

# Overview

## consolidation & upgrade Roman Pots

Consolidation program : TOTEM

Upgrade program : TOTEM+CMS -> CMS-TOTEM Precision Proton Spectrometer (CT-PPS)

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

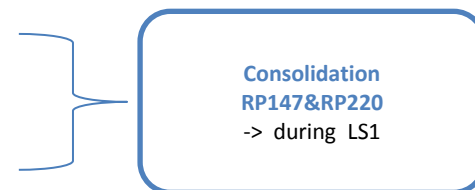
Work packages & ECR related to consolidation & **upgrade** during LS1

-> Status of work packages and schedule – issues on critical path

# Roman Pot consolidation & upgrade strategy

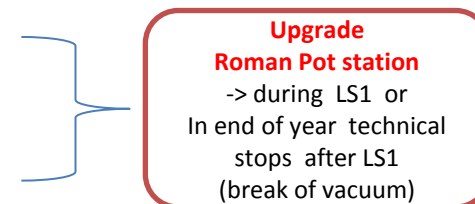
## CONSOLIDATION -> LS1

- 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, Integration of ferrite support spring, integration of RF fingers



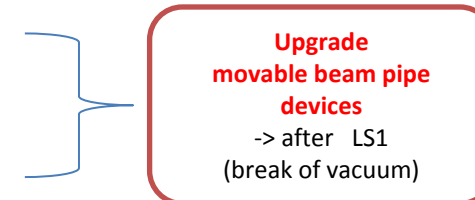
## UPGRADE - Roman Pot station -> LS1

- Installation of additional **new** RP stations (horizontal) in +/-220 m region (1 or 2 new RP stations in each sector (4/5), (5/6))
- Integration of RF optimized horizontal Roman Pots in relocated horizontal stations in +/- 210 m region



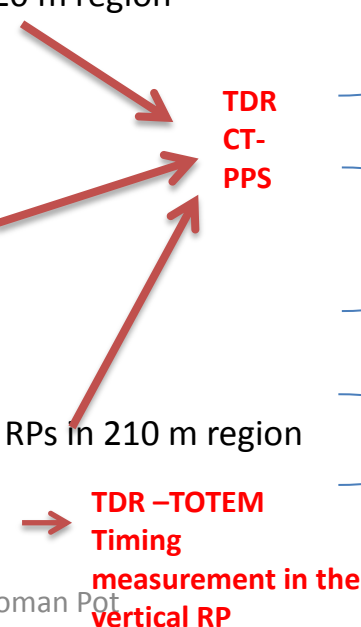
## UPGRADE – new movable beam pipe devices -> after LS1

- Development of new movable beam pipe devices



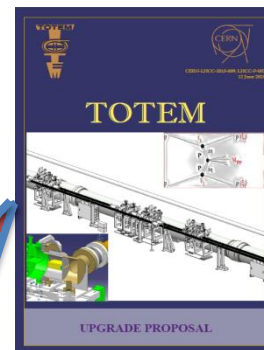
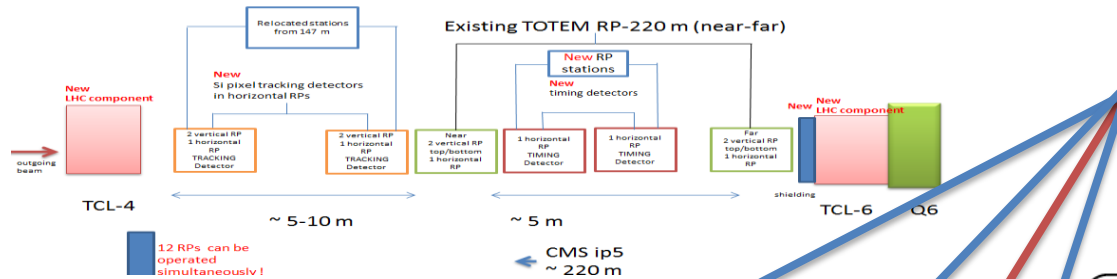
## UPGRADE detector -> LS1 and beyond

- Integration of **new** pixel detectors in the (relocated RP147m) RPs in 210 m region
- Integration of **new** timing detectors in the **new** horizontal RPs
- Integration of **new** timing detectors in the vertical RP (220m)



# ECRs related to consolidation & upgrade @LHC ip5

## Roman Pot consolidation & upgrade overview (schematic)



EDMS NO.	REV.	VALIDITY
1314925	1.0	RELEASED

TOTEM

CMS-TOTEM

EDMS NO.	REV.	VALIDITY
1283826	1.0	RELEASED

### ENGINEERING CHANGE REQUEST

#### Installation and Renaming of Absorbers for Physics Debris (TCL type collimators) on both sides of IP1 and IP5 in front of D2/Q4

##### BRIEF DESCRIPTION OF THE PROPOSED CHANGE(S):

It is proposed to install TCL4 (TCL type) collimators in the forward regions of IR1 and IR5, in front of D2/Q4 cryostats. These collimators were built as part of the present LHC collimation system and their installation was delayed to allow the operation of the "close" TOTEM Roman pot stations in IR5.

EDMS NO.	REV.	VALIDITY
1357736	0.1	DRAFT

### ENGINEERING CHANGE REQUEST

#### Installation of Physics Debris Absorbers (TCL) on both sides of IP1 and IP5 in front of the Q6 Quadrupole

##### BRIEF DESCRIPTION OF THE PROPOSED CHANGE(S):

It is proposed to install TCL, physics-debris collimators, on both sides of IP1 and IP5 in front of the Q6 Quadrupole (TCL6). This request follows the ECR EDMS Doc. 1283867 where the preparation of the TCL6 infrastructure was proposed and approved. This proposal to install the TCL6 is now brought forward taking into account the latest information on collimator production schedule and results of simulations that were deemed necessary before taking the final decision.

### ENGINEERING CHANGE REQUEST

#### TOTEM Consolidation Project

##### BRIEF DESCRIPTION OF THE PROPOSED CHANGE(S):

The TOTEM Roman Pot (RP) stations that were installed on the outgoing beam at a distance of 147m on both sides of IP5 have been de-installed. TOTEM proposes to move these stations to 210 m (between Q5 and Q6) on both sides of IP5, so that after LS1 the TOTEM setup will contain a new 210 m station with a near and far unit in addition to the existing 220m station. The new 210 m far unit will be rotated by 8° around the axis of the beam. To foresee the later addition of timing detector units, TOTEM proposes to add one piece of dummy beam pipe between the existing near and far units of the 220m station.

EDMS NO.	REV.	VALIDITY
1361537	0.1	DRAFT

### ENGINEERING CHANGE REQUEST

#### TOTEM Upgrade Project

##### BRIEF DESCRIPTION OF THE PROPOSED CHANGE(S):

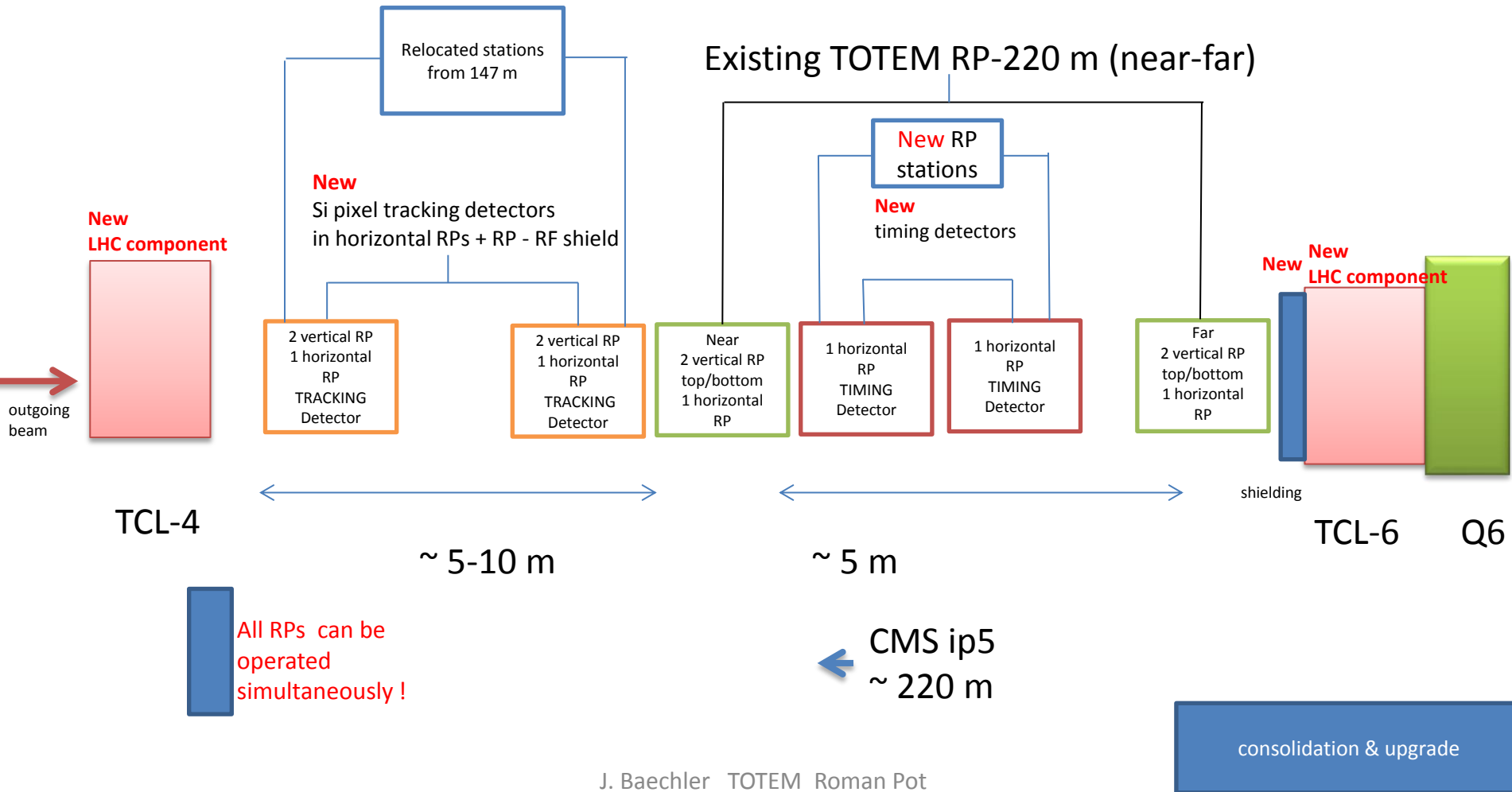
The TOTEM Upgrade Proposal [1] foresees the installation of additional horizontal Roman Pots (RPs) between the existing RP units at 215 and 220 m from IP5. These new RPs, intended to house time-of-flight detectors for elastically or diffractively scattered protons, have been designed in cylindrical geometry minimising the beam impedance and offering enough space for 12 cm long Cerenkov detectors, one of the technologies being explored for the time measurement.

