Data selection criteria for determination of NEMA characteristics for J-PET detector

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Motivation

Comparison between J-PET prototype with current solutions available on the market.

It is required to check possibility of clinical applications.

It is required to define guaranteed quality level of measurements according to worldwide NEMA norms.

Data selection criteria are necessary to determine NEMA performance characteristics of J-PET detector.

Preliminary results of spatial resolution.

Measurements with phantoms.

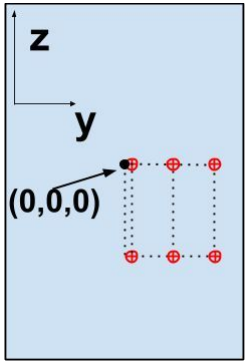
General information

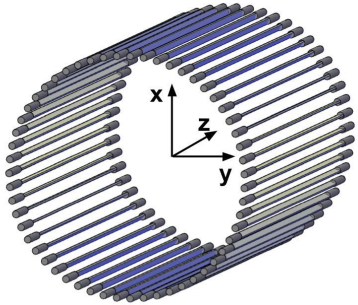
Data: single ^{22}Na source placed in geometrical center of J-PET detector

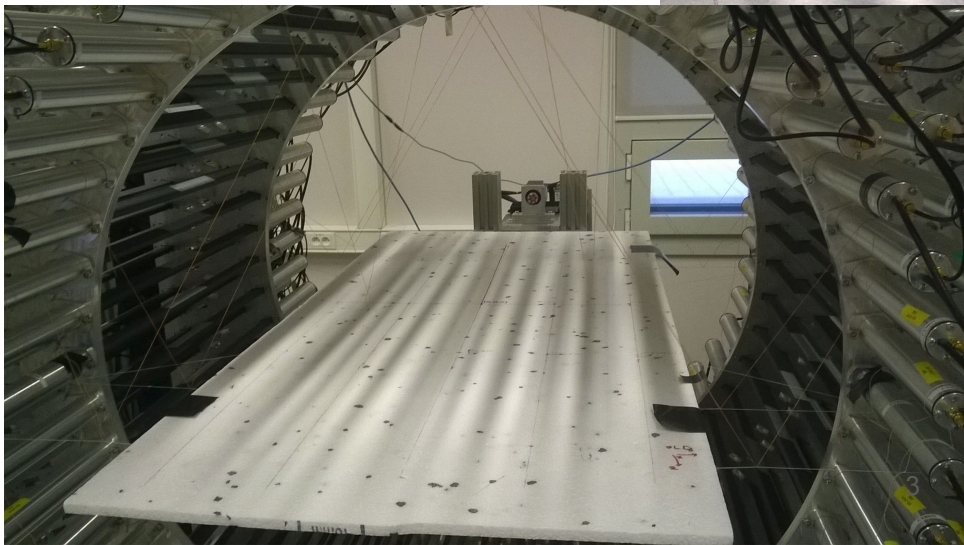
Setup: styrofoam panel with marked position (0,0,0) and positions according to NEMA.

Time of measurement for single source: 1 minute

Activity of source: ~7601 kBq







Data selection criteria

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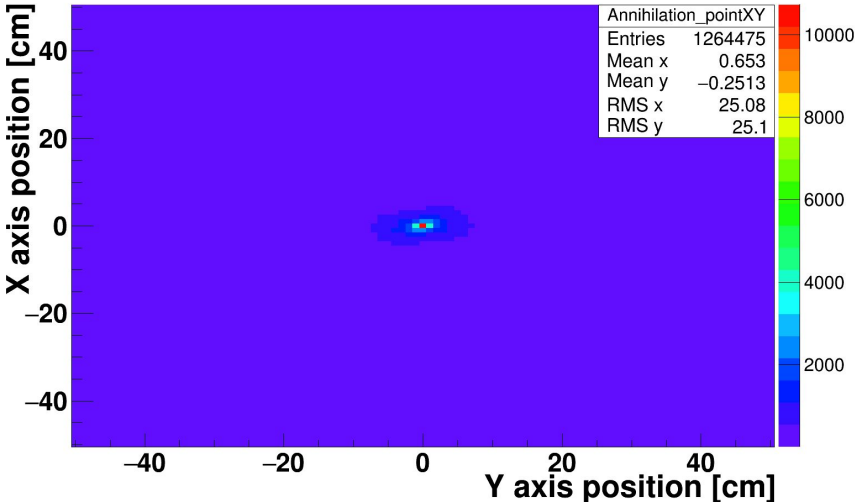

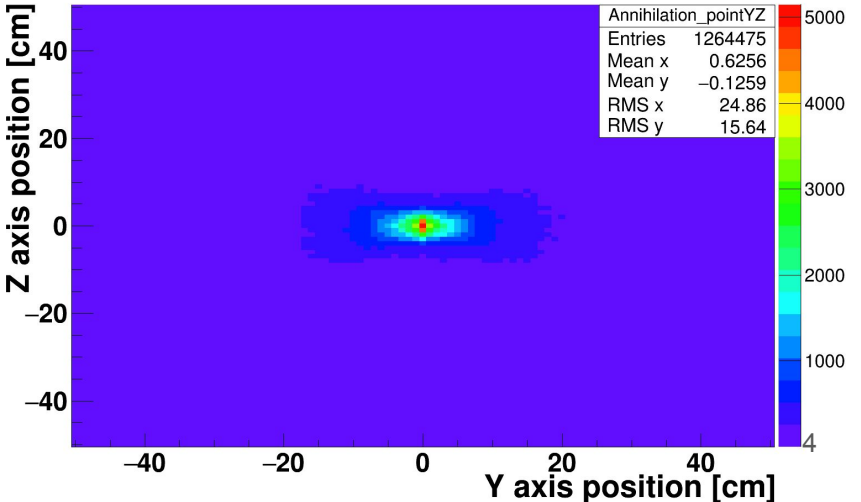

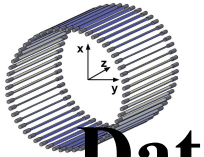

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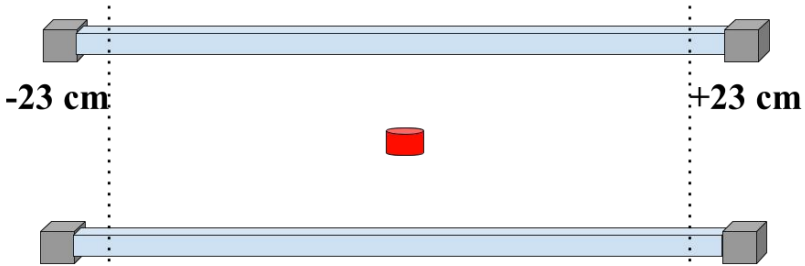
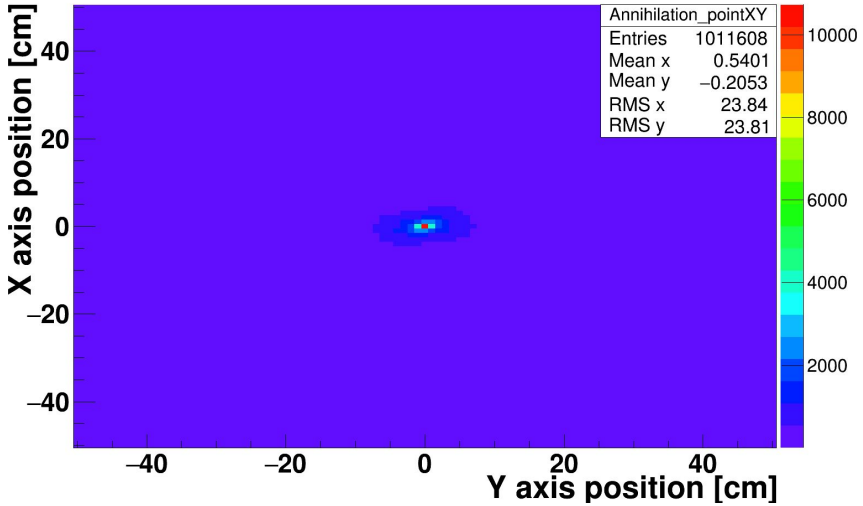
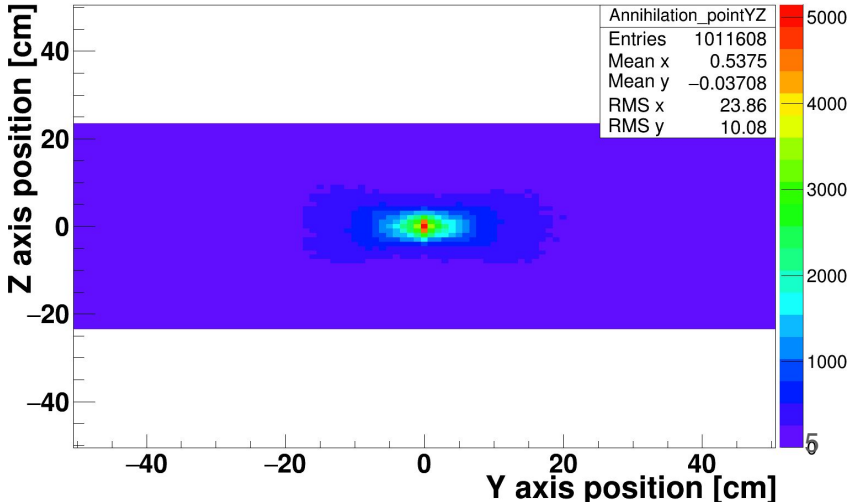
2. ***z* coordinate** of position of annihilation in range ± 23 cm







