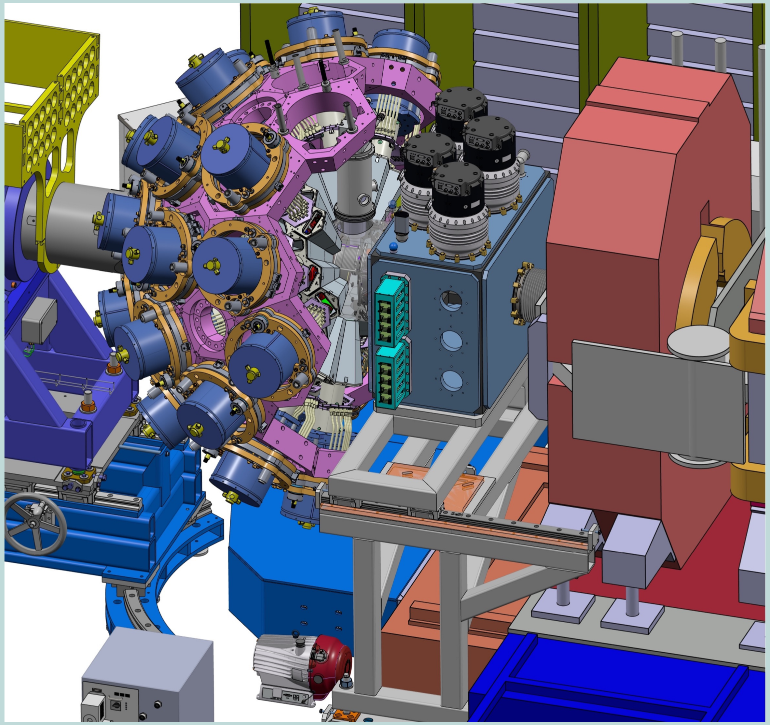
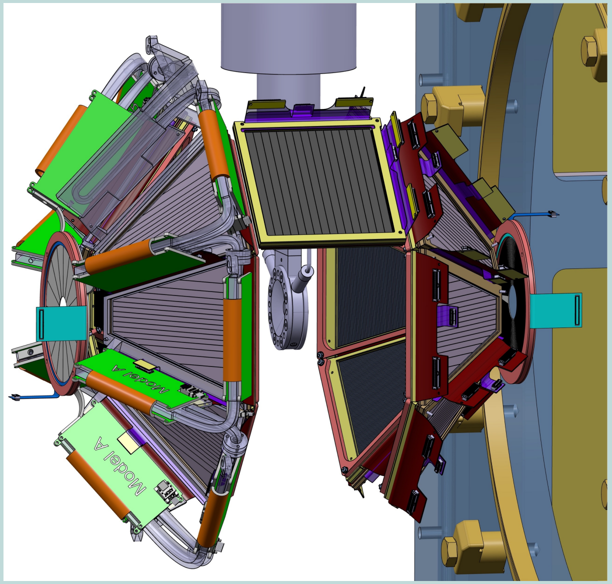
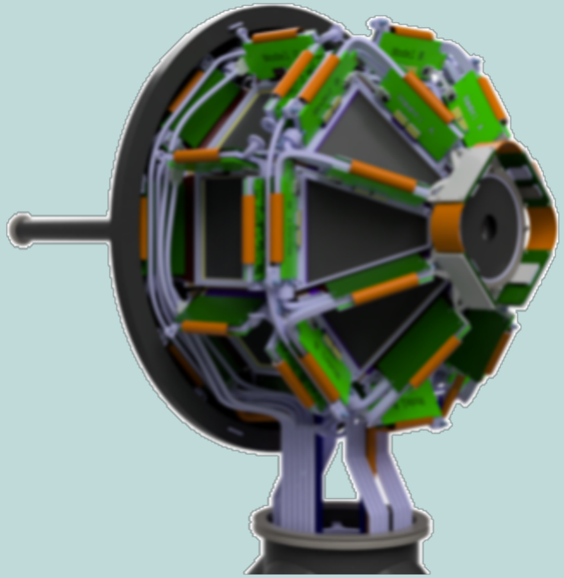






GRIT-AGATA-VAMOS @ GANIL

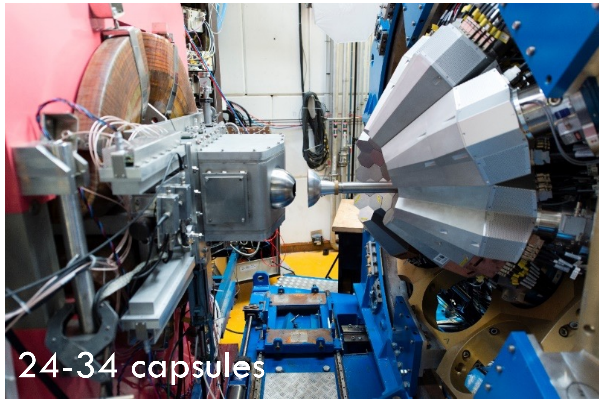
Marlène Assié, IJCLab

2029-2030

FIRST AGATA CAMPAIGN AT GANIL

927 UT have been approved
821 UT have been performed over 29 experiments (90 % done)

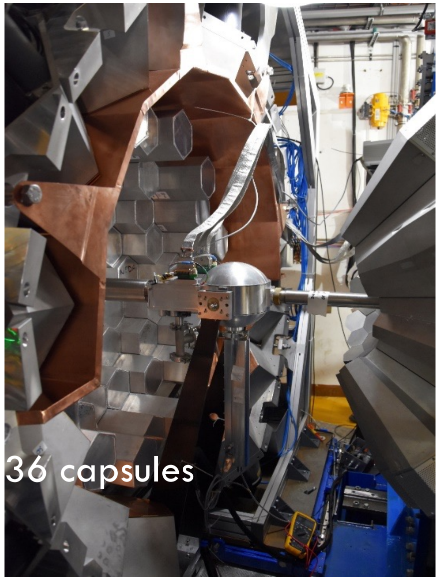
2015-2017



AGATA coupled to VAMOS, FATIMA, PARIS

Exotic nuclei spectroscopy by MNT transfer and fission reaction

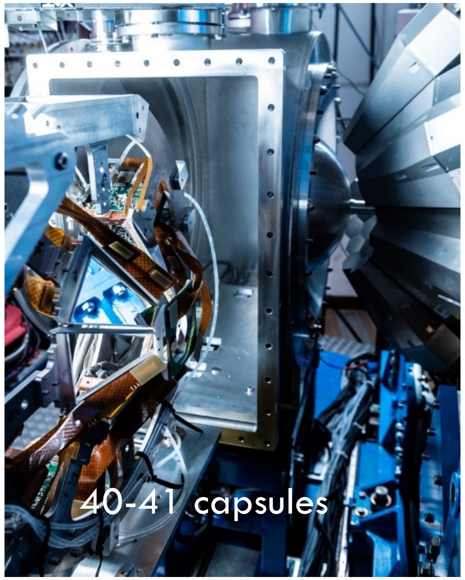
2018



AGATA coupled to NEDA- DIAMANT

N~Z nuclei spectroscopy by fusion evaporation

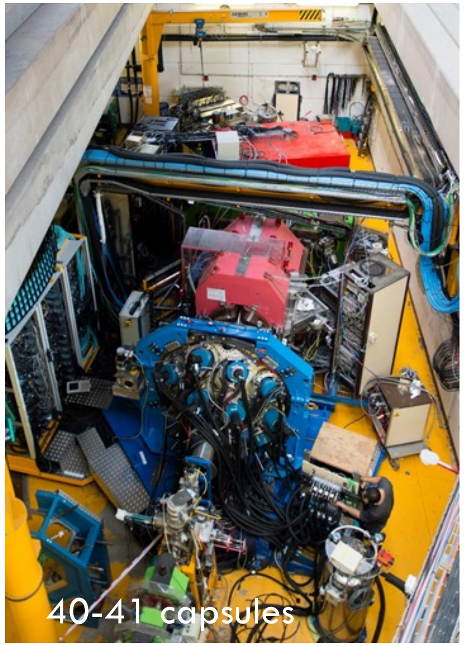
2019-2021



AGATA coupled to VAMOS-MUGAST

Exotic nuclei spectroscopy by transfer reaction using RIB

2021



AGATA coupled to VAMOS, EXOGAM, 2nd Arm, LEPS

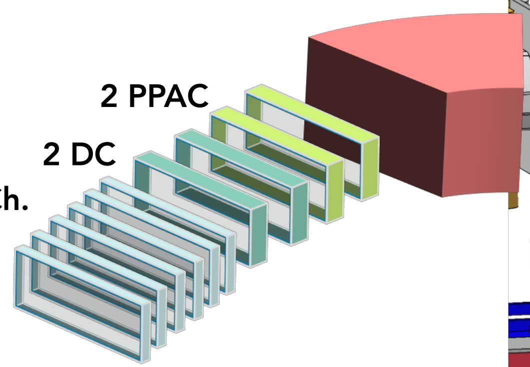
Exotic nuclei spectroscopy by MNT transfer

