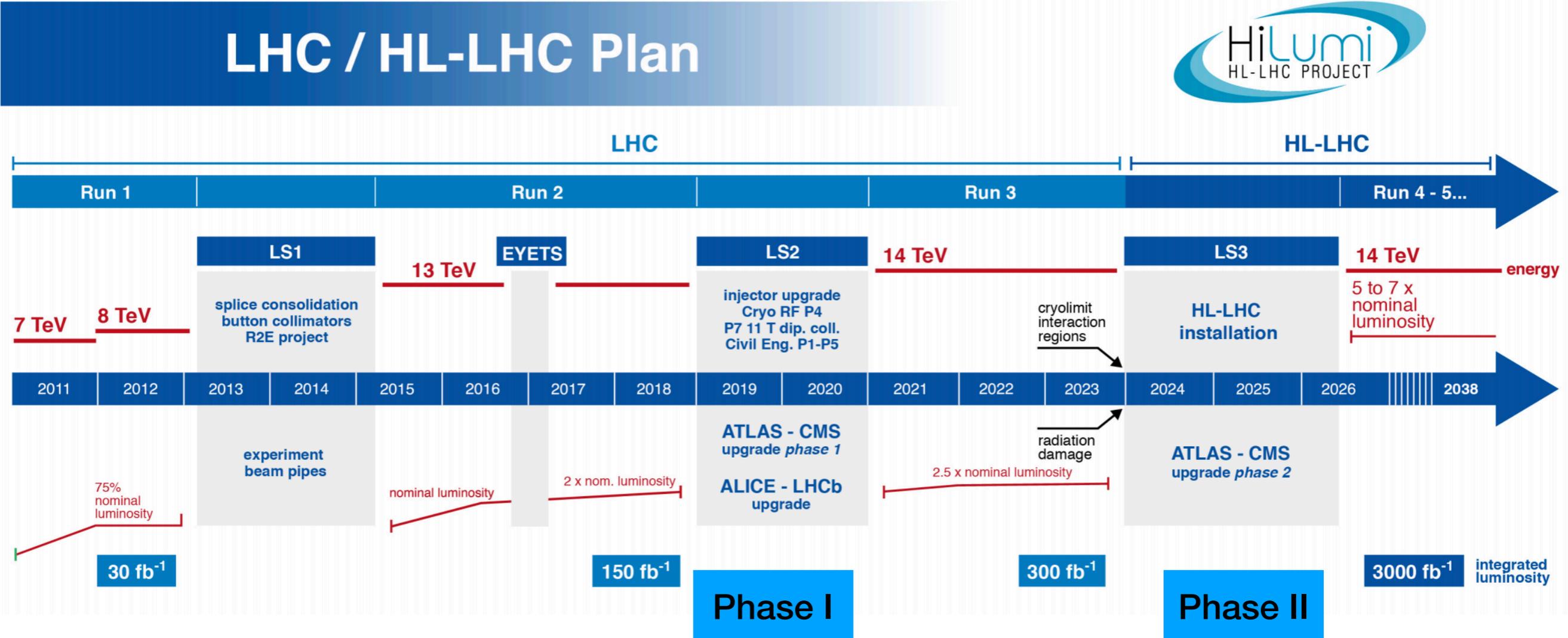


# Israel HEP-EX at the HL-LHC

Enrique Kajomovitz

Town Hall meeting for the European Strategy for Particle Physics  
WIS 5 Dec 2018

