中国原子能科学研究院
CHINA INSTITUTE OF ATOMIC ENERGY

Introduction of GTAF

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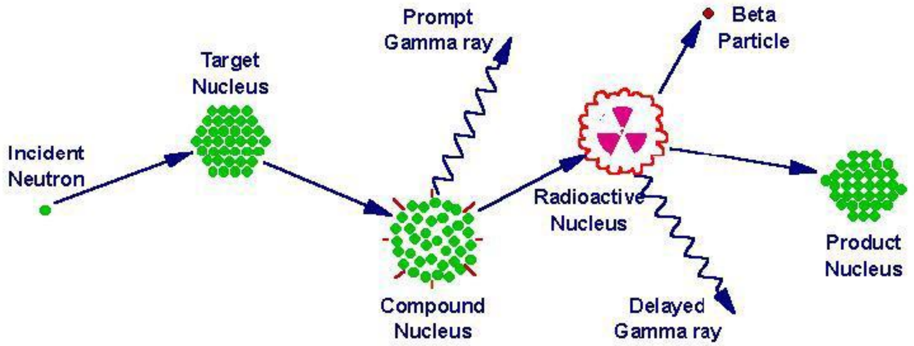
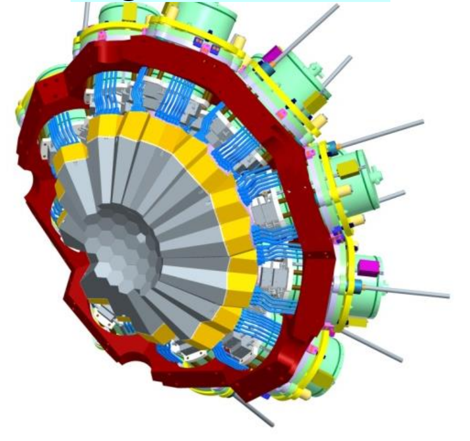
- **GTAF-II introduce**
- DAQ system
- Experiment setup in Air and Vacuum
- Sn and I experiment

Gamma Total Absorption Facility

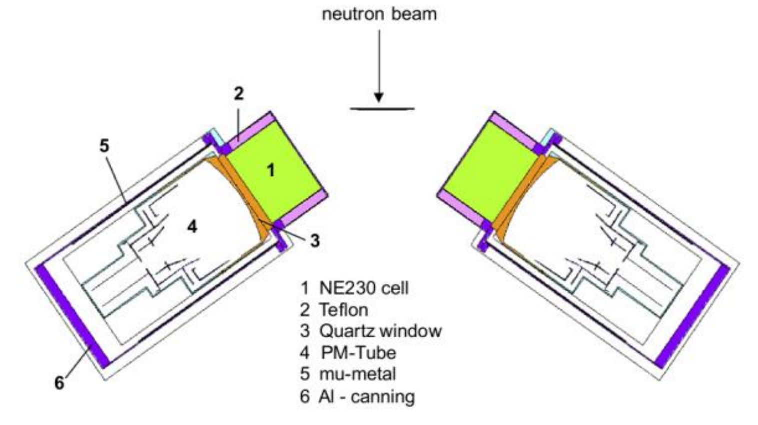
Detect prompt Gamma ray form (n, r) events with coincidence measuring method



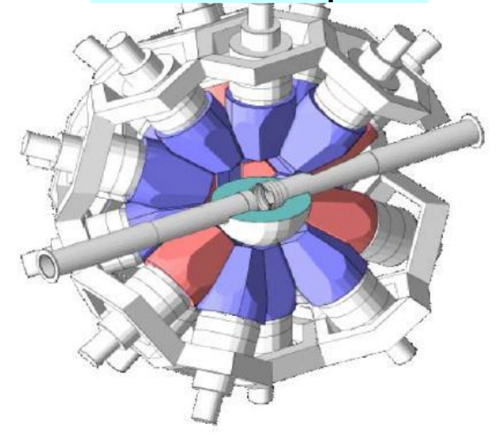
High resolution



Total energy

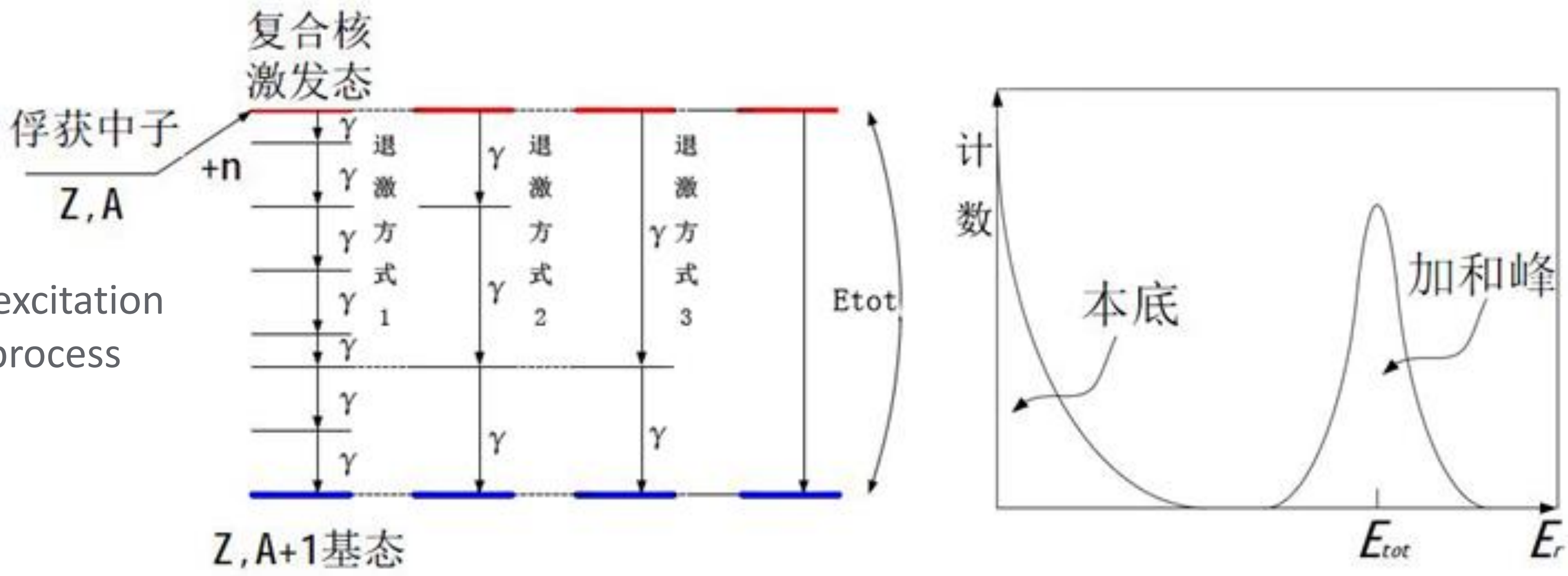


Total absorption

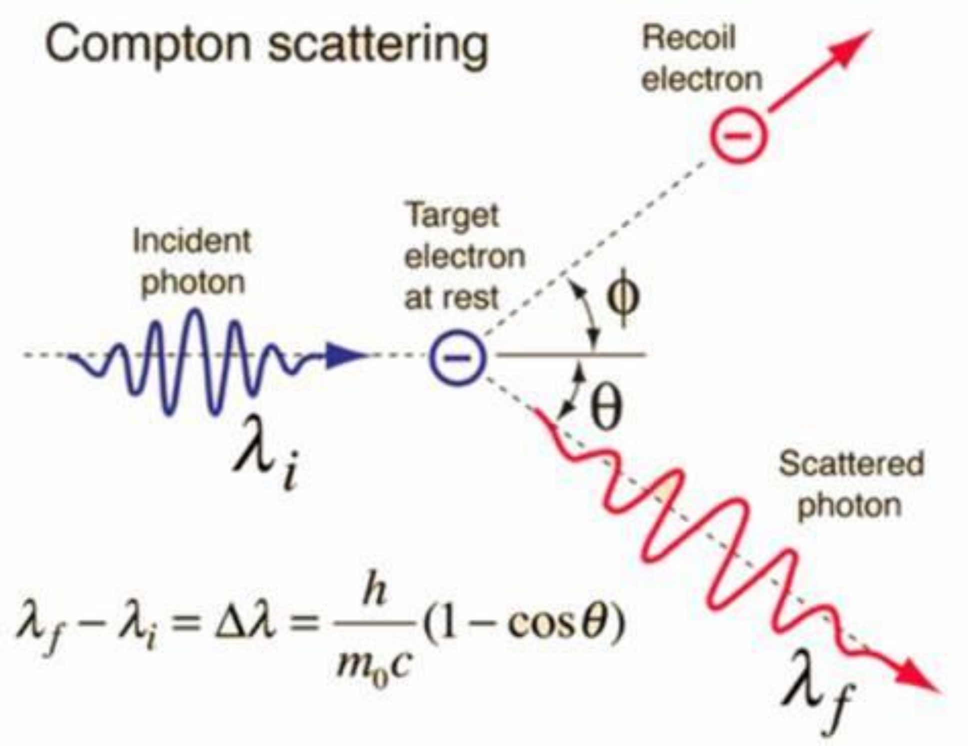


How it works

de-excitation process



How it works



When Compton scattering happens, the adjacent detectors could detect the Scattered photon, thus a better total energy resolution will achieve by the facility than a single detector.

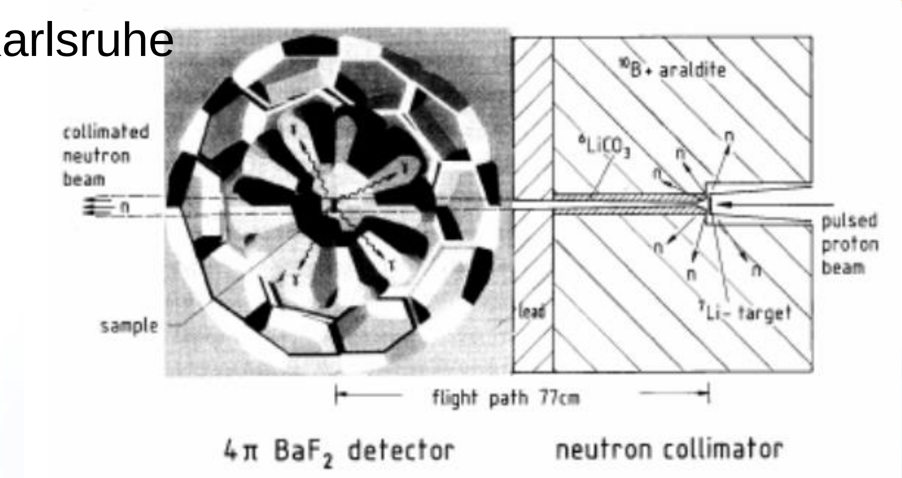
Why is Barium Fluoride

- large density lead to a high detection efficience of gamma
- can not be easily deliquesced
- could be made big with an acceptable cost

- Fast signal

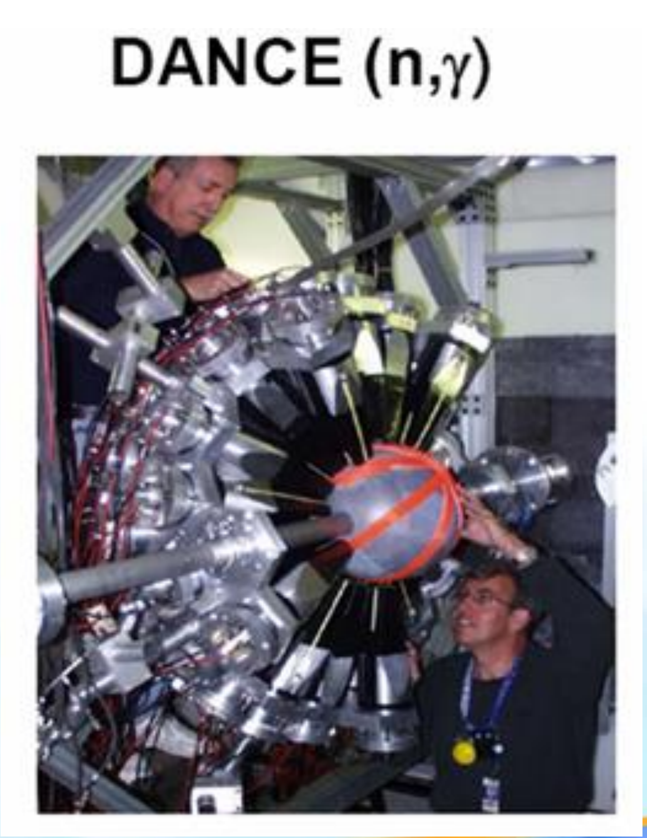
The BaF_2 arrays

Karlsruhe



CERN

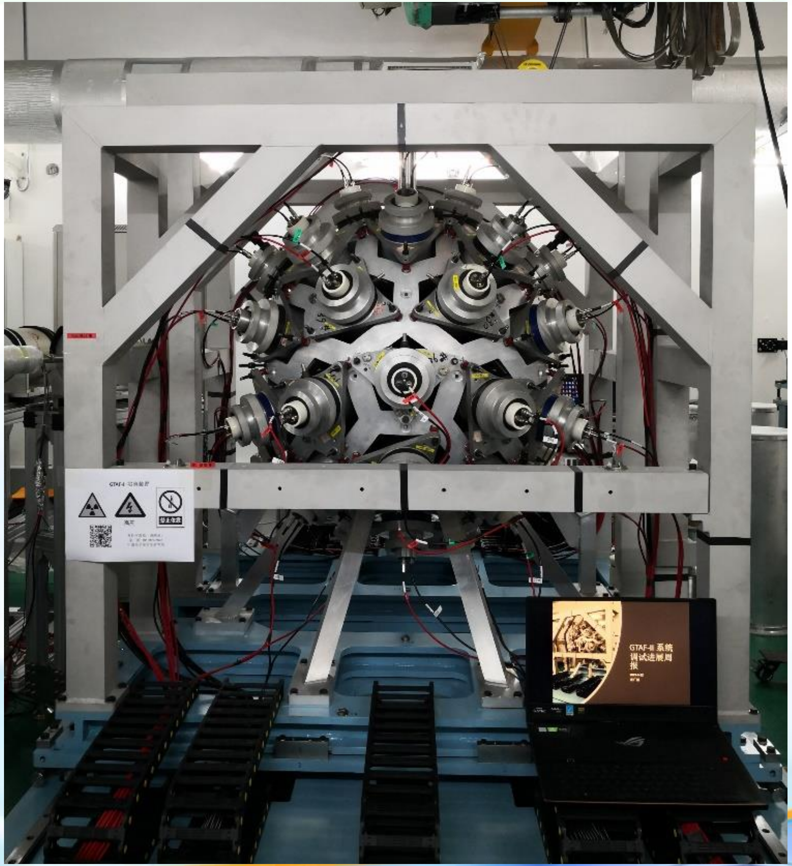
TAC



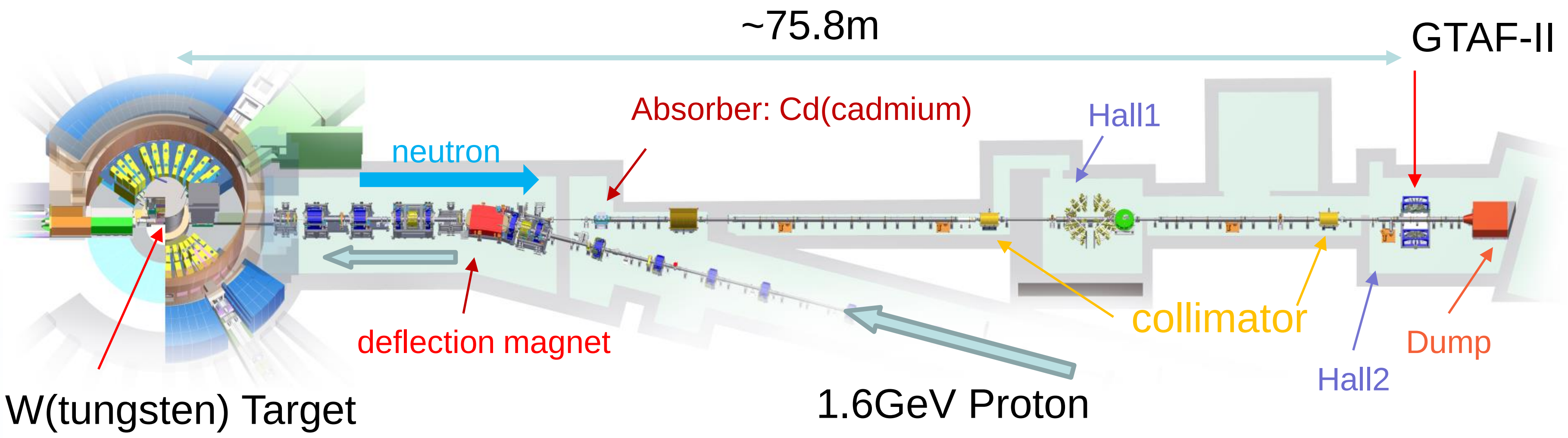
And GTAF

GTAF-II Barium Fluoride Array

- Belongs to CIAE, Designed to measure (n, γ) nuclear data
- 42 segments (40segments with crystals)
  - 2 different crystal shapes
  - Inner radius = 10cm
  - Crystal depth = 15cm
- Condition
  - Facility construction
  - Establishing experiment method
  - Starting physical experiments

