Mengqing Wu

Nikhef Jamboree
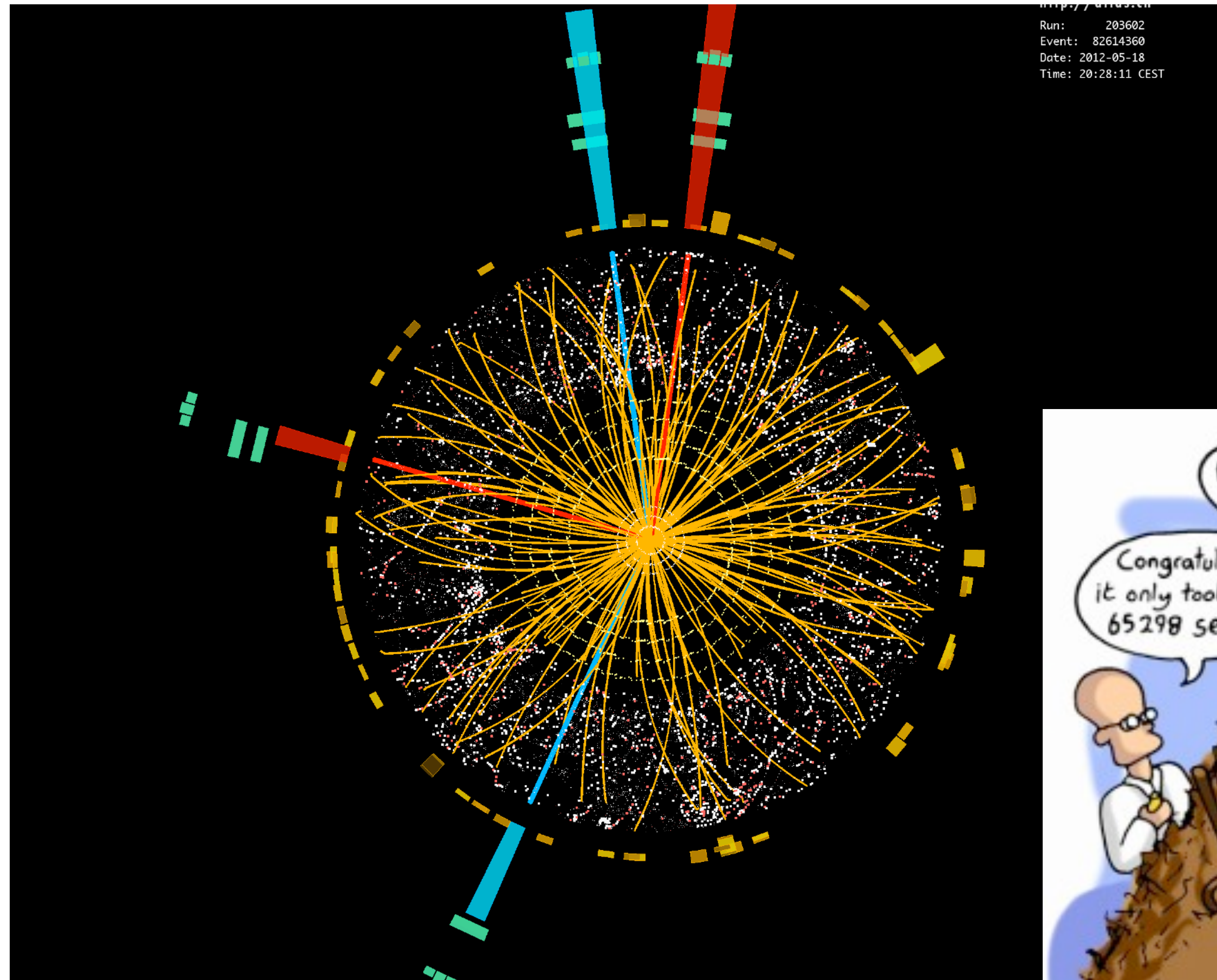9 May 2022

The ATLAS Upgrade

Experimental challenges at energy frontier

Run: 203602
Event: 82614360
Date: 2012-05-18
Time: 20:28:11 CEST

Event display of a H -> 4e candidate event.
Image: ATLAS-PHO-COLLAB-2012-007

By looking for needle in a haystack, LHC embraced the discovery of a SM-like Higgs boson

**What about data
x 2 → Run 3
x 20 → HL-LHC**

Found It!!!

Congratulations, it only took you 65298 seconds

Image: www.iolvon.co.uk

Brings up challenges to the detectors:

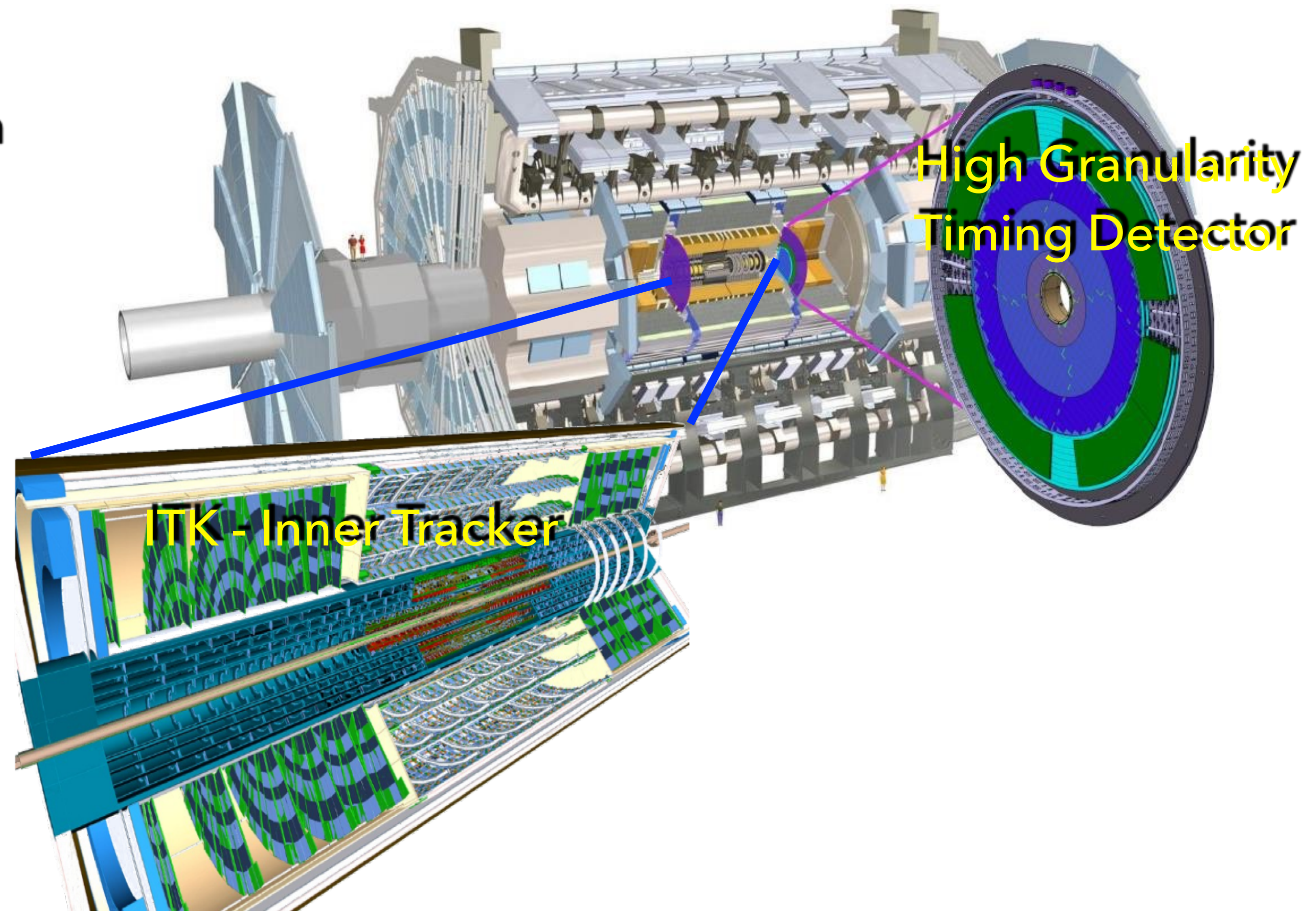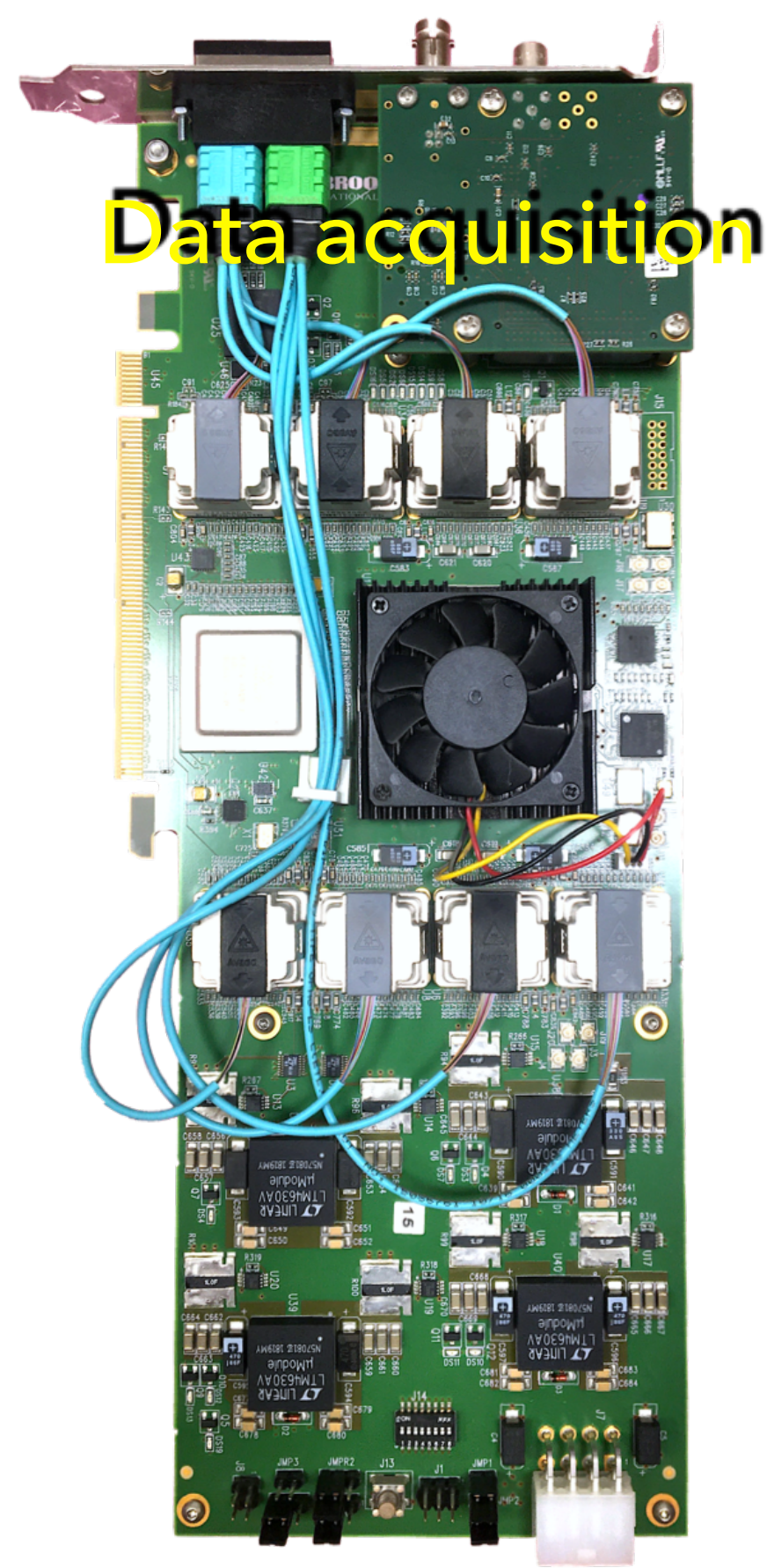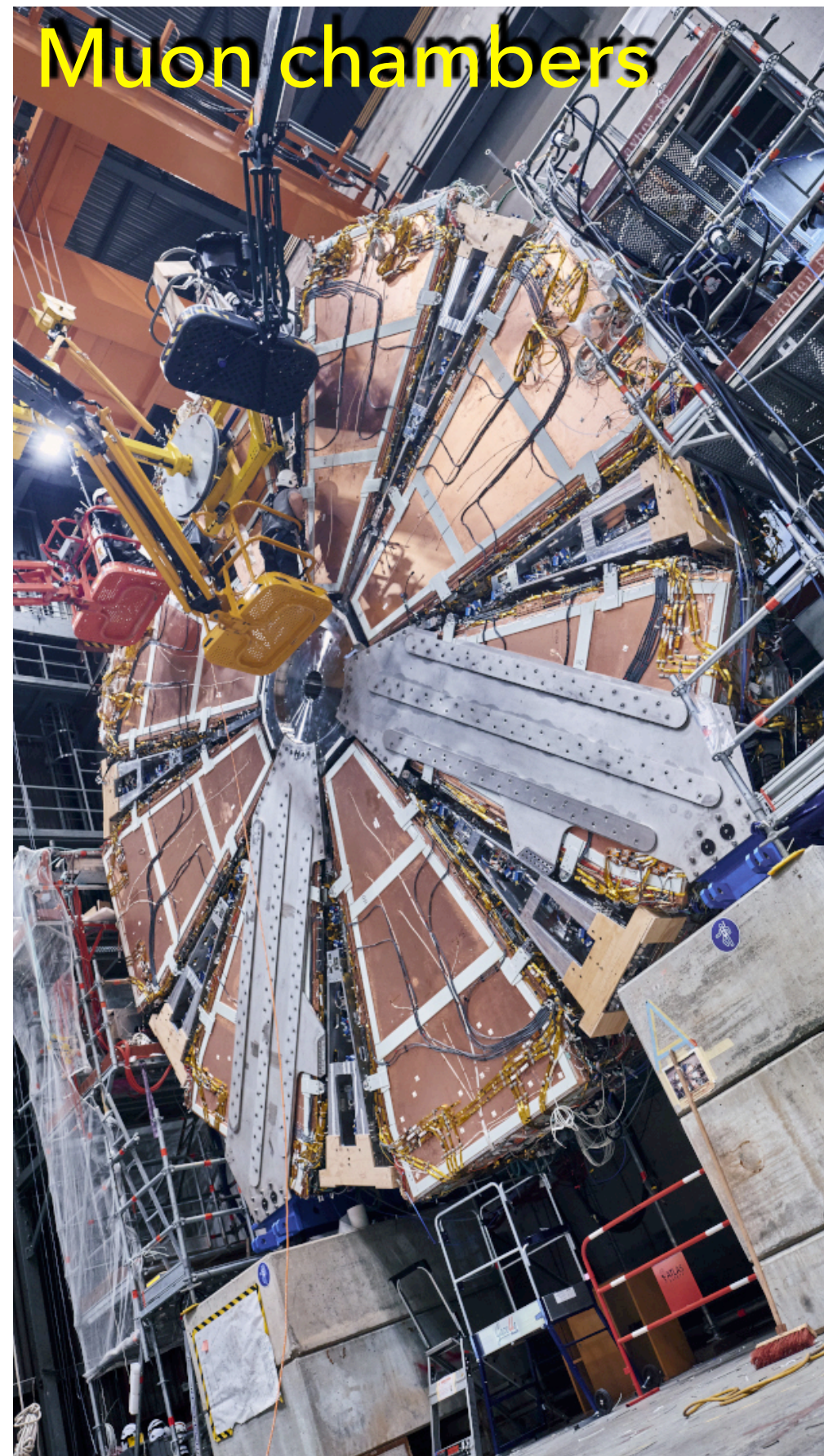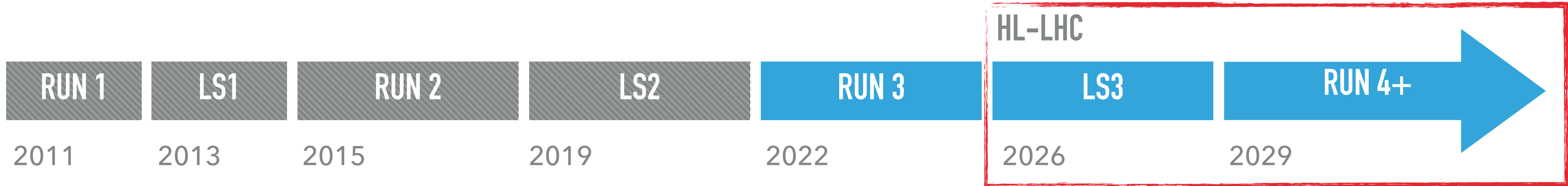▸ How to keep the same or better performance in a harsher experiment environment

HL-LHC: challenges with increased instant luminosity

RUN 1	LS1	RUN 2	LS2	RUN 3	HL-LHC	
					LS3	RUN 4+
2011	2013	2015	2019	2022	2026	2029

25 reconstructed vertices

HL-LHC t$\bar{t}$ event in ATLAS ITK
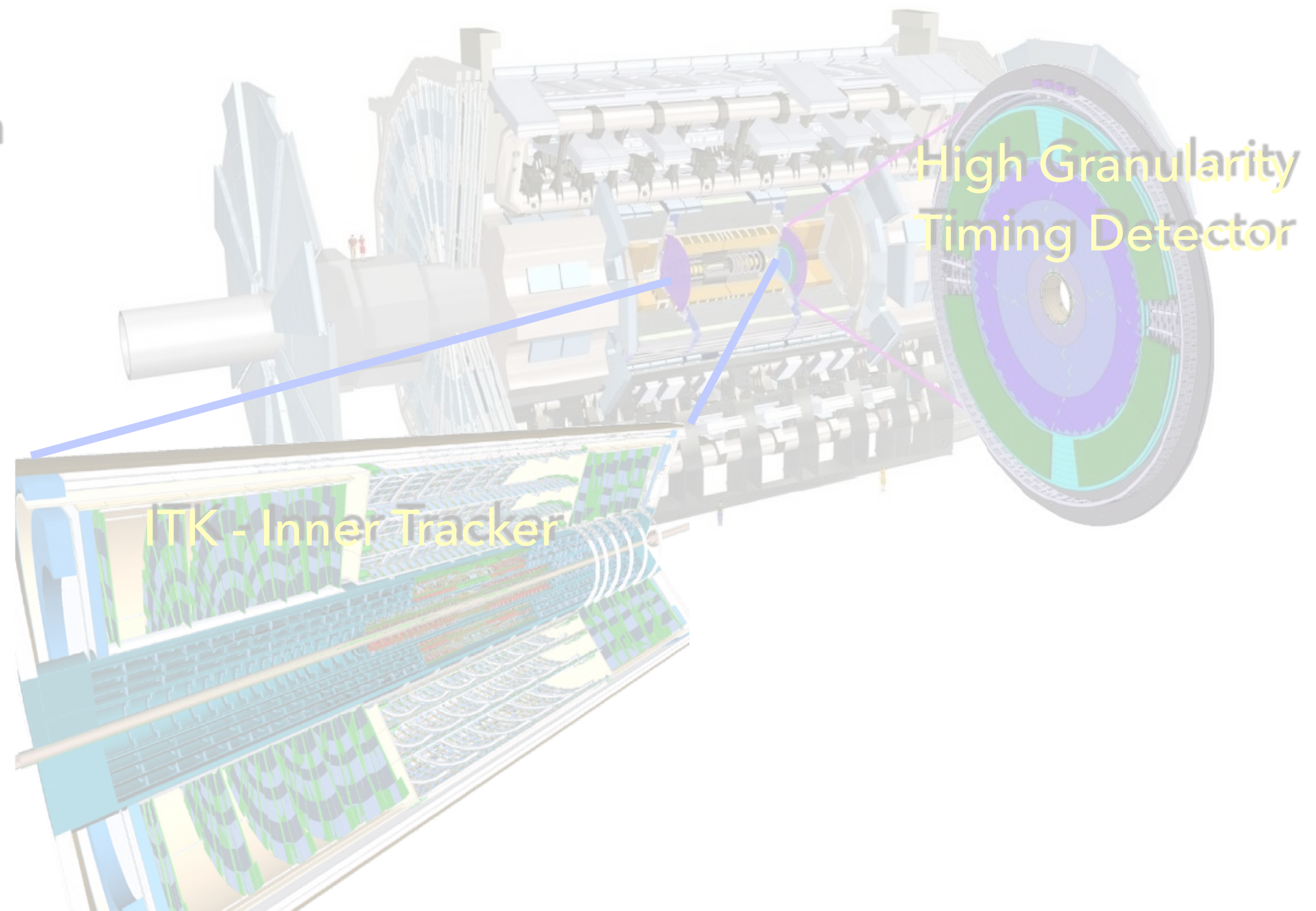at <μ>=200

