Nuclear data measurement activities in China

Xichao Ruan

CHINA NUCLEAR DATA CENTER

I. Institutes involve in nuclear data measurement in China

中国科学院近代物理研究所 Institute of Modern Physics, Chinese Academy of Sciences

ADS related (proton induced)

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

Excitation function, FY, gamma production yields, DX and DDX, benchmark experiments, etc

北京大学 PEKING UNIVERSITY

(n,LCP) reaction

兰州大学 LANZHOU UNIVERSITY

Excitation function around 14 MeV

中国工程物理研究院 CHINA ACADEMY OF ENGINEERING PHYSICS

Integral experiments

SNS 中国散裂中子源 CHINA SPALLATION NEUTRON SOURCE

中国科学院上海应用物理研究所 Shanghai Institute of Applied Physics, Chinese Academy of Sciences SINAP

Th-U cycle related

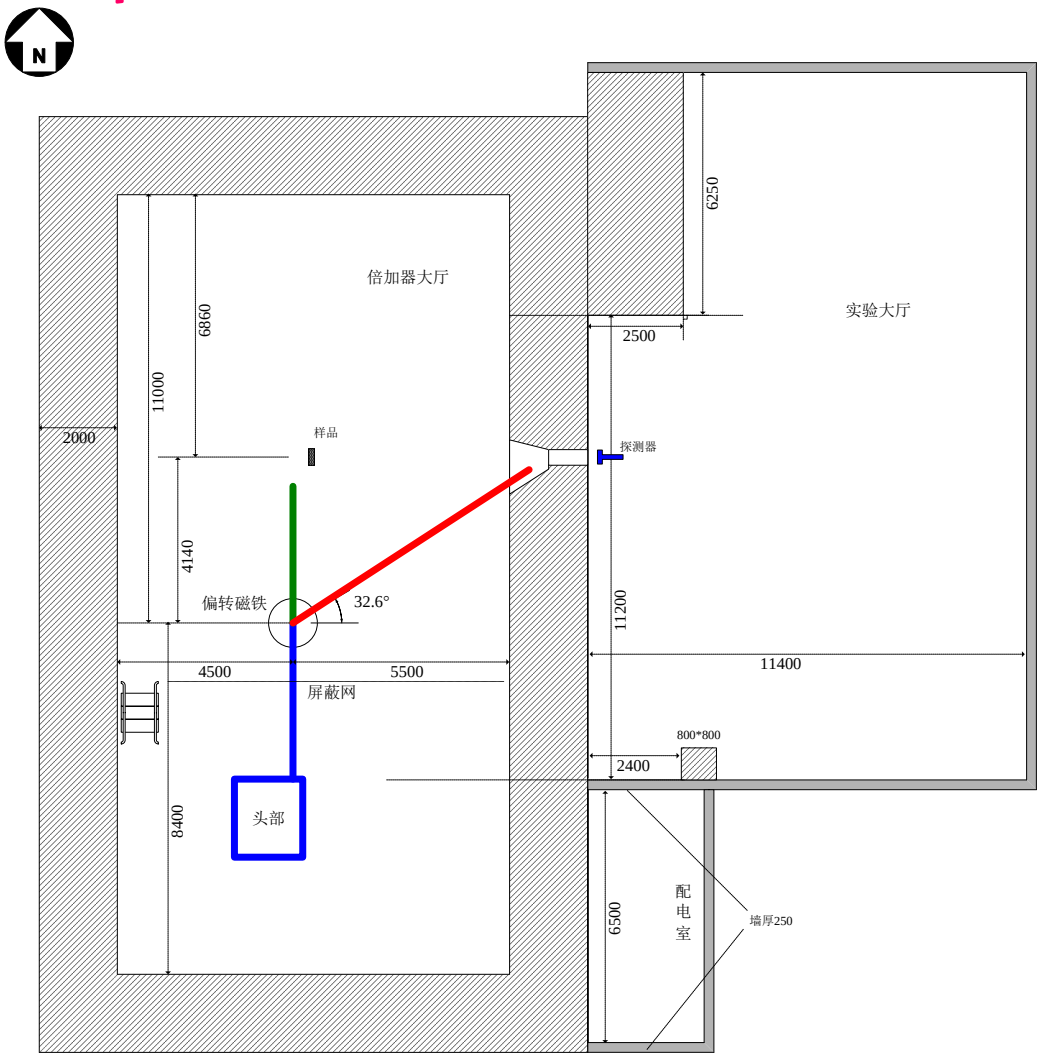
China Institute of Atomic Energy

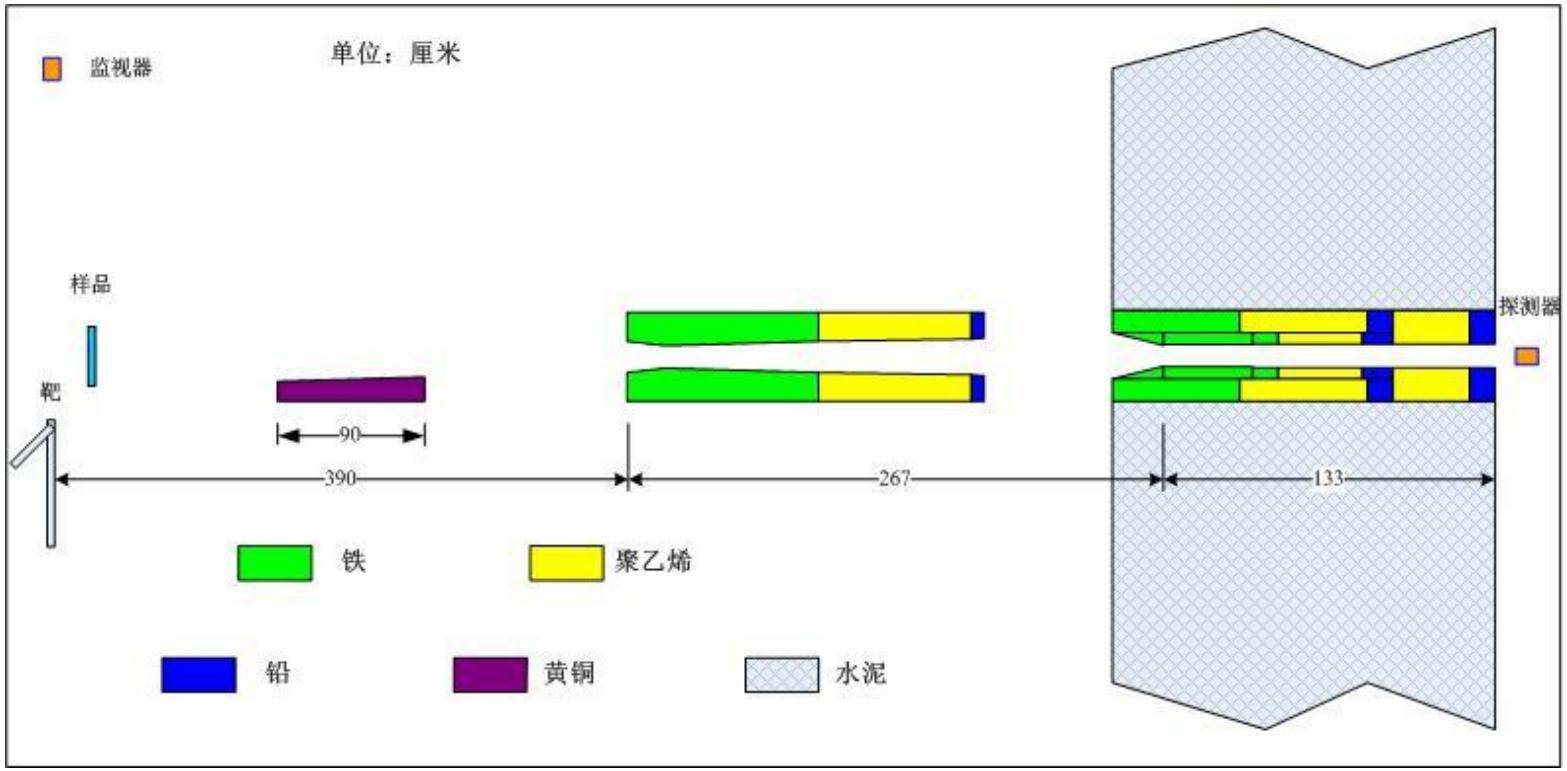
Highlights:

1. Nuclear data integral experiments
   Be, Ga, W, Pb-Bi, ThO_2 finalized
2. Fission fragments measurement system R&D
3. CSNS back-streaming neutron beam construction

Nuclear data benchmark experiment

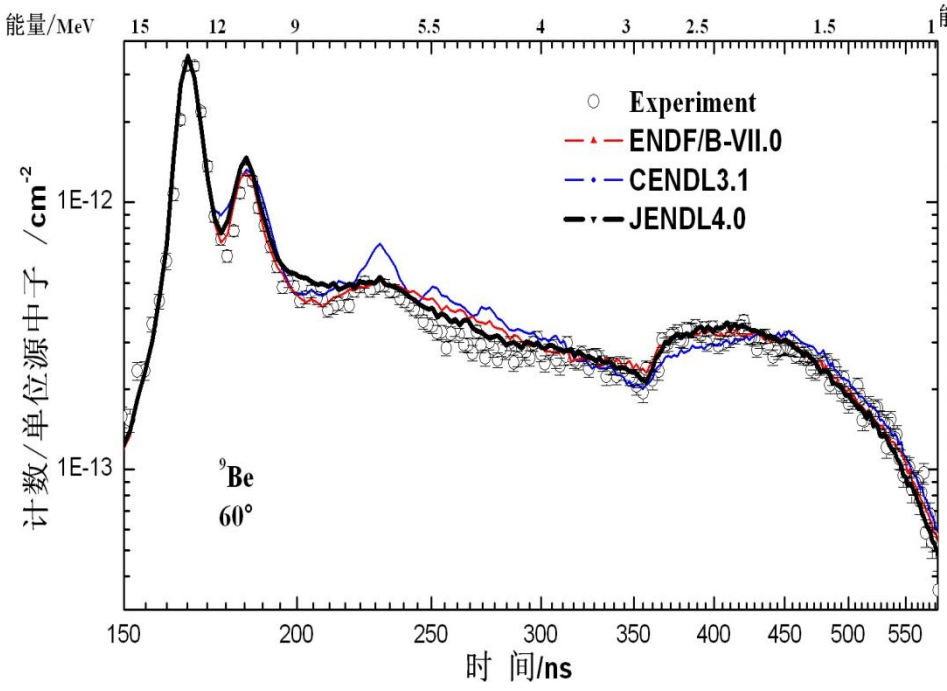
Measure the neutron leakage spectrum from slab samples for different angles with a 14 MeV d-T neutron source

