HCAL的探测单元数量估算

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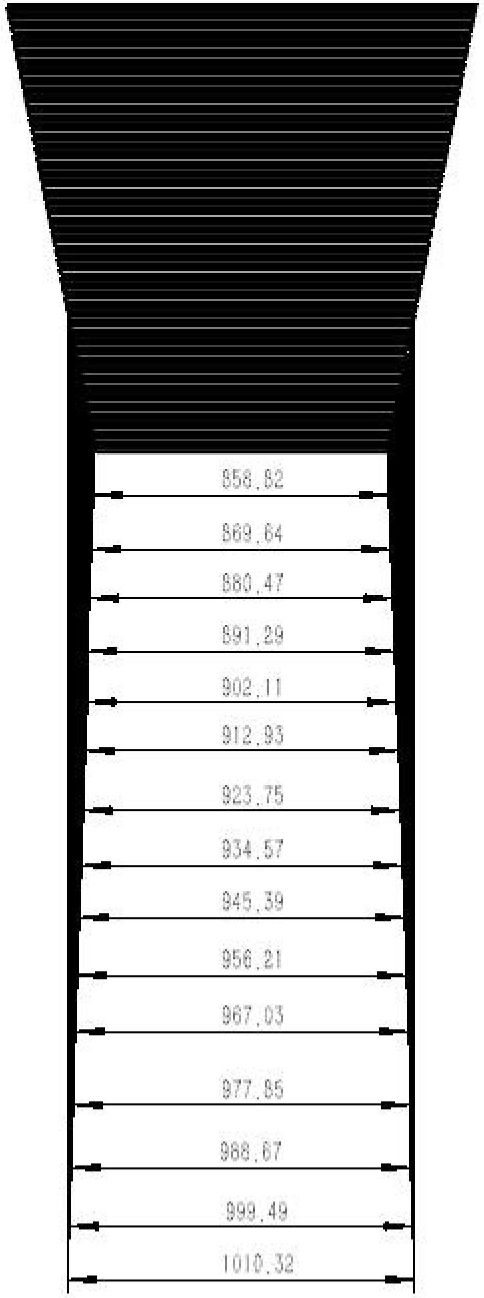
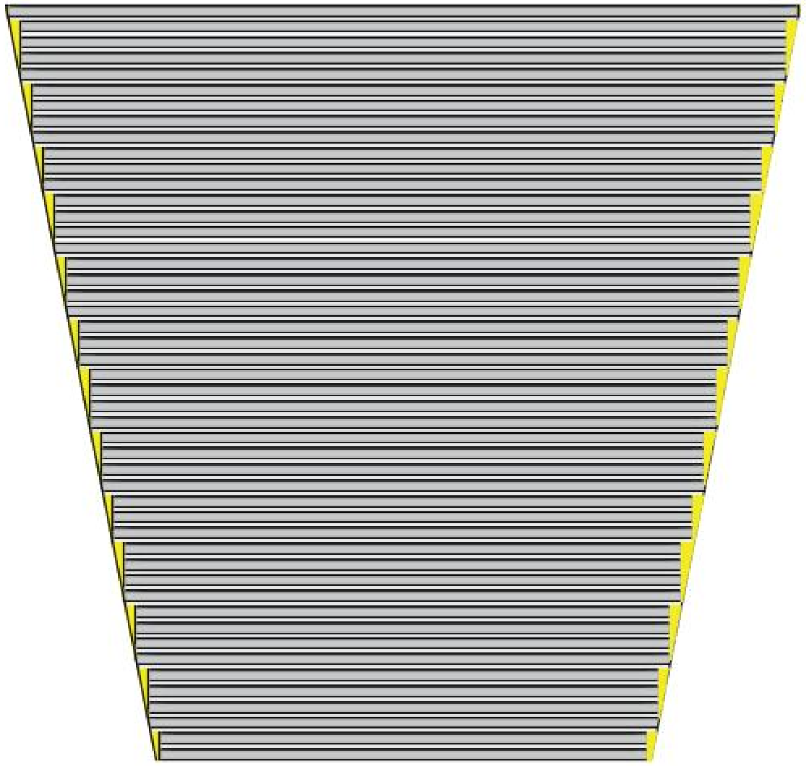
From Yatian's talk





