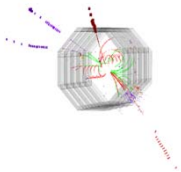
Status of HCAL

Hongbang Liu (on behalf of the CEPC-HCAL Group)

University of Chinese Academy of Sciences

廣西大學

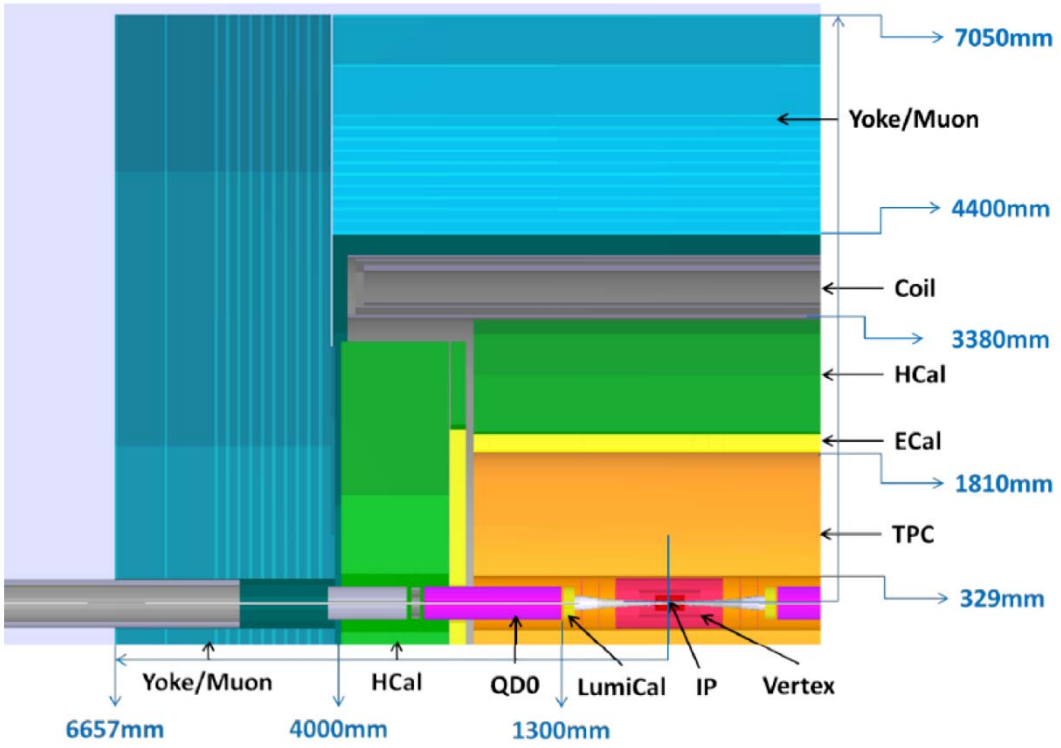
CEPC-SPPC Symposium
April 8-9, 2016

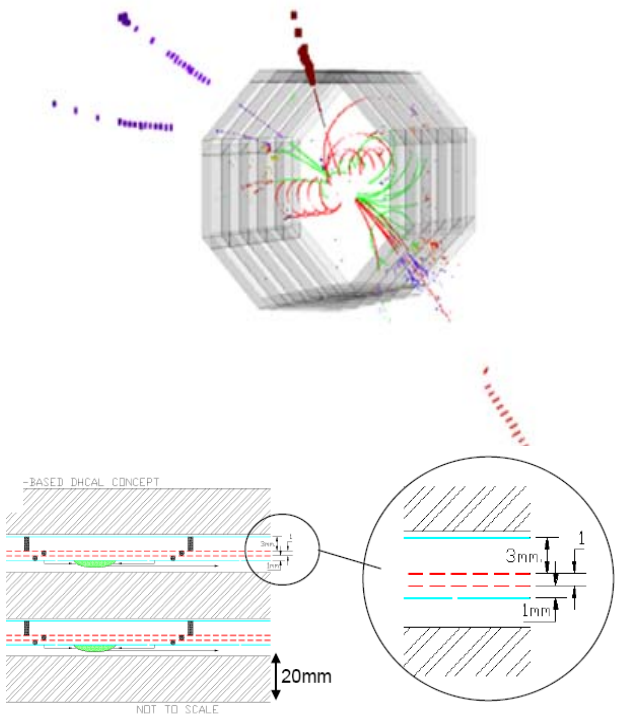


Outline

- Motivation
- Hadron Calorimeter
  - RPC
  - THGEM
  - GEM
- Electronics
- Simulation & Optimization
- Future plan for CEPC HCAL

HCAL-CEPC



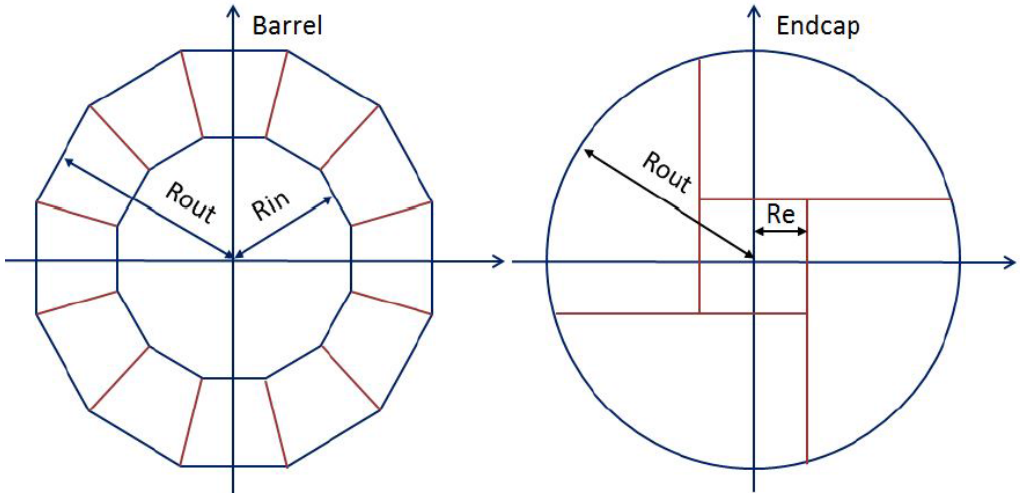


Requirements for calorimeter:
- inside the coil,
- with thin active medium,
- with extremely fine segmentation

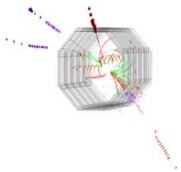
RPC, GEM, THGEM as sensitive detector for HCAL.

Hadron Calorimeter

- The HCAL consists of
  - a cylindrical barrel system: 12 modules
  - two endcaps: 4 quarters
- Absorber: Stainless steel

