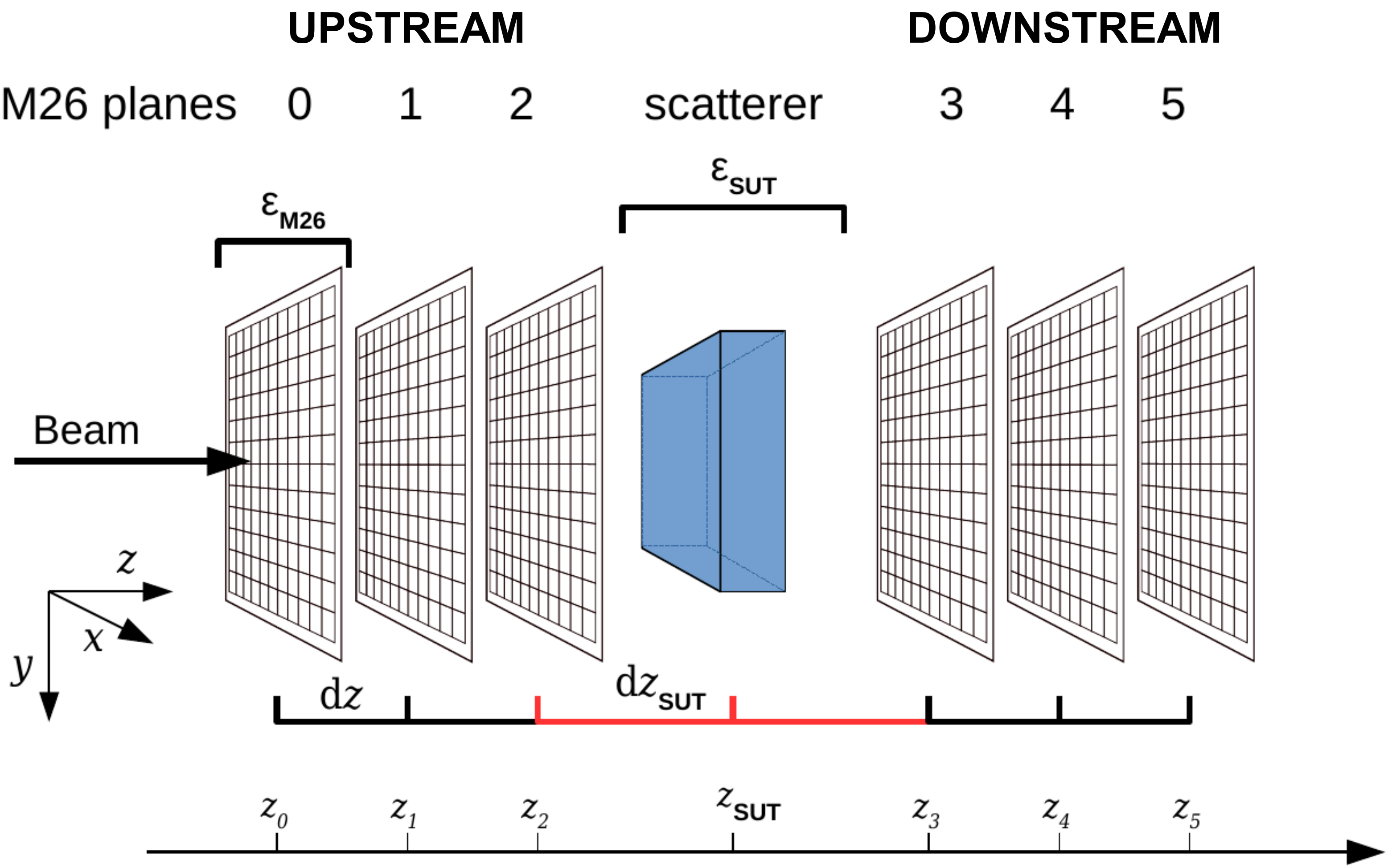
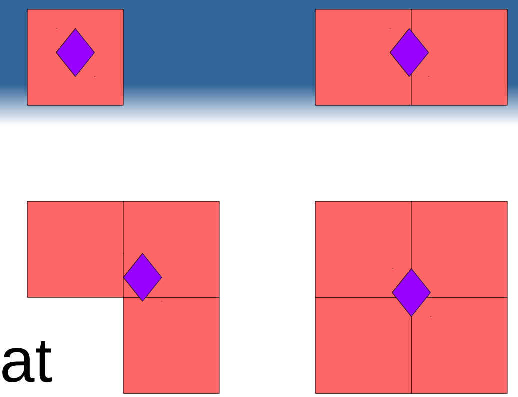
Measurement geometry

- Plane spacing dz = 20 mm, dz_{SUT} = 15 mm
- Total material budget telescope: ε(M26 + air) = 4.8e-3

