Snowmass 2021
Instrumentation Frontier
Calorimetry

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Snowmass 2021
Instrumentation Frontier Calorimetry

- ☛ Calorimetry Requirements from Physics
- ☛ Experiments/Facilities using Calorimetry
- ☛ Technology Tools and Calorimetry Development Areas
- ☛ Performance studies

Contacting Collaborations

Dear Colleagues.

We are writing to you as the conveners of the Calorimetry group of the Instrumentation Frontier for Snowmass 2021. The mission of our Snowmass 2021 process is for all of us to review the current status of calorimetry, put forward new ideas, and define the next 5-10 years in terms of improved experiments.

We look forward to hearing about and discussing your work on calorimetry, lessons learned, ongoing and projected R&D, ideas for new techniques and suggestions for improving existing techniques, and any views or concerns about the state of our research area.

We are presently organizing our activities into several major areas:

- Calorimetry requirements from physics
- Experiments/Facilities using Calorimetry
- Technology Tools and Calorimeter Development Areas
- Performance Studies

We have a few different communication channels that we hope you will participate in.

Webpage for community meeting announcements and minutes: https://snowmass21.org/instrumentation/calorimetry

E-mail list, primarily for announcements: SNOWMASS-IF-06-CALORIMETRY@fnal.gov (to subscribe, send an e-mail to listserv@fnal.gov with the subject line blank and the words SUBSCRIBE SNOWMASS-IF-06-CALORIMETRY FIRSTNAME LASTNAME in the body of the message)

Slack, for real-time discussion: team snowmass2021, channel #if06-calorimetry (using a CERN or Fermilab e-mail address to join the team should work—if not, please e-mail rhbob@fnal.gov with the subject line "snowmass slack" for help)

We look forward to hearing from you, either directly via email, or through the submission of Letters of Interest (https://snowmass21.org/loi) and through contributed papers (https://snowmass21.org/submissions/start). Letters of interest are being solicited now through August 31, 2020.

With best regards,

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Minfang Yeh, Brookhaven National Laboratory (yeh@bnl.gov)

Rachel Yohay, Florida State University (ryohay@fsu.edu)

Snowmass 2021, Instrumentation Frontier – Calorimetry conveners.

Experiments/Facilities using Calorimetry

Colliders

- LHC/HL-LHC, FCChh,…
- Lepton Colliders – ILC, CLIC, CEPC, FCCee, …
- EIC

Neutrino experiments

- DUNE
- neutrinoless double-beta decay (CUORE, nEXO)
- MINOS, SuperNEMO, NovA

Low Energy Experiments

- Mu2e, EDM, rare decays

Dark Matter Search Experiments

- veto (e.g. LZ)
- future G3 concept

Experiments in Space

- AMS

Snowmass 2021
Instrumentation Frontier Calorimetry

-> 29 colleagues have subscribed to SNOWMASS-IF-06-CALORIMETRY so far

-> Continue/complete contacting collaborations

-> Encourage/monitor LOIs (Only one so far…)

-> Discussing plans for a general Instrumentation/Calorimetry meeting

-> Conveners meeting bi-weekly

Instrumentation Frontier Calorimetry

- Collecting/reviewing existing and proposed calorimeter designs
- Input from CPAD, BRN,…
- Extensions of calorimeter designs (e.g. PFA with timing, PID)
- Identify promising areas for future R&D
- Understand potential for future physics performance

Instrumentation Frontier Calorimetry

TODAY:

-> Some examples from expressions of interest (mainly via email so far), and our own areas of research