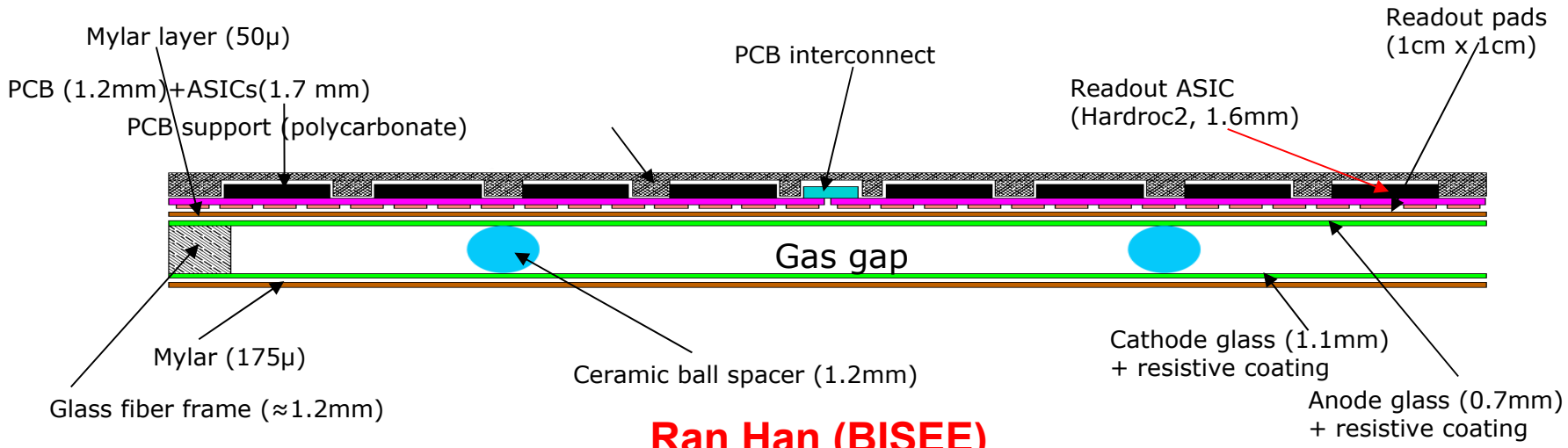


- **Active sensor**
  - 6mm thickness
  - MIP detection efficiency 95%
  - RPC
    - 1×1 m^2
  - Thick GEM or GEM
    - 0.5×1 m^2
    - 1MHz/cm^2
- **Readout (1×1 cm^2)**
  - Digital (1 threshold)
  - Semi-digital (3 thresholds)



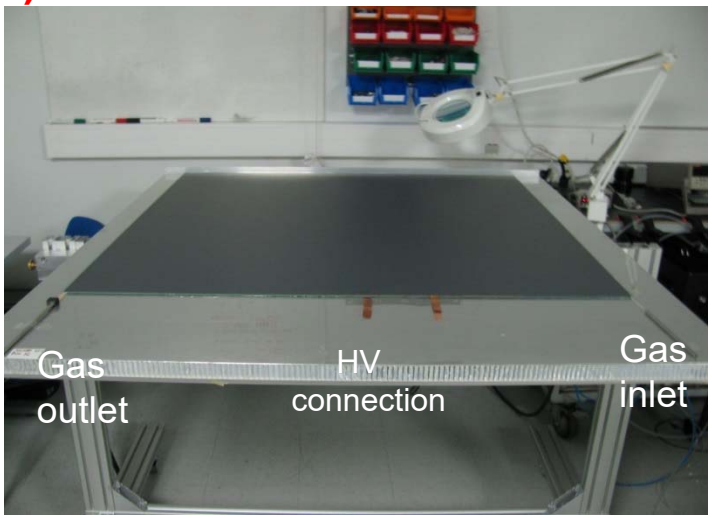
- HCalo detector group meeting
  - IHEP、SJTU、UCAS、GXU、XJTU、BISUU 、…
  - http://indico.ihep.ac.cn/category/322/
- Calo-Optimization group meeting
  - IHEP、SJTU、UCAS、…
  - http://indico.ihep.ac.cn/category/355/

Large GRPC R&D



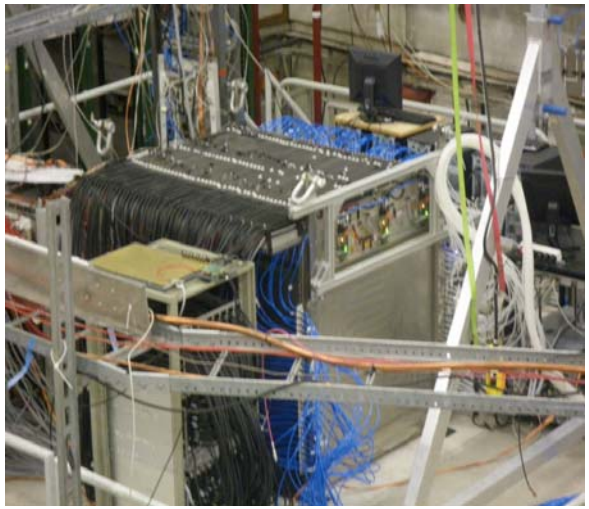
- Negligible dead zone (tiny ceramic spacers)
- Large size: 1×1 m^2
- Cost effective

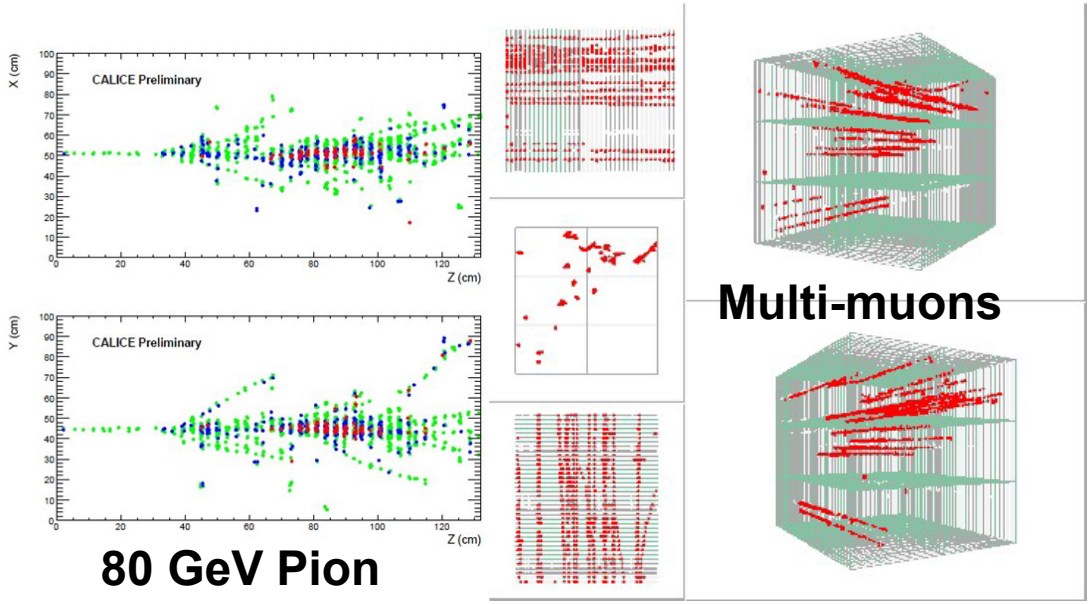
Ran Han (BISEE)



