



带电粒子出射测量实验进展

LPDA实验合作组

Back-n第四次用户研讨会

2020-08-10 腾讯会议

提纲

- 带电粒子出射核反应

地位 意义 测量难点

- 第1条线索：几种核反应



- 第2条线索：3种主要探测器

LPDA阵列($\Delta E-\Delta E-E$) TPC SiC

气体室+硅+CsI

- 总结与展望

1. 带电粒子出射核反应

地位 意义 测量难点

中子核反应 以热堆为例



- (n,f) 裂变反应 释放裂变核能 产生中子
- (n, γ) 辐射俘获反应 核燃料循环 $^{238}\text{U} \rightarrow ^{239}\text{Pu}$, $^{232}\text{Th} \rightarrow ^{233}\text{U}$
- (n,n) (n,n') 弹性散射 非弹性散射 中子的慢化
- (n,lcp) 轻带电粒子出射核反应 ? 反应堆的控制 中子的测量 中子的防护

lcp = light-charged particle (p, d, t, ^3He , α ...)

- 张国辉, 中子诱发轻带电粒子出射核反应实验研究进展, 中国科学: 物理学 力学 天文学 50, 052005 (2020); doi: 10.1360/SSPMA-2019-0226

(n, lcp) 反应研究的意义

- 中子核反应标准截面的完善
- 中子能谱与注量率测量 探测器标定 模拟计算
- 核天体物理与核素的合成
- 核能与核工程、器件的损伤、生物医学、辐射防护...
- 核物理基础研究

(n, lcp) 实验测量难点



- 反应截面一般较小
- 需要足够强的中子源
- 需要足够薄的样品 (使带电粒子能够穿出)
- 需要高富集度同位素样品
- 需要甄别多种带电粒子
- 结构材料+本底反应 干扰严重
- 需要较长的测量时间

中子源 +

待测样品 +

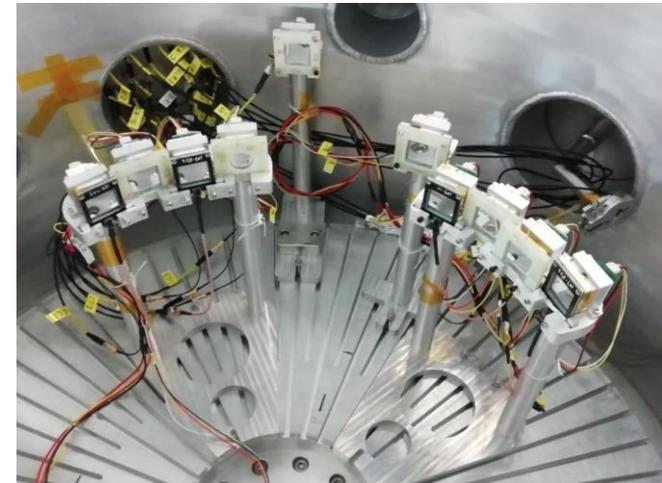
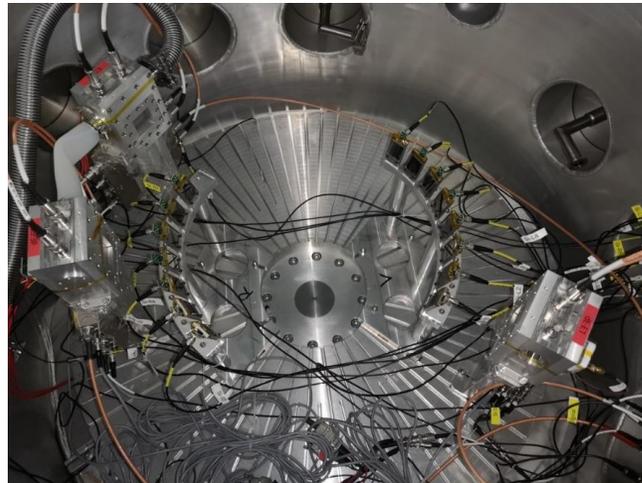
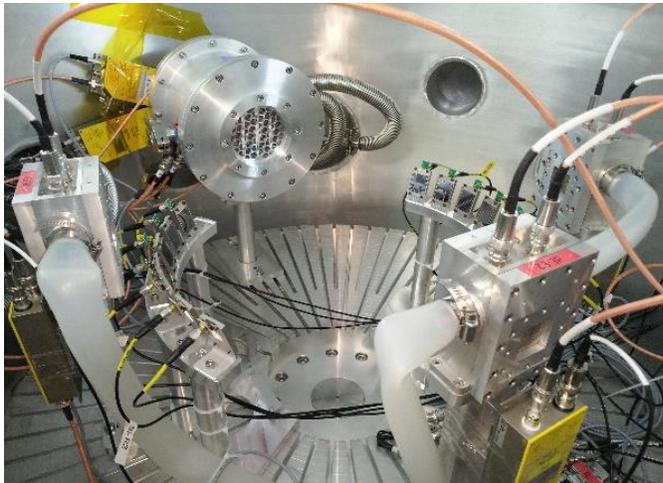
带电粒子探测器

2. 第1条线索： 几种核反应

- 已经完成的实验
- 获批准即将完成的实验
- 申请中待批准的实验

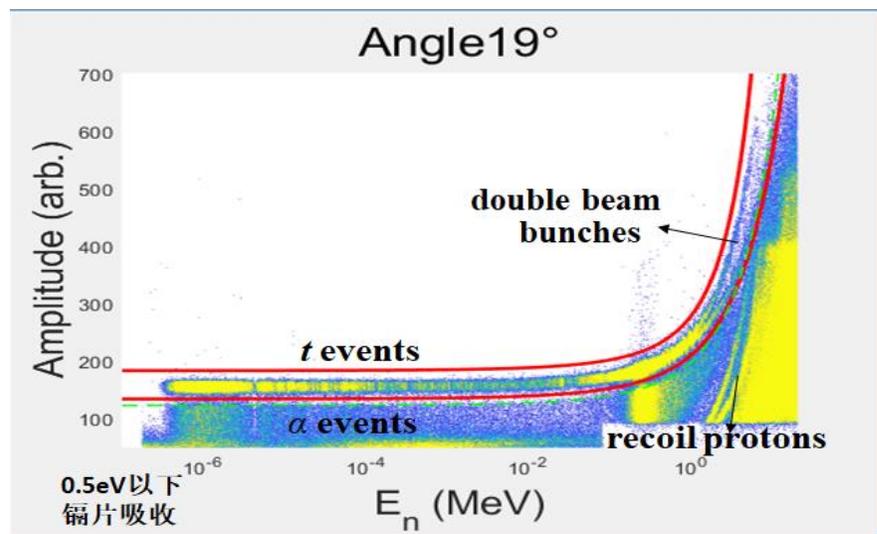
已经完成的实验

- ${}^6\text{Li}(n,t){}^4\text{He}$ ${}^{10}\text{B}(n,\alpha){}^7\text{Li}$ ${}^1\text{H}(n,p)n$ ${}^2\text{H}(n,d)n$
- 北大与高能所合作完成
- 打靶功率 20kW \rightarrow 50kW \rightarrow 80kW
- 探测器 LPDA-v.1(Si阵列 $\times 15$) LPDA-v.2 (Si+CsI $\times 10$)



${}^6\text{Li}(n,t){}^4\text{He}$

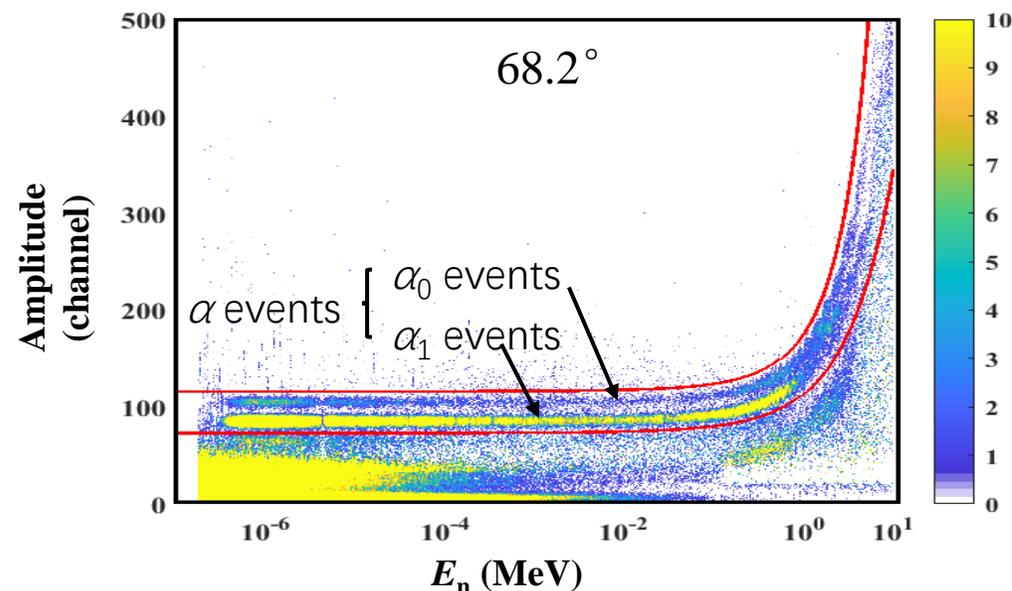
- 首批实验
- 较厚的样品--测t
- 实验测量 数据分析经验



- 向MeV能区拓展(?)
- [胡益伟报告] (明天 第3分会场)

${}^{10}\text{B}(n,\alpha){}^7\text{Li}$

- 薄样品--测α粒子
- 分开 α_0, α_1 两群



- α_0 群统计性 提高
- 向MeV能区扩展(?)
- [刘杰报告] (明天 第3分会场)

Measurement of the differential cross sections and angle-integrated cross sections of the ${}^6\text{Li}(n, t){}^4\text{He}$ reaction from 1.0 eV to 3.0 MeV at the CSNS Back-n white neutron source*

Measurements of differential and angle-integrated cross sections for the ${}^{10}\text{B}(n, \alpha){}^7\text{Li}$ reaction in the neutron energy range from 1.0 eV to 2.5 MeV*

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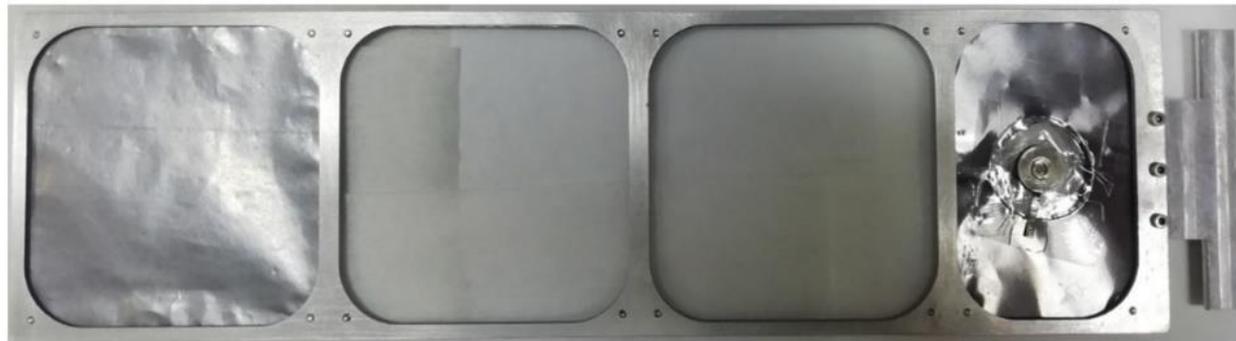
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¹¹School of Physics, Beihang University, Beijing 100083, China

