BESIII 运行情况及主要成果

董明义

On behalf of the BESIII collaboration

dongmy@ihep.ac.cn

IHEP, CAS

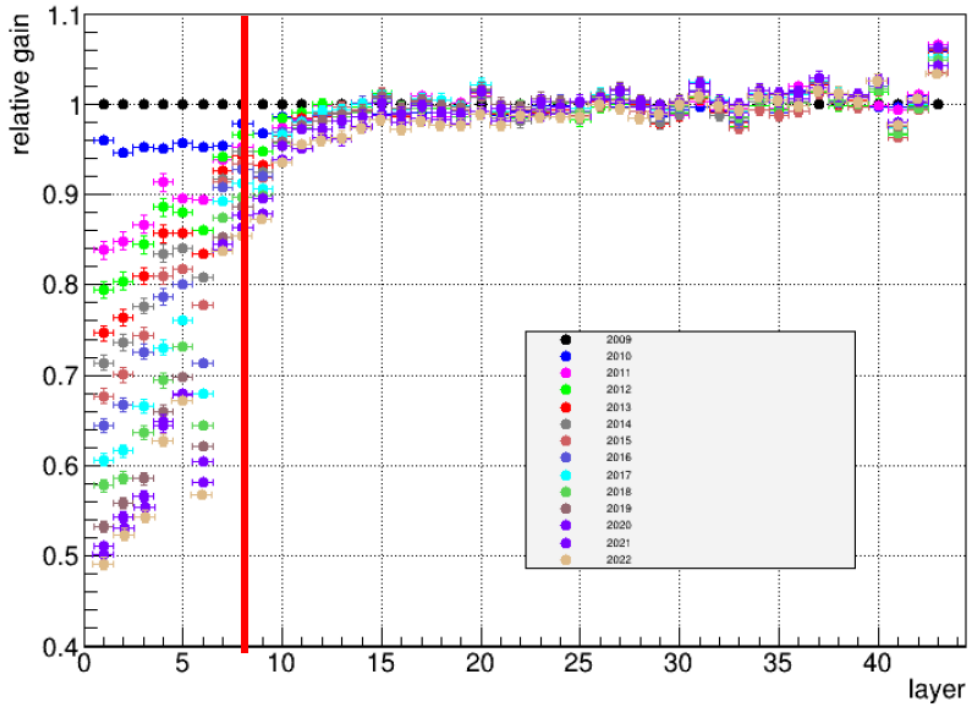
2025.10.13

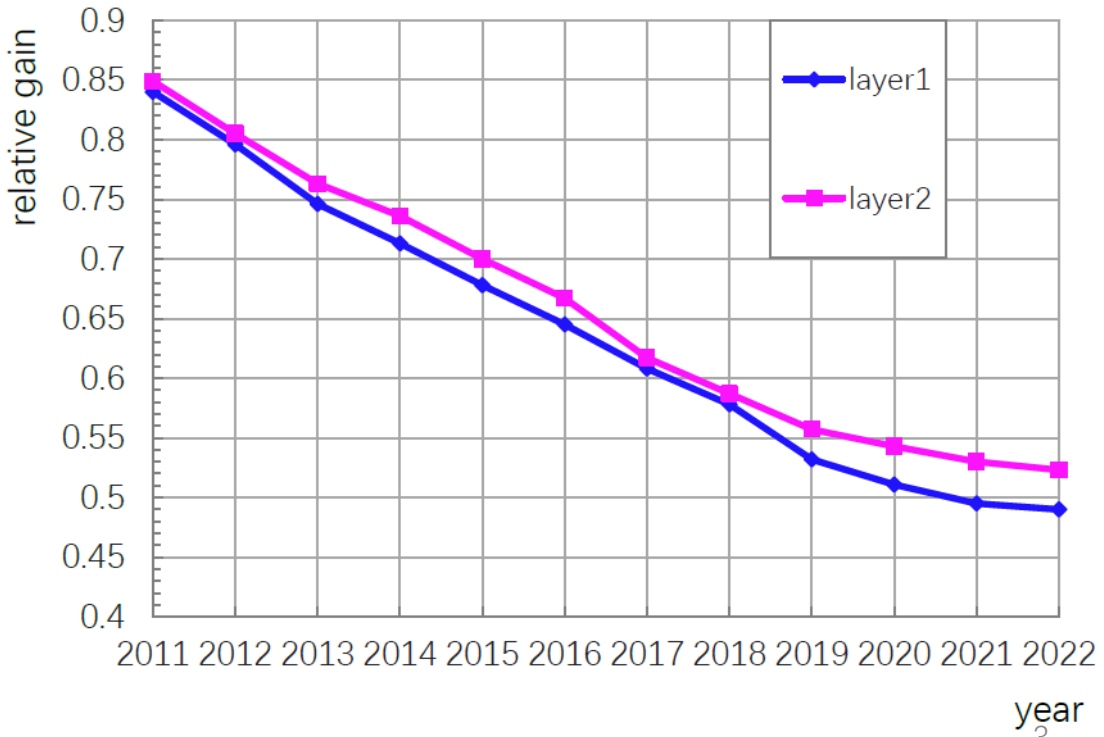
主要内容

- BESIII内径迹探测器升级
- BESIII探测器的运行和性能
- 年度重要物理成果
- 2025-2026取数计划
- 总结

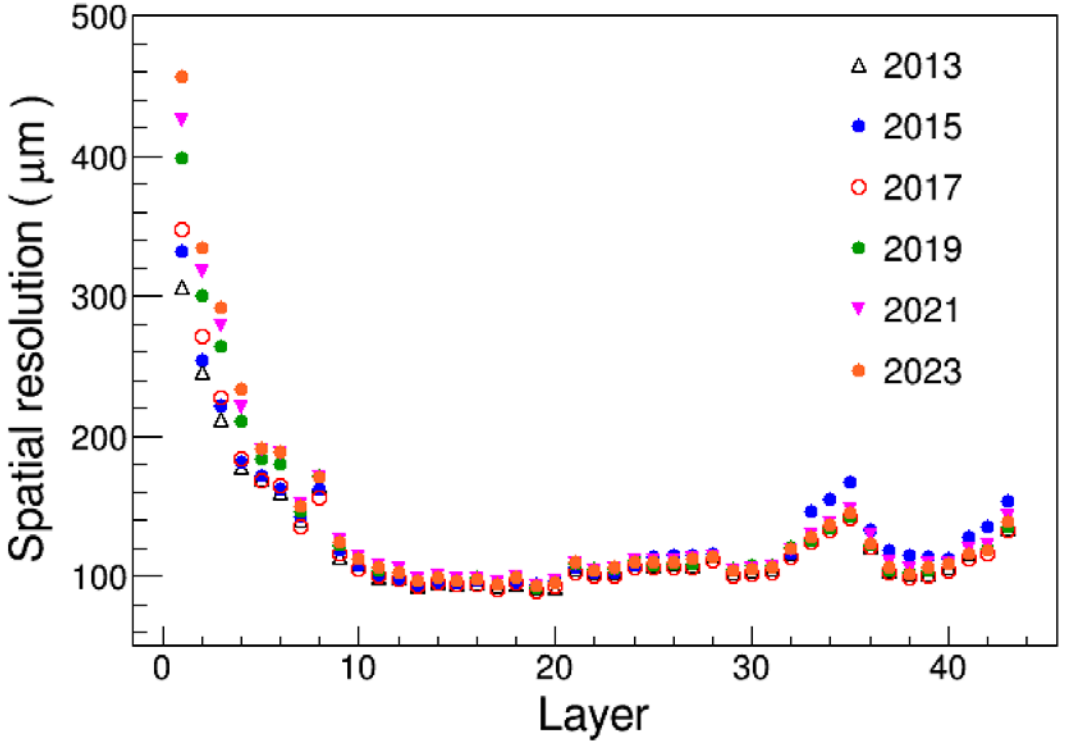
BESIII漂移室老化问题

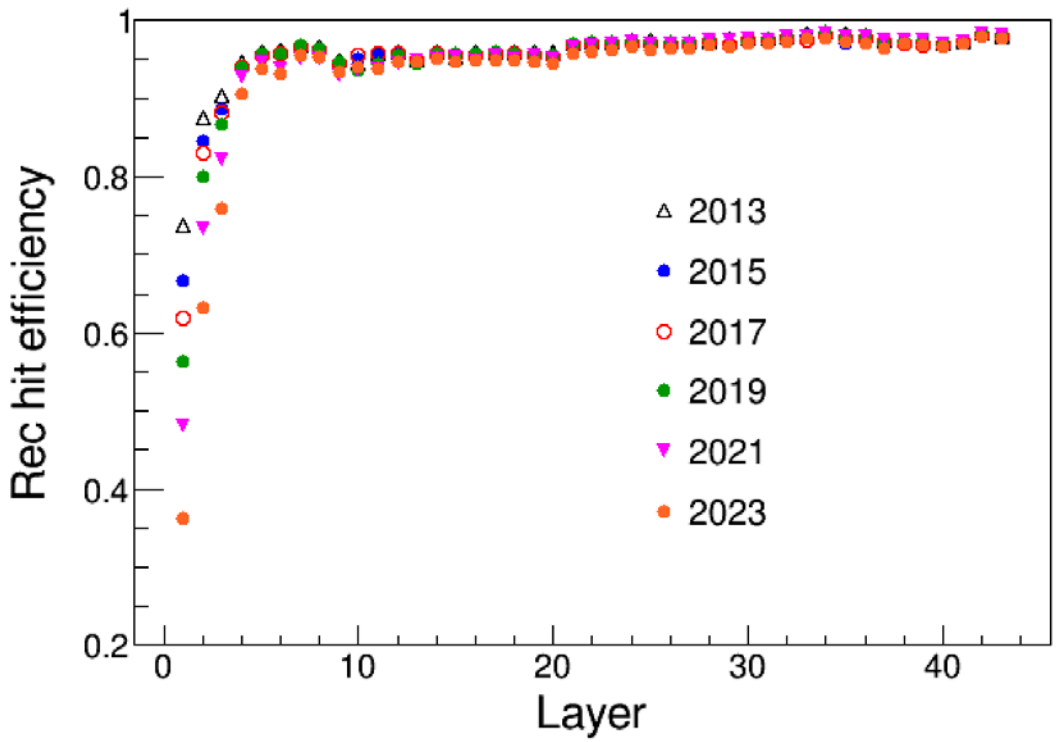
- Gains of inner chamber dropped, about 50% for the first layer cells
- No significant change in gain for outer layers
- Gain decreased by about 3% /year for layer1 and layer2, but slowed down in last three years





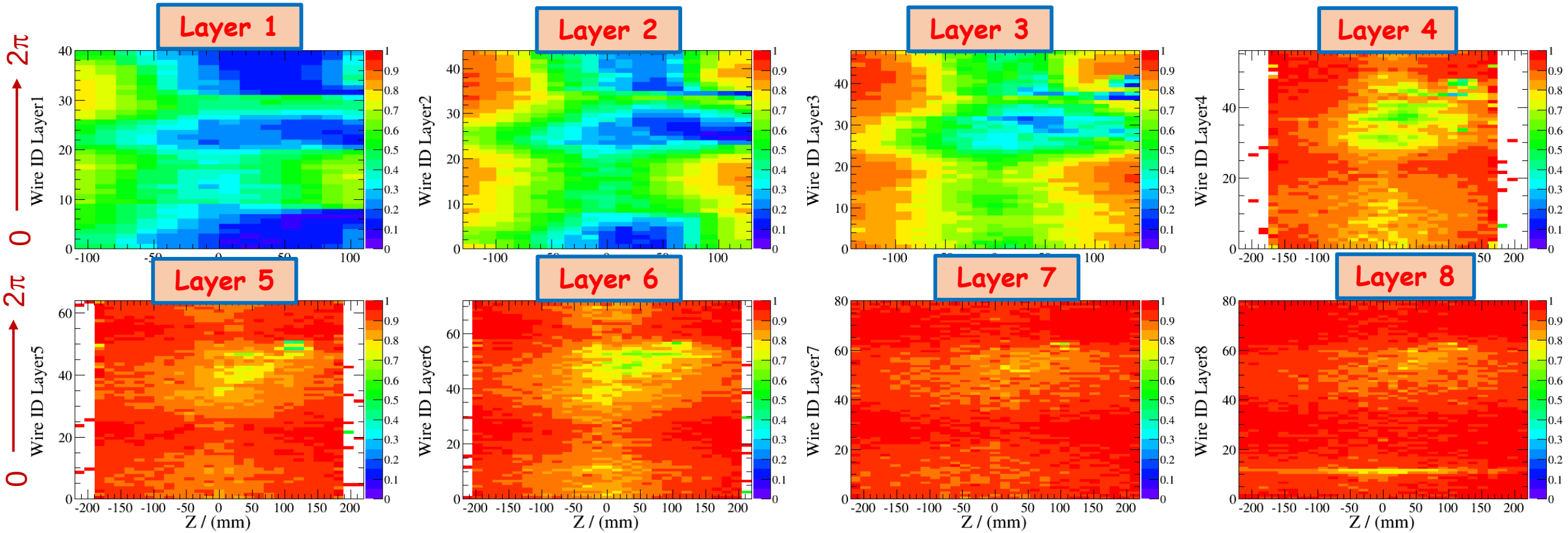
MDC 空间分辨率和重建击中效率





- The resolution of the inner chamber has significantly decreased
  - Decrease in gain caused by aging
  - Low voltage setting leads to low gain for the first four layers
- Hit efficiency of the first three layers decreased year by year
- No significant changes in spatial resolution and hit efficiency for the outer chamber

