

嫦娥七号中子伽马谱仪束流标定试验进展

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目录

CONTENTS

01

载荷科学背景

02

CE-7月球中子伽马谱仪

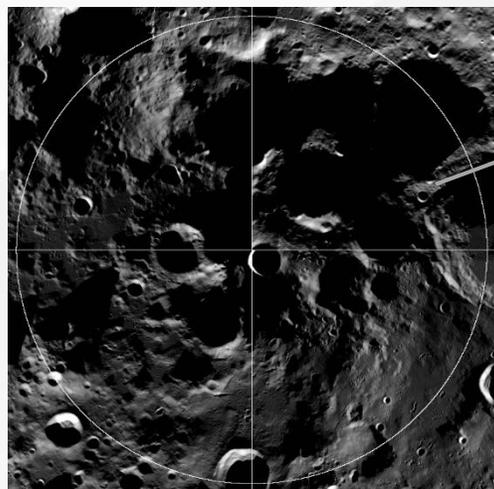
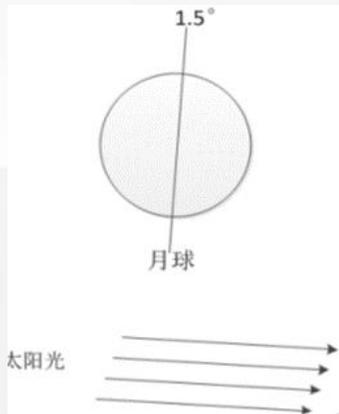
03

多次实验

04

实验成果

载荷科学背景

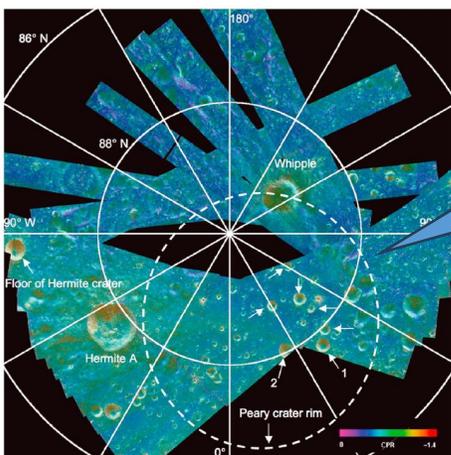


永久阴影区，表面温度常年低于110K，有利于水冰等挥发物储存

deposits up to 100 m at the lunar poles, a prediction that has not proven correct. Nearly 20 years after these initial studies *Arnold* [1979] made detailed predictions of the amount of ice within lunar PSRs by accounting for various factors such as PSR lifetimes, temperatures, and areas, as well as volatile migration and possible endogenic and exogenic sources. *Arnold* [1979] found that when these sources were considered, the total mass of polar water ice could be in the range of 10^{16} – 10^{17} g. *Arnold* [1979] also predicted a water concentra-

