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# The progress of Ecal production in China

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## - Contents









## **MPD-Ecal requirement**

- Energy resolution:  $<5\%/\sqrt{E}$
- ➤The particle occupancy should not exceed 5%
- ➤Calorimeter must be able to operate in the magnetic field up to 0.5T
- ➤Time resolution should be at least below 1ns
- High segmentation, adequate space resolution
- Dense active medium with the small Moli'ere radius;



Distribution of  $\theta_{\gamma\gamma}$  as a function of  $P_t$ .





About MPD-ECAL

## **Shashlyk Ecal structure**

| Parameters of main module        |         |                                   |      |  |  |  |  |
|----------------------------------|---------|-----------------------------------|------|--|--|--|--|
| Transverse size, mm <sup>2</sup> | 40 x 40 | Scintillator thickness, mm        | 1.5  |  |  |  |  |
| WLS fibers                       | 16      | Moliere radius, mm                | 62   |  |  |  |  |
| Number of layers                 | 220     | Radiation length, $X_0$           | 11.8 |  |  |  |  |
| Lead absorber<br>thickness, mm   | 0.3     | Effective radiation length,<br>mm | 32.4 |  |  |  |  |





2022/4/25

## 1 China MOST MPD ECal project

- > Hardware:
  - 1) Construction of 8 sectors ECal prototype. 768 modules in total.
  - 2) Production of FEE PCB (1800 FEEs)
  - 3) R&D on fast readout electronics, time resolution is less than 150ps
- Software and simulation
- Schedule: 2020.6-2024.5
- Institutes: Tsinghua University 60%
  - Shandong University 20%
  - Fudan University 10%
  - **University of South China 10%**
  - Huzhou University

• In the first stage (2020.6-2022.5), 8 sectors will be produced in China

8 sectors = 16 half sectors = 768 modules = 12288 towers



### Modules produced in each institutes

|    | 2  | 3               | 4                      | 5   | 6  | 7   | 8   | Total  |
|----|----|-----------------|------------------------|---|--|---|---|--|
| 19 | 19 |                 | 38                     | 96  | 96   | 96  | 96  | 460  |
|    |    | 96              | 58                     |   |  |   |   | 154  |
|    | 77 |                 |                        |   |  |   |   | 77   |
| 77 |    |                 |                        |   |  |   |   | 77   |
| 1  | 9  | 9 19<br>77<br>7 | 9 19 96<br>96<br>77 7. | 9    19    38      96    58      77    77 | 9      19      38      96        96      58      96        77      7      10      10 | 9      19      38      96      96        9      96      58      1      1        77      7      1      1      1      1 | 9      19      38      96      96      96        9      96      58      1      1      1        77      7      1      1      1      1      1 | 9      19      38      96      96      96      96        10      96      58      1 |

### Material:

JINR: scintillator tiles China: Other material

|                     | Current progress | main target |
|---------------------|------------------|-------------|
| Tower<br>assembling | 7132             | 7360        |
| Tower milling       | 7132             | 7360        |
| Half-module         | 853              | 920         |
| Module              | 310              | 460         |
| WLSF                | 101020           | 117,760     |

MPD\_Ecal production progress (THU)



## 2 Module production in SDU

| Materials Preparation   |                   |             |        |  |  |  |  |  |
|-------------------------|-------------------|-------------|--------|--|--|--|--|--|
|                         | Current progress  | main target | %      |  |  |  |  |  |
| Lead plate              | 563000            | 563000      | 100.0% |  |  |  |  |  |
| WLSF(m)                 | 26000             | 26000       | 100.0% |  |  |  |  |  |
| Stainless steel wire    | 2464              | 2464        | 100.0% |  |  |  |  |  |
| Aluminum plate          | 154               | 154         | 100.0% |  |  |  |  |  |
| Scintillator plate      | 517440            | 517440      | 100.0% |  |  |  |  |  |
| Plastic plate for tower | 2800              | 2800        | 100.0% |  |  |  |  |  |
| Epoxy glue              | 100               | 100         | 100.0% |  |  |  |  |  |
| · · · ·                 |                   |             |        |  |  |  |  |  |
|                         | Production Status |             |        |  |  |  |  |  |
|                         | Current progress  | main target | %      |  |  |  |  |  |
| Tower assembling        | 2549              | 2464        | 103.4% |  |  |  |  |  |
| Tower milling           | 2549              | 2464        | 103.4% |  |  |  |  |  |
| Half Module             | 318               | 308         | 103.2% |  |  |  |  |  |
| WLSF cut(piece)         | 39800             | 39424       | 101.0% |  |  |  |  |  |
| Module                  | 144               | 154         | 93.5%  |  |  |  |  |  |
| Painting                | 144               | 154         | 93.5%  |  |  |  |  |  |
| Final fiber cutting     | 80                | 154         | 51.9%  |  |  |  |  |  |



#### **Production Status**



## 2 Module production in SDU





## 2 Module production in USC

| Materials Preparation   |                   |             |       |  |  |  |  |  |
|-------------------------|-------------------|-------------|-------|--|--|--|--|--|
|                         | Current progress  | main target | %     |  |  |  |  |  |
| Lead plate              | 272272            | 272272      | 100%  |  |  |  |  |  |
| WLSF(m)                 | 12000             | 12000       | 100%  |  |  |  |  |  |
| Stainless steel wire    | 1232              | 1232        | 100%  |  |  |  |  |  |
| Aluminum plate          | 77                | 77          | 100%  |  |  |  |  |  |
| Scintillator plate      | 272272            | 272272      | 100%  |  |  |  |  |  |
| Plastic plate for tower | 2464              | 2464        | 100%  |  |  |  |  |  |
| Epoxy glue              | 10                | 10          | 100%  |  |  |  |  |  |
|                         |                   |             |       |  |  |  |  |  |
|                         | Production Status |             |       |  |  |  |  |  |
|                         | Current progress  | main target | %     |  |  |  |  |  |
| Tower assembling        | 1232              | 1232        | 100%  |  |  |  |  |  |
| Tower milling           | 1050              | 1232        | 85.2% |  |  |  |  |  |
| Half-module             | 125               | 154         | 81.2% |  |  |  |  |  |
| WLSF cut(piece)         | 19712             | 19712       | 100%  |  |  |  |  |  |
| Module                  | 54                | 77          | 70.1% |  |  |  |  |  |

