Nuclear Physics Underground and Beyond: LUNA Winter meeting
2026, Jan. 28 - 30, Debrecen, Hungary

Progress of Jinping Underground Nuclear Astrophysics experiment (JUNA)

Taoyu Jiao for the JUNA collaboration

HUN-REN Konkoly Observatory

Thanks NSFC, Yalong power, THU, CAS and CNNC

北京師範大學 BEIJING NORMAL UNIVERSITY
中国科学院近代物理研究所 Institute of Modern Physics, Chinese Academy of Sciences
中国原子能科学研究院 中核集团 CHINA INSTITUTE OF ATOMIC ENERGY
雅砻江流域水电开发有限公司 YALONG RIVER HYDROPOWER DEVELEPOMENT COMPANY, LTD.
南方科技大学 SOUTHERN UNIVERSITY OF SCIENCE AND TECHNOLOGY
上海交通大学 SHANGHAI JIAO TONG UNIVERSITY
山东大学 SHANDONG UNIVERSITY
四川大学 SICHUAN UNIVERSITY
深圳大学 SHENZHEN UNIVERSITY
中山大學 SUN YAT-SEN UNIVERSITY
清華大学

Nuclear Astrophysics in China

JUNA experiment

Direct in Gamow window (underground)

RIBLL and LEAF experiment

Direct in higher energy

CIAE experiment

