CTPPS Detector Performance

Run 2016

Data summary

SiStrips Performance
- *Data Quality*
- *Radiation Damage*
- *Alignment*
- *Optics*
- *Validation*
- *Acceptance*

Diamond Performance
- *Data Quality*
- *Data consistency checks*

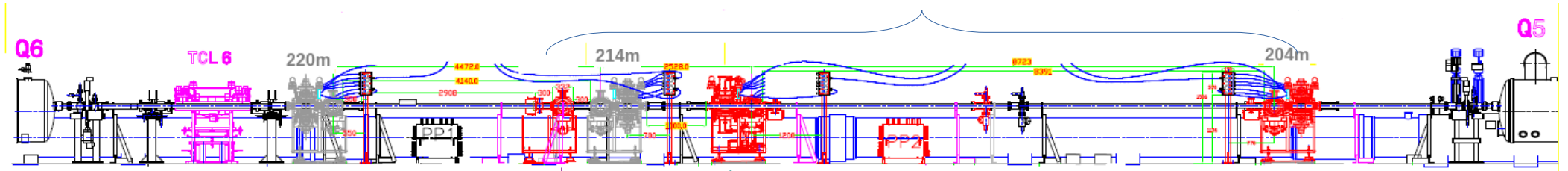
Run 2017

Software readiness
Specific commissioning requests

CT-PPS Project – Run 2016

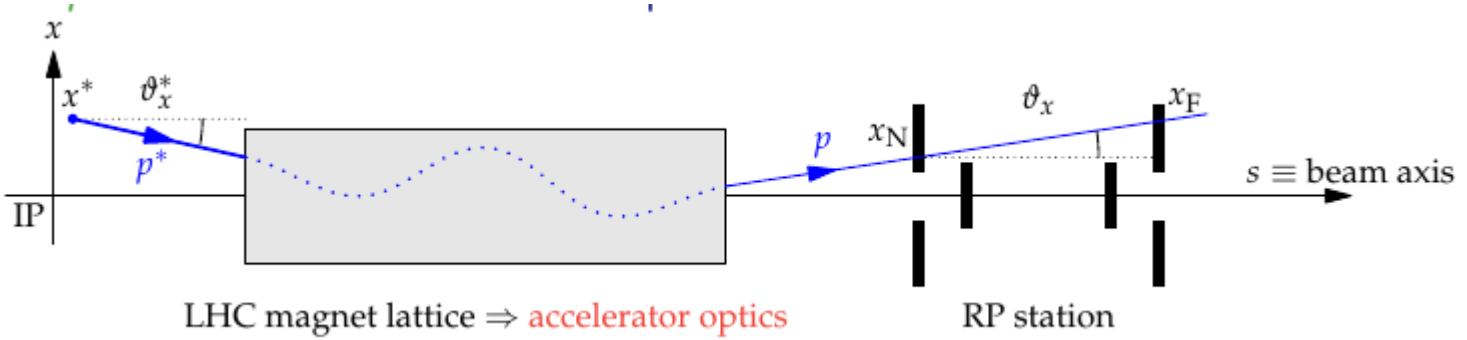
CMS →

3 Horizontal Roman Pots



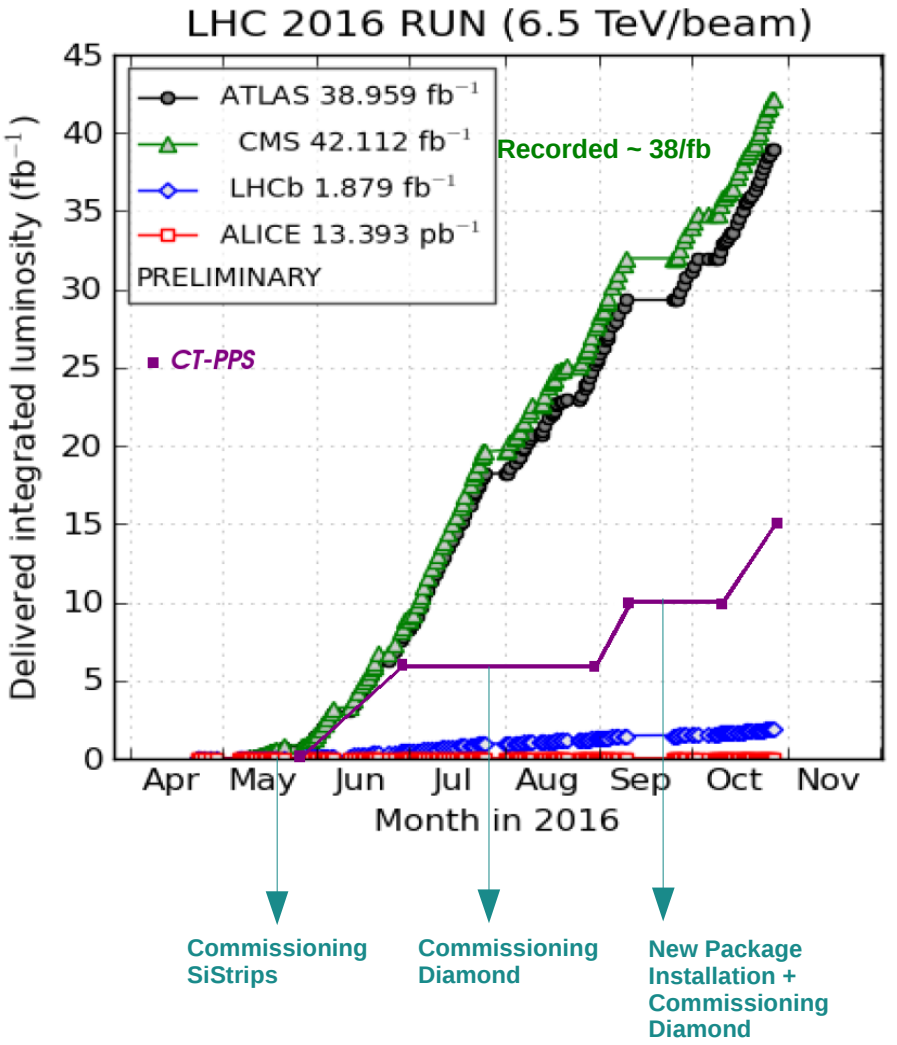
Timing Detectors	Tracking Detectors
Diamonds : Installation June 2016	**TOTEM Si-Strips : operative**

Measure the diffractive proton



2016 CTPPS Data Collected

STRIPS (PACK2) : 45 NR-FR / 56 FR DIAMONDS : 45 / 56 OPTICS_140	L=2.5/fb
STRIPS (PACK2) : 45 NR-FR / 56 FR OPTICS_140	L=2.8/fb
STRIPS (PACK1) : 45 NR-FR / 56 NR-FR OPTICS_185	L=3.8/fb
STRIPS (PACK1) : 45 NR-FR / 56 NR-FR OPTICS_185	L=5.6/fb
STRIPS (PACK1) : 45 NR-FR / 56 NR-FR With margin OPTICS_185	L=0.58/fb