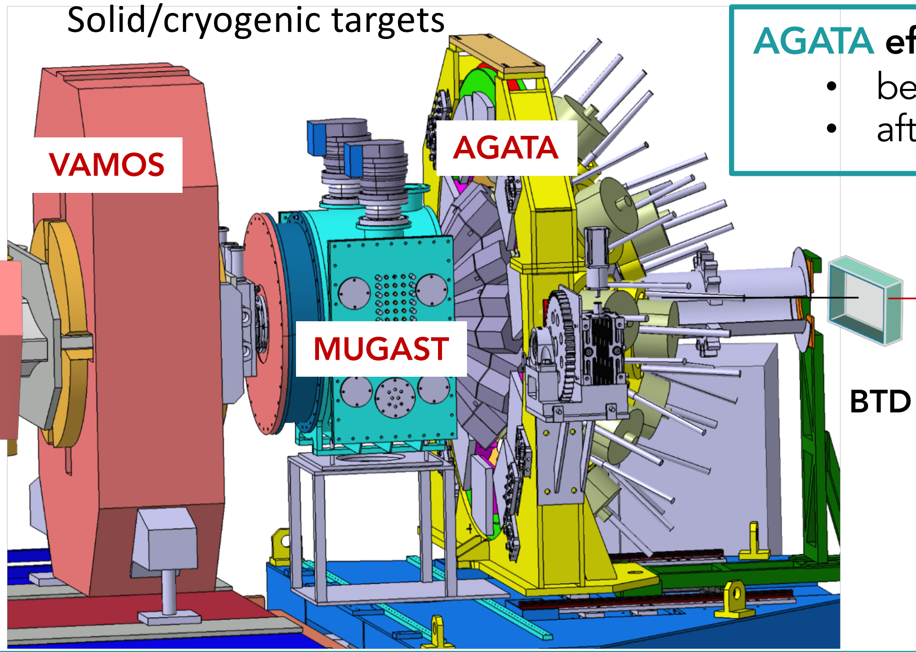
MUGAST-AGATA-VAMOS SET-UP @ GANIL WITH SPIRAL1 BEAMS

An extremely complete set-up for transfer reactions measurement with RIB

M. Assié et al, ***NIMA (2021)***

VAMOS
Acceptance of VAMOS : +/- 6 deg
Numerical electronics NUMEXO2

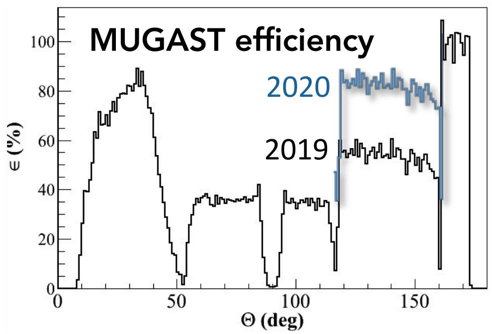




AGATA efficiency (18cm) at 1.3 MeV:

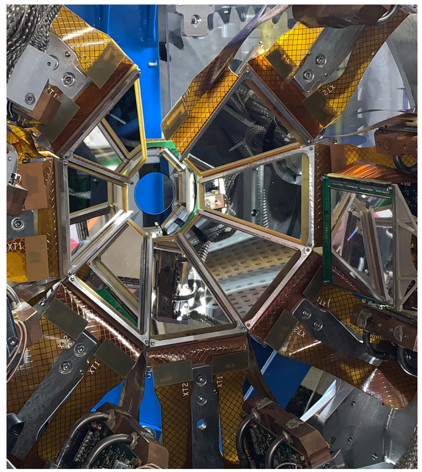
- before add-back : 5.5%
- after add-back : ~8%

Spiral1 radioactive beams



MUGAST :

Forward : 4 MUST2 (128X+128Y) DSSD 300um + CsI
Backward : 5 in 2019 (7 in 2020) trapezoid (128X+128Y) DSSD 500um + **Annular (S1)**
90 deg : square (128X+128Y) DSSD 500um
Granularity : 0.4 deg
~ 3000 channels all read by MUST2 integrated electronics



MUGAST-AGATA-VAMOS CAMPAIGN AND THE REST OF THE PLAN

2019

UNBOUND STATES
Above barrier narrow resonances in ^{15}F
I. Stefan (IPN), F. de Oliveira (GANIL)

$^{14}O(p,p')$ with few 10^5 pps

*V. Girard-Alcindor, **PRC Lett. (2022)***

SHELL MODEL
Is there a problem with protons in N=28 nucleus ^{46}Ar ?
A. Gottardo INFN, M. Assié (IPN)
$^{46}Ar(^3He,d\gamma)^{47}K$ with 4. 10^4 pps

D. Brugnara et al, under review Nature Comm

NUCLEAR ASTROPHY.
Determining the α+^{15}O radiative capture rate
C. Diget (York), N De Séréville (IPN)
$^{15}O(^7Li,t\gamma)^{19}Ne$ with 4. 10^7 pps

J. Sanchez-Rojo et al, draft version

2020

SHELL MODEL
Lifetime measurements of 2_2^+ and 3_1^+ of ^{20}O by direct nucleon transfer
E. Clément (GANIL), A. Goasduf (INFN)

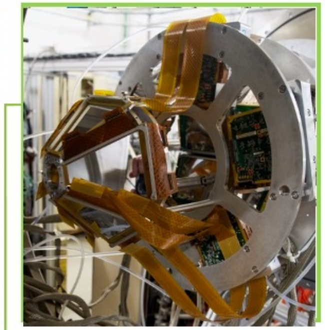
$^{18}O(d,p\gamma)$ + DSAM
*I. Zanon et al, **PRL (2023)***

2021

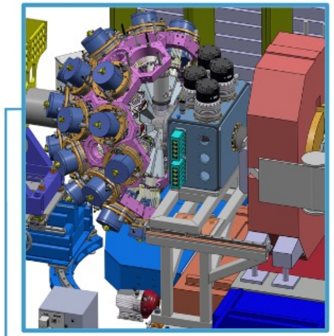
SHELL MODEL
Proton-neutron interactions across the N = 28 shell closure
W. Catford (Surrey), A. Matta (LPC)

$^{47}K(d,p\gamma)^{48}K$ neutron transfer
*C. Paxmann et al, **PRL (2025)***

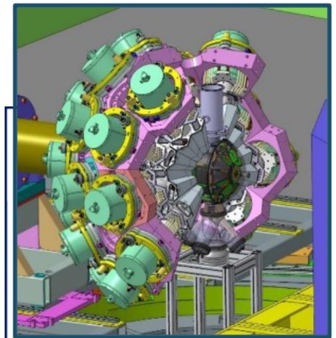
MUGAST-AGATA-VAMOS @GANIL



MUGAST-EXOGAM-LISE @GANIL



GRIT-AGATA @ GANIL



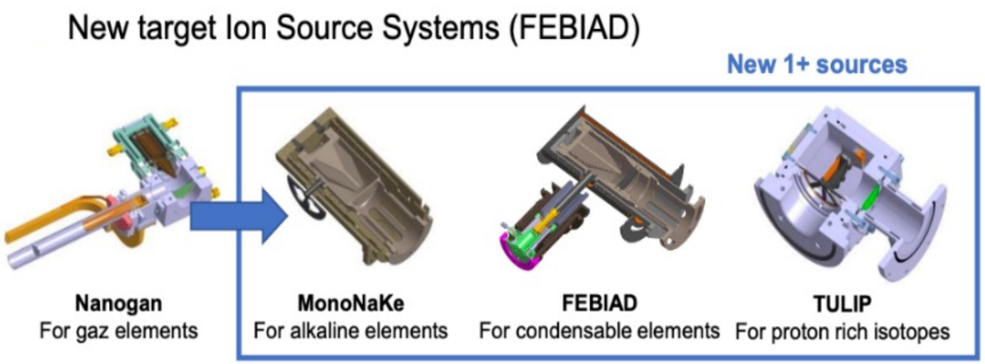
GRIT-AGATA @SPES

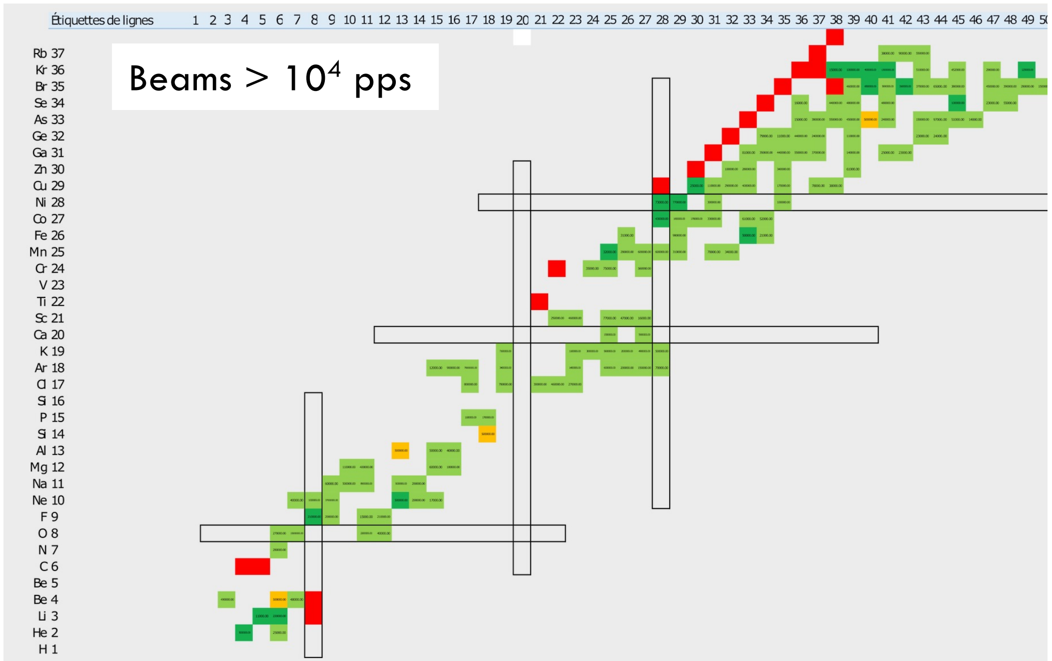
2019-2021 → 2023-2026 ? → 2029-2031 ? → 2032- ???

AGATA@GANIL.2: 0° degree campaign using the SPIRAL1 beams with GRIT and VAMOS

- SPIRAL1 radioactive beams:
  He, Ne, Ar, Kr, O, N, F, K beams are operational.

