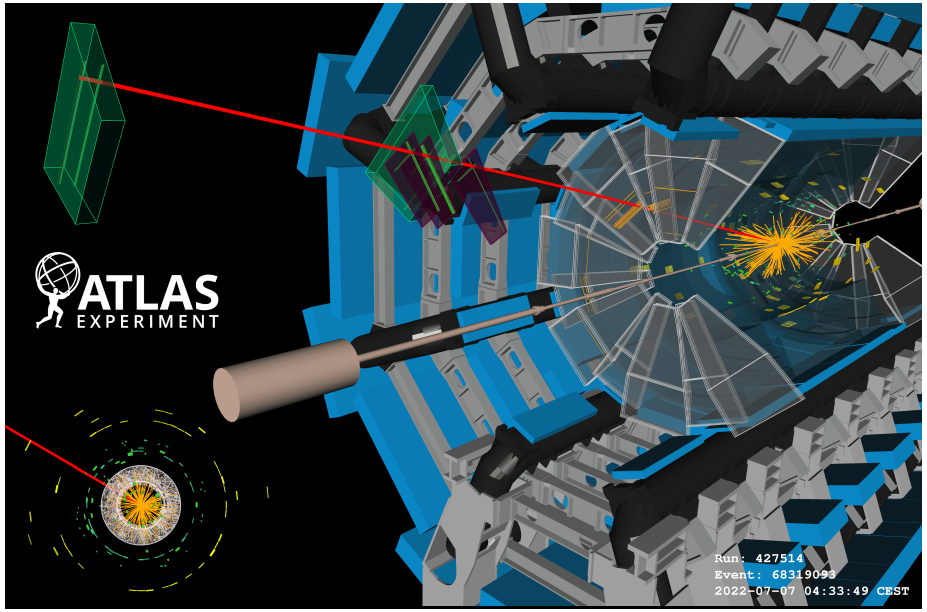
Updates from ATLAS

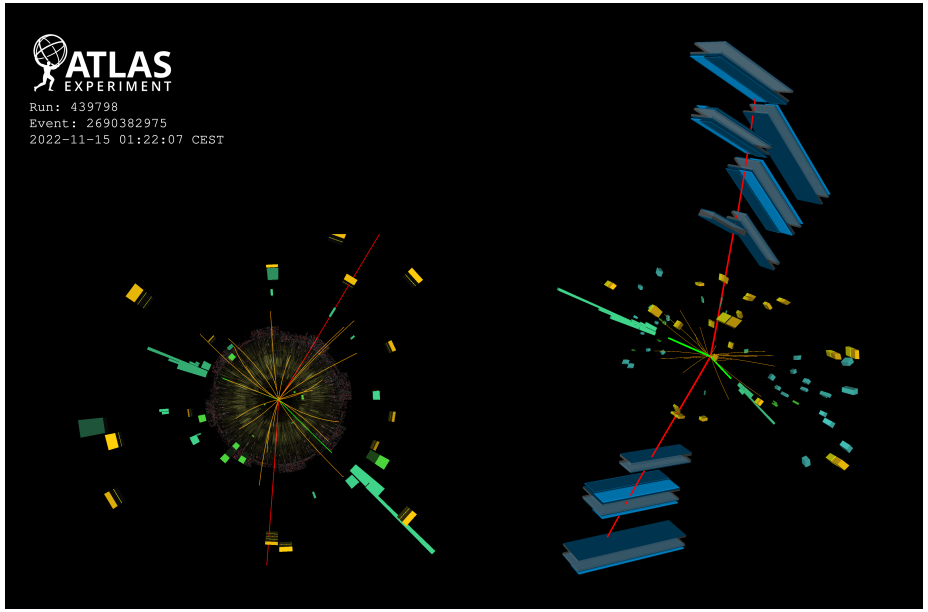
Chiara Arcangeletti on behalf of the ATLAS-LNF Team