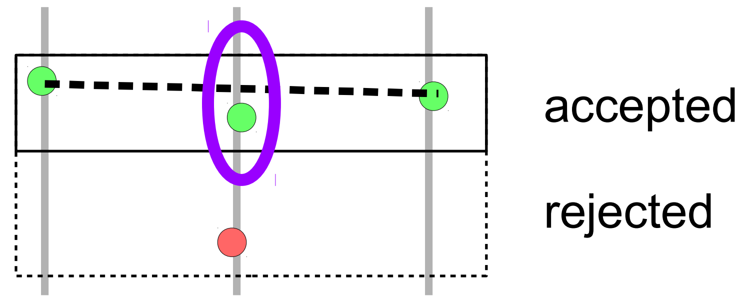


Data analysis flow

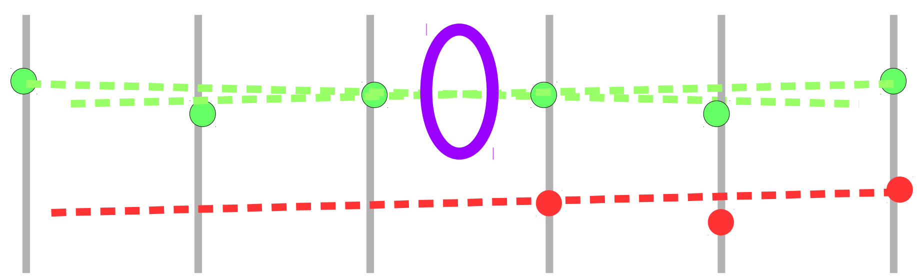


Analysis done with EUTelescope *

- Conversion of Mimosa26 raw data to LCIO format
- Hot pixel search
- Cluster formation, remove clusters with hot pixels
- Construct triplets for up- and downstream plane
- Isolation cut on triplets



- Match up- and downstream
  triplets in the centre
  → *six-tuple* from physical track

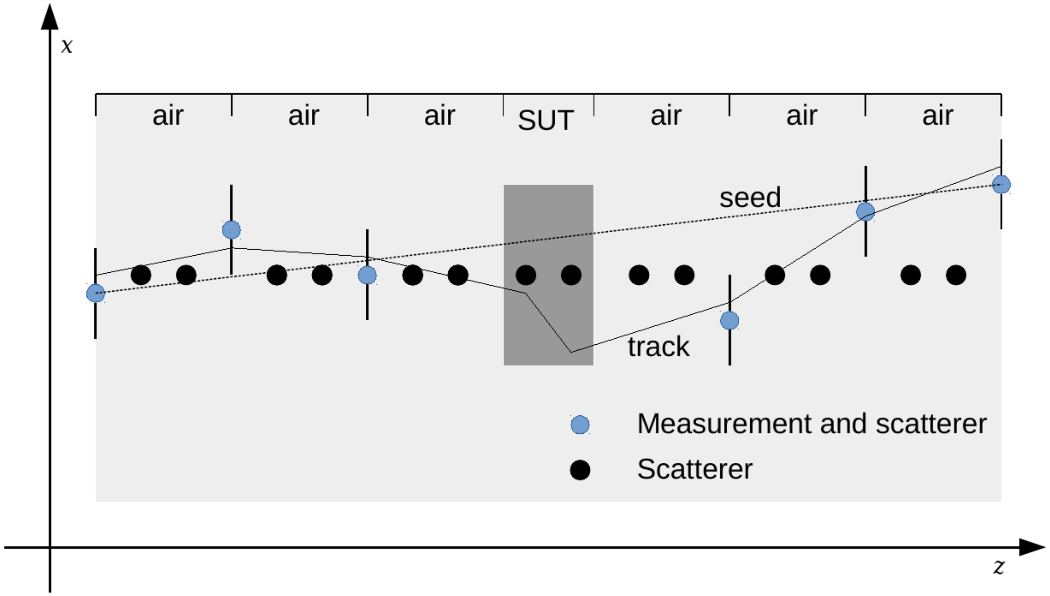


- Feed six-tuple to Millepede for alignment

* http://eutelescope.web.cern.ch/

General Broken Lines

- GBL track model allows for kinks at scatterers
- Calculating corrections to an initial simple seed track
- Perform χ² minimisation to find track parameters
- Simple track model: no bremsstrahlung, no non-Gaussian tails, no non-linear effects
- Inputs: *Measurement + error*, geometry, scattering estimate
- Outputs: residuals, residual width, kinks, track resolution



www.desy.de/~kleinwrt/GBL/doc/cpp/html/

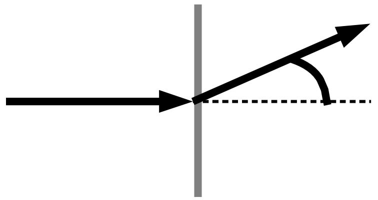
V. Blobel, C. Kleinwort, and F. Meier. Fast alignment of a complex tracking detector using advanced track models. Computer Physics Communications, 182(9):1760 – 1763, 2011.

C. Kleinwort. General broken lines as advanced track fitting method. Nucl. Instr. Meth. Phys. Res. A, 673:107–110, May 2012.

