Doing Physics with novel Detectors at LHC and beyond

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Leadership: experiment drives theory

Leading HEP topics:

- Explore experimentally the Higgs sector: VH, VBF processes.
  - Priority to Higgs to $\gamma\gamma$ final state.
- **Leading now**: the CMS VH first observation in $\gamma\gamma$ (~135/fb)
- **Leading now**: the CMS Heavy diphoton resonance search.

How to continue doing cutting edge research:

- Develop novel detectors/techniques to do the discoveries.
- Detectors/Techniques for non-collider searches (eg DM)
  - Bolometers, UV, X-ray sensors for new experiments.
- Applications benefiting society:
  - Initiated a collaboration with NCU Earth Sciences

Building parts in Taiwan can benefit local economy (electronics)
NTU Leadership in HGCAL

In just 4 years we managed to:

- Assume leadership in the management
- Setup a detector assembly center (MAC)
- Lead the test-beam analyses of prototypes, write papers.

Future 8 to 10 years:

- Build and Commission HGCAL.
- Lead the Calibration efforts.
- Lead the physics analyses in CMS (Higgs, SM and BSM)
- Explore new techniques Machine Learning, Particle Flow.

HEP approach of success: first goes the Project and then comes the Physics (cannot rise in the experiment without leading a hardware project)
Taiwan MAC

- Facility commissioned in March 2019
- In April/19 we assembled a full module.
- On-going R&D in tooling, bonding, encapsulating, biasing.

Milestone: completed a 3-year setup/commissioning phase
Current Opportunities (non-CMS)

- CEPC Calorimetry: student opportunity
  - I have setup a G4 simulation that can run crystal, scintillator, silicon HGCAL type calorimeters or hybrids.

- We have been officially asked to join IAXO experiment (Light Axion-like European search)
  - No subscription needed
  - PhD Student is a possibility (presence in DESY necessary)

- Develop sensors for DM and other searches.
  - Bolometers
  - Gaseous THGEM-type sensors

- Collaboration with Earth sciences to place large area sensors in Earthquake stations
Would like to bring together PP and Particle Astro (PPPA) if possible.
We will be building a novel 5D Si-Sampling Calorimeter. As well as detectors for upcoming International Projects.
Extra Slides
Key Parameters (updated from the TDR):
- HGCAL covers $1.5 < \eta < 3.0$
- Full system maintained at -30°C
- ~640 m$^2$ of silicon sensors
- ~370 m$^2$ of scintillators
- 6.1M Si channels, 0.5 or 1.1 cm$^2$ cell size
- 240k scintillator-tile channels ($\eta$-$\phi$)
- Data readout from all layers
- Trigger readout from alternate layers in CE-E and all in CE-H
- ~31000 Si modules (incl. spares)

Active Elements:
- Si sensors (full and partial hexagons) in CE-E and high-radiation region of CE-H.
- SiPM-on-Scintillating tiles in low-radiation region of CE-H

Electromagnetic calorimeter (CE-E): Si, Cu/CuW/Pb absorbers, 28 layers, 25.5 $X_0$

Hadronic calorimeter (CE-H): Si & scintillator, steel absorbers, 22 layers, ~9.5$\lambda$ (including CE-E)
HGCAL is an imaging Calo

This talk

250 GeV π

CE-E  CE-H-Si  CALICE AHCAL
There are two general classes of calorimeter:

**Sampling calorimeters:**
Layers of passive absorber (such as Pb, or Cu) alternate with active detector layers such as Si, scintillator or liquid argon.

![Diagram of sampling calorimeter](image)

**Homogeneous calorimeters:**
A single medium serves as both absorber and detector, eg: liquified Xe or Kr, dense crystal scintillators (BGO, PbWO₄ .......), lead loaded glass.

![Diagram of homogeneous calorimeter](image)
HGCAL is an imaging Calo

June 2018 run 407 - event 1:

“150 GeV e-“