

SDHCAL and ILD/CEPC activities in Lyon

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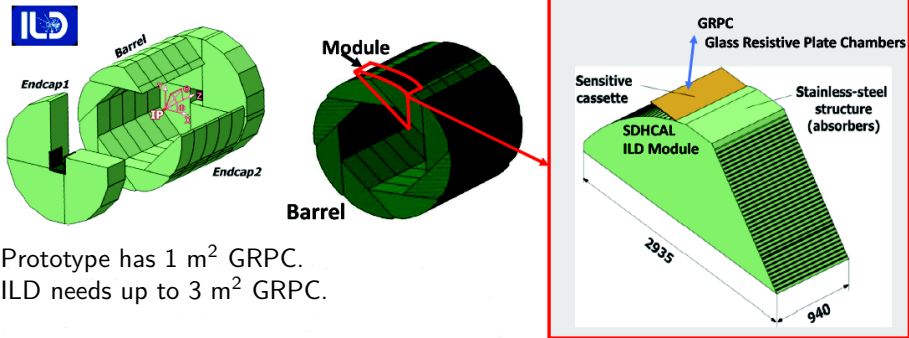
IPN Lyon

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Introduction

The talk will focus on current hardware and software activities. For software, it will also list available software tools and their status. Recent reduction in manpower (Guillaume Garillot, Rémi Ét', ...) is impacting future maintenance.

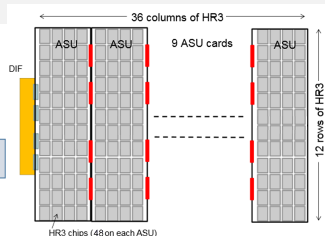
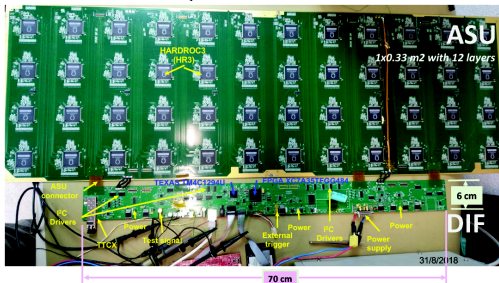
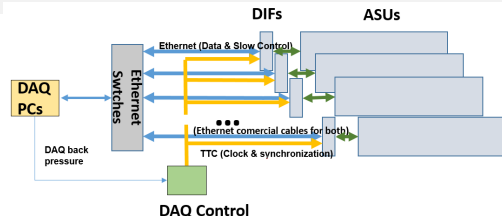
SDHCAL developments



Prototype has 1 m² GRPC.
ILD needs up to 3 m² GRPC.

- A mechanical structure, realised by CIEMAT, able to handle 5, 1 × 3m² GRPC cassettes is stored in Lyon.
- No tools to move it.

New electronics

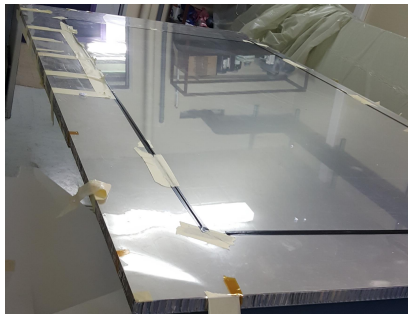


- 1 DIF can handle up to 432 HR3.
- Front end PC on the DIF.
- DIF-ASIC communication through I²C links.

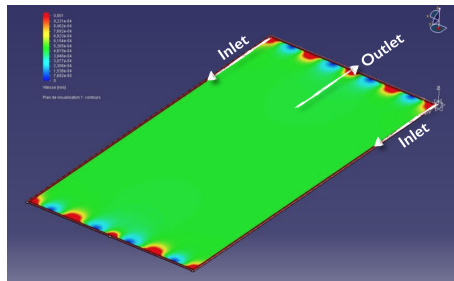
DIF-ASU integration on hold due to lack of manpower.

Larger GRPC

2 m² RPC assembled



Scalable gas distribution



CEPC

Adapt SDHCAL prototype to other leptonic collider projects (CEPC, FCC).
Circular colliders works continuously. No power-pulsing.