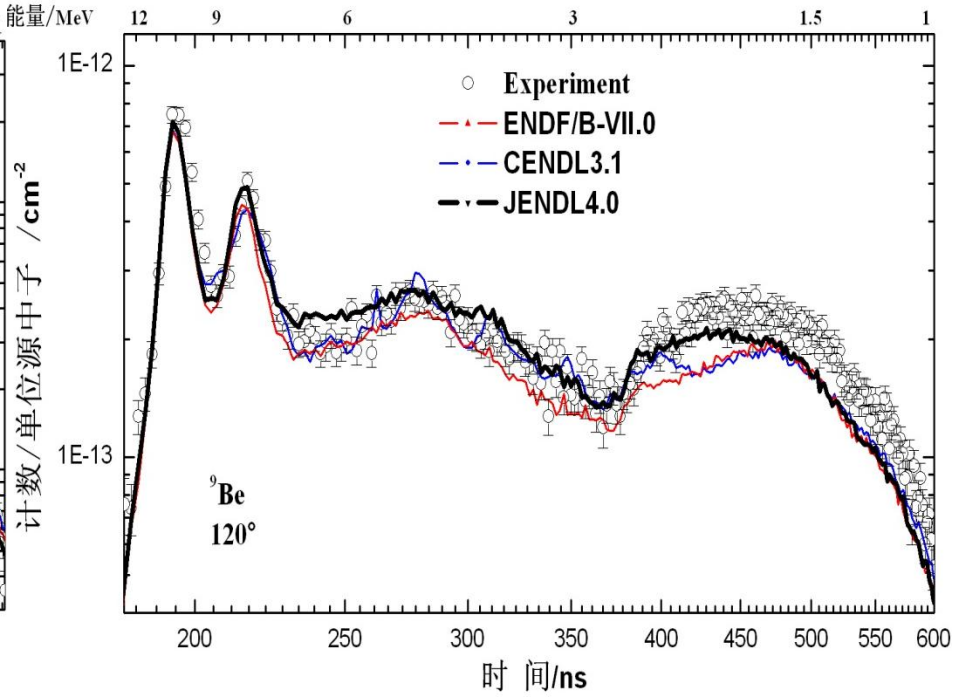




The collimator system

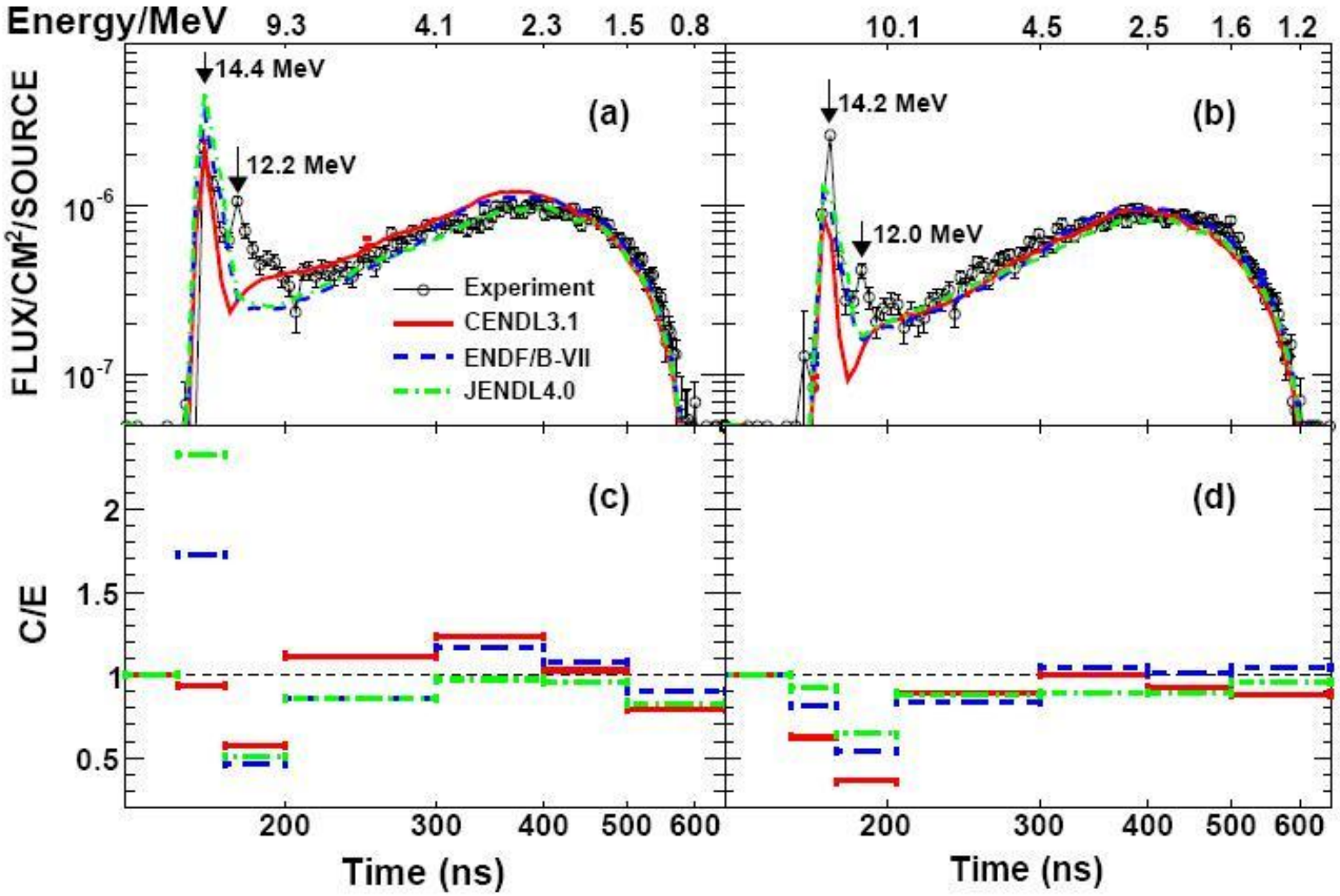
Result of Be





- **In general JENDL-4 agree with the measurement best,**
- **All underestimated at low energy region at 120 degrees.**

Result of Ga (collaborate with IMP)



http://arxiv.org/abs/1411.0403

Tungsten (collaborate with IMP)

France

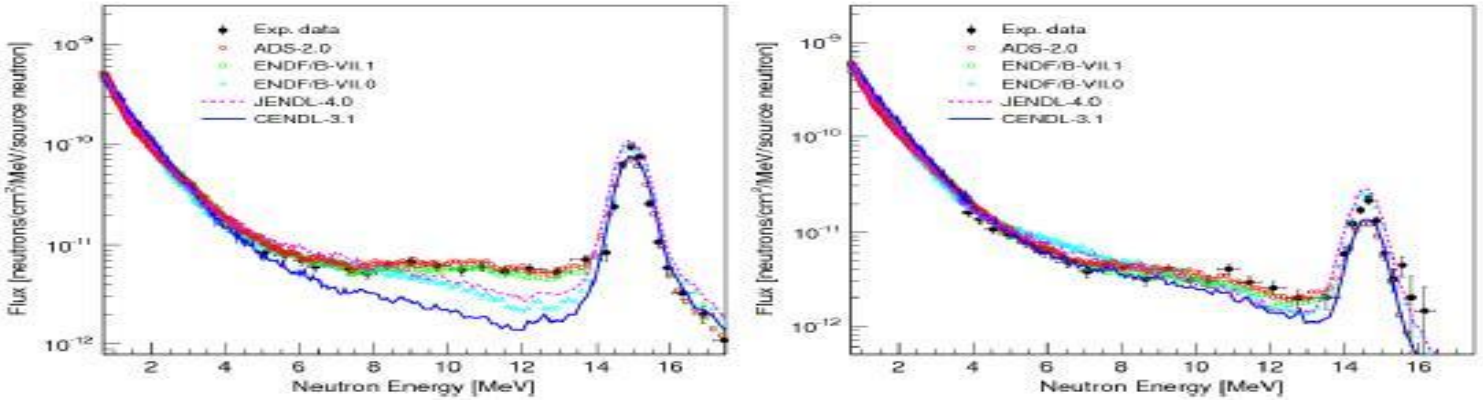


Fig. 4. (Color online) Comparison of experimental and calculated neutron spectra for thickness of 7 cm at 60° (left) and at 120° (right)

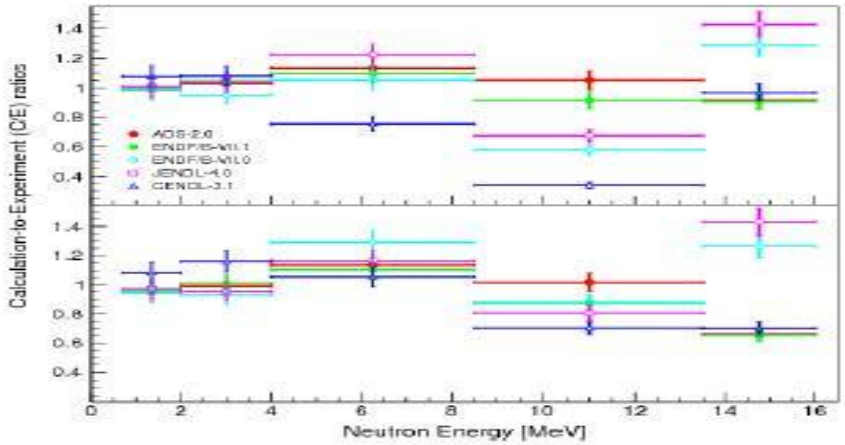


Fig. 5. (Color online) The C/E values integrated over the five energy regions for thickness of 7cm at 60° (top) and at 120° (bottom)

http://arxiv.org/abs/1411.5937

CNDC CHINA NUCLEAR DATA CENTER

Pb and Pb-Bi alloy (collaborate with INEST)

