

ATLAS and *CMS* and HL-LHC upgrade: status and plans

Krisztian Peters

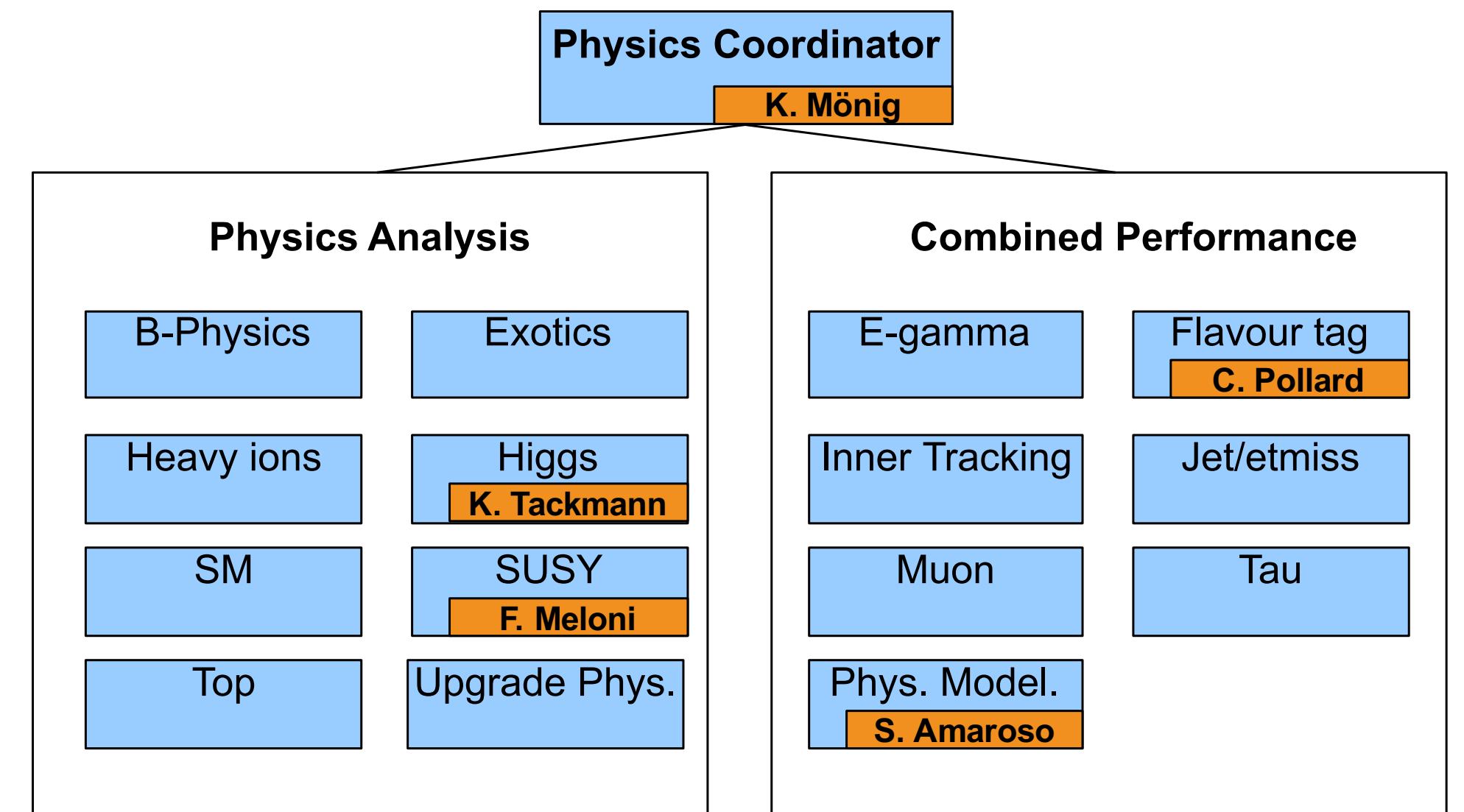
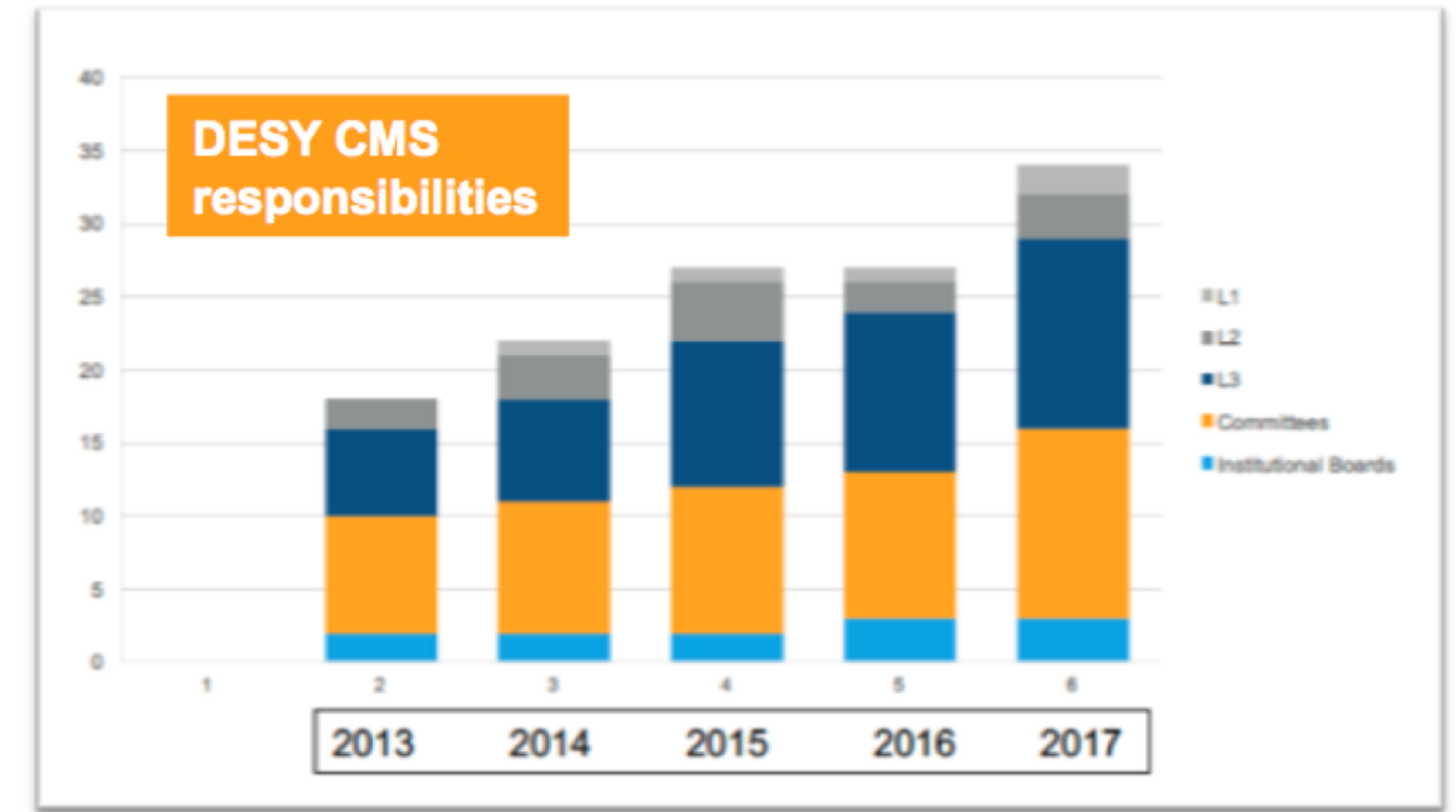
PoF preparation meeting
March 18, 2019



The DESY groups in ATLAS and CMS

Two strong and influential groups on ATLAS and CMS

- Each group has roughly 100 members
- ~4-6 PhDs graduate in both groups every year
- Groups have high visibility and leading roles in detector operation, object reconstruction, physics analysis and upgrades
- Many management and leadership positions covered by DESY scientists
 - Deputy spokesperson, physics coordinator, Collaboration Board Chair, physics and performance group conveners, etc.



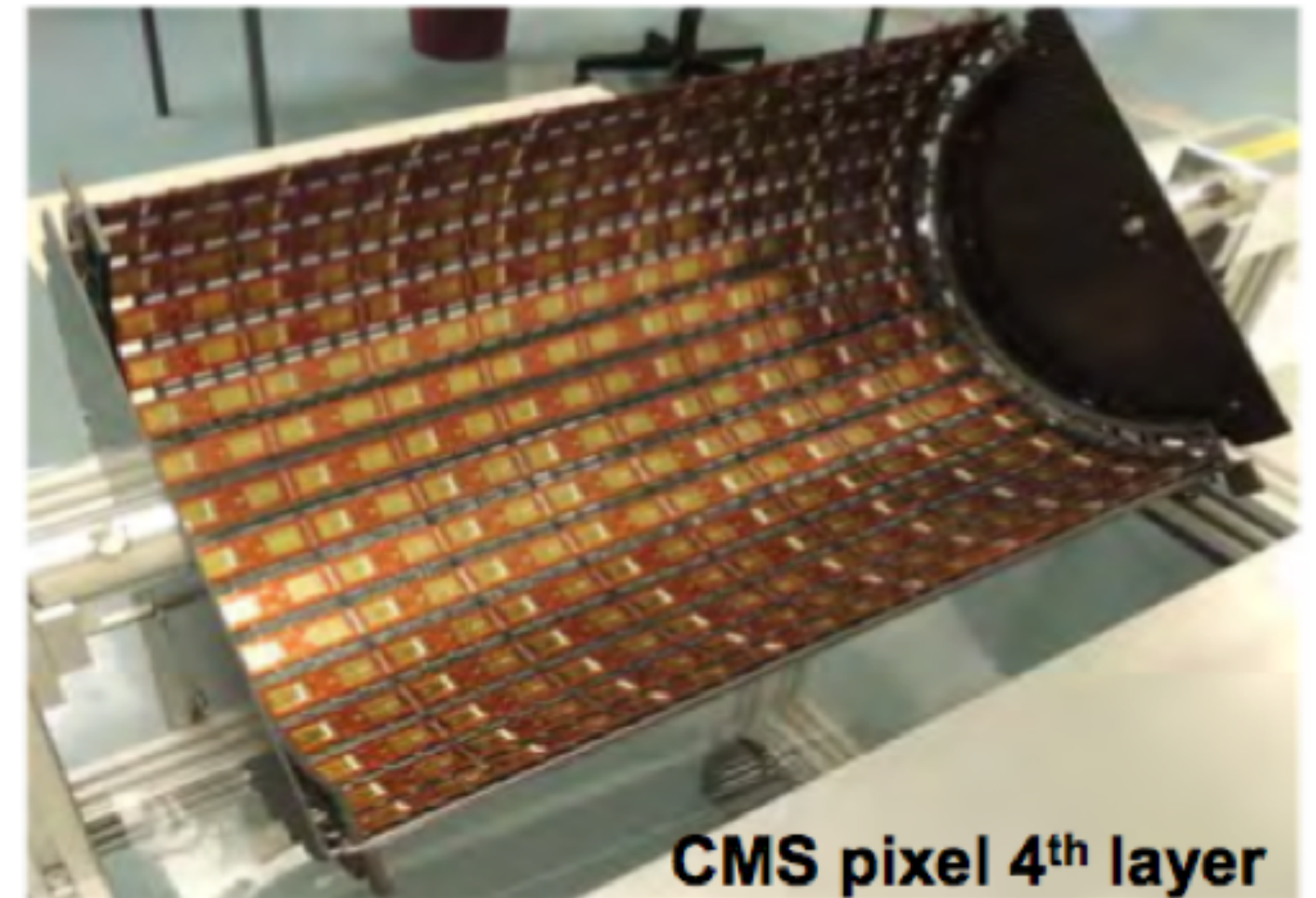
Detector Operations and Upgrade

CMS: fast beam condition monitor (BCM1F) for online measurement of luminosity constructed at DESY and group has a leading role in operation

ATLAS: responsibility for maintenance and further development of prompt calibration loop for the semiconductor tracker (SCT)