Furthermore, the existing horizontal RPs of the units at 203 and 213 m will be equipped with Faraday shields to reduce their impedance.

This ECR elaborates on the technical details of the new RP elements and their integration in the LHC. It thus complements the already approved consolidation ECR [2].

# Roman Pot consolidation & upgrade - LS1

overview (schematic)



# CONSOLIDATION & UPGRADE

## 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-MME-FS (new RP production/purchase)

EN-MEF-DC (ECR)

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,...)

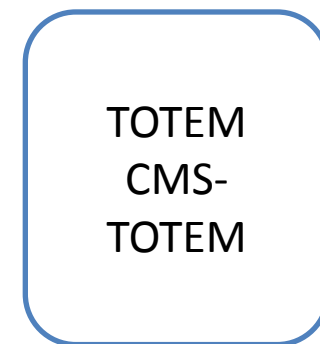
BE-BI-BL (BLM)

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

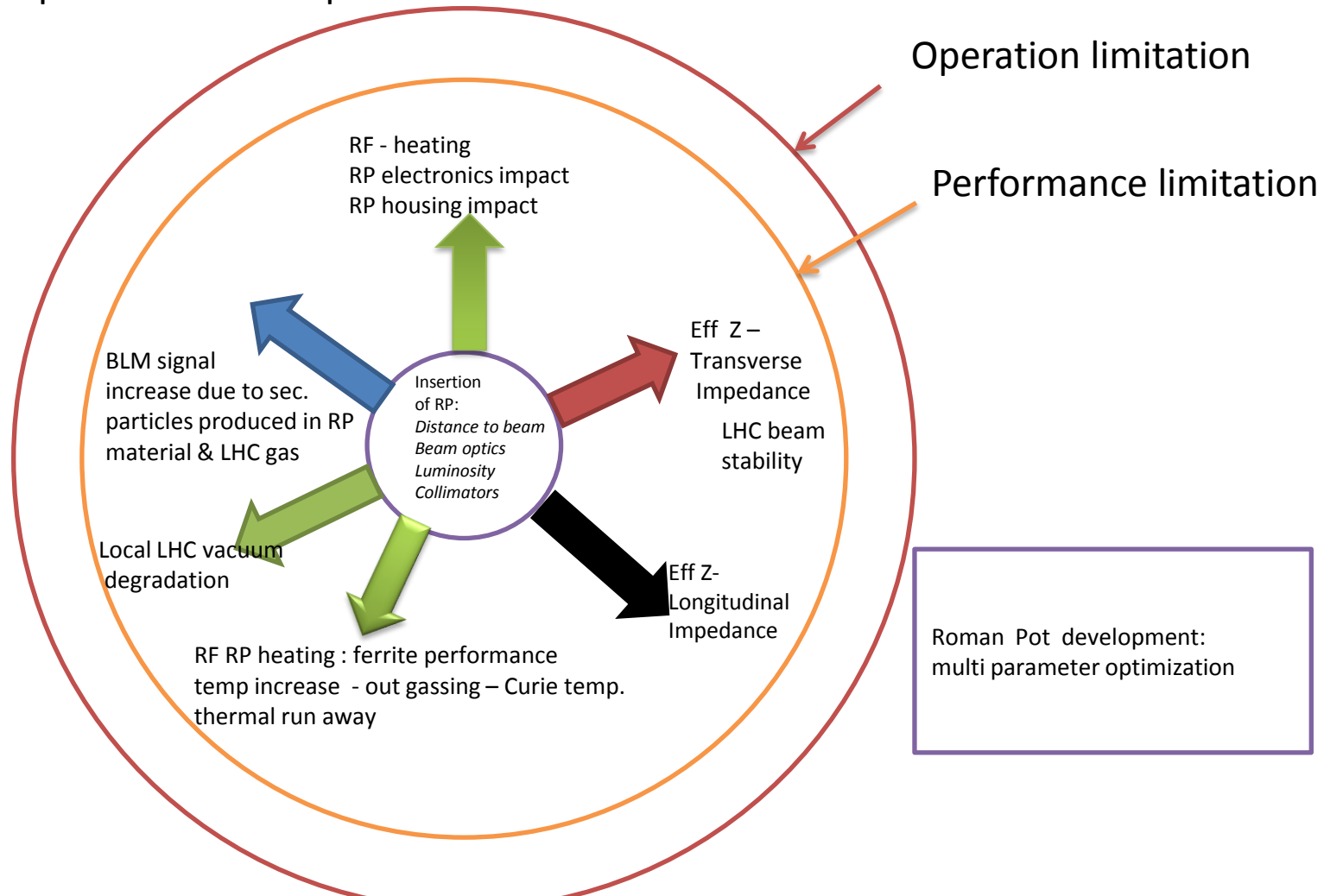
BE-RF-BR (RF study & measurements)

BE-OP-LHC (Operation of RP – CCC)

BE-ABP-LCU (collimators)



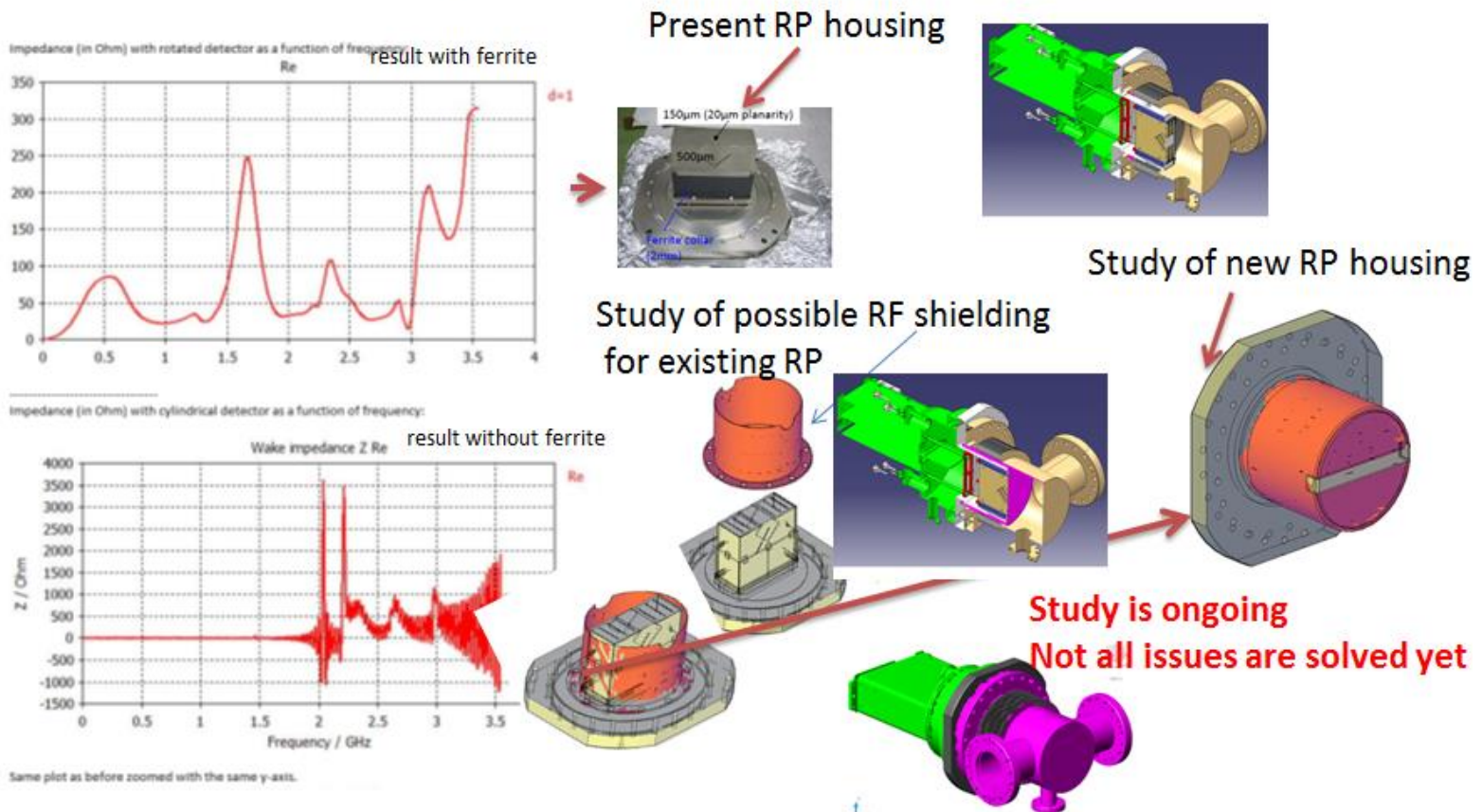
**UPGRADE of Roman Pots -> RP operation at high luminosity and low  $\beta^*$  performance & operation limitation -> LHC and Roman Pot**



# RP optimization started in fall 2012

## Optimization of RF characteristics

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



# Impedance comparison of different RP designs & conclusion

## TOTEM collaboration meeting on June 2013 (E. Metral)

Results for 1 RP with the beam at 1 mm

**IMPEDANCES OF THE TOTEM RPs (2/3)**

*Nicola Minafra*

	$Z_{  }^{eff} / n$ (mΩ)	% to total LHC current impedance (90 mΩ)	$\bar{Z}_{\perp}^{eff}$ (KΩ/m)	% to total LHC current impedance (25 MΩ/m)	Heating (W)
Present RP <sup>1)</sup>	1.7	1.9%	80	< 0.3%	62
Rotated RP <sup>2)</sup>	2.6	2.9%	20	< 0.1 %	241
Cylindrical RP <sup>3)</sup>	1.1	1.1%	50	< 0.2 %	13
Cu shielded RP <sup>4)</sup>	1.2	1.3%	70	< 0.3 %	10

1) and 2)  $\Pi / 2$  rot.

