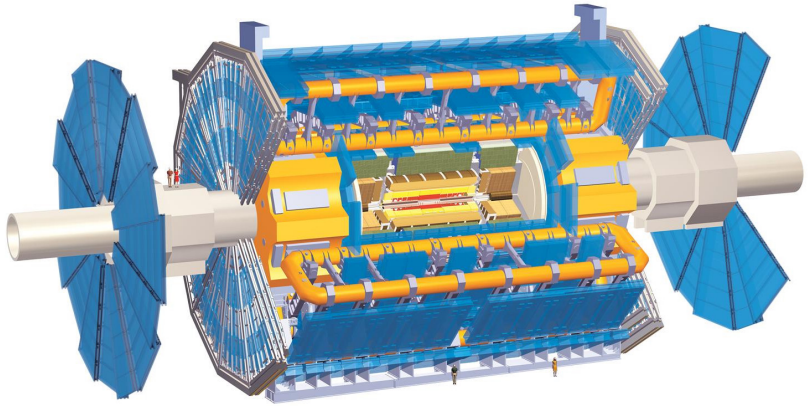
ATLAS – Phase II Completion and Restart

ErUM-Pro Strategy Workshop, Physikzentrum Bad Honnef

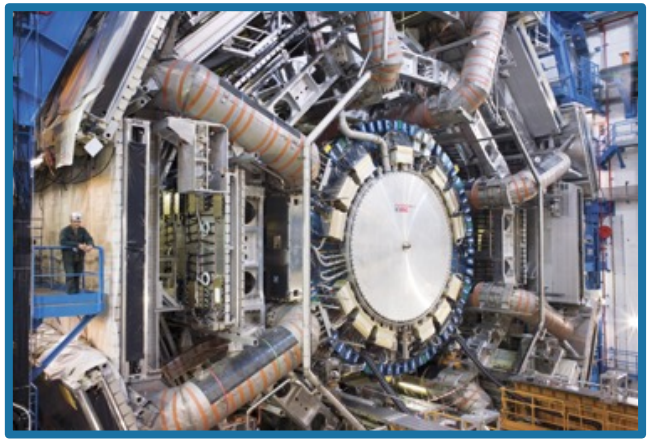
22 November 2025

Wolfgang Wagner



Planned activities of the ATLAS-Deutschland groups in 2027 – 2030:

1) Completion of the Phase II production, detector installation and commissioning
2) Detector operations and maintenance of legacy systems
3) Analyses of Run-3 data and contributions to performance improvements
4) Operation of the WLCG infrastructure



Long term LHC schedule

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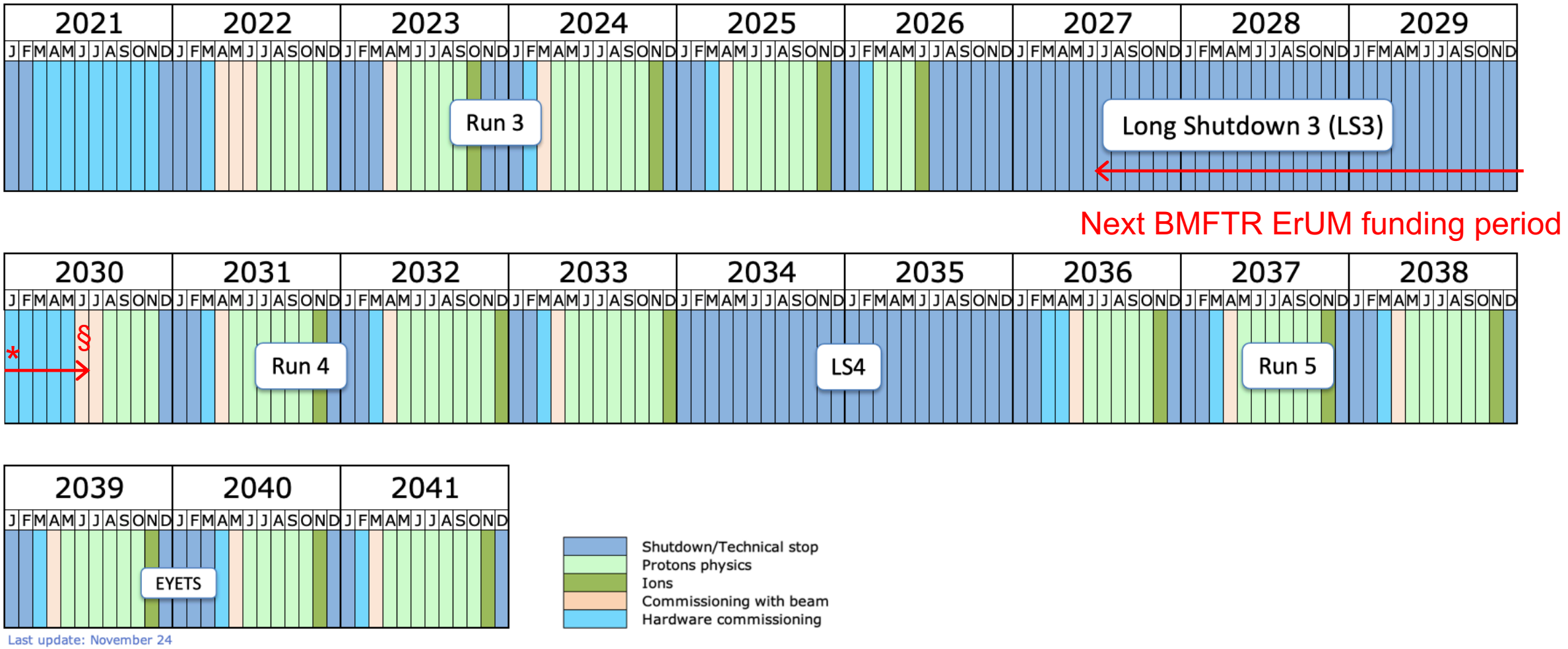