n-p散射 $^1\text{H}(n,p)n$

- LPDA-v.2
- Si + CsI ($\Delta E-E$)
- 50kW 小束斑

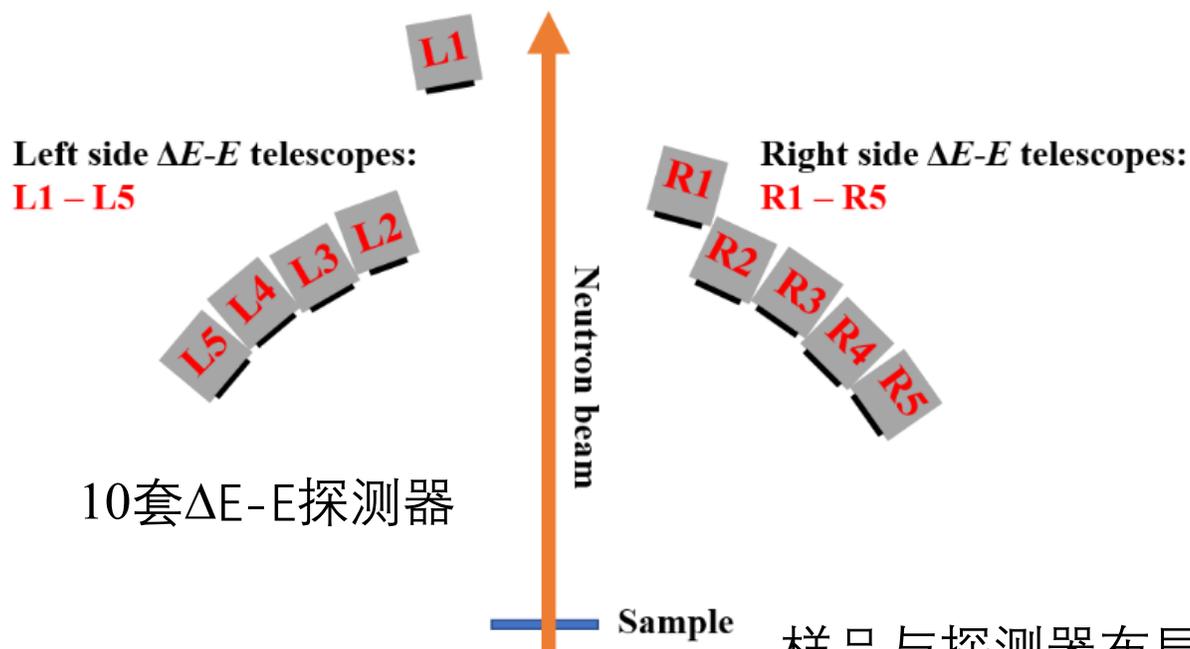


(a)
碳膜

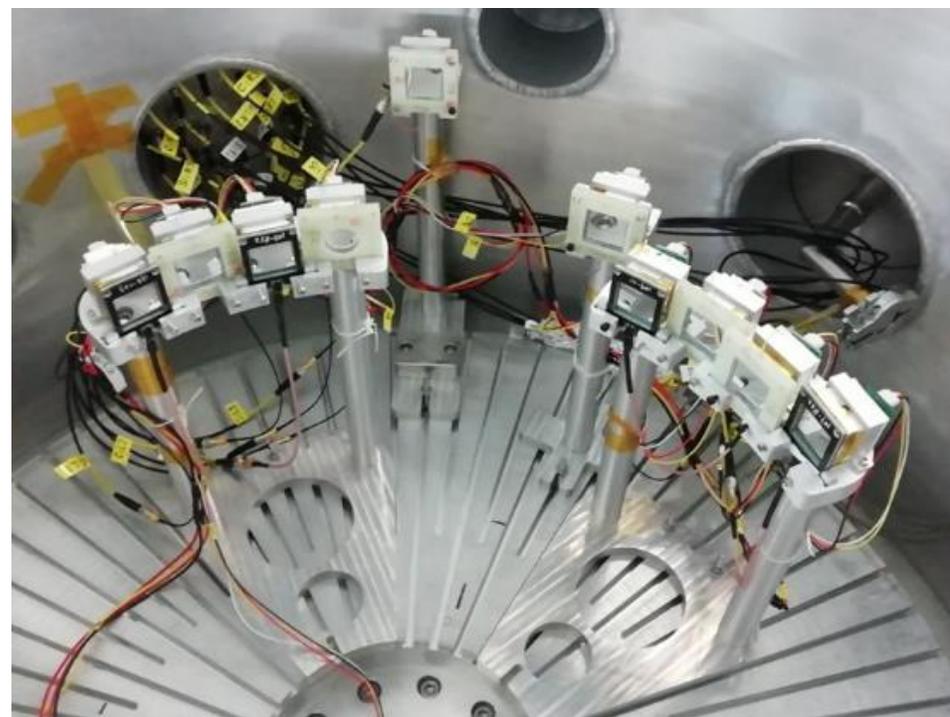
(b)
空靶

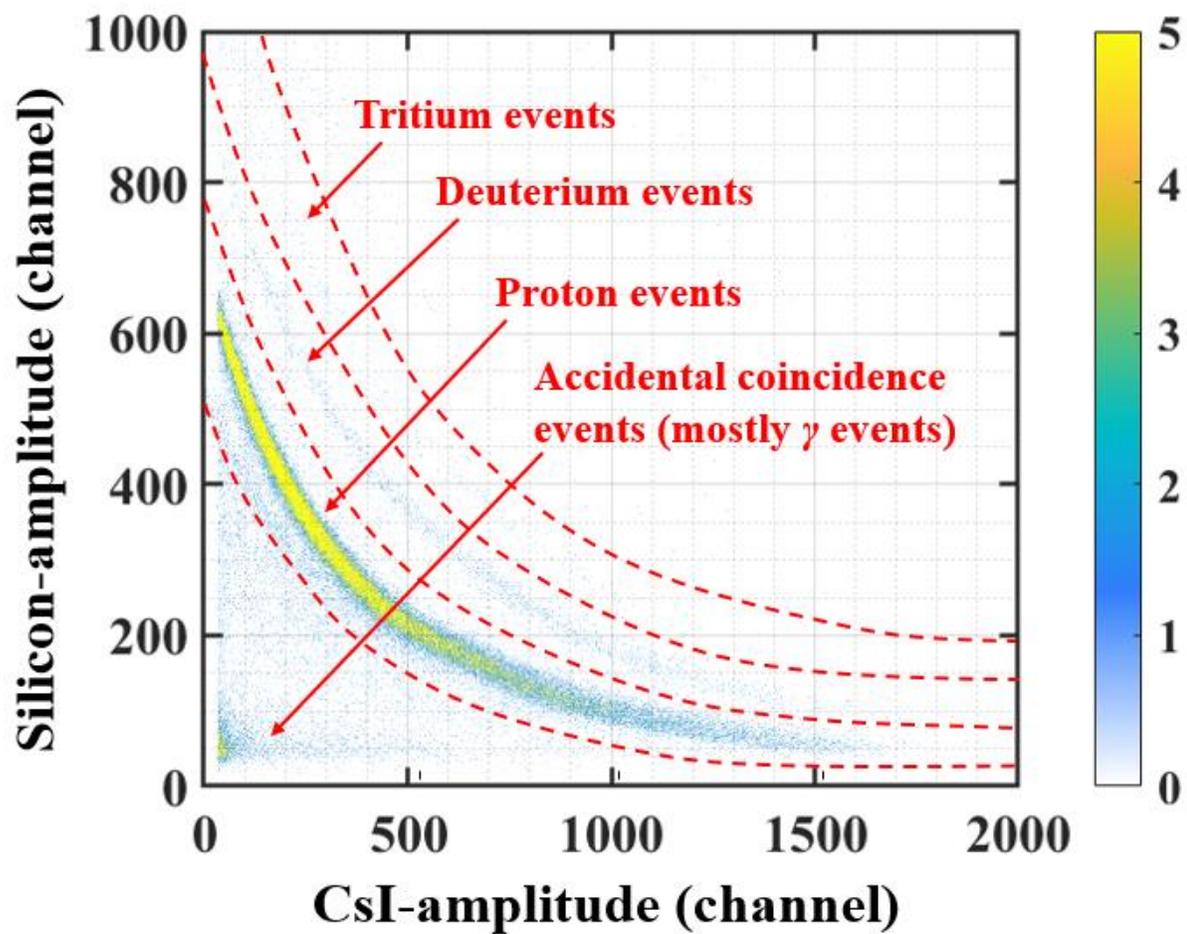
(c)
聚乙烯(CH_2)

