# The Status of the HCAL

2024-09-03


Qian Sen,  on behalf of the HCAL Group

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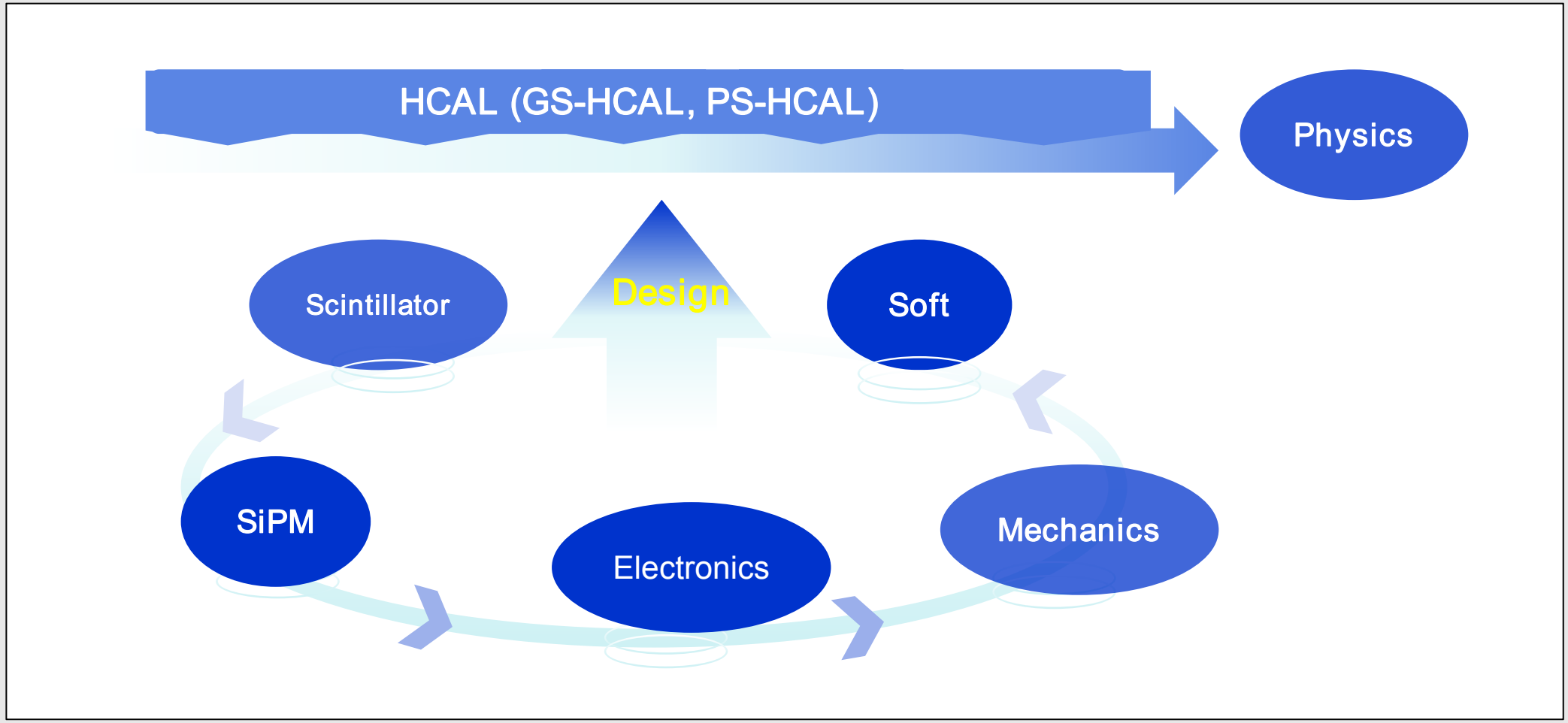
# The Sub-system of HCAL