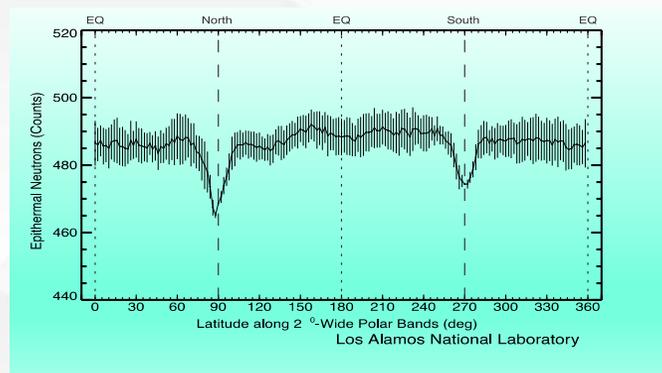
月球南极

上世纪70年代，就有科学家预测月球两极的水冰储量可能达到**100亿吨**

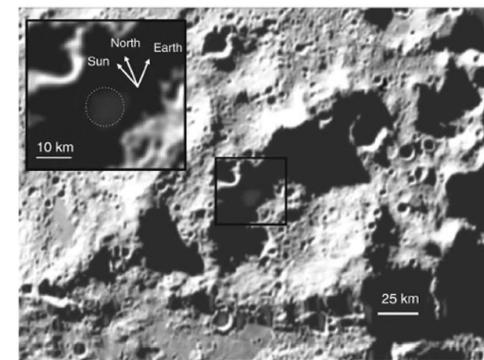


根据雷达信号推算水含量比理论预期小一个数量级，水可能在**月表以下**

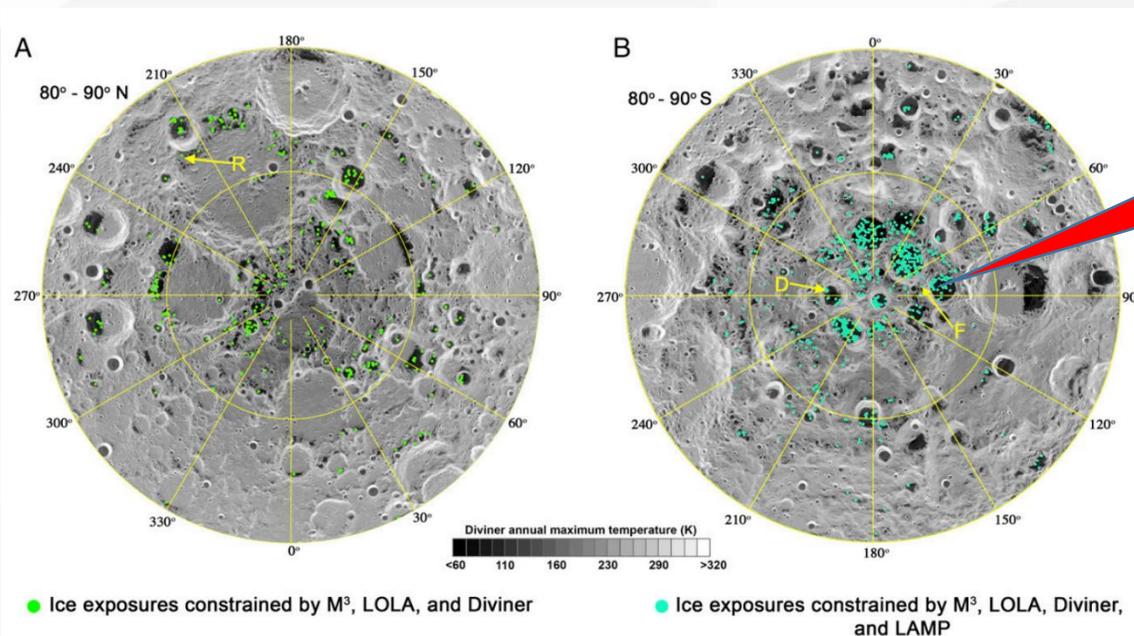
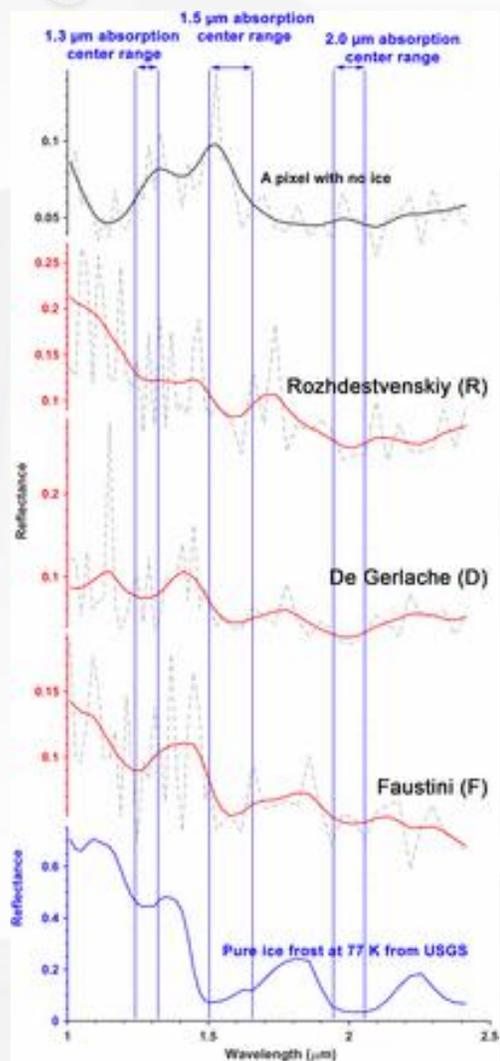
1994 Clementine



1998 Lunar Prospector
月球两极中子计数**明显下降**



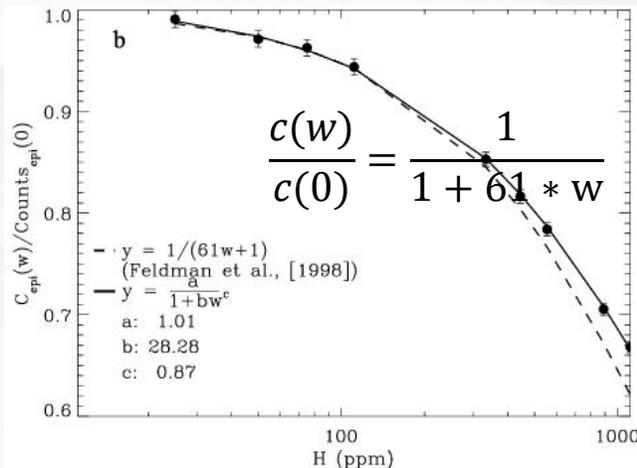
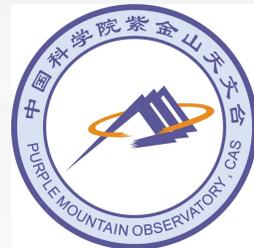
2009 LCROSS
从喷溅物中分析得到水含量为**6%**