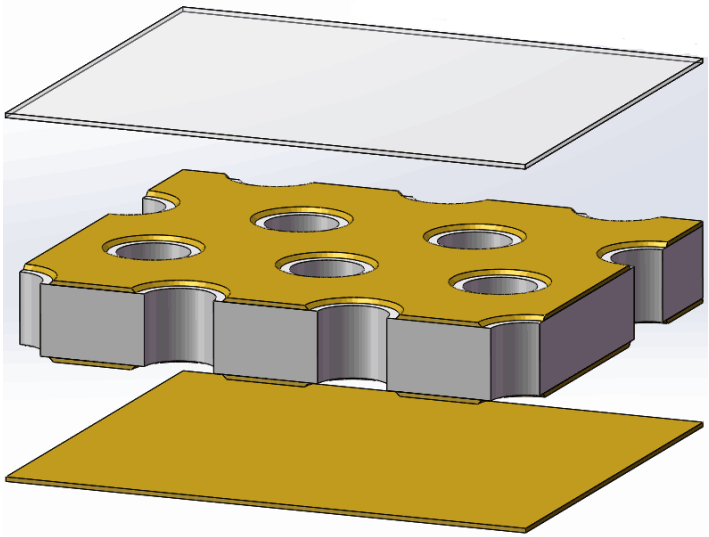
Prototypes of DHCAL with RPC

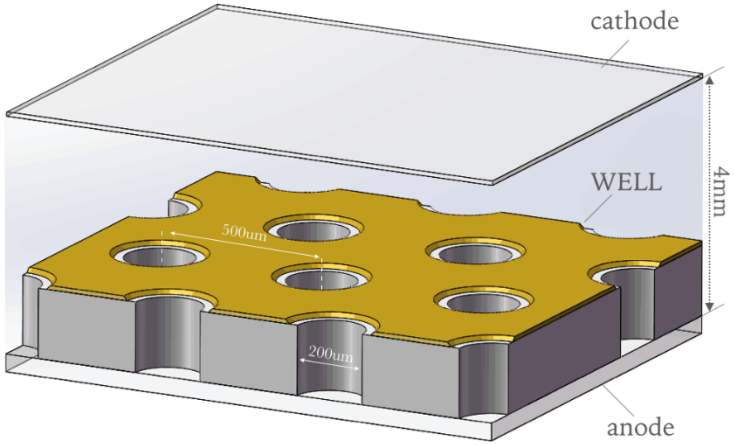
- **Prototypes of DHCAL based on RPC**
  - **ANL (J. Repond, L. Xia et.al.)**
    1m^3, 3 thresholds, TB at CERN in 2014.12
  - **IPNL (I. Laktineh, R. Han et.al.)**
    1m^3, 1 threshold, TB at CERN/Fermilab

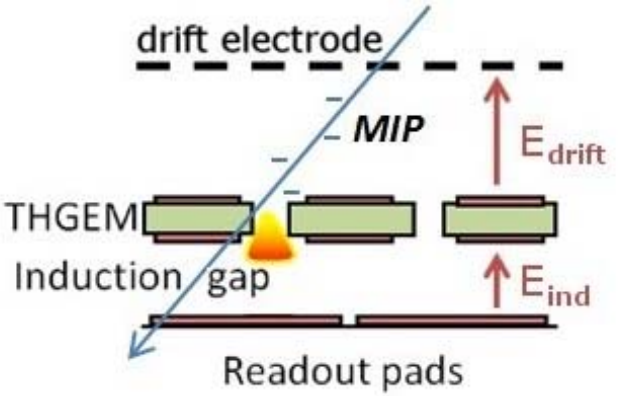


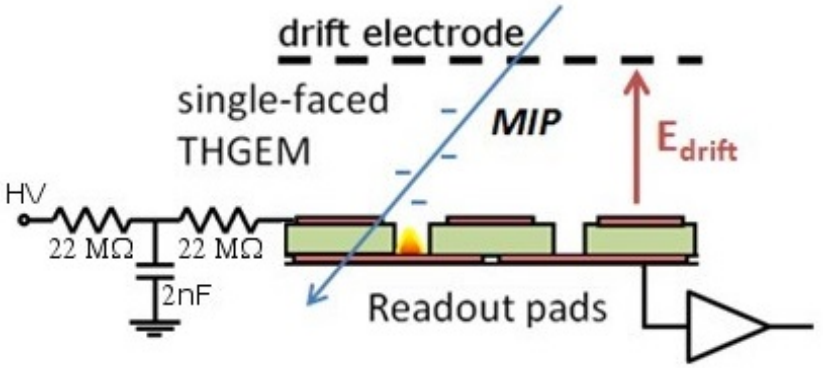


THGEM & Well-THGEM

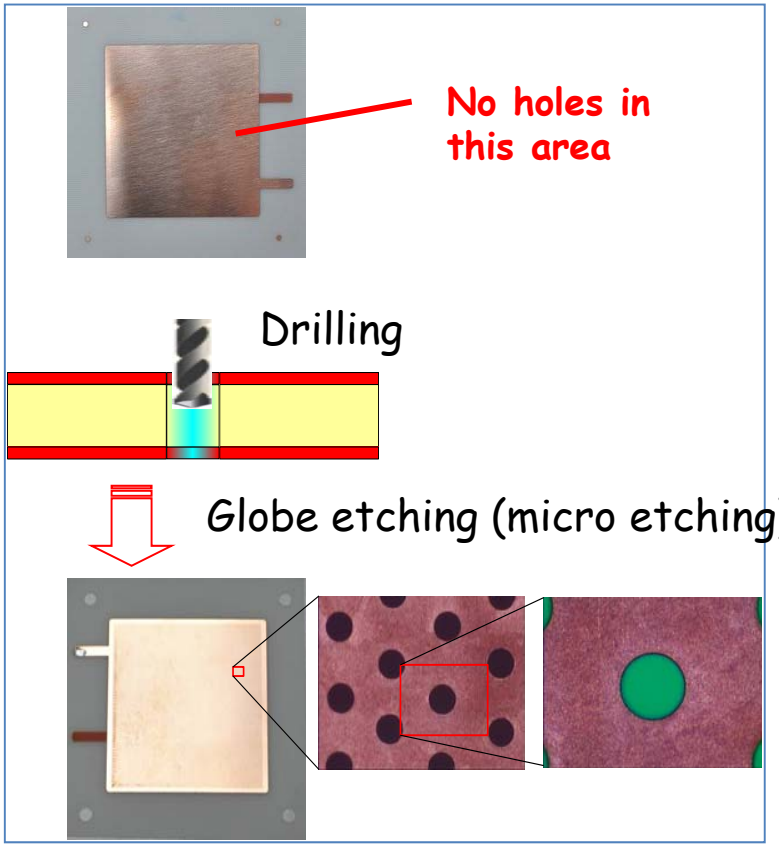




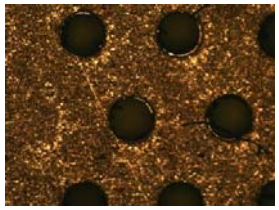
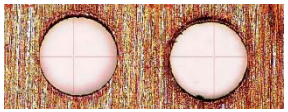




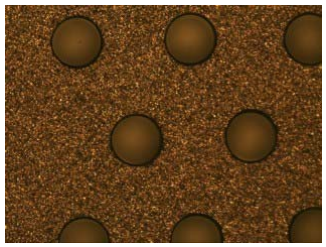
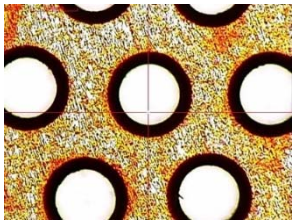
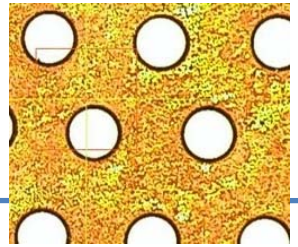
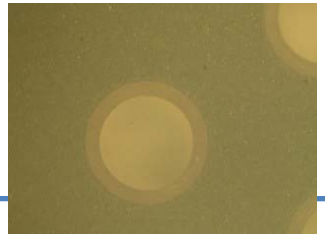
THGEM production



1. Mechanical drilling or laser drilling

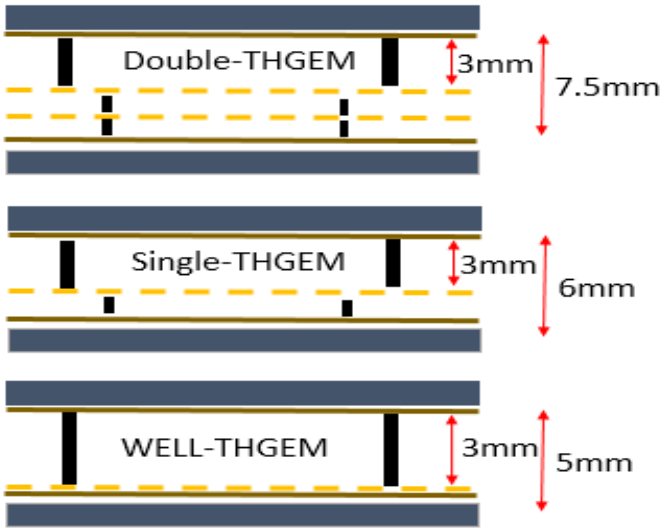
2. Etching：
   globe etching,
   mask etching,
   electrical chemical etching

