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Study of track resolution (for FP420)

plan:

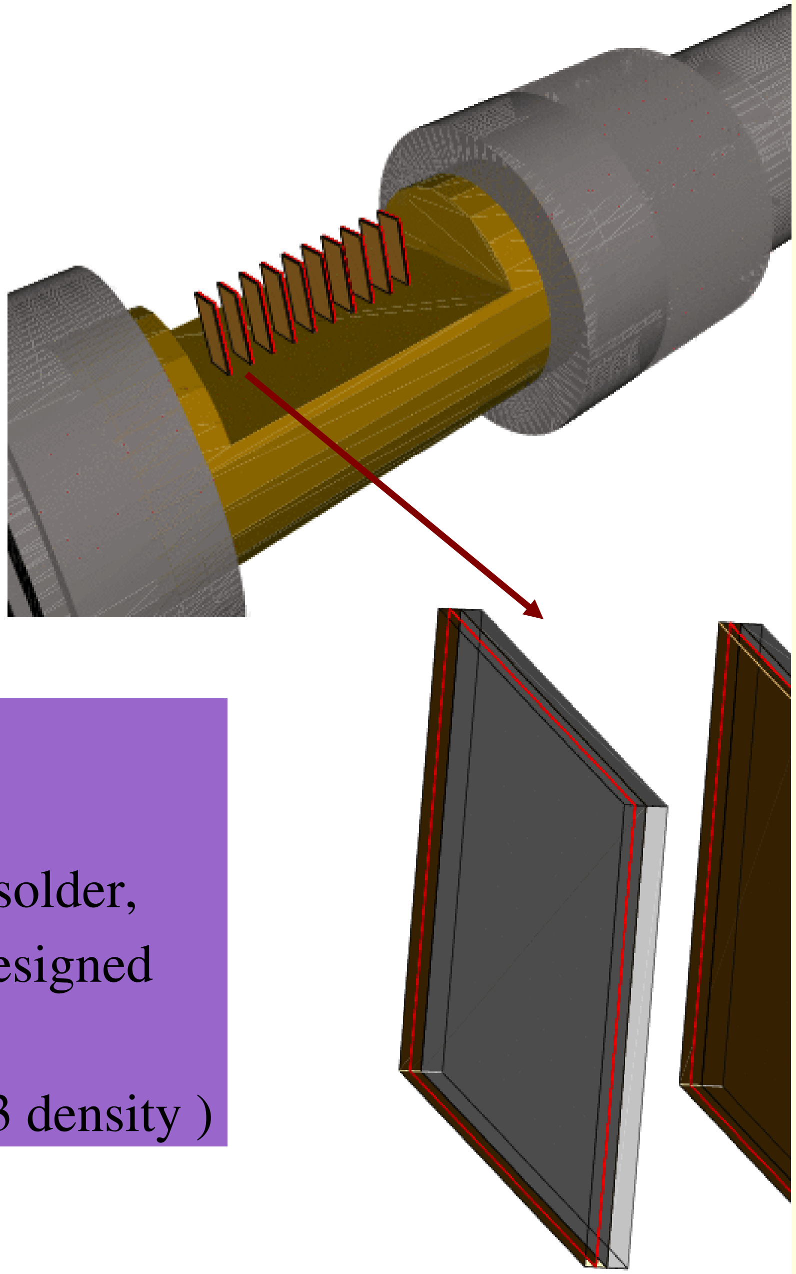
- **geometry of superplane**
- **update for hit reconstruction**
- **track resolution and MI**
- **summary**

Contents of 3D super-plane in MC

Rectangular shape pocket
with
5 superplanes
(sensitive area shown only)

sensitive region of one superplane includes
two planes placed at 6.6 mm distance

one plane contains
0.250 mm Si sensor,
0.025 mm composite material: glue and solder,
0.250 mm composite material: Si layer designed
to place electronics,
0.500 mm Carbon-Carbon blade (1.3 g/cm3 density)



Changes of parameters for charge simulation

- **Consider 50 μm only pitch for X and Y sensors**

- **cut-off value is defined by $W_{cluster} = 5$ instead $= 3$ at charge inducing**

  (integration over channels interval: $W_{cluster} \cdot \sigma_n / pitch$)

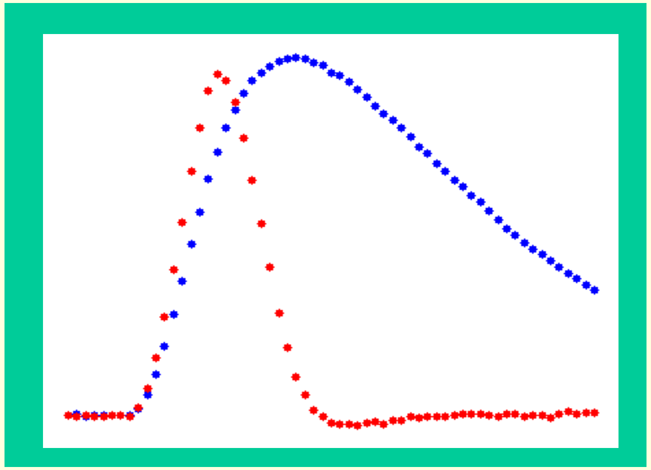
- **diffusion constant $D = \mu kT/q$ is changed due to change of temperature: $t = 24^oC \rightarrow t = -10^oC$**

  $D = (1.38 \cdot 10^{-23}/1.6 \cdot 10^{-19}) \cdot \mu \cdot T[cm^2/sec]$**, where electron mobility:** $\mu_e = 1350.[cm^2/V/sec]$**,**
  temperature $T = 263.^oK$ **(**$-10^oC + 273. = 263.$**)** $\Longrightarrow D_e = 30.6[cm^2/sec]$ **instead** $D_e = 34.6[cm^2/sec]$

  - since electrodes are close $\rightarrow$ low collection distances (thickness of Si layer is NOT related to collection distance) $\rightarrow$ no charge spreading (typical values: t_n = 1.25 ns, σ_n = 3 μm for 50μm drift) $\Longrightarrow$ usually, this advantage of 3D detectors is exploited to improve position resolution

- **shape(constants) need to be specified:**

hit loss is weighted with CR-RC shape peaked at t0
(most commonly used CR-RC amplifier shaper circuit assumed)
1. deconvolution shape: $E_w = E_{loss} \cdot e^{-0.5 \cdot r^2}; \;\; r = (t - t_0)/\sigma; \;\; \sigma = 12.$
2. peak shape:$E_w = E_{loss} \cdot (1 + r) \cdot e^{-r}; \;\; r = (t - t_0)/\sigma; \;\; \sigma = 52.$
(deconvolution shape is used as a default)



