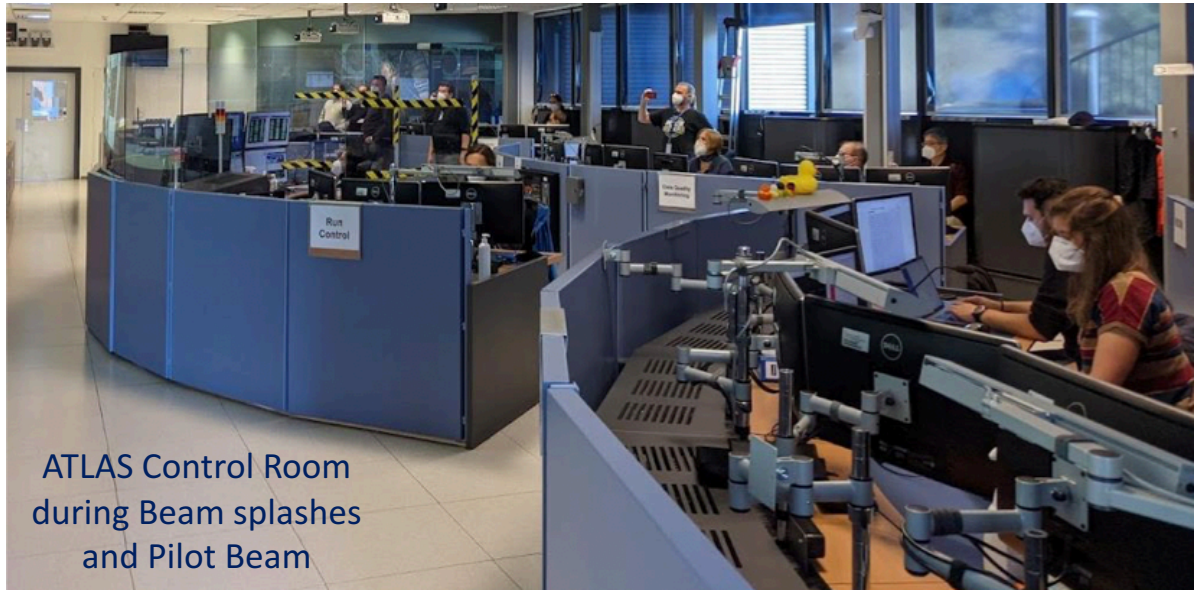
Highlights da ATLAS

Chiara Arcangeletti on behalf of the ATLAS-LNF Team

Riunione Gruppo 1 LNF, 10 Marzo 2022

Introduction

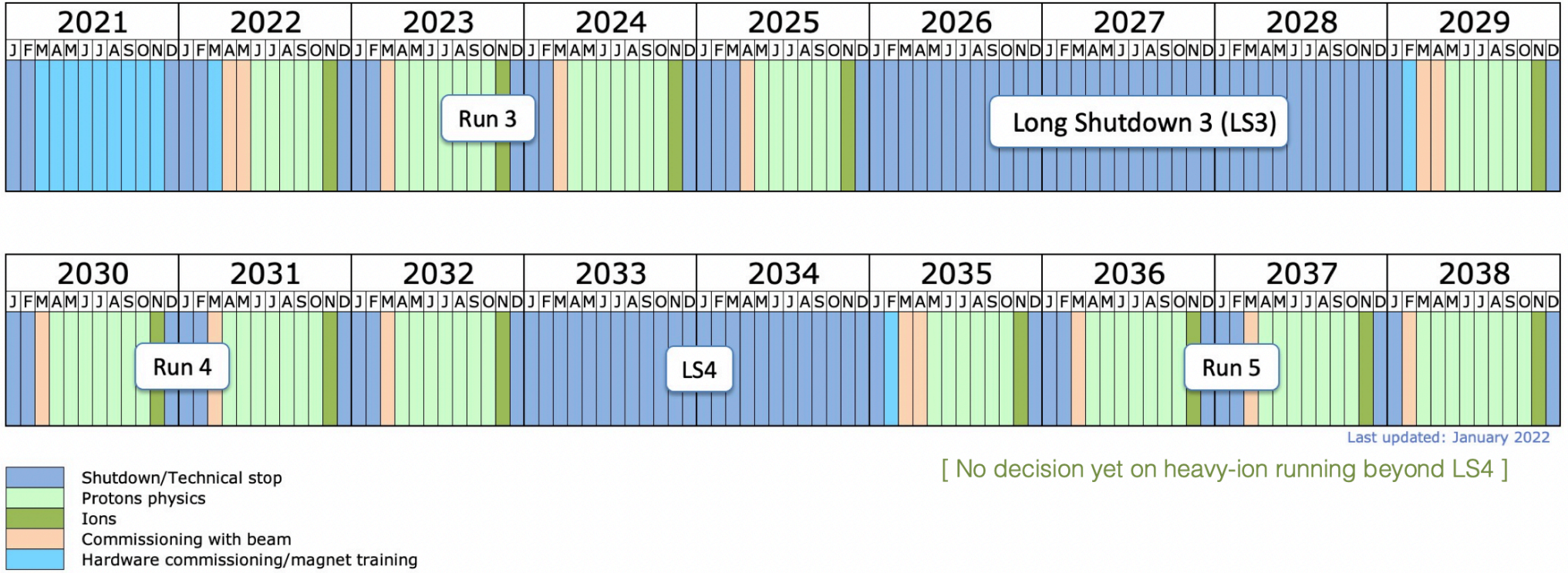
- Highlights from meeting CSN1 on February 2022
  - Inputs from:
    - *ATLAS: Partenza Run 3* (Paolo Iengo)
    - *ATLAS: Aggiornamento Fase 2* (Paolo Morettini)
  - Overview of all ATLAS Activity
    - LUCID
    - TDAQ
    - Pixel
    - LAr and TileCal
    - Muons
- Focus on LNF Activity
  - New Small Wheel
  - Phase II Upgrade:
    - ITk
    - Muon Phase II



ATLAS Control Room during Beam splashes and Pilot Beam

Schedule - LHC

CERN directors confirmed LS3 & Run-4 schedule update

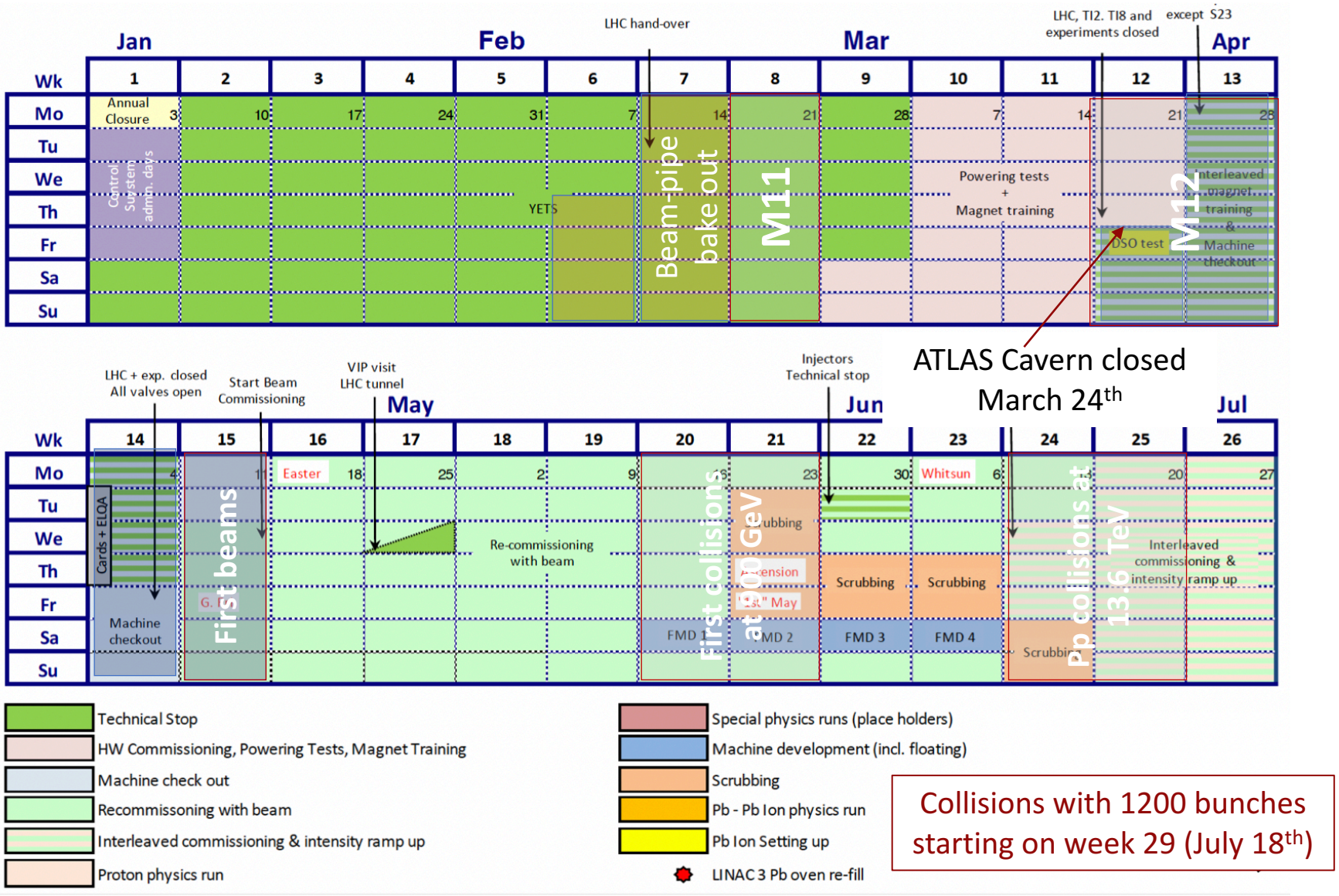


[No decision yet on heavy-ion running beyond LS4]

