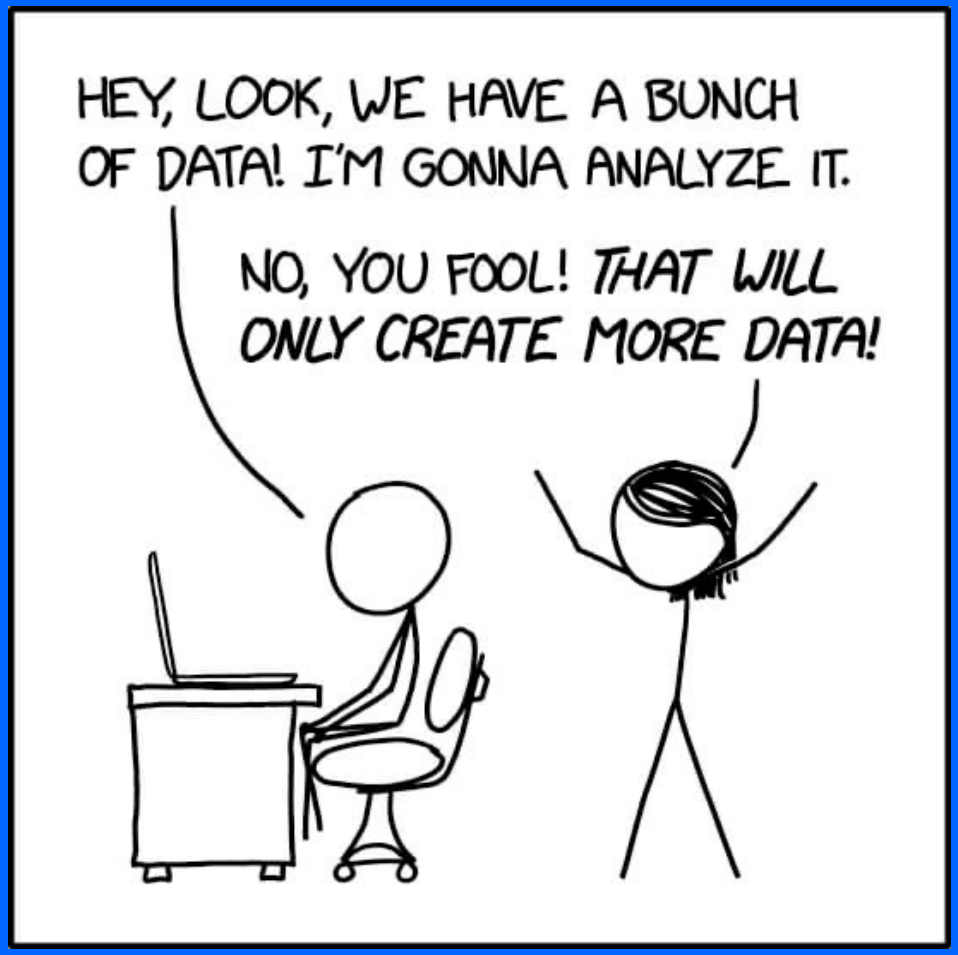
LNF-CS1 meeting

10 March 2022



https://xkcd.com/2582/

Status of LHCb Upgrade

Barbara Sciascia
(INFN and CERN)
on behalf of Frascati LHCb group

INFN
Istituto Nazionale di Fisica Nucleare
LABORATORI NAZIONALI DI FRASCATI

CERN

CSN1 – febbraio 2022

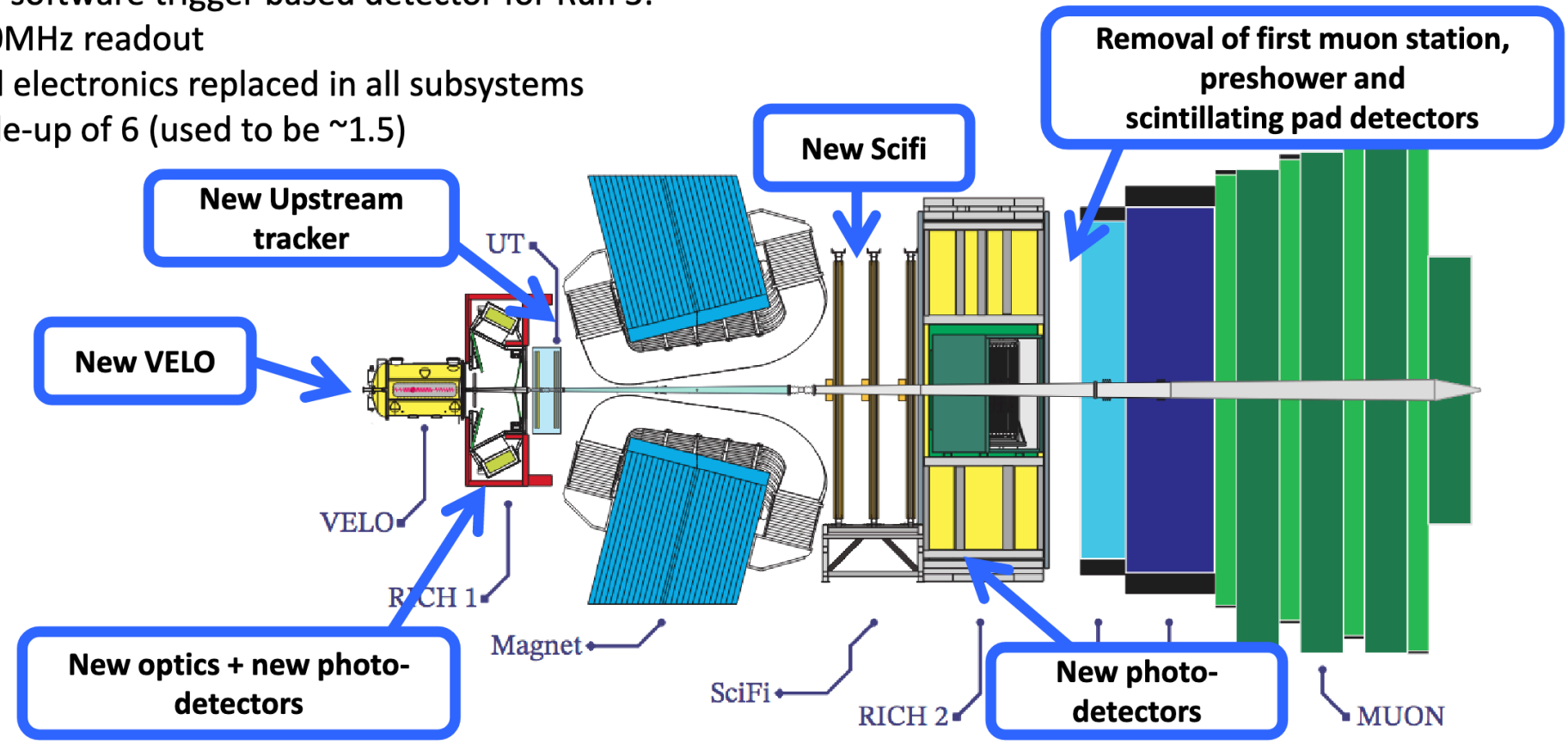
Alcune slides dalla presentazione di Vincenzo Vagnoni (RN LHCb) all'ultimo meeting della CSN1
[https://agenda.infn.it/event/29269/contributions/148830/attachments/88445/118463/CSN1%20febbraio%202022.pdf]
Informazioni anche dalla sessione aperta dell'LHCC di ieri
[https://indico.cern.ch/event/1126938/contributions/4729989/attachments/2404342/4112792/LHCC_LHCb_032022.pdf]