(d)
 α 源

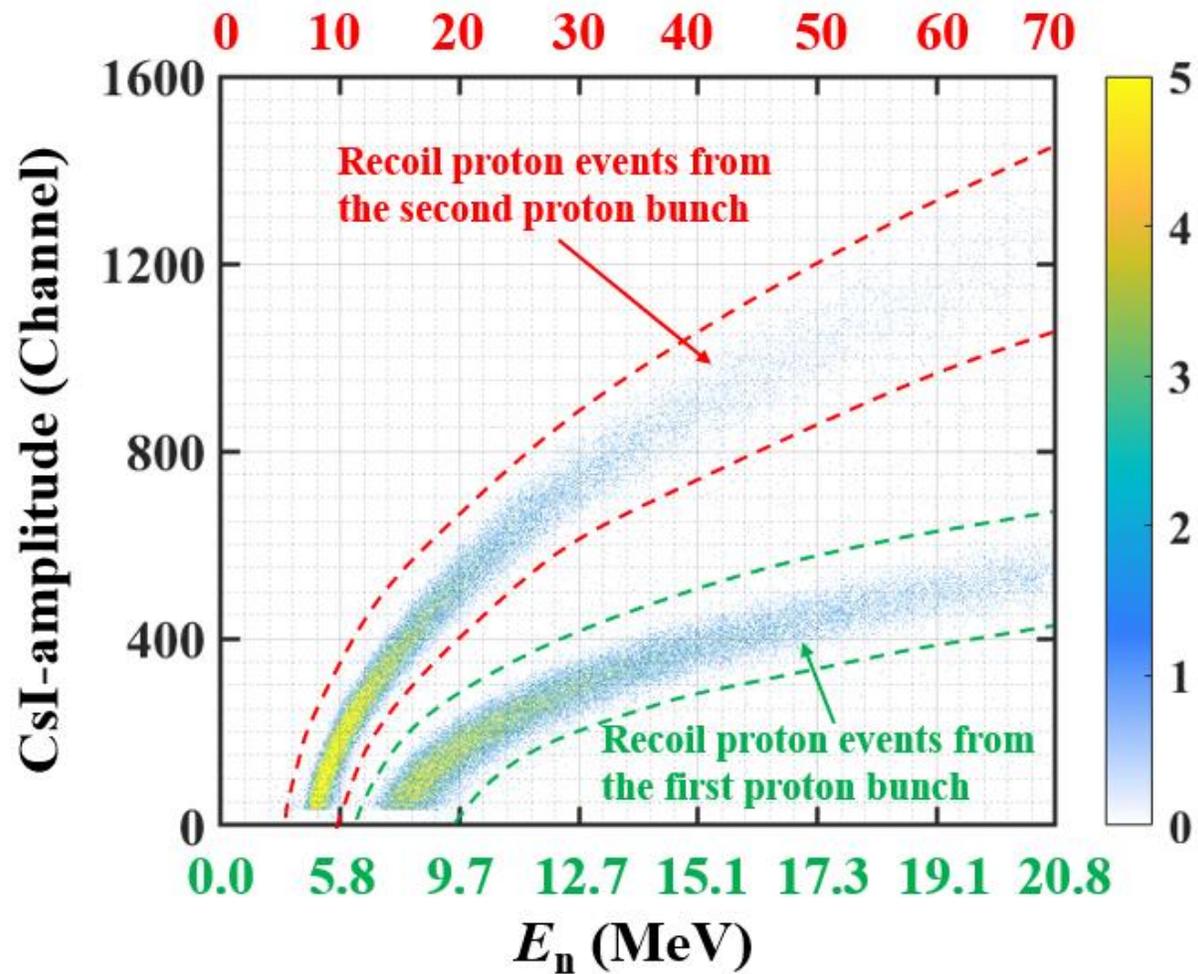


样品与探测器布局

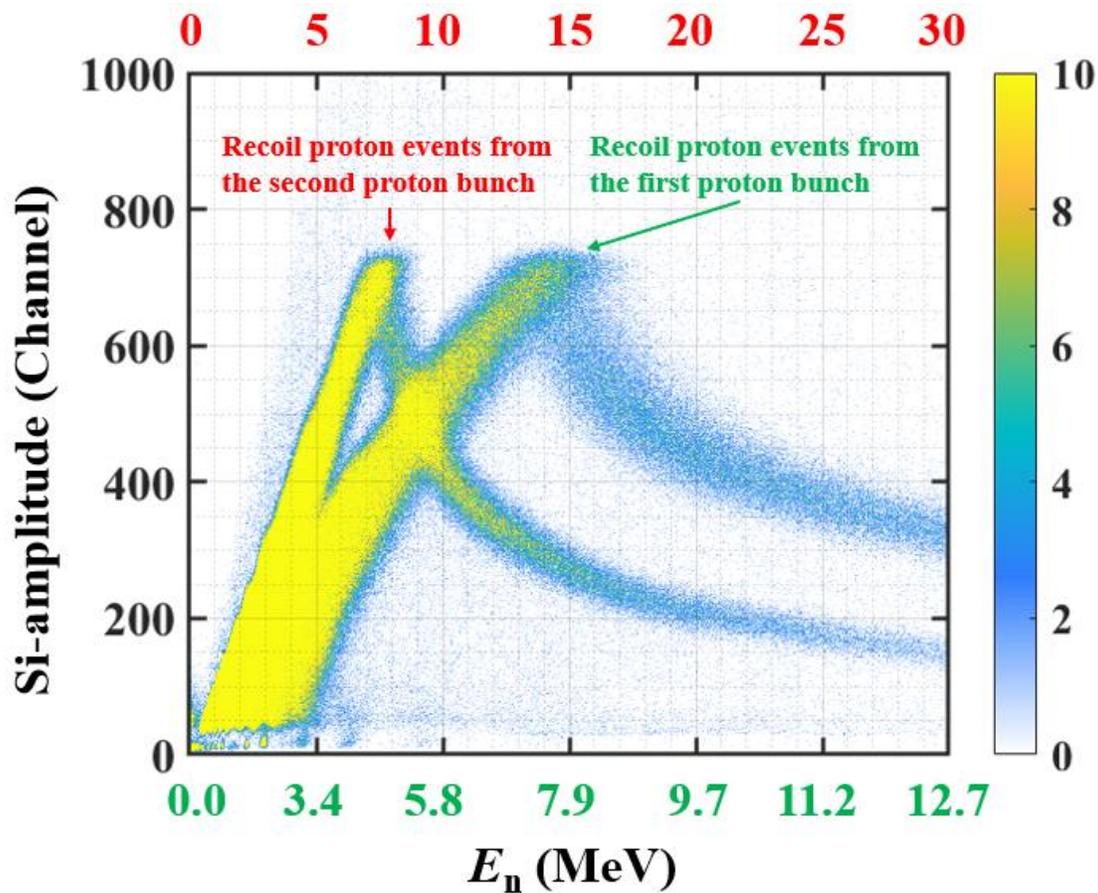




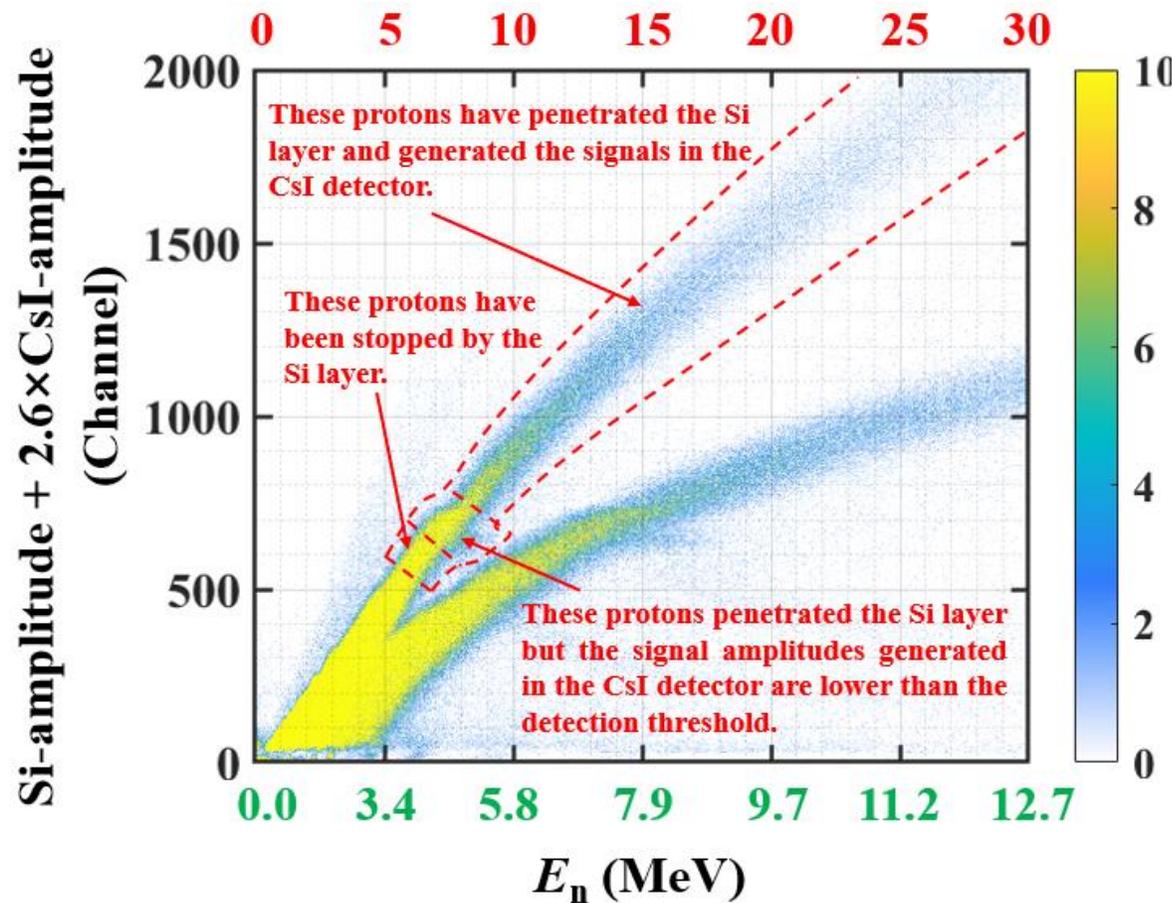
粒子分辨效果



CsI探测到的双束团事件

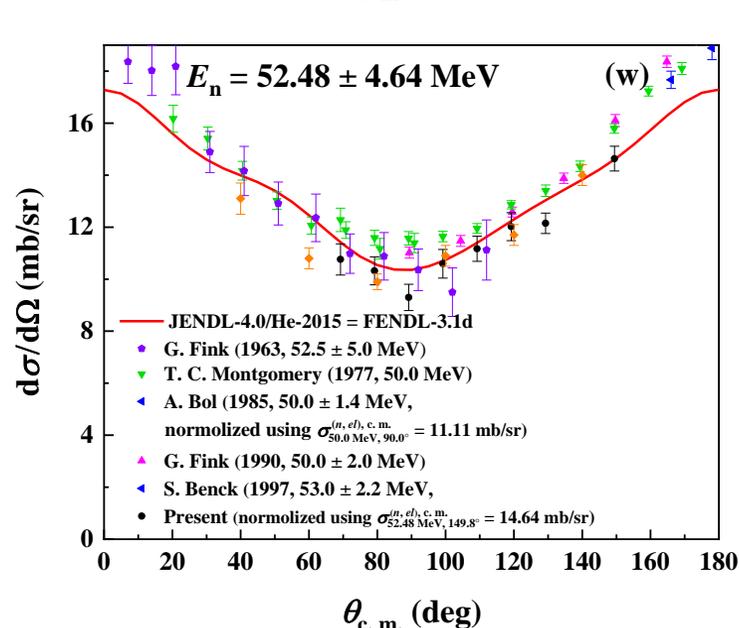
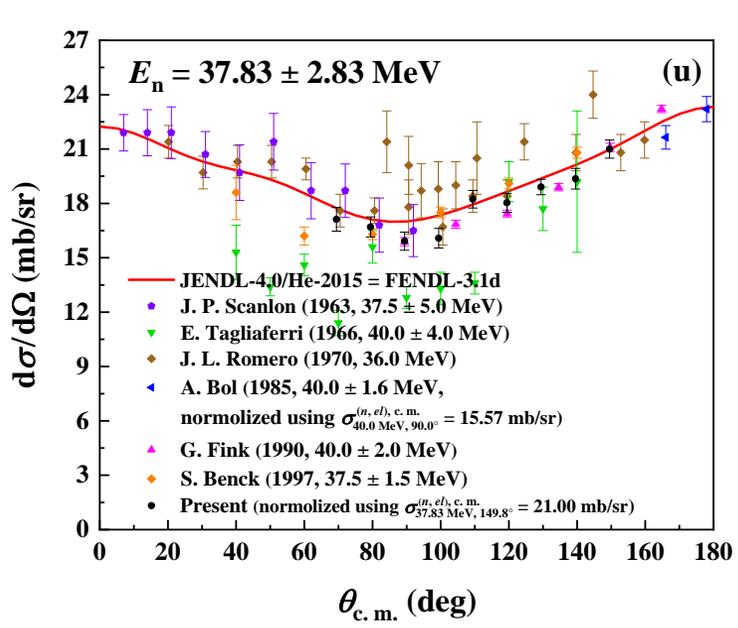
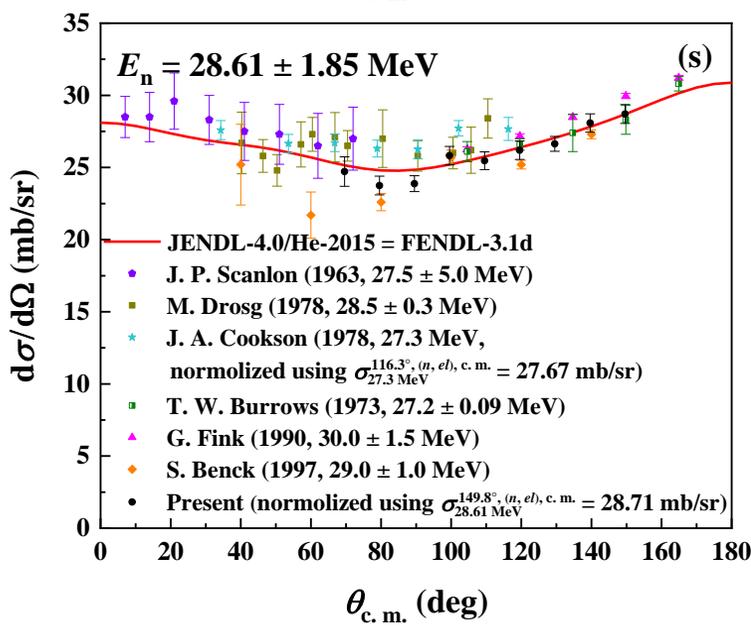
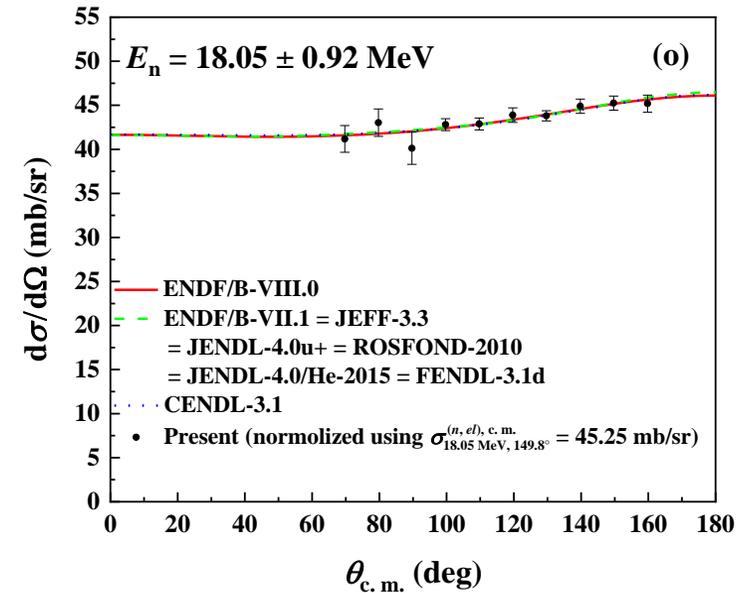
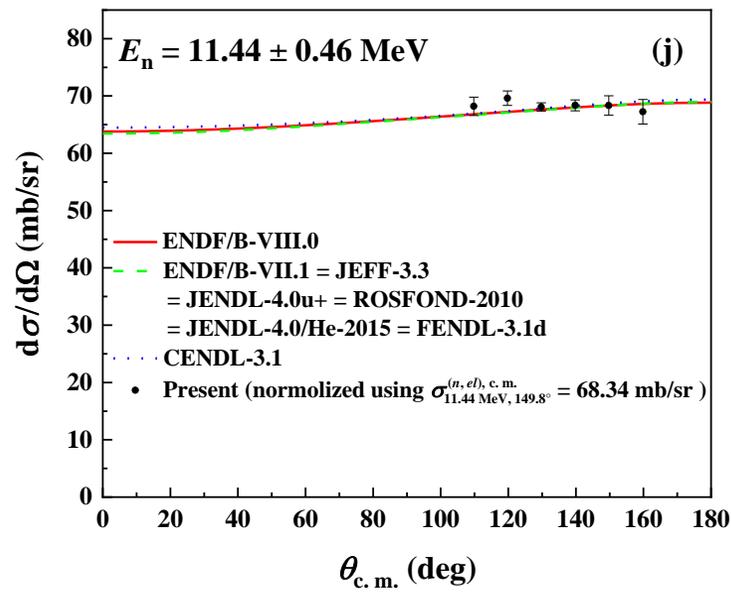
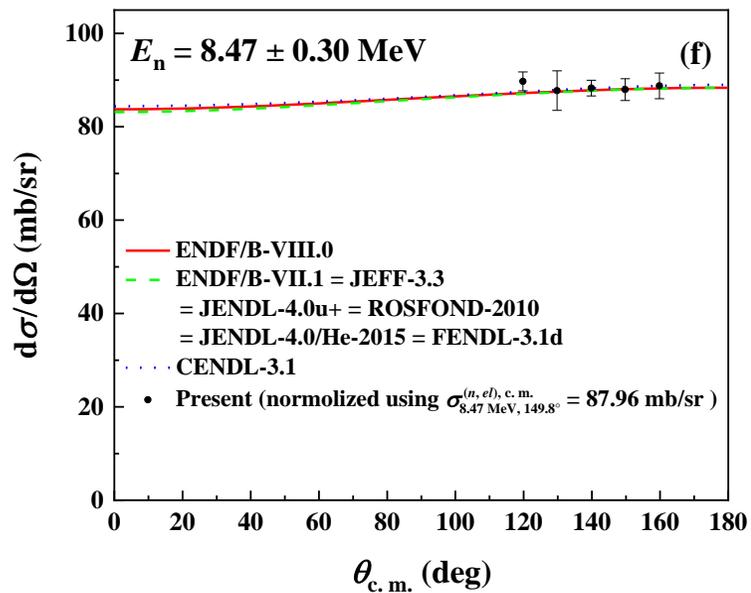


Si探测到的双束团事件



Si与CsI中的双束团事件“叠加”

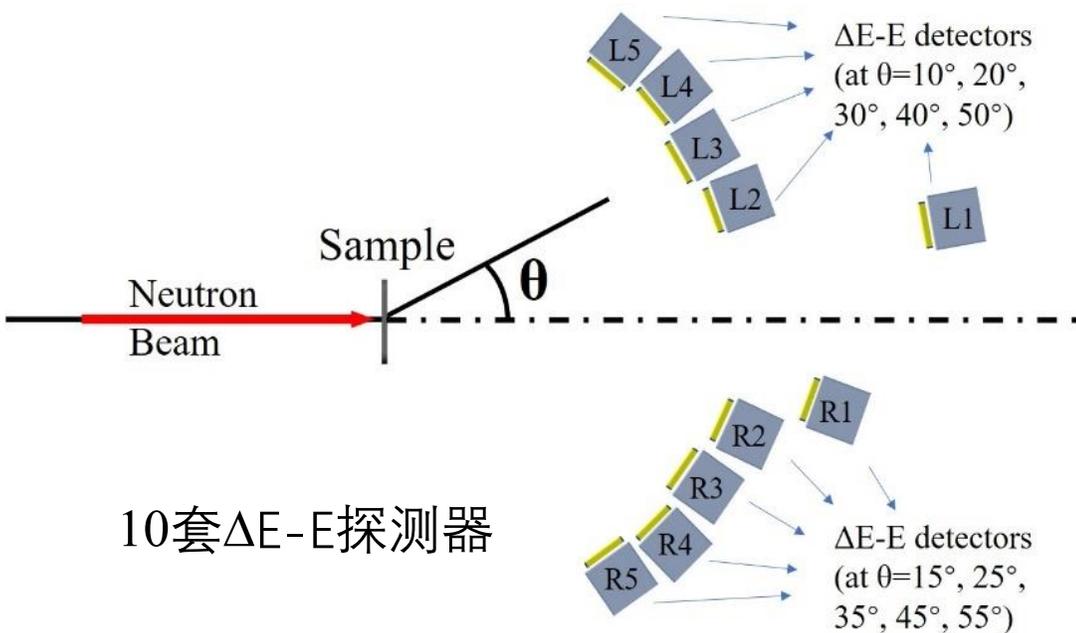
- Haoyu Jiang, Wei Jiang, Zengqi Cui, et al., **Measurement of the relative differential cross sections of the $^1\text{H}(n, el)$ reaction in the neutron energy range from 6 MeV to 52 MeV.** 稿件已投 EPJA.
- 详见 [江浩雨报告] 明天 第3分会场 (第2个报告)