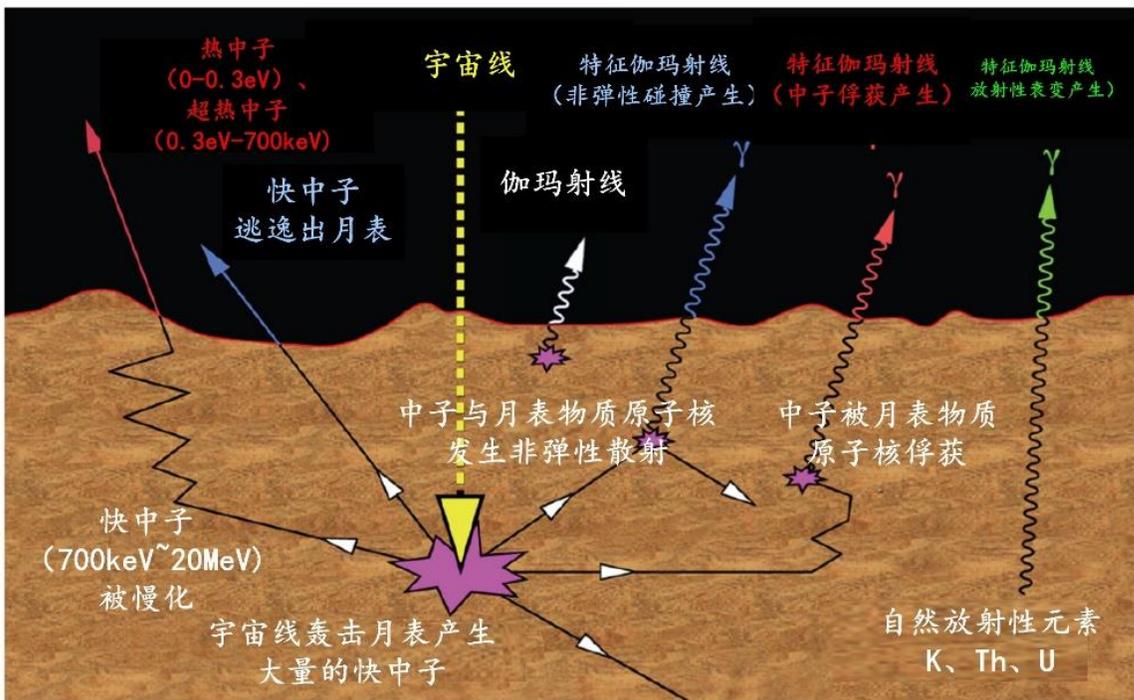
月表存在水冰的直接证据

Li et al., 2018

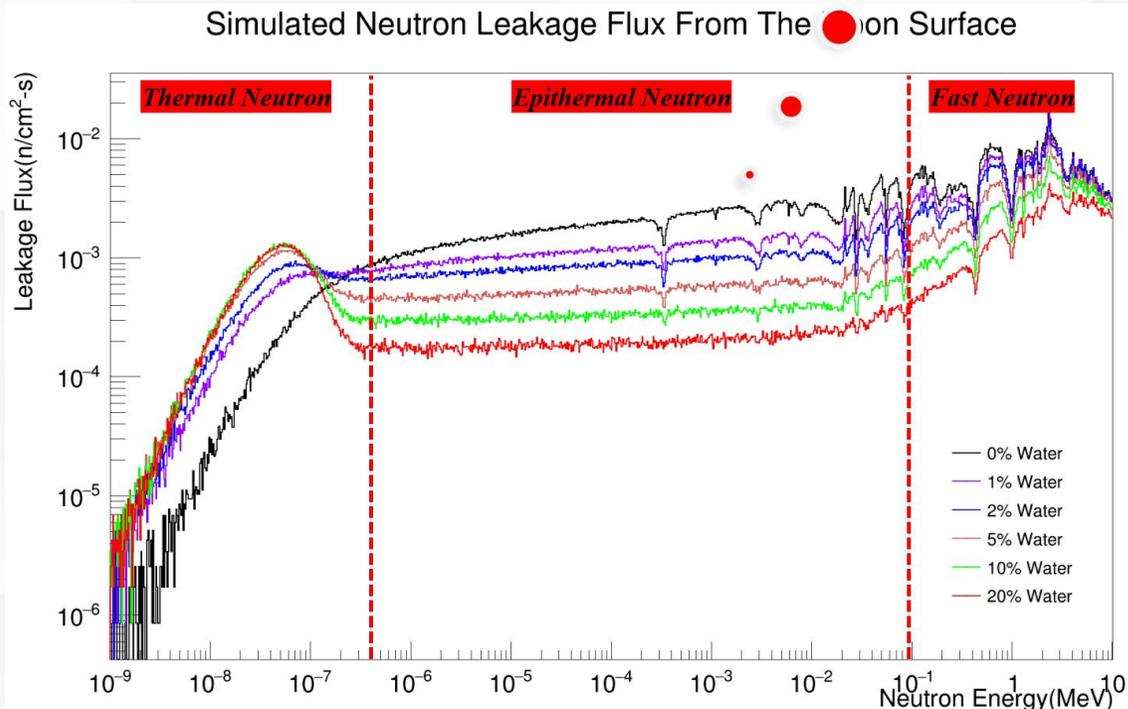
月球次表层 (<1m) 极有可能蕴藏着更多的水, **中子探测**是一种有效手段



**超热中子通量
变化最显著**



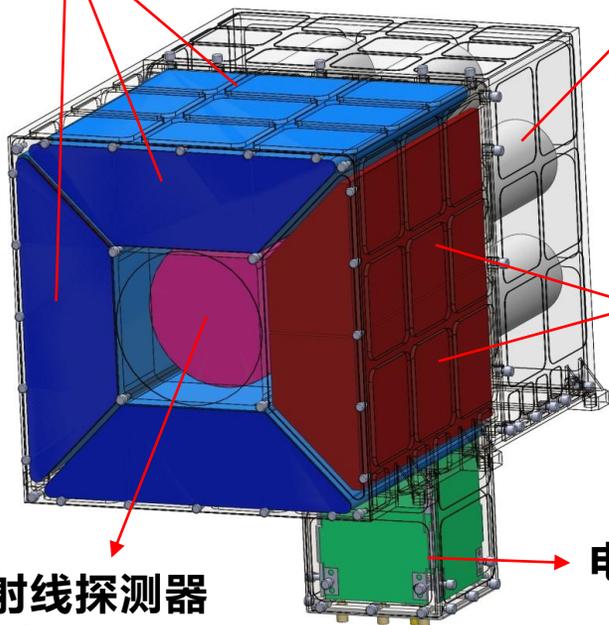
宇宙线轰击月表产生不同能量的中子与伽玛射线的过程





0.63mm钷

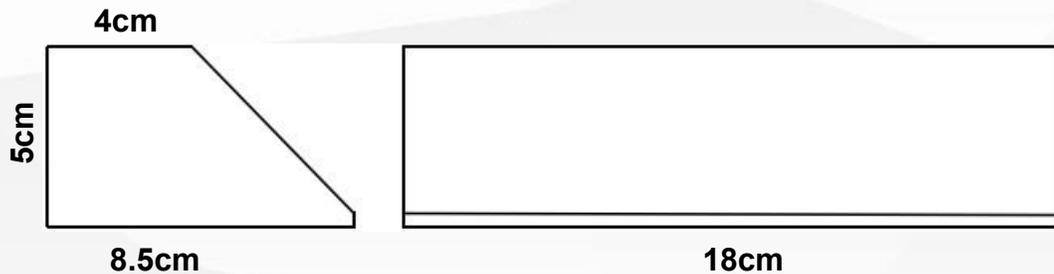
光电管



中子探测单元
(EJ254)

