Acceptance, Resolution and Alignment for ATLAS RP220

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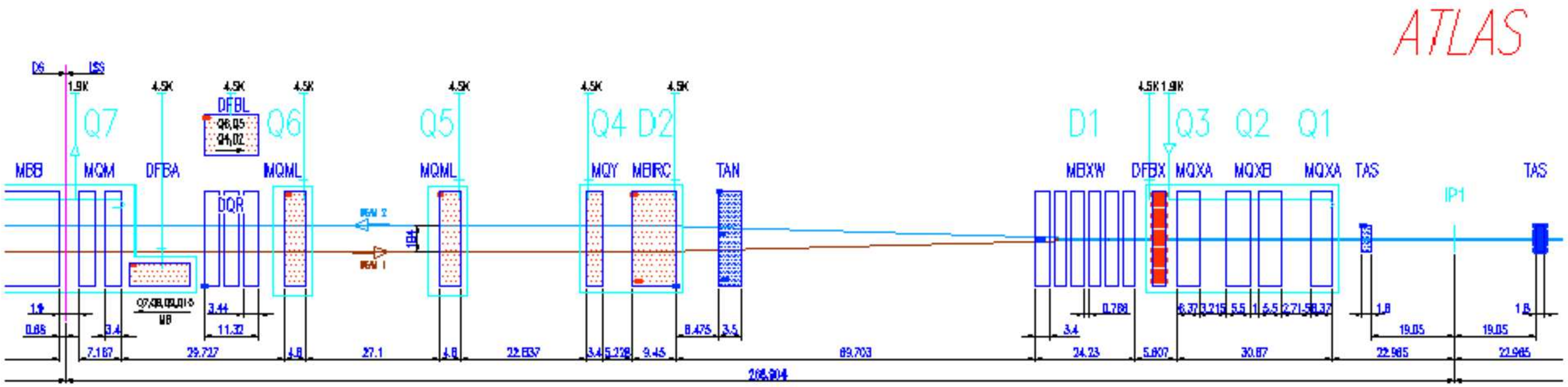
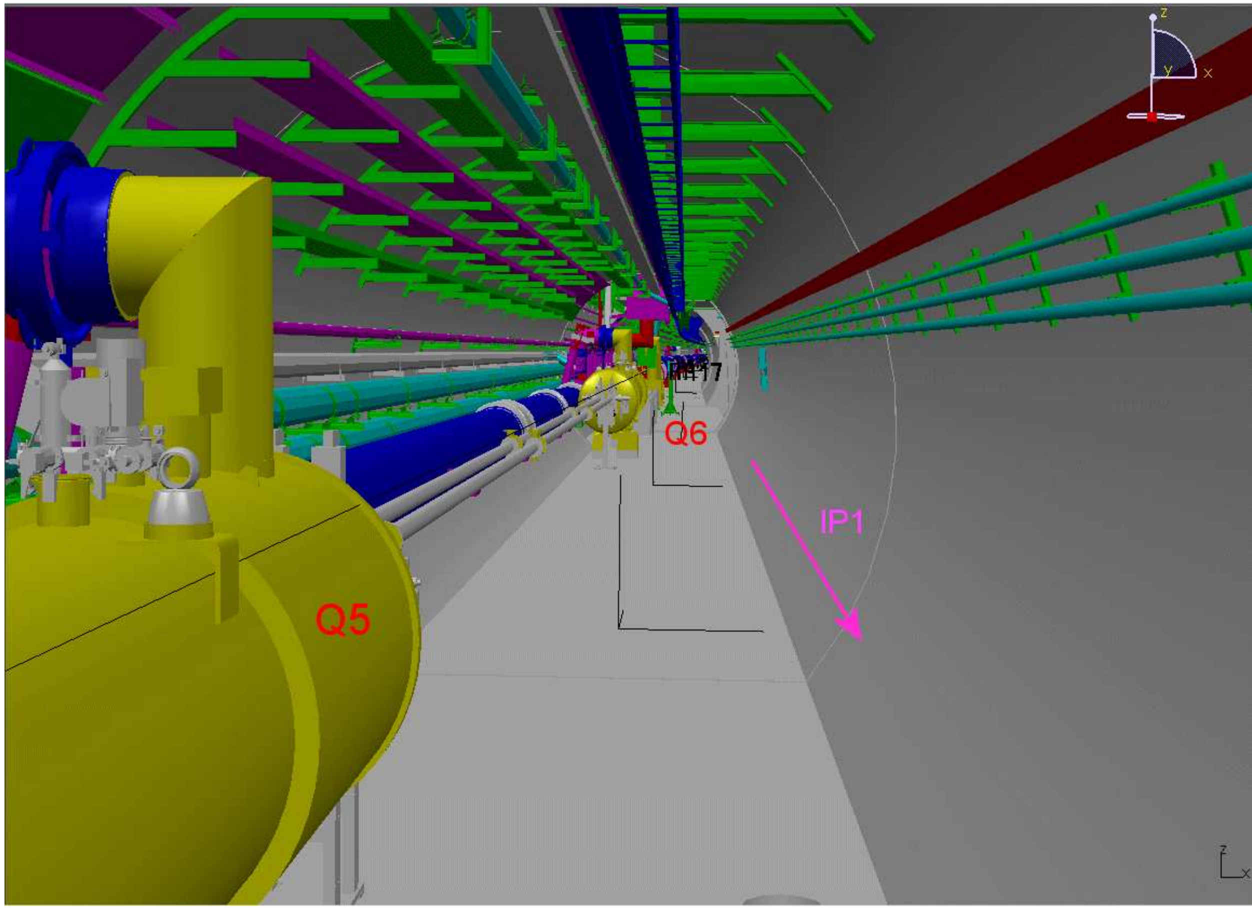
- acceptance in ξ and M_X
- resolution in M_X
- elastics and RP calibration

