Overview of calo readout electronics LOI - High Granularity, High Dynamic Range Readout – IF07 Electronics/ASICS

– Tim Andeen, UT Austin

2020 11 19

High Granularity, High Dynamic Range Calorimeters Readout LOI

LOI (right) submitted in August

- Kept broad to accommodate developing plans.
- Now we need to develop a plan…

Snowmass2021 - Letter of Interest

High granularity, high dynamic range Calorimeter readout electronics

Topical Group(s):
IF07 Electronics/ASICS

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The physics program at future accelerators depends in part on high granularity calorimetry. This is driven by the success of particle flow algorithms from the ATLAS and CMS collaborations, and the requirement of fully capturing multi-TeV electromagnetic and hadronic showers. New ideas in the architecture of the readout electronics for this demanding environment are needed to accommodate the granularity and dynamic range requirements.

The most stringent requirements come from the FCC-hh detector calorimeter designs. The speed, precision, high density (channel count), high-dynamic range and low-power ASICS needed for the readout do not exist in any technology. The team from UT-Austin, Columbia University, Fermilab and BNL will build on synergies with the ongoing calorimeter electronics development to investigate high dynamic range, high granularity readout electronic architectures with a focus on preamplifier/shaper and analog-to-digital converter development.

This work both develops technical expertise in instrumentation and engineering for detector design, and maintains detector design in the physics community. The team will connect with overlapping areas in the IF6 calorimeter group and the relevant EF groups in defining design requirements.

High Granularity, High Dynamic Range Readout

Nearly all detectors designed for the ILC, CliC, CEPC, FCC-ee, FCC-hh, (etc.) includes high granularity detectors, particularly for calorimeters.

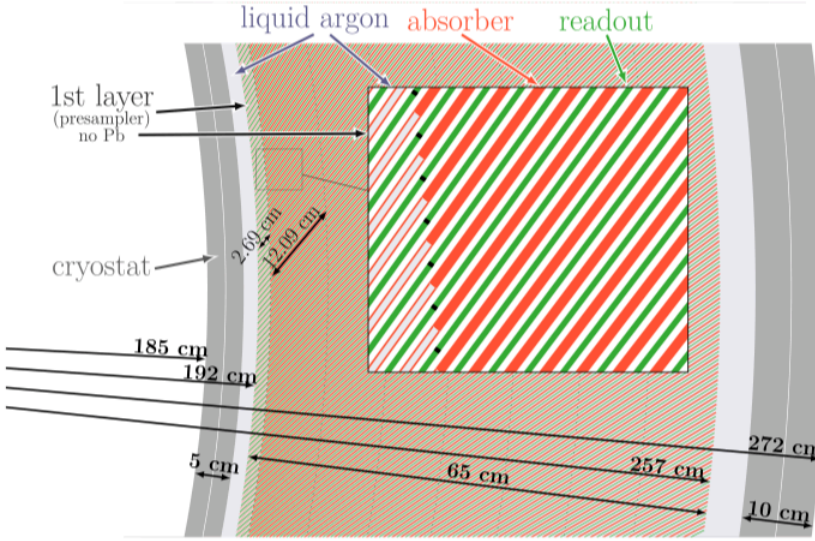
Ex: FCC-hh LAr calorimeter (top), CEPC (bottom) Si-W calorimeter

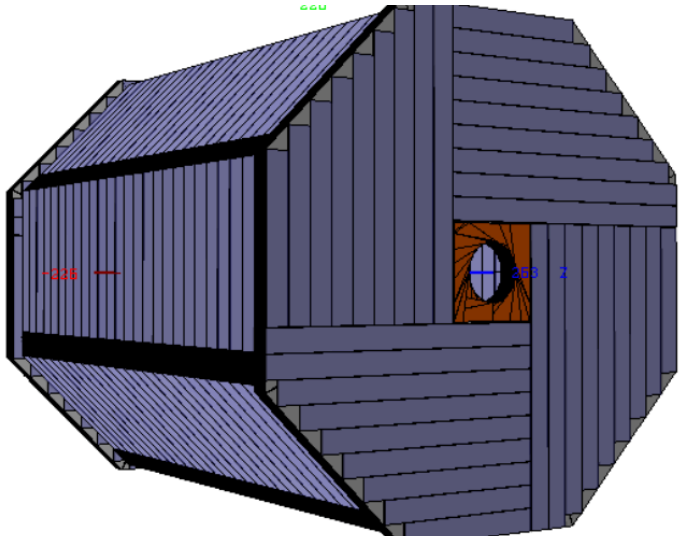
Driven by :