  Several tests have been performed in 2021-2023 leading to a list of 50 new isomers/isotopes with intensities suitable for acceleration using CIME



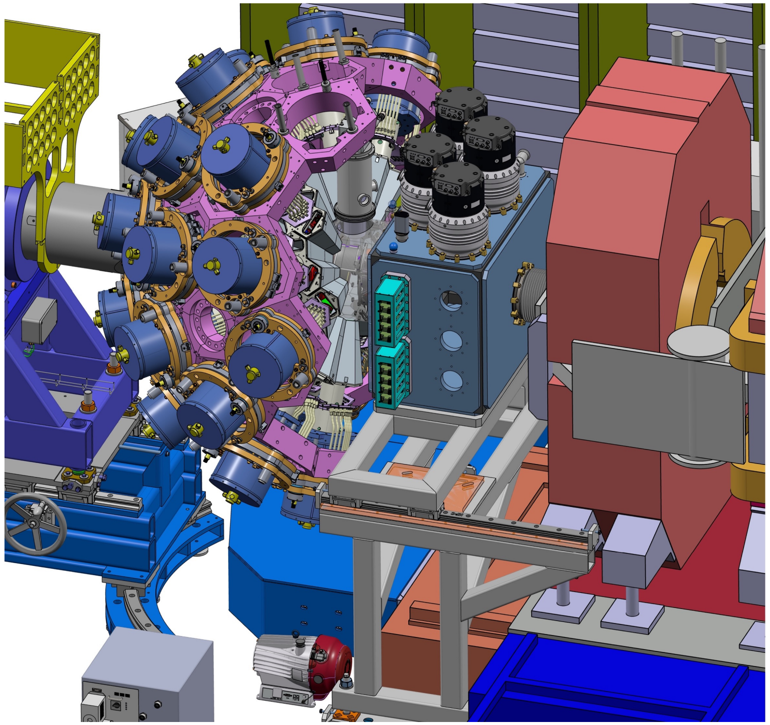


https://www.ganil-spiral2.eu/scientists/ganil-spiral-2-facilities/available-beams/

AGATA@GANIL.2: 0° degree campaign using the SPIRAL1 beams with GRIT and VAMOS

- GRIT-AGATA-VAMOS unique combination for triple coincidence measurement

AGATA: - high resolution and P/T ratio
- high efficiency
- high resolving power



2π simulation at 23 cm

Tracked ε@1.3 MeV ^{60}Co = 13%, P/T = 42%

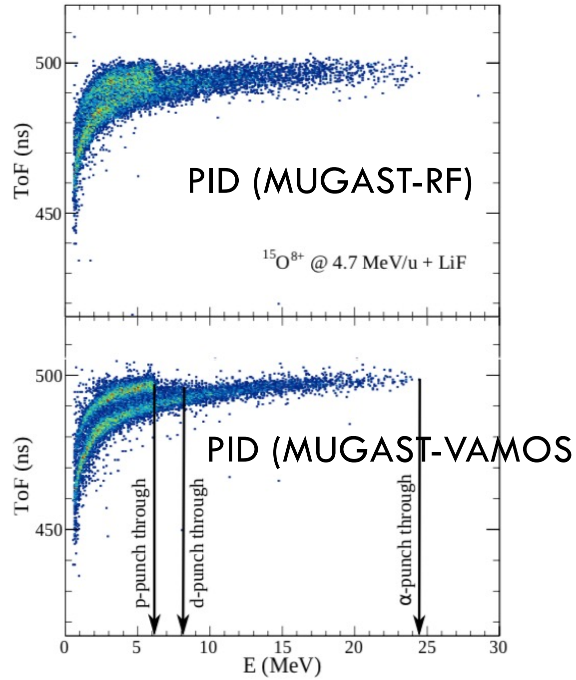
(EXOGAM -12 clovers same distance ~3%)

Resolving power of AGATA 2π is **one order of magnitude** better than EXOGAM in singles
and **without comparison at higher energies** or for DSAM measurement

AGATA@GANIL.2: 0° degree campaign using the SPIRAL1 beams with GRIT and VAMOS

- GRIT-AGATA-VAMOS unique combination for triple coincidence measurement

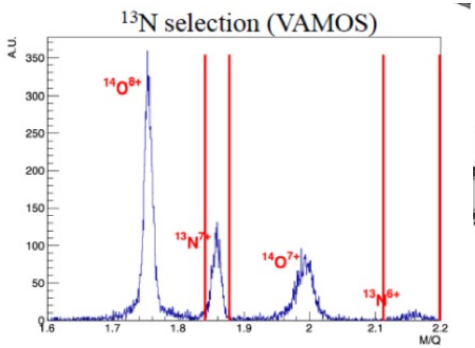
VAMOS: - fast counting
- identification of heavy residues (depending on beam intensity)
- full background rejection (C of target)
- improved light particles identification from time-of-flight

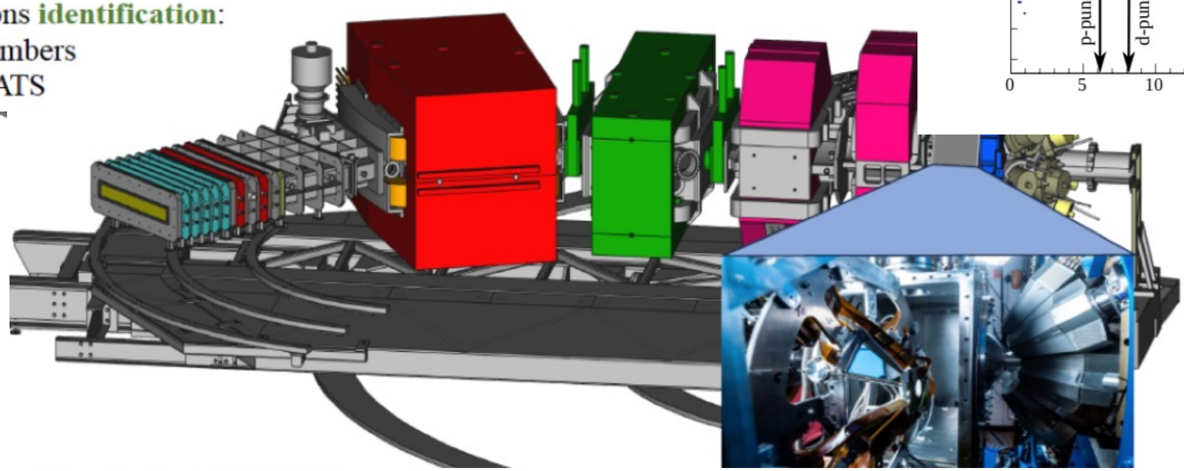


$$^{14}O + p \rightarrow {}^{15}F \rightarrow {}^{13}N + 2p$$

- SPIRAL 1 Beams
- Light Targets
- VAMOS @ 0 deg

- SETUP FOR Z<30 ions **identification**:
- Positions = Drift Chambers
- ToF = Focal Plane CATS





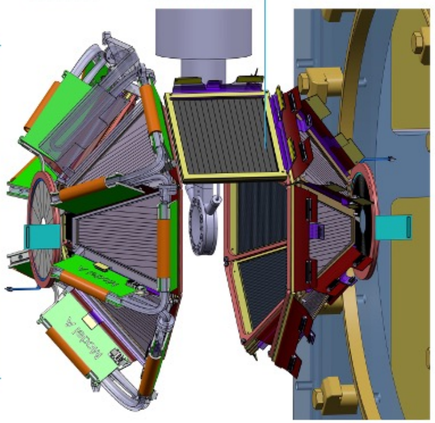
AGATA@GANIL.2: 0° degree campaign using the SPIRAL1 beams with GRIT and VAMOS

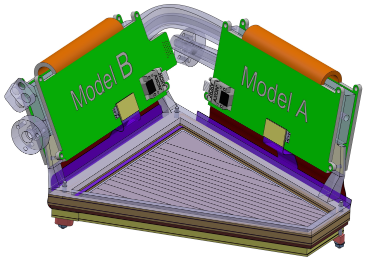
GRIT spokesp : D. Beaumel, D. Mengoni
RT : C. Soulet,
PLAS, BEE : LPC Caen
DAQ : LPC Caen
FEE, preamps: INFN-Milano
Mesytec : IJCLab (post-doc + physicists)
Mechanics : Y. Peinaud, Ph Rosier IJCLab
Phase0 : M.A.

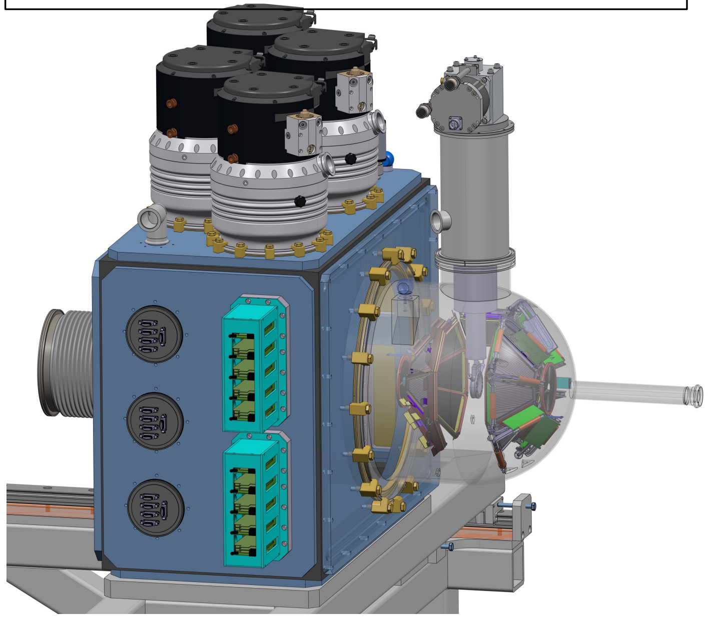
- GRIT-AGATA-VAMOS unique combination for triple coincidence meas.

GRIT Phase0 : hybrid detector covering ~ all angles
2 electronics : final GRIT electronics + Mesytec (PISTA like)

UPSTREAM	90 degrees	DOWNSTREAM
6 trapezoidal detectors (2 stages) read by GRIT electronics (PLAS) **+ 1 annular detector (1stage)** read by Mesytec	**1 square detector (2 stages)** read by Mesytec	**6 trapezoidal detectors (2 stages)** read by Mesytec







AGATA@GANIL.2: 0° degree campaign using the SPIRAL1 beams with GRIT and VAMOS

- GRIT-AGATA-VAMOS unique combination for triple coincidence meas.

