



Totem Status Report

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LHCC 22-feb-2017



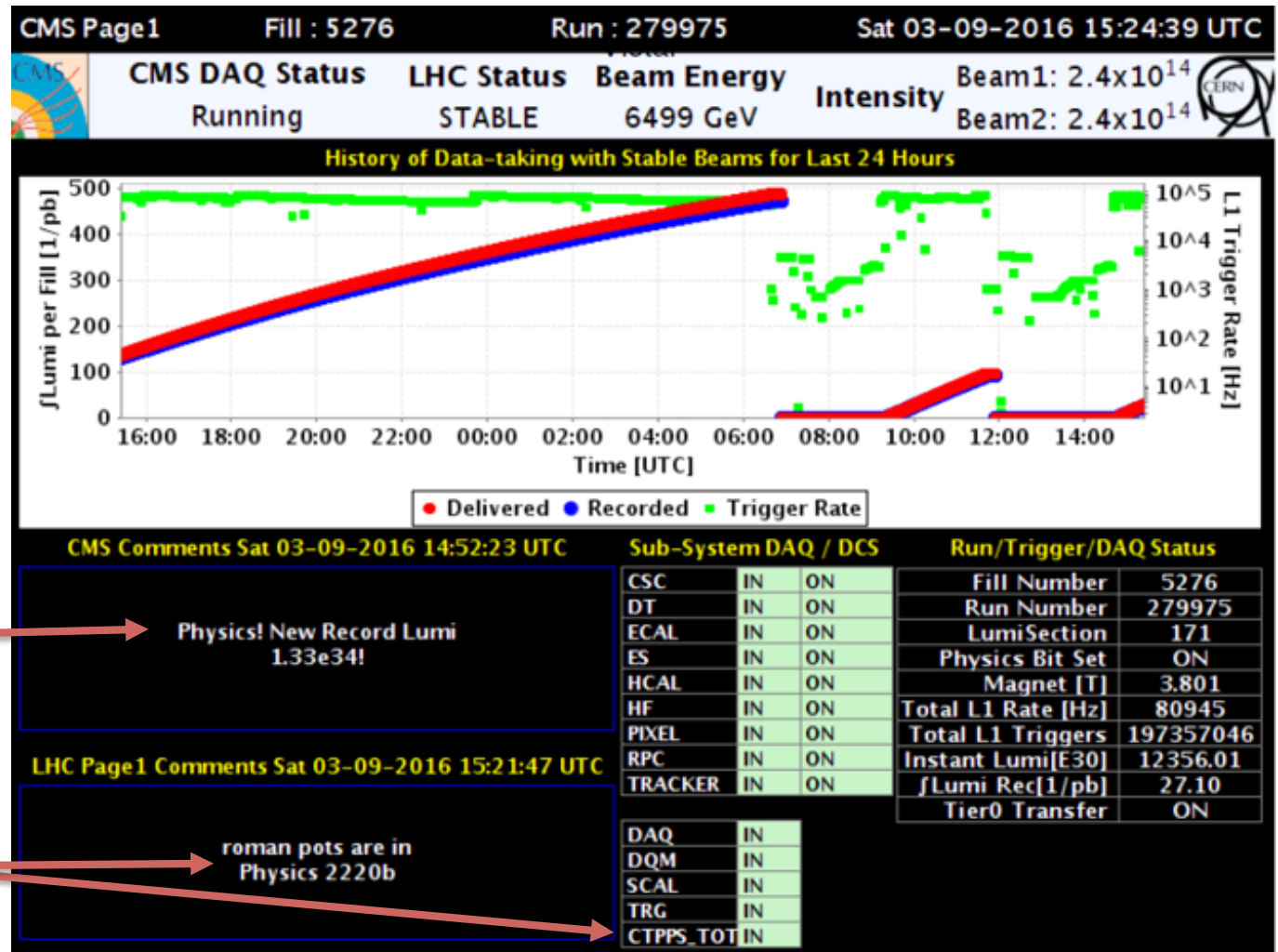
Outline

- CT-PPS
 - Strategies
 - Optics
- EYETS works
 - Roman Pots upgrade
 - Tracking detectors
 - Timing detectors
- TOTEM analysis update



CT-PPS

Roman Pots have been fully qualified and operated with success in 2016 during High Lumi run.



Roman Pots inserted at standard LHC operation luminosity record (so far)