#### Materials Preparation



Current progress main target

#### **Production Status**





# **Painting Area**







## 2 Module production in FDU





Fiber protection and carton



9 modules in one wood box. This design can maximize the space of the container



Moisture proof. This step can prevent rain from affecting the detector during the shipment.



### Wood boxes

### container loading







shipment

3

## NICA/MPD电磁量能器交付发车仪式 Delivery and Departure Ceremony of Electromagnetic Calorimeter for NICA/MPD Project.



2022/4/25

## 4 Cosmic test of module

Photos of Shashlyk ECal module



| trigger       | Sampling<br>rate |
|---------------|------------------|
| Ch0 & Ch7     | 2.5GHz           |
| Ch1 & Ch6     | 5GHz             |
| Ch8 & Ch15    |                  |
| 2 Small Scin. |                  |

#### Muon



### SiPM Calibration\_setup

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0

10

500

| setup                              |                       |  |  |  |  |  |
|------------------------------------|-----------------------|--|--|--|--|--|
| XY plateform (precision is 0.03mm) | LED 420nm (from JINR) |  |  |  |  |  |
| Optical Attenuator, 20X            | 1.5*1.5m dark box     |  |  |  |  |  |



| Time | 12/06<br>20:00pm | 12/06<br>20:05pm | 12/06<br>22:00pm | 12/06<br>23:00pm | 12/07<br>08:00am | 12/07<br>09:00am | 12/07<br>12:00am | 12/07<br>14:00pm |
|------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| Mean | 83.1mv           | 83.2mv           | 84.2mv           | 83.5mv           | 77.5mv           | 77.3mv           | 81.5mv           | 83.2mv           |
| Time | 12/08<br>08:00am | 12/08<br>09:00am | 12/08<br>09:30am | 12/08<br>10:00am | 12/08<br>10:30am | 12/08<br>11:00am | 12/08<br>12:55pm | 12/08<br>13:30pm |
| Temp | 25.0°C           | 25.1℃            | 25.3℃            | 25.6°C           | 25.9℃            | 25.9℃            | 26.3°C           | 26.1°C           |
| Mean | 77mv             | 77mv             | 77.5mv           | 80.5mv           | 82.5mv           | 82mv             | 84mv             | 83mv             |

The results show that there is a positive correlation  $\frac{85}{84}$ between temperature and SiPM performance in the range <sup>32</sup><sub>81</sub> of 25°C-28°C.





|         | SiPM1  | SiPM2  | SiPM3  | SiPM4  | SiPM5  | SiPM6  | SiPM7  | SiPM8   |
|---------|--------|--------|--------|--------|--------|--------|--------|---------|
| Mean[V] | 0.1218 | 0.1063 | 0.1123 | 0.1128 | 0.1067 | 0.113  | 0.115  | 0.09109 |
| X0      | 378    | 328    | 278    | 228    | 178    | 122    | 66     | 0       |
|         | SiPM9  | SiPM10 | SiPM11 | SiPM12 | SiPM13 | SiPM14 | SiPM15 | SiPM16  |
| Mean[V] | 0.1213 | 0.1118 | 0.1041 | 0.0959 | 0.1031 | 0.1108 | 0.1078 | 0.1123  |
| X0      | 378    | 328    | 278    | 228    | 178    | 122    | 66     | 0       |

Position scan of SiPM8:

- X: step length 1mm; from (-12,0) to (7,0)
- Y: step length 1mm; from (0,-11) to (0,3)



After bringing the SiPM calibration results into the energy deposition results of the cosmic ray test, it can be seen that the energy deposition of the tower has a good consistency



### Cosmic test of module

### **Time resolution**



| т                | before slewing<br>correction (ps) | After slewing<br>correction (ps) | Events | Threshold (ps) |
|------------------|-----------------------------------|----------------------------------|--------|----------------|
| Ch3-Ch4          | 830                               | 382.5                            | 198    | 30             |
| Tower-Ch43       | 2204                              | 642.7                            | 198    | 30             |
| Ch7531-Ch6420    | 505.8                             | 252.5                            | 198    | 30             |
| Tower-Ch76543210 | 1767                              | 549.1                            | 198    | 30             |

The time resolution of a single horizontal ECal tower is

 $\frac{T_{ch3-ch4}}{\sqrt{2}} = 270 \text{ps}$ 

The time resolution of a vertical ECal tower is 487.7ps

$$\delta(T_{tower-0}) = \delta(T_{tower}) - \delta(T_0) = \delta(T_{tower} - \frac{(T_1 + T_3 + T_5 + T_7 + T_0 + T_2 + T_4 + T_6)}{8})$$

# Summary

- The China Group has established a complete QA& QC system. QA & QC
  of Material, Tower and Module have reached the requirements.
- ✓ The cosmic test results show that the lightlyield of different tower is very consistent. Time resolution is 270ps.
- More than 500 module have been completed in China. 768 modules will be ready by 2022.7
- 279 modules produced in THU have been shipped to JINR, now is on the way.

# Thanks for your attention

