Update on hardware activities

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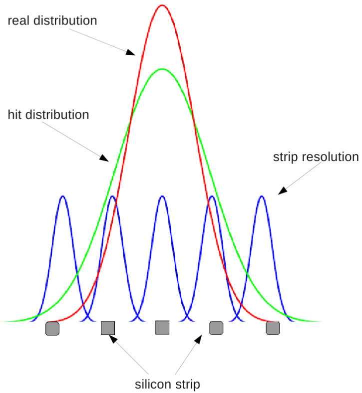
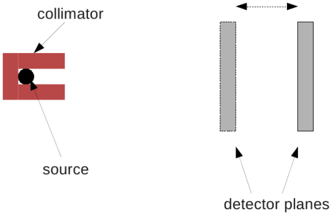
spatial resolution



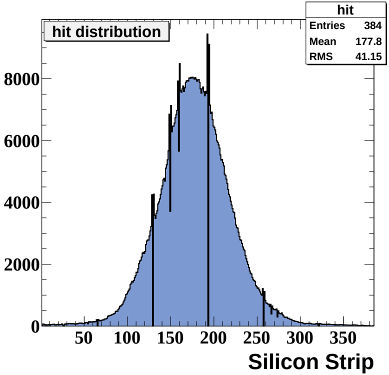


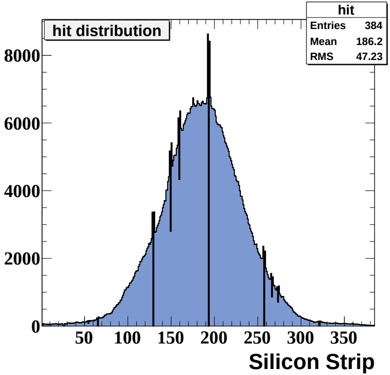
- deconvolute hit distribution for different displacements of detector and source $\Rightarrow$ spatial resolution

spatial resolution

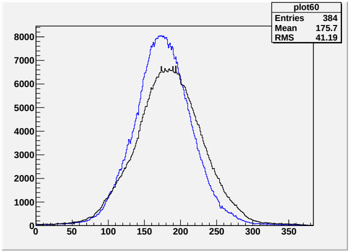
Distance source to sensor:

$d = 60\,\text{mm}$ $d = 85\,\text{mm}$





simple deconvolution



- smoothing of both distributions
- Unfold detector resolution $\vec{x}_{true} = R^{-1}\vec{x}_{meas}$
- Rescale and center one distribution $\vec{y} = S\,\vec{x}_{true}$
- fold distribution with detector resolution again $\vec{x}_{fin} = R\,\vec{y}$
- find minimum of $\chi^2(\sigma_D, w, \mu)$

simple deconvolution

- resolution matrix: Use random number generator to dice inital channel position and add gaussian for smearing

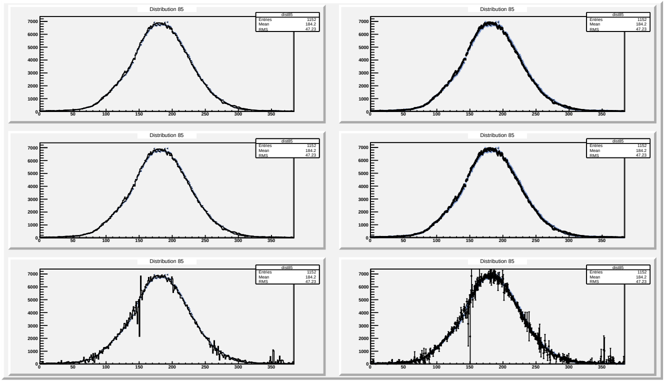
$$f_{ini} = \begin{pmatrix} 1000 \\ 1000 \\ \vdots \\ 1000 \end{pmatrix} \qquad R = \begin{pmatrix} 680 & 150 & 5 & \cdots & 0 & 0 & 0 \\ 150 & 680 & 150 & \cdots & 0 & 0 & 0 \\ \vdots & \vdots & \vdots & \ddots & \vdots & \vdots & \vdots \\ 0 & 0 & 0 & \cdots & 5 & 150 & 680 \end{pmatrix}$$

- scaling matrix: Assume that particle trajectory is a straight line

$$x_2 = \underbrace{\frac{d_2}{d_1}}_{=w} \cdot x_1$$

- other effects like multiple scattering are not included

simple deconvolution



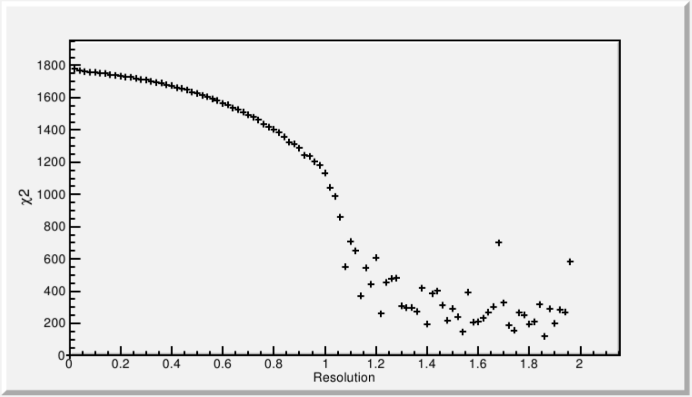
$\sigma_D = 0.3$

$\sigma_D = 0.8$

$\sigma_D = 1.3$

- for detector resolutions $\sigma_D > 1$ distributions start to show oscillations
  $\Rightarrow$ possible minimum in χ^2 is smeared out

