Calorimeter HCAL update

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USTC
On behalf of the CEPC Calorimeter working Group

CEPC Day
January 22th, 2021

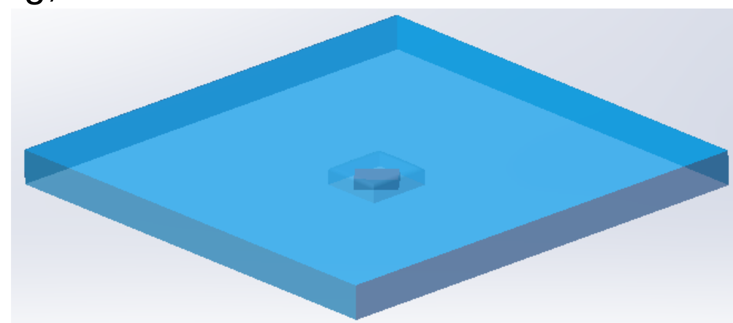
Outline

- **Background introduction**
- **Batch production of AHCAL tiles**
  - Production of injection molding scintillator tiles
  - Sampling test of tiles
  - Wrapping of tiles
- **Batch testing of detector cells**
  - Batch testing platform
  - Batch testing of detector cells
- **Progress of AHCAL prototype base unit**
  - Comparison of SiPMs
  - Development of HBU PCBs
  - New electronics
- **Summary and outlook**

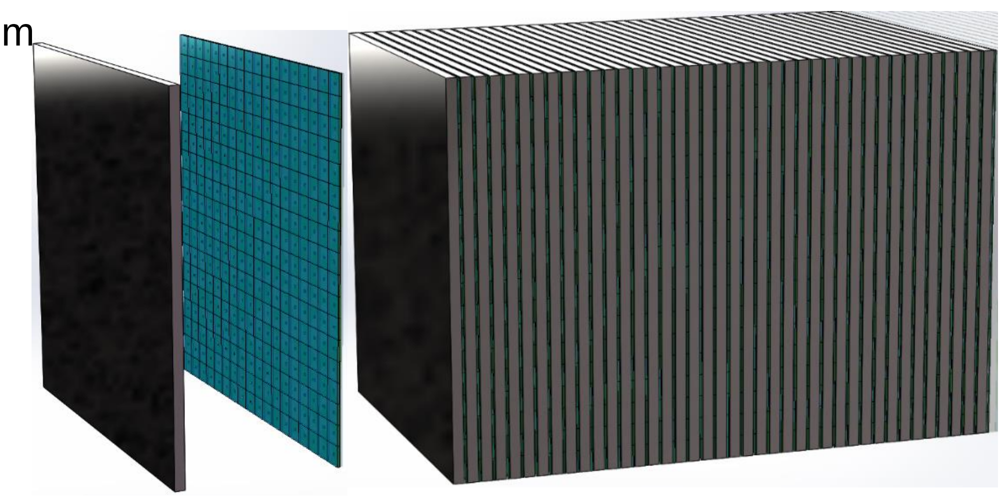
Structure of AHCAL Prototype

- **Task** **BMR < 4% and $60\%/\sqrt{E} \oplus 3\%$**
  - Validate the CEPC AHCAL option by designing, building and testing a full AHCAL prototype.
- **Prototype**
  - Transverse dimension: 72cm×72cm
  - Number of layers: 40
- **Single layer**
  - Stainless steel as absorber: 20 mm
  - Scintillator as sensitive medium: 3 mm
  - SPIROC2E as baseline, KLAUS as another option
- **Detector cells**
  - Cell size: 40mm × 40mm
  - Sensor: SiPMs from HPK & NDL
  - Total number of channels: 12,960

