



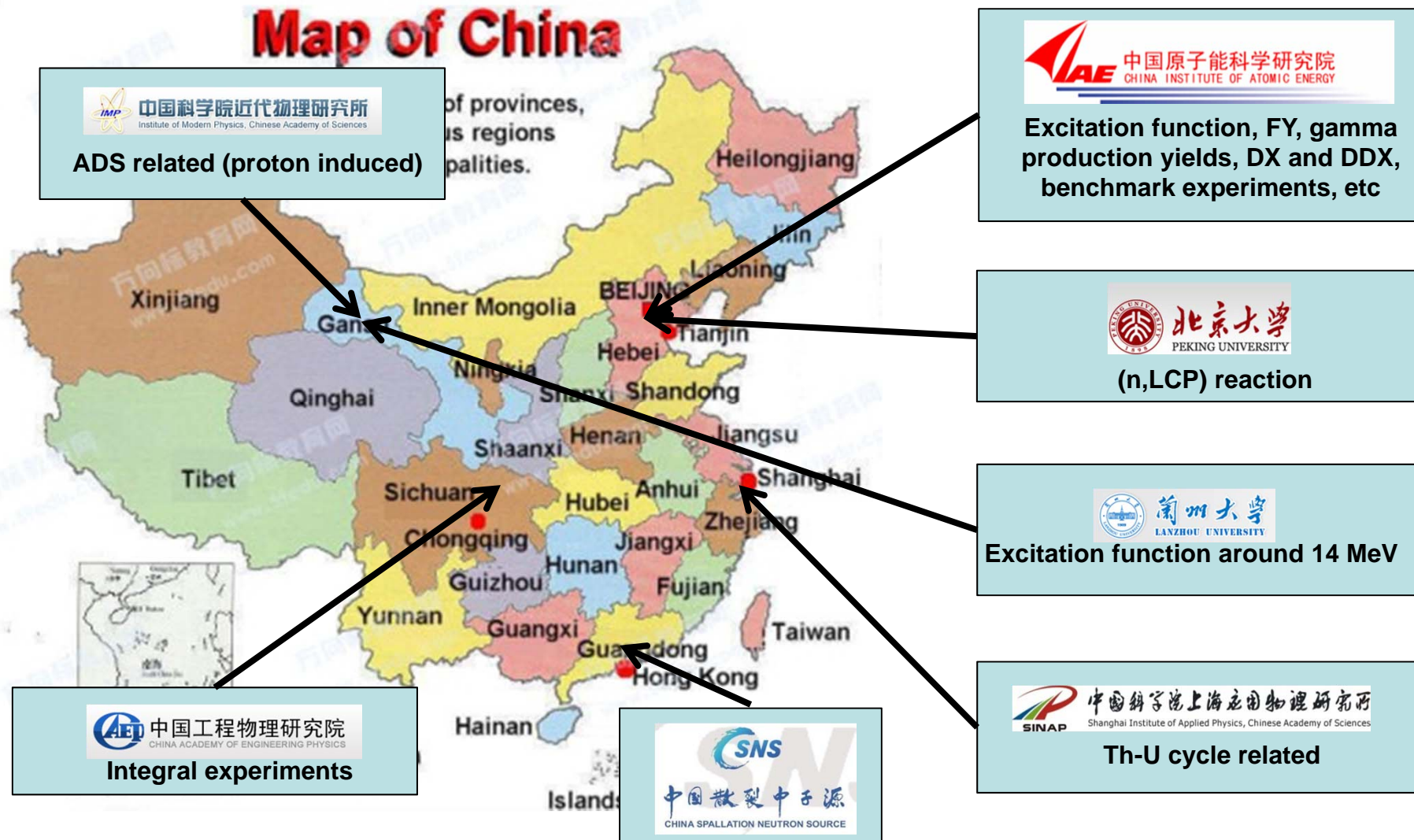
Nuclear data measurement activities in China

Xichao Ruan

China Nuclear Data Center
China Institute of Atomic Energy

WPEC-2017, May 15-19, 2017, Paris, France

Institutes involve in nuclear data measurement in China



China Institute of Atomic Energy

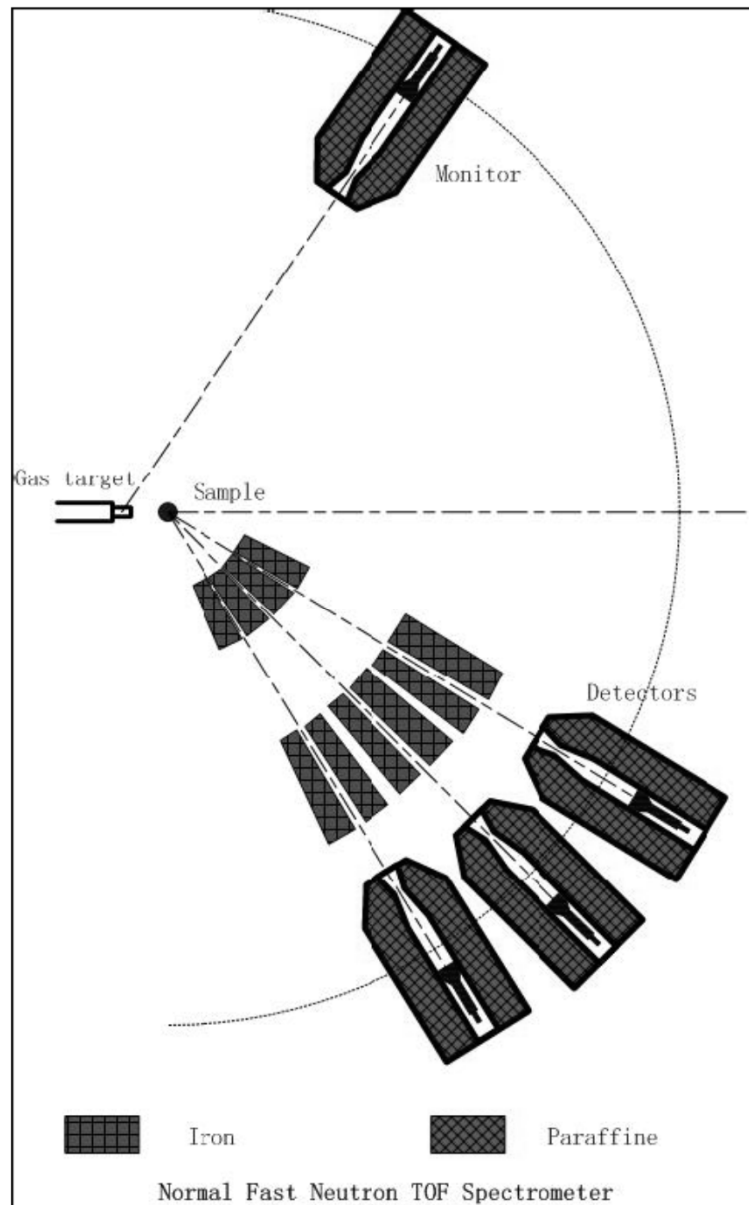
Xichao Ruan

xichao_ruan@126.com

Highlights in 2016:

1. DX and DDX measurement
2. Nuclear data benchmark experiments
3. Progress of CSNS Back-n

1. DX and DDX measurement: Deuterium sample at 8.2 MeV

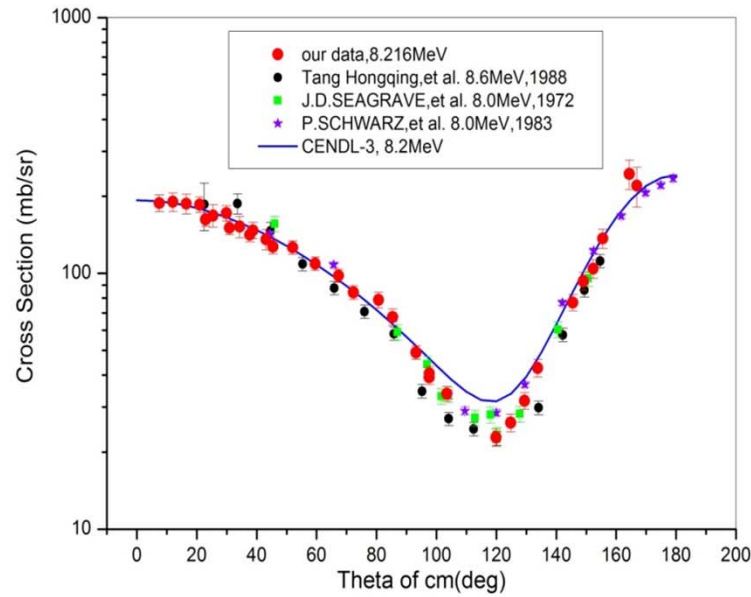


- Facility: TOF spectrometer at HI-13 Tandem accelerator
- Method: TOF technique
- Detectors: 3 BC501A($\Phi 5 \times 2$ inches)+1 monitor($\Phi 2 \times 2$ inches)
- Detection angles: 15 to 155 degrees
- FWHM of pulsed beam: ~ 2 ns
- FP: ~ 6 m
- Target: D_2 , $^{15}N_2$ and T_2 gas target
- Energy range: 2-40 MeV (monoenergetic and quasi-monoenergetic)

