CST Performance 1997

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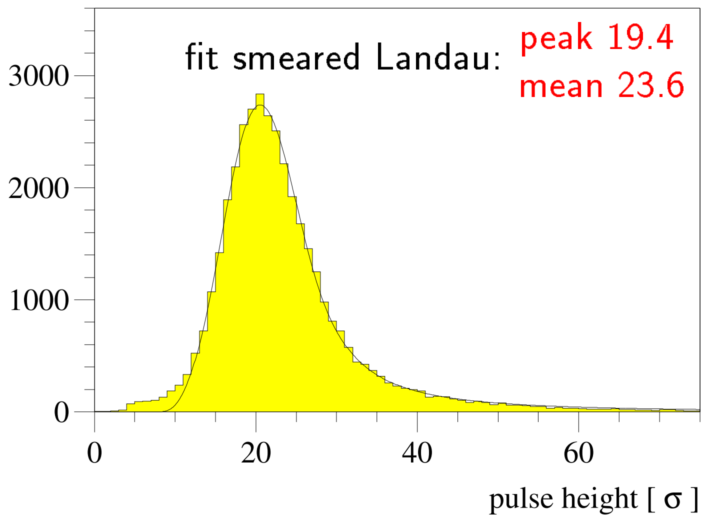
PSI Group Meeting on December 21st, 1998

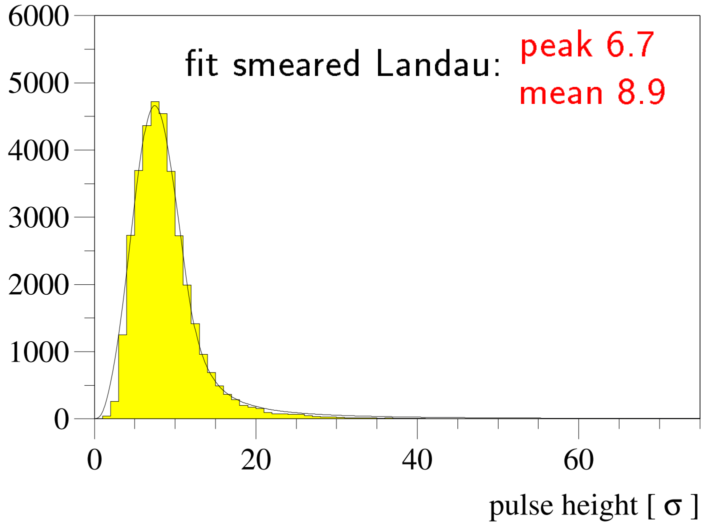
Pulseheight Distributions

- energy loss distribution in a thin layer of silicon is discribed by a Landau distribution (δ-rays) smeared with a Gaussian (δ-ray leaves silicon layer)
- pulseheight distribution compatible with model
- pulseheight distribution in noise units $\Rightarrow$ Signal/Noise Ratio

p-side $(r\Phi)$



n-side (z)



Alignment Method

192·6 = 1152 free parameters
microscope survey of half-ladders
(new 1998: 3d, „dromedar")
$\Rightarrow$ 384 free parameters

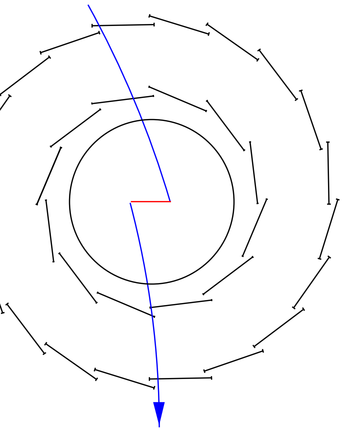
Three data samples:

1. cosmics:
   Track $\vec{T}^t = (\kappa_{CJC}, \Phi_0, \theta, d_{ca}, z_0)$
   Covariance Matrix V includes:
   - CST intrinsic resolution
   - multiple scattering
   - CJC momentum resolution

   $$\chi^2_{cosmics} = \sum_{events} \Delta\vec{T}^t \cdot V^{-1} \cdot \Delta\vec{T}$$
2. ep tracks in overlap regions:
   residuals $\Delta\vec{u}^t = (\Delta x, \Delta z)$
   $$\chi^2_{overlaps} = \sum_{events} \Delta\vec{u}^t \cdot V^{-1} \cdot \Delta\vec{u}$$
3. vertex fit for ep data:
   distance $\vec{D}$ of track to 3d vertex
   $$\chi^2_{vertex} = \sum_{events} \sum_{tracks} \vec{D}^t \cdot V^{-1} \cdot \vec{D}$$

Minimize total χ^2 with respect to 384 alignment parameters

1



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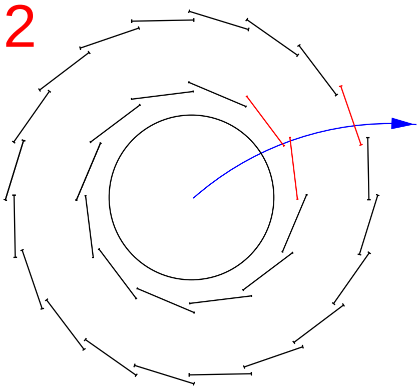

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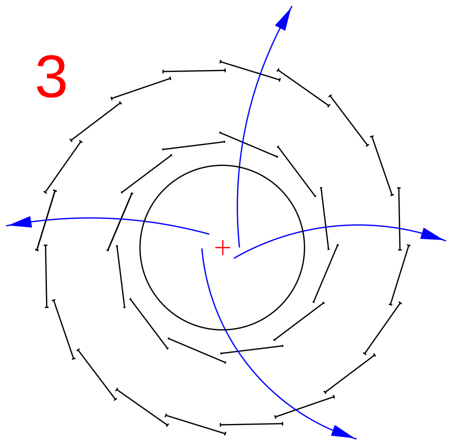
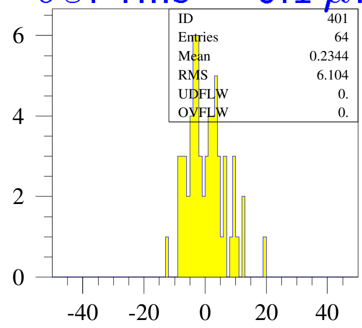
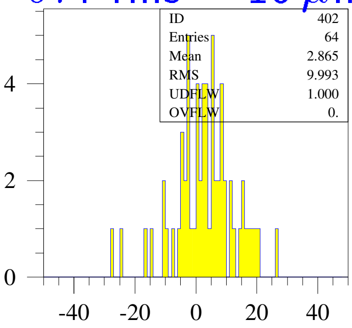


Accuracy and Stability of Alignment

δs: rms = 6.1 μm



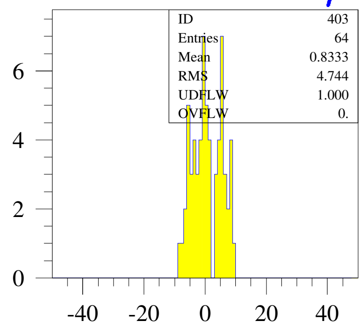
δr: rms = 10 μm



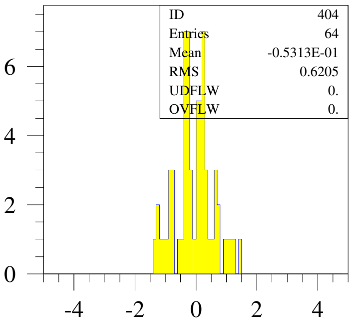
october - july '97: $\Delta\delta$s [μm]

october - july 1997: $\Delta\delta$r [μm]