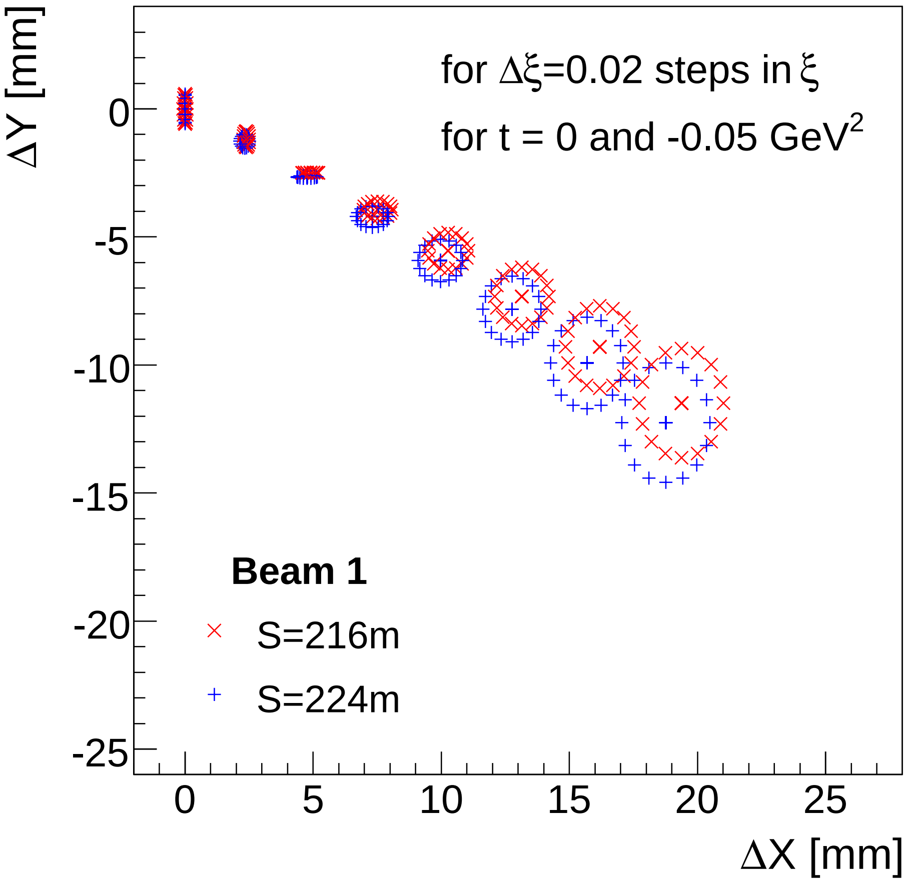
LHC beam-pipe at 220m



- consider space between Q5 (200m) and Q6 (226m)
- try to optimize the performance in terms of acceptance at low values of ξ and in terms of missing mass resolution
- Proposal: two stations at 216 and 224 meters



