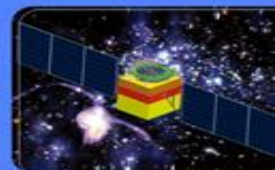


The Status of the HCAL

2024-09-03

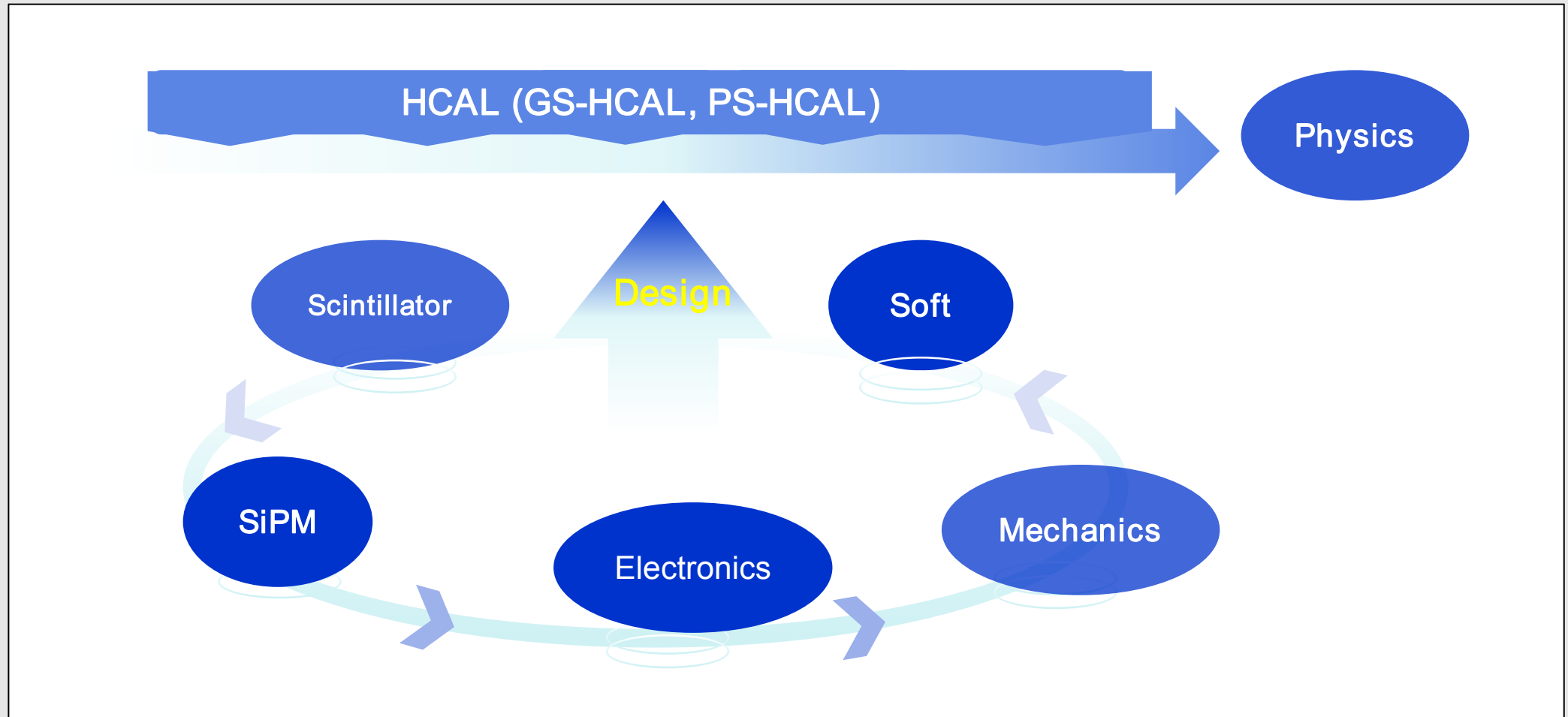
WWW.IHEP.CAS.CN



Qian Sen, on behalf of the HCAL Group

qians@ihep.ac.cn

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

1:00 PM → 1:05 PM Introduction and news
Speakers: Jianbei Liu (University of Science and Technology of China), Sen Qian (高能所)