δz: rms = 4.7 μm



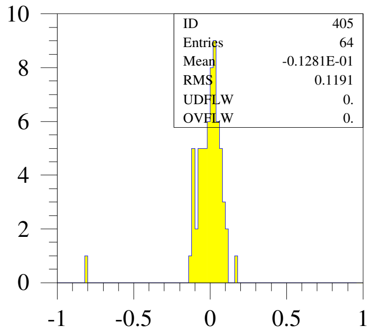
$\delta\theta$: rms = 0.6 mrad



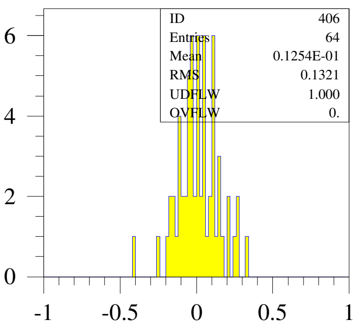
october - july 1997: $\Delta\delta$z [μm]

october - july 1997: $\Delta\delta\Theta$ **[mrad]**

$\delta\Phi$: rms = 0.1 mrad



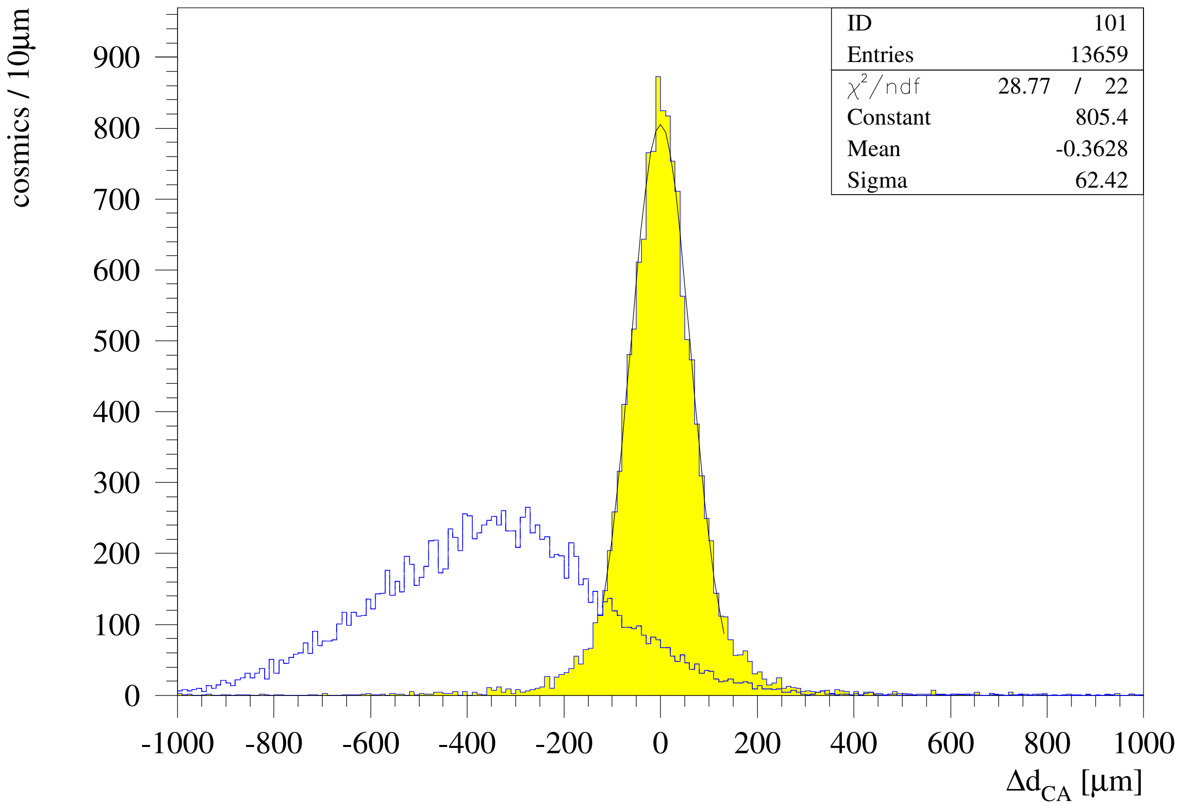
$\delta\Psi$: rms = 0.1 mrad



october - july 1997: $\Delta\delta\Phi$ **[mrad]**

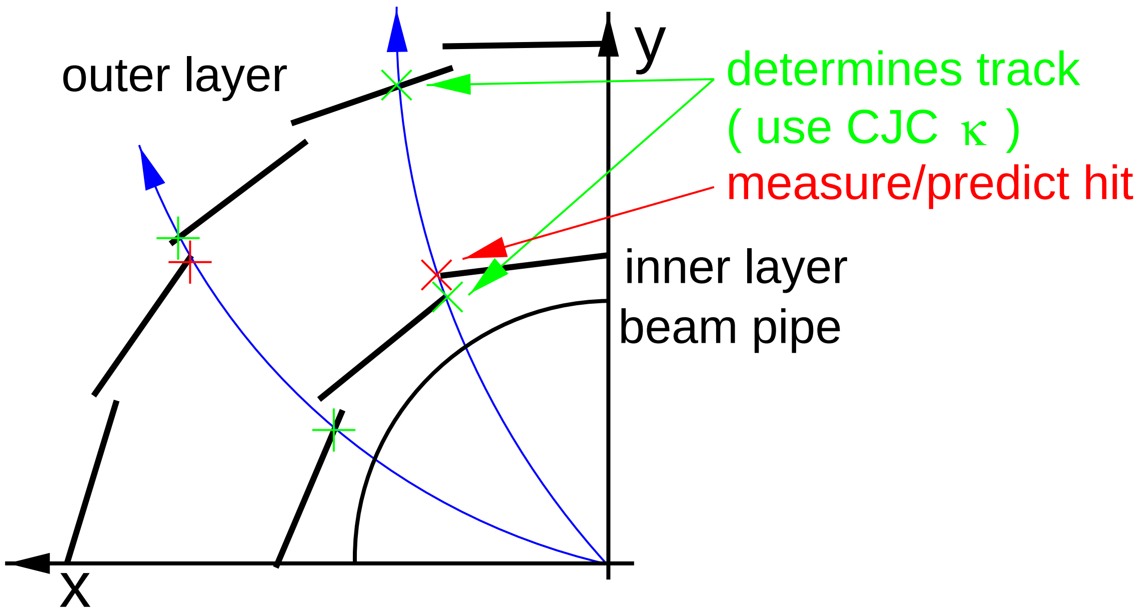
october - july 1997: $\Delta\delta\Psi$ **[mrad]**

