Simulation of silicon detectors of the MiniSPD setup

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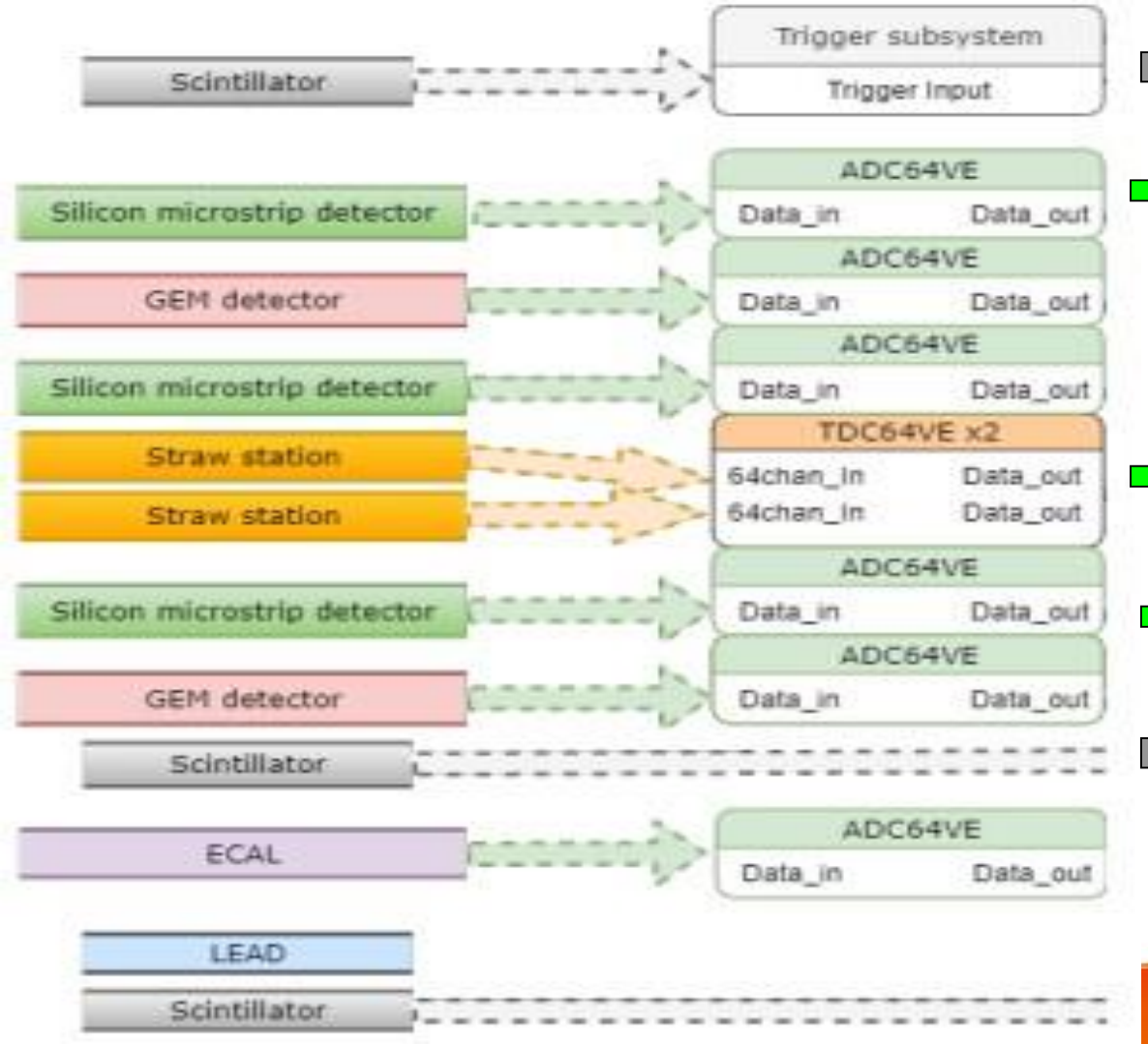
MiniSPD stand

Structure of MiniSPD



Top scintillator

Si

Si

Si

Bottom scintillator

Trigger subsystem consists of two (top and bottom) scintillators. Top: ScintPos[2] = 3 mm. Bottom: ScintPos[2] = 931,5 mm.

Two-sided Si-plates

Top module:

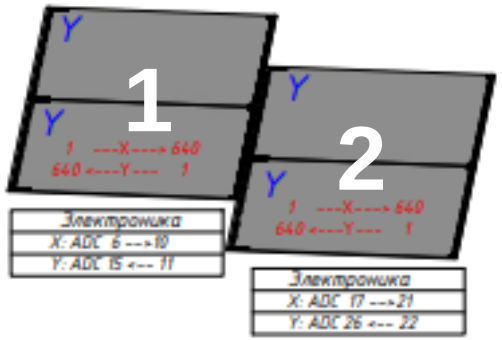
- **1st part - U/X (coordinates)**
- **2nd part – U/X**

Middle module:

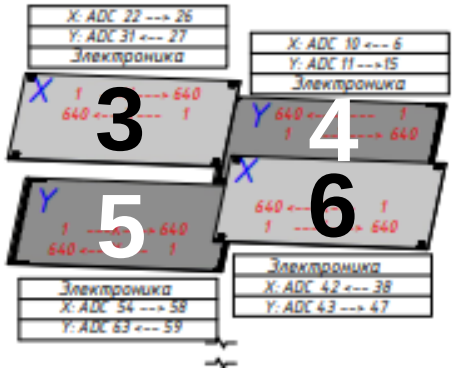
- **3rd – X/U, 4th – Y/U**
- **5th – U/X, 6th – X/U**

Bottom module:

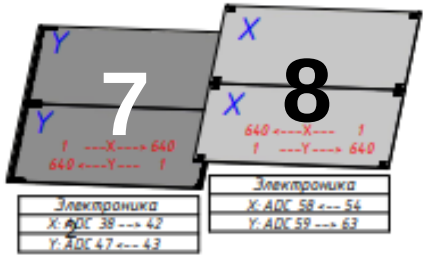
- **7th part - U/X**
- **8th part – X/U**



TOP



MIDDLE



BOTTOM

Geometry of Silicon plates

Thickness of every single Si-plate – 300 microns
Number of strips – 640
Strip's size – 0,095 mm
Measured coordinates – X & U (2,5°)
Strip numeration:
Numeration of strips from left to right:
X1, X2, X4, X5, X7 and U1, U2, U3, U4, U5, U7
From right to left:
X3, X6, X8 and U6, U8.

Geometry of Silicon plates

	X, mm	Y, mm	Z, mm	Size, mm
Sx1, Su1	-28,55	0	35,0	63 x 126
Sx2, Su2	31,55	0	50,3	63 x 126
Sx3, Su3	-32,55	-27,55	387,8	63 x 63
Sx4, Su4	27,55	-32.55	395,1	63 x 63
Sx5, Su5	-27,55	32,55	395,1	63 x 63
Sx6, Su6	32,55	27,55	387,8	63 x 63
Sx7, Su7	-28,55	0	893,5	63 x 126
Sx8, Su8	31,55	0	886,2	63 x 126

Table 1. Detector coordinates

Inclusion in basic packet of StripStepping.cc for simulation of triggering of strips

- Add StripStepping.cc to SteppingAction.cc

In StripStepping for every module and part:

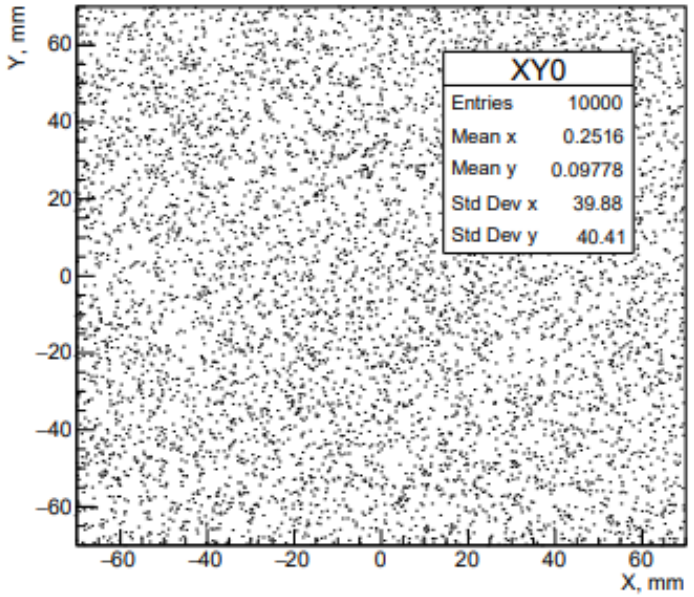
1. Connect the triggered strip number with X-coordinate, define U-coordinate for the same plane and the strip number on U-plate and its E_dep (energy deposition). The counter works.