Multiple scattering

- Variance predicted by Highland at a single scatterer:

$$\Theta_0^2 = \left(\frac{13.6\ \mathrm{MeV}}{\beta c p} \cdot z\right)^2 \cdot \varepsilon \cdot \left(1 + 0.038 \cdot \ln\left(\varepsilon\right)\right)^2$$

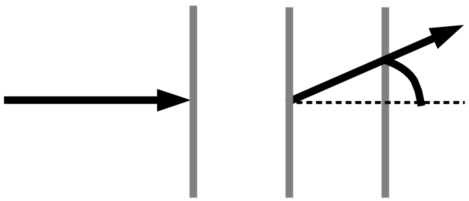


- For a composition of scatterers

$$\varepsilon = \sum \varepsilon_i$$

Highland predicts variance after ***last*** scatterer

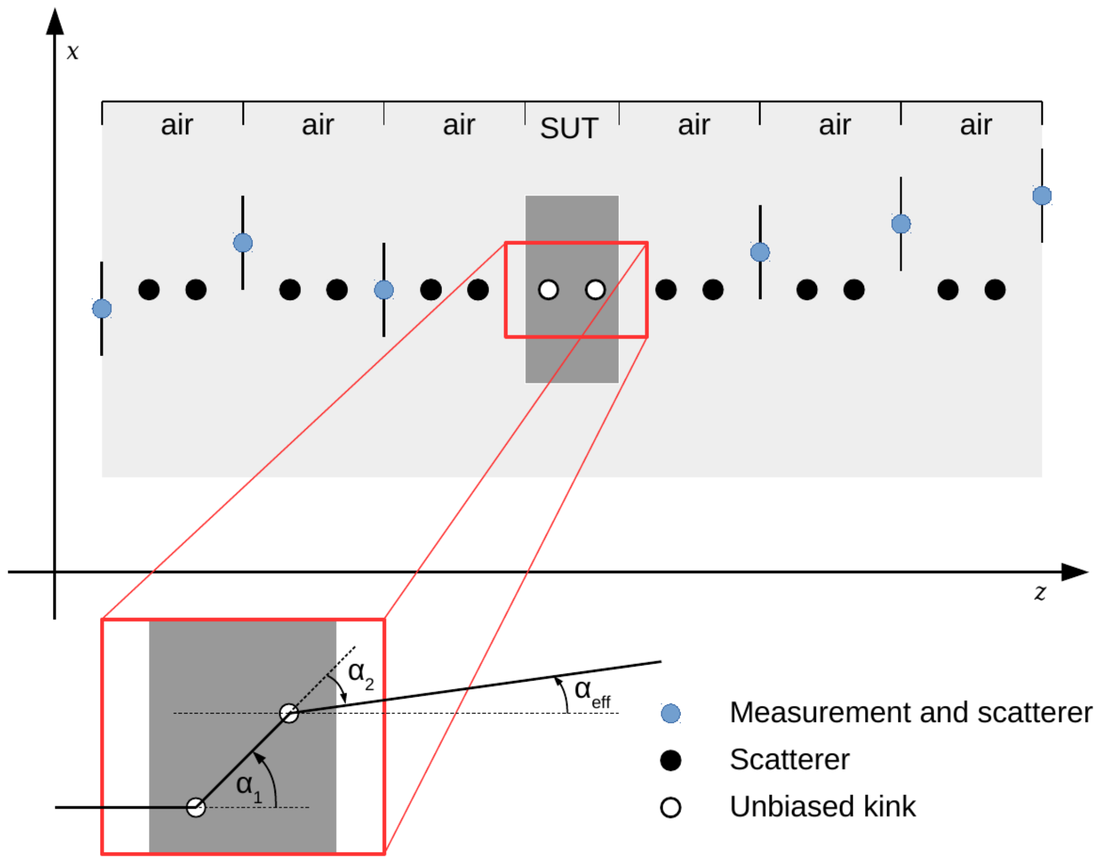
- For individual scatterer within composition:



$$\Theta_{0,i}^2 \equiv \frac{\varepsilon_i}{\varepsilon} \cdot \Theta_0^2 = \left(\frac{13.6\ \mathrm{MeV}}{\beta c p} \cdot z\right)^2 \cdot \varepsilon_i \cdot \left(1 + 0.038 \cdot \ln\left(\varepsilon\right)\right)^2$$

Unbiased kinks

- Last slides: scatterers of ***known*** material budget
  → constrained kink angle in χ^2 (biased)
- Goal: kink for ***unknown*** scatterer (unbiased)
  → introduce free local parameters in track model
    → dedicated track model for unbiased kinks



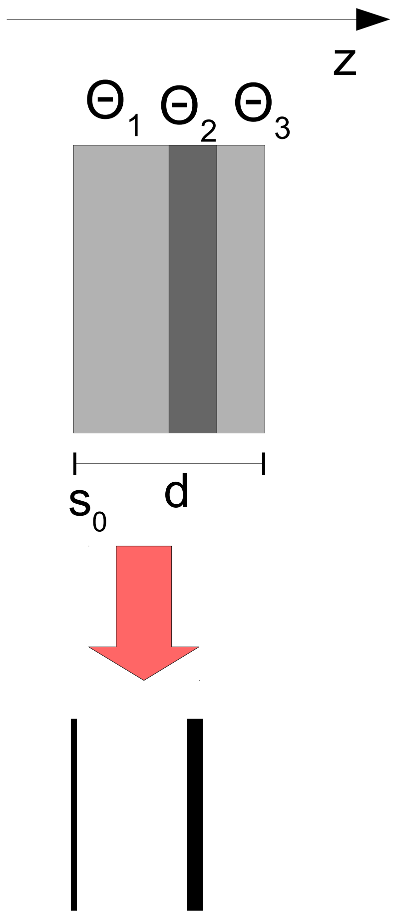
A word on thick scatterers

- Assume a non-homogeneous scatterer along z
- Describe with three parameters:
  length s, mean $\bar{s}$, variance Δs2

$$\theta^2 = \sum_i \theta_i^2, \quad \bar{s} = \frac{1}{\theta^2} \sum_i s_i \theta_i^2, \quad \Delta s^2 = \frac{1}{\theta^2} \sum_i (s_i - \bar{s})^2 \theta_i^2$$

