

# CT-PPS OPERATIONS

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*Jonathan Hollar (LIP)*



LABORATÓRIO DE INSTRUMENTAÇÃO E  
FÍSICA EXPERIMENTAL DE PARTICULAS

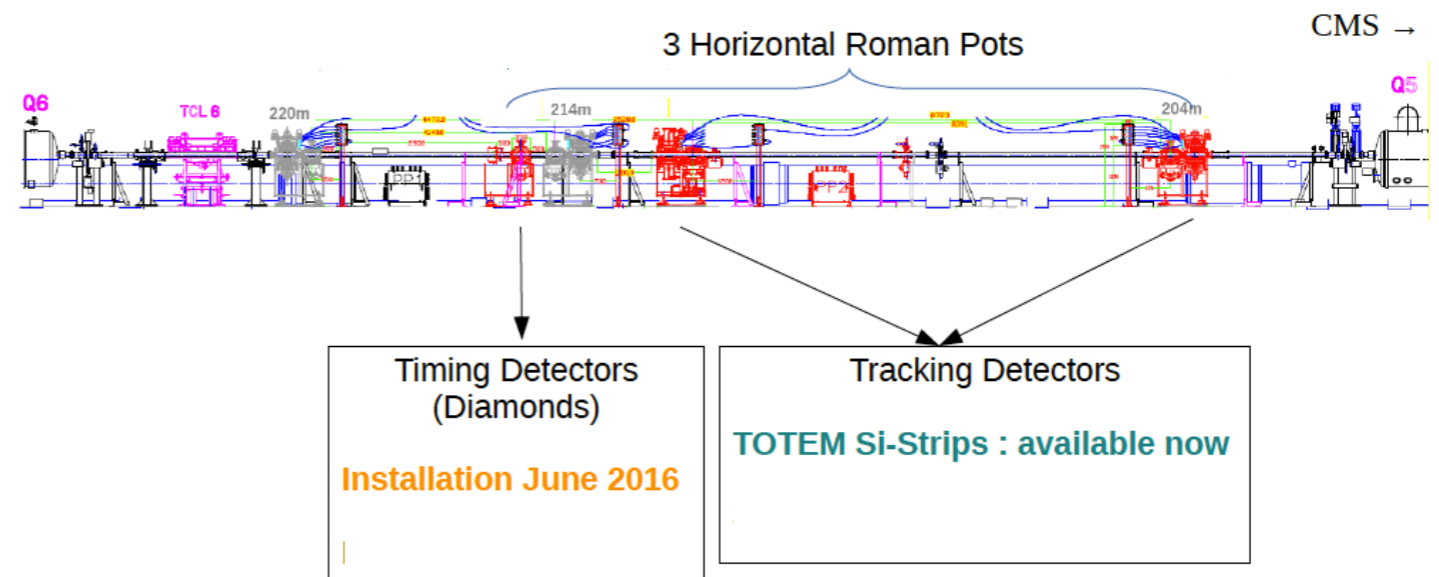
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# 2016

# OVERVIEW: 2016 CONFIGURATION

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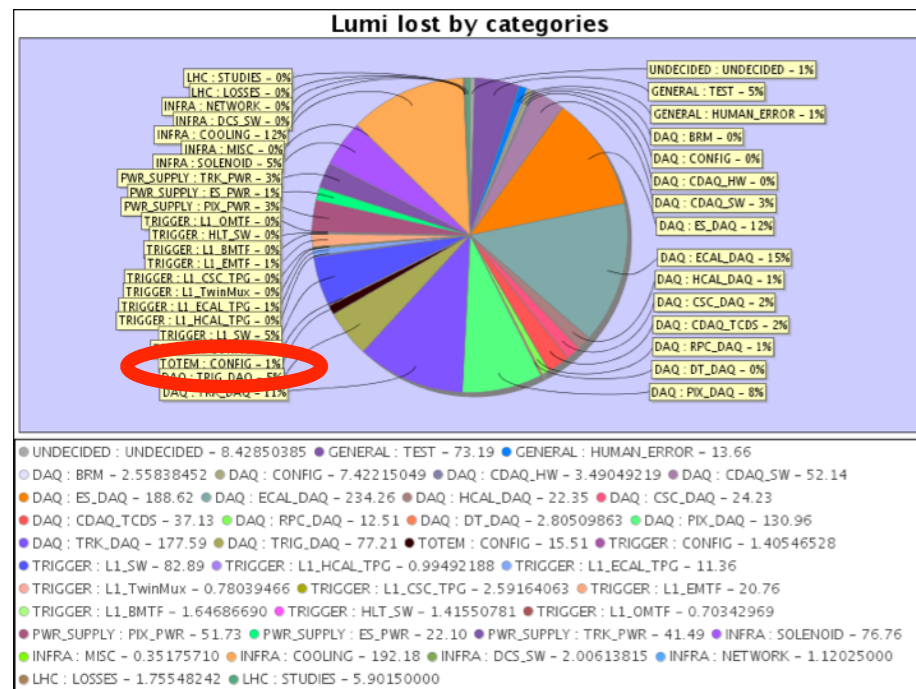
- Reminder of 2016 CT-PPS configuration
  - 3 RP stations on each arm
  - 2 with (non-radiation hard) Si-strip tracking detectors, 1 with diamond timing detectors