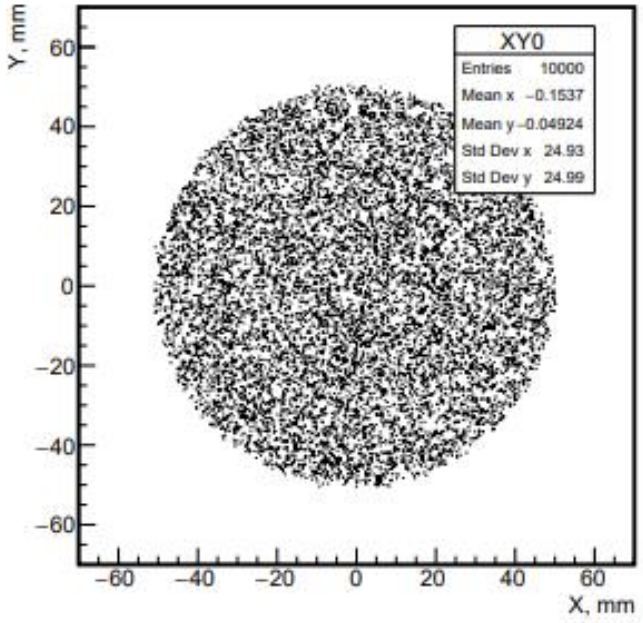
2. Sorting of triggered strip number in increasing order for elimination of repeating numbers (X and U plates).

3. Border accounting. (Complicated programme)

Direction and position of initial muons

- Polar angle distribution by cosine
- X(Y) – R(0, r) (uniform distribution)





