

Status of Production and Quality Control of Scintillator Tiles

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On behalf of the CEPC calorimeter working group

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Content

- 1 AHCAL Prototype
- 2 AHCAL Scintillator Tile Production
- 3 AHCAL Scintillator Tile Batch Testing System
- 4 Batch Testing
- 5 Sum Up

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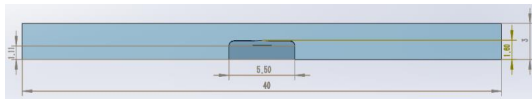
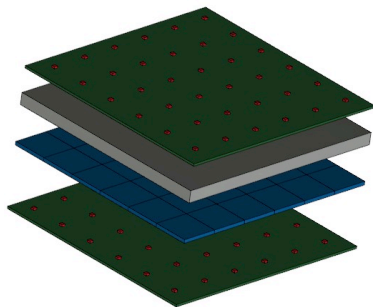
AHCAL Prototype

The AHCAL task:

- To validate the CEPC AHCAL option by designing, building and testing a full AHCAL prototype.

CEPC AHCAL: SiPM-on-Tile configuration, 12,960 channels in total.

- Prototype: 72cm×72cm×100cm with 40 layers
- Detector cell size: 40mm×40mm×3mm
- PCB: 2mm, with SiPMs, temperature sensors and SPIROC2E
- Absorber: steel (20mm Fe)
- Active: scintillator made of polystyrene and wrapped in enhanced specular reflector (ESR) films.
- More information see Yukun's slides



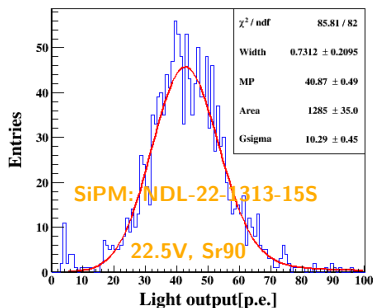
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Scintillator Tile Production

- 11000 scintillators have been produced using the injection molding technique
- The light yield of one scintillator is about 40 p.e. test by NDL-22-1313-15S

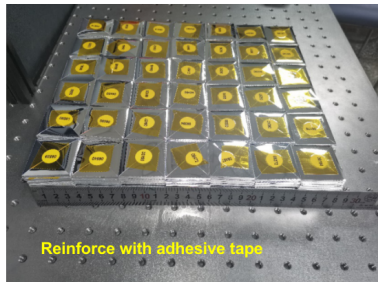
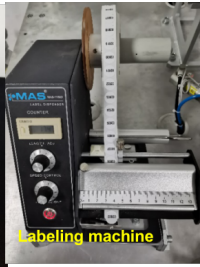
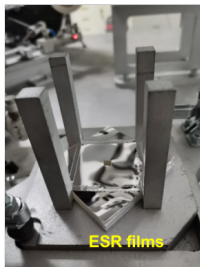
1	2	3	4	5	6	Total
1800	2880	1600	1180	1640	1640	10740



Wrapping of scintillators

Wrapping use automatic wrapping machine and labeling machine

- The wrapper material is ESR
- The whole wrapping and labelling procedure is automatic
- 100 scintillators cost 75min

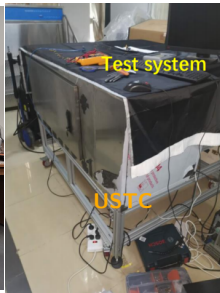
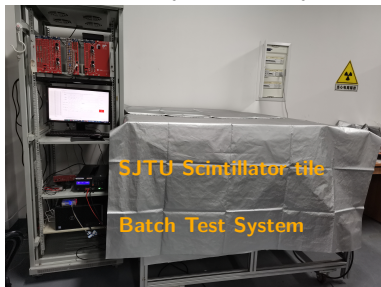
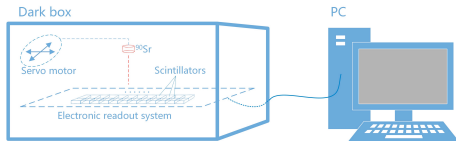


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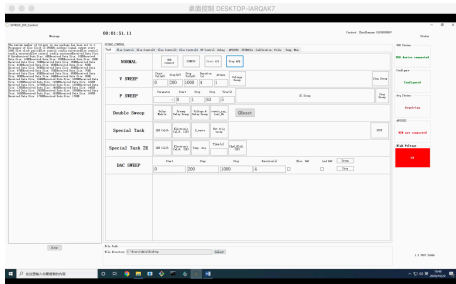
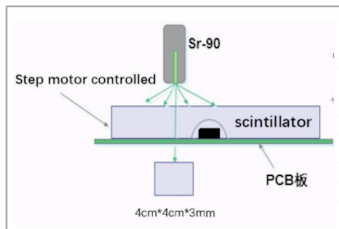
Batch Testing System