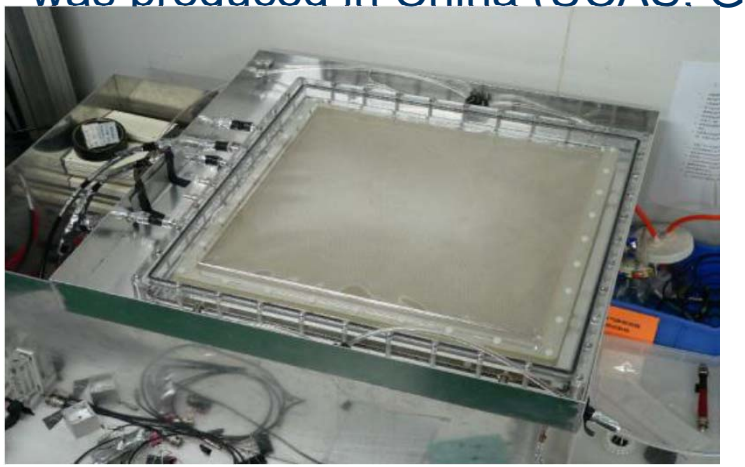





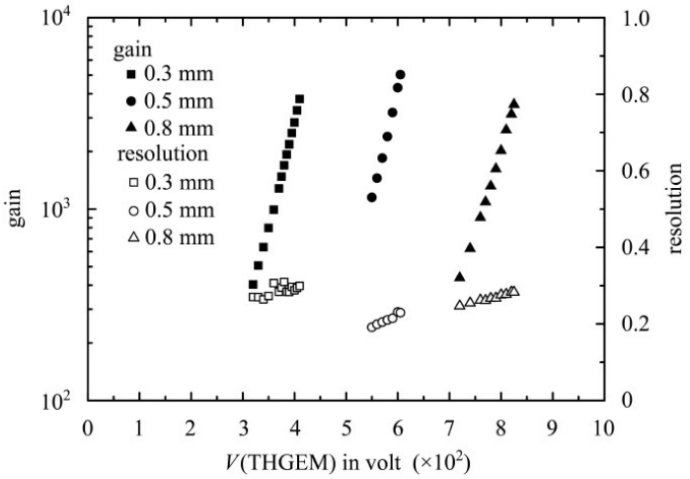
DHCAL based on THGEM

Boxiang Yu (IHEP)

- Four THGEM options are explored:
  - Double - THGEM
  - Single - THGEM
  - WELL – THGEM
  - Hybrid - THGEM
- WELL-THGEM is optimal choice
  Thinner, lower discharge
- 40 ×40 cm^2 of THGEM (below)
  was produced in China (UCAS, GXU, IHEP)