$-10^\circ \leq \theta \leq 10^\circ$, ρ (density) on θ

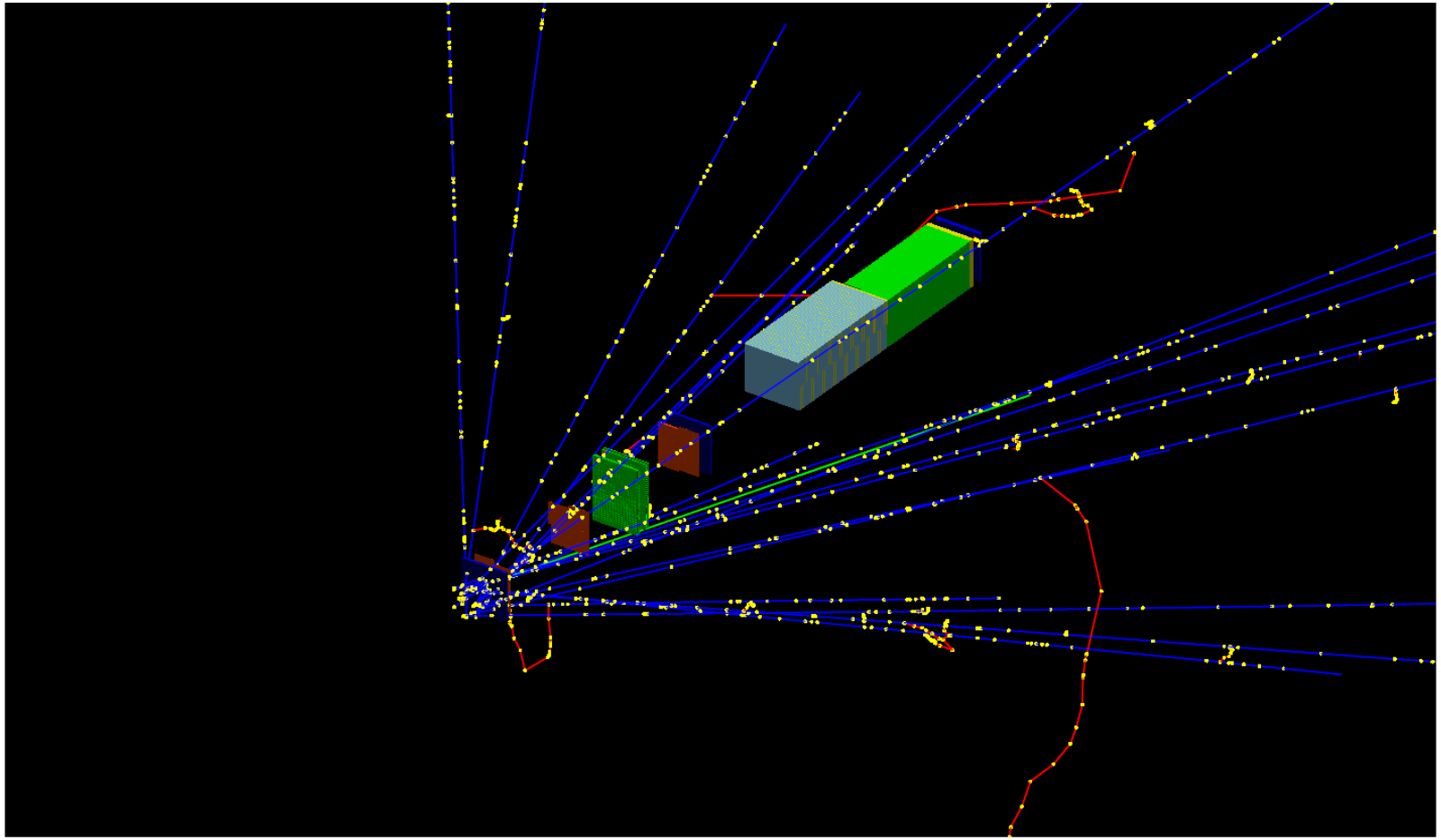
r = 100 mm

$-25^\circ \leq \theta \leq 25^\circ$

r = 50 mm

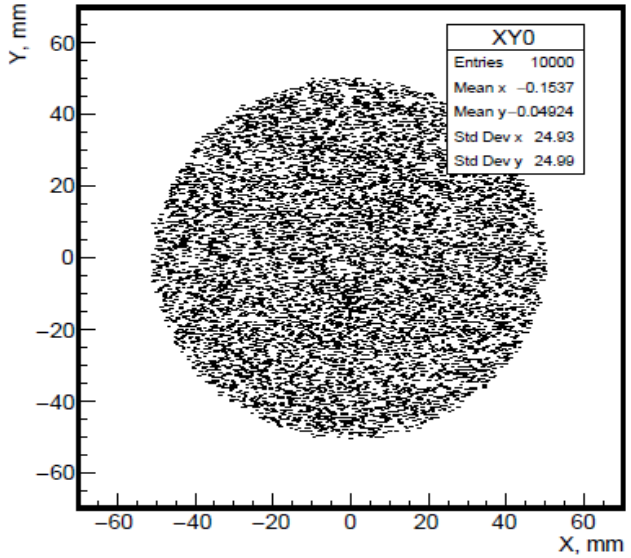
Number of muons - 10000

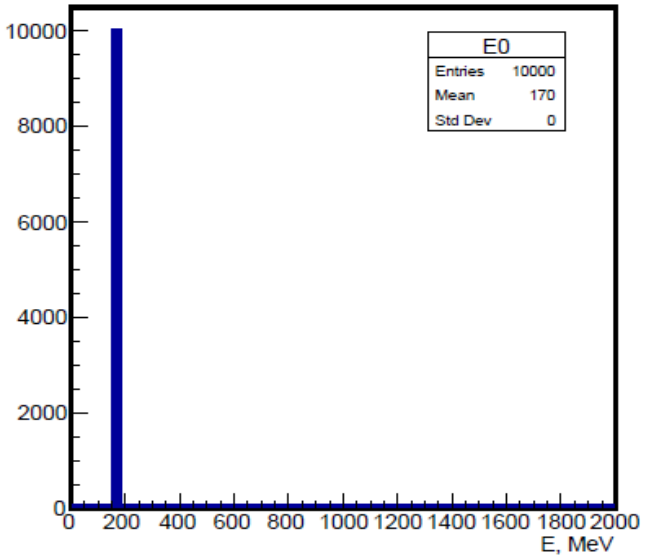
Scheme of MiniSPD

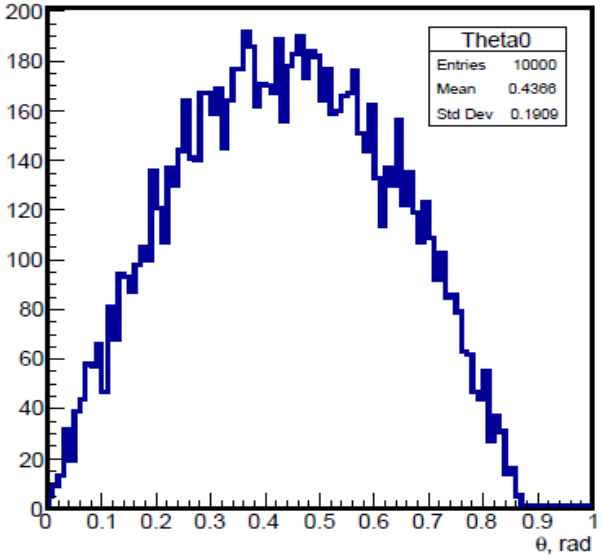


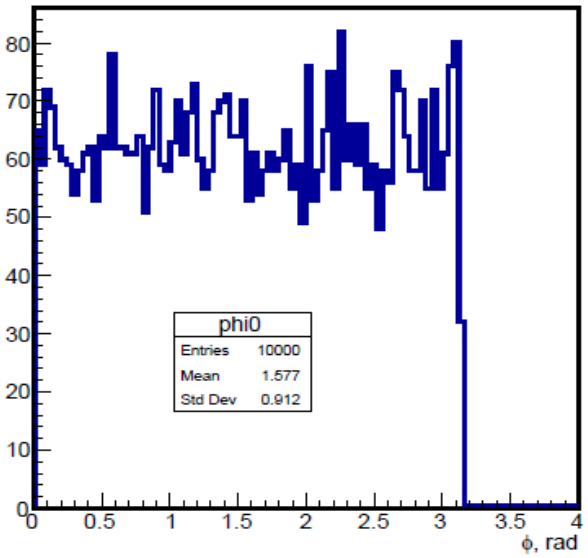
Geant4. Theta = 50 degrees

$-25^\circ \leq \theta \leq 25^\circ$

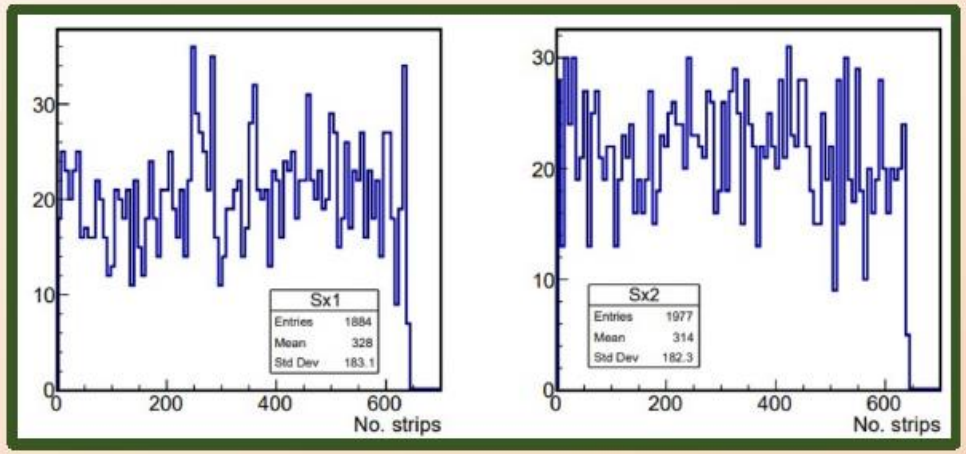


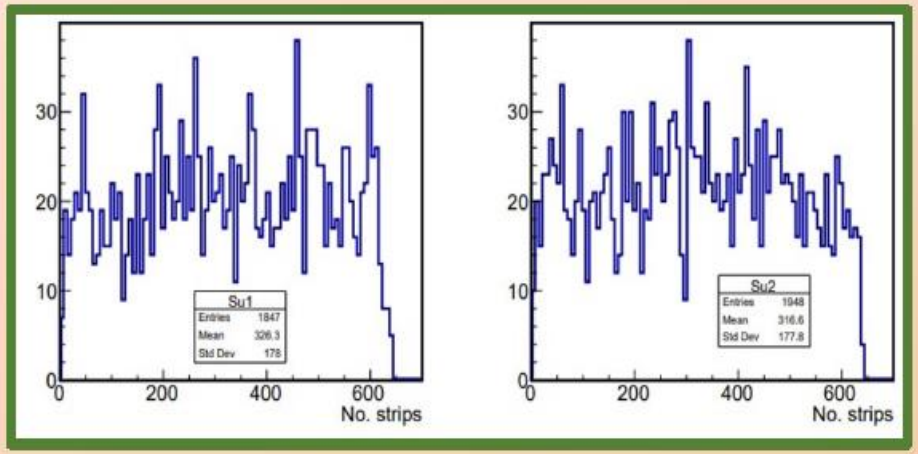




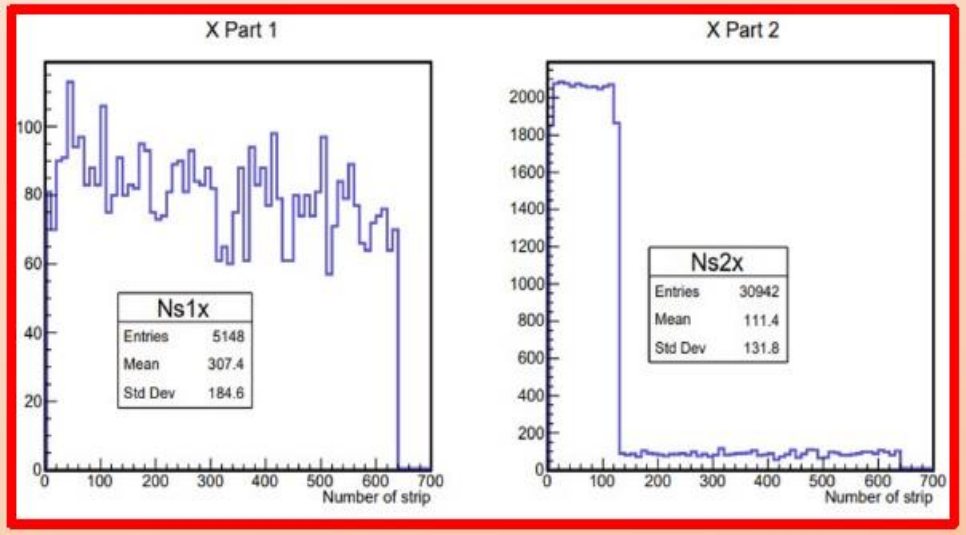


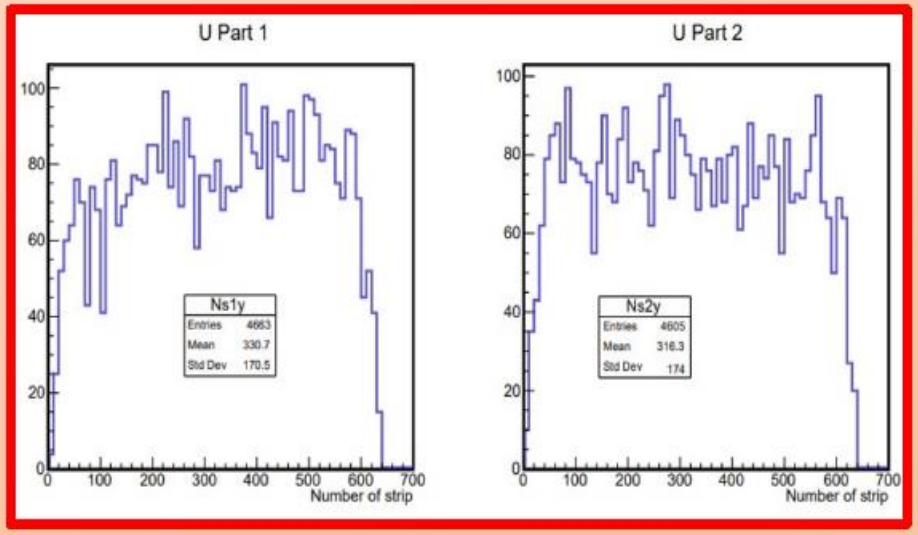
Strip number distributions for X1, X2, U1, U2 plates