重建击中效率二维分布

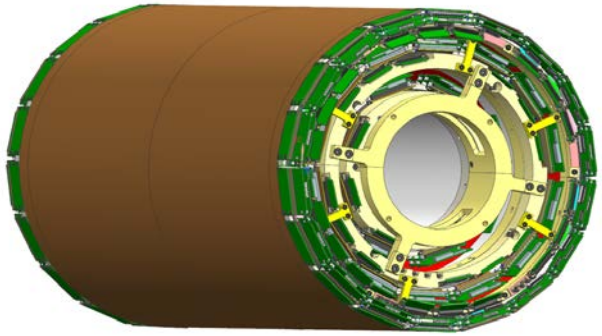


- The efficiency of the first three layers are nonuniform
- Some region is quite low (~*20%*) , Signals are lower than threshold

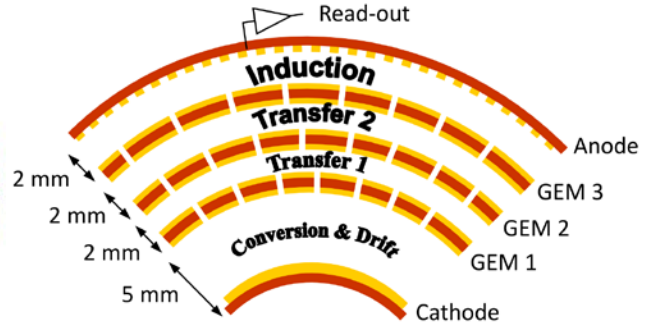
圆筒GEM内径迹探测器(CGEM-IT)

- Built a 3-layer cylindrical GEM inner tracker for inner drift chamber upgrade (INFN and IHEP)
  - High counting rate (>10^4 Hz/cm^2)
  - Strong anti-aging ability
  - Significantly improve z-direction resolution (~1.5 mm →~0.5 mm)

先进微结构气体探测器在BESIII上的首次使用

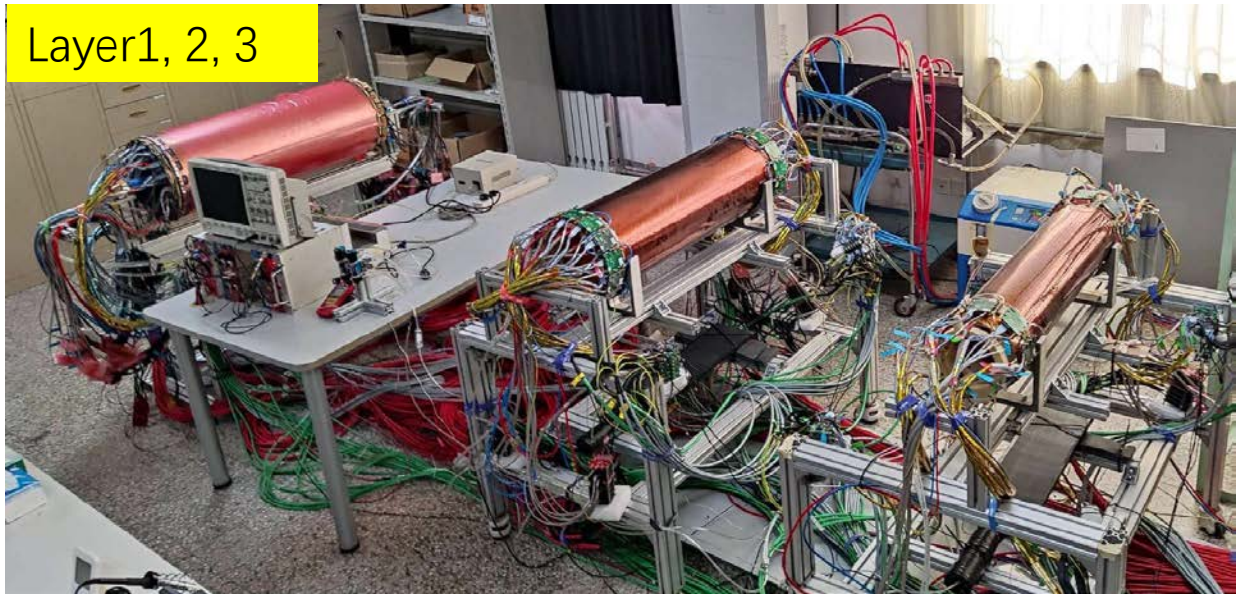


CGEM-IT

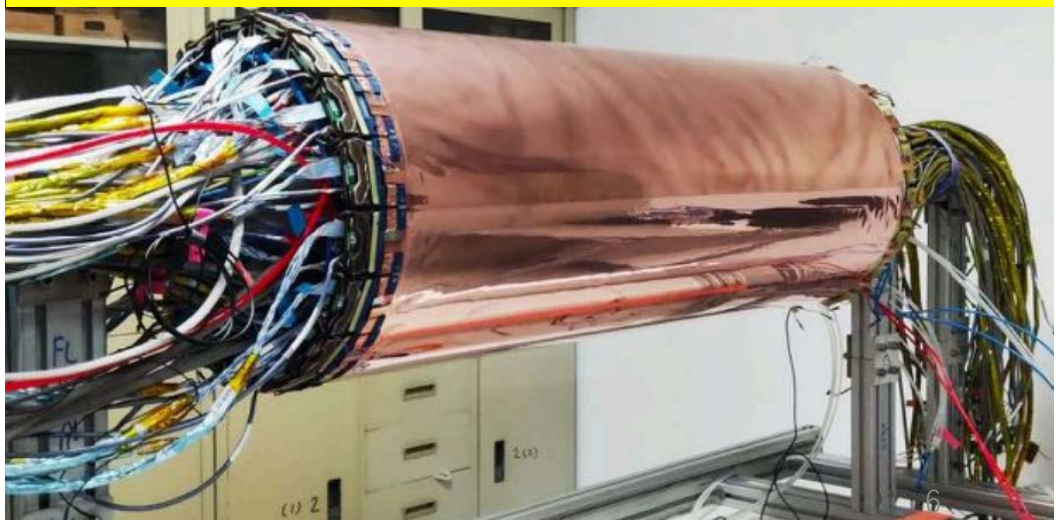


NIMA 824, (2016)515-517

Layer1, 2, 3



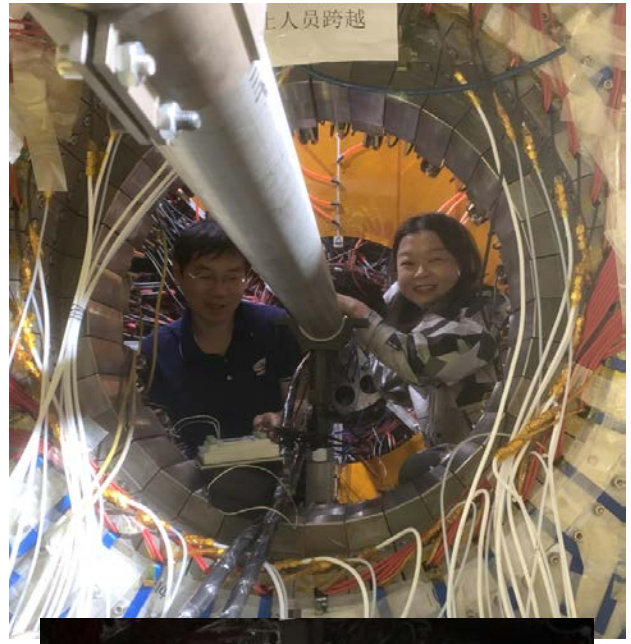
Integrated CGEM for cosmic-ray tests

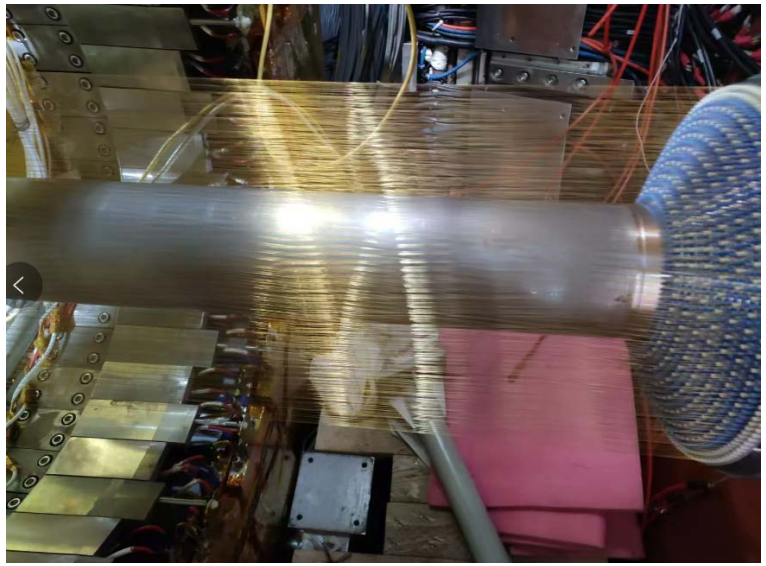


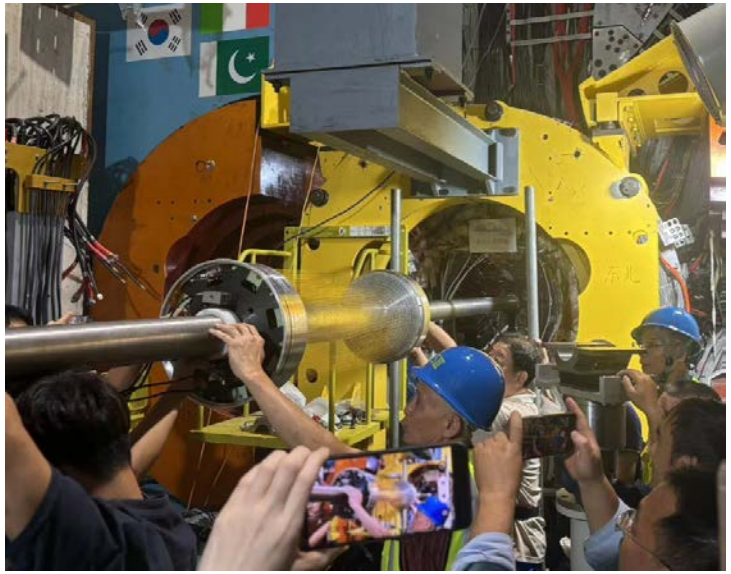
BESIII漂移室内室升级

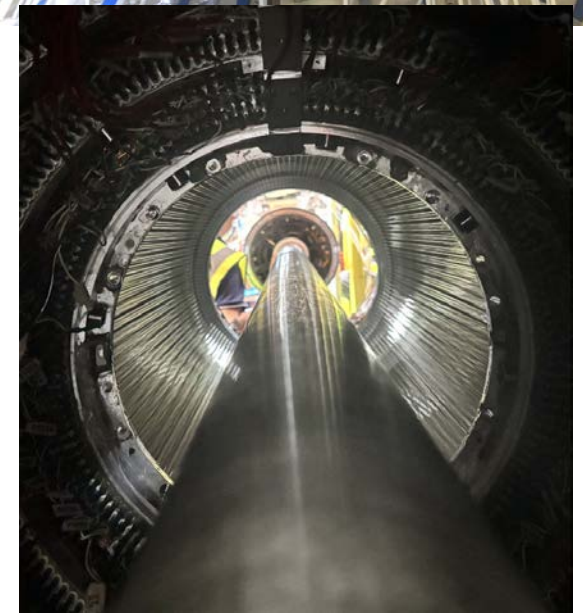
内室拆卸

- MDC内外室公用同一个腔室，在端板处紧密配合以及加胶密封，内室拆卸风险极大
- 多种拆卸方案，充分的实验，确定了最可靠的方案以及可能出现问题的预案
- 拆卸过程中，位移监测、丝张力检测，温度监测等，最终完成内室的安全拆除