GRIT Phase0 : hybrid detector covering ~ all angles
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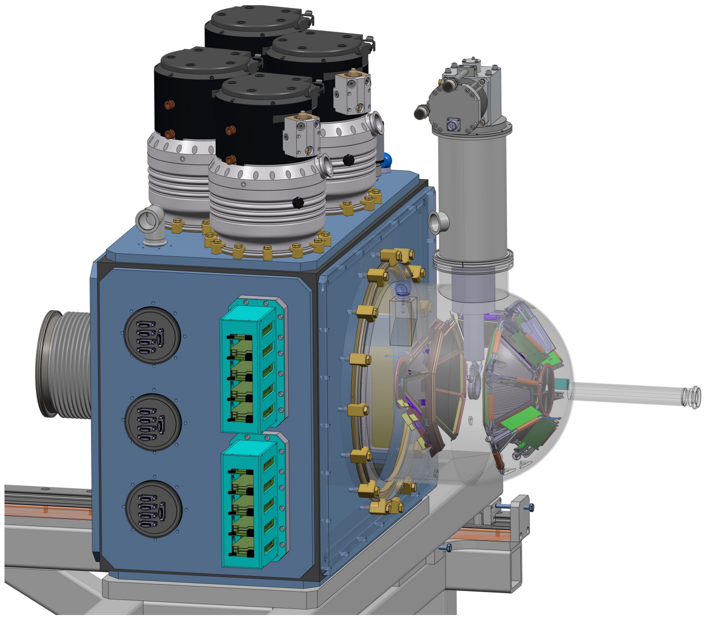
RT : C. Soulet,
PLAS, BEE : LPC Caen
FEE, preamps: INFN-Milano
Mesytec : IJCLab (post-doc + physicists)
Mechanics : Y. Peinaud, Ph Rosier IJCLab
Phase0 : M.A.

ASSETS of GRIT (Phase0)
- **High granularity**
  - ➟ Doppler correction from 2-body kinematics *(Resolution 7 keV)*
  - ➟ Improved E* resolution *(!! reaction kinematics !! target thickness)*

- **Particle identification** : PSA, ToF, DeltaE-E
- Upstream and downstream depending of physics cases
- Versatility for cryogenic targets (see next slides)



AGATA@GANIL.2: New ^{3}He cryogenic target

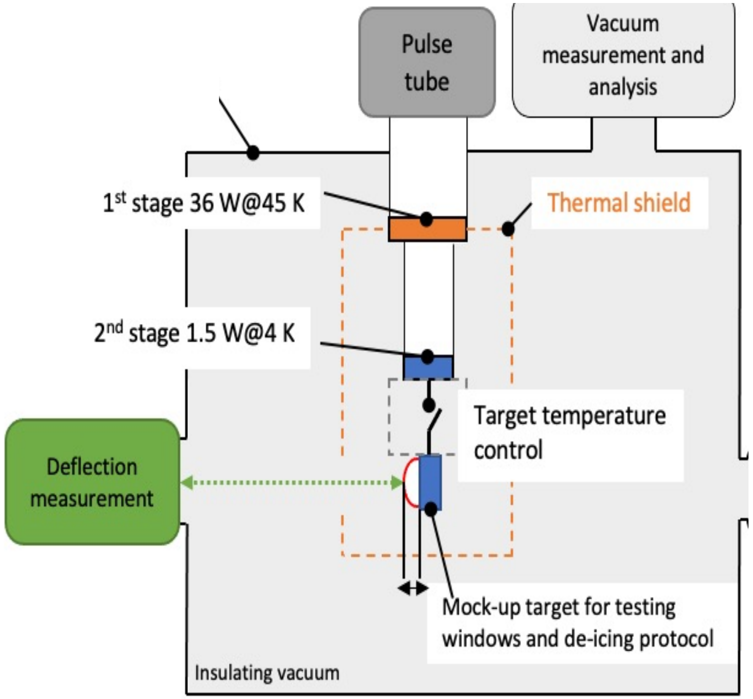
ATRACT

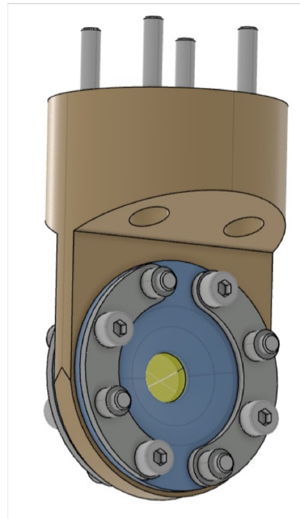
ATRACT ANR : M. Assié, T. Roger
Cryogenics : M. Pierens, P. Duthil, H. Saugnac, R. Thoer
Mechanics : S. Blivet
Opened positions : *CDD thermal engineers*
Physics Post-doc

Limitations identified with HeCTOr (^{3}He cryo target based on LHe circulation):

1. **Ice growth** : 11 µm/day for a vacuum of 10^{-6} mbar.
2. **Lower energy threshold : deuteron <1.5 MeV do not get out of the target.**
3. Strong background contribution from the **havar** windows and **ice** to the **excitation energy resolution**
4. For γ-ray measurement, depending on the lifetime of the populated state, important **absorption from the target cell and shielding**

➡ **Design of a new cryogenic ^{3}He target based on cryocooler**
- new window material *thin synthetic foils (Aramid) or SiN*
- new de-icing protocol (points 1 & 5) *depending on the window*





anr

1ST WORKSHOP : AGATA@GANIL.2

https://indico.in2p3.fr/event/32436/

AGATA at GANIL 2

mercredi 22 mai 2024, 11:00 → 18:30 Europe/Paris

Maison d'Hotes (GANIL)

Open call for LoI for AGATA @ GANIL.2
11 LoI

4 **Spectroscopy of unbound states in light nuclei**
Orateur: Dr Gheorghe STEFAN (IJCLab)

5 **Coulomb excitation of 44Ti and 62Zn - a need for the beam development at GANIL**
Orateur: Dr Kasia Hadynska-Klek (Heavy Ion Laboratory University of Warsaw)

6 **Spectroscopy of proton-rich nuclei using charge-exchange reactions with a 3He target**
Orateur: Beatriz Fernandez Dominguez (USC)

7 **Attacking the quasi-continuum with AGATA: Study of super-deformed and hyper-deformed nuclei**
Orateur: Amel KORICHI (CSNSM-IN2P3/CNRS)

8 **Study of neutron-proton pairing in fp-shell through two-nucleon addition reactions (3He,p)**
Orateur: Marlene Assie (IJCLab)

9 **Probing mixed-spin np pairing in the super-collective Z~60 and A~130 region**
Orateur: Dr Jérémie Dudouet (IP2I)

10 **Can AGATA extract an average lifetime of multiple states?**
Orateur: Dr Shuya Ota (Brookhaven National Laboratory)

15:50

11 **Clustering in medium-mass proton-rich nuclei studied through Li-induced stripping reactions**
Orateur: Didier Beaumel (IPN Orsay)

12 **Studying X-ray Bursts with the AGATA-GRIT-VAMOS Setup**
Orateur: Gavin Lotay

13 **Study of the Heavy Fragment survival in Multi Nucleon Tranfer reaction**
Orateur: Dr Gheorghe STEFAN (IJCLab)
QT_in_deep_inelastic_reactions_with_Agata__Va...

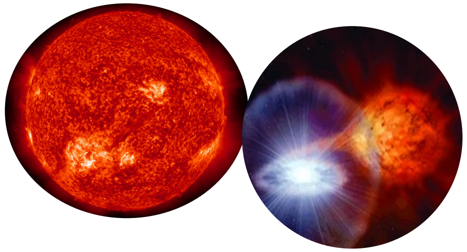
14 **Lifetime measurements of excited states in 24Ne populated by direct nucleon transfer**
Orateur: Emmanuel CLEMENT ((CNRS)UPR3266)
Ne24-Clement.pdf

15 **Spectroscopic prospects of 19Ne above the alpha-particle threshold**
Orateur: François de Oliveira (GANIL)
19Ne_AGATA@GANILpptx.pdf