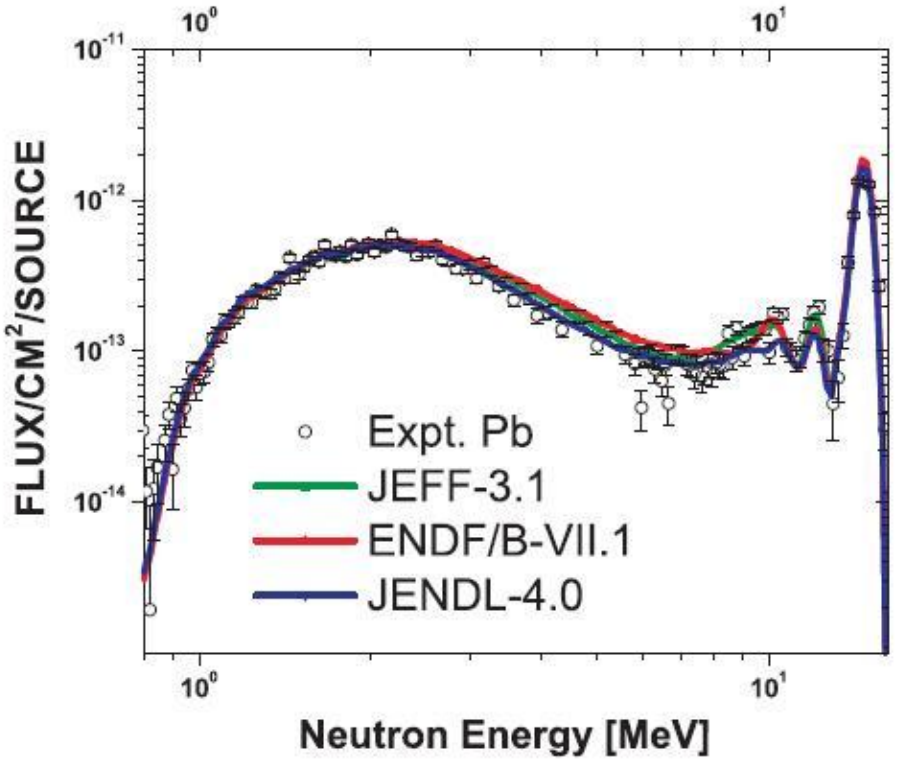


Figure 3: Measured and calculated neutron spectra in Pb experiment

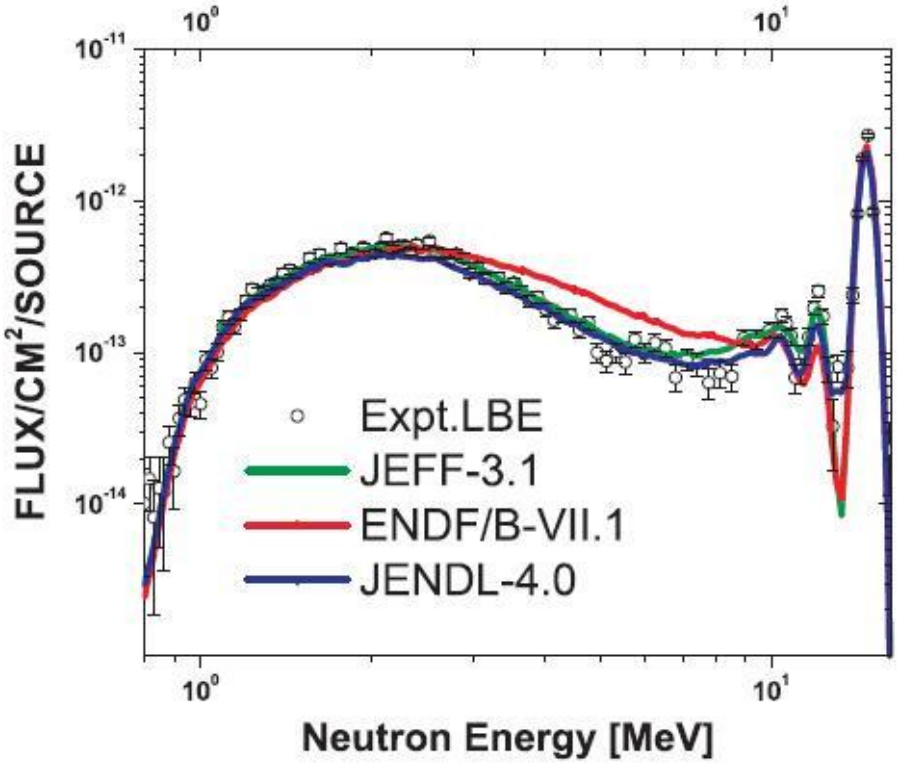
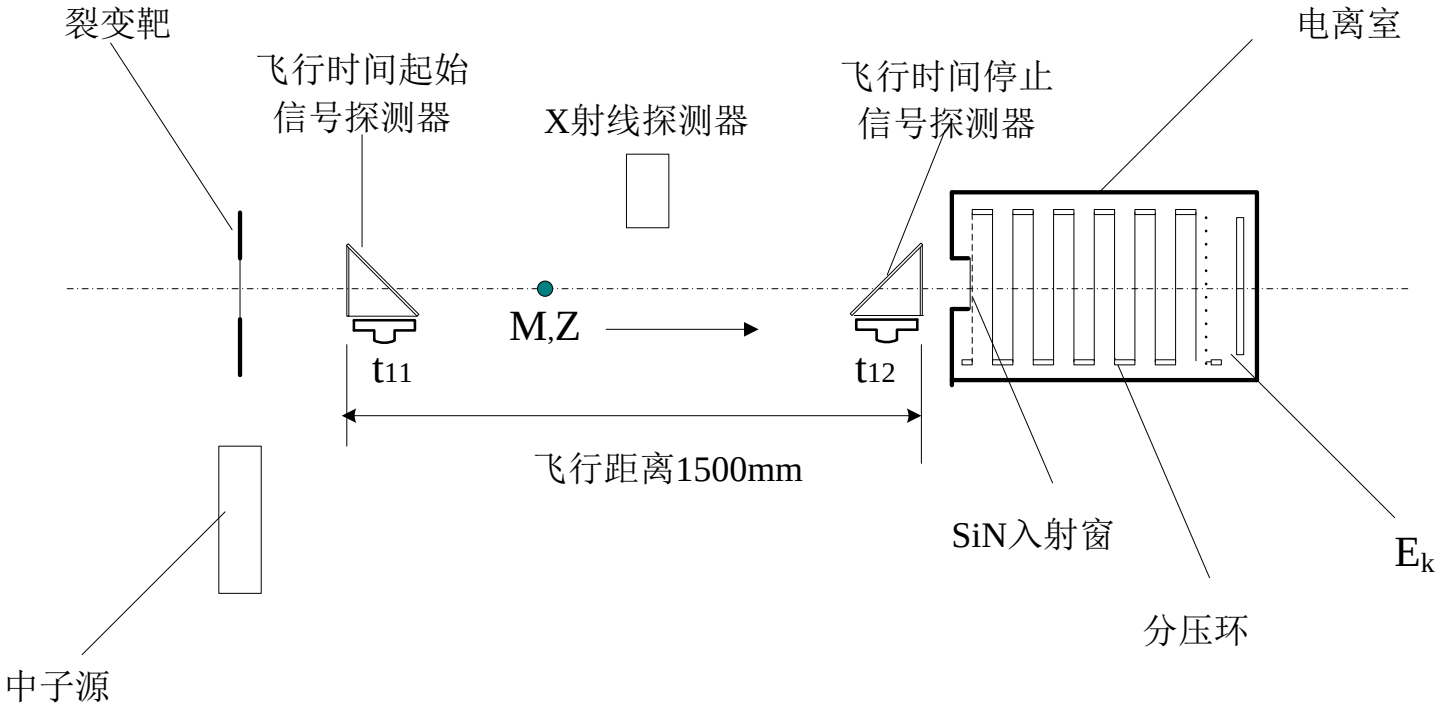


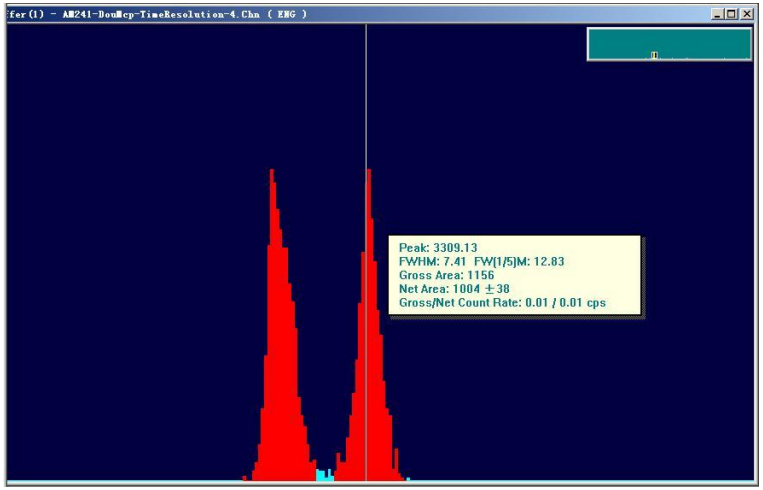
Figure 4: Measured and calculated neutron spectra in LBE experiment

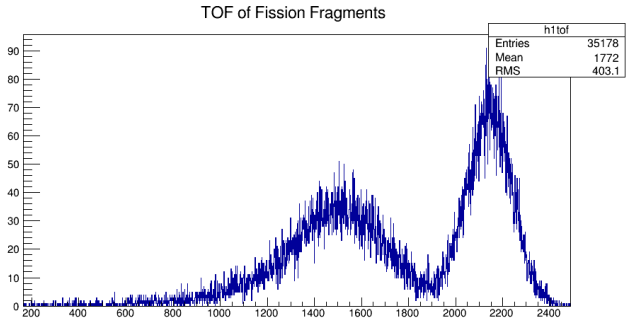
Fission fragments detection system R&D

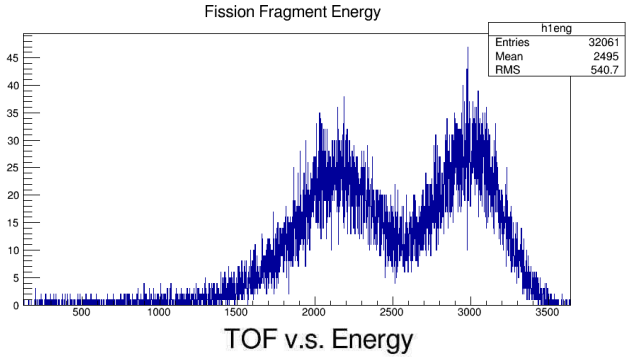


TOF-E system, at this moment use Si as E detector, plan to develop gas detector later on

