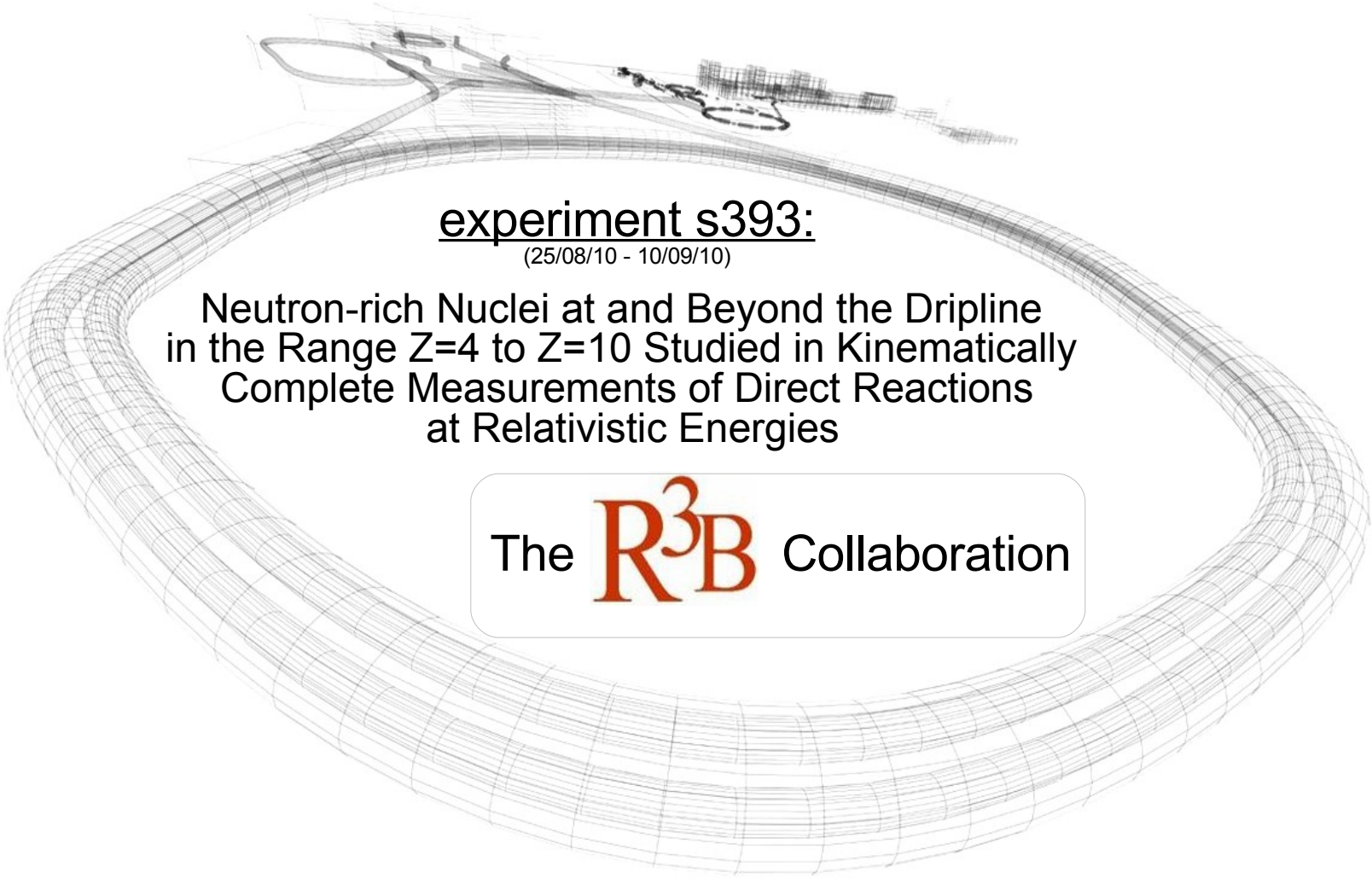
FRS user meeting 2010



experiment s393:

(25/08/10 - 10/09/10)