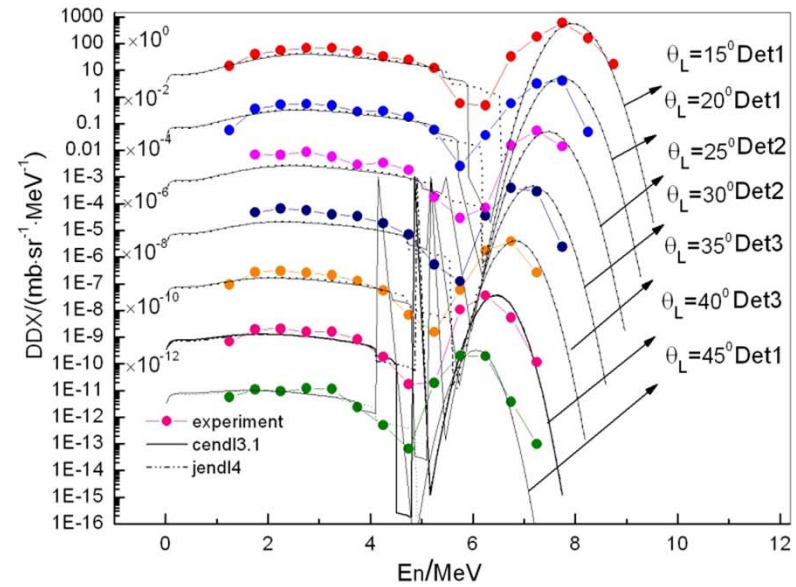
En	Samples
14 MeV	C, ^{238}U , D, ^{209}Bi , $^{6,7}Li$, Zr, Al
6 MeV	Be
8 MeV	$^{6,7}Li$, Fe, Be, D
10 MeV	$^{6,7}Li$, Be, V, ^{238}U , ^{209}Bi , Fe, C
20-40	Be, C, ^{209}Bi

Work accomplished

Results of deuterium at 8.2 MeV



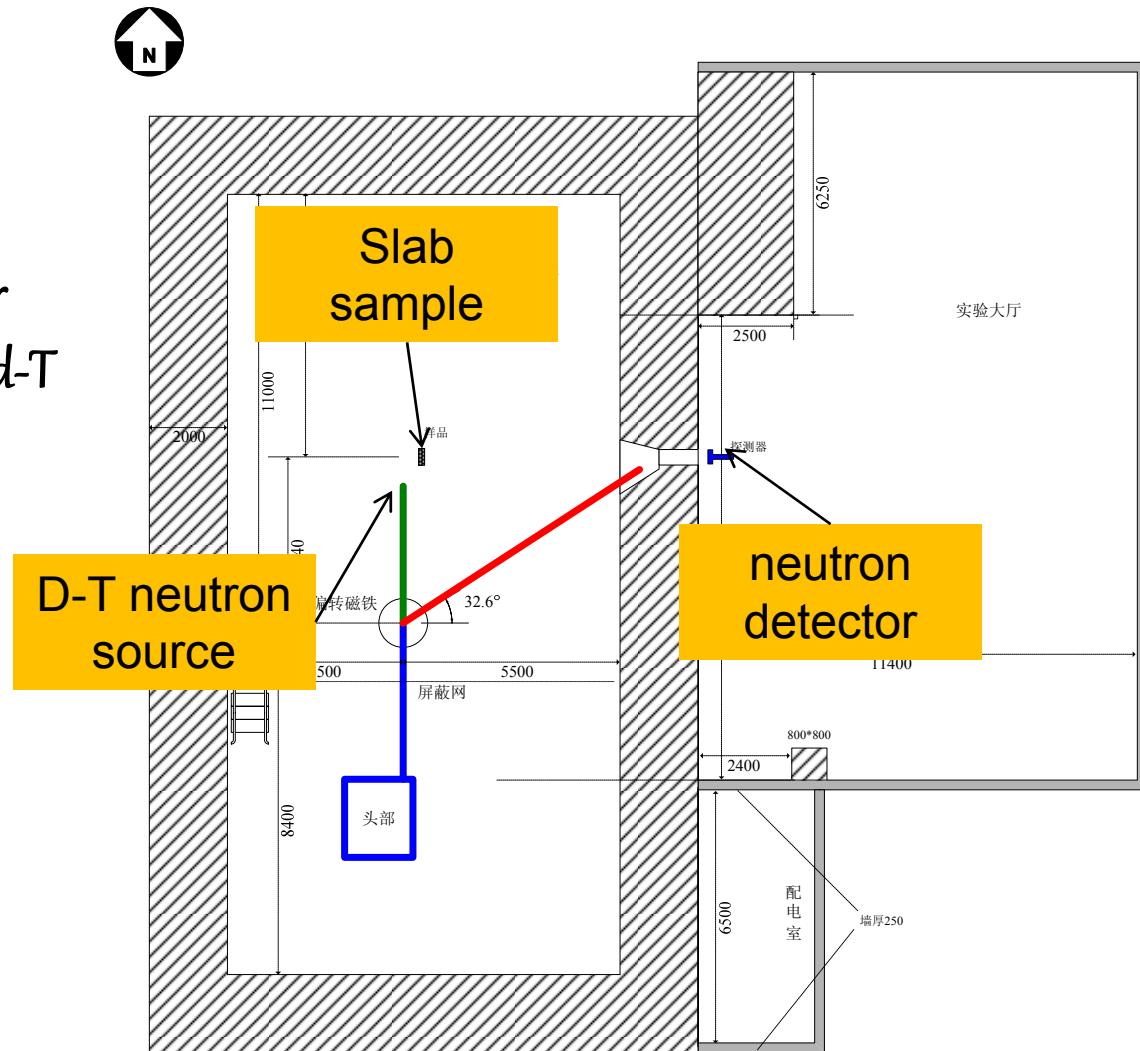
Elastic scattering differential cross section

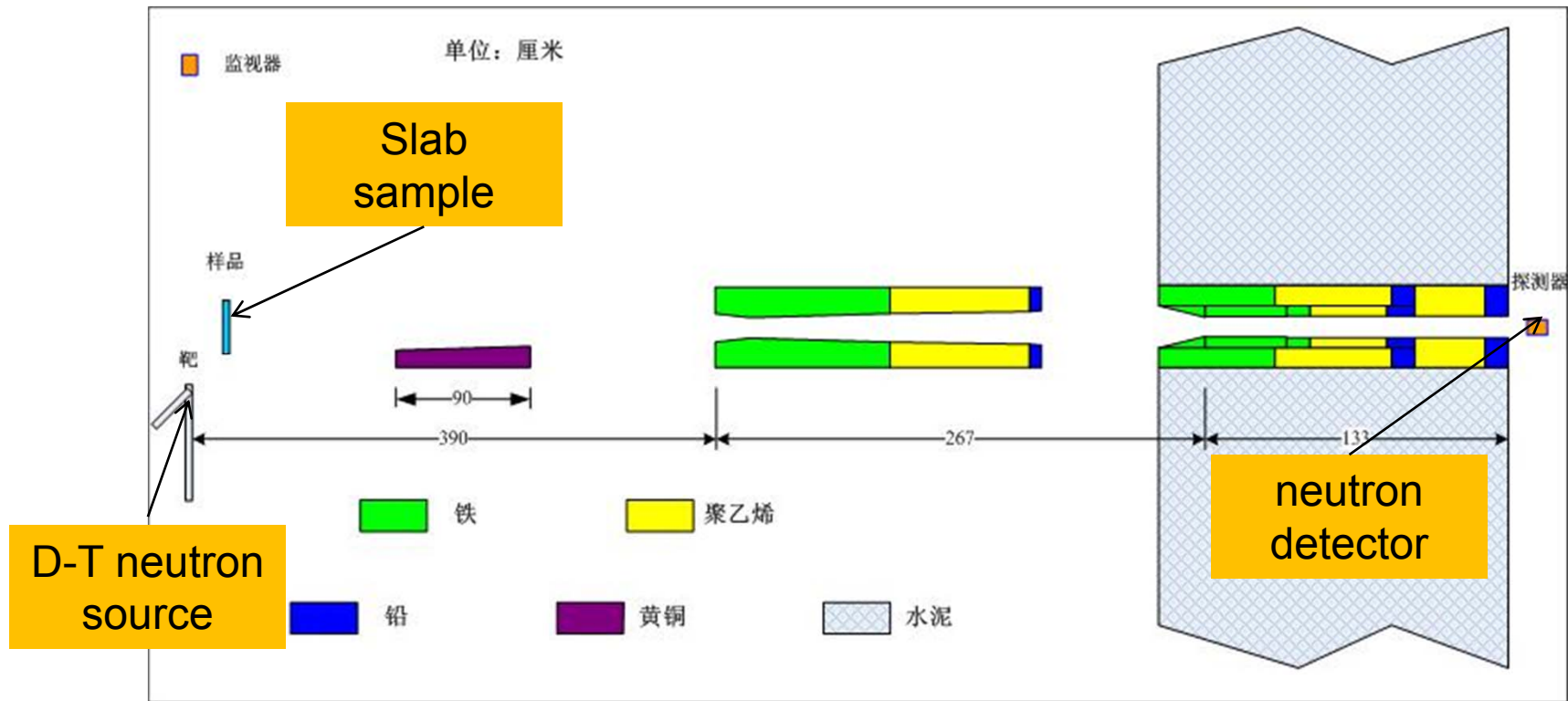


Part of double-differential cross section

2. 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

List of measured samples

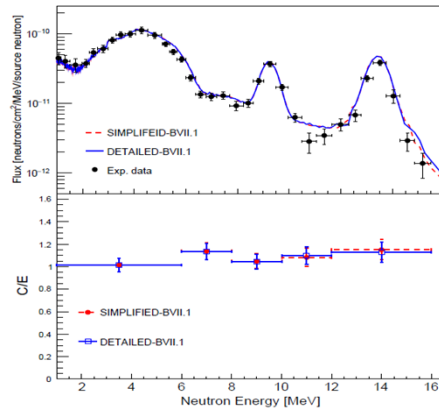
Sample	Sample size/cm	Sample thickness/cm	Angle/°	Institute
²³⁸ U	10×10	5	45、135	CIAE
Be	10×10	5、11	60、120	
^{nat} Fe	10×10	5、10	60、120	
Nb	10×10	5、10	60、120	
H ₂ O	Φ13	5.2	60	
PE	Φ13 10×10	6 5	60 45	
Pb	Φ13	5	60	CIAE-INEST
Pb-Bi	Φ13	5	60	
ThO ₂	Φ13	5.4、10.8	60、120	CIAE-SINAP

