Status of SiBT data analysis

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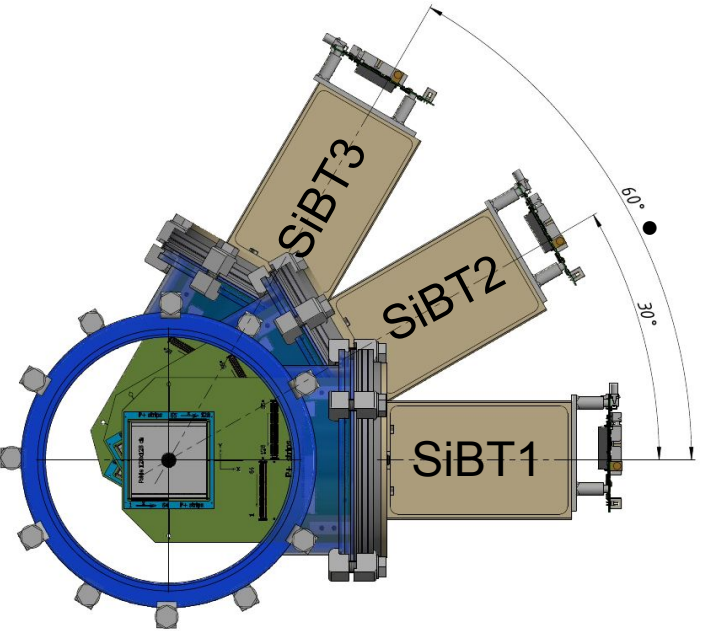
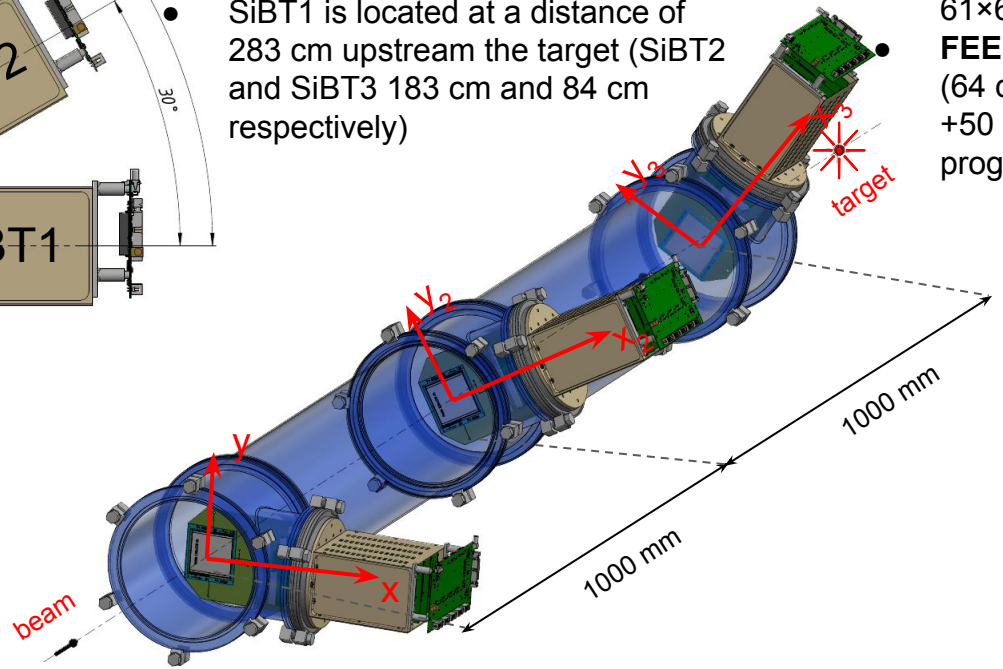
Silicon Beam Tracker



- SiBT1 is positioned inside the beam pipe such that the strips are aligned along the X and Y axes whereas the plates of the SiBT2 and SiBT3 detectors are rotated azimuthally by 30° and 60° respectively;
- SiBT1 is located at a distance of 283 cm upstream the target (SiBT2 and SiBT3 183 cm and 84 cm respectively)



- **Physical purpose**: determination of the reaction plane, *refinement of the vertex definition*, beam profilometry
- **detector:** DSSD, 128×128 strips, pitch p+ / n+ strips 470 μm, thickness 175 μm, active area 61×61 mm^2
- **FEE**: based on VATA64HDR16.2 (64 ch, dynamic range: -20 pC ÷ +50 pC; 50, 100, 150, 300 ns programmable shaping time)

SiBT data implementation to vertex reconstruction

At the moment, the information obtained from SiBT system is not used in reconstruction and analysis of Xe-run (2022-2023) data. A detector system installed upstream the interaction point may be useful to refine the reconstruction of the primary vertex, so an attempt has been made to use the SiBT data in combination with the reconstructed primary vertex

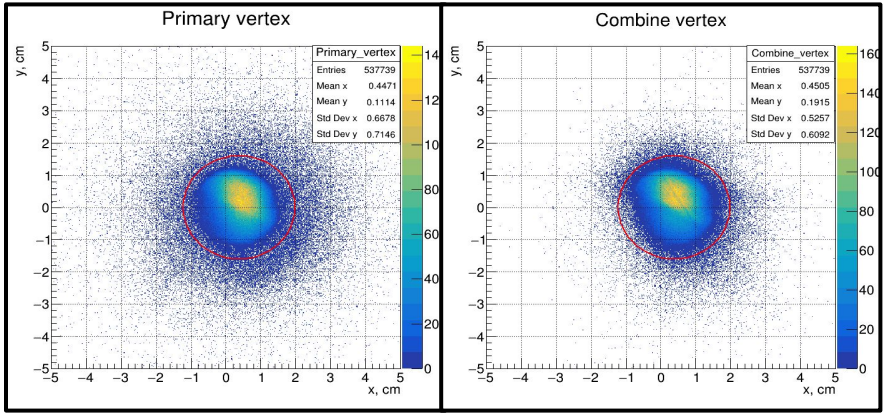
- beam track is propagated to the point $z = z_{primary}$;
- The new x and y coordinates of the vertex are calculated as the weighted mean of the SiBT-vertex and PrimaryVertex:

$$CombineVertex_{x,y} = \frac{primaryVertex_{x,y} \cdot \omega_{primary_{x,y}} + beamVertex_{x,y} \cdot \omega_{beam_{x,y}}}{\omega_{primary_{x,y}} + \omega_{beam_{x,y}}}$$

$$\text{where } \omega = \frac{1}{\sigma^2};\ \sigma^2 = cov(i,i);\ i = 0,\ 1$$

First results: comparison of vertices

All vertices



Run 7830; cuts:

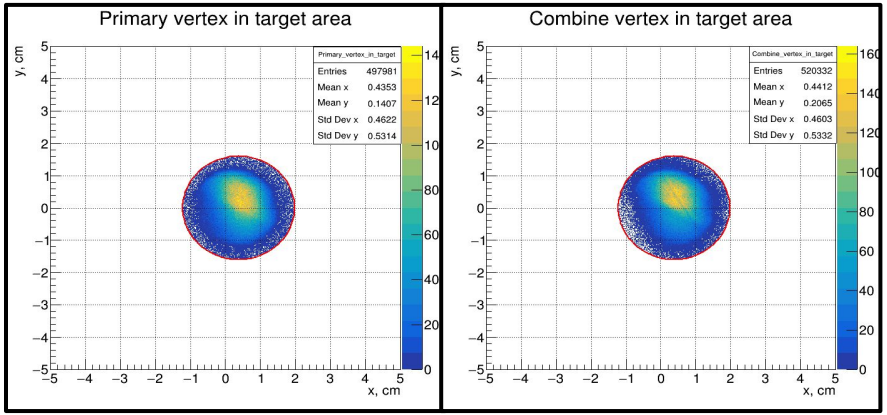
- Number of track in primary vertex > 1;
- there is beam track in event.

By using a vertex combined with a beam track, the number of events in the target area is **increased by 4%**, which can contribute to the statistics in the physical analysis (the particle mass distribution from ToF400 will be presented next)

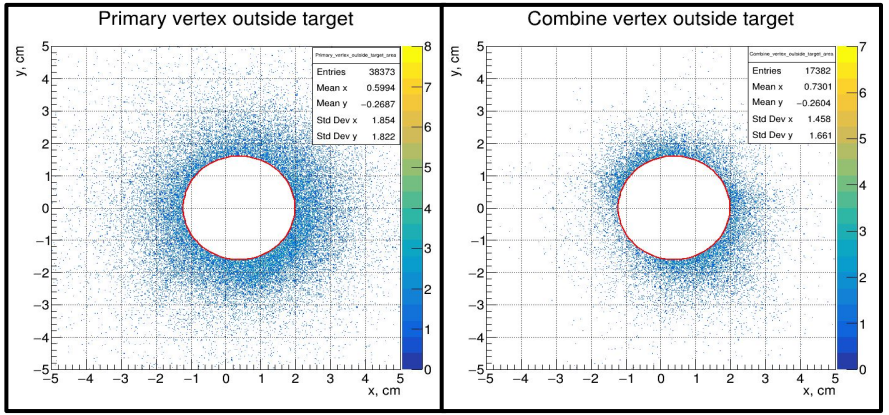
Standard deviations outside target area is:

- For Primary: $\sigma^2_x = 1.85$; $\sigma^2_y = 1.82$
- For Combine: $\sigma^2_x = 1.46$; $\sigma^2_y = 1.66$

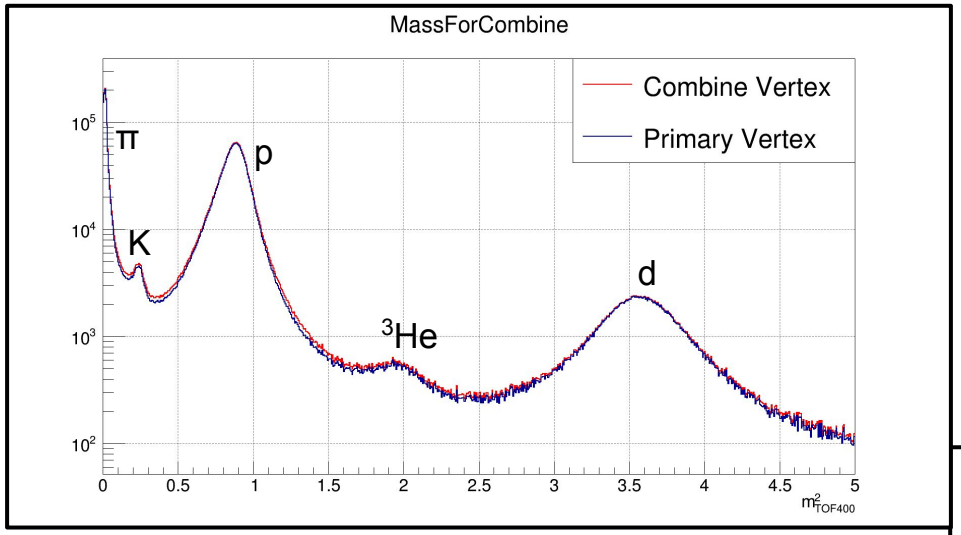
Vertices inside target area



Vertices outside target area

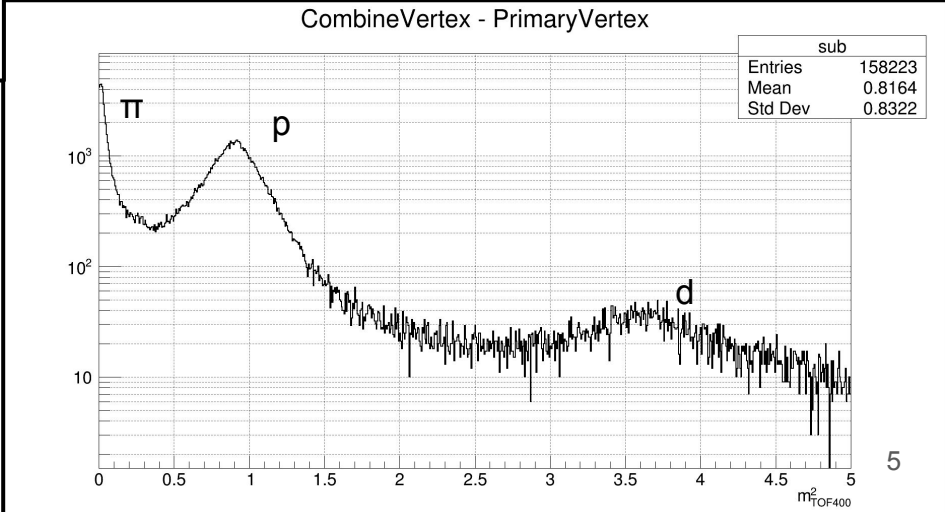


ToF400-mass



Runs 7830 and 7842
Events were selected in which:

- the primary vertex fall in the target area;
- the combined vertex fall in the target area



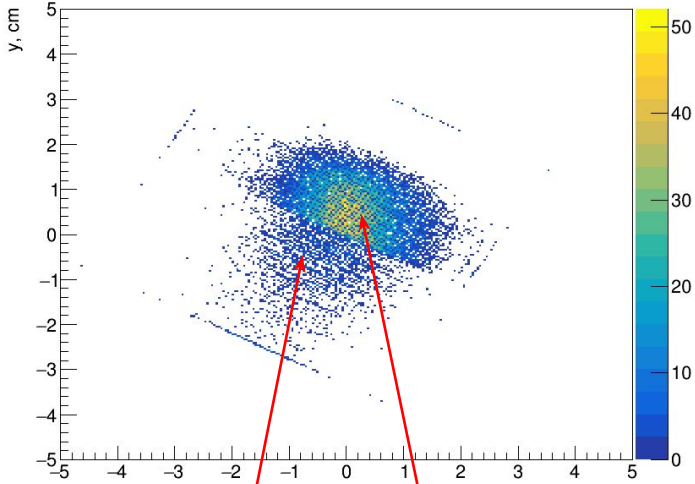
- For the masses selected with PrimaryVertex and CombineVertex the statistics on the interval [0, 5] $(GeV/c^2)^2$ is **4.31e+6** and **4.54e+6** respectively;
- For π [0.0, 0.1] $(GeV/c^2)^2$ the increase in statistics is **3.7%** (3.6e+4 events);
- For p [0.8, 1.1] $(GeV/c^2)^2$ the increase in statistics is **2.95%** (5.9e+4 events)**;**
- For d [3.25, 4.25] $(GeV/c^2)^2$ the increase in statistics is **2.2%** (4.6e+3 events)**;**

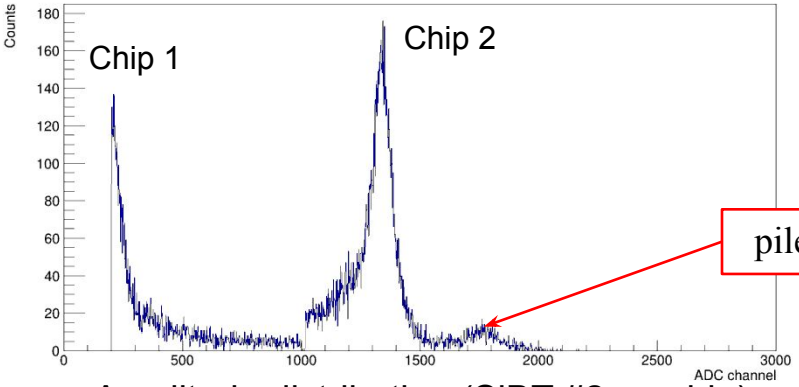
FEE status

SiBT FEE during Xe-run

This slide shows SiBT FEE operation in XE-run on example of SiBT #2 (run 8387, 1.02.2023). The gains of FEE-chips on n+ side were not tuned for signals on the order of 10.9 pC (energy losses of Xe with energy 3.8 GeV/n are 245.5 MeV). Because of this signals from one of FEE-chips were below th threshold and were not written (in this case – chip 1 (channels 0 – 63)

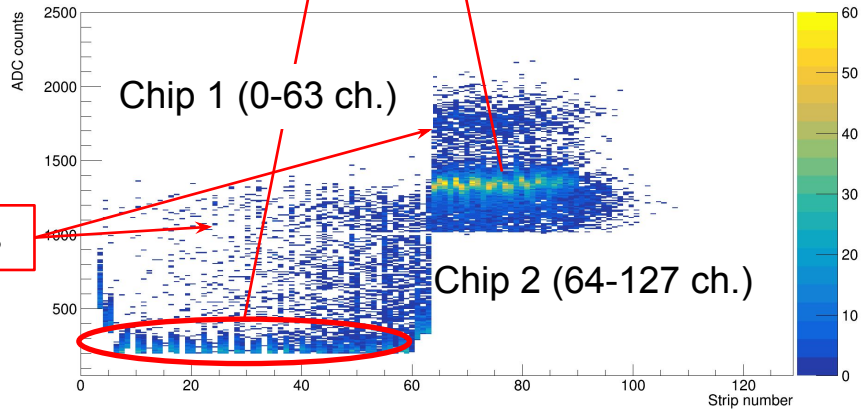
Hit plot SiBT #2





Amplitude distribution (SiBT #2 n+ side)

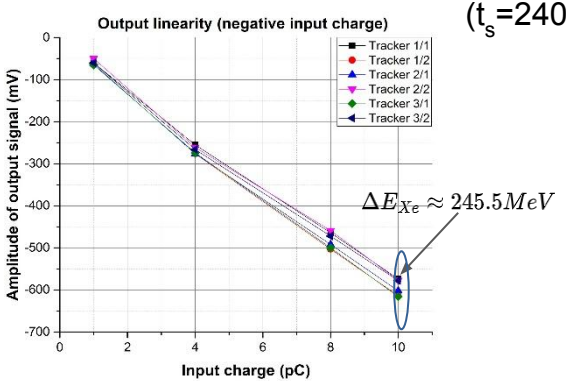
pileups

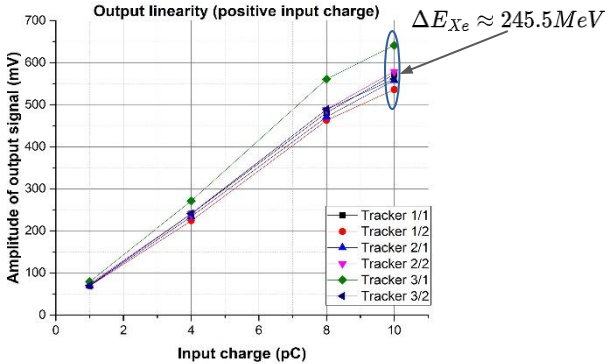


Channel distribution of amplitudes (SiBT #2 n+ side)

