Status of the ATLAS ITk Strip Detector for the HL-LHC

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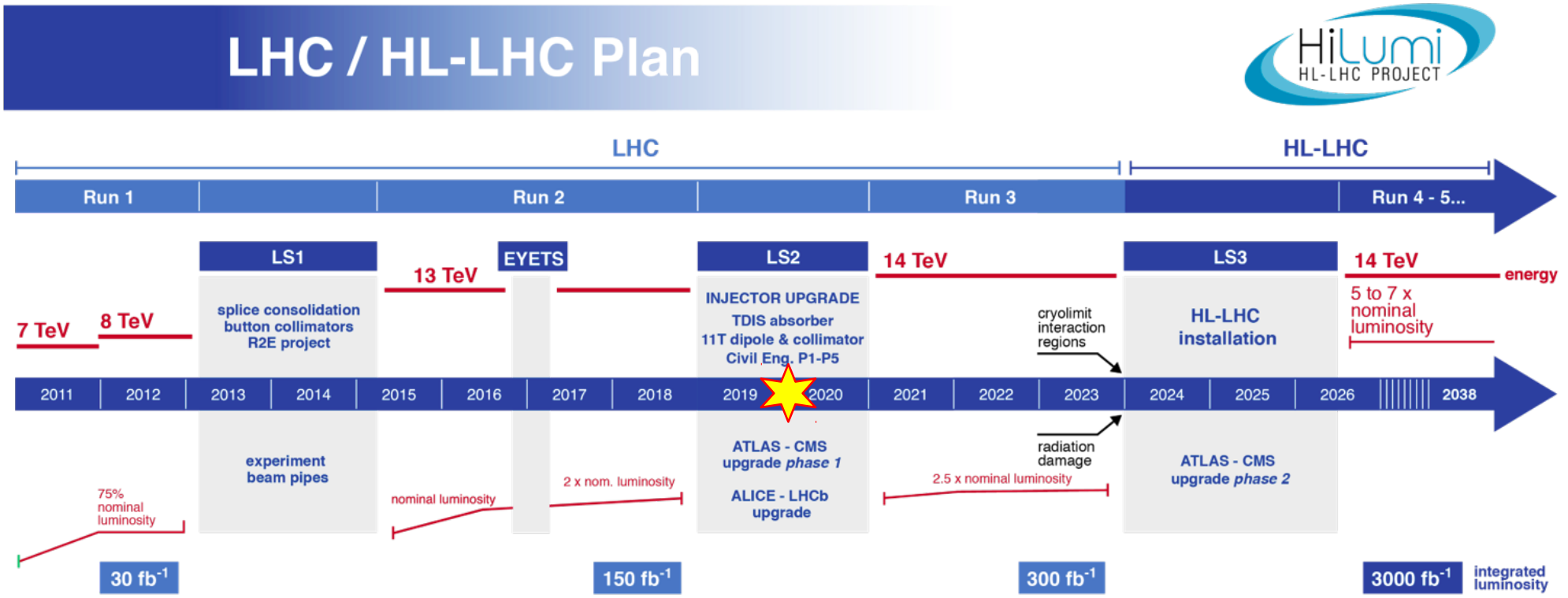
Nordic Conference on Particle Physics

UNIVERSITY OF COPENHAGEN

The High-Luminosity LHC (HL-LHC)



Run 3 (2021) → 14 TeV, 55 – 80 <interactions / BX>, 300 fb^{-1} by ~2023

Run 4+ (2026) → 14 TeV, up to 200 <interactions / BX>, 3000 fb^{-1} by ~2035

The HL-LHC will pose difficult experimental challenges – requiring ATLAS upgrades

