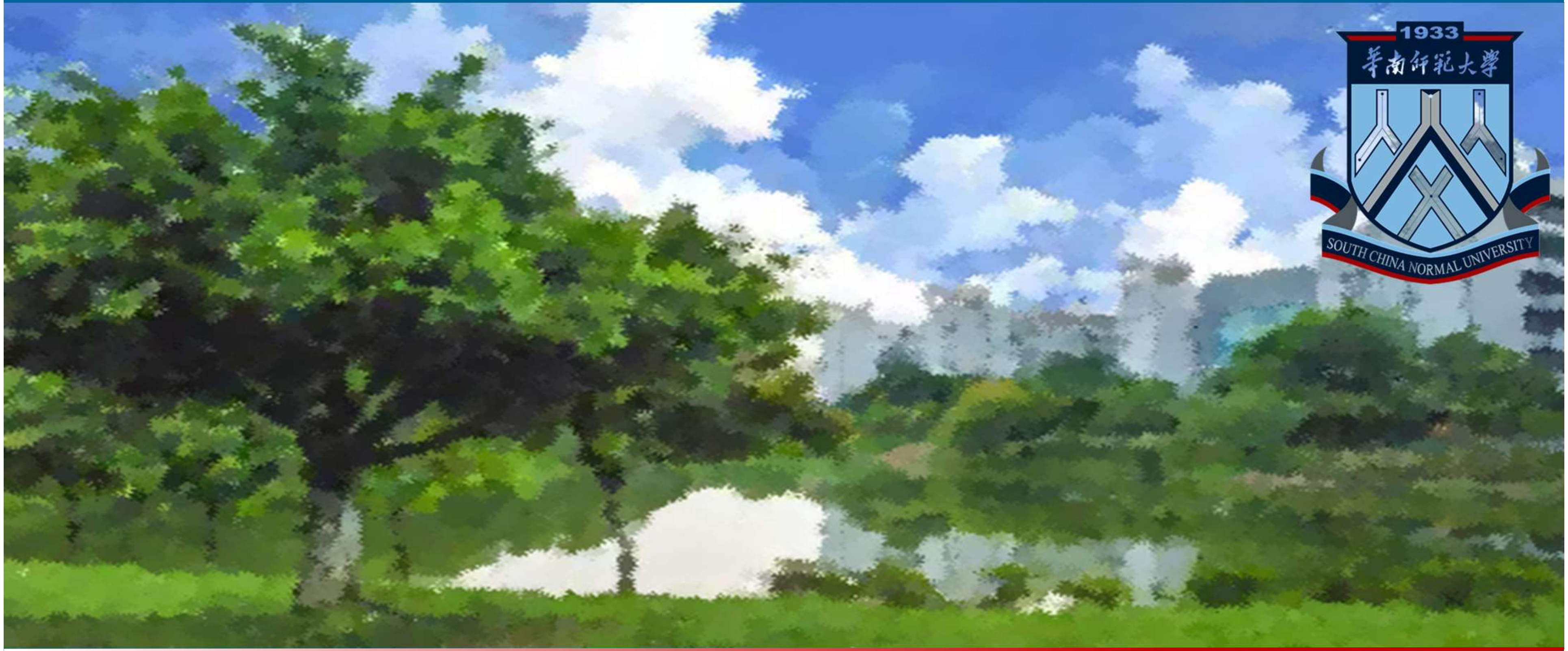


Neutral Particle Identification @ BESIII

Ji-Feng Hu

South China Normal University

Outline

Why ?

How ?

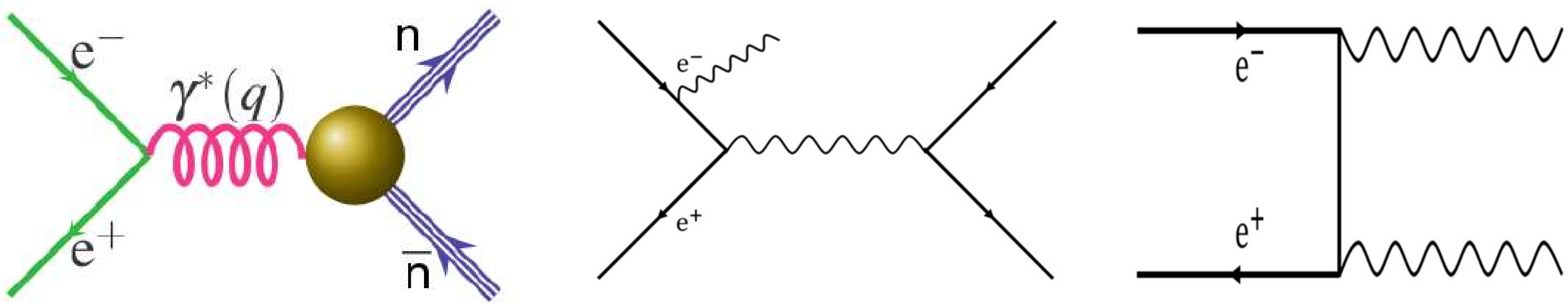
What ?

Summary

Why ?

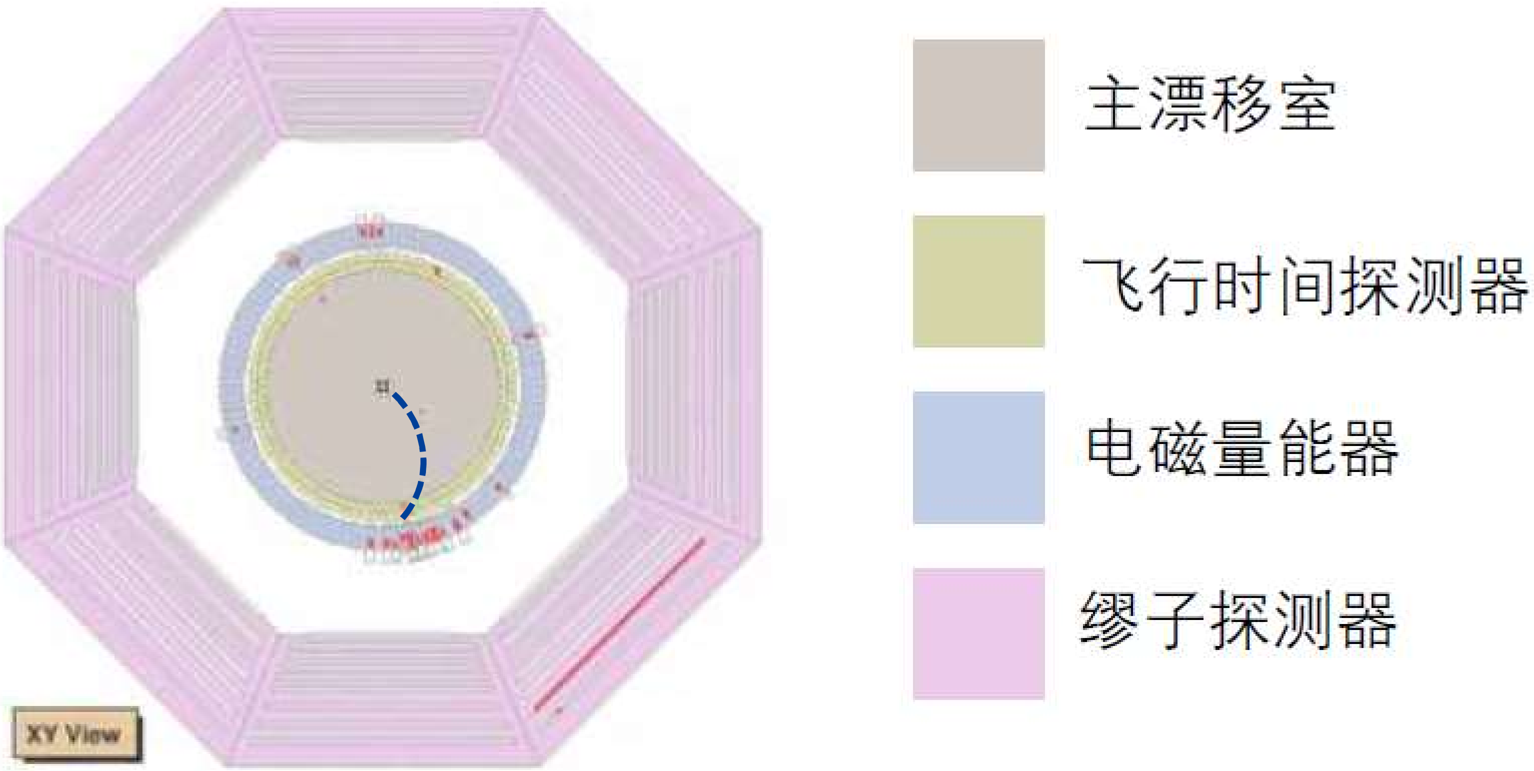
- Import for many physics topics, like:
  - Essential to my work: the neutron form factor measurement.
  - New physics: rare events survived.