MC





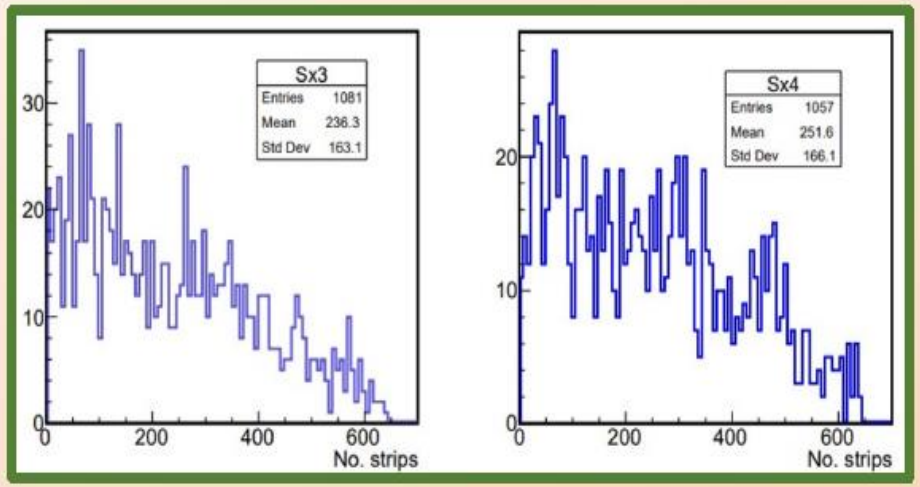
DATA

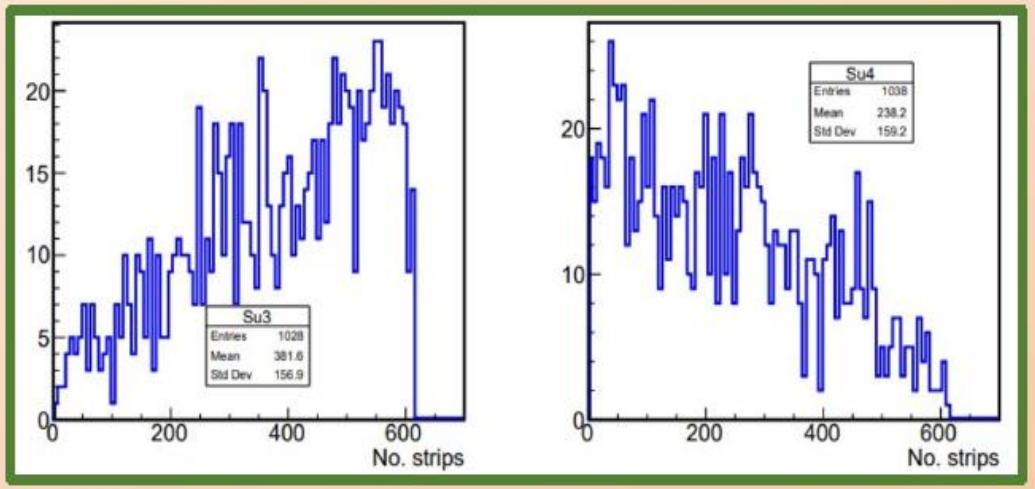
X1 - good work

X2 ~ 100 channels
make enhanced noise

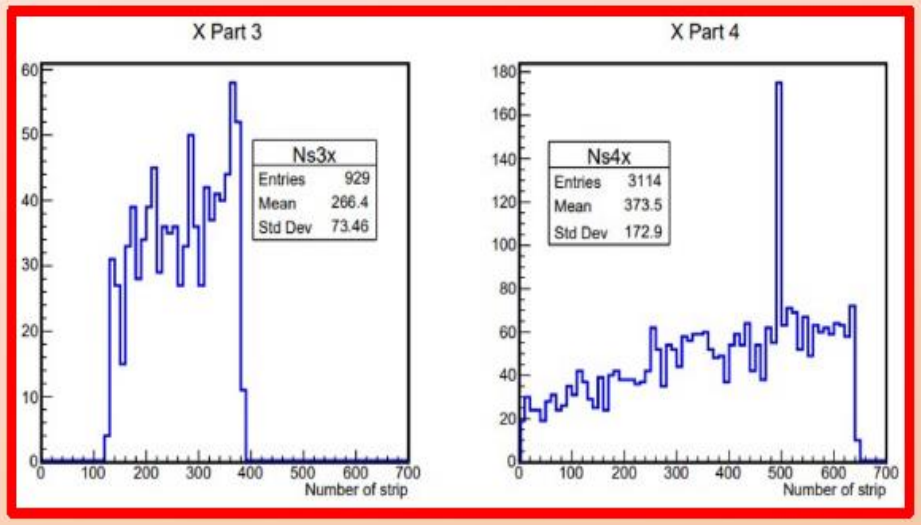
good work

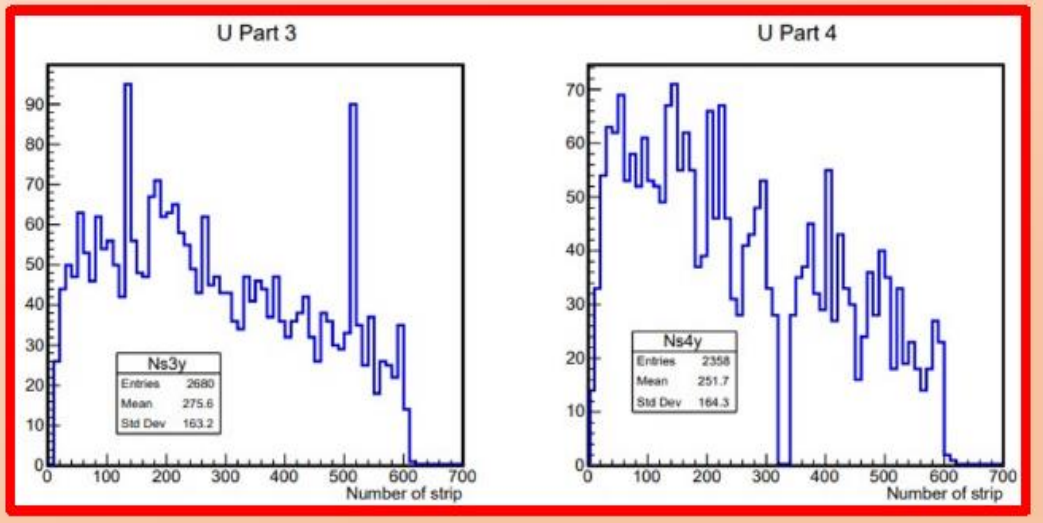
Strip number distributions for X3, X4, U3, U4 plates