-> Status of calorimeter projects, ongoing R&D, promising areas for future R&D

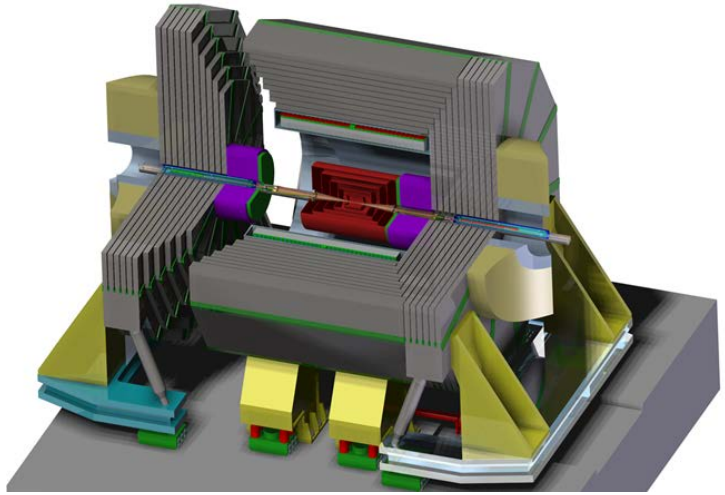
-> Not an unbiased selection!

International Linear Collider - Calorimetry

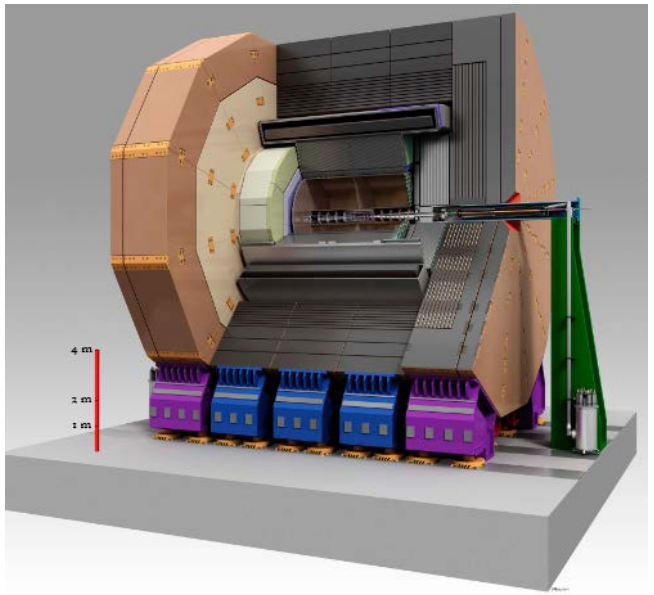
As an example – many parallel developments for CLIC, CEPC, FCC,…

Two detector concepts:

Silicon Detector



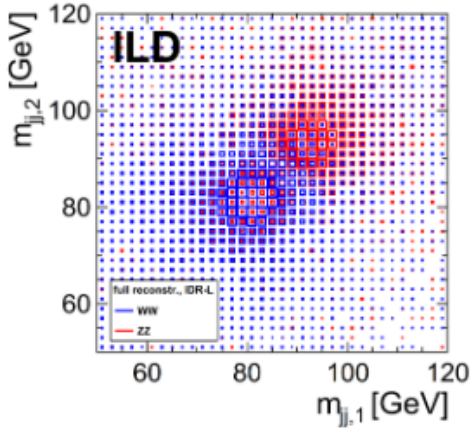
International Large Detector

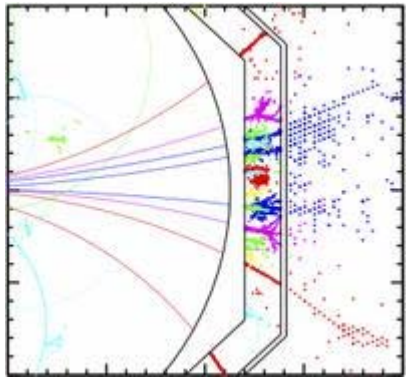


Both detector concepts are based on Particle Flow.

Simulations have shown that e.g. jet energy resolution goals can be achieved.

But…these designs have been proposed for many years and there is room for improvements, new ideas, system integration, detailed studies of design impacts on physics (systematics…).

