Strip telescop

Some tries to estimate the telescope resolution

(Auguste Besson & Jérôme Baudot)

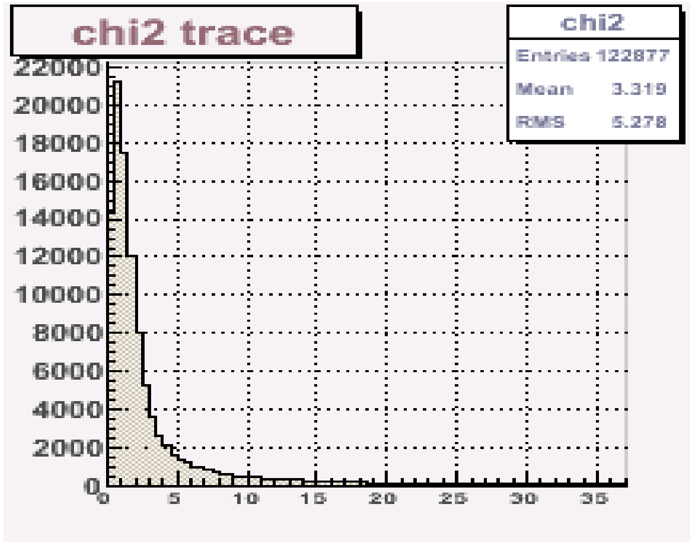
$$\sigma_{Residual}^2 = \sigma_{telescope}^2 + \sigma_{DUT}^2 + \sigma_{M.S.}^2$$

Method 1 : chi-2 law

chi-2 law

- Goal: obtain the strip resolution
- Selection of reconstructed tracks
  - the χ^2 should obey to a χ^2 law:
  - In principal:

$$f(t) = \frac{t^{k/2 - 1} \times e^{-\alpha t/2}}{2^{k/2} \times \Gamma(k/2)}$$



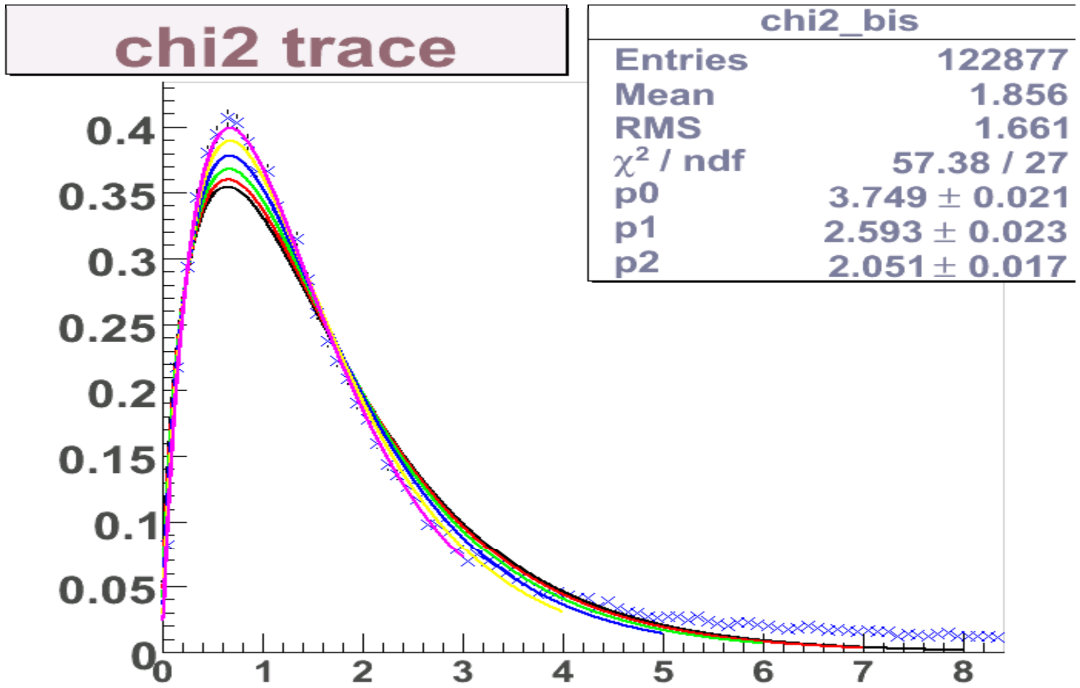
- ✓ k = Number of Degrees of Freedom:
- ✓ Γ = gamma function
- ✓ α = 1 if the uncertainty is correct