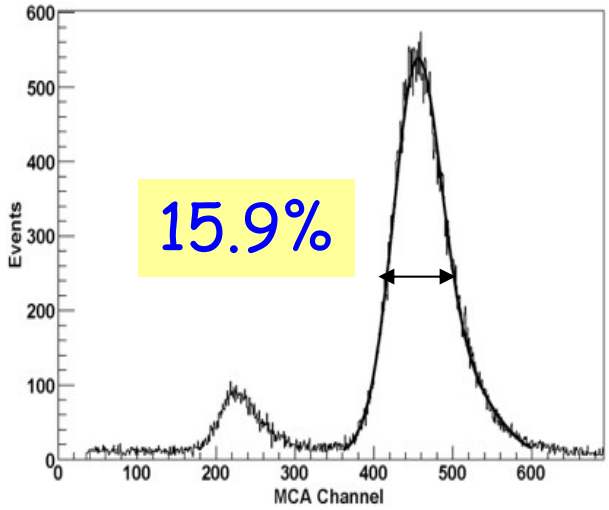


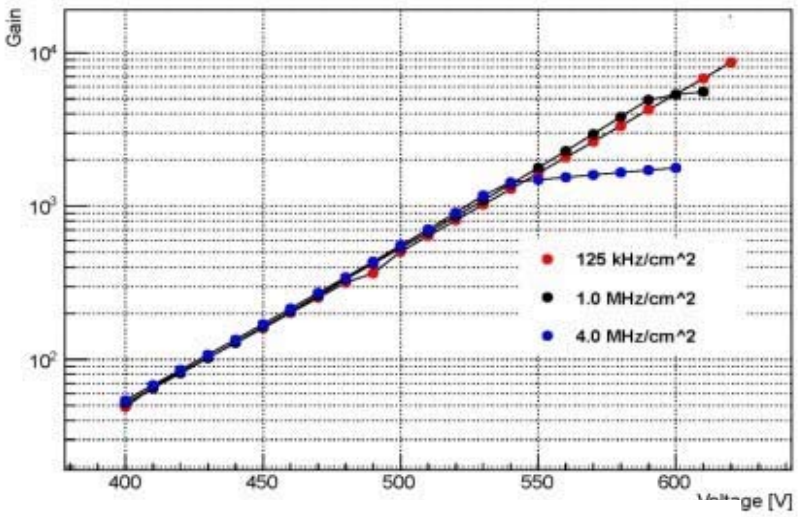


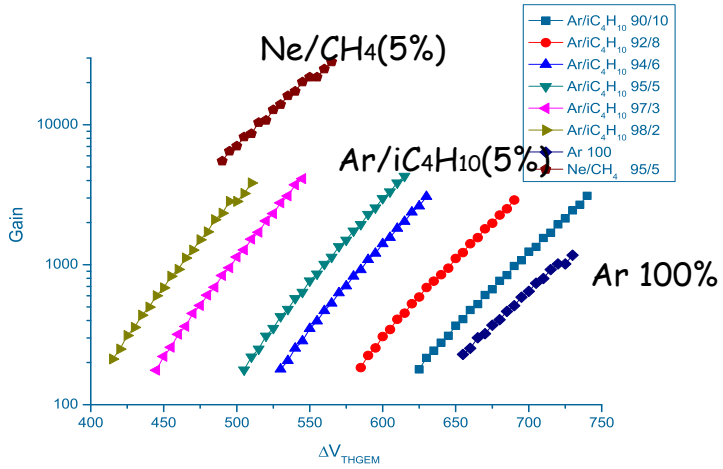


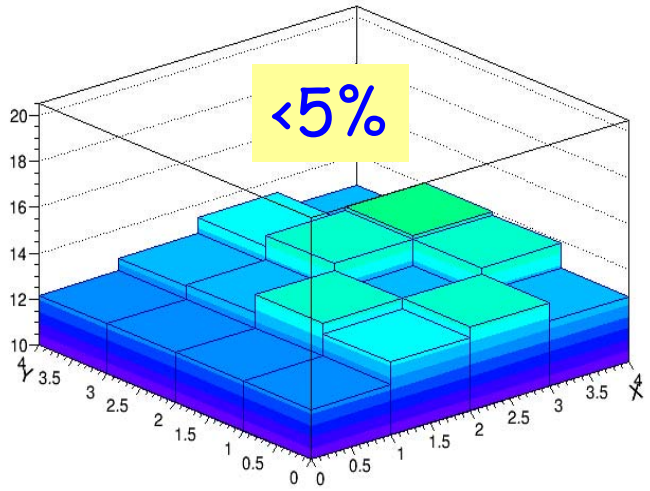
Performance of THGEM

H. Liu , Q. Liu (UCAS , GXU)



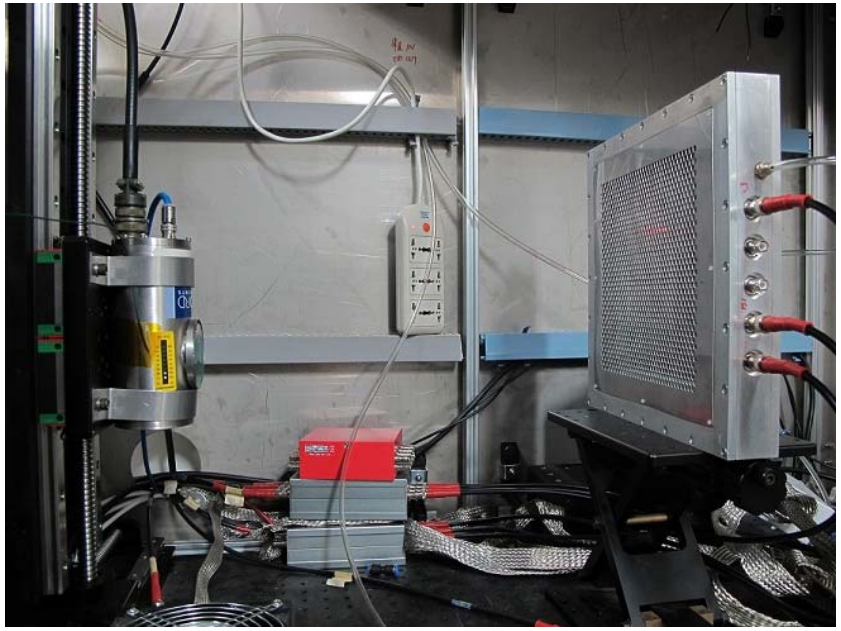




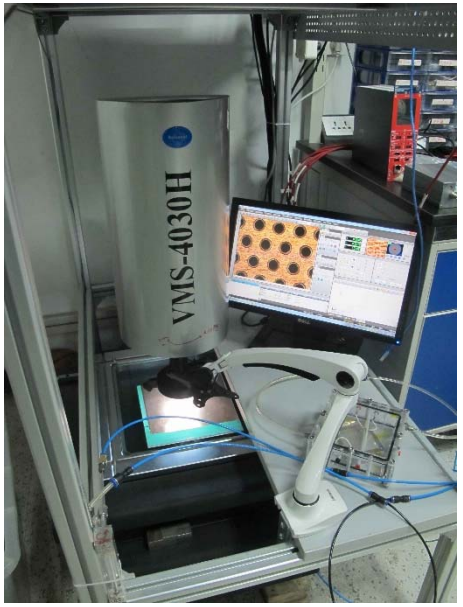


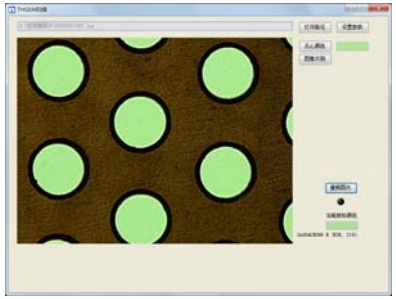
Large area THGEM Testing @UCAS

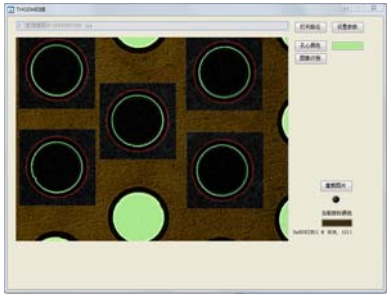
Gain Uniformity Scan



THGEM Microtopography Analysis





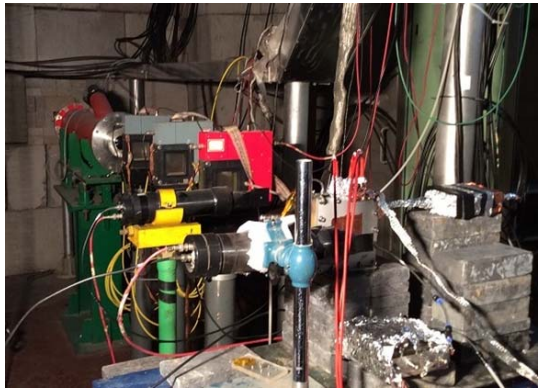


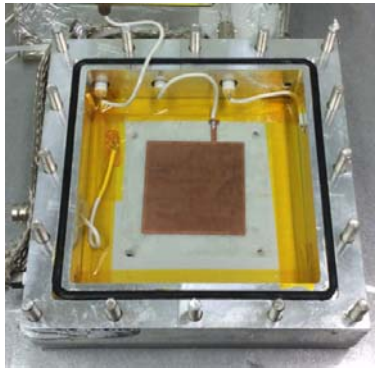
- Gain Uniformity Testing
  - Scan area 60×60 cm^2

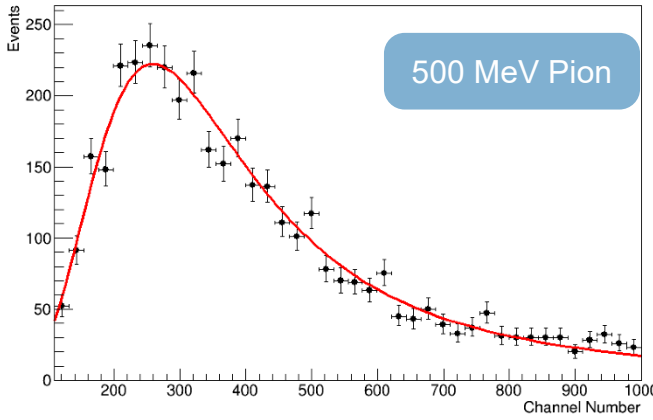
- Microtopography Analysis
  - Scan area 30×40cm^2
  - Find the imperfect holes automatically

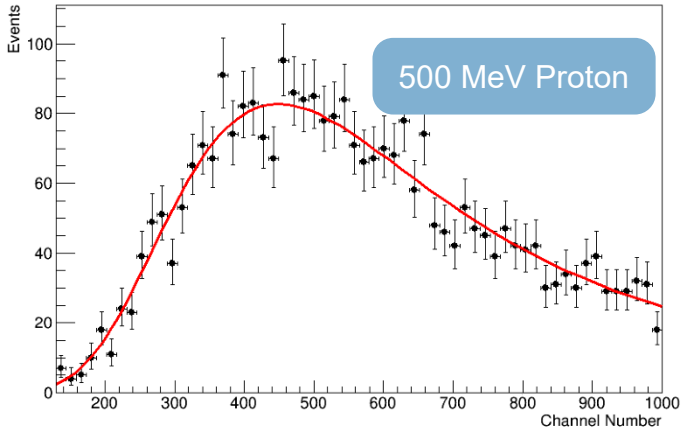
Beam test

- The detection efficiency of well-THGEM was measured with the BEPC pion and proton beams.
- Efficiency:
  - Ar/iso (97/3) ,Gain ~ 2000; Eff (proton) > 93%; Eff(Pion) > 82%
  - Ne/CH4 (95/5) ,Gain ~ 9000; Eff (proton) > 99%; Eff(Pion) > 94%