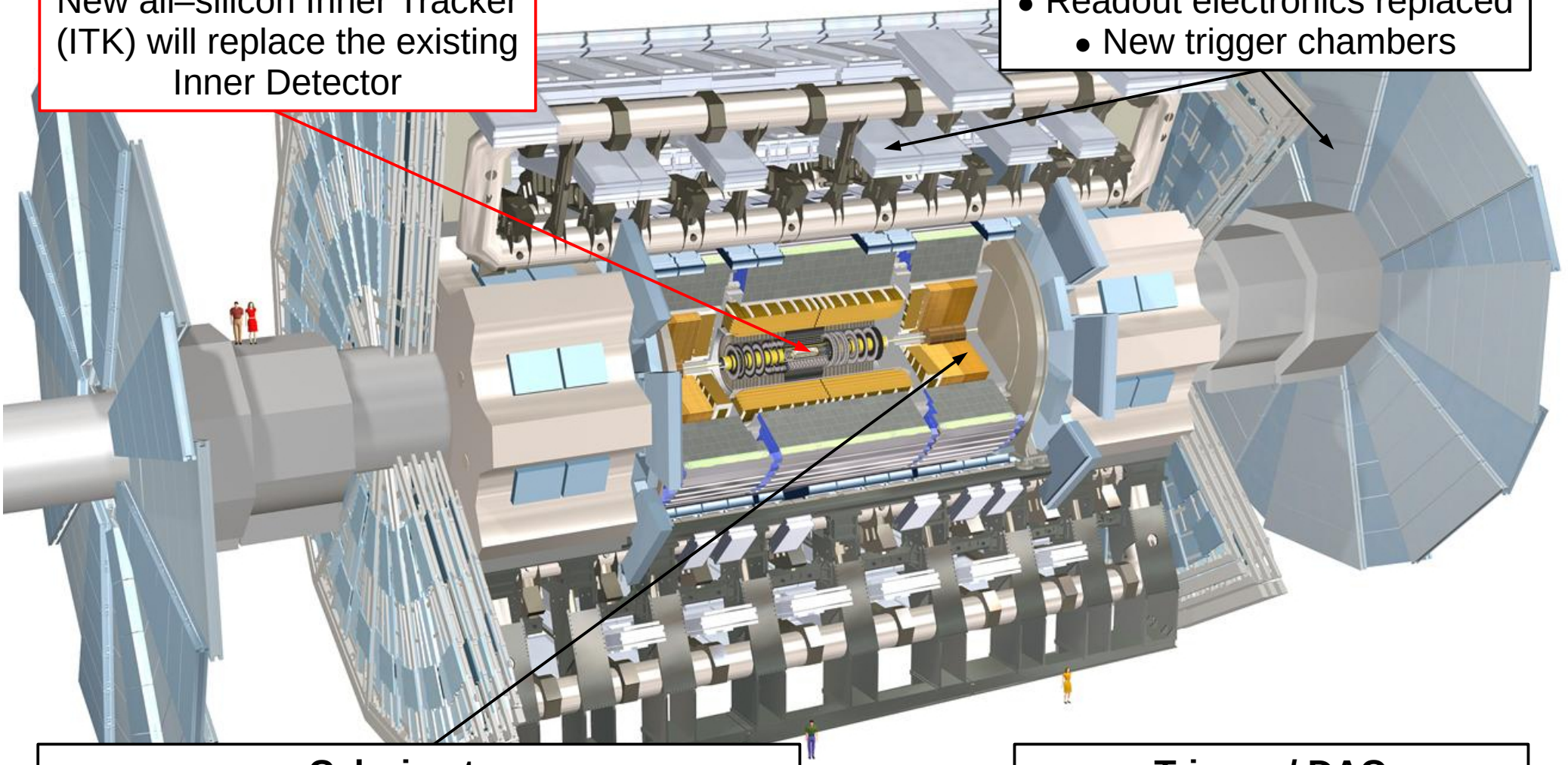
ATLAS Upgrades for the HL-LHC

Tracking

New all–silicon Inner Tracker (ITK) will replace the existing Inner Detector

Muon Spectrometer

- Readout electronics replaced
- New trigger chambers



Calorimeters

- Readout electronics replaced
- New *O*(10's ps) timing detector 2.4<|η|<4.3

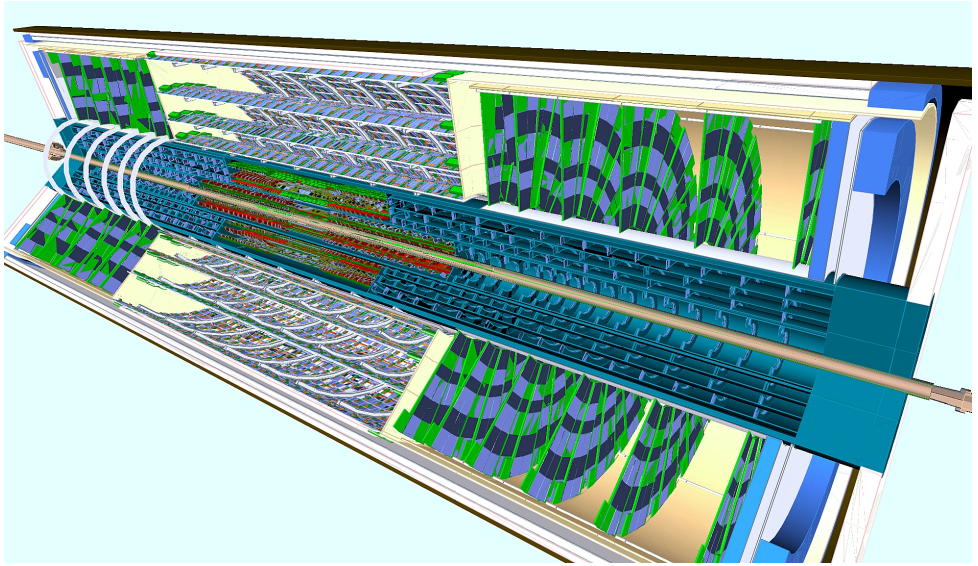
Trigger / DAQ

L0/L1 Hardware Track Trigger

HLT ~ 10 kHz

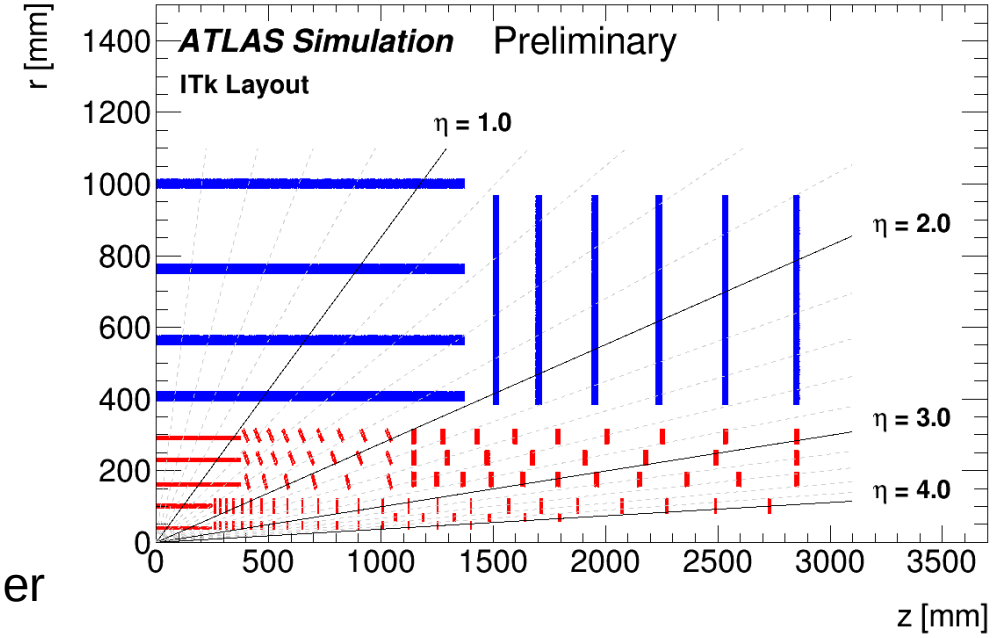
The ATLAS Inner Tracker (ITk)

The new Inner Tracker (ITk) is an all -silicon (pixels & strips) which aims to maintain at least the same performance as the current tracker



Design Highlights:

- Silicon area: ~200 m^2
- Radiation hardness: 10+ year lifetime @ x10 integrated radiation
- Granularity: baseline occupancy of < 0.1% (pixels) < 1% (strips) @ <μ>=200
- Material budget: > 30% less
- Coverage: |η| < 2.5 to |η| < 4.0
- Readout: new scheme allows fast track trigger



