

# LHCC

## TOTEM STATUS REPORT

- Status of Roman Pot Consolidation & Upgrade Program
- Physics Analysis Highlights

# TOTEM

## Status of Roman Pot Consolidation & Upgrade Program

RP 210 m / 220 m (special runs)  
RP 210 m / 220 m (low  $\beta^*$  & high luminosity)  
Consolidation & upgrade work packages  
RP integration of tracking / timing detectors  
RP – horizontal insertion at low  $\beta^*$  (2012)

# Overview

Consolidation program: TOTEM  
(approved by TOTEM management)

Upgrade program (proposal) : TOTEM+CMS  
(under approval by CMS)

-> Layout of RP stations - combination of consolidation program with upgrade program

- Work packages related to consolidation & upgrade  
-> Status of work packages and schedule – issues on critical path
- Observations during insertion of horizontal RPs in November 2012 (high luminosity, low  $\beta^*$ ) and impact on consolidation and upgrade work  
-> Optimization of RP housing (beam heating), ferrite study

# Presentation of TOTEM Roman Pot consolidation & upgrade plans in different meetings

- 1) CMS-TOTEM (management) meeting on 5.10.2012
- 2) 14<sup>th</sup> LTEX meeting on 8.11.2012
- 3) 1st LHC workshop on Collider Experiment Interface on 30.11.2012 (CERN)
- 4) Results and prospects of forward physics at the LHC on 12.2. 2013  
Implications for the study of diffraction, cosmic ray interactions, and more (CERN)
- 5) 16<sup>th</sup> LTEX meeting 14.2.2013

+ several CMS-TOTEM technical meetings , TOTEM collaboration upgrade meetings (2012-2013), ATLAS-AFP (February 2013), ATLAS-ALFA (January 2013)

consolidation & upgrade

# 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)

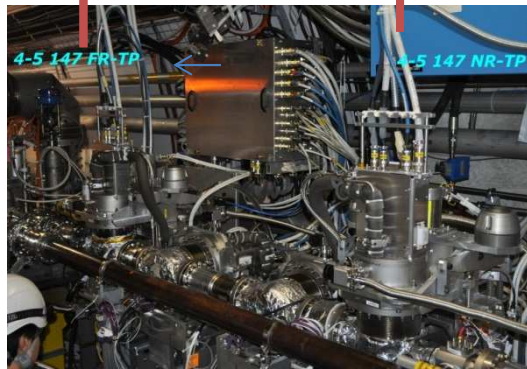
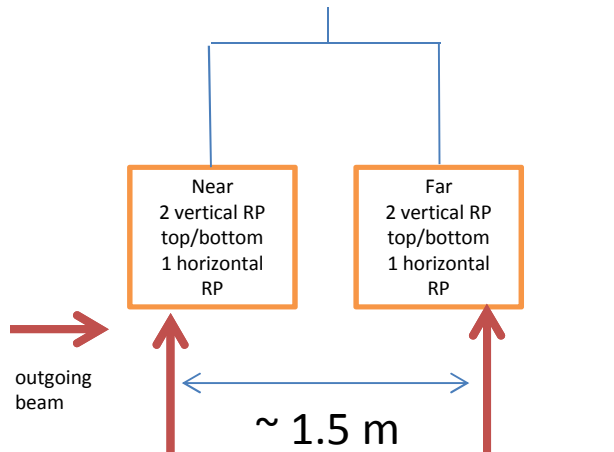
- Forward multiplicity
- Diffractive physics  
(soft & hard diffraction, jets)

TOTEM (stand alone)  
 TOTEM&CMS at low / high  $\beta^*$ , special runs  
**TOTEM&CMS at low  $\beta^*$  and high luminosity**

consolidation & upgrade

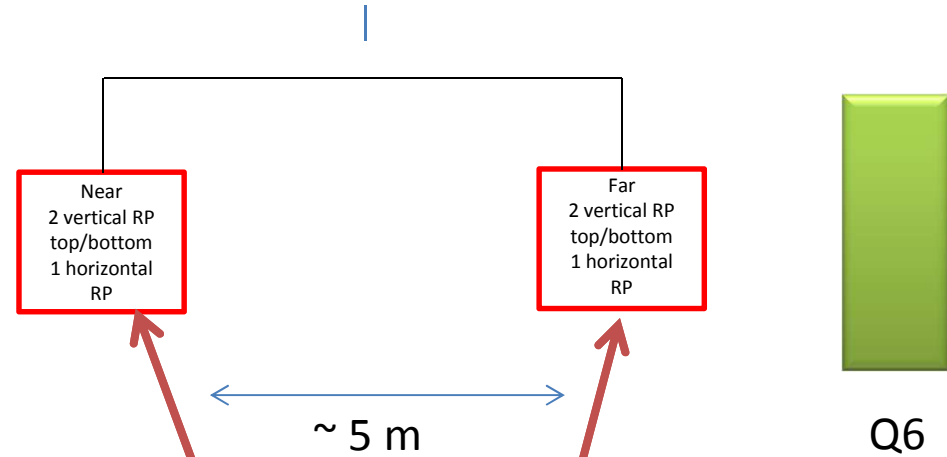
# Present RP installation at IP5

TOTEM RP-147 m (near-far)



4/9/2013

TOTEM RP-220 m (near-far)



consolidation & upgrade

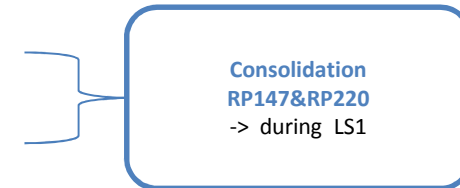
CMS ip5  
~ 147 m  
←

CMS ip5  
~ 220 m  
←

# Roman Pot consolidation & upgrade strategy

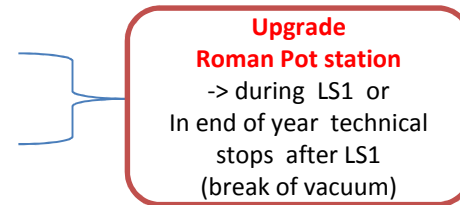
## CONSOLIDATION

- Remove RP147 m stations & patch panel (allows installation of TCL4)
- Relocation of RP147 m stations (including Si strip detectors) in +/- 210 m region
- Exchange of ferrites of all RPs



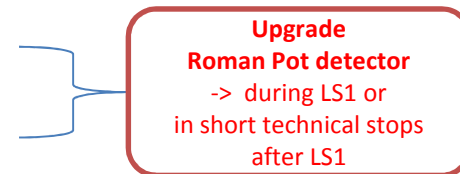
## UPGRADE (Roman Pot station)

- Installation of additional **new** RP stations (horizontal) in +/-220 m region  
(2 new RP stations in each sector (4/5), (5/6))



## UPGRADE (Roman Pot detector)

- Integration of **new** pixel detectors in the (relocated RP147m) RPs in 210 m region
- Integration of **new** timing detectors in the **new** horizontal RPs



Guideline :

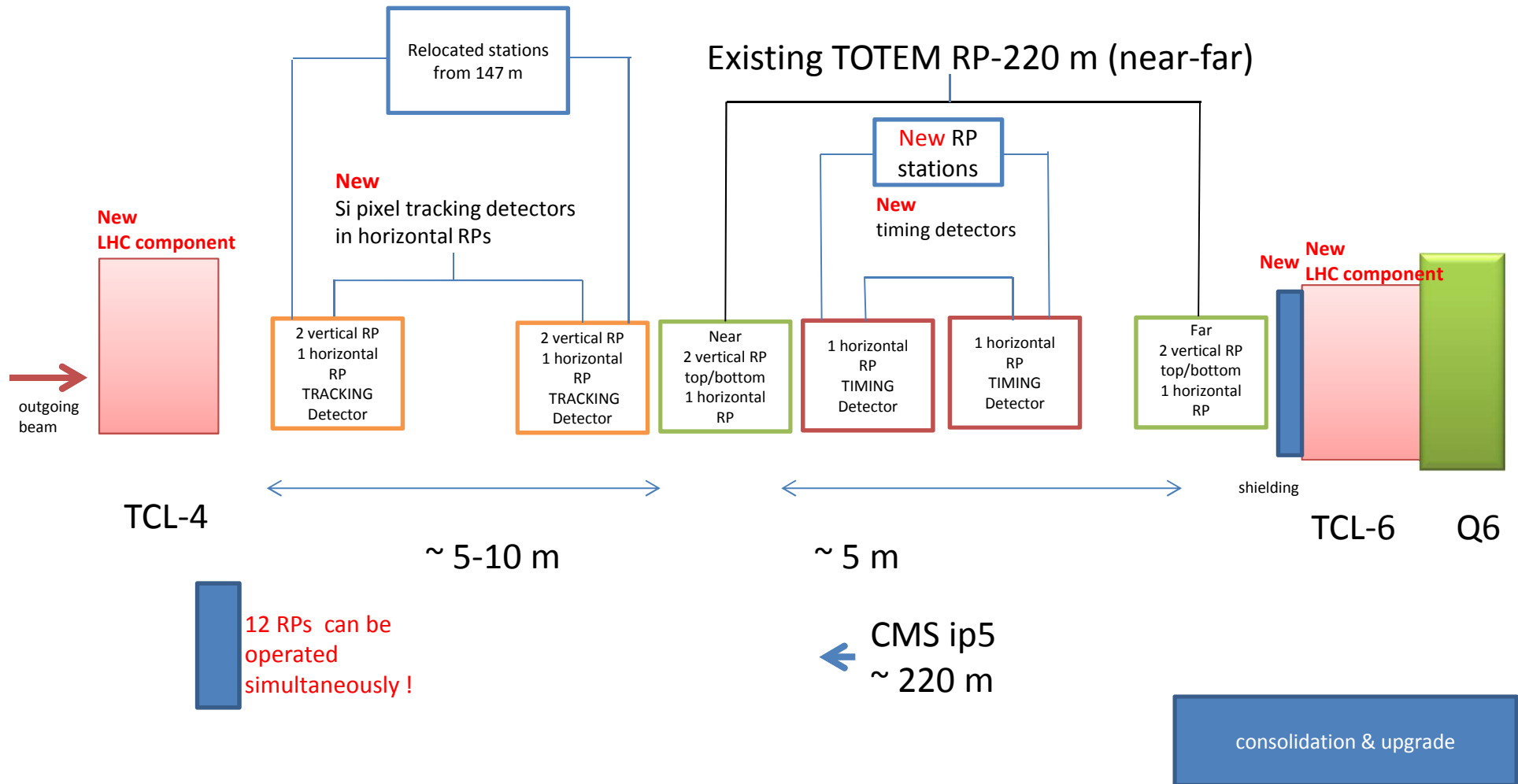
- Reinstallation of RP 147m stations with Si strip detectors in +/- 210m region (during LS1)
- The relocated horizontal RP station (147 m) can be equipped with Si pixel detectors
- The **new** horizontal RPs **could** be installed during **LS1** and equipped immediately/successively with **new** timing detectors.
- The present 220 m 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).

# 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 +/- 220 m and optionally in combination with the relocated RP detectors from +/- 147 m in the region of +/- 210 m (vertical)
- New Si pixel detectors integrated in the horizontal (relocated) RPs in the +/- 210 m region and additional new RP stations equipped with timing detectors in the region of +/- 220 m 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)



# Roman Pot consolidation & upgrade overview (schematic)

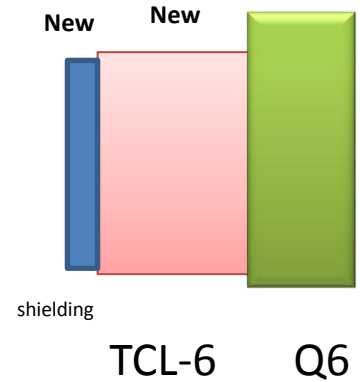
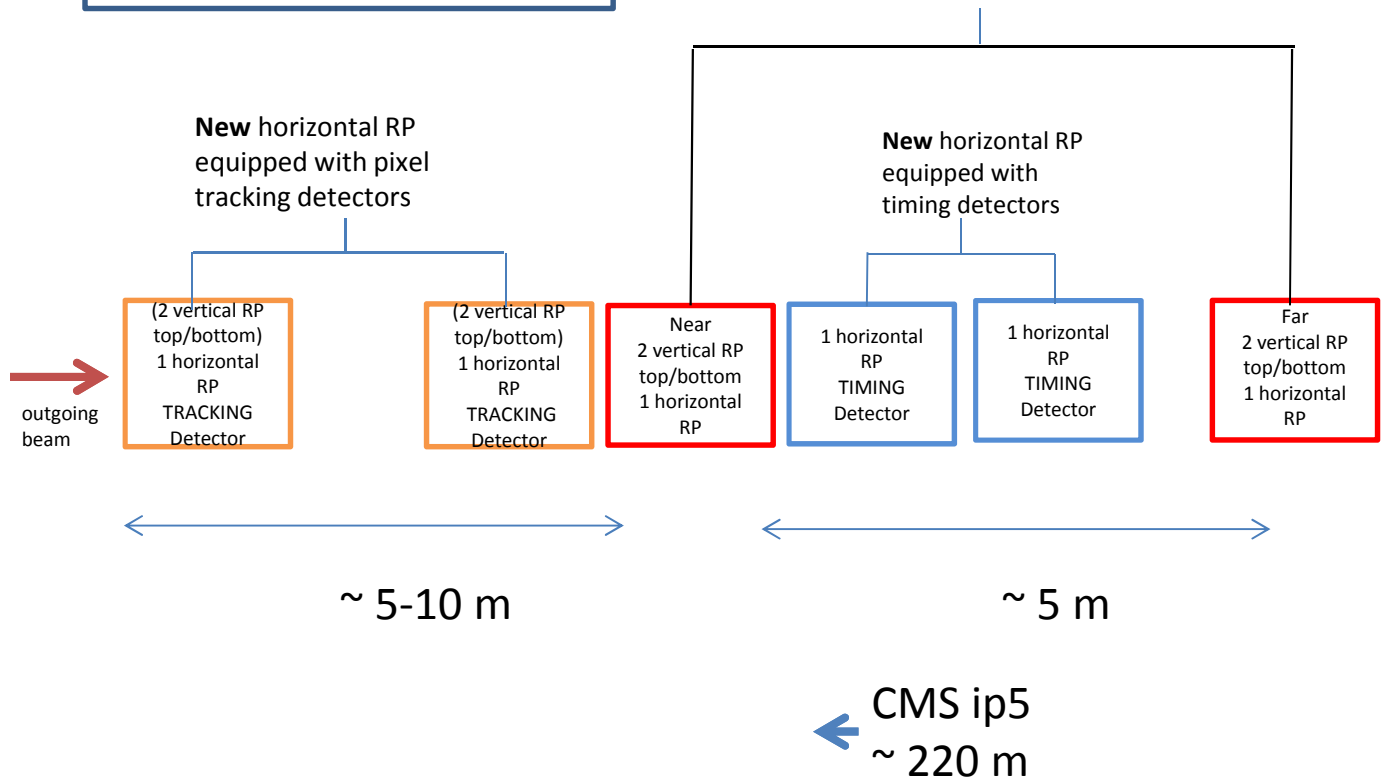


# Roman Pot (schematic-phase 1)

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

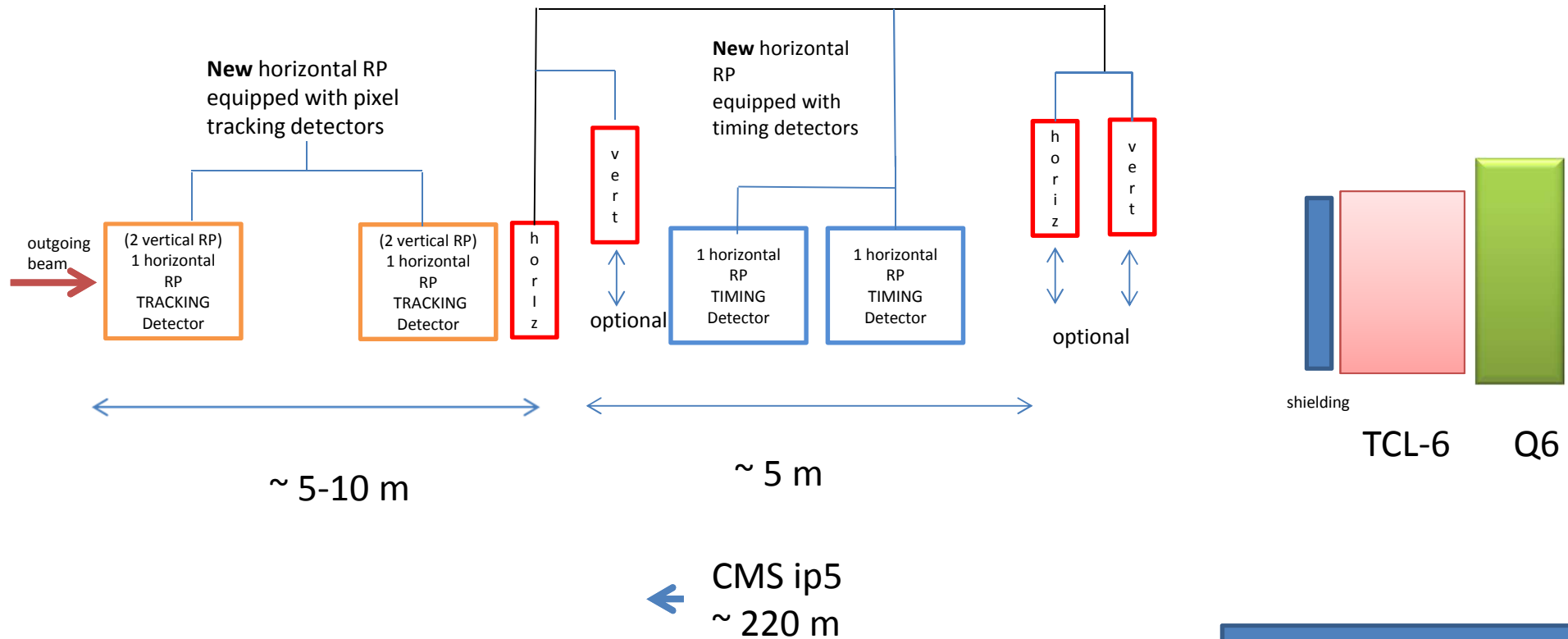
Existing TOTEM RP-220 m (near-far)



consolidation & upgrade

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-220 m (near-far)