- Longer term of Run3 → Physics from June 2022 to Nov 2025
- Possible to achieve 100 fb^{-1}/year if machine succeeds to inject 1.8×10^{11} protons/bunch (baseline 1.4×10^{11} protons/bunch → ~85 fb^{-1}/year)

ATLAS: from LS2 to Run3

- 10 Milestone weeks held in 2021
  - Show that all systems can run at high rate in ATLAS
  - Re-integrate all legacy systems, integrate Phase-I ones
- Beam splashes and Pilot beam run in Oct. 2021
  - Interaction with LHC restored
  - Full shift crew in ACR
  - Expertise before Run 3 start up rebuilt
- Work on-going and plans:
  - Beam-pipe bake-out started on 10th Feb.
  - Magnets on track to rump up to nominal current
  - Plan to take Cosmic run with toroid off for Muon Barrel alignment March 25th – April 13th

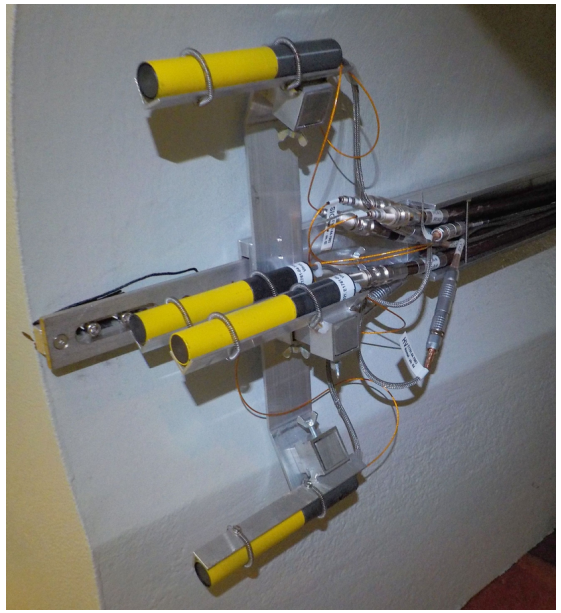


Collisions with 1200 bunches starting on week 29 (July 18th)

LUCID

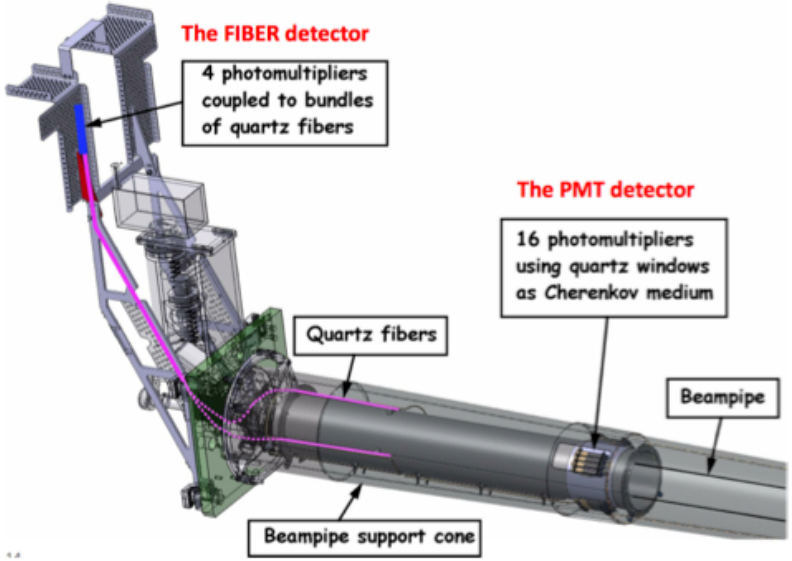
Run 3….

- LUCID refurbished with new PMT
  - All tested and working
- FIBER detector installed
- Status and schedule
  - LUCID connected on both sides. All connection verified

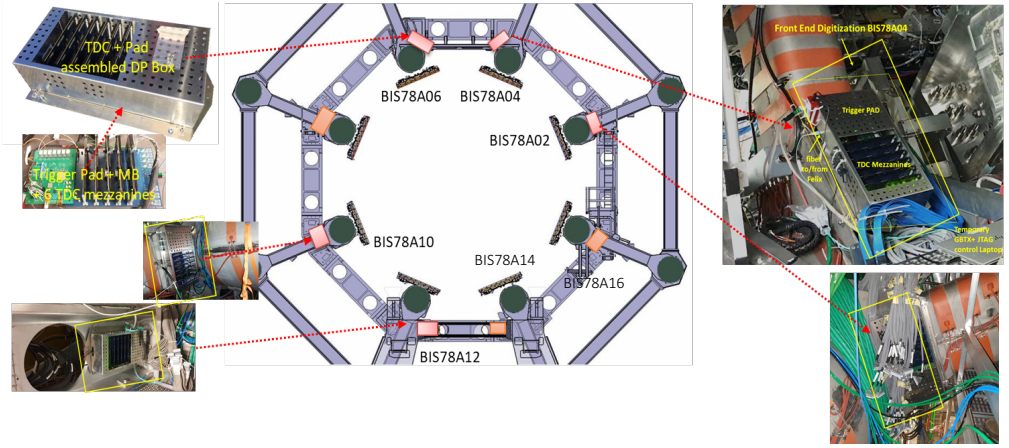


…Phase II

- Initial design report completed and approved
- Study of the prototype for Phase II during Run 3
- Looking for more person power

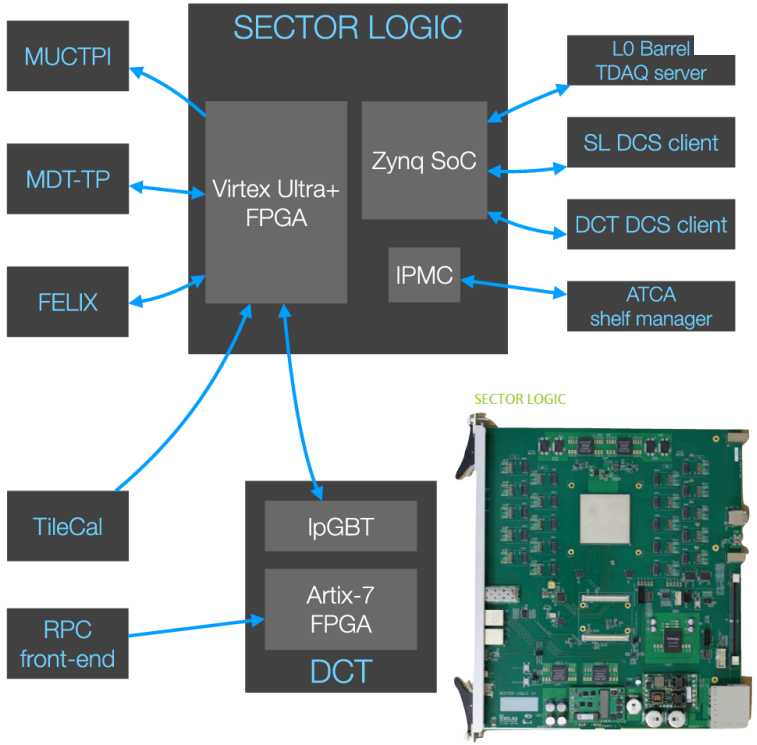


TDAQ



Run 3….