$^1\text{H}(n, el)$ 质心系相对微分截面部分实验结果 6/23

n-d散射 ${}^2\text{H}(n,d)n$

- LPDA-v.2 Si + CsI (ΔE -E)
- 80kW 小束斑



CH_2

C本底片

CD_2

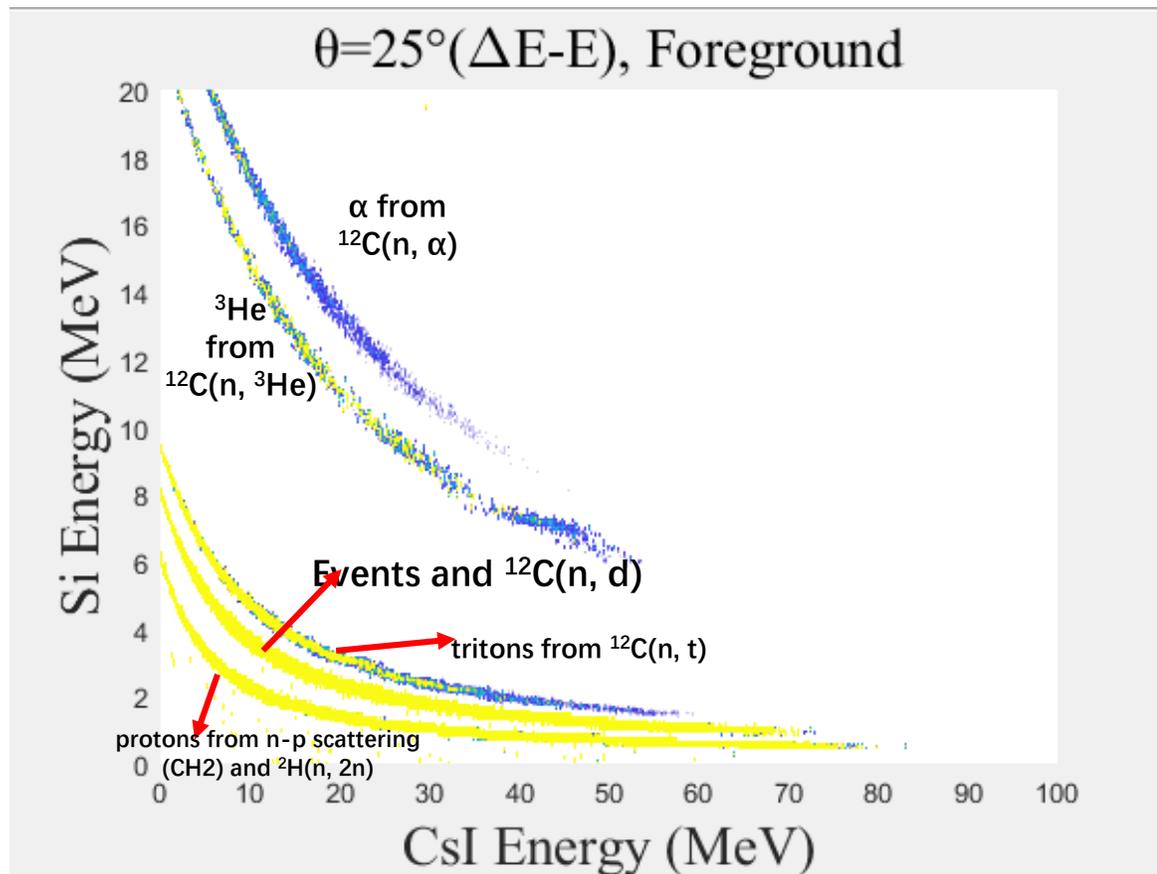
α 源



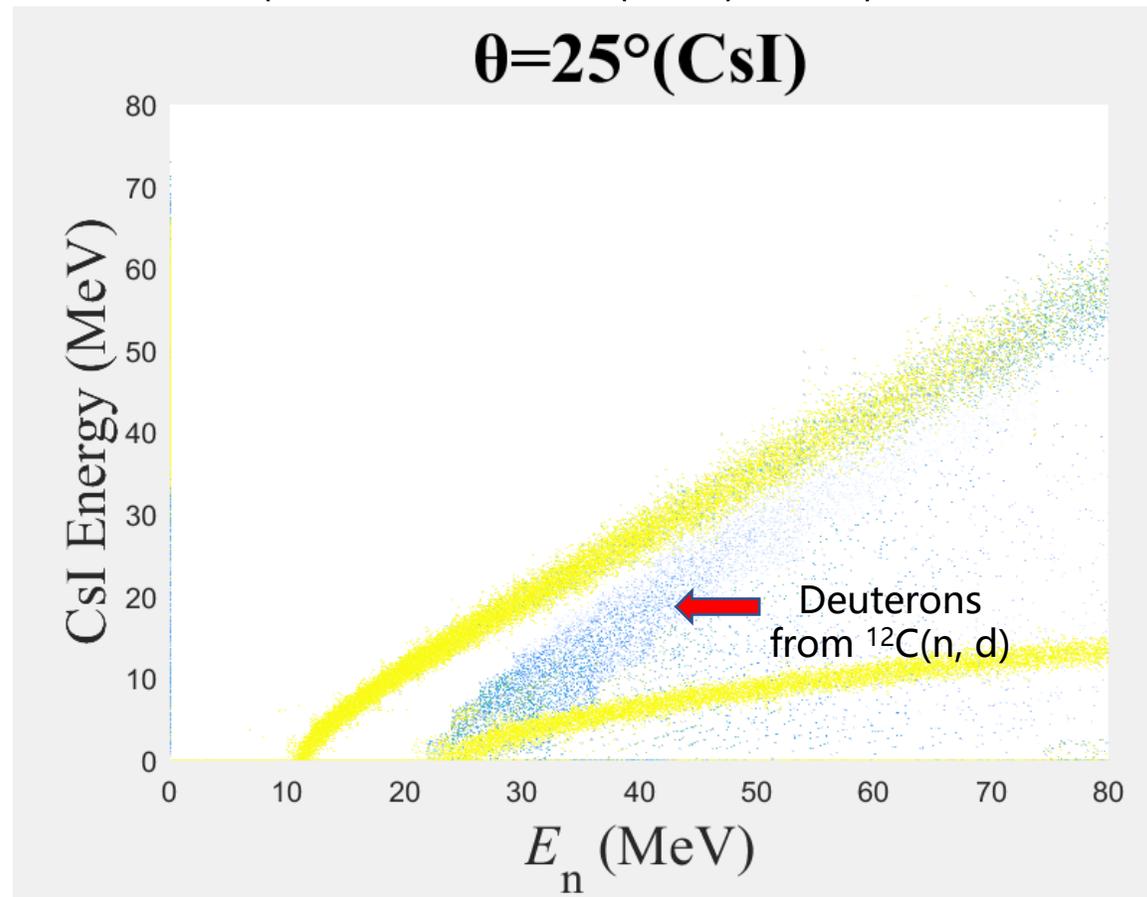
样品与探测器布局

模拟谱

ΔE -E二维谱

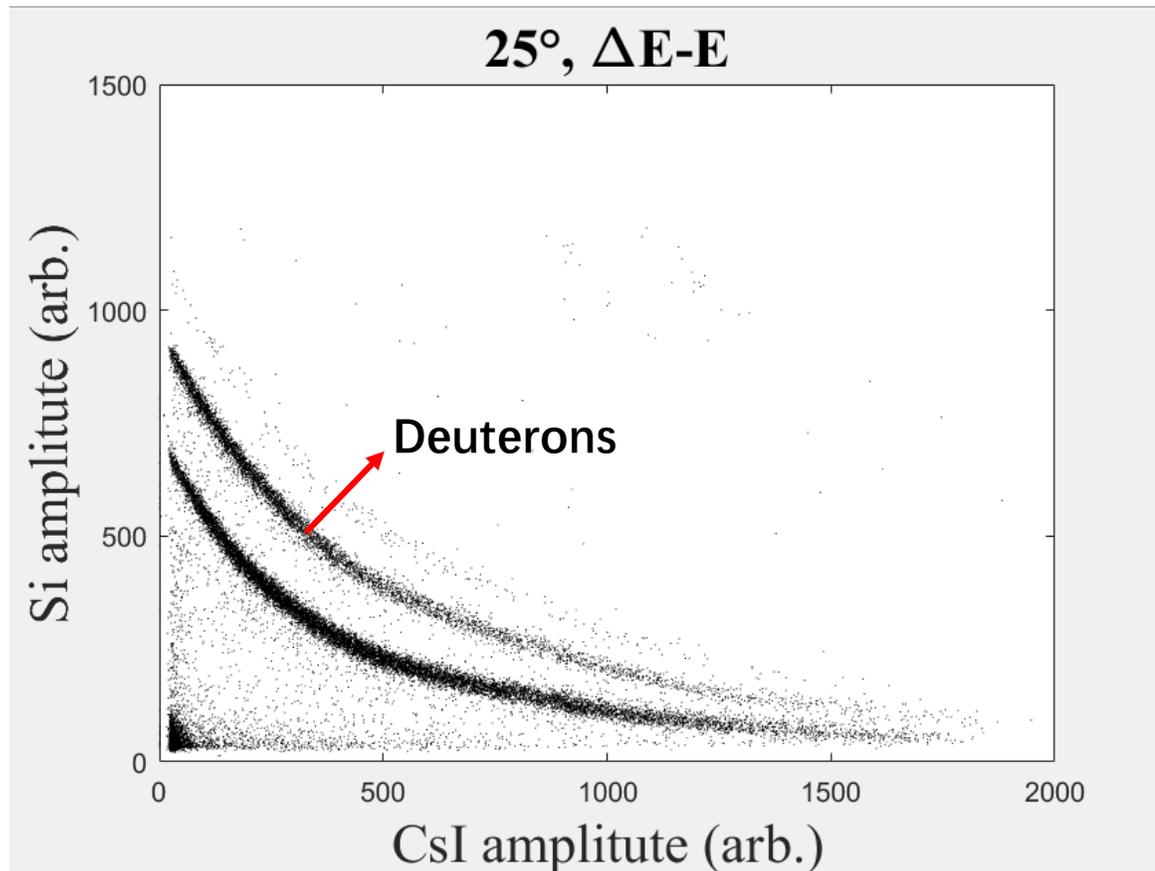


d离子二维谱
(n-d散射+ $^{12}\text{C}(n, d)$ 反应)

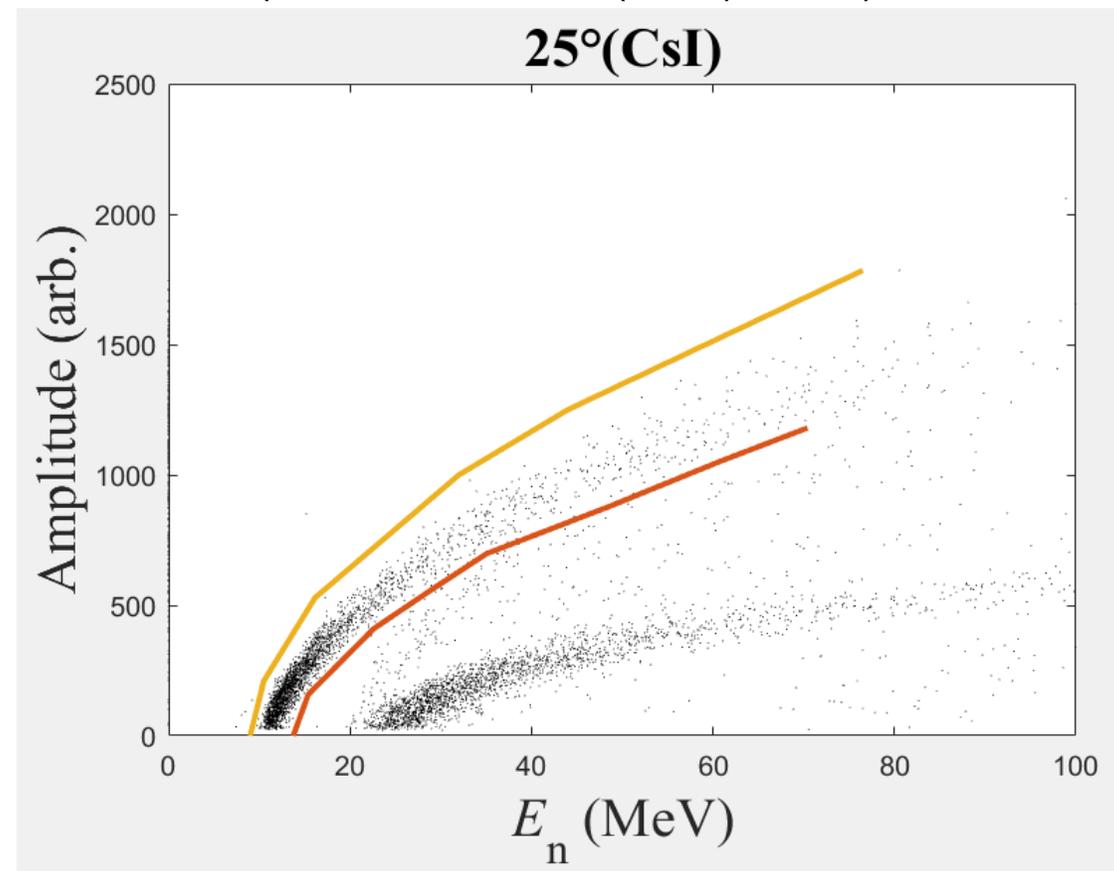


实验谱

ΔE -E 二维谱



d离子二维谱
(n-d散射 + $^{12}\text{C}(n, d)$ 反应)



- 数据分析和稿件撰写正在进行中
- 实验初步结果见 [崔增琪报告] 明天 第3分会场 (第3个报告)

另外2个已经完成的实验:

- $^{63}\text{Ni}(n,\alpha)^{60}\text{Fe}$ $^{17}\text{O}(n,\alpha)^{14}\text{C}$

原子能院: 李志宏 李云居

核天体物理

采用SiC探测器测量

详见 [李云居报告] 明天 第3分会场 (第4个报告)

部分完成 仍在进行的实验:

- $^{12}\text{C}(n,p)^{12}\text{B}$ 实验方法研究 [青年基金]

高能所: 易晗

采用TPC进行试测

详见 [易晗的报告] 明天 第3分会场 (第1个报告)

已获批准 下半年即将完成的2个实验



- $^{33}\text{S}(n,\alpha)^{30}\text{Si}$ ($E_n = 1\text{eV}—300\text{keV}$)

原子能院：贺国珠

可能的癌症治疗核反应 恒星内 ^{36}S 丰度偏高的解释

采用PPAC探测器 n_TOF采用Micromegas探测器得到了10-300keV的截面

- $^1\text{H}(n,p)n$ (低能区, $E_n = 1.5—15\text{MeV}$)

高能所：蒋伟 [与北大合作]

$E_n = 2, 5, 8, 10\text{MeV}$ 出射质子各向异性变化

采用 $\Delta E-E$ 探测器(气体室+硅)---**LPDA-v.3**

已经开展探测器测试(气体室+硅+CsI_{2×8})--**LPDA**

正在申请中待批准的实验

- $^{12}\text{C}(n,\alpha)^9\text{Be}$ $^{12}\text{C}(n,3\alpha)n$ ($E_n = 10\text{—}50\text{MeV}$)

“基于LPDA的 ^{13}C 集团结构实验测量” [青年基金]

中科院上海高等研究院：刘龙祥

基于LPDA阵列进行测量

测量 α 粒子能量 角度双微分截面

具体情况 [请见“束流申请报告”]

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3. 第2条线索： 3种带电粒子探测系统

LPDA 探测器阵列

时间投影室(TPC)

抗辐照半导体探测器(SiC)