3) Ferrite, Cap 2.5mm (mechanical resonances), Distance from beam (φ)

4)

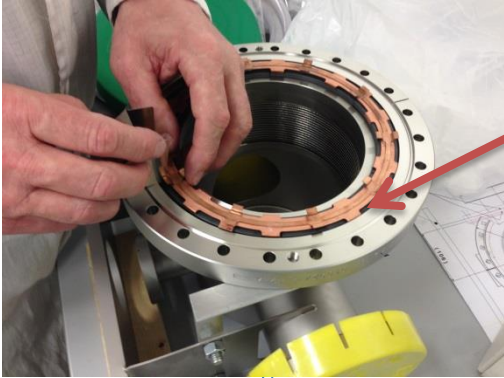


- ### CONCLUSION
- ◆ 3 or max 4 H RPs for high-intensity runs => Should be OK but depends also on all the other impedance contributors => Imagine 10 impedance contributors each increasing by 5%... The other equipments linked to the RPs need to be also considered (collimators, etc.)
  - ◆ Detailed heat transfer studies to be done with the ferrite
  - ◆ Recommended Cu coating for the Resistive-Wall impedance: > ~ 5 μm is OK (10 μm if possible)
  - ◆ EM simulations based on several assumptions => Measurements on a prototype should be performed as a final check / validation!

proto type production started with this design for cylindrical RP and RF shield



# RF test of new Roman Pot design combination of new bellow & beam pipe & circular ferrite with new cylindrical RP or RF shield February 2014

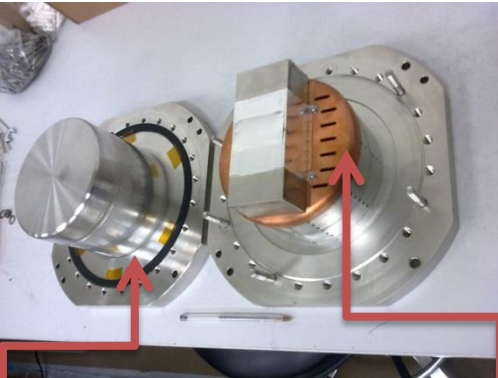
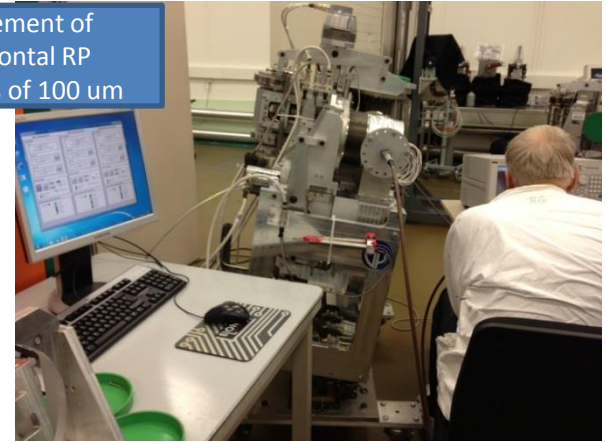


New bellow & beam pipe with circular ferrites & ferrite support ring → integrated in horizontal RP test station

Horizontal RP test station



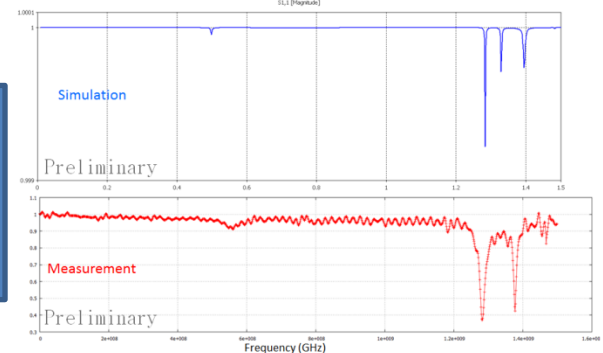
Movement of horizontal RP in steps of 100 um



New cylindrical Roman Pot & RF shield for box Roman Pot

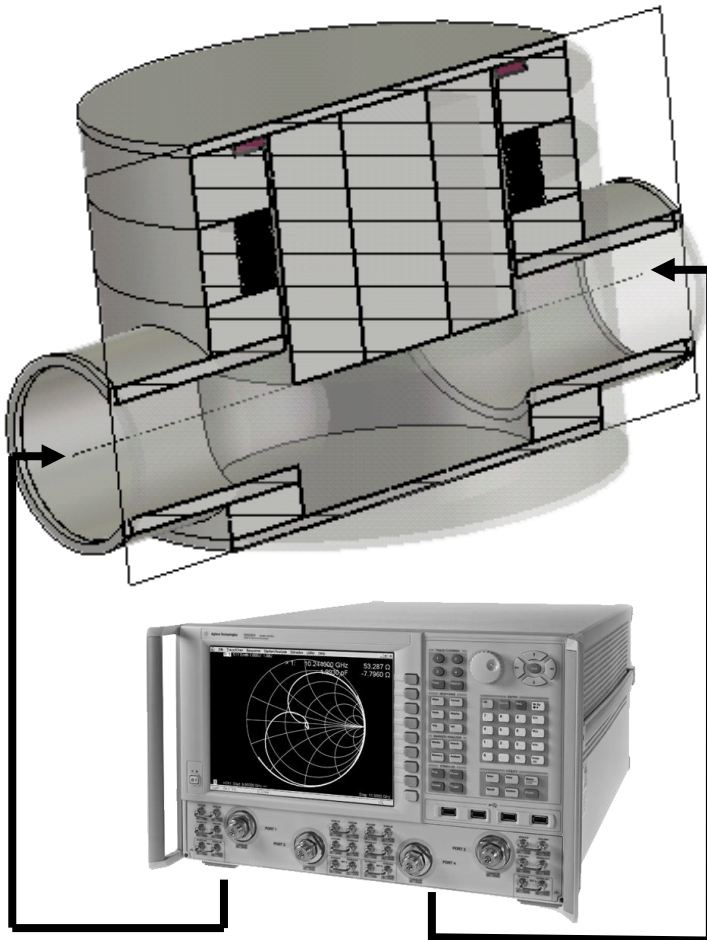
Measurements with and without ferrites  
First results show agreement with simulation

Good agreement between simulation and measurements

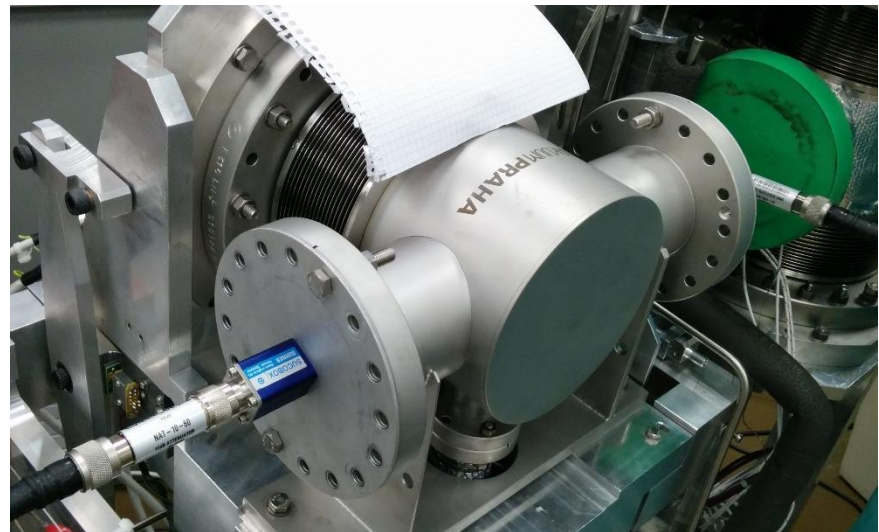


Cylindrical RP without ferrite in garage position, probe 16 cm inside

# Wire measurement



A thin wire is used to create an electrical line and the reflection and the transmission are measured using a Network Analyzer.



# RF test with RF shield & RP cylinder

(with and without ferrites)

## Test results

Wire test for Cylindrical Roman Pot **with** and **without** Ferrite



9 to 1 visible resonances!

Nicola Minafra - RF study and optimization of the TOTEM Roman Pot

2 June 2014

22

## Conclusion

- New TOTEM Roman Pot designs
  - Cylindrical RP
    - ~ 5 times less heat
    - ~ 35% lower Effective Longitudinal Impedance
  - Shielded Box RP
    - ~ 6 times less heat
    - ~ 30% lower Effective Longitudinal Impedance
- Extensive RF (and other) tests on prototypes
  - Good agreement with simulations
  - Clear effect of the ferrite

Waiting for last approval from CERN Impedance Team



Nicola Minafra - RF study and optimization of the TOTEM Roman Pot

2 June 2014

23

# INCREMENTAL APPROACH

- RP 220 & RP 210 (consolidation)



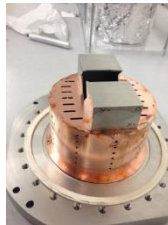
## Consolidation of Roman Pots

- New ferrite TT2
- Ferrite lifter
- Anti-collision

## Relocation

- relocation of 147m at 210m

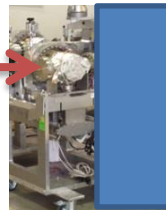
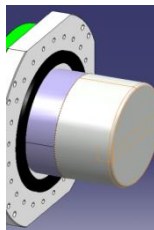
- RP RF\_upgrade