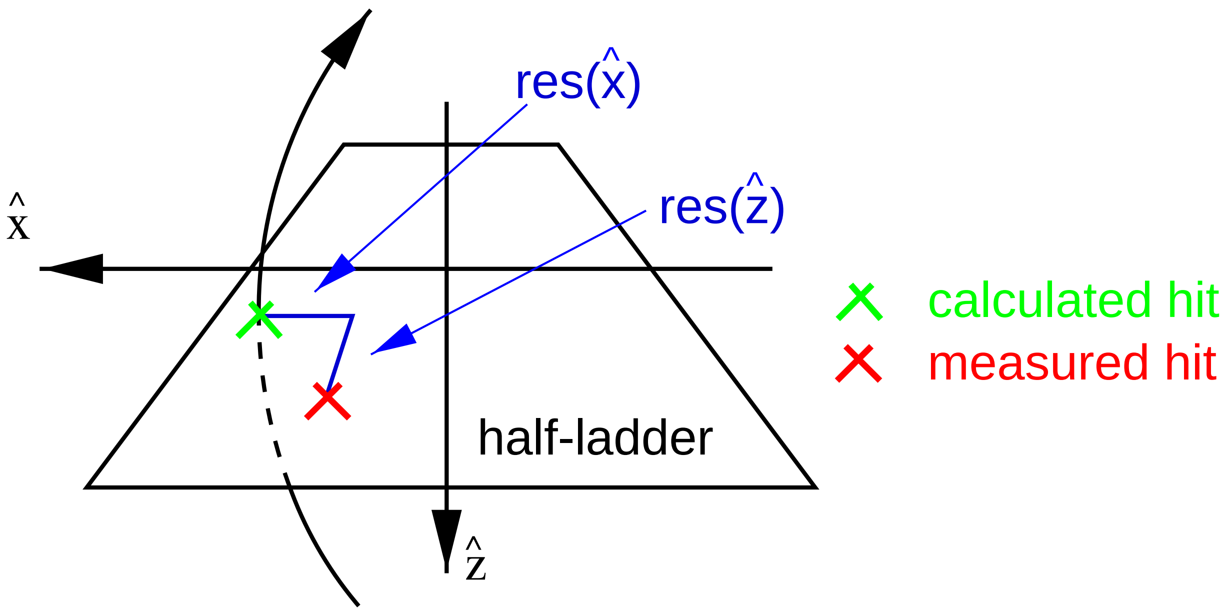
Improvement after Alignment



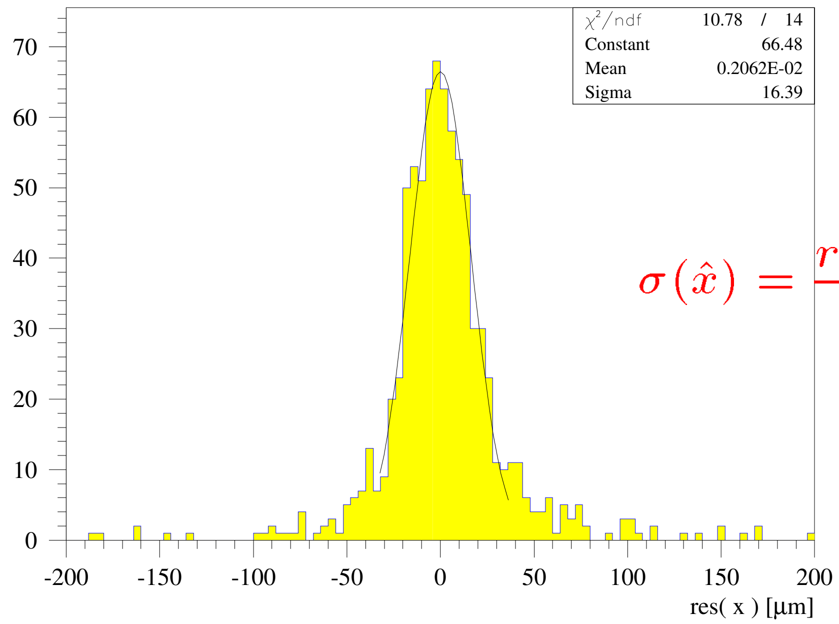
impact parameter resolution for cosmics
before and after alignment

Intrinsic Resolution with Overlaps



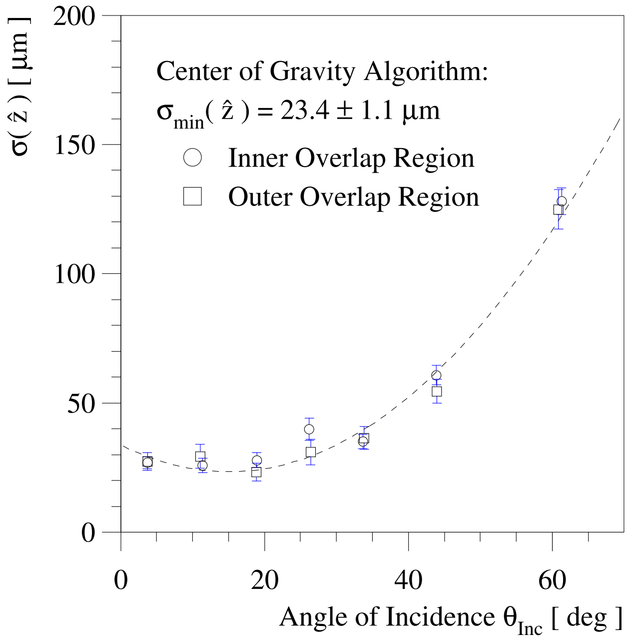


Intrinsic Resolution



Overlap residuals in r-ϕ for p_t > 0.4 GeV/c

$$\sigma(\hat{x}) = \frac{res(\hat{x})}{\sqrt{2}} = 11.6\ \mu m$$



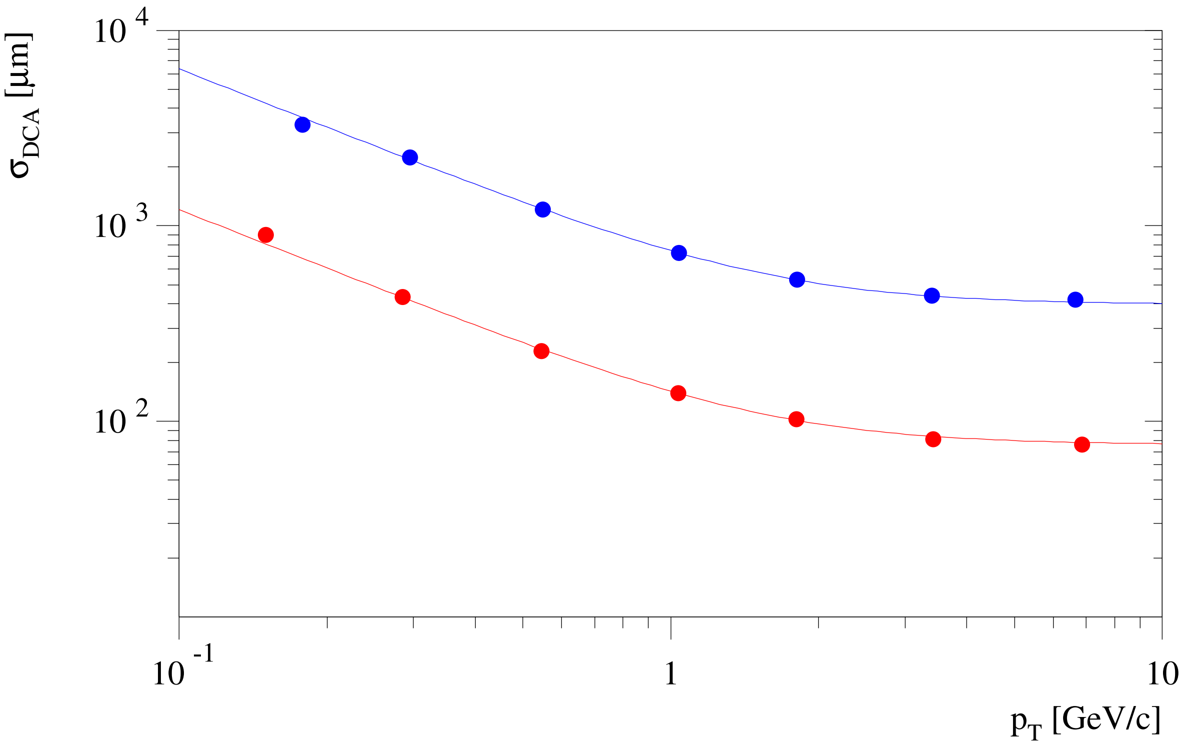
$$\sigma(\hat{z})\ [\mu m] = 23.4 + 0.014 \cdot (\theta_{Inc}\ [deg] - 15.0)^2$$

Impact Parameter Resolution 1997

measure d'_{ca} resolution of CJC and CST tracks versus p_t

$\Rightarrow$ unfold multiple scattering: $\sigma_{ms} = \frac{const}{p_t}$

$$\Rightarrow \sigma^2_{d'_{ca}} = \sigma^2_{d'_{ca}}(p_t) = \sigma^2_{d'_{ca}}(\infty) + \left(\frac{const}{p_t}\right)^2$$



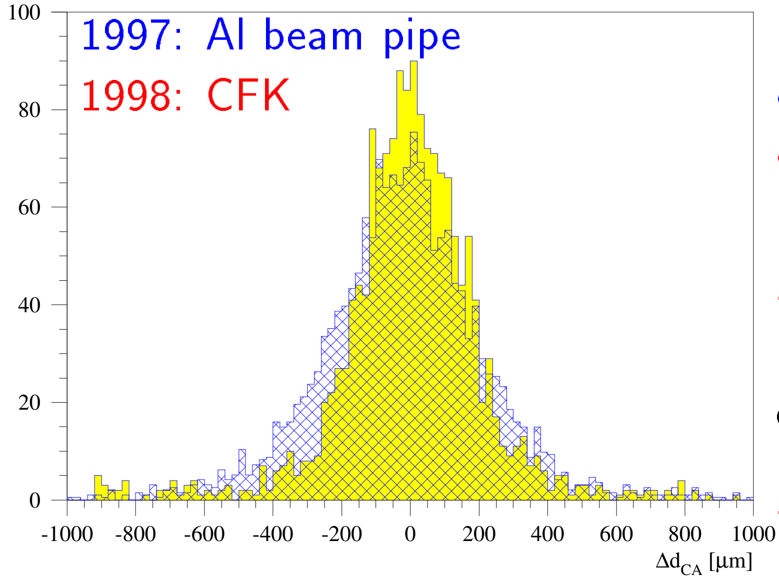
CJC: $\sigma^2_{d'_{ca}} = 400^2 + \left(\frac{630}{p_t}\right)^2 \ \mu m^2$

CST: $\sigma^2_{d'_{ca}} = 76^2 + \left(\frac{121}{p_t}\right)^2 \ \mu m^2$ (beam spot not unfolded)

1997 ep data, d'_{ca} to CST run vertex, CJC: l_{track} >55 cm,
CST: $|z_{vertex}| <$ 20 cm, horizontal tracks

CFK Beam Pipe

impact parameter resolution in 1997 and 1998 cosmics



$0.5\ GeV/c\ <\ p_t\ <\ 1.0\ GeV/c$

multiple scattering dominates

measure:

$\sigma(97) = 183\mu m$

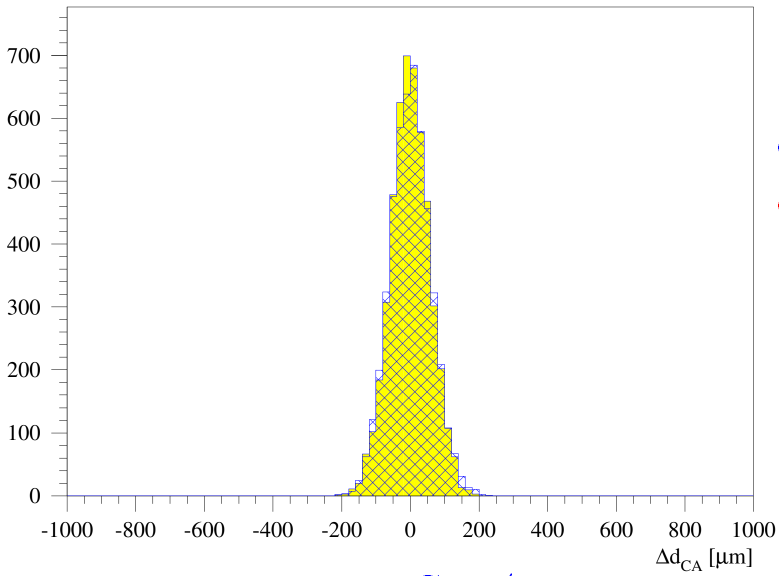
$\sigma(98) = 140\mu m$

measured ratio:

$$\frac{\sigma(97)}{\sigma(98)} = 1.36 \pm 0.04$$

expect ratio (MS):

$$\frac{\sigma(97)}{\sigma(98)} = 1.33$$



$p_t\ >\ 6.0\ GeV/c$

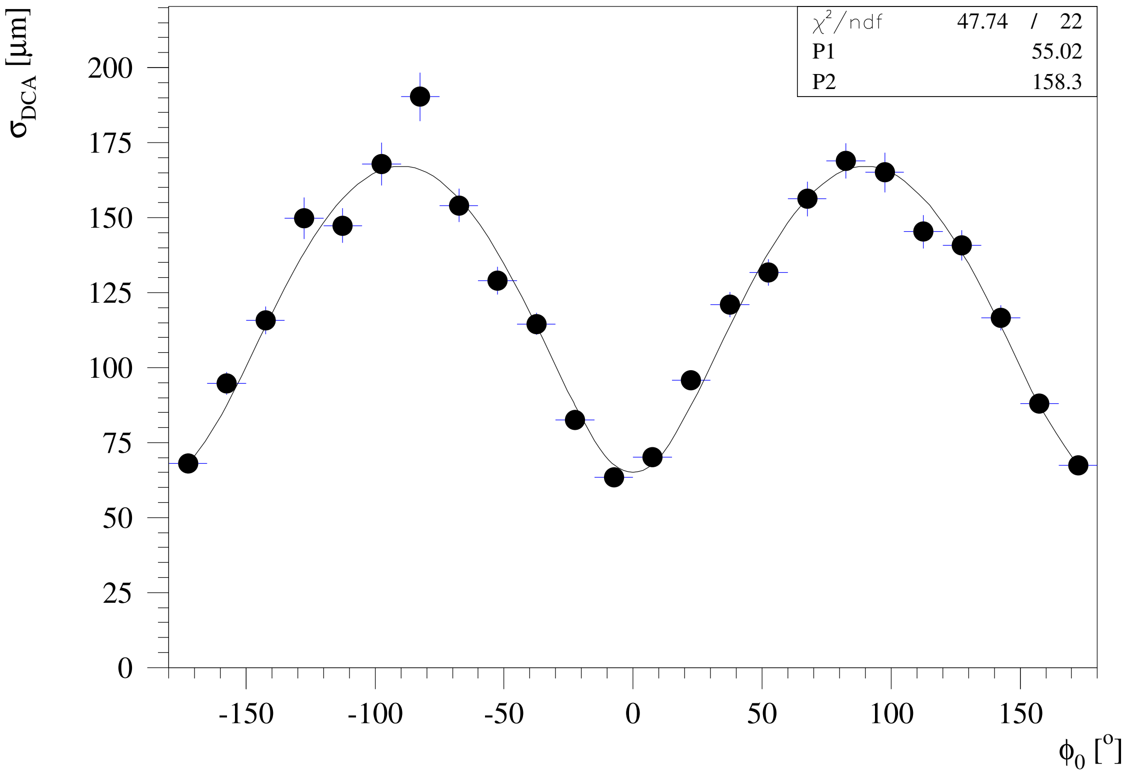
intrinsic CST resolution

measure:

$\sigma(97) = 59\mu m$

$\sigma(98) = 57\mu m$

Measure the Beam Spot 1997



(d'_{ca} to CST run vertex, $p_t > 4$ GeV/c)

parameters: $\sigma_{beam}(x)$, $\sigma_{beam}(y)$, σ_{track}

can fit only 2 (offset and amplitude)

$\Rightarrow$ fix $\frac{\sigma_{beam}(x)}{\sigma_{beam}(y)} = 5$ (well known machine parameter)

result in agreement with HERA beam scan:

$\sigma_{beam}(x) = 158\ \mu m \Rightarrow \sigma_{beam}(y) = 32\ \mu m$

CST track resolution $\sigma_{track} = 55\ \mu m$

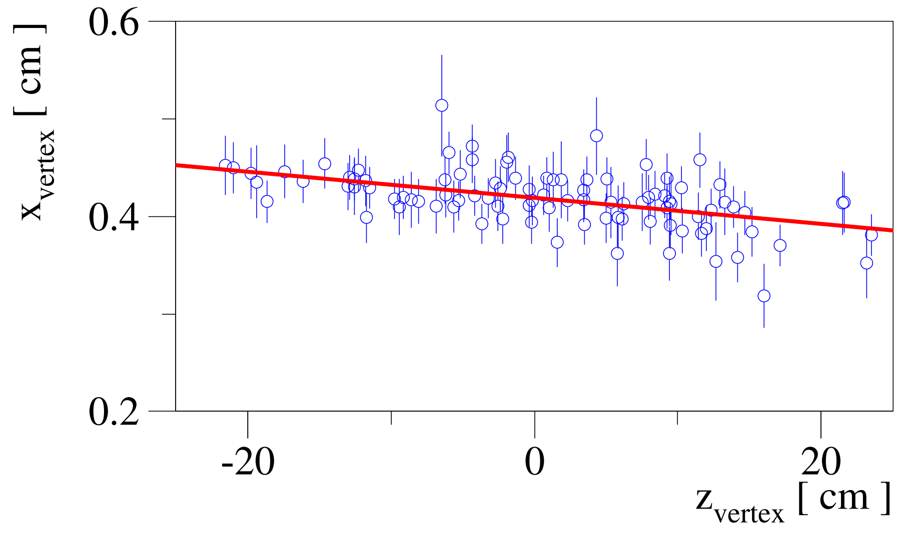
CST Run Vertex

problem of CJC run vertex:

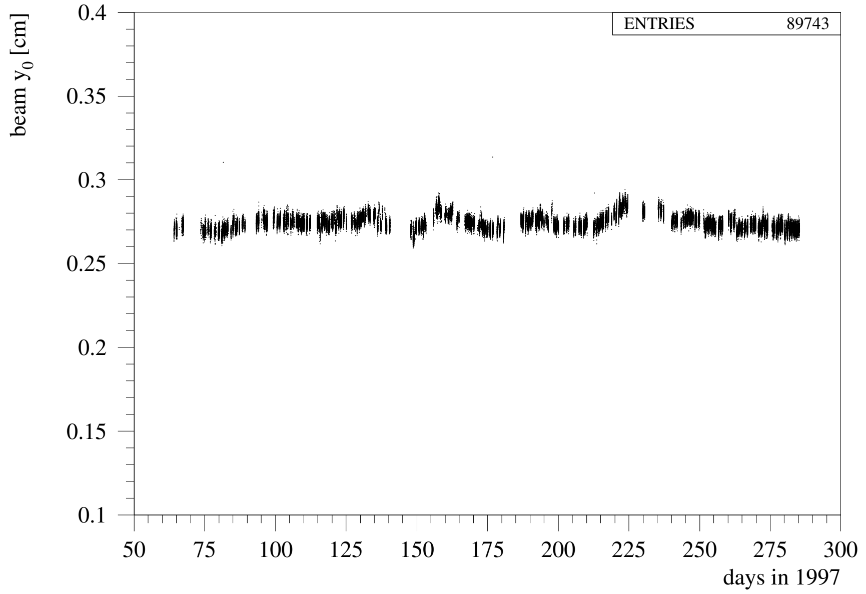
- needs a lot of statistics $\Rightarrow$ fails in short H1 runs
- only average in long H1 runs

short term CST run vertex:

