用于BESIII 内径迹室的圆筒GEM探测器的研制

董明义

On behalf of the IHEP and Italy CGEM collaboration group

核探测与核电子学国家重点实验室
中科院高能物理研究所

2015.7.24

Outline

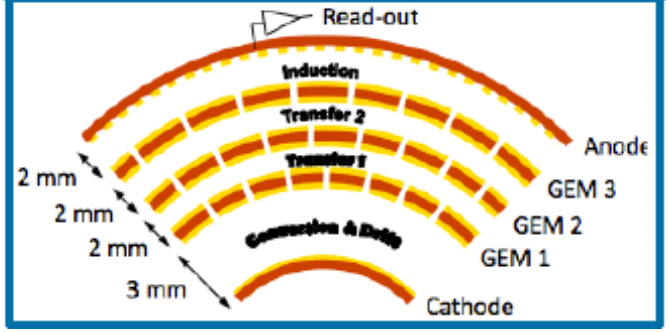
- CGEM 探测器的制作
  - CGEM电极 、阴极、阳极
- 束流测试
- 读出电子学芯片设计
- 与北京谱仪接口的初步设计
- 总结

CGEM作为BESIII内径迹室升级方案

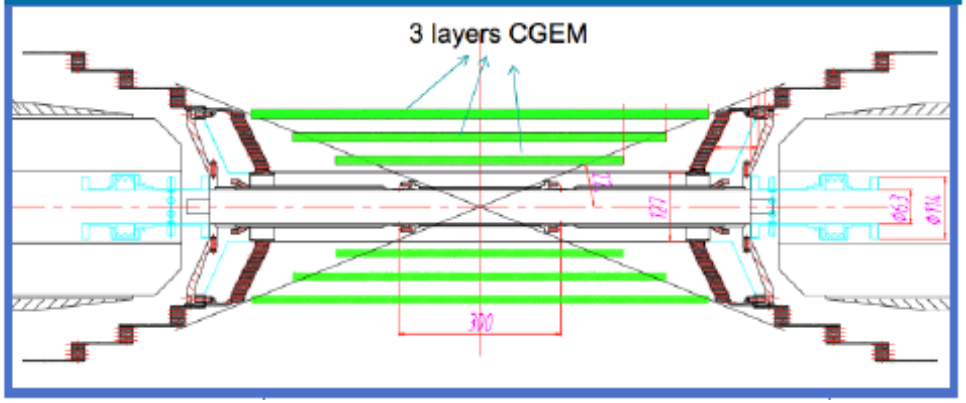
采用3层CGEM探测器替换漂移室内室，第二层探测器可以直接使用KLOE2的mold，建造从第二层开始

THE CGEM-IT

A cylindrical triple GEM



Three layers of CGEM for BESIII



Requirements

Rate capability: ~10 KHz/cm^2

Spatial resolution: σ_{xy} =~100μm : σ_z=~1mm

Momentum resolution (INNER+MDC): σ_{pt}/P_t =~0.5% @1GeV

Efficiency = ~98%

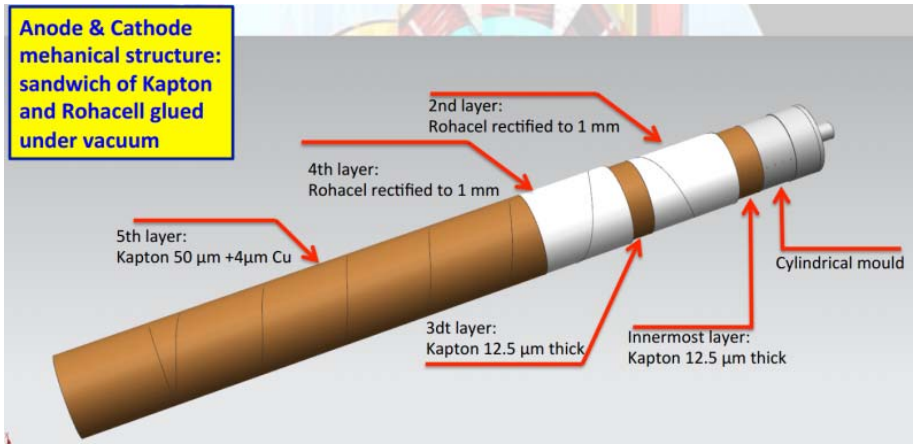
Material budget ≤ 1.5% all layers

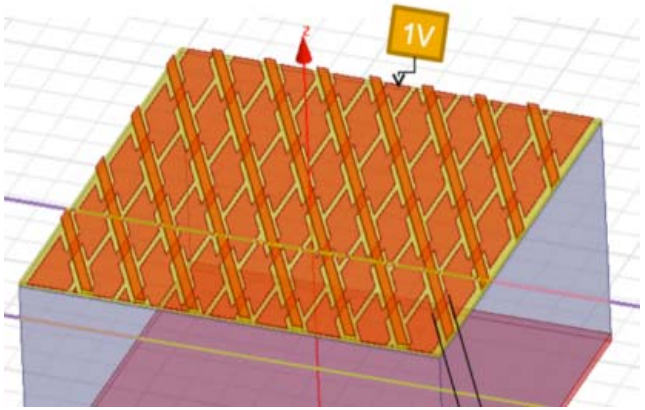
Coverage: 93% 4π

- Three active layers
- Active area
  - L1 length 532 mm
  - L2 length: 690 mm
  - L3 length: 847 mm
- Inner radius: 78 mm
- Outer radius: 178 mm

