

4D-Tracking Detectors

**Ariel Schwartzman
(SLAC)**

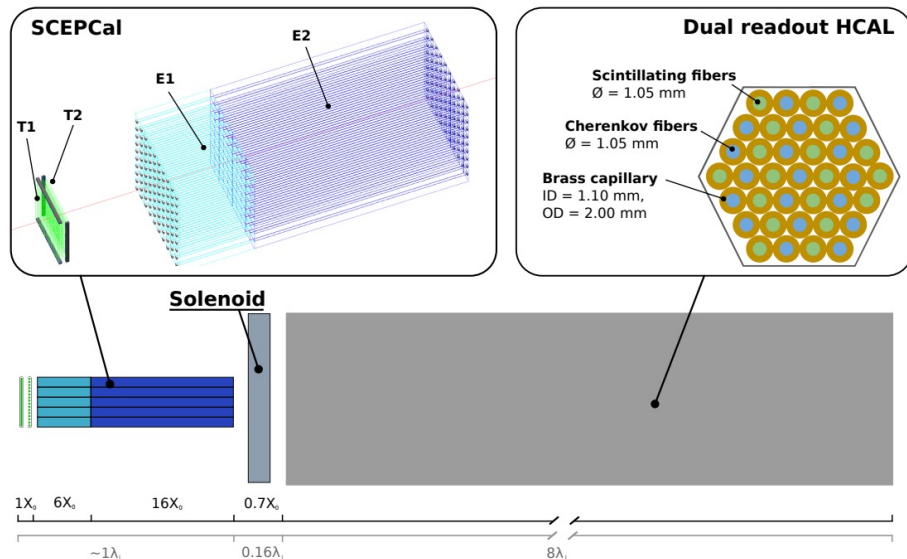
SLAC 4D Tracking Monthly Meeting
03-Feb-2022

Fast timing for Future Calorimeters

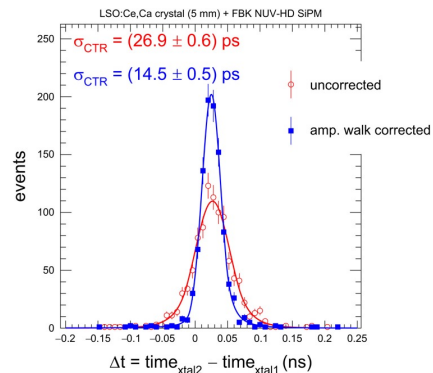
- Broad interest in the incorporation of 10-100ps timing capabilities in the next generation of calorimeters for particle colliders
- Could be an interesting opportunity to leverage our SLAC expertise in electronics, sensing, and simulation/physics/machine learning
- Three main applications
 - Dedicated timing layers in front of the ECal for ToF particle ID (synergetic with our current 4D tracking effort, but integrated with the calorimeter system)
 - Improved particle flow reconstruction exploiting time profile of showers
 - Timing layers within calorimeter
 - Timing on every cell
 - Provide longitudinal segmentation in fiber calorimeter concepts (Dual Readout)

Timing layers

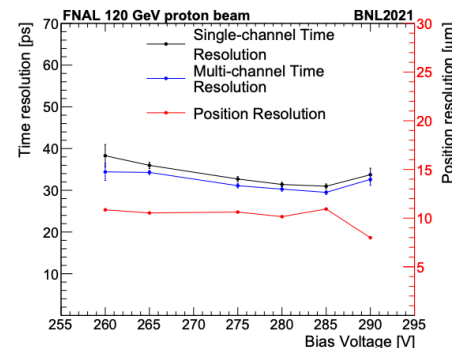
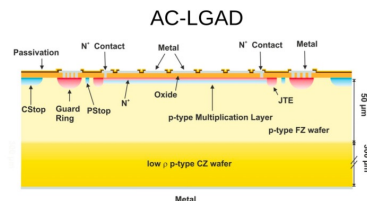
[New perspectives on segmented crystal calorimeters for future colliders](#)
[Lucchini, et. al.]



- Hybrid segmented dual-readout calorimeter
 - Two thin timing layers in front of EM Calorimeter



[Detection of high energy muons with sub-20 ps timing resolution using L\(Y\)SO crystals and SiPM readout](#)
[Benaglia, et. al.]