Collaboration between CIAE-IMP for ADS purpose

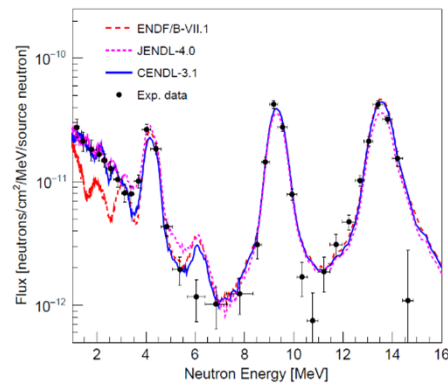
sample	dimension	Angle
Polyethylene	10cm*10cm*5cm	60
Gallium	10cm*10cm*5cm, 10cm*10cm*10cm, Ø13cm*3.2cm, Ø13cm*6.4cm	60,120
Tungsten(block)	10cm×10cm×3.6cm, 10cm×10cm×7.2cm	60,120
Tungsten(Granular)	9.8*9.9*7.2cm , (granular diameter:1mm)	60
Graphite	Φ13*2cm, Φ13*20cm	60,120
SiC	Φ13*2cm, Φ13*20cm	60,120
238U	10cm*10cm*2cm,	60
238U	10cm*10cm*5cm, 10cm*10cm*11cm	60, 120
W+U	W:10cm*10cm*3.5cm , U: 10cm*10cm*2cm	60
W+U+C	W:10cm*10cm*3.5cm, U: 10cm*10cm*2cm C: 10cm*10cm*2cm	60
W+U+C+CH2	W:10cm*10cm*3.5cm , U: 10cm*10cm*2cm C: 10cm*10cm*2cm, CH2: 10cm*10cm*2cm	60
U+C	U: 10cm*10cm*5cm , C: 10cm*10cm*10cm	60
U+C+CH2	U: 10cm*10cm*5cm , C: 10cm*10cm*10cm CH2: 10cm*10cm*10 cm	60