In-direct measurements

BRIF, CSR experiment

Nuclear decay

CSR experiment

Nuclear mass

theoretical study

Nuclear astrophysics and sensitivity study

theoretical study

Shell model and mean field calculation

theoretical study

Shell model and mean field calculation

theoretical study

Nuclear astrophysics network calculation

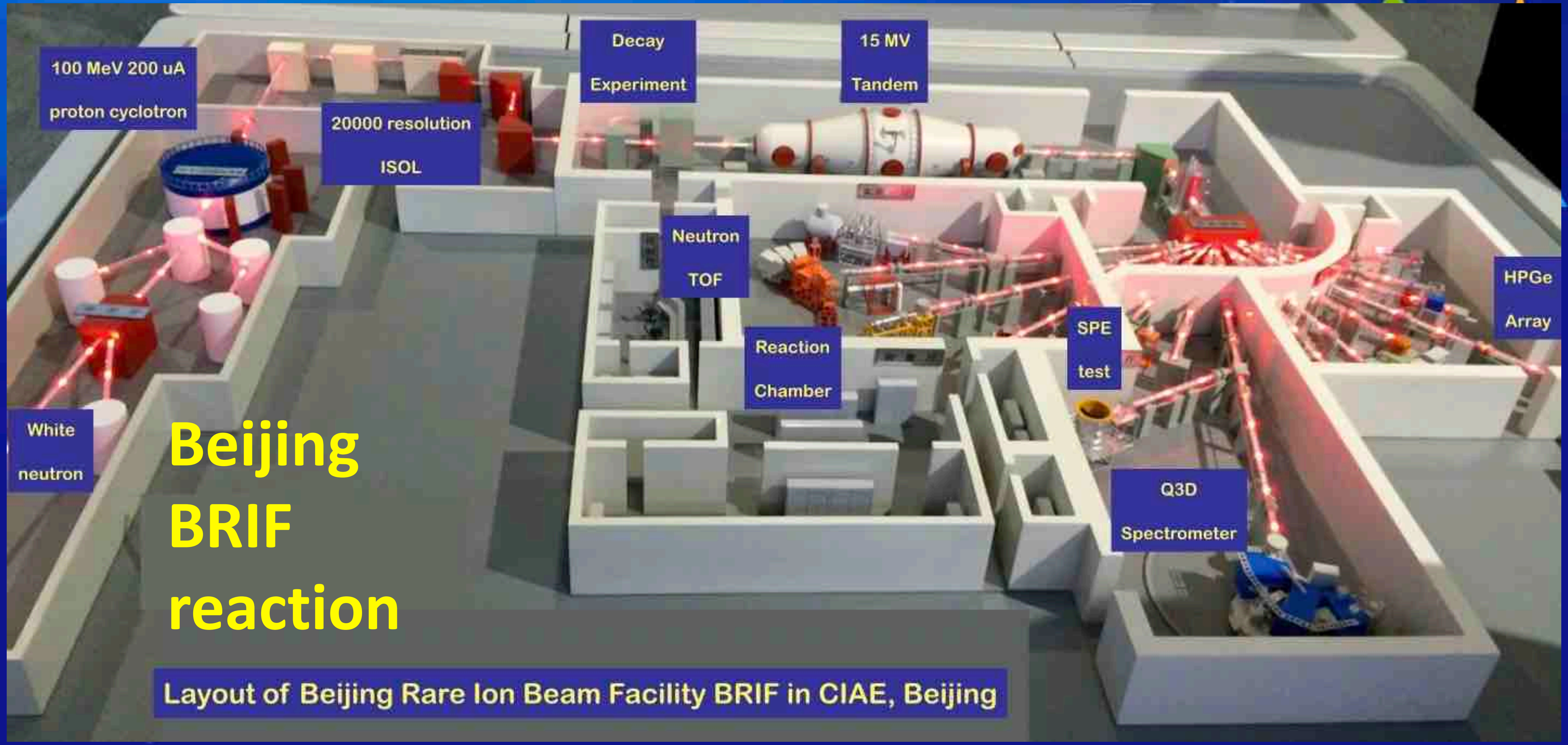
Reaction rate database

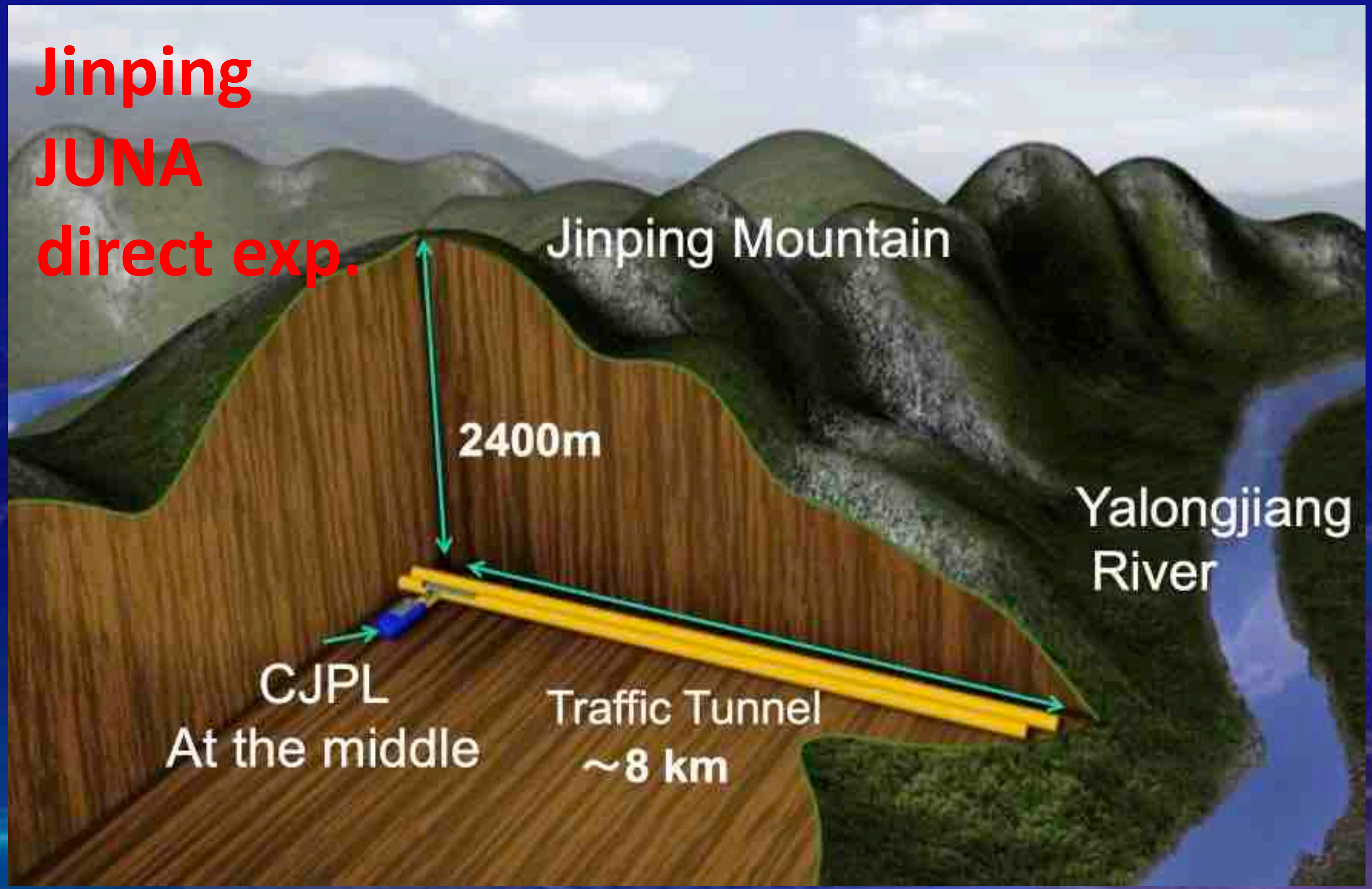
Nuclear input database

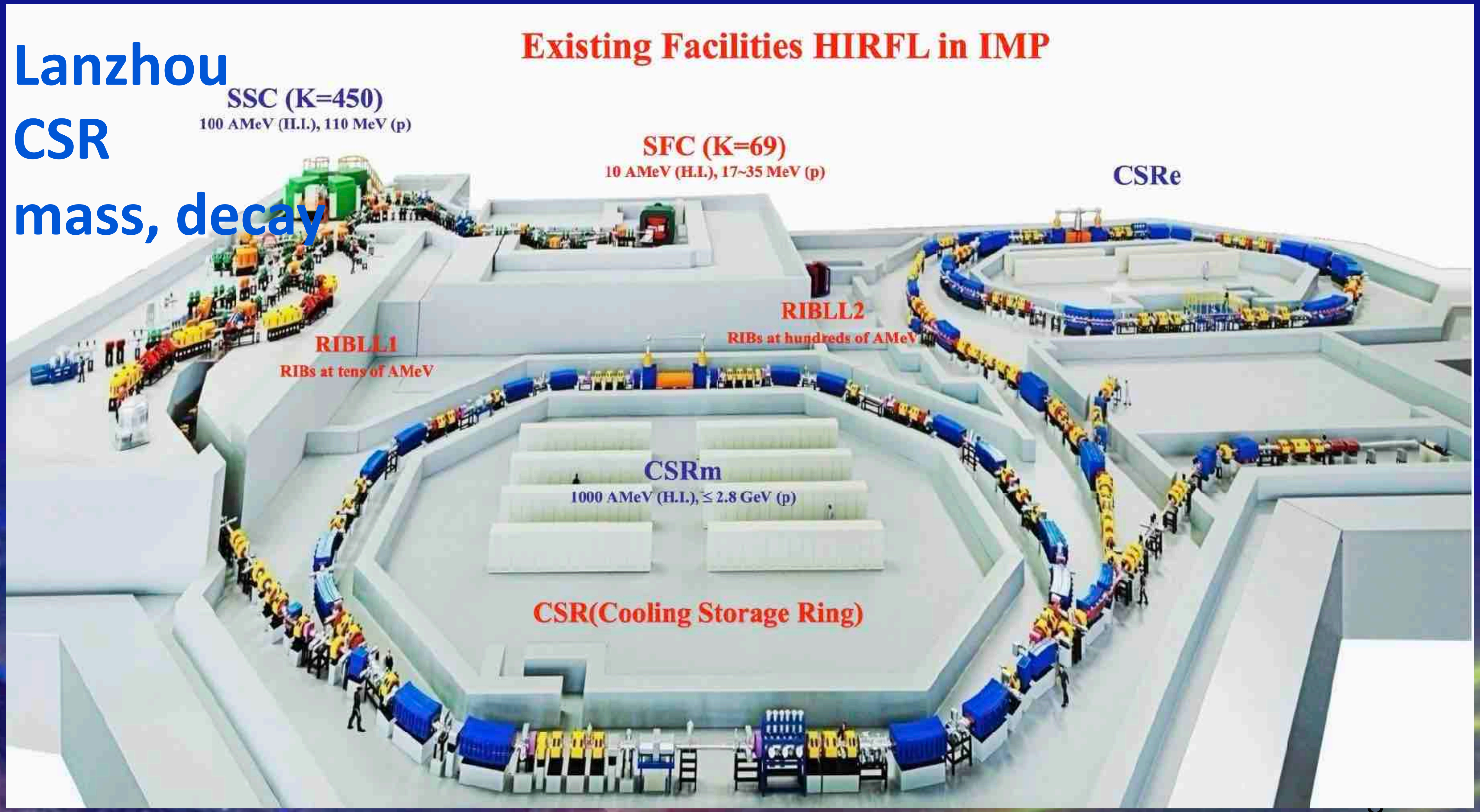
Mass data compilation in China

Mass and decay rate database

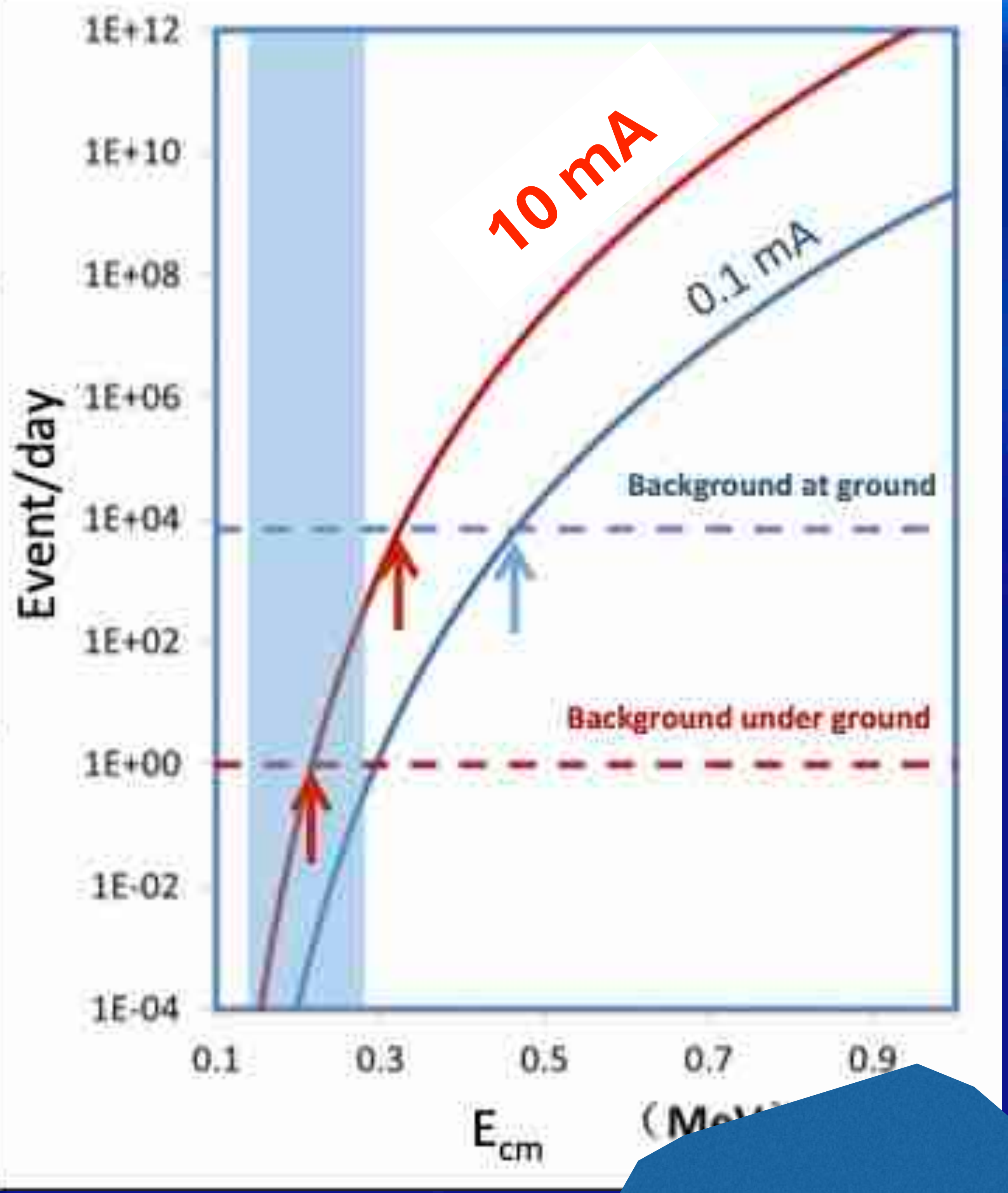
Major facilities in China

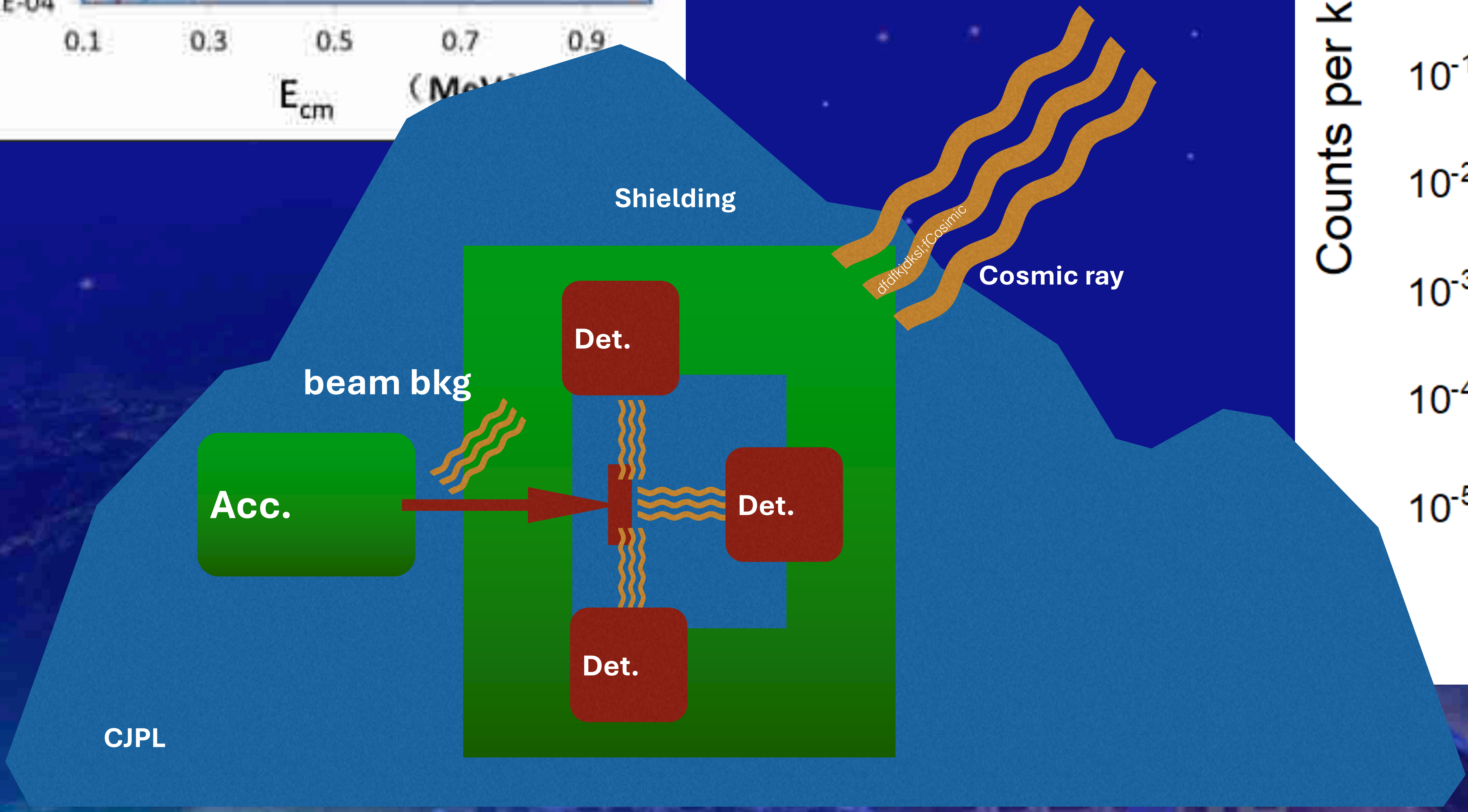


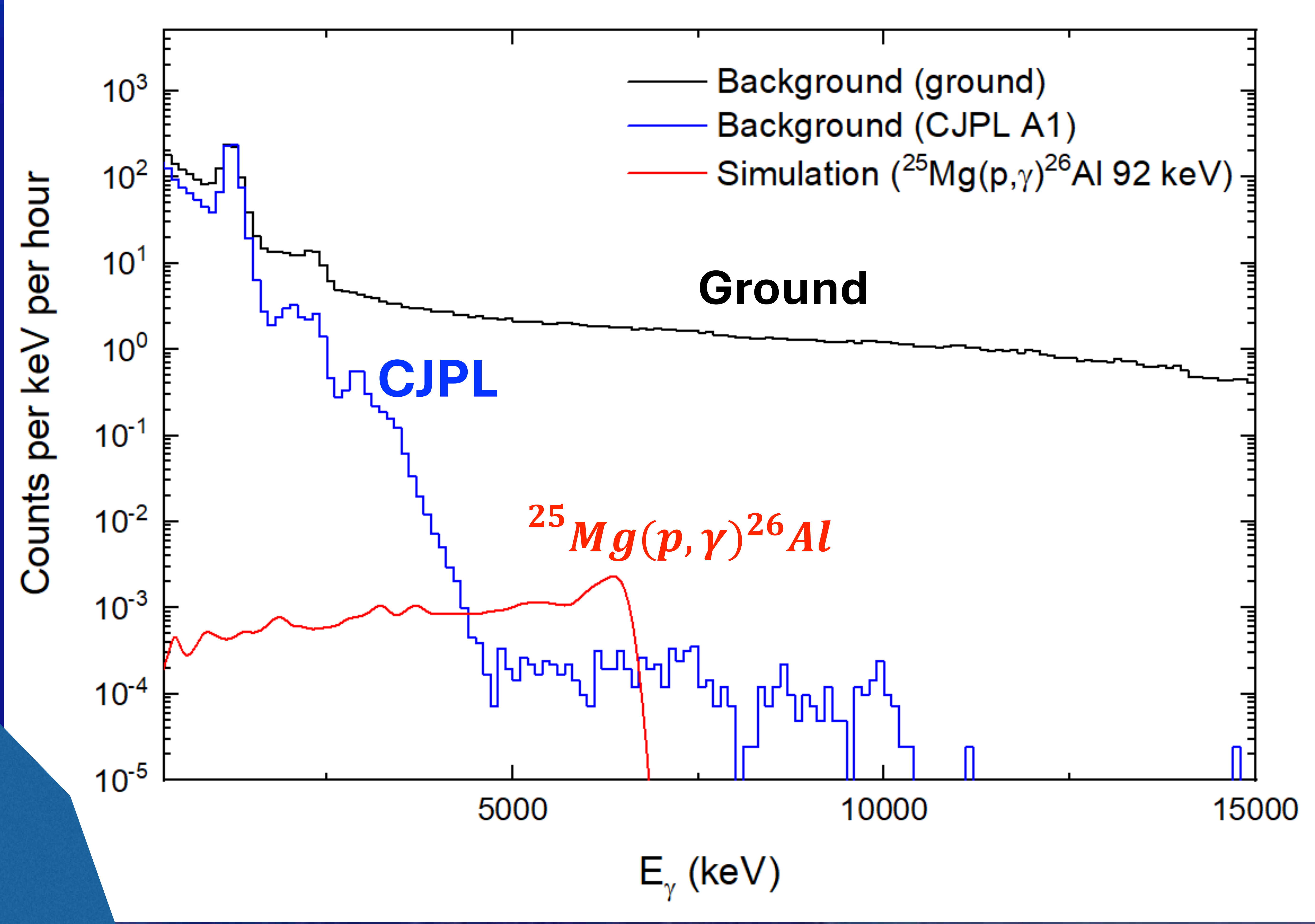




Low bkg + high intensity

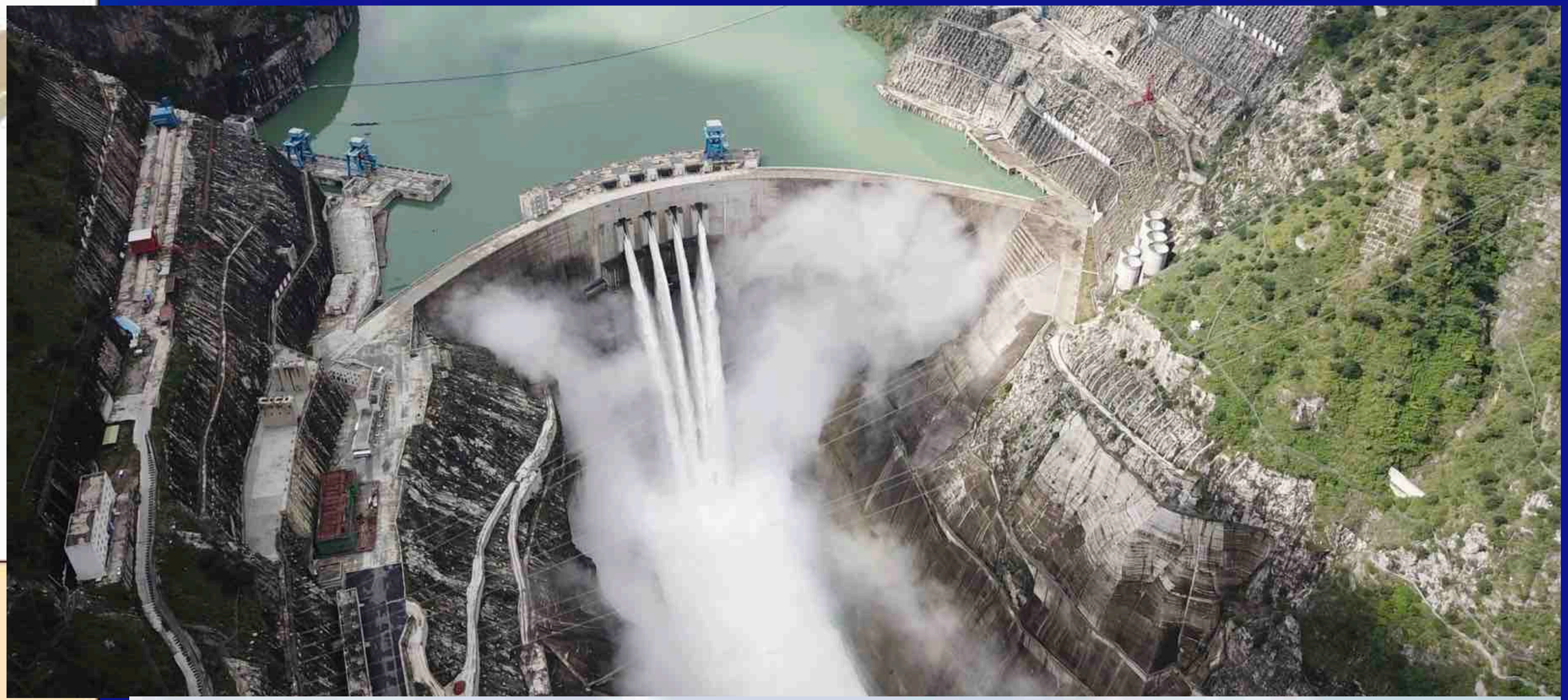






WPL et al., Sci. China 59(2016)2

China Jinping Underground Laboratory(CJPL)