* Start of final hardware commissioning: January 2030

§ First beam: June 2030

Contributions to Phase II Upgrade Projects

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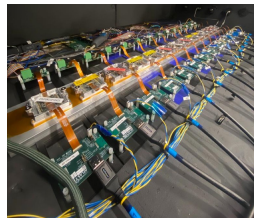
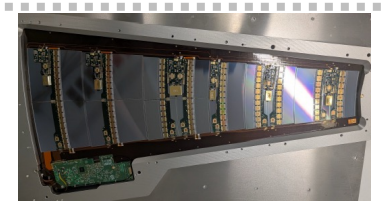
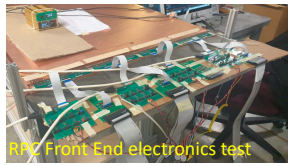
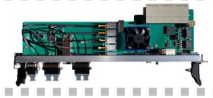
Upgrade Project	Involved Groups	Contributions	
Inner Tracker Pixel	Bonn, TU und FH Dortmund, Göttingen, FH Köln, MPP München, Siegen, Wuppertal	Front-end wafer and flex testing; module production, loading and integration; local supports, DCS chip, interlock system, type-1 cable testing, DAQ firmware, online software, CO_2 cooling.	
Inner Tracker Strips	HU Berlin, DESY (HH, Zeuthen), TU Dortmund, Freiburg	Module production, petal production and loading, endcap hybrids and power-boards, endcap petal integration.	
Liquid Argon Calorimeter (LAr), HGTD	LAr: TU Dresden, Mainz, MPP München. HGTD: Gießen, Mainz	LAr Signal Processors, firmware. HEC low-voltage system; purity FE board. HGTD module assembly and loading, low-voltage system.	 
Muon System	Bonn, LMU München, MPP München, Würzburg	MDT on-detector ASIC and electronic cards. BIS sMDT chambers, RPC mechanics, triplet assembly. BOM/BOR RPC gas gaps. MDT TDC ASIC. HV system.	
Tile Calorimeter	Heidelberg (KIP)	Tile calorimeter pre-processor.	
Trigger and Data Acquisition	Heidelberg, Mainz, MPP München	Forward L1 trigger (fFEX), firmware on Global Trigger, tracking firmware/software for Event Filter. L0 MDT trigger processors.	

ITk Pixel

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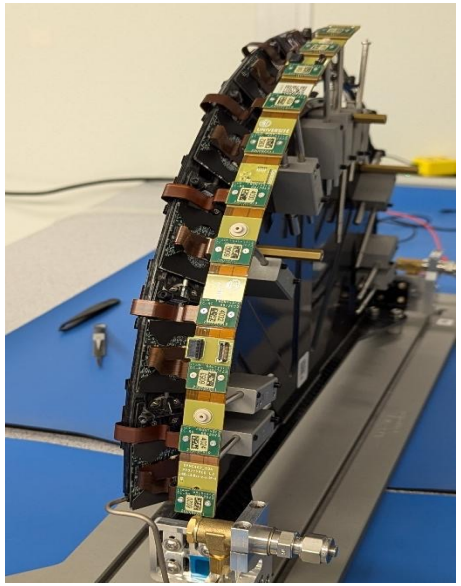
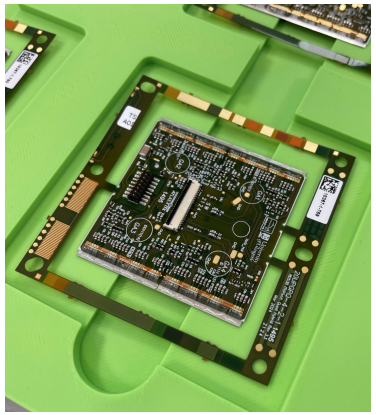
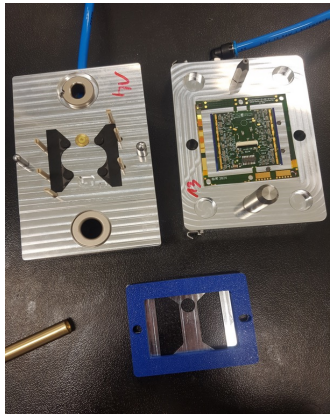
- Institutes: Bonn, TU and FH Dortmund, Göttingen, FH Köln, MPP München, Siegen, Wuppertal
- University groups contribute to Pixel Outer Barrel
- Finish production at institutes:
  - Module production until Q4/2027. Cell loading until Q1/2028.
  - Cell integration in Bonn until Q2/2028.
- Risks: Front-end chips damaged in dicing step for 2 of 3 vendors (mitigation steps taken), quality and schedule of type-1 cables
- Contribute to Outer Barrel integration and installation at CERN (Peak effort in 2027 and 2028)
  - Responsibilities: DCS, DAQ, configuration data base and calibration software, interlock.
    Activities: software, firmware, QC shifts
- ITk Commissioning Q3/2029 – Q3/2030



Integrated half-ring (Bonn)





OB module production and QC (Bonn, Göttingen, Siegen)

