Decay studies of nuclei far from β stability line

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第十七届全国核物理大会，2019年10月8-12日，华中师范大学

报 告 提 纲

一、研究背景

二、研究内容

三、研究展望

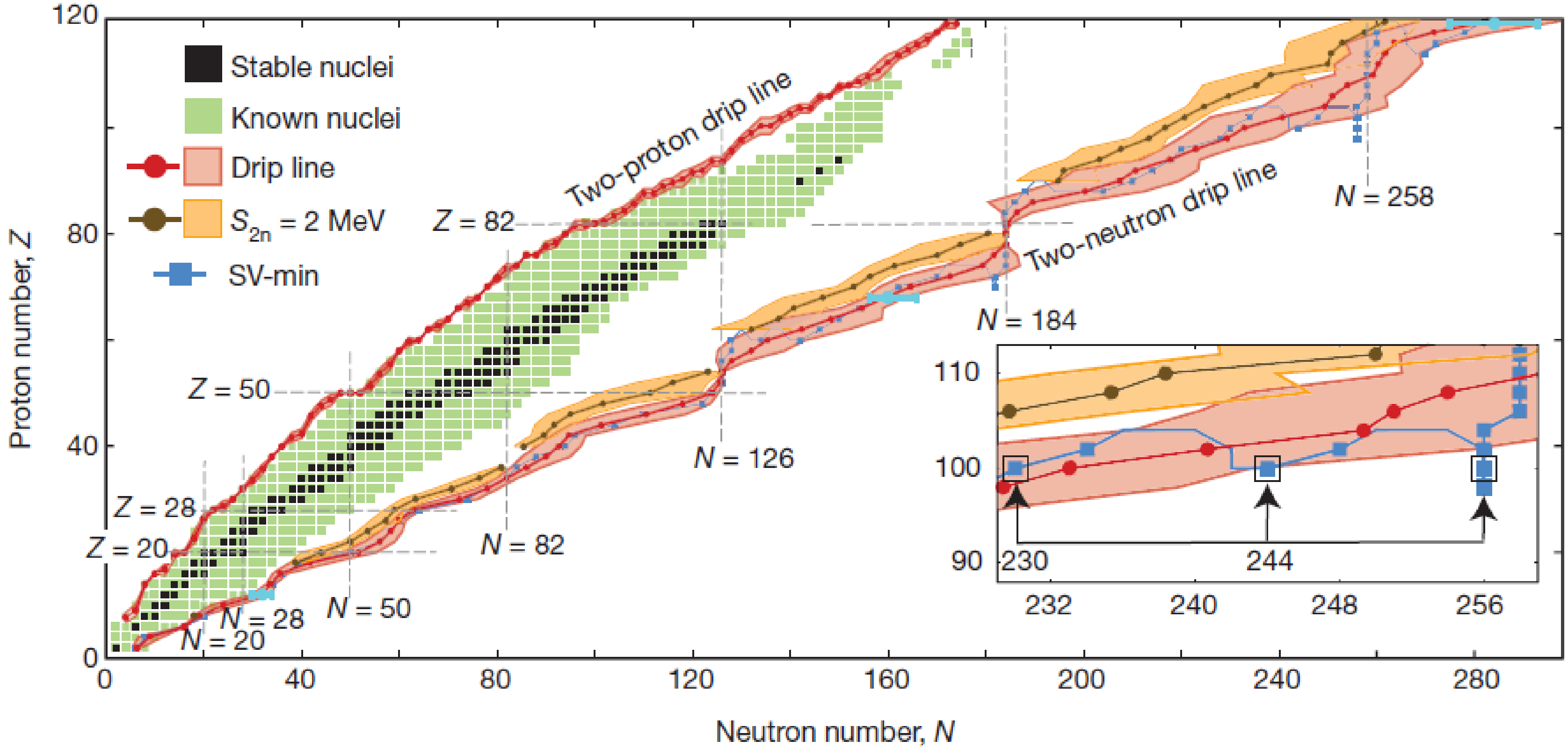
一、研究背景

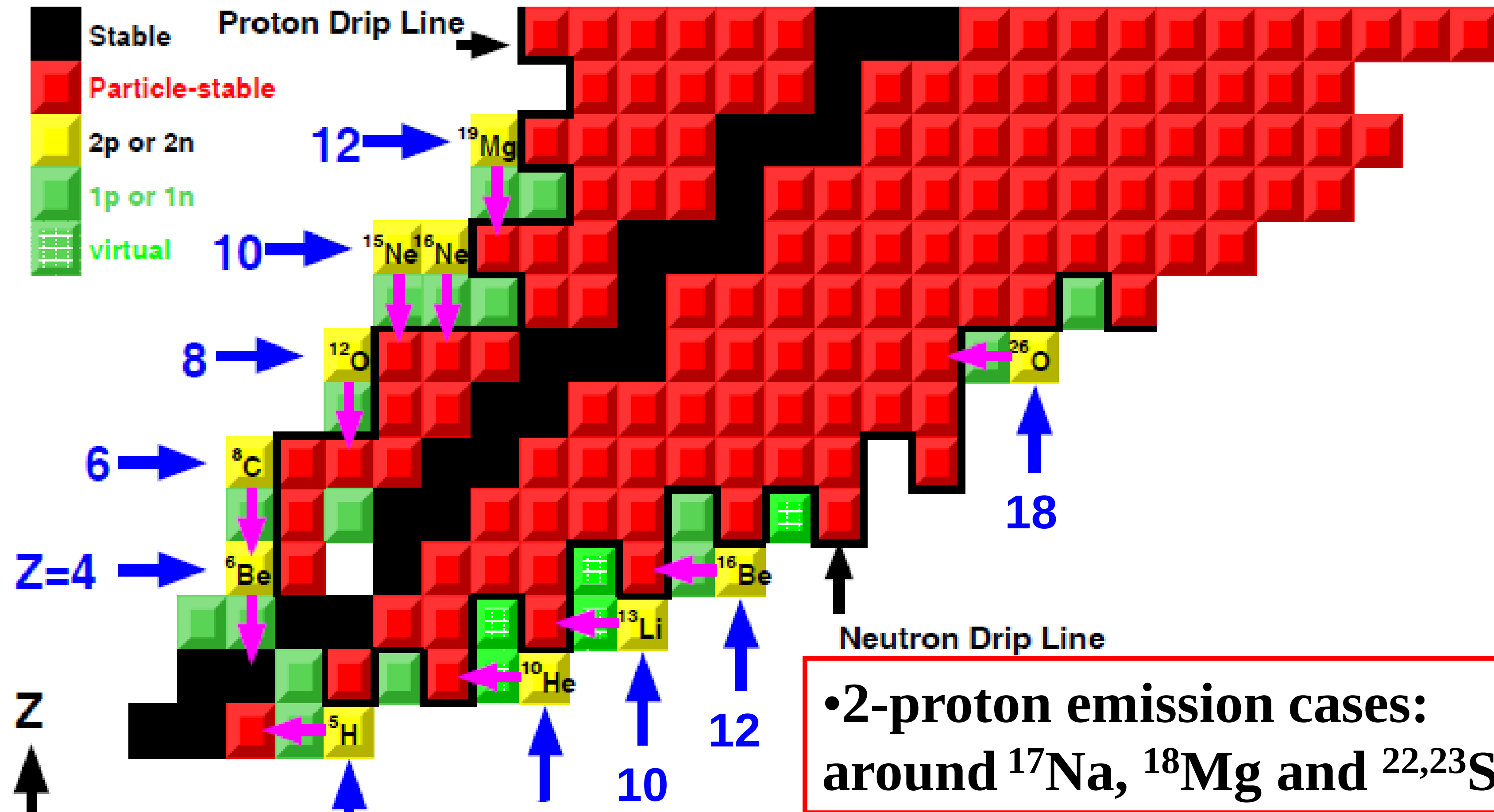
LETTER

doi:10.1038/nature11188

The limits of the nuclear landscape

Jochen Erler[1,2], Noah Birge[1], Markus Kortelainen[1,2,3], Witold Nazarewicz[1,2,4], Erik Olsen[1,2], Alexander M. Perhac[1] & Mario Stoitsov[1,2]‡



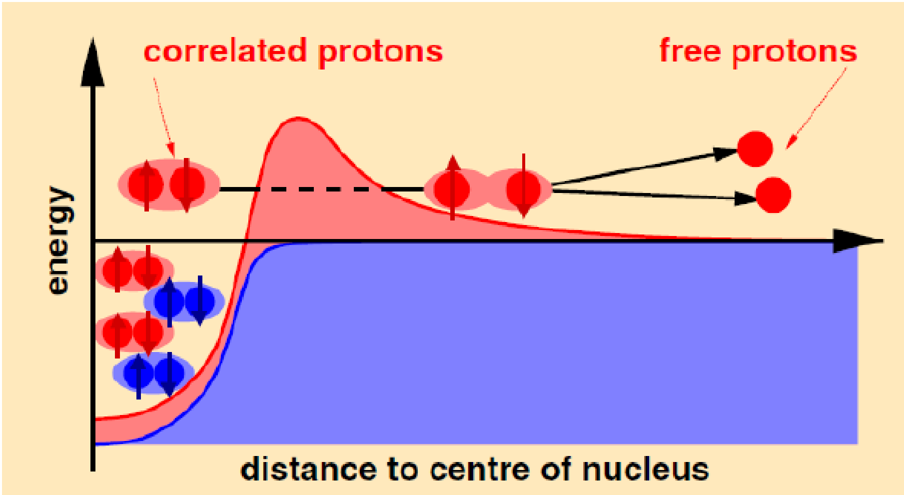


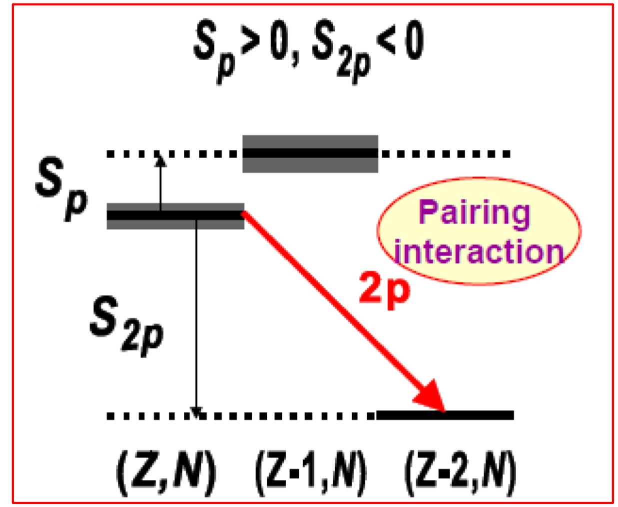
•2-proton emission cases: around ^{17}Na, ^{18}Mg and ^{22,23}Si

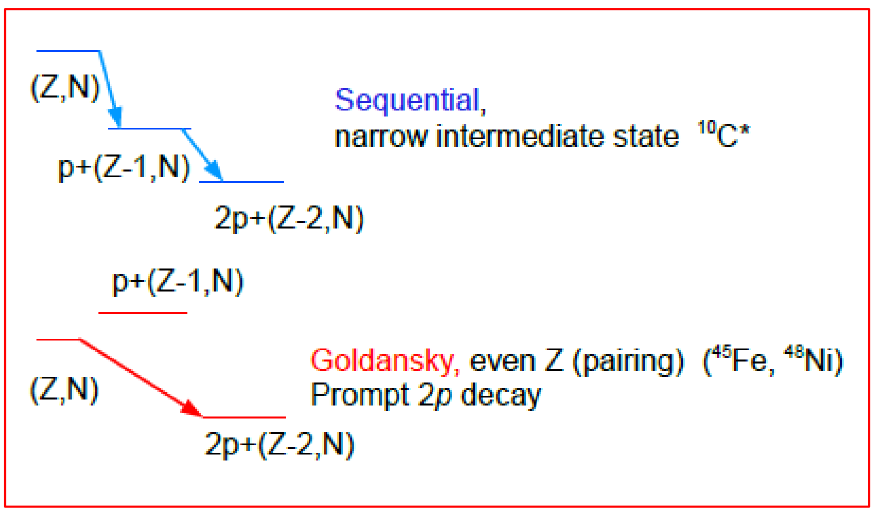
•β -delayed 2-neutron emission cases: ^{11}Li (4%), ^{17}B (11%), ^{17}C (7%), ^{30,31}Na (1%), ^{32,33}Na (10%)

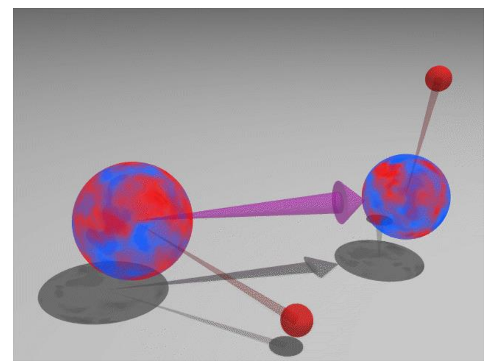
• β -delayed 3,4-neutron emission cases: ^{11}Li (3n), ^{17}B (3n, 4n)