Riunione Gruppo 1 LNF, 16 Maggio 2024

Introduction

Detector status and data taking:
New Small Wheel status @ CERN

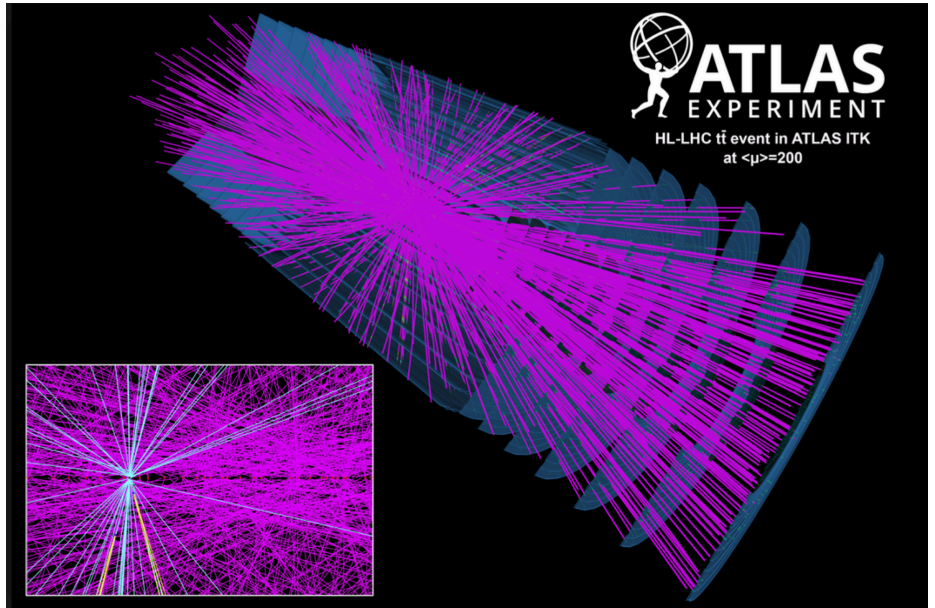




Physics Highlights:
Higgs boson properties measurements

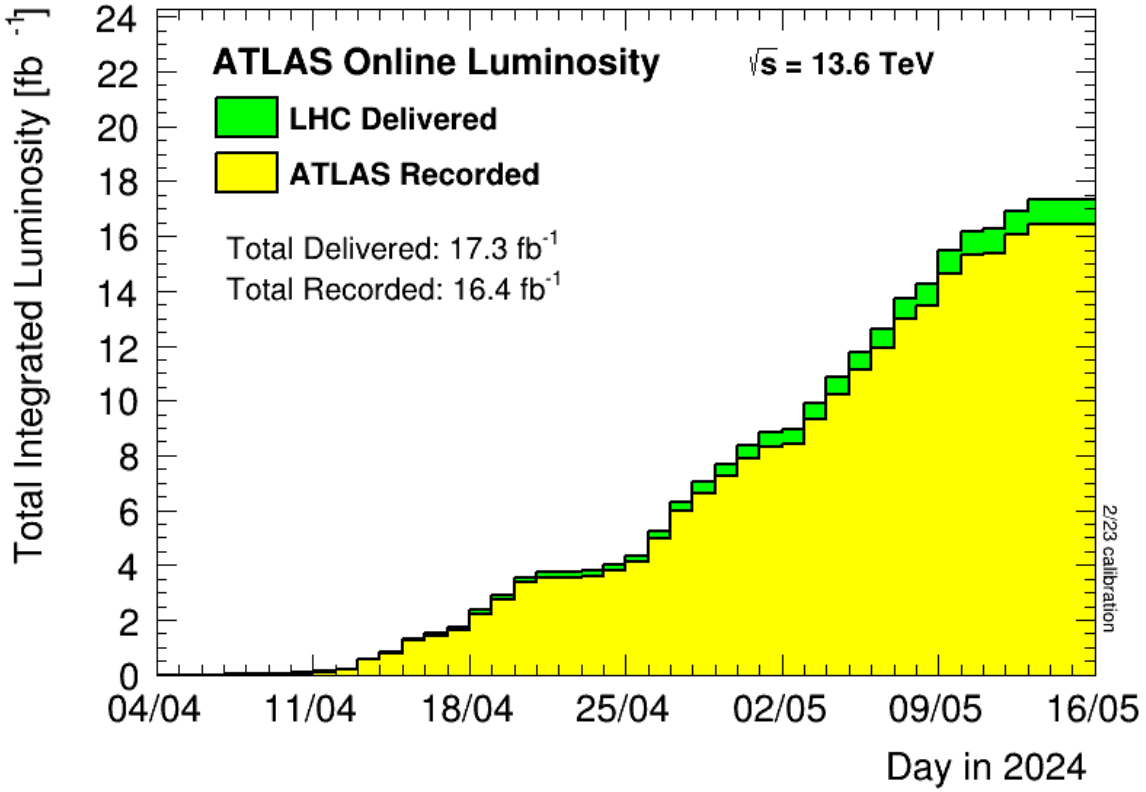
Status of Phase II Upgrade: **ITk** activity @ LNF

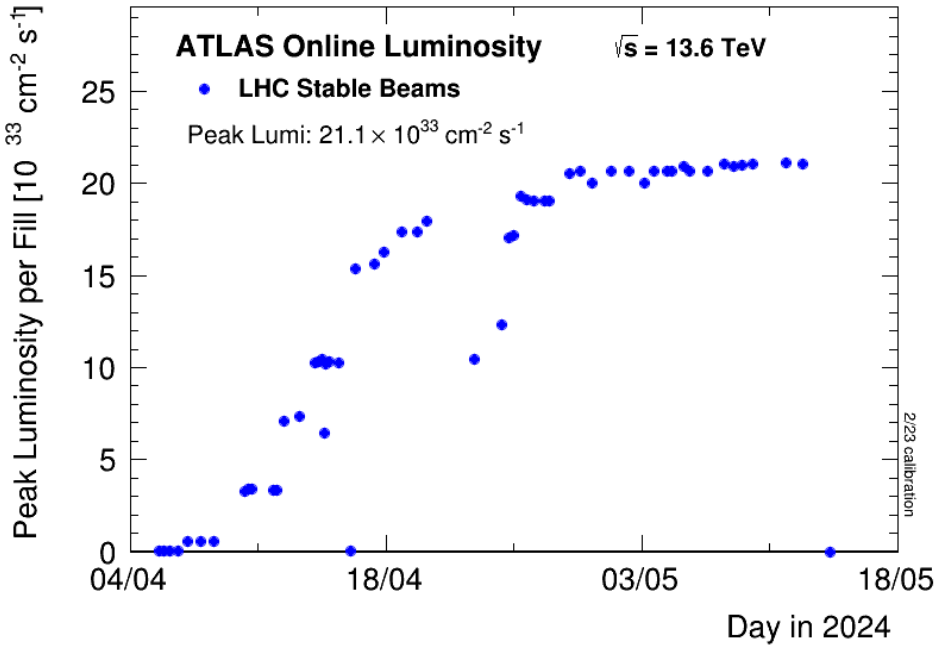
Input slides from latest *ITk Pixel Global Mechanics and Integration FDR* and *ITk OEC Integration Workshop in Otranto*

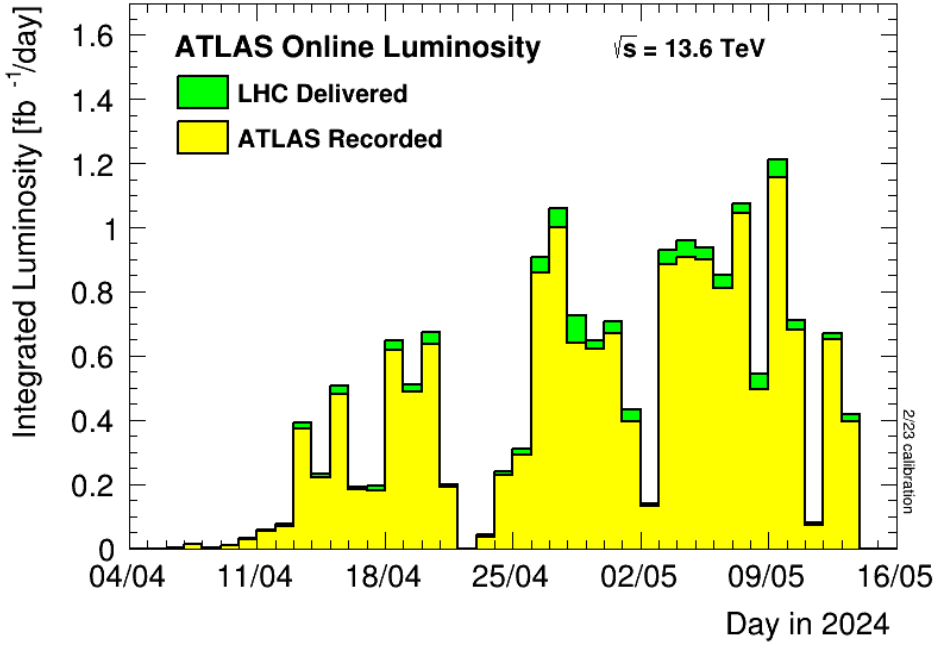


Restart of data taking

- Data taking re-started in April smoothly
  - Already collected >16 fb^{-1} with an incredible rate up to 1 fb^{-1}/day and a recording efficiency of 94% → hoping to hit the desired >100 fb^{-1} (including 2022+2023)
- End of run postponed by 4 weeks (2025 run shortened by same amount)