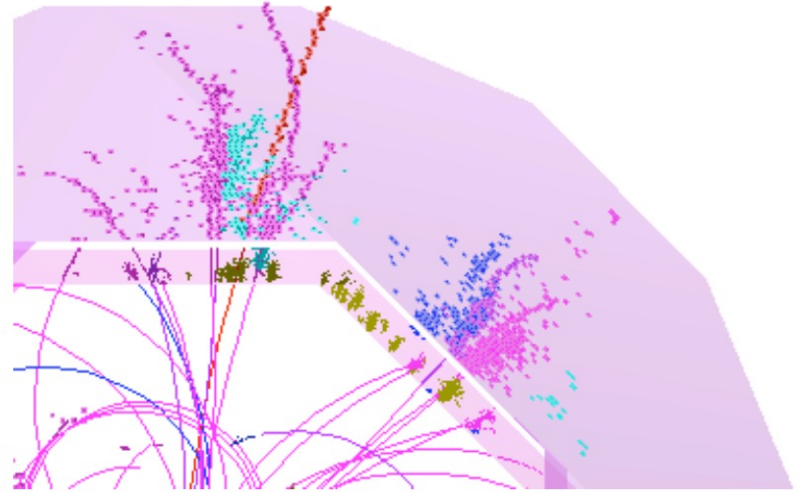


[Characterization of BNL and HPK AC-LGAD sensors with a 120 GeV proton beam](#) [Heller, et. al.]

Calorimetry

[Precision timing for collider-experiment-based calorimetry \[Chekanov, et. al.\]](#)

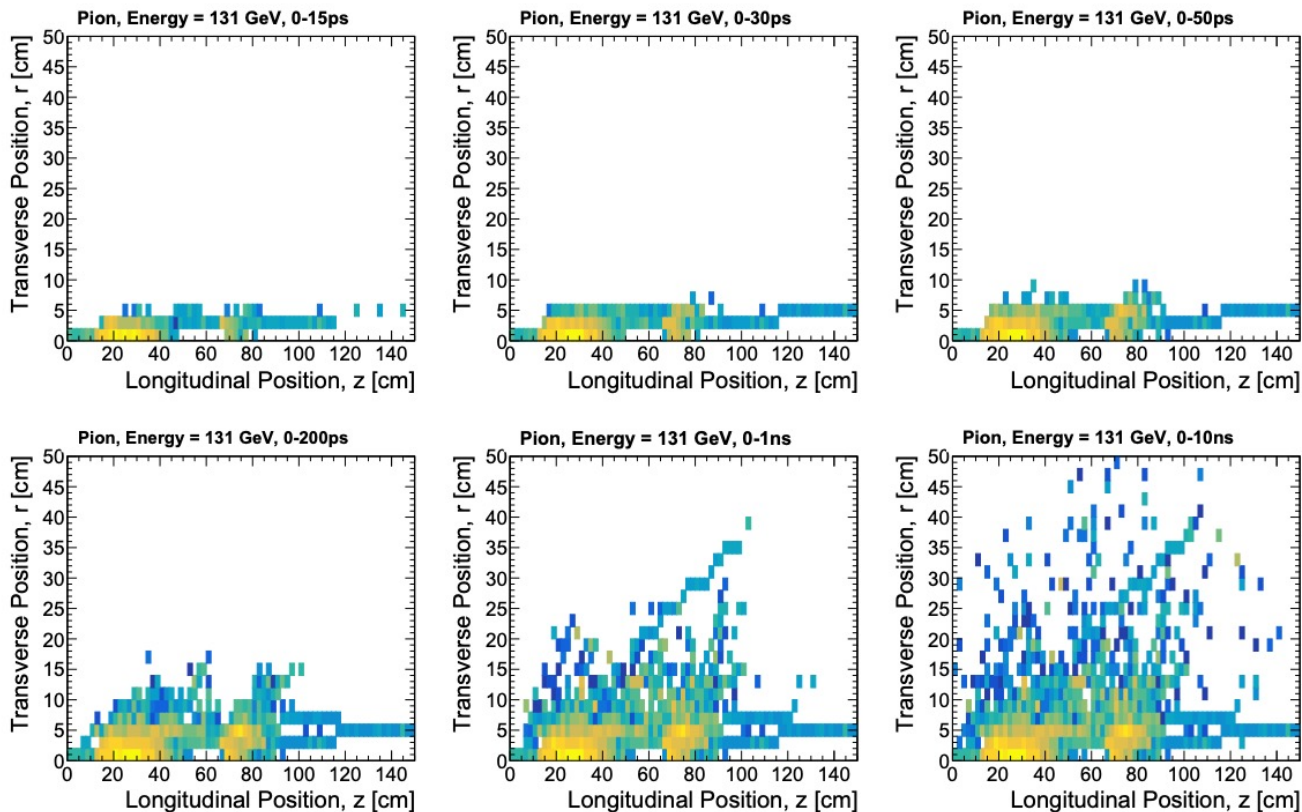
- Performance of particle flow reconstruction depends on the ability to associate showers to particles
 - Challenging when showers overlap in space
- Precision timing information can help resolve close-by showers, exploiting the full space-time structure of showers, improving the jet energy resolution



