Across the neutron drip-line: Study of the heaviest nitrogen isotopes at RIKEN

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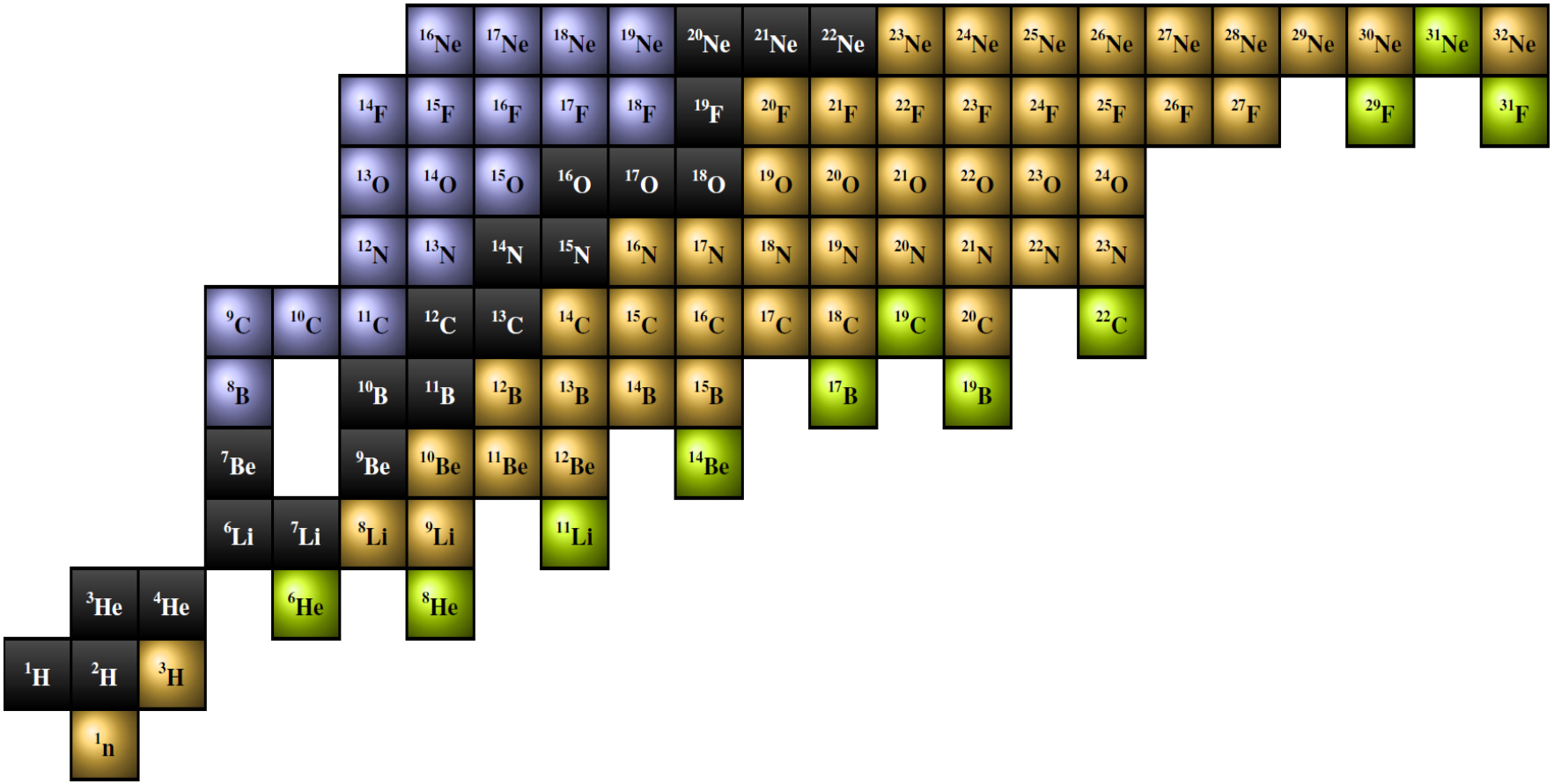
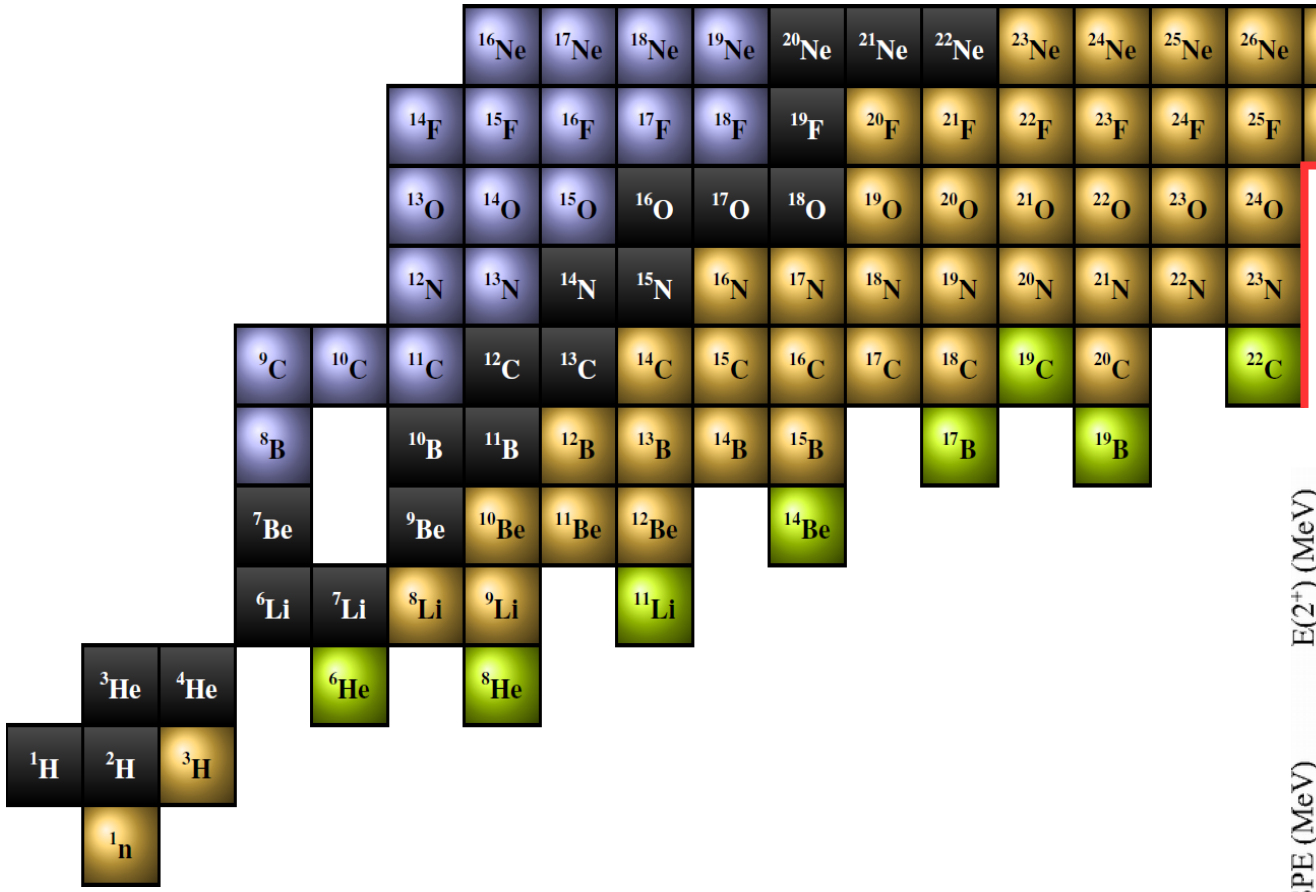
Colloque GANIL 2017

Motivation

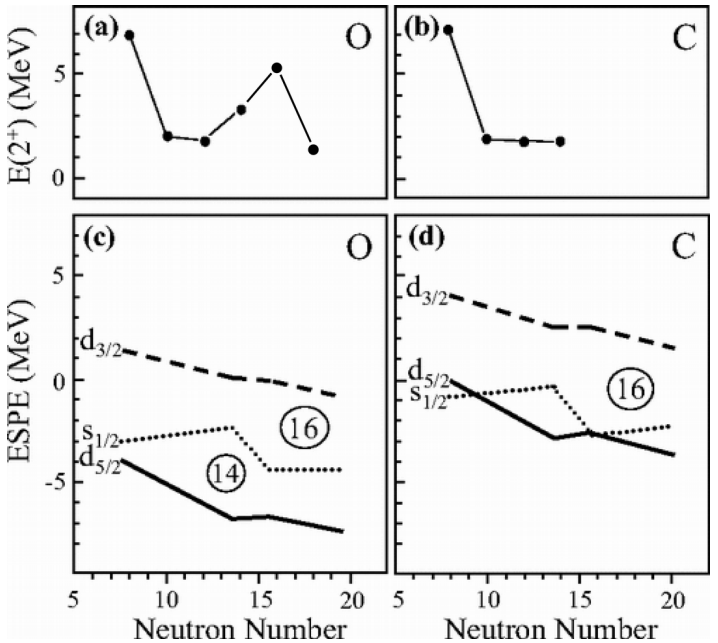


- Where are the limits ?
- Why are there limits ?