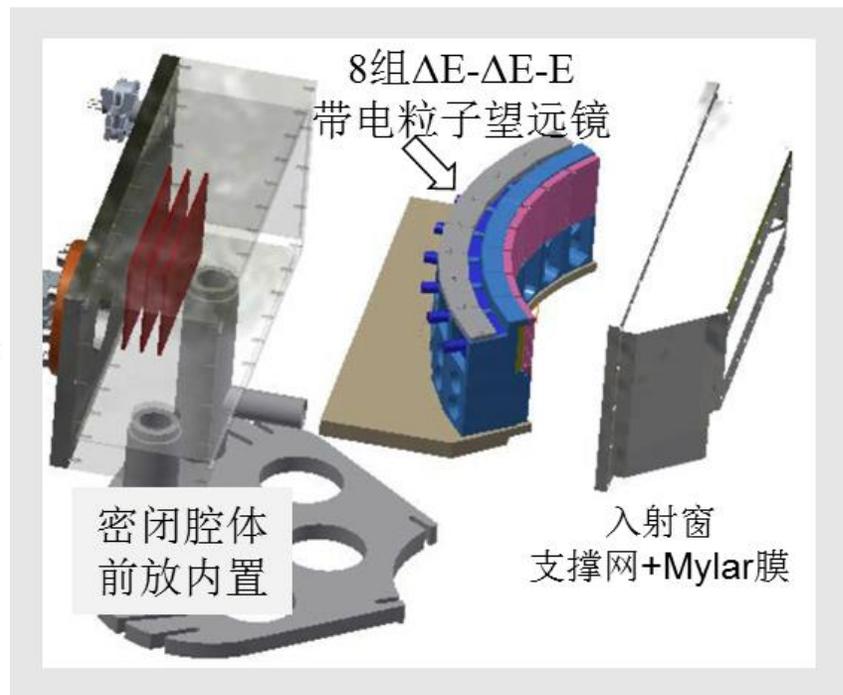
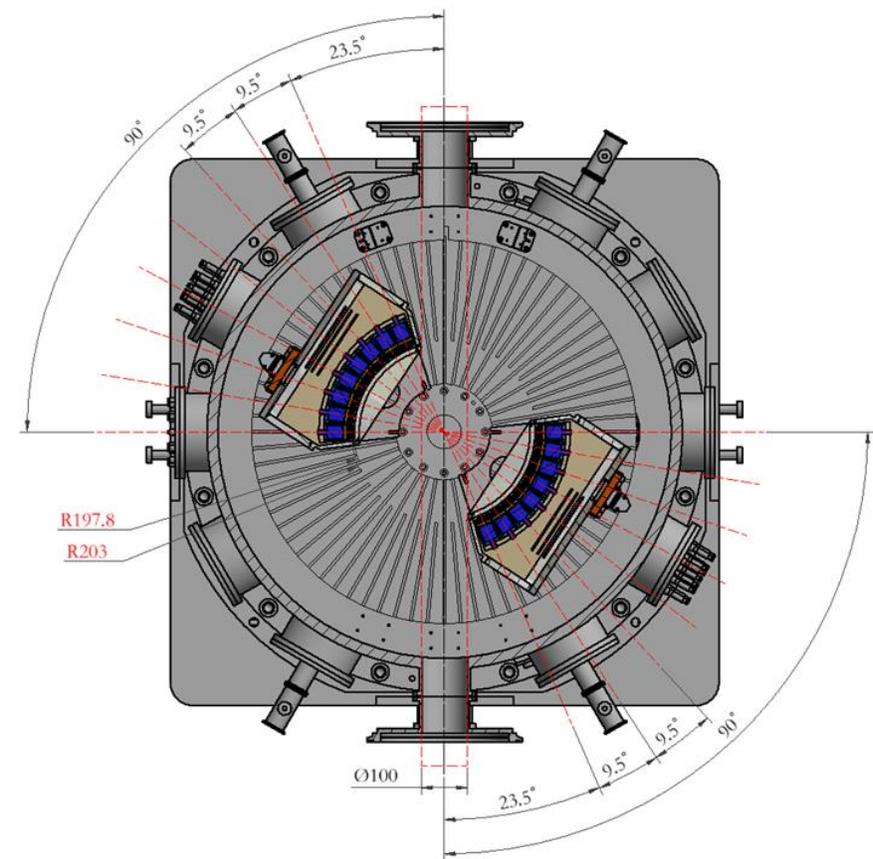
LPDA阵列(ΔE - ΔE -E望远镜)

- 与国际上同类探测器对比性能全面，功能强大

	LANSCE	MEDLEY	Crocker	CYCLONE	LPDA
探测器构架	气体室+硅+CsI	硅+硅+CsI	硅+NaI	塑闪+CsI	气体室+硅+CsI
探测器数量	4	8	3	6	16
带电粒子测量能区	4MeV-50MeV	8-100MeV	<80MeV	1.5MeV-80MeV	0.5-100MeV
中子测量能区	0.2-50MeV	70MeV	10-60MeV	25-65MeV	1eV-100MeV
时间分辨	3ns (300keV@10MeV)	2-4ns	200keV	0.8ns	<5ns

- 1) 薄窗气体探测器安装在真空靶室内
- 2) 有限体积安装探测器、电缆、气路
- 3) 48路信号, 目前Back-n最复杂的探测器系统

ΔE - ΔE -E望远镜



单个 ΔE - ΔE -E望远镜模块

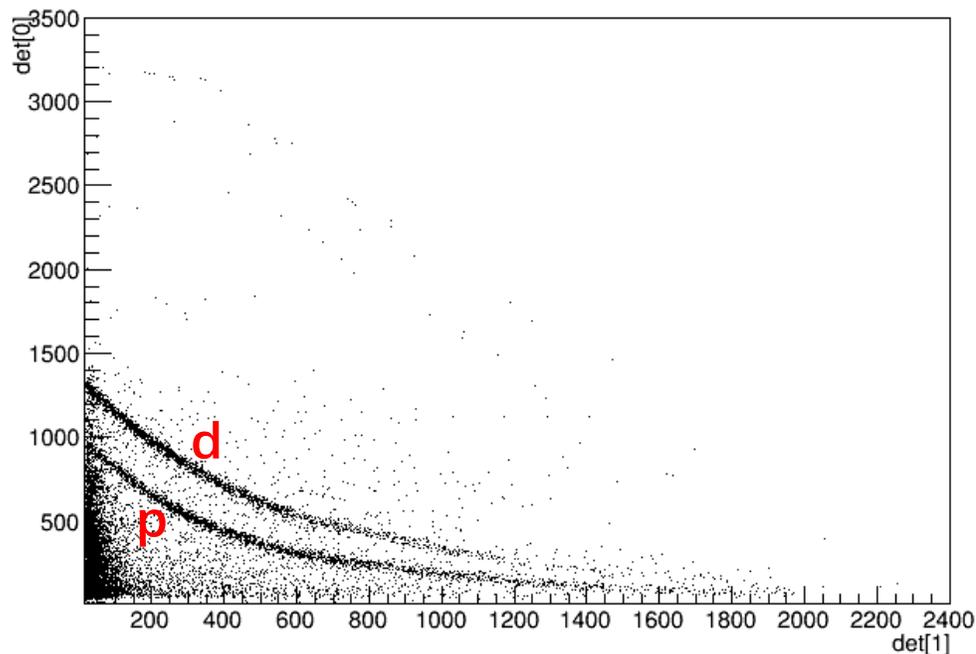
- 分为两个模块，每个模块在实验室系覆盖 66.5° 。设计值为 23.5° - 90°
- 束斑： $R=44\text{mm}$ 进入负9次方量级，按照 $R=50\text{mm}$ 设计
- 探测器高度：与靶中心等高
- 靶尺寸：最大 $\phi 60\text{mm}$

ΔE - ΔE -E望远镜在LPDA靶室中的示意图

ΔE - ΔE -E望远镜——测试

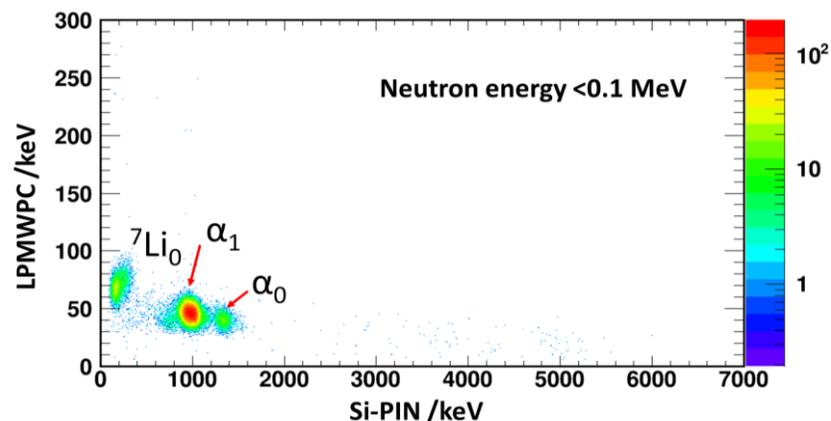


MWPC气体室+Si 得到的 ΔE -E谱

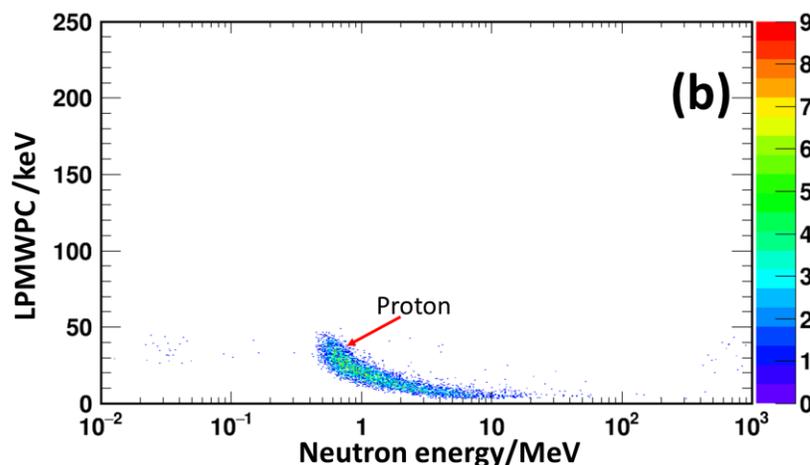


Si+CsI得到的 ΔE -E谱

横轴为CsI中信号幅度
纵轴为Si探测器中信号幅度



$^{10}\text{B}(n, \alpha)^7\text{Li}$ 实验
中子能量小于0.1MeV引发
反应得到的粒子鉴别谱
最低可以得到1 MeV ^7Li



n-p散射中得到的中子能量
和多丝室能量沉积二维谱可
以测量到0.5 MeV中子散射
的质子，其能量约470keV

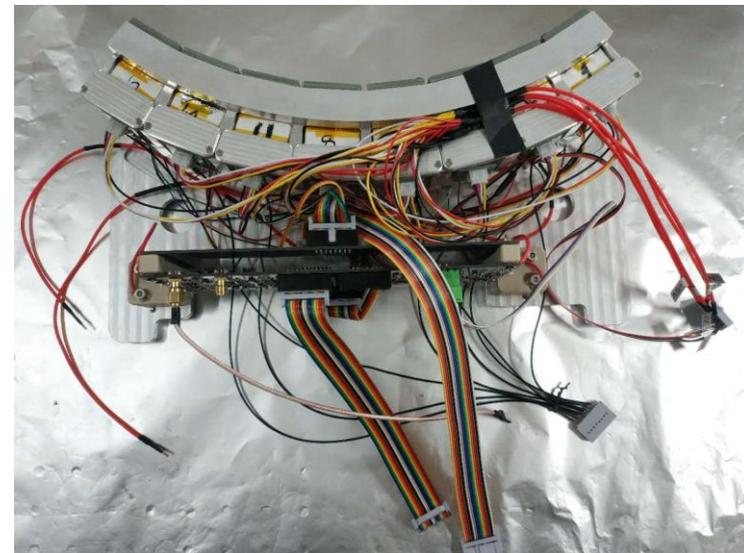
MWPC幅度-En双维谱

ΔE - ΔE -E望远镜—安装

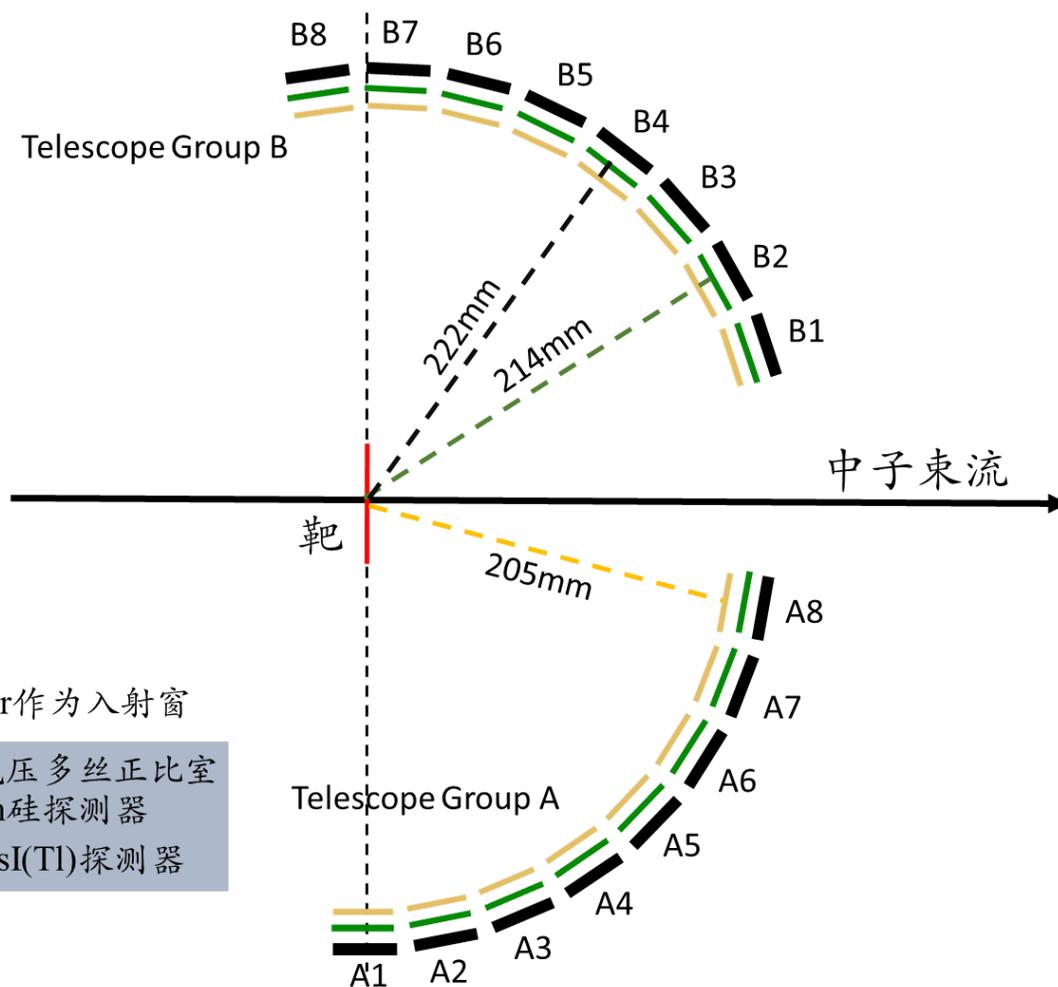


探测器组装图

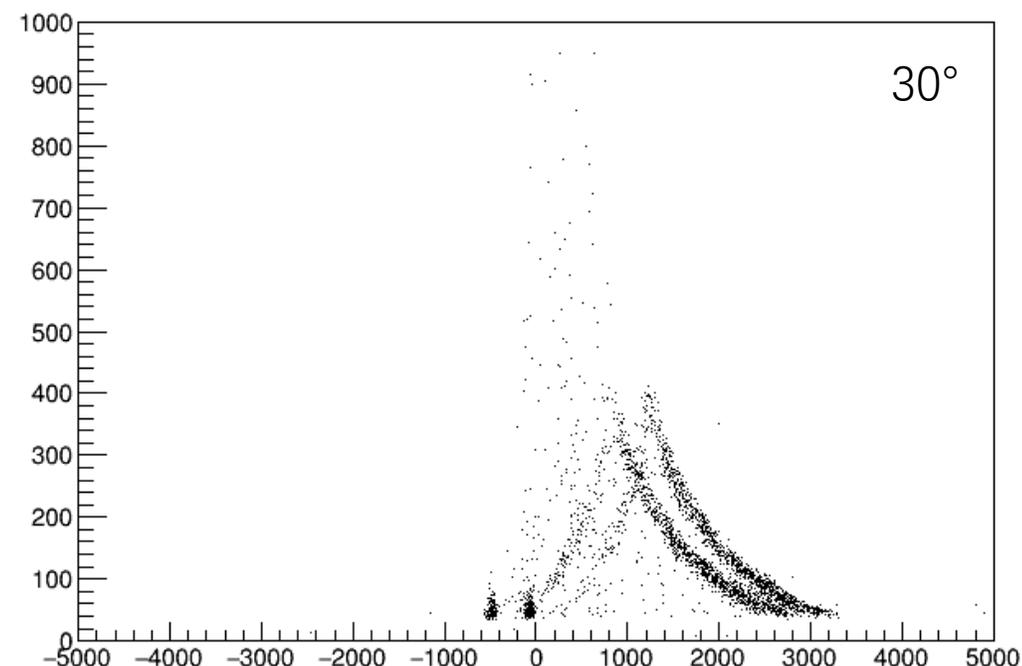
探测器及前放均放置于模块内，
探测器信号由模块后法兰引出



ΔE - ΔE -E望远镜——测试



2020年6月 利用 ΔE - ΔE -E望远镜测试实验
选用n-p散射、 ${}^6\text{Li}(n, t)$ 反应开展测试



详见 [蒋伟的报告] (明天 第3分会场)