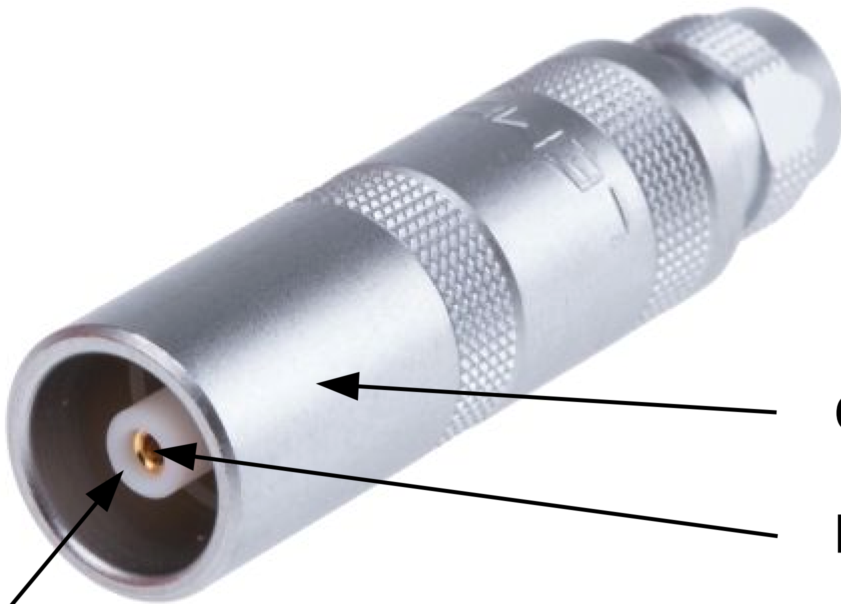
- Find a toy scatterer composed of two thin scatterers resembling the thick scatterer;
  s_1, s_2, Θ_1, Θ2.
  - e.g. for homogeneous scatterer
    - $s_1 = \bar{s}$ – d/sqrt(12)
    - $s_2 = \bar{s}$ + d/sqrt(12)
    - $\Theta_1 = \Theta_2 = \Theta/2$
  - e.g. for inhomogeneous scatterer

$$s_1 = s_0, \quad s_2 = \bar{s} + \frac{\Delta s^2}{\bar{s} - s_1}, \quad \theta_1^2 = \theta^2 \frac{\Delta s^2}{\Delta s^2 + (\bar{s} - s_1)^2}, \quad \theta_2^2 = \theta^2 \frac{(\bar{s} - s_1)^2}{\Delta s^2 + (\bar{s} - s_1)^2}$$



Inhomogeneous sample

- Can we resolve structured samples?
  → electron-illuminated a coax connector



Inhomogeneous sample

- Can we resolve structured samples?
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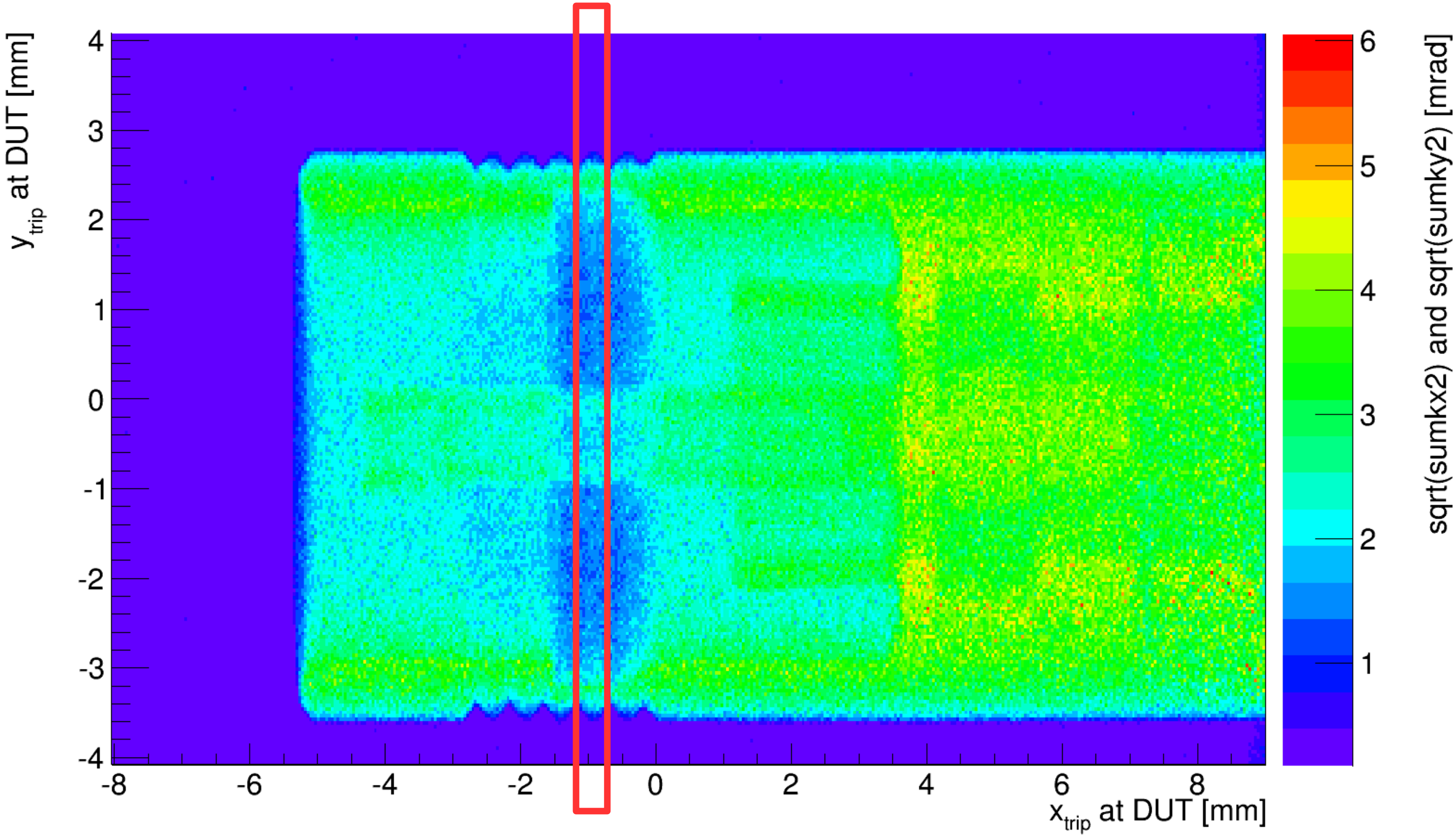