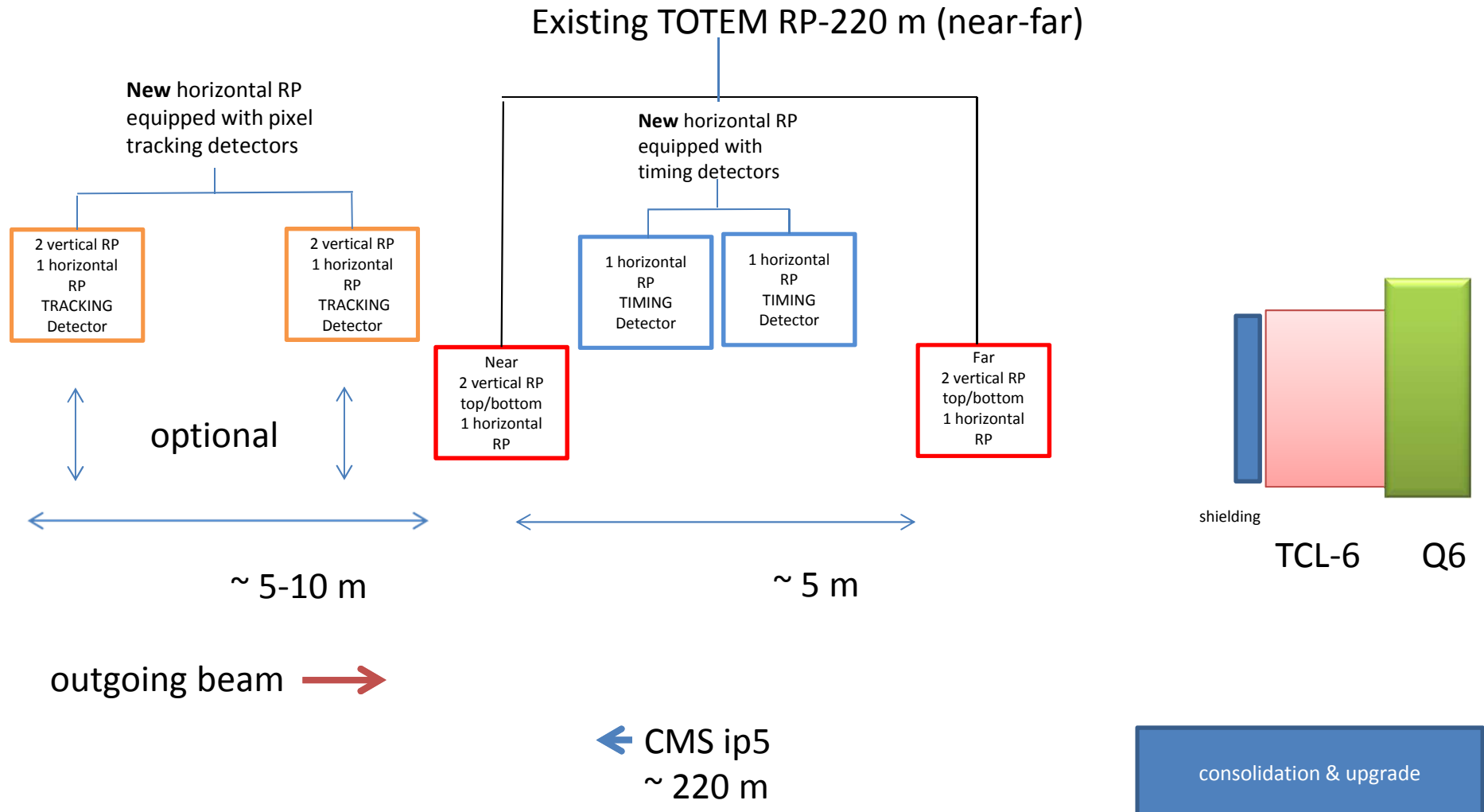


consolidation & upgrade

# Roman Pot (schematic-phase 1)

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

NEW installed horizontal RPs (timing) are retracted (parking position)

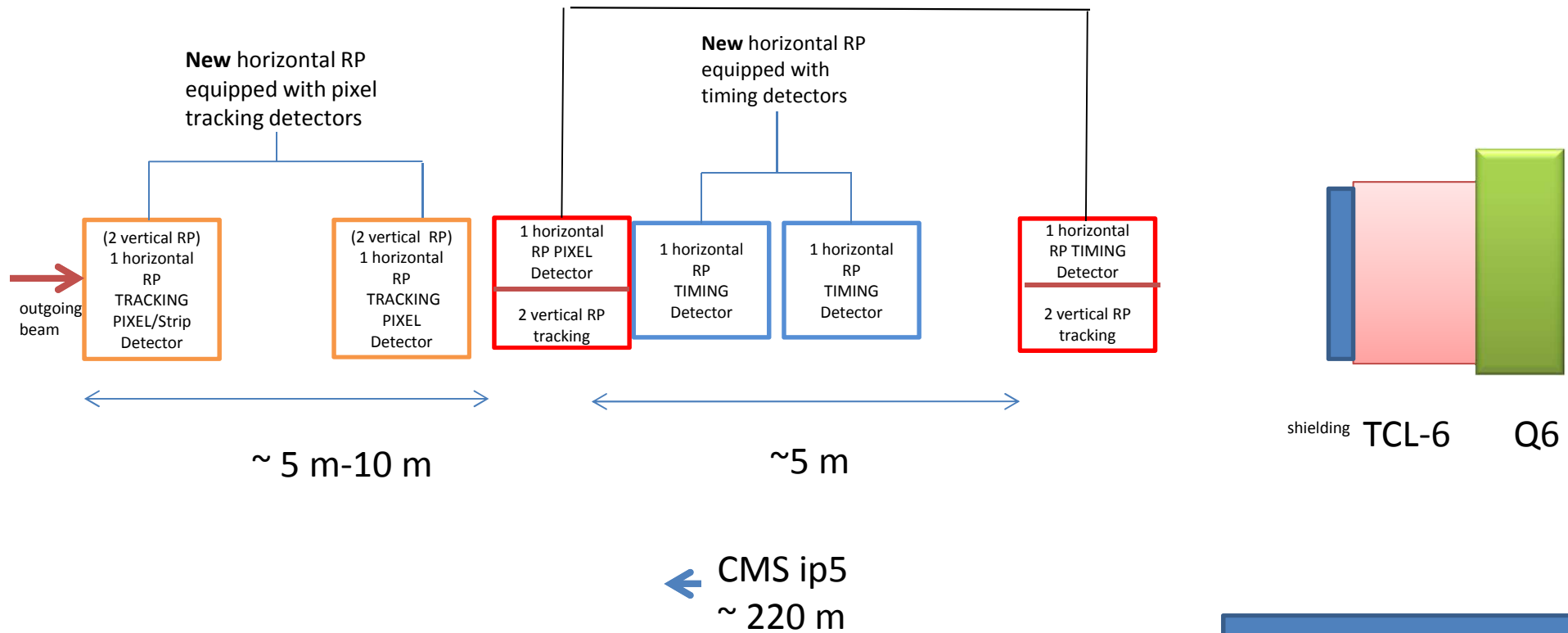


# Roman Pot (schematic-phase 2)

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

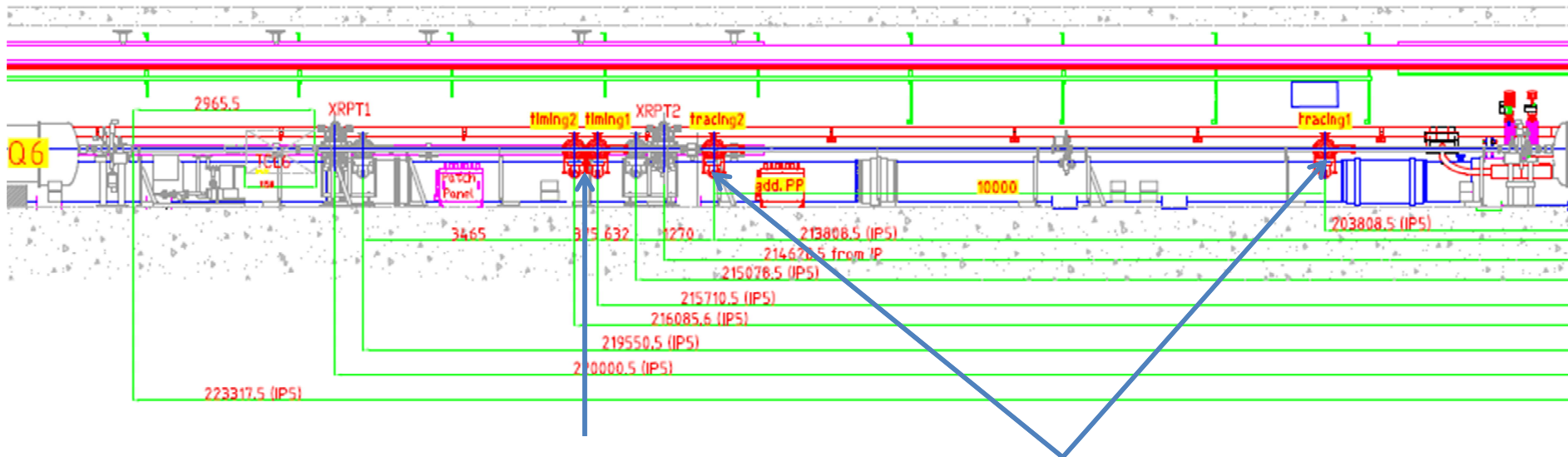
ALL horizontal RPs are inserted

Existing TOTEM RP-220 m (near-far)



# RP Integration study timing & tracking

Sector 4/5




Upgrade:  
new RP station  
new timing detector

Consolidation:  
147 m relocated RP station  
Upgrade:  
Si-pixel detectors

consolidation & upgrade

# Overview

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(under approval by CMS)  
-> Layout of RP stations - combination of consolidation program with upgrade program
-  Work packages related to consolidation & upgrade  
-> Status of work packages and schedule – issues on critical path
- Observations during insertion of horizontal RPs in November 2012 (high luminosity, low  $\beta^*$ )  
and impact on consolidation and upgrade work  
-> Optimization of RP housing (beam heating), ferrite study

work packages & schedule

# MAIN Work packages LS1 and beyond

- **TOTEM -> consolidation**
  - extraction & service of RP147 m
  - re-installation of RP147 m at 210 m (upstream of RP220 m near)
  - extension of services from 147 m to 210 m
  - extraction & re-installation of RP220 m & service work
  - service work on RP 220 m vacuum
  - service work on RP 220 m motor drive (hardware & software)
  - service work on RP (ferrite, RF housing)
- **TOTEM -> upgrade**
  - installation of 2 new RP horizontal stations on each side of IP5 (downstream of RP 220 m near, upstream of RP 220 m far)
  - adaptation of horizontal RPs to be used for low  $\beta^*$
  - production new RP housing, optimized for RF heating and beam feedback
  - installation of electrical services for new detectors (standard services will be re-used from RP147)
  - installation of new tracking/timing detectors
- **LHC beam line modifications at +/- 220 m -> consolidation + upgrade**
  - adaptation of beam line for installation of RP147m at 210m (consolidation) and new horizontal RPs (upgrade)
- **LHC collimators -> consolidation + upgrade**
  - installation of TCL4 (4/5, 5/6)
  - installation of TCL6 (4/5, 5/6) + relocation of cooling components close to +/- RP220m far.



# Sharing of work overview with CERN groups (not complete)

EN-MEF-LE (coordination, synchronization with LHC planning & scheduling)

PH-DT (RP mechanics, vacuum, motor, services, cable production ...)

PH-ESE (electronic issues, fibers, HV cables...)

EN-CV-DC (RP cooling system)

EN-MEF-SI (cables)

EN-MME-DI (new RP production)

EN-ICE-SIC (FESA)

TE-VSC-LBV (ferrite – vacuum measurements, beam pipe)

TE-MPE-PE (LHC machine protection)

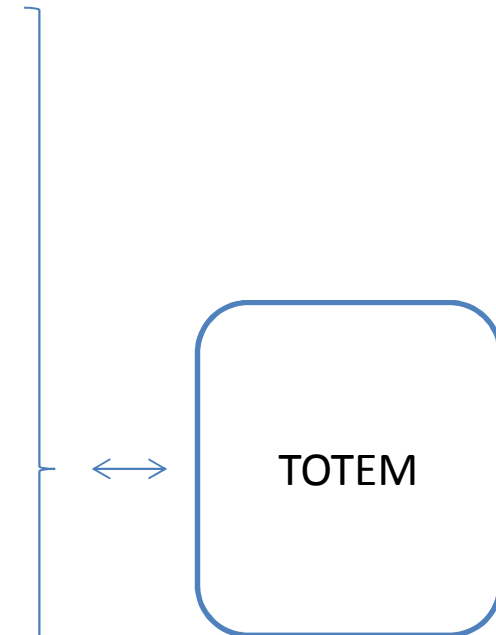
DGS-RP-AS (radiation protection)

PH-UCM (RP engineering, integration,...)

BE-ABP-ICE (RP – RF study & optimization)

BE-OP-LHC (Operation of RP – CCC)

BE-ABP-LCU (collimators)



work packages & schedule

# Work packages → Roman Pot tunnel installation

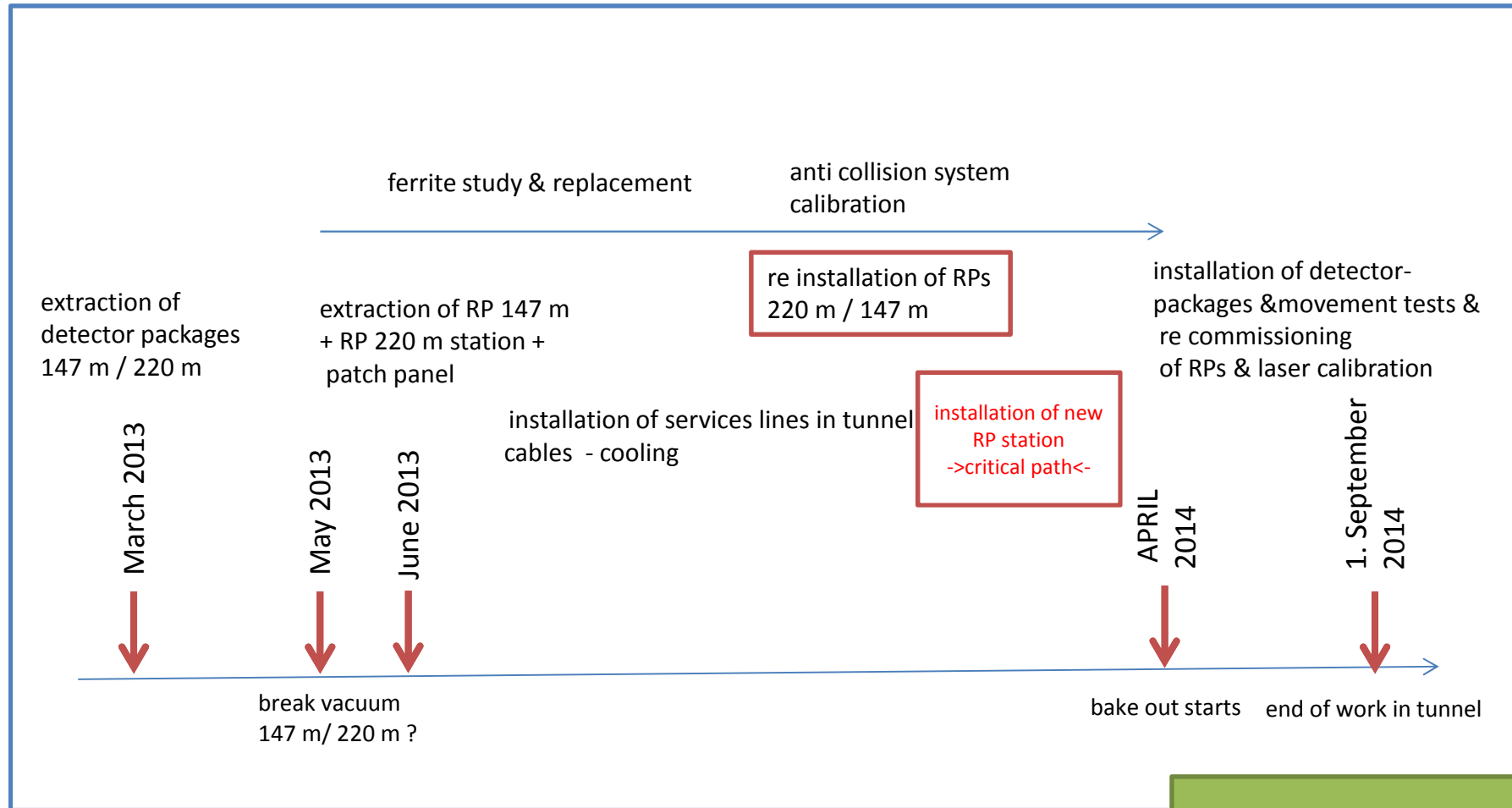
(CMS, PH-DT, EN-CV, BE-ABP-ICE, LTEX)