ITk Strips

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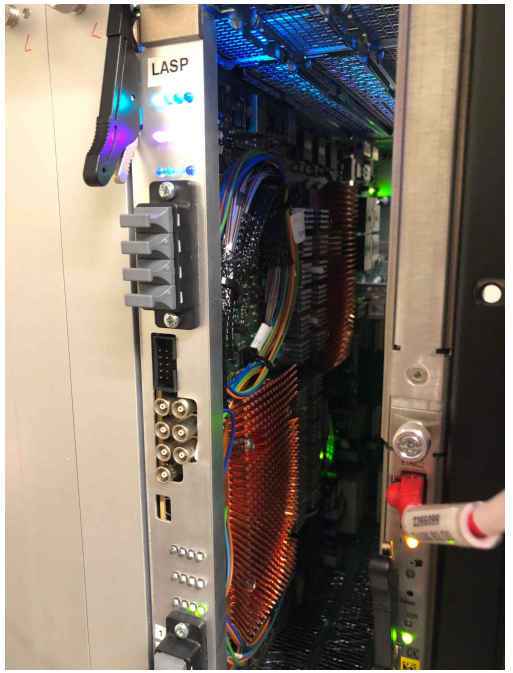
- Institutes: HU Berlin, DESY, TU Dortmund, Freiburg
- Module production and petal loading will continue until Q2/2028.
- Petal integration at DESY HH in one complete endcap. Runs until Q3/2028 with personnel from universities.
- Installation at CERN will start in Q4/2028. Significant personnel from universities needed. Commissioning until 2030.
- Visible impact: Sole responsibility for endcap hybrids and EC power-boards, and integration of one endcap.
- Main risk: Further delay due to radiation damage of DC-DC converters (bPOL12V). Evaluation of issue is ongoing. Mitigation strategies of production schedule and operation mode of converters are ongoing.

Liquid-Argon Calorimeter (LAr)

- Institutes: Dresden, Mainz, MPP München
- Completion of series production and QA/QC of LAr Signal Processors (LASP) until Q2/28
- Installation of off-detector electronics infrastructure and commissioning with front-end until Q2/29
- Commissioning of off-detector electronics with trigger system until Q2/30
- Production-firmware development and commissioning until Q2/30
- Coordination roles: LAr Upgrade Project Co-Leader, LAr off-detector electronics coordinator, LASP firmware technical management



LASP test-board

High Granularity Timing Detector (HGTD)

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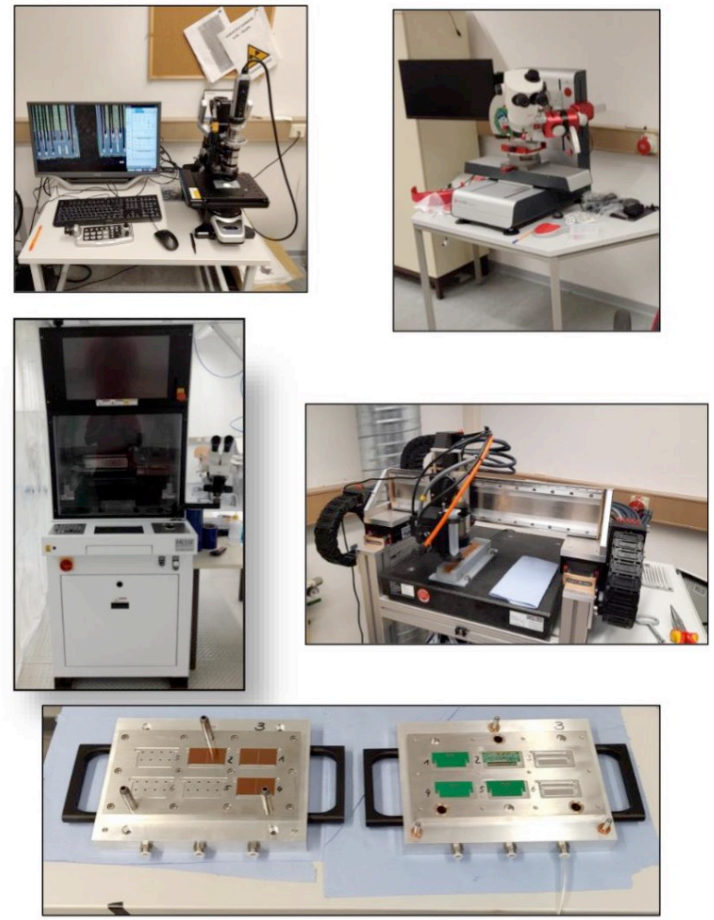
- Institutes: Gießen, Mainz
- Module assembly and loading for second half of the detector in Mainz until Q1/28 (10% of HGTD)
- Detector assembly and installation, including low-voltage system until Q4/28
- Detector commissioning until Q2/30
- Coordination roles: HGTD detector unit loading and testing coordinator



HGTD module assembly at Mainz

Muon Spectrometer (MS)

