第三届“粤港澳”核物理会议

南方科技大学
SOUTHERN UNIVERSITY OF SCIENCE AND TECHNOLOGY

^{12}Be(d,p)实验评估和模拟

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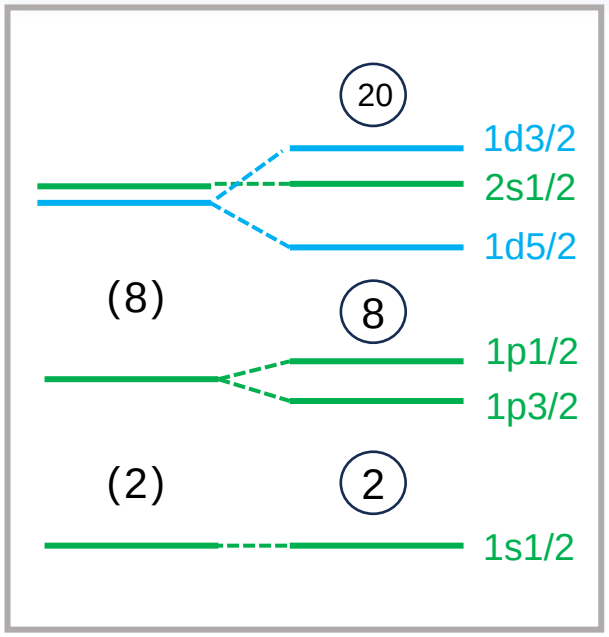
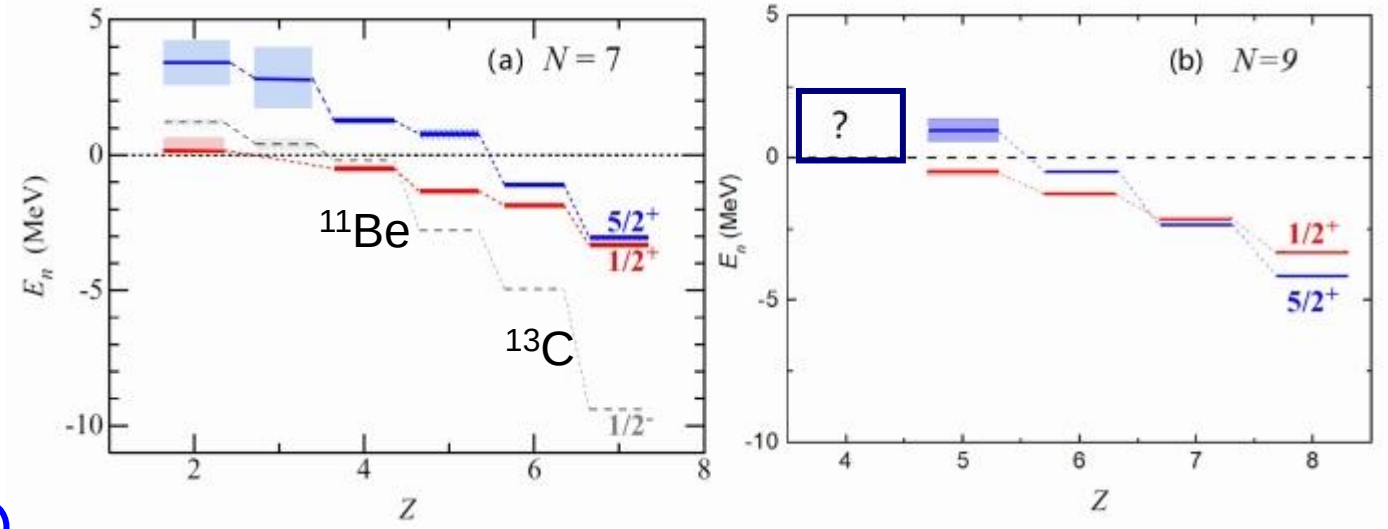
指 导 老 师：陈洁、柳卫平

