# Task 3: Imaging Hadronic Calorimeter Introduction and Overview

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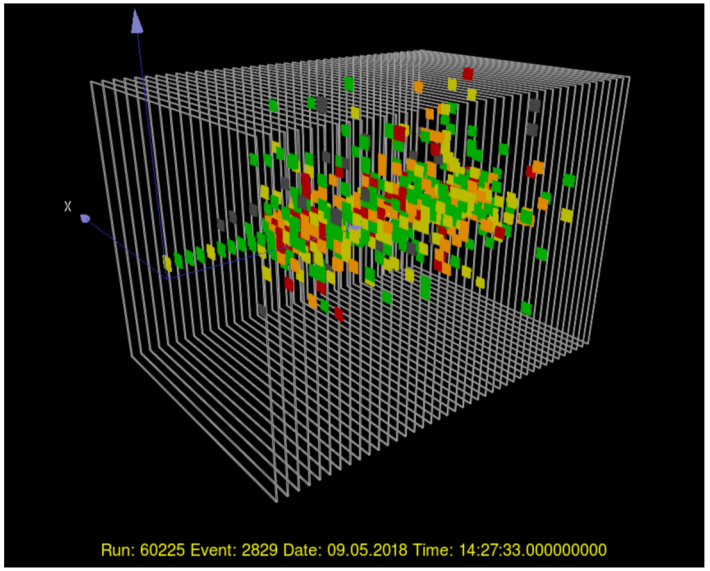
# Central task

- Building a large AHCAL technological prototype
  - More than 10 k channels of scintillator + SiPM + embedded electronics
- Testing it with high energy particle beams at CERN




Taken from CALICE AHCAL, for illustration purpose only.

# Task Breakdown (I)

- AHCAL design and optimization
  - Key parameters: number of layers, sampling fraction, cell-size, number of readout layers, total thickness
- Technology R&D
  - Active layers
    - Cell design and optimization: scintillator + SiPM
    - Production and wrapping of scintillator tiles
    - Scintillator tile gluing
    - Structure design of active layers
    - SiPM monitoring and calibration
  - Readout electronics and DAQ
- Design and manufacturing of absorber stack, calorimeter mechanical structure and test platform

# Task Breakdown (II)

- Production of active components
  - Scintillator tiles,  wrapping
  - FEE boards
  - Active layer assembling
- Calorimeter assembling
- System integration (detector + electronics + DCS)
- Beam test
- Data analysis and performance studies

# Task Breakdown and Assignments

- USTC: detector monitoring and calibration,  readout electronics and DAQ, structure design and manufacturing, 20% of batch testing and assembling, design and development of cosmic-ray test system, cosmic-ray test.
- IHEP: scintillator tile design, production and wrapping, active module assembling technique, 40% of batch testing and assembling, beam test platform
- SJTU: calorimeter design and optimization, tile batch testing system, 40% of batch testing and assembling
- All: calorimeter integration, beam test, data analysis

