Bows and kinks with MP-II

C. Kleinwort
for the tracker alignment group

Calibration/Alignment meeting 03.08.10

Overview

- Study of sensor surface with MP
  - Surface model
  - Parametrization w(u,v)
  - First results
  - Recent results
- Cross check (TrackerOfflineValidation)
- Summary
- Remarks
- Outlook

Surface model

- ⋆ Current model
  - Each module is one flat surface
- ⋆ Extensions
  - Some (TOB, TEC) modules consists of 2 sensors: allow for misalignment between them ("kinks")
    - ✦ align on sensor instead of module level
  - Surface may deviate from flatness ("bows")
    - ✦ allow curvature (and higher orders)

Parametrization w(u,v)

- ★ Legendre polynomials L_n

$$w(u_r, v_r) = \sum_{i=0}^{N_l} \sum_{j=0}^{i} c_{ij} L_j(u_r) L_{i-j}(v_r) \qquad x_r = 2x / \mathrm{len}(x), \text{ uniform in } [-1,+1]$$

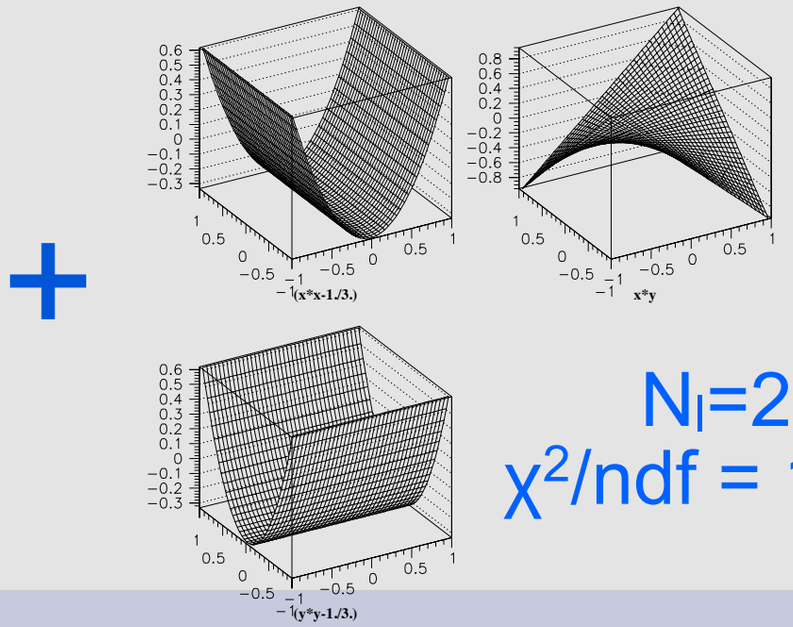
  - u, v normalized to [-1,+1] to exploit orthogonality
    - ✦ no correlations between parameters c_{ij}
    - ✦ only approximate for endcaps (sensors are trapezoids)
  - Until now: N_l=1, flat surface
  - New: N_l=2, curved surface, sagitta

$$S_u = \tfrac{3}{2} c_{22}, S_v = \tfrac{3}{2} c_{20}$$

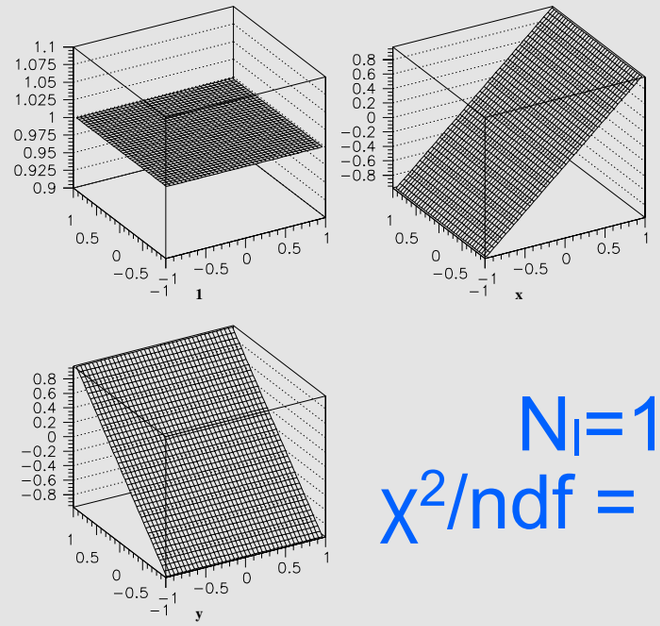
- ★ MP fits tan(α)·w(u_r,v_r) to u (and v) residuals
  - (N_l+1)(N_l+2)/2 parameters [length] per alignable

