New Pixel detector: construction, installation, checkout, commissioning

On behalf of the pixel phase 1 upgrade group

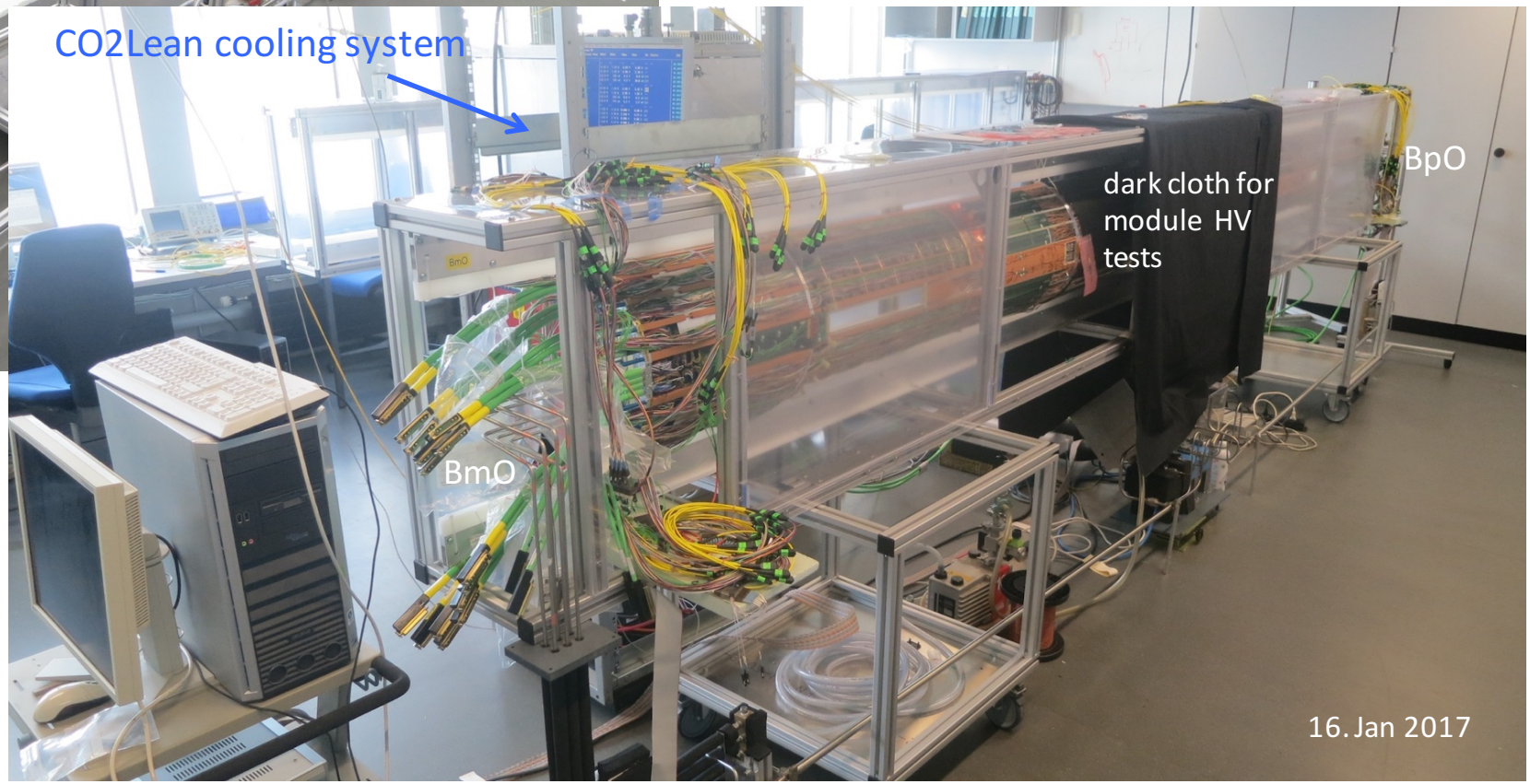
Outline

- Detector status: BPIX and FPIX
- Installation: status and plans
- Checkout
- Calibration