- Different approaches:
 - “Volume” (cell-level) timing
 - Dedicated timing cells
 - Timing layers within the calorimeter

Calorimetry

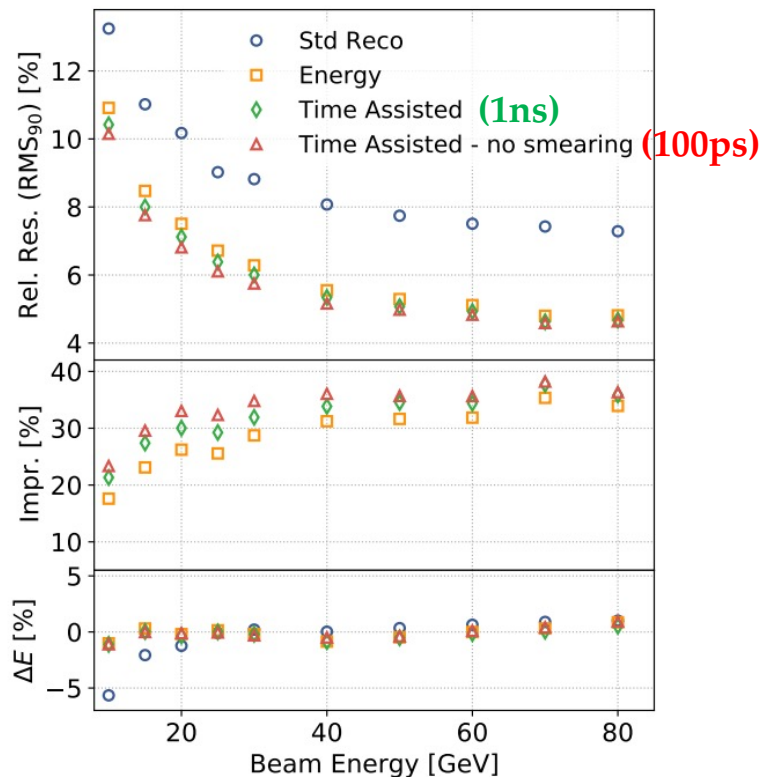
[On the Use of Neural Networks for Energy Reconstruction in High-granularity Calorimeters \[Akchurin, et. al.\]](#)



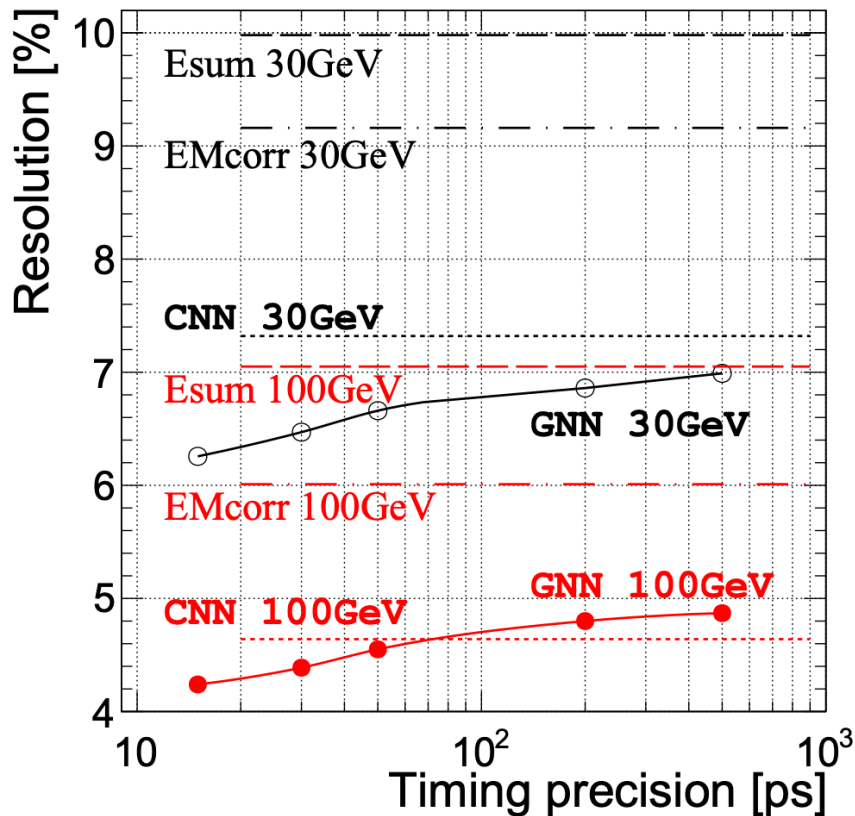
Calorimetry

[On the Use of Neural Networks for Energy Reconstruction in High-granularity Calorimeters \[Akchurin, et. al.\]](#)

