Insight in neutron-rich Zn isotopes

Overview

Structure evolution in the Zn neighborhood

Island of inversion in the Fe and Cr isotopes - intruder states as g.s.

Spherical semi magic Ni isotope g.s. however

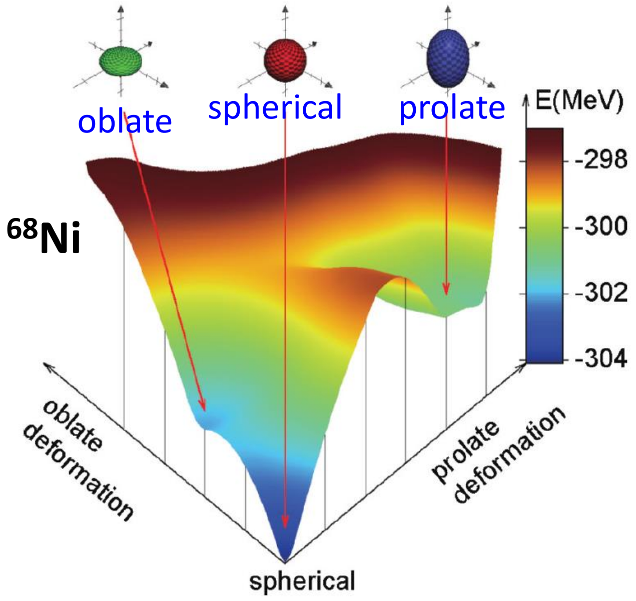
Structure evolution in the Zn neighborhood

Island of inversion in the Fe and Cr isotopes - intruder states as g.s.

Spherical semi magic Ni isotope g.s. <u>however</u>

- shape coexistence was exhibited in ^{68}Ni
three 0^+ states below 3 MeV
S. Suchyta et al., Phys. Rev. C 89, 021301(R) (2014)

- confirmed in ^{68,70,74}Ni by MCSC
Y. Tsunoda et al., Phys. Rev. C 89, 031301(R) (2014)



Structure evolution in the Zn neighborhood

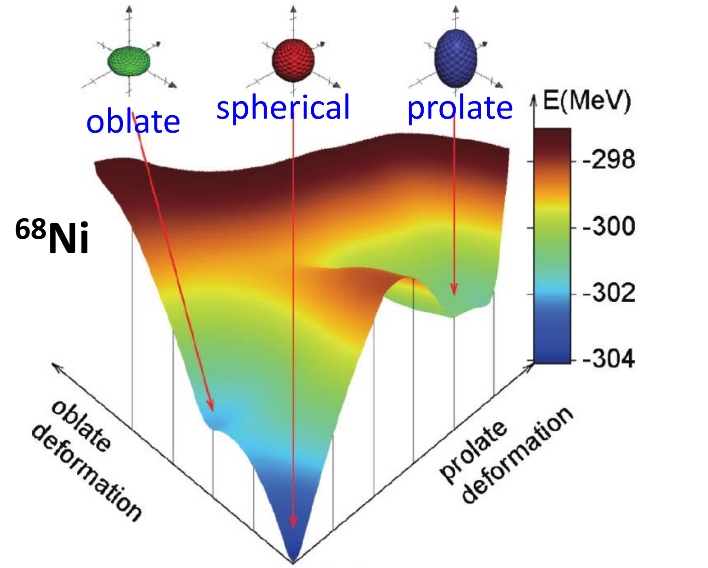
Island of inversion in the Fe and Cr isotopes - intruder states as g.s.

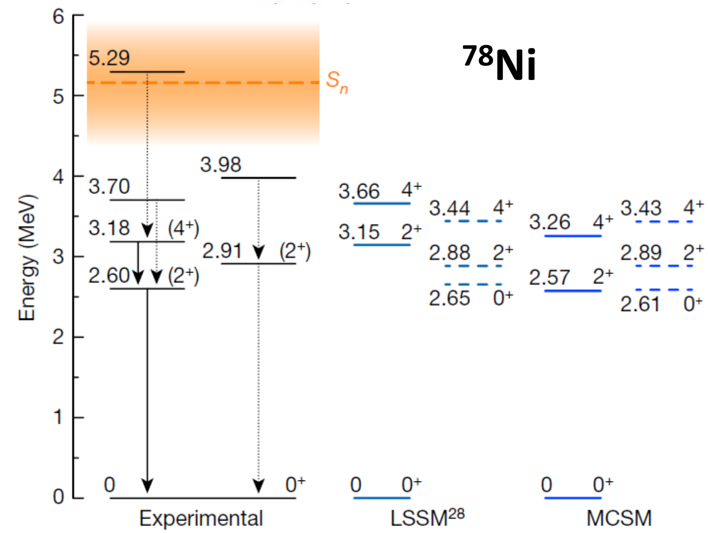
Spherical semi magic Ni isotope g.s. <u>however</u>

- shape coexistence was exhibited in ^{68}Ni
three 0^+ states below 3 MeV
S. Suchyta et al., Phys. Rev. C 89, 021301(R) (2014)

- confirmed in ^{68,70,74}Ni by MCSC
Y. Tsunoda et al., Phys. Rev. C 89, 031301(R) (2014)

- recently evidenced at low excitation energy in ^{78}Ni
R. Taniuchi et al., Nature (London) 569, 53 (2019)





Structure evolution in the Zn neighborhood

Island of inversion in the Fe and Cr isotopes - intruder states as g.s.

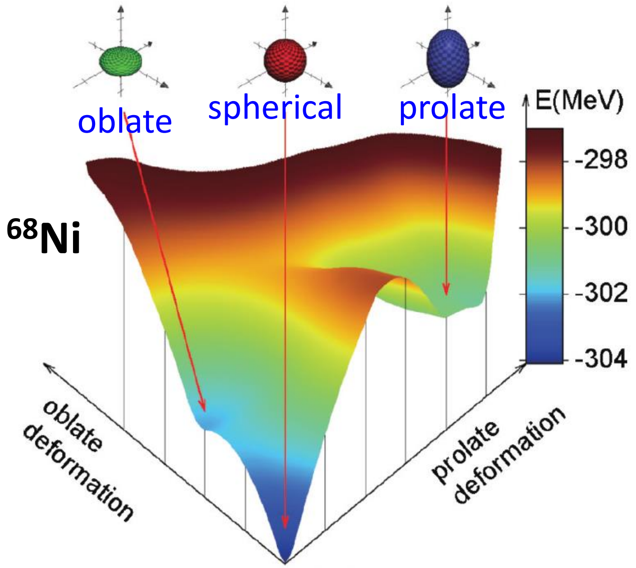
Spherical semi magic Ni isotope g.s. <u>however</u>

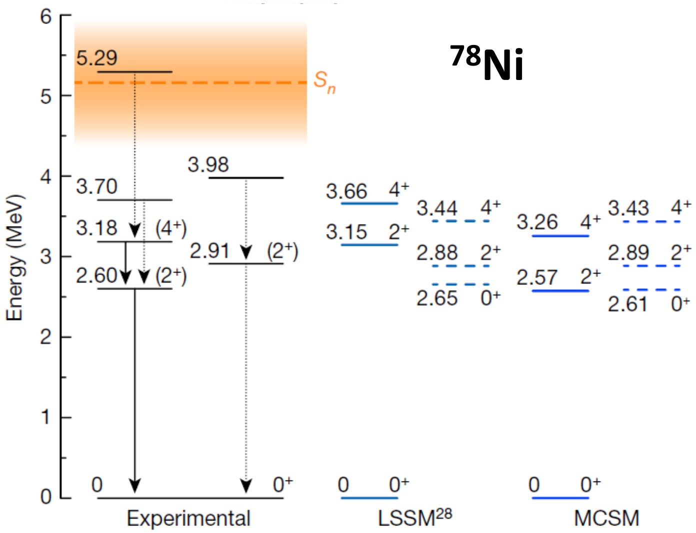
- shape coexistence was exhibited in ^{68}Ni
  three 0^+ states below 3 MeV
  S. Suchyta et al., Phys. Rev. C 89, 021301(R) (2014)

- confirmed in ^{68,70,74}Ni by MCSC
  Y. Tsunoda et al., Phys. Rev. C 89, 031301(R) (2014)

- recently evidenced at low excitation energy in ^{78}Ni
  R. Taniuchi et al., Nature (London) 569, 53 (2019)

Ge isotopes are known to present triaxial trends



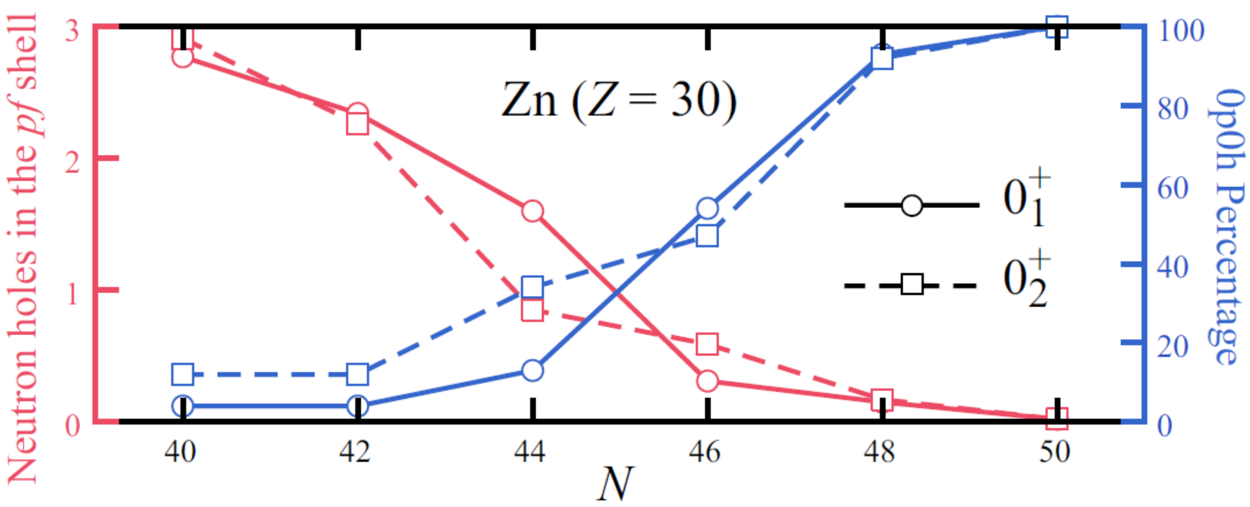


Structure evolution in the Zn neighborhood

Very recently, ^{74}Zn was investigated and two new excited bands K=0 and K=2 were observed. From data and large-scale shell-model (SM) calculations, it was shown that