- Collected  $\sim 15.3\text{fb}^{-1}$  with Si-strip detectors,  $2.5\text{fb}^{-1}$  with diamonds+strips
- Compared to original TDR-era plans
  - TOTEM Si-strips were used to advance high-luminosity physics data-taking by  $\sim 1$  year
  - Final LHC optics less favorable than assumed for acceptance at low mass (improved by IP5 bump + crossing angle change after TS2)

# 2016 OPERATIONS, DOWNTIME/DEADTIME

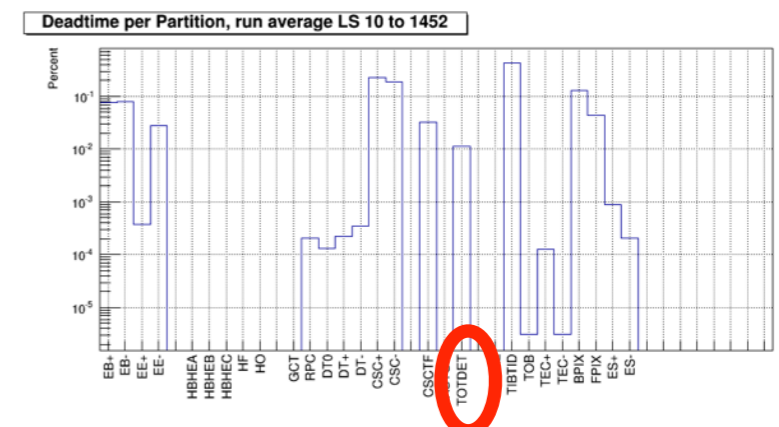
➤ No problems related to operation of RP's 15 $\sigma$  from the beam at highest luminosities



- Period in Summer when CT-PPS was out due to focus on debugging diamonds readout, rad-damage to Si-strips
- Otherwise high data-taking efficiency
  - <1% of downtime assigned to CT-PPS (“TOTEM\_CONFIG”)
    - June 29: HV discharge->LV trip
    - October 9: Strip FED578 sync-loss error
    - October 23-26: Diamond FED583 sync-loss errors (4x in 90:35 hours)

➤ Average deadtime over highest lumi fills ~0.01% (per WBM FMM deadtime plots)

- Most of that from diamonds
- Si-strips negligible after zero-suppression implemented in May



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# EYETS->2017

# MAIN AREAS OF WORK

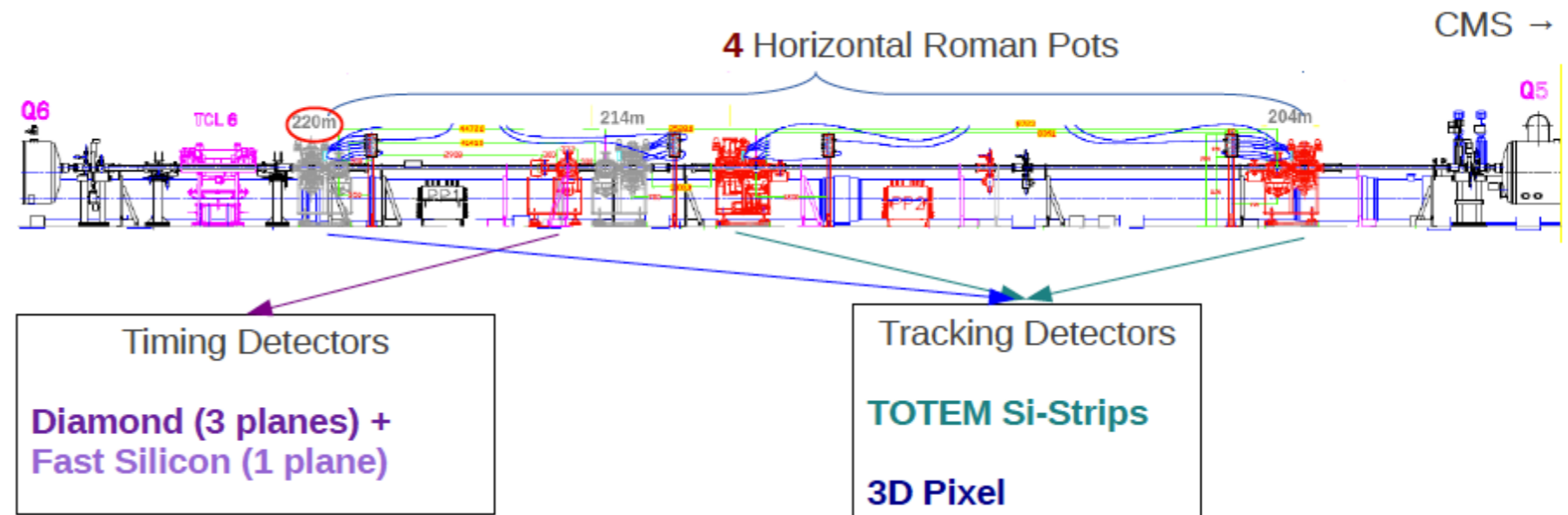
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- Tunnel infrastructure
  - Refurbishment of 4th Roman Pot station for high-luminosity running
- Partial/staged installation of new detectors
  - radiation hard 3D pixel tracking (1 station)
  - fast silicon timing (1 plane of 1 station)
- Consolidation/improvements to timing DAQ+readout chain
  - Front-end hardware/firmware
  - Complete reference timing systems (RF + optical)

