Status of the LHCb Upgrade

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on behalf of the LHCb Collaboration

FSP Meeting, 01/10/2019, Rostock, Germany

LHCb in Run 3

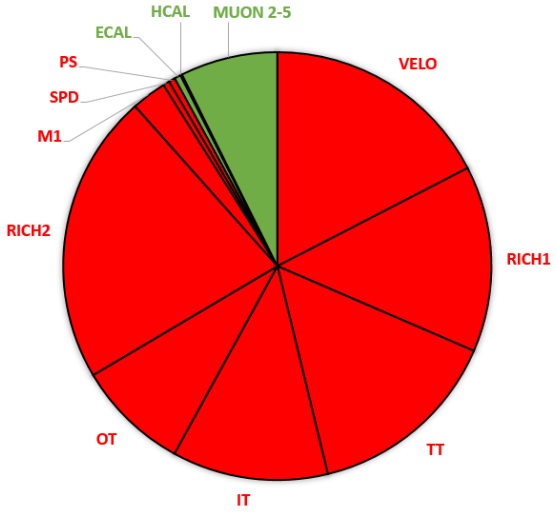
Major upgrade → it's a new detector all together.

Upgraded LHCb Detector

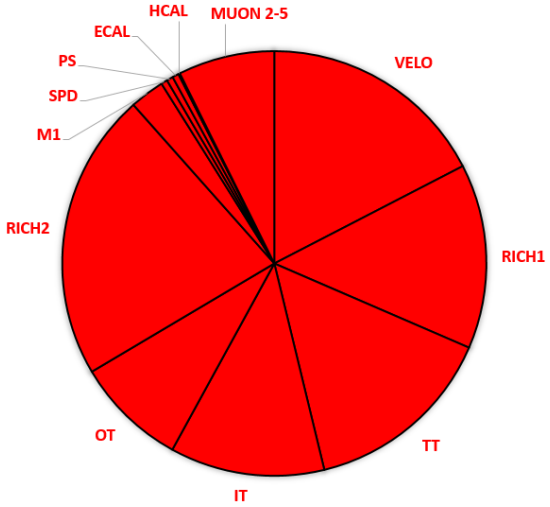
To be UPGRADED

To be kept

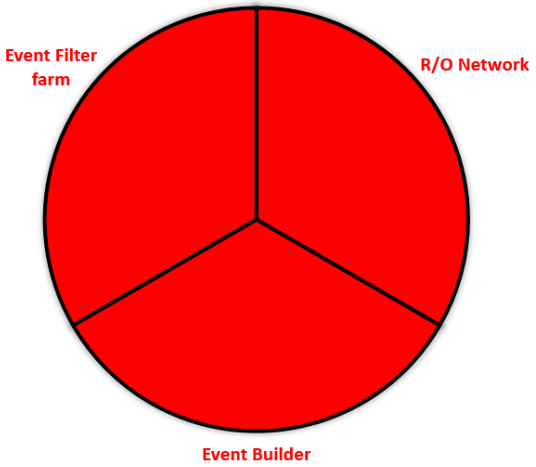
Detector Channels



R/O Electronics



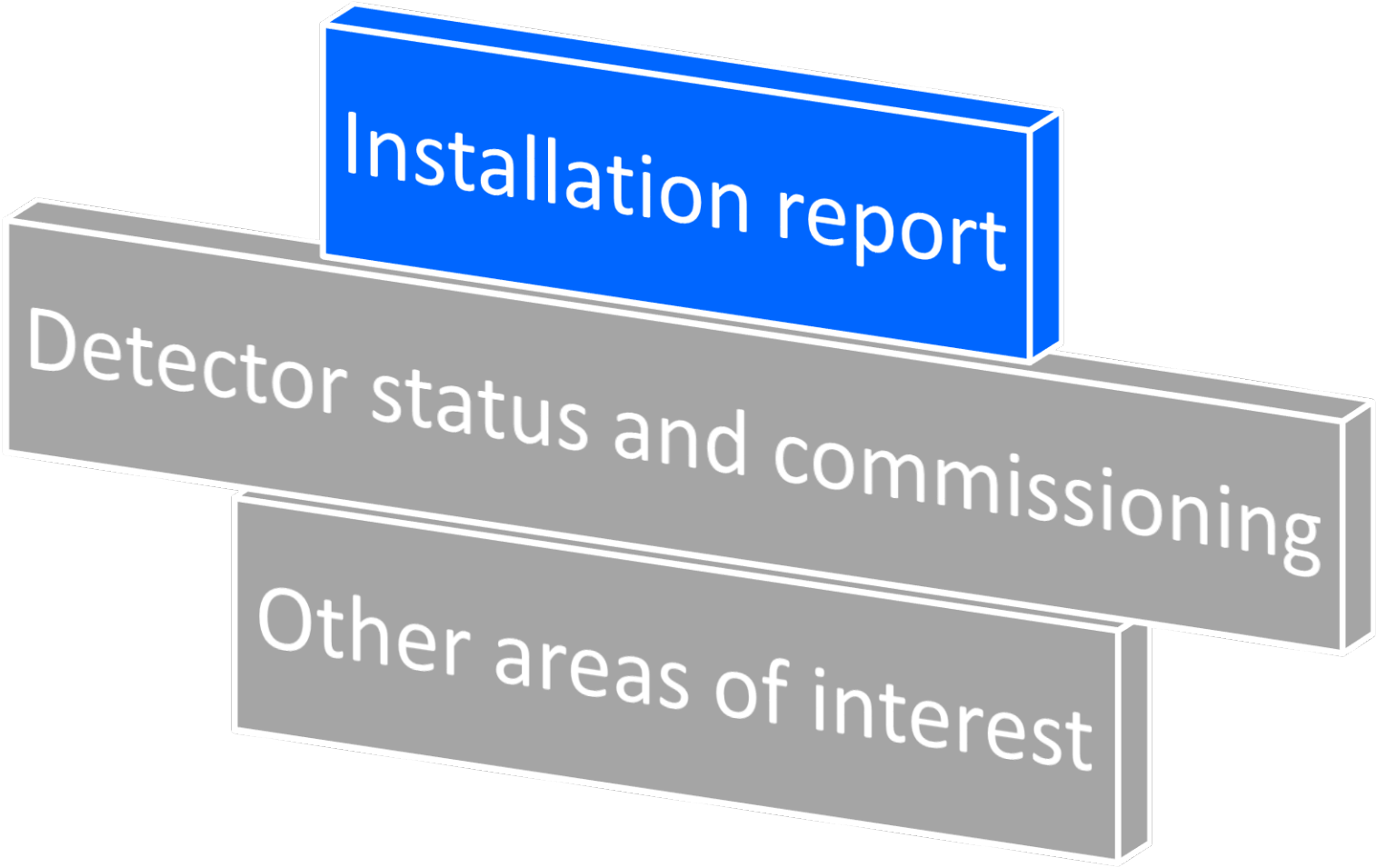
DAQ



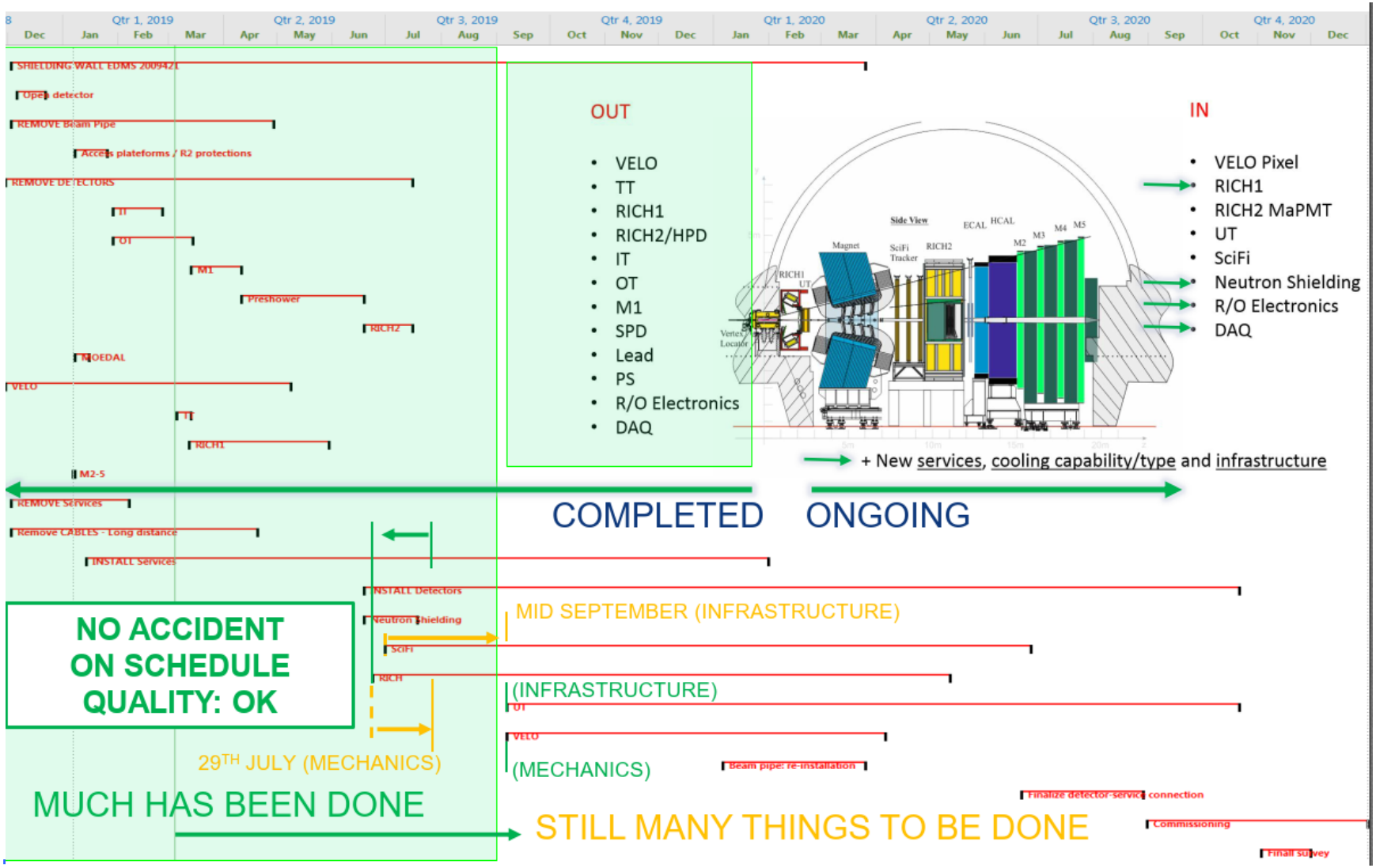
- ✓ Less than 10% of LHCb detector channels will be kept
- ✓ 100% of R/O electronics will be replaced
- ✓ NEW DAQ system and DATA CENTER

Outline

* not touching on RTA, offline and computing aspects which are covered in separate presentations


Installation report
Detector status and commissioning
Other areas of interest

Installation planning and status



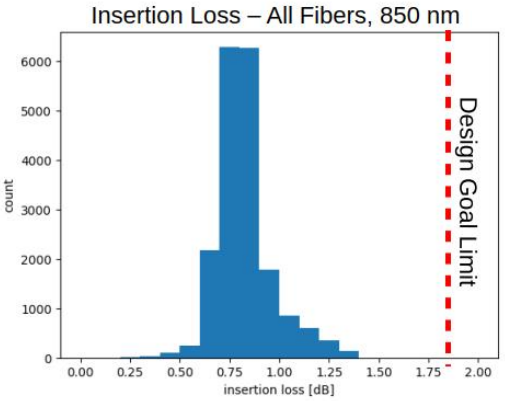
Installation of fibers & data center

Fibers: installed 19008 (132 trunks)

- Only 44 pieces out of spec
  - yield 99.77% vs contractual limit 95%
- Insertion loss < 1.4 dB @ 99.77%

Data center: 6 module fully delivered and pre-commissioned

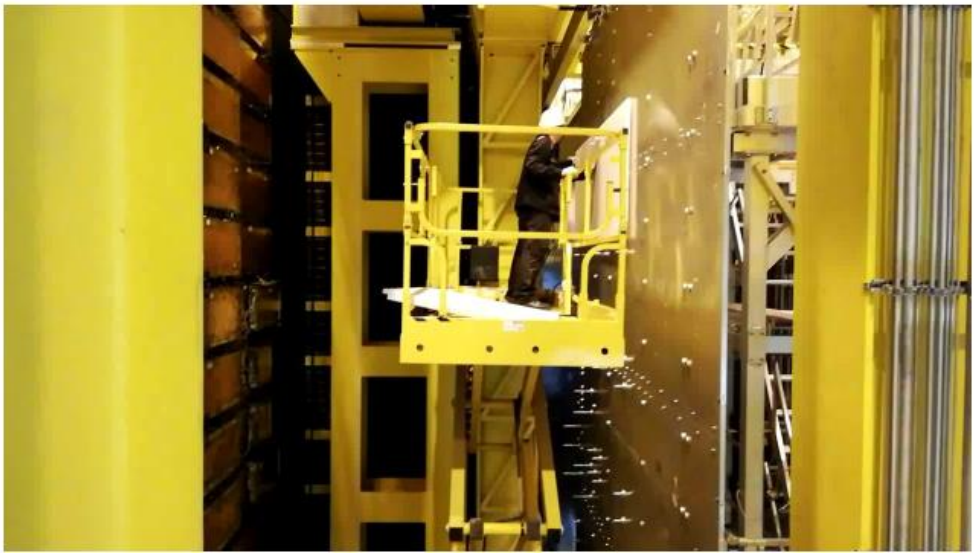
- Many little “and not so little” bugs ironed out

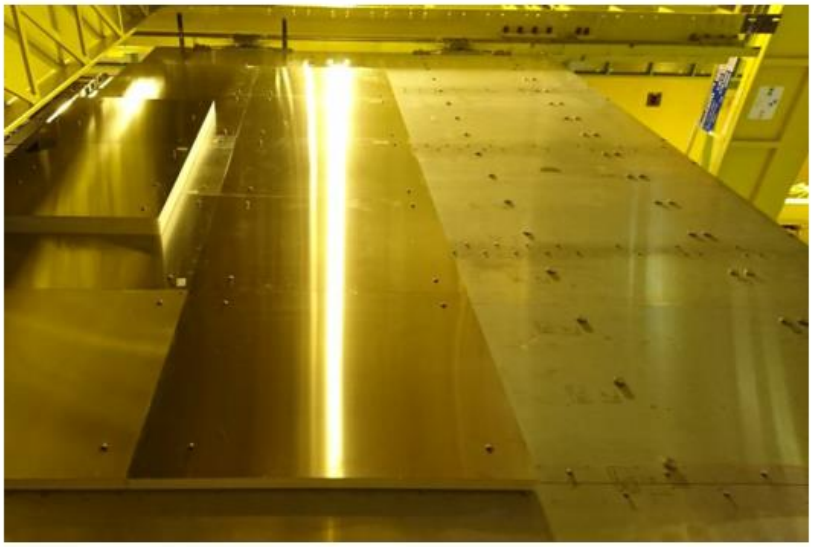


Installation of detector cooling

Installation of SciFi neutron shielding

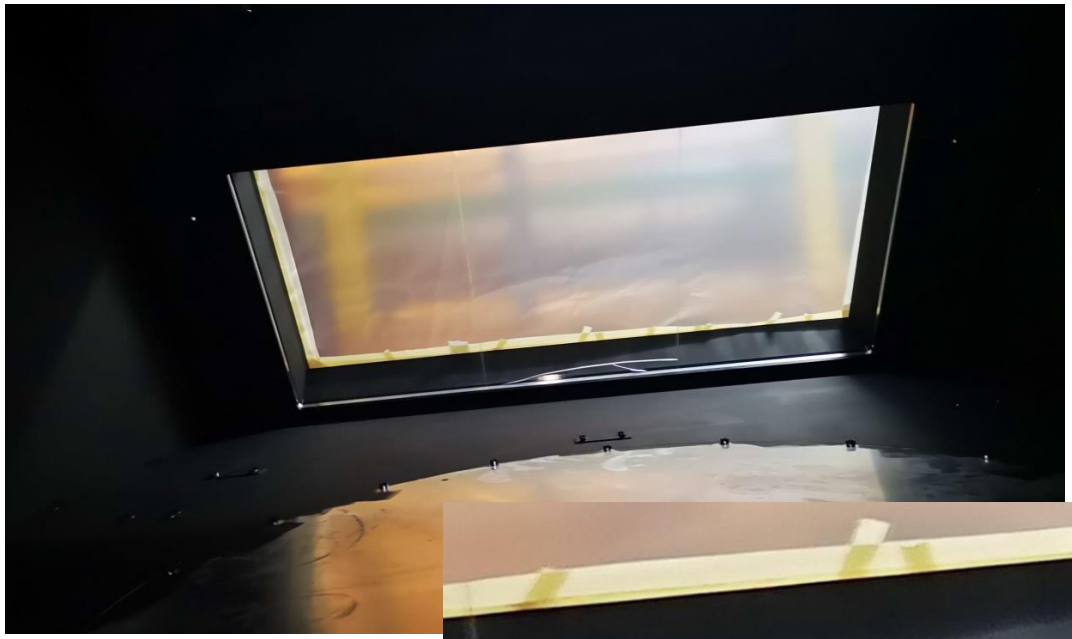
- Shielding of the SiPM against neutron
- Installation already completed by end of June 2019