First results - N_l

- ★ CRAFT09 data
  - Barrel **modules**
  - 200k tracks
  - N_l=2 sufficient

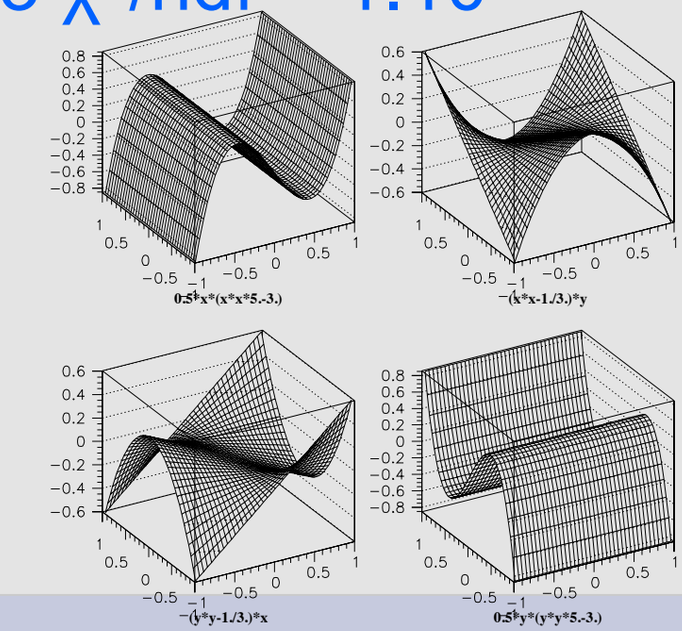


N_l=2
χ^2/ndf = 1.12

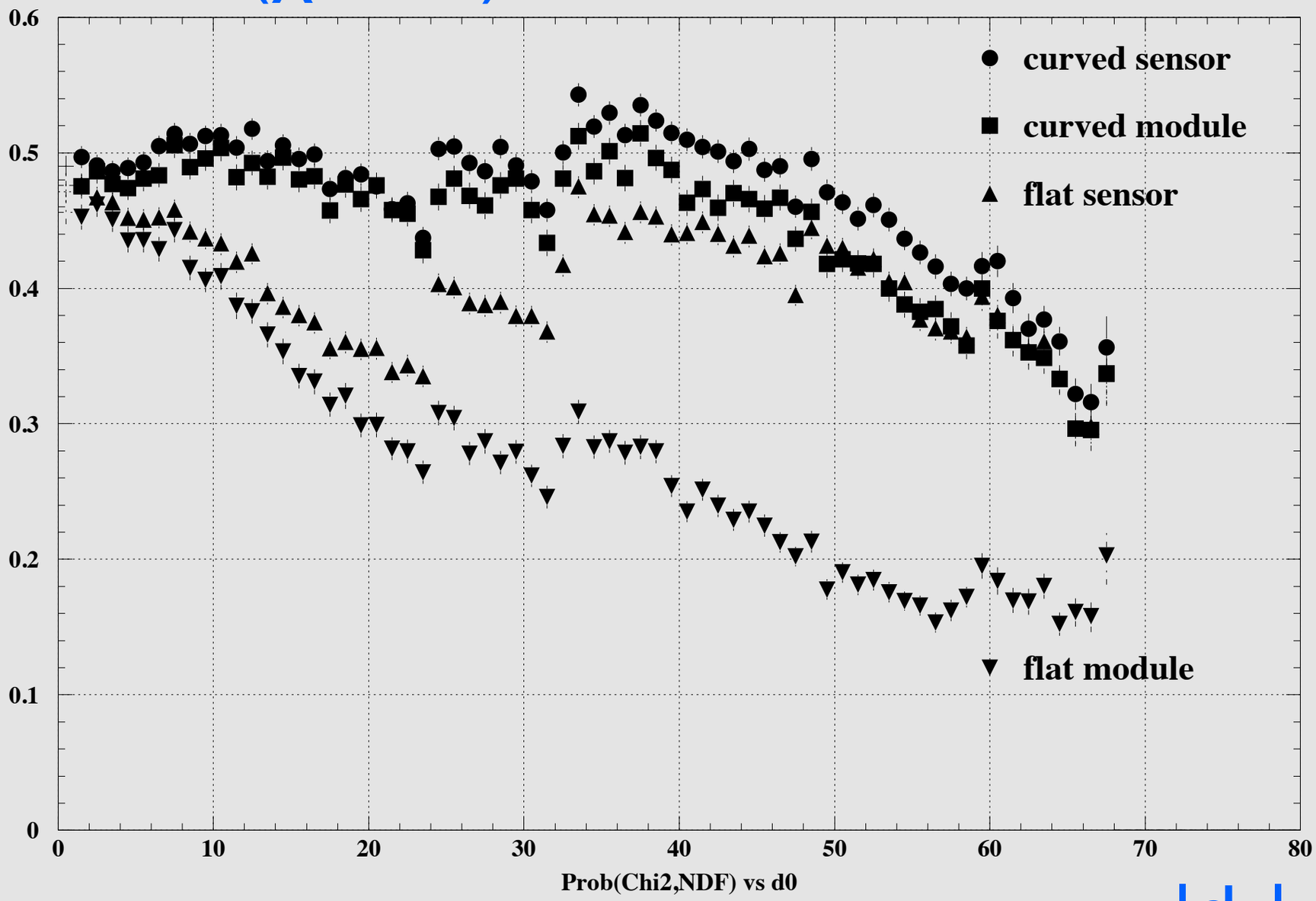


N_l=1
χ^2/ndf = 1.44

N_l=3 χ^2/ndf = 1.10



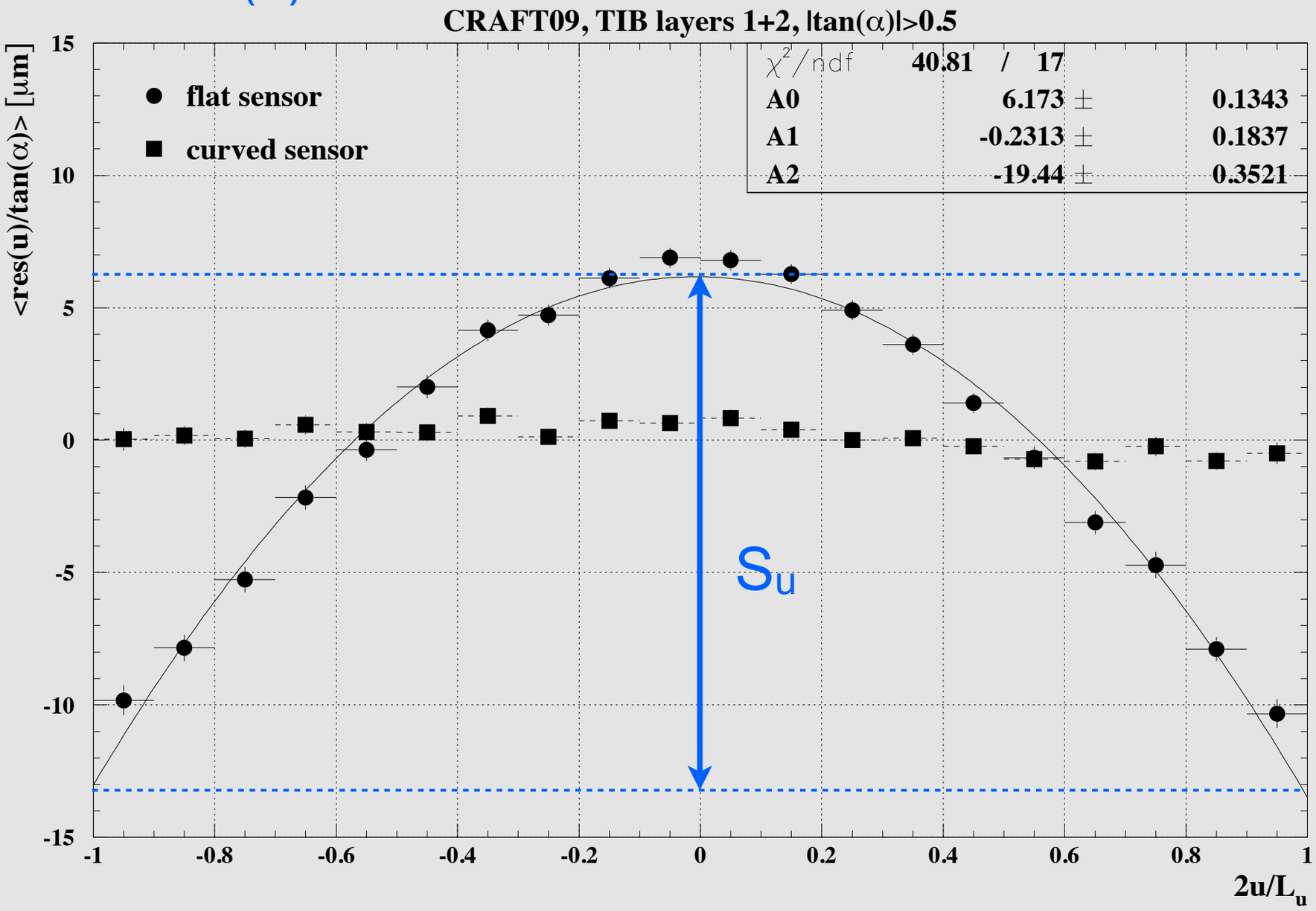
First results - track fit