CALICE SiPM-on-file analog
hadron calorimeter



[Time-assisted energy reconstruction in a highly-granular hadronic calorimeter Christian \[Graf, Simon\]](#)



Detector R&D

Detector R&D

[Detector projects](#)[Detector Facilities](#)[Research Techniques Seminar](#)[Publications and talks](#)[Conferences](#) [↗](#)[Getting Research Resources](#) [↗](#)[Contact](#)

CalVision

CalVision is a collaboration of FNAL (PIs Freeman, Hirschauer, Merkel, Wenzel), Argonne (Sergei Chekanov), Caltech (Newman, Zhu), Maryland (Belloni, Eno), Michigan (Qian, Zhou, Zhu), Milano-Bicocca (Lucchini), MIT (Harris), Oak Ridge (Demarteau), Princeton (Tully), Purdue (Jung), Texas Tech (Akchurin, Kunori), U. Virginia (Hirosky, Ledovskoy). Our aim is to work on pushing forward homogeneous calorimetry using multiple measurements such as wavelength, polarization, and timing to improve calorimeter hadronic resolution while maintaining state-of-the-art electromagnetic resolution, developing new lower-cost materials such as scintillating glasses, optimizing its incorporation into a future detector at a future accelerator, and developing novel particle-flow or machine-learning algorithms to best use them in particle identification. We work in collaboration with the proposed IDEA experiment for future Higgs factories.


We welcome new collaborators. Please contact Sarah Eno (eno@umd.edu) The Caltech, Maryland, Michigan, MIT, Princeton, Purdue, Texas Tech, and UVA groups are funding by DOE grant DE-SC0022045.


ECFA Detector R&D Roadmap Task Force 6: Calorimetry Community Meeting












Thursday 12 Jan 2023, 09:00 → 18:00 Europe/Zurich

222/R-001 (CERN)

Felix Sefkow (Deutsches Elektronen-Synchrotron (DE)), Felix Sefkow (DESY), Roberto Ferrari (INFN Pavia (IT)), Roberto Ferrari, Roman Poeschl (Université Paris-Saclay (FR))

Videoconference  ECFA Detector R&D Roadmap Symposium Meeting [Join](#)

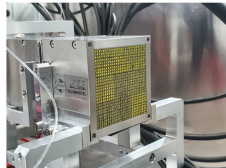
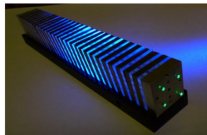
Registration  You are registered for this event. 135 [Check details](#)

Participants  Abhik Jash  Adelina D'Onofrio  Adrian Irls  Aleksandar Bordelius  Alessandro Iovene  Aman Desai  Andrea Pareti  Andreas Loeschke Centeno  Andreas Schopper  Anna Ferrari  Anna Sfyrta

Introduction: picosecond scintillating sampling ECALs

Most common approaches:

- Shashlik
- SpaCal
- Molière radius tunable in both cases
- Lower cost than homogenous crystal



Key R&D challenges for future experiments:

- Radiation hardness:
→ Crystal scintillators suitable for future experiments at hadron colliders
→ No radiation-hard WLS fibres available (yet)
- Small cell sizes: dense absorber, e.g. tungsten
- Picosecond time resolutions:
→ Fast photon detectors (e.g. MCD PMTs, SIPM, ...) needed for O(10-20) ps time resolutions

12/01/2023

Picosecond scintillating sampling ECALs

Philipp Roloff

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ECFA

very short wrap-up



Nice overview of ongoing calorimetry R&D -> very interesting and positive - not exhaustive (it could not be)

Many thanks for the lively discussion!

Not going over any details

Lots of open challenges over different time scales -> they depend on physics case and machine

Many common issues (not exhaustive):

high granularity
timing -> from O(100) ps down to O(10) ps
sensors and readout elx
connectors, mechanical integration, ...
infrastructures/facilities (beam test lines, ...)

Many different specific issues

Many synergies with (or dependence on) other Tfs -> need transversal collaboration(s)
calorimeters are at the top and bottom of the chain