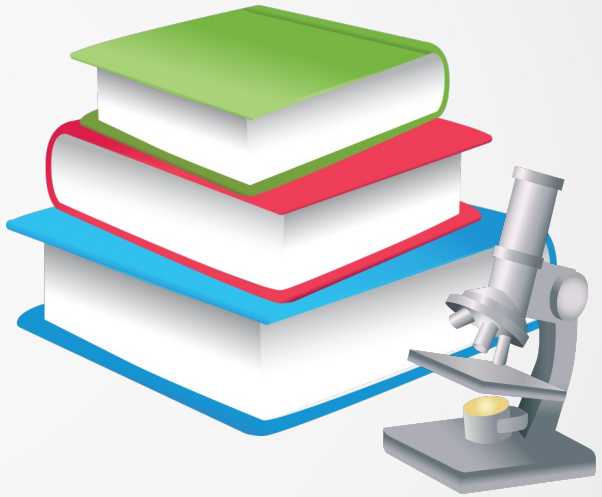
First introduction to CMS and Alignment

First look at ALCARECO kinematics

Tracking Alignment meeting

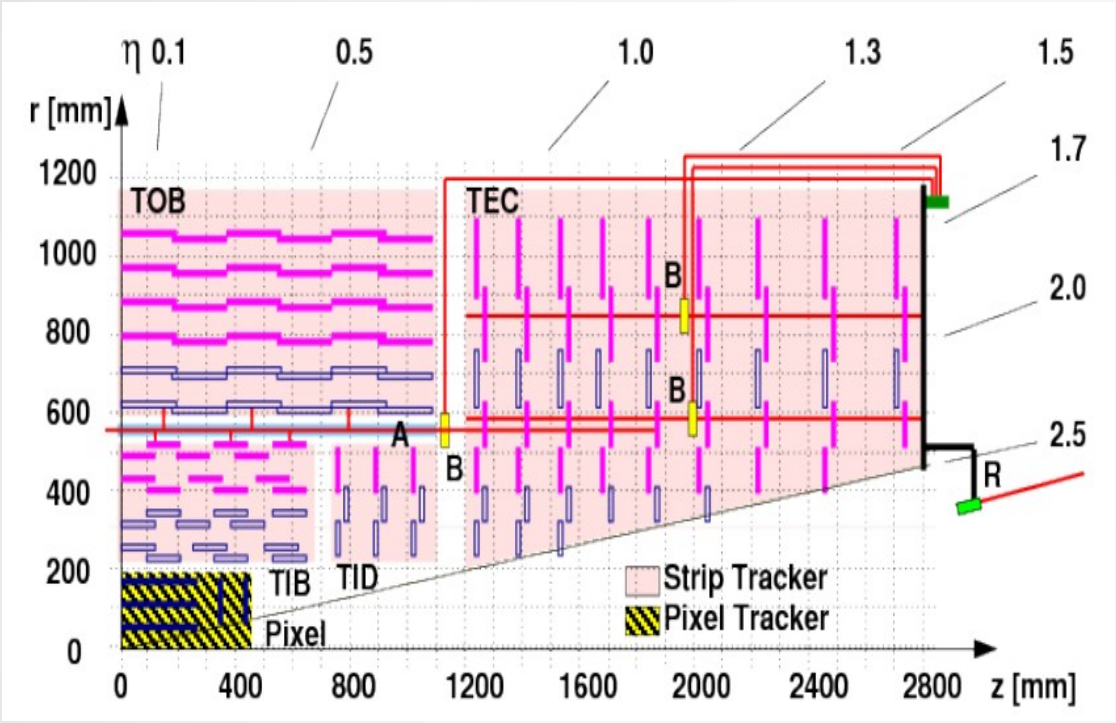


- CMS silicon tracker
- Alignment procedure
- First plots ...

Nazar Stefaniuk, Andrii Gizhko, Matthias Schröder

Thanks guys for the big help!