14MeV n + Polyethylene, Graphite, SiC

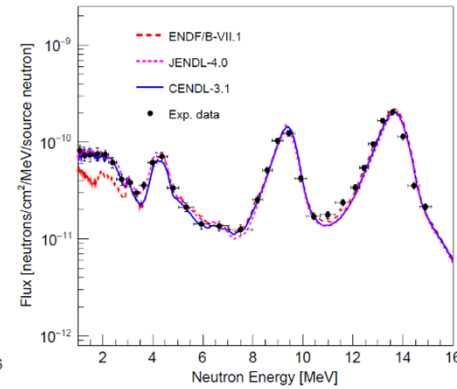
Polyethylene: 60°



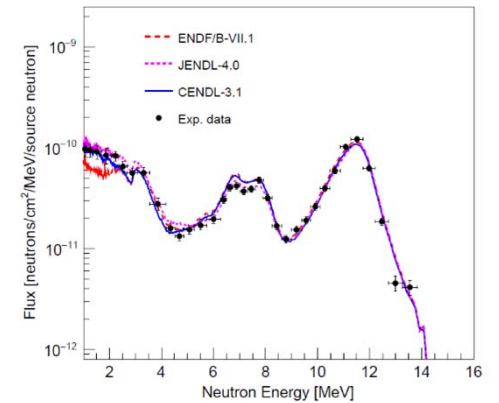
Graphite: 2cm, 60°



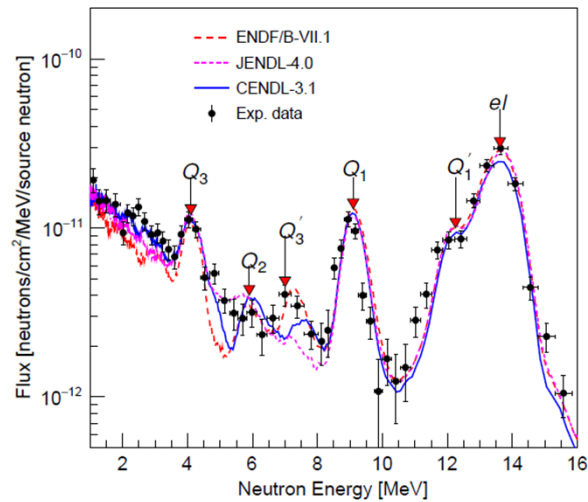
Graphite: 20cm, 60°



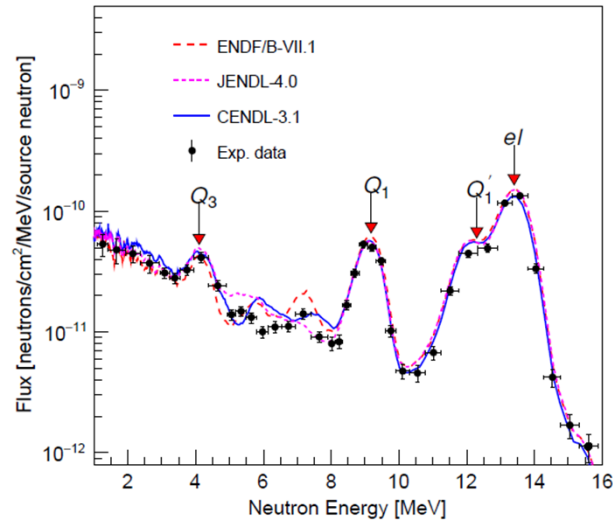
Graphite: 20cm, 120°



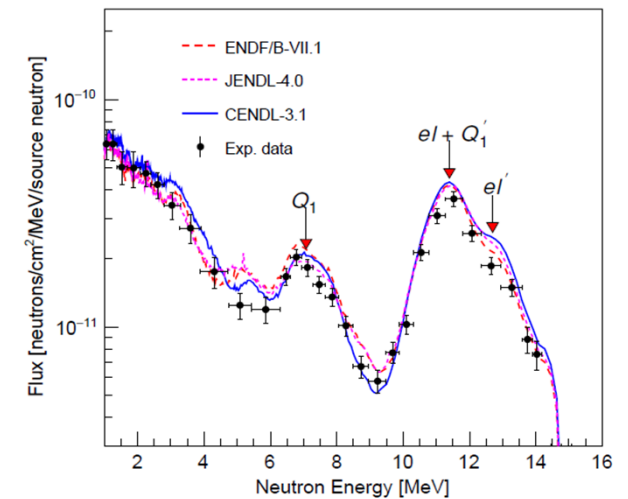
SiC: 2cm, 60°



SiC: 20cm, 60°



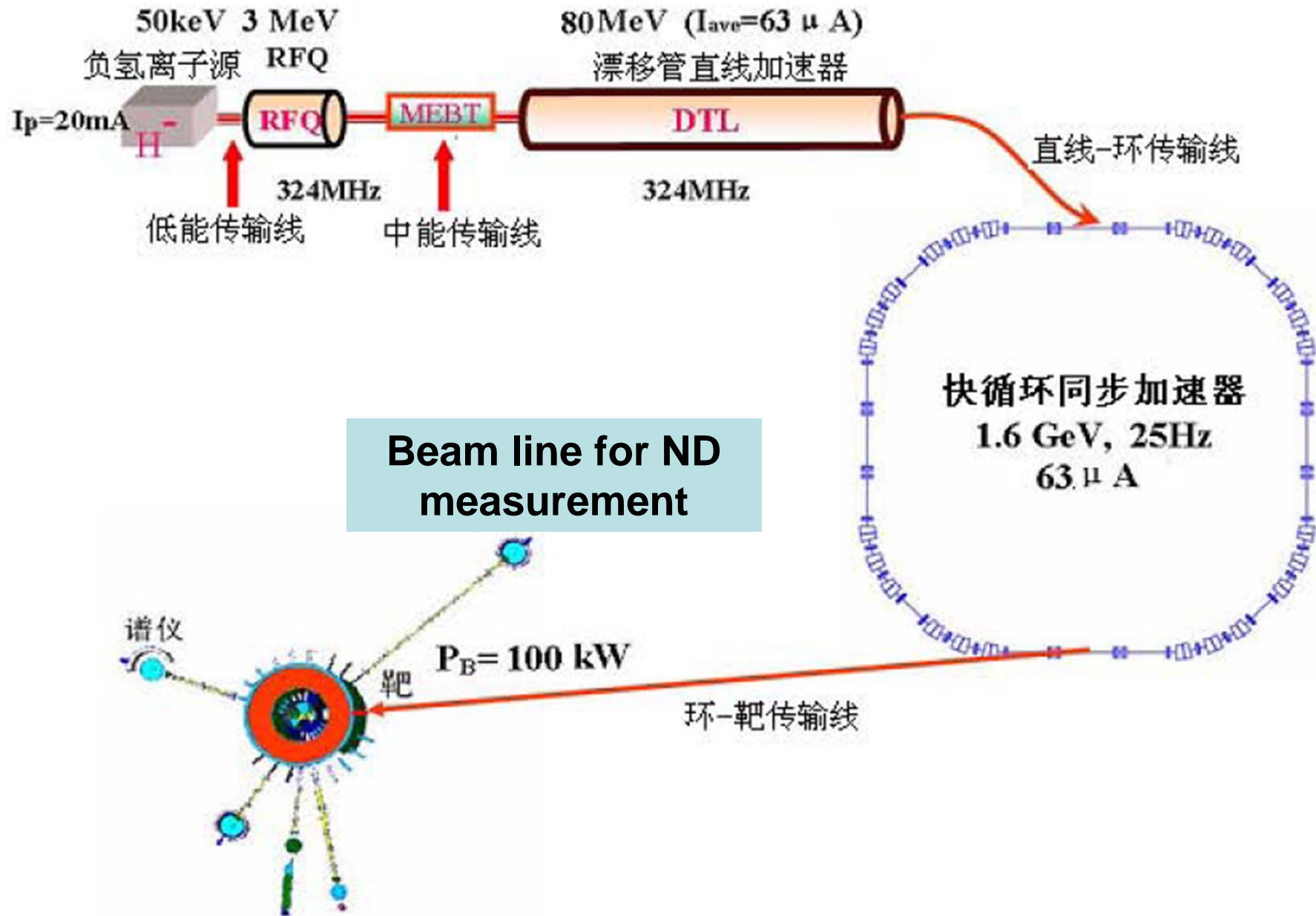
SiC: 20cm, 120°



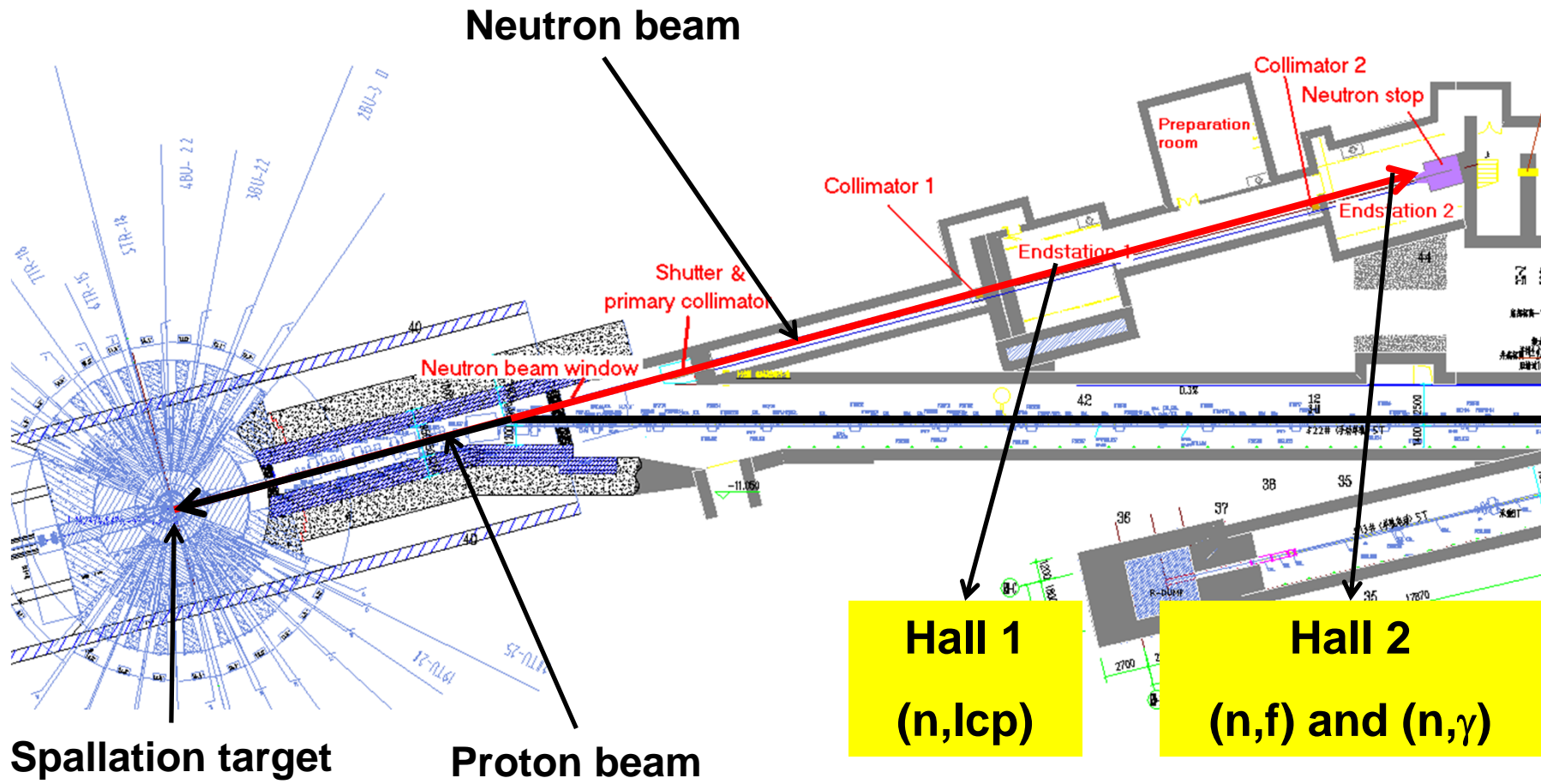
3. Progress of CSNS Back-n

1. The beam line installation will be finished in June, 2017
2. Proton on target in September, 2017.
3. Commissioning experiments:
 - 1) beam test (flux, beam profile, backgrounds)
 - 2) capture cross section measurement with C6D6 detector ($Tm-169$)
 - 3) fission cross section measurement with a parallel ionization chamber ($U-236$).

The back-streaming neutron beam of CSNS



Layout of the back streaming neutron beamline

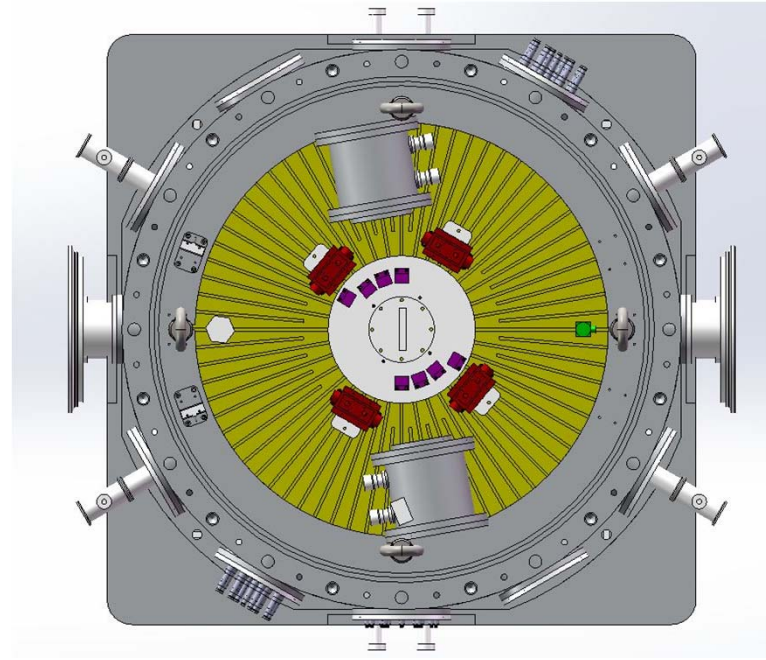




Beamline installation April 20, 2017



C6D6 detector



Charged particle detection chamber



Fission chamber

Peking University

Prof. Guohui Zhang
ghzhang@pku.edu.cn

$n + {}^{10}\text{B} \rightarrow \text{t} + \alpha + \alpha$ measurement

Zhimin Wang, Huaiyong Bai, Luyu Zhang, Haoyu Jiang, Yi Lu,
Jinxiang Chen, Guohui Zhang*

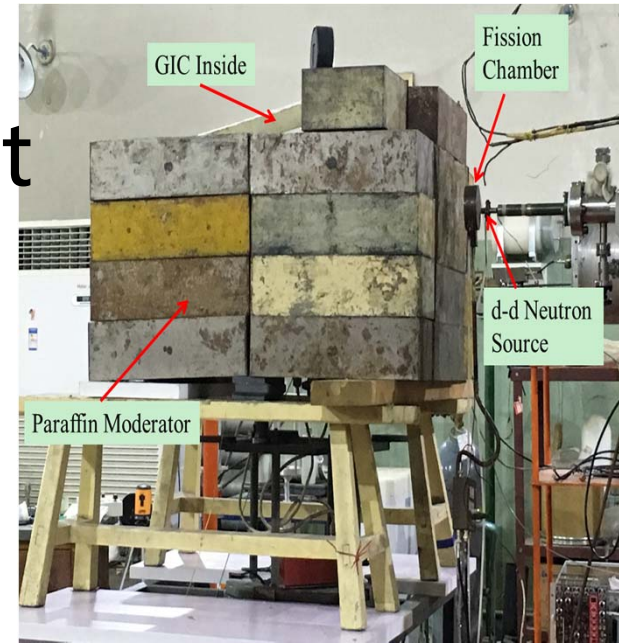
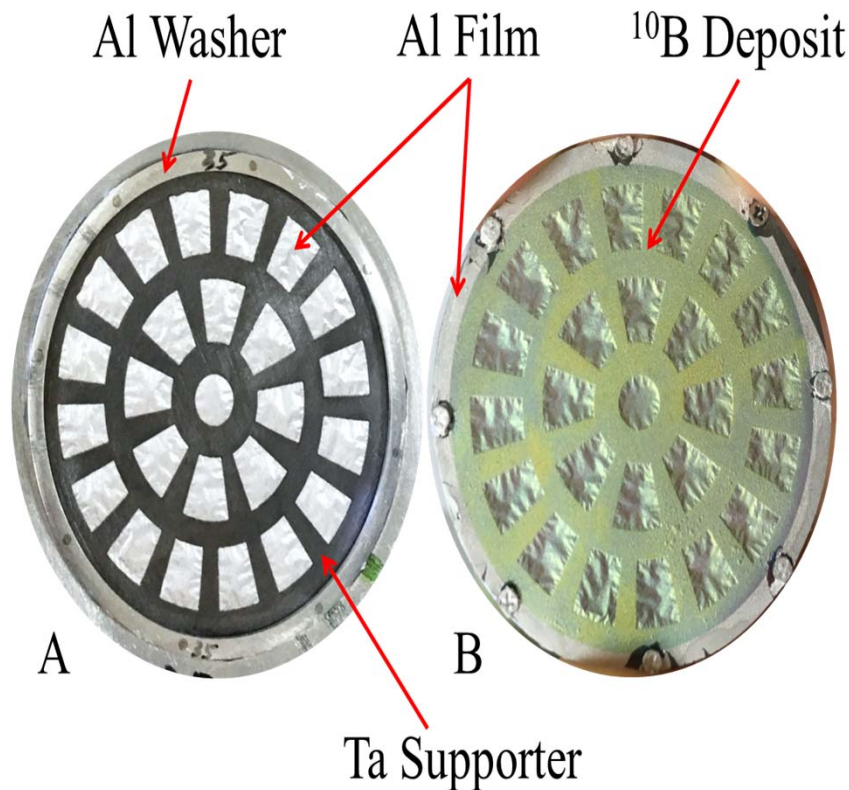
State Key Laboratory of Nuclear Physics and Technology,
Institute of Heavy Ion Physics, School of Physics,
Peking University, Beijing 100871, China