- Operations: dataflow updates already validated in 2021
  - Hardware replacement: several on-going, aim to be completed in few weeks
  - Software and readout upgrades completed
  - Two TDAQ technical runs before beginning of operations: TR21 (7-11 February successfully completed) and TR22 (7-11 March)
- Muon-TDAQ
  - MDT and RPC: Basic DAQ software ready
    - TDAQ equipment (PAD+TDC) for all the 8 BIS78 sectors is installed and connected → aim to join M12
  - New SL2MUCTPI Interface boards
    - Completion of commissioning and calibration in 2022
    - Few experts, involvement and training of young colleagues is difficult
  - L1 Muon Barrel legacy system
    - OK during Run2, needs to be verified for Run3: ageing limitations and new calibrations needed



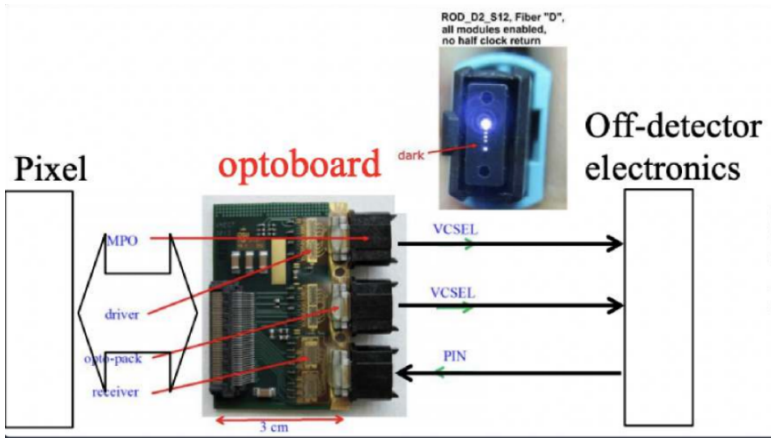
…Phase II

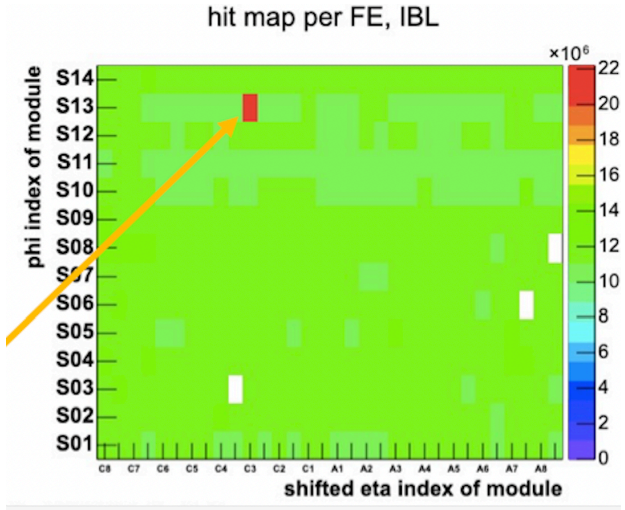
- New DCT board and SL
  - Prototype produced in 2021
  - 2021-2022: test, firmware, radiation hardness certification

Pixel

Run 3….

- Main LS2 activity: optoboard reparation
- Pixel during Pilot Beam Run
  - Hit-on-track efficiency measured (comparable to Run2)
- Improved offline software ready
- DQ Monitoring working
- DCS in good shape

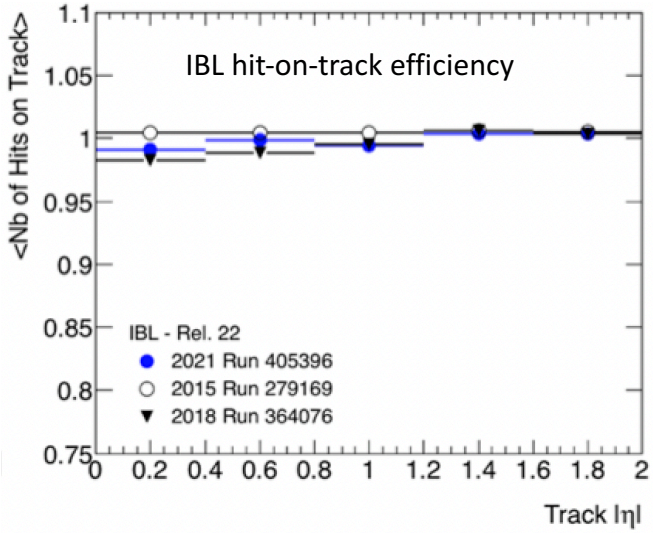




1-2 new noisy pixel modules identified during pilot run

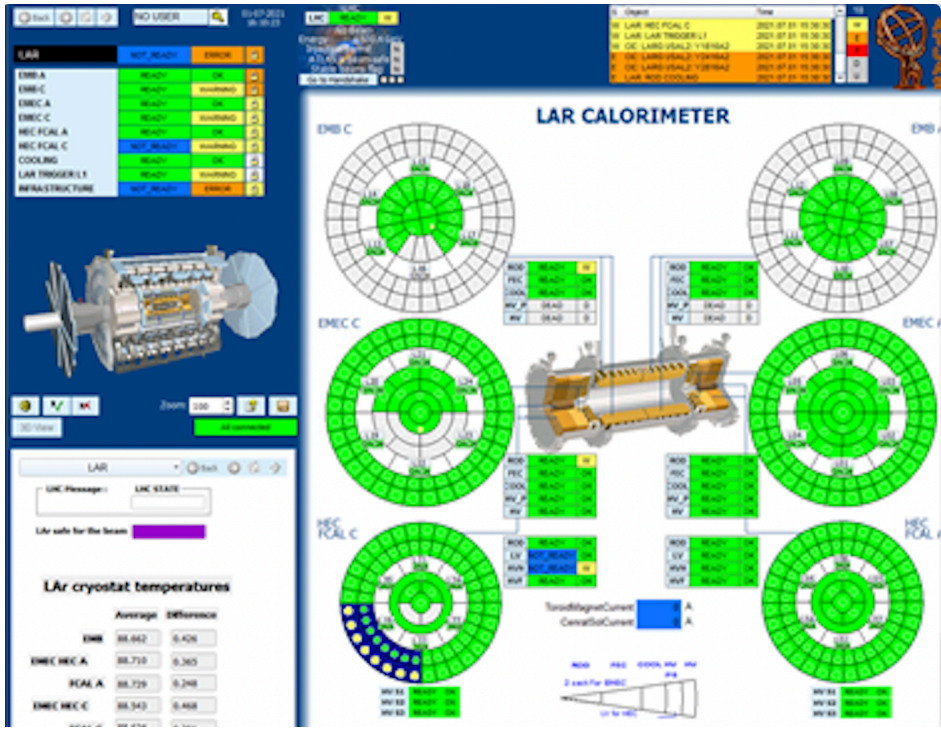
Longevity concerns for extended Run3

- IBL (installed during LS1) not a concern (x5 more rad-hard than ‘old’ pixel system)
- Radiation damage: B-layer mostly concerned
  - With the extension of Run3, the B-layer will hit the fluence spec limit (currently at 50%) → Possible reduction of the hit-on-track efficiency
  - The Pixel group is constantly monitoring the effects of radiation damage with cosmics during LS2 and has developed mitigation strategies (HV and threshold tuning)



…Phase II →new **InnerTracker ITk**

Calorimeter: LAr and TileCal



Run 3 LAr….

- Installation and re-cabling of the system completed in August 2021
  - Some hardware interventions (board/fiber replacement, cooling maintenance,…)
- Large commissioning/recommissining activities in the past months
  - All front-end readout boards modified
  - New trigger needs to be commissioned
  - Legacy trigger needs to be recommissioned
- The system was successfully operated during 2021 Milestone Weeks and with pilot beam

…Phase II LAr

- New power system for the Front-End electronics
- Working on Slice Test Board mezzanines for FEB2

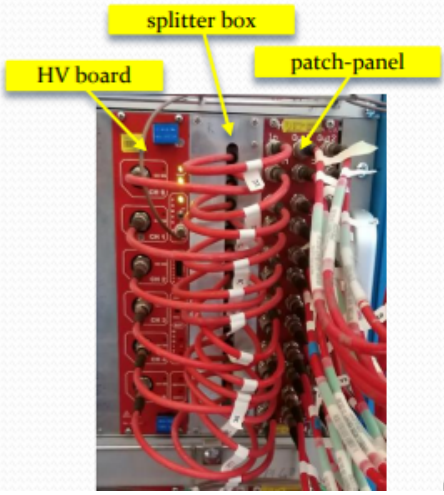
Run 3 TileCal…

- Maintenance and consolidation work mainly on cooling and calibration with Cs source

…Phase II TileCal

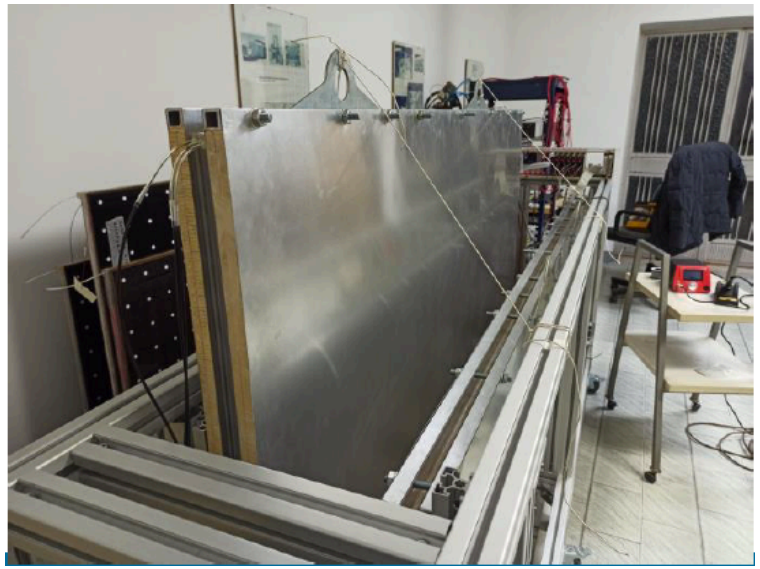
- Italian contribution in:
  - Test the new PMT that will replace 10% of the current → PRR in November 2021: success!
  - New laser calibration system