New tracking detectors for Phase-1 upgrade

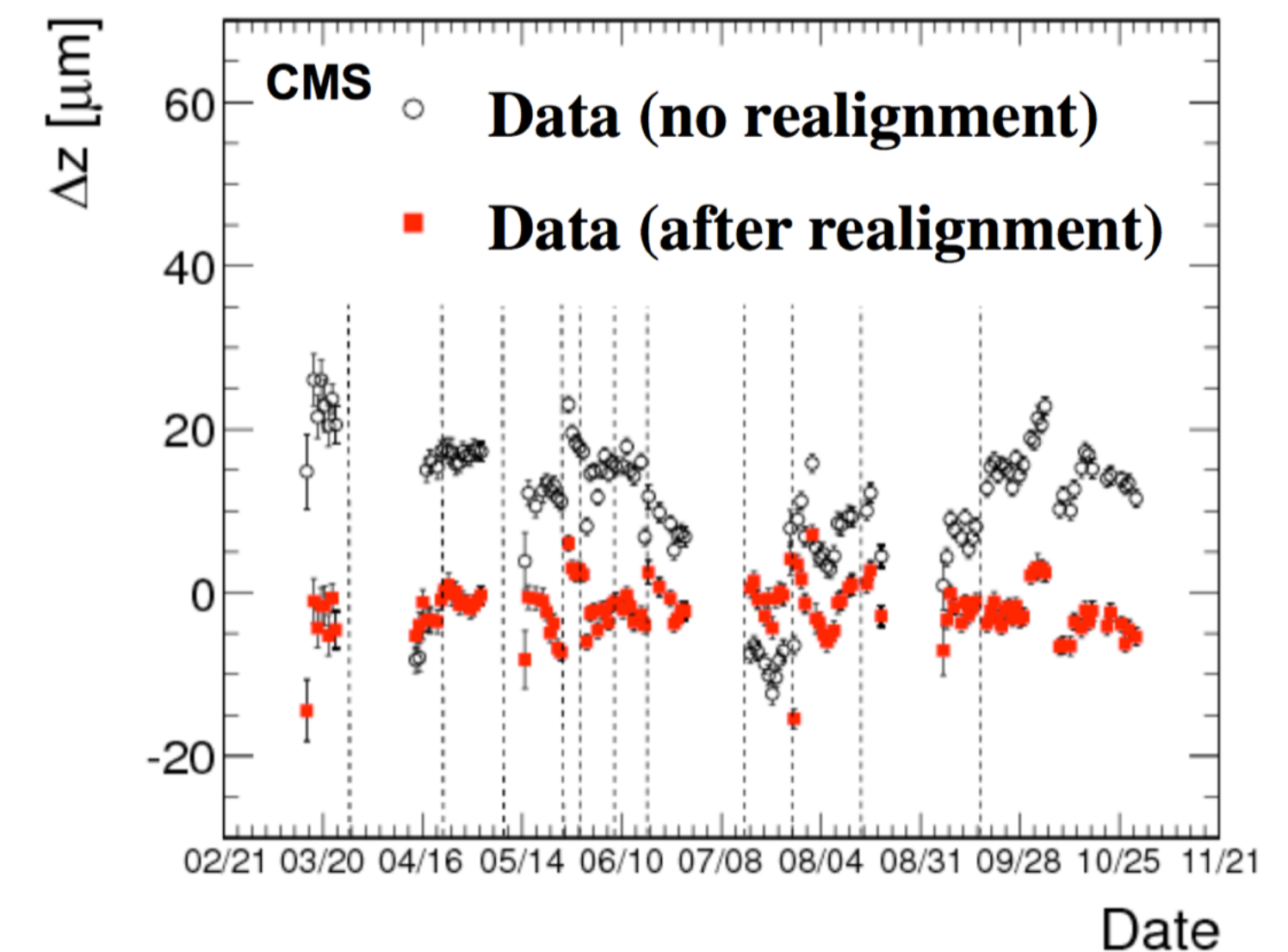
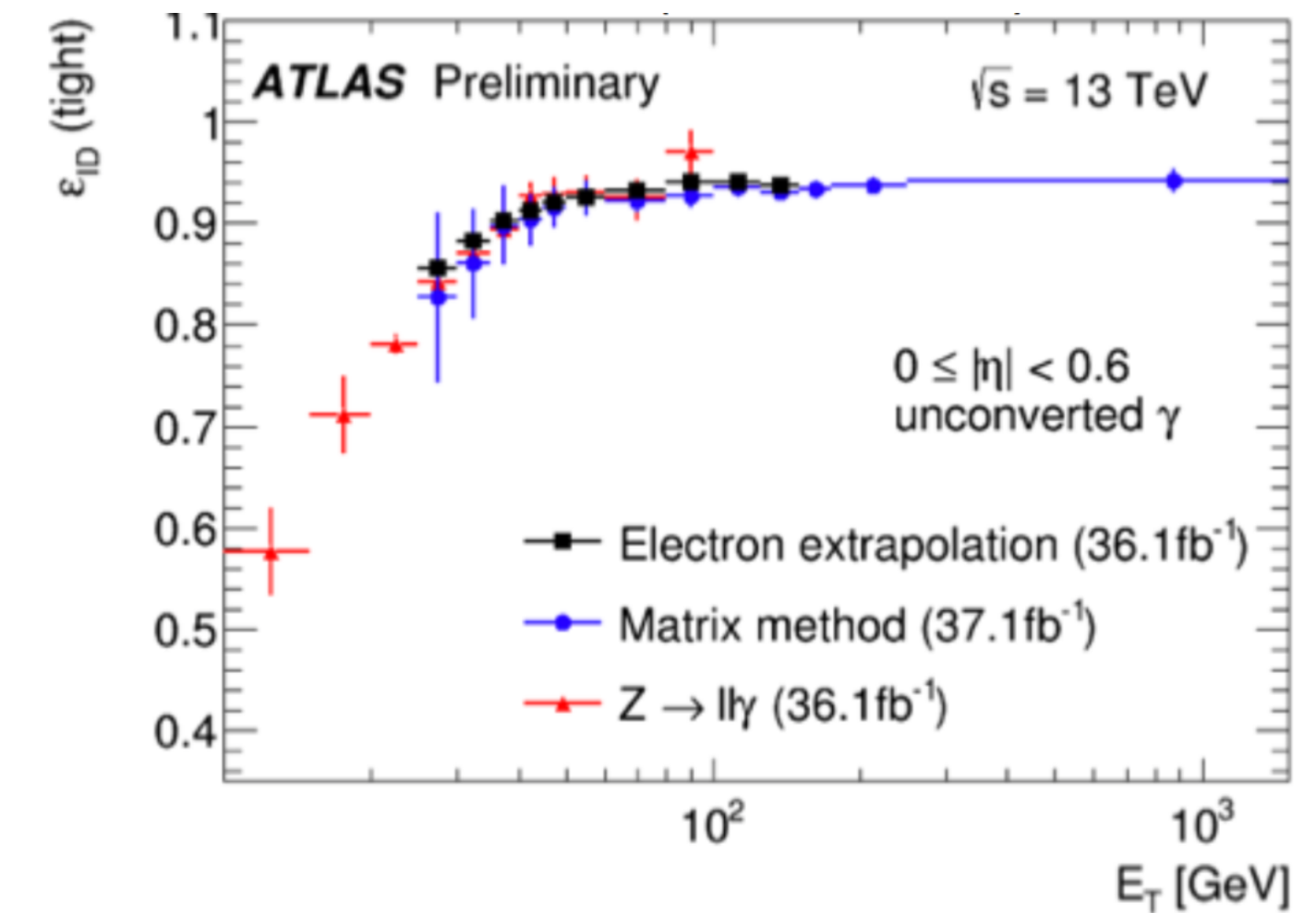
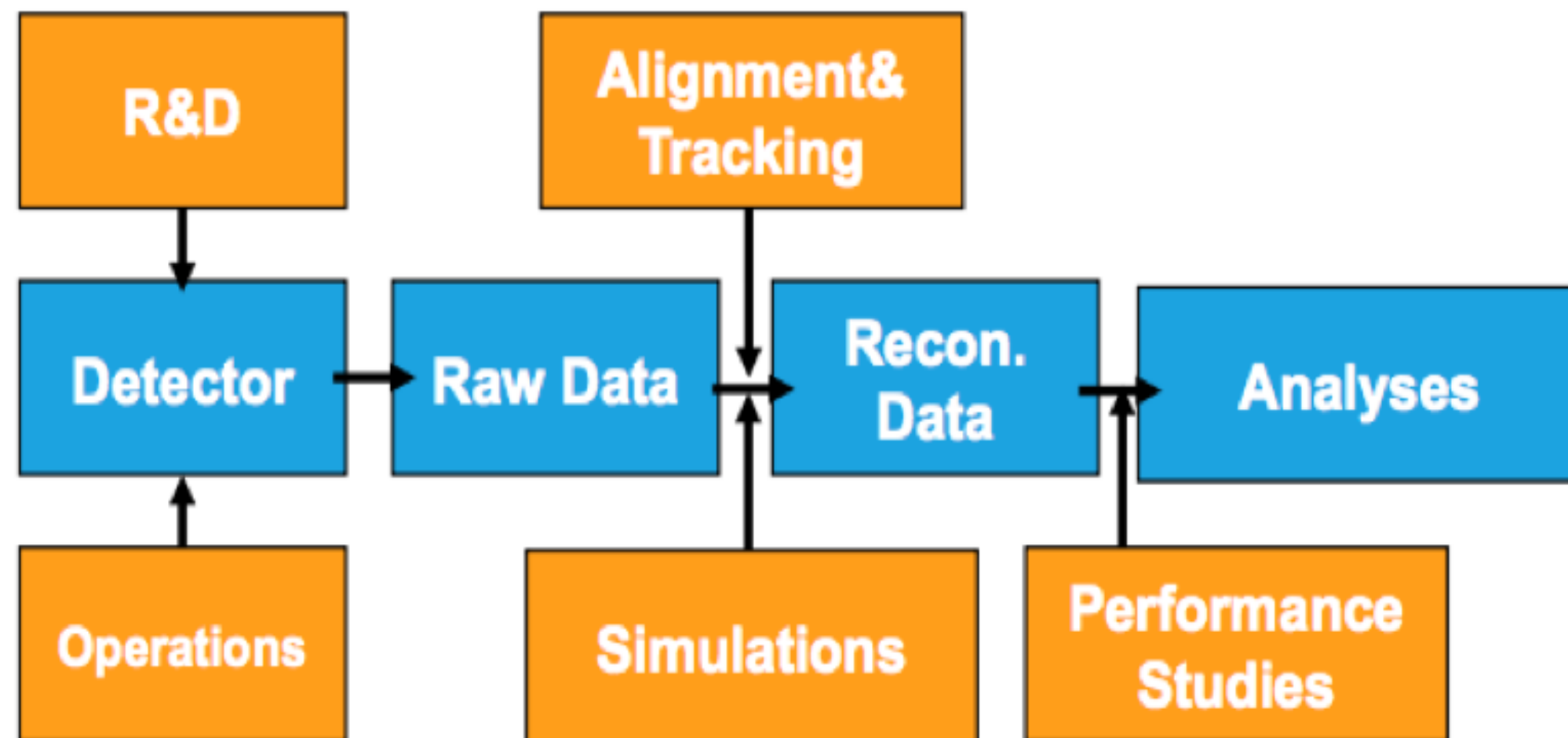
- Construction of 287 modules for 4th layer of CMS pixel detector at DESY, installed in early 2017
- ATLAS added innermost layer (IBL) and track trigger (FTk) with collaboration of DESY



Detector and algorithm performance studies

Involved in many performance studies required for successful data analyses:

- From photon identification to Monte Carlo studies
- CMS: pivotal role in alignment of CMS detector, handling about 200000 alignment parameters simultaneously
- ATLAS: strong contributions to tracking aspects for current and future tracking systems to adjust to ever increasing pile-up events