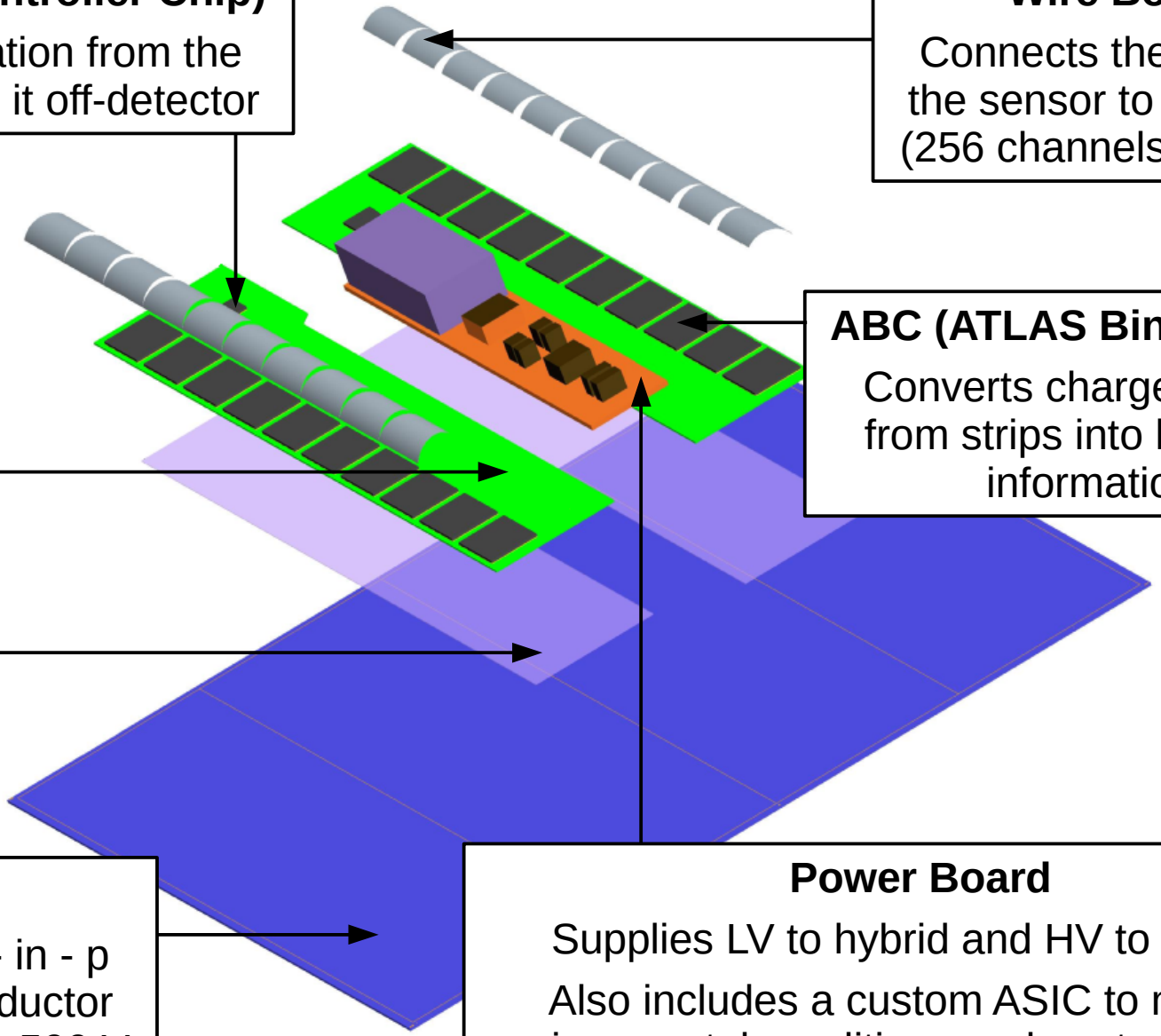
ITk Strip Detector Module

HCC (Hybrid Controller Chip)

Collects information from the ABCs and sends it off-detector

Wire Bonds

Connects the strips of the sensor to the ABCs (256 channels per ABC)



Hybrid

A kapton circuit board housing ABCs and HCC

ABC (ATLAS Binary Chip)

Converts charge signals from strips into hit/no-hit information

Glue

Sensor

320 μm thick n^+- in - p silicon semi-conductor operating at up to 500 V

Power Board

Supplies LV to hybrid and HV to sensor

Also includes a custom ASIC to monitor environmental conditions and control powering