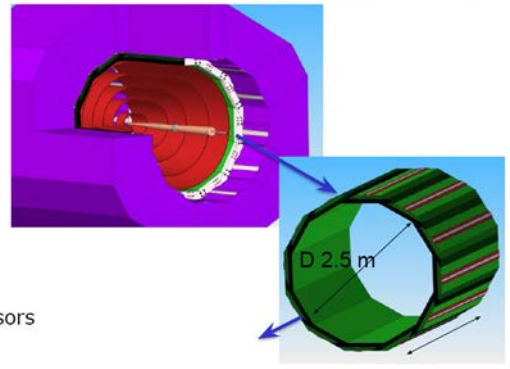




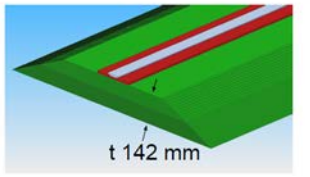
ILC Electromagnetic Calorimetry

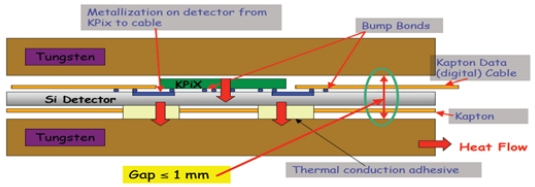
SiD

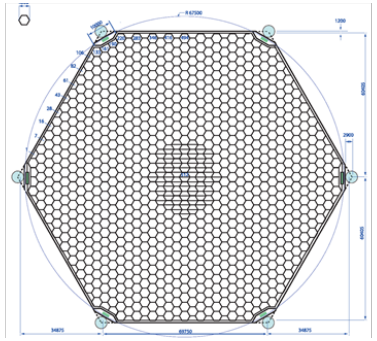
Compact Electromagnetic Calorimeter w 13 mm Moliere Radius



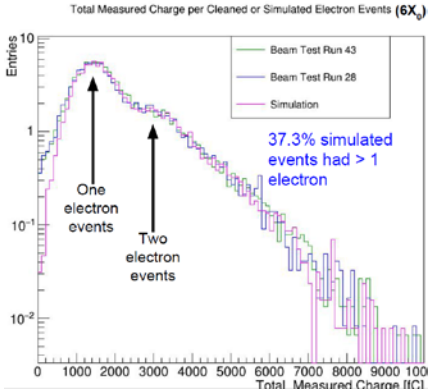
20 layers 2.5 mm W (5/7 X0)
10 layers 5 mm W (10/7 X0)
30 gaps 1.25 mm w Si pixels sensors
29 X_0; 1 λ
$\Delta E/E = 17\%/\sqrt{E}$