arXiv:2103.12486v4



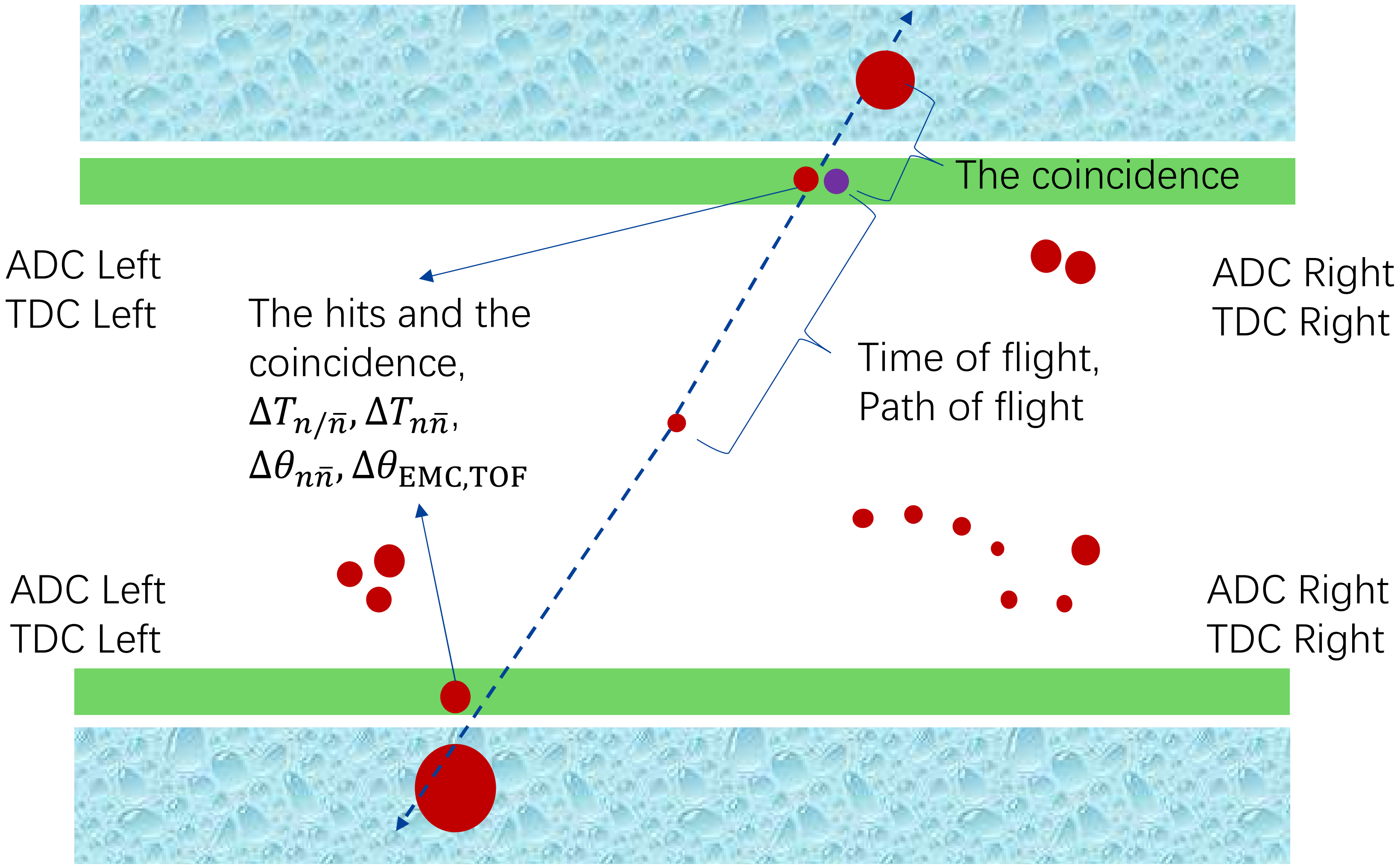
- Not implemented in BOSS.

How ?



1. If a charged track is reconstructed, then TOF and EMC will be associated.
2. **If no charged tracks, then TOF and EMC will be not associated.**

How ?



The coincidence
ADC Left
TDC Left
The hits and the coincidence,
$\Delta T_{n/\bar{n}}, \Delta T_{n\bar{n}},$
$\Delta\theta_{n\bar{n}}, \Delta\theta_{\mathrm{EMC,TOF}}$
Time of flight,
Path of flight
ADC Right
TDC Right
ADC Left
TDC Left
ADC Right
TDC Right

The work is not as simple as it looks

DST events are stored without ~~digis~~.

We have to do many things even from a new scratch, like decode **the RAW events.**

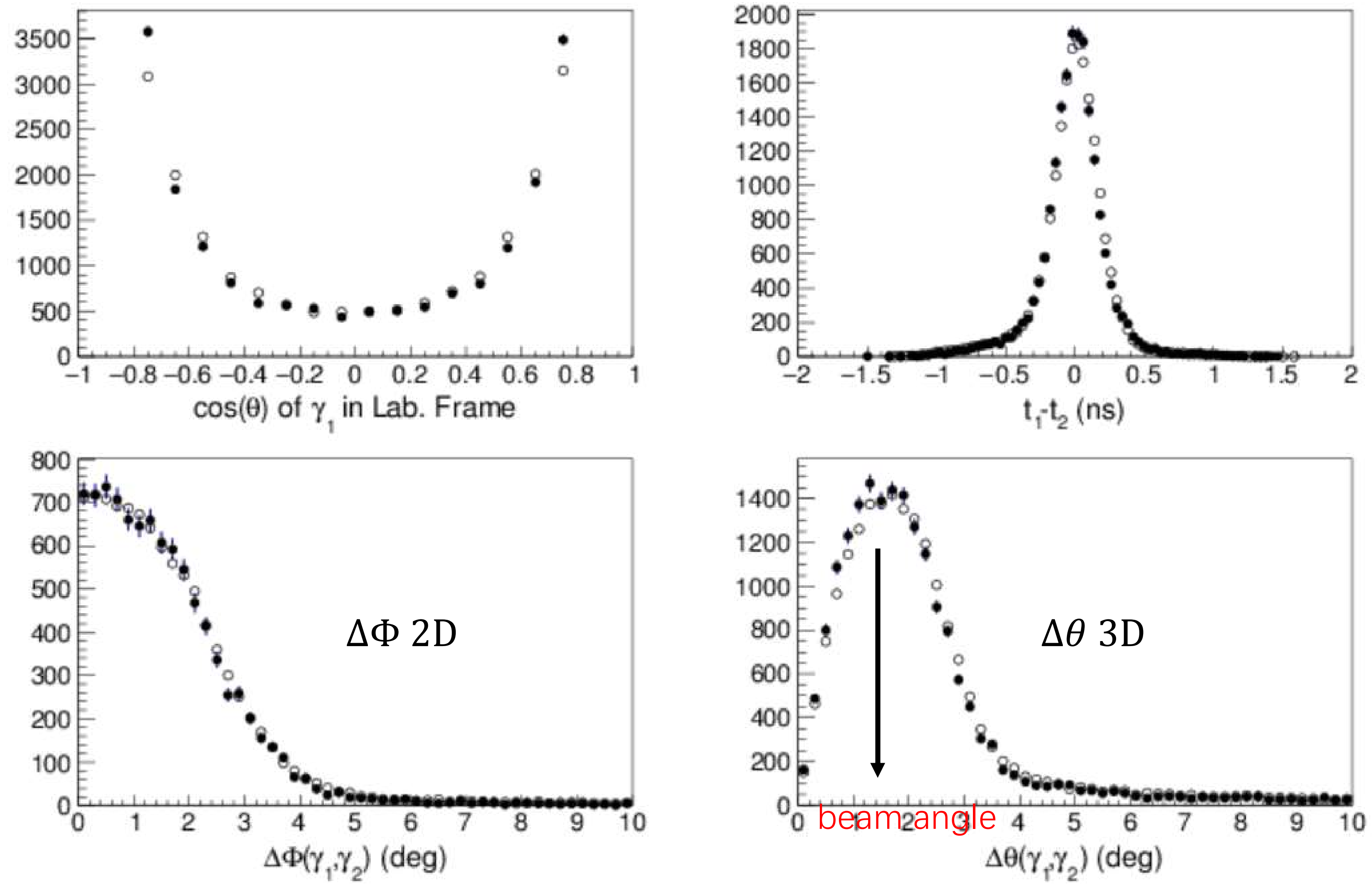
Lots of work:

- ~**7** packages, new + revised.
- 3 months development.
- debug event by event, number by number.
- 5 months verification, 7 round checks.

What I did

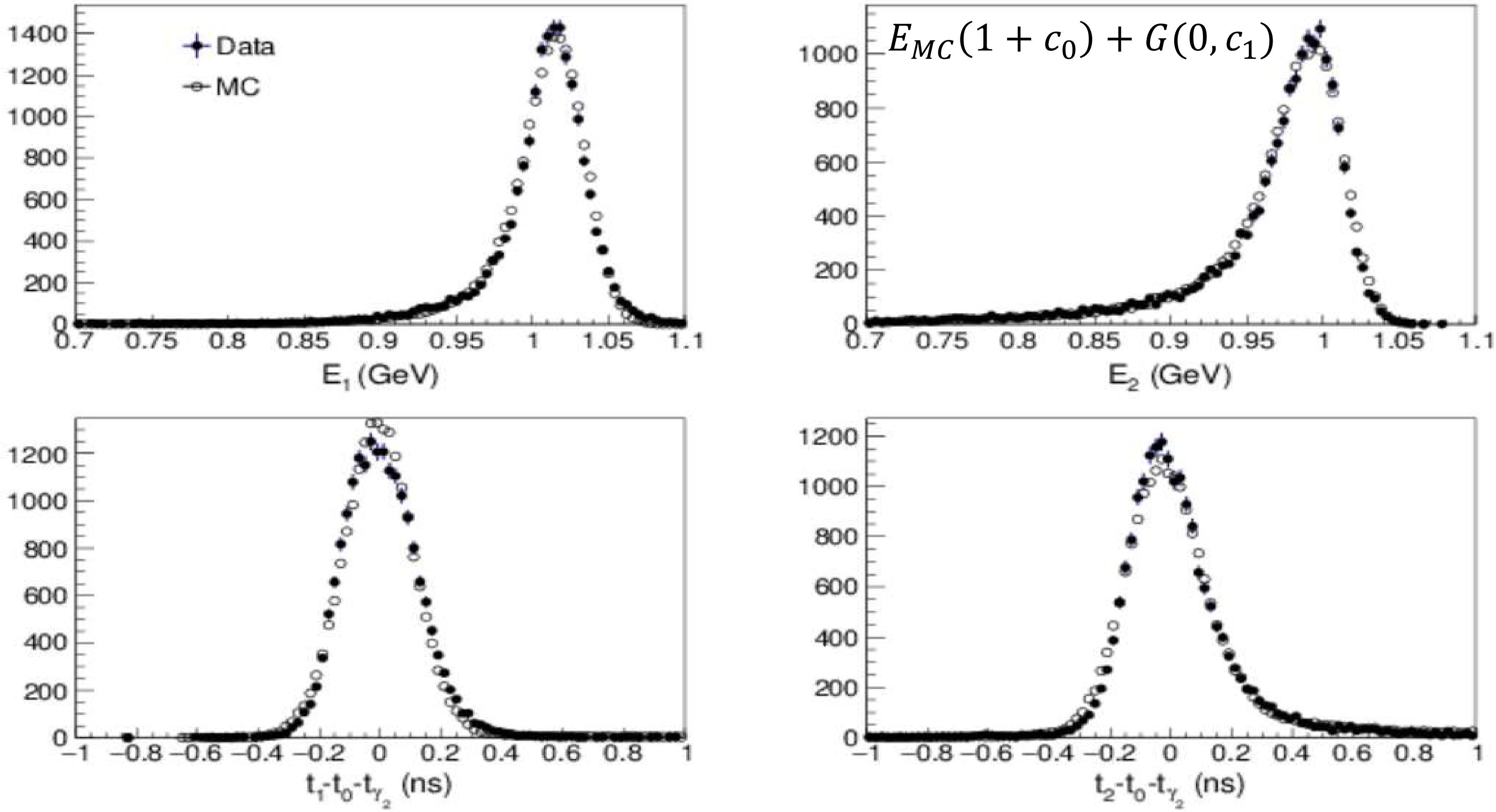
simultaneously loading the DST/RAW data within BOSS.	ID of run/event cross-check
	TOF digis associated to EMC showers
	Neutral reconstruction/identification
Naturally we will question that are these new packages reliable?	Validation with e+e-→2γ (MC+DATA)
	Validation with J/Ψ→ **nnbar (MC+DATA)**
	Validation with e+e- →nnbar (MC)
	Validation with J/Ψ→ $\pi^+\pi^-\pi^0$→2γ

Verification with $e^+e^- \rightarrow \gamma\gamma$@2.125 GeV



Verification with $e^+e^- \rightarrow \gamma\gamma$@2.125 GeV

The key is to restore the T_0 without any charge tracks in an event.