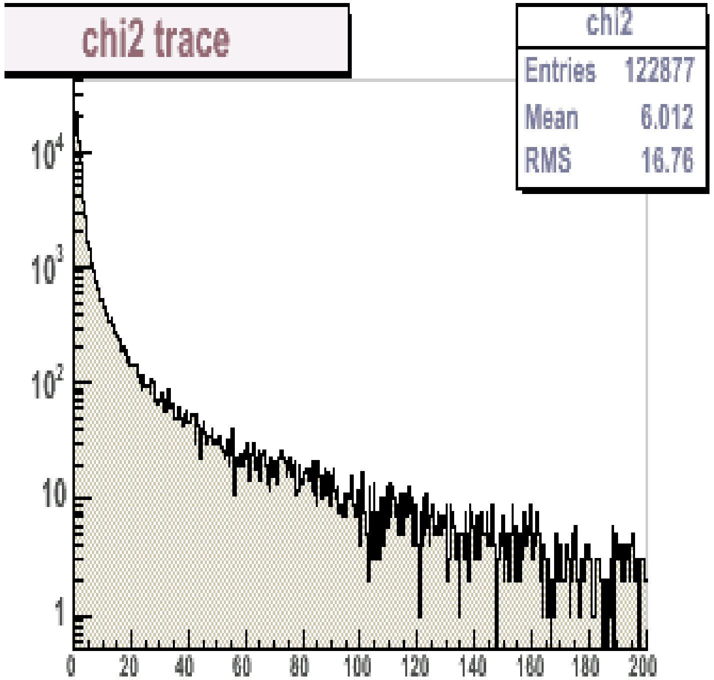
  - k = (4 points – 2 parametes of the straight line) x 2 dimensions = 4 ?
  - Fit the function with α, k , norm
  - True resolution: $\sigma_{true} = \sigma_{used} / \sqrt{\alpha}$
  - 1ere step: Reconstruct data with an assumed resolution of 2 µm

$F(t) = t^{\alpha k/2-1} \times e^{-\alpha t/2} / (2^{\alpha k/2} \times \Gamma(k/2))$

Result of the fit

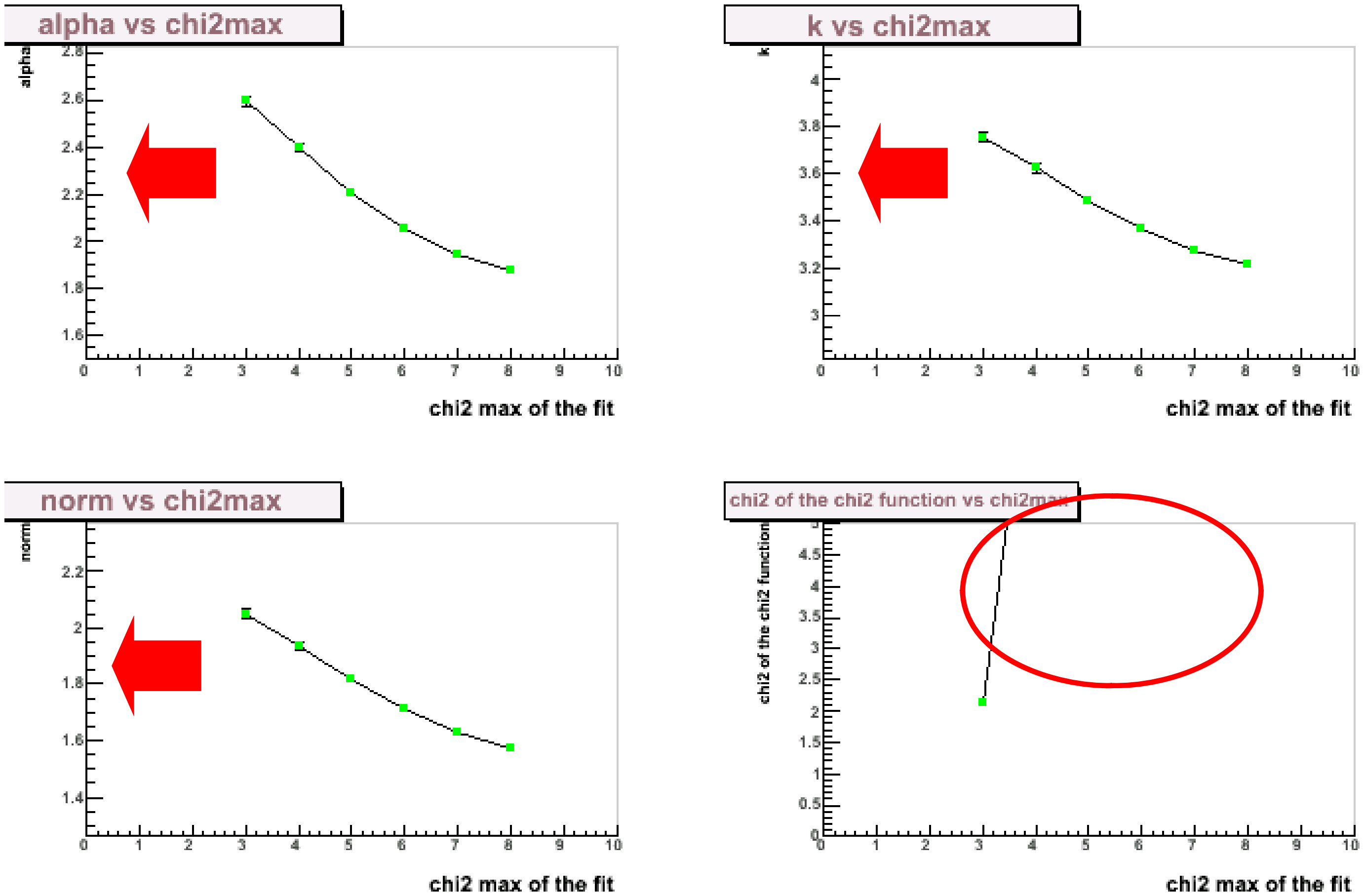
- Problem : the fit depends on the maximum range
  - The data doesn't follow exactly a χ^2 law
    - ✓ multiple scattering ?
    - ✓ No homogeneous resolution in each plane ?