1:05 PM → 2:15 PM sub-system progress on GSHCAL
Conveners: Jinfan Chang (高能所), Manqi Ruan (HEP), Sheng-Sen Sun (Institute of High Energy Physics), 伯祥 俞 (高能所), 宇广 谢 (高能所)

1:05 PM Design
Speakers: Fangyi Guo, Hengne Li (University of Virginia)

1:15 PM Glass Scintillator
Speakers: Prof. Jin Ren, Sen Qian (高能所), UNKNOWN 华哲浩
0902衰减小长度测试...

1:25 PM SIPM
Speakers: 宇广 谢 (高能所), 纪锋 韩 (四川大学)
SIPM for GS-HCAL...

1:35 PM Electronics
Speakers: Jinfan Chang (高能所), Wei WEI (高能所)

1:45 PM layout and Mechanics
Speakers: 伯祥 俞 (高能所), Haijun Yang (Shanghai Jiao Tong University), Quan Ji, Shaojing 侯少静 (高能所), Sheng-Sen Sun (Institute of High Energy Physics), UNKNOWN 张俊高, Weizheng Song (Institution of High Energy Physics), 亚田 裘 (高能所)
CEPC端部强子量能... HCAI 端部初步的结...

1:55 PM Calorimeter software
Speakers: Sheng-Sen Sun (Institute of High Energy Physics), Fangyi Guo, Weizheng Song (Institution of High Energy Physics), 洪滨 刁 (中国科学院大学)

2:05 PM Physics performance related to calorimeters
Speaker: Manqi Ruan (HEP)

2:15 PM → 2:25 PM sub-system progress on AHCAL

2:25 PM → 2:45 PM Discussions on CEPC-TDR

Tencent conference with Video and Record by AI

CEPC-PreTDR-HCAL例会
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正在考虑合理的悬挂设计方案

优化PCB板结构方案的探索

讨论了两种方案：第一种是长条形模块，但考虑到晶体和PCB板的角度，不太可能实现；第二种是凹凸结构，通过计算发现1368排布已经超出了PCB的尺寸，因此需要优化。经过对比，凹凸方案是最优的，但仍需进一步优化。下周将重点讨论机械和电子学问题，希望与实验室的同事一起解决。

玻璃与VPM的耦合与应用探索

讨论了智能机厚度、玻璃的优点、模具铸造过程、VPM与玻璃的耦合位置、微纳结构加工等方面。提出了一些实验方案，如激光微纳加工、不需要抛光等。同时，提到了软件框架的完善，物理方面的进展，以及分工合作的重要性。最后，确定了下一步的工作重点，包括玻璃VPM电子学、layout机械、软件和探测器设计等方面。

CPC专选情况与会议准备

讨论了CPC的reference TDR的专选情况，以及三点钟前面玻璃的例会。会议结束后，大家需要提前将报告上传，以便有问题可以及时解决。Jim负责提供一张highlight的片子，用于在明天的T加会上汇报HR group的进展。片子内容应简洁明了，包括方案进行、结论和问题。请大家今晚七点前将英文片子发给他。会议最后感谢大家的报告和参与，并提醒大家有问题可以加入微信群或邮件列表。

收起全部

会议待办

- 与电子学陈老师一起评估不同玻璃样品的电子学数据指标，以选择合适的指标
- 收集使用VPM的探测器需求，以优化前端电子学设计
- 在10月中旬之前完成包括悬挂设计和装配的TDR方案初版设计