## Integration of RF shield in horizontal RP 210 m

- RF shield
- Circular Ferrite
- New bellow with flange

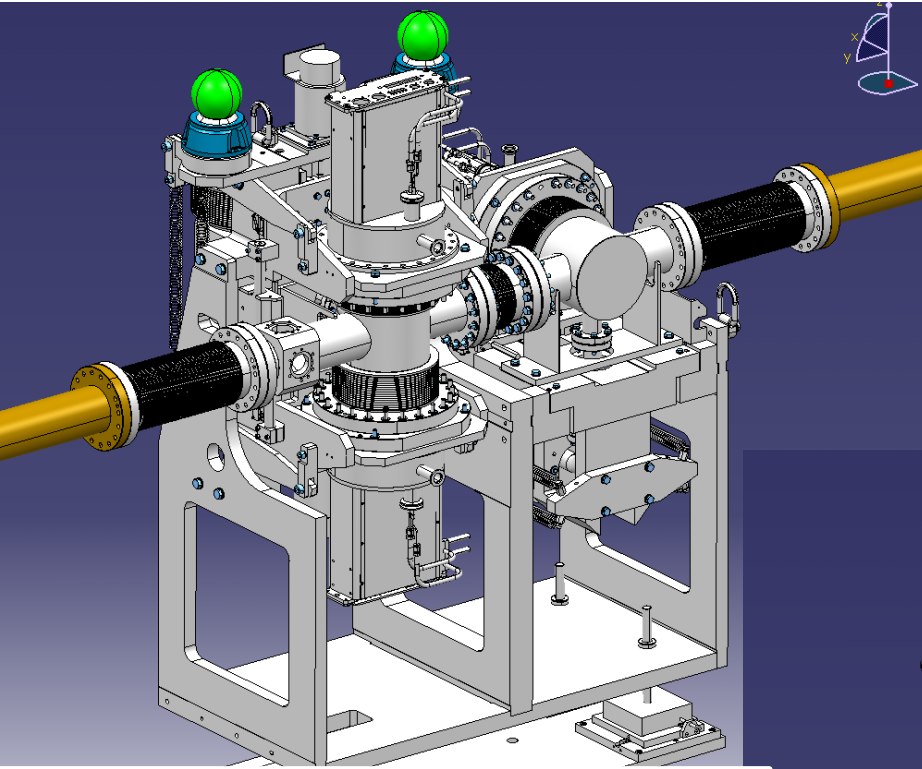
- RP CY\_upgrade



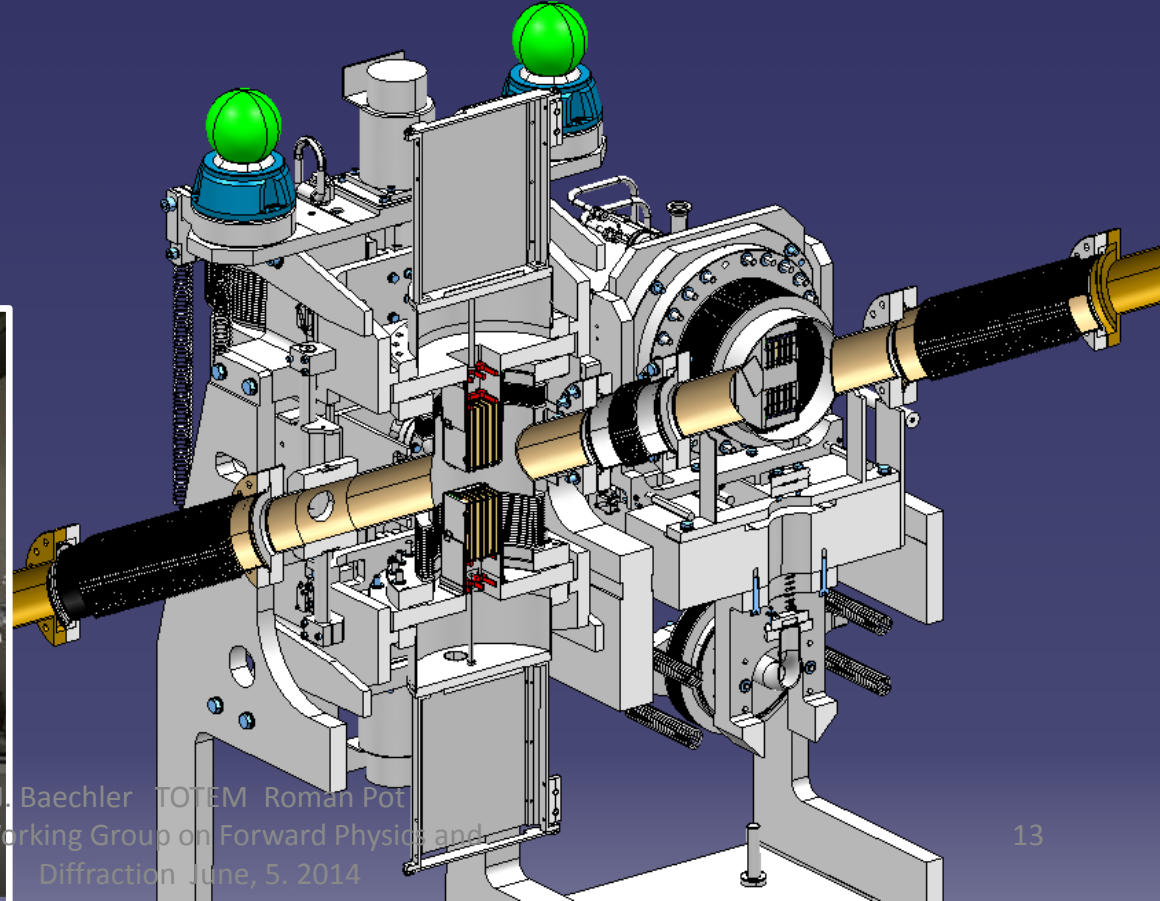
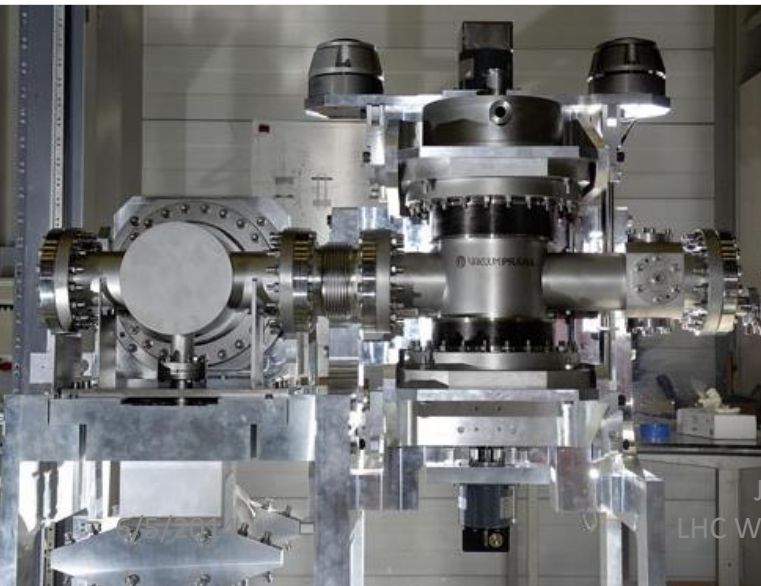
## Installation of new horizontal cylindrical RP

- Cylindrical Roman Pot
- Circular Ferrite
- New bellow with flange
- New RP station (motor etc.)

# Roman Pots 210 m (two stations per sector). Upgrade & consolidation

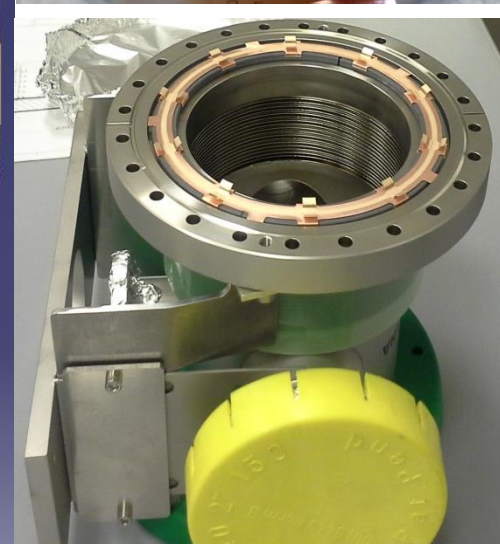
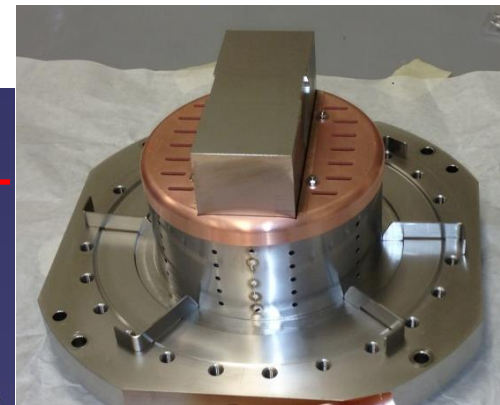
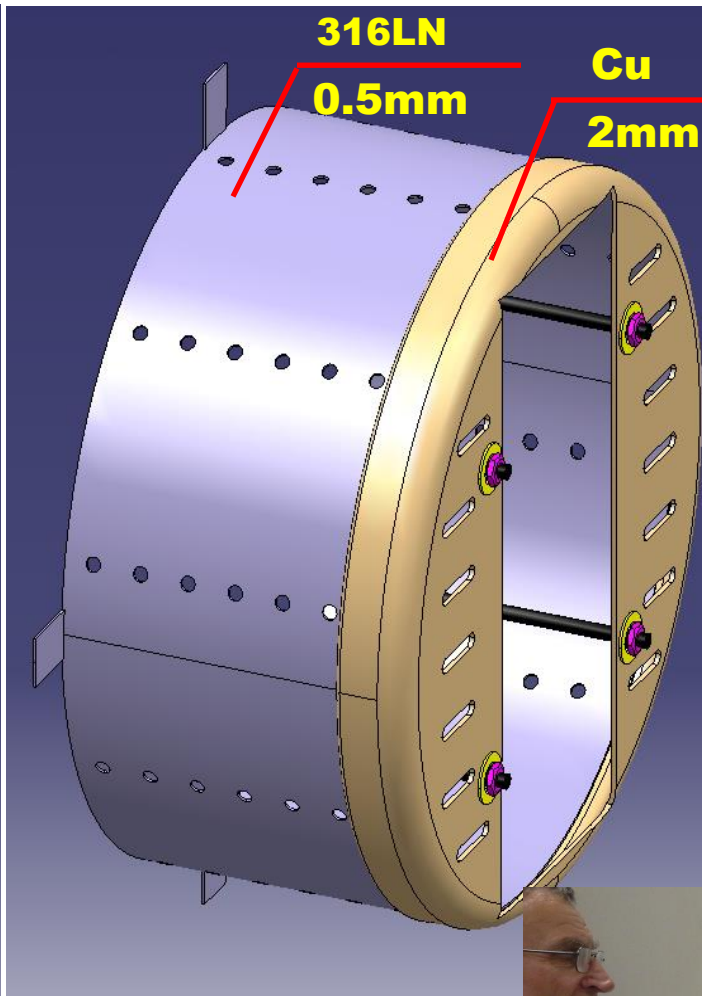
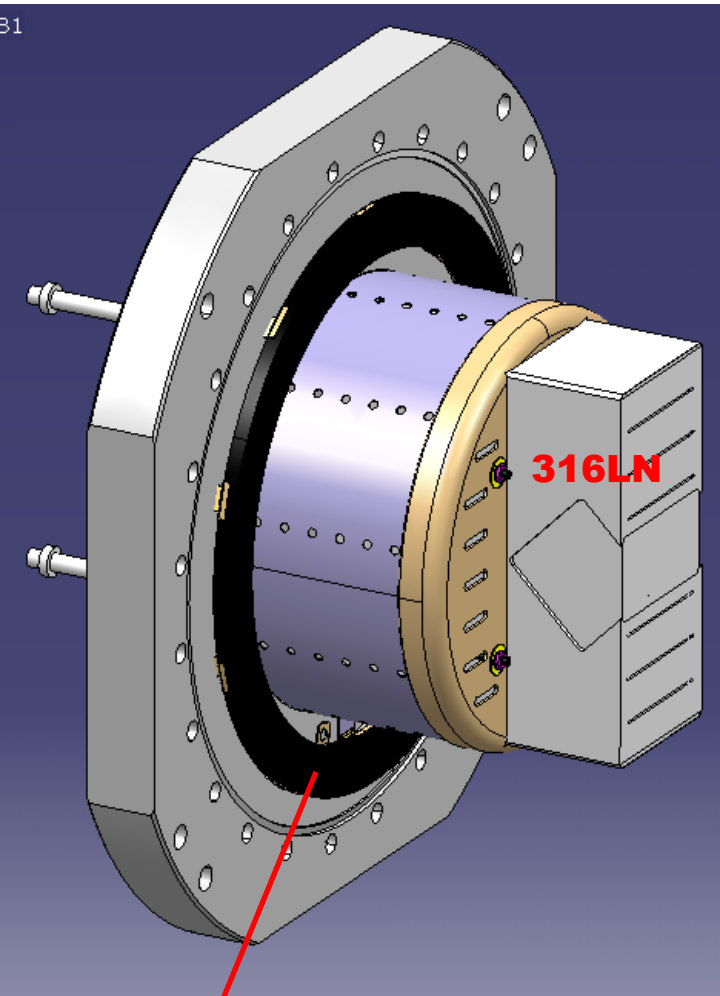


The same stations as 220 m (two vertical pots and one horizontal). For horizontal pot new circular ferrite and faraday cage due to impedance improvement (for high lumi and low  $\beta^*$  beam).