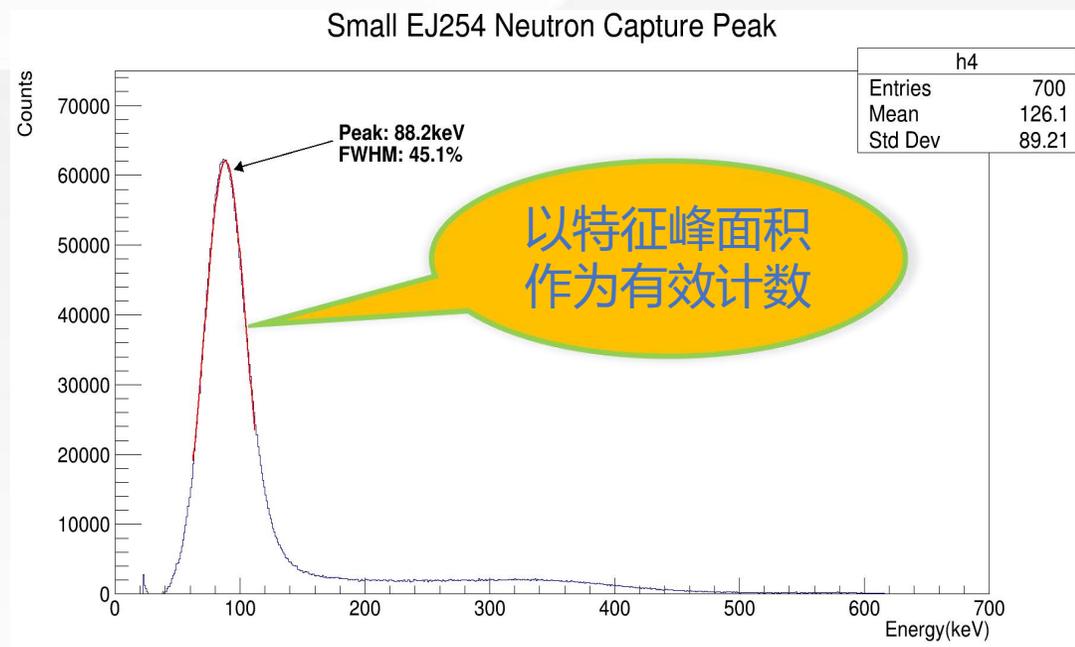
电子学模块

伽马射线探测器
(CeBr3)

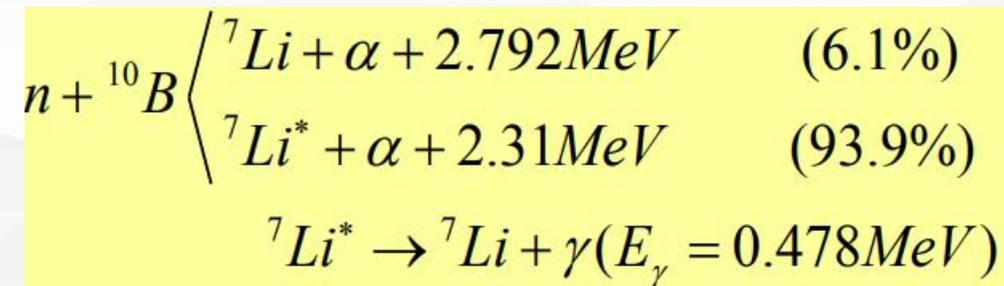
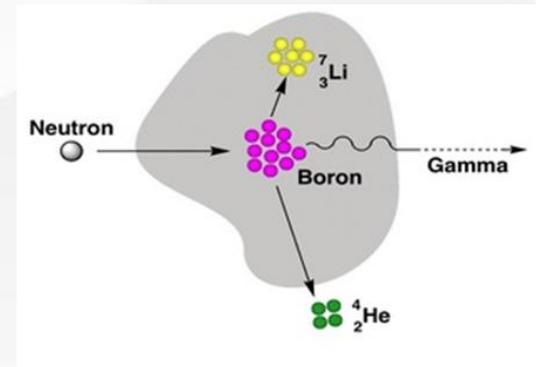


任务名称	Lunar Prospector 美国1998)	Mars Odyssey 美国2001	Messenger 美国2004	DAWN美国 2007	LRO美国 2009	Lunar H Mapper 美国2021	嫦娥7号
探测器材料	^3He	^{10}B , 塑料	^{10}B , 塑料	^{10}B , 塑料	^3He	^6Li	^{10}B , 塑料
探测器有效面积 (cm^2)	74	90	360	104	50	200	443
本底抑制	√	√	-	√	√	-	√

探测器有效面积国际领先



EJ254中子俘获反应能谱

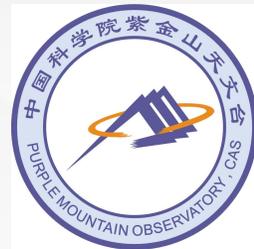


有机聚合物基体可以有效慢化中子，**拓宽超热中子探测能段**

3



多次实验



2021年

初次摸底实验

2022年

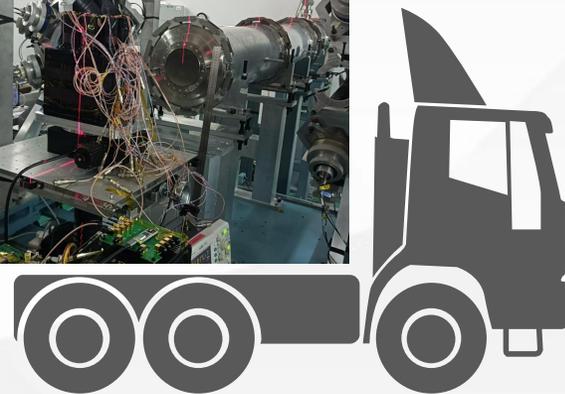
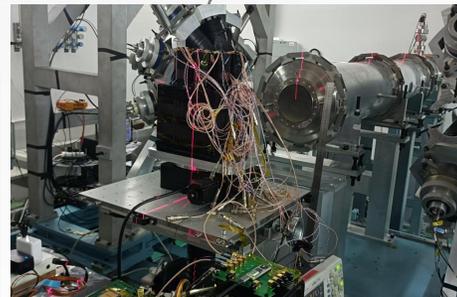
原理样机标定实验