Readout of RP Si detectors fully integrated in CMS DAQ Global run



CT-PPS



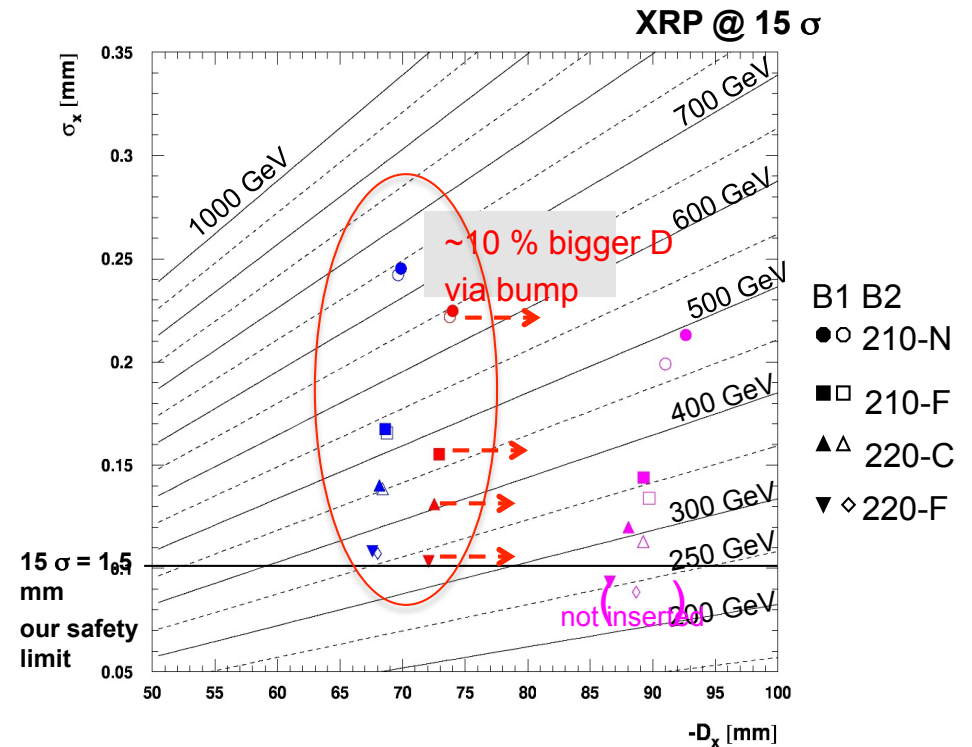
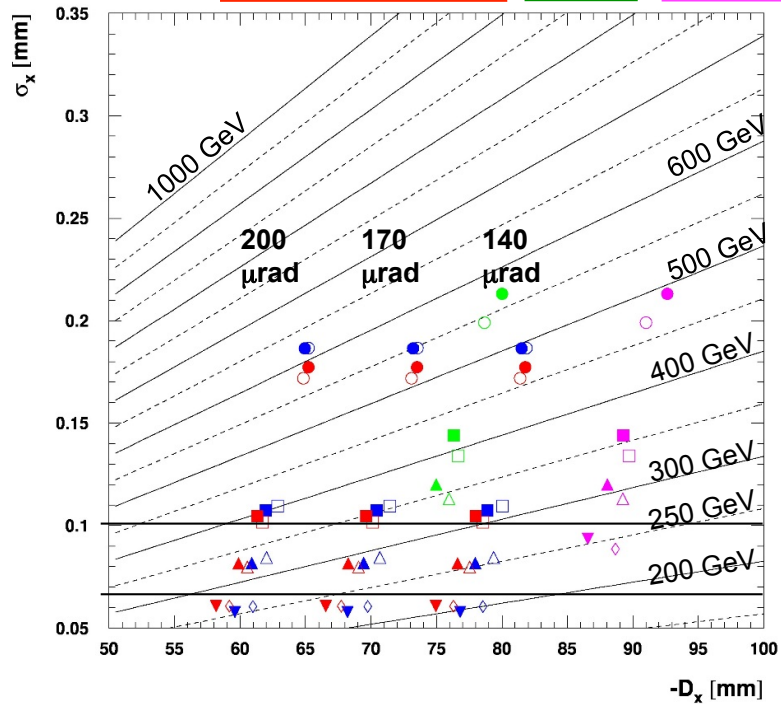
- Totem strategy for 2017
 - Run only at full luminosity with forward detectors
 - Upgrade and install only detectors needed for low β^* runs
 - Reach the lowest mass that the machine optics could deliver (beam approach)

$$M = \sqrt{\xi_1 \xi_2 s}$$



CT-PPS Optics

<p>non-ATS, $\beta^* = 0.33$ m</p> <p>non-ATS, $\beta^* = 0.40$ m</p>	<p>2016</p> <p>$\beta^* = 0.4$ m,</p> <p>$\alpha/2 = 185 \mu\text{rad}$,</p> <p>mild bump</p>	<p>2016</p> <p>After TS2:</p> <p>$\beta^* = 0.4$ m,</p> <p>$\alpha/2 = 140 \mu\text{rad}$</p> <p>mild bump</p>	<p>optimised</p> <p>ATS,</p> <p>$\beta^* = 0.33$ m,</p> <p>$\alpha/2 = 170 \mu\text{rad}$</p> <p>without bump</p>	<p>optimised</p> <p>ATS,</p> <p>$\beta^* = 0.40$ m,</p> <p>$\alpha/2 = 155 \mu\text{rad}$</p> <p>without bump</p>	<p>2016 after</p> <p>TS2:</p> <p>$\beta^* = 0.4$ m,</p> <p>$\alpha/2 = 140 \mu\text{rad}$</p> <p>mild bump</p>
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In Chamonix has been chosen ATS optics that lower the dispersion. Anyhow the machine experts are working on bumps to increase it and give us a better acceptance
 Lowest mass reach depends crucially on dispersion D_x @ RP and horizontal beam size σ_x @ RP