ITk Strip Detector in Scandinavia

UPPSALA UNIVERSITET

UiO : University of Oslo

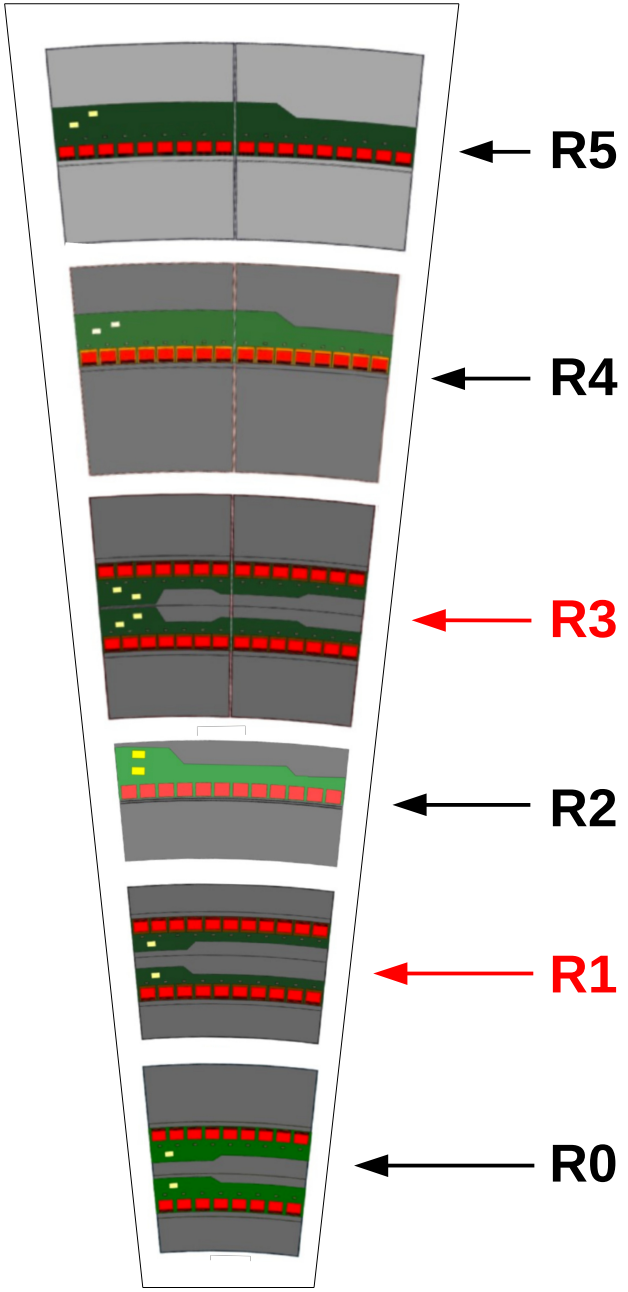
UNIVERSITY OF COPENHAGEN

LUND UNIVERSITY

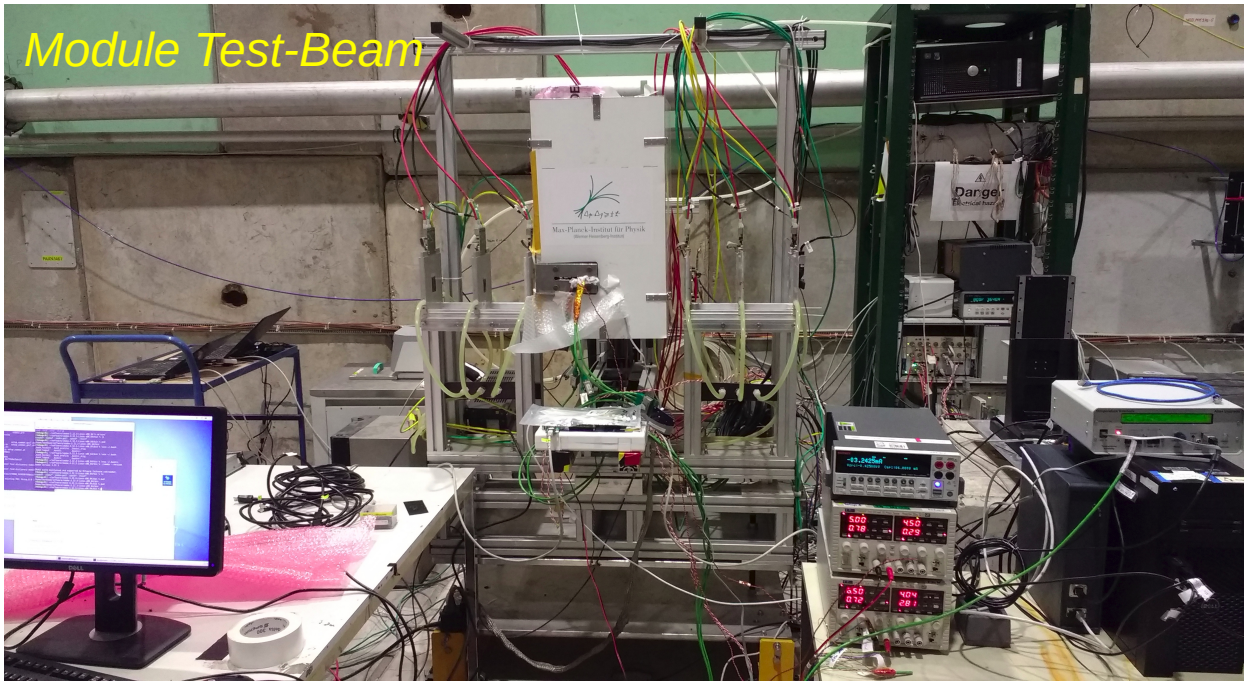
The Scandinavian Cluster will produce **576** endcap modules, in collaboration with an industrial partner

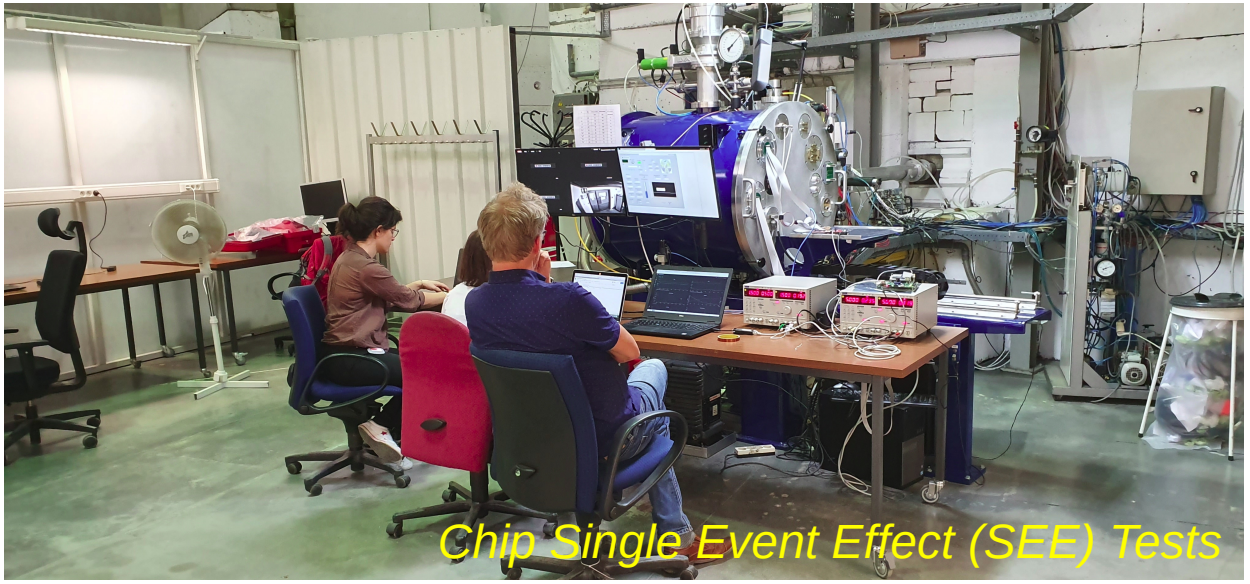
This corresponds to ~10% of endcap modules

