
CERN

Readout Chain Testing for ATLAS ITk Strip Detector

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Agenda

Background
- ATLAS & the Inner Detector
- HL-LHC & ITk
- ITk Design and Readout

Lab Testing of Hybrid Chips
- Testing Setup
- Progress & Goals

Acknowledgements

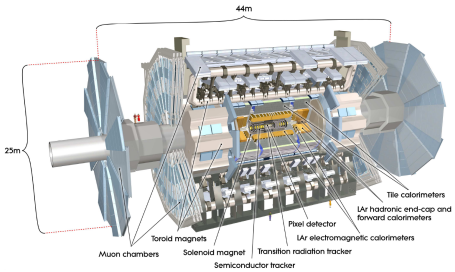
ATLAS & the Inner Detector

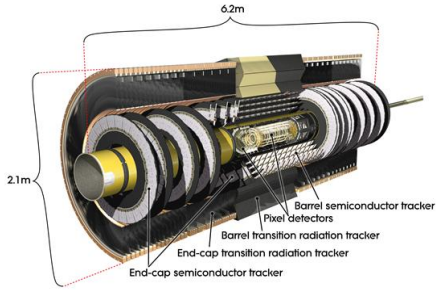
ATLAS Detector

- Inner Detector
- Calorimeters
- Muon Spectrometer

Inner Detector

- Pixel Detector (PIX)
- Semiconductor Tracker (SCT)
- Transition Radiation Tracker (TRT)

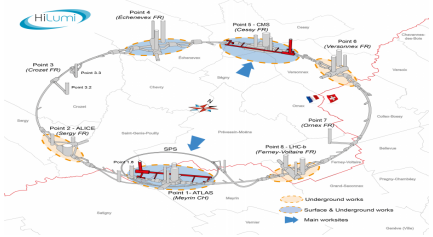


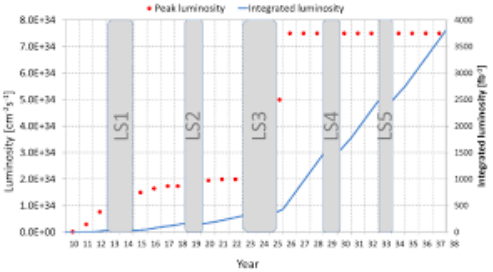


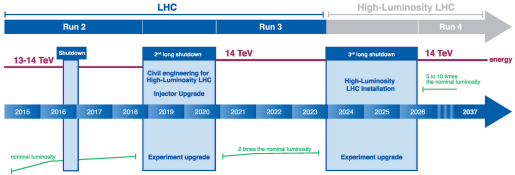
High Luminosity LHC & ITk Upgrades

3x increase in instantaneous luminosity!

- L =2e73 fb^{-1} s^{-1} $\rightarrow$ L = 7e73 fb^{-1} s^{-1}







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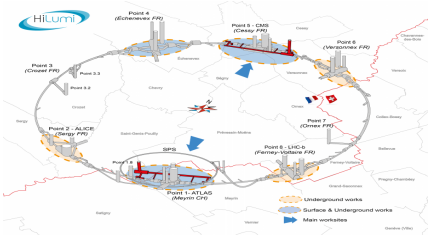
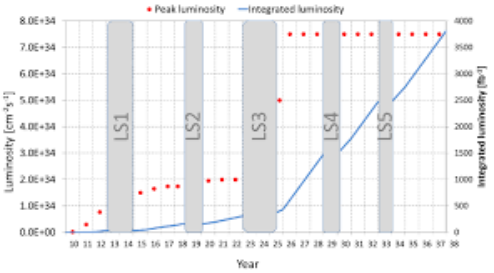
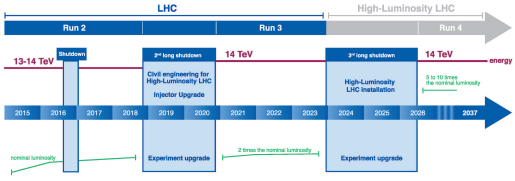
- $L = 2\text{e}73\ \text{fb}^{-1}\ \text{s}^{-1} \rightarrow L = 7\text{e}73\ \text{fb}^{-1}\ \text{s}^{-1}$
- **More particles, more problems**







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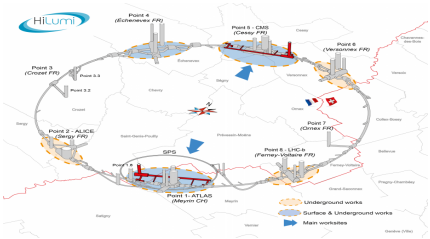