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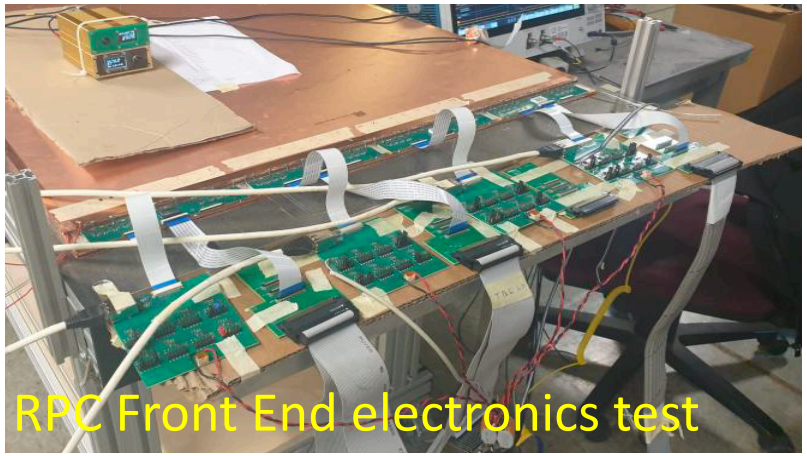
- Institutes: Bonn, LMU München, MPP München, Würzburg
- Replacement of on-detector electronic cards (20,000 pieces) and commissioning of readout on muon detector modules (1200) in full MS.
- New HV system
- BMFTR (financial) share on the Phase-2 muon upgrade: 27.4%
- Installation: 07/2026 – 12/2029
- Commissioning: 07/2029 – 03/2030
- Significant person power needed to finish installation on schedule during LS3. Access not possible at a later stage.
- NSW Micro-Megas detectors require person power during LS3 for maintaining detectors operational.


RPC Front End electronics test

Tile Calorimeter TDAQ interface

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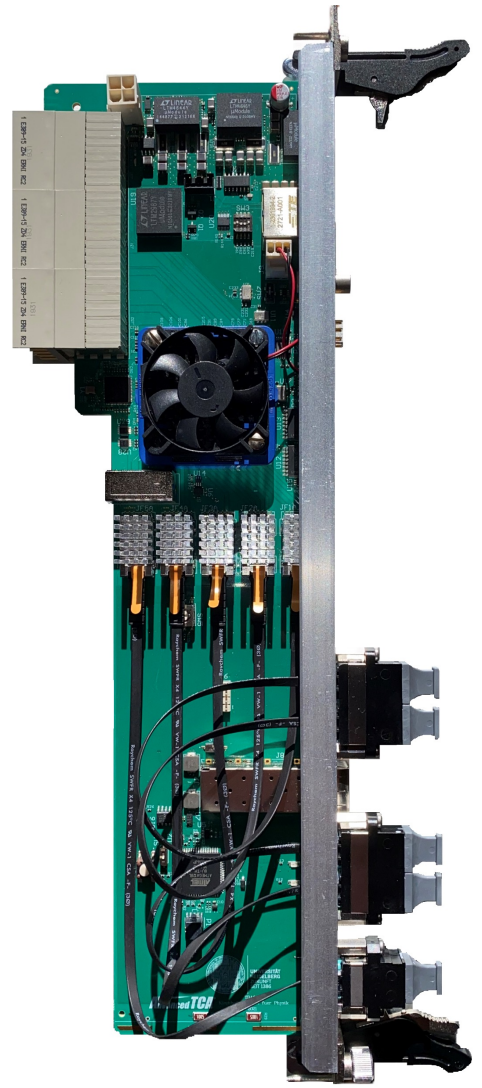
- Institutes: Heidelberg (KIP)
- The Tile Calorimeter Trigger and Data Acquisition Interface (TDAQi) is an essential part of the new Phase-II TileCal PreProcessor.
- Production of 40 TDAQi until Q3 2026, on schedule, no delays expected
- Integration until Q3 2027
- Commissioning, including connectivity validation to TDAQ, as well as DCS & monitoring (2027 – 2029)
- Run 4 startup operations and optimizations in 2030



TDAQi v3.5 pre-production

Trigger & Data Acquisition (TDAQ)

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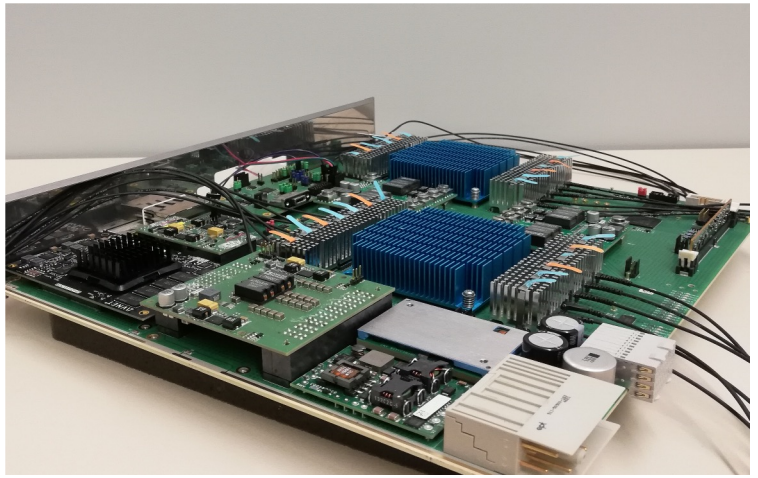
- Institutes: Heidelberg, Mainz, MPP München
- New forward L1 trigger (fFEX), firmware on Global Trigger (Mainz)
  - Significant person power needed for firmware completion, integration and commissioning during LS3 and startup
  - Main risk: Availability of 25 Gb optical modules (vendor problems, affects both ATLAS & CMS). A vendor change would require PCB redesign!
  - Additional Core resources needed at moderate level.

