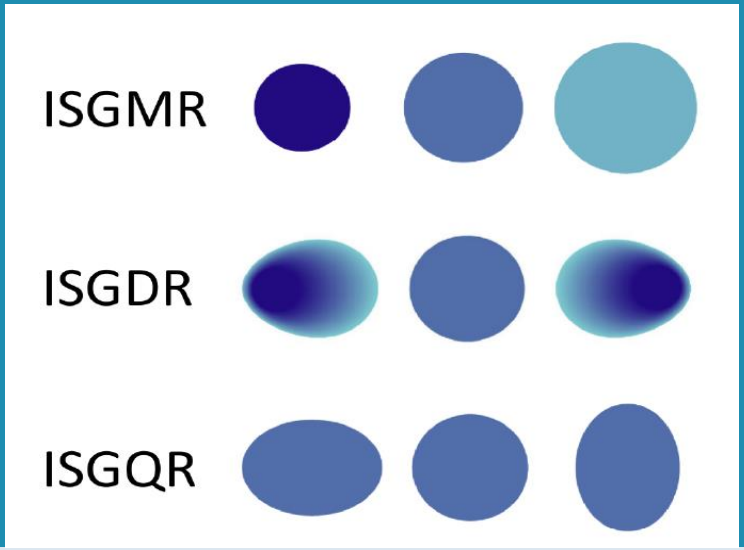
KU LEUVEN

Searching for isoscalar resonances in 68Ni with ACTAR TPC



Alex Antony Arokiaraj

Supervised by: Prof. Riccardo Raabe, Dr. Marine Vandebrouck

GANIL Colloque – 11 September 2019

Motivation: Giant Resonances

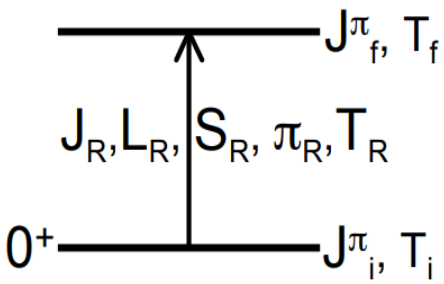
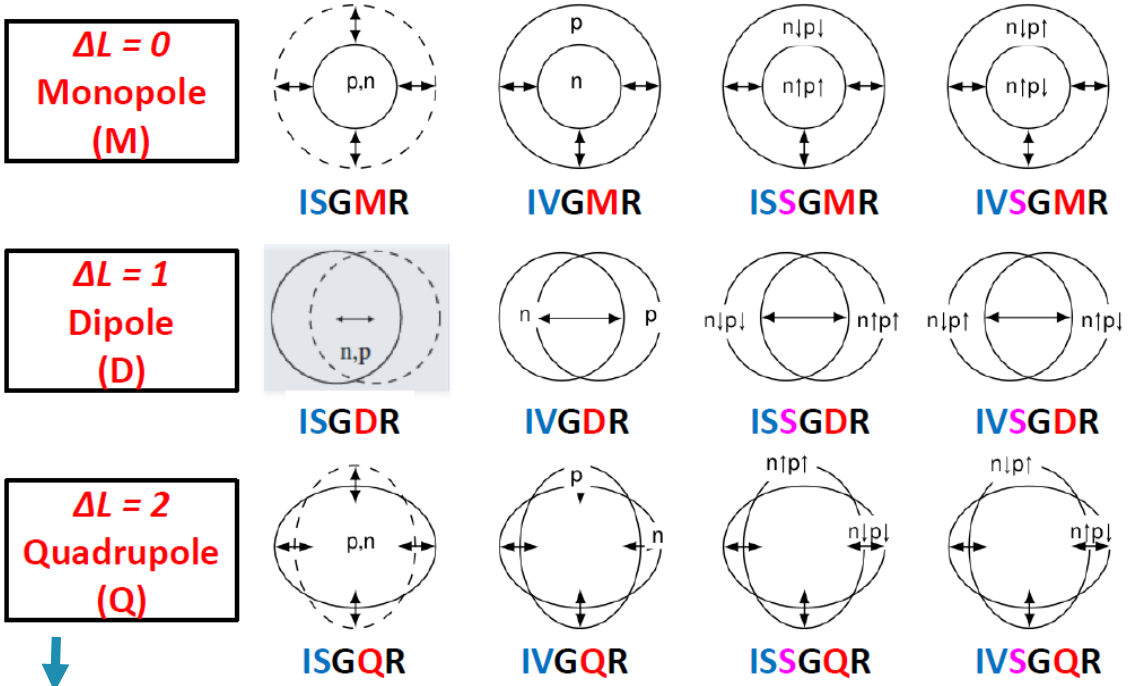