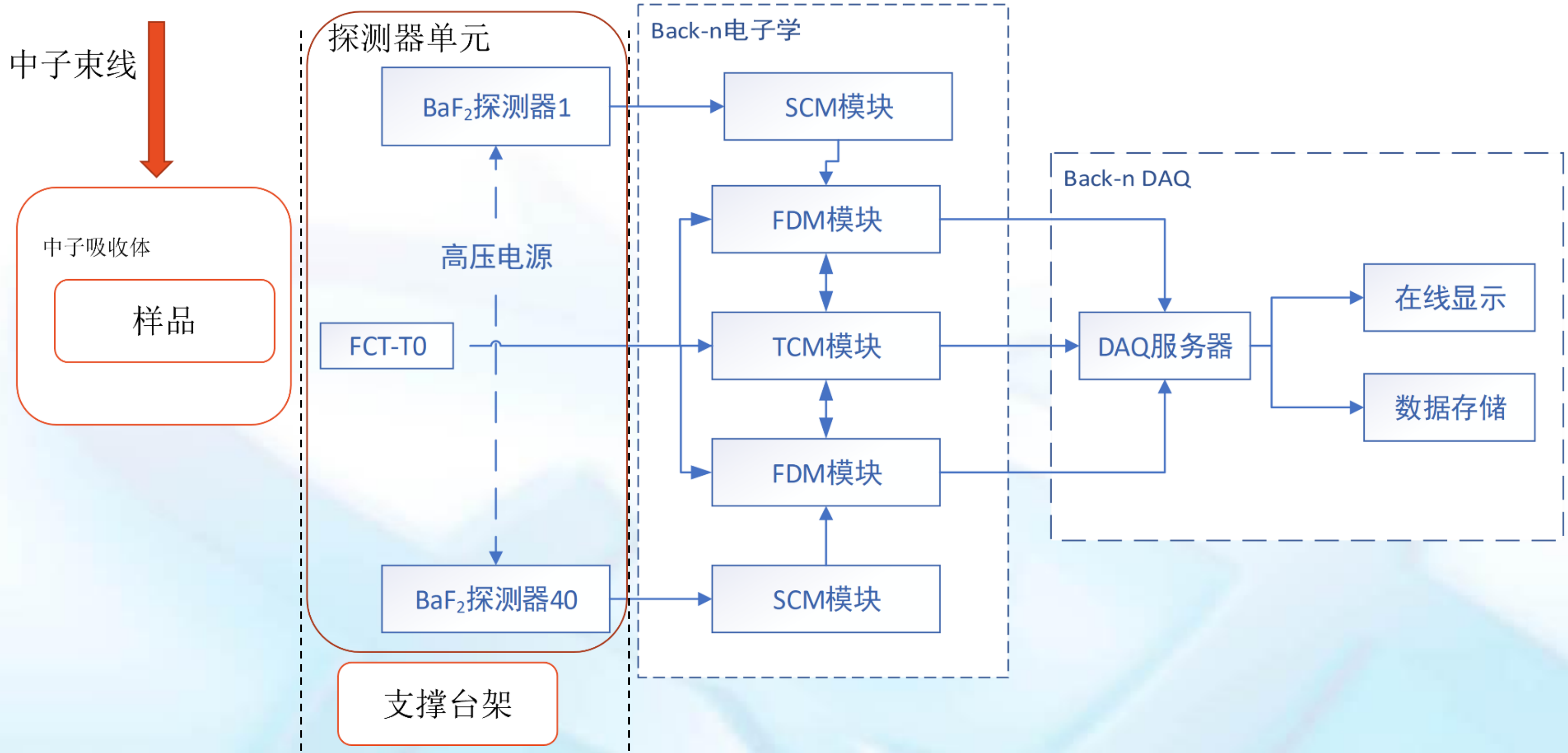


CSNS Back-n WNS and GTAF-II



GTAF-II is located on Back-n WNS at CSNS,
Target of GTAF-II is about 75.8m from the Spallation source.

Experiment Setup



中子束线 GTAF-II装置 电子学及数据采集系统

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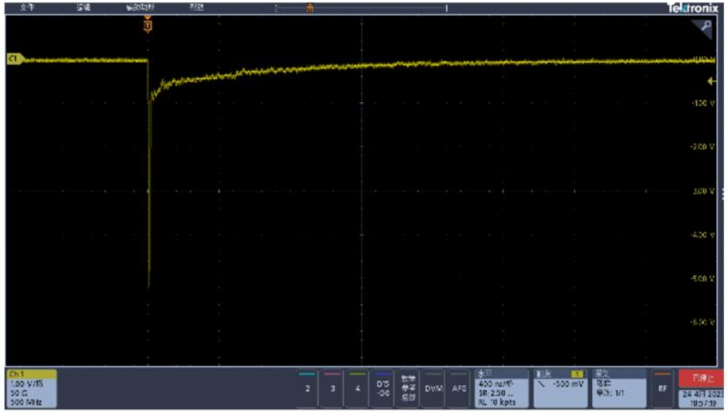
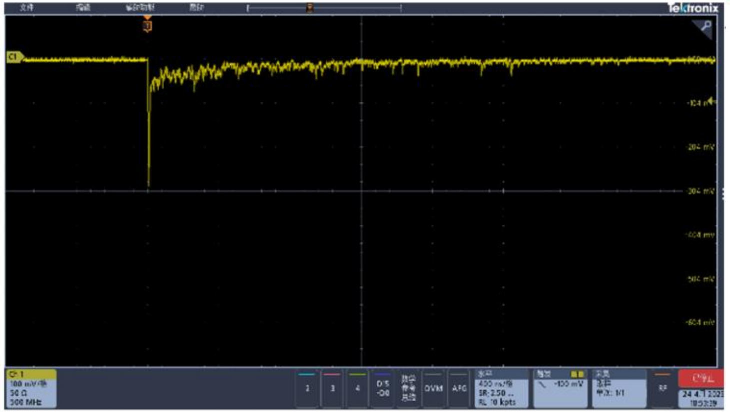
- GTAF-II introduce
- **DAQ system**
- Experiment setup in Air and Vacuum
- Sn and I experiment