Results for $\sigma_{used} = 2\ \mu m$

- α, k, norm: non constants depending on the maximum range of the fit.



$\alpha \sim 2$

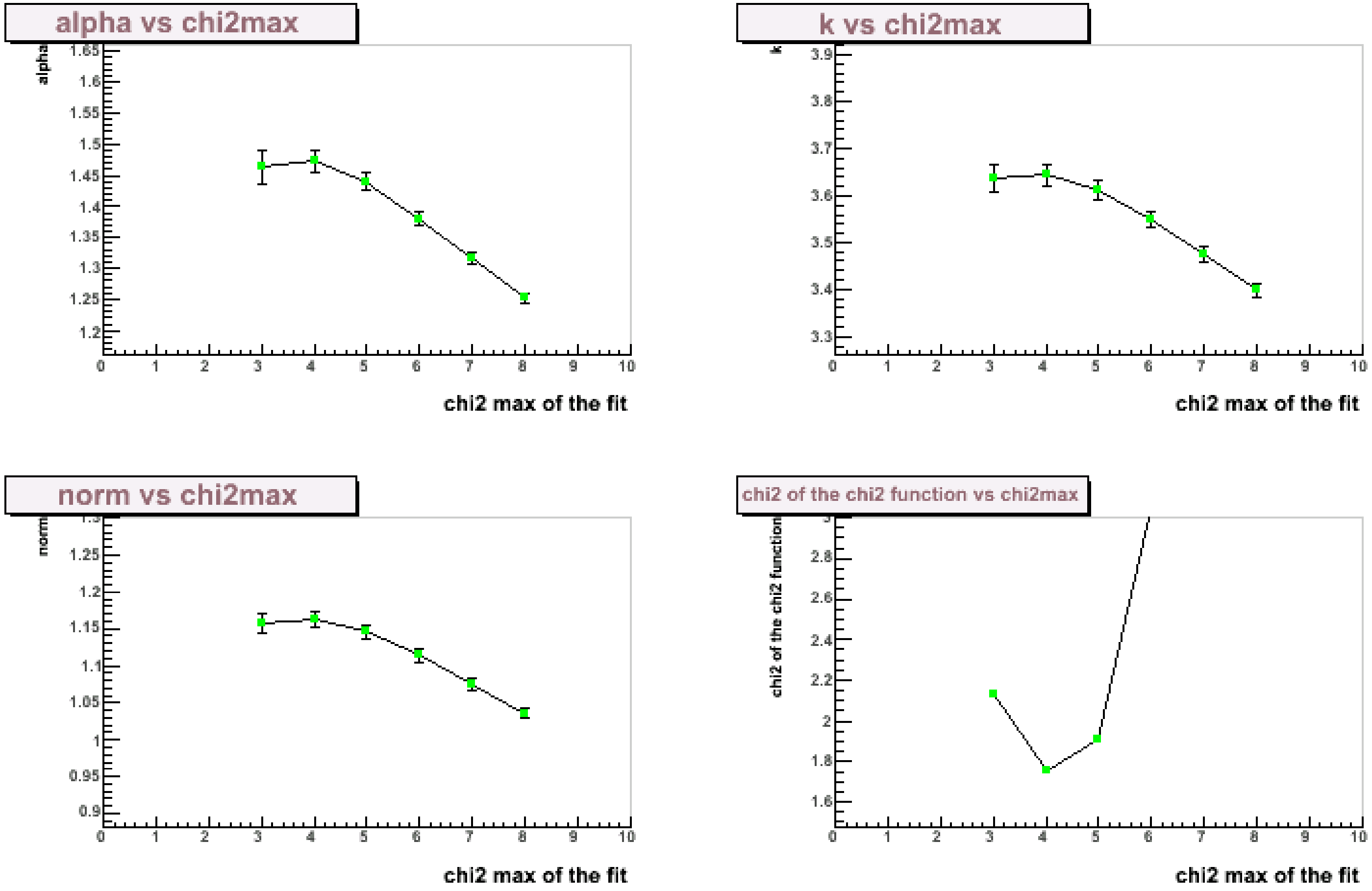
$\sigma_{true} \sim \sigma_{used} / \sqrt{\alpha}$