- Studies to design cooling in SDHCAL with minimal impact on budget material non-uniformity (Imad, Jean-Christophe).
- Change electronics to displaced reading ASIC outside the SDHCAL structure. New PCB : Tricot electronics.

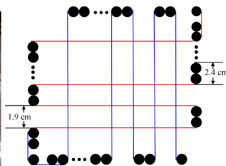
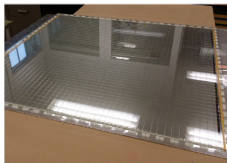
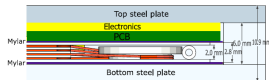
Tricot electronics

- Originally developed for projects with very large area (100 m²) GRPC.
- Designed, patented, and few realised.
- Reduced number of ASICs : cost and consumption effective.

Timing

Timing ASIC

- PETIROC ASIC (< 20 ps time jitters) developed for CMS muon upgrade.
- Design of multi-gap GRPC, tested with SDHCAL ASU.
- Multi-gap also for higher detection rate (also looking for lower resistivity and/or thinner electrodes)



Data reconstruction

Trivent or EventBuilder

- The raw data output has a collection of LCIO RawCalorimeterHit for each LCEvent. 1 LCEvent = 1 readout = many particle-detector interaction (physics event).
- Trivent (EventBuilder) is the software to split readout LCEvents in physics events.
- It usually also converts raw data to CalorimerHit (with position).
- There are many Trivent codes available.

Streamout

- Streamout is the conversion of raw data buffers into LCIO RawCalorimeterHit collection.
- Now done by the DAQ.
- Step needed offline to reprocess older data.

Trivent

- <https://github.com/ggarillot/Trivent> Marlin Processors, include streamout, used for latest SDHCAL test beam analysis (Guillaume Garillot, Bing Liu), SDHCAL proto only. (C++)
- <https://github.com/apingault/Trivent4HEP> Marlin processors, include streamout, used for Antoine Pingault's analysis. (C++)
- <https://github.com/SDHCAL/EventBuilder> Original Trivent, Marlin processors, bloated code, some support for CMS strip electronics, no more in use. (C++)
- <https://github.com/flagarde/GRPCAnalysor/tree/master/src> used by Franois Lagarde analysis at GIF++ (pad+CMS strip), depends only on ROOT (will install LCIO and a lightweight Marlin (Marlino)), include streamout. (C++)
- https://github.com/SDHCAL/GRPC_RawHit_Readout_Analyse, depends on LCIO and ROOT only, supports PAD+CMS strip (partially)+Tricot (Coming soon) electronics. No streamout. Used by G.G. for analysis. (C++ & Python)

Trivent software summary

Code	dependence	streamout	electronics	status
Trivent	full ilcsoft	yes	PAD in SDHCAL	recent
Trivent4HEP	full ilcsoft	yes	PAD	???
EventBuilder	full ilcsoft	yes	PAD	abandoned
GRPCAnalysor	ROOT	yes	PAD+strip	recent
GRPC_RawHit_Readout_Analyse	ROOT, LCIO	no	PAD+strip+tricot	active

Testbeam data analysis

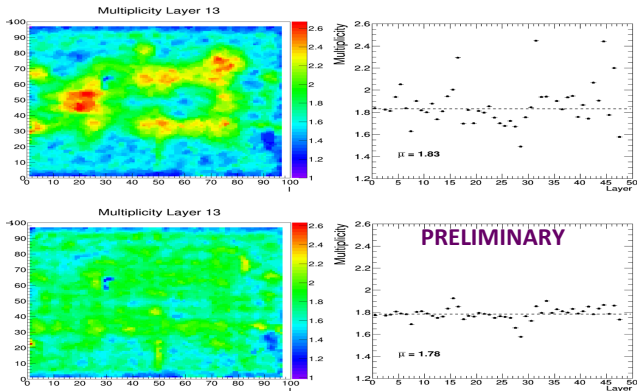
Analysis activities are mostly related to last (september 2018) test beam