Detector cell of 40mm × 40mm × 3mm



Single layer and detector part

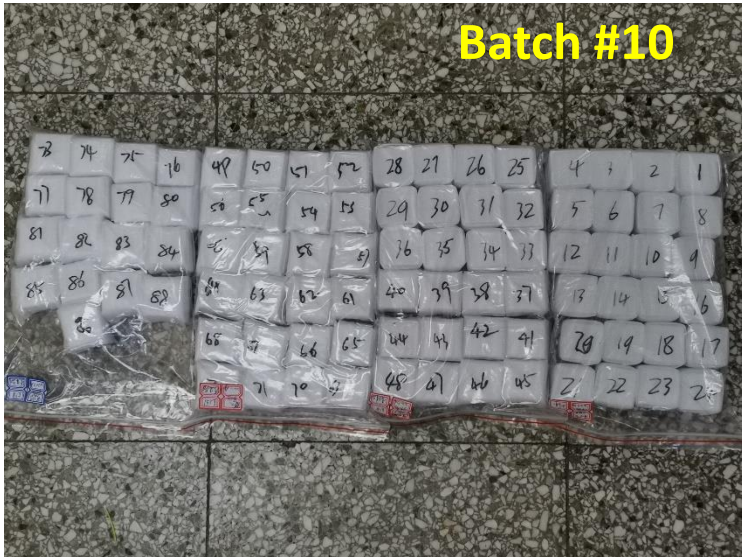


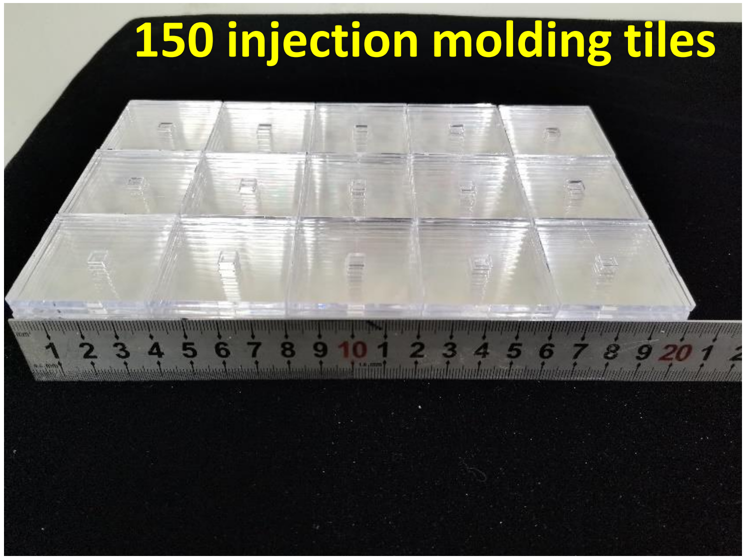
Batch production of AHCAL tiles

Injection molding scintillator tiles

- Massive production of scintillator tiles since November 2020 in GNKD
  confirmation of craft: temperature, pressure, ratio of solute and solvent
- Tiles of around 16,000 have been produced

1	2	3	4	5	6	7	8	9	10	11	Total
1800	2880	1600	1180	1640	1640	1540	430	2160	890	410	16170