χ^2/ndf
1.09
1.12
1.22
1.44

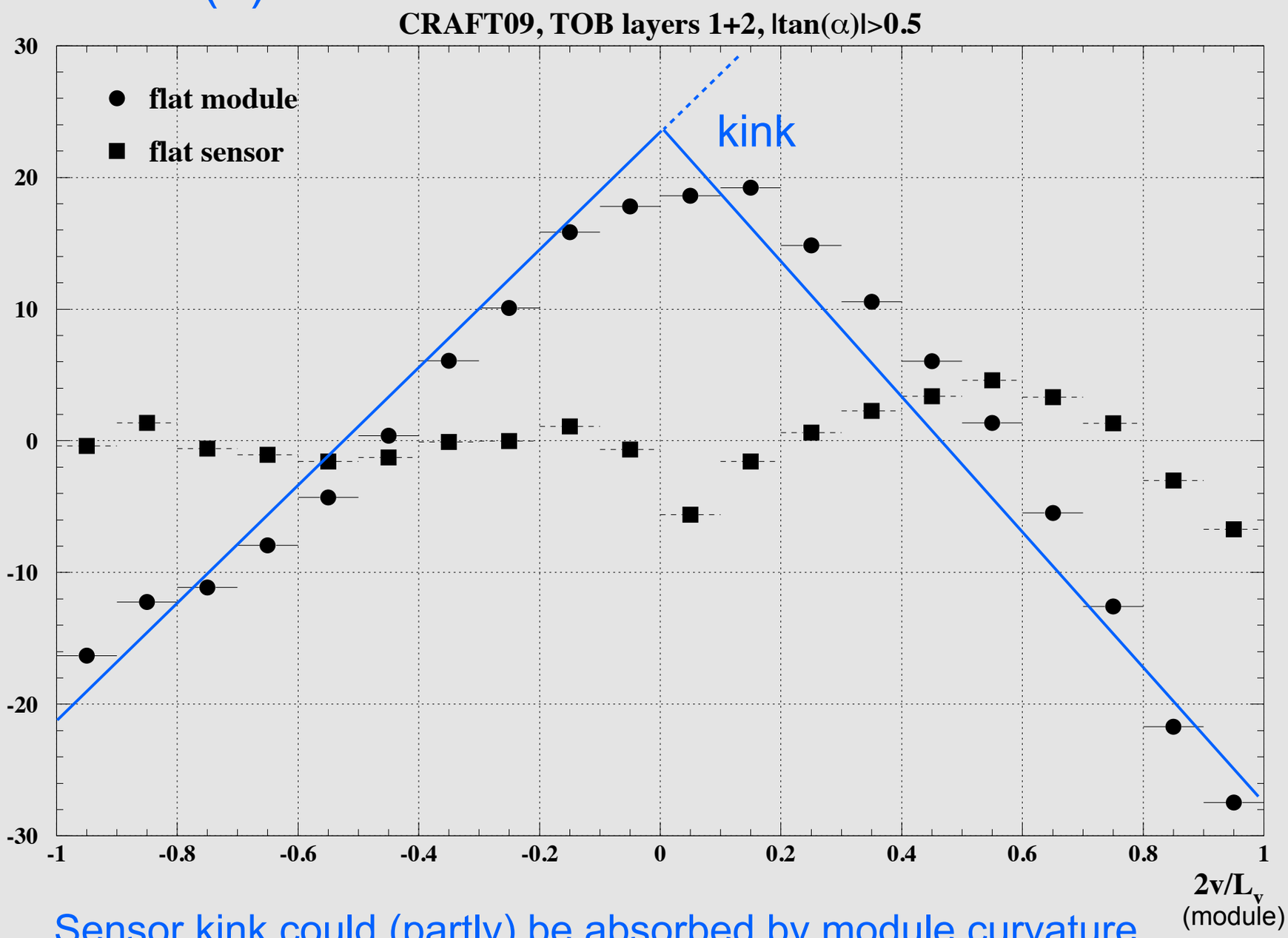
First results - TIB: Δw vs u_r

Δw=Δu/tan(α)



First results - TOB: Δw vs v_r

Δw=Δu/tan(α)



Sensor kink could (partly) be absorbed by module curvature

Recent results (F.Meier)

"Kinks and bows" with MinBias and Cosmics (2010 data)