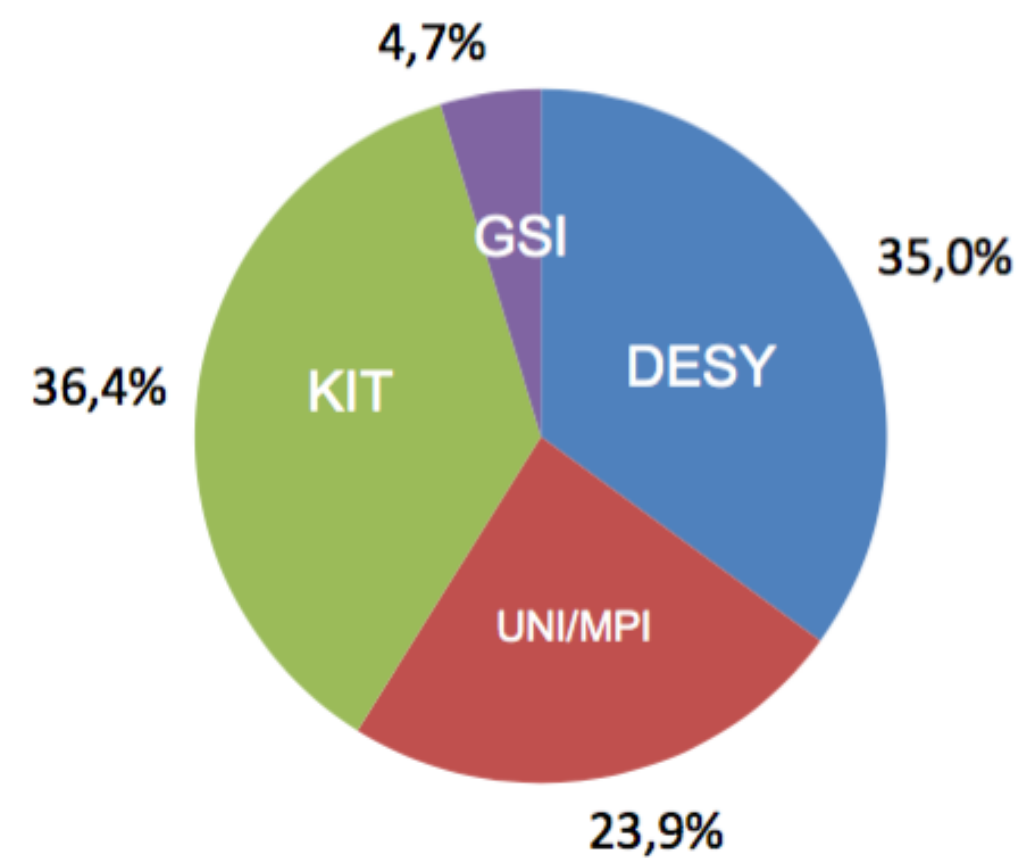


Computing

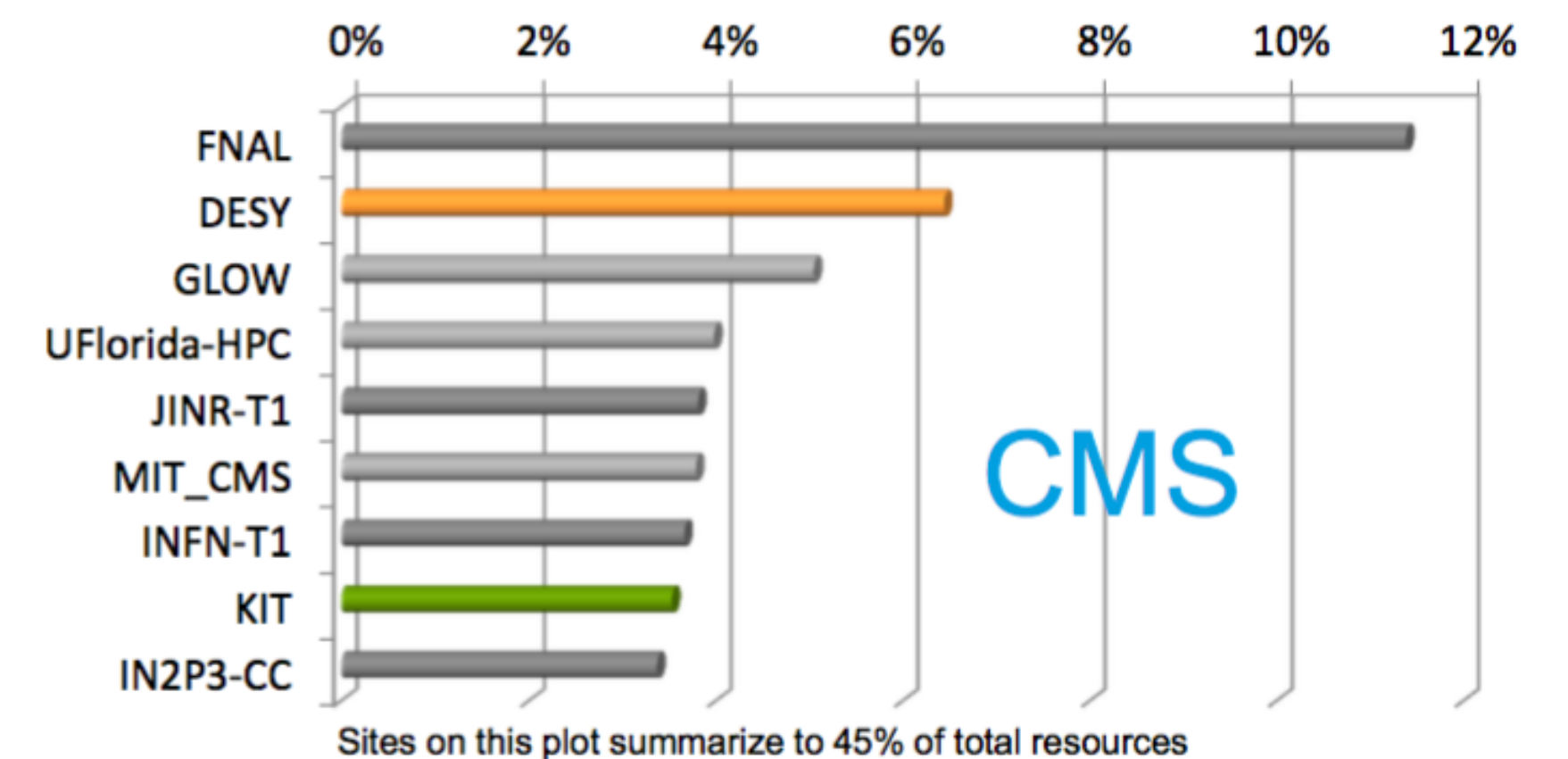
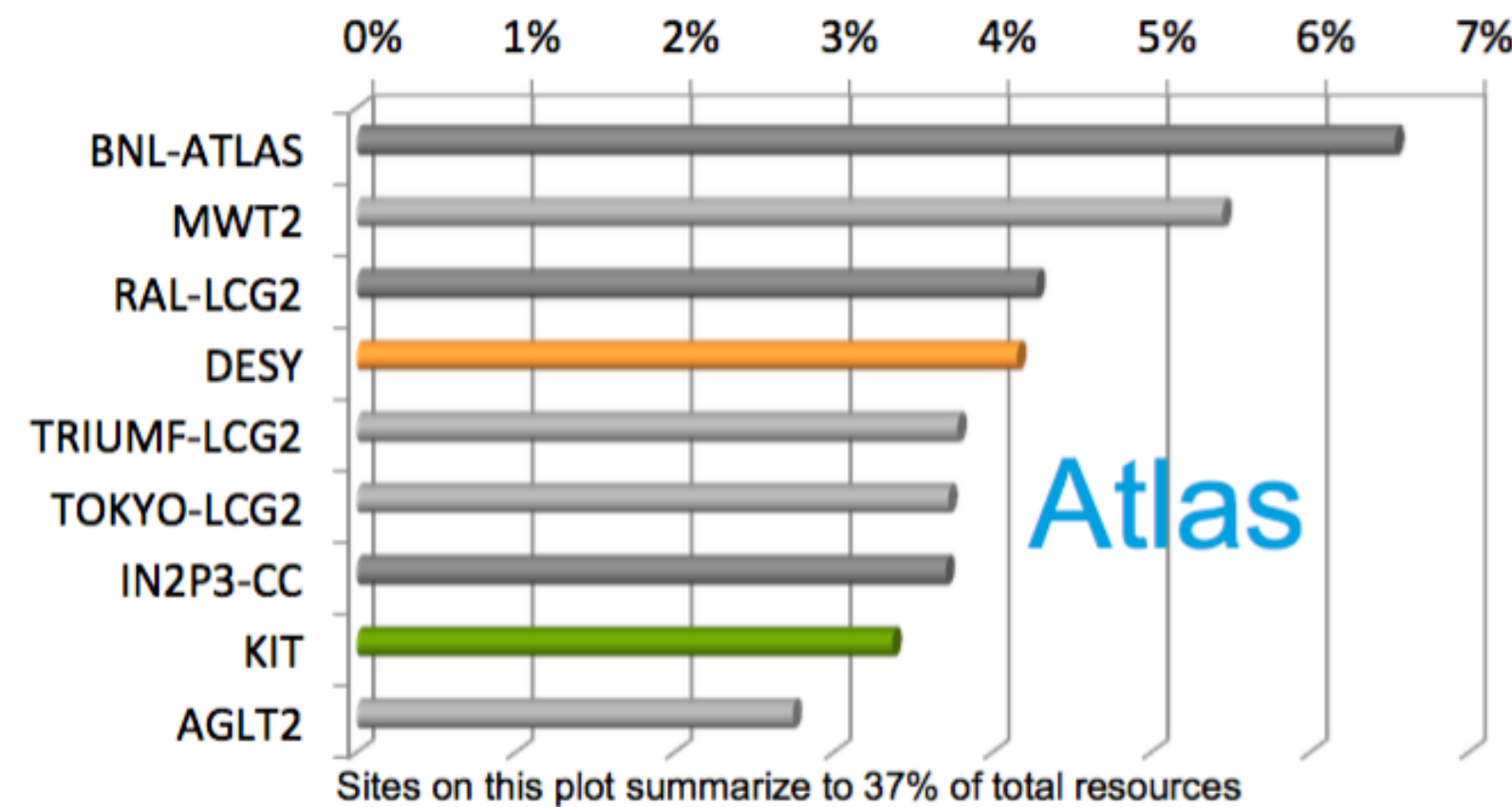
TIER-2 and National Analysis Facility (NAF)

- Allow for complementary usage of the same data source
- TIER-2: large national and international impact on the WLCG
- NAF: more than 600 users registered. Direct access to the entire TIER-2 GRID storage with ~7000 CPU cores

