Roman Pot Insertions in High-Intensity Beams for the CT-PPS Project at the LHC

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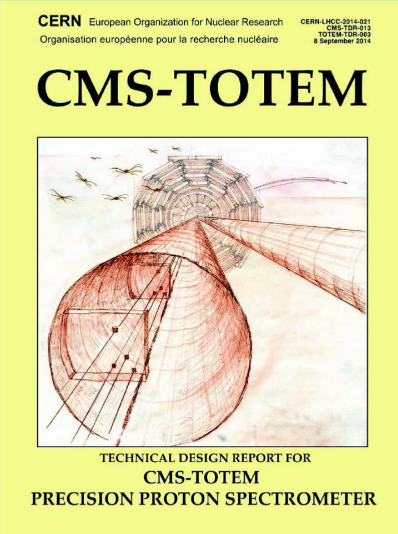
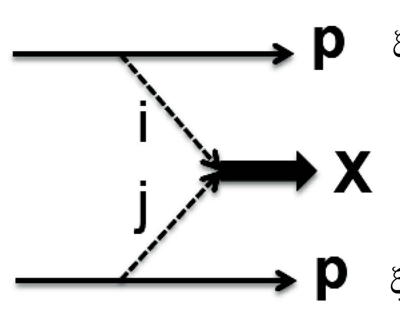
The CMS - TOTEM Precision Proton Spectrometer (CT-PPS) Project
(founded in 2014)

Technical Design Report [CERN-LHCC-2014-021]



Physics Objective: Central Production with 2 surviving protons:



$\xi_1 = \Delta p_1 / p$ = fractional momentum loss

750 GeV resonance ?

X = high E_T jets, Z, WW, ZZ, $\gamma\gamma$… measured in central CMS detectors → reconstruction of mass M_X

$\xi_2 = \Delta p_2 / p$

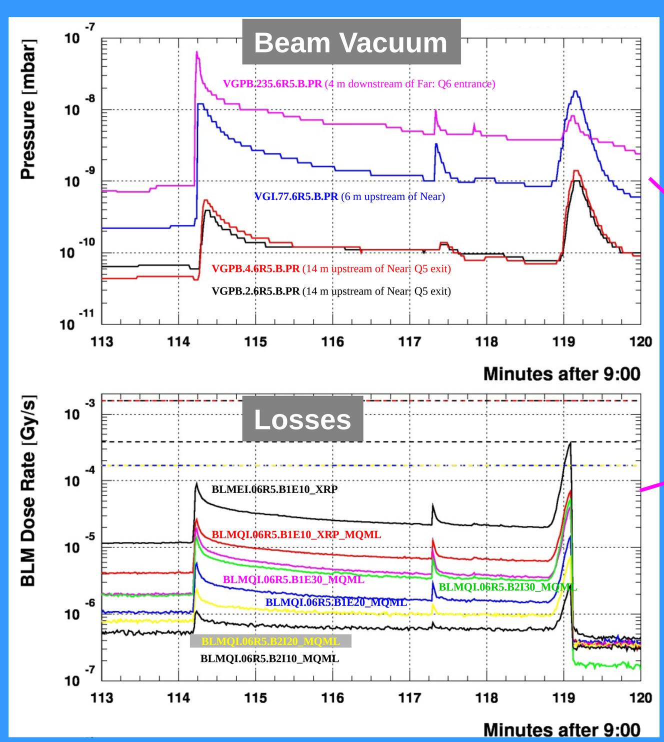
kinematic redundancy proton system – central system, e.g. $M_X^2 = \xi_1 \xi_2 s$

i, j = photon, Pomeron / Odderon (gluonic) exchanges

Detection of both surviving protons with Roman Pots:

- Tracking detectors: reconstruction of the momentum losses ξ_1, ξ_2
- Time-of-flight detectors: measurement of longitudinal vertex position → vertex identification in high pileup
  first diamond detectors to be installed in June 2016 !

