Investigating the transition probability discrepancy along the N=28 neutron shell closure via direct transfer reaction on ^{46}Ar

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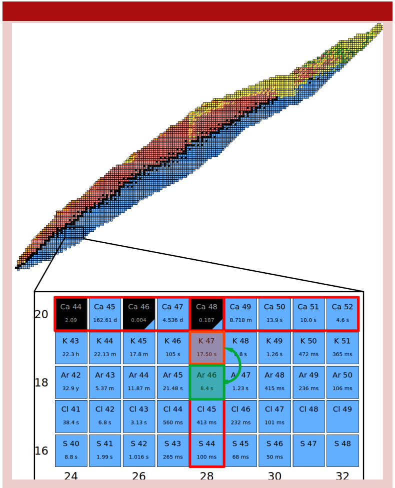
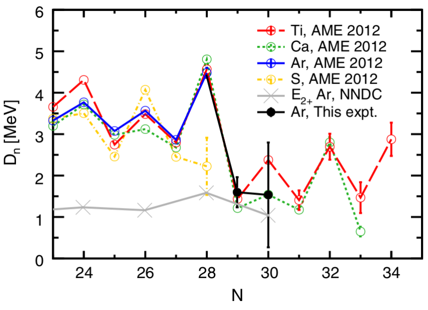
The N=28 shell closure



- **How does the N=28 shell closure evolve?** While ^{48}Ca is a famous proof of its existence, neutron-rich isotopes below ^{42}Si no longer demonstrate its presence.
- Transition probabilities measured by (intermediate and near-Coulomb-barrier) *coulex* measurements hint at a reduced B(E2) compared to the possibility of an onset of *collectivity* in ^{46}Ar
- Shell model calculations, which account correctly for the breakdown of the shell gap in S and Si are at odds with B(E2) measurements
- Is there more to be understood of the proton contribution to the wave-function?

A neutron deponent observable: D_n

D_n [Z. Meisel et al. PRL 114, 022501 (2015)]



- Mass measurements confirm the N=28 shell closure in ^{46}Ar and its breakdown in the S isotopes (by observing a peaked value of D_n at N=28 with a sudden drop for more neutron-rich ^{46}Ar isotopes)
- **Experimental data and theory well in agreement** ($\Longrightarrow$ SPDF-U describes well the valence-core neutron interaction)

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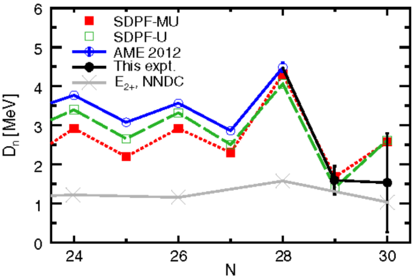

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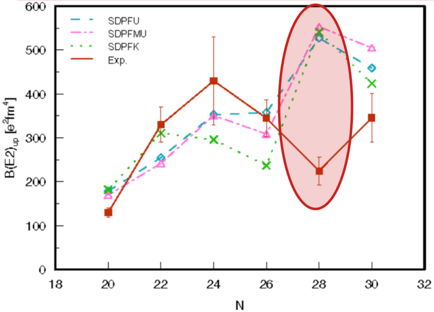
Quadrupole transition probabilities

B(E2) [A. Gade et al., PRC 68, 014302; S. Calinescu et al., PRC 93, 044333]



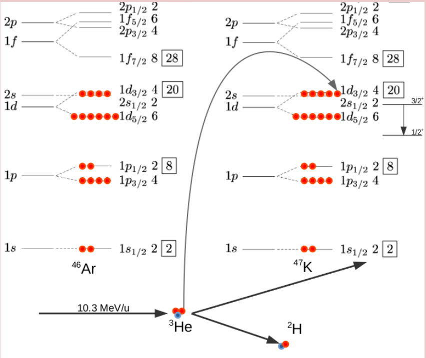
- **Divergence in trend and in value between shell model calculations and coulomb excitation measurements**
- Other isotopes are well reproduced
- A systematic calculation of the contribution on the matrix elements from protons and neutrons hints that a discrepancy that lies on the former would explain the observed divergence in B(E2)

The physics case

The aim of the experiment is to probe the proton wavefunction by a transfer direct reaction in ^{46}Ar

- We are looking into a well studied isotope $\Longrightarrow$ Spin assignments are well established
- The crucial aspect is to investigate the relative *s* and *d* transfer
- Spectroscopic factors are known for ^{48}Ca p removal: what for ^{46}Ar p addition?

(Simplistic) single particle picture



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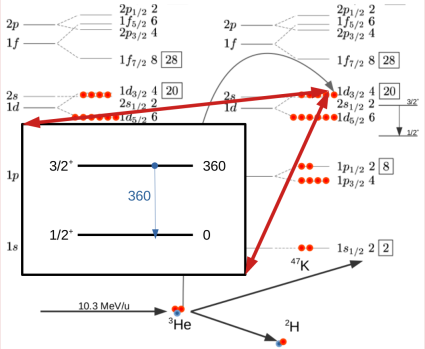
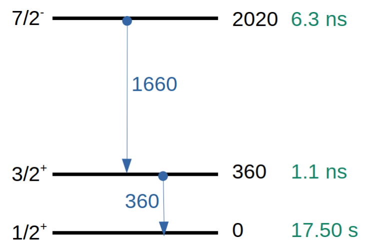


What we expect

- ^{46}Ar(^{3}He, d)^{47}K @ 10MeV/u. (primary beam ^{48}Ca) $I_{beam} = 3 \times 10^4$ Hz