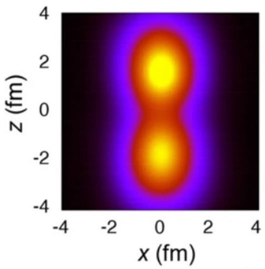
OVERVIEW OF THE LOI WITH AGATA-GRIT-VAMOS @GANIL-SPIRAL1

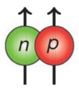
Nuclear astrophysics

- Studying X-ray Bursts with the AGATA-GRIT-VAMOS Setup G. Lotay et al



(New) clustering and pairing





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- Neutron-proton pairs in the self-conjugate nuclei (Ti,Ni) of the *fp*-shell through two-nucleon transfer, M. Assié, et al
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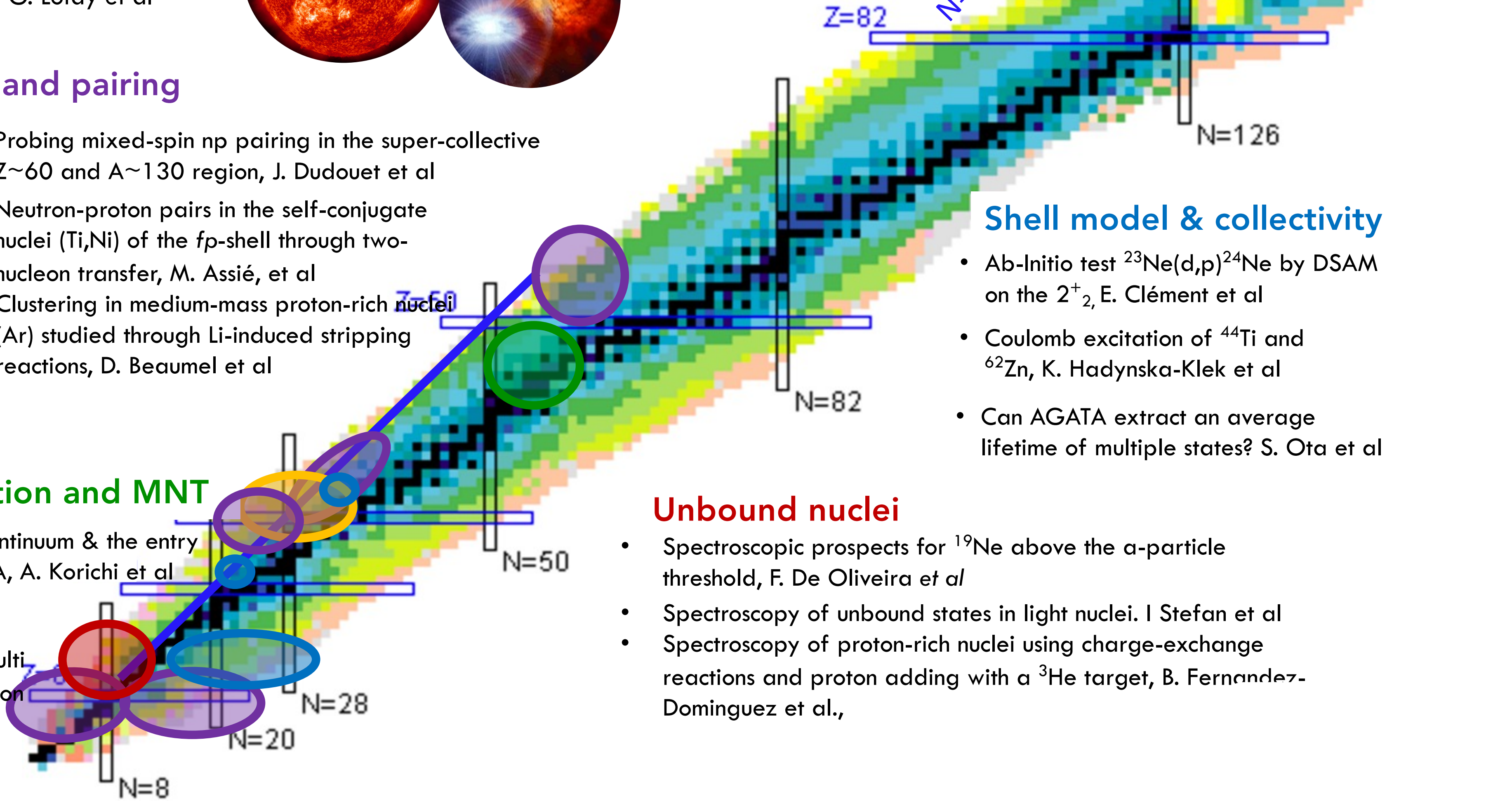

Shell model & collectivity

- Ab-Initio test $^{23}Ne(d,p)^{24}Ne$ by DSAM on the 2^+_2, E. Clément et al
- Coulomb excitation of ^{44}Ti and ^{62}Zn, K. Hadynska-Klek et al
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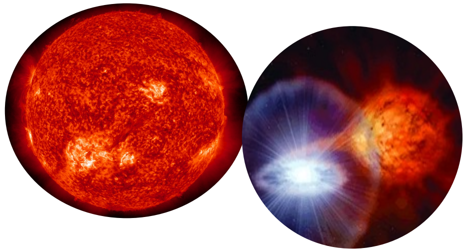

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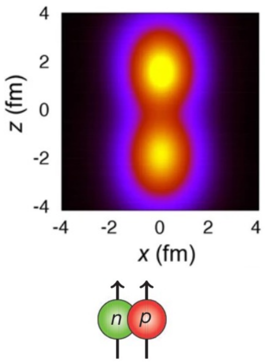

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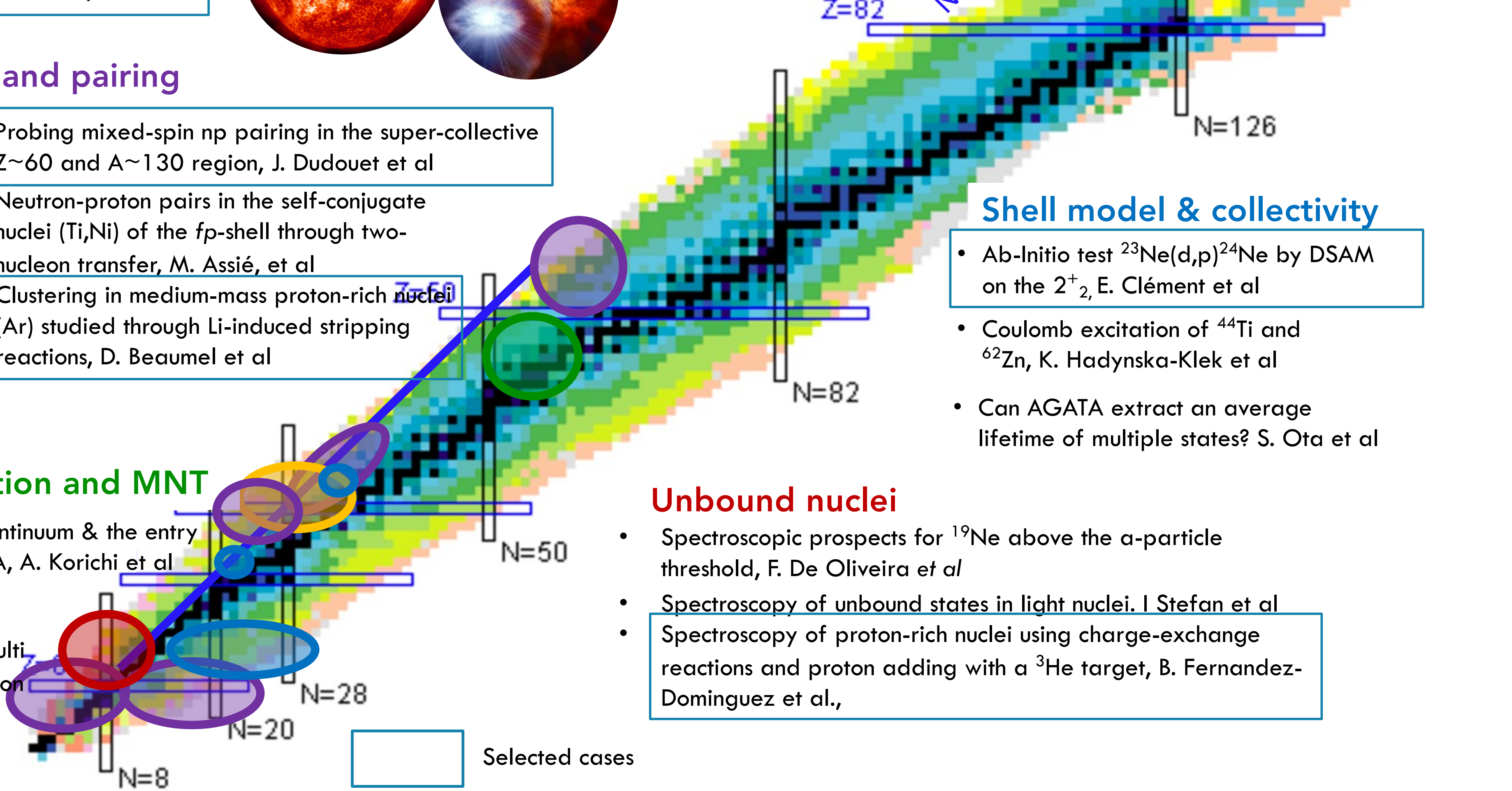

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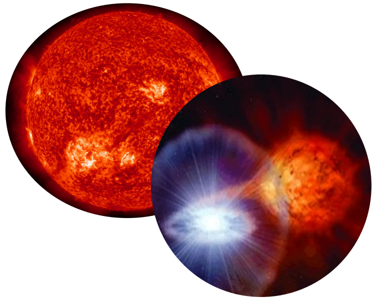
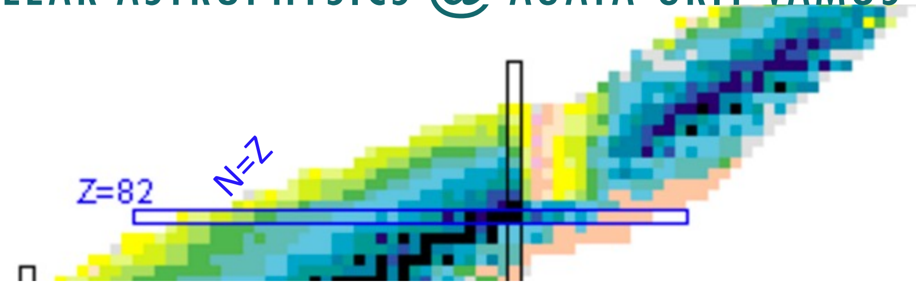
Selected cases