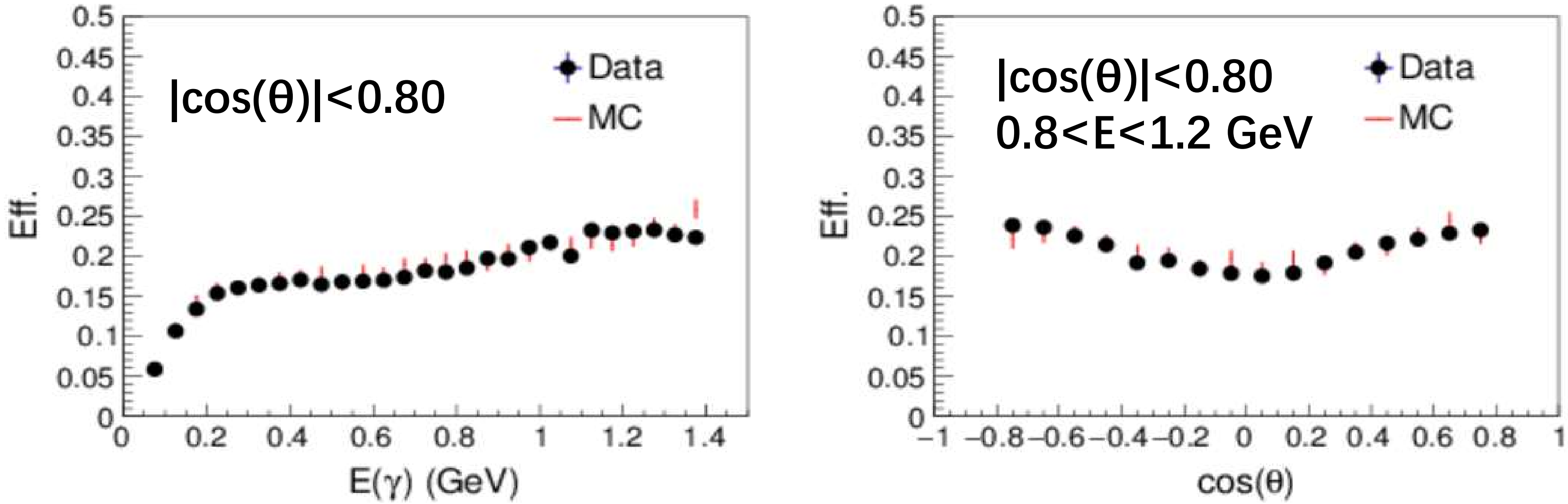
Verification with $e^+e^- \rightarrow \gamma\gamma$

Ecm (GeV)	Luminosity (pb^{-1})	EFF. (%)	N(obs)	XS_OBS (nb)	error	XS_GEN (nb)	error
2	10.1	2	17808	**87.6**	0.7	**88**	0.9
2.125	108	2	167428	**76.2**	0.2	**77.4**	0.3
2.175	10.6	2	15737	**72.9**	0.6	**74.6**	0.3
2.2	13.7	2	19867	**71.2**	0.5	**72.5**	0.3
2.2324	11.9	2	16827	**69.7**	0.5	**70.5**	0.3
2.396	66.9	2	82185	**60.2**	0.2	**61.1**	0.3
2.6444	33.7	2.1	67623	**48.4**	0.2	**50**	0.2
2.9	105	2.1	89826	**41.2**	0.1	**41.7**	0.2
3.08	126	2.1	95549	**36.8**	0.1	**37.2**	0.2

基于TOF所开发的算法：**准确**

γ Detection of TOF with J/Ψ→ π+π-π⁰

By searching for the photon along the recoiling direction of the other photon.

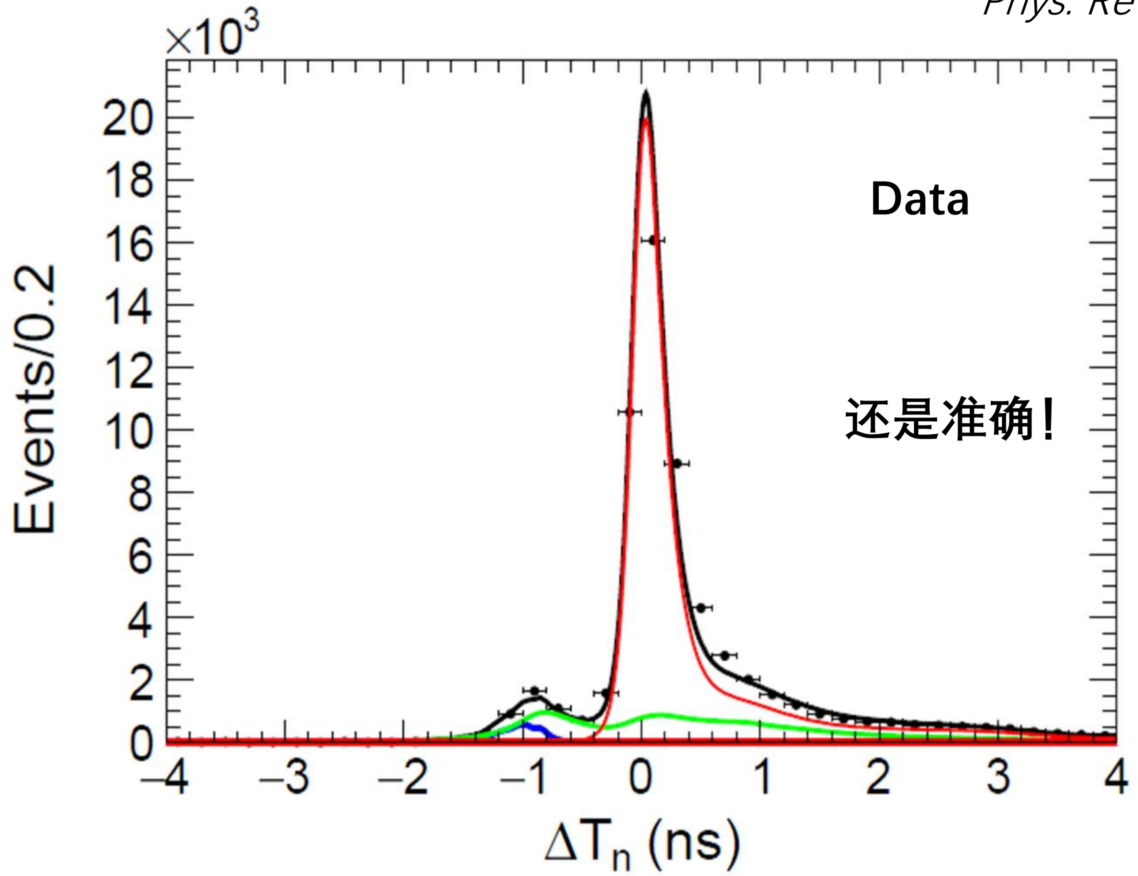


也准确

A well agreement of γ detection

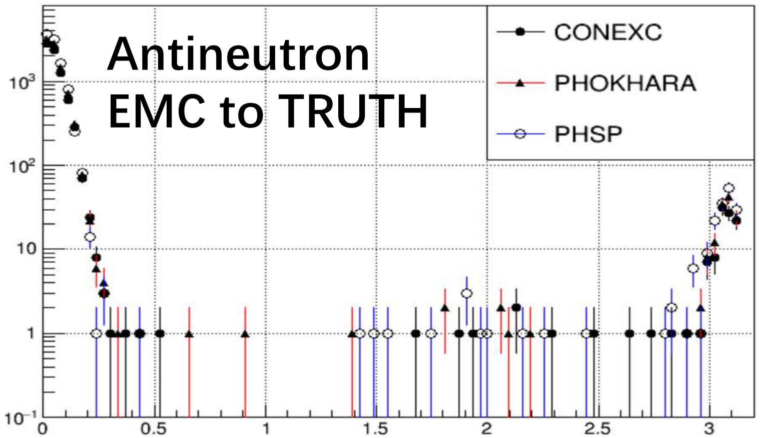
Verification with J/Ψ→$n\bar{n}$

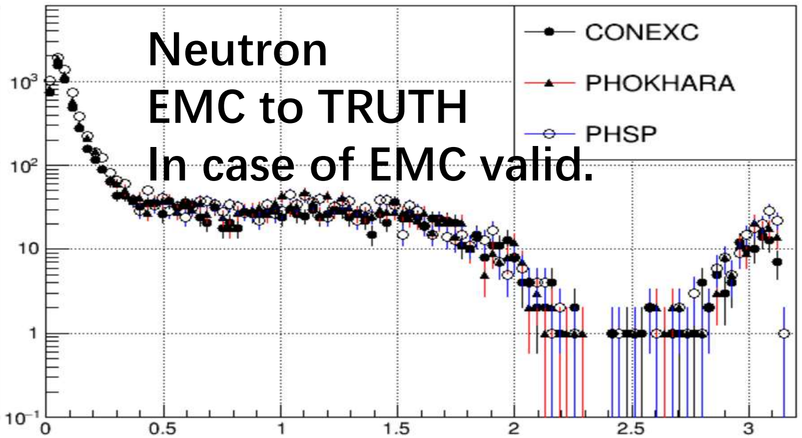
Phys. Rev. D 86 (2012) 032014



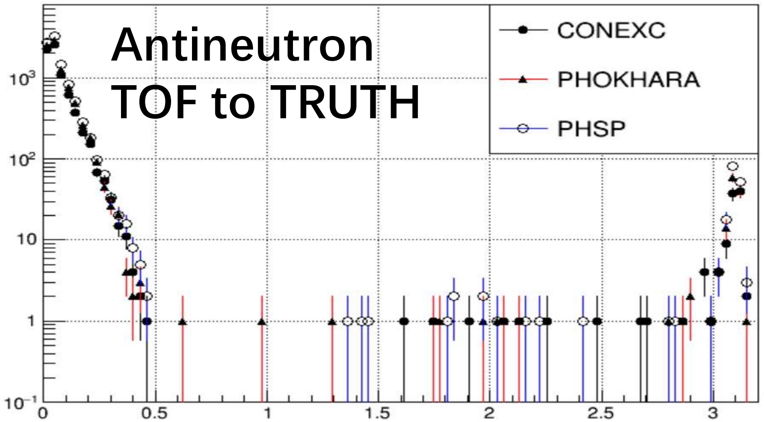
Br(J/Ψ→$n\bar{n}$)		
3.097	2009 data only, EXP = (2.02+-0.01)x10^{-3}	PDG (2.07+-0.01)x10^{-3}

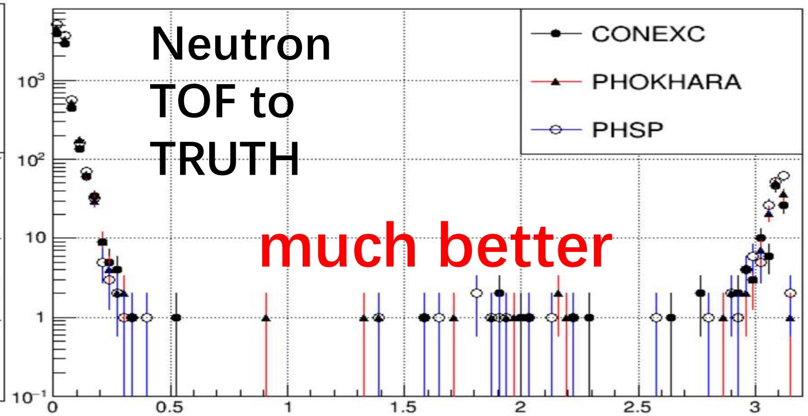
Validation with MC simulation





Δθ： between the reconstructed position and the truth position.