DESY's share of the German WLCG Infrastructure



Relative share of normalized CPU hours w/o the TIER-0

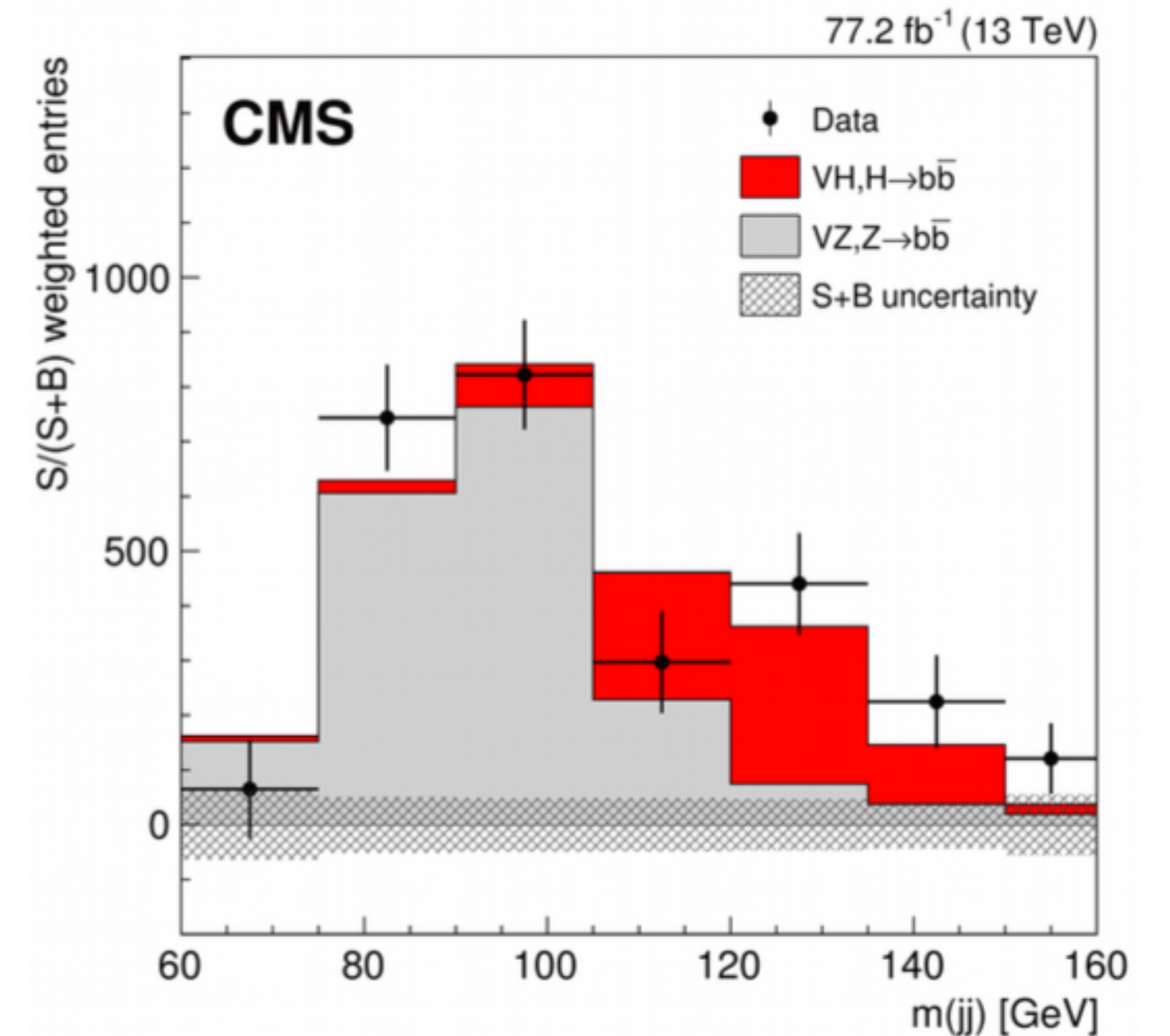
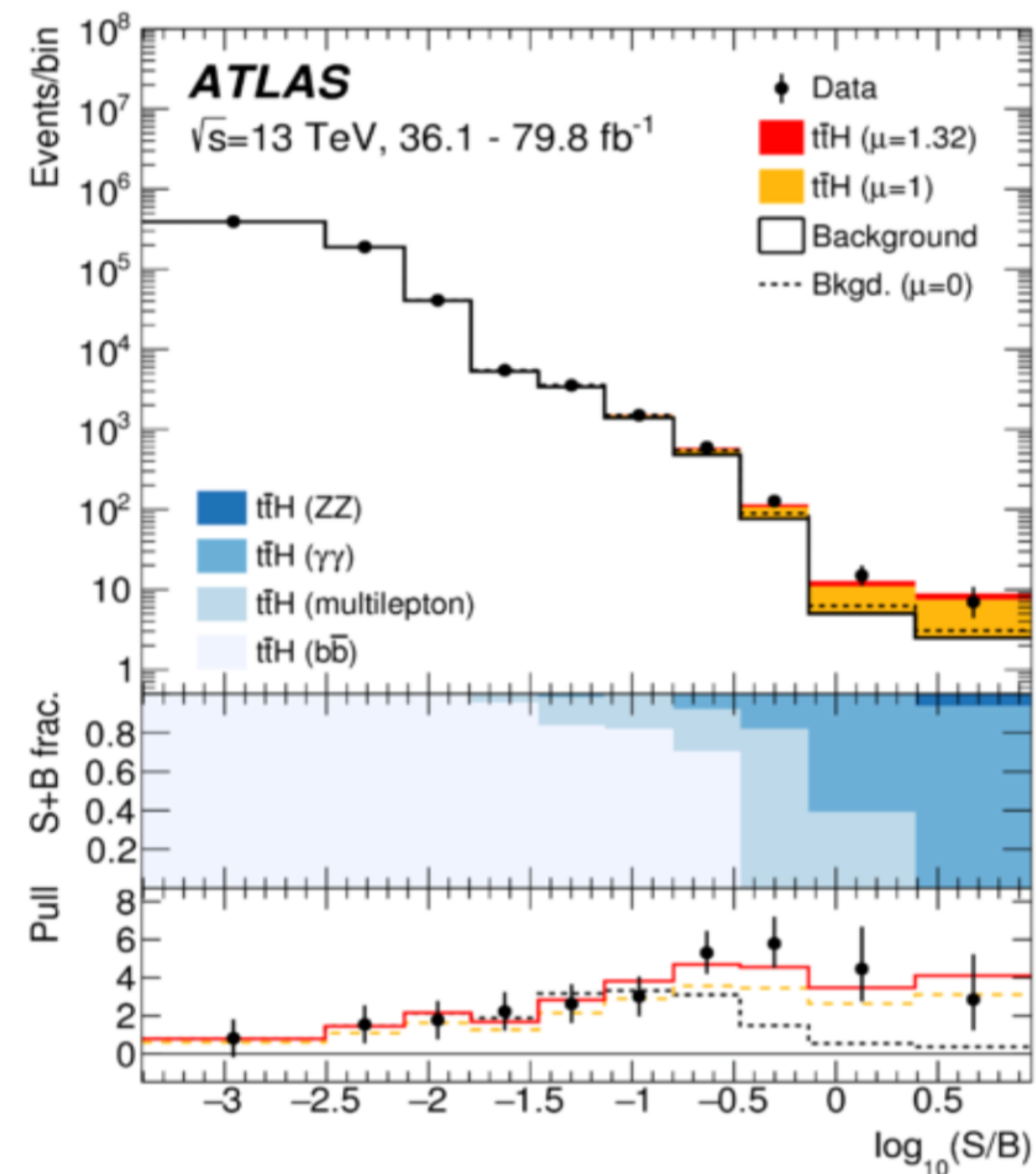
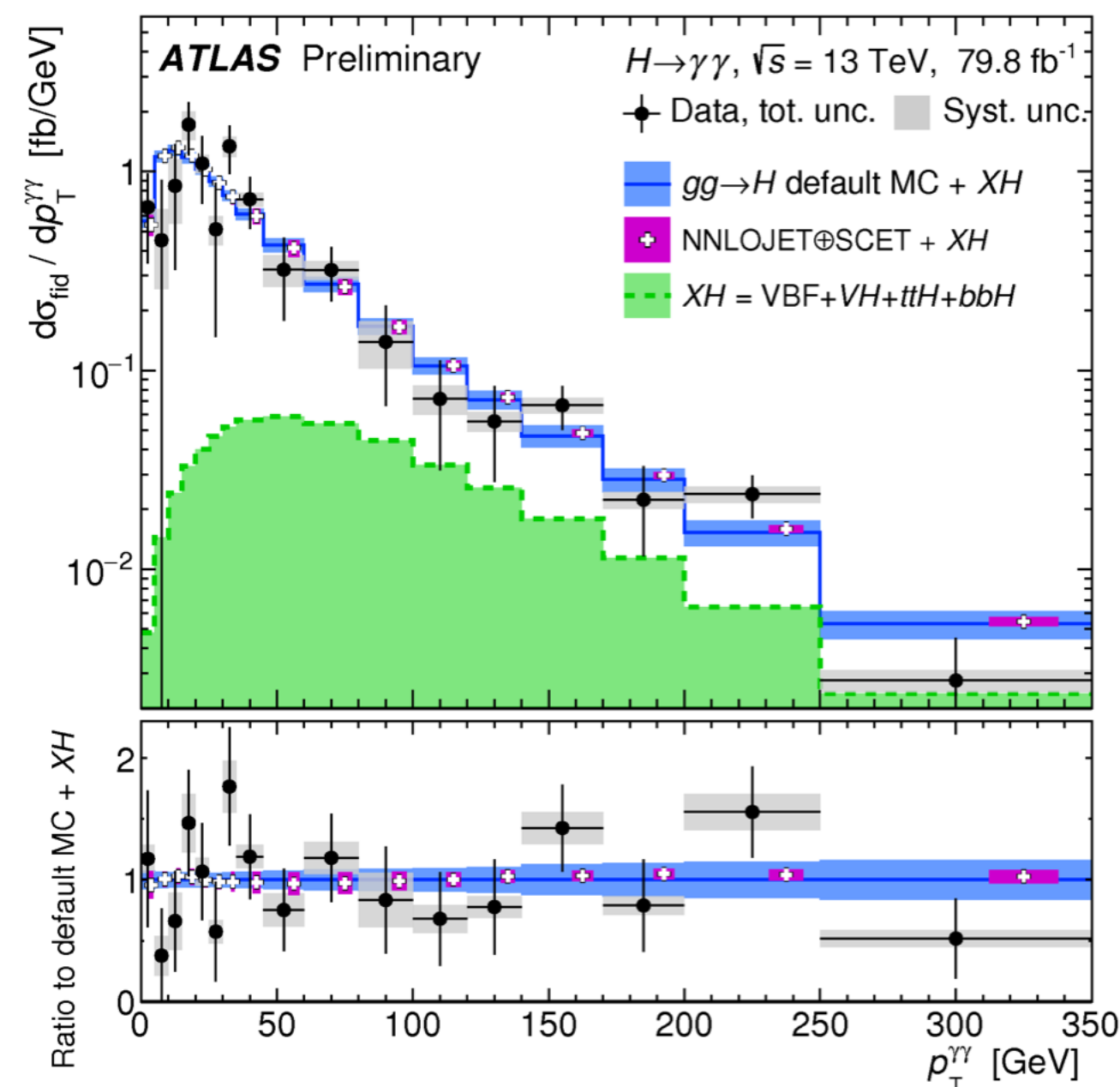


Physics analysis

Large impact to the overall LHC physics programme

Higgs physics:

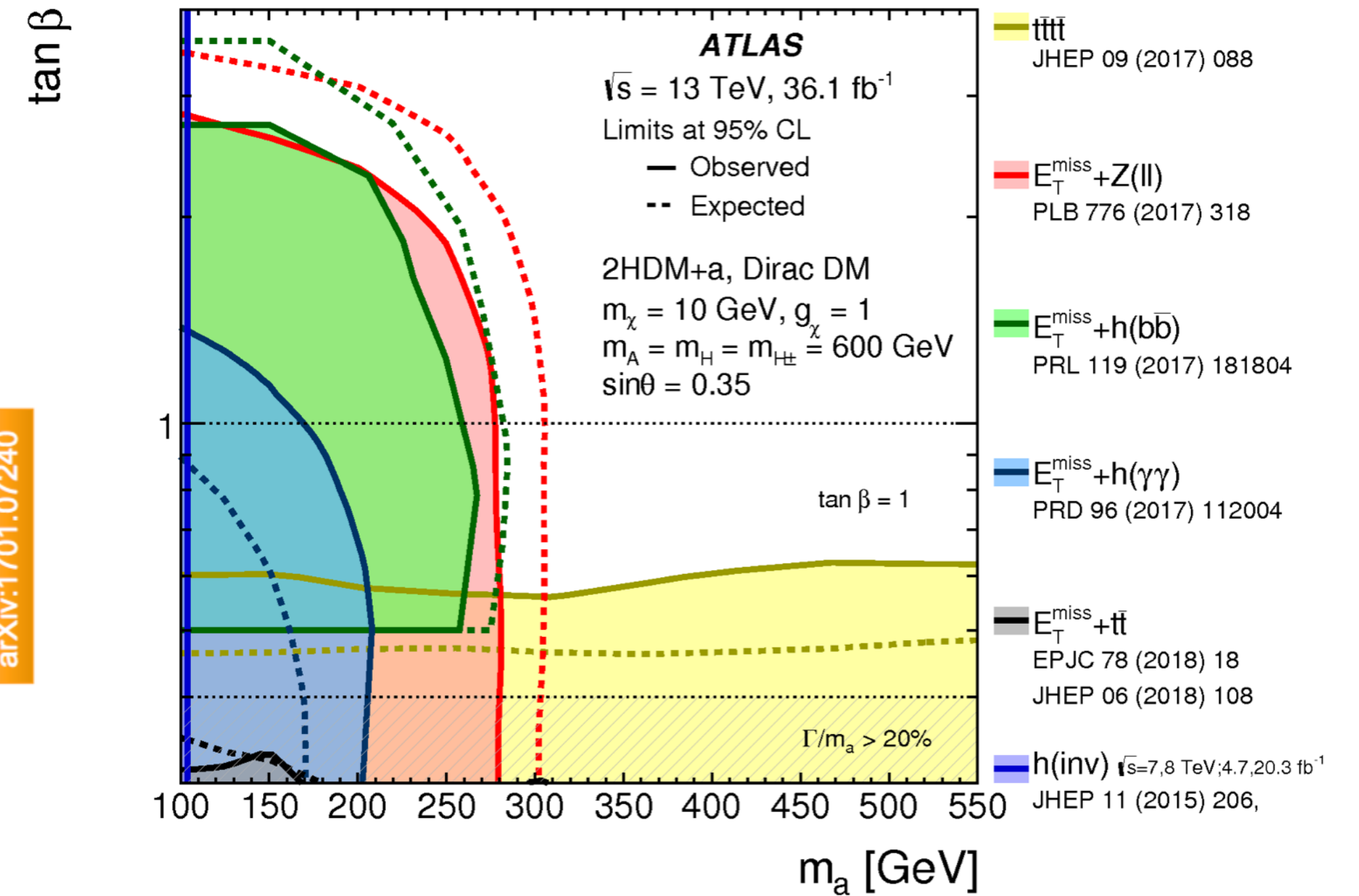
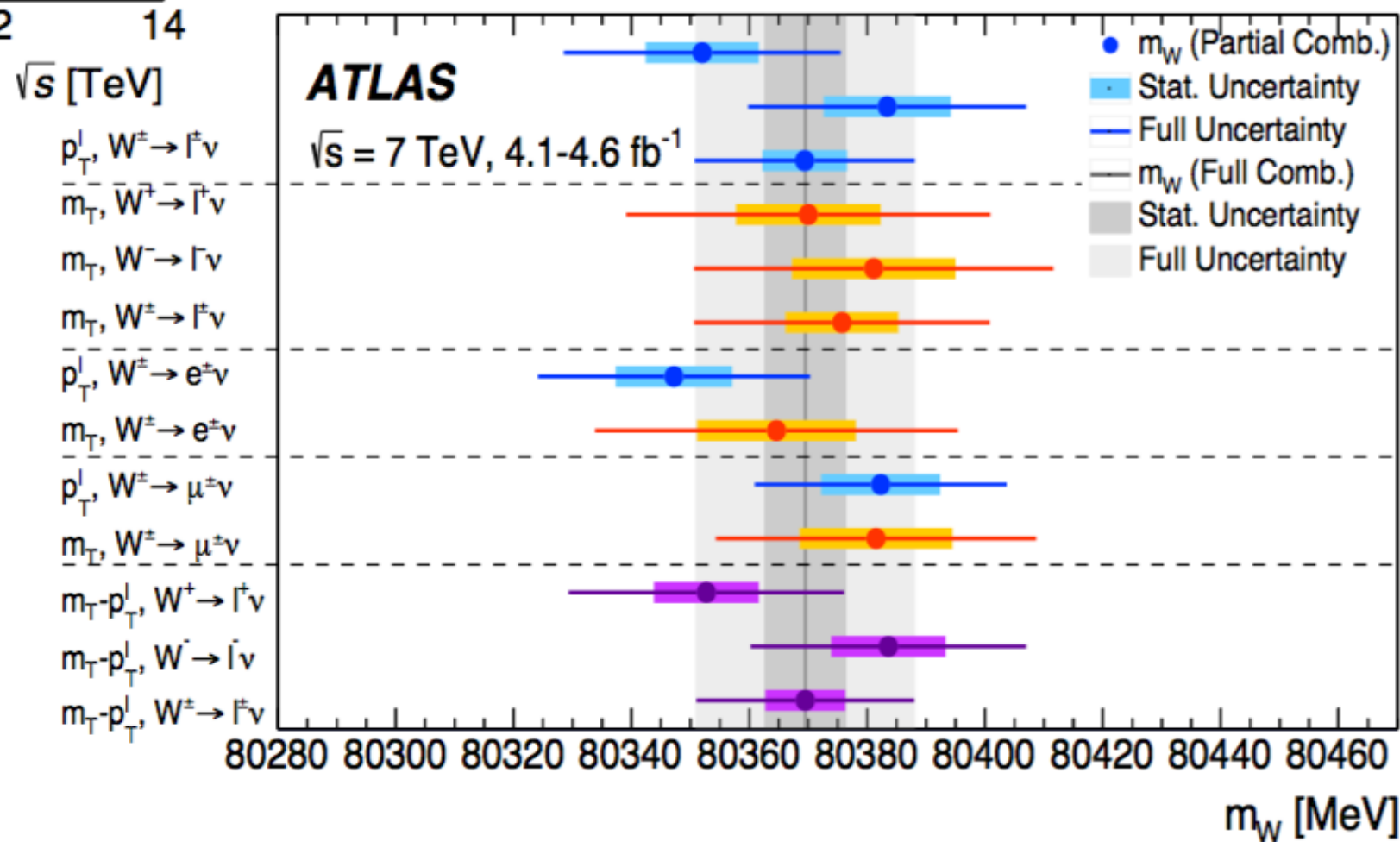
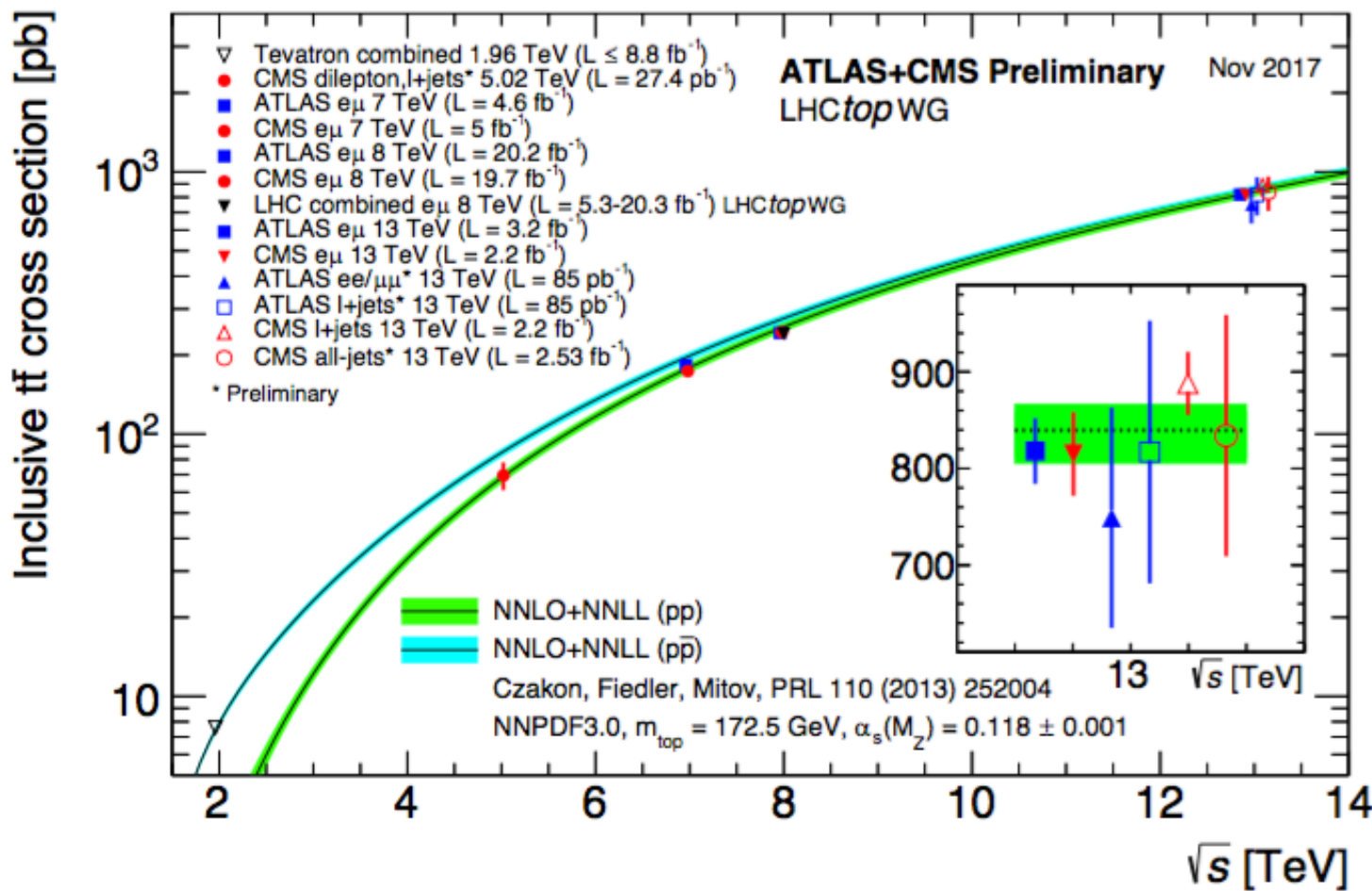
- Move from Higgs discovery (DESY contribution) in Run 1 to precision Higgs physics
- Leading contributions to recent observations of $t\bar{t}H$ production and $H \rightarrow b\bar{b}$ decays



Physics analysis

Large impact to the overall LHC physics programme

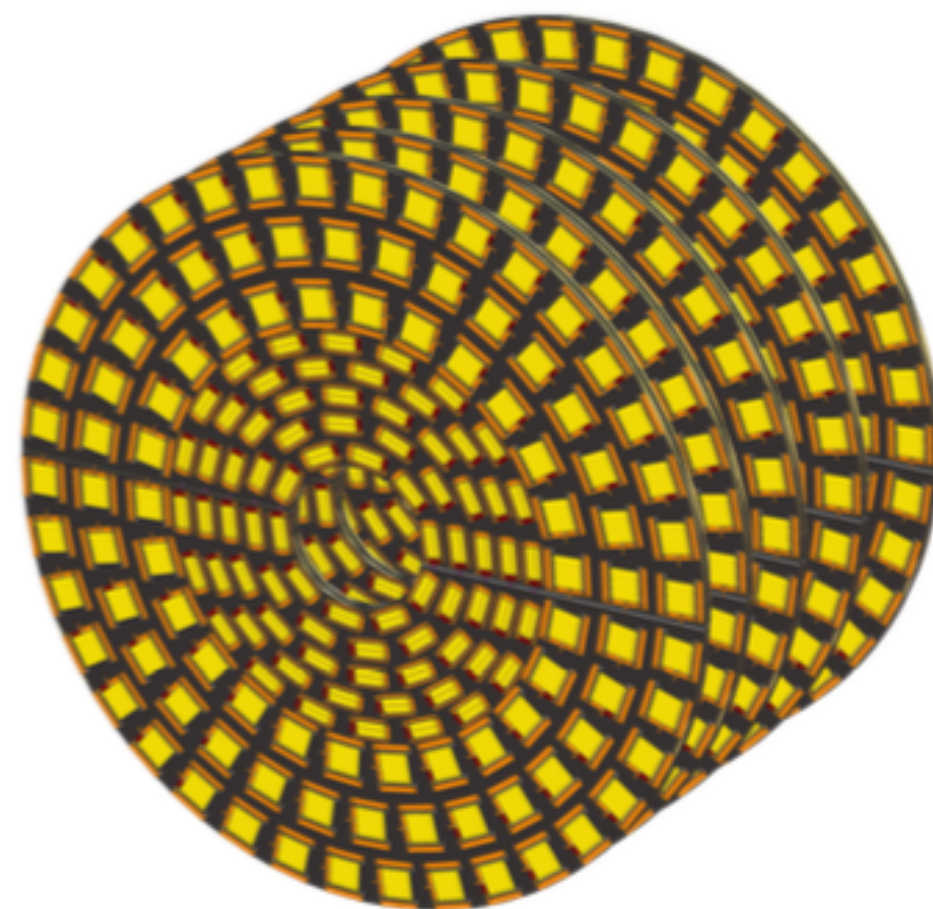
Top physics, Standard Model measurements and DM and other BSM searches:



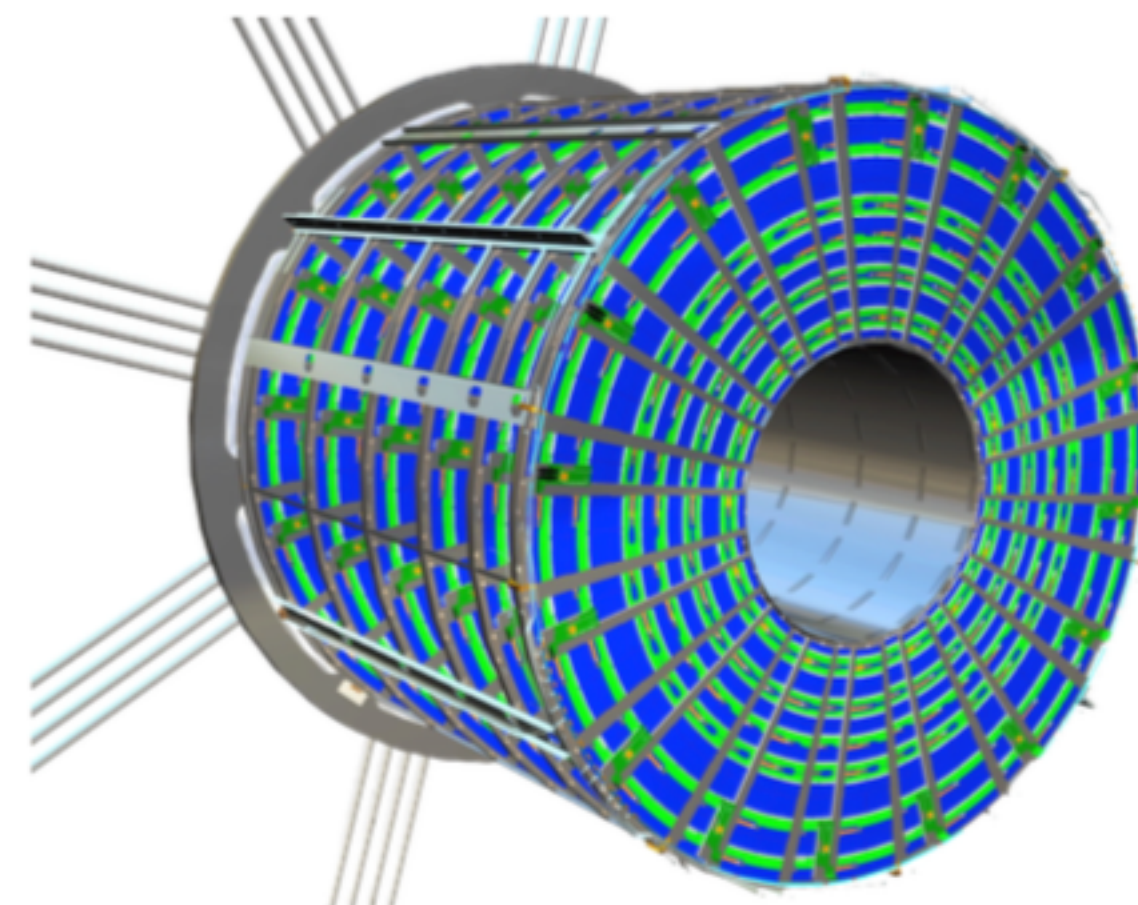
Phase 2 upgrade

DESY groups are delivering a silicon strip end-cap detector as a German contribution to each experiment end of 2024

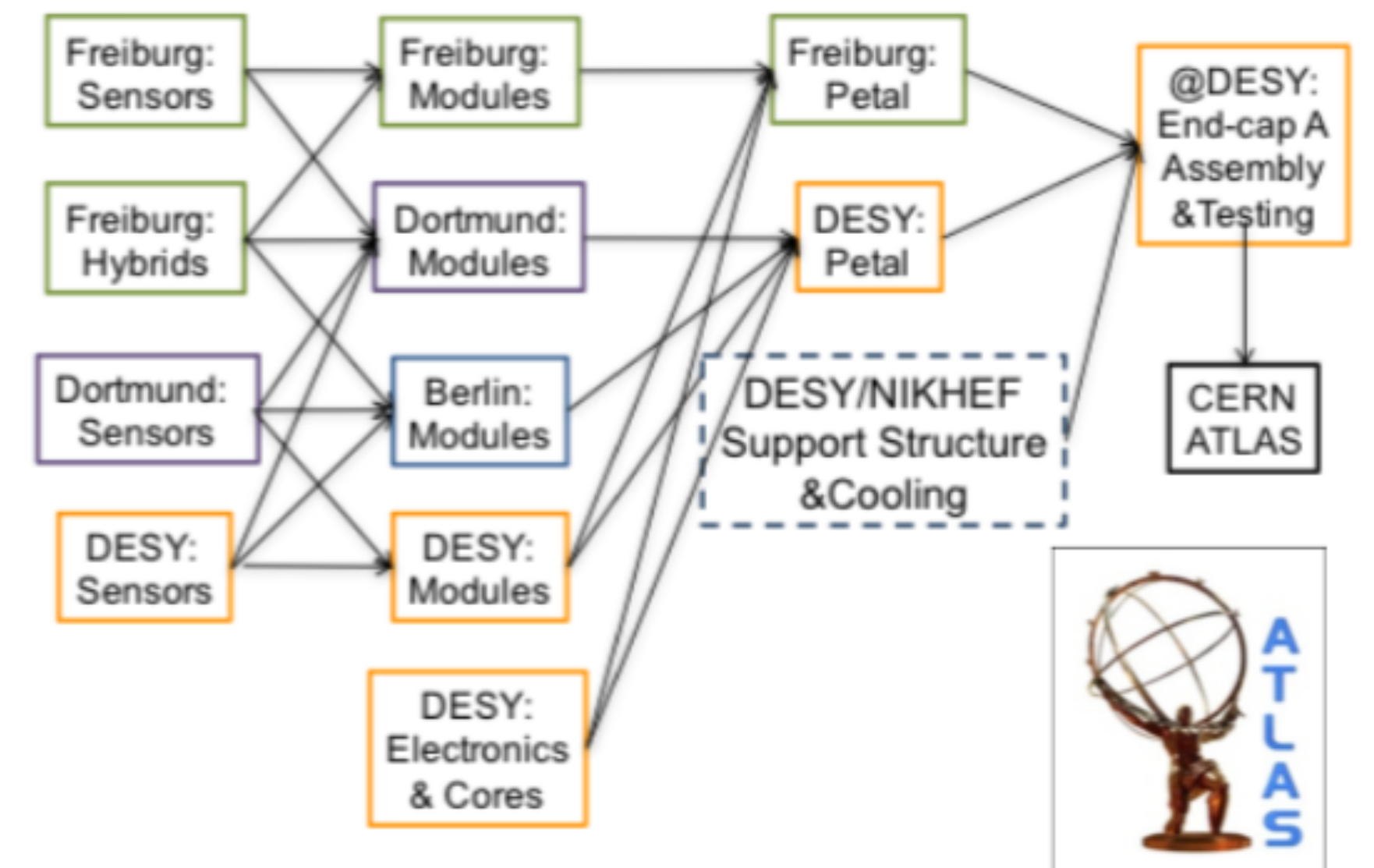
- Includes 3 years of module production
- In strong collaboration with German institutes
- DESY groups play leading roles in the design and construction of tracking detectors



CMS Outer Tracker end-cap.



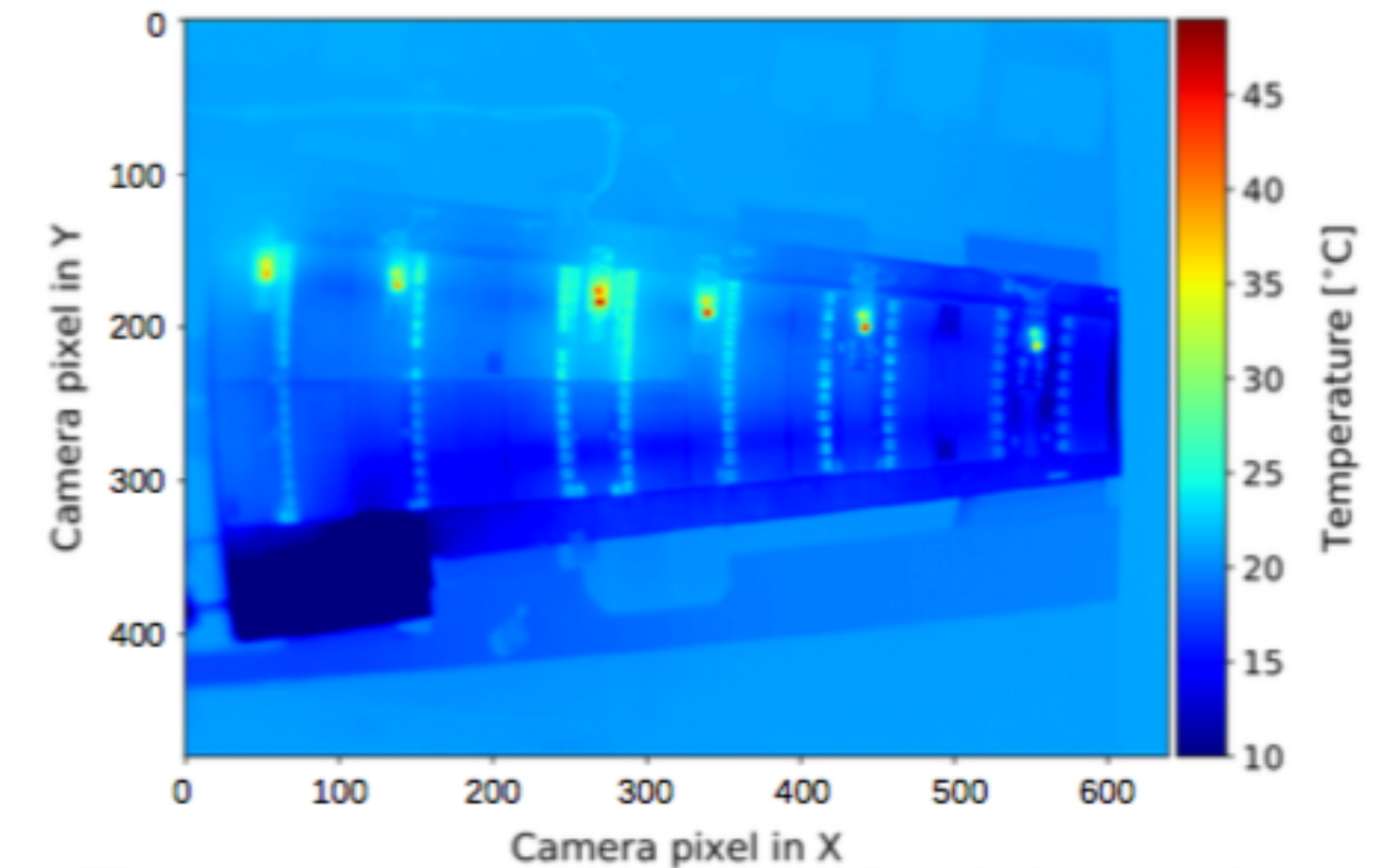
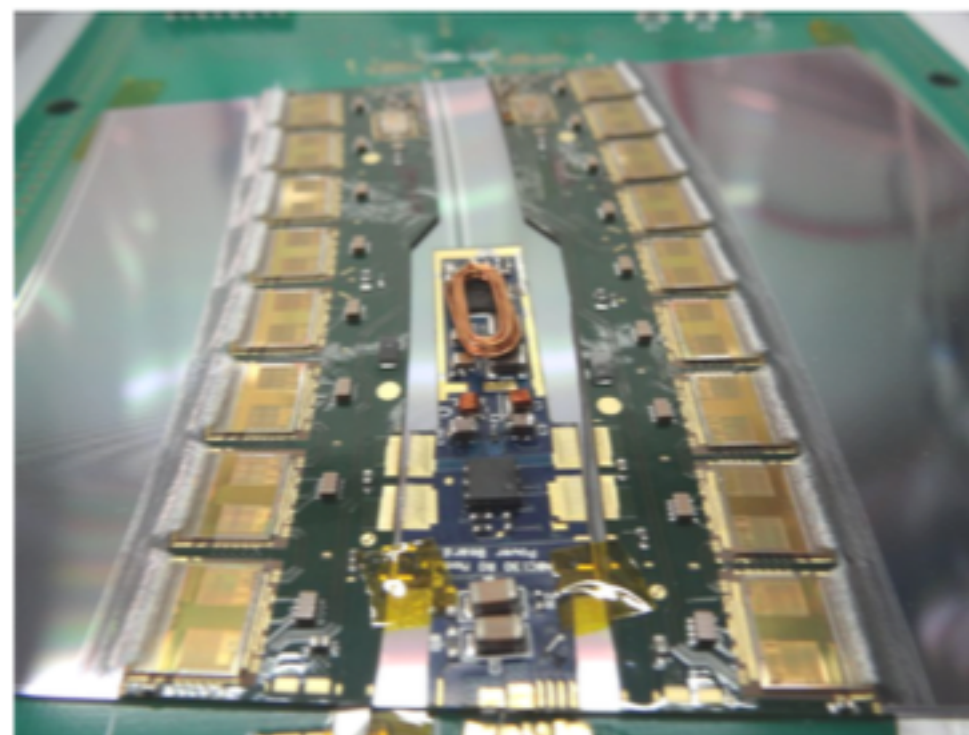
ATLAS ITk Strips Detector end-cap



