

# TOTEM

Status of Roman Pot CONSOLIDATION & UPGRADE PROGRAM

TOTEM RP 210/220 m stand alone (special runs)  
TOTEM&CMS (low  $\beta^*$  & high luminosity)  
RP integration of tracking/timing detectors  
RP – horizontal insertion at low  $\beta$

# Overview

- Presentation of TOTEM RP consolidation & upgrade plans in different meetings:
    - 1) CMS-TOTEM (management) meeting on 5.10.2012
    - 2) LTEX meeting on 8.11.2012
    - 3) 1st LHC workshop on Collider Experiment Interface on 30.11.2012
- + several CMS-TOTEM technical meetings

# Roman Pot consolidation & upgrade strategy

## Upgrade of RP detector system at 210m

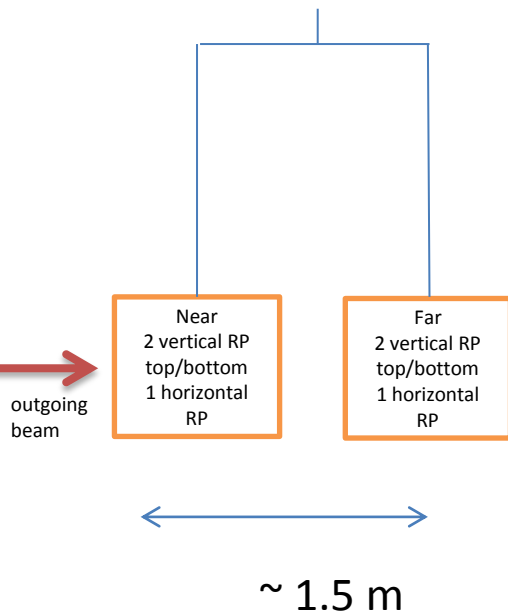
- Remove RP147m and relocation at 210m
- Installation of additional RPs (horizontal) at 210m
- Integration of timing and pixel detectors in horizontal RPs

### Guideline:

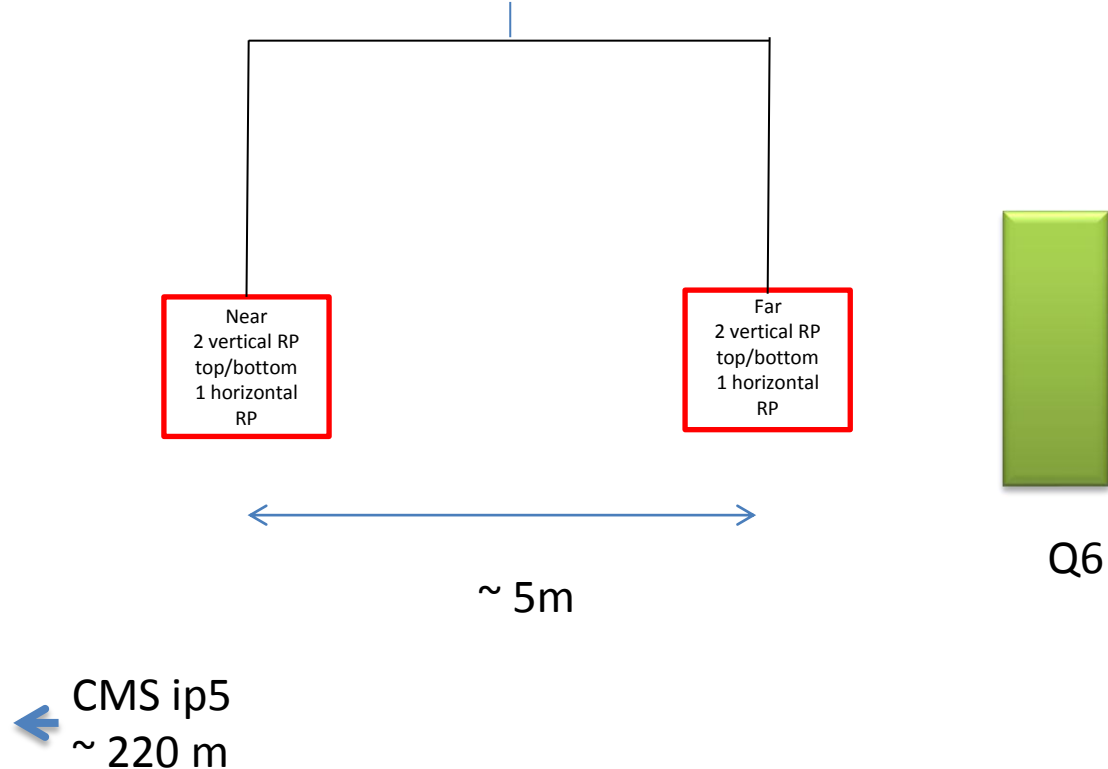
- Reinstallation of RP 147m stations at 210m
- Re-use of RP 147m infrastructure as much as possible (motor, cables etc.)
- The new horizontal RPs could be installed during **LS1** and equipped immediately/successively with new tracking & timing detectors.
- The present 220m stations must not be affected (touched) by any upgrade activity, until the high beta special runs after **LS1** are finished.  
(Research Board approved stand alone program of TOTEM at full LHC energy)
- The timing detectors are installed downstream relative to the tracking detectors. (high material budget).
- Depending on the running scenario after LS1 (physics high  $\beta^*$ /low  $\beta^*$ , calibration, alignment), relevant RPs are inserted or retracted (parking position).

# Present RP installation at IP5

TOTEM RP-147m (near-far)



TOTEM RP-220m (near-far)



# Remarks on Roman Pot detectors

- The TOTEM physics program at high  $\beta^*$ , special runs and p-A will be performed with the RP detectors at +/- 220m and relocated RP detectors from +/- 147m in the region of +/- 210m.
- Possible additional RP detectors in the region of +/- 210m from IP5 are presently discussed in the framework of “detector upgrade studies” by TOTEM in collaboration with CMS  
(related to diffractive physics at low  $\beta^*$  and high luminosities)

# Main goals of TOTEM experiment

- Measurement of total cross section

$$\sigma_{TOT}^2 = \frac{16\pi(\hbar c)^2}{1+\rho^2} \cdot \left. \frac{d\sigma_{EL}}{dt} \right|_{t=0}$$

Using luminosity from CMS

$$\frac{d\sigma_{EL}}{dt} = \frac{1}{L} \cdot \frac{dN_{EL}}{dt}$$

$\rho$  parameter from compete fit

$$\sigma_{TOT} = \frac{16\pi(\hbar c)^2}{1+\rho^2} \cdot \frac{\left. \frac{dN_{EL}}{dt} \right|_{t=0}}{N_{EL} + N_{INEL}}$$

Luminosity independent

TOTEM detectors integrated in CMS (T1, T2)

TOTEM detectors integrated in LHC (RP)

- Forward multiplicity
- Diffractive physics  
(soft& hard diffraction, jets)

TOTEM (stand alone)

TOTEM&CMS at low/high $\beta^*$ , special runs

TOTEM&CMS at low  $\beta^*$  and high luminosity

## TOTEM operation beyond LS2 in special runs – high $\beta$

# LHC operation



## Update of the European Strategy for Particle Physics



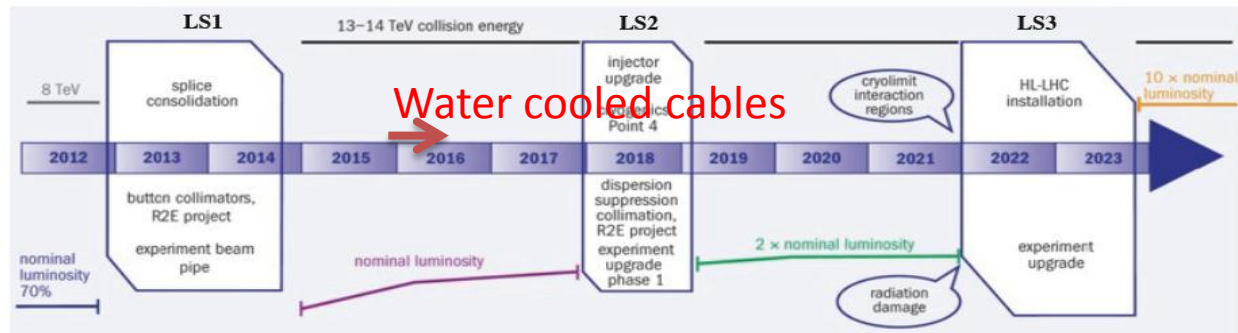
With contributions from accelerators side and experiments, submitted to the [Open Symposium](#) in Krakow 10-12/9/2012

The list of all contributions is on the web [here](#) ,

with [HL-LHC](#), [LIU](#), [HE-LHC](#) (20 T,  $2 \times 16.5$  TeV,  $2 \times 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$ )

and separated contributions from the experiments.

Based on a common timeline and parameters

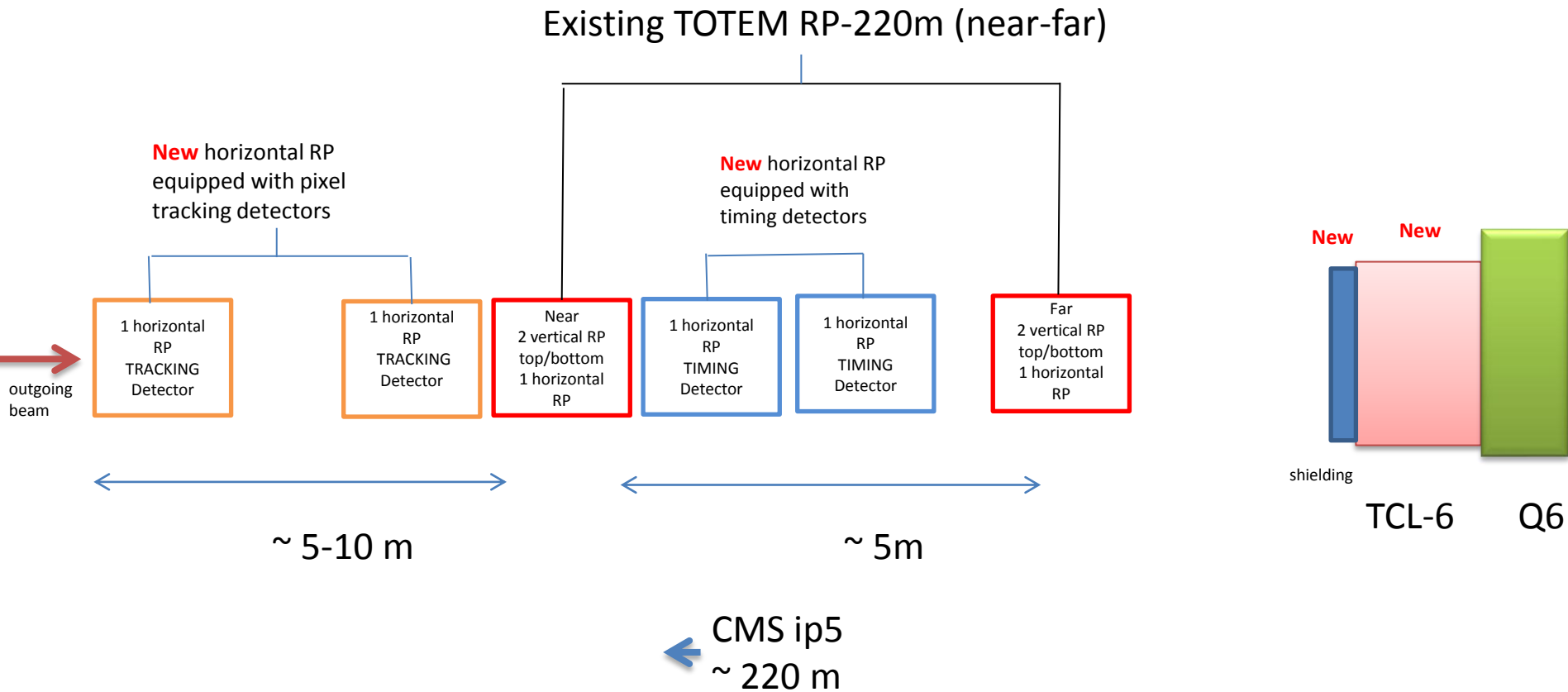


LHC baseline plan for the next ten years. In terms of energy of the collisions (upper line) and of luminosity (lower lines). The first long shutdown 2013-14 is to allow design parameters of beam energy and luminosity. The second one, 2018, is for secure luminosity and reliability as well as to upgrade the LHC Injectors.