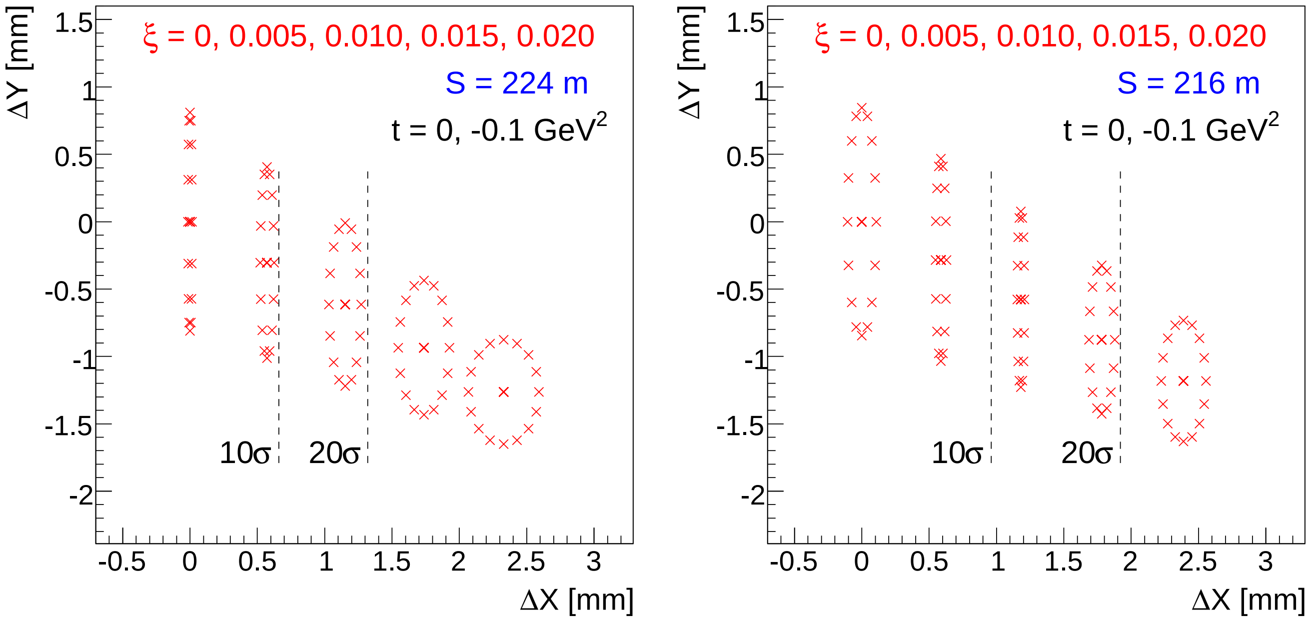
Acceptance in ξ



- MadX tracking with LHC6.5 low-β optics
- diffractive protons deflected mostly in the horizontal direction away from the ring center (the best possible configuration)
- similar, for the second beam

- aperture of LHC optics stops protons with $\xi > 0.15 \Rightarrow$ determines the detector size to be about 2×2 cm