- Thin ${}^{10}\text{B}$ sample was prepared. ${}^{10}\text{B}$ atom number was measured with respect to ${}^6\text{Li}(\text{F})$ using thermal neutrons
- GIC Grid-anode as well as forward-backward coincidence was achieved for DAQ
- Both $n + {}^{10}\text{B} \rightarrow \text{t} + \alpha + \alpha$ and ${}^{10}\text{B}(n, \alpha){}^7\text{Li}$ cross section were measured at 4.0, 4.5 and 5.0 MeV @ 4.5MV VDG of PKU (preliminary)
- Wall effect of the sample position well of the GIC was measured, simulated and corrected

$n + {}^{10}\text{B} \rightarrow t + \alpha + \alpha$ measurement

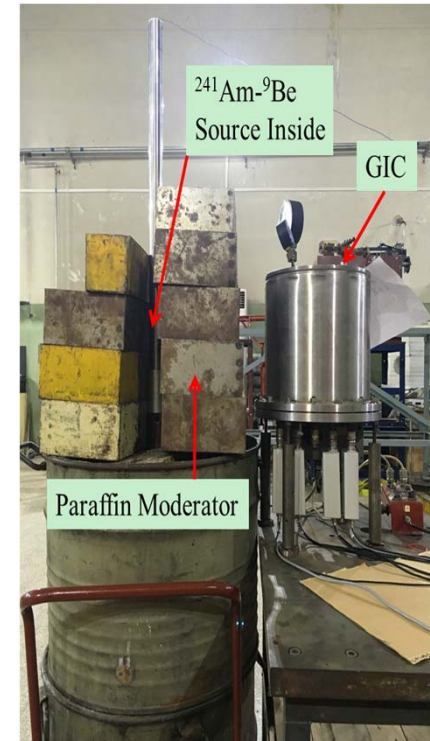
${}^{10}\text{B}$ sample preparation

${}^{10}\text{B}$ atom number measurement using thermal neutron with respect to ${}^6\text{LiF}$



VDG
accelerator

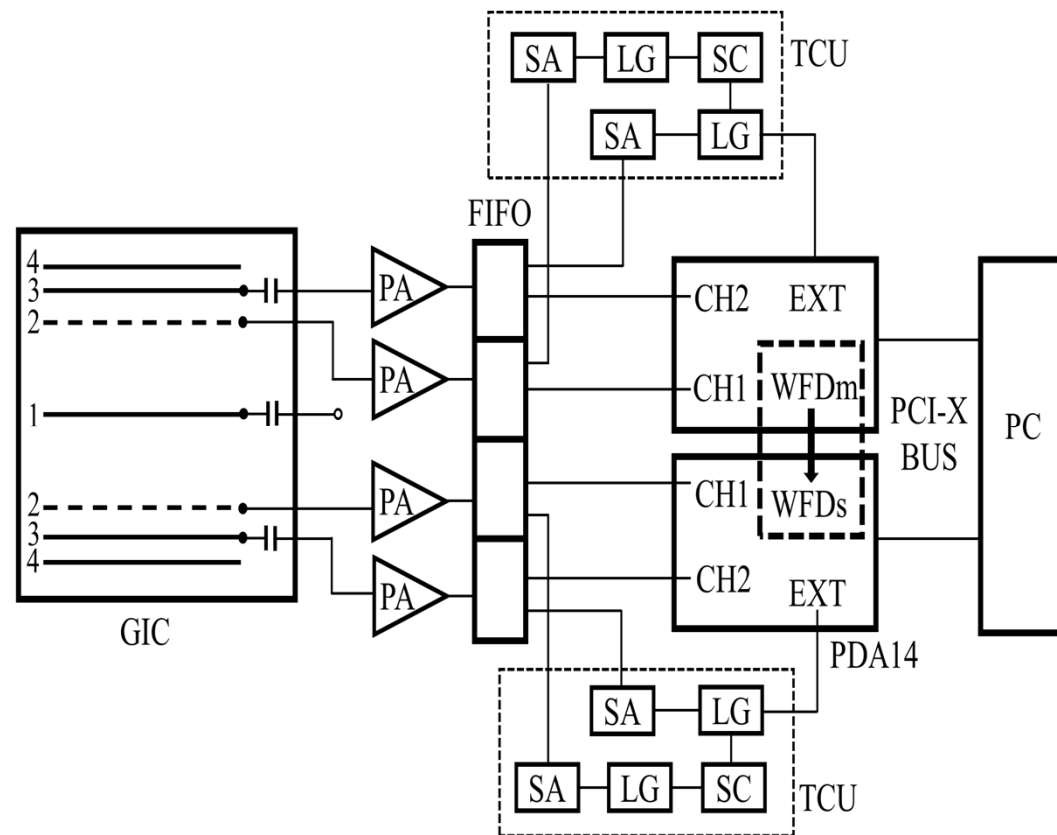
Am-Be
source



$n + {}^{10}\text{B} \rightarrow t + \alpha + \alpha$ measurement

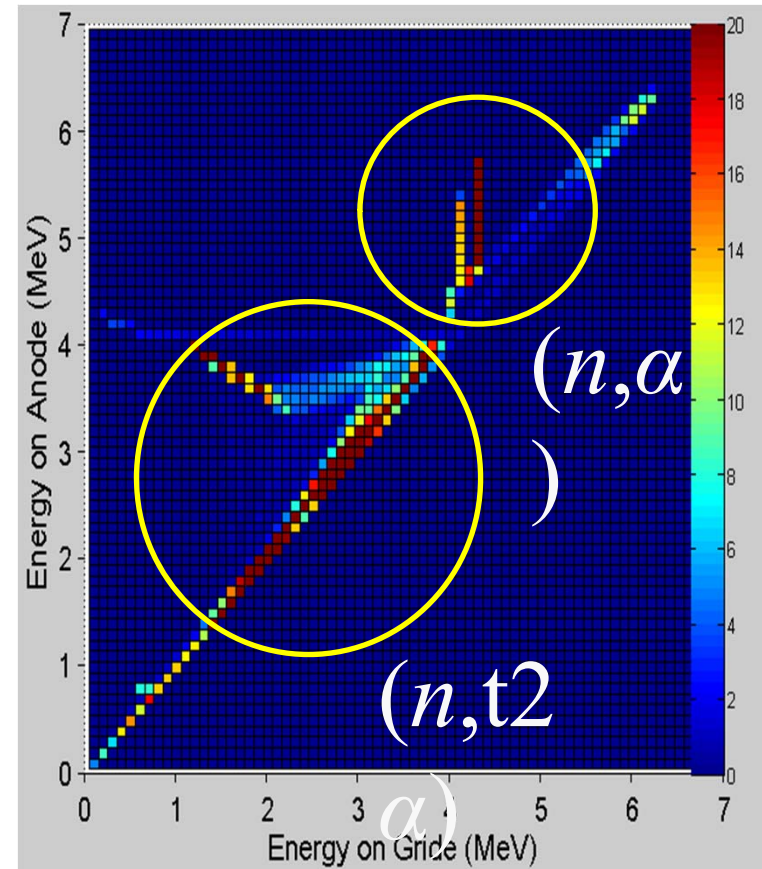
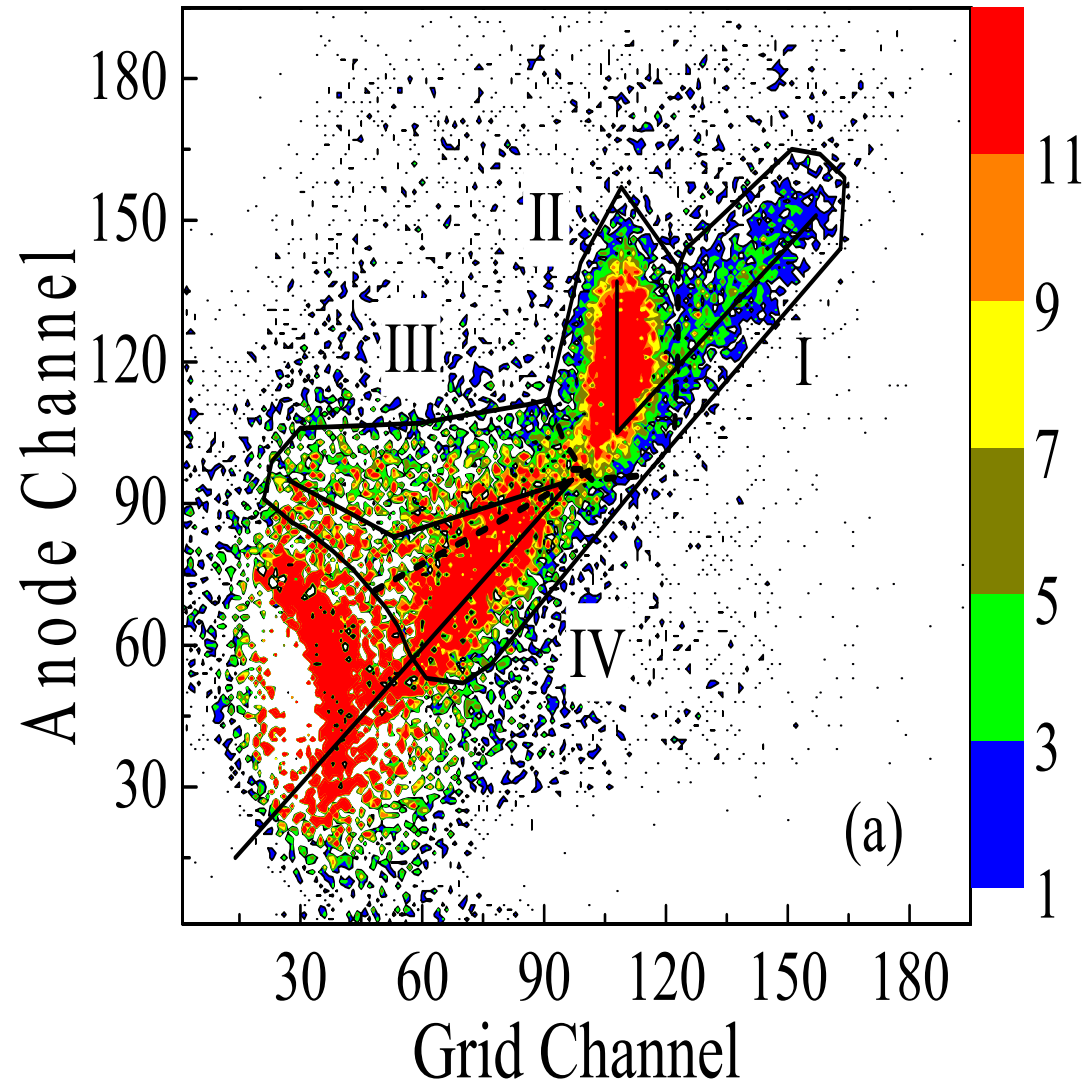
DAQ system based on LabVIEW