2024.11.18

目录

Be同位素

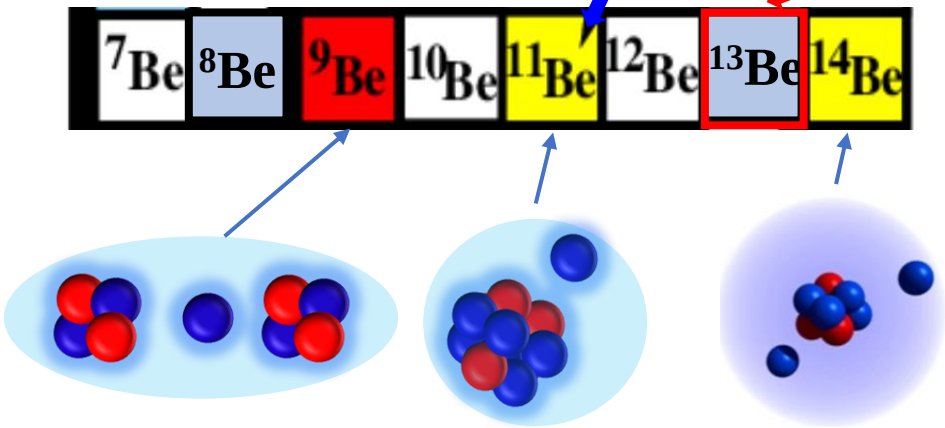




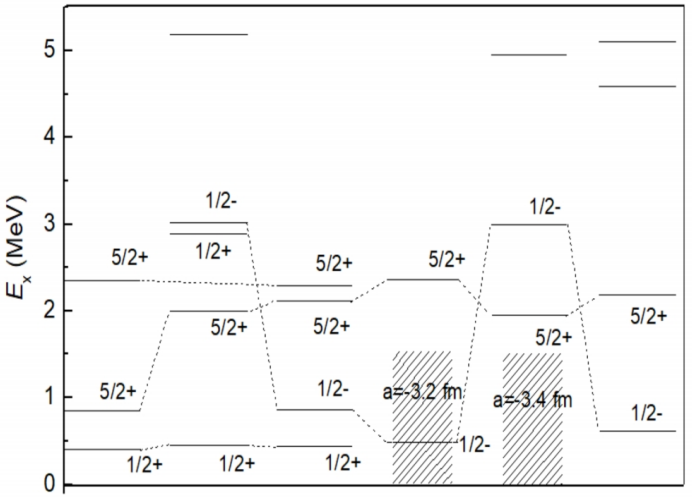
$^{10}\mathrm{Be}(0^+) \otimes n(2s_{1/2})$

$^{10}\mathrm{Be}(2^+) \otimes n(1d_{5/2})$

Be 同位素



- 电荷交换
- 质子移除(^{14}B)
- 中子移除(^{14}Be)
- 中子增加(^{12}Be)

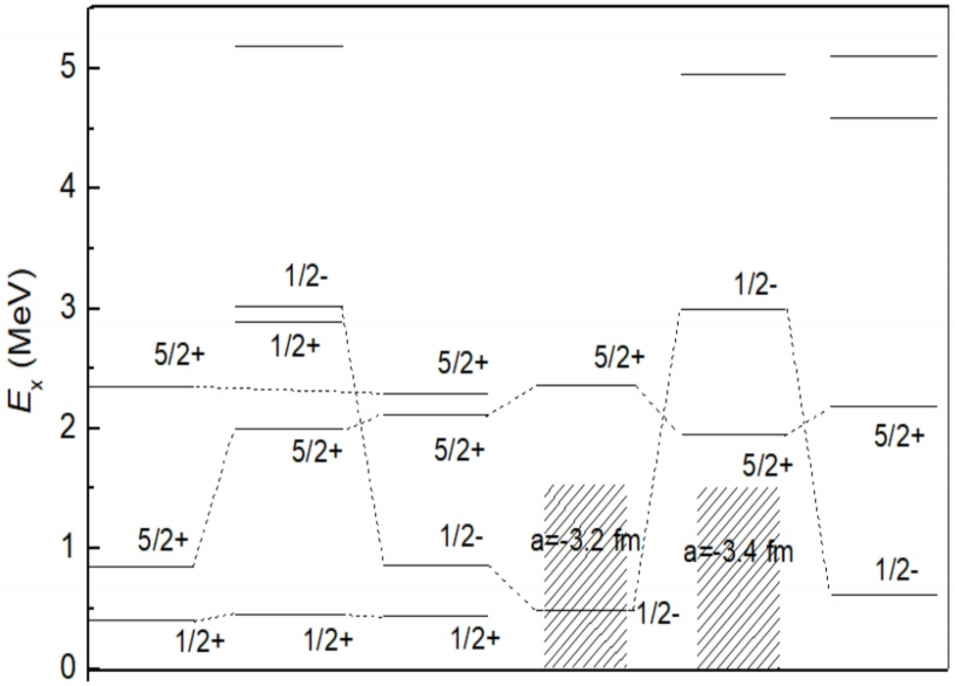


不同实验得到的^{13}Be自旋宇称

实验目标

^{12}Be (d, p)^{13}Be

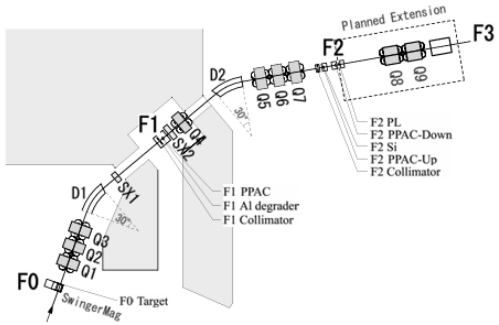
- ^{13}Be 激发态:
  - 共振态自旋宇称 (0.5 MeV)?
  - 谱因子和态宽度 (2 MeV), 核心激发成分的贡献?
  - 可能的共振态(1 MeV)的自旋宇称?
- 其他反应道:
  - ^{12}Be^{g,m}(d,t): 激发态数据的完善
  - ^{12}Be^{g,m}(d,d): 光学模型参数的优化