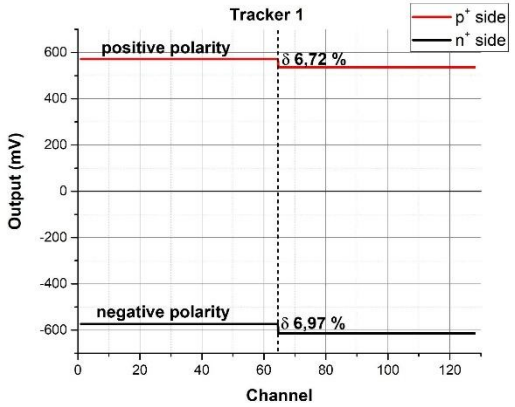
SiBT FEE status

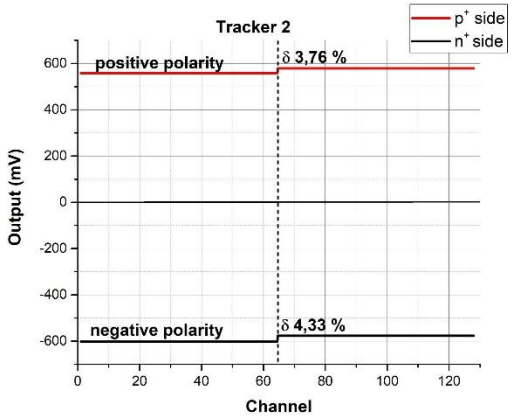
Linearity of ASICs after PCB tuning (t_s=240 nS)

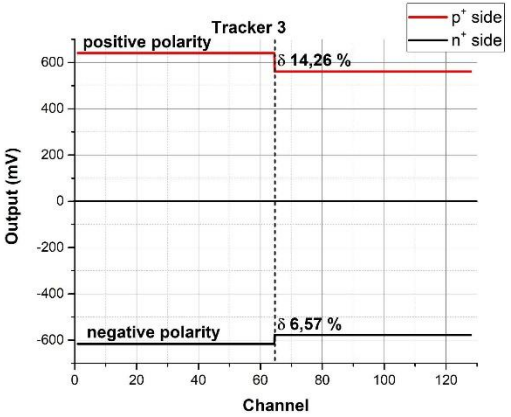




The gain spread of ASICs (input 10 pC, t_s=240 ns+120 ns)

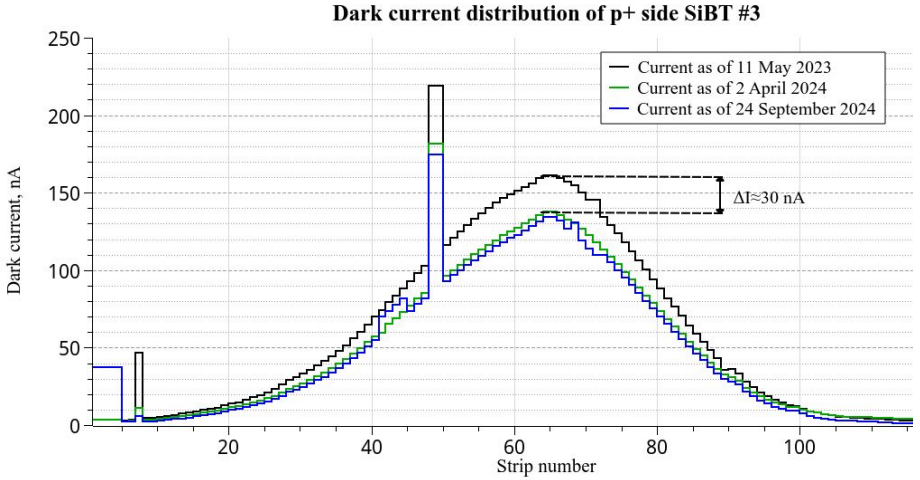


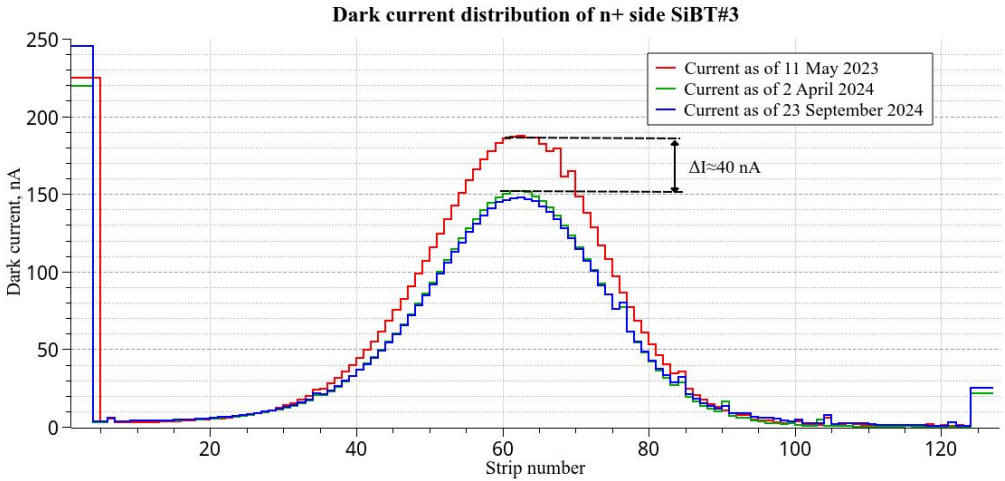




SiBT dark current

SiBT3 was kept at room temperature for 16 months, during this time the detector dark current decreased by 1.3 μA as a result of self-annealing