- 11,000 tiles need to be tested, massive production from November 2020 in GNKD
- 3 batch test system in total (SJTU, USTC, IHEP).
- 4 SPIROC2E+ 144 SiPM (S13360-1325PEs)+FPGA in DIF
- Calibration and Light Yield Measured by batch test system



Batch Testing System

- MIP source : Sr 90
- SiPM 13360-1325PE working: 5V overvoltage



Batch Testing System - Debugging

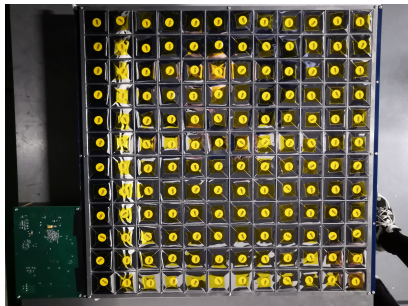
- Positioning of 144 pieces of Scintillator
- Test the stability of batch test system
- Test the effect of temperature (temperature sensor: HTU21, data taking by Raspberry Pi 4B. Temperature (24°C-28°C) increase 1 °C, light yield decrease 1%)
- Test the effect of humidity (humidity 40%-50%, light yield affected by 2%)

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Batch Test

- Store in a constant temperature and humidity cabinet , temperature 23°C, humidity 34%



Testing data

SJTU: 49 Batches, 143 channels in use (1 dead channel), 6924 pieces tested

- 12h test (200k events/channel): 01, 03, 08, 11, 17, 20, 23, 26, 29, 32, 35, 38, 41, 44, 47
- 4h test (60k events/channel): 02, 04, 05, 06, 07, 09, 10, 11, 12, 13, 15, 16, 18, 19, 21, 22, 24, 25, 27, 28, 30, 31, 33, 34, 36, 37, 39, 40, 42, 43, 45, 46, 48, 49
- 3 backups of the test data, cloud disk, IHEP farm, testing PC hard disk

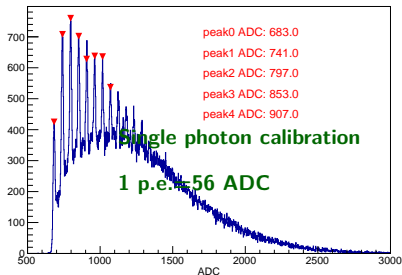
USTC: 23 Batch, 140 channels in use (4 large noise channels), 3220 pieces tested

- 3.5h test (30k events/channel)
- calibrated between USTC and SJTU by 5 scintillators

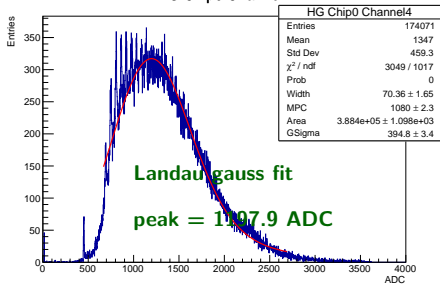
ID	light yield(USTC)	p.e.(USTC)	light yield(SJTU)	p.e.(SJTU)
2558	12.453	53.4243	14.3261	58
2476	14.2225	54.8962	15.7018	65
2477	13.315	55.5119	14.9899	65
2706	11.8791	57.2737	14.2634	60
2557	12.2475	58.7323	14.2871	60