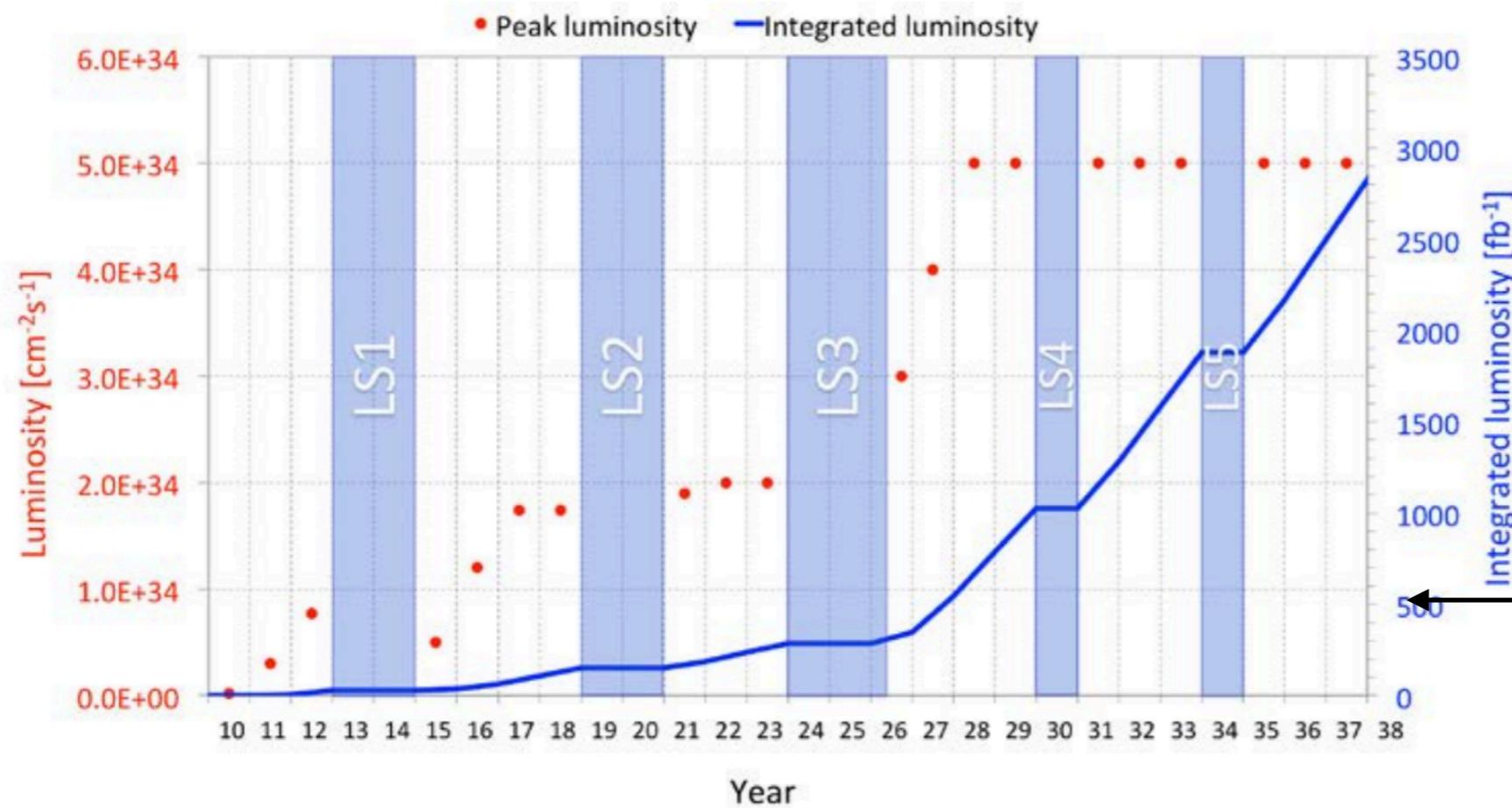
# The road to the HL-LHC



**Timeframe of the strategy document**

# The High Luminosity LHC

- The High Luminosity LHC targets an integrated luminosity  $>3000/\text{fb}$ , a factor of 10 or higher than the one expected at the end of Run-3 (2023)
  - In Run-4 (2026): the instantaneous luminosity will increase to  $L=5 \times 10^{34} \text{cm}^{-2}\text{s}^{-1}$ , and may ultimately reach  $L=7.5 \times 10^{34} \text{cm}^{-2}\text{s}^{-1}$
  - The average number of interactions per bunch-crossing may reach 200



Nominal LHC

# Measurements and searches

Main aim - BSM

Rapidly closing window on many BSM models. Focus on exploring new theoretical ideas that have not been excluded yet;

- Precise measurements that will focus on discrepancies from the SM as a signal for new Physics
  - Example: Lepton flavor violation
- Higgs portal
  - Example: Higgs to charm
- BSM searches with linear increase in sensitivity (background free searches)
  - Example: Long lived particles
- BSM searches that were not sensitive at low luminosity but will become so with increasing quantities of data at high luminosity
  - Example: New muon forces
- Developing new experimental and analysis techniques
  - Example: Long lived particles, data focused paradigm, trigger level analysis, new 'rich-sub-structure' taggers

# HL-LHC experiments

- Luminosity increase to the HL-LHC will requires a major upgrade of the experiments
- Phase-I that takes place during LS2 (now) before Run 3
- Phase-II planned during LS3 (2023-2026)

# ATLAS-IL

- General Purpose experiment allows us to pursue our very diverse interests
  - SM, Higgs, B-Physics, SUSY, Exotics, Heavy Ion



We make up ~1.6% of the ATLAS collaboration

- Since 1995
  - Significant contributions to many areas of the experiment, particularly centred around the Muon Spectrometer End-Cap trigger - TGC (Giora)



- Phase-I upgrade of the New Small Wheel
  - Main contributors: Detectors, Electronics Analog and Digital, Integration / comisioning / installation, simulation, reconstruction
- Committed to the Phase-II upgrade of the experiment (this talk)