MC





DATA

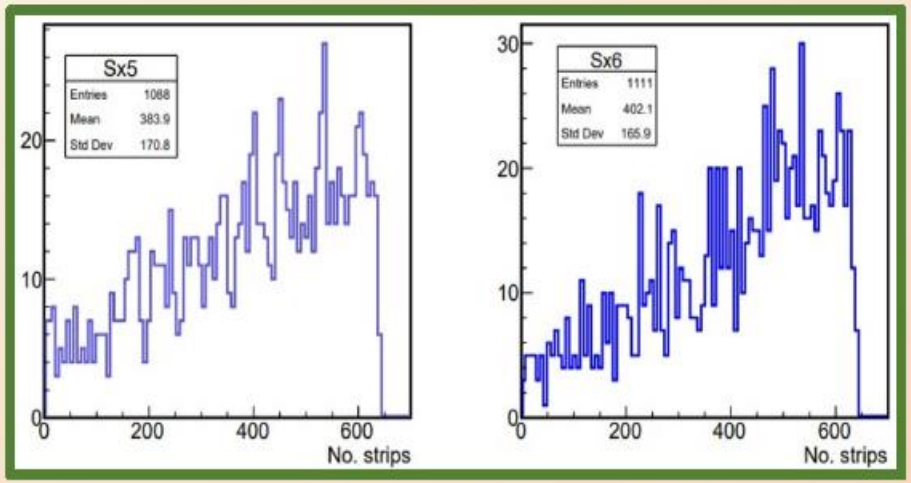
X3 ~ ½ of trips don't work

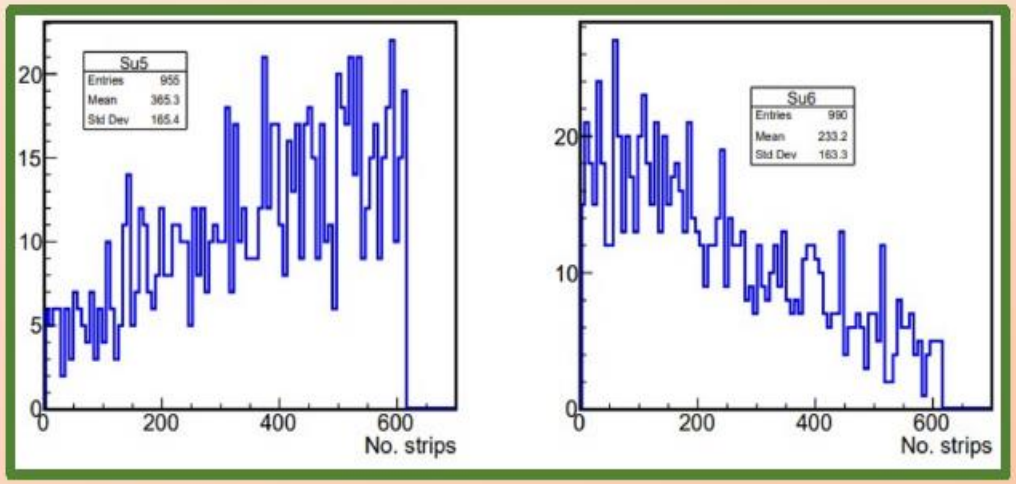
X4 – there are noise channels

U3 - noise channels

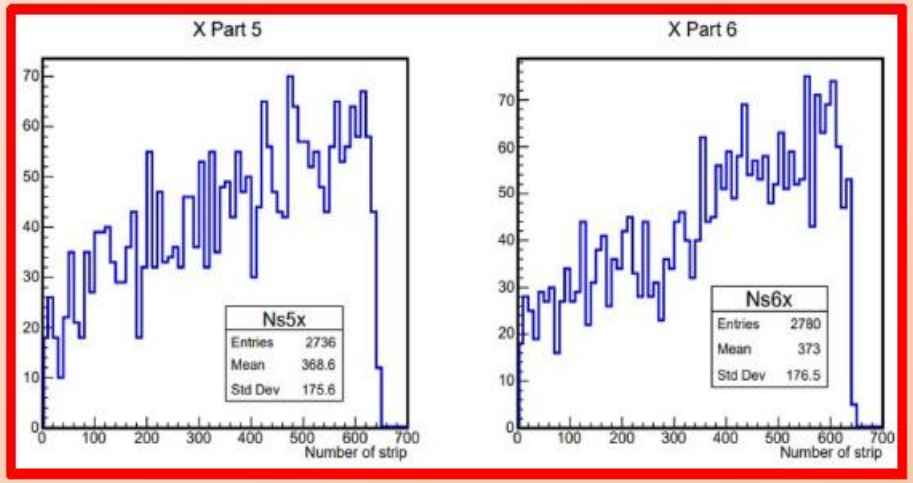
U4 - dead channels

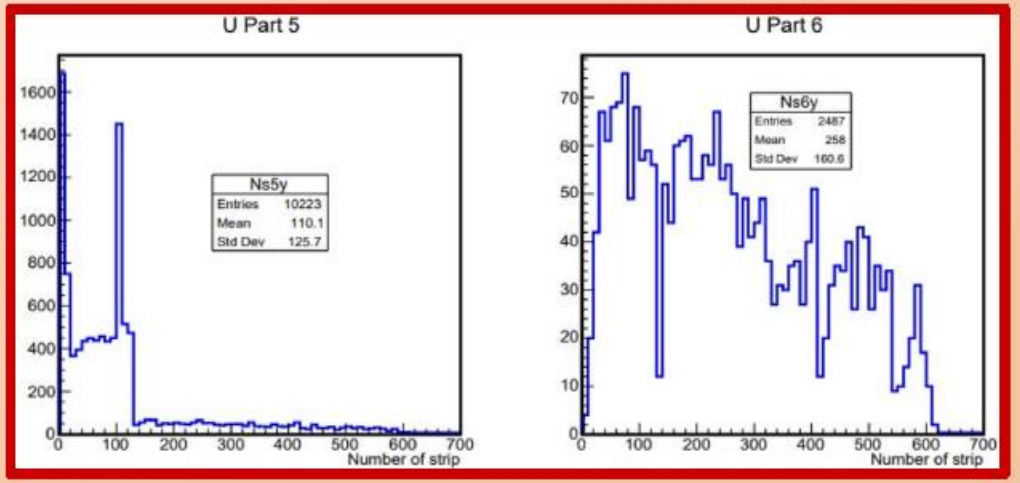
Strip number distributions for X5, X6, U5, U6 plates