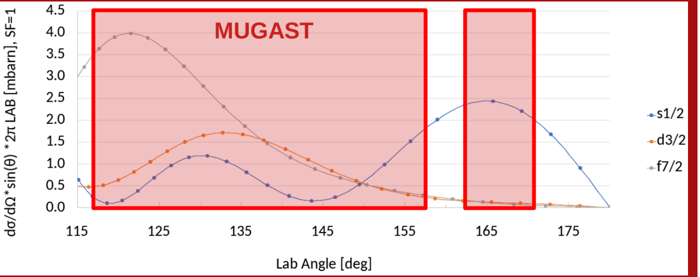
Level Scheme



Well studied spectroscopy

[C. A. Ogilvie et al., NPA 465, 3 (1987)]

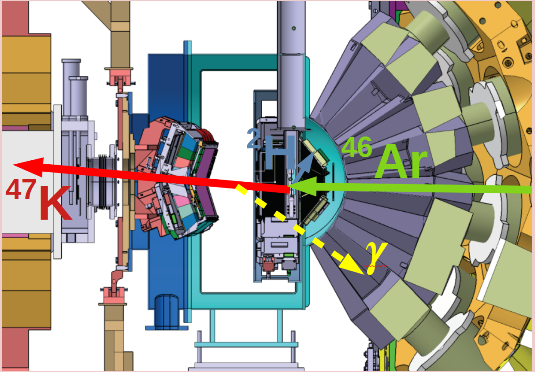
Calculated lab angular distribution



Distributions show a high sensitivity to the transferred wave's L

Detection Arrays

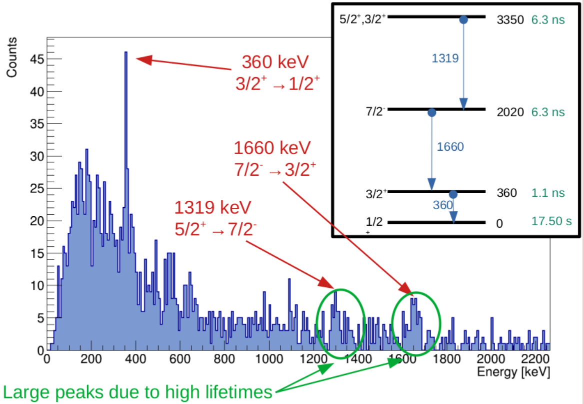
- AGATA+MUGAST+VAMOS+Cryo ^{3}He Target+Must2+Cats2



- MUGAST: Energy, Position, Particle discrimination
- VAMOS: Reaction fragment identification, Beta
- AGATA: Gamma energy, Position
- CATS2: Time of flight
- Cryogenic target: cooled to 7K, density of $\approx 1.5 \times 10^{-3}$ g/cm^2, equiv. to $\approx 5.0 \times 10^{-3}$ g/cm^3

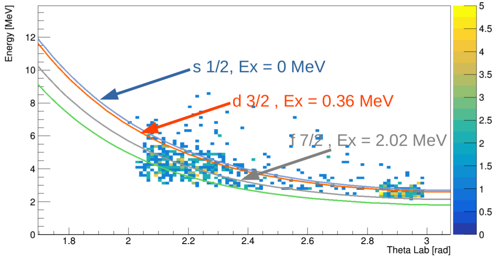
Double coincidences: VAMOS + AGATA

γ spectrum on AGATA with ^{47}K identified in VAMOS



- Many protons are identified in MUGAST (one order of magnitude more respect to the deuterons) $\Longrightarrow$ Deuteron breackup reaction channel, three body reaction
- The level scheme of ^{47}K is observed

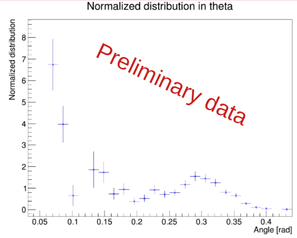
Double coincidences: MUGAST+VAMOS (Kinematics)



- Ice deposition and target thickness affect the energy resolution (an thus the kinematic plot).
- As expected, the transfer to the $\frac{1}{2}^+$ g.s. and the 360 keV $\frac{3}{2}^+$ level cannot be disentangled based on Excitation energy.

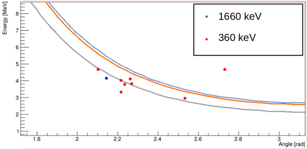
The PDF de-convolution on the angular distribution will assess the ratio between L=0 and L=2 transfer.

Eff. corrected $d\sigma/d\theta$.



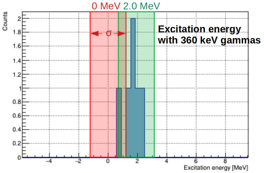
Triple coincidences: AGATA+VAMOS+MUGAST

Kinematic line in coincidence with 360 KeV γ-ray



- 360 keV γ detected by AGATA+^{47}K identified in VAMOS+ deuteron measured in MUGAST $\Longrightarrow$ clear kinematic line
- Narrow γ gate removes background

γ-rays in coincidence with d and ^{47}K



- Despite the majority of counts in the Excitation energy peak are centered at 0 MeV, the only counts in coincidence with AGATA are at 2 MeV
- No gammas seen for Ex$<$ 1MeV
- Suppressed direct transfer to $\frac{3}{2}^{+}$?

Concusions and future perspectives

- The reaction is correctly populated and identified thanks to the granularity of the setup
- Final refinements on the data analysis are needed
- Results will be compared and discussed in the framework of theoretical models, namely the shell model

The Collaboration

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Thank you for your attention

Overview

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