- Our proposal and current activities were reviewed in the summer (Chaired by E. Elsen <https://indico.cern.ch/event/751074/> )

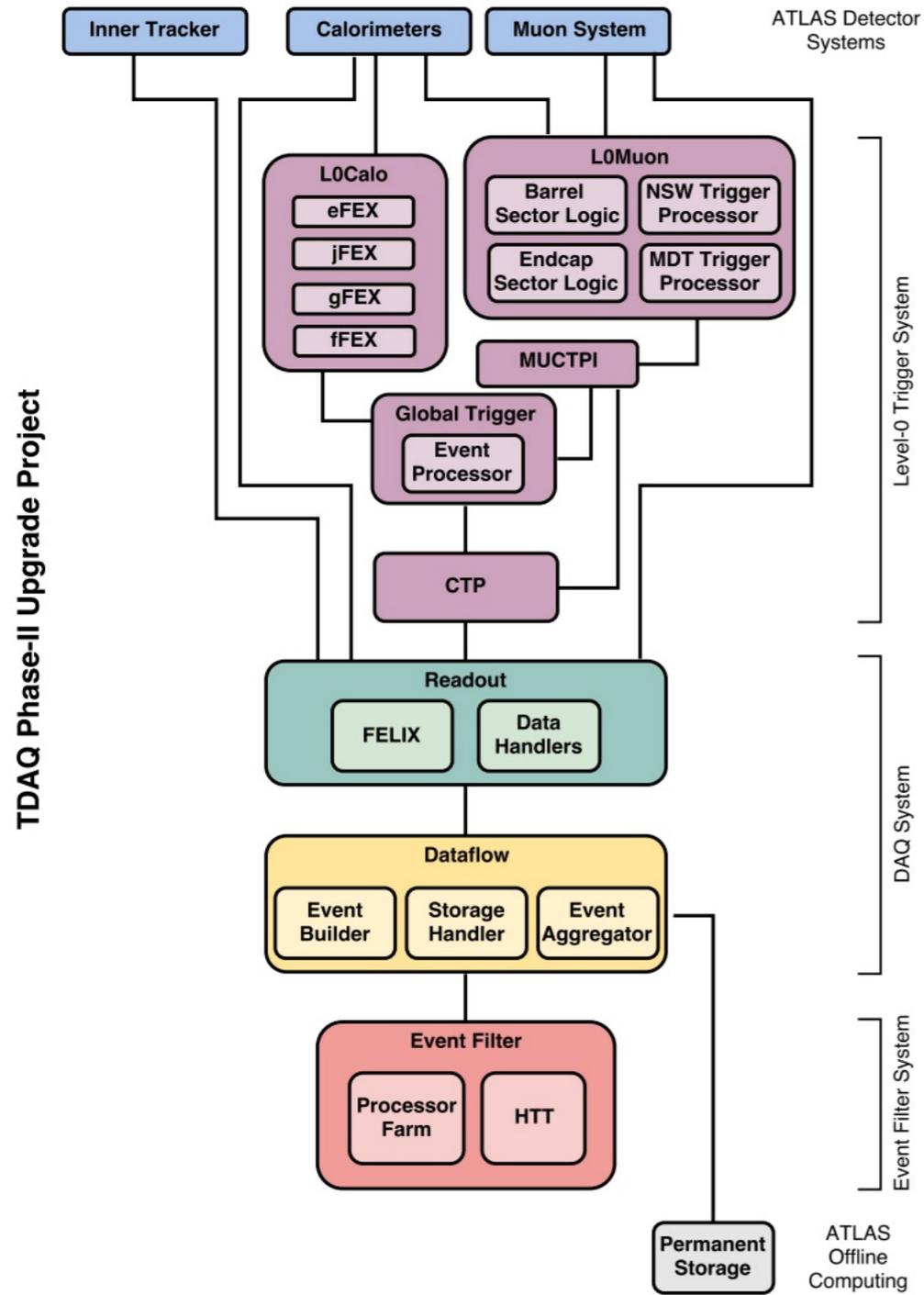
# Guiding principles

- Physics
  - Aligned with ATLAS physics goals and approved upgrade projects
  - Aligned with the group's physics interests
- Strategy
  - Rely on the group expertise to guarantee significant and visible contribution
  - Transfer important knowledge from the experts to the young generation
  - Develop new fronts identified as important in the future of HEP
- Organization
  - National project - sharing of responsibilities
  - Build and support the leadership of the younger generation
- Budget
  - Complete our CORE contribution to ATLAS
    - We have to contribute our fair share (1.6%) to the upgrade of the experiment
  - Sufficient to ensure significant contribution to ATLAS