# 2017 CONFIGURATION (OVERVIEW)

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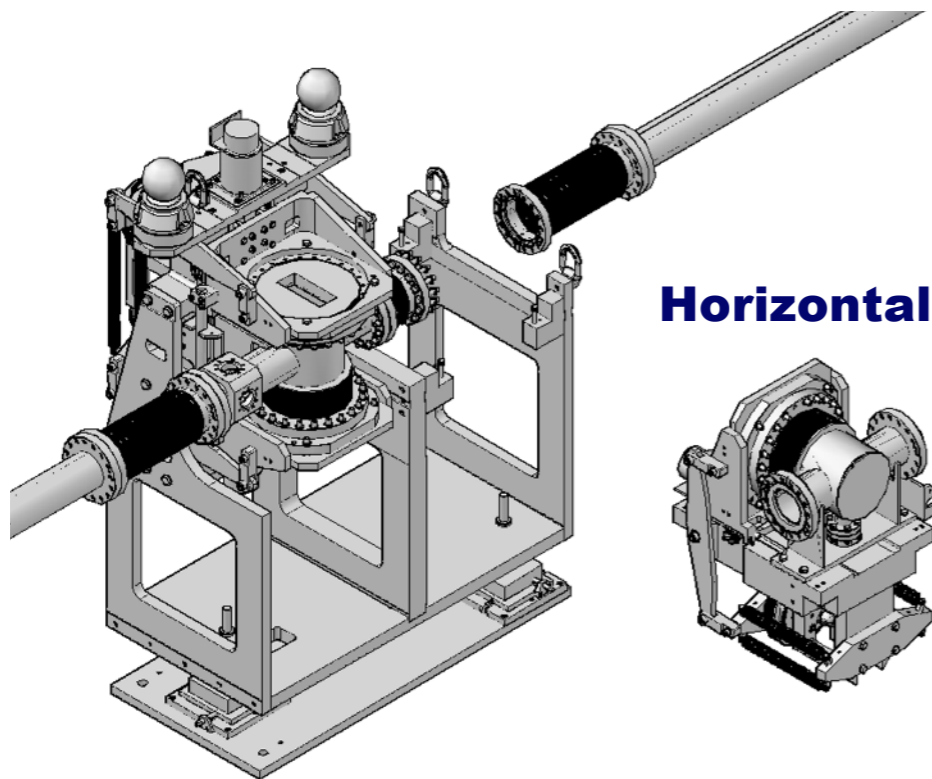
- 4th RP station will be equipped at 220m
- 1 station on each arm will house new pixel tracking detectors