# Assessment Indicators

- Performance of the HCAL prototype at test beam has to reach a level of

Energy Linearity：

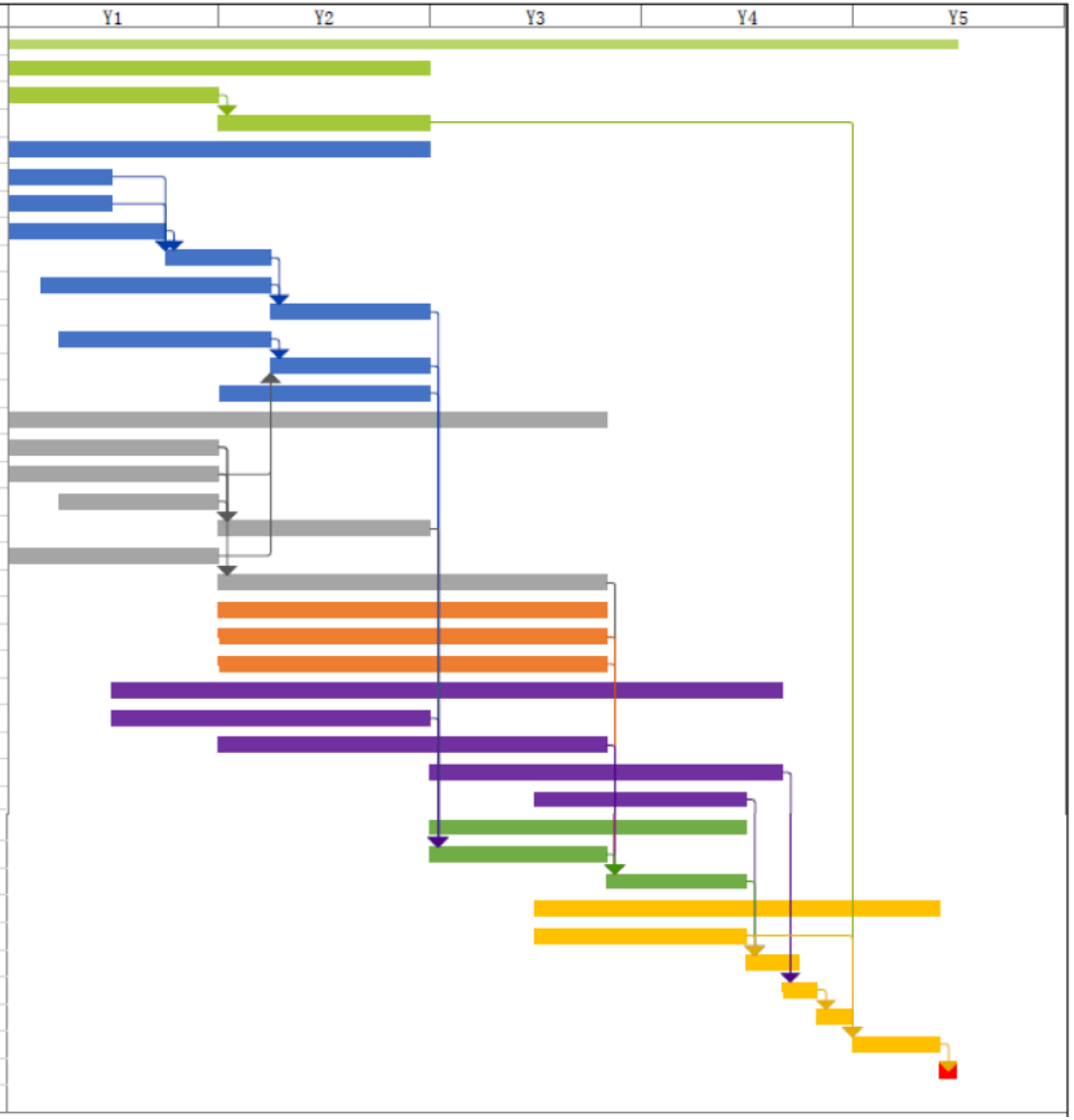
3% （10GeV < E < 80GeV）

Energy resolution：

60%/(E/GeV)⊕3% （10GeV < E < 80GeV）

# Task Schedule

| 标识号 | 任务名称 |
|---|---|
| 1 | **成像型强子量能器技术验证** |
| 2 | **1）量能器原型机物理设计** |
| 3 | 1.1）量能器关键参数的选取和优化 |
| 4 | 1.2）量能器性能模拟研究 |
| 5 | **2）灵敏探测器的研制** |
| 6 | 2.1）原材料、器件采购 |
| 7 | 2.2）灵敏单元结构的设计和优化 |
| 8 | 2.3）闪烁单元生产工艺的研究 |
| 9 | 2.4）闪烁单元批量生产 |
| 10 | 2.5）闪烁单元包装工艺的研究 |
| 11 | 2.6）闪烁单元批量包装 |
| 12 | 2.7闪烁单元批量测试装置制作 |
| 13 | 2.8）闪烁单元批量测试 |
| 14 | 2.9）单层灵敏探测器工艺摸索 |
| 15 | **3）读出电子学和数据获取系统** |