Approfondimenti su
- attività con coinvolgimento diretto del gruppo di Frascati
- ultimissime notizie

LHCb Upgrade

New software trigger based detector for Run 3:

- 40MHz readout
- All electronics replaced in all subsystems
- Pile-up of 6 (used to be ~1.5)



New data center
Trigger-less readout
SW only trigger on GPU (HLT1) and CPU (HLT2)

[B. Sciascia]

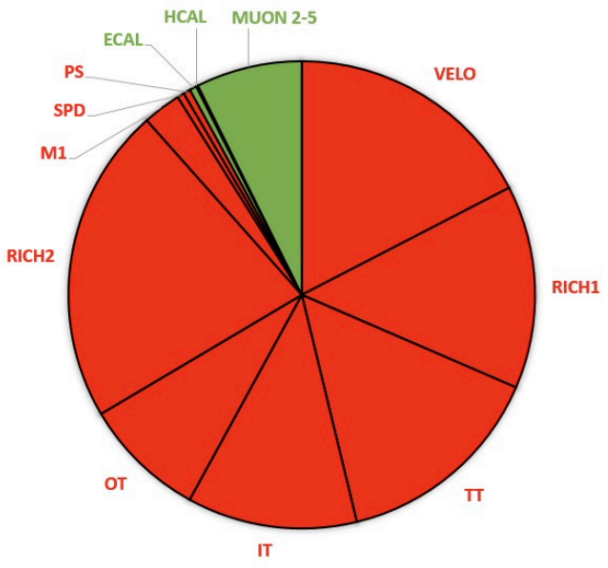
Reminder: rivelatore LHCb Upgrade I

To be removed/replaced

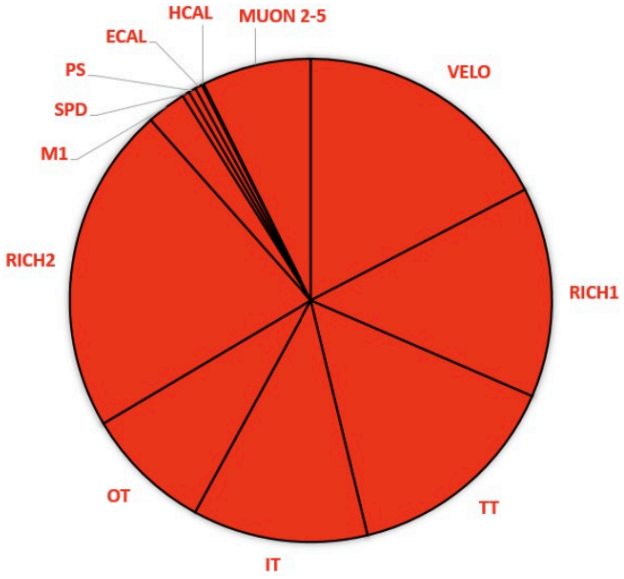
To be kept

- Mantenuto meno del 10% dei canali del vecchio rivelatore
- 100% dell'elettronica di R/O rimpiazzata
- Nuovo Sistema di DAQ e nuovo data center

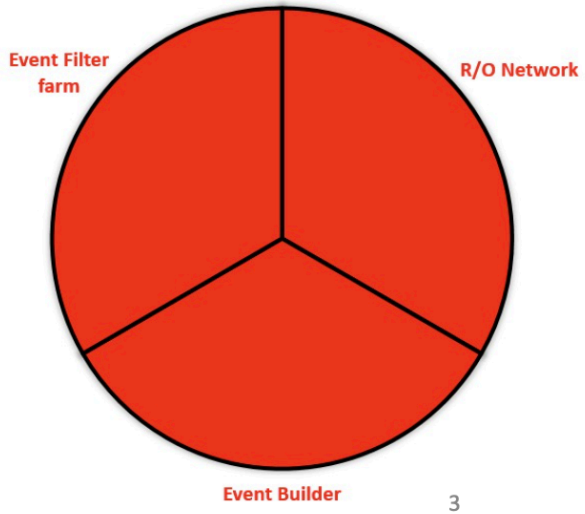
Detector Channels



R/O Electronics



DAQ



3

[B. Sciascia]

Stato di SMOG2

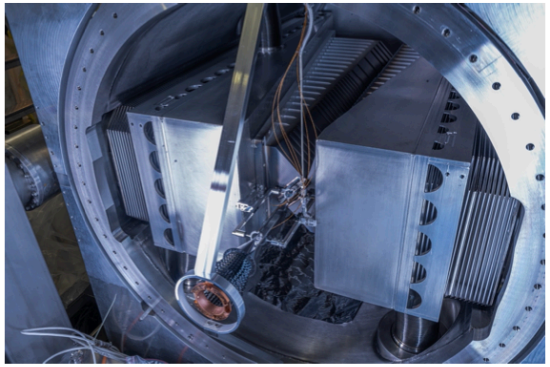
- Per la prima volta a LHC, collisioni *pp* e *p*-gas andranno in parallelo con varie tipologie di gas

$H_2, D_2, N_2, O_2, He, Ne, Ar, Kr, Xe$

iniettabili a fine Run

nessuna limitazione

ok iniezione
flusso max in fase di definizione



- Storage cell installata già nell'agosto 2020
- Sistema lettura termocoppie installato in settembre 2021
- Gas Feed System terminato e calibrato in laboratorio
  - Istallazione in caverna è prevista nella settimana del 7 marzo
- Monte Carlo *pp* + *p*-gas in sviluppo, pronto per presa dati
- Metodo misura luminosità in sviluppo: incertezza <3%
- Sistema monitorato durante l'LHC test beam di ottobre 2021
  - Tutto ha funzionato perfettamente, sia localmente sia come feedback da LHC
- SMOG2 pronto per Run-3

Muon system and its upgrade at LS2

Muon detector has performed exceptionally well in Run 1 and Run 2 of the LHC.