Signals of BaF_2 detector

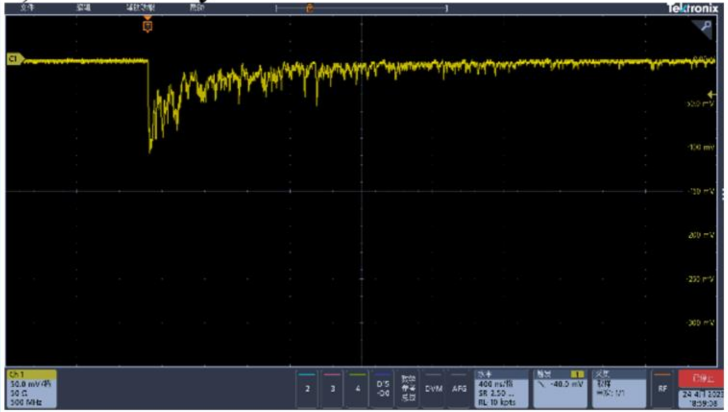


a) Cosmic ray

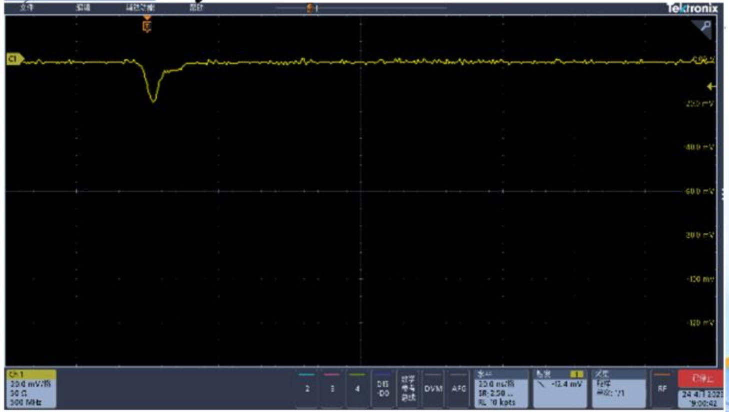


b)Gamma ray

α particle
from Radium
impurity in BaF_2



c)α particle

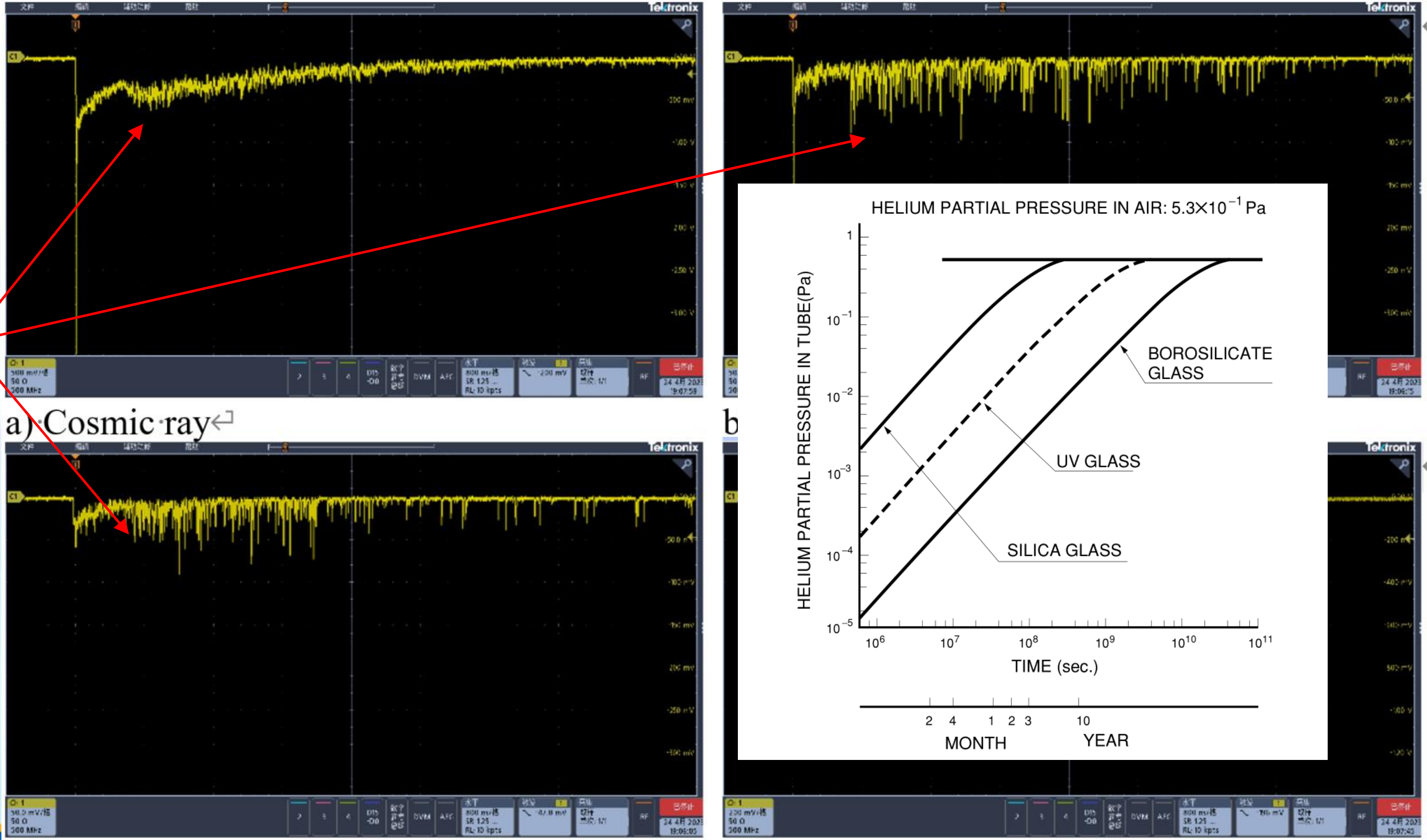


d)spike

Signals of BaF_2 detector

Afterpulses

Caused by He



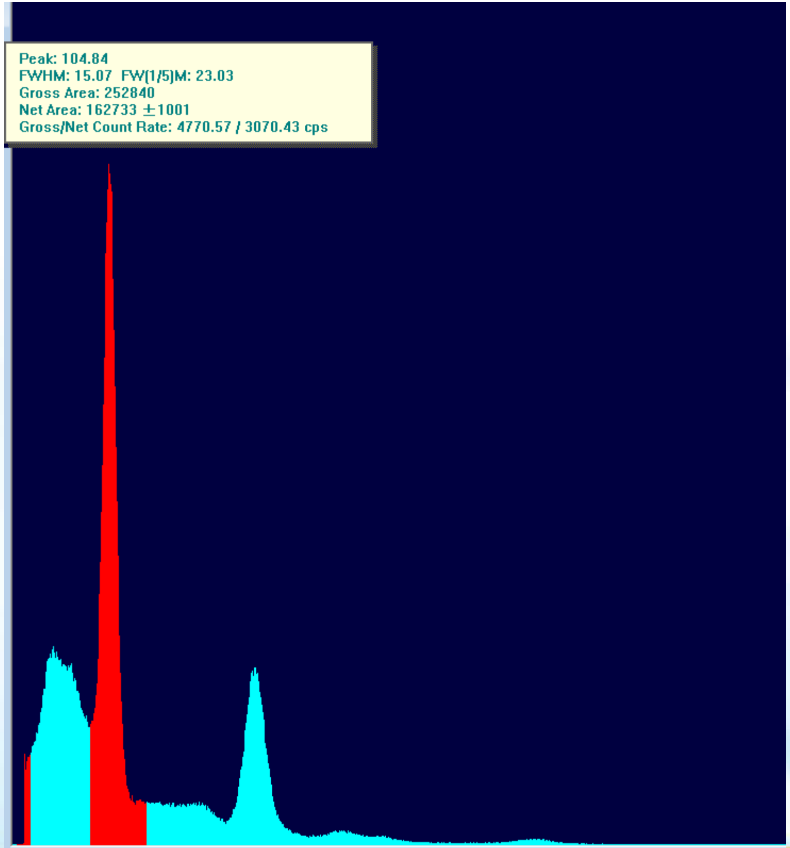
a) Cosmic ray

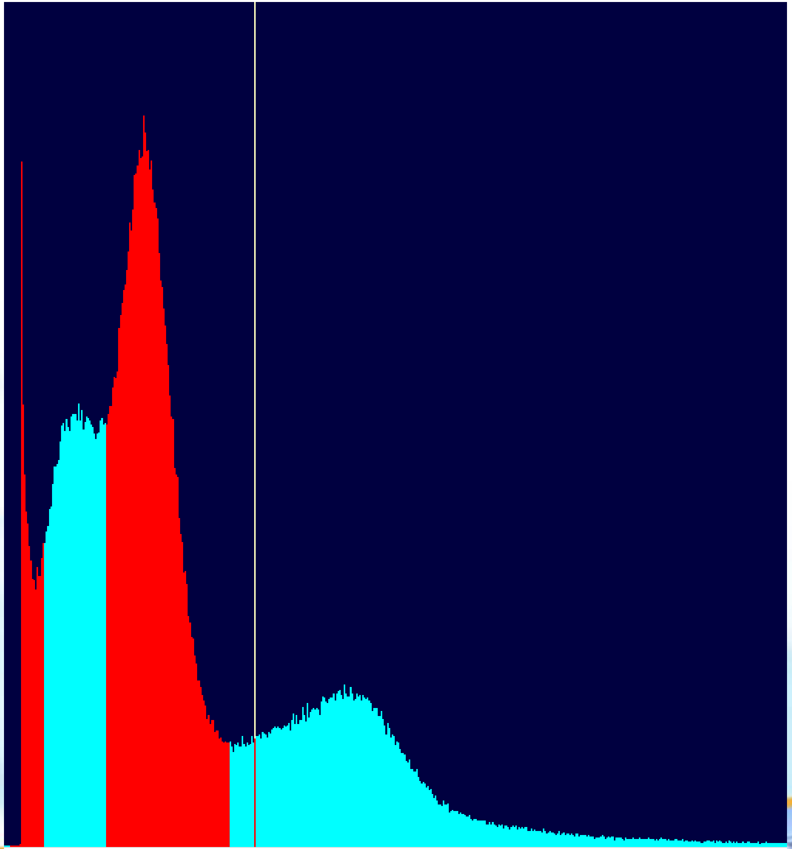
b

c) α particle

d) spike

Energy resolution of Detectors

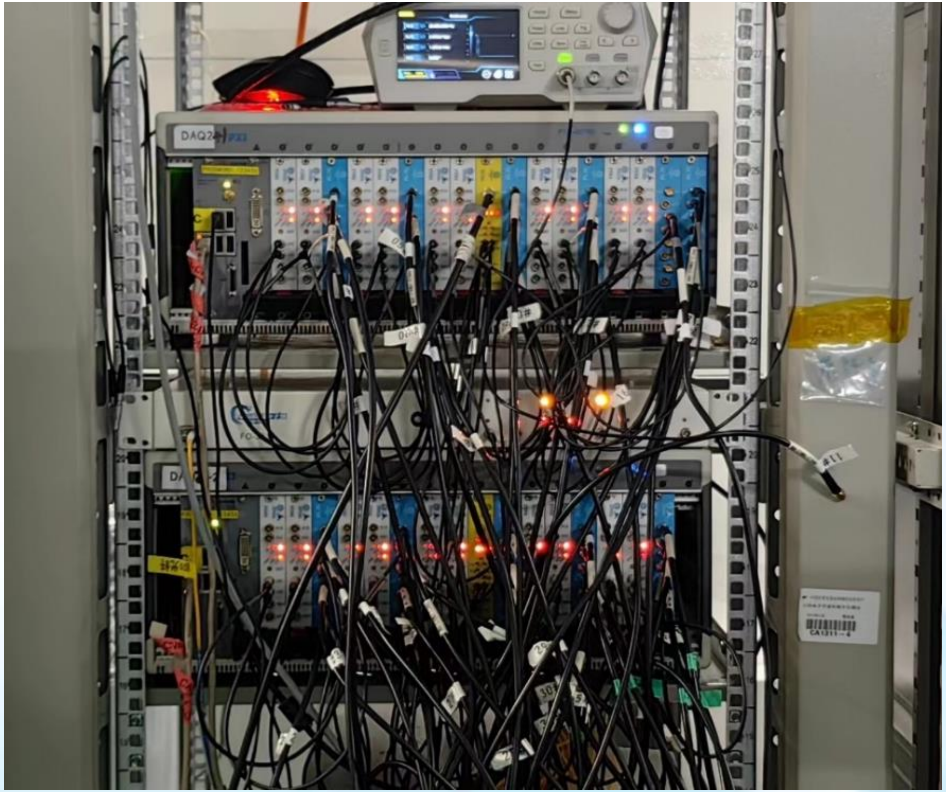




Detector renewal Plan

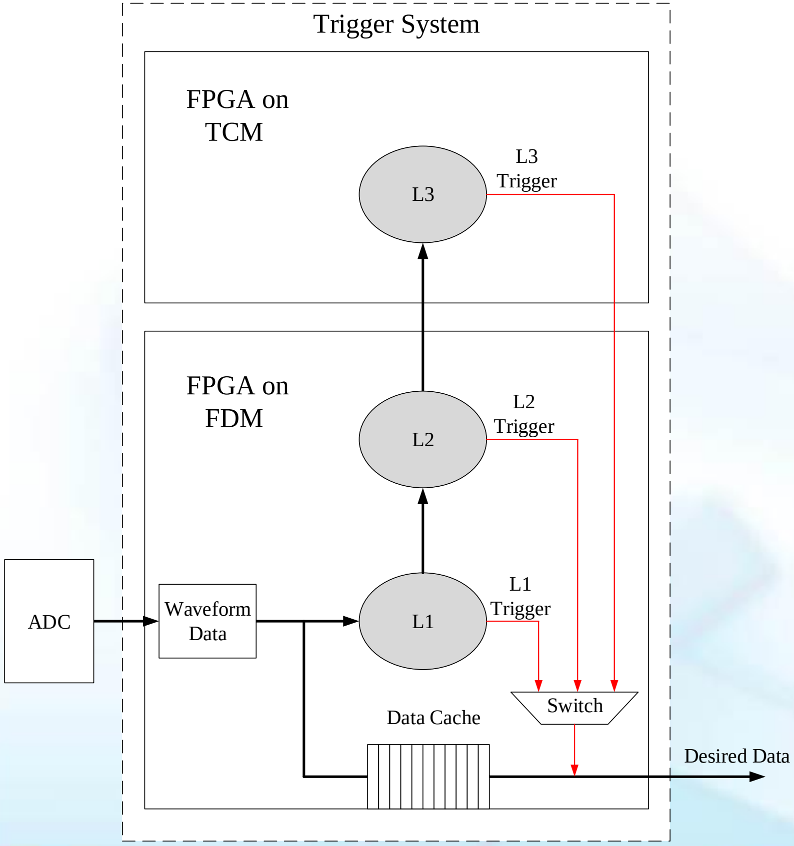
- To solve Afterpulses and improve energy resolution
- PMT replacement will be processed in summer of 2023

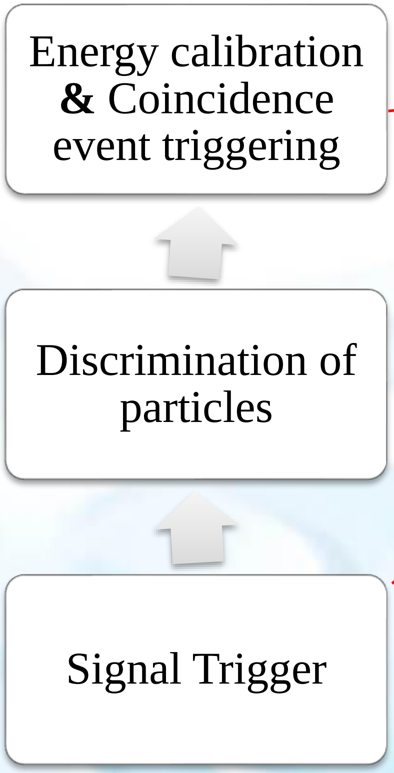
DAQ system



- General-purpose readout electronics by University of Science and Technology of China
- Waveform acquisition
- TCM、SCM、FDM
- Double crate is used
- New General-purpose readout electronics will be available soon

Trigger in GP-re





Eliminate:

1. (n, n'),
2. scattering gamma,
3. background gamma

Eliminate: background α

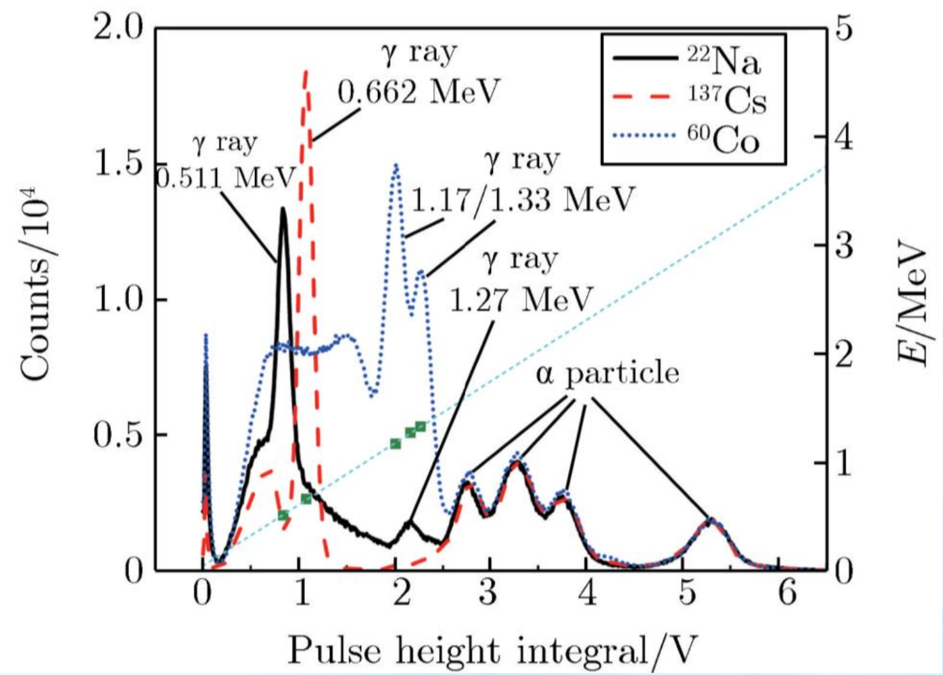
Eliminate:

1. null data
2. spike signal

Usually used trigger mode:

- L1 only;
- L1+L3(coincidence only)

GTAF-II calibration and energy resolution



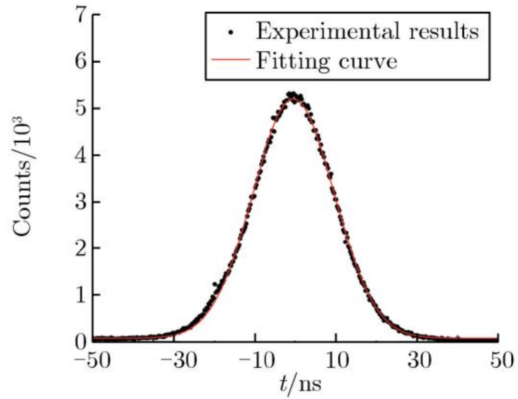
BaF$_2$探测器单元的脉冲积分谱和能量刻度

GTAF-II energy resolution

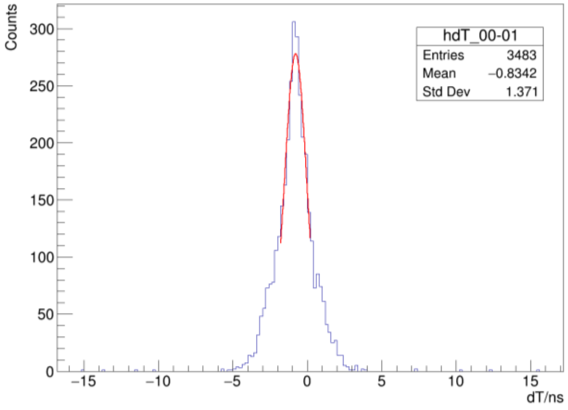
放射源	能量分辨率/%
^{22}Na（0.511MeV）	20.9±2.8
^{137}Cs（0.662MeV）	20.2±2.4
^{60}Co（1.17MeV&1.33MeV）	19.6±2.2
^{22}Na（1.27MeV）	19.5±1.9

GTAF-II time resolution（^{60}Co cascade gamma rays）

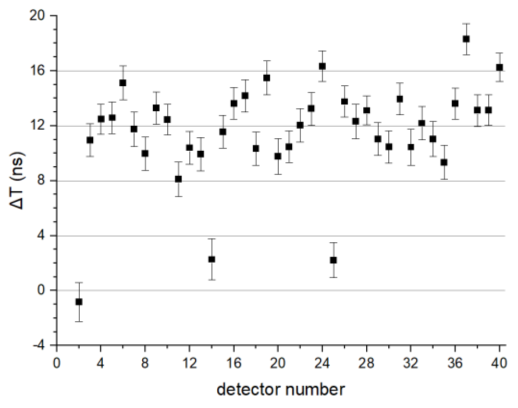
Total time resolution



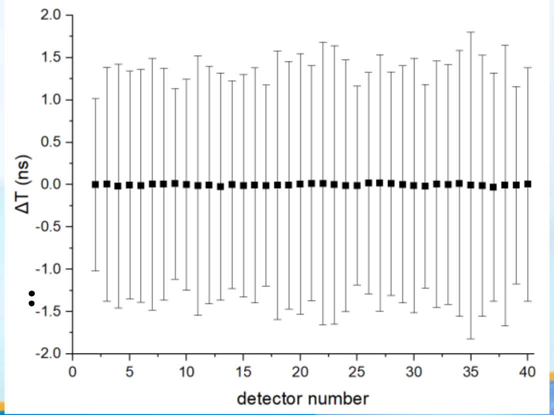
Relative time Resolution of two detector：