$\sigma_{true} \sim 1.4$

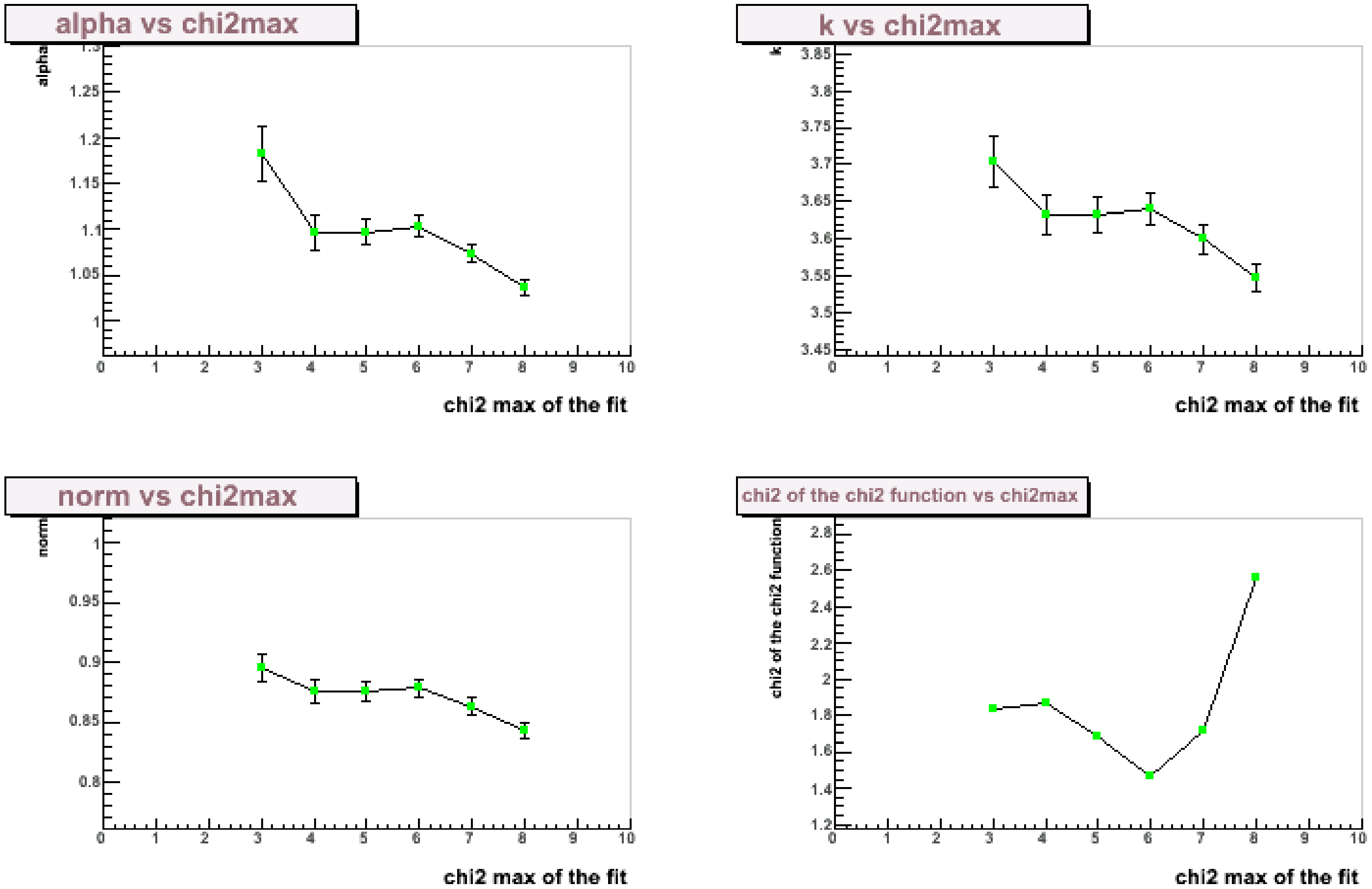
Start again with

$\sigma_{used} \sim 1.5$

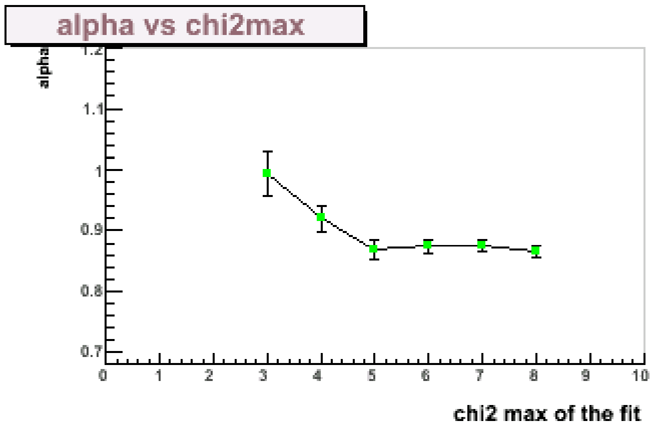
Results for σ_{used} = 1.5 µm

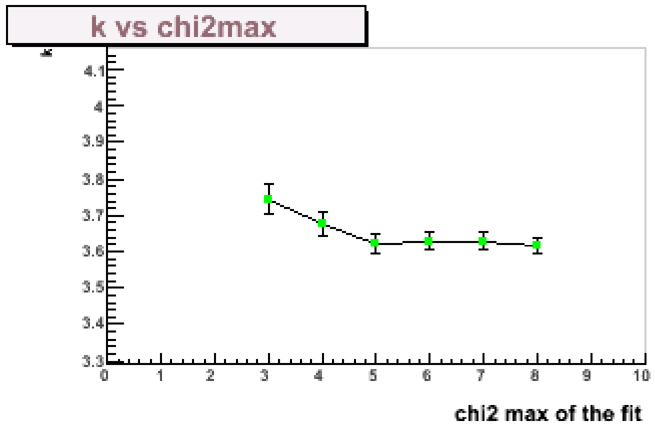


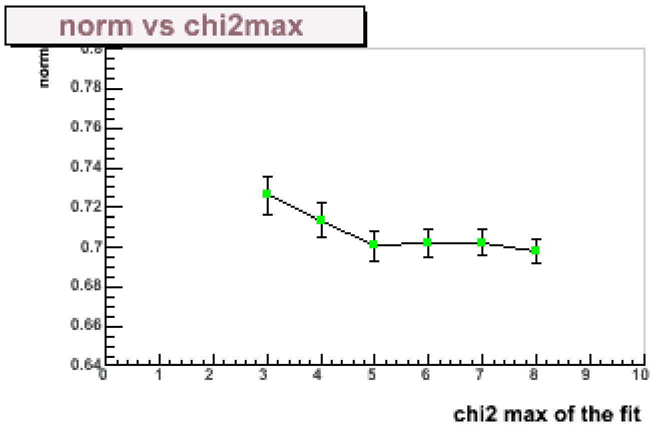
Results for σ_{used} = 1.3 µm

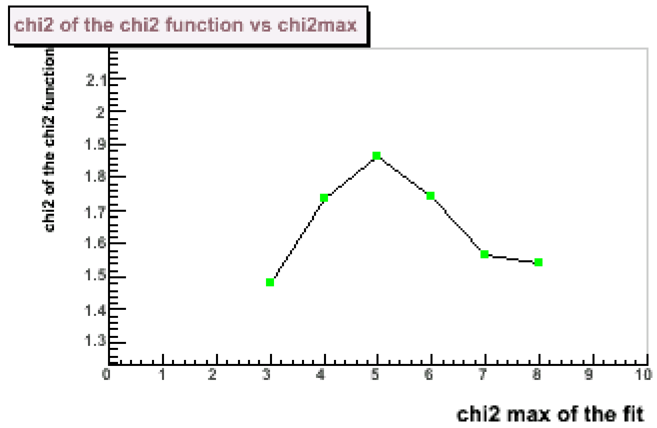


Results for σ_{used} = 1.16 µm









Summary: σ which fits best ~1.2-1.3 µm

Assumed resolution = 1.16µm				
Max range of the fit	α	k	norm	$\chi 2$/NdF of the fit
3	0.99±0.008	3.7±0.02	0.72±0.010	1.54
4	0.92±0.008	3.7±0.02	0.71±0.009	1.54
5	0.87±0.008	3.6±0.02	0.70±0.008	1.54
6	0.87±0.015	3.6±0.02	0.70±0.008	1.54
7	0.87±0.010	3.6±0.02	0.70±0.006	1.56
8	0.87±0.008	3.6±0.02	0.70±0.006	1.54

Assumed resolution = 1.3µm				
Max range of the fit	α	k	norm	$\chi 2$/NdF of the fit