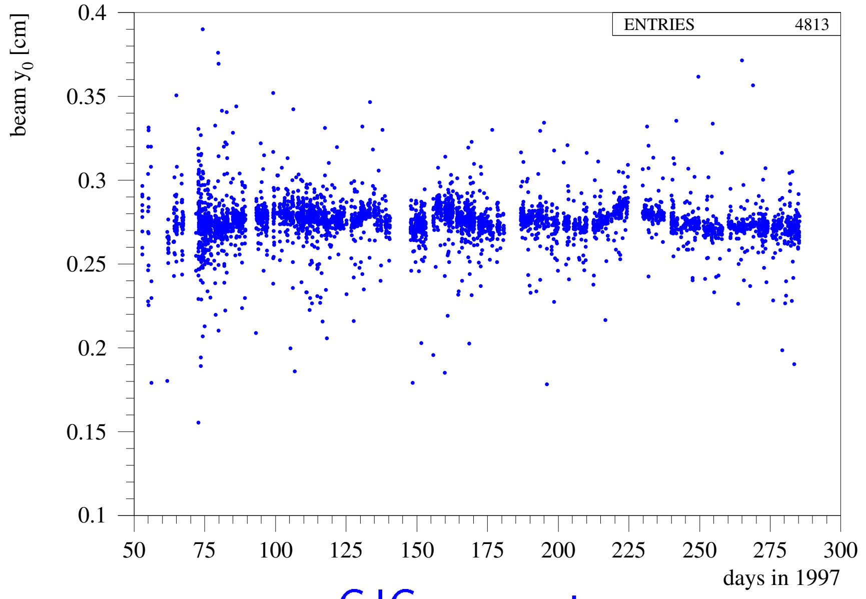
- fit event vertices with CST tracks
- collect vertices of several events
  (100 vertices are enough to resolve beam spot)
- fit beam line into event vertices
  $\Rightarrow$ beam offset (x_0, y_0) and beam tilt (α_x, α_y)