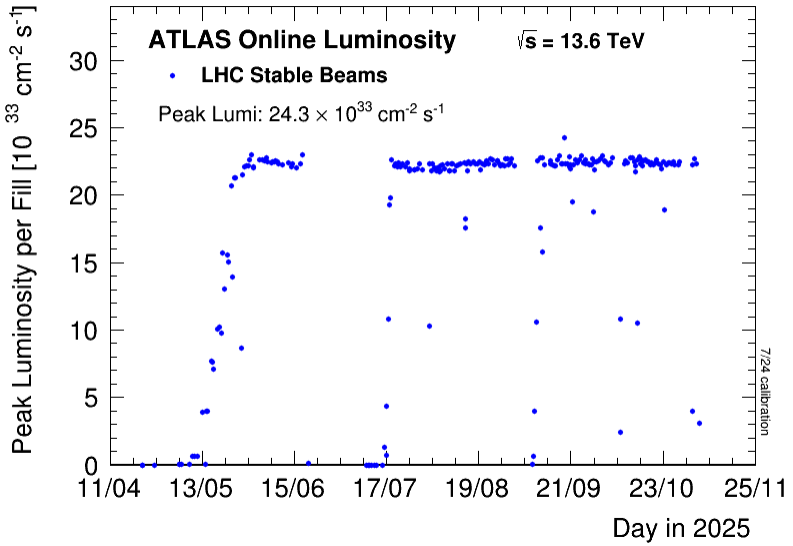


fFEX Prototype in Mainz

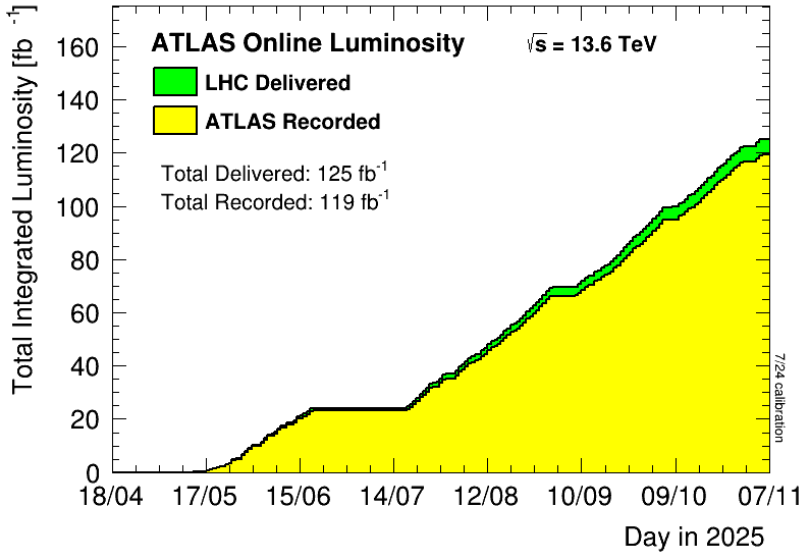
- Tracking firmware/software for Event Filter; L0Calo/Global algorithms calibration (Heidelberg)
  - Technology decision (CPU-only, CPU+GPU or CPU+FPGA) early 2026
  - Installation of processing units from Q1/2028 to Q2/2029
  - Person power needed for firmware/software development and commissioning
  - Coordination roles: Firmware coordinator of the Event Filter Tracking Group

Run 3 of the LHC: A big success

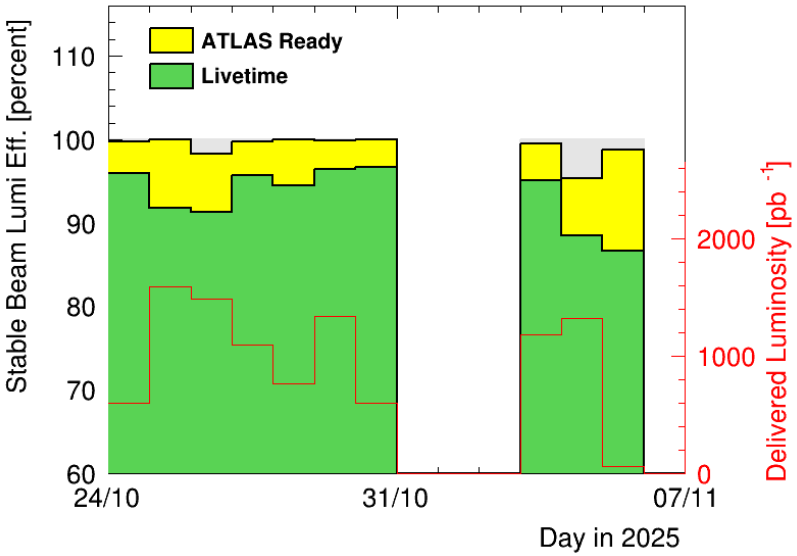
- Record luminosity!



- Goal of integrated luminosity for 2025 (> 120 fb^{-1}) exceeded!



- High data taking efficiency!



- Luminosity levelling:
  - β^*
  - Separation
  - Crossing angle

- High availability:
  56% of the time in stable beams.

Involvement in data analysis

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	Standard model	Top quark	(Di)-Higgs	HMBS	Heavy Ion	Exotics
HU Berlin		✓	✓	✓		✓
Bonn	✓	✓	✓	✓	✓	✓
DESY	✓	✓	✓	✓		✓
TU Dortmund	✓	✓		✓		
Dresden	✓		✓	✓		✓
Freiburg	✓		✓			
Gießen	✓					
Göttingen		✓	✓	✓		✓
Heidelberg	✓		✓	✓		✓
Mainz	✓	✓	✓	✓		✓
LMU München			✓			
TU München			✓	✓		
MPP München	✓	✓	✓	✓		✓
Siegen		✓	✓			
Wuppertal	✓	✓				✓
Würzburg	✓	✓				✓

- The German ATLAS groups are involved in a broad range of physics analysis.