Contents lists available at ScienceDirect

Nuclear Inst. and Methods in Physics Research, A

journal homepage: www.elsevier.com/locate/nima

Application of a silicon detector array in (n, lcp) reaction cross-section measurements at the CSNS Back-n white neutron source

Wei Jiang^{a,b}, Huaiyong Bai^c, Haoyu Jiang^c, Han Yi^{a,b}, Ruirui Fan^{a,b,d,*}, Guohui Zhang^c, Jingyu Tang^{a,b}, Zhijia Sun^{a,b,d}, Changjun Ning^{a,b}, Kang Sun^{a,b,e}, Keqing Gao^{a,b}, Zengqi Cui^c, Qi An^{d,f}, Jie Bao^g, Yu Bao^{a,b}, Ping Cao^{d,f}, Haolei Chen^{d,f}, Qiping Chen^h, Yonghao Chen^{a,b}, Yukai Chen^{a,b}, Zhen Chen^{d,f}, Changqing Feng^{d,f}, Minhao Gu^{a,d}, Fengqin Guo^{a,b}, Changcai Hanⁱ, Zijie Han^h, Guozhu He^g, Yongcheng He^{a,b}, Yang Hong^{a,b,e}, Hanxiong Huang^g, Weiling Huang^{a,b}, Xiru Huang^{d,f}, Xiaolu Ji^{a,d}, Xuyang Ji^{d,j}, Zhijie Jiang^{d,f}, Hantao Jing^{a,b}, Ling Kang^{a,b}, Mingtao Kang^{a,b}, Bo Li^{a,b}, Chao Li^{d,f}, Jiawen Li^{d,j}, Lun Li^{a,b}, Qiang Li^{a,b}, Xiao Li^{a,b}, Yang Li^{a,b}, Rong Liu^h, Shubin Liu^{d,f}, Xingyan Liu^h, Guangyuan Luan^g, Qili Mu^{a,b}, Binbin Qi^{d,f}, Jie Ren^g, Zhizhou Ren^h, Xichao Ruan^g, Yingpeng Song^{a,b}, Zhaohui Songⁱ, Hong Sun^{a,b}, Xiaoyang Sun^{a,b,e}, Zhixin Tan^{a,b}, Hongqing Tang^g, Xinyi Tang^{d,f}, Binbin Tian^{a,b}, Lijiao Wang^{a,b,e}, Pengcheng Wang^{a,b}, Qi Wang^g, Taofeng Wang^k, Yanfeng Wang^{a,b}, Zhaohui Wang^g, Jie Wen^h, Zhongwei Wen^h, Qingbiao Wu^{a,b}, Xiaoguang Wu^g, Xuan Wu^{a,b}, Likun Xie^{d,j}, Yiwei Yang^h, Li Yu^{a,b}, Tao Yu^{d,f}, Yongji Yu^{a,b}, Linhao Zhang^{a,b,e}, Qiwei Zhang^g, Xianpeng Zhangⁱ, Yuliang Zhang^{a,b}, Zhiyong Zhang^{d,f}, Yubin Zhao^{a,b}, Liang Zhou^{a,b}, Luping Zhou^{a,b,e}, Zuying Zhou^g, Danyang Zhu^{d,f}, Kejun Zhu^{a,d,e}, Peng Zhu^{a,b}

^a Institute of High Energy Physics, Chinese Academy of Sciences (CAS), Beijing 100049, China

^b Spallation Neutron Source Science Center, Dongguan 523803, China

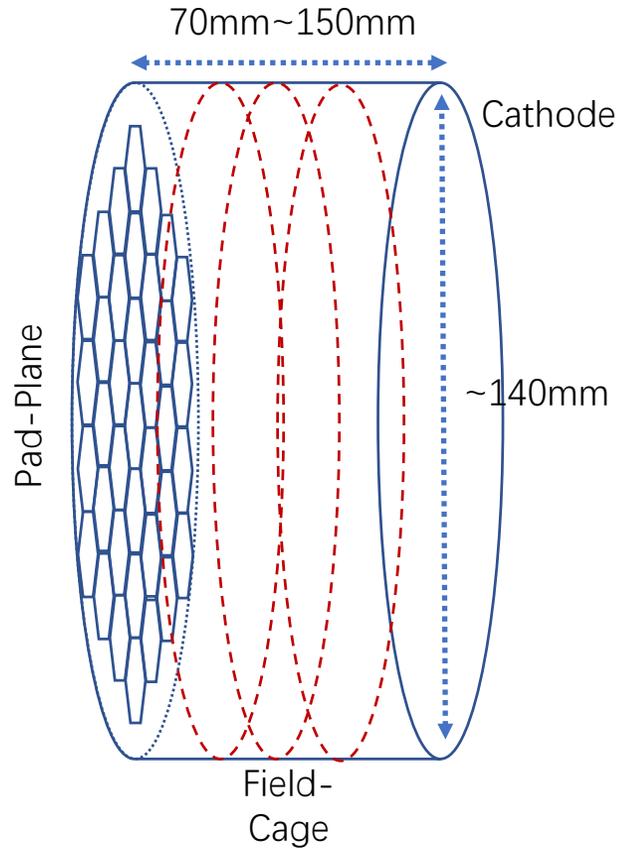
^c State Key Laboratory of Nuclear Physics and Technology, School of Physics, Peking University, Beijing 100871, China

^d State Key Laboratory of Particle Detection and Electronics, China

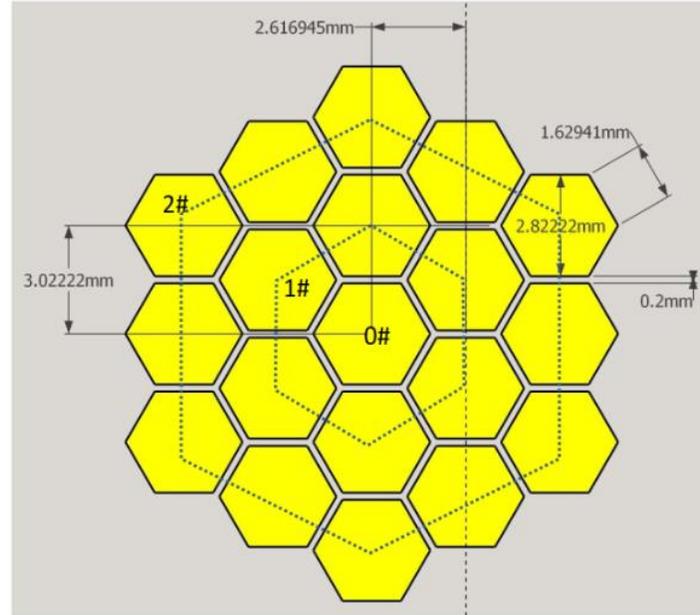


Ruirui Fan, Haoyu Jiang, Wei Jiang, et al., **Detection of low-energy charged-particle using the $\Delta E-E$ telescope at the Back-n white neutron source.** Accepted by NIMA.

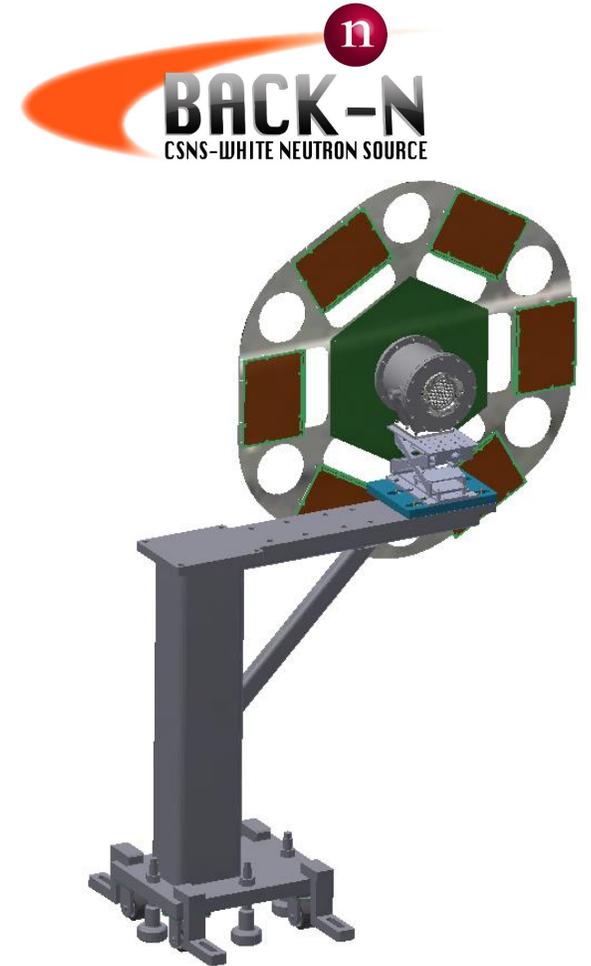
TPC探测器设计



- 探测器外壳设计为圆柱体，灵敏区直径160mm，长70mm
- 模拟中探测器材料为Al，厚度100 μ m；
- 工作气体：Ar+CO₂ (93:7)



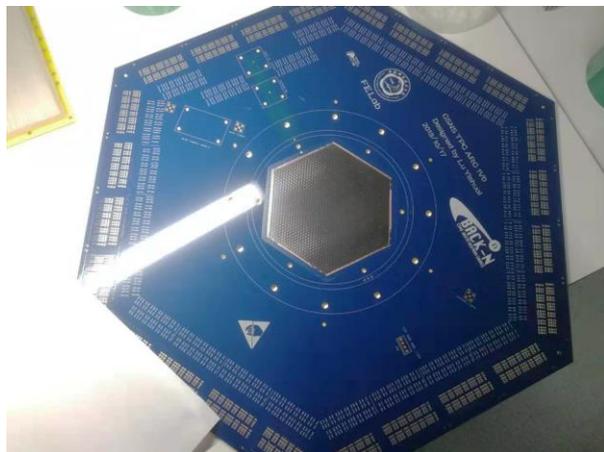
- 采用六边形密堆方式，构成1519个阳极pad，每个pad边长64mil(1.63mm)，阳极区为边长约为68.5mm的六边形



- 探测器气室外壳通过升降平台固定于支撑底座
- 六边形背板与探测器阳极读出板相连，用于固定6块前端电子学板

TPC探测器制作

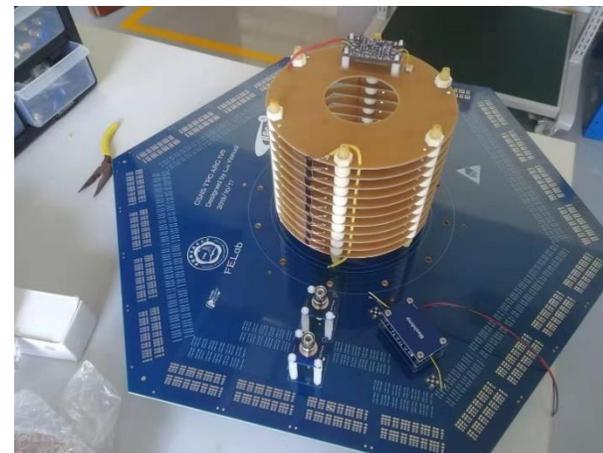
读出Pad区域表面镀锗;