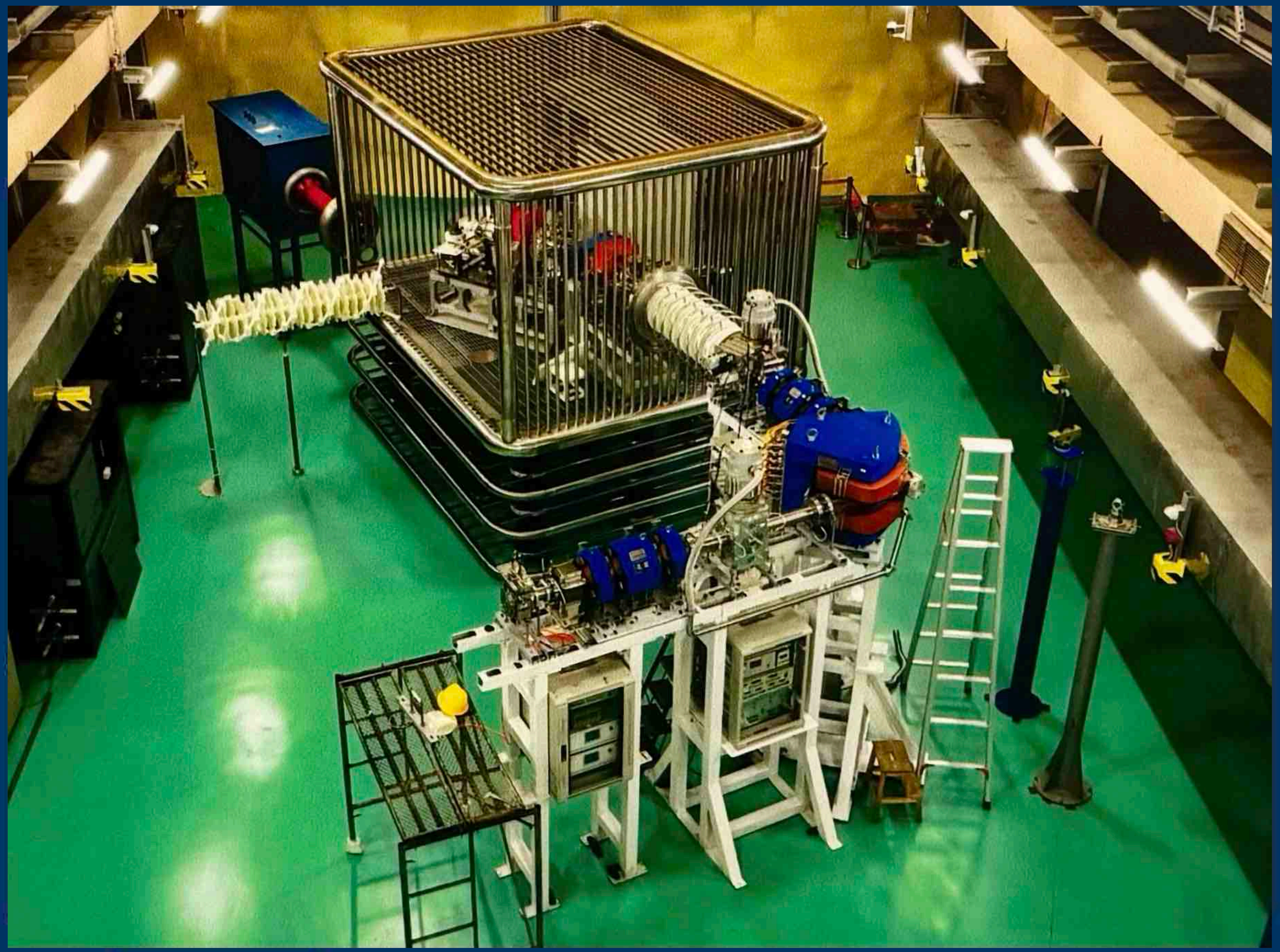



出口
入口

CJPL-II

Space: 300,00

JUNA dream team



Group leader

Weiping Liu
$^{12}C(\alpha,\gamma)^{16}O$
Yangping Shen, CIAE
Jun Su, BNU
PI

Bing Guo
$^{22}Ne(\alpha,n)^{25}Mg$
CIAE

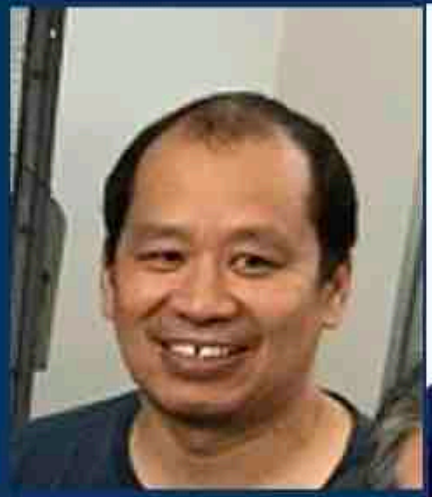
Shuo Wang
$^{14}N(p,\gamma)^{15}O$
SDU

Xiaodong Tang
$^{13}C(\alpha,n)^{16}O$
Ion source IMP

Zhihong Li
$^{25}Mg(p,\gamma)^{26}Al$
CIAE
Jun Su, BNU

Jianjun He
$^{19}F(p,\alpha)^{16}O$
BNU

Gang Lian
Lab. exp. sup.
CIAE



Bao Quncui,CIAE
Liangting Sun, IMP
Ion source and acc.

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

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

SDIC 国投集团
雅砻江流域水电开发有限公司
YALONG RIVER HYDROPOWER DEVELOPMENT COMPANY, LTD.

JUNA

__Acc. installation__
Arjun Li

__A1 construction__
Hongwei Yang

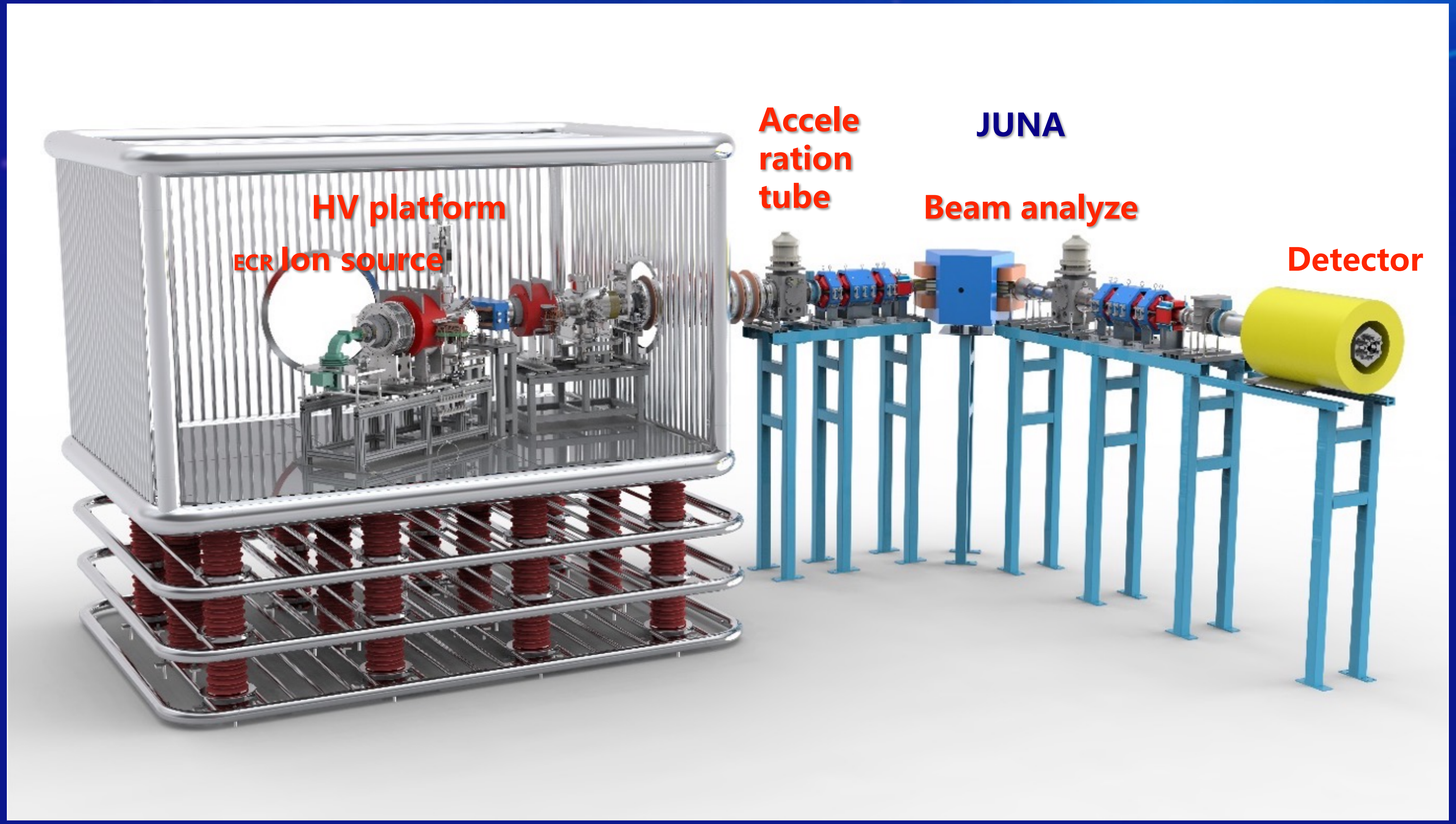
__Site support__
Xiaopan Cheng

__Acc. operation__
Long Zhang

Supported by the National Natural Science Foundation of China, Grant No. 11490560, 2015