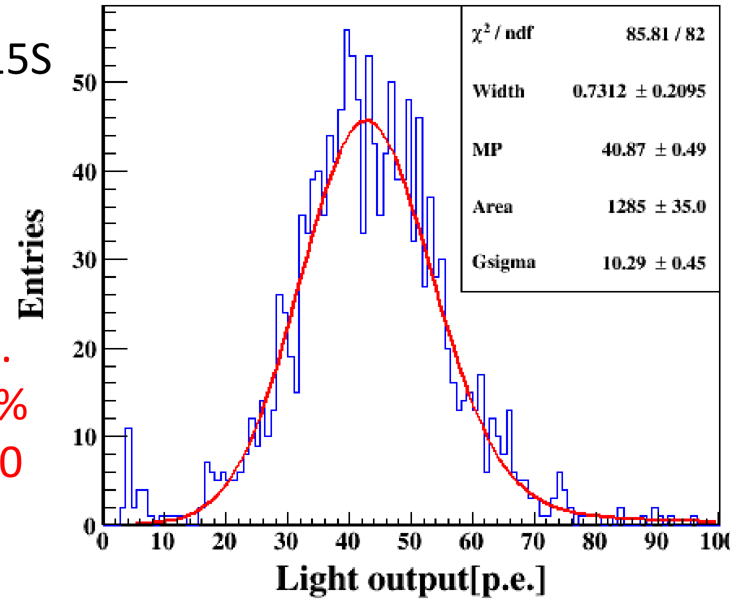


Batch production of AHCAL tiles

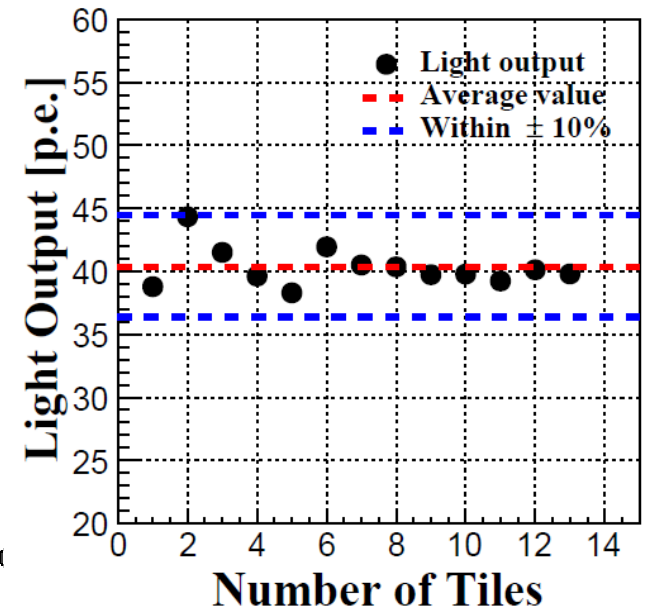
Quality inspection of tiles

- SiPM: NDL-22-1313-15S
- Voltage: 22.5V
- Source: Sr-90
- Sample: ~1/100
- Selection:
  Light output > 38 p.e.
- Quantified ratio: ~70%
- Tiles of around 11,000 have been done