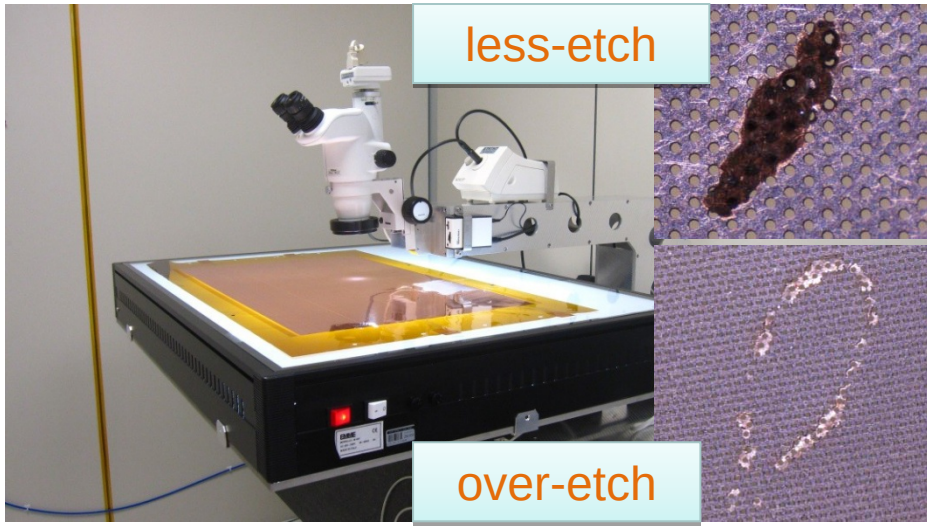
CGEM作为BESIII内径迹室

- 根据模拟结果，选用更低物质量的阴极和阳极支撑材料，rohacell（聚甲基丙烯酰亚胺硬质泡沫 ）代替honeycomb，单层探测器的物质量由0.49%减小到0.33% X_0
- XV阳极读出条结构
- 为了实现更好的位置分辨，采用模拟读出电子学
- 尽量利用KLOE2的mold工装，降低成本