Change of noise and cluster selection cuts

- **noise is usually expressed as equivalent noise charge (ENC) in units of electron charge e;**

  if 2160e in Si of 300 μm, then
  $\longrightarrow ENC$ **= 1800** e **in Si of 250** μm**;**

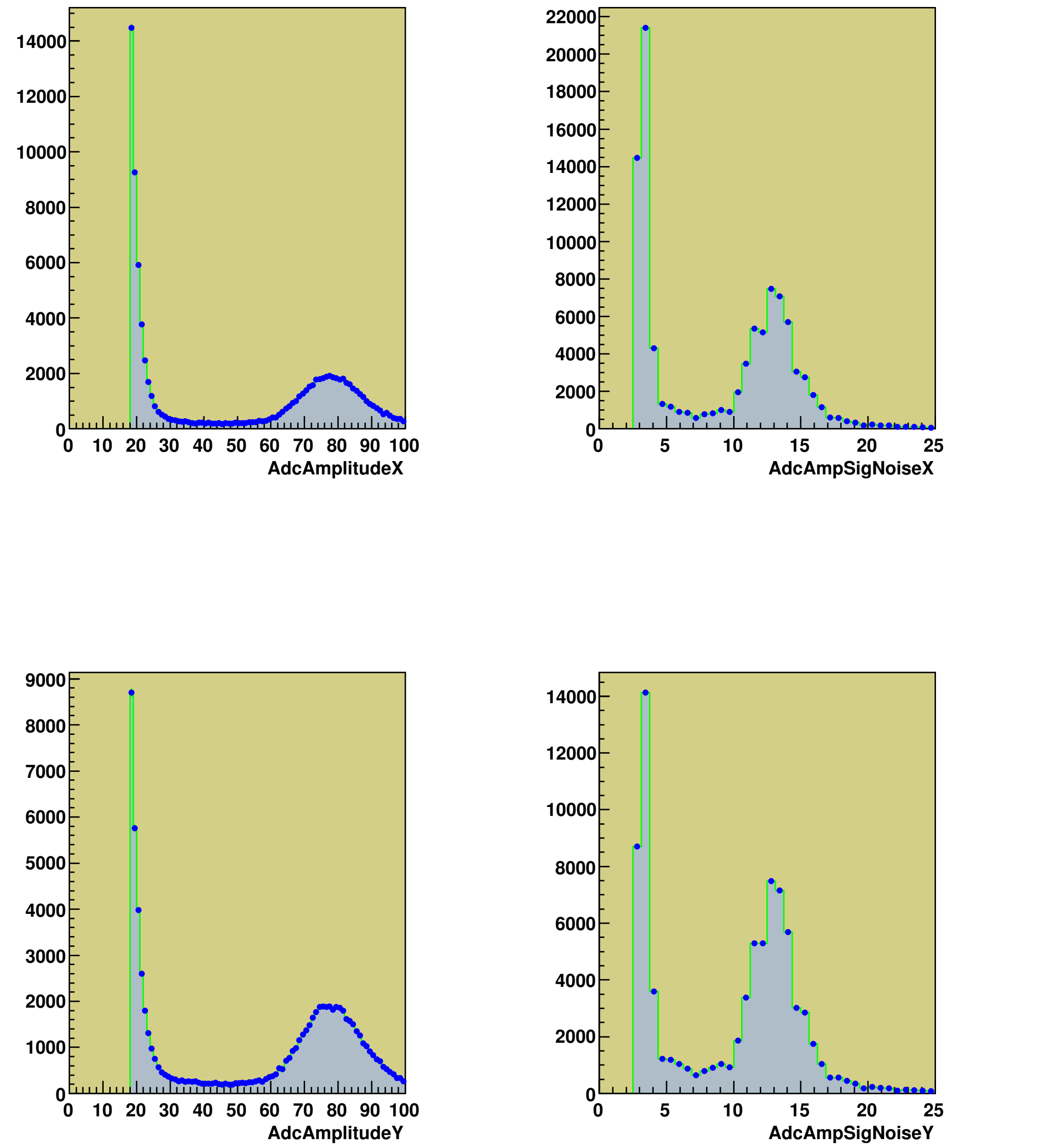
  so, $NoiseInAdc$**=**σ_{noise}**/**$ElectronPerADC$**,**
  where σ_{noise} **=** ENC **= 1800** e

- **channel zero suppression:**
  $FedThreshold$ **= 3** $\sigma_{noise} = 5400\ e^-$

- **with parameters for signal simulation: Adc distributions for X & Y planes** $\Longrightarrow$

- **for cluster selection apply the cuts:**

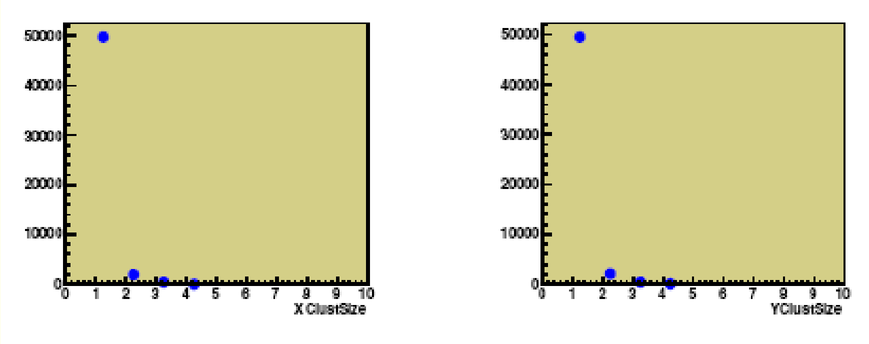
  $ChannelThreshold = 6 \cdot \sigma_{noise}$
  $SeedThreshold = 7 \cdot \sigma_{noise}$
  $ClusterThreshold = 7 \cdot \sigma_{noise}$