CMS silicon tracker



- Pixel modules provide a two-dimensional measurement of the hit position
- Strip modules has worse resolution in two-dimensional measurement

- *1440* silicon pixel
- over *15* thousands silicon microstrip modules

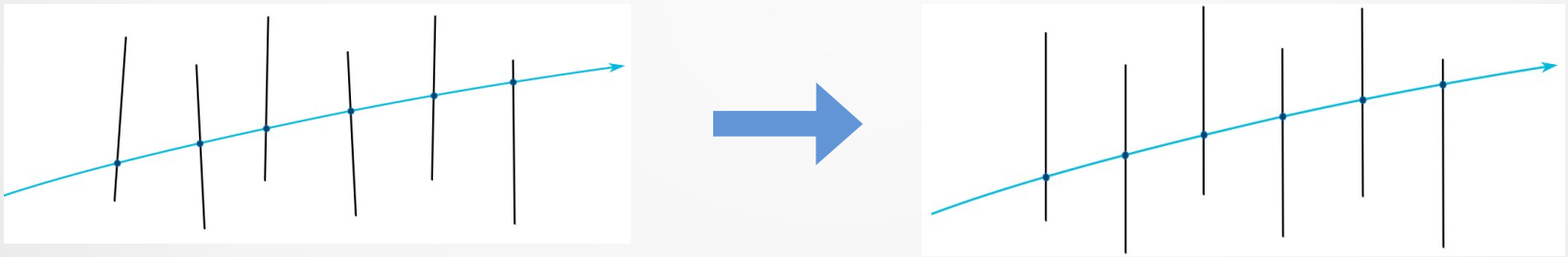
Organised into six sub-assemblies:

- BPIX - barrel pixel
- FPIX - forward pixel
- TIB - tracker inner barrel
- TOB - tracker outer barrel
- TID - tracker inner disks
- TEC - tracker endcups

Alignment procedure :: goals

Problems:

- global position and orientation of the tracker
  alignment can not ascertain the absolute position of tracker
- displacement of modules (rotations, movement)



- coulomb force – magnetic field change electron distribution inside modules → cause inaccuracy during measurements
- weak modes during alignment procedure

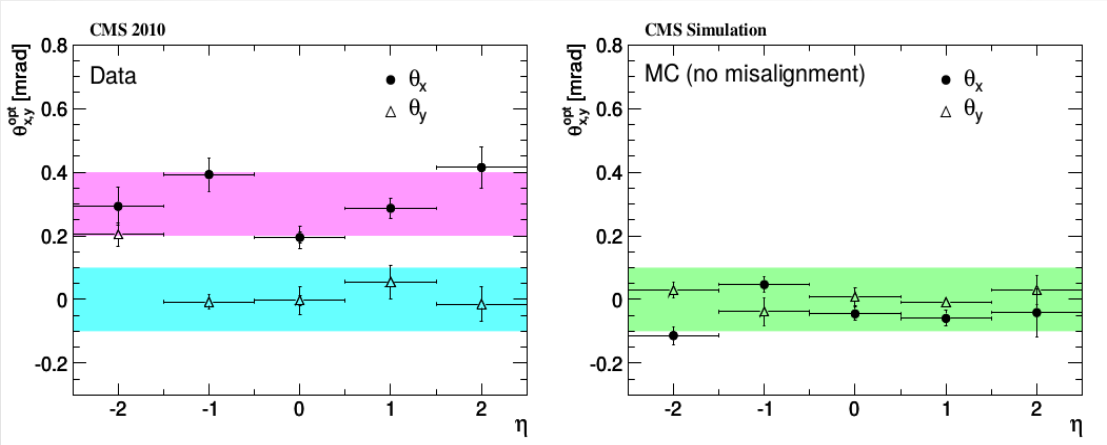
Alignment procedure :: technique

Global position and orientation of the tracker

- measurement of the tilt angles is based on the tracks quality
- non-optimal tilt angles →
  - incorrect information about transverse field components relative to the tracker axis

this may degrade track quality →

calculated χ^2 / N_{dof} for all tracks in different η region:



θ_x systematically shifted by ~ 0.3 mrad

θ_y close to zero

Alignment procedure :: technique

- Alignment algorithm follow the least squares approach, minimize χ^2

$$\chi^2(\mathbf{p},\mathbf{q}) = \sum_{j}^{\text{tracks}} \sum_{i}^{\text{measurements}} \left(\frac{m_{ij} - f_{ij}(\mathbf{p},\mathbf{q}_j)}{\sigma_{ij}} \right)^2$$