Before correction

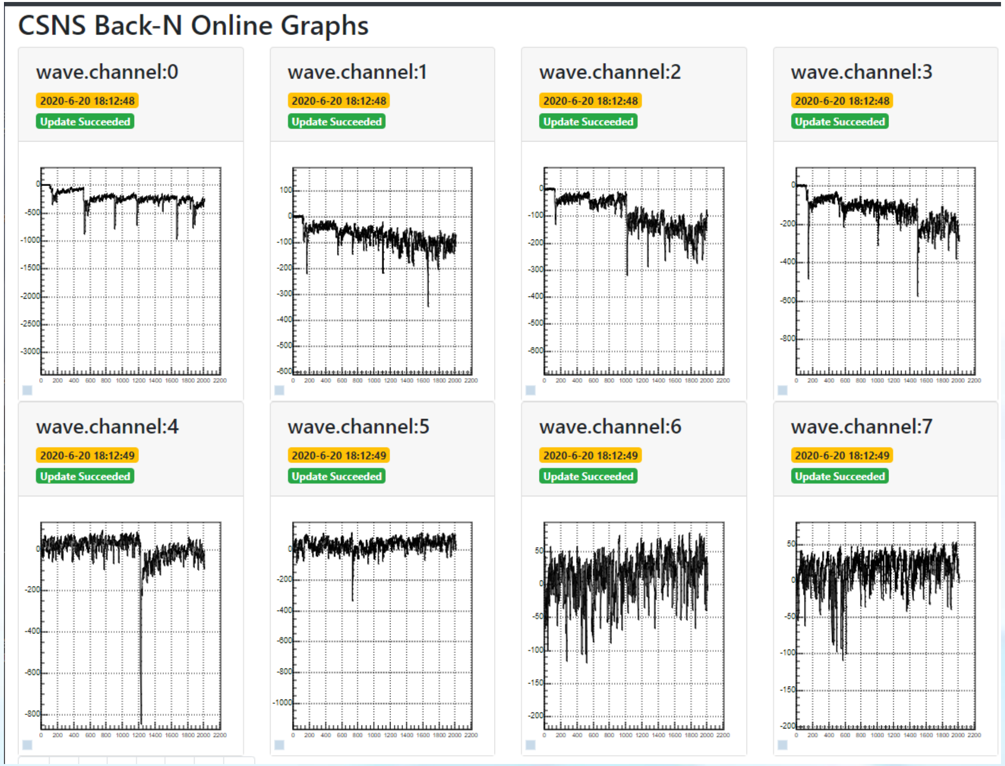


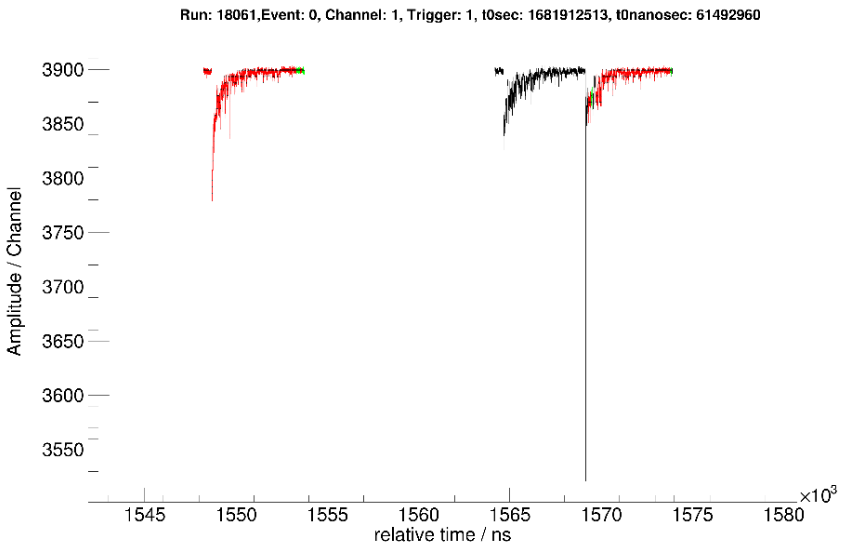
After correction：



所有探测器之间的时间差平均值已经调整到0.1ns以内，所有探测器之间级联γ射线信号时间差的分布集中在±2ns以内

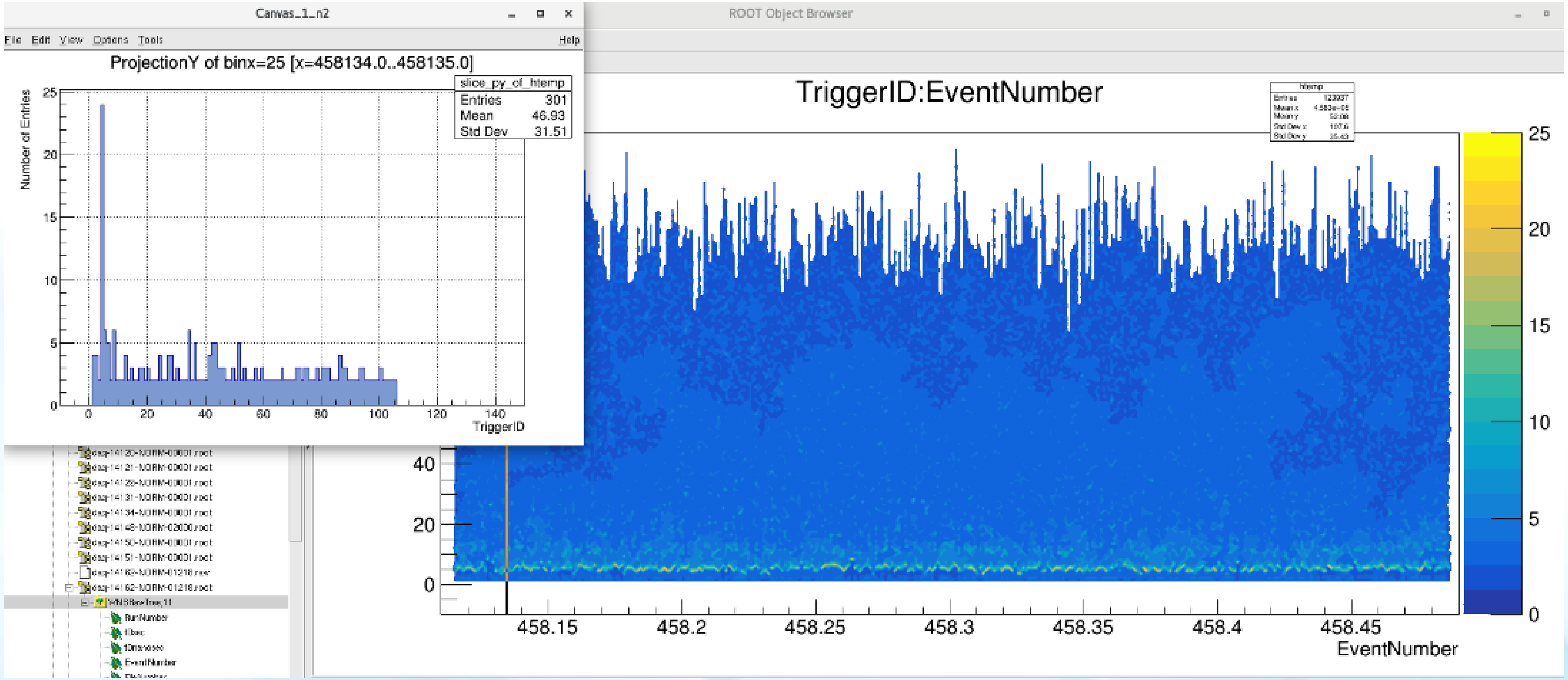
GTAF-II on beam signals



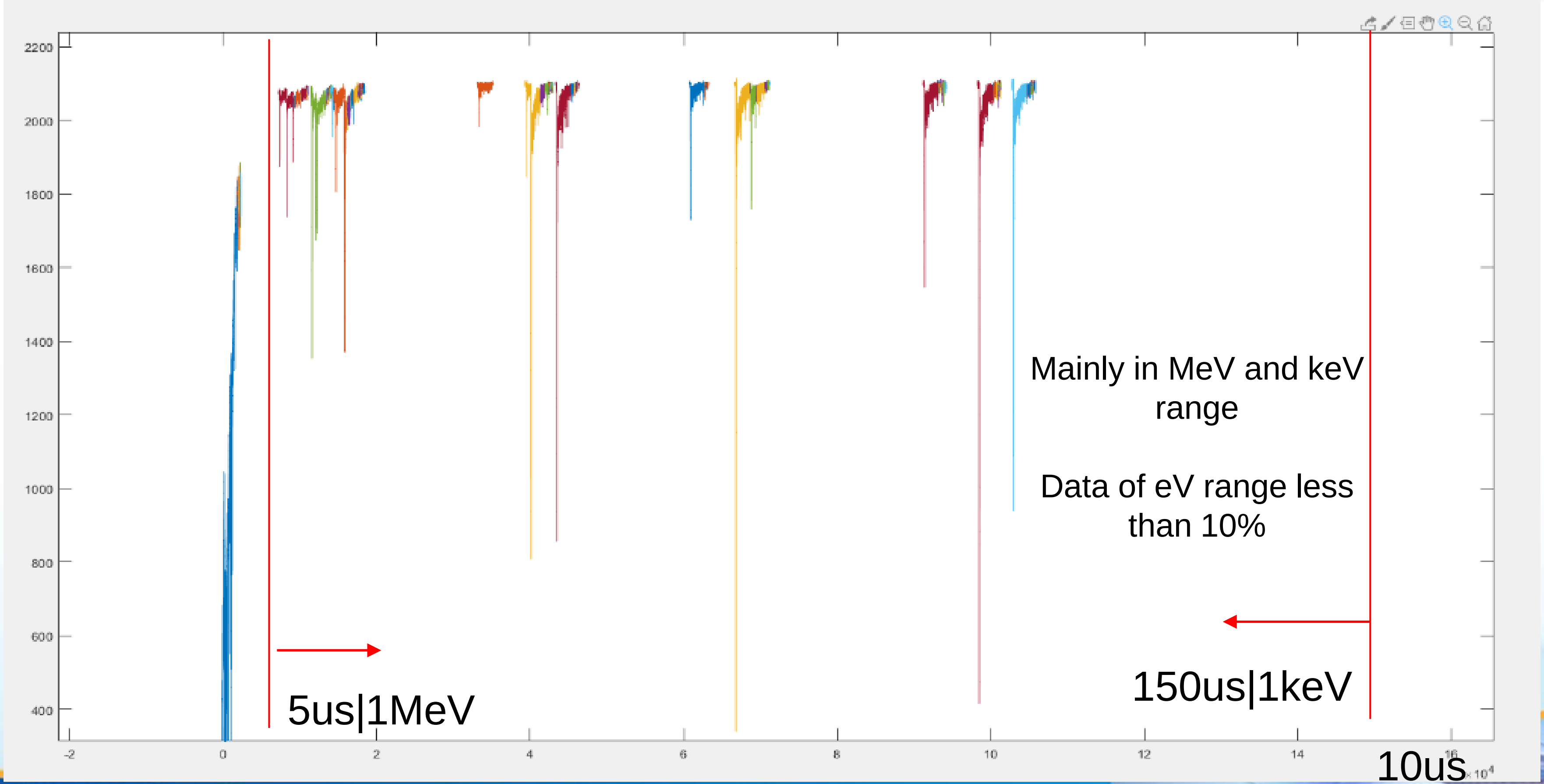


共用电子学采集逻辑改进后：过阈时间（触发）正常

Data of GTAF experiment



Signal distribution



Mainly in MeV and keV range

Data of eV range less than 10%

DAQ system

- General-purpose digital data acquisition system (GDDAQ) by Peking University
- https://github.com/wuhongyi/PKUXIADAQ
- Customization for BaF_2 detectors by WU HongYi
- Real-time processing， no need to record Waveform

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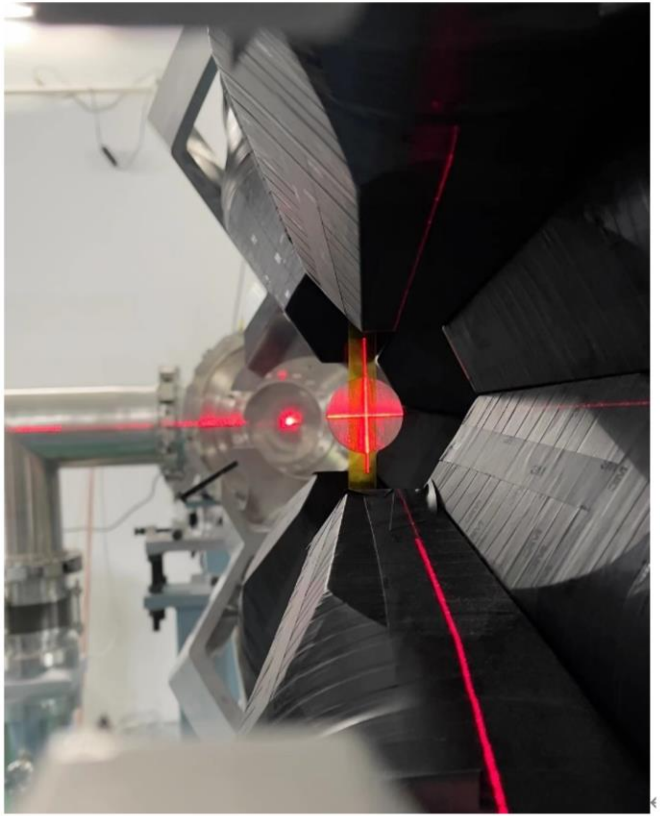
- GTAF-II introduce
- DAQ system
- **Experiment setup in Air and Vacuum**
- NOPTREX related experiments