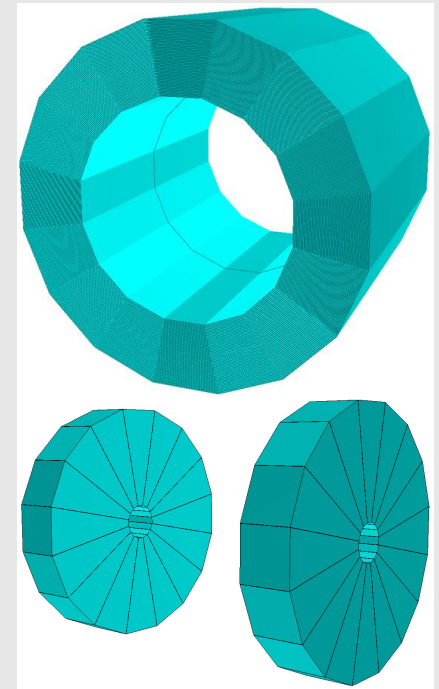
1. The detailed report could be seen in CEPC Day in Aug. <https://indico.ihep.ac.cn/event/22548/>

■ 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 $\sim 3.70\%$.
- Software is flexible and ready for coming ref-det TDR studies.

■ Design goal of the GS-HCAL: BMR < 4%

- BMR in HCAL = intrinsic resolution (σ_E/E) + separation (cell size, N layers, etc.)
- **Cell size etc. are studied with CEPCSoft + Arbor, so focus on σ_E/E in recent simulation efforts.**



Recent plans for GS-HCAL--Design

--by Fangyi Guo & Hengne Li

- **Study the parameters to intrinsic resolution σ_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 $6\times 6\text{ mm}^2$ SiPM or 4 $3\times 3\text{ mm}^2$ 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:

- $E_{hit} \rightarrow N_{p.e.}: N_{p.e.} = Poisson(\frac{E_{hit}[GeV]}{E_{mip}[GeV/MIP]} \times LY)$
- $E_{mip} = 7.1$ MeV from simulation, $LY = 80$ p.e./mip from tests.

Poisson抽样

• Tile的不均匀性:

- $N_{p.e.} \rightarrow N_{p.e.} \times (1 + Uniform(\pm 5\%))$
- 不同样品的间随机差异。考虑刻度后应设到0.

均匀抽样

• SiPM饱和

- $N_{pix} = [N_{pix}^{SiPM} \times (1 - e^{-N_{p.e.}/N_{pix}^{SiPM}})]$
- 使用HPK S13360-6025 PE (6×6 mm²) SiPM: $N_{pix}^{SiPM} = 57600$.

非线性效应

• 电子学响应

- $\langle ADC \rangle = N_{pix} (p.e.) \times 30$ (ADC/p.e.), $\sigma_{ADC} = 3.5 \times \sqrt{N_{pix}[p.e.]}$.
- 双增益模式:
 - $ADC_{HG} = [ADC + Baseline_{HG}]$, $Baseline_{HG} = Gaus(377.4, 3.3)$;
 - $ADC_{LG} = [ADC / Gain Ratio(29.9) + Baseline_{LG}]$, $Baseline_{LG} = Gaus(373.9, 2.2)$;
- 电子学饱和: $ADC = 3000$
- 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)