Acceptance at low values of ξ



- 2×2 cm detector
- $200 + 50\,\mu$m dead edge

10σ

- beam 1: $0.010 < \xi < 0.15$
- beam 2: $0.012 < \xi < 0.14$

15σ

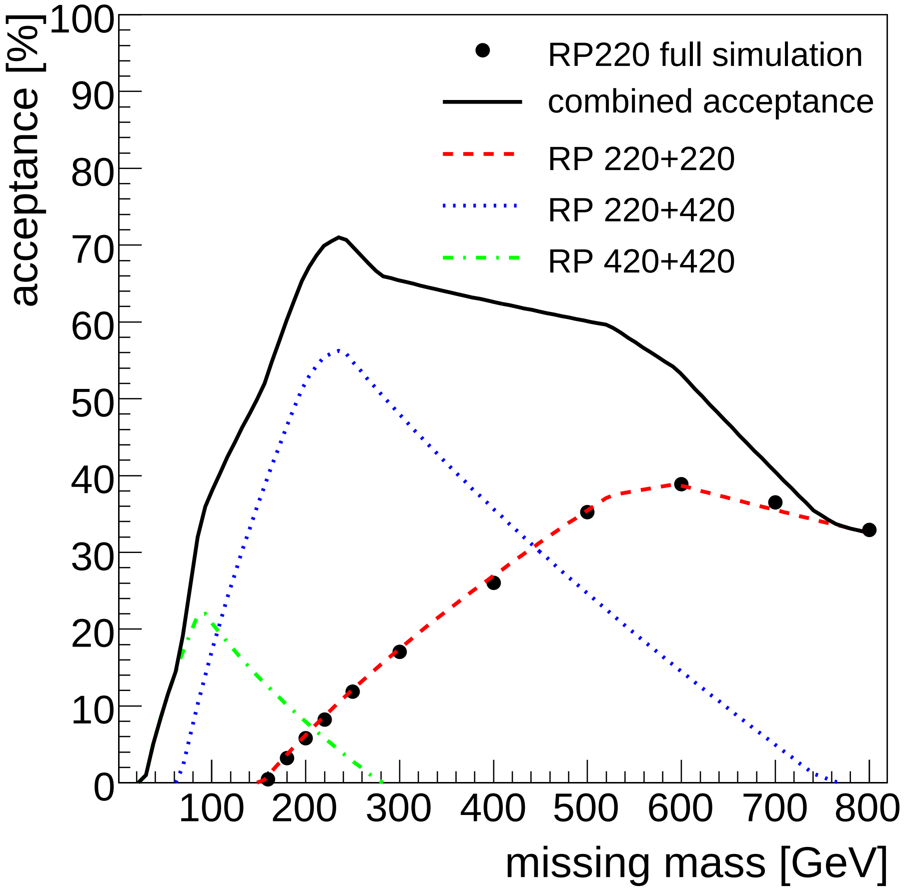
- beam 1: $0.014 < \xi < 0.15$
- beam 2: $0.016 < \xi < 0.14$

20σ

- beam 1: $0.018 < \xi < 0.15$
- beam 2: $0.021 < \xi < 0.14$

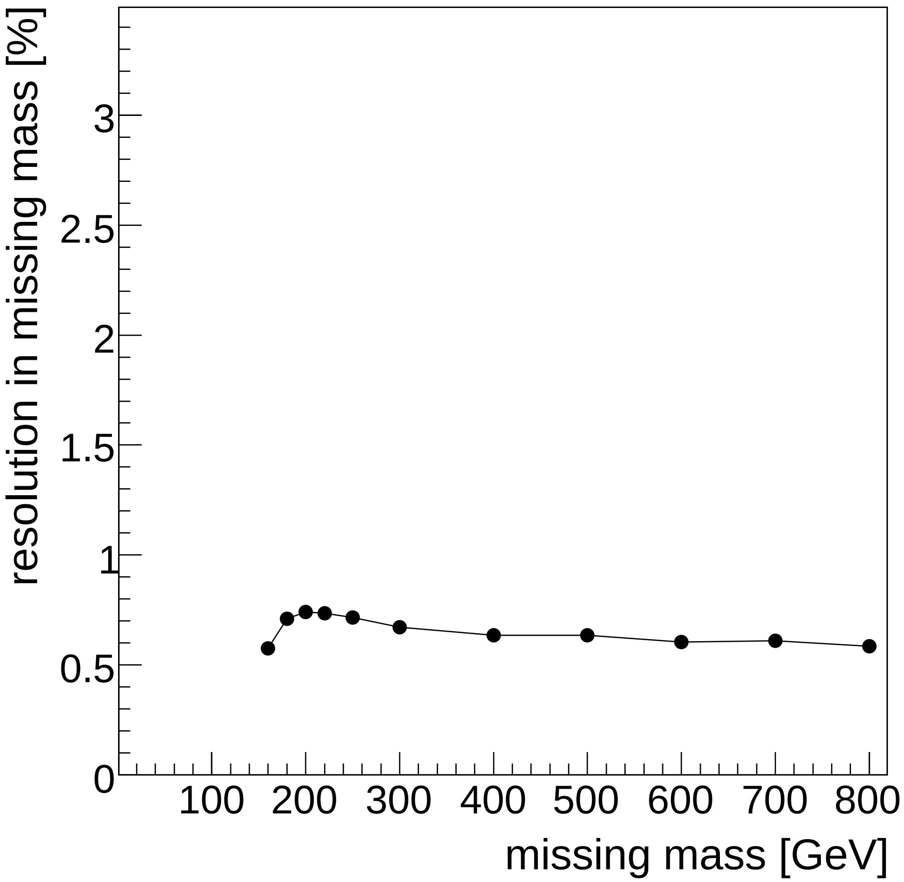
- best acceptance is around Q6 magnet
- spectrometer acceptance is determined by the RP that is closer to the IP
- larger distance between stations means better resolution