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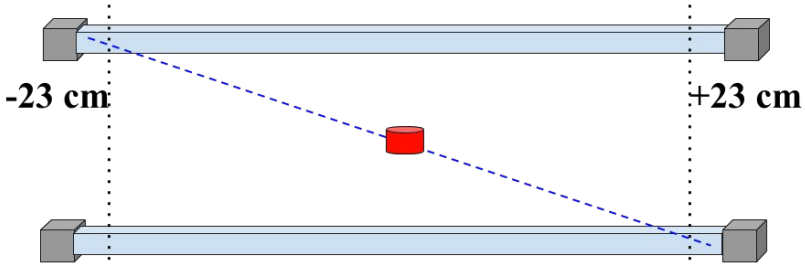

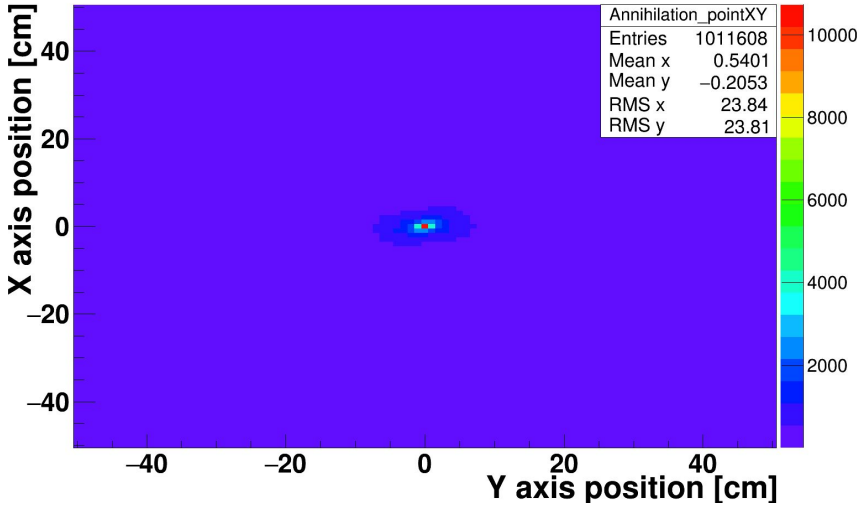

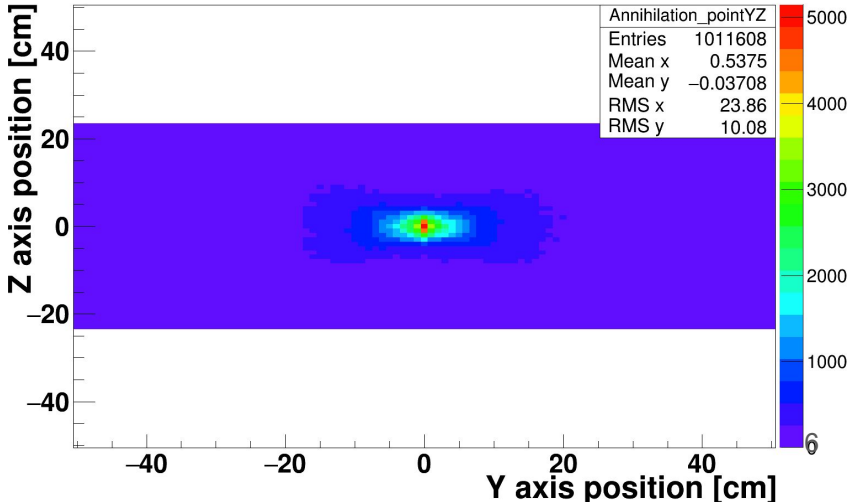

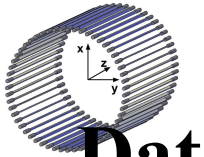

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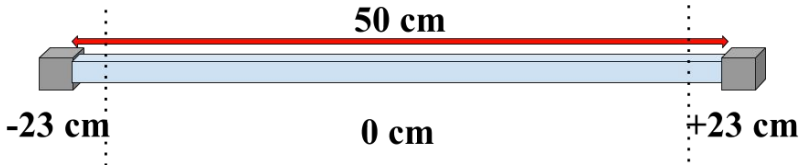