不同实验得到的^{13}Be自旋宇称

^{12}Be束流和AT-TPC

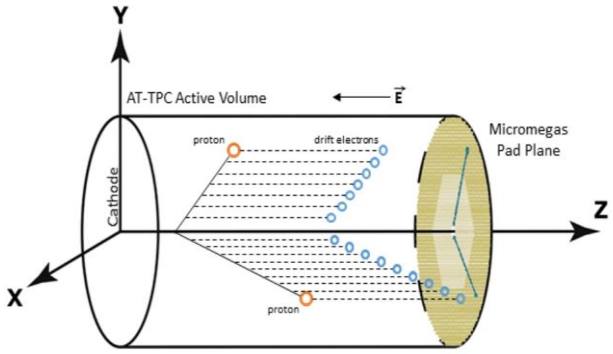
AT-TPC + EN-course



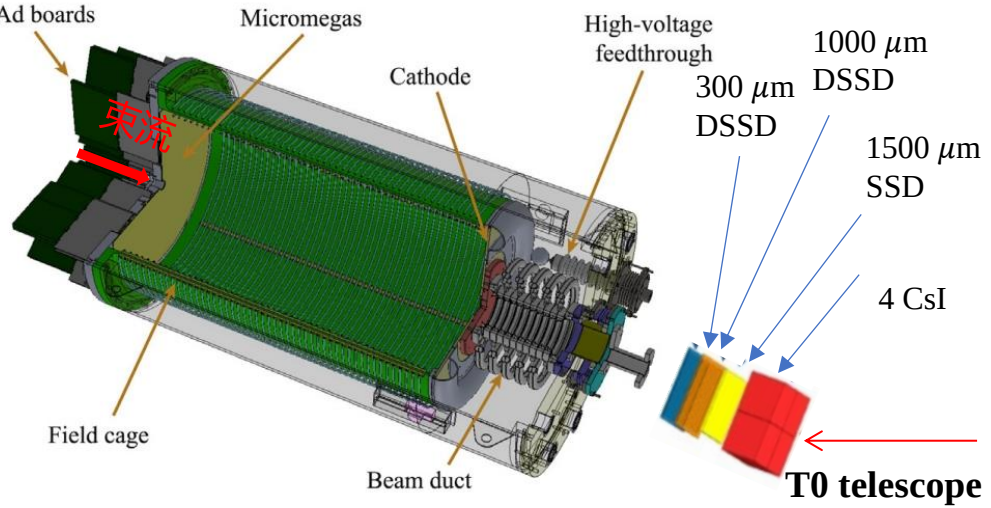
Tanihata, I et. al, Radio-isotope Beams at RCNP(2016).

活性靶时间投影室

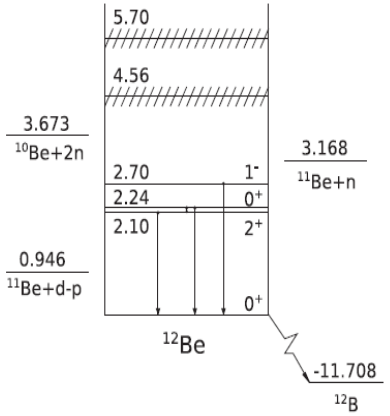
Active Target - Time Projection Chamber



PhD thesis of Alexander B. Carls



电离　漂移　电子倍增　Pad读出



^{12}Be同核异能态: 0_2^+　331 ns

E2衰变: **2.11 MeV+0.144 MeV γ ~14%**

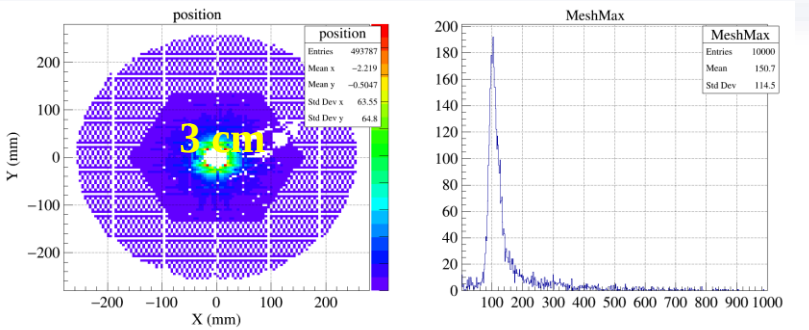
通过Q值区分^{12}Be^{m}(d,p) 和 ^{12}Be^{g}(d,p)