ADC高斯抽样

基线高斯抽样

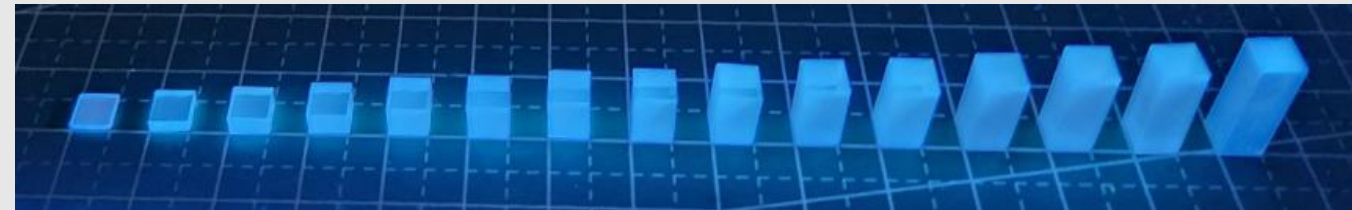
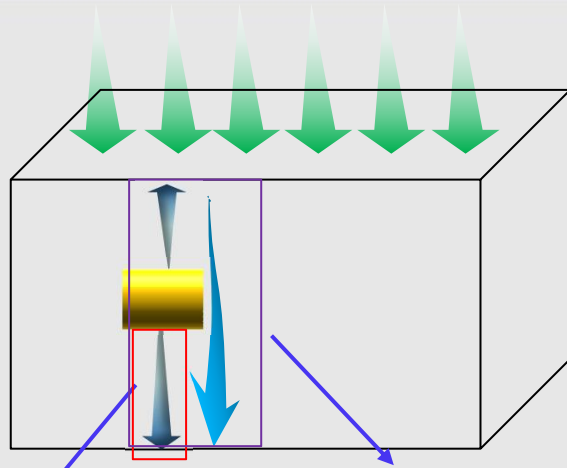
电子学饱和截断

• 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

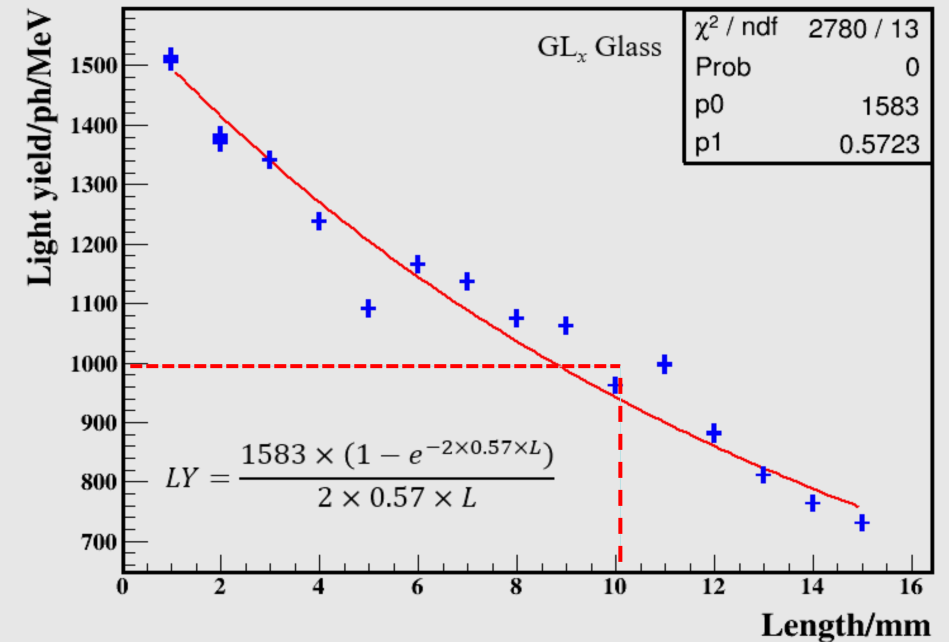
--by Ren Jing



LY: light attenuation length (2.30 cm)
 μ : 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
 μ —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,滨松)
- 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)