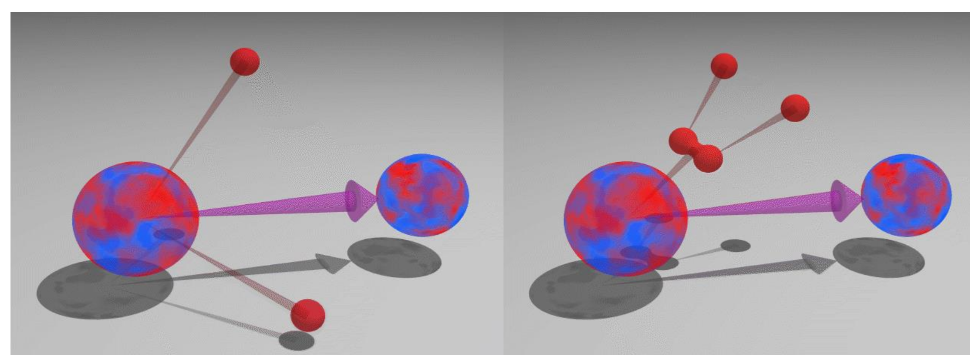
Mechanism of two-proton radioactivity





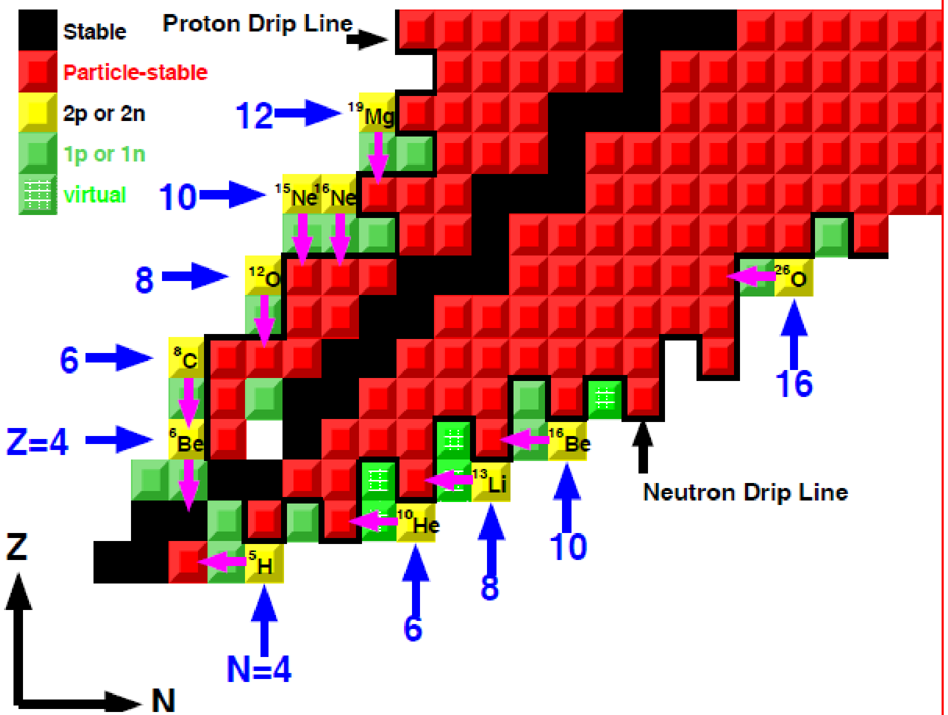






二、研究内容

➢ 2p, 4p decay of ^{18}Mg



MICHIGAN STATE UNIVERSITY

May 3, 2018

Dear Hui Hua:

The Program Advisory Committee (PAC 42) of the National Superconducting Cyclotron Laboratory met on May 2-3, 2018 to consider proposals for beam time at the Coupled Cyclotron Facility and ReA3. Your proposal, "Spectroscopy of 18Mg by 14O + 4p correlations" (No. 18015), was included in this review.

In spite of the large amount of time requested (7060 hours) compared to the limited running time available, the Committee recommended your full time request of 205 hours (178 hours on-target time and the rest beam development and delivery time) for your experiment. I concur with the Committee's recommendation.

For PAC 42 experiments, the approval duration is 24 months from the beginning of the running period on October 1, 2018.

Please notify your colleagues on the proposal of this decision. As spokesperson, you are responsible for communicating information regarding your experiment to your collaborators. For information on the scheduling process, you may find it useful to browse the user section of the NSCL website, especially the User Guide (http://nscl.msu.edu/users/guide.html). All collaborators should be made aware of the Experimenter Responsibilities (http://nscl.msu.edu/users/ExperimenterResponsibilities1.pdf).

We wish you the best of luck on your experiment.