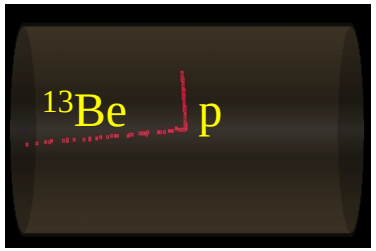
- 三维径迹重建
- 大角度覆盖
- 低探测阈值

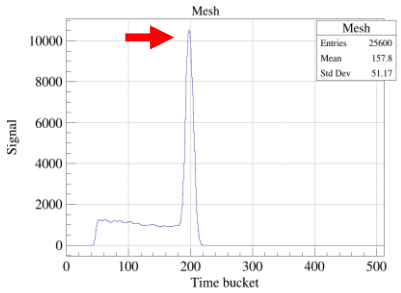
- 初级束: ^{18}O(60 MeV/u)
- 次级束: ^{12}Be (Isomer(2.24 MeV), 18 MeV/u, ~5×10^{3}pps)
- 工作气体: C_3D_8
- 气压: 450/500 torr

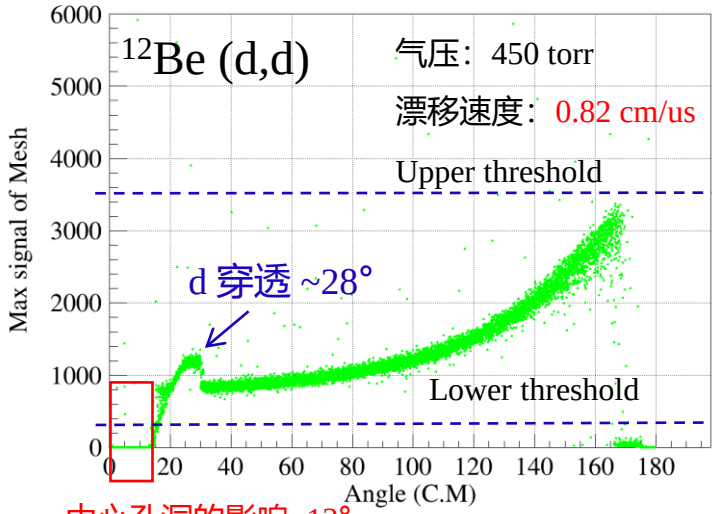
触发信号模拟

- 反应道: ^{12}Be (d, p)、 ^{12}Be(d , d)、 ^{12}C(^{12}Be,^{12}Be)
  - 反应发生在中心（18 MeV/u）
- Micromegas 上的信号
  - 信号最大值随质心系角度的变化
  - 限制上下限阈值