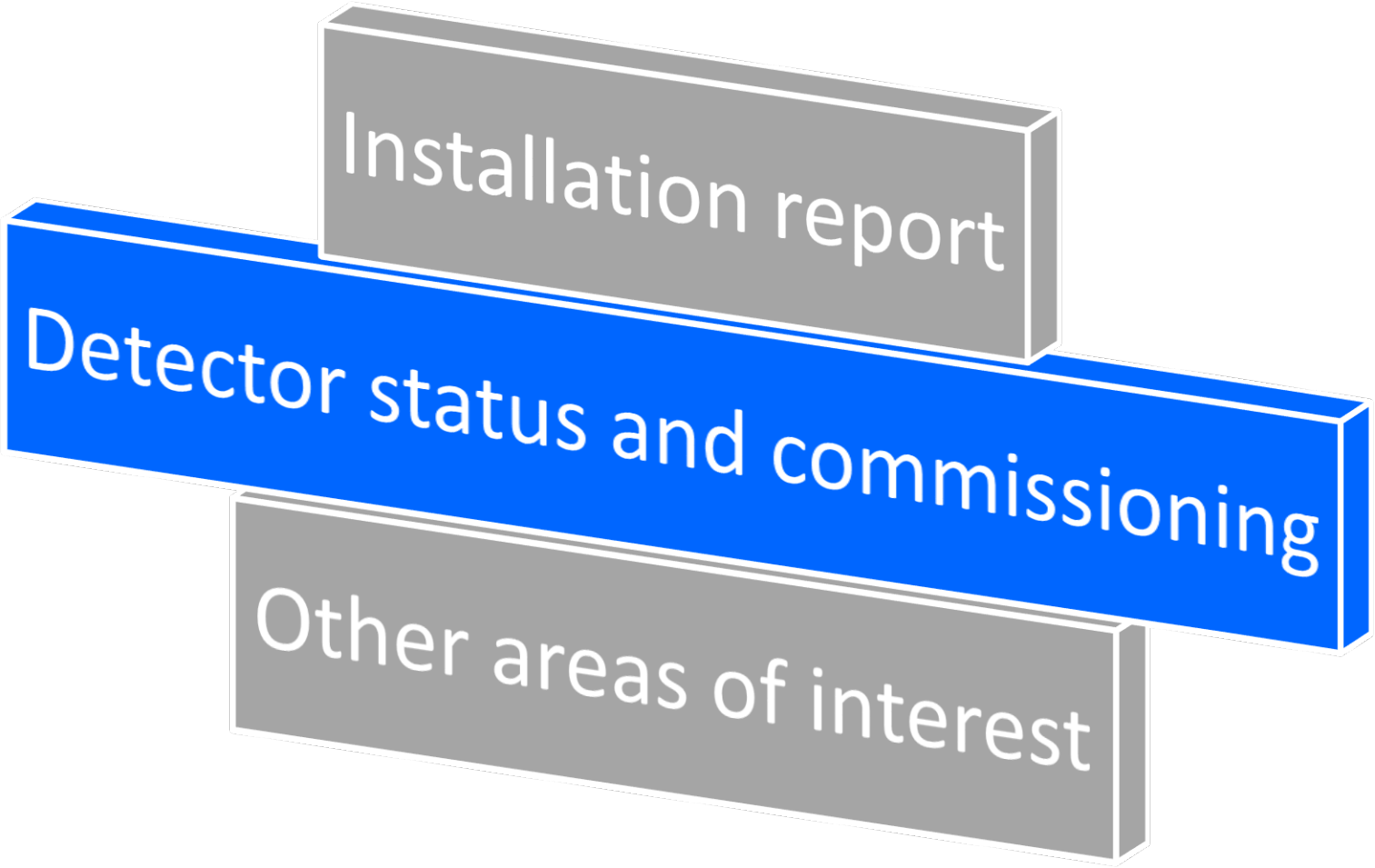




Installation of RICH1 mechanics

- Magnet shielding modifications
- MaPMT support mechanics
- Gas enclosure
- Quartz window broken
  - ✓ delay being absorbed in global planning

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Commissioning timeline

2018/2019 Local test-benches to early commissioning

Here now!

2020 Global commissioning

2021 Final commissioning with first beams and data taking

VELO status: modules

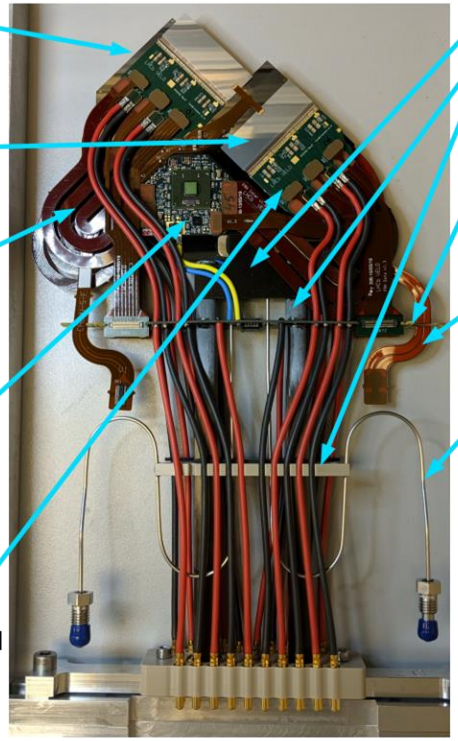
Microchannel substrates (52): 49 wafers at CERN with a *minimum* of 55 grade A susbtrates.

Tiles (208): 300 at CERN, 220 qualified, almost done.

Interconnect flex sets (52): all available but mounting fault. All being reworked at CERN (expect done beg. Oct).

GBTX hybrids (104): 112 produced, being assembled. Issue with com loss at -15°C was understood (config fix)

FE hybrids (208): 157 delivered, being assembled, and delivery of 143 expected soon



Midplates, **legs**, **capillary clamps** (52): fully produced, no issue

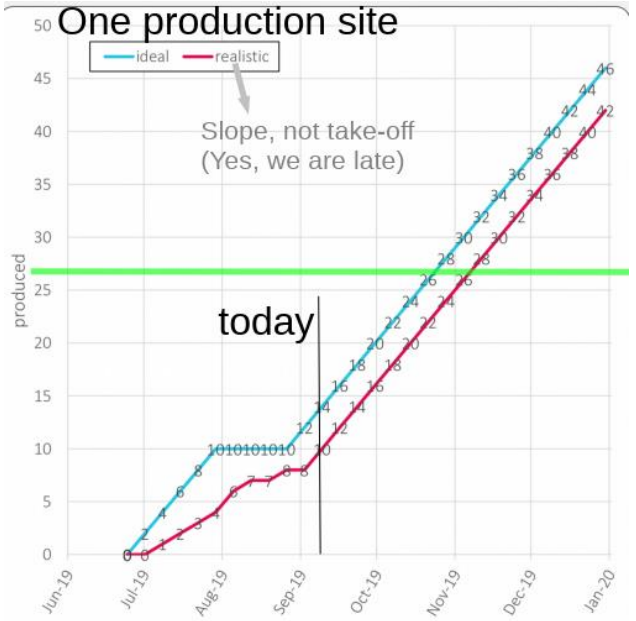
LV harnesses (52): 11 produced. More coming.

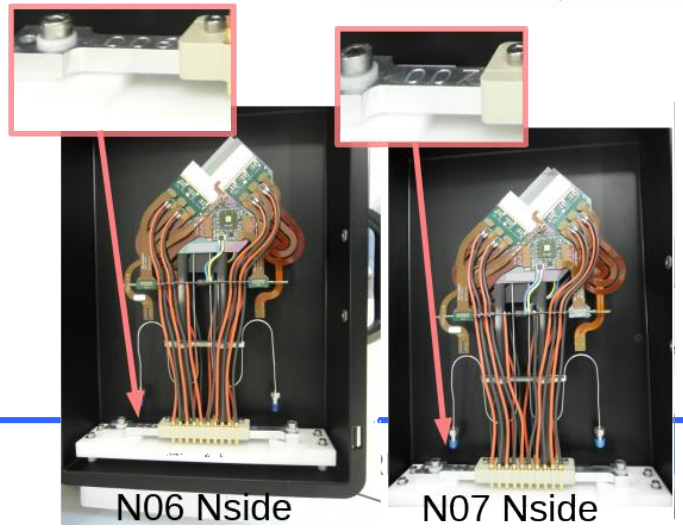
HV cable sets (52): original design had a small modification on the C side.

Cooling connector assemblies (52): 62 delivered, 35 usable, more being produced

VELO module components (for 52 modules + few spares)

VELO module production





VELO status: rest of production

Rest of Production: Respecting a “just in time” schedule, but some concerns for parts (tiles, microchannels, connectors)

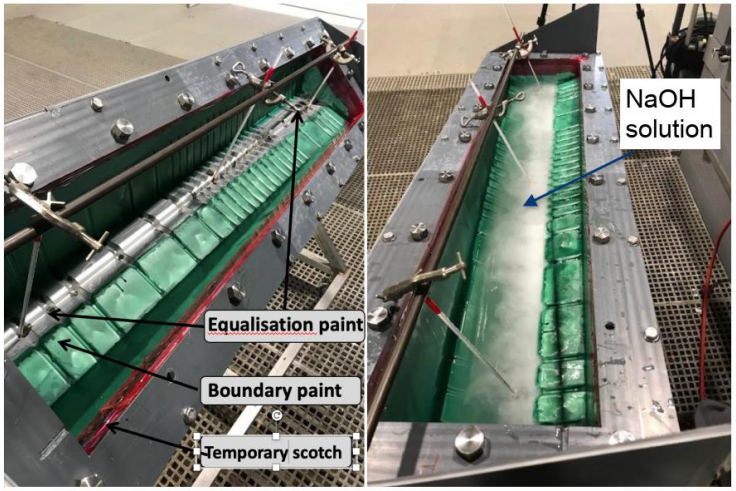
Mechanical production on track

- Commissioning plans underway at Liverpool
- Modules Integration sign-off by assembly sites

1 prototype and 3 production RF boxes **completed**

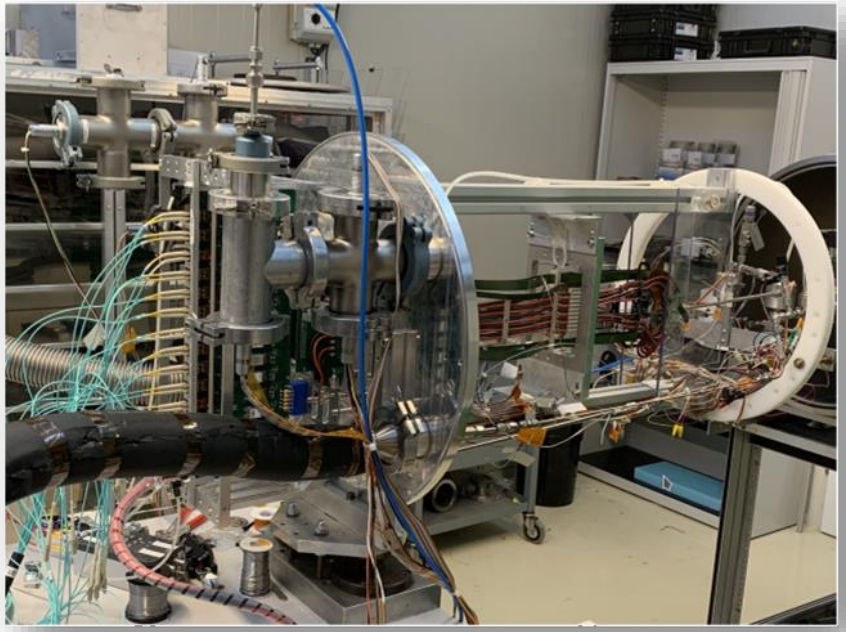
4th production box to be completed in a few weeks.

	Leak tightness	*Shape*	*Thickness*	*Comment*
A1	✓	✓	~ 500 µm to ~ 200 µm (min 150 µm) before and after etching	Pathfinder R&D box. 17 etching steps. Shape slightly deformed, problably during transport
C1	✓	✓	~ 280 µm	First successful demonstration of milling to 250 µm. Residual thickness variations, though small, disfavour etching
A2	✓	✓	~ 280 µm	Milled with granular offsets applied. Candidate for etching
C2	✓	✓	~ 280 µm	Milled with highly granular offsets applied. Candidate for etching
A3	In production, successful so far, expected results similar to C2 and A2			



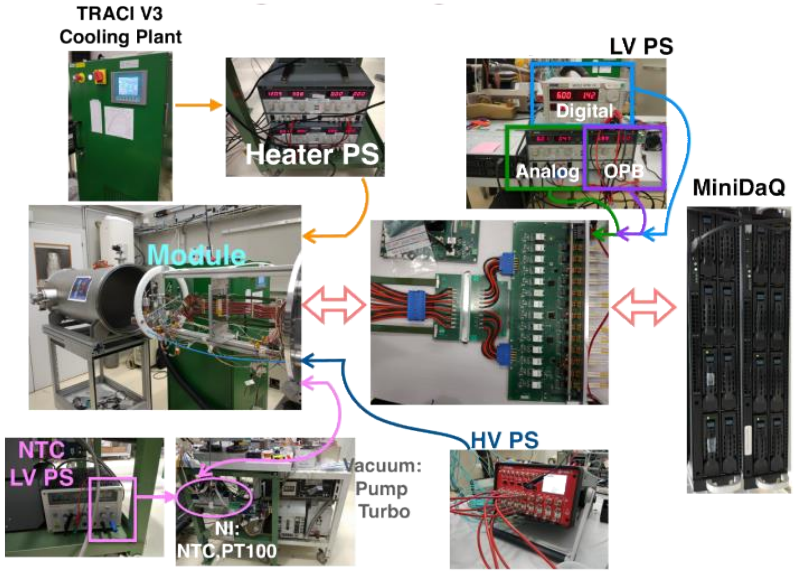
VELO commissioning activities

- Will ramp-up in the coming month with production fading down.



SLICE TEST @ CERN

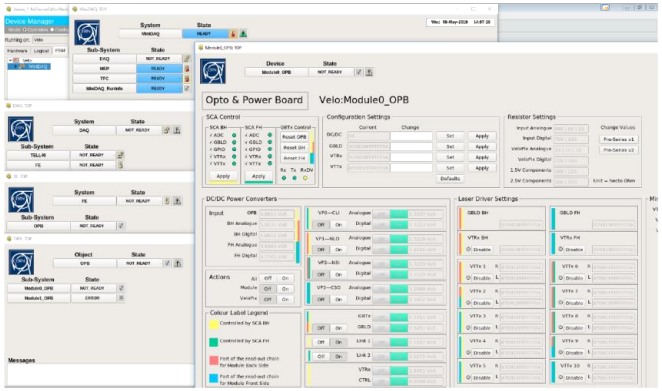
see Claudia's talk



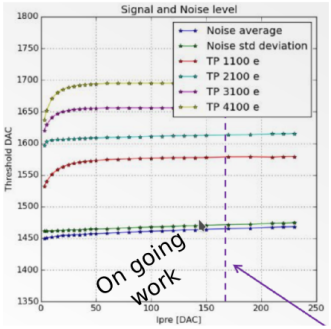
Non final components to be replaced with time and their control integrated to ECS

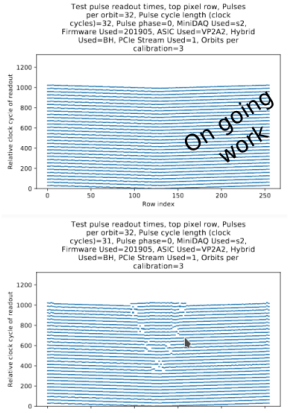
Complete slice test prepared at CERN

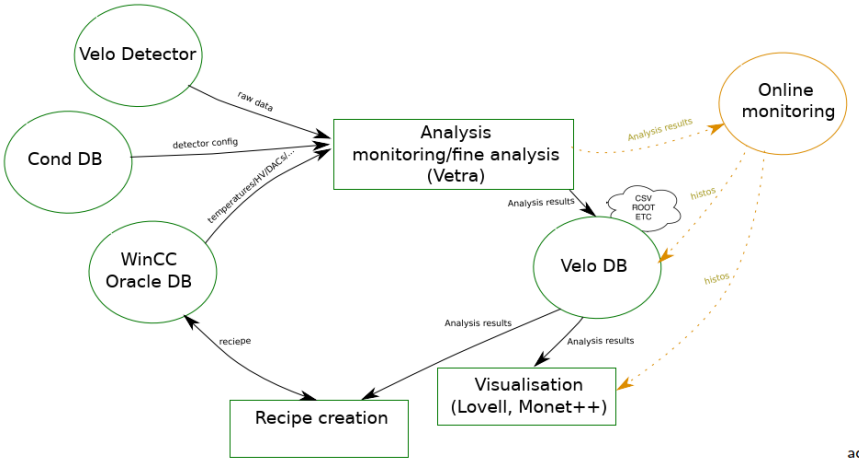
VELO commissioning activities



- Integrate temperature monitoring and interlock board when ready.
- Integrate data analyses in "final" software environment.
- VeloPix setting optimisation, equalisation, noise scan, test pulses, IV scan, CCE scan, timing scan, online monitoring, ...
- Preliminary implementation for most of the procedures.
- Several based on ECS → change procedure and move to GWT data.
- To be integrated to our FSM, and analysis in LHCb software
- Tell40 router not ready yet → developed a decoder that time order GWT data output (see Tom's talk)







adapted from here

- Discussions with the online group and online data quality monitoring.