Fig courtesy: Elias Khan



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

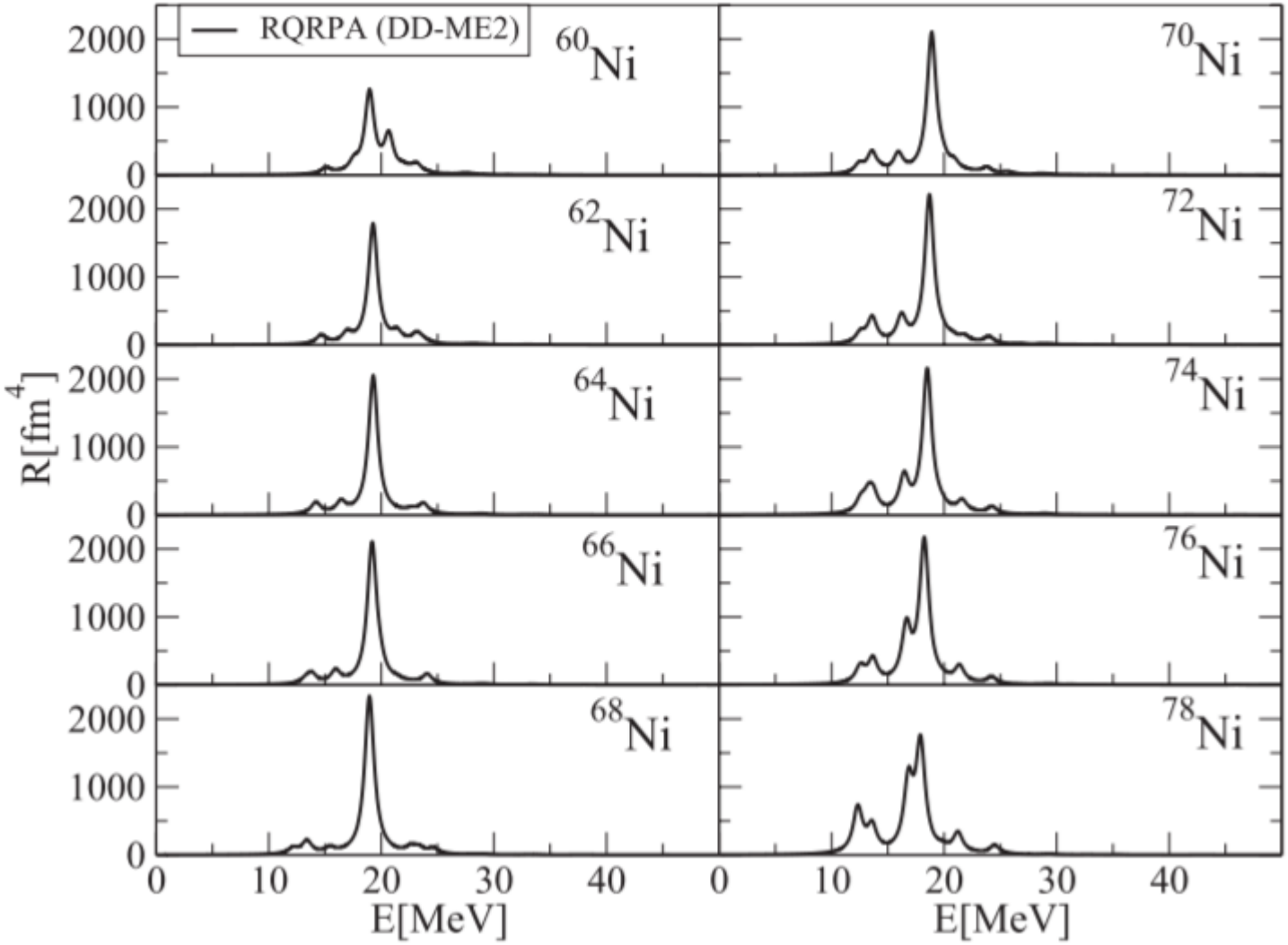
Motivation: Incompressibility of Nuclear Matter