NSW Operation in ATLAS

M. Antonelli, G. Mancini,
C. Arcangeletti
E. Capitolo, B. Ponzio,
G. Pileggi

LNF still involved in operation and maintenance activity. Several responsibilities covered during the construction and installation phases

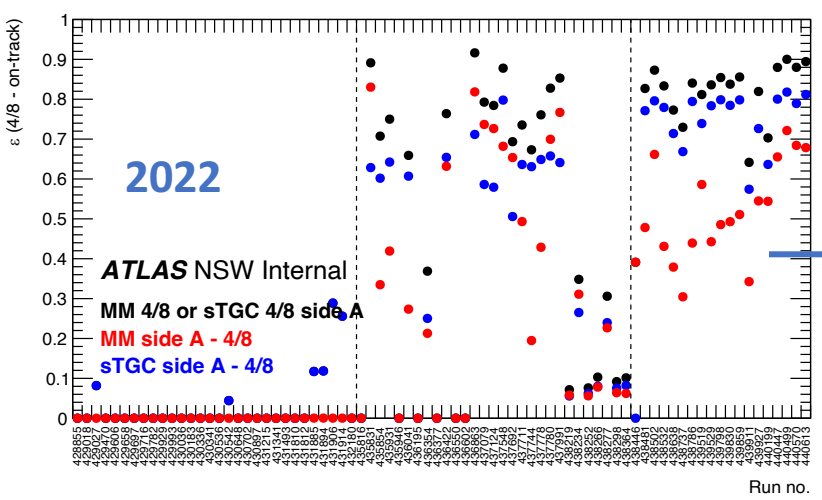
Micromegas HV status

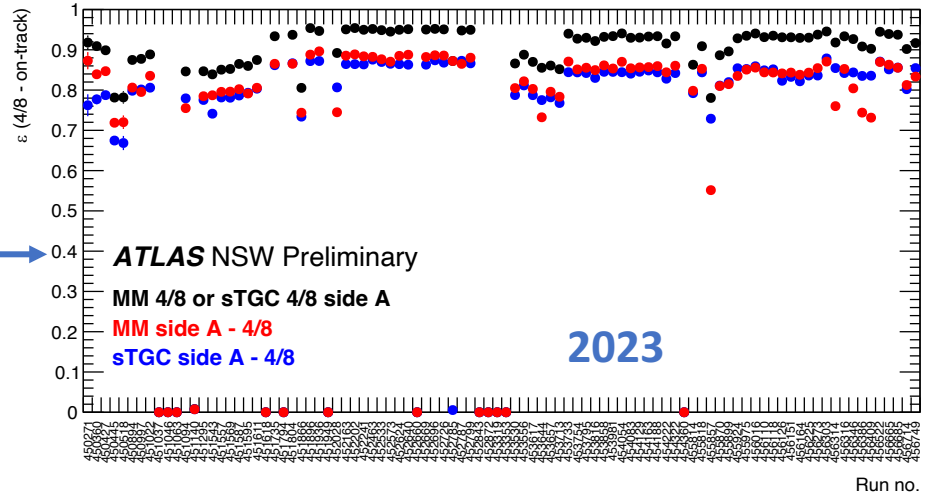
- Gas mixture with Isobutane → Only 1.5% channels are not working
- *Argon curing* procedure regularly applied on problematic HV channels →Improvement rate ~ 60%

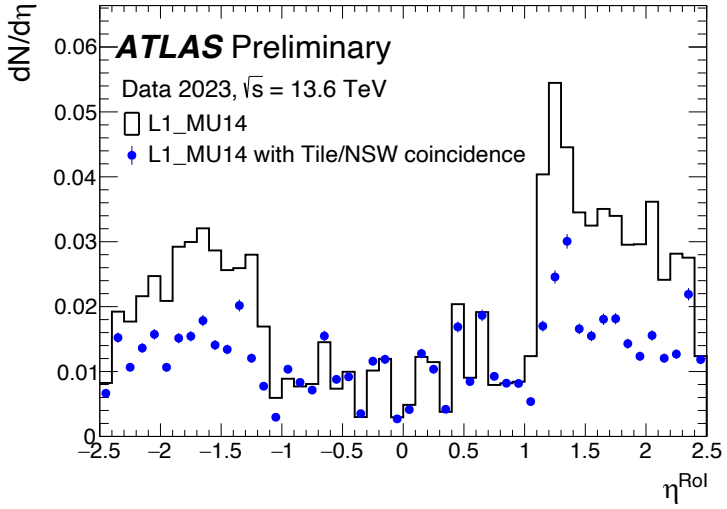
Data Taking & Performance

- DAQ stability issue since start of the run in 2022: could not run stable with many sectors and for long time → Situation very much improved in 2023
- Noise variations observed with respect to surface commissioning → threshold adjusted
- Track reconstruction is >95% thanks to the high-redundancy of the NSW

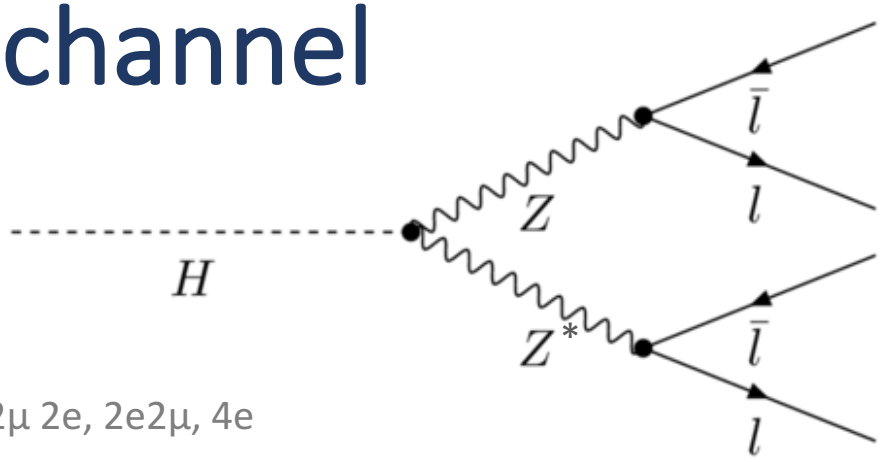
NSW in Level-1 Trigger chain included lead to fake rate reduction in the end-cap