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→ TOTEM operation with RP +/- 220 - and +/-210m after LS2 in special runs

# Roman Pot upgrade overview (schematic)



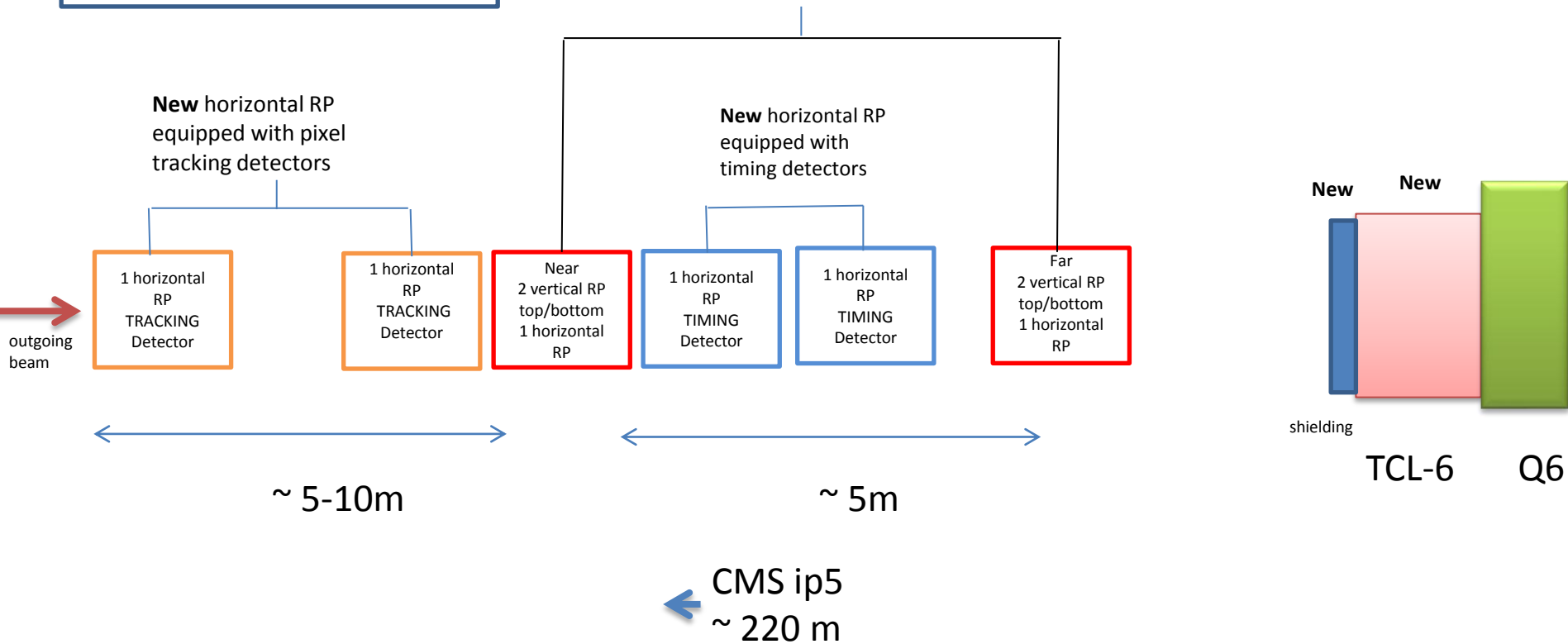


# Roman Pot (schematic-phase 1)

**CALIBRATION & Alignment -RUNNING** with high  $\beta^*$  & low luminosity

Possibility to test new timing & tracking detectors in the LHC environment →  
Tests in combination with existing RP detectors

Existing TOTEM RP-220m (near-far)



# Roman Pot (schematic-phase 1)

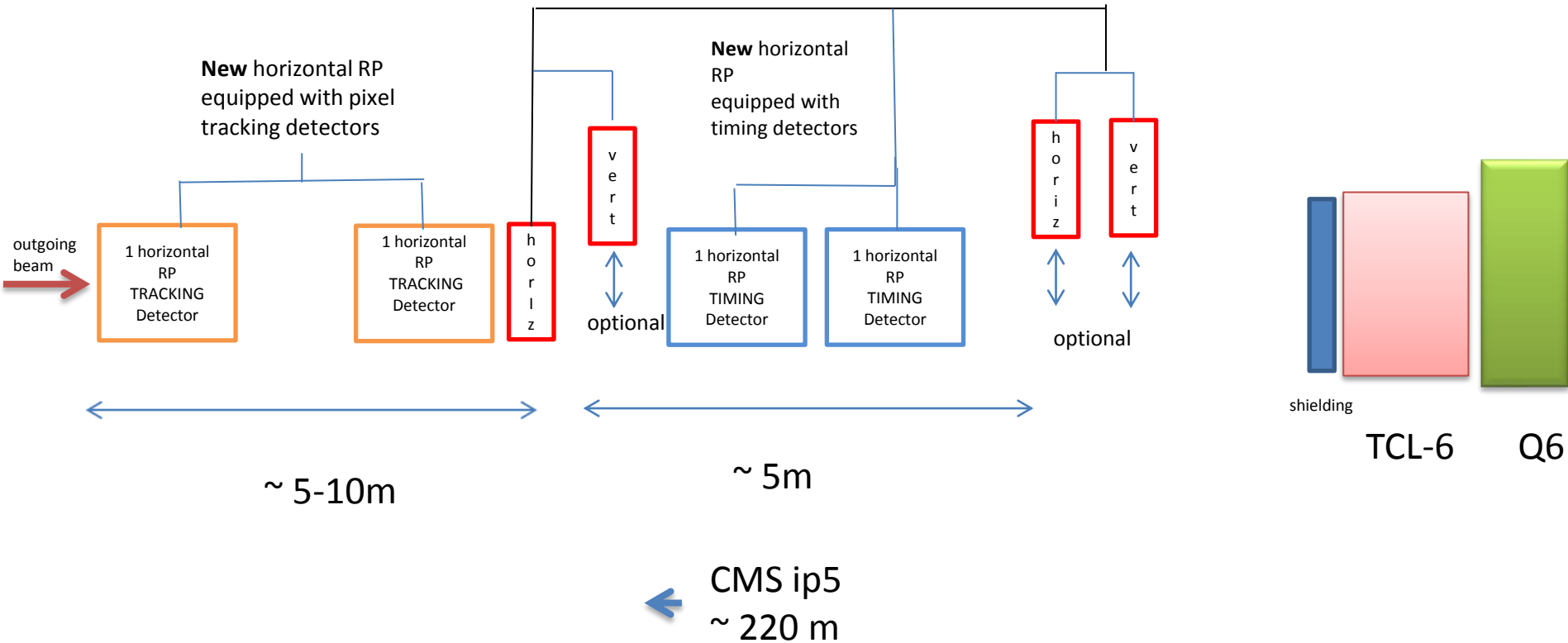
**PHYSICS-RUNNING** with low beta\* & high luminosity

horizontal and vertical RPs (far) are retracted (parking position) &

vertical RPs (near) are retracted (parking position)

horizontal RP near inserted

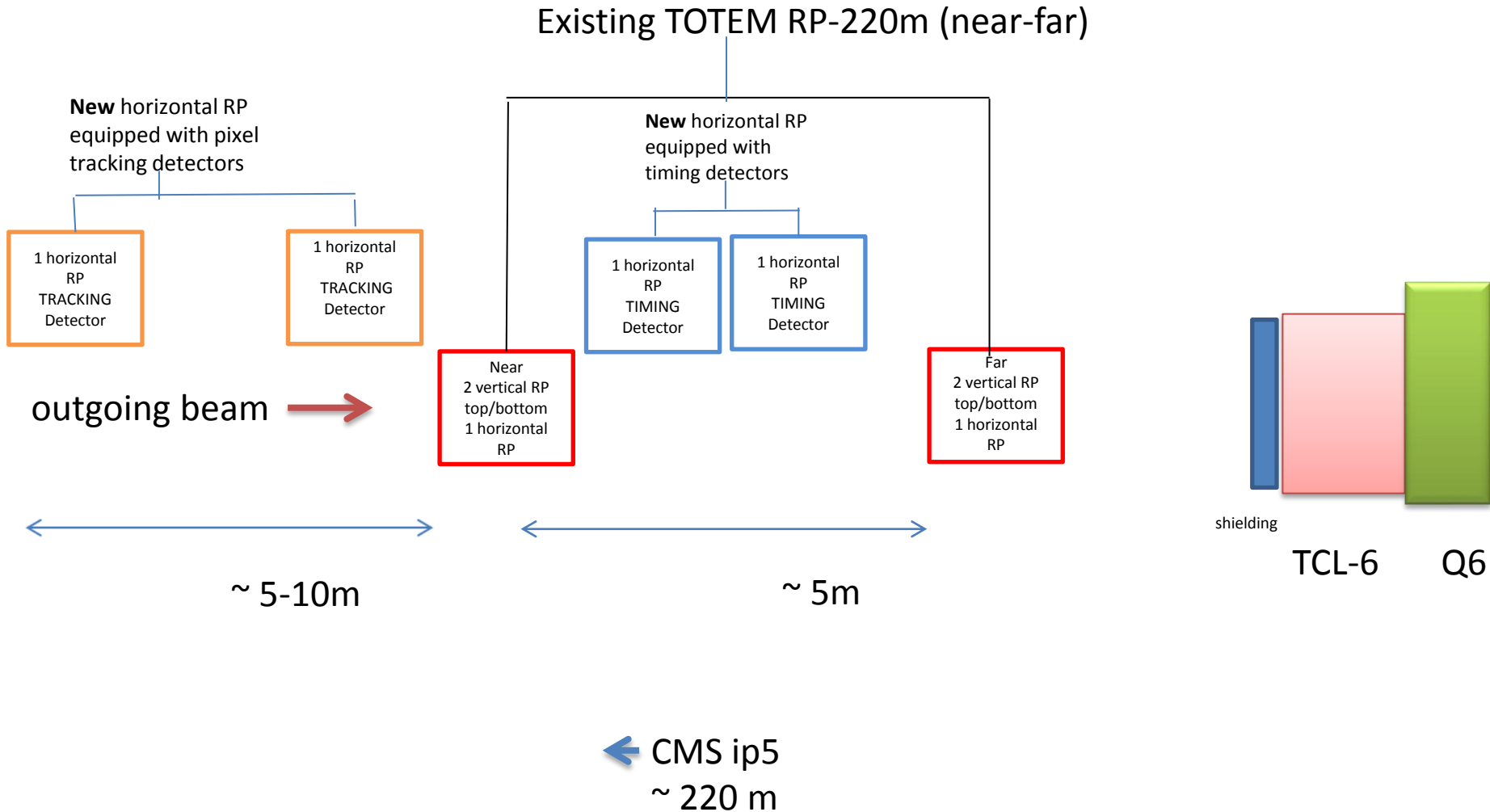
## Existing TOTEM RP-220m (near-far)



# Roman Pot (schematic-phase 1)

PHYSICS-RUNNING with high  $\beta^*$  & low luminosity

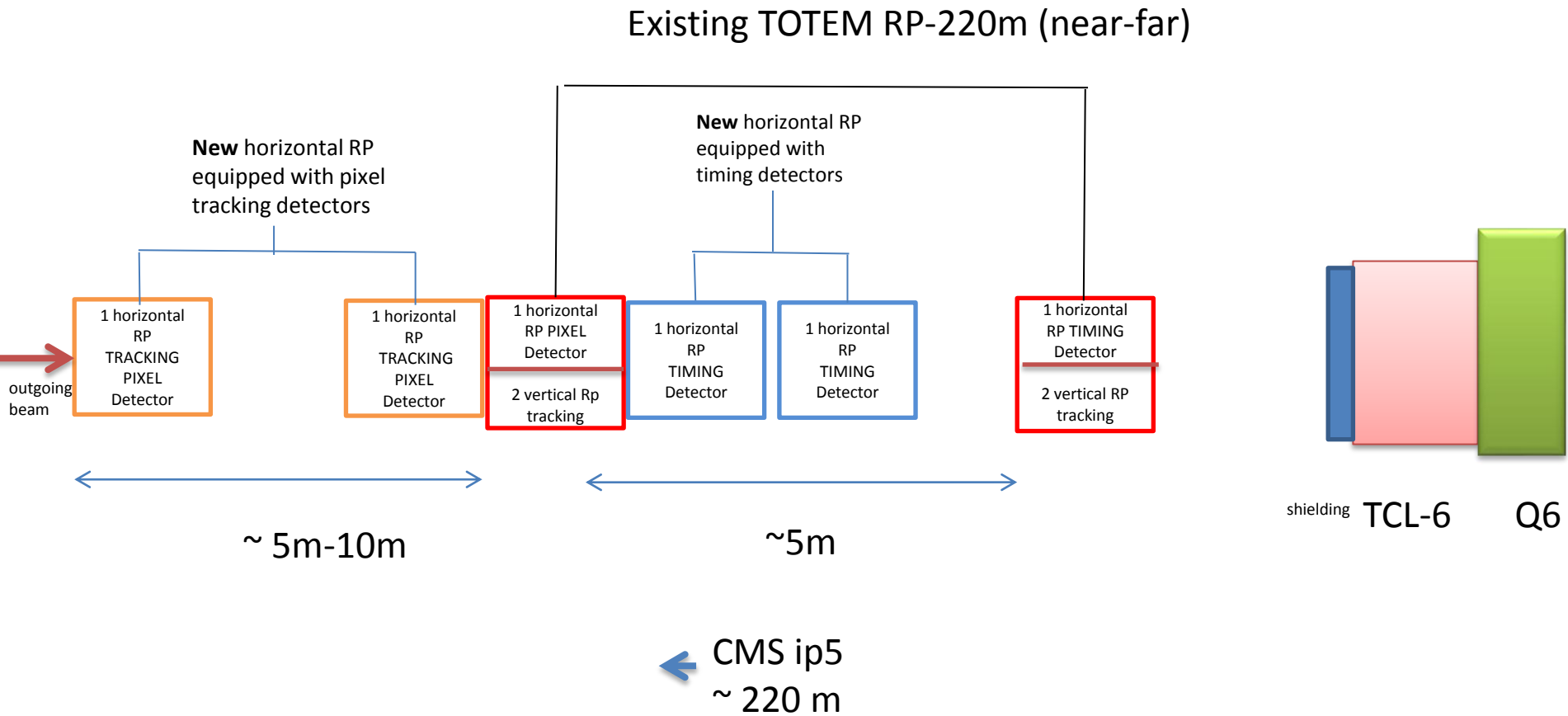
NEW installed horizontal RPs are retracted (parking position)



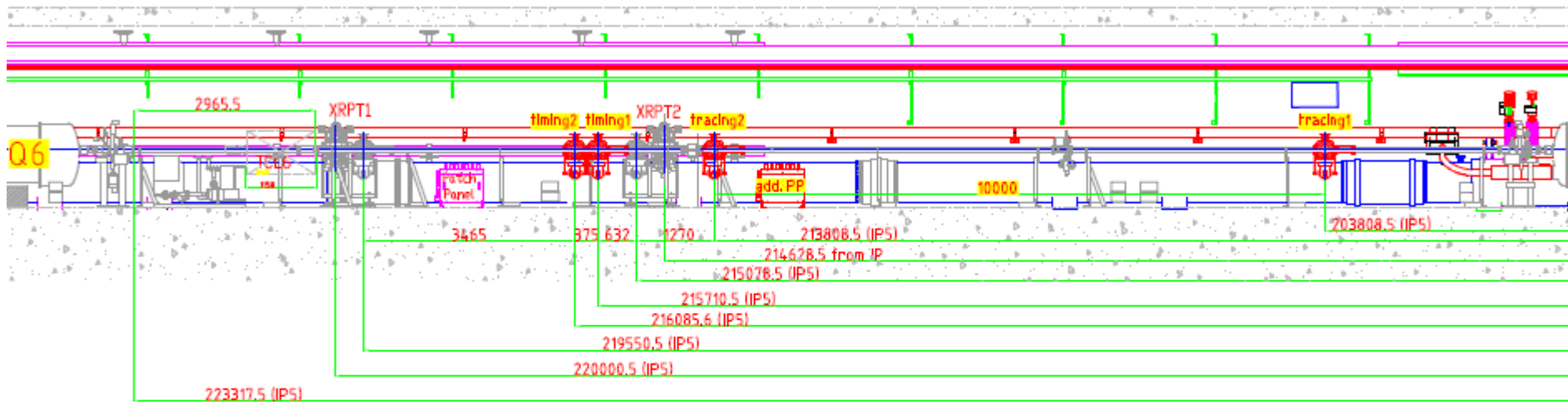
# Roman Pot (schematic-phase 2)