Detector status: BPIX

- BPIX fully assembled at PSI
  - Modules, mechanics, cooling, supply tubes
- Far side (-x) half fully tested
  - All 16 sectors tested & all correctly working
    - test performed with CO2 cooling at room temperature (15C)
    - 2 modules (out of 544) do not respond
- Near side (+x) half being tested
  - All the sectors tested at least once
  - 3 sectors being debugged to fix some problems (similar to what happened with the first half)
- Transport is foreseen on Tuesday Jan 31st.
  - After the transport we will be testing the detector again in the P5 clean room

BPIX (-x) fully assembled & all sectors tested



Status of FPIX half cylinders (i)

Half Cylinder	Location	Repairs complete	Tested after repairs	Ready for installation
BmI	P5 (since Nov)	Wed 14 Dec	Yes	Yes
BpI	P5 (since Dec 19)	Mon 12 Dec	Yes (quick check after covers @ P5 this week)	Needs few hours work (install covers), done before Jan 26
BmO	P5 (today)	Fri 13 Jan	Yes (will complete this week @ P5)	Ready for installation after checkout at P5 (Jan 27)
BpO	TIF	This/next week	Jan 26 – Feb 21 @ TIF Feb 28 – Mar 5 @ P5	Ready for installation after checkout at P5 (Mar 5)

All FPIX half cylinders are stored in their cold boxes both at TIF and at P5
BmO transported to P5 on Mon 23 Jan, BpO will be kept at TIF to continue online firmware / software development and testing until Feb 21
BpO will be transported to P5 on Mon 27 Feb, checked again at P5
FPIX half cylinders will be moved into CTUs ready for installation (-Z side: 1-2 Mar, +Z size 3, 7 Mar)
FPIX installation planned for 6 + 8 Mar

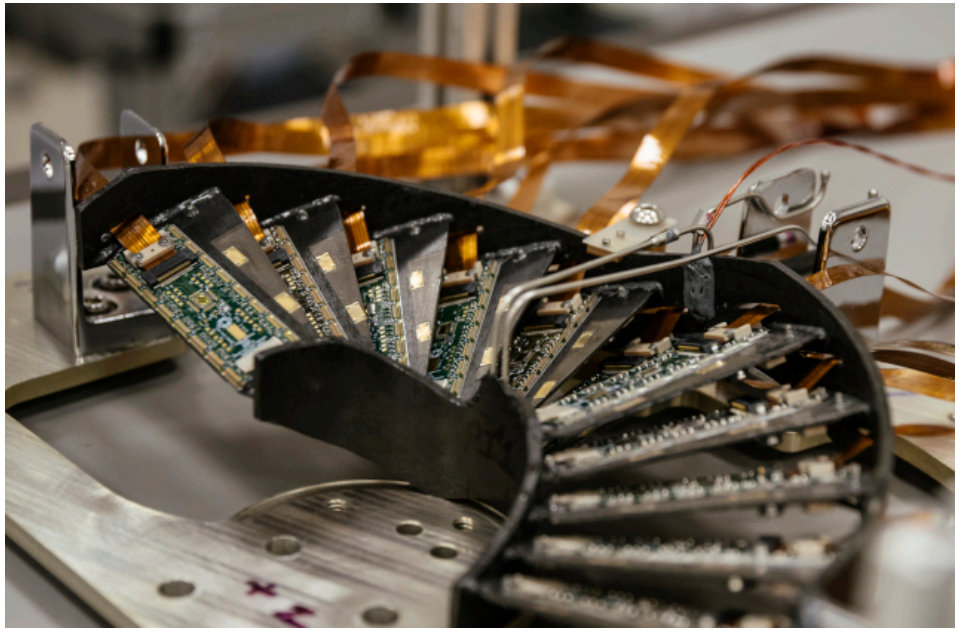
Status of FPIX half cylinders (ii)

Half Cylinder	Problems (after repairs)	Repairs done
BmI	1 dead ROC (broken wire bonds) 1 damaged aluminum flex cable	Replaced different aluminum flex cable (recovered module) Replacement of 2 aluminum flex cables on outer disk 1 not attempted (module attached to 2nd one will run through LS2)
BpI	1 unresponsive module with damaged TBM 3 more unresponsive modules due to damaged aluminum flex cables	11 aluminum flex cables replaced (10/11 modules recovered) [6 modules were not responsive, aluminum flex cable replaced on 5 others as preventive measure]
BmO	1 Module to check again at P5 (issues last run at TIF). 1 Module has signal level issue (works with DTB)	Replaced 17 aluminum flex cables (6 non responsive modules, 2 found with electronic tests, 9 as preventive measure)
BpO	Results by begin Feb	Replace at least 10 aluminum flex cables, plus others if needed after visual inspections / further electronic tests