Work on procedures, automation and monitoring

UT status: production

To be produced: 68 staves + spares

COMPONENTS

Sensors:
- Type A: 1020 tested OK (60 not as good but usable).
- Types B,C,D: pre-series tested, expect 48xB, 16xC & 16xD by mid Sep.

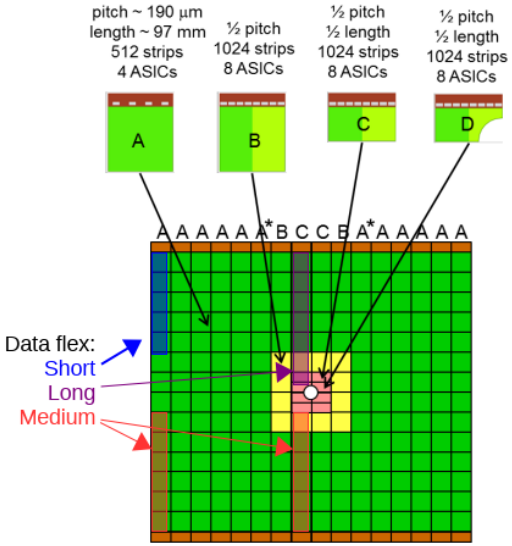
Bare staves: 100% produced + spares

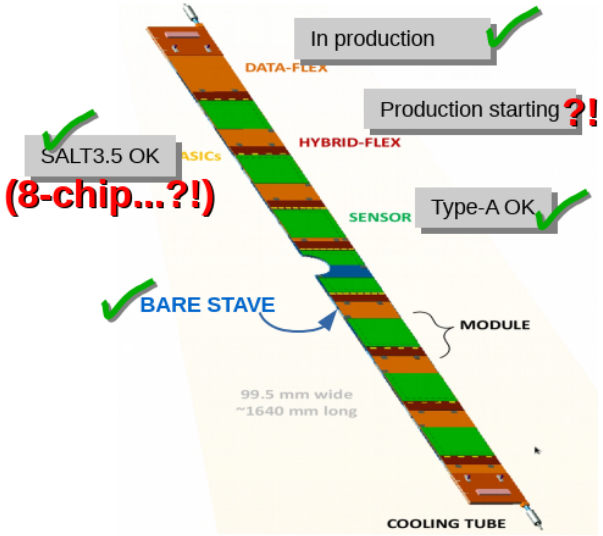
Data Flex: produced at CERN, ongoing
- Preproduction batches “Short-1” (27pc) and “Medium-1” (20pc) tested and delivered
- Batches Short-2to5 and Medium-2to5, and Long-1 in production (different stages).
- Production expected finished by ~end of Oct.

SALT chips: v3.5 OK, v3.8 pending tests

Hybrids: critical path
- 4-chip hybrids: firm chosen, started production
- This drives now the stave production schedule
  - decided to use a “firm-validation” preproduction (~80 hybrids) from one of the bidding firms for the first 5 staves.

And inner staves: 8-ASICs, to be assessed.



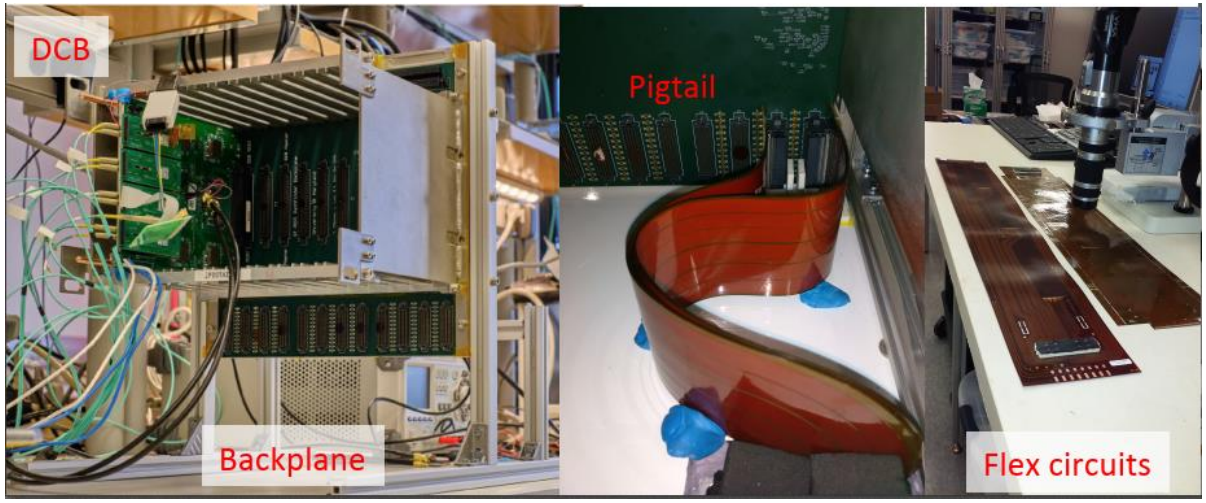


UT commissioning activities

Slice test prepared at CERN

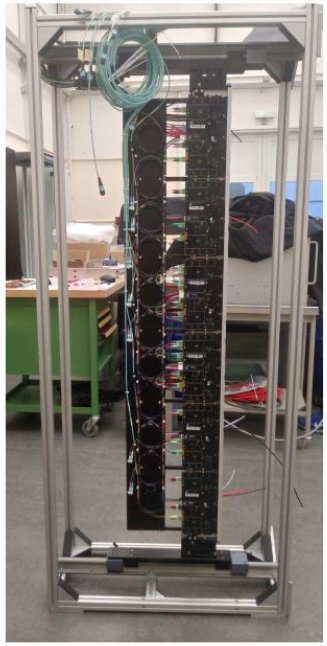
- Pre-production stave successfully shipped from USA
- First test of full stave with realistic power distribution and grounding, plus CO2 cooling and mechanics
- Two PEPI crates with two DCBs
  - Connected to stave via flex cables
- One MiniDAQ2 with control and readout firmware

✓ Mostly excellent results up to now → low noise



RICH status: column production

- test column thoroughly tested
- RICH upgrade column production phase started
- mechanics for first five RICH 2 production column assembled, full RICH 2 mechanics produced
- Elementary Cells Quality Assurance: two facilities (Ferrara and Edinburgh) at full speed 80 ECs/week
- Photon Detector Module Digital Board Quality Assurance: assembly and testing (Cambridge, Oxford and Bucharest) at full speed
- cabling and fibre mounting strategies finalised for production chain



- flow of components (EC and PDMDB) from Quality Assurance test centres well synchronised to keep up with the column assembly schedule
- column assembly accelerating!

first column assembled in June: test column

used to develop test protocol, DAQ infrastructure and tools, ECS...

RICH commissioning activities

Columns being tested and commissioned @ CERN
- Commissioning lab equipped with readout server + HV/LV + ECS

PCIe40 Server installed by Online group:
- 3 boards installed for RICH commissioning: 2 TELL40 and 1 SOL40
- temperature issues mitigated during summer

Storage (file server) installed:
- 39 TB for data (dedicated 10Gb/s link to PCIe40 server)
- 2TB for shared software and WinCC projects (running elsewhere)

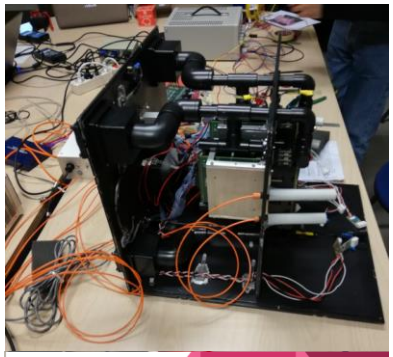
DAQ software:
- it can generate both MDF and FRG files
- Online monitoring under development

Test facility (very stable in the past months) allowed us to fully validate test column performing:
- test pulse injection runs to calibrate electronics (step run)
- threshold scans to set working points and calibrate MaPMTs gain (step run)
- dark counts runs
- dedicated runs for SIN

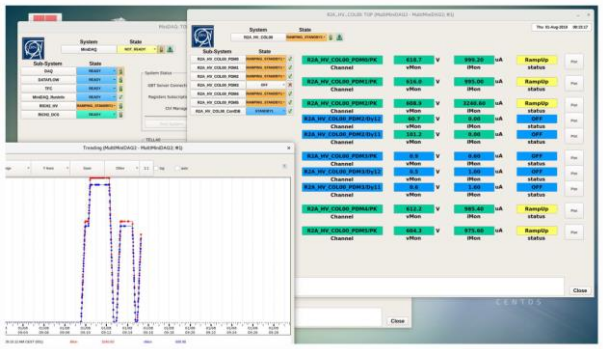
general news:
- switch to WinCC-OA 3.16 successful
- OPC-UA servers for Caen (HV), Maraton (LV) and ELMBs (temperature and humidity monitoring) installed and working

HV:
- recipes for CALIBRATION and PHYSICS runs created
- implementation of dynodes powering in the FSM
- almost complete implementation

DCS:
- LV control
- monitoring of temperature and humidity on the test column and SSB1 environment via ELMB
- Safety FSM, reacting to temperature too high or column temperature too close to the dew point, is running
- Calibration of SCA-ADC current source, used to monitor ~100 temperatures per column, is ongoing
- monitoring of the Pt1000 ADC registers from SCA will be done from the DCS project

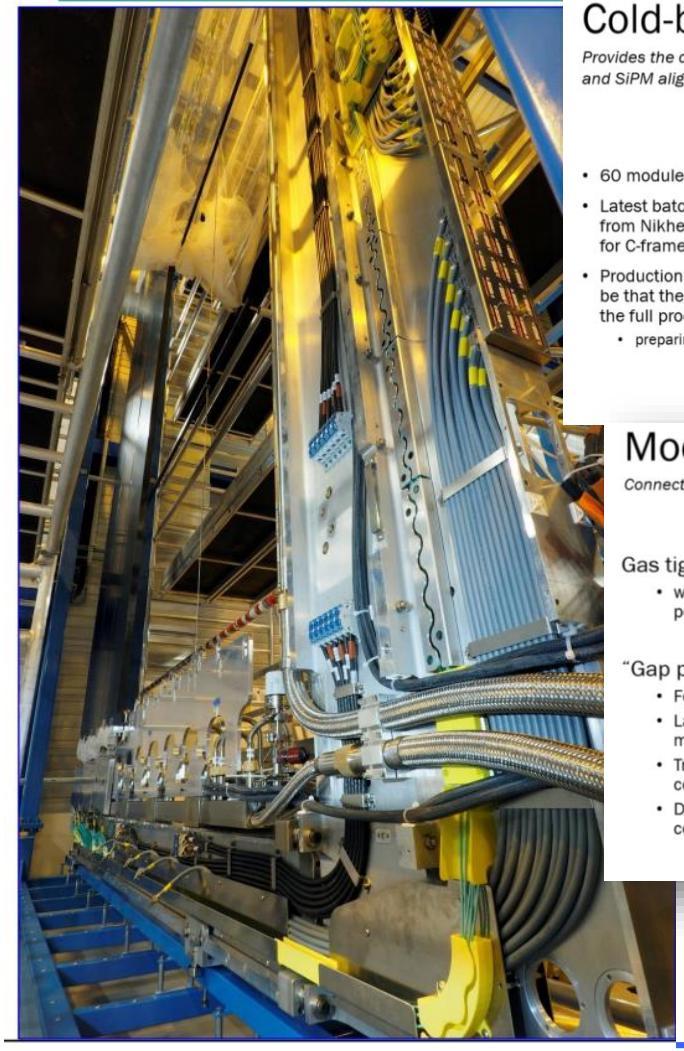


Ferrara



SciFi status: C-frame assembly

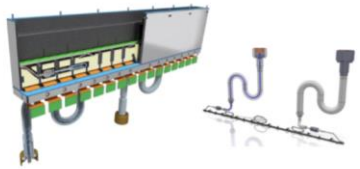
Assembly of one full C-frame @ CERN

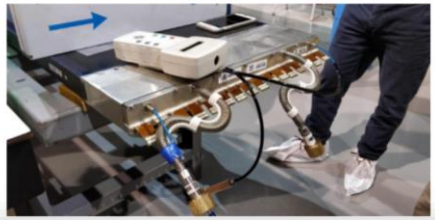


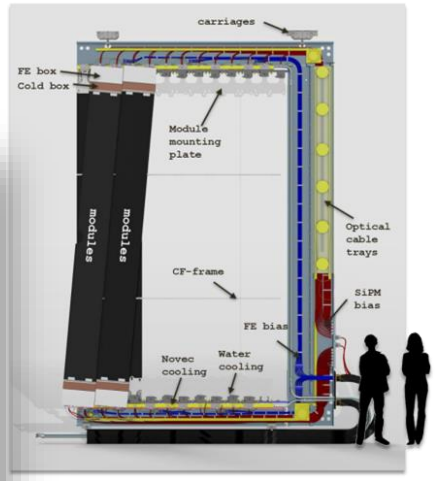
Cold-boxes

Provides the cooling feedthrough, insulation, and SiPM alignment to the fibre modules.

- 60 modules equipped and tested
- Latest batch of 40 boxes delivered to CERN from Nikhef will allow for equipping modules for C-frame 7 and 8.
- Production progressing well. However, it might be that there are components missing to finish the full production (incl. spares)
  - preparing an inventory of recoverable parts.







Module Finishing

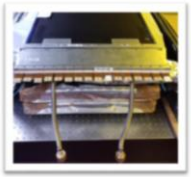
Connecting modules and cold-boxes

Gas tightness of C-frame #1

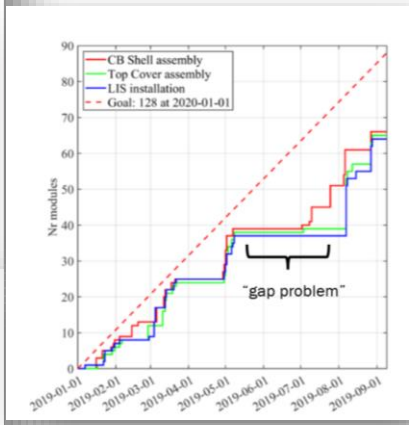
- with flow of 0.8 l/min we reach dew points below -50 degC.

"Gap problem"

- Found around last LHCb Week
- Larger clusters at one edge of the modules in QA indicating a gap
- Traced to a defect in one plastic component pressing on the cold-bar
- Disassembled and Repaired all the coldboxes (lots of work)



- More than 60 modules assembled and tested (6 C-Frames worth)
- 20 more modules in progress
- No bottlenecks to keep pace with C-Frame production



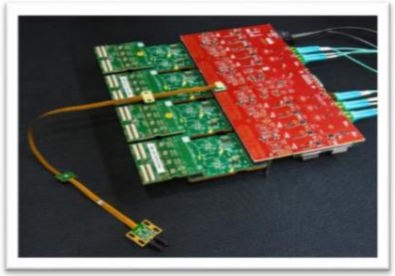
SciFi status: FE electronics & commissioning

Front-end Electronics

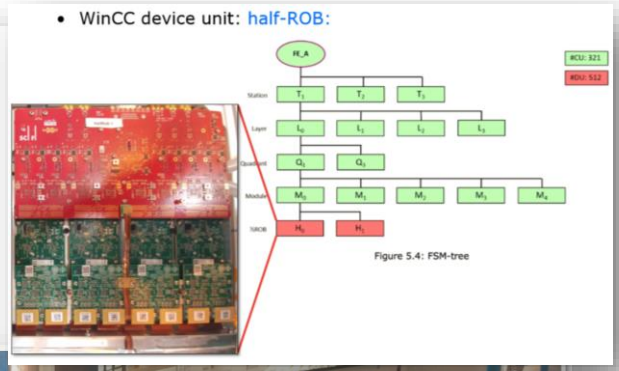
Digitises the SiPM signals, finds the cluster barycentre, output to PCIe40

PACIFIC Chip	100% produced and tested
PACIFIC Board	100% produced and tested *(updated)*
Cluster Board	100% prodcued and tested *(updated)*
Master Board [35% done]	Preseries 50 MBs: ok Main production (570 boards): Batch 1: 96 MBs in July Batch 2: 104 MBs in Aug *(updated)* Next batches: 20 Sep, 08 Nov, 06 Jan
Mechanical Parts	100% produced
Front-end boxes	Preseries (23) ready → frame1 Batch 1: 30 boards at CERN *(updated)* Next batches: 30 FEBs/3 weeks

In time wrt to the C-Frame assembly

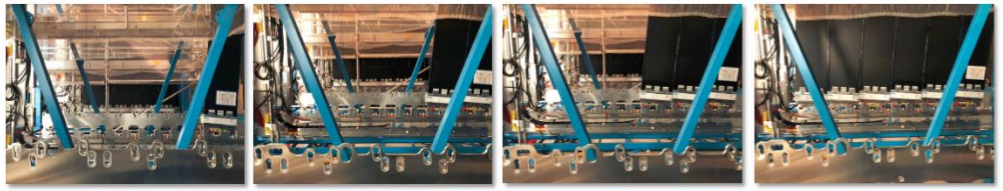


- WinCC device unit: half-ROB:



C-frame status

- 1st C-frame: **All modules + 6 ROBs (FEs) installed**
- 2nd C-frame: module mounting started
- 3rd C-frame: mechanics in place
- 4th C-frame: wait for displacement of prototype frame...