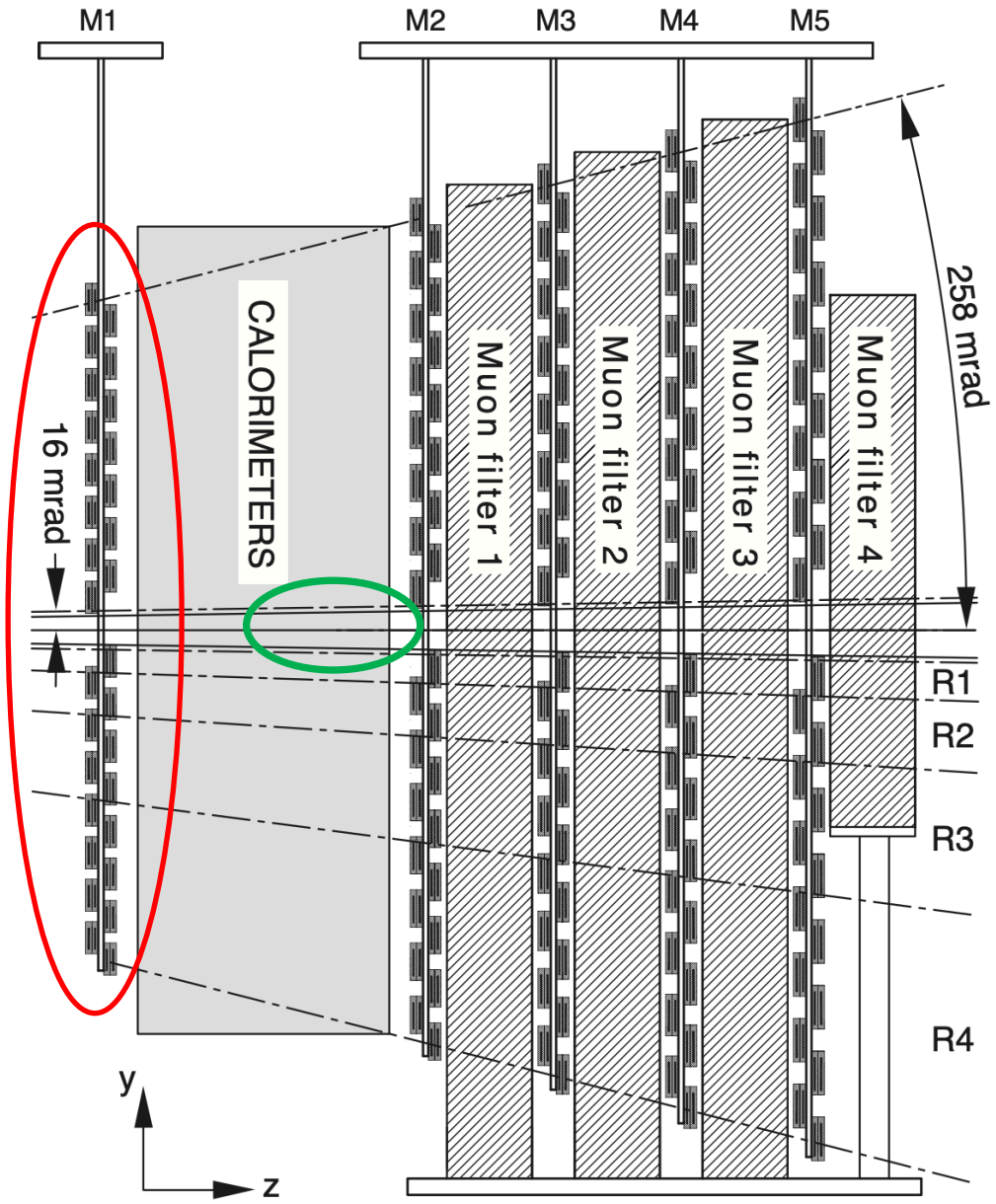
Main changes for the Run 3:

- **removal of M1 (done at the beginning of LS2)**

- **installation of a new shielding in front of the inner region of M2**

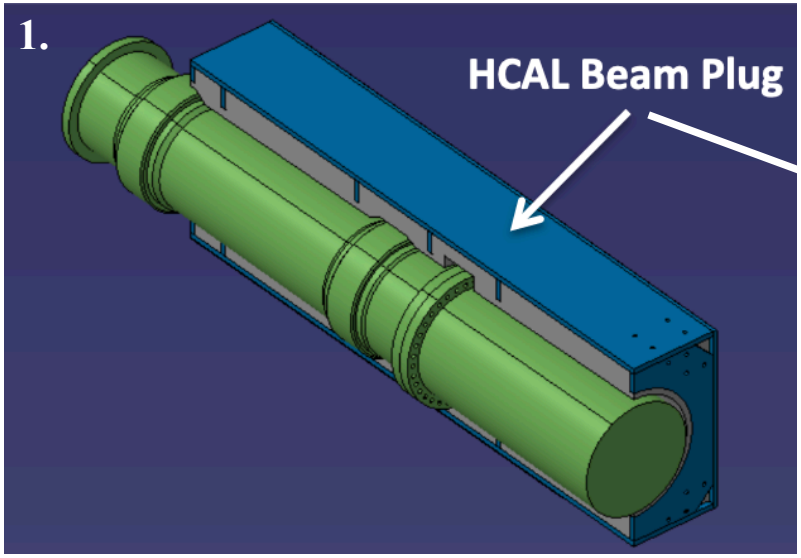
- **redesign of the off-detector electronic**

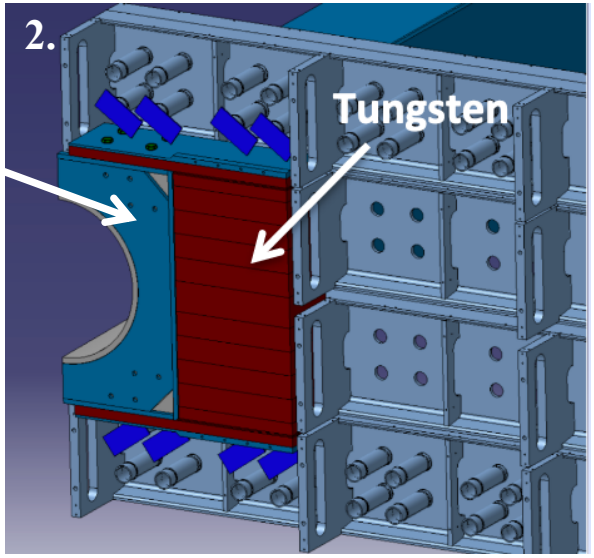
Detectors (MWPC) will stay until the end of Run 4; a few new pad chambers in preparation to be installed at LS3 in inner regions (M2R1, M3R1, and M2R2).