轴向有20mm没有布塑闪

单块重量：60813kg
钢：45639kg
无氧铜：下盖板6169kg，上盖板6187kg
塑闪：1179kg
PCB板：1639kg
元器件和SiPM可以忽略不计

总重：973吨

层编号	宽度	塑闪数量	向下取整	实际铺层宽度	可利用支撑结构宽度
1	858.82	21.4705	21	840	18.82
2	869.64	21.741	21	840	29.64
3	880.47	22.01175	22	880	0.47
4	891.29	22.28225	22	880	11.29
5	902.1108	22.55277	22	880	22.1108
6	912.9316	22.82329	22	880	32.9316
7	923.7524	23.09381	23	920	3.7524
8	934.5732	23.36433	23	920	14.5732
9	945.394	23.63485	23	920	25.394
10	956.2148	23.90537	23	920	36.2148
11	967.0356	24.17589	24	960	7.0356
12	977.8564	24.44641	24	960	17.8564
13	988.6772	24.71693	24	960	28.6772
14	999.498	24.98745	24	960	39.498
15	1010.319	25.25797	25	1000	10.3188
16	1021.14	25.52849	25	1000	21.1396
17	1031.96	25.79901	25	1000	31.9604
18	1042.781	26.06953	26	1040	2.7812
19	1053.602	26.34005	26	1040	13.602
20	1064.423	26.61057	26	1040	24.4228
21	1075.244	26.88109	26	1040	35.2436
22	1086.064	27.15161	27	1080	6.0644
23	1096.885	27.42213	27	1080	16.8852
24	1107.706	27.69265	27	1080	27.706
25	1118.527	27.96317	27	1080	38.5268
26	1129.348	28.23369	28	1120	9.3476
27	1140.168	28.50421	28	1120	20.1684
28	1150.989	28.77473	28	1120	30.9892
29	1161.81	29.04525	29	1160	1.81
30	1172.631	29.31577	29	1160	12.6308
31	1183.452	29.58629	29	1160	23.4516
32	1194.272	29.85681	29	1160	34.2724
33	1205.093	30.12733	30	1200	5.0932
34	1215.914	30.39785	30	1200	15.914
35	1226.735	30.66837	30	1200	26.7348
36	1237.556	30.93889	30	1200	37.5556
37	1248.376	31.20941	31	1240	8.3764
38	1259.197	31.47993	31	1240	19.1972
39	1270.018	31.75045	31	1240	30.018
40	1280.839	32.02097	32	1280	0.8388
41	1291.66	32.29149	32	1280	11.6596
42	1302.48	32.56201	32	1280	22.4804
43	1313.301	32.83253	32	1280	33.3012
44	1324.122	33.10305	33	1320	4.122
45	1334.943	33.37357	33	1320	14.9428
46	1345.764	33.64409	33	1320	25.7636
47	1356.584	33.91461	33	1320	36.5844
48	1367.405	34.18513	34	1360	7.4052