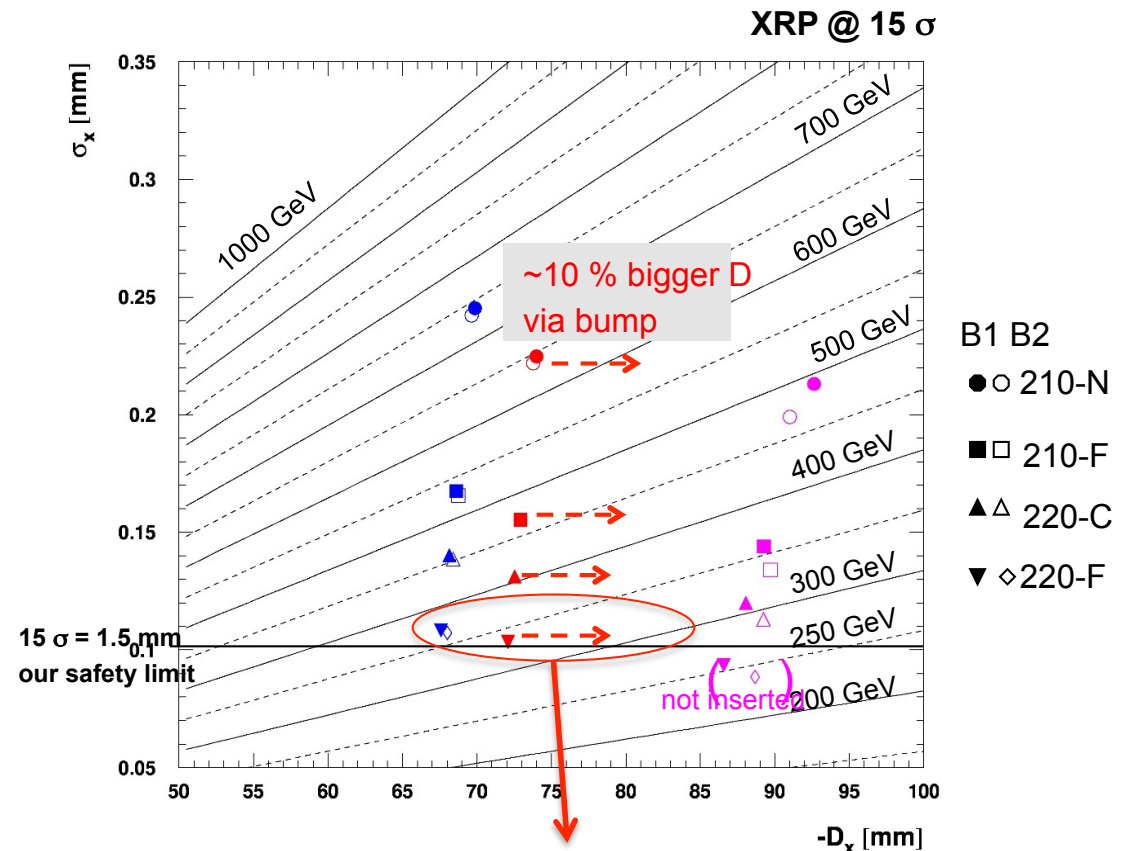
CT-PPS Optics/Strategy

- Optimize Mass reach
 - Qualify 220 far Roman Pots
 - In 2016 they had not faraday cages to limit their impedance
 - Have Rad Hard tracking detectors in there (3D pixels)
 - Difficult package exchange during Tech Stops due to the proximity of a collimator (TCL6) introducing Safety Issues for the working personnel.
 - Backup solution with Silicon Strips (limited lifetime)
 - Put anyhow Silicon Strips in the 210 far and operate them at lower temperature and higher voltage to increase their lifetime

optimised
ATS,
 $\beta^* = 0.33 \text{ m}$,
 $\alpha/2 = 170 \mu\text{rad}$
without bump

optimised
ATS,
 $\beta^* = 0.40 \text{ m}$,
 $\alpha/2 = 155 \mu\text{rad}$
without bump

2016 after
TS2:
 $\beta^* = 0.4 \text{ m}$,
 $\alpha/2 = 140 \mu\text{rad}$
mild bump



RP220 far- not qualified in 2016



EYETS works

- Remove all detector packages -> inspection at SX5 ✓
- Reinstallation
- Exchange ferrites & install RF shields in RP220 far sectors 4/5 and 5/6 ✓
- Separate the secondary vacuum lines of the RP 210 & 220 ✓
- Warm mode cooling in RP220 near and RP cylindrical ✓
- Installation of new LHC ion pumps ✓
- RP movement interlock spare (MPP) ✓
- Benchmarking of timing detector electronics - precision clock
- Diamond detector HV test before re installation ✓
- Installation of Si-pixel detector packages
- Integration of Si-pixel detector in readout

EYETS Schedule

2016

	Oct			Nov				Dec					
Wk	40	41	42	43	44	45	46	47	48	49	50	51	52
Mo	3	10	17	24	31	7	14	21	28	5	12	19	26
Tu	MD 4					Ions setup							
We					TS3								
Th													
Fr				MD 5									
Sa													
Su									Pb MD			Xmas	New Year

Dismount beam tube

Dismount detector package
RP 220 far 4-5 & 5-6

Dismount RP-unit
220 far 4-5 & 5-6
-> transfer to CMS
RP zone surface lab

Dismount remaining
detector packages

2017

Installation of RF shield & vacuum test
RP bake out Preveessin
RP 220 far 4-5&5-6 back in LHC tunnel
Bake out 4-5 & 5-6 Between Q5-Q6
Re - installation of Detector packages
Laser calibration & movement test