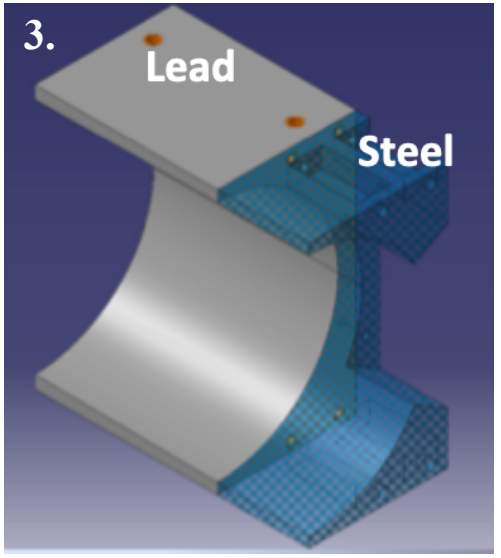


Additional shielding in front of M2

[CERN + Ferrara + LNF + Technical Team]







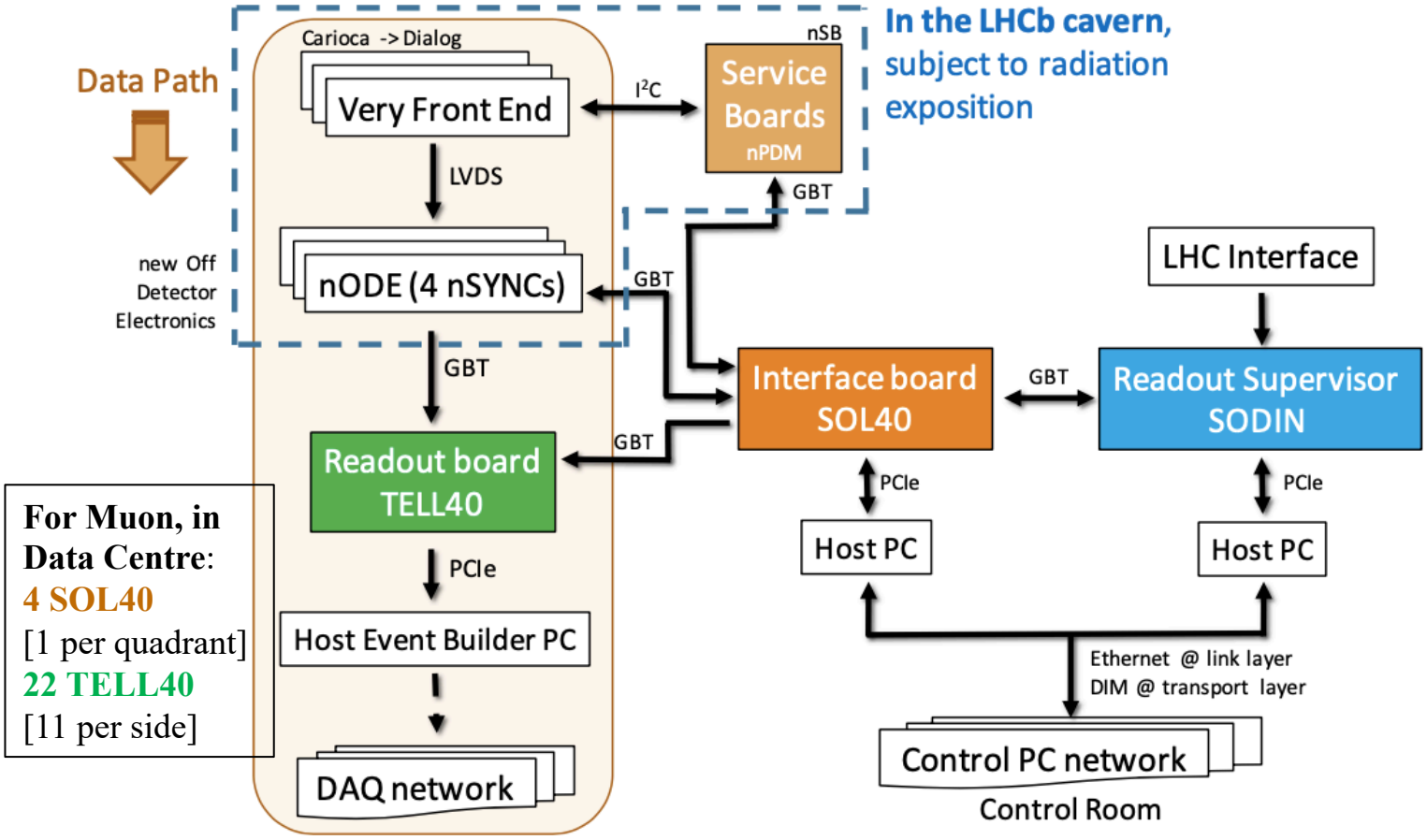
1. **New HCAL beam-plug** lead in a steal carcass;
2. **Additional shielding** (tungsten) in place of PMTs of the innermost HCAL cells;
3. An **improved M2 beam plug,** identical to the old one, but partially made of lead.

1) and 2) done in 2020
3) done in 2021

Commissioning - readiness

[Cagliari, CERN, Ferrara, LNF, PNPI, Roma 1, Roma 2]

Chambers and very FE: all ok; working on residual ~100 problematic channels out of 100k
LV, HV, Gas, Temperature: all projects ready and tested during LHC test in October
FE electronics (ECS and DAQ): all new boards (nSB, nPDM, nODE) tested and ready
Monitoring: rewritten from scratch; tested during LHC test; to be deployed in the Online cluster



[Muon - B. Sciascia]