NOTE™ YOUR MANUFACTURING PARTNER

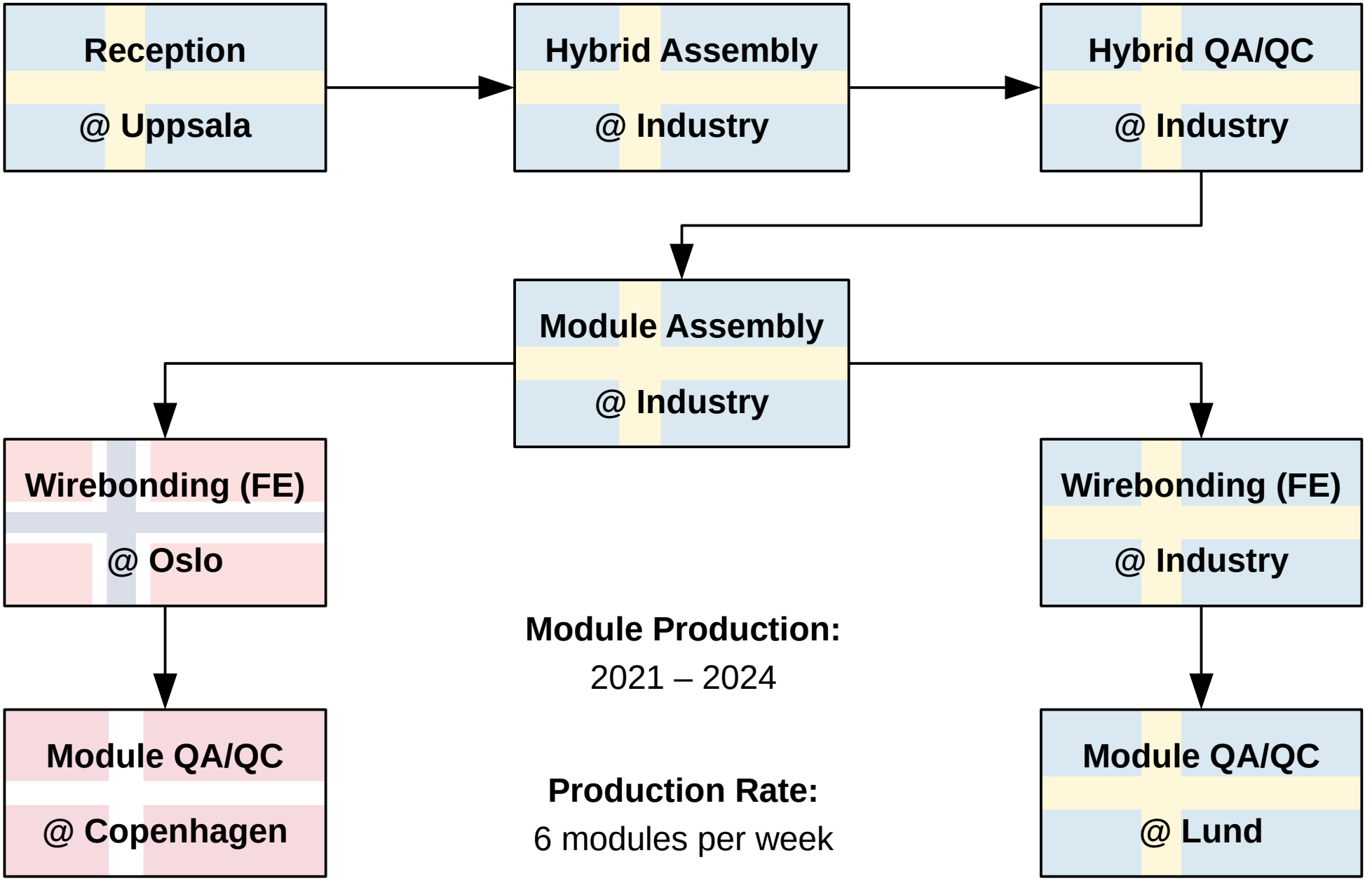


Other Scandinavian Contributions





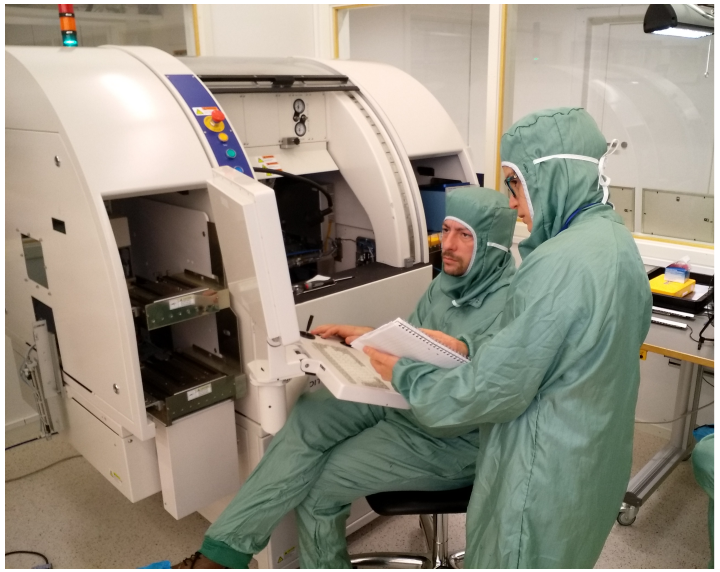
Module Production Plan

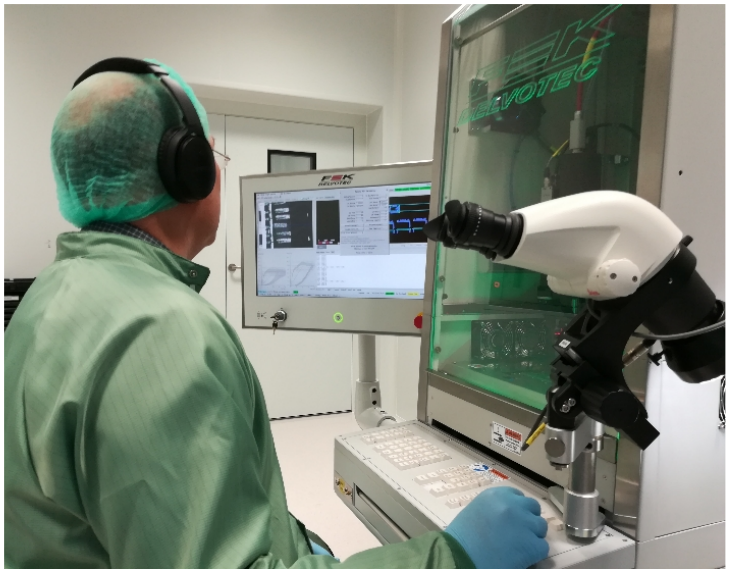


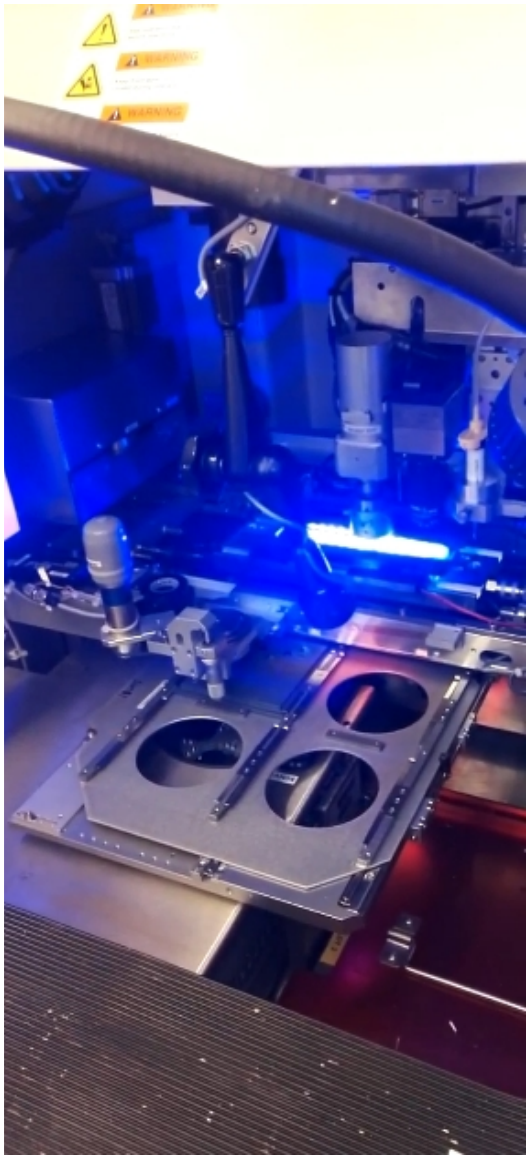
Module Production:
2021 – 2024