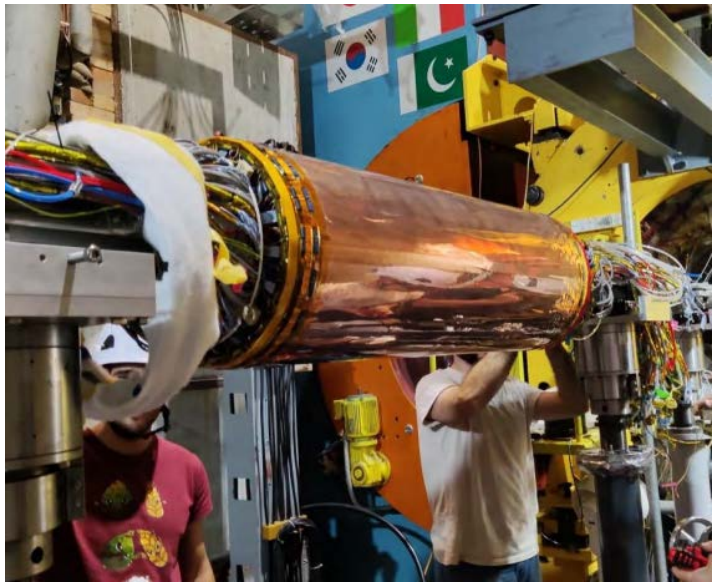


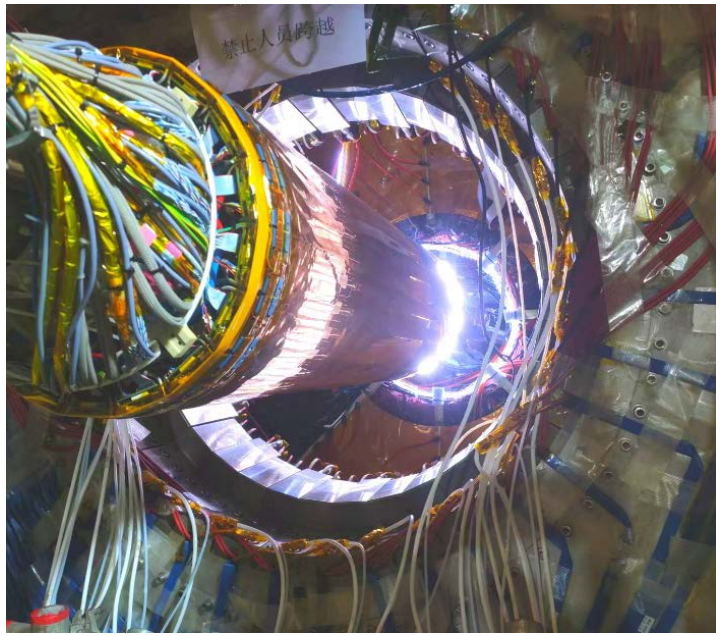


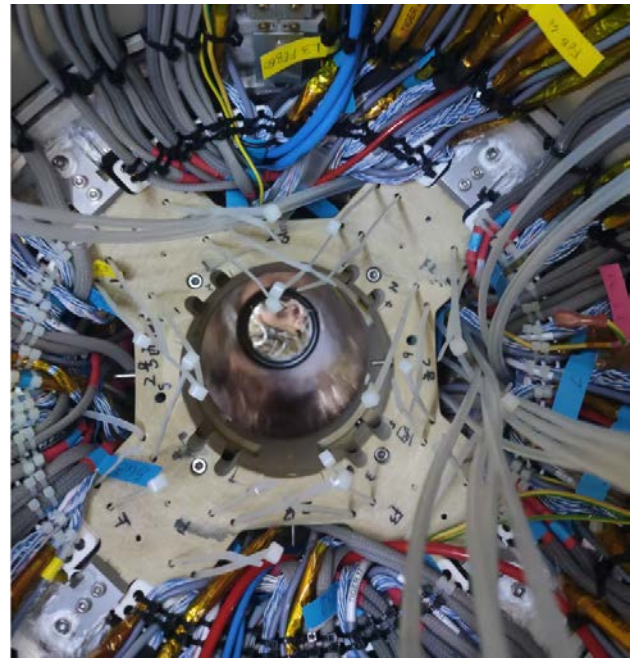
BESIII漂移室内室升级

CGEM的安装

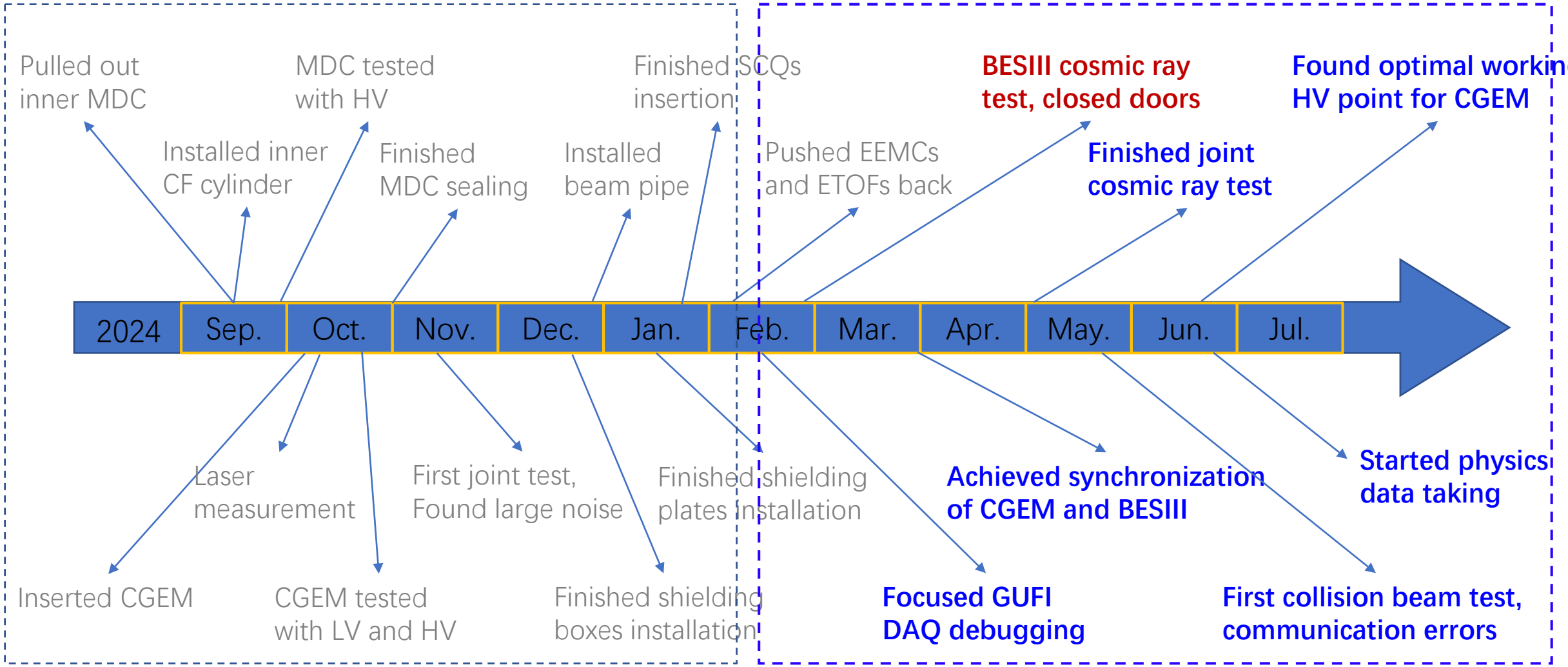
- 通道数约增加20倍：484 —> 约10000
- 电缆数增加3倍，且电缆直径大
- 安装空间紧张
- 最终完成CGEM的安装、集成、噪声问题处理，以及DAQ调试和与BESIII的联合测试
- CGEM可以在正常高压下工作并正式参与物理取数。标志着BESIII内径迹室升级的成功



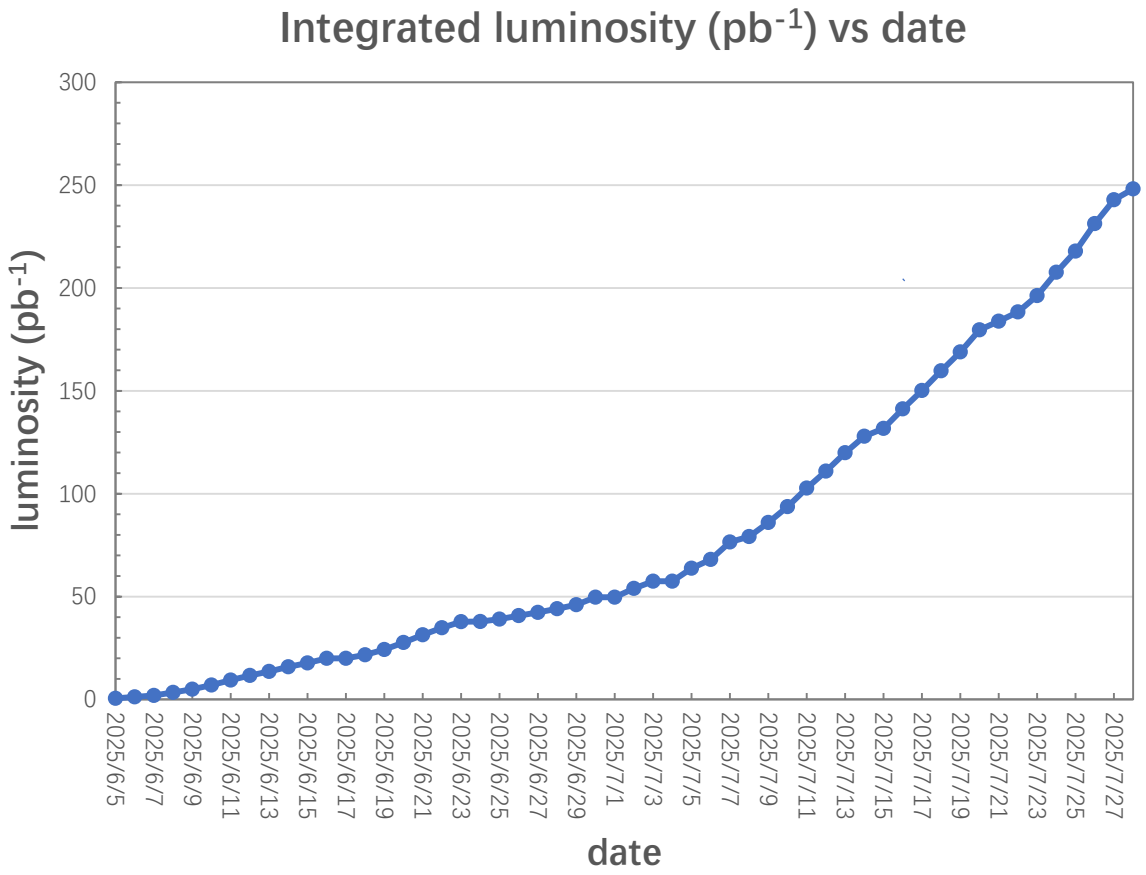


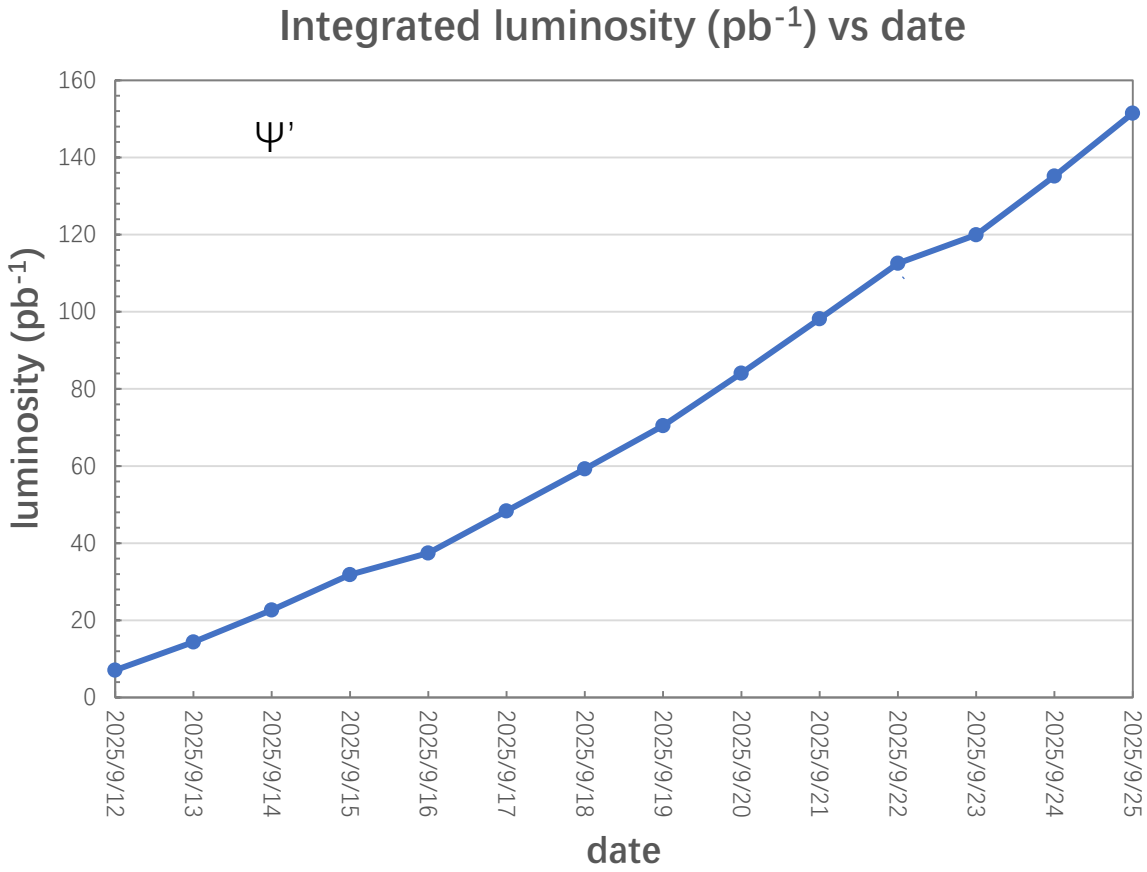


Inner tracker upgrade



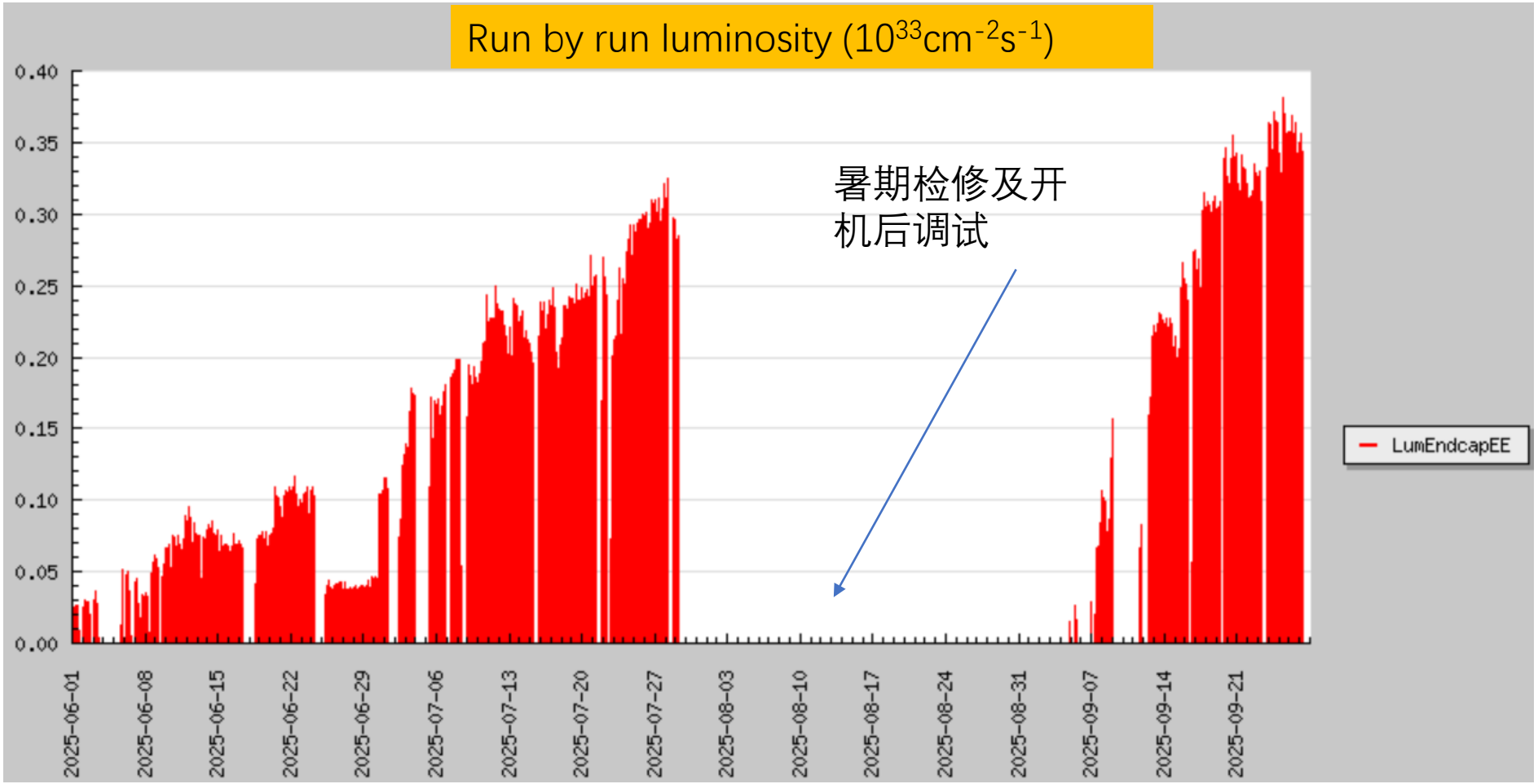
数据获取和积分亮度





- 升级后，首先进行Ψ'取数（2025.6.5-7.28，2025.9.12-）：探测器刻度及物理研究
- 积分亮度420.3 pb^{-1}（暑期前248.2pb^{-1}， 暑期后172.1pb^{-1}）
- The maximum integrated luminosity/day : 16.5 pb^{-1} (on Sep. 26^{th})