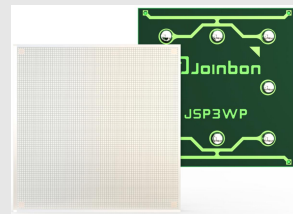
➤ Next plan

- 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

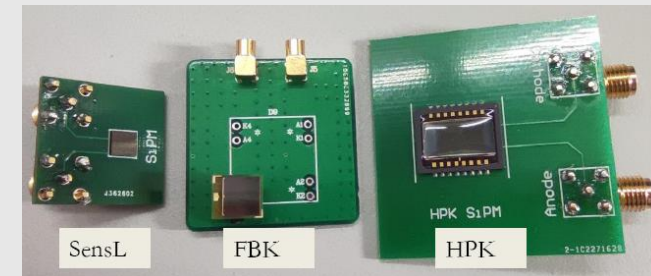
HPK-S14160



JBT-JSP-TP3050-SMT

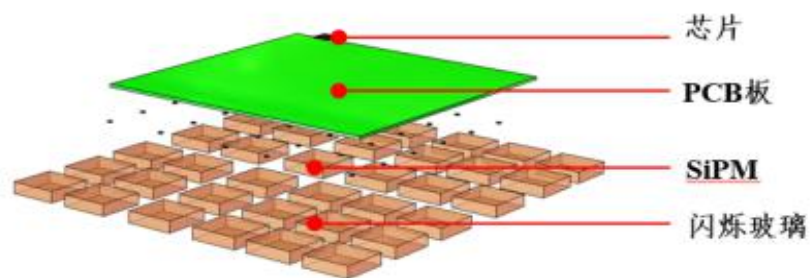


CPT-EQR20

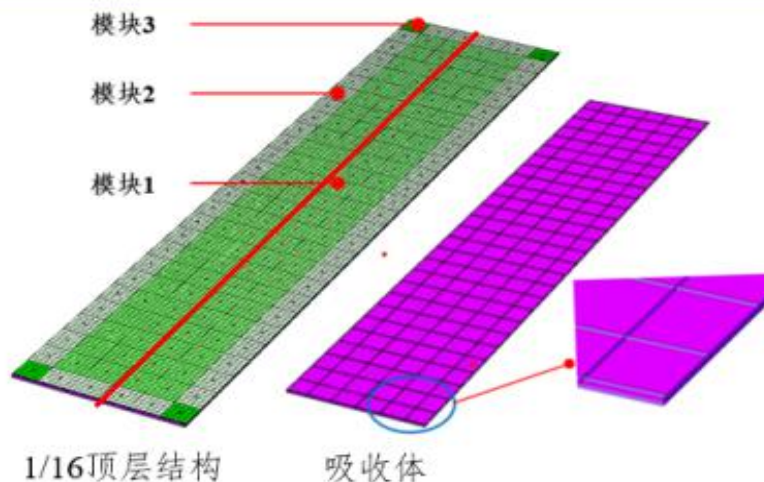


GS-HCAL桶部结构设计

GS方案1：井子型方案



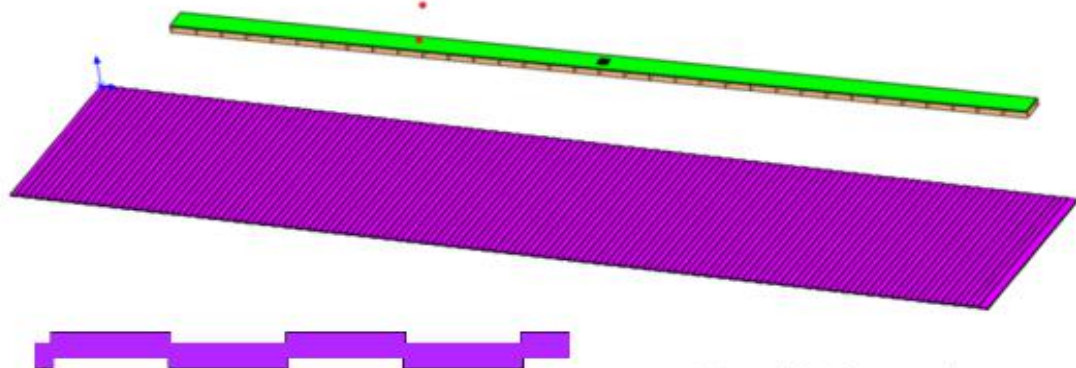
灵敏层模块 (3种)



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;



第十三届中国功能玻璃学术研讨会
暨新型光电子材料国际论坛

- 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.