Motivation

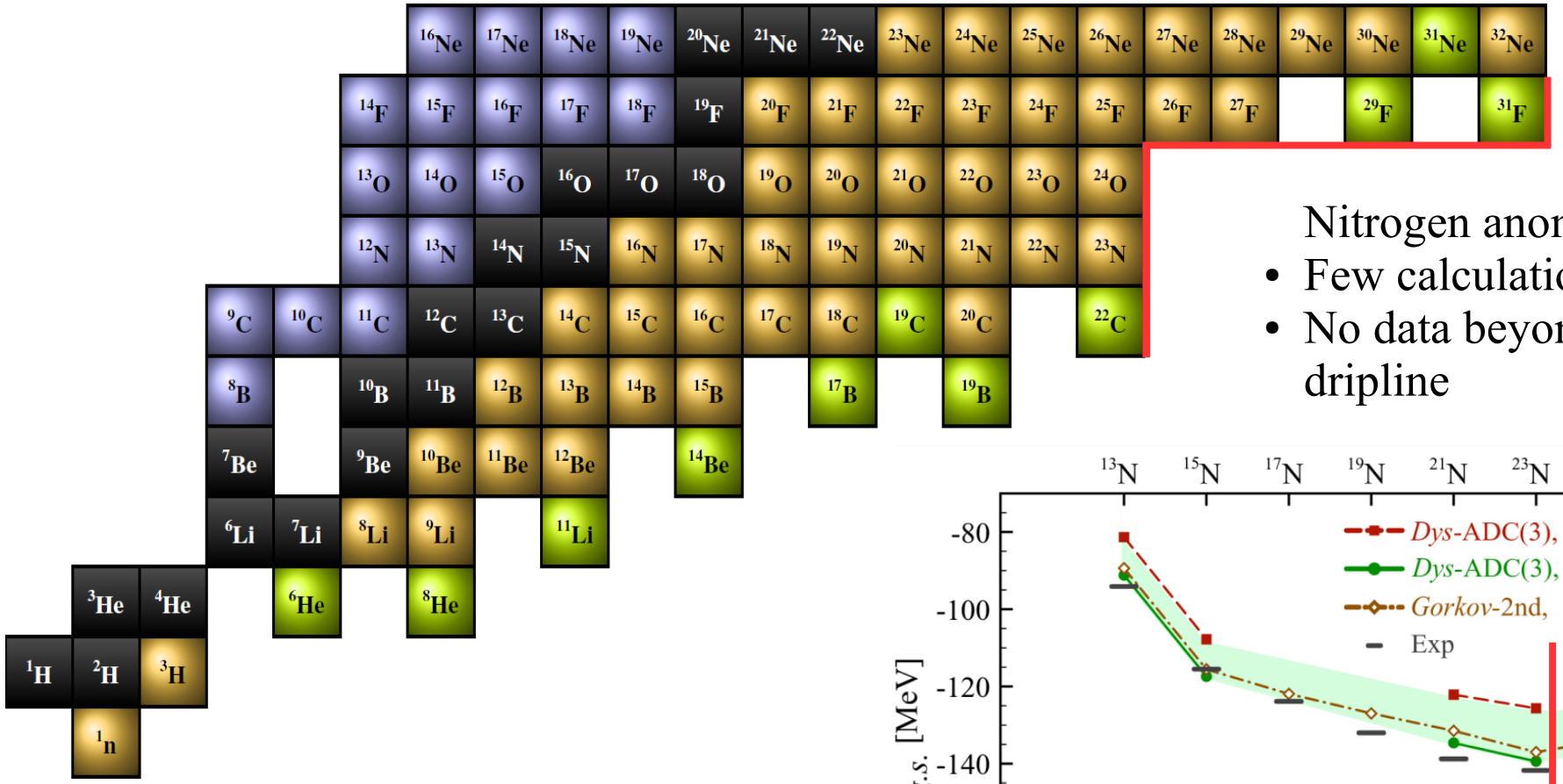


- Anomaly: N=16 → 22
- Some results for Oxygen



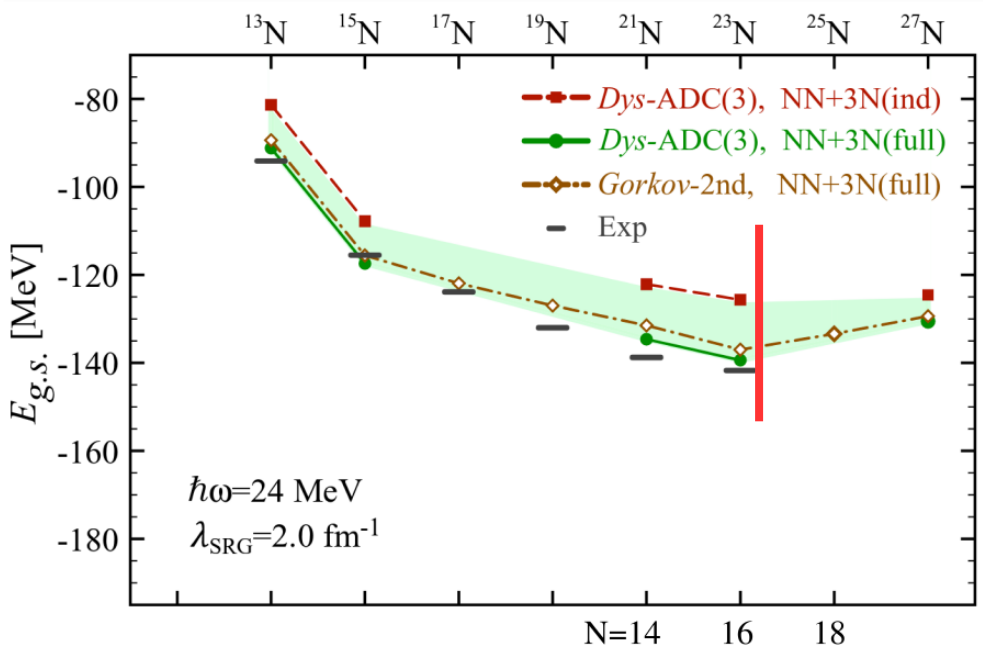
- Where are the limits ?
- Why are there limits ?
- Explore both sides of the dripline