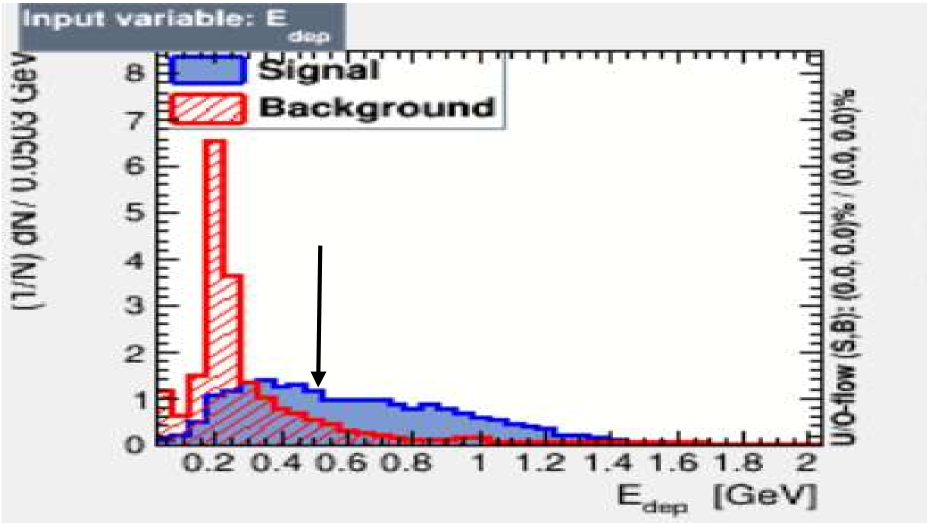


没有理由不准确！

Identification: Anti-neutron VS others

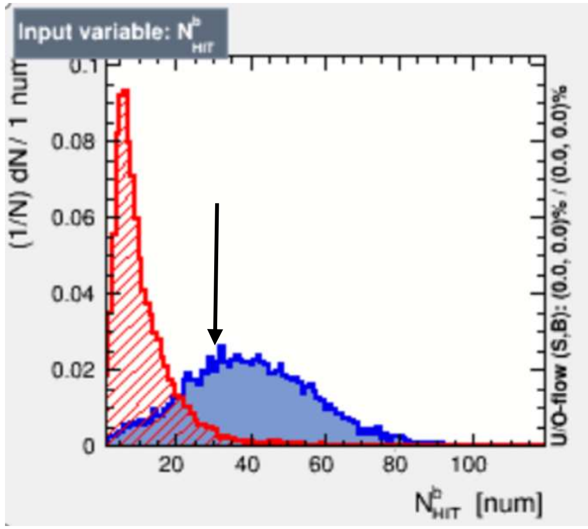
Phys. Rev. D86 (2012) 032014

Antineutron in EMC



反中子在电磁量能器中沉积的能量 (GeV)

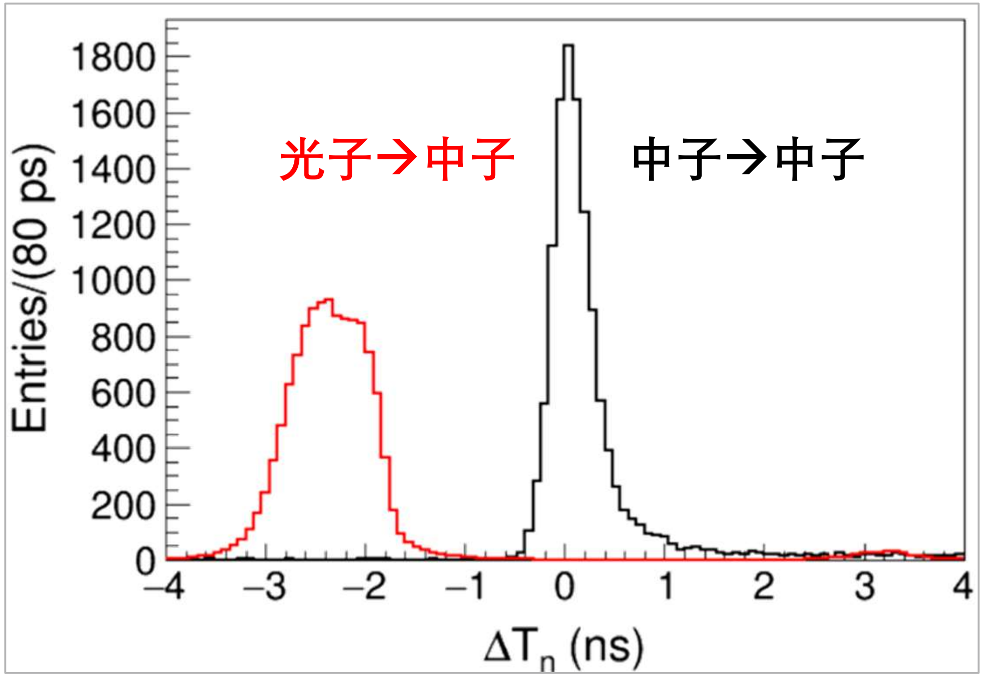
Number of hits within a cone.



反中子在电磁量能器中触发晶体的计数

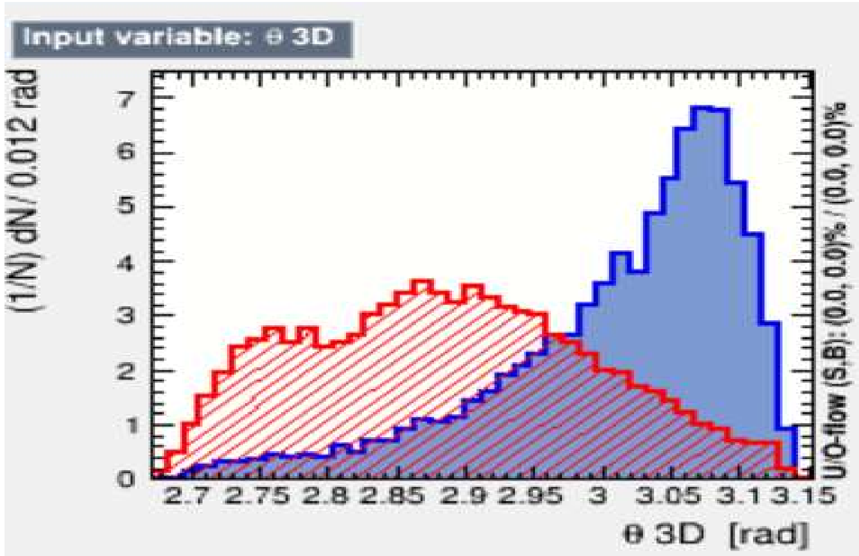
Identification: neutron VS photon

The method is identical to the particle identification of charge tracks.

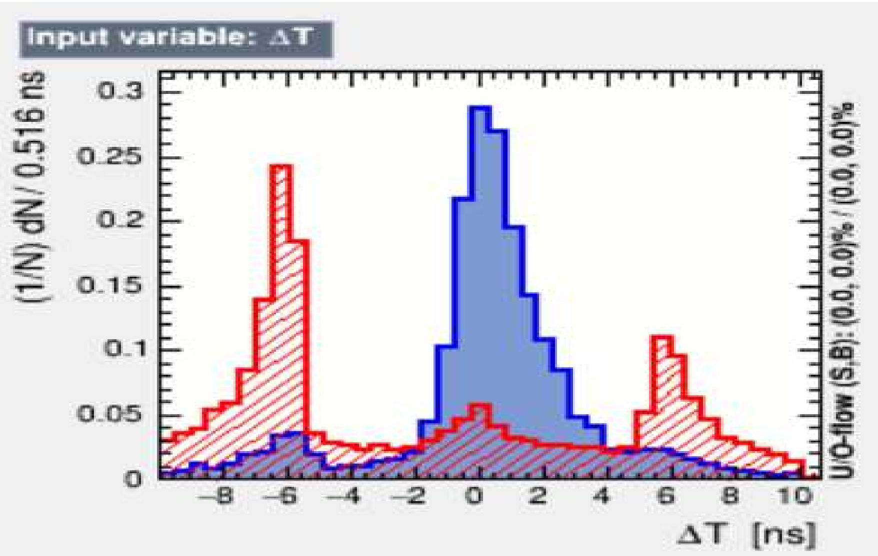


光子和中子在中子假设下的飞行时间与预期飞行时间之间的差值分布.
显然，适用于所有更重的中性粒子，如果它们在TOF中留下了信息。

Identification: collision VS cosmic rays



测量位置与反参照方向的夹角 (rad)