Experiment in Air

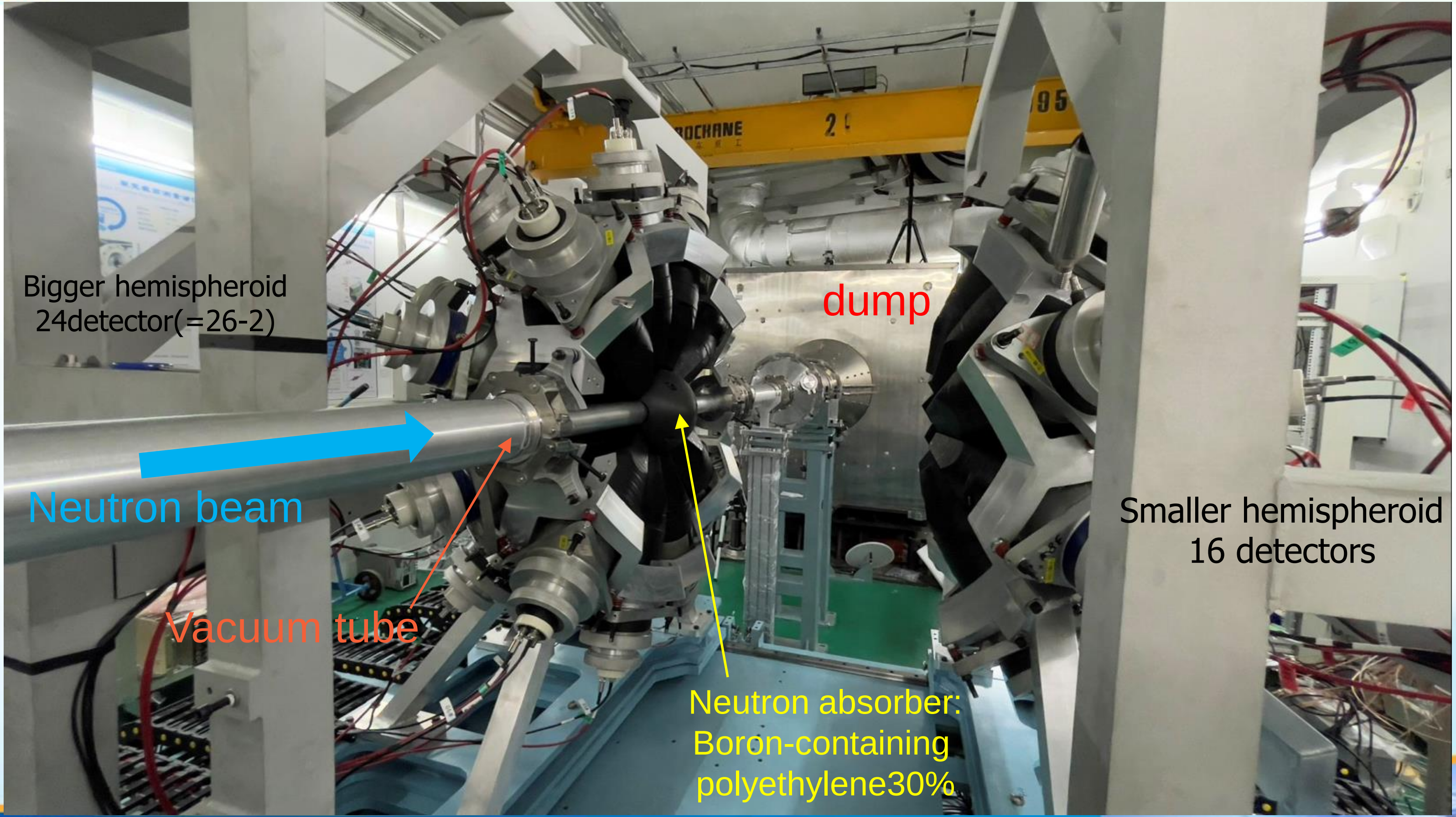


a) Sample

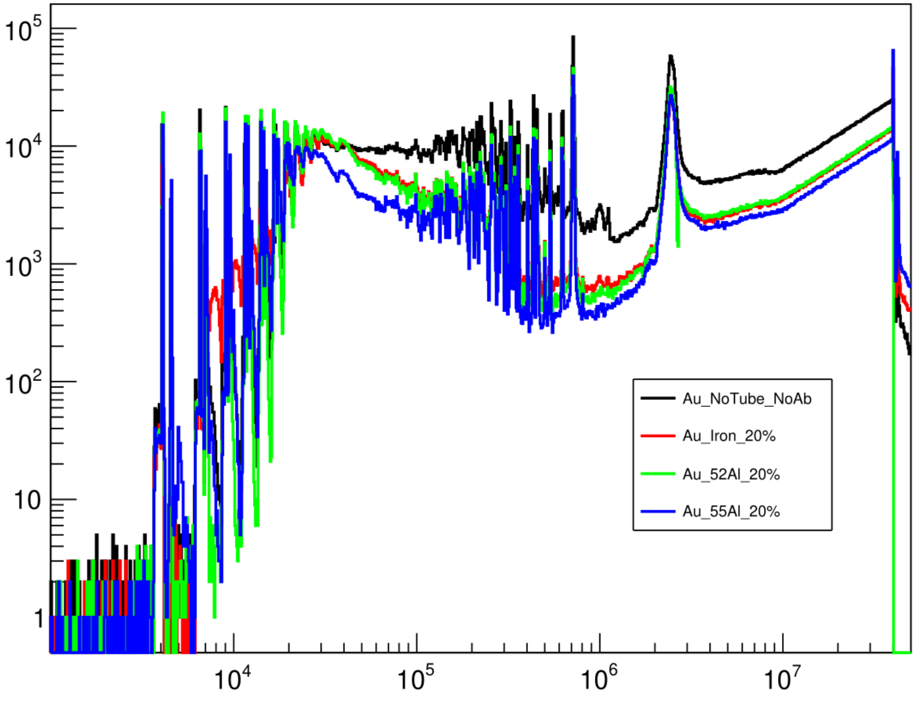
b)Upstream of GTAF-II

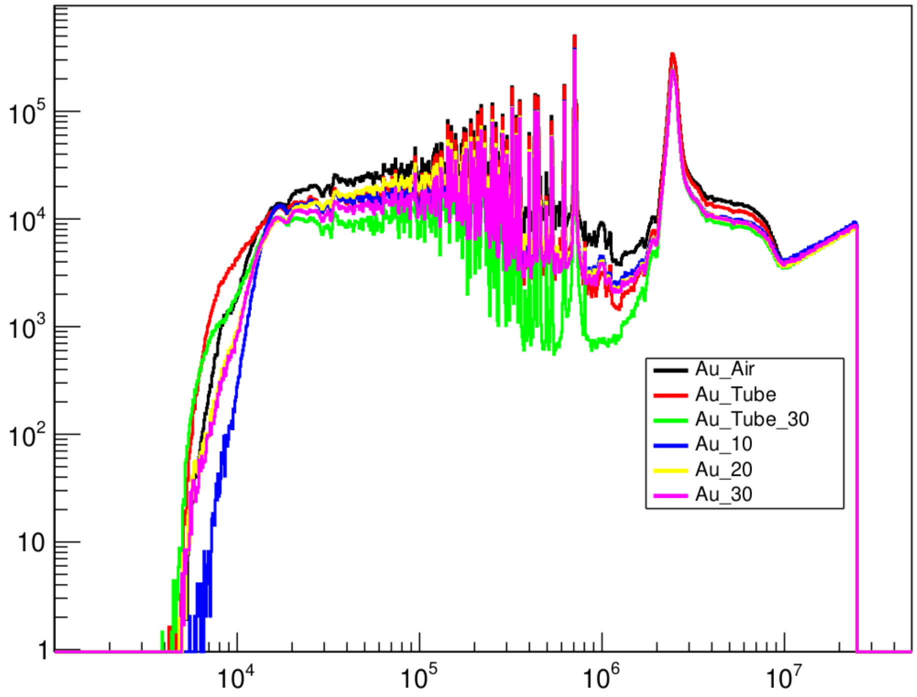
c) Downstream of GTAF-II

Experiment in Vacuum condition



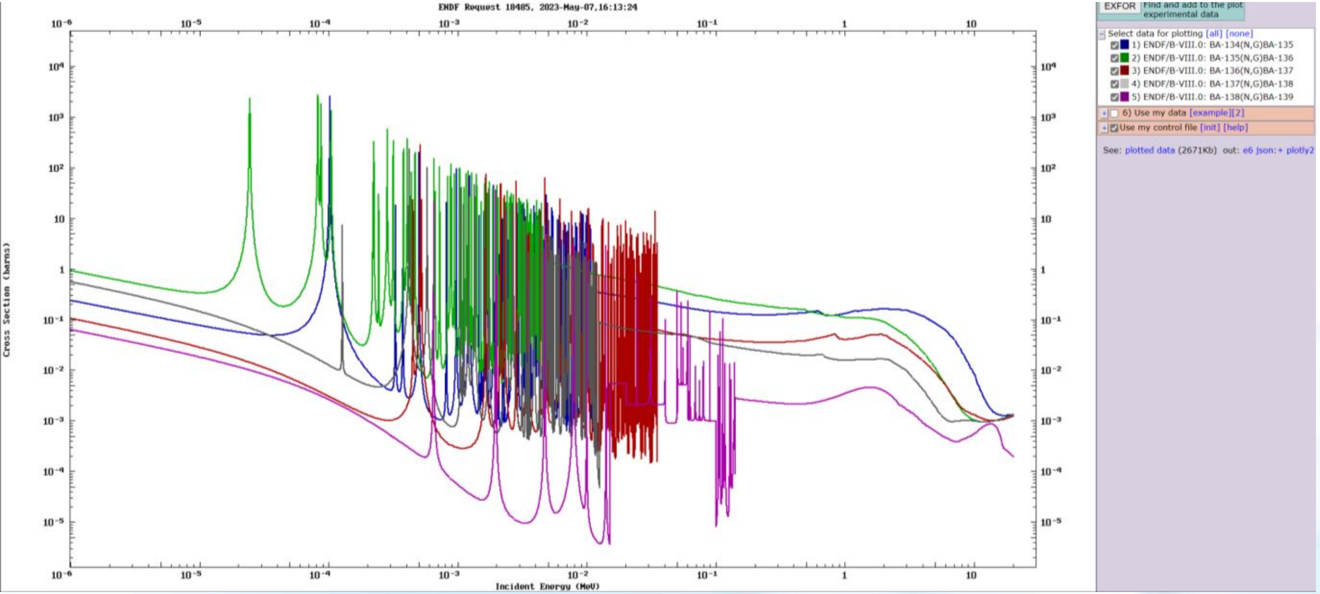
Comparison of experiment condition





Au(n，γ) experiment

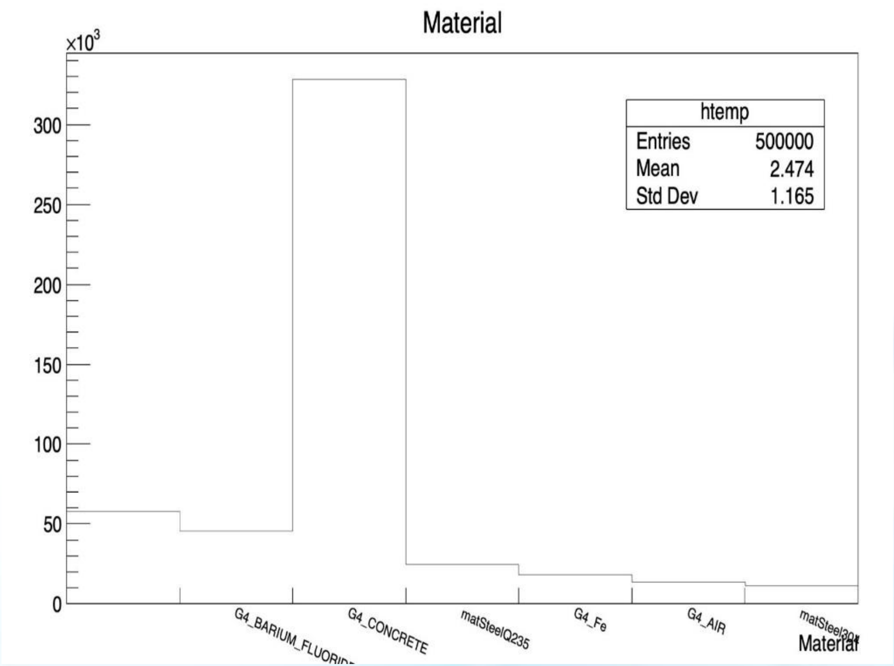
Background (n,γ) events



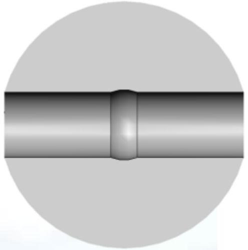
Q value

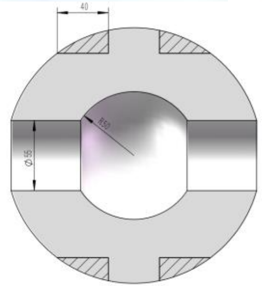
isotopes	abundunce	(n, γ)Q value
^{134}Ba	2.417%	6972.0 keV
^{135}Ba	6.592%	9107.7keV
^{136}Ba	7.854%	6905.6keV
^{137}Ba	11.232%	8611.7keV
^{138}Ba	71.698%	4732.4keV
^{19}F	100%	6601.34keV
^{48}Ti	73.72%	8142.38keV
^{27}Al	100%	10833.3keV
^{56}Fe	92%	7646.2keV