| 16 | 3.1）原材料、电子元器件的采购 |
| 17 | 3.2）前端读出板和数据接口板的设计和开发 |
| 18 | 3.3）SPIROC芯片功能测试板开发 |
| 19 | 3.4）前端读出板和数据接口板的批量制作与测试 |
| 20 | 3.5）测试用数据获取板的开发与制作 |
| 21 | 3.6）数据获取板的开发与制作 |
| 22 | **4）SiPM性能监测和刻度系统的研究** |
| 23 | 4.1）基于LED的监测系统的开发 |
| 24 | 4.2）基于光纤的监测刻度系统的研究 |
| 25 | **5）机械设计和制作** |
| 26 | 5.1）探测器灵敏层结构 |
| 27 | 5.2）原型机吸收体和支撑结构 |
| 28 | 5.3）束流测试平台 |
| 29 | 5.4）宇宙线测试平台 |
| 30 | **6）量能器原型机系统集成** |
| 31 | 6.1）探测器灵敏层的组装和测试 |
| 32 | 6.2）整体样机的集成 |
| 33 | **7）量能器原型机测试和性能研究** |
| 34 | 7.1）数据分析软件的开发和准备 |
| 35 | 7.2）原型机宇宙线测试及质量检验 |
| 36 | 7.3）原型机束流测试前期准备和运输 |
| 37 | 7.4）原型机束流测试及样机运回 |
| 38 | 7.5）测试数据分析及原型机性能研究 |
| 39 | **8）项目总结** |
| 40 | |