WPL et al., Sci. China 59(2016)2

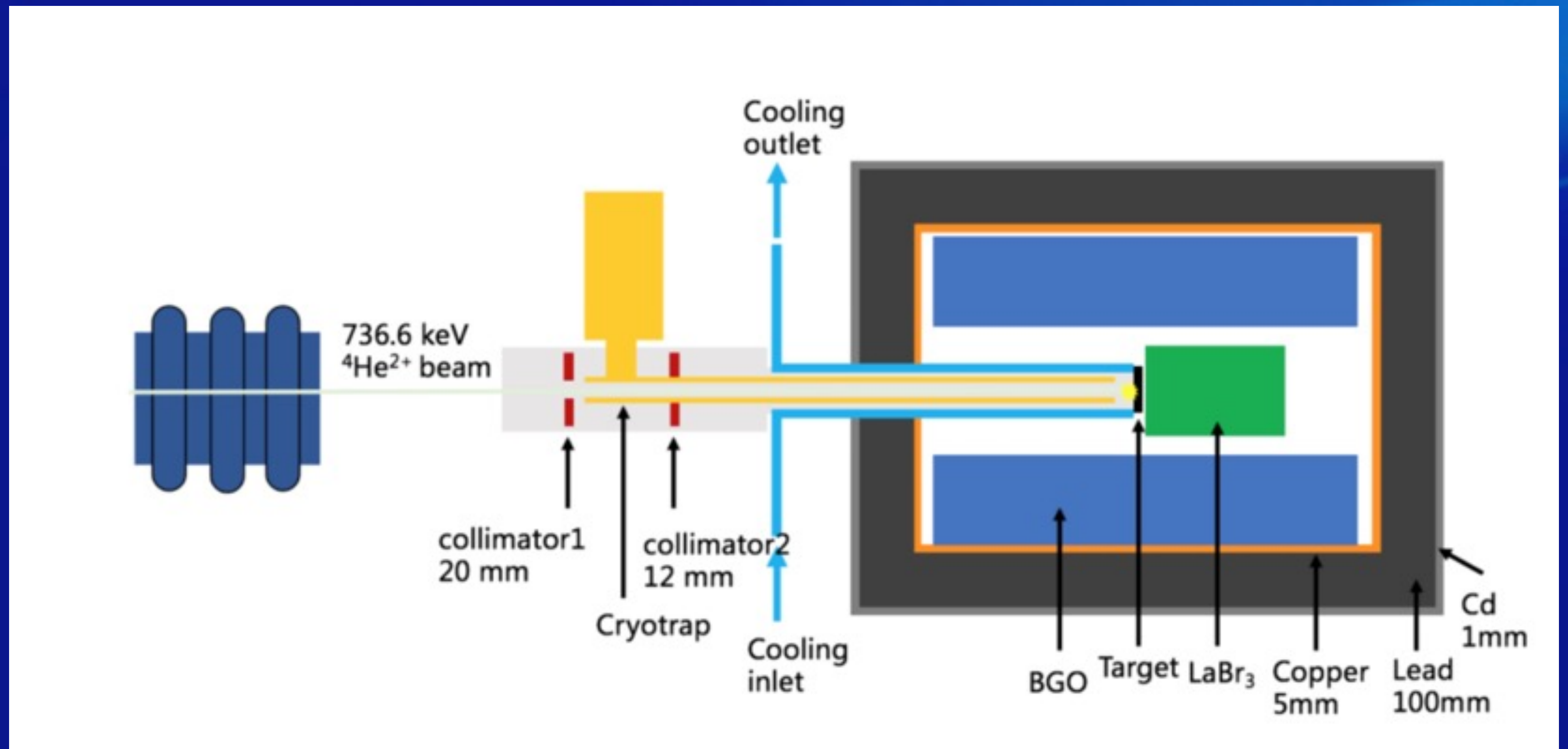
Capabilities



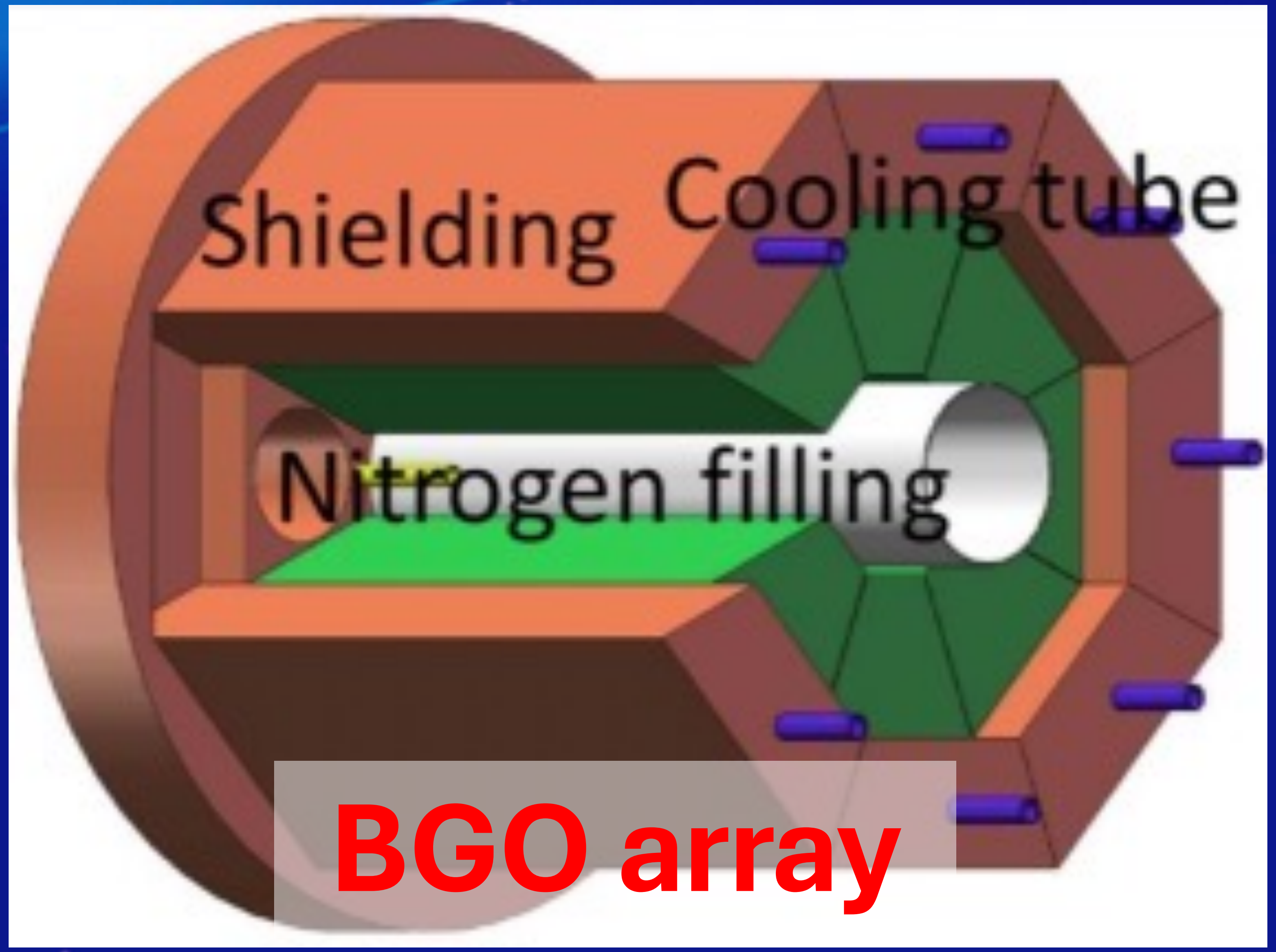
	cosmic muon bkg ($cm^{-2} s^{-1}$)	beam energy (keV)			beam intensity (emA)			energy stability
		H^+	He^+	He^{2+}	H^+	He^+	He^{2+}	
JUNA	2×10^{-10}	50-400	50-400	100-800	10	10	2	0.04%