# Present (rectangular) housing with new Faraday cage (RF shield)

For the 210m stations, just for horizontal detectors

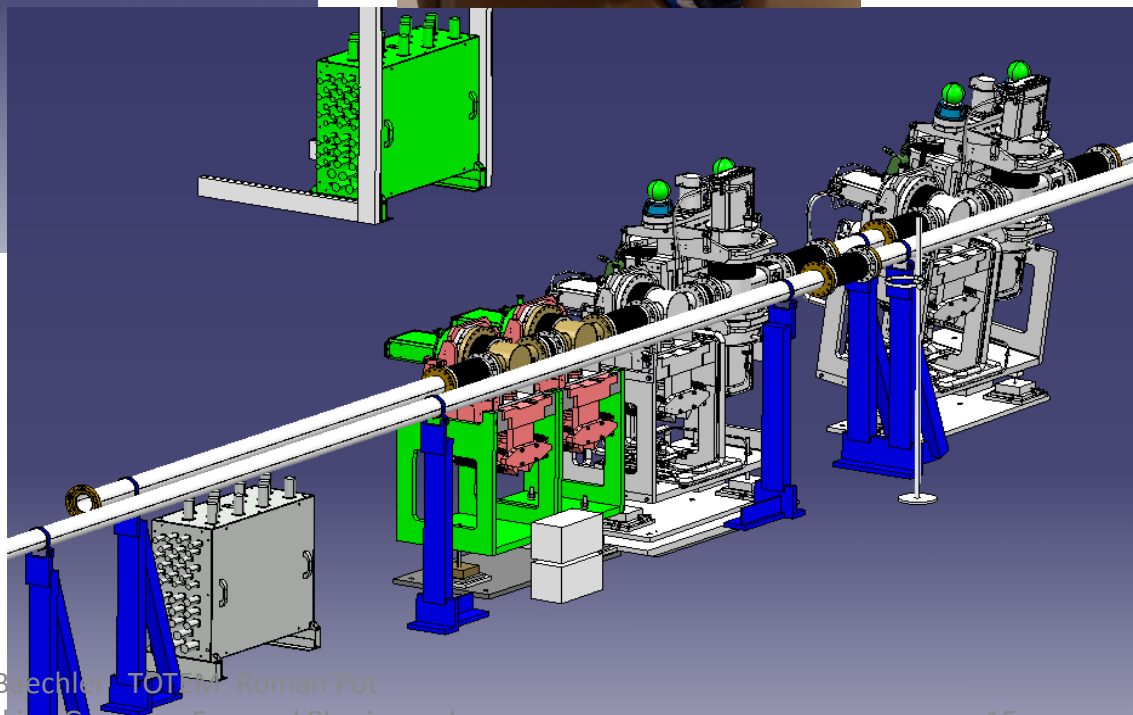
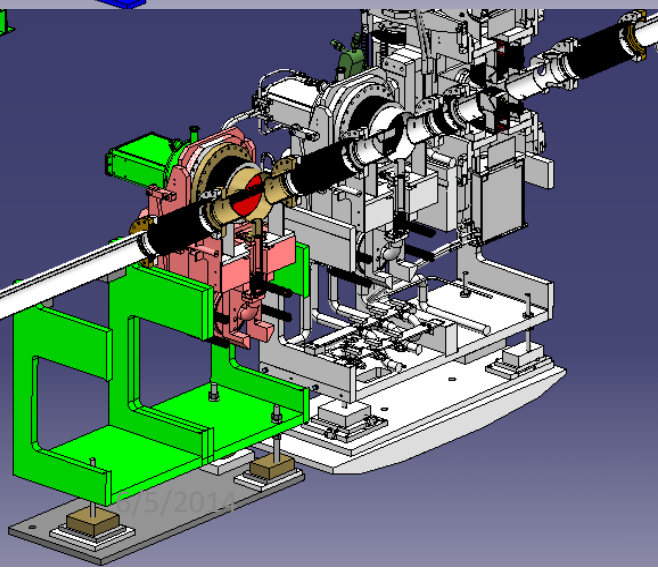
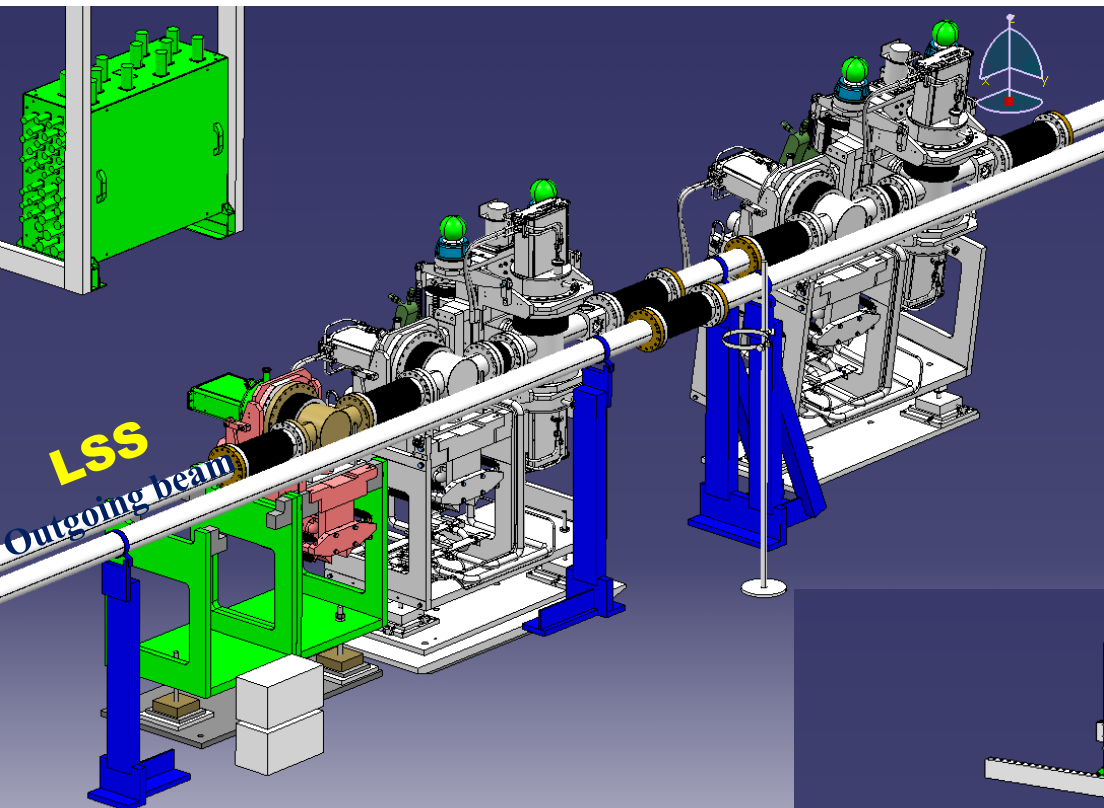