Repair of BmO done in 4 working days (Tue – Fri past week)
Work on BpO (last one) will finish today or tomorrow

Estimated number of not working modules: 8/672

FPIX:
Installation of the disks into the half cylinders at TIF

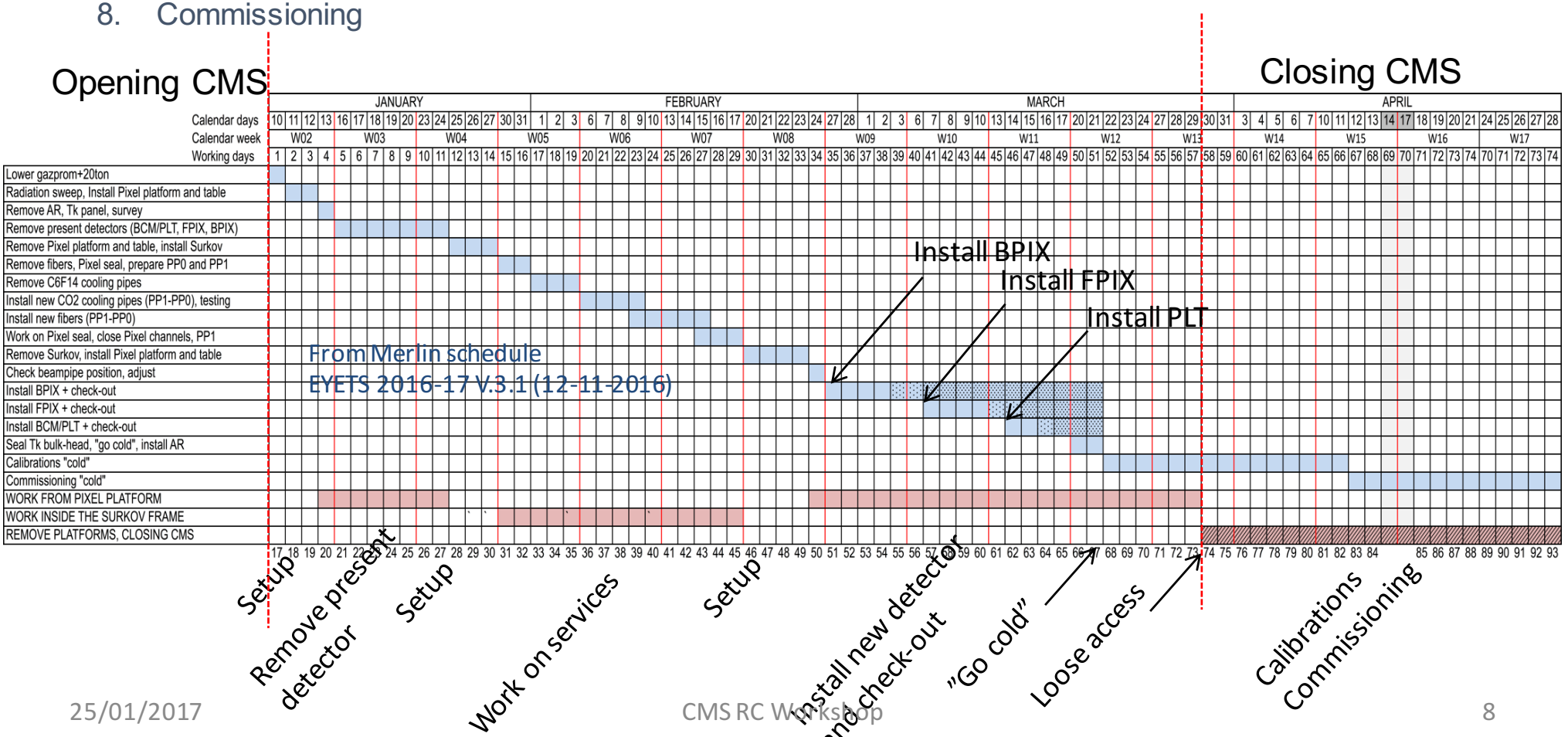


Installation during EYETS 2016-17

- Planned Sequence:
  1. ✓ Setup for extraction (20ton, Pixel platform and scissor table)
  2. ✓ Extract present detector
  3. Setup for working on services (Surkov frame, 20ton can stay)
  4. Work on services (remove old fibers and cooling pipes, install new)
  5. Setup for installation (remove Surkov, install Pixel platform and scissor table)
  6. Installation and check-out of the new detector
  7. Seal and "go cold"
  8. Commissioning

We are here: ON SCHEDULE!