- the g.s. is strongly triaxial as well as the excited bands
- the g.s. involves more neutron (ν) excitations across the N=40 gap than the 0_2^+ state extending the island of inversion above Fe
- SM calculations predict in Zn isotopes a drastic reduction of the pf-to-dg ν excitations from N=40 to N=50

M. Rocchini et al., Phys. Rev. Lett. 130, 122502 (2023)

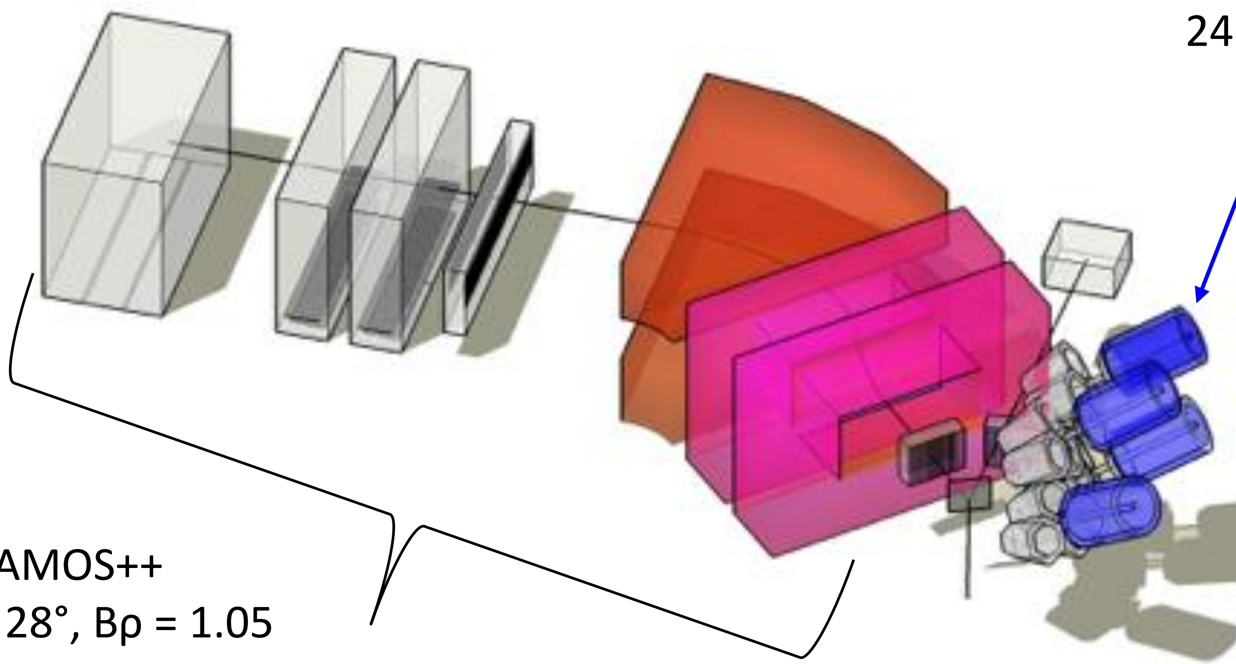


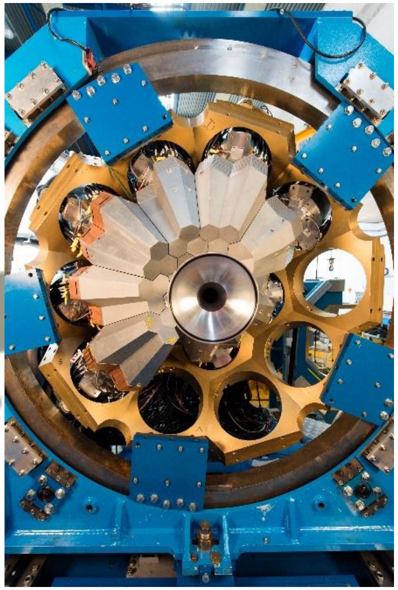
Experimental setup

Fusion-fission reaction in inverse kinematics – ^{238}U(6.2 MeV/n) + ^{9}Be – at GANIL

Couple AGATA (8 ATC) to the recoil spectrometer VAMOS++

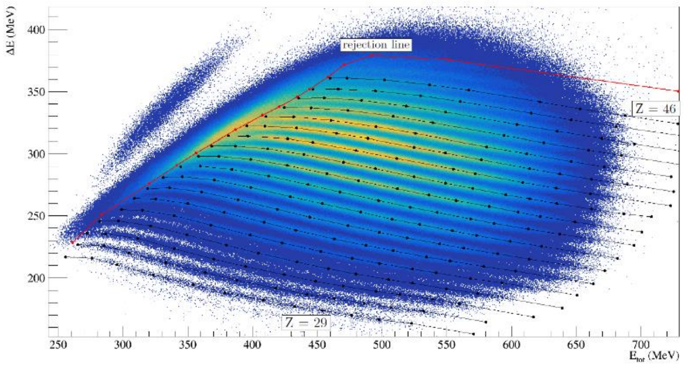
AGATA
24 crystals





VAMOS++
θ_{Vamos}= 28°, Bρ = 1.05

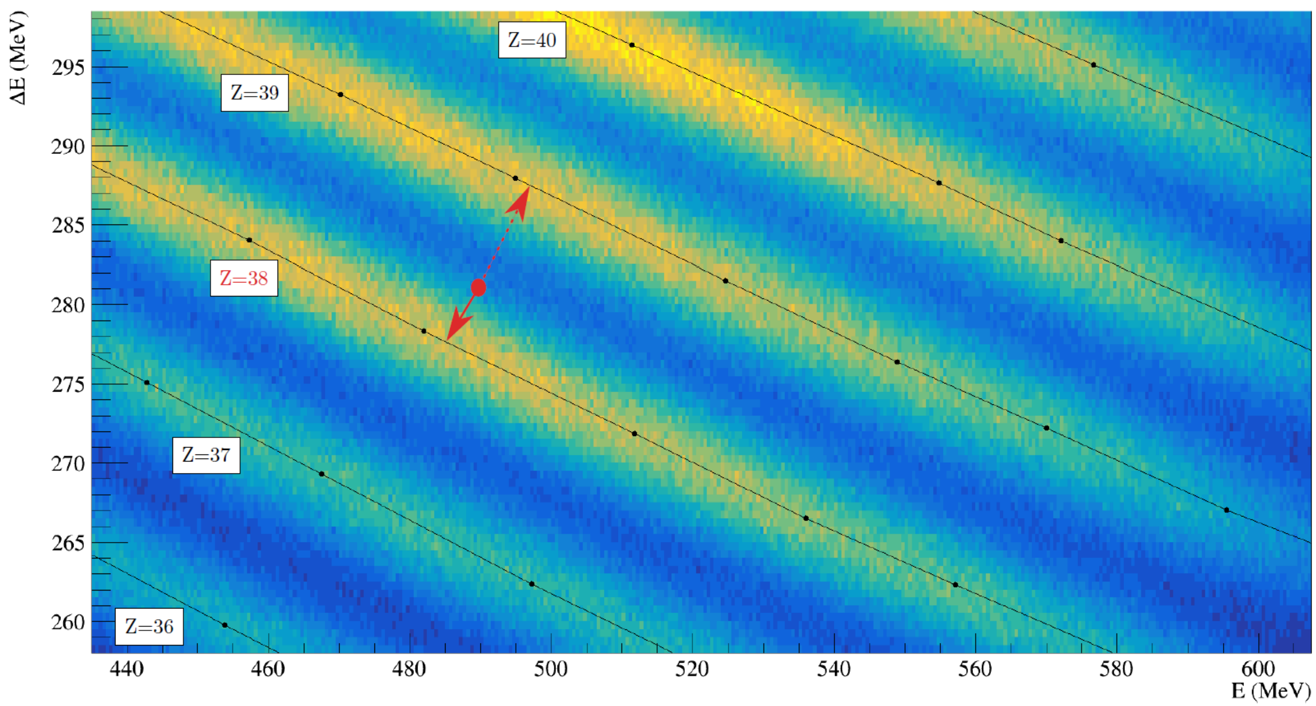
Fission-fragments identification



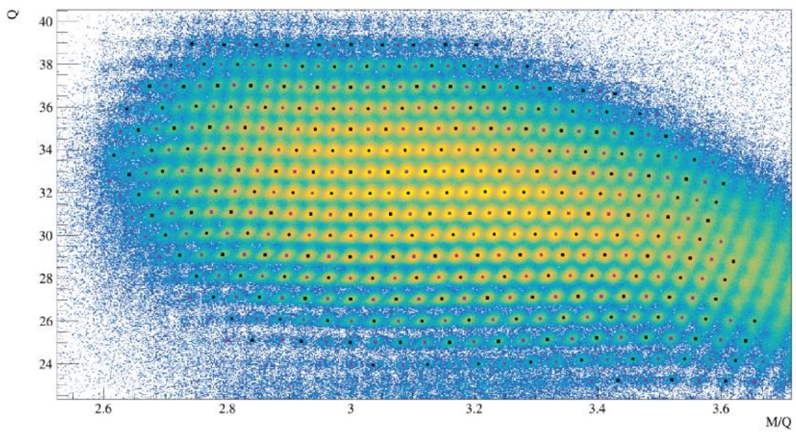
Z identification

- the identified Z value is chosen as the one of the closest line
- the distance to line is used as a quality factor