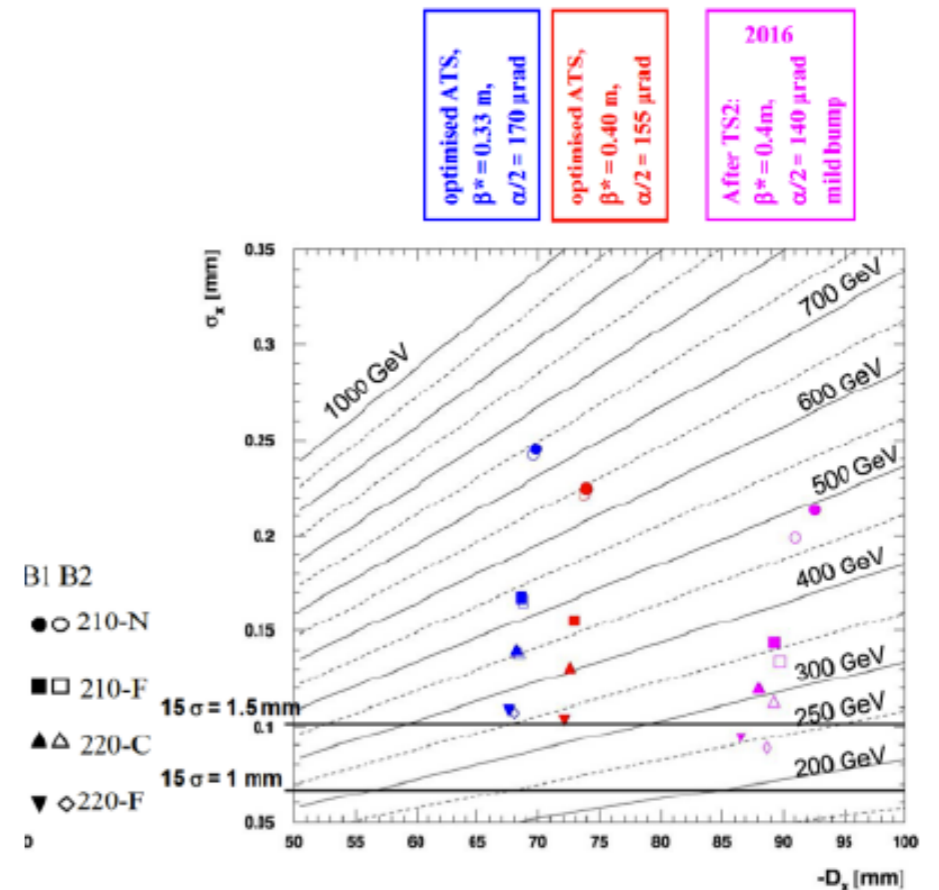
- 2 stations will still have Si-strips tracking (as in 2016) at startup
  - LHC will do alignment/loss map fills at the beginning of the intensity ramp
    - => important to have at least 1 tracking detector guaranteed to work on “day 1”
- 1 station of timing detectors (as in 2016)
  - 3 planes of diamonds + 1 plane of fast silicon

# INFRASTRUCTURE(I)

- Main operation: equipping a 4th Roman Pot station at 220m with RF shielding to operate at high-luminosity
- For a given optics, station farthest from P5 has best acceptance at low masses (shown for ATS optics)