Light output of a quantified tile

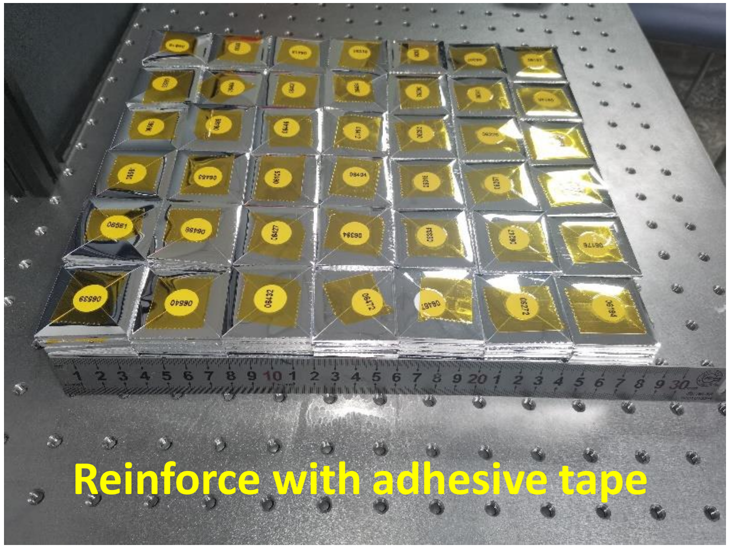


Sampling testing of batch #9



Batch wrapping of AHCAL tiles

Tiles wrapping



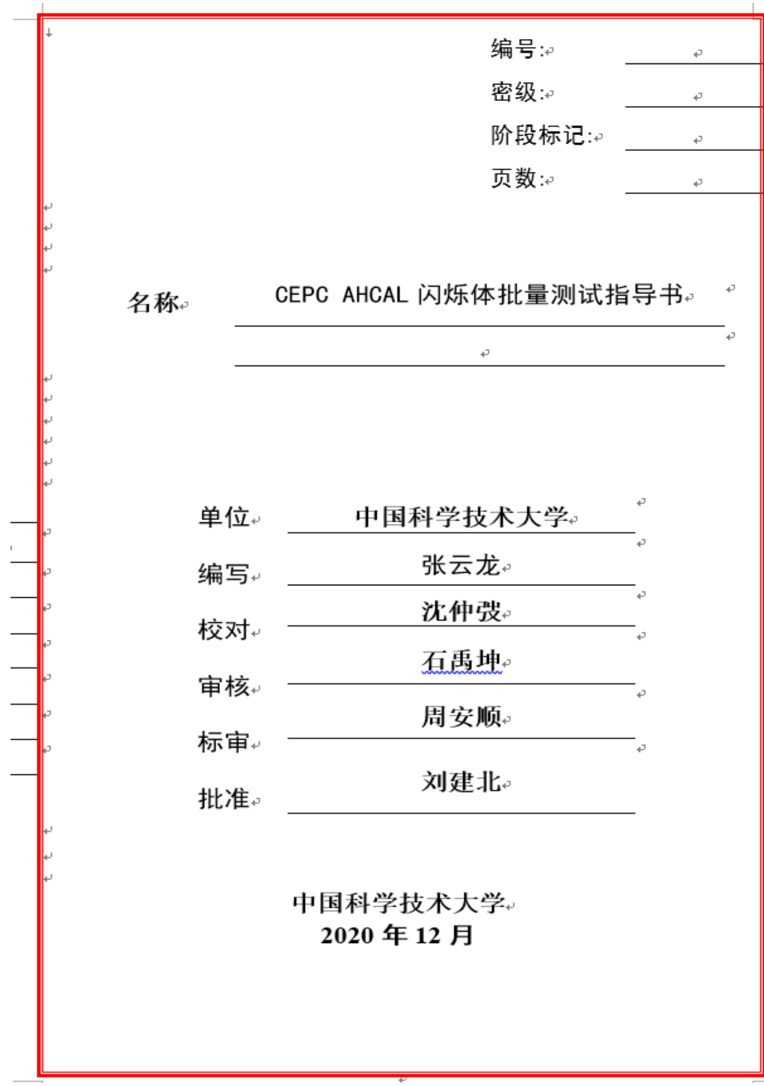
Progress

- Automatic wrapping machine is ok
- Labeling machine is ok
- ESR preparation
  - craft optimization
  - start producing at the end of December
- 400 tiles for 10 hours
- 5,000 wrapped tiles will be done in IHEP at the end of this month