3	1.18±0.030	3.7±0.03	0.90±0.011	1.83
4	1.09±0.019	3.6±0.03	0.88±0.010	1.87
5	1.09±0.014	3.6±0.02	0.88±0.008	1.69
6	1.10±0.011	3.6±0.02	0.87±0.008	1.46
7	1.07±0.010	3.6±0.02	0.86±0.007	1.71
8	1.04±0.008	3.5±0.02	0.84±0.007	2.55

Assumed resolution = 1.5µm				
Max range of the fit	α	k	norm	$\chi 2$/NdF of the fit
3	1.46±0.026	3.6±0.03	1.16±0.013	2.13
4	1.47±0.017	3.6±0.02	1.16±0.011	1.75
5	1.44±0.013	3.6±0.02	1.15±0.010	1.91
6	1.38±0.011	3.5±0.02	1.11±0.009	3.05
7	1.32±0.010	3.5±0.02	1.07±0.008	5.09
8	1.25±0.008	3.4±0.02	1.03±0.007	8.43

Assumed resolution = 2.0µm				
Max range of the fit	α	k	norm	$\chi 2$/NdF of the fit
3	2.59±0.023	3.7±0.02	2.05±0.017	2.12
4	2.40±0.017	3.6±0.02	1.93±0.014	8.3
5	2.20±0.015	3.5±0.02	1.81±0.013	18
6	2.05±0.013	3.4±0.02	1.71±0.012	31
7	1.94±0.013	3.3±0.01	1.63±0.012	42
8	1.88±0.013	3.2±0.01	1.57±0.011	50