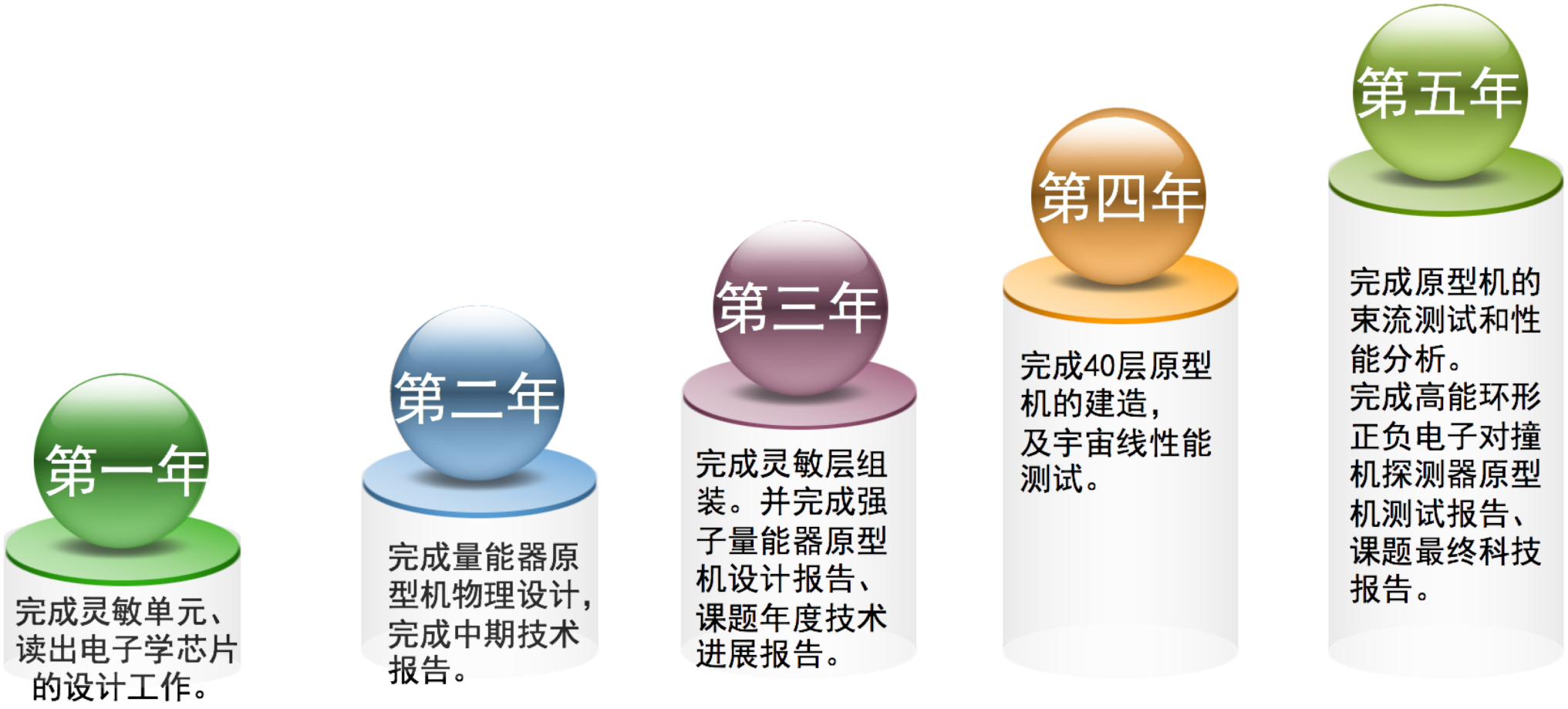
# What was planed for the first year

- Prototype physics design and optimization.
- Scintillator + SiPM cell design and optimization
- Development of scintillator title production technique
- Launching scintillator title production
- Development of auto tile wrapping device
- Design and development of tile batch testing system
- Design of the structure of sensitive layers.
- Design of FEE and DIF boards

# Where We Are

- Prototype design and optimization
  - Progressing well, hopefully to finish by this summer
- Scintillator + SiPM cell design and optimization
  - Done (cell size subject to further optimization)
- Development of scintillator title production technique
  - Done
- Starting scintillator title production
  - Pending cell size optimization
- Development of tile wrapping device
  - Design done
- Design and  development of tile batch testing system
  - Preliminary design available
- Design of the structure of sensitive layers
  - Not started yet
- Design of FEE and DIF boards
  - Exploring lots of synergies with MOST1 sci-ECAL