Sincerely,

Bradley M. Sherrill
NSCL Director

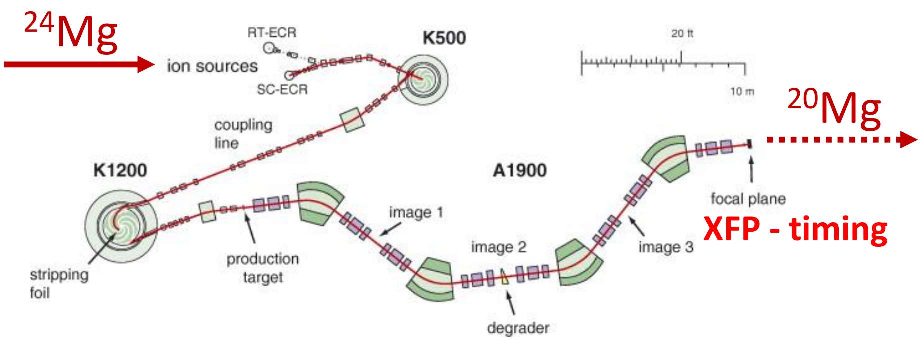
NSCL
Bradley Sherrill
NSCL Director

National Superconducting Cyclotron Laboratory

East Lansing, MI
48824

517-908-7718
sherrill@nscl.msu.edu

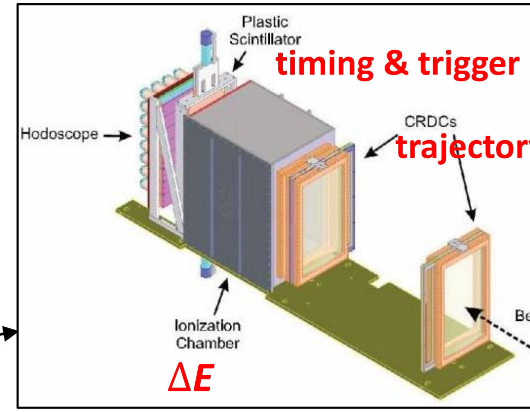
实验设置

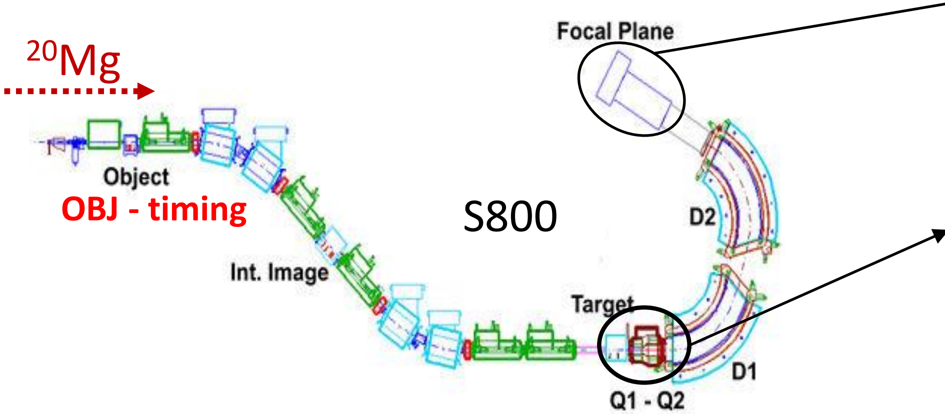


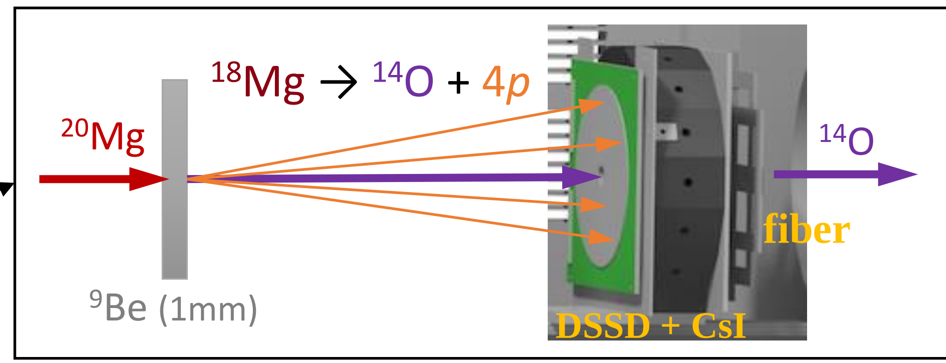
<u>束流参数</u>

纯度： ~20%

流强： ~8000 pps





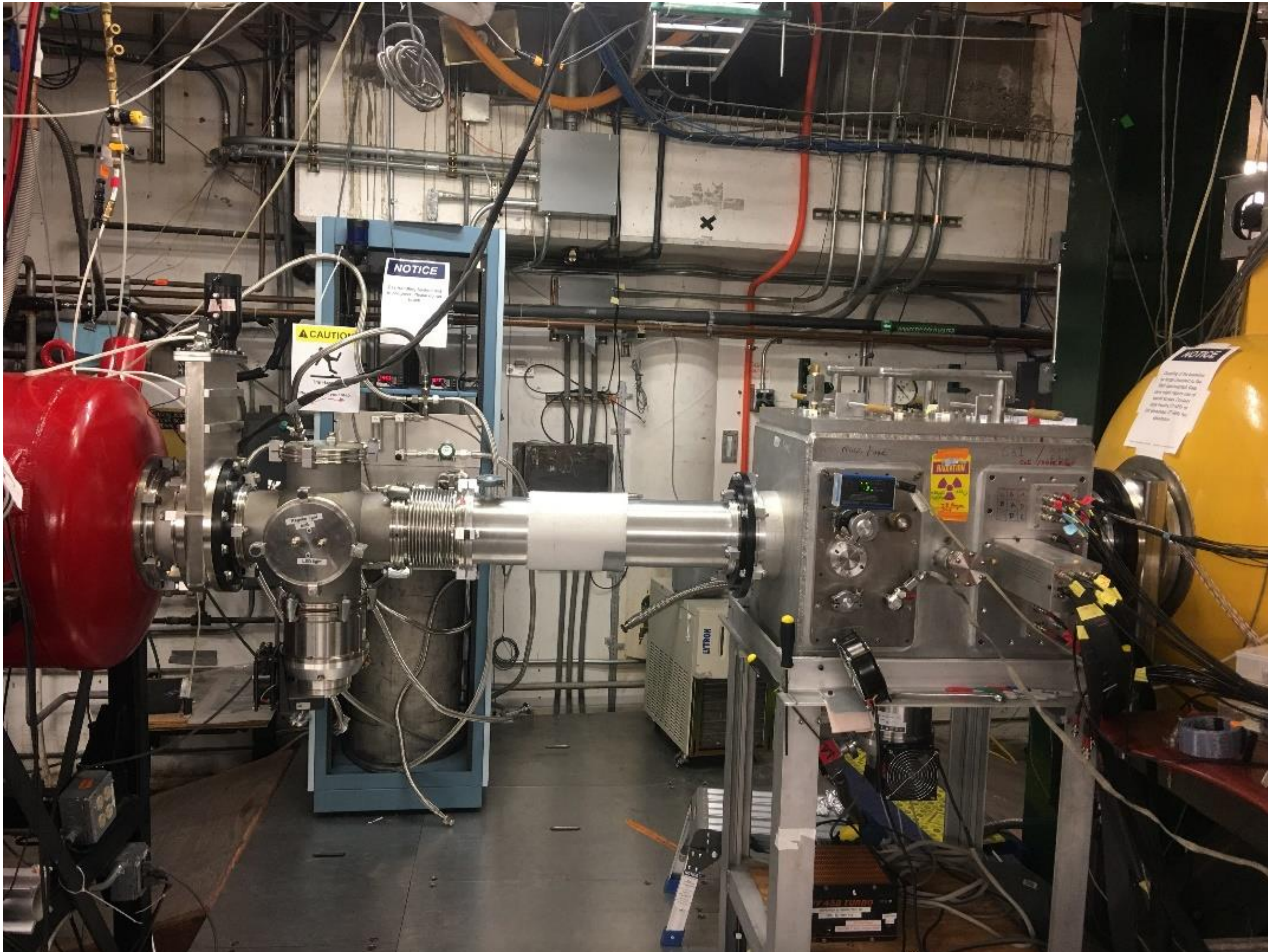


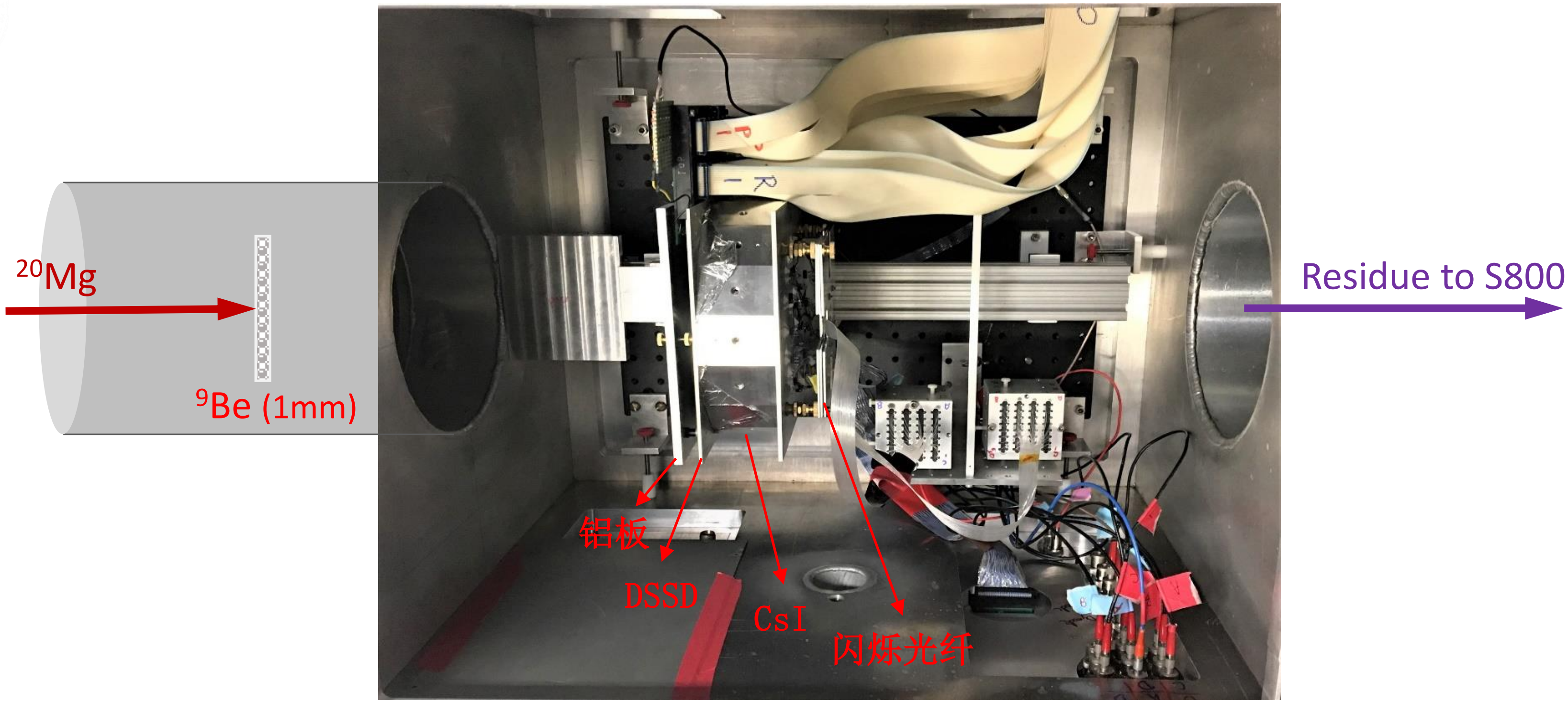
<u>束流</u>： ^{24}Mg离子源 → CCF加速 → 打初级靶发生碎裂反应 → A1900分离得到次级束^{20}Mg

<u>反应</u>： ^{20}Mg敲出两个中子得到目标核^{18}Mg → ^{18}Mg衰变为^{14}O+4p

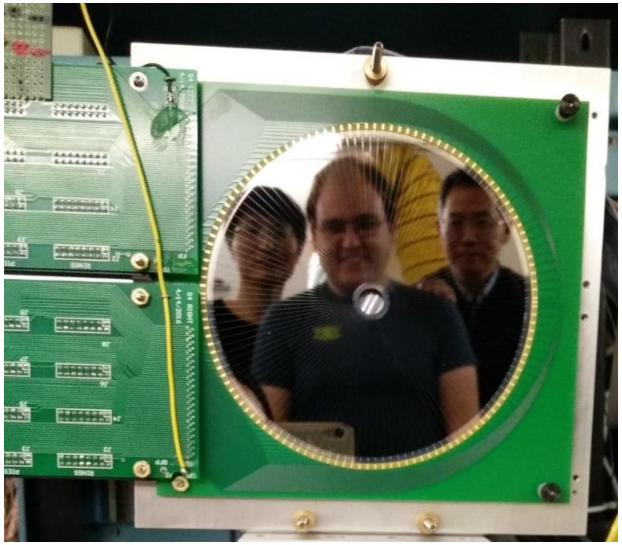
<u>探测</u>： [轻粒子] DSSD+CsI进行粒子鉴别，得到能量和动量方向

[剩余核] 闪烁光纤测量出射角度 → S800磁谱仪进行粒子鉴别，给出粒子能量


NOTICE
CAUTION
NOTICE



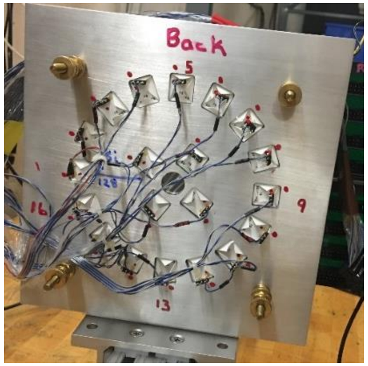
^{20}Mg
^{9}Be (1mm)
Residue to S800
铝板
DSSD
CsI
闪烁光纤



正面

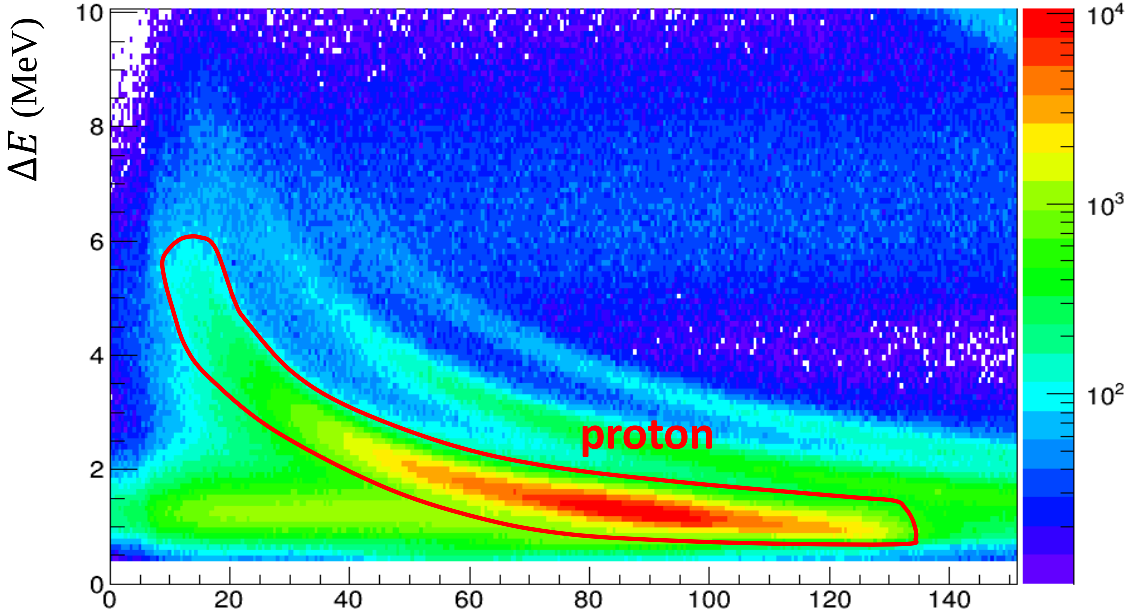
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