	Jan			Feb				Mar					
Wk	1	2	3	4	5	6	7	8	9	10	11	12	13
Mo	2	9	16	23	30	6	13	20	27	6	13	20	27
Tu													
We													
Th													
Fr													
Sa													
Su													

Access at 4-5 & 5-6
CT-PPS

- partially reduced access
- reduced access
- no access

	Apr			May					June				
Wk	14	15	16	17	18	19	20	21	22	23	24	25	26
Mo	3	10	Easter Mon	17	24	1st May	8	15	22	29	Whit	6	13
Tu													
We													
Th													
Fr													
Sa													
Su													

CT-PPS technical coordination 31.1.2017 J.B



RP Si strip detector packages

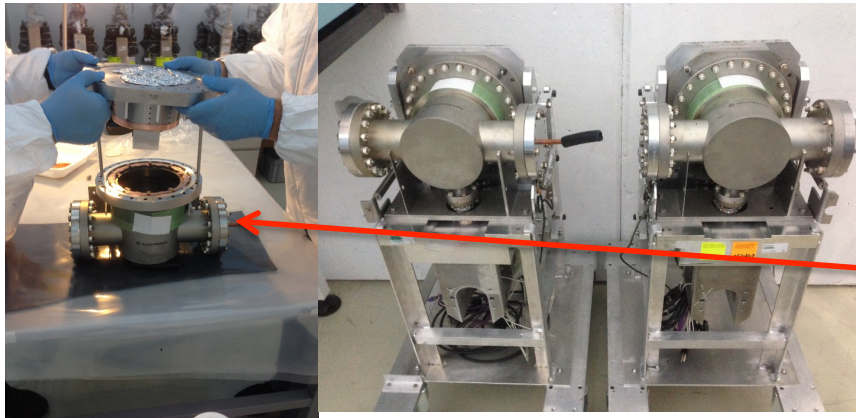
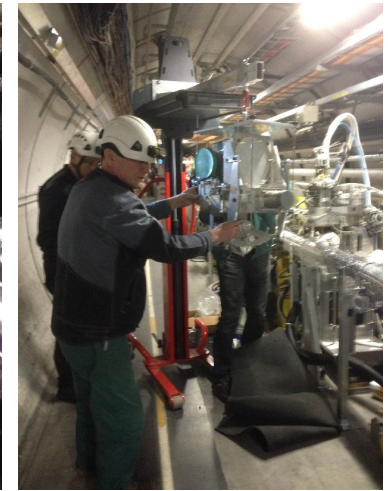
extraction – storage - service - test