# Annual Milestones

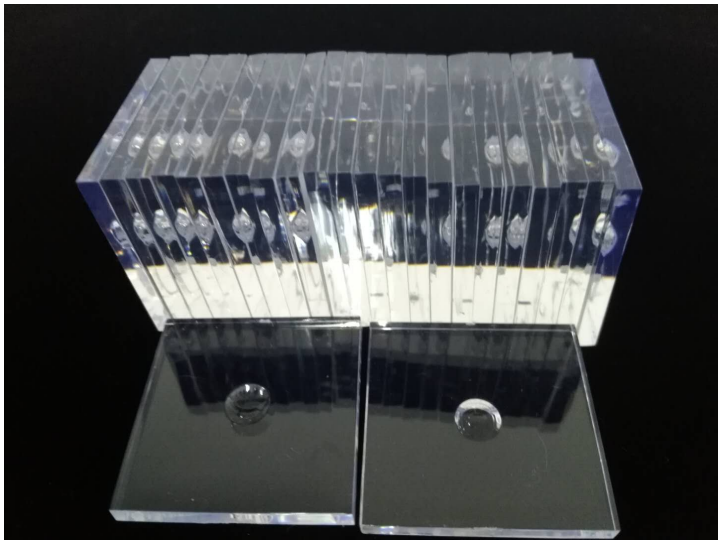


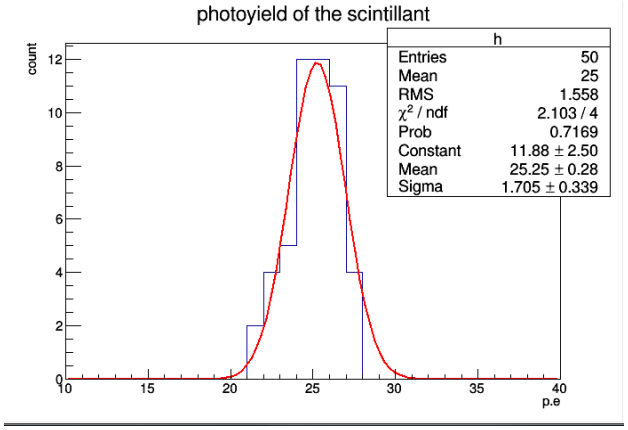
# Highlights of accomplishments

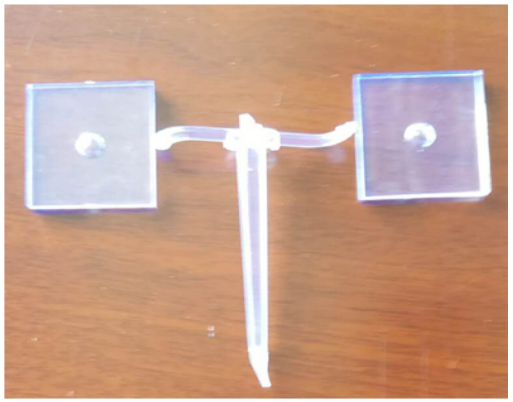
- Optimized AHCAL design
  - SiPM dynamic range
  - Sampling fraction and number of readout layers
- Developed software compensation algorithms
- Developed injection moulding technique for producing scintialtor tiles
- Designed an automatic scintialtor tile wrapping machine
- Designed a batch testing system for scintialtor tiles
- Developed SiPM readout board based on SPIROC-2e (in synergy with the ECAL task from CPEC MOST1)

# *Injection moulding Scintillator tiles*

- 300 tiles polystyrene, BisMSB
  - injection moulded at Beijing
  - incl. dimple, no further surface treatment;
- Mechanical tolerances is fine for assembly, the size error less than 50um;
- Scintillators Light output fluctuation is σ<7%;