1) The success of particle flow algorithms CMS and ATLAS

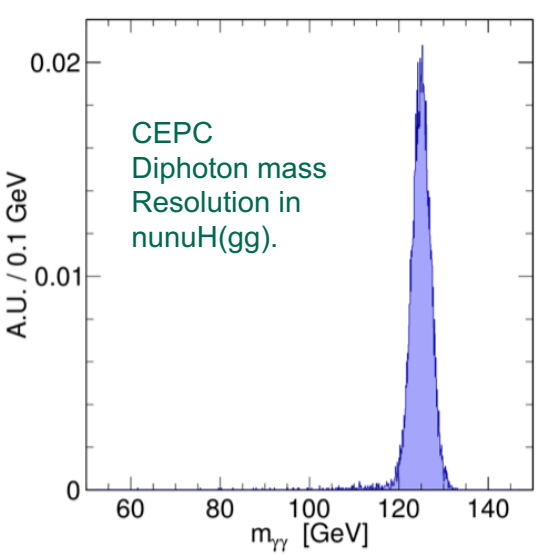
2) The need to capture full EM and hadronic showers (of eg potentially many TeV electrons).

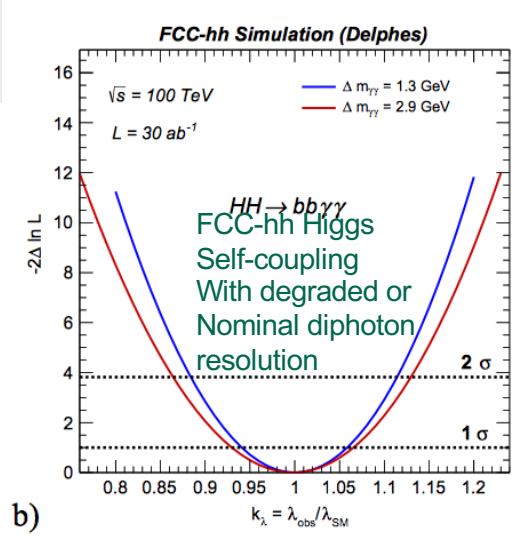
Electronic readout must be developed to accommodate high granularity, high dynamic range detector requirements.





Science Need





Physics drivers - The physics focuses are different for each detector, but Higgs physics with photons will continue to be driver (above benchmark plots from CEPC and FCC-hh).

Technology opportunity – At the extreme end (FCC-hh) the speed, precision, high density (channel count), high-dynamic range "low-power readout" ASICS needed do not exist in any technology. Creative system architecture is needed. For the ILC and CEPC electronics readout design is already well underway (SKIROC chip, SPIROC chip, respectively).

This work both develops technical expertise in instrumentation and engineering for detector design, and maintains detector design in physics community.