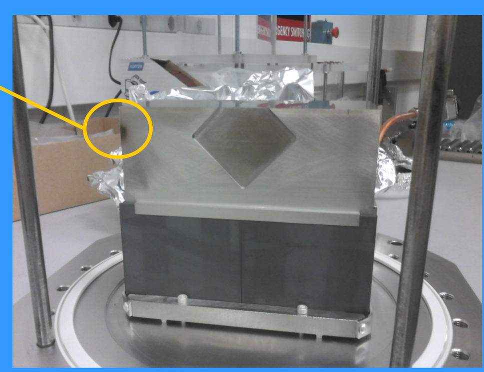
First RP Insertion Tests with High Intensity Beams before the Long Shutdown 1: Impedance Problems

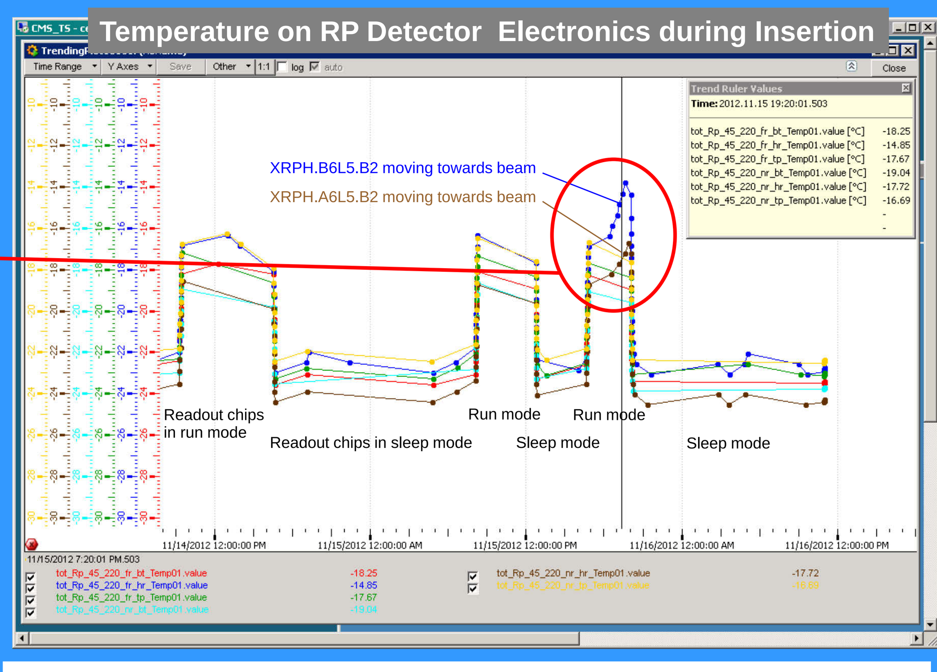


Impedance heating combined with outgassing:

- temperature rise on electronics cards inside RPs despite active cooling
- trace (black spot) of metal overheating on inserted RP box next to a broken ferrite
- ferrite (Ferroxcube 4S60, not baked out at 1000 °C) outgassing
  → beam vacuum deterioration
  → amplification of collision debris showers → strong correlation of vacuum and BLM signals