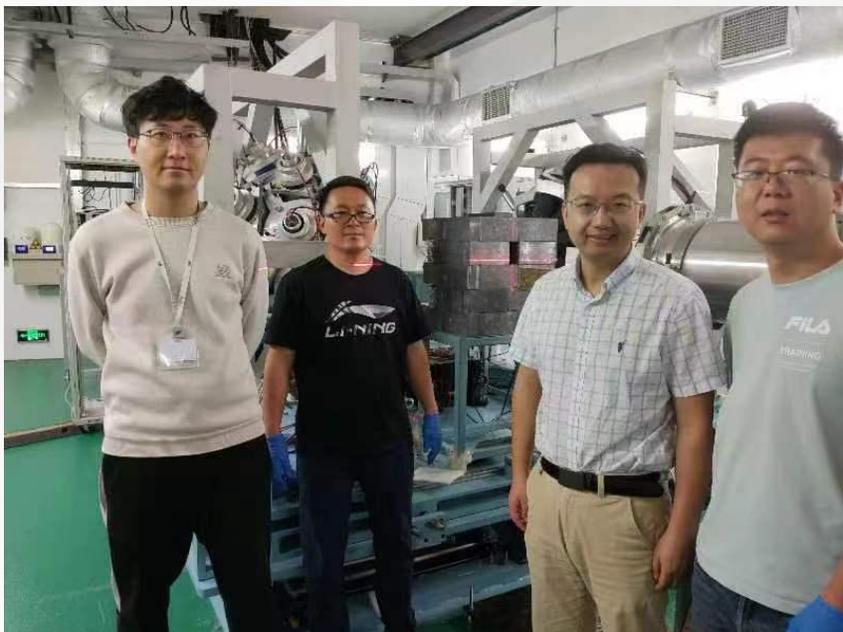
2023年

鉴定件单机标定实验

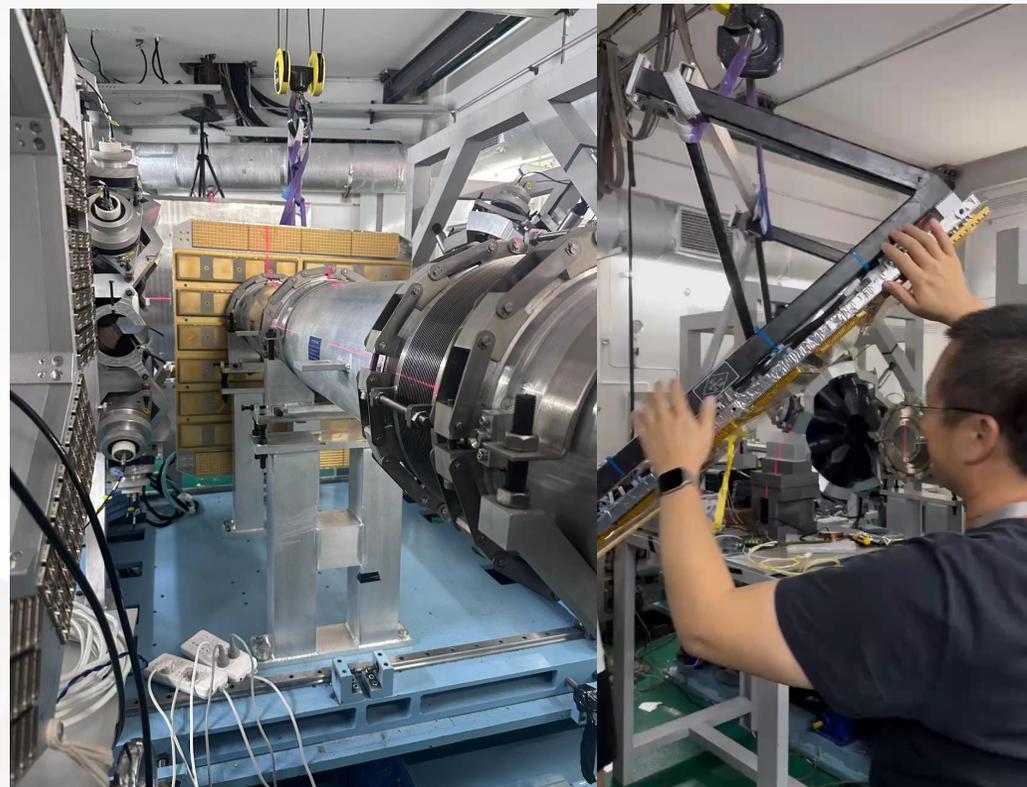
2024年

正样件单机标定实验



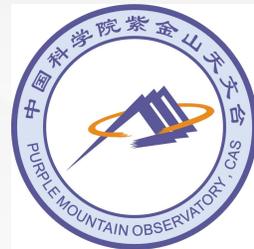


参试人员合影

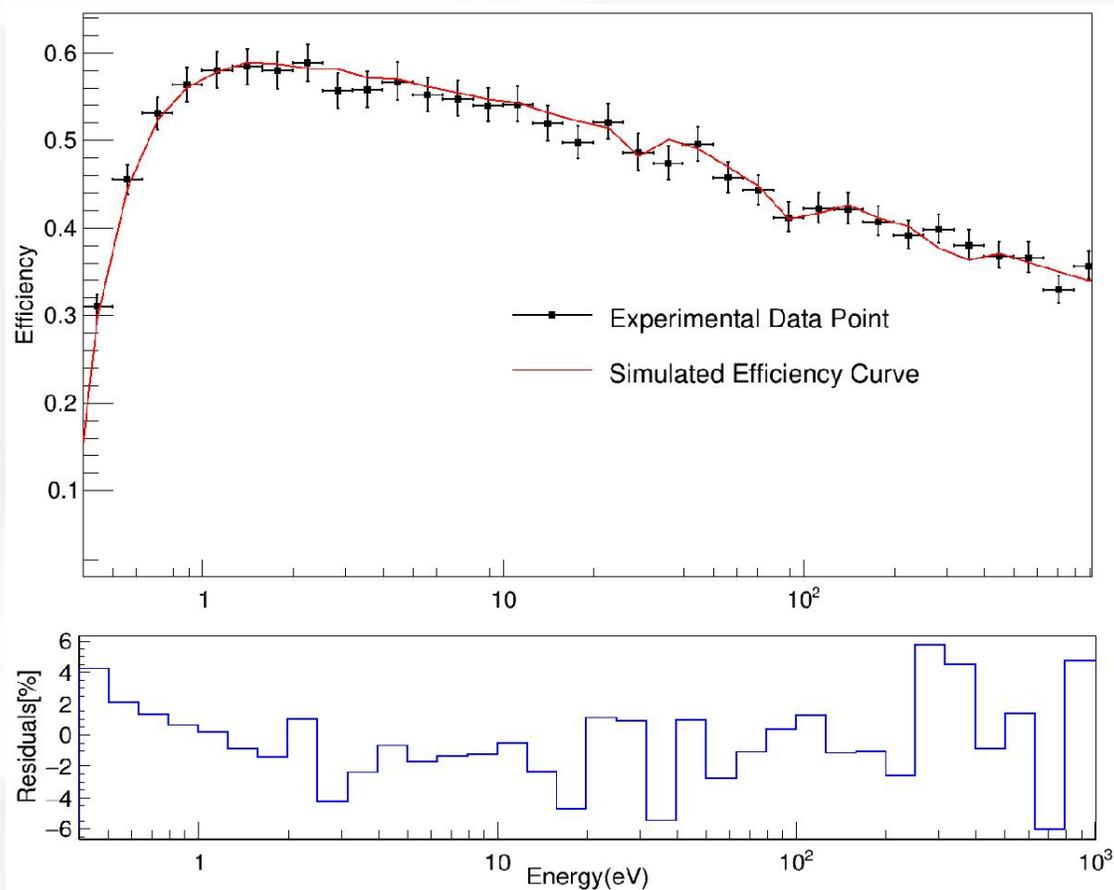


卫星在轨SAR遮挡效应评估实验

4 实验成果



中子效率曲线



效率计算公式:

$$eff(i) = \frac{c(i)}{t \cdot F(i) \cdot S}$$

c: 该能量窗口里的俘获特征峰计数

t: 测量时间 (3600s)