The inner detector has insufficient:

- radiation hardness
- granularity
- readout bandwidth
- trigger readout

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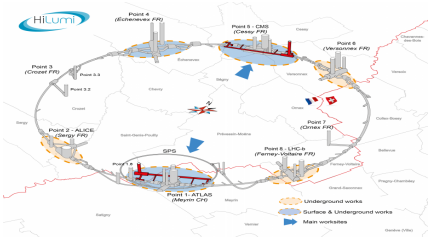

The inner detector has insufficient:

- radiation hardness: HL-LHC will deliver 4000 fb^{-1} integrated luminosity, ID PIX is designed for 400 fb^{-1}, ID SCT for 700 fb^{-1}, IBL for 800 fb^{-1}

High Luminosity LHC & ITk Upgrades

3x increase in instantaneous luminosity!

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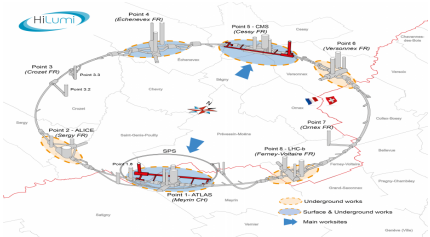

The inner detector has insufficient:

- granularity: Increasing fluence means higher granularity is needed to maintain performance; compensate for instrinsic dead time

High Luminosity LHC & ITk Upgrades

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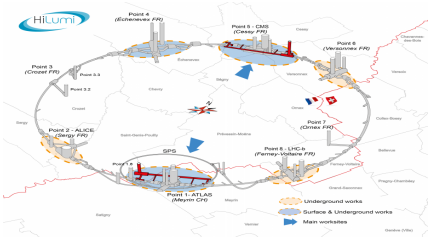


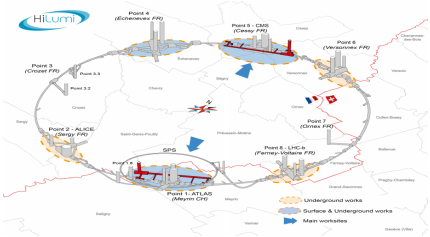
The inner detector has insufficient:

- readout bandwidth: HL-LHC will roughly quadruple ID designed bandwidth saturation

High Luminosity LHC & ITk Upgrades

$x10$ increase in instantaneous luminosity!

- $L = 1e73\ \text{fb}^{-1}\ \text{s}^{-1} \rightarrow L = 1e74\ \text{fb}^{-1}\ \text{s}^{-1}$
- **More particles, more problems**



The inner detector has insufficient:

- trigger readout: readout chain must accomadate much higher hardware (level 1) trigger rate, and ideally include tracking info

High Luminosity LHC & ITk Upgrades

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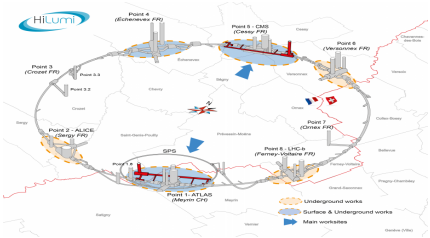
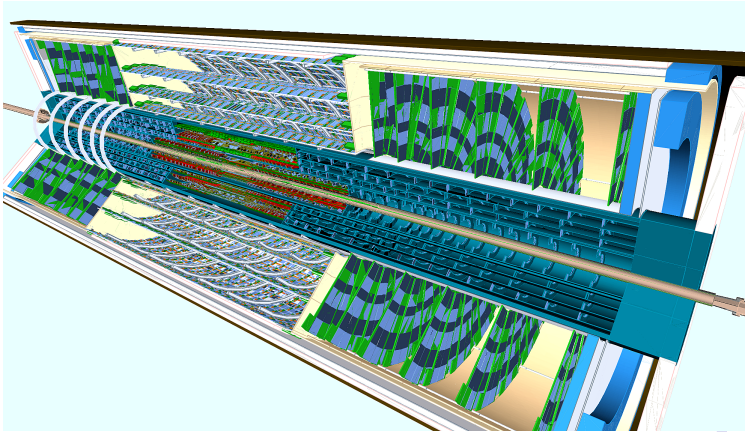


Goal of ITk:

Same or better performance than ID in harsh environment of HL-LHC

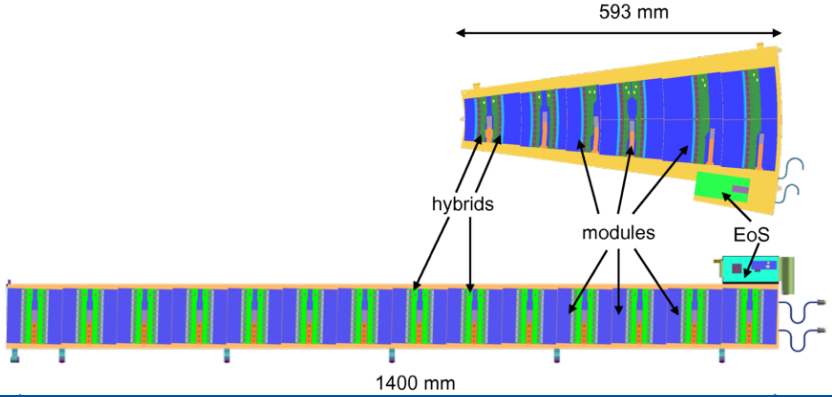
ITk design

- Pixel detector: 600M channels (80M in PIX): 5 barrel layers, encap system
- Strip detector: 70M channels (6M in SCT): 4 barrel layers, 6 EC rings



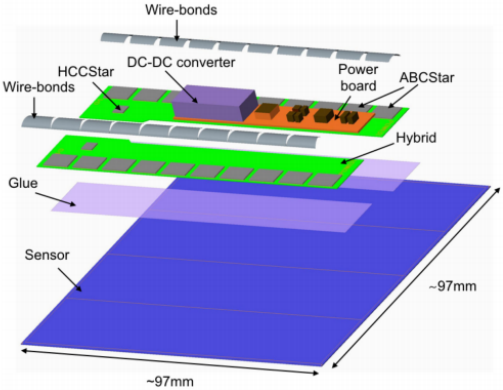
ITk Strip Detector

- Stave/petal: structure, cooling, power, electrical, etc.
- Module: silicon sensor + ASIC + readout hybrid + power board
- Hybrid: Flexible PCB with Hybrid Controller Chip (HCC) to interface w/ ASIC

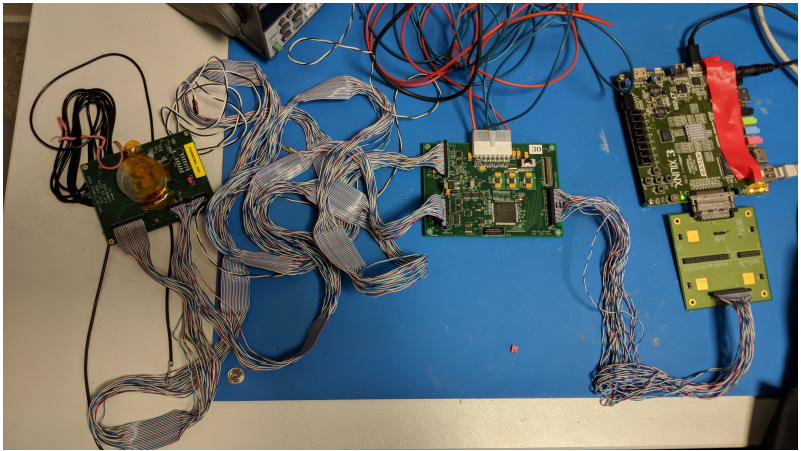


ITk Strip Detector Readout

- sensor $\rightarrow$ front-end ASIC for signal amplification shaping, & discrimination
- 10-12 ABC ASICs per hybrid; each ASIC reads out 256 ch
- Hybrid Controller Chip interfaces the stave/petal service bus & front-end ASICs