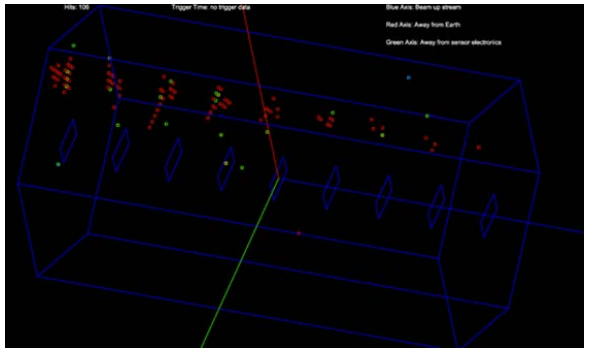




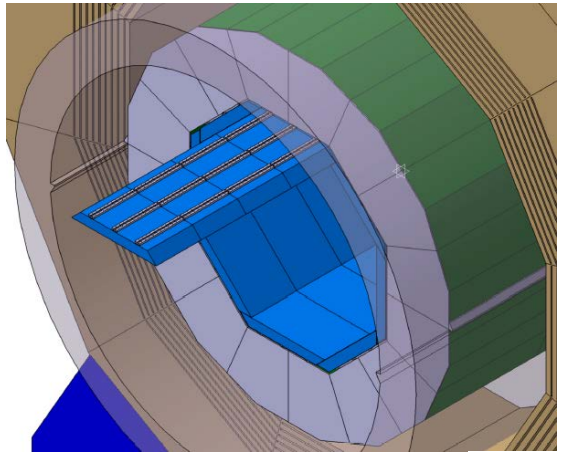


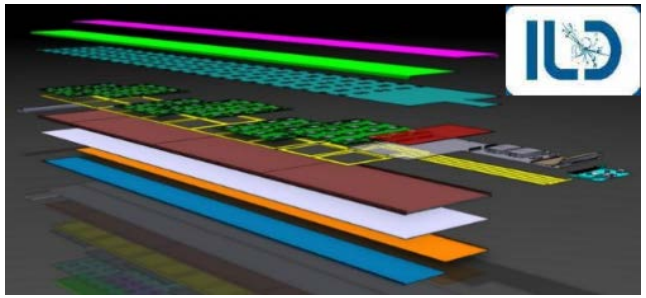
- Well developed designs, prototypes, ongoing R&D, but…
- Ultimate granularity?
- e.m. resolution
- Calibration, monitoring, systematics,…
- System integration with TRK, HCal
- Issues for higher energies, cost

