ATLAS Upgrade

Liebenberg Retreat 2024





Hybrid with readout chips

ATLAS ITk Strip Tracker Upgrade

Micro-Intro: why ATLAS upgrade @ DESY

- LHC: higher luminosity with "HL-LHC" Upgrade
- at HL-LHC, current ATLAS tracking detector will not
 - withstand radiation nor
 - be able to separate dense tracks in time and space
- ATLAS needs new tracker
 - higher radiation hardness and
 - higher granularity and
 - faster readout (and new trigger) capabilities
- DESY joined ATLAS late, without contributing to orig. ATLAS construction
 - required that large labs do this, to be accepted into collaboration
 - we fulfill this "dept" retroactively with contribution to tracker upgrade
- DESY-Z contributed significantly to dev of new tracker
- will also build modules for ~60% of one endcap
 - currently concluding pre-production and production prep
 - ITk Strips module production was scheduled Q4-2023
 - delayed by two significant issues
 - now planned to start Q1-2025 :(



Sensor



Module types produced at Zeuthen

Building 4 Types





The (main) cause for the severe delay: Sensor cracking and Cold Noise

- Cold Noise luckily only seen in module types that are ٠ not built in Zeuthen
- Sensor cracking however is bad luck ٠
 - with glue glass transition at 40°C ٠ (not at >100°C as advertised by vendor)
 - stress by differences in thermal expansion is relieved at 40°C in glass transition (soft glue)
 - leads to excessive stress in sensor below 40°C •
 - can pull the sensor apart locally
 - and with "glue support dots" •
 - leading to high local stress on sensor

PCB on sensor sensor with crack

small support dot

→ high stress

The (main) cause for the severe delay: Sensor cracking and Cold Noise

- Cracking solutions: Two known options
 - 1) drop glue support dots and keep below 35°C
 - 2) add flexible layer at back of PCBs as stress relief (design change!)
- Solution 2) is preferred for barrel type modules but poses severe personpower issues in endcap
 - we are trying to show that solution 1) is ok for endcap
 - also have to test solution 2)
 - this is central for the whole project and hinges on personpower being available NOW in Zeuthen to build modules in this way





ATLAS ITk Schedule – status Sep 2023

we thought this was unlucky...



- a. Issues with modules: Cold Noise (mostly solved), HV breakdown (indications for solution), EC module noise (solved)
 - b. Russian war on Ukraine
 - c. Global supply chain crisis

ATLAS ITk Schedule – status Sep 2024

Effect od current delays in theory (not all delays might yet have been captured)