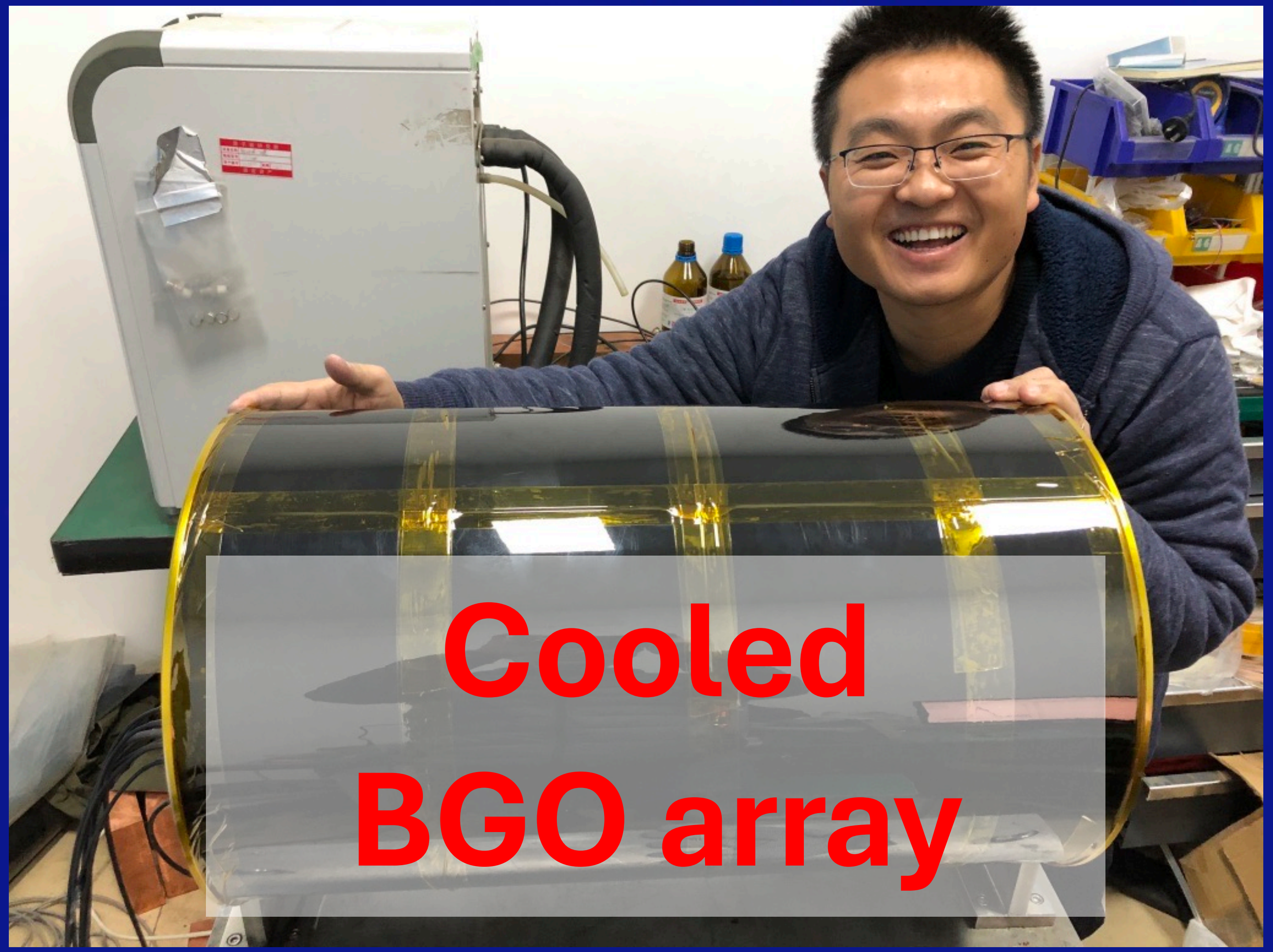
WPL et al., Sci. China 59(2016)2

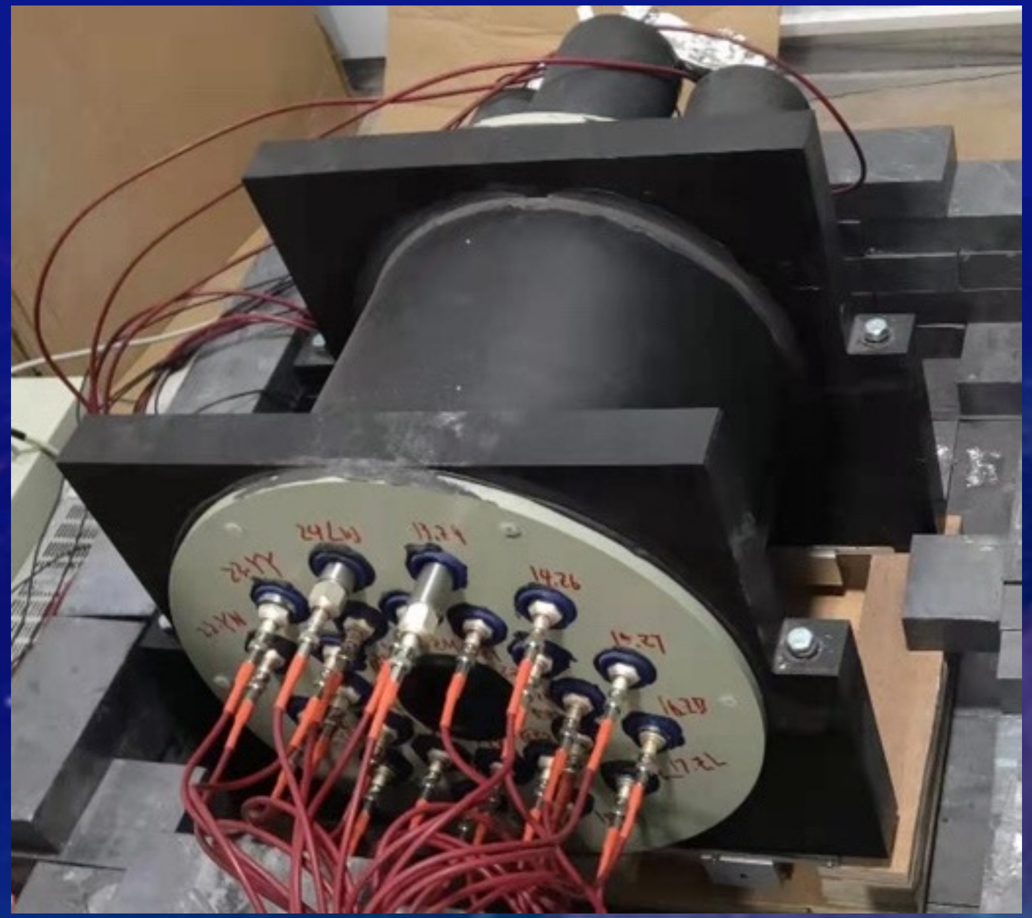
Detection systems

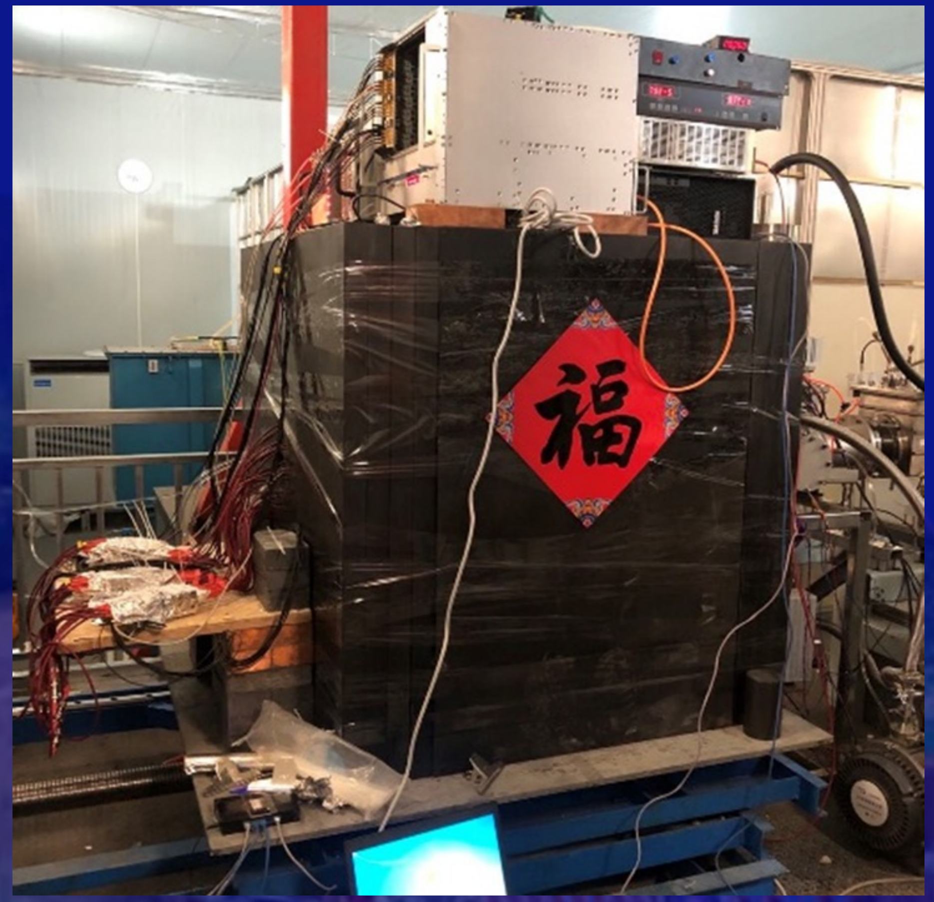


$LaBr_3$+BGO array



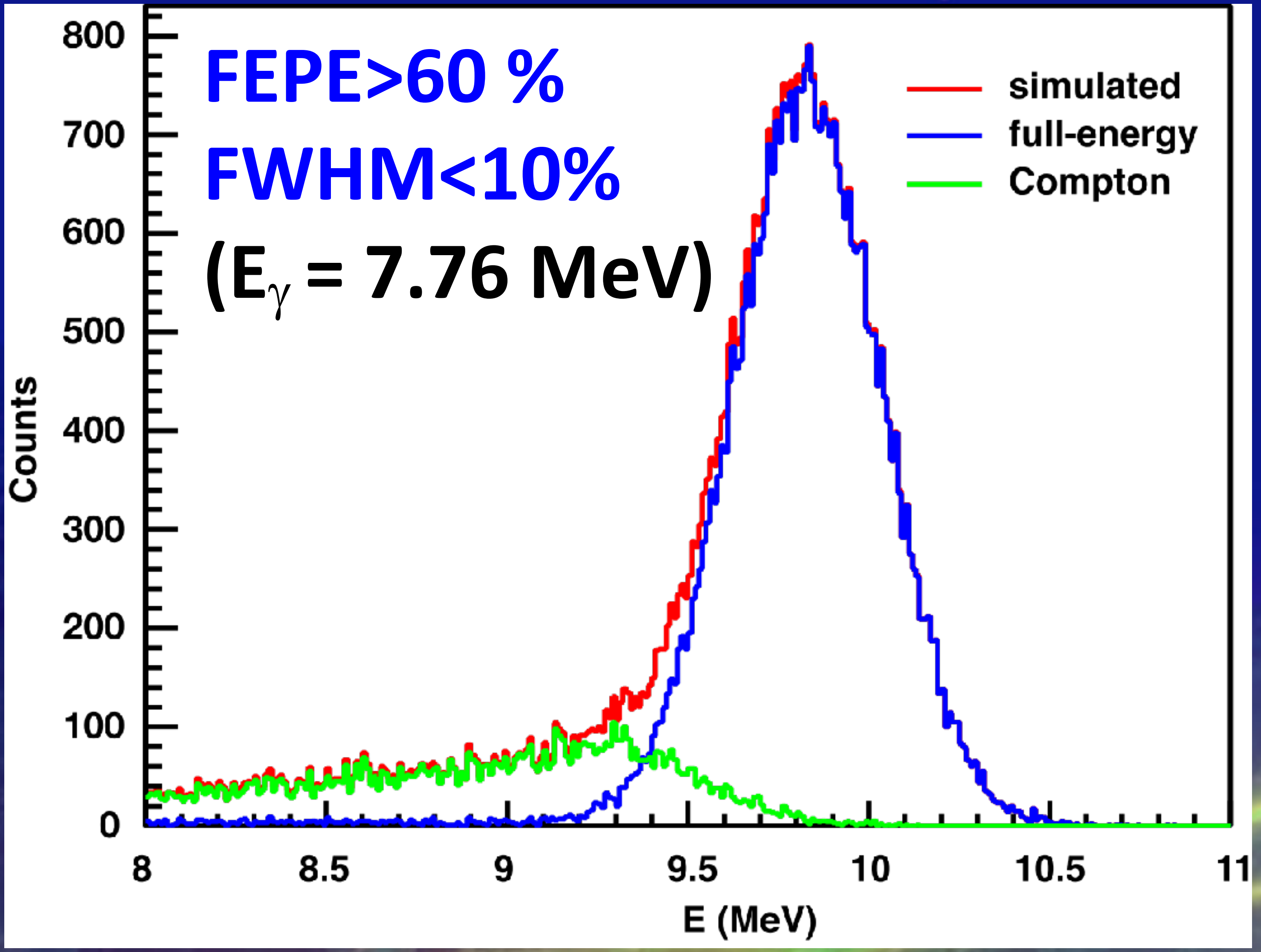






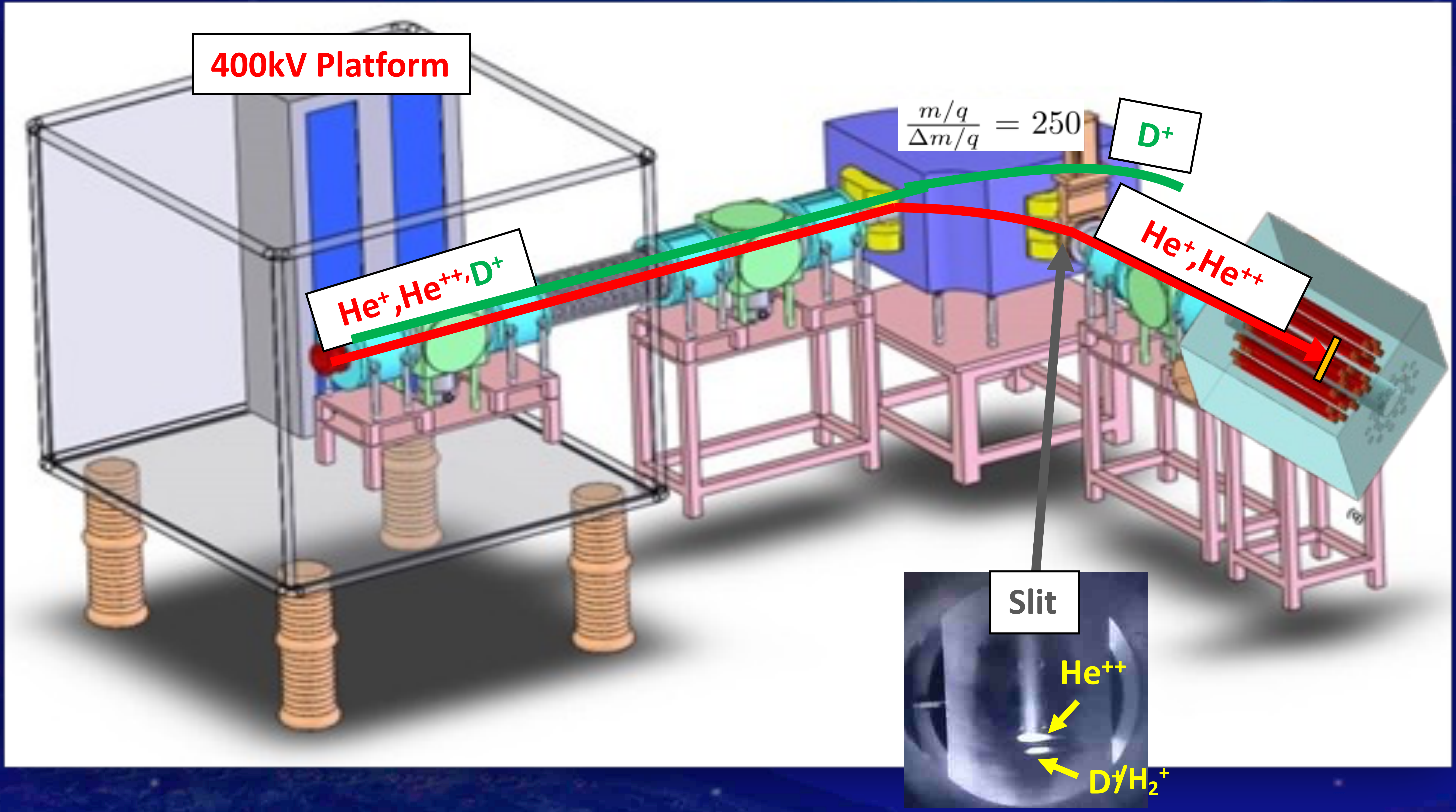
^3He detector array

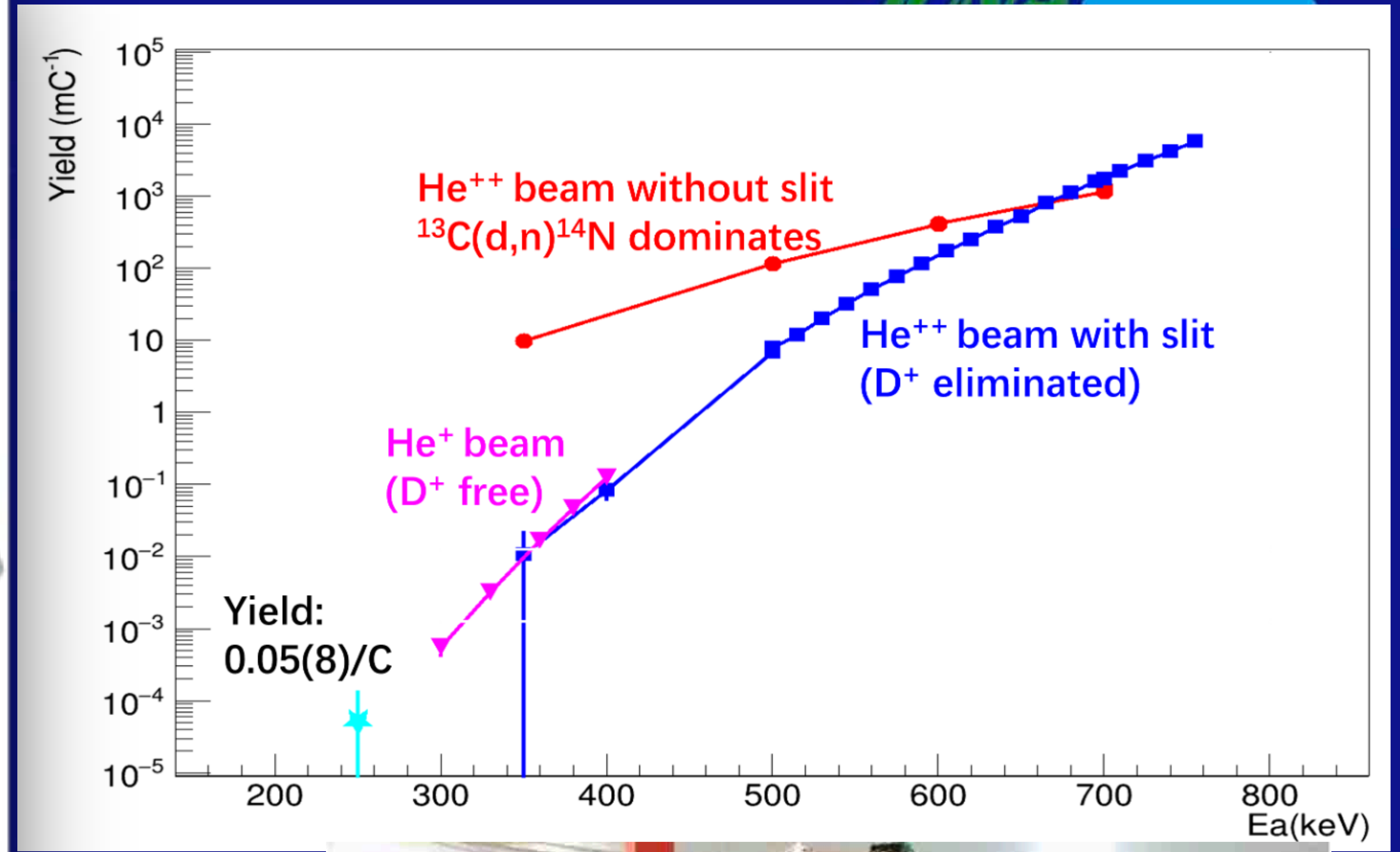
26%@2.5MeV neutron

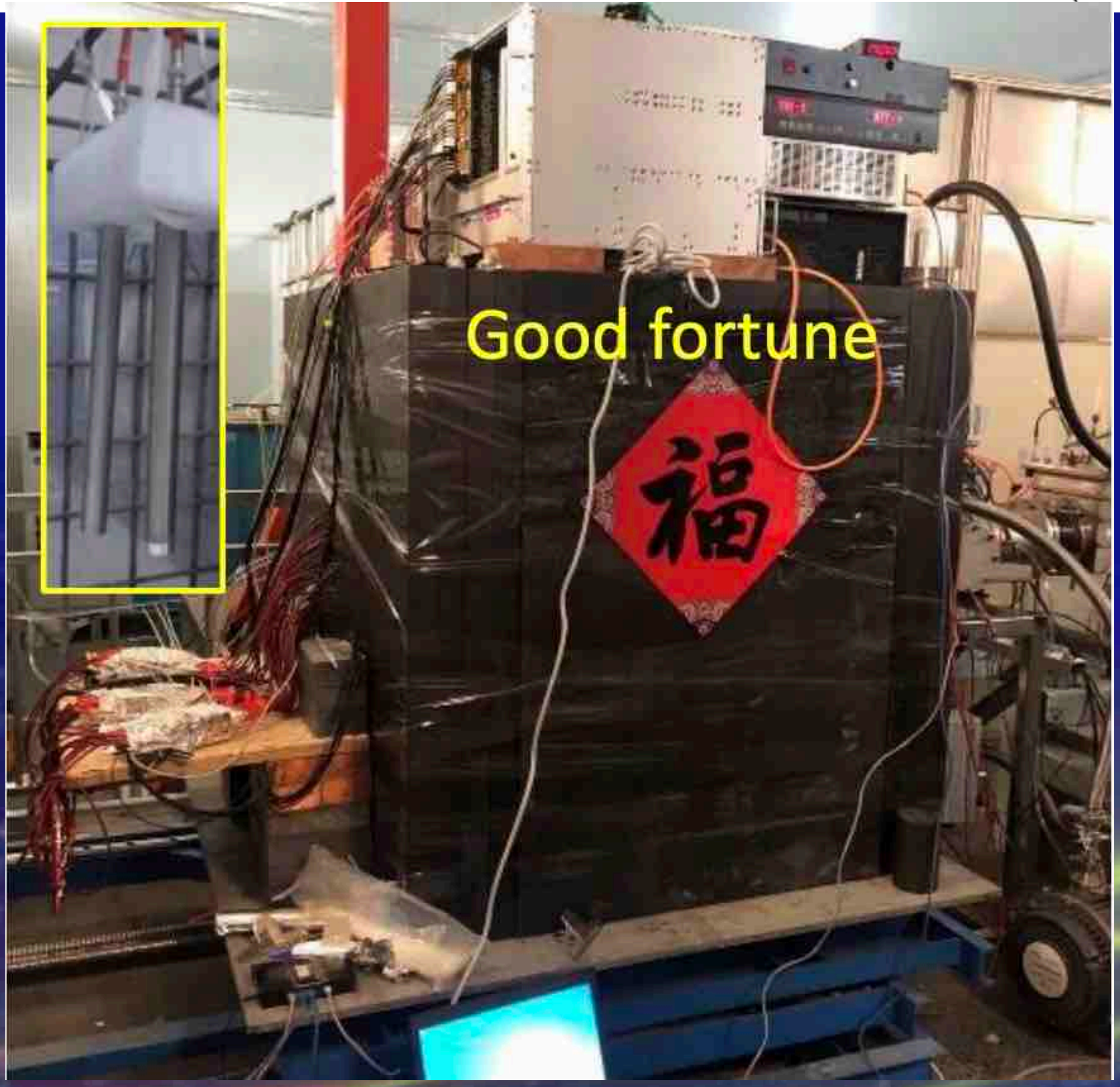


WPL et al., Sci. China 59(2016)2

$^{13}C(\alpha,n)^{16}O$ Measurement



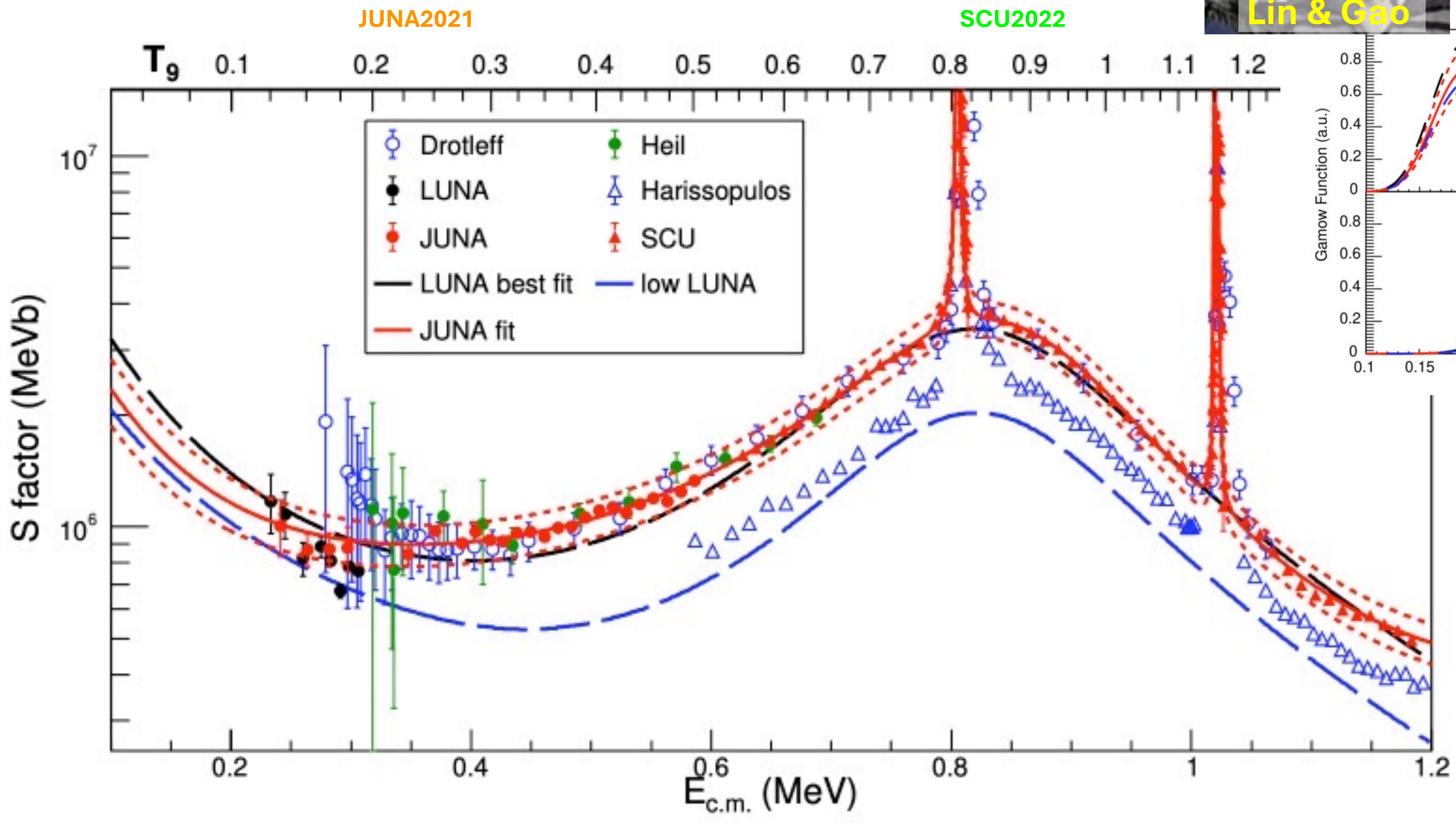


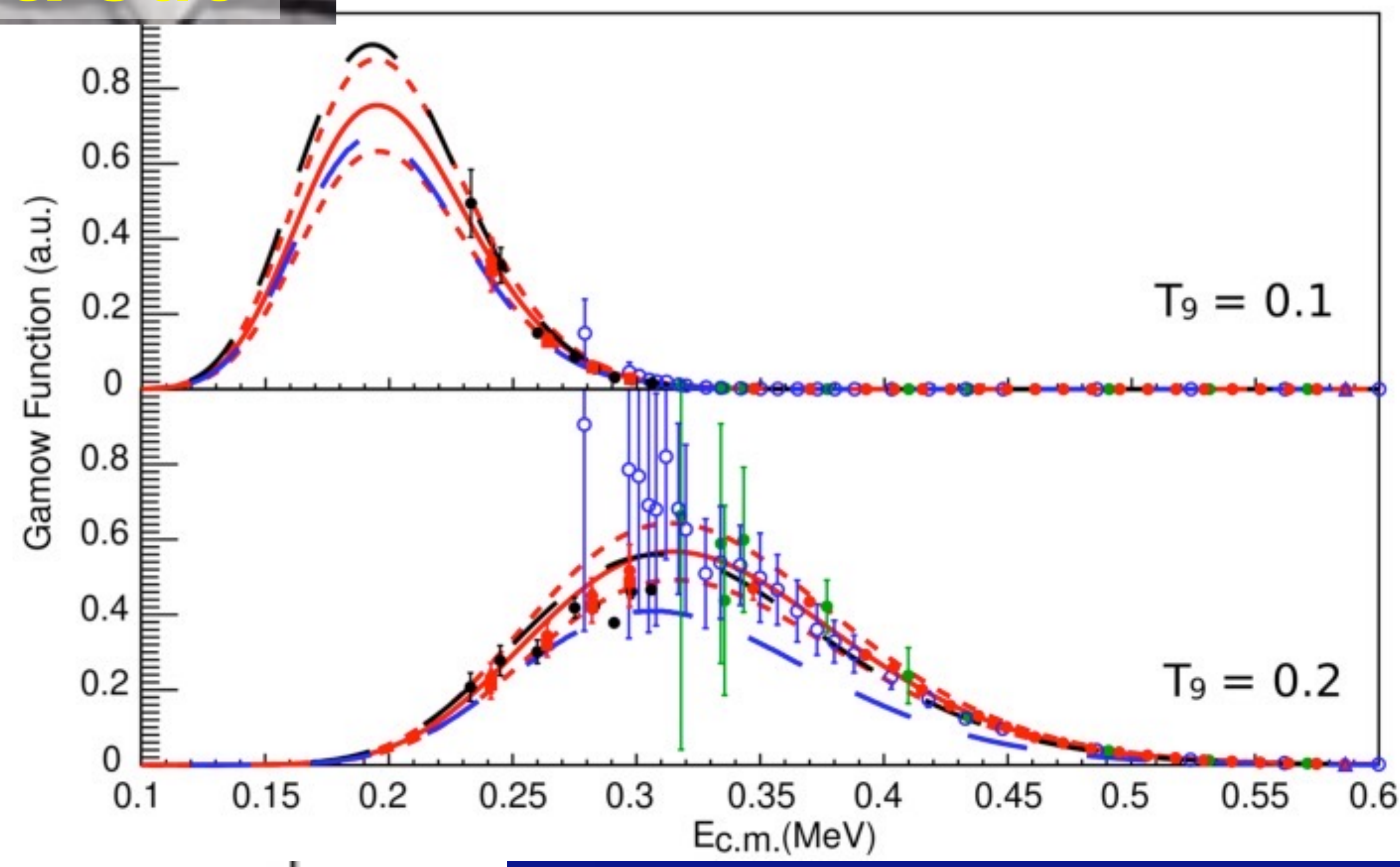


- **Beam intensities from tens of uA up to 2.5 pmA**
- **Use thick target to eliminate target-thickness related uncertainties**
- **He^{++} beam extends the beam energy up to 800 keV (Use slits to remove D^+)**

B. Gao, T. Jiao..., X. D. Tang*,..., WPL*, ..., M. Pignatari $^{13}C(\alpha,n)^{16}O$, PRL 129(2022)132701

$^{13}C(\alpha,n)^{16}O$ Measurement





- mA thick target, differential method to pin down thickness
- magnetic removal of D+ from He^{2+}, cover 0.4 MeV to 0.8 MeV (JUNA), cover i-process; to 1.9 MeV tandem, calibration of eff. , cross check other date
- n background 5/hour, 2.5 MeV eff. 25%, good S/N

B. Gao, T. Jiao..., X. D. Tang*,..., WPL*, ..., M. Pignatari $^{13}C(\alpha,n)^{16}O$, PRL 129(2022)132701

JUNA results from Run -1