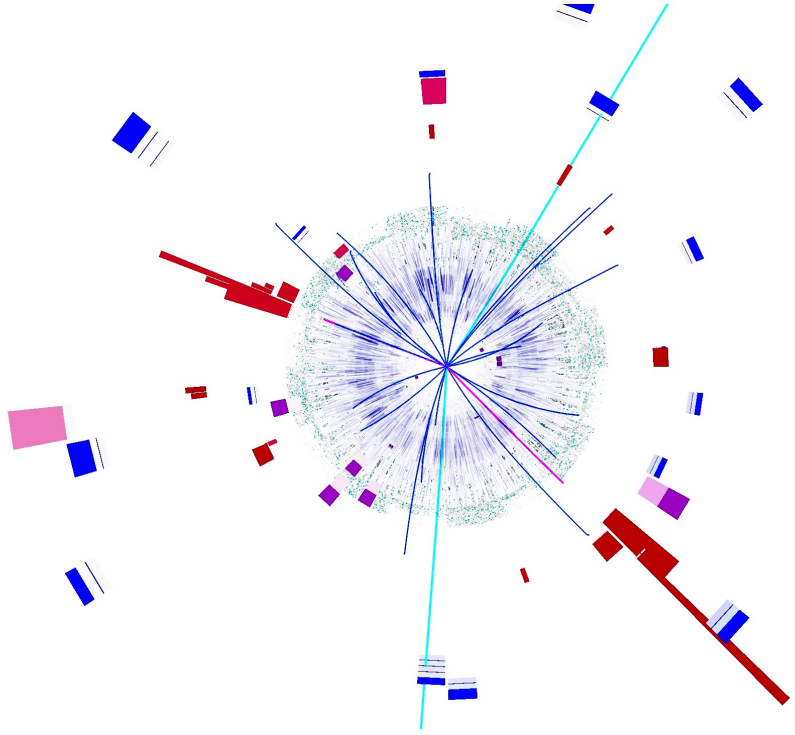




LNF activity on H→ZZ*→4l decay channel



Final States: 4μ, 2μ 2e, 2e2μ, 4e



- Fully leptonic final state lead to a very clear signature of the event
- Very good mass resolution thanks to the excellent lepton reconstruction performance
- Very good Signal/Background ratio: S/B ~ 2
  - despite the low Branching Ratio, it makes this channel clearly identifiable

Background processes

- ZZ* non-resonant production (irreducible component)
- $t\bar{t}$ and Z+jets (reducible component)
- tXX, VVV (very small component)

LNF contribution

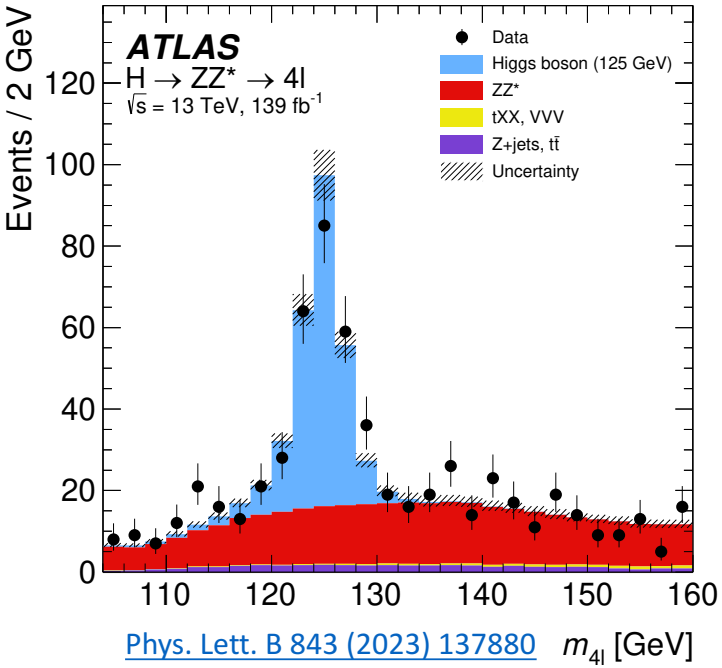
C. Arcangeletti, G. Mancini, L. Vannoli

- HZZ group convenorship
  - Focusing on performing measurements of the Higgs boson properties in the H→ZZ* and H→μμ decay channels at 13.6 TeV
    - Setup a baseline for future analysis with full Run 3 stat.
- First Higgs boson production cross section measurement @ 13.6 TeV
- Higgs boson Mass measurement with full Run 2 statistics
- Higgs coupling measurements and test for possible BSM effects in different frameworks
  - Working on alternative interpretations in collaboration with theorists