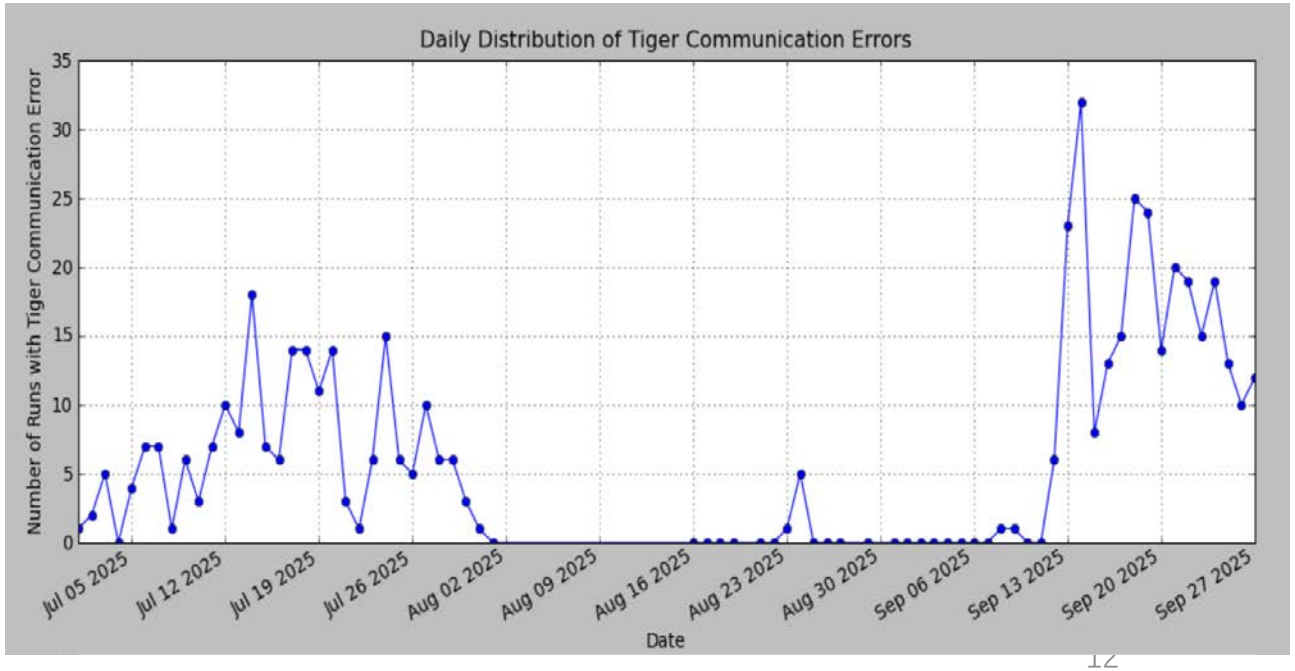
Luminosity run by run



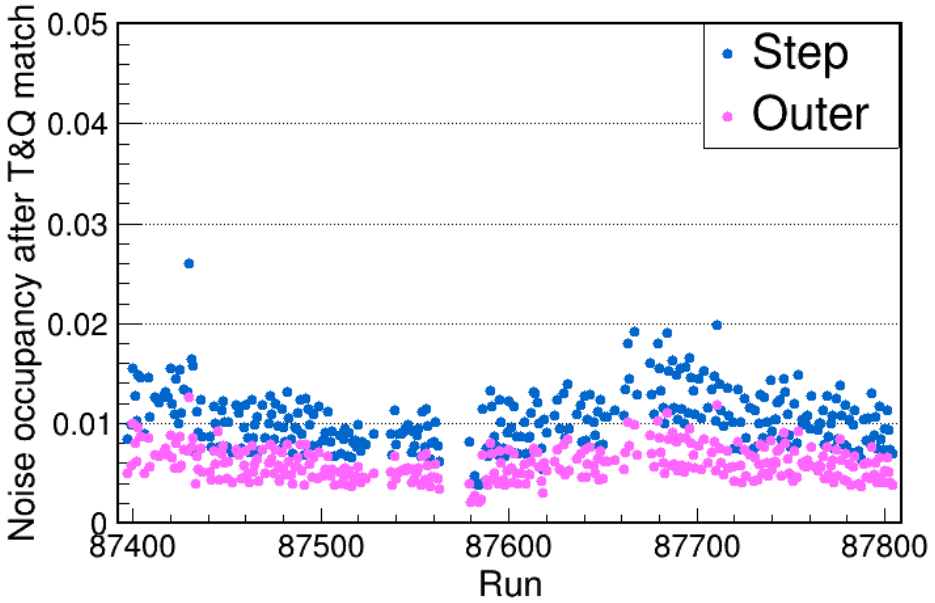
- The peak luminosity gradually increases
- Reached to 0.38×10^{33} $cm^{-2}s^{-1}$ @ 700mA (on Sep. 25^{th})

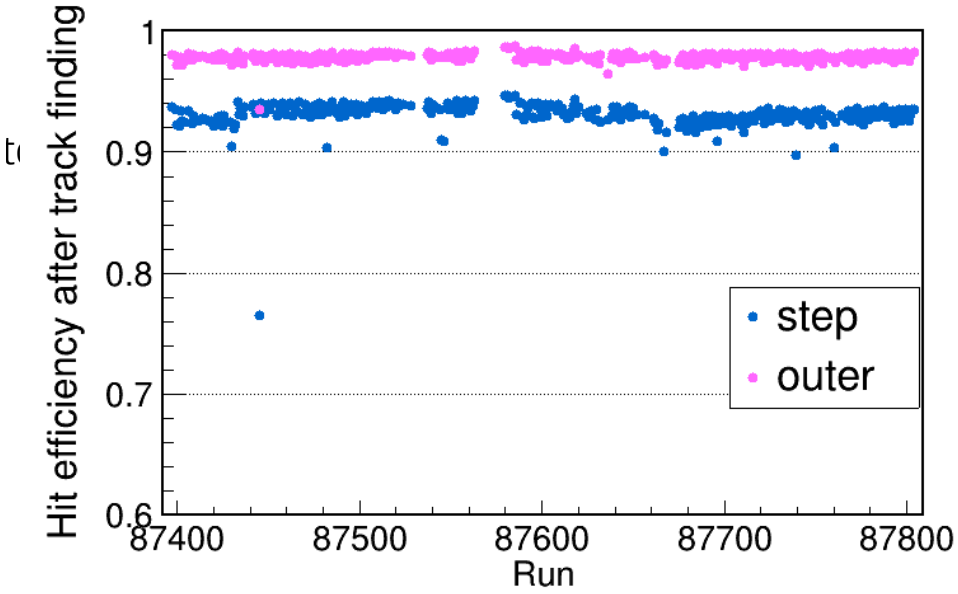
BESIII运行情况

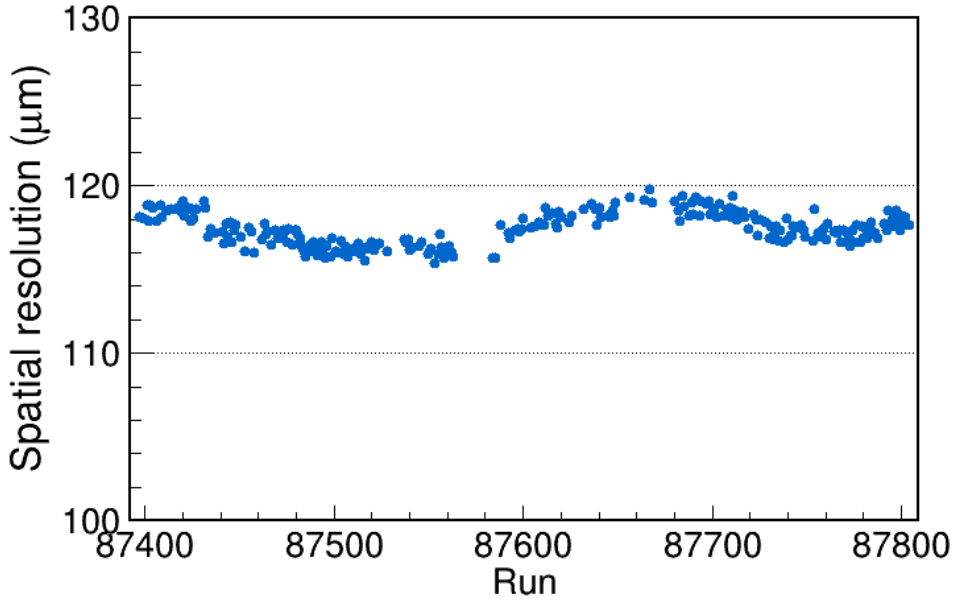
- BESIII子探测器运行良好，故障率较低，运行中的故障都及时解决。
- 9月27日，低温故障造成谱仪超导磁铁失超，阀箱出现严重故障，目前正在全力检查及抢修
- 新安装的CGEM处于运行磨合期，故障率较高，中意双方合作努力解决这一问题，目前情况有改善
  - “Communication errors” frequently occurred during data taking. Several minutes were need to recover the DAQ at the beginning.
  - Optimized the high voltage setting of L2 (down) (lower L2_T1 and L2_T2 from 550V to 400V) on Sep.14, and reduced the communication errors
  - Moved “CGEM configuration” to the DAQ “Start ” workflow, therefore, no need to configure other sub detectors for recovering DAQ, and saved DAQ recovery time.
  - The situation is currently improving

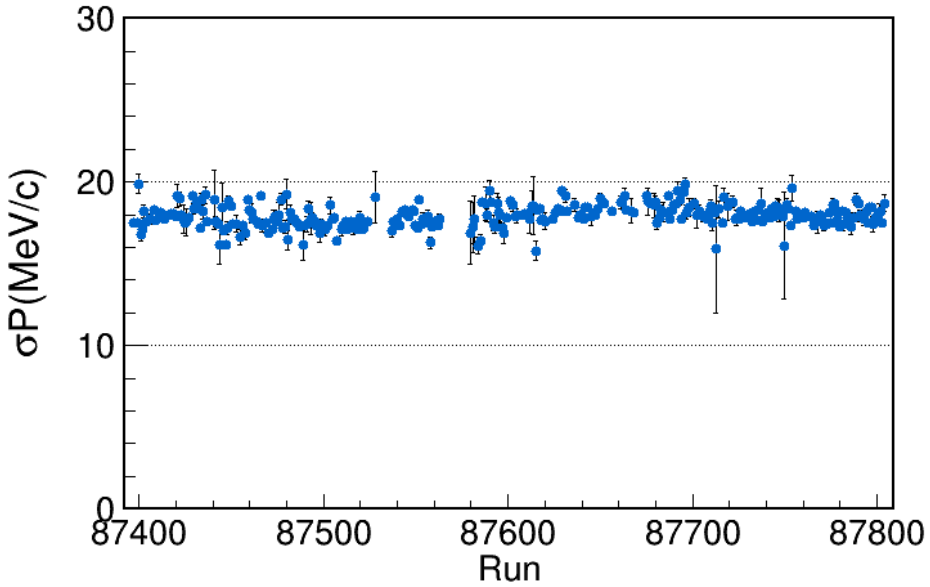


漂移室 (MDC)