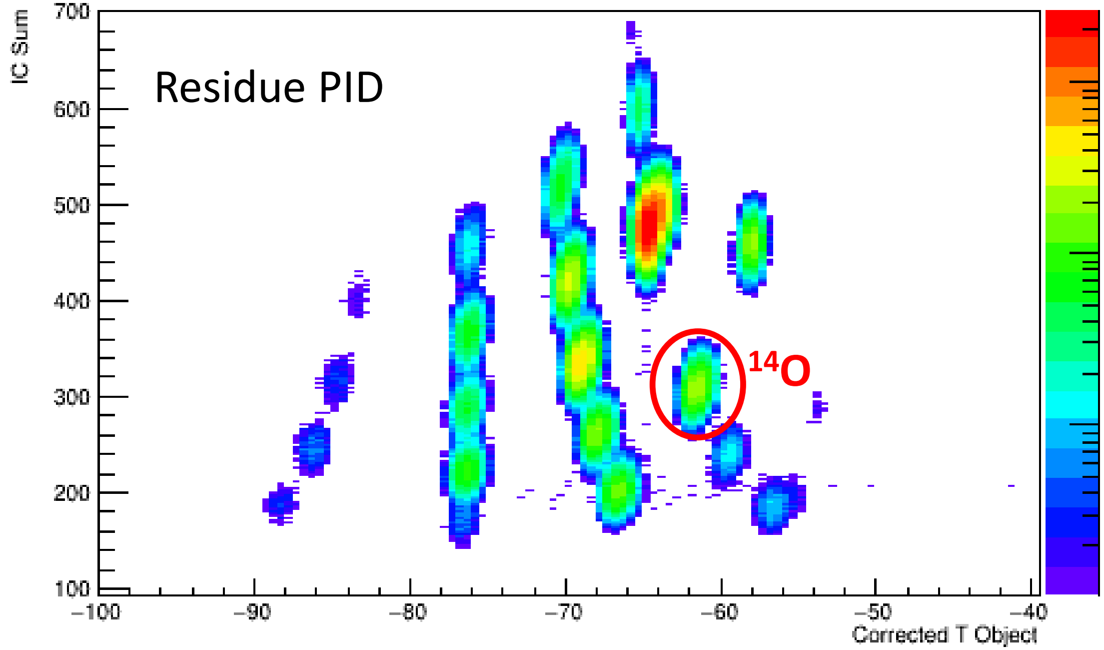
背面



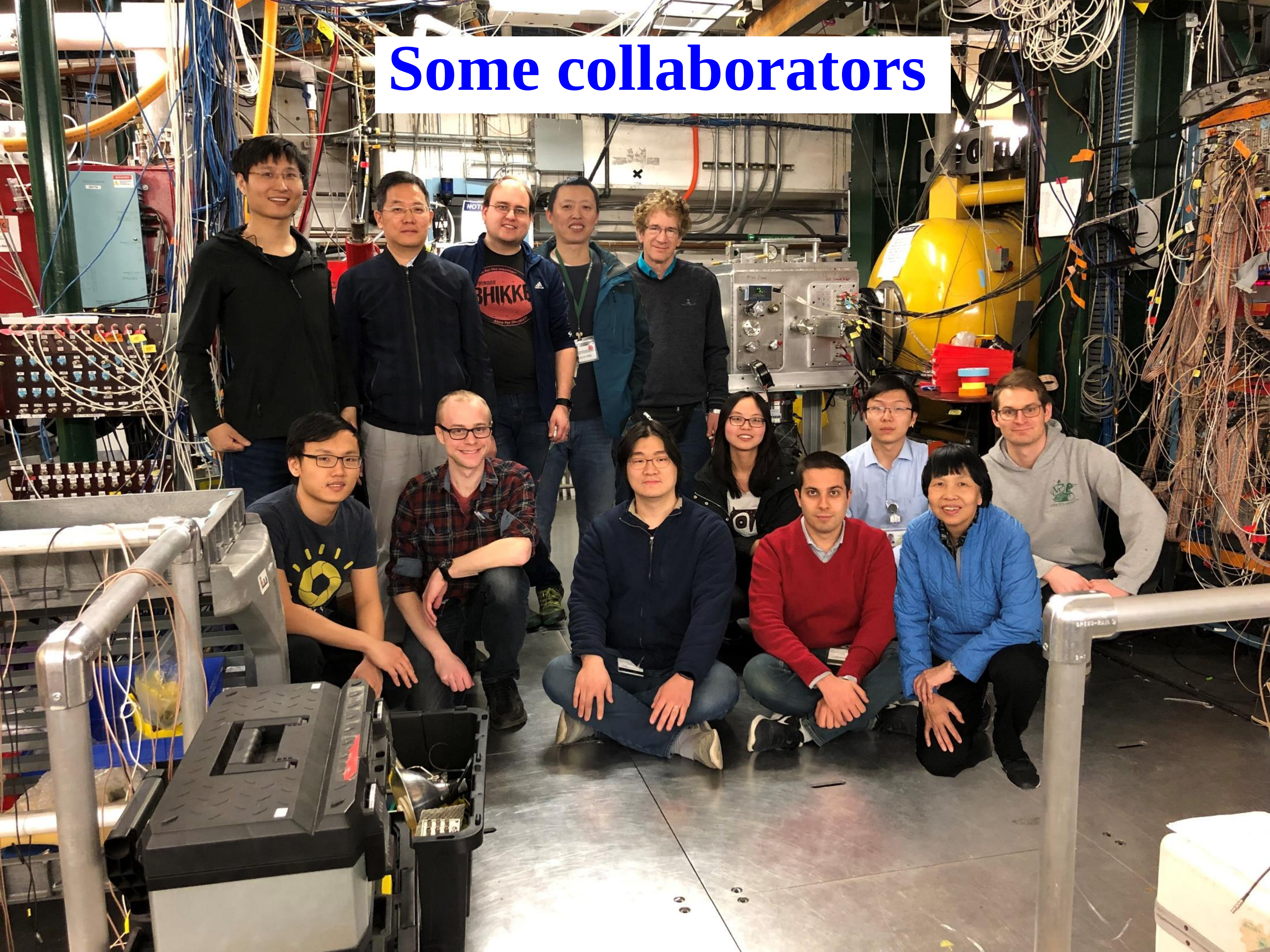
Back

Proton and Residue



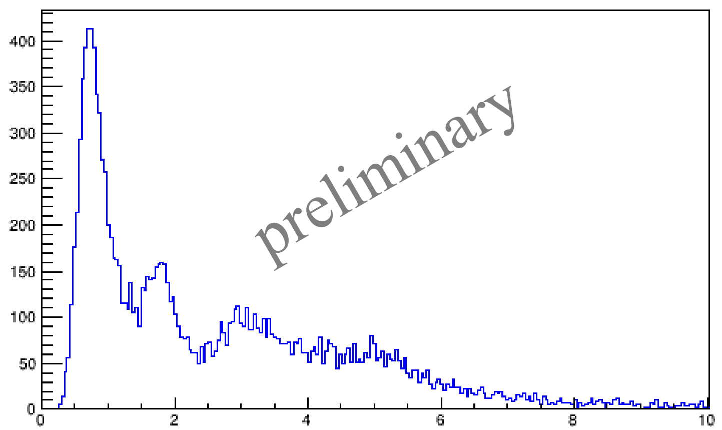


Some collaborators

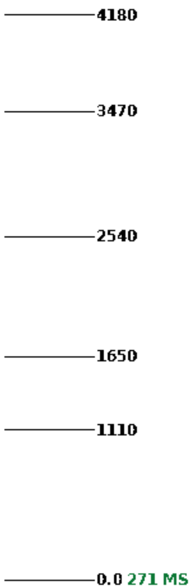


Mg19 invariant mass

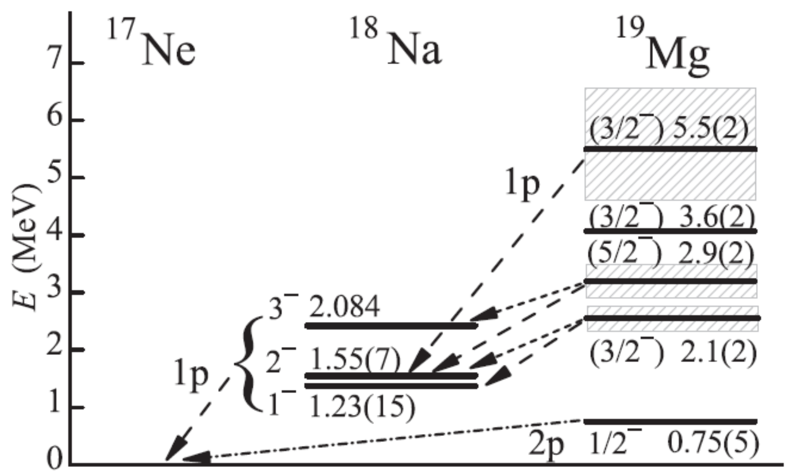
$^{20}Mg \rightarrow {}^{19}Mg + 1n$



State	mean	sigma	Excitation energy
g.s	0.727	0.17	0
1Ex	1.74	0.35	1.013
2Ex	3.11	0.68	2.383
3Ex	4.74	1.03	4.013



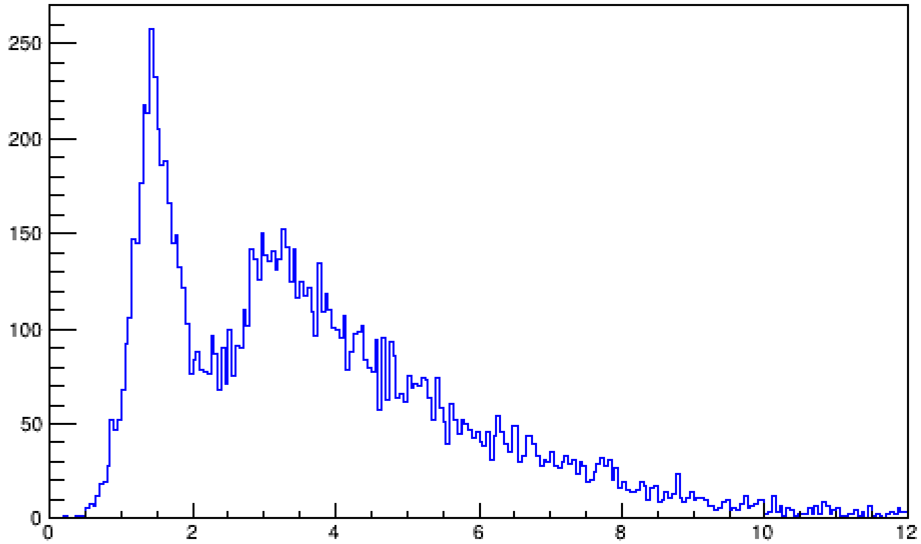
^{19}N level scheme (from NNDC)



Mukha et al. PRC 85, 044325 (2012)

Ne16 invariant mass

$^{20}Mg \rightarrow {}^{16}Ne + \alpha$



State	mean	sigma
g.s	1.448	0.27
2+	3.18	0.61

Previous experimental value:
Q2p (g.s.) = 1.466 MeV
Q2p (2+) = 3.156 MeV

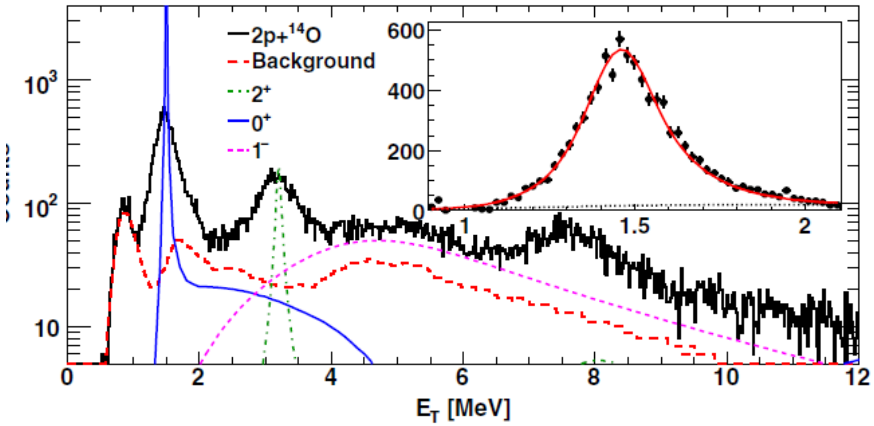


FIG. 1 (color online). Experimental spectrum of ^{16}Ne decay energy E_T reconstructed from detected $^{14}O + p + p$ events. The dashed histogram indicates the contamination from $^{15}O + p + p$ events. The smooth curves are predictions (without detector resolution) for the indicated ^{16}Ne states. The inset compares the contamination-subtracted data to the simulation of the g.s. peak for $\Gamma = 0$, $f_{tar} = 0.95$, where the dotted line is the fitted background.

Brown et al. PRL 113, 232501 (2014)

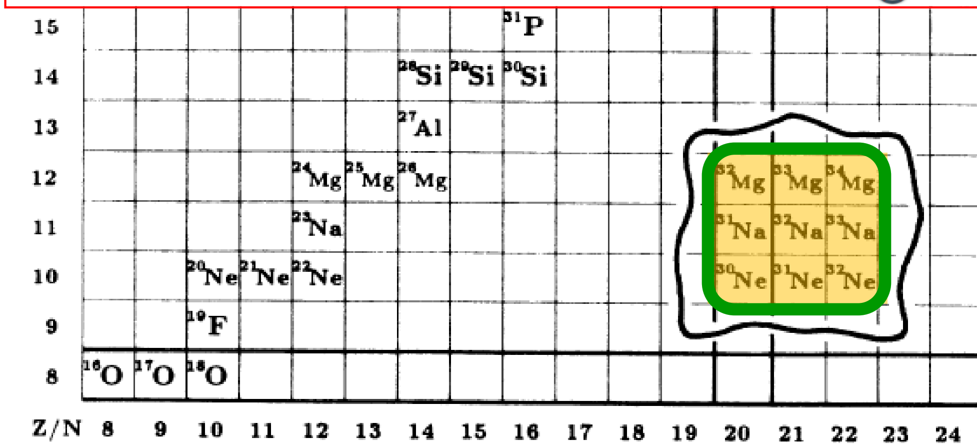
➢ 1n&2n decay of ^{34}Al

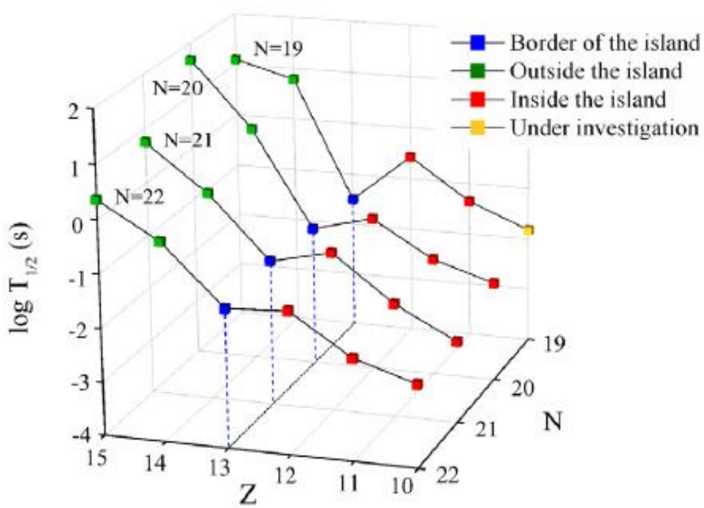
Contents lists available at ScienceDirect
Physics Letters B
www.elsevier.com/locate/physletb

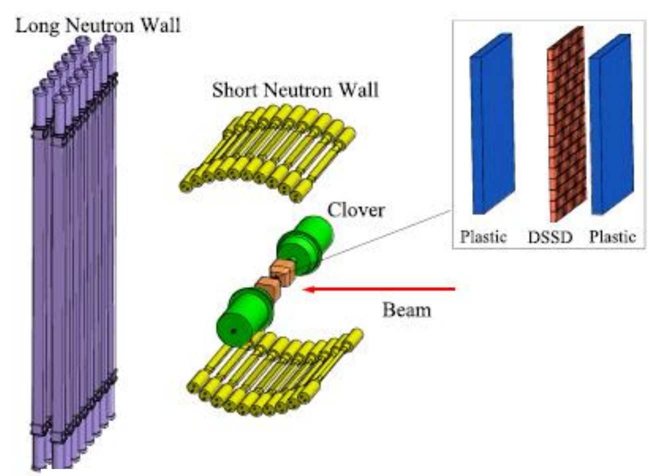
Northern boundary of the “island of inversion” and triaxiality in ^{34}Si

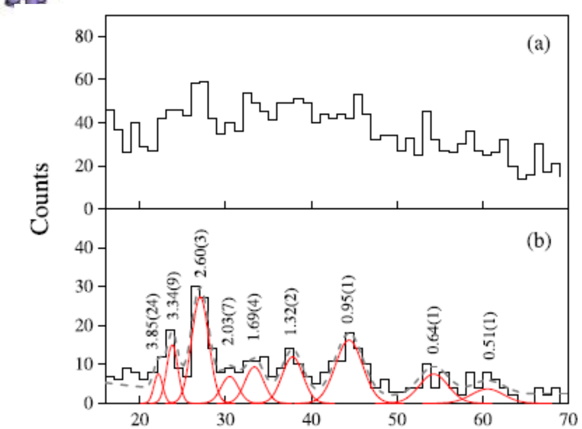
Contents lists available at ScienceDirect
Nuclear Inst. and Methods in Physics Research, A
journal homepage: www.elsevier.com/locate/nima