Acceptance in M_X



- computed assuming $F(\xi) \propto 1/\xi$ distribution for DPE events
- analytical results in good agreement with full simulation
- RP420 acceptance was assumed to be $0.002 < \xi < 0.02$ (only analytical calculation)
- complementarity with RP420 project: combined acceptance covers wide range in M_X

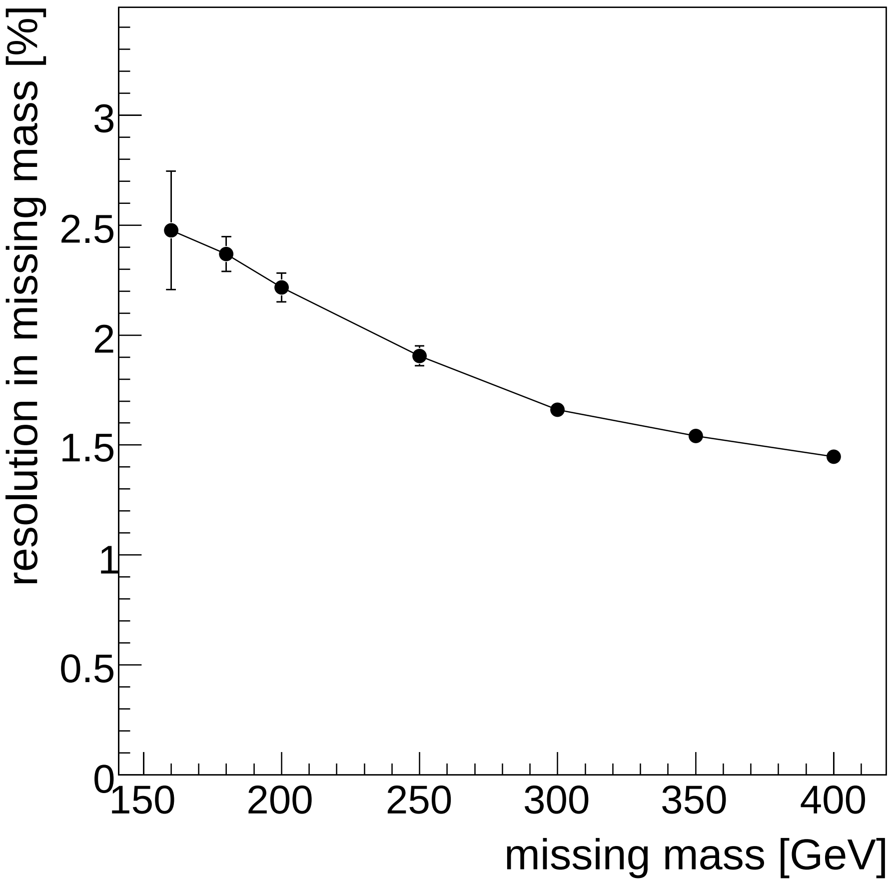
Missing mass resolution



- reconstruction code:
  - precomputed table in ξ,p_T, and ϕ for hits in the two RP stations
  - linear interpolation
  - tracks reconstructed using brute force by minimizing χ^2
  - full detector simulation being developed by Krakow group
- for $\sigma_i = 10\,\mu$m, the expected detector resolution is about 0.6%

- realistically, due to uncertainties in the detector alignment, final precision of about $15 - 20\,\mu$m can be achieved
- 8 meters distance between RP stations gives acceptable resolution of about 1%