200 simulated vertices
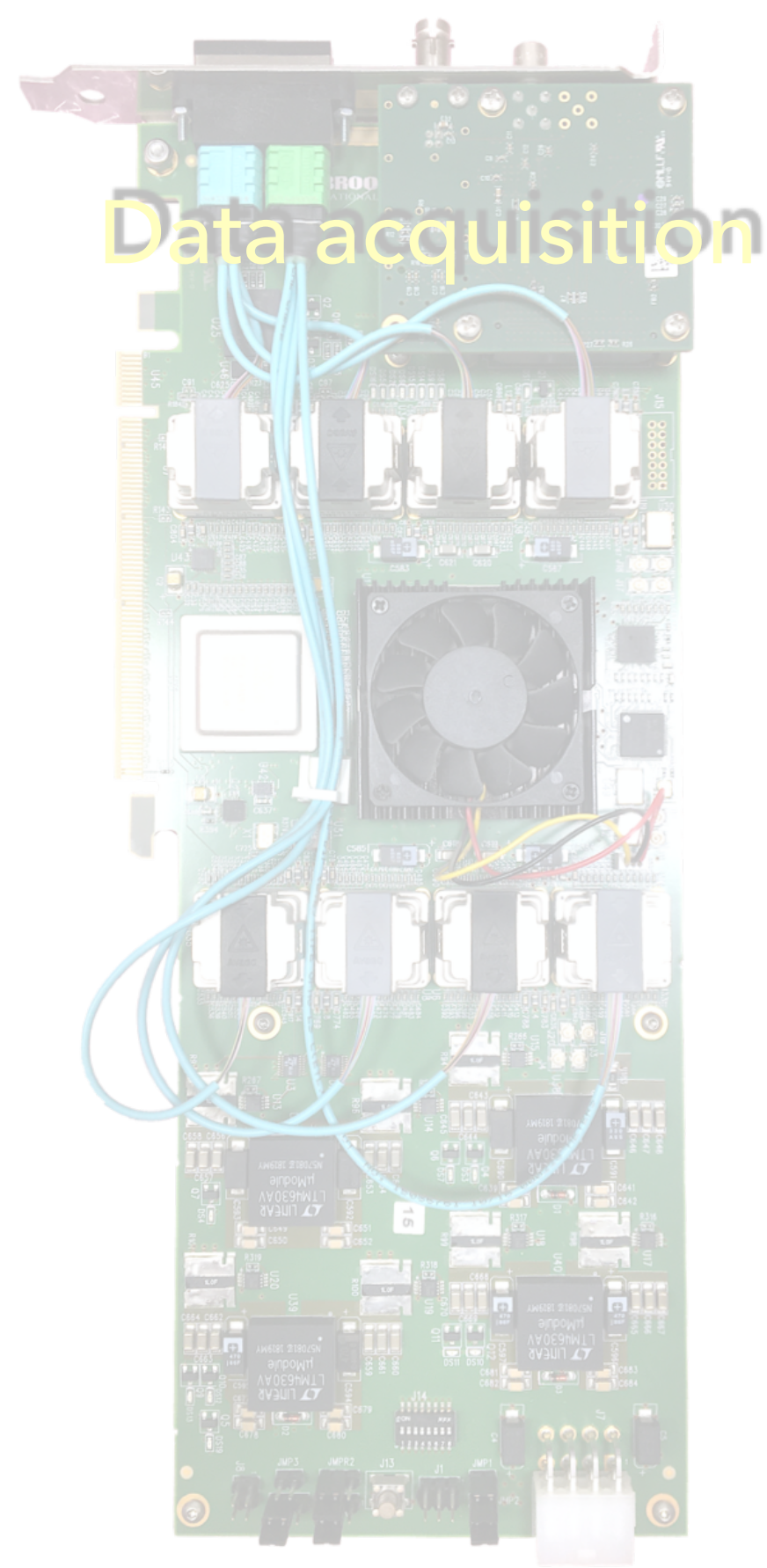
SLICE THIS PICTURE INTO FEW SUB-FRAMES
☞ 4D WANTED
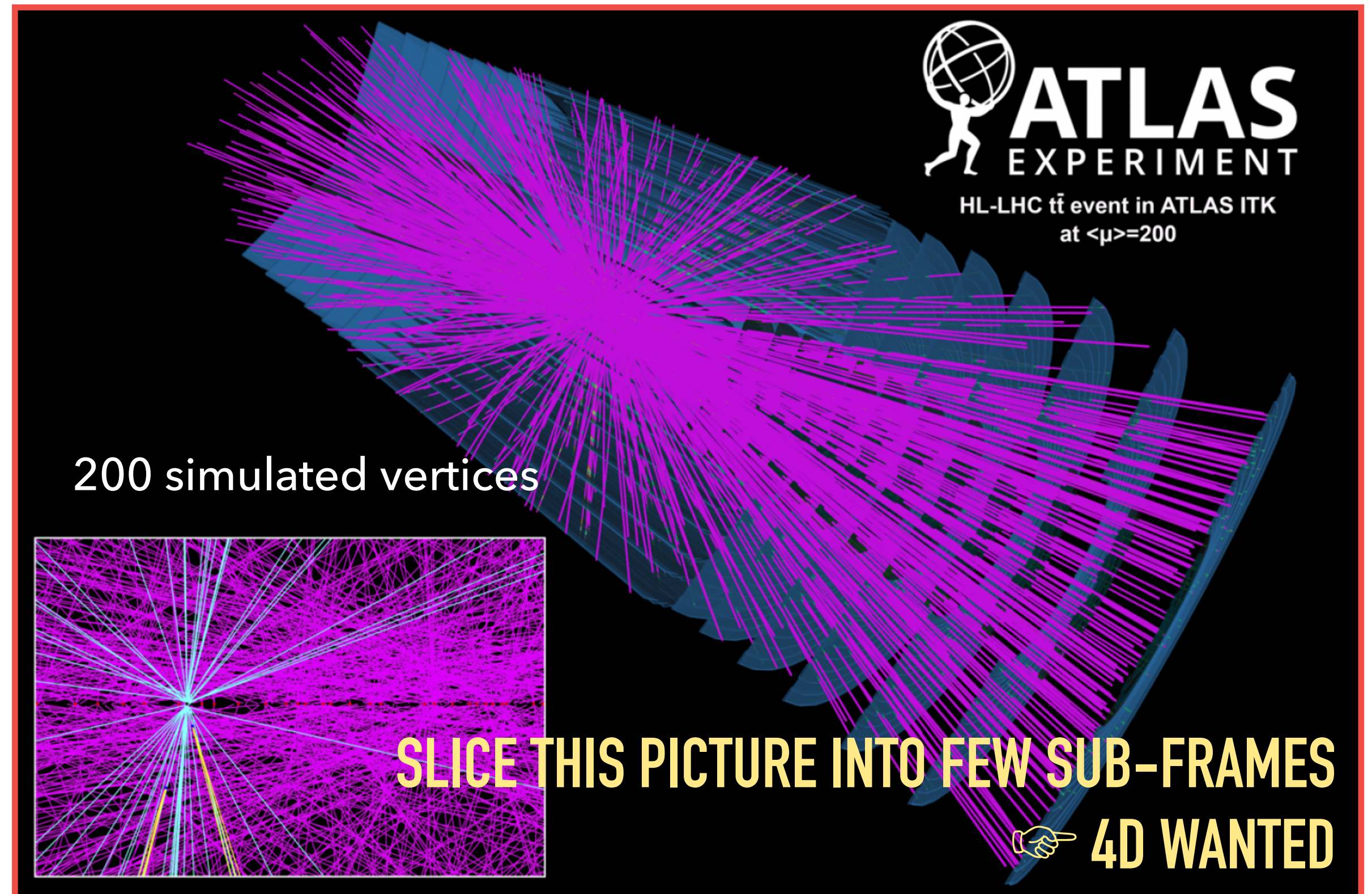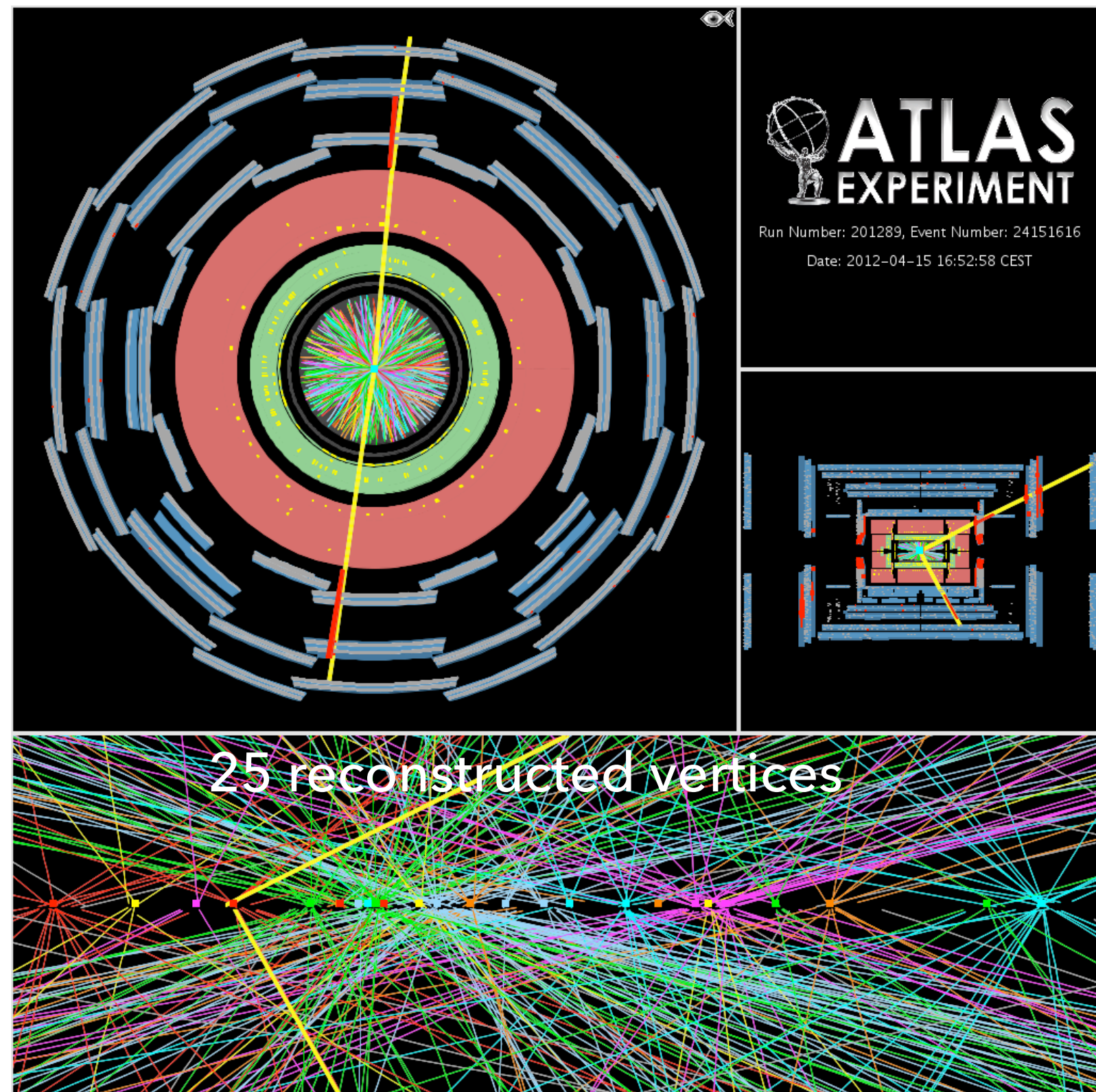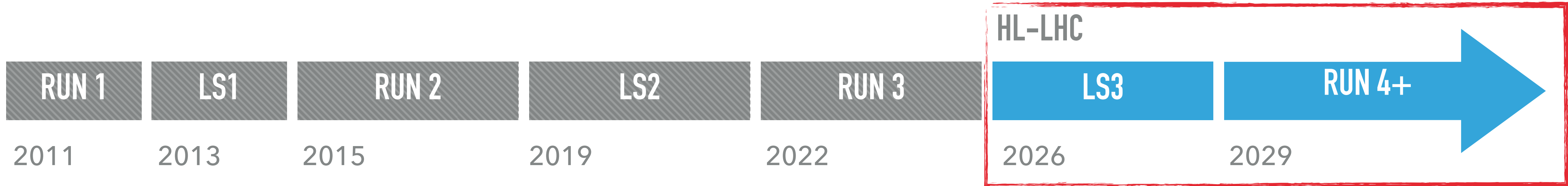
Nikhef projects in ATLAS upgrade

Nikhef projects in ATLAS upgrade

HL-LHC

| RUN 1	LS1	RUN 2	LS2	RUN 3	LS3	RUN 4+
2011	2013	2015	2019	2022	2026	2029

Muon chambers

Data acquisition

High Granularity Timing Detector

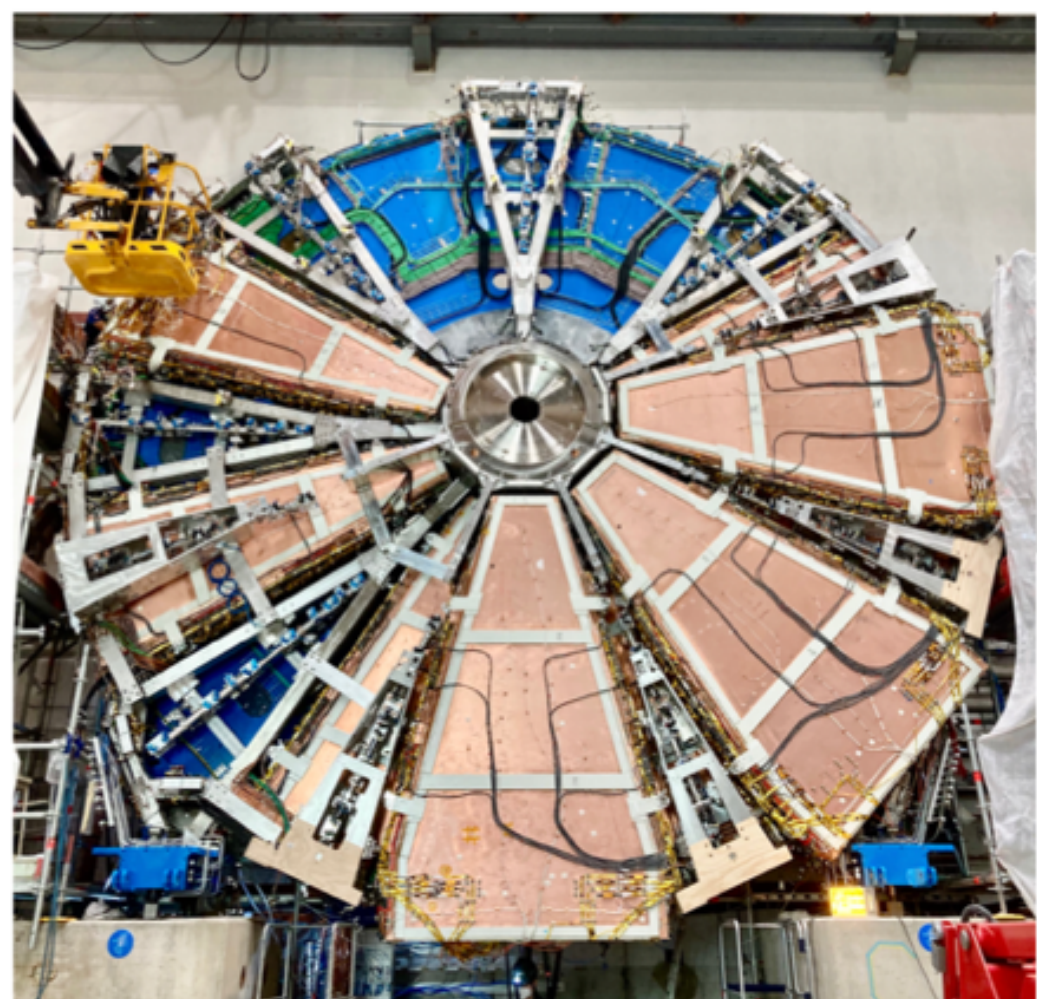ITK - Inner Tracker

Muon upgrade for Run 3 & Run 4+ (HL-LHC)

▸ Upgrade target:

➜ "Sharpening" of the level 1 trigger threshold

▸ Upgrade at LS2 for Run 3: New Small Wheels (NSW)