Neutron-rich Nuclei at and Beyond the Dripline in the Range Z=4 to Z=10 Studied in Kinematically Complete Measurements of Direct Reactions at Relativistic Energies

The R3B Collaboration

Aims of Experiment

Five physics topics using rare-isotope beams have been studied:

1. **r-process nucleosynthesis**
2. **spectroscopy of valence and deeply bound nucleons in exotic nuclei**
3. **isospin dependence of nucleon-nucleon correlations**
4. **alpha clustering in exotic nuclei**
5. **spectroscopy of unbound nuclei**

Run as single experiment by R3B Collaboration:

- **same experimental setup for all topics (Cave C → R^3B)**
- **one FRS setting addresses several topics**
- **Use different reactions (⇒ targets) dependent on topic**
- **heavy-ion induced electromagnetic excitation (Pb target)**
- **(p,2p), (p,pn) and (p,pα) quasifree scattering (proton in CH_2 target)**
- **one- and two-neutron removal (Carbon in CH2 target)**

Maximise efficiency of beam time

Topic I: R-Process Nucleosynthesis

Extension of r-process reaction network, including light nuclei, has effect on abundances.

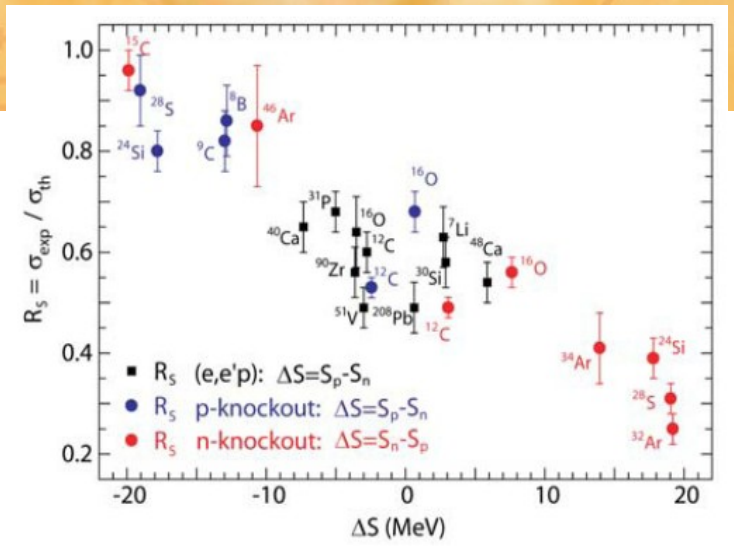
We measured (by Coulomb dissociation and detailed balance):

- (n,γ)-rates of neutron-rich carbon isotopes
- At the same time we will get ^{13}B(n,γ), ^{14}B(n,γ), ^{10}Be(n,γ), ^{11}Be(n,γ)

Topic II. Spectroscopy of Valence and Deeply Bound Nucleons

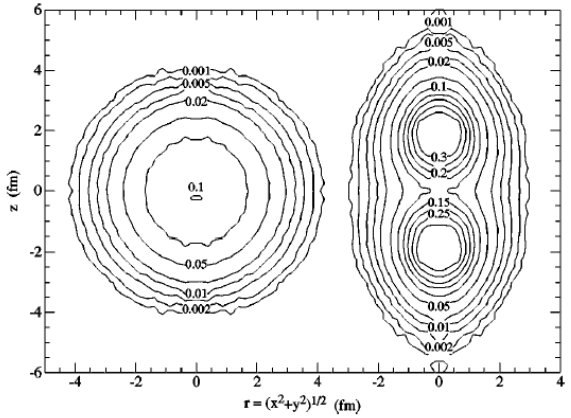
- **extend measurements to O, F and Ne isotopes**
- **(p,2p) *and* (p,pn)**
- **full reconstruction of final states (momentum of charged fragment, gammas, neutrons, etc.)**

Topic III. Isospin Dependence of Nucleon-Nucleon Correlations



A. Gade et al.,
Phys. Rev.C 77 (2008) 044306.

Topic IV: Probing the Cluster Structure of Neutron-Rich Be Isotopes



GFMC calc.
realistic n-n interaction
R. B. Wiringa, S. C. Pieper,
J. Carlson, and
V. R. Pandharipande,
Phys. Rev. C **62**, 014001 (2000).