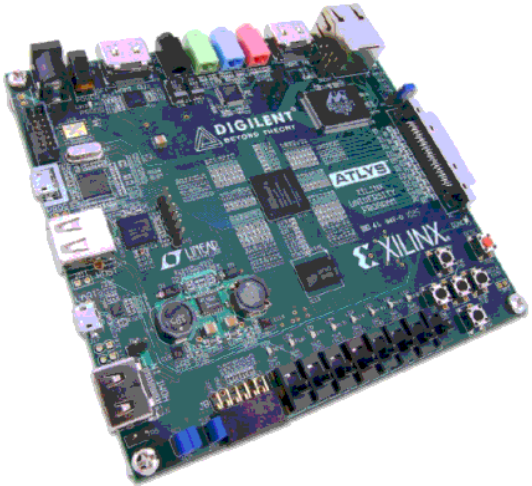


Current DAQ Readout Chain



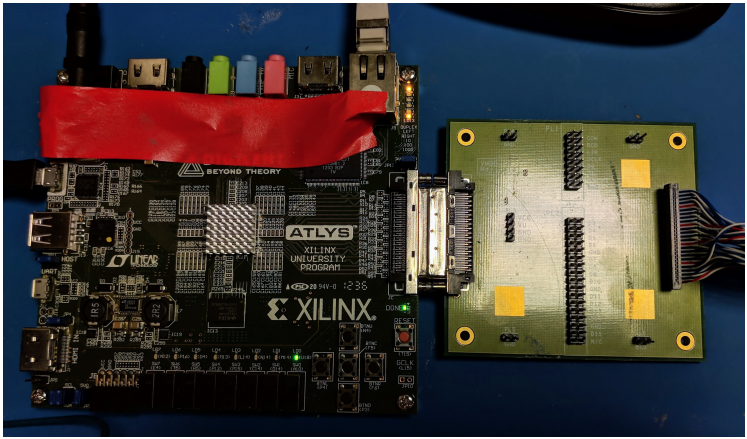
A look at the fully assembled readout chain, ending in the ABC130 prototype test board.

ATLYS Board



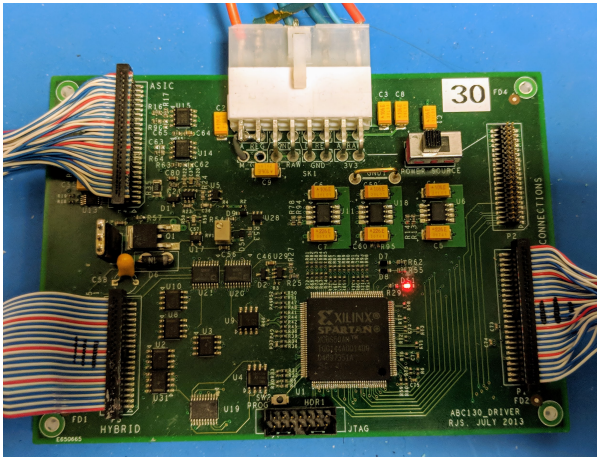
ATLYS is a low cost, widely available board that supports single chip, hybrid, and module tests.

Interface Connection



The ATLYS board is connected to to its interface board, VMOD-IB.

Driver Board



Orientation of the power, ABC130, and ATLYS connections.

ABC130 Single Chip Test Card

Test card, with connection to the driver board.

Progress & Obstacles

Progress

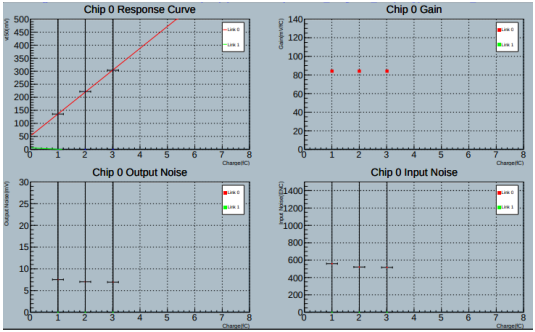
- Able to run correct versions of NI-VISA, NI-DAQMX Base, and NI-488.2 and communicate with devices
- Able to successfully interface with the ATLYS board
- Able to use the ITSDAQ software to run tests on actual chips

Obstacles

- The cabling connections to both the power supply and the ABC chips have been very sensitive
- The distributions generated from a 3-point voltage gain test are far too wide

3 Point Gain

Measures gain & noise at 3 power supply currents



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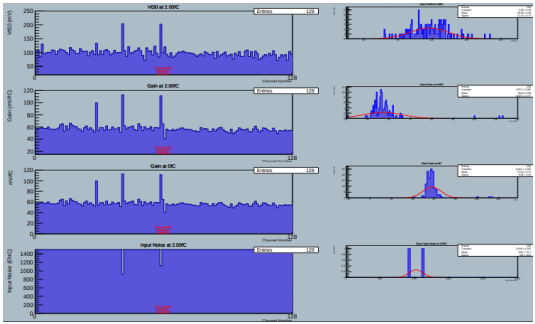
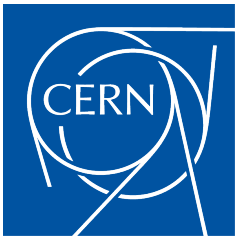


Goals

- Resolve strange 3-point gain behavior
- Obtain a stable cabling setup
- Integrate FELIX chip (optical, rad-hardened comm protocol drivers) into readout chain

Acknowledgements

We would like to acknowledge the University of Michigan Department of Physics, specifically Jean Krisch, Tom Schwarz, and Steven Goldfarb. We would also like to acknowledge the support of the Lounsbery foundation.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