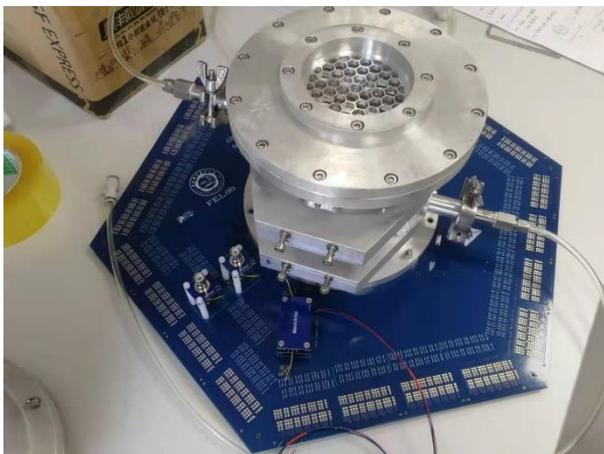
采用热压工艺进行Mesh压贴



TPC场笼结构



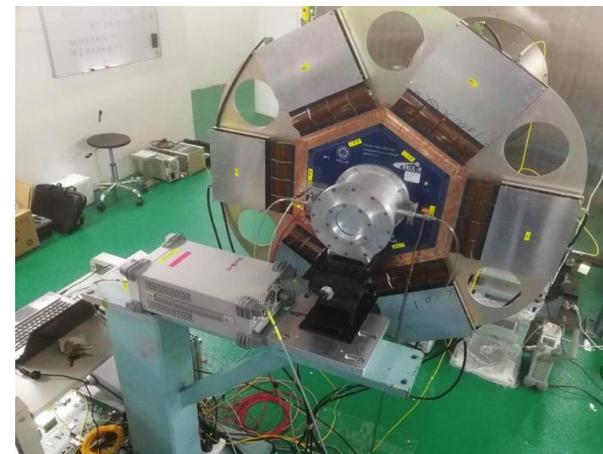
整体结构



探测器组装



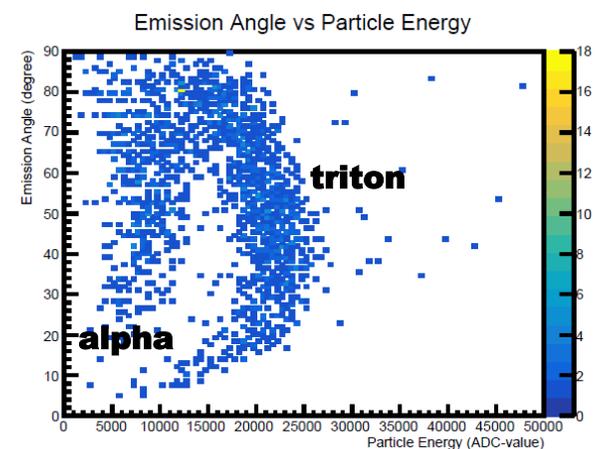
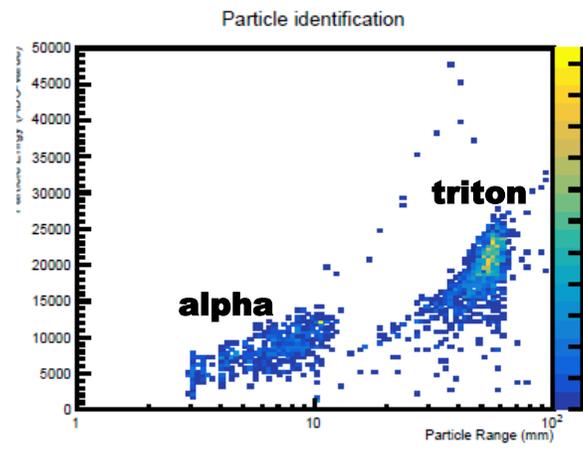
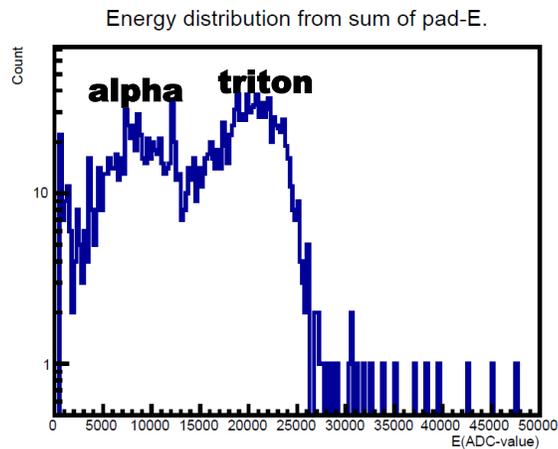
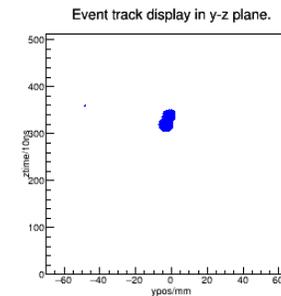
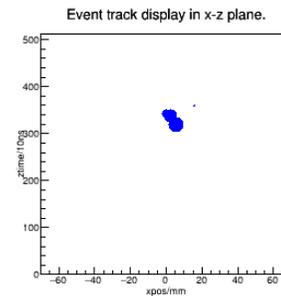
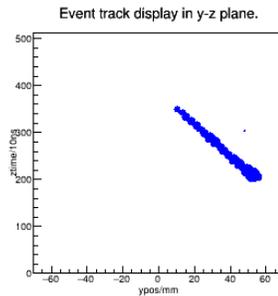
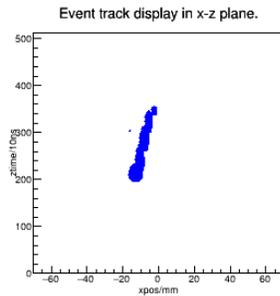
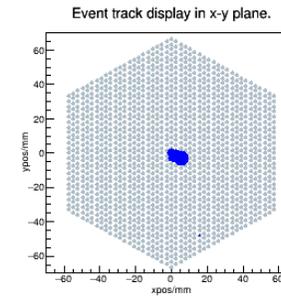
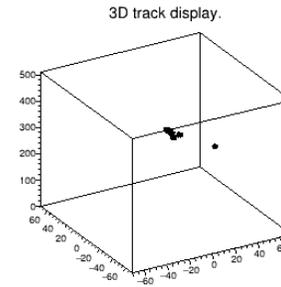
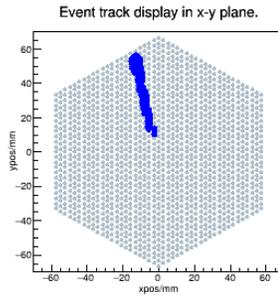
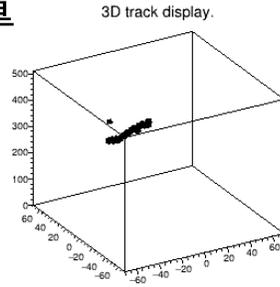
探测器整体



TPC初步测试

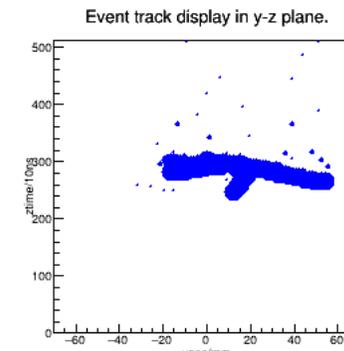
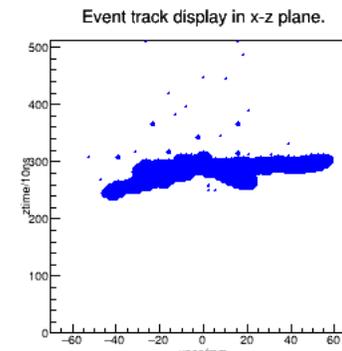
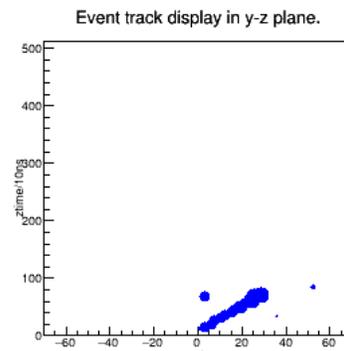
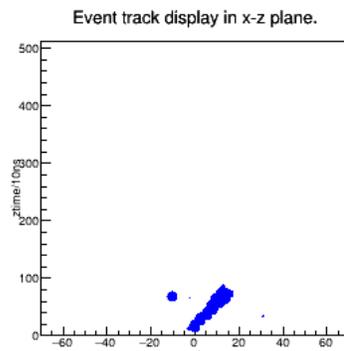
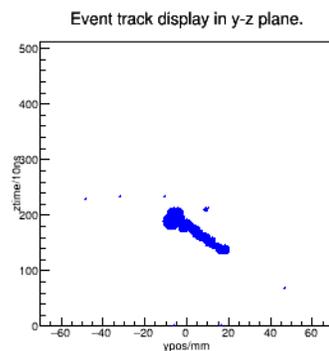
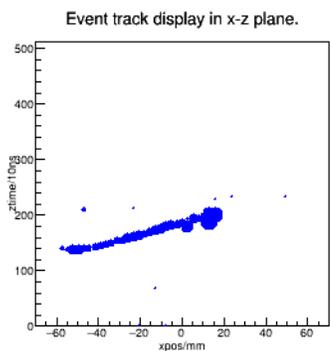
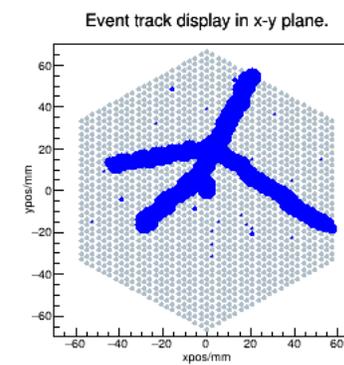
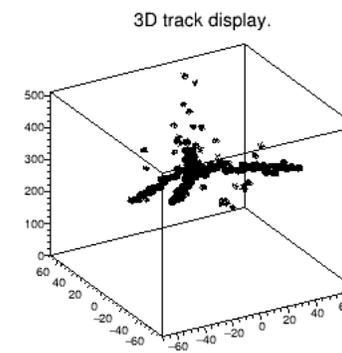
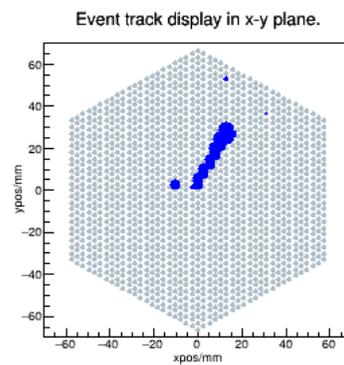
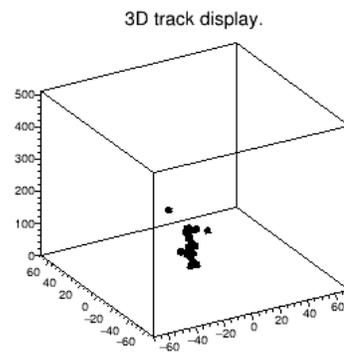
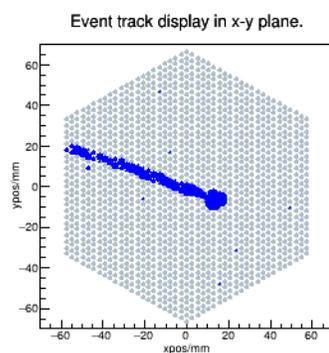
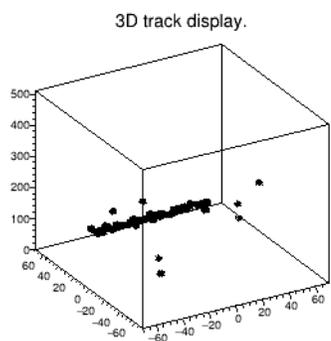


- ${}^6\text{Li}(n,t){}^4\text{He}$ 反应测量
- t 和 α 事例甄别



TPC初步测试

- $^{12}\text{C}(n,p)^{12}\text{B}$ 和 $^{14}\text{N}(n,p)^{14}\text{C}$ 测量
- 多体反应事例测量



详见 [易晗的报告] (明天 第3分会场)

Triton identification in the ${}^6\text{Li}(n, t){}^4\text{He}$ reaction measurement with the grid ionization chamber at CSNS Back-n white neutron source



The CSNS Back-n collaboration

H. Yi,^{a,c} Y. Zhao,^d W. Jiang,^{a,c} R. Fan,^{a,b,c,1} Y. Li(b),^{a,c} Y. Chen,^{a,c} H. Bai,^e H. Jiang,^e Z. Cui,^e G. Zhang,^e P. Cao,^{b,g} T. Yu,^{b,g} L. Zhou,^{a,c} C. Ning,^{a,c} M. Gu,^{a,b} Y. He,^{a,c} Z. Sun,^{a,b,c} J. Tang,^{a,c} Q. Zhang,^d Q. An,^{b,g} J. Bao,^h Q. Chen,^k P. Cheng,ⁱ C. Feng,^{b,g} F. Guo,^{a,c} C. Han,^j Z. Han,^k G. He,^h Y. He,ⁱ H. Huang,^h W. Huang,^{a,c} X. Huang,^{b,g} X. Ji,^{a,b} X. Ji,^{b,f} H. Jing,^{a,c} L. Kang,^{a,c} M. Kang,^{a,c} B. Li,^{a,c} Q. Li,^{a,b,c} X. Li,^{a,c} Y. Li(a),^{a,b} R. Liu,^k S. Liu,^{b,g} X. Liu,^k G. Luan,^h Y. Ma,^{a,c} J. Pan,^g B. Qi,^g J. Ren,^h X. Ruan,^h Z. Song,^j H. Sun,^{a,c} X. Sun,^{a,c} Z. Tan,^{a,c} H. Tang,^h P. Wang,^{a,c} Q. Wang,^h T. Wang,^l Y. Wang,^{a,c} Z. Wang,^h Z. Wang,^{a,c} J. Wen,^k Z. Wen,^k Q. Wu,^{a,c} X. Wu,^h X. Wu,^{a,c} L. Xie,^{b,f} Y. Yang,^k L. Yu,^{b,g} Y. Yu,^{a,c} J. Zhang,^{a,c} L. Zhang,^{a,c} L. Zhang,^{a,b,c} Q. Zhang,^h X. Zhang,^j Y. Zhang,^{a,c} Z. Zhang,^{b,g} Z. Zhou,^h D. Zhu,^g K. Zhu,^{a,b} and P. Zhu^{a,c}

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^cDongguan Neutron Science Center,
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^dXi'an Jiaotong University,
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^eState Key Laboratory of Nuclear Physics and Technology, School of Physics, Peking University,
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^fDepartment of Engineering and Applied Physics, University of Science and Technology of China,
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^hKey Laboratory of Nuclear Data, China Institute of Atomic Energy,
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¹Corresponding author.