- Hierarchical constraint → smaller set of parameters:
  - useful in case of small track sample, not enough info to find all alignment parameters
  - can be used in hierarchical alignment approach with the alignment parameters of the sensors

- Weak modes:
  when coherent changes of alignment parameters can be compensated by changes of the track parameters

Fixed by physics constraints :

- cosmic ray tracks that break the cylindrical symmetry
- straight tracks without curvature in zero magnetic field
- information about the production vertex of tracks
- invariant mass constraint

Alignment procedure :: results

Tracks from different data sets are using in the same time during alignment procedure:

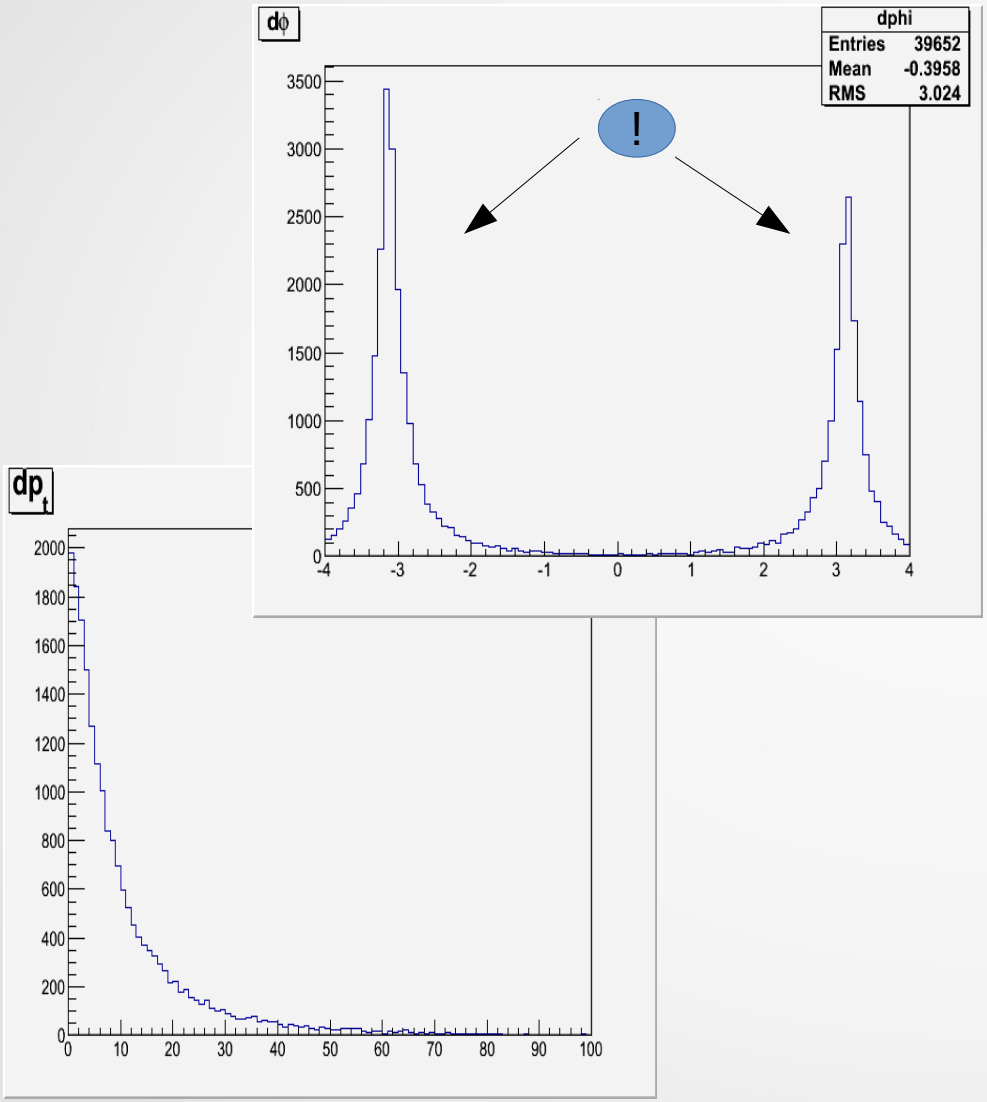
- cosmic run at four Tesla (CRAFT) ~ 4 million cosmic ray tracks
- cosmic run at 0 Tesla + straight tracks
- resonance data (Z, Jpsi, Upsilon) , mass constrained (~ 400 000 muon pairs from Z etc.)
- isolated muons (connect tracker and muon system ~ 15 million tracks)