Final Z resolution ΔZ/Z ~ 1.5%



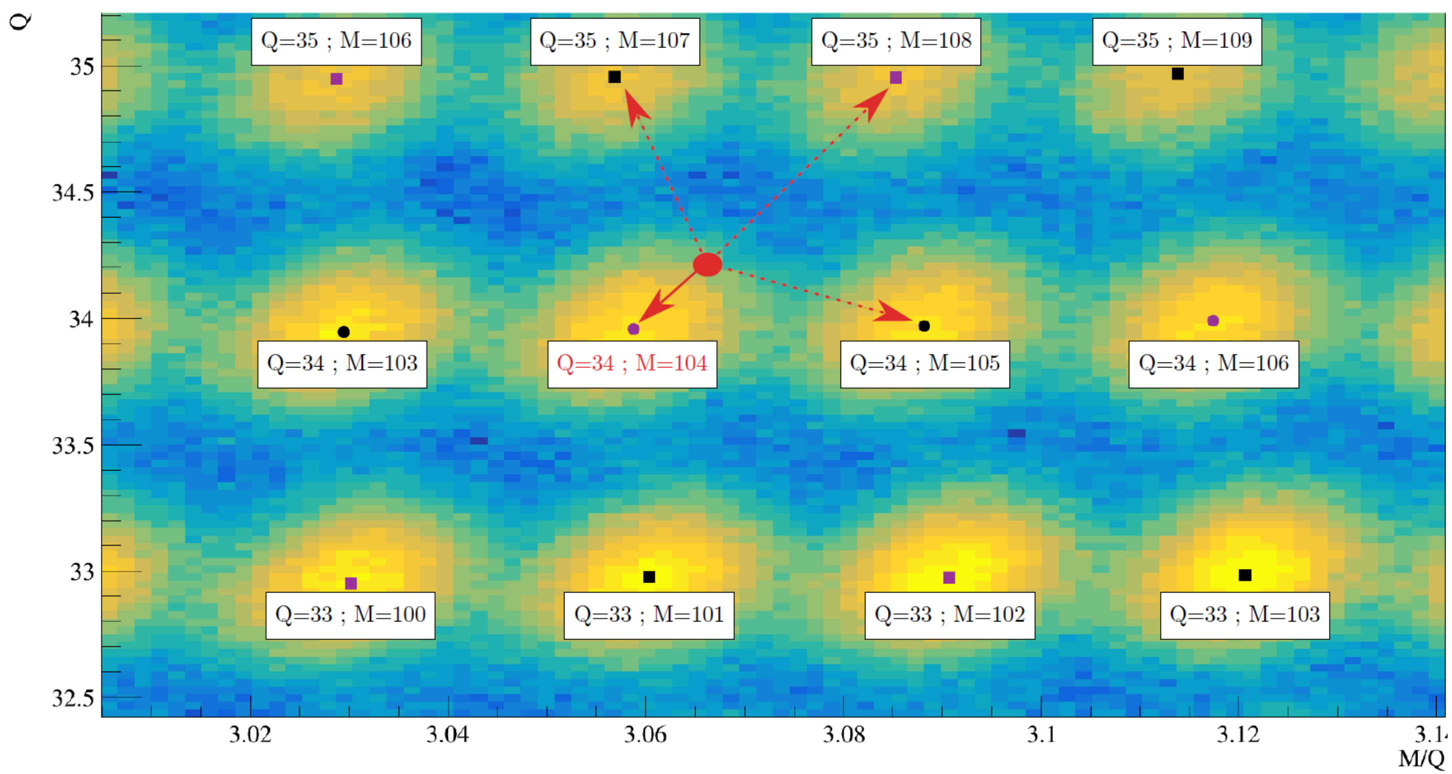
Fission-fragments identification



Mass identification

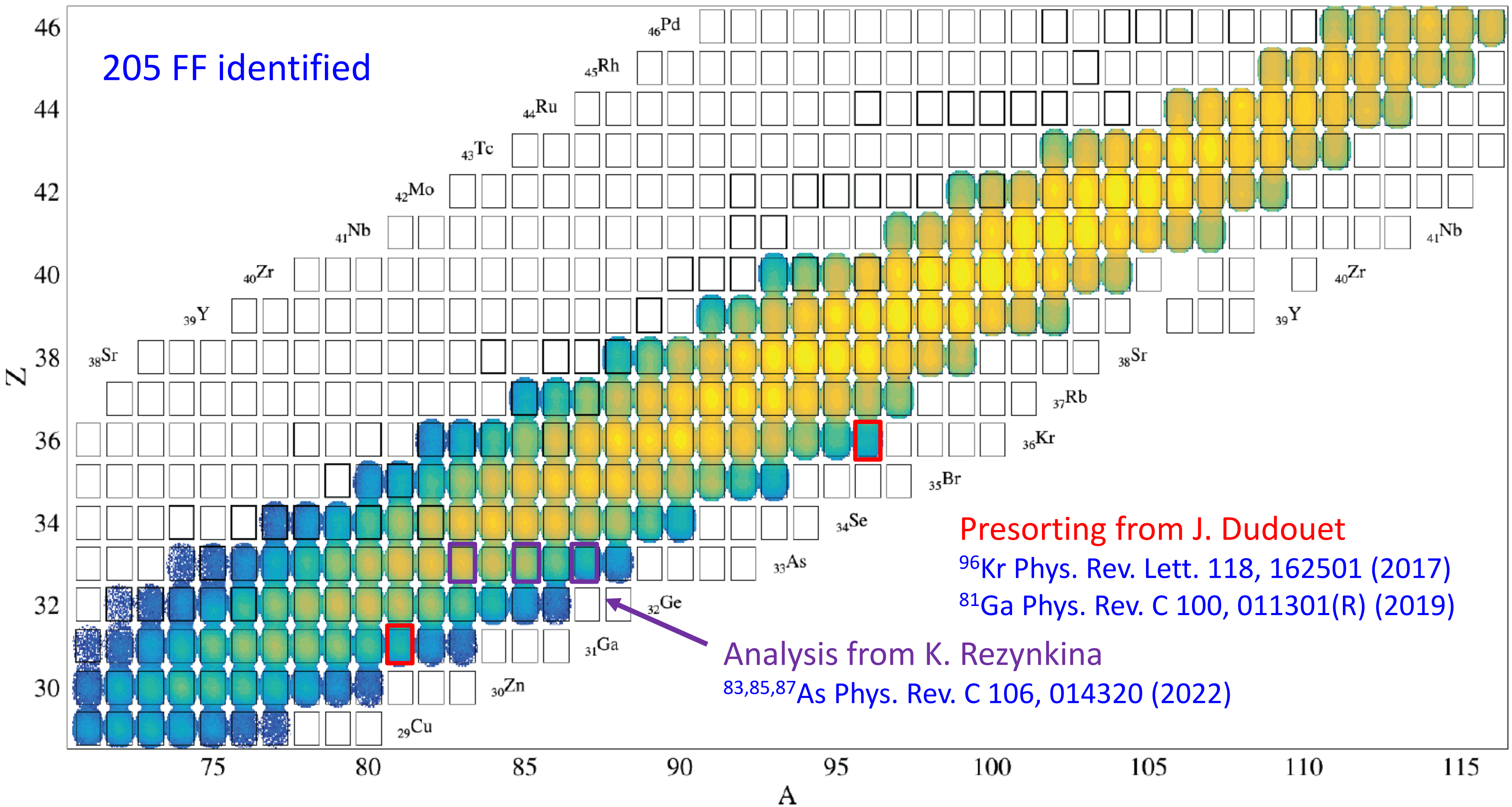
- distance to marker is used as a quality factor