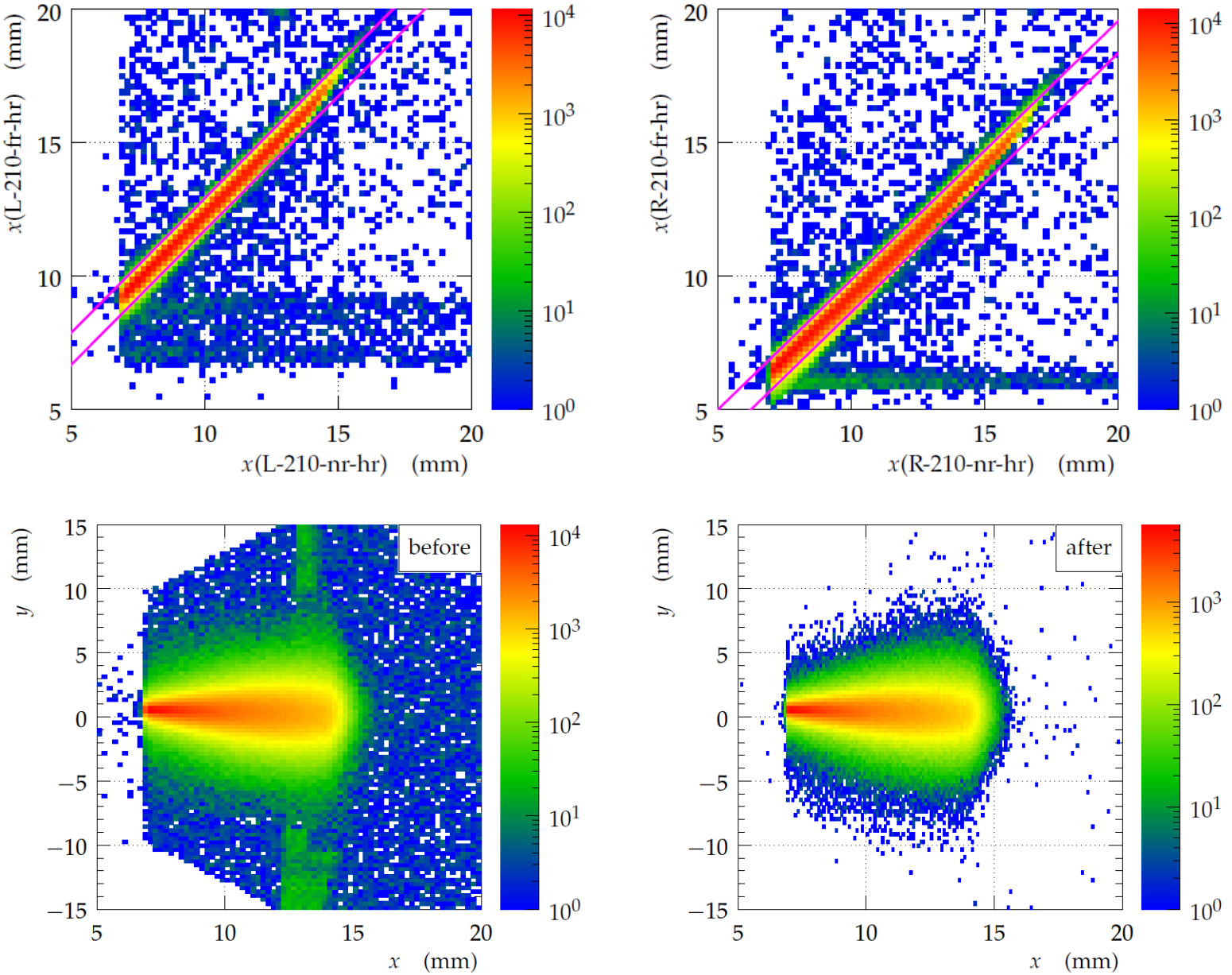


Lumi collected ~ 15 /fb

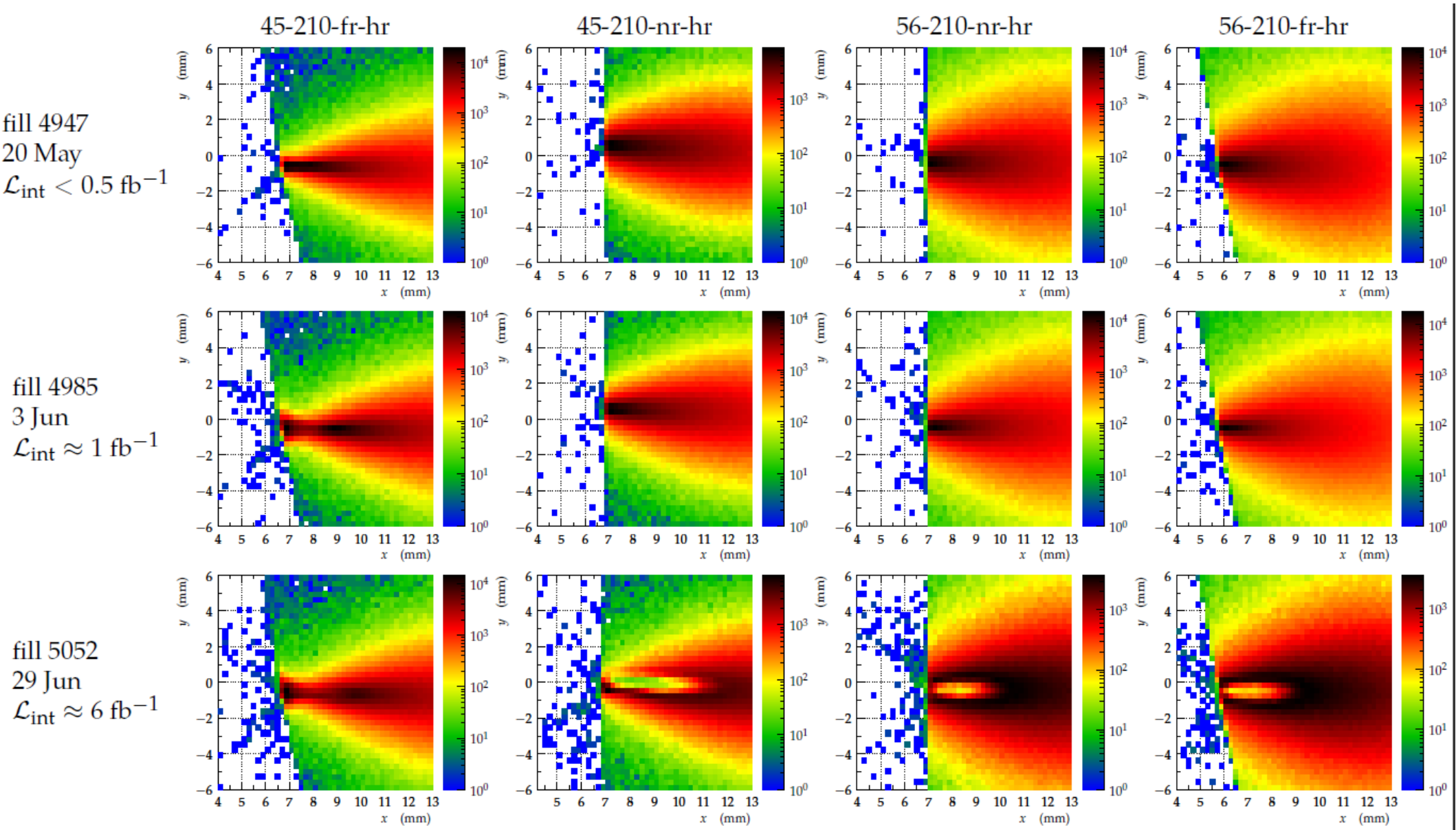
TOTEM SiStrip Performance: Data Quality

x correlation near vs. far RP

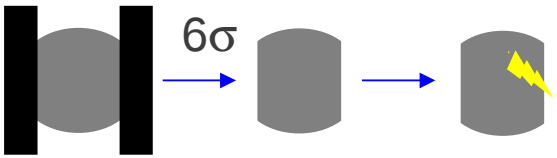
dominant term in proton propagation: x ~ Dξ

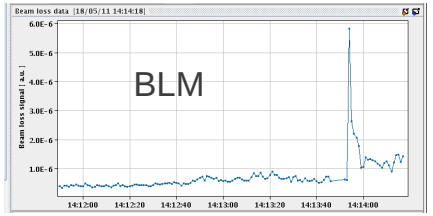


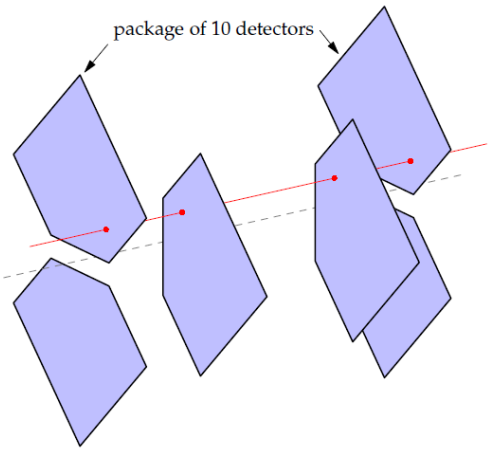
TOTEM SiStrip Performance: radiation damage



(Beam based) Alignment Run





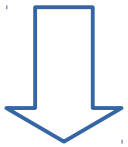


Data taking with TOTEM DAQ

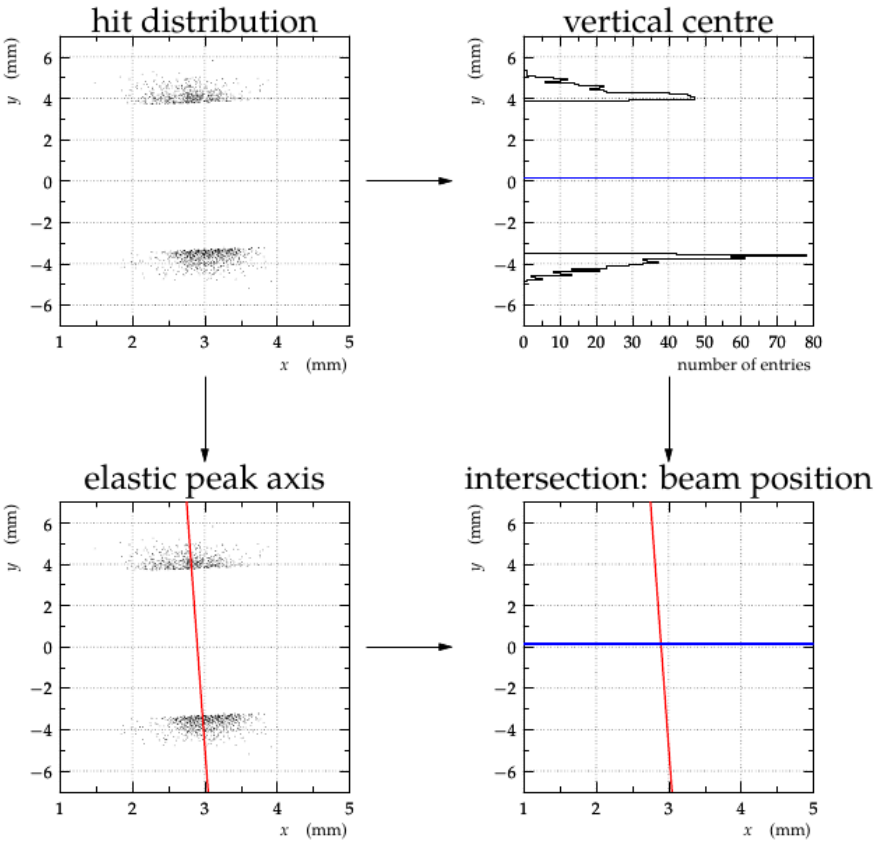
Vertical Pots included, will be used for :

– relative pots alignment

– determine the distance to the beam selecting elastic scattering

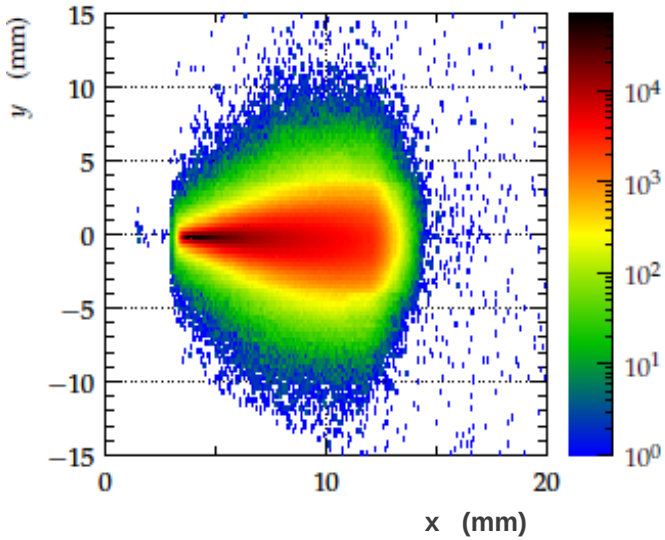


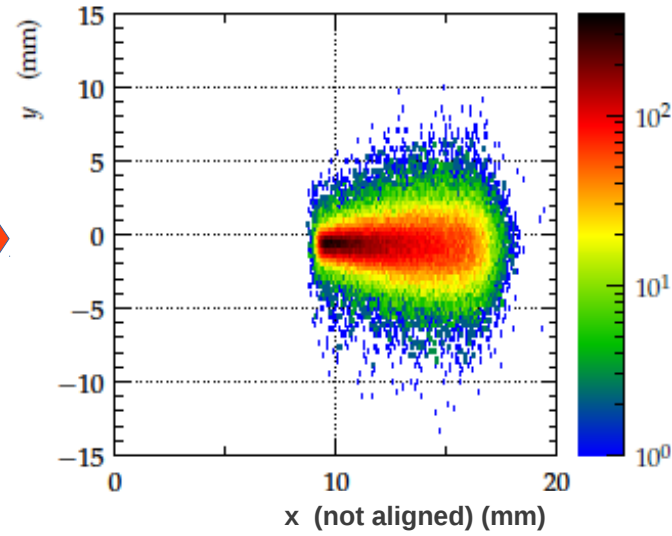
“propagate” the alignment to the physics runs



Roman Pot Alignment - horizontal

match hit distributions (per RP):
alignment run ↔ physics run

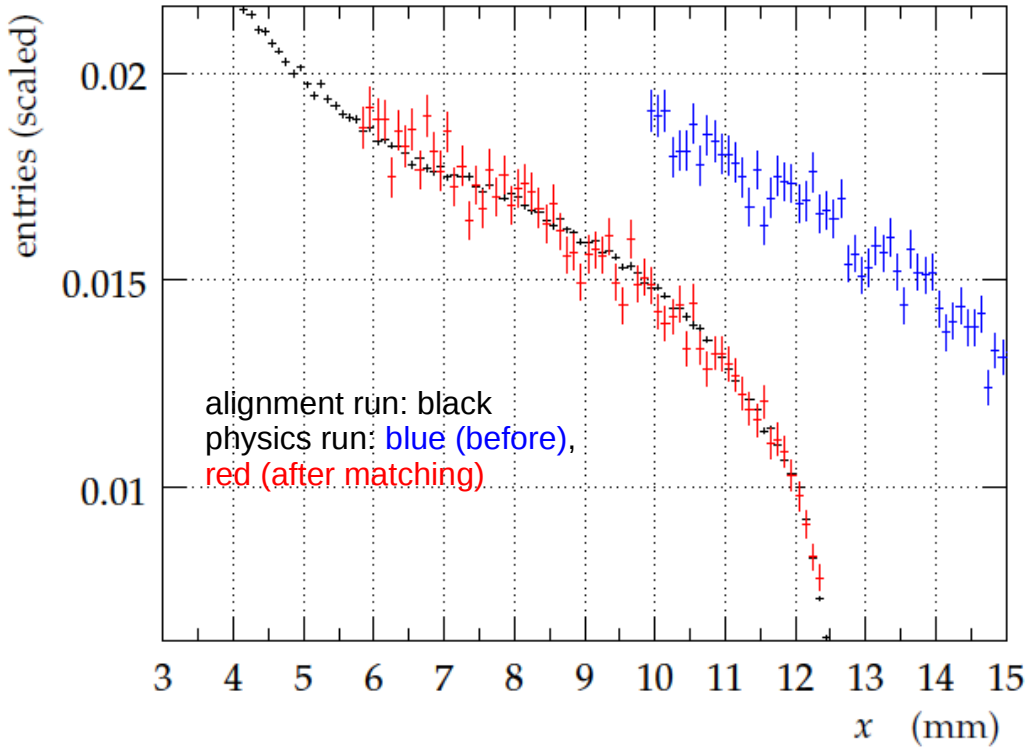




Match 1D distributions

Optimise only horizontal position, i.e. alignment in x

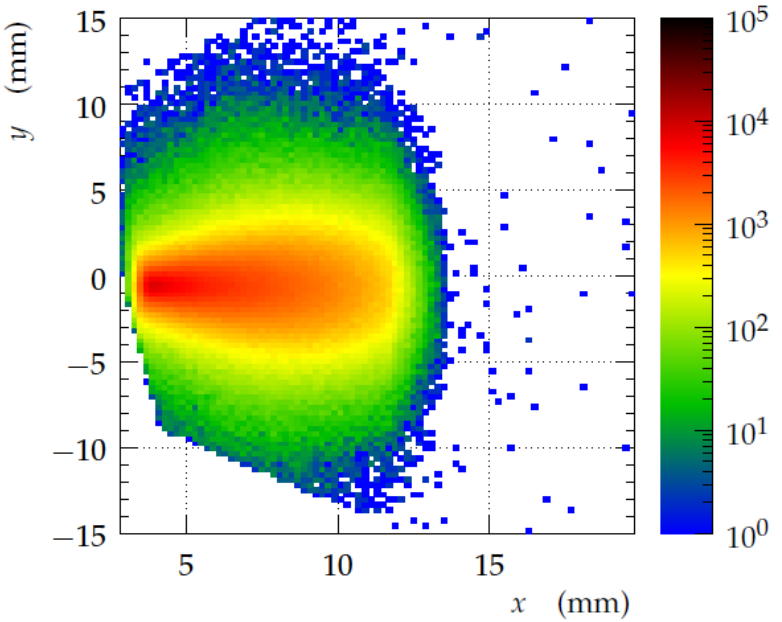
Need to adjust normalisation of each dataset
→ sensitive only to shape differences