Inhomogeneous sample

- Can we resolve structured samples?
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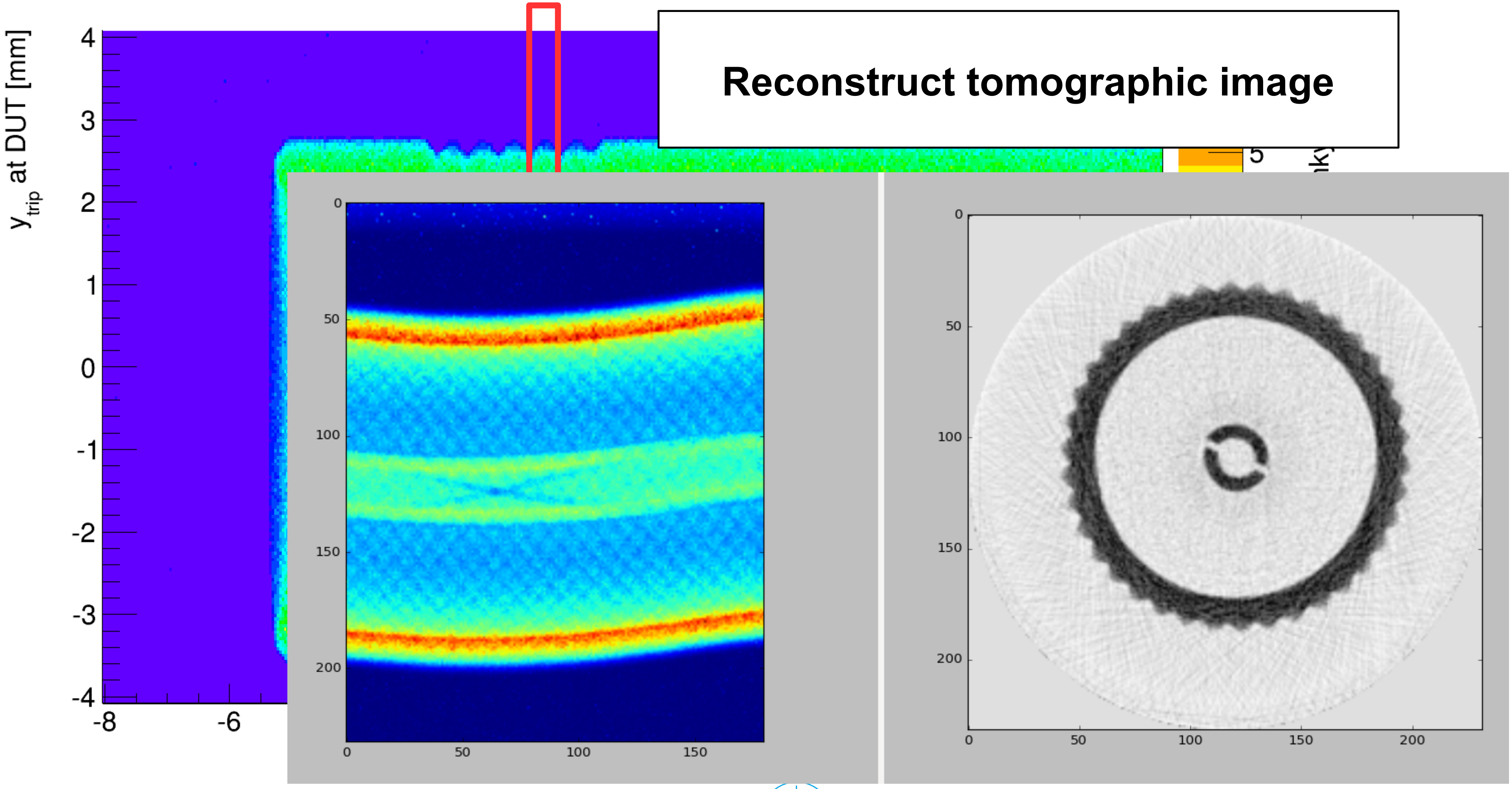