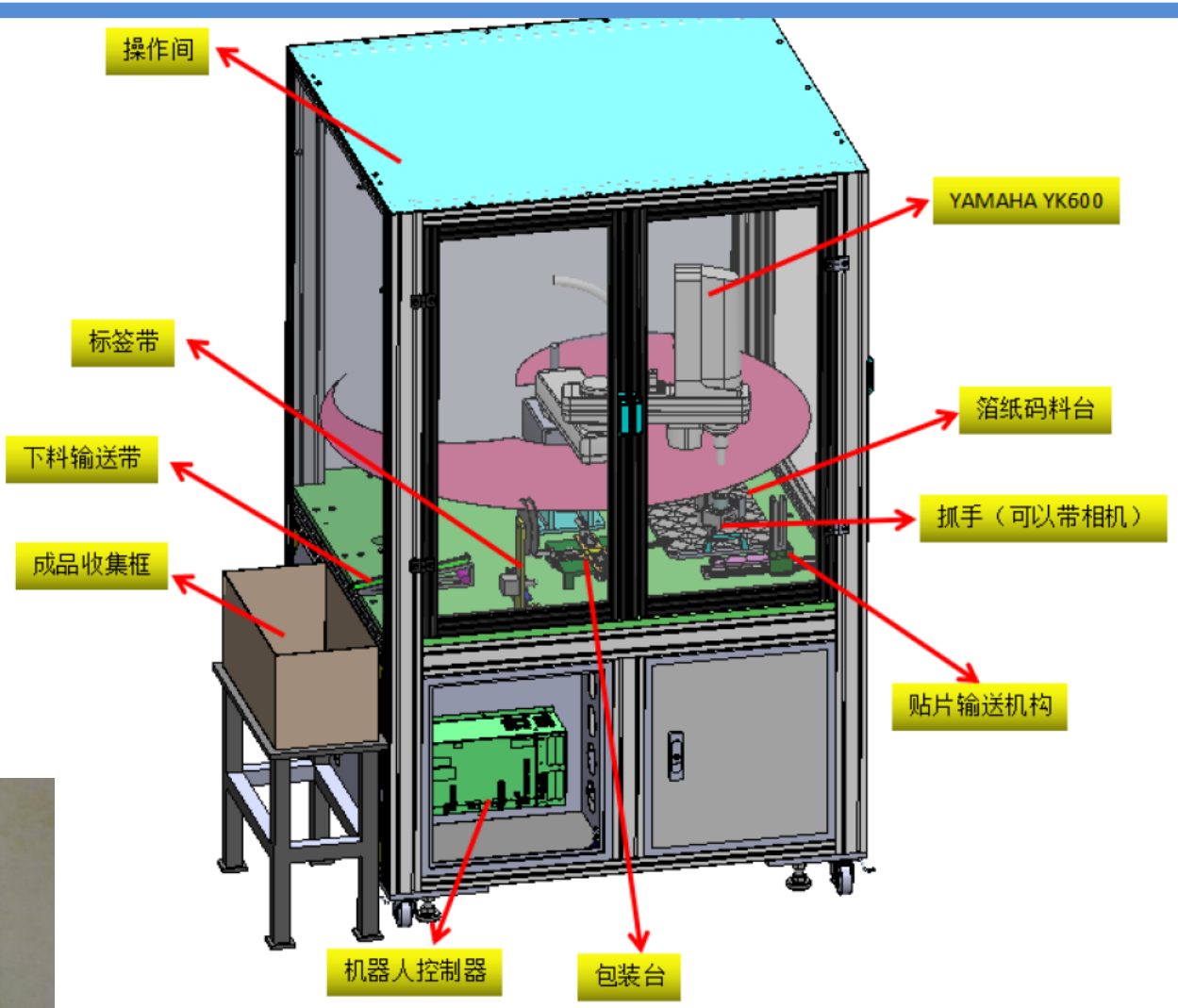
Size uniformity

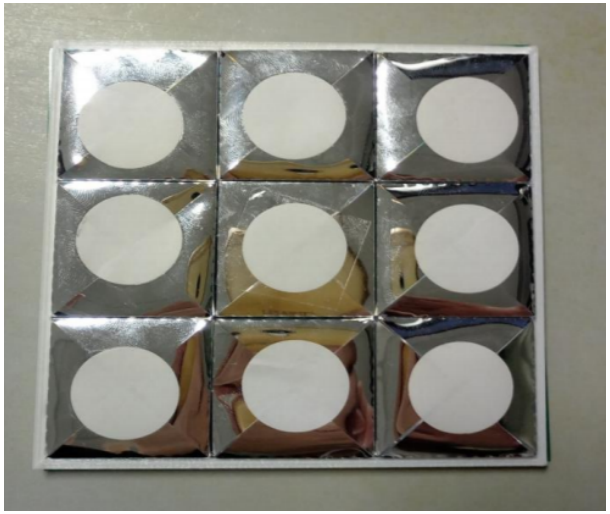
| Tiles size(mm) | 30.08x30.01 x3.08 | 30.07x30.04 x3.09 | 30.04x30.02 x3.09 | 30.09x30.09 x3.09 | 30.05x30.03 x3.09 |
|---|---|---|---|---|---|
| Light output(p.e.) | 23.5 | 22.78 | 22.86 | 25.02 | 23.54 |

# *Scintillator tile automatic wrapping*

— Motivation:
- 7M detector cells;
- Reflective foils packaging can't be done by manual;

— Progress:
- Companies give they preliminary design;
- Robotic arm design is the best way;