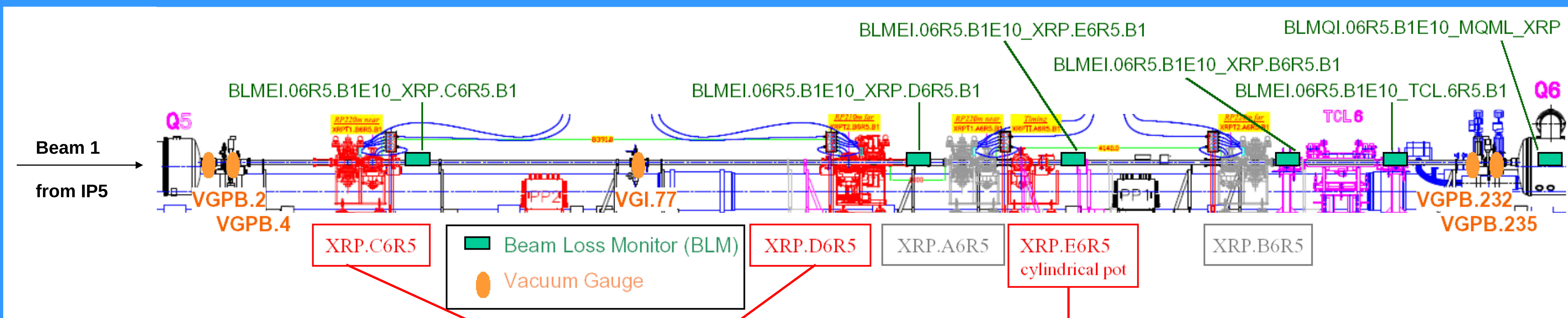
No beam instabilities observed



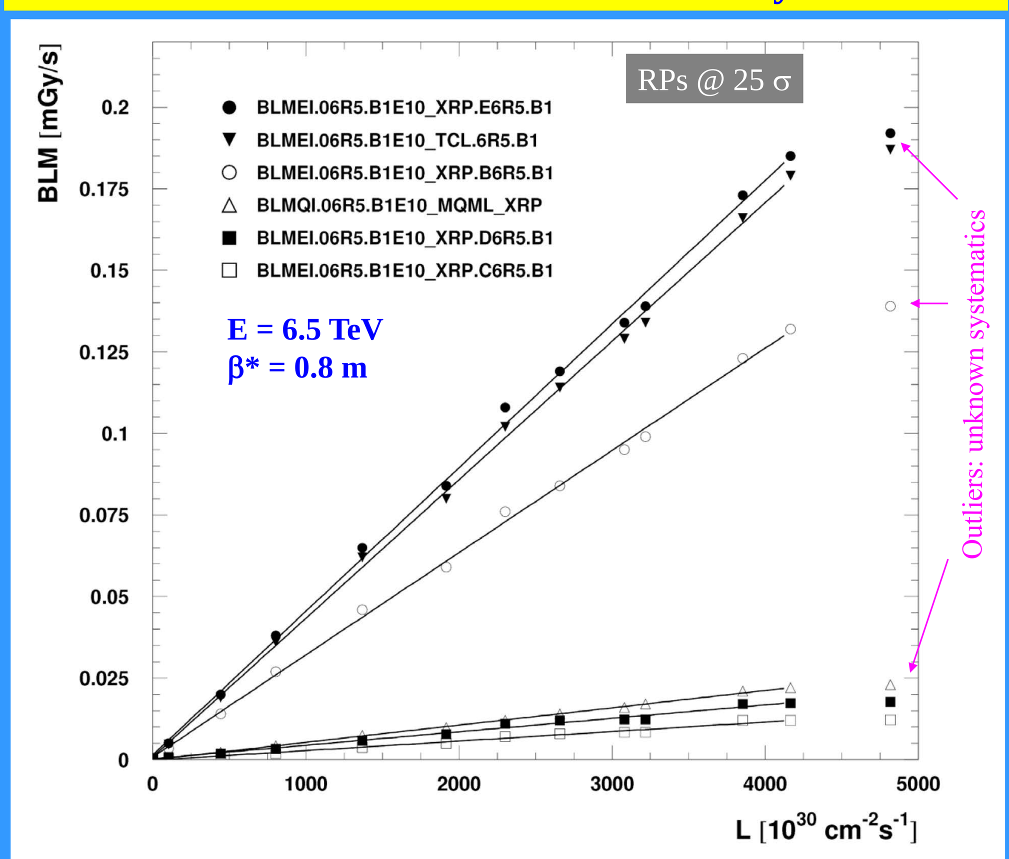


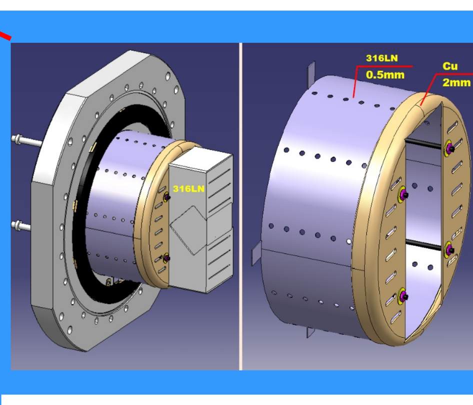
Main temperature effect from R/O chips changing to run mode; additional increase (3 °C) from pots moving to ~ 3 mm from the beam.