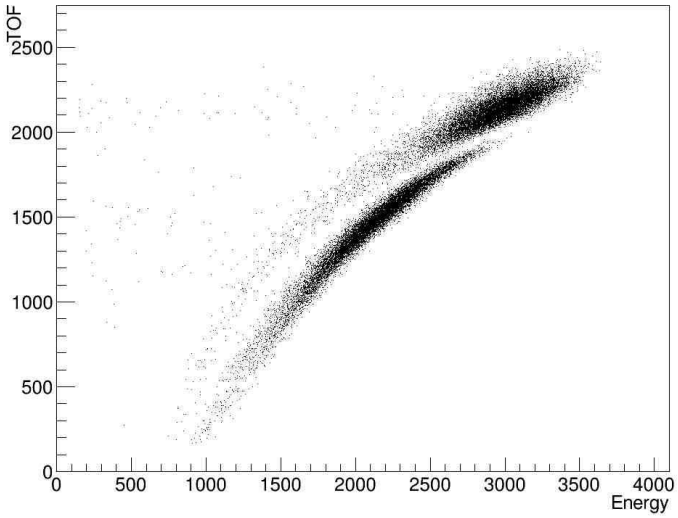
The prototype



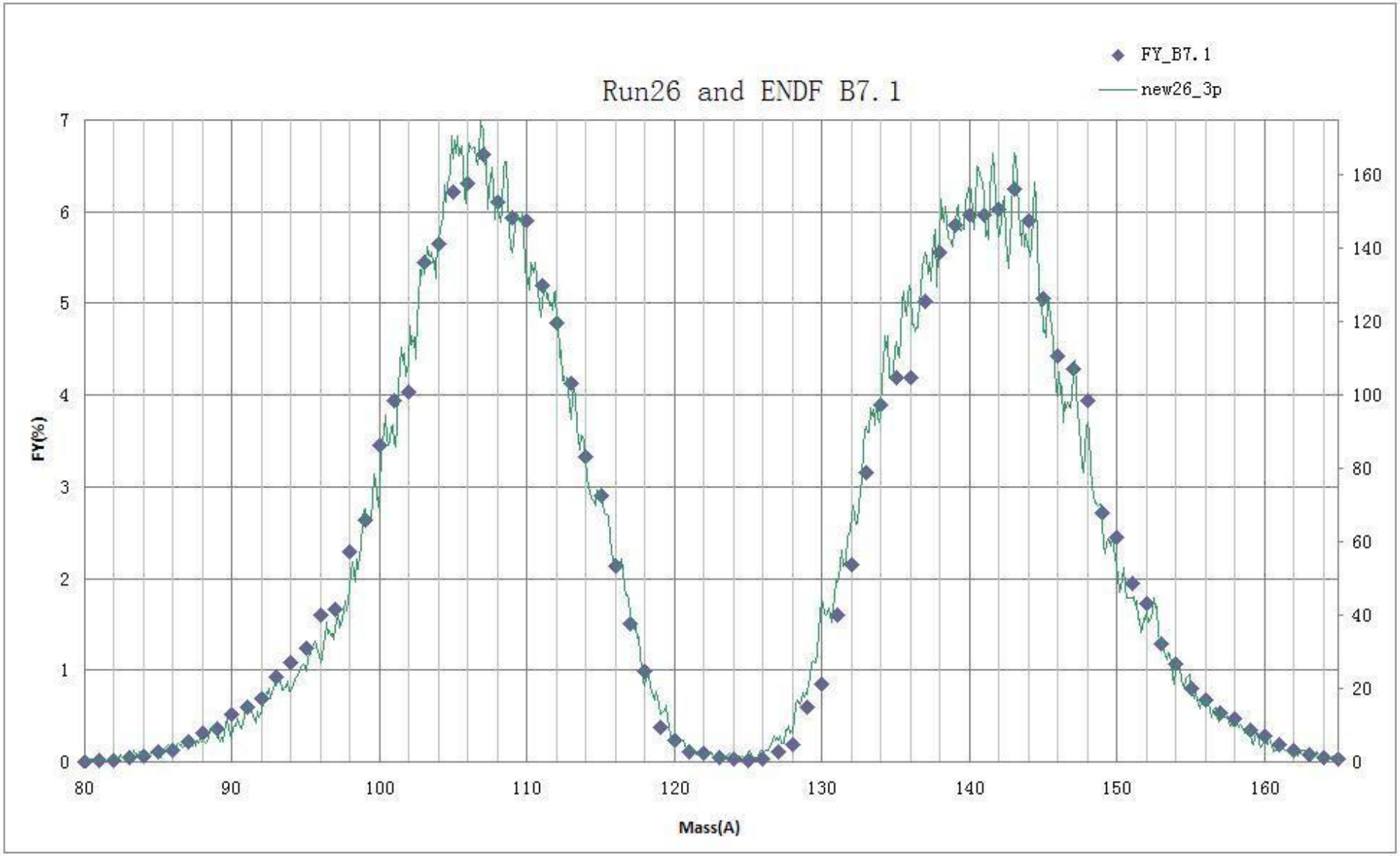




Time resolution tested with alpha source;
Better than 200 ps;
Test run with Cf source



Preliminary result

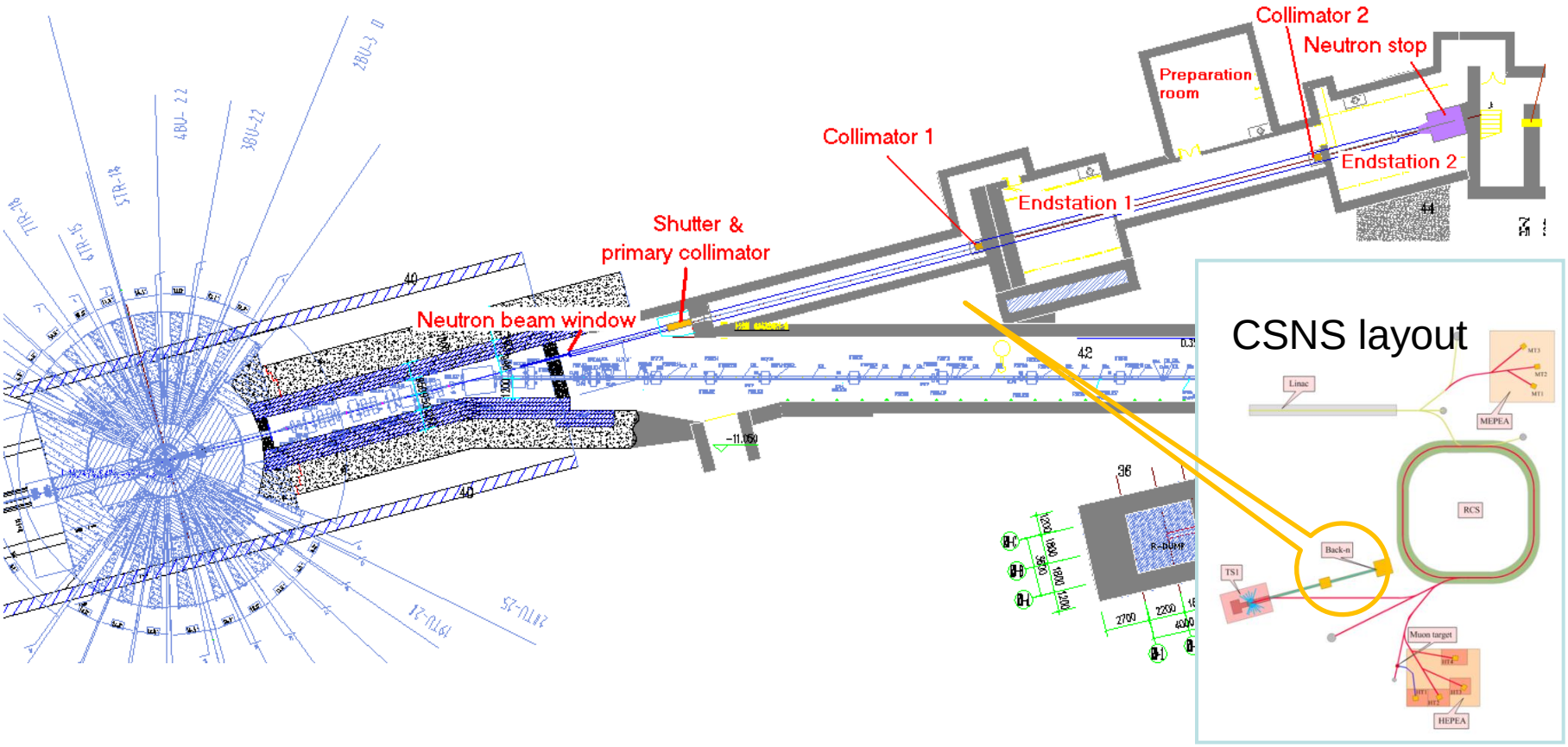


CSNS back-streaming neutron beam line

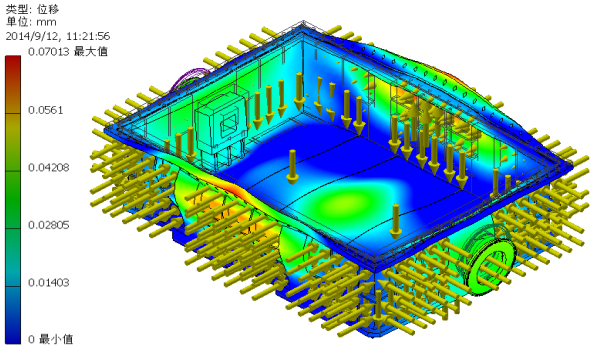
Highlights:

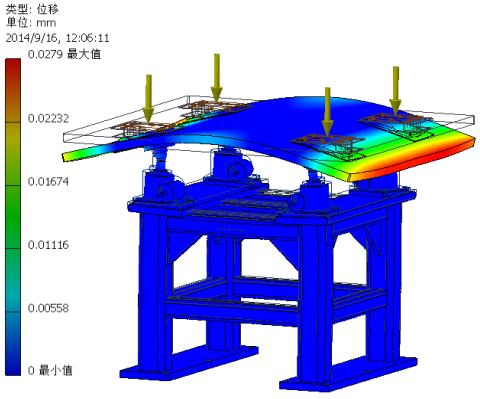
1. The tunnel civil construction finished
2. The beam line design (shutter, collimator, neutron dump, etc.) finalized. Some equipements under fabrication.
3. Detector system under design and waiting for funding approvement.