CST and CJC Run Vertex



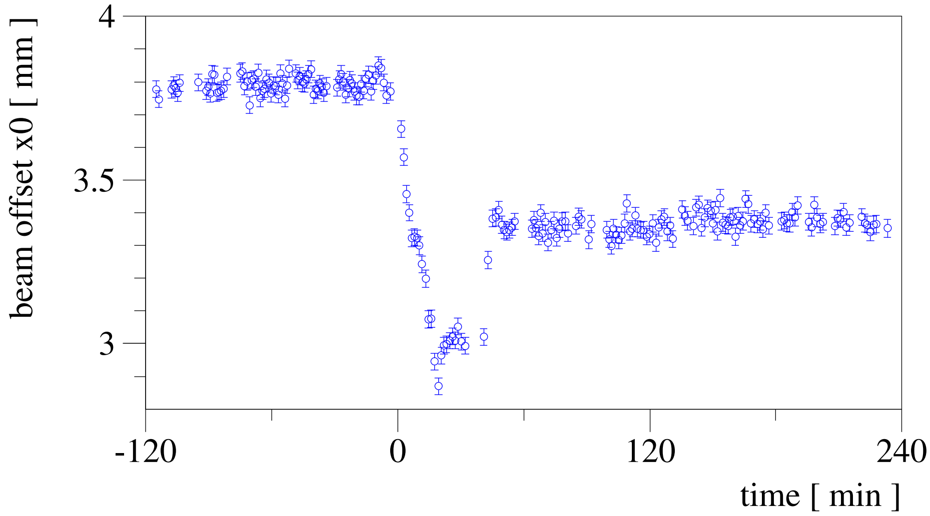
CST short-term run vertex

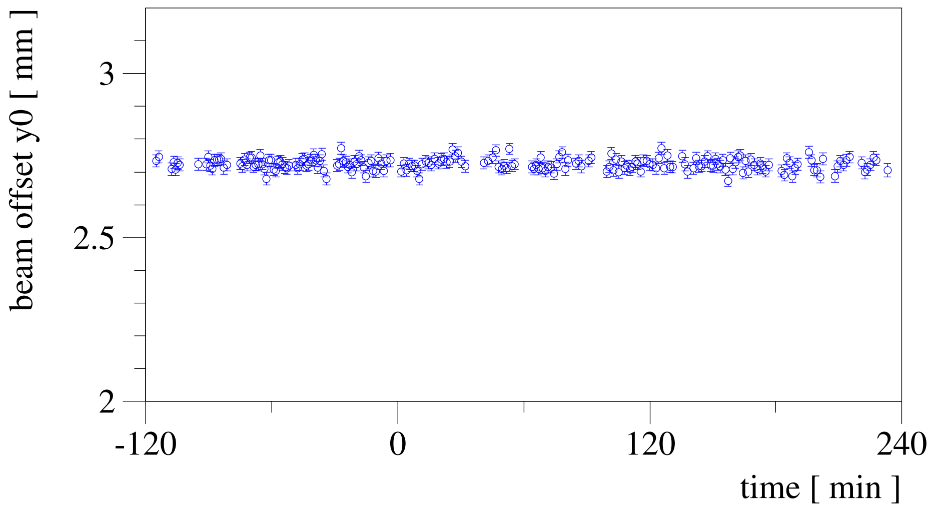


CJC run vertex

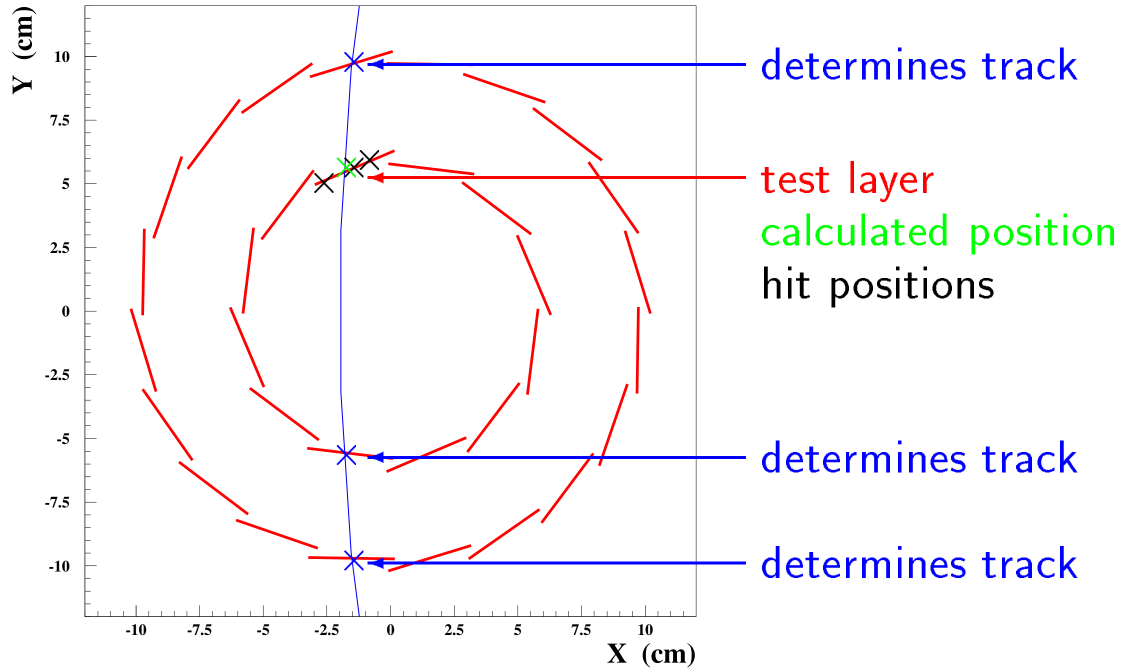
HERA Beam Movements

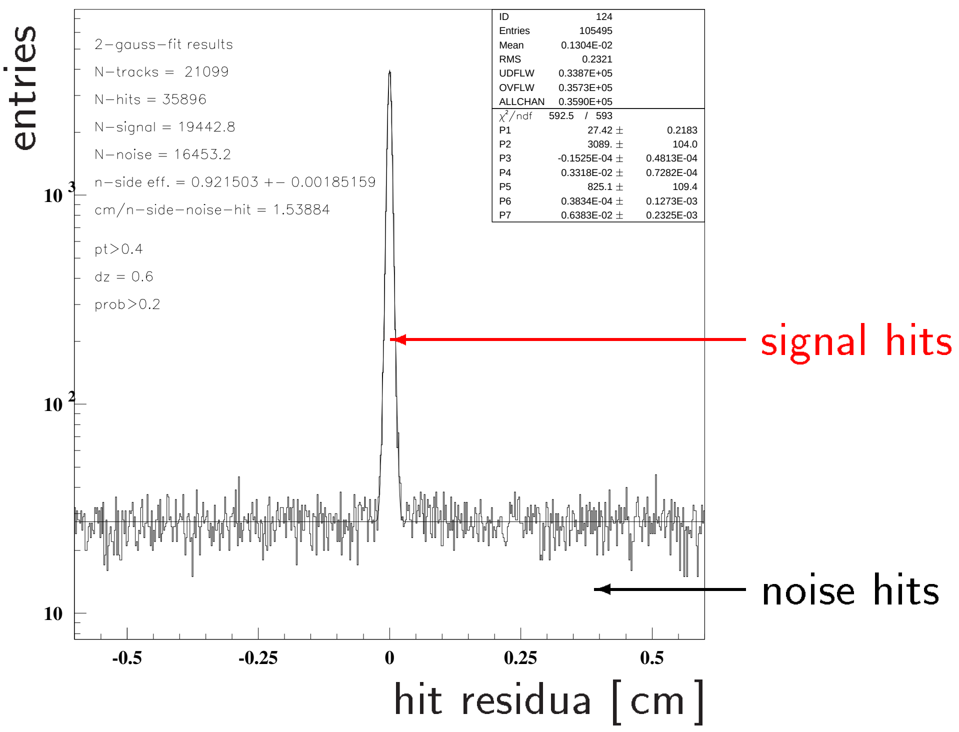
HERA beam steering with fully operational H1 detector:
beam is moved about 1 mm in x-direction, stable in y-direction



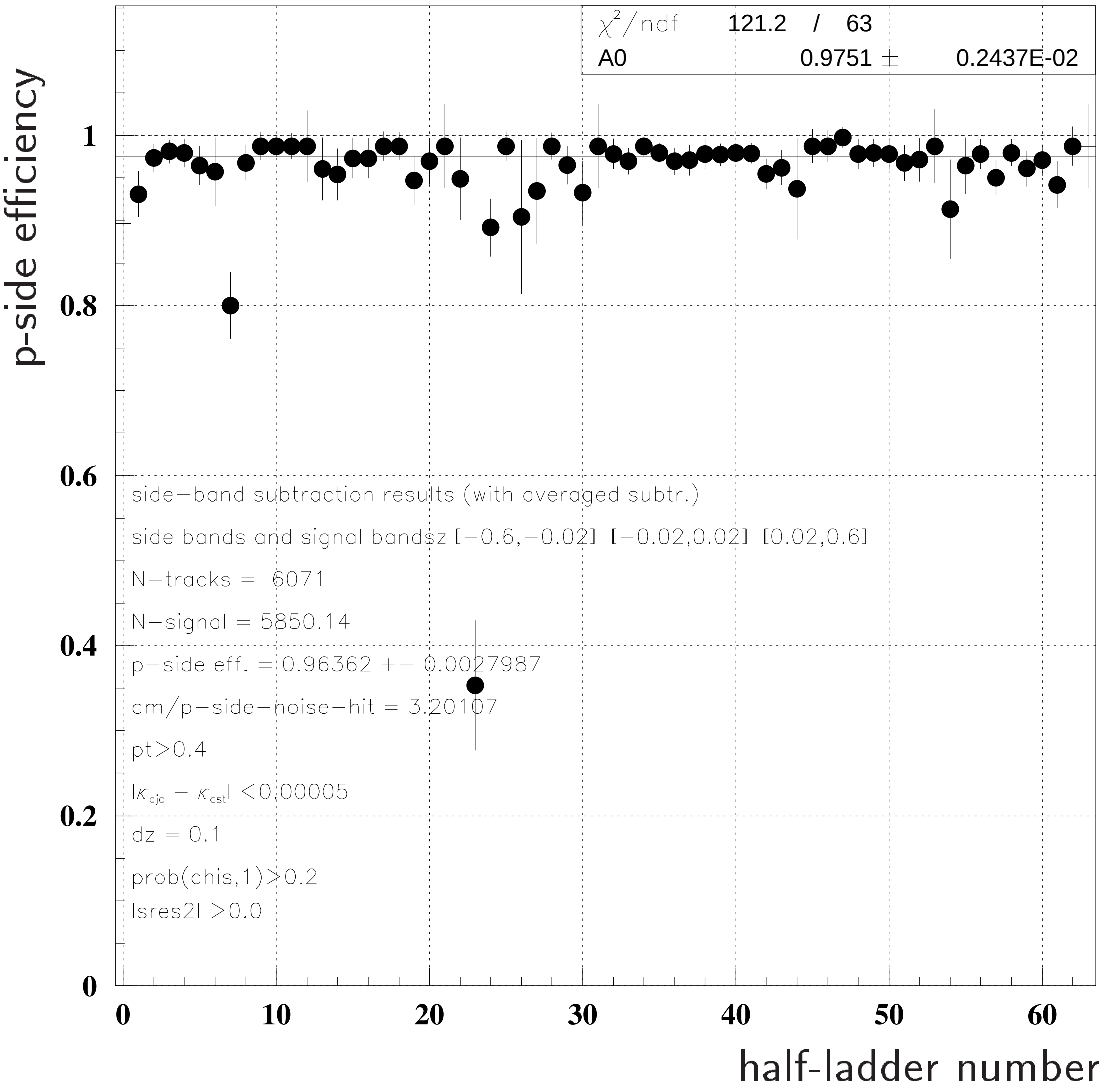


Efficiency from Cosmics





Hit Efficiencies



	mean efficiency	good half-ladders
p-side	96.4 %	∼ 98 %
n-side	92.2 %	∼ 93 %

Physics with CST

physical process studied (by T.Kuhr, O.Behnke):

$$\begin{aligned} D^{*+} \; &\longrightarrow \; D^o \, \pi_s^+ \\ &\qquad \longrightarrow K^- \, \pi^+ \end{aligned}$$

study CST improved mass resolution:

- $D^{*\pm} \rightarrow D^o \pi_s$ is a strong decay
  $\Rightarrow$ production point $=$ decay point $\approx$ CST run vertex

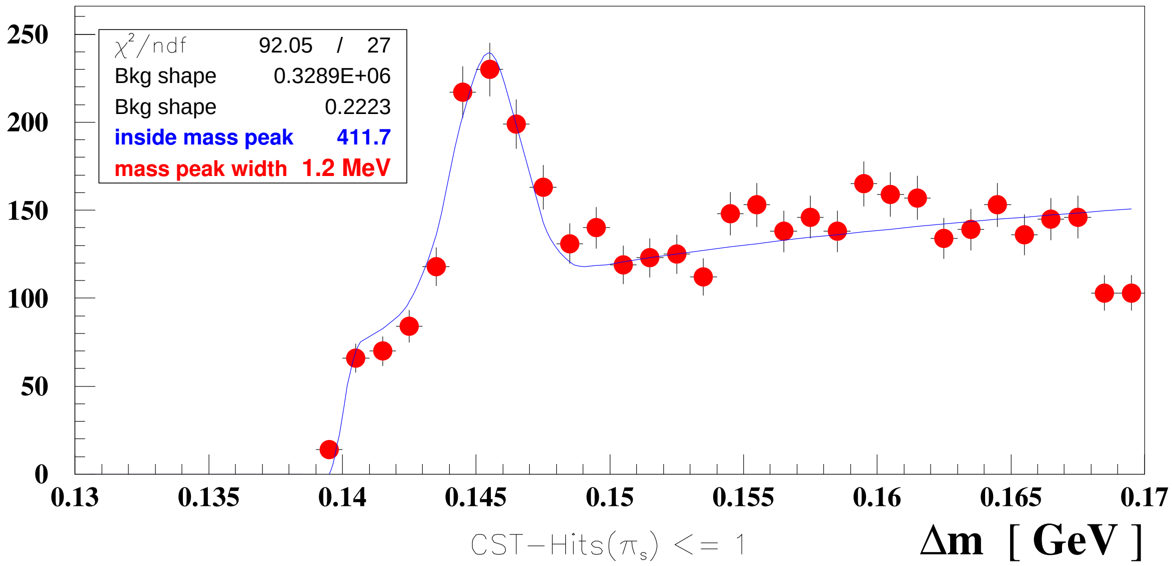
- reconstruct D^o decay point ($=$ secondary vertex)
  with tracks of Kaon and Pion