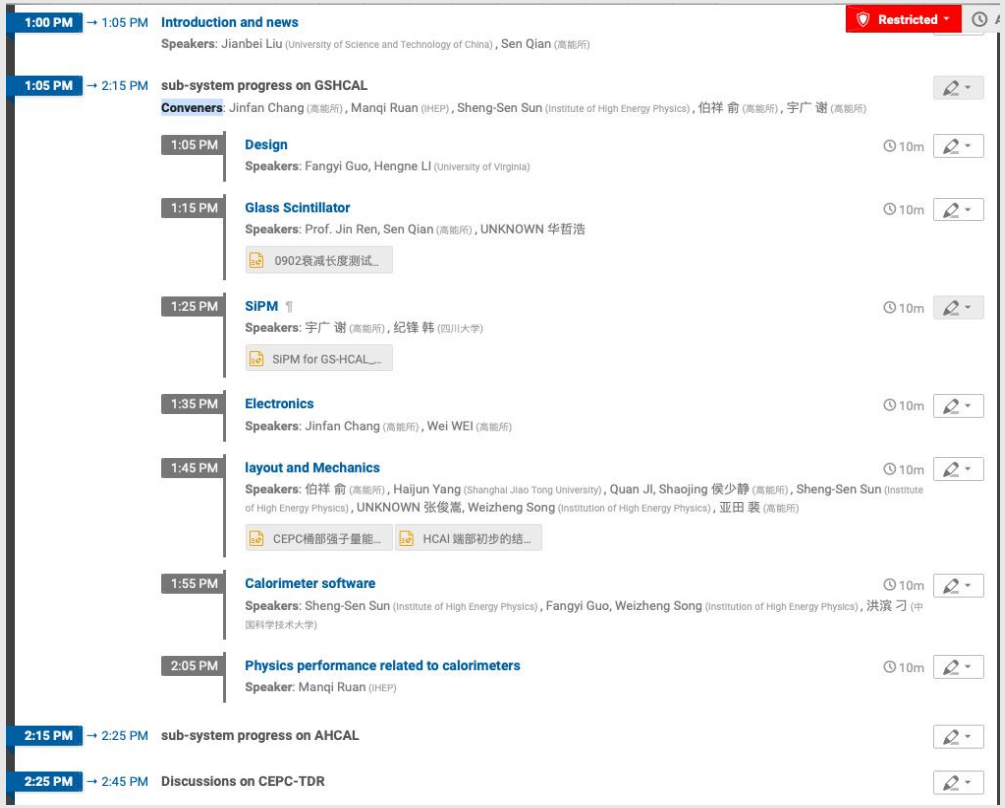


# The manpower of the HCAL

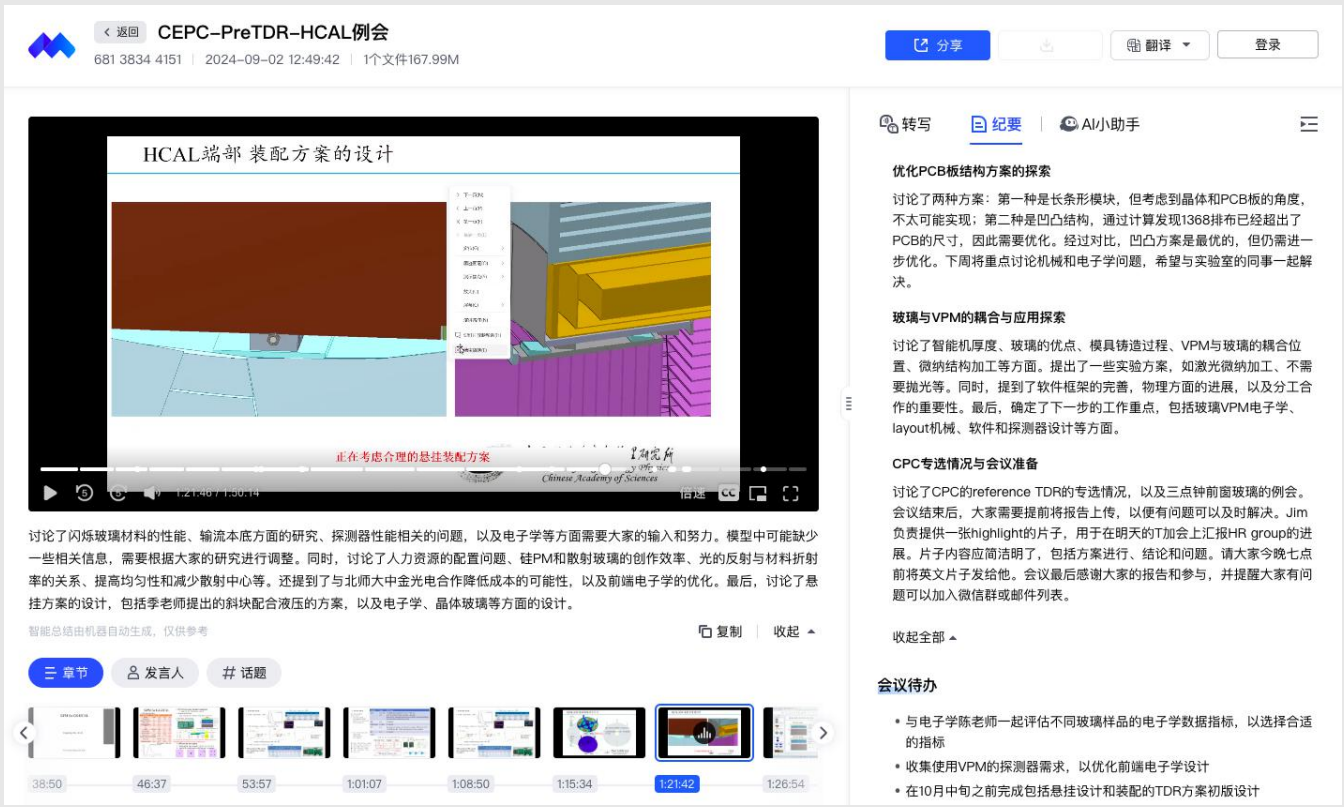
- 1. The PS-HCAL
  - Jianbei Liu, Haijun Yang, Boxiang Yu，Yunlong Zhang，……，
- 2. The GS-HCAL
  - Sub-system: the Conveners
  - Design:  Fangyi Guo(IHEP), Hengne Li(SCNU)
  - Glass Scintillator: Sen Qian(IHEP), Jing Ren(HEU)
  - SiPM: Yuguang Xie(IHEP), Jifeng Han(SCU)
  - Electronics: Jingfan Chang(IHEP),
  - layout and Mechanics: Boxiang Yu(IHEP),
  - Software: Sengsen Sun(IHEP),
  - Physics: Manqi?(IHEP),