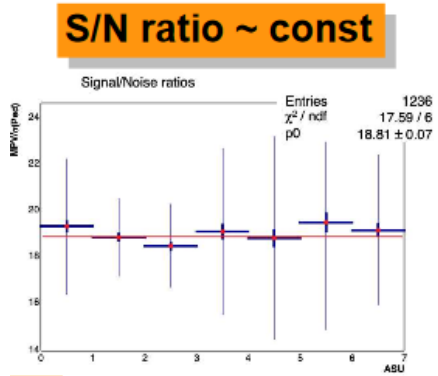


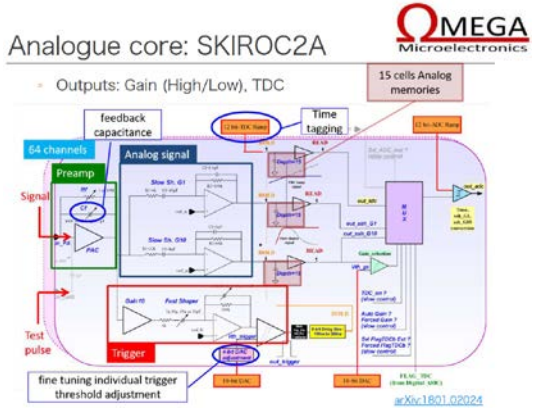


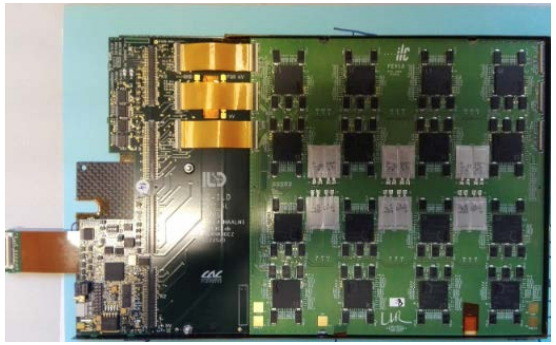
ILD





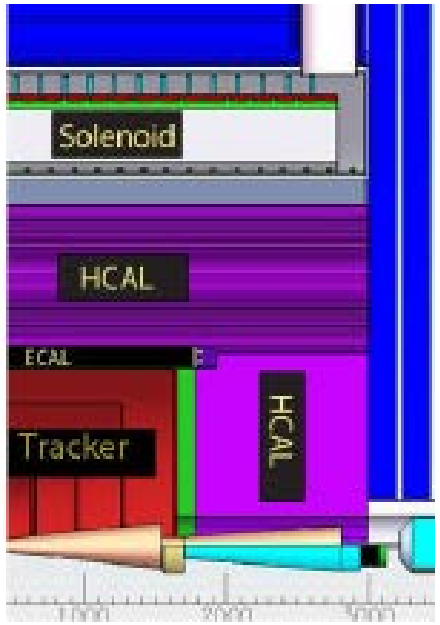


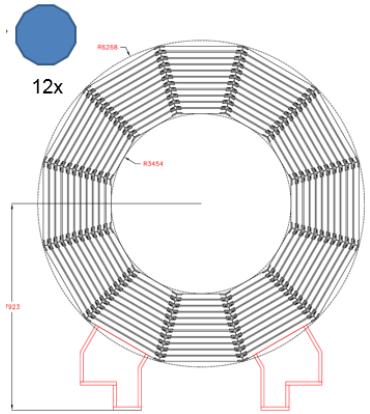


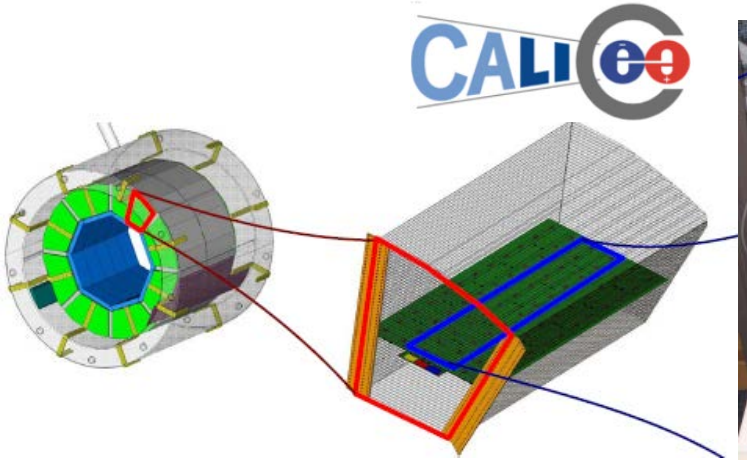


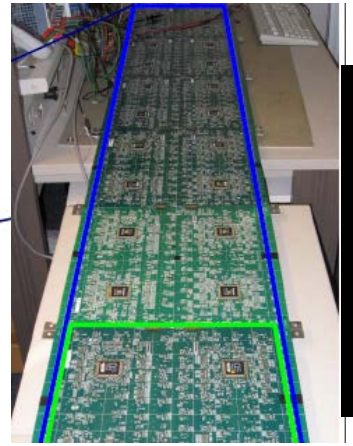
ILC Hadronic Calorimetry

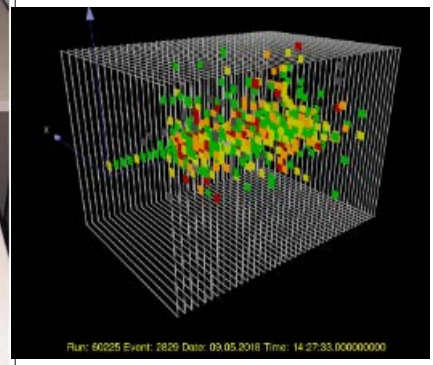
SiD



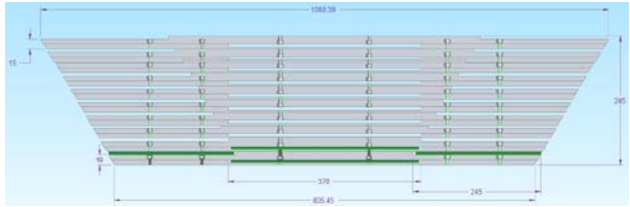


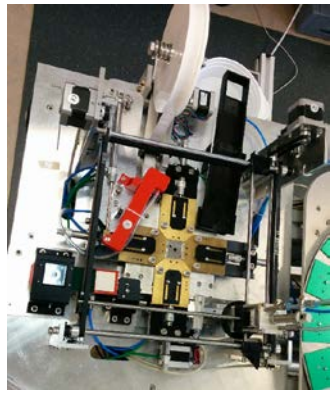


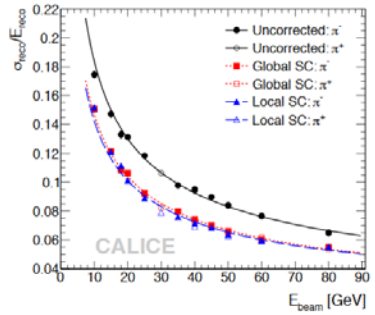




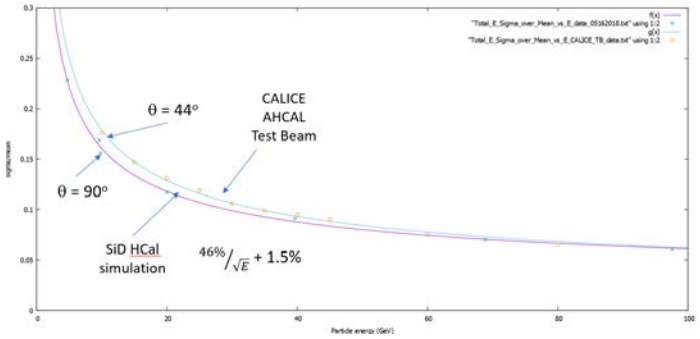