Batch test of detector cells

- quickly check the uniformity of detector cells
- 144 channels
- Auto-moving

Batch Test Platform



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名称 CEPC AHCAL 闪烁体批量测试指导书

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中国科学技术大学

2020 年 12 月

Batch test of detector cells

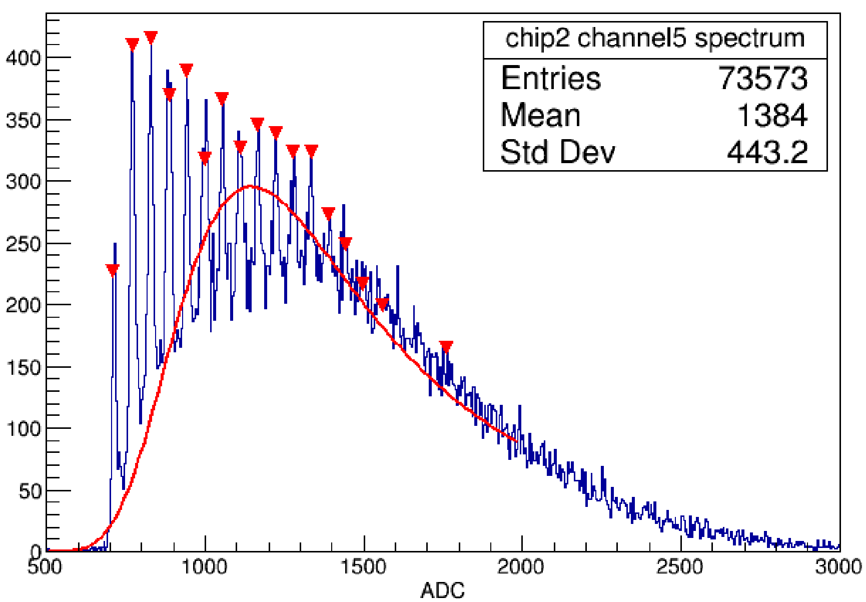
By Yanyun

Batch test of detector cells

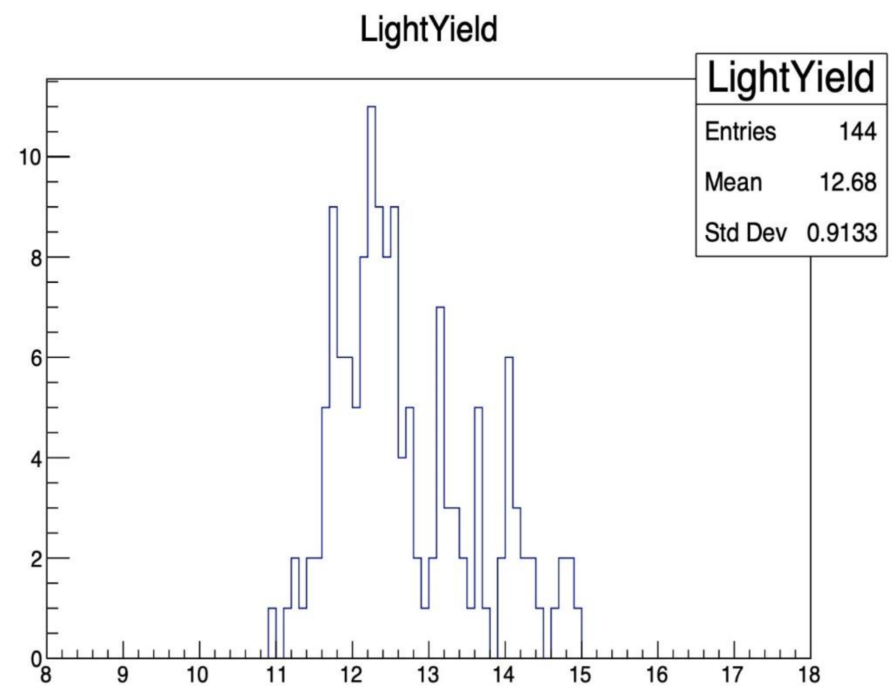
- SiPM:13360-1325PE
- Overvoltage: 5V

- Electronics with SPIROC2E chip
- 1-5 min./channel

- Uniformity within ±15%
- Batch testing platforms can work



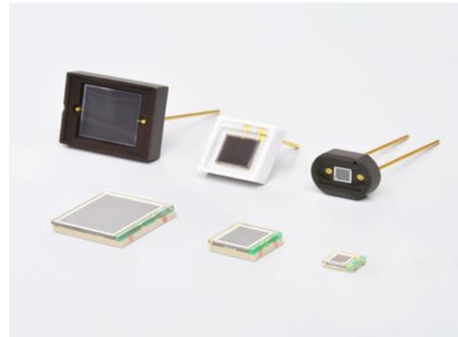
MIPs Spectrum of Sr-90



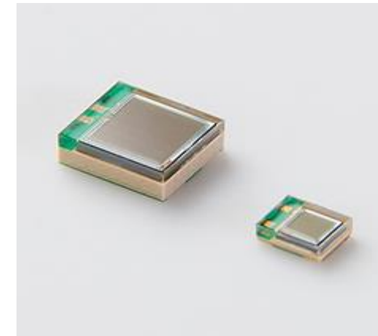
Uniformity: $(LO - LO_{mean})/LO_{mean}$

SiPM Selection

NDL



S13360-1325PE



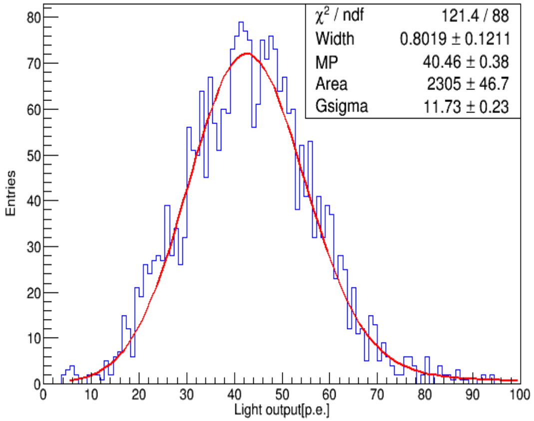
S14160-1315PS

Company	NDL	HPK	HPK
Type	22-15	S13360-1325PE	S14160-1315PS
Sensitive area (mm^2)	1.6*4	1.69	1.69
PDE (%)	40	25	32
Gain ($*10^5$)	2.4	5.1	3.6
Pixel No.	7400*4	2700	7284
Breakdown Voltage (V)	19	53	38
OverVoltage (V)	4	4	4
Dark Count (kHz)	330*4	120	120
Cross Talk (%)	8.5	1.0	1.0

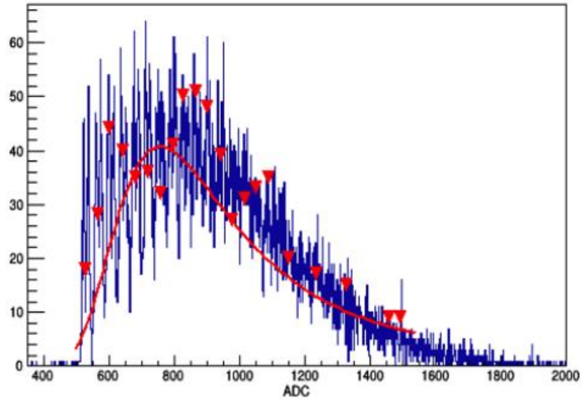
SiPM Selection

- The light yield of plastic scintillator when coupled with SiPM
- Light yields of the three type are 40, 13 and 16 pe/MIP
- Comprehensive consideration, we choose NDL SiPM as our main choice, and small batch S14160-1315PS as the contrast in our prototype