→ Final track fit within MILLEPEDE II

N_{events} for 2010 data

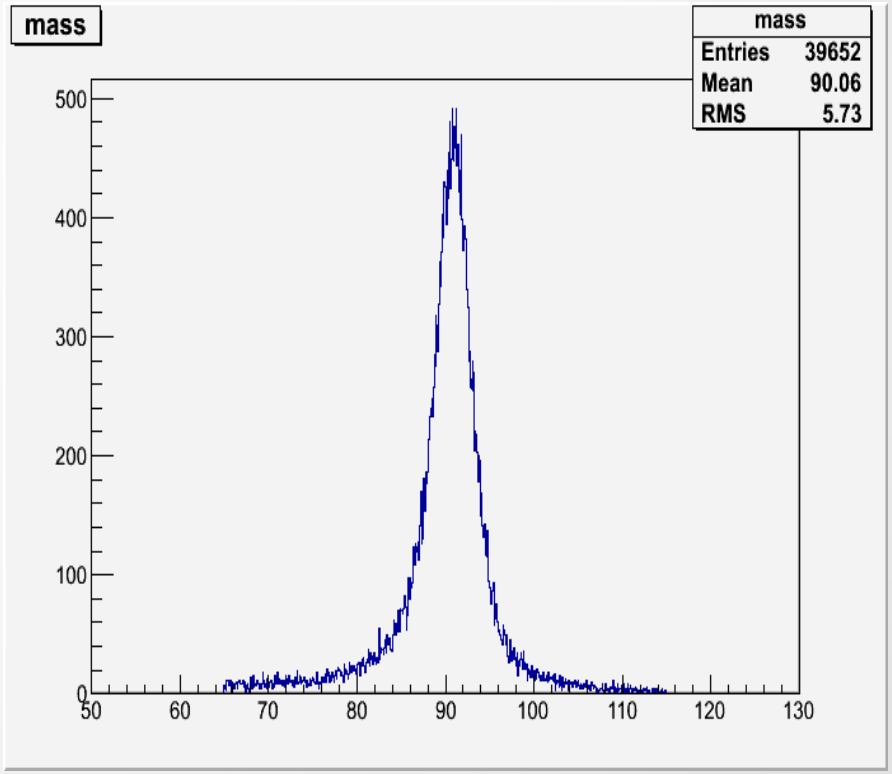
Accuracy on the module may be better than 10 μm