▸ Upgrade at LS3 for Run 4+: Barrel Chambers

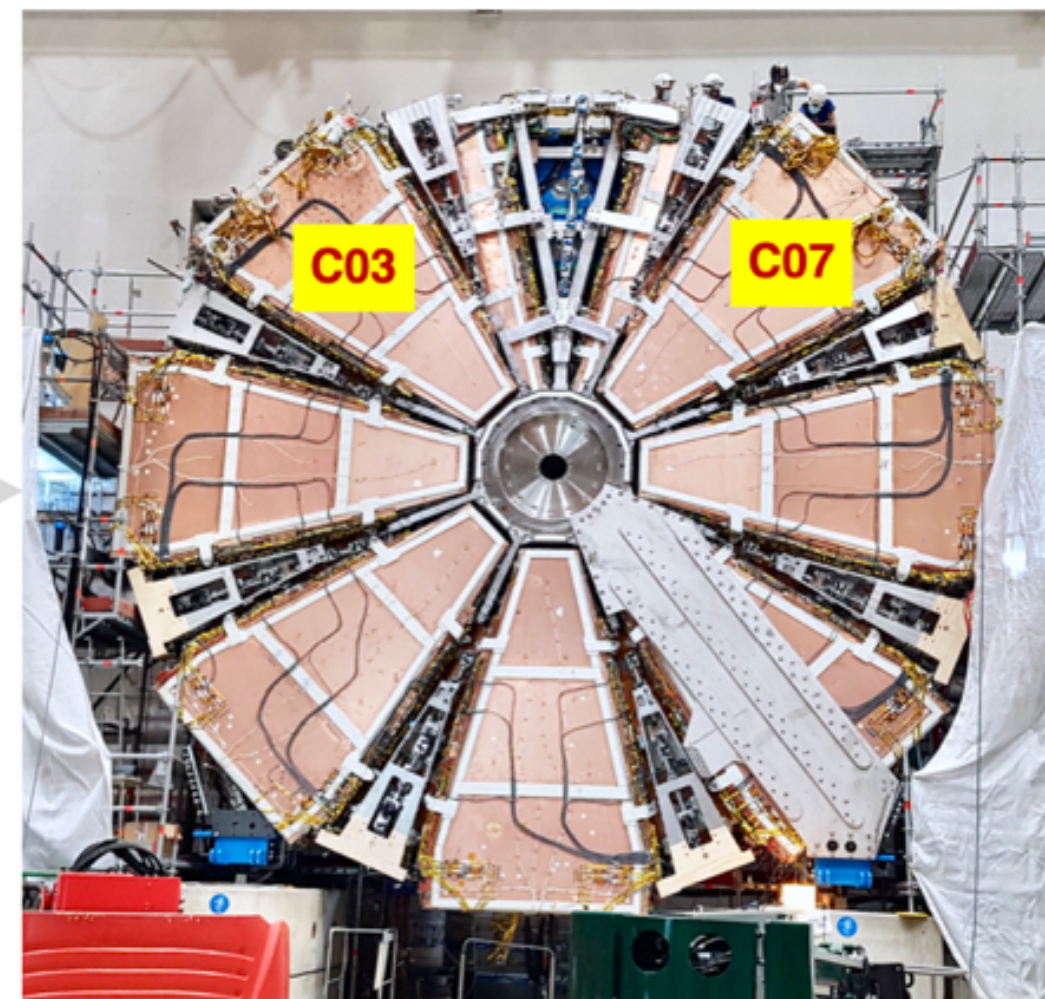▸ **Nikhef** contributions to various parts of both LS2 and LS3 muon upgrades

MM: MicroMegas
sTGCs: small-strip thin-gap chambers
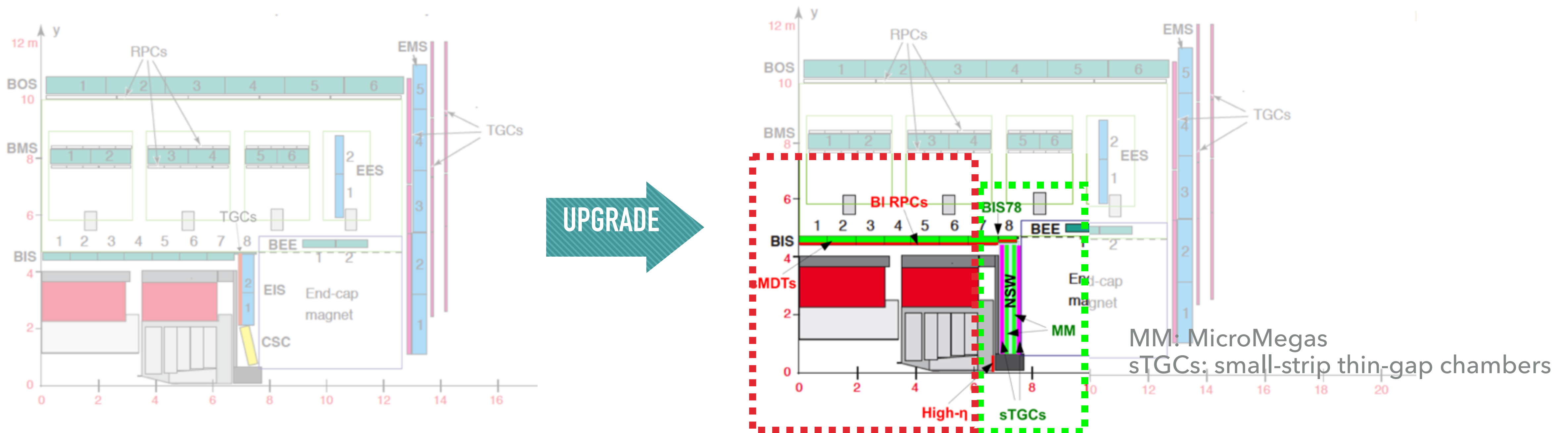
LS2: New Small Wheels

Assembly

Installation

NSW-C in B191 on **9 August**
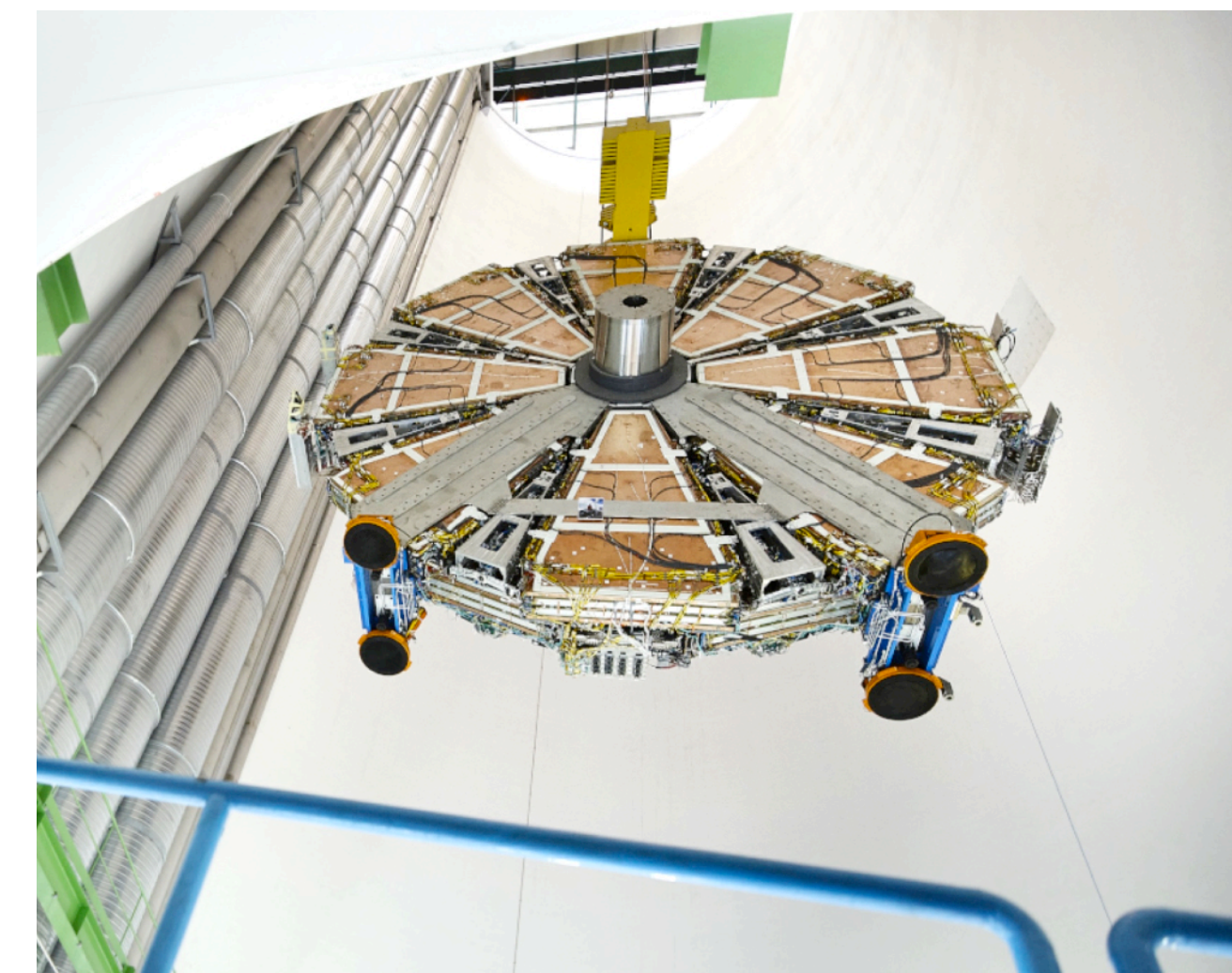
NSW-C in B191 on **25 August**

NSW-C in B191 on **7 September**

Lowering the NSW-C in the carven on **14 October**

▸ **Nikhef contributions to NSW infrastructure:** Sensors (B-field and Temperature), Cabling, DCS (detector control system), and FELIX

▸ **Commissioning at CERN during lockdown:** Vladimir and Mesfin (**Nikhef** engineers)

▸ Despite setbacks (i.e. pandemic) successfully installed
  ▸ NSW-A: July 2021
  ▸ NSW-C: October 2021

Slide credit: Tristan du Pree

LS3: Barrel Chambers

Robert   Jordy   Tristan

PROTOTYPE CONSTRUCTION AT MPI

- ▸ ~100 inner barrel chambers for HL-LHC
  - ▸ for better resolution
- ▸ Nikhef designed & produced new RasNik alignment system
- ▸ Mezzanines and DCS: software by Nikhef engineer Henk Boterenbrood

Slide credit: Tristan du Pree

Nikhef Muon team

Slide resource: Tristan du Pree

Tristan du Pree   Harry van der Graaf   Jordy Degens   Henk Boterenbrood   Karol Poplawski

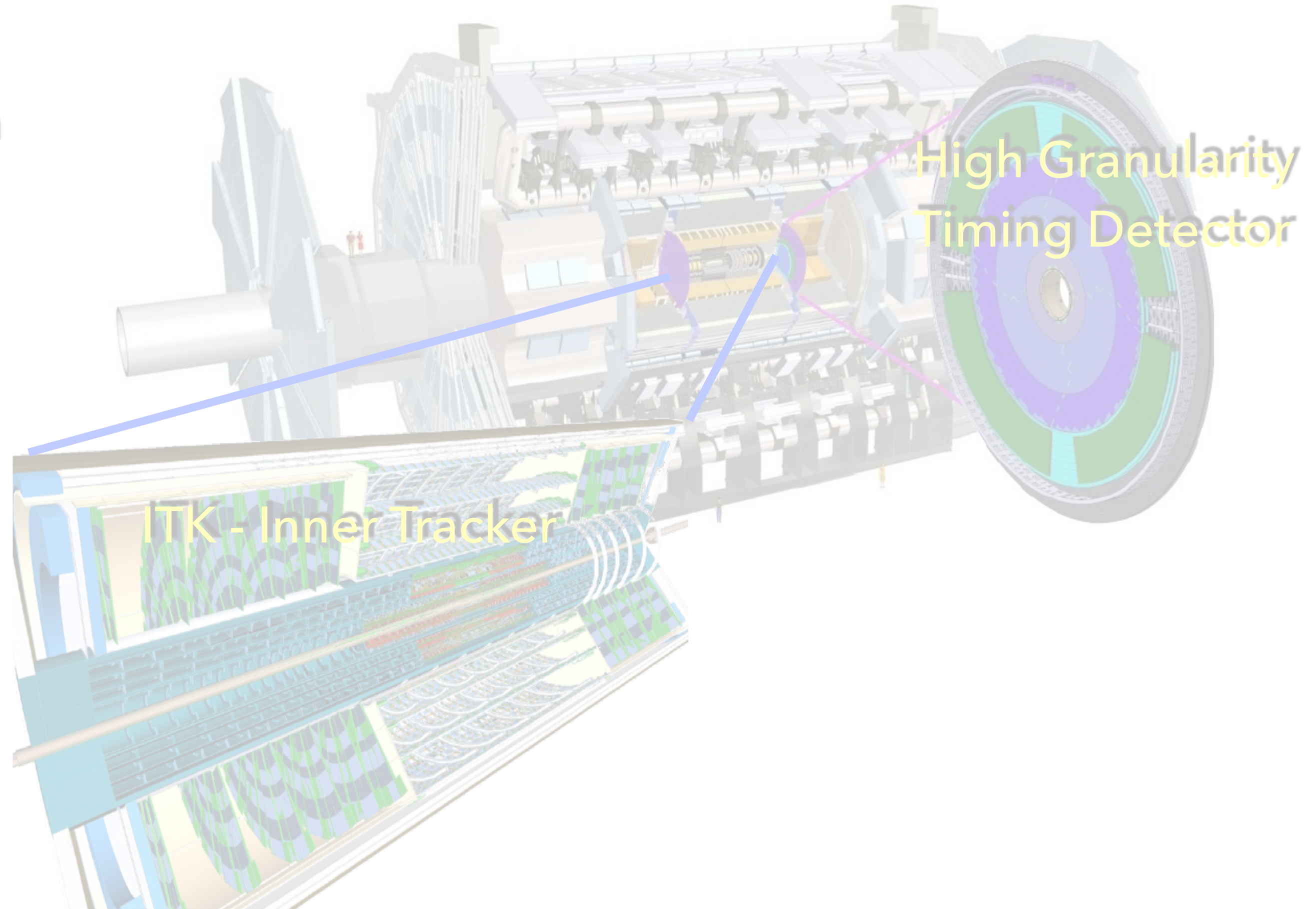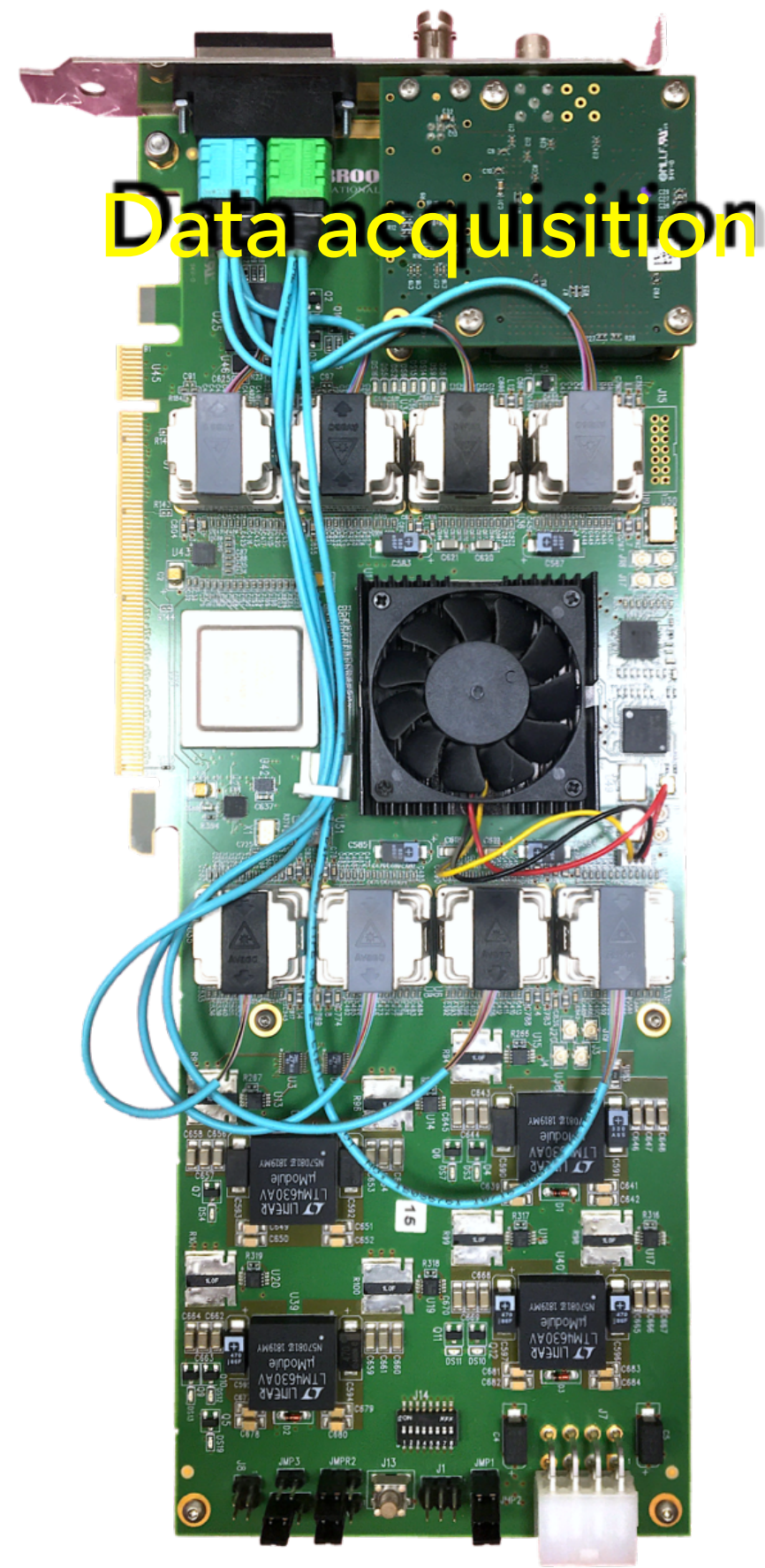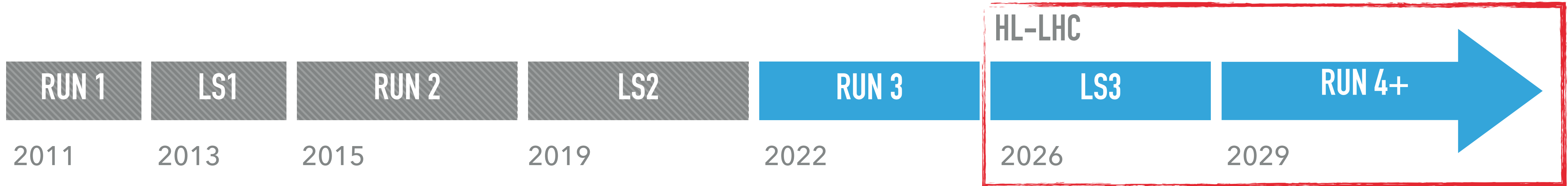Wim Gotink   Hans Verkooijen   Hans Band   Stan Heijnen   Vladimir Gromov   Mesfin Gebyehu