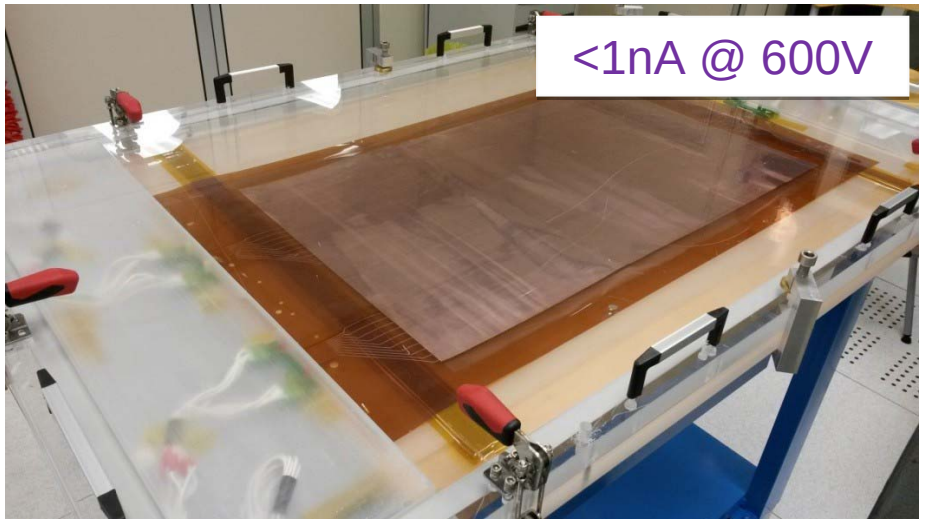




首个BESIII-CGEM探测器CGEM 电极： GEM测试

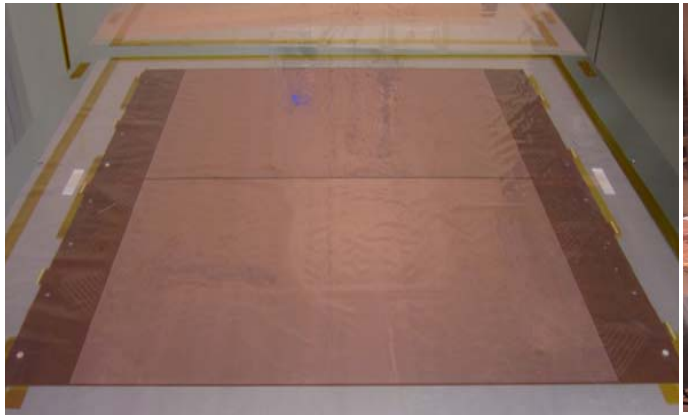


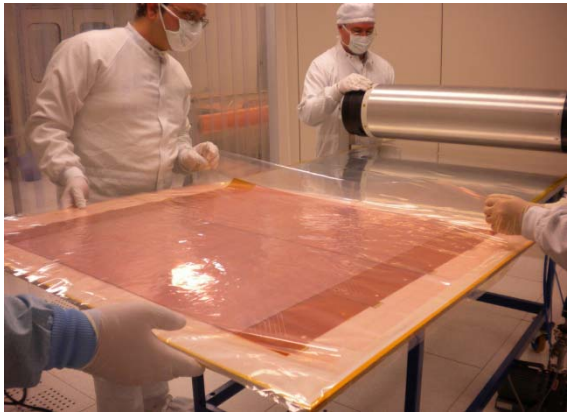
显微镜检查…不合格的送回CERN返修



氮气环境下的高压测试

首个BESIII-CGEM探测器CGEM 电极： CGEM制作1





利用真空技术将2片GEM膜粘接成一张平板电极,尺寸为700×860mm^2

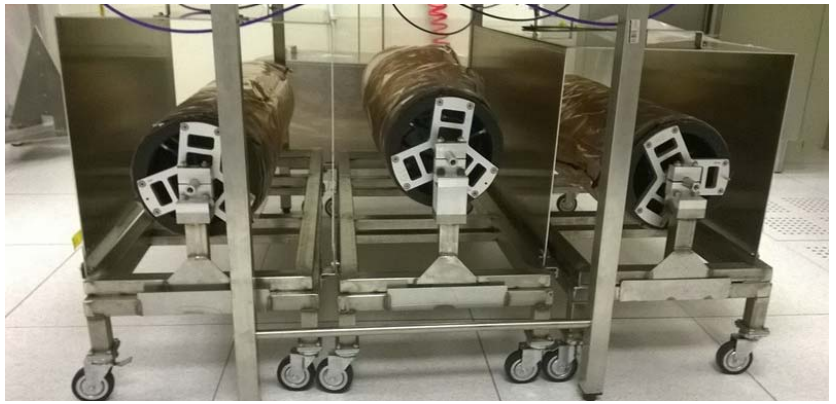
交叠处涂胶

框架涂胶

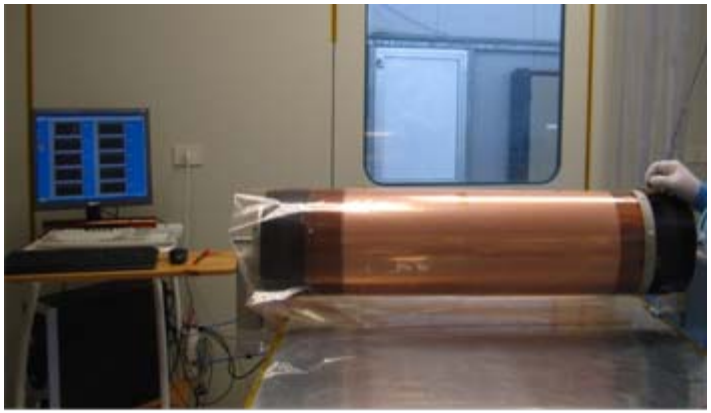
合拢到圆桶模具上，利用真空技术粘接

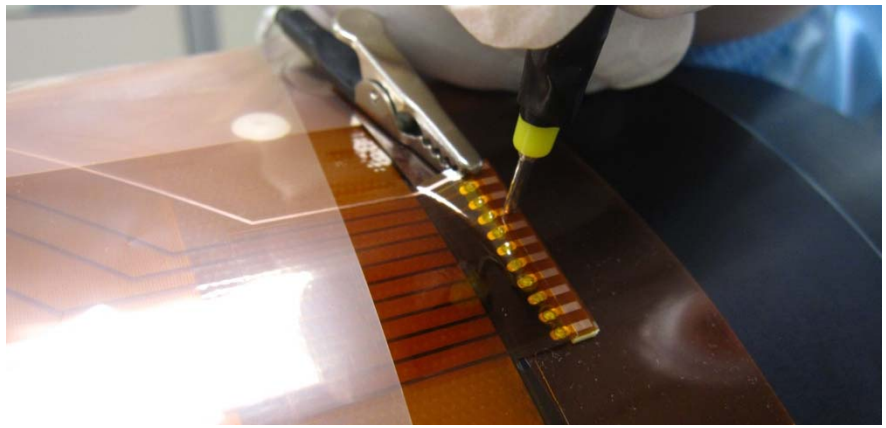
首个BESIII-CGEM探测器CGEM 电极： CGEM制作2

完成了第二层GEM探测器的 3个CGEM电极，打包以待最后组装



制作完成后在空气中进行的新一轮高压测试 (<1nA@300V)



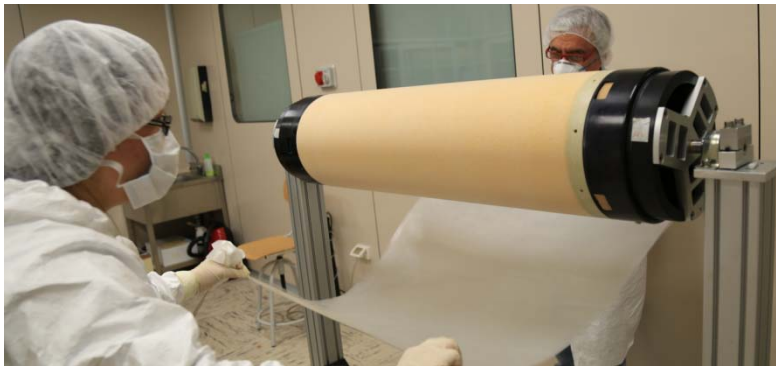


首个BESIII-CGEM模型的研制： 阴极

创新点

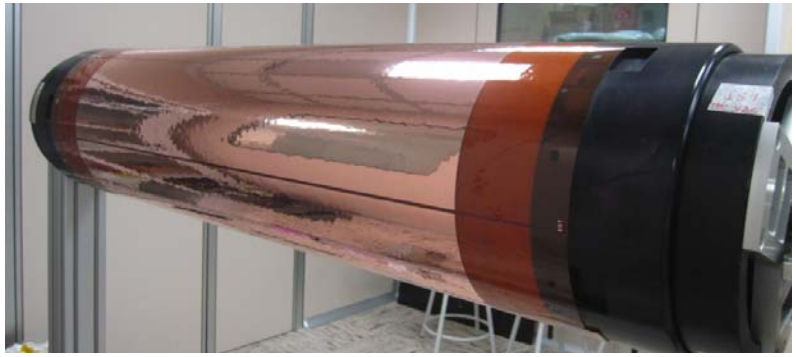
	BESIII	KLOE-2
# of X_0 for 1 layer	0.33	0.49
# of X_0 for 3 layers	0.99	1.47

12.5 μ kapton foil around the Al mold;



Rohacell plane is glued on the kapton.