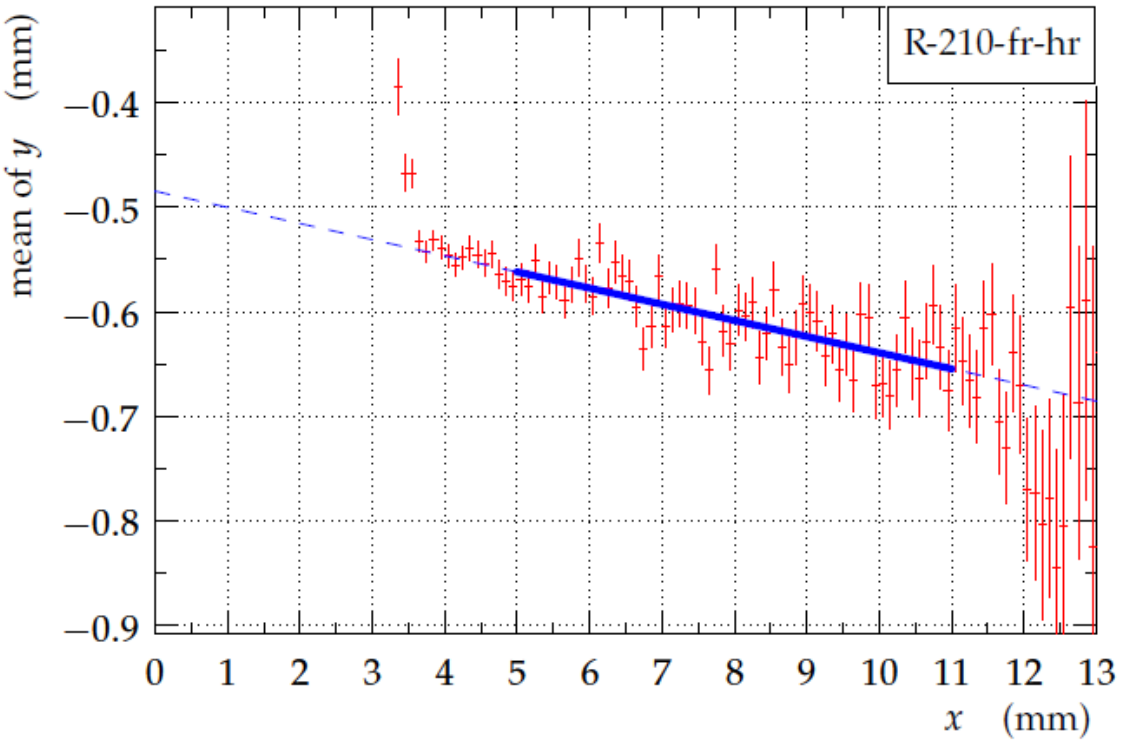


Roman Pot Alignment - vertical

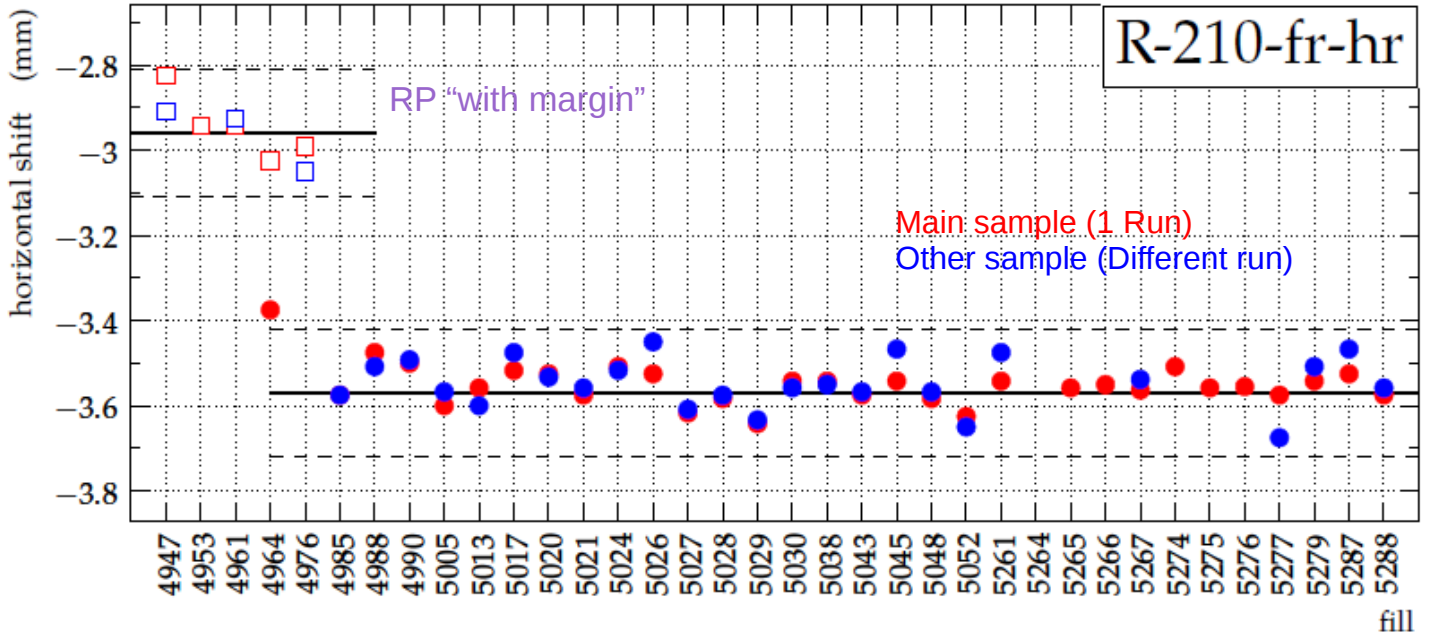
Basic idea: mean of y should be 0

After x alignment, plot mean y as function of x
extrapolate to x = 0

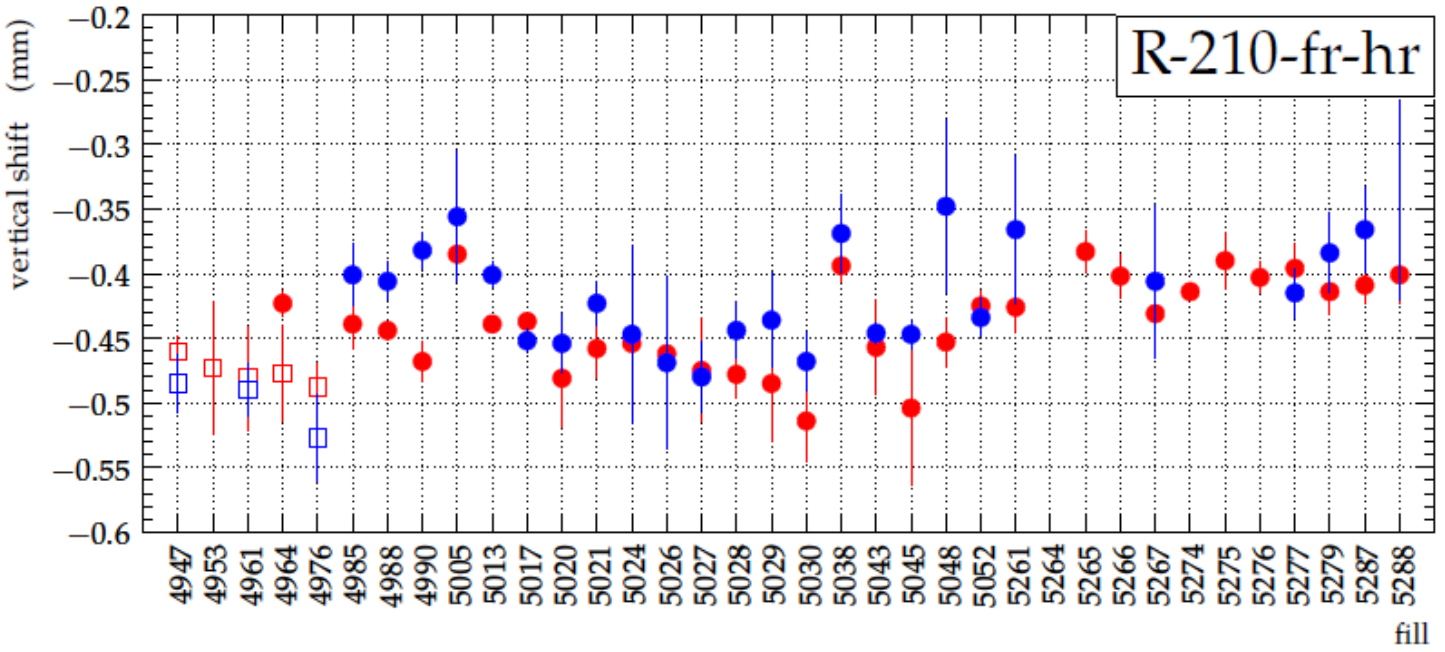




Roman Pot Alignment

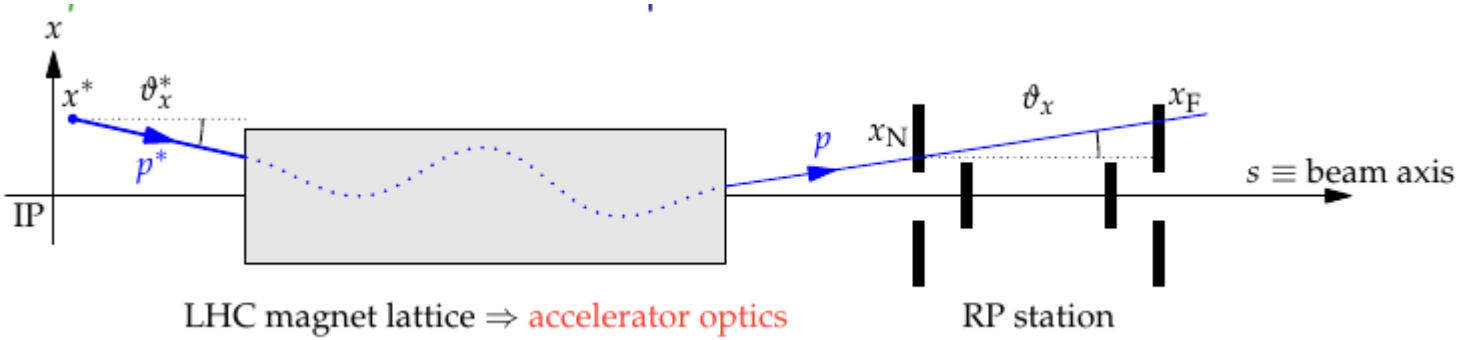


± 150µm



± 150µm

Optics determination



Proton transport description with matrices

ξ=Δp/p

$$\vec{d} = T \cdot \vec{d}^{\,*},$$

where $\vec{d} = (x, \vartheta_x, y, \vartheta_y, \xi)^T$ and

$$T = \begin{pmatrix} v_x & L_x & m_{13} & m_{14} & D_x \\ \frac{dv_x}{ds} & \frac{dL_x}{ds} & m_{23} & m_{24} & \frac{dD_x}{ds} \\ m_{31} & m_{32} & v_y & L_y & D_y \\ m_{41} & m_{42} & \frac{dv_y}{ds} & \frac{dL_y}{ds} & \frac{dD_y}{ds} \\ 0 & 0 & 0 & 0 & 1 \end{pmatrix}$$

