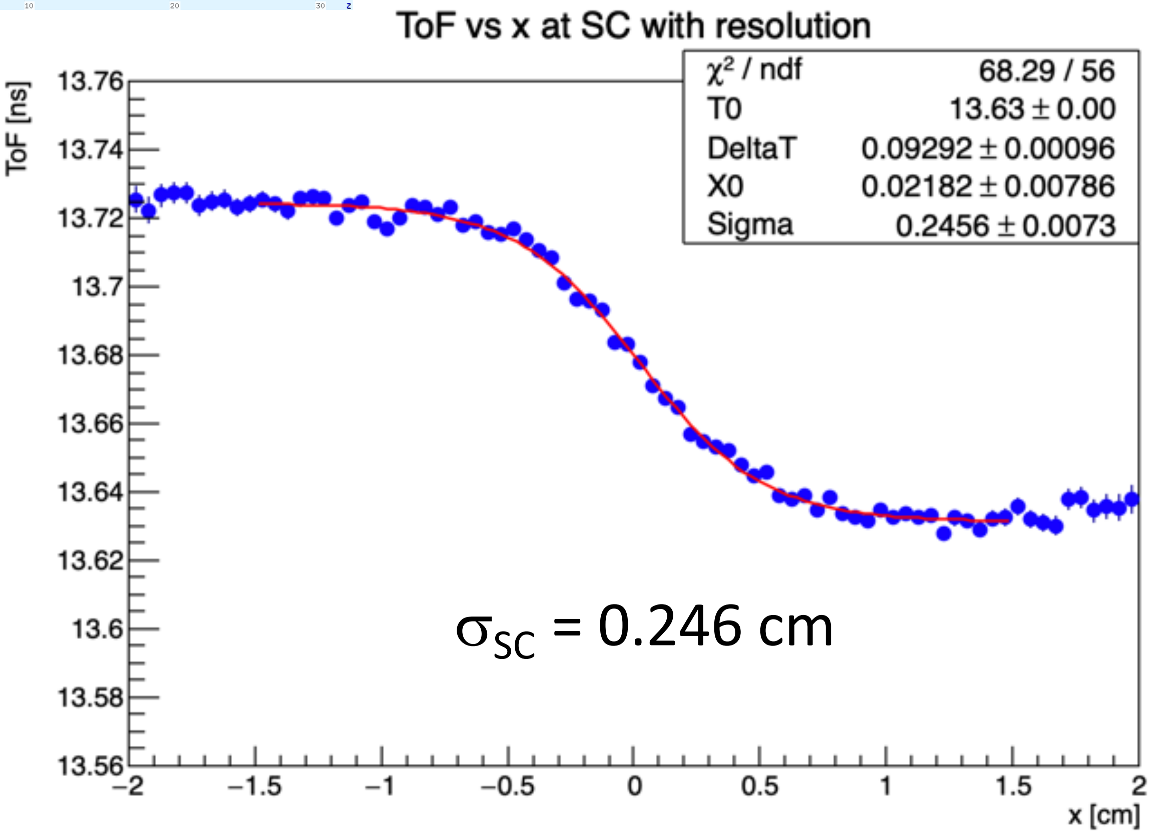
ToF vs X as a function of gap(0.5 cm) position