**Horizontal unit (70kg)**

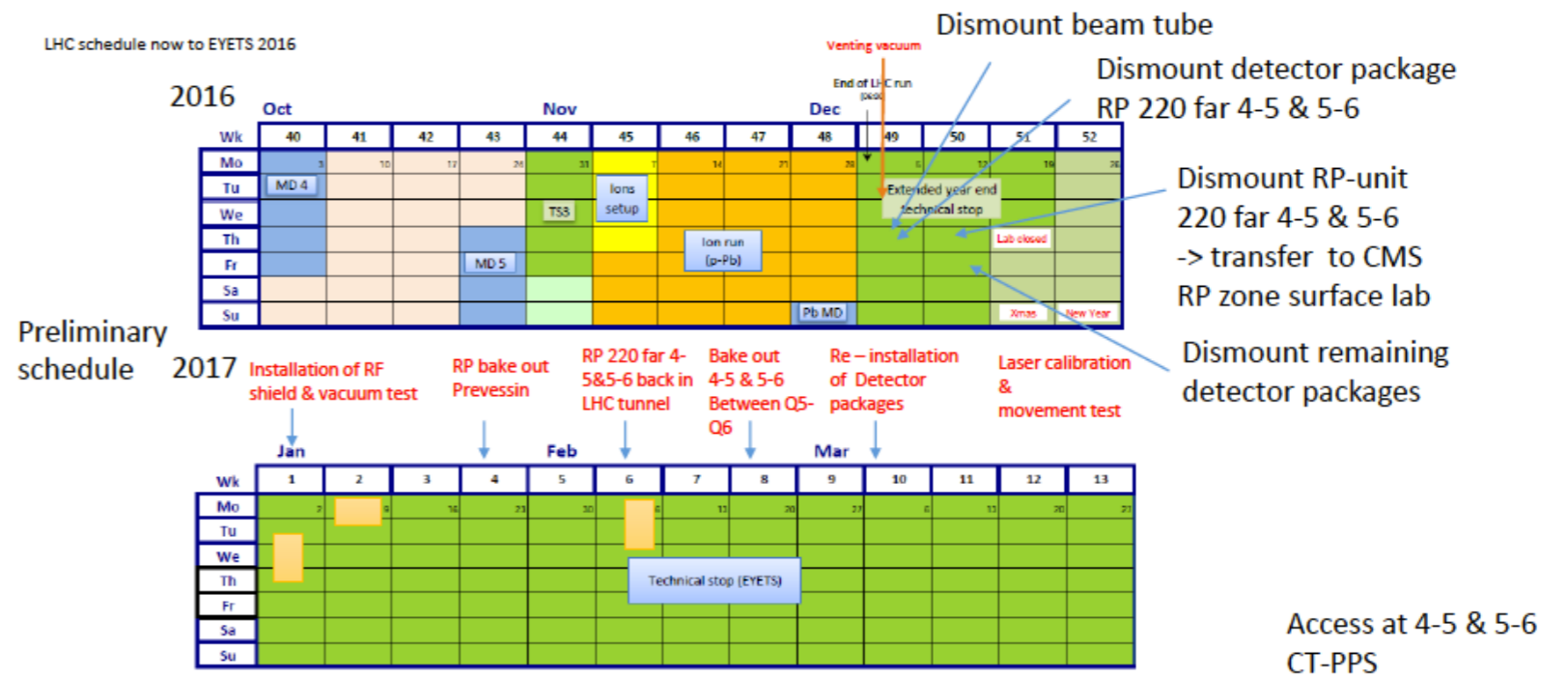


- Requires breaking vacuum to remove RP unit
  - => removal and reinstallation of \*all\* detector packages before bake-out



# INFRASTRUCTURE (II)

- Work proceeding according to schedule
  - 220m RP removed
  - RF shielding added
  - Bakeout tests in Preveessin in preparation for re-installation



J. Baechler

- Additional infrastructure improvement to split cooling loops between tracking & timing detectors
  - -> more flexibility to raise HV for radiation damaged Si-strips

# TIMING DETECTORS: SENSORS/HV

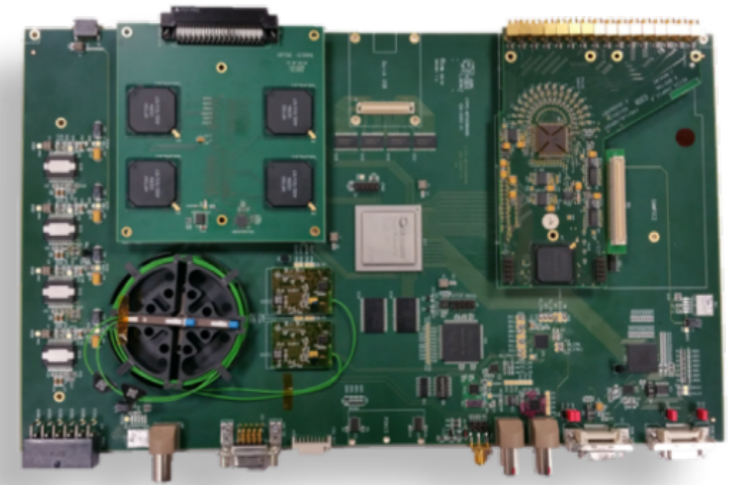
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- Successfully recorded  $\sim 2.5\text{fb}^{-1}$  with diamond timing detectors in late 2016 (see Valentina's talk)
- Some issues with HV trips
  - Beam separation tests indicated likely not related to diamond detectors themselves -> confirmed in high-radiation test campaign at CERN IRRAD facility
  - Further tests point to feedthrough, hybrid board connectors possibly discharging, mitigation work ongoing
- For 2017 aim to insert 1 plane of fast silicon together with 3 planes of diamonds
  - Fast Si has reached  $\sim 30\text{ps}/\text{plane}$  in testbeams (1st generation of diamond detectors installed in 2016  $\sim 90\text{ps}/\text{plane}$ )
  - No significant change to DAQ/backend readout needed

# TIMING DETECTORS: READOUT HW/FW

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- Version2 of front-end “digitizer board” in final production for use in tunnel
  - Main change relevant for CT-PPS: uniform distribution of high-precision reference clock to all components on board
- Firmware to be adapted for v2 of board
  - Several other FW improvements based on 2016 experience
    - improved handling of clock changes ( problems switching between local <-> LHC clock for cosmics during interfill in 2016)
    - Improved error handling
    - POH output option for future uTCA readout



*Digitizer board v1*

# TIMING DETECTORS: ONLINE SW AND READOUT TESTS

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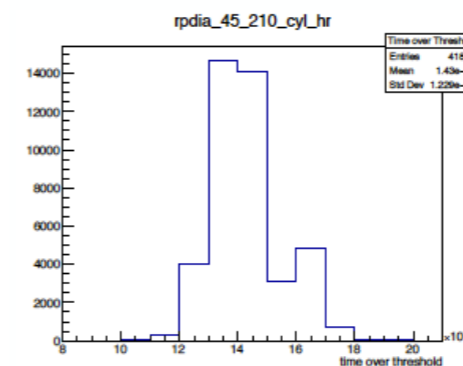
- Online SW
  - Highest priority: remote firmware uploads via FEC -> CCU25 ring
    - Major limitation in 2016 commissioning campaign for diamonds - difficult tunnel access required for (multiple) minor FW updates
    - Status: successfully tested+validated in lab in December, to be re-verified with full system in tunnel
  - Automating reconfiguration of HPTDC / digitizer board components: final tests of XDAQ-L1 FM integration ongoing
  - Development of configuration database for HPTDC settings
- New DAQ test system being assembled for more realistic tests with diamond detector packages