The Higgs boson Mass

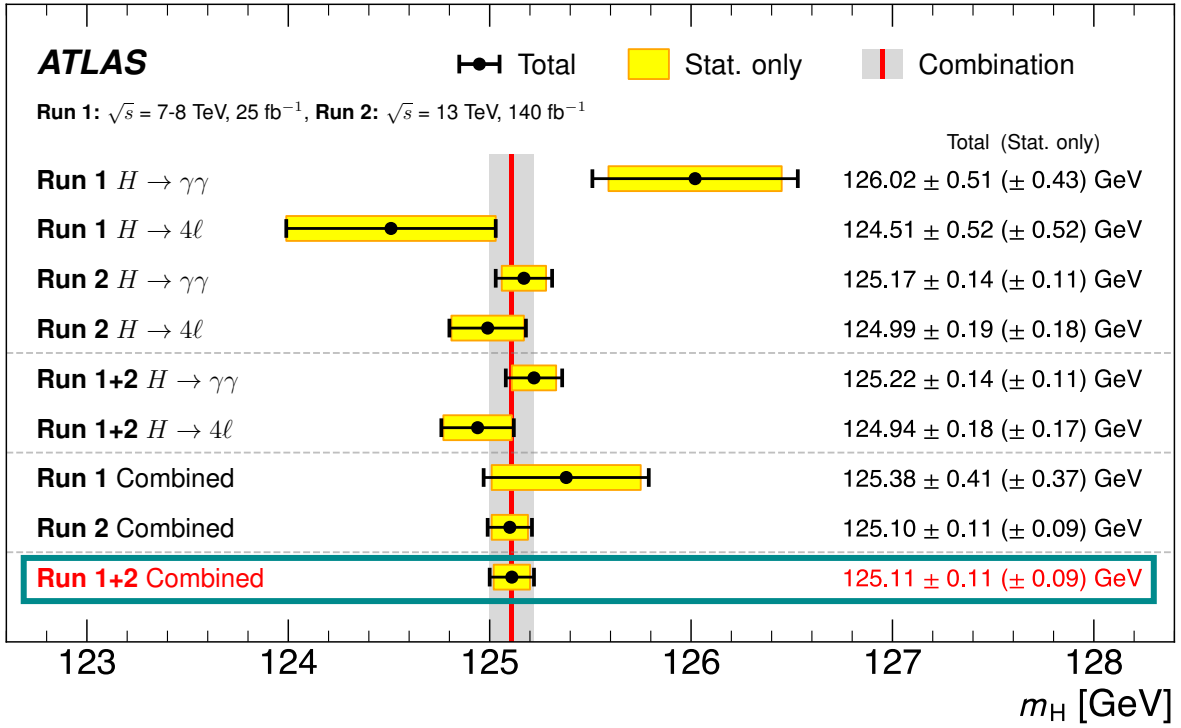
H→ZZ*→4l and H→$\gamma\gamma$ are the most sensitive channels

- Clear signature final states → High mass resolution
- Main uncertainties: Electron/Photon energy scale and Muon momentum scale
  - Excellent new calibrations reduced significantly their impact!
- Combination of the two channels and of the two runs lead to the **most precise measurement of the Higgs boson mass!**



Phys. Lett. B 843 (2023) 137880

Phys. Rev. Lett. 131 (2023) 251802



m_H = 125.11 ± 0.11 GeV

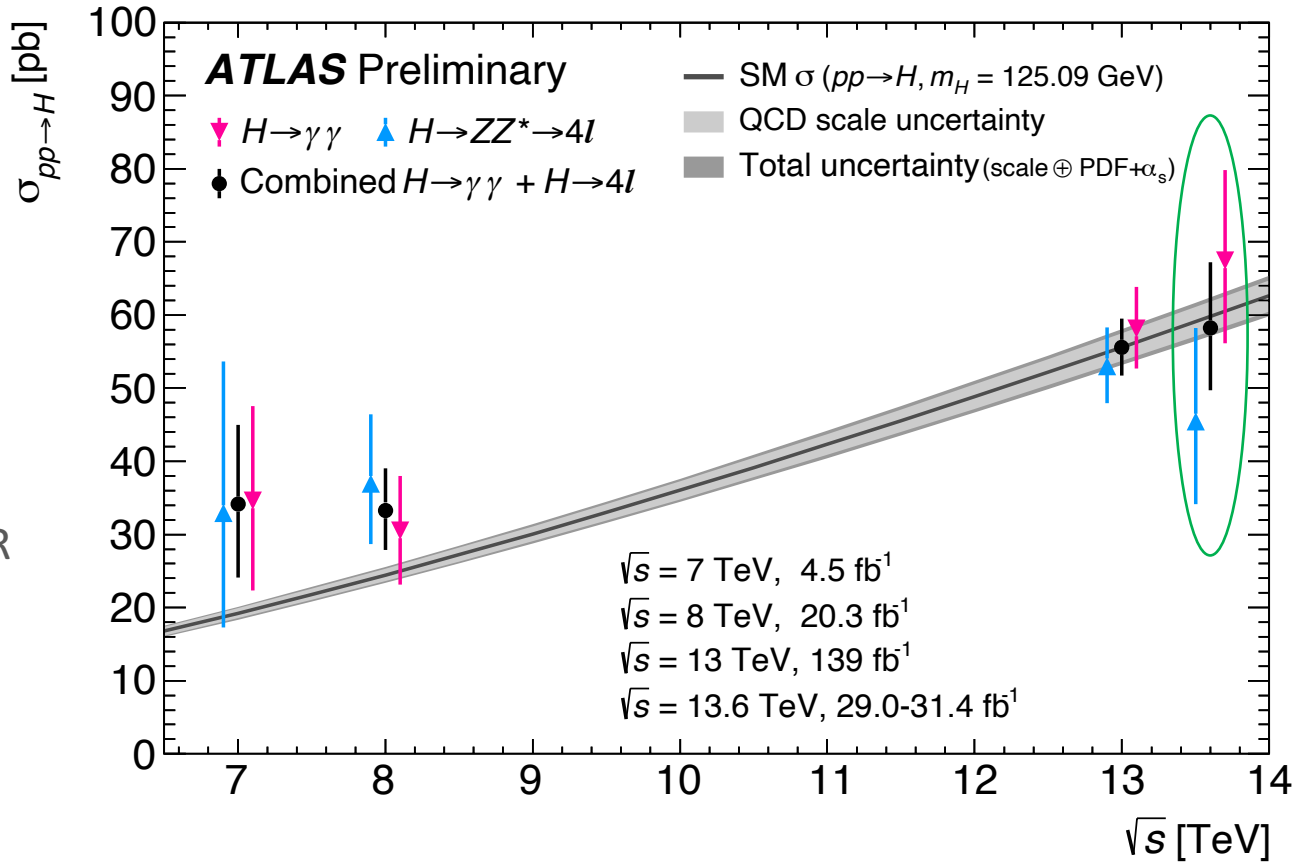
Higgs boson production cross section @ 13.6 TeV

Fiducial cross section measurement performed in H→ZZ*→4l and H→$\gamma\gamma$ channels

- Fiducial phase space definition based on detector acceptance to minimize the model dependency
- Unfolding to correct for detector level effects, efficiency and resolutions

Extrapolate the fiducial cross section measurement to the full phase space

- Additional uncertainties on the acceptance and on the BR
- Statistically dominated channels benefit from the reduction of the statistical error
- In the combination the experimental and theoretical systematics that affect both channels are correlated



