



# 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

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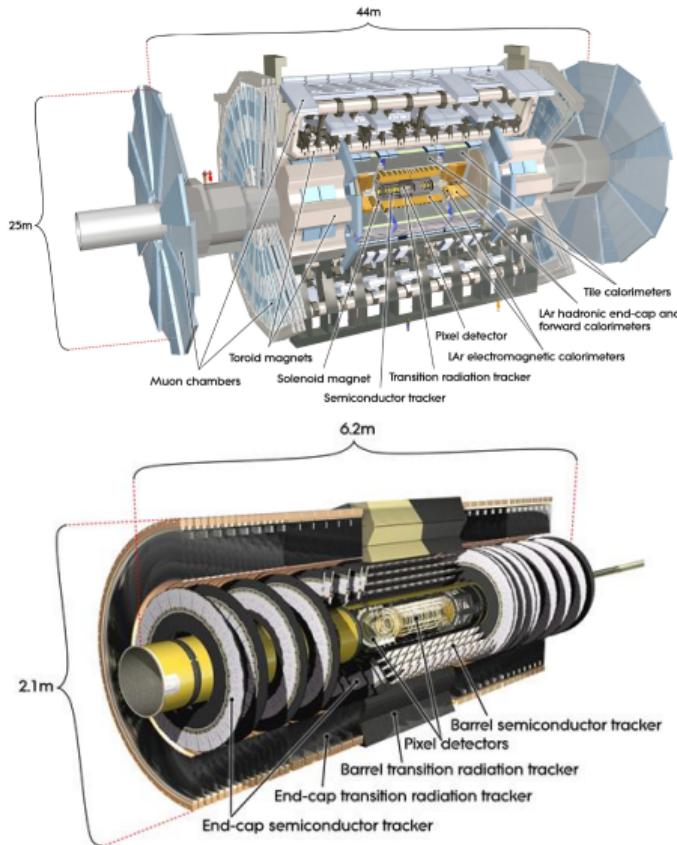
# ATLAS & the Inner Detector

## ATLAS Detector

- ▶ Inner Detector
- ▶ Calorimeters
- ▶ Muon Spectrometer

## Inner Detector

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



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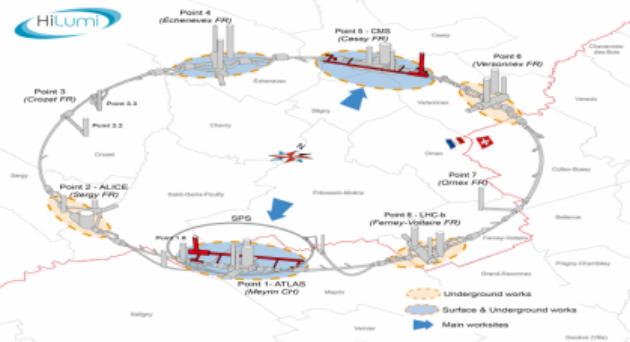
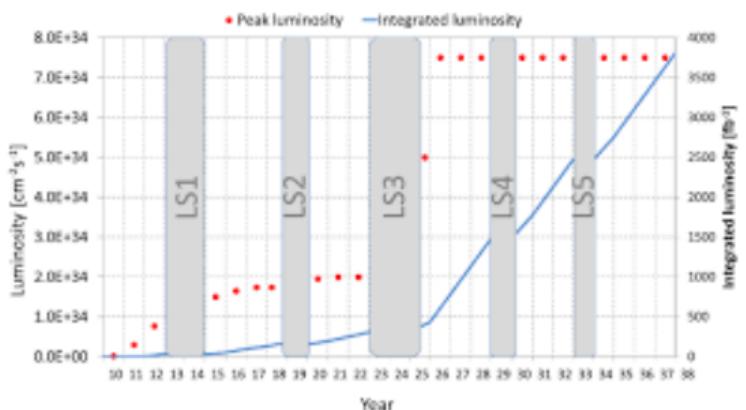
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# High Luminosity LHC & ITk Upgrades

3x increase in instantaneous luminosity!