Vertically (no coupling and D_y)

$$y = v_y \cdot y^* + L_y \cdot \theta_y^*$$

Horizontally:

$$x = v_x \cdot x^* + L_x \cdot \theta_x^* + D_x \cdot \xi$$

1) Build real optics starting from measured magnet currents (strength)

2) Optics matching with elastic events
TOTEM standard [New J. Phys. 16 (2014) 103041]

- clean sample with strong experimental signature
- ξ=0
- protons back-to-back: correlation between the two sectors

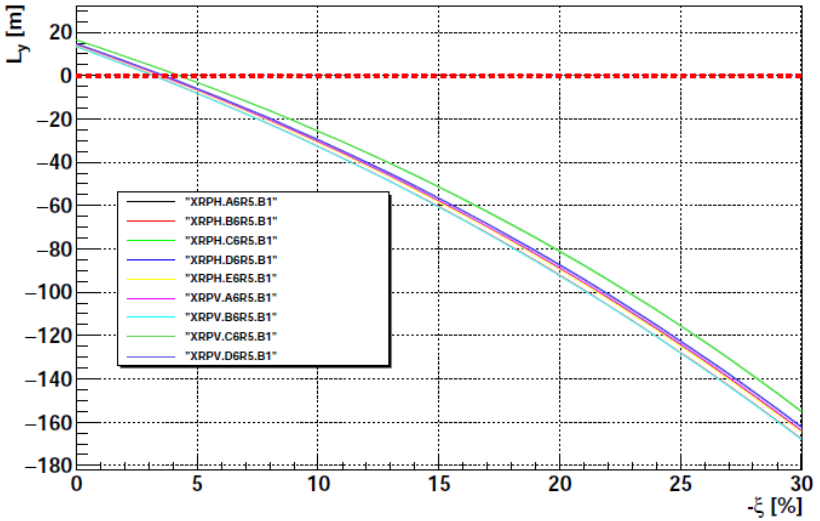
=> determine deviation from nominal optics

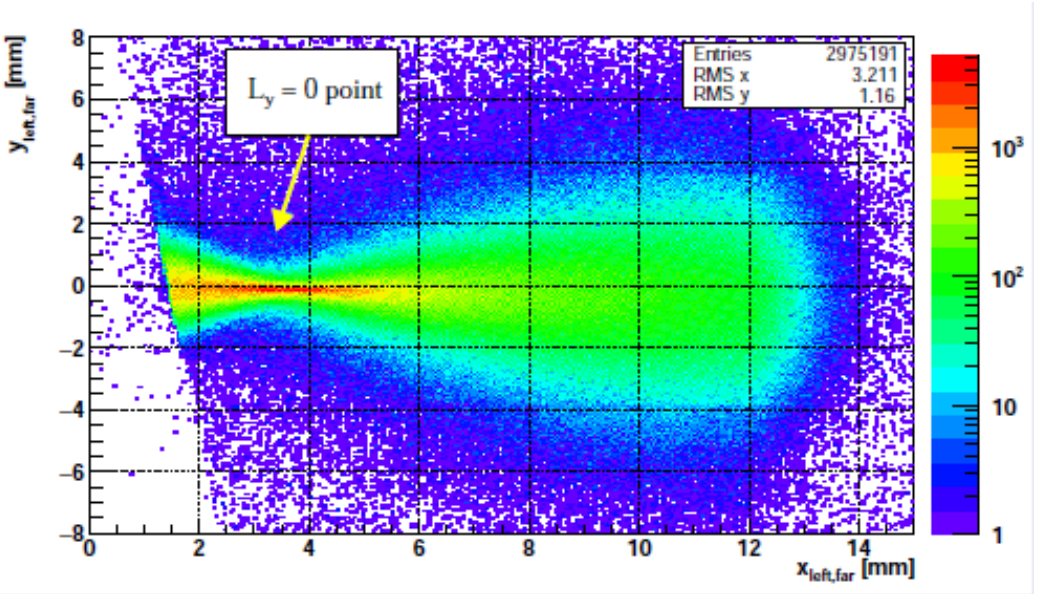
3) Dispersion calibration using Ly(ξ) = 0 point

4) LHC lattice/optics matching

Optics determination (2)

Dispersion calibration using Ly(ξ) = 0 point





Nominal optics: symmetric dispersion (~ 7 cm)
Measured dispersion: ~ 5 cm (right arm) ~ 9cm (left arm)

LHC lattice/optics matching

Tuned magnet strength (previous steps)
Measured dispersion
BPM measurements
Beam position measurement with RP

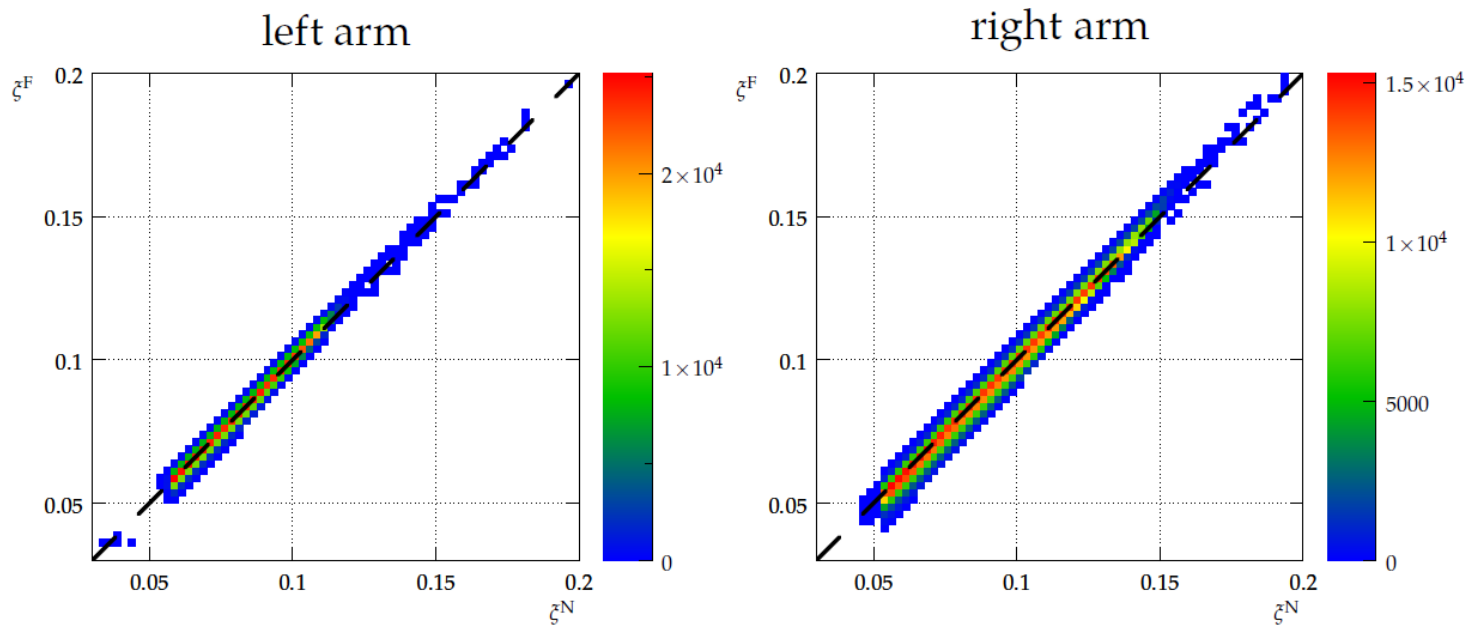
=> crossing-angle
Quadrupole positions
Kicker strength

Proton kinematics reconstruction

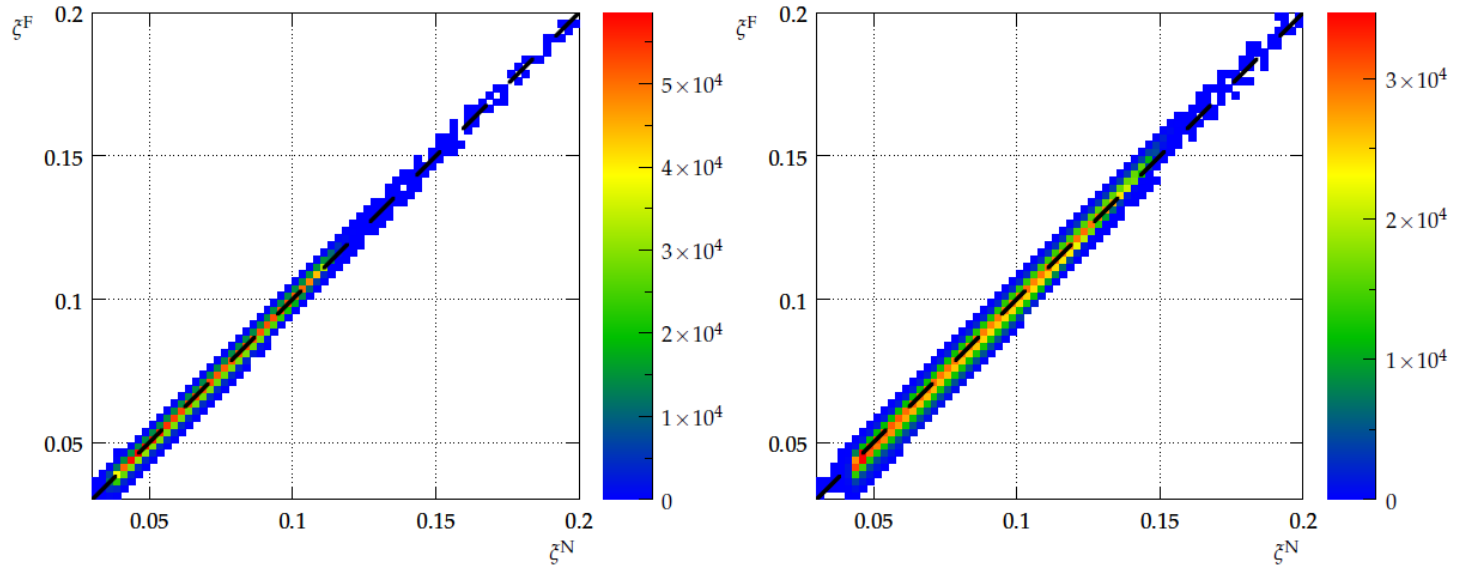
Alignment and optics validation : Near-Far correlation in ξ, stability