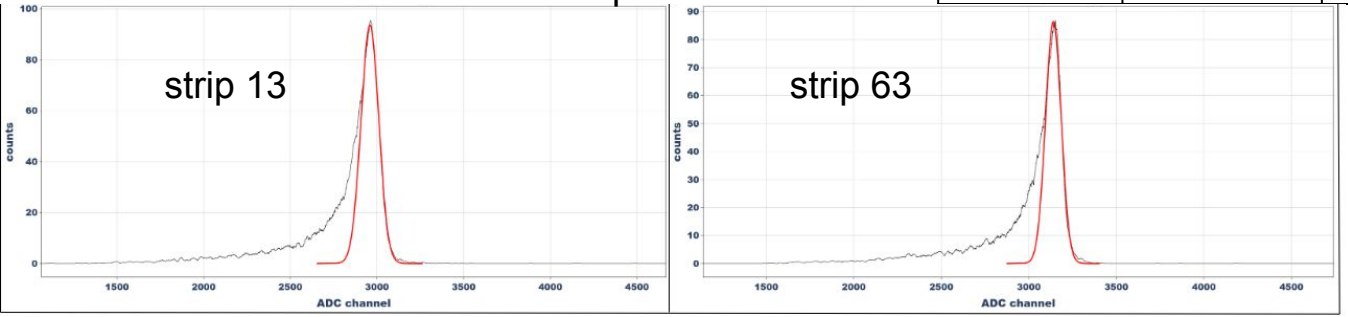
	$I_{66\ p+}$, nA	$I_{63\ n+}$, nA	I_{Σ}, μA
May 2023	161.5	187.5	7.1
April 2024	138.0	151.8	5.9
September 2024	134.4	147.8	5.8
Delta	27.1	39.7	**1.3 (18%)**

Alpha-source test

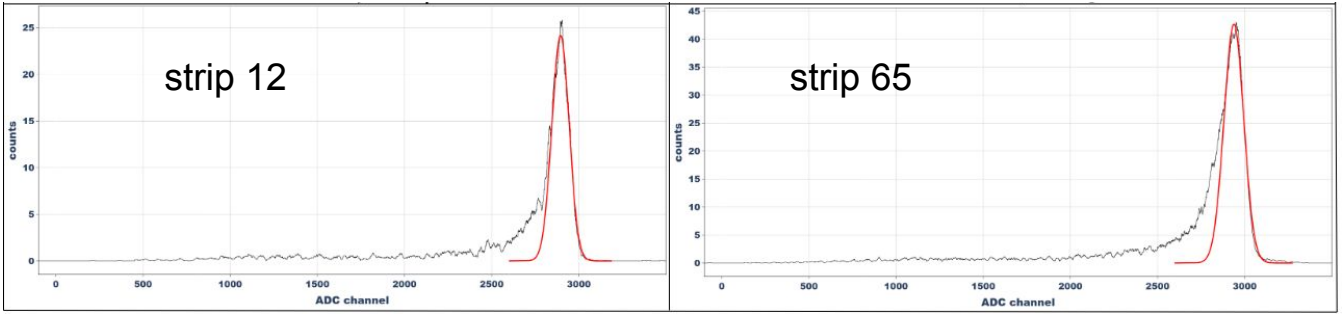
In the damaged regions of the detector, the spectrometric characteristics are not worse than in the undamaged ones. It is worth noting that we are talking about radiation with energy about of **5.5 MeV**, while the BM@N experiment uses beams of heavy nuclei with energies of several GeV per nucleon. In the Xe-run E = 3.8 AGeV, losses in the detector are **245.5 MeV**, almost 44 times greater.

	p+ side		n+ side	
	strip 13	strip 63	strip 12	strip 65
Mean, ADC channels	2960,0±0,2	3146,6±0,4	2894,8±0,3	2937,9±0,4
σ, ADC channels	50,3±0,2	38,2±0,3	49,0±0,4	56,5±0,4

p+ side



n+ side



Alpha source placed on most damaged strips (66 and 63 for p+ and n+ side respectively) and least damaged strips (13 and 12 strips for p+ and n+ side) to comparison