$$E_{ISGMR} = \hbar\sqrt{\frac{K_A}{m < r^2 >}} \qquad E_{ISGDR} = \hbar\sqrt{\frac{7}{3}\frac{K_A + \frac{27}{25}\epsilon_F}{m < r^2 >}}$$

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

- Fully Consistent RPA (Random Phase Approximations)
- Provides at the same time K_∞ , E_{ISGMR}
- K_∞ = 240 ± 10 MeV, ^{208}Pb *B.K.Agrawal et.al 2003*
- K_∞ = 230 ± 40 MeV, ^{208}Pb, ^{120}Sn *Khan et.al 2013*

Motivation: Soft Modes

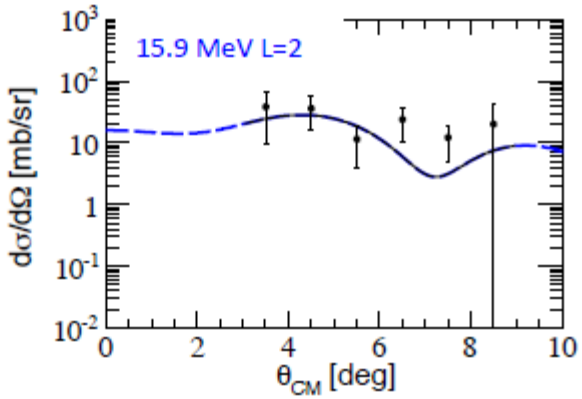


E.Khan et.al PRC (2011)

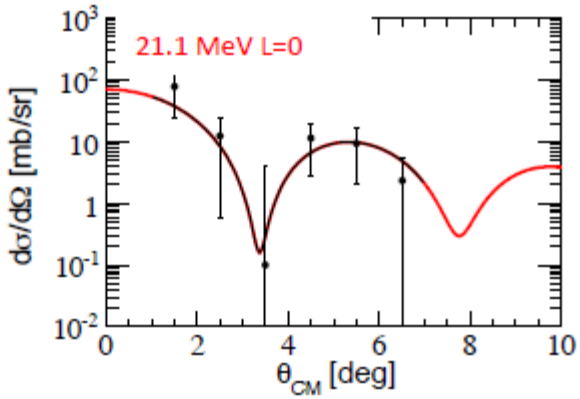
Motivation: Soft Modes – Experiment using MAYA