Cut: Near-far x-correlation

Fill 4947

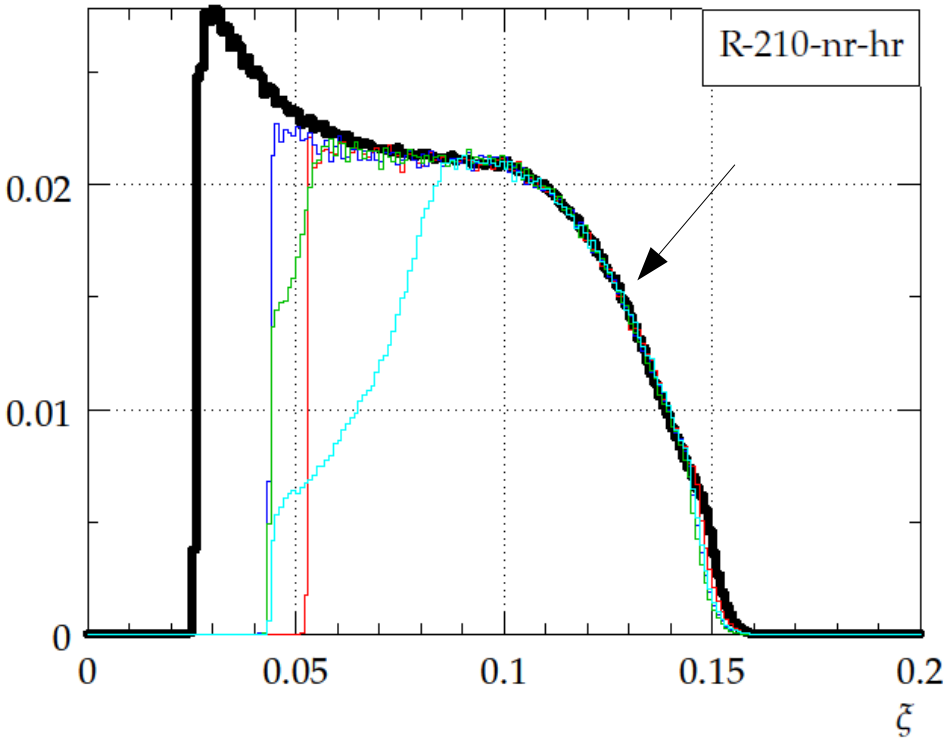


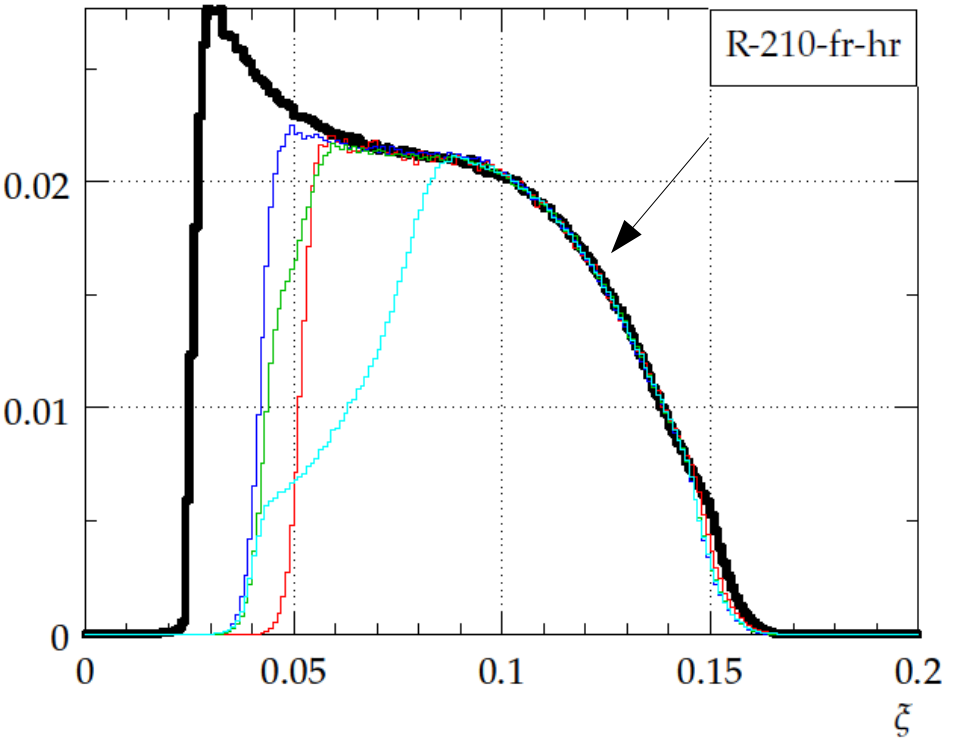
Fill 5261

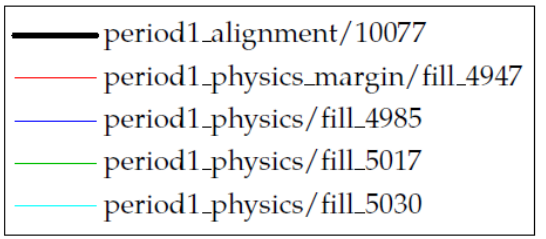


Alignment and optics validation : ξ distribution - Fill comparison per RP

Cut: Near-far x- correlation

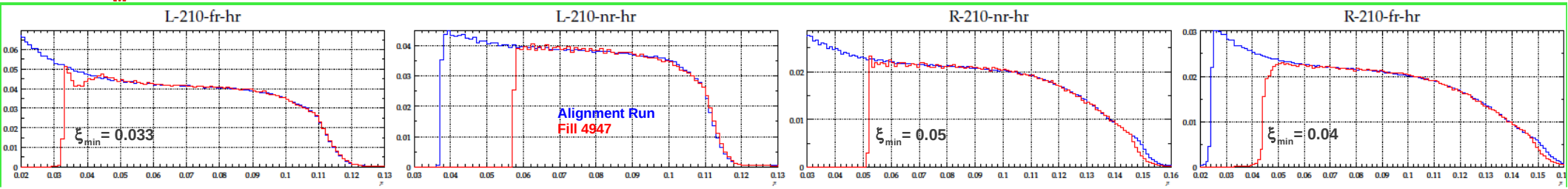




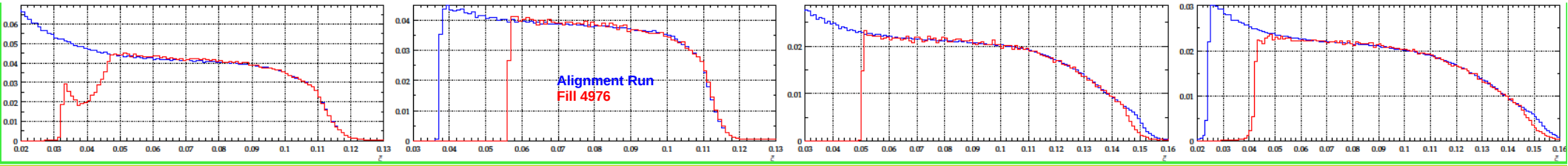


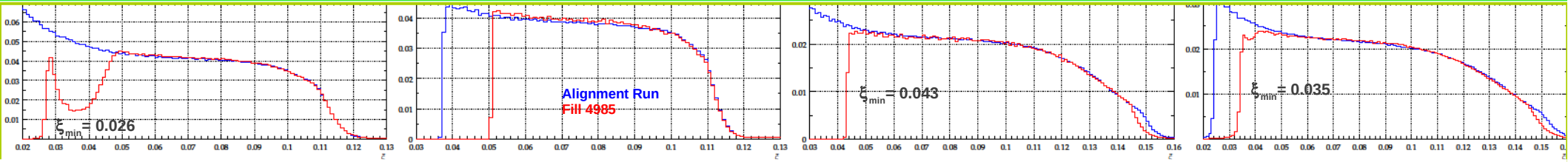
Very good agreement in the region not affected by radiation damage

TOTEM SiStrip Performance: ξ acceptance

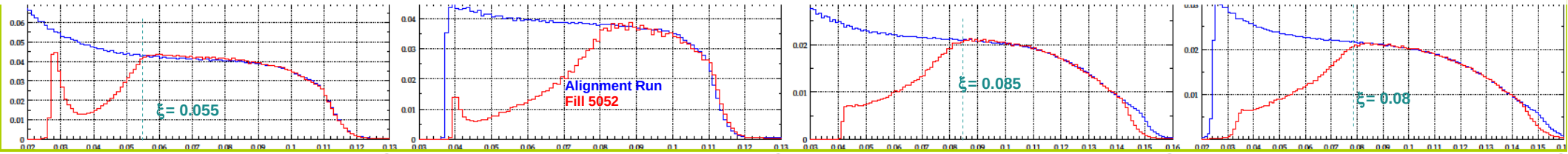


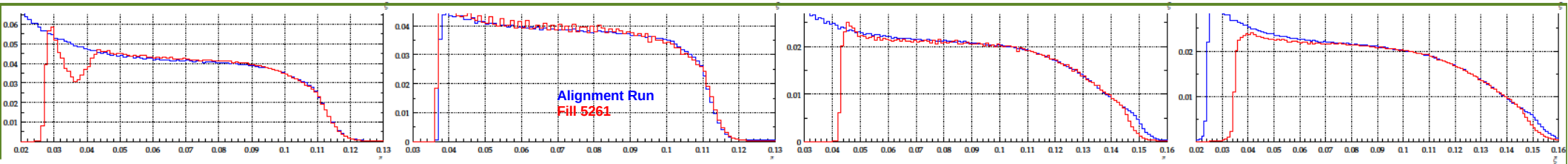
STRIPS (PACK1) : 45 NR-FR / 56 NR-FR – With margin – OPTICS_185 L=0.58/fb



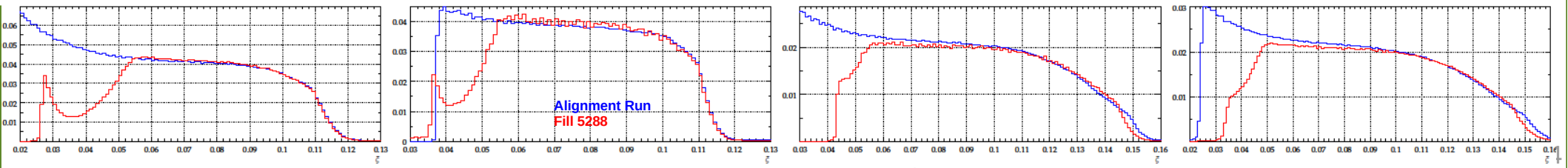


STRIPS (PACK1) : 45 NR-FR / 56 NR-FR OPTICS_185 L=5.6/fb





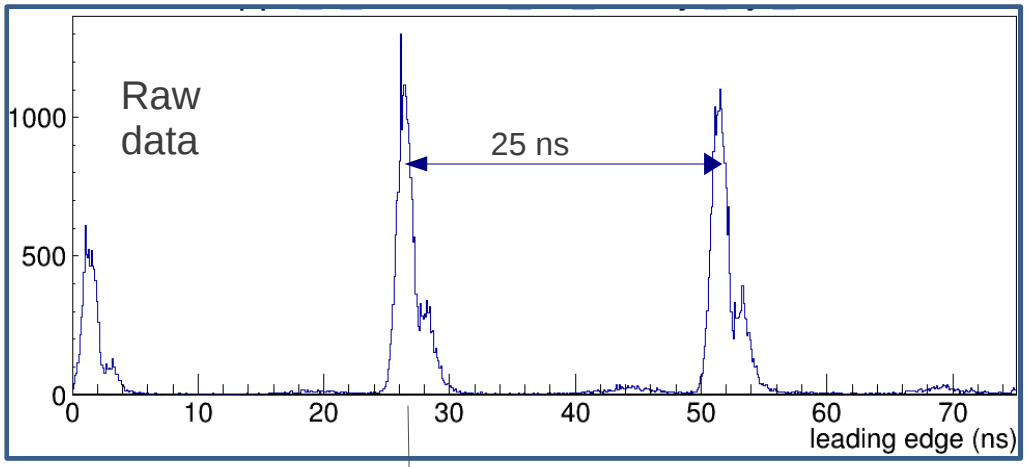
STRIPS (PACK1) : 45 NR-FR / 56 NR-FR OPTICS_185 L=3.8/fb