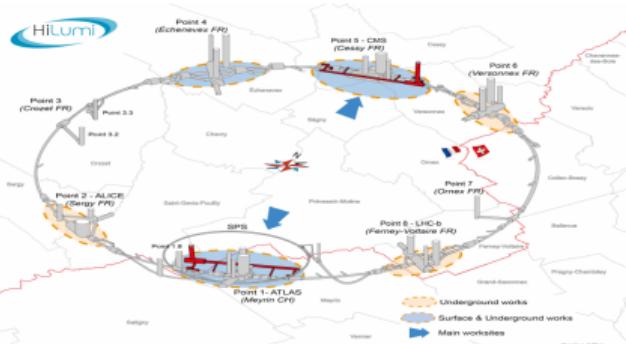
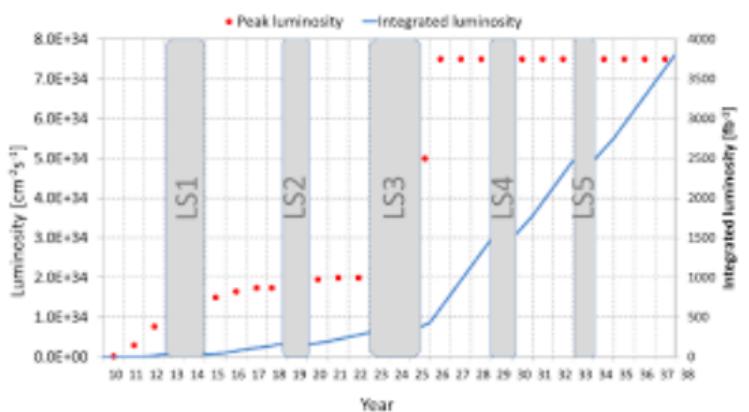
$$\blacktriangleright L = 2 \text{e}73 \text{ fb}^{-1} \text{ s}^{-1} \rightarrow L = 7 \text{e}73 \text{ fb}^{-1} \text{ s}^{-1}$$



# High Luminosity LHC & ITk Upgrades

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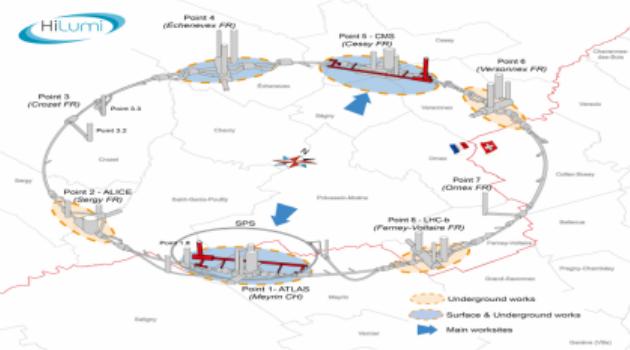
- $L = 2 \times 10^{33} \text{ fb}^{-1} \text{ s}^{-1} \rightarrow L = 7 \times 10^{33} \text{ fb}^{-1} \text{ s}^{-1}$
- More particles, more problems



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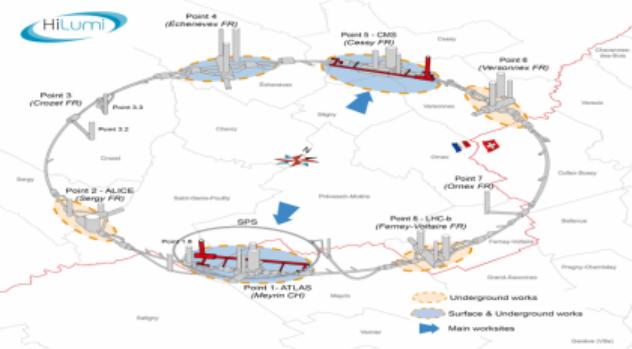
The inner detector has insufficient:

- ▶ radiation hardness
- ▶ granularity
- ▶ readout bandwidth
- ▶ trigger readout

# High Luminosity LHC & ITk Upgrades

**3x increase in instantaneous luminosity!**

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



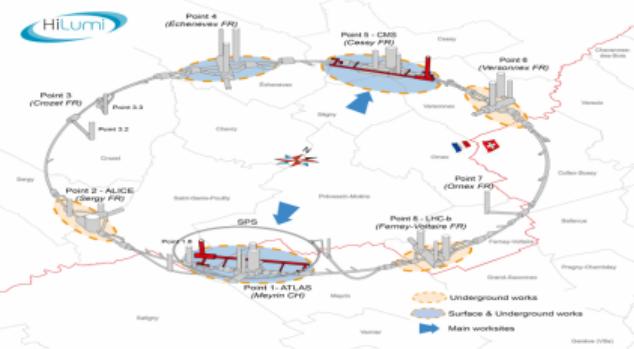
**The inner detector has insufficient:**

