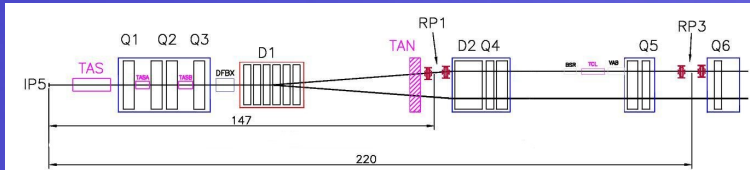


Roman Pot Alignment at TOTEM

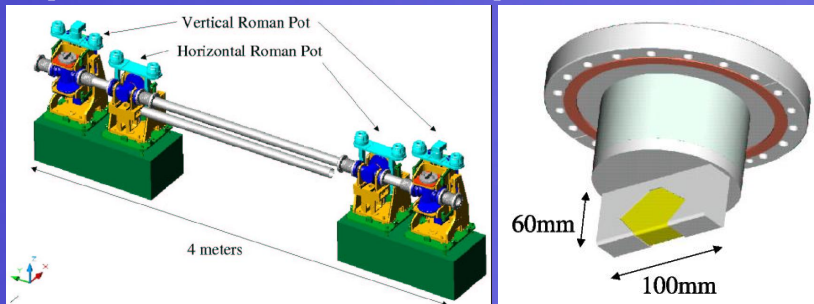
Jan Kašpar on behalf of the TOTEM Collaboration

TOTEM Roman Pots

- 2 Roman Pot stations at 147 m and 220 m from IP5 on both sides



- Station comprises 2 sets (in 4 meter distance) of top, bottom and horizontal RP.



- Each RP contains 5+5 silicon strip detectors with pitch 66 μm .

Alignment methods

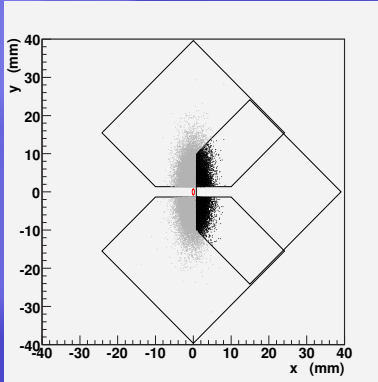
- The idea is to exploit **elastic scattering** and **diffraction** of protons.
- Two aspects:
 - 1) **Relative alignment** – alignment of detector pieces with respect to the others. I.e. alignment of detectors in a RP, RPs in a station and stations in both arms.
 - 2) **Absolute alignment** – alignment of the detector system with respect to the beam.
- Applicable methods:
 - **Rates comparison**, i.e. comparison of particle fluxes in top and bottom RPs. Simple and robust.
 - **Track & residual based** alignment. Powerful, especially in case of detector overlap. Problem with χ^2 -invariant misalignments. Millepede software package is planned to be used.
 - **Hit position** distribution analysis. Particularly comparison of distributions in top and bottom RP.
 - ***t*-distribution survey**.
 - Usage of **BPM**.
 - Combination of all: cross check and refinement.

Different optics – different conditions – different strategies

β^*	RP at 147 m	RP at 220 m
1535 m	Both components of hit position can be measured, large overlap of vertical and horizontal RPs. Ideal case.	
90 m	Both coordinates measurable, but L_x still quite low. Small vertical/horizontal RP overlap.	Only vertical coordinate can be measured, horizontal RP is not hit \rightarrow no overlap.
0.5 m	–	Exploiting mainly the horizontal RP, the vertical RPs get some hits too. Still reasonable overlap.

Table 1: Conditions at various optics.

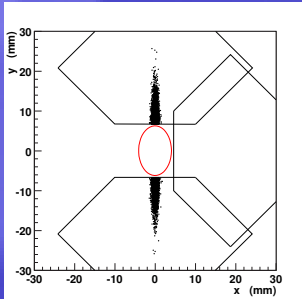
Strategy for the optics with $\beta^* = 1535$ m



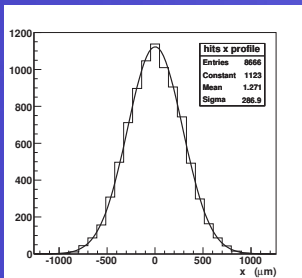
- One can employ tracked based alignment.
- Bottom, top and horizontal RPs well aligned due to the large overlap (26% of elastic events).
- Distance between top and bottom RP given by the horizontal RP.
- By rates comparison, top and bottom RP can be placed symmetrically around the beam \Rightarrow we know distance between the beam and the detector edge.
- Horizontal hit distribution in vertical RPs \Rightarrow horizontal alignment of the RP system with respect to the beam.

Strategy for the optics with $\beta^* = 90$ m

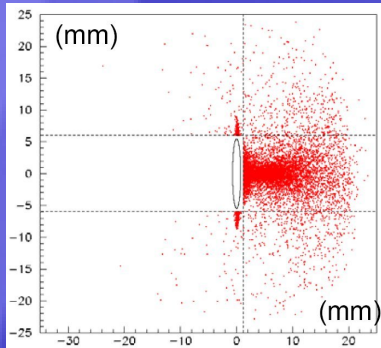
- For the 147 m station, one may in principle apply the same strategy as above.



- At the 220 m station, the horizontal RP is not hit (even for diffractive events) \Rightarrow issue with absolute alignment. Still under investigation.
- Misalignment is not the limiting issue – it is the beam divergence. Compared to the 1535 m optics it is even enforced by factor $\sqrt{3.75}$ due to higher emittance.
- Relative error $\delta_t \sim \Delta / \sqrt{|t|}$. $|t|_{min}$ accessible at this optics is $10\times$ greater than for the 1535 m optics (due to thicker beam) \Rightarrow error of hits used for extrapolation to $t = 0$ is suppressed by factor $\sqrt{10}$ compared to the dedicated optics.
- Horizontal alignment achieved with the use of the horizontal hit distribution.



Strategy for the optics with $\beta^* = 0.5$ m



- Similar strategy to the 1535 m optics.

Making use of BPM

- Another issue: beam position variation during a run.
- BPM absolute precision is $\approx 200 \mu\text{m}$ while relative precision goes down to $5 \mu\text{m}$. Hence, the BPM might be used to watch beam variations and enhance alignment results.

Backup

- Known problems of tracking based alignment
 - χ^2 -invariant misalignments
 - it is not sensitive to shifts along detector strips
 - both effects are reduced by particle rates analysis