Batch Test Result - Light Yield

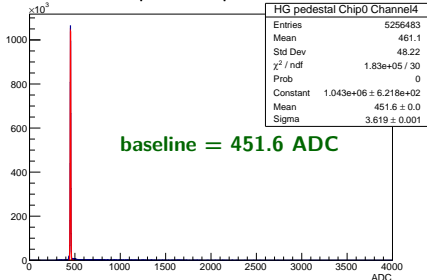
chip0 channel4 multi peak



HG Chip0 Channel4



HG pedestal Chip0 Channel4

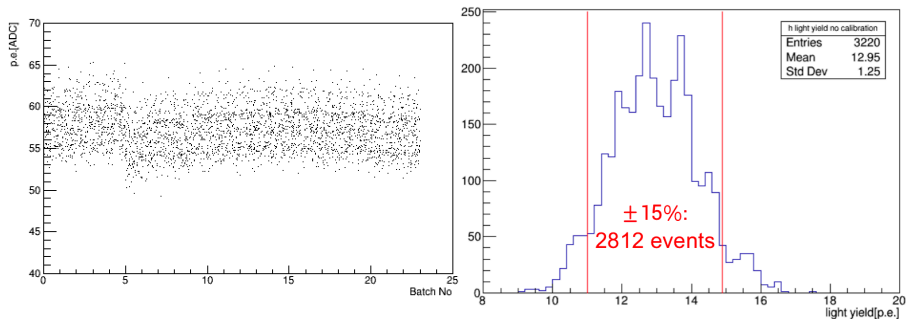


$$LY = \frac{ADC_{MIP} - ADC_{baseline}}{Gain_{SinglePhoton}} (perMIP) \quad (1)$$

$$LY = (1197.9 - 451.6) / 56 = 13.33 \text{ p.e.}$$

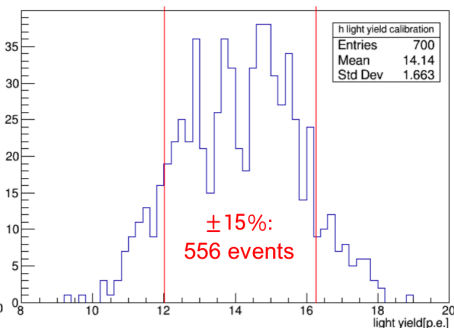
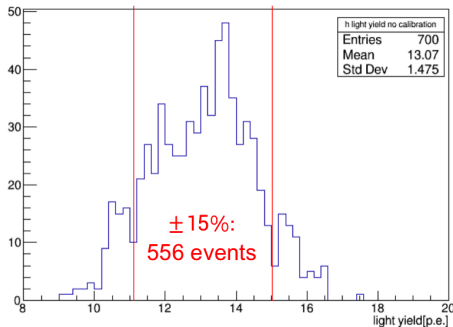
Batch Test Result (USTC)

- The DIF was changed after spring festival
- The temperature change may also be the reason
- The status of the system before spring festival is different
 - rms/mean: 0.097 without calibration
 - $\pm 15\%$: 87% without calibration



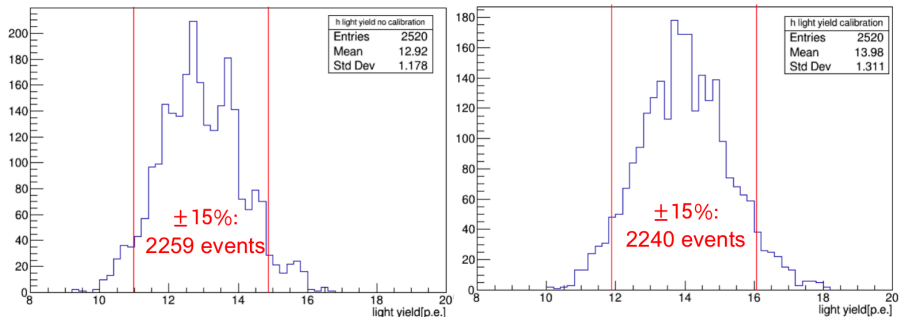
Results before spring festival (USTC)

- The status of the system before spring festival is unstable
 - rms/mean: 0.113 before calibration, 0.118 after calibration
 - $\pm 15\%$: 79% before calibration, 79% after calibration



Results after spring festival (USTC)

- Calibration doesn't have obvious impact on uniformity
 - rms/mean: 0.091 before calibration, 0.094 after calibration
 - $\pm 15\%$: 90% before calibration, 89% after calibration
 - The status of the system is not stable enough comparing to SJTU's system

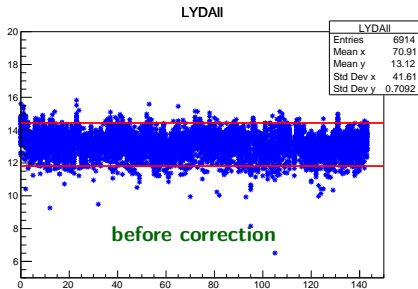
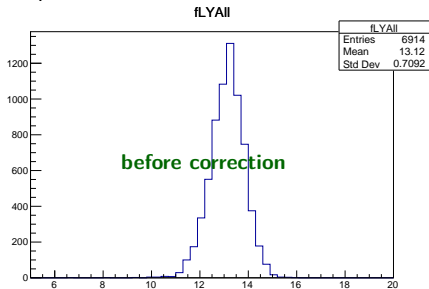