Final mass resolution ΔM/M ~ 0.6%

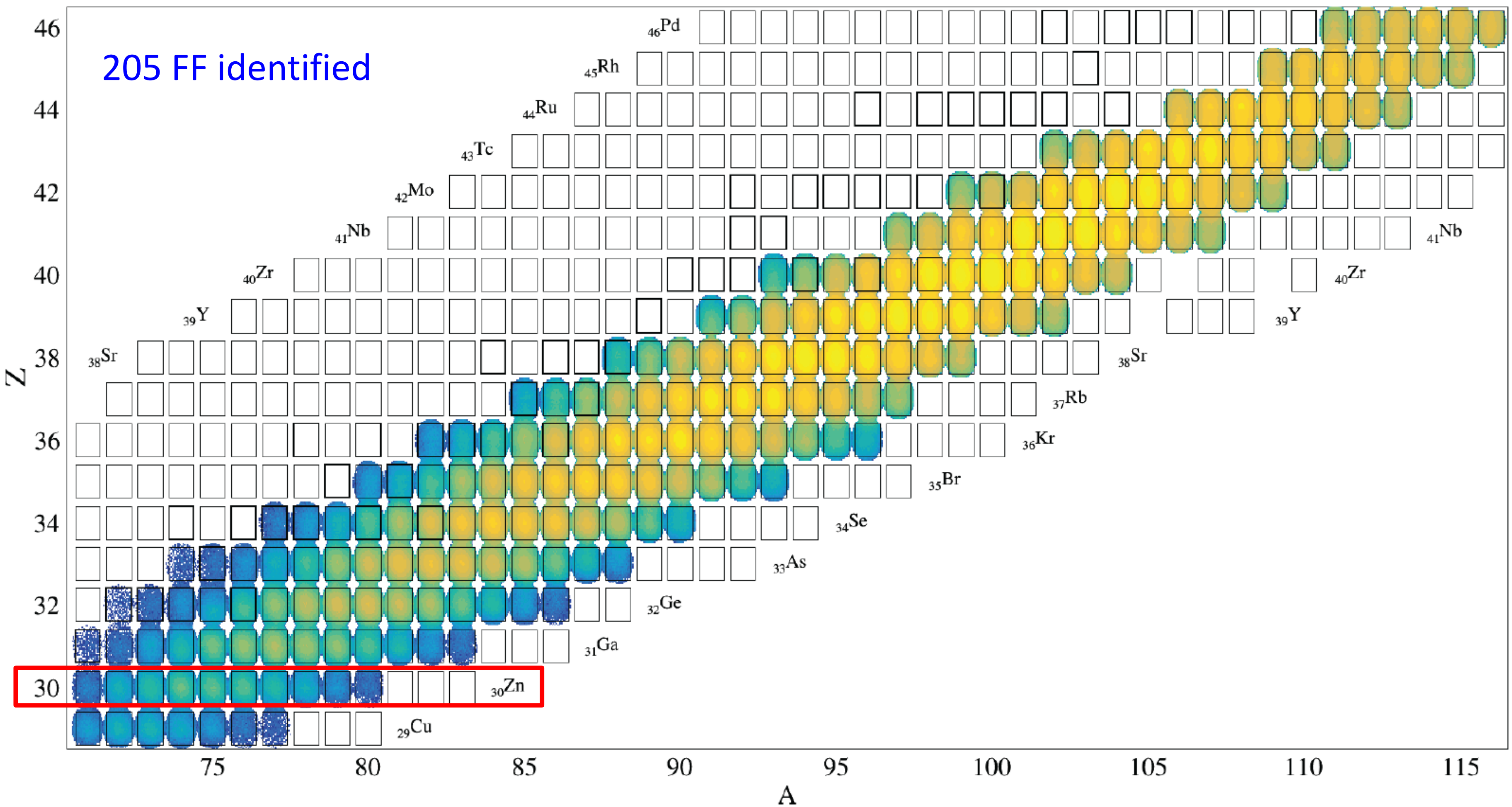


G. Duchêne

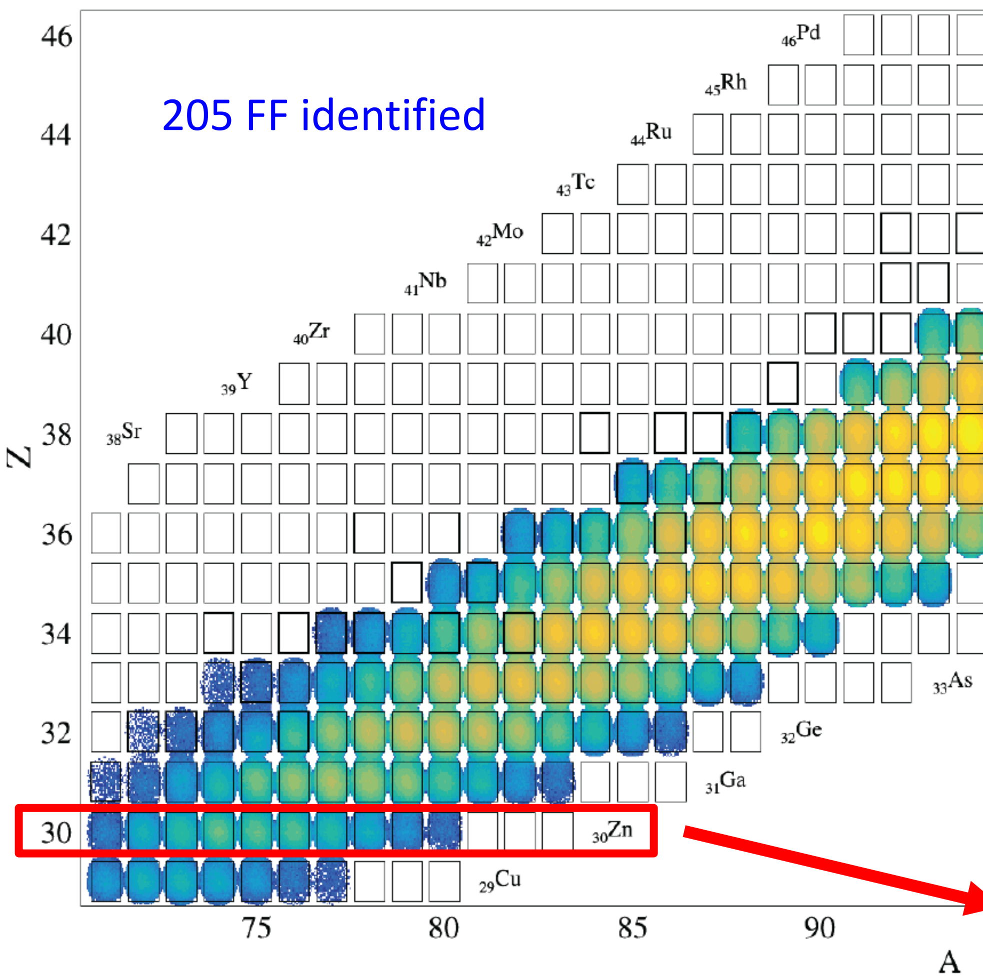
Fission-fragments selection

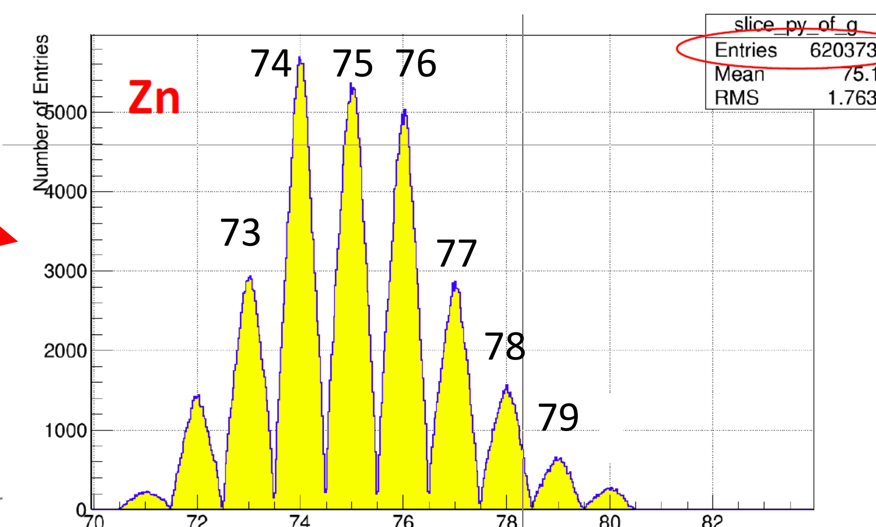


Fission-fragments selection

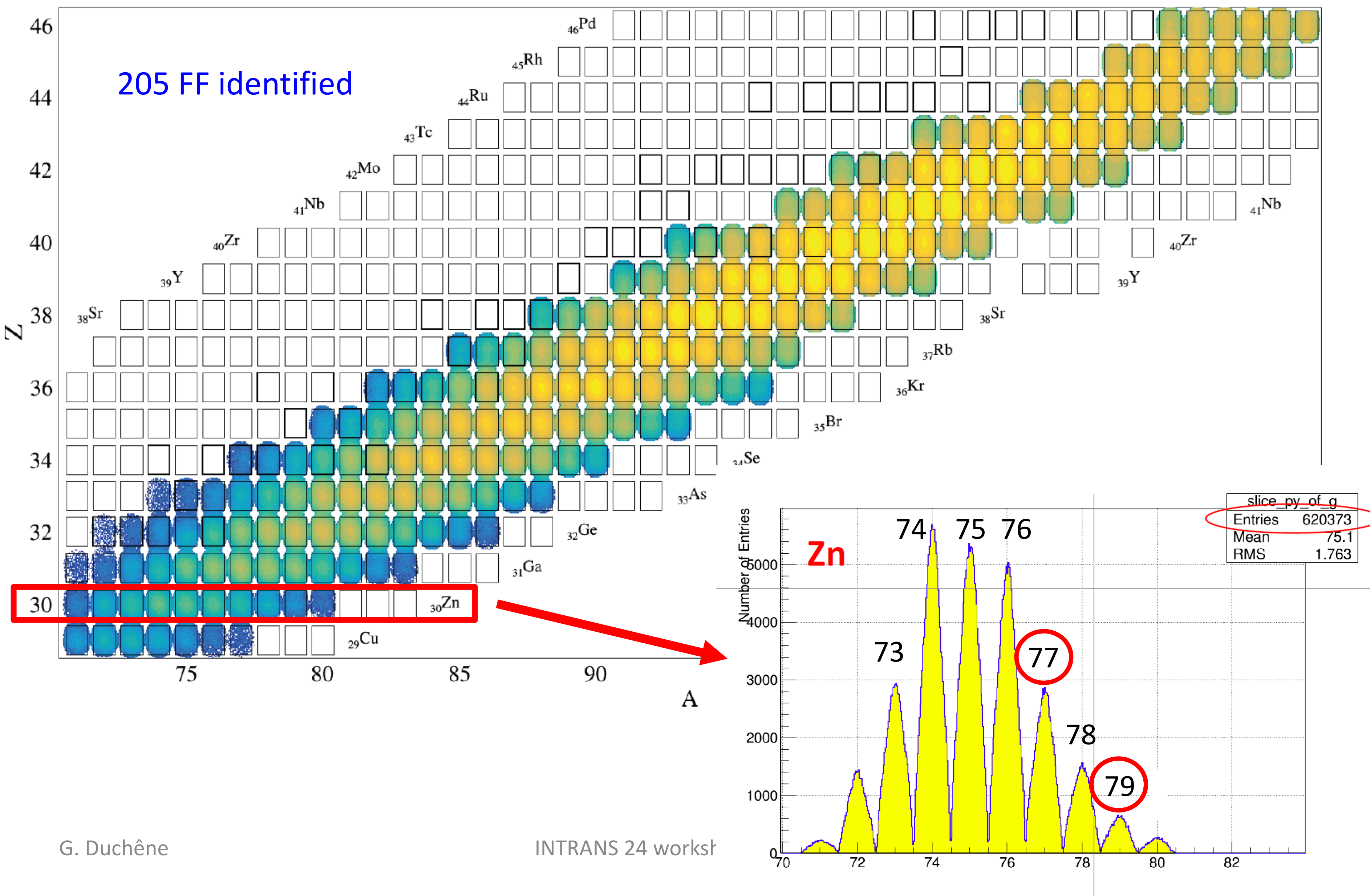


Fission-fragments selection



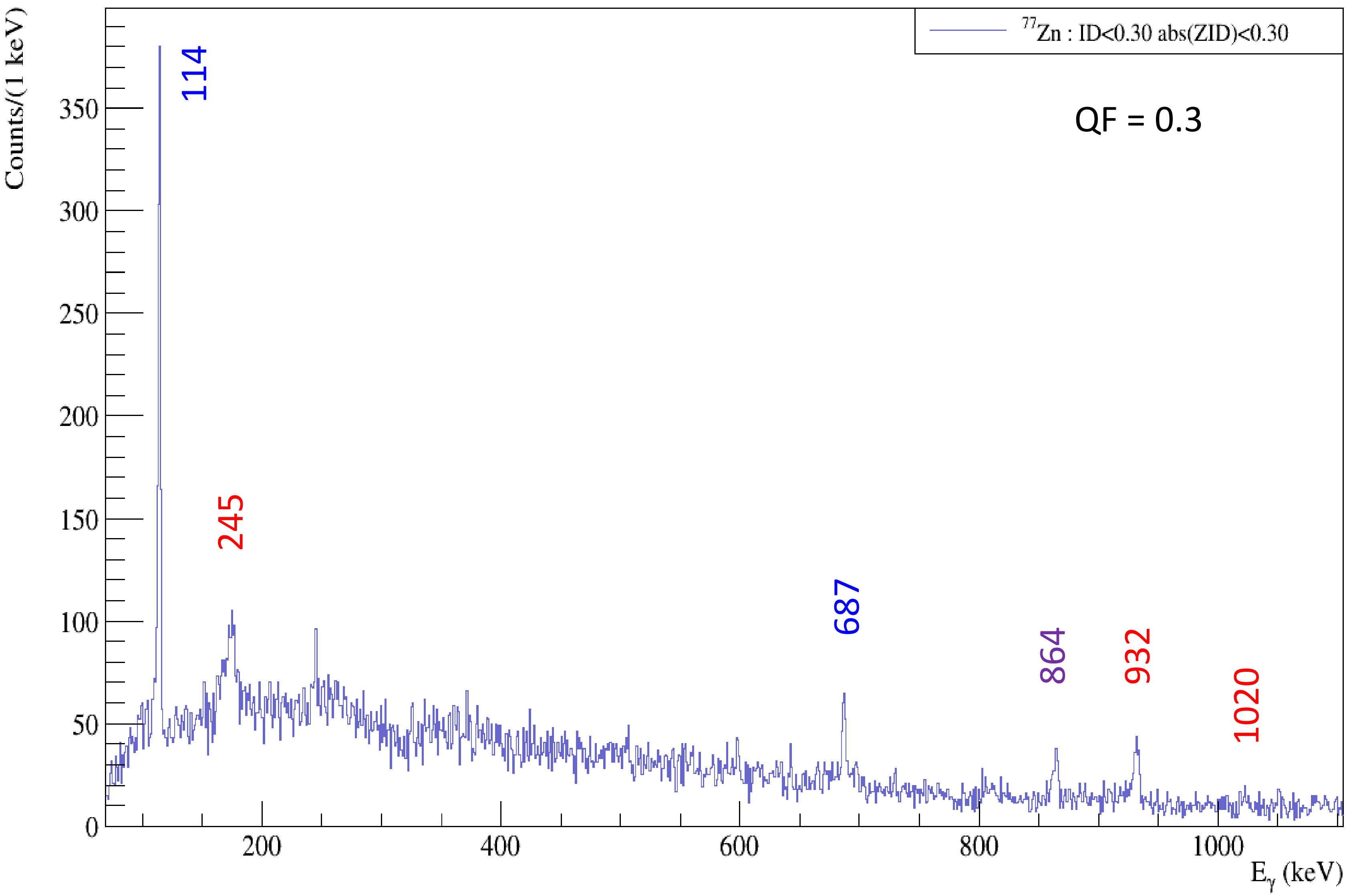


Fission-fragments selection



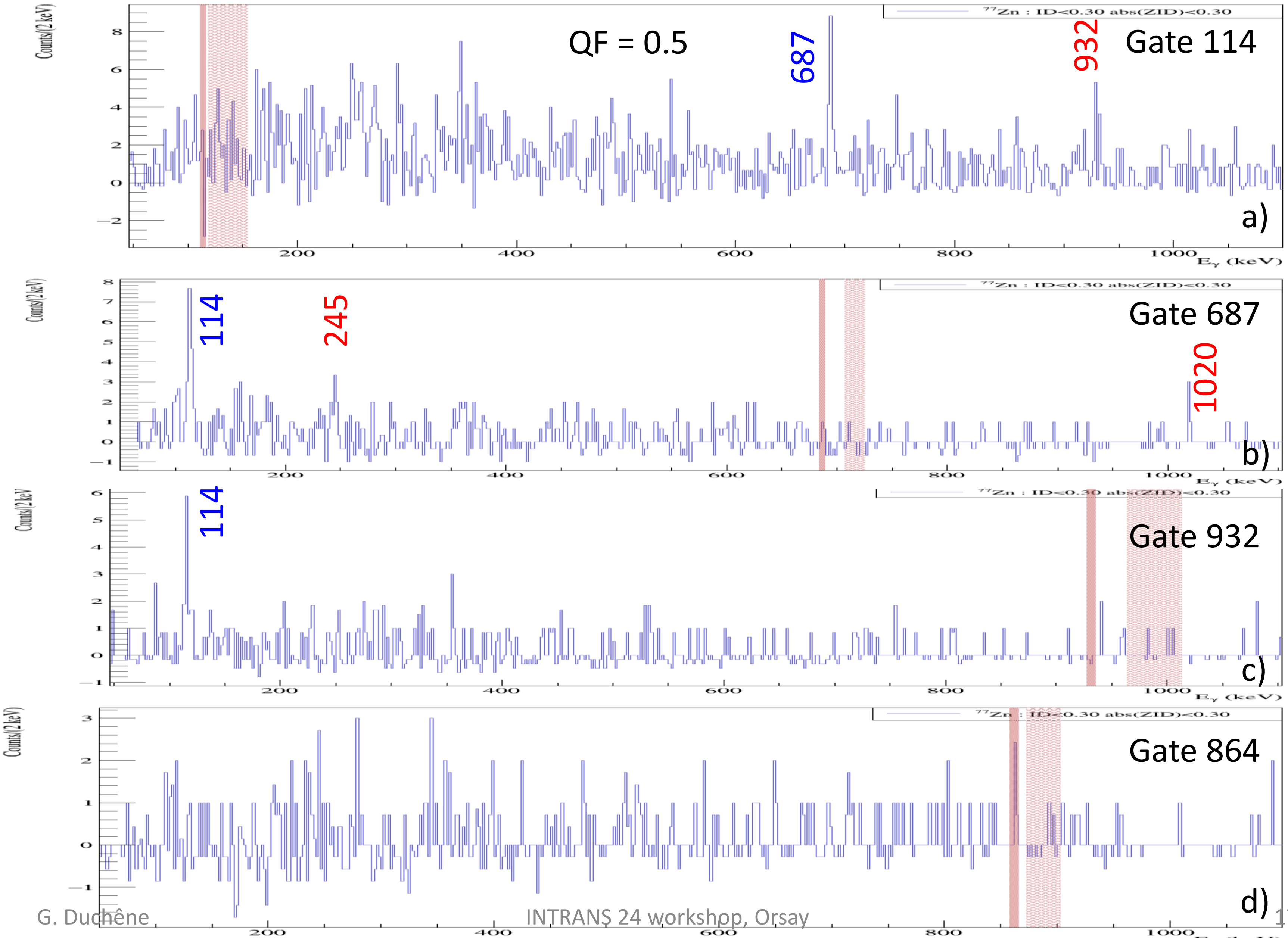
^{77}Zn

^{77}Zn



^{77}Zn : ID<0.30 abs(ZID)<0.30
QF = 0.3