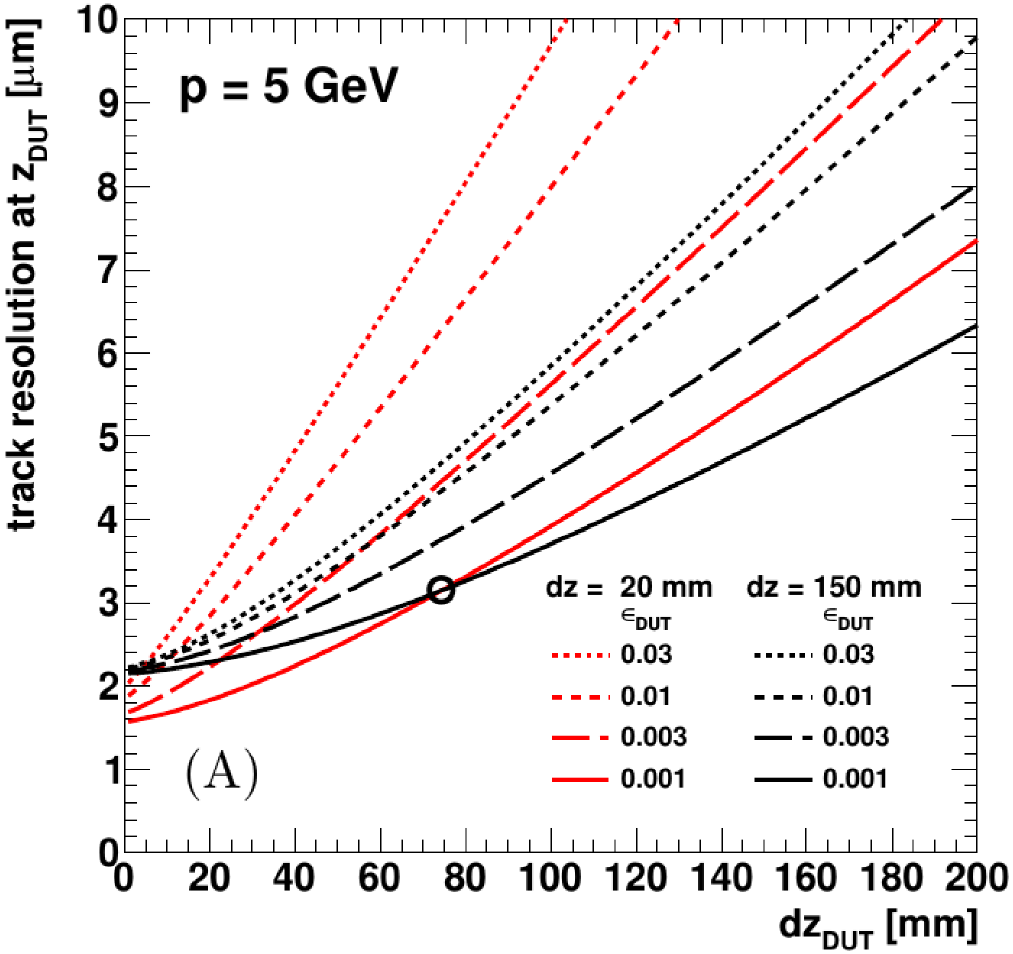
Systematics

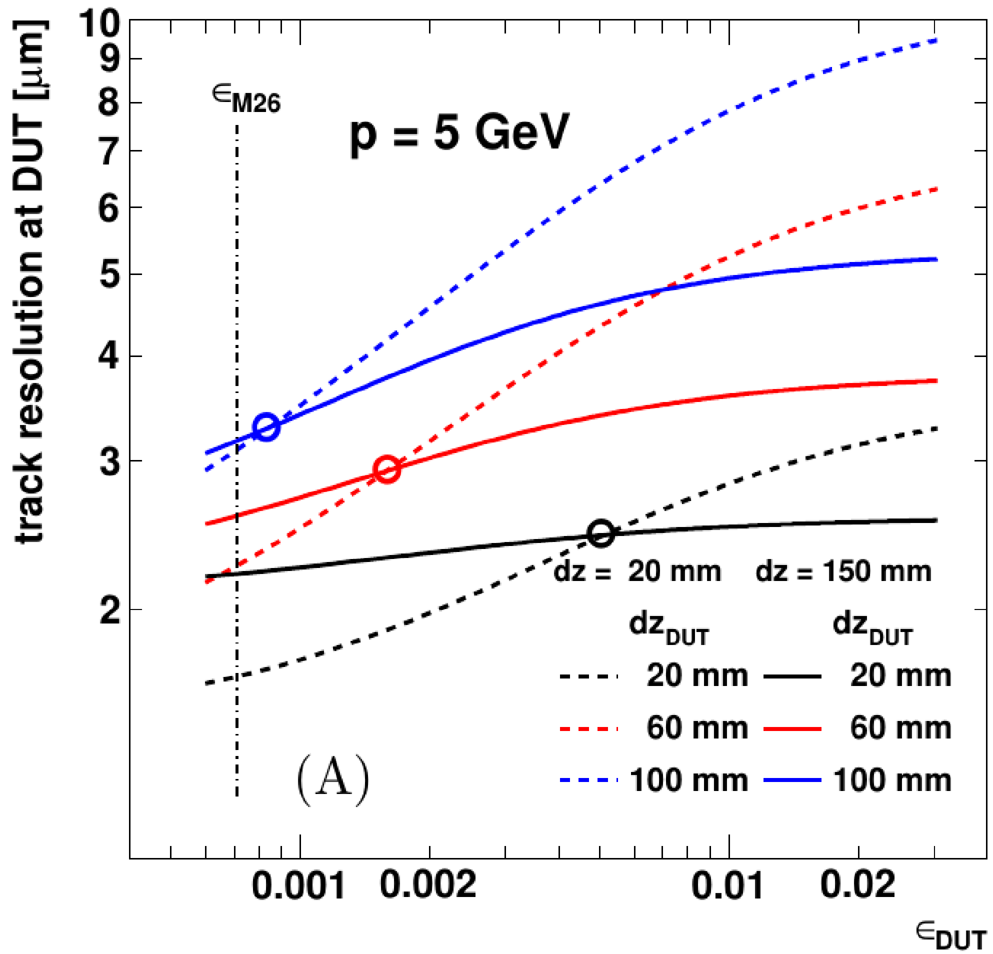
- Estimate systematic uncertainties of intrinsic resolution based on the input uncertainties

