

Requirement on SubD for Elec-TDAQ

■ Common question template on requirement

- On physics requirement
 - Detector target: $2\%/\sqrt{E} \text{ GeV} \oplus 1\%$
 - Parameters that measures: energy, time
- On signal processing
 - Detector channels for electronics: ~1M channels
 - Counting rate:
 - Signal characteristics: Charge, rising edge, width
 - Dynamic range: (0.2 fC - 40pC,BGO+PD,PWO+APD) ,4fC – 800 pC (BGO+APD), 40pC – 120nC(BGO+SiPM)
 - Requirement on measurement (linearity, accuracy...)
 - ❑ Charge: ADC ~1% linearity, 10/12-bit ADC, multi-gain modes (e.g. high/low gain) + TOT
 - ❑ Time: ~1ns timing resolution
- On overall system
 - Detector interface (cabling, socket, detector impedance ...)
 - Power budget & material budget: ~20kW, + no specific requirement
 - Working conditions (temperature, cooling, special mechanics...)
 - ❑ Active cooling for ~20kW heating load
- Other special requirements

Reference:

- **L3: BGO+PD, no stereo structure(↑), lower Ecm energy (↓), 2cm*2cm(↑):**
 - 1200 electron (0.2fC) per MeV shower energy
 - Dynamical range: 0.2 fC to 40pC (1MeV to 200 GeV)
- **CEPC 4D long bar crystal: BGO + SiPM, cross-structure(↓)**
 - 0.1 – 3000 MIP (1MIP = ~40 pC)
- **CMS: PbWO(↓) + APD, 2cm*2cm (↑):**
 - Dynamical range: 0.4fC to 32 pC(20MeV to 2 TeV)

Light Yield:

BGO: 8-10 photon/KeV

CMS PWO: 10 photon/MeV

Gain:

SiPM: $1.8 \cdot 10^5$; PD: ~1; APD: 50

APD sensor	Cut of charge	Timing resolution
S8664-50K (Inverse type)	> 18 fC	123 ps
	> 36 fC	63 ps
S2385 (reach through type)	> 18 fC	178 ps
	> 36 fC	89 ps

以CEPC顶点探测器为例

• 探测器方案

- 信号特征、动态范围
 - 阈值~200e, 动态范围~1000e

• 感兴趣量

- 位置分辨: 3~5 μm

• 事例率

- Hit Density from background: 2.5hits/bunch/cm² for Higgs/W; 0.2hits/bunch/cm² for Z
- Bunch Spacing: Higgs: 680 ns; W: 210 ns; Z: 25 ns

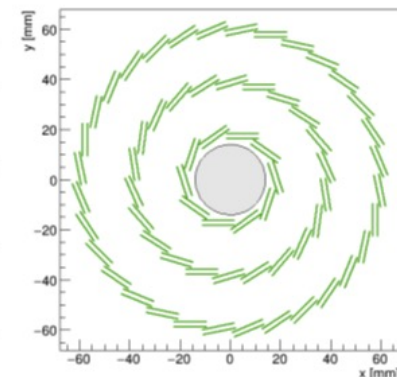
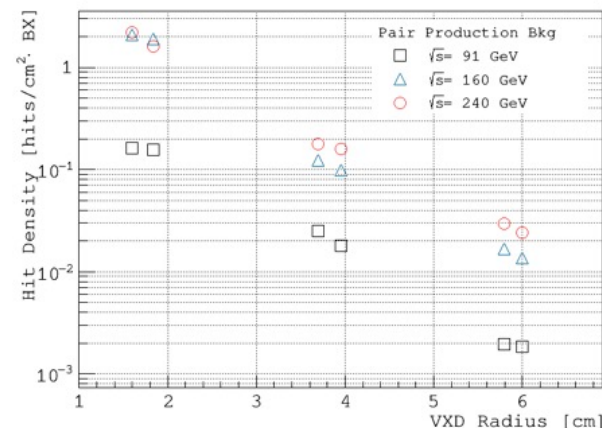
• 其他要求

- 物质质量: 0.15%

• 探测器规模 (Taichu原型机)

- 三层: Ladder共约64个
- 双面ladder共含芯片1280片

	R (mm)	z (mm)	Number of ladders	Number of chips
Layer 1	16	125.0	10	200
Layer 2	18	125.0		
Layer 3	37	125.0	22	440
Layer 4	39	125.0		
Layer 5	58	125.0	32	640
Layer 6	60	125.0		



以CEPC顶点探测器 (Taichu) 为例

- 电子学方案
 - MAPS像素探测器@small electrode ——物质量、阈值200e
 - 像素尺寸: 16~25 μm ——位置分辨
 - 计数率: 40MHz/cm²
- 触发方案
 - 不参与触发, 仅接收触发
- 数据处理方案
 - 数字像素、像素自触发
 - 像素地址编码——感兴趣量
 - 辅助时间戳来帮助高计数率Trigger ID判断
- 数据率
 - 触发后数据率: 160Mbps/chip (50kHz触发率)
 - Triggerless: 4Gbps/chip
 - 读出方案: 高速串行
- 数据量
 - Ladder: 3.2Gbps@Trigger; 80Gbps@Triggerless
 - 探测器总体: 205Gbps@Trigger; 5.12Tbps@Triggerless