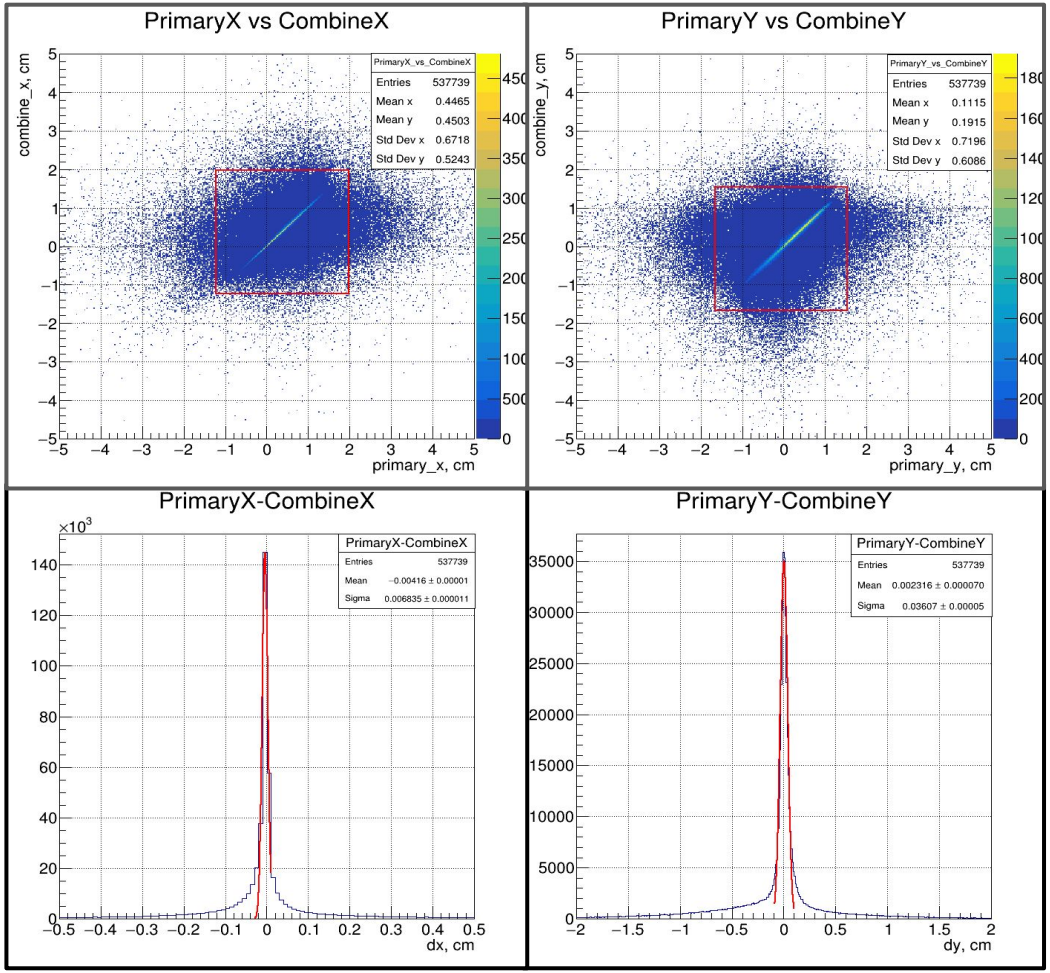
Conclusions

- FEE of SiBTs were tested and its gain is set to optimal values;
- Dead strip at SiBT №3 have been eliminated;
- Dark current of SiBT №3 has decreased by 1.3 μA over the past year and a half as a result of self annealing at room temperature;
- An attempt was made to use SiBT data to refine the reconstruction of the transverse coordinates of the primary vertex:
  - The number of vertices falling in the target area increased by about 4% for a statistic of 1 million events;
  - An increase in π, p and d statistics is observed for the TOF-400 mass spectra;
  - **Further analysis is required to verify.**
- Future plans: work is underway to use the transverse vertex position data from SiBT as a first approximation in the primary vertex calculation algorithm

Thank you for your attention!

Backup

X and Y coordinates correlations between Primary vertices and Combine vertices



The correlation plots show that PrimaryVertex has more scatter compared to CombineVertex

Residuals between X- and Y- coordinates for PrimaryVertex and CombineVertex is:

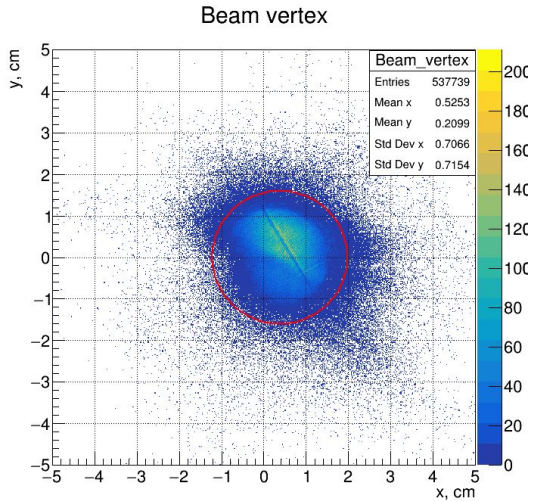
- X-coordinate:

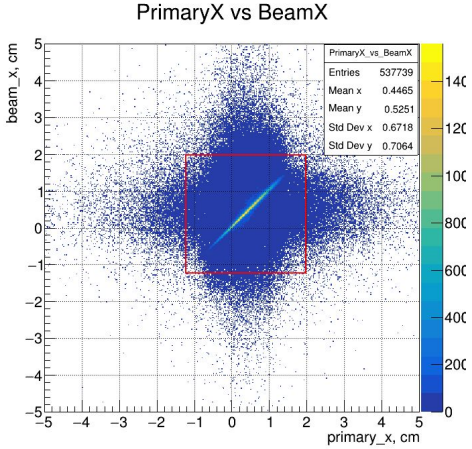
$x = -4e\text{-}3$ cm; $\sigma_x = 6.8e\text{-}3$ cm;

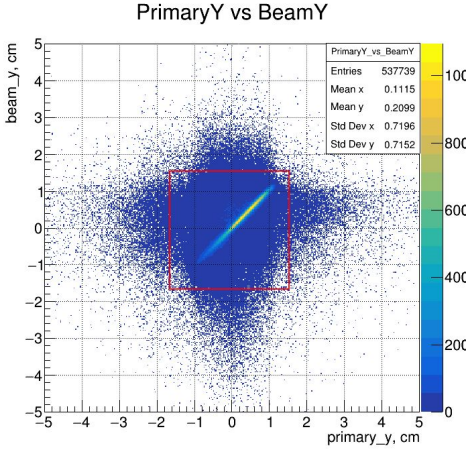
- Y-coordinate:

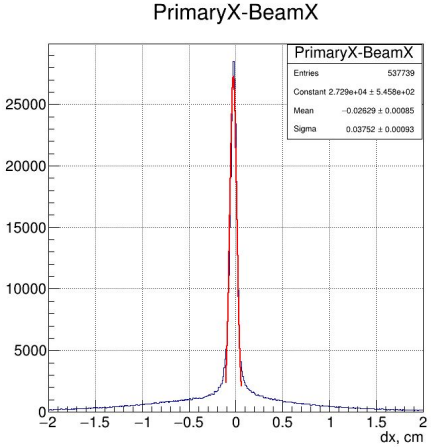
$y = 2.3e\text{-}3$ cm; $\sigma_y = 3.6e\text{-}2$ cm;