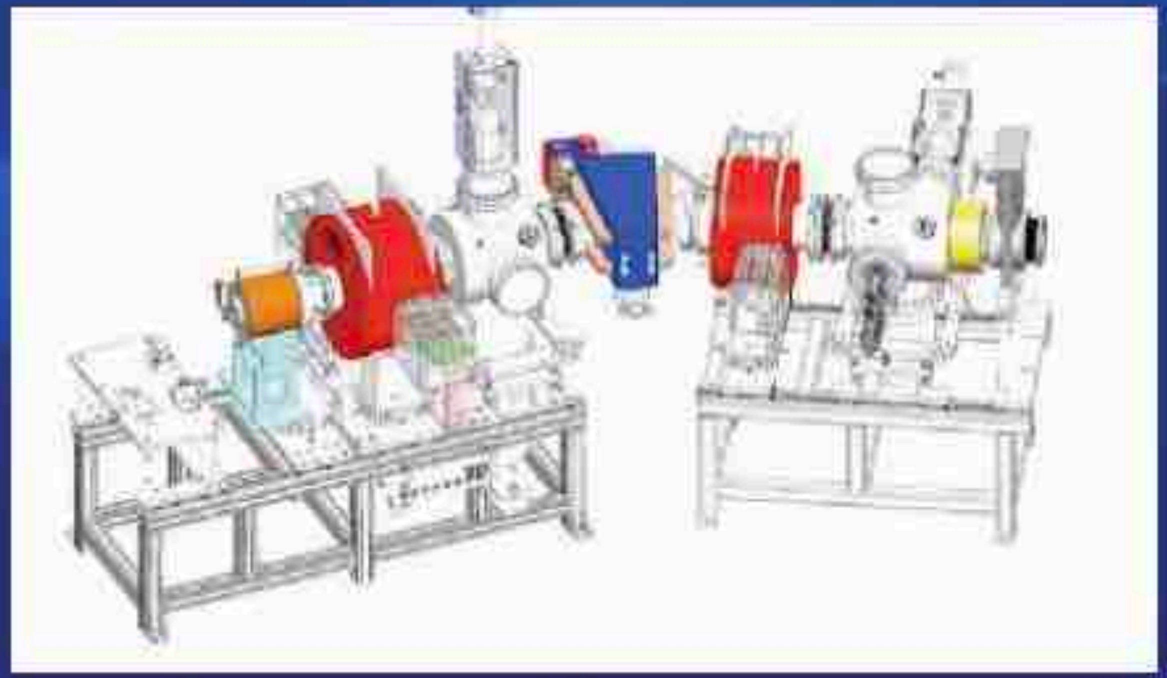
Reaction	Quantities	Best data before	JUNA data	Publication
Holy grail $^{12}C(\alpha,\gamma)^{16}O$	Lowest energy/keV	891	**552**	**In preparation**
	Cross section/b	10^{-11}	**10^{-12}**	
Neutron source $^{13}C(\alpha,n)^{16}O$	Energy range/keV	230-300	**240-1900**	**PRL 129(2022)132701**
	s-process	50%	**20%**	
^{26}Al abundance $^{25}Mg(p,\gamma)^{26}Al$	Uncertainty	21%	**8%**	**Science Bulletin 67(2022)2 cover paper**
F abundance $^{19}F(p,\alpha\gamma)^{16}O$	Lowest energy/keV	189	**72**	**PRL 127(2021)152702 Editor suggestion**
	Uncertainty	80%	**5%**	
Ne isotope ratio $^{18}O(\alpha,\gamma)^{22}Ne$	Uncertainty	472±18 keV	**474.1±1.1 keV**	**PRL 130(2023)092701**
CNO breakout $^{19}F(p,\gamma)^{20}Ne$	Lowest energy/keV	300	**200**	**Nature 610(2022)656 news and views**

Progress of the Jinping Underground Nuclear Astrophysics (JUNA) Experimental Platform, W.P. Liu et al., ARNPS (2025)

Green lights for JUNA Run-2

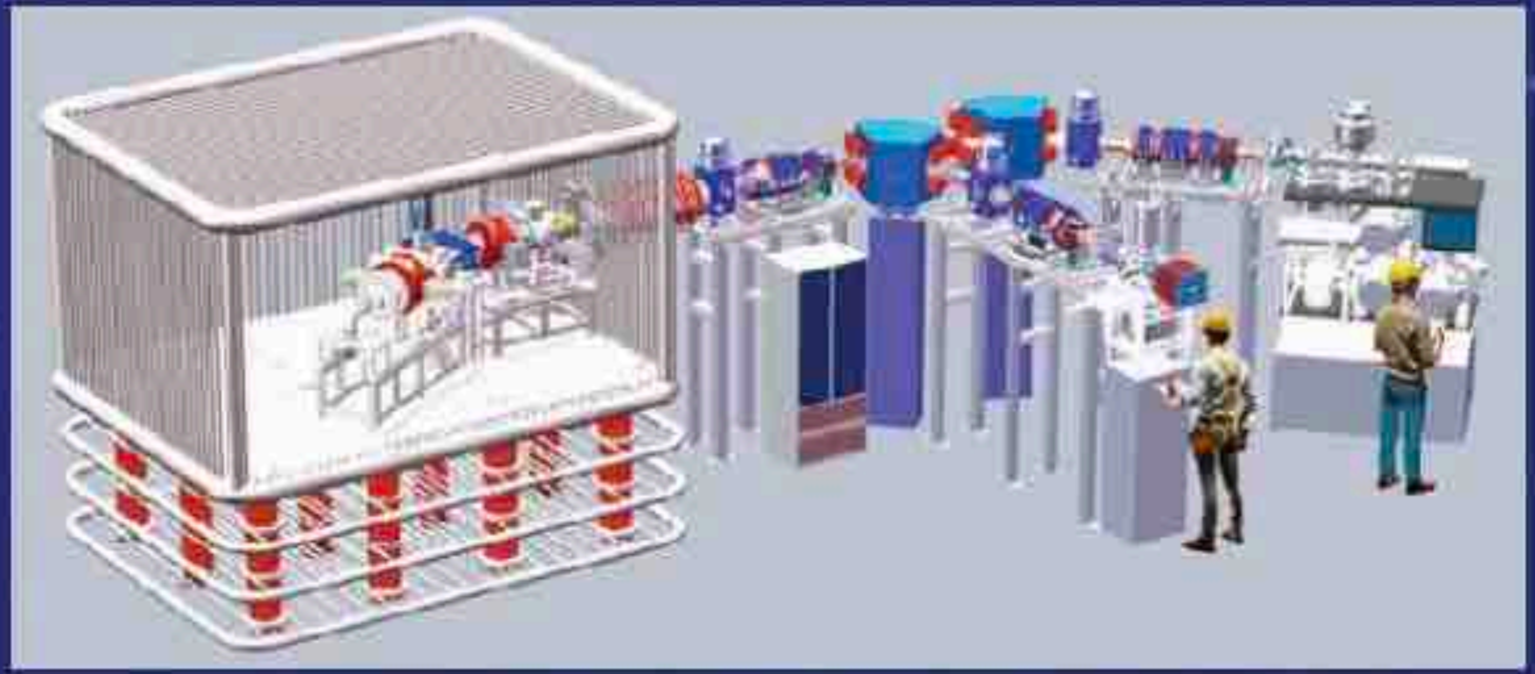
Courtesy of W.P. Liu

- CJPL IAC highly recommend JUNA and gave green lights for next 5 years and support JUNA using A1 space
- High density radiation hard target and gas target, higher efficiency neutron and gamma detectors
- Run 2 proposal evaluated and approved from July 2025 to February 2026