A β-delayed neutron detection system working with the continuous beam mode

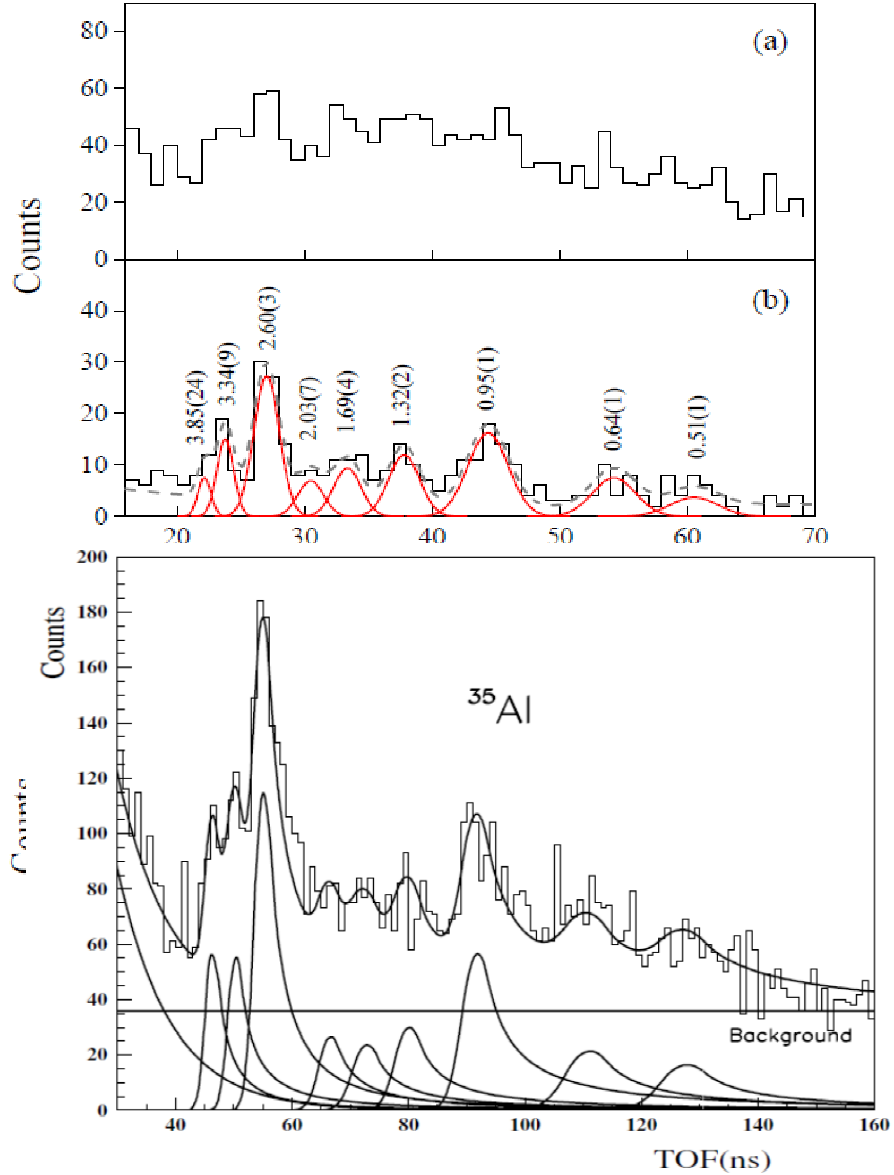






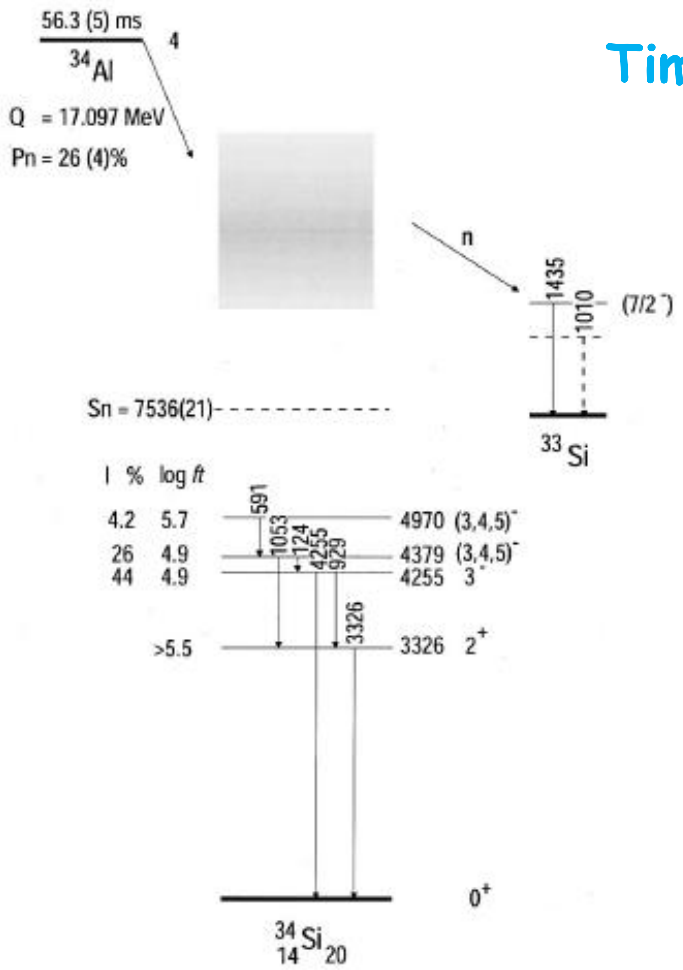


^{35}Al β-delayed neutron

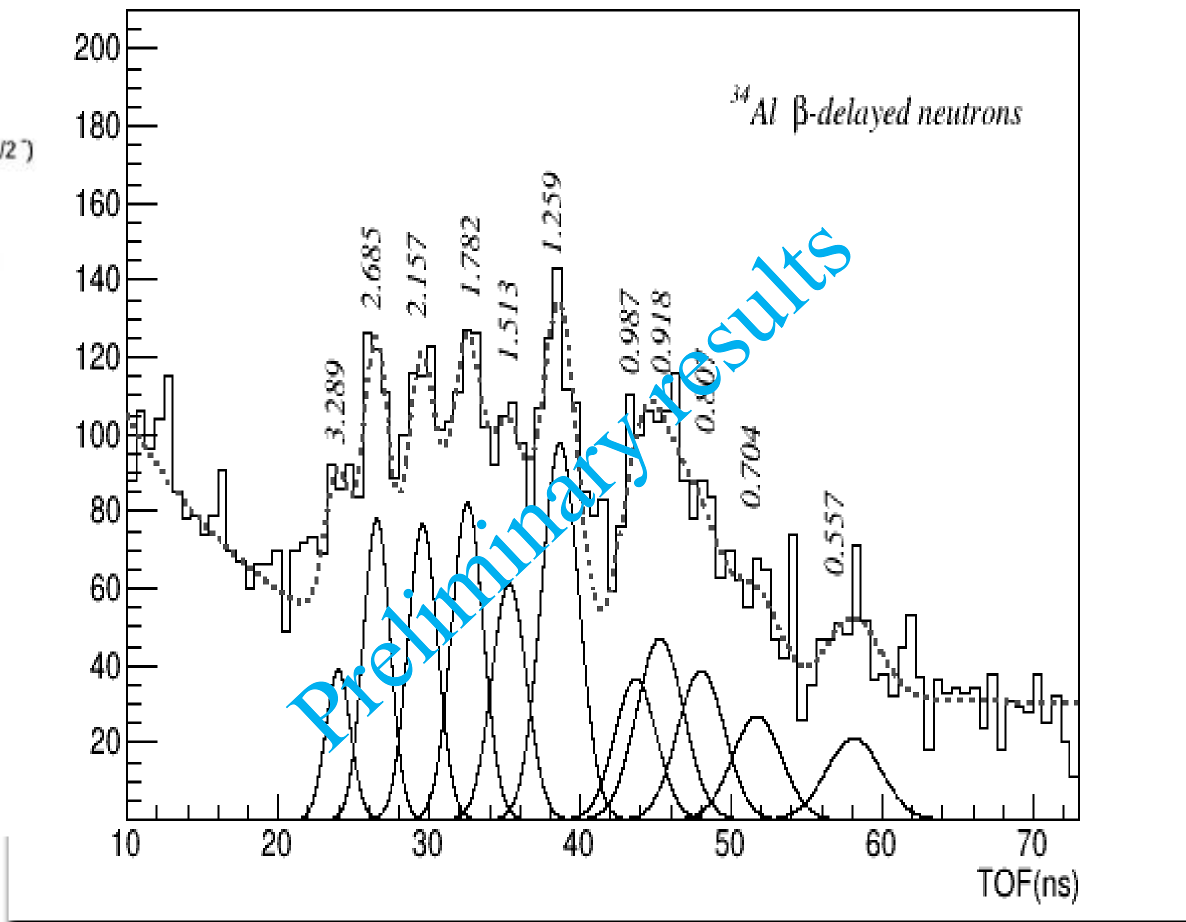


C. Timis, *et. al.*, J. Phys. G˙. Nucl.Part.Phys., 31, S1965 (2005).

^{34}Al β-delayed neutron

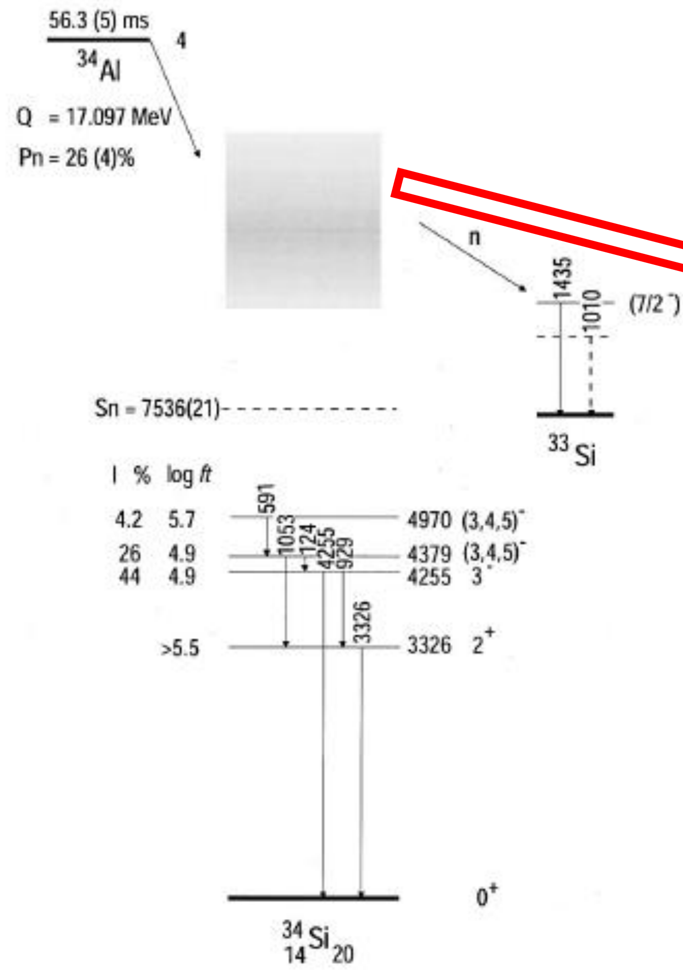


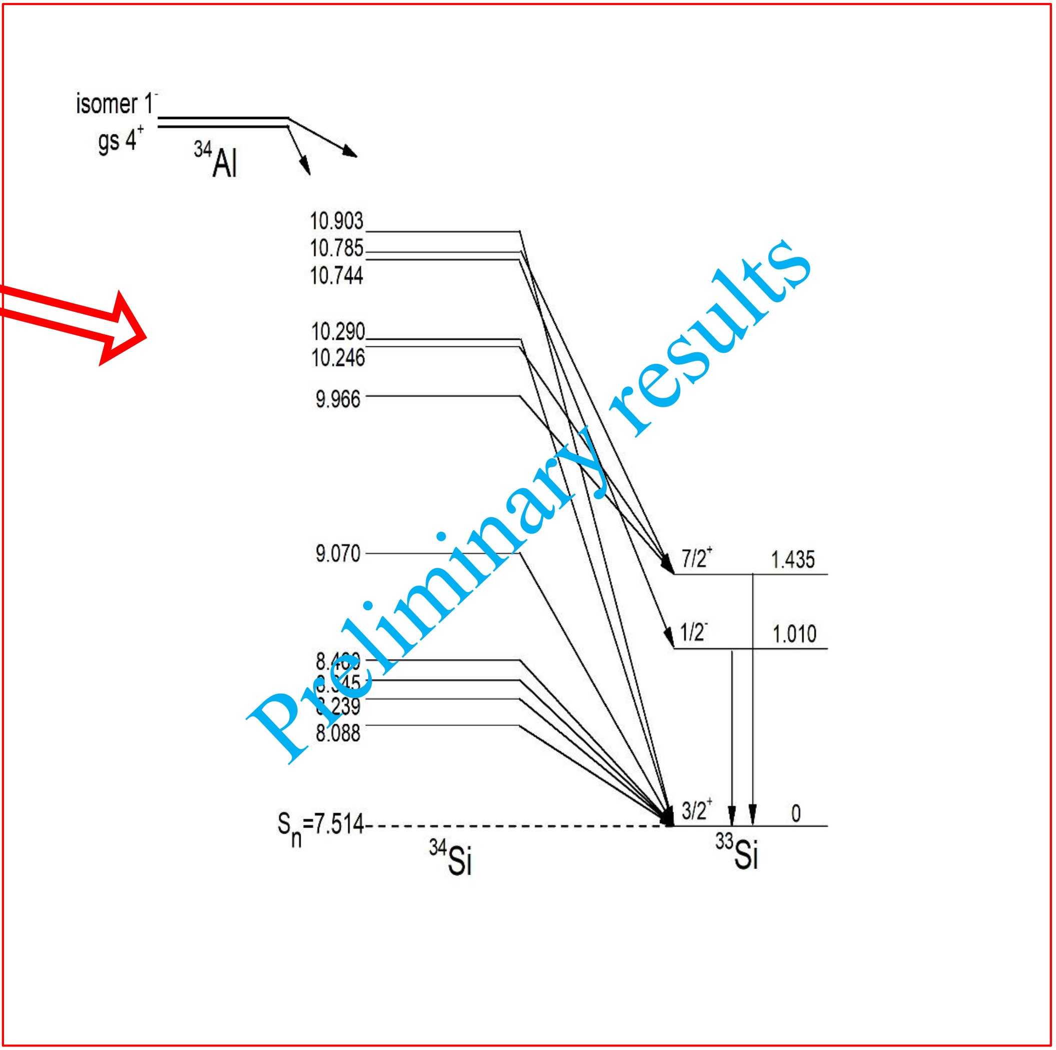
Time of flight spectrum of β-delayed neutron