Grid-anode as well as forward-backward coincidence



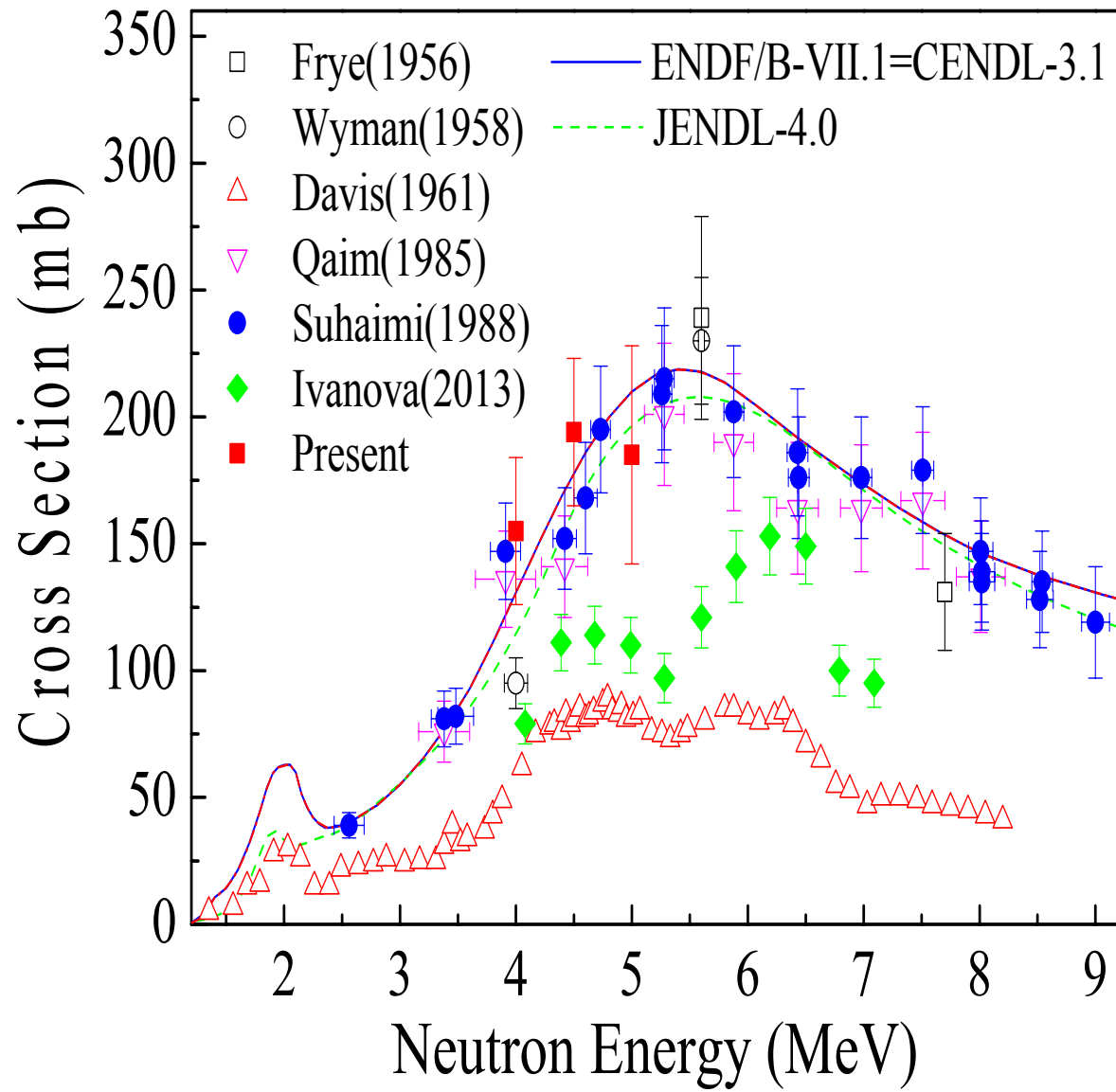
1-cathode, 2-grid, 3-anode, 4-shield

$n + {}^{10}\text{B} \rightarrow t + \alpha + \alpha$ measurement

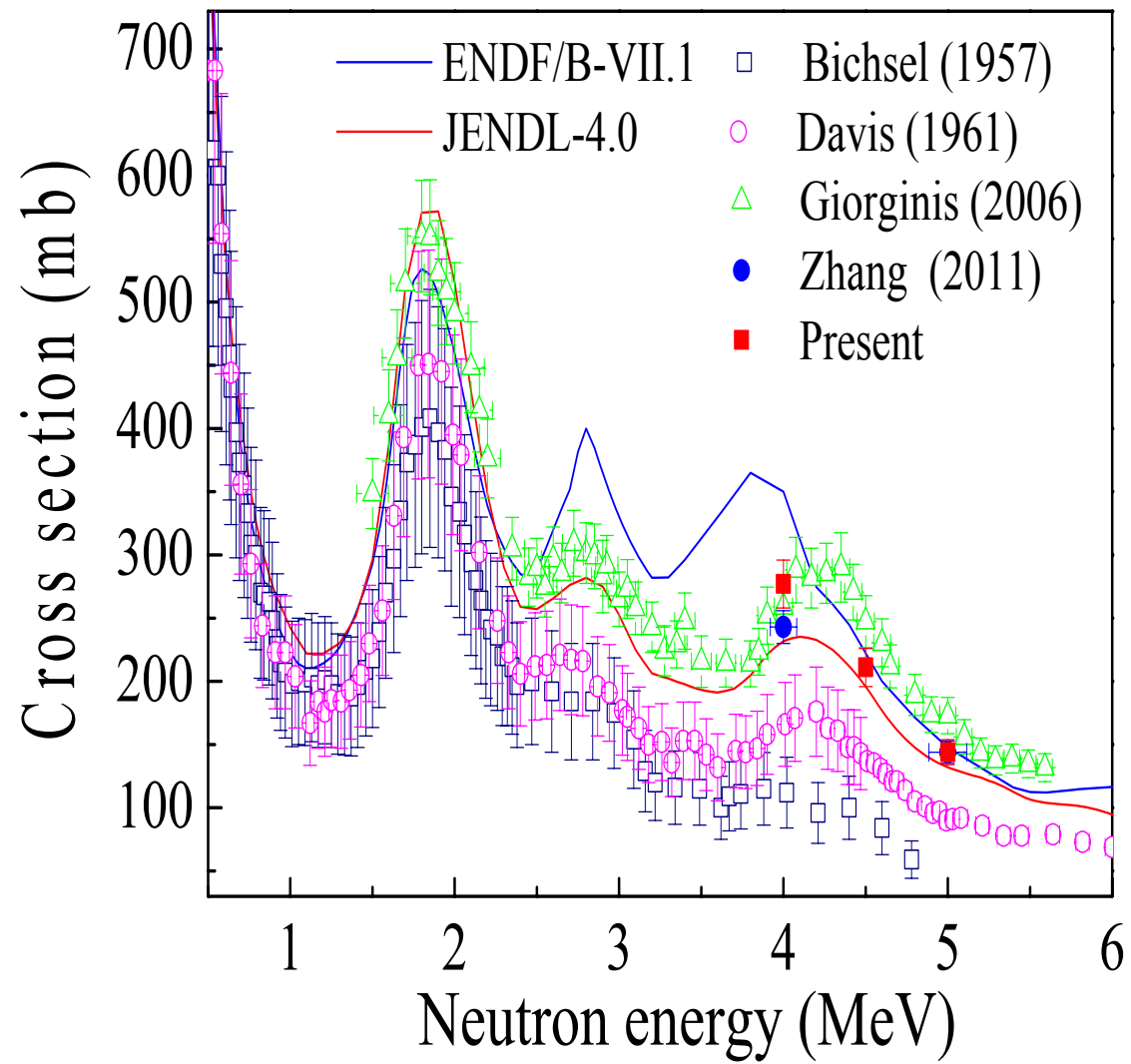


Spectra from theory

$E_n = 4.0$ MeV Forward grid-anode spectra



$n + {}^{10}\text{B} \rightarrow t + \alpha + \alpha$ cross section (preliminary)



$^{10}\text{B}(n,\alpha)^7\text{Li}$ reaction cross section (preliminary)

ADS related nuclear data measurements at IMP,CAS (2016)

Dr. Zhiqiang Chen
zqchen@impcas.ac.cn

ADS Nuclear Data Laboratory
Institute of Modern Physics,
Chinese Academy of sciences (IMP,CAS)