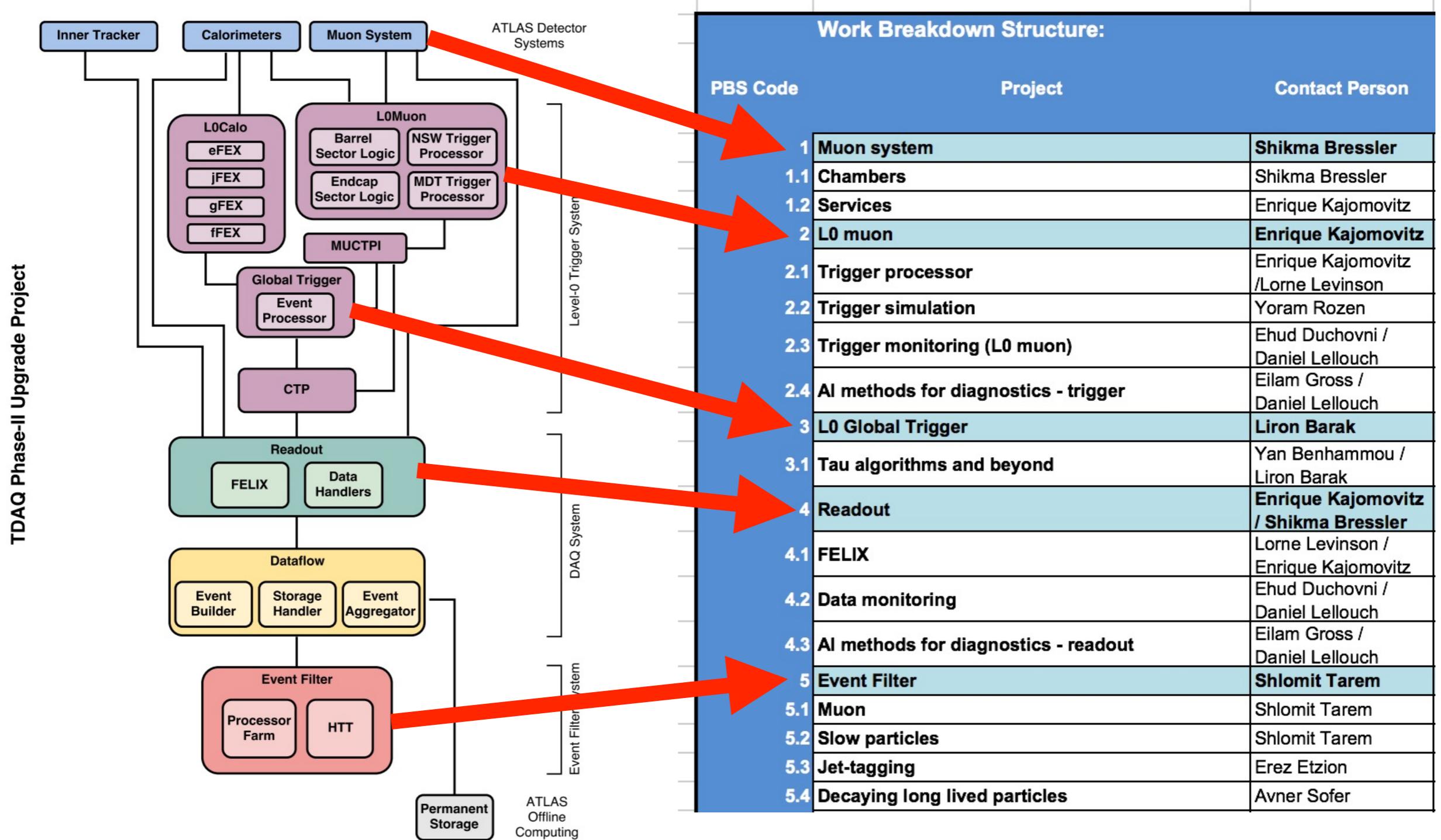
# ATLAS Phase-II upgrade program

- The overall strategy of the Phase-II upgrade is outlined in the ATLAS Phase-II scoping document
- ATLAS-IL proposes to contribute in two main areas of the upgrade program
  - **Muon Spectrometer**: Main focus is the muon trigger.
    - New RPC detectors in the barrel
    - **Upgrade the TGC in the EIL4 region**
    - Level-0 Electronics for TGC and RPC
    - MDT readout
  - **High-Granularity timing detector**
  - **TDAQ: New architecture**
    - Single hardware level trigger (Rate 1MHz, Latency 10 $\mu$ s)
    - Readout system based on FELIX (Front End Link eXchange)
    - EF system (Rate 10 KHz to permanent storage)