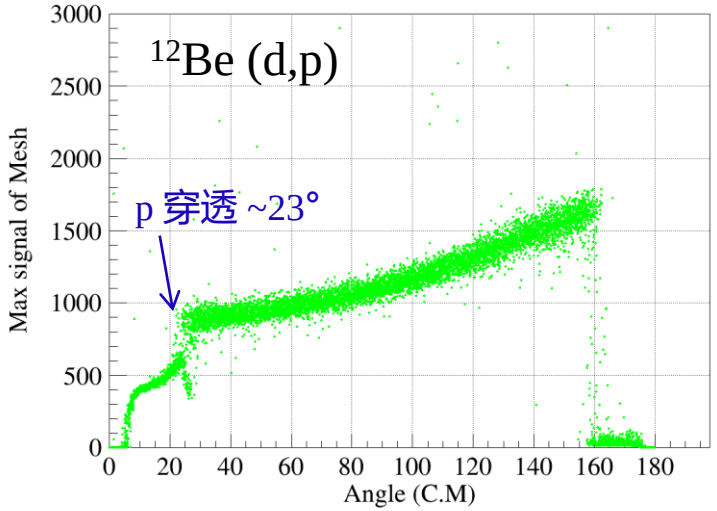


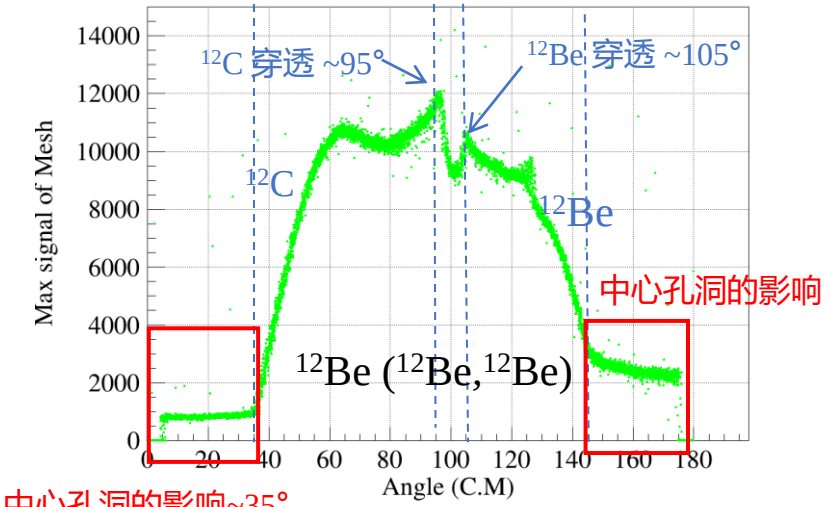






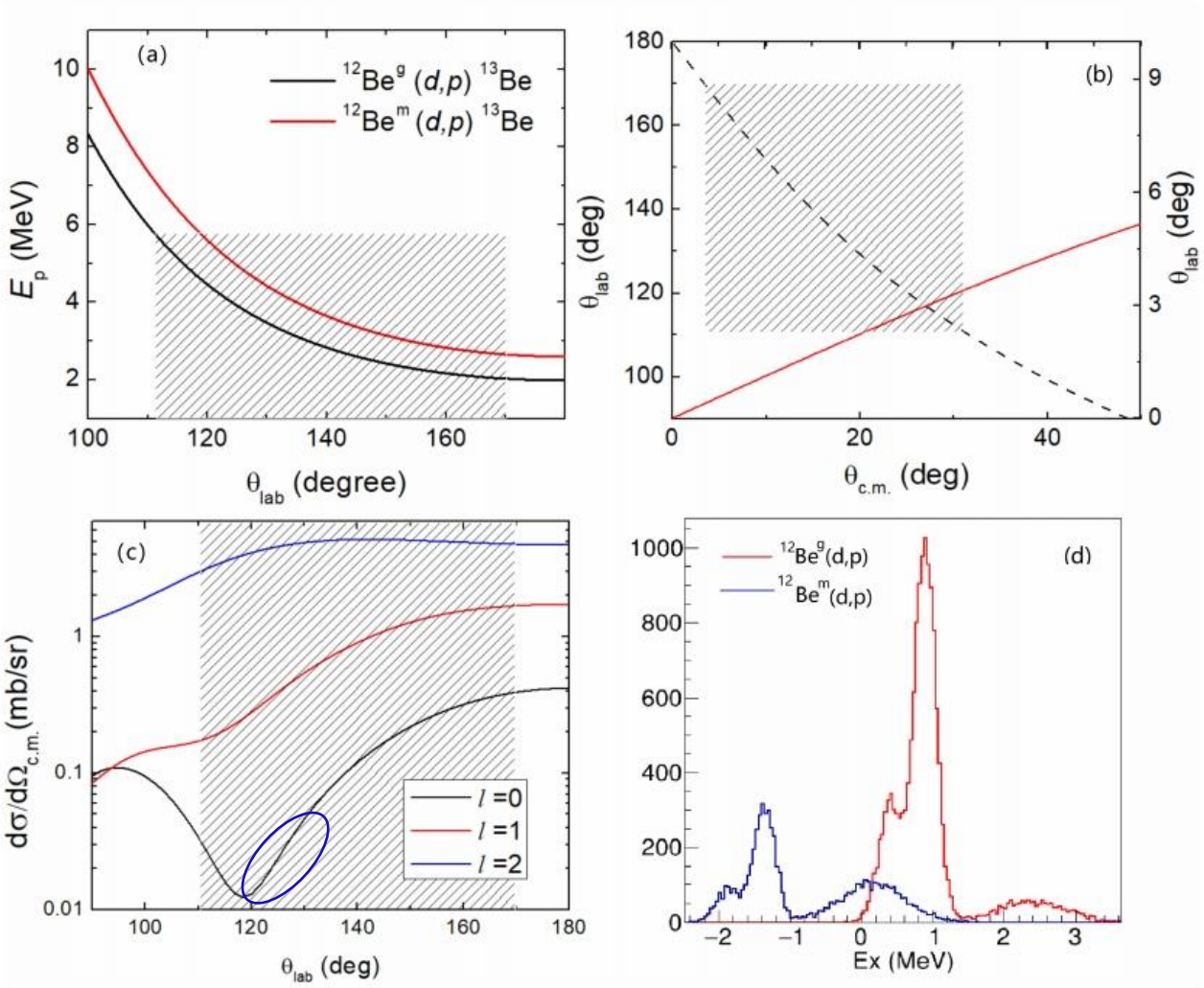
中心孔洞的影响~13°





中心孔洞的影响~35°

角覆盖



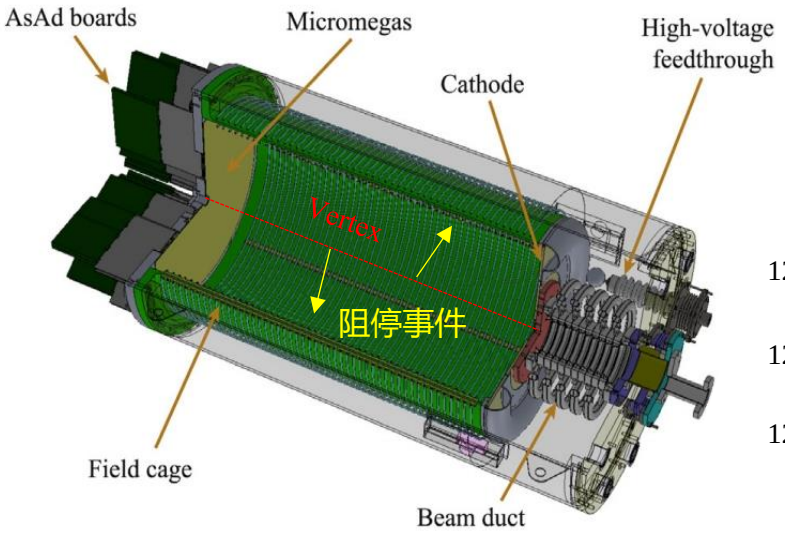
450 torr

Reaction	Min detection angle(C.M)	Max detection angle(C.M)	Max detection angle(Lab)	Max detection energy(MeV/u)	Angle of residual(lab)
d(^{12}Be,d)^{12}Be	11.8°	28.4°	75.6°	3.2	3.97°
d(^{12}Be,p)^{13}Be	~0°	22.5°	118.5°	5.0	2.17°