Combination of the total cross section measurement

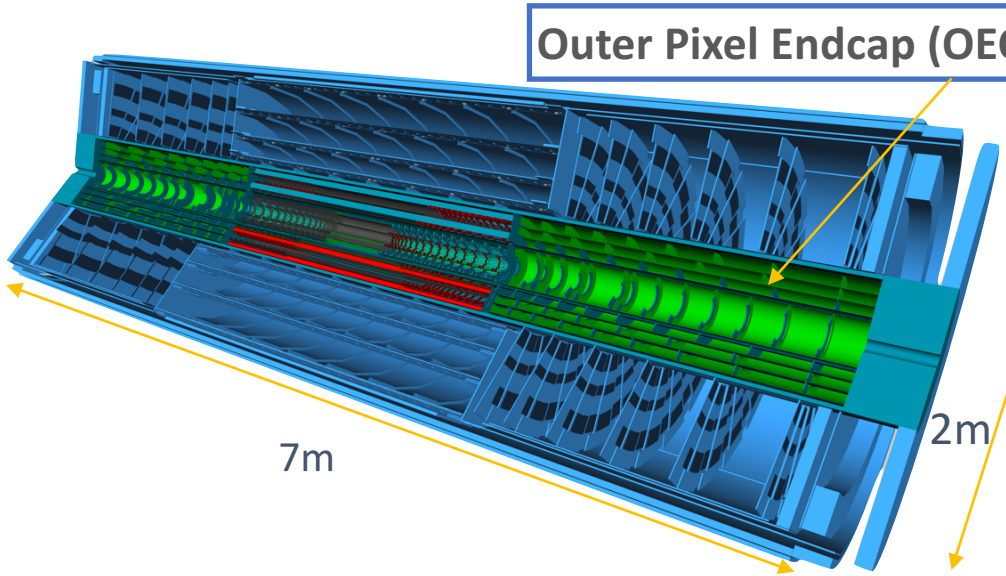
σ_{total} = 58.2 ± 7.5 (stat.) ± 4.5 (syst.) pb

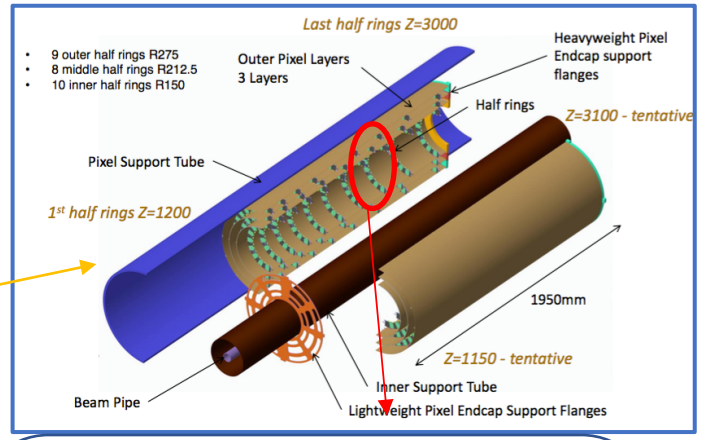
(SM: 59.9 ± 2.6 pb)

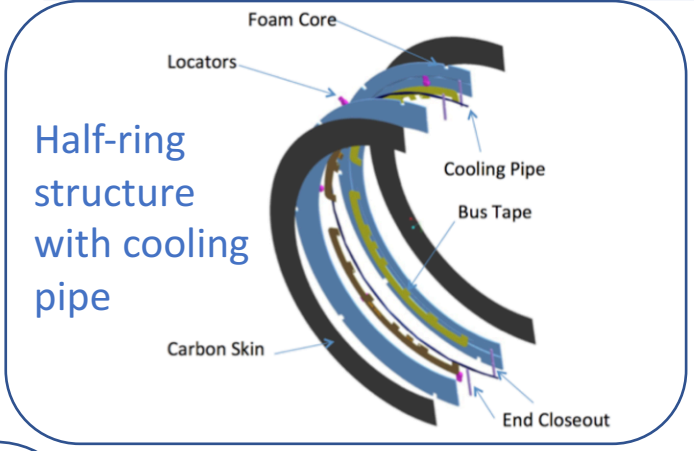
Pixel Endcap of the InnerTracker (ITk)

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







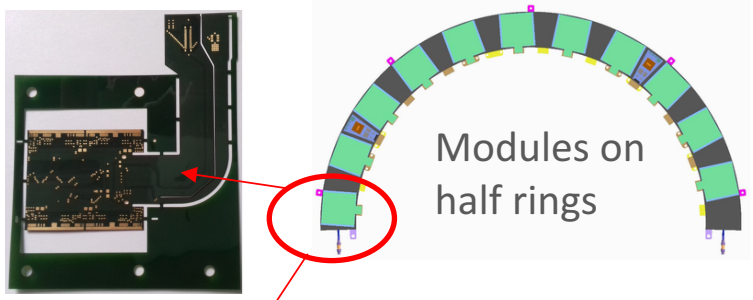
Italy is building one outer pixel endcap of the ITk detector

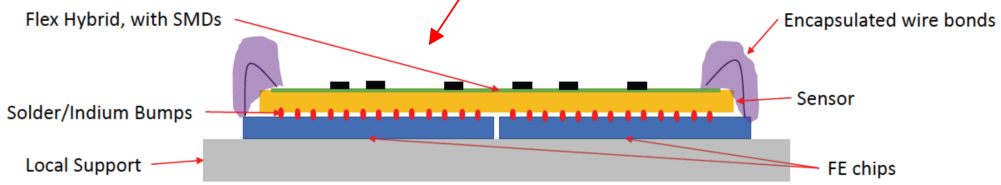
Hybrid Module:

- 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 activity @ LNF

LNF is responsible for the integration and commissioning

Mechanical assembly

Tooling and procedures design

- Cradle prototype @ LNF ready
- Service trolley to be finalized
- Design support to move the central tool to be finalized
- Services installation procedure definition
- Shipping trolley/Box optimization

Global Mechanics FDR on May 14th

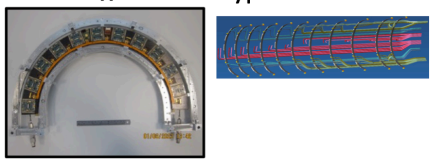
Pixel Half-Shell installation @LNF

New Clean Room is almost complete!