$RecHit$ space resolution

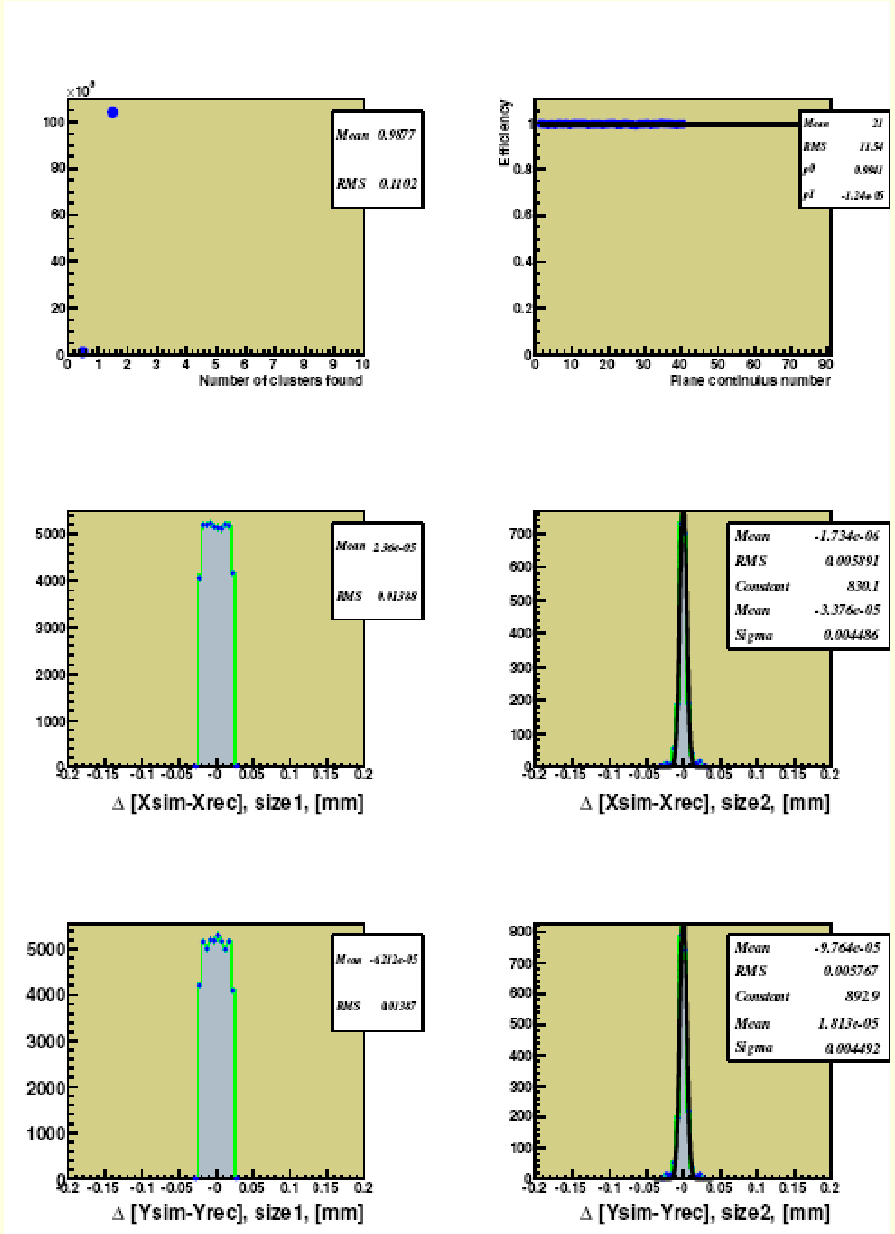
- 99.7 % efficiency per plane to find at least 1 cluster
- one cluster per plane is selected at the most

Cluster mainly includes just one channel (<u>90</u> %):



Track fit hang upon RecHit space resolution which depends on cluster size, therefore ClusterSize distribution should be in agreement with Tests !

- space resolution:
  - for one channel size clusters: 14 μm
  (follow the expression: $\sigma = pitch/\sqrt{12} = 14.4 \mu m$)
  - for two channels size clusters: 4.5 μm



Track selection and fit

- select cluster with max channel amplitude per plane and provide straight line least squares fit in XZ and YZ planes using $gsl-fit-wlinear$ routine;

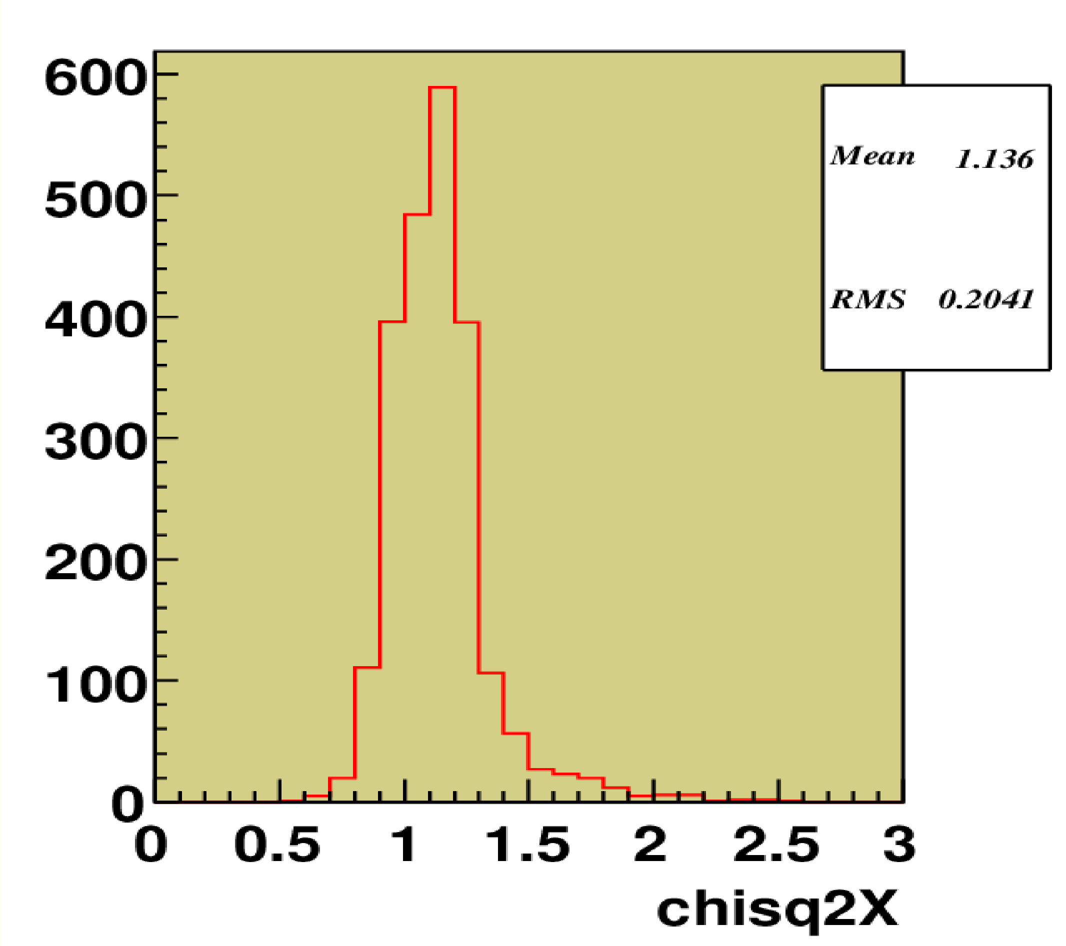
  track is found if $\chi^2/dof < 3$

- hit position uncertainties to define the fit arise from the cluster size(1ch-14μm, 2ch-4.5μm) and multiple scattering (MSC);

  MSC contribution was added in quadrature to the hit position uncertainties;