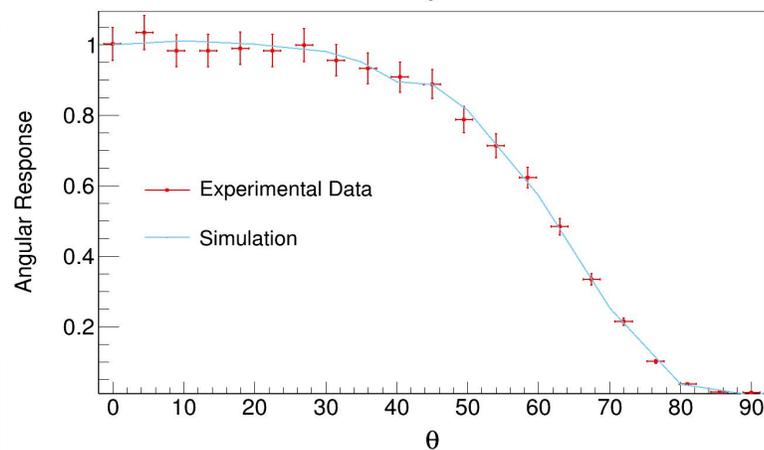
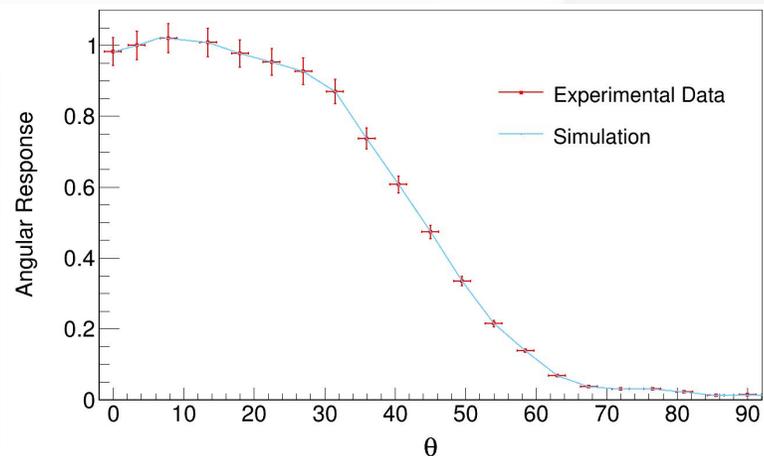
F: 中子束流能谱里该能量窗口的流量 (ϕ_{606060})