simple deconvolution



- due to oscillatios regularization is required

deconvolution using SVD

- incoporate general assumptions about size or smoothness of unfolded distribution (second derivative)

$$x'' \approx x_{i-1} - 2x_i + x_{i+1}$$

$$C = \begin{pmatrix} 1 & -2 & 1 & 0 & \cdots & 0 & 0 & 0 \\ 0 & 1 & -2 & 1 & \cdots & 0 & 0 & 0 \\ \vdots & \vdots & \vdots & \vdots & \ddots & \vdots & \vdots & \vdots \\ 0 & 0 & 0 & 0 & \cdots & 1 & -2 & 1 \end{pmatrix}$$

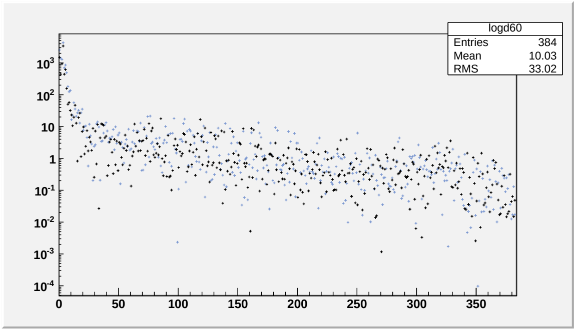
- calculate AC^{-1} and use singular value decomposition

$$AC^{-1} = U\Sigma V^T$$

U, V contain eigenvectors of AC^{-1}
Σ is a diagonal matrix containing the singular values

deconvolution using SVD

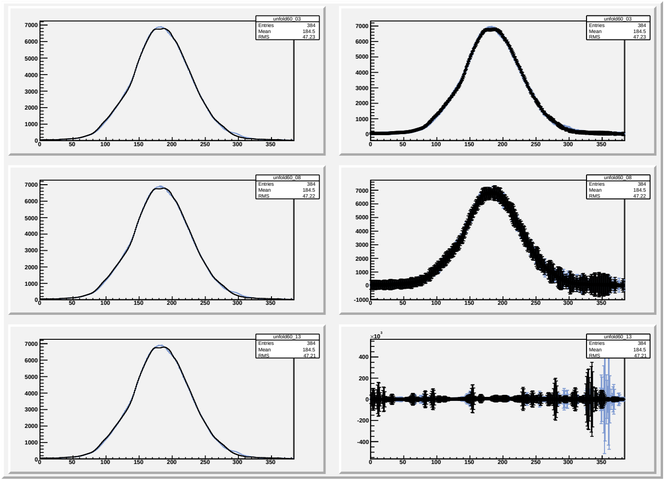
- In order to obtain the effective rank k of the response matrix and the regularisation parameter $\alpha = \sigma_k^2$, plot $\log(|d|)$ with $d = U^T \vec{x}$



- unfolded solution given by

$$w^{(\alpha)} = C^{-1} V \cdot \frac{d_i \sigma_i}{\sigma_i^2 + \alpha}$$

deconvolution using SVD



$\sigma_D = 0.3$

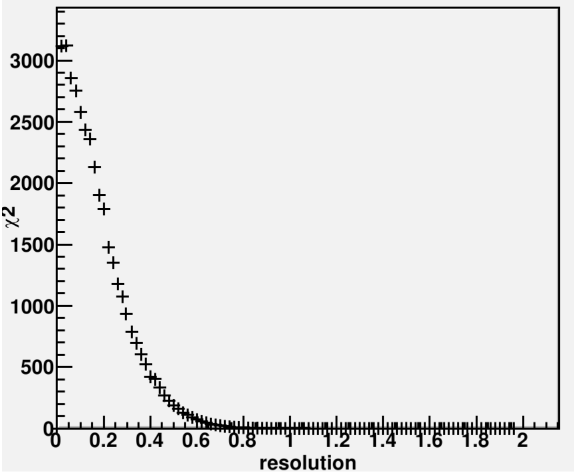
$\sigma_D = 0.8$

$\sigma_D = 1.3$

- oscillations disappear, but very high and oscillating errors at high resolutions

deconvolution using SVD

- after regularisation still no minimum in χ^2



spatial resolution - conclusion

Results so far:

- neither simple deconvolution nor deconvolution using SVD give a value for spatial resolution
- using *RooUnfold* without sucess

Ideas:

- test of algorithms with simple distribution (gaussian)
- include multiple scattering