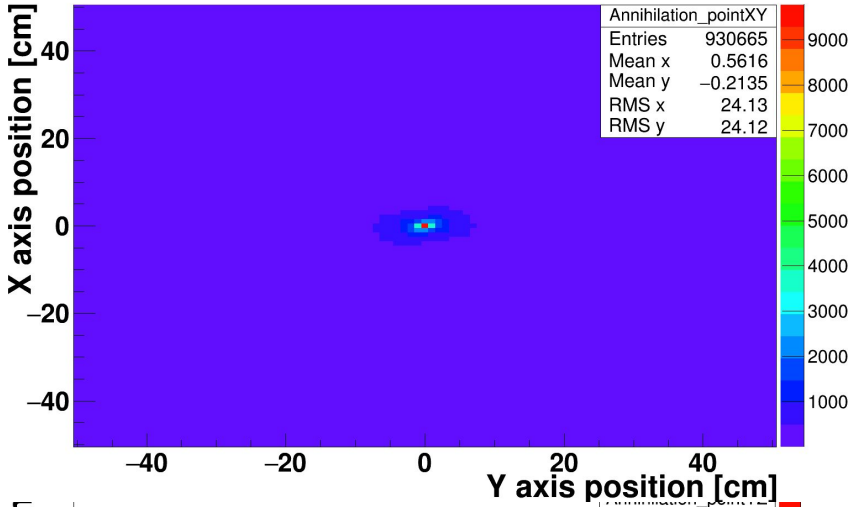

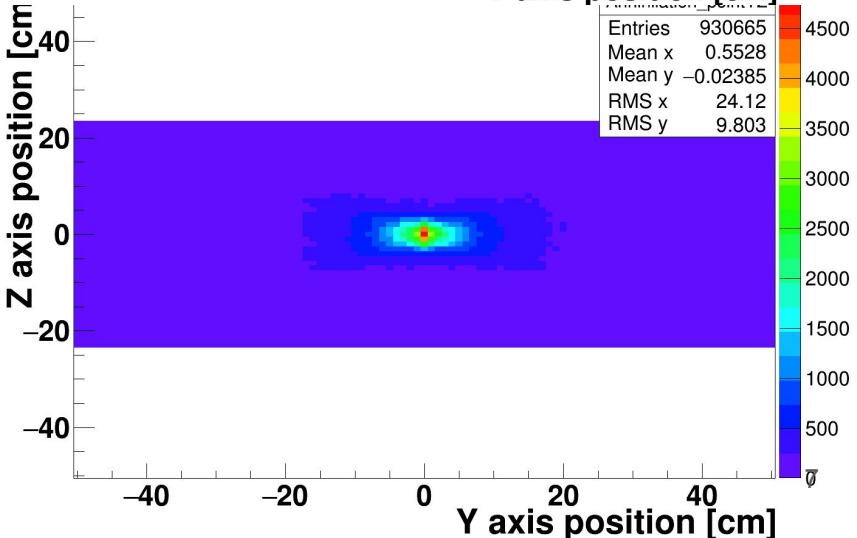

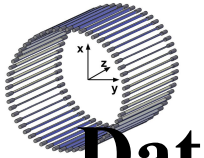

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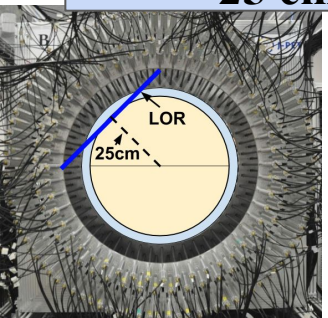
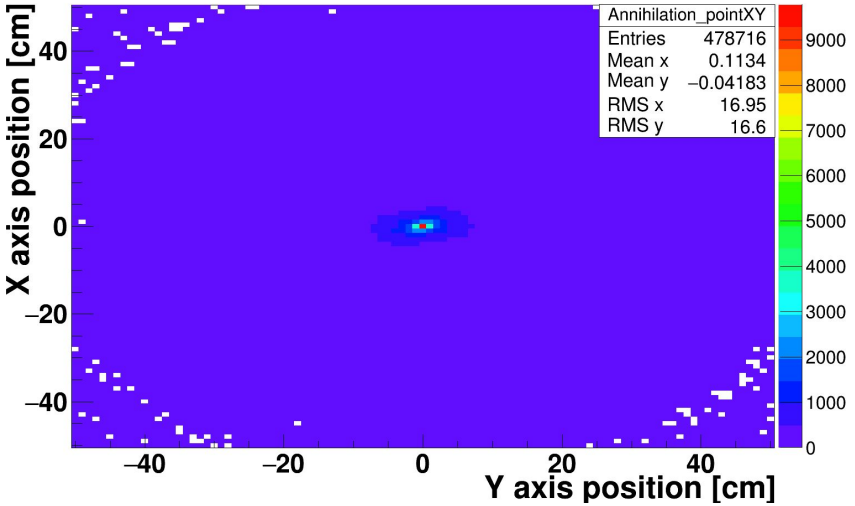
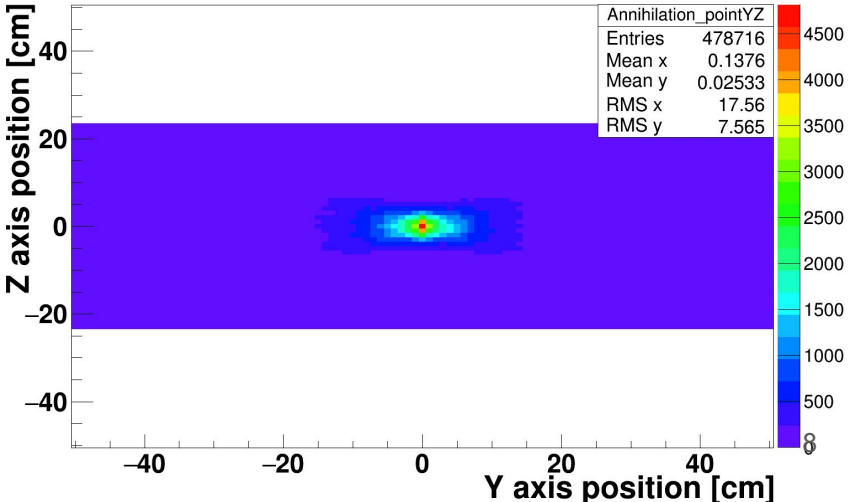
4. **LOR distance** from geometrical center of J-PET detector always **< 25 cm** in x and y coordinates







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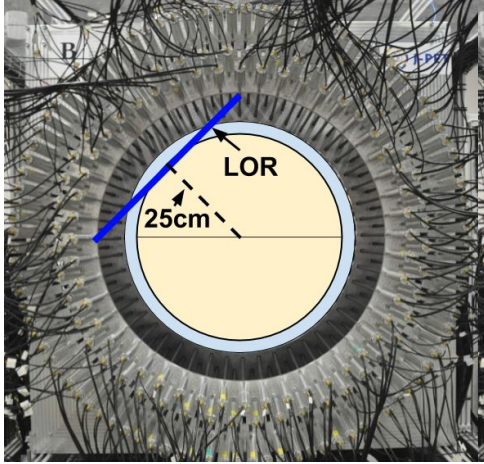

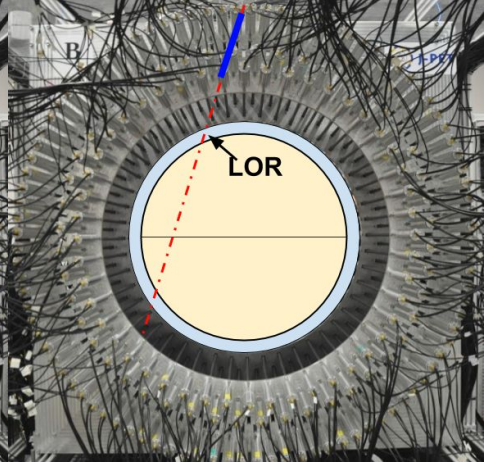

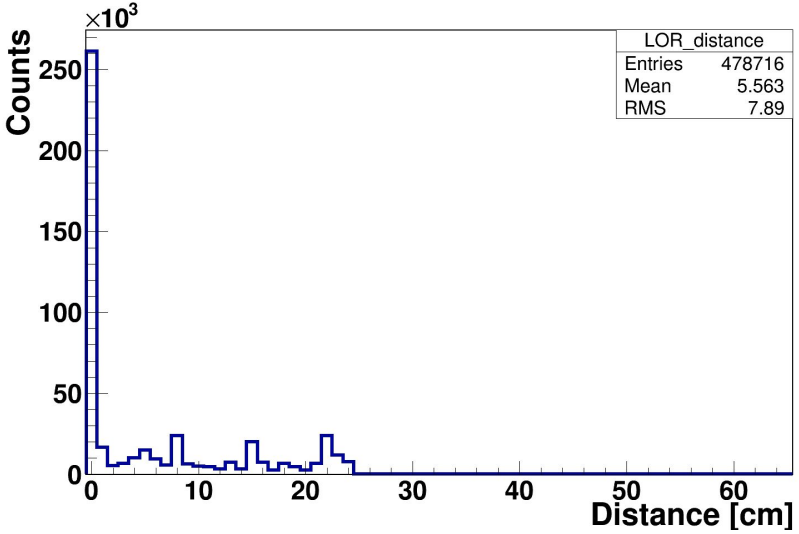

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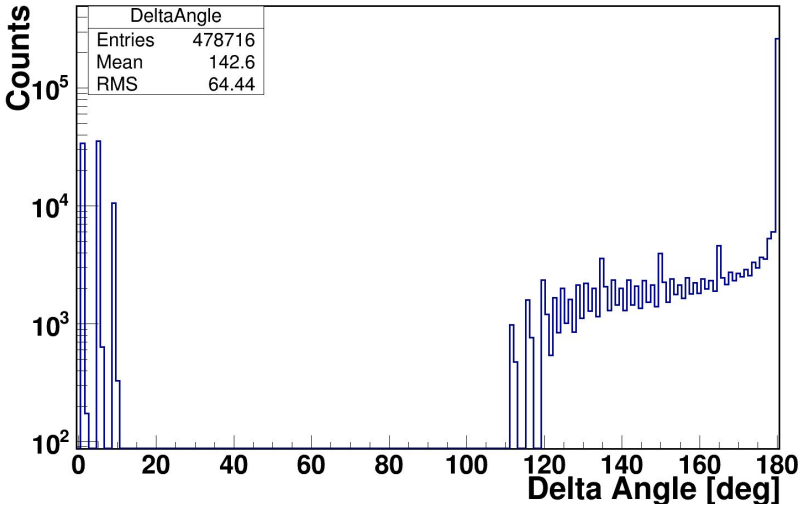