Diamond Detectors performance

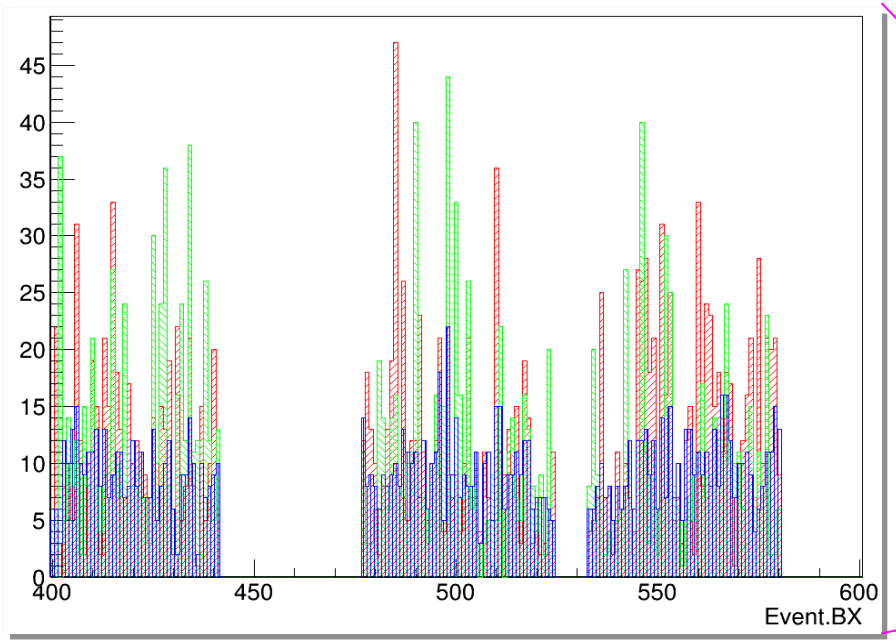
Consistency checks: leading edges

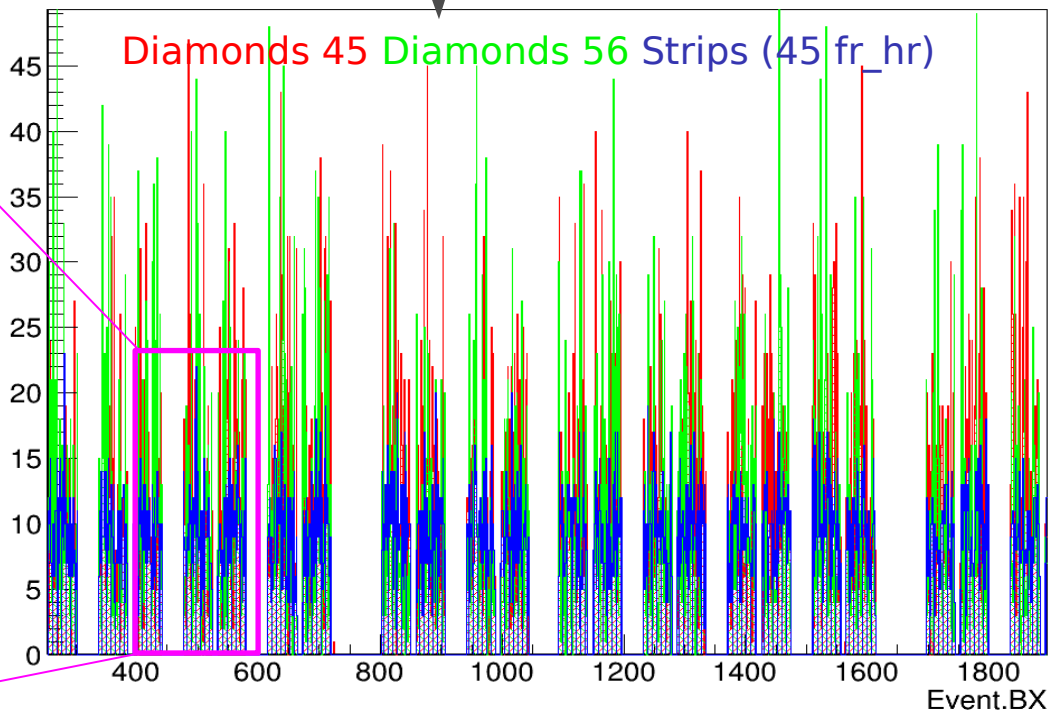
Acquisition windows 3 clock cycles: 3 peaks



Off-line selection of only 1 peak

Synchronization with strips: latency

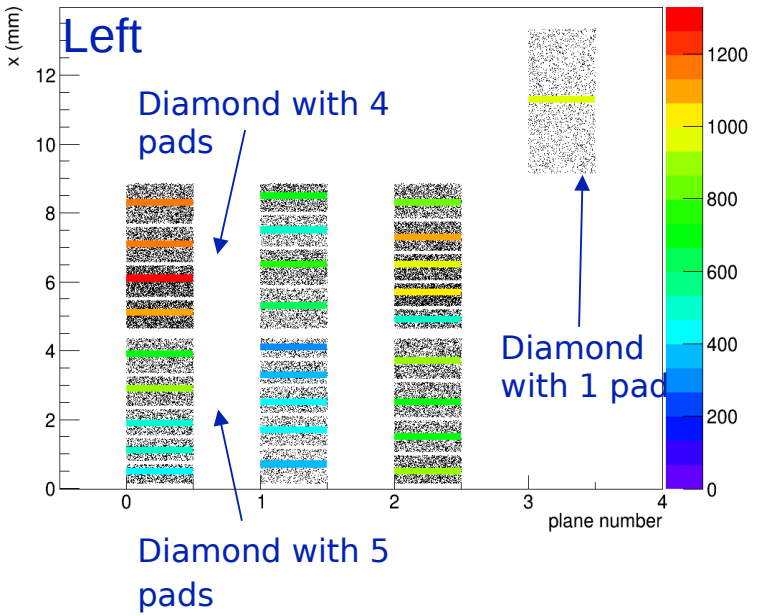


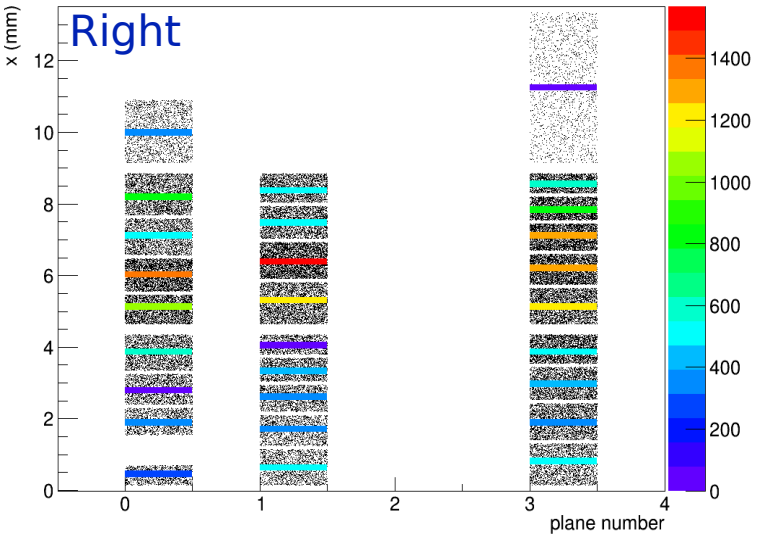


Same bunch structure

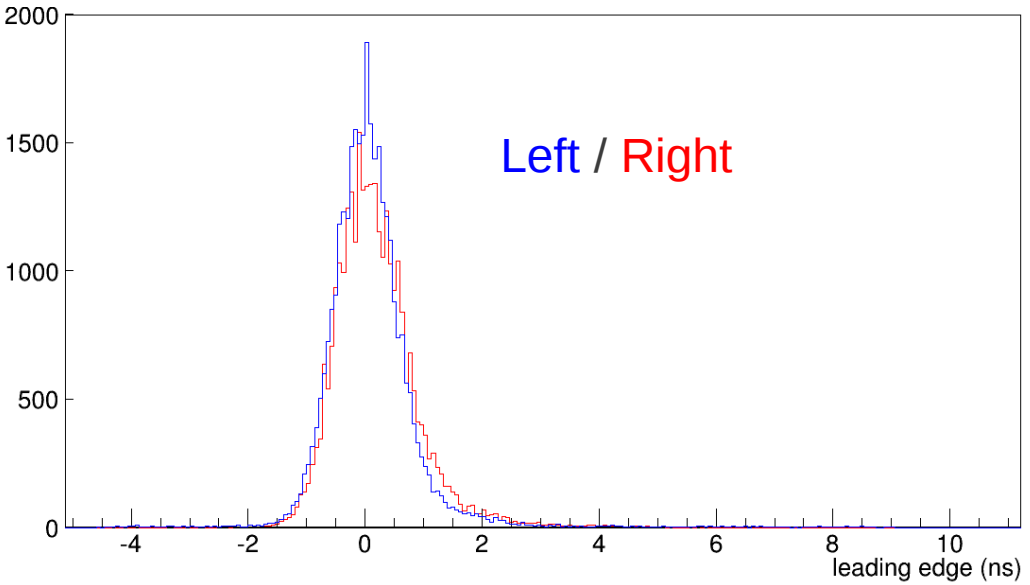
Diamond Detectors performance

Mapping

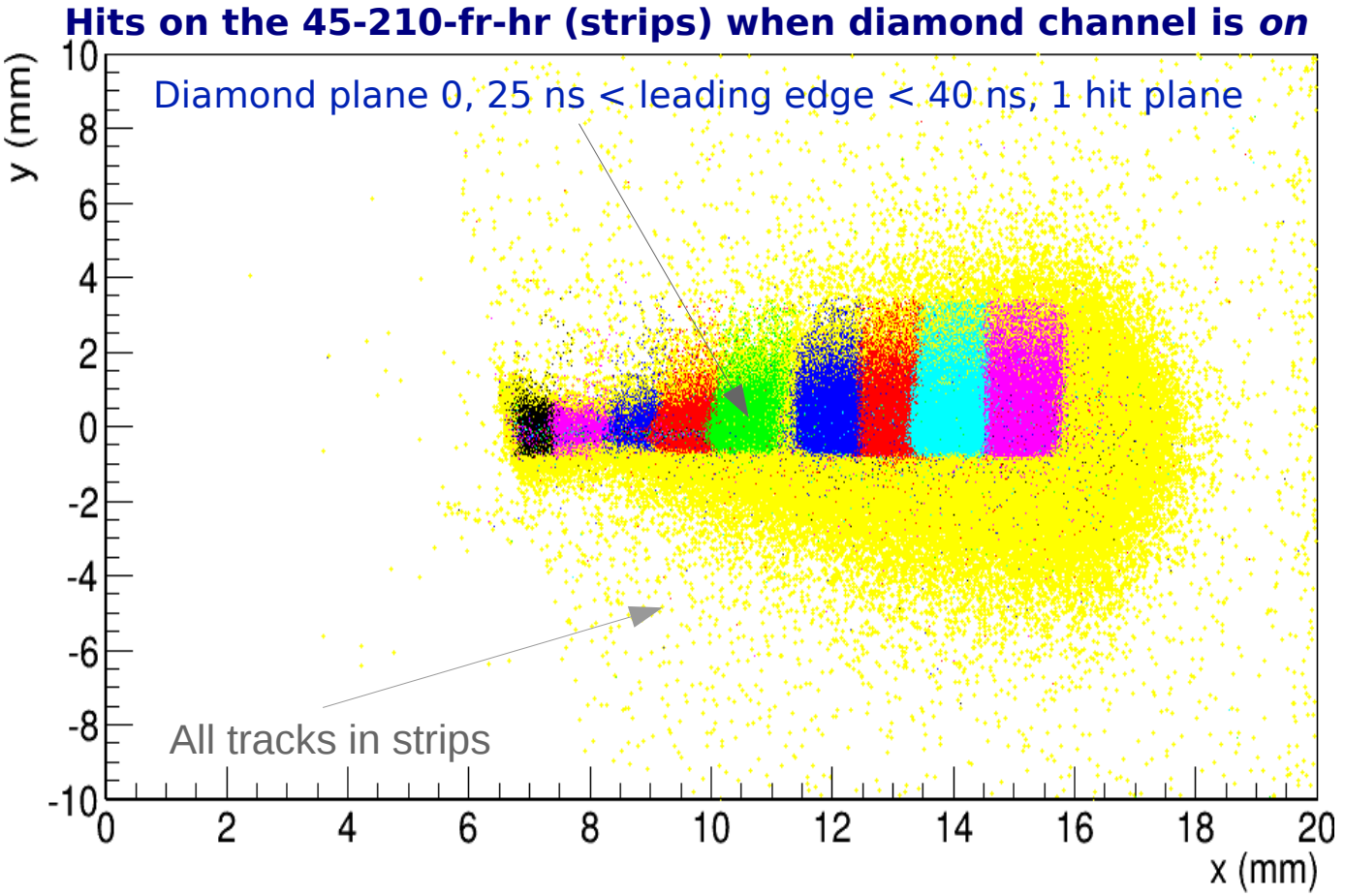




Leading edge: consistency between the two arms



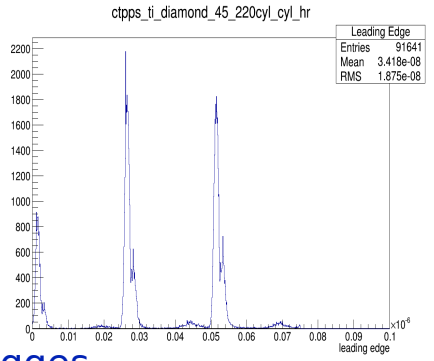
Diamond Detectors performance: coincidence with SiStrips & alignment with beam