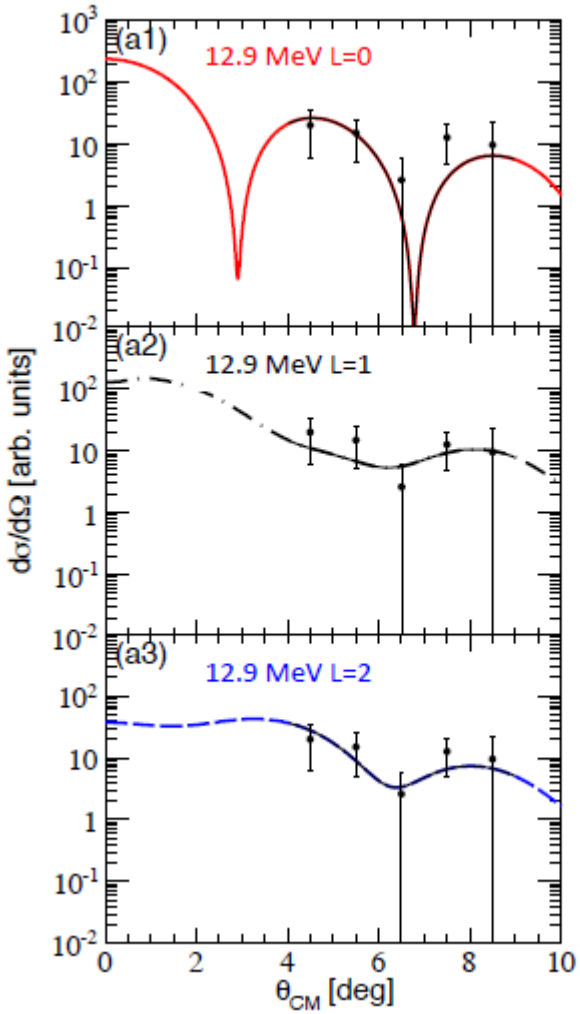
M.Vandebrouck et.al PRC (2015)

ISGQR



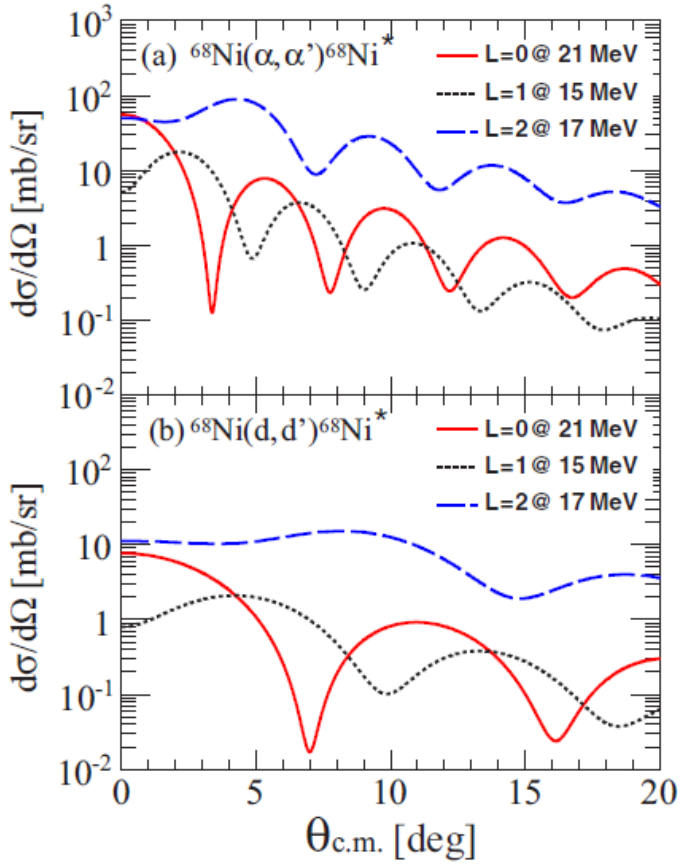
ISGMR





Soft ISGMR ?