The TOTEM / CT-PPS Roman Pot System after Long Shutdown 1: symmetric about IP5, shown here: sector 5-6

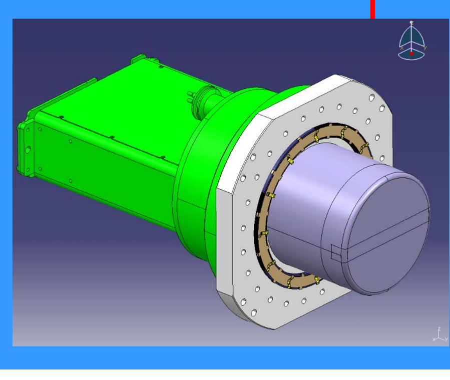


Collision Debris Showers Interacting with the RP as a Function of the Luminosity





RF shield for old box-shaped RPs
(no cavities → resonance minimisation)

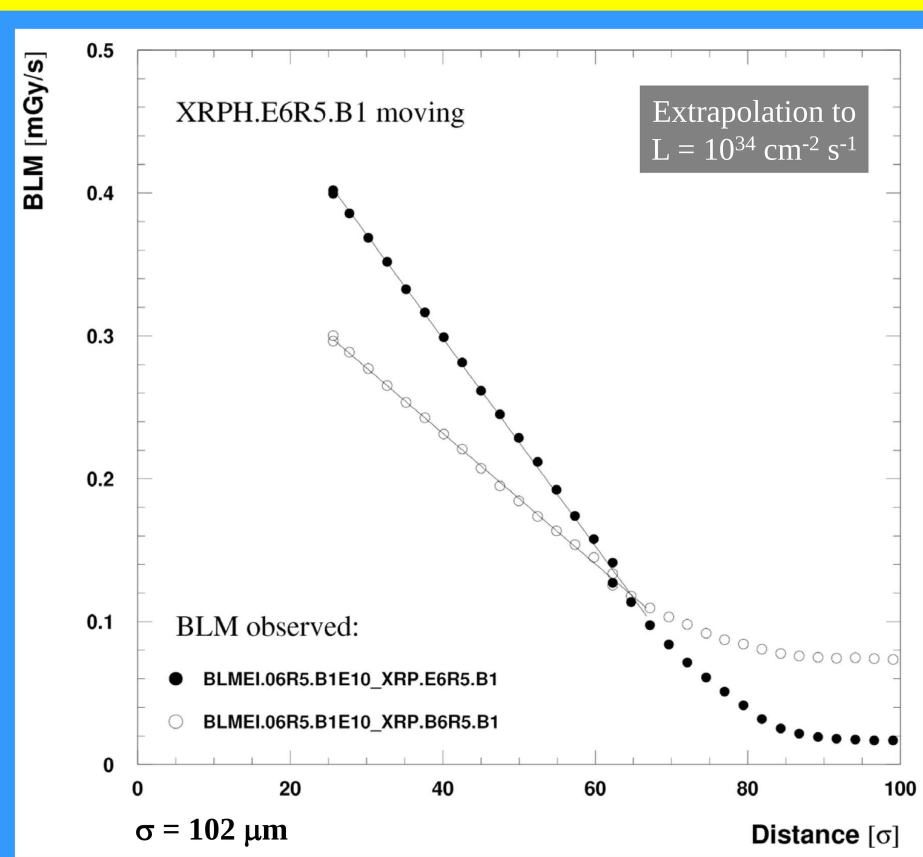


Impedance-optimised cylindrical RP
(no cavities → resonance minimisation)