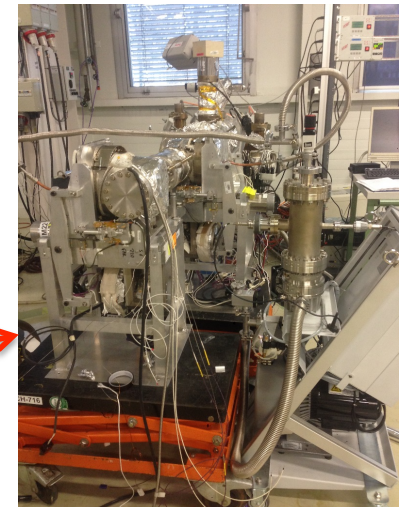
RP 220 Far qualification

Roman Pots Extraction from the Beam-line



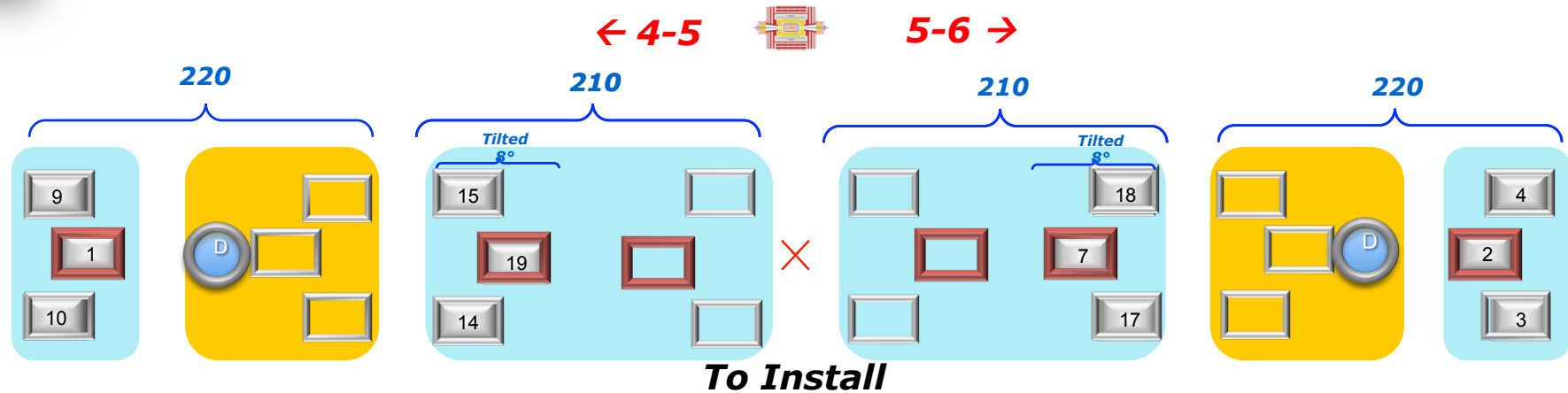
Faraday cages and ferrite Installation

Bake -Out





Cooling and Vacuum



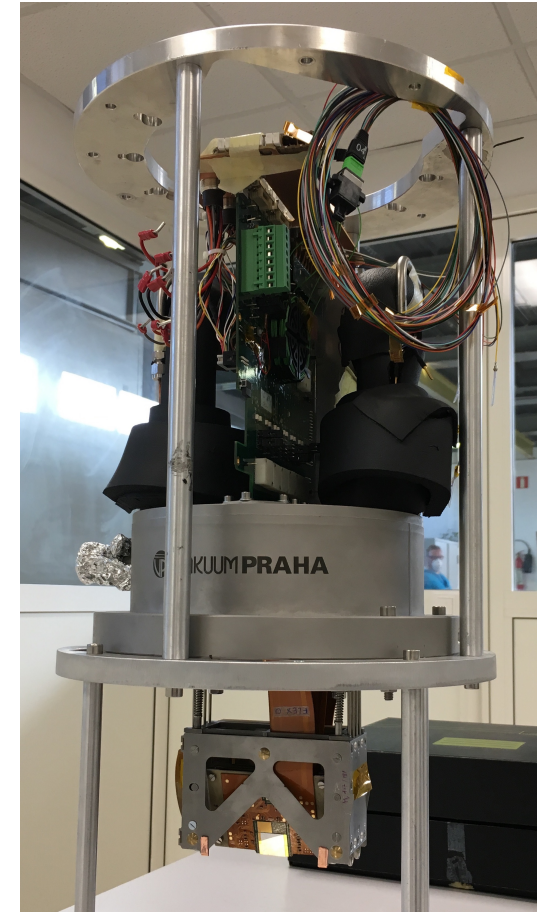
The Roman Pots cooling and vacuum of timing detectors has been separated from the tracking ones.

This allow to push down the Silicon Strip and pixel temperature to allow a larger radiation tolerance.



Tracking Detectors

- Mount back on **210 near and far Si strip detectors** (can be exchanged in TS when damaged)
 - Increase lifetime
 - Lower temperature
 - Higher HV, tested up to 300V in 2016
- Mount **Si 3D pixel detector** in 220 far, the new qualified pot.
 - Pre-commissioning of two detector packages ongoing in H8
 - Vacuum
 - Cooling
 - HV
 - LV
 - FEE and Readout
 - New Daq electronics to be commissioned in march
 - Different path and FED electronics (μ TCA)
 - Different FEC (Control path based on μ TCA)
- In case of fatal failure of any of the previous items we foresee a backup solution based on the old Si strip detectors (lifetime limited)

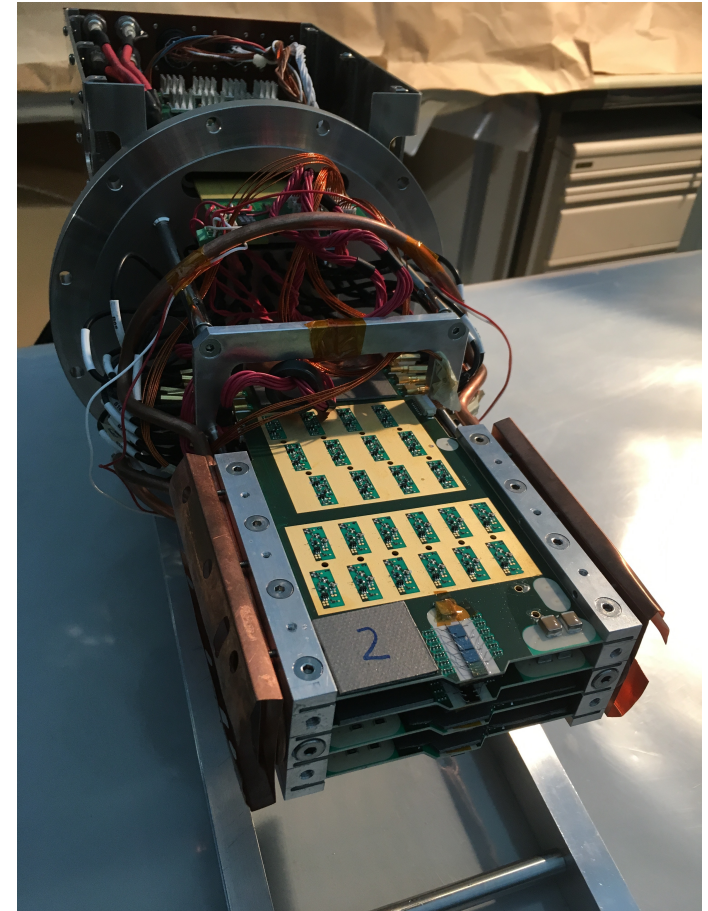


New Si 3D pixel detector



Timing Detectors

- Observed some discharge during 2016 operations
- Diamond detector packages tested in vacuum and irradiation to spot the weak points
 - Need to do minor reworking on the hybrids
 - New procedure to reinforce HV stability
 - Need to increase the internal pressure of the cylindrical pots
 - The detector hybrids will be ready early March for the final assembly
- Substitute one layer of diamond detectors with the new LGAD Ultrafast Silicon Detectors to test the technology in the real operating environment.
 - Test radiation damage
 - Test functionality
- Beam center in RP location is foreseen displaced vertically by $\sim 2\text{mm}$
 - Limited active vertical size
 - Beam out of detector acceptance
 - Need to displace the RP up or down with respect to the center of the beam