Topic V: Spectroscopy of Nuclei Beyond the Neutron Dripline

^{24}F 0.34 s	^{25}F 50 ms	^{26}F 10.2 ms	^{27}F 4.9 ms	^{28}F unbound	^{29}F 2.6 ms
^{23}O 82 ms	^{24}O 61 ms	^{25}O unbound	^{26}O unbound		

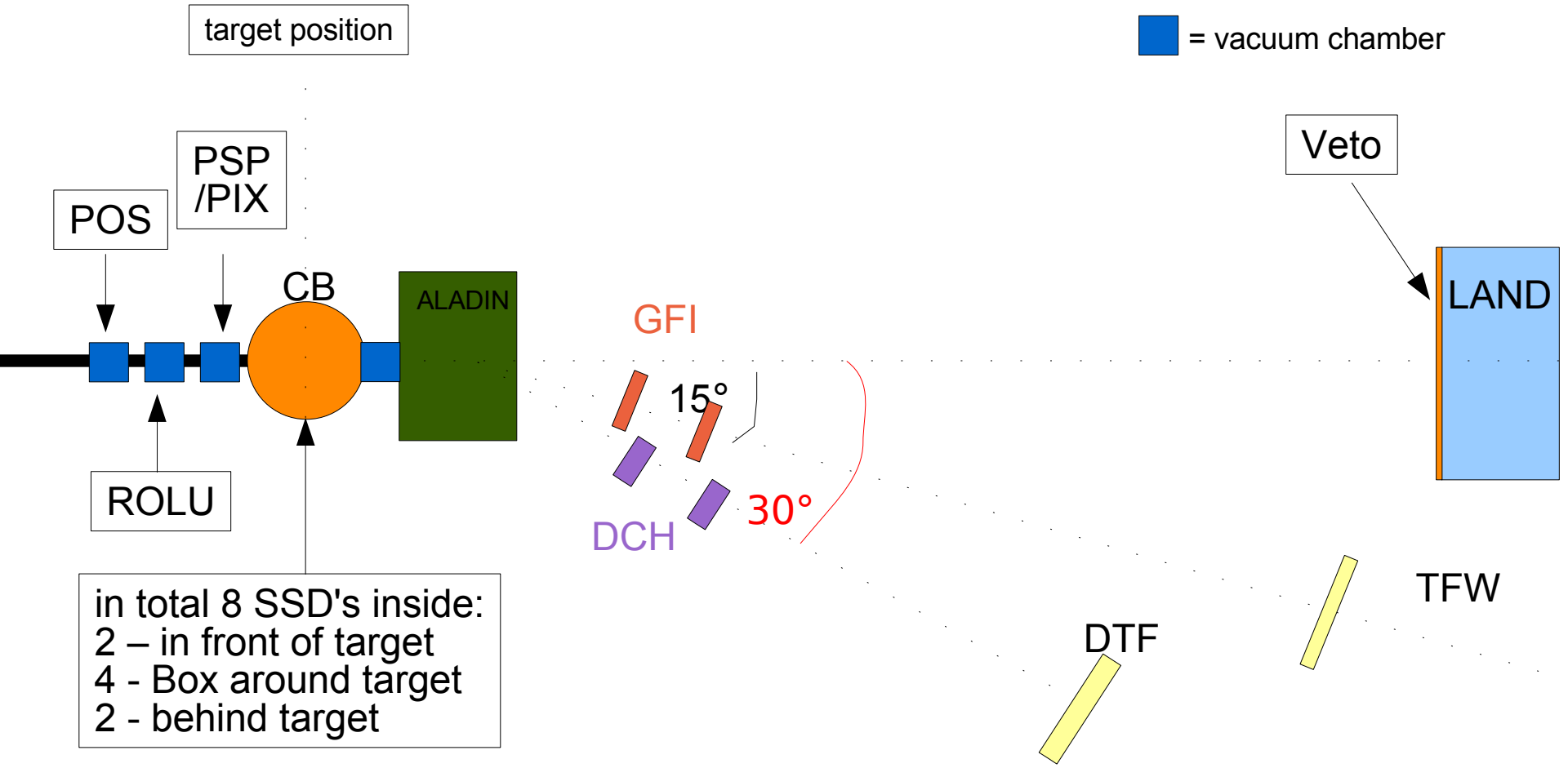
One neutron removal measurement reveals ^{24}O as a new doubly magic nucleus