HCAL桶部探测单元数量估算

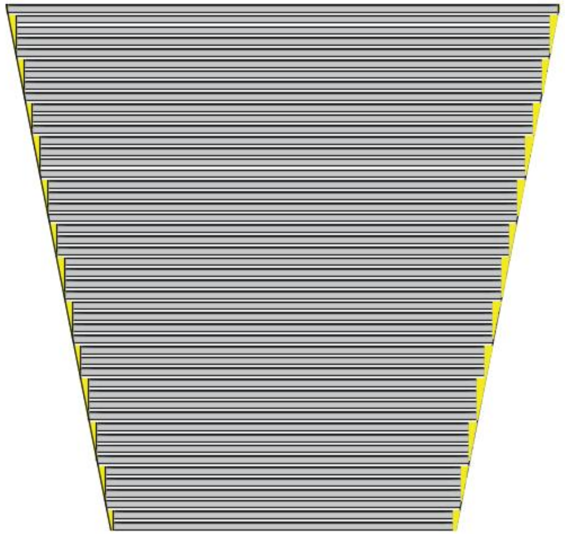
闪烁体尺寸：4cm×4cm

侧面一层的探测单元数量：1312个单元。

模块长度：6460mm,40mm/cell，161个单元。

1312×161=211232,一个1/16模块的探测单元数量。

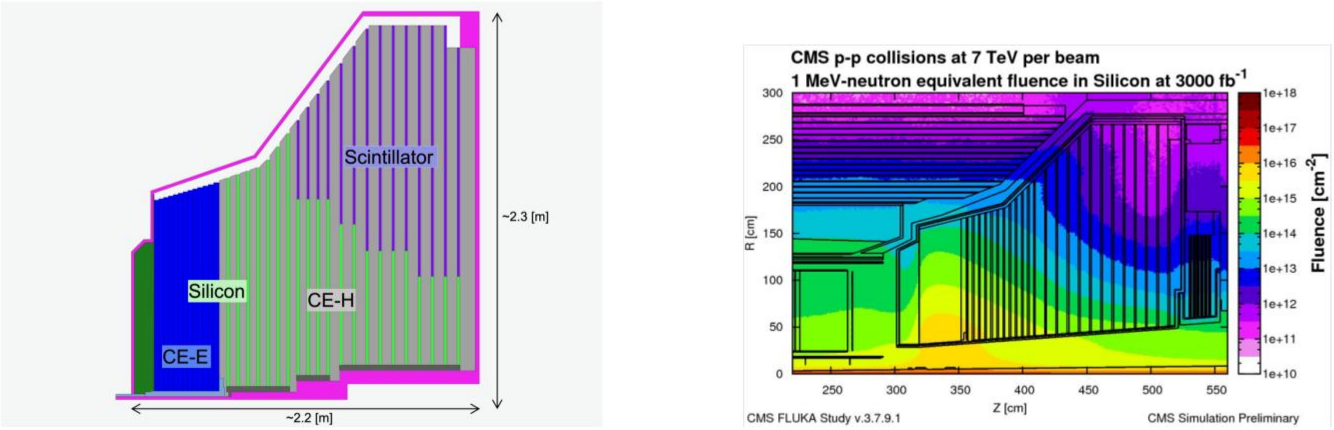
整个HCAL桶部：211232×16=3379712，约338万个探测单元。



HCAL端盖量能器
的探测单元考虑

The CMS HGCAL which will be installed in the HL-LHC will be a novel calorimeter with an unprecedented transverse and longitudinal granularity. As shown in Fig. 1a, the active detectors uses two technologies: hexagonal silicon sensors will be used in areas where the expected neutron fluence at end-of-life is above $5 \times 10^{13}\ n_{eq}/cm^2$ (see Fig. 1b), covering the entire electromagnetic and part of the hadronic calorimeters; and trapezoidal scintillator tiles individually wrapped and placed on SiPMs (SiPM-on-tiles) will be used in the rest of the hadronic calorimeter. Both detector systems are designed to have a signal-to-noise ratio of >3 for minimum ionising particles throughout the detector's lifetime [1]. The scintillator part of the detector was inspired by the CALICE AHCAL [2], a prototype of which was successfully operated in a combined beam test [3] together with a prototype of the silicon section of the HGCAL.