			$\sigma_{\sigma_{\text{int}}}$ in %				
			per plane			all planes	$\sqrt{\sum(x_i)^2}$
			E $\pm5\,\%$	Θ_0 $\pm3\,\%$	fit range ±1 std.	$\text{rms}(p_\text{b})$	
6 GeV	20 mm	biased	-0.34 $+0.21$	$+0.08$ -0.28	$+1.76$ -1.27	1.57	2.6
		unbiased	-0.43 $+0.71$	$+0.44$ -0.25	-0.93 -1.00	1.23	1.8
	150 mm	biased	-3.5 $+2.9$	$+1.95$ -2.60	$+6.4$ -5.4	1.51	7.9
		unbiased	-4.80 $+5.43$	$+2.97$ -4.13	-5.29 $+3.11$	0.75	8.7
2 GeV	20 mm	biased	-1.56 $+1.13$	$+0.65$ -1.22	$+0.23$ $+0.33$	3.1	3.7
		unbiased	-1.67 $+1.21$	$+0.92$ -1.10	-2.15 $+1.35$	1.94	3.1
	150 mm	biased	-10.5 $+15.7$	$+10.2$ -6.59	$+8.0$ $+0.82$	0.82	20.3
		unbiased	-17.5 $+24.9$	$+14.9$ -15.2	-23.9 $+25.1$	1.03	38.5