Counts/(1 keV)
0
50
100
150
200
250
300
350
200
400
600
800
1000
E_γ (keV)
114
245
687
864
932
1020

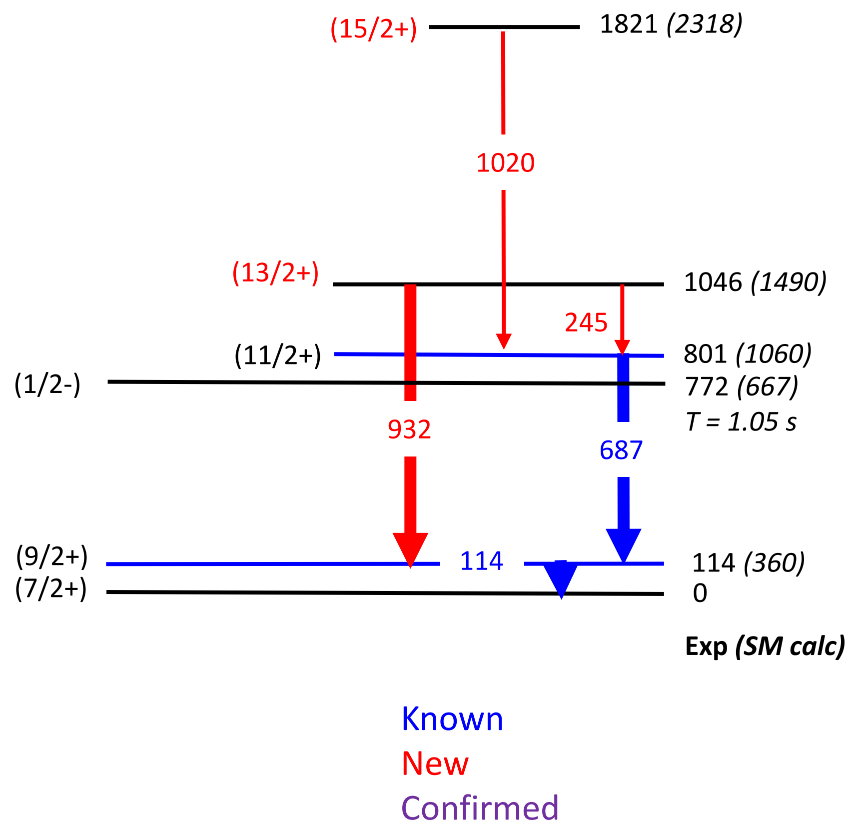
^{77}Zn


QF = 0.5
687
932
Gate 114
a)
114
245
Gate 687
1020
b)
114
Gate 932
c)
Gate 864
d)
Counts/(2 keV)
E_γ (keV)
^{77}Zn : ID<0.30 abs(ZID)<0.30

^{77}Zn

Gamma rays observed in e680 data

114, 687, 245, 864, 932, 1021 (2 keV/c)



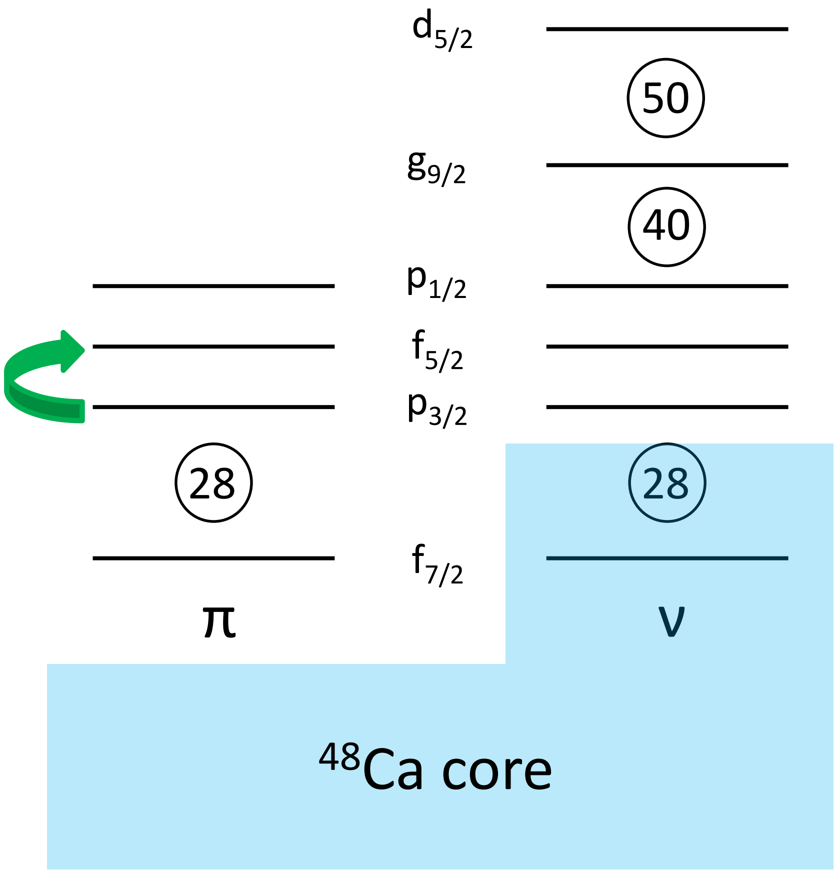
^{77}Zn

Shell-model calculations LNPS-U interaction
(F. Nowacki)