Nikhef projects in ATLAS upgrade
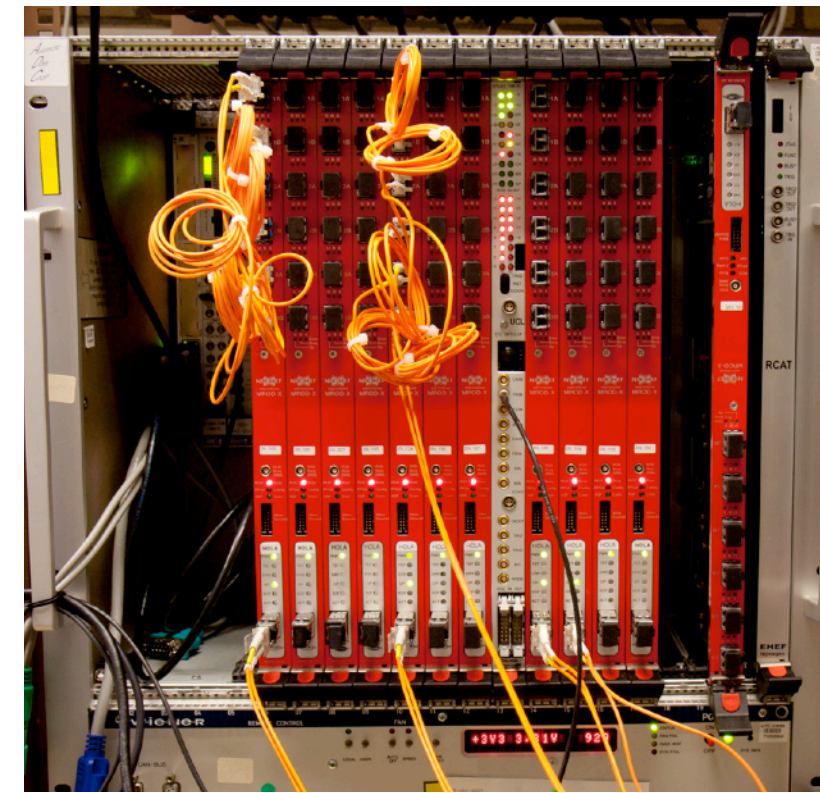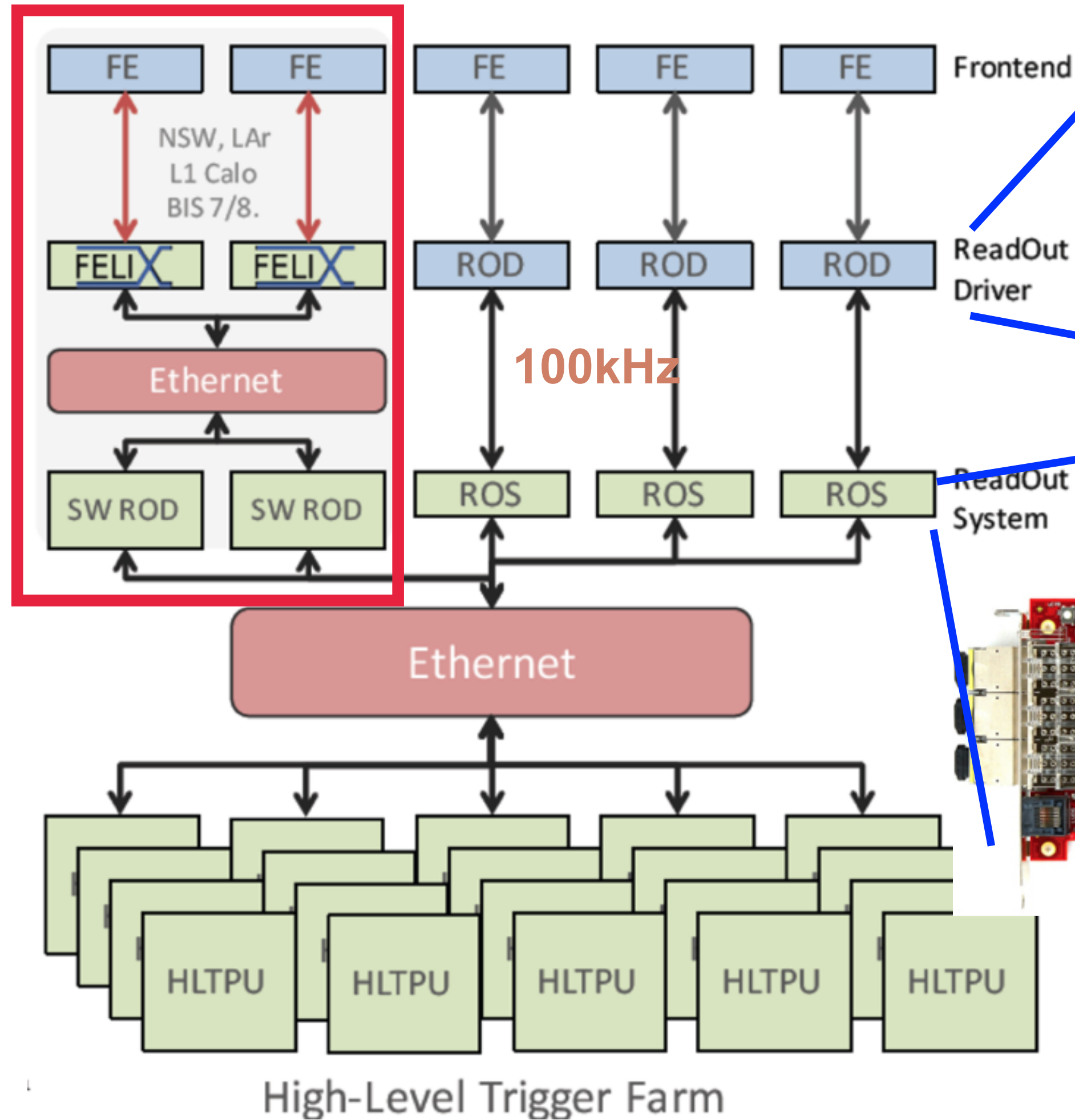
HL-LHC

RUN 1	LS1	RUN 2	LS2	RUN 3	LS3	RUN 4+
2011	2013	2015	2019	2022	2026	2029

Muon chambers

Data acquisition

High Granularity Timing Detector

ITK - Inner Tracker

LS2: Run 3 FELIX system

Same custom electronics for every sub-detector

UPGRADE

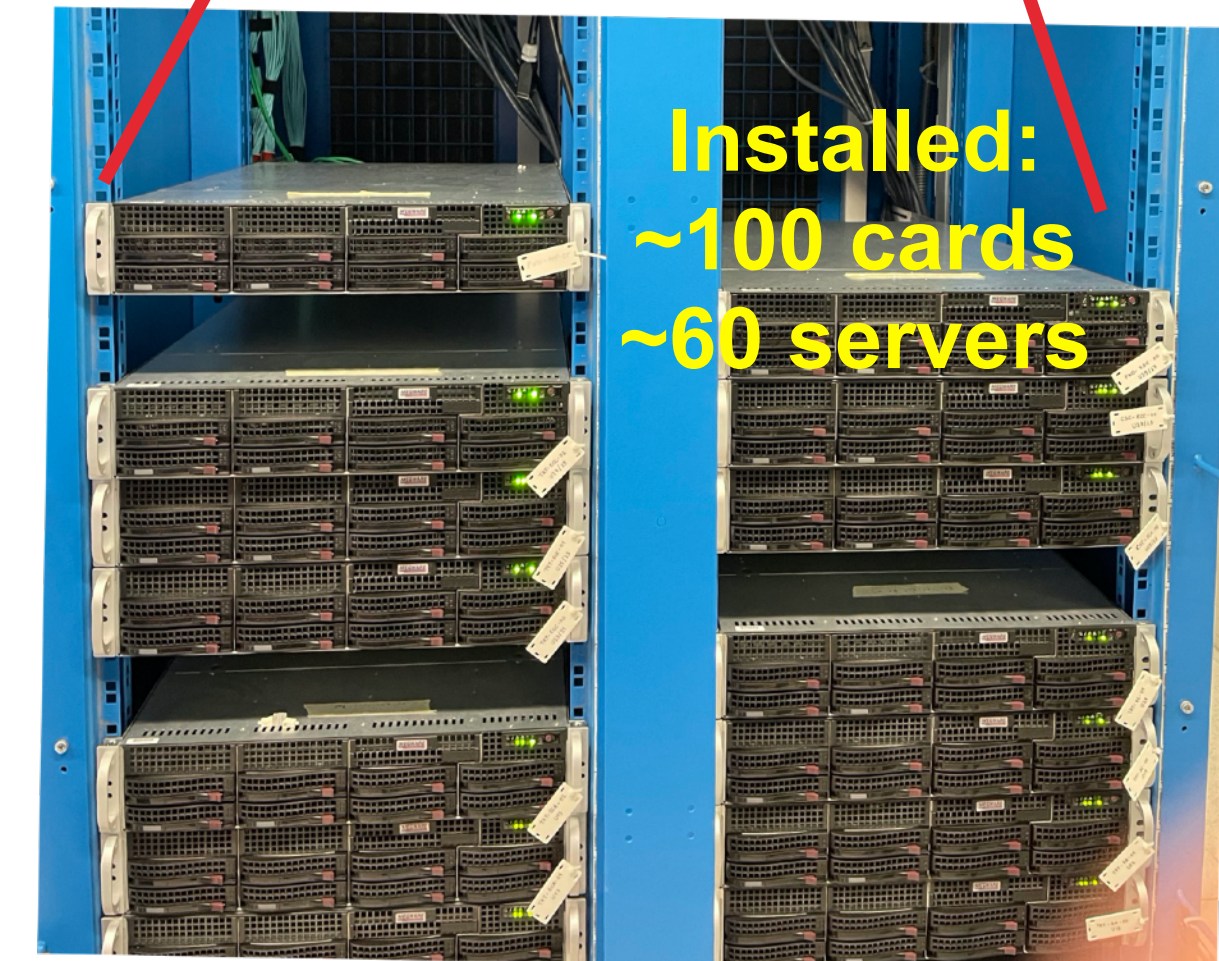**One custom electronics for every sub-detector**

NEW for Run 3

100kHz

MROD: Nikhef

ROBinNP card
[arXiv 1710.05607]

607]

Custom hardware

UPGRADE

Bonus: card hosted by commercial servers!

Installed: ~100 cards ~60 servers

Image: Carlo Gottardo

Software running on commercial server

LS3: HL-LHC FELIX system
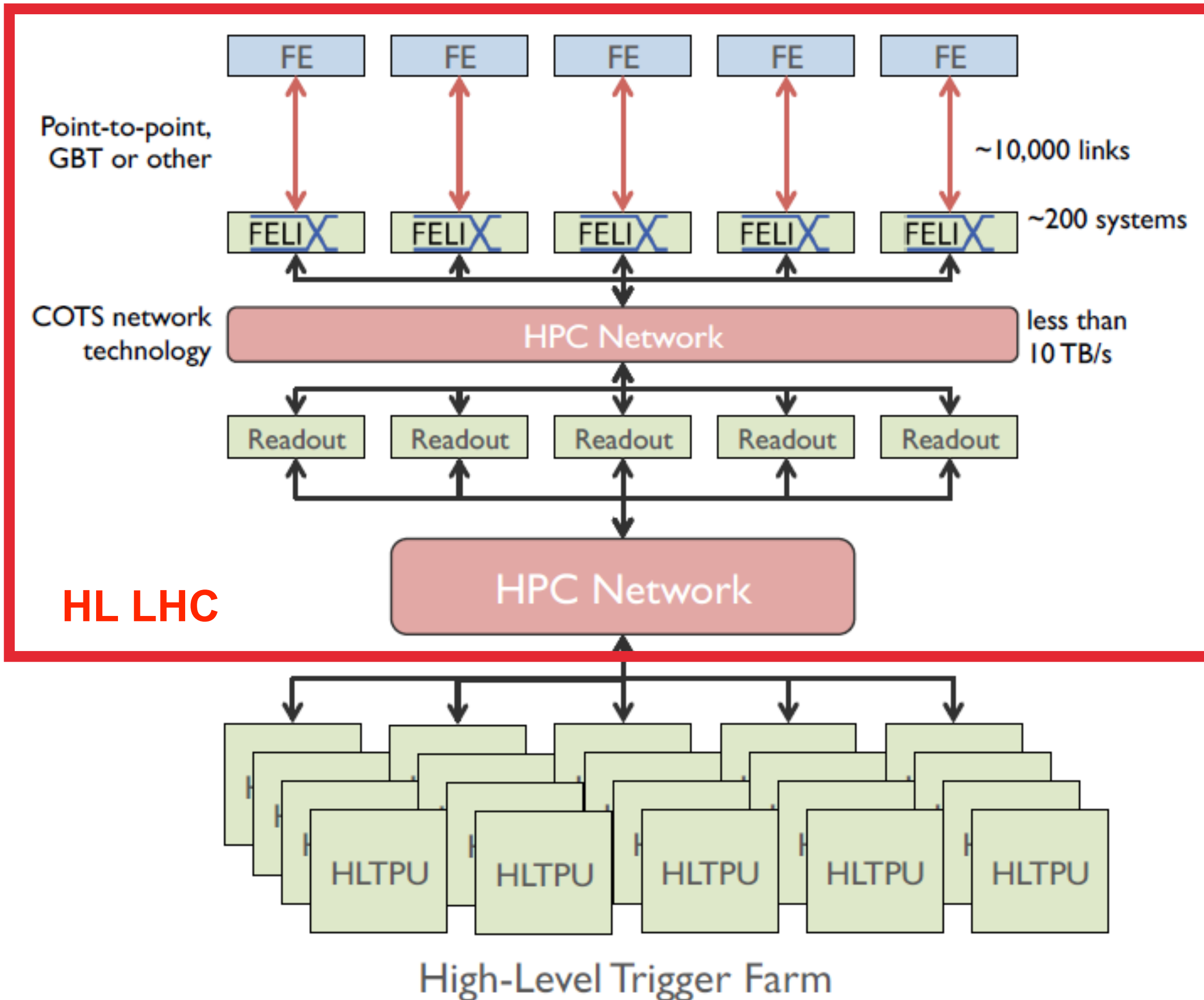
Challenges compared to Run2/3

▸ **~3x** mean number of interactions per crossing

▸ **~10x** level-0 trigger rate

▸ **~20x** data readout rate (larger event size)
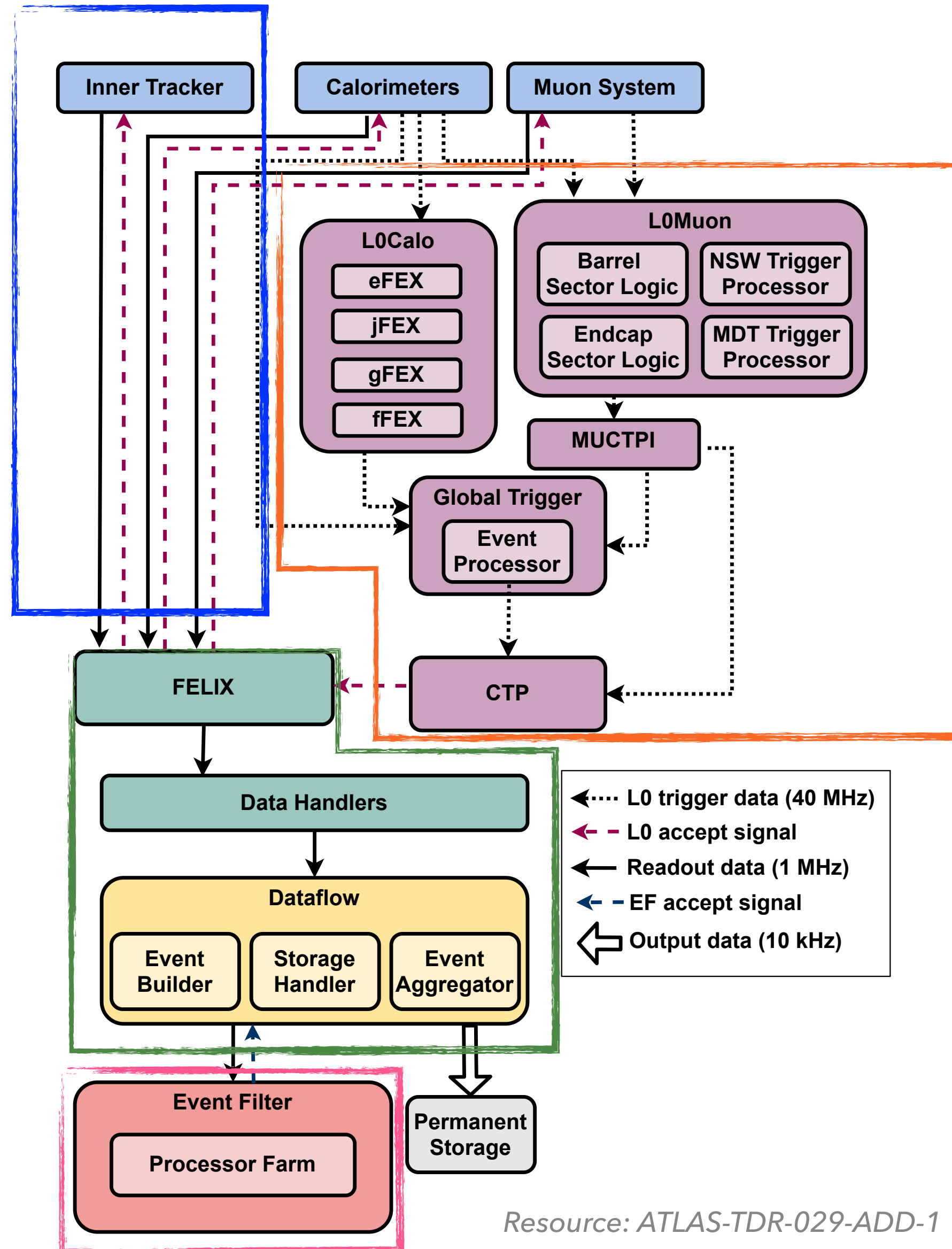
Strong Nikhef contributions to all aspects

HL-LHC FELIX system:
FELIX + readout software (aka data handler)

▸ For all sub-detector systems: including Muon, ITK and HGTD to which Nikhef makes strong contributions
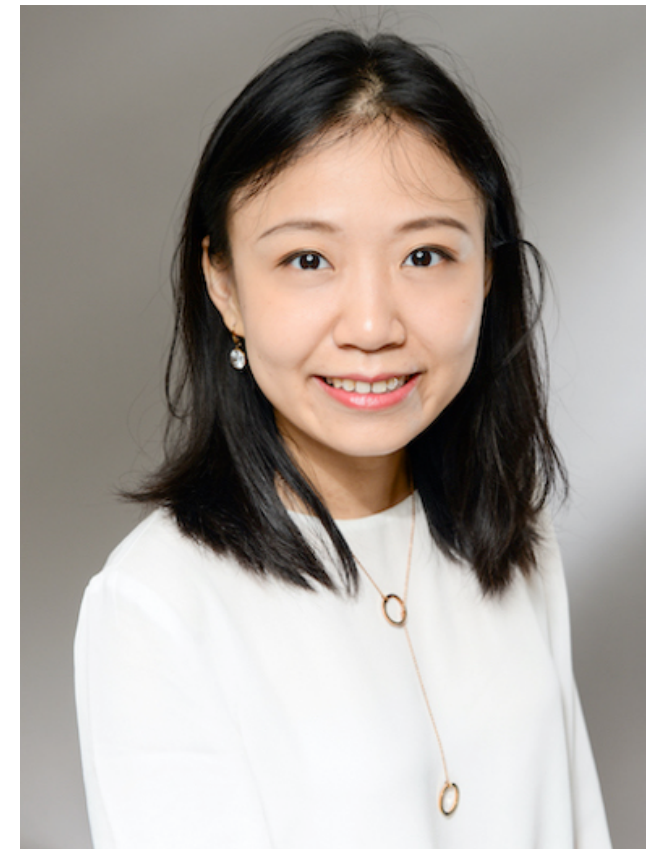
LS3: New trigger system architecture for HL–LHC

Resource: ATLAS-TDR-029-ADD-1

▸ 2021:

Important decisions made on the Trigger architecture:

<TDR for the Phase-II Upgrade of the ATLAS TDAQ System Amendment>

  ▸ Keep only one level HW trigger (L0)

  ▸ ▥▶ move from a **custom** High level Track Trigger system to a **commercial-based** system for tracking at the Event Filter (high level trigger) level