First plots, $Z \rightarrow \mu\mu$

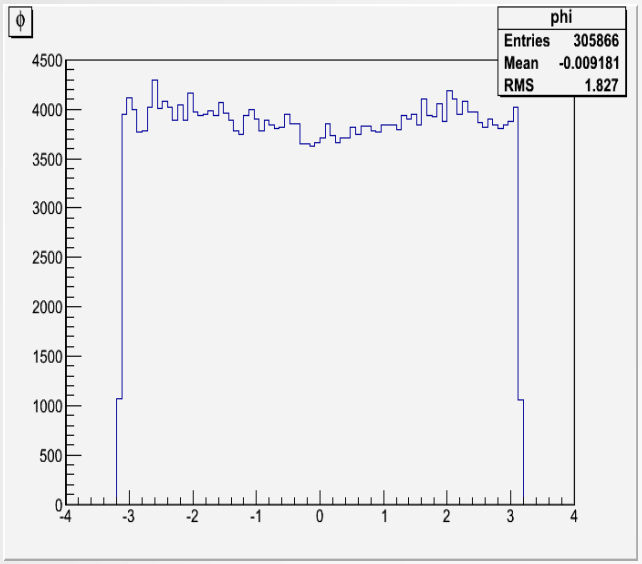


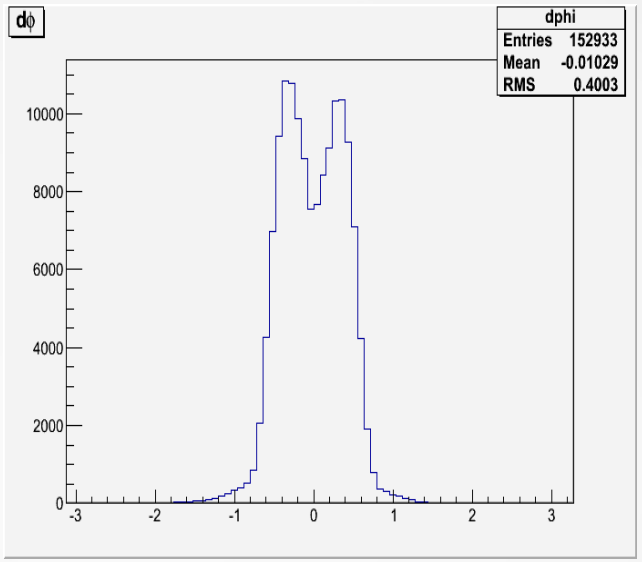
- Program from Andrii + explanations
- Run on a bigger data sample

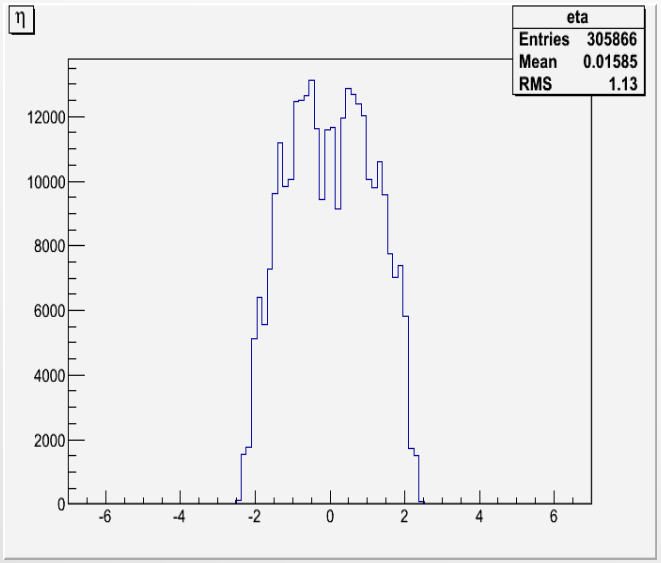
  "ALCARECOTkAlZMuMu"
- Same shape for the distributions

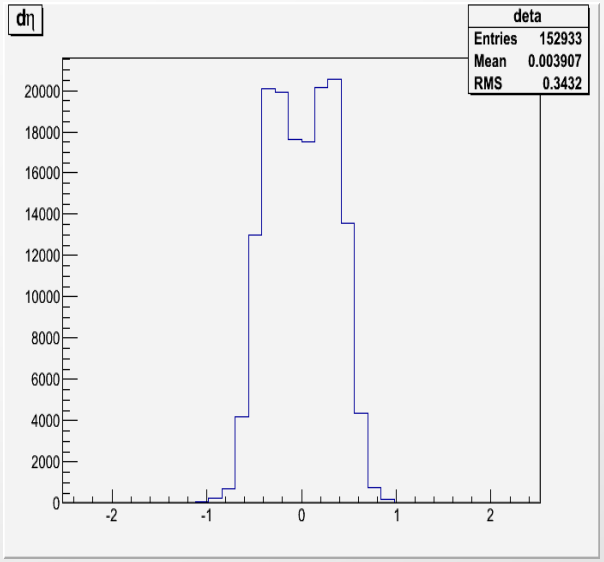


First plots


ϕ
phi
Entries 305866
Mean -0.009181
RMS 1.827


dϕ
dphi
Entries 152933
Mean -0.01029
RMS 0.4003


η
eta
Entries 305866
Mean 0.01585
RMS 1.13


dη
deta
Entries 152933
Mean 0.003907
RMS 0.3432

Results & Plans

Results:

- got simple knowledge how alignment works
- set up my work environment (certificates, access ...)
- start work with programs → preparation to MILLEPEDE II
- got first plots → understanding how the code works

Plans:

- familiarity with Github, MILLEPEDE II, working environment
- define a project for the technical task

Thanks for your attention!