Highlights of the Run 3 Physics Program

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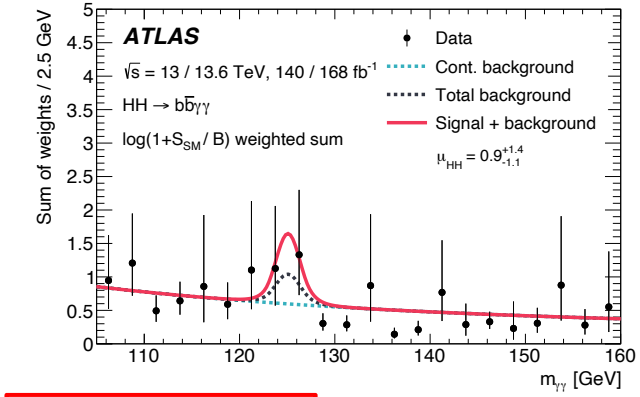
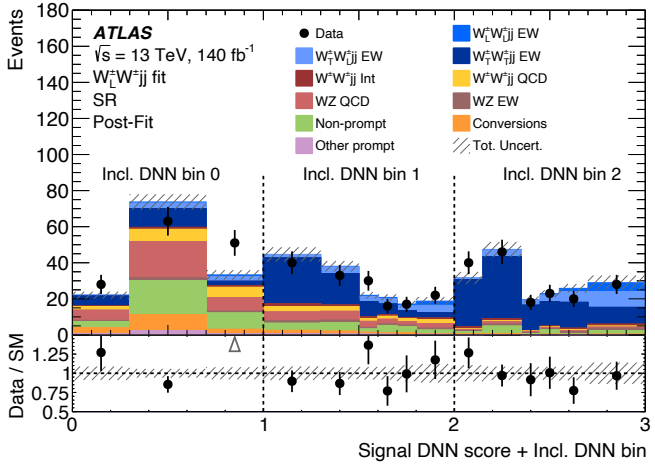
- The German ATLAS groups plan to perform high-profile measurements and searches based on the Run 3 data set. A few highlights of the analysis program are indicated below (plots from previous analyses):

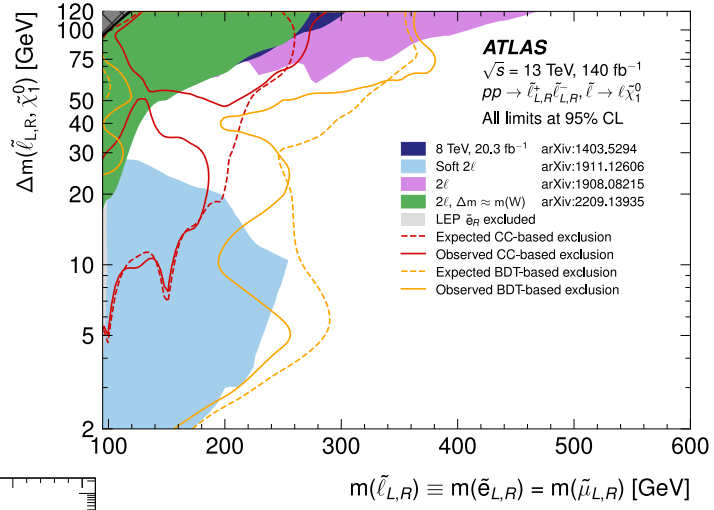
Searches for HH production



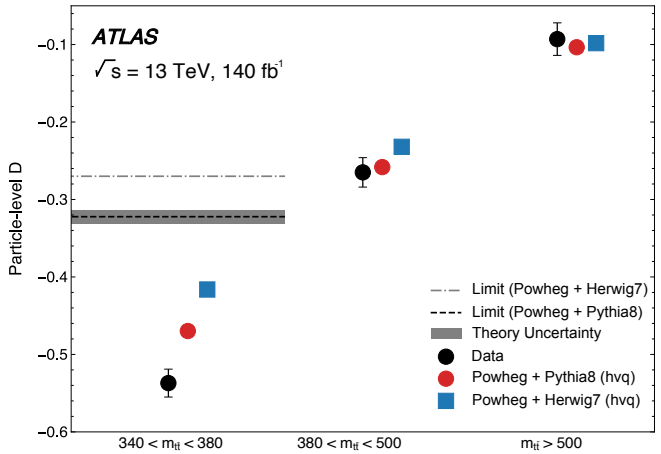
Polarisation in same-sign WW production



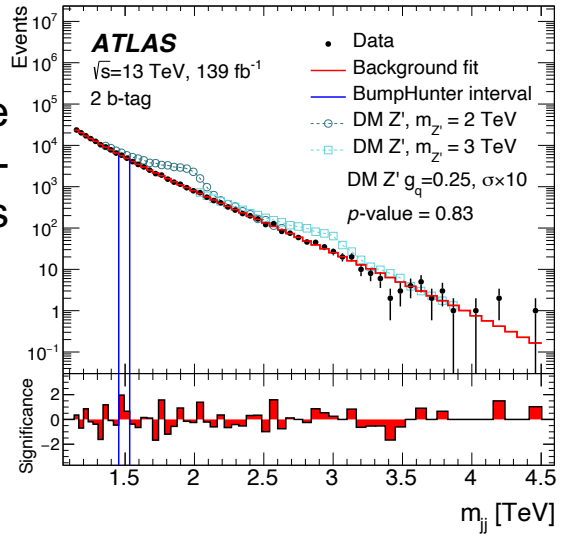
Search for slepton production in the compressed-mass corridor



The ATLAS-D team leaders consider it essential that data analysis remains part of the call for grant proposals, even if it is not a priority.