Method 2 : from the digital resolution

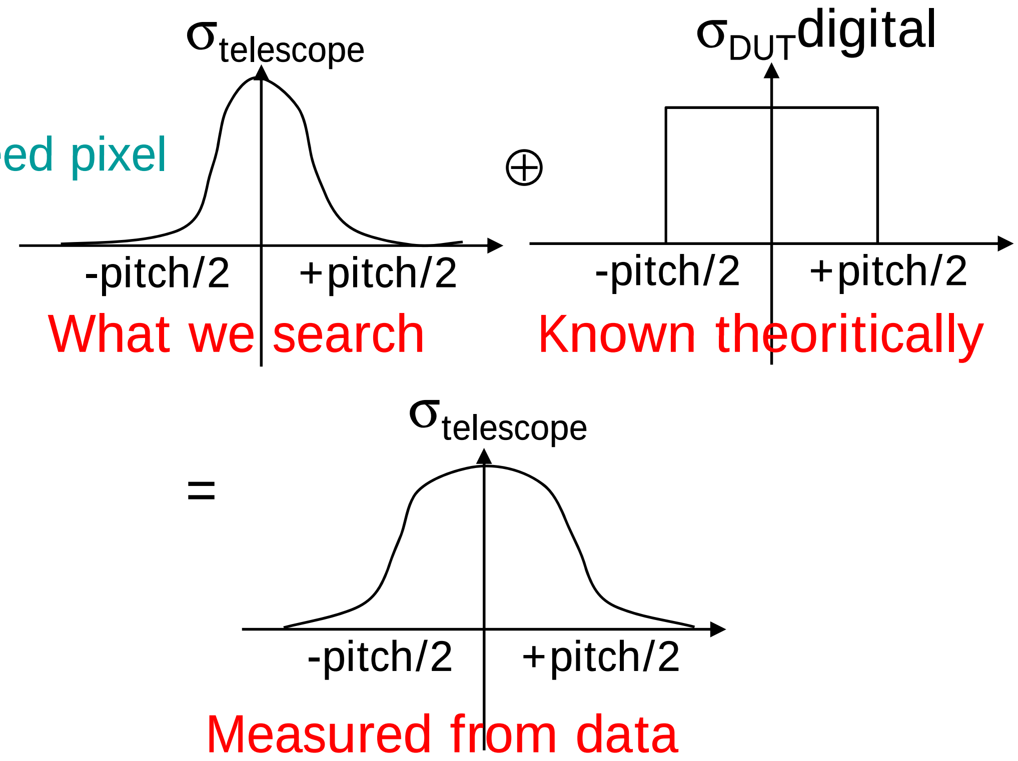
Residual with the digital position

- $\sigma^2_{residual} = \sigma^2_{telescope} + \sigma^2_{DUT}$
  - Digital Position = center of the seed pixel
- Need to deconvoluate (p = pitch)

$$f(r) = \int_{r-p/2}^{r+p/2} f_{DUT}(r-\varepsilon) \times f_{telescope}(\varepsilon)\, d\varepsilon$$

1/p

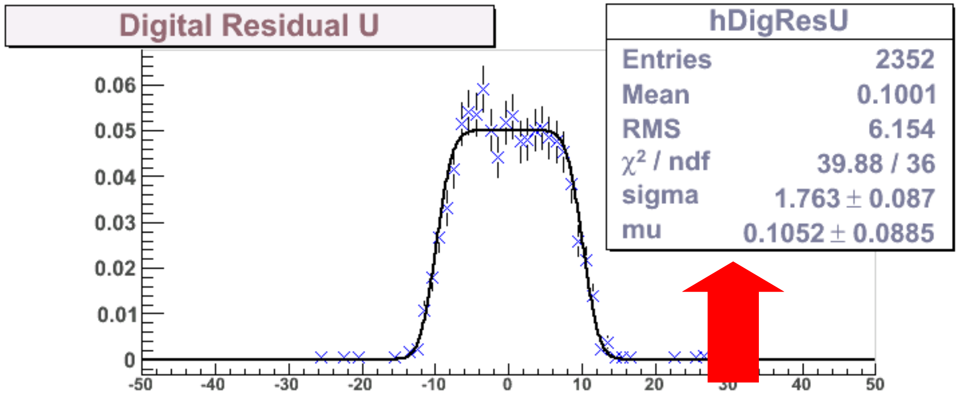
$$\frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(\varepsilon-\mu)^2}{2\sigma^2}}$$