# ATLAS Data Flow $\Rightarrow$ Proposed Plan



# Our plan

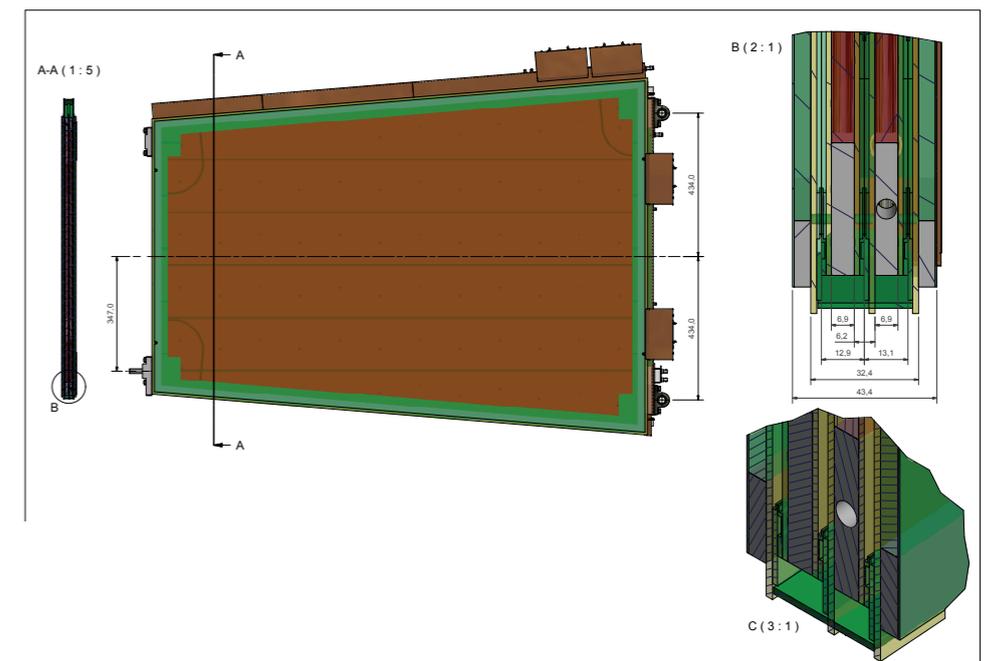
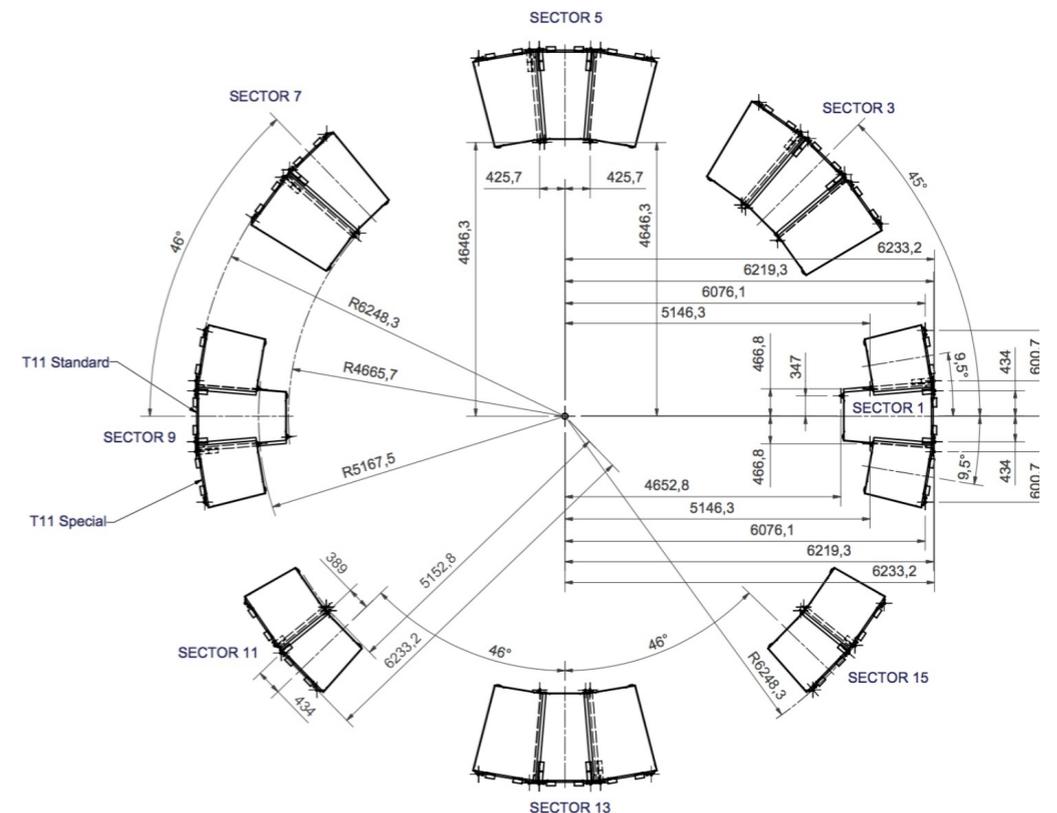


# Upgrade of the EIL4 chambers

Strategy: Maintain our leadership in the muon system.