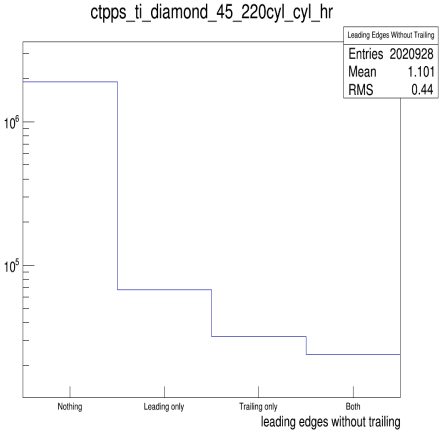


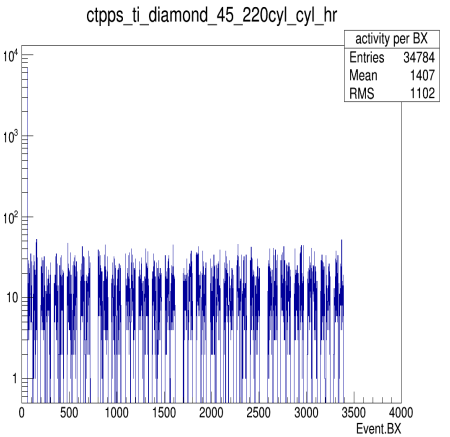
Misaligned by almost 2 mm on both arms.
Not clear yet if it is a mechanical problem only or it is in combination with a beam off center. More investigation has to be pursued.

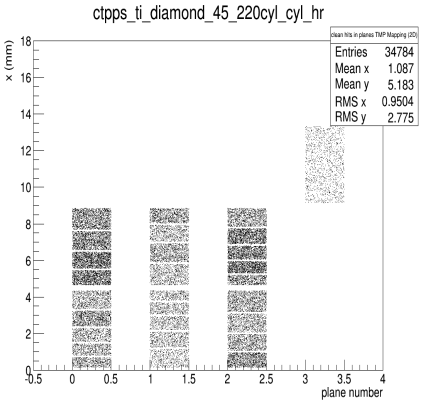
DQM for Diamond Detectors

- Run 284038;1 ← Run number
  - CTPPS;1
    - Run summary;1
      - events per BX;1
      - events per BX (short);1
      - track correlation RP-210-hor;1
      - DAQ;1
      - EventInfo;1
    - TimingDiamond;1
      - TimingDiamond;1 ← Timing subdirectory
        - sector 45;1
          - station 220cyl;1 ← Cylindrical RP subdirectory
            - cyl_hr;1
              - Leading Edge;1 ← All leading edges
              - Leading Edges Without Trailing;1 ← Leading edges without trailing
              - Leading Trailing Correlation;1
              - Time over Threshold;1
              - active planes;1
              - activity in planes (2D);1
              - activity per BX;1 ← Activity vs BX
              - activity per BX (short);1
              - activity per FED BX;1
              - activity per FED BX (short);1
              - activity per FED BX all;1
              - activity per FED BX all (short);1
              - activity per FED BX filtered;1
              - activity per FED BX filtered (short);1
              - clean hits in planes TMP Mapping (2D);1
              - hits in planes TMP Mapping (2D);1 ← Hits distribution
              - hptdc_Errors;1
              - optorxEC(8bit) - vfatEC;1
              - plane 0;1
                - Threshold Voltage;1
                - digi profile;1
                - hit multiplicity;1
                - hit profile;1
                - channel 0;1
                - channel 05;1
                  - Leading Edge;1
                  - Leading Edge Without Trailing;1
                  - Leading Trailing Correlation;1
                  - Time over Threshold;1
                  - hit rate;1
                  - hptdc_Errors;1
                  - optorxEC(8bit) - vfatEC vs optorxEC;1
                - channel 06;1
                - channel 07;1



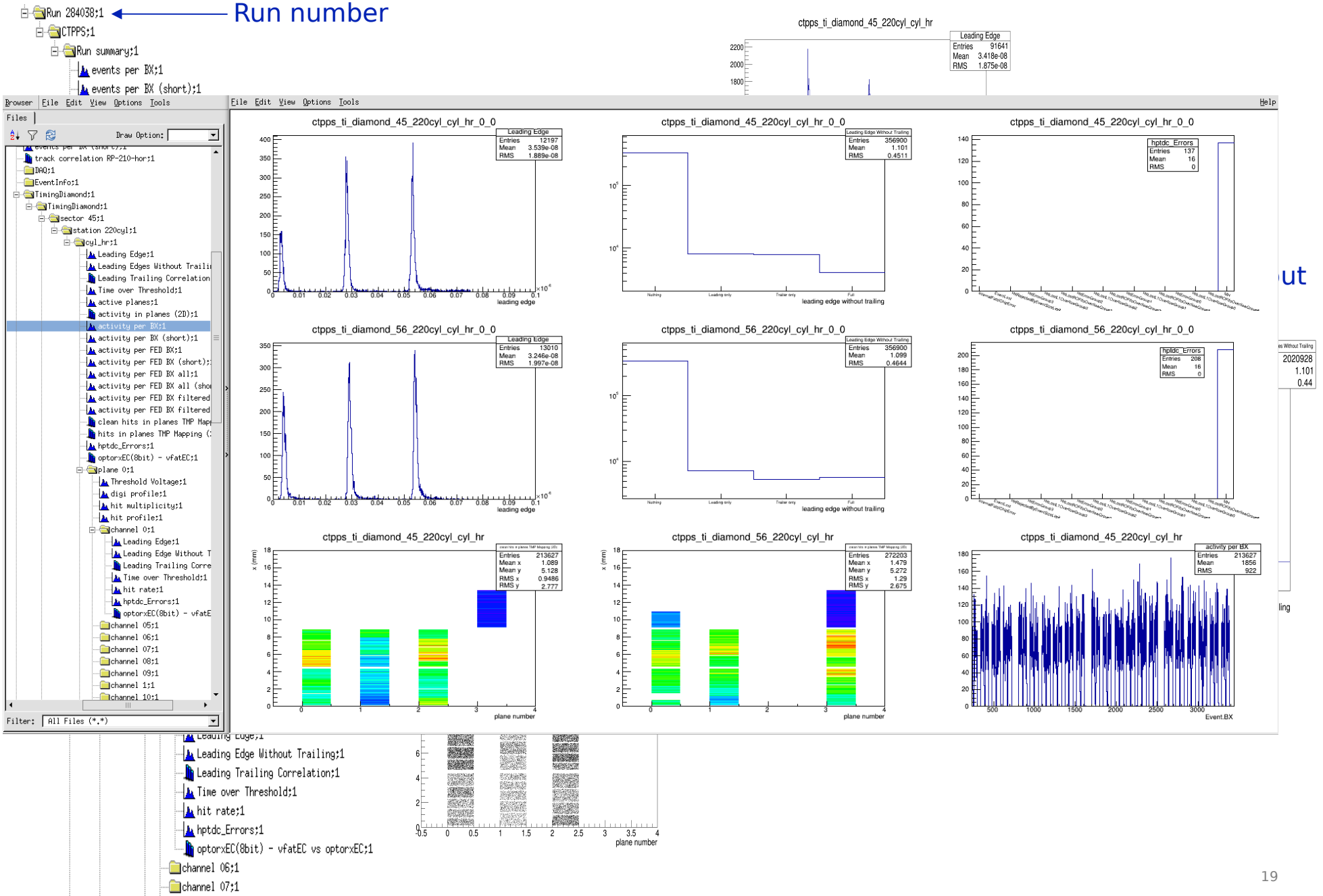






DQM for Diamond Detectors

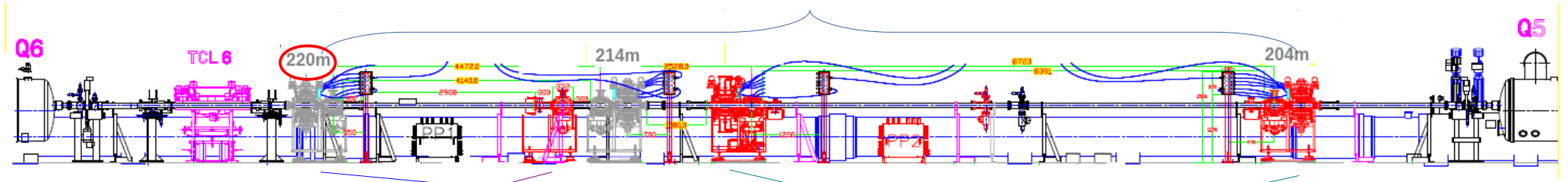
Work in progress, to be integrated in official release for 2017 run



CT-PPS Project – Run 2017

CMS →

4 Horizontal Roman Pots



Timing Detectors

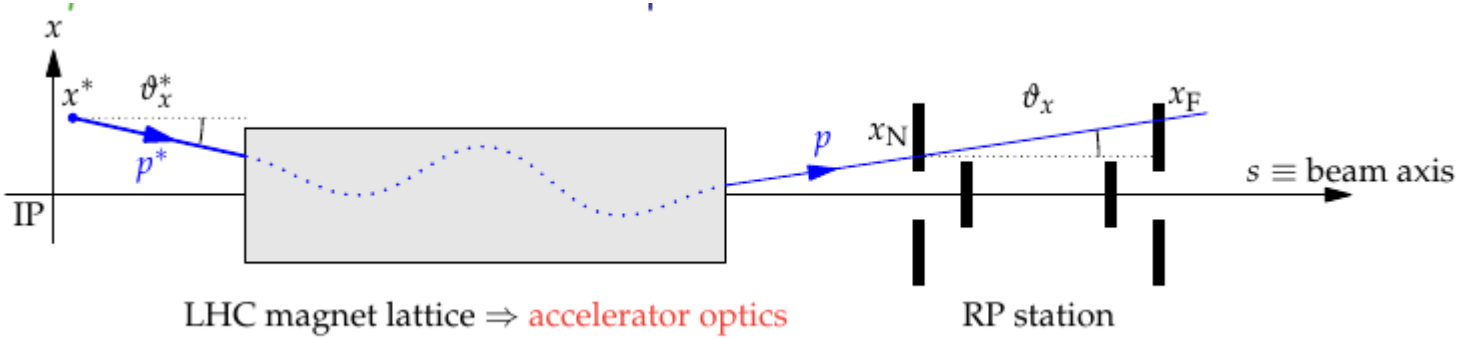
Diamond (3 planes) +
Fast Silicon (1 plane)