Ferrites

6/5/2014 **See back-up slides**

J. Baechler TOTEM Roman Pot  
LHC Working Group on Forward Physics and  
Diffraction June, 5. 2014

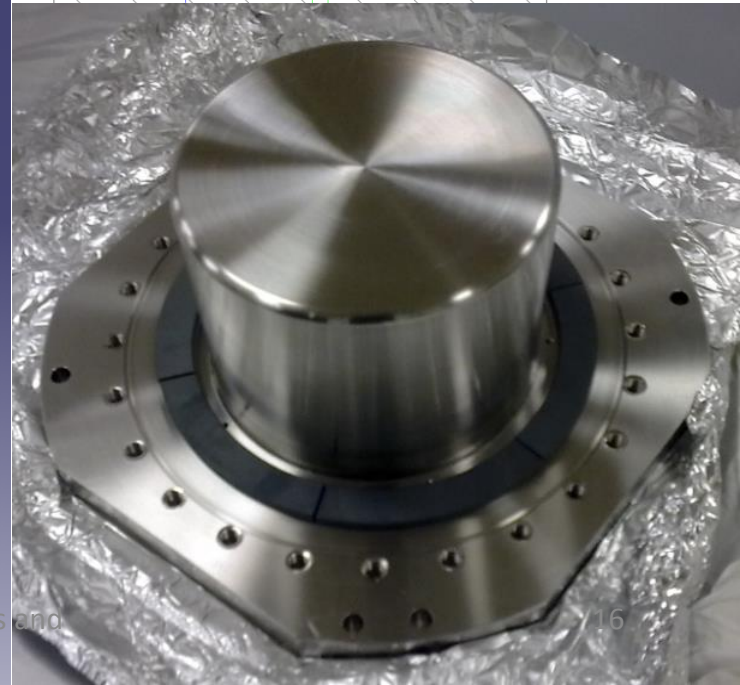
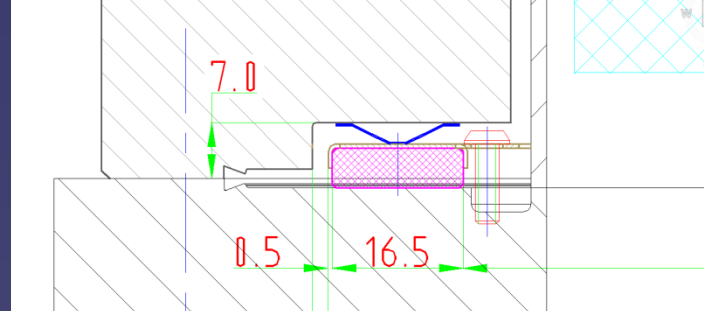
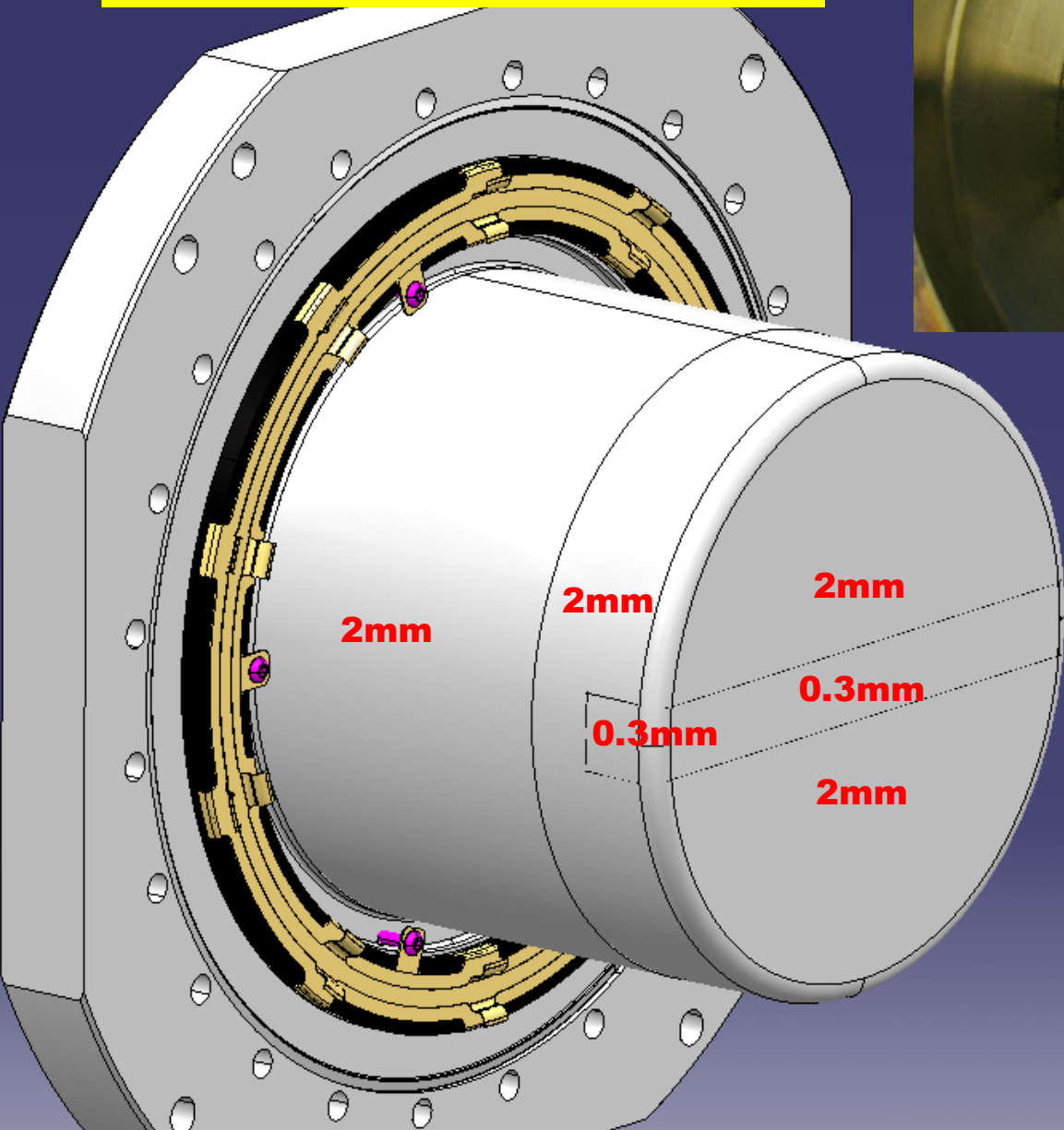
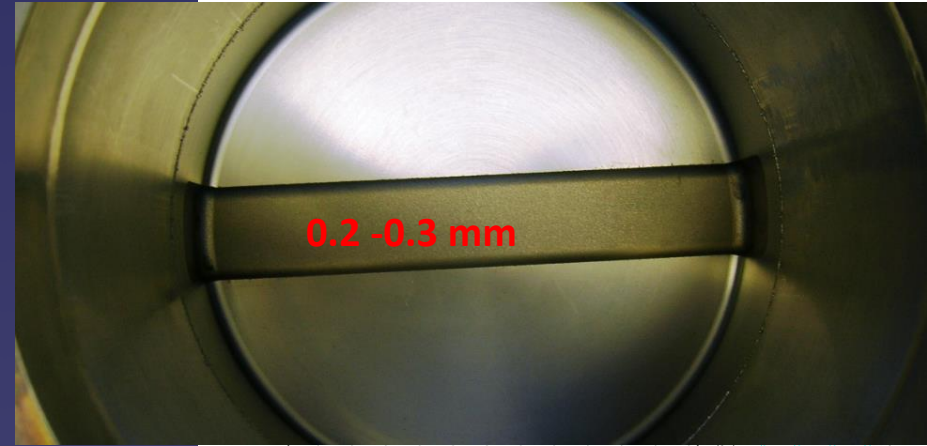
# Roman Pots with timing detector (one station per sector). Upgrade.



J. Beecher, TOT for Roman Pot  
LHC Working Group on Forward Physics and  
Diffraction, June 15, 2014

**Duplicate timing detector (complete variant)**

# Cylindrical Housing (316LN)



The design and technology were created with help of  
D. Perini and F. Bertinelli (CERN).

LHC Working Group on Forward Physics and  
Diffraction June, 5. 2014



# Material certificate



IMBACH & CIE AG | Solutions in Metal  
 Stampfenfeldstr. 8 | CH-8204 Heikonen | Schweiz  
 T: +41 82 748 44 44 | F: +41 82 748 44 40  
 www.imbach.com | imbach@imbach.com

## Abnahmeprüfzeugnis nach EN 10204-3.1

Herstellereichen

TÜV-Zulassung nach AD2000-Merkblatt WO / TRD 100  
 TÜV-Zulassung nach Druckgeräterichtlinie 97/23/EG Anhang I, Absatz 4.3  
 TÜV-SÜD ISO 9001:2008 / EN 9100:2009  
 SVT-Zulassung  
 LLOYD'S-Register of Shipping Zulassung  
 ABS (American Bureau of Shipping) Zulassung

Kunde: CERN  
 Organisation Européenne pour  
 Herr Pierre Moyrot  
 1211 Genève 23

Bestell-Nr.: CA5486254 Auftragsnummer: 166328  
 Bestelldatum: 18.11.2013 Lieferscheinnummer: 23710

Pos.-Nr. 1 Total 7 Stk. Schmelzen-Nr. Probe-Nr.  
 Unsere Artikel Nr. 111392 7 Stk. 366126 A295  
 Artikelbezeichnung: Schraube vorgedreht  
 VM Ø 150 x 39 mm  
 Erzeugnisform: multidirektional geschmiedet und vorgedreht  
 Prüfgrundlagen: laut Technical Specification N° 1001 - Ed. 4 - 11.10.2006  
 Wärmebehandlung: austenitisch gegülht, abgeschreckt auf max. 250 HB  
 Werkstoff: AISI 316 LN ESU (1.4429)  
 Kennzeichnung: 1-14429 - BSU - 366126 - A295 - HB

Zustimmungsschreiben des TÜV SÜD Industrie  
 Service GmbH liegt vor. Heikonen, 28.01.2014, CI

Die gestellten Anforderungen sind laut Anlagen  
 erfüllt. Der Werkssachverständige Stempel

Prüfergebnisse gemäss Anlage Hans Bucher  
 Anlage 1: A295, IWT Nr. 17009670  
 3.1 des Vormaterials  
 Wärmebehandlungs- und  
 Härteprüfungsprotokoll Nr. 131212-17  
 UT-Protokoll Nr. 140123



# Full metrology control (EDMS.1375622; CRNHZMW\_2027)

## CERTIFICAT DE CONTRÔLE

CONCLUSION CONTRÔLE		VISA MME	ACCEPTATION CLIENT
X	OK Non Conforme	Nom : Date :	Nom : Date :

NUMERO DE PLAN: CRNHZMW\_2027 REQUERANT: BAECHLER J.  
 DESIGNATION: cylindrical housing with holes  
 Nombre de pièces: 4  
 N° EDMS: 1375622 CONTROLEUR: J.Ph.RIGAUD page 1/2

COTES DU PLAN	résultats de mesure					local plan
	face B	0.334	0.597	0.628	0.270	d9
	face A	0.076	0.042	0.103	0.115	b4
	Ø 82 A	0.064	0.051	0.083	0.065	b4
0.3 +0.02 / -0.10 pièce en appui sur B		0.342 / 0.334	0.285 / 0.288	0.367 / 0.366	0.290 / 0.271	k7

DATE: 22.04.2014  
 APPROUVE PAR: A.CHERIF  
 Turbulomètre: 20 °C Moyens utilisés (incertitude de mesure estimée): Unités de mesure: mm  
 colonne de mesure TRIMOS: ± 0.005[mm]; comparateur à levier ± 0.005[mm]

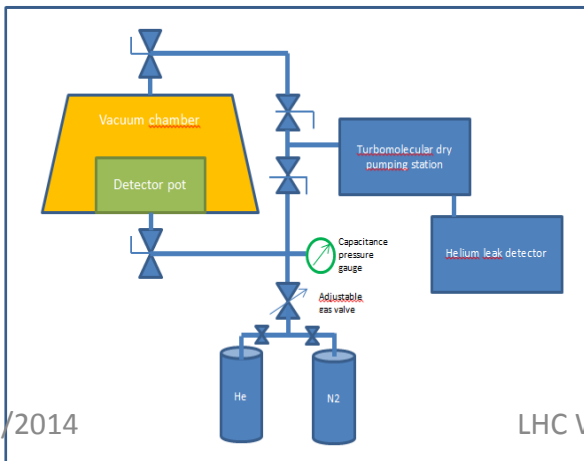
CONCLUSION CONTRÔLE		VISA MME	ACCEPTATION CLIENT
X	OK Non Conforme	Nom : Date :	Nom : Date :

NUMERO DE PLAN: CRNHZMW\_2027 REQUERANT: BAECHLER J.  
 DESIGNATION: cylindrical housing with holes  
 Nombre de pièces: 4  
 N° EDMS: 1375622 CONTROLEUR: J.Ph.RIGAUD page 2/2

COTES DU PLAN	résultats de mesure					local plan
	face B	0.334	0.597	0.628	0.270	d9
	face A	0.076	0.042	0.103	0.115	b4
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0.3 +0.02 / -0.10 pièce en appui sur B		0.342 / 0.334	0.285 / 0.288	0.367 / 0.366	0.290 / 0.271	k7

DATE: 23.04.2014  
 APPROUVE PAR: A.CHERIF  
 détail points de mesure et déformation disponible en archive métrologie  
 Turbulomètre: 20 °C Moyens utilisés (incertitude de mesure estimée): Unités de mesure: mm  
 colonne de mesure TRIMOS: ± 0.005[mm]; comparateur à levier ± 0.005[mm]