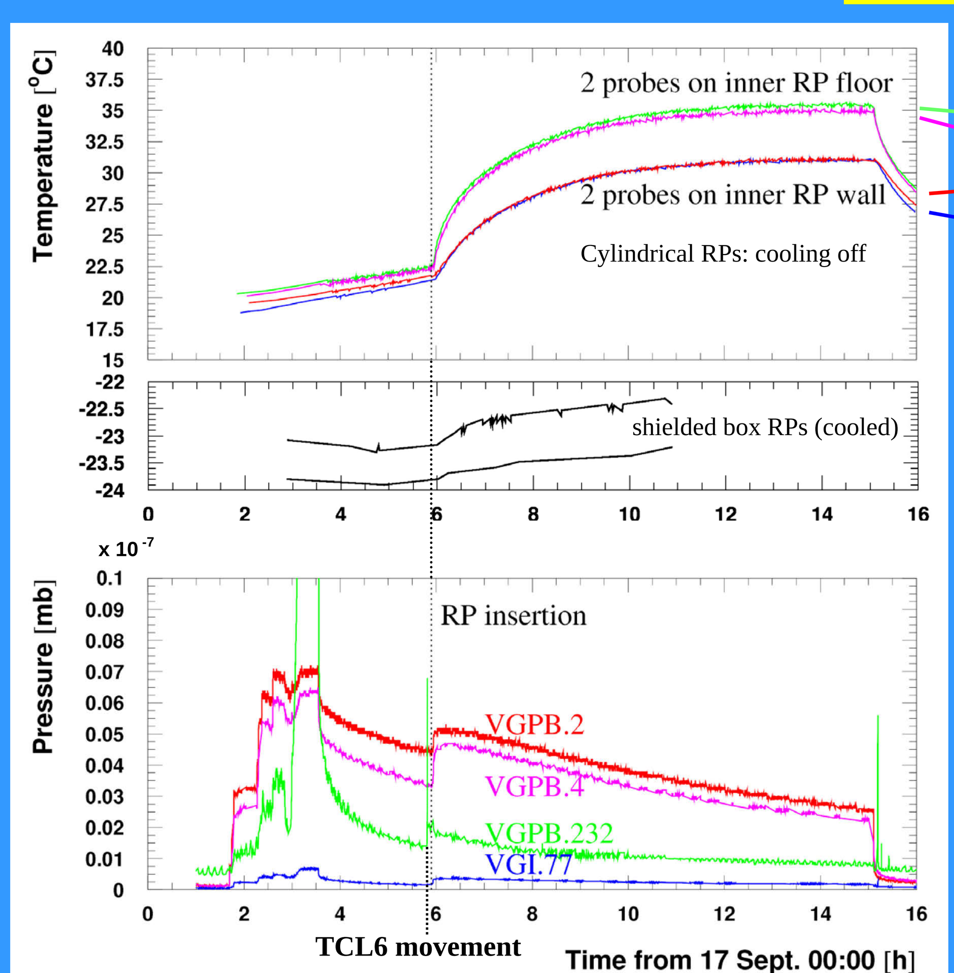
New ferrite material for all RPs (Transtech TT2-111R, higher Curie temperature) baked out at 1000 °C

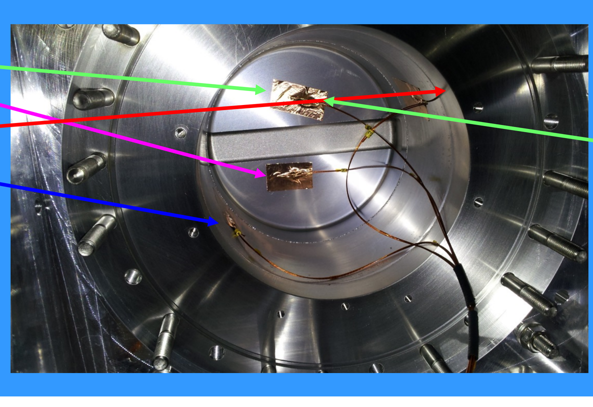
- Dose rates proportional to luminosity (showers = collision debris)
  Linear extrapolation to L = 10^{34} cm^{-2} s^{-1} : BLM(XRP.E6R5) = 0.47 mGy/s = **0.07 Threshold**
  → no problem from BLMs expected
- RP generating strongest shower dose rate: cylindrical pot: most material along the beam: 12cm (old box pot: 5cm)
- Strong dose rate in BLM of TCL6, very small signals in BLMs of Q6 → **TCL6 is effective**