Tracking Detectors

TOTEM Si-Strips

3D Pixel

Measure the diffractive proton



CTPPS Offline Software Status

Legacy Re-Reco

CTPPS: raw-to-digi for diamond detectors PR16616 **(in 90X)** pending backporting **80X**

CTPPS: detector id update PR 16010 (in **80X**) pending

CTPPS: miniAOD PR 17162 in **90X (80X)**

Next (if on schedule) :

CTPPS Geometry for diamond detectors ==> 90X/80X

CTPPS Reconstruction for diamond detectors ==> 90X/80X

Data 2017

CTPPS 3d pixel detid PR 17075 in **90X**

CTPPS DQM for diamond detector & UFSD

CTPPS 3d pixel (Digi,Reco,DQM)

CTPPS Offline Software Status

Simulation

- RP detectors not yet integrated in the full simulation

- the major issue is that the real optics is known only during data taking

- “private” production of the RP detectors is not a problem

- try to profit from the central production for the CMS detector

- discussion is going on between experts (Generator, Simulation) to include the forward proton information in GEN-SIM/RECO

Ready for 2017 Run

- Optics: discussion is ongoing with machine experts to optimize the optics to improve CTPPS acceptance.
  Official request to LPC, it will be discussed in Chamonix (see backup slide)

- Commissioning Roman Pots
  - → Alignment Run : vertical pots data are needed, if Pixel are already operative data taking with central DAQ?
  - → Insertions strategy probably as in 2016

- Detectors (more details in J. Hollar talk)

  - → the goal is to have the DQM ready for the new detectors
  - → for specific calibration checks the DIGI are needed
    (in Strips and Diamond DIGI are included in AOD; for Pixel not yet clear)

- Request MD to study the TCL4/5 aperture in order to optimize the acceptance (see backup slides)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CT-PPS acceptance

CT-PPS acceptance reduced with larger crossing angle (cancellation of dispersion from crossing angle and D1 magnets). In 2016 a dedicated orbit bump was introduced (after a late request) to improve the acceptance.

For 2017 the plan was to optimize optics (reduced beam size at pots so they can be inserted closer to beam) so bump would not be needed. However acceptance still worse than 2016 and CT-PPS requesting a bump to improve this. Available corrector strength for bump depends on beam-line re-alignment bump in IP5.

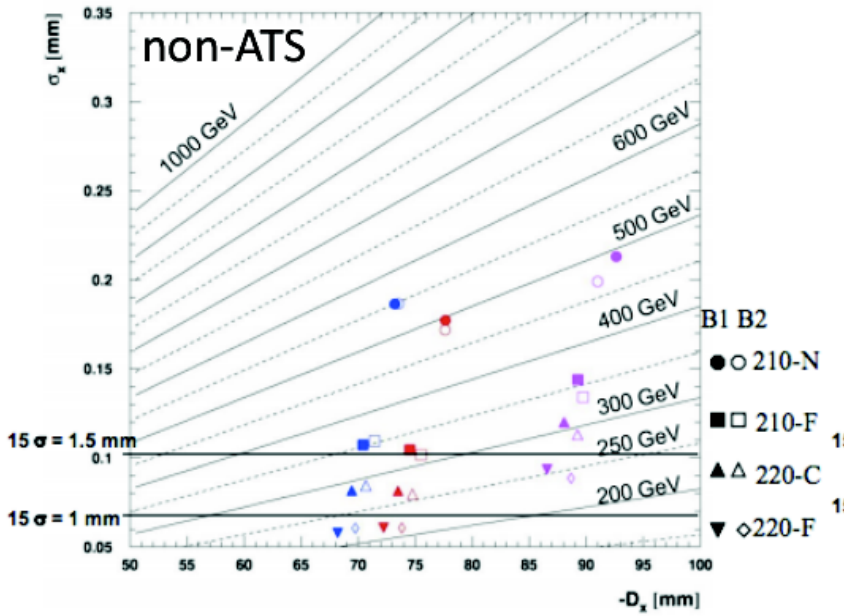
Minimum mass with acceptance (3 pots)
non-ATS ~300-350 GeV
ATS ~450-500 GeV
2016 with bump ~350 GeV

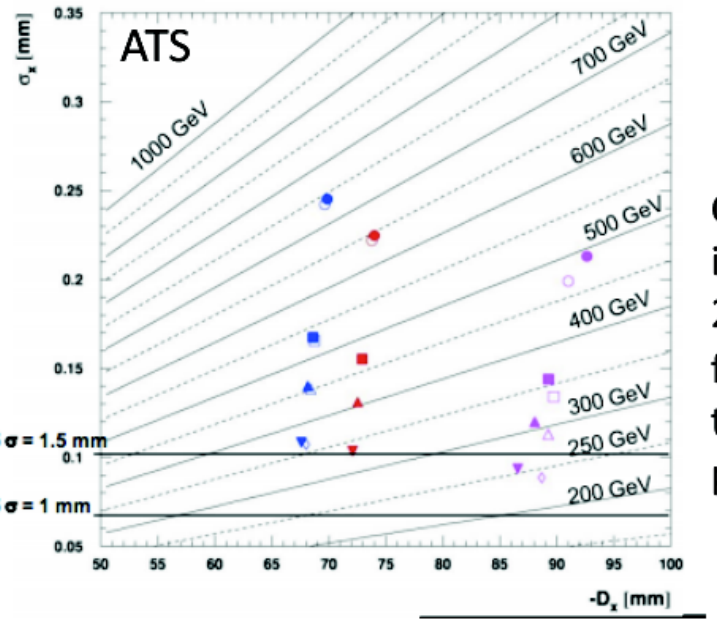
Plots from M. Deile

non-ATS, $\beta^* = 0.33$ m, $\alpha/2 = 170$ µrad

non-ATS, $\beta^* = 0.40$ m, $\alpha/2 = 155$ µrad

2016 After TS2: $\beta^* = 0.4$m, $\alpha/2 = 140$ µrad mild bump





CT-PPS pots inserted to 15σ in 2016 but 1.5mm from beam, closer than this may be problematic.

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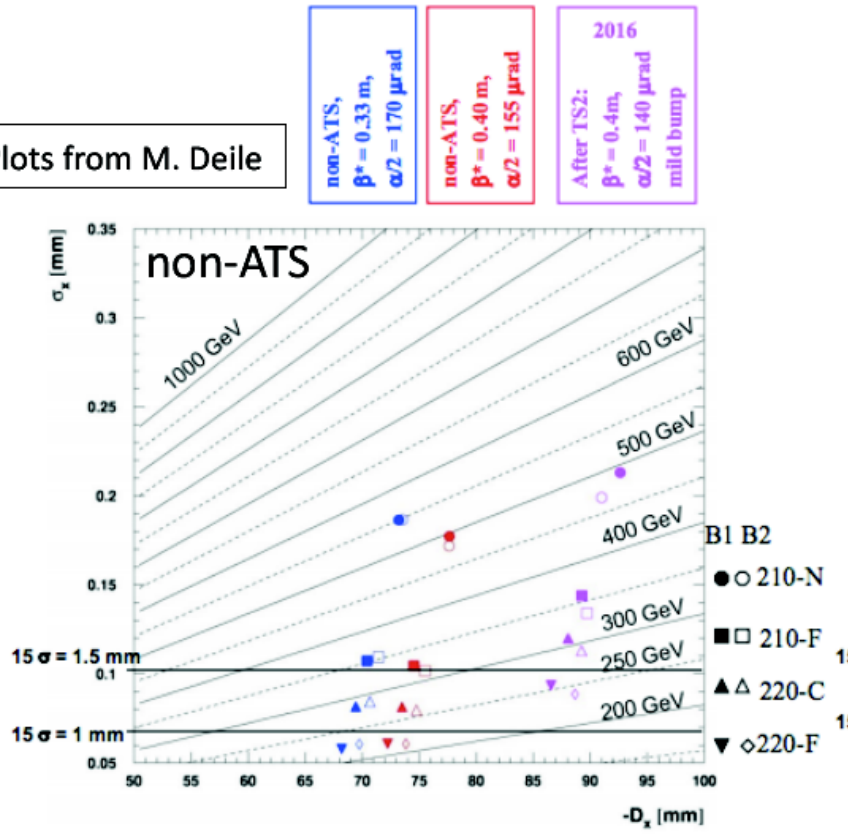
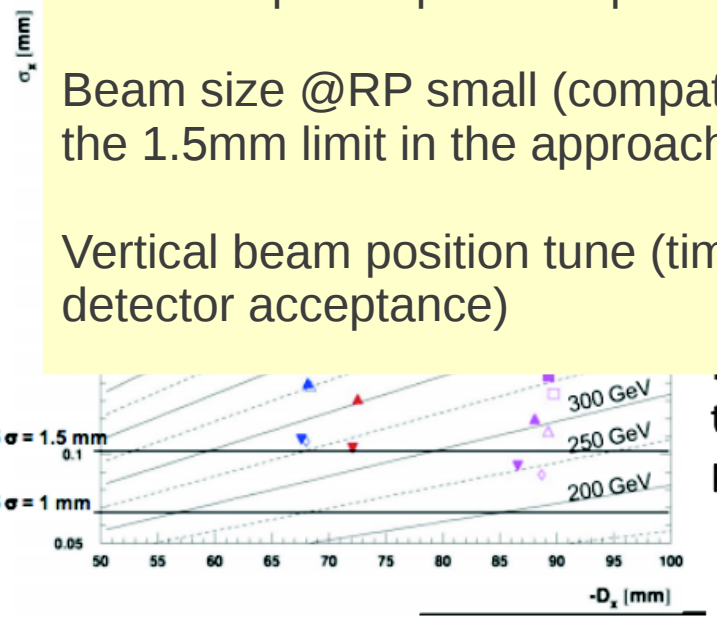
Plots from M. Deile





- Non-ATS optics preferred
- Crossing angle as small as possible
- Orbit bump to improve dispersion
- Beam size @RP small (compatible with the 1.5mm limit in the approach)
- Vertical beam position tune (timing detector acceptance)

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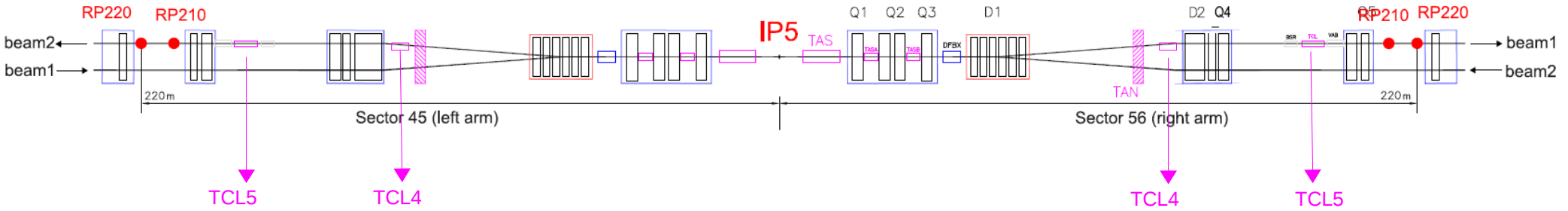
than this may be problematic.

TCL4/TCL5 aperture MD



In 2016 the aperture (with RPs inserted) was
TCL4 ~ 15σ
TCL5 ~ 35σ
corresponding to $\xi_{max}=\Delta p/p \sim 0.15$ [Mass ~ 2 TeV]

In the MD it should be tested if these apertures can be relaxed in order to extend the mass acceptance.

Some comments:

→ these collimators are on the OUTGOING beams
→ these collimators are supposed to protect the magnets: the MD is needed to establish up to which aperture they can go WITHOUT changing the conditions in IP5
→ in 2016 TCL5 was closed to 15σ when RP were NOT inserted: did central detector noticed any change in backgound?