Installation on Feb 27th (BPIX) and March 7th-8th (FPIX)

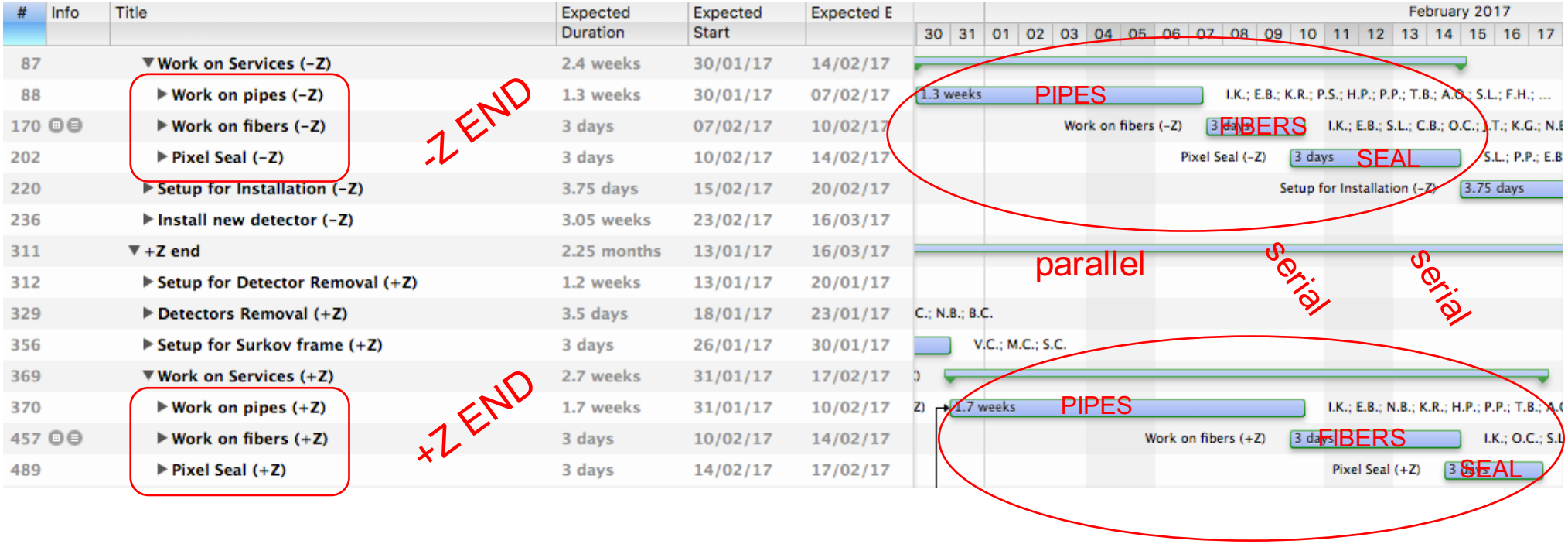


Installation of services (30/01 – 17/02)

3 major steps:

1. Work on pipes (30 JAN – 10 FEB)
2. Work on fibers (07 FEB – 14 FEB)
3. Work on sealing, contingency (10 FEB – 17 FEB)

NEXT WEEK

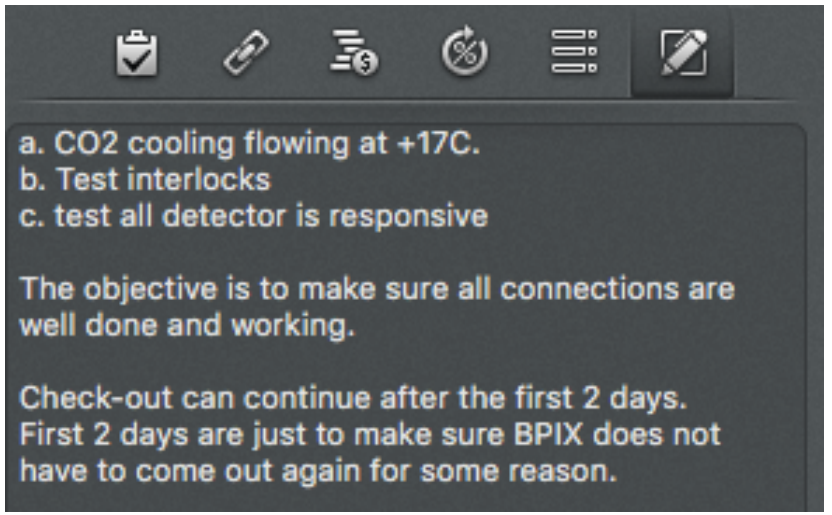


#	Info	Title	Expected Duration	Expected Start	Expected E
87		▼Work on Services (–Z)	2.4 weeks	30/01/17	14/02/17
88		▶Work on pipes (–Z)	1.3 weeks	30/01/17	07/02/17
170		▶Work on fibers (–Z)	3 days	07/02/17	10/02/17
202		▶Pixel Seal (–Z)	3 days	10/02/17	14/02/17
220		▶Setup for Installation (–Z)	3.75 days	15/02/17	20/02/17
236		▶Install new detector (–Z)	3.05 weeks	23/02/17	16/03/17
311		▼+Z end	2.25 months	13/01/17	16/03/17
312		▶Setup for Detector Removal (+Z)	1.2 weeks	13/01/17	20/01/17
329		▶Detectors Removal (+Z)	3.5 days	18/01/17	23/01/17
356		▶Setup for Surkov frame (+Z)	3 days	26/01/17	30/01/17
369		▼Work on Services (+Z)	2.7 weeks	31/01/17	17/02/17
370		▶Work on pipes (+Z)	1.7 weeks	31/01/17	10/02/17
457		▶Work on fibers (+Z)	3 days	10/02/17	14/02/17
489		▶Pixel Seal (+Z)	3 days	14/02/17	17/02/17

Pixel Safety System

- All crates from S1G02 removed at the beginning of EYETS
- Reshuffled and rewired in Meyrin to comply with the Phase I Pixel setup
- Re-installed at the beginning of January.

- Firmware in the process of being installed and checked.
- Final testing only possible when the detector will be connected.



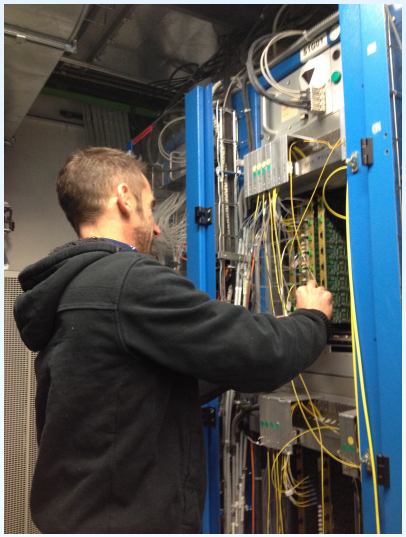
Pixel Power Supplies

- All CAEN power supplies refurbished into A4603D during the week of January 9th
- All supplies already burnt-in and re-installed in UXC55
- In the process of completing the check-out/mapping of the power system by connecting a dummy load at PP0) and reading back the values from the supplies via DCS.

Pixel DAQ

- All crates S1G01, S1G03 and S1G04 stripped naked and completely reworked with new water distribution manifolds and heat exchangers.