- **WP1-T: removal & reinstallation of RP147 m**  
(radio protection, RP storage , machining of flanges, ferrite, anti collision switch?)
- **WP2-T: removal & reinstallation of RP220 m**  
(anti collision switch, ferrite)
- **WP3-T: transfer of supplies from 147 m -> 210 m**  
(motor power lines, patch panel, LV, + new HV cable)
- **WP4-T: installation of new fibres**
- **WP5-T: RP@147 m motor & mechanics**  
(preparation for reuse at 210 m)
- **WP6-T: Flanges – interface to LHC**
- **WP7-T: beam-pipe & TCL**

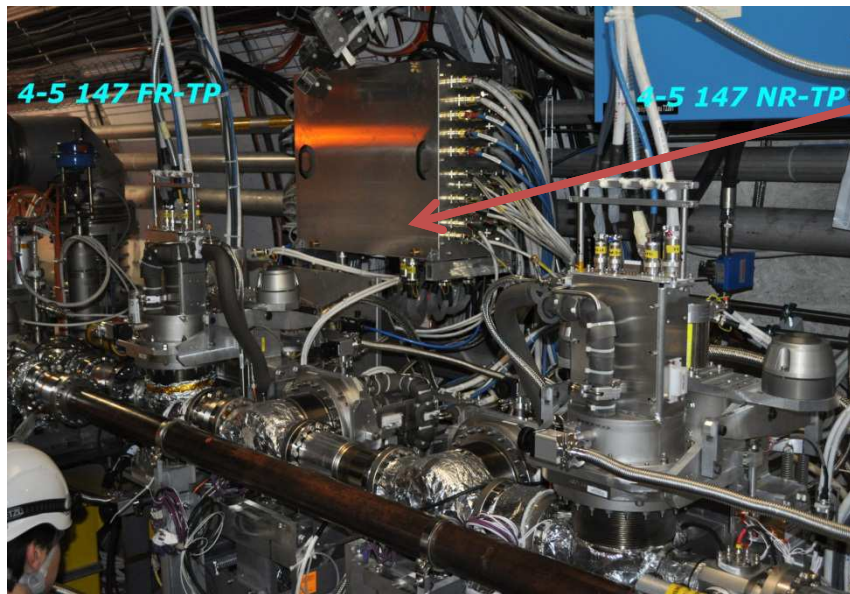
work packages & schedule

# LS1 activity -> TIMELINE

(main activities in tunnel)



# Roman Pot at 147 m & 220 m



patch panel

Position of new RPs

TCL 6

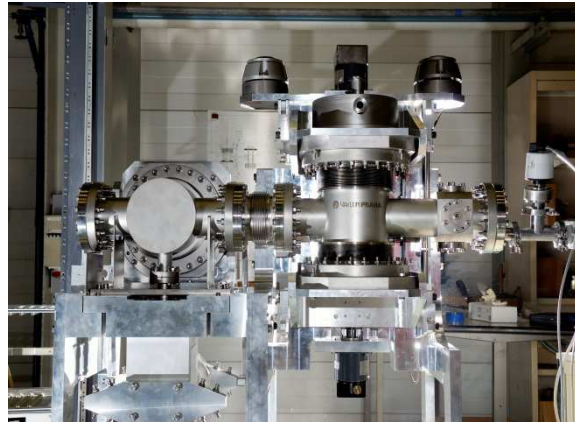
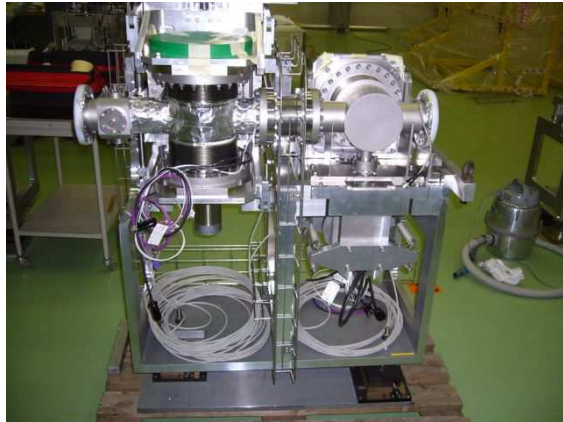


Relocation of RPs & patch panel from 147m to 200m

patch panel (relocated from 147m)

work packages & schedule

# Roman Pot & detector package



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

4/9/2013

LHCC TOTEM 13.3.2013 CERN J. Baechler


work packages & schedule

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# TOTEM & PH-DT L1 work package

-> activities of PH-DT (summarizes not all activities)

## Main tunnel activities

		<b>TOTEM &amp; PH/DT – LS1 WORK PACKAGE</b>	
<i>TOTEM Project Document No:</i> -	<i>PH/DT Document No.</i> 	<i>Created:</i> 15/01/2013	<i>Page:</i> 1 of 11
		<i>Modified:</i> 15/01/2013	<i>Rev. No.:</i> 2
<p><b>TOTEM &amp; PH/DT – LS1 WORK PACKAGE</b></p> <p><b>Technical Description</b></p> <p><i>Abstract</i></p> <p>This work package describes the M&amp;O tasks foreseen by the TOTEM experiment for LS1 (2013/2014) where the group PH/DT will get involved providing resources and expertise. This work package complements the existing agreement for the <i>Maintenance and Operation of TOTEM Detectors 2012 to 2016</i> (<a href="#">EDMS 1230888</a>)</p>			
<i>Prepared by:</i> Xavier Pons <i>PH/DT</i>	<i>Checked by:</i> Joachim Baechler <i>PH/TOT</i> Mar Capeans <i>PH/DT</i> Christian Joram <i>PH/DT</i> Mario Deile <i>PH/TOT</i> Sylvain Ravat <i>PH/DT</i> Dorothea Pfeiffer <i>EN/MEF</i> Luc Kottelat <i>PH/DT</i> Jerome Noel <i>PH/DT</i> Walter Snoeys <i>PH/ESE</i> Gueorgui Antchev <i>PH/TOT</i>	<i>Approved by:</i> Joachim Baechler <i>PH/TOT</i> Mar Capeans <i>PH/DT</i> Walter Snoeys <i>PH/ESE</i>	

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work packages & schedule

# Work package EN-CV

(maintenance of pumps and prolongation of cooling lines from 147m to 220m)

<p>CERN CH-1211 Geneva 23 Switzerland</p>		
<p>Reference <b>2013-093 V1.0</b></p>		
<p>CERN Div./Group or Supplier/Contractor Document No. <b>EN / CV</b></p>		
<p>EDMS Document No. 1270089</p>		
<p>EN Engineering Department Date: 2013-02-25</p>		
<p><b>Work Package Description</b></p> <p><b>TOTEM &amp; EN/CV-LS1 WORK PACKAGE</b>          This work package describes the M&amp;O tasks foreseen by the TOTEM experiment for LS1 (2013/2014)          Where the group EN/CV/DC will get involved providing resources and expertise.          The concerning location are in the tunnel sector 4-5 and 5-6 (R532 &amp; R571) + USC55 and H8</p> <p style="text-align: center;"><b>DRAFT</b></p>		
<p><i>Prepared by :</i></p> <p>EN/CV Olivier.Crespo-Lopez@cern.ch</p>	<p><i>Checked by :</i></p> <p>Joachim Baechler PH/TOT Mario Deile PH/TOT Gueorgui Antchev PH/TOT <a href="#">Vic Vacek PH and CTU/TOT</a> Michele Battistin EN/CV</p>	<p><i>Approved by :</i></p> <p>Mauro Noris EN/CV Joachim Baechler PH/TOT</p>
<p>Distribution list: Totem collaboration</p>		

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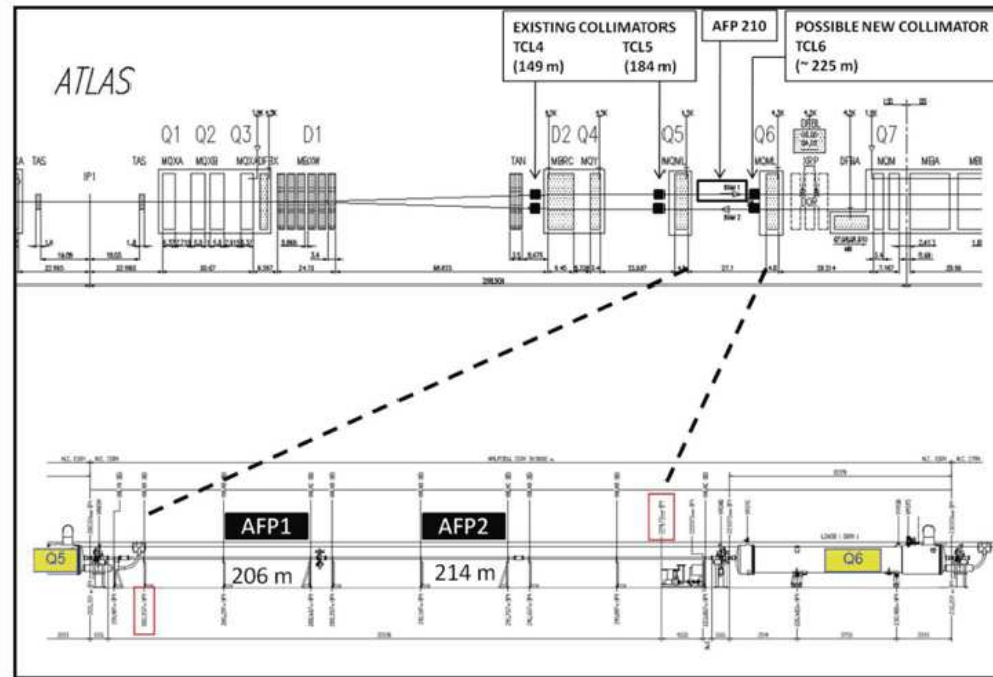
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work packages & schedule

# 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 doc

work packages & schedule



# 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.

# Work packages → Detector Sensor

CMS-TOTEM

- WP1-D: Si Pixel
- WP2-D: Timing-Detector
- WP3-D: Timing-TDC
- WP4-D: Timing-Clock distribution
- WP5-D: Readout board interface to CMS

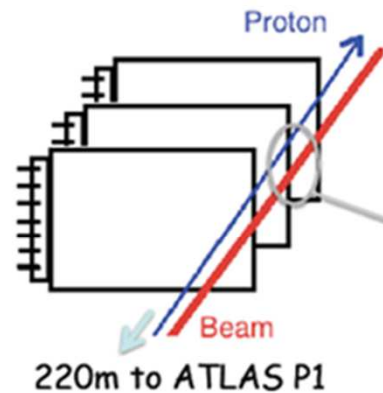
# TOTEM-RP

## study of 3D sensors

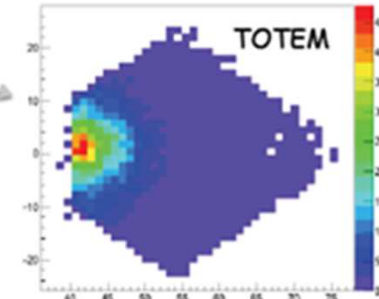
### TOTEM-RD50 (G. Pellegrini) [IBL – CNM]

## 3D Sensor for Forward Physics Trackers

- Interest in 3D sensors for forward physics detectors
  - ✓ AFP (ATLAS) HPS (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

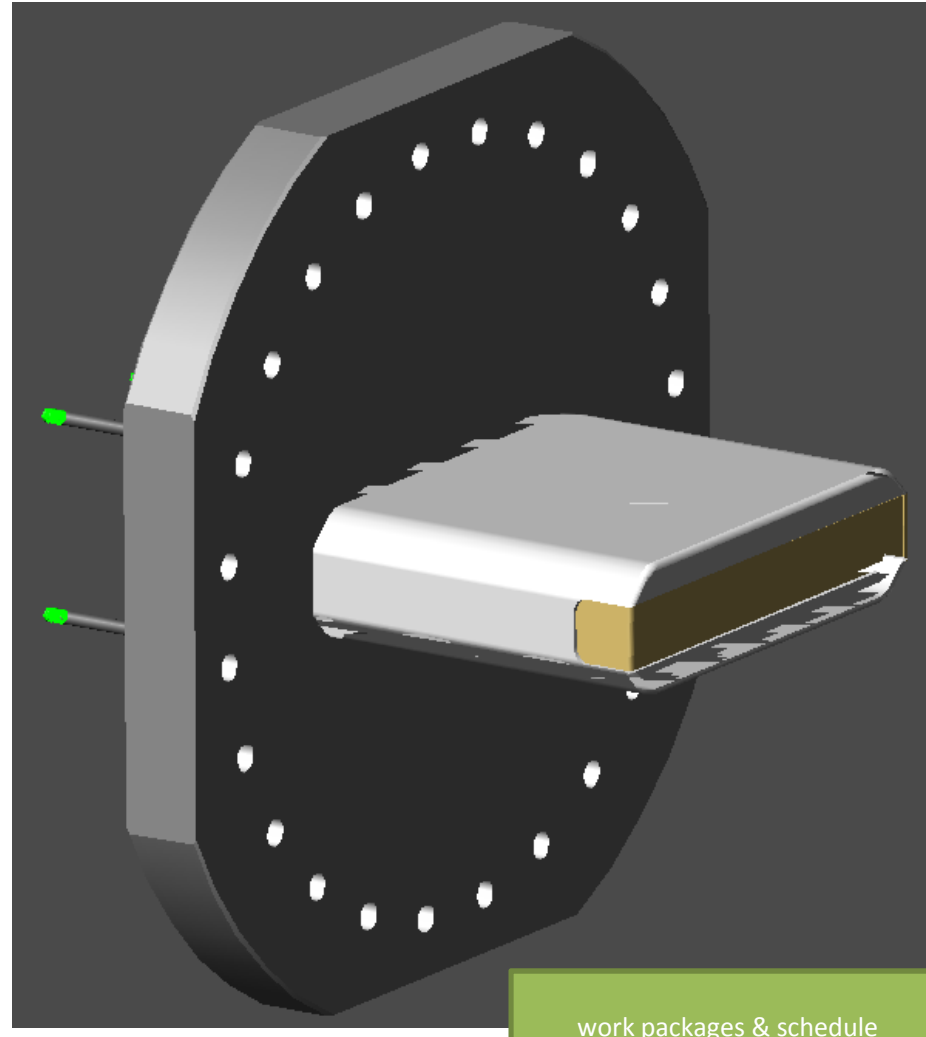
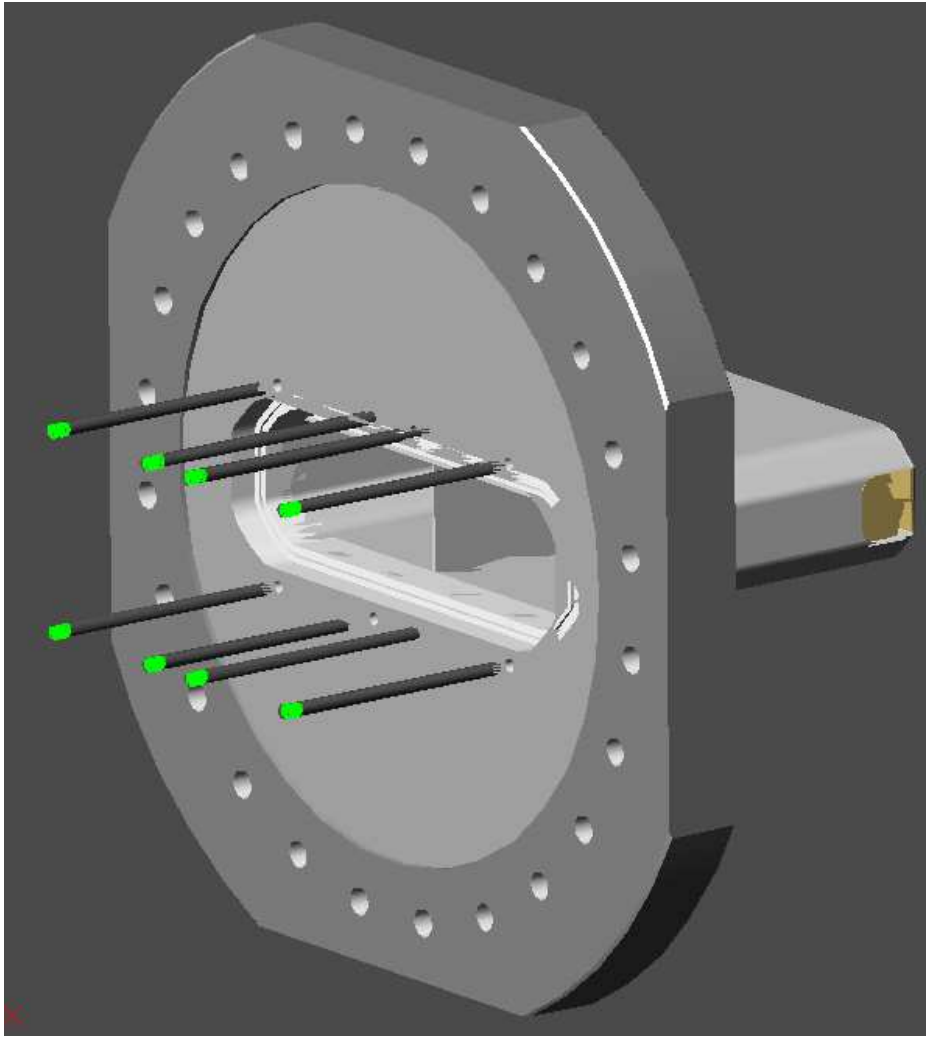
RD50 Workshop Nov 2012