  MSC was estimated in advance with use of the same simulation code;

  monitoring of χ^2/dof distribution: mean value should be in range $0.9 \div 1.1$;



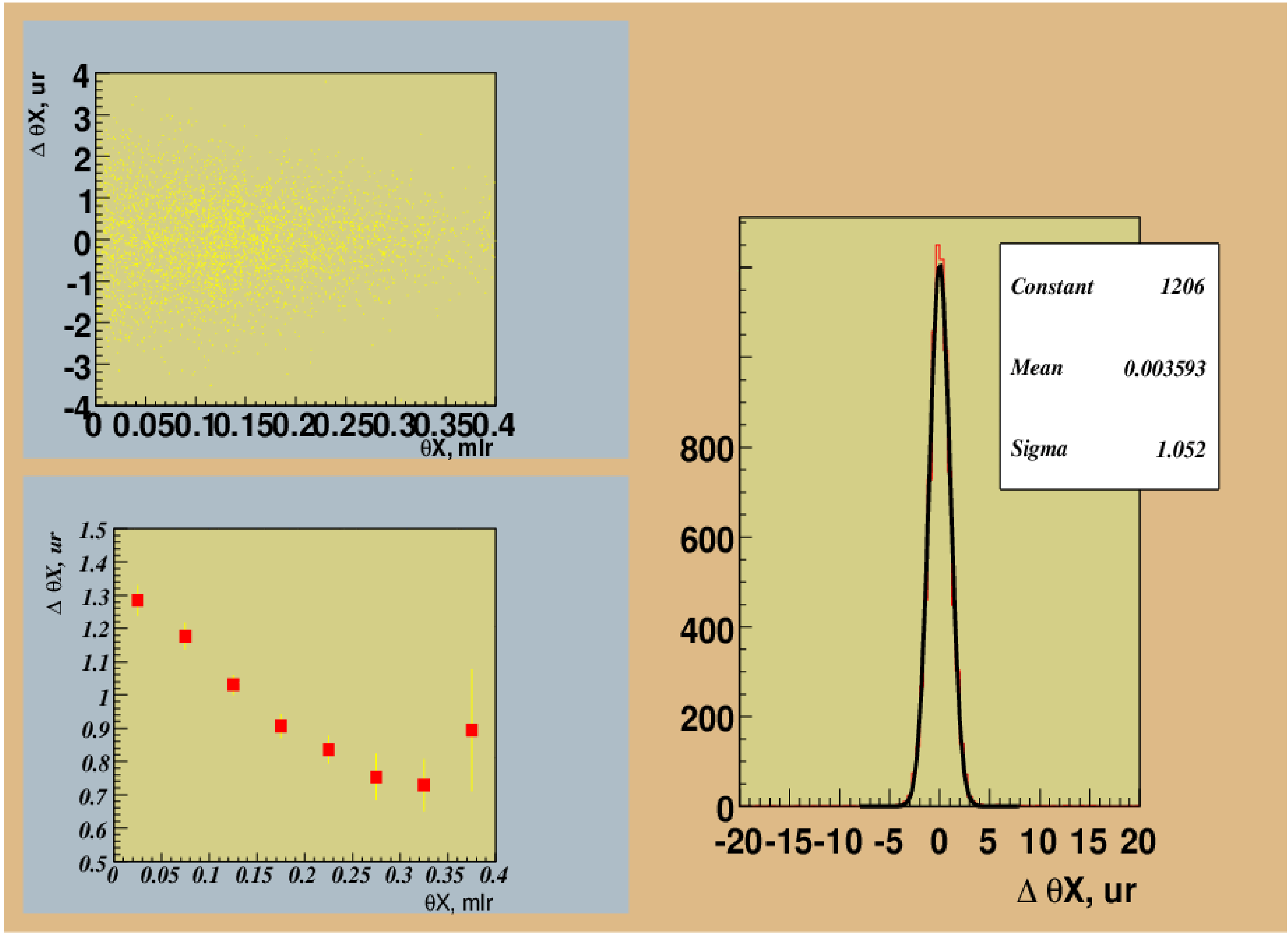
- result of fit is the coefficients of straight lines

Track resolution dependence on θ_X

Use 7 TeV protons with $\theta : 0.06 \div 0.11mr, \phi : 0 \div 360^0 \Longrightarrow \theta_X = 0.0 \div 0.3mr$ with mean value $\sim 0.05mr$.

Vertex: Z - in front of detector,
X, Y - over detector acceptance

Configuration of set up:
2 stations, 1/2 pitch shift,
5 superplanes per station,
8m arm