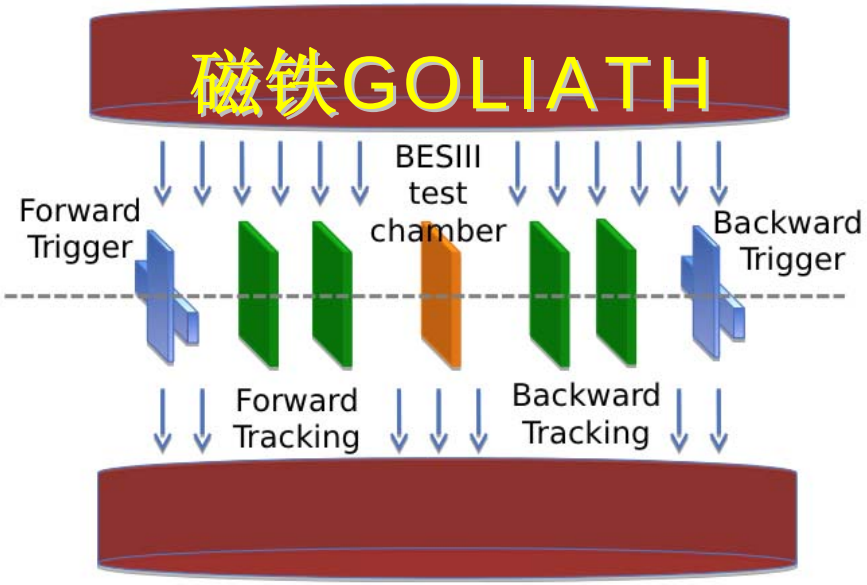
Cathode rolled on the rohacell



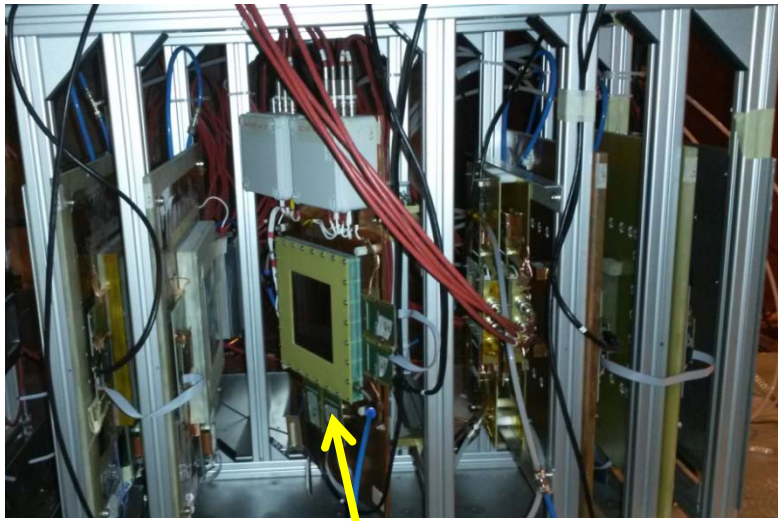
Cathode ready

探测器模型的束流实验

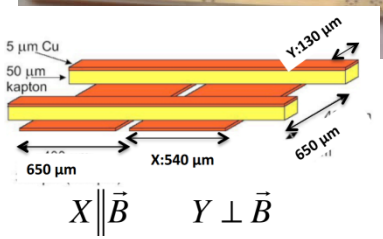
- 2014.12束流测试
  - 验证1T磁场下的模拟读出性能
  - 验证Garfield模拟结果
  - 测试不同结构及不同工作气体下探测器的性能
    - Ar /CO_2(70/30); Ar /C_4H_{10}(90/10)
    - Two layouts: 5/2/2/2 mm, 3/2/2/2mm
- 2015年束流测试
  - 测试”jagged”阳极