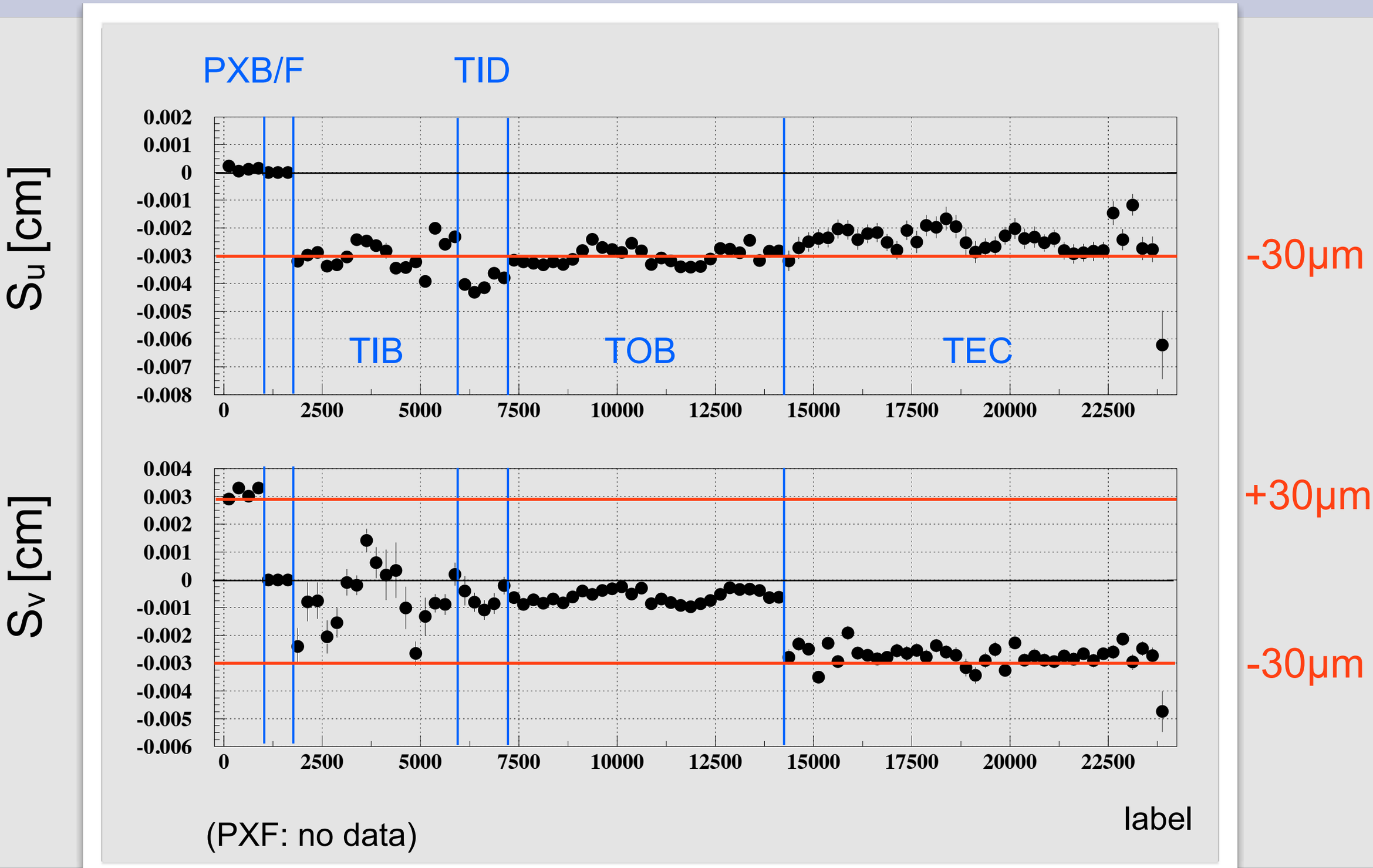
(MP-II feels well with 24GB memory and 8 cores, available at PSI)

Result overview:

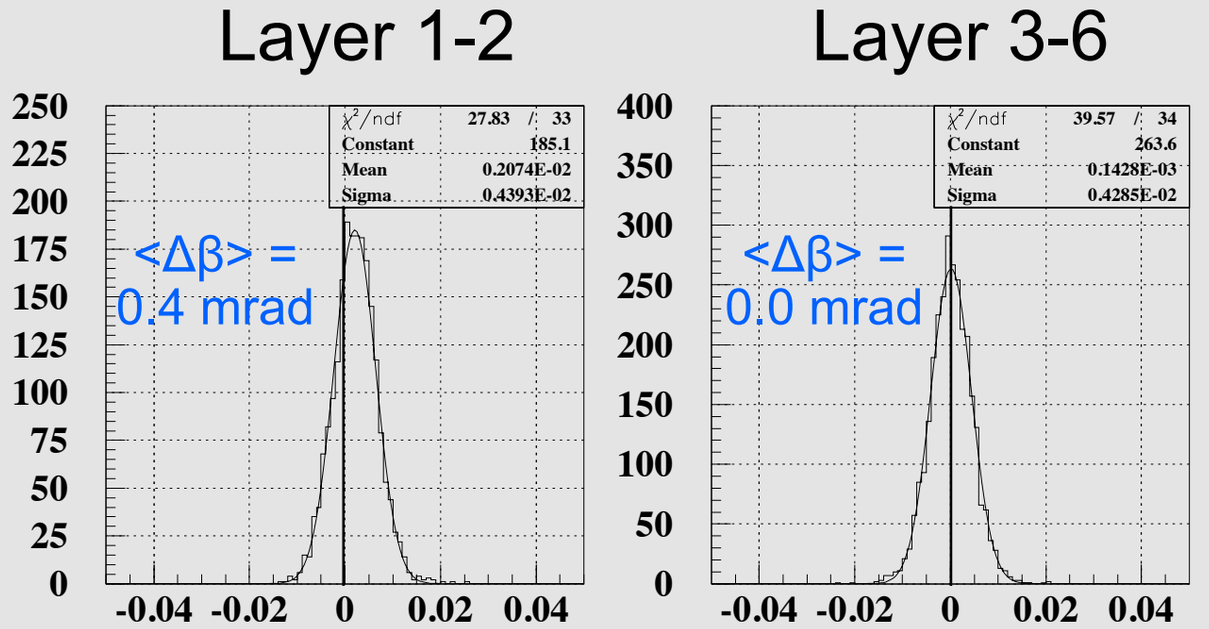
	Cosmics	Cosmics + MinBias
no. of tracks (NREC)	1 821 564	4 602 703
no. of parameters	198 044	198 153
wall-clock time	4.9 h	8.6 h
CPU time	15.3 h	22.3 h
– parallelization gain	3.1×	2.6×
memory used	17.81 GB	18.47 GB
# used off-diagonal elements	3 900 828 711	3 980 108 625
frac. non-zero o.d. el.	20.04 %	20.37 %
compr. ratio for o.d. el	37.91 %	38.53 %
$\chi^2/ndof$	1.103	0.995
rejected tracks (last it.)	8.96%	6.28%