Layout of the CSNS back-streaming neutron source



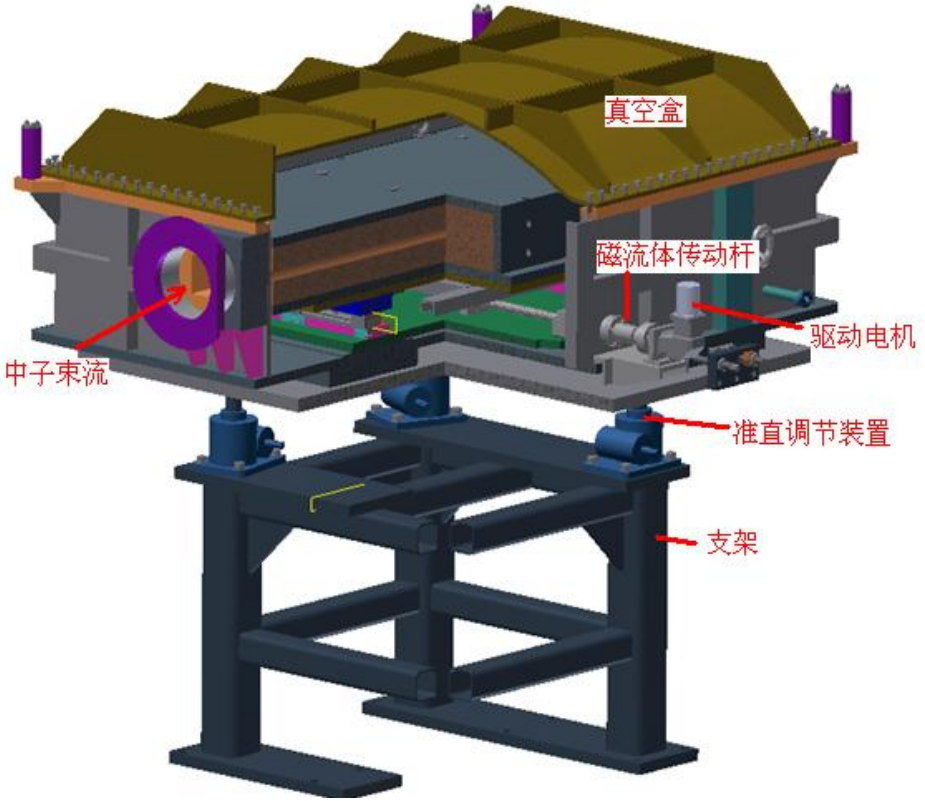
The shutter and the beam window under fabrication





Main features:

- Stress analysis
- Magnetic fluid transmission
- Vacuum sealing



Peking University

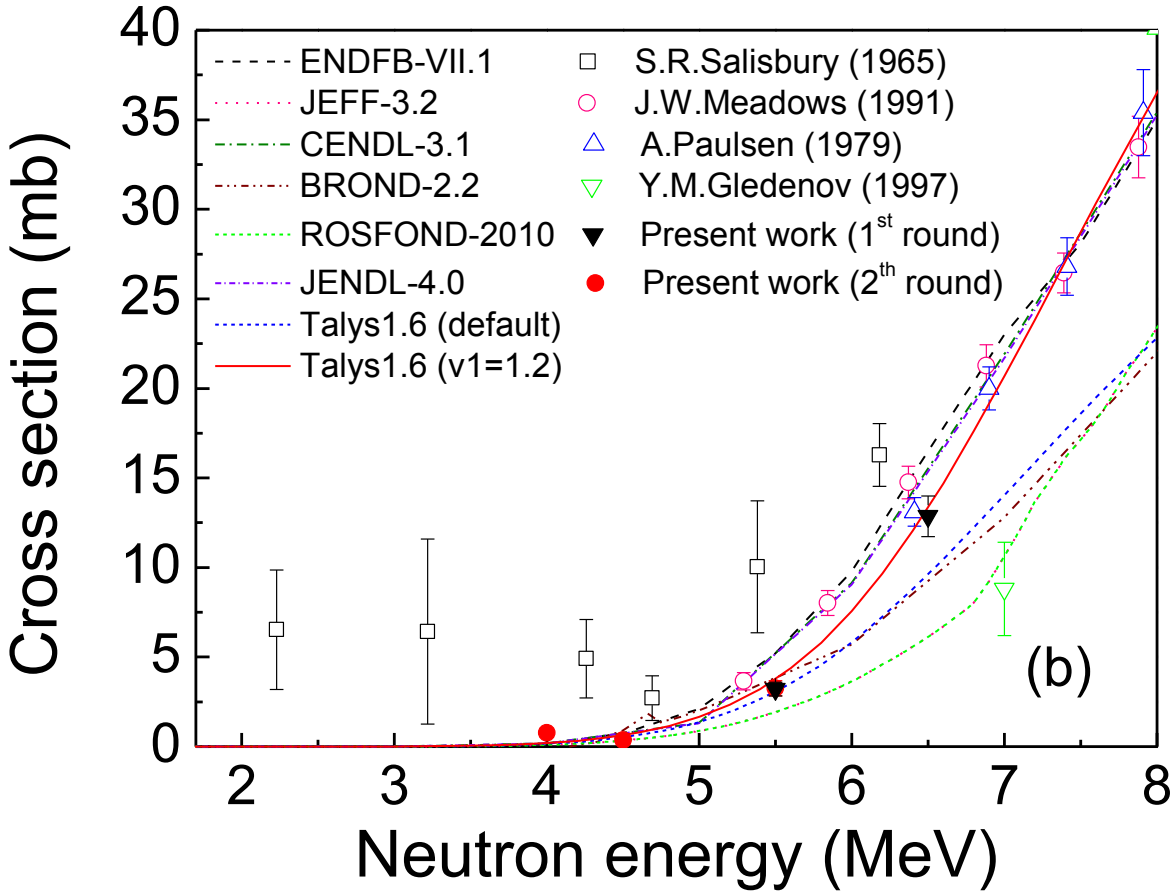
Cross sections of the $^{56}Fe(n,\alpha)^{53}Cr$ and $^{54}Fe(n,\alpha)^{51}Cr$ reactions in the MeV region

Zhimin Wang, Xiao Fan, Luyu Zhang, Huaiyong Bai, Jinxiang Chen, Guohui Zhang*
State Key Laboratory of Nuclear Physics and Technology, Institute of Heavy Ion Physics, Peking University, Beijing 100871, China

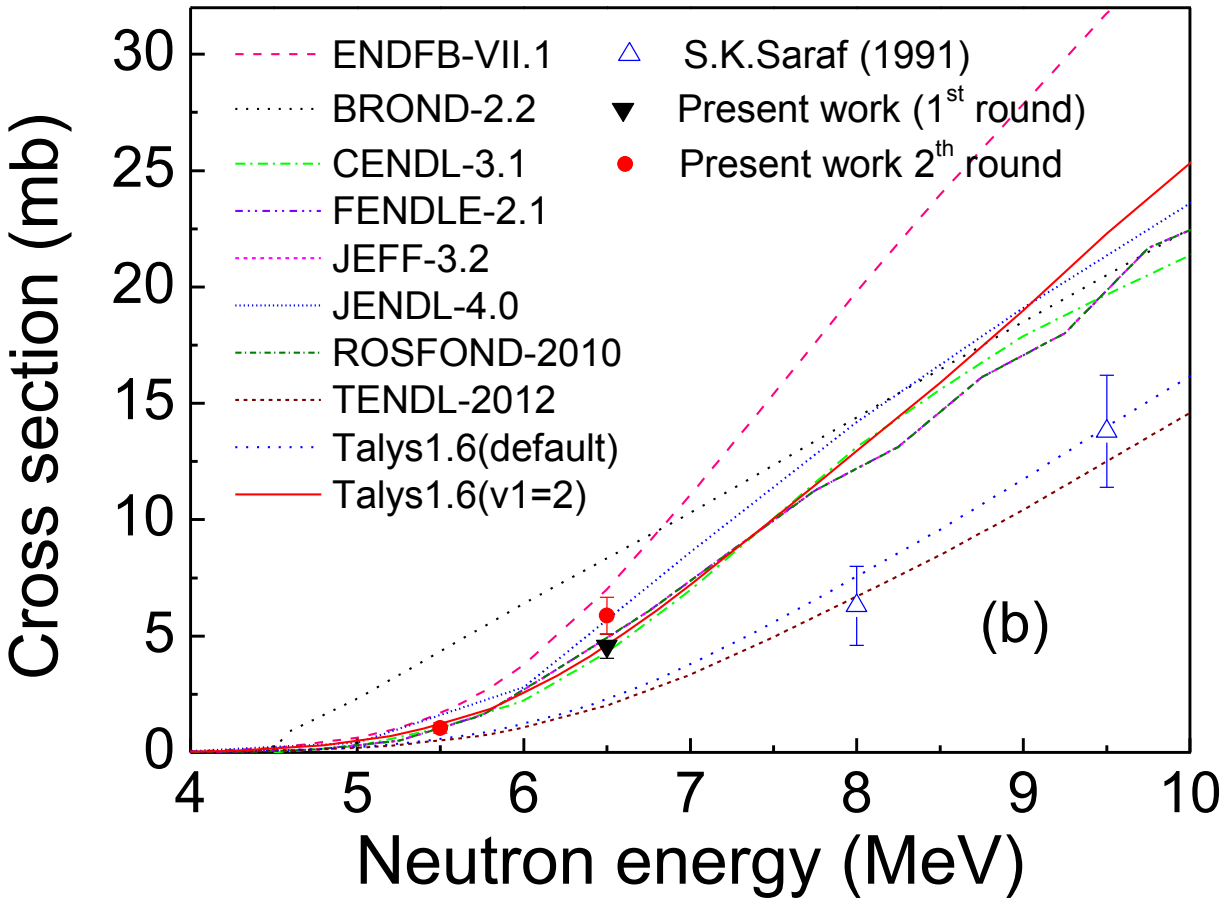
Yu. M. Gledenov, M. V. Sedysheva, L. Krupa
Joint Institute for Nuclear Research, Dubna 141980, Russia

G. Khuukhenkhuu
Nuclear Research Centre, National University of Mongolia, Ulaanbaatar, Mongolia

Submitted to PRC


ENDFB-VII.1
JEFF-3.2
CENDL-3.1
BROND-2.2
ROSFOND-2010
JENDL-4.0
Talys1.6 (default)
Talys1.6 (v1=1.2)
S.R.Salisbury (1965)
J.W.Meadows (1991)
A.Paulsen (1979)
Y.M.Gledenov (1997)
Present work (1st round)
Present work (2th round)
(b)
Cross section (mb)
Neutron energy (MeV)
0
5
10
15
20
25
30
35
40
2
3
4
5
6
7
8

^{54}Fe result


ENDFB-VII.1
BROND-2.2
CENDL-3.1
FENDLE-2.1
JEFF-3.2
JENDL-4.0
ROSFOND-2010
TENDL-2012
Talys1.6(default)
Talys1.6(v1=2)
S.K.Saraf (1991)
Present work (1st round)
Present work 2th round
(b)
Cross section (mb)
Neutron energy (MeV)
0
5
10
15
20
25
30
4
5
6
7
8
9
10

^{56}Fe result

ADS related nuclear data measurements at IMP,CAS (2014)