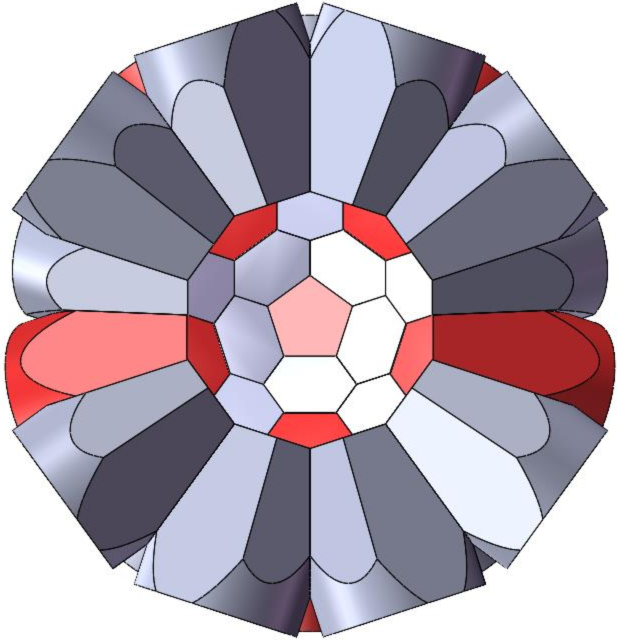
Neutron Absorber with vacuum conditon



e

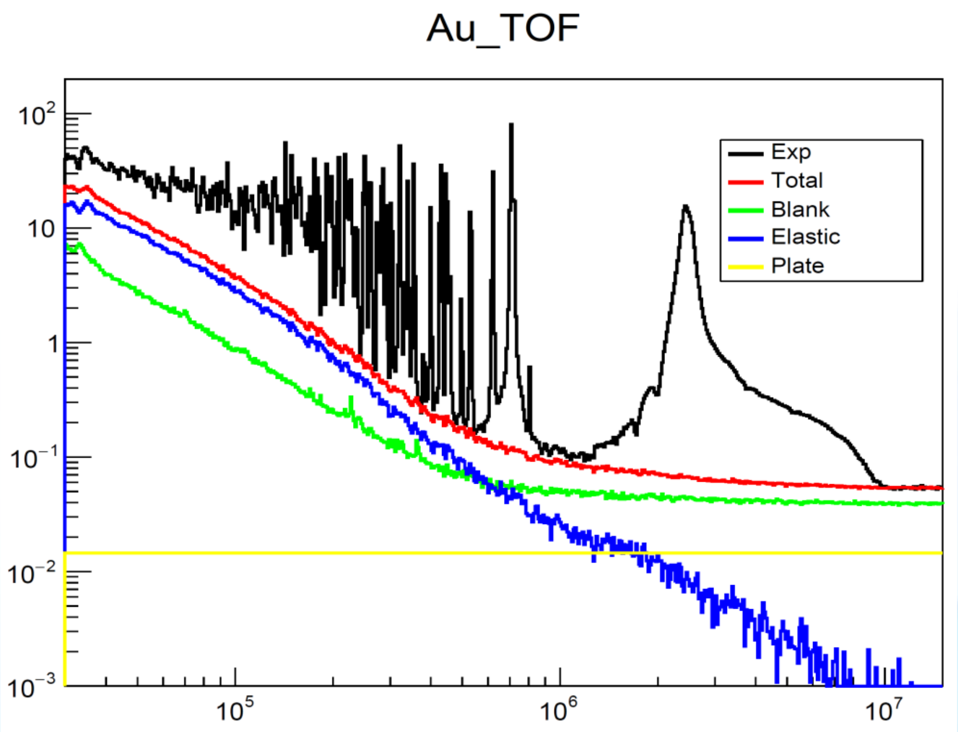


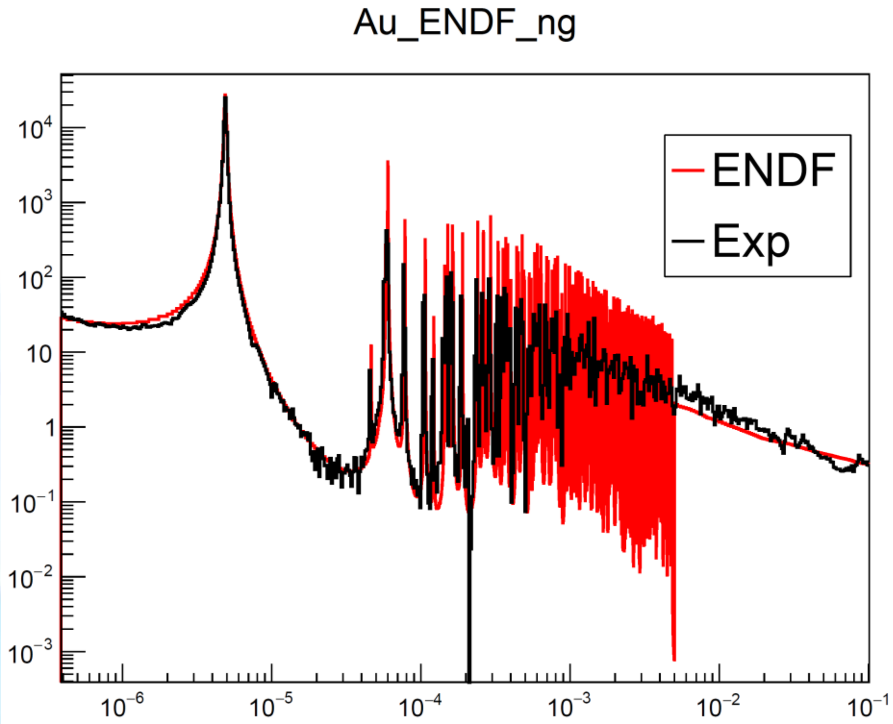




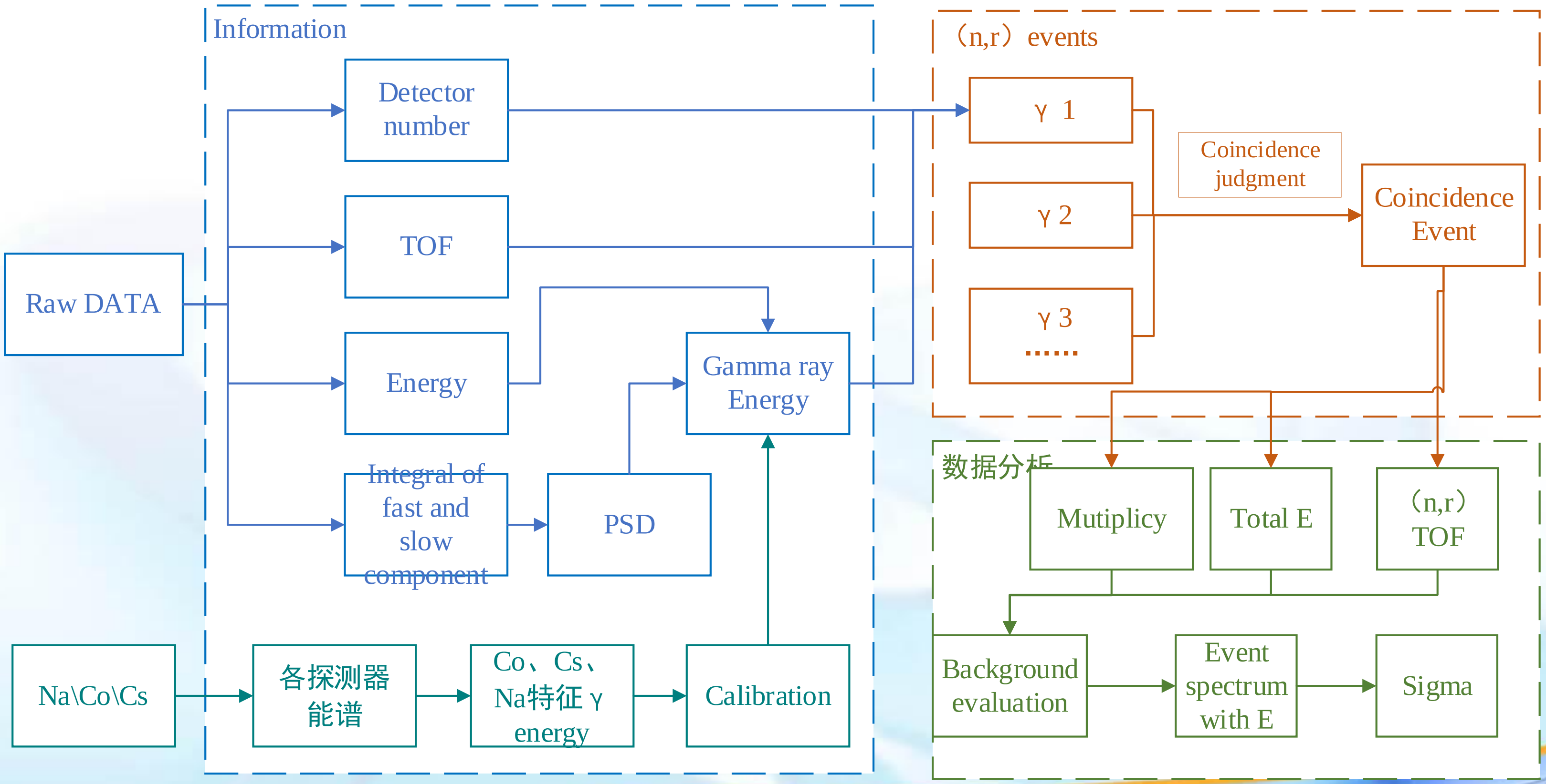
- **Absorbers around GTAF in future(Li_2CO_3、B、Pb)**

Background rejection





DATA Dealing Process



Background evaluation

$$C_{Sample\_Net} = C_{Sample} - C_{Bk} - C_{Sample\_PBg} - C_{Sample\_El}$$

C_{El}、C_{Bk}、C_{PBg}表示样品散射中子本底、样品无关的束流本底和无束流本底（TOF谱末端平本底）；
C_{Sample} 表示实验中样品原始计数；
C_{Net}表示样品减去本底后的净计数。

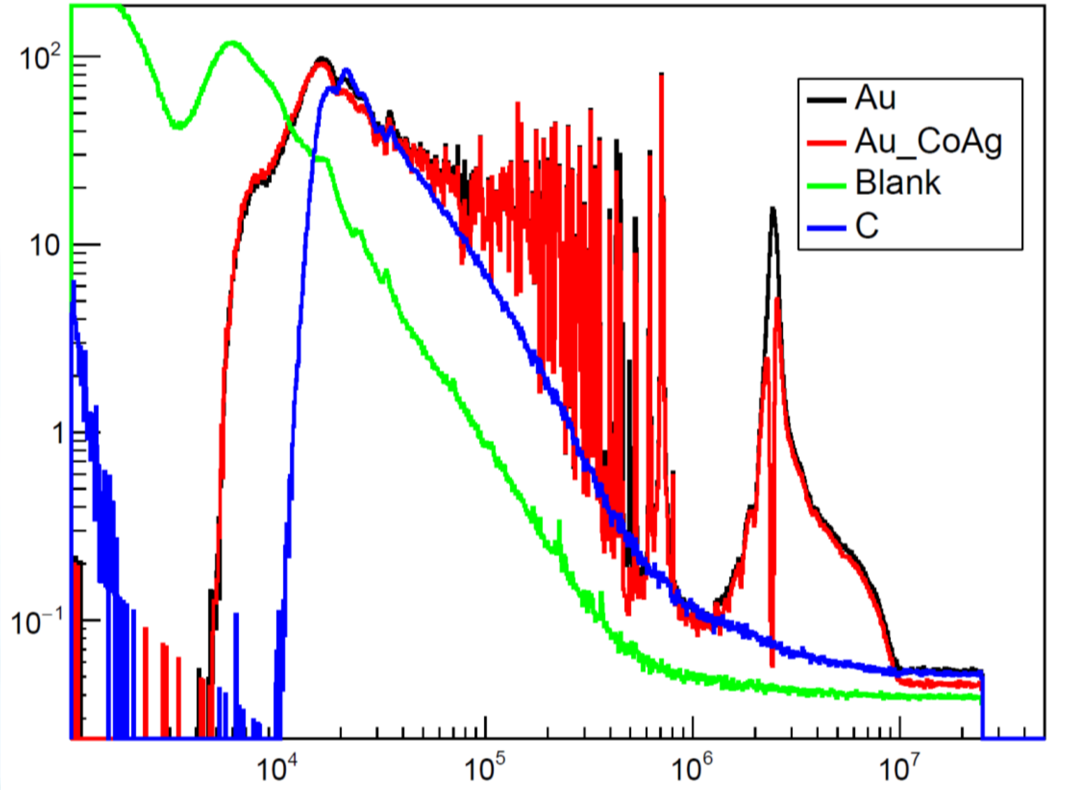
C、Pb主要是散射截面贡献，因此：

$$C_{C\_El} = C_C - C_{Bk} - C_{C\_PBg}$$

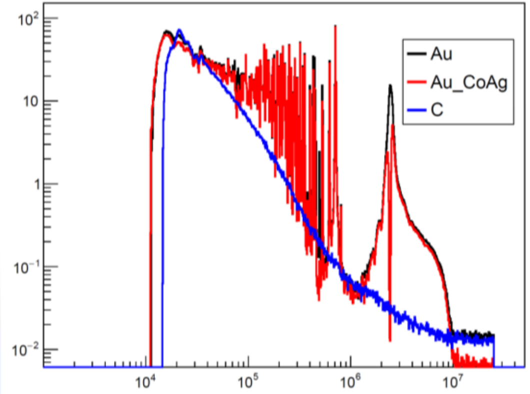
使用η表示待测样品与C样品的散射中子贡献比值，则：

$$C_{Sample\_Net} = C_{Sample} - C_{Bk} - C_{Sample\_PBg} - \eta \cdot C_{C\_El}$$

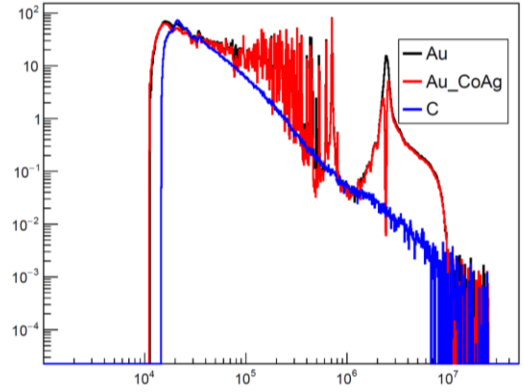
根据确认η的方法的不同，分为吸收片定量法、模拟计算扣除法、TOF-加和能二维谱扣除法三种



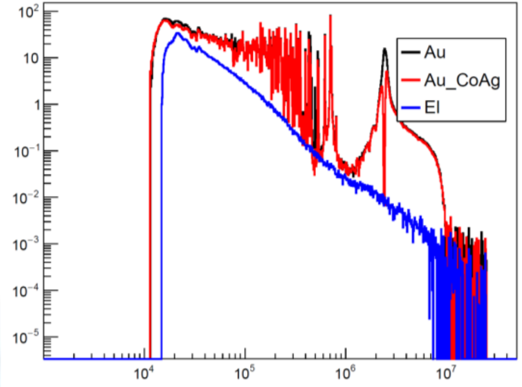
吸收片定量法



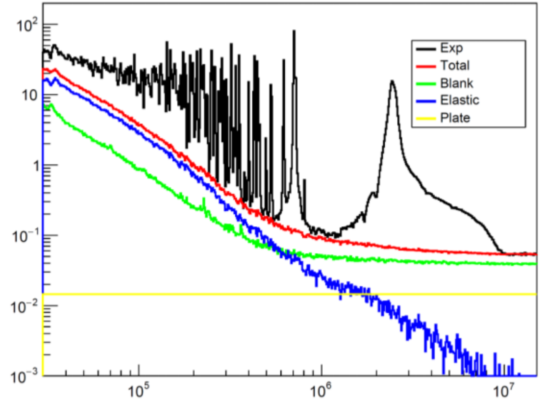
a)扣除空样品贡献后 TOF 谱



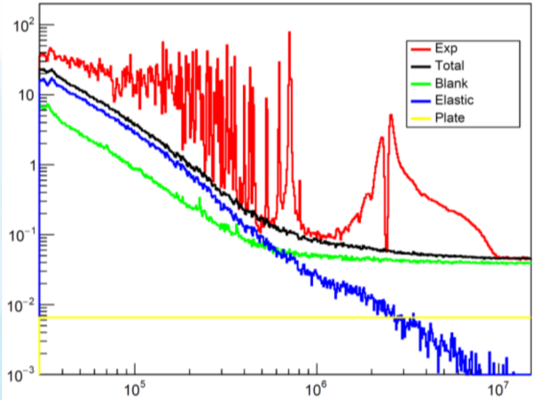
b)扣除平本底后 TOF 谱



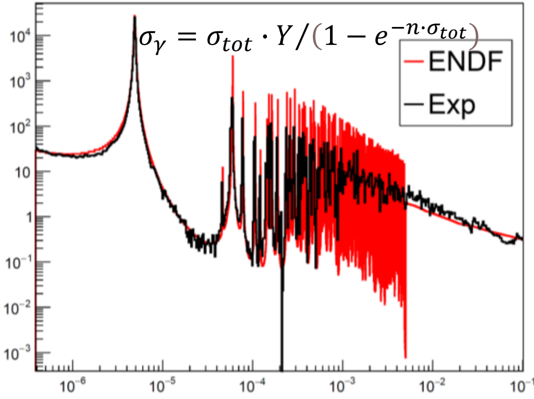
c)波谷定量散射中子本底



d)本底在 Au-TOF 谱的贡献



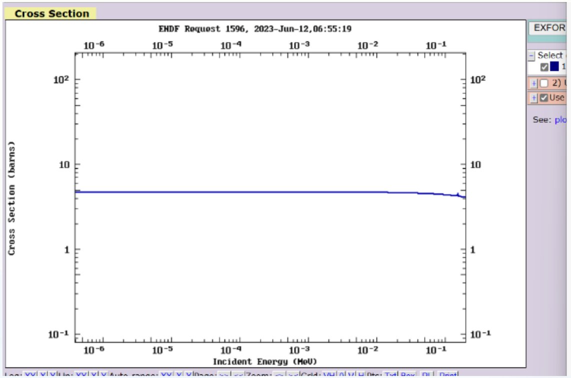
e)带吸收片的金样品本底

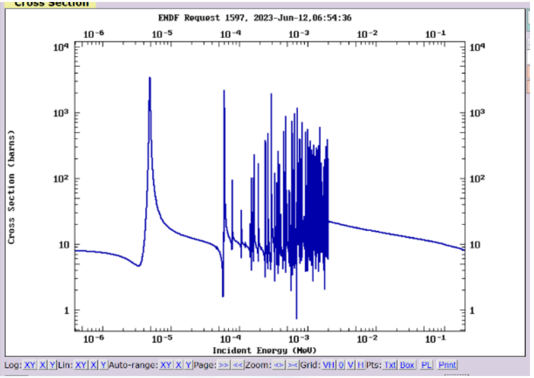


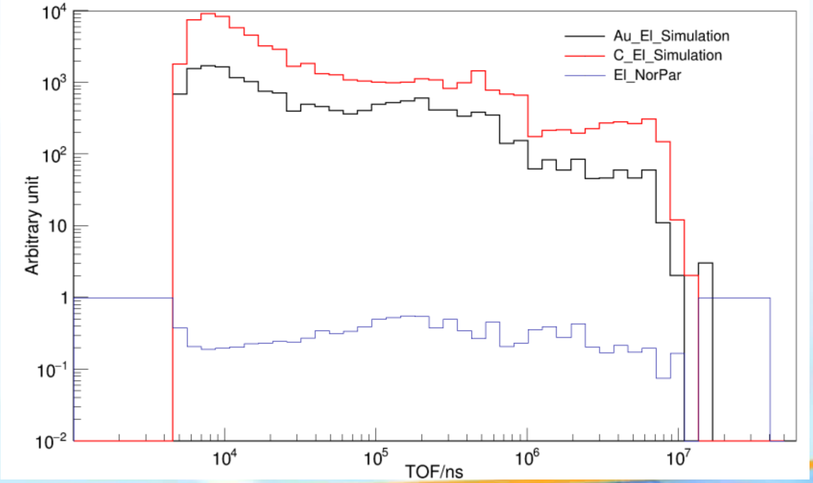
f)Au 截面实验谱与 ENDF 谱

Background Simulation

- 吸收片定量法在所有能量点处使用同一个η，也就是认为待测样品与C样品的散射中子贡献比值不随能量而变化；由于不同核素激发曲线趋势不一致，实际上η也应当随入射中子能量有一定的变化。
- 但由于样品自吸收的影响，无法直接用截面计算，需要通过模拟确认二者的比例。
- 模拟过程中可以耦合样品尺寸、自吸收效应、探测效率等方面的影响