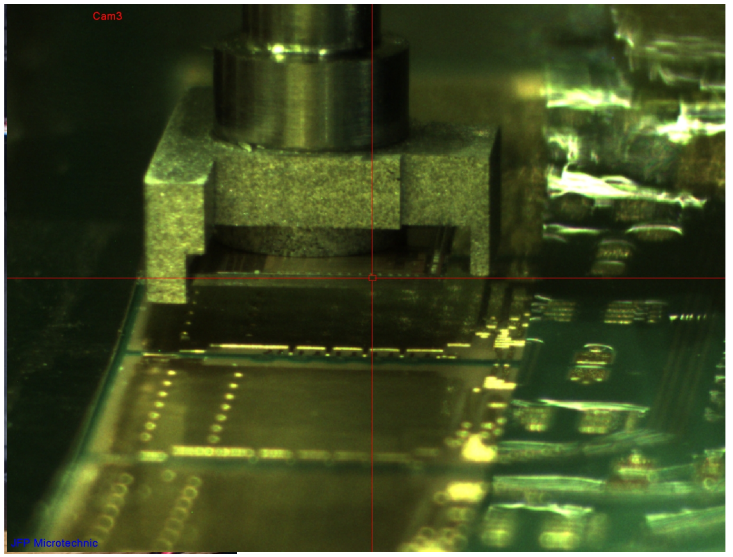
Production Rate:
6 modules per week

Preparations For Module Production

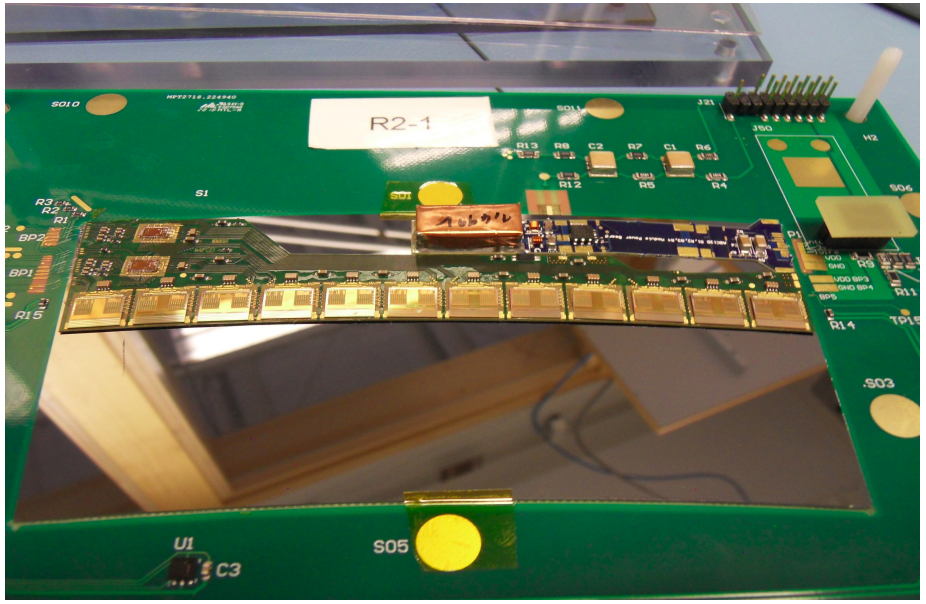






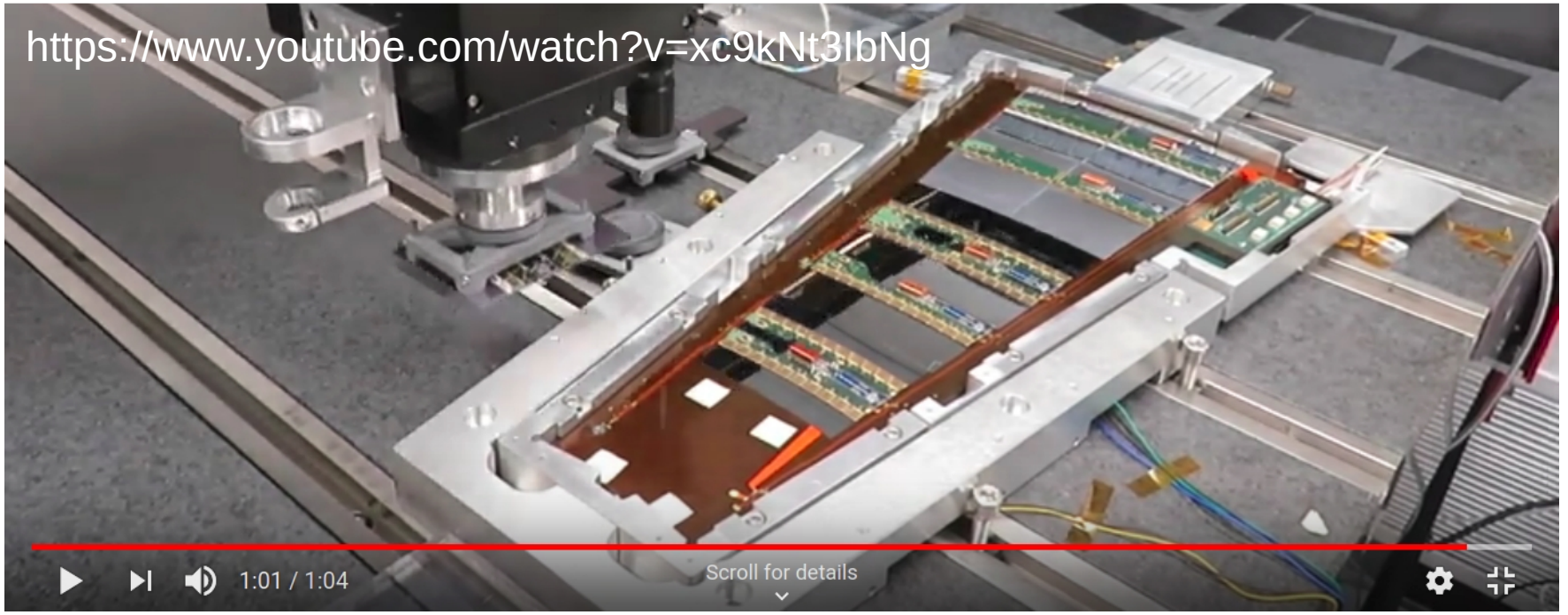


Semi-Electrical Modules

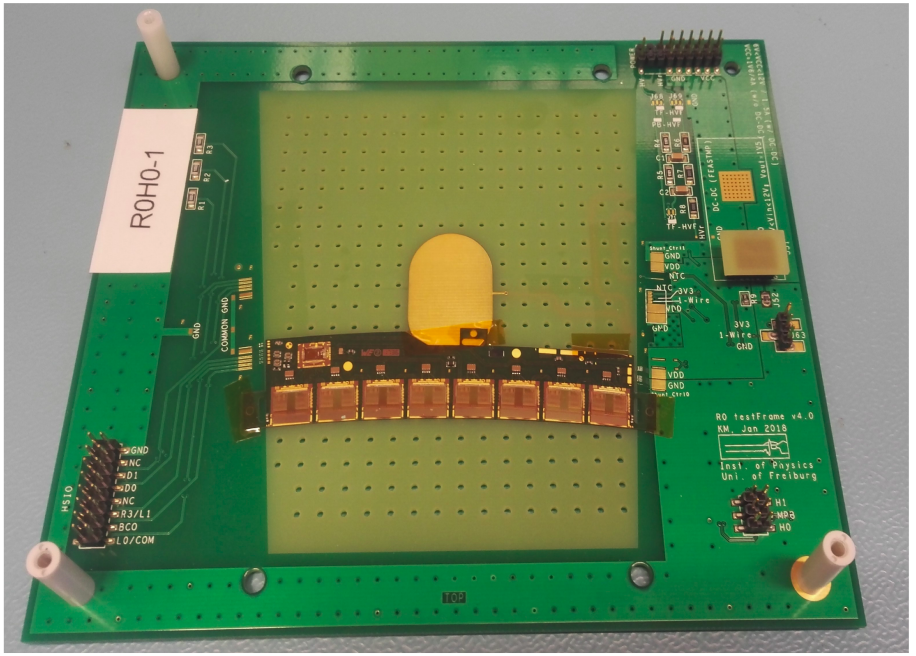