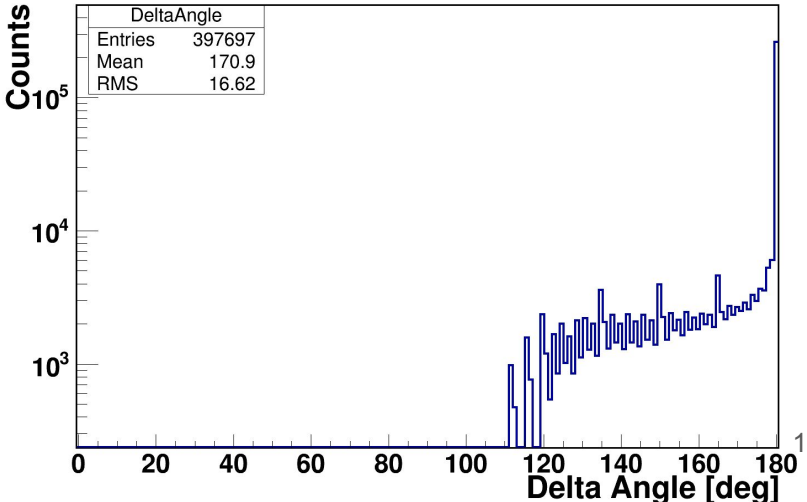

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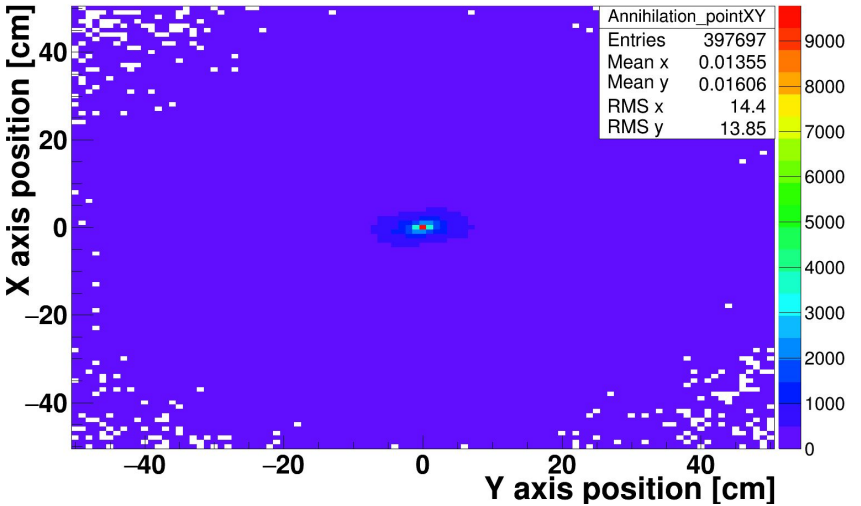

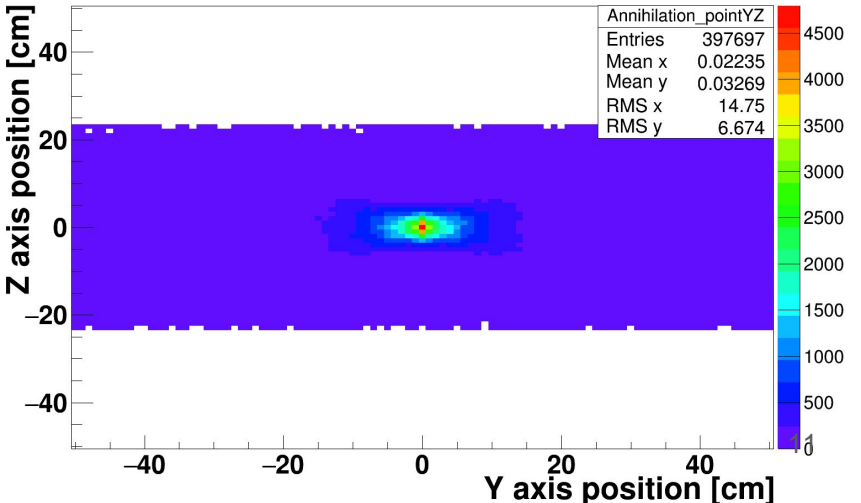

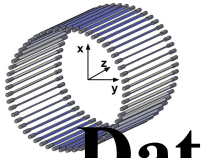

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6. Energy cuts estimation

→ done once on data from source inside collimator, measurements done for different positions of collimator along z axis

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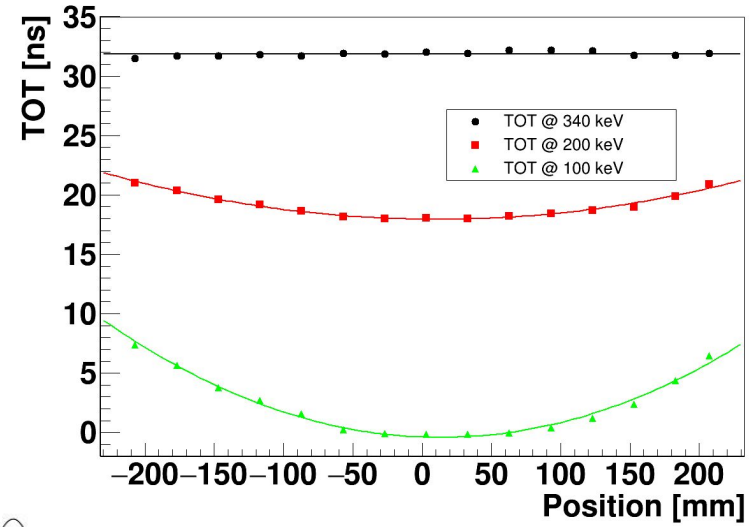
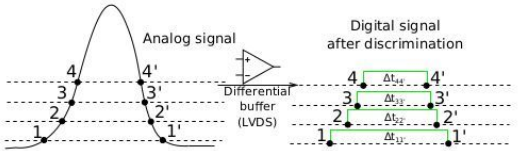
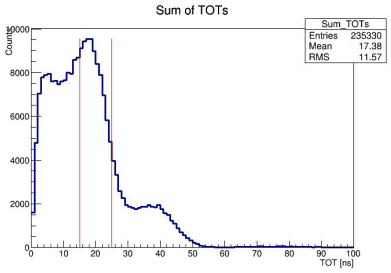
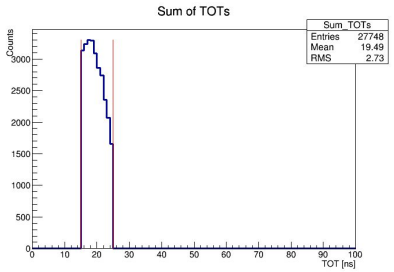




$$\mathrm{TOT} = \sum_{\mathrm{side=A,B}} \sum_{\mathrm{thr=1}}^{4} \mathrm{TOT}_{\mathrm{side,thr}} ,$$





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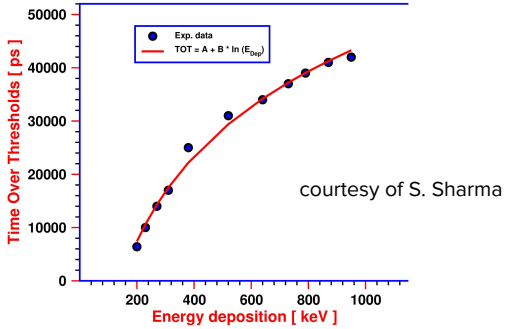
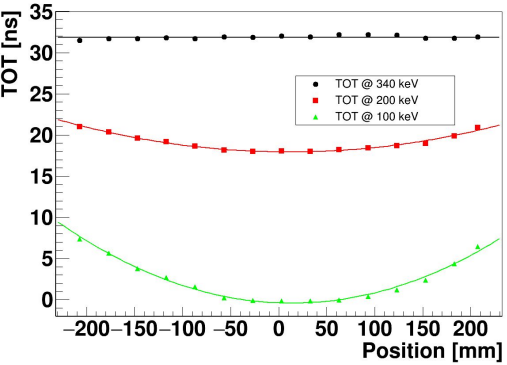
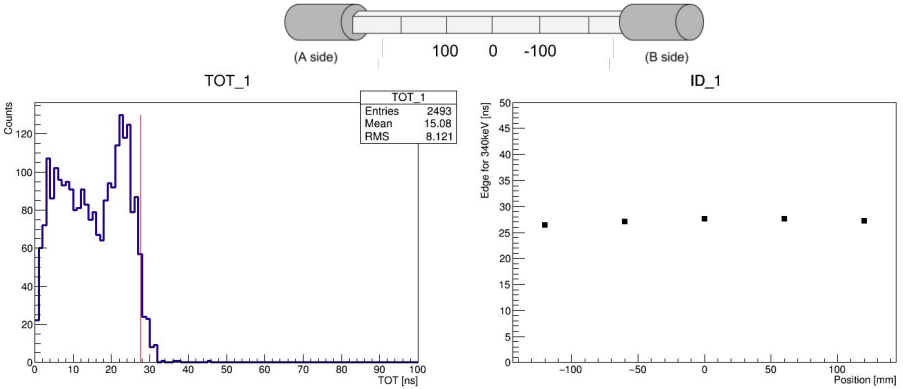




results from two strip studies

Drawing for each scintillator ID histogram TOT vs position of collimator along z axis