## PHYSICS-RUNNING with low $\beta^*$ & high luminosity

### ALL horizontal RPs are inserted



# Integration study of new horizontal RPs at 200m



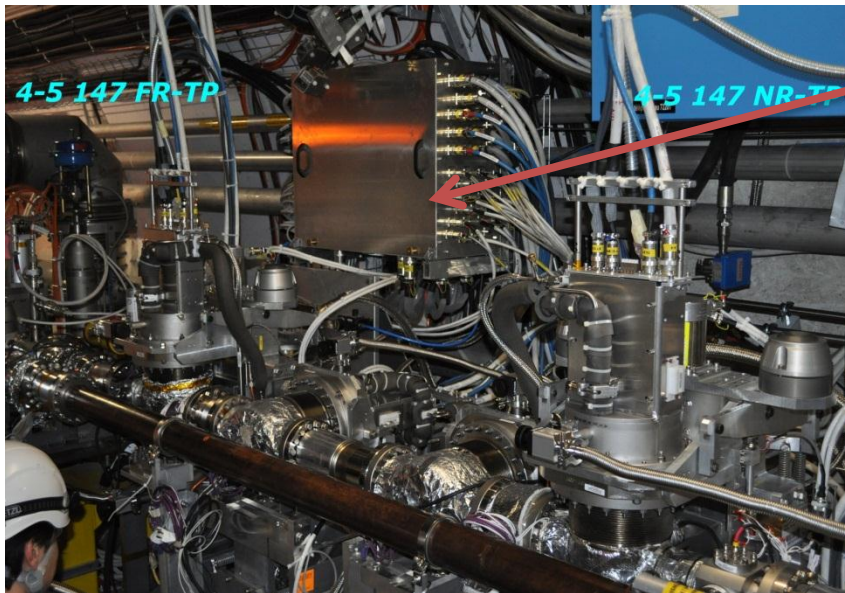
Sector 4/5

# Work packages → Roman Pot installation

(CMS, PH-DT, EN-CV, BE-ABP-ICE, LTEX)

- **WP1-T: removal of RP@147m**  
(Radio protection, RP stockage, machining of flanges)
- **WP2-T: transfer of supplies from 147m -> 220m**  
(motor power lines, patch panel, LV, + new HV)
- **WP3-T: installation of new fibres**
- **WP4-T: RP@147m motor & mechanics**  
(preparation for reuse at 220m, adaptation of mechanics, installation of motors etc.)
- **WP5-T: Flanges – interface to LHC**  
(adaptation of thin window, rotation by 90° for timing detector, flanges, beam-pipe )
- **WP6-T: beam-pipe**
- **WP7-T: LHC Impedance study**  
(impedance study – RP was approved for highest luminosities -> RP rotated by 90°, concentration at 220m)

# Roman Pot at 147m & 220m

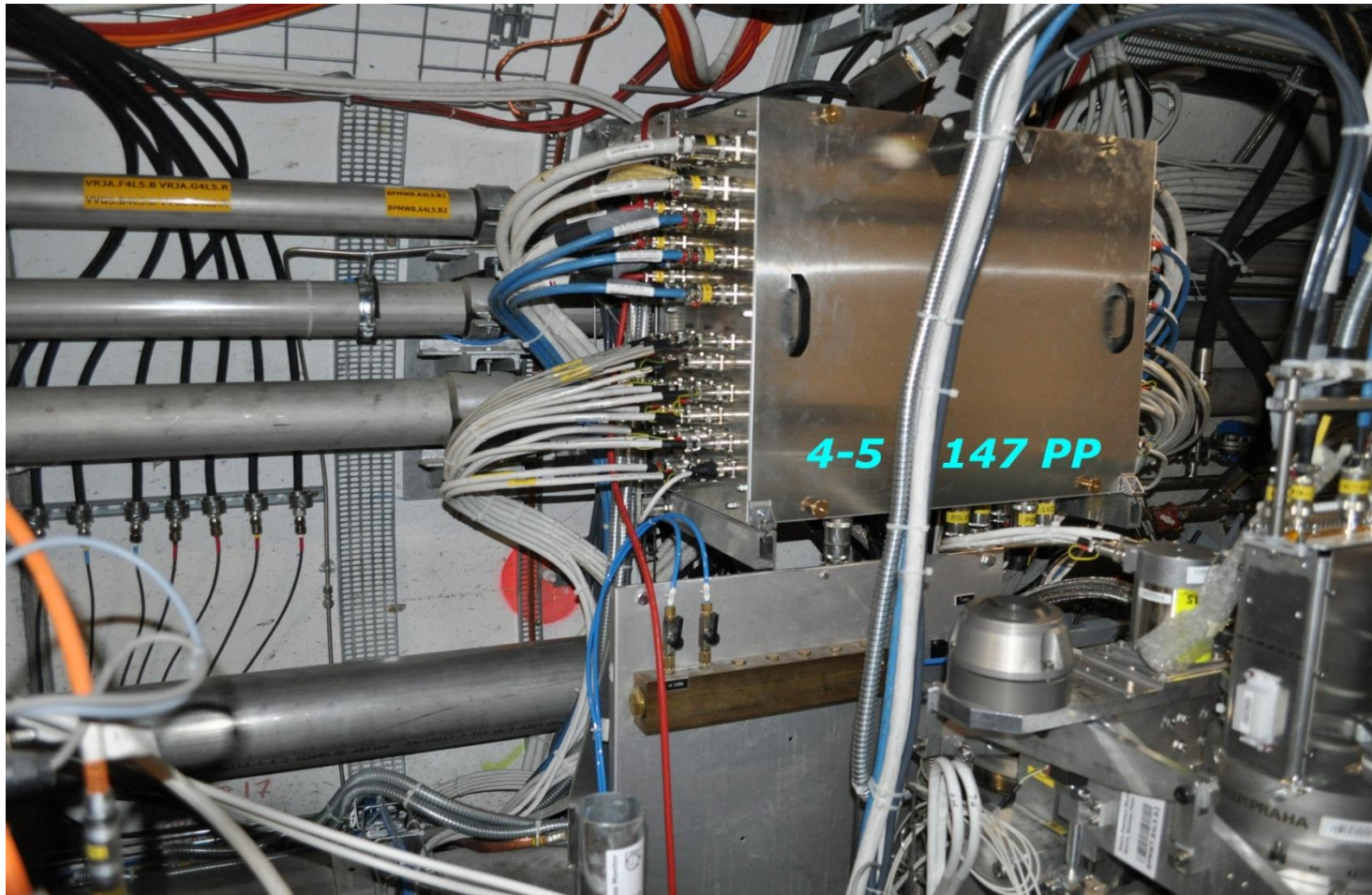


Relocation of RPs & patch panel from 147m to 200m

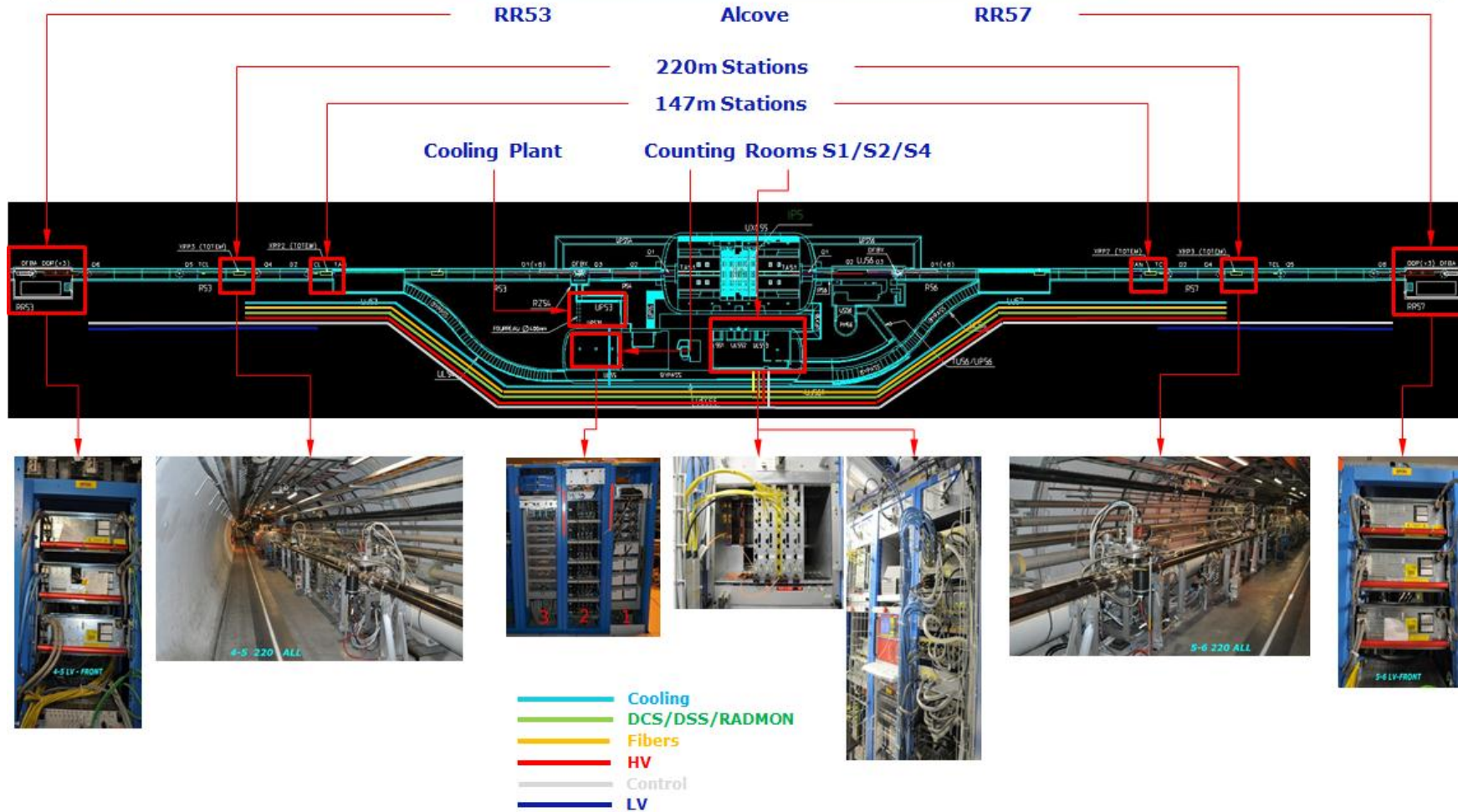
patch panel (relocated from 147m)



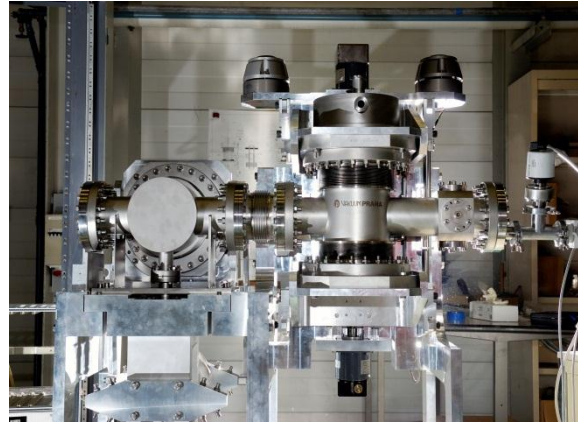
# Patch panel at 147m







# Roman Pot & detector package



Temporary location of RP 147m components in H8 TOTEM test beam line after dismounting