Motivation



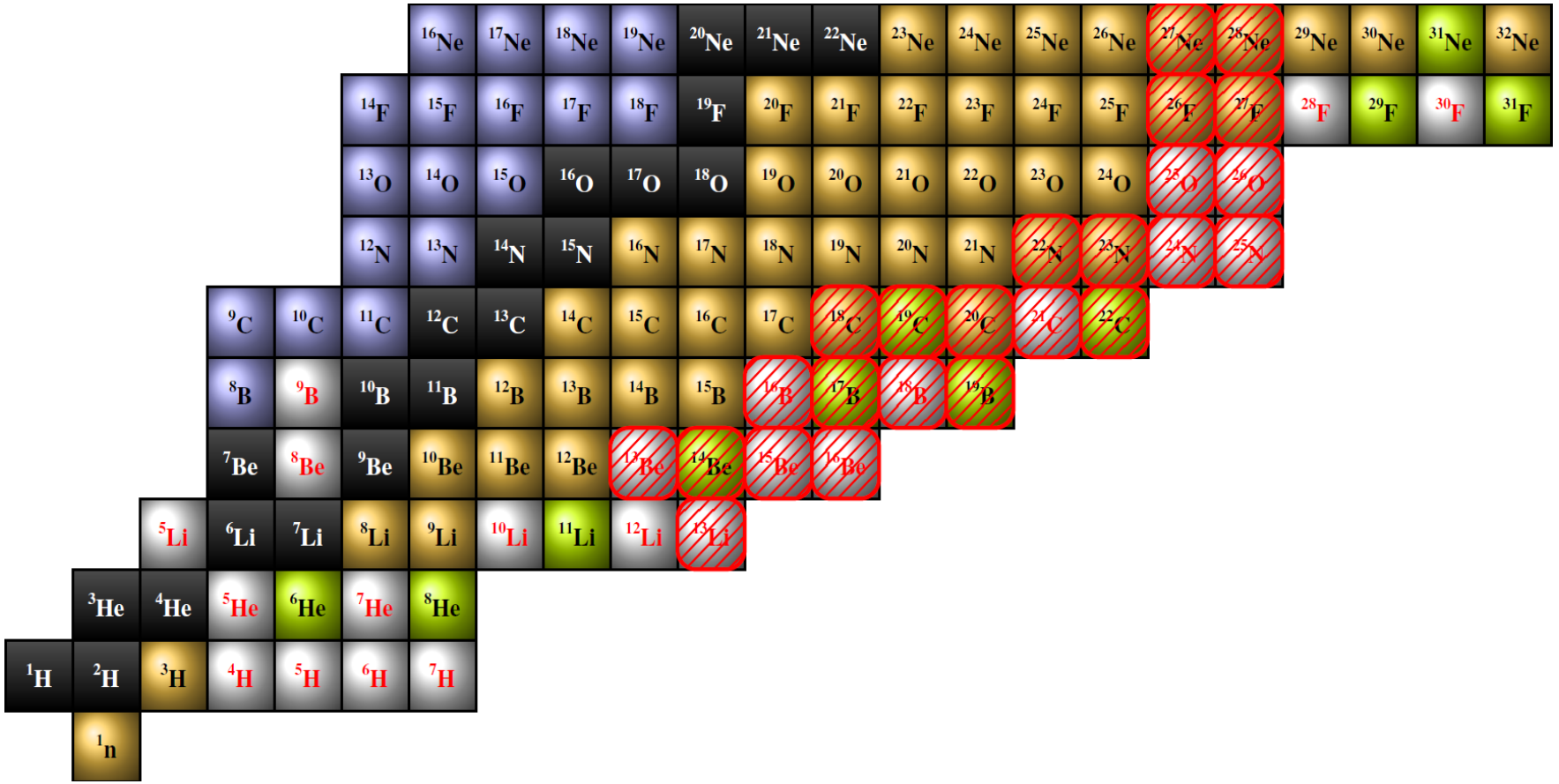
Nitrogen anomaly

- Few calculations
- No data beyond the dripline



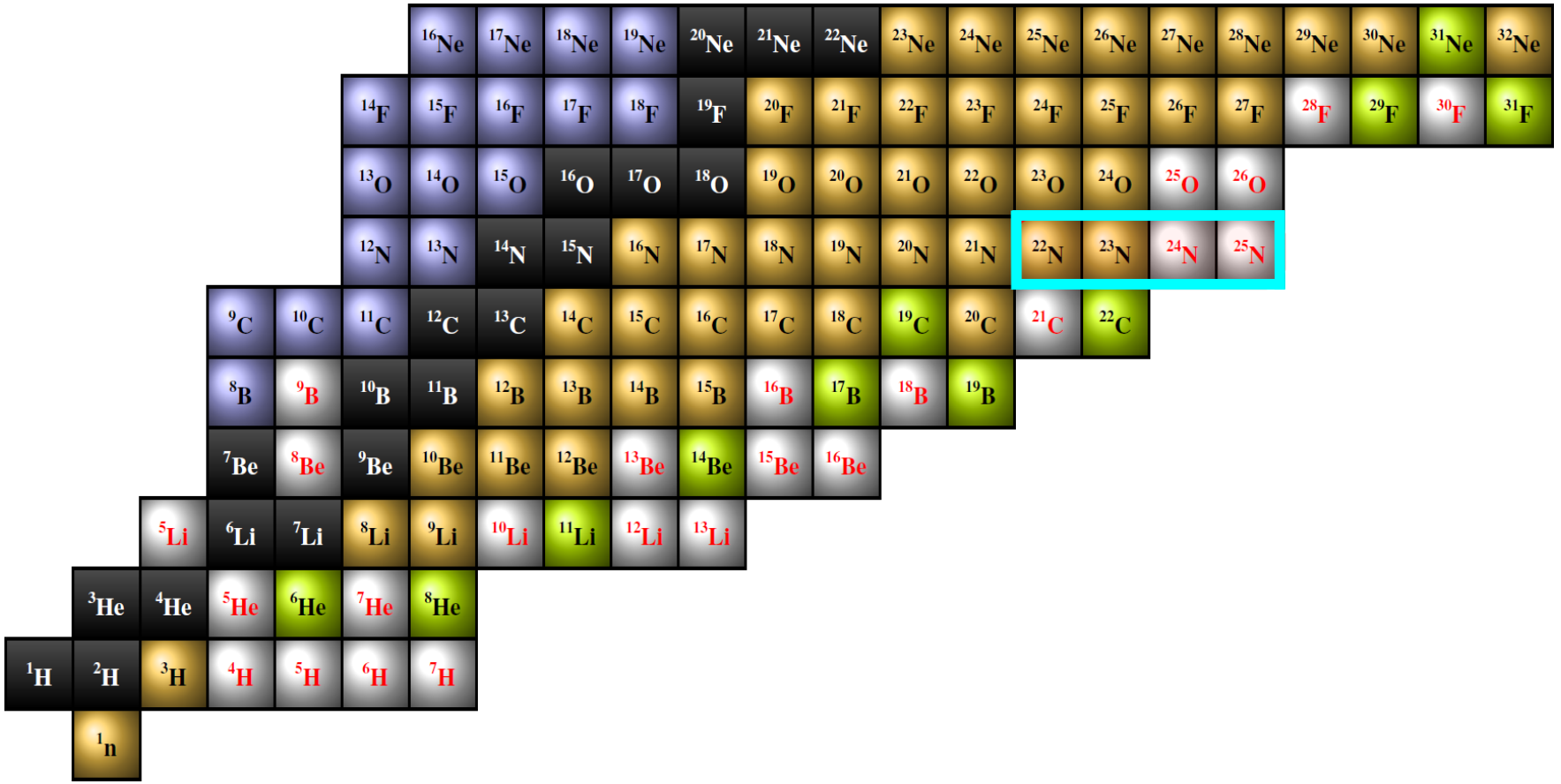
- Where are the limits ?
- Why are there limits ?
- Explore both sides of the dripline

SAMURAI DayOne Campaign



- Study of the heaviest two-neutron halo nuclei (^{19}B and ^{22}C)
- Survey of systems around the neutron dripline (^{12}Li → ^{26}O)

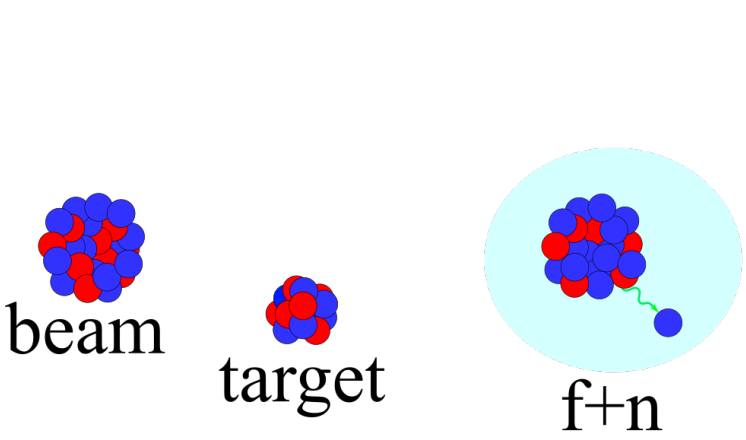
SAMURAI DayOne Campaign

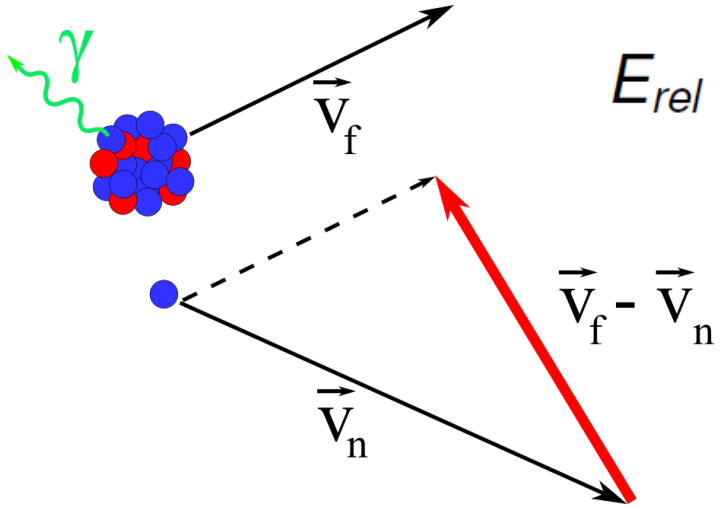


- This work : End point of the nitrogen isotope chain
- This talk : First observation of ^{24}N and ^{25}N

Invariant mass spectroscopy

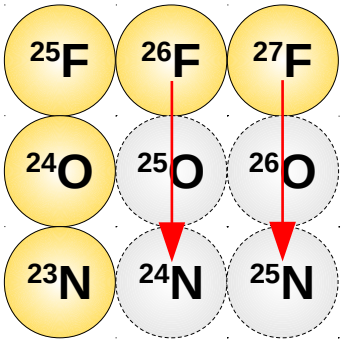
- Nucleon knockout ($\beta \sim 0.6$) + in flight decay
- Selective population of the states



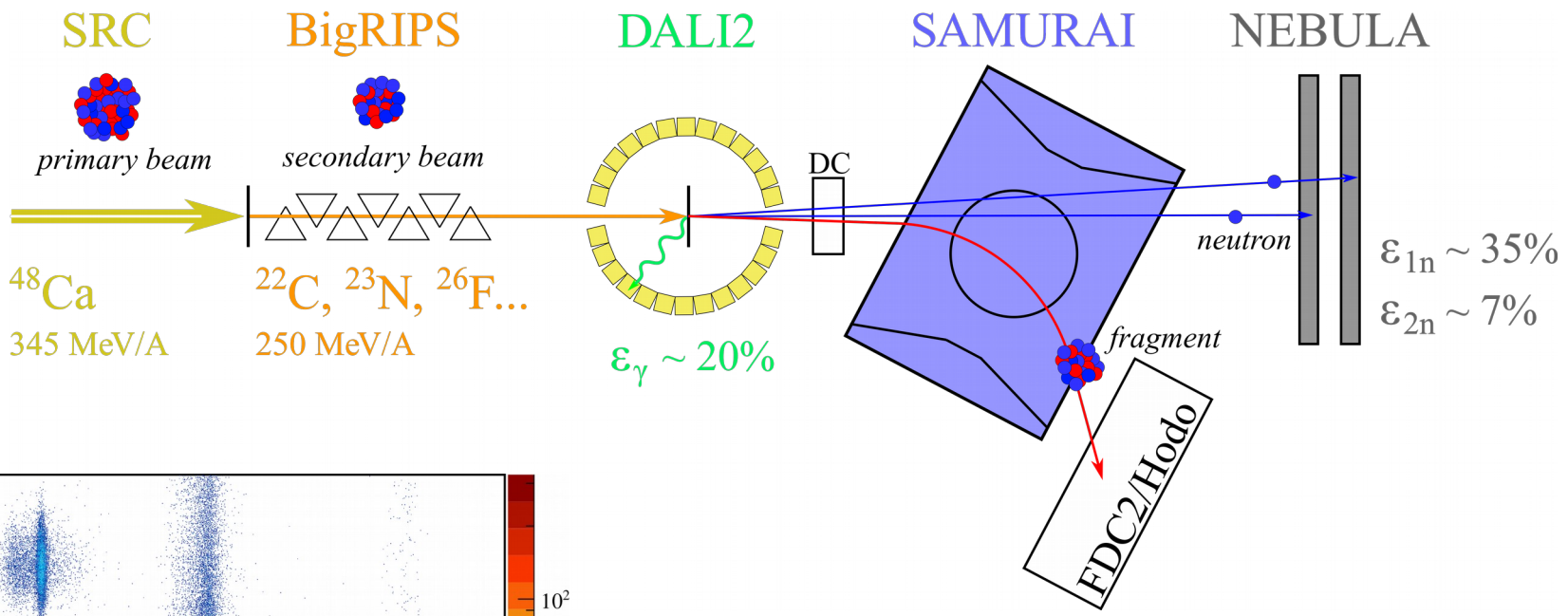


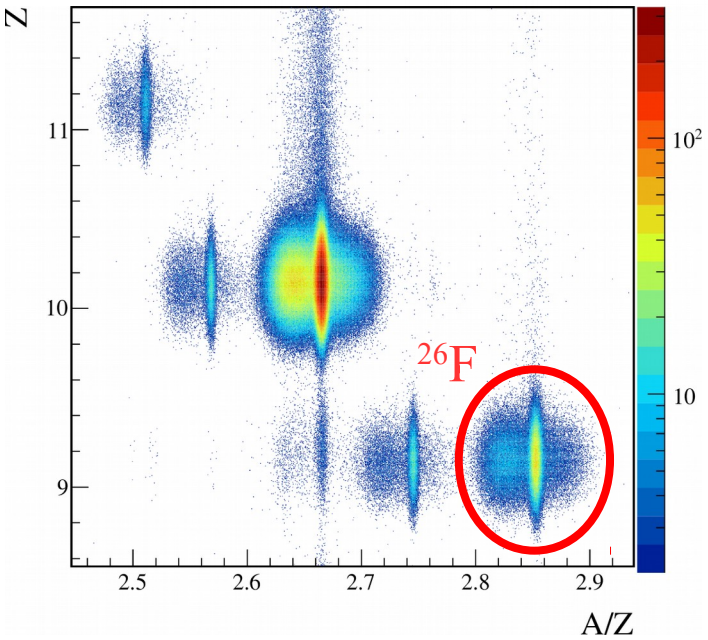
$$E_{rel} \approx \frac{1}{2}\mu(\vec{v}_n - \vec{v}_f)^2$$

$$E_{rel} = \underbrace{\sqrt{\left(\sum_i E_i\right)^2 - \left(\sum_i \vec{p}_i\right)^2}}_{M_{inv}} - \sum_i m_i$$