R. Kanungo [1], C. Nociforo[2], A. Prochazka[2,3], T. Aumann[2], D. Boutin[3], D. Cortina-Gil[4], B.

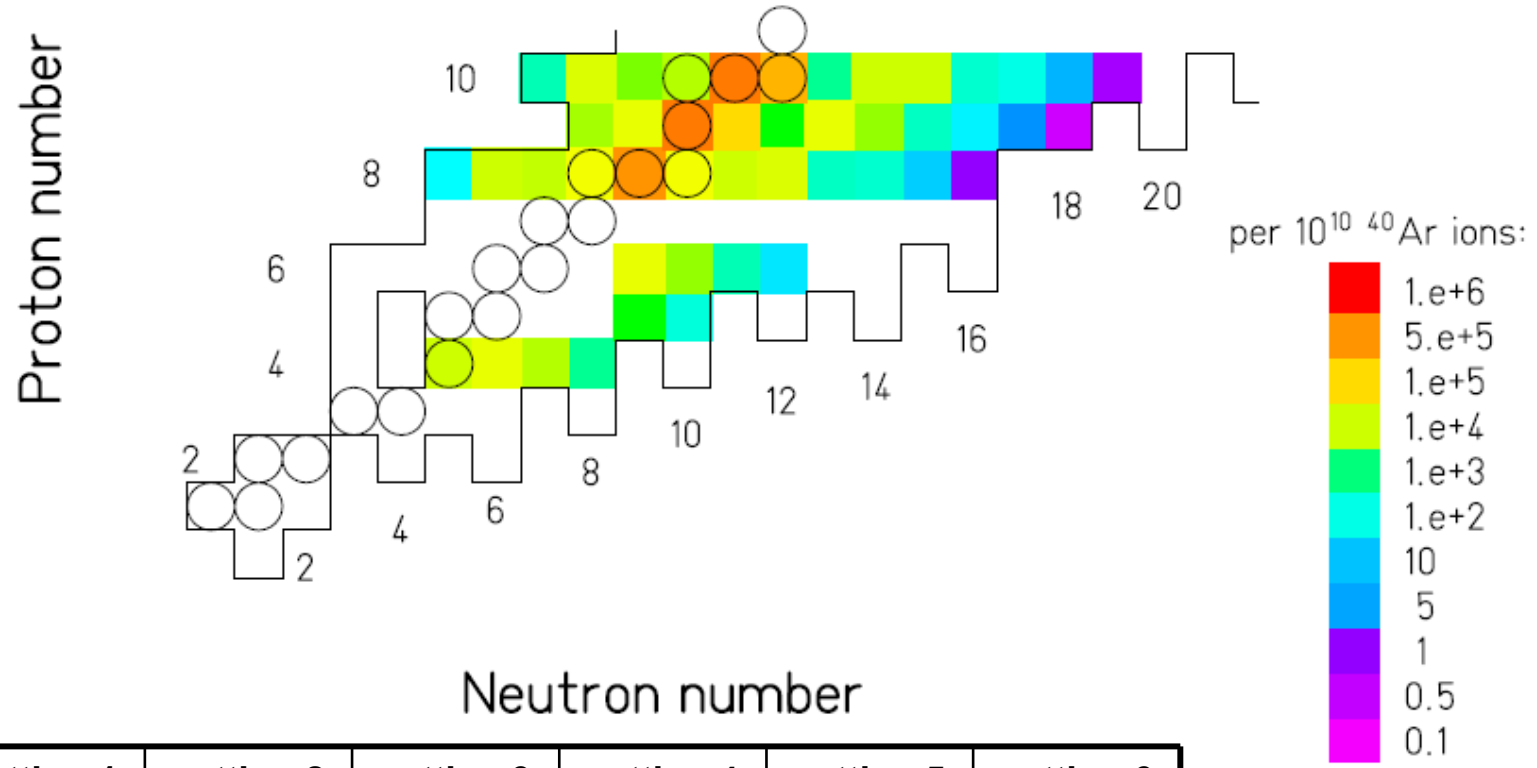
- Different topics analyzed by different groups of the collaboration
- > 15 phd students from 11 universities/institutes