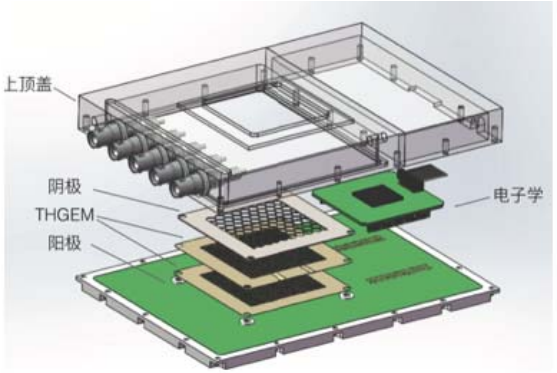


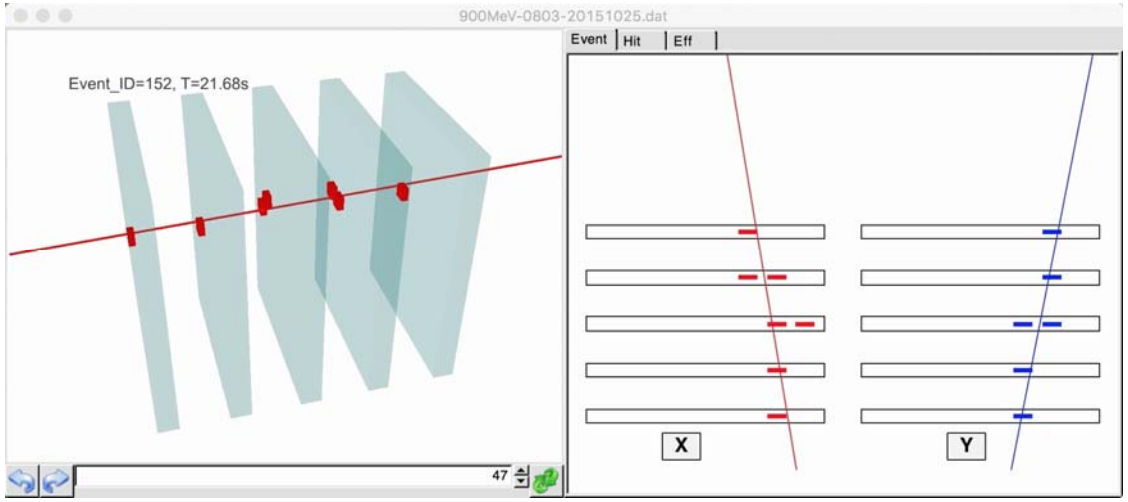


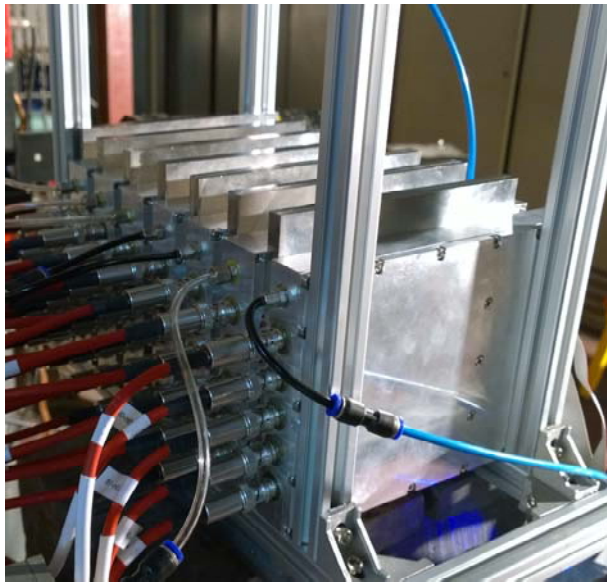
THGEM Beam Test in Oct., 2015

S. Chen , W. Huang(UCAS)

- 7 THGEMs ware installed, 5 of them were used, and flushed with Ar/iso-butane = 97:3.
- 1 threshold, binary readout
- 900 MeV proton/pion beam used
- 5cm x 5cm sensitive region



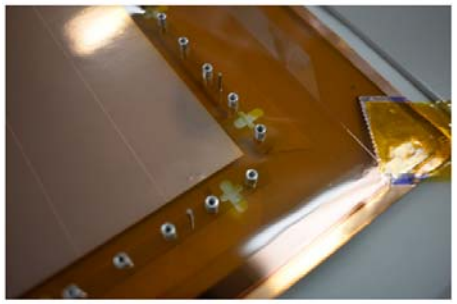
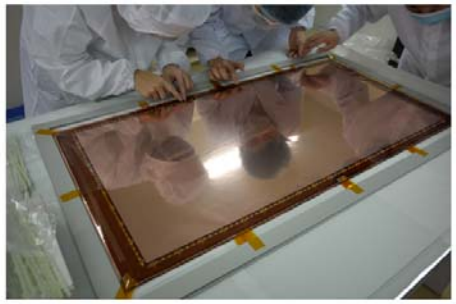
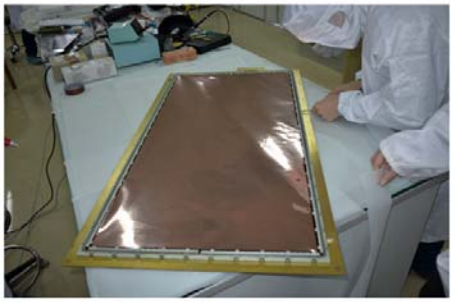
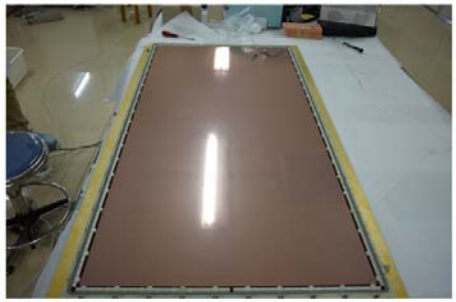


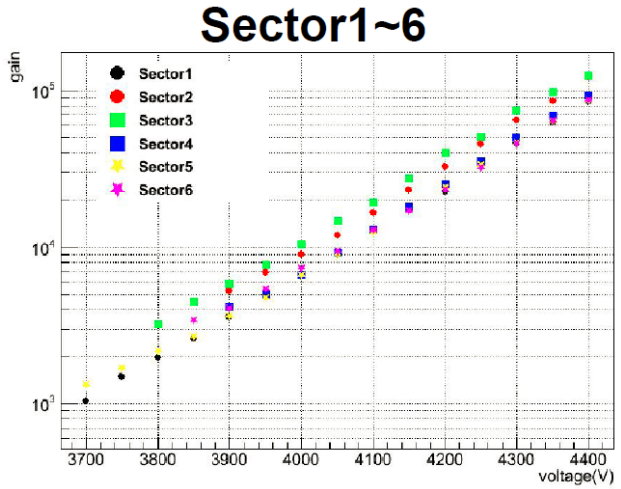


Large-area GEM @ USTC

GEM assembly using a novel self-stretching technique

Jianbei Liu (USTC)

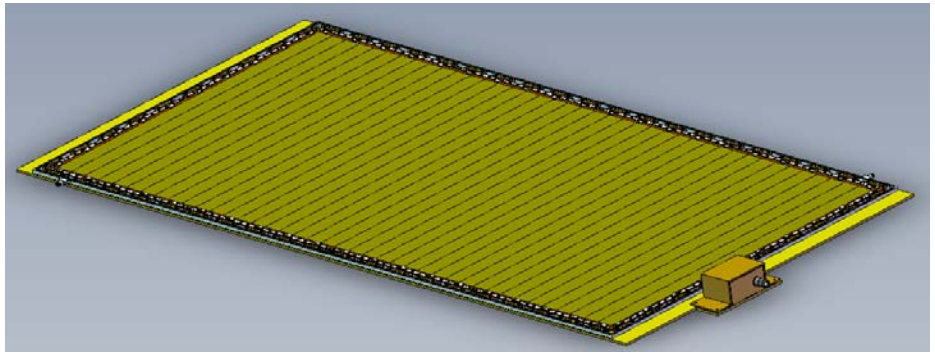


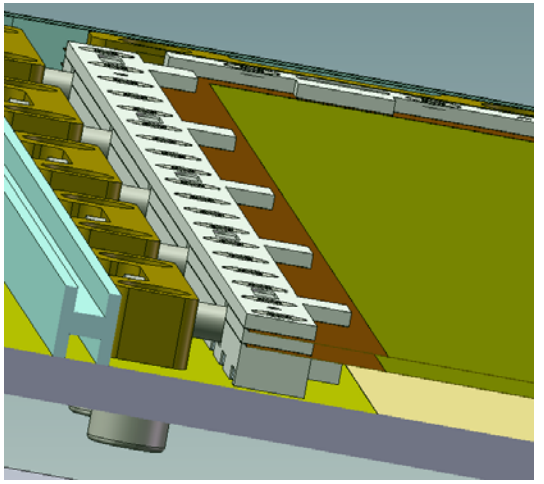
- Large-area GEM (0.5x1m^2) has been one of the main detector R&D focuses at USTC.
- Technology has been developed and matured to produce high-quality GEM detectors as large as ~1m^2 for CEPC DHCAL.