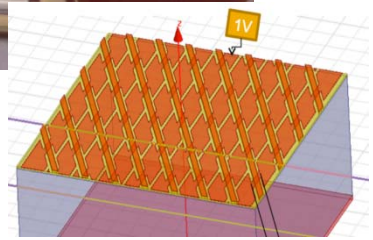


探测器模型在磁场下，前后各设置两个寻迹室体



模型有效面积：10x10 cm²



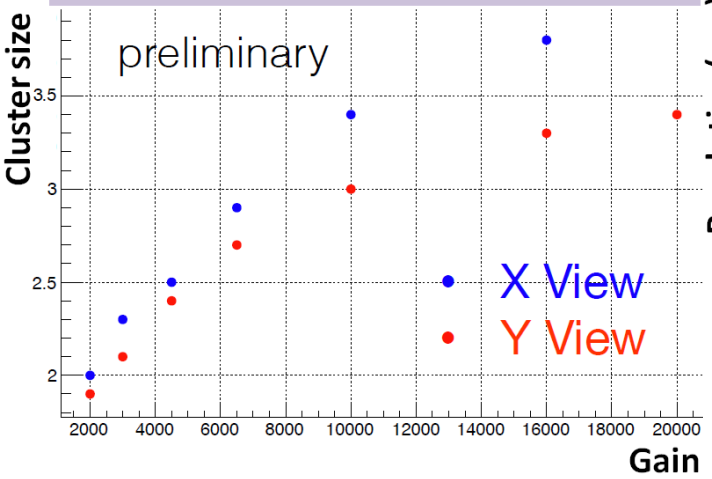


X, Y or V条读出， pitch :650 μ m APV25 芯片

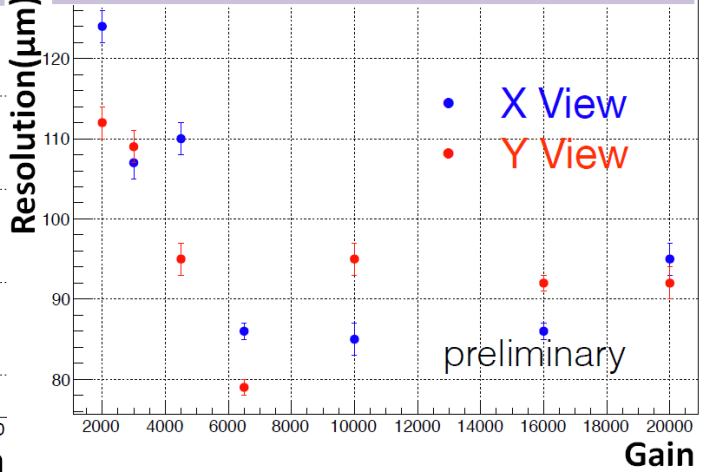
束流测试初步结果（1）：XY-条读出结构Vs 无磁场

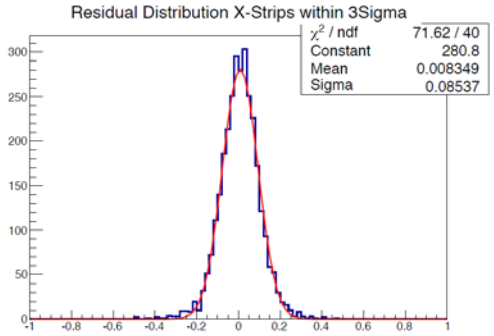
gas mixture: Ar/Isobutane (90/10)

Cluster size Vs Gain (B=0)

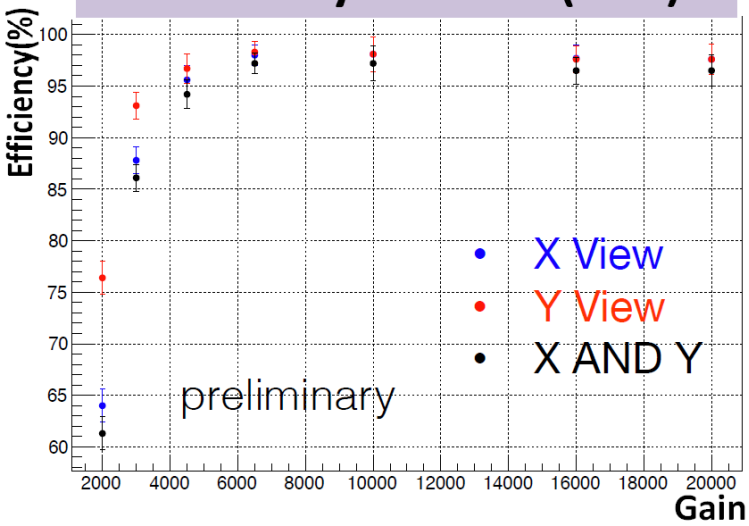


Spatial resolution Vs Gain (B=0)





Efficiency Vs Gain (B=0)

