Searching for isoscalar resonances in 68Ni with ACTAR TPC

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Motivation: Giant Resonances

ΔL = 0
Monopole (M)

ΔL = 1
Dipole (D)

ΔL = 2
Quadrupole (Q)

Multipole Decomposition Analysis

Inelastic scattering – alpha probe

ΔT = 0
Isoscalar (IS)
ΔS = 0
Electric

ΔT = 1
Isovector (IV)
ΔS = 0
Electric

ΔT = 0
Isoscalar (IS)
ΔS = 1
Magnetic (S)

ΔT = 1
Isovector (IV)
ΔS = 1
Magnetic (S)

Fig courtesy: Bagchi 2015 PhD Thesis
Motivation: Incompressibility of Nuclear Matter

\[ E_{\text{ISGMR}} = \hbar \sqrt{\frac{K_A}{m < r^2 >}} \]

\[ E_{\text{ISGDR}} = \hbar \sqrt{\frac{7 K_A + \frac{27}{25} e_F}{3 m < r^2 >}} \]

\[ K_A = K_\infty + K_{\text{surf}} A^{-1/3} + K_\tau \left( \frac{N - Z}{A} \right)^2 + K_{\text{Coul}} Z^2 A^{-4/3} \]

- Fully Consistent RPA (Random Phase Approximations)
- Provides at the same time \( K_\infty \), \( E_{\text{ISGMR}} \)
- \( K_\infty = 240 \pm 10 \text{ MeV}, \quad ^{208}\text{Pb} \) B.K.Agrawal et.al 2003
- \( K_\infty = 230 \pm 40 \text{ MeV}, \quad ^{208}\text{Pb}, ^{120}\text{Sn} \) Khan et.al 2013
Motivation: Soft Modes

E.Khan et.al PRC (2011)
Motivation: Soft Modes – Experiment using MAYA

M.Vandebrouck et.al PRC (2015)
Experimental setup: ACTAR TPC

Constraints:

1. Short Lived nuclei – Inverse Kinematics

2. Low momentum transfer reactions – active target

3. Angular distributions at low center of mass angles – good resolution near the beamline
Experimental setup: ACTAR TPC

B.Mauss et.al NIM (2020)

High resolution pads – 2 mm * 2mm as compared to MAYA
Experiment – e780 @ LISE

Use the validated reconstruction code to explore the soft monopole strength between 10 and 15 MeV

Lui, Youngblood et.al (2006) PRC

Vandebrouck, Gibelin et.al (2014) PRL
Experiment – e780 @ LISE

Experimental conditions:

1. 98 % He Gas with 2 % of CF4 as quencher

2. Pressure = 400mbar (chosen based on simulations and experimental constraints)

3. Around 10 UT of successful beam time for 68Ni and 13 UT of successful beam time for 58Ni with an intensity of around $10^4$ pps.
Identification of the scattered particle

Fig credits: B. Mauss
e780 PRELIMINARY online analysis – $^{58}\text{Ni}(\alpha,\alpha')^{58}\text{Ni}^*$

Kinematics curve

$E^*(^{58}\text{Ni}) = 20 \text{ MeV}$  $E^*(^{58}\text{Ni}) = 10 \text{ MeV}$  $E^*(^{58}\text{Ni}) = 0 \text{ MeV}$

Fig credits: Marine Vandebrouck
Excitation Energy spectrum

- $^{58}\text{Ni}$
  - Mean = 160 KeV
  - Resolution = 420 KeV

- $^{68}\text{Ni}$
  - Mean = 370 KeV
  - Resolution = 650 KeV

Fig credits: Marine Vandebrouck
Identification of the scattered particle

Fig credits: Marine Vandebrouck
e780 PRELIMINARY online analysis – $^{68}$Ni(α,α')$^{68}$Ni*

Kinematics curve

$E^*(^{68}\text{Ni}) = 20 \text{ MeV}$  $E^*(^{68}\text{Ni}) = 10 \text{ MeV}$  $E^*(^{68}\text{Ni}) = 0 \text{ MeV}$

Fig credits: Marine Vandebrouck
e780 – OFFLINE ANALYSIS – Tracking Algorithms

1. Adaptations to reconstruction routine to analyse the exotic Ni experimental data.
2. Identification and corrections for the pads that did not fire during the experiment.
3. Identification of Clusters using density based spatial clustering approach.
5. Weighted 3D Charge projection.
missing pads
Identification of clusters, track orientation, cluster merging for tracks with holes
e780 – OFFLINE ANALYSIS – Tracking Algorithms

• Charge profile with hole corrections
Weighted charge projection in 3D
Summary

• Successful beam time utilization for 58Ni and 68Ni
• Online Analysis and reconstruction of elastic peak shows improved resolution compared to MAYA
• Less events observed in 3-4 deg CM, however correction for geometric efficiency needs to be done.
• So far, the soft monopole strength is not clearly visible, needs more correction to find indications.
• Adaptation Routines for offline analysis has been developed and tested. Analysis will continue further to derive the resonance strength
Collaboration
Thank you for your attention