Expertise in detectors, minimal investment in infrastructure - make use of facilities

- In Run-4 with the current granularity - the EIL4 will issue a trigger 22% of the event  $\Rightarrow$  low rejection power
- Upgrade to Triplets
  - Allow 2 out of 3 logic
  - Robust  $\Rightarrow$  Rejection power remains high even if a layer is lost
- Finer granularity
  - Smaller RoI
- Trigger & Readout
  - Reuse ASD boards + spare AS

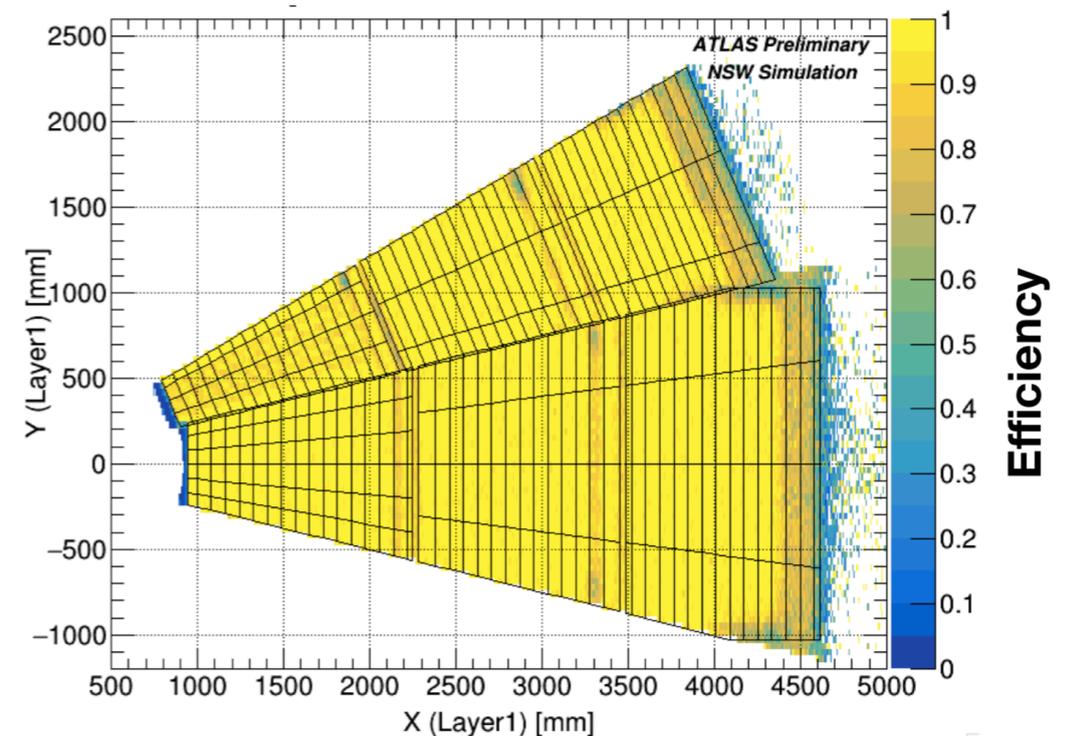


# L0 firmware

- Strategy: HEP-EX community moves increasingly in this direction, NSW (our technologies) necessary for analyses we are interested
- Trigger processor for the NSW
  - A main goal of the NSW is to reduce fake muon triggers, the trigger processor provides the input to sector logic (hardware level trigger)
  - Improvements in technology and allowed latency - The new version will include MM and sTGC and provide better precision, coverage, robustness
- Global L0
  - The new Global Trigger will make available high granularity information from the calorimeters for Level-0 triggering
  - Offline algorithms - like tau lepton id, jet finding can be implemented at L0