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

# High Luminosity LHC & ITk Upgrades

**3x increase in instantaneous luminosity!**

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



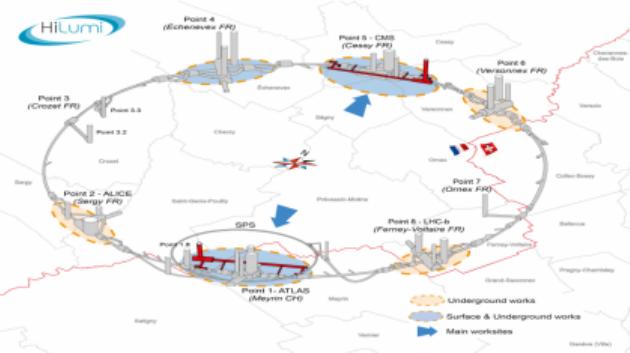
**The inner detector has insufficient:**

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

# High Luminosity LHC & ITk Upgrades

**3x increase in instantaneous luminosity!**

- ▶  $L = 2e73 \text{ fb}^{-1} \text{ s}^{-1} \rightarrow L = 7e73 \text{ fb}^{-1} \text{ s}^{-1}$
- ▶ More particles, more problems



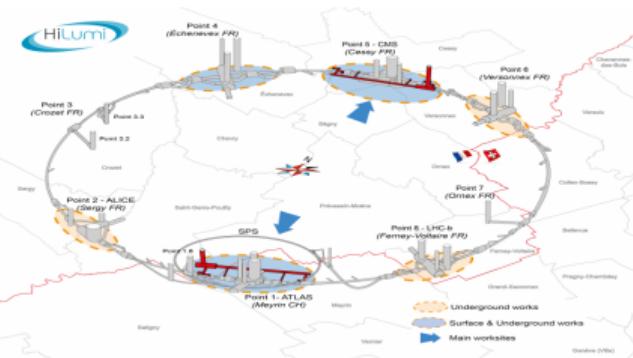
**The inner detector has insufficient:**

- ▶ 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



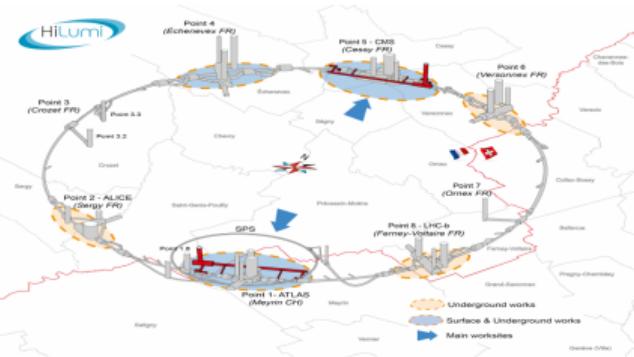
The inner detector has insufficient:

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

# High Luminosity LHC & ITk Upgrades

x10 increase in instantaneous luminosity!

- $L = 1e73 \text{ fb}^{-1} \text{ s}^{-1} \rightarrow L = 1e74 \text{ fb}^{-1} \text{ s}^{-1}$
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Goal of ITk:

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

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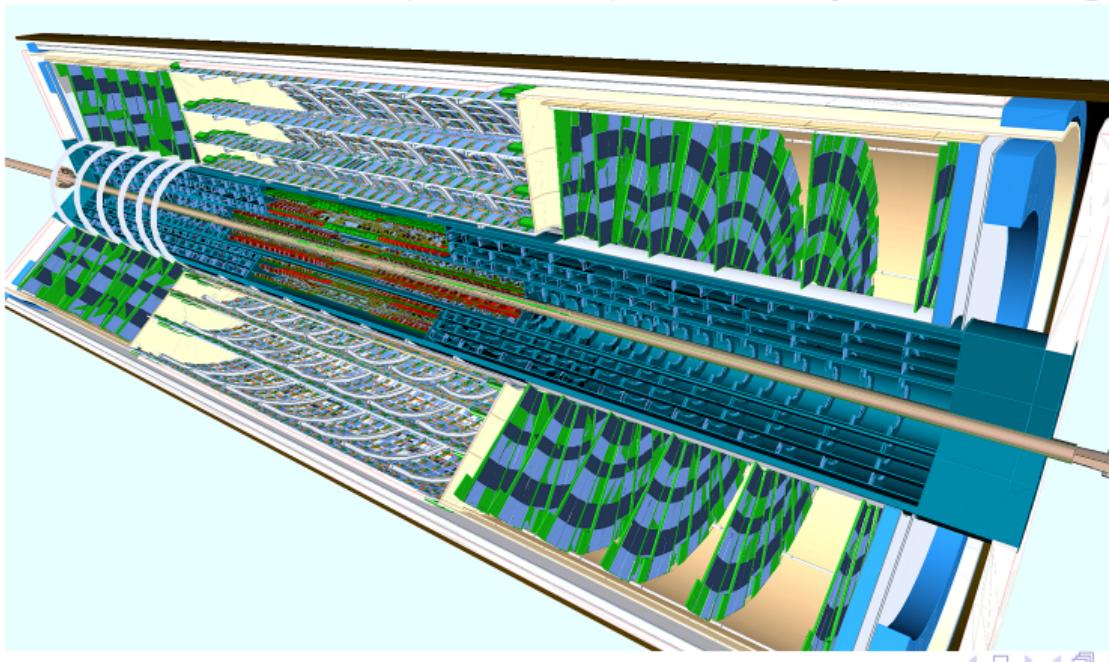
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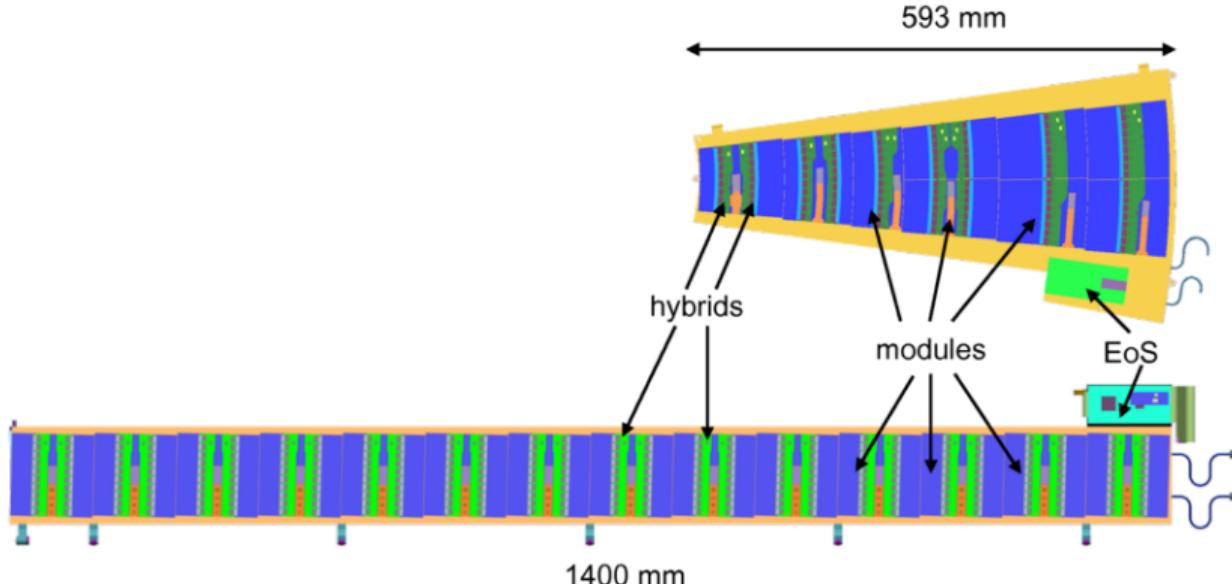
# ITk design

