Argonne NATIONAL LABORATORY

Status of the White paper:
Precision Timing for Collider Experiment based Calorimetry

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Goals: to discuss physics cases and requirements for precision timing for electromagnetic (ECAL) and hadronic (HCAL) calorimeters for future particle-collision experiments

Recent News

- LoI associated with this topic are identified
  - 18 LoI in total
  - 2 contributed papers
- 2 emails have been sent to the LoI authors with the proposal.
- 4 responses received so far

Submitted LOI

1) The potential of timing as a jet-substructure variable in future collider detectors, C.-H Yeh, S.V. Chekanov ,A.V. Kotwal,S. S Yu, https://www.snowmass21.org/docs/files/summaries/EF/SNOWMASS21-EF8-IF6-008.pdf
a9510130375@gmail.com,

(2) High Precision Timing with the PICOSEC Micromegas Detector. The RD51 PICOSEC-Micromegas Collaboration https://www.snowmass21.org/docs/files/summaries/IF/SNOWMASS21-IF5_IF0_C.Lampoudis-098.pdf

3) Frank Simon, Dirk Zerwas for the CALICE Collaboration Physics potential and prototyping of technological solutions for timing layers in highly granular calorimeters https://www.snowmass21.org/docs/files/summaries/IF/SNOWMASS21-IF6_IF0_CALICE-038.pdf, fsimon@mpp.mpg.de,

4) Snowmass paper: S.V. Chekanov, A.V. Kotwal, C.-H. Yeh, S.-S. Yu. Physics potential of timing layers in future collider detectors. 2020 JINST 15 P09021 https://arxiv.org/abs/2005.05221,

5) Feasibility study of combining a MIP Timing Detector with the Dual-Readout Calorimeter at future e+e colliders. https://www.snowmass21.org/docs/files/summaries/IF/SNOWMASS21-IF6_IF3_Hwidong_Yoo-059.pdf

(6) PRECISION TIMING DETECTORS FOR FUTURE COLLIDERS. Artur Apresyan, Karri Folan Di Petrillo, Ryan Heller, Ron Lipton, Alessandro Tricoli, and Gabriele Giacomoni https://www.snowmass21.org/docs/files/summaries/IF/SNOWMASS21-IF3_IF7_Karri_DiPetrillo-142.pdf

7) Timing Semi-Digital Hadronic Calorimeter (T-SDHCAL). .Laktineh for the SD-HCAL groups of the CALICE Collaboration https://www.snowmass21.org/docs/files/summaries/IF/SNOWMASS21-IF6_IF5_Laktineh-Calice-050.pdf

8) Calorimetric Picosecond Timing Planes for Future 100 TeV-scale Collider Detectors https://www.snowmass21.org/docs/files/summaries/IF/SNOWMASS21-IF6_IF2-EF6_EF0_Peter_Gorham-039.pdf
gorham@hawaii.edu

9) Novel silicon sensors for high-precision 5D calorimetry. T. Suehara, M. Kuhara, T. Yoshioka, K. Kawago, https://www.snowmass21.org/docs/files/summaries/IF/SNOWMASS21-IF6_IF3-078.pdf,

10) High density 3D integration of LGAD sensors through wafer to wafer bonding. S. M. Mazza et al. https://www.snowmass21.org/docs/files/summaries/IF/SNOWMASS21-IF3_IF5_Simone_Mazza-175.pdf,

11) Neutral Long-Lived Particles at Future Colliders. Cristinao Alpigiani et al, https://www.snowmass21.org/docs/files/summaries/EF/SNOWMASS21-EF9_EF2_John_Stupak-236.pdf,

12) High-Granularity Crystal Calorimetry Letter of Intent. S.Eno et al. https://www.snowmass21.org/docs/files/summaries/IF/SNOWMASS21-IF6_IF0_Yong_Liu-064.pdf

13) Geant4 and fast simulations for physics and detector performance studies for a 100 TeV collider [note: in the context of timing, all it does is reference 4)] M. Beydler et al. https://www.snowmass21.org/docs/files/summaries/EF/SNOWMASS21-EF0-IF6-007.pdf

14) Searching for Bs [...] and other b [...] processes at CEPC [note: suggests study of timing requirements on CEPC calo] https://www.snowmass21.org/docs/files/summaries/EF/SNOWMASS21-EF3_EF0-RF1_RF0-IF3_IF6-077.pdf

15) Detector optimisation and detector technology RD for the CLIC detector and for the CLD detector of FCC-ee [timing detectors as a possible RD direction]. Mathieu Benoit et al, https://www.snowmass21.org/docs/files/summaries/IF/SNOWMASS21-IF3_IF6_Mathieu_Benoit-188.pdf

16) Dual-Readout Calorimetry [Timing both for shower reco, and addition of dedicated TLs - but then not DR anymore?]. J.Agarwala et al, https://www.snowmass21.org/docs/files/summaries/IF/SNOWMASS21-IF6-008.pdf

17) Development of Novel Inorganic Scintillators for Future High Energy Physics Experiments [Material development, ultrafast scints in context of TOF rather than calo]. https://www.snowmass21.org/docs/files/summaries/IF/SNOWMASS21-IF6_IF0-EF1_EF0-RF5_RF0-069.pdf

18) Developments Towards a SiPM-on-Tile Based Analogue Hadron Calorimeter (AHCAL) [connects to 3)]. Katja Krüger and Felix Sefkow https://www.snowmass21.org/docs/files/summaries/IF/SNOWMASS21-IF6_IF0_CALICE-099.pdf

Status

Overleaf draft is created:
https://www.overleaf.com/project/615b6678cb069afe6b799d14

Table of content

- **(1) Introduction**
- **(2) Physics case**
  - Event and object reconstruction
  - Shower reconstruction and PFA (~2 pages)
  - Particle identification (1 page)
  - Pileup mitigation (1 page)
- **(3) System options**
  - Volume timing
  - Timing layers (2 pages added from a contributed paper)
  - Possible technologies

Table of content (cont.)

Technology candidates for timing layers:
➔ Low-Gain Avalanche Detectors (LGADs)
➔ Ultra-fast silicon monolithic sensors using the CMOS
➔ Depleted Monolithic Active Pixel Sensor (DMAPS)
➔ Micro channel plate (MCP)
➔ Sampling calorimeters based on a Lutetium-yttrium oxyorthosilicate (LYSO)

Technology candidates for volume timing:
➔ Various options of silicon sensors
➔ Plastic scintillator tiles or strips with SiPM readout
➔ Resistive plate chambers, in particular multi-gap RPCs
➔ Highly granular crystal-based detectors

Technology candidated for TM
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