# Simulation

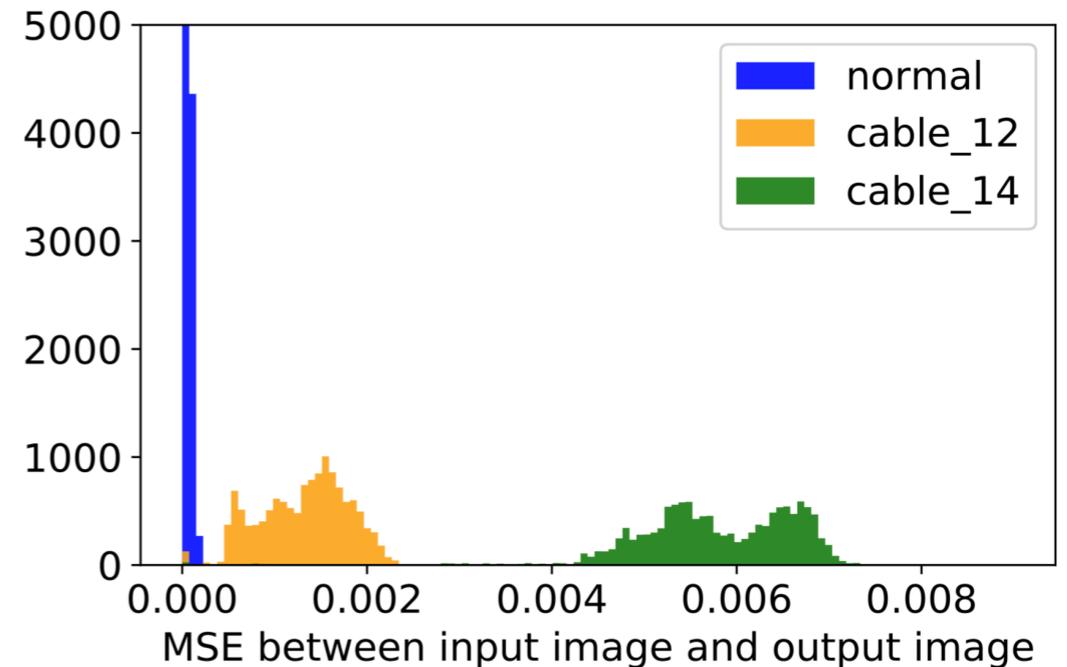
- Strategy: ‘Our’ hardware, necessary effort for analyses, important to optimize configuration/firmware
- Simulation is essential for Physics Analysis, but not only, it is also necessary for the optimization / debugging of the hardware
- We are lead the simulation of the NSW sTGC trigger, plan is to expand our activity to include the systems to be upgraded and the rest of the Muon Spectrometer



# Monitoring and advanced monitoring

- Strategy: 'Our' hardware, necessary for the experiment, may be revolutionary
  - Online monitoring: Objective is to find and diagnose the weak links in the sTGC system in real time
    - Real detector experts are needed for this
  - Advanced monitoring: AI
    - Discover difficult cases in real time, promising new results (for example for a flip case) - this may revolutionize how we do monitoring at our experiments