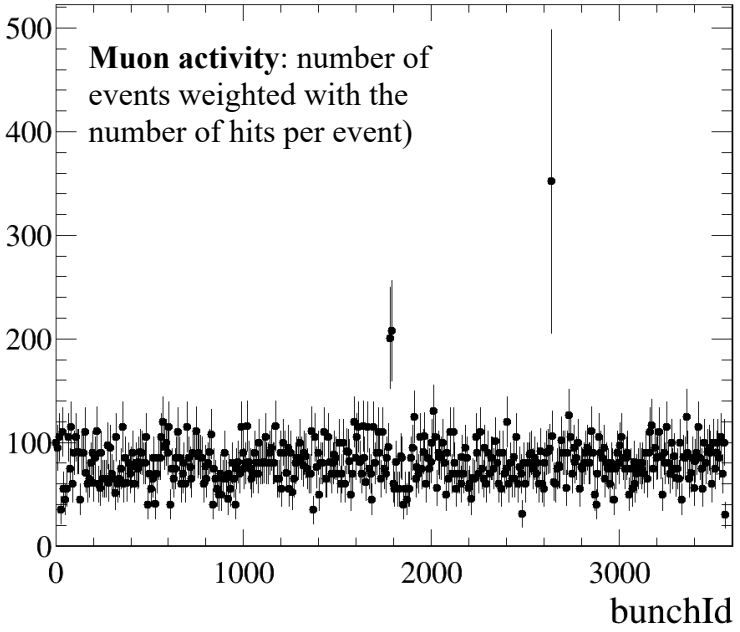
Muon System during LHC October test

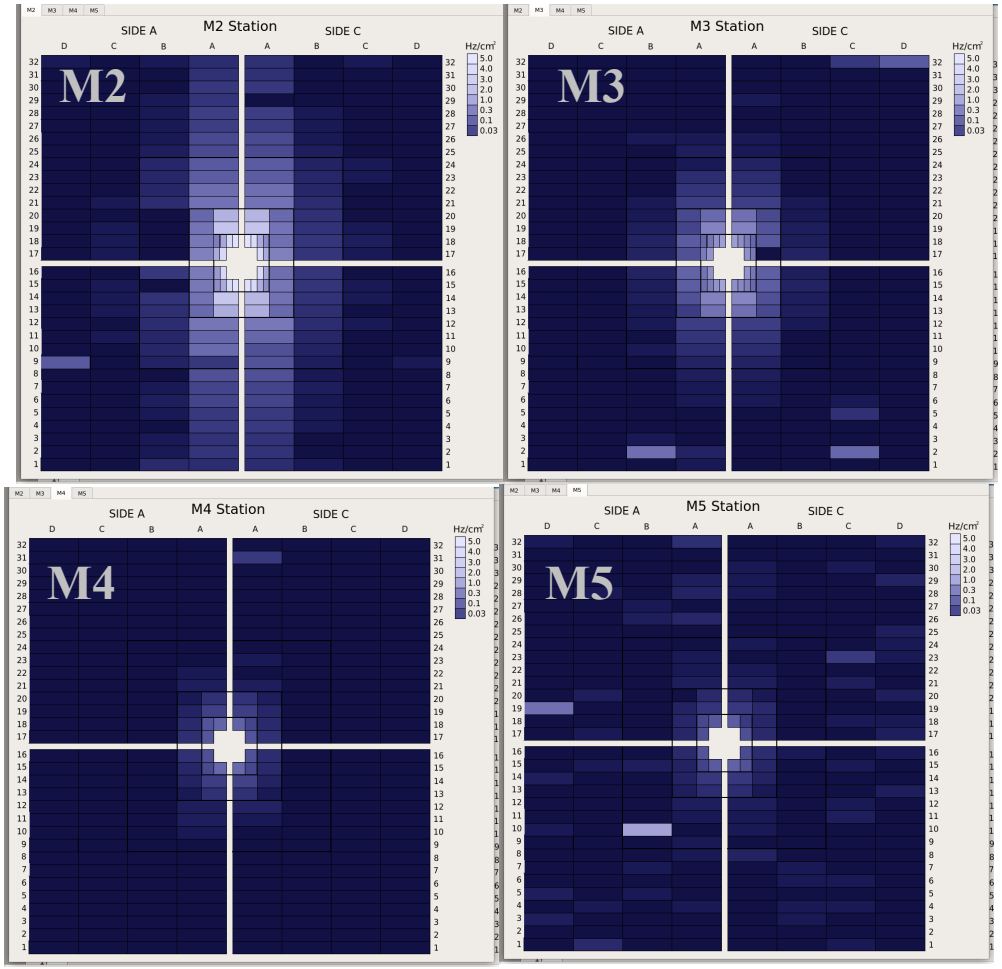
[Cagliari, CERN, Ferrara, LNF, PNPI, Roma 1, Roma 2]

Detector worked perfectly as well as the ECS, some more effort to have DAQ running

- very useful to define next tests and qualifications (Muon time-aligned to LHC clock)

No show-stopper for a smooth Commissioning towards Mar 2022





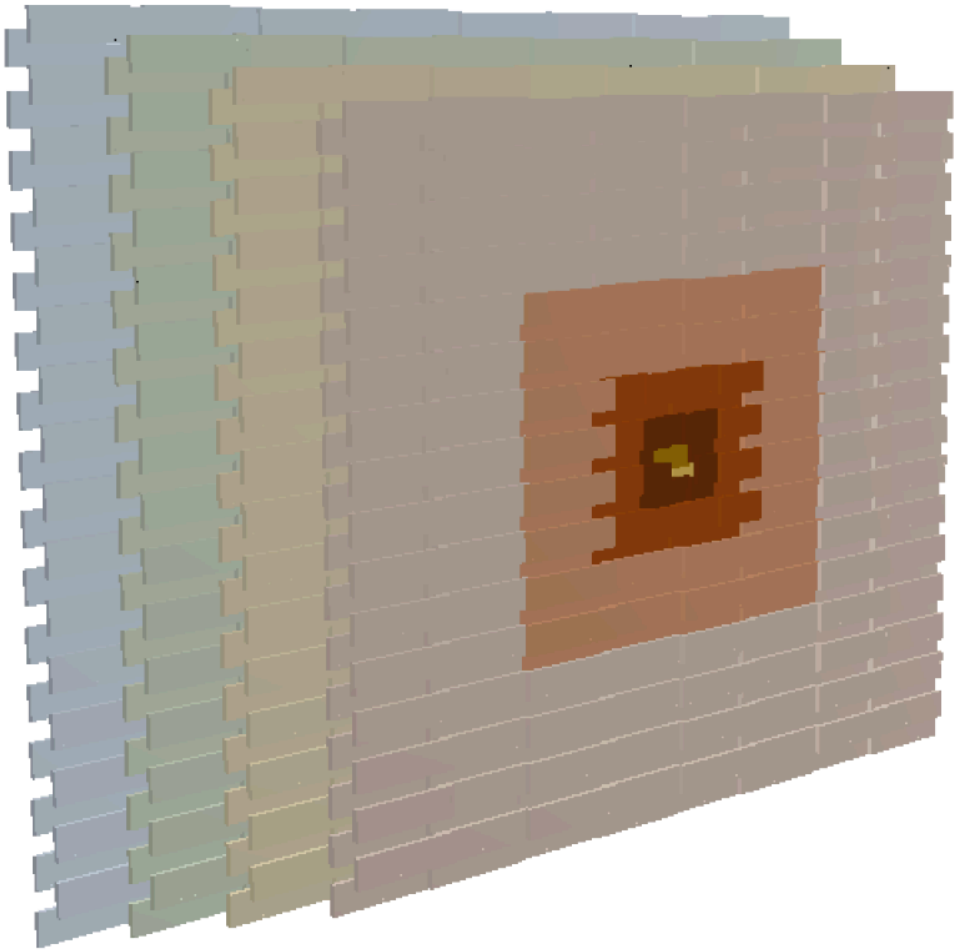
Muon **M2 and M3 station "sees" that the Calo is a bit open** (about 15 cm from both sides of the BP): horizontal chamber dimensions magnify the effect; M4 and M5 - screened by the Muon filters - see the "expected" activity around IP

[Muon - B. Sciascia]

Software and simulation

[Barcelona, Bari, Cagliari, Ferrara, LNF, LPNHE, Roma 1, Roma 2, Yandex]

A lot of effort to update Run 1 - Run 2 Muon software to Run 3 detector and environment.