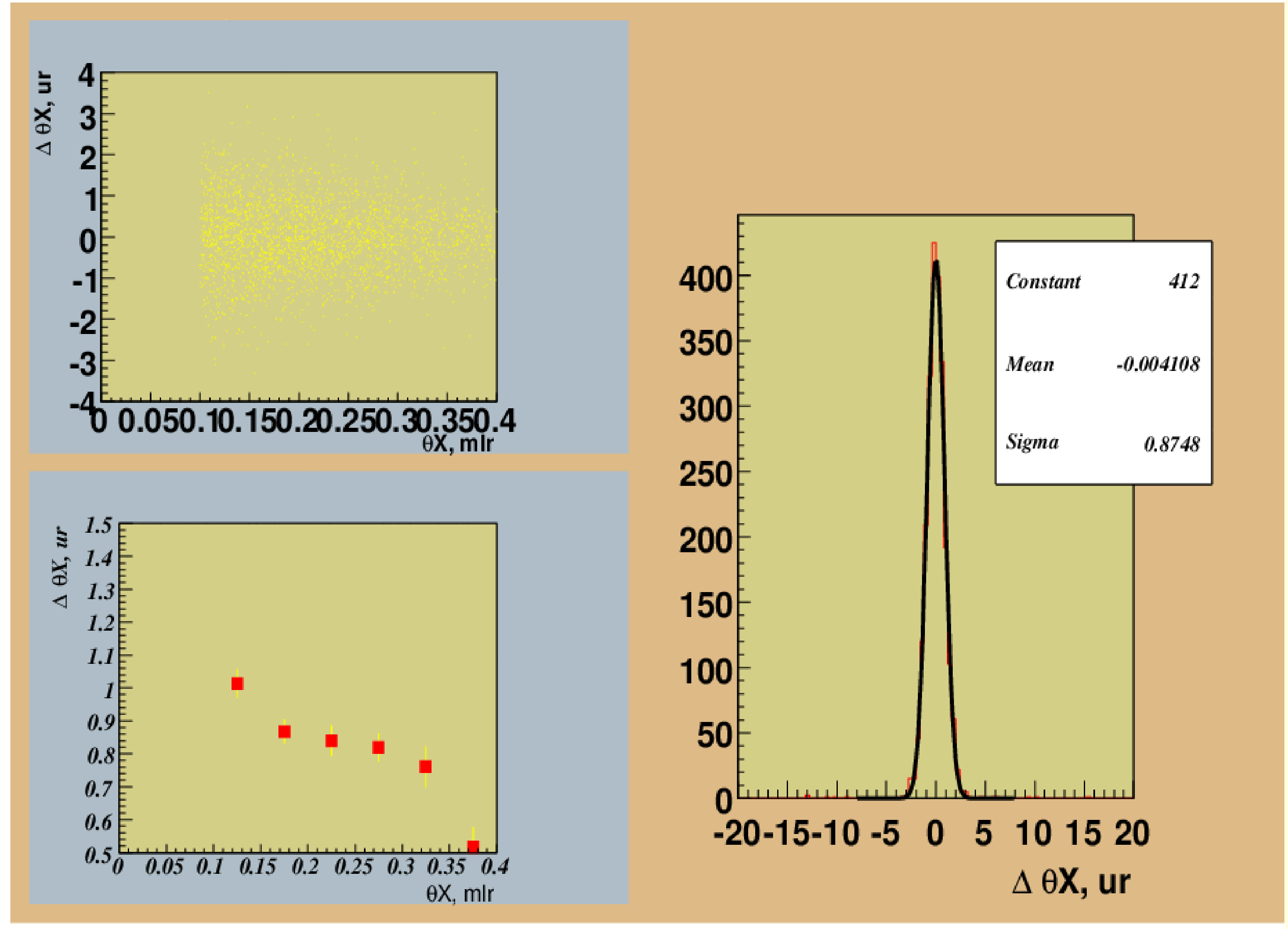


With such a small angles the track divergence is very small and therefore two closely spaced planes have highly correlated hits. Due to that the track resolution does not depend on number of planes (at least for numbers from 2 to 10). But, angle dependence on resolution is rather strong.

Therefore, angle range for resolution study is very important

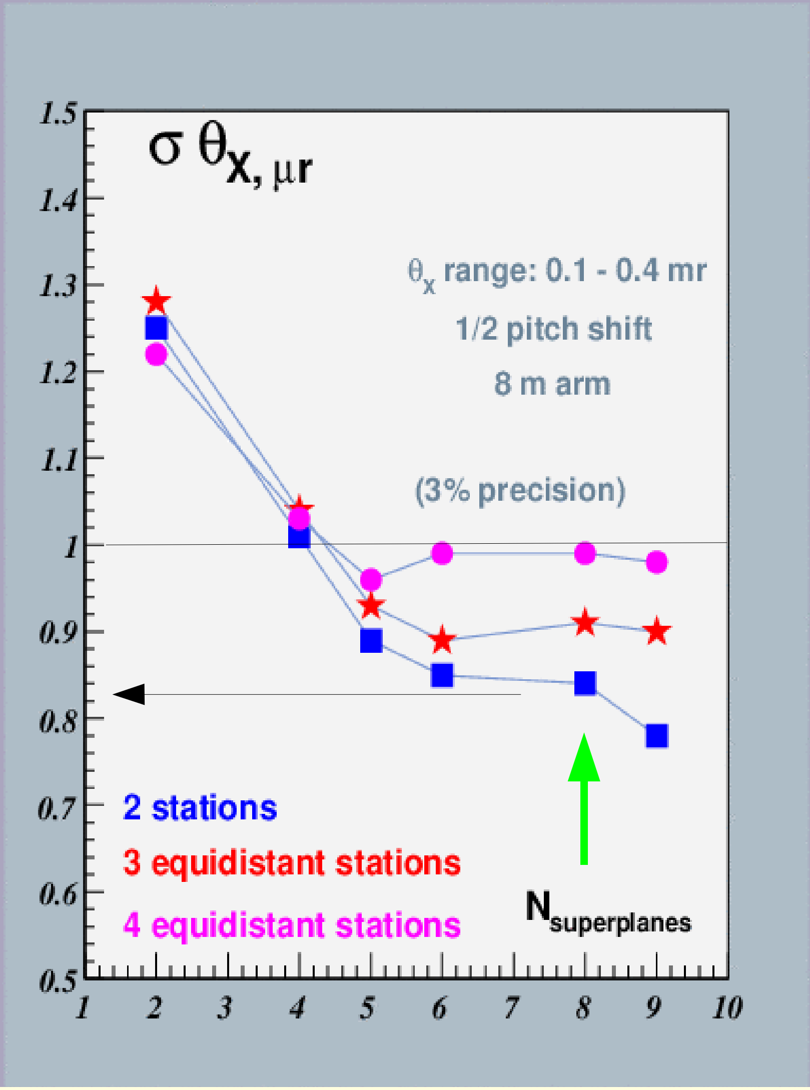
Track resolution dependence on θ_X

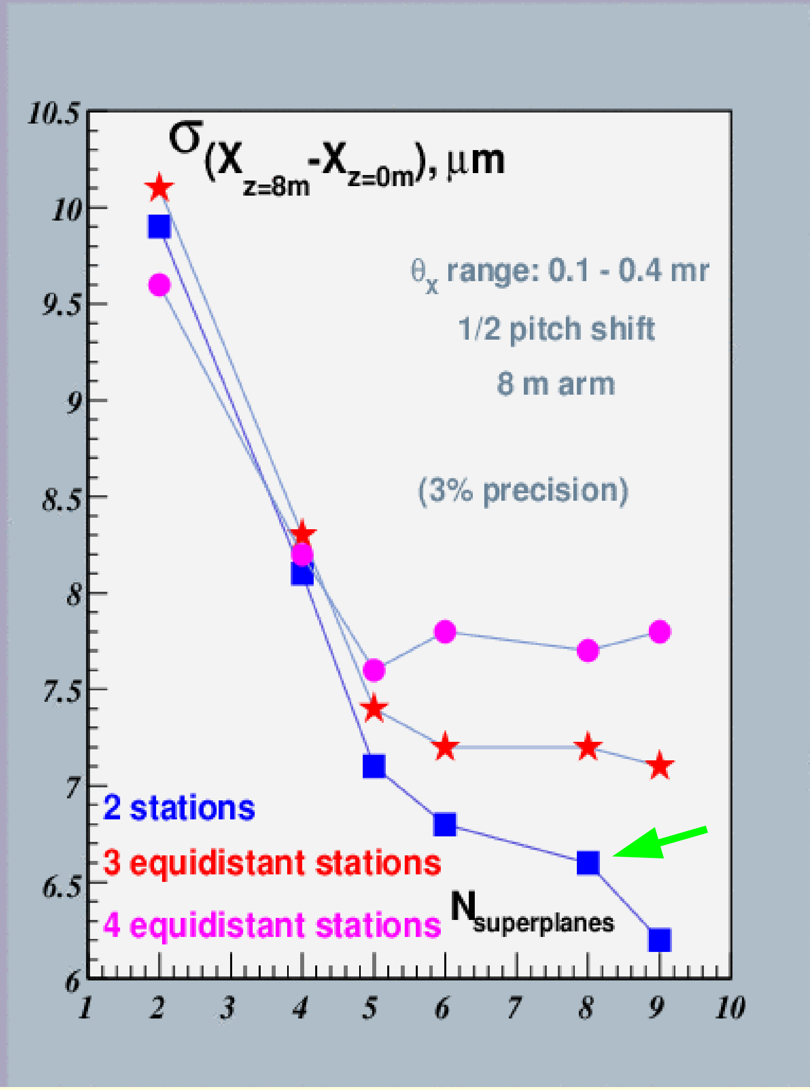
(second option for angle generation: $\theta : 0.1 \div 0.4 mr, \phi : 179 \div 181^0$**)**