S. Nummela *et al*., Phys. Rev. C. 044316(2001)

^{34}Al β-delayed neutron



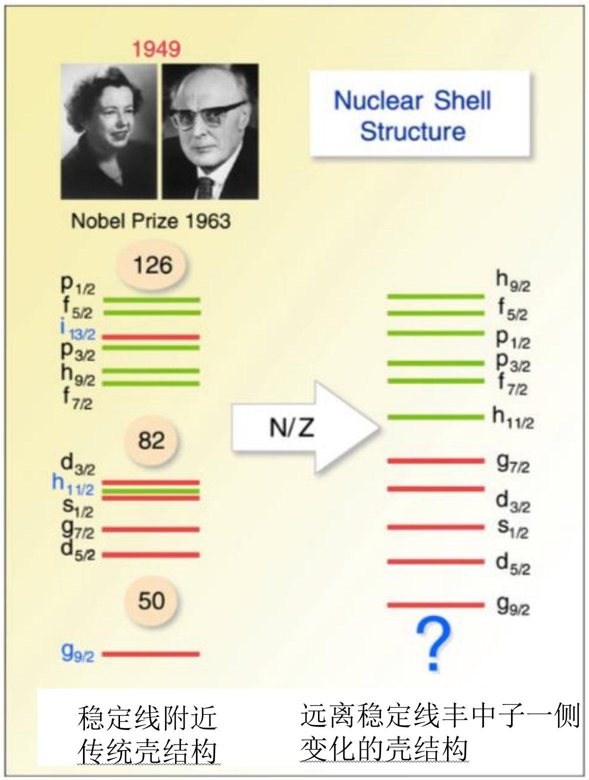


S. Nummela *et al*., Phys. Rev. C. 044316(2001)

- **Some collaborators**

➢ Shell evolution near N = 82

原子核壳结构和“壳演化”

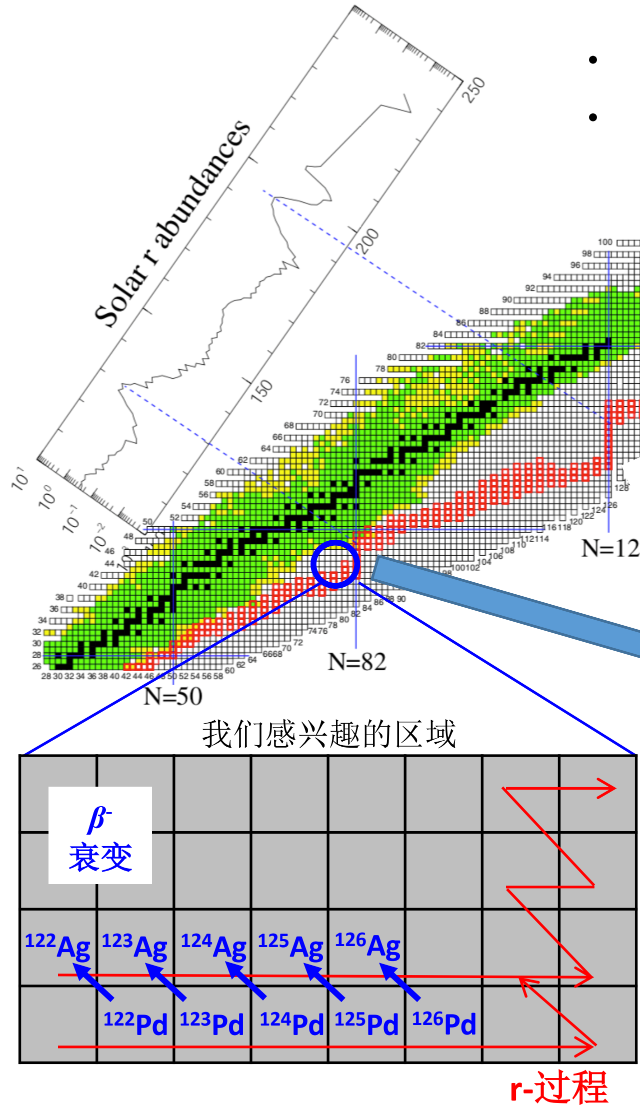


Progress in Particle and Nuclear Physics 59, 432 (2007).

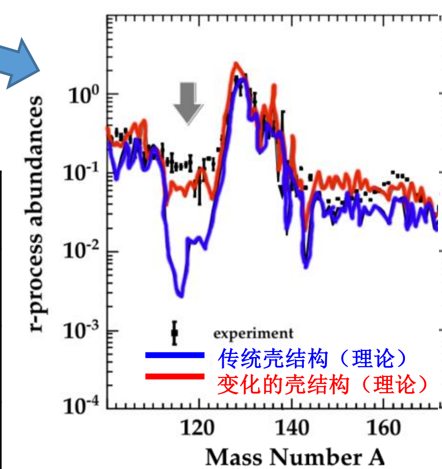
已证实在某些远离稳定线的轻质量区，壳结构显著变化！

原子核壳结构对核天体物理的影响

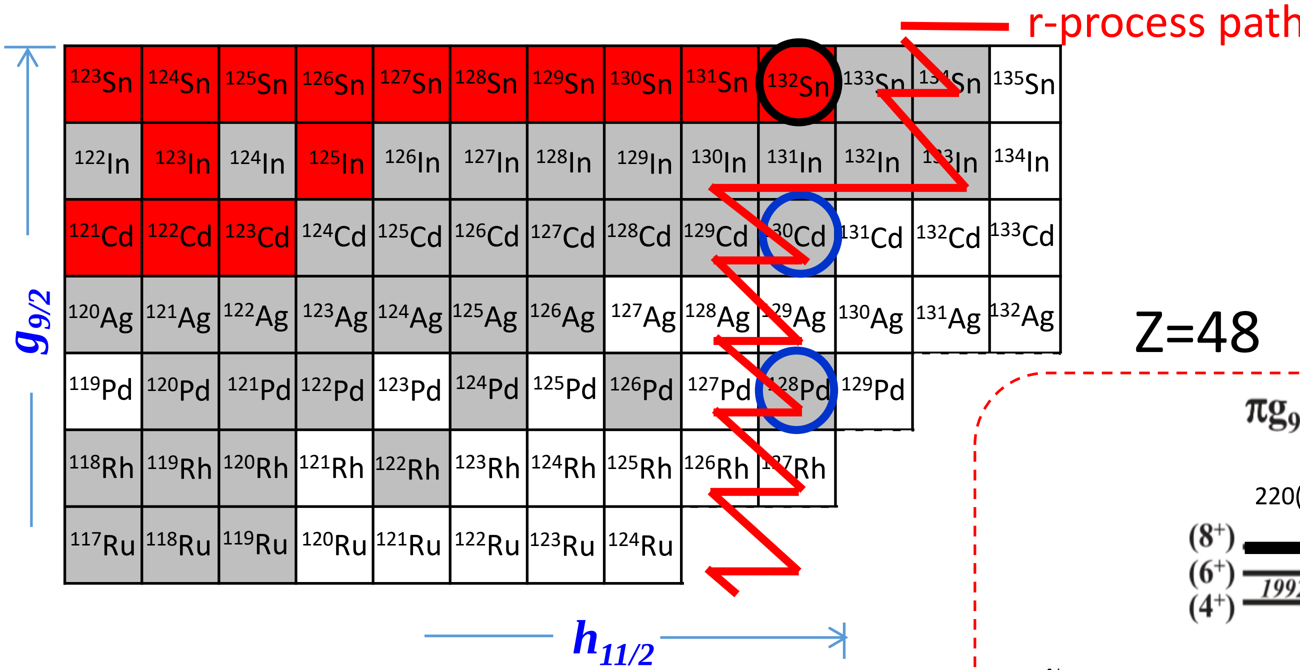
- 比Fe重元素，>50%通过r-过程
- 壳结构对太阳系元素丰度研究具有重要影响



Rep. Prog. Phys. 70, 1525 (2007).



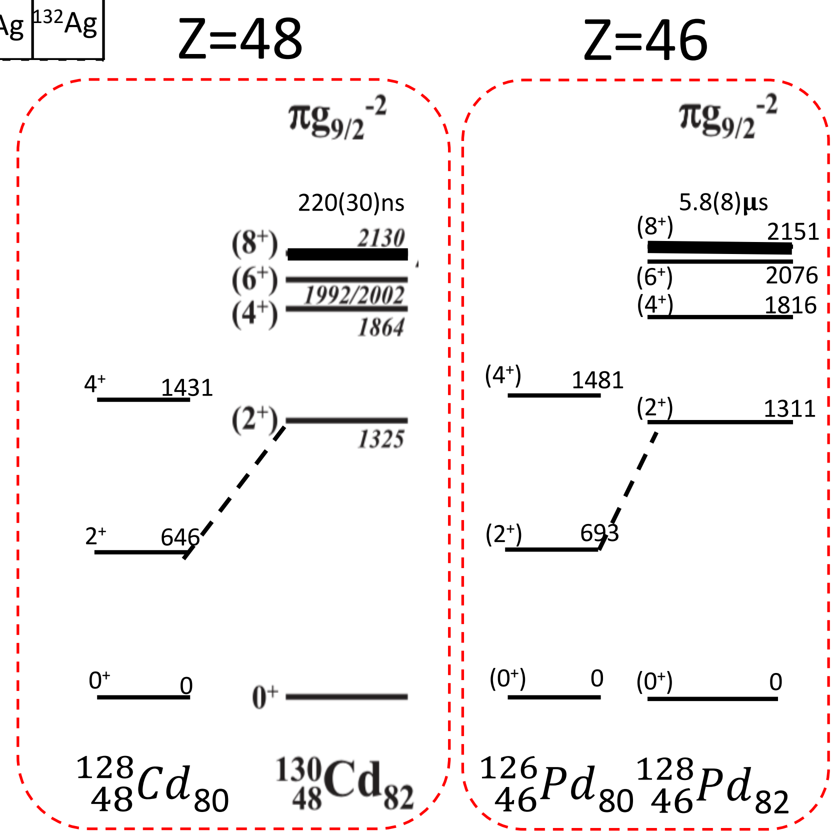
^{132}Sn附近壳演化研究现状



- N=82 ‘shell quenching’ 预言

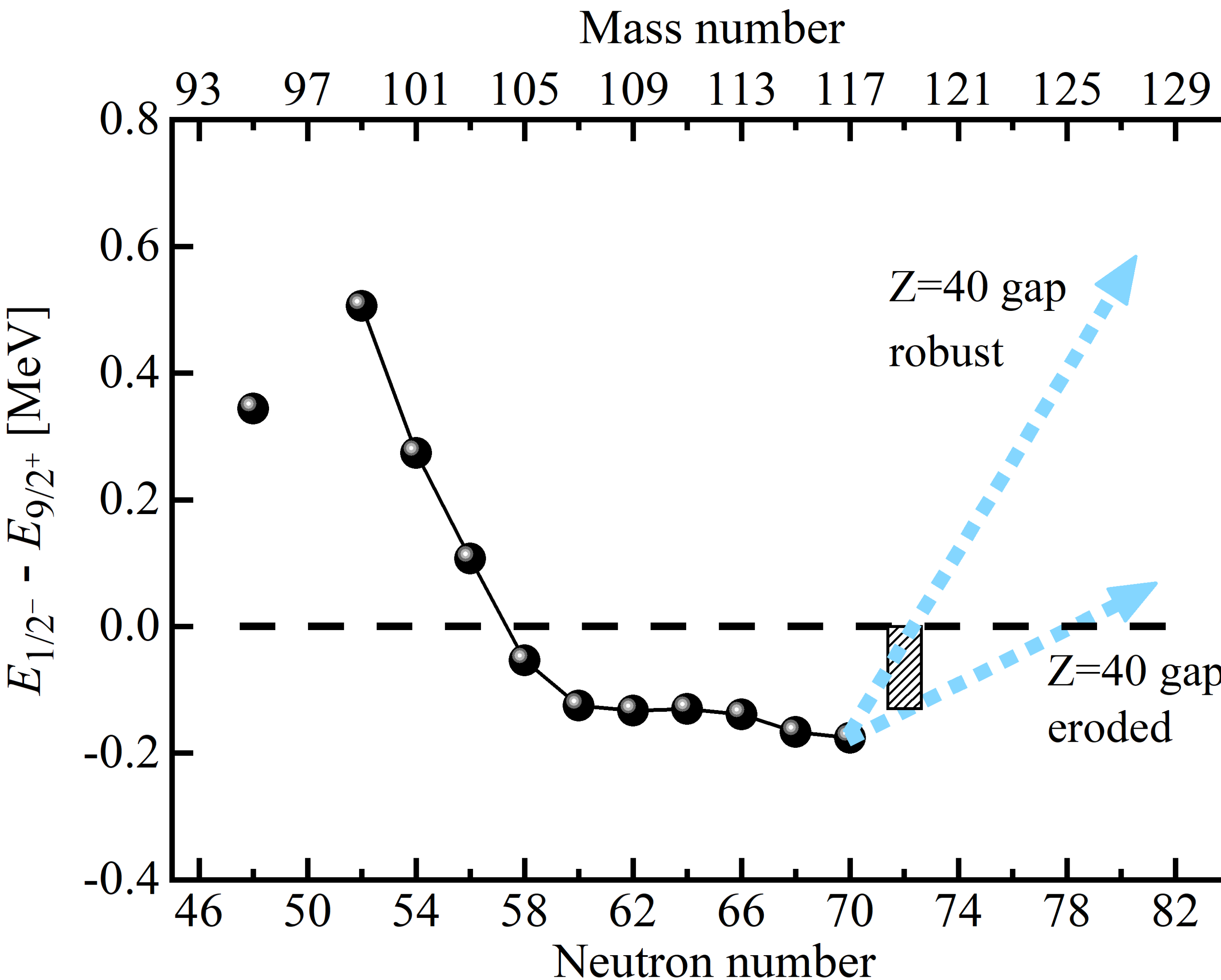
J. Dobaczewski *et al.*, PRL 72, 981 (1994).
J. Dobaczewski *et al.*, Phys. Scr. T56, 15 (1995).