7

work packages & schedule

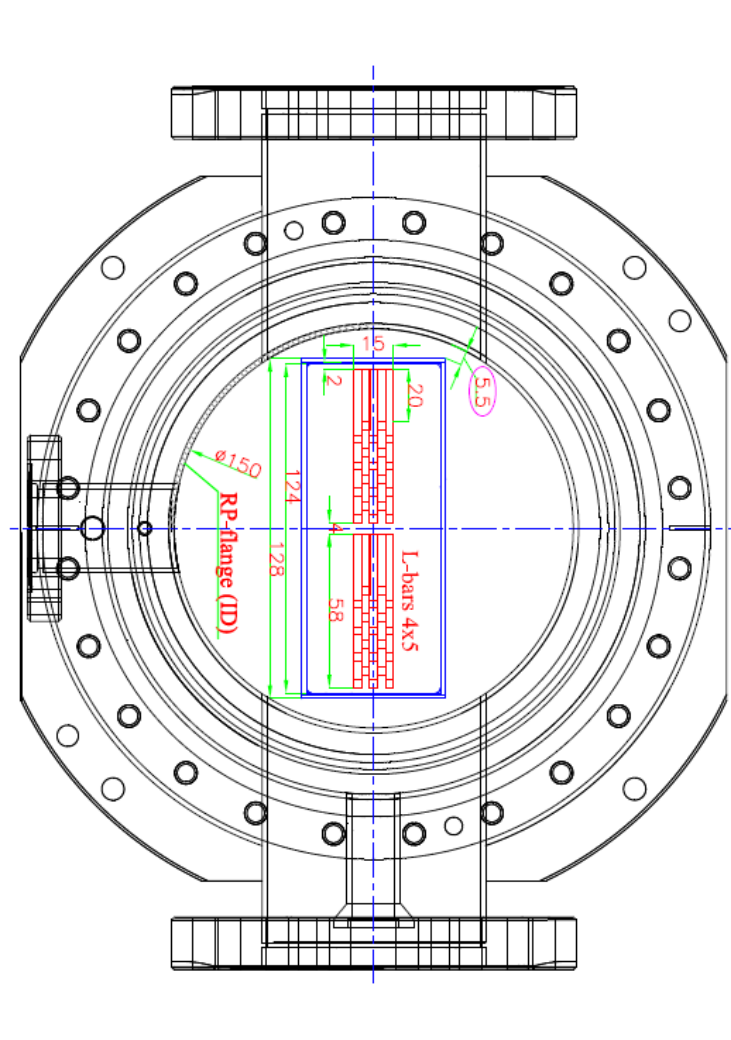
## Possible housing for timing detector

- Flange size big enough to integrate the timing detector
- Housing rotated by 90°
- Impedance not favorable



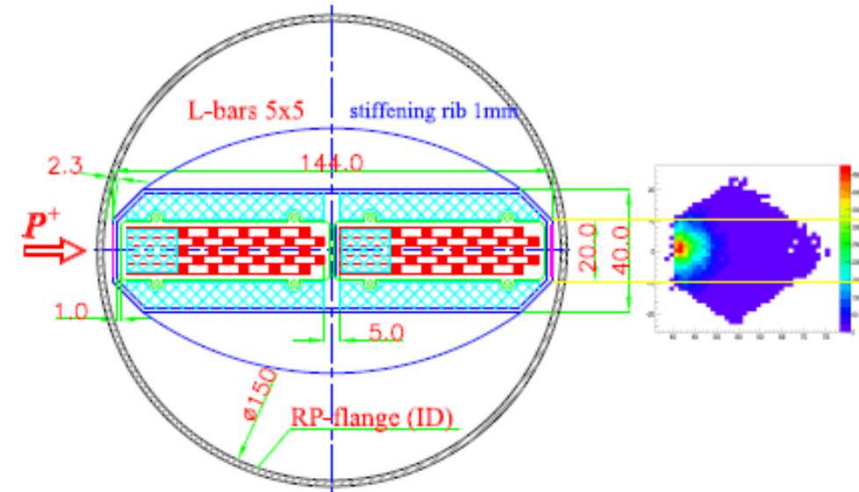
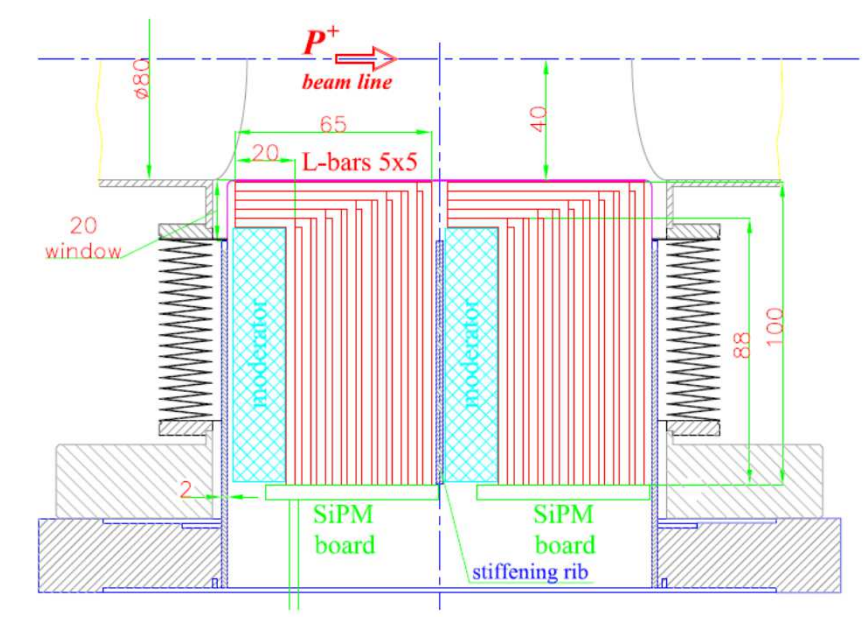
work packages & schedule

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



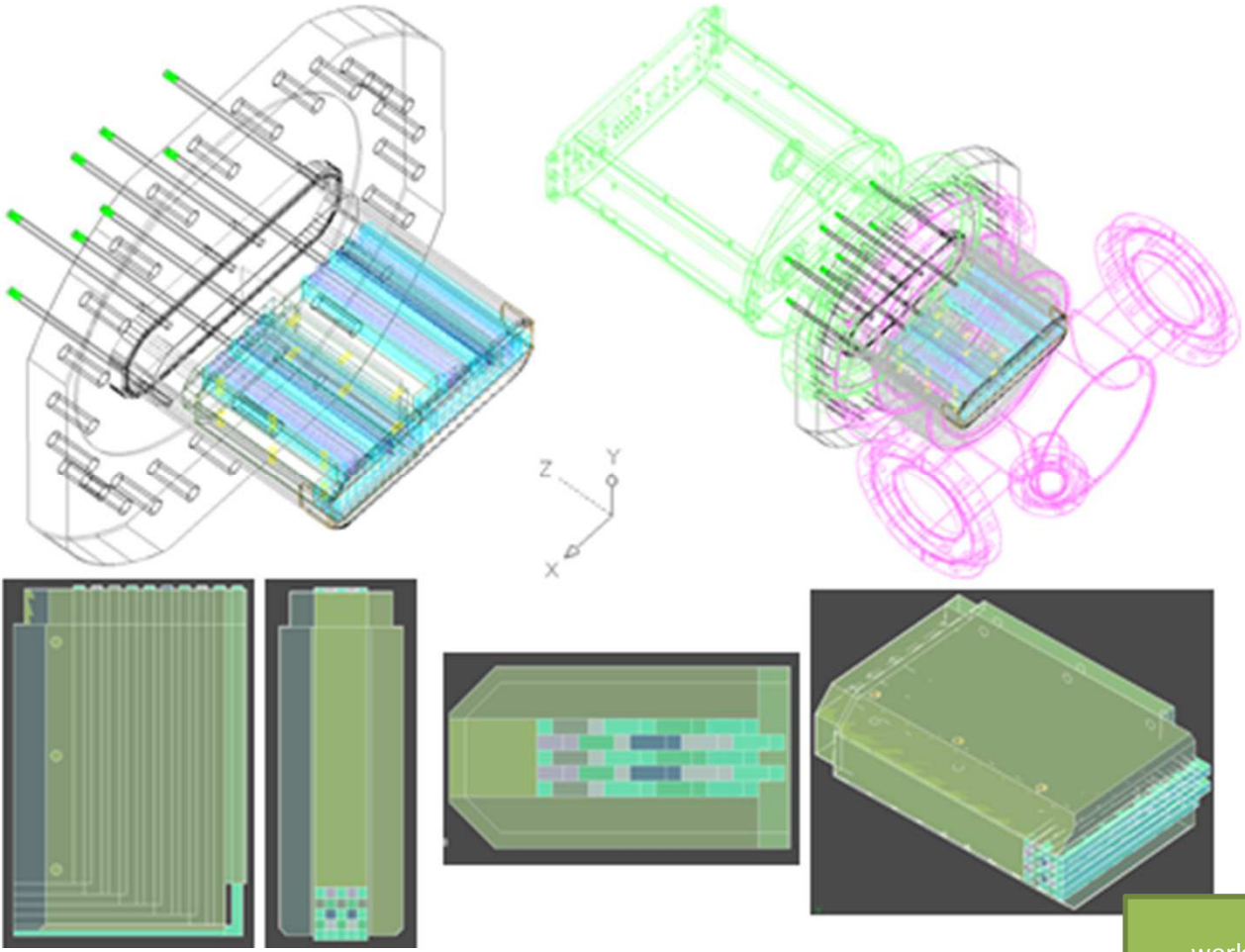
work packages & schedule

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



work packages & schedule

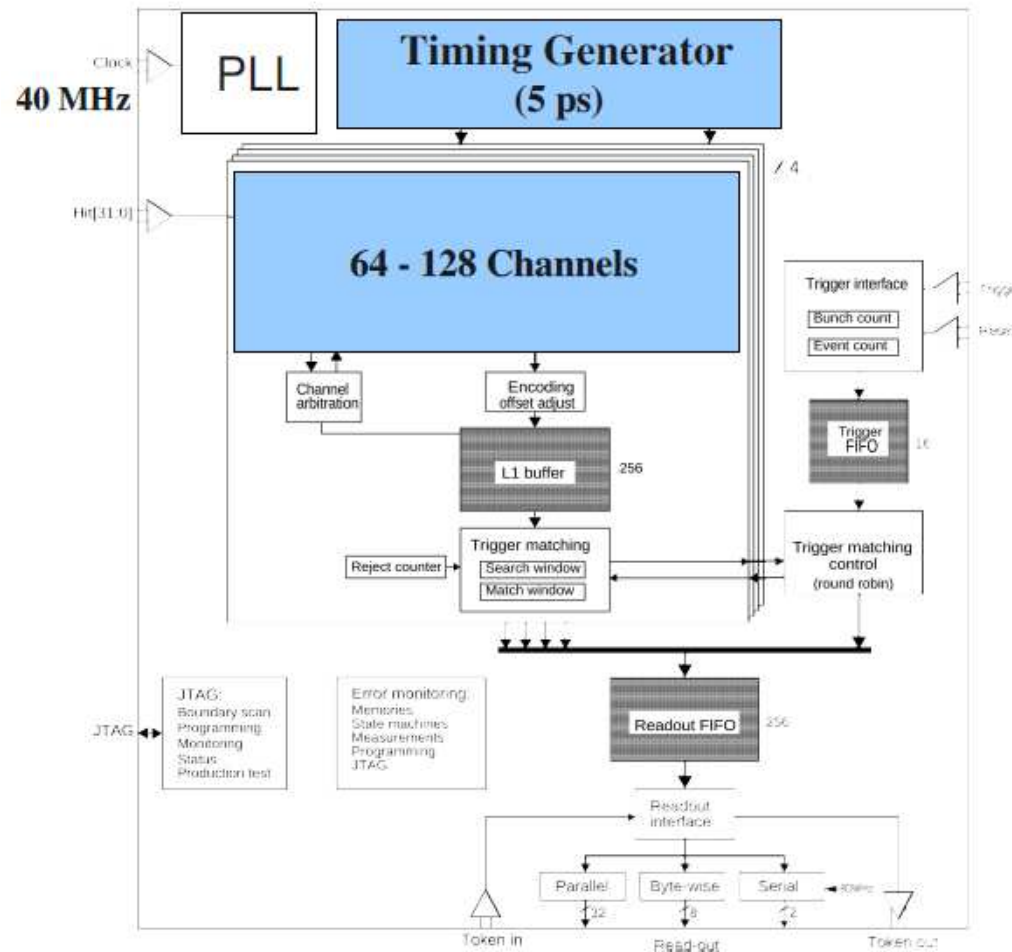
# Horizontal RP with Cherenkov timing detector



work packages & schedule

# PH-ESE: TDC status & perspectives

## TDC Architecture:



## Status

- demonstrator ASIC (130 nm)
- < 3 ps-rms resolution
- < 50 mW/channel
- missing counter, PLL and digital logic

## Perspectives

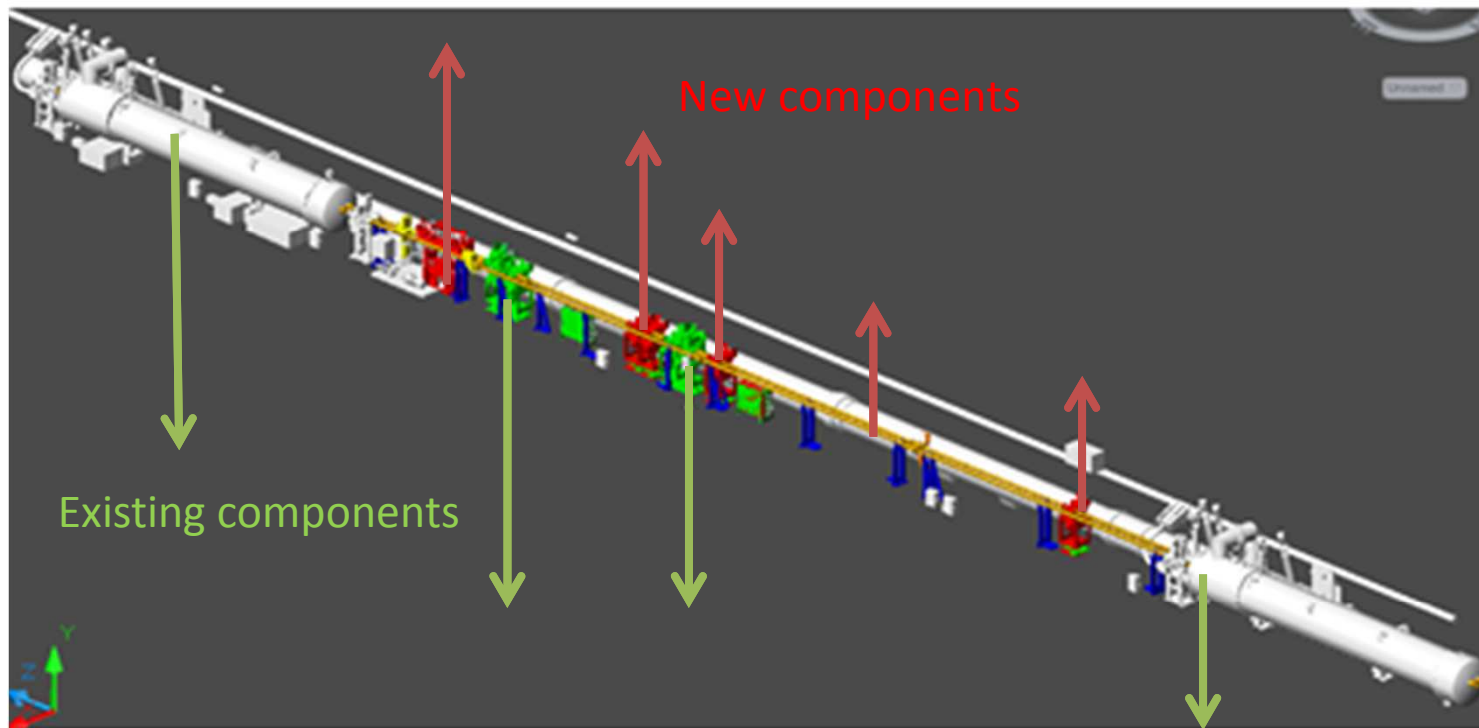
- full TDC (based on HPTDC)
- 64 - 128 channels per ASIC
- < 5 ps-rms timing precision
- radiation tolerant
- flexible readout architecture
- development time: 2 - 3 years