Zhiqiang Chen

ADS Nuclear Data Laboratory

Institute of Modern Physics, Chinese Academy of Sciences(IMP,CAS)

HIRFL-CSR Complex in Lanzhou

SSC(K=450)
100 AMeV (H.I.), 110 MeV (p)

SFC (K=69)
10 AMeV (H.I.), 17~35 MeV (p)

RIBLL2
RIBs at hundreds of AMeV

CSRe

RIBLL1
RIBs at tens of AMeV

PISA

Proton:2.5GeV

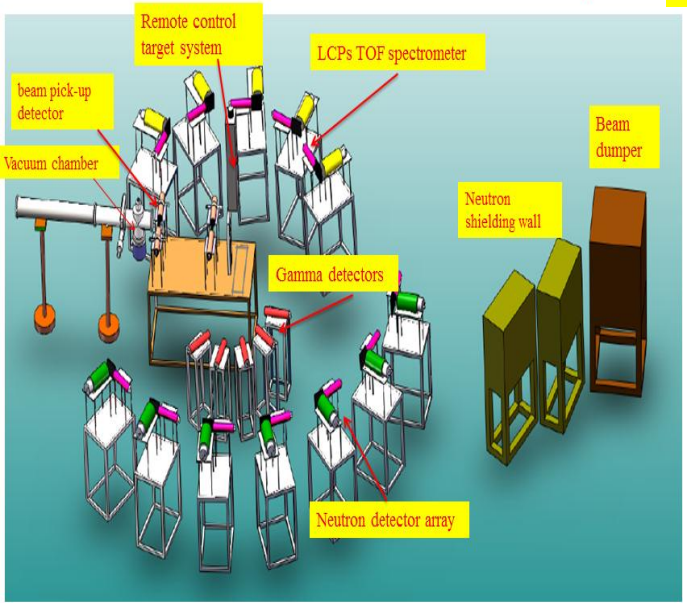
Cancer Therapy

CSRm
1000 AMeV (H.I.), ≤ 2.8 GeV (p)

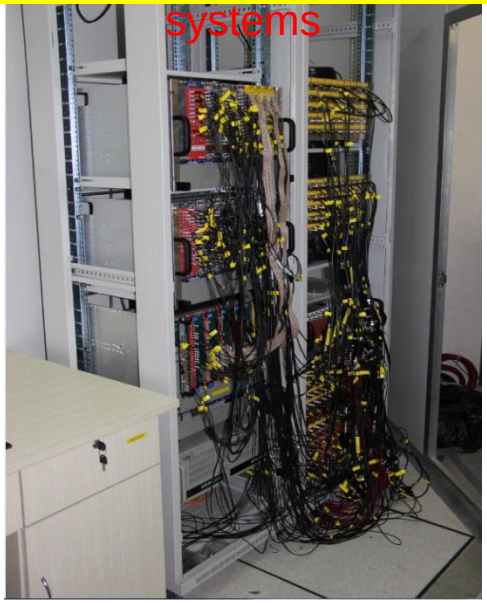
PISA terminal is used for ADS Nuclear data measurements.

400 MeV/u 16O + Pb/W Experiments (TOF methods)

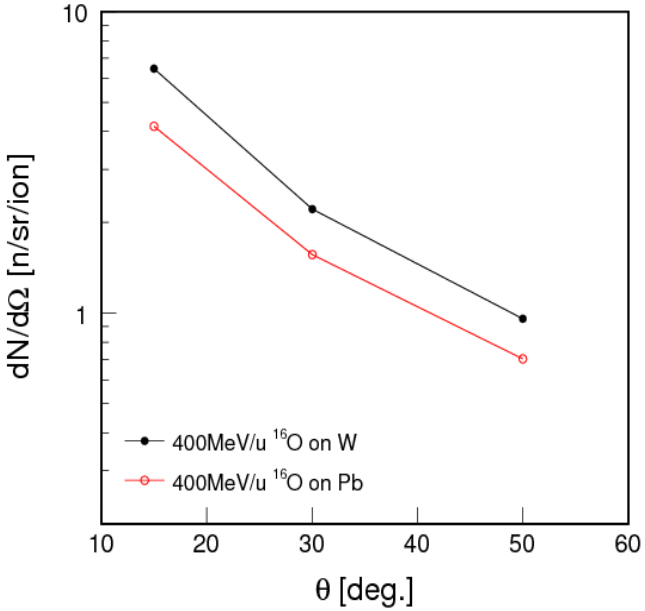
Nuclear data measurement facility



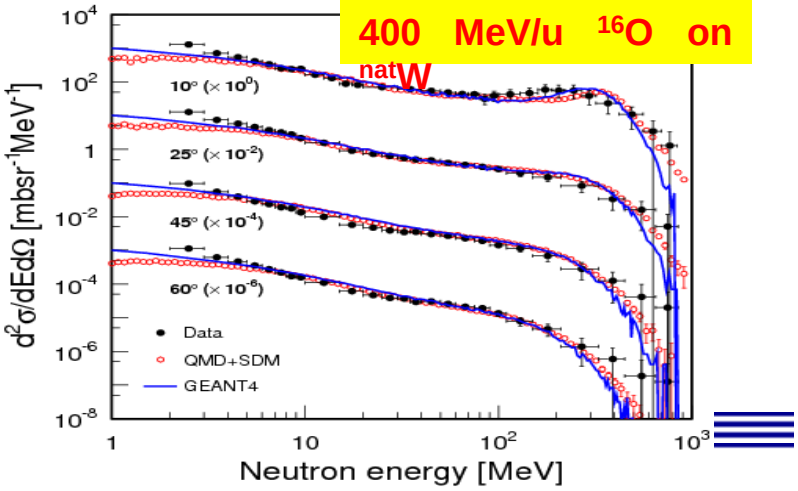
Electronics and DAQ systems



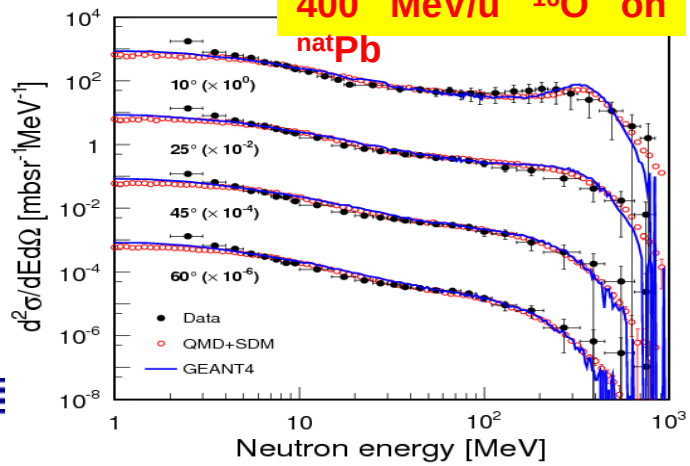
Light charged particles



400 MeV/u ^{16}O on ^{nat}W

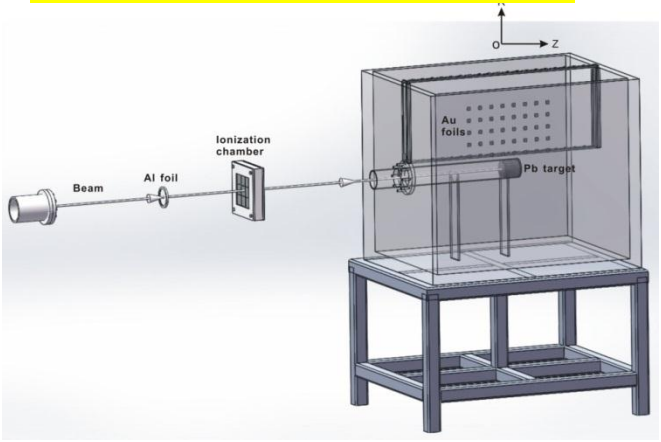


400 MeV/u ^{16}O on ^{nat}Pb



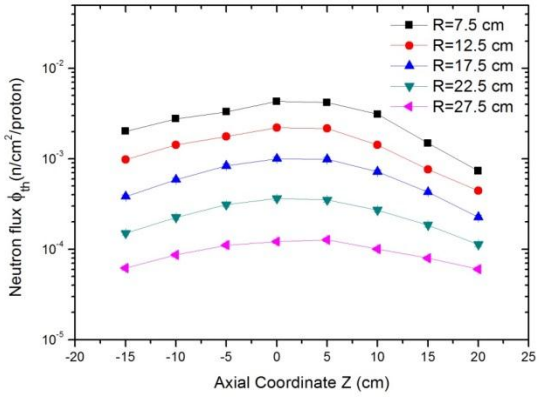
250 MeV p + Pb/W/Cu Experiments (water-bath activation)

Experimental setup

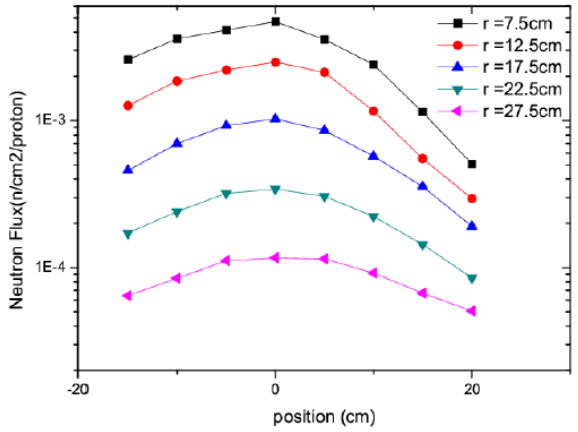


Water-bath device

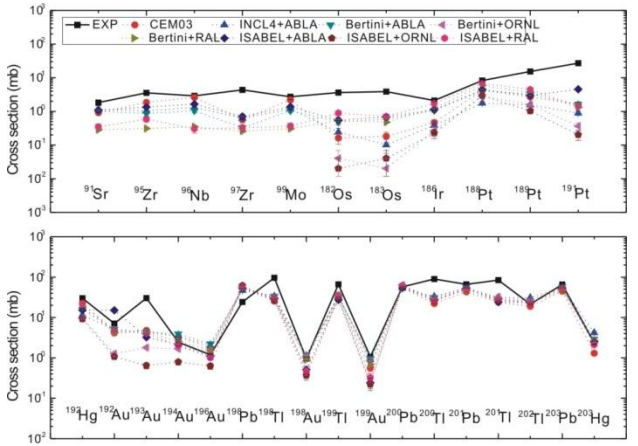
Hp-Ge detector



Neutron flux distribution for Pb target



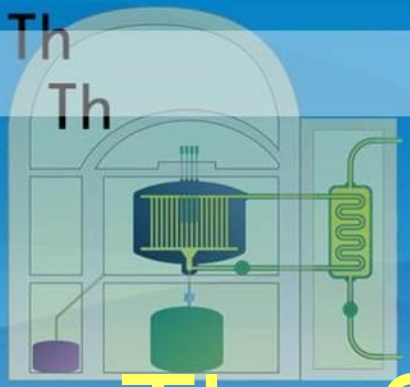
Neutron flux distribution for W target



Spallation products for Pb target

publications

1. R. Han, R. wada, Z. Chen, et al., Fast neutron scattering on Gallium target at 14.8 MeV, Nucl.Phys. A936, 17(2015).
2. S. Zhang, Z. Chen, Y. Nie, et al., Measurement of leakage neutron spectra for Tungsten with D-Tneutrons and validation of evaluated nuclear data, Fusion Engineering and Design 92 (2015) 41-45.
3. ZHANG Su-ya-la-tu, CHEN Zhi-qiang, LIU Jian-li, et al., Development and the First Test Experiment of Experimental Setup for Measuring of ADS Nuclear Data.
4. Li Yan-Yan, Zhang Xue-Ying, Ju Yong-Qin, Ma Fei, et al., Study of neutron spectra in a water bath from a Pb target irradiated by 250 MeV protons, Chinese Physics C 39, 044001 (2014).
5. L. Chen, F. Ma, X.Y. Zhang et al., Spallation yield of neutrons produced in thick lead target bombarded with 250 MeV protons, Nucl. Inst. Meth. B 342 (2015) 87-90.