The R3B Collaboration

Experimental Setup



FRS Settings and Exotic Nuclei to be Produced



	setting 1	setting 2	setting 3	setting 4	setting 5	setting 6
A/Z	**1.75**	**2.12**	**2.5**	**2.75**	**2.88**	**3.0**
Example nuclei produced	$^{13\text{-}15}$O	$^{16\text{-}18}$O ^{9}Be	^{19,20}O ^{10}Be	^{21,22}O ^{11}Be	^{23}O ^{11}Be ^{17}C, ^{14}B	^{18}C ^{24}O ^{12}Be ^{26,27}F

The plan for the Beam Time was:

	setting 1	setting 2	setting 3	setting 4	setting 5	setting 6	Physics
A/Z	**1.75**	**2.12**	**2.5**	**2.75**	**2.88**	**3.0**	
example nuclei of interest	$^{13\text{-}15}$O	$^{16\text{-}18}$O ^{9}Be	^{19,20}O ^{10}Be	^{21,22}O ^{11}Be	^{23}O ^{11}Be ^{17}C, ^{14}B	^{18}C ^{24}O ^{12}Be ^{26,27}F	Astro p,2p p,pα unbound
target							
Pb	-	-	-	-	-	10	
C	1	1	1	2	2	3	
empty	1	1	1	2	2	4	
CH2	3	3	3	6	6	10	
setting FRS	1	1	1	1	1	1	Total
	6	6	6	11	11 → **9**	28 → **23**	68 +6