Collision Debris Showers Interacting with the RP as a Function of the Distance from the Beam



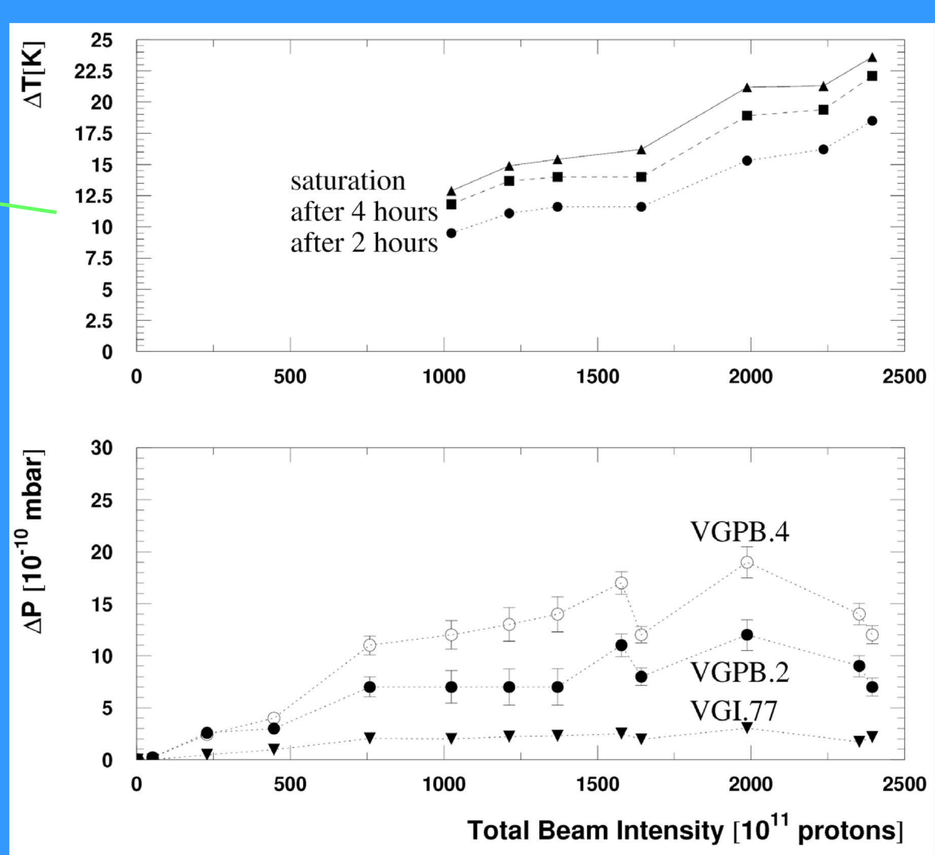
RP Temperature and Beam Vacuum Response to RP Insertion





PT100 temperature probes glued on the inner walls (barrel and floor) of the cylindrical RP in sector 4-5

- Slow temperature increase starting at RP insertion and tending towards saturation
- Immediate, moderate vacuum pressure rise at RP insertion, no further increase following the temperature
- Vacuum response to RP insertion only visible for VGPB.2, VGPB.4, VGI.77; spike in VGPB.232 occurs earlier at TCL6 movement



Summary:

- BLM response:
  linear with luminosity and with insertion distance
  extrapolation to 10^{34} and to 15 σ distance:
  no problem expected.
- Vacuum pressure:
  unclear dependence on luminosity, generally rising,
  other strong systematic effects,
  no problem expected
- Temperature in RP:
  moderate increase with beam intensity,
  no problem expected.
  Active cooling will protect detectors
- No beam instabilities introduced

Plan for 2016:

- **RP insertions to 15 σ + 0.5 mm, later to 15 σ**
- **Physics data taking with diamond timing detectors**