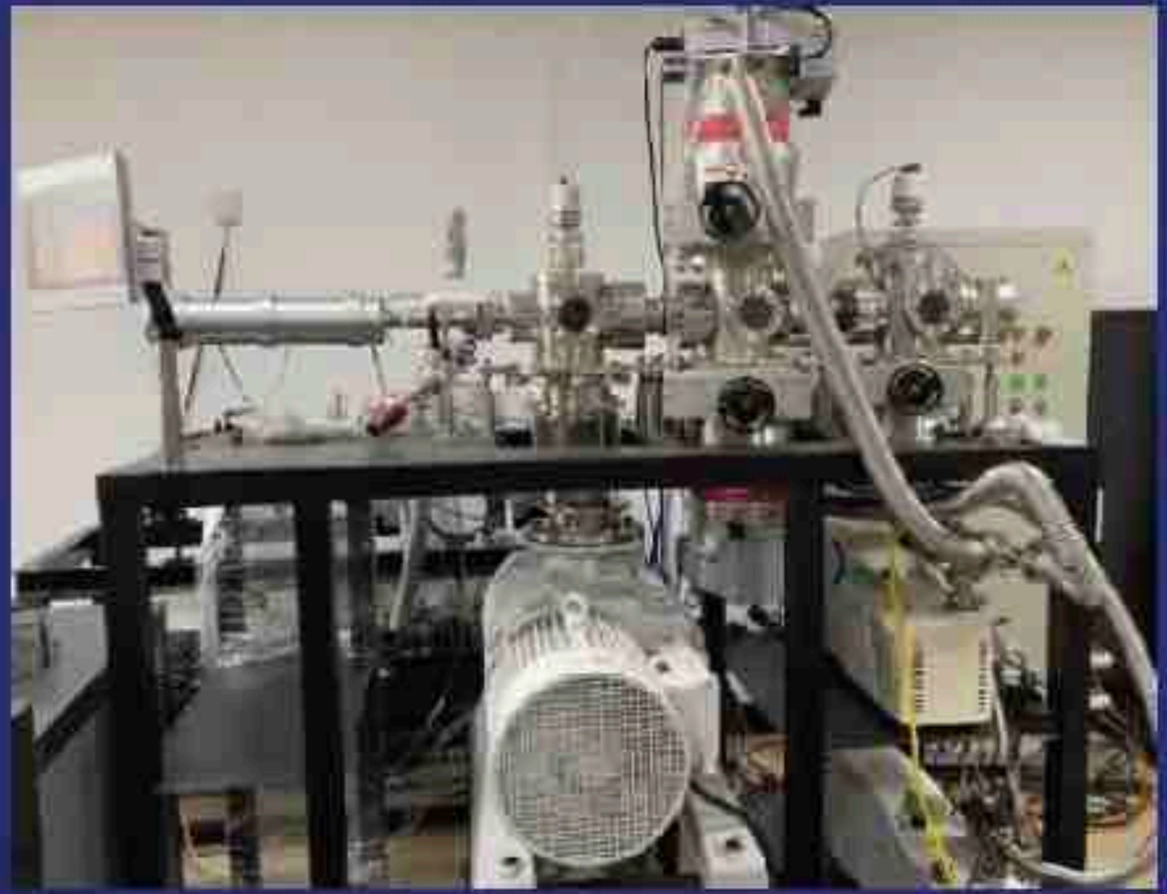


Improved ion source

Run-2 kickoff meeting April 24, 2024, CIAE

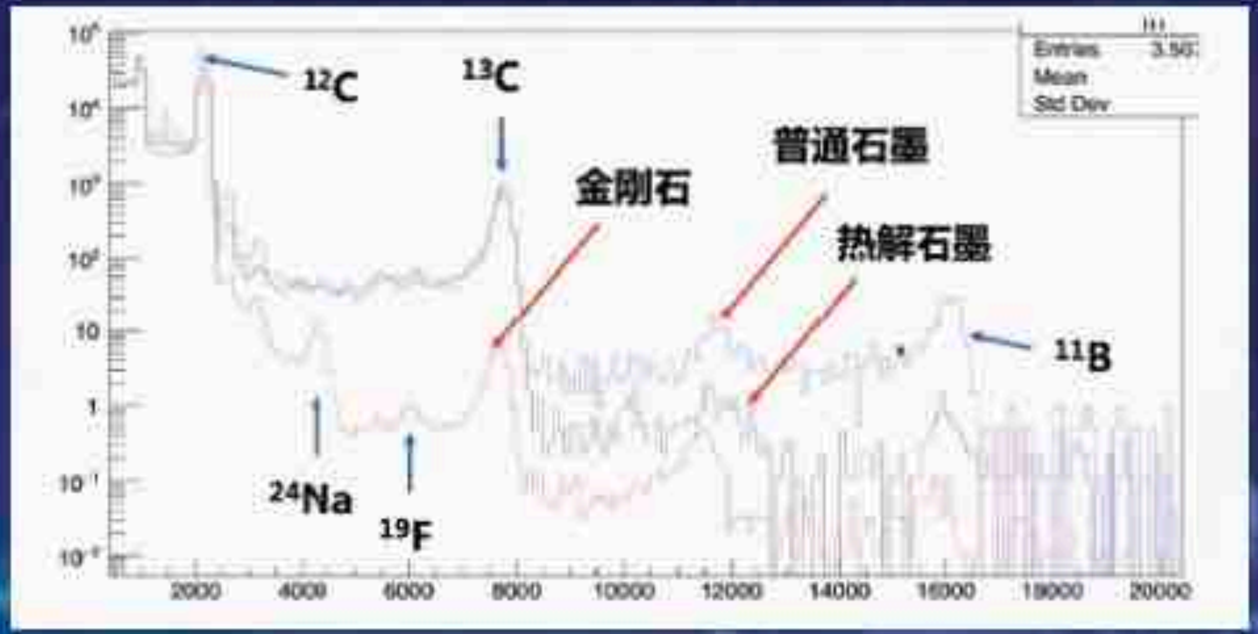


floor plan for JUNA Run-2



Gas jet target

Run-2 plan approved May 15, 2025, BNU



test result for diamond target

Enlarged BGO array

Sept., 2024
CJPL-II A1 ready

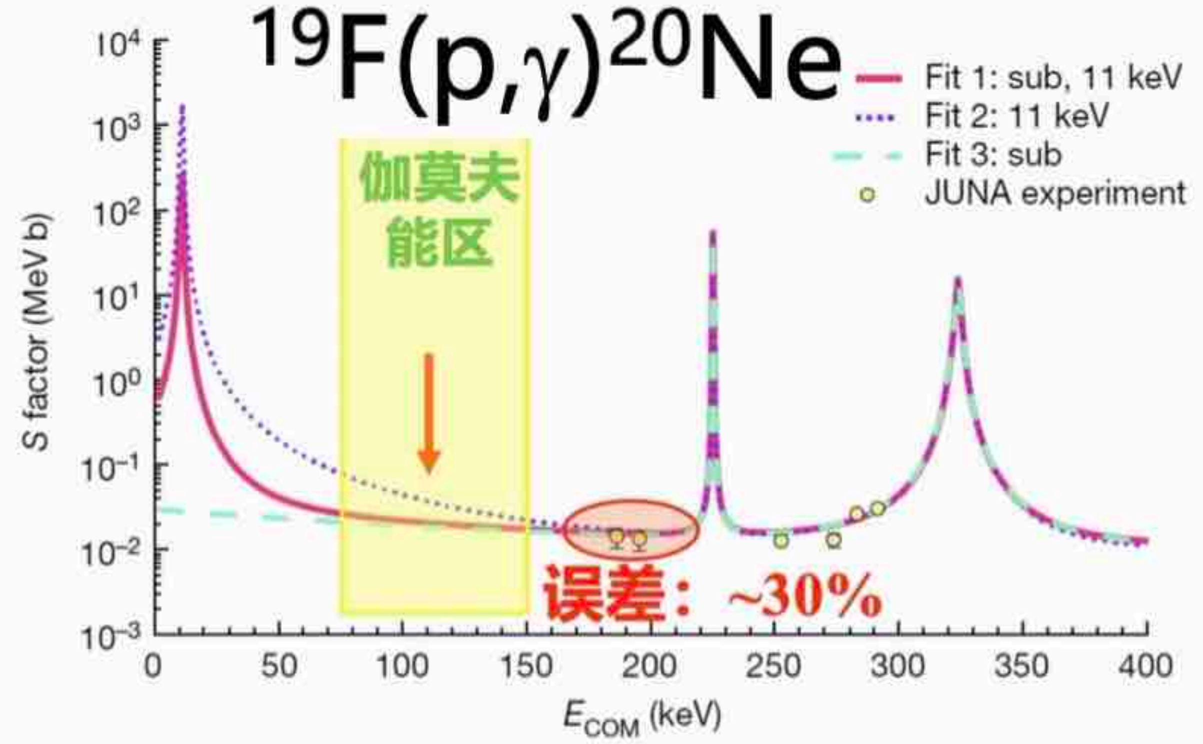
October, 2024
Accelerator in A1

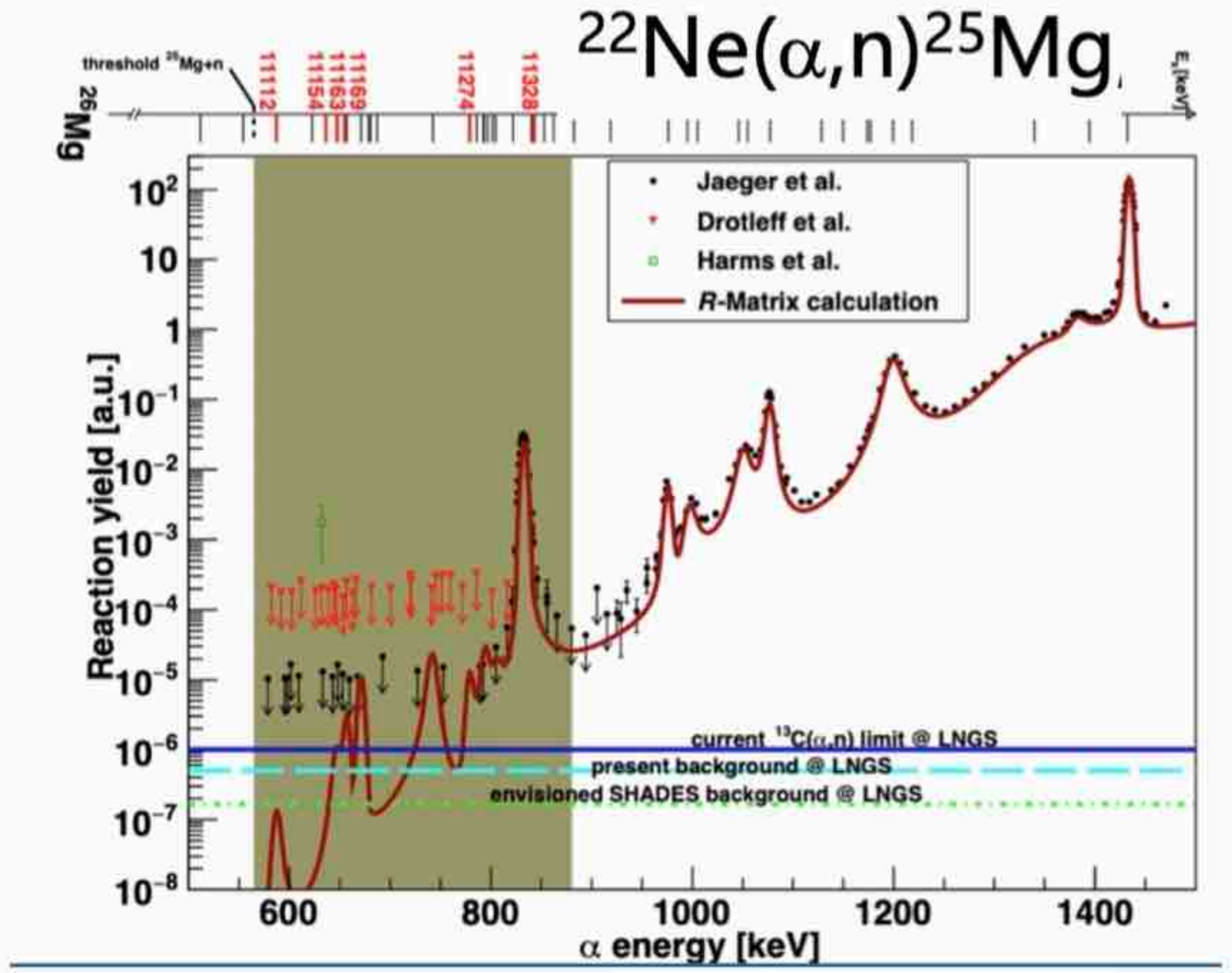
May, 2025
Accelerator ready for beam

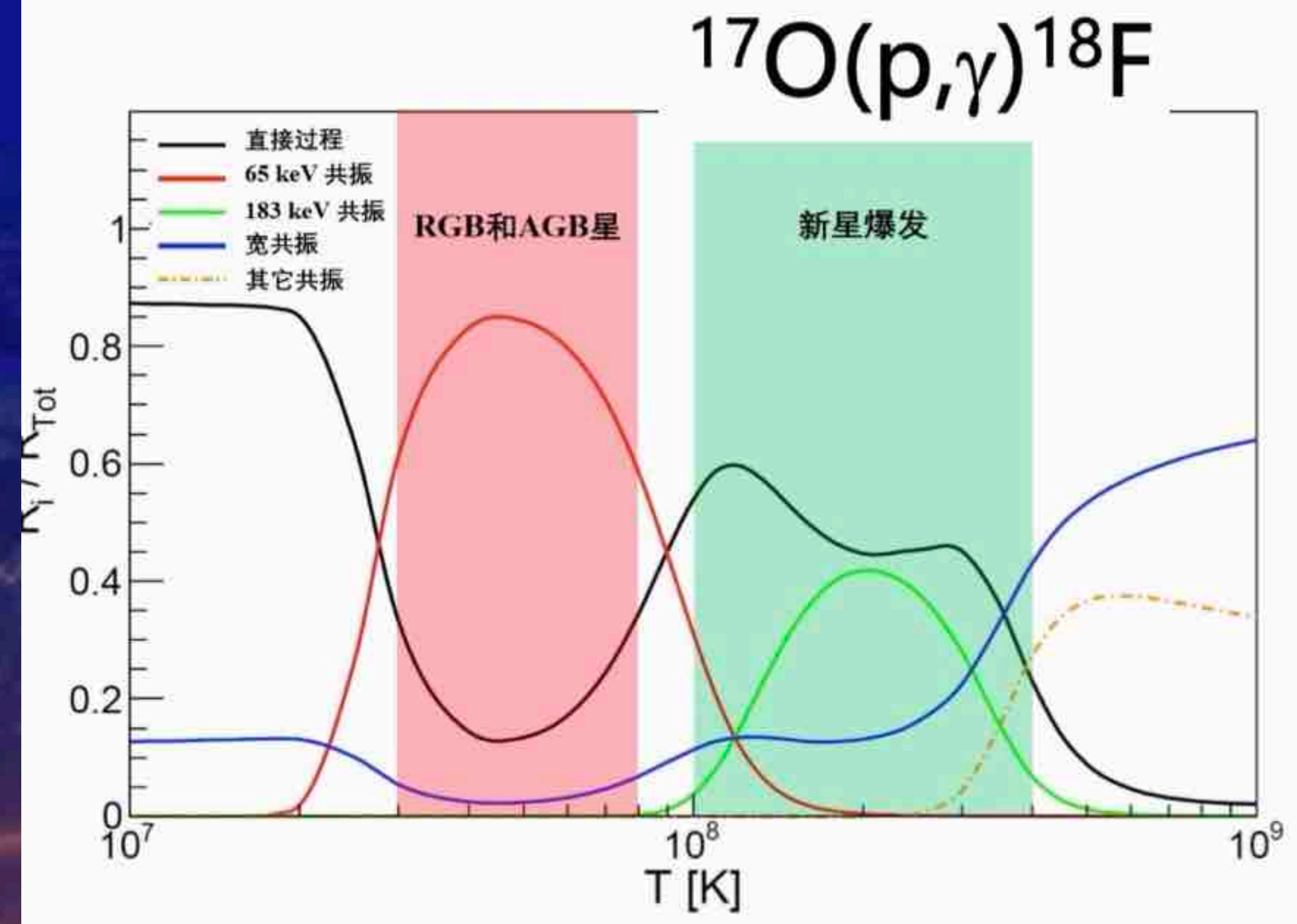
JUNA Run-2 Exp.: 2025-2027

- **From Run-1 to lower energy**
  - $^{12}C(\alpha,\gamma)^{16}O$, **precision from 1s to 3s**
  - $^{13}C(\alpha,n)^{16}O$, **full coverage of s-process**
  - $^{19}F(p,\gamma)^{20}Ne$, **cover 80-150 keV with high precision**
  - $^{14}N(p,\gamma)^{15}O$, **Solar neutrino**

- **Using gas target**
  - $^{22}Ne(\alpha,n)^{25}Mg$, **weak s-process n source**
  - $^{3}He(\alpha,\gamma)^{7}Be$, **solar neutron, Li problem, 80-380 keV**







JUNA
锦屏深地核天体物理实验
Jinping Underground Nuclear Astrophysics Experiment
Super-JUNA
25
20
15
10
5
0
I(⁴He) / mA
0.1
1
E(⁴He) / MeV
¹²C(α,γ)¹⁶O
Super JUNA
²²Ne(α,n)²⁵Mg
JUNA
¹³C(α,n)¹⁶O
400 kV
800 kV
JUNA
Super JUNA

2024-2030 JUNA and Super-JUNA

	JUNA	Super-JUNA	JUNA Exp.	Super-JUNA Exp.
2024	ground test run Run-2 exp.	R&D	(p,g)	
2025	Run-2	Ground test and fabrication	(a,n) and (a,g) gas target	
2026	Run-2	Setup and test	cont.	
2027	Upgrade Run-3 exp.	Test run Run-4 exp.	Test run	(p,g) test
2028	Run-3	Run-4	cont.	(a,g), (a,n) Exp.
2029	Run-3	Run-4	cont.	(a,g), (a,n) Exp.
2030	Run-3	Run-4	cont.	(a,g), (a,n) Exp.

JUNA and Super JUNA coverage

H burning

$^{7}Be(p,\gamma)^{8}B$

$^{12}C(p,\gamma)^{13}N$

$^{14}N(p,\gamma)^{15}O$

$^{15}N(p,\gamma),(p,\alpha)^{16}O,^{12}C$

$^{17}O(p,\gamma),(p,\alpha)^{18}F,^{14}N$