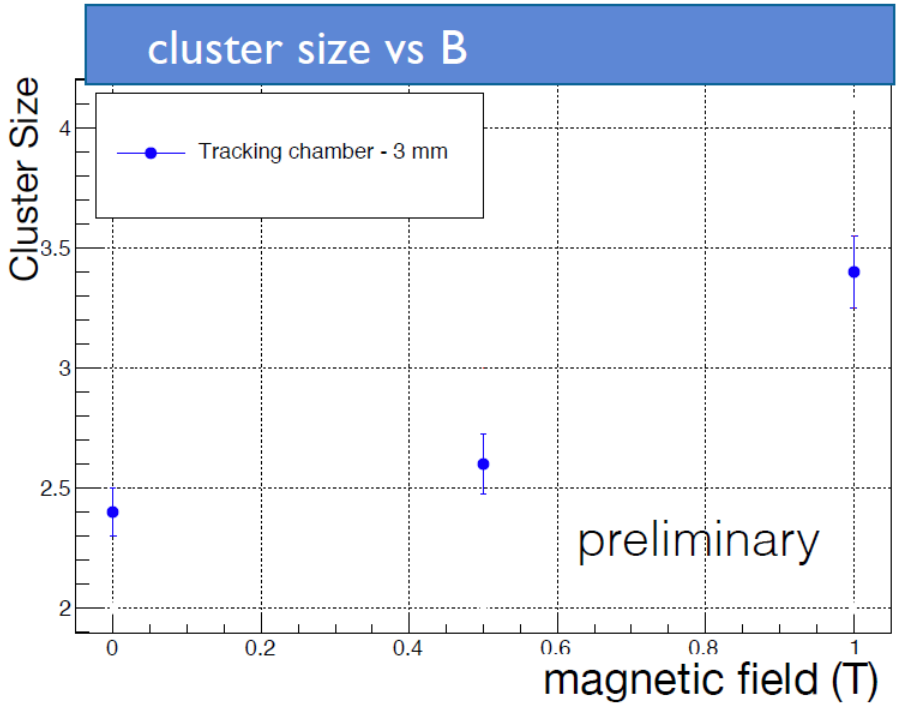


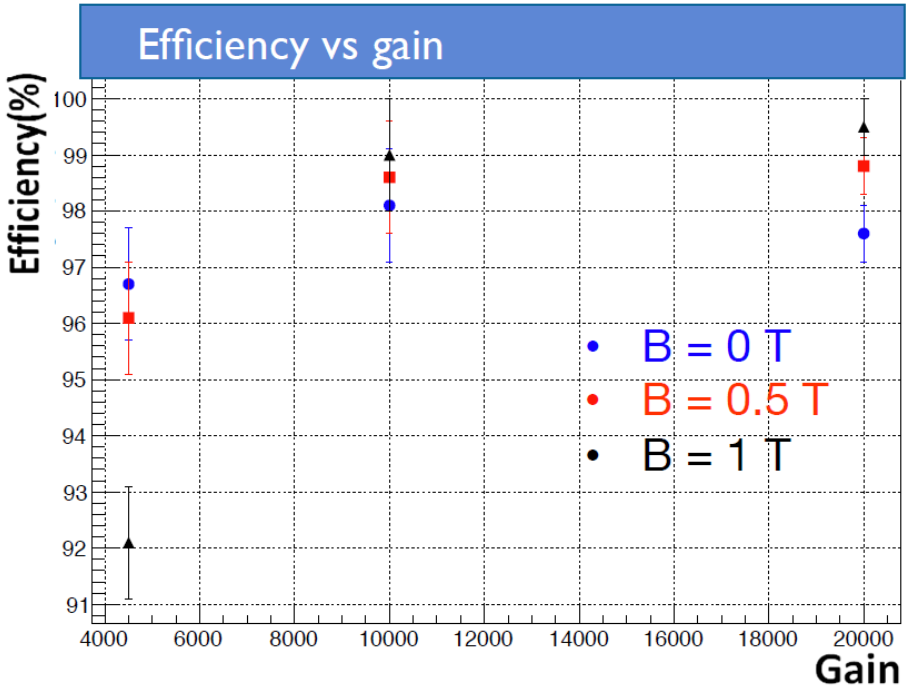
With Ar/Isob (90/10) gas mixture, 650 μm strip pitch, 3mm gap, B=0 :

- Efficiency plateau starts @ gain≈6000.
- Efficiency for 2 dimensional clusters ~97%
- σ≈ 90 μm

速流测试初步结果（2）：XY-条读出结构Vs有磁场

gas mixture: Ar/Isobutane (90/10)