Rescale model Compton Edge value to my Compton Edge

a. find model TOT mean value for 340keV → **fReference340keV = 31.90844 [ns]**
b. for a given **ID**: find TOT mean value from TOT vs z ID for each scintillator ID
c. find rescale factor for a given ID: **fRescaleFactorPerID = fMeanTOTPerID/fReference340keV**

Data selection criteria

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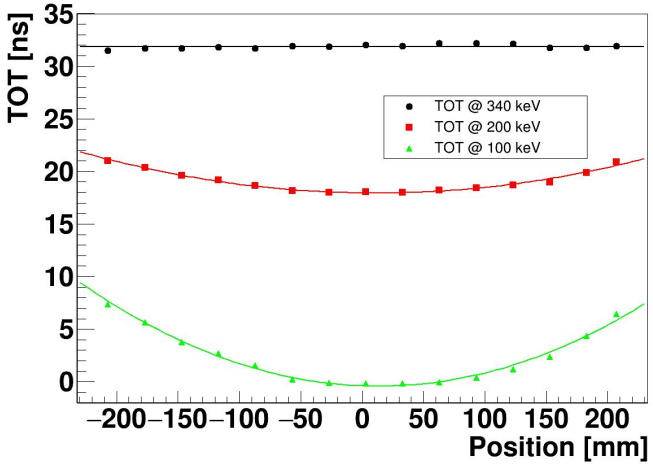


fRescaleFactorPerID=fMeanTOTPerID/fReference340keV

Estimation of cut for 200 keV

d. fit parameters for 200 keV in model case **(pol2)**: in ROOT
P(x) = p[0] + p[1]*x + p[*2*]*x2**
p[0] = 17.6905 p[1]=-0.00141427
p[2]=6.52106e-05;

e. rescale model equation to my case (for all IDs, each ID individually):
p_id[0]=p[0]*fRescaleFactorPerID
p_id[1]=p[1]*fRescaleFactorPerID
p_id[2]=p[2]*fRescaleFactorPerID

f. save to file **TOTCutsTable.txt**

id p_id[0] p_id[1] p_id[2] fMeanTOTPerID

lowerTOTCut < TOT < upperTOTCut

Reconstruction by MLEM

algorithm created by A. Strzelecki and P. Białas (MLEM- Maximum Likelihood Expectation Maximization)

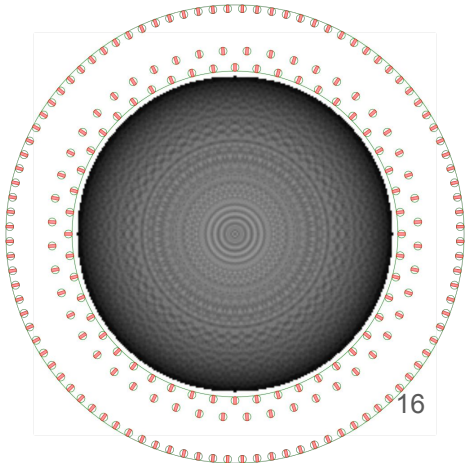
parameters to be provided:

- --s-z sigma Δz along axis [m] (default: [= 0.015])
- --s-dl sigma Δ l [m] (default: [= 0.06])

used values:

- --s-z = 0.0185
- --s-dl = 0.114

number of iterations: 20
1 pixel = 4 mm
system matrix dimension: 256 x 256 x 256



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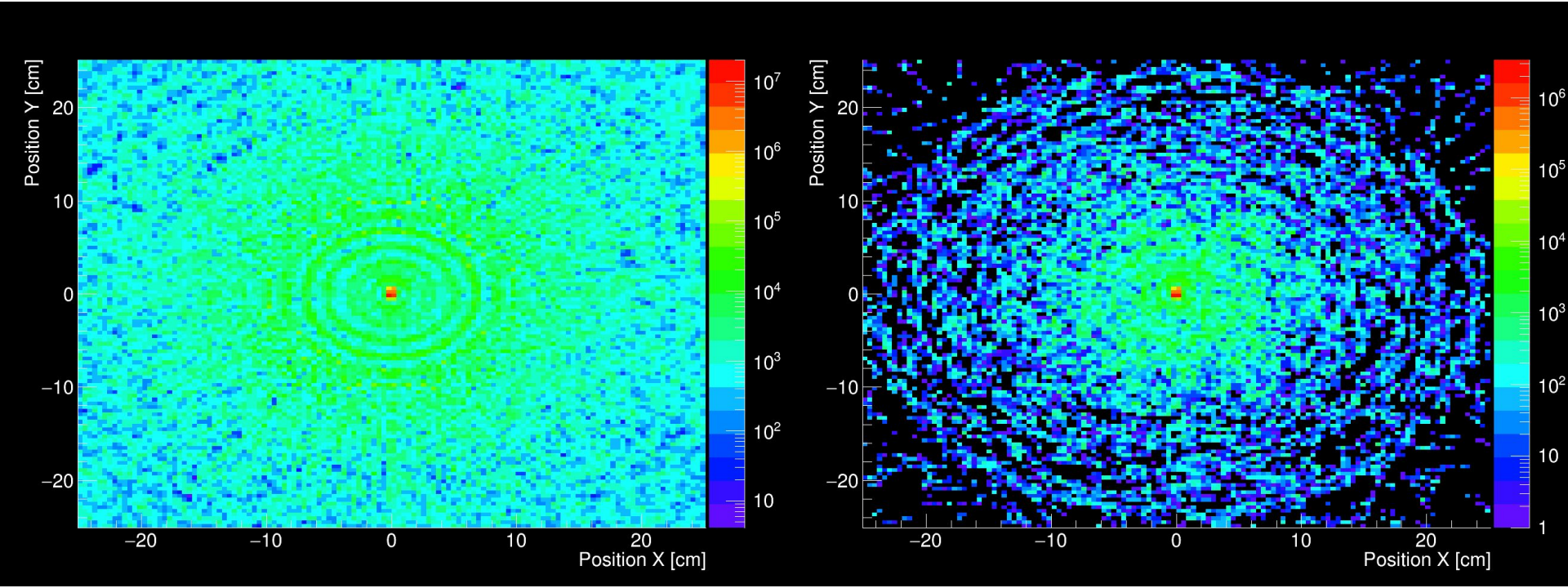