accepted shifts reduced by 24 to 50

➔ proposal: skip settings 1 & 4, reduce settings 5 & 9

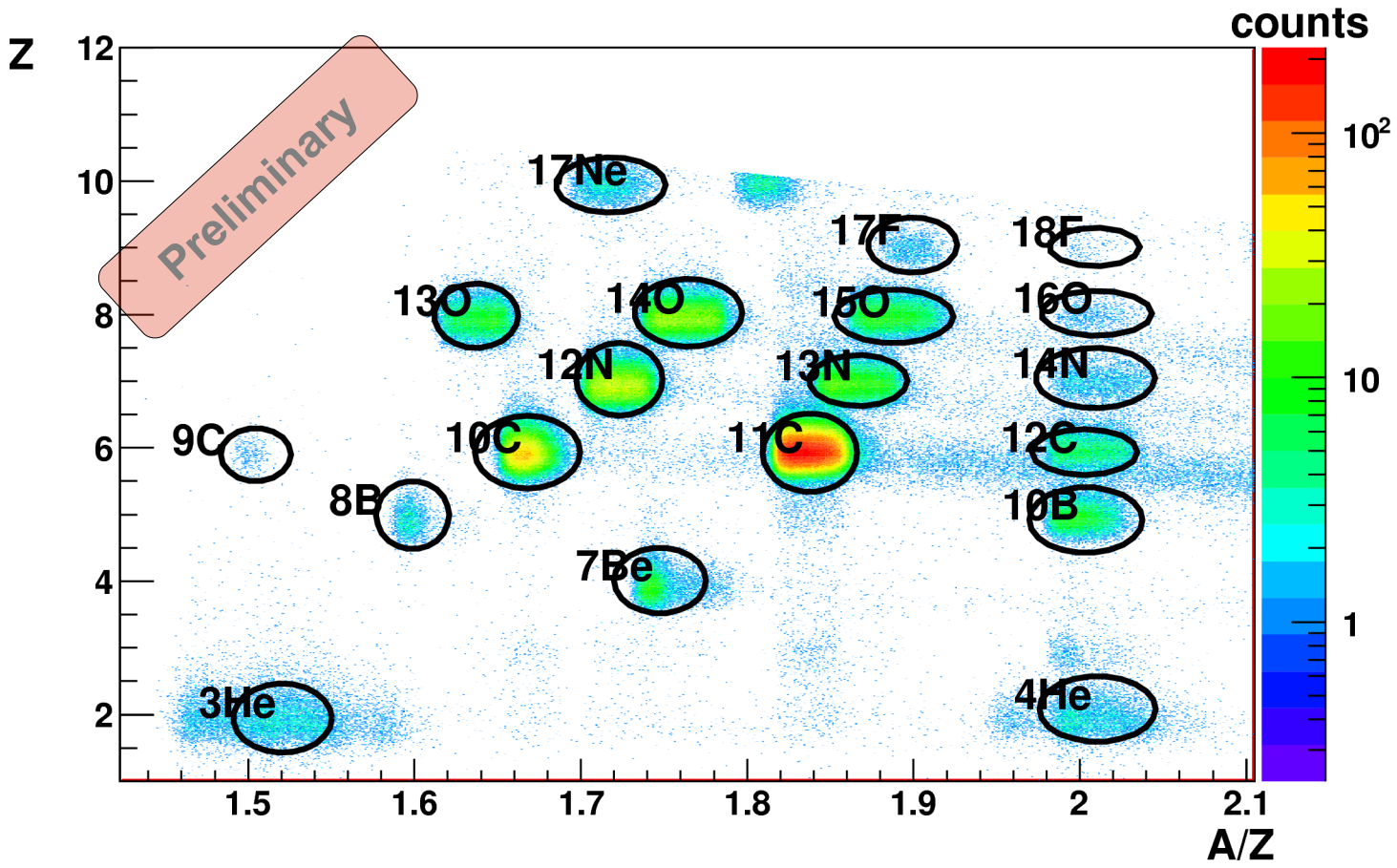
real process of the experiment:

	setting 1	setting 2	setting 3	setting 4	setting 5	setting 6	Physics
A/Z	**1.75**	**2.12**	**2.5**	**2.75**	**2.88**	**3.0**	
example nuclei of interest	$^{13\text{-}15}$O	$^{16\text{-}18}$O ^{9}Be	^{19,20}O ^{10}Be	^{21,22}O ^{11}Be	^{23}O ^{11}Be ^{17}C, ^{14}B	^{18}C ^{24}O ^{12}Be ^{26,27}F	Astro p,2p p,pα unbound
target							
Pb	-	-	Ti -1	-	-	10 4	
C	1 0.5	1 1	1 1	2 1	2 1	3 1.5	
empty	1 0	1 0	1 1	2 0	2 0	4 1.5	
CH2	3 1.5	3 2	3 3	6 3	6 2.5	10 5	