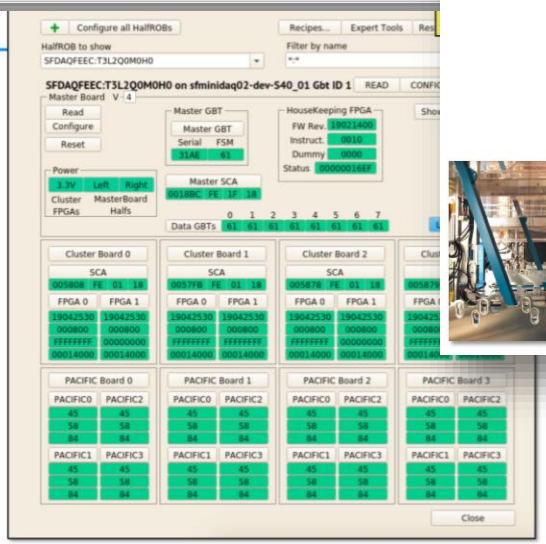


+ configuration recipes and DB

FEE controls

Controls exist
- Not final

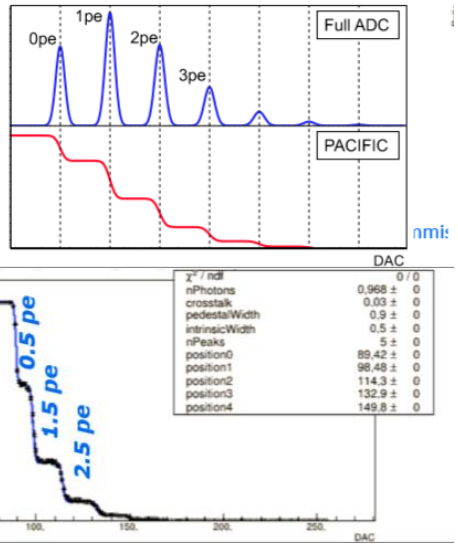
Main issues:
1) Prepare FSM
   - Propagate states
2) Rewrite RESET
   - No power-up at CONFIGURE
3) Possibility to exclude slice of ½ ROB

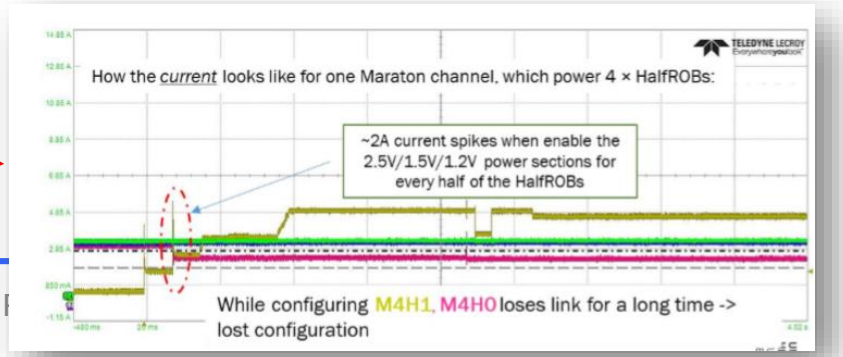


SciFi status: FE electronics & commissioning

QA check of main series FE boxes ongoing

- Cabling checks : done
- Readout commissioning ongoing with final PCIe40 cards
- One C-frame quarter electronics installed
  - ✓ 6 x FEBs = 96 data links
  - o Further installation suspended due to "condensation" problem on Novec and dry-gas lines
- First Light calibration done
  - ✓ Scan of pulse delays between 0ns and 15ns in steps of 1ns → being analyzed
  - ✓ S-curves for all channels → being analyzed
- Charge injection done
  - ✓ Scan of pluse injection timing in steps of 3.125ns. All channel show a uniform plateau
- Bit-error rates tests performed: good results < 10^{-15}
- Issue with GBT losing lock during FE reset
  - ✓ Problem investigated, found and solved
  - ✓ Issue when current consumption on Maraton channel > 10A

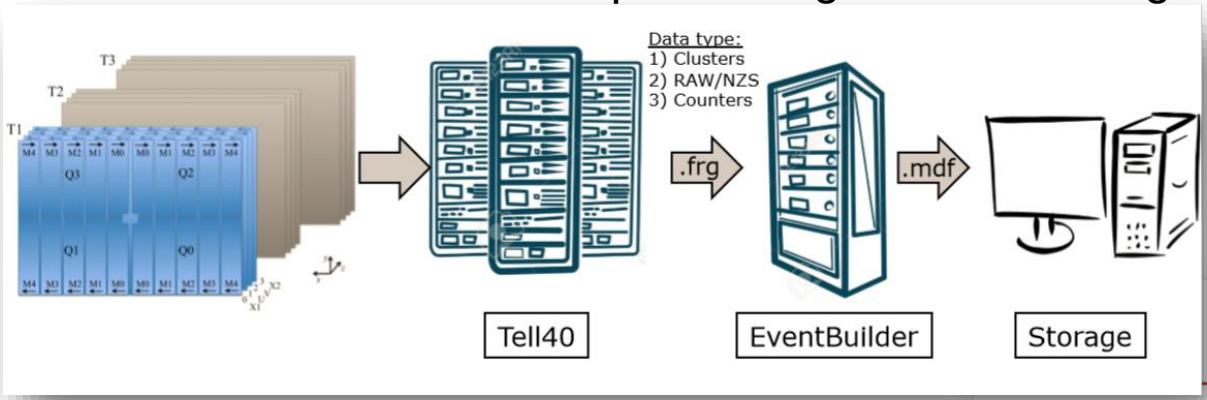




SciFi commissioning of monitoring system

A lot of pioneering work ongoing in commissioning first monitoring system (of LHCb)

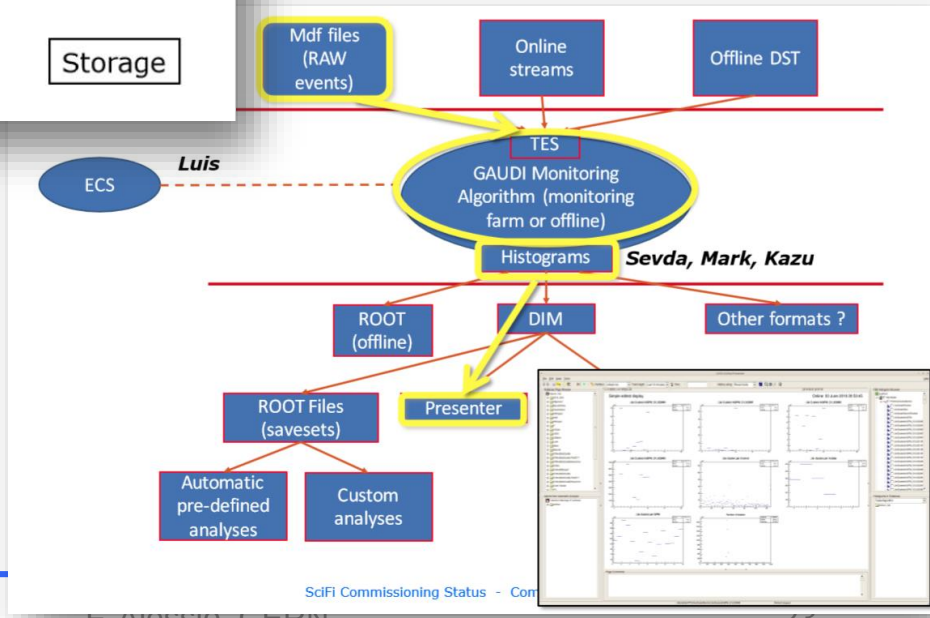
- Allows for fast analysis and visualization of acquired data
- Fast feedback when performing commissioning/calibrations



Still some inconsistencies with data interpretation, but can run over acquired files offline

→ Next step: make it work online (prepare plots in presenter)

→ Adapt decoding when final output data format is finalized



SciFi commissioning summary

➢ Progress on many fronts, but also some worries:

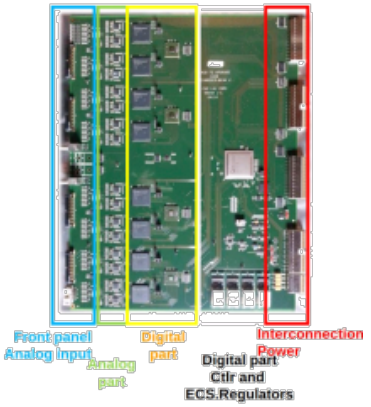
- FEE control
  - Major restructure ahead (RESET function, disable parts)
  - **Suffering from GBT instabilities**
- Databases/recipes
  - Database for Calibration values missing
- LV+DCS control
  - Ok
- HV control
  - Recipe creation from database values missing
- PCIe40
  - All 3 final data formats in progress: 1) Cluster 2) NZS/RAW 3) Counters
  - **Cannot connect 48 links per pci40 ; only 4 pci40 cards installed**
- Data monitoring
  - **Setting up Gaudi versioning non-trivial**
- PACIFIC calibration
  - Validation of S-curve fits needed for **large** number of channels

SciFi Commissioning Status - Commissioning meeting 10 Sep 2019 - Niels/Snow

CALO status: production

New Electronics Status

- **ICECAL:** 40MHz ASIC for CALO upgrade (new gain / low noise)
- **FEB:** front-end digitizer board, hosts 8 ICECAL, 40 MHz readout
- **CB:** control board
- **HV & Moni & Calib:** control mezzanine, ECS mezzanine, GBT fanout



Board Type	Needed	Produced	Tested	Installed	Full production Expected delivery time	Comments
ICECAL	2224	2x3050	100%	n.a.	completed	2 types (2 gains)
FEB	278	2	2	-	Finish in February 2020 *	2+16 pre-series, then batches of ~32
CB	21	-	-	-	Finish in December**	3 boards to be received soon Full production in parallel with the FEB
Ctrl mezz	66	100%	95%	-	completed	Completion of the tests this summer
ECS mezz	66	100%	95%	-	completed	Completion of the tests this summer
GBT fanout	12	100%	95%	-	completed	Completion of the tests this summer

* Found a producer mistake in the preprod of 2 (used wrong files)
=> delay of one iteration ~ 3 months

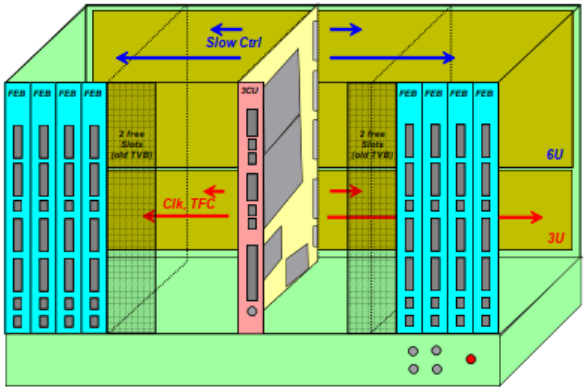
** Because wait for 16 FEB before production

CALO status: at the pit

Status at the pit

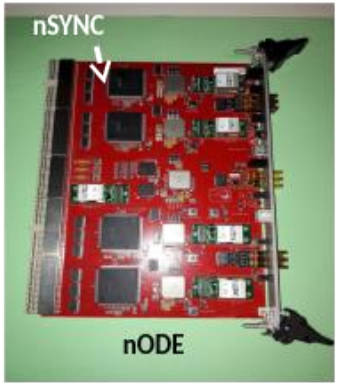
- The SPD/PS/Lead and old FEB electronics dismantling is completed
  - some mechanical parts of the XCAL FEB will be re-used for the new boards:
    - Front panels, handles, bars etc
- Almost all unnecessary old cables have been removed
  - except SPECS
- The MARATON power supplies have been modified by Bruno Allongue
- The backplane and connection cables should also be adapted
  - The procedure was tested at lab and at pit
  - All crates will be modified in situ, at the platform, in September (?) and tested (test procedure to be defined)

- Detector side
  - Removal of the very central HCAL PMTs, preparations to the installation of the new beam plug
  - Replacement of ECAL signal connectors at the PMT side (tbc)
  - Maintenance of the ECAL & HCAL movement systems
    - Hardware and software
    - A dedicated meeting will be organized in October
    - No (or) limited detector displacement during some operations !
      - To be planned



MUON status: production

New Electronics Status



- **nSYNCs, nODE:** 40MHz readout, each nODE equipped with 4 nSYNCs
- **nSB, nPDM:** system configuration and pulsing
- **nBP:** custom Back Plane for nPDM/nSB crates

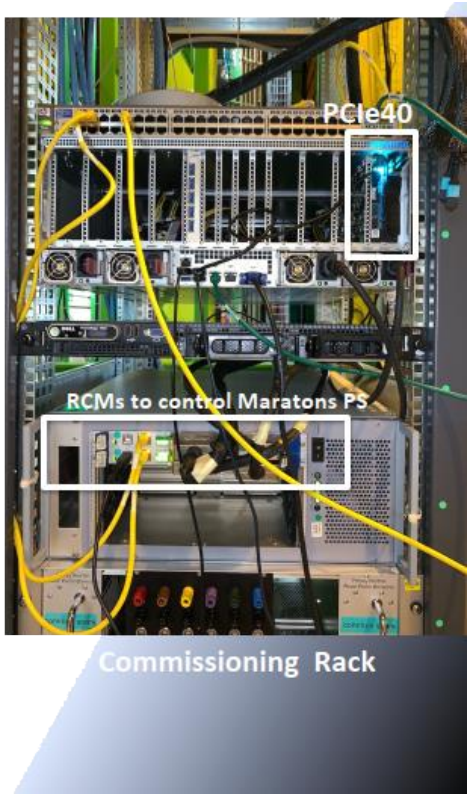
Board Type	Needed (+ spares)	Produced	Tested	Installed	Full production Expected delivery time	Comments
nSYNC	760	2800	2800	96	Done	All nSYNCS sent to the company for ODE production
nODE	148+42	24	17	8	Dec*	Pre-production delivered
nSB	120+20	20	20	14	Oct - Nov*	(new) Pre-production delivered
nPDM	8+2	2	2	1	Nov*	Pre-production delivered
nBP	8+2	2	2	1	Nov*	Pre-production delivered

* some delay compared to last LHCC, but not critical.