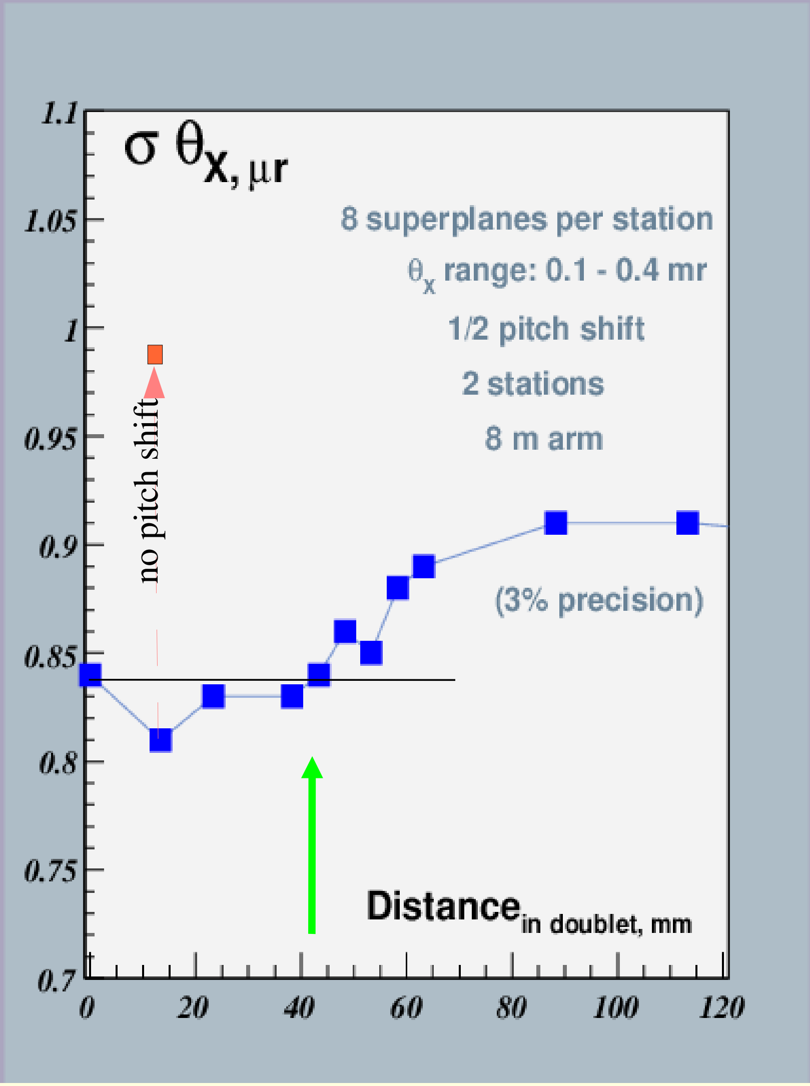
At larger angles the silicon planes give a mixture of effective offsets which increases the precision.
Let us see how it depends on a number of planes and stations for realistic angle range.

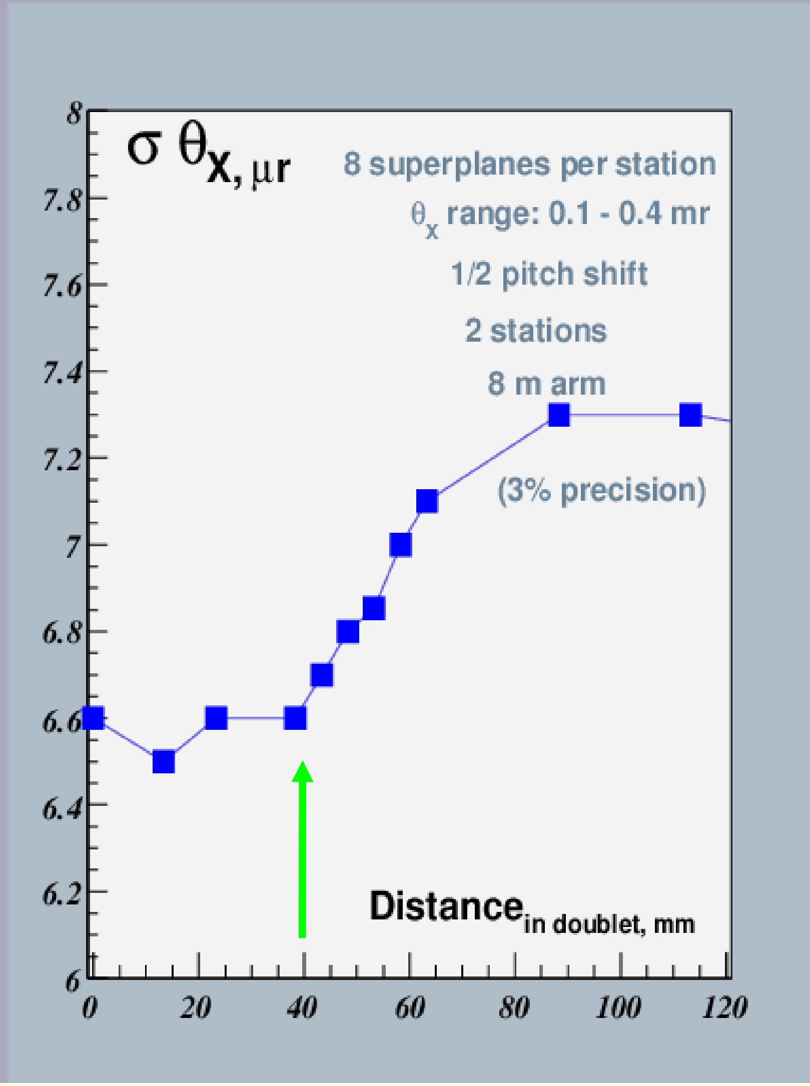
Track resolution for FP420 set up (Si 3-D)