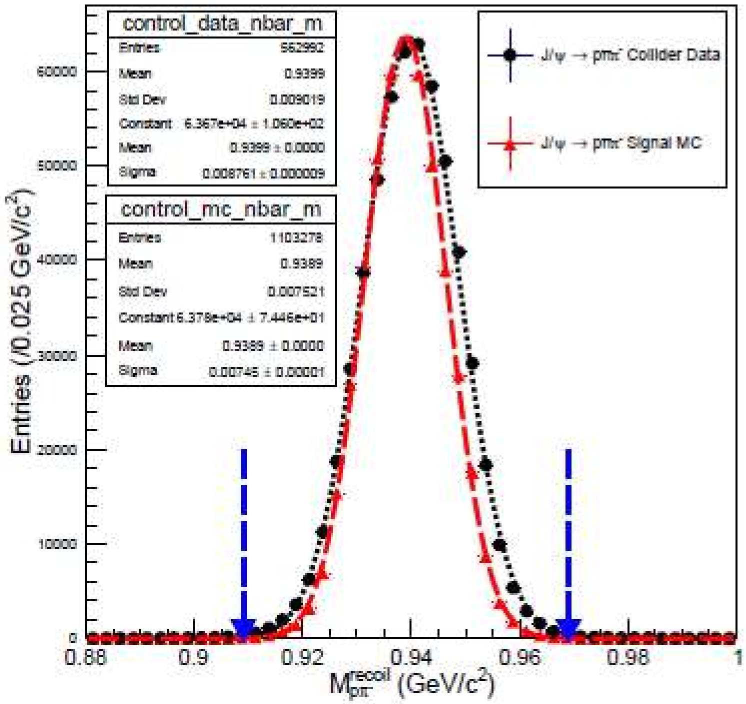
测量飞行时间与预期飞行时间的差 (ns)

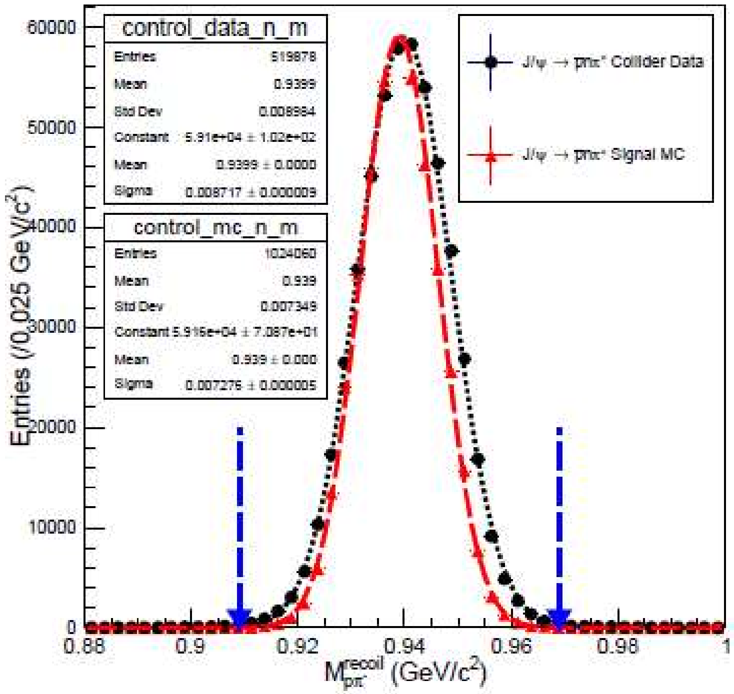
2-body like events with known kinetic features.

Select $n/\bar{n}$ control samples

CPC 2017, 41(1): 013001

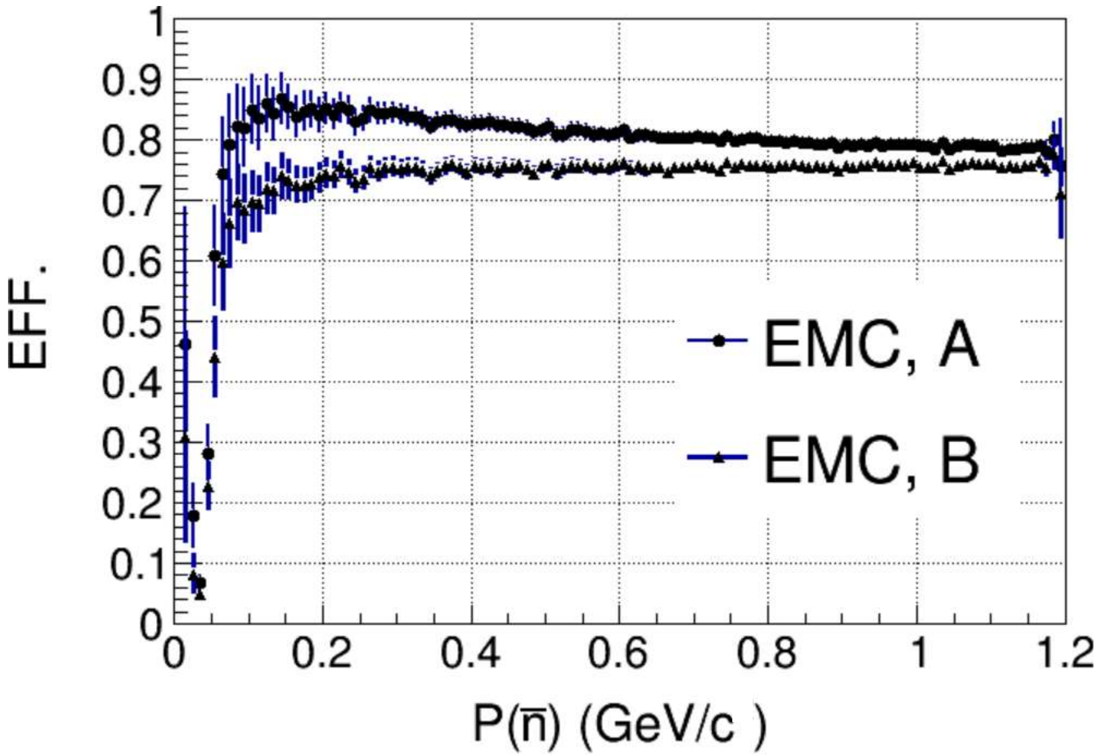
Taking advantages of 10 billion J/Ψ events.





Partial reconstruction and Recoiling the antineutron (neutron).
Thanks to huge J dataset collected by BESIII.

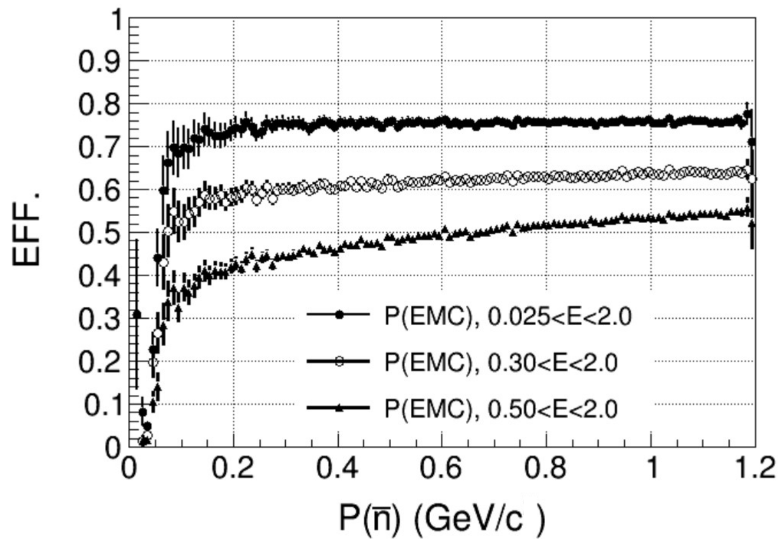
Antineutron Detection Efficiency (I)

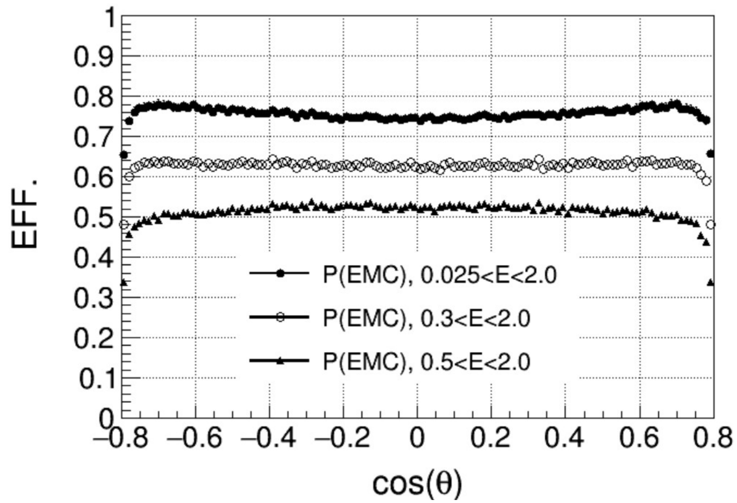


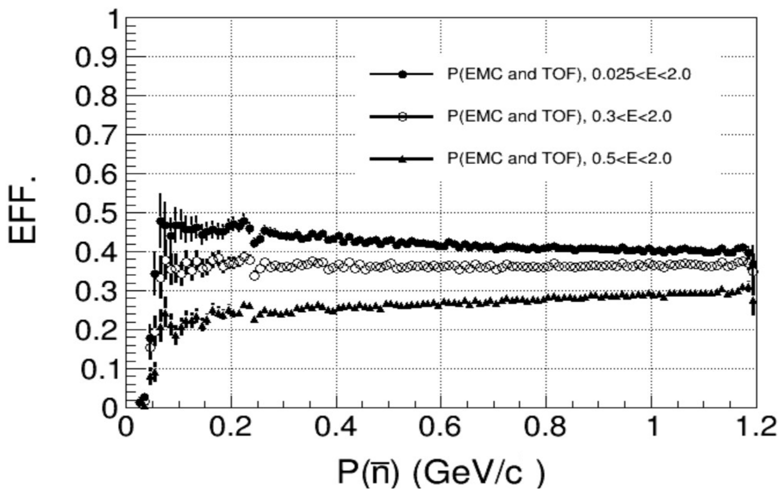
A: 在参照方向的立体锥角内搜索沉积能量最大的EMC簇射

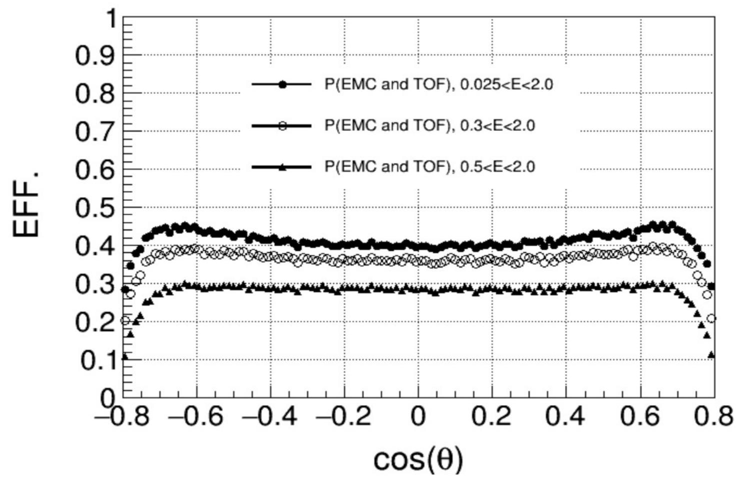
B: 寻找沉积能量最大的簇射是否在参照方向的立体锥角内

Antineutron Detection Efficiency (II)