- 最新的实验数据证明，在$^{130}Cd_{82}$和$^{128}Pd_{82}$，N=82闭壳效应依然很强。



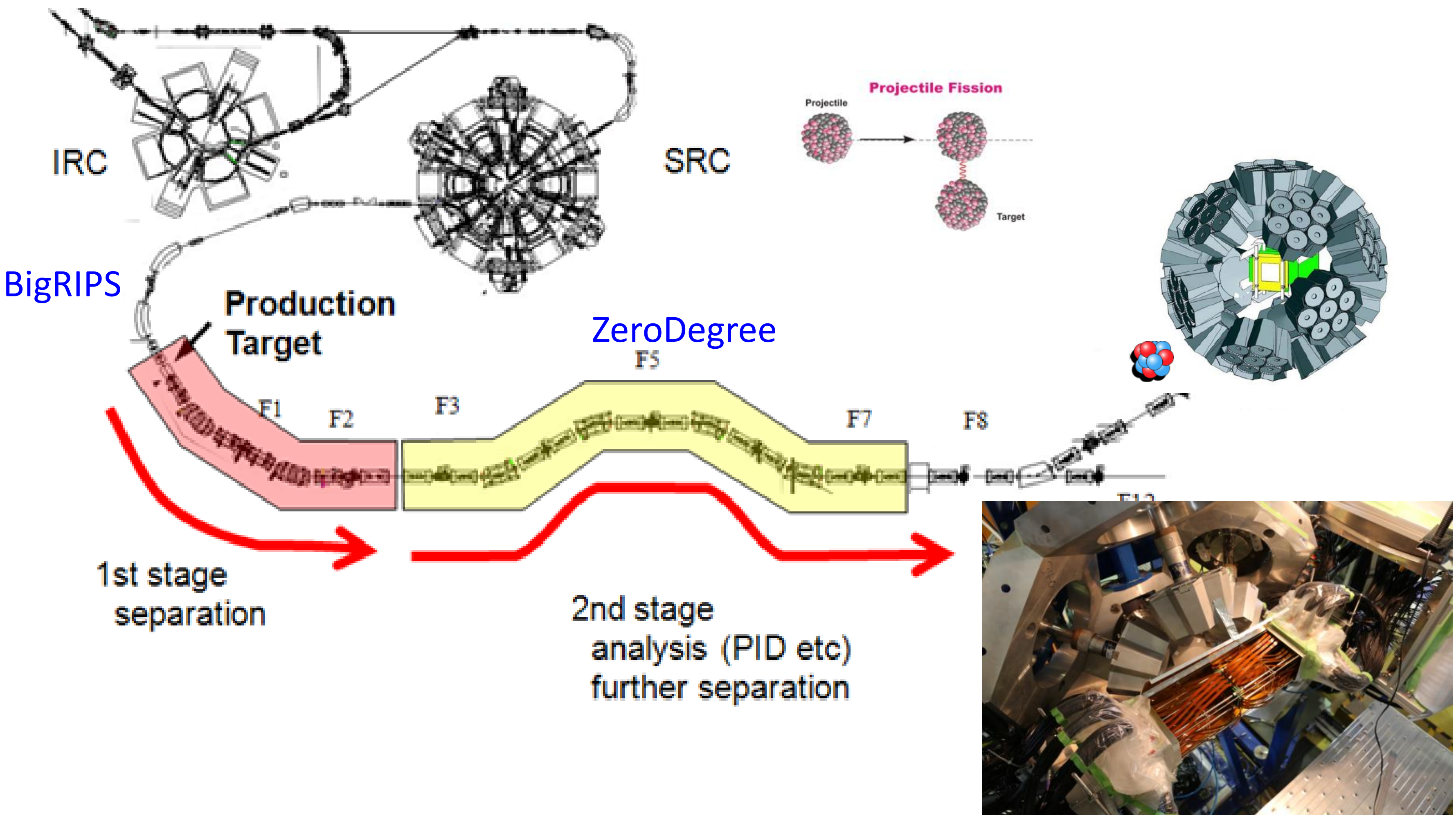
A. Jungclaus *et al.*, PRL 99, 132501(2007).
H. Watanabe *et al.*, PRL 111, 152501(2013).

Ag同位素中的质子轨道演化

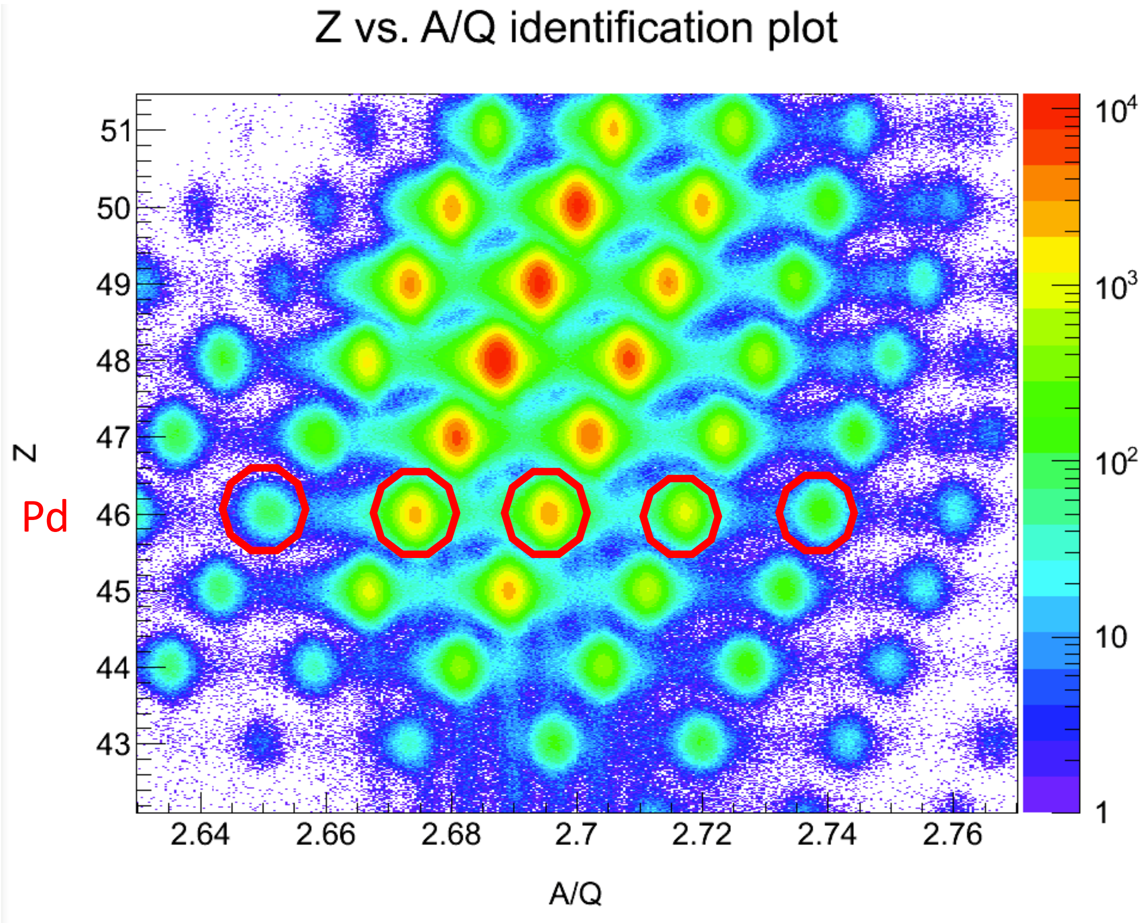


实验设置

^{238}U : 345 MeV/u, Intensity = 7 – 12 pnA， 3mm ^{9}Be target



实验中得到的粒子鉴别图



本次实验中Pd母核的产额：

^{122}Pd: 3.0 × 10^5

^{123}Pd: 8.1 × 10^6

^{124}Pd: 9.5 × 10^6

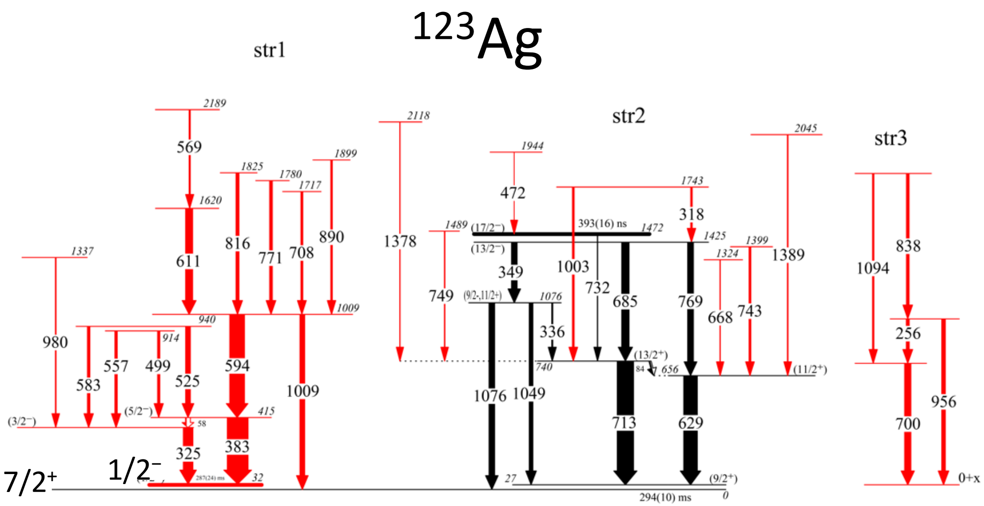
^{125}Pd: 2.8 × 10^6

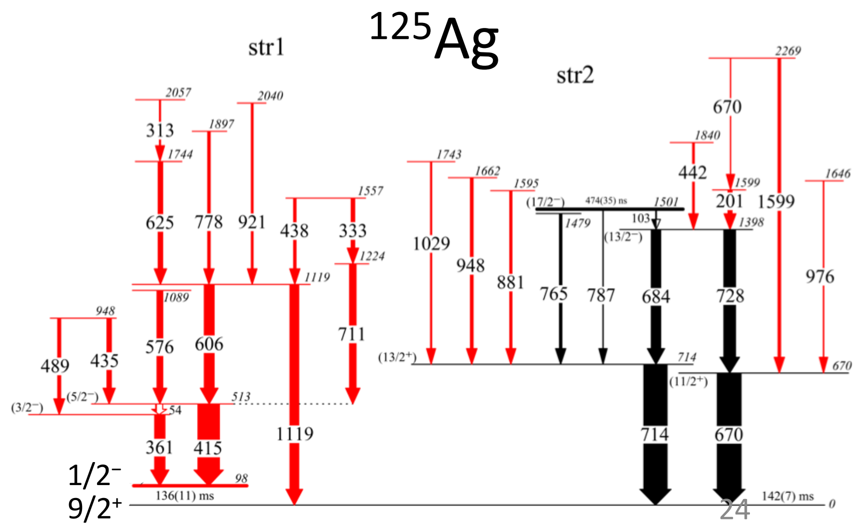
^{126}Pd: 5.5 × 10^5

^{123,125}Pd衰变子核能级结构

Red: 新能级和跃迁
Black: 前人工作

E_γ [keV]