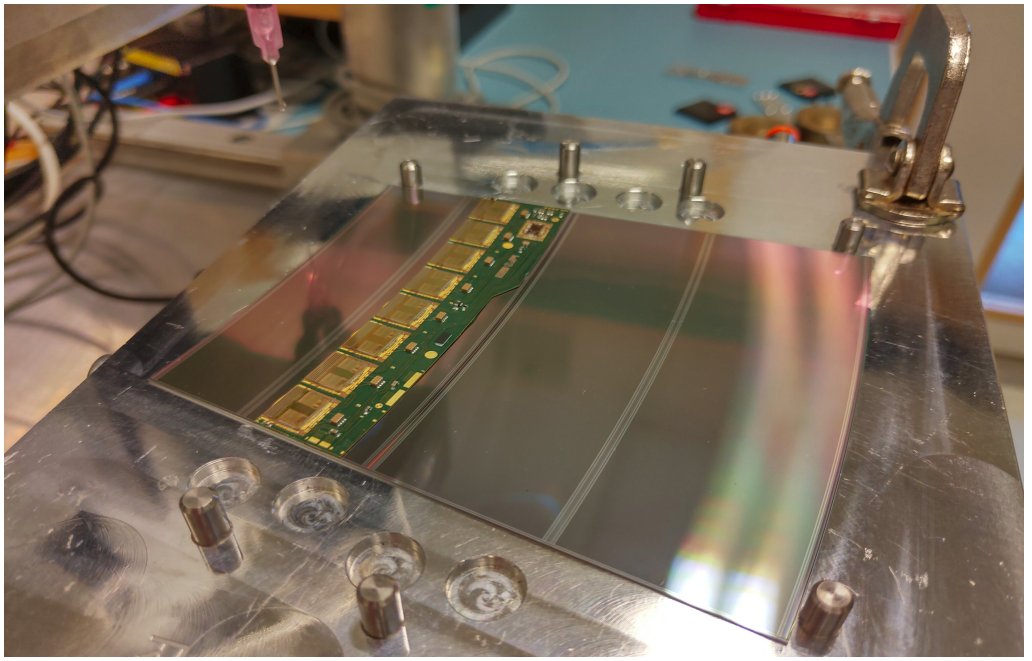
We have built x2 semi-electrical R2 modules for the purposes of performing:

- Petal assembly routines
- (Prototype) system tests



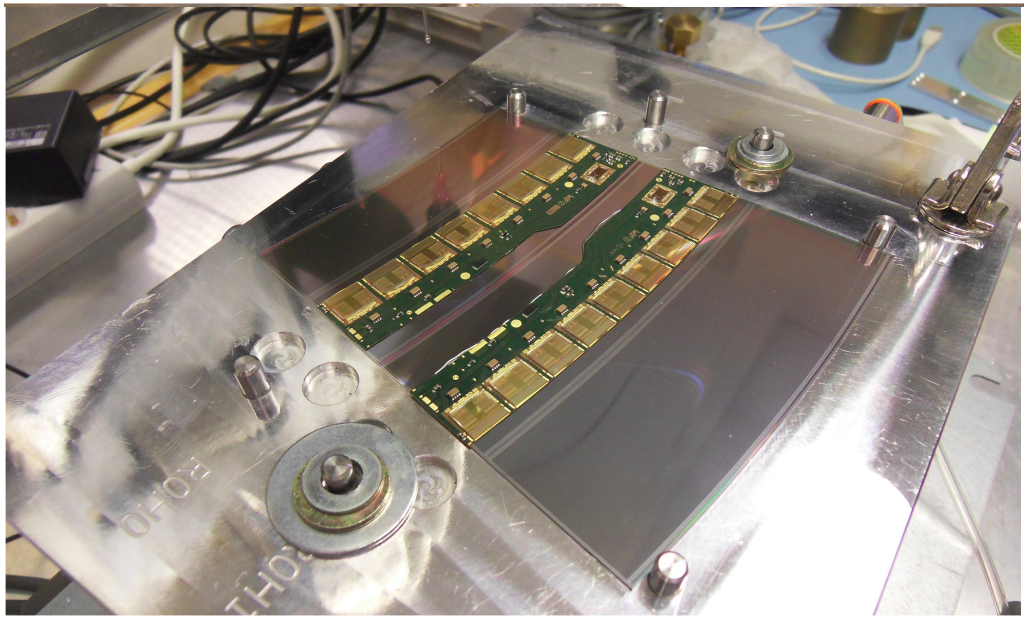
First Electrical Module





We have now almost completed our first operating (R0) module!