# TIMING DETECTORS: REFERENCE CLOCK

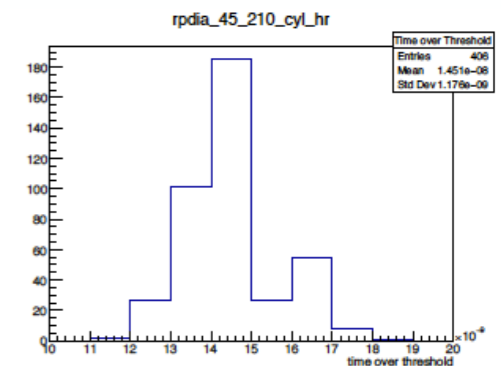
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- Precision timing detectors require precise reference clock
  - Will be possible to fully use in 2017 with digitizer board v2
- Two systems available with sub-ps jitter
  - Optical (based on FAIR system)
    - Installation of components in S2 to be completed in EYETS
  - RF (based on SLAC-LCLS system)
    - Installed and limited MiniDAQ tests done in 2016
    - HV supplies in tunnel died, moving to alternative power supplies in alcove

Internal clock to sector 45



External clock to sector 45

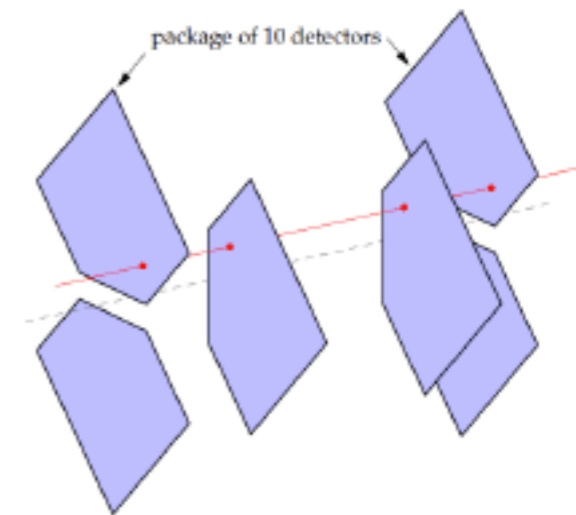


*F. Rebassoo*

# TRACKING: SI-STRIPS

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- Minimal changes from 2016
- 2 additional VME FED's requested to readout strips in vertical RP's
  - These are not used in normal high-luminosity running (physics protons are ~all bent into the horizontal stations)
  - Needed in alignment/loss map fills to determine absolute alignment (see DPG talk for details)
    - In 2016 was done using TOTEM standalone DAQ



# TRACKING: PIXELS

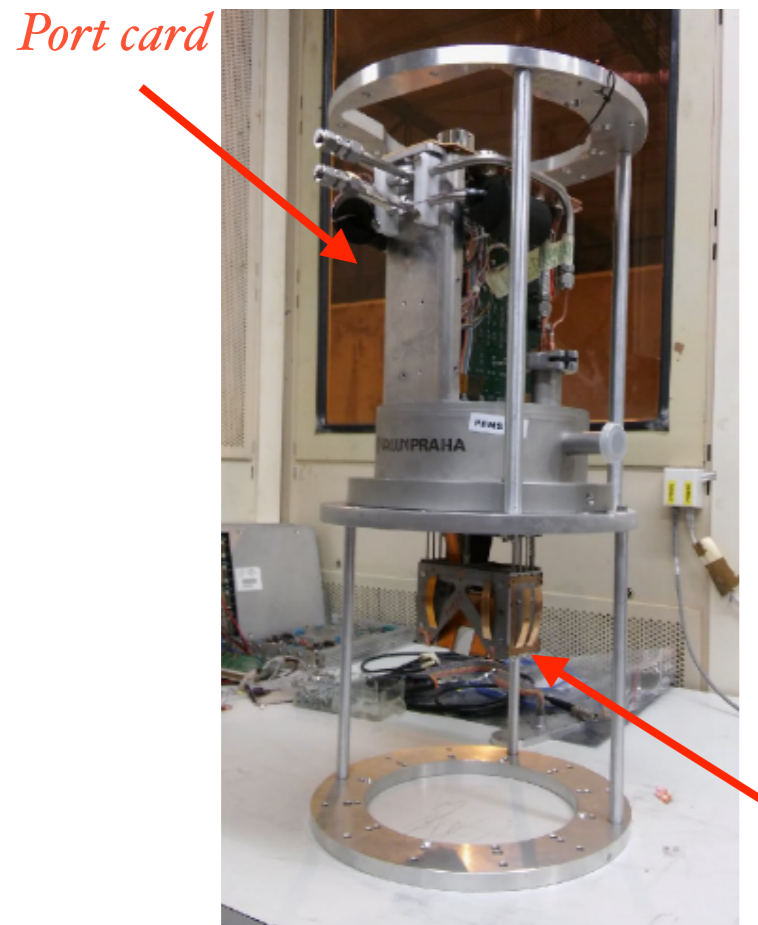
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- Status of production
  - Enough good modules produced for installation of 1 station on each arm (17 2x2, 18 3x2)
  - 2 complete “champignon” mechanical assemblies complete+tested
  - All optical components available (previously a potential issue with POH)
  - Version1 of front-end port card available, version2 sent for production
- 3D pixels irradiated up to expectation for  $\sim 100\text{fb}^{-1}$  (eq.  $5 \times 10^{15}$  p/cm<sup>2</sup>)
  - No inefficiency, but some slewing of signal pulses into adjacent BX due to highly non-uniform irradiation
    - Exploring alternate readout schemes to compensate