Beam influence on M_X resolution



- beam energy ($\sigma_E = 0.77$ GeV) and angular spread ($\vartheta_{x,y} = 30.2\,\mu$rad) have negligible effect on M_X resolution
- this is not true for the beam transversal size ($\sigma_{beam} = 16.6\,\mu$m)
- interaction region is smaller

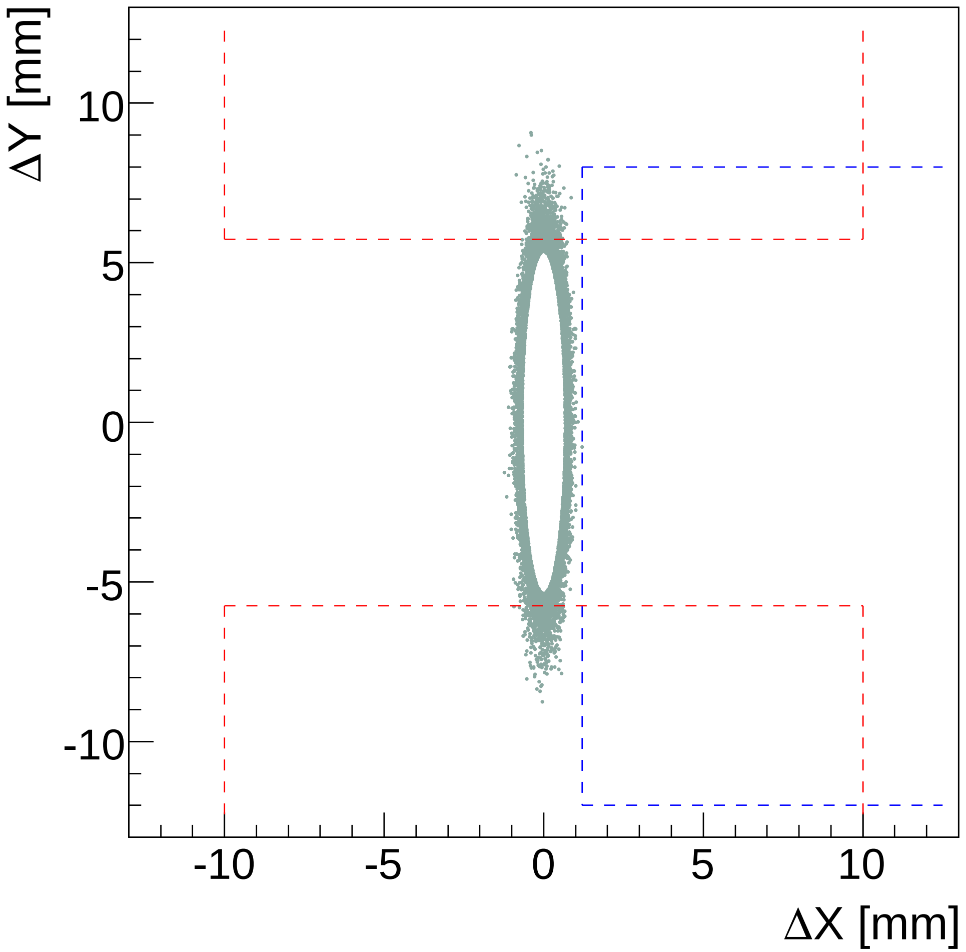
$$\sigma_{int} = \sigma_{beam}/\sqrt{2} = 11.7\,\mu\text{m}$$

but it still leads to large resolution degradation

- we would clearly benefit if the ATLAS central tracker can constrain vertex transversal position with accuracy better than 10 microns
- protons reconstructed independently, resolution may improve if one uses the information that both are coming from the same vertex