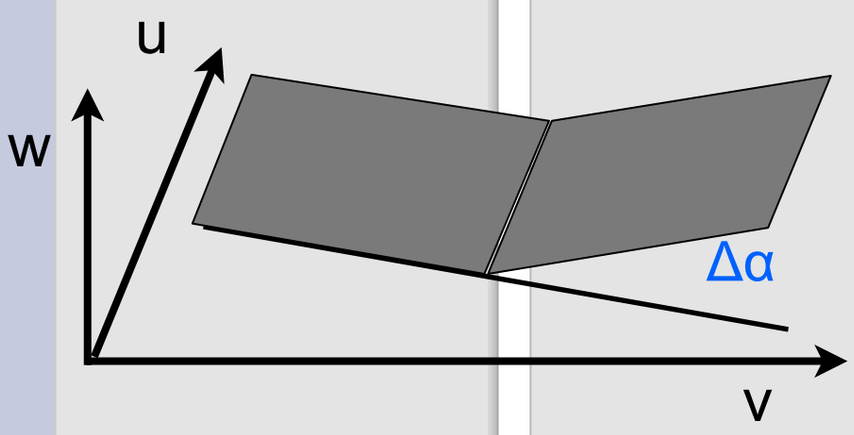
Bows

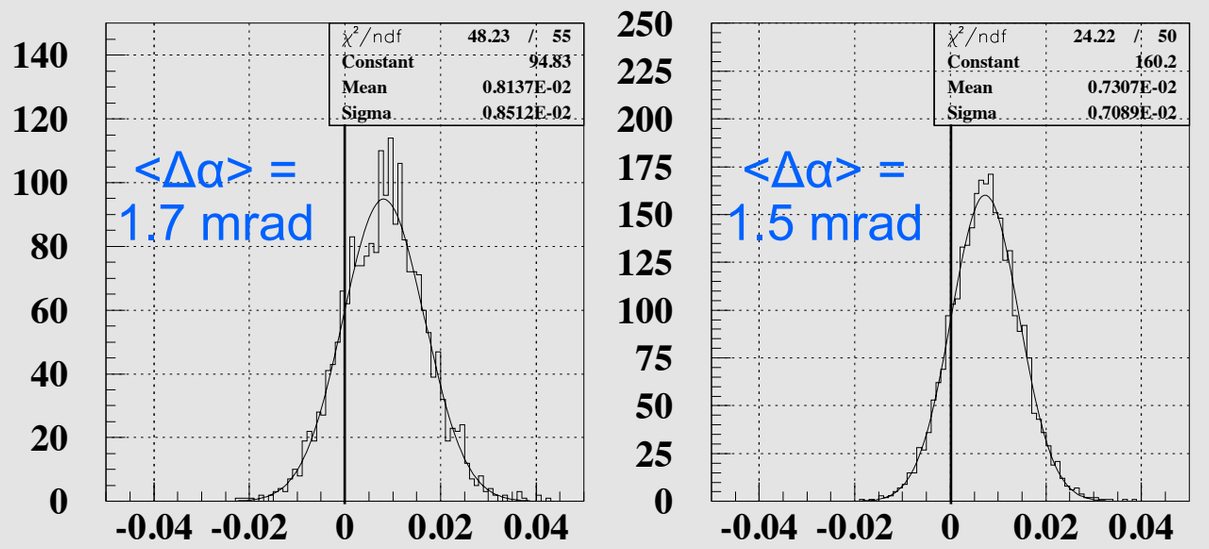
$$\Delta w(x) = S_x((\frac{2x}{L})^2 - \frac{1}{3})$$



Kinks - TOB







Difference Δc_{1j} between the 2 sensors of a module = kink·L_{sens}/2

Cross check (I)

Excerpts from

BOWS AND KINKS IN TIB AND TOB FROM RESIDUALS

ERNESTO MIGLIORE
UNIVERSITÀ DI TORINO/INFN

TProfiles for residuals vs local coordinate added in **TrackerOfflineValidation.cc** to exploit the settings of the commonValidation area

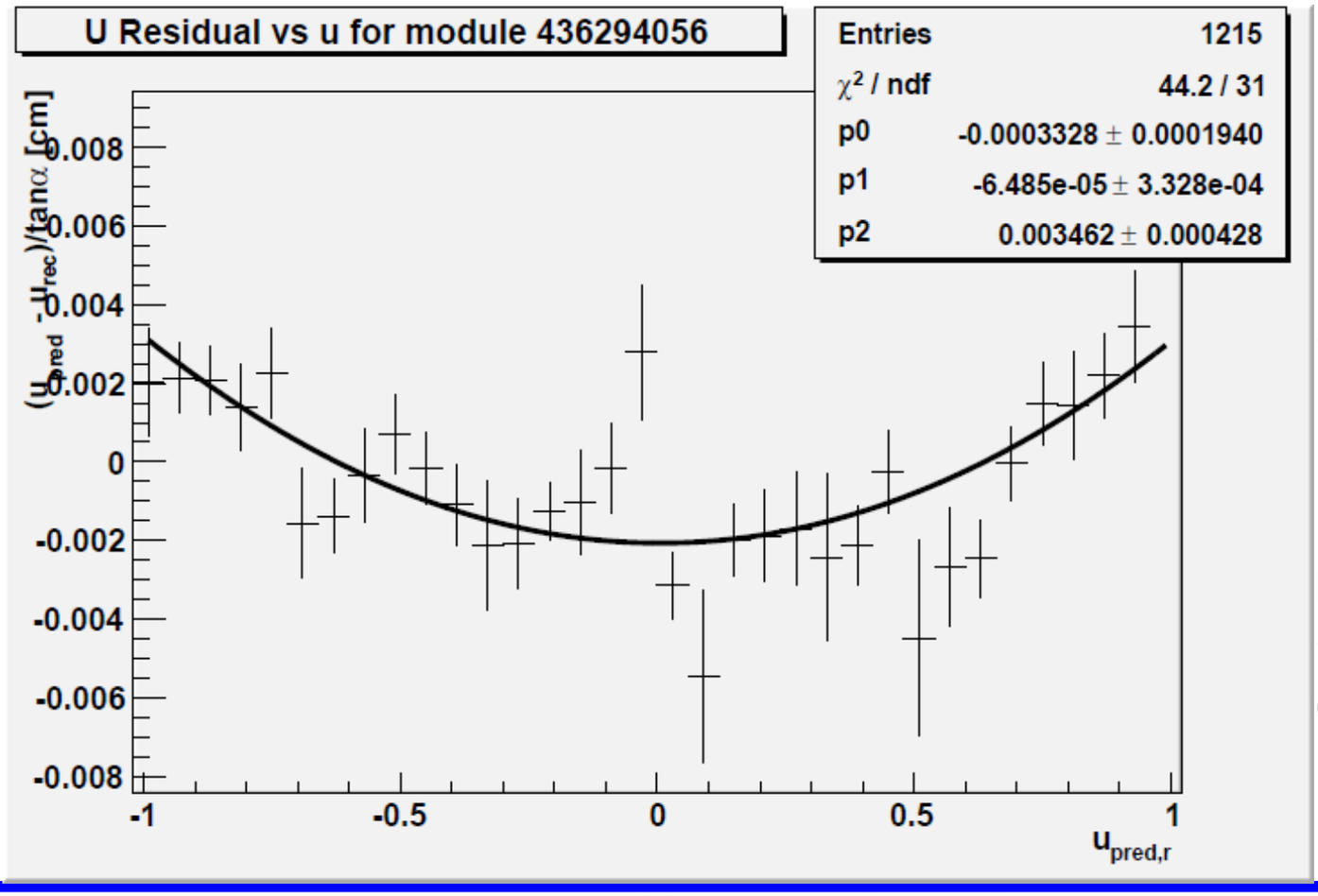
http://indico.cern.ch/getFile.py/access?sessionId=4&resId=0&materialId=0&confId=82610