$$f(x) = t_0 + \Delta t\left(\frac{1}{1+e^{\frac{x-x_0}{\sigma}}}\right)$$



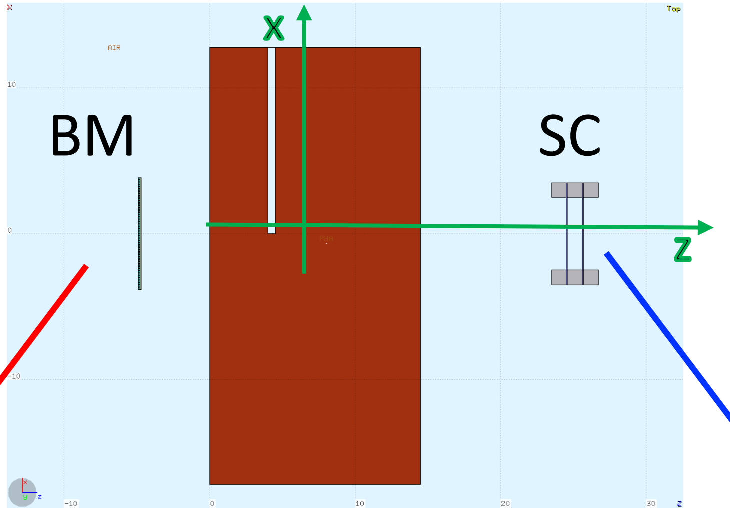
$Z_{fenditura}$ = 2 cm, gap = 5 mm



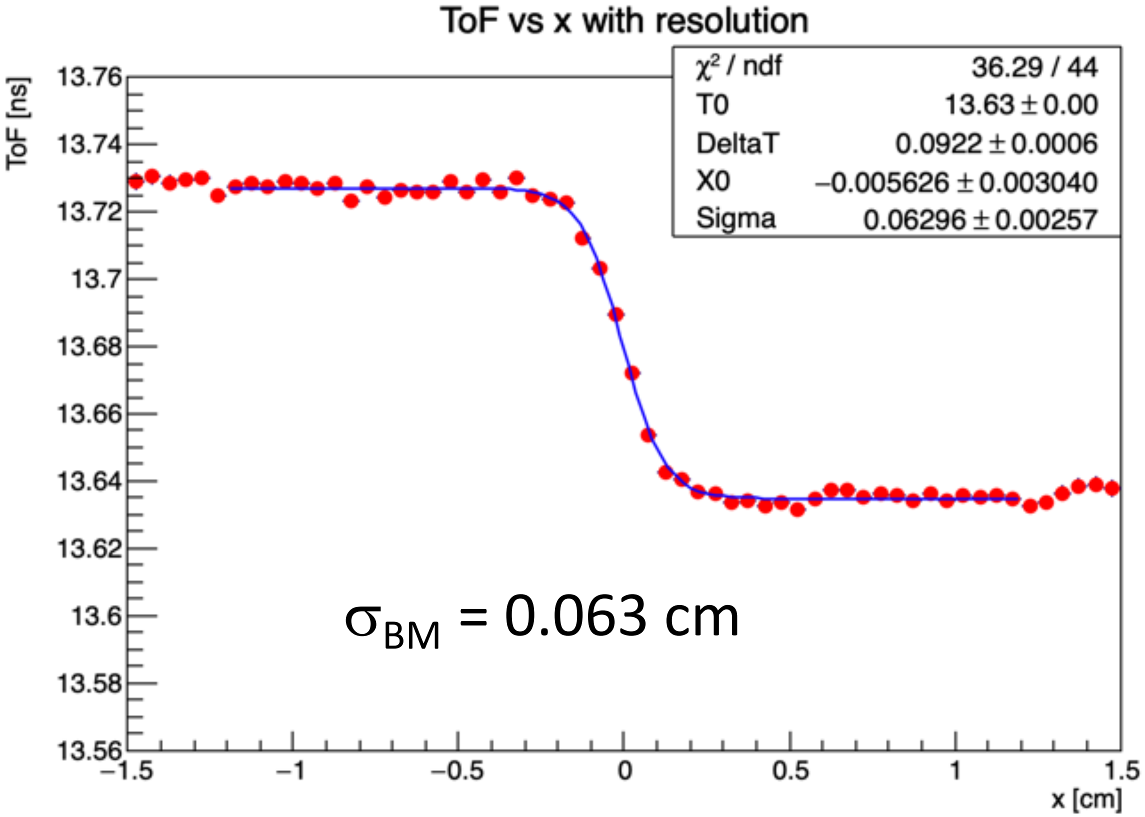