Muons



Run 3…

- Pilot beam run in October: most of MDT and RPC chambers ON (final gas mixture and full HV), RPC sending triggers consistent with collisions and cosmics
- Quite intense last months of LS2 to finish with all the cavern activities
- Preparations for the 2022 Muon shifts on the way
- **HV recommissioning**: installation of the HV power supplies for channel doubling of BO chambers is done except for BOF12 and BOF14
- **RPC Gas system**: installation of 1168 no-return valves (1 valve per output line) needed to reduce leak rate from newly broken inlets → Activity close to completion
- **RPC BIS78**
  - Stations of side A installed
  - Gas provided with a secondary gas system
  - All HV sectors tested
  - All LV systems successfully installed
  - DCS software overall in good shape



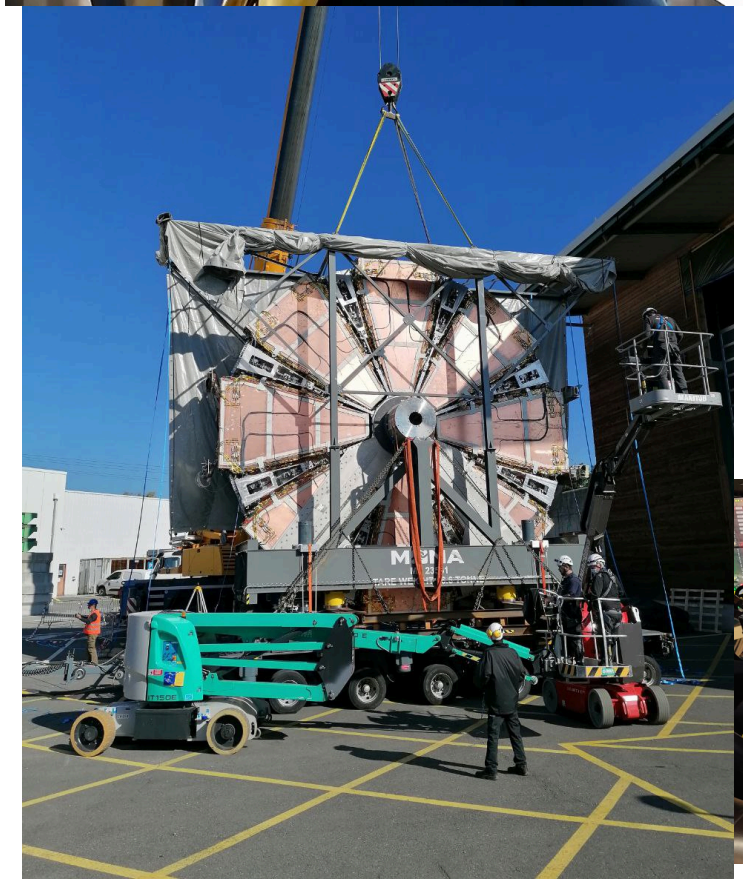
…Phase II: INFN commitments

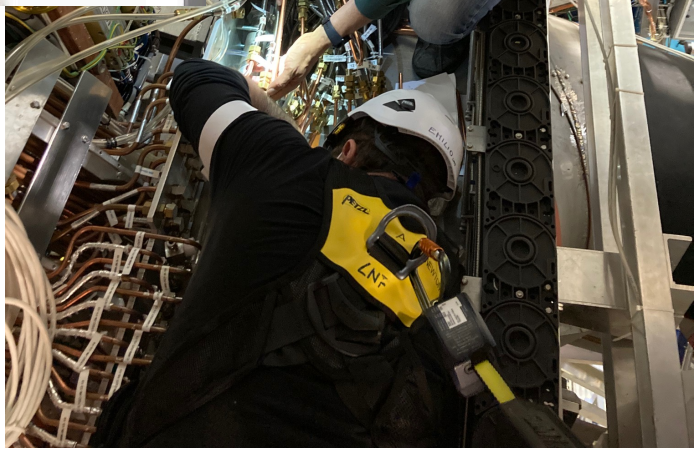
- BI Chambers
  - New 300 RPC triplets to increase trigger acceptance
  - New FE electronics
- BIS78-Side C installation
- Full replacements of the RPC trigger and RO electronics
- Replacement of the power system

Phase I:
New Small Wheel Activity

NSW General Status

- **NSW-A installed on July 12, 2021**
  - in run position since Jan 13, 2022
- **NSW-C installed on Nov. 9, 2021**
  - in run position since Jan 26, 2022
- Micromegas
  - Connectivity OK and cooling tuned
  - Both wheels are under gas since their installation in the cavern with HV on as much as possible
  - Baselines and calibrations are acquired continuously to monitor the evolution
- Joined the ATLAS partition during pilot beam run with 1 sector (not during stable beam collisions)
  - Stability issues observed with Felix and OPC server
- Main news from CSN1
  - Able to run with 1 sTGC sector during M11 for 2-3 nights (crash in the end, so still stability issues)
  - From yesterday: also an MM sector integrated!





LNF responsibilities for NSW

M. Antonelli as **Project Leader**

Work @ LNF

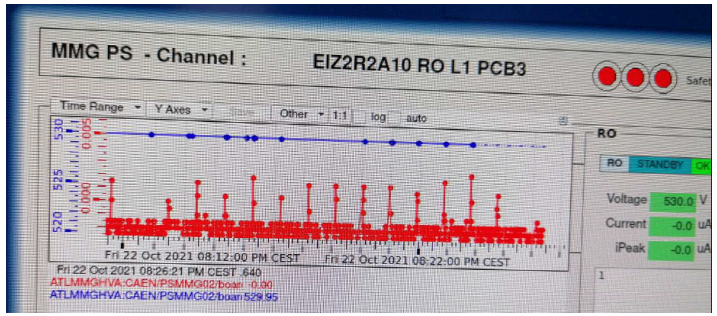
- Assembly of the 36 final SM1 Modules ended in 2020

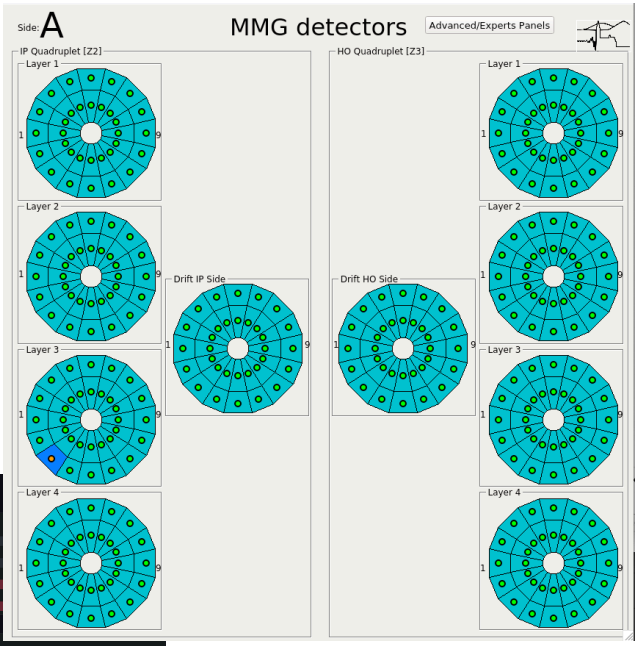
Work @ CERN

- Integration of the modules into MM-sectors @ BB5 (HV Team: G. Mancini (resp.), C. Arcangeletti et al.)
- Cosmic Ray Stand on modules @ BB5 (G. Mancini (resp.), C. Arcangeletti, E. Capitolo)
- Hospital Facility (M. Antonelli, C. Arcangeletti (resp.), E. Capitolo, S. Cerioni, S. Lauciani, G. Mancini, B. Ponzio and G. Pileggi)
- Installation and commissioning of the MM @ B191 (G. Mancini (coordinator), C. Arcangeletti (HV resp.))
- MM Commissioning @ P1 (M. Antonelli (coordinator), C. Arcangeletti (HV resp.))
- Services installation (E. Capitolo, B. Ponzio and G. Pileggi)
- Task Forces:
  - New gas mixture with Isobutane (M. Antonelli, G. Mancini, C. Arcangeletti)
  - Elx noise problem (B. Ponzio, P. Albicocco)

MM Commissioning

Splashes during Pilot Run!!!