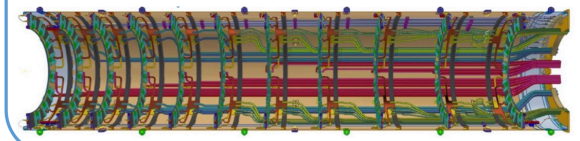
M. Testa, Z. Chubinidze, B. Buadze, L. Vannoli, G. Cesarini, E. Dane', P. Albicocco, M. Beretta, F. Rosatelli, G. Mancini, M. Antonelli, M. Battisti, A. Croce, E. Capitolo, B. Ponzio, G. Pileggi

OEC Integration Process

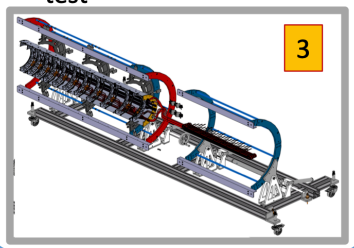
Reception tests of Half-rings type 1-services 1



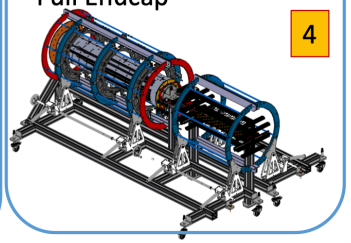
Insertion type-1 services and Half-rings on Half-Shells 2



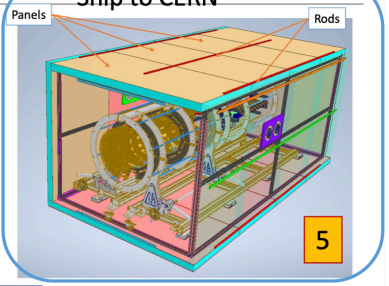
HS test – thermal cycle -- test 3



Test on Complete Layer/ Full Endcap 4



Ship to CERN 5



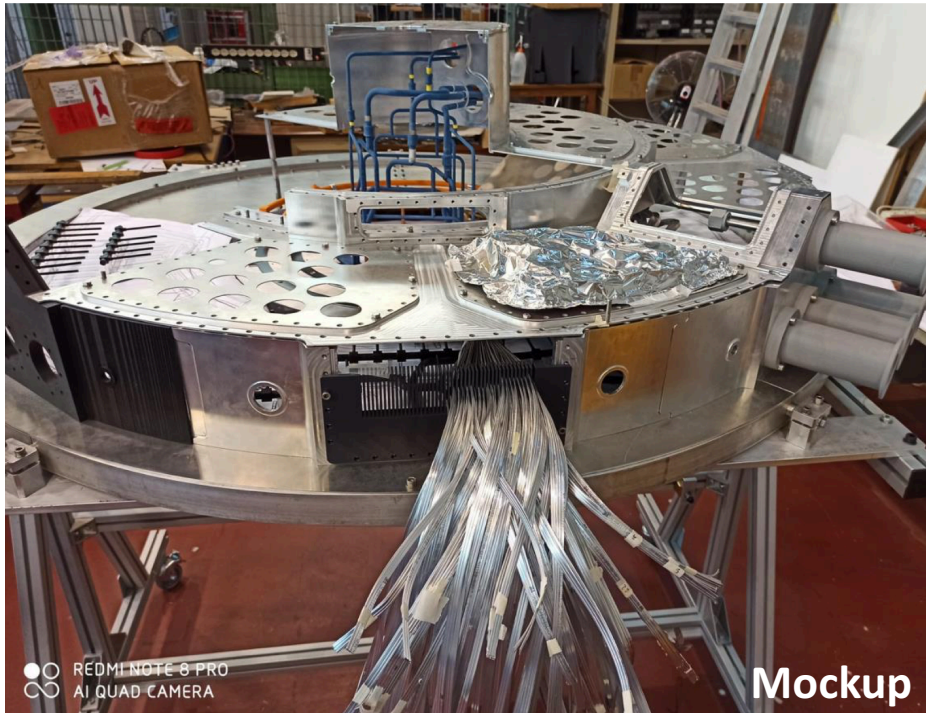
- Ground Fault Monitoring to spot unwanted connection between HS and type1 services /HR
- Convective cooling demonstrated with HR prototype
- Integrate the system with the interlock create LISSY to develop interlock logics
- DAQ system development

Patch Panel 1 @ LNF

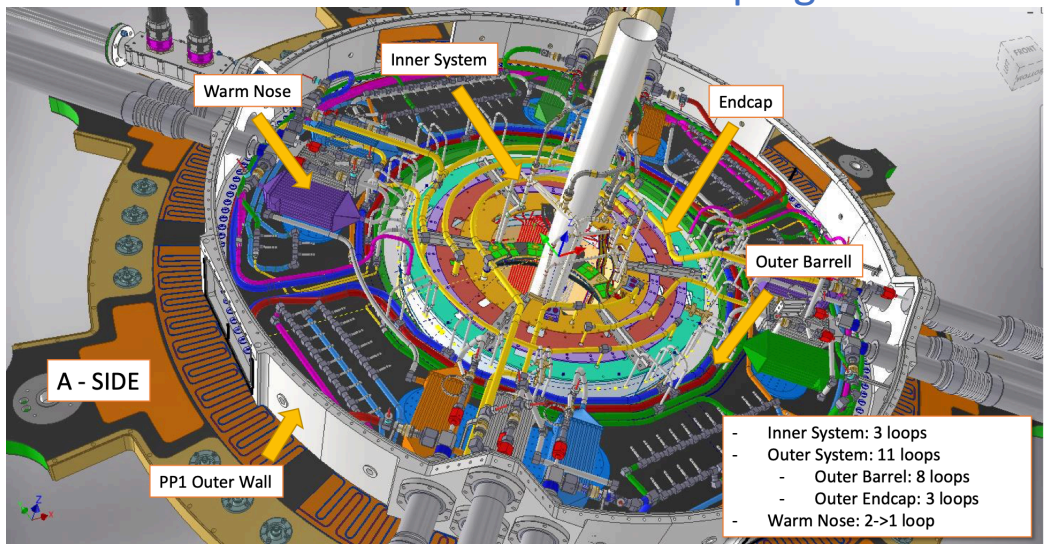
M. Testa, F. Rosatelli, G. Cesarini, E. Dane', B. Buadze