RTA (tight time constraints in HLT):
- HLT1 runs on GPU
- HLT2 runs in CPU

Detector alignment

Muon Identification algorithms

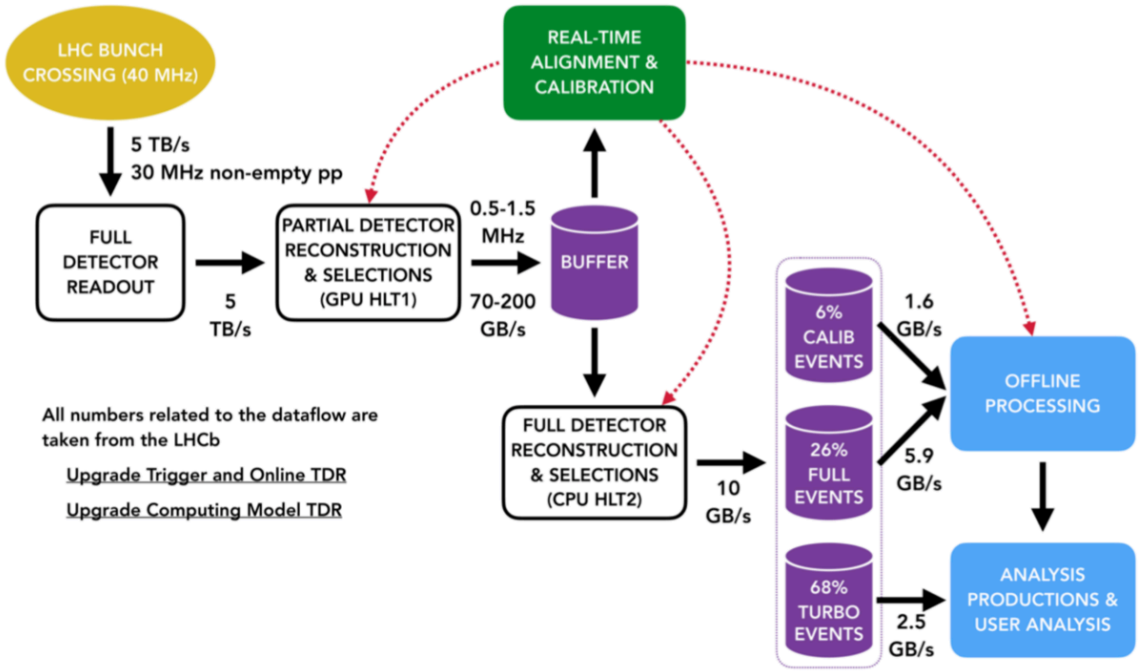
Monitoring of detector and reconstruction

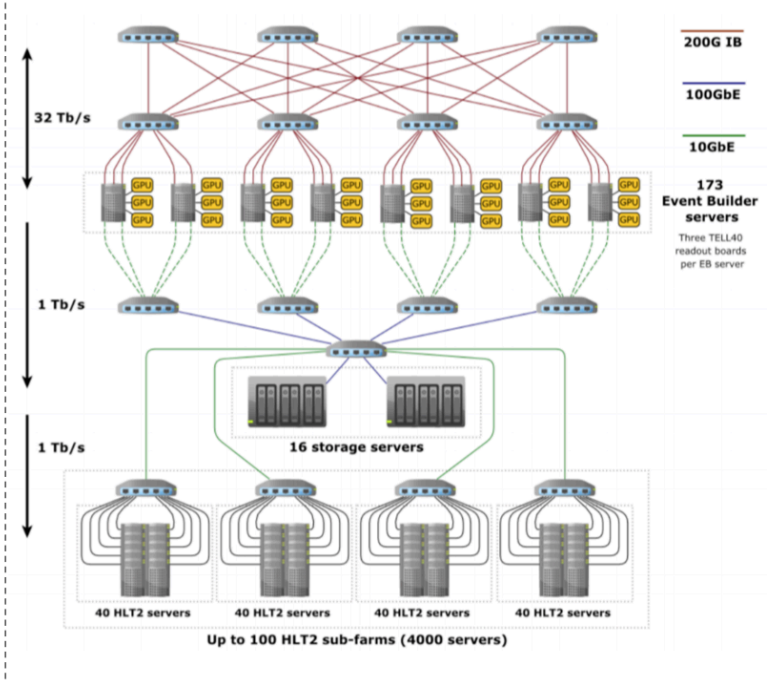
Raw data decoding and MC encoding (readout cabling description largely changed)

Detector description: no more M1, new beam plugs/shielding, + porting of the geometry in DD4HEP

Simulation:
- Modelling of detector response: Low Energy Background, Spill over
- Future (Run 4 and beyond): Iron wall [to replace HCAL], FEE performance

Trigger, DAQ e Online





Online: In corso di finalizzazione prima della chiusura della caverna

- Check end-to-end delle fibre ottiche dei FE dei rivelatori
- Rimozione del vecchio network utilizzato in Run1 e Run2
- Connessione degli elementi di controllo dei rivelatori e test
- Installazione dei server (nel nuovo data center in superficie) e del nuovo network
- Stess test di tutto il sistema

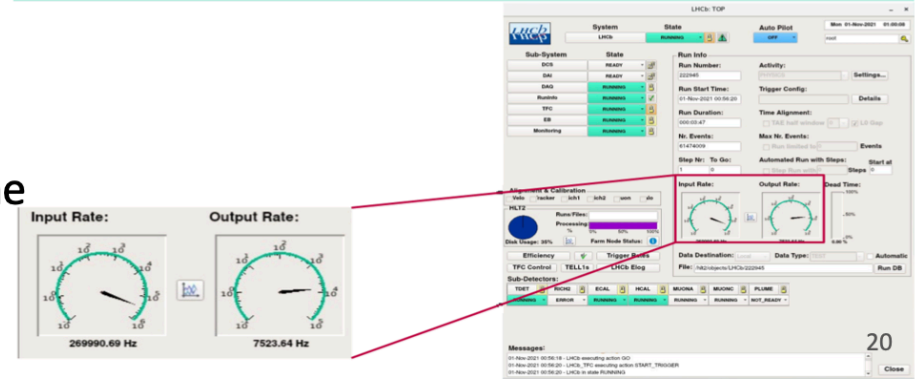
[B. Sciascia]