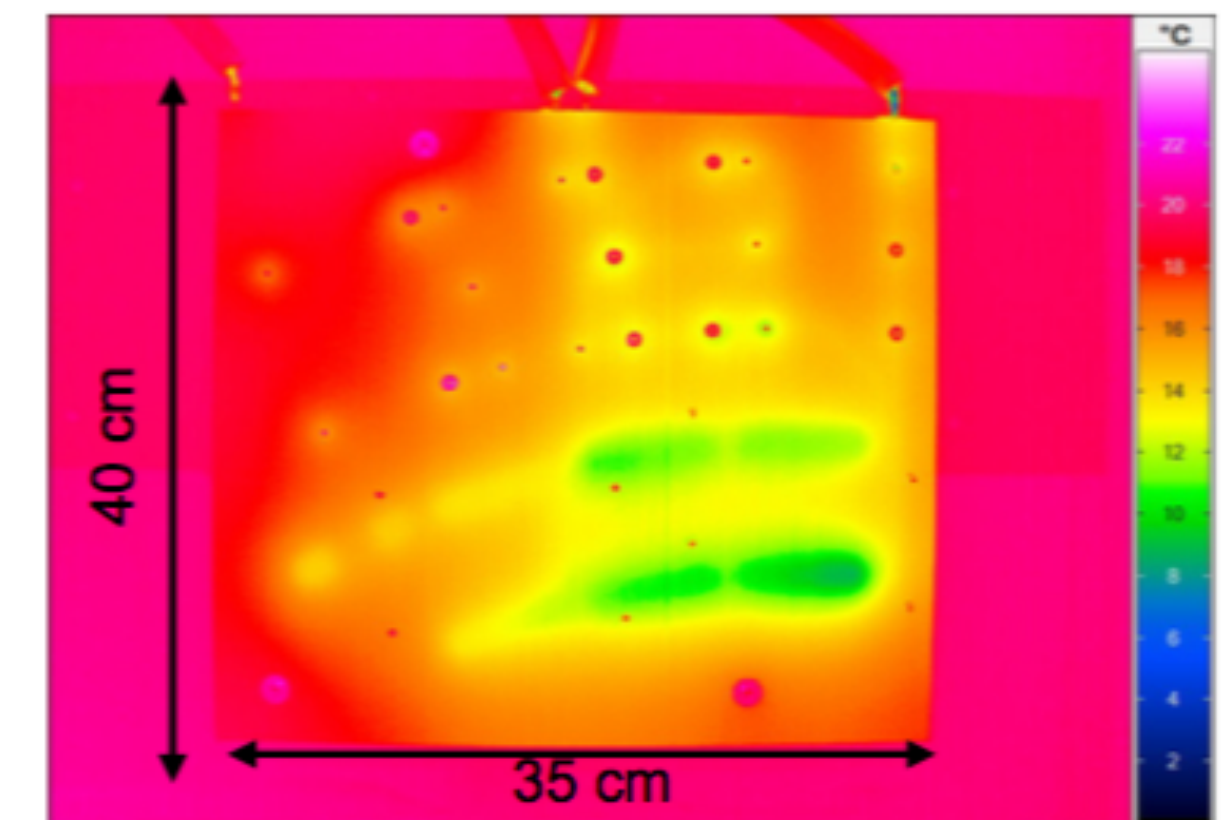
R&D for Phase 2 upgrade

Based on R&D from detector concept to production

- Novel silicon concepts developed for HL-LHC
 - DESY leading role in sensor studies and module designs
- Performance studies on sensors and full modules
 - DESY test beam key for tracker developments
- From silicon modules to full detector: covering many areas from simulation to mechanical construction
- Supported by R&D performed within “Matter and Technologies”
- TDRs approved, with DESY members as main authors



Thermo-camera images of petal prototype and the Dee small prototype.



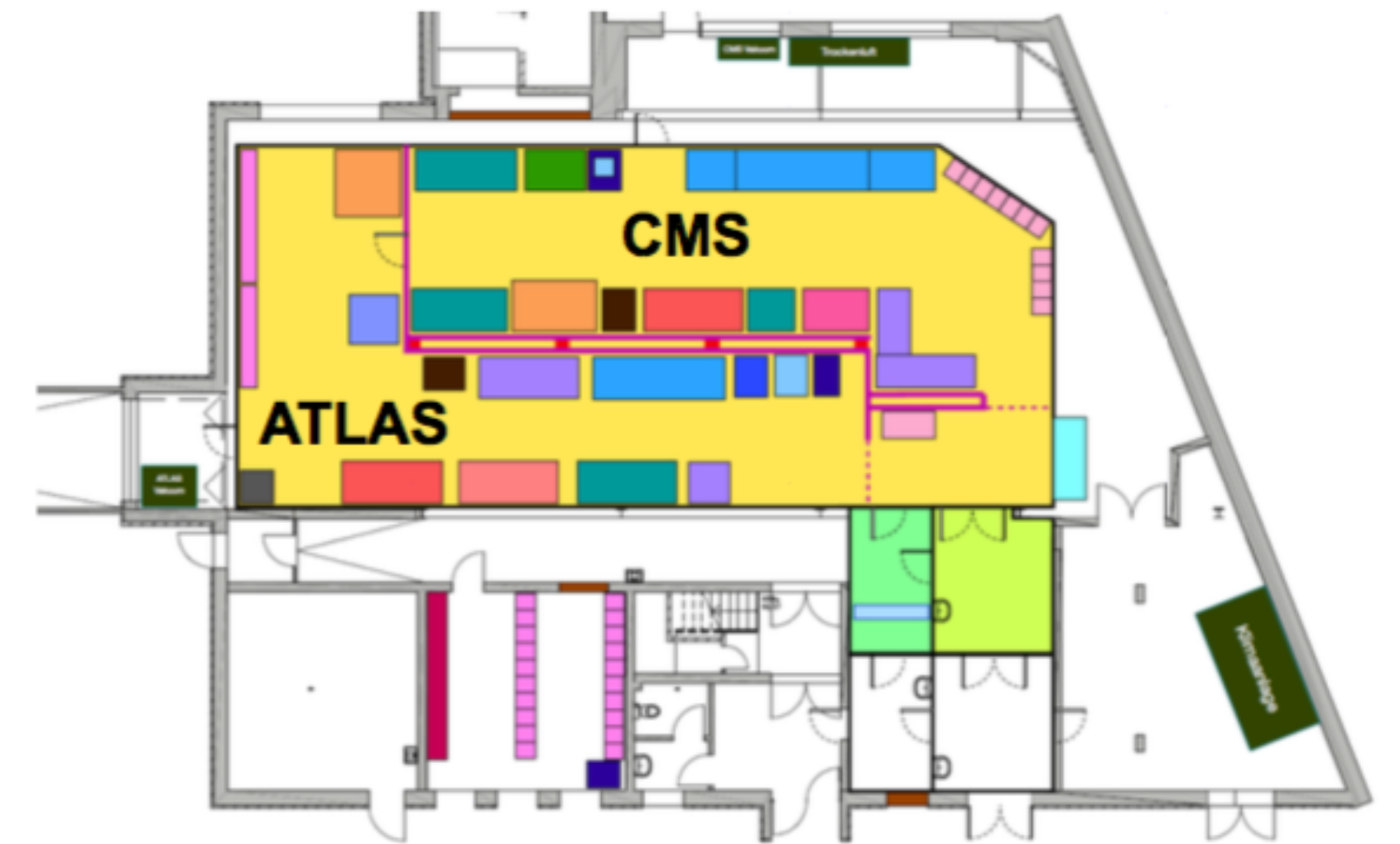
Detector Assembly Facility (DAF)

Dedicated facility for detector development and construction to be used for HL-LHC tracking detectors

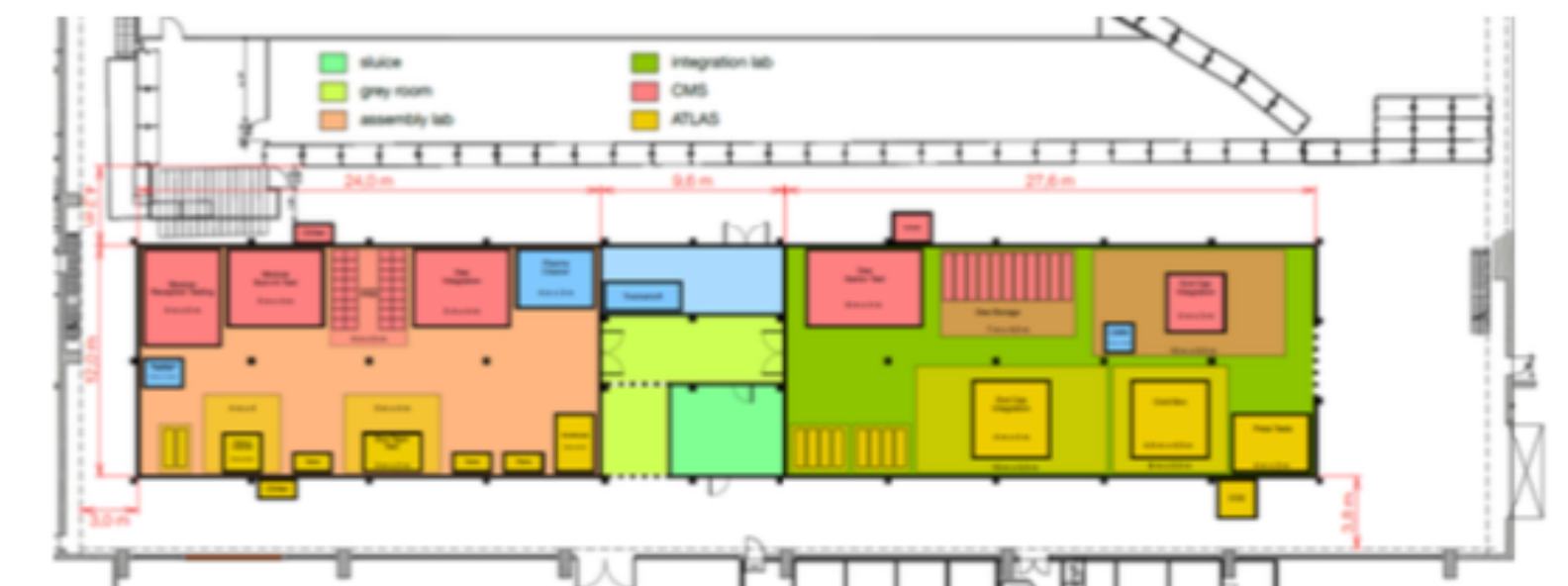
- Existing buildings 25c and 26. About 1000 m² clean rooms and 200 m² lab space
- 10 MEUR from DESY for refurbishment and lab equipment

DAF status:

- Clean rooms in 25c is now in operation and ready for the upcoming production
- Assembly hall in 26 is also completed and is now being commissioned
- DAF will be in use for LHC Upgrades until about 2026
- Lab infrastructure for module production in Zeuthen in preparation to complement DESY facilities



250 m² clean room infrastructure for module production of ATLAS and CMS.