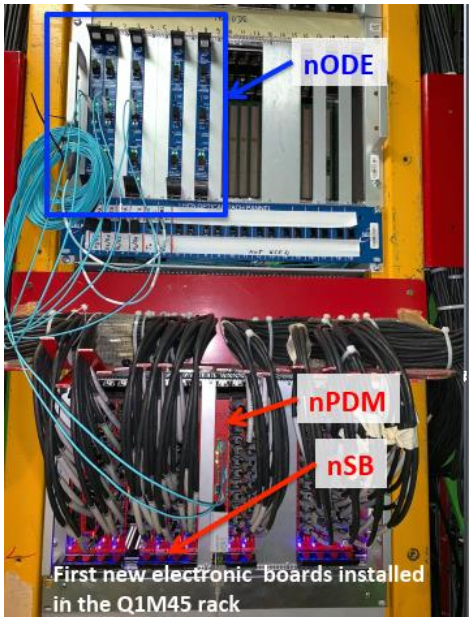
Started installation of nODE boards in the pit

MUON status: commissioning at the pit

- **The first test is ongoing with the commissioning rack:**
  - 1 PCIe40 + Server
  - 2 Primary PS + 2 RCMs to power up and control the 2 Maratons of each Muon rack
- **Conditions approximately as in RUN3:**
  - PCIe40 "DAQ" board, configured as SOL40
  - 350m long fibers (from PCIe40 to nODE/nPDM)
- **We are starting with the connectivity test:**
  - at first, to debug/test the new software, on a "good" detector region (Q1M4) where no IB have been removed
  - then we move to all other regions
- **Switch to the official online system as soon as available**



- the **Q1M45** rack is now equipped with new electronics (for M4):
  - **5 nODE (3 more available)**
  - **14 nSB + nPDM + nBP**
- **Communication with nSBs & nODEs is established:** we can configure them, read back, send pulses from nSBs to FEBs and receive counts from FEBs to nODEs (this part we need for the connectivity test)



ONLINE status: plan

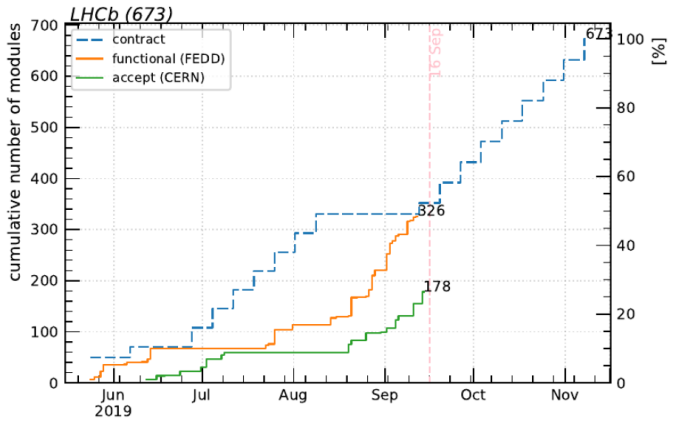
Online procurement and installation planning

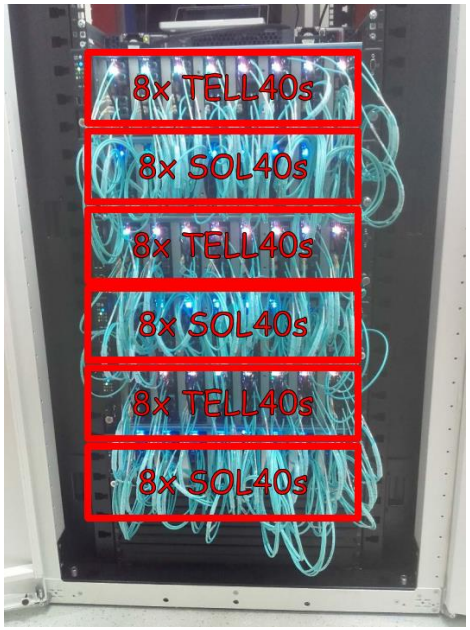
Item	Date
Long-distances fibers ready	Q3 19
Data-centre ready	Q4 19
ECS network and TFC distribution	Q3 – Q4 19
Readout servers	Q4 19 – Q1 20
Event-builder network (core)	Q1 20 – Q2 20
Prototype storage	Q1 20 (together with IT department)
Servers and storage (bulk)	Q4 20 Q1 21 (together with IT department)
GPGPUs **OR** event-builder network (distribution)	Q1 21

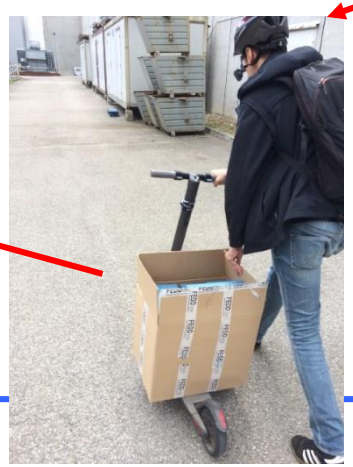
ONLINE status: readout cards production

~50% produced by end of September:

- Initial delay of ~5 weeks, now reduced to 2 weeks
- Investigating final needs → are the numbers still enough?







Being "accepted" in IT4 Data Center

- Final operating conditions
- Using validated cards as injectors (SOL40) for cards to be validated (TELL40)
- Afterwards stored away

ONLINE status: 1° fw/sw production release

Spent the past months in preparing first production releases of:

- central firmware and software
  - → For commissioning and assemblies: control, readout, timing
  - → Validation and continuous integration ongoing
    - ✓ Firmware/software workshops 18-22/03 and 15-19/04 and 20-24/05 and 24-26 /06 and all summer…

Fundamental cooperation with sub-detector experts

- Adiabatic commissioning of sub-detectors and central systems
  - → Checkpoints to follow sub-detectors development
  - → At the same time, grow expertise in the community
    - Such expertise will be necessary during detector commissioning!

Few aspects are still missing towards global commissioning:

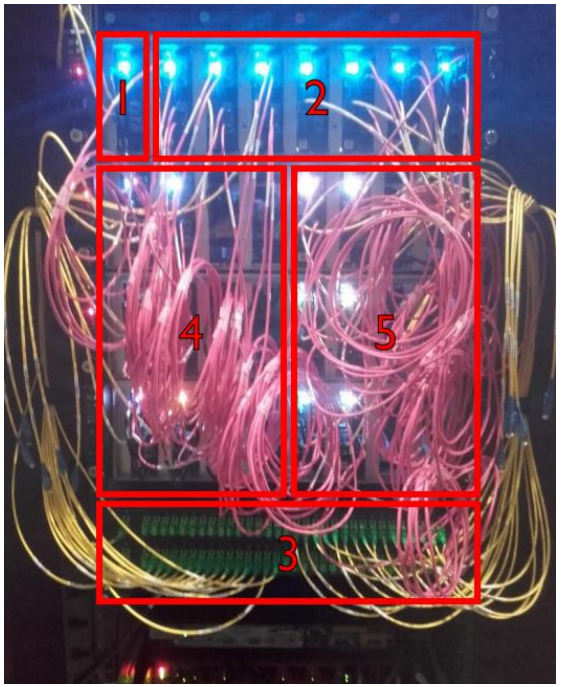
- Timing distribution to FE with fixed latency
- Integrate system with Event Builder as in final configuration
- Scalable control firmware covering full 48 links
- Integrate in global system

  + a very long list of small little tasks...

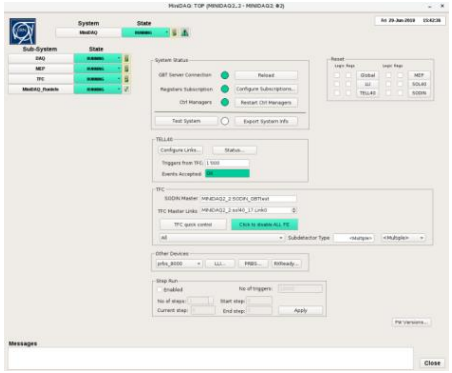
ONLINE status: online integration

Developed setup for integration tests ("*Vertical slice*"):

- Identical final operating conditions
- Using bidirectional accepted cards as injectors (SOL40)
- Two partitions:
  - Readout supervisor and interface cards (1-2)
  - Optical splitter for clock and timing distribution (3)
  - Readout cards (4-5, two partitions)



- Production versions of:
  - Firmware
  - Control system
  - Event building
  - HLT
  - Storage



Plan to use it for:

- ~~PCIe40 testing, multi-card integration, WinCC~~ → ~~April~~
- Event Builder validation/review/testing → Finishing
- Integration with production releases → Now
- Ultimately for monitoring + HLT + online + storage integration → November

ONLINE status: event builder

Two options on the table: dedicated vs distributed

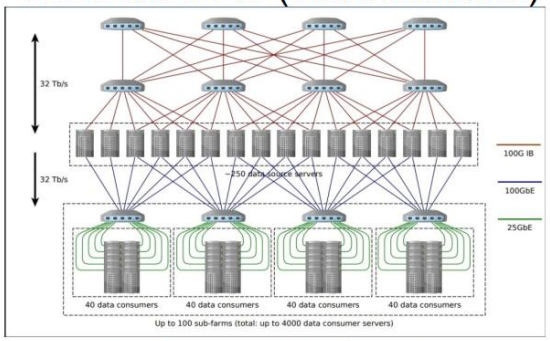
→ Reviewed on June 6, 2019

- Check for appropriate performance, scalability, usability and cost
- Probe possible risks, both technical and financial

Conclusion:

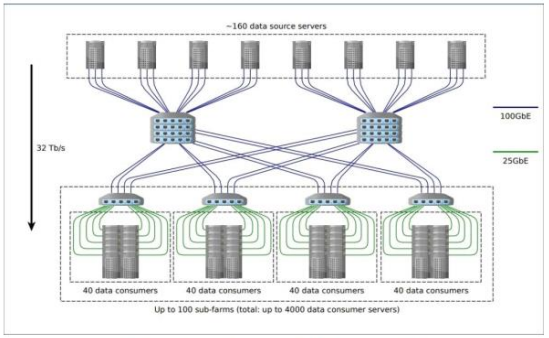
- Confident that the EB team can get both solutions to work (distributed w/ deep buffers)
- The cost does not seem to be a determining factor in the choice
- Set of recommendations
  - Continue testing the distributed options
  - Set up complete data-flow chain with event-building, monitoring and ECS in the Vertcal Slice test (ongoing)
  - Prepare a document describing flow-control and overflow handling and dead-time accounting

Dedicated EB (TDR baseline)



Technology: **Infiniband**
+ Ethernet for Distribution

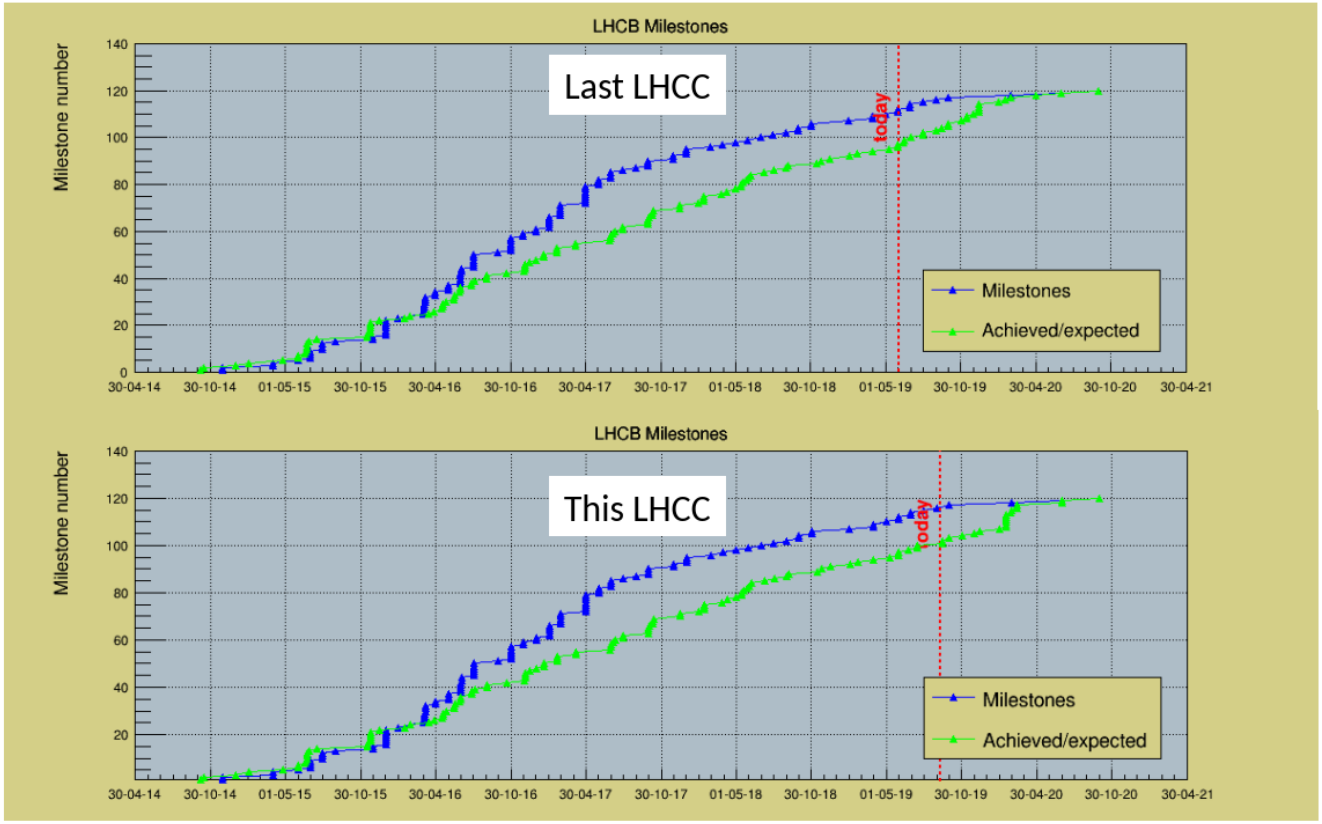
Distributed EB



Technology: **Ethernet**
Switches: deep-buffer (expensive) vs shallow-buffer (cheap)

→ Final choice by December 2019

LHCb Upgrade milestones plot



Achieved 3 more milestones => total 100

Remain: 7 UT + 4 VELO + 1 SciFi + 1 CALO + 0 RICH + 0 MUON + 7 Online = 20

Early commissioning to global commissioning

Currently moving from local test-benches to early commissioning

- most delicate phase: move towards “final” and “global” systems coherently
  - develop tools targeting final system already
  - final software/firmware/hardware commissioning currently ongoing
    - ✓ early commissioning phase

- sub-detectors need to move in parallel towards developing tools
  - The tools are system tests
    - ✓ Test-beams, validation slices, assembly setups are the *opportunities* to be able to arrive at the commissioning step ready and prepared
    - ✓ Gauge the level of preparedness at each step

(moving target)

- global commissioning can start once central online infrastructure is installed and commissioned itself!
  - to start beginning of 2020
    - ✓ overlap between local commissioning and global commissioning
    - ✓ adiabatic inclusion of new sub-systems as they become ready
    - ✓ coordination between sub-detector activities and centralized (online) activities

Global commissioning short-term goals

Spring:

- Readout part of a detector (slice test) with new electronics ✓
- Coordinate the needs from sub-detectors (early) commissioning ✓
  → Currently all sub-detectors are equipped with central hardware and software to kick-start local commissioning work and follow production

Summer: make sure we arrive at the Online commissioning ready

Here now!

- New PCIe cards coming in now
  → currently being accepted/validated in Online
  - Keep track of sub-detectors' development
  - Make sure to move ahead in parallel with development
- Broken record: It's not just the cards: monitoring, infrastructure, Event Building, ECS...

Autumn:

- Central online system commissioning
  - Fibers + data center then TFC and ECS
- Iron out last issues with central tools
  - Continuous integration and validation framework developed
- Support sub-detectors with commissioning to be ready for 2020

Next steps in the next months (aka commissioning milestones)

First thing in the pipeline → Online commissioning

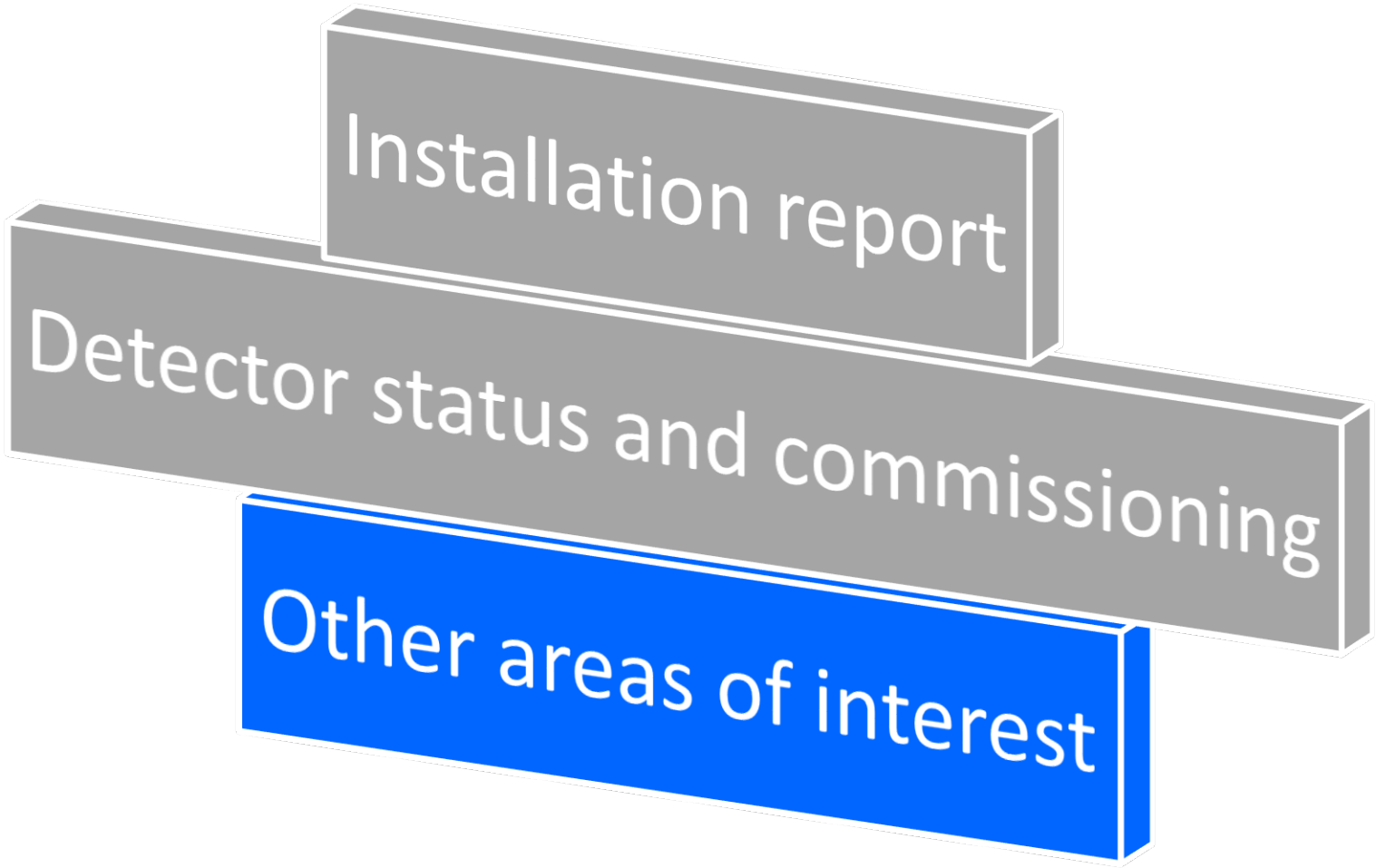
1. Data center commissioning

2. PCIe40 acceptance, validation
   - All SOL40s already tested
   - Now testing first batch of TELL40s using SOL40s as data generators

3. Vertical slice party
   - New cards + timing distribution + partitioning + WinCC + EB + HLT passthru

4. Online system installation + commissioning
   - TFC + ECS hardware and software
   - TELL40s and clock distribution/recovery
   - Event Builder + online network

5. Sub-detectors commissioning with global online system
   - ETA beginning of 2020
   - With reduced resources in FARM then towards 2021 with full resources


Installation report
Detector status and commissioning
Other areas of interest

Online Data Monitoring (data quality)

The monitoring of the LHCb detector should be considered a broader and important task/activity than it has been up to now.