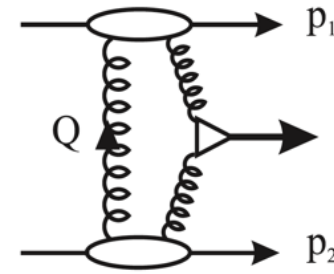
CTPPS readiness

- The commissioning of the Roman Pots is almost in schedule
 - the bake-out of the beamlines is foreseen next week.
 - Detectors reinstallation is foreseen to start the 6th of March
 - New tracking 3D Silicon pixel detector is foreseen to enter the 220 far Roman Pots the last week of March
 - Timing detectors packages will be ready almost the same period
- Daq tests and commissioning foreseen in April
 - New Daq setup for pixels
 - Upgrade of timing daq chain.

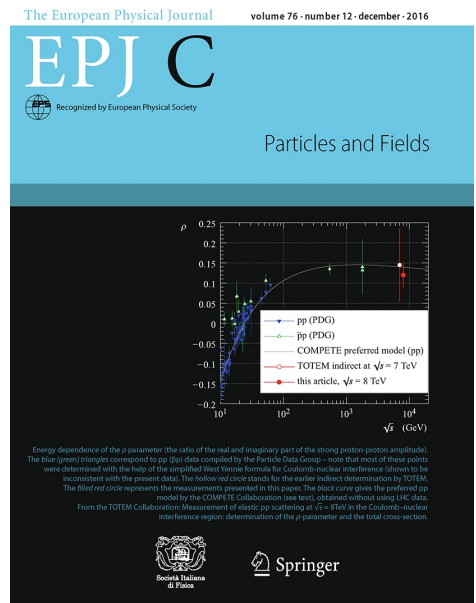


Totem analysis update

- 2.76 TeV Cross Section has been finished
- 13 TeV Cross Section well advanced.
- Hadronic-Coulomb interference studies with data at $\beta^*=2.5\text{Km}$ well advanced.
- Low mass resonances studies and Glueballs searches with diffractive events in progress.
- CT-PPS data analysis just started.
 - Central Exclusive Production.
 - $\mu\mu$ exclusive production analysis almost finalized
 - $\gamma\gamma$ exclusive production analysis in progress
 - Missing masses search.
- Published the paper: Measurement of Elastic pp Scattering at $\sqrt{s} = 8$ TeV in the Coulomb-Nuclear Interference Region - Determination of the ρ Parameter and the Total Cross-Section



[CERN-PH-EP-2015-325, Eur. Phys. J. C76 \(2016\) 661](#)