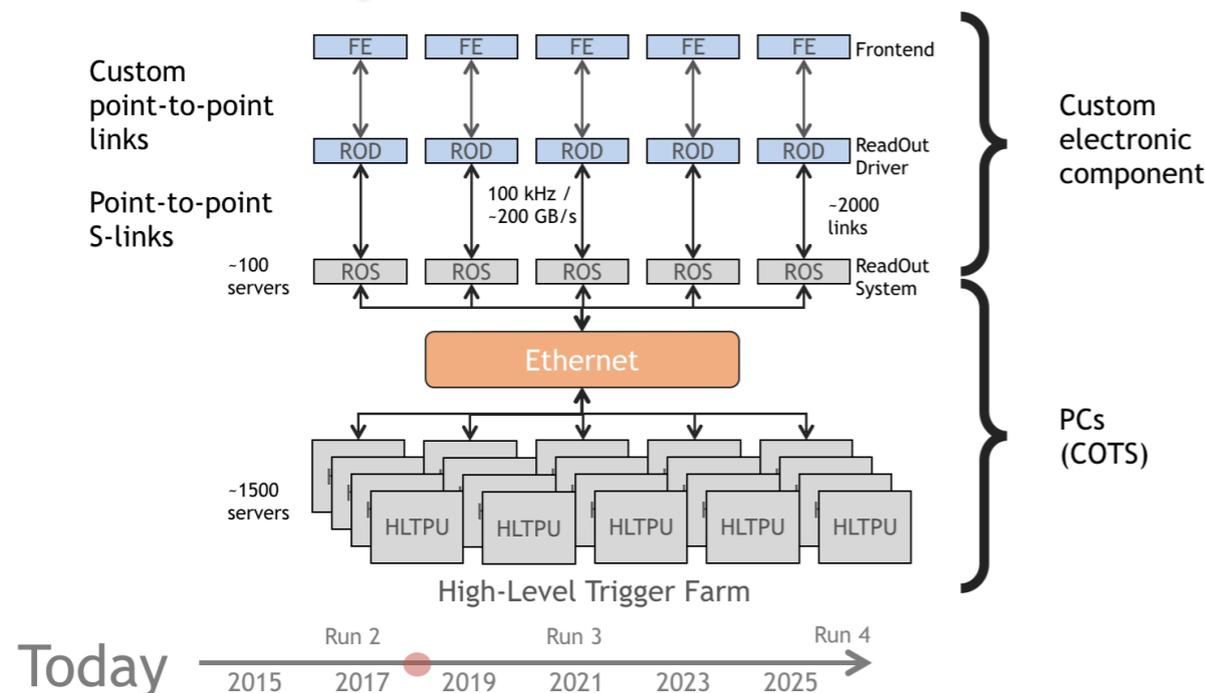
## Swap Cabling 14



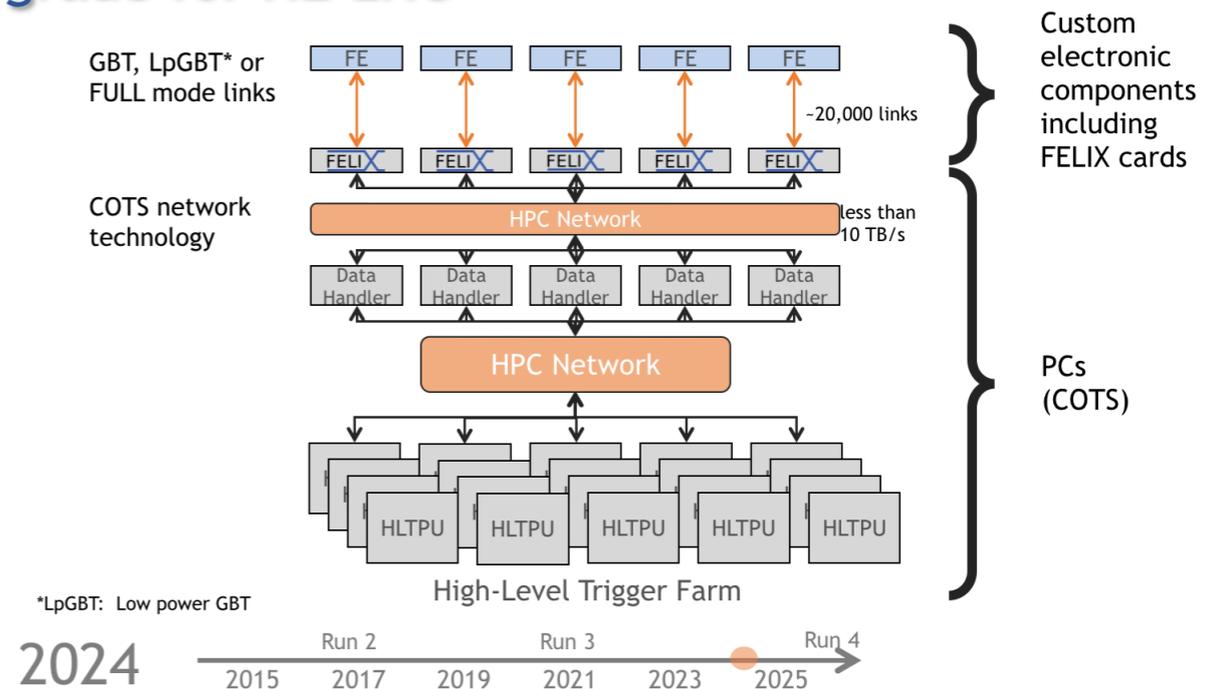
# FELIX

- Strategy: HEP-EX community moves increasingly in this direction, concept born within our community (LL). critical for the experiment
  - Felix is the new readout architecture for ATLAS
    - In Phase-I will be used for NSW and LAr, for phase 2 it will be used for the whole of ATLAS
  - The basic idea is to aggregate custom links from / to the FE electronics to a standard network
    - The project originated in Israel (Lorne Levinson), and is being adopted for the whole of ATLAS and beyond (proto Dune)

## ATLAS DAQ Today



## Upgrade for HL-LHC



# Event Filter

- Strategy: Maintain/Increase expertise, close to the analyses that interest us, lots of flexibility on what can be done, and also essential for the experiment
  - Include upgraded detectors and take advantage of more precise information
    - Essential to ATLAS: Muon EF
  - Essential not to miss the possible signals BSM
    - Slow particles, Long Lived particles, Trigger level analysis

# Summary

- Within ATLAS upgrade framework
- Rely on our expertise, strong collaboration between groups, and vision for the future
  - Main focus on the Muon Spectrometer Trigger and DAQ system
    - Areas where we can make a significant impact
    - New ideas that can potentially make a big impact on the experiment operations
  - Beyond the Muon Spectrometer
    - Upgrades that are necessary to reach sensitivity to particular physics that otherwise would be missed
    - Build expertise in areas we see as crucial now and in future experiments
  - Fulfills our CORE commitments to the ATLAS upgrades
  - Strengthens the collaboration between institutes and across generations