Stato della Real Time Analysis (RTA): trigger HLT1

- 200 Nvidia A5000 GPU board acquistate
- Raggiunta una rate di 30 MHz con ~178 board in condizioni di data taking nominali
- Integrazione in DAQ/ECS pronta per la validazione
- Una novità saranno le selezioni semi-esclusive $K_s\pi\pi$, K_sK_s , K_s+X, Λ_0+ X, etc non disponibili in Run-1 e Run-2: esempio concreto dell'aumento di efficienza di trigger in canali adronici grazie alla rimozione del trigger hardware (L0)
- Si sta lavorando alacremente per ottimizzare il tracciamento senza UT, in attesa dell'istallazione completa del rivelatore a fine 2022
- HLT1 è sostanzialmente pronto

Test HLT1 effettuato durante il Pilot Run di ottobre 2021

- Dati da RICH, CALO e MUON
- Cruciale per verificare tutta la catena con dati reali (inclusa la gestione di condizioni di errore)



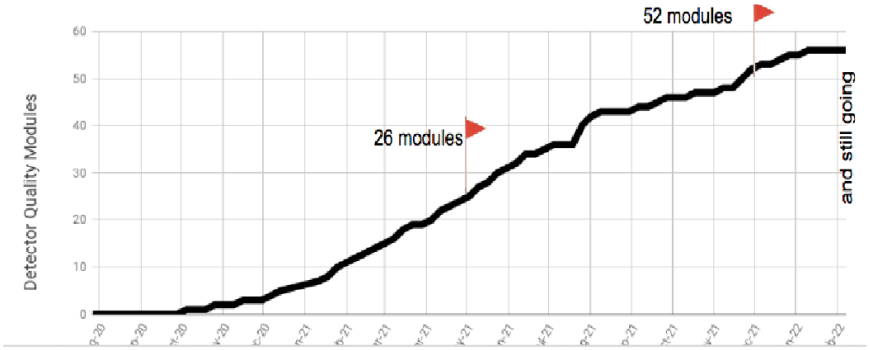
[B. Sciascia]

VELO

- Side C safely arrived at CERN end of January: no connection or bond wire lost in transport
- Detailed inspection, testing and fixing of last issues performed at CERN
- Installation of side C performed March 1-2

  → Commissioning launched:

  scans, calibrations, clustering, tracking, closure
- Assembly of side A being completed
- Shipping for side A scheduled for April



[B. Sciascia]

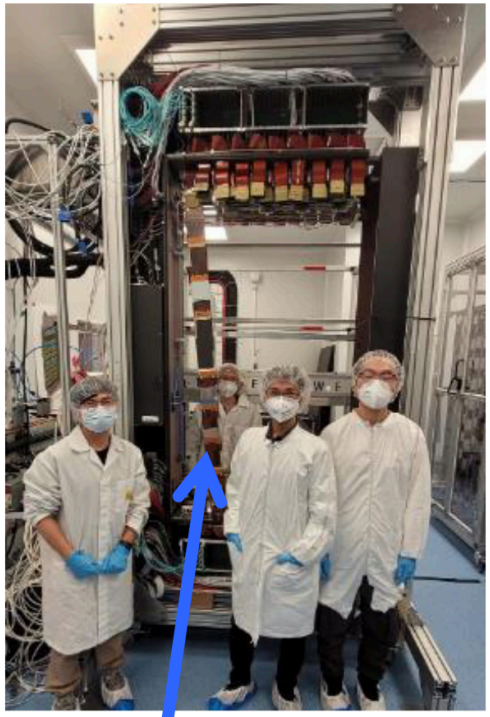
UT

Decision taken in December not to install before cavern closure:

- Complete Service and Mechanics before cavern closure
- Requested installation of first side in September
- Installation of second side during YETS

Status:

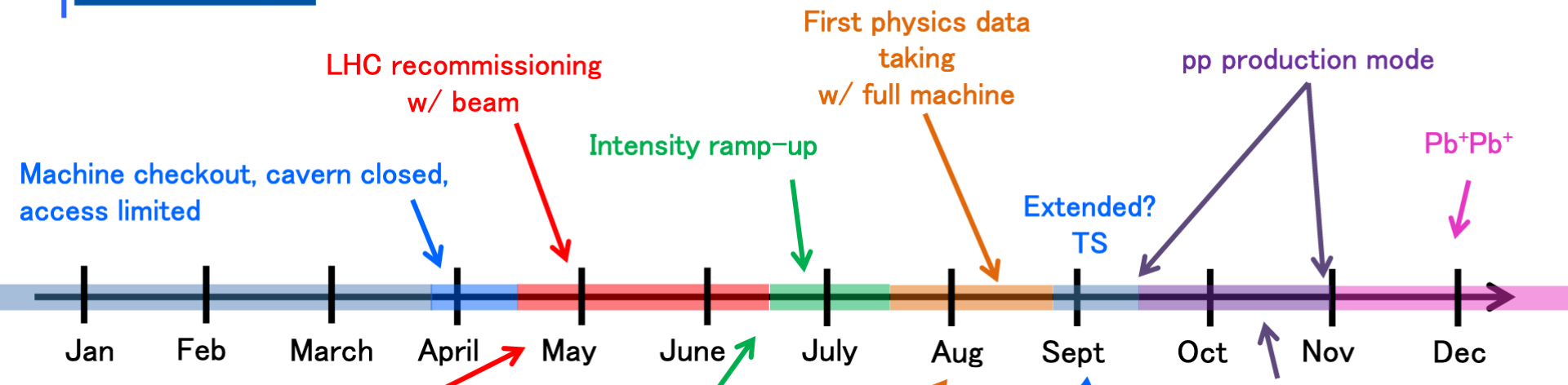
- All staves produced
- Most staves arrived at CERN
- Assembly started on the surface, first stave in UT installed
- Test installation of empty UT side last week



[B. Sciascia]

The LHCb 2022 plan for data taking

*as of March 2022



Global commissioning with trackers (VELO+SciFi), using SMOG2 and early collisions -> profit from scheduled and unscheduled accesses/stops

Record first early data and use its physics output to validate full detector chain

Aim at collecting good 500pb^{-1} of pp data in autumn, leveling at <= 1x10^{33} to and pushing μ to nominal value for short periods to collect datasets for winter work
Local commissioning in // of half UT

Validate trigger + online infrastructure with first Stable Beams and perform first fine tuning of new detectors (timing, calibration, spatial alignment, scans, early data taking)

Technical Stop is critical:

- Utilize it to implement short-term changes and fixes
- Installation of UT (partly) is very important as it will allow to advance local commissioning work with beam that otherwise would need to be done in 2023, affecting LHCb's global efficiency.