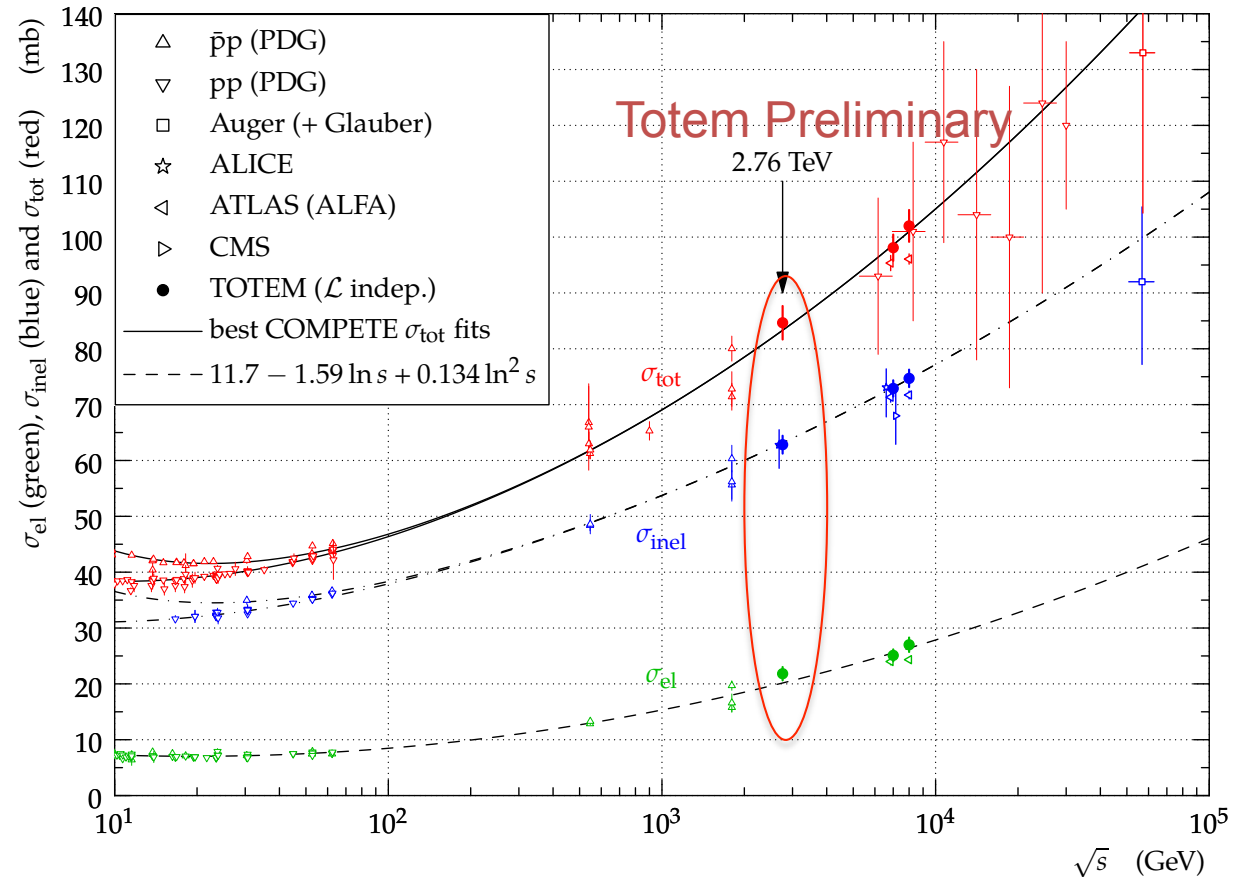


2.76 TeV Cross Section Measurement

The Cross section measurement at 2.76 TeV has been completed and the paper is in the editing phase

$$\begin{aligned}\sigma_{\text{tot}} &= 84.7 \pm 3 \text{ mb} \\ \sigma_{\text{inelastic}} &= 62.8 \pm 1.6 \text{ mb} \\ \sigma_{\text{elastic}} &= 21.8 \pm 1.2 \text{ mb}\end{aligned}$$

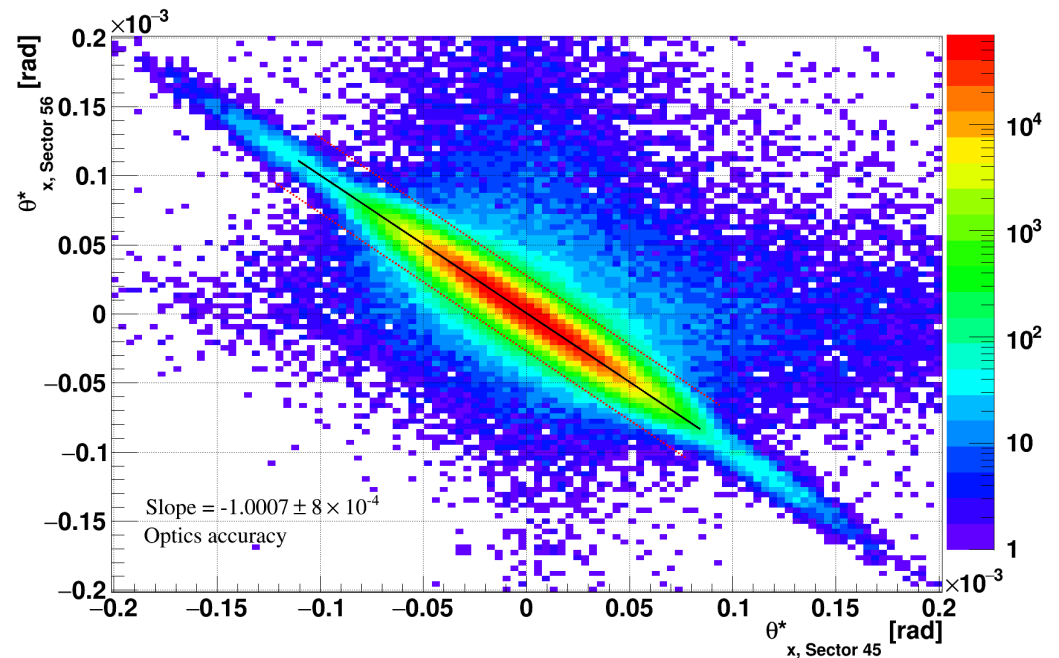
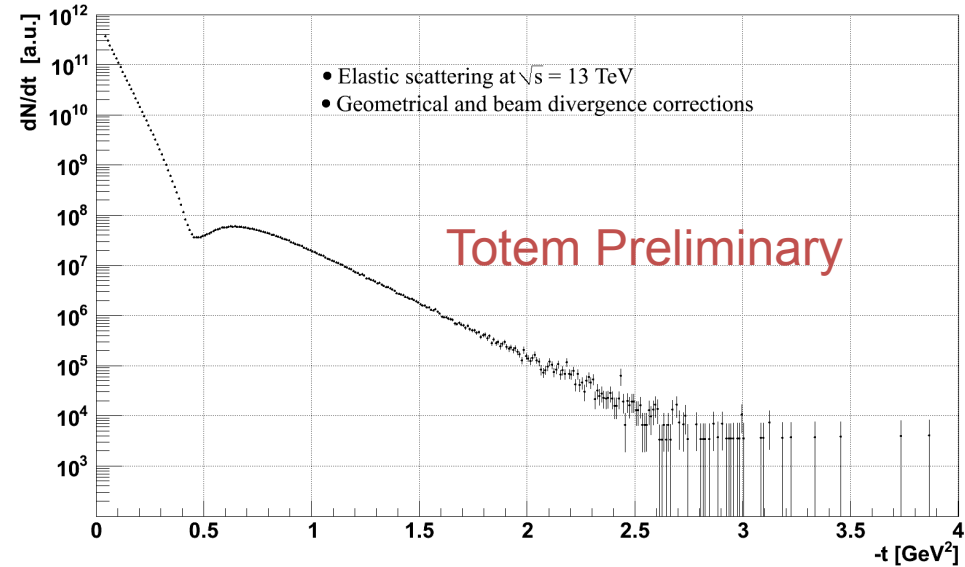
$$B = (17.14 \pm 0.3) \text{ GeV}^{-2}$$