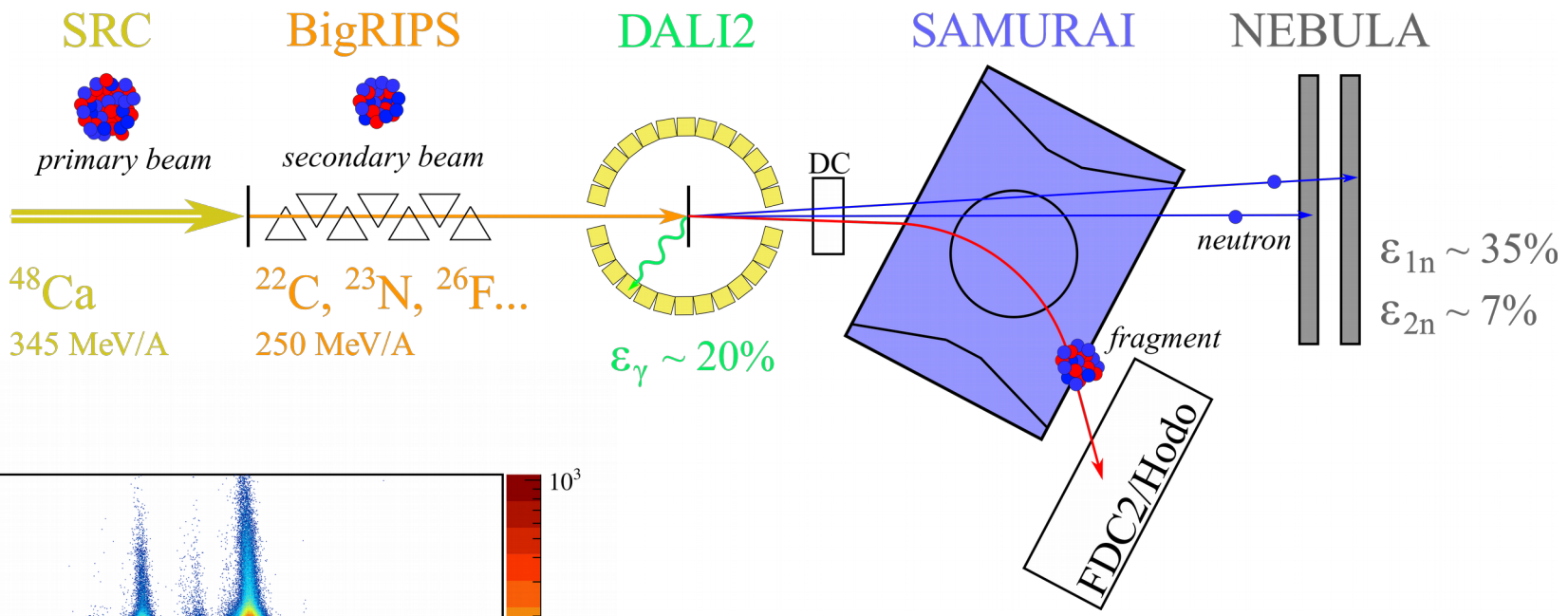
Experimental setup

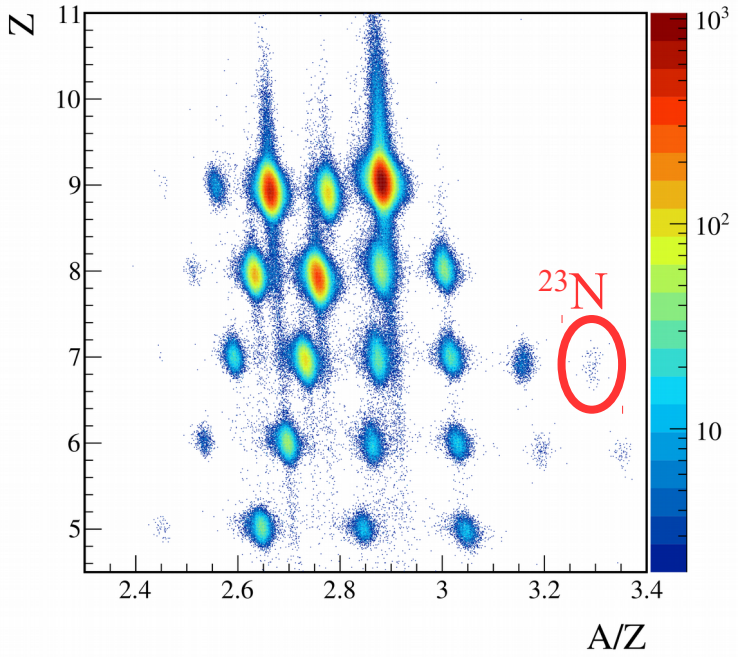




- Primary beam on Be target
- Secondary beam selected by BigRIPS separator
- Secondary beam on C target

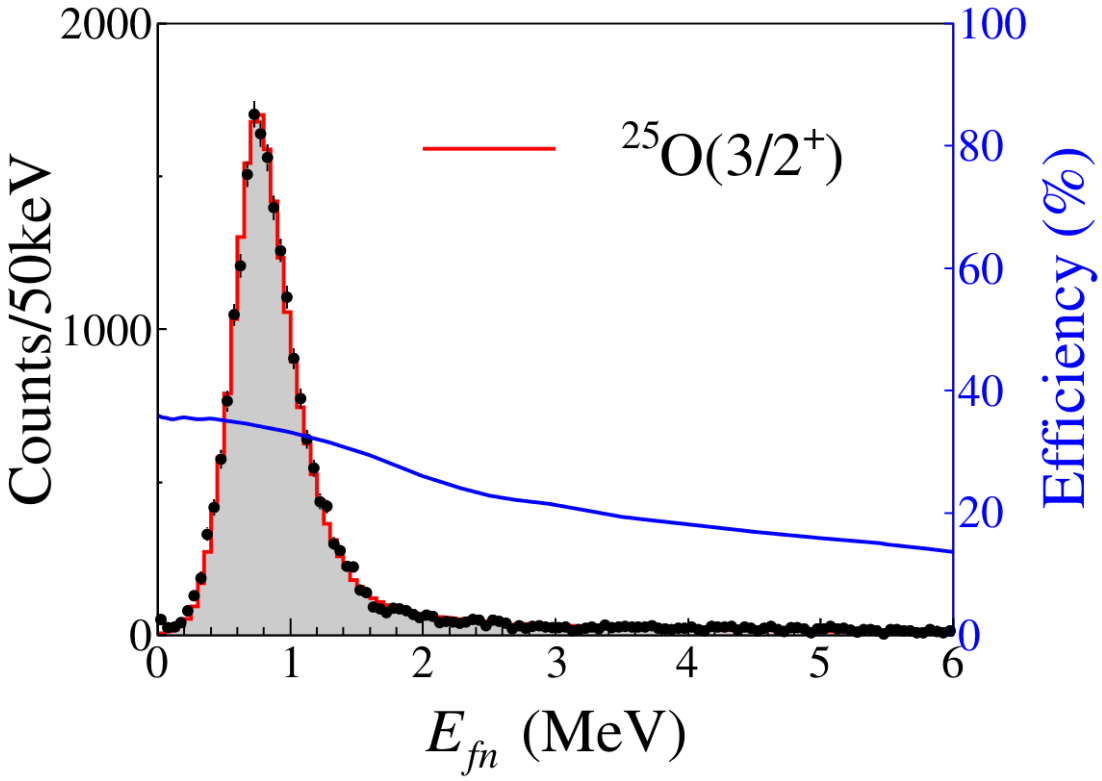
Experimental setup

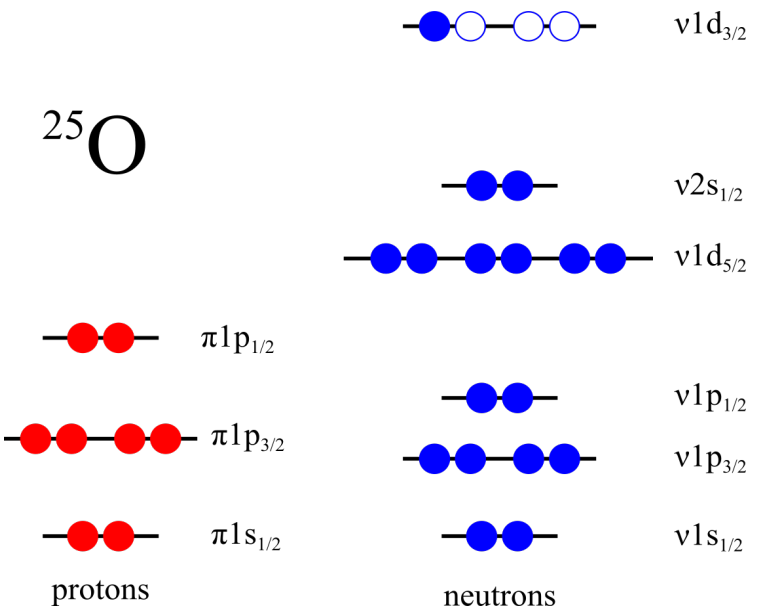


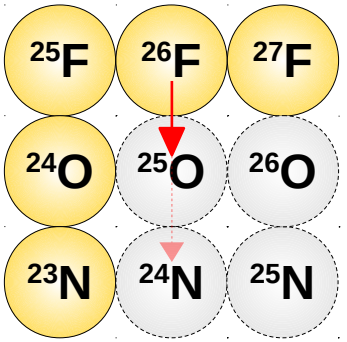


- Fragments are deflected in SAMURAI
- Bρ reconstructed through two drift chambers
- Neutrons go straight to NEBULA