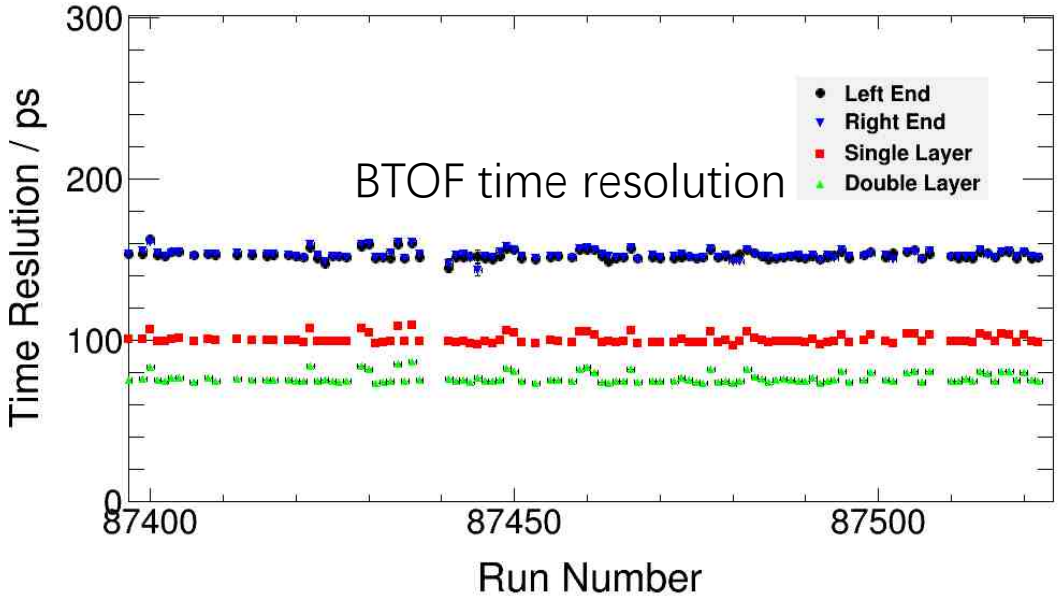


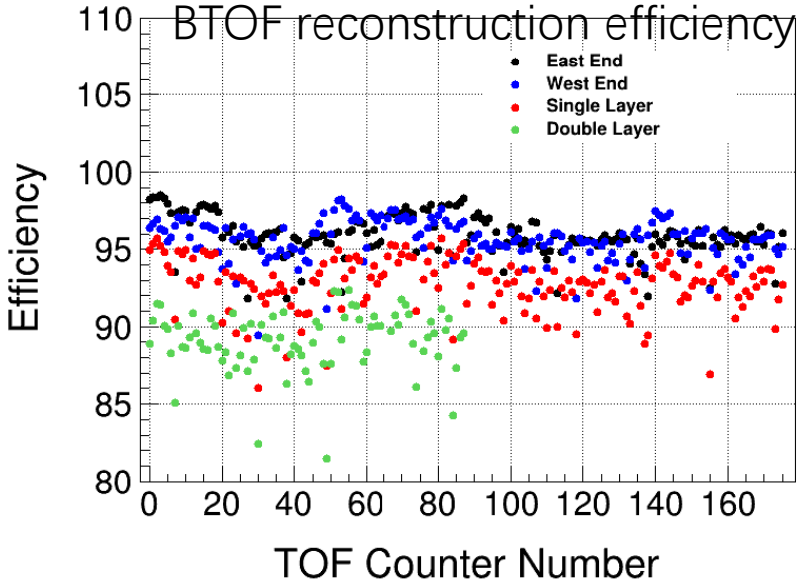


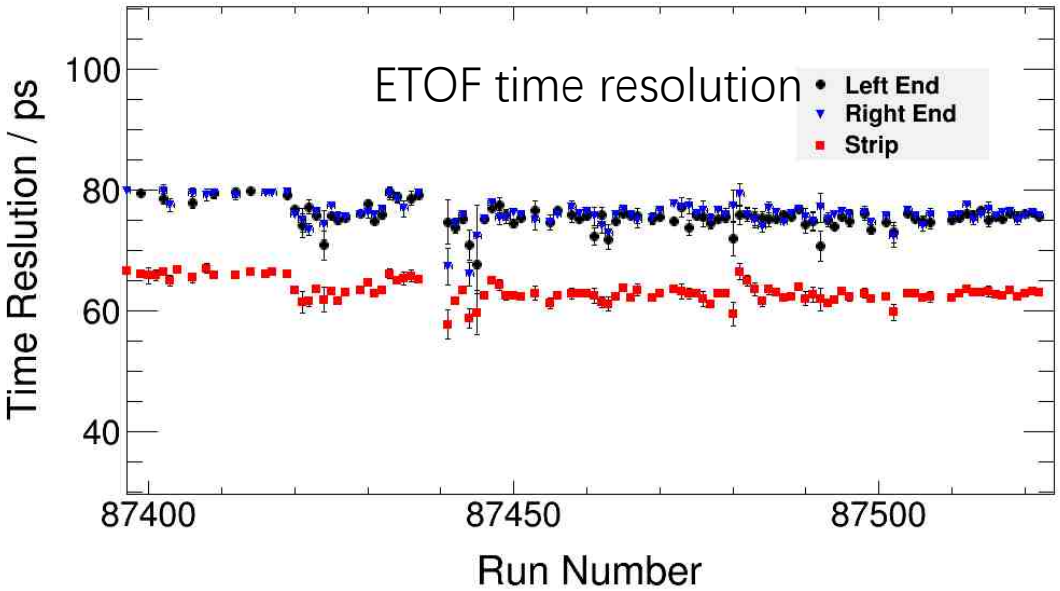


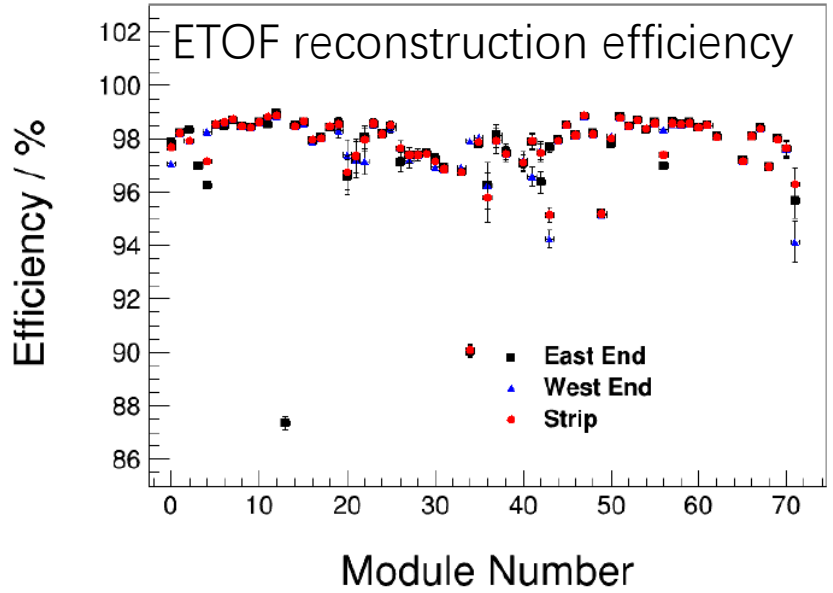
- 漂移室整体运行稳定
- 漂移室空间分辨: 约117 μm
- σ_P=18MeV/c

飞行时间探测器（TOF）



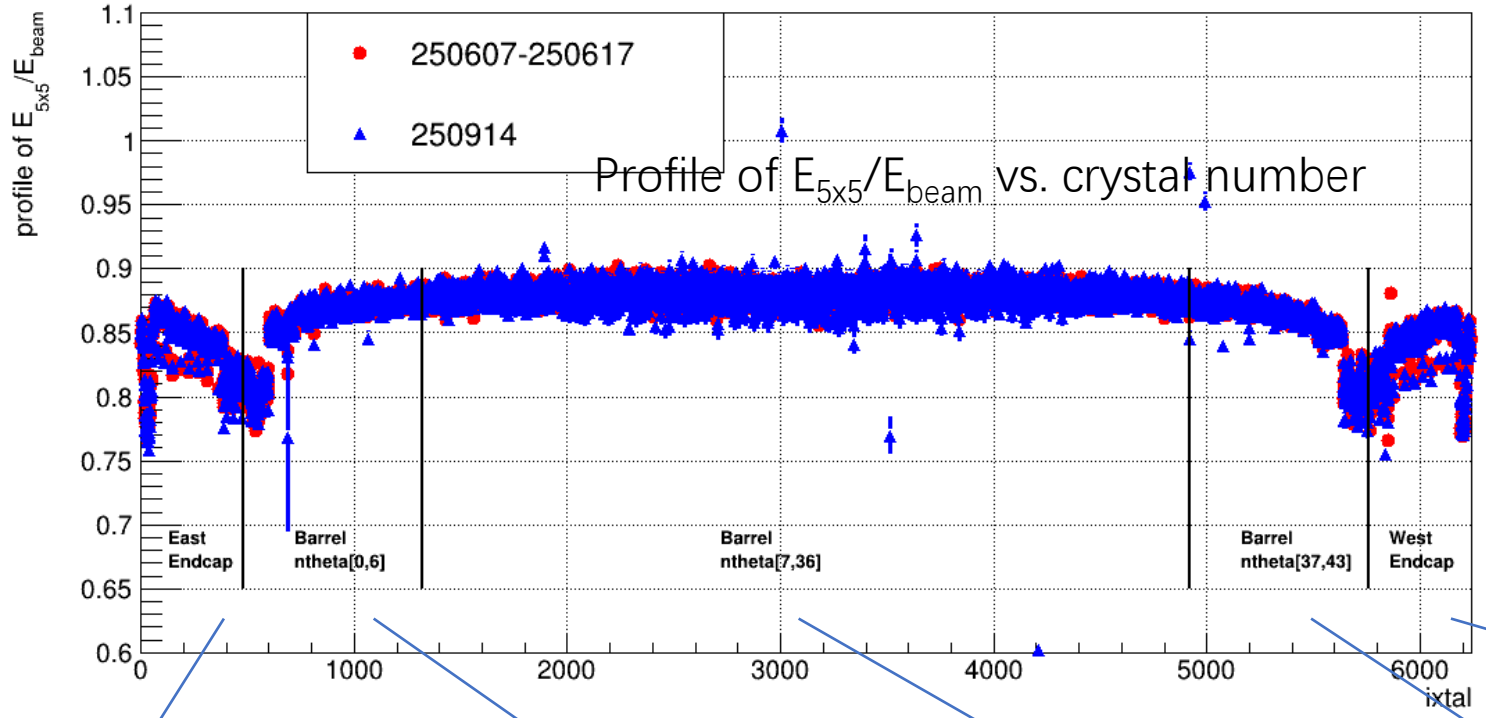






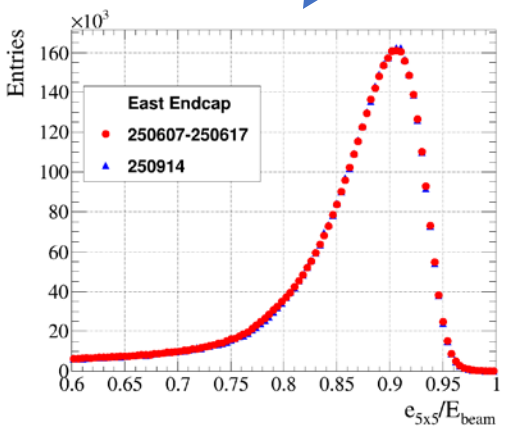
- TOF运行稳定
- BTOF时间分辨率74ps，效率~90%(双层),
- ETOF时间分辨率65ps，效率>95%

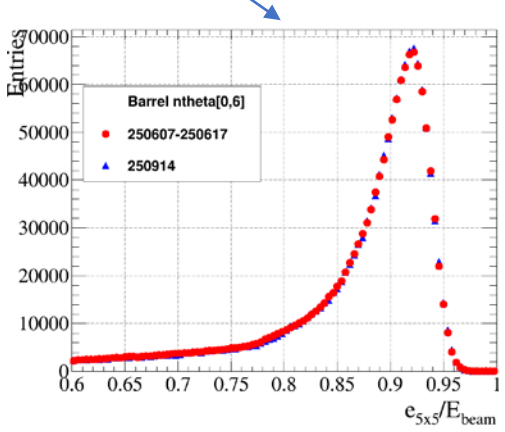
电磁量能器（EMC）

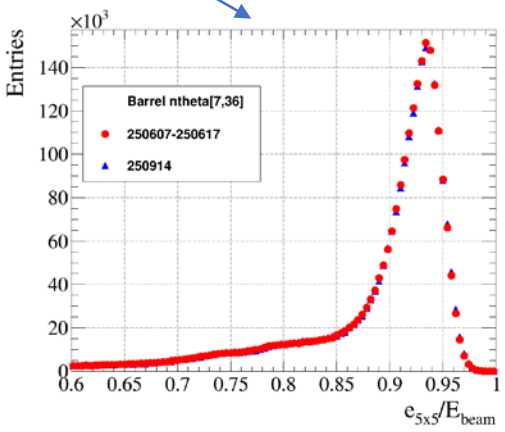


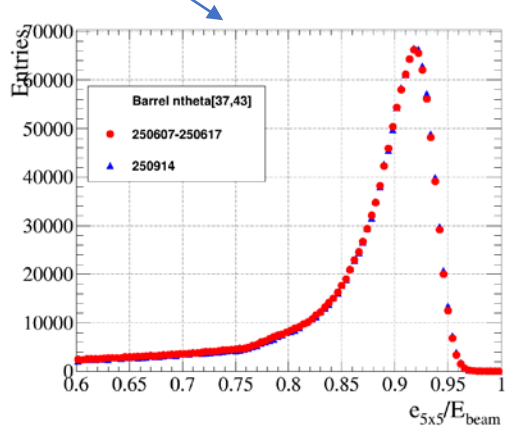
- 量能器晶体单元性能良好
- 没有出现失效单元

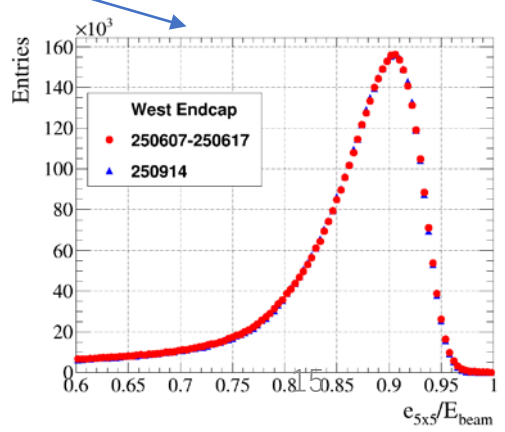
- Compared to last run period, the performance of EMC is almost the same