- Missing FE bonds & power-board
- Couple of (fixable) readout issues



Summary and Next Steps

ATLAS ITk project is moving out of R&D phase and into ***production*** phase

Our priority is now to finish the first (R0) module & then build a few more with the remaining prototype parts that we have

Aim is to develop production procedures & exercise our QA / QC routines

(Scandinavian) Module Production Milestones

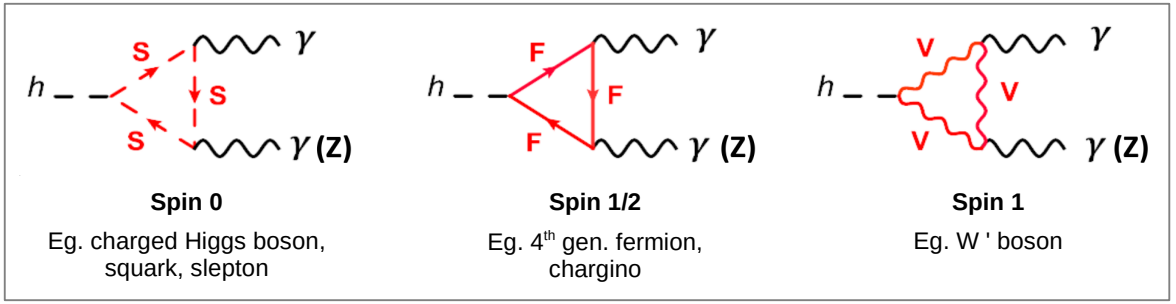
- Site Qualification: Mid/End of Year
- Module Pre-Production: Mid/End of Year
- Module Production: Early Next Year

Backup Slides

Physics @ HL-LHC

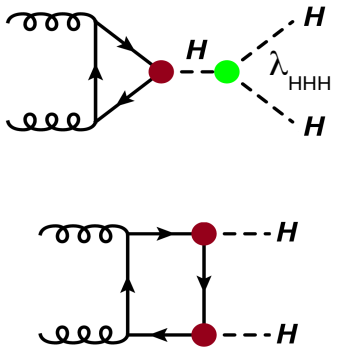
• **WH / ZH / ttH and H→μμ:** Statistically limited → large gains in $\Delta\mu/\mu$ at HL-LHC. Allow access to the top and muon-Yukawa couplings.

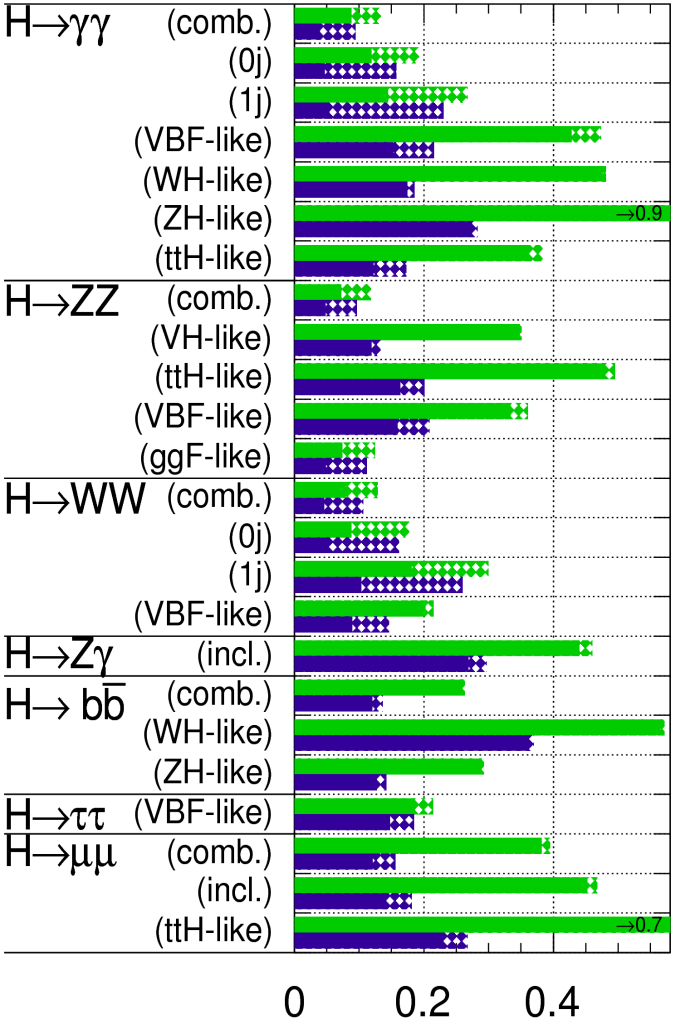
• **H → Zγ / H → γγ:** Improved precision can probe new physics via loop diagrams.



• **Higgs Self-Coupling:** Measurement is important to confirm the Higgs mechanism. Triple Higgs coupling (λ_{HHH}) could be observable via HH pair production.

Decay Channel	Branching Ratio	Total Yield (3000 fb^{-1})
$b\bar{b} + b\bar{b}$	33%	40,000
$b\bar{b} + W^+W^-$	25%	31,000
$b\bar{b} + \tau^+\tau^-$	7.3%	8,900
$ZZ + b\bar{b}$	3.1%	3,800
$W^+W^- + \tau^+\tau^-$	2.7%	3,300
$ZZ + W^+W^-$	1.1%	1,300
$\gamma\gamma + b\bar{b}$	0.26%	320
$\gamma\gamma + \gamma\gamma$	0.0010%	1.2





https://twiki.cern.ch/twiki/bin/view/AtlasPublic/UpgradePhysicsStudies

Expected ITk Performance