## Work packages → Optimization

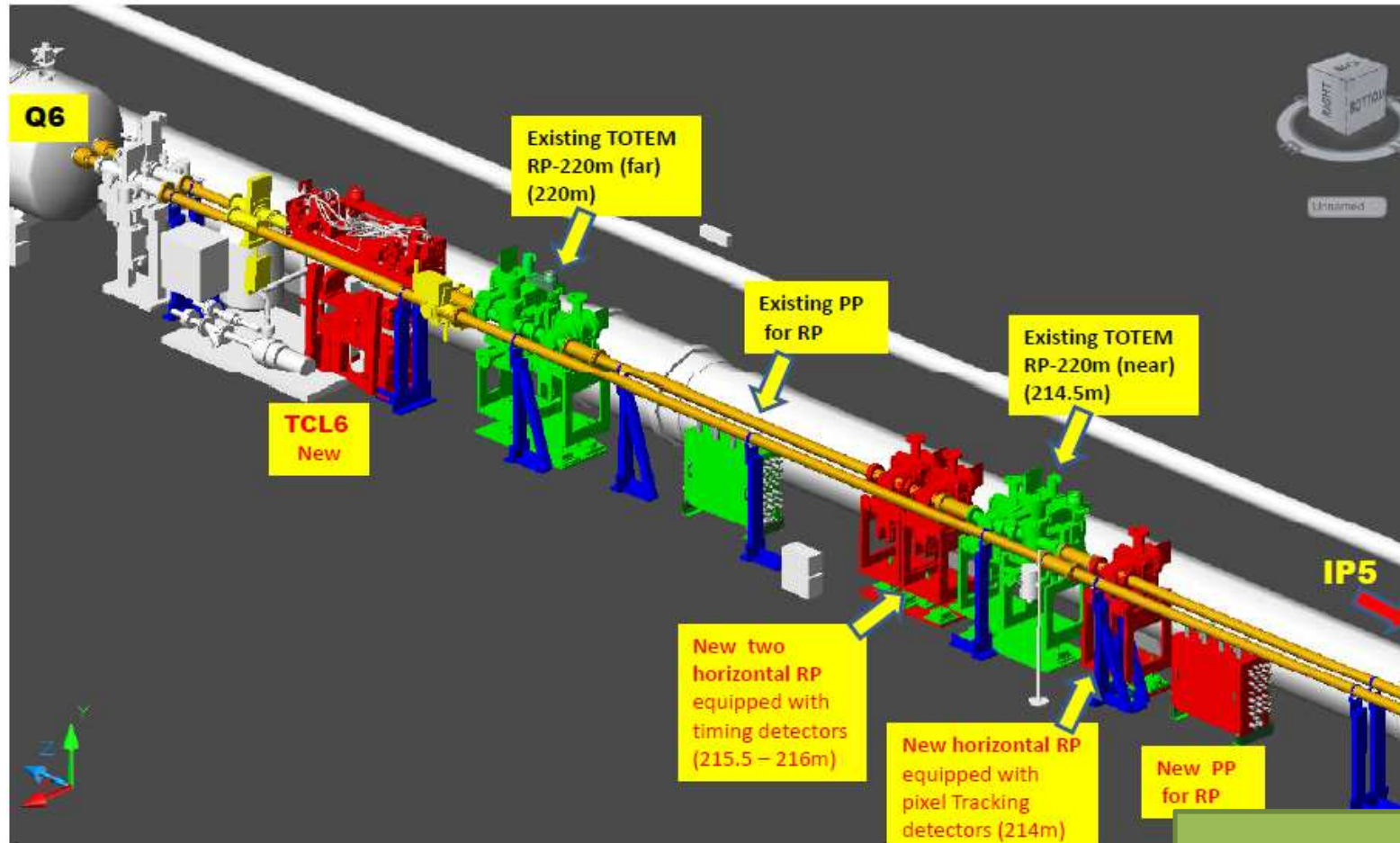
- WP1-O : optimal position and geometry of new RPs (RF, physics)
- WP2-O: optimal shape & size of sensors  
WP3-O: particle timing – vertex reconstruction
- WP4-O: detector position  
WP5-O: Material budget

# RP Integration study



work packages & schedule

# Integration study of TCL6 and Roman Pots



work packages & schedule

# Overview

- Consolidation program: TOTEM  
(approved by TOTEM management)  
Upgrade program (proposal) : TOTEM+CMS  
(under approval by CMS)  
-> Layout of RP stations - combination of consolidation program with upgrade program
  - Work packages related to consolidation & upgrade  
-> Status of work packages and schedule – issues on critical path
- Observations during insertion of horizontal RPs in November 2012 (high luminosity, low  $\beta^*$ ) and impact on consolidation and upgrade work
- > Optimization of RP housing (beam heating), ferrite study

insertion at low  $\beta^*$   
beam heating – LHC vacuum – RP optimization-  
rates

# Roman Pot (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 ->

insertion at low  $\beta^*$   
beam heating – LHC vacuum – RP optimization-  
rates

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



Date	Pots involved	min. dist.	Observations, Result	Consequence
16.10.	all V all H	12 $\sigma$ 30 $\sigma$	no problem dump on XRPH.A6R5.B1 (slow losses, 5s)	no UFO activity
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

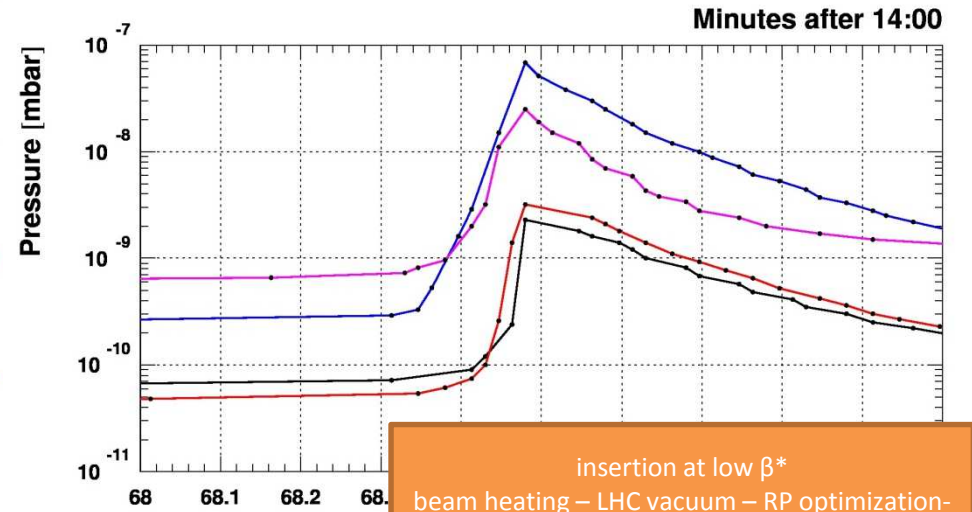
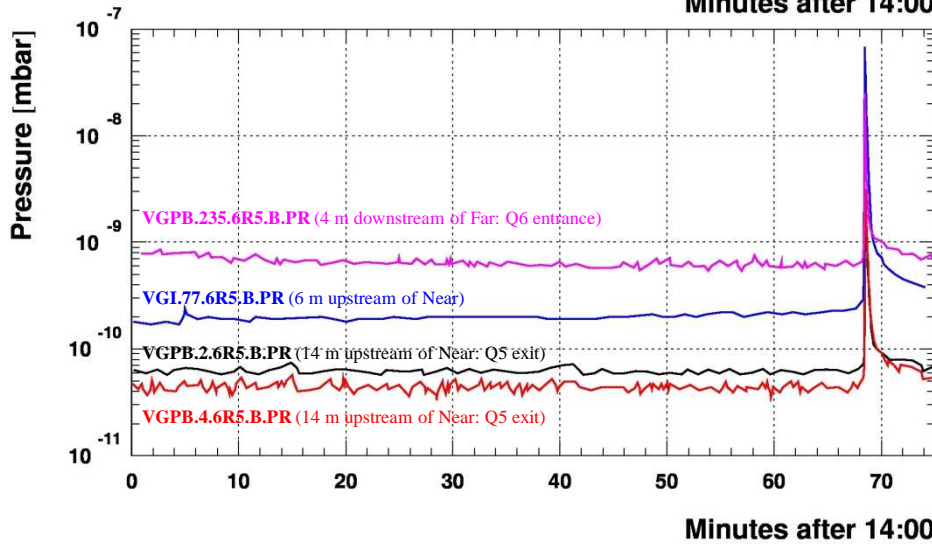
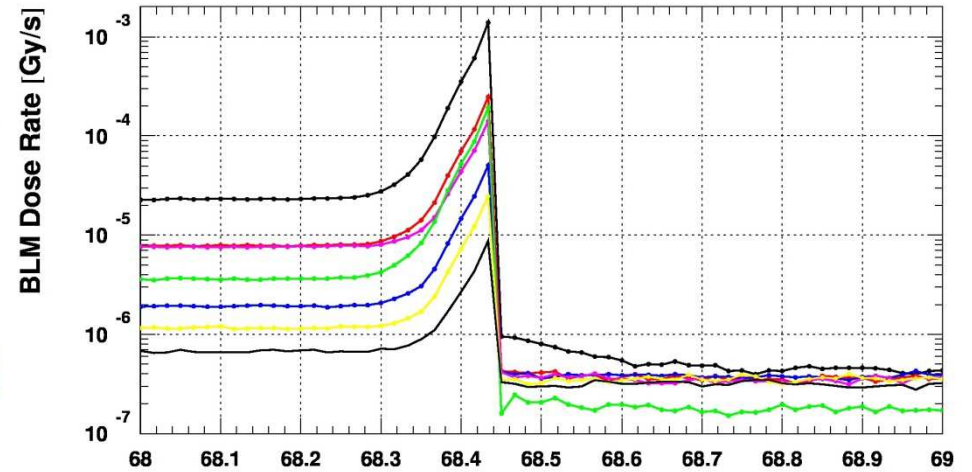
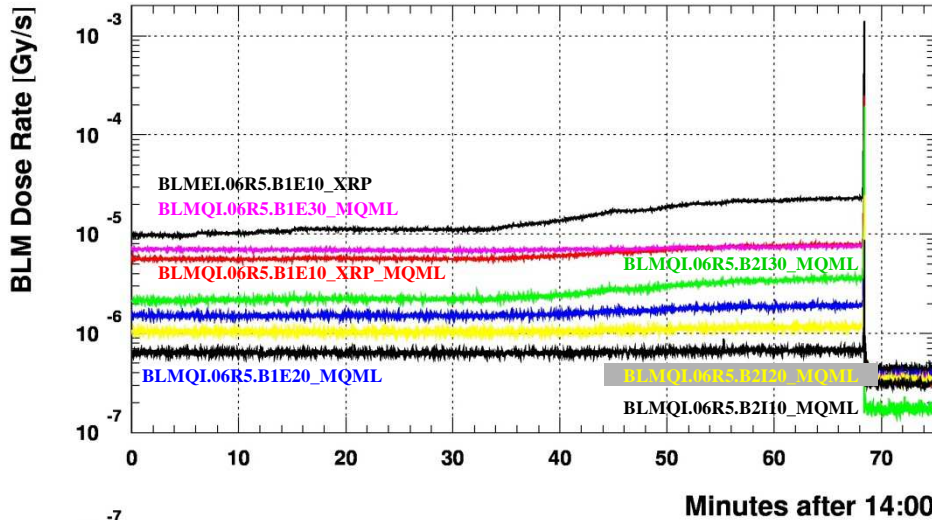
(\*) The (fast) UFOs in 6L5 were later found to originate from TCL5 [Tobias]

insertion at low  $\beta^*$   
beam heating – LHC vacuum – RP optimization-  
rates

# Comparison BLMs & Beam Vacuum



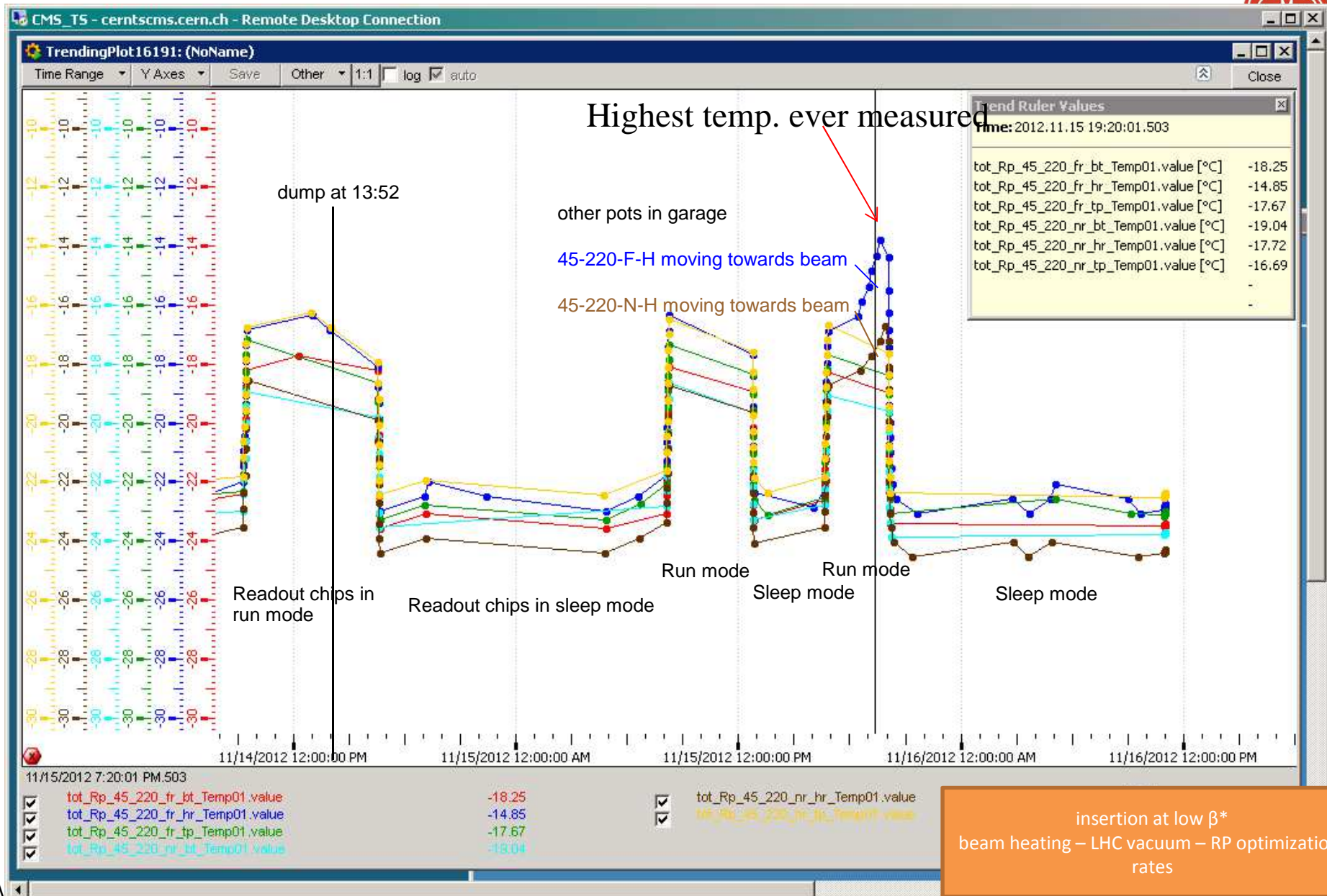
## Sector 5-6



insertion at low  $\beta^*$   
 beam heating – LHC vacuum – RP optimization-rates

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

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



the beam. UFOs cannot be resolved.

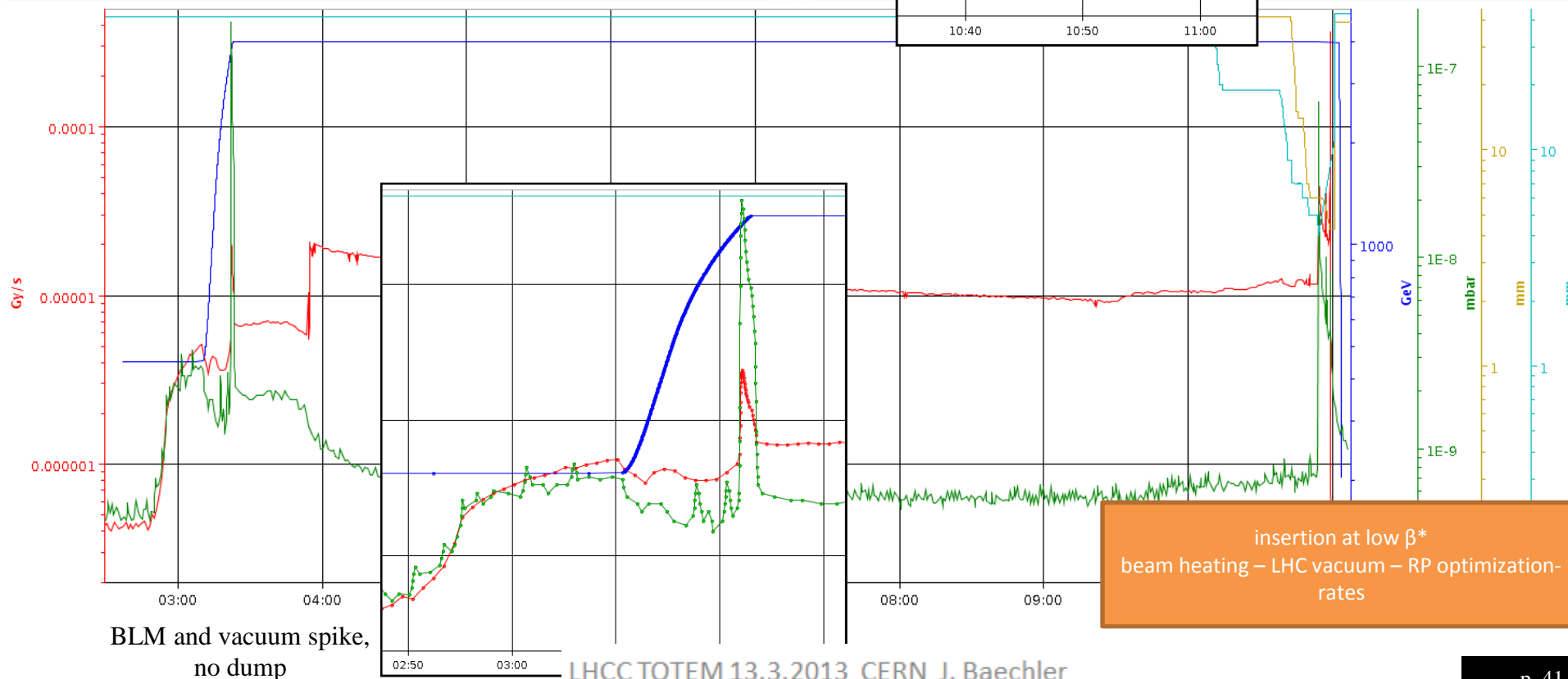
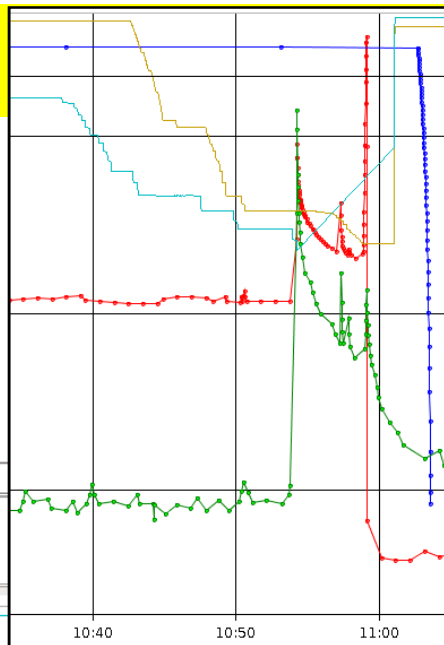