Cross check (II)

Residuals vs u-local

- $\Delta w=(u_{pred}-u_{rec})/tg\alpha$ vs u_r
  - filled only for hits with abs(tgα)>0.5
  - fit with Legendre polynomials $\Delta w=p_0L_0(u_r)+p_1L_1(u_r)+p_2L_2(u_r)$ [bows]

TOB L5



Sagitta:

$$S_u=3/2*p_2$$

NB: not an alignment job → p_0 and p_1 can be different from zero

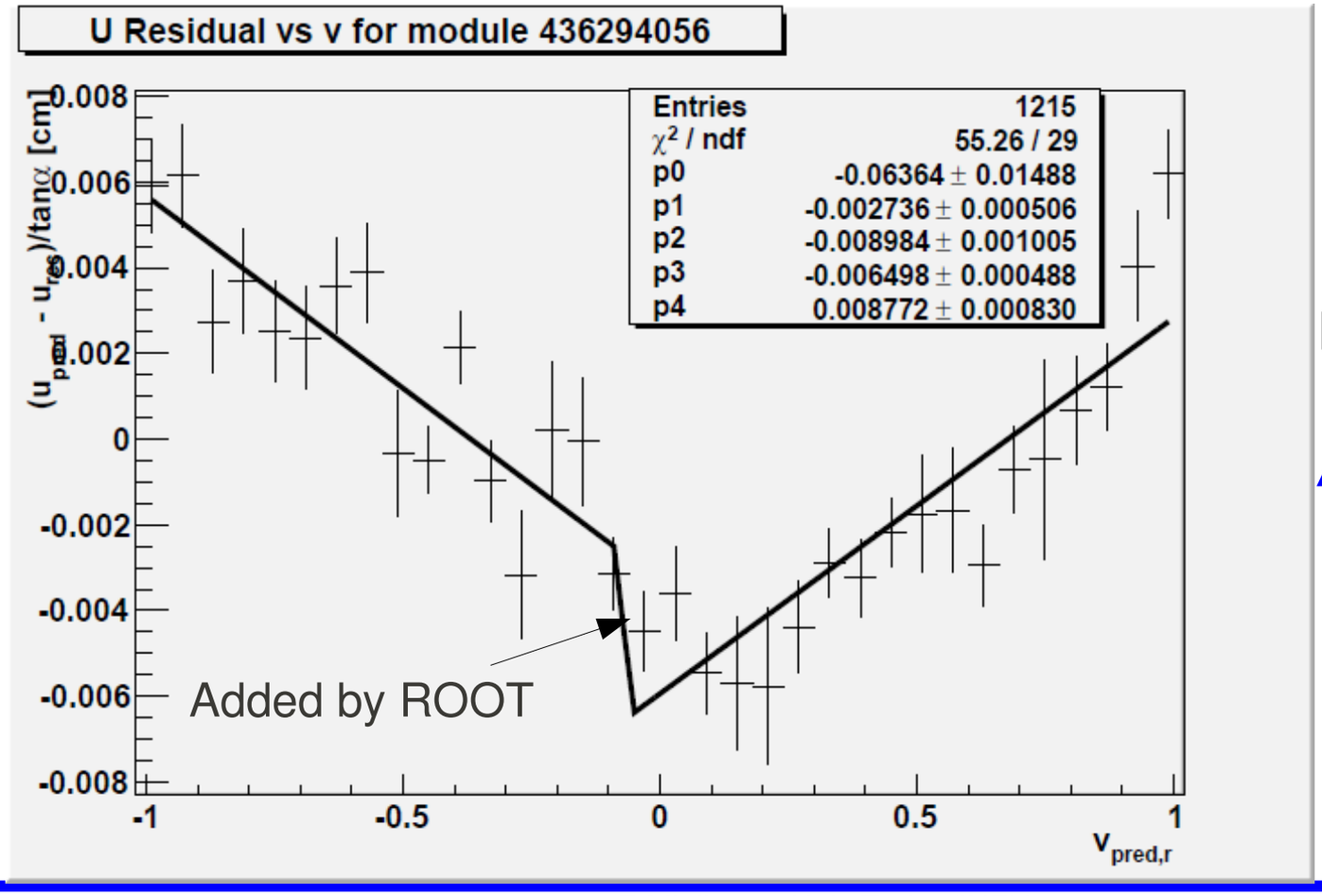
Cross check (III)

Residuals vs v-local

- $\Delta w=(u_{pred}-u_{rec})/tg\alpha$ vs v_r
  - filled only for hits with abs(tgα)>0.5
  - fit with piecewise line function $\Delta w=p_1+p_2(v_r-p_0)$ [kinks]

$$\Delta w=p_3+p_4(v_r-p_0)$$

TOB L5



Kink:

$\Delta\alpha = 2/L_v*(p_4-p_2)$

Summary

- ★ Proper χ^2 for alignment with cosmics requires
  - Curved sensors as alignables
    - ✦ 200k par. (24244*8) instead of 75k (15148*5) for SST
    - ✦ Allmost all sensors show some sagitta of typically 30µm
    - ✦ TOB modules show kink between sensors of about 1.6mrad

- ★ Cosmics at $|d_0|$>50cm still have some problems
  - Hit (CPE) error correct at those extreme angles?