# The Weekly Meeting of HCAL

## The Indico Page




## Tencent conference with Video and Record by AI

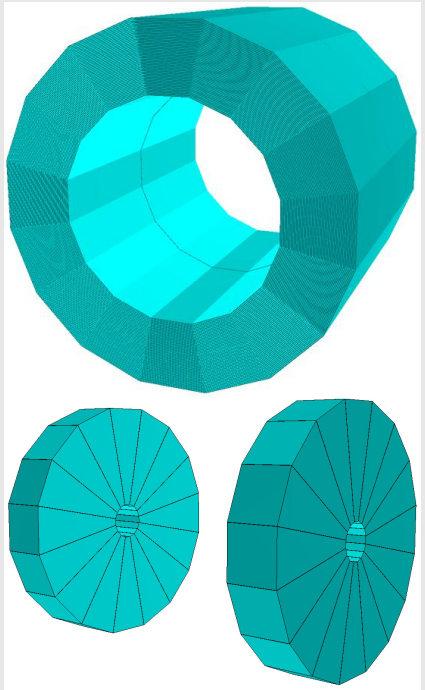


# Current status of the GS-HCAL Software

--by Sengsen Sun

1. The detailed report could be seen in CEPC Day in Aug. https://indico.ihep.ac.cn/event/22548/

- **The 1st version of HCAL software in CEPCSW is available.**
  - Geometry: ILD-AHCAL like barrel + new developed endcaps following mechanics design.
  - Digitization: scintillation, SiPM saturation, electronics, threshold.
    - Intrinsic resolution $36.06\%/\sqrt{E} \oplus 2.07\%$ (need validation)
  - Reconstruction: CyberPFA
    - truth track + crystal bar ECAL + GS-HCAL PFA, BMR ~ 3.70%.
  - Software is flexible and ready for coming ref-det TDR studies.



- **Design goal of the GS-HCAL: BMR<4%**
  - BMR in HCAL = intrinsic resolution ($\sigma_E/E$) + separation (cell size, N layers, etc.)
  - **Cell size etc. are studied with CEPCSoft + Arbor, so focus on $\sigma_E/E$ in recent simulation efforts.**

# Recent plans for GS-HCAL--Design

--by Fangyi Guo & Hengne Li

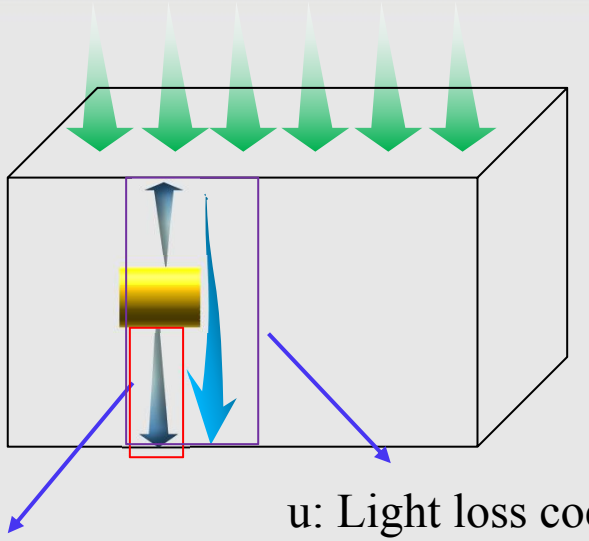
- **Study the parameters to intrinsic resolution $\sigma_E/E$ (rank with priority).**
  - Understand the difference between CEPCSW and standalone simulation:
    - Lateral & longitudinal leakage, glass/absorber thickness, ?
  - Glass Light yield, attenuation length and non-uniformity
    - Effective detected light yield 80 p.e./MIP is too simple. Need a better model & more inputs from glass sample tests.
  - SiPM response, electronics readout.
    - SiPM saturation effects (related to design: 1 $6\times6\ mm^2$ SiPM or 4 $3\times3\ mm^2$ SiPMs or ?).
    - Electronics precision: follow electronics group design and show the impacts to performance.
    - Noise effects: should be negligible in 0.1 MIP threshold. To be proved.
  - Detector optimization
    - Cell size, different thickness in layers, etc and corresponding PFA performance.
- **Need close cooperation with GS/SiPM/electronics/mechanics groups.**