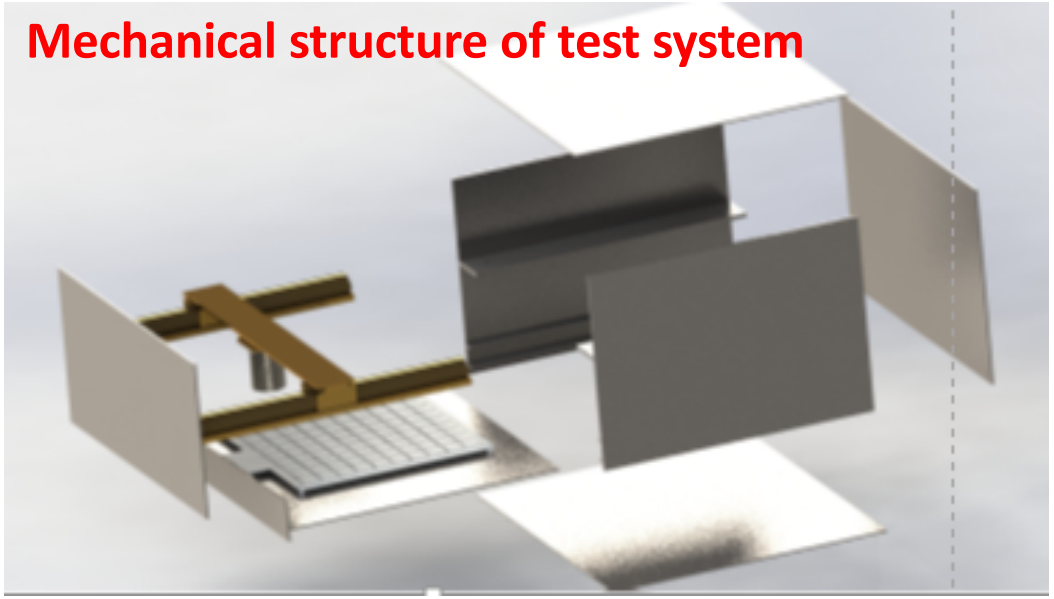



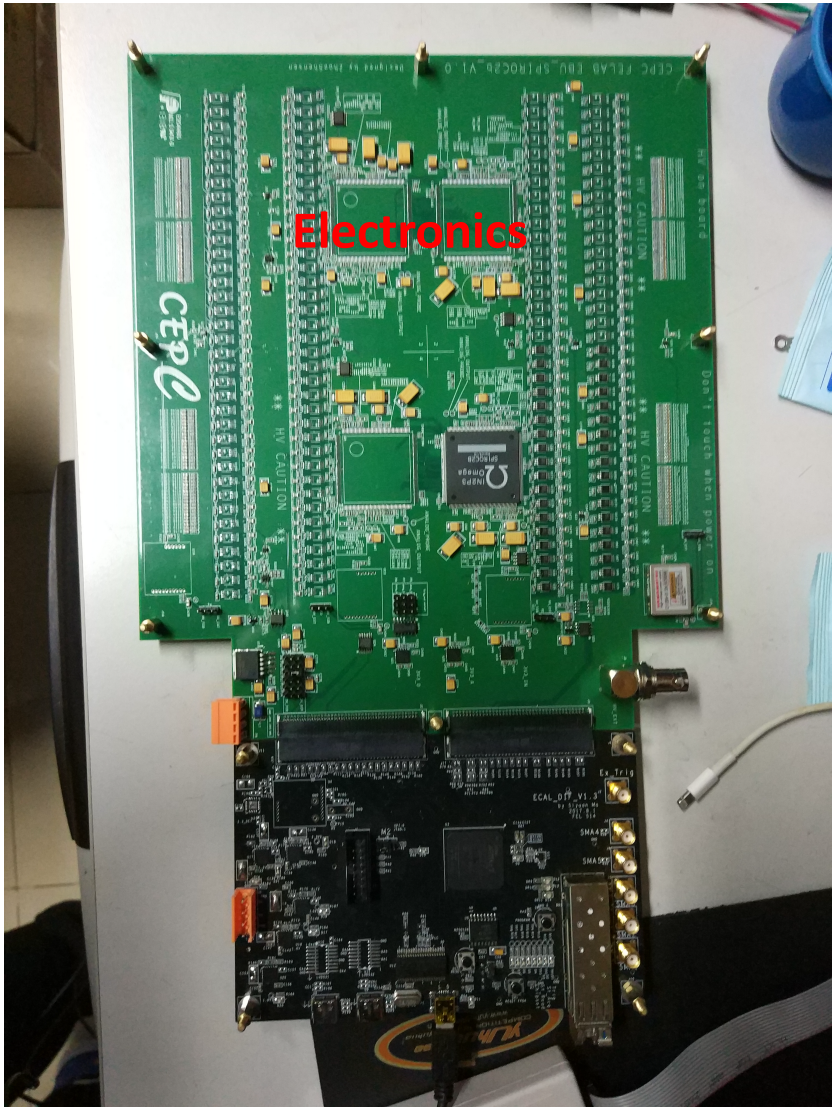
Packaged cell

It can be used for 3cm*3cm, 4cm*4cm and 5cm*5cm detector cell;

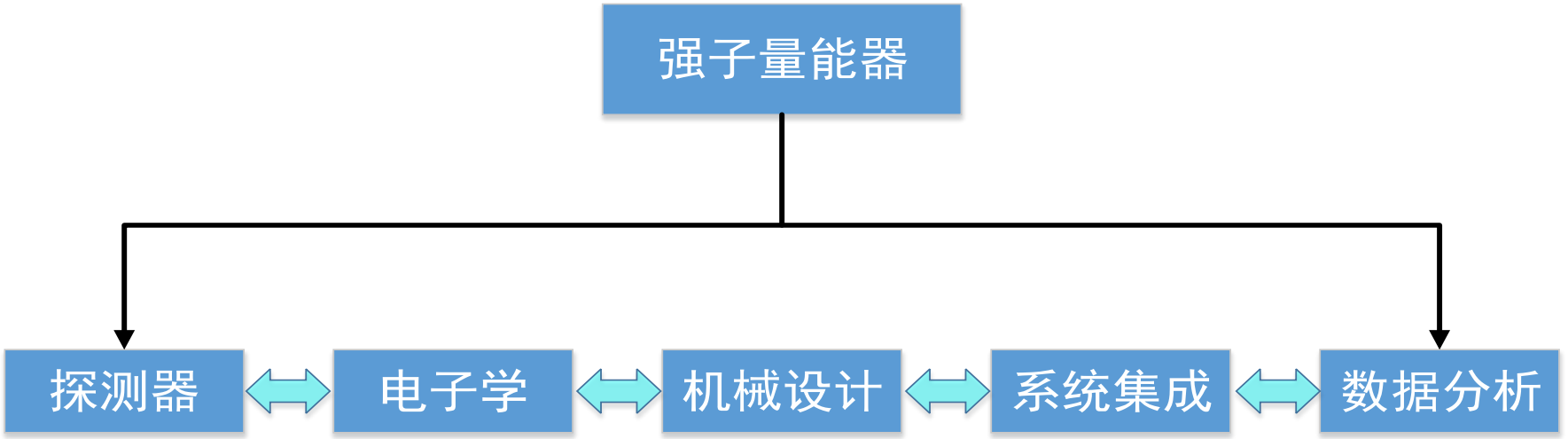
# *Detector cell test system design*

- Capable to test about 100 detector cells a time
- Preliminary design of electronics and mechanical structure available



# Task Breakdown




灵敏单元的设计、批量制作与测试，灵敏层的制作和组装，大规模 SiPM 性能监测与刻度系统的研制

读出电子学和数据获取系统的开发和制作

量能器原型机各种机械结构的设计和加工制作，测试所需的各种支撑装置的设计和加工制作。

量能器样机的系统集成和性能测试

量能器物理设计、性能模拟、测试数据的分析。