- ▶ 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



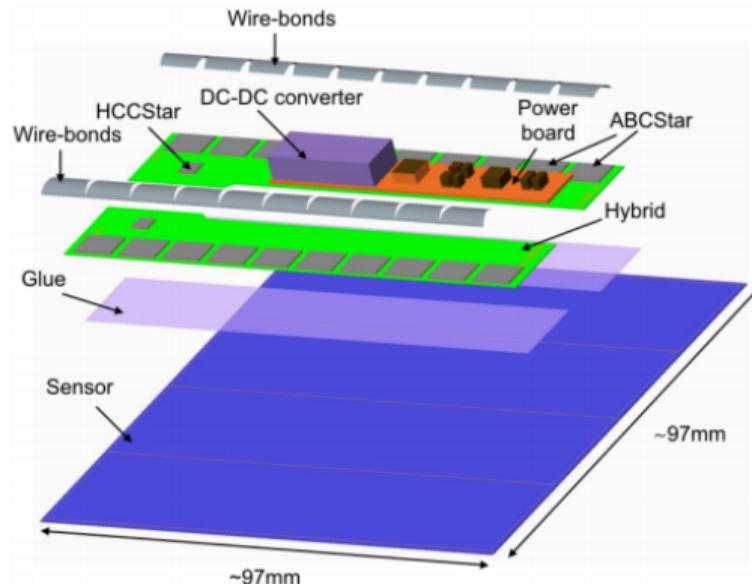
# ITk Strip Detector

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



# ITk Strip Detector Readout

- ▶ sensor → 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



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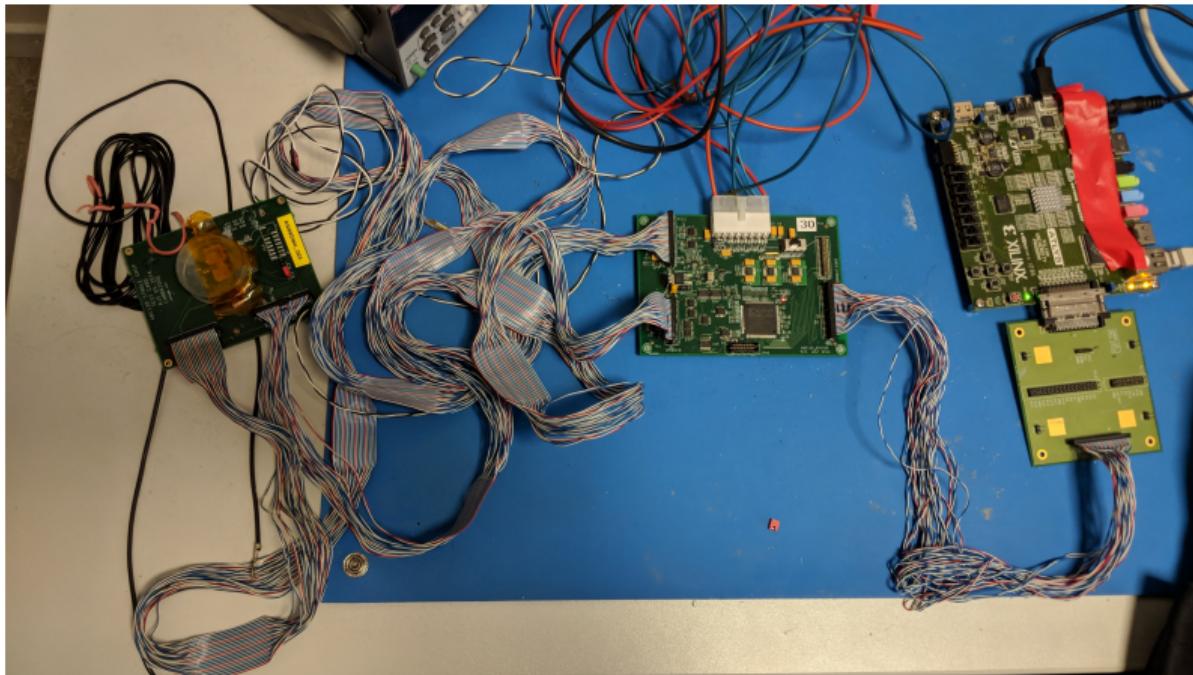
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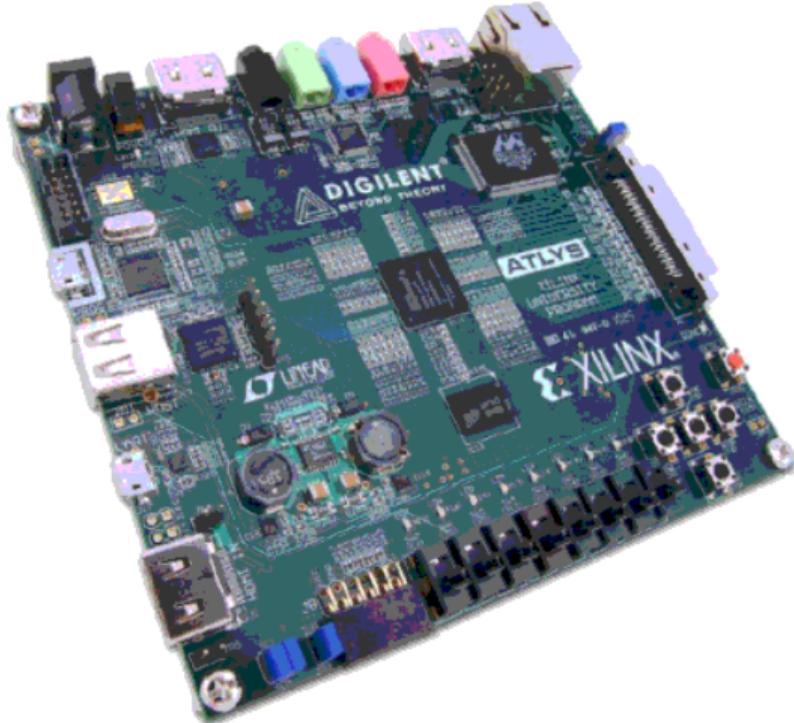
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# Current DAQ Readout Chain