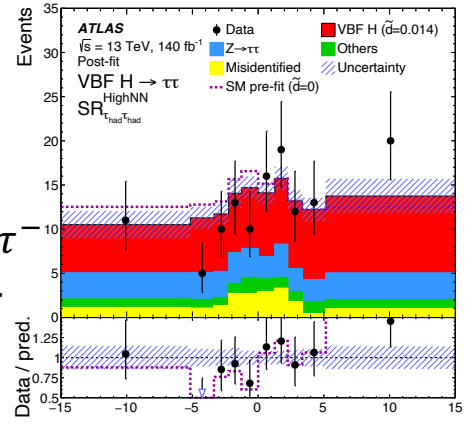


Di-jet resonance search with b-tagged jets



Quantum entanglement in $t\bar{t}$ production

CP properties in VBF $H \to \tau^+\tau^-$ production



Reconstruction, calibration and performance

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- The German ATLAS groups contribute to many aspects of object reconstruction, calibration and performance topics.
  - Their work led to impressing improvements in the past years.

	Electrons & photons	Muons	Taus	Jets & missing transverse energy	Flavour tagging	Luminosity	Simulation & software	Generators & modelling	Grid data processing
HU Berlin				✓	✓	✓			
Bonn		✓	✓				✓	✓	
TU Dortmund	✓			✓				✓	
DESY	✓			✓	✓	✓	✓	✓	✓
Dresden	✓		✓				✓	✓	
Freiburg			✓		✓	✓			✓
Gießen						✓	✓	✓	
Göttingen			✓	✓	✓		✓	✓	✓
Heidelberg				✓					
Mainz									
LMU München		✓							✓
TU München				✓	✓		✓		
MPP München		✓		✓	✓		✓	✓	✓
Siegen		✓		✓	✓		✓	✓	
Wuppertal				✓			✓	✓	✓
Würzburg									

Advancements in reconstruction performance

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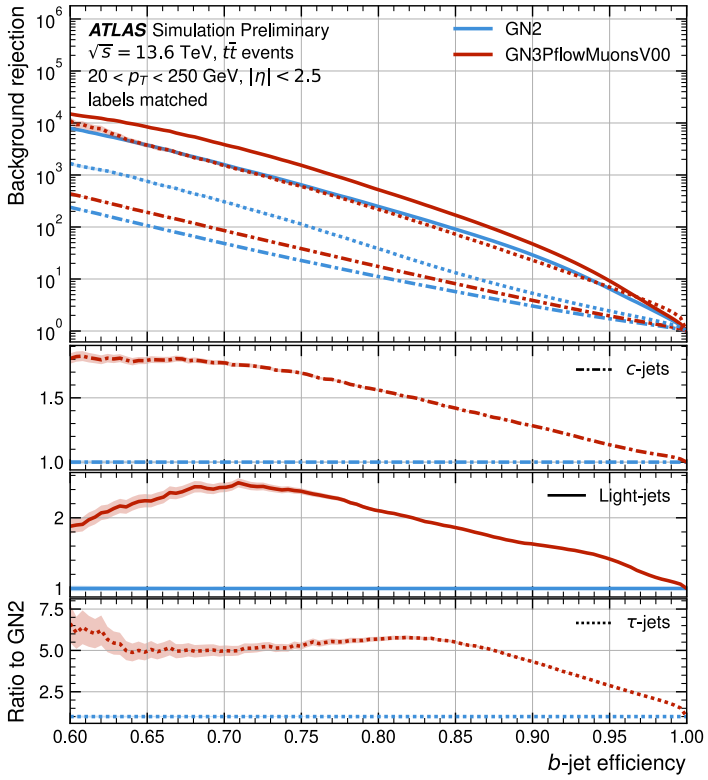
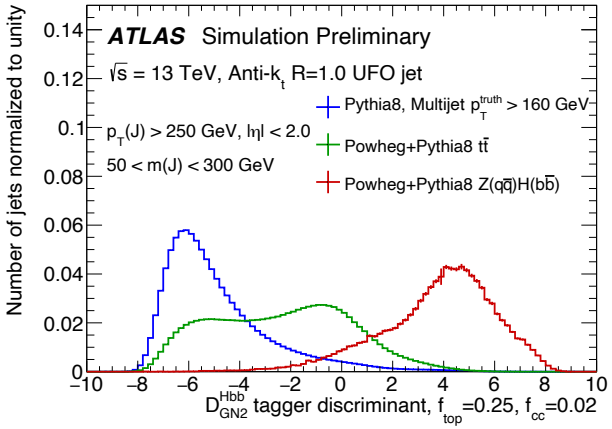
- General theme: The progressing application of more advanced machine-learning tools leads to striking improvements in reconstruction, identification and calibration of detected objects.
- The ATLAS-D groups plan to pursue various projects aiming for further improvements.