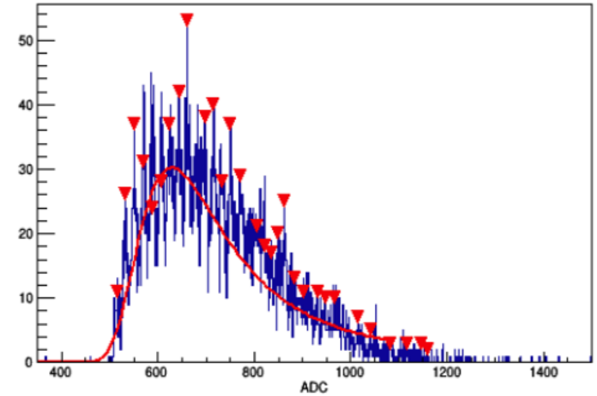
NDL
40 pe/MIP



S13360-1315PE
13 pe/MIP



S14160-1315PS
16 pe/MIP



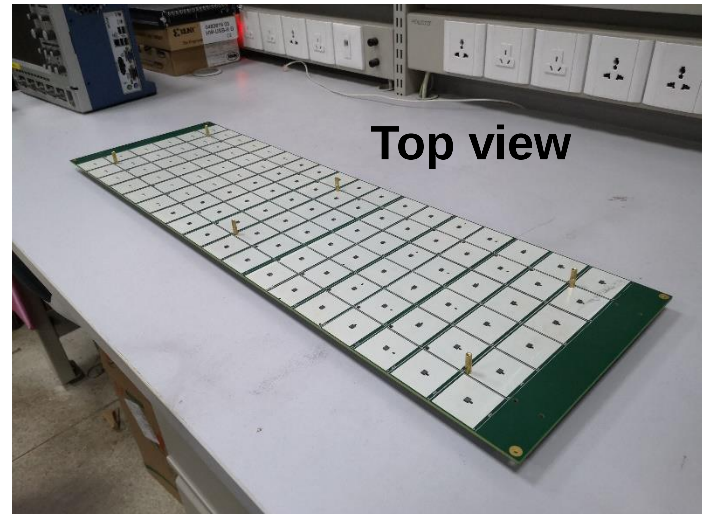
Development of HBU

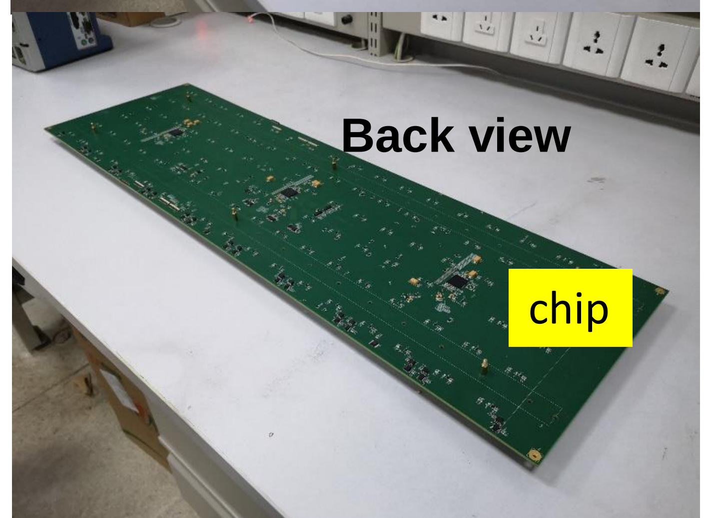
AHCAL prototype base units

By Anshun

- PCB Size : 24.1 cm × 78.6 cm
- 3 PCBs and 324 channels for each layer
- LED calibration, DAC calibration, temperature monitor and compensation