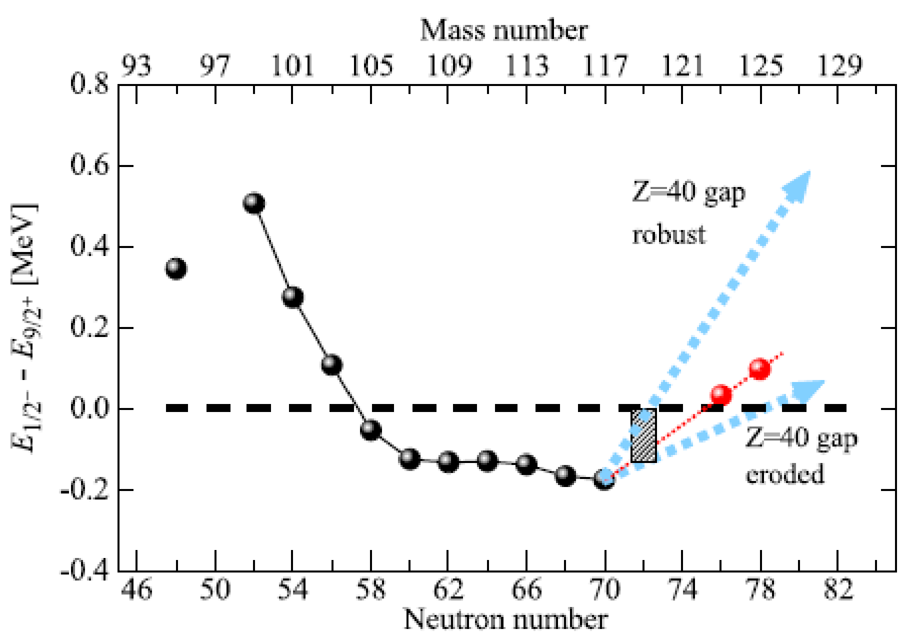


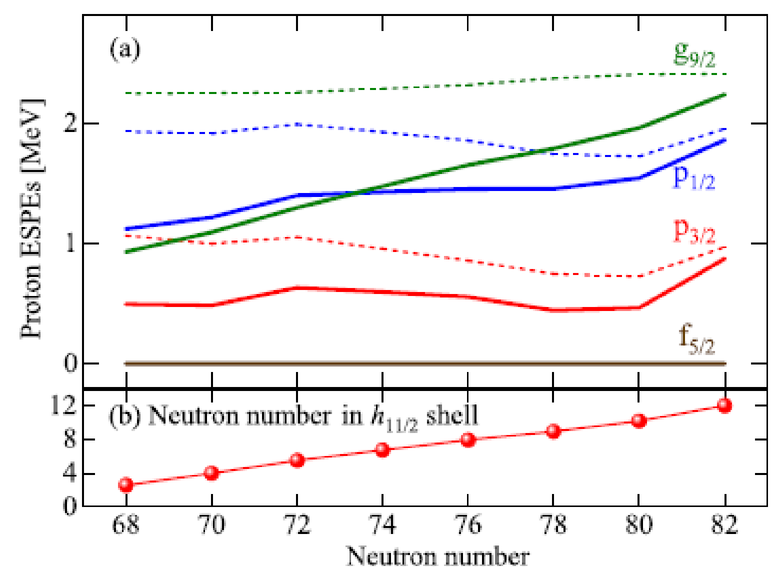


PHYSICAL REVIEW LETTERS **122,** 212502 (2019)

Proton Shell Evolution below ^{132}Sn: First Measurement of Low-Lying β-Emitting Isomers in ^{123,125}Ag

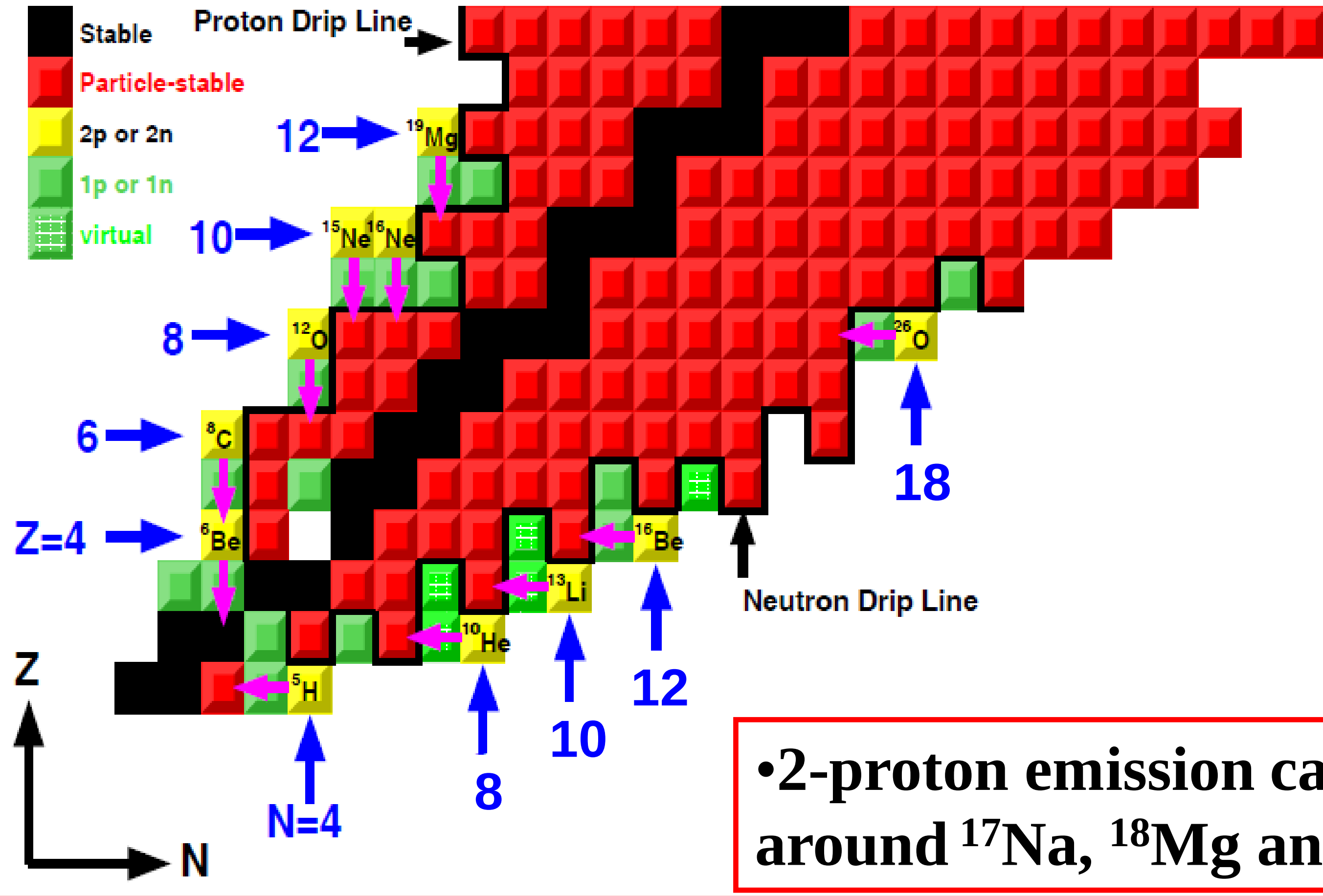
Z. Q. Chen,[1] Z. H. Li,[1,*] H. Hua,[1,†] H. Watanabe,[2,3] C. X. Yuan,[4] S. Q. Zhang,[1] G. Lorusso,[3,5,6] S. Nishimura,[3] H. Baba,[3] F. Browne,[3,7] G. Benzoni,[8] K. Y. Chae,[9] F. C. L. Crespi,[8,10] P. Doornenbal,[3] N. Fukuda,[3] G. Gey,[3,11,12] R. Gernhäuser,[13] N. Inabe,[3] T. Isobe,[3] D. X. Jiang,[1] A. Jungclaus,[14] H. S. Jung,[15,16] Y. Jin,[1] D. Kameda,[3] G. D. Kim,[17] Y. K. Kim,[17,18] I. Kojouharov,[19] F. G. Kondev,[20] T. Kubo,[3] N. Kurz,[19] Y. K. Kwon,[17] X. Q. Li,[1] J. L. Lou,[1] G. J. Lane,[21] C. G. Li,[1] D. W. Luo,[1] A. Montaner-Pizá,[22] K. Moschner,[23] C. Y. Niu,[1] F. Naqvi,[24] M. Niikura,[25] H. Nishibata,[26] A. Odahara,[26] R. Orlandi,[27,28] Z. Patel,[6] Zs. Podolyák,[6] T. Sumikama,[3] P.-A. Söderström,[3] H. Sakurai,[3] H. Schaffner,[19] G. S. Simpson,[11] K. Steiger,[13] H. Suzuki,[3] J. Taprogge,[3,14,29] H. Takeda,[3] Zs. Vajta,[3,30] H. K. Wang,[31] J. Wu,[1,20] A. Wendt,[23] C. G. Wang,[1] H. Y. Wu,[1] X. Wang,[1] C. G. Wu,[1] C. Xu,[1] Z. Y. Xu,[25,32] A. Yagi,[26] Y. L. Ye,[1] and K. Yoshinaga[33]





三、研究展望

2p and β-delayed 2n decay



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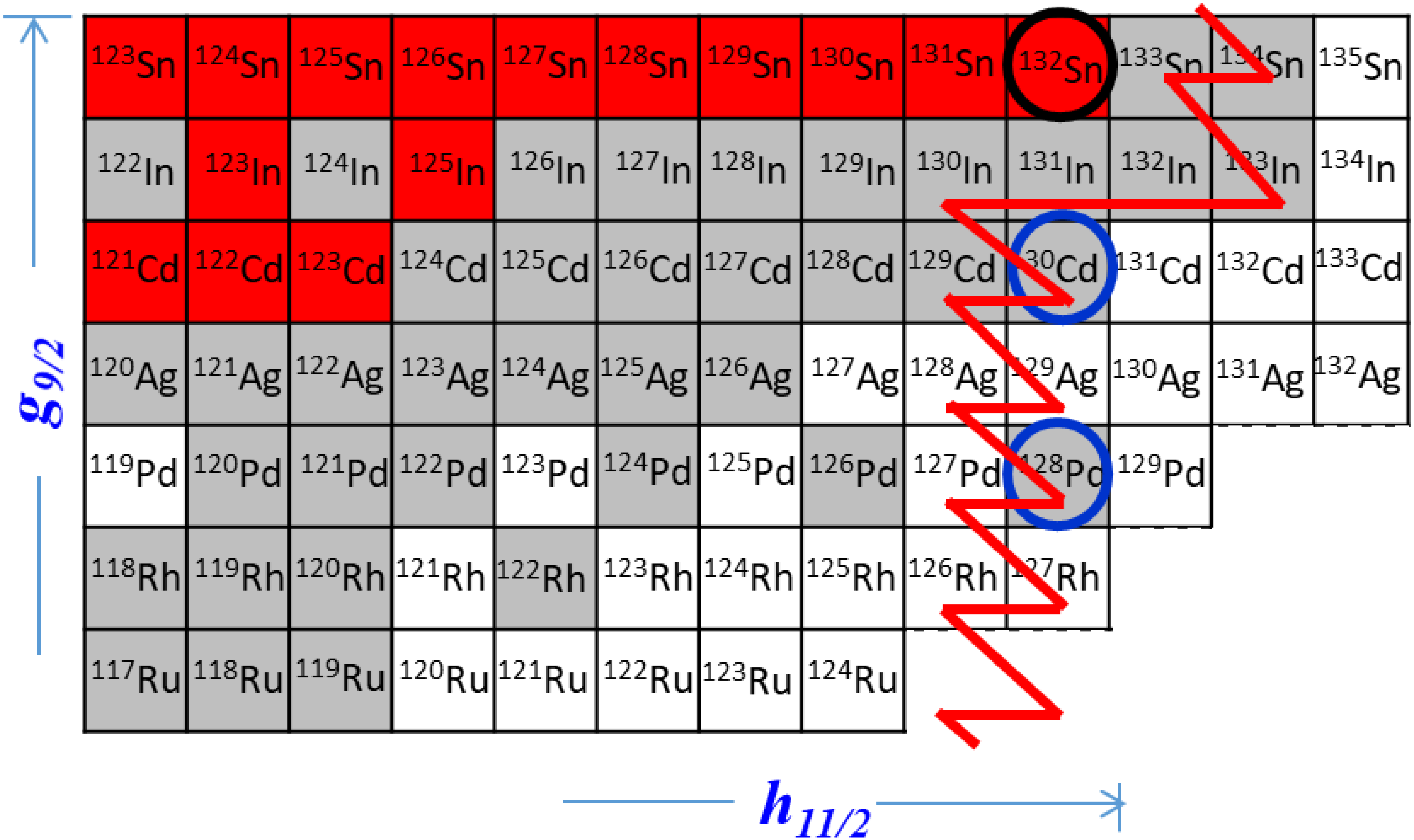
•β -delayed 2-neutron emission cases: ^{11}Li (4%), ^{17}B (11%), ^{17}C (7%), ^{30,31}Na (1%), ^{32,33}Na (10%)

Toward more neutron-rich Ag isotope




谢谢大家!!