NUCLEAR ASTROPHYSICS @ AGATA-GRIT-VAMOS

- Studying X-ray Bursts with the AGATA-GRIT-VAMOS set-up, G. Lotay et al





-- **Type I X-ray bursts**

. Sensitive study --> few tens of reactions play an important role

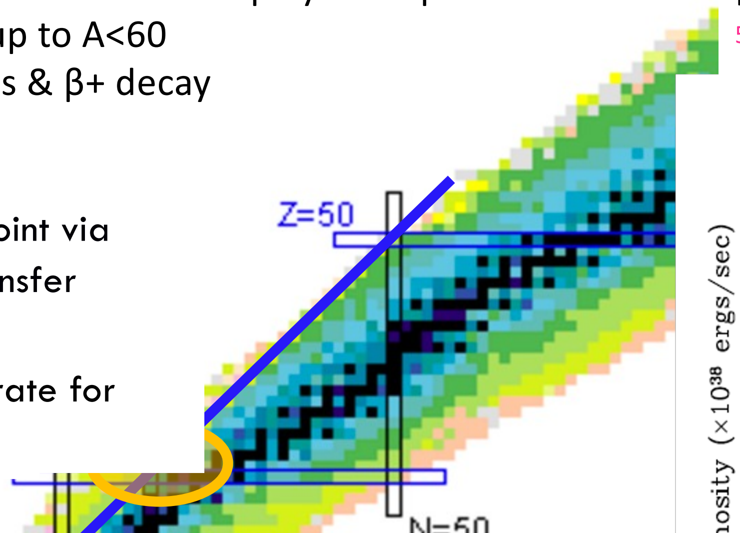
➟ (α,p) process: (α,p)(p,γ) up to A<60

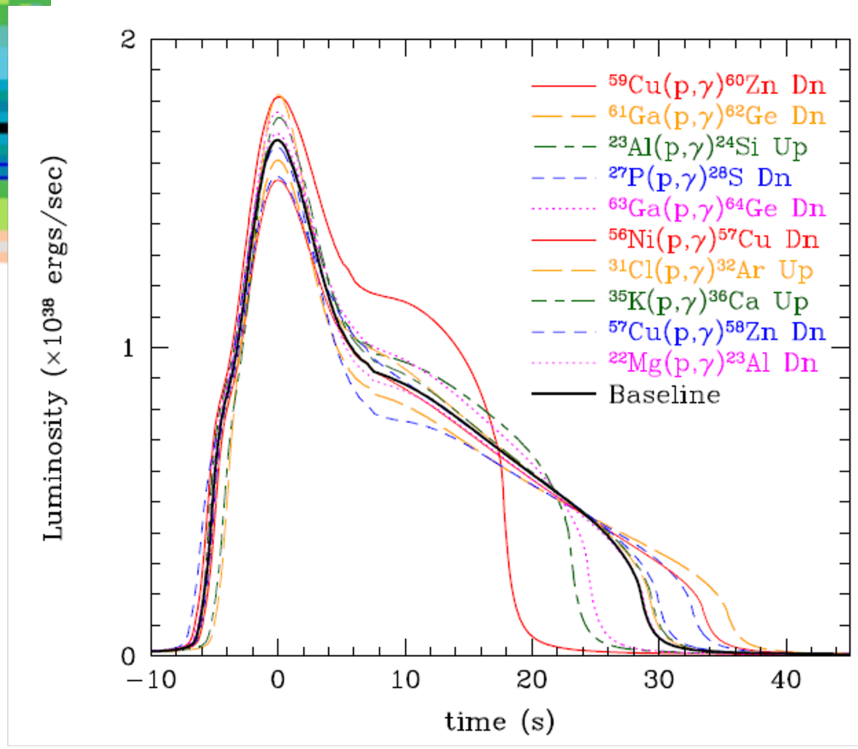
➟ rp-process: (p,γ) reactions & β+ decay

Most important effect on the light curve :

^{59}Cu(p,γ)^{60}Zn, ^{56}Ni(p, γ)^{57}Cu and ^{57}Cu(p, γ)^{58}Zn

- Probing the ^{56}Ni waiting point via ^{55}Co(d,p) and ^{57}Ni(d,p) transfer (mirror reactions)
- Determination of reaction rate for ^{59}Cu(p,γ) via ^{59}Cu(^{3}He,dγ)





Assets of AGATA-GRIT-VAMOS

High energy gamma-rays efficiency and P/T

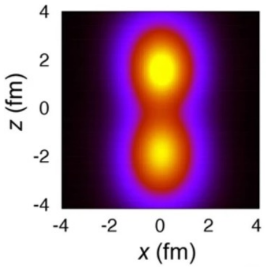
Triple coincidence

^{3}He cryogenic target

Energy thresholds

NEW CLUSTERING @ AGATA-GRIT-VAMOS

- Clustering in medium-mass proton-rich nuclei (Ar) studied through Li-induced stripping reactions, D. Beaumel et al

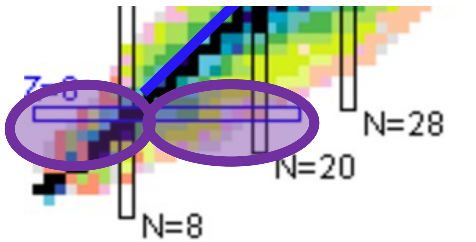


- Triton clustering in Be observed @ RIKEN via QFS *(D. Beaumel et al)*

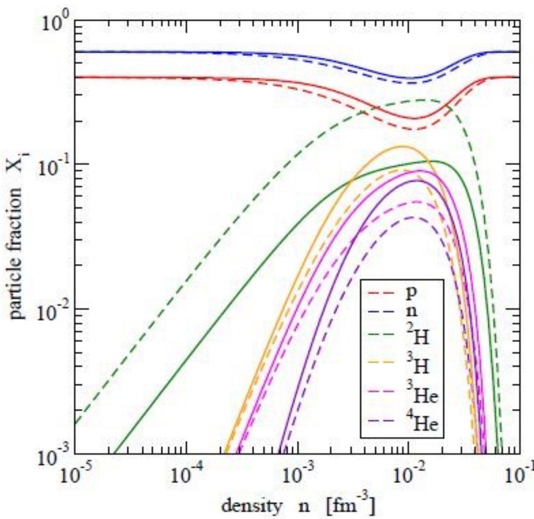
→ further investigation by transfer (p,alpha) on Be *(experiment performed in 2024 with MUGAST-EXOGAM-LISE)*

- Hint for ^{3}He clustering in N=2 isotones *(S. Koyama et al)*

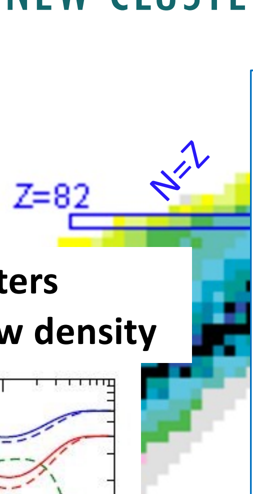
→ **Further experimental program: heavier nuclei (Ar) and ^{3}He clustering (proton-rich) through (^{6}Li,t), (^{6}Li,^{3}He), (^{7}Li,t)**

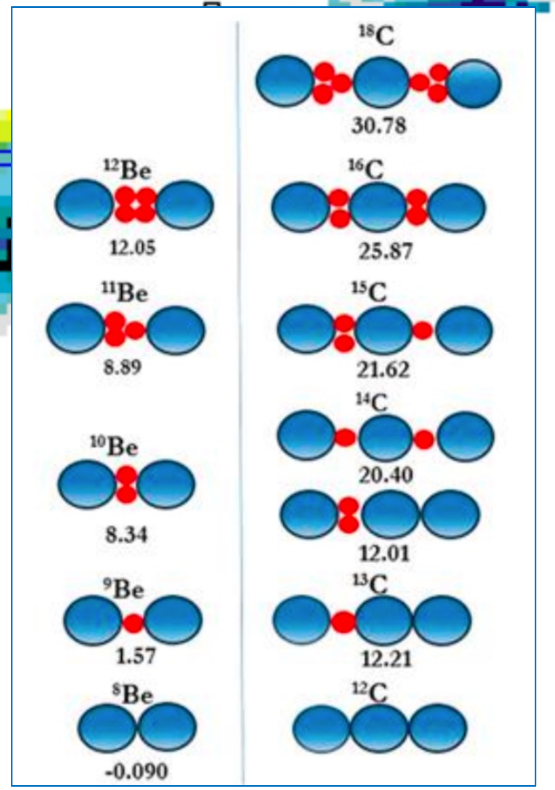


Theory: All kind of clusters should be formed at low density



S.Typel, J.Phys.Conf.Ser.420,012078(2013)





Assets from AGATA-GRIT-VAMOS
Triple coincidence
Study of clustering in excited states
low CS --> efficiencies

3N FORCES WITH AGATA-GRIT-VAMOS

- Ab-Initio test ^{23}Ne(d,p)^{24}Ne by DSAM on the 2^+_2, E. Clément et al

-- **3N forces**

. ^{24}O is the last bound isotopes : striking anomaly !

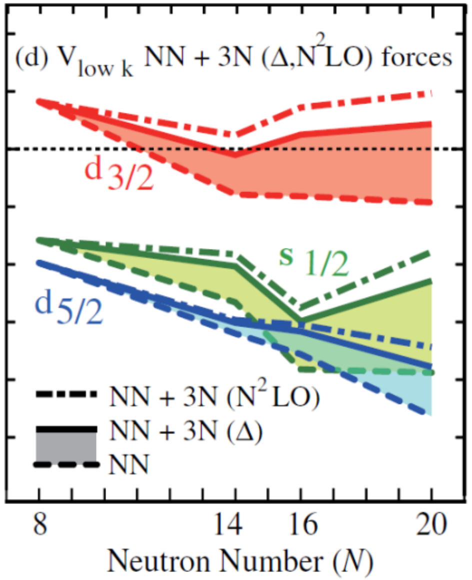
➟ need for **3N forces** to understand the neutron dripline

--> Constraining ab-initio models towards the dripline:

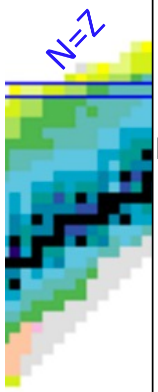
^{19}O(d,pɣ) measured at GANIL

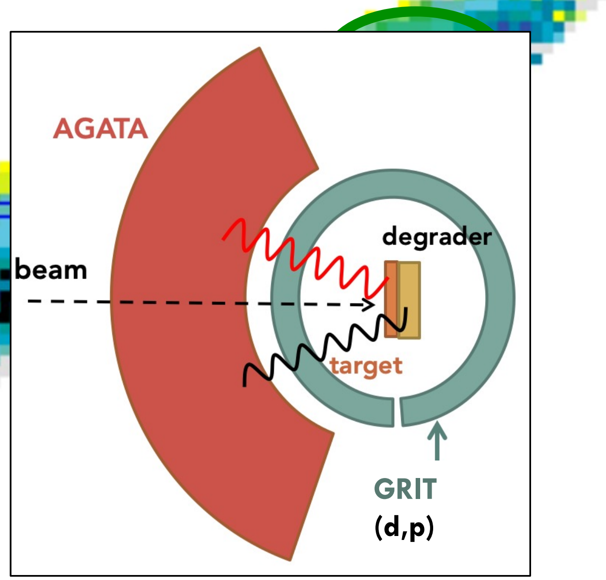
^{23}Ne(d,pɣ) to be measured !