考虑辐照损伤
塑料闪烁体探测单元全寿
命中子数：$<10^{14}/cm^2$

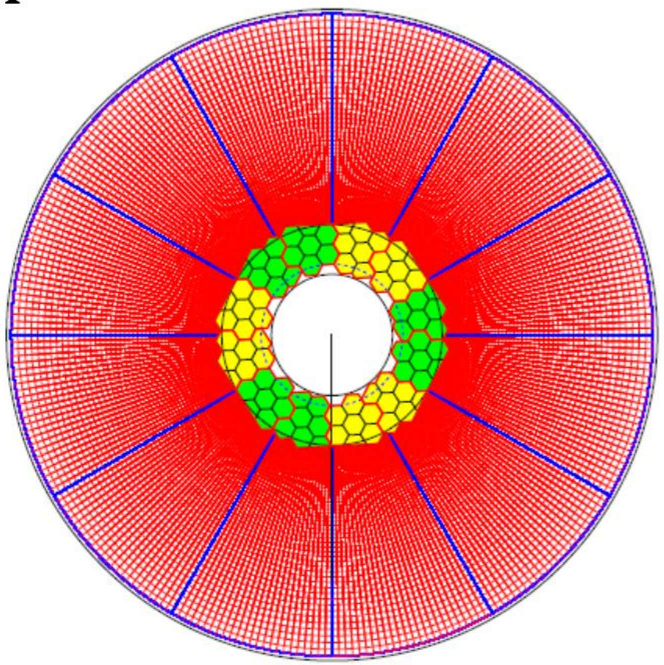


(a) (b)

Figure 1: (a) shows a schematic view of the CMS high granularity end-cap calorimeter [4]. (b) shows the expected 1 MeV equivalent neutron fluence in silicon obtained from FLUKA studies at the end-of-life [1].