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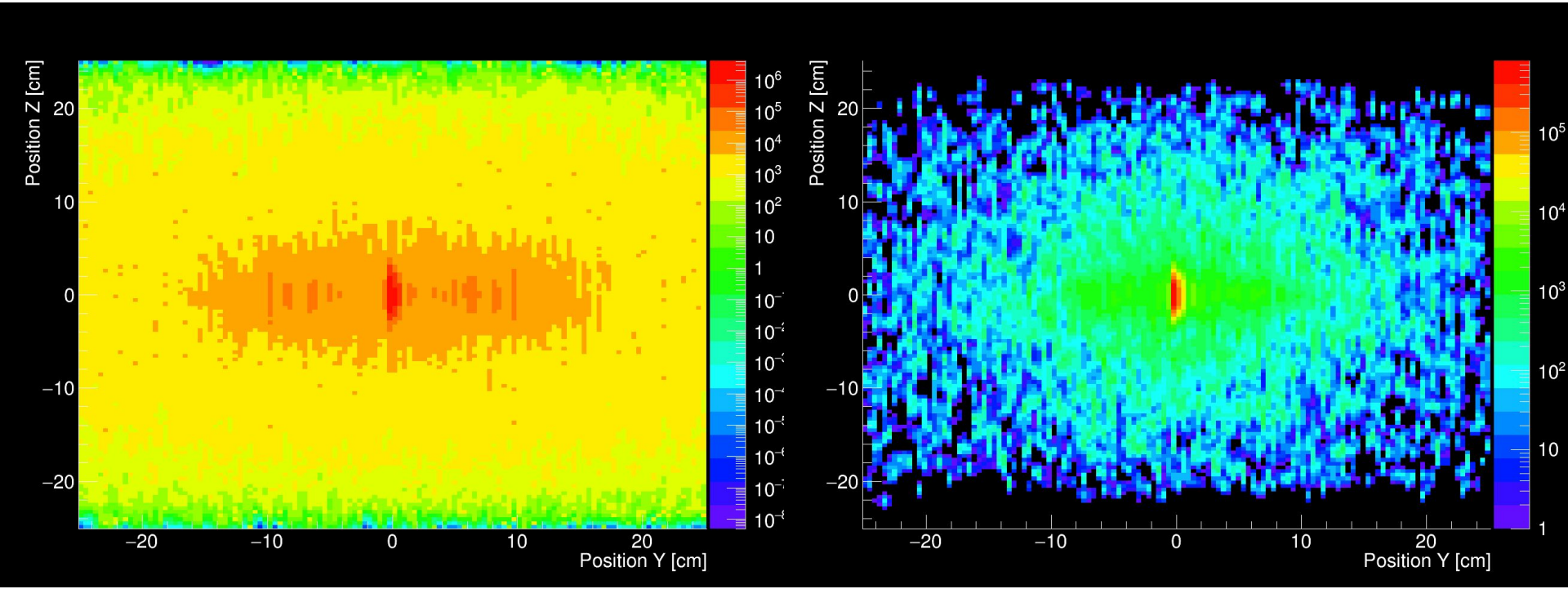
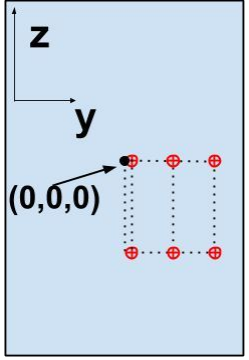