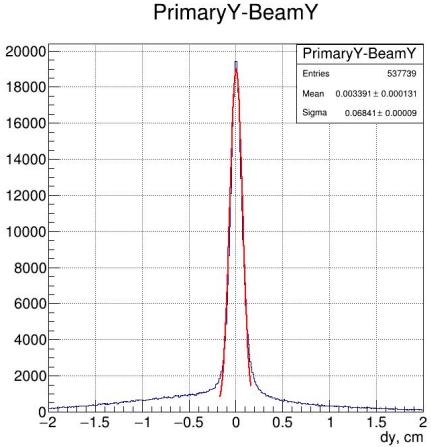
Beam vertices







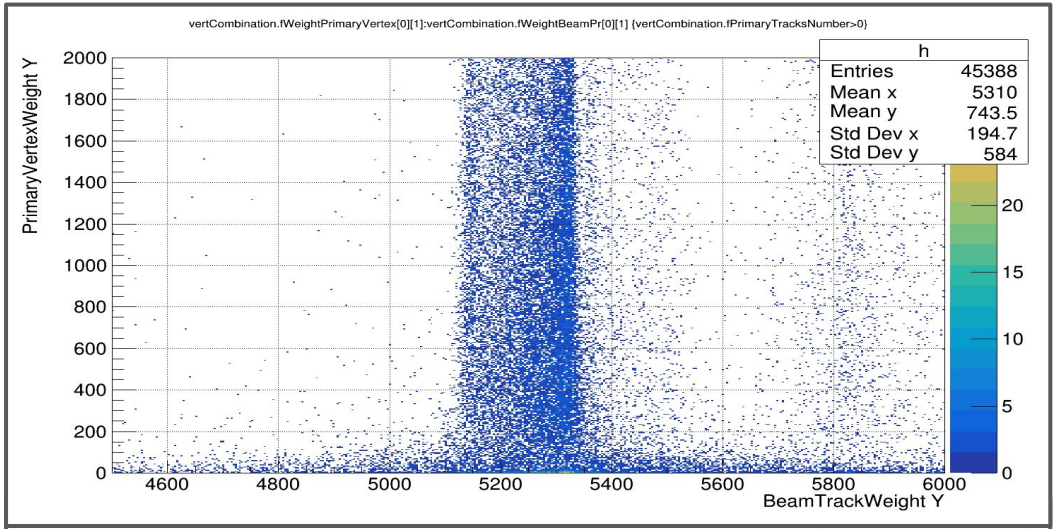




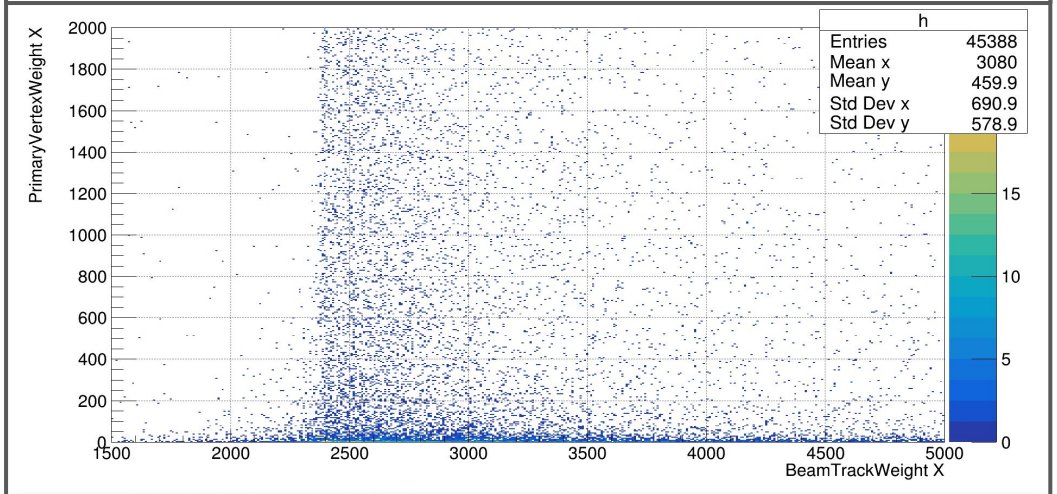
Currently, BeamVertecis coordinates are stored in ParamLast of BmnBeamTrack (BeamTrack is propagated to z=0)

Weights of PrimaryVertex and BeamTrack

X-coordinates weights



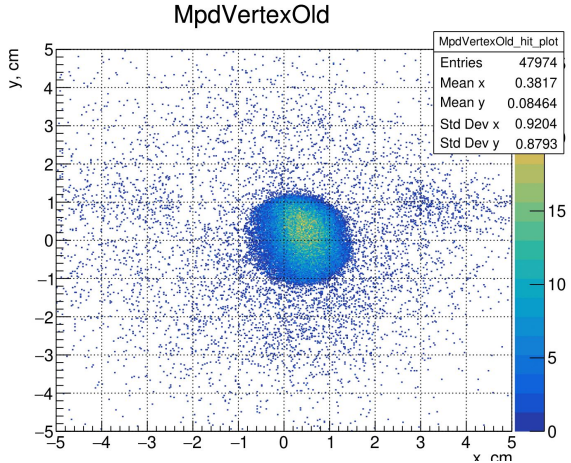
Y-coordinates weights

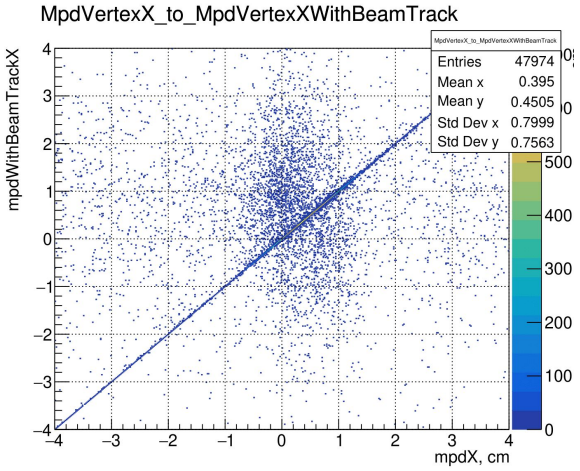


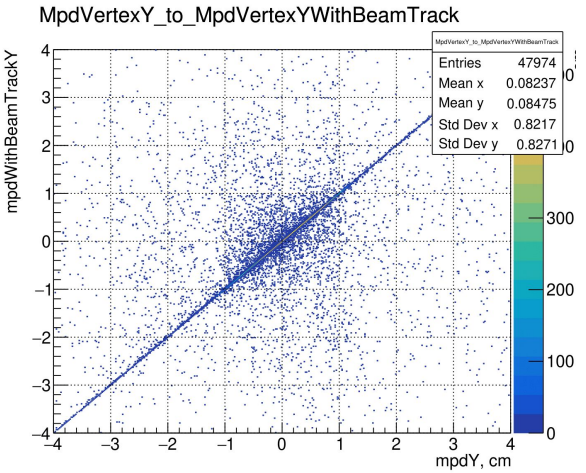
Beam track as Initial approximation for MpdVertex

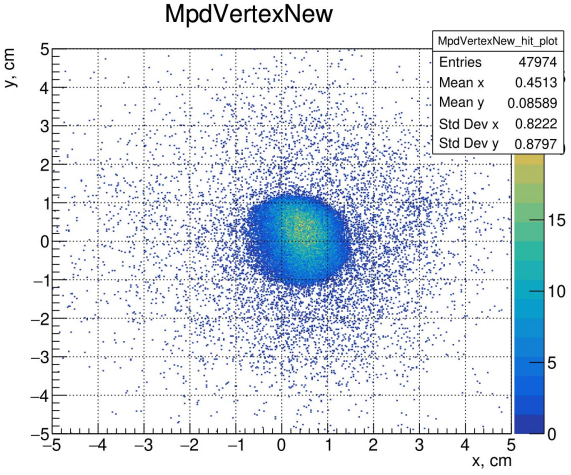
An attempt was also made to use the x and y coordinates of BeamTrack as an initial approximation for computing the vertex of MpdVertex. For this purpose BeamTrack was propagated to the point z=0, after which the obtained parameters X and Y were used in the calculation algorithm as initial approximations