# Fill 3188 with RP Insertion, Cell 6R5



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.MKCB1.B1\_E\_CH1 
 → VGPB.235.6R5.B.PR 
 → XRPB.A6R5.B1:MEAS\_LVDT\_LU 
 → XRPB.B6R5.B1:MEAS\_LVDT\_LU

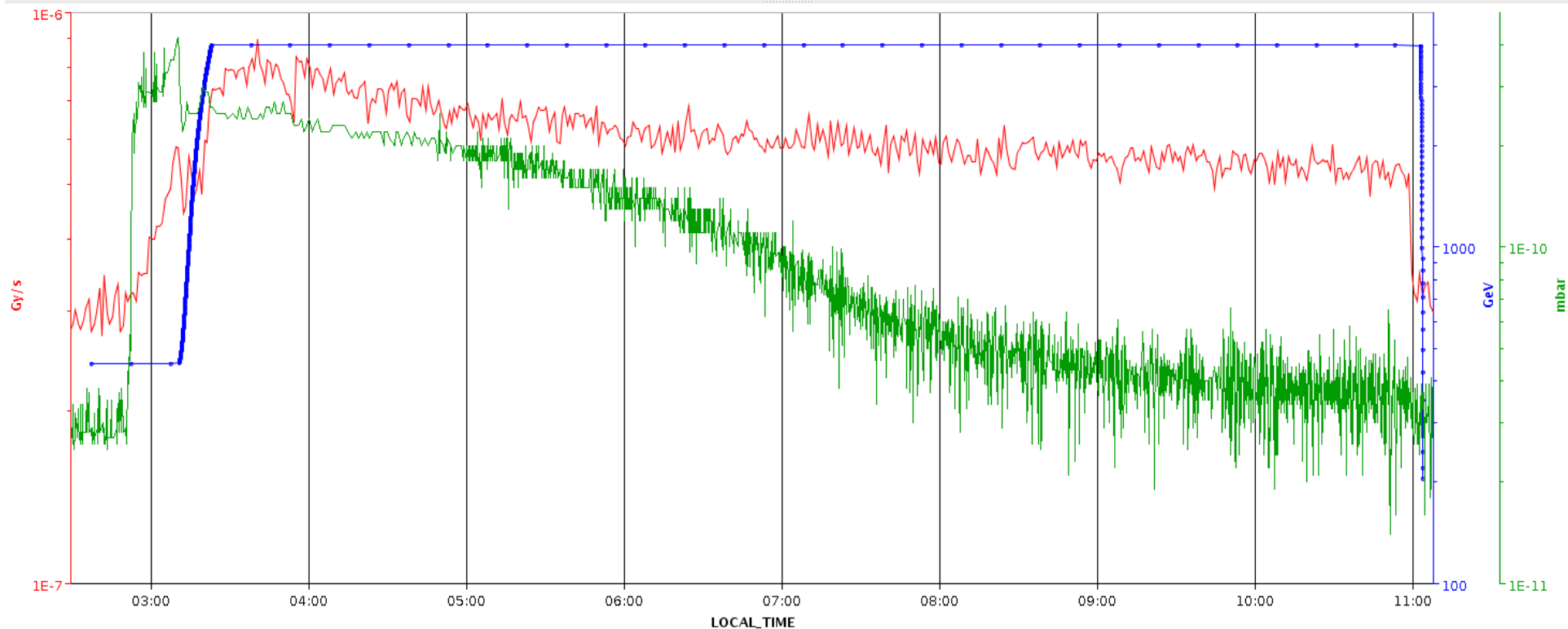


# Fill 3188, Cell 7R1 (ALFA)



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.MKCB1.B1.E.CH1 → VGPB.235.7R1.B.PR



slight vacuum degradation at injection,  
no spike in ramp

insertion at low  $\beta^*$   
beam heating – LHC vacuum – RP optimization-rates

# EM coupling of RP

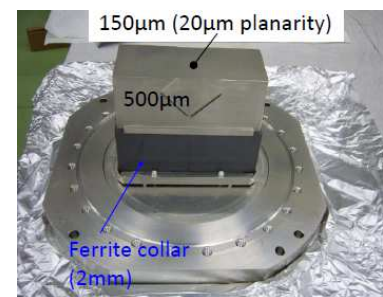
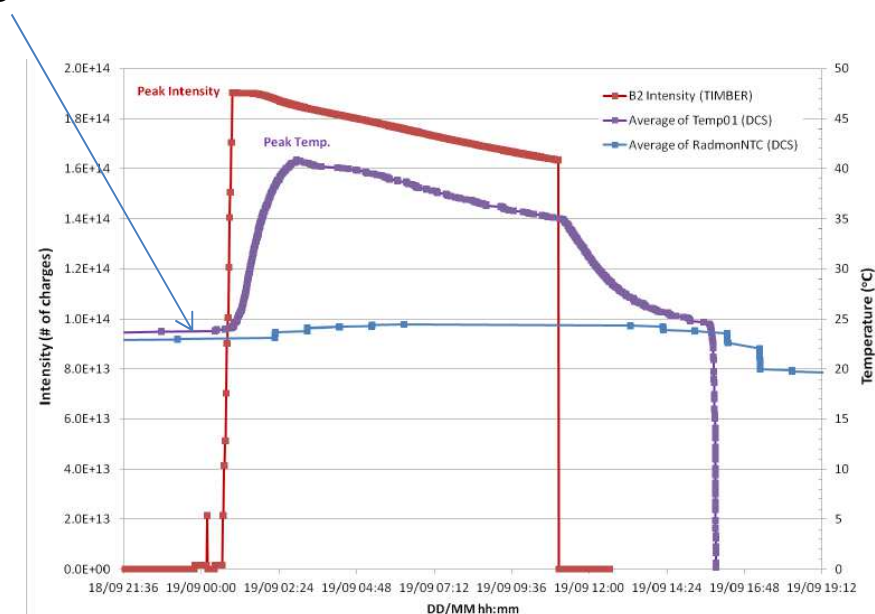
(RP in garage position)

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 safe mode to operate above dew point in case of vacuum problem

## Cooling of RP was switched off



insertion at low  $\beta^*$   
beam heating – LHC vacuum – RP optimization-rates

# Summary

## main observations

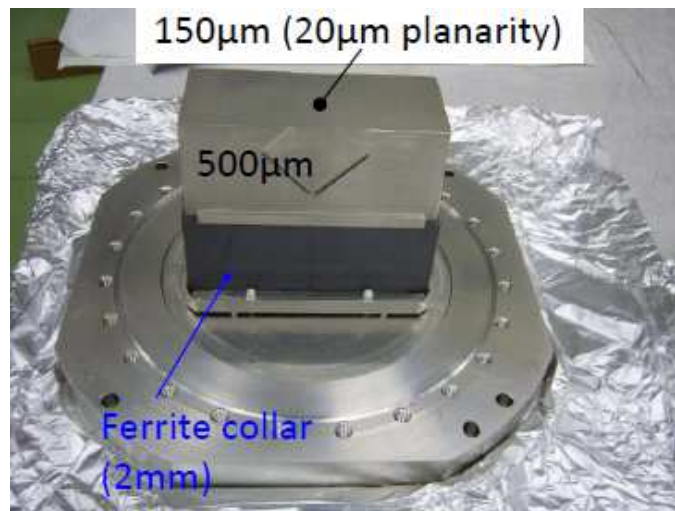
- Temperature increase in RP due to LHC beam
- LHC vacuum degradation in the region of RP147 m and RP220 m

- > Optimization of ferrite
- > Optimization of RP housing

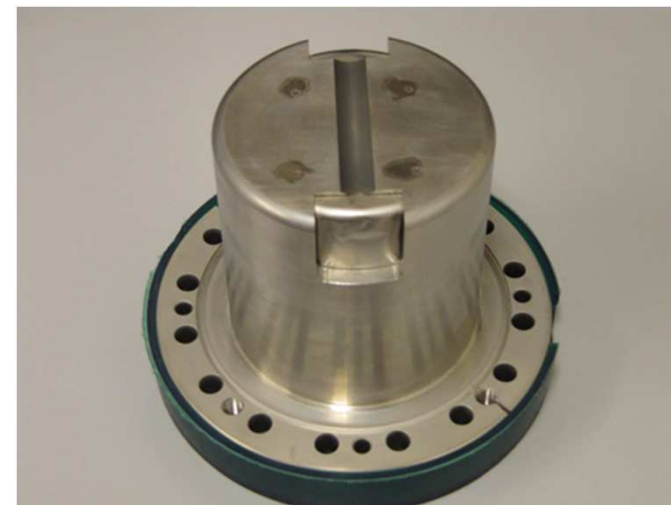
insertion at low  $\beta^*$   
beam heating – LHC vacuum – RP optimization-  
rates

# RP optimization

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



TOTEM – RP

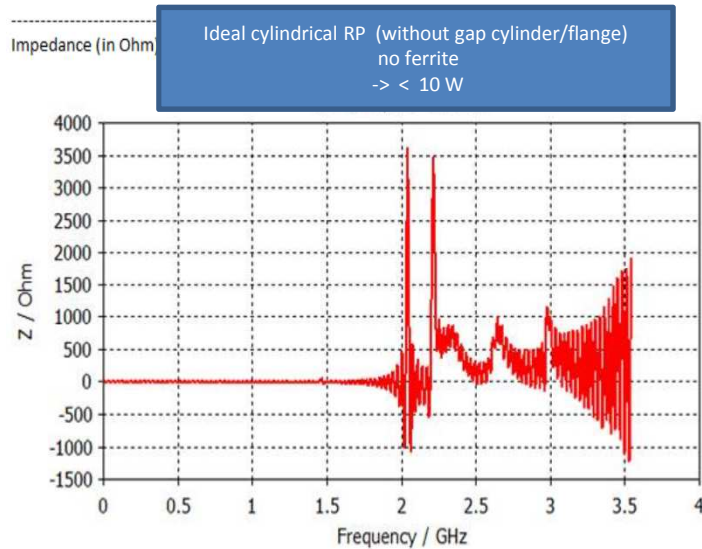
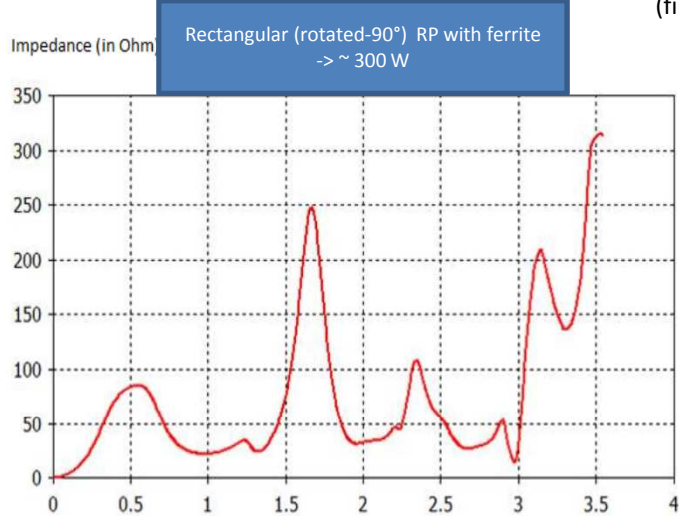


OLD TOTEM RP prototype

insertion at low  $\beta^*$   
beam heating – LHC vacuum – RP  
optimization-rates

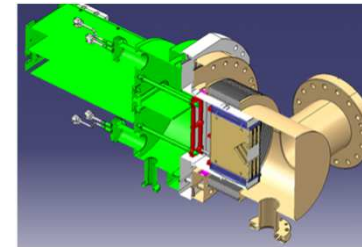
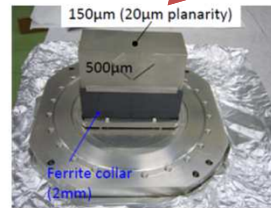
# Optimization of RF characteristics

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



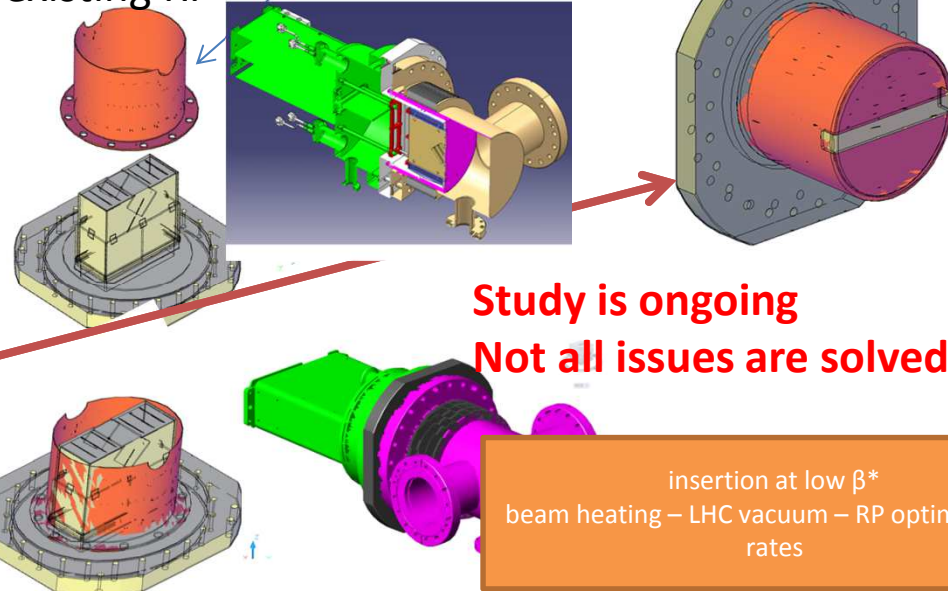
Same plot as before zoomed with the same y-axis.

Present RP housing



Study of new RP housing

Study of possible RF shielding for existing RP

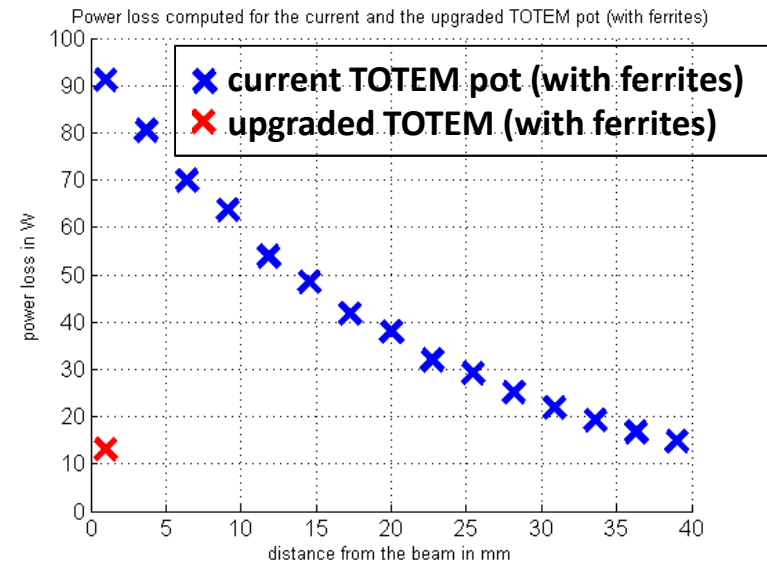
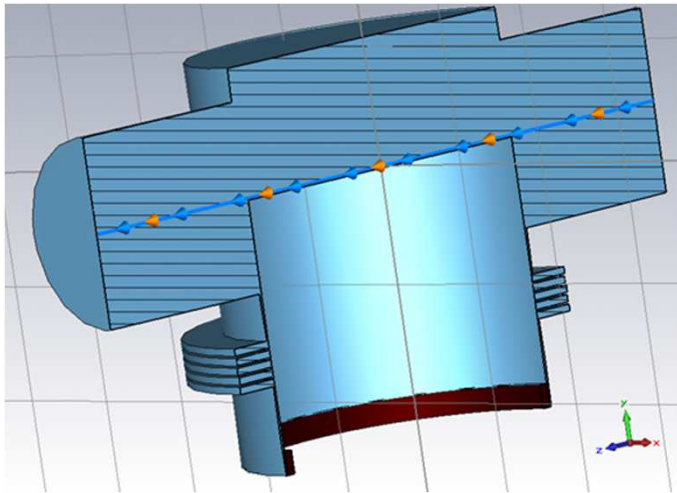