Results : First observation of ^{24}N

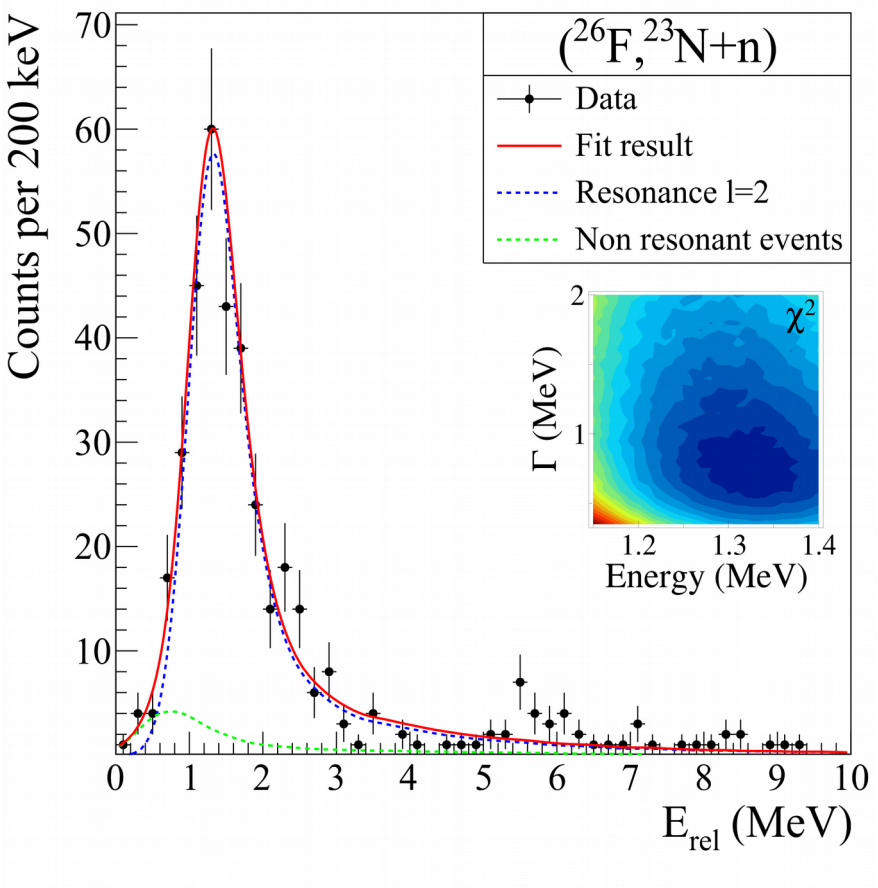


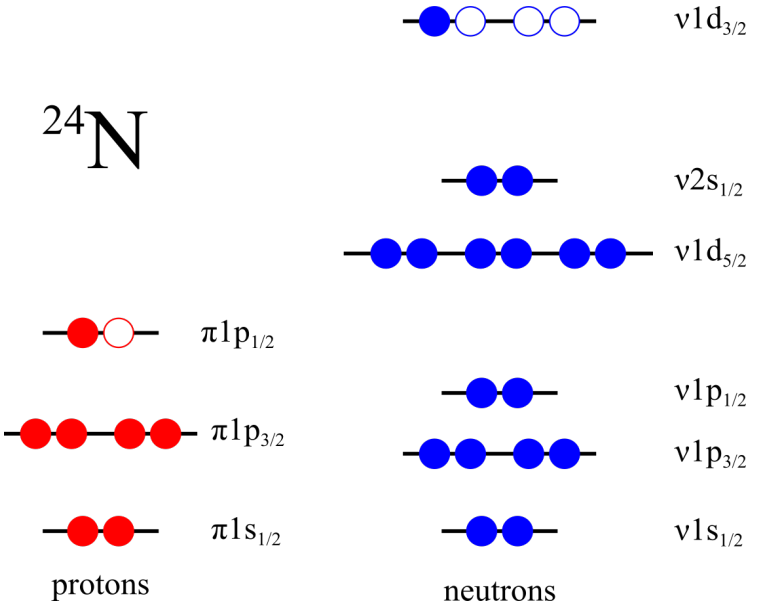


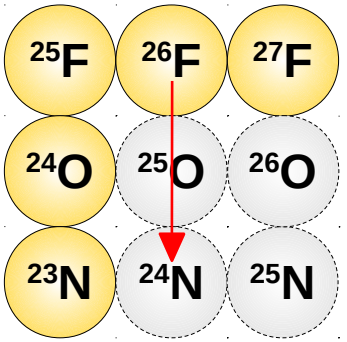


- Only one state populated (3/2$^+$)
- Selectivity : -1p preserves neutron configuration

Results : First observation of ^{24}N

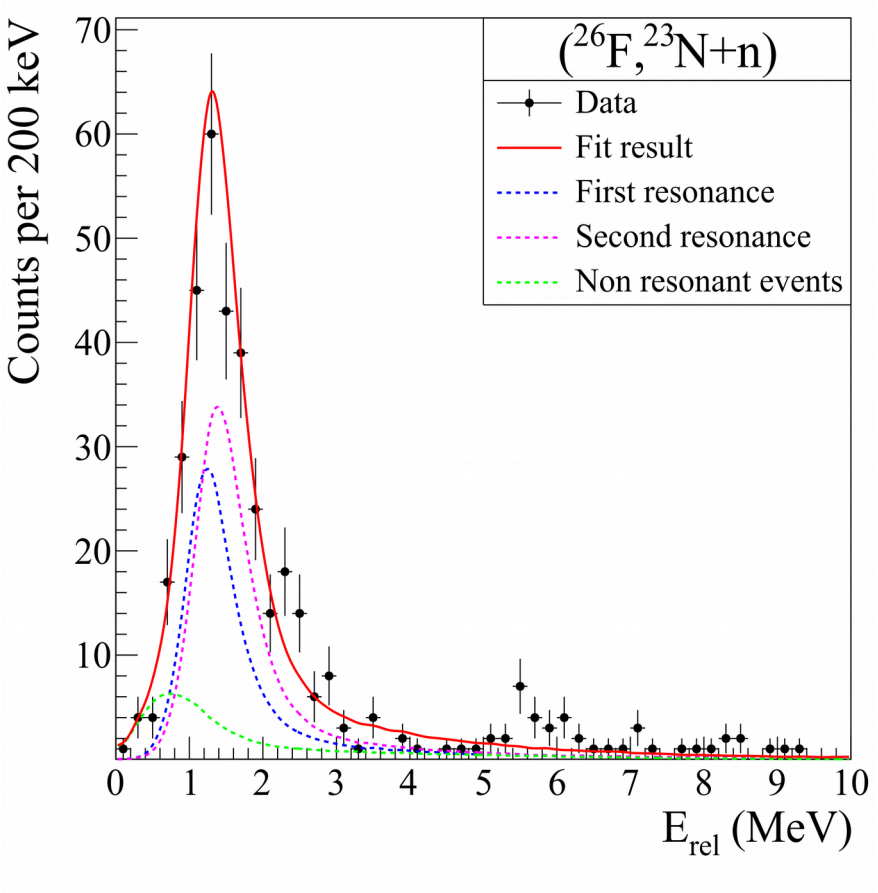


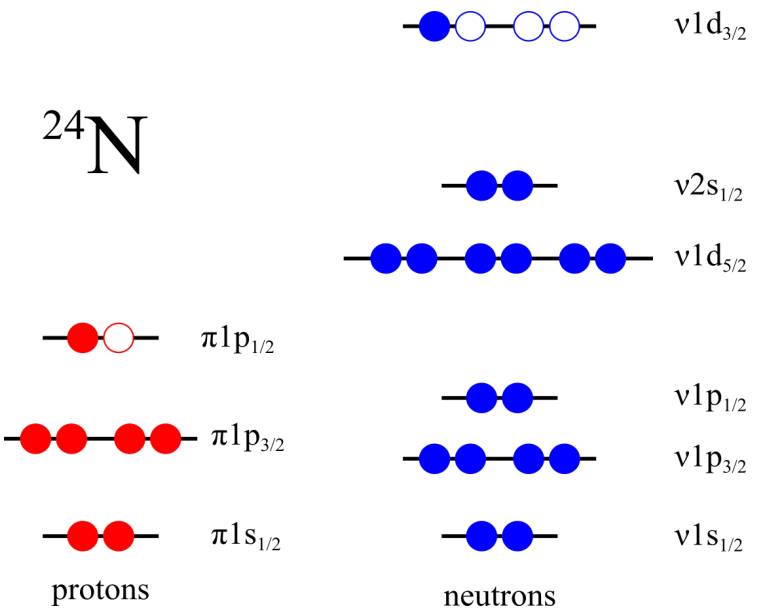


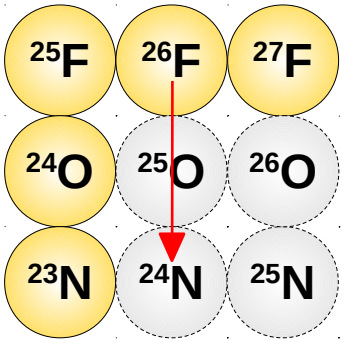


- $\pi(1p_{1/2})^{-1} \otimes \nu 1d_{3/2}$
- Expected doublet : $J^{\pi} = 2^-, 1^-$
- Only one structure observed in the E_{rel} spectrum

