



# News on technological developments within CALICE

Taikan Suehara (Kyushu University) on behalf of CALICE Collaboration

Most of the materials taken from 2 previous CALICE meetings https://agenda.linearcollider.org/event/8343/ https://agenda.linearcollider.org/event/8608/

# **CALICE Technologies**



# Silicon-Tungsten ECAL (SiW-ECAL)

## **ILD and SiW ECAL**







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**lrène Joliot-Curie** Laboratoire de Physique des 2 Infinis

**PNHE** 

Silicon-tungsten ECAL 25-30 layer sandwich calorimeter 5 mm cell 100 M ch, 0.4 M sensors

# **Silicon sensors**

#### Sensor made by Hamamatsu



#### p-on-n structure



5.5 mm x 256 pixels,  $9 \times 9$  cm / sensor (6 inch) 8 inch sensors: will be tested in 2021-22

> Edge size is ~ 0.5 mm No guard rings  $\rightarrow$  no need for wire-bonding HV from back side Full depletion: ~120 V w/650 μm



VoltageIV

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320um B2 320um C2

# **Development of novel sensors (1)**

LGAD

Silicon + avalanche multiplication (same structure to APD) < 50 psec timing resolution @ MIP is desired for ToF PID of hadrons



# **Development of novel sensors (2)**

PSD 4 pads / cell: obtain hit position by charge sharing to identify angle and direction of the particles (photons)



## **Front-end Electronics**



SKIROC2A by OMEGA 64 ch readout Preamp + 2 gain (1/10) slow shaper + fast shaper for triggering retriggering issue is being investigated





FEV-COB Chip-on-board version of SKIROC2A equipped with wire-bonding

FEV13 with 16 SKIROC2A (BGA packaged) for 4 x 6-inch sensors

# Study on long slab



Daisy-chain of ~10 slabs is expected for the real detector

Tested with slabs partiallyequipped with small Si sensors



MIP drop due to insufficient power observed: better setting being prepared

### **Back-end electronics**



SL-BRD : Interface board to Slab

#### New readout scheme being introduced (replace of old DIF/CCC)



Scintillator ECAL (ScW-ECAL)

# **Scintillator-strip ECAL for ILD**

- Long developed in Japan with electronics of DESY
  - China joins for CEPC application
- 5 x 45 mm sci. trips (2 mm thick), 30 layers, ~10<sup>7</sup> cells in total
- EBU (ECAL base unit) with 4 SPIROC (2b)





# Scintillator, SiPM and EBU



### **SiPM location studies**

### Side-bottom readout (substitute to side readout)



# **Double-sided readout**



With double-sided readout,

- More light yield by adding outputs of two SiPMs on the side.
- Background suppression by coincidence of the outputs.
- Position ID (s = 22 mm) by fraction of the light yield and timing difference.
- EBU with double-sided strips has been prepared
- for the coming test beam.



# **Coming test beam for CEPC ECAL**

See talk by Y. Niu this morning for details

Hodoscope for cosmic test prepared in Tokyo (now in China)







30 full layers prepared in China-Japan collaboration

Test beam at DESY in Feb. 2021



# Analog HCAL (AHCAL) with Scintillator tiles

# **Analog HCAL**



# **Scintillator tiles**











30mm×30mm

60mm×60mm

### Standard sci. tiles, 3 x 3 cm<sup>2</sup>, 3 mm thick

Bigger tiles possible on the back side (with larger SiPMs)



# Megatile



recovered by spraying TiO2 varnish on the edges





Easier assembly <u>No de</u>ad area

> ~15% crosstalk seen: should be improved by gluing films on the top at each cell

# **HBU with Klaus ASIC**

Alternative to SPIROC series

### I2C configuration



### 2 x 6 HBUs tested and OK 3 x 6 planned

Klaus HBU: DAQ working soon be tested with beam

# **CMS(HGCAL)/CEPC efforts**



#### See talk by J. Jiang this morning for details



FELIX Card (VC709)





DIF board

# Electronics for CEPC similar to ScECAL being commissioned

- Channels with 2mm<sup>2</sup> and 4mm<sup>2</sup> SiPMs
- Trapezoidal tiles
- HGCROC ASIC
- MIP seen at latest TB



Machine-wrapped tiles of 3x3 and 4x4 cm<sup>2</sup>

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ELINK前端接口

# Semi-digital HCAL (SDHCAL) with glass RPC

### **SDHCAL Overview**



# **New frontend with HARDROC3**

HARDROC3: Zero suppression and I2C communication implemented DAQ integration ongoing



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of HR3

# **Picosec timing with Multi-gap RPC**

100 psec timing can be used to separate nearby showers











# **Picosec timing with PETIROC**

### TDC: 40 MHz digital + analog (TOA)

- Time resolution: below 40ps
- Negative or positive
- 32 voltage inputs

PETIROC2A

- Sensitivity: Trigger on first photo-electron
- 3000 photoelectrons (10<sup>6</sup> SIPM gain), Integral Non Linearity : 1% up to 2500 photoelectrons



https://www.weeroc.com/products/sipm-readout/petiroc-2a



Jitter < 20 psec at Q > 0.3 pC Prototype design ongoing

# Summary

- Lot of activities in CALICE for high-granular calorimetry, both in ECAL and HCAL including test beam campaigns
  - Some delay due to Covid-19 pandemic
  - Activities gradually being recovered
- Large-scale prototypes with semi-final design for realization of a Higgs factory
  - CEPC-related efforts quite significant recently
- Tendency for timing measurements
  - For ToF PID and improvements on PFA