➔ **Resolution uniformity ~11%**
➔ **Gain uniformity ~16%**
➔ **Can reach gain of 10^4 at 4000V**

Conceptual Design for DHCAL GEM

- Detector size: 1m*0.5m, limited by GEM foil size
- Double-GEM structure (3mm-1mm-1mm) adopted to minimize the thickness of detectors to accommodate the compactness requirement of DHCAL.
- Double-GEM can still produce reasonable gain under safe operation condition according to our measurements and experience.



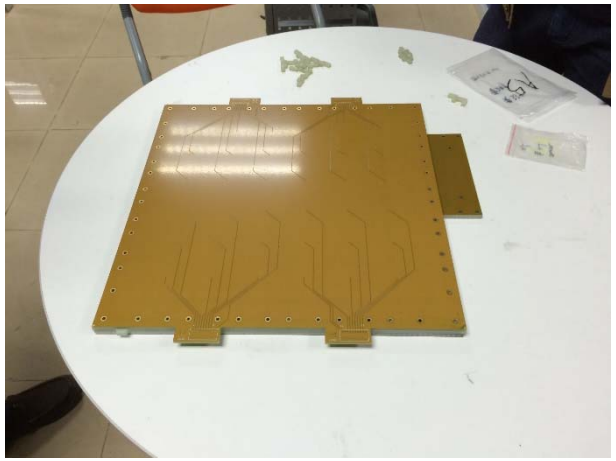


Mechanical design already finished !

Double-GEM prototyping

- Starting with 30cm*30cm. All components have been made ready. Detector to be assembled soon.

Drift PCB and main frame

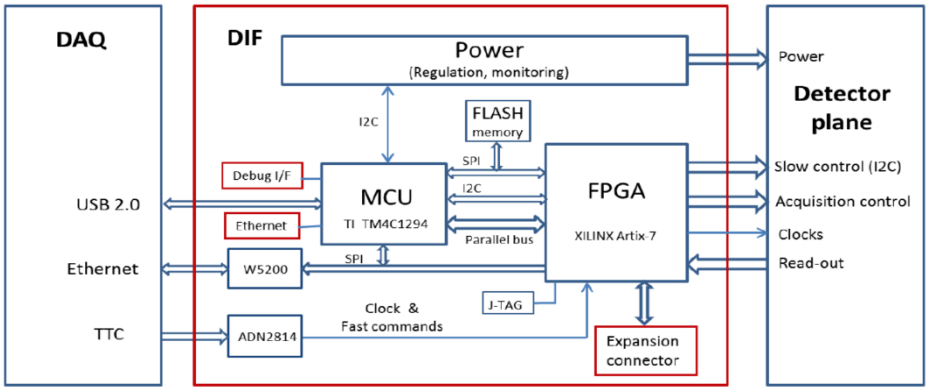


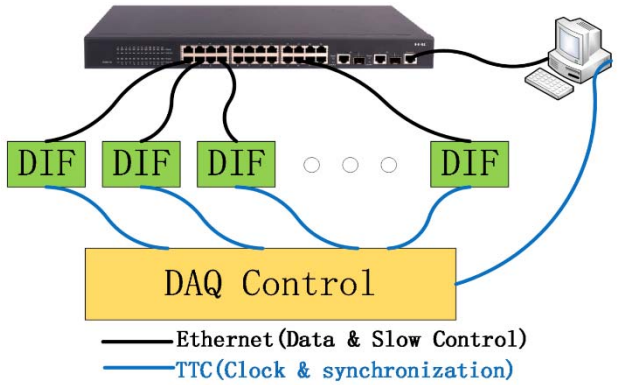
Readout PCB

GEM-DHCAL Readout Design

- Readout design is underway.
- Using MAROC chips that are suitable to read out GEM/ThGEM.

MAROC chip



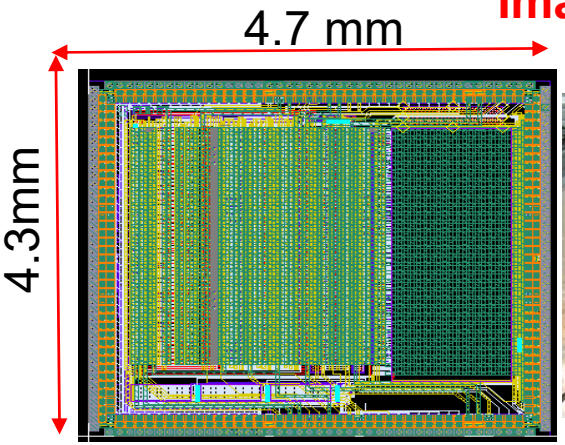


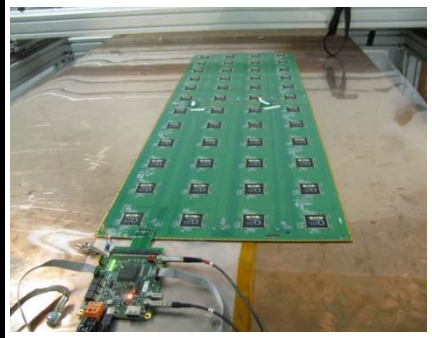
Readout scheme

Electronics Readout System R&D

Imad Laktineh (IPNL)

ASICs : HARDROC2
64 channels
Trigger less mode
Memory depth : 127 events
3 thresholds
Range: 10 fC-15 pC
Gain correction → uniformity

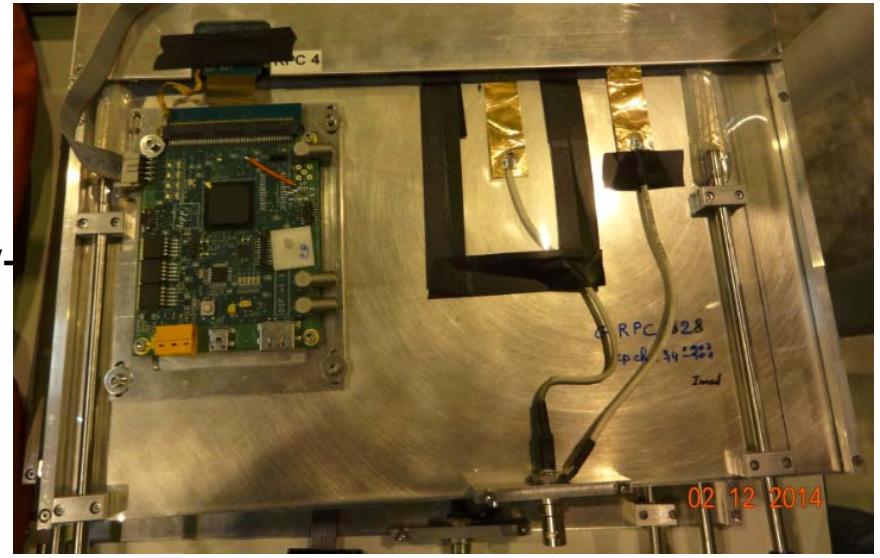




Printed Circuit Boards (PCB) were designed to reduce the cross-talk with 8-layer structure and buried vias.