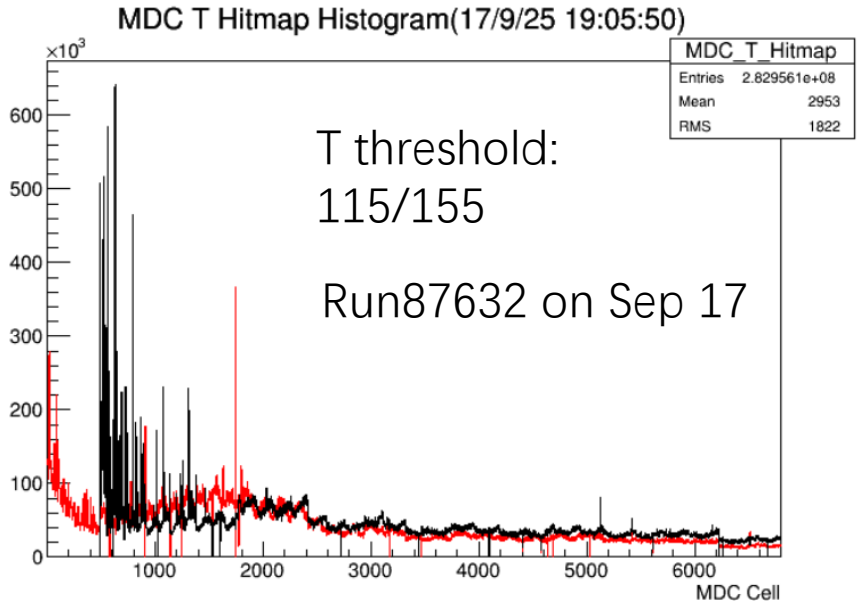


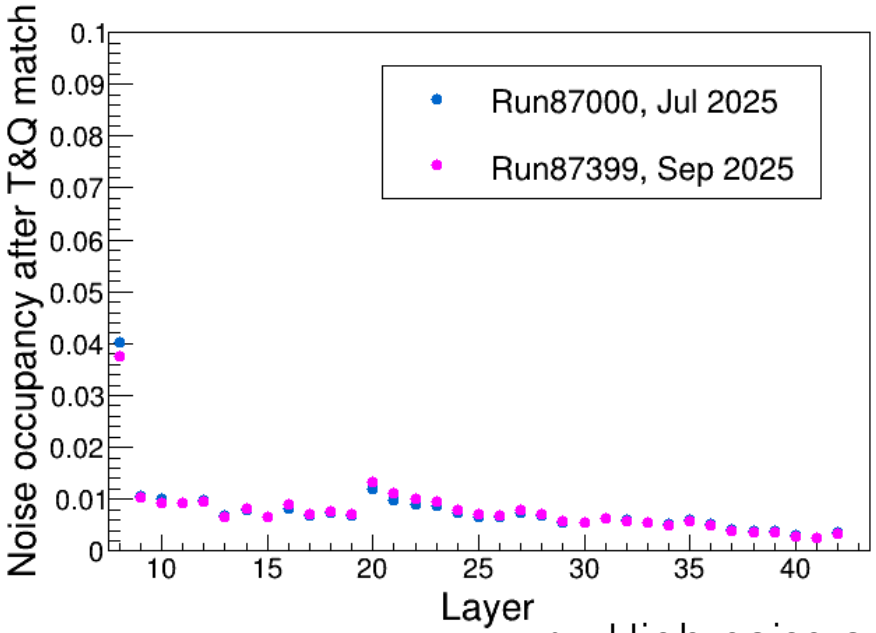


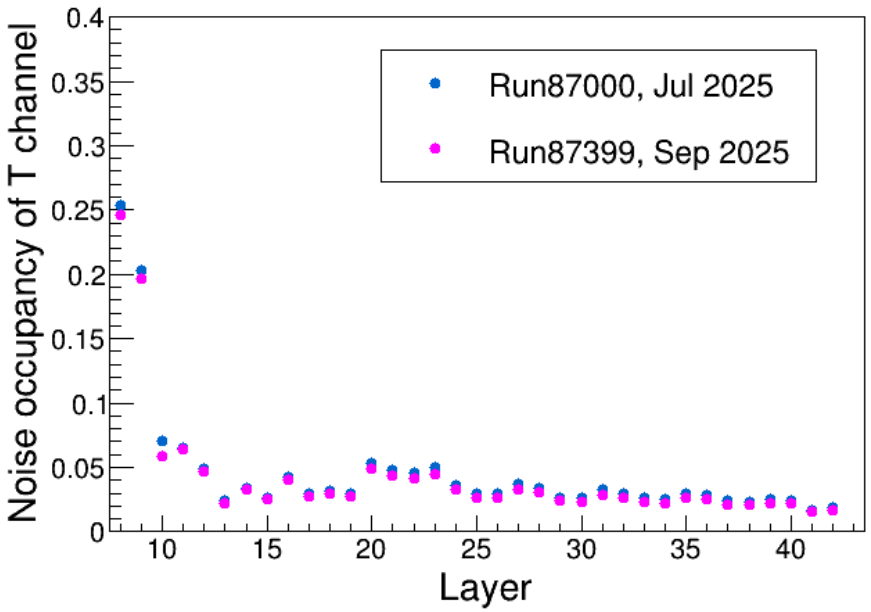


噪声问题

- CGEM电子学相关的噪声得到了有效控制，仅影响MDC前几层
- 其他噪声大部分时间控制在较低水平，但不稳定，有时会变大
- 与SSM 电源相关的噪声问题已基本解决



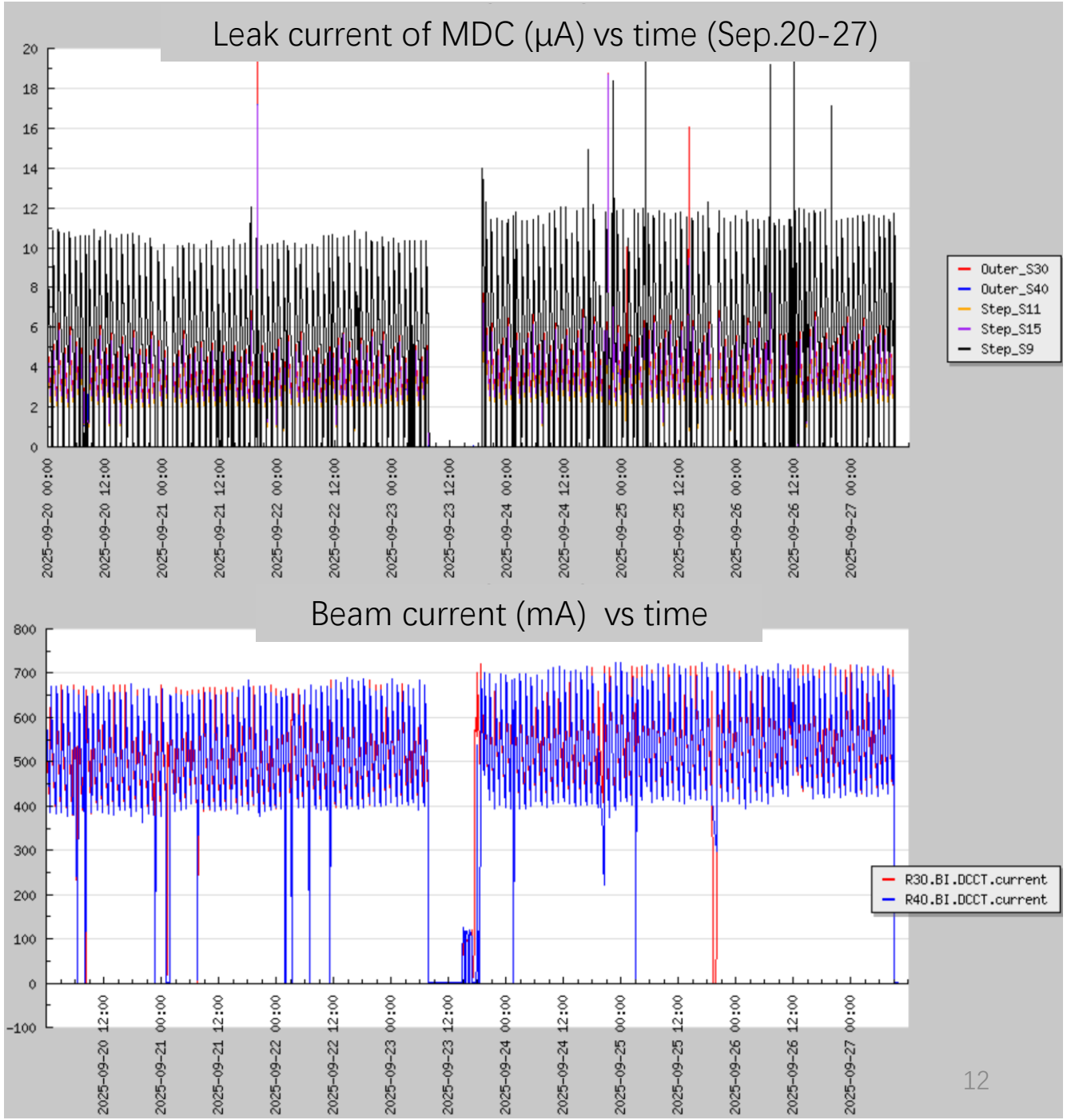




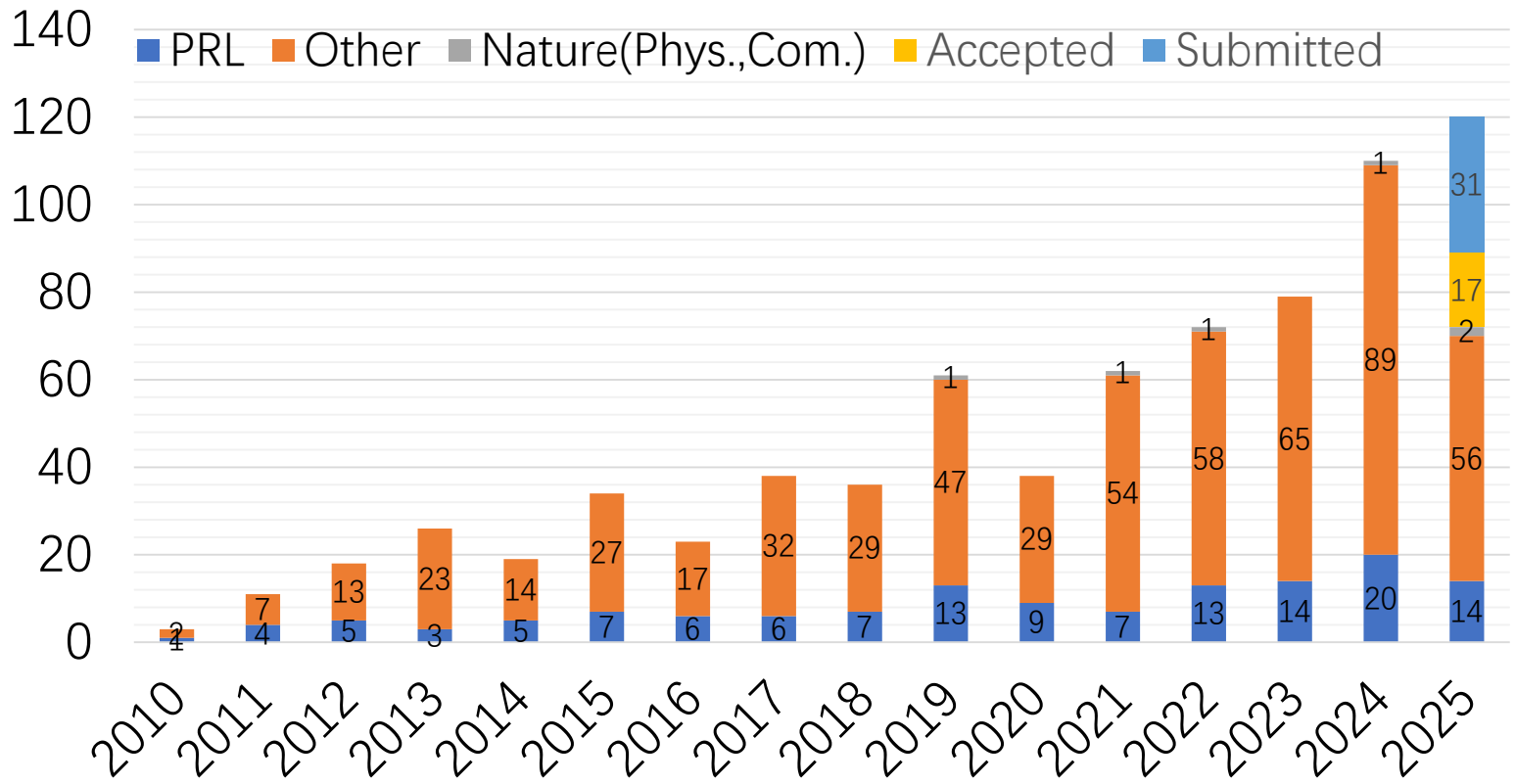
- High noise occupancy in the inner two layers