Assembly hall for the end-caps with 750 m² clean room infrastructure.

CMS endcap calorimeter phase 2 upgrade

SiPM-on-Tile technology developed by CALICE for Linear Collider calorimeters

Largely adopted for CMS endcap upgrade, where radiation permits

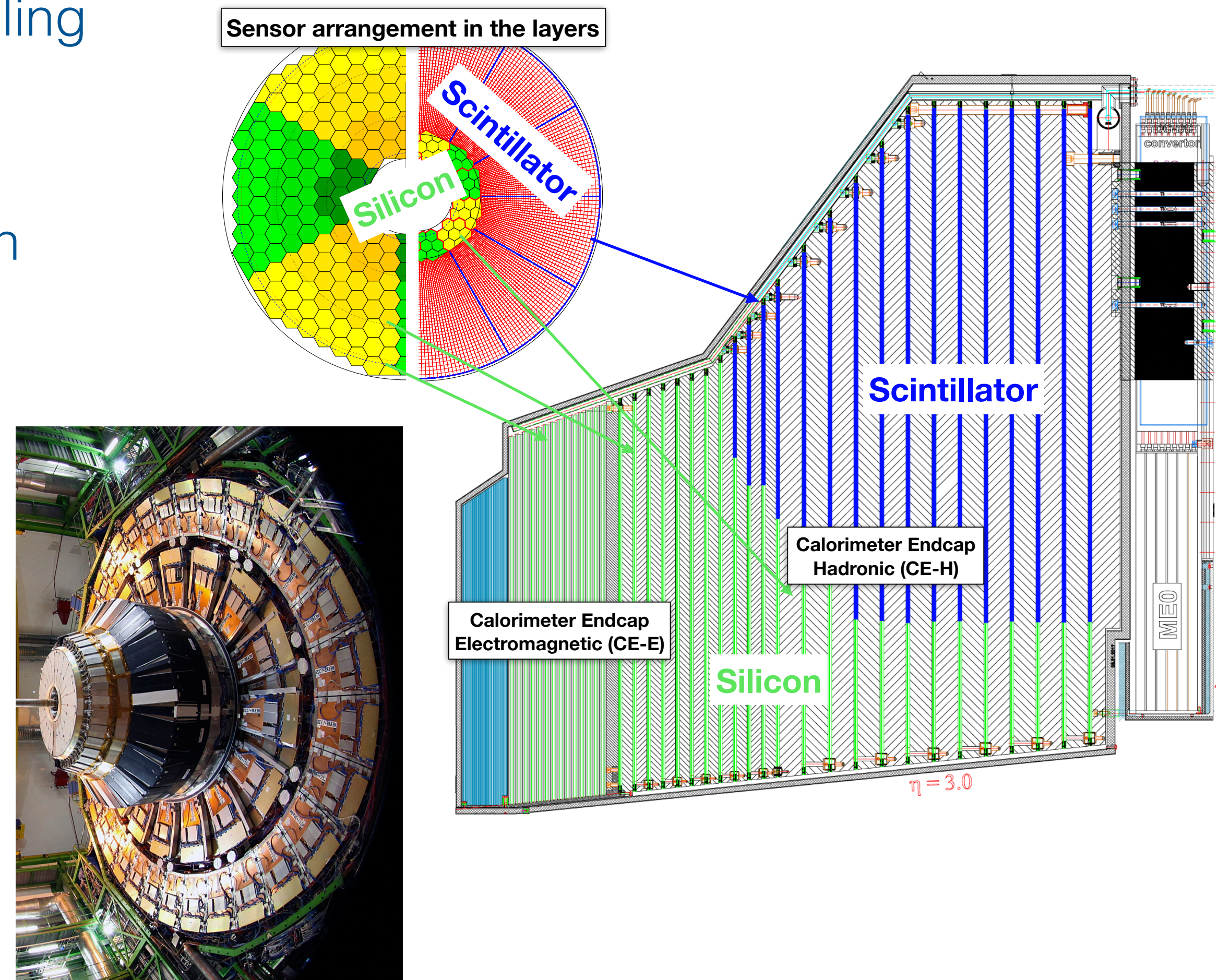
- new challenges: radiation hardness, data rates, cooling

DESY contributes to engineering design

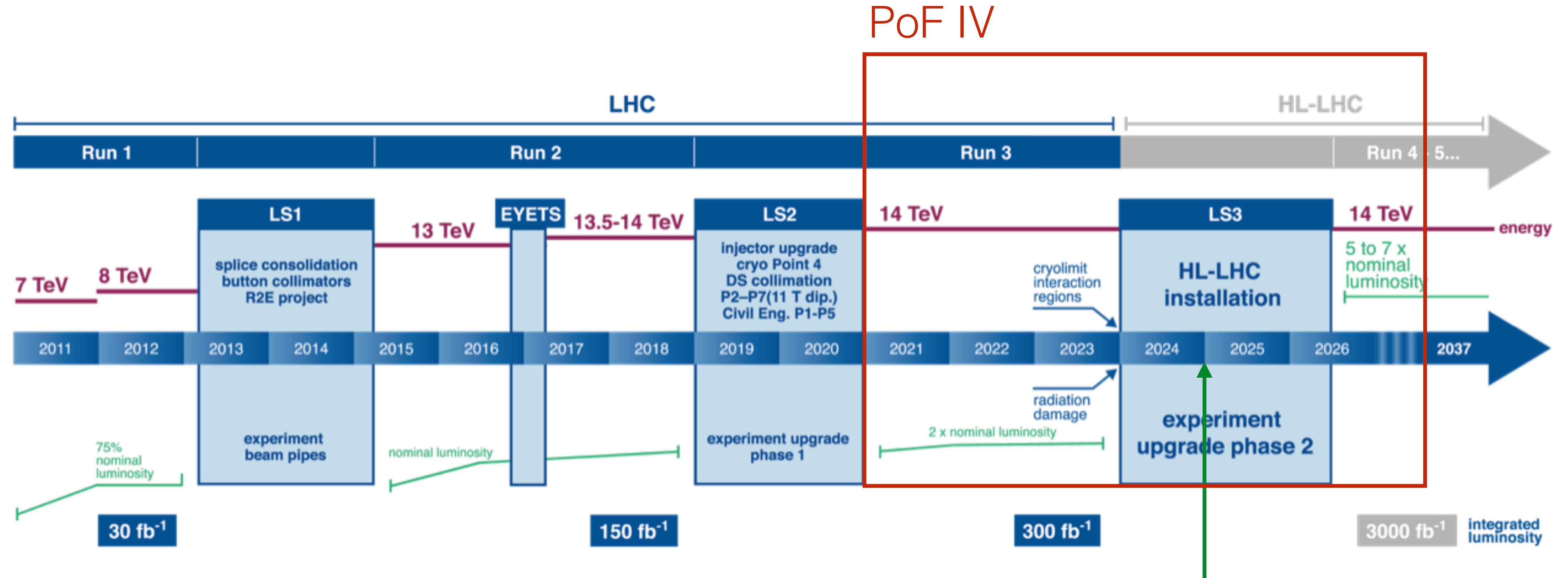
- SiPM-on-Tile read-out boards, electronics integration
- Automated assembly and QC procedures
- 3x0.5 engineers, 2x0.5 physicists, 0.5 postdoc

TDR due early 2021

- then support production and commissioning



Future plans



Milestones:

- Endcap assemblies
- Detector operation, performance studies and analysis of LHC Run 3 data
- Prepare for HL-LHC

Finalise phase 2 upgrades

Main milestones and challenges

- End of 2019: start of pre-production (e.g. ATLAS modules)
- 2020: start of production
- ~2023: completion of substructures with modules
- 2024: finalisation and testing
- End of 2024: delivery to CERN

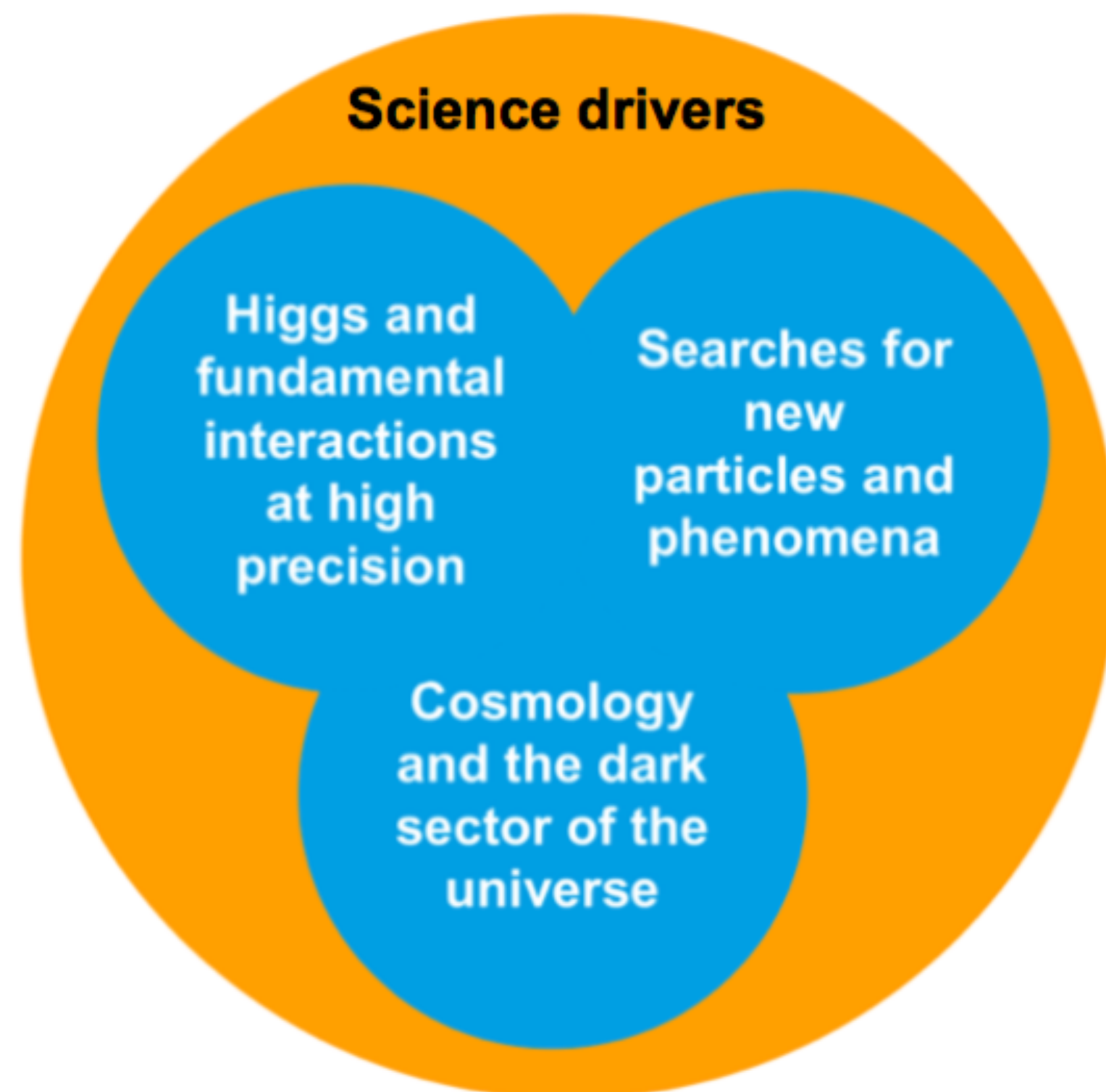
After its use for the ATLAS and CMS tracker end-caps for the HL-LHC, the DAF will be a major asset for any large-scale, high-precision detector development project at DESY



Data analysis

Germany is funding HL-LHC upgrades with 120 MEUR (in addition to the 200 MEUR annual contribution) → Responsibility to carry out a long term programme at the LHC

Prepare to fully exploit the wealth of LHC data – get the full “return on investment” of our upgrade efforts



Physics analyses along two major themes in MU

- Higgs and standard model precision physics
- Search for new physics and for dark matter candidates

Accommodate to the change in physics reach which comes with the larger dataset but only minor energy increase