σ_{ToF} = 160 ps, $\sigma_{BM} = \sigma_{SC}$ = 1 mm

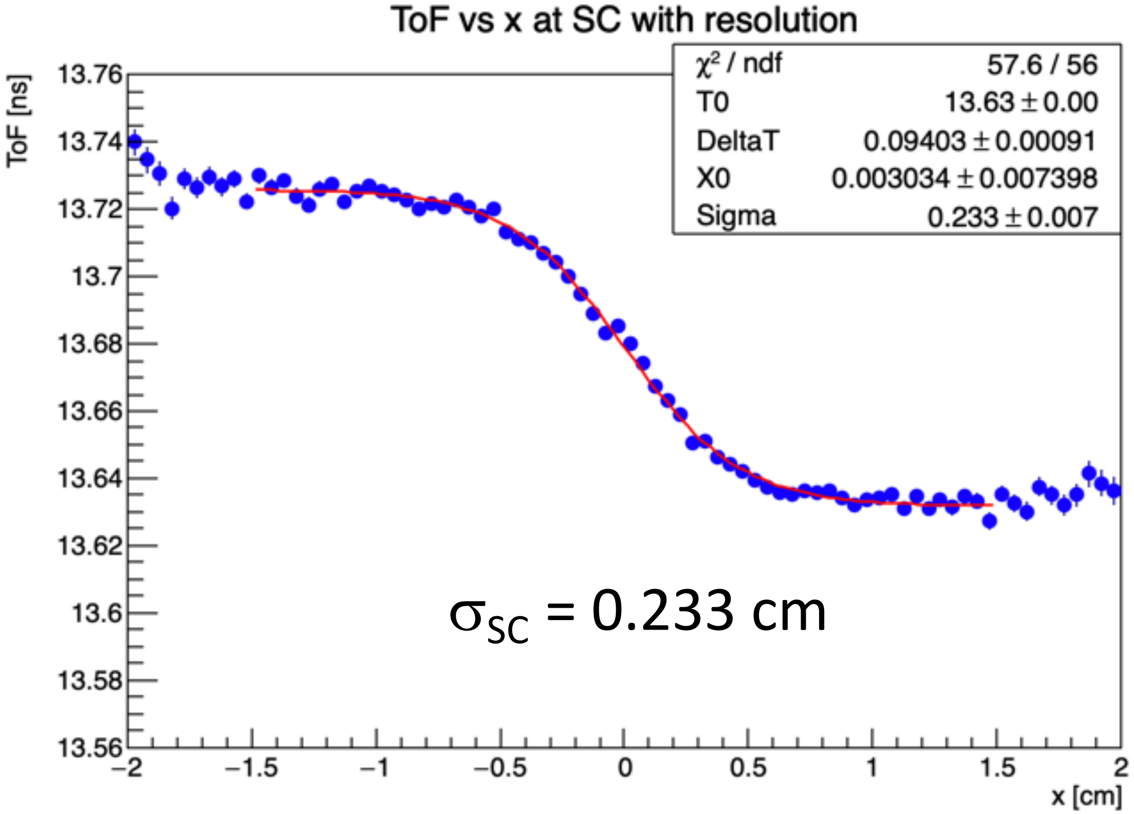
$$f(x) = t_0 + \Delta t \left(\frac{1}{1 + e^{\frac{x - x_0}{\sigma}}} \right)$$