# TRACKING: PIXELS INTEGRATION

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- Series of above-ground integration tests in December 2016



*Pixel detector package*

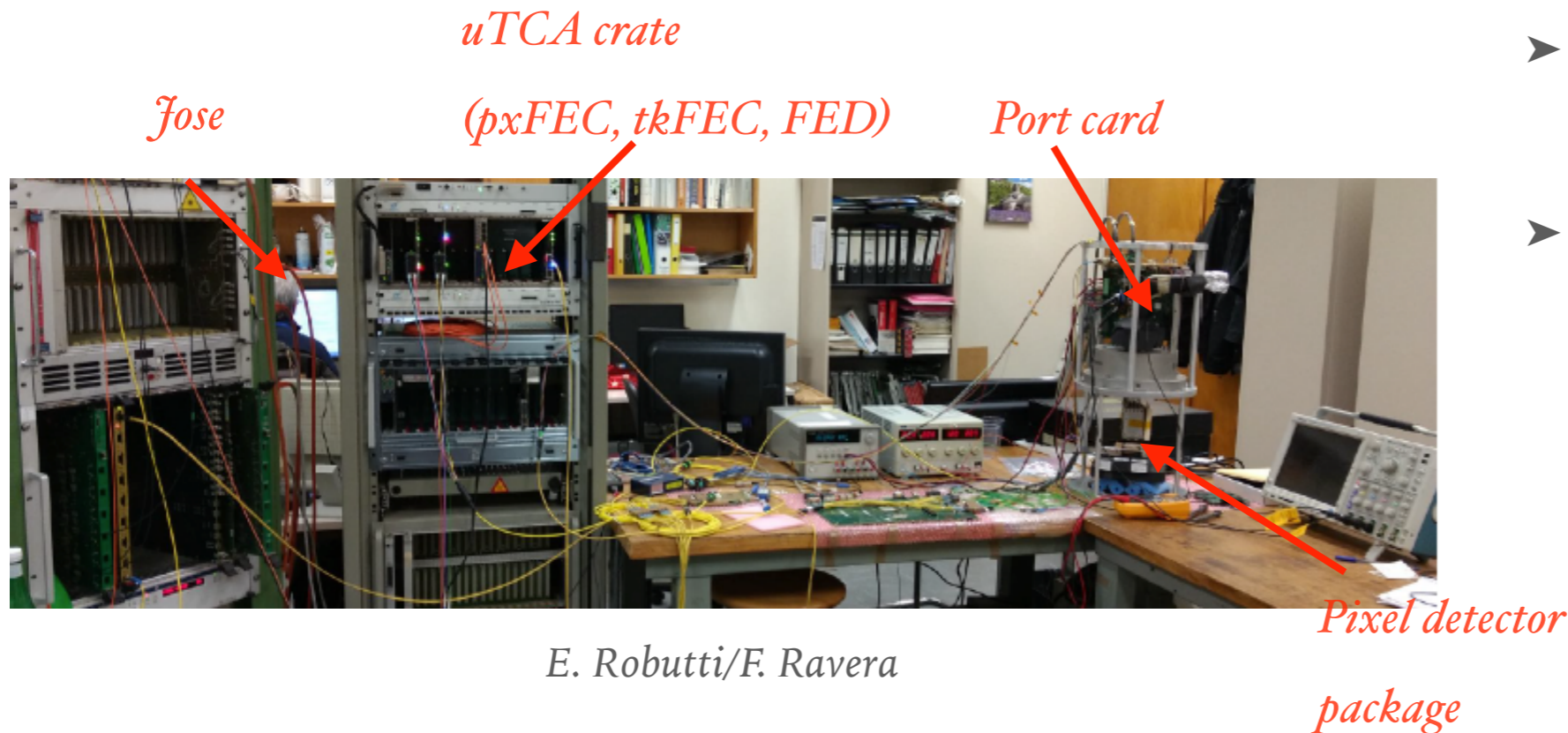
*E. Robutti*

- Mechanical + cooling tests in H8 beamline of SPS
- Pixel detector packages integrated in full mockup of tunnel system with Roman Pots + cooling
- Tests OK - minor changes to mechanical constraints & temperature sensors implemented