Some SDHCAL raw data are on CERN [/eos/project/s/sdhcal/data/](https://eos.cern.ch/project/s/sdhcal/data/)

- Uniformity study : started by Guillaume, pursued by Bing.
- Energy reconstruction :
 - low energy (Bing)
 - high energy (done, orphaned)
 - software compensation (orphaned)
 - AI tools : deep learning, ... (not started)
- SDHCAL-SiWECAL analysis
 - Production of root-tree for common SiWECAL-SDHCAL.
 - Done for SiWecal in CERN
[/eos/project/s/siw-ecal/TB2018-09/Common/ECAL](https://eos.cern.ch/project/s/siw-ecal/TB2018-09/Common/ECAL)
 - Not yet done for HCAL (GG : coming soon from Trivent/ and GRPC_RawHit_Readout_Analyse)
 - Analysis itself (not started)

GRPC uniformity

- Efficiency and multiplicity varies. Can be measured per layer, per ASIC, per pad, depending on statistics
- SDHCAL : Equalize response by adjusting ASIC thresholds or gains.



SDHCAL simulation

Prototype simulation

- Stand alone GEANT4 application :
<https://github.com/SDHCAL/SDHCALSim>
- Fully rewritten by Guillaume Garillot in main branch.
- A second branch that was for CMS-GIF++ studies.
- ongoing activities : dead time simulation study (GG + student intern David Gential) based on GIF branch.
- Wish list for main branch (orphaned)
 - Have absorber material configurable.
 - Add Interactive+visualisation Mode.
 - Incorporate GIF branch Particle Source

ILD simulation

DD4HEP based, written and maintained by Tibor Kurca.

Digitizer

Status

- simulate GRPC+electronics response to Geant4 steps.
- Originally developed by GG+Arnaud Steen. Rewrote by Guillaume Garillot.
- Part of MarlinReco <https://github.com/iLCSoft/MarlinReco/tree/master/CaloDigi/SDHCALDigi>
- Compatible with ILD and prototype simulation.

current issue

- recent development to allow modulation in multiplicity response.
- For that, change the charge spread from a 2-width function to a single-width function.
- However, electron data less well reproduces by single-width.

Need to combine modulation in multiplicity with 2-width charge-width function.
Idea=modulate multiplicity with the larger width. (not started)

Optimisation studies

Change cell size

- Can be done at simulation or at digitizer level.
- More flexible at digitizer level.
- Geometry description might be a bit tricky.
- not started, maybe Bing Liu+GG.

Timing studies

- Use hit time information at sub-ns resolution for shower reconstruction.
- started by Guillaume Garillot, orphaned.

PFA

APRIL : the SDHCAL PFA for ILD

- Original ARBORPFA developed by Rémi Été using PandoraPFA.SDK.
- Currently developed by Bo Li.
- Will be orphaned this autumn (Bo's end of contract).

Other activities and plan

- Clustering comparison using Rand index (started, GG)
- Clustering with Minimal Spanning Tree (planned, GG)
- AI methods in PFA
 - inside algorithm : in APRIL (Bo Li)
 - for configuration (planned GG)
- PFA studies at generator level (started GG student intern Antoine Armatol)

Physics analysis

- Support by Lyon (simulation Tibor Kurca, ILD Analysis GG)
- ILD Higgs decay study by Guillaume Garillot (orphaned)
- Planned for CEPC (Bing Liu)

Outlook

Lots of development are being followed. Rooms to get involved. Don't hesitate to pick up one activity.

Backup

Simulation

Simulating GRPC response

For each crossing charged particle :

- Start an avalanche with a probability corresponding to the measured efficiency.
- Generate an avalanche charge according to a Gamma probability law.
- Correct the charge depending on the crossing angle.
- Spread spatially the charge to reproduce the observed mean multiplicity.
- If crossing particle are too close, generate only one avalanche.
- Sum all contribution for each pad and apply thresholds.

Parameters are tuned from muon and electron data and can be varied at different locations to reproduce efficiency and multiplicity maps.