^{12}C(^{12}Be,^{12}Be)^{12}C	31.5°	95.8°	42.5°	9.6	42.62°

500 torr

Reaction	Min detection angle(C.M)	Max detection angle(C.M)	Max detection angle(Lab)	Max detection energy(MeV/u)	Angle of residual(lab)
d(^{12}Be,d)^{12}Be	12.2°	29.3°	75.1°	3.4	4.08°
d(^{12}Be,p)^{13}Be	~0°	23.6°	116.6°	5.3	2.26°
^{12}C(^{12}Be,^{12}Be)^{12}C	32.8°	97.3°	41.1°	10.2	41.3°

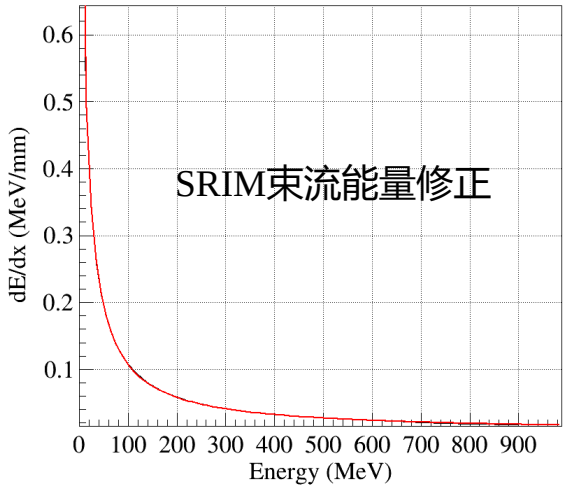
能量分辨率

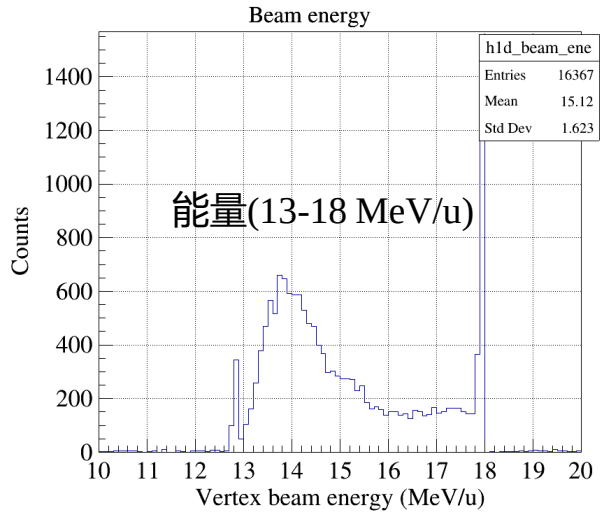


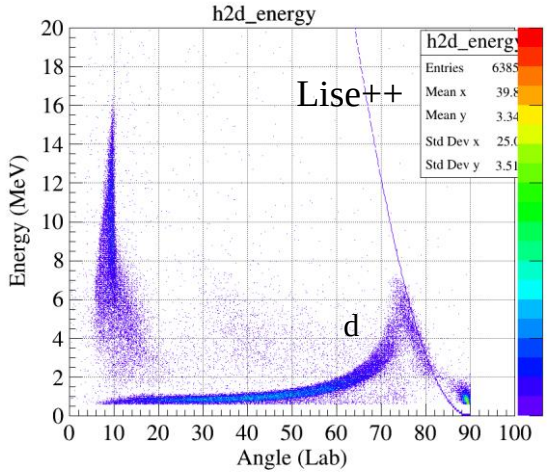
^{12}Be(d, p)