# GS-HCAL数字化模型 [git]

- **玻璃闪烁发光:**
  - $E_{hit} \rightarrow N_{p.e.}$: $N_{p.e.} = Poisson(\frac{E_{hit}[GeV]}{E_{mip}[GeV/MIP]} \times LY)$ Poisson抽样
  - $E_{mip}$ = 7.1 MeV from simulation, LY = 80 p.e./mip from tests.
- **Tile的不均匀性：**
  - $N_{p.e.} \rightarrow N_{p.e.} \times (1 + Uniform(\pm 5\%))$ 均匀抽样
  - 不同样品的间随机差异。考虑刻度后应设到0.
- **SiPM饱和**
  - $N_{pix} = [N_{pix}^{SiPM} \times \left(1 - e^{-N_{p.e.}/N_{pix}^{SiPM}}\right)]$ 非线性效应
  - 使用HPK S13360-6025 PE ($6 \times 6\ mm^2$) SiPM: $N_{pix}^{SiPM} = 57600$.
- **电子学响应**
  - $\langle ADC \rangle = N_{pix}\ (p.e.) \times 30\ (ADC/p.e.)$, $\sigma_{ADC} = 3.5 \times \sqrt{N_{pix}[p.e.]}$. ADC高斯抽样
  - 双增益模式:
    - $ADC_{HG} = [ADC + Baseline_{HG}]$, $Baseline_{HG} = Gaus(377.4, 3.3)$;
    - $ADC_{LG} = [ADC/Gain\ Ratio(29.9) + Baseline_{LG}]$, $Baseline_{LG} = Gaus(373.9, 2.2)$; 基线高斯抽样
  - 电子学饱和: ADC = 3000 电子学饱和截断
  - 增益选择:
    - if($ADC_{HG} < 2930$): $N_{mip} = (ADC_{HG} - Baseline_{HG})/2400$(ADC/mip)
    - if($ADC_{HG} > 2930$): $N_{mip} = (ADC_{LG} - Baseline_{LG}) \times Gain\ ratio\ (29.9)/2400$(ADC/mip)
- **阈值效应：if ($N_{mip} < 0.1$) 扔掉这个hit** 能量阈值

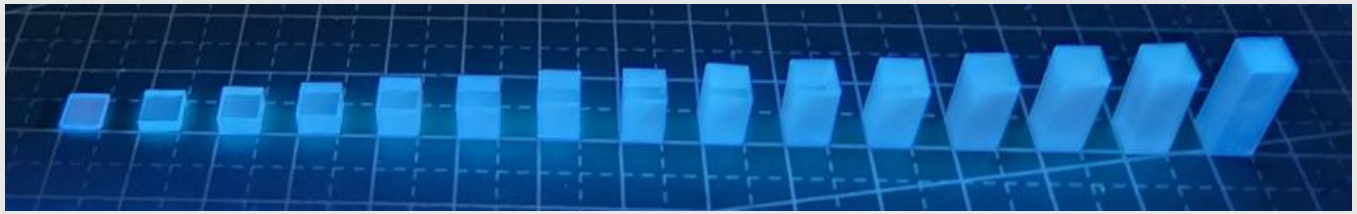
# Current status of the GS-HCAL Glass Scintillator

--by Ren Jing



LY: light attenuation length （2.30 cm)

u: Light loss coefficient (0.57 $cm^{-1}$)