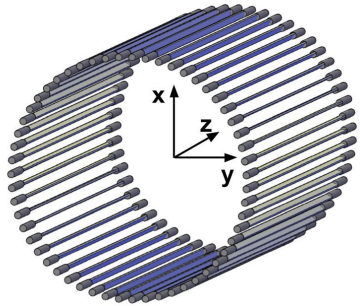
Reconstruction by MLEM

Data: single ^{22}Na source placed in positions according to NEMA

Time of measurement for single position: 3 hours

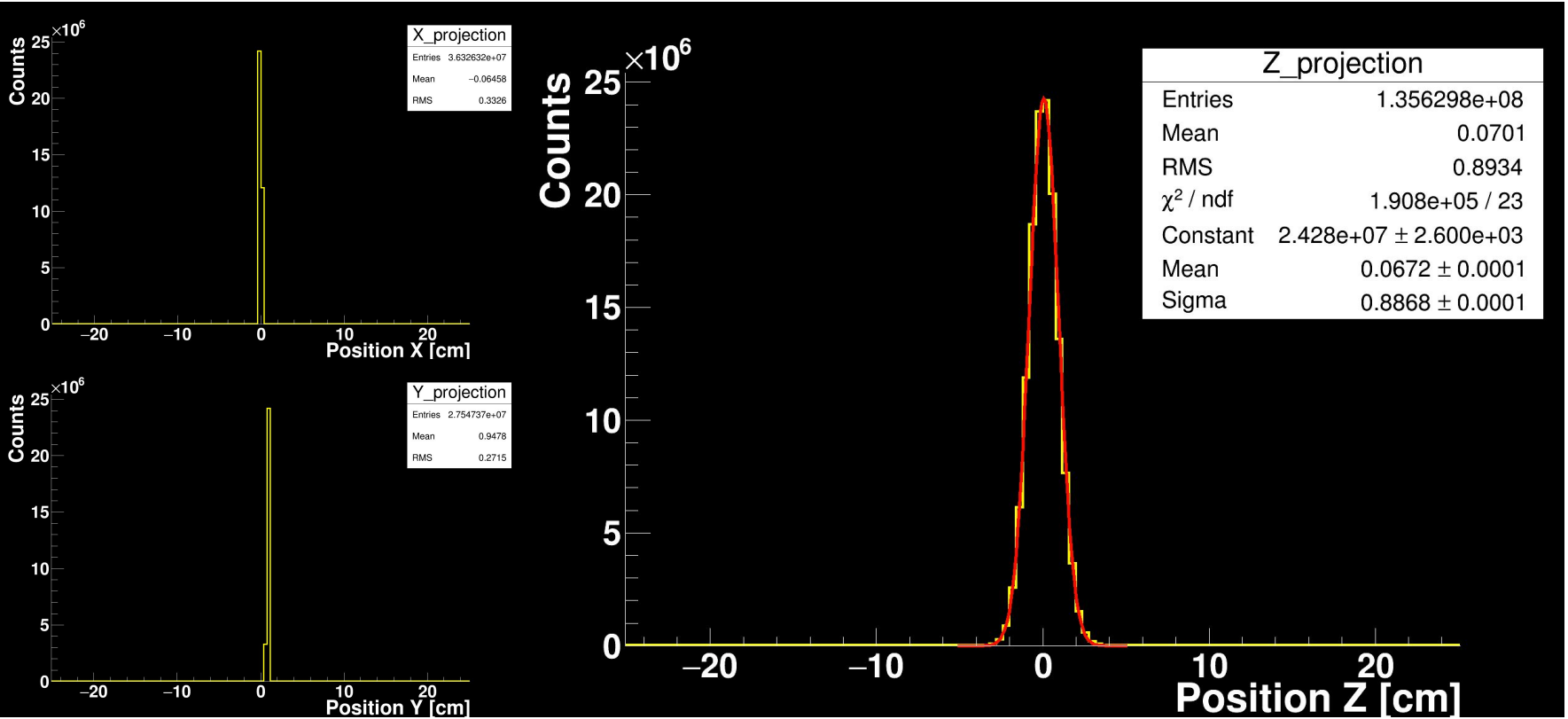
Activity of source: ~1134 kBq



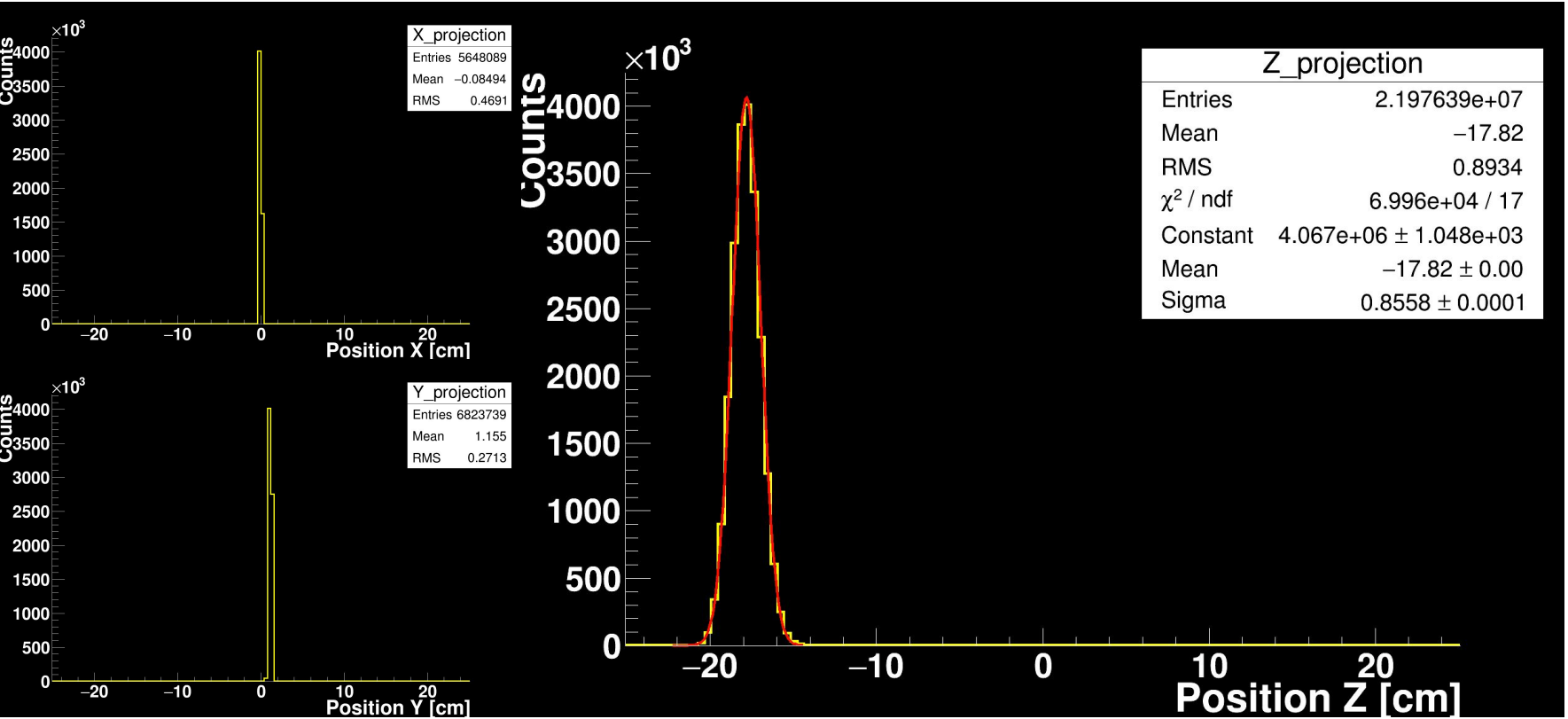


Source position	Number of files
(0,1,0)	33
(0,1,-18.75)	24
(0,10,0)	31
(0,10,-18.75)	37
(0,20,0)	24
(0,20,-18.75)	29

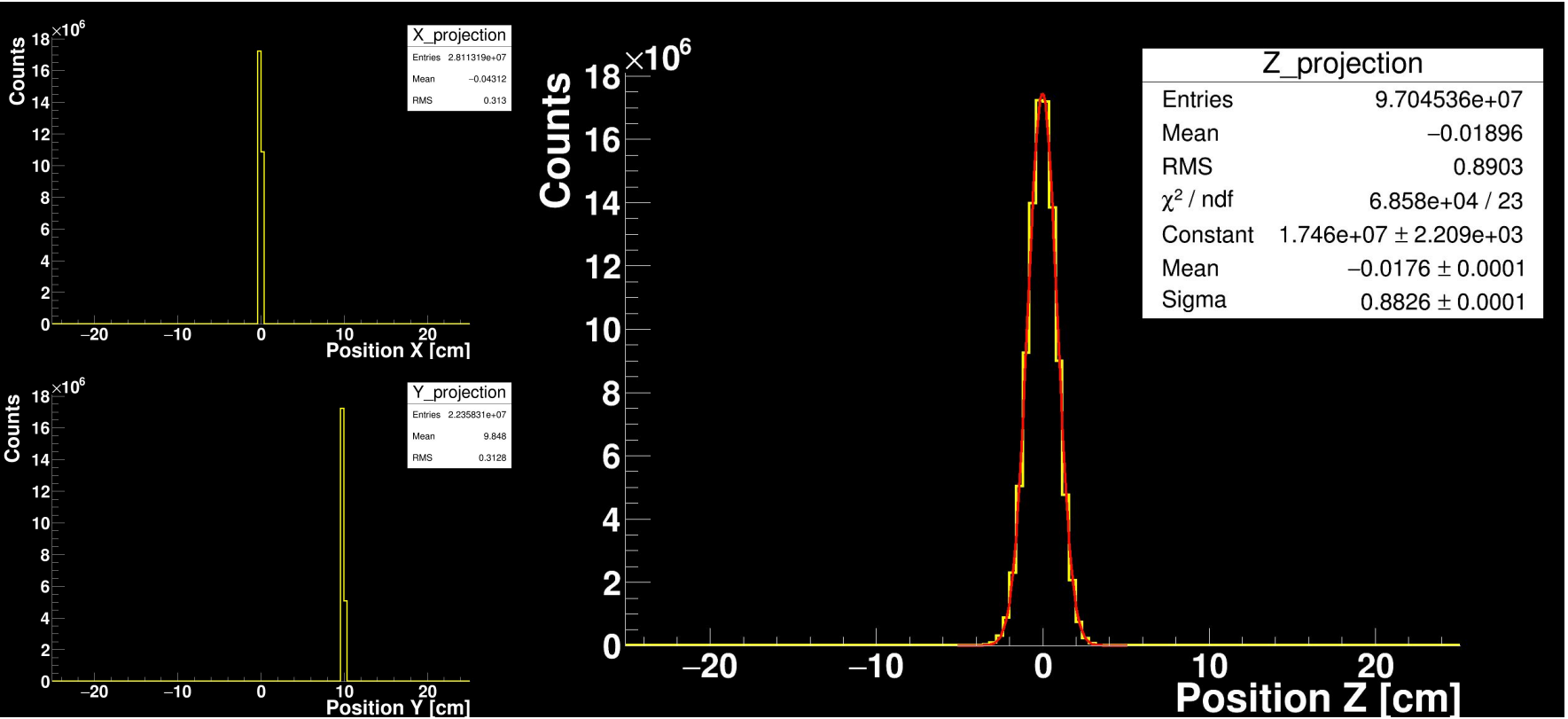
Results of spatial resolution - position (0,1,0)



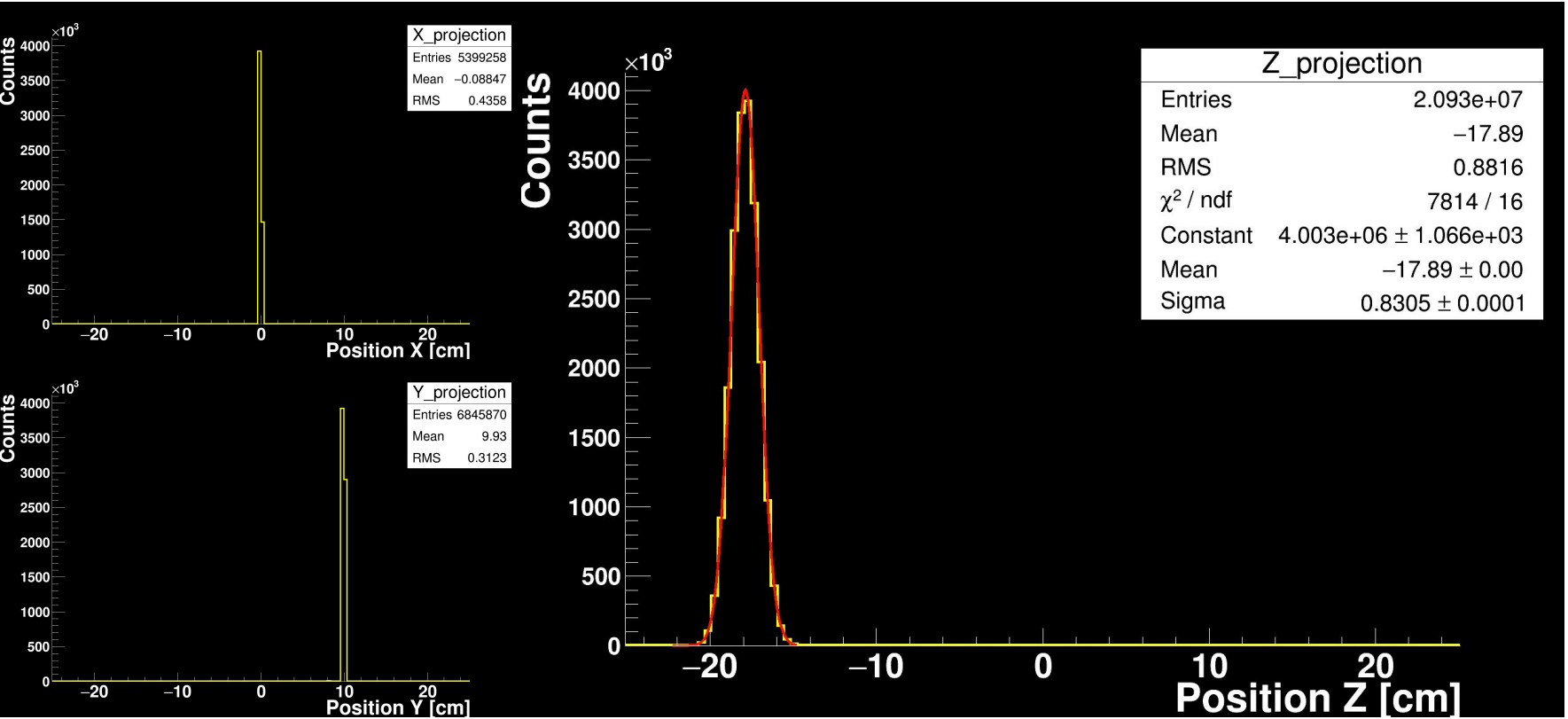
Results of spatial resolution - position (0,1,-18.75)