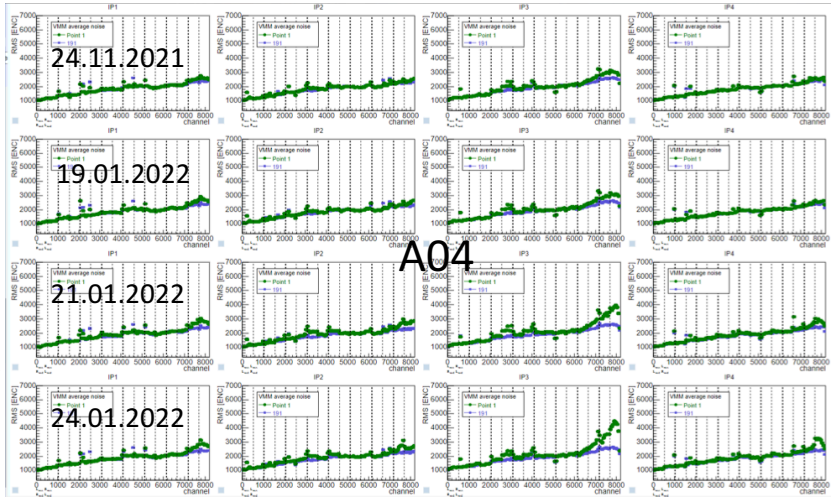


High Voltage

- All channels connected except 4 sections (1 section = ½ of the 2048 total channels)
  - 2 known from surface commissioning, 2 new just after installation
- HV test done with both $Ar:CO_2$ and $Ar:CO_2:iC_4H_{10}$ gas mixtures
- HV continuously on (at operating voltage) with $Ar:CO_2:iC_4H_{10}$
- HV DCS ready and working
  - Some functionalities under development + debug from users ongoing
  - Definition of FSM transition thresholds and alarm to be implemented
- HV (I and V) Monitoring with Grafana (new within Muons)

Electronics

- System ok all FE boards (MMFE8) working
- Integrated into the DCS
- 4 LVBD not working (0.78%)
  - 3 known from surface commissioning, 1 new
  - All on A-side, none on C-side
- Noise increase observed on NSW-A, after the movement and later, now stable
  - Several sectors affected, particularly A04, A05, A07, A09, A11. Investigation ongoing



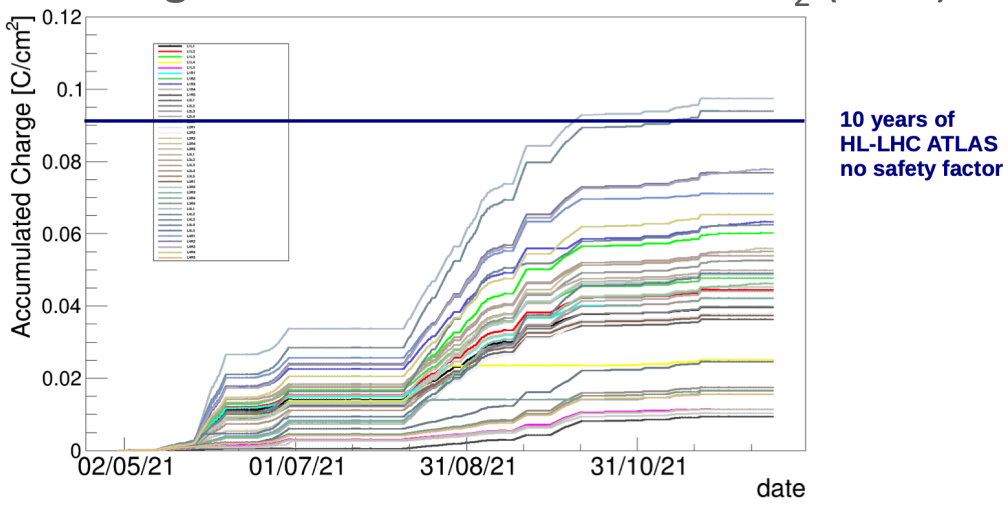
Micromegas: gas mixture enriched with Isobutane

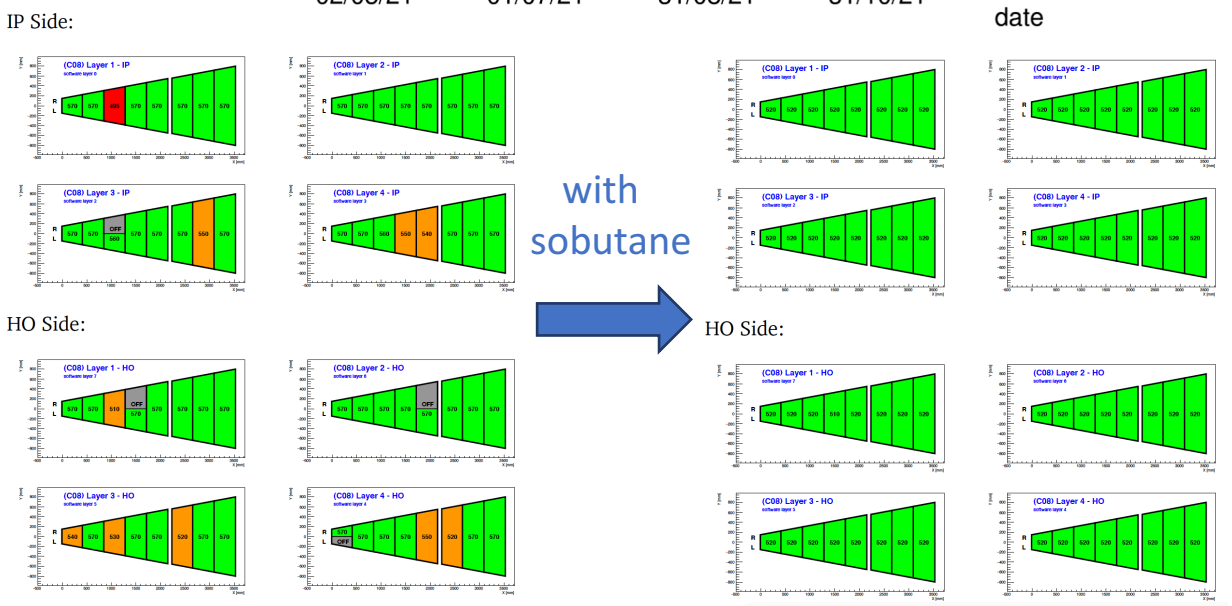
- Gas mixture Ar:CO_2:iC_4H_{10} (93:5:2) allows to run at lower amplification voltages wrt to the nominal Ar:CO_2 (93:7) to reach better performances

  → Unstable HV sections behave better with the Isobutane enriched mixture

Several activities ended/on–going to study the performance and the ageing effects

- Ageing studies
  - GIF++[1] long term studies to reach an accumulated charge compared with HL LHC
    - Some HV sections accumulated >10 years of HL–LHC!
  - Test with neutron sources @ LMU (Munich)
  - Test with X–rays @ CERN
- HV stability and performance studies
  - Test @ construction sites on single modules
  - Test @ BB5 during integration on Wedges → cosmic results
  - Test beam @ H4/GIF++ 100 GeV muon tracking under γ–bkg





Review on 2nd February 2022: Success!!!

Final Recommendation

The ATLAS MM team has gained an incredible amount of knowledge, analysis and reaction capacity. The MM detector is in good hands.

The panel recommends to start Run 3 with Ar-CO2-iC4H10 93-5-2.