Disconnection



Disconnection complete

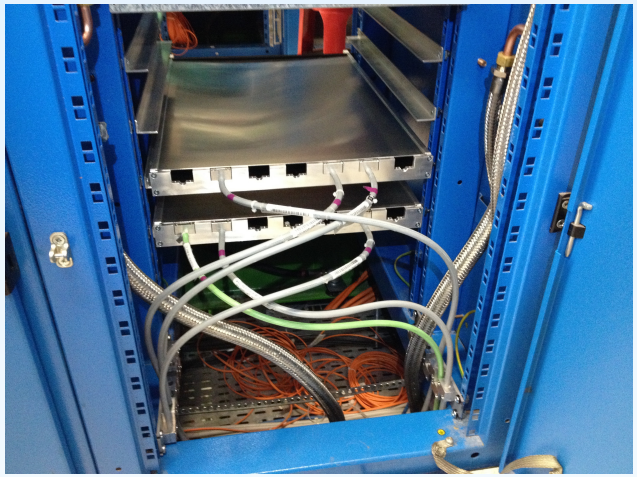
Cable-end protection

Empty Racks
Cables in
false floor

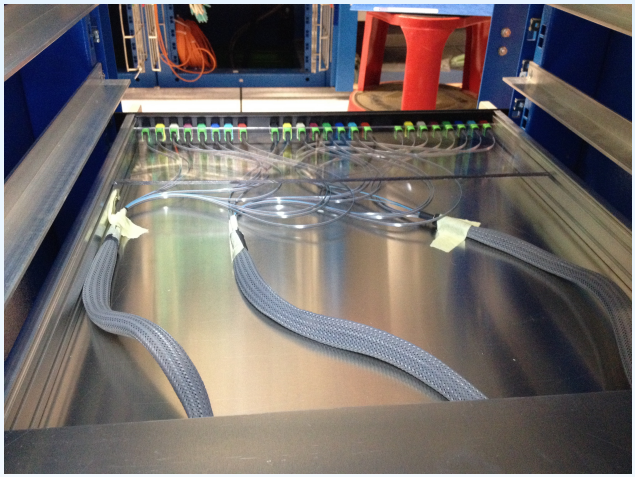
VME system
ready for
storage

Pixel DAQ

Cable entry into PP2 boxes



PP2 internals



All PP2s installed

Slack storage in false floor

Completed Rack

- The DAQ crates at P5 have been installed and will be ready to be checked by the cDAQ team soon

DAQ: status and developements

- Firmware
  - pxFEC:
    - used in test stands for commissioning and last weeks of pilot run
    - Ready to be used for detector commissioning and running
      - Further developments is possible to improve configuration time: urgency to be assessed
  - tkFEC:
    - Used in test stands. All functionalities are available
      - An issue with an expert command which causes the loss of communication to be fixed
      - Events which require power cycling of the control ring will be investigated this week
  - FED:
    - A lot of developments in 2016 focused on the pilot system: real collisions but only 6 channels. Results from the last week of run are satisfactory
    - Bandwidth to be increased by a factor 4 to cope with 24 channels and by an additional factor 2 to reach TDR specs (PU ~ 100 or more)
- Online software
  - For commissioning and calibration: validated and improved continuously in the assembly sites
  - For data-taking: pilot system experience. Additional monitoring tools being developed

FED f/w development plan

- First version with a FSM for each TBM FIFO available
  - Compatible with 160 MHz clock: it synthesis with Vivado and timing constraints are met. To be completed by the end of January
  - It allows parallel readout of the TBM FIFOs: by the end of February
    - With an intermediate FIFO level as in the present detector FEDs
  - Tests will be performed at B186 (1 FED) and at P5 (8 FED crate connected to cDAQ)
  - FED internal data emulation and FED tester as inputs
  - Tests to be completed by the end of March to join the global runs (when not busy with the detector calibration)

Commissioning and Calibration

The full pixel commissioning & calibration process:

By Danek

A. Module testing during production, many locations.
B. Sector/disk testing during integration at PSI/FNAL/TIF(CERN).
C. Quick checkout in the P5 clean-room after transportation.
D. Commissioning in P5 after installation, before collisions.
E. Final calibrations with collisions.

This talk is about C, D and E.

Period C start with the transport FPIX/BPIX to P5.
Period D starts after the pixel detector is inserted and ends with readiness for collisions.
Period E continues after collisions start.

Commissioning and Calibration: quick reception check-out

The main goal of C is to make sure that nothing got damaged during the trip from PSI (from FPIX from Meyrin) to P5.

By Danek

Tests done at room temperature and at a cold temperature.

For FPix a whole half-cylinder will be tested at a time.
For BPix 2 (or 4) sectors will be done in parallel, therefore many cycles are needed.

We will use the infrastructure available in the P5 clean room, CO2 cooling, uTCA DAQ, CAEN PS.

Period D starts after the bpix detector is transported to the P5 clean-room and ends with the insertion into CMS.

Time available is about 3 weeks for BPix. This is enough for the test itself and, hopefully not needed, “simple” repairs.
Simple repairs can be e.g. reconnecting a connection in the supply tube, a replacement of a POH. Most likely we will not attempt to replace single broken modules.
Only simple tests will be performed, no advanced calibrations.