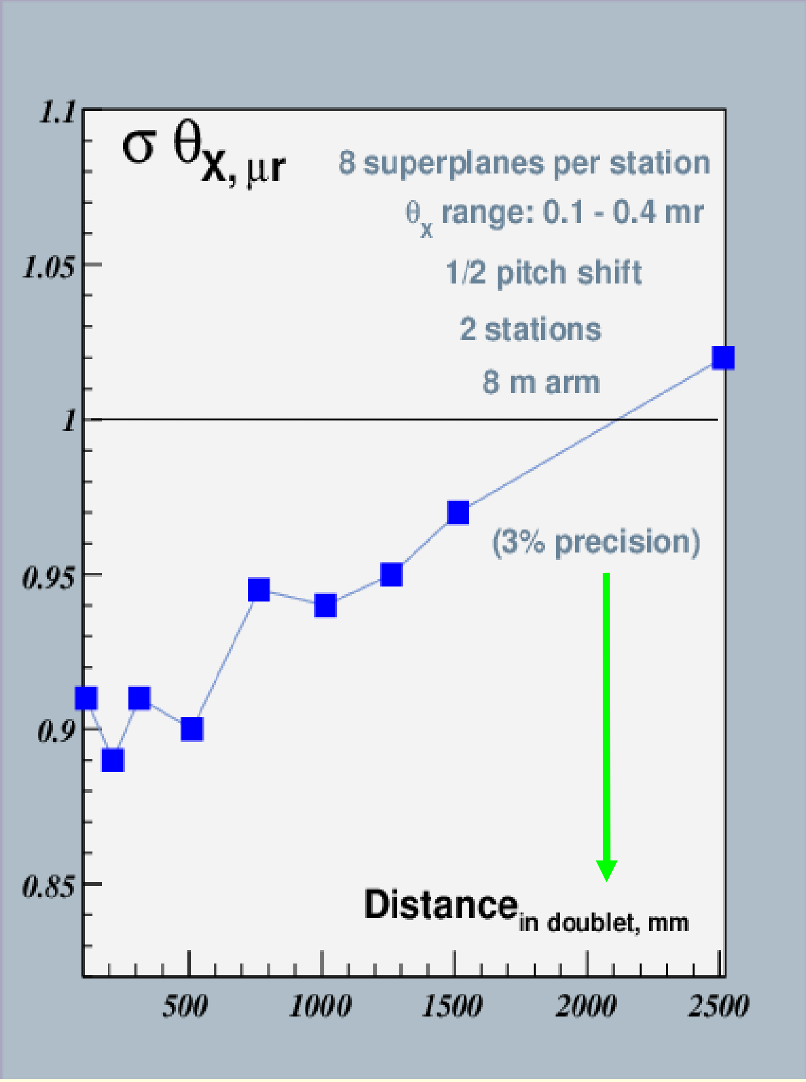


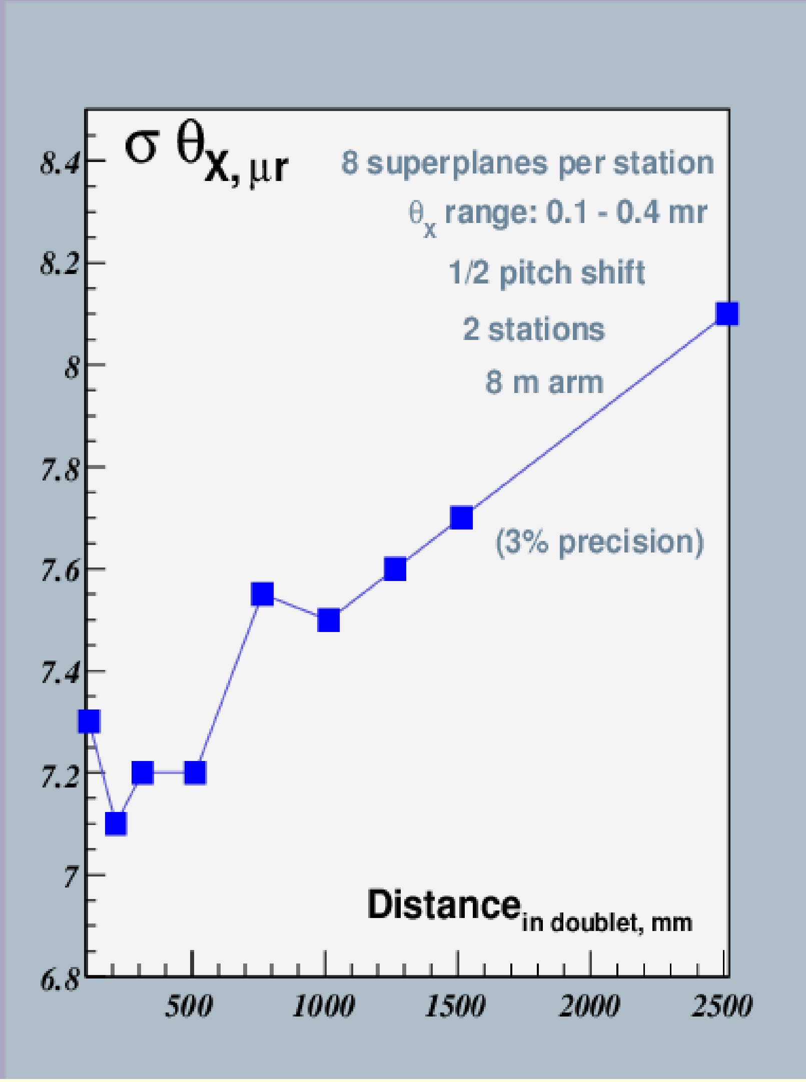
Track resolution for two double stations