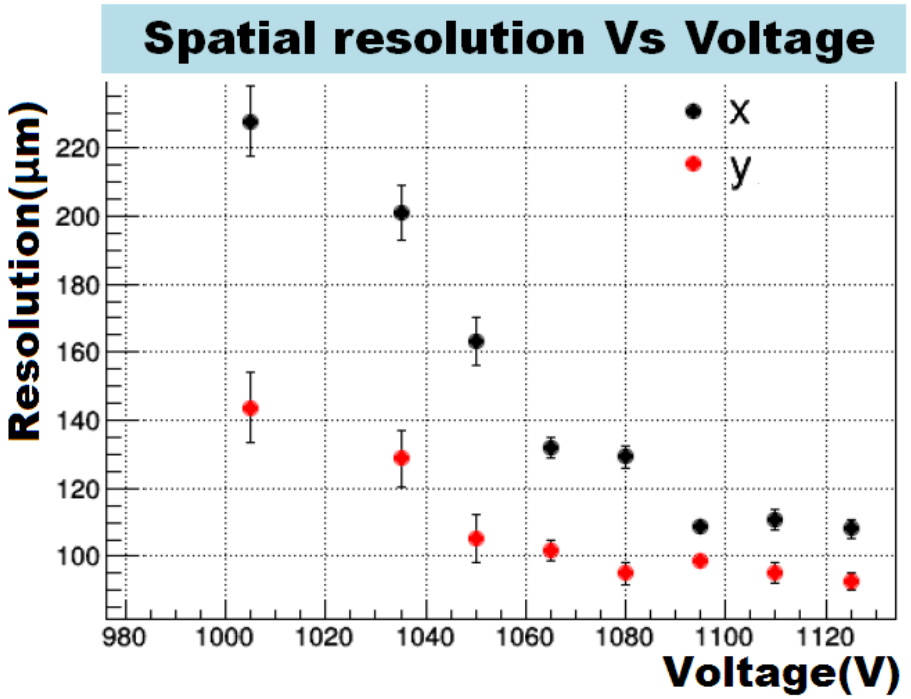


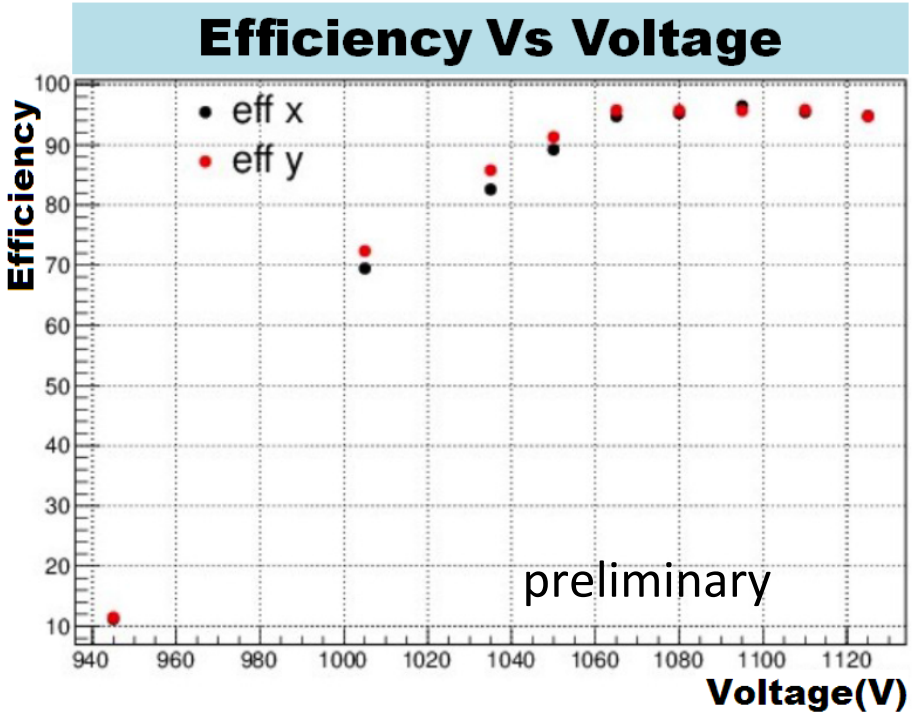
磁场对效率无影响

速流测试初步结果（3）：XV-条读出结构Vs无磁场

gas mixture: Ar/CO_2 (70/30),5mm drift gap:

- **Efficiency plateau starts around V = 1065V (~ gain = 10^4)**
- **The resolution in this region is around 100-120 um**



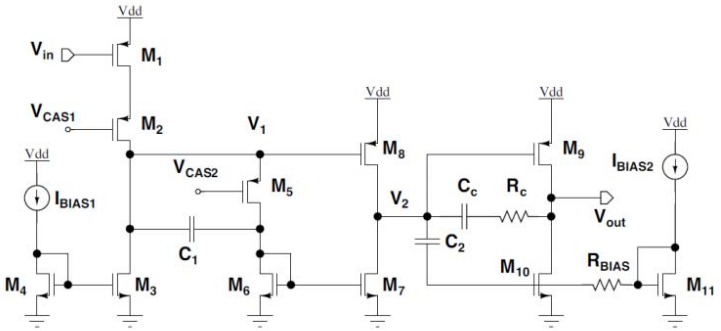


二维Jagged X、V条读出结构效果良好；

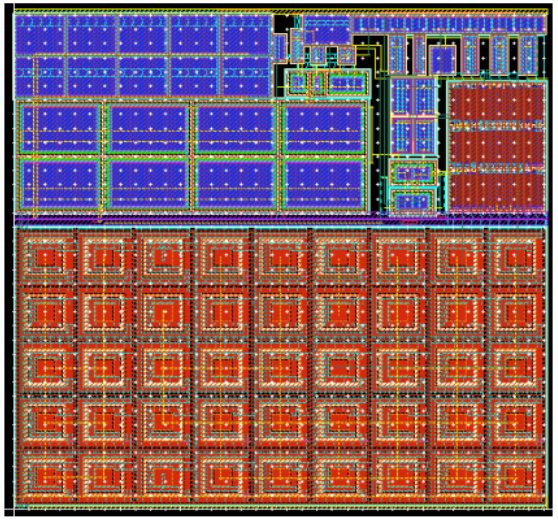
CGEM-XV圆桶阳极预计今年8月份完成

读出电子学芯片设计

- 前端
  - 前放第一版基于NMOS，噪声较大
  - 第二版基于PMOS为了降低噪声
    - 模拟结果<2000 e rms for 150pF@1mA of input current，本月完成layout
- 后端
  - 在已有的芯片上进行优化，基于TOT技术，已完成基准电压源等设计，今年底提交