$Z_{fenditura}$ = 4 cm, gap = 5 mm



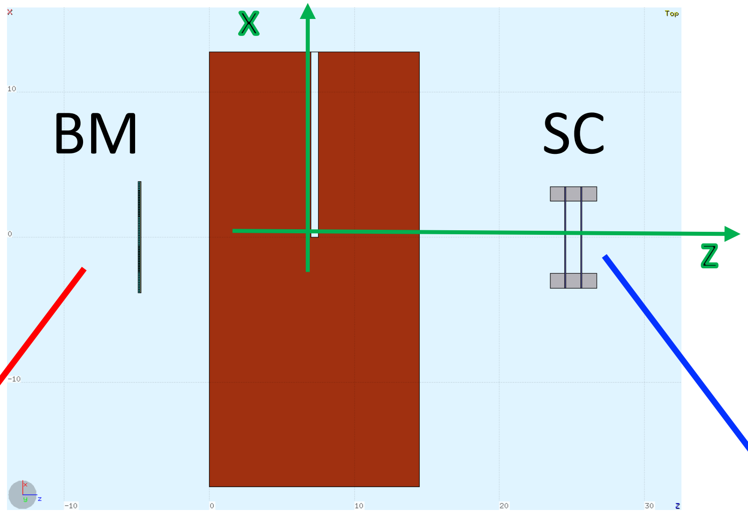
σ_{BM} = 0.063 cm



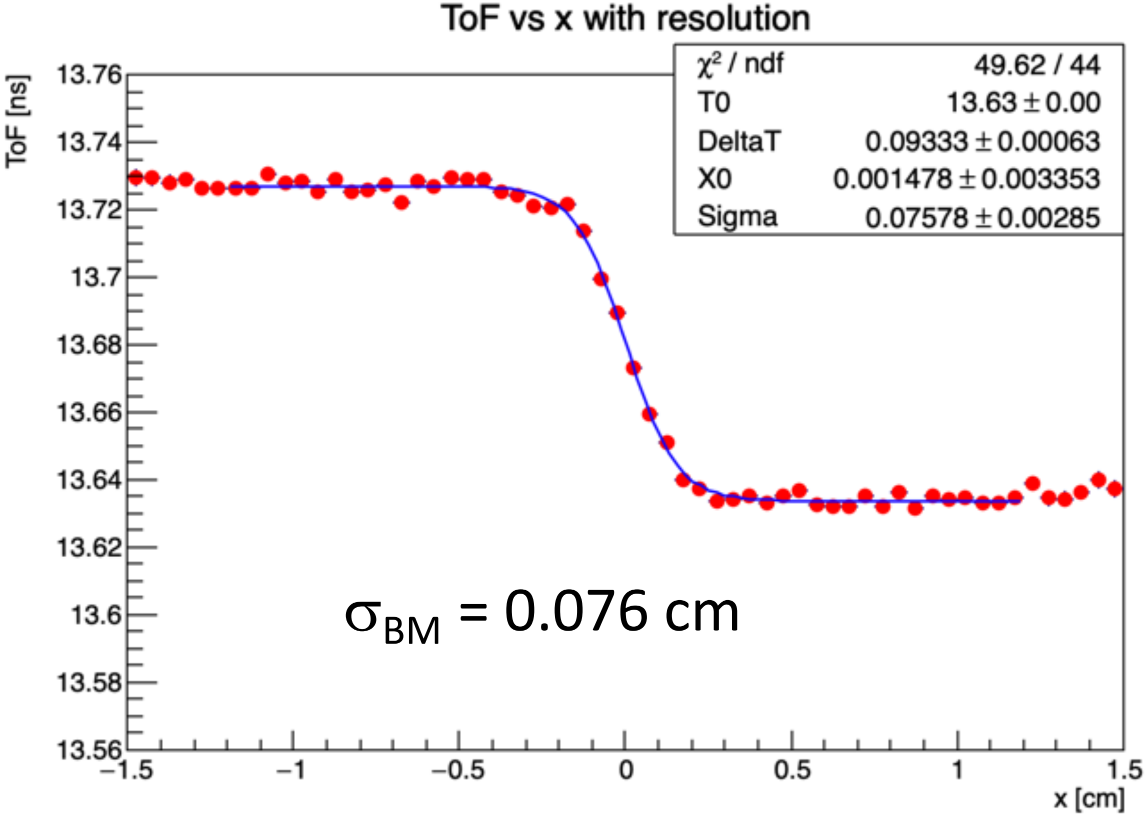
σ_{SC} = 0.233 cm

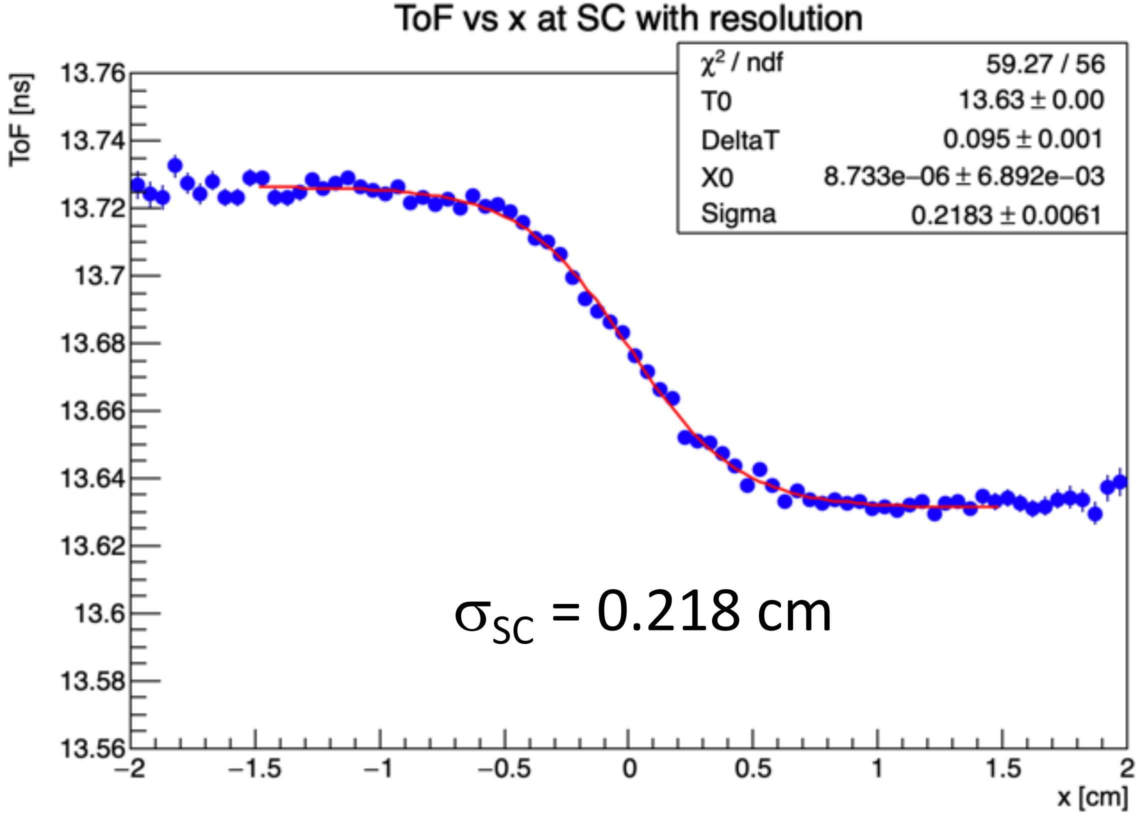
σ_{ToF} = 160 ps, $\sigma_{BM} = \sigma_{SC}$ = 1 mm