One shifter is entirely dedicated to "monitor" the detector: the tools should make his/her work easy and should be adequate to the task

Monitoring system will be the rock on which our future detector will rely on: not many chances to go back and fix an "alignment bug"

Monitoring system is an absolutely essential tools for commissioning and it should not be a burden on the experts.

Work on global monitoring system is going to pick up momentum from now on

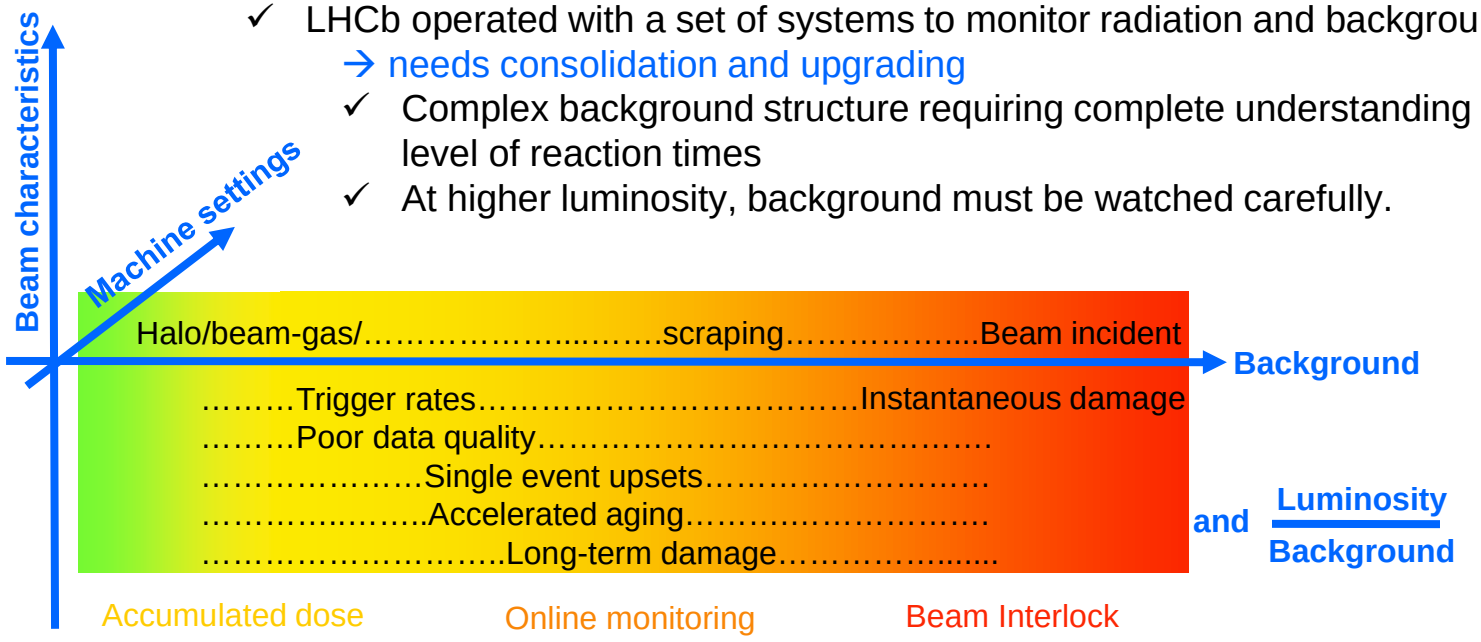
- from diagrams on a paper to real implementations
- commissioning of monitoring system to happen with commissioning of detector
  - → Thinking about solutions and implementations should start now
    - Online – RTA collaboration fundamental here

- Use local commissioning setups to "build up" features
- Coordination by Patrick Robbe, second monitoring workshop currently scheduled for 11th October 2019: https://indico.cern.ch/event/849009/

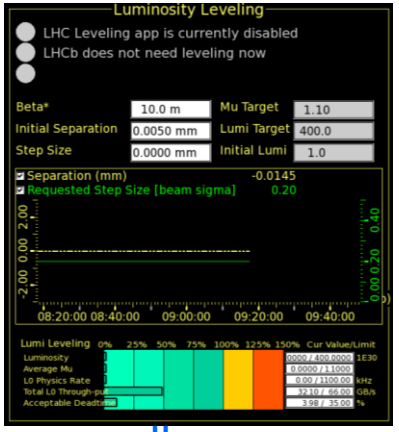
Online luminosity and beam monitoring

From Run3, beam and luminosity monitoring will become an important tool to evaluate the performance of our detector in the LHC environment

- High radiation levels for a long enough time can trigger a beam dump
- Background is the normal life around an accelerator but it can be unacceptably high such that it affects the quality of data
- If high, it can also decrease the expected life of the detectors
  - ✓ LHCb operated with a set of systems to monitor radiation and background in Run 1&2
    - → needs consolidation and upgrading
    - ✓ Complex background structure requiring complete understanding and widely different level of reaction times
    - ✓ At higher luminosity, background must be watched carefully.



Online luminosity and beam monitoring



1. Online luminosity determination

- This is absolutely fundamental.
- Today, we use activity in the calorimeter to infer the mu
  - ✓ Use the zero-bin (no activity), then *mu = -log(fraction_ncalo)*
  - ✓ *But after the upgrade, no L0 trigger (+ zero-bin depleted)*
- We need to find a strategy to measure mu
  - ✓ We need a live counter: Leveling is a *real-time* application as well
    - updated regularly and within a few seconds
  - ✓ Cannot rely 100% on just HLT events
    - because the luminosity determination should also be independent from running the DAQ → heavy machinery !
    - But it should be integrated in it in order to cross calibrate various sources
  - ✓ Ideas developing regarding an LHCb "*dedicated luminometer*"
    - as a flexible system that can be used also for other applications
    - a lot of opportunities here for young scientists w/o a huge budget...

- Involve more people in the luminosity working group.
  - ✓ Manpower there is very limited and will surely profit from additional help.

Online luminosity and beam monitoring

2. Beam interlocks and beam monitoring

Today we use the BCM (beam conditions monitoring) and the BLS (beam loss scintillators) to monitor beam induced background

- Beam/background conditions must be watched at higher luminosities.
  - ✓ Evaluate impact of bad vacuum, UFOs, bad machine conditions etc
- BCM worked beautifully during the entire Run1&2
  - ✓ Interlocked when needed, always justified and followed up
  - → In LS2: readout system replaced and consolidation on the sensors

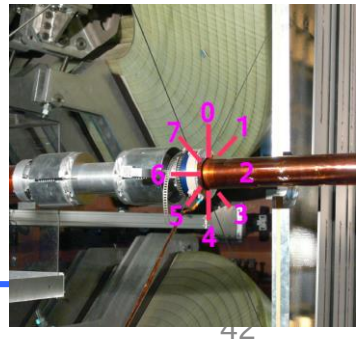
→ On a longer term, need to start thinking of a new BCM to be deployed from Run4 and beyond

- ✓ HL-LHC will be a different pp environment
- ✓ 25ns readout, dump logic/thresholds, what technology? Couple with luminometer?
- ✓ Not needed for Run 3, but ideal to have it under test before end of Run3

3. LHC clock reception, distribution and monitoring

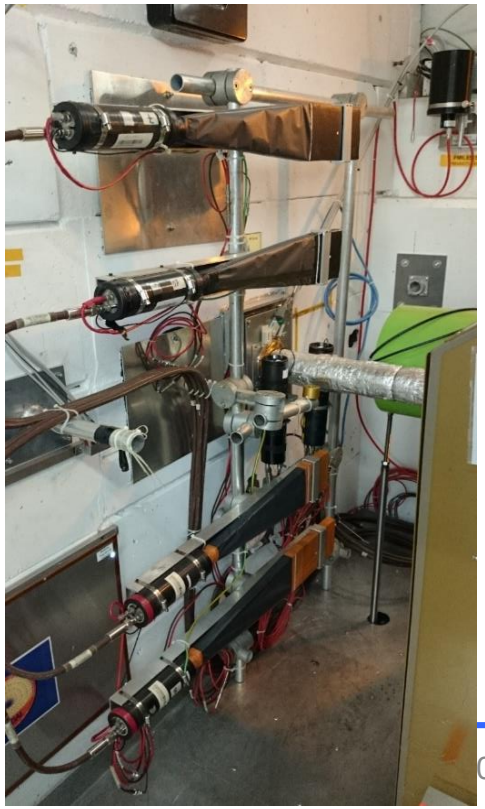
- LHC clock distribution won't change until LS3.
  - ✓ But clock phase changes due to temperature dependent fibers
- What about adding timing information in the upgrade?
  - ✓ Old system to monitor clock phase could profit from this additional piece of information. Beam timing must be monitored.

BCM



LHCb is in a unique position

- ✓ We can literally “see” our IP
- ✓ We have bigger beams (b* = 1.5m in Run3)
- ✓ We have SMOG(2)
- ✓ We have an innovative and creative attitude
- ✓ We have the handle of a huge upgrade → LHCb in the spotlight in Run3



We have some “free” space in front of the VELO

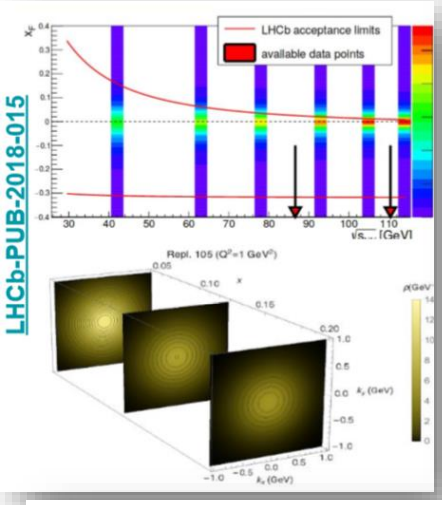
List of *desiderata*
- bunch-by-bunch quantities
- time information
- “live” beam shapes/emittance
- integration in upgraded DAQ
- automatic reports/monitoring
- correlations with other quantities

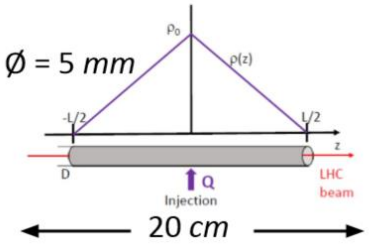
(vacuum, mu, detectors…)

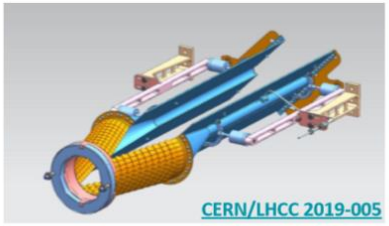
→ Invite proposal of new detectors!

→ Some being already reviewed

SMOG2





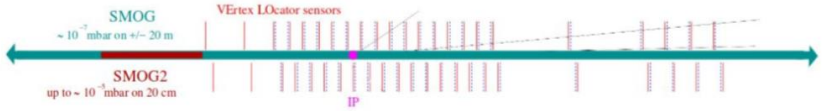


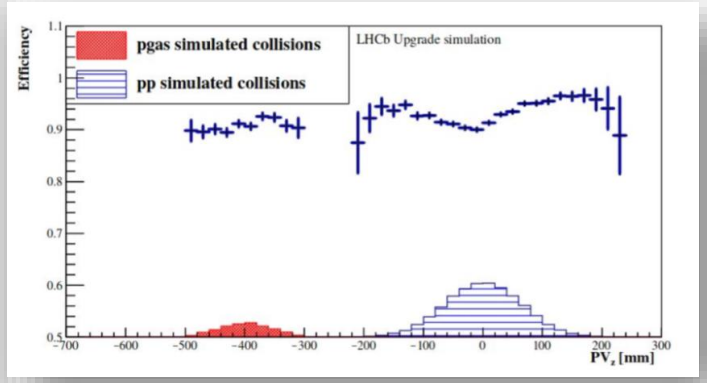
- The gas pressure follows a **triangular profile**.
- System composed of **two retractable halves** to follow the Velo closing procedure.
- Light and thin material, to keep low the **material budget** and appropriately **coated** to prevent electron clouds forming.
- **Electrical connectivity** ensured by the wake field suppressor.
- Cell installation approved for November 2019.

- **Smog2:** Upgrade of the fixed-target programme consisting in the installation of a confinement cell covering the [-500, -300] *mm* region.
- Cell installation approved for November 2019.
- In principle, excellent candidate for a **super-early measurement**: can we measure in *pgas* system with **only beam1** stably circulating?

CERN/LHCC 2019-005

- ❑ Gas density can be **increased** up of **two orders of magnitude** with the same gas flow of Smog.
- ❑ Gas pressure, and thus luminosity, can be **precisely measured**, notably reducing systematic uncertainties.
- ❑ With machine approval, **more gas species** can be injected (H, O, N..).





- Unique FT physics program!

Run 3 running conditions requests to the LHC

For Run3, what beam parameters are we going to expect and what running conditions are we going to ask? We need to start thinking about it now!

1. Levelling at $2x10^{33}$ cm^{-2} s^{-1} throughout entire length of fill
   → Enough margin to do so in 2021 and 2022/2023
2. Maximize number of colliding bunches
3. Minimize crossing angle differences between magnet polarities
   → Add V x-angle and remove external H x-angle
4. Include new VELO aperture, investigate limitations on β* reach
5. Energy stable throughout Run 3
6. Luminous region size (in z) above 37mm
   → If new crossing angle, bunch length leveling may not be needed
7. Mixed filling scheme ok if homogeneous pileup distribution among bunches

→ Many requests taken in considerations and accepted by LHC

- 2021 will be a commissioning year for the LHC as well
- 2022-2023 will be production year. 2024 is uncertain.

Run 3 expectations: LHCb commissioning with beam

At the beginning of 2021, LHCb will have 90% of its detector new

- Need some early collisions to commission time alignment, initial scans, operational aspects, understand detector.
  - ✓ Schedule early 450 GeV collisions (more than once)
    - → Stable Beams & closing the (new) VELO @ 450 GeV would be highly appreciated
    - → to cross check with LHC what the limit is
  - ✓ Schedule early 2x2 bunches beam at ~7 TeV (more than once)
    - → Also more than 2 bunches/beam, but no trains yet.
- TED shots may still be useful even if coming from opposite direction
  - ✓ Commission the "mechanics" of time alignment
  - ✓ Does not give final values → need beam for that.
    - → We could use/commission the new LHCb SMOG2 system for that
    - → Can profit from simple circulating beams
- Need to schedule a full set of safety interlock commissioning with LHC
  - ✓ According to installation/commissioning schedule, expect Q4 of 2020.
  - ✓ New vacuum valve? Logic and connections to the BCM

Tight collaboration with EMTF (Early Measurement Task Force)

- ✓ Before "early" measurement, perform "early" commissioning ☺

Conclusions

Installation is on schedule and absorbing delays where necessary

Sub-detectors local commissioning activities taking momentum

- SciFi, RICH, VELO and UT daily clients. Now also with CALO and MUON.
- Vertical slice ready w/ new PCIe40 cards being extensively used
- Firmware and software released in the first production versions + online commissioning

Strongly fostering a spirit of collaboration, sharing, inclusion and communication:

- We highly welcome the cooperation with sub-detector experts
- While keeping an eye on consistency and guidelines: do not repeat things twice!

Attention in covering all aspects of operations

- Data quality and detector monitoring
- Beam/background/online luminosity monitoring + interlocks
  - Monitoring of beam conditions and online luminosity is fundamental for our success!

LHC being very cooperative in preparing the LHCb running conditions for Run3

Many possibilities to contribute to the success of LHCb Upgrade I !!

Backup

Global commissioning ultimate goal

The goal of 2020 should be to be able to take data with the vast majority of the upgraded devices included and using the global centralized system

- "*cosmics*" data taking over long periods of time
- remember: there is no hardware trigger, so seeing a "*cosmics*" event would be an interesting moment…

A et of milestones for this phase are being defined in collaboration with sub-detectors experts.