**Study is ongoing**  
**Not all issues are solved yet !**

insertion at low  $\beta^*$   
beam heating – LHC vacuum – RP optimization-rates

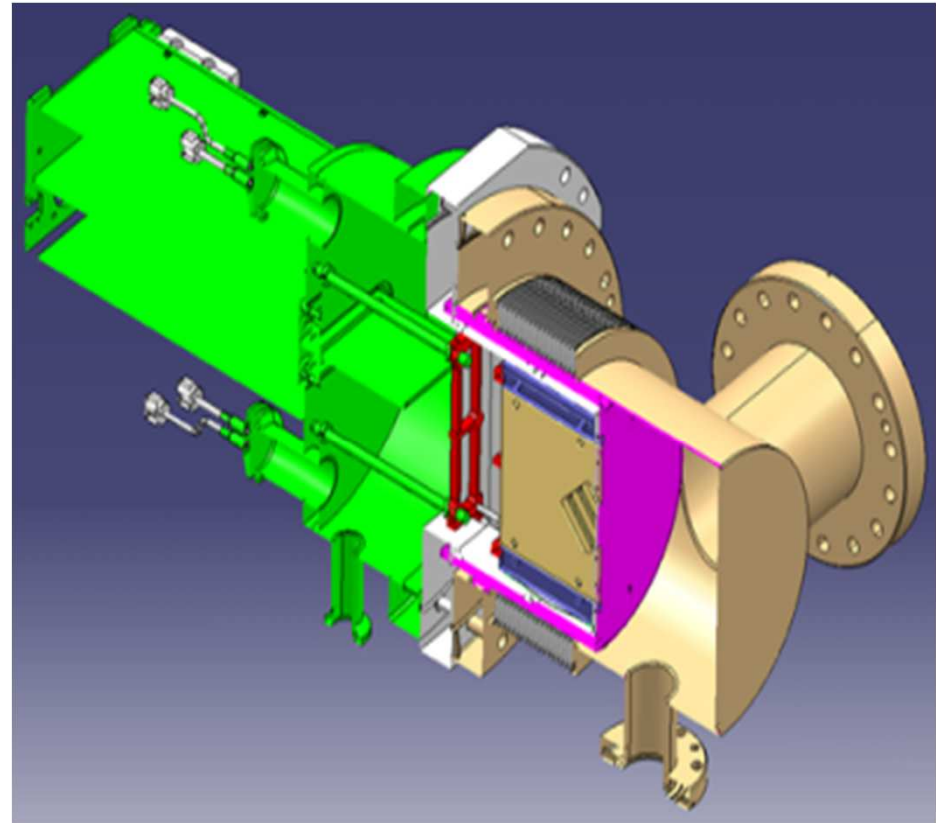
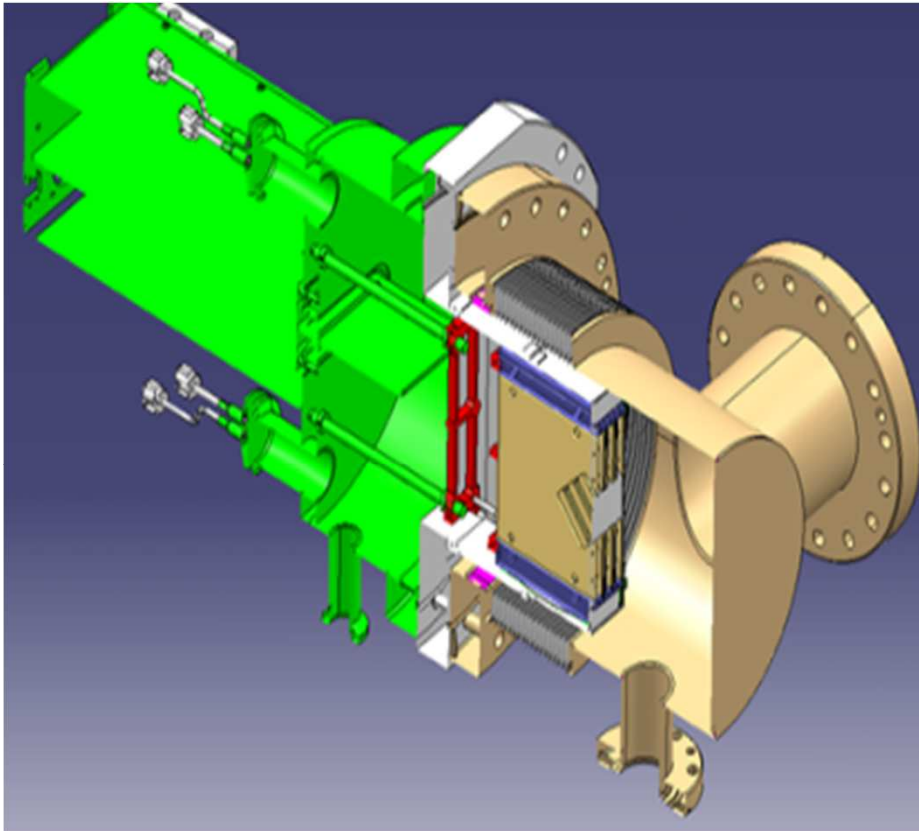
# Computed power loss

present RP box  $\leftrightarrow$  RP cylindrical (B. Salvant)



insertion at low  $\beta^*$   
beam heating – LHC vacuum – RP optimization-  
rates

## Comparison of rectangular and cylindrical RP

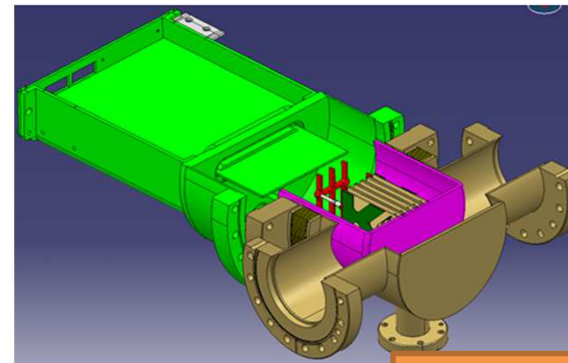
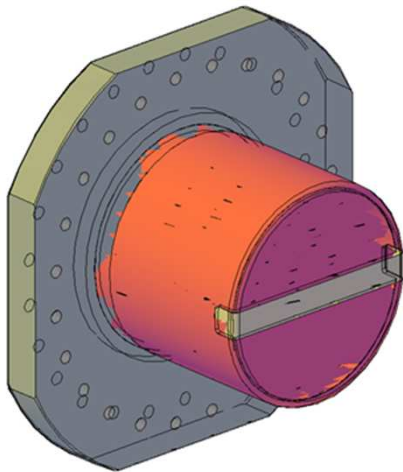
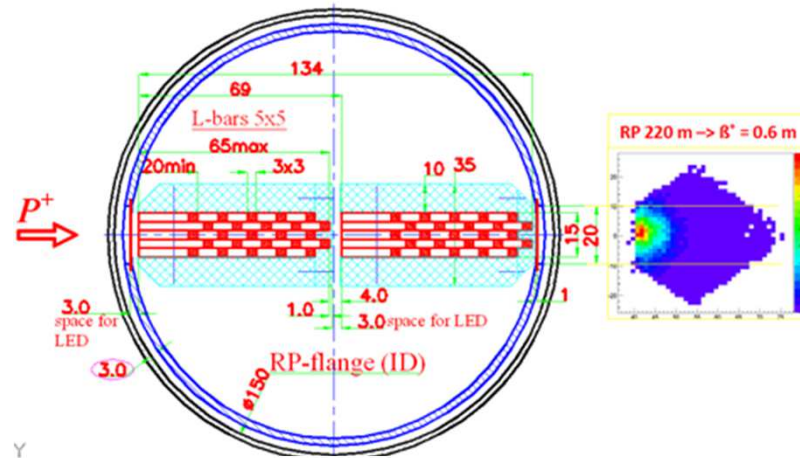
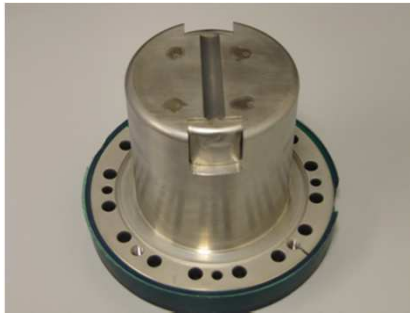


insertion at low  $\beta^*$   
beam heating – LHC vacuum – RP optimization-  
rates



# Integration study:

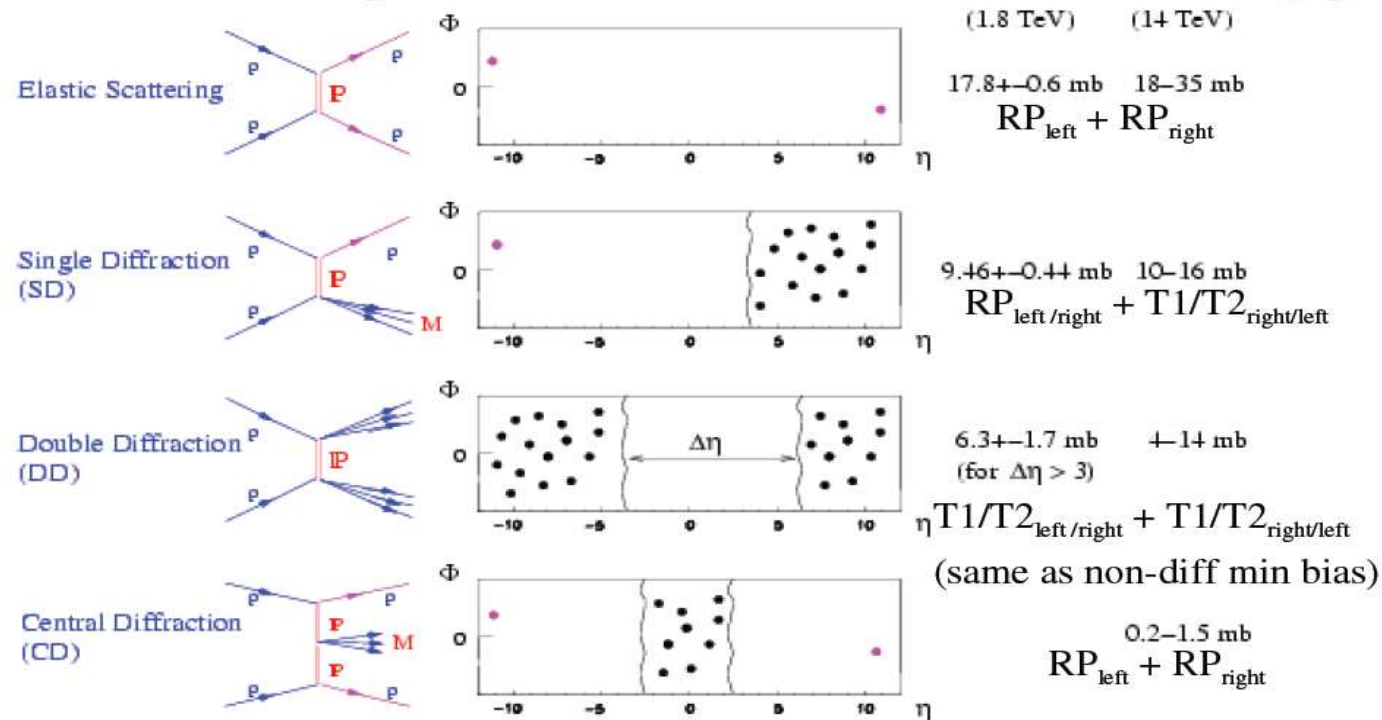
cylindrical pot with integrated Cerenkov timing detector / Si detector



insertion at low  $\beta^*$   
beam heating – LHC vacuum – RP optimization-rates

# Rate & background measurement

## Diffractive processes & their TOTEM trigger



cross-section large ( $\geq 5 \mu\text{b}$ ), even TOTEM acceptance included for any  $\beta^*$

insertion at low  $\beta^*$   
beam heating – LHC vacuum – RP optimization-rates

# Horizontal RP Rate at $14 \sigma$

	56-F	45-N	45-F
Rate for 1368 b with beam separation	2 MHz	1 MHz	3 MHz (incl. showers from N)
separation lumi factor	1 / 15.7	1 / 18.6	1 / 22.6
Rate for 1368 b without separation	31 MHz	19 MHz	68 MHz (22.6 * 3 MHz)
Rate for 1 b without separation	23 kHz	14 kHz	50 kHz
Hits per bx w/o separation	2.0	1.2	4.4 (50 kHz/11.2kHz)

Expected rates after LS1 are different (L, bunch scheme)

Beam conditions (fill # 3288):

$1.6 \times 10^{11}$  p/b

E = 4 TeV

$\beta^* = 0.6$  m

$\epsilon_n = 2.8 \mu\text{m rad}$

$\mu = 31$  (without separation)

L =  $6.7 \times 10^{33}$

Revolution frequency: 11.2 kHz

average crossing rate :  $11.2 * 1368 = 15.3$  MHz

average interaction rate (without separation) :  $15.3 * 31 = 47.4$  MHz

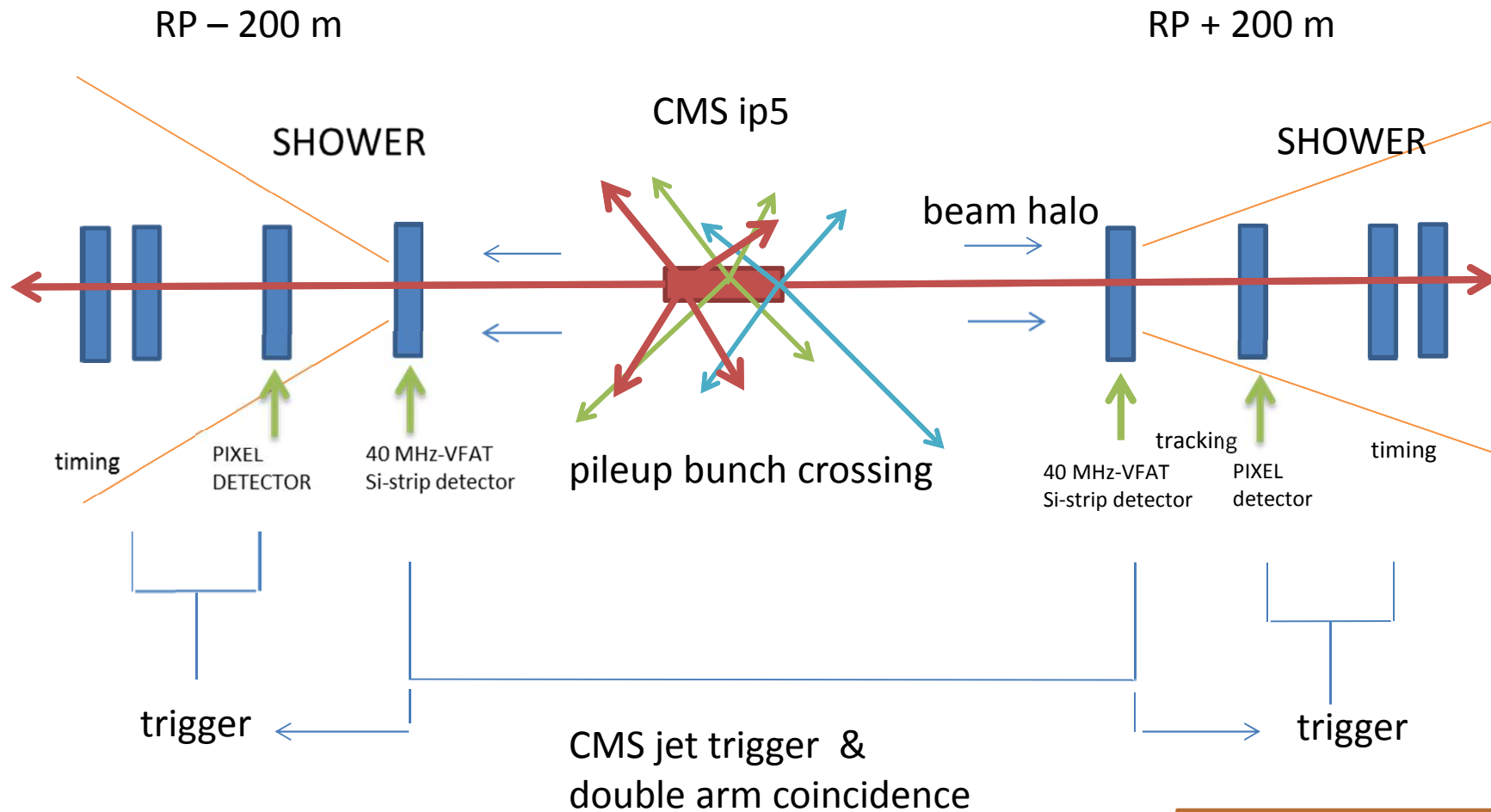
expected SD rate per arm within acceptance:

$\sim 0.4 / \text{bx}$  (event rate / bunch crossing)

insertion at low  $\beta^*$   
beam heating – LHC vacuum – RP optimization-rates

# Roman Pot detector system

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



insertion at low  $\beta^*$   
beam heating – LHC vacuum – RP  
optimization- rates

# TOTEM standalone operation

presented at 1<sup>st</sup> LHC workshop on Collider Experiment Interface on 30.11.2012 (CERN)



## Update of the European Strategy for Particle Physics

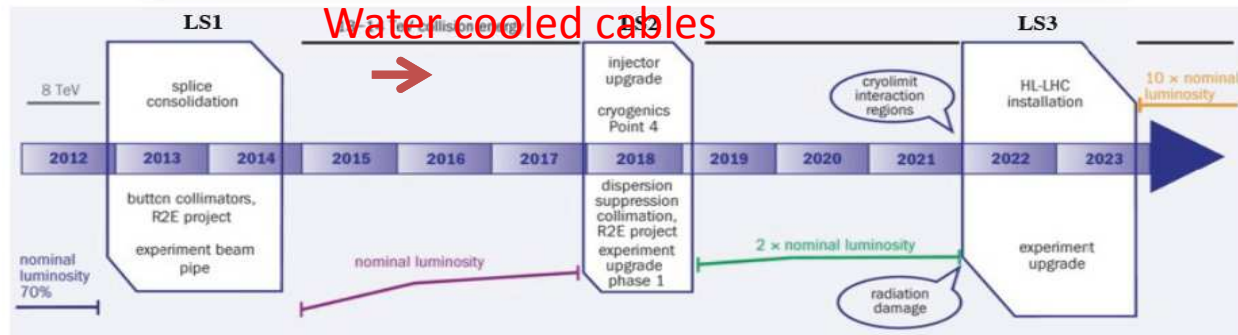
With contributions from accelerators side and experiments, submitted to the [Open Symposium](#) in Krakow 10-12/9/2012

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.