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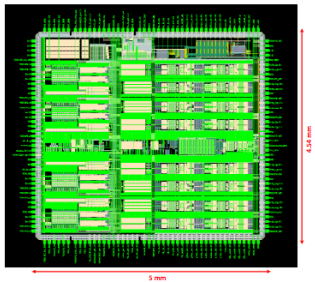

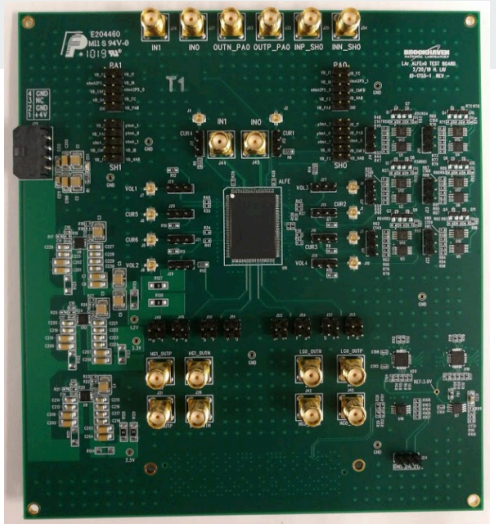

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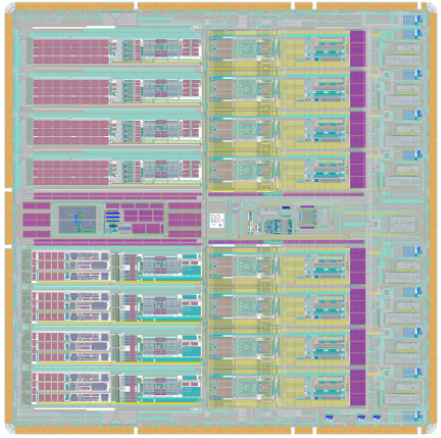


Current effort

ASICS design and system architecture – determine specifications need, possible technological implementations, identify areas that require novel design work.

Team : Columbia U, BNL, UT Austin

Existing team involved in ATLAS LAr calorimeter electronics development. Current challenge is “high” dynamic range, “high” granularity (by HL-LHC standards) PA/S and ADC ASICS investigating novel ”dynamic ranging enhancing” architectures. - Can we apply these techniques to meet the coming challenges?

New people and new ideas welcome!

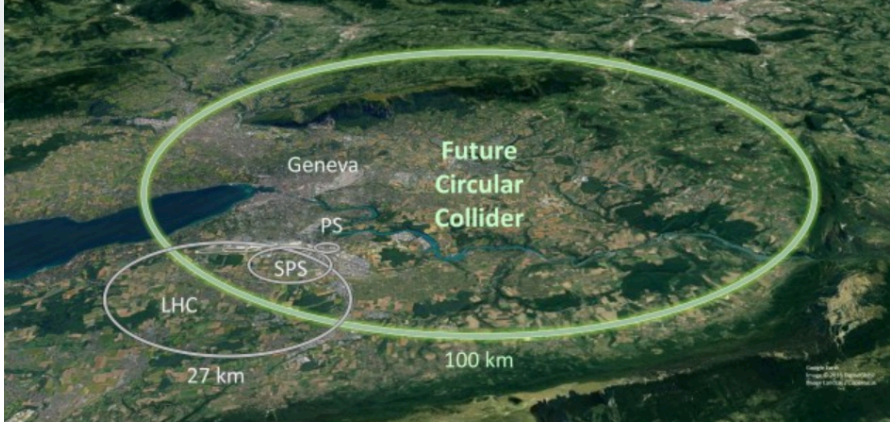
Synergies

There is significant overlap with specific detector design groups. Important to connect with existing efforts in detector design, simulation, reconstruction.

Connects **IF6 Calorimetry**, and to some degree the rest of the IF groups.

Detailed electronics specifications for specific detectors are driven by (sometimes) a specific, single physics case (eg. Mass resolution in nunu(H->diphotons) process). Important to know what we are designing for, and possible area for students to participate in reconstruction and analysis details.

Connects to EF, probably most substantially to **EF01 Higgs properties**.



Conclusion

Future detectors and future calorimeters will need high-granularity. The extreme: A 100 TeV collider requires extraordinarily high-dynamic range readout, along with high-granularity to reconstruct photon showers at the EW-scale up to O(10 TeV). **Absolute need for new** ideas for electronic readout of these detectors.

In any new detector electronics and ASIC development are natural areas for US to contribute. We need to be involved now.

New people and new ideas welcome!