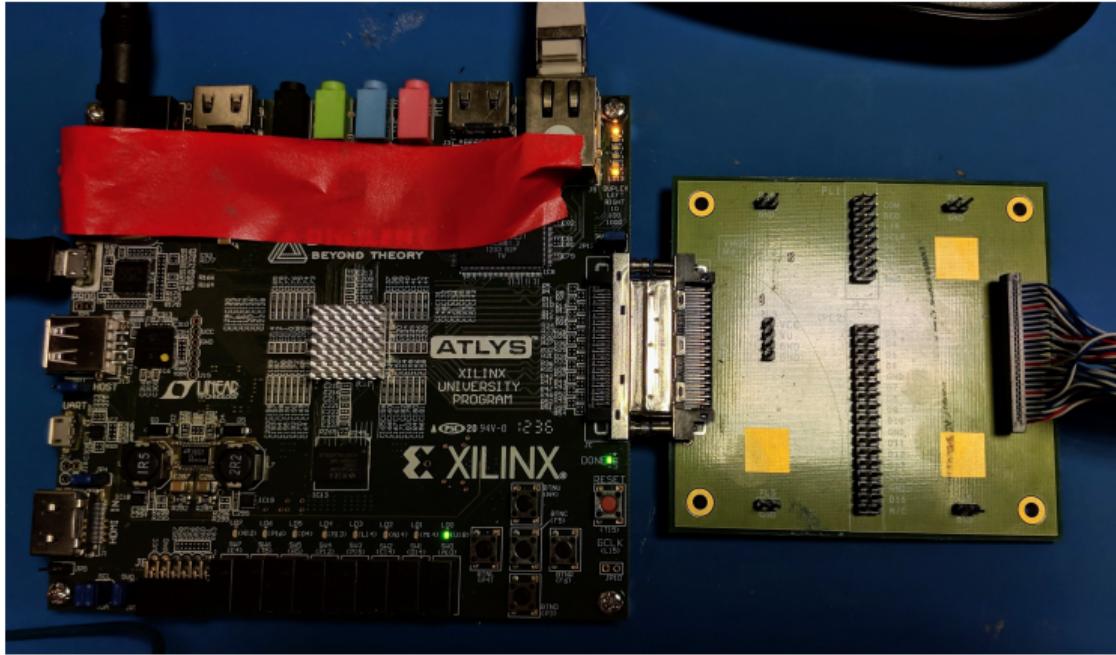
A look at the fully assembled readout chain, ending in the ABC130 prototype test board.