Nikhef TDAQ team

Antonio Pellegrino

Mengqing Wu
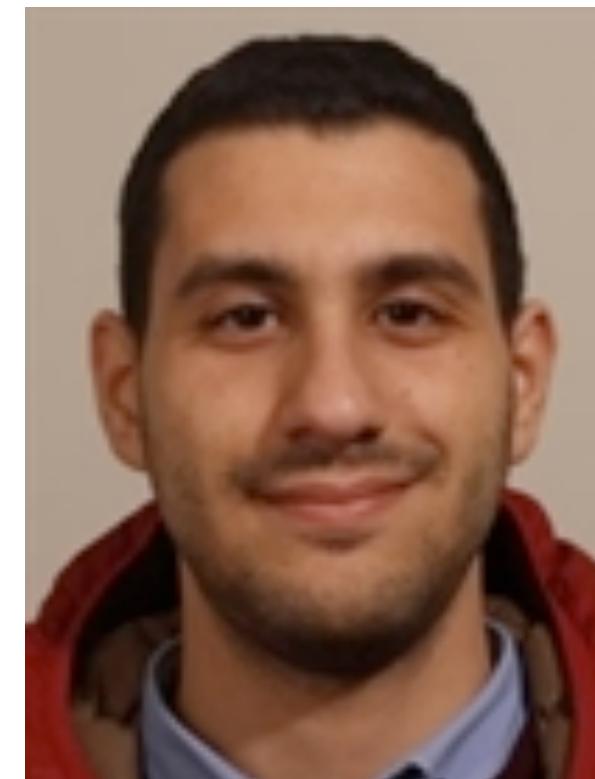
Mark Donszelmann

Frans Schreuder

Bas van der Heijden

Ton Fleuren

Jos Vermeulen

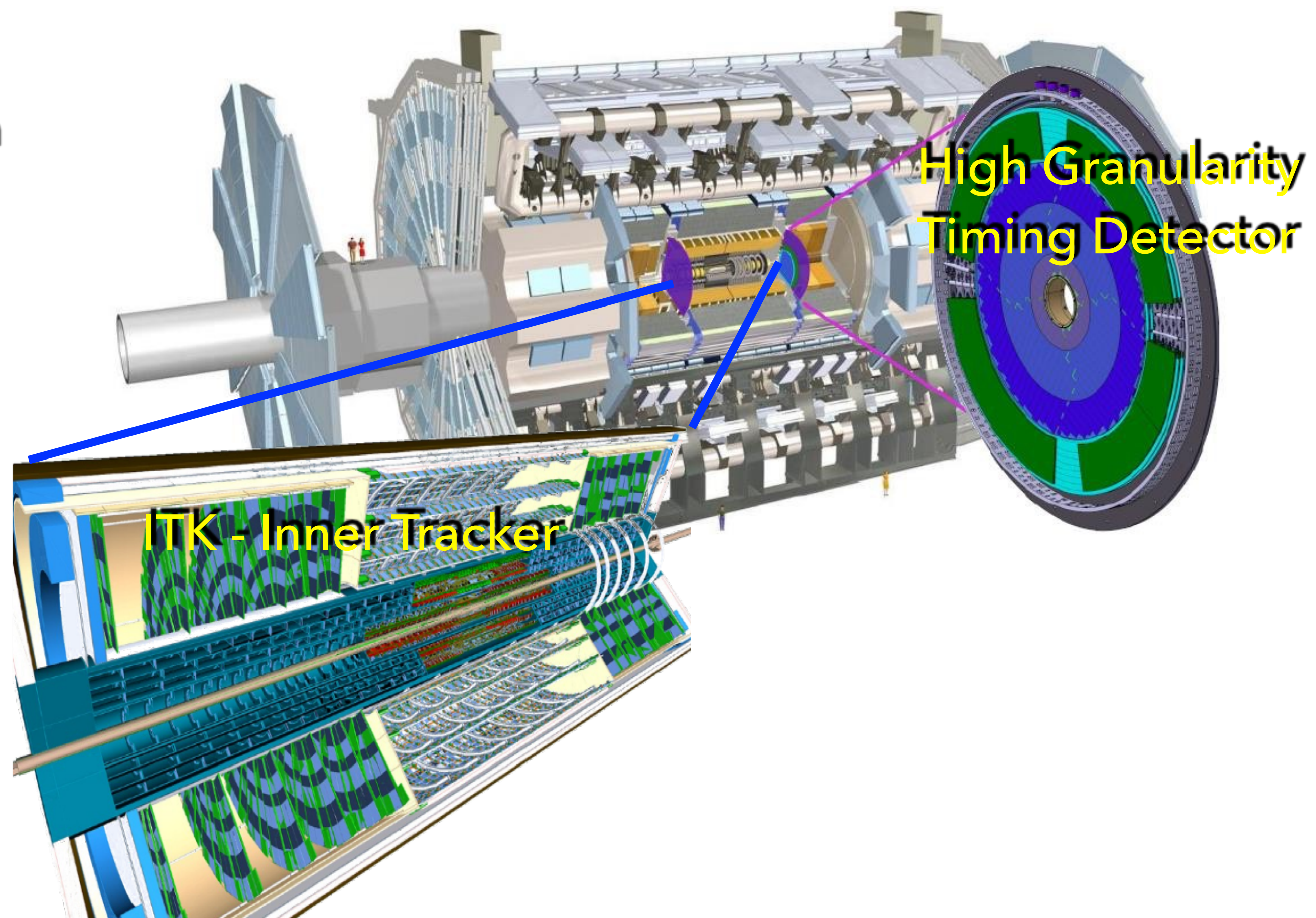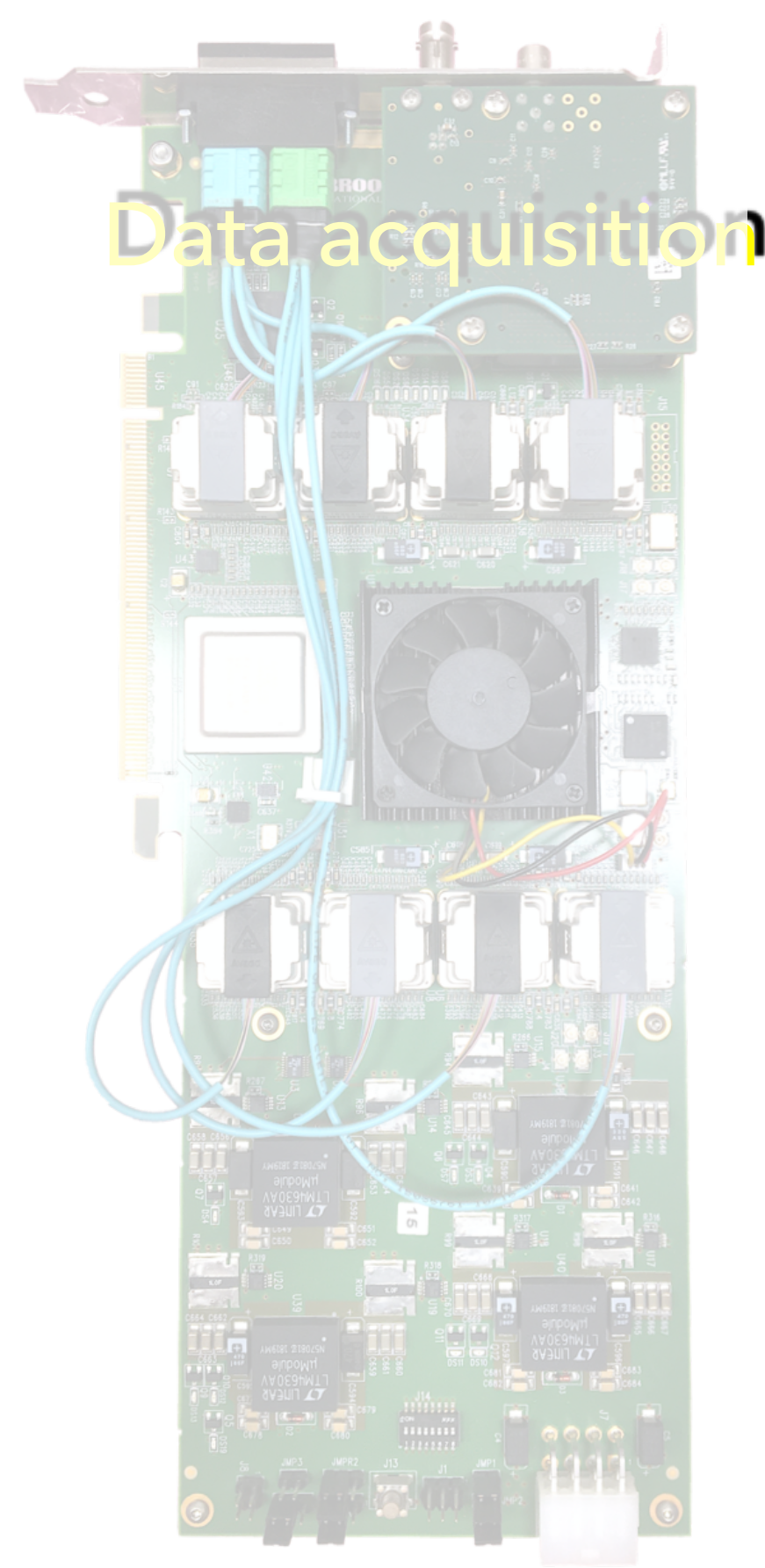Carlo A. Gottardo
**Until Feb 2022
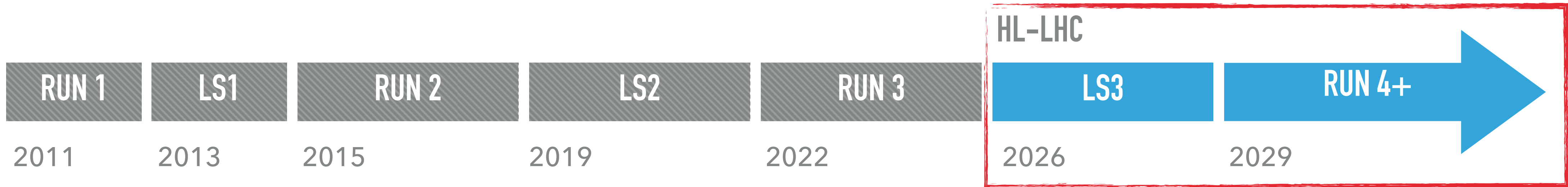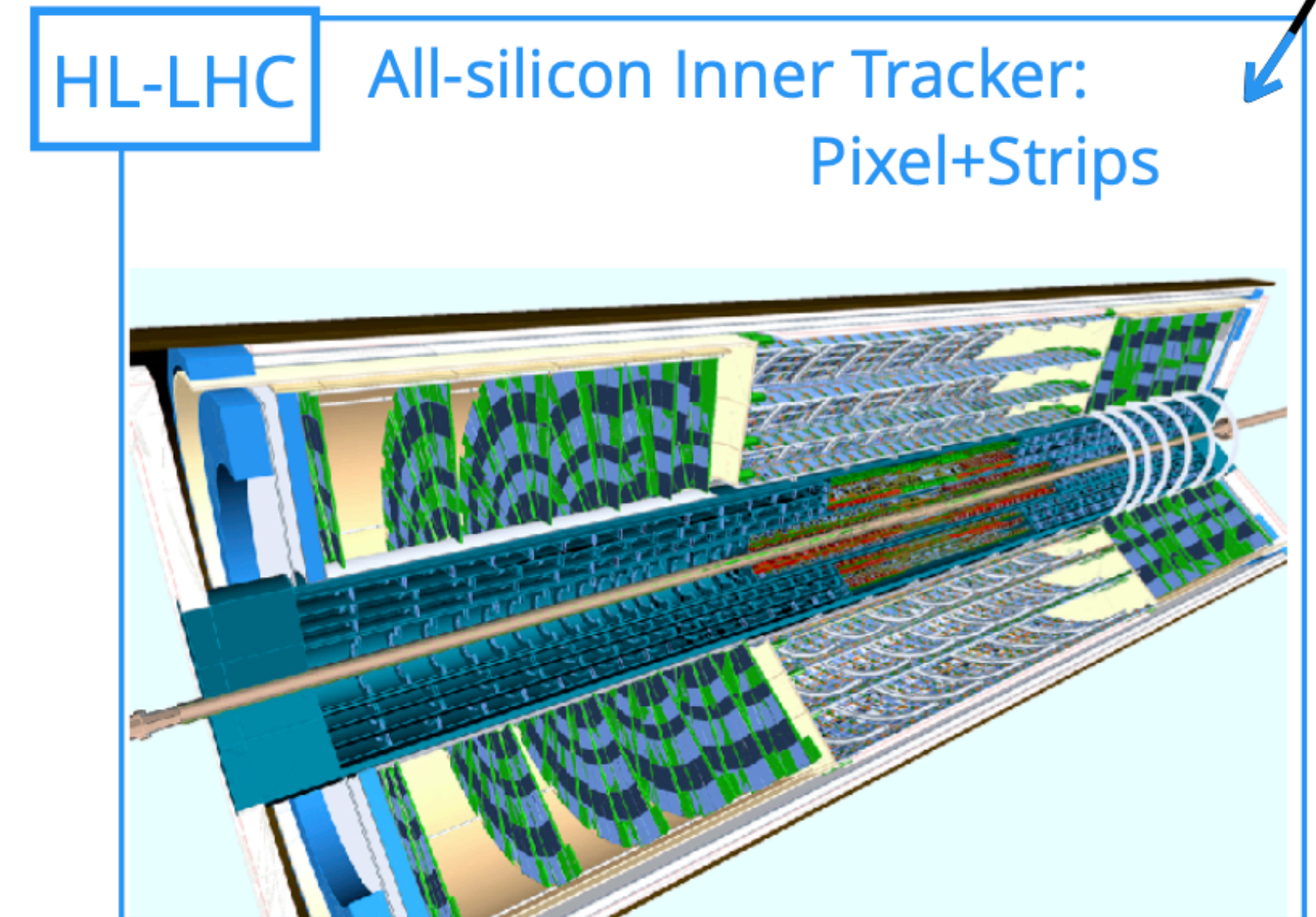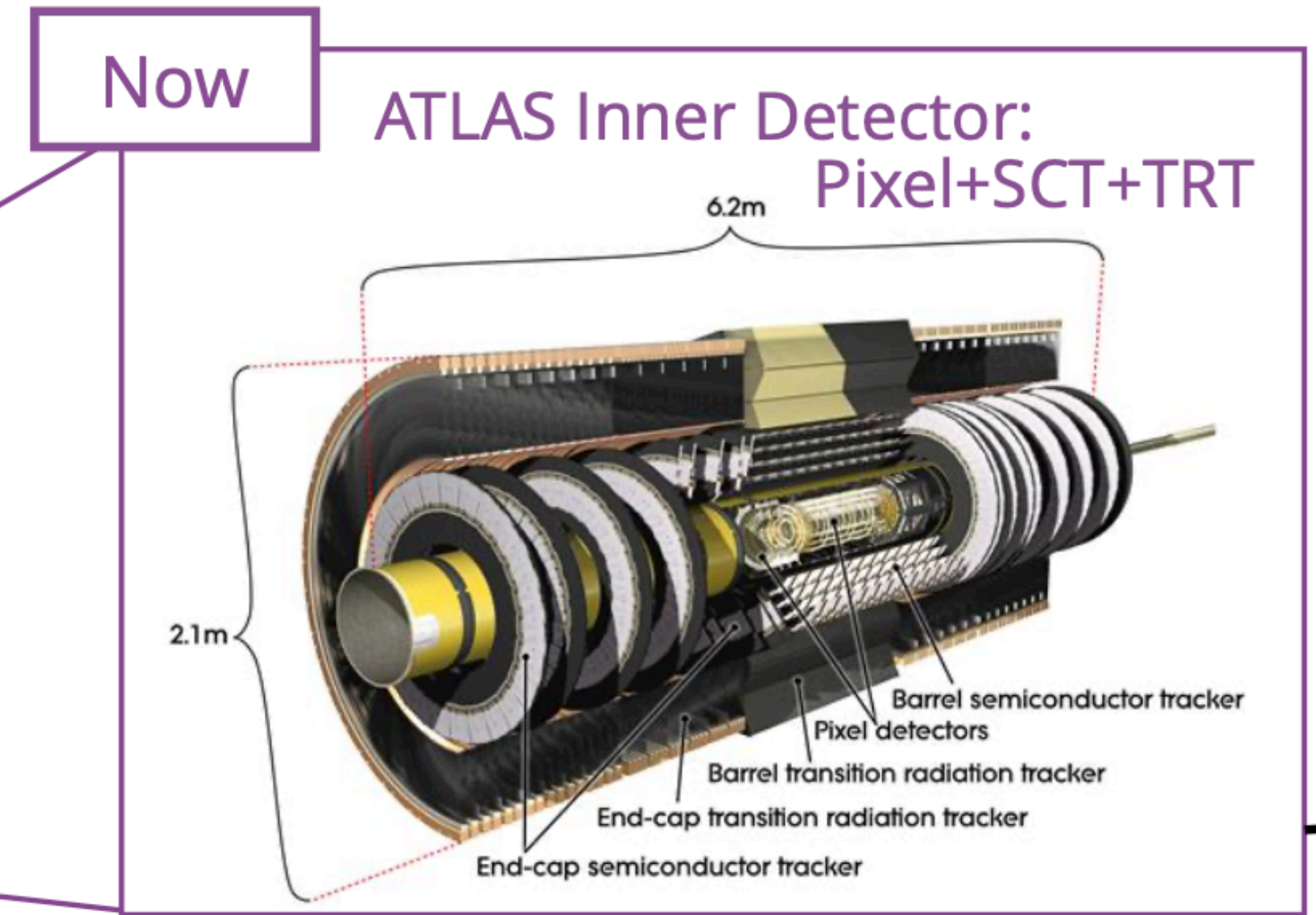Now with CERN as FELIX expert**