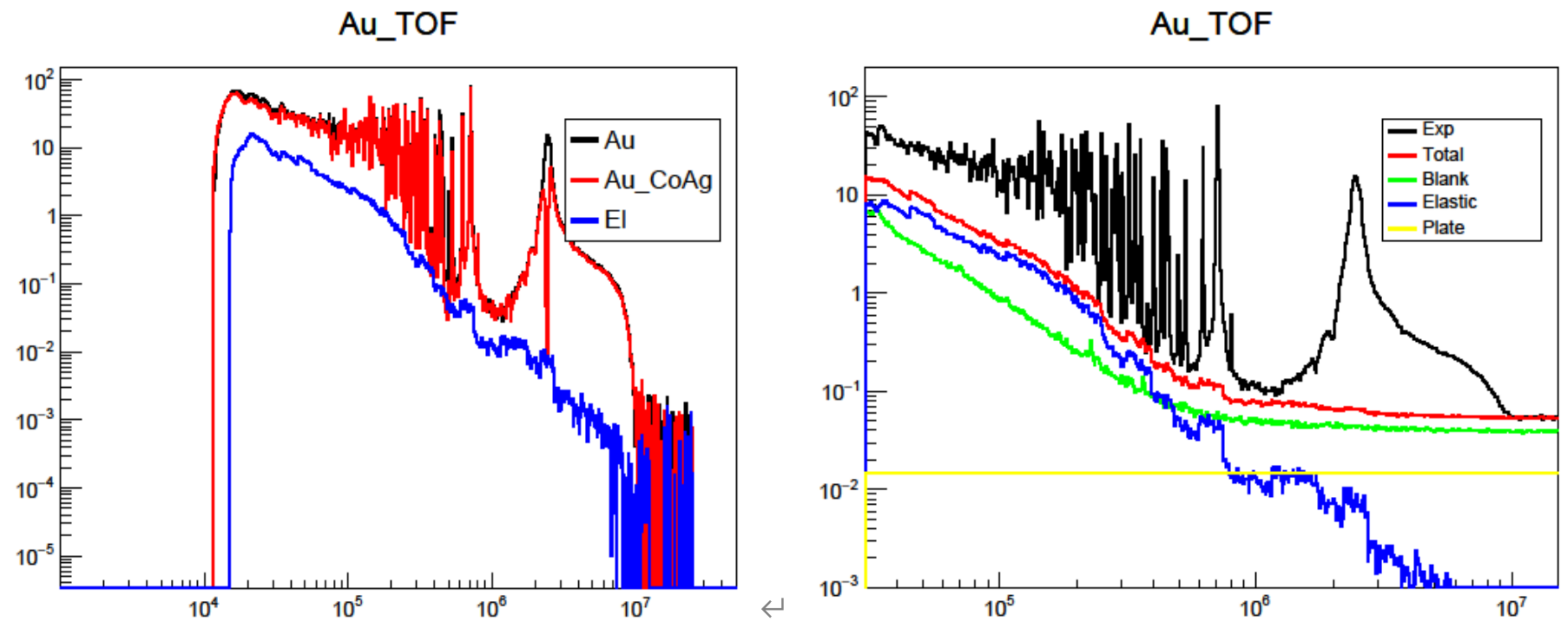






NanHua University,
CHENG Pinjing

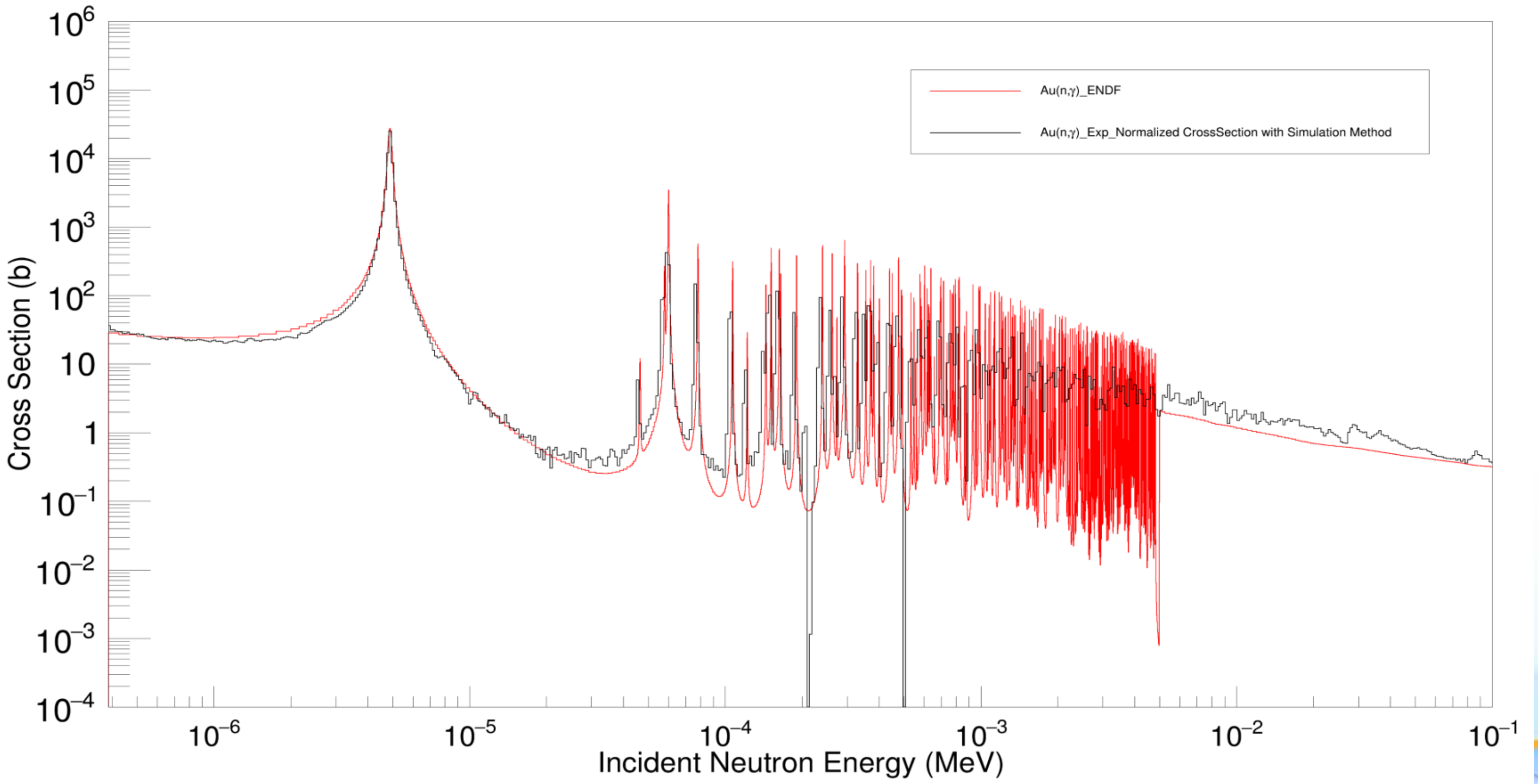
Background evaluation by Simulation



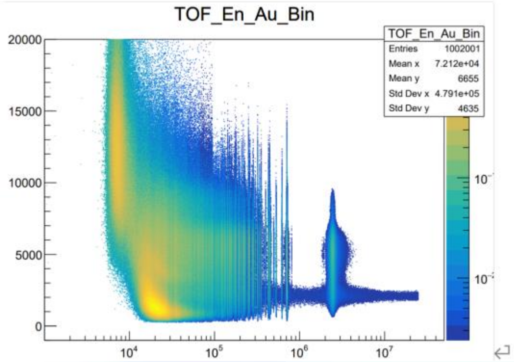
a)依模拟比例确定的金散射本底

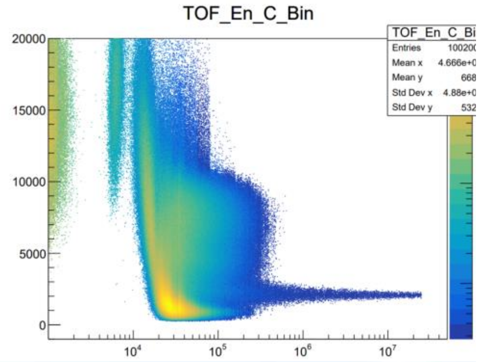
b)Au(n, γ)效应及本底来源的 TOF 分布

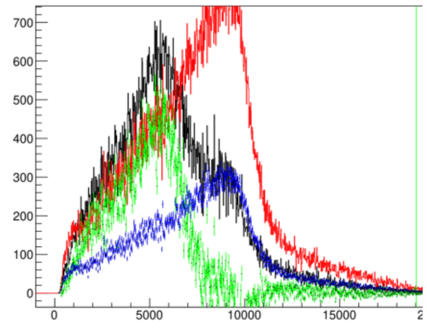
Result by Simulation Background evaluation



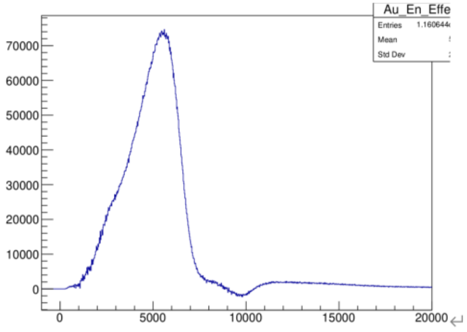
TOF-Total E evaluation



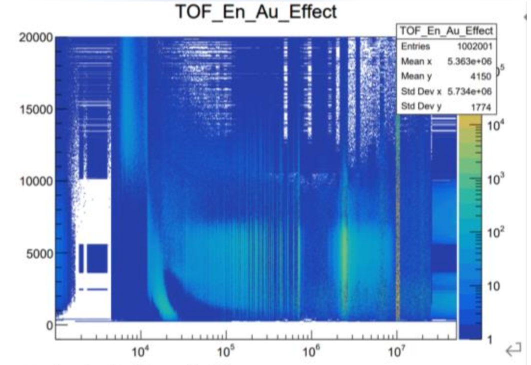




a) 某能区 Au 加和能谱扣散射影响示意

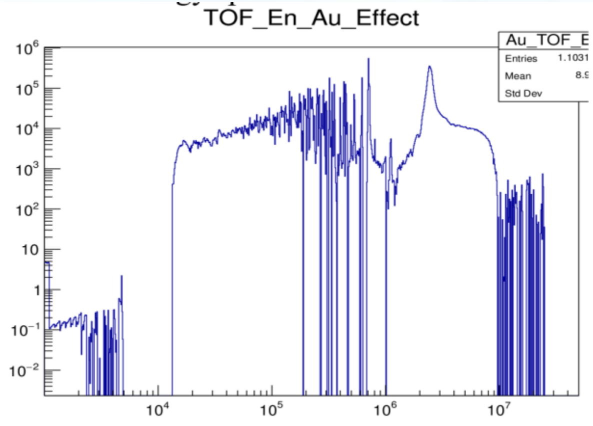


b)扣减后的 Au 效应加和能谱

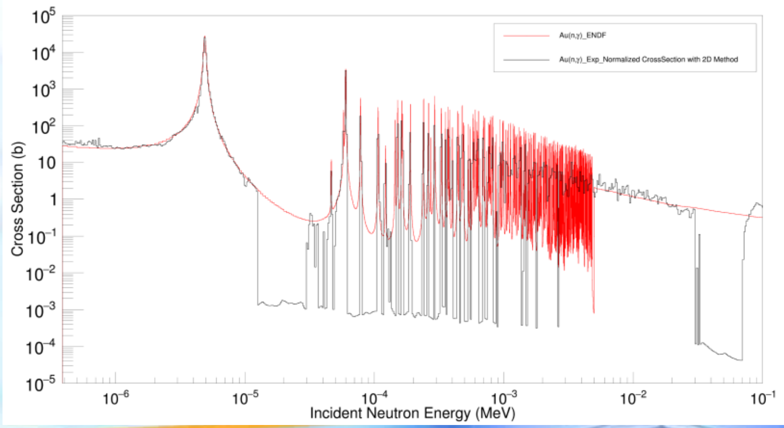


TOF-加和能量二维谱

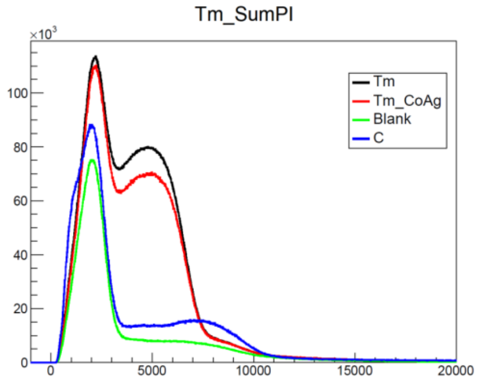
需要较高的实验数据统计量



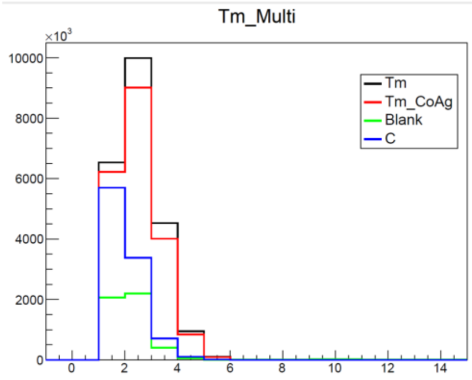
c)扣减后 Au 的 TOF 谱



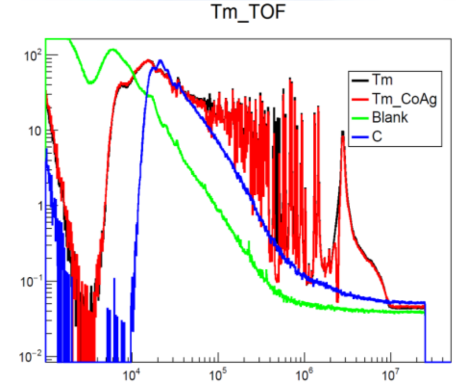
Tm(n, γ) cross section by GTAF experiment