	2025					2026				2027				20		
Q3 Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2		
Powerb Module Module Sit EC mod EC mod Ec mod Ec mod Ec mod Ec mod	oard prototy prototyping odule pre-pri- te qualification C Hybrid/Mod dule preprod odule Pre-prod EC Module r S and Powe owerboards	ping oduction odule Sit uction oduction FDR -old Module rboards availabl	e -incl. Hy te Qualifi Complet d name: f rPRR - e -endca	vbrids and cation Co te EC Modul p-	Powerbo mpleted	oards-	Ų.	~	- VI	¥2	Ų.	<u> </u>	Ų.			
	First product EC po	ion mod owerboa	ules avai rds	ilable -end	dcap-						EC	Modules				
			2 Di	sks of Mo	dules Co 4 Disks	mplete of Module 6	es Compl Disks of	lete Modules (8 Dis	Complete sks of Mo	dules Cor 10 Disk	nplete s of Modu	iles Compl	lete Modulos	Complet		
)3 Q4 Powerb Module Si EC mod EC mod Production p	23 Q4 Q1 Powerboard prototy Module prototyping Module prototyping Module pre-prisite Site qualification EC Hybrid/Module preprod EC module preprod Module Pre-prisite Module Pre-prisite EC Module Pre-prisite Modul	23 Q4 Q1 Q2 Powerboard prototyping Module prototyping Module prototyping Module pre-production Site qualification EC Hybrid/Module Site EC module preproduction Module Pre-production Module Pre-production Module Pre-production Module Pre-production Module Pre-production Module Pre-production Module Site Production First production mod Production powerboards Availabl First production mod EC powerboards	23 Q4 Q1 Q2 Q3 Powerboard prototyping Module prototyping Module prototyping Module pre-production -incl. Hy Site qualification EC Hybrid/Module Site Qualifie EC module preproduction Module Pre-production Complete EC Module rFDR -old name: Module rPRR Module rPRR Module rowerboards Production powerboards available -endca First production modules ava EC powerboards 2 Di	23 Q4 Q1 Q2 Q3 Q4 Powerboard prototyping Module prototyping Module prototyping Module pre-production -incl. Hybrids and Site qualification EC Hybrid/Module Site Qualification Co EC module preproduction Module Pre-production Complete EC Module rFDR -old name: EC Modul Module rPRR Module rowerboards- production powerboards available -endcap- First production modules available -end EC powerboards 2 Disks of Module	23 Q4 Q1 Q2 Q3 Q4 Q1 Powerboard prototyping Module prototyping Module prototyping Module pre-production -incl. Hybrids and Powerboard Site qualification EC Hybrid/Module Site Qualification Completed EC module preproduction Module Pre-production Complete EC Module rFDR -old name: EC Module PRR For Module rPRR Module rPRR Production powerboards available -endcap- First production modules available -endcap- EC powerboards 2 Disks of Modules Co 4 Disks	93 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Powerboard prototyping Module prototyping Module prototyping Module pre-production -incl. Hybrids and Powerboards- Site qualification Powerboards- Site qualification EC Hybrid/Module Site Qualification Completed EC module preproduction Module Pre-production Module Pre-production Complete EC Module rFDR -old name: EC Module PRR Follow up- Module rPRR In -incl. Hybrids and Powerboards- Module savailable -endcap- EC powerboards In -incl. Hybrids and Powerboards Im Complete Im Complete Im -incl. Hybrids and Powerboards- Im Complete Im Complete Im -incl. Hybrids and Powerboards- Im Complete Im Complete Im -incl. Hybrids and Powerboards- Im Complete Im Complete Im -incl. Hybrids and Powerboards- Im Complete Im Complete Im -incl. Hybrids and Powerboards- Im Complete Im Complete Im -incl. Hybrids and Powerboards- Im Complete Im Complete Im -incl. Hybrids and Powerboards- Im Complete Im Complete Im -incl. Hybrids and Powerboards- Im Complete Im Complete Im -incl. Hybrids and Powerboards- Im Complete Im Complete Im -incl. Hybrids and Powerboards- Im Complete Im Complete </td <td>23 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Powerboard prototyping Module prototyping Module prototyping Module pre-production -incl. Hybrids and Powerboards- Site qualification Powerboards- Site qualification Site qualification Completed EC Hybrid/Module Site Qualification Completed EC module preproduction Complete EC Module PRR Follow up- Module PRR Module Pre-production powerboards Module rPRR Module rPRR Module route to module available -endcap- First production modules available -endcap- EC powerboards 2 Disks of Modules Complete Q2 Q3 Q3 Q4 Q1 Q2 Q3</td> <td>23 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Powerboard prototyping Module prototyping Module pre-production -incl. Hybrids and Powerboards-Site qualification Site qualification Site qualification Site qualification Completed EC Hybrid/Module Site Qualification Completed EC Module preproduction Module Pre-production Complete EC Module rFDR -old name: EC Module PRR Follow up- Module rPRR In -incl. Hybrids and Powerboards- Module rPRR Module savailable -endcap- EC powerboards In production powerboards available -endcap- EC powerboards Image: Prist production modules available -endcap- Image: Prist production prist production modules available -endcap- Image: Prist prist production Prist prist</td> <td>23 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1 Powerboard prototyping Module prototyping Module prototyping Module prototyping Module preproduction -incl. Hybrids and Powerboards- Site qualification EC Hybrid/Module Site Qualification Completed EC module preproduction Module Pre-production Complete EC Module rFDR -old name: EC Module PRR Follow up- Module rPRR In -incl. Hybrids and Powerboards Module rPRR Module savailable -endcap- EC powerboards In production powerboards available -endcap- EC powerboards Image: Production modules available -endcap- Image: Prist Pr</td> <td>23 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Powerboard prototyping Module prototyping Module pre-production -incl. Hybrids and Powerboards-Site qualification Module pre-production -incl. Hybrids and Powerboards-Site qualification EC Hybrid/Module Site Qualification Completed EC module pre-production Complete Module Pre-production Complete Module Pre-production Complete Module rPRR Module PRR Module rPRR Module rPRR Module rPRR Module rPRR Module savailable -endcap- EC powerboards Modules available -endcap- EC powerboards Modules complete Mod</td> <td>23 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Powerboard prototyping Module prototyping Module pre-production -incl. Hybrids and Powerboards-Site qualification Module pre-production Image: Complete description Image: Complete de</td> <td>23 Q4 Q1 Q2 Q3 Q4 Powerboard prototyping Module prototypi</td> <td>23 Q4 Q1 Q2 Q3 Q4 Q1 Powerboard prototyping Module pro</td>	23 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Powerboard prototyping Module prototyping Module prototyping Module pre-production -incl. Hybrids and Powerboards- Site qualification Powerboards- Site qualification Site qualification Completed EC Hybrid/Module Site Qualification Completed EC module preproduction Complete EC Module PRR Follow up- Module PRR Module Pre-production powerboards Module rPRR Module rPRR Module route to module available -endcap- First production modules available -endcap- EC powerboards 2 Disks of Modules Complete Q2 Q3 Q3 Q4 Q1 Q2 Q3	23 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Powerboard prototyping Module prototyping Module pre-production -incl. Hybrids and Powerboards-Site qualification Site qualification Site qualification Site qualification Completed EC Hybrid/Module Site Qualification Completed EC Module preproduction Module Pre-production Complete EC Module rFDR -old name: EC Module PRR Follow up- Module rPRR In -incl. Hybrids and Powerboards- Module rPRR Module savailable -endcap- EC powerboards In production powerboards available -endcap- EC powerboards Image: Prist production modules available -endcap- Image: Prist production prist production modules available -endcap- Image: Prist prist production Prist	23 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1 Powerboard prototyping Module prototyping Module prototyping Module prototyping Module preproduction -incl. Hybrids and Powerboards- Site qualification EC Hybrid/Module Site Qualification Completed EC module preproduction Module Pre-production Complete EC Module rFDR -old name: EC Module PRR Follow up- Module rPRR In -incl. Hybrids and Powerboards Module rPRR Module savailable -endcap- EC powerboards In production powerboards available -endcap- EC powerboards Image: Production modules available -endcap- Image: Prist Pr	23 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Powerboard prototyping Module prototyping Module pre-production -incl. Hybrids and Powerboards-Site qualification Module pre-production -incl. Hybrids and Powerboards-Site qualification EC Hybrid/Module Site Qualification Completed EC module pre-production Complete Module Pre-production Complete Module Pre-production Complete Module rPRR Module PRR Module rPRR Module rPRR Module rPRR Module rPRR Module savailable -endcap- EC powerboards Modules available -endcap- EC powerboards Modules complete Mod	23 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Powerboard prototyping Module prototyping Module pre-production -incl. Hybrids and Powerboards-Site qualification Module pre-production Image: Complete description Image: Complete de	23 Q4 Q1 Q2 Q3 Q4 Powerboard prototyping Module prototypi	23 Q4 Q1 Q2 Q3 Q4 Q1 Powerboard prototyping Module pro		