束流本底情况

- 束流本底整体控制的比较好
- MDC第9层电流最大约12μA（在束流流强700mA情况下）
- 探测器高压trip偶尔出现

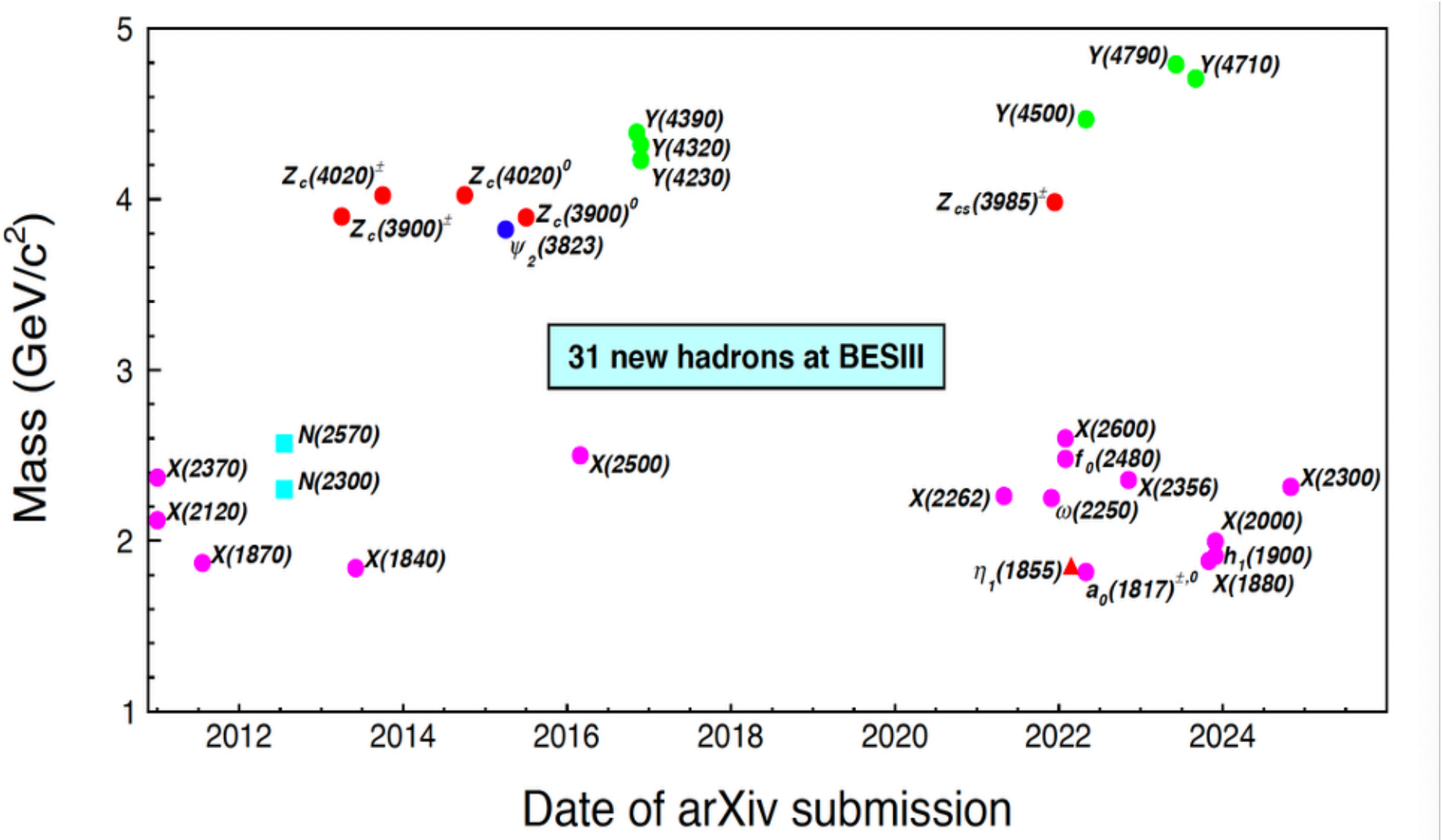


BESIII年度成果统计



- 2024年10月至2025年9月：发现1个新粒子（累计发现31个）；BESIII年度发表文章100篇 (其中18篇PRL)（累计突破700篇）
- BESIII已经备受世界关注，成为在强子谱学和标准模型的精确检验等领域领跑世界的重要实验。

31 New Hadrons Discovered at BESIII



成果亮点：发现类奇异偶素态$X(2300)$和重子激发态W(2109)$^-$

奇特强子态研究

发现类奇异偶素态$X(2300)$

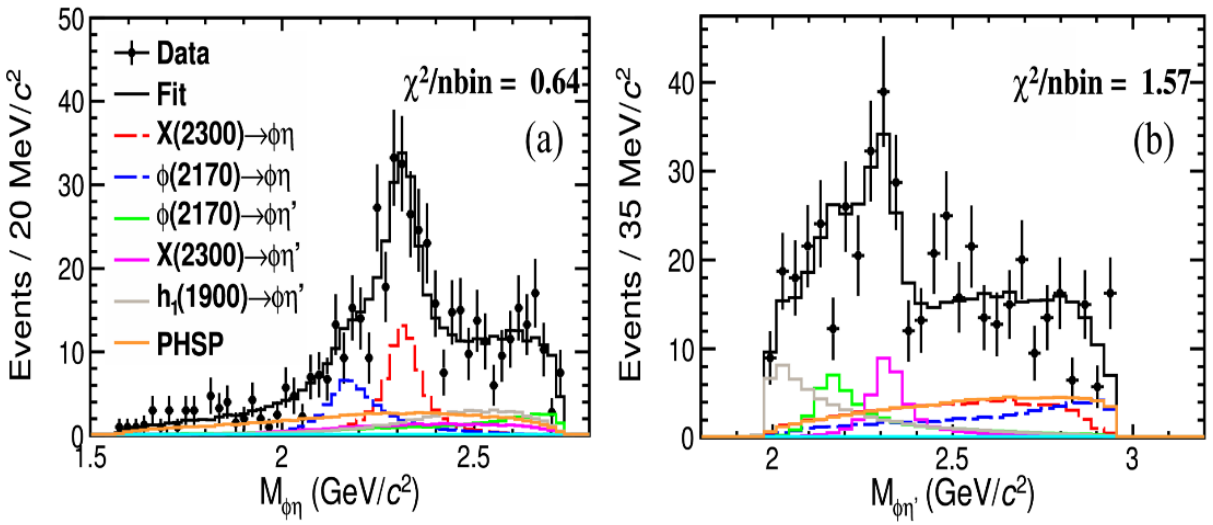
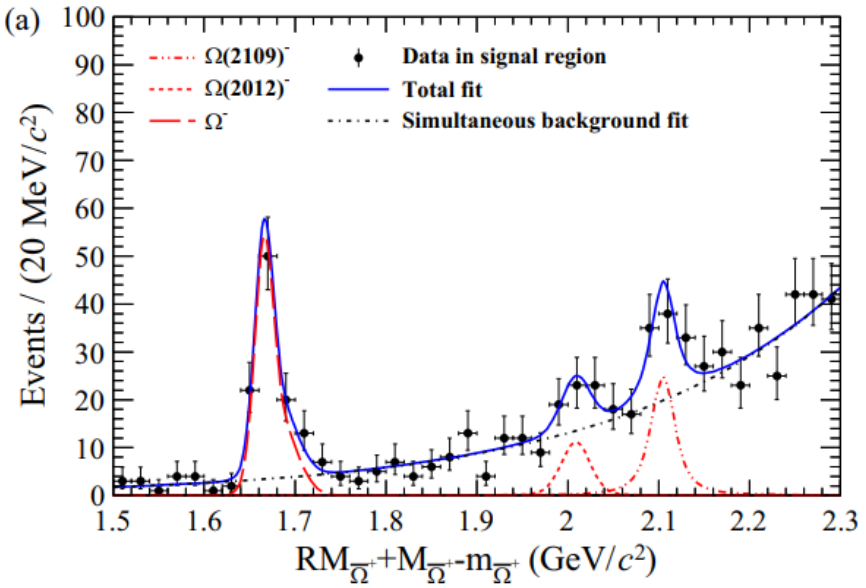


Fig.1 Invariant-mass distributions (a) $\phi\eta$, (b) $\phi\eta'$

Phys. Rev. Lett. 134 (2025) 191901

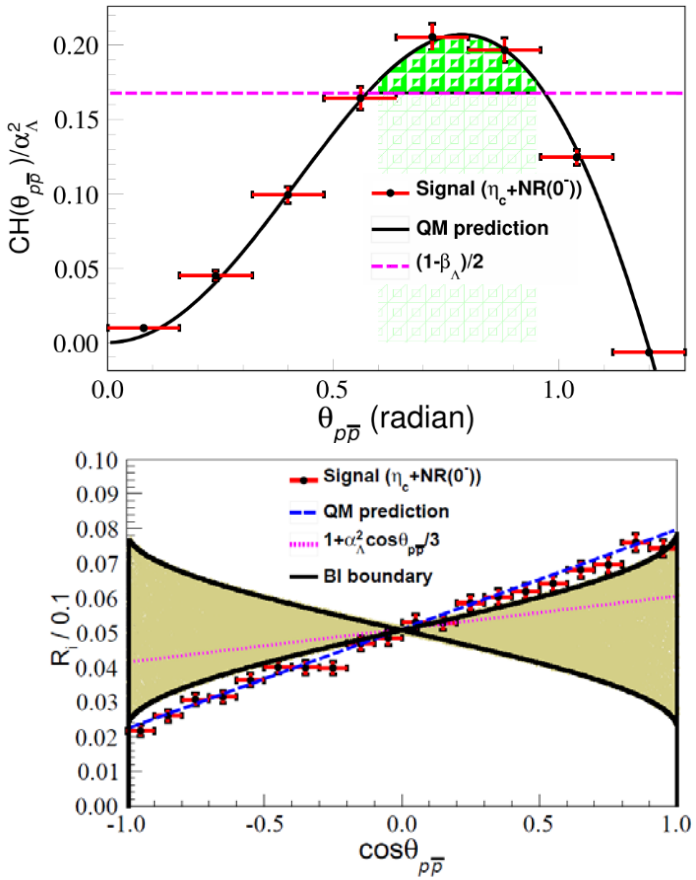
重子激发态$\Omega(2109)^-$的迹象



Phys. Rev. Lett. 134 (2025) 131903

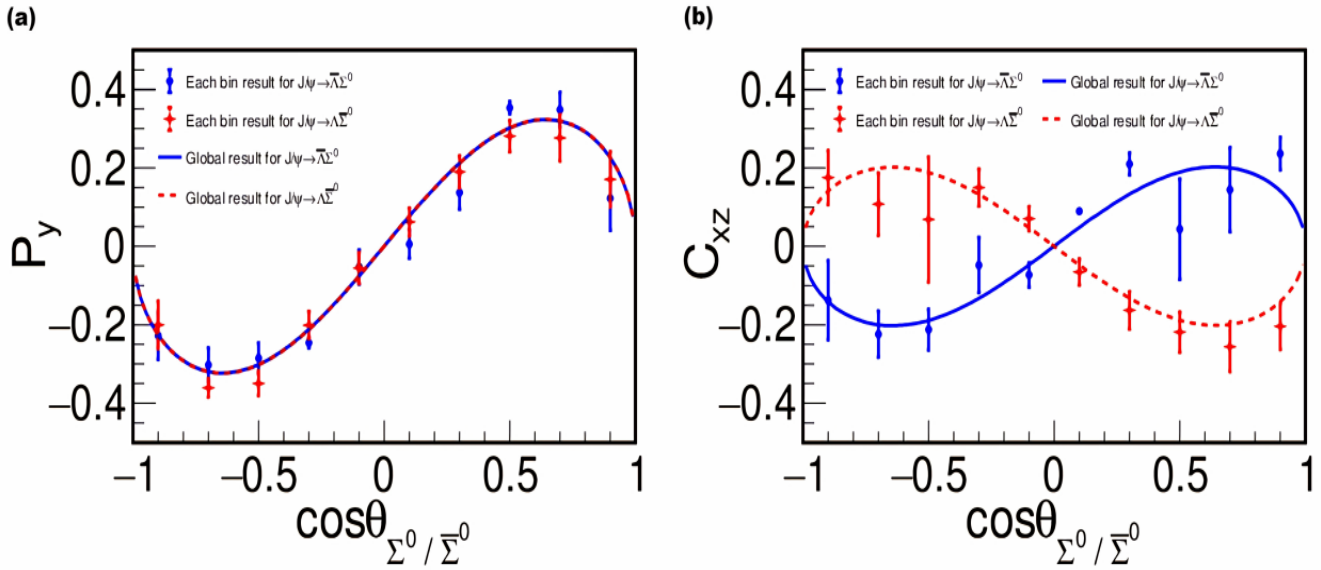
成果亮点：重子物理研究方面

首次在实验上证实在强相互作用下量子纠缠和贝尔不等式破坏



Nature communication 16, 4948 (2025)

提出探究超子精细结构的新方法，精确确定超子横向极化和CP破坏



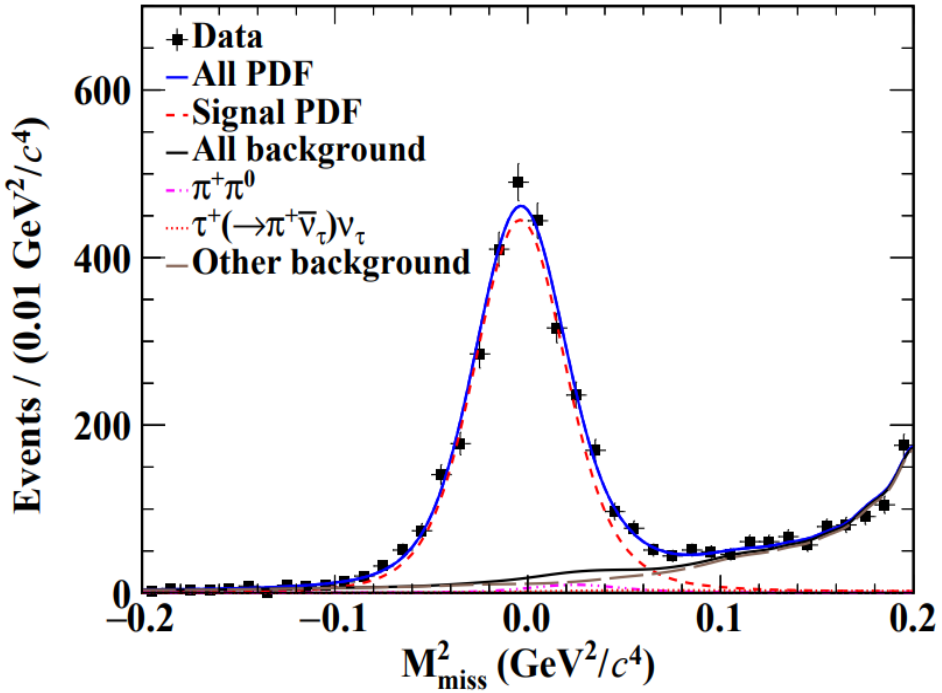
Nature communication 15, 8812 (2024)