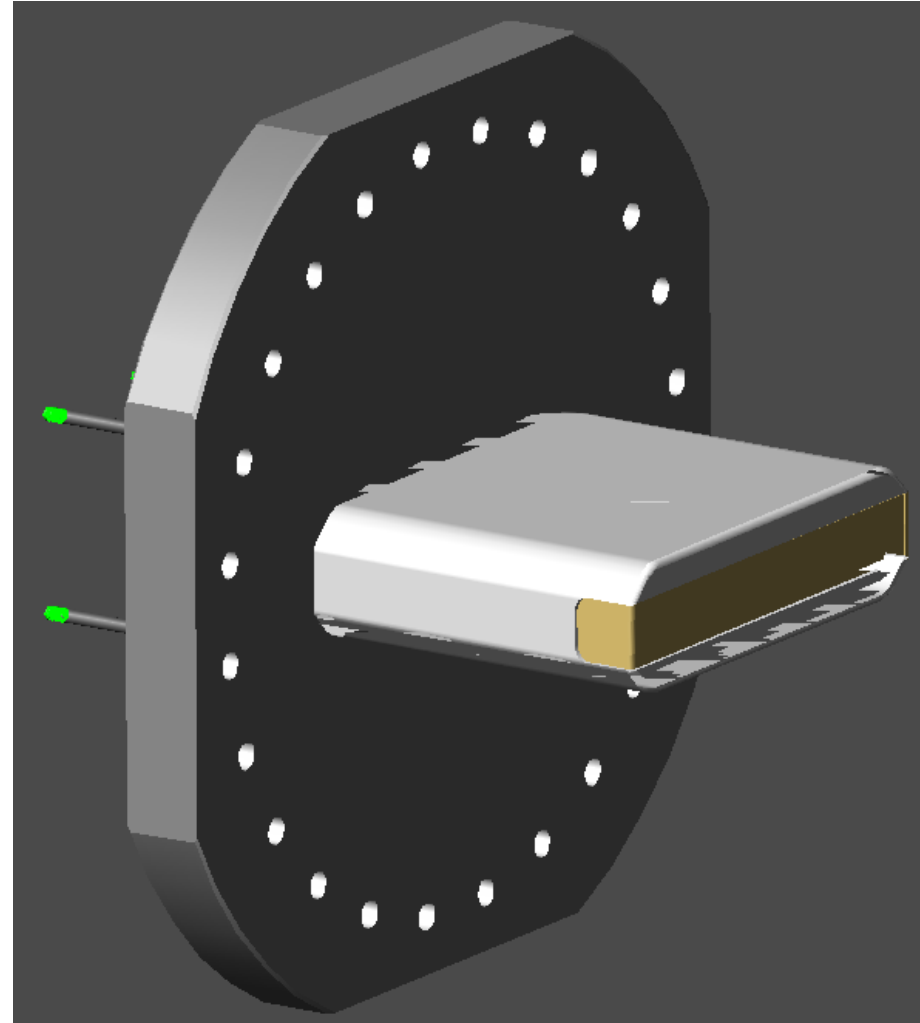
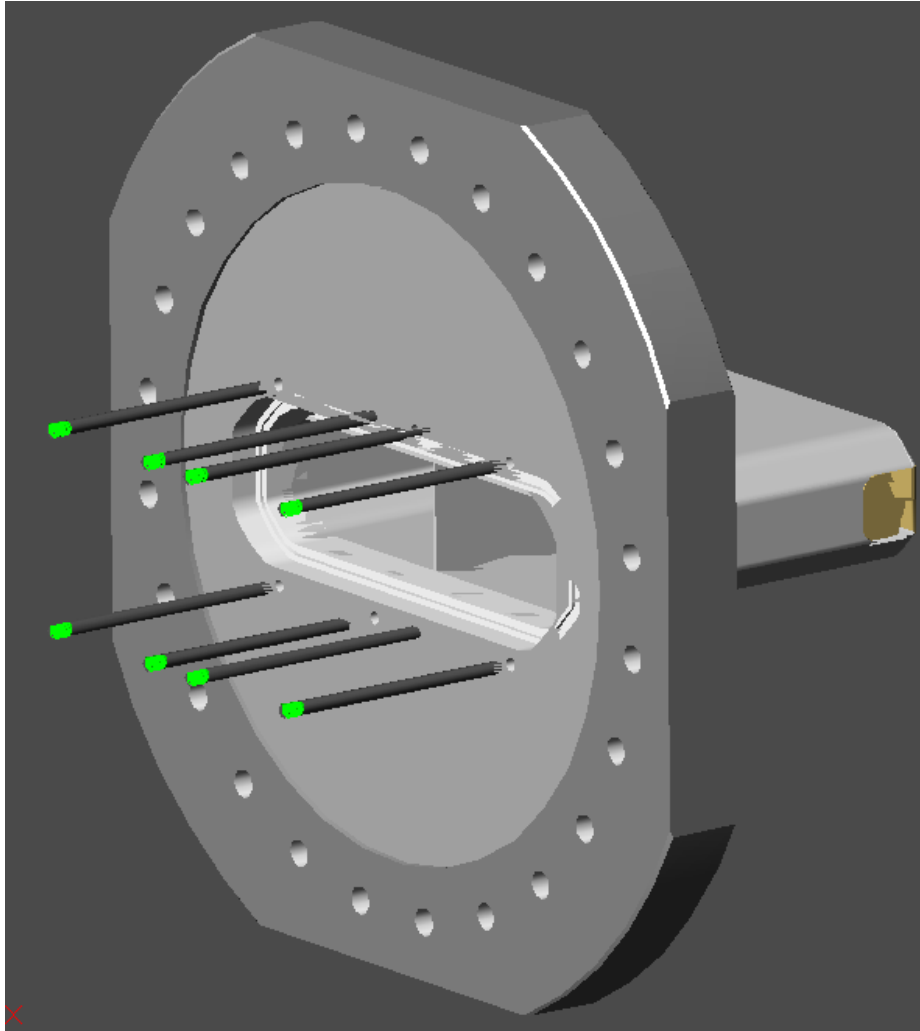
# Work packages → Detector Sensor

CMS-TOTEM

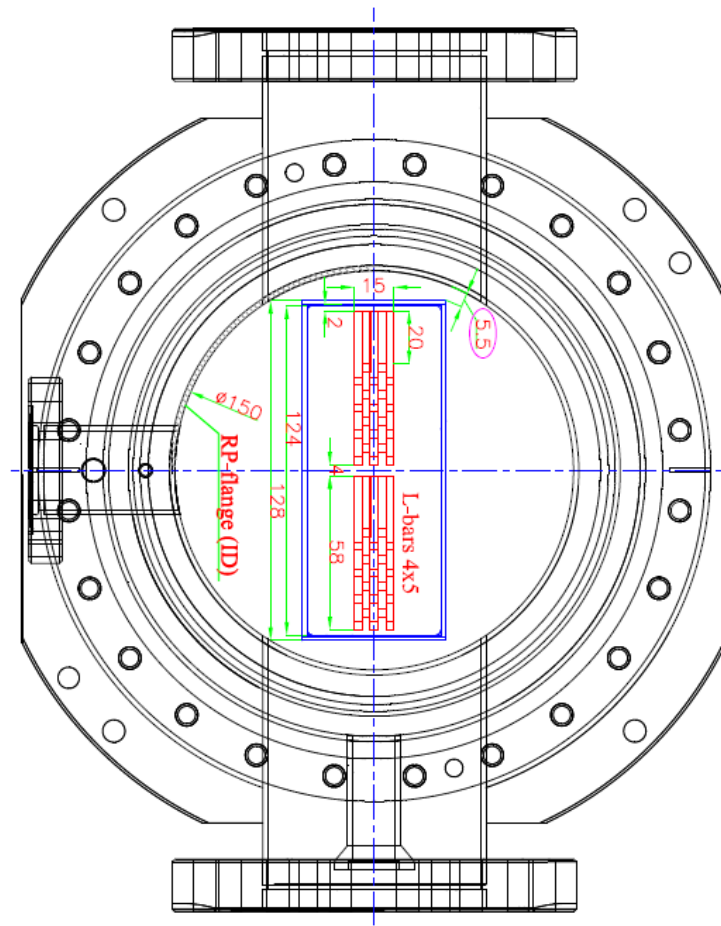
- **WP1-D: Si Pixel**  
(prototype test, integration & preamp, readout)
- **WP2-D: Timing-Detector**  
(prototype test)
- **WP3-D: Timing-TDC**
- **WP4-D: Timing-Clock distribution**
- **WP5-D: Readout board interface to CMS**

## Possible housing for timing detector

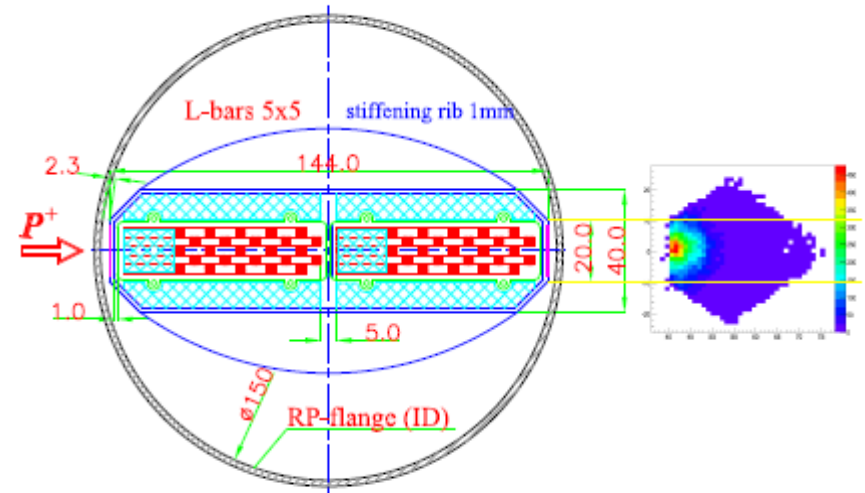
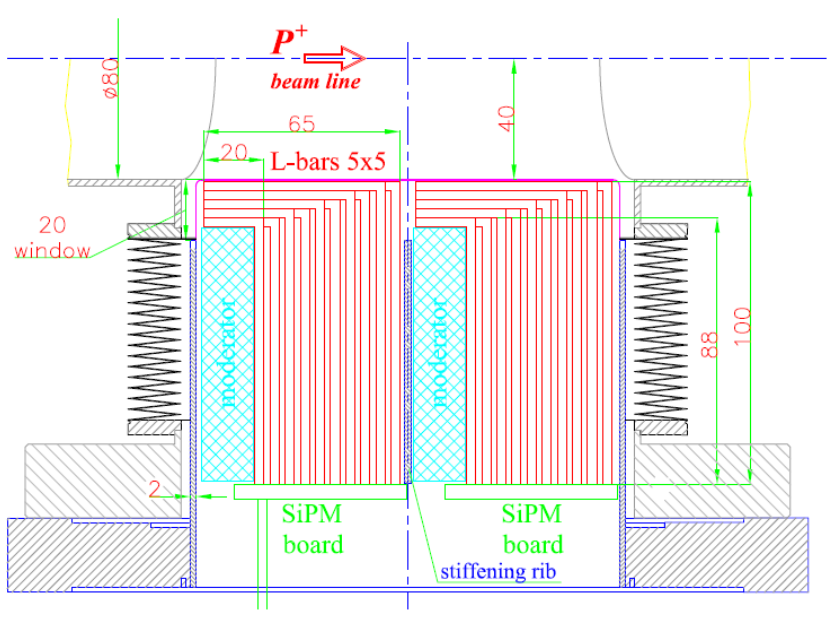
- Impedance not favorable
- Flange size big enough to integrate the timing detector



# Roman Pot (rotated by 90°) Integration of Cherenkov timing detector

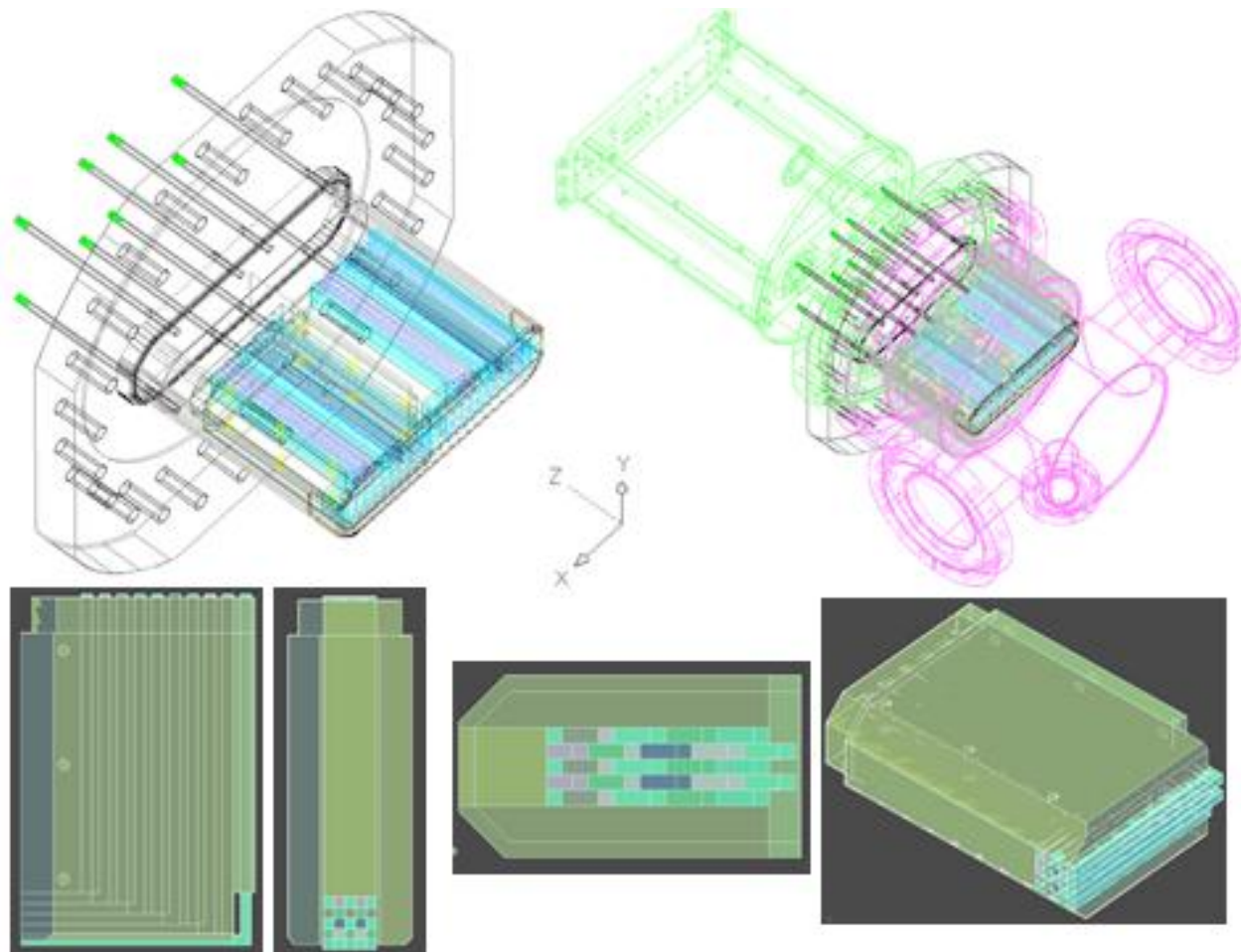


# Integration study of C-timing detector in RP (CMS-TOTEM)





# Horizontal RP with Cherenkov timing detector



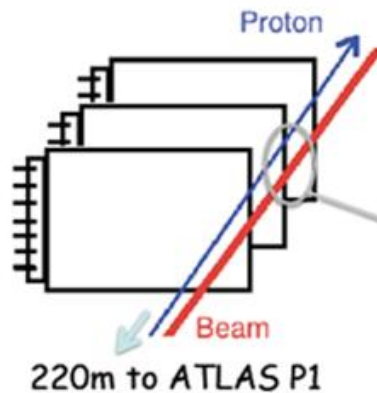
# TOTEM-RP

## study of 3D sensors

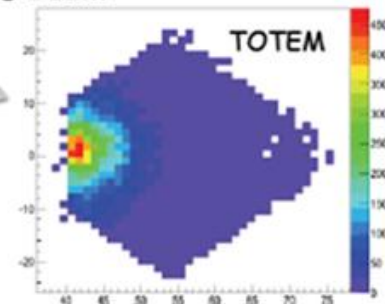
### TOTEM-RD50 (G. Pellegrini) [IBL – CNM]

## 3D Sensor for Forward Physics Trackers

- Interest in 3D sensors for forward physics detectors
  - ✓ AFP (ATLAS), HSP (CMS), Totem...