## Pressure test (+40%), test of cyclic loading, He-leak tests (vacuum test) for each housing; EDMS №1340920



# Assembly of new Roman Pot station at bat 186 (TIF)

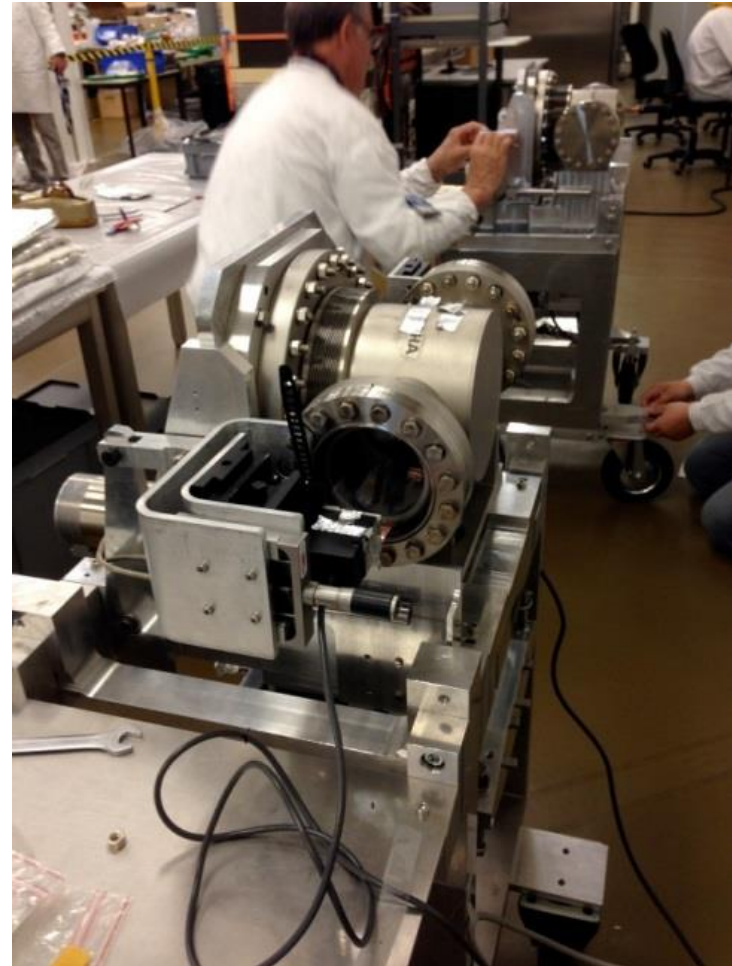
- Material arrived for production of 4 RP stations (17.3.2014)



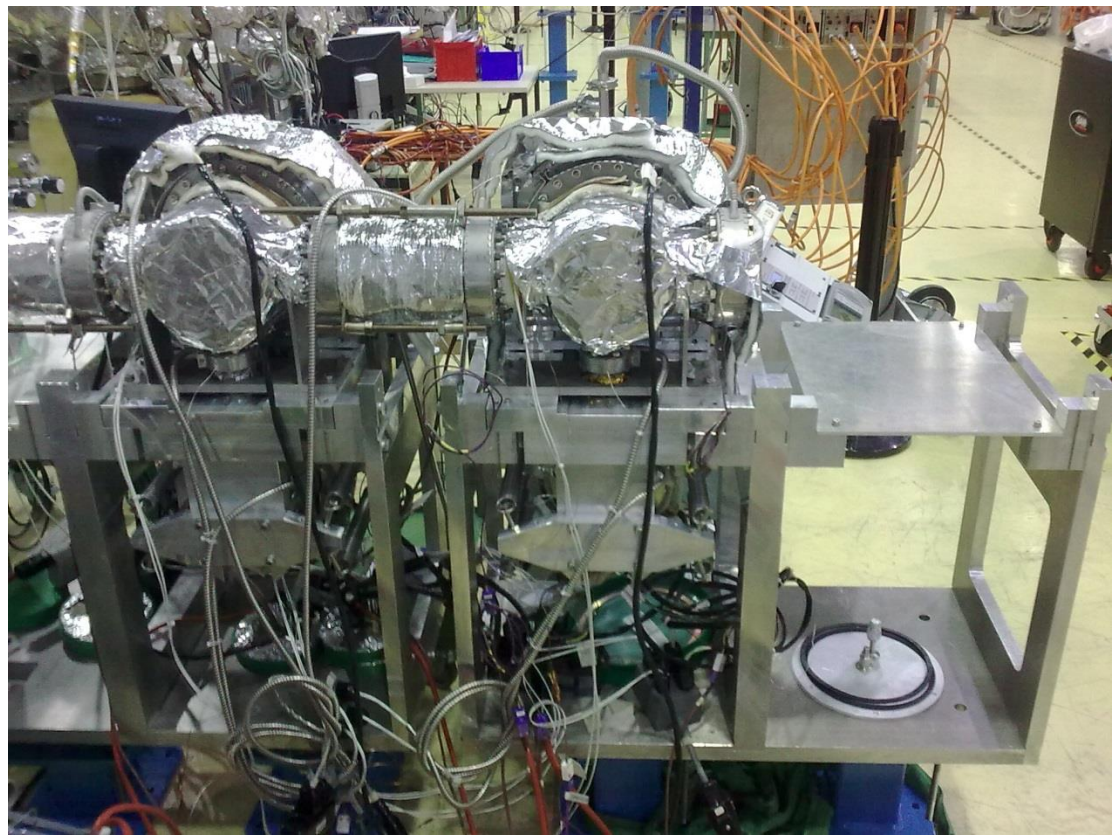
**Moving tests (in steps of 100 um)  
with and without vacuum;  
checking of safety mech.,  
compensation mech., stoppers.**

**Housing calibration laser test  
(Mirko)**

**Bake out, vacuum test, outgassing test.  
Started at 19 May for both Timing stations**



6/5/2014

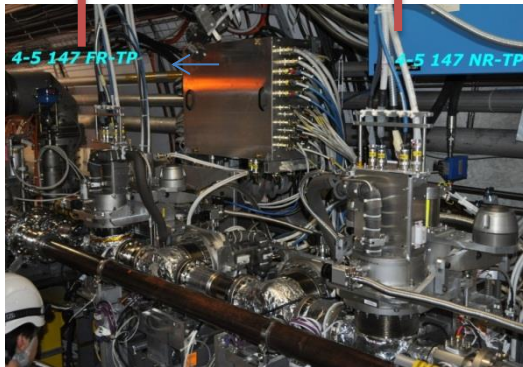
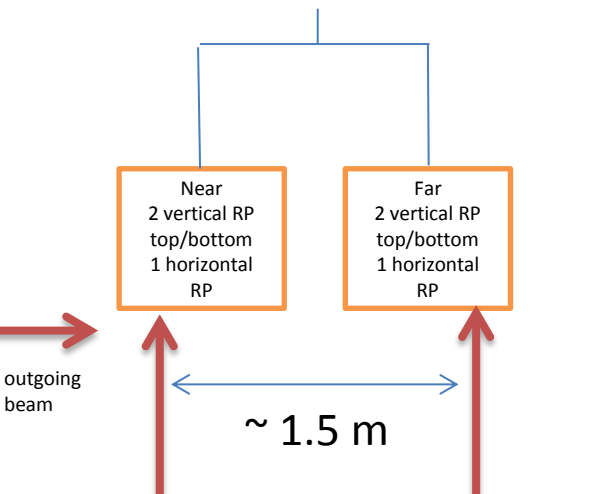


J. Baechler TOTEM Roman Pot  
LHC Working Group on Forward Physics and  
Diffraction June, 5. 2014

19

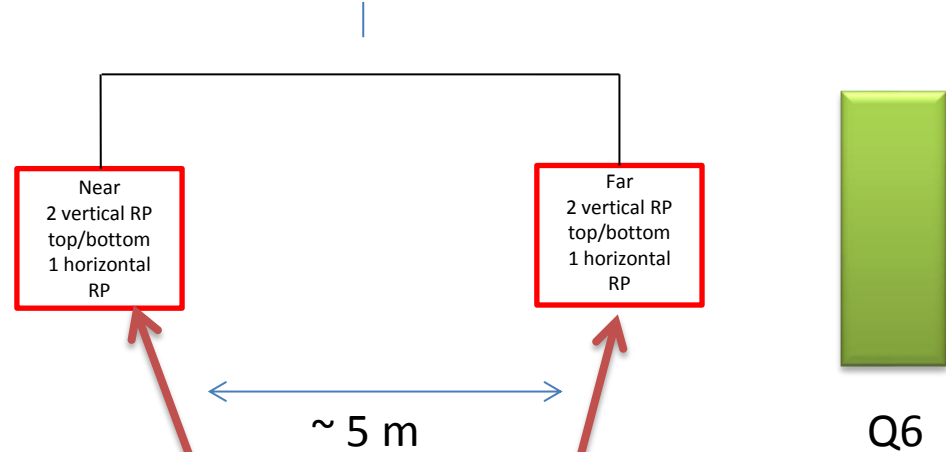
# RP installation at IP5 before LS1

TOTEM RP-147 m (near-far)



CMS ip5  
~ 147 m  
←

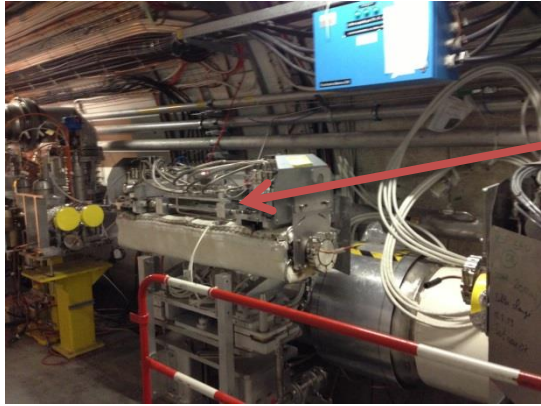
TOTEM RP-220 m (near-far)



CMS ip5  
~ 220 m  
←

Status & schedule

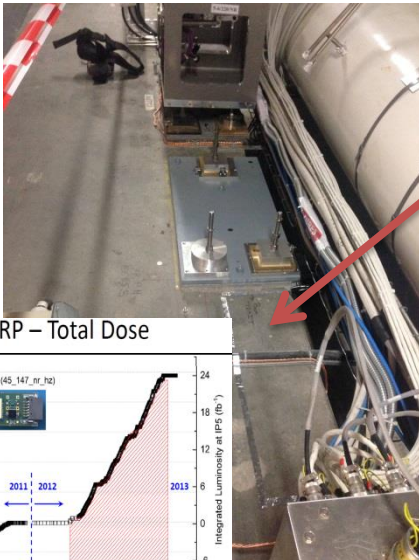
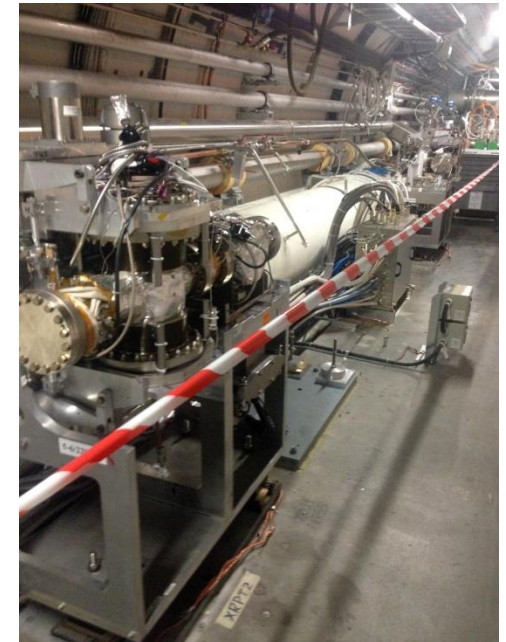
# Status tunnel sector 5/6-220m & 5/6-210 m – May 2014