2017-5-18

HIRFL-CSR Complex in Lanzhou

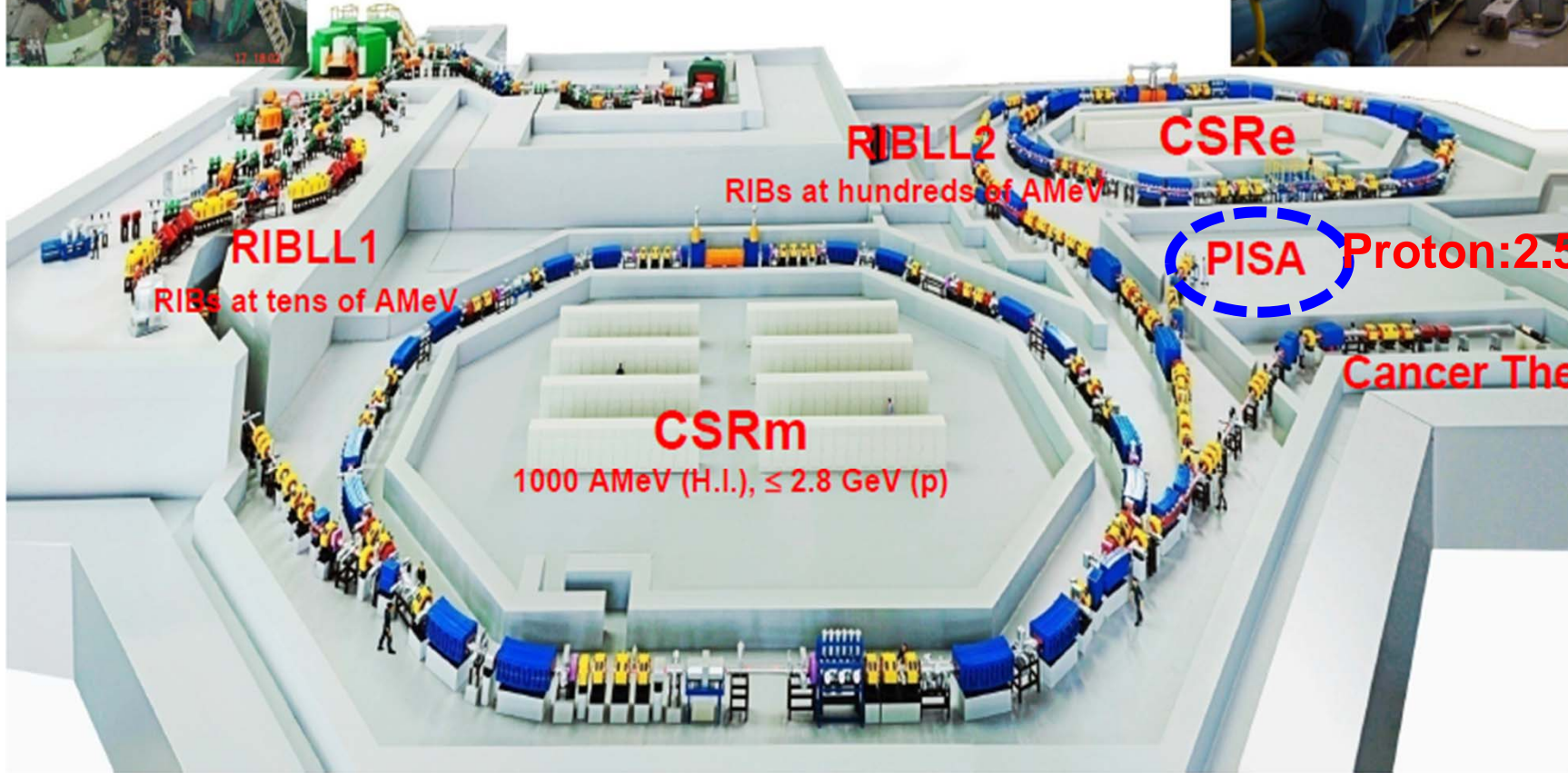


SSC(K=450)

100 AMeV (H.I.), 110 MeV (p)

SFC (K=69)

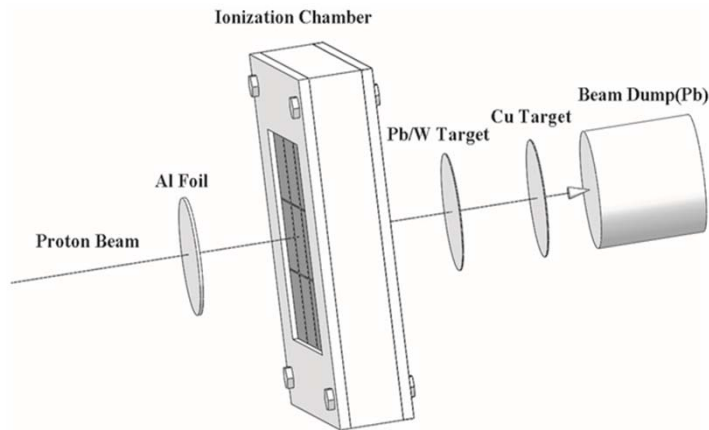
10 AMeV (H.I.), 17~35 MeV (p)



PISA terminal is used for ADS Nuclear data measurements.

The production of residual radionuclides by a 250MeV proton beam on Pb, W, Cu targets

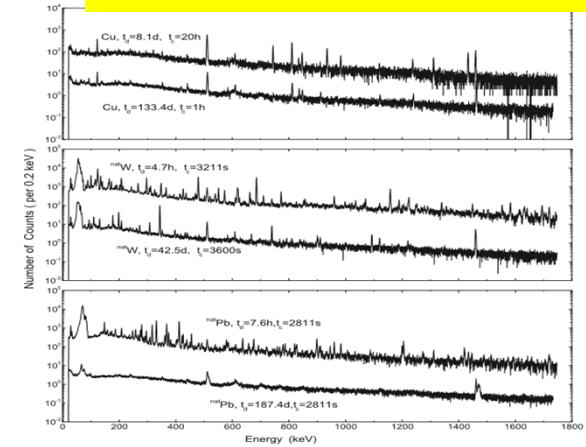
Experimental setup



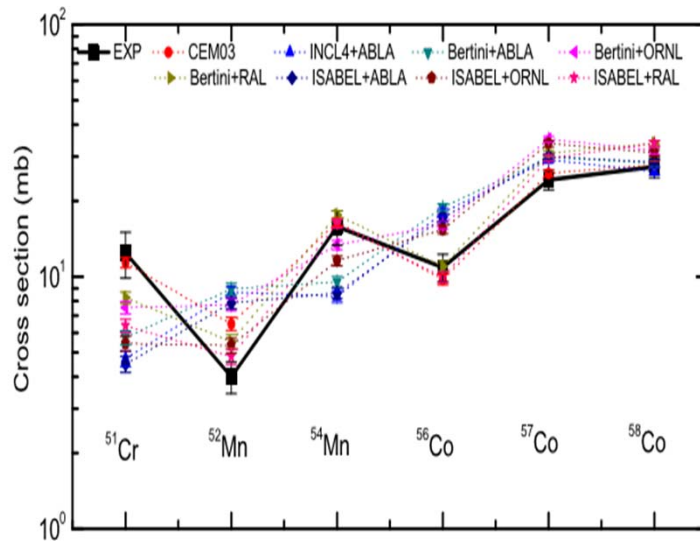
HPGe detector



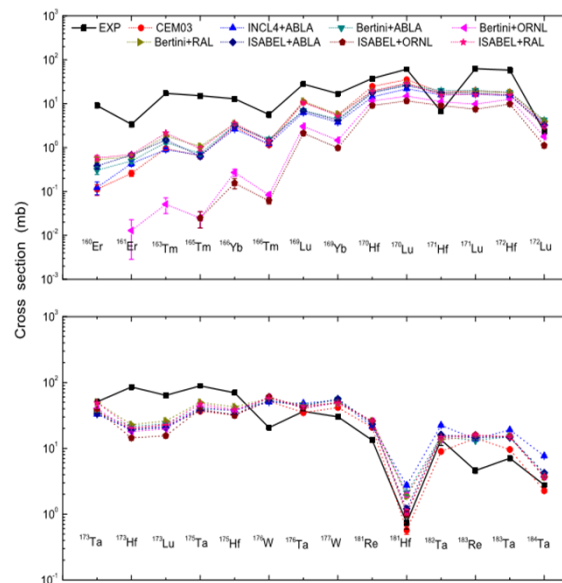
γ spectra after irradiation



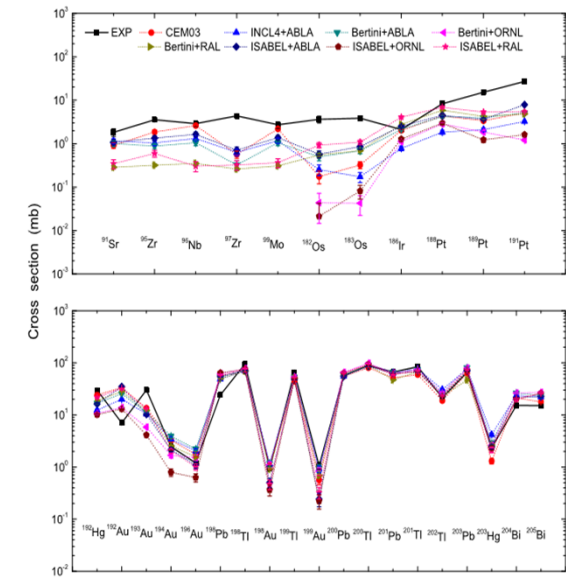
Cross sections of residual nuclides for Cu target



Cross sections of residual nuclides for W target

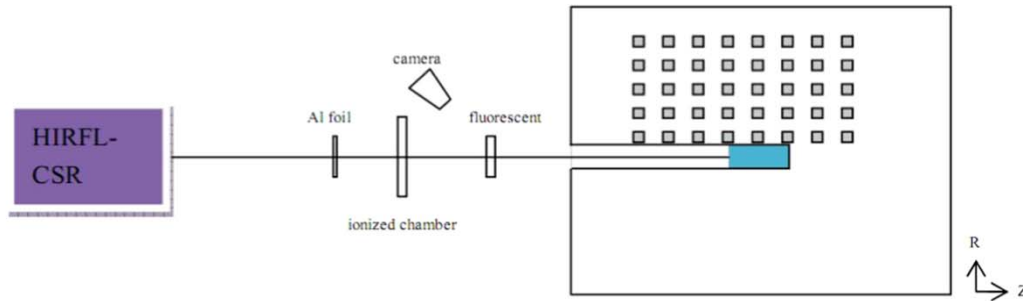


Cross sections of residual nuclides for Pb target

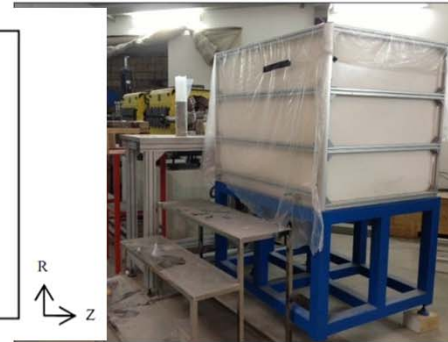


Neutron production for 250MeV protons bombarding on thick grain-made tungsten target