The Study of the Th/U Cycle Nuclear Data in TMSR

Reactor Physics Division,
Center for Thorium Molten Salt Reactor System,
SINAP,CAS

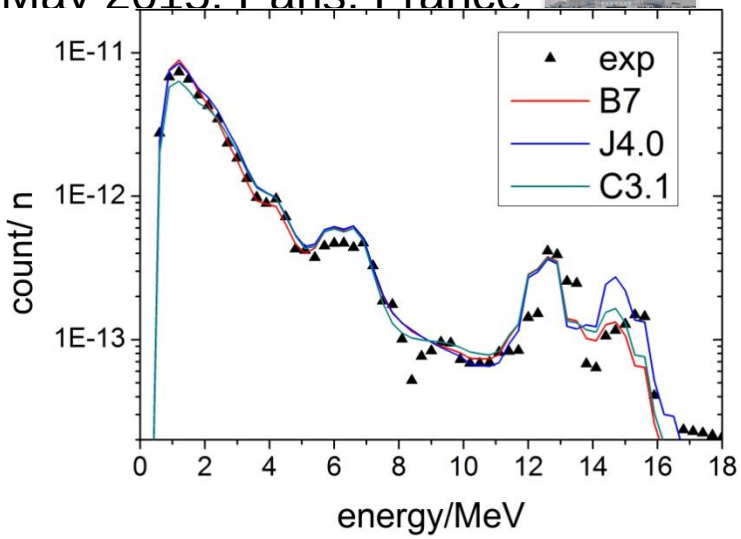
➢Experiment

- The neutron beam test
- ThO_2 integral experiment (CIAE)

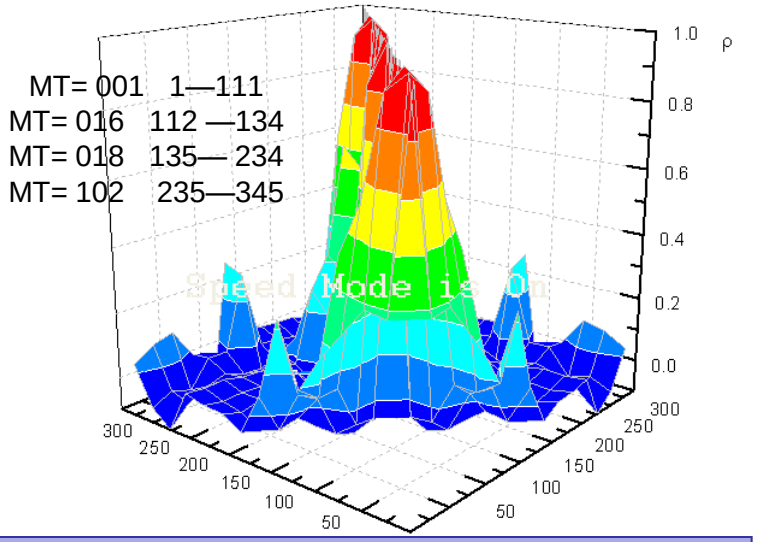
➢Data evaluation(CNDC)

- ^{6}Li data improved
  - ✓$^{6}Li(n, 2np)\alpha$, $^{6}Li(n, n\alpha)$
- ^{232}U data improved, (n,f), (n,non) and (n,n′)
- ^{232}Th covariance data

Benchmark testing show that these data can satisfy the 1st step engineering design!