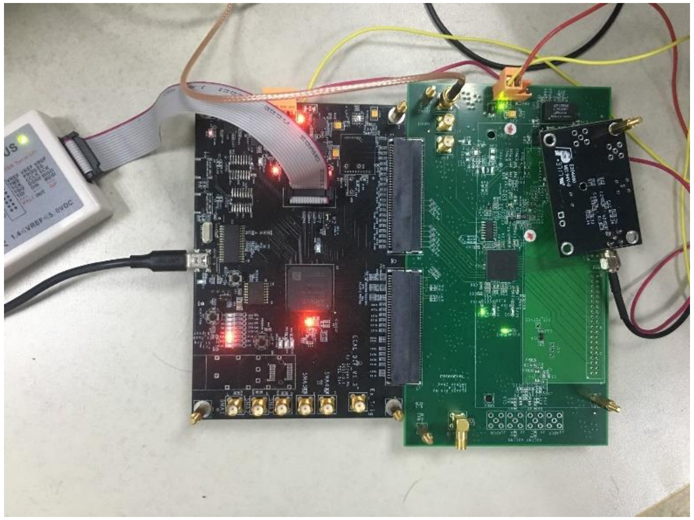
- Tuning of hardware
  - Re-encapsulate of SP2E
  - Position of LED
- Progress of PCBs
  - PCBs have been done
  - Components are assembled
- Tuning of software
  - Data acquisition software is OK



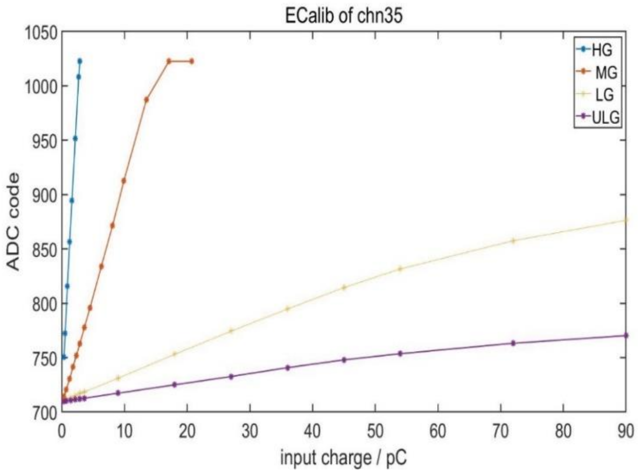


New electronics

- Another electronic scheme based on KLAUS chip was designed
- It is a specially developed low noise electronics, suitable for relatively low gain SiPM