[B. Sciascia]

Prestazioni trigger e ricostruzione senza UT

- Studi preliminari alla luminosità nominale di $2x10^{33}$ $cm^{-2}s^{-1}$
  - Ma nel 2022 si livellerà a $1x10^{33}$ $cm^{-2}s^{-1}$ per la maggior parte del tempo

HLT1: -50% in throughput

First results with 1k events $B_s \to \varphi\varphi$

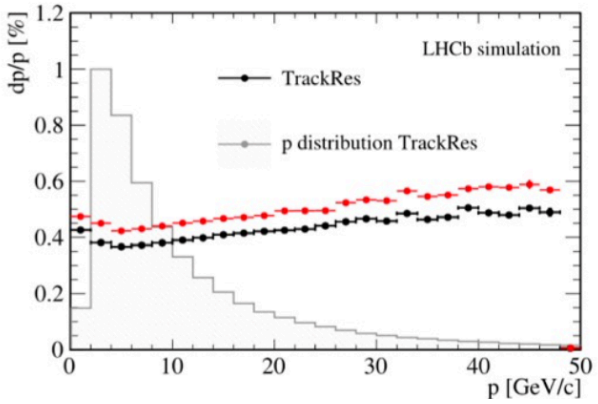
- Requiring tracks with P > 5 GeV and PT > 1 GeV
- Throughput measured on Tesla V100 GPU (nominal A5000 card has ~ 170kHz)

	Hlt1_pp_default	Hlt1_pp_noUT
Efficiency long	90.64%	76.31%
Efficiency long from B	91.46%	81.07%
Ghosts	3.24%	7.98%
Throughput	140kHZ	99kHz
Hlt1TrackMVA	(19.6 ± 1.2)%	(21.6 ± 1.3) %
Hlt1TwoTrackMVA	(30.3 ± 1.4)%	(28.4 ± 1.4)%

HLT2:

- No downstream tracks (senza hit nel VELO)
  - Penalizzazione ricostruzione per grandi lunghezze di volo, leggi: K_S, Λ
- Risoluzione sull'impulso degradata del 15-20%
- Effetti su efficienza di tracking e ghost-track rate non significativi

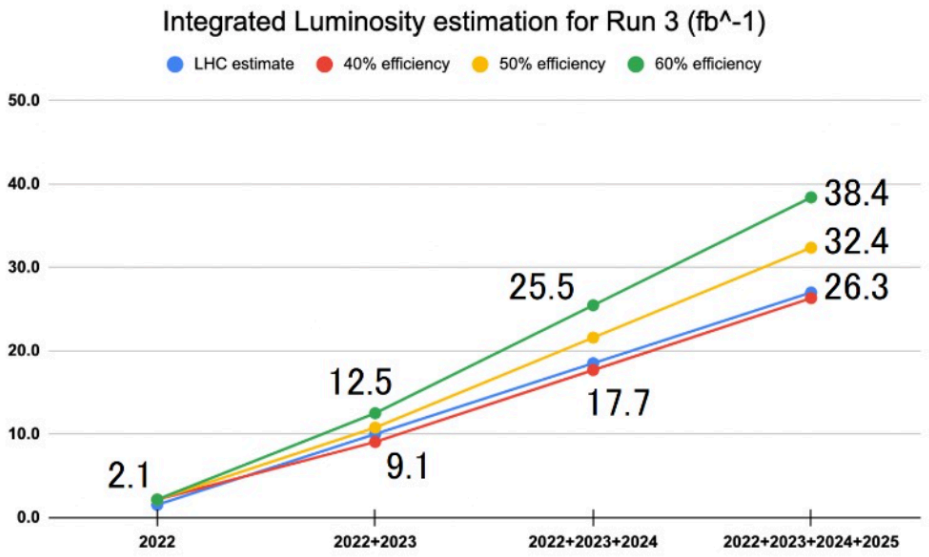
Momentum resolution



[B. Sciascia]

Luminosità attesa da LHCb

- La stima della macchina di 26 fb^{-1} per tutto il Run 3 è conservativa
  - Corrisponde ad un'efficienza totale durante il Run 3 del 40%, mentre ad esempio nel 2018 si raggiunse il 56%
  - Considerando un'efficienza tra il 40 e il 60% ogni anno, si arriva ad una forchetta tra 26 e 38 fb^{-1} a fine Run 3

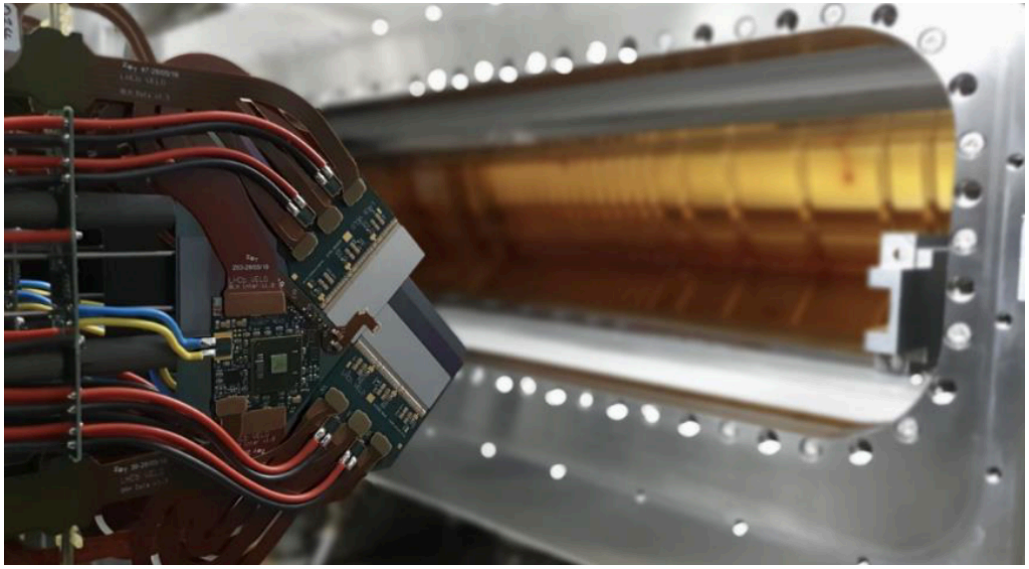


- Per il 2022 comunque si stima una luminosità limitata, circa 2 fb^{-1}
  - Anche per dire che non ci si attende che i ritardi dei rivelatori, in particolare UT, limitino in maniera significativa il reach di fisica del Run 3

[B. Sciascia]

Conclusions

For the months ahead LHCb is looking forward to the challenge of commissioning the entire readout and trigger, and soon, the completion of the VELO installation and the UT.



[B. Sciascia]