Luca Franco

Henk Boterenbrood

Nayib Boukadida

Mesfin Gebyehu

Nikhef projects in ATLAS upgrade
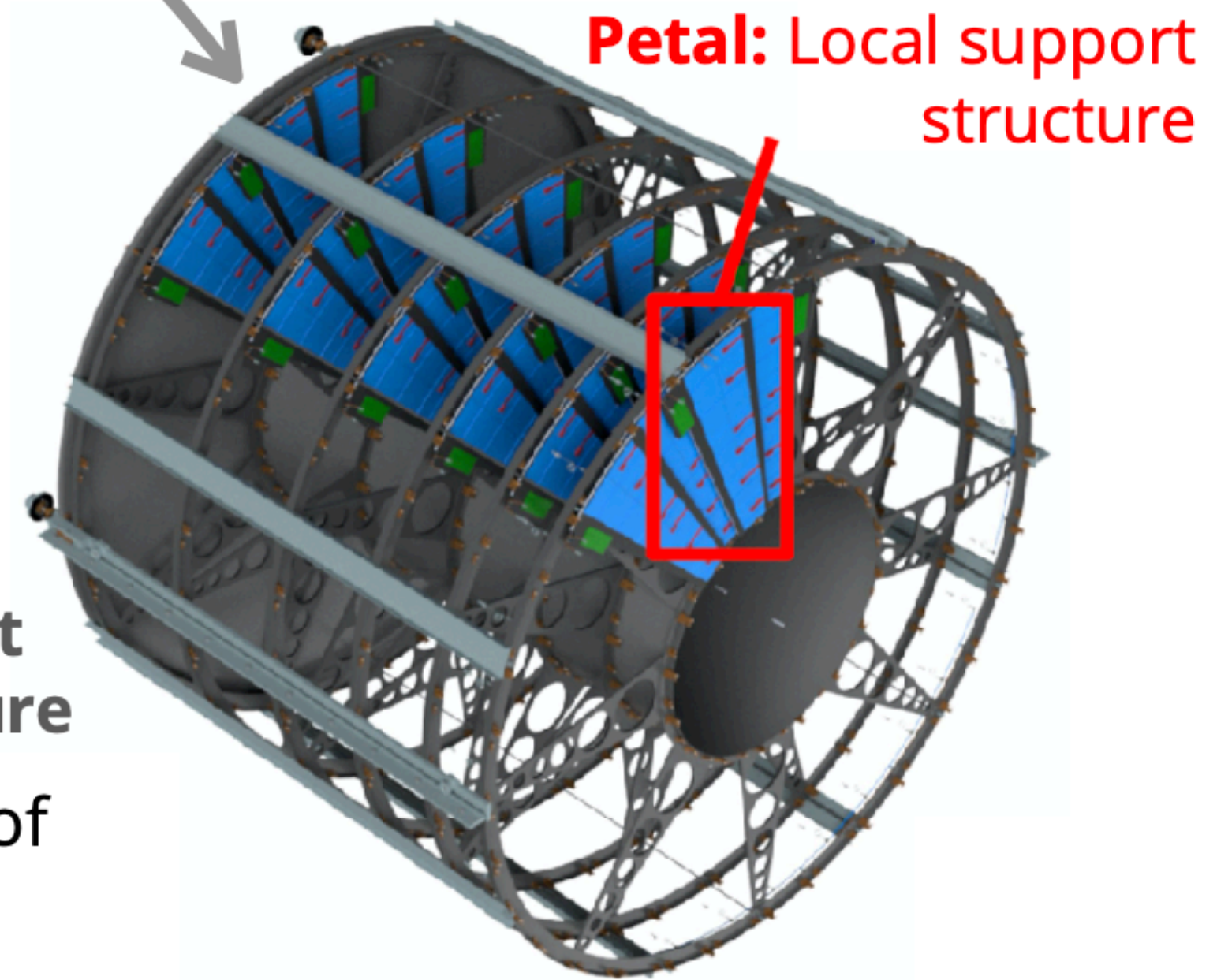
HL-LHC

RUN 1	LS1	RUN 2	LS2	RUN 3	LS3	RUN 4+
2011	2013	2015	2019	2022	2026	2029

Muon chambers

Data acquisition

High Granularity Timing Detector

ITK - Inner Tracker

ITK: ALL silicon Inner Tracker for HL–LHC

Now

ATLAS Inner Detector:
Pixel+SCT+TRT

HL-LHC **All-silicon Inner Tracker:**
Pixel+Strips
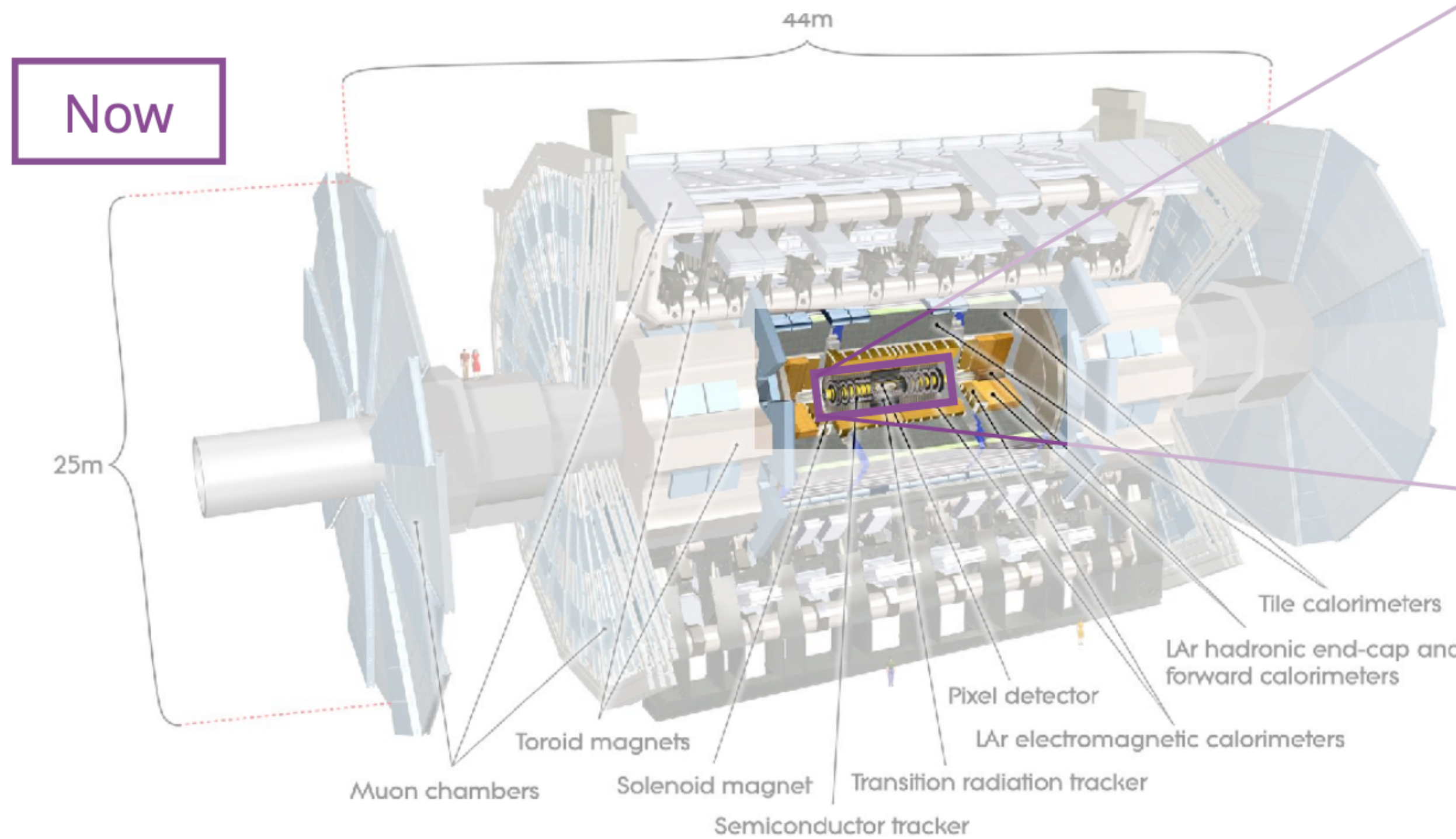
Design Goal:
provide same or better performance in
the harsher environment of the HL-LHC

Slide credit: Ashley McDougall

ITK strip detector

Module
Basic building block

Petal: Local support structure
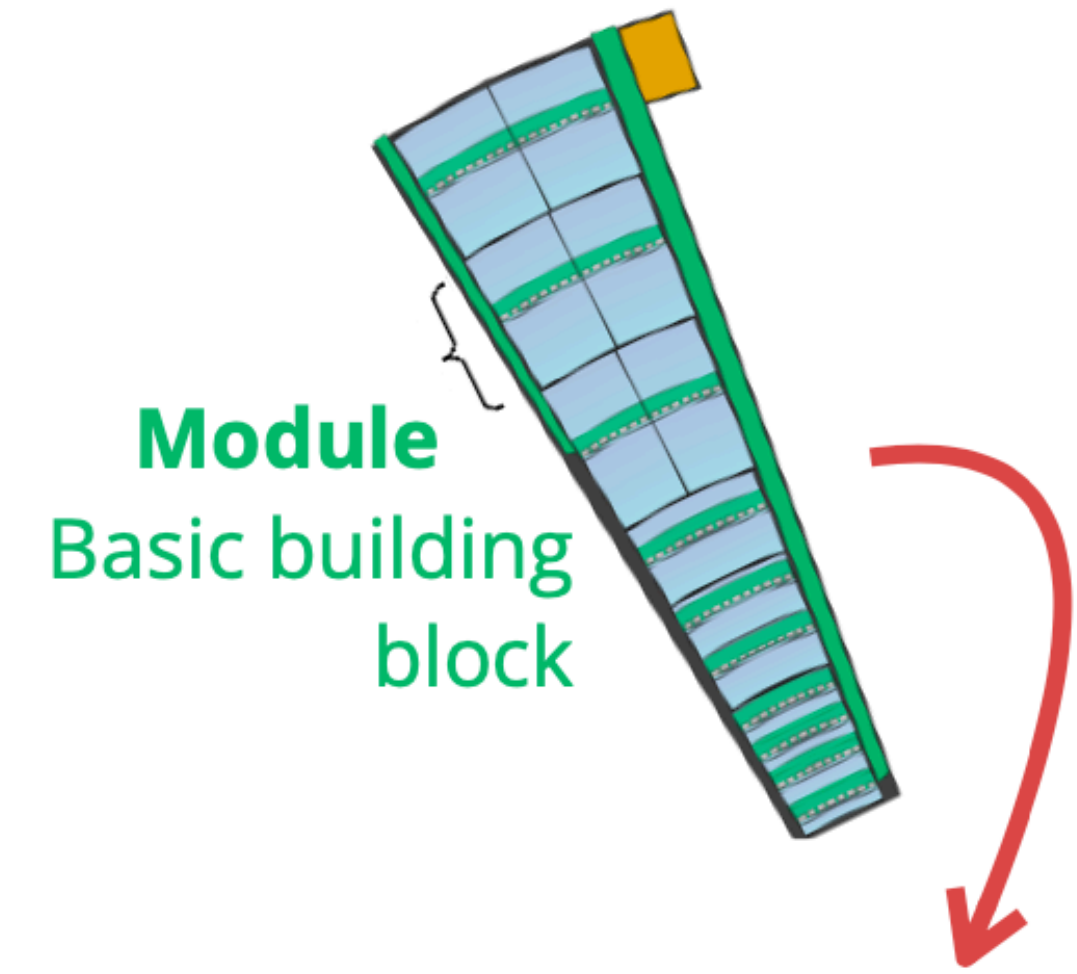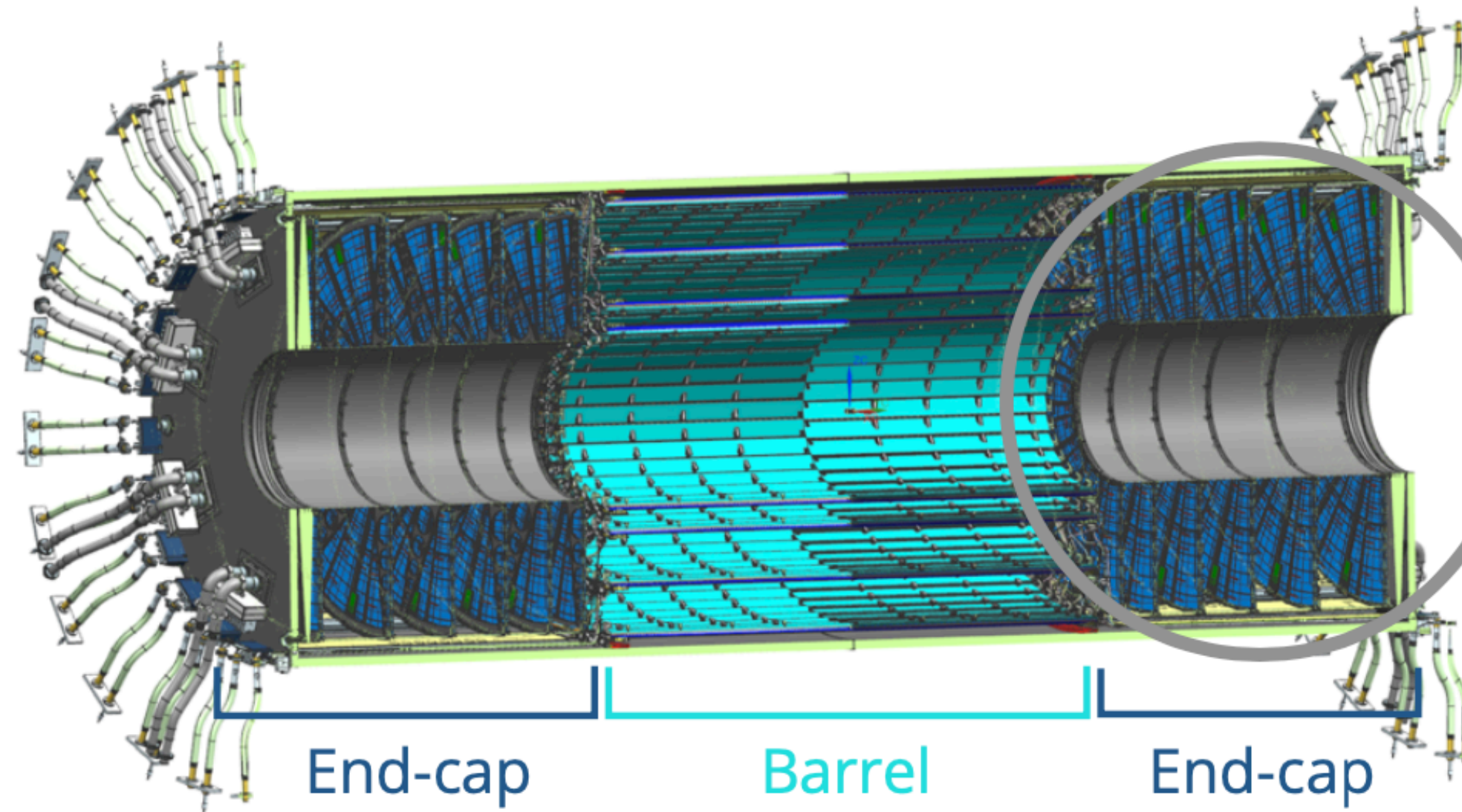
Global support structure

Responsible for full fabrication of **ITk strip EC global structure**.

End-cap   Barrel   End-cap

Slide credit: Ashley McDougall

End Cap: production of elements & start of assembly

NEW SINCE LAST JAMBOREE!

Attach Bulkhead & Services 2x, and Horizontal test 2x: DESY and Nikhef

2 xTransport CERN

CERN test and installation

Petal Insertion DESY + NIKHEF

PRR

Assembly 2x

Petal Reception
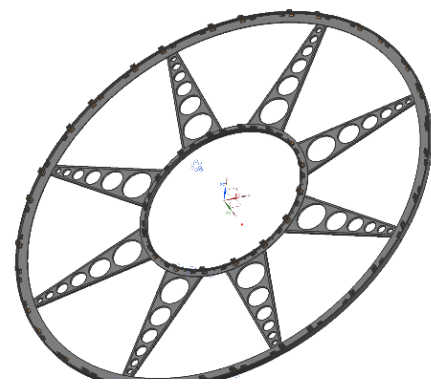
2020 2021 2022 2023 2024