Batch Test Result (SJTU)

表 1: SJTU Scintillator tiles

Received Number	IHEP sent	SJTU receive	Number of scintillator
1	2020.12.22	2020.12.24	150
2	2021.01.07	2021.01.09	500
3	2021.01.17	2021.01.19	600
4	2021.01.27	2021.01.29	750
5	2021.02.20	2021.02.23	4930

6914 pieces result shown below:



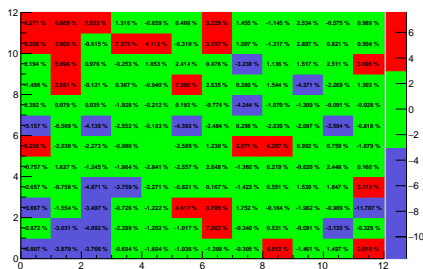
channel difference calibration

Use 2478 do the channel difference calibration (temperature=24°C, humidity is 36%):

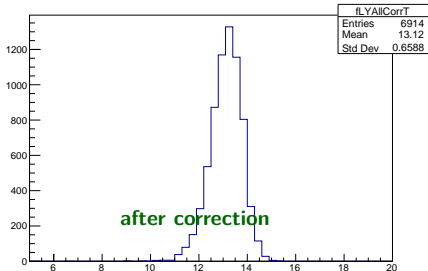
LY



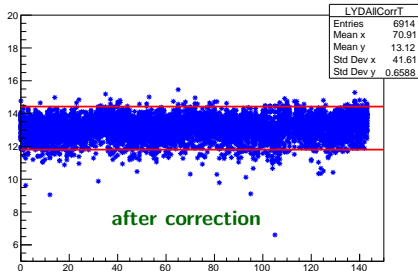
channel uniformity from test data



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LYDAIICorrT



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10144 pieces tested. 9688 pieces with the uniformity $\pm 15\%$.

SJTU result:

- 49 batches(6914 pieces) have been tested
- before calibration: 99% meet the requirement.
- after calibration: 99% meet the requirement.

USTC result:

- 23 batches(3220 pieces) have been tested
- Light yield is consistent with SJTU
- 5 sintillator will be used to do inter calibration between USTC and SJTU
- The system was unstable
 - before calibration, 87.4% meet the requirement.
 - after calibration, 86.8% meet the requirement.

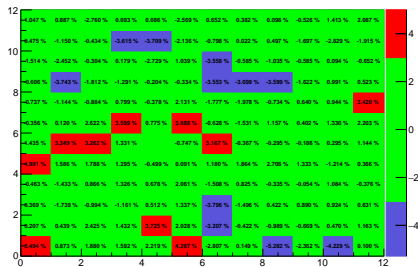
IHEP in process.

Thank You!

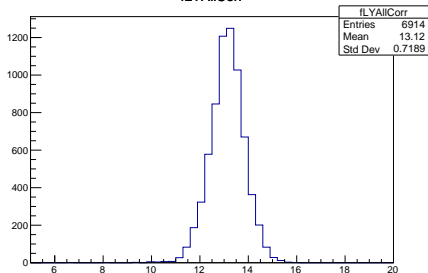
Batch Test Result

- Due to the random placement of plastic flashes in different channels, it is assumed that the LY of scintillator measured on each channel obeys Gaussian distribution.
- Calculate the channel difference, and use this parameter to correct the data, get the following results.

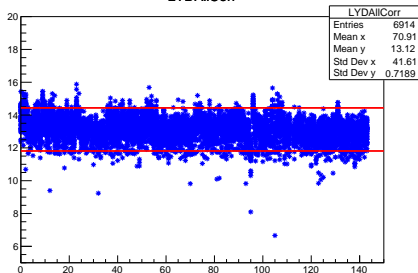
channel uniformiry



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LYDAIICorr



Test Result Sum Up

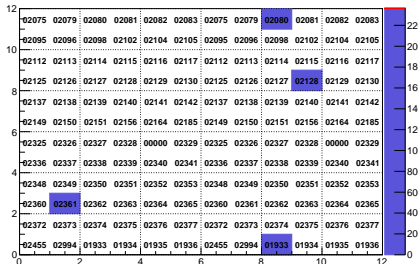
LY Batch[1]



LY Batch[5]



Low LY Batch[5]



High LY Batch[5]

