Israel HEP-EX
at the
HL-LHC

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Town Hall meeting for the European Strategy for Particle Physics
WIS 5 Dec 2018
The road to the HL-LHC

LHC / HL-LHC Plan

Timeframe of the strategy document
The High Luminosity LHC

- The High Luminosity LHC targets an integrated luminosity $>3000$/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 $L=5\times10^{34}\text{cm}^{-2}\text{s}^{-1}$, and may ultimately reach $L=7.5\times10^{34}\text{cm}^{-2}\text{s}^{-1}$.
- The average number of interactions per bunch-crossing may reach 200.
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 require 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 / commissioning / 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 10µs)
    - Readout system based on FELIX (Front End LInk eXchange)
    - EF system (Rate 10 KHz to permanent storage)
ATLAS Data Flow ⇒ Proposed Plan
Our plan

**Work Breakdown Structure:**

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<th>Project</th>
<th>Contact Person</th>
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<td>Muon system</td>
<td>Shikma Bressler</td>
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<tr>
<td>1.1</td>
<td>Chambers</td>
<td>Shikma Bressler</td>
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<tr>
<td>1.2</td>
<td>Services</td>
<td>Enrique Kajomovitz</td>
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<tr>
<td>2</td>
<td>L0 muon</td>
<td>Enrique Kajomovitz</td>
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<tr>
<td>2.1</td>
<td>Trigger processor</td>
<td>Enrique Kajomovitz</td>
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<tr>
<td>2.2</td>
<td>Trigger simulation</td>
<td>Yoram Rozen</td>
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<td>2.3</td>
<td>Trigger monitoring (L0 muon)</td>
<td>Ehud Duchovni / Daniel Lellouch</td>
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<td>2.4</td>
<td>AI methods for diagnostics - trigger</td>
<td>Elam Gross / Daniel Lellouch</td>
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<td>3</td>
<td>L0 Global Trigger</td>
<td>Liron Barak</td>
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<td>3.1</td>
<td>Tau algorithms and beyond</td>
<td>Yan Benhammou / Liron Barak</td>
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<td>Readout</td>
<td>Enrique Kajomovitz</td>
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<td>4.1</td>
<td>FELIX</td>
<td>Lorne Levinson / Enrique Kajomovitz</td>
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<td>Data monitoring</td>
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<td>Event Filter</td>
<td>Shlomit Tarem</td>
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<td>Erez Etzion</td>
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<td>5.4</td>
<td>Decaying long lived particles</td>
<td>Avner Sofer</td>
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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 ⇒ low rejection power

- Upgrade to Triplets
  - Allow 2 out of 3 logic
  - Robust ⇒
    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
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)
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