- AFP: detect very forward protons at 220m from IP, with pixel detectors for position resolution and timing detectors for removal of pile up protons.
- Both Si and timing detectors mounted very close to the beam



J. Baechler, 12th Pisa Meeting on Advanced Detectors, 20 May 2012, Isola d'Elba, Italy

- Key issues for Forward Si detectors:**
- Silicon detector has to have small dead inactive region on side into beam
  - Non-uniform irradiation of the detectors

RD50 Workshop Nov 2012

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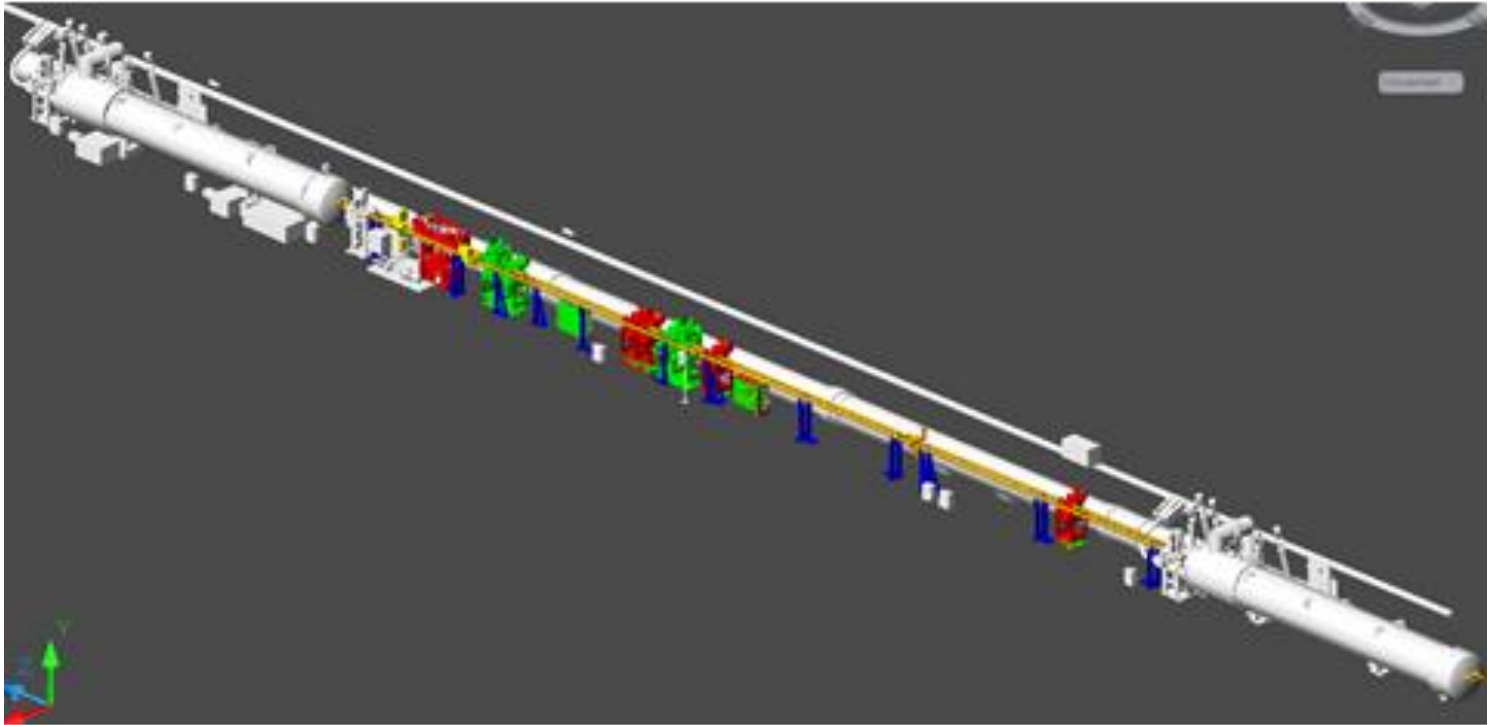


# Work packages → Optimization

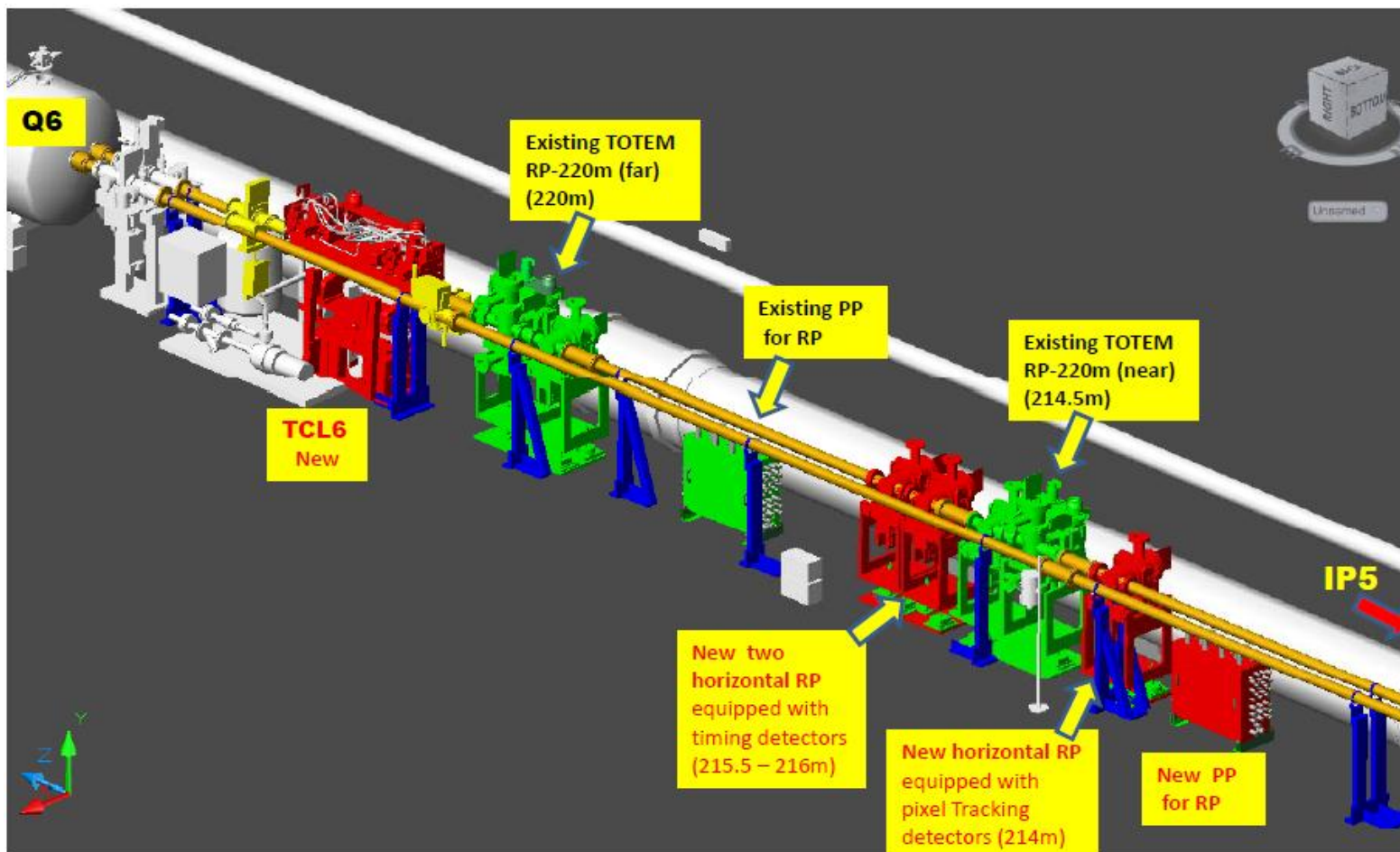
CMS-TOTEM

- **WP1-O** : optimal position of new RPs
- **WP2-O**: optimal shape & size of sensors  
(pixel size, adaptation, radiation zone)
- **WP3-O**: particle timing – vertex reconstruction
- **WP4-O**: detector position  
(calibration, alignment)
- **WP5-O**: Material budget  
(detector performance, machine protection)

# RP Integration study



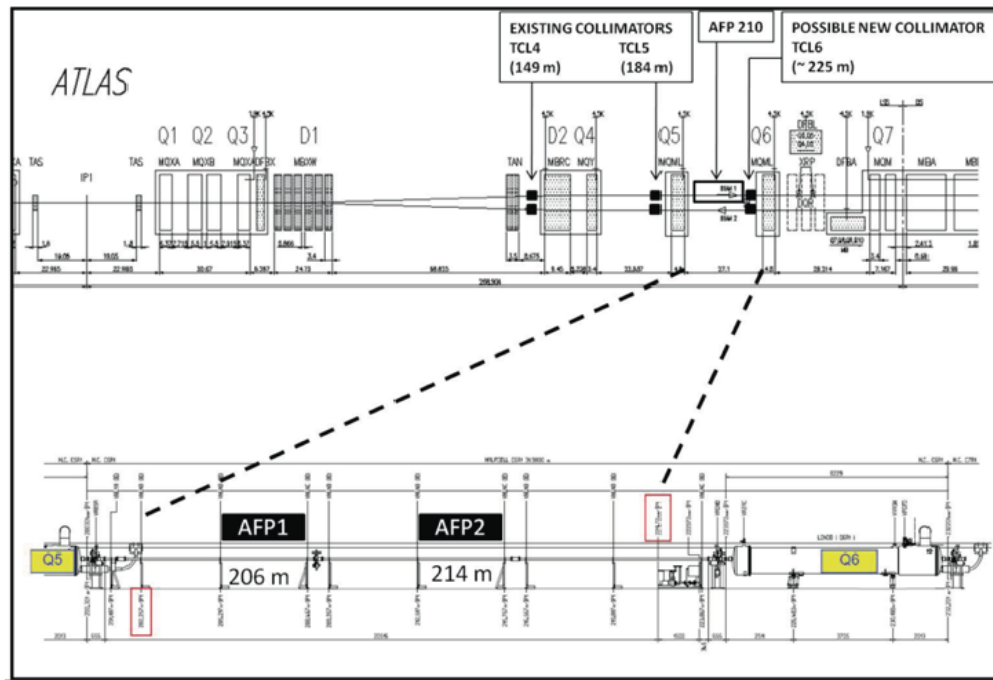
# Integration study of TCL6 and Roman Pots



# COLLIMATOR requirements for forward physics



## New experiment requirements



*Request to change TCL layout in IR1 to install the forward detector AFP (D. Macina, LHC-XAFP-EC-0001)*

*Presently approved a space reservation only.*

*AFP can not take data with TCL-5 at nominal settings. Need to consider new layouts with TCL-4 and an additional TCL-6.*

*Proposal from ATLAS, if AFP approved:*  
 Install the TCL-4 and use it at nominal settings  
 Install a new TCL-6 collimator in front of Q6  
 Keep the TCL-5 and open it when AFP takes data  
**More studies were deemed necessary before endorsing this option!**

S. Redaelli, LMC 07/11/2012

*Also CMS plans an update of the forward physics detectors. Not yet outlined into an ECR document.*

# COLLIMATOR TCL4 & TCL6



## Proposal for TCL layout after LS1

*(discussed with ATLAS, CMS, TOTEM)*



- Propose **symmetric layouts** in IR1 and IR5
  - *Similar forward-physics program expected to be requested in IR5*
- **Install TCL-4 both in IR1 and IR5**
  - *Removal of Roman pot station in cell 4 confirmed by TOTEM+CMS*
  - *No additional cabling / infrastructures: slots are essentially ready!*  
*(take ALARA into account: removal of Roman pots vs new installation)*
  - *Collimators already produced - no issue for planning vs production schedule*
- **Keep the TCL-5 operational at their present locations**
  - *Minimize LS1 works close to these collimators that are hot.*
  - *Only open them when forward physics. Keep them as an additional "safety".*
- **Prepare the infrastructure for an installation of the TCL-6**
  - *Requires new collimator supports, cabling and services!*
  - *Needs update of the vacuum layout (replacement chambers?)*
  - *Installation of the collimator is subject to the availability of new TCTPs!*
  - *Possibility to install the collimators in a short shutdown otherwise.*

# RP-TOTEM <-> LHC

In 2011 and 2012 specific RP tests & insertions were performed at standard LHC settings to study:

- Roman Pot <-> LHC : RP heating & beam stability
- Roman Pot detector : rates & background

Observations during low  $\beta^*$  run (2012):

[LHC-MPP M. DEILE, December 2012]

Insertion of RP horizontal at 220m ->

# List of Insertions at $\beta^* = 0.6$ m



Date	Pots involved	min. dist.	Observations, Result	Consequence
16.10.	all V	$12 \sigma$	no problem	no UFO activity
	all H	$30 \sigma$	dump on XRPH.A6R5.B1 (slow losses, 5s)	
05.11.	all H	$30 \sigma$	dump on XRPH.A6R5.B1 (slow losses, 5s)	no UFO activity
14.11.	all H	32mm $\sim 270 \sigma$	dump on XRPH.A6R5.B1 (fast losses)	<del>UFO activity in 6L5 (*)</del>
16.11.	H, not A6R5.B1	$14 \sigma$ $\sim 2$ mm	no problem, beams separated by $4\sigma$	slow losses (5s) in each ramp until conditioning (heat up) of beam screen in Q6