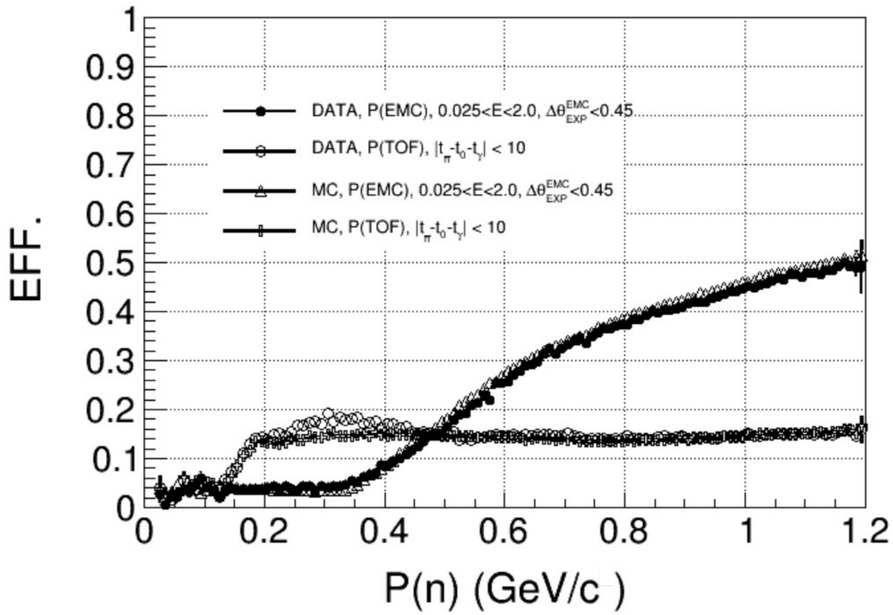


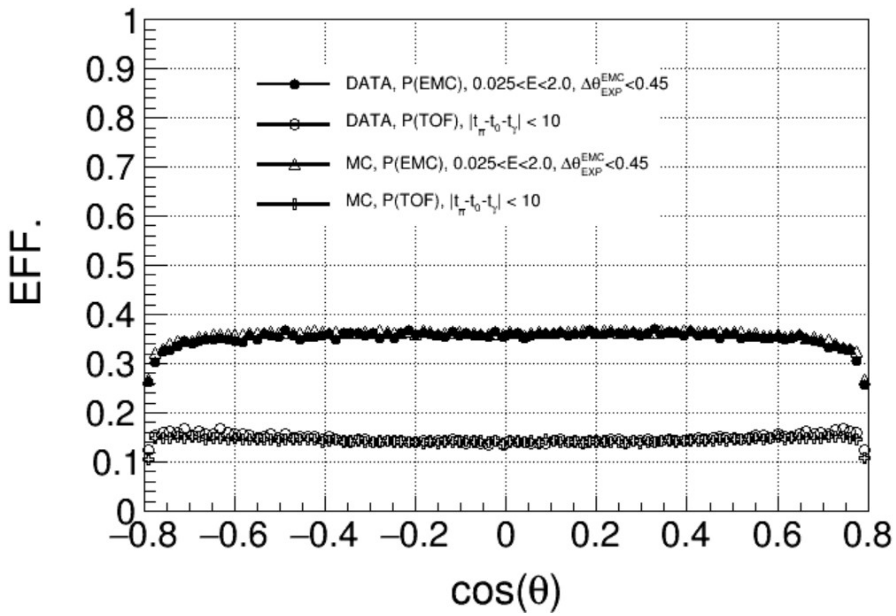






Neutron Detection Efficiency (1)

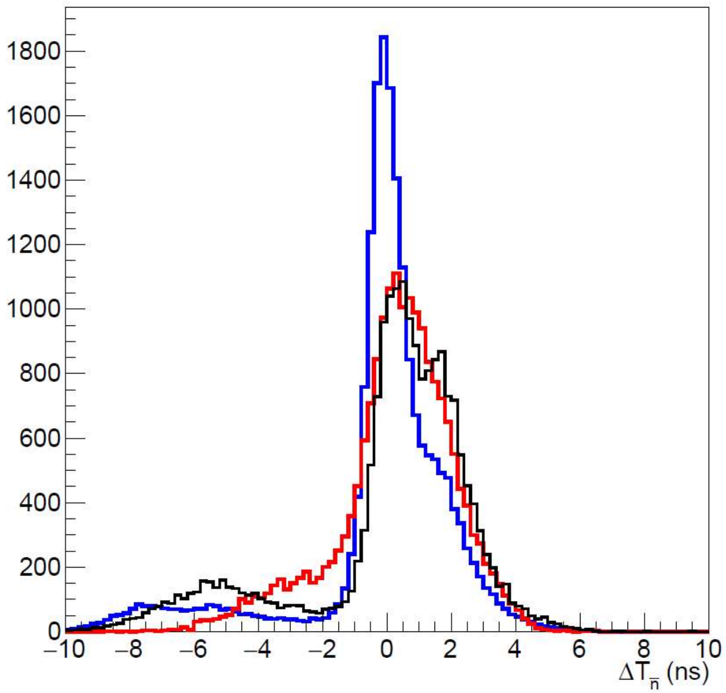




用TOF探测低动量中子(<0.5 GeV/c)更有优势。

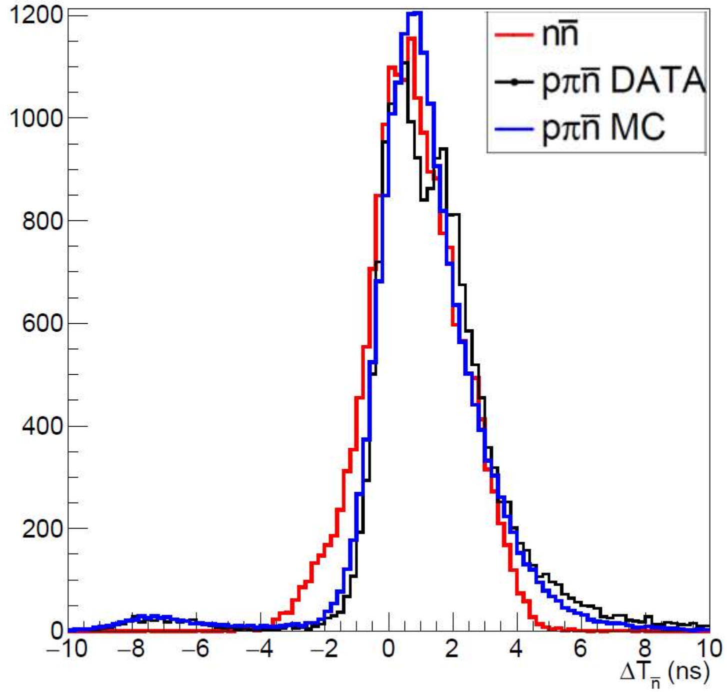
Flight Time of Antineutron

T_0 calculation with **gamma** hypothesis



测量飞行时间与预期飞行时间的差 (ns)

T_0 calculation with **neutron** hypothesis

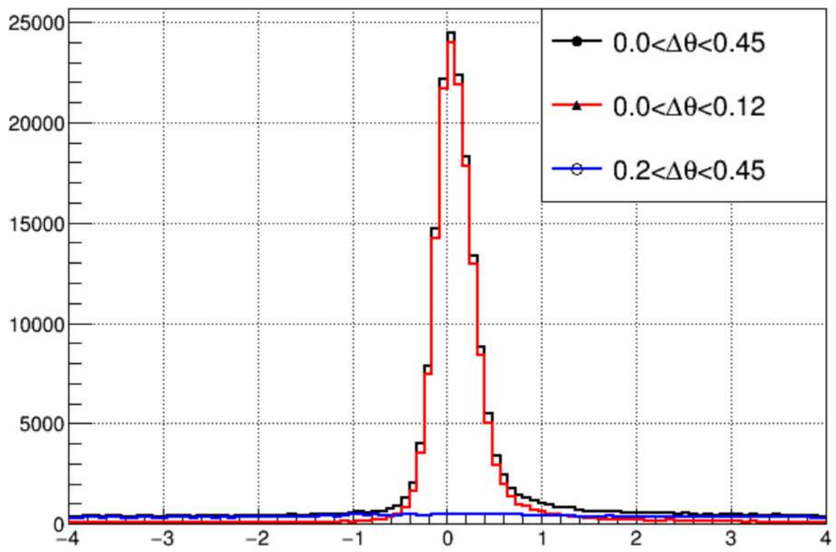


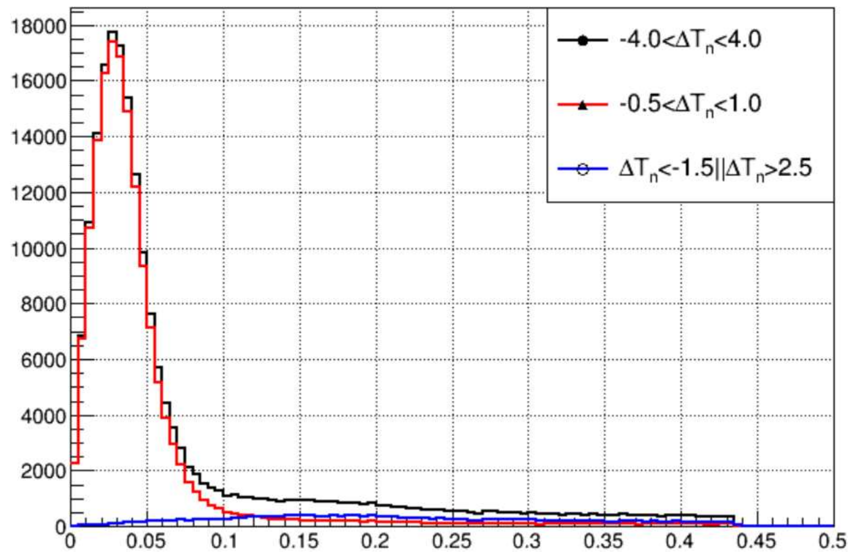
测量飞行时间与预期飞行时间的差 (ns)

$\Delta T_n = t_{TOF} - t_0 - t_n$, t_0 is determined by anti-neutron's time,

t_n is estimated under the momentum of $p = \sqrt[2]{E_{beam}^2 - M_n^2}$.