Results : First observation of ^{24}N

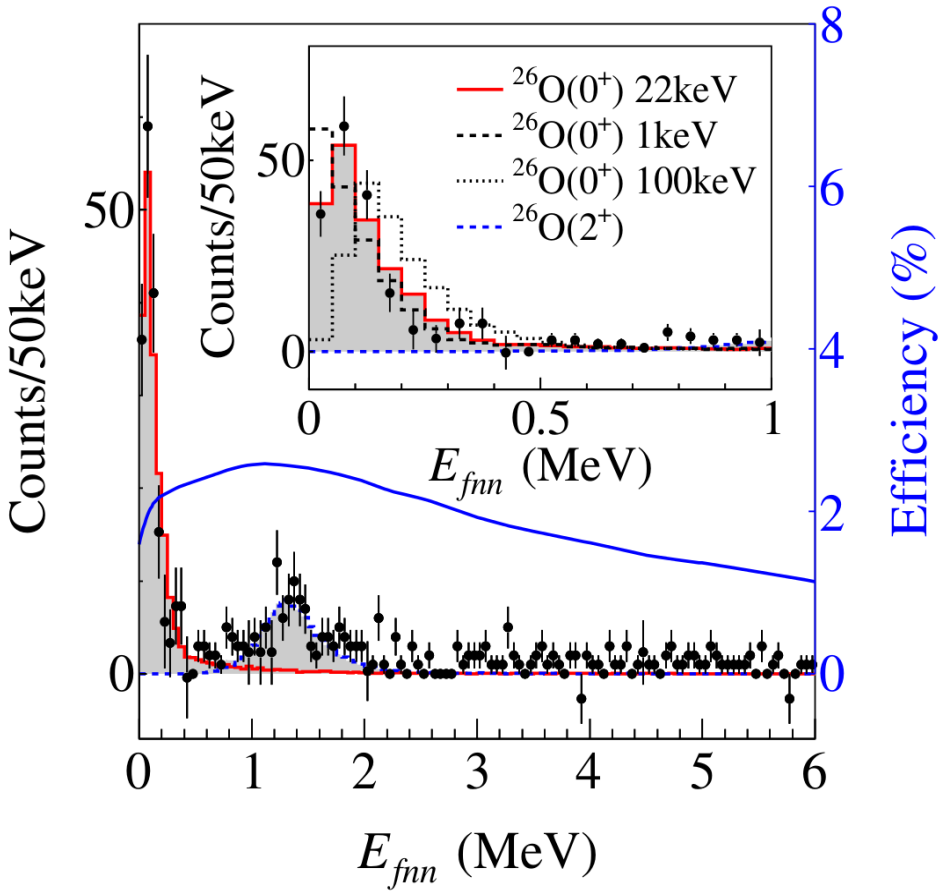


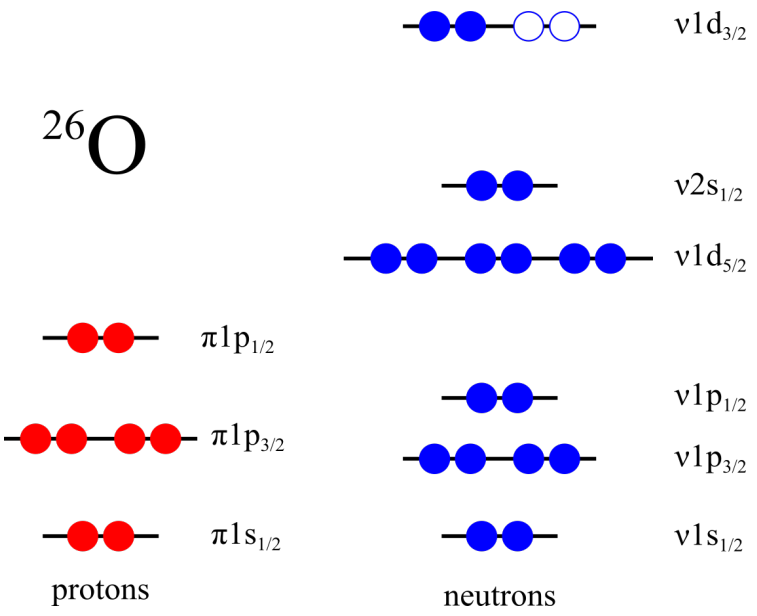


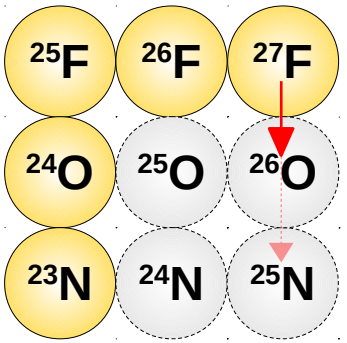


- Compatible with two resonances
- $\Delta E_r \leq 400$ keV

Results : First observation of ^{25}N

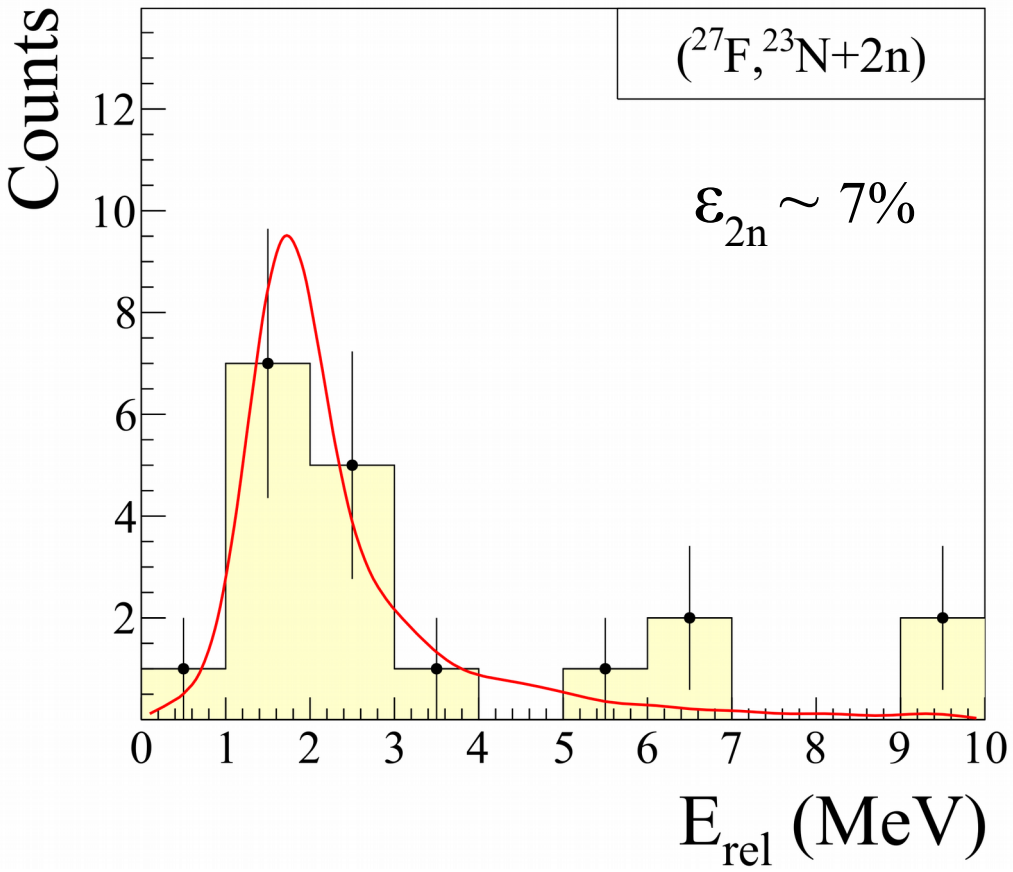


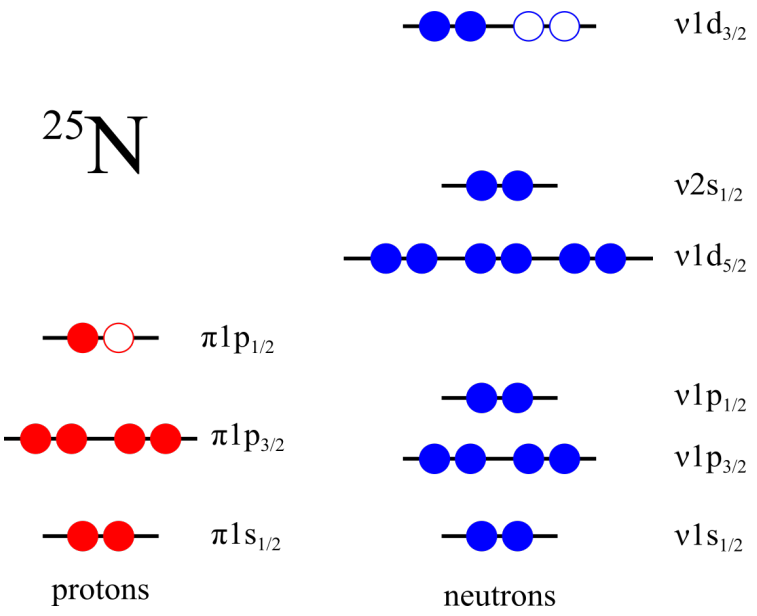


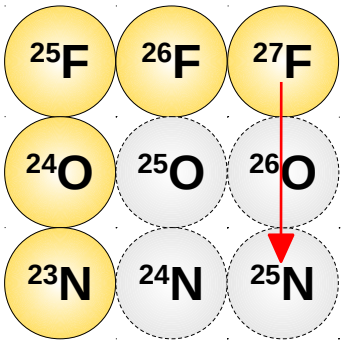


- Mostly populates 0$^+$ G.S.
- Selectivity : -1p preserves neutron configuration

Results : First observation of ^{25}N



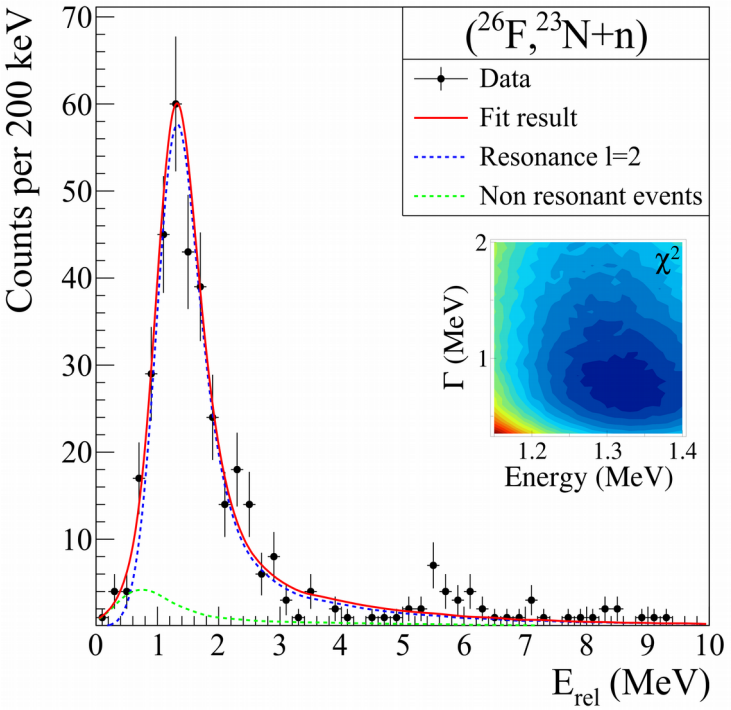




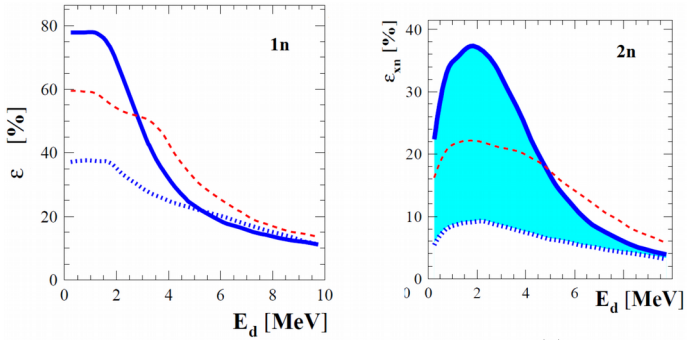
- $\pi(1p_{1/2})^{-1} \otimes (\nu 1d_{3/2})^{2}$
- Expected state : $J^{\pi} = 1/2^{-}$