^{48}Ca core
Valence space: π full pf and ν $p_{3/2}f_{5/2}p_{1/2}d_{5/2}g_{9/2}$
11p – 11h excitations

$7/2^+$ and $9/2^+$ dominated $\pi(f_{5/2})^2$ $\nu(g_{9/2})^7$
$15/2^+$ dominated $\pi(p_{3/2}f_{5/2})$ $\nu(g_{9/2})^7$

π=+ states are driven by π excitations

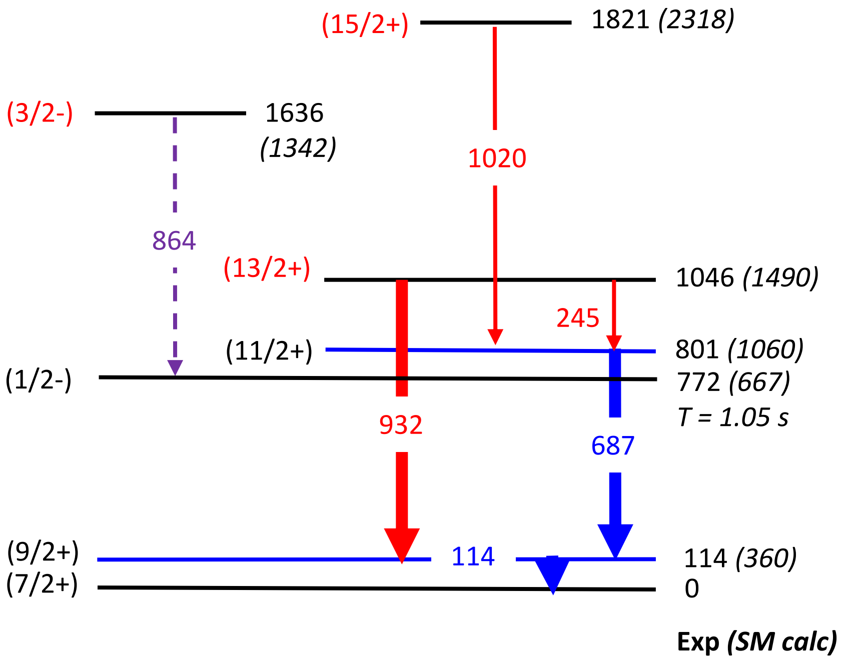


^{77}Zn

Gamma rays observed in e680 data
114, 687, 245, 864, 932, 1021 (2 keV/c)

No coincident gamma-ray with the 864 keV.
No corresponding SM prediction for direct decay to g.s.

So 864 keV may feed directly the ½- isomeric (1.05 s) state which lies at 772 keV
The transition decays a π=- state



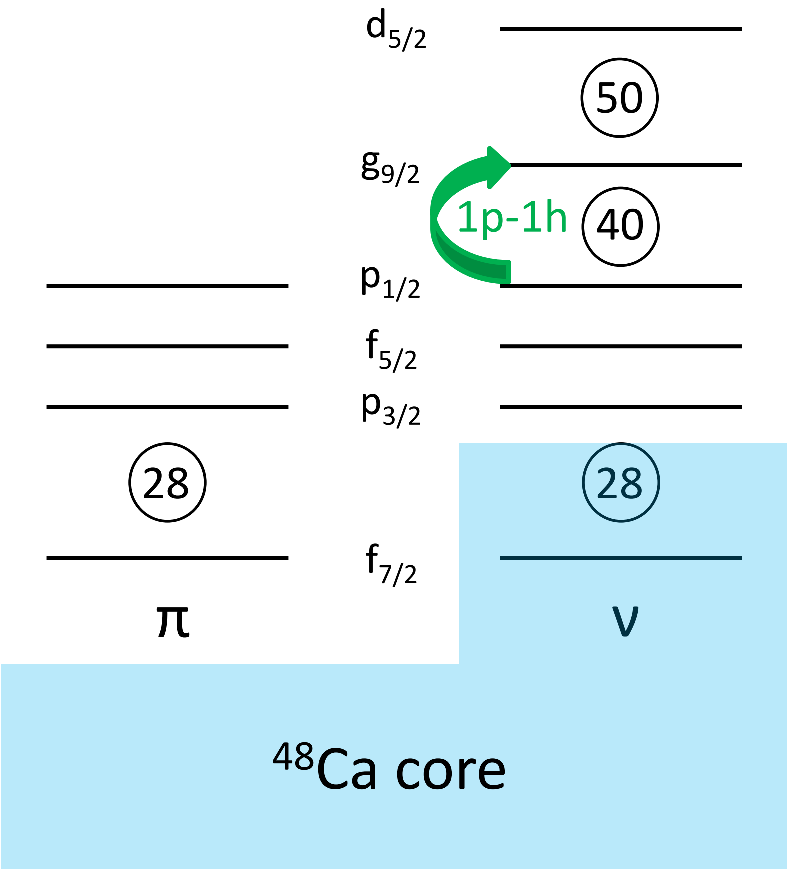
Known
New
Confirmed

^{77}Zn

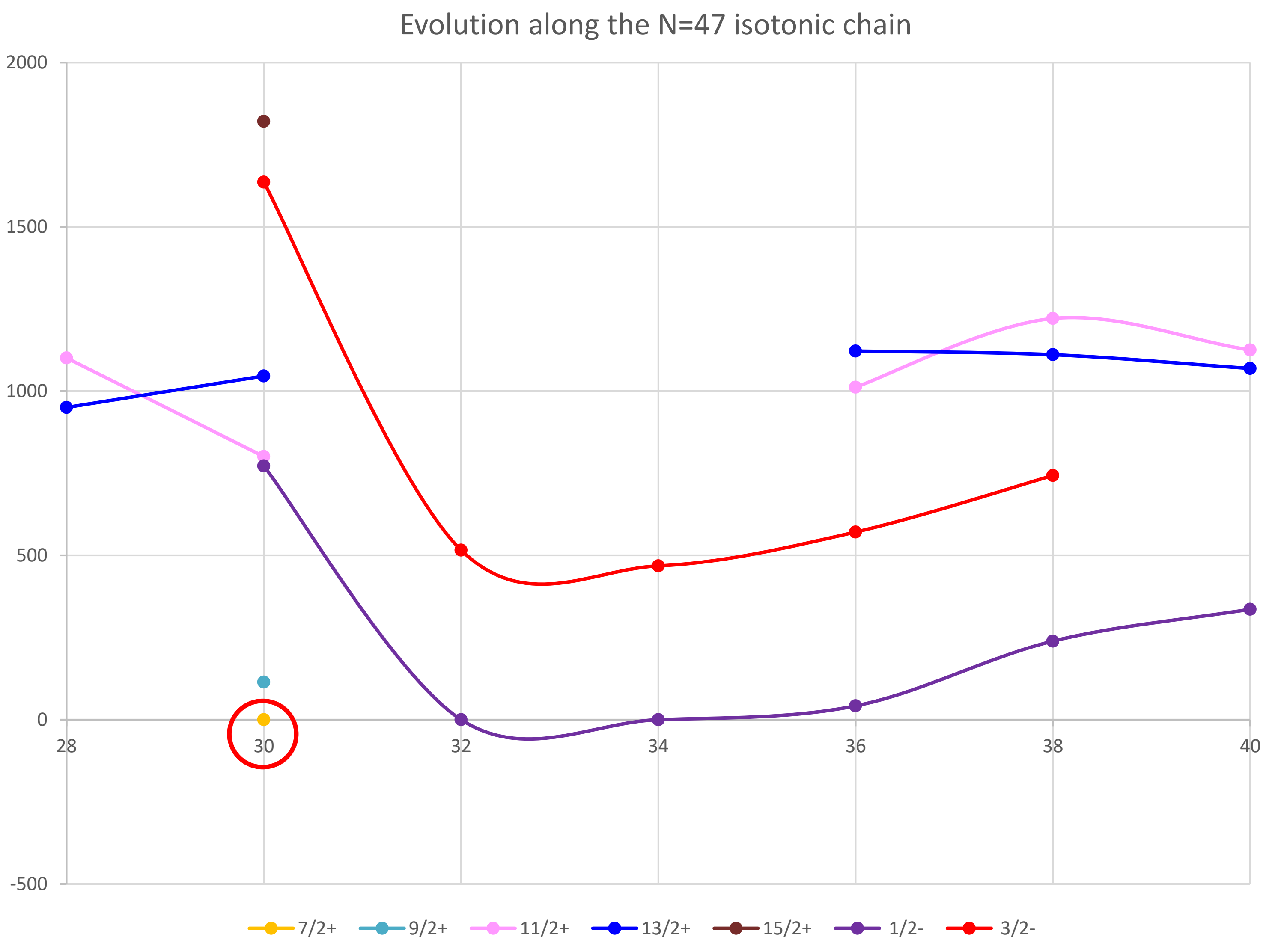
Shell-model calculations LNPS-U interaction

^{48}Ca core
Valence space: π full pf and ν $p_{3/2}f_{5/2}p_{1/2}d_{5/2}g_{9/2}$
11p – 11h excitations

π=- states are dominated $\nu(p_{1/2})^{-1}(g_{9/2})^8$ excitation across the N=40 gap