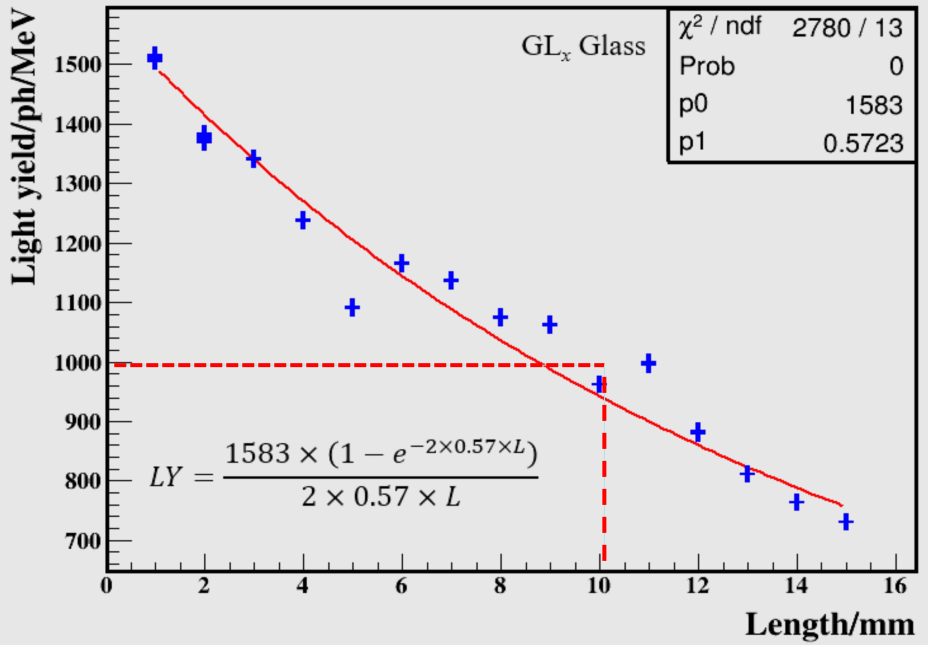


$$LY = LY_0 \frac{1 - e^{-2\mu h}}{2\mu h}$$

$LY_0$—本征光产额

$\mu$—光损失系数 ($cm^{-1}$，重吸收及反射)

$h$—材料厚度




**How to increase the length of light attenuation (reduce the coefficient of light loss )?**

**----Reducing flickering glass defects, improving uniformity, and controlling self-absorption can and**

# Current status of the GS-HCAL SiPM

--by Yuguang Xie

➢ Survey of SiPM suppliers

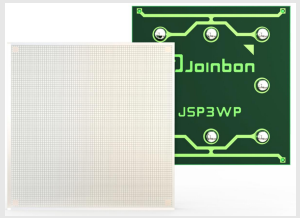
- Hamamatsu(HPK,滨淞)
- Fondazione Bruno Kessler (FBK)
- ON Semiconductor Corp(OSM,安森美,收购Sensl）
- First Sensor
- Capital Photonics Technology (Tianjin) Co., Ltd (CPT,中京光电,北师大）
- Joinbon Technology Co., Ltd.(Hubei) (JBT,湖北锐光科技有限公司)
- Xilight Technology (XLT,芯辉科技)

➢ Next plan

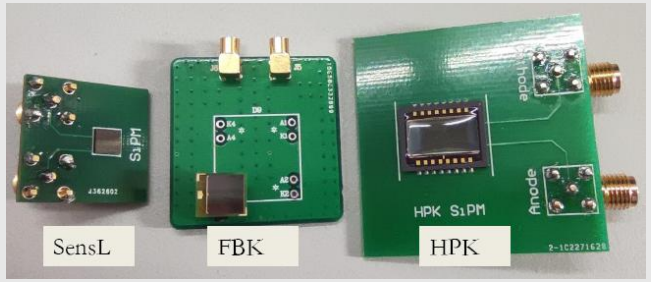
- Estimate the visible number of p.e in 40*40*10mm GS unit coupling with different sizes of SiPMs
- Identify the requirement of SiPM for GS-HCAL
- Compare and test the performance of SiPM candidates