MC





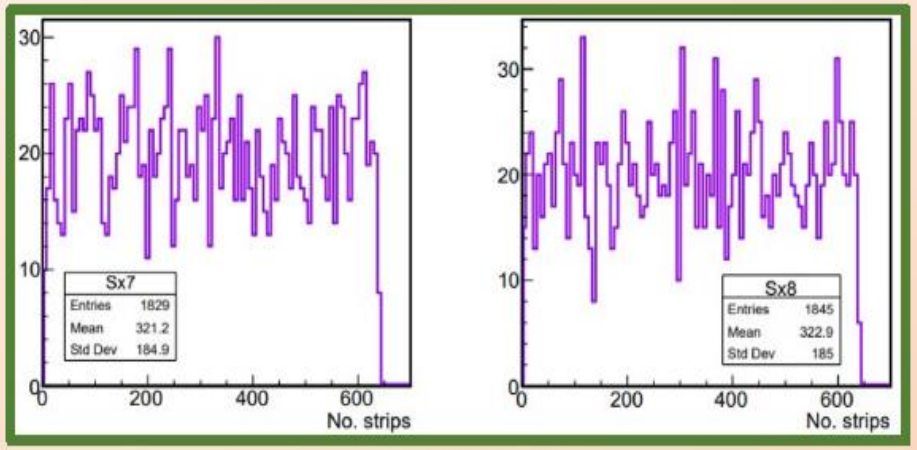
DATA

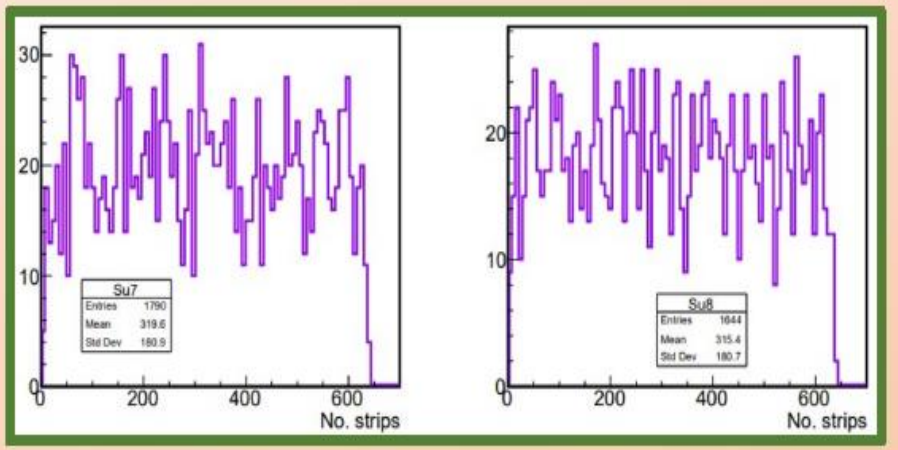
X5 and X6 - good work

U5 ~1/4 channels make noise

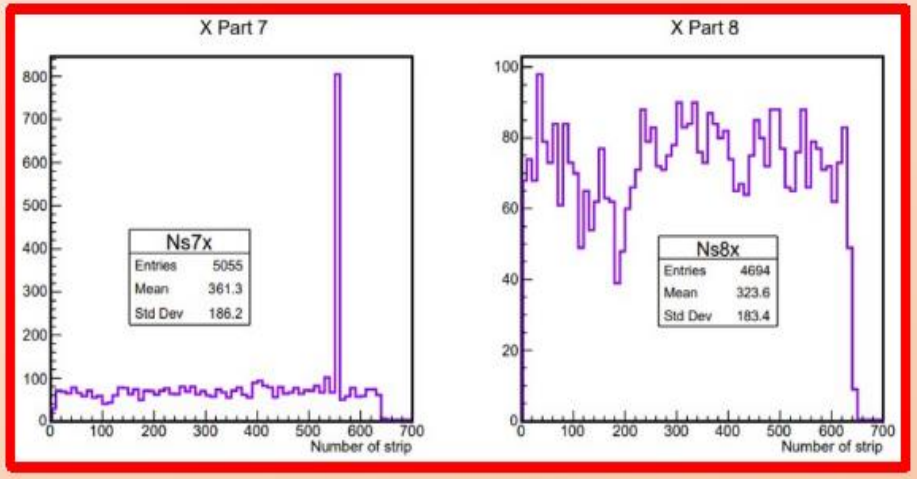
U6 - almost good work

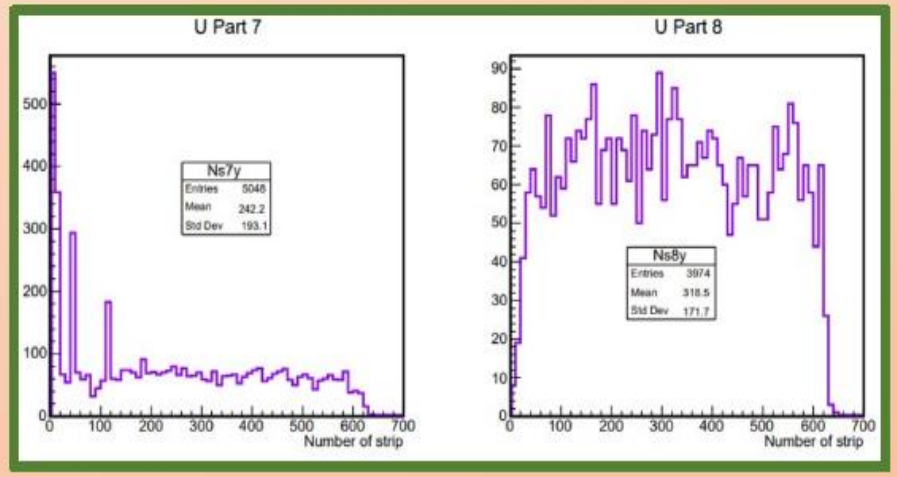
Strip number distributions for X7, X8, U7, U8 plates