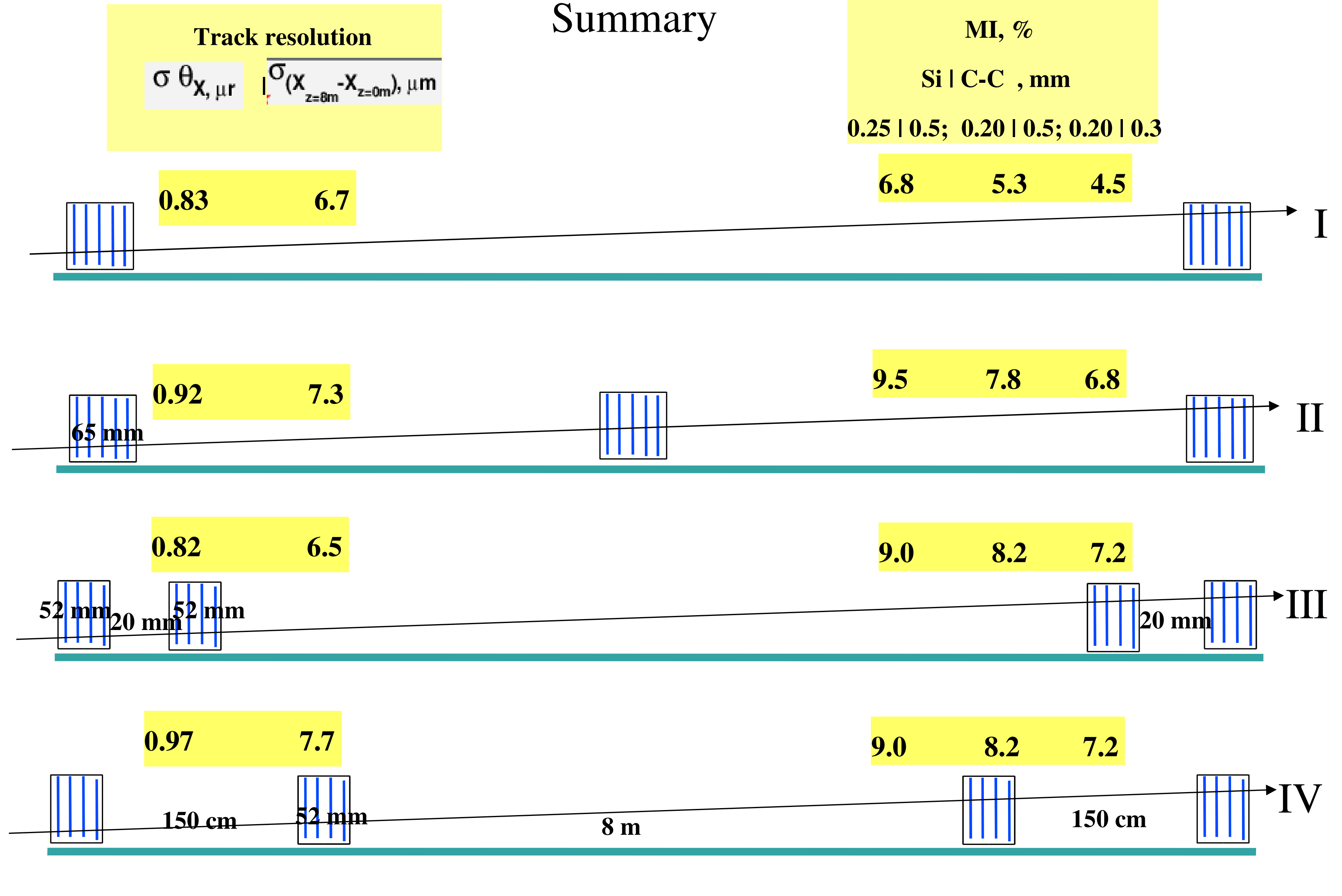


Track resolution for two double stations



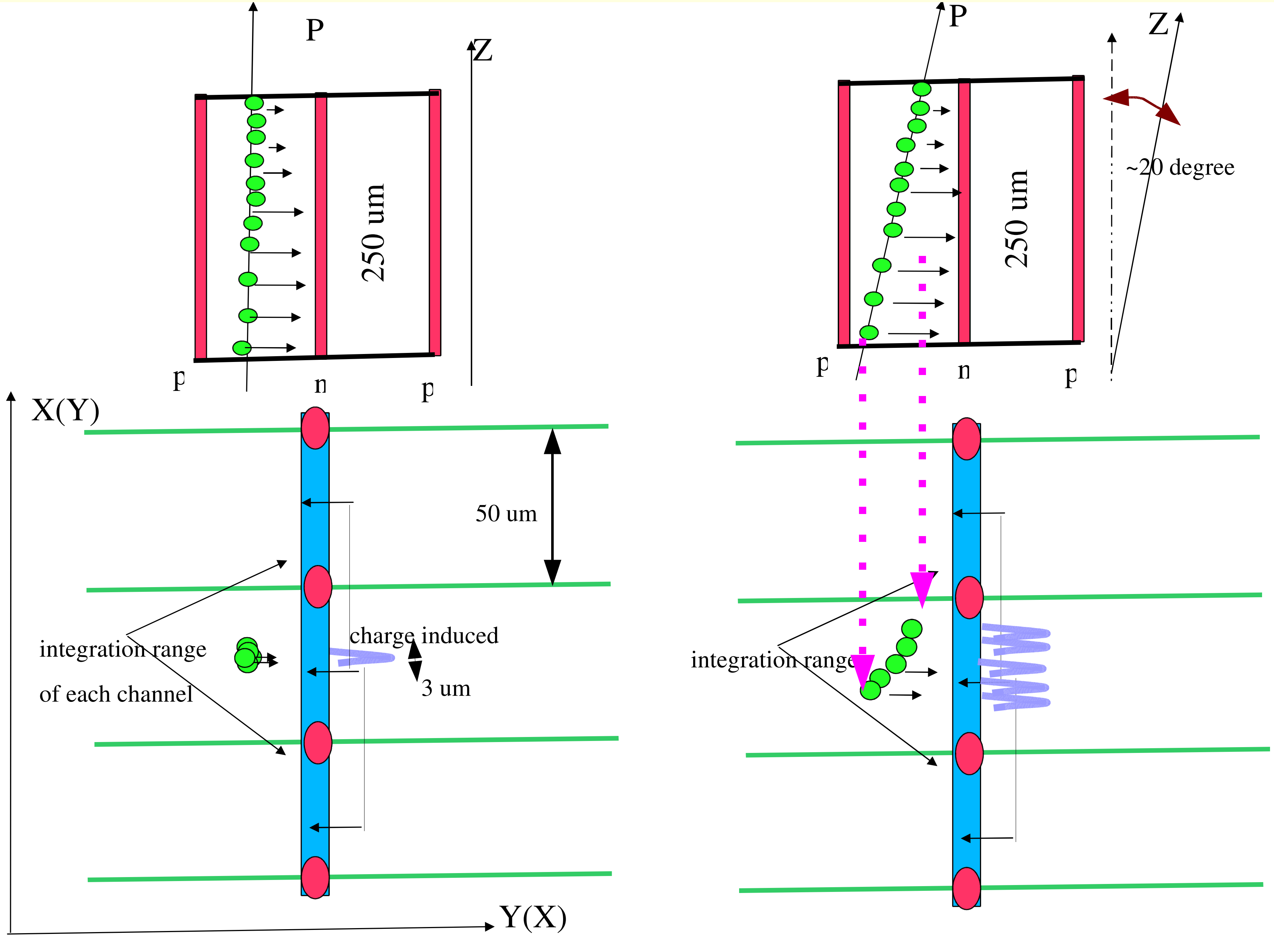


Summary



What is our choice: I, II, III, IV, ... ???

Backup


P
Z
p
n
p
250 um
X(Y)
50 um
integration range
of each channel
charge induced
3 um
Y(X)
P
Z
~20 degree
250 um
p
n
p
integration range