- Design and performance verified through major CALICE Test Beam campaigns
- …system integration (TRK+ECal+HCal), depth (higher energies), cost (HCal and SC coil), timing,…
- Need to study calibration, monitoring, systematics affecting e.g. for < 1% limits on Higgs couplings,…

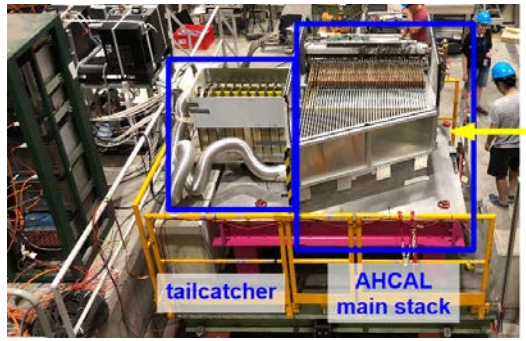




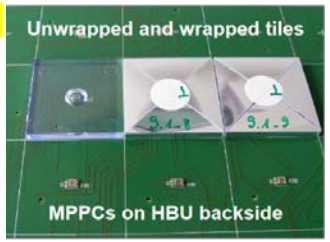


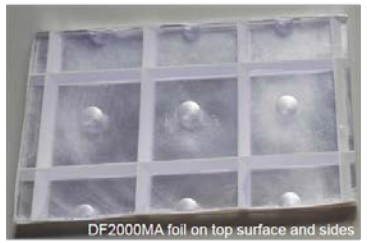
$\sigma/E = 45.1\%/\sqrt{E} \oplus 1.7\% \oplus 0.18/E$



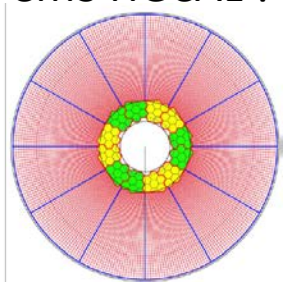


beam





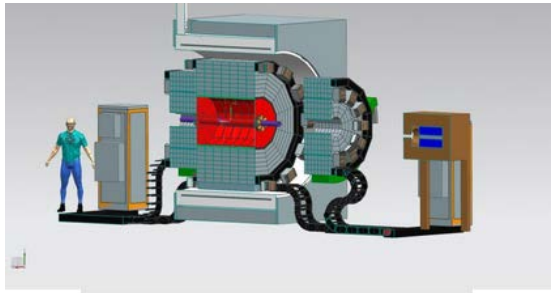
CMS HGCAL !