$$f(x) = t_0 + \Delta t \left(\frac{1}{1 + e^{\frac{x - x_0}{\sigma}}} \right)$$



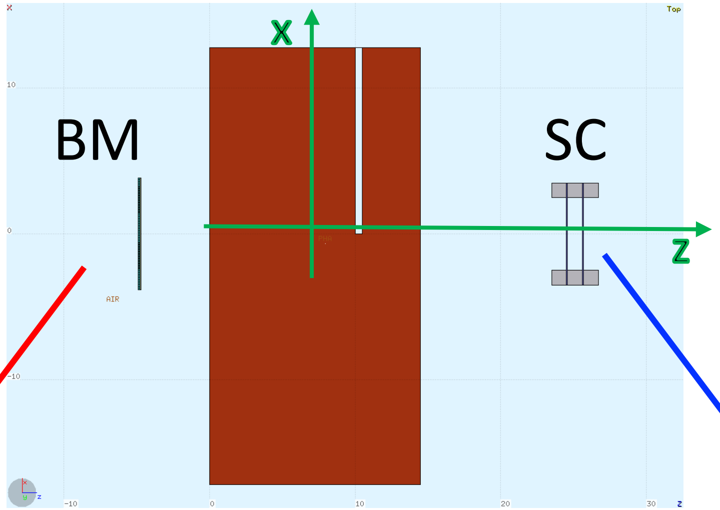
$Z_{fenditura}$ = 7 cm, gap = 5 mm