I. Zanon et al PRL (2023)



T. Otsuka et al, PRL 104, 012501 (2010)



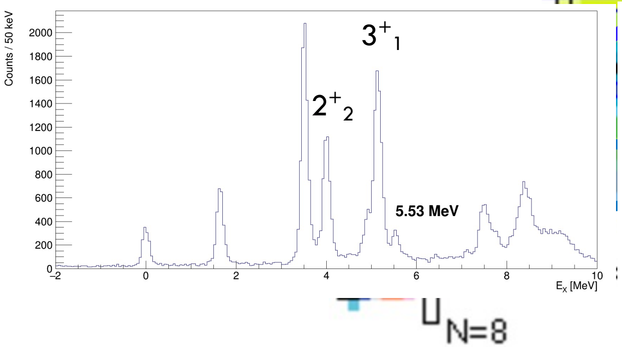


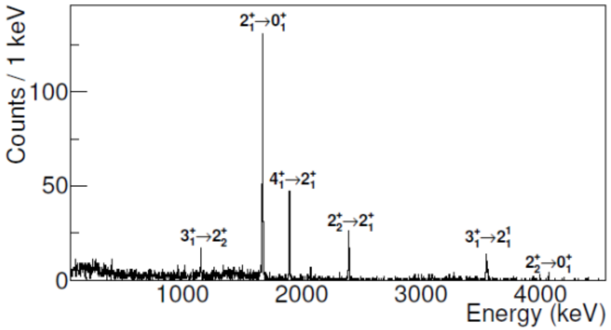
Assets from AGATA-GRIT-VAMOS

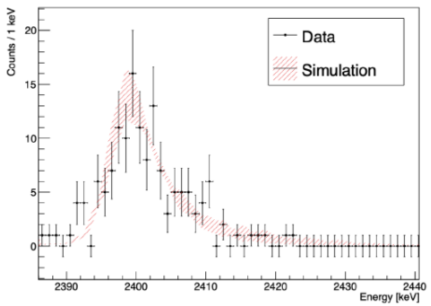
Triple coincidence

Resolving power of AGATA

Entry point control (GRIT)







I. Zanon et al, PRL(2023)

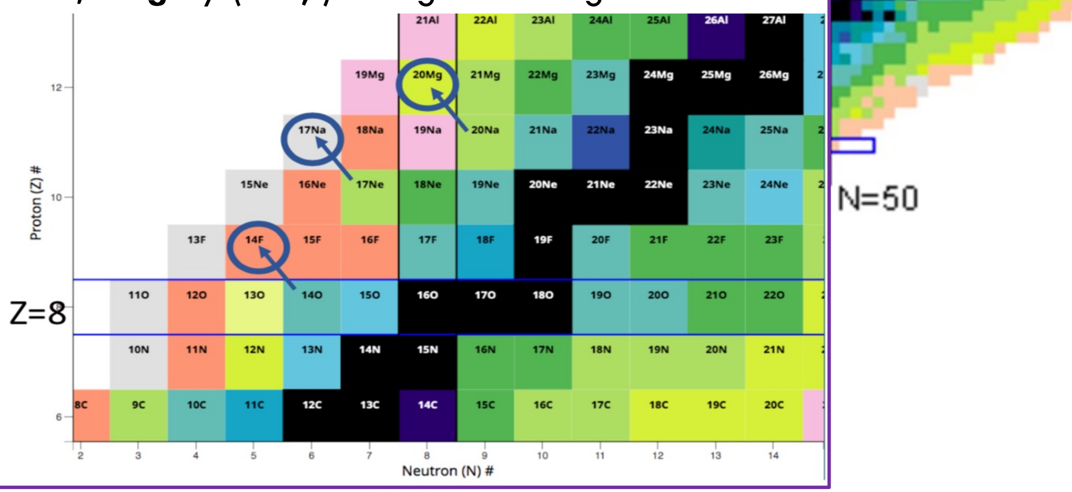
UNBOUND NUCLEI AT THE PROTON DRIPLINE WITH GRIT-AGATA-VAMOS

- Spectroscopy of proton-rich nuclei using charge-exchange reactions and proton adding with a ^{3}He target,

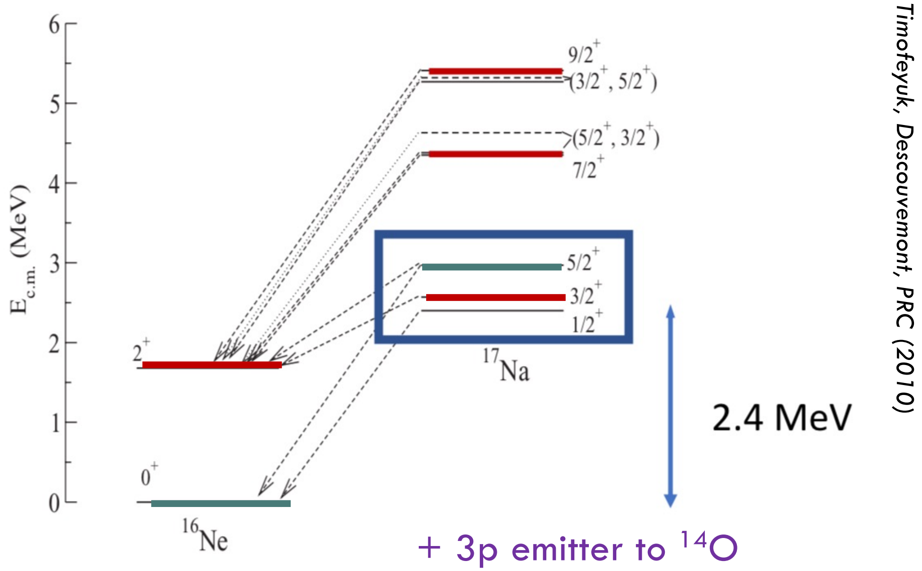
B. Fernandez-Dominguez et al.,

Nuclei at the confluence of shell gaps between standard Z=8, N=8
- *sd-* space with intruder presence
- Effects of 3N-body forces at low-energy
- Influence of the continuum

GOAL : proton-rich nuclei and 1p emitters: ^{14}**F**, ^{17}**Na**,^{20}**Mg** by (^{3}He,t) charge exchange reactions



^{17}Na predicted levels (from mirror nucleus ^{17}C)



Assets from AGATA-GRIT-VAMOS

Triple coincidence

^{3}He cryogenic target

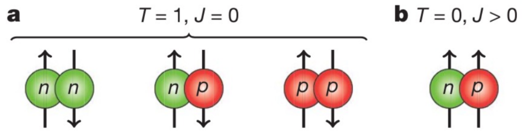
Granularity : 3p decay

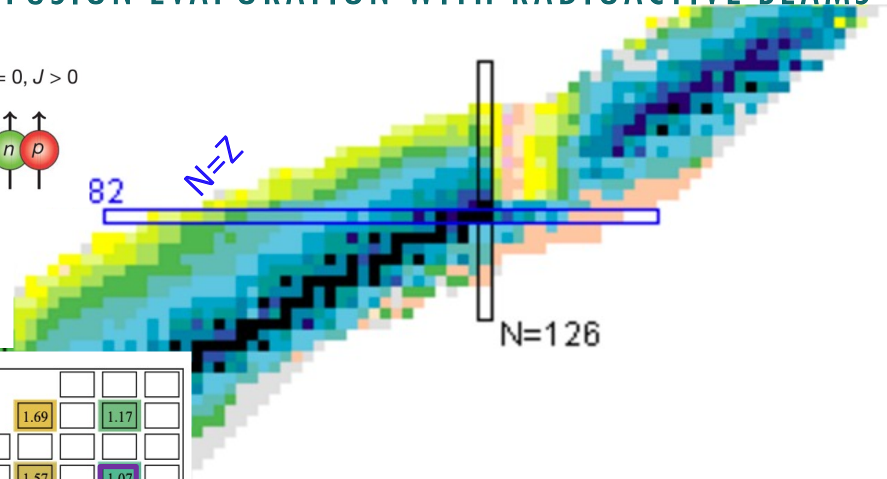
background rejection (^{15}O)

Gamma decay from unbound states

MIXED NP PAIRING AND SUPER-CLLECITIVTY BY FUSION EVAPORATION WITH RADIOACTIVE BEAMS

- Probing mixed-spin np pairing in the super-collective Z~60 and A~130 region, J. Dudouet et al

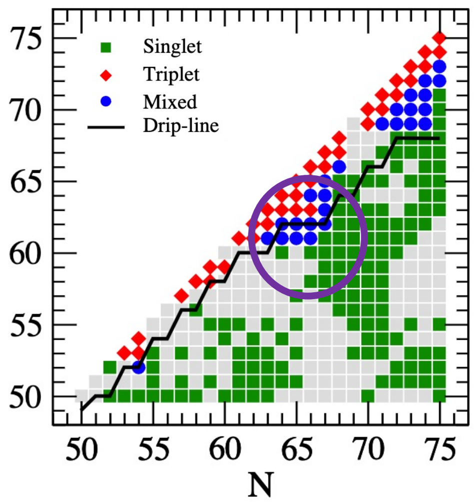




Mixed pairing candidates :