MC





DATA

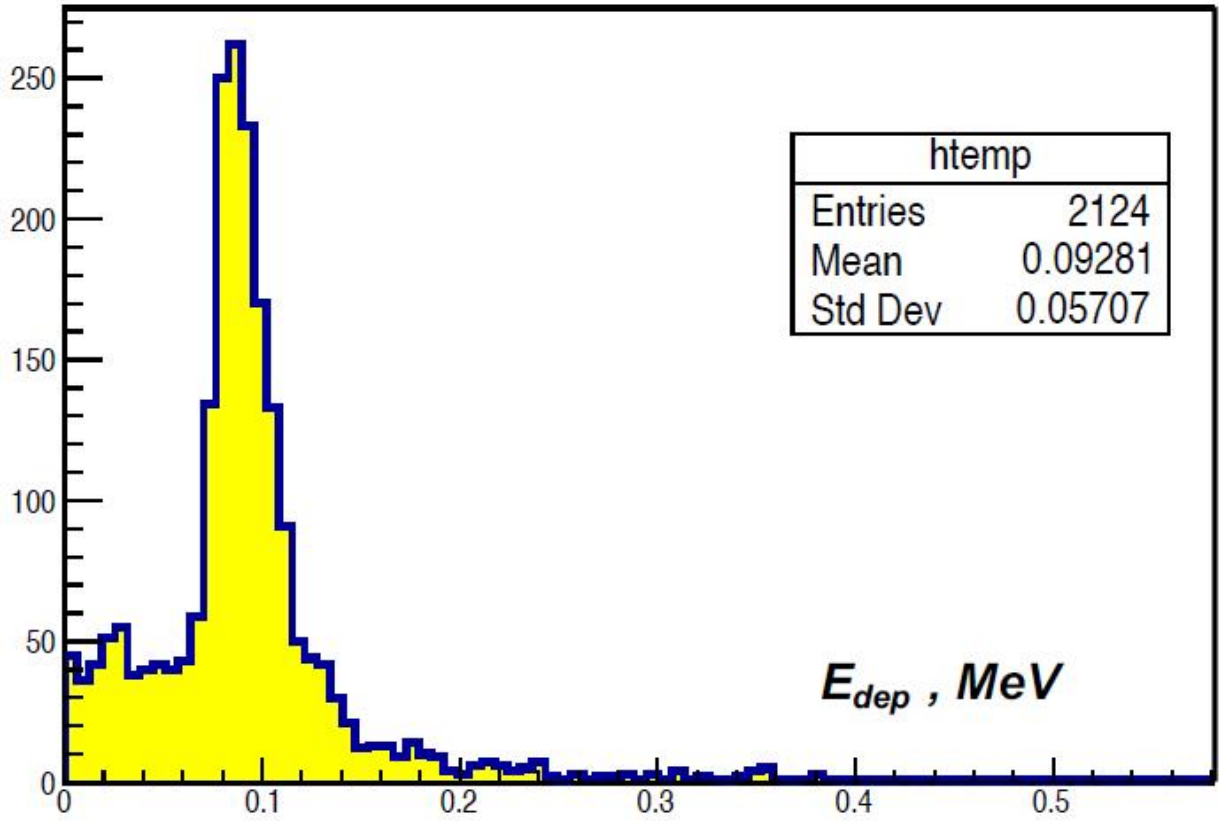
X7 - there are few noise channels

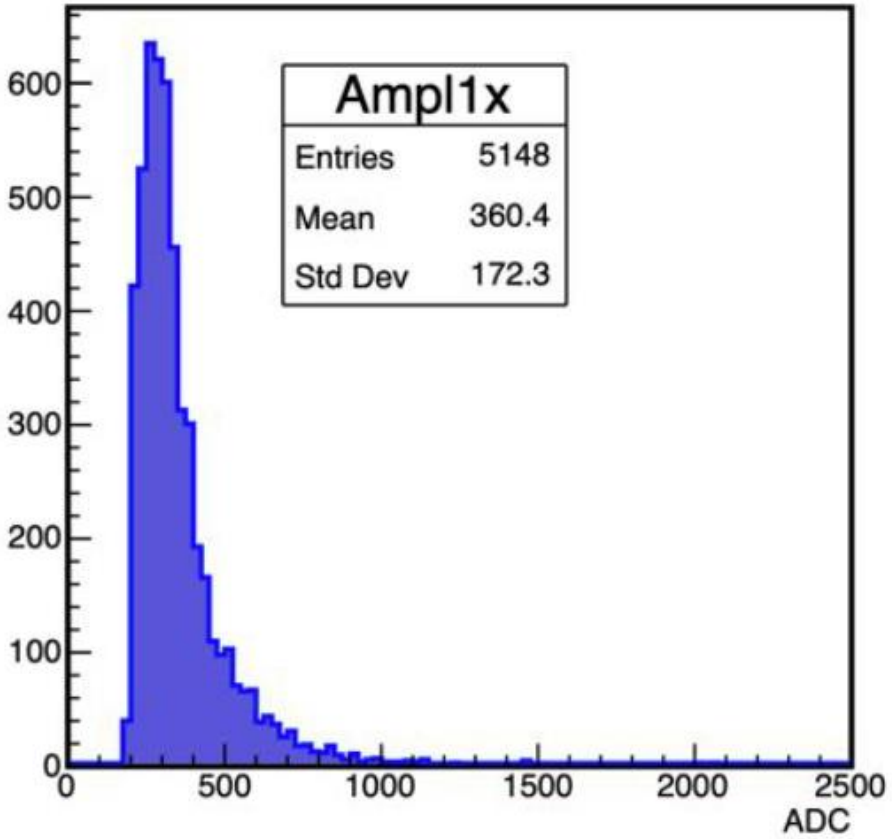
X8 - work almost well

U7 - there are some noise channels

U8 works well

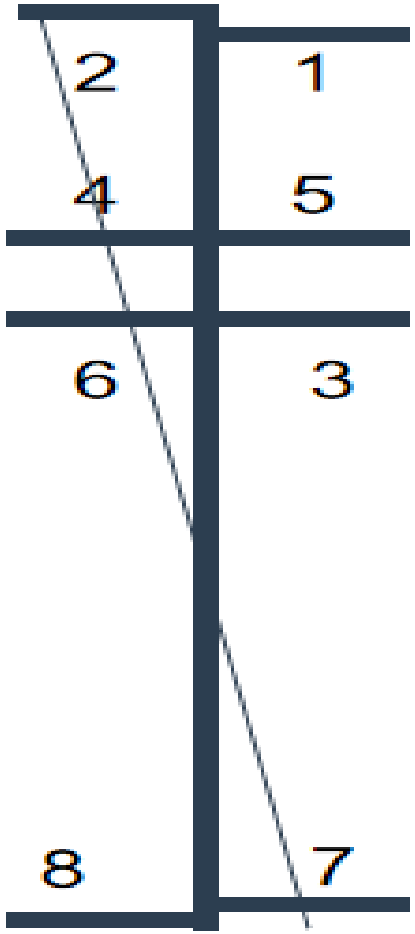
Energy deposition in a one strip at the X1-side for simulation events (left) and experimental data (right).





Possible combinations of Si-modules for tracks passing through MiniSPD setup

	Nfile	Comb.	Ntracks	
I	268	LLL	5602	Vertical tracks
	157	RRR	4378	
	248	LLL	3558	
	137	RRR	2187	
II	158	RLL	3428	Oblique tracks
	267	LLR	2396	
	247	LLR	2105	
	138	RRL	378	
III	257	LRR	2392	
	148	RLL	1550	
	168	RLL	1037	
	237	LRR	3	
IV	258	LRL	88	Noise
	147	RLR	3	
	167	RLR	0	
	238	LRL	0	



Alignment is minimization of residuals of functional:

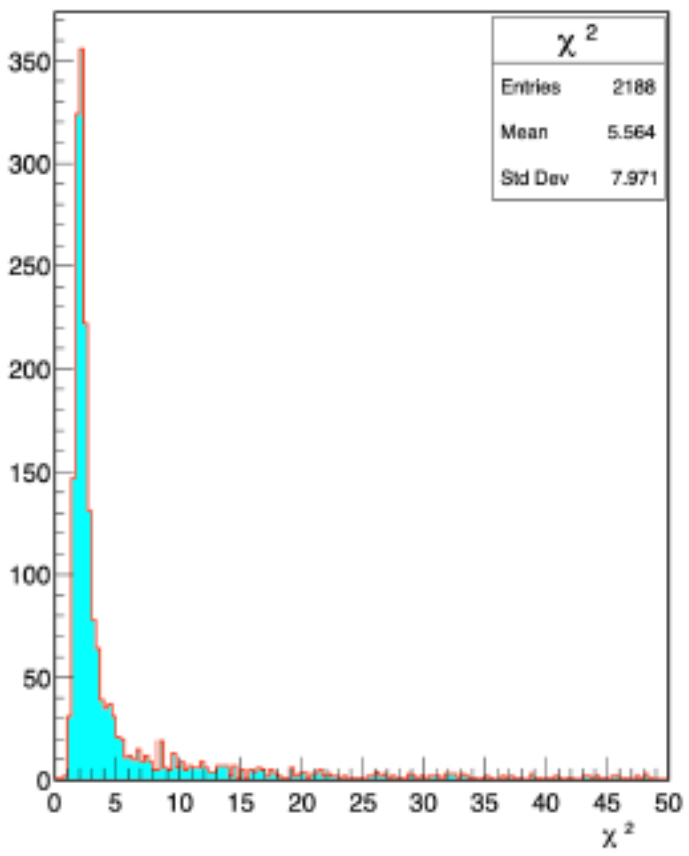
$$F = \sum_{events} \sum_{tracks} \sum_{hits} \left(\frac{d_i^2}{\sigma_{d_i}^2} \right)$$

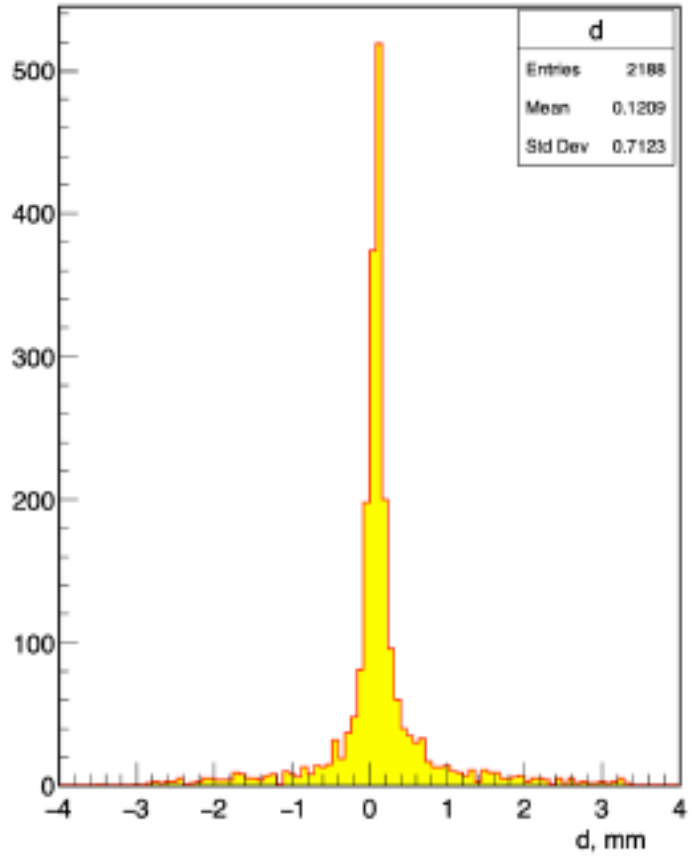
$$d_i = u_{fit} - u_{mes}$$

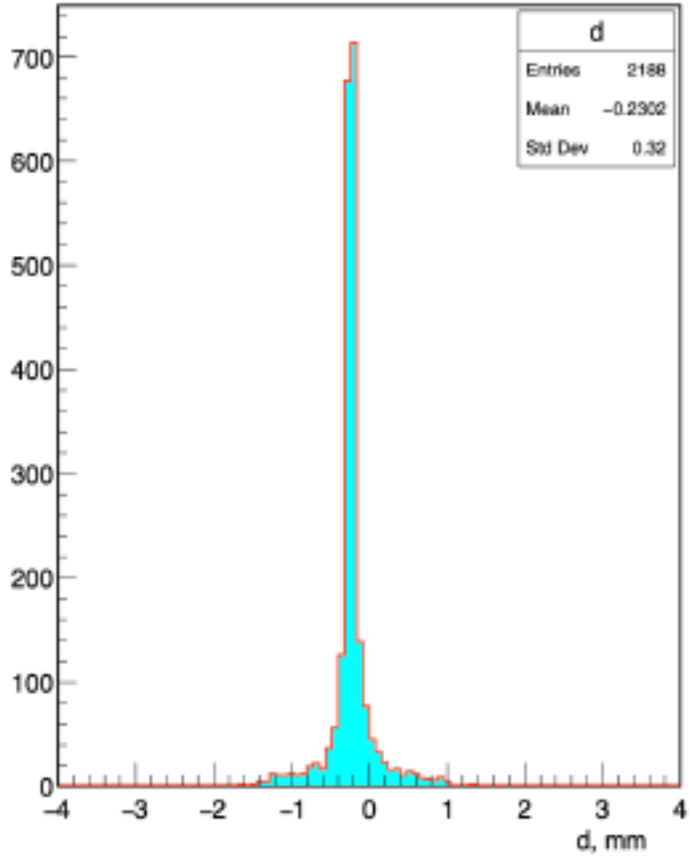
Large number of parameters: track parameters (4 * number of tracks) and shifts (numbers of detectors), number of hits >> parameters.