Slide credit: Marcel Vreeswijk
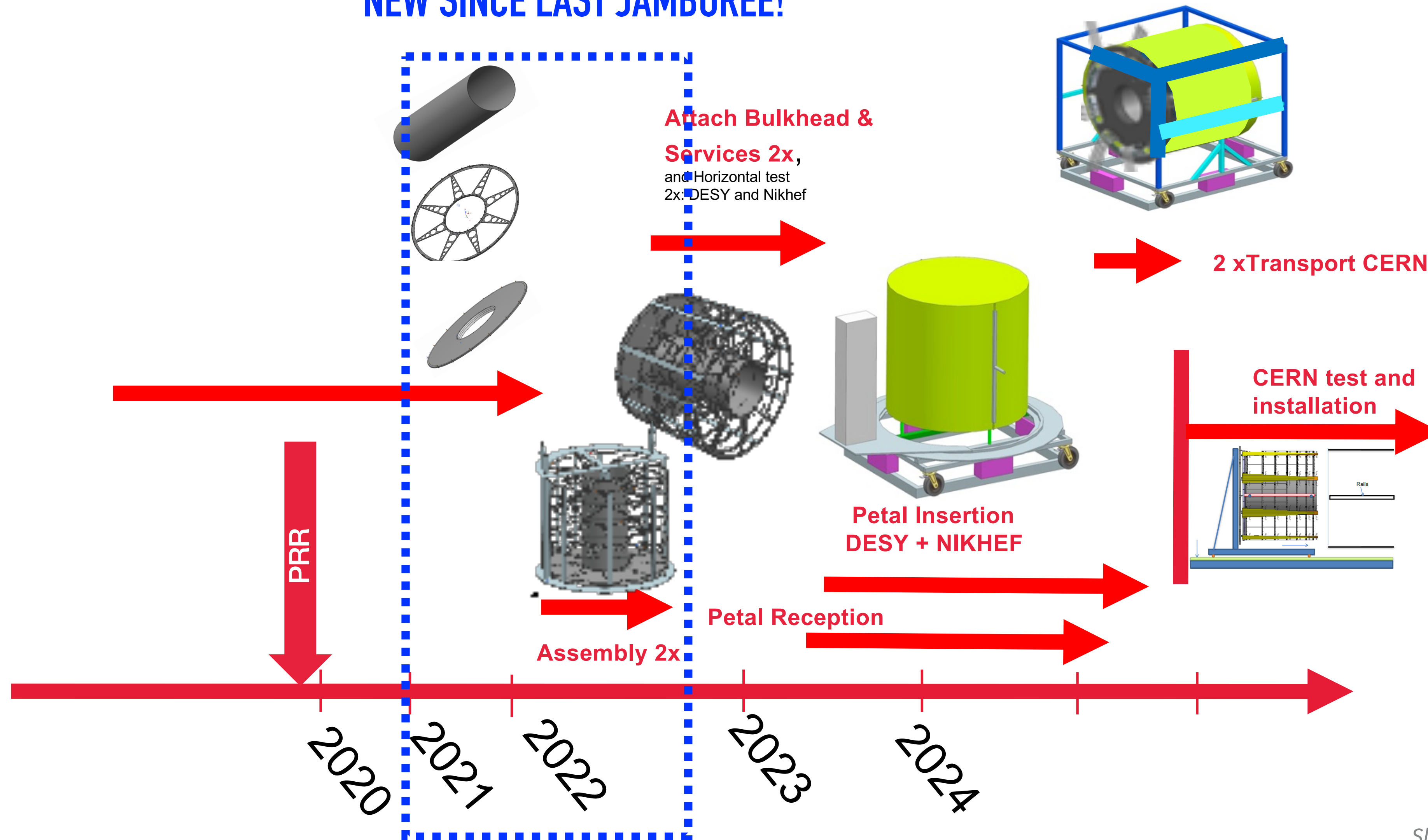
End Cap: basic structure elements production
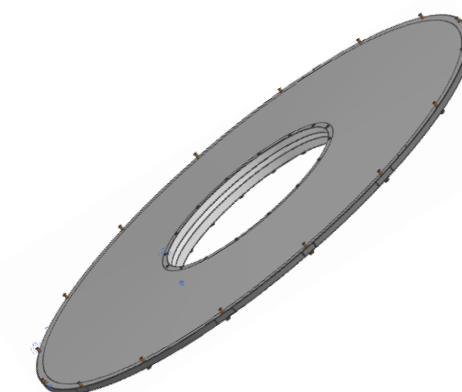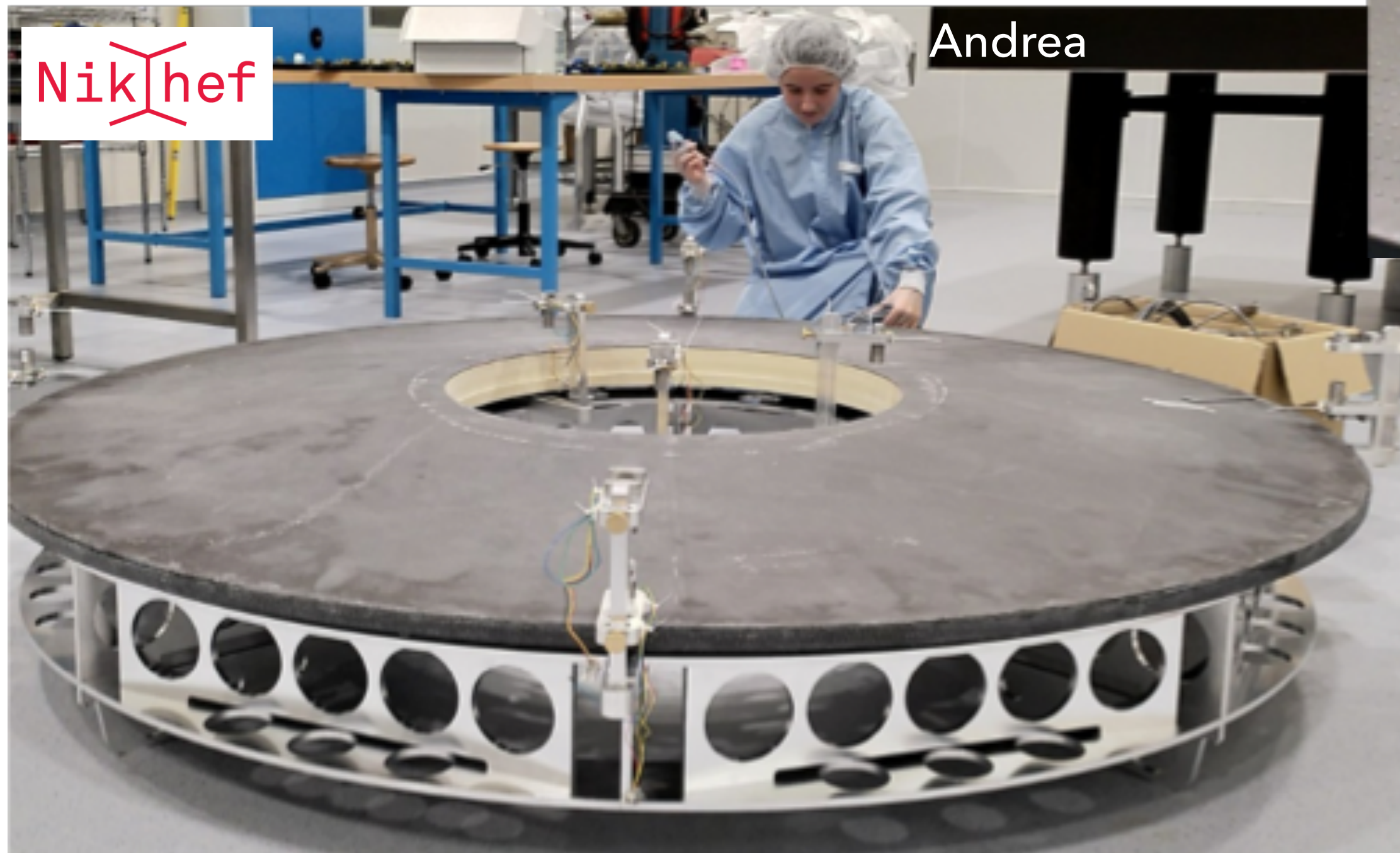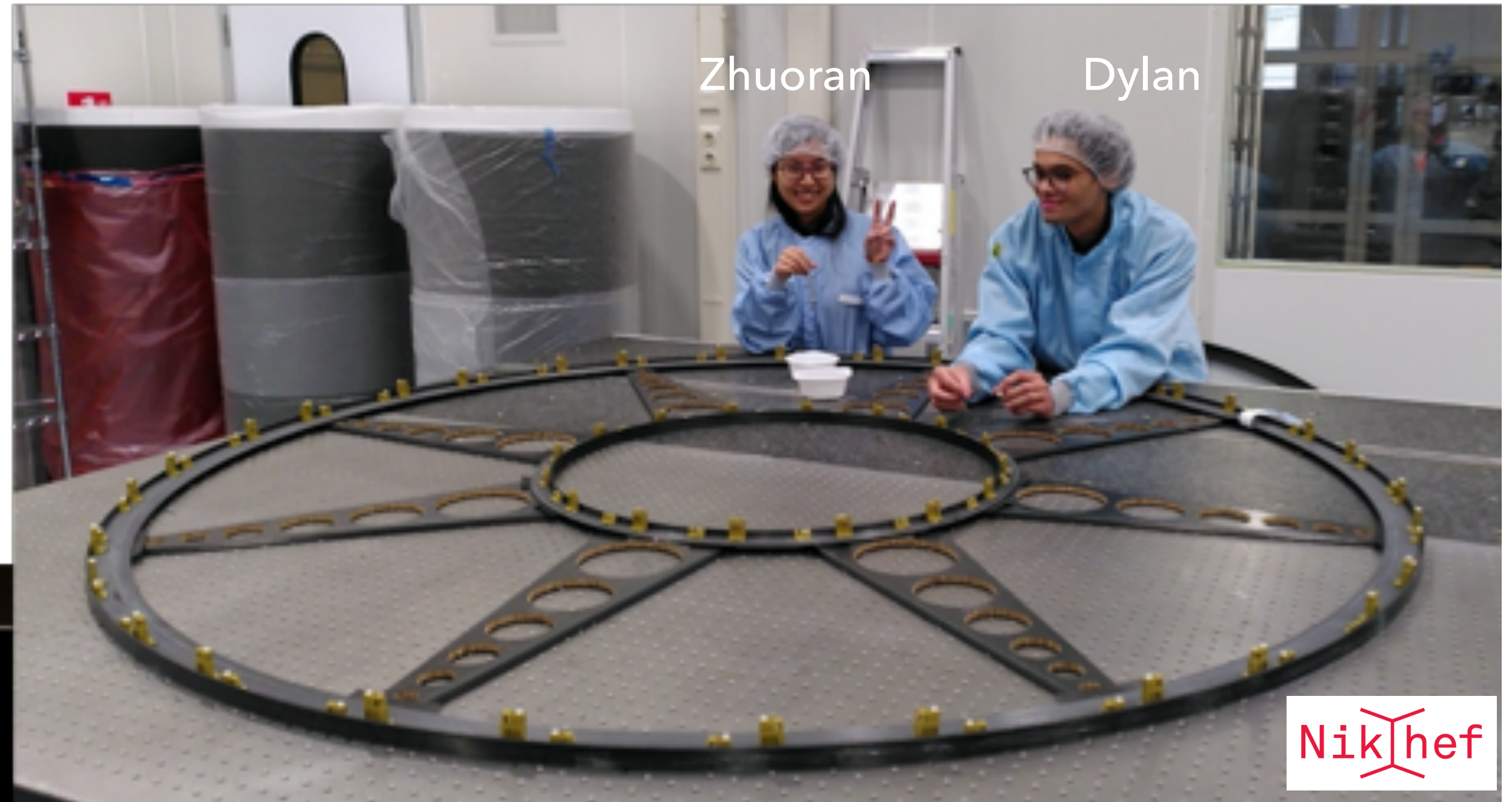
☑ 3 cylindric support structures done at Nikhef

☑ 14 support wheels done at Nikhef

☑ Quality Assurance/Quality Control measurements

Zhuoran   Dylan
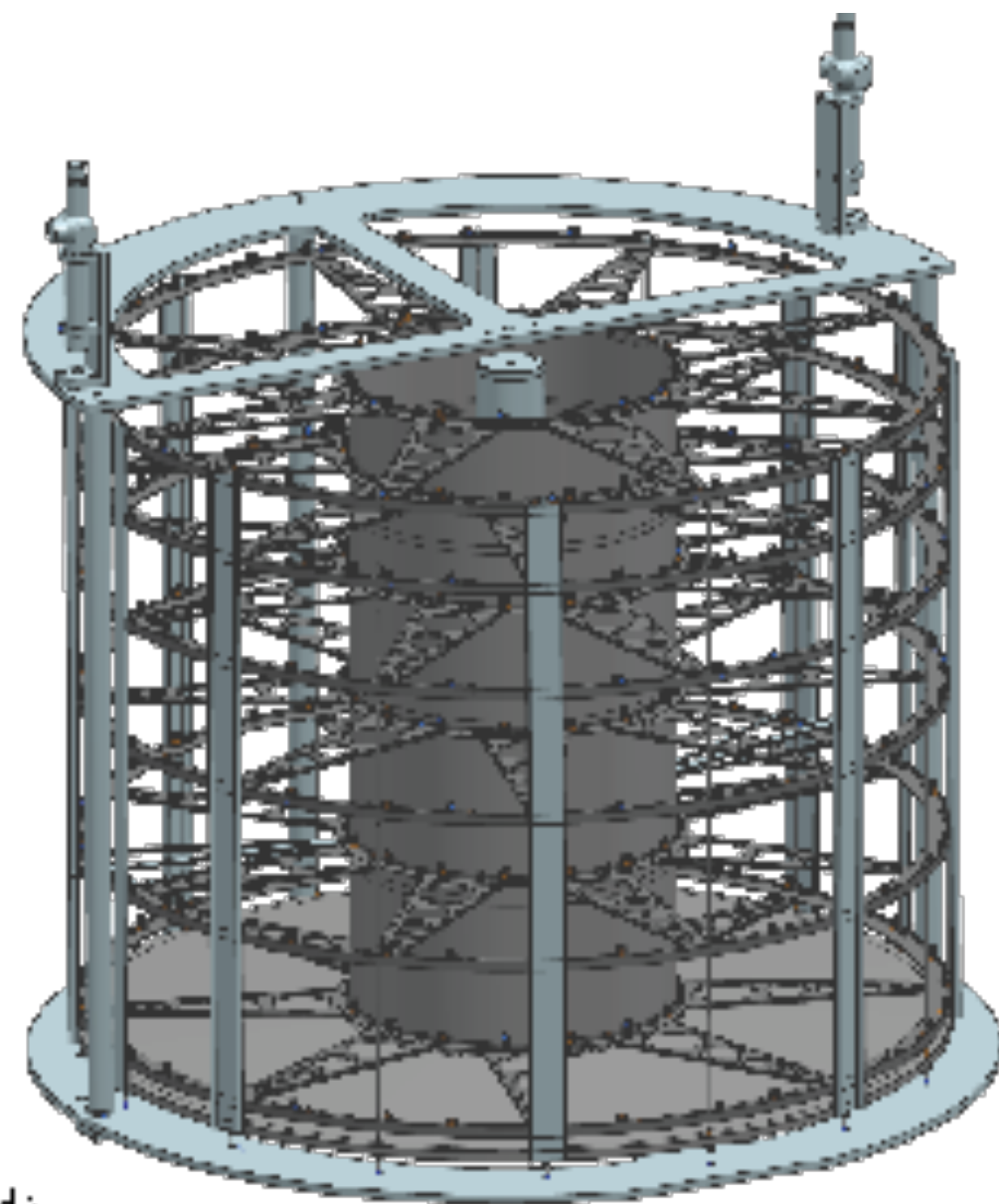
Andrea

☑ 3 Stiff disks produced at Nikhef

☑ Qualify Assurance/Quality Control measurements

Slide credit: Marcel Vreeswijk

End Cap: start assembly
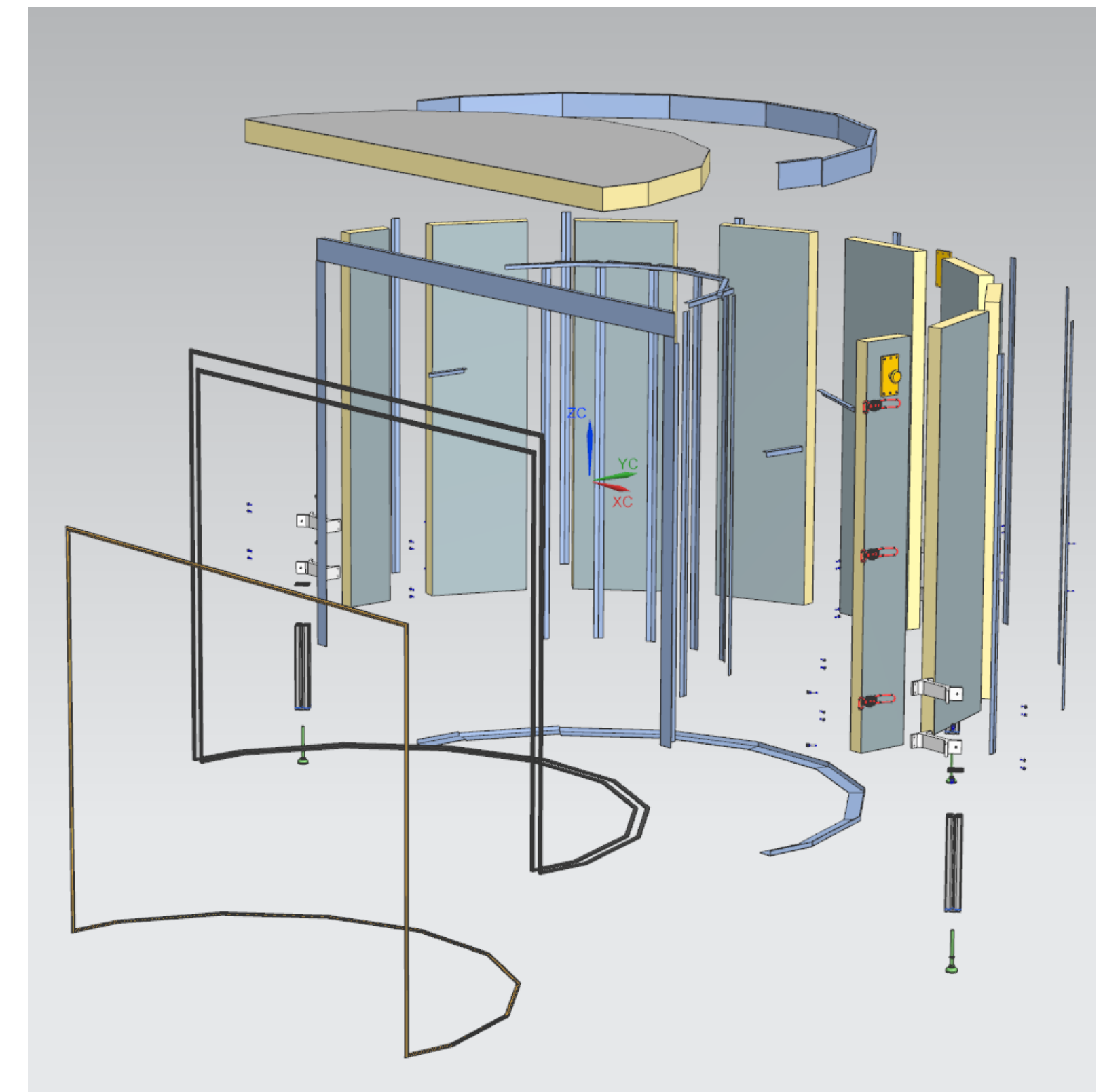
▸ Elements of End Cap (almost) all finished

▸ 2022 April: assembly starts

☑ Thermal box being designed by
Nikhef engineer Marko Kraan

Start with naked End Cap
with Cooling services added later in 2023

Slide credit: Marcel Vreeswijk

Nikhef ITK team

Slide resource: Marcel Vreeswijk

Physicists:

Engineers (Cooling):

Dylan van Arneman

Krista de Roo

Berend Munneke

Andrea Garcia Alonso

Marcel Vreeswijk
Project Lead

Jeff Templon
Scrum Master

Martijn van Overbeek
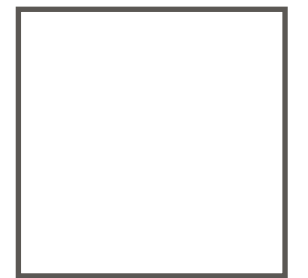
Engineers (Mechanical)

Lydia Brenner

Zhuoran Feng

Ivo van Vulpen

Technicians:

Rob Leguijt

Espen de Wit

Tommi Mikkola

Johan van den Berg

Hans Band

Auke Korporaal

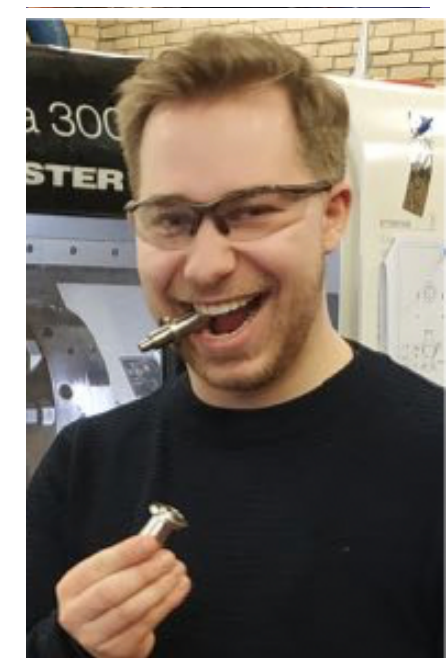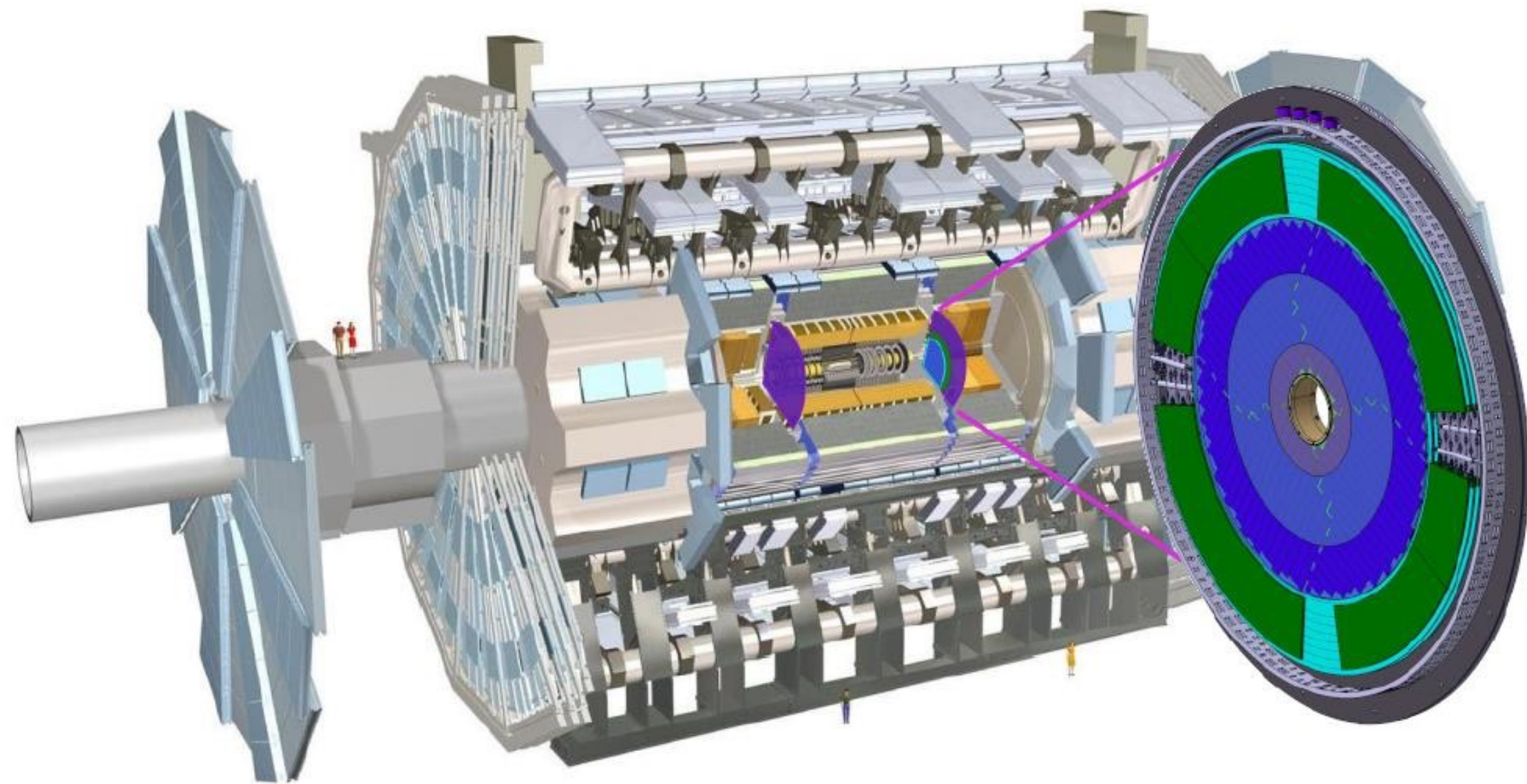Marco Kraan