# ATLYS Board



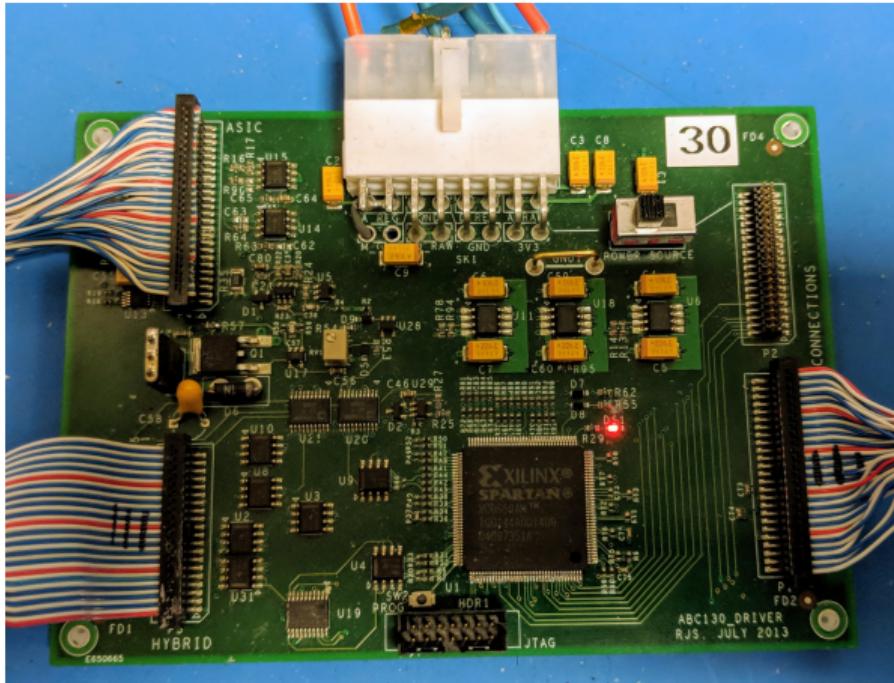
ATLYS is a low cost, widely available board that supports single chip, hybrid, and module tests.

# Interface Connection



The ATLYS board is connected to 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.

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# Progress & Obstacles

## Progress

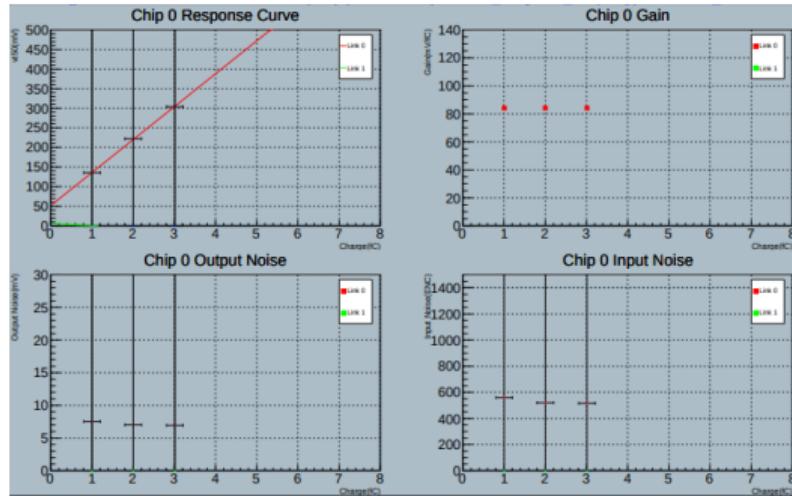
- ▶ Able to run correct versions of NI-VISA, NI-DAQMX Base, and NI-488.2 and communicate with devices
- ▶ Able to successfully interface with the ATLYS board
- ▶ Able to use the ITSDAQ software to run tests on actual chips

## 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

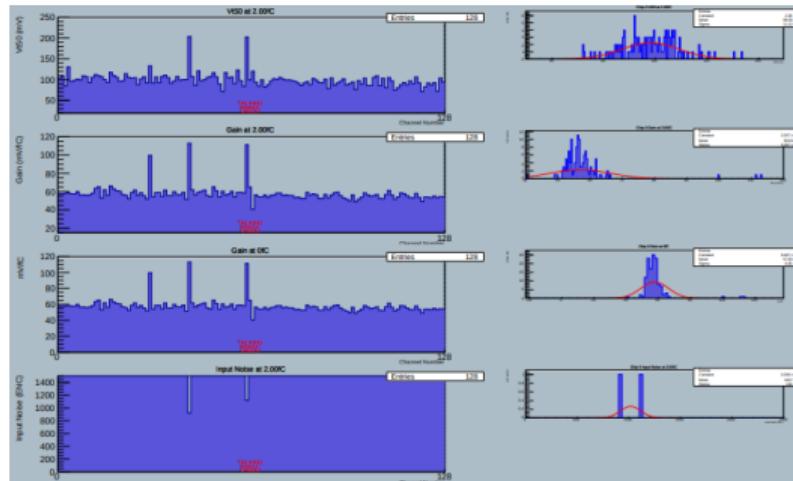
# 3 Point Gain

Measures gain & noise at 3 power supply currents



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Measures gain & noise at 3 power supply currents



# Goals

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

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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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