Conclusion and outlook

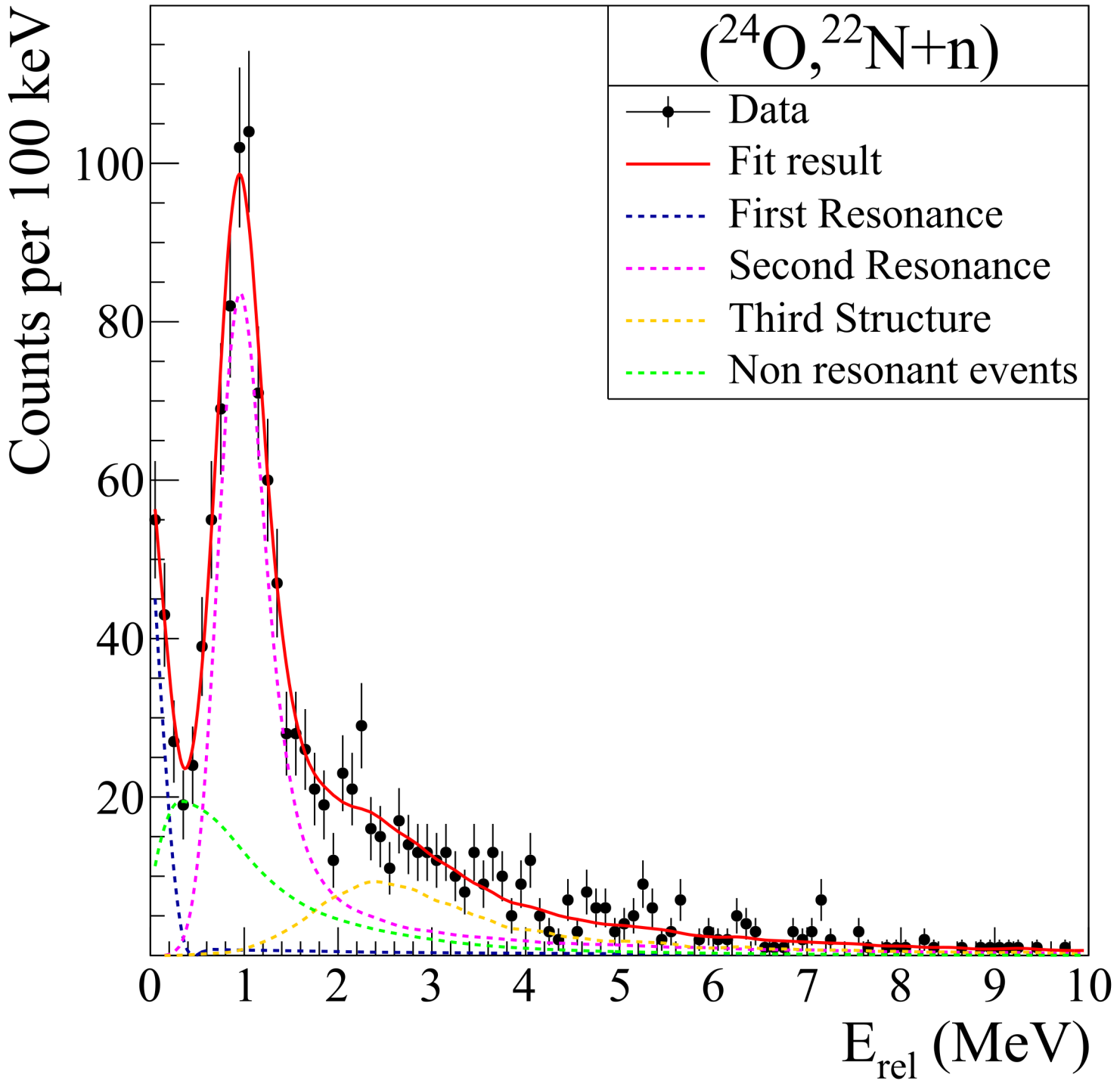
- First observation of two new nuclei!
  - ^{24}N
    - Ground state @ E = 1.32(20) MeV above S_n
    - About 1 MeV difference with AME2012
    - Compatible with doublet if $\Delta E_r \leq 400$ keV
  - ^{25}N
    - Ground state @ E = 1.7(4) MeV above S_{2n}
    - Compatible with AME2012

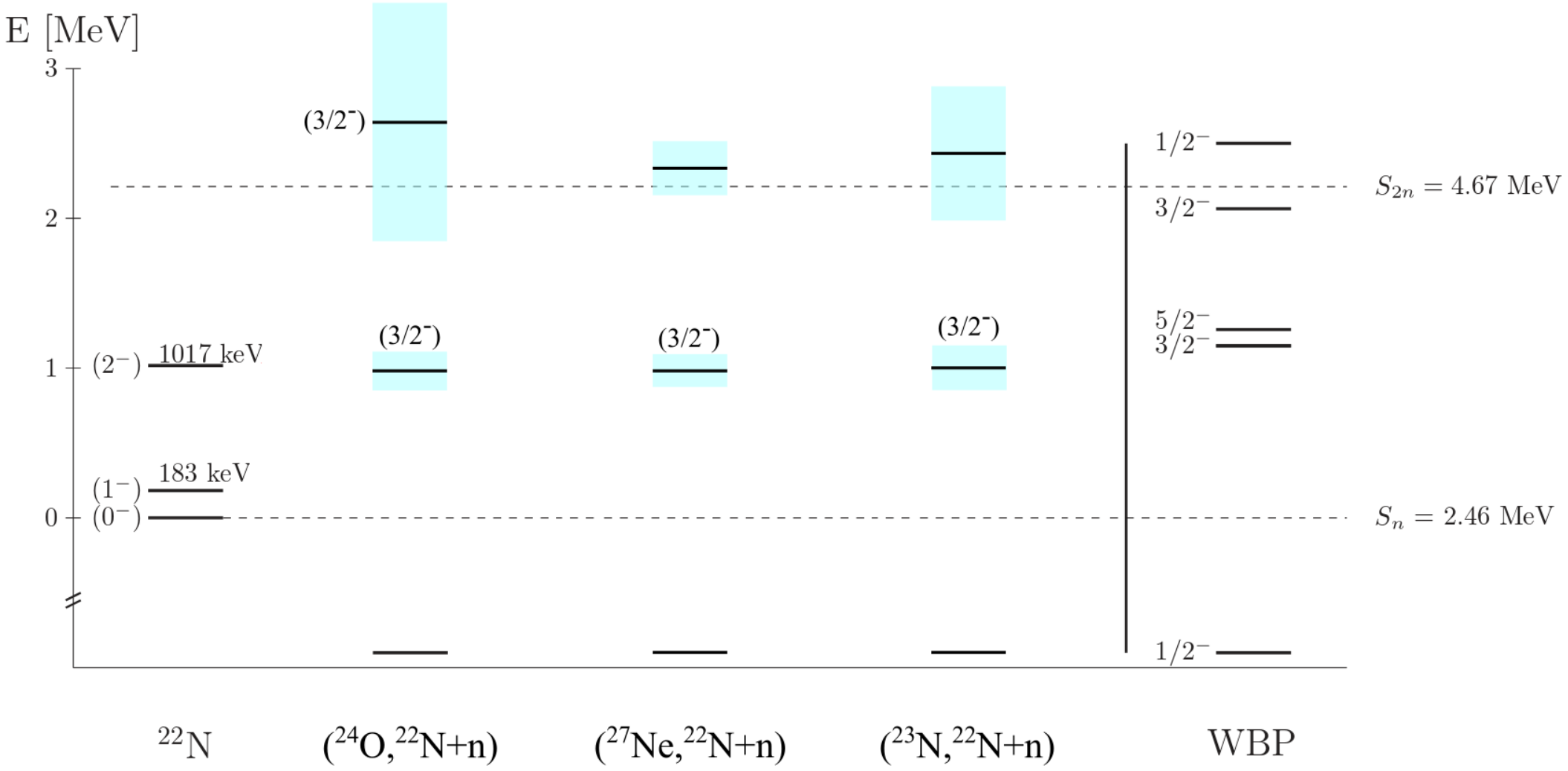


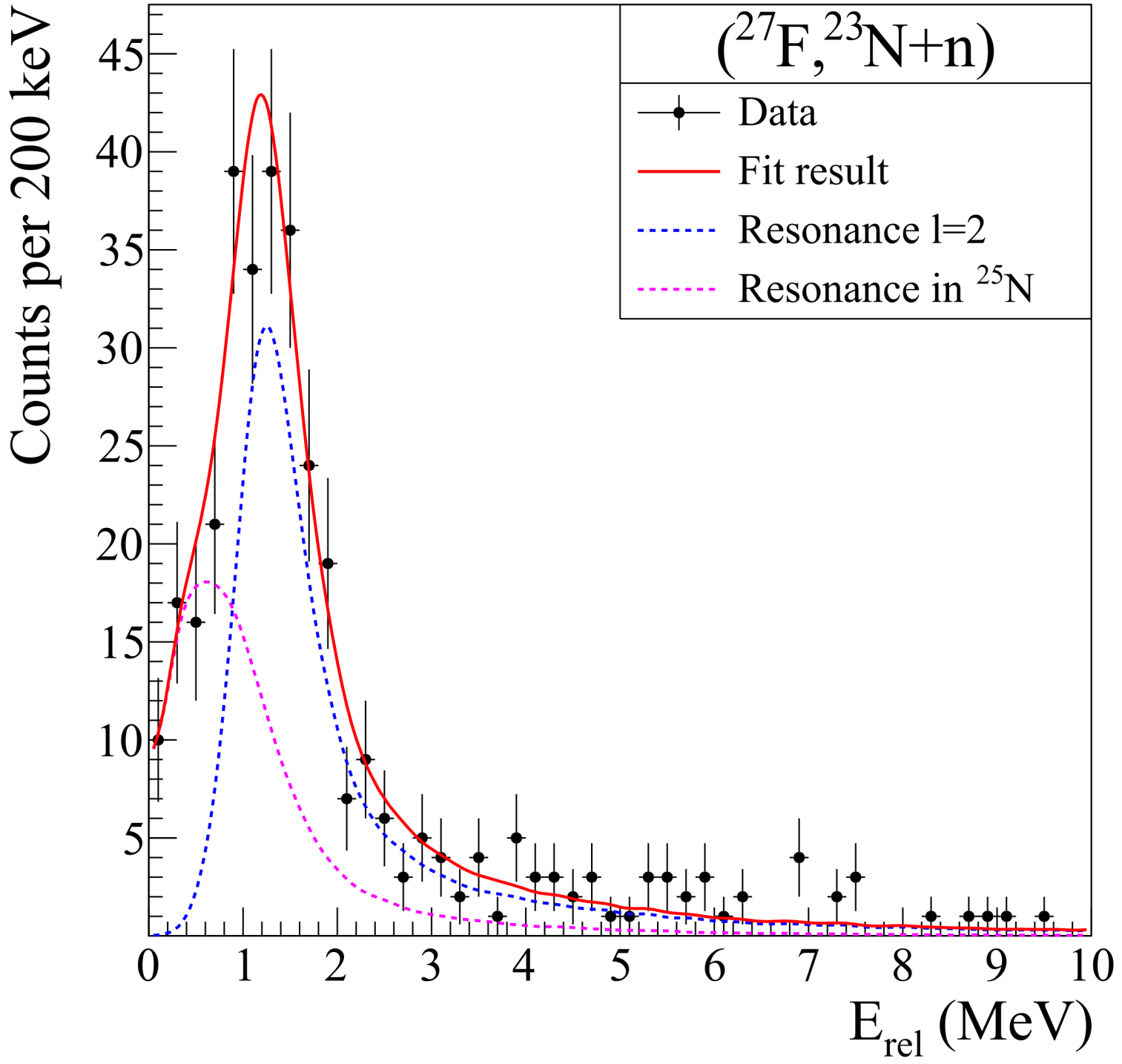
- Perspectives
  - Beam time approved for re-measurement of ^{24,25}N
    - Better resolution (HIME)
    - More statistics (NEBULA Plus)