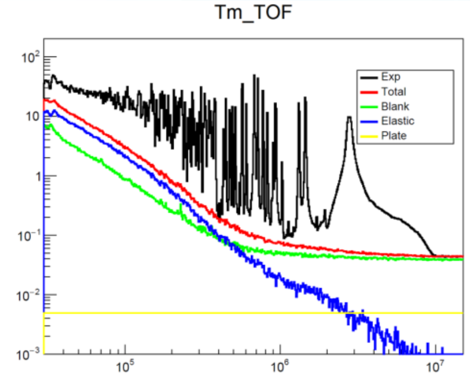
a)加和能谱



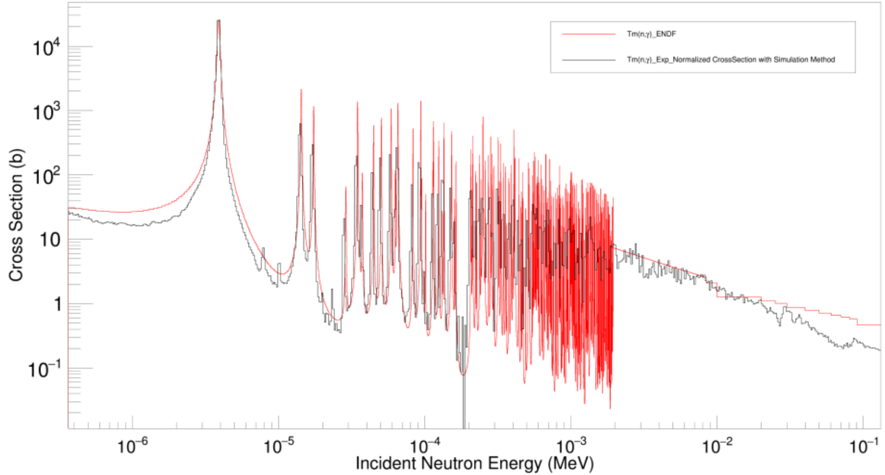
b） 多重性



c)多样品的 TOF 谱对比

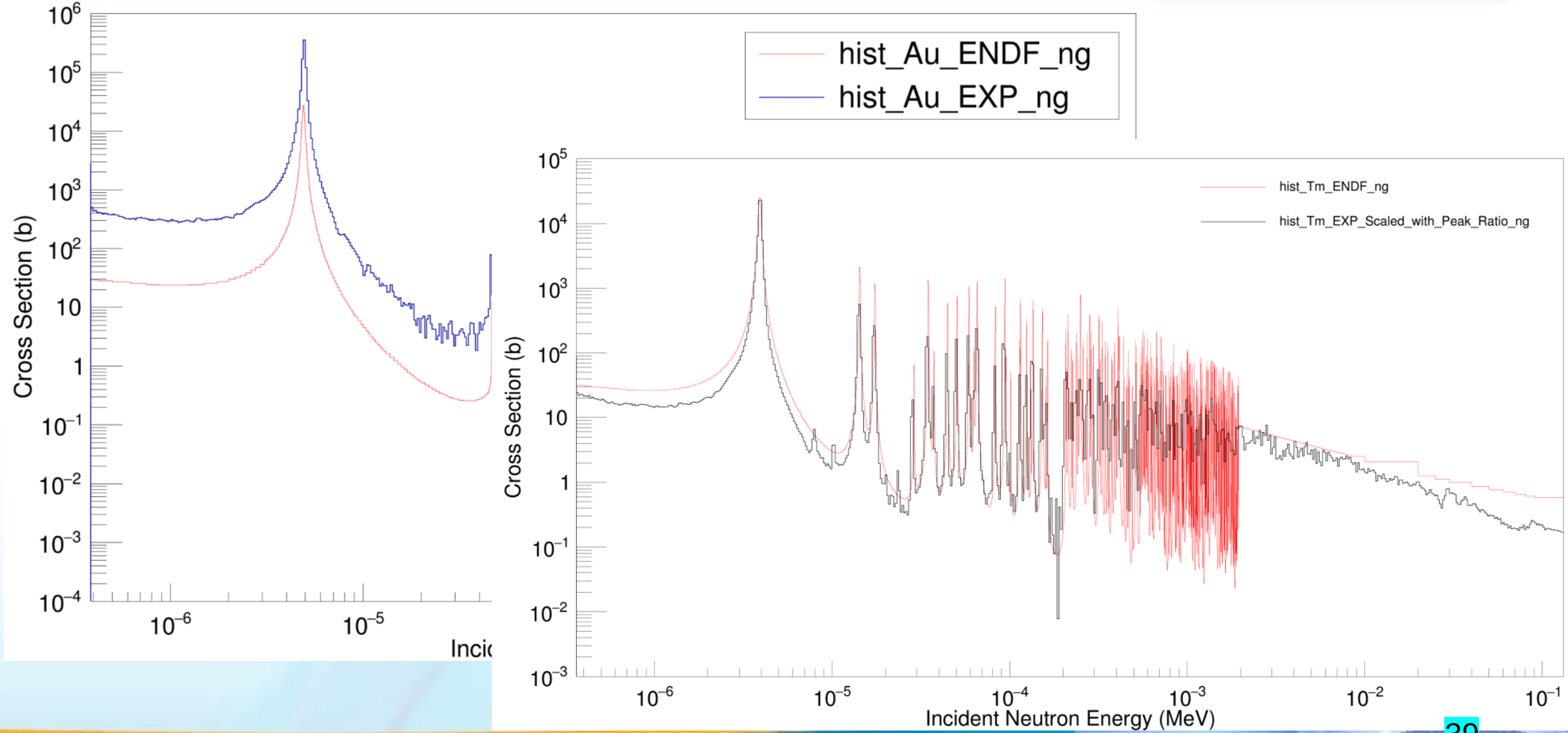


d） 本底来源



采用共振峰归一的结果

Tm(n, γ) sigma relative to Au(n, γ) ENDF



Index

- GTAF-II introduce
- DAQ system
- Experiment setup in Air and Vacuum
- **NOPTREX related experiments**

Sn Experiment in 2022.3

No.	Neutron Absorber of Back-n	Vacuum Condition	Neutron Absorber of GTAF-II	Beam time	
1	Cd	-	-	58h	
2	Cd+Ag+Co	-	-	5h	
3	Cd	Φ55Aluminium-Alloy pipe	PE with 30% B_4C	$\boxed{50h}$	9h
4	Cd+Ag+Co	Φ55Aluminium-Alloy pipe	PE with 30% B_4C	8h	
5	Cd	Φ55Aluminium-Alloy pipe	-	15h	
6	Cd+Ag+Co	Φ55Aluminium-Alloy pipe	-	4h	

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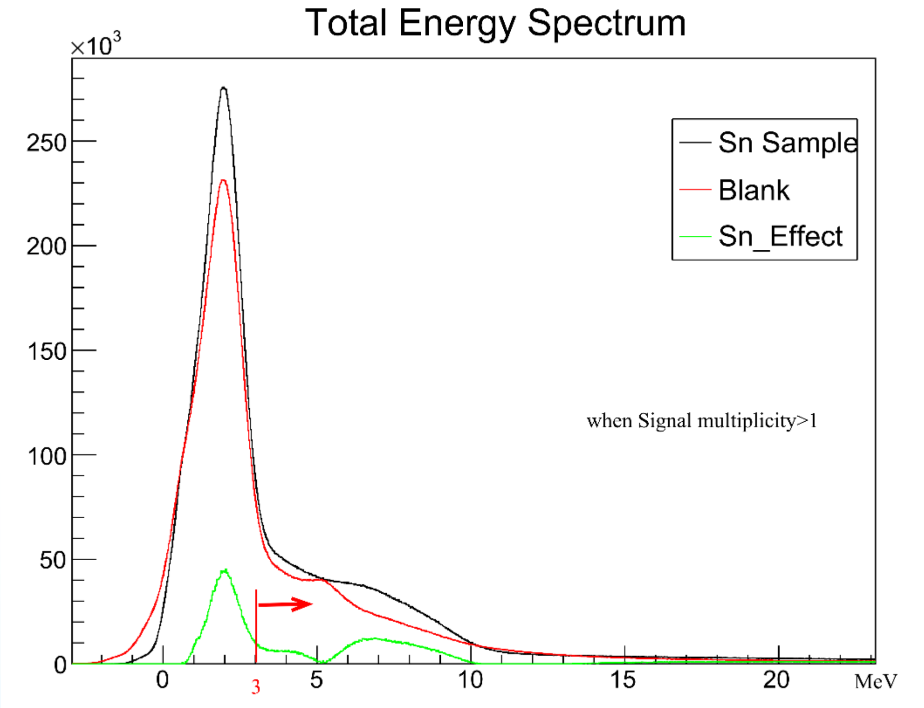
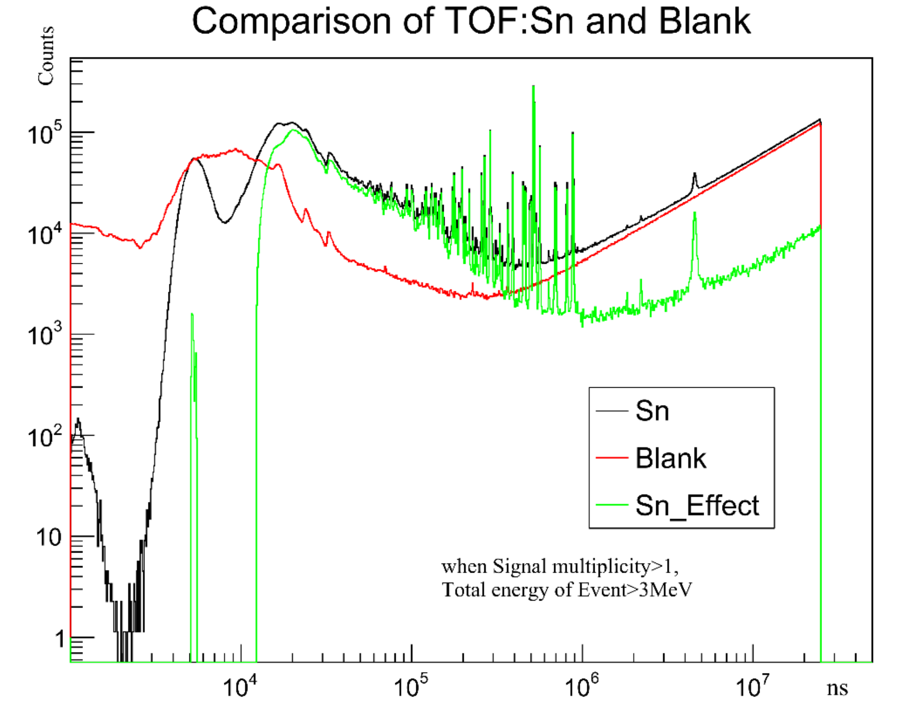
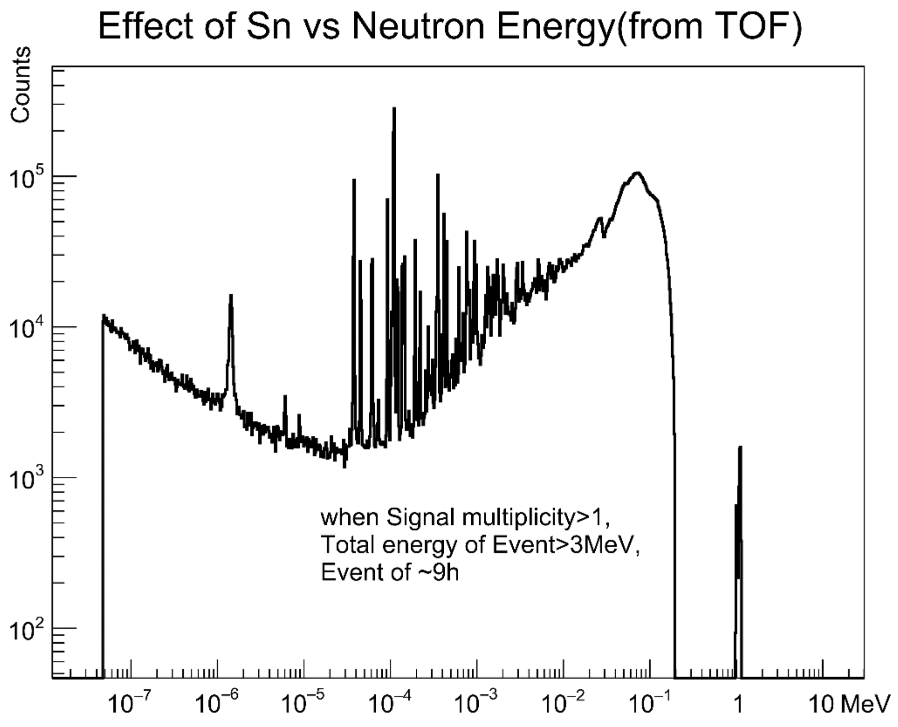
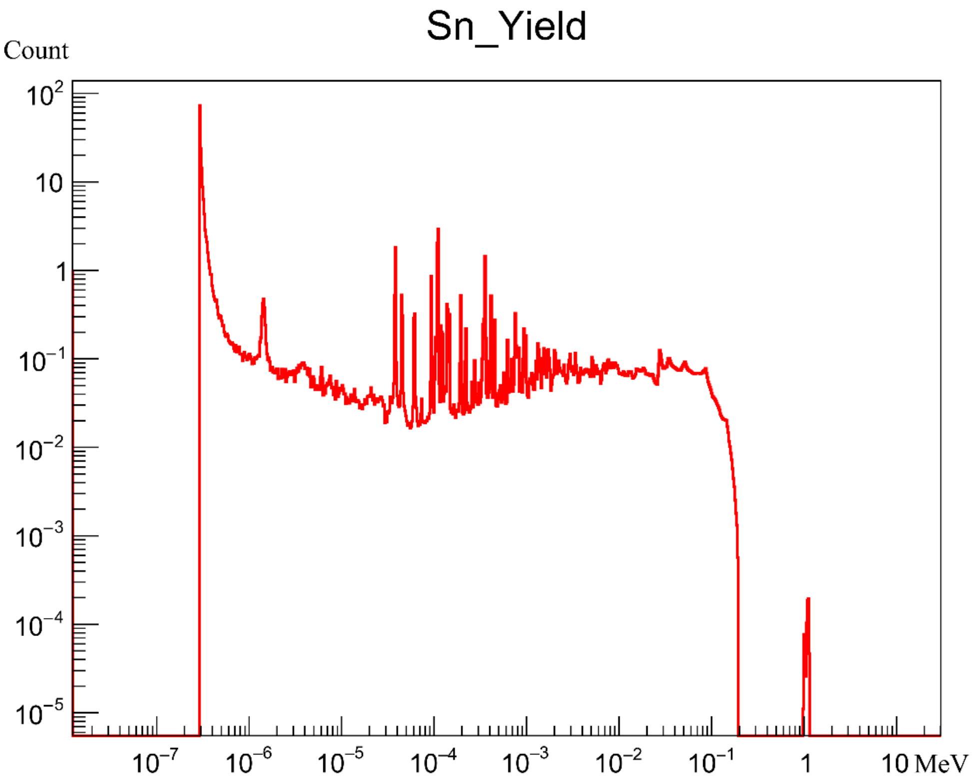
Preliminary Result





Preliminary Result





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CHINA INSTITUTE OF ATOMIC ENERGY
中核集团 CNNC

Experiment in July 2023

- Sample : NaI crystal、 La 、Sn
- Beam time: ~300h

	2023/6/29	2023/6/30	2023/7/1	2023/7/2	2023/7/3	2023/7/4	2023/7/5	2023/7/6	2023/7/7	2023/7/8	2023/7/9	2023/7/10	2023/7/11	2023/7/12	2023/7/13	2023/7/14	2023/7/15
0							Pb+AgCo									Au 25mm	
1																	
2																	
3																	
4																	
5																	
6																	
7																	
8																	
9																DAQ	
10					La				Sn								
11						C+AgCo		calibration				nobeam	NaI				
12																	
13							Empty+Ag	no beam									
14						C											
15		La													C 25mm		
16					Au+AgCo												
17																	
18							Empty										
19																	
20					Au												
21																	
22																	
23																	

Thanks