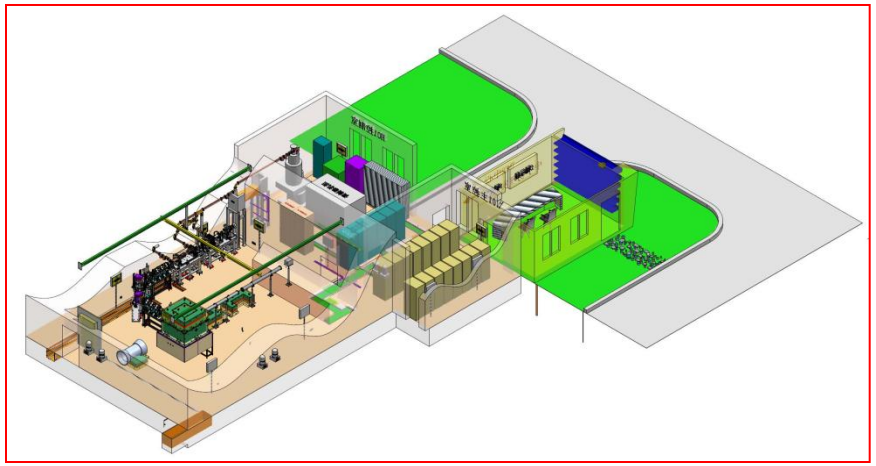


Leakage spectra from ThO_2

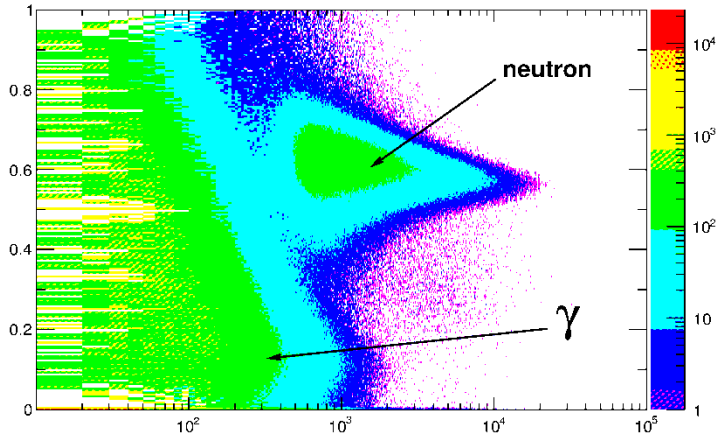


^{232}Th covariance matrix

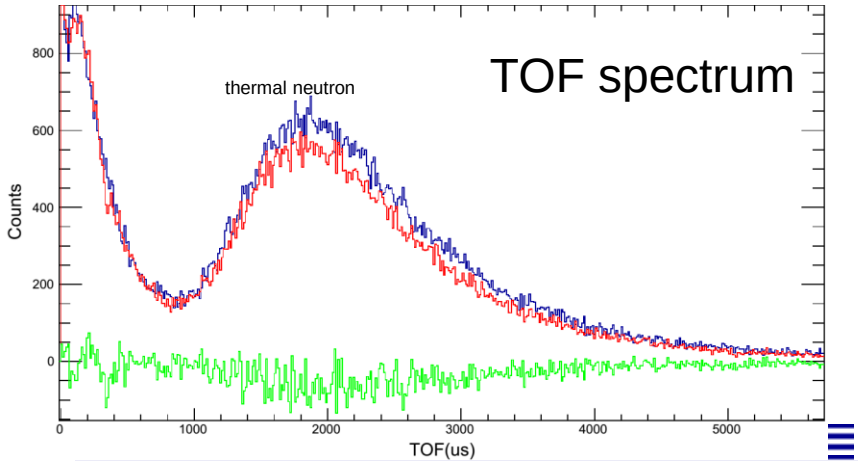
TMSR 15MeV e-LINAC test running

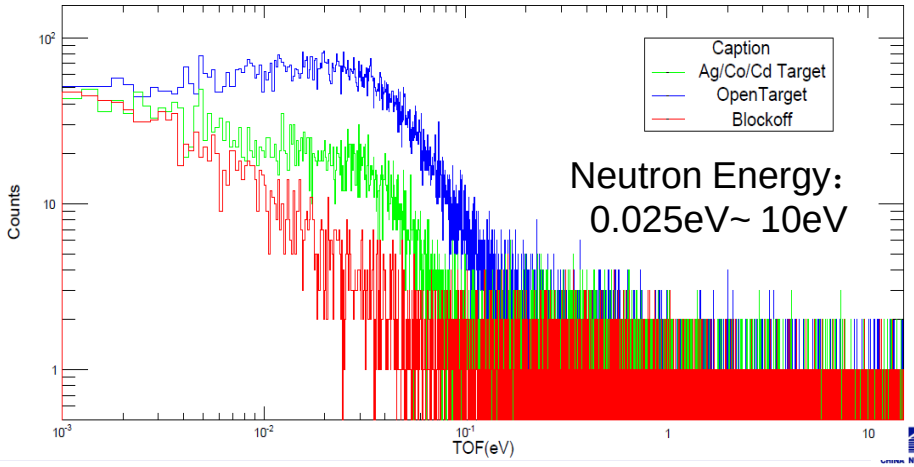


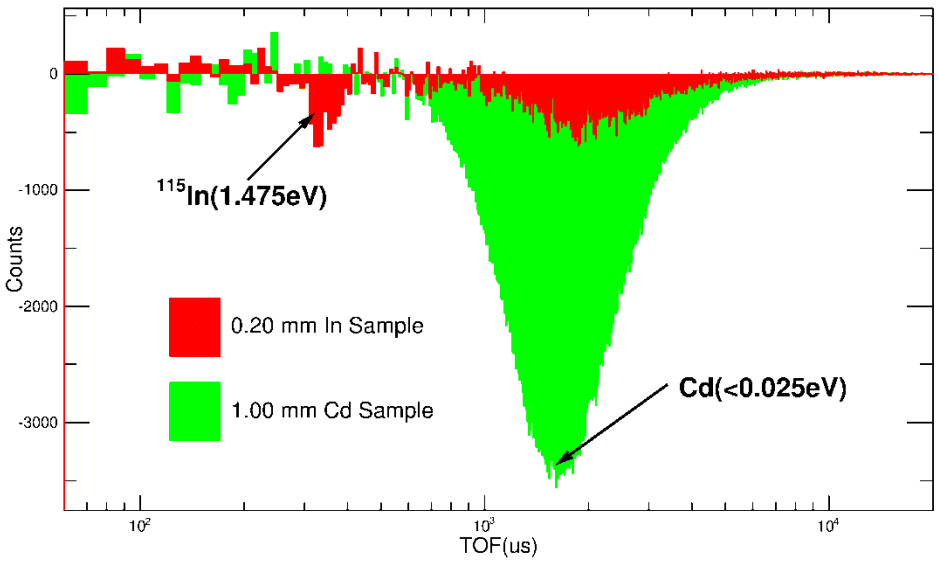
Neutron Experimental Facilicity



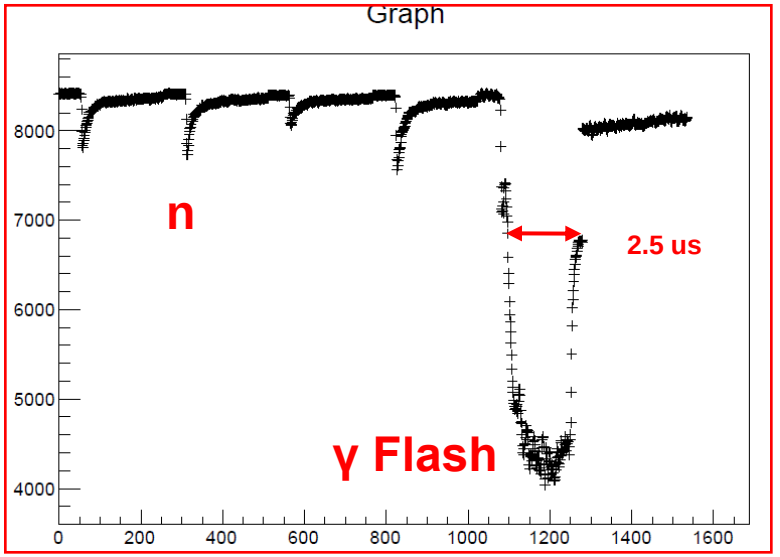
TOF detector：EJ426HD2(6LiF·ZnS(Ag) Size ϕ50mm×0.5mm)
PSD- QDC 2D spectrum for n/γ Discrimenation







- 吸收片测量结果



☞ WaveForm of TOF Detector

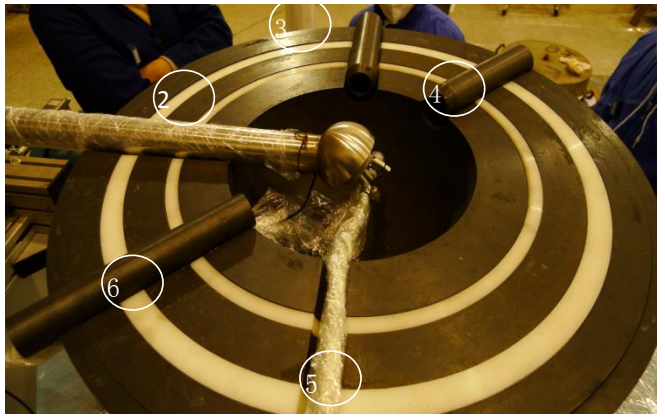
Some test measurements performed for the source intensity, detector and electronic system, DAQ, etc.

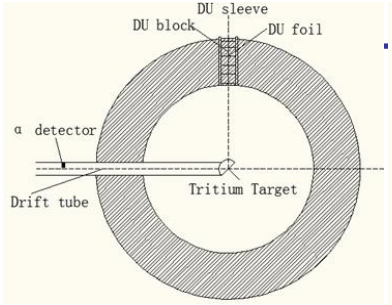
China Academy of Engineering Physics (CAEP)

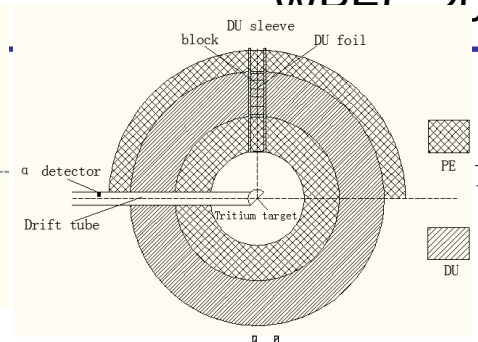
U&Th Integral Experiment with D-T Neutrons

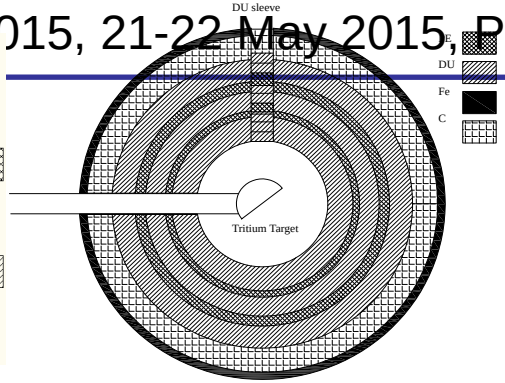
Prliminary work

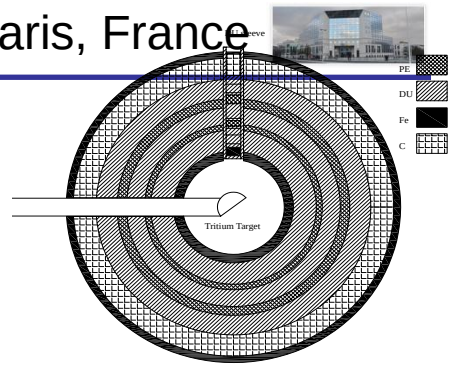
- Design and construct the integral setups of U&Th
- Develop the measurement technique
- Measure $^{238}U(n,\gamma)$, $^{238}U(n,f)$, $^{238}U(n,2n)$, $^{235}U(n,f)$ reaction rate
- Measure $^{232}Th(n,\gamma)$, $^{232}Th(n,f)$, $^{232}Th(n,2n)$ reaction rate

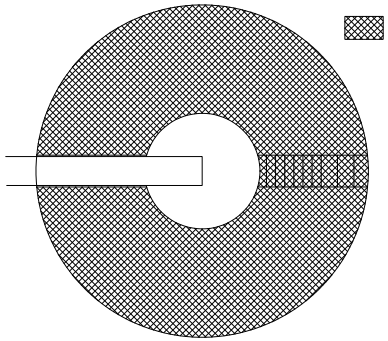


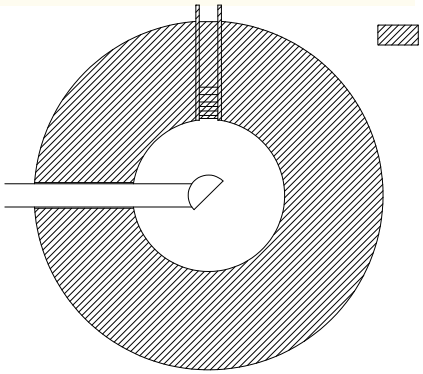


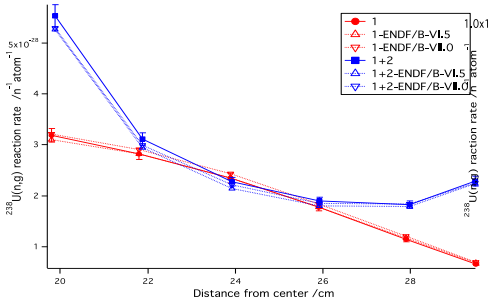


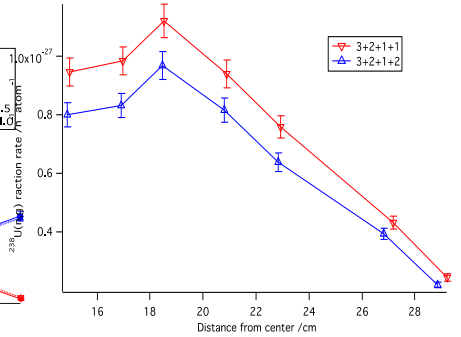


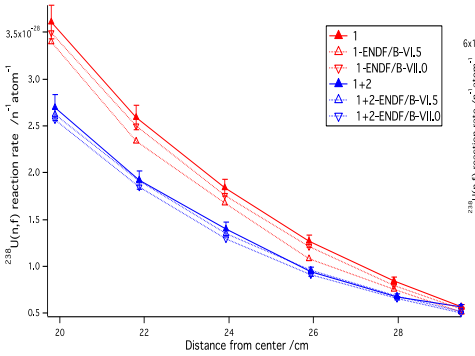


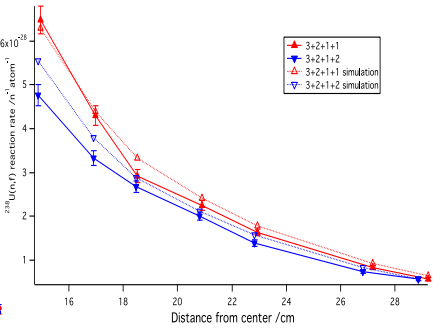


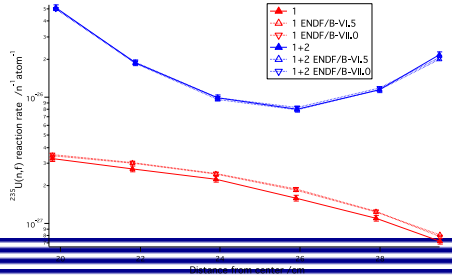


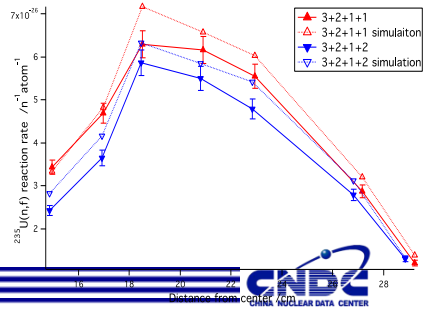












- Determined the reaction rates in different integral setups
- Calculated using Monte Carlo method and primary nuclear database
- These data was provided to the designer of Fusion-Fission Hybrid reactor

Thank you for your attention !