13 TeV pp Cross Section

- Acceptance and analysis cuts carefully defined for all fills
- Geometrical and beam divergence corrections
- Advanced study:
 - DAQ inefficiency,
 - unfolding,
 - pile-up from background,
 - alignment uncertainty propagation

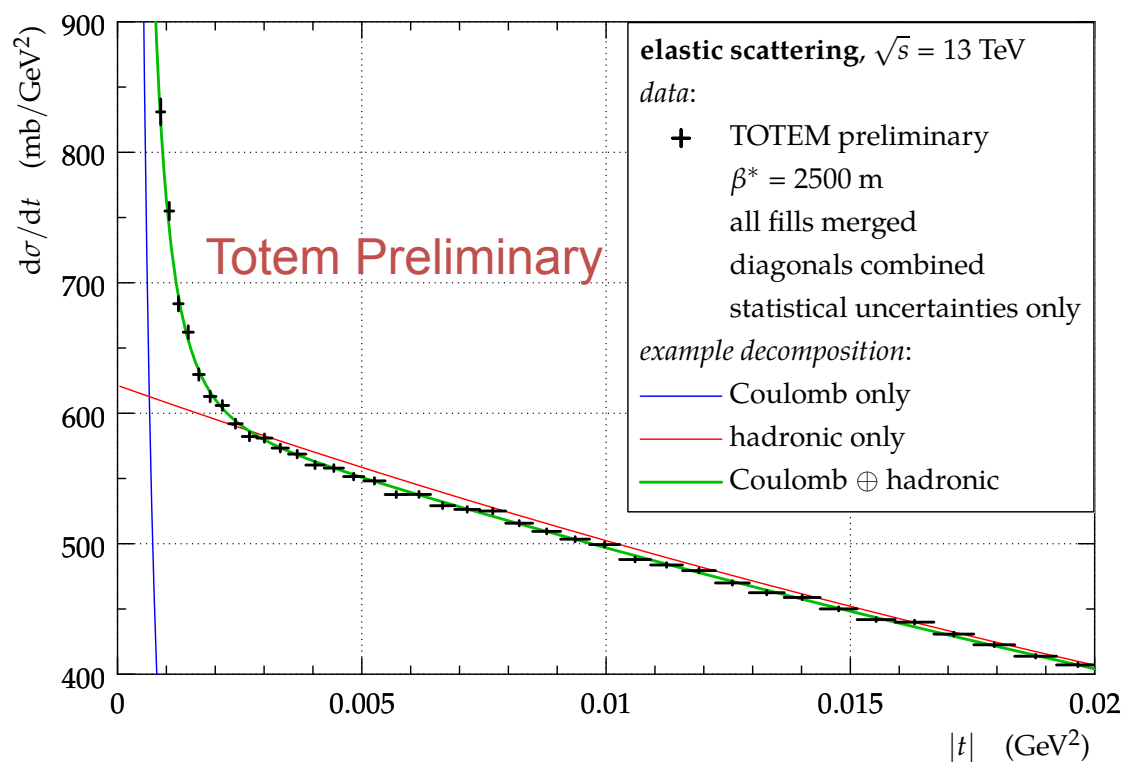




$\beta^*=2.5\text{Km}$ Run Analysis

Hadronic Coulomb Interference

First full analysis cycle completed with all corrections applied





Conclusions

- Totem has committed for the 2017 run only in High Luminosity run with the CT-PPS apparatus.
- Due to the bad acceptance of the new ATS optics, the farthest Roman Pots (220 far) have been refurbished with new faraday cages and new ferrites to qualify them for high luminosity. This improves the reach of lower masses of the diffractive processes.
- The detector packages have been removed from the beam line to allow the baking of the region that has been opened.
- The detector are stored and tested and only the needed one for Hi Lumi will be installed back.
- A new Tracking detector with 3D Silicon pixel will be installed in the new refurbished Roman Pots.
- The Timing detector has been upgraded to limit the discharge probability
- A new layer with the brand new LGAD Ultrafast Silicon Detectors has been added to allow the study of this technology in the real environment.
- Analysis:
 - 2.76 TeV Cross Section has been determined and a paper will be submitted soon.
 - 13 TeV Cross Section measurement well advanced
 - Hadronic- Coulomb interference region studies well advanced
 - Glueballs searches promising.
 - CT-PPS data analysis advancing.
 - First observation of di-muon exclusive production paper in progress