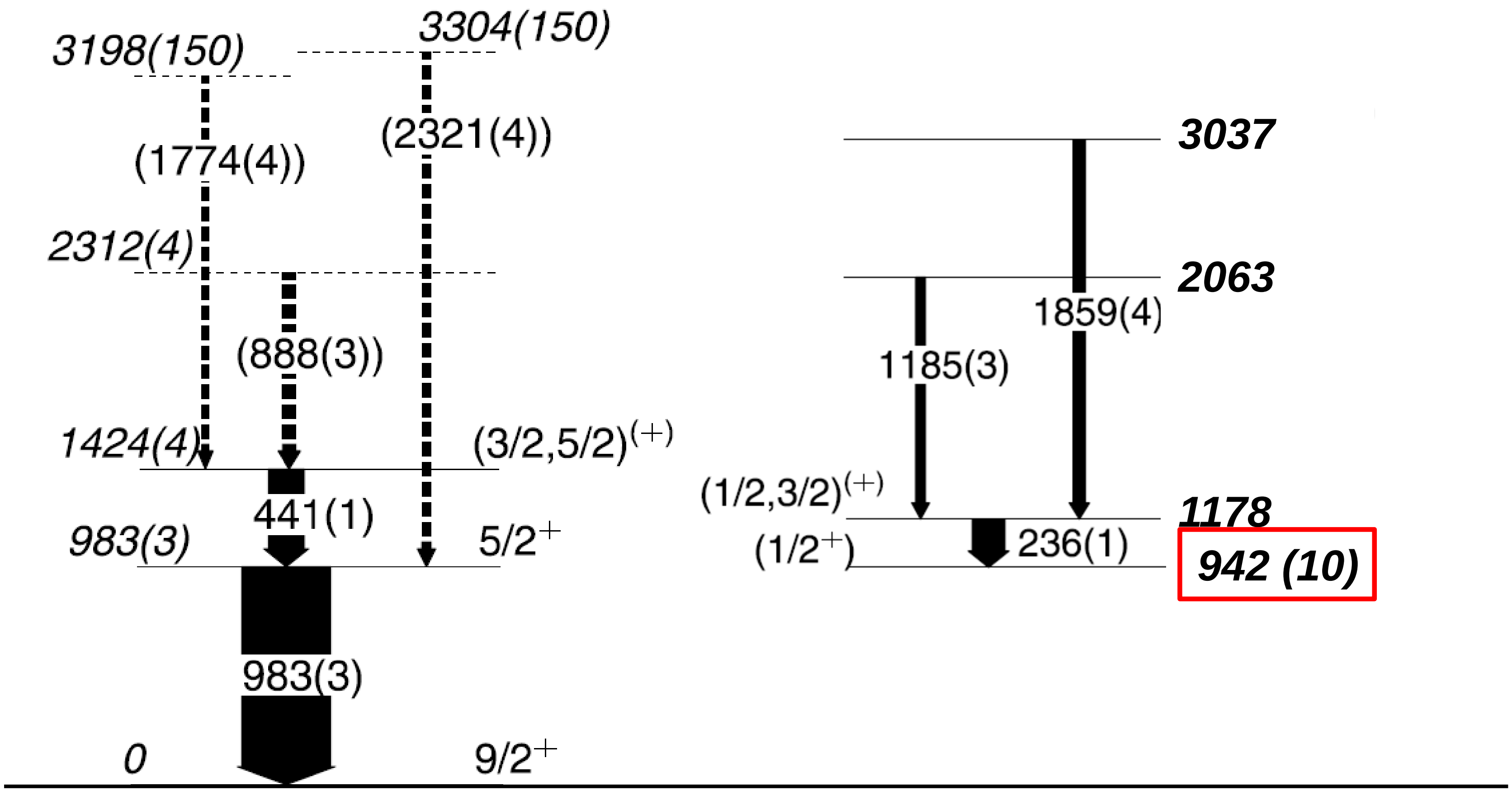
^{77}Zn


Evolution along the N=47 isotonic chain
2000
1500
1000
500
0
-500
28
30
32
34
36
38
40
7/2+
9/2+
11/2+
13/2+
15/2+
1/2-
3/2-

^{79}Zn

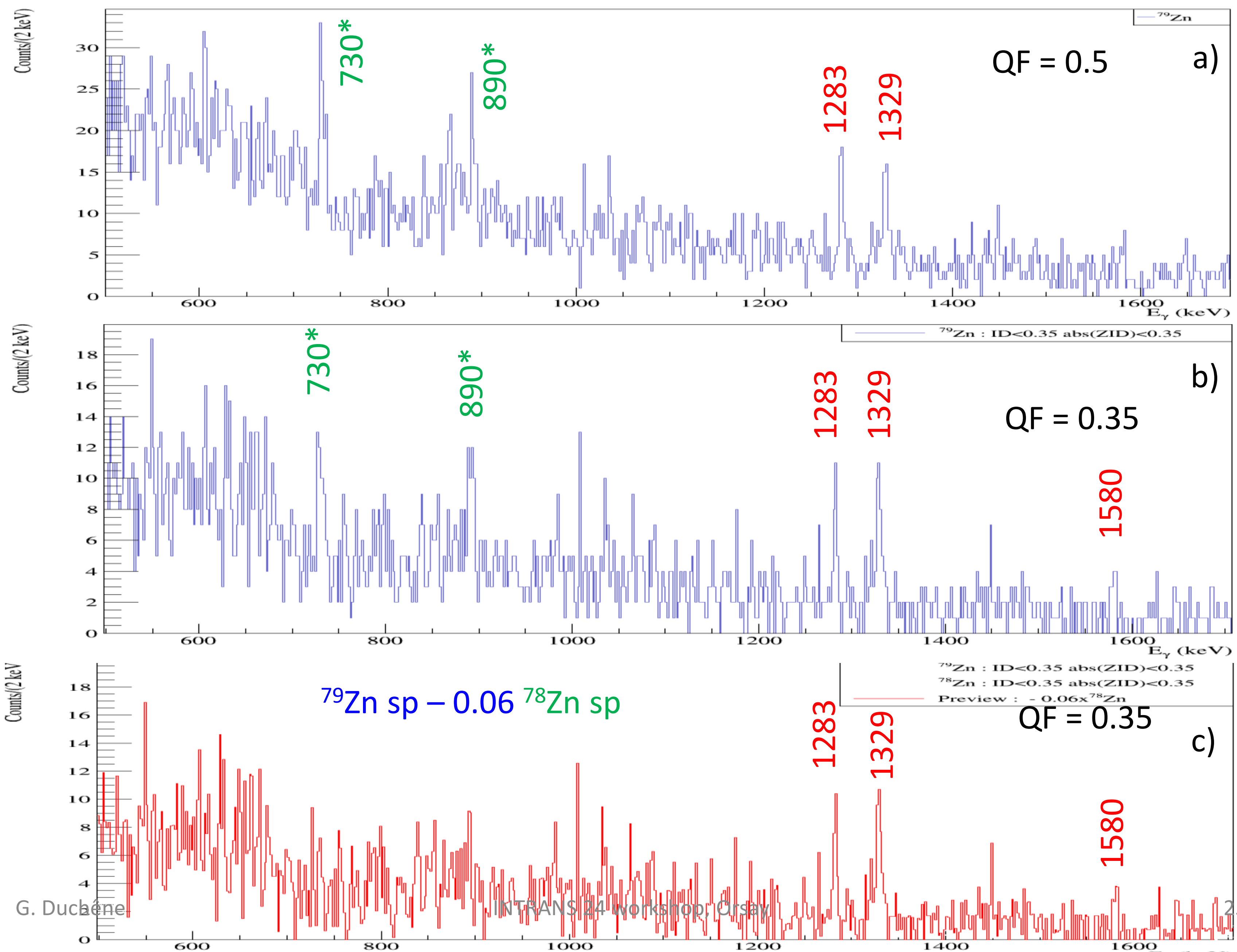
^{79}Zn

Known level scheme from
Orlandi et al., Phys Lett B740, 298 (2015)
and Nies et al., Phys Rev Lett 131, 222503 (2023)



* ^{78}Zn contaminants

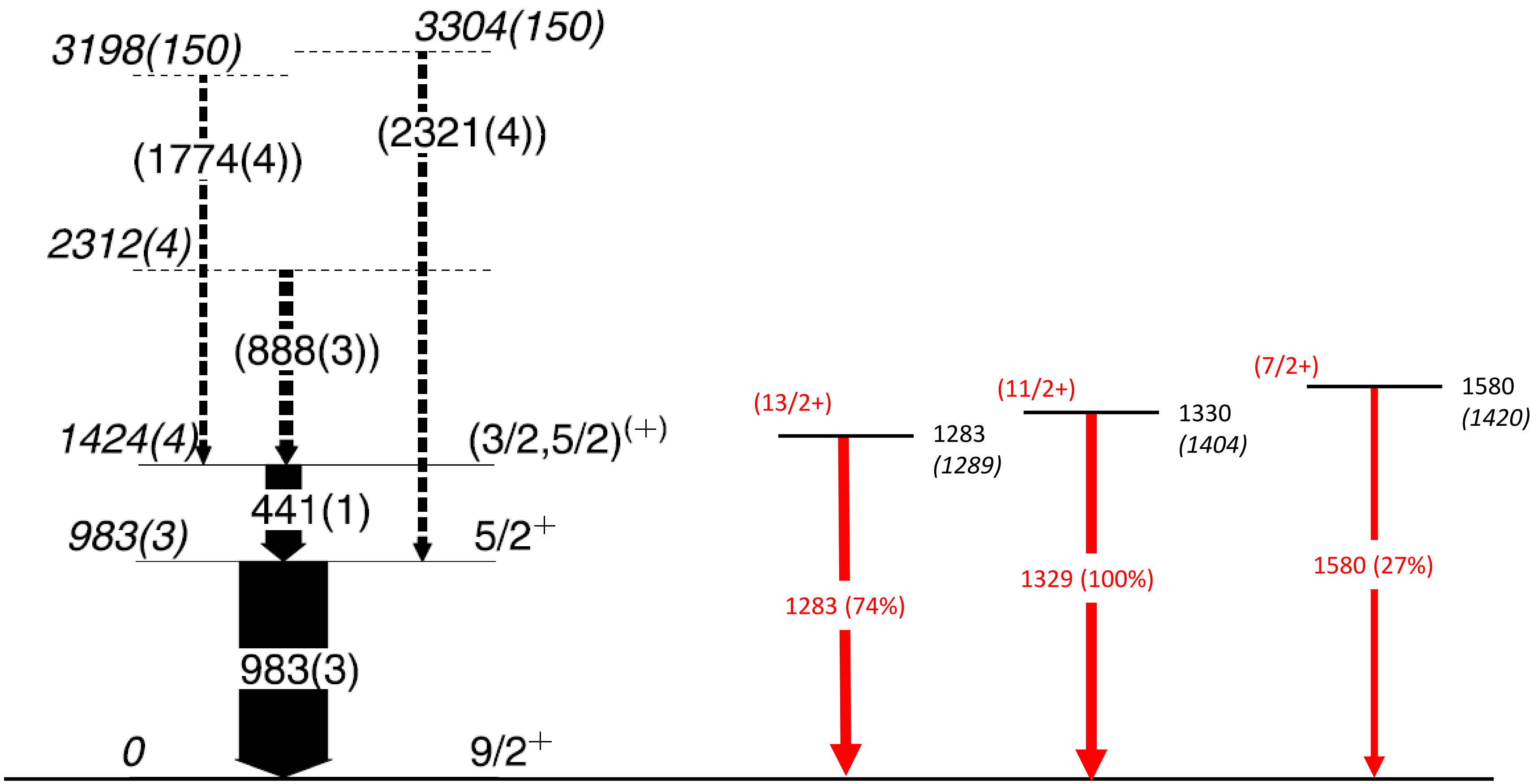
^{79}Zn



^{79}Zn

Gamma observed in e680 data

1283, 1329, 1580 (2 keV/c)