Flight Time of Neutron

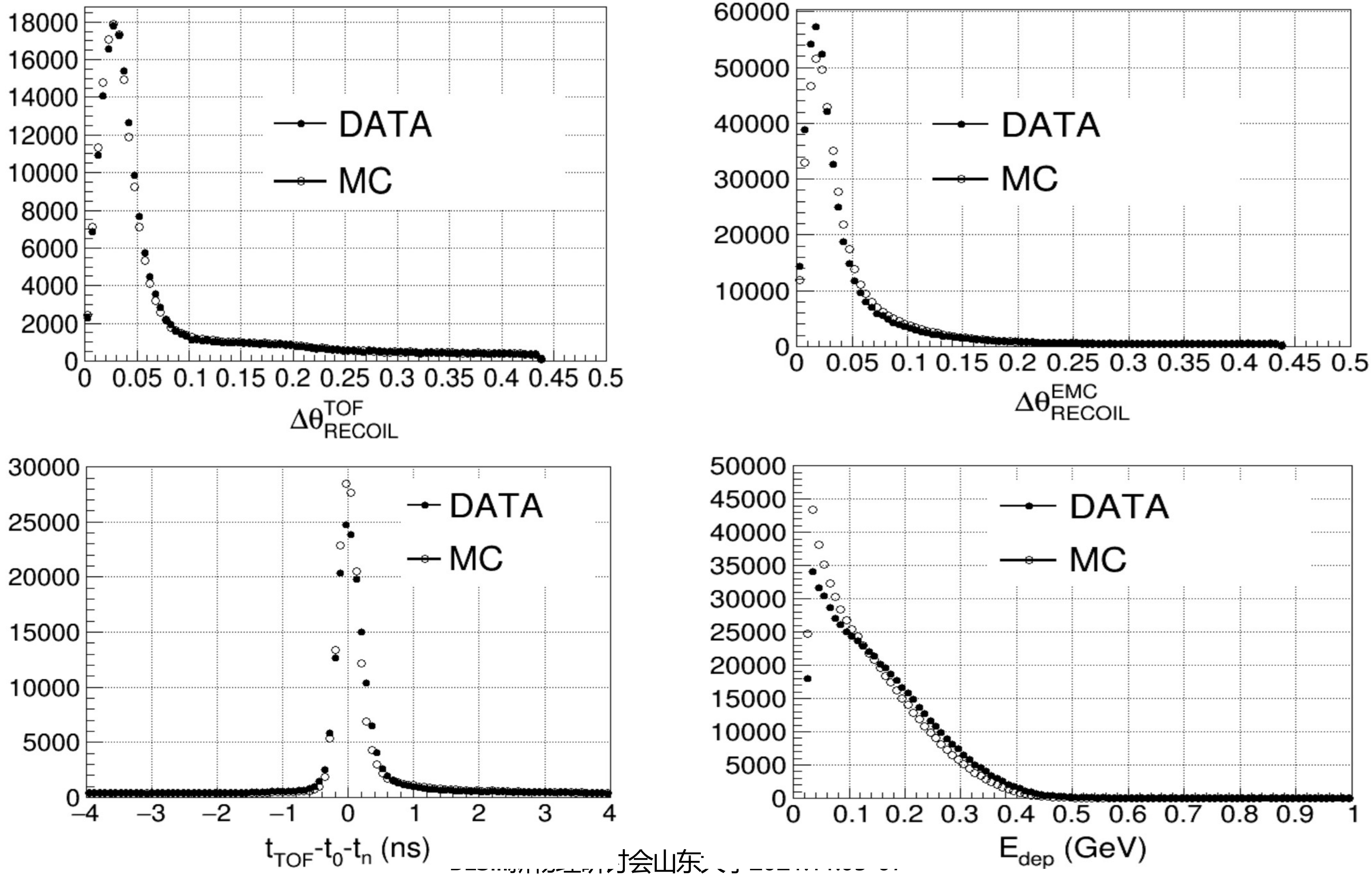




ΔT_n versus $\Delta\theta$ for Neutron

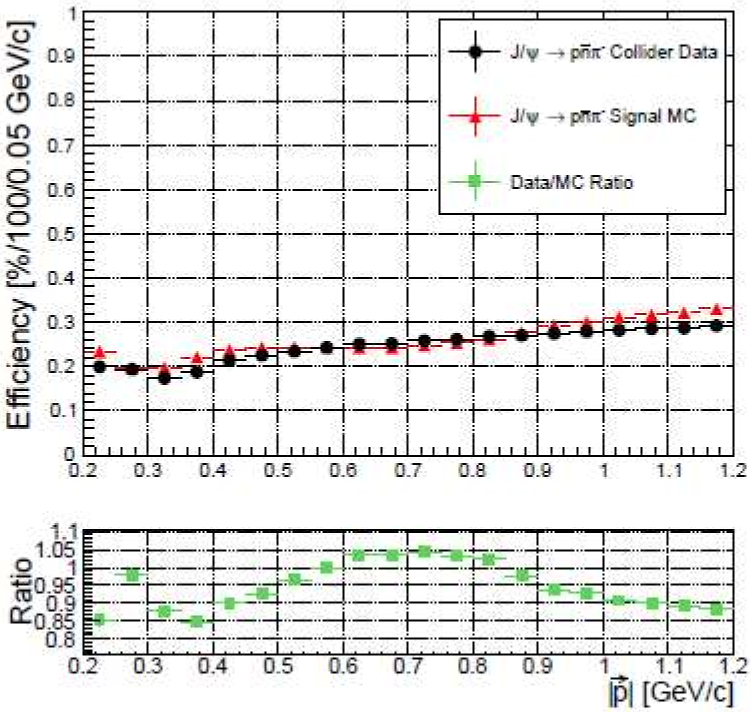
$\Delta\theta$: a cross-angle between the measured position and the reference position.

Discrepancy in Neutron Detection

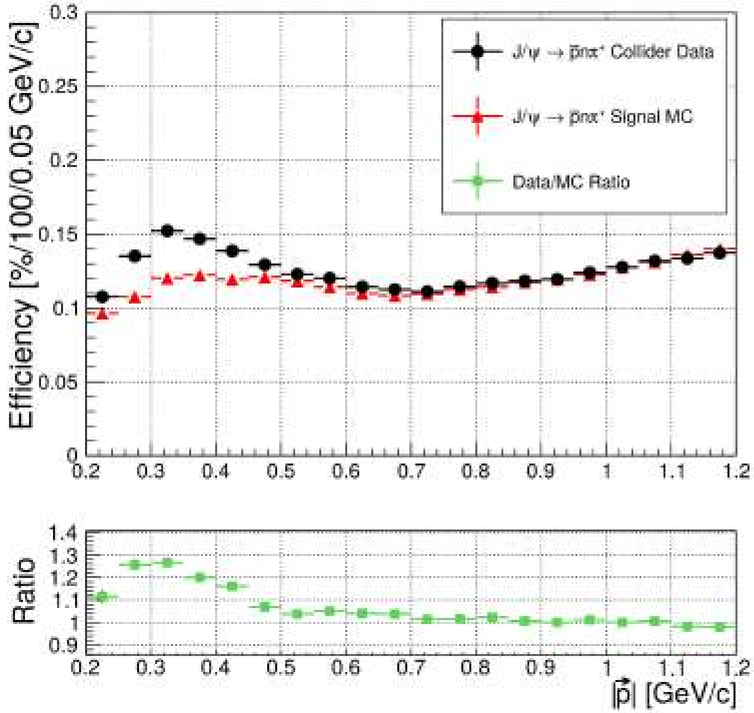


Calibration

Chinese Phys. C 2017, 41(1): 013001

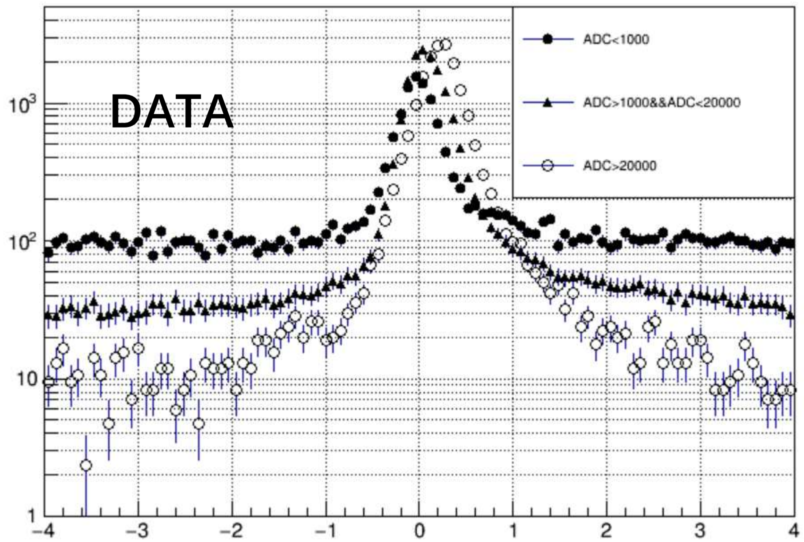


反中子动量（GeV）

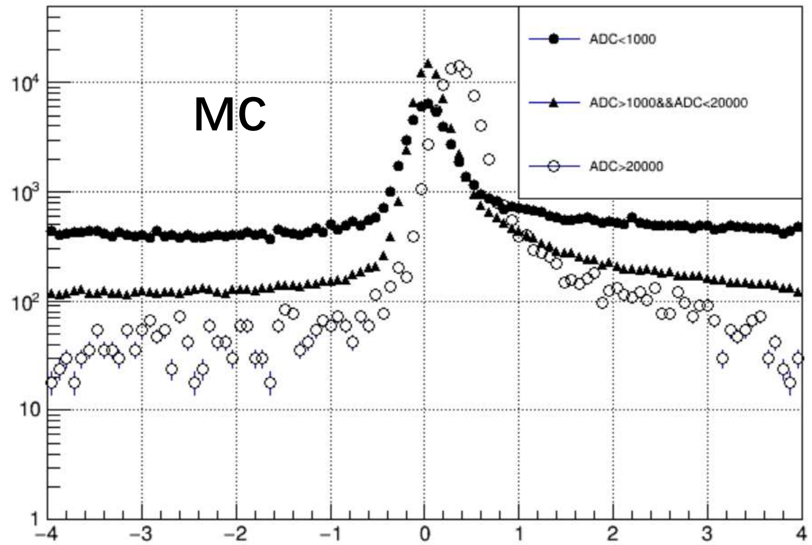


中子动量（GeV）

ΔT$_n$ versus ADC for Neutron



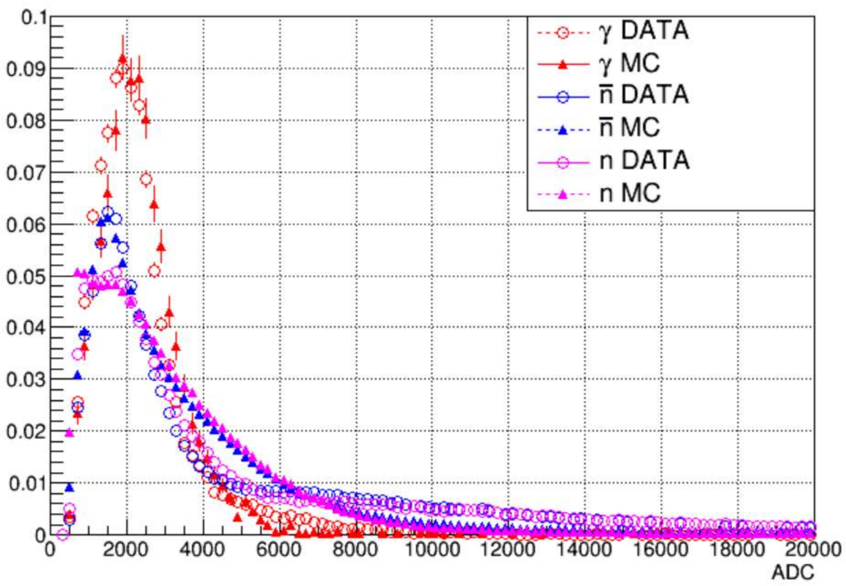
测量飞行时间与预期飞行时间的差 (ns)