S: 束斑面积

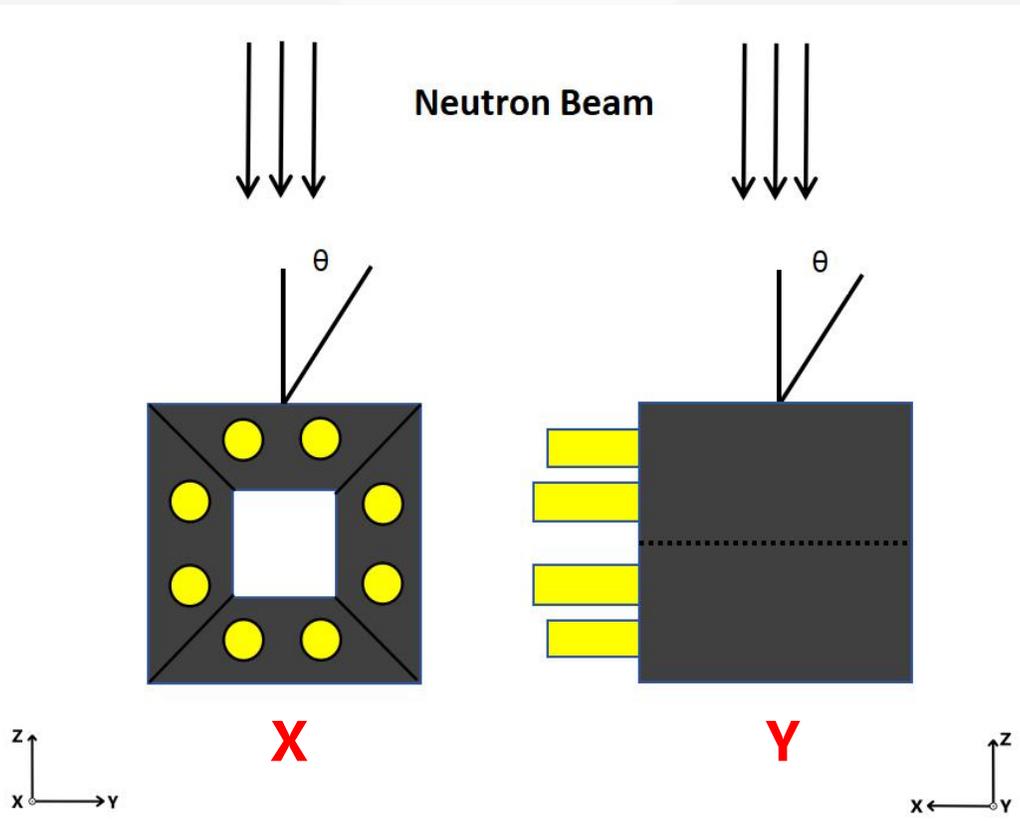
100eV中子探测效率41.7%，而LPNS的100eV效率只有10%

4 实验成果

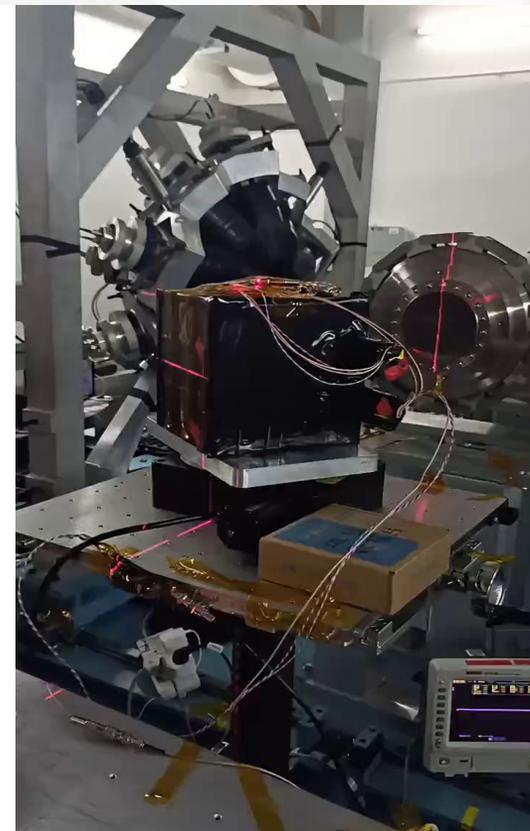
角度响应



绕X轴旋转 (上) 绕Y轴旋转 (下)