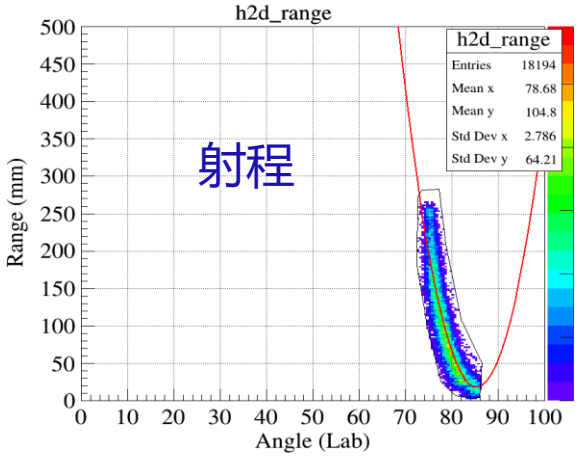
^{12}Be(d, d)

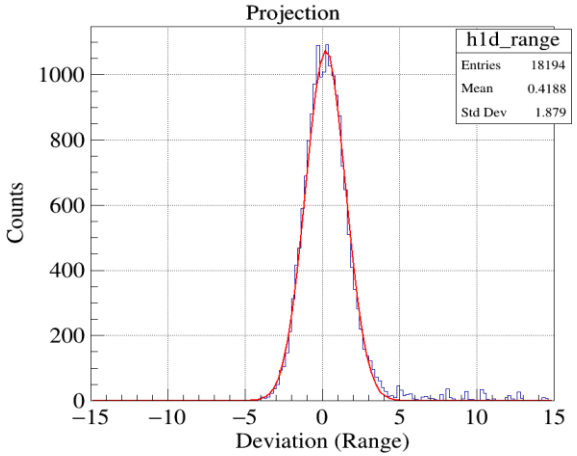
^{12}Be(α, α)











$$R = aE^b$$

$$Q = \frac{E}{W_e} \cdot \mathrm{G}$$

- 考虑反应中阻停事件
- 电荷、射程 ➡ 能量
- 能量分辨率约600 keV(σ)