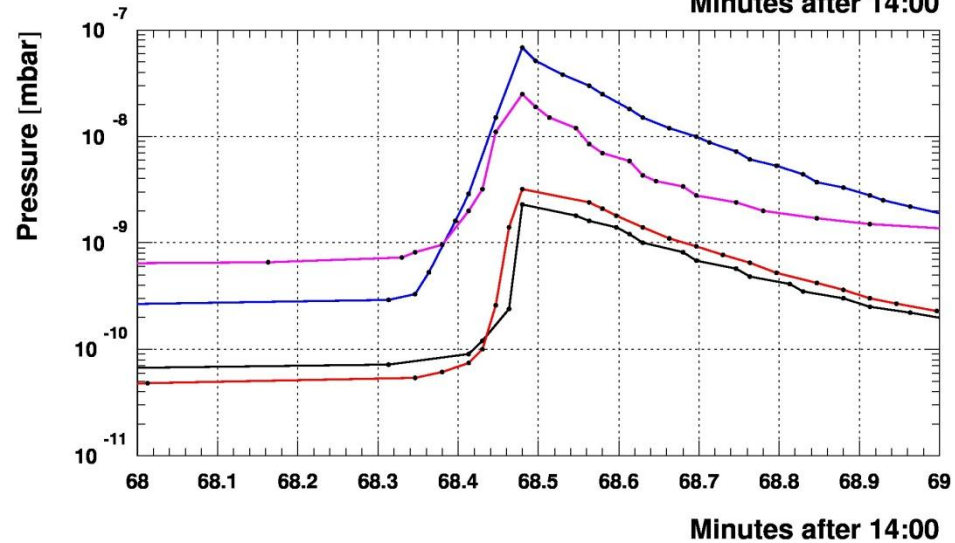
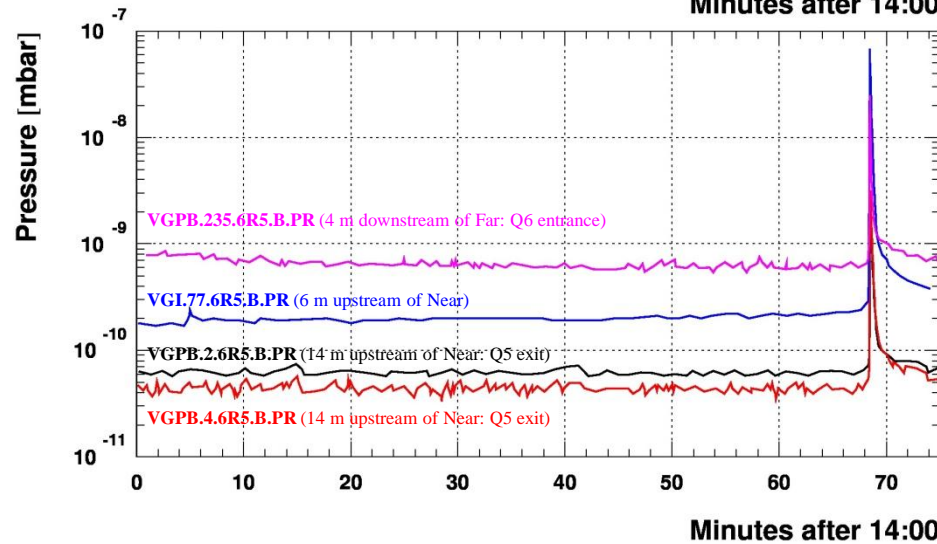
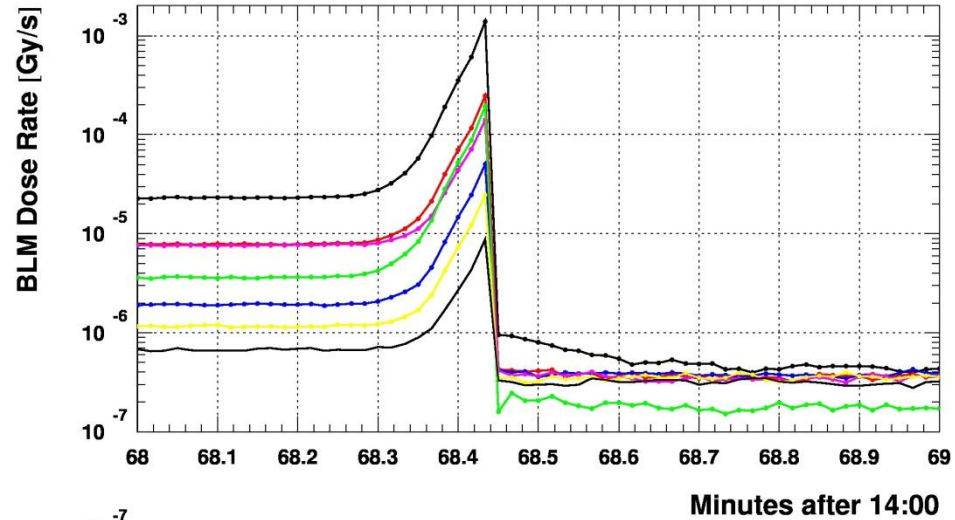
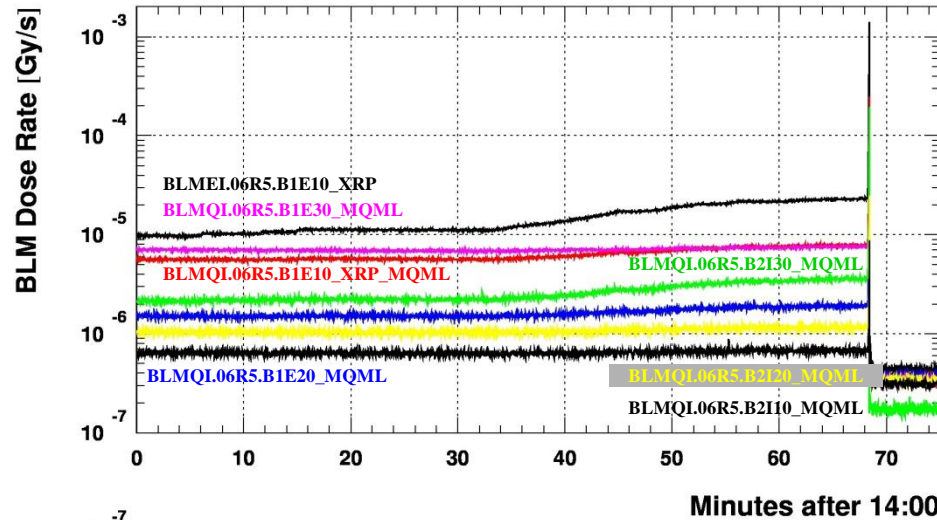
(\*) The (fast) UFOs in 6L5 were later found to originate from TCL5 [Tobias]



# Comparison BLMs & Beam Vacuum



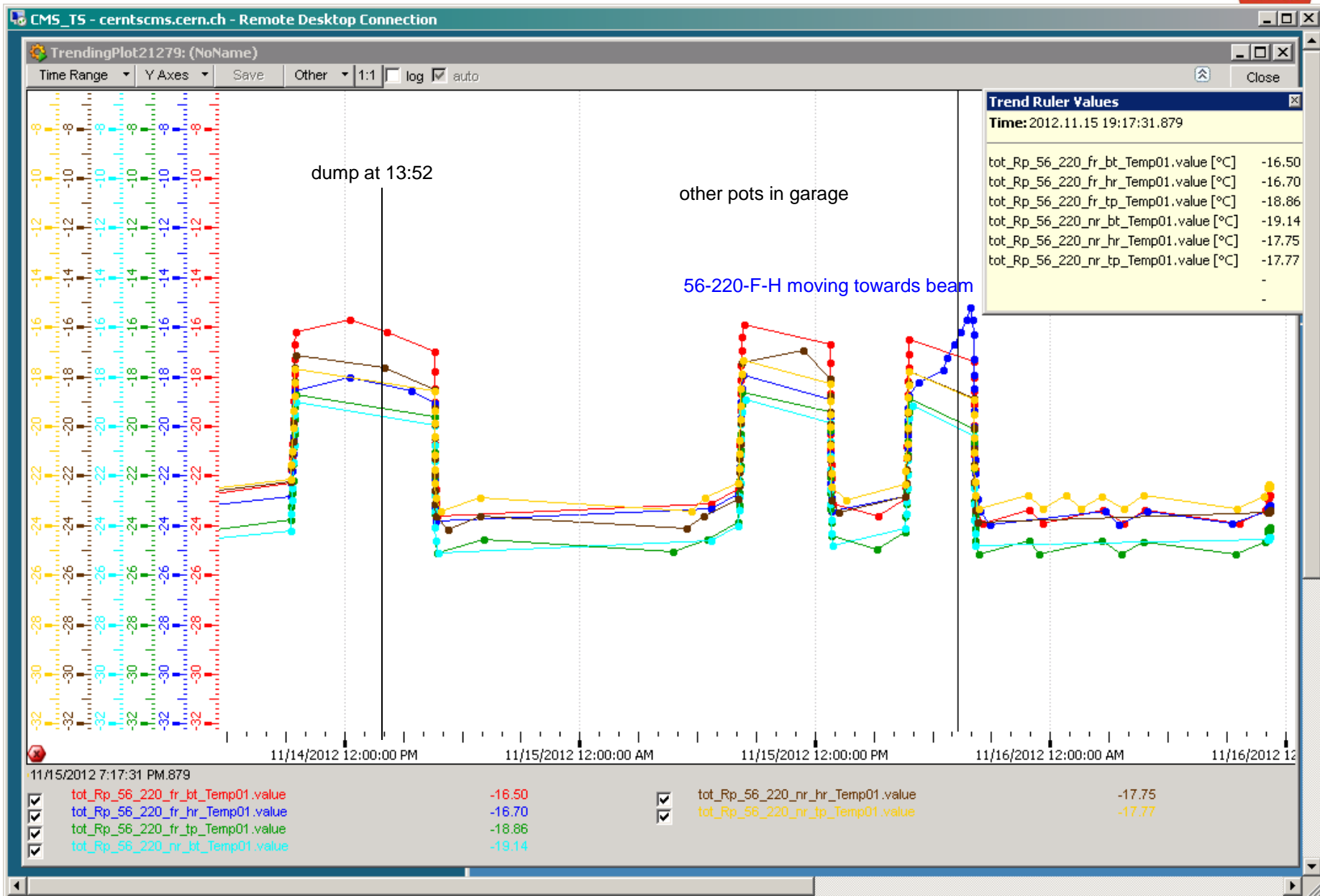
## Sector 5-6



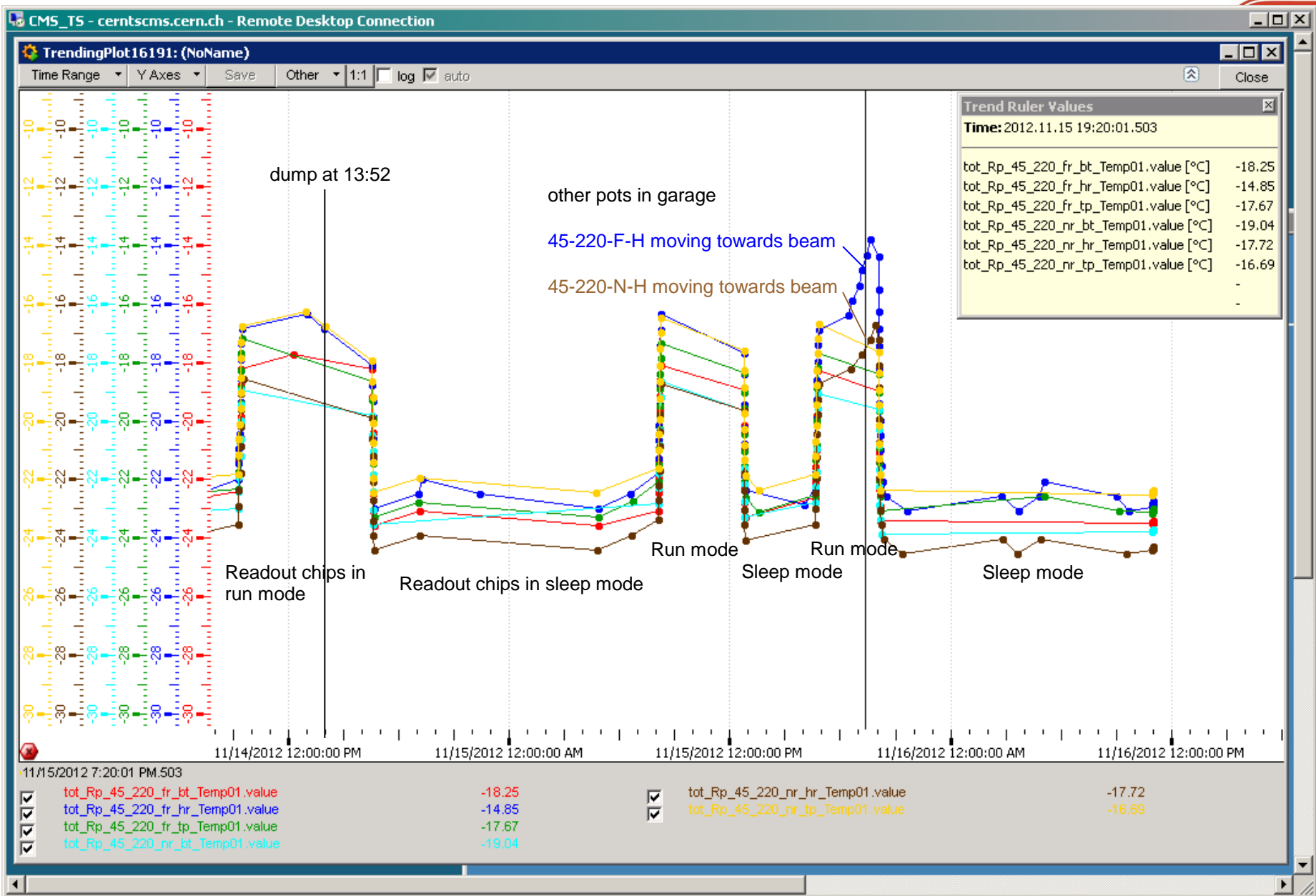
Note: no pressure increase in any gauge further upstream (cell 5R5).