LNF is responsible for design of Patch Panel 1 for ITk

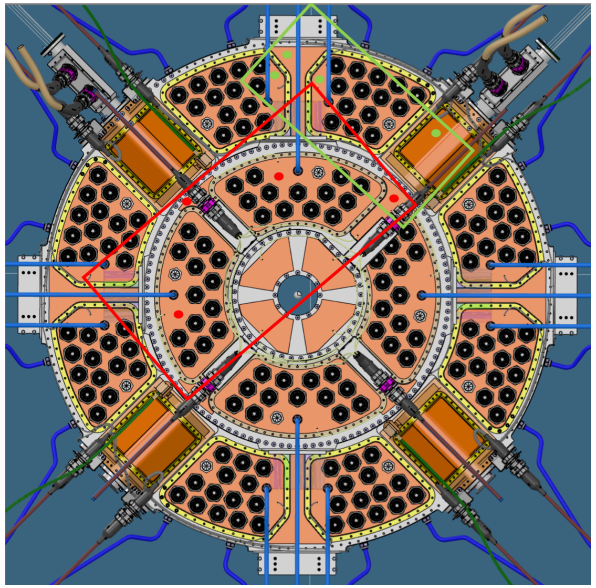
- In the **PP1** the services from **all** sub-detectors (inner and outer pixel system, strips) are routed to the off-detector electronics
- LNF is taking care of mechanics, piping, cabling, prototyping and the final production
  - Mockup just sent to CERN two weeks ago



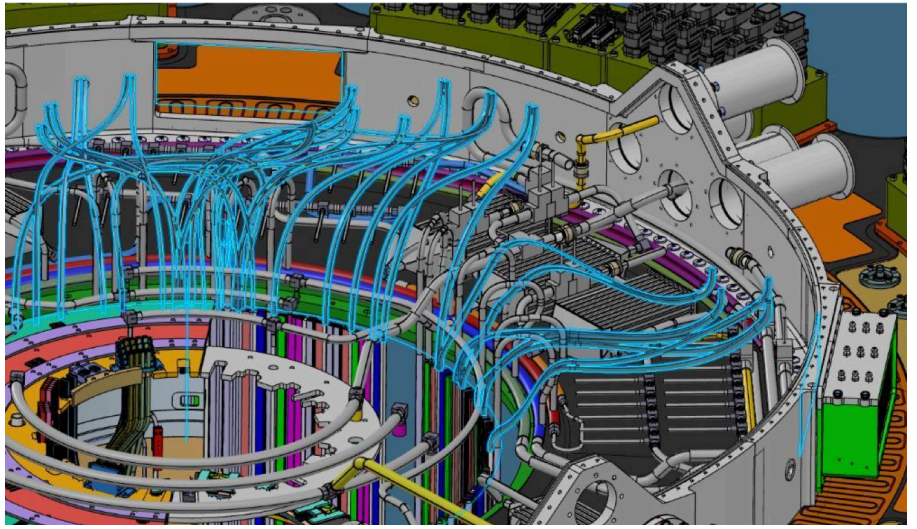
Piping overview



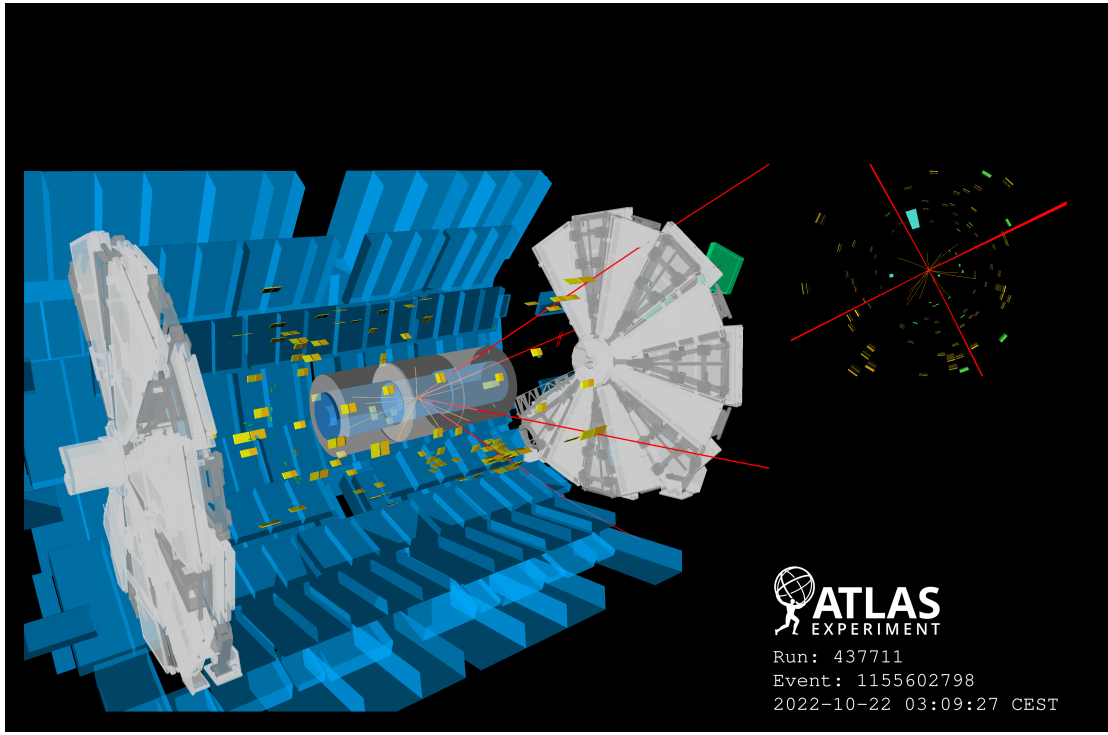
Heating System



detail of routing design



Conclusions



Run 3... Despite the sudden stop of last year in summer, 2024 had a very promising start with data taking

- NSW improved significantly the DAQ stability and NSW performance since the beginning in 2022
  - LNF continuing its contribution in operations and maintenance activity
- New results on the Higgs boson properties with coming data → hit 100 fb^{-1} for Run 3 and combining with Run 2 will allow a sensible reduction of the statistical uncertainty and possibly open the door to the evidence (even observations) of rare decays and New Physics!

...Phase II

- Intense ITk activity @ LNF aiming to start the integration soon

Stay Tuned!