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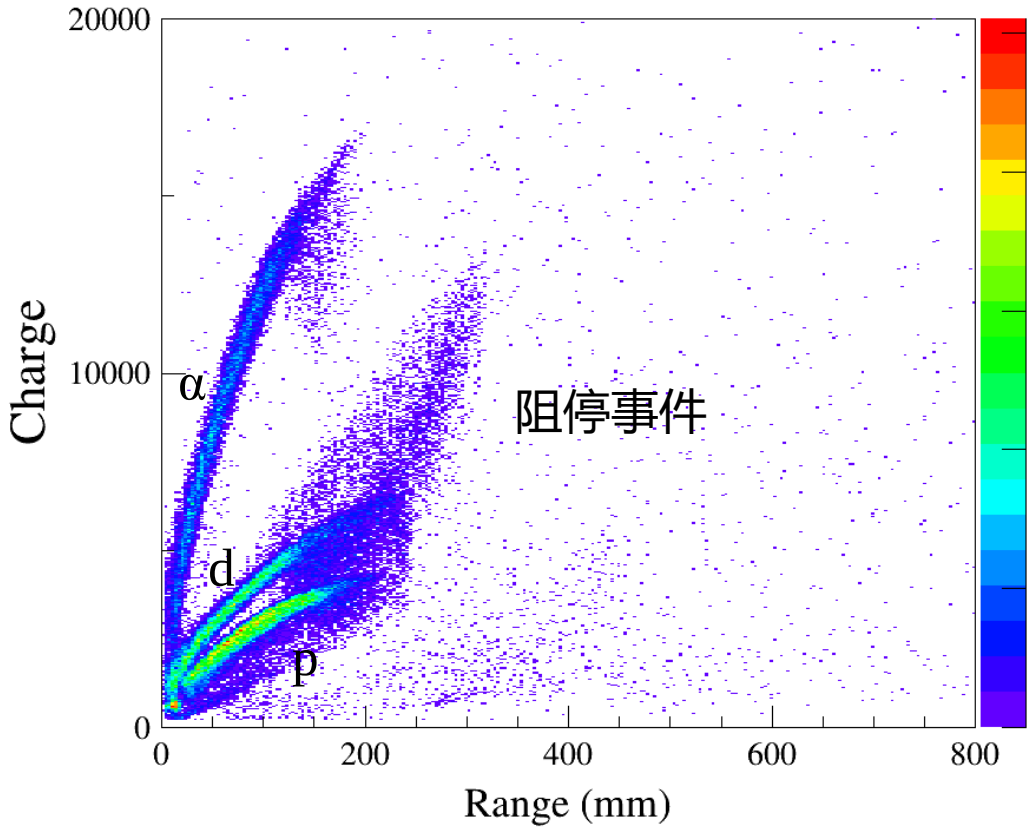
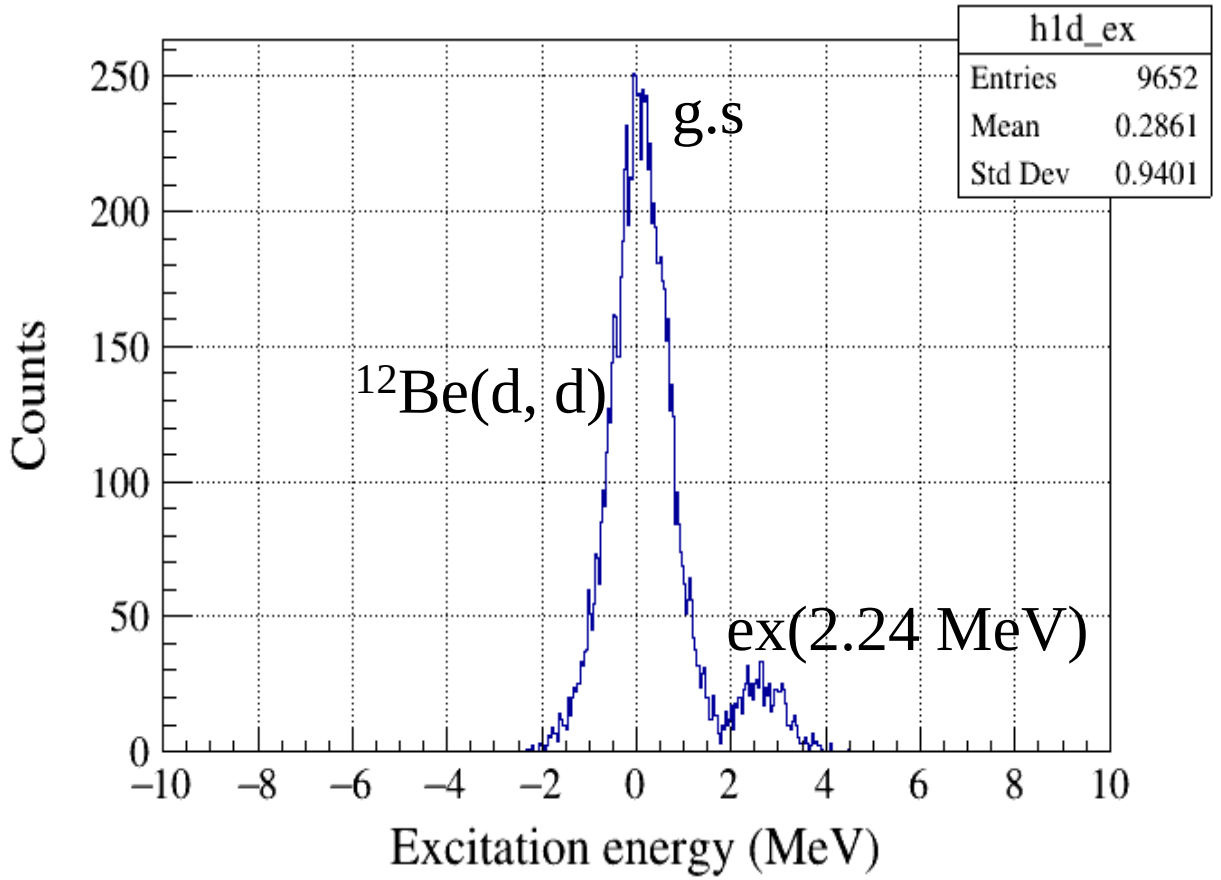
粒子鉴别和激发能

能够很好地区分d和p

激发能分辨率极限: 1.5 MeV





总结

- ^{12}Be (d, p)^{13}Be 将帮助厘清非束缚核^{13}Be的激发态信息
- 使用ATTPCROOT模拟了主要反应道的触发
- 模拟得到AT-TPC能量分辨率约为600 keV

下一步计划

- 更准确的射程-能量转换关系，优化PID
- 零度硅探测器的模拟
- 更真实的条件进行模拟
- …

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谢　谢