$$u_{fit} \rightarrow u_j(z_i) = (x_0 + t_x z_i)\cos(\alpha_i) + (y_0 + t_y z_i)\sin(\alpha_i) + \Delta u_i$$

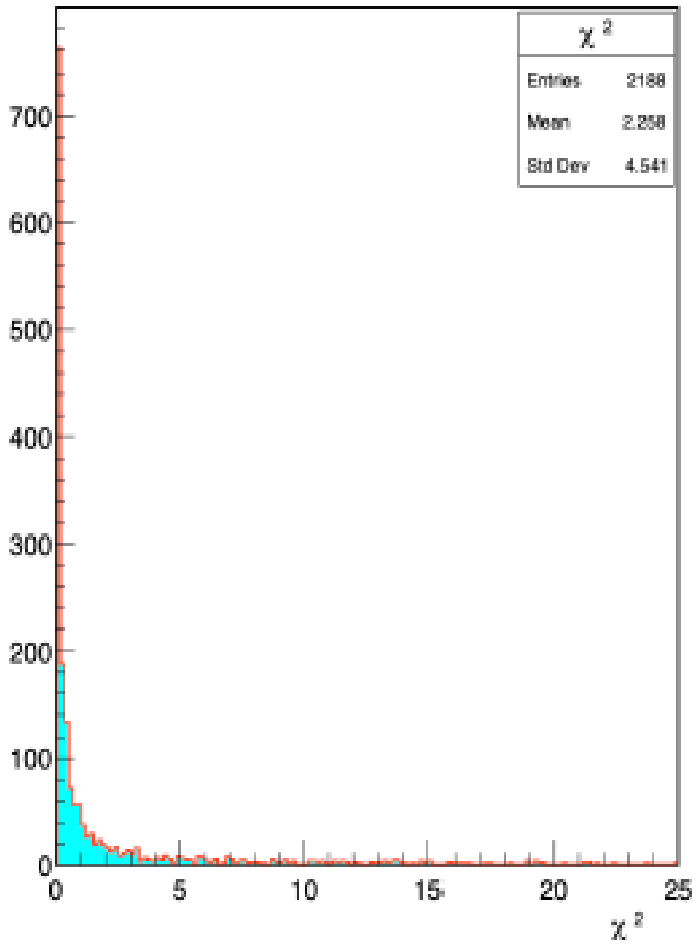
χ2 and residual distributions of track passing through part 1,3 and 7 for X3(yellow) and U3(blue) before alignment

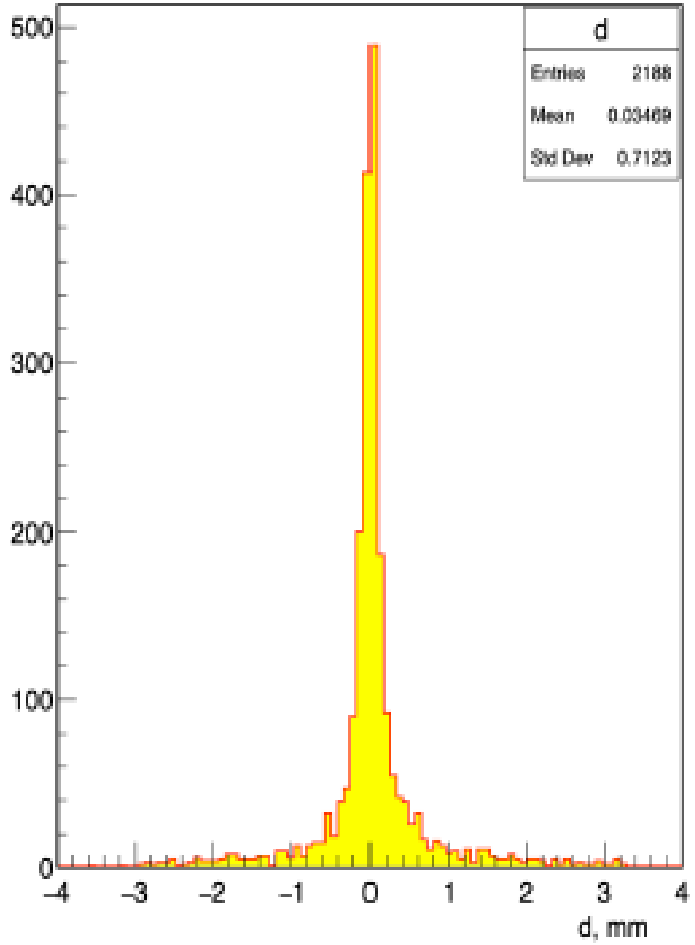


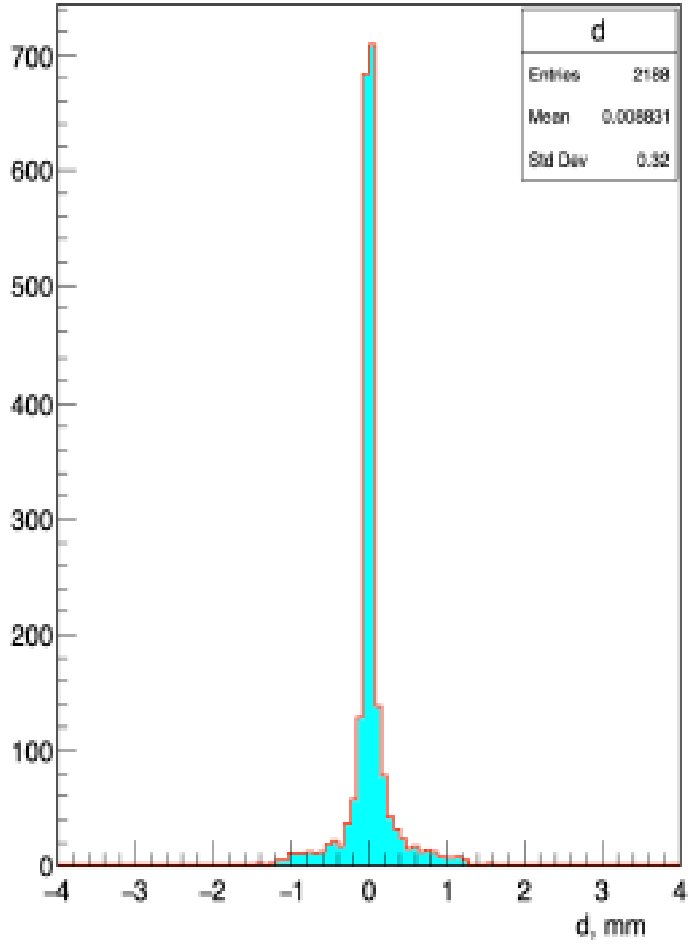




χ2 and residual distributions of track passing through part 1,3 and 7 for X3(yellow) and U3(blue) after alignment







Conclusion

- Monte Carlo simulation of two-sided silicon plates of MiniSPD stand is carried out for two cases: with and without taking into account operation of the scintillator triggers. Comparison Monte Carlo simulation with experimental data allows to estimate the lower threshold on energy for a single strip operation. It is about 55 keV.
- Work of all parts (1-8) and their sides (X and U) of MiniSPD Si-detectors was analyzed and compared with Monte Carlo simulation. Noisy and dead channels are seen directly from the distributions according to the numbers of triggered strips. The alignment task is solved for parts of the middle module. The distributions on residuals of its parts and $\chi 2$ on tracks are obtained.