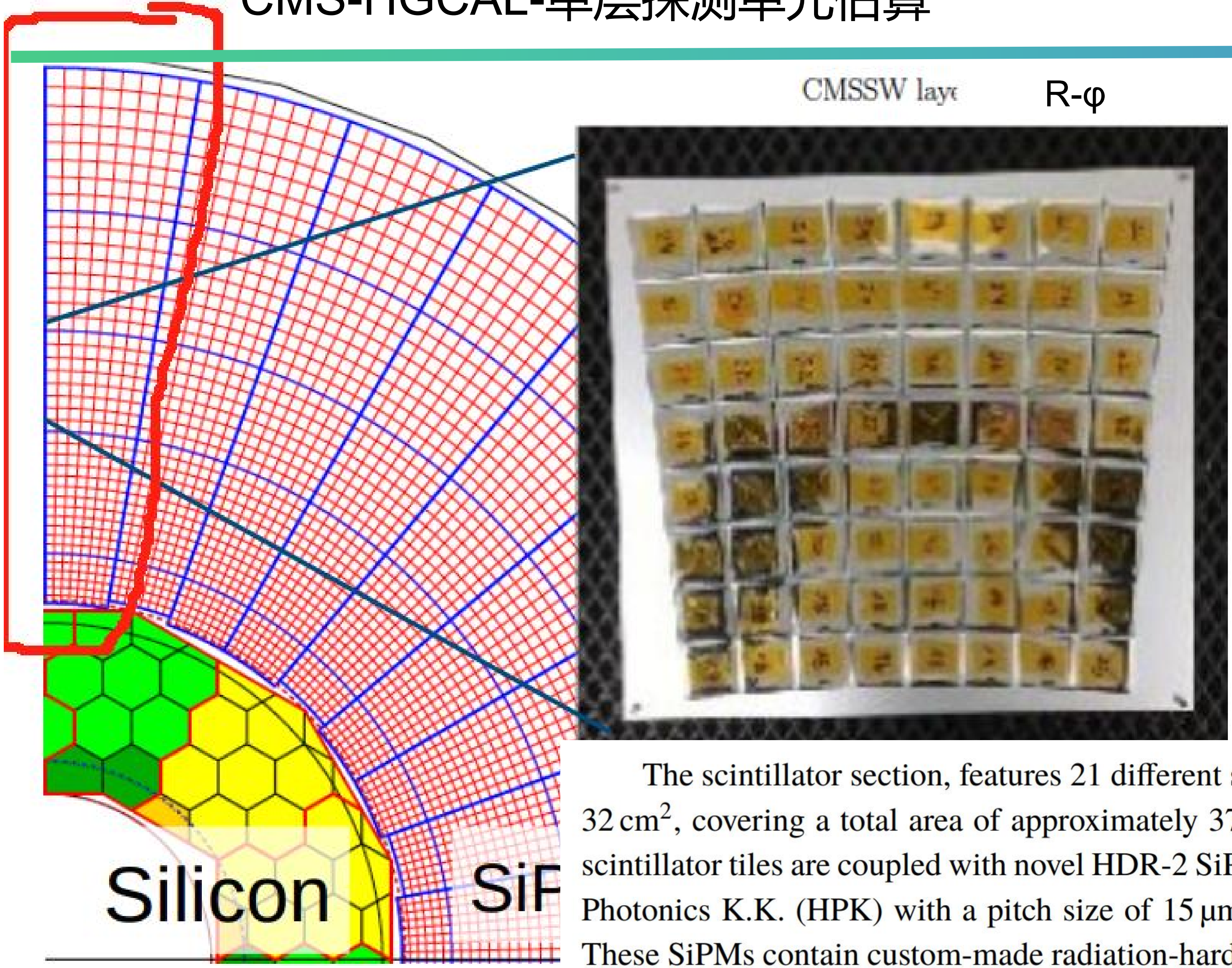
Scintillator Geometries

- Tiles arranged in $r - \varphi$ grid, with sizes ranging from $4 - 30\ cm^2$
- Magnitude of MIP signal $\sim \frac{1}{\sqrt{\text{Tile Area}}}$
  - Smaller sized tiles at small radii
    - High light yield where the radiation damage is highest
  - Larger tiles at large radii
    - Larger area per channel