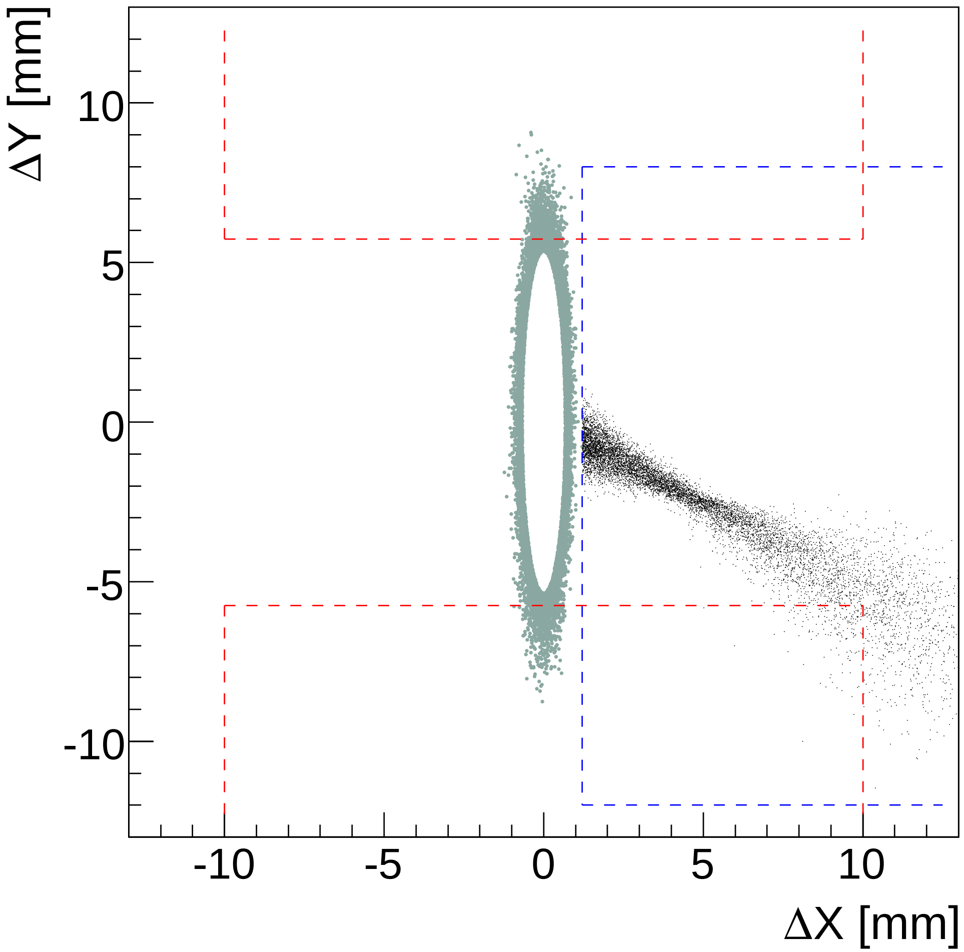
Using elastics for alignment/calibration

- Can we use some events to align/calibrate our detectors?
- $pp \to p\mu\mu p$ cross section drops with $M_{\mu\mu}$, good for RP420 but probably not for RP220



- operating at $10\sigma + 0.25$ mm:
  - $\sim 2\pm0.4$ elastic events per day expected in horizontal RP
  - $\sim 10^4$ elastic events per day expected in vertical pots
- operating at $15\sigma + 0.25$ mm
  - $p_T > 3$ GeV for vertical pots $\Rightarrow \sim 100$ events per day
- operating at $20\sigma+0.25$ mm ($p_T > 4$ GeV) would mean seeing 0.2 events per day

Overlap for soft SD events



- soft SD cross section is $14\,\text{mb}$ $\rightarrow 10^{12}$ events per store
- out of them, $\sim 0.02\%$ (0.005% for 15σ) are in the overlapping region with vertical RP
- should be more than enough to perform relative vertical-to-horizontal cross alignment
- we still need to evaluate how much we would benefit from elastic events in terms of improving the calibration of missing mass M_X

Summary

- Configuration of proton spectrometers with roman pots at 216 and 224 meters gives reasonable balance in missing mass acceptance and resolution
- Proposed RP detectors will significantly improve the accessible range in missing mass with respect to RP420 only
- Required spatial resolution of the detectors is about $\sim 10\,\mu$m, and similar precision must be reached for the detectors alignment with respect to the beam position
- Under this conditions, the dominant contribution to the missing mass resolution is the smeared vertex transversal position
- Detection of elastic events is possible if vertical roman pots are built in addition to the horizontal ones. However, we need to understand how much we can benefit from them.