[1] ^{137}Cs 662 keV Gammas 14 TBq 15 kHz/cm2 at 3m distance

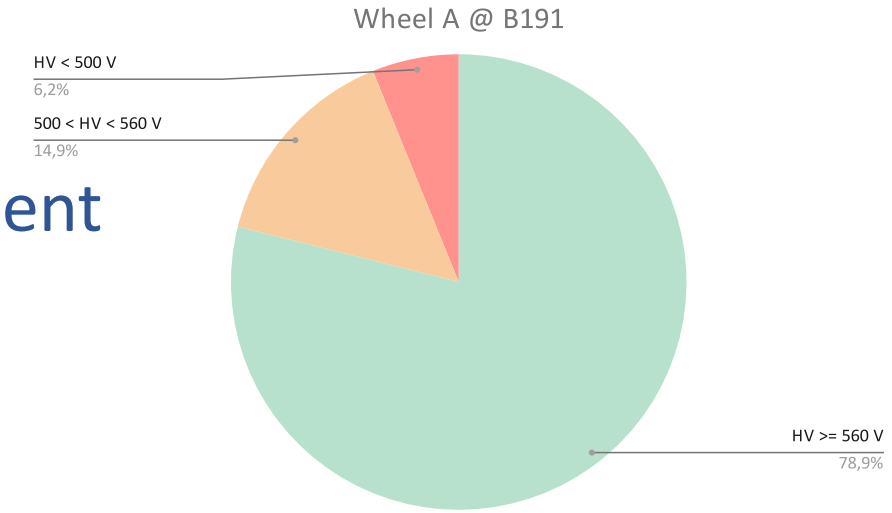
HV Test with Isobutane @ P1

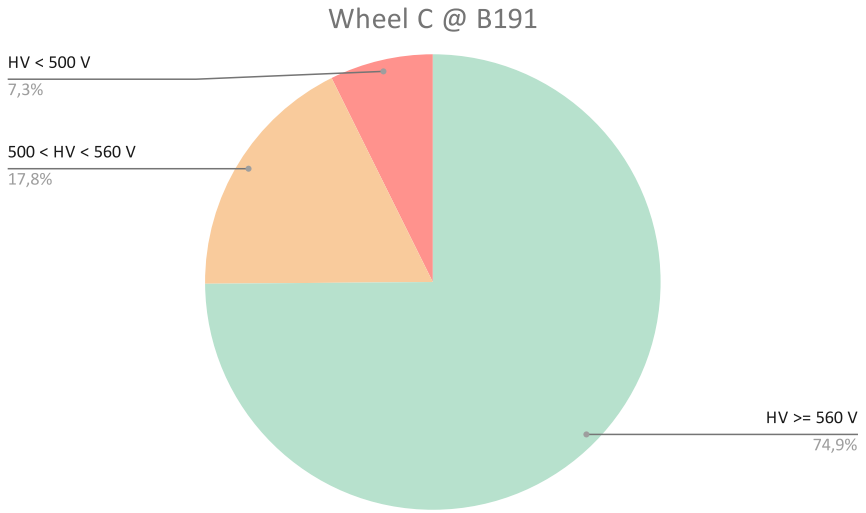
Performance improvement

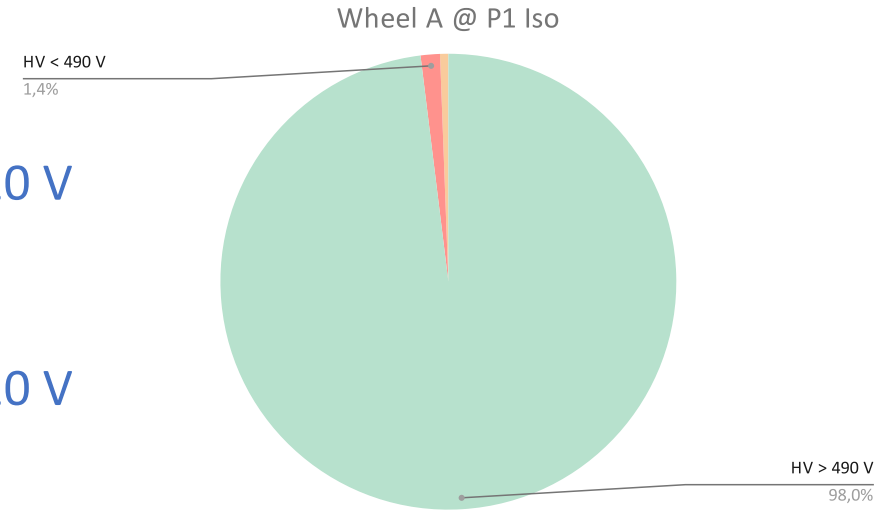
$ArCO_2$ @ B191

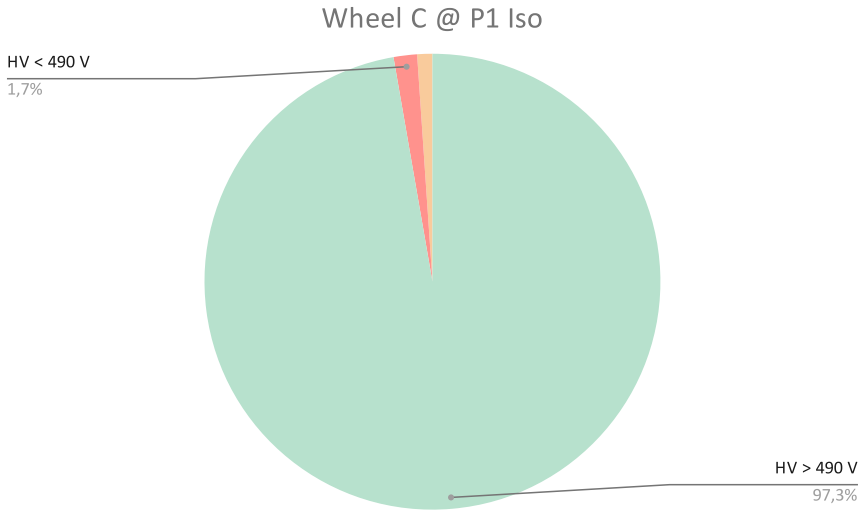
vs.

$ArCO_2$:Iso @ P1









Side A

79 % @ 570 V → 98 % @ 505–520 V

Side C

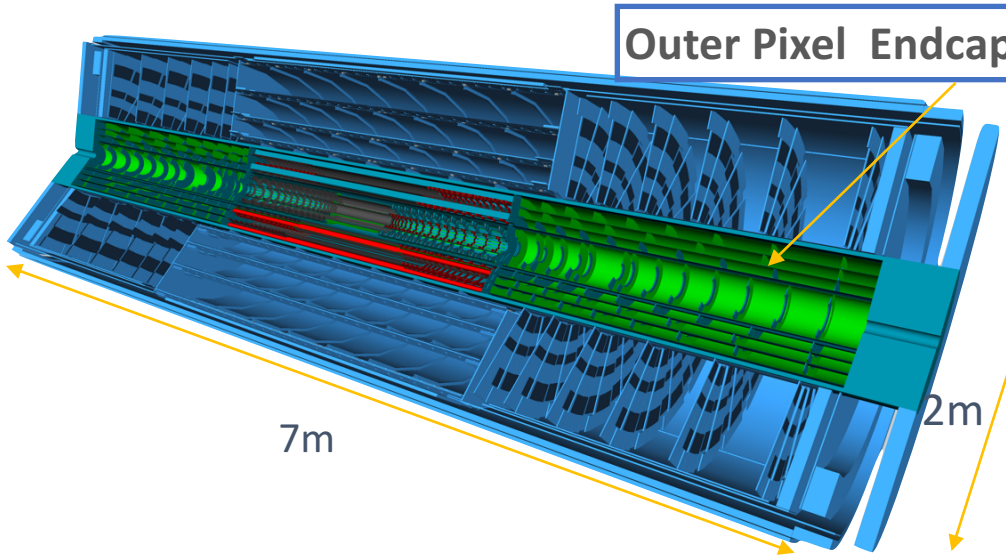
75 % @ 570 V → 97 % @ 505–520 V

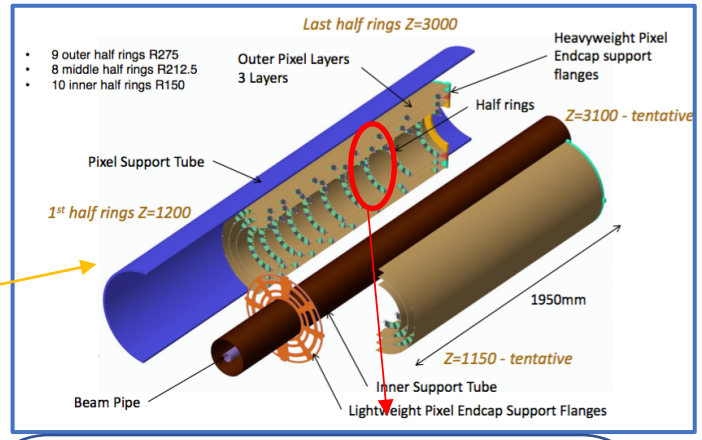
Phase II:
ITk and Muon Activity

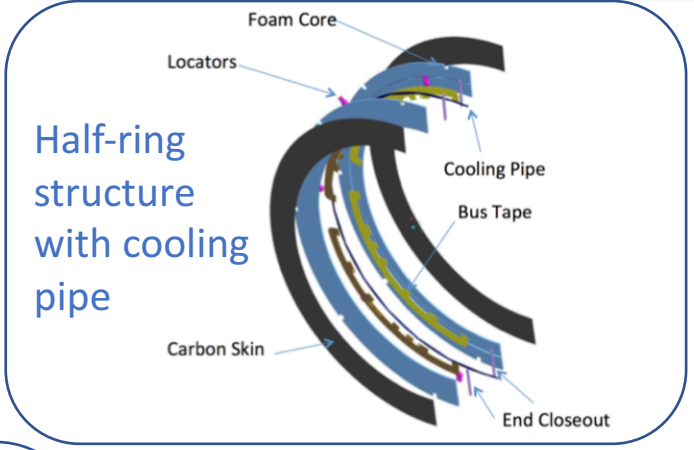
Pixel Endcap of the InnerTracker (ITk)

Full silicon tracker: strip + pixel

- Keep occupancy at few % level → finer segmentation
- Increase data rate capability
- Increase radiation hardness
- Track reconstruction efficiency >99% for muons, >85% for electrons and pions
- Fake rate < 10^{-5}
- Low material budget