Track resolution predictions

- Using 6 planes, assuming DUT in the centre





→ dz_{DUT} as small as possible

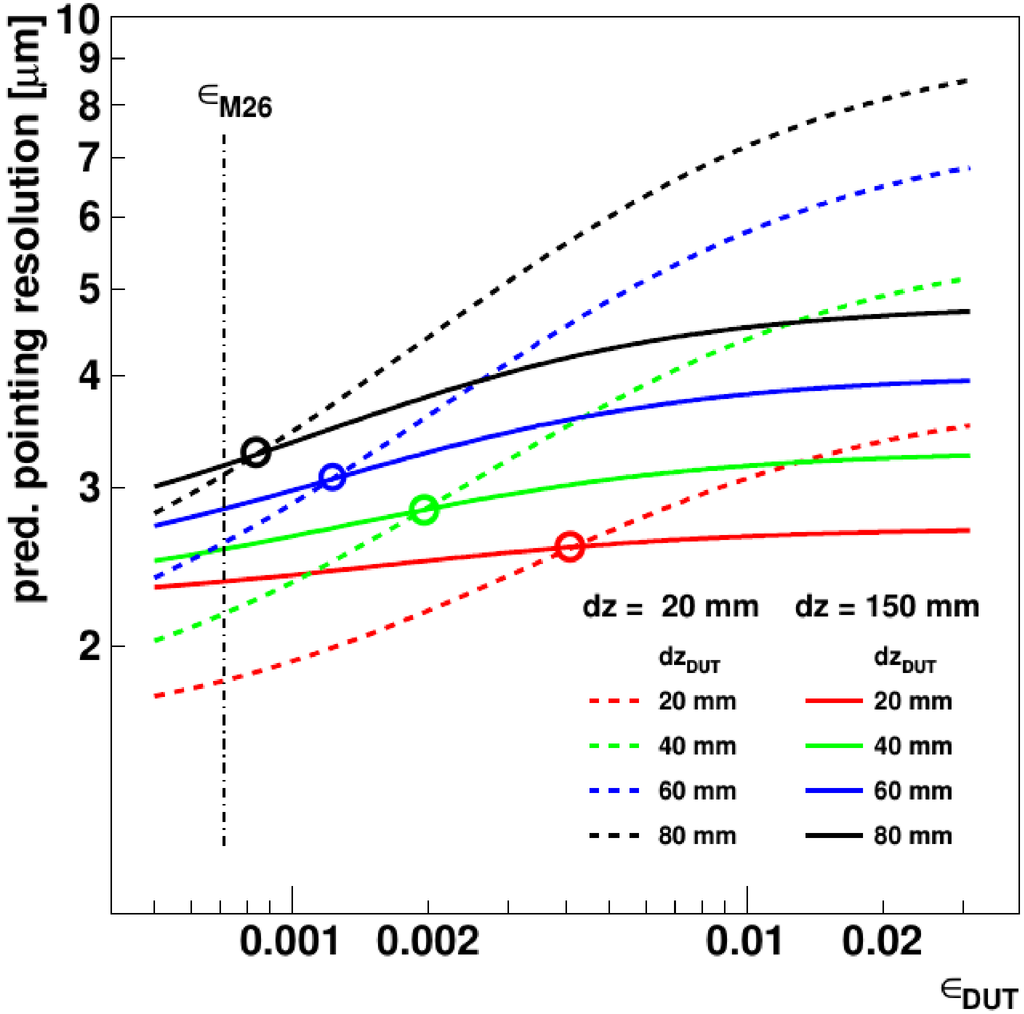
→ Thick DUT: use wide set-up

Thin DUT: use narrow set-up

Track resolution predictions

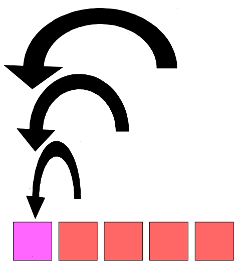
- Using 6 planes, assuming DUT in the centre
- Wide set-up offers superior track resolution with thicker DUTs and vice versa.
- Intersection is function of material budget

→ Optimise resolution prior to your test beam



Looking even closer ...

Fold occurrence into one pixel for intra-pixel studies

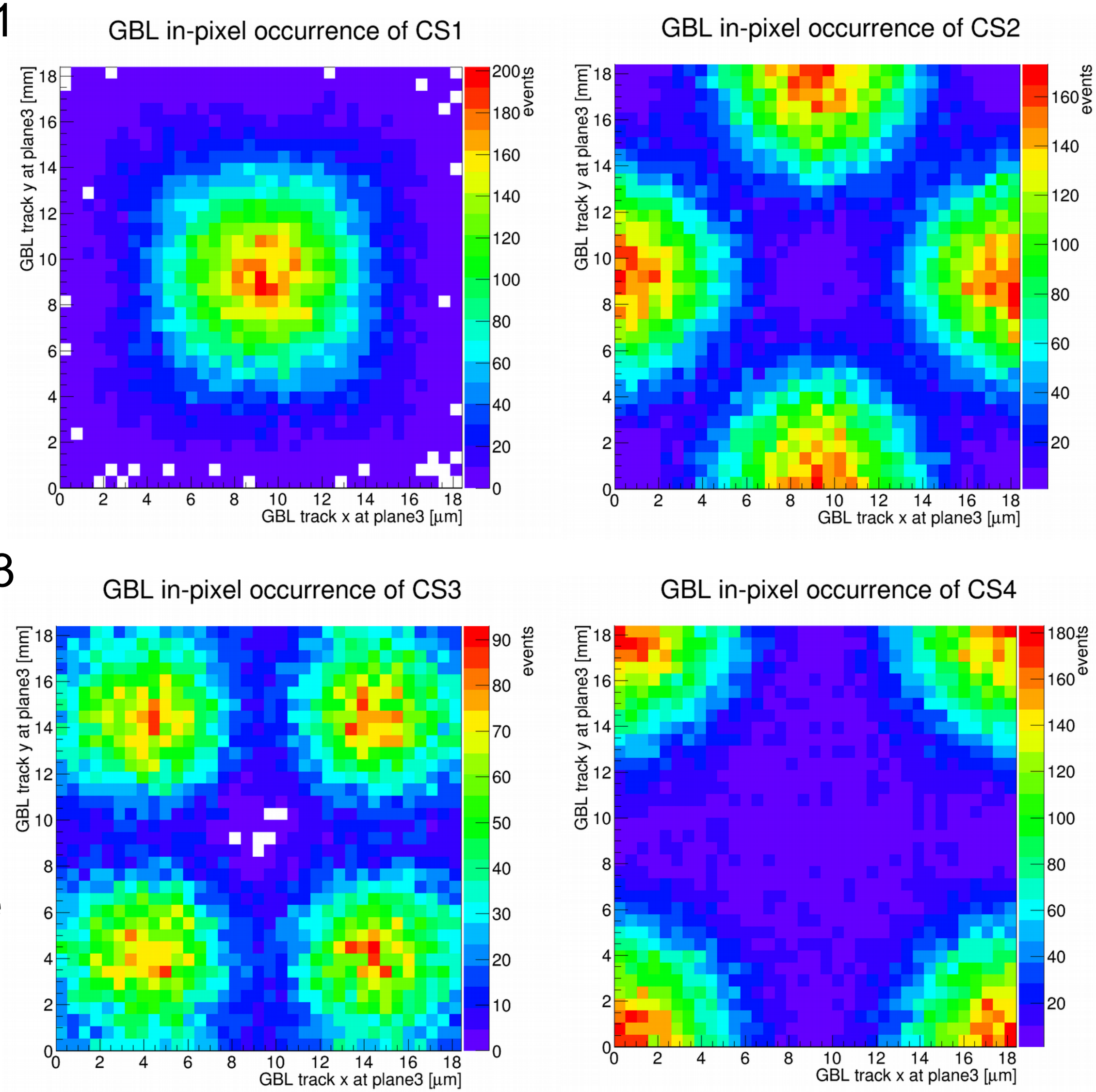


CS 1

CS 2

CS 3

CS 4



→ **Density of recon. track position is non-uniform, it depends on cluster size**
→ **Populated areas differ in size**
→ **Resolution is CS dependent**
→ **Calculate differential intrinsic resolution**