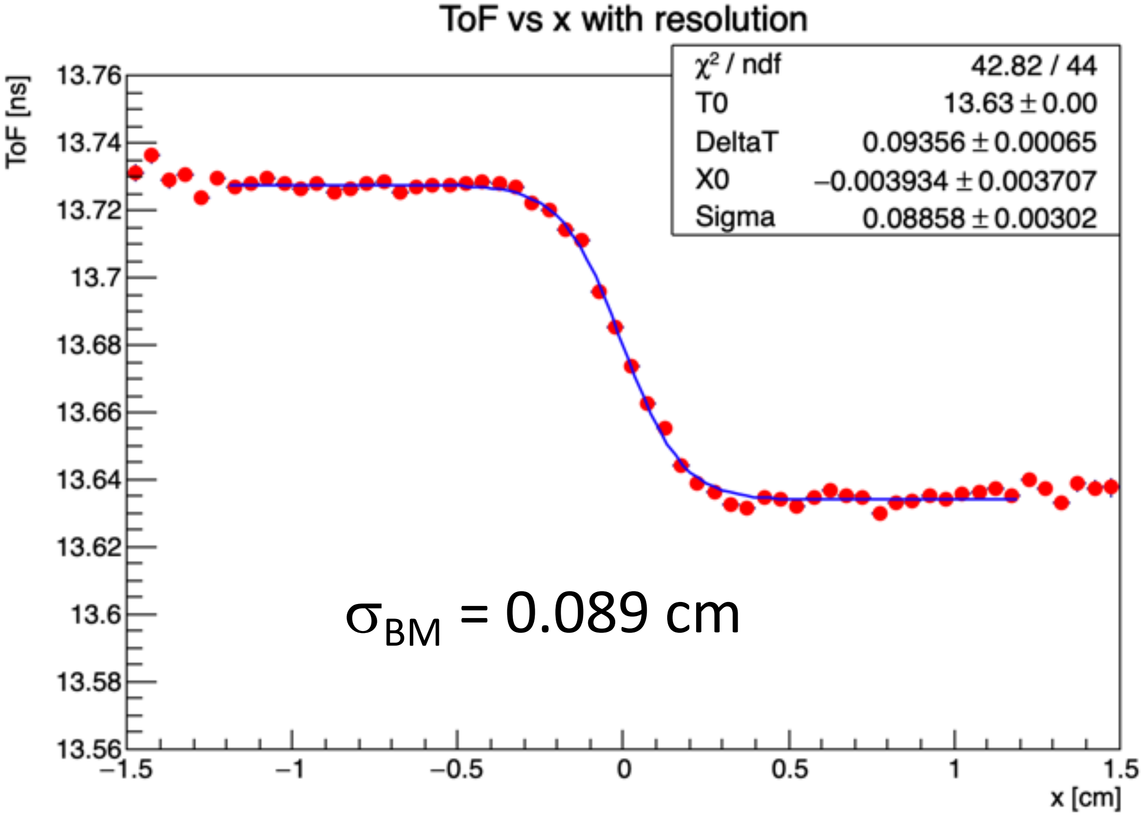


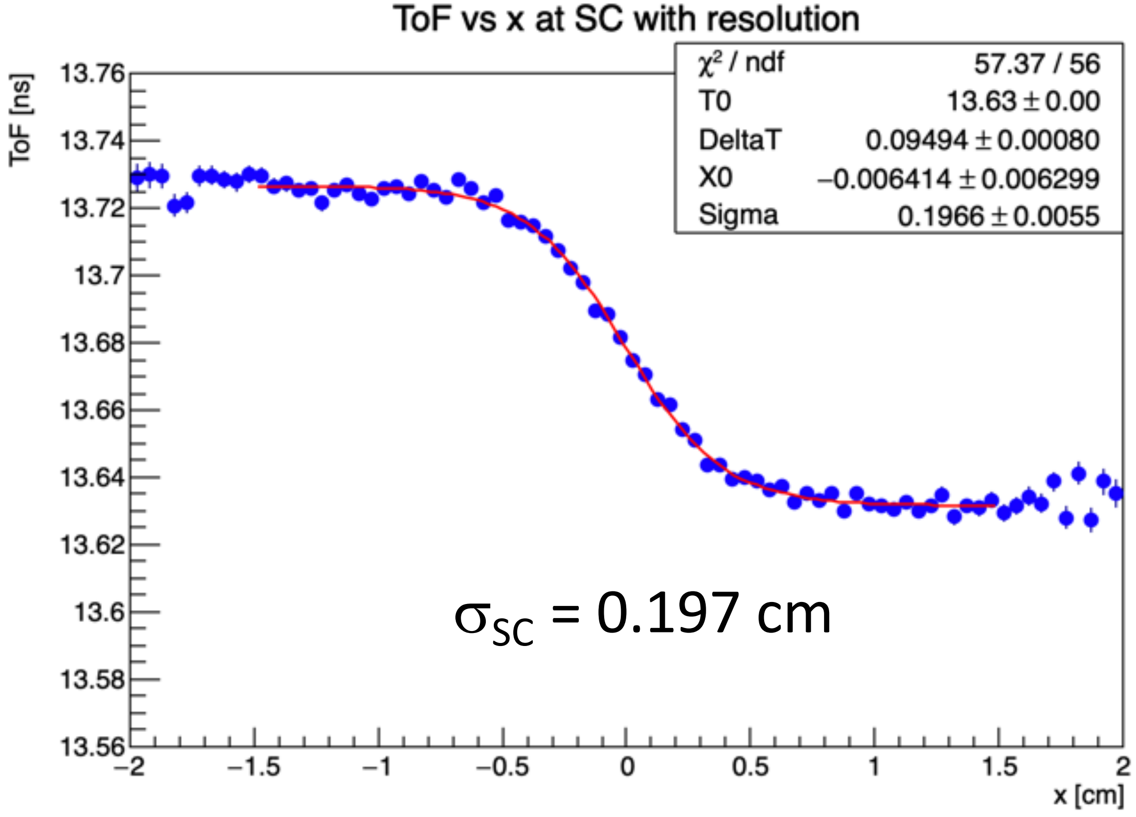
σ_{ToF} = 160 ps, $\sigma_{BM} = \sigma_{SC}$ = 1 mm