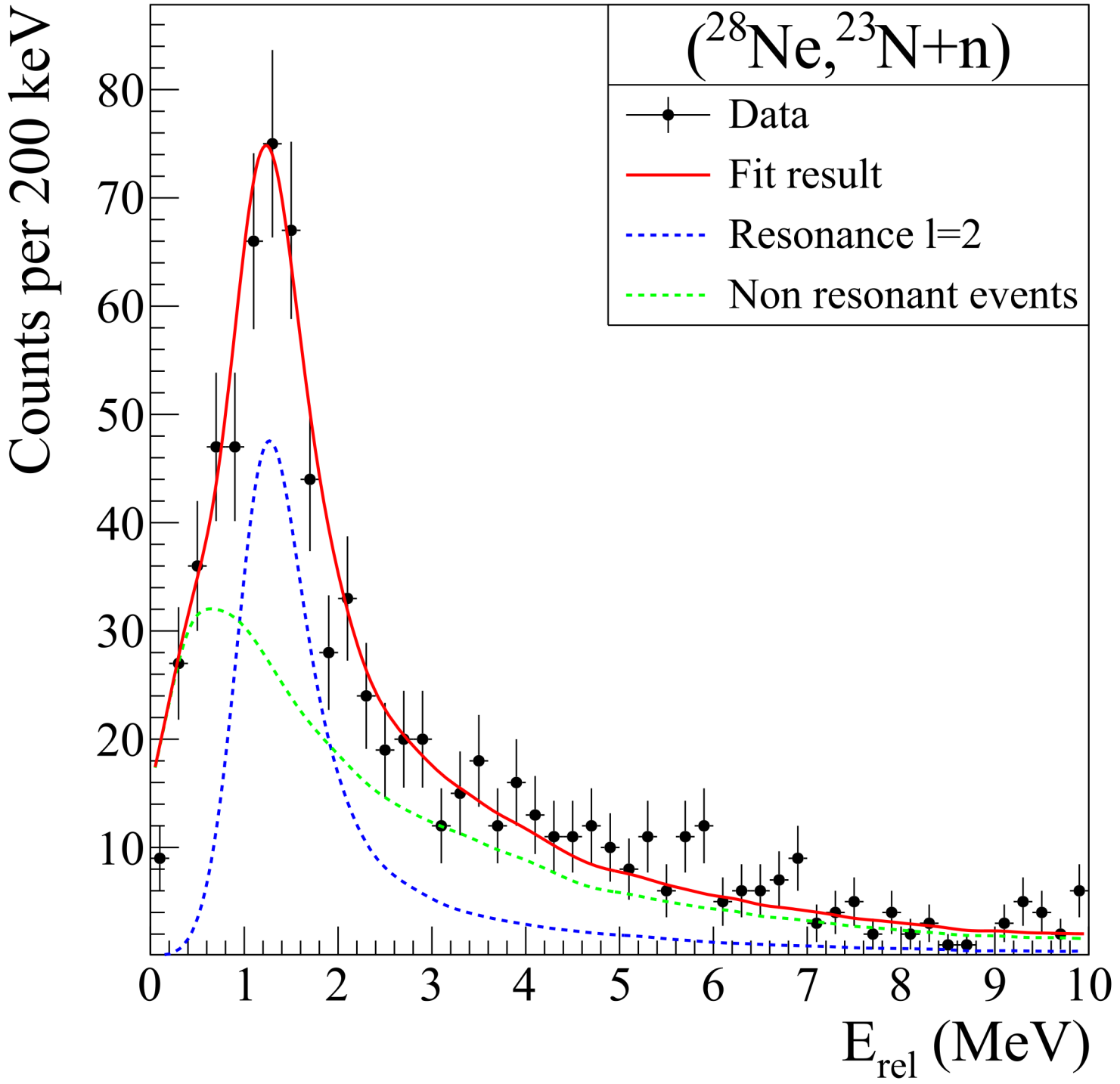


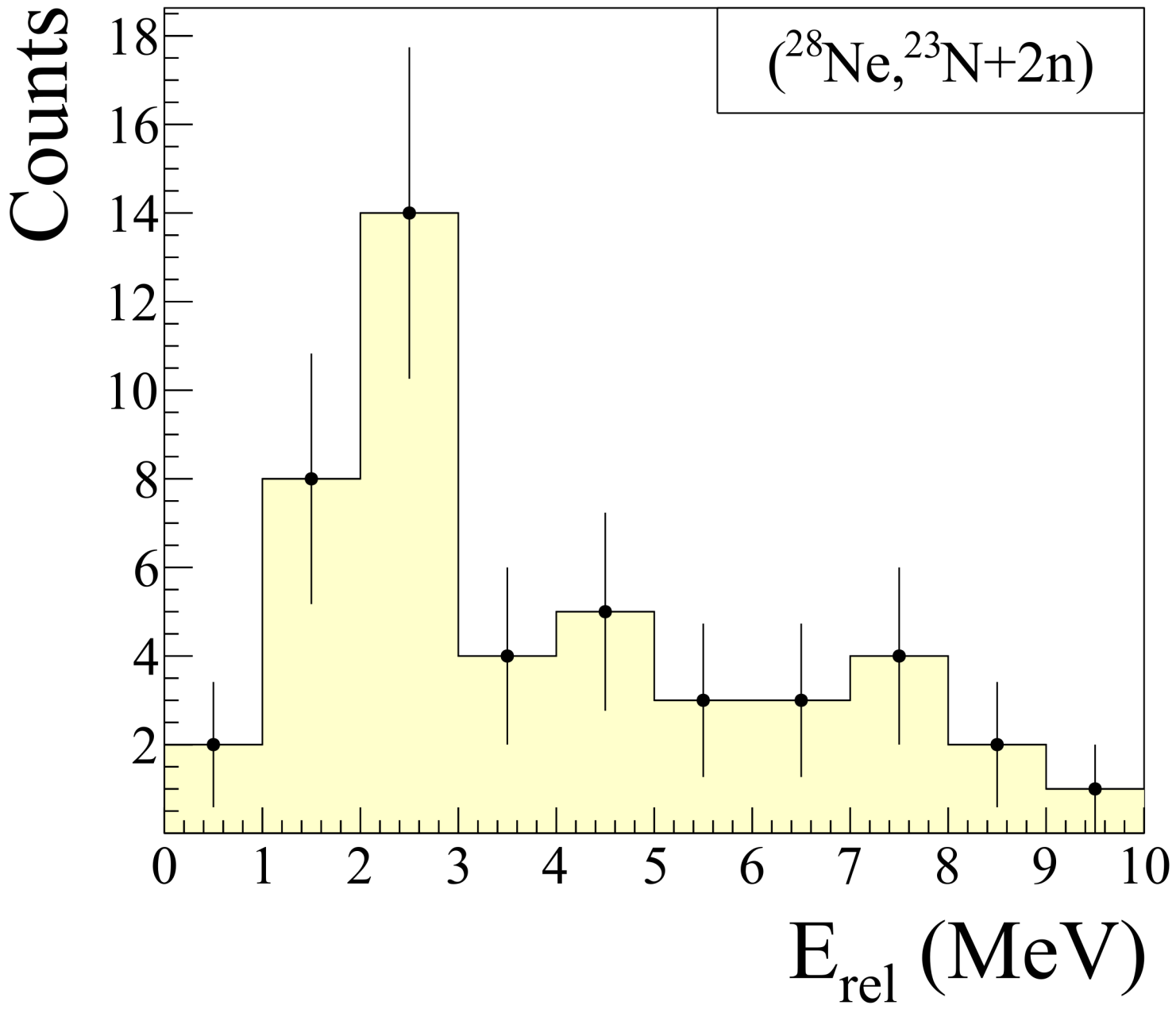
Thank you for your attention !


(^{24}O,^{22}N+n)
Data
Fit result
First Resonance
Second Resonance
Third Structure
Non resonant events
Counts per 100 keV
E$_{rel}$ (MeV)
0
1
2
3
4
5
6
7
8
9
10
20
40
60
80
100


E [MeV]
3
2
1
0
(3/2⁻)
(3/2⁻)
(3/2⁻)
(3/2⁻)
(2⁻)
1017 keV
(1⁻)
183 keV
(0⁻)
1/2⁻
3/2⁻
5/2⁻
3/2⁻
1/2⁻
S_{2n} = 4.67 MeV
S_n = 2.46 MeV
^{22}N
(^{24}O,^{22}N+n)
(^{27}Ne,^{22}N+n)
(^{23}N,^{22}N+n)
WBP


(^{27}F,^{23}N+n)
Data
Fit result
Resonance l=2
Resonance in ^{25}N
Counts per 200 keV
E_{rel} (MeV)
0
1
2
3
4
5
6
7
8
9
10
5
10
15
20
25
30
35
40
45


(^{28}Ne,^{23}N+n)
Data
Fit result
Resonance l=2
Non resonant events
Counts per 200 keV
E_{rel} (MeV)
0
1
2
3
4
5
6
7
8
9
10
10
20
30
40
50
60
70
80


Counts
18
16
14
12
10
8
6
4
2
0
1
2
3
4
5
6
7
8
9
10
E_{rel} (MeV)
(^{28}Ne,^{23}N+2n)