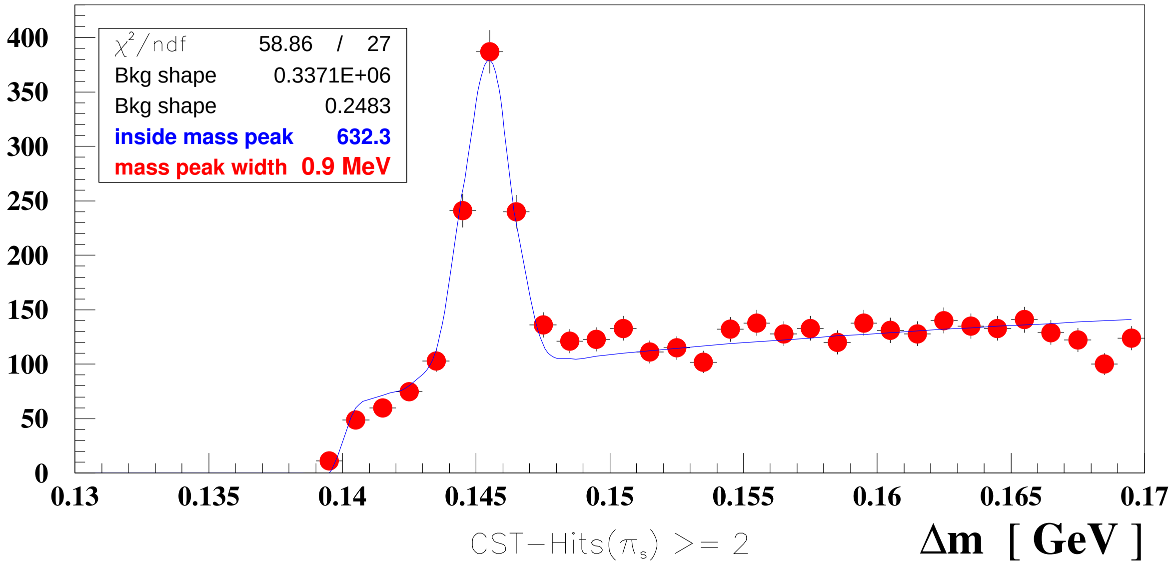
- fit tracks to vertices (improves tracks),
  ask for momentum direction $\vec{p}(D^o) \; || \; \vec{\ell}$ flight direction

- measure mass and massdifference:

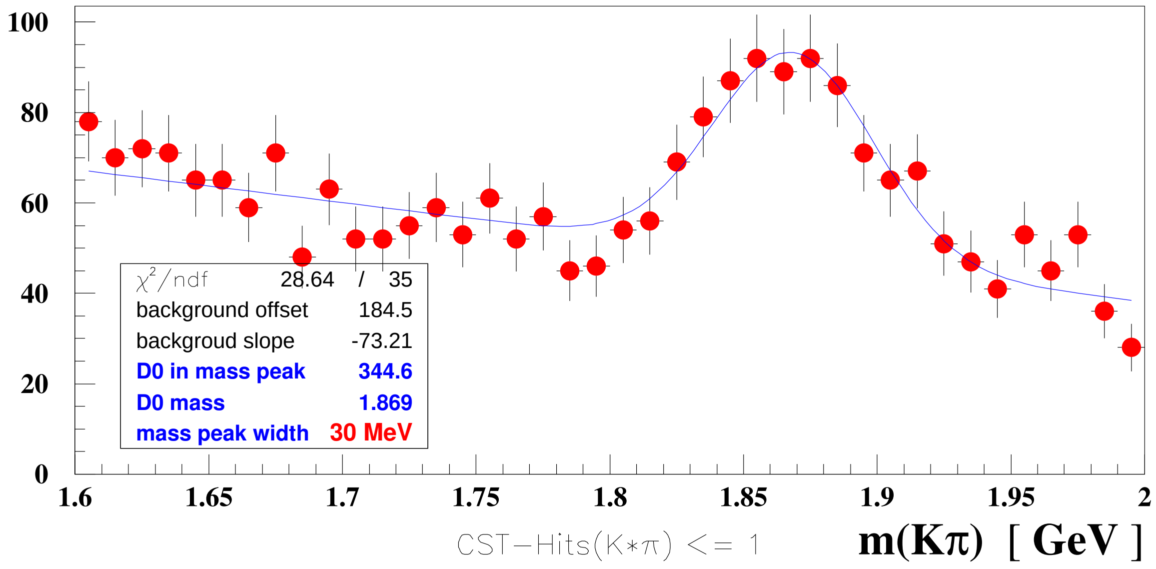
$$\begin{aligned} m(D^o) \quad &= m(K\pi) \\ \Delta m \quad &= m(K\pi\pi_s) - m(K\pi) \end{aligned}$$

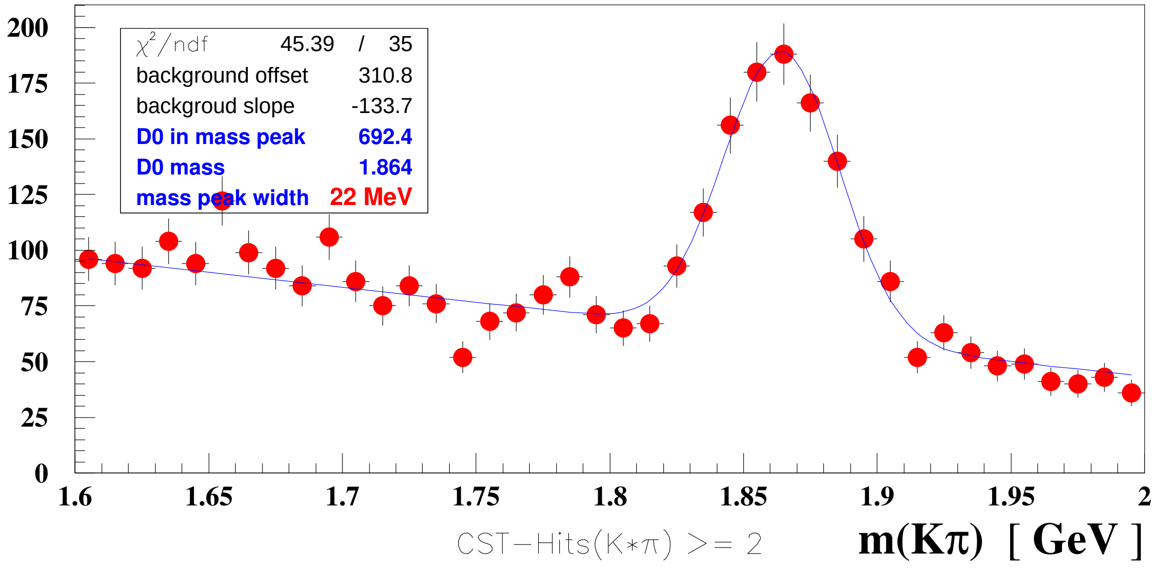
Mass Resolution Δm





Mass Resolution D^o





A Lifetime Measurement

measure D^o lifetime with CST:

$\Rightarrow$ know production point (asumed as CST run vertex) and decay point (reconstructed secondary vertex) of D^o

$\Rightarrow$ can measure D^o decay length (in lab frame):
decay length $= \ell = |decay\ point - production\ point|$
projected to rΦ plane $\Rightarrow \ell_t$