Remarks

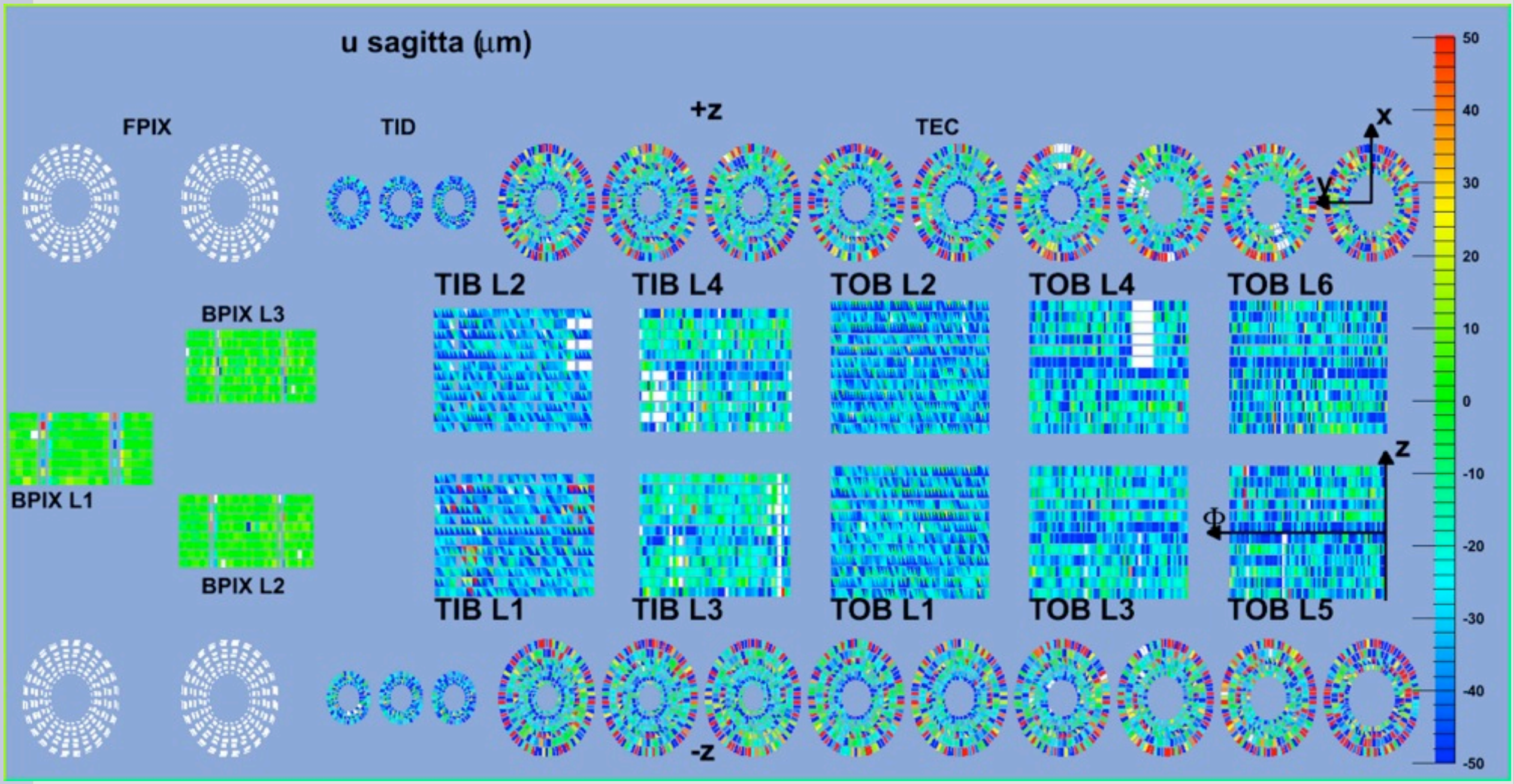
- ★ Track angle coverage ($\Delta u \sim \tan a \, \Delta w$)
  - Straight tracks from interaction point
    - Angles up to 80° (end of innermost PXB layer, tan(a)=6!)
  - Different sets of tracks cover different domains
    - high/low momentum (from i.p.)
    - tracks from displaced vertices (decays, conversions, ..)
    - cosmics, ..
  - Alignment without curvature would mean:
    - Δw absorbed differently in other alignment parameters
    - ➜ different alignments produced for different data sets

Outlook

- Extensions needed to exploit "bows" and "kinks" in CMS tracking
  - "bows"
    - 3 new (curvature) parameters per alignable
    - use curved detector surfaces in tracking (expanded locally into planes?)
  - "kinks"
    - extend hierarchy structure by introducing sensors as new lowest level (new DetID's?)