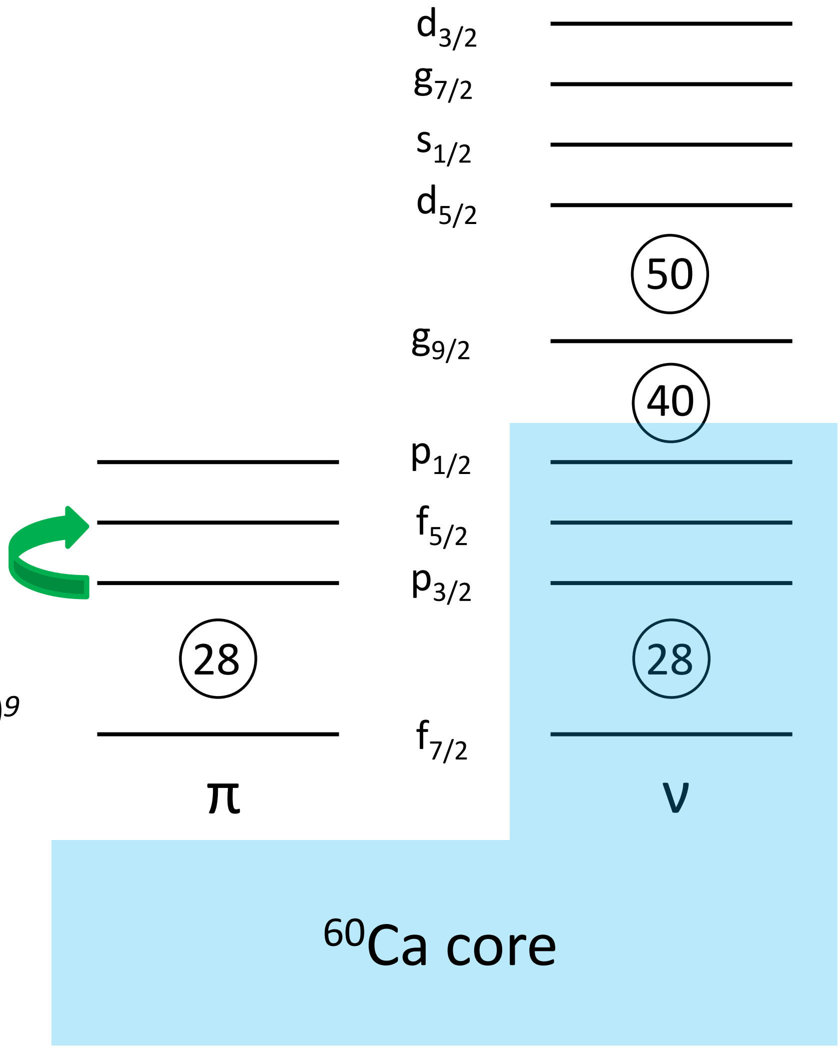
^{79}Zn

Shell-model calculations PFSDG interaction

^{60}Ca core
Valence space: π full pf and ν full sdg
6p – 6h excitations

$7/2^+$ and $9/2^+$ dominated $\pi(f_{5/2})^2\ \nu(g_{9/2})^9$
$11/2^+$ and $13/2^+$ dominated $\pi(p_{3/2}f_{5/2}p_{1/2})\ \nu(g_{9/2})^9$

π=+ states are driven by π excitations into the pf shell



^{79}Zn

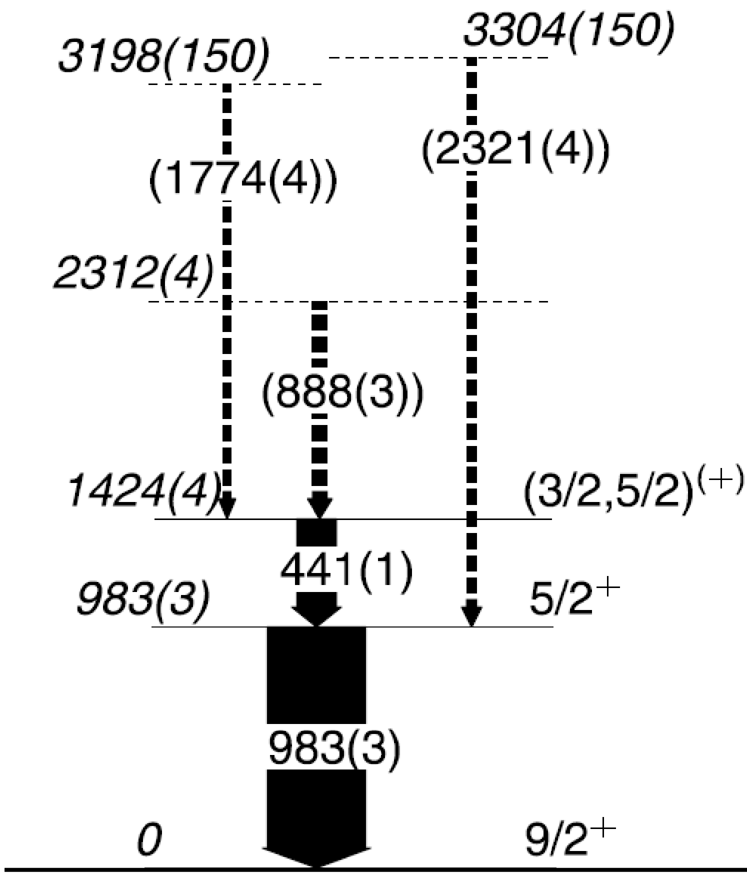
Gamma observed in e680 data

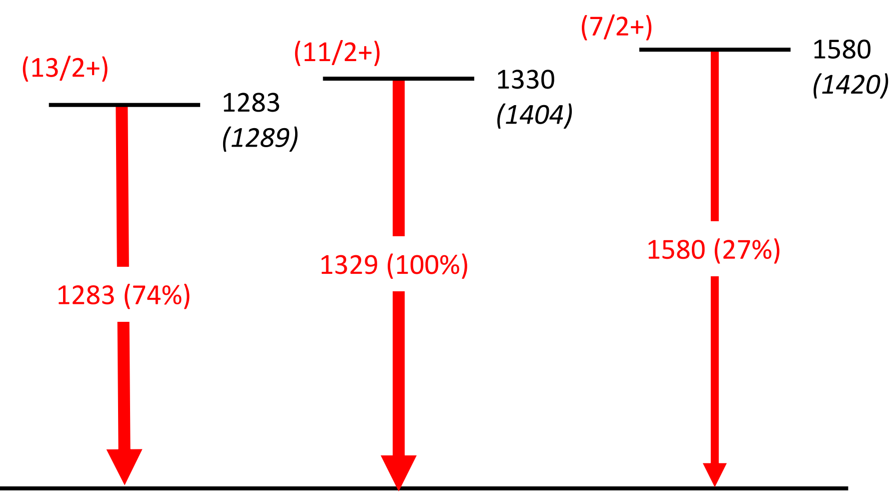
1283, 1329, 1580 (2 keV/c)

States with very similar configurations

$\nu(g_{9/2})^{-1} \otimes 2^{+}$ (^{80}Zn) vibrational coupling

Generates a 9 states multiplet $1/2^{+}$ to $17/2^{+}$





Conclusions and perspectives

Conclusion and perspectives

Conclusion

In $^{77,79}Zn$, single –particle excitations dominate the low-lying spectra

No xp – xh excitations across gaps leading to deformed structures could be evidenced which confirms Rocchini's expectations and draws the upper border of the island of inversion to N<47 in Zn isotopes

Perspectives

Complete the theoretical analysis for A=73, 75

Develop an isotopic systematic

…and publish!!!

Analyse the Nu-Ball 2 data for Zn and Ga isotopes

1. ***G. Duchêne****, F. Didierjean, D.D. Dao* ***F. Nowacki****, Ch. Schmitt,*
Université de Strasbourg, CNRS, IPHC UMR 7178, F-67000 Strasbourg – F

2. ***J. Dudouet****, G. Maquart, O. Stezowski,*
Université Lyon, Université Claude Bernard Lyon , CNRS/IN2P3, IP2I Lyon – F

3. G. de France, E. Clément, B. Jacquot, A. Lemasson, A. Navin, M. Rejmund,
GANIL, CEA/DRF-CNRS/IN2P3, BP 55027, 14076 Caen Cedex 5 – F
4. C. Michelagnoli,
Institut Laue-Langevin, 71 avenue des Martyrs, 38042 Grenoble Cedex 9 - F

5. D. Verney, A. Astier, C. Delafosse, I. Deloncle, A. Gottardo, T. Konstantinopoulos, A. Korichi,
F. Le Blanc, R. Lozeva, C.M. Petrache,
Université Paris-Saclay, CNRS/IN2P3, IJCLab, 91405 Orsay – F

6. M. Ramdhane, LPSC, Université Grenoble-Alpes, CNRS/IN2P3, Grenoble – F

7. G. de Angelis, D.R. Napoli, INFN LNL, Legnaro – It

8. S. Lenzi, INFN and University of Padova – It

9. B. Million, INFN and University of Milano – It

10. G. Li, GSI, Darmstadt – G

11. C. Lizarazo, N. Pietralla, D. Ralet, IKP Tecknische Universität Darmstadt – G

12. A. Gadea, R. Perez, CSIC-Instituto de Fisica Corpuscular, Valencia – Sp

13. B.Z. Dombradi, I. Kuti, D. Sohler, MTA ATOMKI, Debrecen – Hu

14. P. Jones, iTemba LABS, National Research Fondation, Somerset West – South Africa

15. C. Andreoiu, Simon Fraser University – Ca

Thank you for your attention