4 cm^2与30 cm^2的探测单元的光输出相差2.7倍。

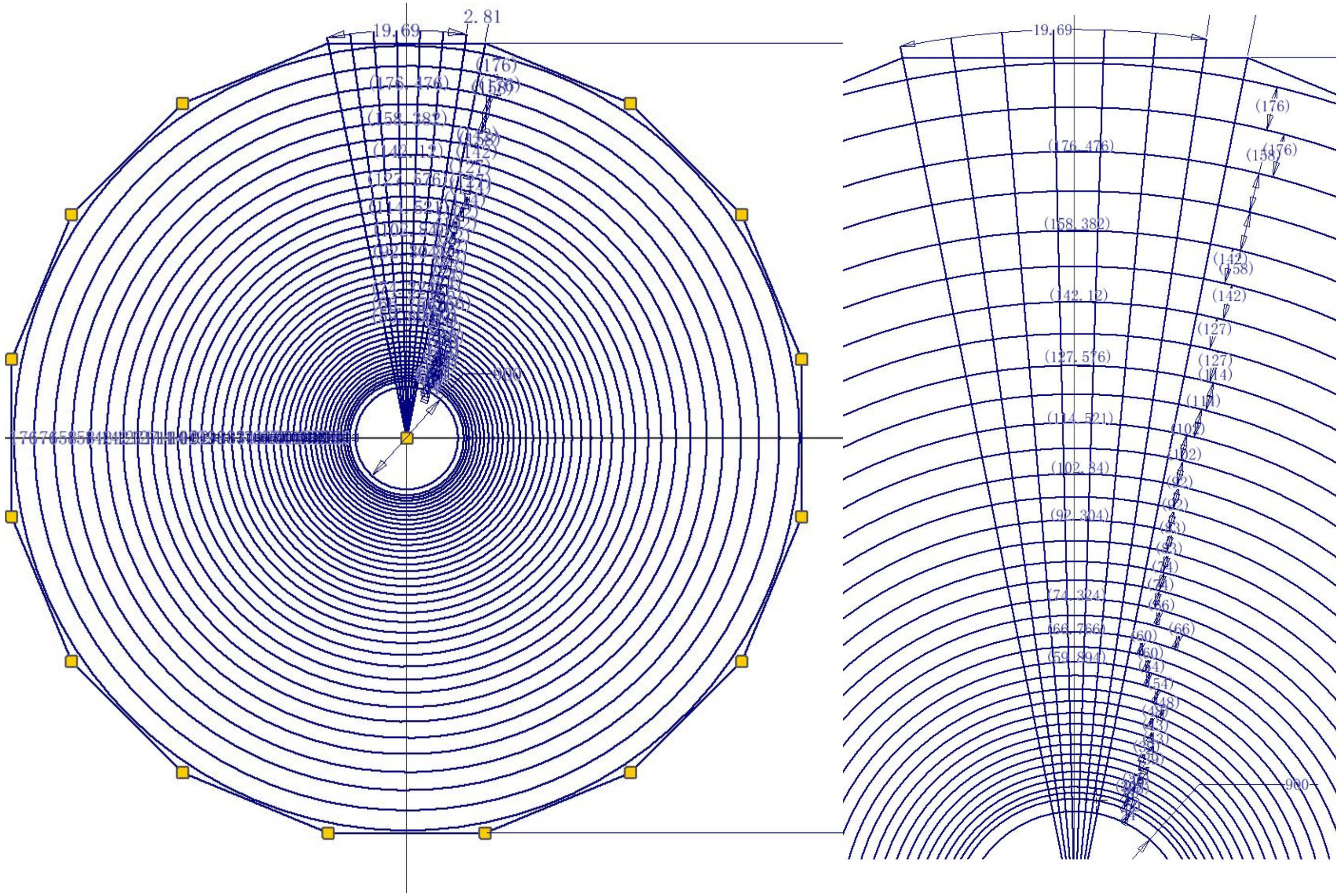
CMS-HGCAL-单层探测单元估算



- 小尺寸的闪烁体收到辐照强，但是光子数输出更多，辐照损伤后pe数减少，但还能继续工作。
- 21中不同尺寸的闪烁体条。
- 根据φ方向的尺寸来确定R方向的尺寸，闪烁体为正方形。
- 单层42×8×9×4=12906

The scintillator section, features 21 different scintillator tiles with areas ranging from 4 cm^2 to 32 cm^2, covering a total area of approximately 370 m^2 out of the HGCAL's 1000 m^2 area. These scintillator tiles are coupled with novel HDR-2 SiPMs (S14160 series [5]) produced by Hamamatsu Photonics K.K. (HPK) with a pitch size of 15 μm and active areas of $2 \times 2\,mm^2$ and $3 \times 3\,mm^2$. These SiPMs contain custom-made radiation-hard packaging with an improved thermal contact for the HGCAL upgrade.

CEPC-HCAL-端盖探测单元估算（探测单元占φ值，需要模拟决定）



- 简单假设每个探测单元占φ值2.8度。
- 最小探测单元24mm。
- 在一个扇区内，一共18种闪烁体 每种14个 最小的24X24mm，最大的176X176mm（太大）。
- 扇区单元数：18×14=252
- 单层单元数：252×16=4032
- 一端端盖单元数：4032×48=19.35万
- 合计：19.35×2=38.7万

如果φ值1.4度，最小探测单元12mm，最小探测单元8.8mm，探测单元数量×4,154.8万。

CEPC-HCAL-探测单元估算

- 桶部：约338万个探测单元。
- 端盖：约154.8万个探测单元。
- 合计：约493万个探测单元。

Scintillator Material

- Polyvinyltoluene-based scintillator (PVT)
  - Higher light yield
  - Ex: EJ-200, EJ-260, EJ-262

- Polystrene-based scintillators (PS)
  - Produced economically with injection molding techniques
  - Ex: SC-301, SCSN81

	EJ-200	BC-408	IHEP SC-301
Base material	PVT	PVT	PS
Light output (% anthracene)	64	64	60
Scintillation efficiency γ/MeV	9000	9000	8500
Wavelength of max. emission (nm)	425	425	420
Rise time (ns)	0.9	0.9	1.4
Decay time (ns)	2.1	2.1	2.5
CTE (K^{-1})	78×10^{-6}	78×10^{-6}	70×10^{-6}