Erno Roeland

Jelle van der Werff
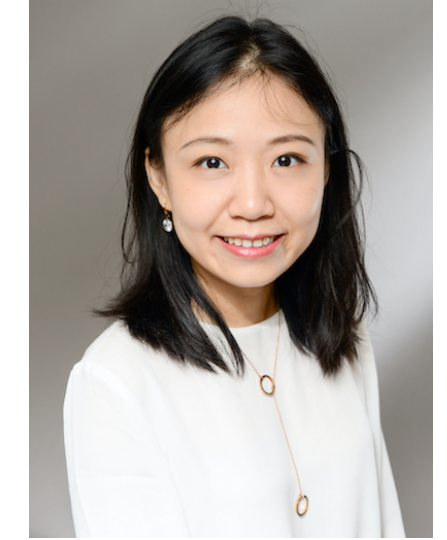
Maarten Lunenburg

High Granularity Timing Detector

▸ Bring up 4D information (tens of ps) to zoom in the single event picture:

  ▸ Features: Suppress pile-up, enhance forward region physics e.g. VBF Higgs

  ▸ Using an innovative LGAD sensor technology

▸ A new Nikhef project officially from Jan 2021

Frank Filthaut
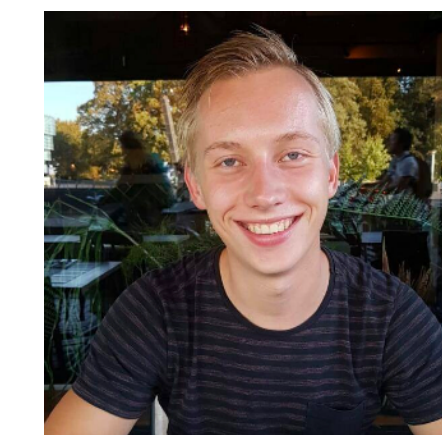
Hella Snoek

Mengqing Wu

Martin van Beuzekom

Marion Missio

Andrea Visibile

Francisco Javier Rosas Torres

Daniel Szalas-Motesiczky

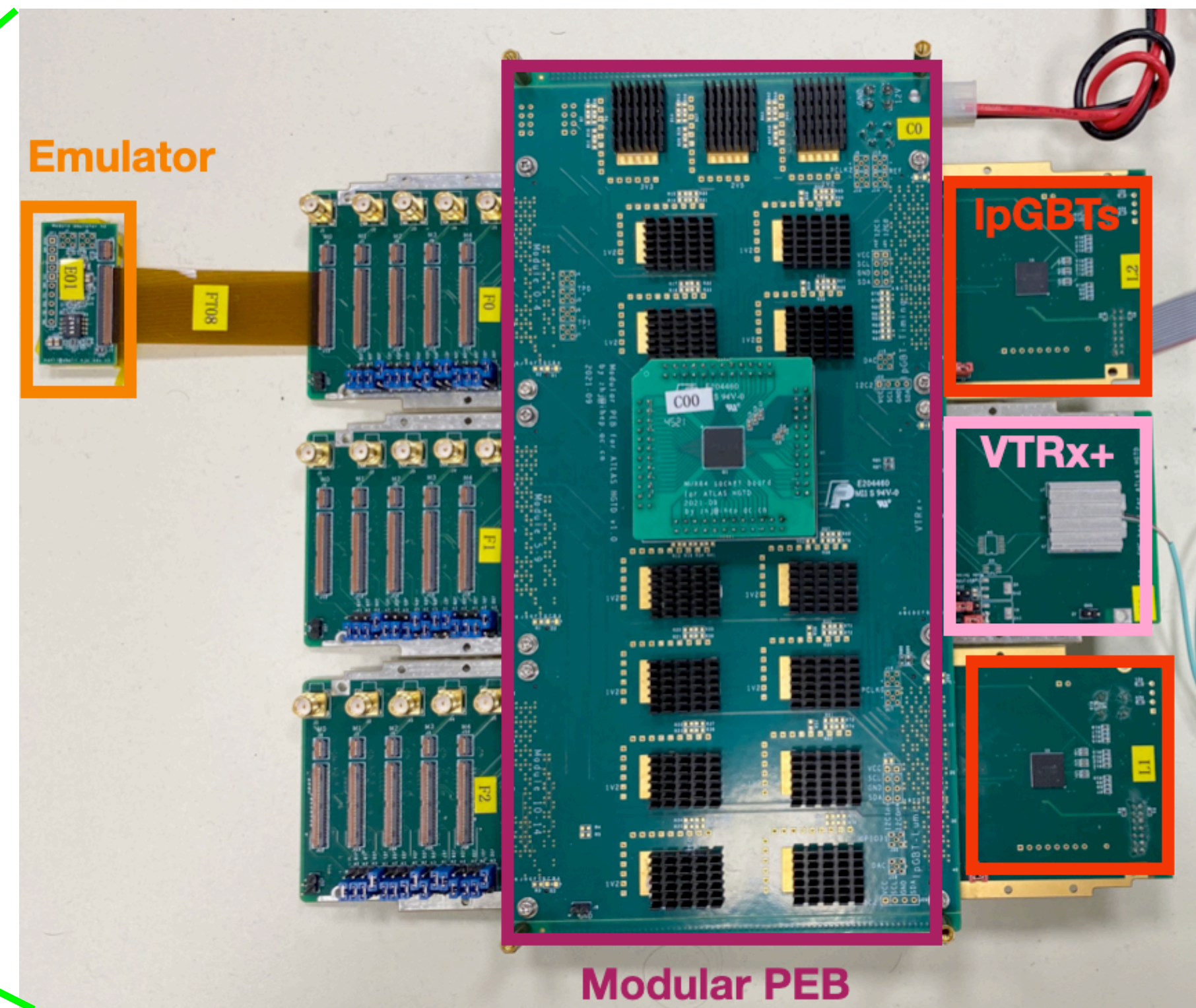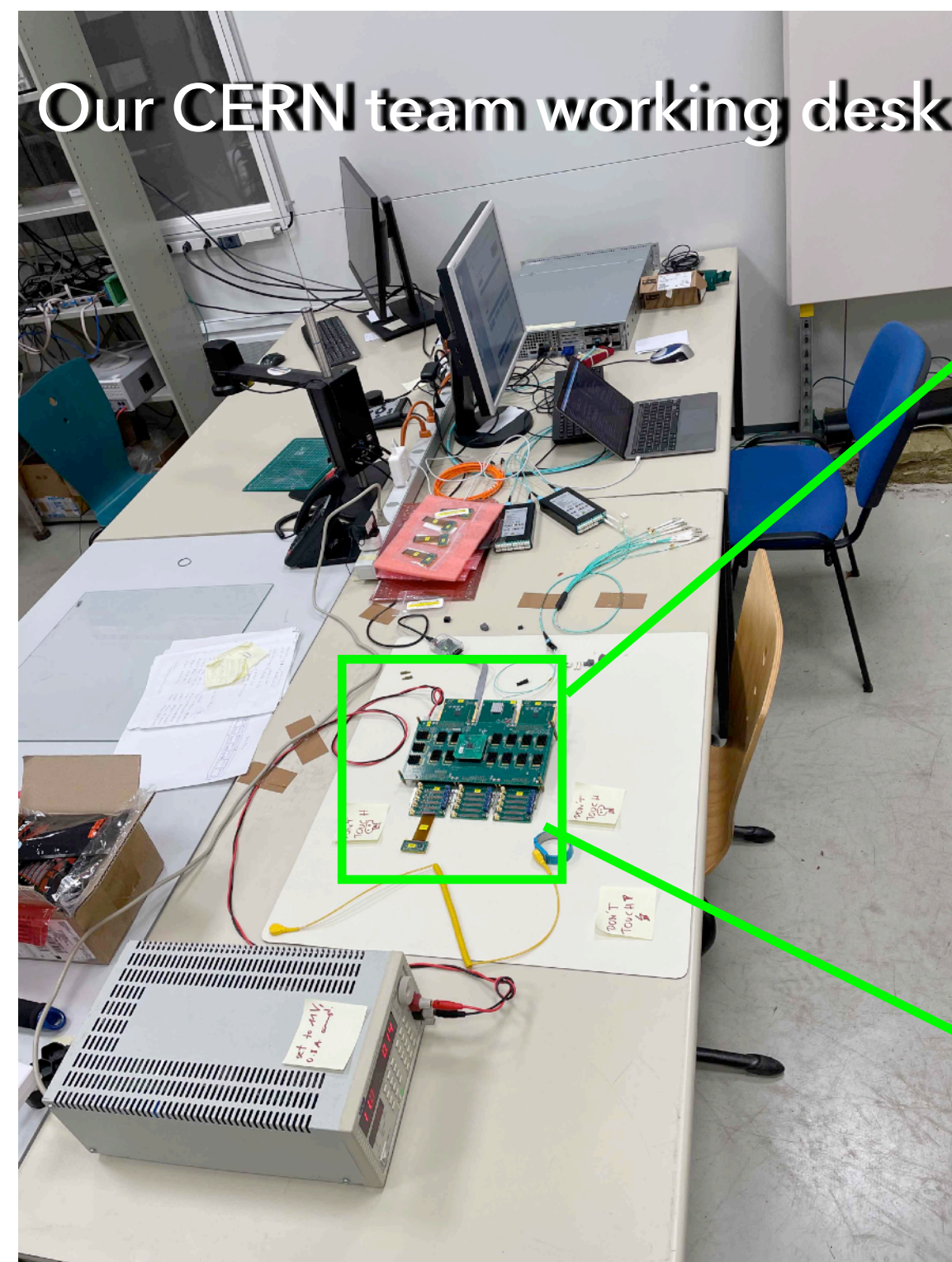**Bart van der Linden**
Feb - Jun 2021

Susanne Auwens

Hannah Arnold

Leading the DAQ development

▸ Coordinating the Luminosity, DAQ and monitoring business in HGTD – Mengqing

▸ Nikhef responsible for the DAQ software development

▸ Gear the DAQ demonstrator activities at CERN - Marion, Francisco, Hannah
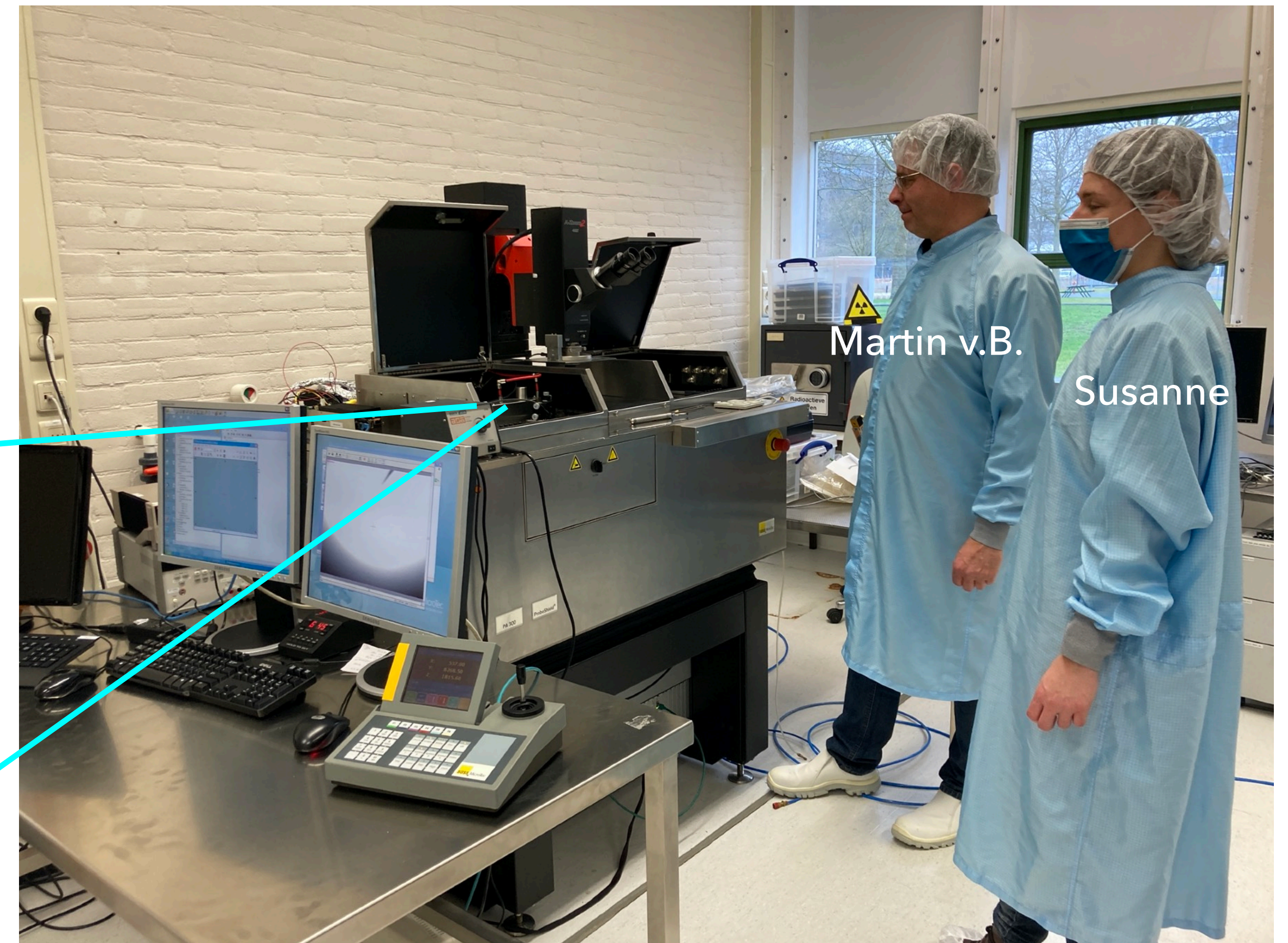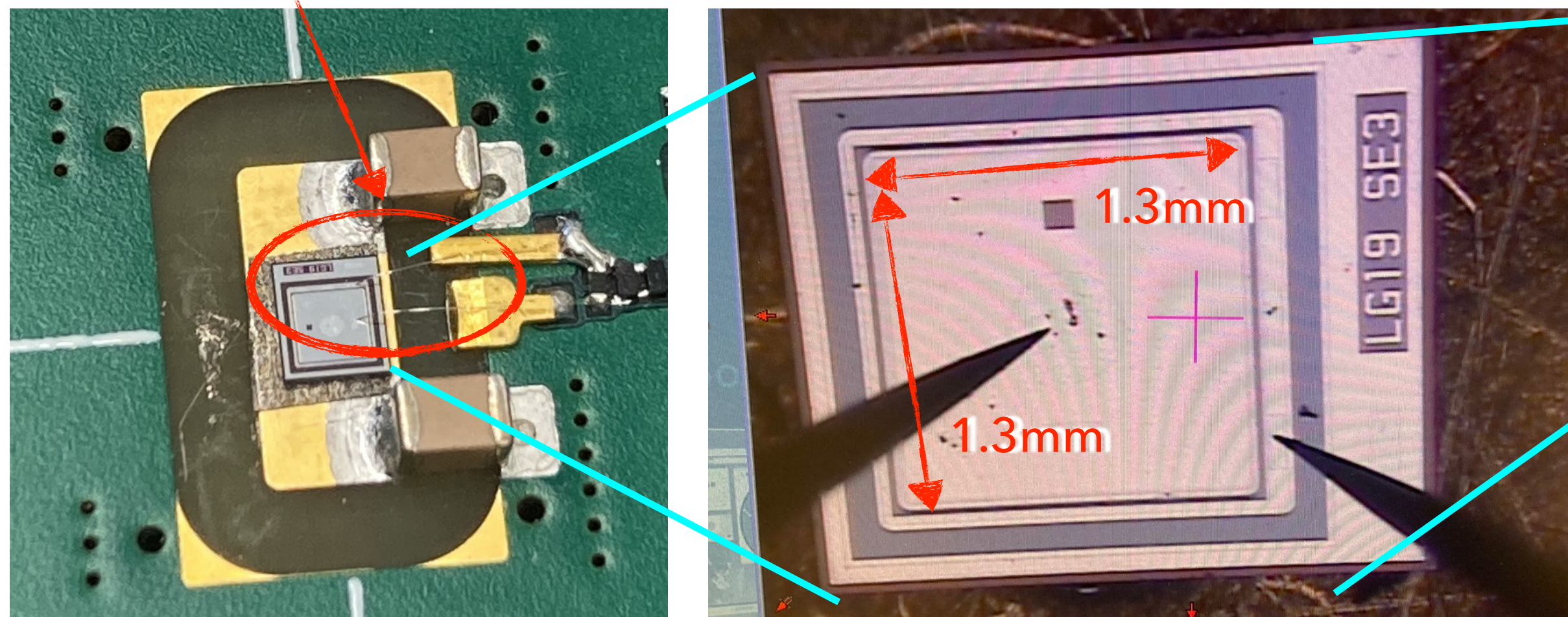
  ▸ Special thanks to strong support from our local TDAQ team

Ramping up in sensor business

▸ LGAD simulation with Allpix2 framework at Nikhef - Andrea

▸ Sensor characterisation at Nikhef - a lot support from Martin v.B and Daniel

Nikhef In-house Wire-bonding

1.3mm

1.3mm

LG19 SE3

Martin v.B.

Susanne

Summary & Outlook

▸ Strong Nikhef contributions to the ATLAS upgrade towards LHC Run 3: Muon and TDAQ

　▸ first splash event on 22 April 2022, efforts paid off

▸ Nikhef contributions move forward to the ATLAS upgrade towards HL-LHC that is planned to start from 2029

　▸ Nikhef joined one new upgrade project last year: pico-second timing detector

　▸ Synergies across the four upgrade projects

　▸ Looking forward to the next milestones!