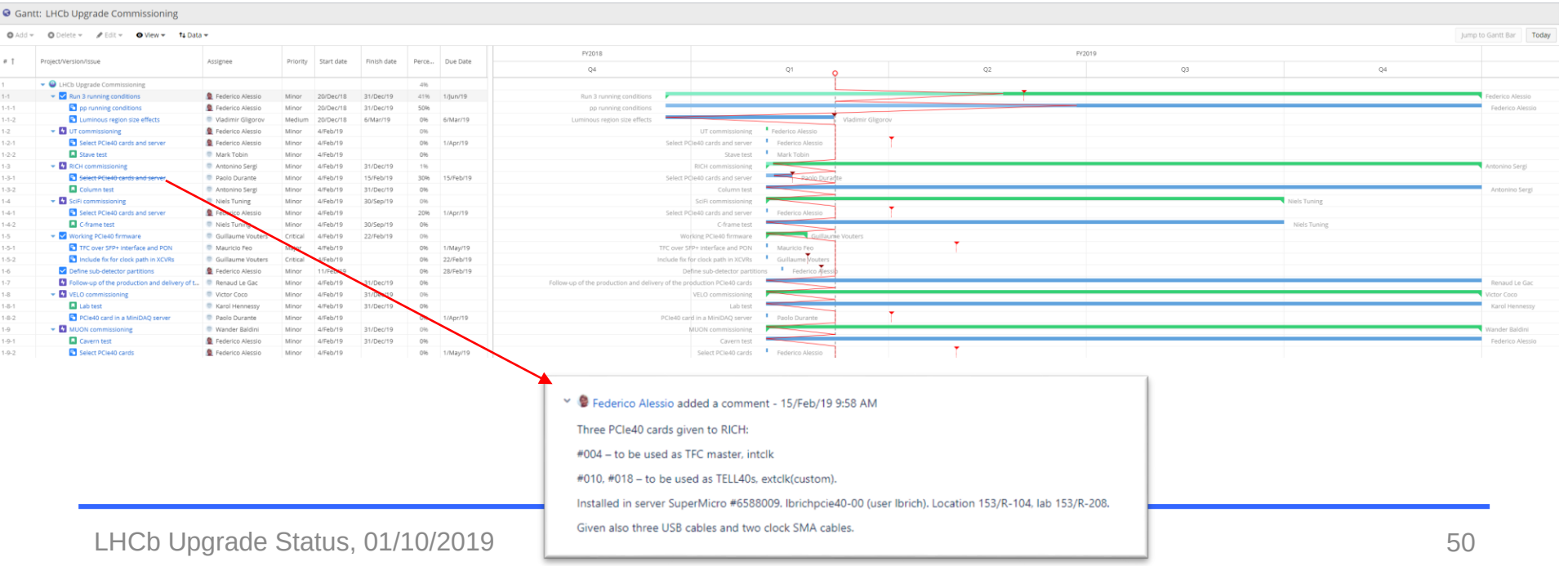
- (JIRA) Tasks generation
- Action lists and follow-up during regular commissioning meetings
- Coordination of parallel activities, sharing of resources
- Definition of data taking activities, conditions, modes
- Training of experts and non-experts
  - ✓ Build a strong team of operational experts such that many can use the weapons at our disposal

Commissioning tasks and follow-up

Set-up a JIRA project to follow-up commissioning activities
https://its.cern.ch/jira/secure/RapidBoard.jspa?projectKey=LHCBUPGCOMM&rapidView=6465

→ Being setup over time as I get information/generate tasks

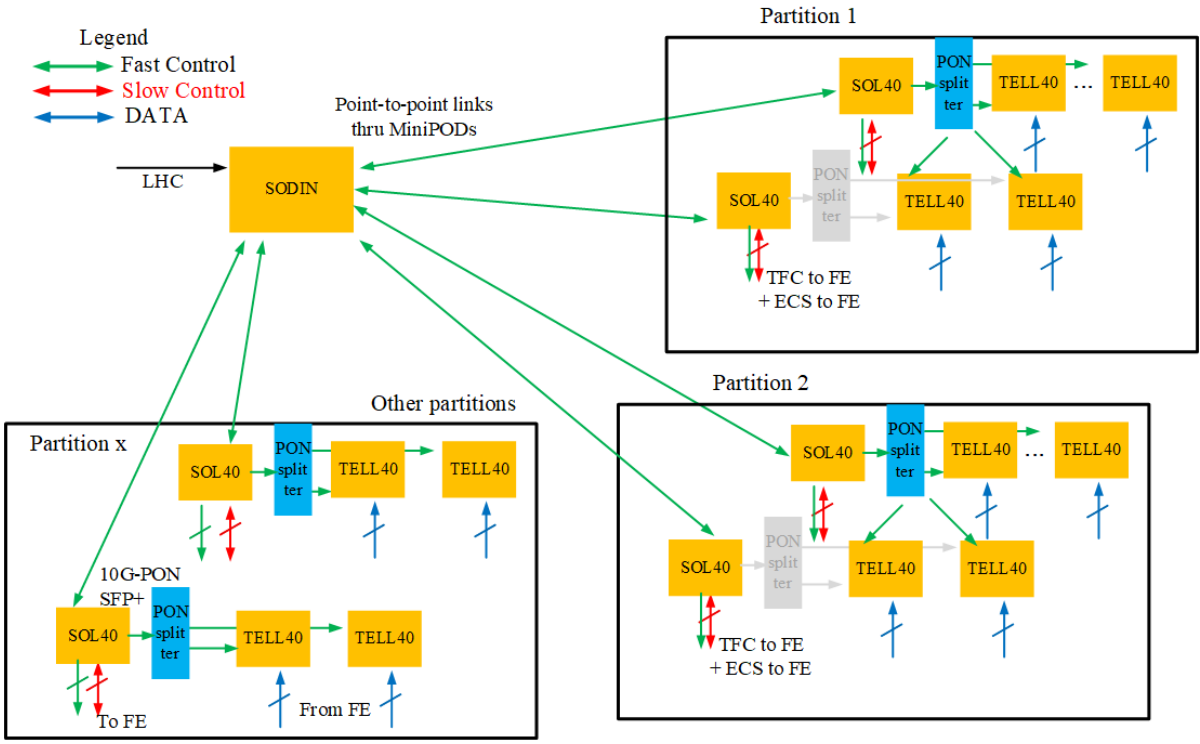
- Added more tasks recently and assigned tasks to users
- Integrate with other sub-detectors and their tasks/charts
- Also used as documentation and resources tracking



Defining sub-detector partitions

Important not to break partitioning

- ✓ Put together SOL40 and TELL40 that are connected to same FEs!
- ✓ Dynamic SODIN-SOL40 association based on recipes (partition ID)



- ✓ TFC to TELL40 is distributed through dedicated PON link (over SFP+ and optical splitter)

EDMS document being updated
https://edms.cern.ch/file/2112652/1/Partitioning_TFC_edms2112652_v2r1.doc

Defined sub-detector partitions

Partition denotes which part of the detector that can be operated standalone and/or in parallel to others.

→ *LHCb is the "global" partition*

Sub-system	# of divisions	Naming	Bit
VELO	2	A/C	2(A) 3(C)
RICH 1	1		4
UT	2	A/C	5(A) 6(C)
SCIFI	2	A/C	7(A) 8(C)
RICH 2	1		9
ECAL	1		11
HCAL	1		12
MUON	2	A/C	13(A) 14(C)
T(est)DET(ector)	1		15
	Tot = 13		

- Also defines the so-called "partition ID" that is used by ECS for global control
- Increased to 32 bits so we can welcome more future sub-detectors

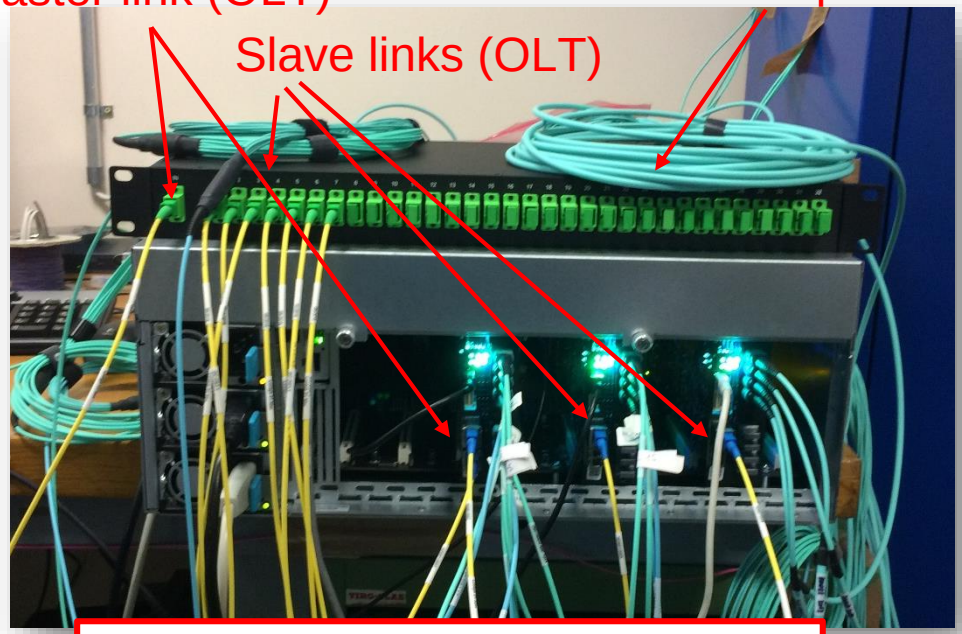
EDMS document prepared and in circulation with sub-detectors

Extensive work with PCIe40 cards

Vertical slice fully setup for testing the PCIe40 cards and distributed Event Builder

- ~~PCIe40 testing, multi-card integration, WinCC → April~~
- Event Builder validation/review/testing → Ongoing
- For final PCIe40 production acceptance and validation → Now
- Ultimately for monitoring, HLT, online integration "party" → November

© Paolo Durante



Now moving to final timing and clock distribution using PON architecture

Building events and output data format

Online team defined the “event bank format”: https://edms.cern.ch/document/2100937

- EDMS document prepared and in circulation for approval with sub-detectors
  - → Swiftly included in the central firmware/software tools
- Tried out already with SciFi test-bench with multiple sources

First ever built event

```
StoreExplorerAlg     INFO ========== /Event[0x2abb900@EventDataSvc]:
StoreExplorerAlg     INFO +--> /Event [Address: CLID=0x1 Type=0xa000000]  DataObject
StoreExplorerAlg  VERBOSE ServiceLocatorHelper::service: found service EventDataSvc
StoreExplorerAlg     INFO   +--> /DAQ [Address: CLID=0x1 Type=0xa000000]  DataObject
StoreExplorerAlg     INFO     +--> /RawEvent [Address: CLID=0x3ea Type=0xa000000]  LHCb::RawEvent
DumpRaw           VERBOSE ServiceLocatorHelper::service: found service EventDataSvc
DumpRaw              INFO Evt No:1      has 1 bank(s) of type 15 (DAQ)
DumpRaw              INFO Bank:  [Size:  48 Type: 15          [DAQ] Source:  0 Vsn:16 cbcb]
DumpRaw              INFO   Data:      2fc      2fc      2fc        0    10036 ffffffff ffffffff ffffffff ffffffff        0
DumpRaw              INFO   Data:        0        0
DumpRaw              INFO Evt No:1      has 4 bank(s) of type 64 (UNKNOWN)
DumpRaw              INFO Bank:  [Size: 138 Type: 64       [UNKNOWN] Source:  2 Vsn: 5 cbcb]
DumpRaw              INFO   Data:31210110 5992ac08 2b551f33  8000001  2040608 d3e08081 22011019 b644d191 58ad4969  80091ad
DumpRaw              INFO   Data:488d1212 ed8a63c5  102e284     903f        0 20000000     f913        0 49000000 2d572d01
DumpRaw              INFO   Data:e8619906  4403ef8 151d0cf0 22c5088e 85eeb4e1 752a0149 549746b3 c0fef9b4 11000001  487890d
DumpRaw              INFO   Data: 8f50983     1090 40608080  80e1828
DumpRaw              INFO Bank:  [Size: 263 Type: 64       [UNKNOWN] Source:  3 Vsn: 5 cbcb]
DumpRaw              INFO   Data:362c0110 e9b04143 9529d18c 19120041 83060b12 100d4ac3 80001090 4870a0c0  c0f1a2c 12c0c486
DumpRaw              INFO   Data: b142443 231f9e06  110d8a1 bc083121 9d365b82   31a9d0 1826371a 2a94674d  dd17e55 a1722401
DumpRaw              INFO   Data:5289f2b4 102f5cad 6b1908b0 1d7970ba e9b3f76e 7121014a  54be549 3ff8ec8c 131280d0 b463c310
DumpRaw              INFO   Data:  fcaf7a  8101000 92618284 1f3c74e3  8009110  9070a0c a1029525   10b860 dc68c180 ab376580
DumpRaw              INFO   Data:  a1ac57  e182840 a1c3860c  dd952f1 aa71a201 920793cd 11d8edd8 16180800 13a6ca91 b914e941
DumpRaw              INFO   Data:a0000010 4268a0d0 4911192c 1a0c00a1 460a1016 2a1dea23 820410a3 88f0a0c1  c172a4c 1320c086
DumpRaw              INFO   Data:      f9        0   100000 70a0c080  f1a2c48
DumpRaw              INFO Bank:  [Size: 125 Type: 64       [UNKNOWN] Source:  4 Vsn: 5 cbcb]
DumpRaw              INFO   Data: 1010010 70aa1401 6c582a40 15040081 a5098e18  add6973 21011095 82bc0831 901d335b 120021c9
DumpRaw              INFO   Data:4a901013 21fa5306   10a932 d0206181 2747818a    1cc95 8a0f1500 4a33a508 10a1180d 6071a201
DumpRaw              INFO   Data:446da2f0 712cd7a9 28451200 35288f17 bc64ad0a 12010010 6eca6459 ced9b042 a71a0011  edbb35a
DumpRaw              INFO   Data:9b066dd9
DumpRaw              INFO Bank:  [Size: 150 Type: 64       [UNKNOWN] Source:  5 Vsn: 5 cbcb]
DumpRaw              INFO   Data:91210110 6594ec68 ac55a741 15040091 e5488f10 281d4a03 2001109e 82cc4871 d2a1365d 1200f1aa
DumpRaw              INFO   Data:52a22639 391b560a   10fdc2 bc080141 a12c4470   21ca51 10120800 8244284e 10ce6ea5 38918100
DumpRaw              INFO   Data:375186e4 a189919e 10131200 22c4c68a 950aa5a1 a1000110 69a42c89 6e5bb461 19120091 264b8f16
DumpRaw              INFO   Data:82b5ea93 230110cb  2cd4972 562a4b8d     21ec ca901410 11b3b52a
```

2018/2019 commissioning events

4 Upgrade commissioning meetings:

- 02 October 18, 10 December 18, 11 February 19, 03 September 19

Sub-detectors commissioning workshops:

- UT 15-16 October 2018 https://indico.cern.ch/event/759996/
- VELO 2 November https://indico.cern.ch/event/765995/

Monitoring brainstorming: 11 October, https://indico.cern.ch/event/764181/

ECS workshop: 29 November

SMOGII presentation at MPP and LMC 14 December and 16 January
VELO presentation at MPP 25 January

Online workshop 28 January

PCIe40 production started 31 January

DAQ workshop

DAQ workshop (14 March): https://indico.cern.ch/event/803218/

- Online and commissioning bodies organized a workshop specifically targeting DAQ systems

  - ✓ Similar to the ECS workshop
  - ✓ Presented current guidelines/tools in online regarding DAQ
  - ✓ Sub-detectors asked to present what they expect from central online
    - what do you expect from the central teams (Online and support) in terms of local and global commissioning?
    - how do plan to do your integration / commissioning and how do you plan to perform the transition from local test-benches to the central system? A rough timeline would be welcome as well.
    - what does your integration / commissioning system look like in terms of architecture, resources and infrastructure?

  - ✓ Got to know experts who will actually do commissioning/integration

ECS and Online one-day workshops

https://indico.cern.ch/event/758213/

ECS team to discuss guidelines, implementations, tools and strategies

- Sub-detectors presented their developments and strategies

Finished with excellent Portuguese food and drinks

https://indico.cern.ch/event/781236/

Online team & friends got together to discuss most recent developments in:

- Storage
- Event builder and its architecture
- Architecture of the dataflow
- Online monitoring infrastructure and strategy

Minutes w/ actions attached to the agenda by Niko
https://indico.cern.ch/event/781236/attachments/1789624/2915092/online_ws0119_summary.pdf

As usual very proficuous discussions and exchange of ideas.

→ To repeat it with another one-day workshop dedicated to DAQ!

PCIe40 resources distribution

Sub detector	PCIe40 requests	ETA	Notes	Who
VELO	1 MiniDAQ2	done	1 MiniDAQ2 (Liverpool) Put 1 PCIe40 in MiniDAQ2 server	Karol
RICH	1 SOL40 + 2 TELL40 Server ok	done	1 MiniDAQ2 (CERN)	Tonino/Silvia
UT	1 SOL40 + 2 TELL40 Server ok	1 before 01/05/2019 Then +2 after acceptance	4 MiniDAQ2 (Maryland, Syracuse, Krakow, Milano) Requested 1 extra MD1/2 for Beijing Put 1 PCIe40 in MiniDAQ2 server	Mark
SCiFi	1 SOL40 + 3(+9) TELL40 Server ok	1+3 done Then +9 after acceptance	2 MiniDAQ2 (Paris, CERN) 1 extra MiniDAQ2 for FE tester	Snow/Daniel/ Mauricio
CALO	1 MiniDAQ2	-	1 MiniDAQ2 in Paris Requested 1 more (19/06/2019)	Frederic
MUON	1 Server ok	done	1 MiniDAQ2 (Rome) PCIe40 in commissioning rack	Wander
Online	10 (oo 22)	Until acceptance		

Milestones per subdetector

SciFi milestones

					Old	new
73	SCIFI	Fibres, mats, modules	100% modules produced	sept..17	01.02.2019	01.02.2019
74	SCIFI	SiPM + Electronics + ROB	PACIFIC first production chips available for mountin	févr..18	01.06.2018	01.06.2018
75	SCIFI	Frames	Start module installation on C frames	mai.18	15.12.2018	15.12.2018
76	SCIFI	Frames	12 fra	juil..18	31.05.2019	31.05.2019
77	SCIFI		ready for installation	juin.19	Delayed Nov-19	Delayed Feb-20

Renamed: First C-frame ready

- Overall OK. Equipping of C-frames started in earnest.
- Accumulated delays due to a few components and system-level challenges.
- Could work with more serenity with a couple more months before installing the first half.