Transformer-based jet-flavour tagging



[FTAG-2025-01]

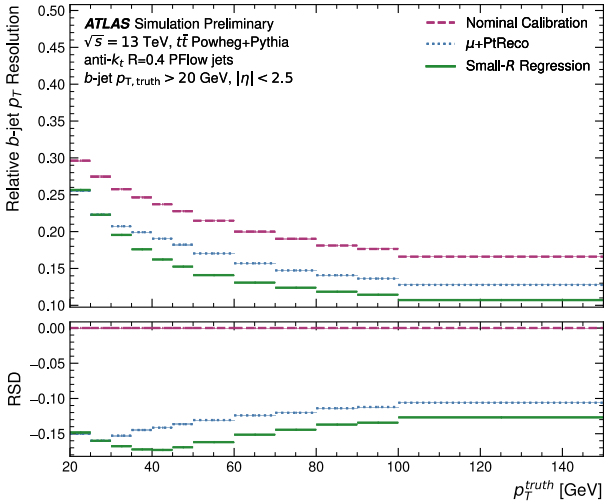
Large-R-jet tagging



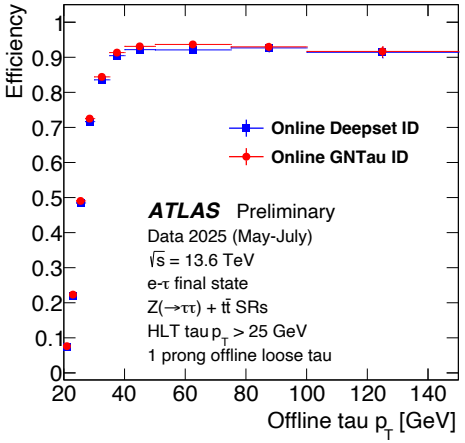
[FTAG-2023-06]

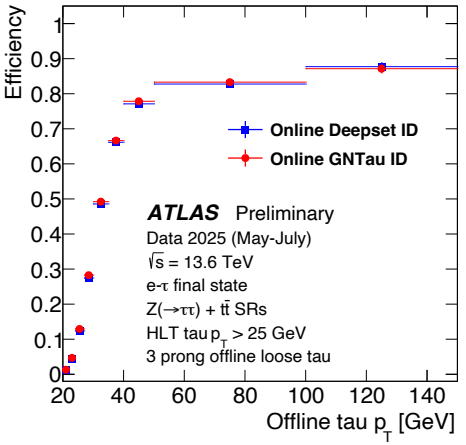
Tau trigger with online ID based on graph-neural networks (2025) and DeepSet (2023 – 2024).

[Tau CP plots]



Transformer-based b-jet p_{T} calibration

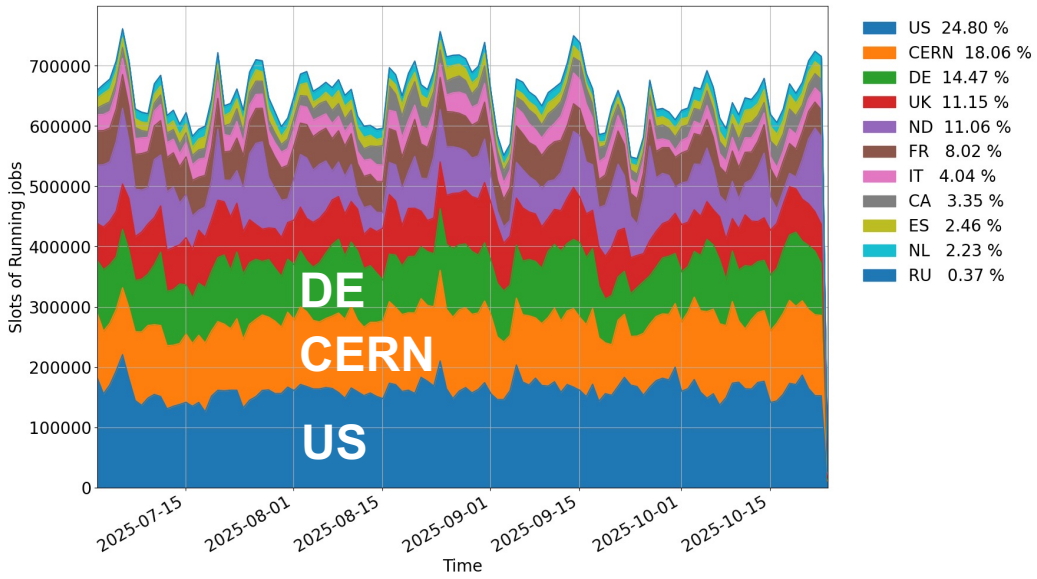




Continued operation of the WLCG

- Transition from Tier-2 centres at universities to Helmholtz Centres (DESY, KIT) / MPP (storage) and NHR centres (CPU) started successfully.
  - Will be finished in 2029.
- Person power requirements will remain at least at the present level.
  - Further development needed to establish smooth operation at NHR centres. Challenges:
    user analysis jobs are diverse and some demanding in resources, network connections NHR-Helmholtz centres, caching solutions
  - Support job submission at NHR centres
  - Continue operations at university-based Tier-2 centres until 2029

Effective and successful operation of the ATLAS DE cloud by teams from DESY HH, Freiburg, Göttingen, München, Wuppertal



July-Sept 2025: Wall clock time DE:

GridKa : 20.12%
DESY/MPI : 26.74%
DE Unis : 53.13%

Conclusions

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- In the next funding period (2027 – 2030) the groups of ATLAS-Deutschland consortium plan major contributions to ATLAS in the following areas:

  1) Completion of the Phase II production, detector installation and commissioning
  2) Detector operations and maintenance of legacy systems
  3) Analyses of Run-3 data (> 300 fb^{-1}) and contributions to performance improvements
  4) WLCG infrastructure operation

- Federal funding is required since the institute resources are not sufficient to fulfil the commitments of the German groups in all four areas.
- The funds are urgently needed (“Dringlichkeit”) to finish the required tasks in a proper time frame defined by the CERN schedule.