Experimental setup



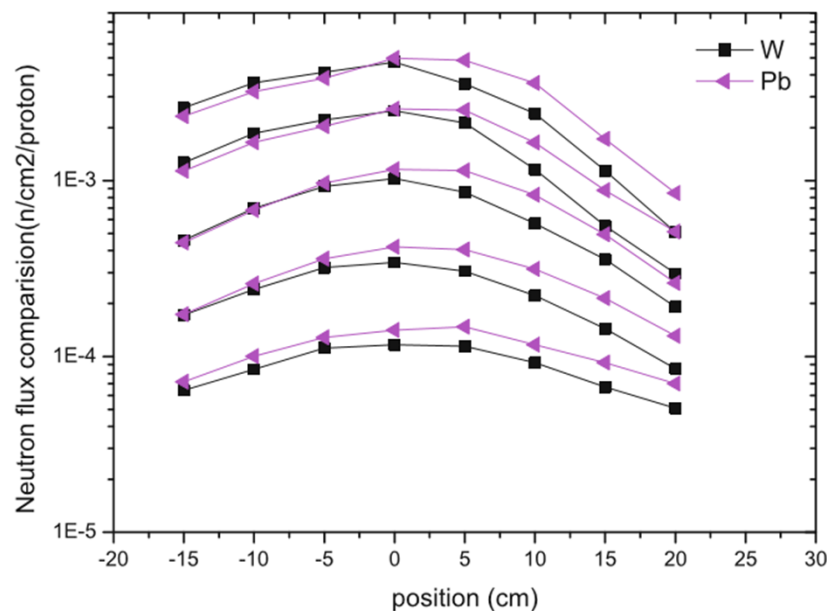
Water-bath device



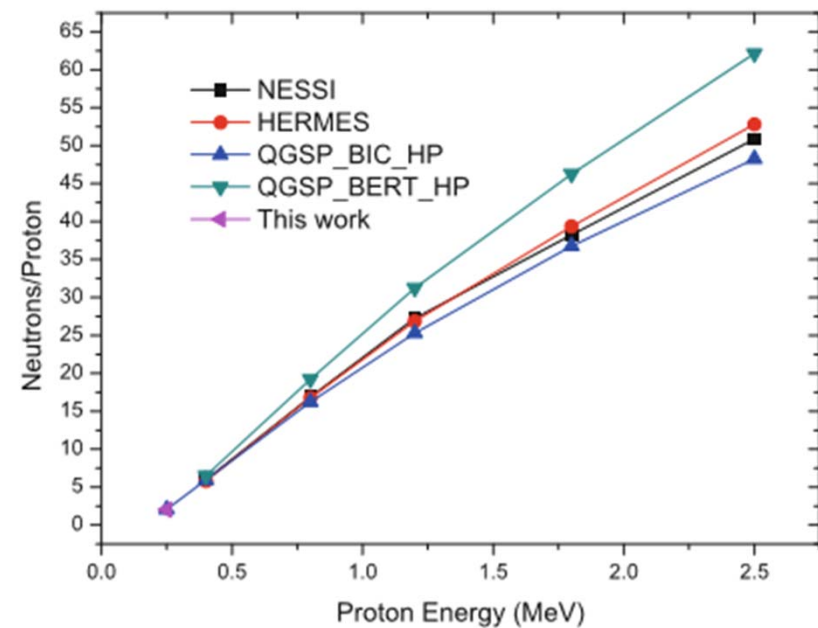
HPGe detector



Neutron flux distribution for W and Pb



The average neutron production per incident proton as a function of energy

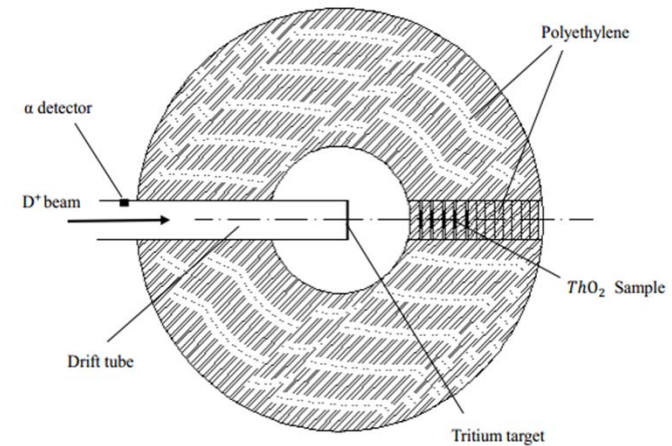


**China Academy of Engineering
Physics (CAEP)**

Dr. Rong Liu
liurongzy@163.com

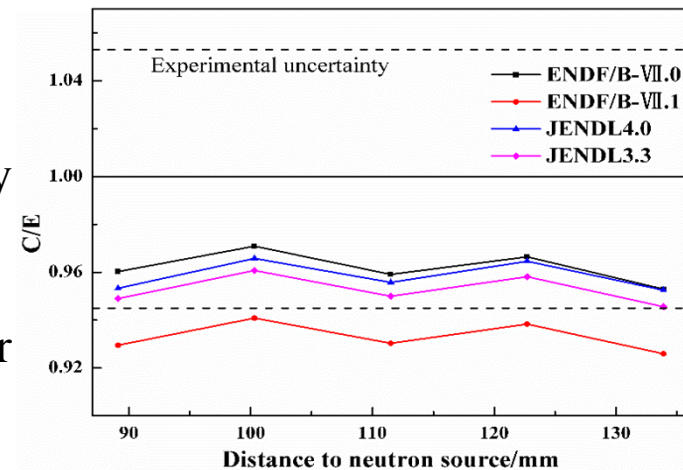
Thorium fission rate in a polyethylene shell

- Objective: integral checking of thorium fission parameters;
- Inner/outer radius of PE shell: 80mm/230mm;
- D-T neutron source: $6.34 \times 10^9 \text{ n/s}$;
- Thorium oxide powder: $\Phi 30\text{mm} \times 1\text{mm}$;
- γ measurement: 151.195keV characteristics γ emitted from $^{85\text{m}}\text{Kr}$ was detected by HPGe spectrometer



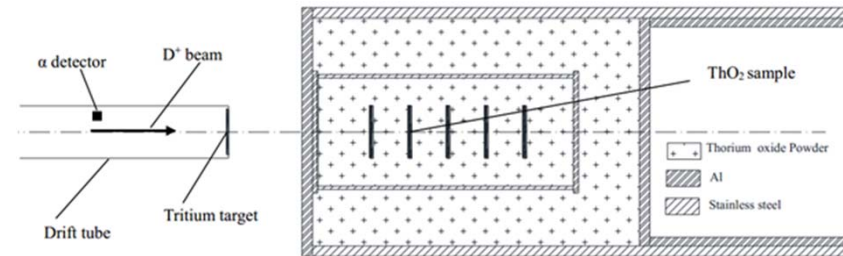
Sketch view of experiment setup

- Experimental uncertainty: 5.3%;
- Simulation : MCNP employing ENDF/B-VII.0 、 ENDF/B-VII.1 、 JENDL-3.3 、 JENDL-4.0 library data ;
- Average C/E values: 0.962, 0.933, 0.952, 0.958;
- Conclusion: thorium fission rate deduced from $^{85\text{m}}\text{Kr}$ agreed with simulation



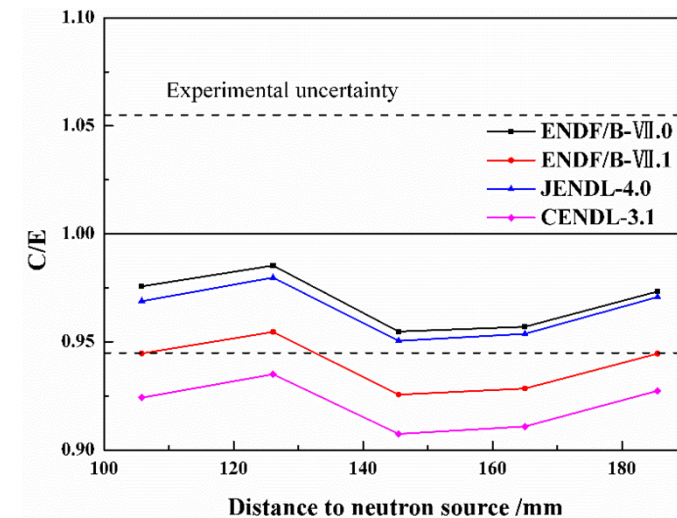
Thorium fission rate in thorium oxide powder cylinder

- Size of experimental setup: $\Phi 189.6/192.4 * 168.9(\text{mm})$
- Density of thorium oxide powder cylinder: $1.5\text{g}/\text{cm}^3$
- D-T neutron source: $2.02 * 10^{10}\text{n}/\text{s}$;
- Thorium oxide powder: $\Phi 30\text{mm} * 1\text{mm}$;
- γ measurement: 151.195keV characteristics γ emitted from $^{85\text{m}}\text{Kr}$ was detected by HPGe spectrometer



Sketch view of experiment setup

- Experimental uncertainty: 5.5%;
- Simulation : MCNP employing ENDF/B-VII.0、ENDF/B-VII.1 、 JENDL-4.0 、 CENDL-3.1 library data ;
- Average C/E values: 0.970, 0.940, 0.965, 0.921;
- Conclusion: thorium fission rate deduced from $^{85\text{m}}\text{Kr}$ agreed with simulation



Thank you for your attention !