# Temperature Sensors on Detector Hybrid Boards: Sector 5-6 (Beam 1)



# Temperature Sensors on Detector Hybrid Boards: Sector 4-5 (Beam 2)



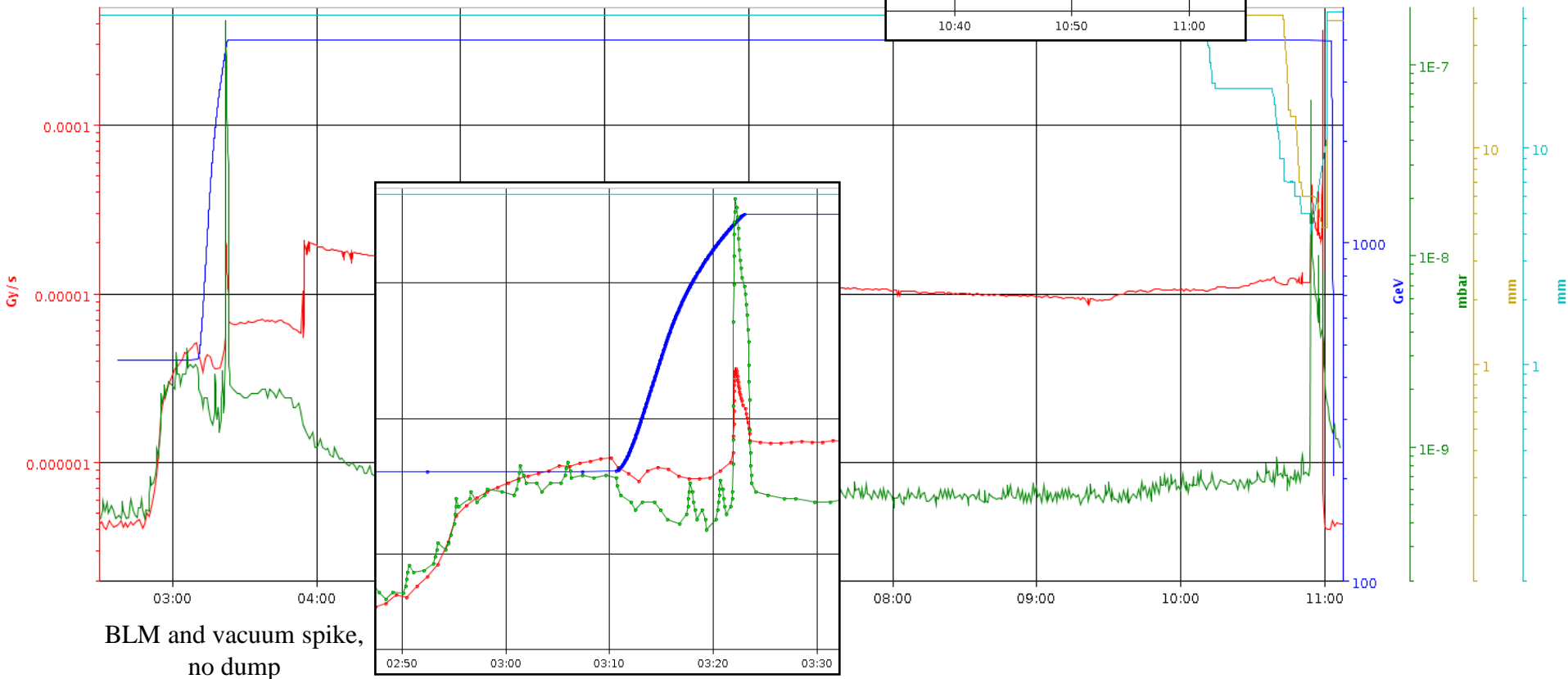
Main temperature effect from chips changing to run mode; small additional increase (3 deg.) from pots moving very close to the beam. UFOs cannot be resolved.

# Fill 3188 with RP Insertion, Cell 6R5



Timeseries Chart between 2012-10-16 02:29:21.286 and 2012-10-16 11:07:26.457 (LOCAL\_TIME)

BLMEI.06R5.B1E10\_XRP\_LOSS\_RS09    MSD.UA63.MKCBI.B1\_E\_CH1    VGPB.235.6R5.B.PR    XRPB.A6R5.B1.MEAS\_LVDT\_LU    XRPB.B6R5.B1.MEAS\_LVDT\_LU

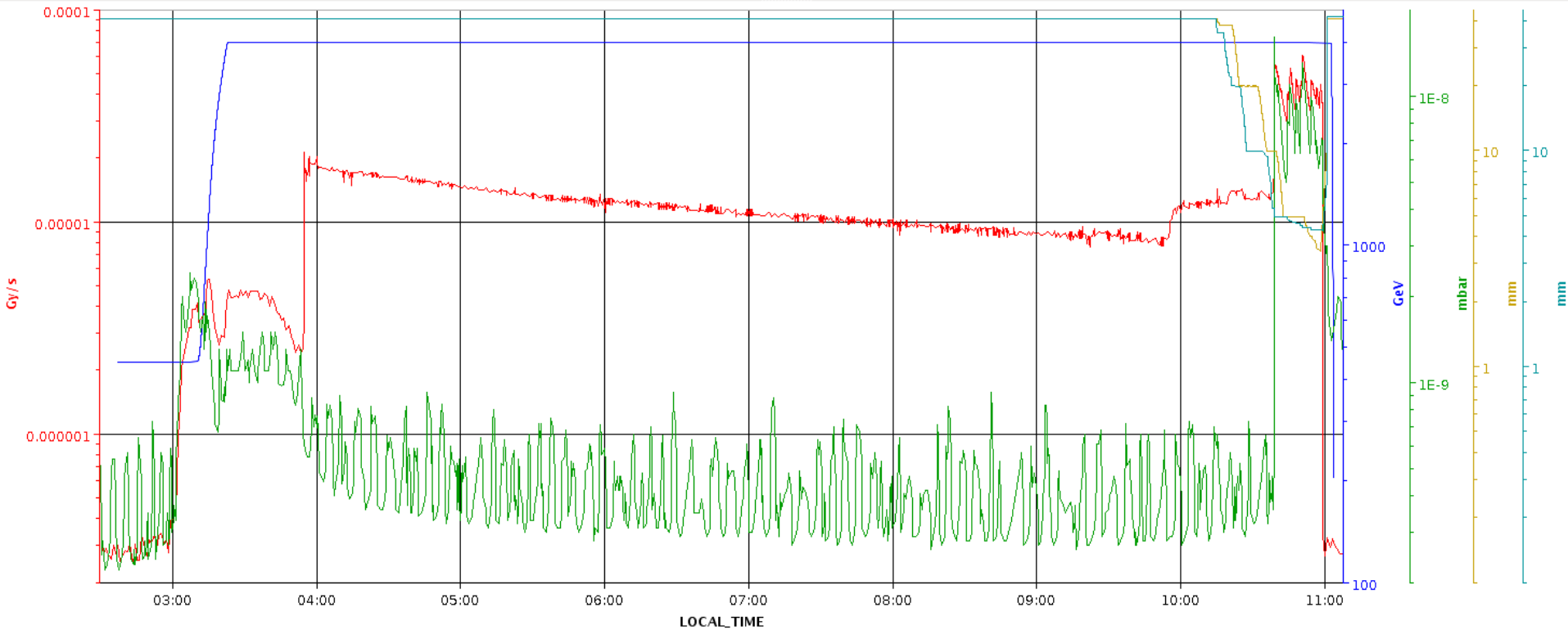


# Fill 3188 with RP Insertion, Cell 6L5



Timeseries Chart between 2012-10-16 02:29:21.286 and 2012-10-16 11:07:26.457 (LOCAL\_TIME)

BLMEI.06L5.B2E10\_XRP\_LOSS\_RS09    MSD.UA63.MKCBI.B1.E\_CH1    VGPB.235.6L5.R.PR    XRPB.A6L5.B2:MEAS\_LVDT\_LU    XRPB.B6L5.B2:MEAS\_LVDT\_LU

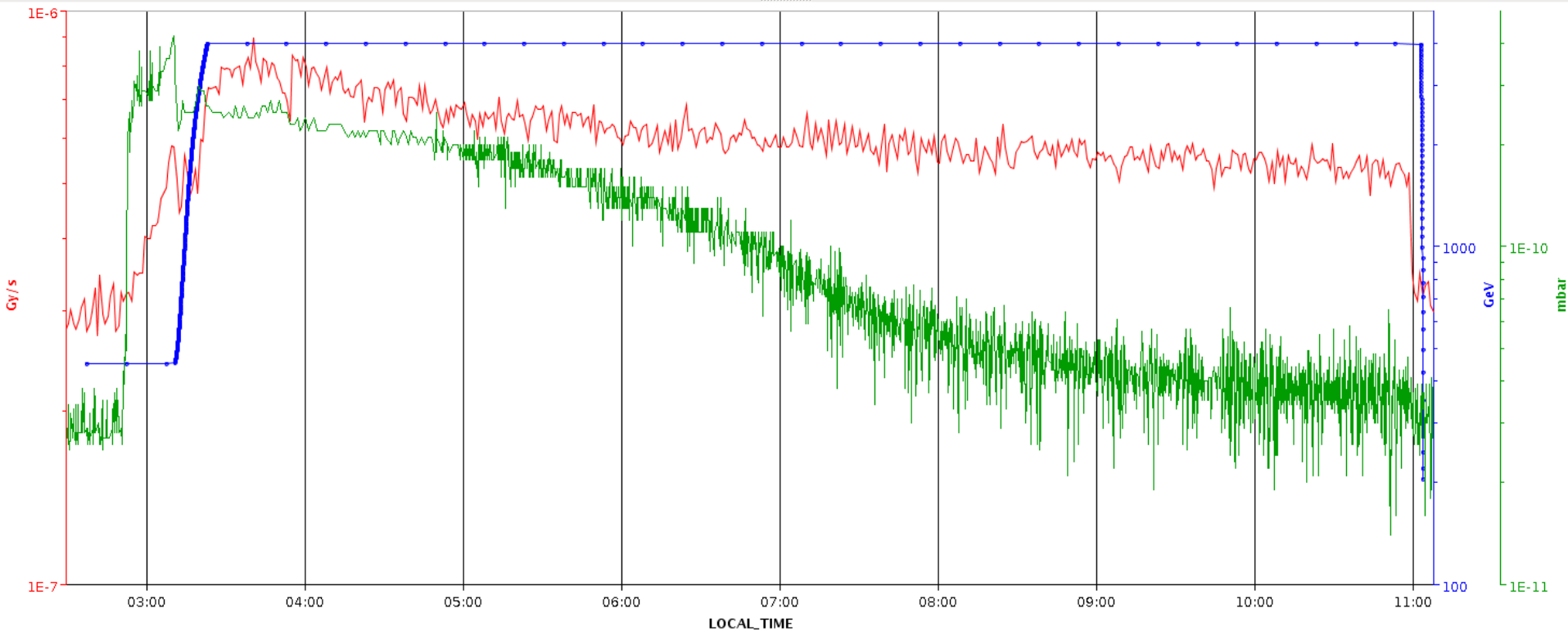


# Fill 3188, Cell 7R1 (ALFA)



Timeseries Chart between 2012-10-16 02:29:21.286 and 2012-10-16 11:07:26.457 (LOCAL\_TIME)

BLMEI.07R1.B1E10\_XRP:LOSS\_RS09    MSD.UA63.MKCBI.B1:E\_CH1    VGPB.235.7R1.B.PR



slight vacuum degradation at injection,  
no spike in ramp

# EM coupling of RP

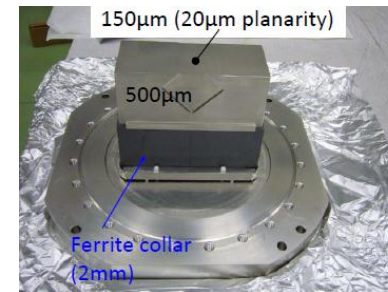
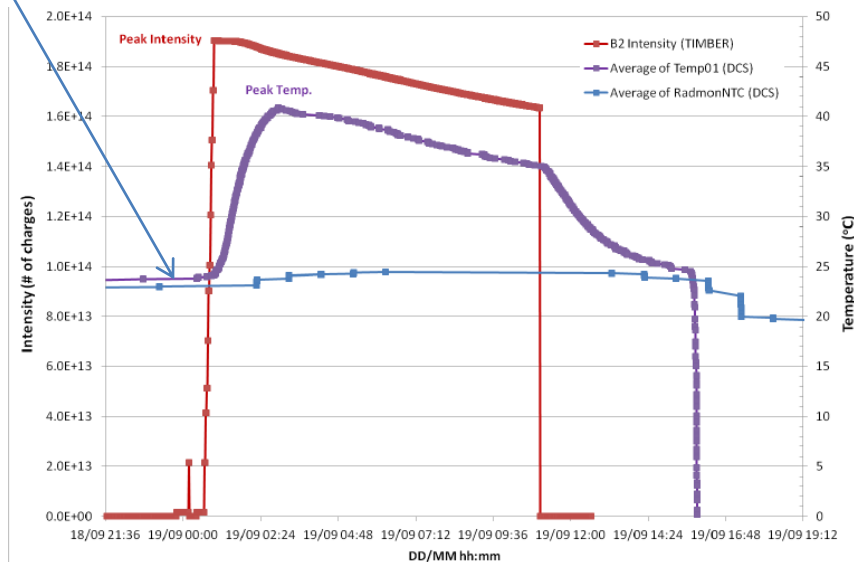
(RP in garage position)

The temperature in the Roman Pot increases due to the EM coupling with the LHC

-> cooling of RPs is mandatory when LHC beam is injected

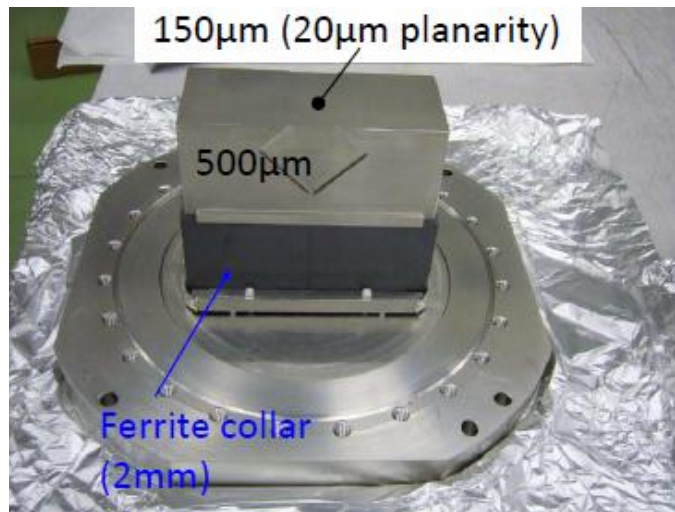
-> modification of evaporative cooling system by integrating a safety mode to operate above dew point in case of vacuum problem