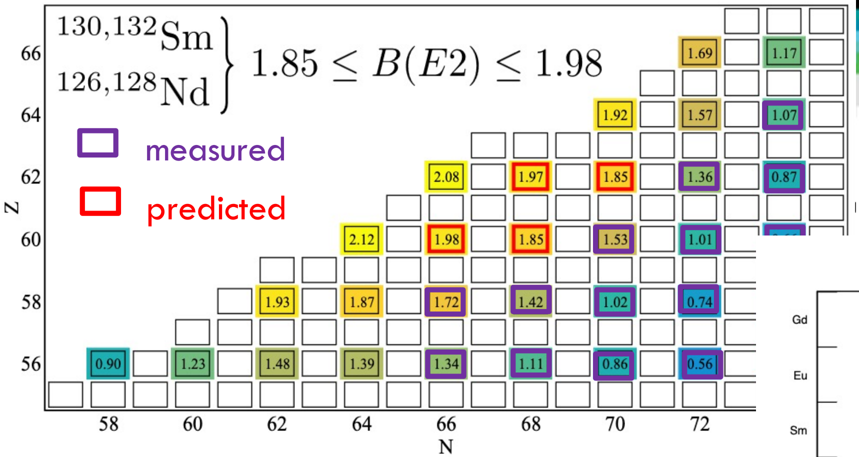
np pairing + realistic deformation

G. Palkanoglou ,A. Gezerlis, arXiv (2024)



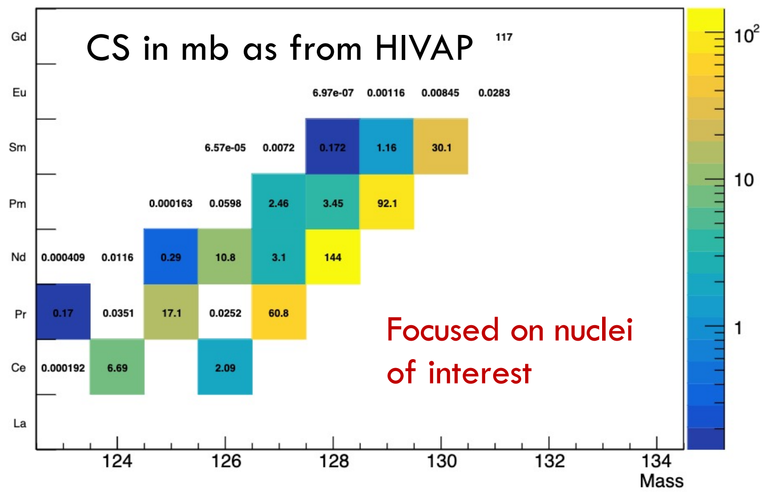
Super-collectivity candidates :

Z~60 and A~130, B(E2) ~2

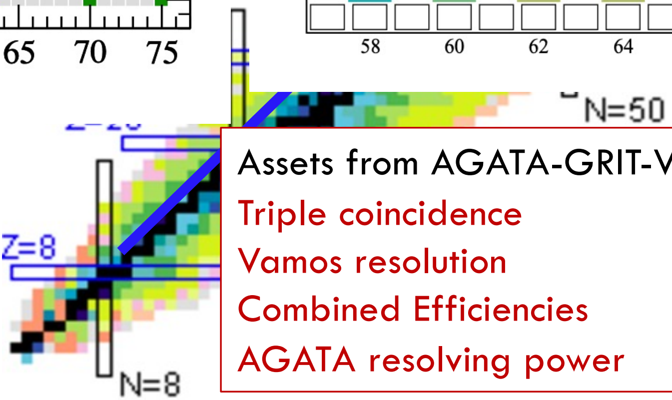


Method: fusion-evaporation with radioactive beam ^{74}Kr + ^{58}Ni

^{74}Kr (1e4 pps) + ^{58}Ni @ 320 MeV



Focused on nuclei of interest



Assets from AGATA-GRIT-VAMOS

Triple coincidence

Vamos resolution

Combined Efficiencies

AGATA resolving power

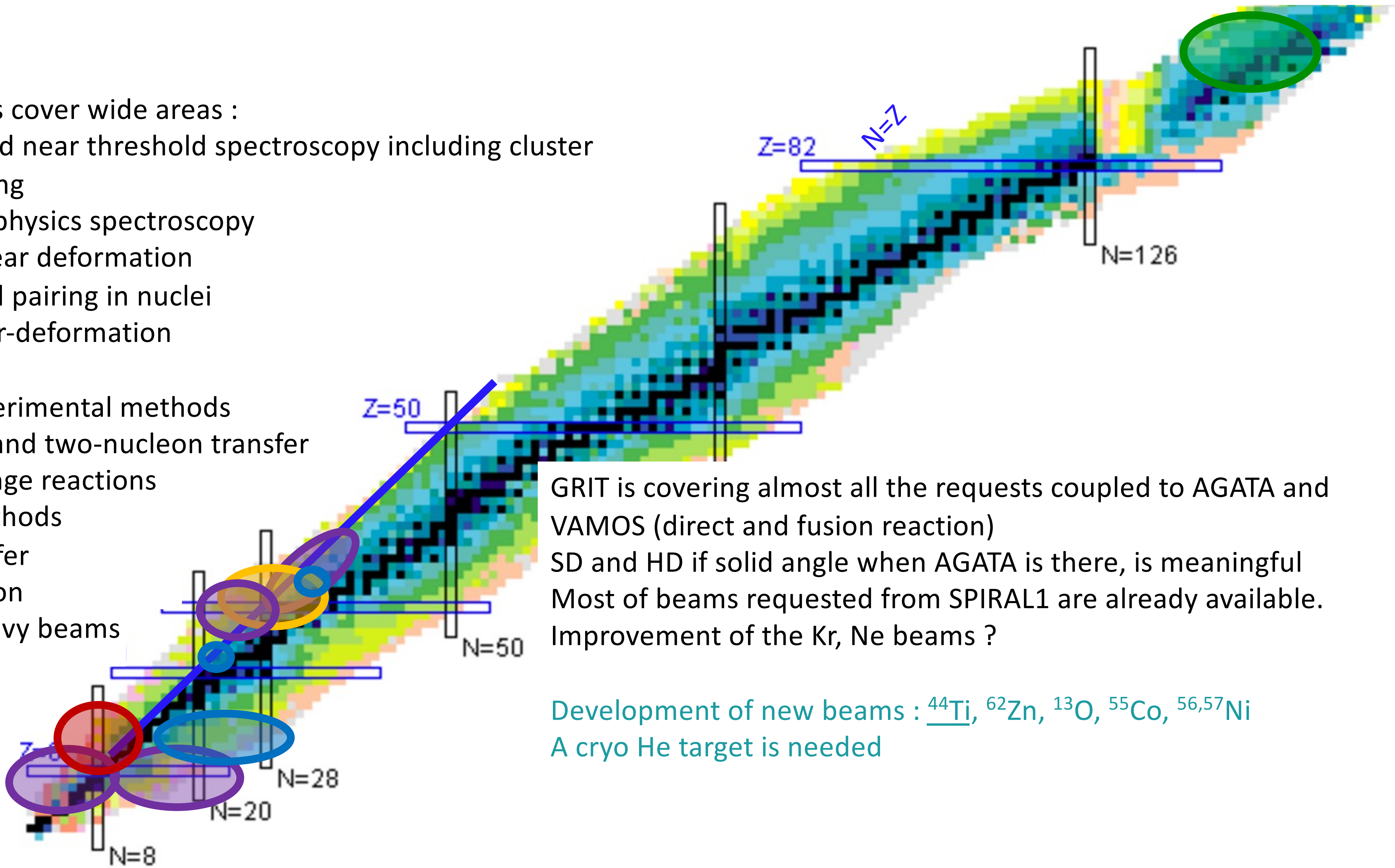
Conclusions

The physics cases cover wide areas :

- Resonance and near threshold spectroscopy including cluster
- Ab-initio testing
- Nuclear astrophysics spectroscopy
- Study of nuclear deformation
- Clustering and pairing in nuclei
- SHE and hyper-deformation

with various experimental methods

- one-nucleon and two-nucleon transfer
- charge exchange reactions
- surrogate methods
- DSAM + transfer
- coulex or fusion
- MNT with heavy beams



GRIT is covering almost all the requests coupled to AGATA and VAMOS (direct and fusion reaction)
SD and HD if solid angle when AGATA is there, is meaningful
Most of beams requested from SPIRAL1 are already available.
Improvement of the Kr, Ne beams ?

Development of new beams : ^{44}Ti, ^{62}Zn, ^{13}O, ^{55}Co, $^{56,57}Ni$
A cryo He target is needed

Conclusions

The physics cases cover wide areas :

- Resonance and near threshold spectr…
- Ab-initio testing
- Nuclear …

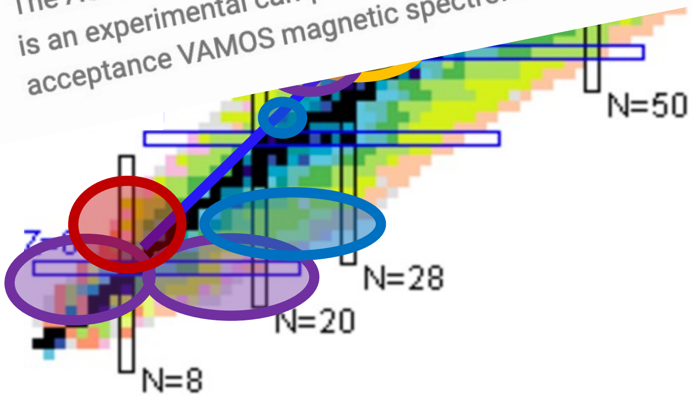
Physics cases to be updated and technical aspects to be discussed at the forthcoming GRIT-AGATA-VAMOS $workshop @ GANIL from 11th to 13rd of June
https://indico.in2p3.fr/event/34661/

GRIT AGATA VAMOS 2029-2030 Campaign

11 juin 2025, 14:00 → 13 juin 2025, 12:00 Europe/Paris

GuestHouse (GANIL)

Description The AGATA European Tracking array will be hosted at the GANIL Facility in 2029 and 2030 with a possible extension in 2031. The primary objective is an experimental campaign using a 2\pi AGATA coupled to GRIT, a 4\pi silicon array for light charged particle spectroscopy, and the high acceptance VAMOS magnetic spectrometer.



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… and fusion reaction)
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