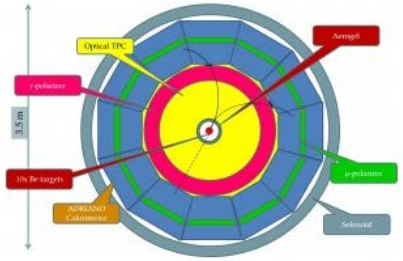


Instrumentation Frontier Calorimetry

REDTOP Experiment

High statistics study of η, η' mesons

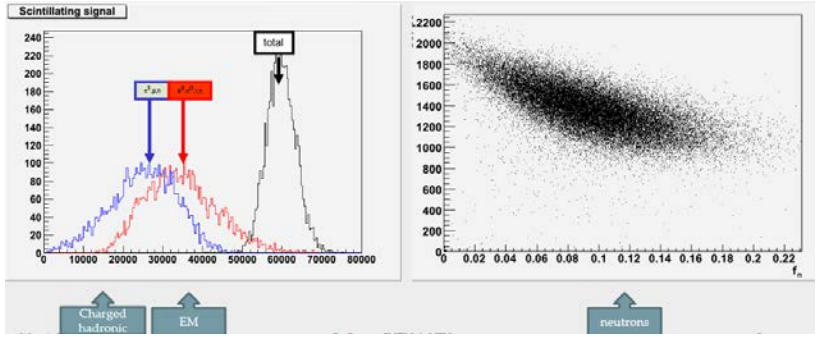




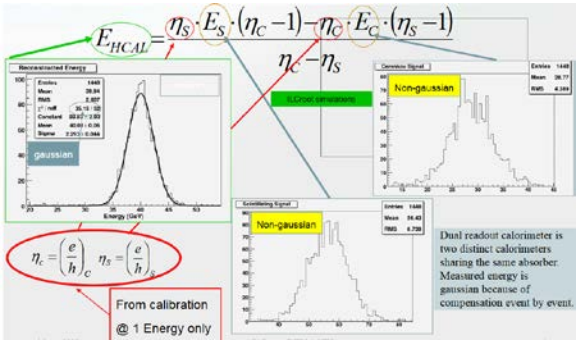
C.Gatto -INFN&NIU

Incorporates ADRIANO Dual-readout calorimeter

Multiple readout calorimetry

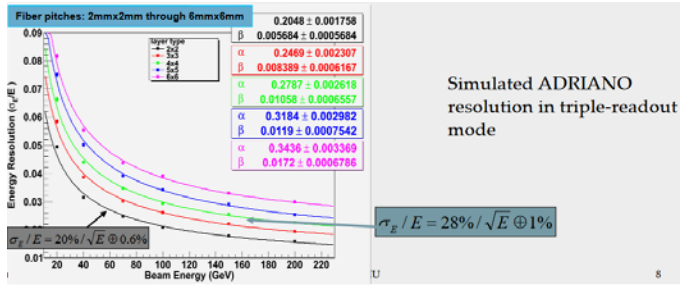


Dual-readout



+ neutron component

Triple-readout



PRD #1 High precision 5D calorimetry with a resolutions of ~15%/√E EM and ~35%/√E hadronic and shower ΔT < 30 ps for linear and circular e^+e^- machines.
Timescale ready in 10 years.

PRD #2 High precision 5D calorimetry for *hh* machines with an EM resolution of < 10%/√E and <30%/√E hadronic ΔT < 5 ps in an irradiation environment of > 10^{17} n/cm^2.
Timescale ready in 20 years.

PRD #3 Ultrafast calorimetry media with order 1 ps precision for low-energy electrons and photons.

Snowmass 2021
Instrumentation Frontier Calorimetry

Plans

-> Build up mailing list

-> Review inputs from LOIs, CPAD, BRN, ESPP,…

-> Plan dedicated IF/Calorimetry topical discussions

-> Request slots at Instrumentation Workshops, Physics Conferences

-> Build up profile of potential future R&D areas