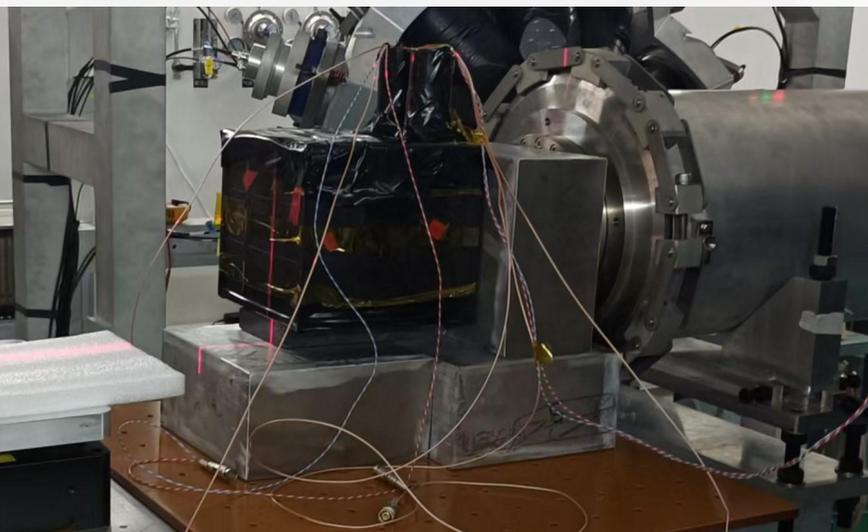


角度范围 $0^\circ - 90^\circ$ 旋转步长 4.5°



4 实验成果

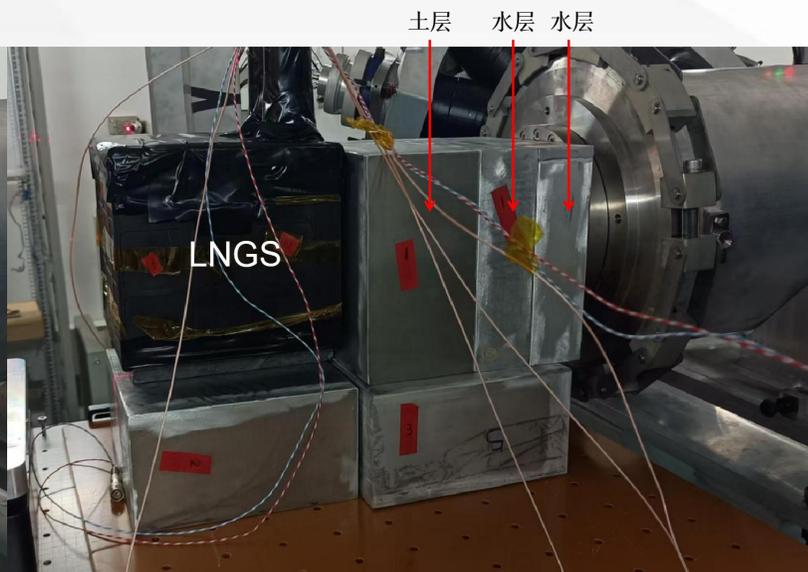
水含量实验



1层土



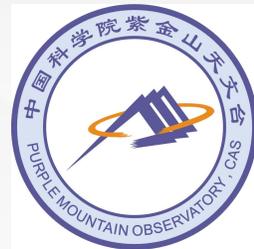
1层土+1层水



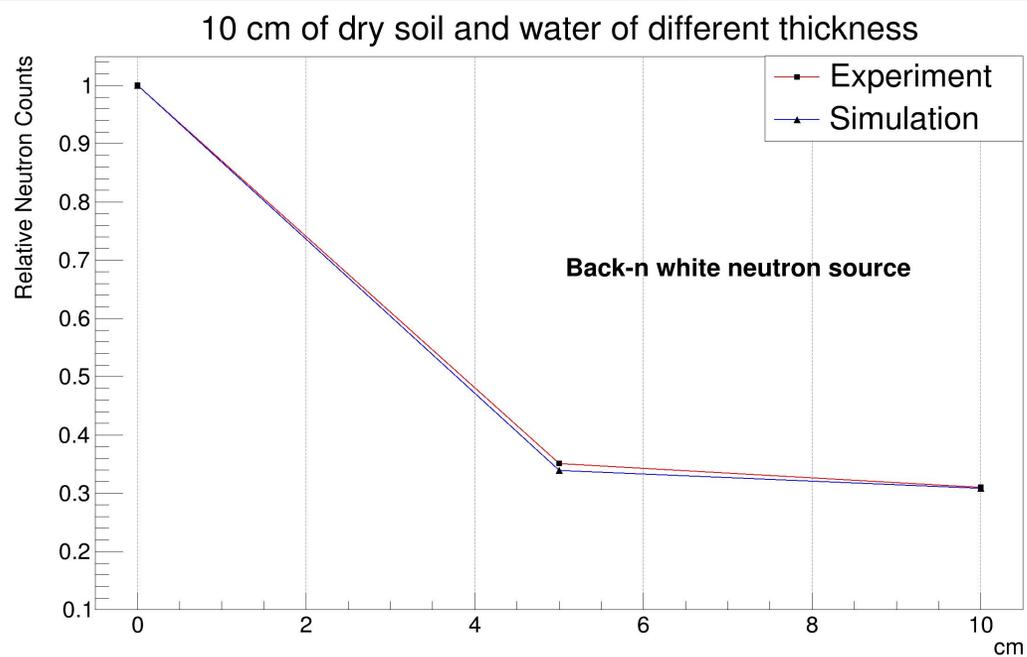
1层土+2层水

4

实验成果

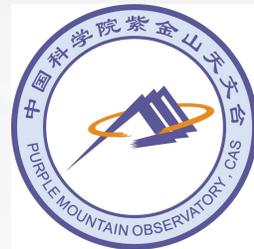


◆ 含水量实验



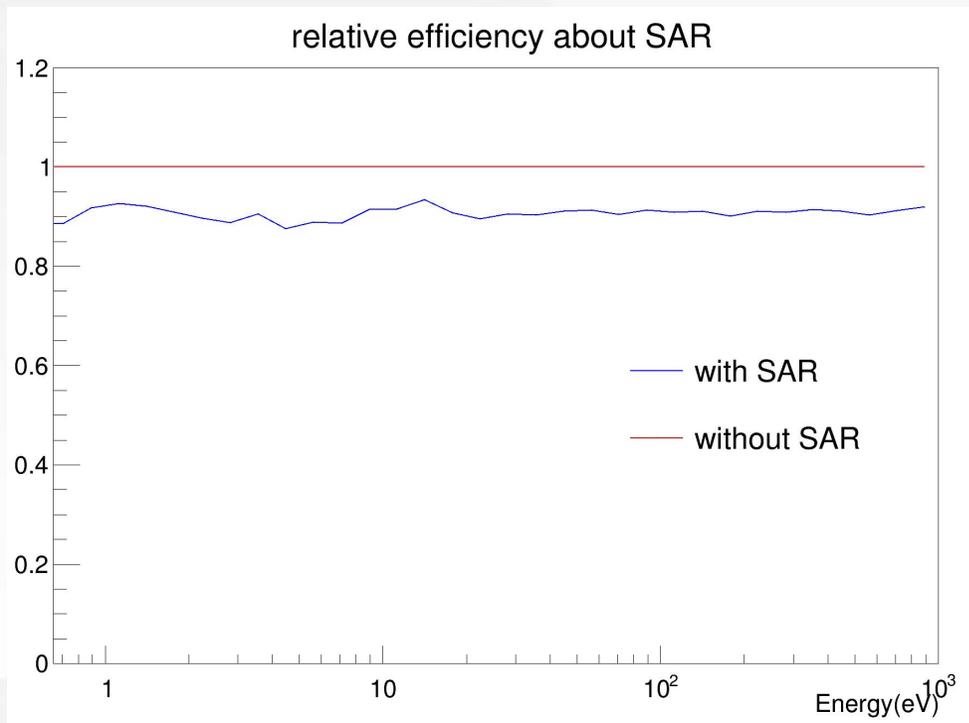
	实验	模拟	能量范围 (keV)
1层土	1	1	12.6-25.1
1层土+1层水	0.3513±0.00466	0.3389	39.8-63.1
1层土+2层水	0.3103±0.00438	0.3086	100-199.5

4 实验成果

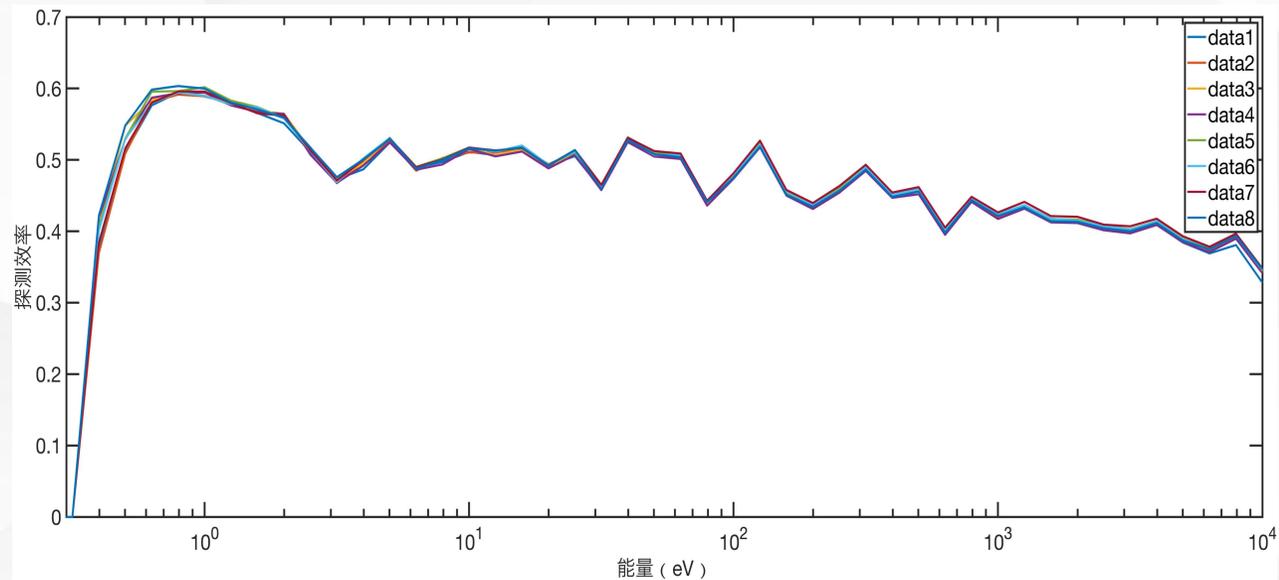


其他成果

SAR对中子通量抑制效应评估



在<1keV能段, 中子通量下降约**10%**



8个中子探测单元, 中子效率差异小于**1%**

感谢观看