Assumed rate in proposal: 1.5 * 10^10 40Ar/spill

Rate during experiment: ~ 3 * 10^10 40Ar/spill

setting-1

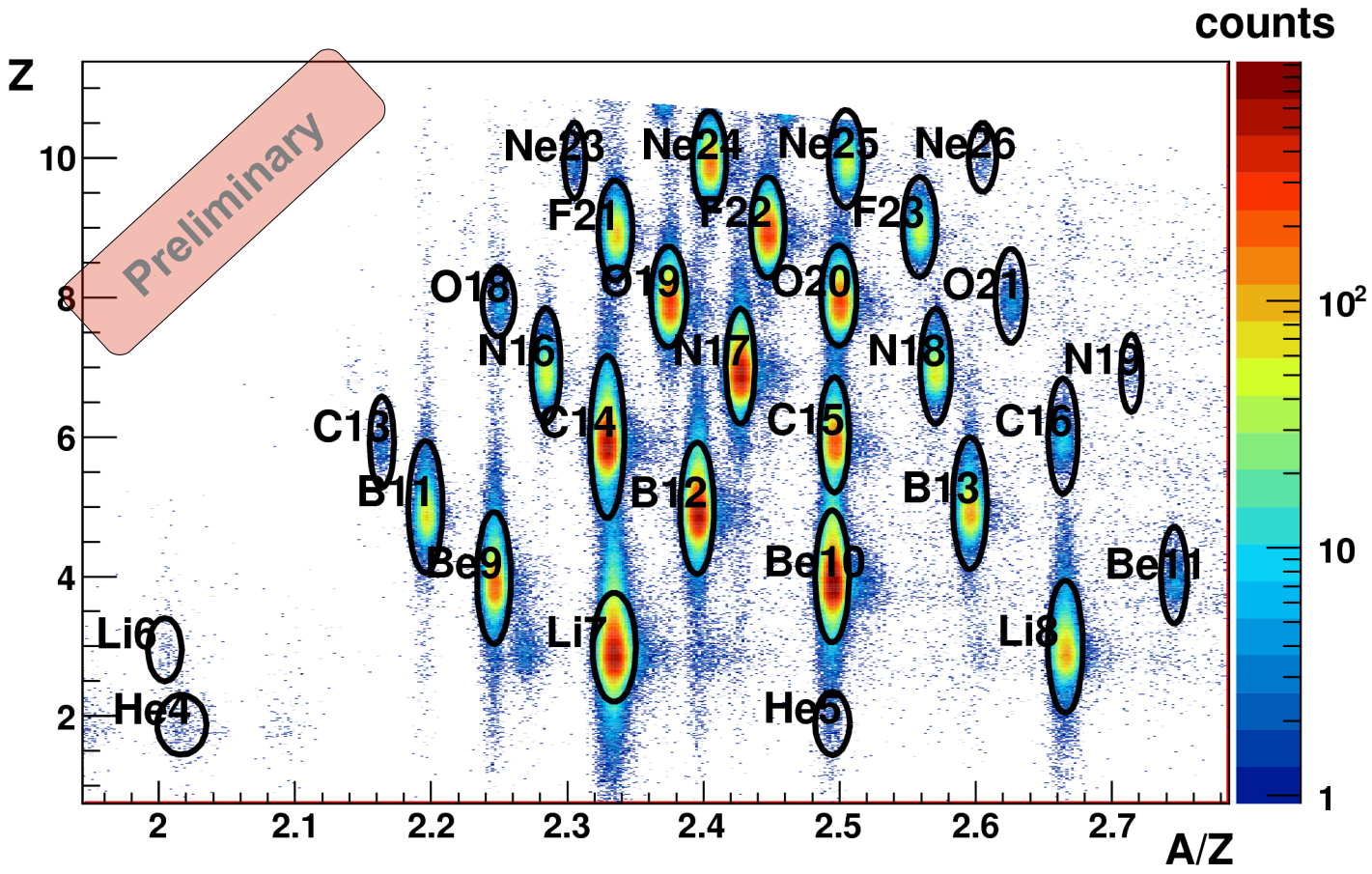


Full statistic of setting-1

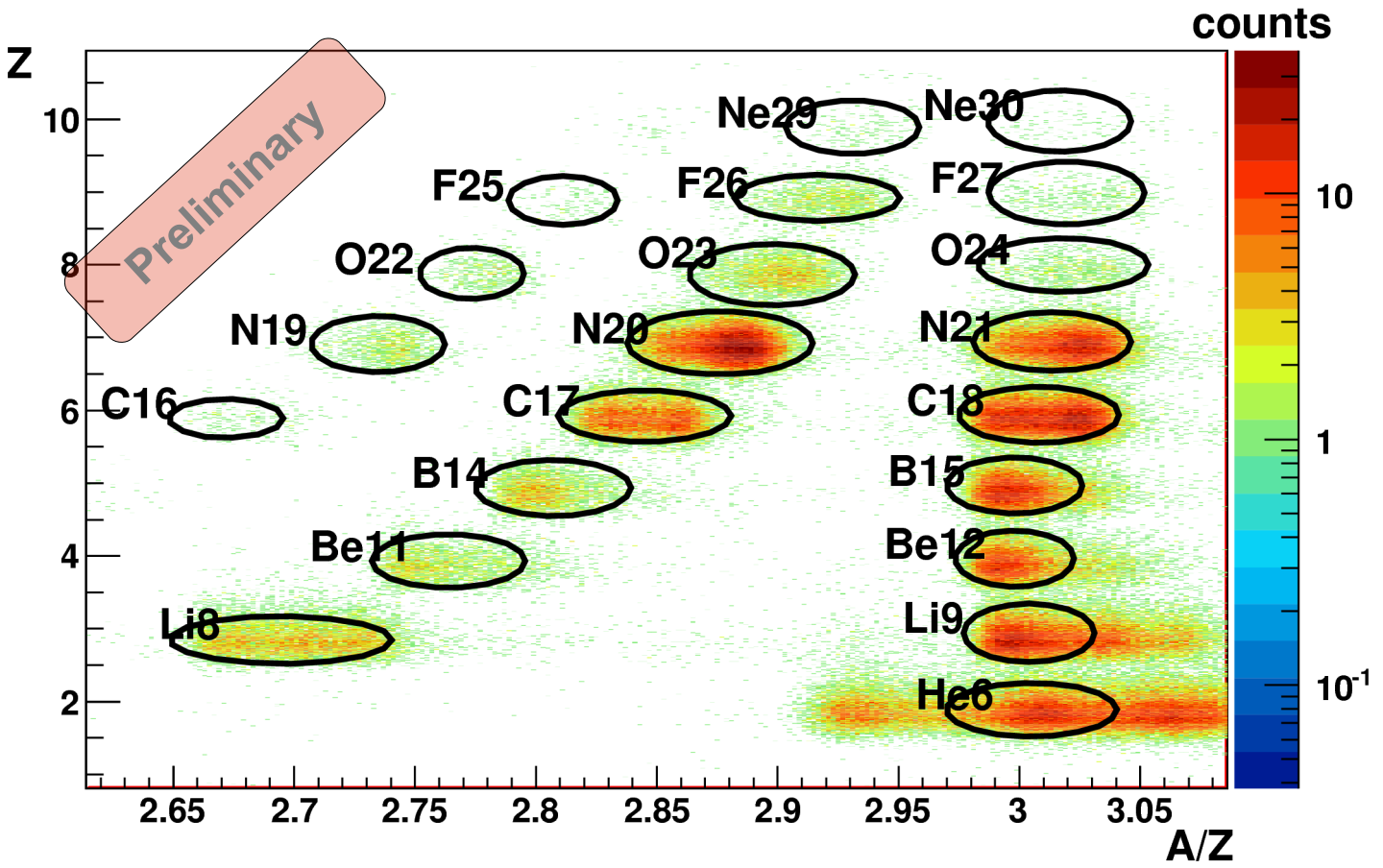
Target: CH2

	statistic		Rate/Hz	
nuclei	proposal	experiment	proposal	experiment
O13	2.07E+06	2.70E+06	24	~60
O14	6.05E+08	7.79E+06	~7000	~175
O15	2.84E+08	3.51E+06	~3000	~80

setting-3


counts
Z
A/Z
Preliminary
Ne23
Ne24
Ne25
Ne26
F21
F22
F23
O18
O19
O20
O21
N16
N17
N18
N19
C13
C14
C15
C16
B11
B12
B13
Be9
Be10
Be11
Li6
Li7
Li8
He4
He6
10
8
6
4
2
2
2.1
2.2
2.3
2.4
2.5
2.6
2.7
10^2
10
1

setting-6



Full statistic of setting-6

Target: CH2

	statistic		Rate/Hz	
nuclei	proposal	experiment	proposal	experiment
O22	4.32E+02	3.16E+04	0.0015	~0.2
O23	4.90E+05	1.80E+05	1.7000	~1.2
O24	1.73E+05	6.44E+04	0.6000	~0.42
F25	1.44E+03	8.83E+03	0.0050	~0.06
F26	1.30E+05	8.64E+04	0.4500	~0.56
F27	4.32E+04	3.21E+04	0.1500	~0.21


THE END