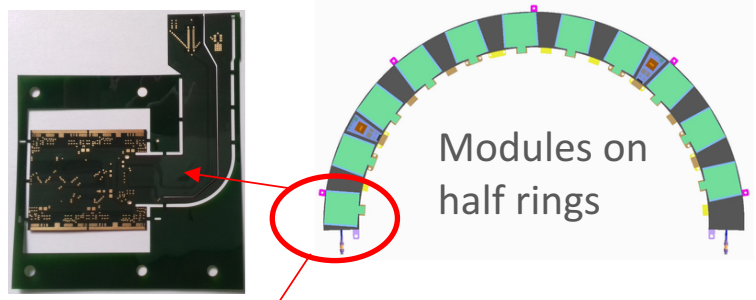
Italy is building one outer pixel endcap of the ITk detector

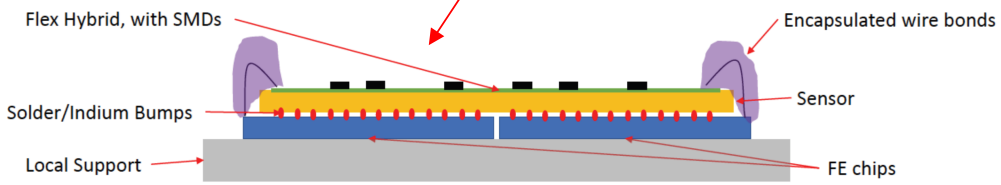
Hybrid Module:

- Sensor bump-bonded to a FE chip
- 4 FE chips for one sensor in the endcap
- **1172 modules** for one endcap

Frontend Chip

- 65nm technology
- Pixel sizes 50x50 um^2 (25x100 um^2)
- Pixels 384x400
- Readout Data rate= max 5.12 Gbits/s
- **8912 data-links** for one endcap





ITk General Status

- 3D sensors: Pre-production completed
- Hybridization
  - Starting the pre-production phase
  - Task force to study the thermic stress on the detector
- Module Assembly
  - Assembly activity based on the RD53A program at Milano and Genova ended
  - Ready to start the pre-production as soon as the first bare modules will be ready (end of summer)
- Modules QA/QC: Site qualification (BO, UD, TIFPA) almost completed
- DAQ , DCS, cooling for system test: Tools preparation @ BO, GE, LE and LNF
- Integration @ LNF
  - Prototype ready to be tested with a test- half-shell coming from UK
  - Clean room and climate chamber work in progress → ended by Spring/Summer

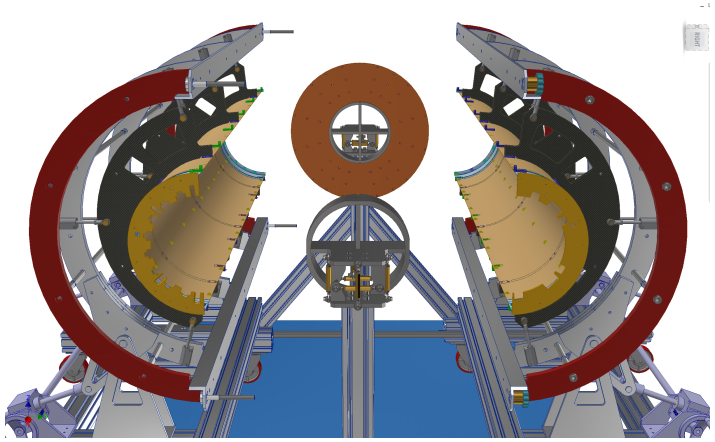
- ITk milestones related to 3 important reviews
  - Module FDR (19th May)
  - Loaded local supports FDR (21st Oct)
  - Bare Local supports PRR (18th Nov)

LNF responsibilities for ITk

LNF is responsible for the integration and commissioning

Mechanical assembly

- Tooling and procedures design

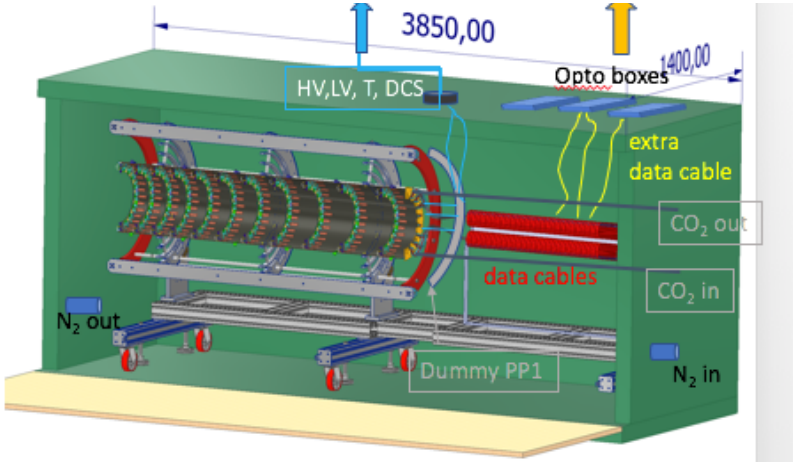


S. Tomassini, D. Orecchini

Prototype @ LNF

Commissioning

- Reception test of half-rings
- Electrical services design and prod.
- TIG welding
- Pressure & leak tests
- Functional tests of half-shells at warm and cold CO_2 temperature
- Thermal cycle of half-shells with detector off



M. Testa, P. Albicocco, E. Dane',
M. Beretta, G. Cesarini, S. Tomassini

Pixel ITk: Infrastructures for LNF

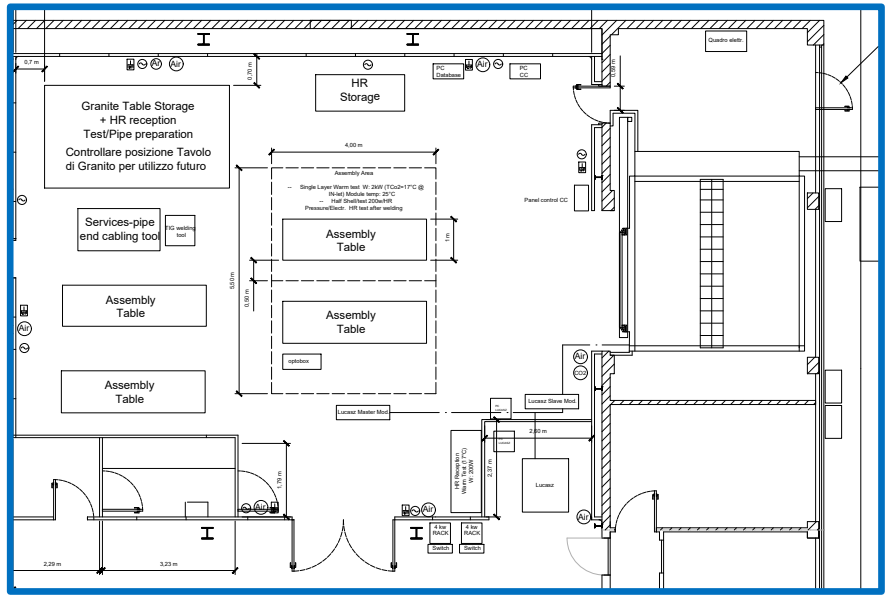
- New infrastructures for the commissioning:
  - Climate chamber for thermo-cycles
  - CO_2 cooling to cool down the modules
  - Clean room refurbishment

CO_2 cooling system

last commissioning week@DESY in next months

C. Ligi

Clean room refurbishment @ Capannone G. Sasso



S. Cantarella, E. Dane', C. Ligi, M. Testa

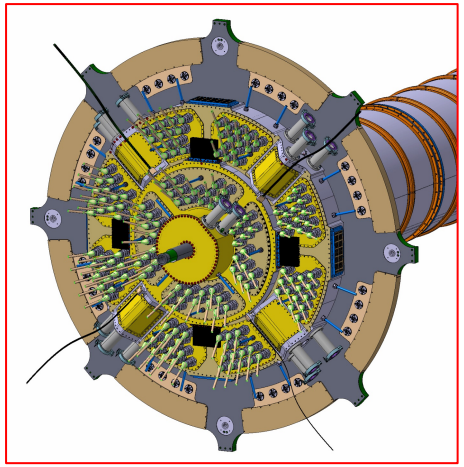
Large Climate Chamber

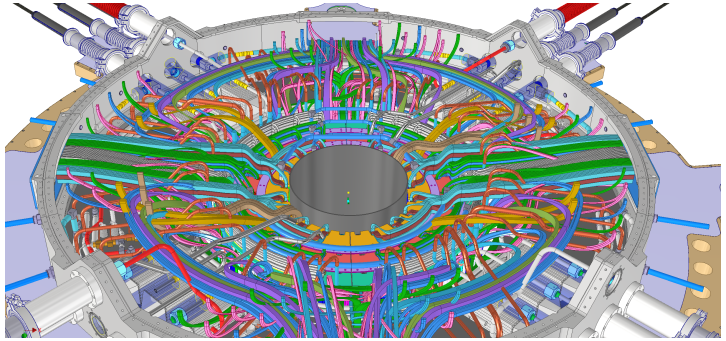
Ready for shipment

E. Dane' , G. Cesarini, M. Beretta

Patch Panel 1 for ITk

- **LNF** is responsible for design of
  - mech. structure,
  - piping, cabling
  - prototypes
  - production