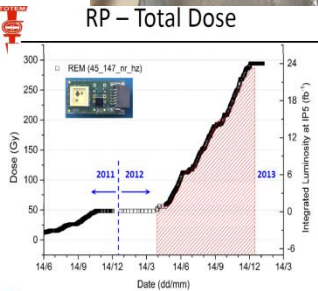
TCL 4

- Almost complete

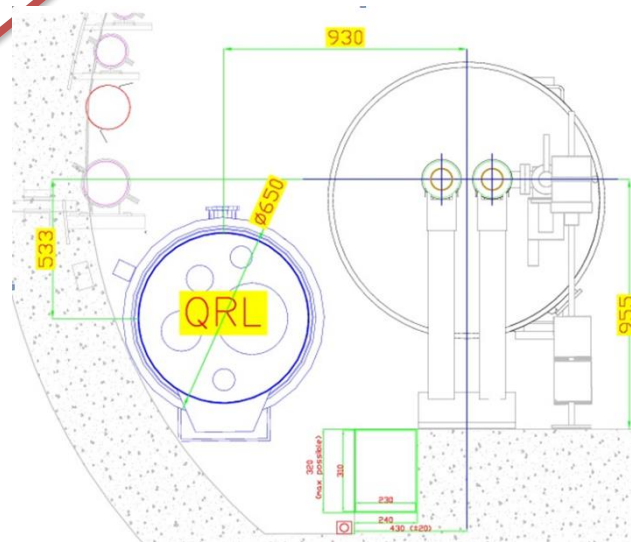
missing :  
 cooling patch panel  
 vacuum line from alkov  
 radiation limiter



RP – Total Dose



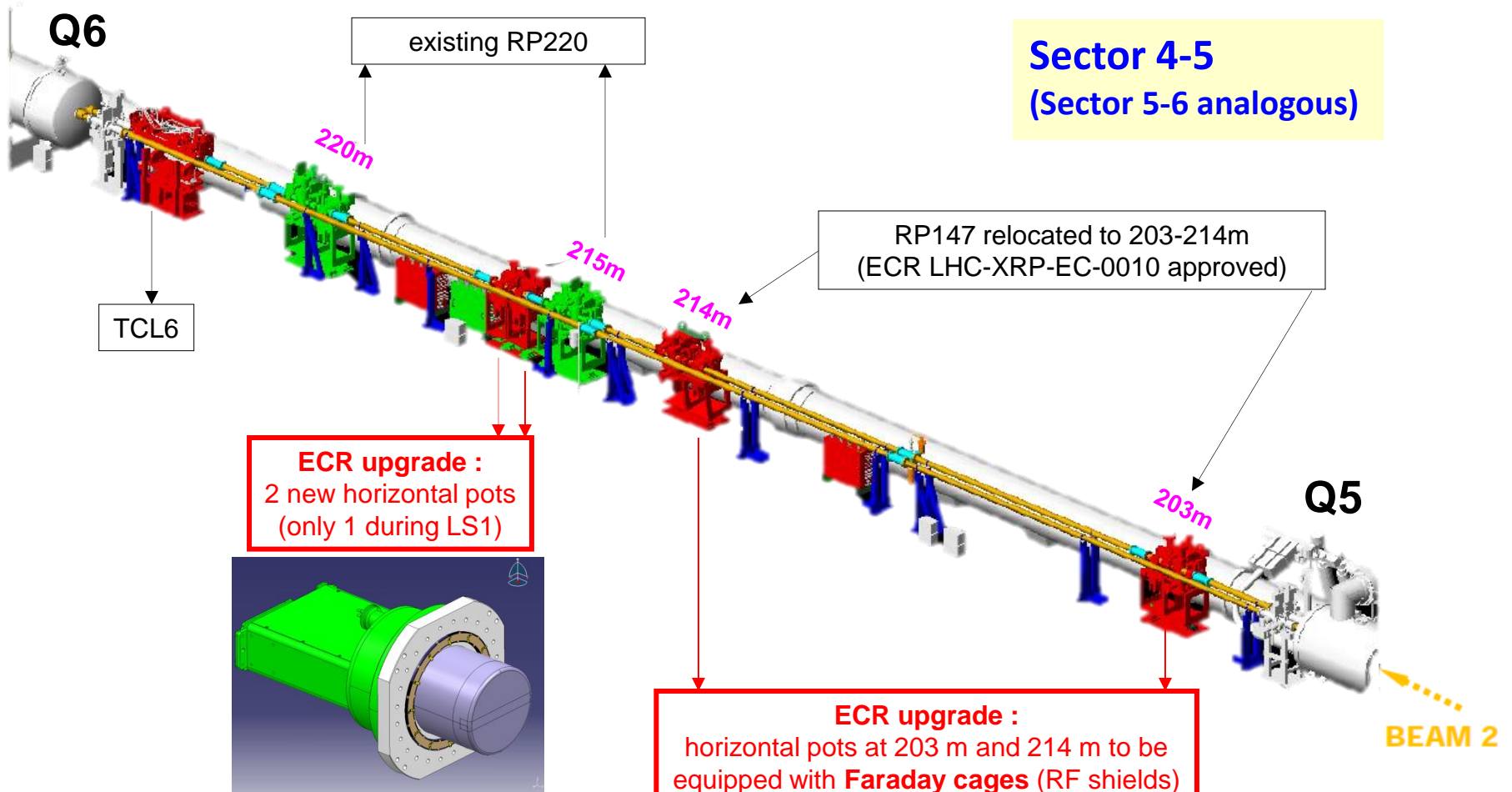
6/5/2014



LHC Working Group on Forward Physics and  
 Diffraction June, 5. 2014

Status & schedule

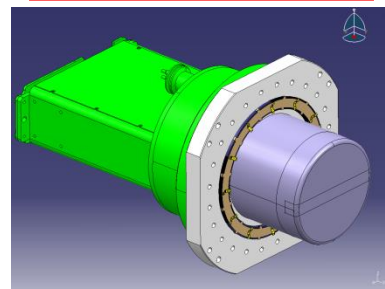
# The Upgraded Roman Pot Spectrometer ECR upgrade



**Sector 4-5**  
(Sector 5-6 analogous)

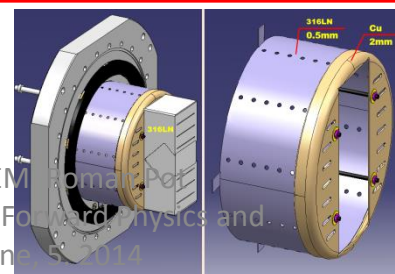
RP147 relocated to 203-214m  
(ECR LHC-XRP-EC-0010 approved)

**ECR upgrade :**  
2 new horizontal pots  
(only 1 during LS1)

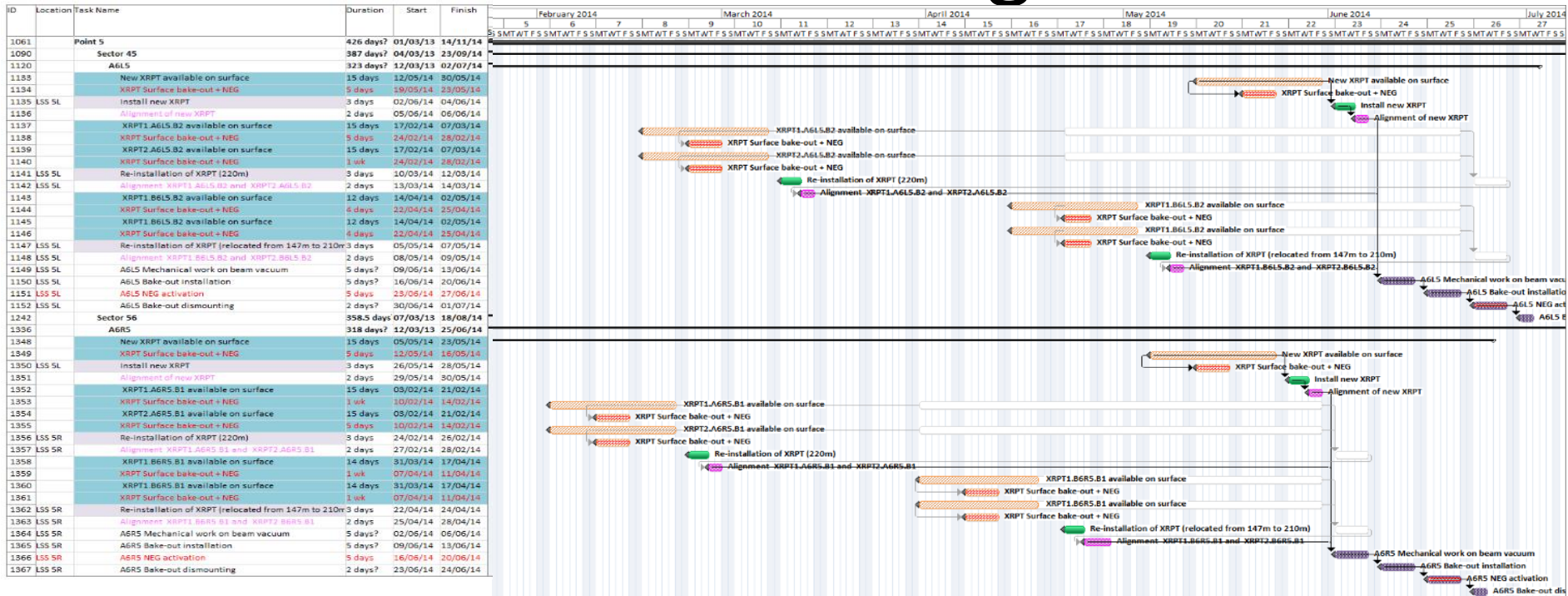


**ECR upgrade :**  
horizontal pots at 203 m and 214 m to be  
equipped with **Faraday cages** (RF shields)

**timing detectors**  
(first year: only temperature  
sensors for insertion tests)



# LHC Planning



## A6R5(5/6)

- 220m far : 219.384 <-> 220.314 -> XRPT2.A6R5.B1
- 220m near : 214.3 14 <-> 215.244 -> XRPT1.A6R5.B1
- 210m far : 212.384 <-> 213.314 -> XRPT2.B6R5.B1 (relocated 147m)
- 210m near : 203.063 <-> 203.993 -> XRPT1.B6R5.B1 (relocated 147m)
- New XRPT : 215.544 <-> 215.876 -> XRPTT.A6R5.B1 (new Timing – single horizontal)

## A6L5 (4/5)

- 220m far : -220.314 <-> -219.384 -> XRPT1.A6L5.B2
- 220m near : -215.244 <-> -214.314 -> XRPT2.A6L5.B2
- 210m far : -213.314 <-> -212.384 -> XRPT1.B6L5.B2 (relocated 147m)
- 210m near : -203.999 <-> -203.063 -> XRPT2.B6L5.B2 (relocated 147m)
- New XRPT : -215.876 <-> -215.544 -> XRPTT.B6L5.B2

Status & schedule

# Conclusions

- All Roman Pots are assembled
- Installation is ongoing