成果亮点：精确测量标准模型基本参数、夸克混合矩阵元$|V_{cd}|$

粲强子含轻衰变研究

精确测量标准模型基本参数、夸克混合矩阵元$|V_{cd}|$，开启CKM矩阵幺正性检验的新时代

首次或精确测量粲强子若干半轻衰变形状因子，检验粲夸克衰变中的轻子普适性

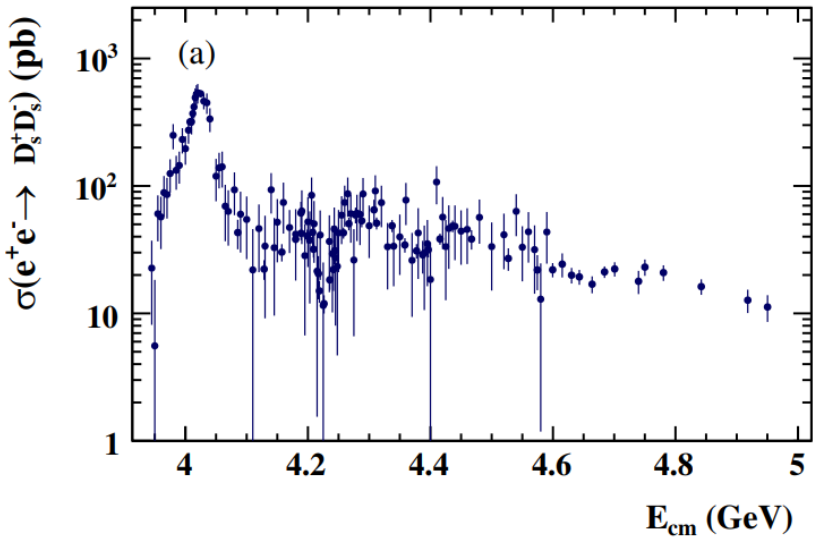


Phys. Rev. Lett. 135 (2025) 061801

Decay	Publication
$D^0 \to K^-\pi^0\mu^+\nu_\mu$	PRL134 (2025) 011803
$\Lambda_c^+ \to ne^+\nu_e$	Nat. Com. 16 (2025) 681
$D^+ \to \eta' l^+\nu_l$	PRL134 (2025) 111801
$D^{0,+} \to \bar{K}_1(1270)e^+\nu_e$	PRL135 (2025) 091801
$D^0 \to K_S^0\pi^-\mu^+\nu_\mu$	PRL135 (2025) 111803
$D^+ \to K_S^0\pi^0 l^+\nu_l$	Accepted by PRL

成果亮点： (类)粲偶素研究

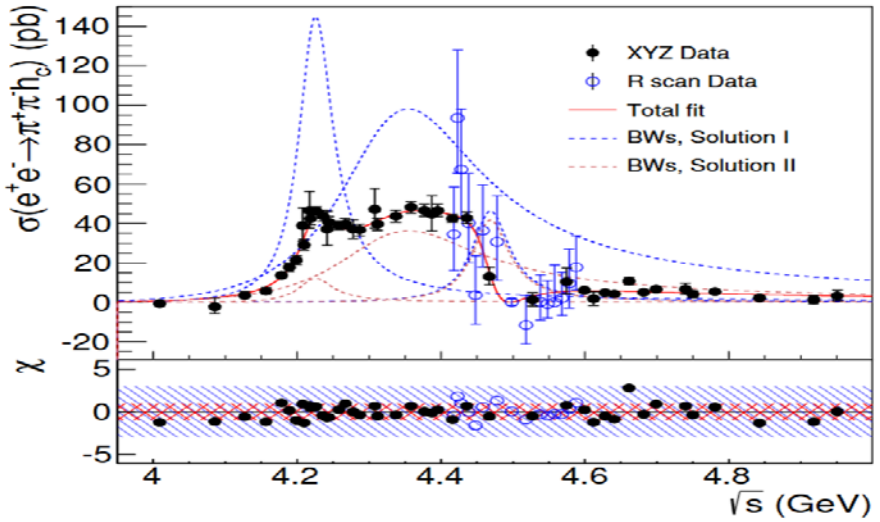
精确测量$e^+e^- \to D_s^+D_s^-$截面谱



Phys. Rev. Lett. 133 (2024) 261902

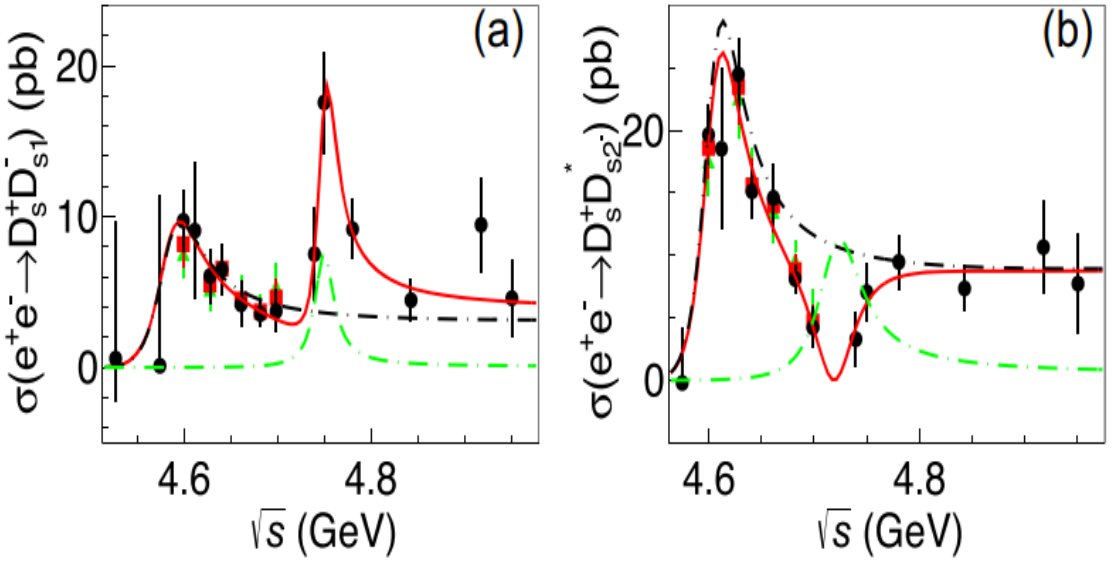
发现类粲偶素粒子
$Y(4230)$、$Y(4360)$、$Y(4500) \to \pi^+\pi^- h_c$

Phys. Rev. Lett. 135 (2025) 071901



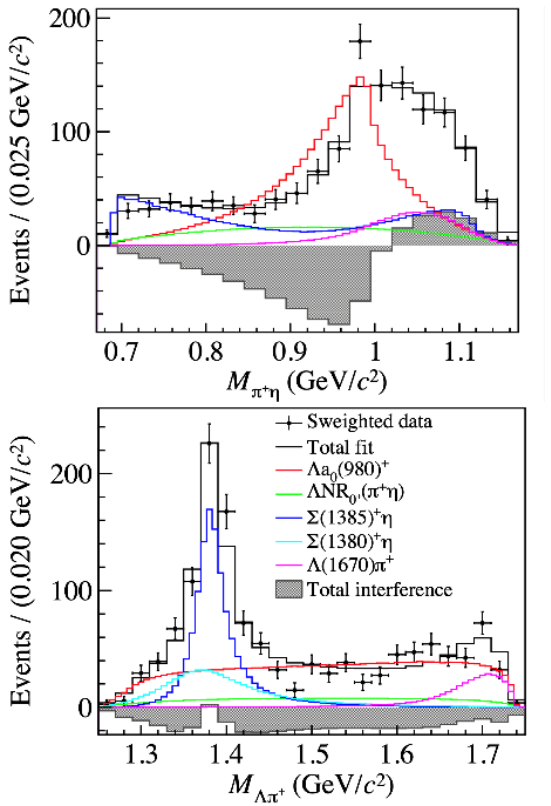
发现类粲偶素粒子$Y(4600) \to D_s^+D_{s1}(2536)^-$和$D_s^+D_{s2}^*(2573)^-$

Phys. Rev. Lett. 133 (2024) 171903



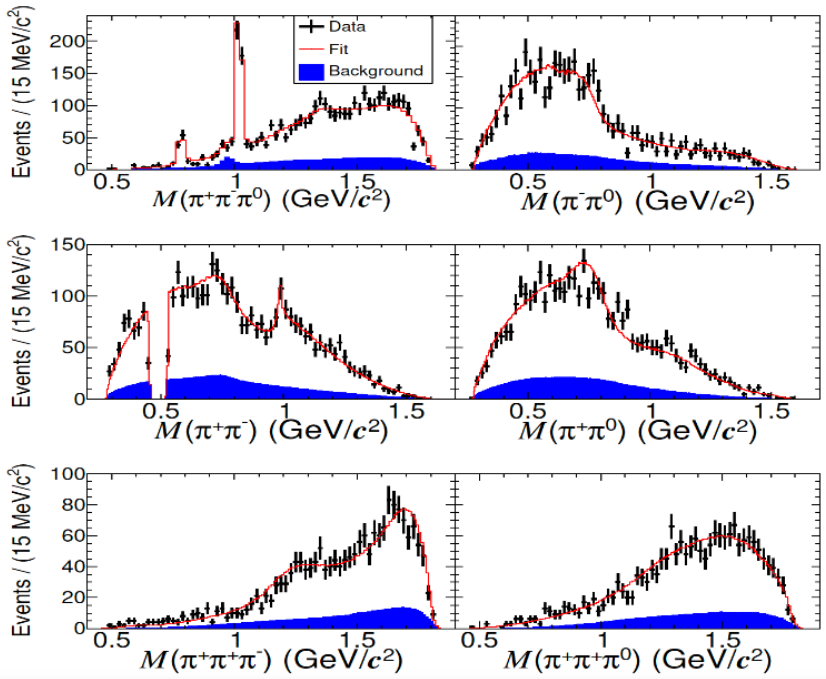
成果亮点：粲强子强衰变振幅分析研究 → 轻强子性质

首次发现$\Lambda_c^+ \to \Lambda a_0(980)$



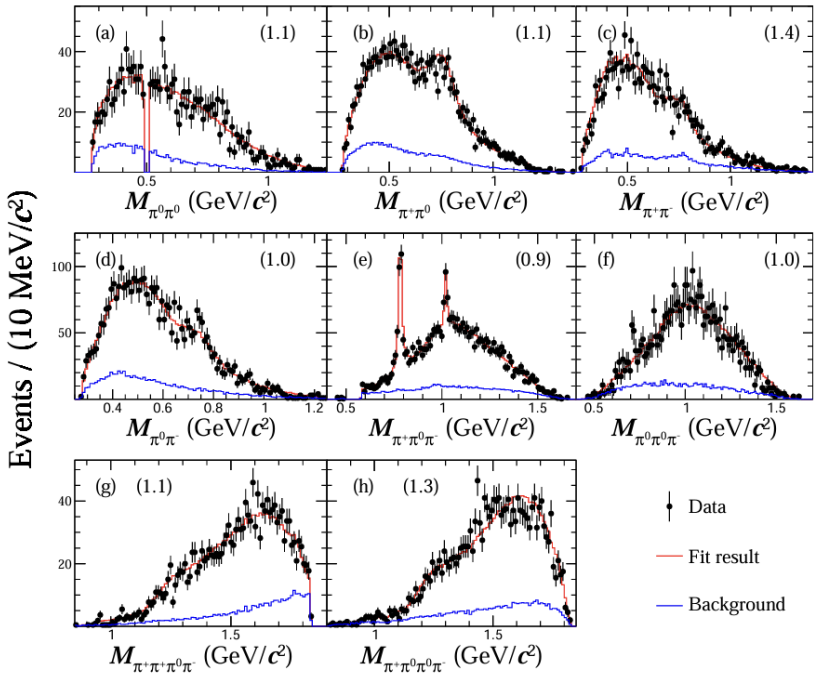
Phys. Rev. Lett. 134 (2025) 021901

首次发现$D_s^+ \to f_0(980)\rho(770)$



Phys. Rev. Lett. 134 (2025) 011904

首次发现$D_s^+ \to \omega\rho(770)$



Phys. Rev. Lett. 134 (2025) 201902

取数计划 (2025-2026)

- No dedicated synchrotron runs any more:
  - 9–10 months of physics running per year!
- BEPCII-U goals:
  - Recover high-current machine operation
  - Demonstrate operation at high energy
  - Show gain in luminosity
- Beam time allocation (not final)
  - Collect more data on Ψ' peak
  - Run at 4.680 GeV — start collecting $\Lambda_c^+ \bar{\Lambda}_c^-$ sample (requested total of 9 fb^{-1})
  - Scans around X(3872) and χ_{c2} (about one month each)
- Probably need some more Ψ' running: to be discussed in EB

总 结

- 本年度完成探测器的升级，并开始正常物理取数（Ψ’），亮度逐步提高，感谢加速器同事的辛苦付出与重要贡献！

- BESIII各子探测器运行稳定，性能也较稳定。新安装的CGEM探测器处于运行磨合期，目前communication error会中断取数，但通过高压及DAQ程序优化，减少了错误率和中断时间。另外，CGEM升高压的时间有优化的空间

- BESIII物理研究成果取得了丰富及突出的成果，发表重要成果超过700篇，年度超过100篇，确保陶粲能区的物理研究处于国际领先地位

Thanks for your attention!