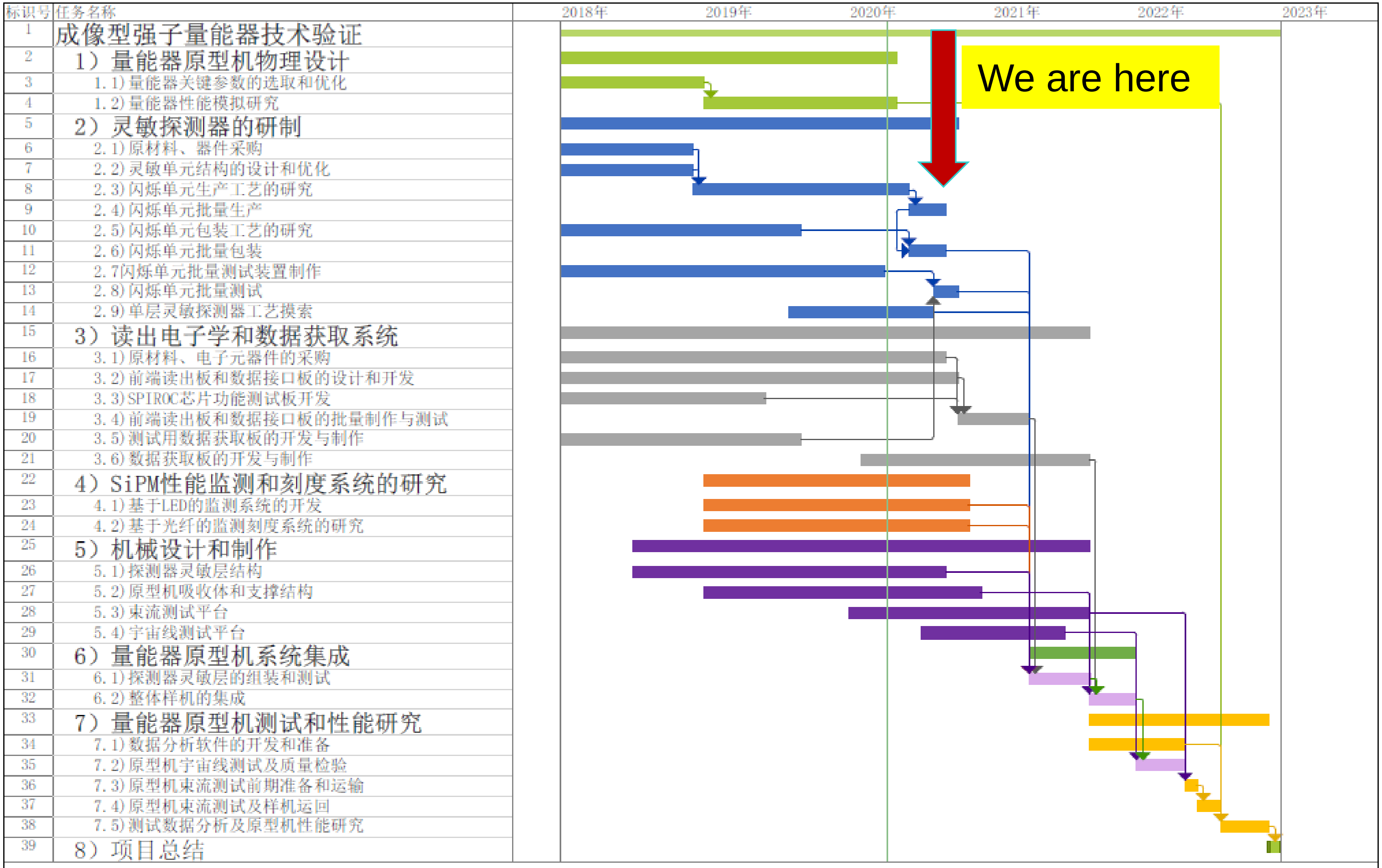


- Dynamic range: 66 fC – 54 pC
- Channels: 36
- Dead time: 500 ns
- Polar: positive
- Power: 3.6 mW/channel



linearity

Schedule of prototype



Summary and Plan

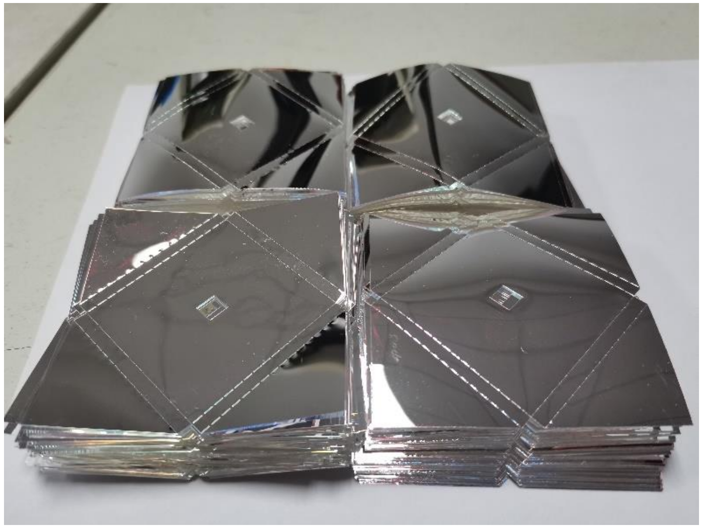
- **Scintillator tiles and wrapping**
  - → The tiles of 11,000 have been done. The last few tiles will be produced at the end of this month.
  - → Tiles wrapped by machine are ongoing, 5,000 tiles will be wrapped in IHEP at the end of this month. All of them could be wrapped and tested at the end of March
- The **SiPMs of NDL** could be finished in July
- **HBU board** (78.6 cm×24.1 cm)
  - → The first one has been successfully designed, produced and welded and is being tested. The batch replication of HBU boards could be completed in the end of 2021
  - → Then we will start to assemble scintillators to HBUs at the end of this year
- The design and processing of the **mechanical structure** of the calorimeter will also be completed this year
- **The prototype** could be assembled and tested in the middle of next year. Meanwhile, we prepare the beam test in autumn of 2022

Thanks

Back up

ESR Measurements

- Deviation from the mean value is within ±4% within the same batch



2230cps	1	2	3	4	5
p.e	43.67	47.78	43.8	45.39	45.72

1070cps	1	2	3	4	5	6	7	8	9	10
p.e.	43.82	40.59	44.73	43.22	41.11	41.32	41.88	42.63	42.1	41.9

Position of LED

LED position within a detector unit

By Yukun

- LED is used to excite SiPMs and calibrate the single photon peaks. In order to determine the appropriate position of LED, we compared several different designs
- For the convenience of calibration in the future, we hope that the light intensity of the LED with a certainly large range of driving voltage is not very sensitive, which the single photon electron level of SiPMs can be excited.
- After testing and comparison, we tend to place the LED close to each SiPM.