$$f(x) = t_0 + \Delta t \left(\frac{1}{1 + e^{\frac{x - x_0}{\sigma}}} \right)$$



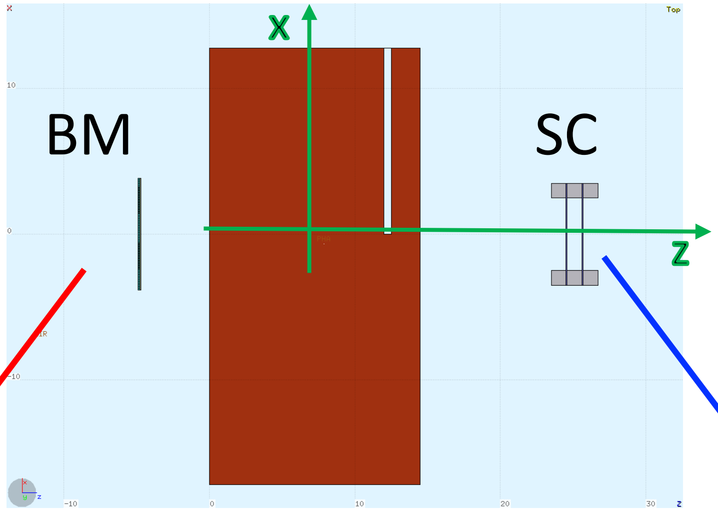
$Z_{fenditura}$ = 10 cm, gap = 5 mm



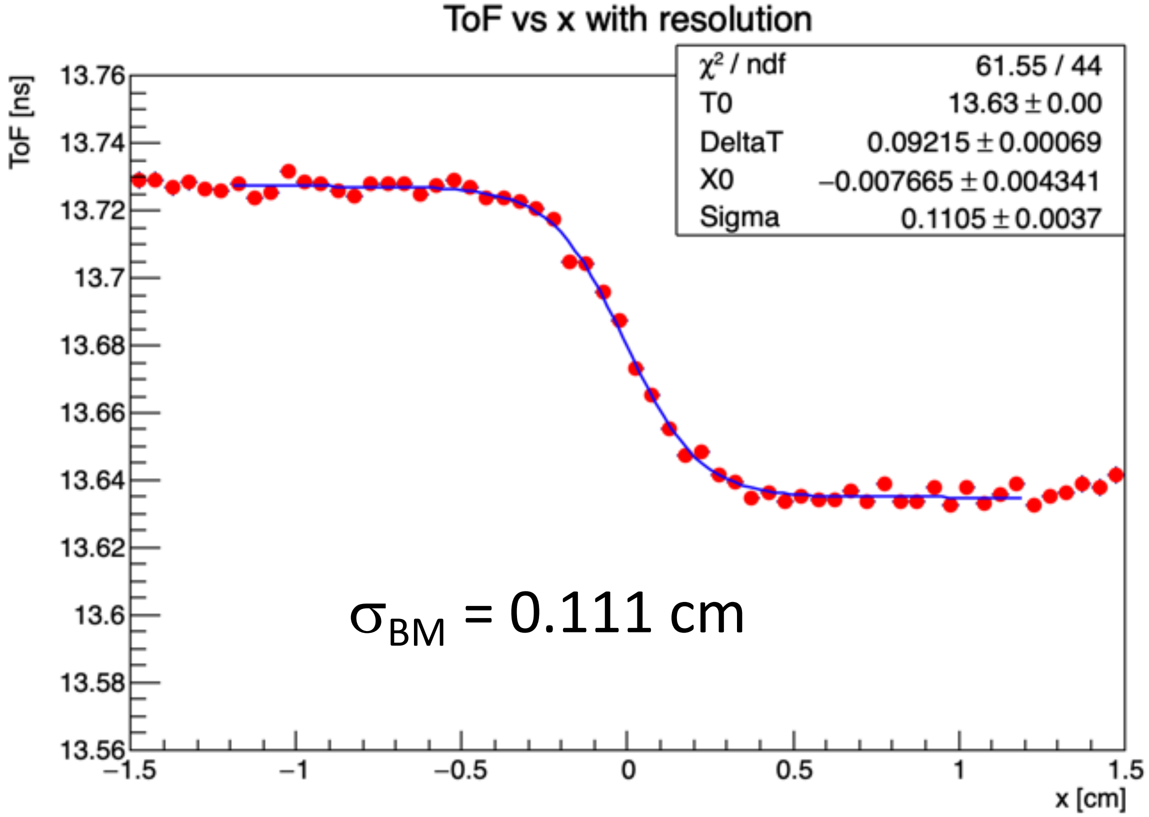


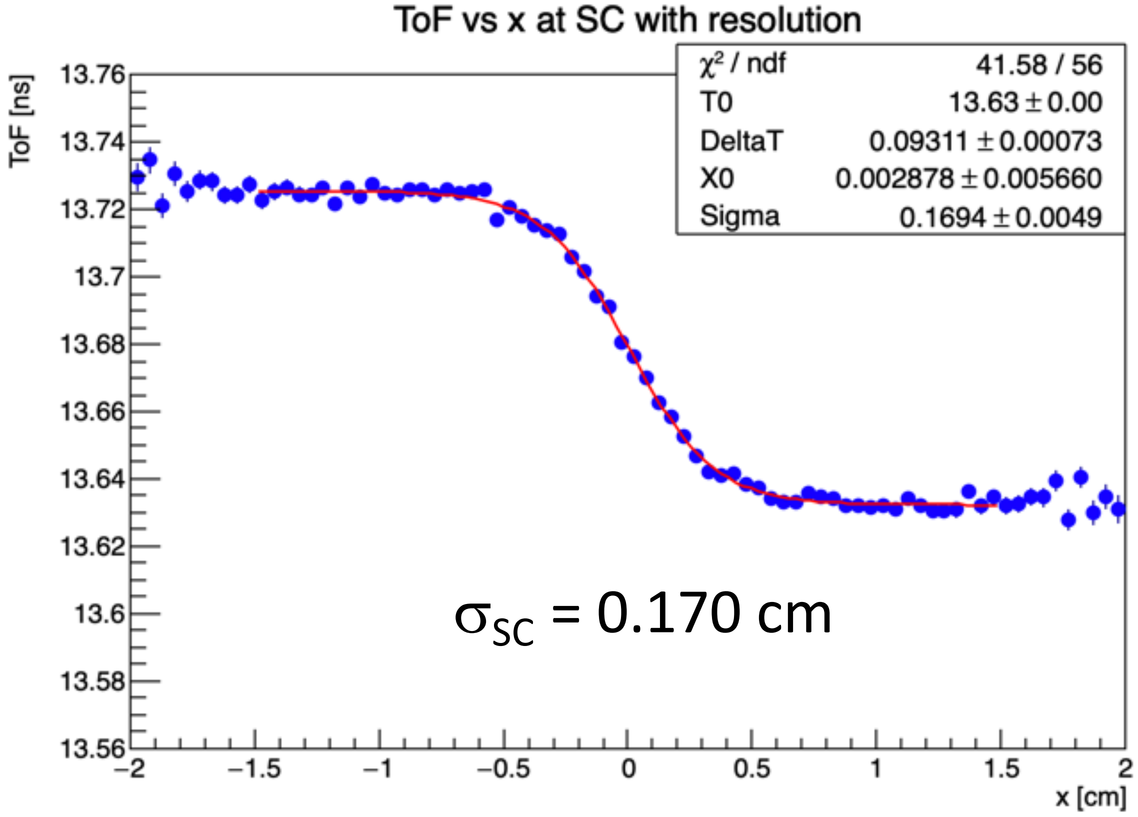
σ_{ToF} = 160 ps, $\sigma_{BM} = \sigma_{SC}$ = 1 mm

$$f(x) = t_0 + \Delta t \left(\frac{1}{1 + e^{\frac{x - x_0}{\sigma}}} \right)$$



$Z_{fenditura}$ = 12 cm, gap = 5 mm





σ_{ToF} = 160 ps, $\sigma_{BM} = \sigma_{SC}$ = 1 mm

Conclusions

- The effect of SC frame is confirmed, but this implies that the field width is somewhat larger than 3x3 cm^2
- ToF values should be around 13.8 ns for the considered energies
- The simulation of ToF calibration points out to consider the effective average energy in the path SC-TW, considering also energy loss in air
- When fitting ToF vs x, the resolution parameter scales reasonably with the position of the gap:
  - it's larger at increasing distance from the tracker
  - it's larger for a possible tracker downstream the phantom