Double-bunch unfolding methods for the Back-n white neutron source at CSNS



The CSNS Back-n collaboration

H. Yi,^{a,b} T.F. Wang,^c Y. Li,^{a,b} X.C. Ruan,^d J. Ren,^d Y.H. Chen,^{a,b} Q. Li,^{a,b} J. Wen,^e J.Y. Tang,^{a,b,1} Q. An,^{f,g} H.Y. Bai,^h J. Bao,^d Y. Bao,^{a,b} P. Cao,^{f,g} H.L. Chen,^{f,g} Q.P. Chen,^e Y.K. Chen,^{a,b} Z. Chen,^{f,g} Z.Q. Cui,^h R.R. Fan,^{a,b,f} C.Q. Feng,^{f,g} K.Q. Gao,^{a,b} M.H. Gu,^{a,f} C.C. Han,^f Z.J. Han,^e G.Z. He,^d Y.C. He,^{a,b} Y. Hong,^{a,b,j} H.X. Huang,^d W.L. Huang,^{a,b} X.R. Huang,^{f,g} X.L. Ji,^{a,f} X.Y. Ji,^{f,k} H.Y. Jiang,^h W. Jiang,^{a,b} Z.J. Jiang,^{f,g} H.T. Jing,^{a,b} L. Kang,^{a,b} M.T. Kang,^{a,b} B. Li,^{a,b} C. Li,^{f,g} J.W. Li,^{f,k} L. Li,^{a,b} X. Li,^{a,b} R. Liu,^e S.B. Liu,^{f,g} X.Y. Liu,^e G.Y. Luan,^d Q.L. Mu,^{a,b} C.J. Ning,^{a,b} B.B. Qi,^{f,g} Z.Z. Ren,^e Y.P. Song,^{a,b} Z.H. Song,^f H. Sun,^{a,b} K. Sun,^{a,b,j} X.Y. Sun,^{a,b,j} Z.J. Sun,^{a,b,f} Z.X. Tan,^{a,b} H.Q. Tang,^d X.Y. Tang,^{f,g} B.B. Tian,^{a,b} L.J. Wang,^{a,b,j} P.C. Wang,^{a,b} Q. Wang,^d Z.H. Wang,^d Z.W. Wen,^e Q.B. Wu,^{a,b} X.G. Wu,^d X. Wu,^{a,b} L.K. Xie,^{f,k} Y.W. Yang,^e L. Yu,^{a,b} T. Yu,^{f,g} Y.J. Yu,^{a,b} G.H. Zhang,^h L.H. Zhang,^{a,b,j} Q.W. Zhang,^d X.P. Zhang,^f Y.L. Zhang,^{a,b} Z.Y. Zhang,^{f,g} Y.B. Zhao,^{a,b} L.P. Zhou,^{a,b,j} Z.Y. Zhou,^d D.Y. Zhu,^{f,g} K.J. Zhu^{a,f,j} and P. Zhu^{a,b}

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^cSchool of Physics, Beihang University, Beijing 100083, China

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^gDepartment of Modern Physics, University of Science and Technology of China,
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^hState Key Laboratory of Nuclear Physics and Technology, School of Physics, Peking University,
Beijing 100871, China

ⁱNorthwest Institute of Nuclear Technology, Xi'an 710024, China

^jUniversity of Chinese Academy of Sciences, Beijing 100049, China

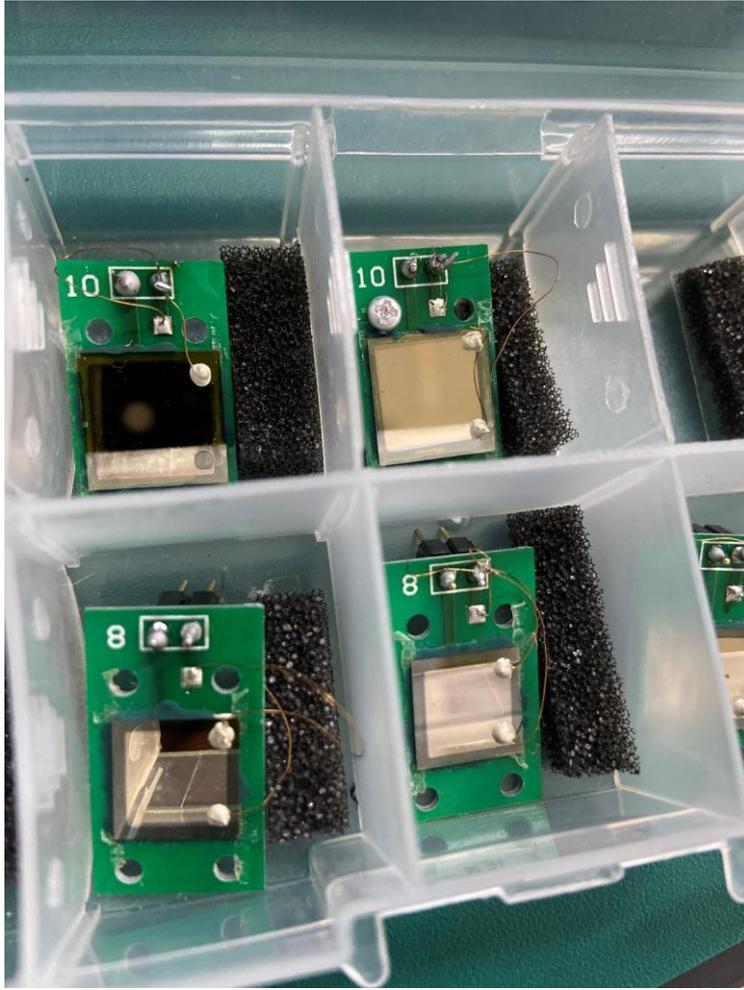
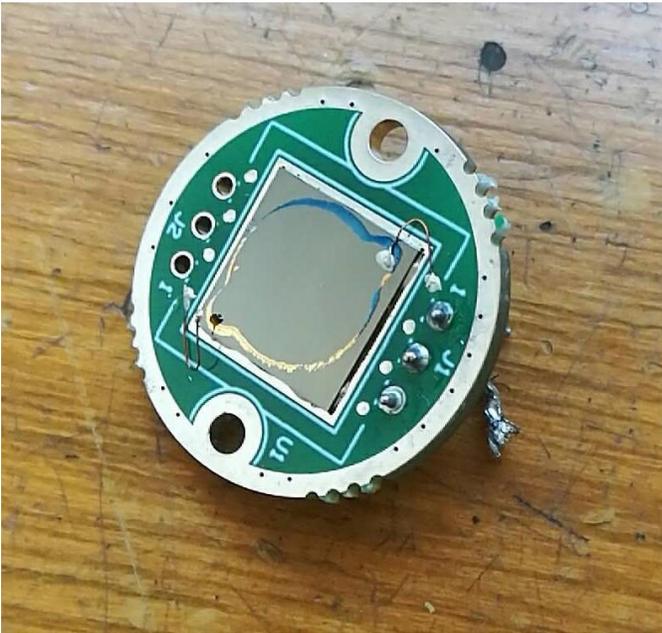
^kDepartment of Engineering and Applied Physics, University of Science and Technology of China,
Hefei 230026, China

E-mail: tangjy@ihep.ac.cn

¹Corresponding author.

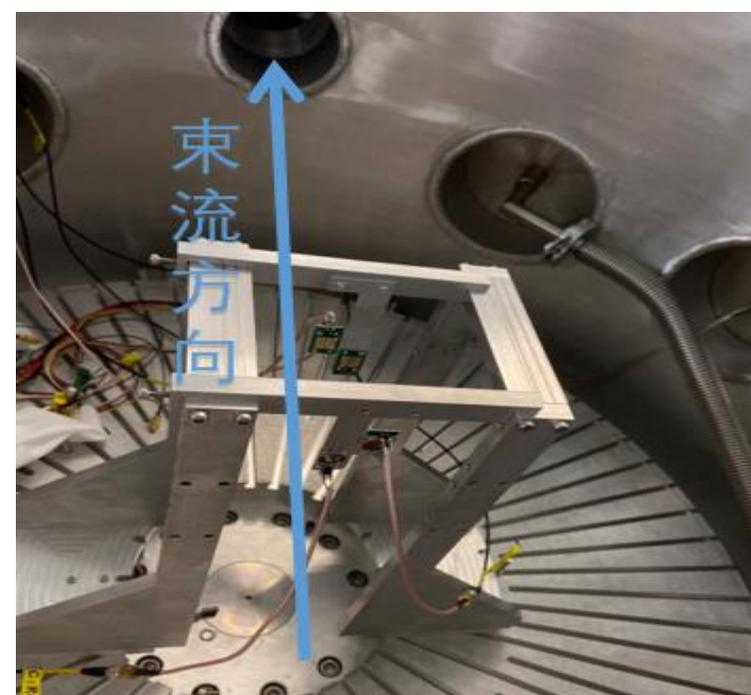
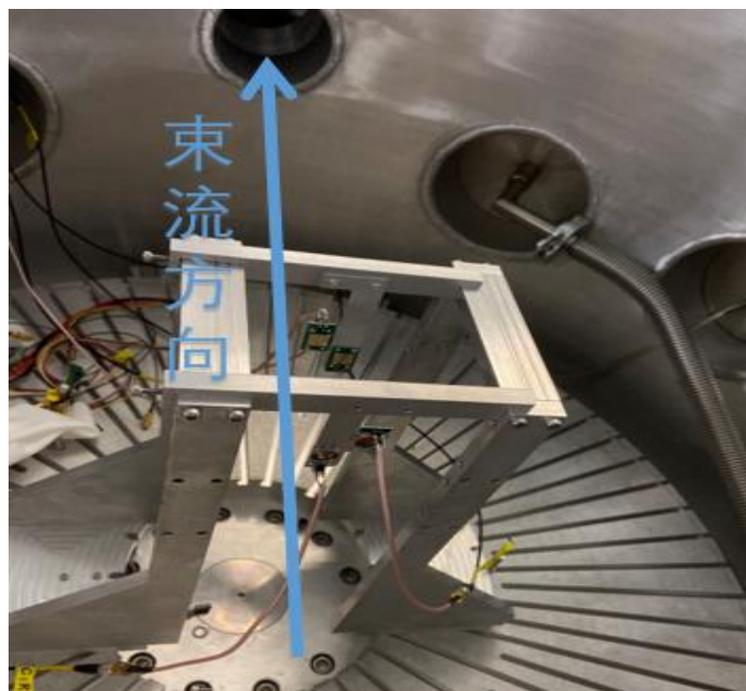
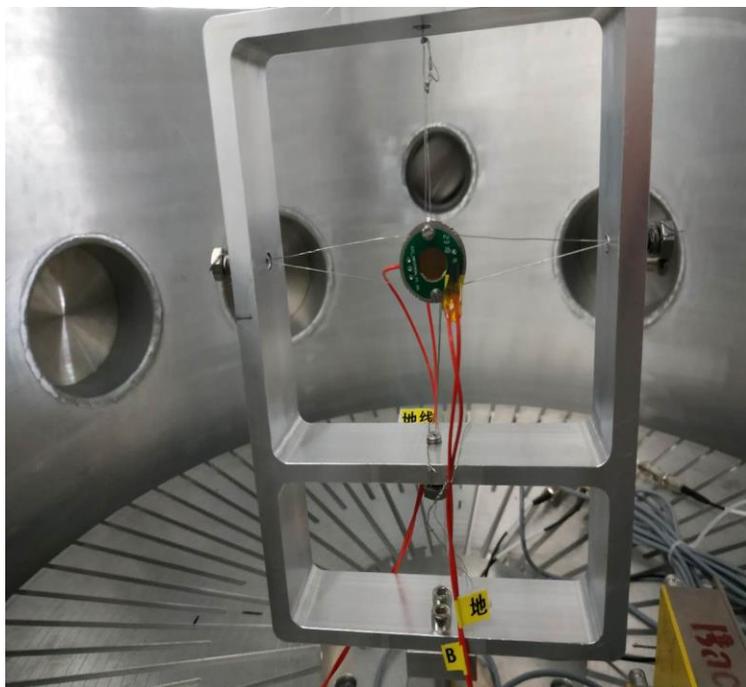
SiC探测器在白光源上的应用

- SiC: 抗辐照半导体
- 从2019年2月至今，在白光中子源上陆续开展了3次使用碳化硅探测器为主的(n, lcp)反应测试实验：
- ${}^6\text{Li}(n,t)$ 测试实验
- ${}^{63}\text{Ni}(n,\alpha)$ 实验
- ${}^{17}\text{O}(n,\alpha)$ 实验



实验过程

3次实验中SiC的使用情况： ${}^6\text{Li}(n,t)$ 实验中探测器**正对束流**和样品，用铁丝网固定
 ${}^{63}\text{Ni}(n,\alpha)$ 实验中使用前后角共**4块探测器**贴近(5mm)样品，用支架安装
 ${}^{17}\text{O}(n,\alpha)$ 实验中使用**8块SiC探测器**做阵列
在不同的安装情况、样品、流强下的摸索SiC探测器的适用范围



实验结果见 [孙康报告、李云居报告] (明天 第3分会场)

三种探测系统的比较



- 目前在实验中应用的带电粒子探测器主要有带电粒子探测器阵列(LPDA)、TPC和SiC探测器等
- 各有优势+各有缺陷:

探测器名称	优势	缺陷	适用实验
LPDA	<ol style="list-style-type: none">1. 较强的通用性2. 微分截面测量3. 较强的抗γ-flash性能	<ol style="list-style-type: none">1. 覆盖立体角较小2. 存在粒子分辨阈值	<ol style="list-style-type: none">1. 较大的反应截面2. 微分截面测量
TPC	<ol style="list-style-type: none">1. 大立体角覆盖 低测量阈2. 微分截面测量 截面测量3. 较强的粒子鉴别能力	<ol style="list-style-type: none">1. 目前正在开发适用电子学系统2. 数据处理复杂	<ol style="list-style-type: none">1. 通用测量2. 微分截面测量3. 多体反应
SiC	<ol style="list-style-type: none">1. 大立体角覆盖2. 抗辐照	<ol style="list-style-type: none">1. 面积较小2. 粒子鉴别能力差	<ol style="list-style-type: none">1. 小截面样品

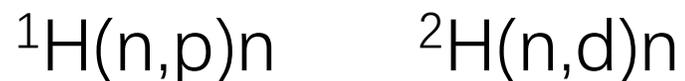
LPDA和SiC实施难度较小，可以互补；TPC实施难度大，未来通用型探测器

4. 总结 和展望

总结



- **第1条线索：多种核反应**



LPDA-v.1(Si阵列)

LPDA-v.2(Si+Csl)

SiC探测器

PPAC LPDA-v.3(气体室+Si)

LPDA

- **第2条线索：3种探测器**

LPDA阵列($\Delta E - \Delta E - E$) TPC SiC
气体室+硅+Csl

展望



- **中子能谱**需要进一步准确测量 (不同能区, 不同束斑)
- 实验测量和**模拟预测分析**紧密结合
- 提高**理论**水平 掌握共振能区数据分析方法
- 研发新型**探测器** 改进已有探测器 拓展测量能力
- 加强国内外合作 提高**样品**研制和实验测量水平

展望

- 核反应

需求：核天体物理 堆&器结构材料 IAEA-NDS

天然丰度大的样品 → 天然丰度小的样品 → 放射性样品(国际合作)

固体样品 → 固体+气体样品 → 气体样品

两体反应 → 三体反应 (→ 四体反应)

- 探测器

改进完善LPDA **TPC** SiC

Micromegas(MGAS) 金刚石 …

模拟计算数据分析与软件编制 //

致谢



- 感谢LPDA合作组成员的通力合作与辛勤付出!
- 感谢Back-n各合作单位和成员的支持!
- 感谢各位专家的大力支持!
- 感谢大家的认真听讲!
- 欢迎批评、关注和参与我们的工作!

第3分会场报告安排



- 1) 易晗：出射带电粒子核反应总体实验情况介绍(含TPC初步结果)
- 2) 江浩雨：n-p散射实验结果
- 3) 崔增琪：n-d散射实验结果
- 4) 李云居： ^{17}O (或 ^{63}Ni) (n, α) 实验初步结果
- 5) 蒋伟：反角白光中子源 ΔE - ΔE -E望远镜
- 6) 孙康：SiC探测器在(n, x)反应测量中的应用
- 7) 胡益伟：MeV能区 ^6Li (n, t) 实验模拟预测
- 8) 刘杰：MeV能区 ^{10}B (n, α) 实验模拟预测