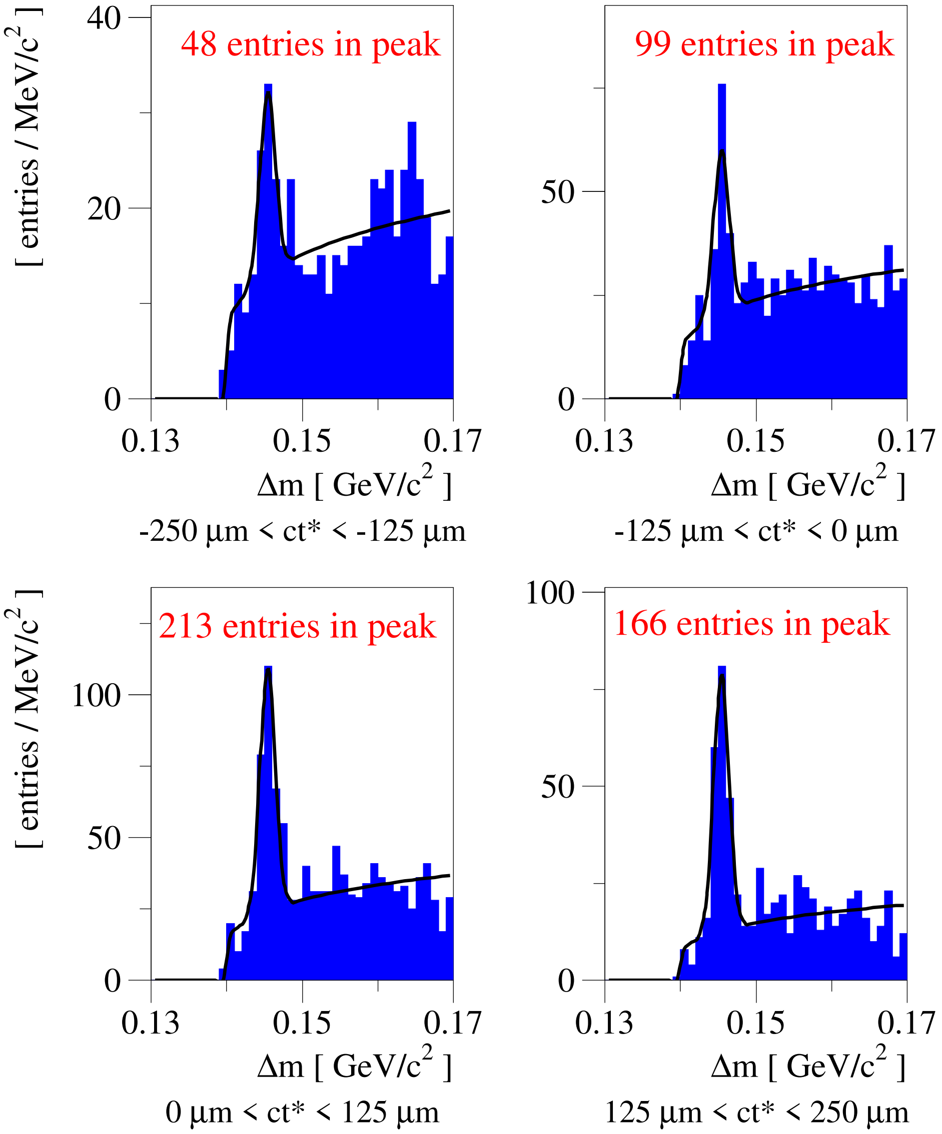
$\Rightarrow$ can extract lifetime of D^o by transforming ℓ_t to the D^o rest frame:

$$\ell^* = \frac{m(D^o) \cdot c}{p_t(D^o)} \cdot \ell_t = c \cdot t^*$$

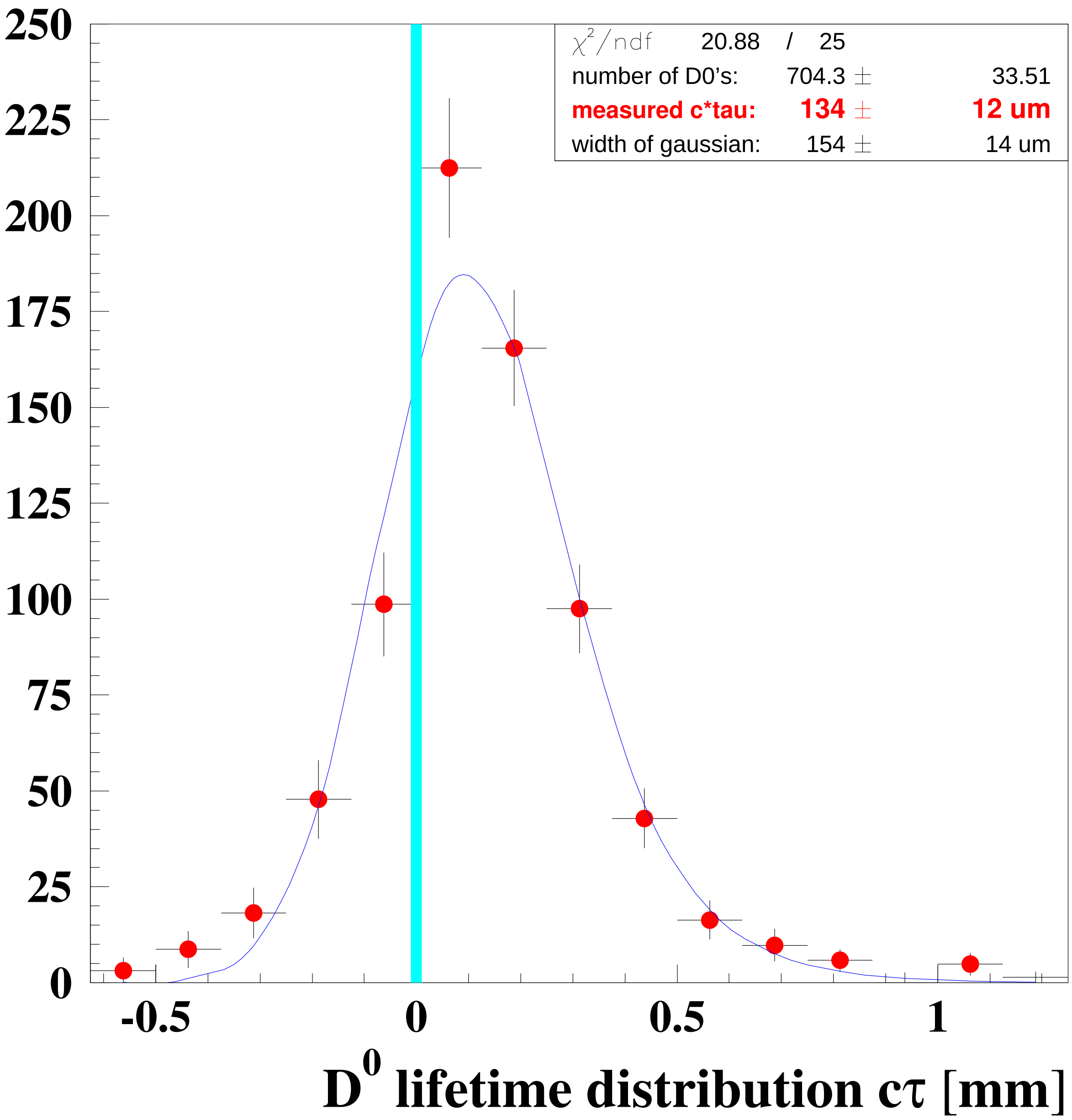
$\Rightarrow$ can measure mean D^o lifetime $\tau \;\; = < t^* >$!
(PDG98: $c \cdot \tau(D^o) = 124.4 \pm 1.2\ \mu m$)

Method of $c \cdot \tau$ Measurement

measure number of entries inside the Δm peak
in different bins of $c \cdot t^*$



$c \cdot \tau(D^o)$ Measurement



(PDG98: $c \cdot \tau(D^o) = 124.4 \pm 1.2\ \mu m$)

Summary

- Signal/Noise Ratio:

p-side:	peak =	19.4	mean =	23.6
n-side:	peak =	6.7	mean =	8.9

- Intrinsic Resolutions:
  p-side: $\sigma(\hat{x}) = 11.6\,\mu$m
  n-side: $\sigma(\hat{z}) = 23.4\,\mu$m ($\theta_{inc} = 15^o$)
- Alignment:
  stable in 1997 and precise (5-10 μm)
- Impact Parameter Resolutions:

$\sigma(d_{ca}) =$	57 μm	CFK '98	$6\ GeV/c < p_t$
	59 μm	Al '97	
	140 μm	CFK '98	$0.5 < p_t < 1.0\ GeV/c$
	183 μm	Al '97	

- Measured Beam Spot Size:
  $\sigma_{beam}(x) = 158\ \mu m$, $\sigma_{beam}(y) = 32\ \mu m$
- CST Run Vertex:
  1997 availible in database, 1999 already on L5,
  more stable than CJC, follows short term beam movements
- Hit Efficiency:

p-side:	mean	= 96.4 %	good moduls	$\sim$ 98 %
n-side:	mean	= 92.2 %	good moduls	$\sim$ 93 %