$^{18}O(p,\gamma),(p,\alpha)^{19}F,^{15}N$

$^{19}F(p,\alpha)^{16}O$

He burning

$^{12}C(\alpha,\gamma)^{16}O$

$^{16}O(\alpha,\gamma)^{20}Ne$

$^{20}Ne(\alpha,\gamma)^{24}Mg$

$^{18}O(\alpha,\gamma)^{22}Ne$

$^{22}Ne(\alpha,\gamma)^{26}Mg$

$^{24}Mg(\alpha,\gamma)^{28}Si$

N source

$^{13}C(\alpha,n)^{16}O$

$^{22}Ne(\alpha,n)^{25}Mg$

$^{25}Mg(\alpha,n)^{28}Si$

$^{26}Mg(\alpha,n)^{29}Si$

C\O burning

$^{12}C+^{12}C$

$^{12}C+^{16}O$

$^{16}O+^{16}O$

γ-astronomy

$^{25}Mg(p,\gamma)^{26}Al$

$^{26}Al(p,\gamma)^{27}Si$

JUNA achieved (yellow box)

Super JUNA proposed (red box)

Summary

- JUNA is an advanced deep astrophysics platform. China, follow Italy and United States and others, started to carry out direct measurement of key astrophysical reactions, which leading the nuclear astrophysics to the stage of precision numerical simulation stage

- JUNA accurately measured key nuclear astrophysical reactions, compared with previous experiment, beam intensity is higher, detector efficiency, target exposure, sensitivity and energy coverage are greatly improved

- From JUNA Run-1, Gamma-ray astronomical reaction has reached the highest precision, and the astrophysical holy grail reaction has achieved the highest sensitivity, new resonances revealing the origin of heavy element abundance in the oldest stars, and the discrepancies of neutron source reactions was resolved

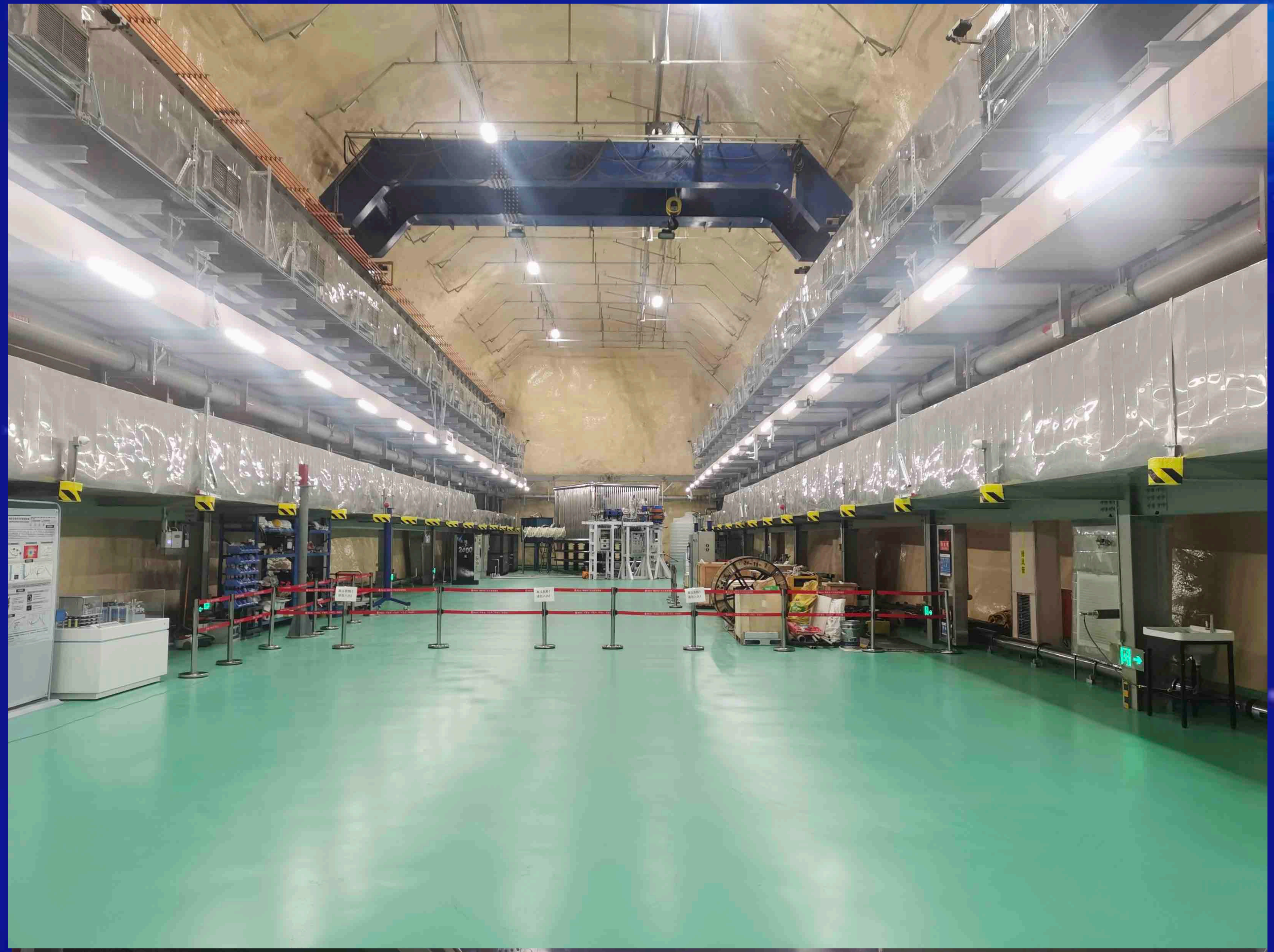
- JUNA Run-2 started by the end of 2025, welcome to join JUNA collaboration and submit your proposals deep underground!

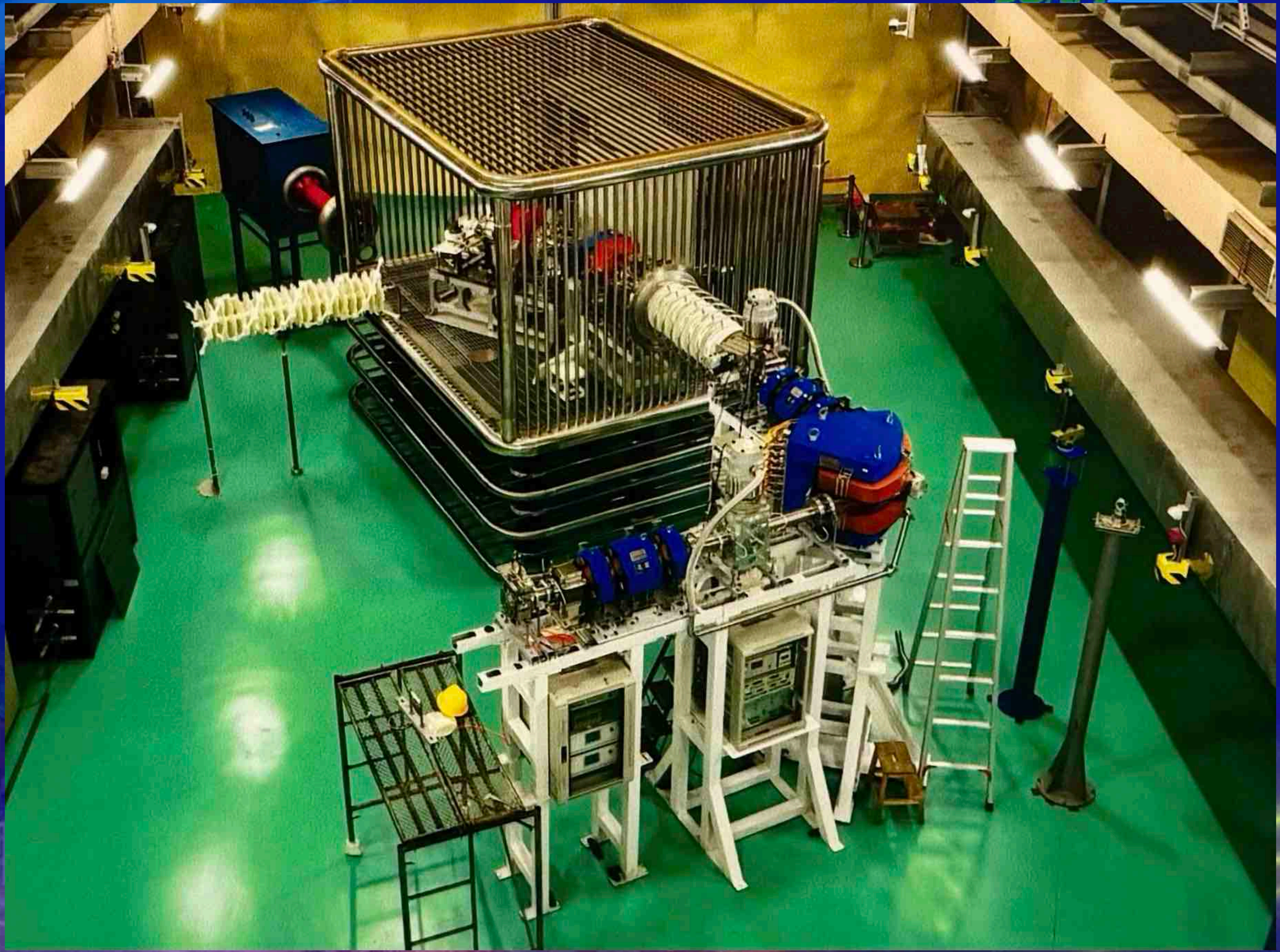
Progress of the Jinping Underground Nuclear Astrophysics (JUNA) Experimental Platform, W.P. Liu et al., ARNPS (2025)
https://doi.org/10.1146/annurev-nucl-121423-101021





Some more pictures





Köszönöm!

Grazie!

Thank you!

谢谢!