## Cooling of RP was switched off

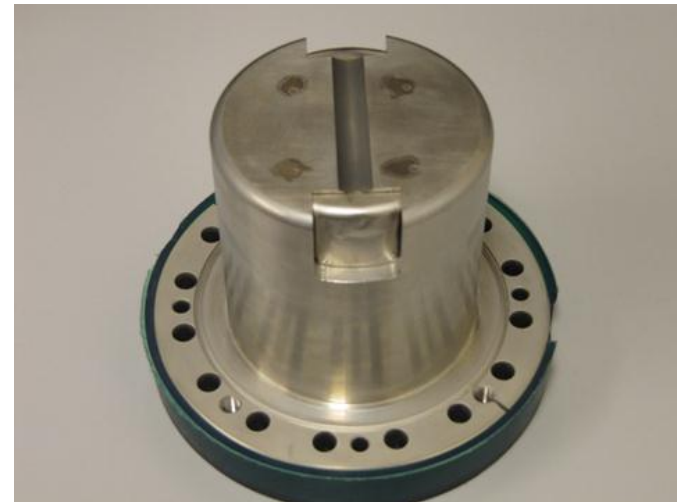


# RP optimization

- RP optimization ongoing –highest priority
- Ferrite treatment during LS1



TOTEM – RP



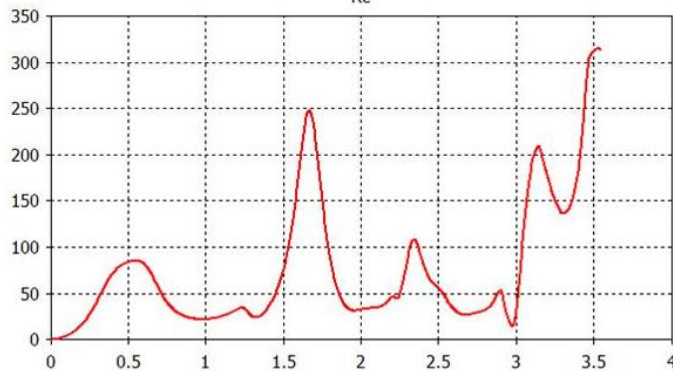
OLD TOTEM RP prototype



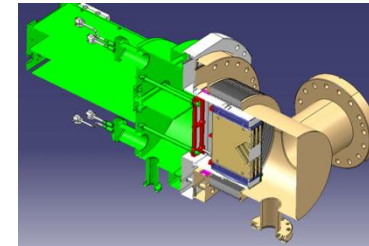
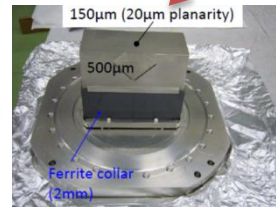
# Optimization of RF characteristics

(first preliminary results B. Salvant, BE-ABP-ICE)

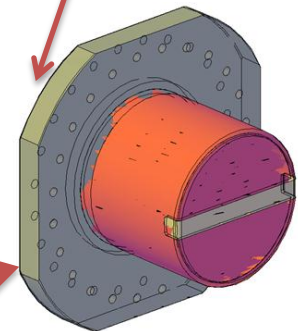
Impedance (in Ohm) with rotated detector as a function of frequency: result with ferrite



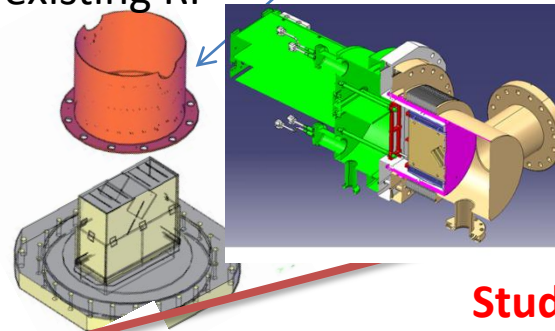
Present RP housing



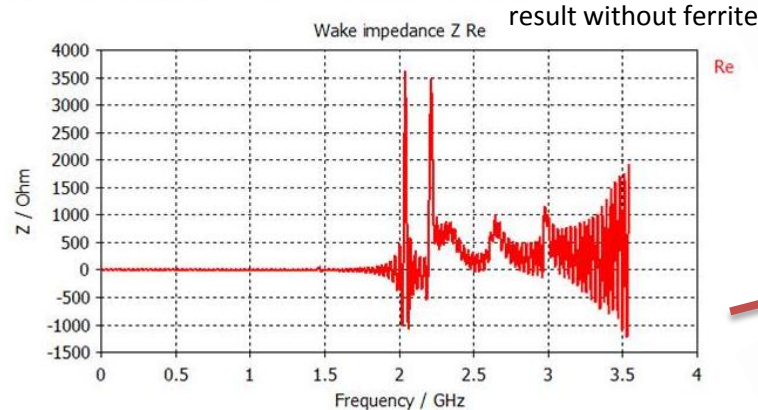
Study of new RP housing



Study of possible RF shielding for existing RP

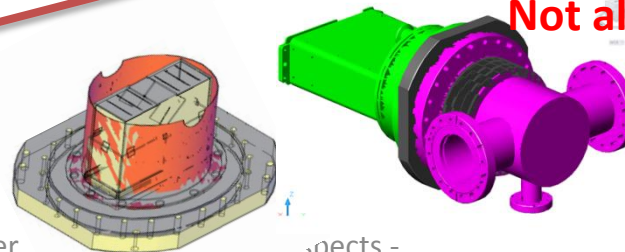


Impedance (in Ohm) with cylindrical detector as a function of frequency:



Same plot as before zoomed with the same y-axis.

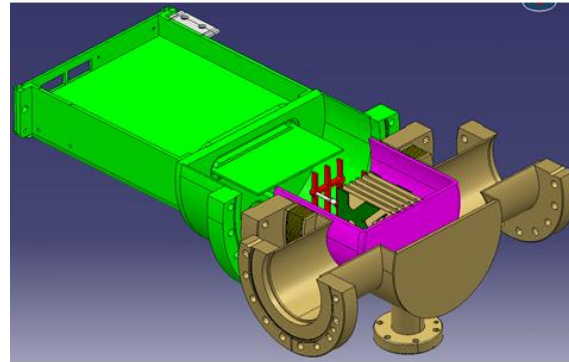
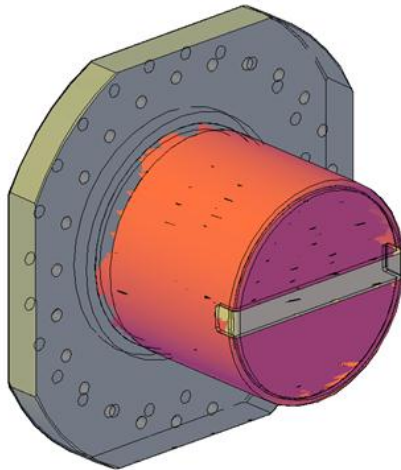
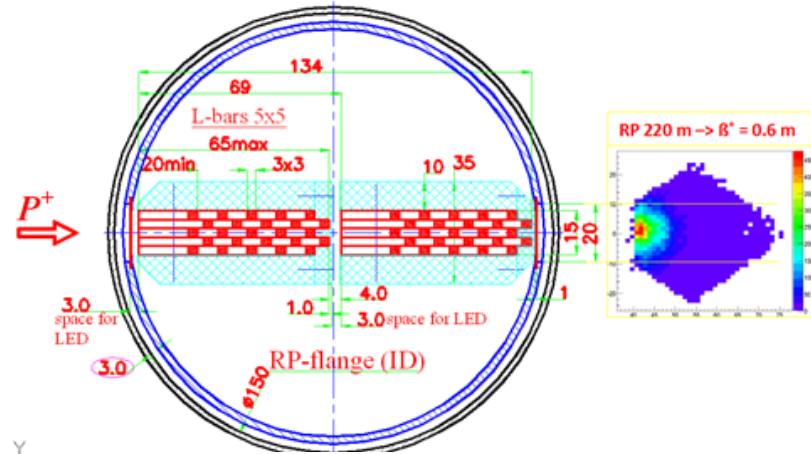
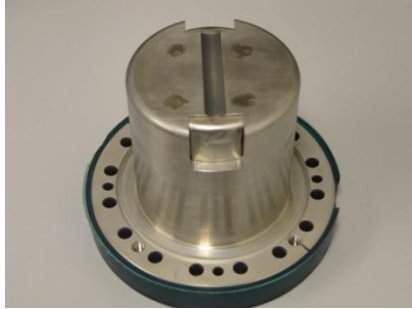
**Study is ongoing**  
**Not all issues are solved yet !**





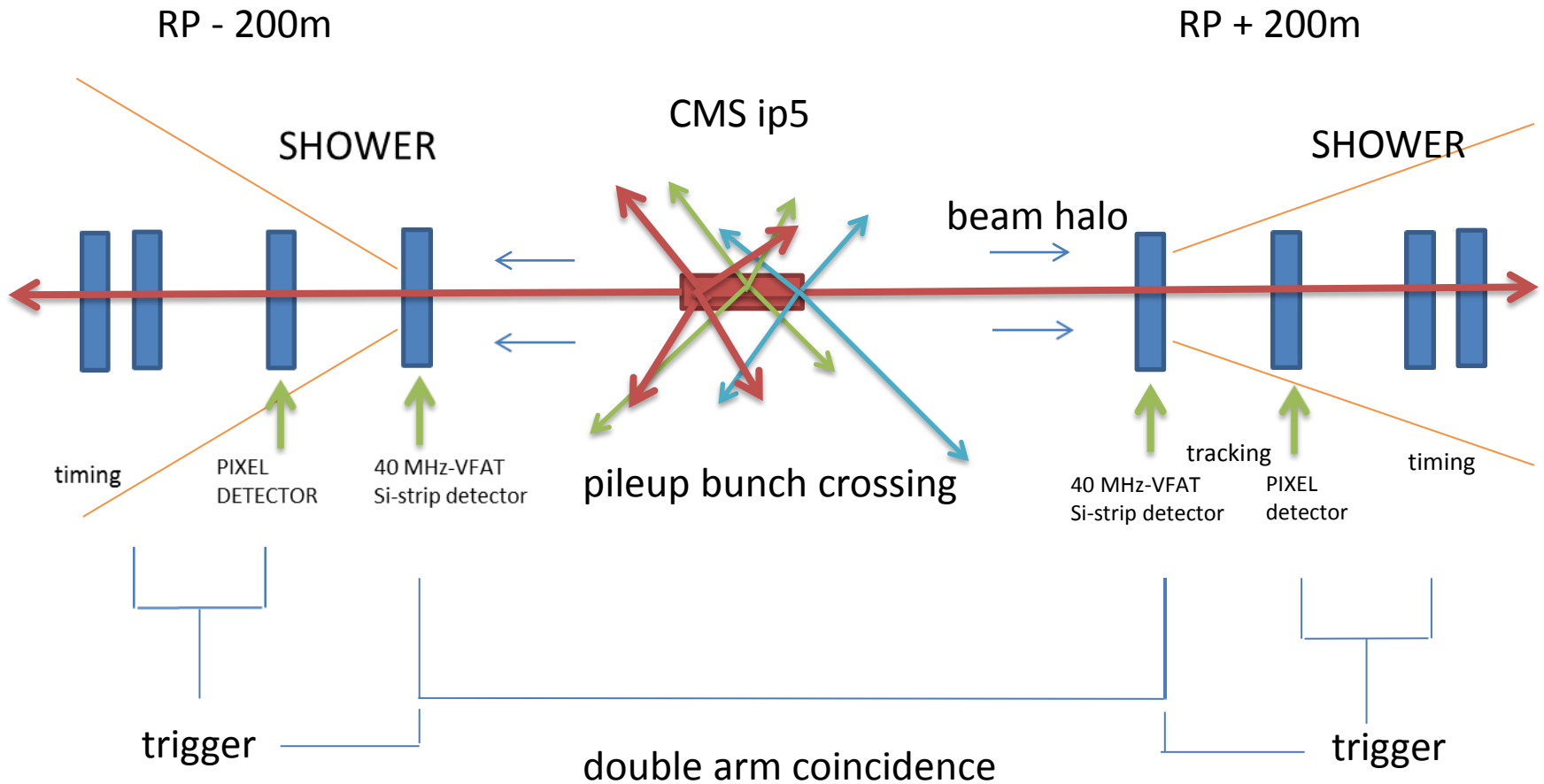
# Integration study:

cylindrical pot with timing/tracking detector



# Roman Pot detector system

study of combination: Si strip- Si pixel- timing (schematic)



# Conclusion (1)

- TOTEM has confirmed the complete dismounting of RP 147m stations during LS1 (as early as possible)
- The removal of the RPs at +/- 147m allows the installation of TCL4
- The RPs of +/- 147m will be reinstalled in the +/- 210 m region
- TOTEM has proposed to install additional horizontal RPs around +/-210m of ip5 during LS1
- These new horizontal RP detectors will allow tracking & timing at low  $\beta^*$  and high luminosity
- Integration studies were performed by TOTEM and CMS to integrate a “Cherenkov” timing detector in a (horizontal) RP
- The re-use of motor and infrastructure (patch panel, cooling) was studied
- Impedance studies for the horizontal RPs are ongoing
- Studies are ongoing to improve the RP geometry (RF, material budget)

# Conclusion (2)

- The developments of Roman pots as 'carriers' for tracking and timing detectors with the potential to approach the LHC beam to very close distances are ongoing.
- The combination of the existing TOTEM RPs (alignment, trigger) with new RPs, equipped with tracking and timing detectors is under study.