Commissioning and Calibration: right after installation in CMS

Install BPix (1-2 days)

By Danek

1) Connect cooling, power cables and fibers (**1 day**)
Cooling needs to be tested before runnig it (**1 day**)

2) Basic connectivity test at 15 deg
Using DELAY25, TBMPLL, POH-scan
and channel mapping – 2 **days** (bpix only)

Total (bpix) – 6 **days.**

Install FPix (1 day)

3) Connect cooling, power & fibers. **1 day**
Cooling tests. **1 day.**
4) Fpix connectivity test (like above), at 15 deg. **1 day**

This will end the "fast" checkout part. PP0 could be closed.

Total (fpix) – **4 days**.

Commissioning and Calibration: right after installation in CMS

Total (fpix + bpix) – **10 days**.

By Danek

This will end the “fast” checkout part. PP0 can be closed.

In the schedule we have 3 weeks (15 days) before the final closing of PP0.
Looks like we could do more things.

A few more calibrations could be done at room temperature but they will have to be repeated at the final -20 deg.
Perhaps use this time to prepare better for the “cold” calibration phase so it can go faster.

Commissioning and Calibration: in CMS, cold operation

By Danek

PP0 closed, detector at **-20deg.**
Continue with standard calibrations.

BPix and FPix done in parallel using 2 DAQ partitions.
Actually TCDS/cDAQ made it possible to have 4 partitions for us.
So one could do +/-z side Fpix/Bpix in parallel.
If things go smoothly we probably do not need this but if there are problems we could split.

Two teams will work in parallel:
Fpix (mostly USA: FNAL, Cornell, UCDavis,Kansas, Rice, ...)
and BPix (PSI, UZH, ETHZ, Hamburg, Aachen, Milano).

We do not plan shift work. But we will establish a system where 1-2 people start calibrations very early in the morning (6:00-7:00) and another 1-2 people stay until late at night (23:00-24:00).

Commissioning and Calibration: in CMS, cold operation

By Danek

Here I list the approximate steps (at -20deg) needed to be ready for cosmic data taking.
The estimates are for BPix, since the FPix are usually much faster due to the smaller number of channels.

1) Run basic calibrations

Delay25 (clock phases).
Adjust POHs (laser's bias).
Adjust TBM-phases (400MHz digital readout).
Threshold vs. CalDel: Establish basic working point (Toronado)

– 4 DAYs

2) Do Iana scan to verify analog currents

– 1 DAY

Commissioning and Calibration: in CMS, cold operation

3) Threshold optimization

Using the same tools as for the present detector.

- 5 DAYS for bpix (fpix needs less. maybe 2)

By Danek

4) Analog signal optimization &gain calibration.

Using almost the same tools as for the present detector.

- 1 DAY

Total at -20 deg is : 11 days.

This assumes working cooling and DAQ.
Potentially (3) could go faster if the miniDAQ is used.

If all this works as planned we could be read for cosmics in week 15 (April 12).

However the priority will always be given to detector calibrations and not to taking cosmic data.

Commissioning and Calibration: in CMS, cold operation with beam

By Danek

Done with first collisions, part of it can be done (less accurately) with cosmics.
This part involves the offline system (CMSSW).

1) Timing scans.
Must be done!
Even WBC finding (course scan) is not trivial with so many changes in the system.
Reserve appropriate collision time for this:
- WBC finding, course scan (1 fill, wide bx spacing preferred)
- Fine phase finding (1 fill).

This data will be declared bad for physics.
Use the same software ("hit efficiency analysis") as for phase0.
Should be straightforward.

Bias scans can be skipped. We will have new & well known sensors.

Commissioning and Calibration: in CMS, cold operation with beam

By Danek

2) Lorentz-angle and Template (hit reconstruction) calibration.

Not critical. We will start we new, un-irradiated, sensors, so in principle we know what parameters to use.
However we will be working at a new temperature,
some small adjustments might be needed.

Uses normal physics runs. All analysis offline.
Might need a conditions update (new global-tag).

Will use the same analysis software as for phase0.

There is also Alignment but it is not part of my talk.