6

→ TOTEM operation with RP +/- 220 m - and optionally in combination with +/- 210 m after LS2 in special runs possible (covered by TOTEM co

insertion at low  $\beta^*$   
beam heating – LHC vacuum – RP optimization-rates

# Proposal for upgrade

## A CMS-TOTEM proton spectrometer

Gilvan Alves<sup>1</sup>, Roberta Arcidiacono<sup>2</sup>, Michele Arneodo<sup>2</sup>, Igor Azhgirey<sup>3</sup>, Igor Bayshev<sup>3</sup>, Gino Bolla<sup>4</sup>, Nicolò Cartiglia<sup>5</sup>, Robert Ciesielski<sup>6</sup>, Domenico Dattola<sup>7</sup>, David D'Enterria<sup>8</sup>, Albert De Roeck<sup>8</sup>, Konstantin Goulianos<sup>6</sup>, Eric Hazen<sup>9</sup>, Duane Ingram<sup>10</sup>, Mohsen Khakzad<sup>11</sup>, Christina Mesropian<sup>6</sup>, Luiz Mundim<sup>12</sup>, Michael Murray<sup>13</sup>, Helio Nogima<sup>12</sup>, Edwin Norbeck<sup>10</sup>, Maria Margherita Obertino<sup>2</sup>, Yasar Onel<sup>10</sup>, Maria Elena Pol<sup>1</sup>, Vladimir Popov<sup>14</sup>, James Rohlf<sup>9</sup>, Andrey Rostovtsev<sup>14</sup>, Marta Ruspa<sup>2</sup>, Alberto Santoro<sup>12</sup>, Ada Solano<sup>15</sup>, Vladimir Samoylenko<sup>3</sup>, Antonio Vilela Pereira<sup>12</sup>, and Alexander Zhokin<sup>14</sup>

<sup>1</sup>CBPF, Brazil

<sup>2</sup>INFN, Turin; Piemonte Orientale University, Novara, Italy

<sup>3</sup>IHEP, Protvino, Russia

<sup>4</sup>Purdue University

<sup>5</sup>INFN, Turin, Italy

<sup>6</sup>Rockefeller University, USA

<sup>7</sup>INFN, Turin, Italy and CERN, Switzerland

<sup>8</sup>CERN, Switzerland

<sup>9</sup>Boston University, USA

<sup>10</sup>University of Iowa, USA

<sup>11</sup>IPM, Teheran, Iran

<sup>12</sup>Rio de Janeiro State University, Brazil

<sup>13</sup>University of Kansas, USA

<sup>14</sup>ITEP, Moscow, Russia

<sup>15</sup>INFN, Turin; Turin University, Italy

March 3, 2013

### Abstract

We demonstrate the feasibility to use the roman pots made available by the TOTEM collaboration in the 200-225 m region downstream

# Conclusion (1)

- TOTEM has confirmed the complete dismounting of RP 147 m stations during LS1 (as early as possible)
- The removal of the RPs at +/- 147 m allows the installation of TCL4
- The RPs of +/- 147 m will be reinstalled in the +/- 210 m region
- The re-use of service infrastructure (patch panel, cooling) was studied
- Installation of additional horizontal RPs in region of +/-220 m of ip5 during LS1 is proposed (CMS-TOTEM document submitted to CMS management)
- 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
- Impedance studies for the horizontal RPs are ongoing
- Studies are ongoing to improve the RP geometry (RF, material budget)

# Conclusion (2)

- Insertion tests ( $\sim 2$  mm) have shown, that the LHC is not affected by the RP
- The vacuum in the 147 m and 220 m region is very likely influenced by the ferrites
- Insertion of the RP lead to a temperature increase (measured on cooled e-cards)
- The installation of TCL6 is mandatory !
- 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. (cylindrical RP for timing detector, possible RF shield around existing horizontal RPs)
- Installation of new RPs during LS1 is realistic
- The combination of the existing TOTEM RPs (alignment, trigger) with new RPs, equipped with tracking and timing detectors is under study
- The TOTEM-CMS upgrade program will combine challenging developments : timing detectors  $\sim 10$  ps, TDC  $\sim 5$  ps, low jitter clock distribution, 3D pixel, innovative cooling etc.





# LHCC – closed session

TOTEM would ask the LHCC to endorse the following points:

- Relocation of 147 RPs (full package as is) upstream of RP220 (major physics impact for free by 8deg rotation)
- Services and infrastructure for installation of possible new RP stations (to host detector upgrades such as pixels, timing,... under discussion also with CMS)
- Installation of TCL6 during LS1

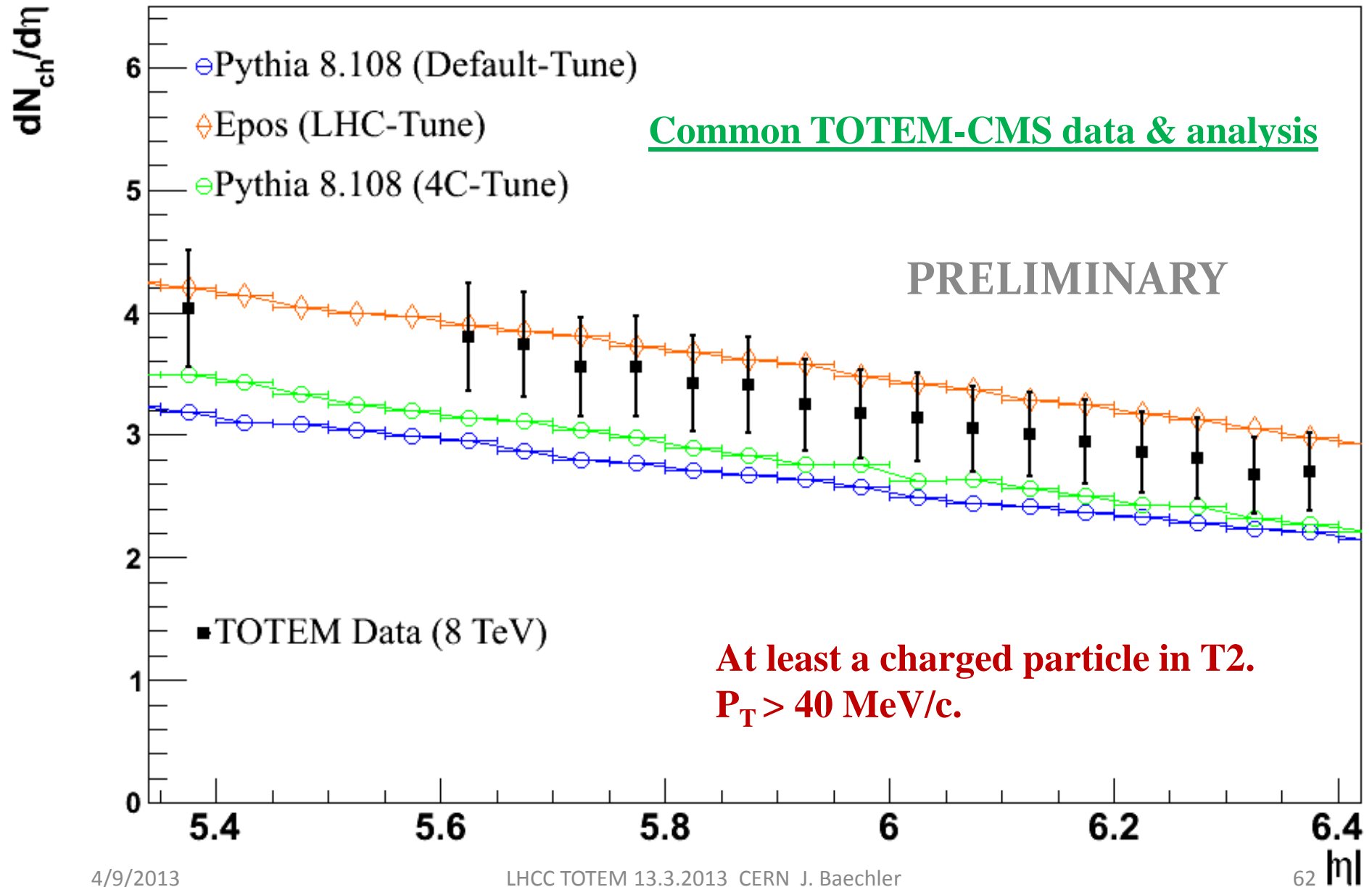
# Cost estimation

- Consolidation
- Upgrade Experiment
  - RP-station
  - RP-cylindrical housing
  - RP-timing detector
  - RP 3D Si detector
- Upgrade LHC
  - Beam line modification
  - TCL4 / TCL6

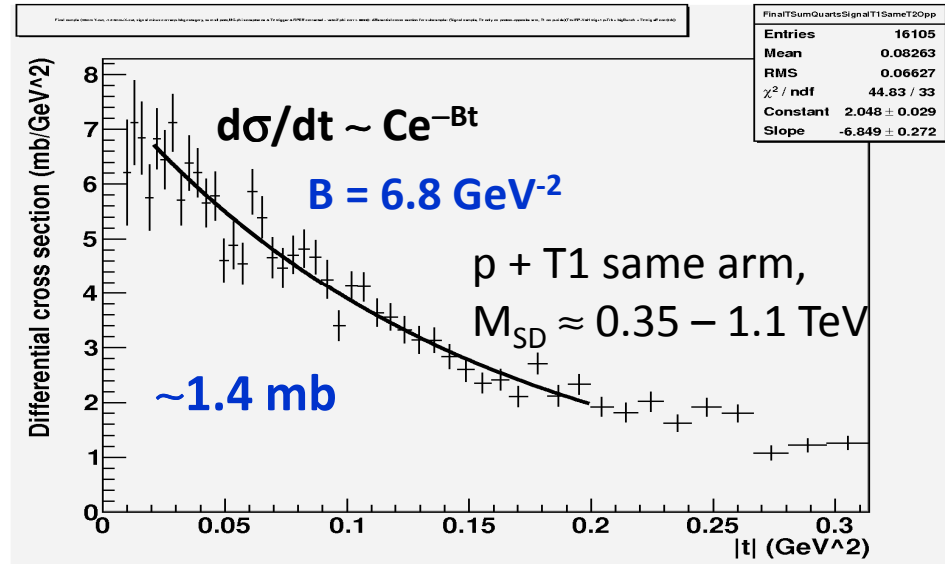
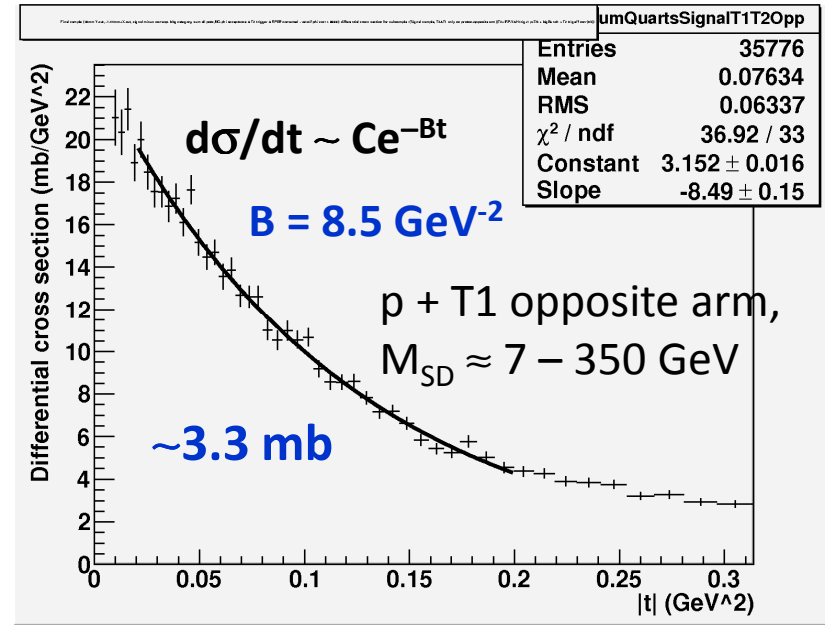
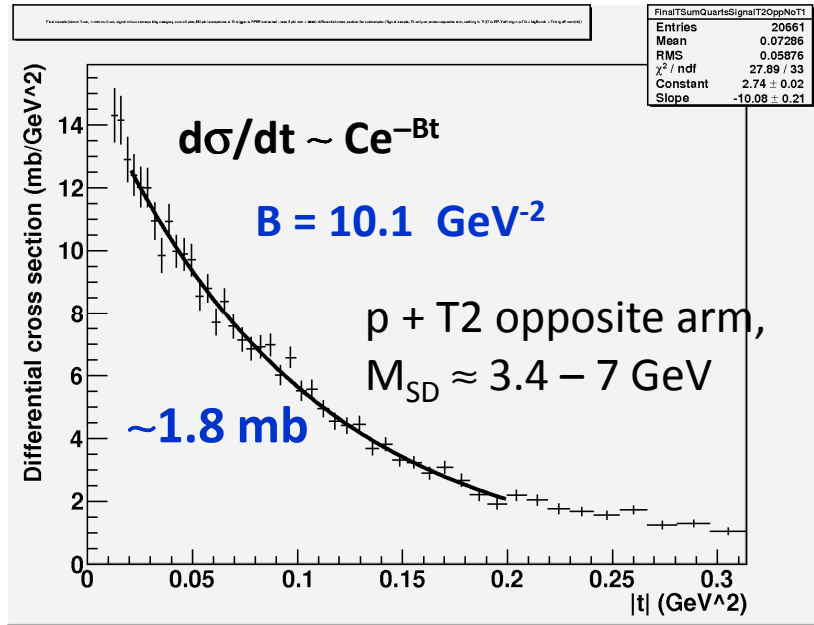
# TDR

# Physics Analysis Highlights

# 8 TeV Inelastic $dN/d\eta$



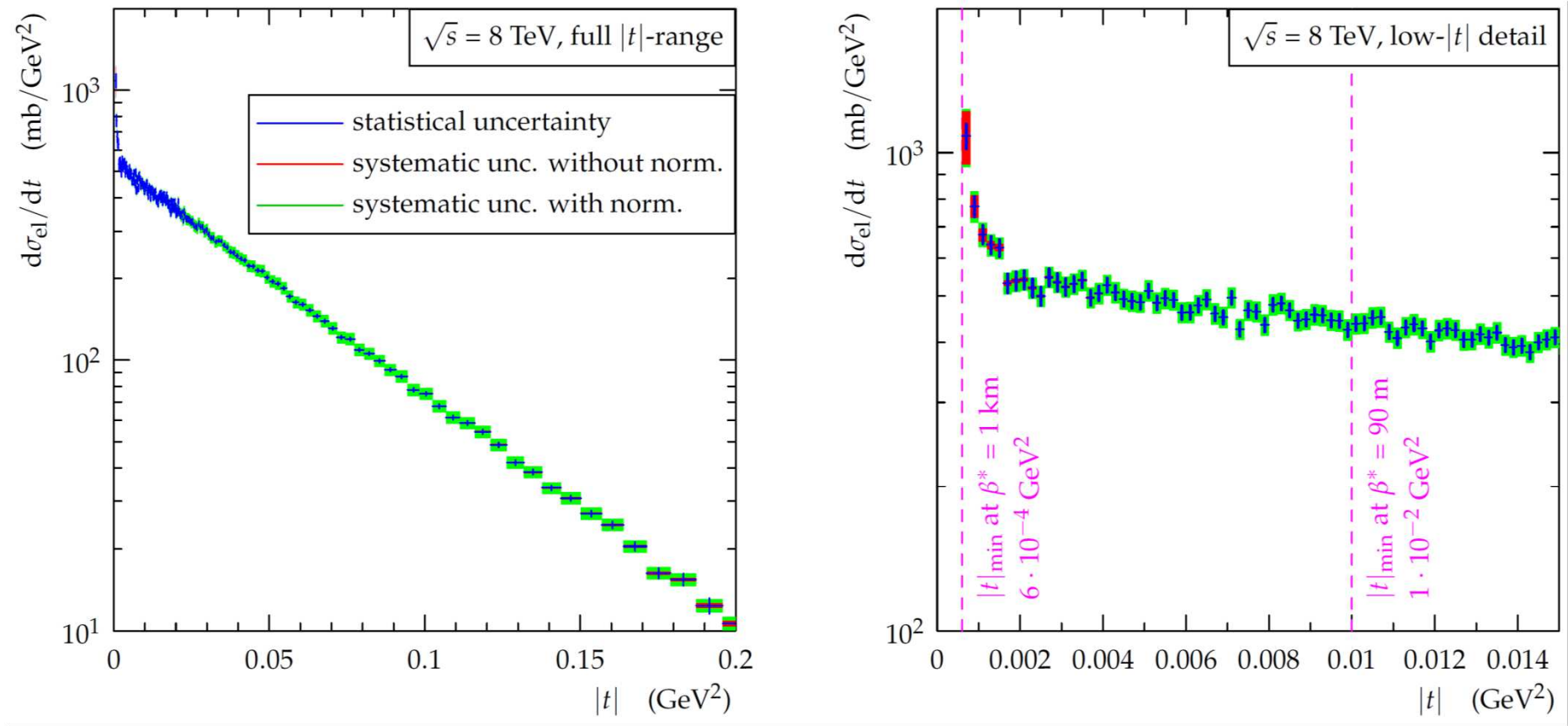
# Soft single diffraction t-spectra at 7 TeV



Uncertainty  
estimated on  
slope  
 $B \sim 15 \%$

Preliminary

# Study of Hadronic-Coulomb interference region at low- $t$ ( $B^*=1\text{km}$ )



Started theoretical study of phase models and rho evaluation with different methods.