# TRACKING: PIXELS DAQ AND INSTALLATION

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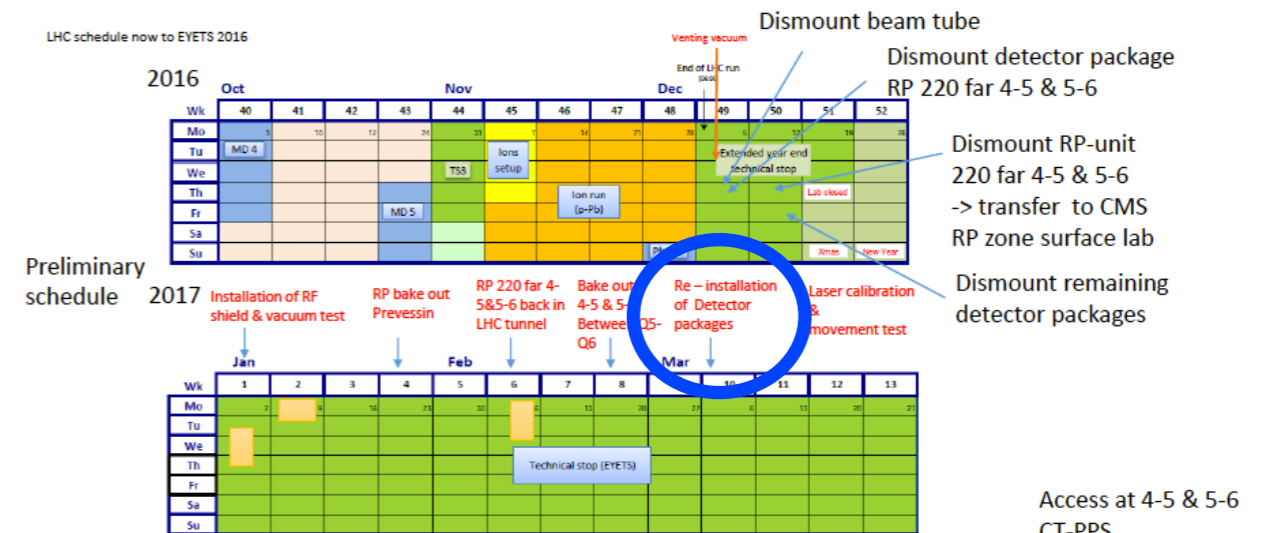
- DAQ/readout chain tests + validation ongoing
- Using same backend + SW as phase-1 pixels
  - FC7 uTCA FED (1), tkFEC, pxFEC
  - PixelSupervisor XDAQ SW extended to RPIX naming/numbering scheme

- (1) uTCA crate installed in P5 since 2016
- Plan final round of integration tests in H8 testbeam area in February, including DAQ (possibly with v1 of port card)
  - => Qualify 2 complete packages for installation

# COMMISSIONING

- Basic readout chain for pixels, updated timing, can be tested without beam
  - Readiness for high-rate pixels readout depends on phase1 uTCA FED developments
- Understanding response, timing scans, etc. requires stable beams (cosmics not very useful due to small area and perpendicular orientation of detectors, RP not inserted w/o stable beams)
  - Pixels will be in a separate (uTCA) partition from diamonds/strips -> more flexibility to run pixels in MiniDAQ without removing other detectors from global
- With new optics, expect LHC will start RP insertions with an extra safety margin, as in 2016 startup

- NB. Due to need for bakeout, detectors likely to be (re-)installed in tunnel only after MWGR#2



# SUMMARY

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- CT-PPS successfully took  $\sim 15\text{fb}^{-1}$  of physics data in 2016, a year ahead of original plan
- Several upgrades/additions in progress during EYETS
  - Conversion of 4th RP station proceeding according to schedule
  - 1 station/arm of 3D pixels and 1 plane of fast silicon-timing
    - Tight schedule but no showstoppers
- Also work ongoing to improve operations with existing detectors used in 2016
  - Timing detector readout (firmware, digitizer board, remote programming)
  - Integrated readout option for vertical RP's for alignment runs
  - Reference timing system