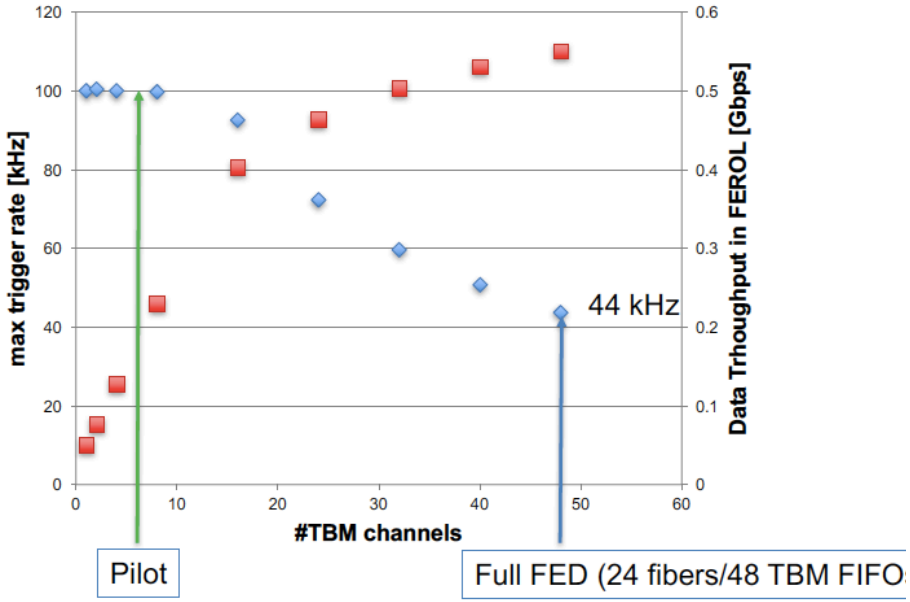
Conclusions

- The installation is progressing according to the schedule
- The detector readiness is compatible with this schedule
  - The present fraction of active channels is excellent
- The plan to complete the development of the FED f/w is being followed
- The plans for the detector checkout and calibration once installed are defined and fit in the allowed time

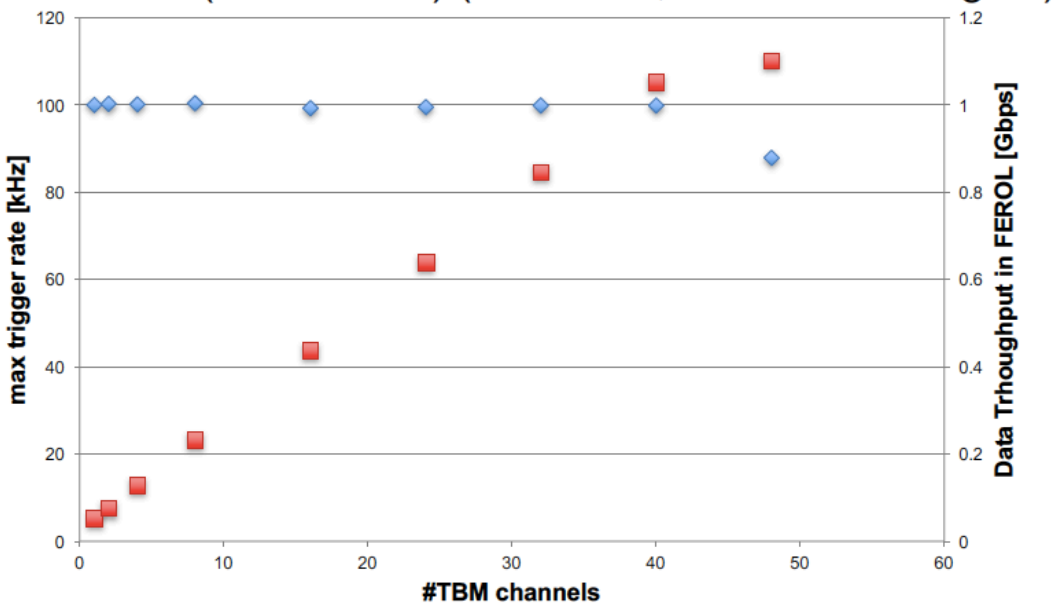
Backup

FED bandwidth measurements

- 40 MHz TBM FIFO draining
- 1 Hit/ROC (no headers) (<PU>~35, ~50% of 2017 goal)



- 80 MHz TBM FIFO draining
- 1 Hit/ROC (no headers) (<PU>~35, ~50% of 2017 goal)



- FED f/w version used for pilot system is limited at 22 kHz with PU~70
- Moving to 80 MHz draining is OK for 100 kHz but PU only ~35 (a factor 2 is missing)
- The present f/w architecture cannot be “upgraded” to 160 MHz