Backup

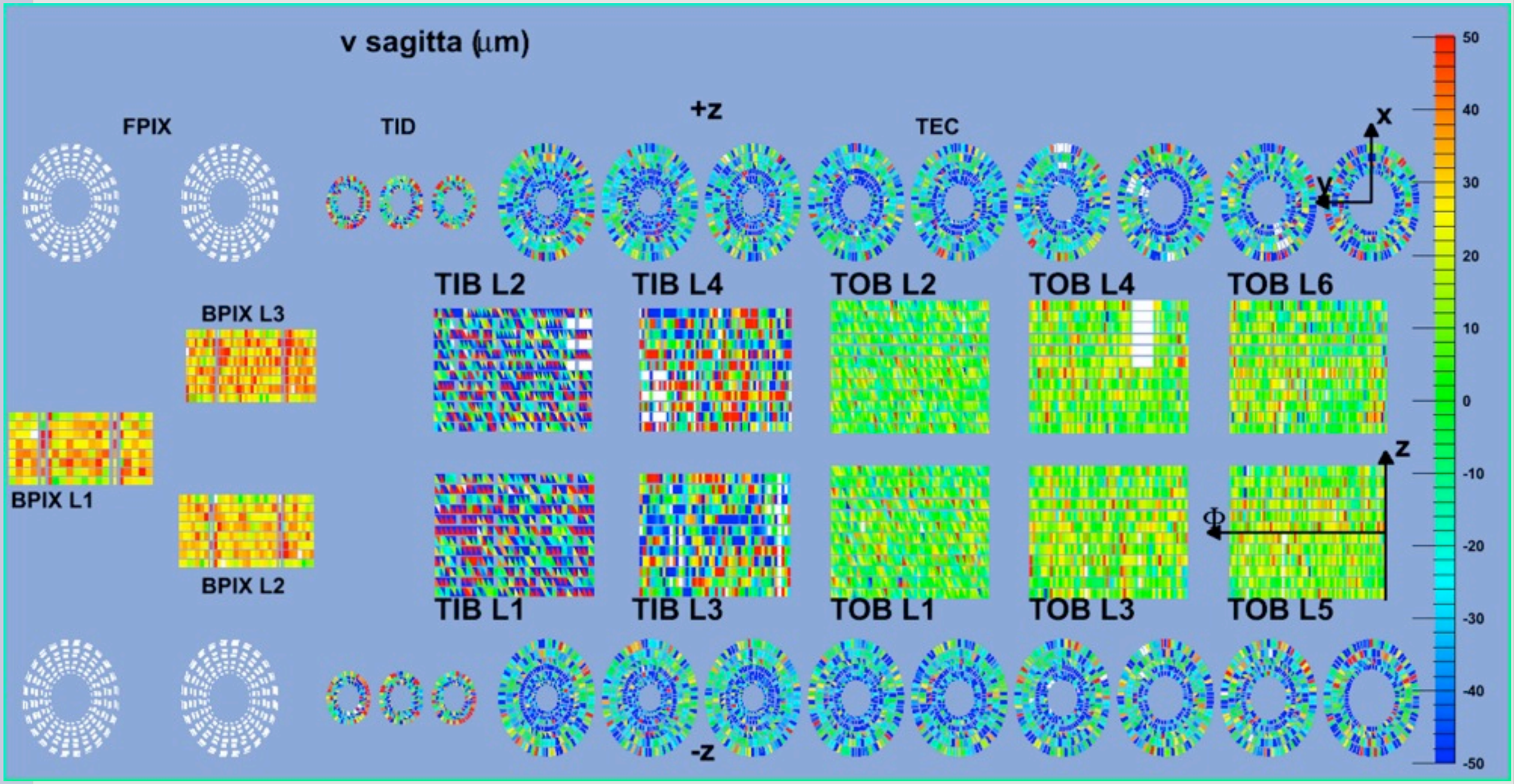
Tracker map - S_u



Significant sagittas vs u for TIB, TOB, TID, TEC

Web page

Tracker map - S_v

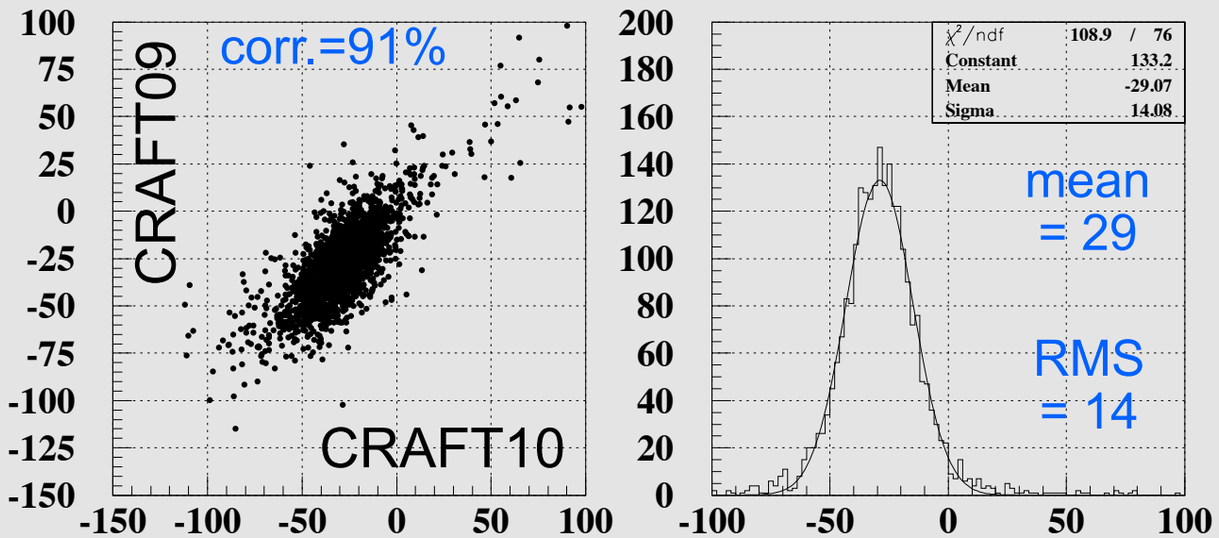


Significant sagittas vs v for PXB, TEC

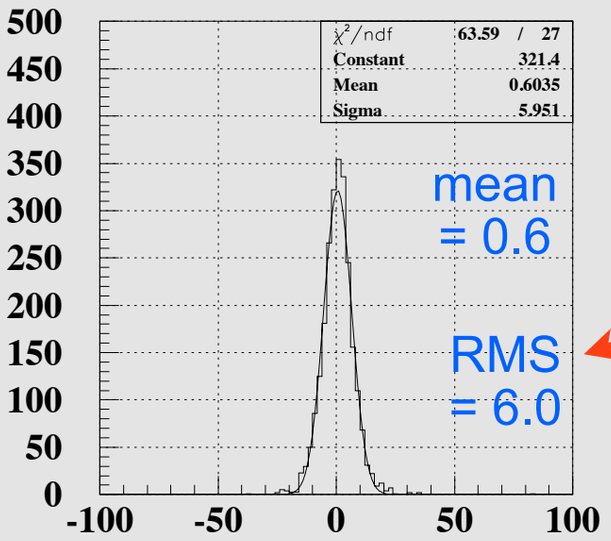
Web page

CRAFT09 vs CRAFT10

TIB, S_u [μm]



(CRAFT09+CRAFT10)/2



(CRAFT09-CRAFT10)/2

CRAFT09 200k tracks
stat.err. ≤ 12μm

CRAFT10 1800k tracks
➜ stat.err. ≤ 4μm