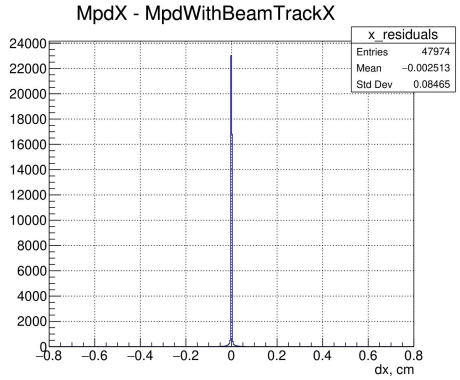
Beam track as Initial approximation for MpdVertex

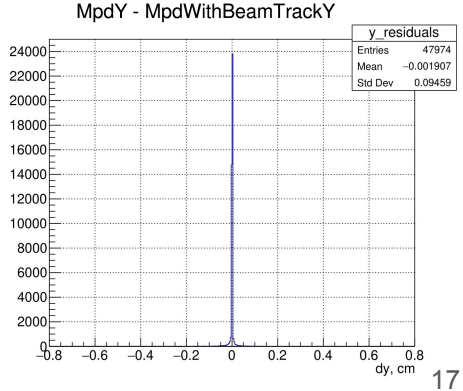






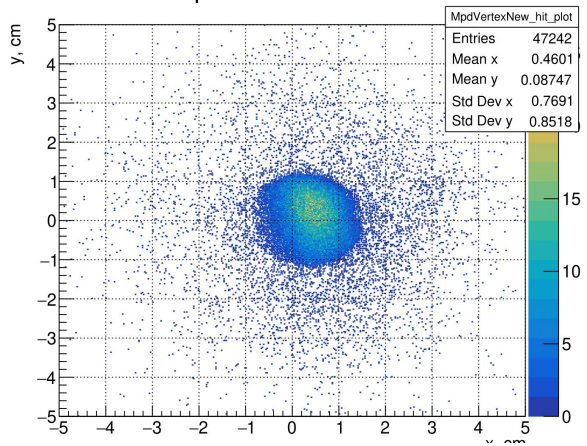




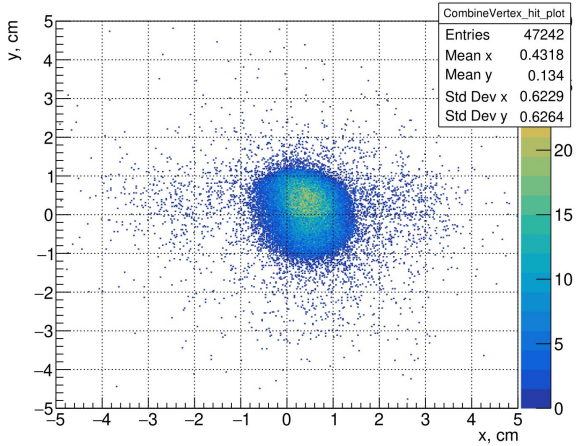


MpdVertex with initial approximation comparison with CombineVertex

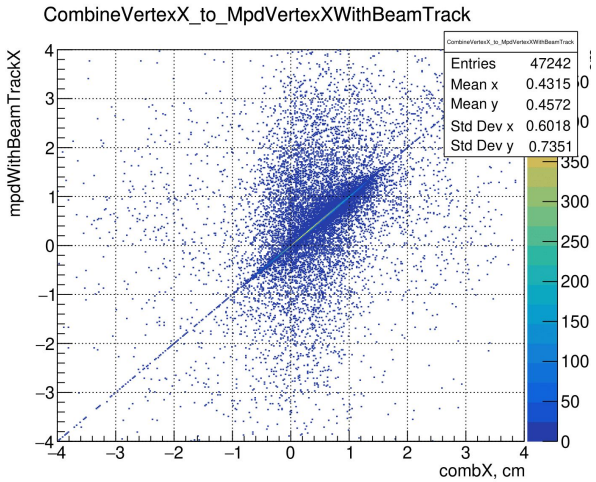
MpdVertexNew



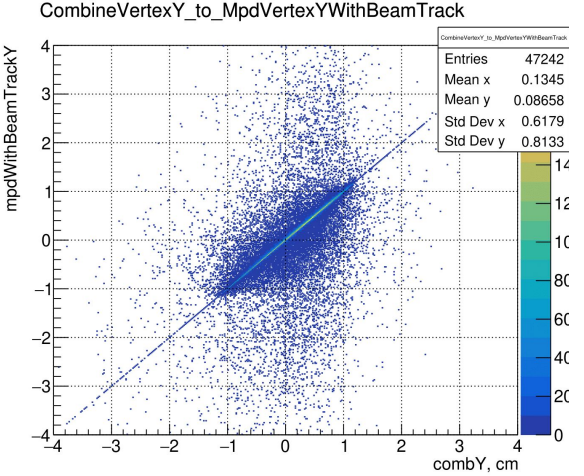
CombineVertex



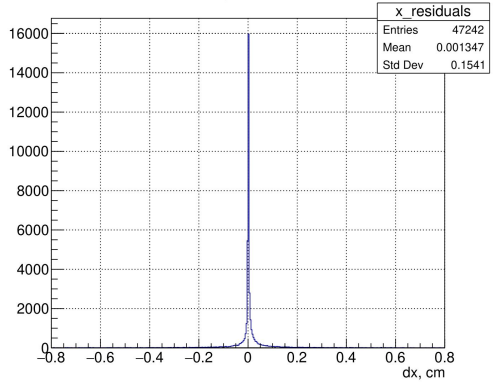
CombineVertexX_to_MpdVertexXWithBeamTrack



CombineVertexY_to_MpdVertexYWithBeamTrack



CombineVertexX - MpdWithBeamTrackX



CombineVertexY - MpdWithBeamTrackY