- End of EC module production moved from Mid 2026 to Mid 2027 due to
 - a. Mainly sensor cracking (and cold noise)
 - b. as well as part availability in EC and personpower

Team and Status

- Technicians
 - Martin Renzmann [Bonding expert]
 - Carl Beichert (HU) [setups expert, carer]
 - Mandy Radicke [Gluing and QC expert]
 - Oliver Schäde [Glue focus]
 - Maik Daniels (HU) [Glue focus, still learning]

- Scientists
 - Ben Bruers
 - Alavaro Lopez
 - Hagen Moebius
 - Christian Scharf
 - Thorsten Kuhl
 - Ingo Bloch

[parental leave till 2025, s/w and h/w developer]
[part time Postdoc, till Dec 2024, sensor QC]
[SHK, 10 hours a week, sensor QC]
[very part time Postdoc, HU, inventory]
[sensor QC, module QC, PCB QC]
[something of everything]

- 2 of 5 technicians currently re-assigned to other projects
 - severely slowing our progress
 - Mandy especially cannot be replaced
- Status end of pre-production
 - building modules to help finding solutions for sensor cracking issue
 - high pressure from collaboration
 - in parallel preparing production
 - automation and QC setup streamlining
 - optimisation of glue- and bonding programs
 - first production steps: preparation of sensors and PCBs for use in modules

Backup slides...



DESY wide laboratories and clean rooms operational - images as of last year, now less unused looking

Zeuthen ATLAS upgrade production lab (ISO-6)



Hamburg DAF module/petal building Clean Room (ISO-6)



Hamburg DAF assembly and QC Clean Room (ISO-7)



Hamburg DAF Integration Clean Room (ISO-7)



DESY Deliverables

Need to deliver more than 4600 parts

- Petal cores (400)
 - Planning based on delivering parts for all cores for BOTH end-caps
 - Co-cured facings, Titanium pipes with welded insulating breaks, smaller parts

produced in

Zeuthen

- Main process of building the petals taken over by company AVS (Spain)
- Leuthen focus Endcap modules (2000 + 500)
 - -20% of all EC Split into 3/4 in Zeuthen and 1/4 in modules Hamburg
 - 500 modules for the HU delivery
 - Backup for each other
 - End of Substructure (EoS) cards (1630)
 - Custom board to be produced in industry •
 - Test of every single EoS board for both • end-caps and the barrel
 - FE group strongly involved



- Fully instrumented petals (100-125)
 - $\sim 50\%$ of an end-cap
- **End-cap integration structure (1)**
 - Structure will be built at NIKHEF
 - DESY involved in overall design and producing • some of the carbon fiber components (service trays)
- Fully instrumented end-cap (1)
 - In close collaboration with Berlin, Dortmund and Freiburg

at DESY - Zeuthen Campus

- Quality test infrastructure
 - hybrid burn in crate
 - module thermal cycling and testing box
 - cycles between -35°C and +40°C (now reduced to +20°C)
 - cycling and testing fully automated to run over night







ATLAS ITk Schedule – status Sep 2022

Highlighted on DESY Deliverables (Status: PRC - May 2022)



- Overall strong impact due to Covid-19 many delays in all areas
- Hard to disentangle "normal" delays and Covid-delays, but estimates assume at least 70% of delays due to lockdowns etc.
- Running with 50% top speed compared to "normal" times
- Many reviews ongoing

DESY.