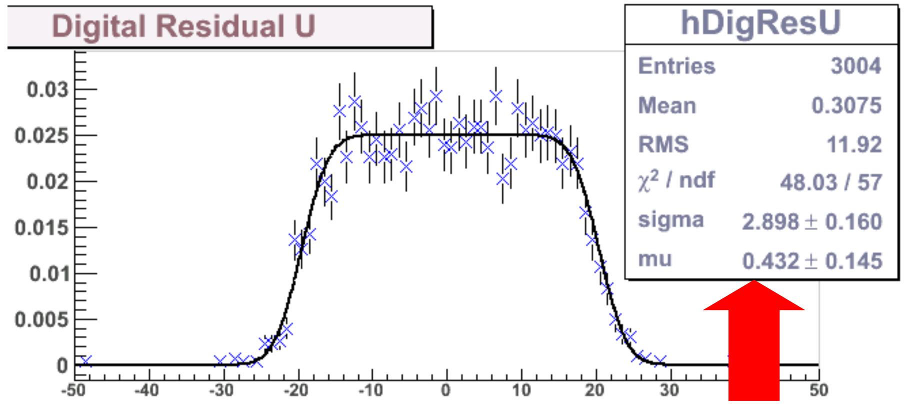


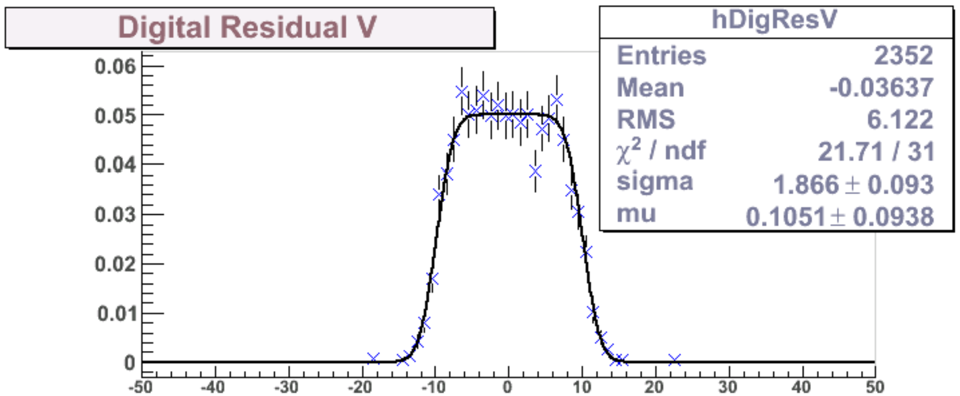
- Fit from the data
  - Parameters : σ, μ

Results for M9, pitch 20 µm & 40 µm

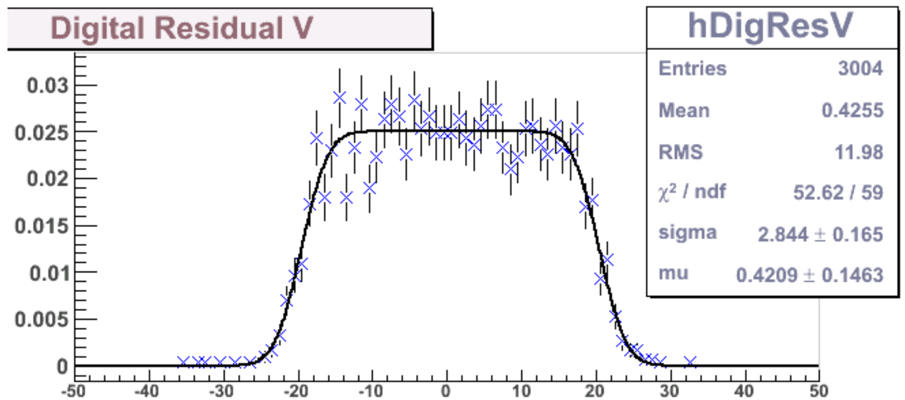
- Good chi-2
- Problem: σ is not constant !! (1.8 ou 2.8 µm ???)
  - ➢ There is another source of uncertainty which degrades the residual (seed choice ?)







Pitch = 20 µm



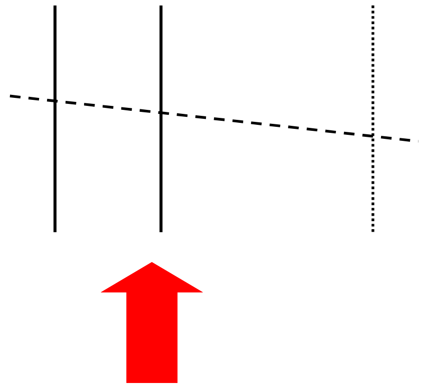
Pitch = 40 µm

Other methods

- Dirk Meier thesis: (RD42)
  - Estimate from the residual = 1.35 µm = 1.93 / √2 (no uncertainty given)
  - BUT: residual fitted in a ±4 µm range ⇨residual = 1.93 µm

- Estimate the resolution from the Alignment residual
  - Residual with « long tails »
  - Residual fitted in a range of ± 10 µm
    - ✓ $\sigma_{residual}$ in one plane ~ 2.5-3.7 µm ~ $\sigma_{spatial}/\sqrt{2}$
    - ✓ $\sigma_{spatial}$ ~1.7-2.6 µm
  - Residual fitted in a range of ± 4 µm
    - ✓ $\sigma_{residual}$ in one plane ~ 2.2-3.5 µm ~ $\sigma_{spatial}/\sqrt{2}$
    - ✓ $\sigma_{spatial}$ ~1.5-2.5 µm
  - Spatial resolution = 2 ± 0.5 µm

    (classical method)



Summary

- chi-2 method:
  - ~ 1.2-1.3 µm ± xxx
  - why k ~3.5 and not 4 ?
  - Multiple scattering ?
  - Resolution not constant between planes and inside a plane ?
- Digital position method
  - ~ between 1.8 and 3 µm ...
- Other estimates:
  - D.Meier's thesis: 1.35 µm ± xxx
  - Residual of the alignement: ~ 2 ± 0.5 µm

  - There are additionnal effects which make these methods incompatible
    (alignment, moves, inhomogeneity, different plans, etc.)
  - A better estimate needs a dedicated study
  - Our uncertainty on the DUT resolution ~ few 10^{-1} µm
  - Which uncertainty do we want on the DUT resolution ?