HPK-S14160

JBT-JSP-TP3050-SMT




CPT-EQR20

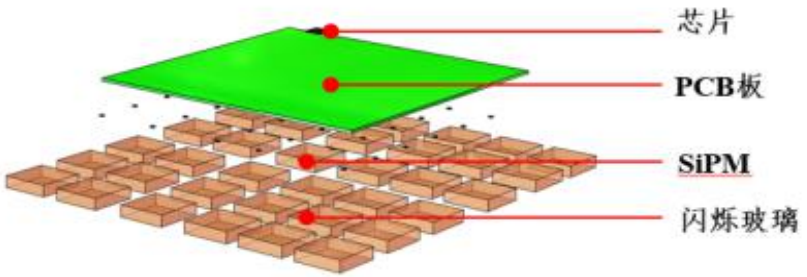


# Current status of the GS-HCAL Mechanics

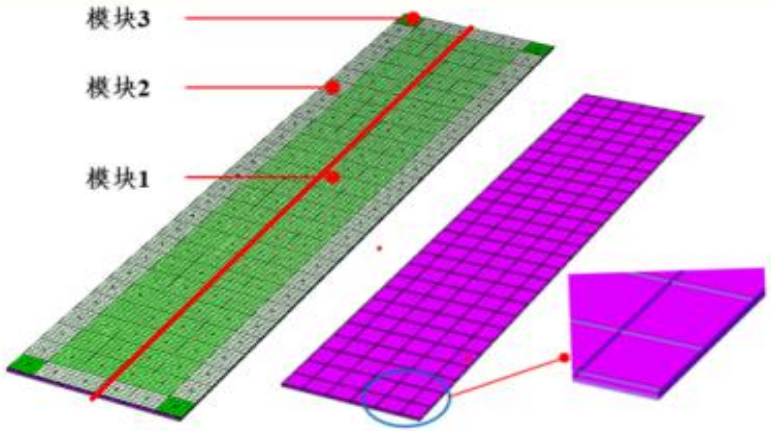
--by Yatian Pei

## GS-HCAL桶部结构设计

### GS方案1：井子型方案




灵敏层模块（3种）




1/16顶层结构　　吸收体

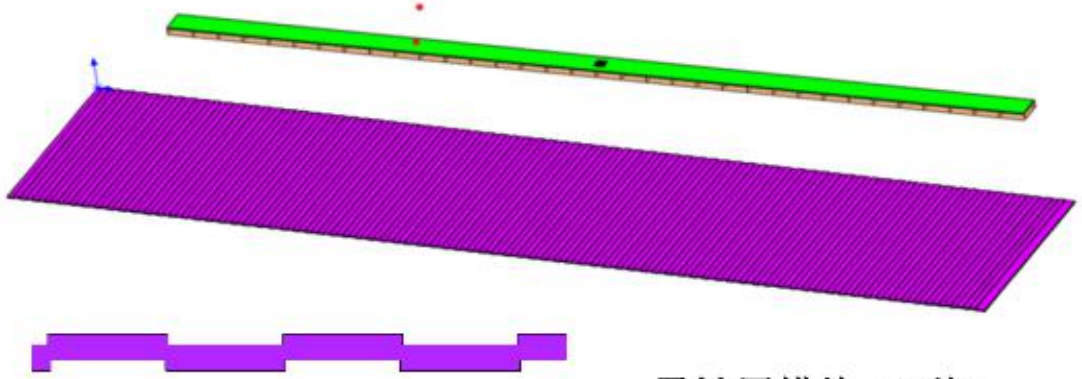
有限元计算结果：

- 最大变形1.01mm

方案优化：

- 在中间肋板十字交处（红线位置）施加支撑
- 最大变形0.05mm

### GS方案2：凹凸方案



灵敏层模块（1种）

| | 平板方案 | 井字型加强筋方案 | 井字形加强筋优化方案 | 凹凸加强方案 |
|---|---|---|---|---|
| 吸收体自重变形 | 0.93mm | 0.62mm | —— | 0.48mm |
| 吸收体载重变形 | 1.87mm | 1.01mm | **0.05mm** | 0.96mm |

# The Plan of this Week

The GS-HCAL

- Software: Sengsen Sun(IHEP), CEPC Day in Aug
- Physics: Manqi?(IHEP) -----
- **Design:** the discuss meeting on 2024-08-30 13:00-14:00, Tencent Meeting with record;
- **Glass Scintillator:** weekly meeting on Monday 15:00-17:00, Tencent Meeting with record;

  20240830-20240901， Qinghuangdao， Glass Meeting，8 talks;


- **SiPM:** the discuss meeting on 2024-08-31 14:00-15:00, Tencent Meeting with record;
- **Electronics: ? Layout and Mechanics: ?**

----we will have discussion with people from Electronics & Mechanics together this week.

----Layout of the detector for Beam Test.