E. Dane'; F. Rosatelli; D. Orecchini
S. Tomassini.

In the **Patch Panel 1** the services from **all** sub-detectors (inner and outer pixel system, strips) are routed to the off-detector electronics

Phase II Muon

Responsible: M. Beretta

Replacement of the entire power supply system of the ATLAS spectrometer

- Technical specifications of the various detectors defined
- The tender was divided into three lots:
  - Lot 1 - MDT and sMDT ELV, LV and HV, and sTGC HV;
  - Lot 2 - TGC ELV, LV and HV;
  - Lot 3 - Legacy RPC and BI RPC ELV, LV, HV and Monitor / Control.
- Two reviews with the sub-detectors and the ATLAS management passed
- First iteration with the CERN procurement office → the definitive review will be made in April
- Feedback from the CERN Legal office received two weeks ago
  - request to make several changes to the technical specifications

  → implementation on-going

Conclusions

Run 3…

- Despite the limitation due to COVID pandemic affecting some activities:
  - Huge effort to successfully complete the challenging Phase1 upgrade projects and system consolidation
- Crucial contribution from Italian ATLAS community in many areas
  - LNF main role in the NSW completion
  - Work is continuing to complete the (re)commissioning of the detector on time for the start on Run3

…Phase II

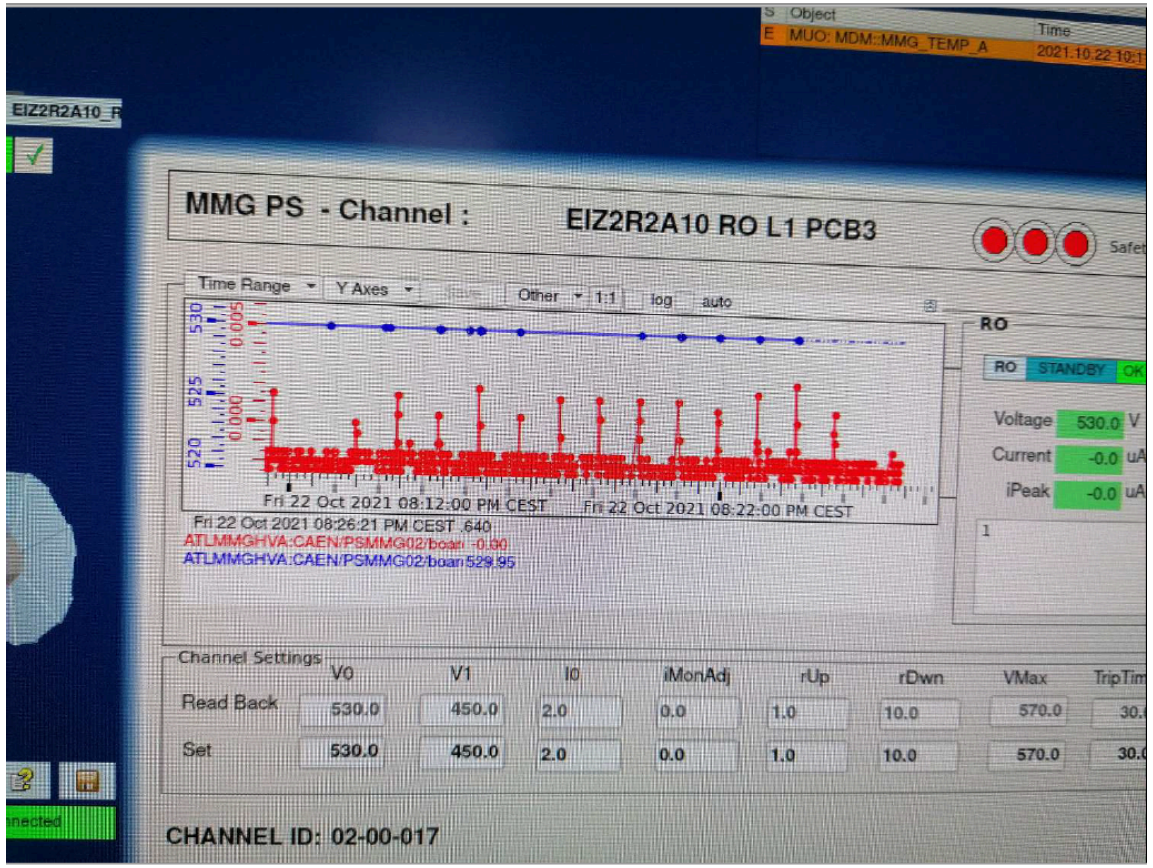
- Lots of activities on-going for the next ATLAS upgrade

Stay Tuned!

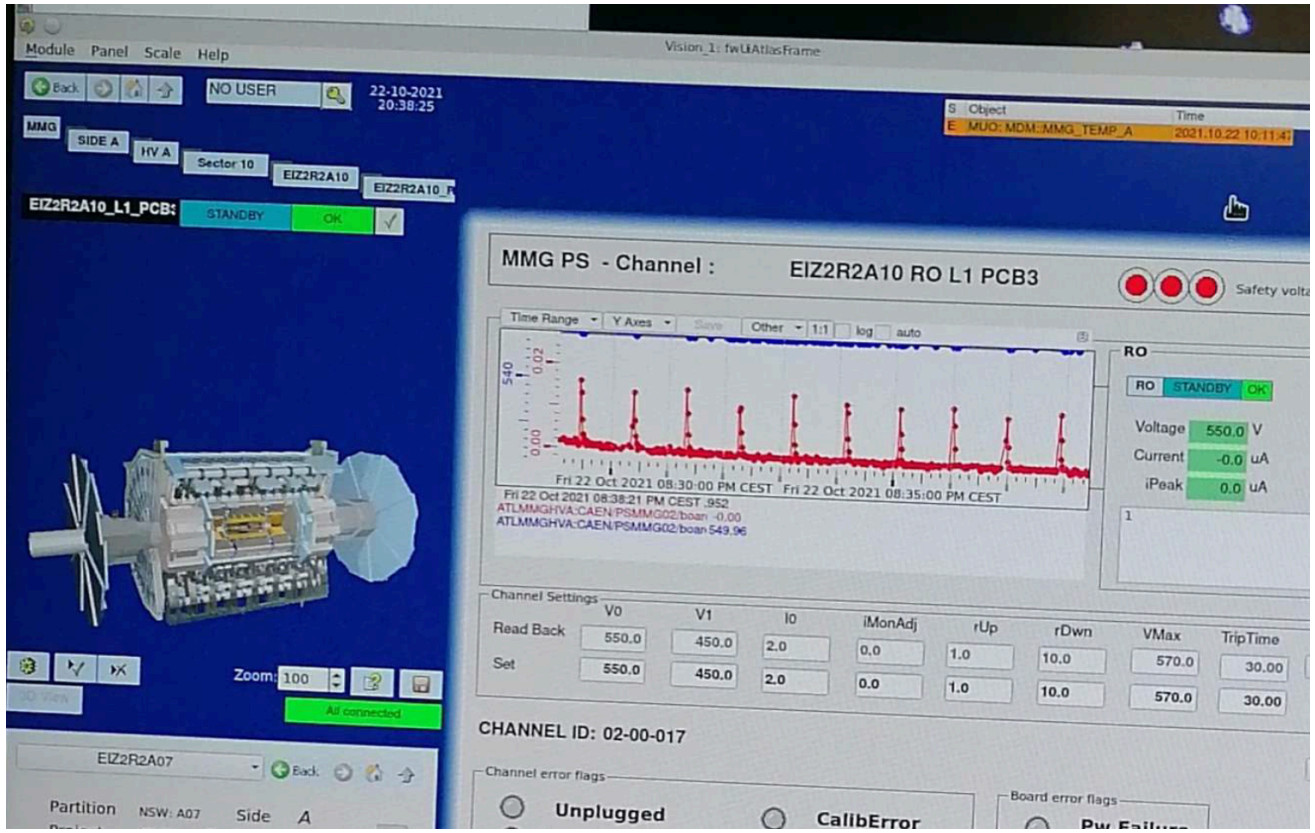
Backup

Splashes!

A10 SM2 – IP L1 PCB3 @ 530 V
Spike train of about 5 nA



Ramped up @ 550 V
Spike train of about 20 nA



Micromegas: gas mixture enriched with Isobutane

HV Working Points in $Ar:CO_2:iC_4H_{10}$

- 490 V
  - ε ~ 93 % (almost equivalent to 555 V in $ArCO_2$)
- 505 V
  - Efficiency and gain equivalent to 570 V in $ArCO_2$
- 520 V
  - Better Efficiency and gain wrt 570 V in $ArCO_2$
    - Higher gain for µTPC