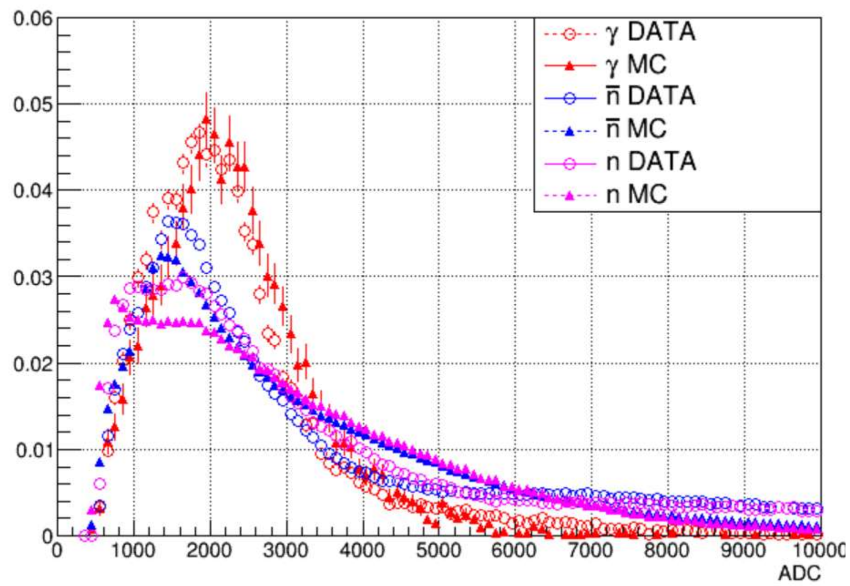
测量飞行时间与预期飞行时间的差 (ns)

事实上，我们可以获得更精确的时间测量。

ADC of Anti-neutron/Neutron/Photon

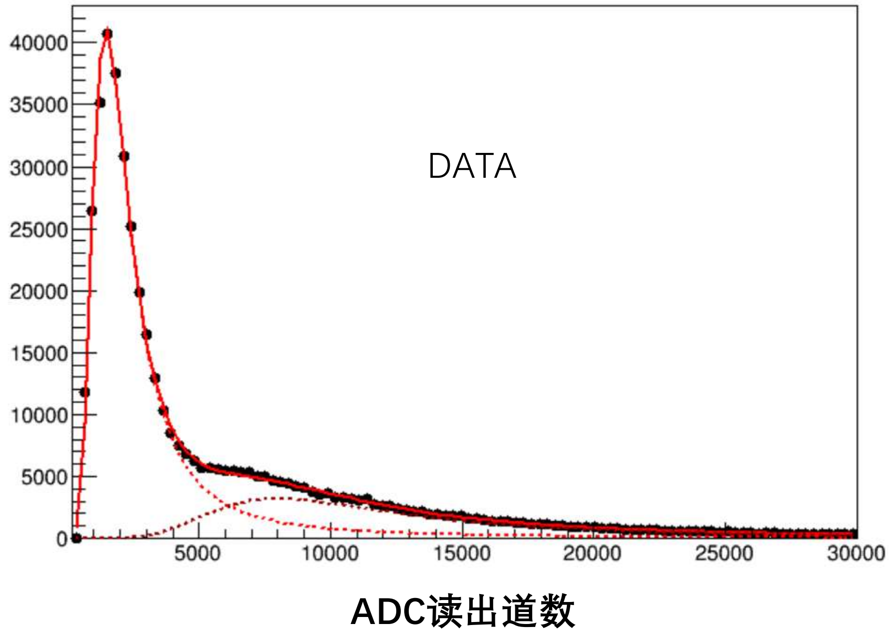


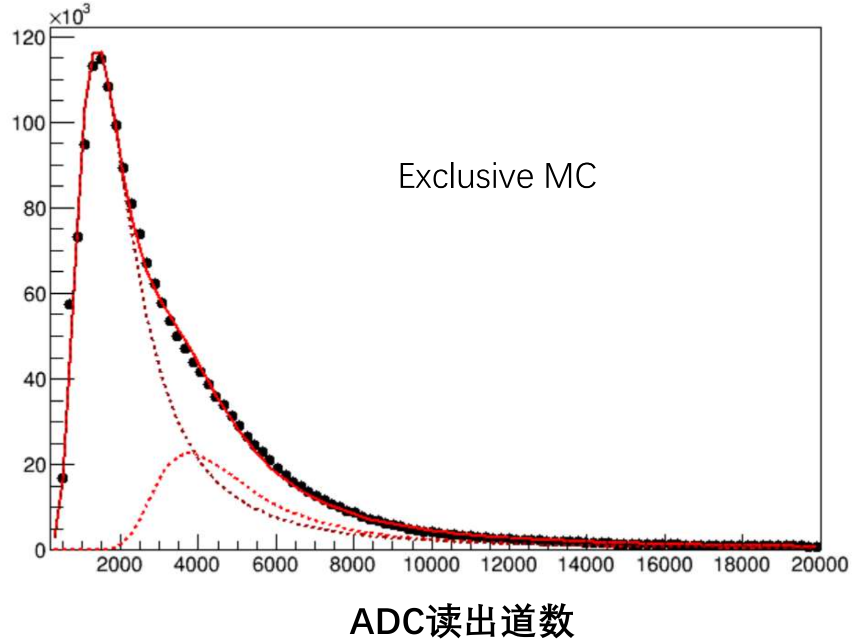
ADC读出道数



ADC读出道数，缩放至 (0,10000)

ADC of Anti-neutron

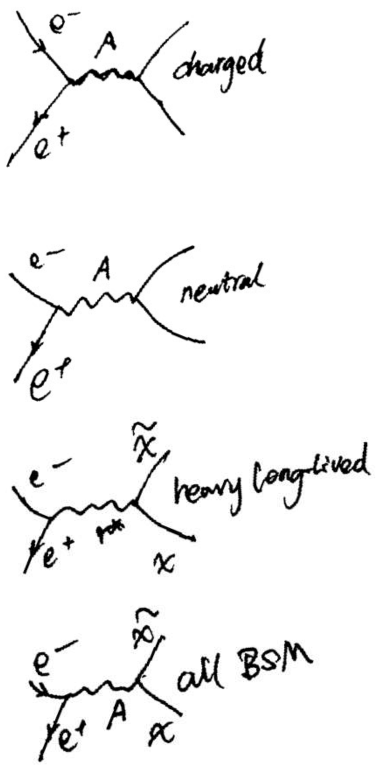


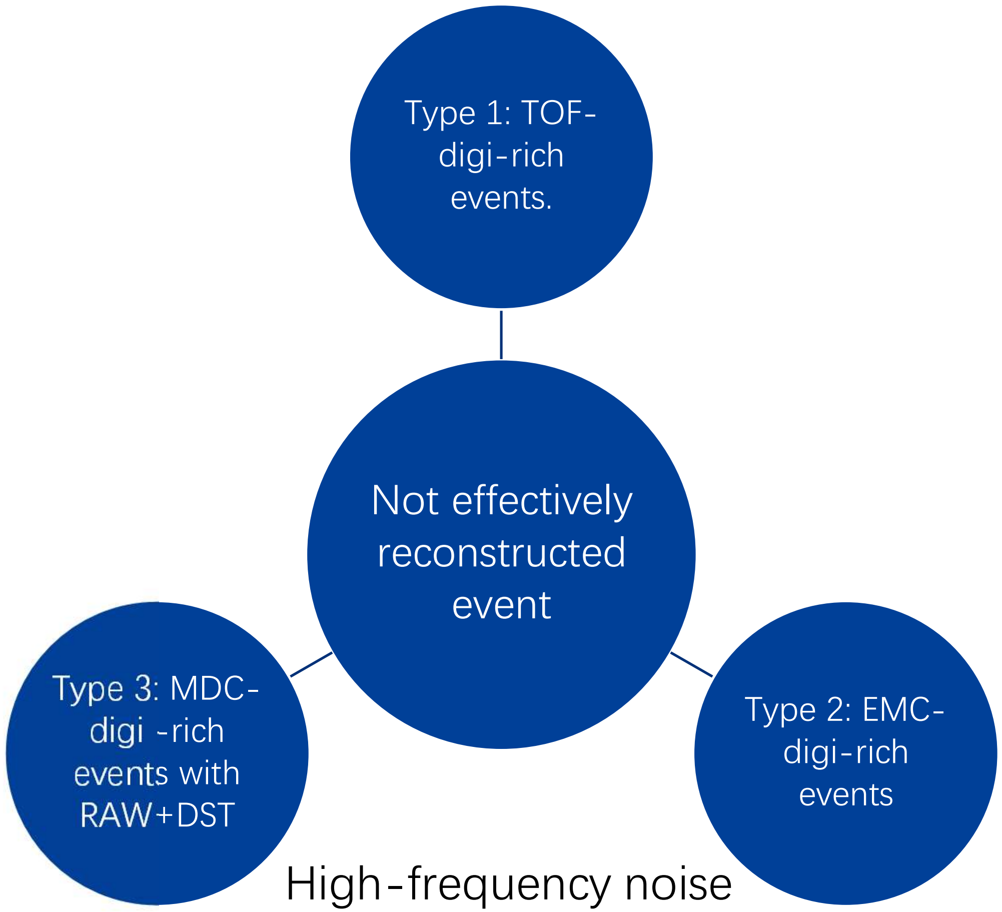


Double Landau can describe the ADC spectrum.

About new physics research

少之又少，众妙之道





Summary & Acknowledge

TOF-based reconstruction and identification is carried out and verified.

Many thanks to Prof. Shengsen Sun (IHEP) for his very useful suggestions, Prof. Peirong Li (LZU) for his effort on MC production of control samples, Doctor Pei-Lian Li (USTC) for her hard effort on cross-check of TOF-based performance.