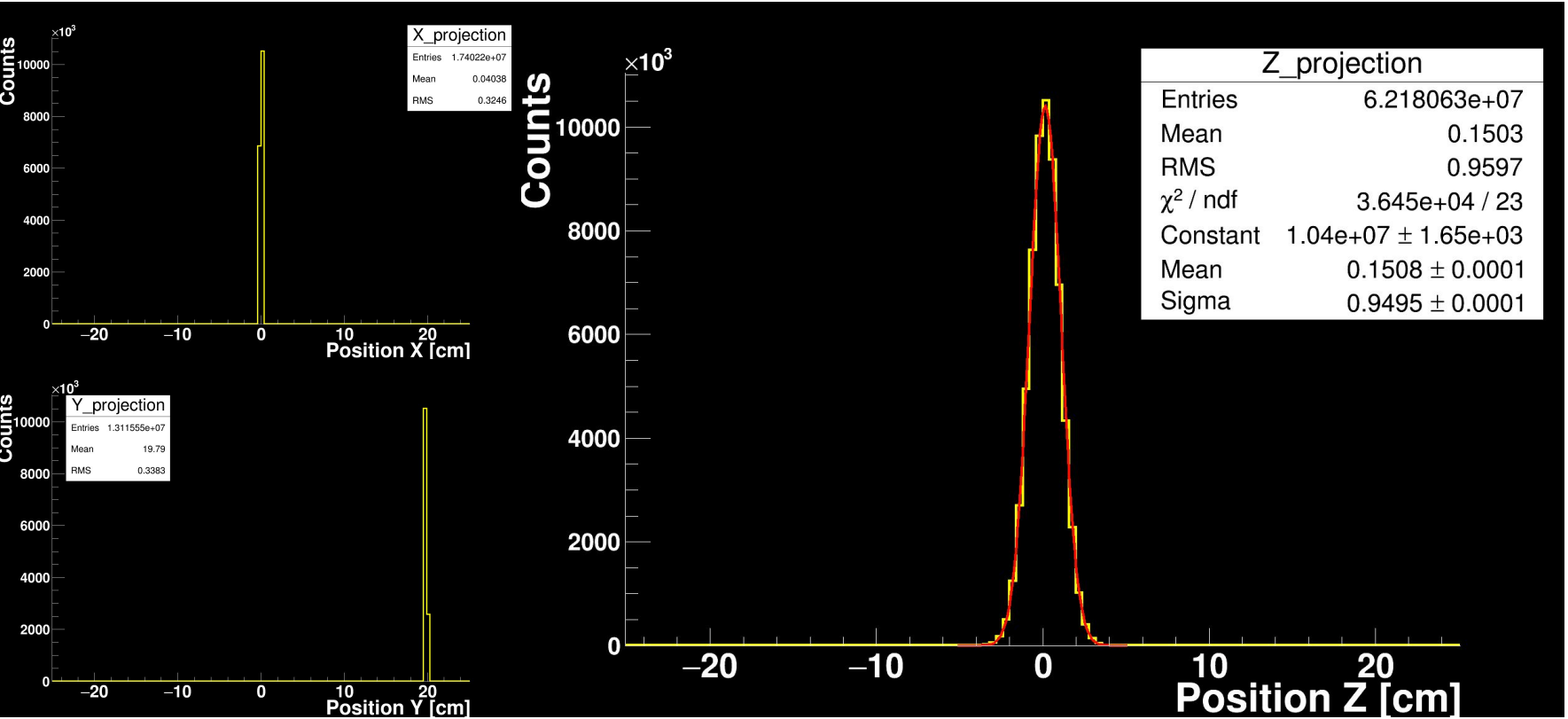
Results of spatial resolution - position (0,10,0)



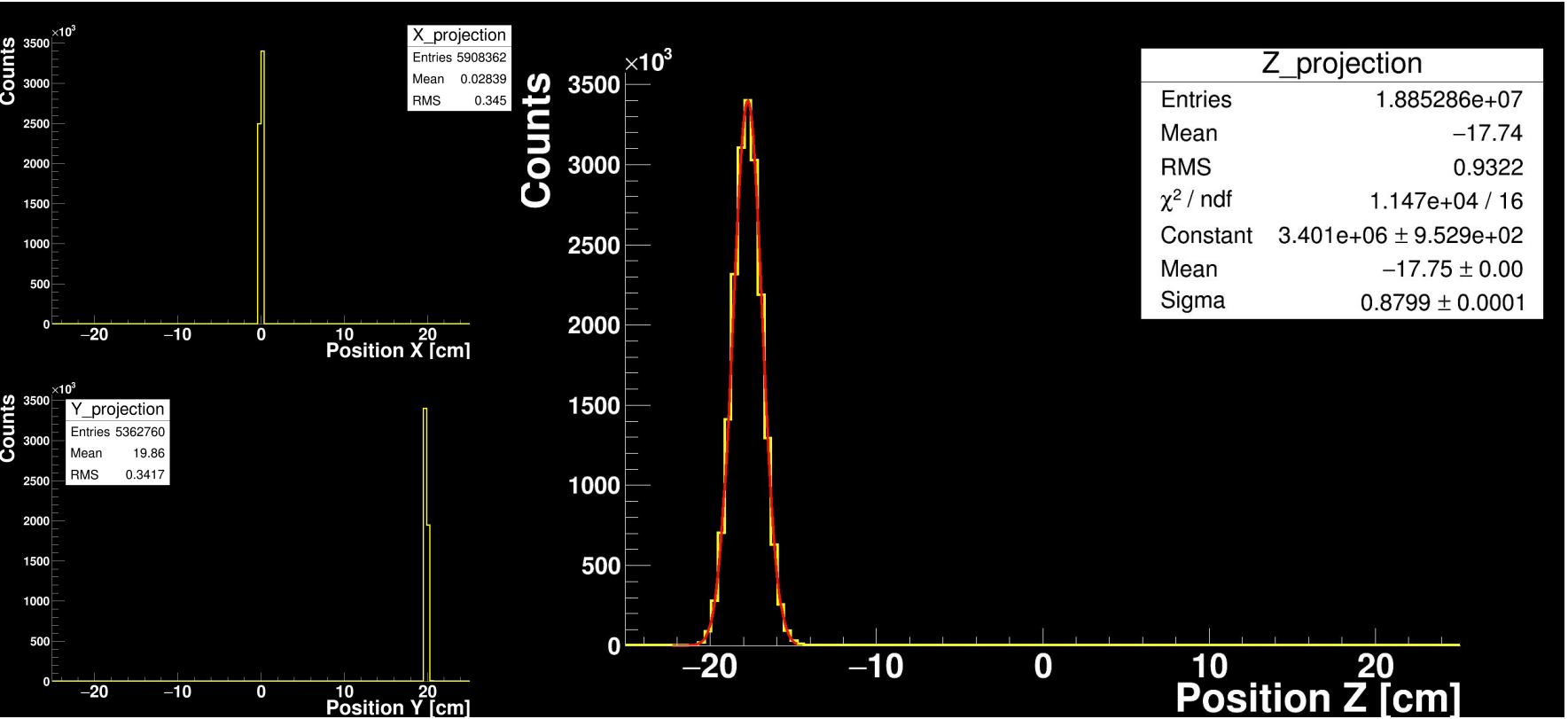
Results of spatial resolution - position (0,10,-18.75)



Results of spatial resolution - position (0,20,0)



Results of spatial resolution - position (0,20,-18.75)



Results of spatial resolution

Position	Width at half maximum along x axis [cm]	Width at half maximum along y axis [cm]	Sigma along z axis [cm]	FWHM (2.3548σ) [cm]
(0,1,0)	0.8	0.4	0.8868	2.09 cm
(0,1,-18.75)	0.4	0.8	0.8558	2.02 cm
(0,10,0)	0.8	0.4	0.8826	2.08 cm
(0,10,-18.75)	0.4	0.8	0.8305	1.96 cm
(0,20,0)	0.8	0.4	0.9495	2.24 cm
(0,20,-18.75)	0.8	0.8	0.8799	2.07 cm

Thank you