Online

					Old	new
25	DATA PROCESSING	Computing	TDR	déc..17	28.05.2018	28.05.2018
26	DATA PROCESSING	Trigger	2nd Bi-annual update (CPU growth, code performance, strategy, alternative plateforms, review optimisation tasks, bandwidth division)	mars.18	Delayed Dec-19	Delayed Q1-20
27	DATA PROCESSING	Computing	Computing model for the Run 3	sept..18	26.11.2018	26.11.2018
28	DATA PROCESSING	Farm and Data centre	Decide on readout network technology	oct..18	Delayed Jan-20	Delayed Jan-20
29	DATA PROCESSING	Trigger	Decision on output bandwidth and on output dat	oct..18	Delayed Dec-19	Delayed Q1-20
30	DATA PROCESSING	Generic readout board	Production is over	juin.19	Delayed Nov-19	Delayed Nov-19
31	DATA PROCESSING	installation	Online ready for sub-detectors commissioning	sept..19		
32	DATA PROCESSING	Trigger	Trigger configuration for startup	juin.20		
33	DATA PROCESSING	Installation	Online system ready for data-taking	sept..20		

Align with RTA planning

- Overall OK. PCIe40 production ongoing.
- Attention shifted towards performance optimization and commissioning.

Milestones per subdetector

VELO milestones

achieved | delayed

					Old	new
119	VELO	module	Module production site qualification	nov..17	Delayed Jun-19	24.06.2019
120	VELO	module	Module-base integration PRR	avr..18	Delayed Jul-19	Delayed sep-19
121	VELO	module	Module production complete	janv..19	Delayed Jul-2019	Delayed feb-20
122	VELO	module	Module-Base integration complete	août.19		Delayed feb-20
123	VELO	Installation	ready for installation	févr..20		

Passed module production site PRR, module production started.
Next important milestone: Module-base integration PRR.
Still OK with global installation schedule, but challenging.
Detector halves to be ready by Feb 2020.

UT milestones

					Old	new
93	UPSTREAM TRACKER	SALT Chip	SALT production starts	nov..16	10.05.2019	10.05.2019
94	UPSTREAM TRACKER	Hybrid	128 CH HYBRID PRR	janv..17	30.05.2019	30.05.2019
95	UPSTREAM TRACKER	Hybrid	hybrid production starts	févr..17	Delayed Jun-19	15.07.2019
96	UPSTREAM TRACKER	FLEX cables	first batch of cable production completed	avr..17	20.05.2018	20.05.2018
97	UPSTREAM TRACKER	ELECTRONICS	PEPI/DCB PRR	avr..17	01.08.2018	01.08.2018
98	UPSTREAM TRACKER	FLEX cables	FLEX cable production completed	août.17	Delayed Nov-19	Delayed Nov-19
99	UPSTREAM TRACKER	Hybrid	hybrid mounting completed	juin.18	Delayed Feb-20	Delayed Feb-20
100	UPSTREAM TRACKER	Sensor	sensor production completed	août.18	Delayed Sep19	Delayed Sep19
101	UPSTREAM TRACKER	Staves	half of instrumented modules ready	sept..18	Delayed Nov-19	Delayed Feb-20
102	UPSTREAM TRACKER	Staves	stave instrumentation completed	avr..19	Delayed Apr-20	Delayed Jun-20
103	UPSTREAM TRACKER	ELECTRONICS	PEPI electronics completed and ready	mai.19	Delayed Dec-19	Delayed Feb-20
104	UPSTREAM TRACKER	Installation	ready for installation C-half	juil..19	Delayed Dec-19	Delayed Mar-20

1 more wafer v3.8 to do

Sensor Type A is completed (90% of total), rest is expected in Sep

CRITICAL! Stave schedule now driven by hybrid production (and... the salt/hybrid 8-chip version?)
All flex circuits in production.
Electronics: started production.
Rest of project is progressing well. (sensors, staves, cooling, integration, software).
Detector halves *could* go underground in ~Mar 2020 and ~Jul 2020

Online luminosity and beam monitoring

Reminder: satisfy needs of beam/background and online luminosity monitoring

→ Workshop on 7 June: https://indico.cern.ch/event/824952/

- Summary at last LHCb week: few interesting proposals were shown

→ Since then, set out a lightweight strategy to review proposals:

- Write up a specification document (LHCb-INT-2019-xx). Out ~next week.
- Use the template for opportunistic experiments at LHCb
  https://edms.cern.ch/ui/#!master/navigator/document?D:100350541:100350541:subDocs
  - Ask proponents to fill up document (ongoing)
- Present the findings to the TB (maybe October already?)
  - Heinrich Schindler and F.A.

→ RMS and Quartz Counters under way.

✓ More proposals are welcome and encouraged! Don't be shy!

→ BCM consolidation also under way (see Martin's presentation)

LHCb feedback I

LHCb highly appreciated the work of the Run 3 machine configuration WG

- High quality output that made us confident in reaching our goals in Run3
- Many of LHCb's requests were taken in consideration
  - LHCb thanks the LHC colleagues for this.

LHCb supports the statement of "exploiting Run3 not only for performance but also as a full scale demonstrator of the HL-LHC …"

- But at the same time aiming for a high performance reach in Run3
- LHCb will collect whatever amount of luminosity will be given to…
  - ✓ Your "reach" is our "reach" (or maybe our goal…? ☺)

Few topics still under discussions

- Leveling in 2021
- Type of filling scheme
- Vertical crossing angle
- Luminous region evolutions/variations
- Energy

LHCb feedback II

Leveling in 2021

- OK not to be able to fully level at 2×10^{33} for most of the year

Type of filling scheme

- LHC strongly prefers pure BCMS filling scheme
  - Anything else will result in a loss of colliding bunches
- However, if needed, LHCb accepts to go for a mixed scheme
  - Keep μ homogeneous across bunches → level to average pileup.

Vertical crossing angle instead of horizontal crossing angle

- Request still stands: PPWG still worried about the effect that difference between + vs – magnet polarity (LHCb-PUB-2019-001)
  - Much more evident effect at higher luminosity than in Run2
  - Can help with leveling to keep LHCb leveled throughout full fill
  - Can help with luminous region sizes (wrt to + polarity)
- We understand this needs work/investigation
  - Willing to sacrifice (some) time in 2021 to allow LHC to commission and try out such solution during the recommissioning phase to be tried in 2021

LHCb feedback III

Luminous region evolution/variation

- Studies from PPWG still ongoing: no conclusive results yet
- Evolution during the fill does not seem to be considered an issue
- Still studying if luminous region size <37mm can be a problem
  - Currently, there is indication that this is a problem that can be dealt with
  - Major issue is the asymmetry + vs – polarities in PV mis-association
    → more studies ongoing and to be presented

Energy

- LHC neutral with respect to energy value for Run 3
  - 7 TeV (globally) less of an impact for LHCb
  - Some additional physics can profit from 7 TeV, but collecting statistics has higher priority
- We support the idea of trying to train magnets in 2021
  - Willing to sacrifice time in 2021 to allow LHC to try to reach 7 TeV
  - Request not to spend sizeable amount of time in 2022(or 2023)
  - LHCb can use this extra time to complete new detectors commissioning

On the path to preparing Run3

Many options on the table, that needs discussion, addressing and active proposals:

- What value of μ do we want to run at in 2022/2023?
- What value of μ is it desirable to run at for the EM(TF) in 2021?
  - Is it acceptable to run at a changing μ ? Or shall we choose two values and level the fill at two values of luminosities (two blocks).
  - What is the maximum acceptable value of μ before we can horribly degrade our basic reconstruction performance?

- What battles do we pick and do we choose them? (i.e. we can't fight them all…)
  - Fill length won't seem to be an issue thanks to higher protons-per-bunch
  - V xing angle still on the table, can help with asymmetries and variations
  - Bunch-by-bunch must be measured, is it impacting us? If so, by how much?
  - Mixed scheme gives us ~10% less colliding bunches
    → this may hurt but better than not taking data...

→ Input from all experts is paramount

- EMTF + commissioning needs your input!
- Especially when we will get beams again...

Small guide for intepreting LHC messages

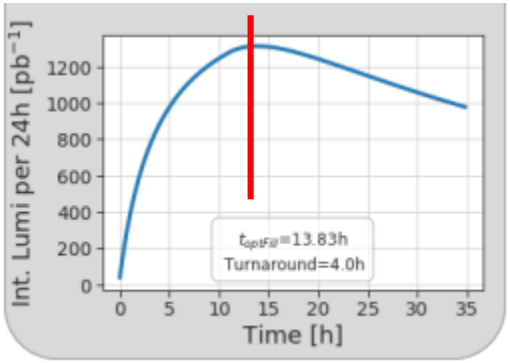
i.e. how to get Run3 running conditions right

The LHC should be available to accept **a max bunch population of:** $N_b = 1.8 \times 10^{11}$ppb

	2021	2022
# bunches	Up to 2748 (BCI	
ϵ_n [μm]	1.3	1.3
N_b [10^{11}p]	0 →1.4	1.4 →1.8

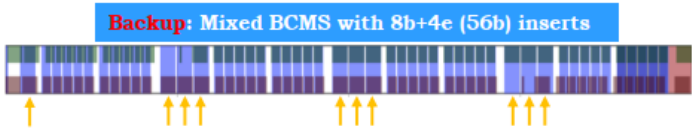
Cannot level at 2x10^{33} cm^{-2} s^{-1} for full fill until end of 2021 and ok in 2022-2023

Fill length will be ~10-15h in Run3!



Lumi levelling at $2.0 \times 10^{33} Hz/cm^2$ in LHCb over the full fill length only if Nbunch @ Start of Fill is:

Emitt 2.5um (1.8 um)	LHCb pol – [770 urad]	LHCb pol + [330 urad]
BCMS [2376 b]	~1.4e11 (1.25e11)	~1.15e11 (1.05e11)
Mixed scheme [2131 b]	~1.5e11 (1.35e11)	~1.3e11 (1.2e11)



240 bpi,
2484 collisions in ATLAS/CMS,
1949/2131 in Alice/LHCb

10.3% less collisions at IP8 compared to pure BCMS scheme

We may have to face lower # of colliding bunches and we won't know until we get to ~full machine

Small guide for intepreting LHC messages

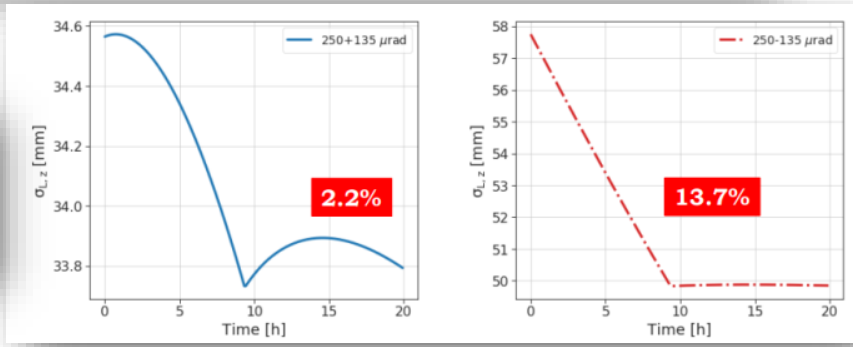
i.e. how to get Run3 running conditions right

- Studies ongoing to check the feasibility of operating with **V xing angle in IR8**, while maintaining the flexibility of internal polarity flip (without machine re-validation).
  - Challenging beam-beam interaction wise and parasitic encounters during optics gymnastics along the cycle.
  - May be included in LHC commissioning and may even require some MD time.

V xing angle still on the table but needs to wait until 2021 – cannot sign off yet

- With a lumi BbB rms spread of ~25% (60% peak to peak) after 10h (intensity effect). **Levelling** will be based on **average pileup**.

- Longitudinal luminous region evolution in IP8:
  - SMOG2 upgrade and the improved ***beam imaging*** could be an interesting tool also for the special machine studies. For emittance growth studies investigate also the possibility of ***emittance scans*** in IP8 for the first year when L_{max}<2E33.
    - Bunch by bunch instantaneous luminosity over DIP is highly appreciated.



Running conditions may evolve significantly over the course of a fill and if we don't monitor it we won't be able to negotiate changes

(yet another) red flag: from the LHC

(probably this slide doesn't have enough red on it...)

LHC mostly concerned with variations in luminous region and bunch-by-bunch lumi (pileup)

→ Leveling for ATLAS/CMS

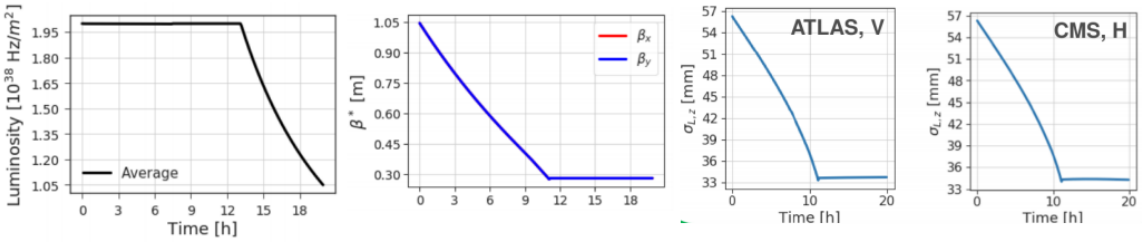
→ Follow-up needed and feedback appreciated

→ Must measure bunch-by-bunch to monitor the effect

Feedback for Run-3 pp Planning?

5

- Still open questions still related to luminous region
  - Large size variation foreseen, particularly IP1/5, leading to varying pile-up density even if pile-up remains constant
    - Will this give problems? Do we need to limit variations?
  - Maximum/minimum allowed longitudinal size?



- Impact of large bunch-by-bunch luminosity variations?
  - With luminosity leveling, pile-up spread could grow during fill
    - What would be impact on trigger performance & data quality?
  - Ilias will show latest studies from machine side on Run-2 data

- A general growth of up to **20% RMS** observed for the BCMS fills of 2018, mainly due to fluctuations in the **bunch intensities**.
  - The maximum spread for the bunch luminosities goes up to **60%** for a sizeable fraction of the bunches in the fill, typically for the ~10 head bunches of the trains

Online luminosity and operation

Last minute added slide: luminosity

Online luminosity is the most important tool with which we operate our experiment!

→ Luminosity leveling is at the basis of our operational stability

- Unknown or wrongly measured running conditions (μ) means unknown working points for trigger, monitoring and operational aspects
  - Eventually more work down the line…
- New injectors will try to deliver more bright beams
  - Varying bunch-by-bunch
  - Emittance measurement will be fundamental (emittance scan or other)

Last LHCb Week

Stability of LHCb luminometers in Run 2

https://indico.cern.ch/event/821917/contributions/3459014/attachments/1865714/3068678/lumi_balagura.pdf

Critical person-power

~ 1.2 FTE on collider lumi in LHCb (0.2 Rosen + 1 VB)

BGI discontinued

3 years PhD term finished in March

From an operational point-of-view these are not good news!
Please come forward and try to contribute!

92° LHCb Week, 21/06/19 F. Alessio, CERN

BGI, BBI abandoned, only vdM calibration:

Most difficult vdM systematics:

- non-factorizability, solution: 2D scans (unique to LHCb, others will follow)
- orbit drifts: DOROS BPM (excellent precision) + special mini-scans
- beam-beam (B*B confirmed with COMBI; required and in my TODO: simulate beam-beam in 3 other IPs)

Propagation to physics

problems with CALO lumi counter instabilities, missed online during Run 2

Plan to finish Run 2 pp this year and switch to Run 3 next year.

No expertise in new HLT / monitoring / FSR core software, need training and help from others.

Critical situation and high risks due to lack of personpower and difficulties in knowledge transfer: no promises beyond 10% lumi precision in Run 3 pp.

If you need 10% or better, you are very welcome to the lumi group!

For a moment, nobody working on Run 3. Beam Gas Imaging is abandoned (currently, without hopes to resume). In Run 2:

- vdM calibration (∼ 2% after finishing orbit drifts + beam-beam)
- propagation to physics (large problems).

Vladislav Balagura(LLR, CNRS, Ecole Polytechnique, I The most precise LHCb absolute measurement LHCb week, 17 Sep 2019 2 / 15

This impacts everything!
→ operations, monitoring of running conditions, offline analysis, data taking, relation with LHC!