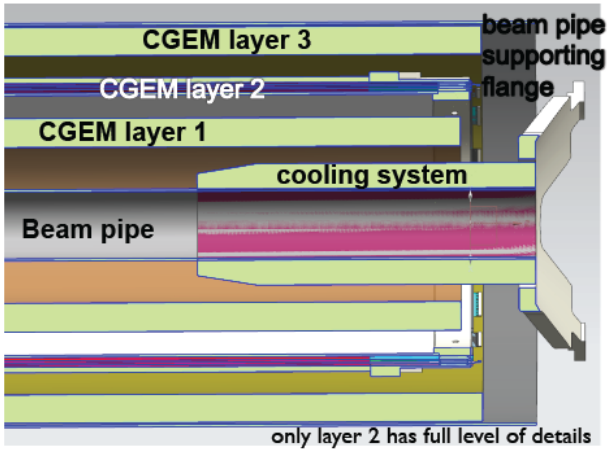
Preamplifier Schematic

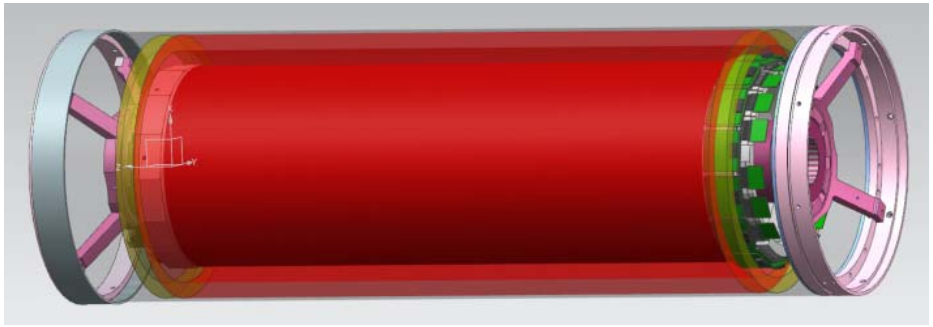


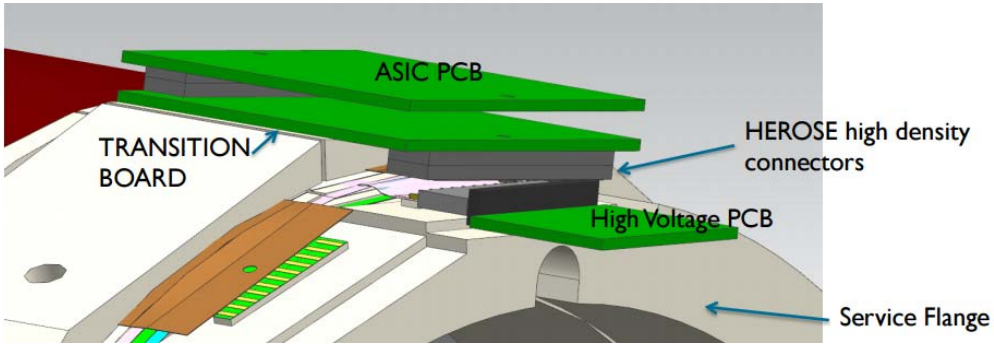
Layout of the BandGAP

CGEM与BESIII的接口初步设计

- 改造对撞区的束流管支撑架，使其固定CGEM探测器和束流管
- 探测器的高压和信号电缆在东西端各分4个扇区，按扇区引出到谱仪1层和3层电子学平台
- 探测器的气体可以利用现在漂移室内室的8路气管

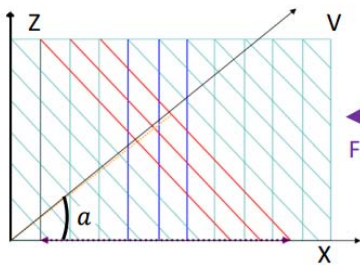


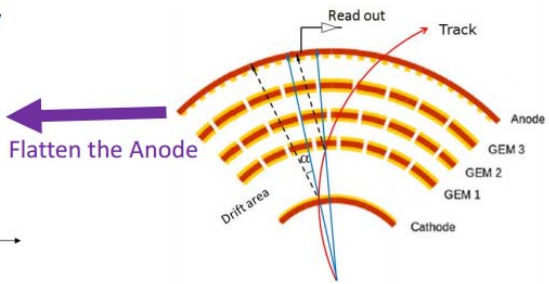




软件进展

- 模拟
  - Geant4-based full simulation
  - Garfield simulation
  - Digitization
- 重建
  - CGEM cluster reconstruction
  - Kalman track fit
  - CGEM tracking
    - CGEM track segment finding
    - Track finding combining CGEM and outer MDC
- 校准和刻度 （next to do）

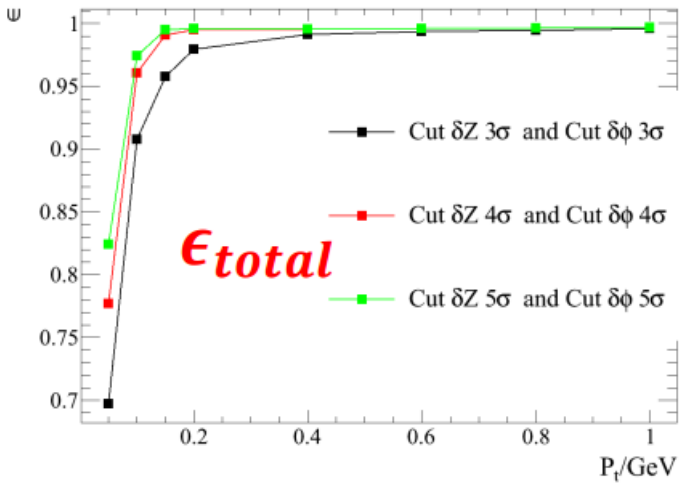


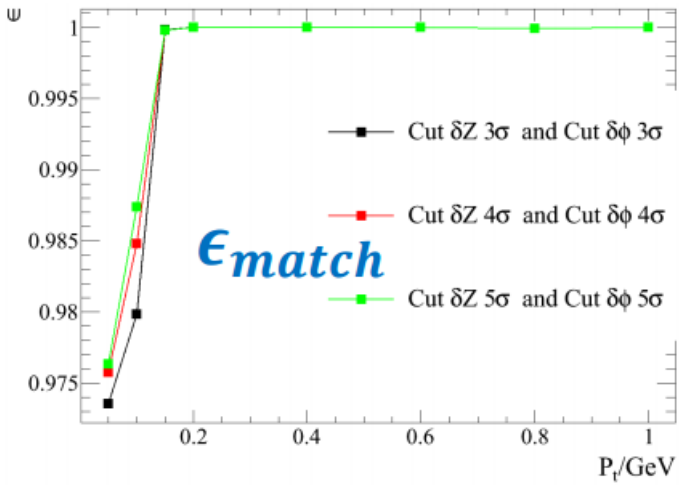


Charge-weighted average

$$\begin{cases} X = \frac{\sum_i x_i \times Q_i}{\sum_i Q_i} \\ V = \frac{\sum_i V_i \times Q_i}{\sum_i Q_i} \end{cases} \Rightarrow \begin{cases} \varphi = \frac{X}{r_{layer}} \\ Z = (V - X\,cosa)/sina \end{cases}$$

Efficiency with different cuts(n = 3, 4, 5)





总 结

- 中意双方合作开展了用于BESIII内径迹室的CGEM探测器的研制，已完成了第二层GEM探测器GEM电极及阴极的制作和测试
- 进行了平面探测器模型的束流测试，验证了不同探测器结构、工作气体及阳极结构在磁场下的性能
- 该项目计划2017年完成探测器的研制、测试以及在高能所的调试

谢 谢！