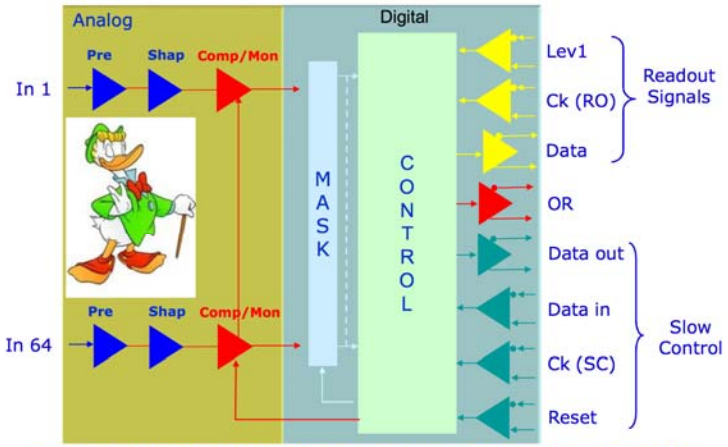
Tiny connectors were used to connect the PCB two by two so the 24X2 ASICs are daisy-chained. 1×1m^2 has 6 PCBs and 9216 pads.

DAQ board (DIF) was developed to transmit fast commands and data to/from ASICs.



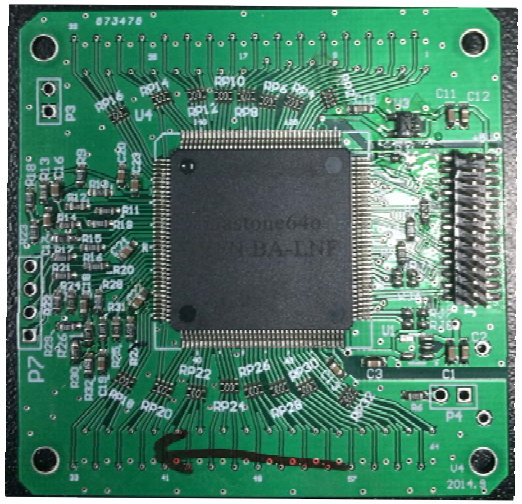
ASICs : GASTONE

Q. Liu (UCAS)



GASTONE (Gem Amplifier Shaper Tracking ON Events)

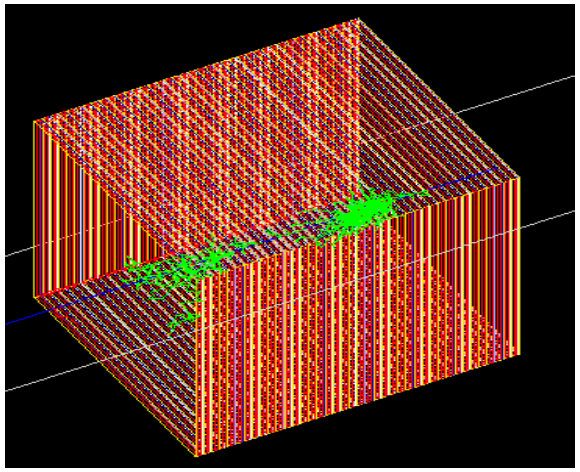
N channels	64
Chip dimensions	4.5×4.5 mm^2
Input impedance	120 Ω
Charge sensitivity	16 mV/fC (C_{det} = 100 pF)
Peaking time	90 ns (C_{det} = 100 pF)
Crosstalk	< 3%
ENC	800 e$^-$+40 e$^-$/pF
Power consumption	~6 mW/ch
Readout	Serial LVDS (100 Mbps)

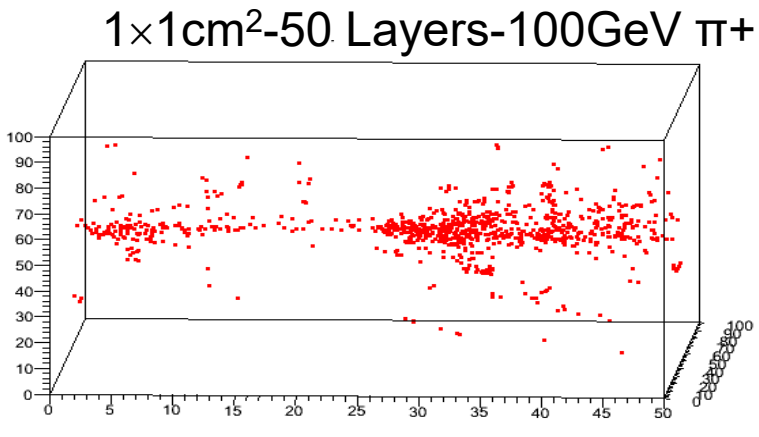


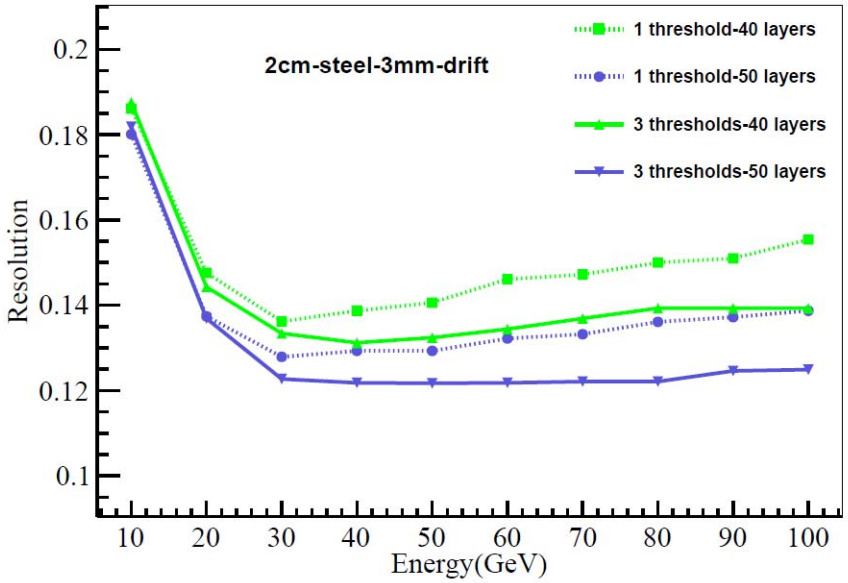
DHCAL Detector Optimization

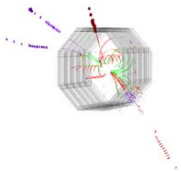
D. Hong(GXU , UCAS)

- DHCAL Simulation and Optimization
  - Standardalone ➔ Full simulation
    (eg. single particle, ZH→qqbb events)
  - Number of layers
  - Thickness of Absorber
  - Readout cell size
  - Thresholds (1, 3, ..)



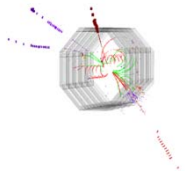






Future Plan

- Detector design and optimization
- Granularity of calorimeters
- Number of layers of calorimeters
- Absorber thickness
- Detector R&D(RPC/THGEM/GEM+Iron)
- Readout electronics (PCB, low power VFE ASIC)
- Gas recirculation system
- High voltage distribution system
- Calibration system
- Mechanical: self-support and compact module



Many thanks to all members of the CEPC HCalo working group.

THANK YOU !