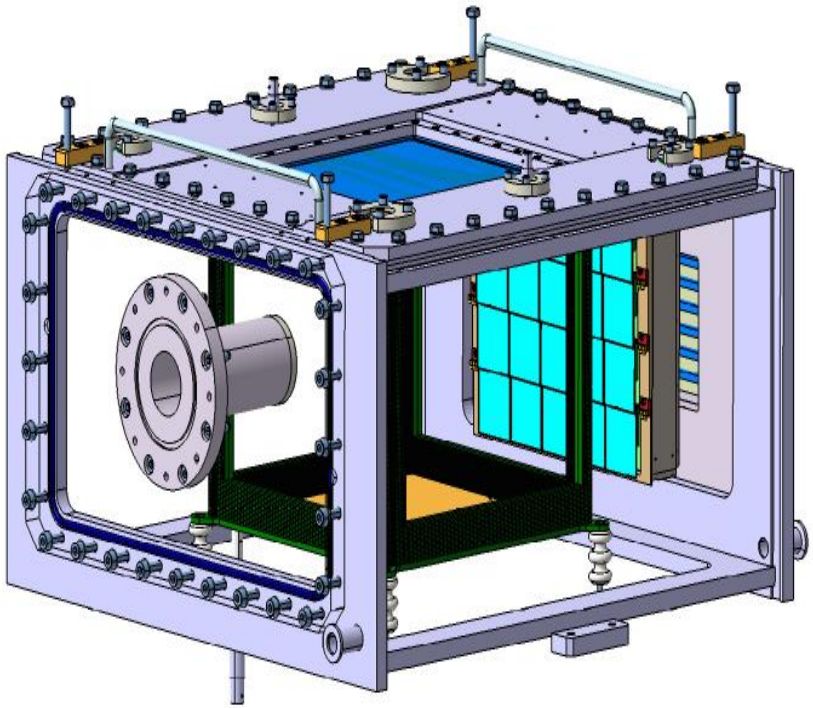
Experimental setup: ACTAR TPC

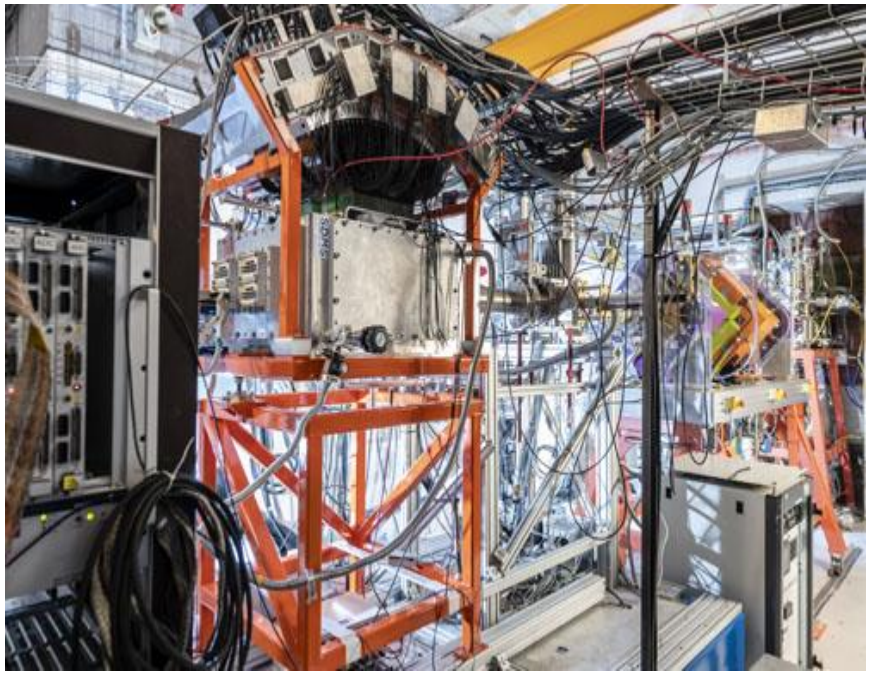


Constraints:

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

e780

58Ni, E=49 MeV/nucleon

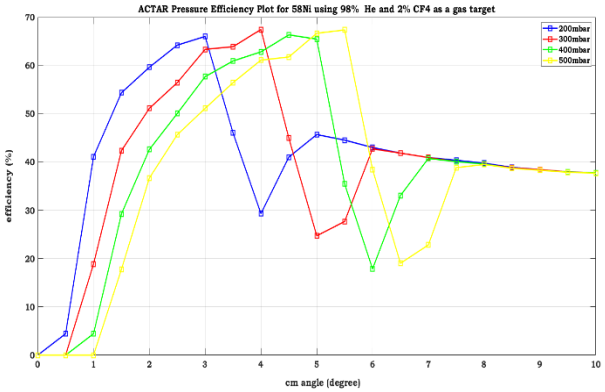
68Ni, E= 49MeV/nucleon

Lui, Youngblood et.al (2006) PRC

Vandebrouck, Gibelin et.al (2014) PRL

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

Experiment – e780 @ LISE



<u>Experimental conditions</u>:

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.

e780 PRELIMINARY online analysis – $^{58}Ni(\alpha,\alpha')^{58}Ni^*$

Identification of the scattered particle

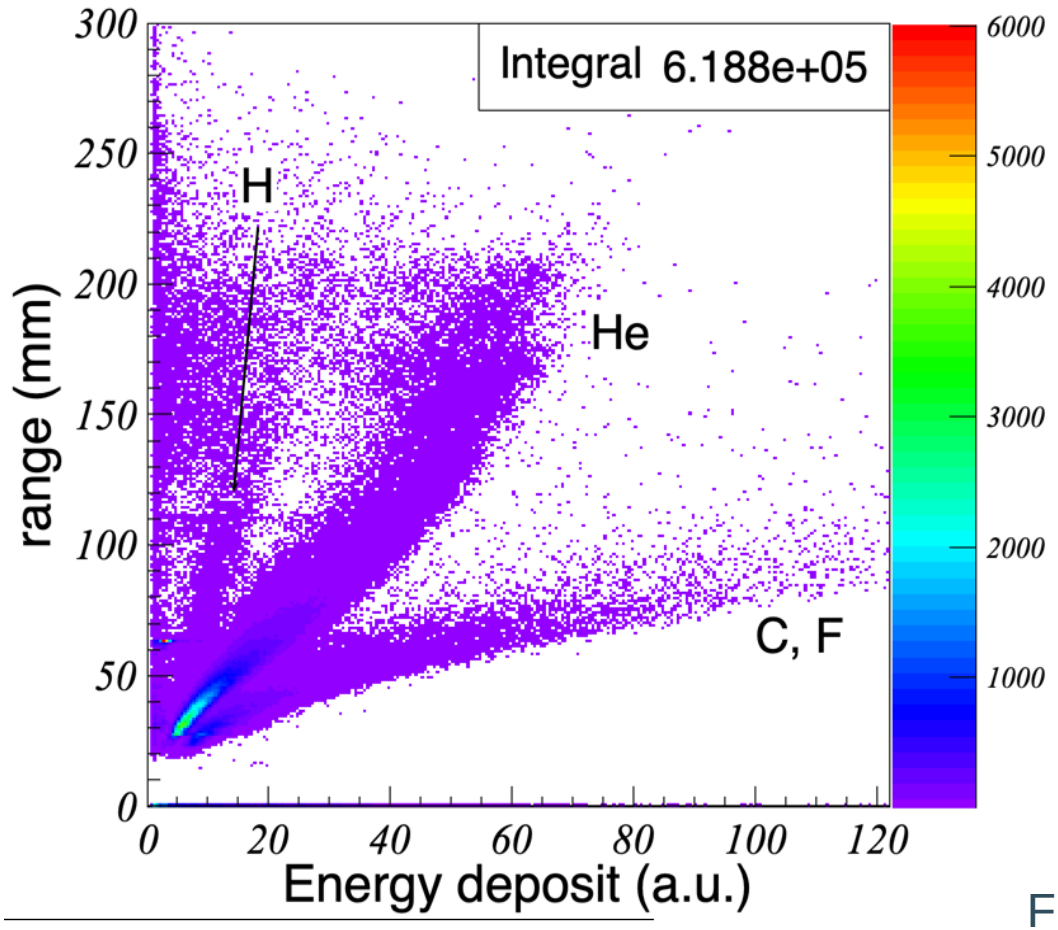


Fig credits: B.Mauss

e780 PRELIMINARY online analysis – $^{58}Ni(\alpha,\alpha')^{58}Ni^*$

Kinematics curve

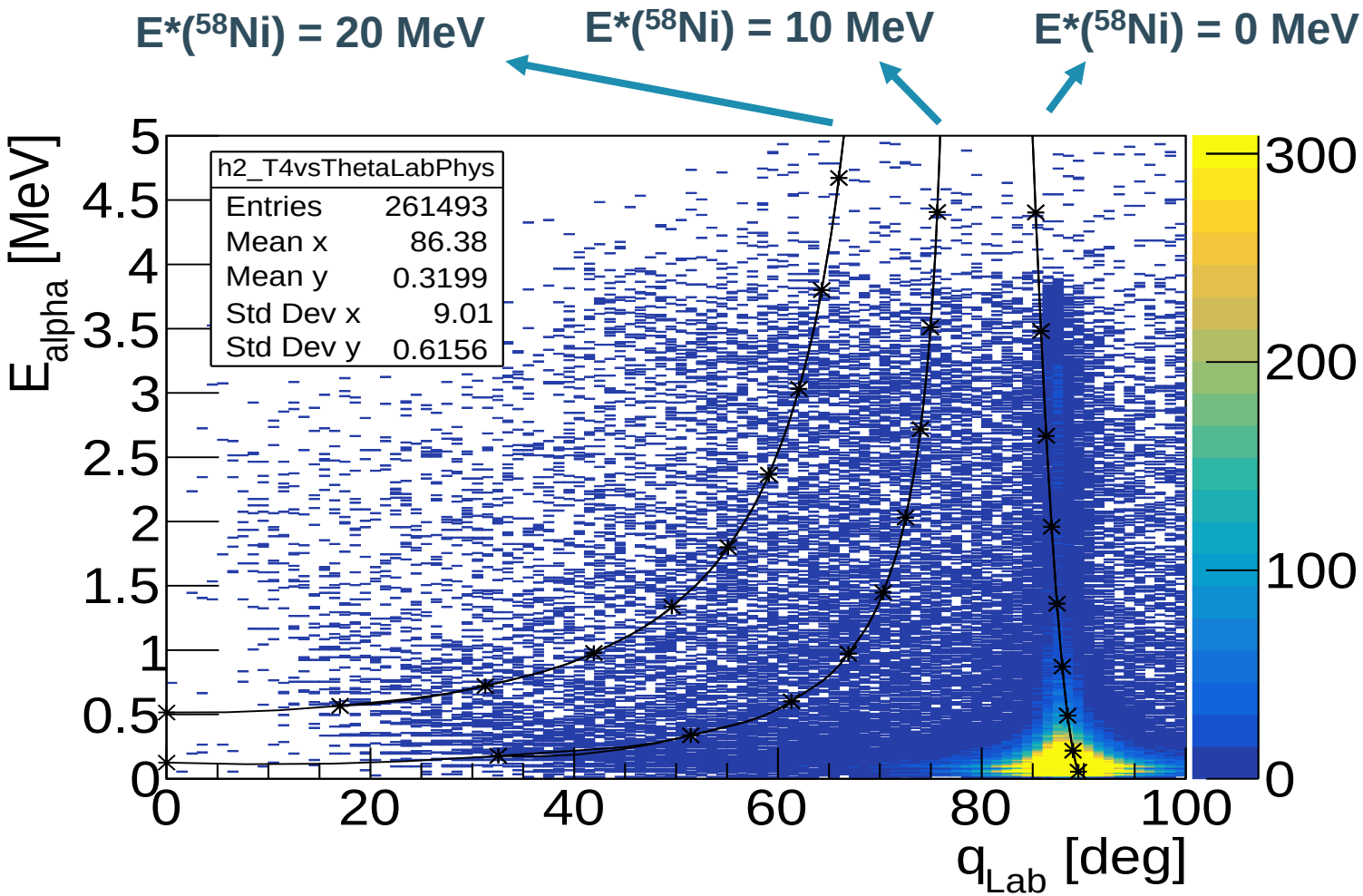
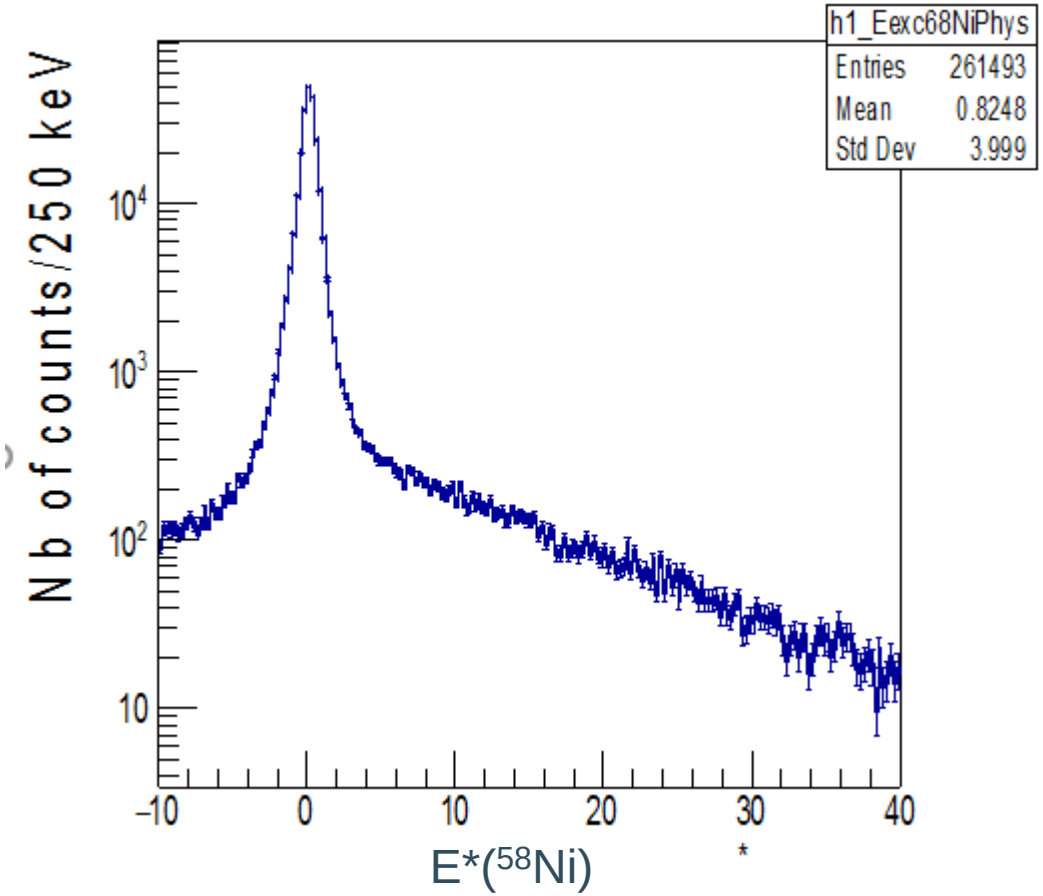


Fig credits: Marine Vandebrouck

e780 PRELIMINARY online analysis – $^{58}Ni(\alpha,\alpha')^{58}Ni^*$

Excitation Energy spectrum



^{58}Ni

Mean = 160 KeV
Resolution = 420 KeV

^{68}Ni

Mean = 370 KeV
Resolution = 650 KeV

Fig credits: Marine Vandebrouck

e780 PRELIMINARY online analysis – $^{68}Ni(\alpha,\alpha')^{68}Ni^*$

Identification of the scattered particle

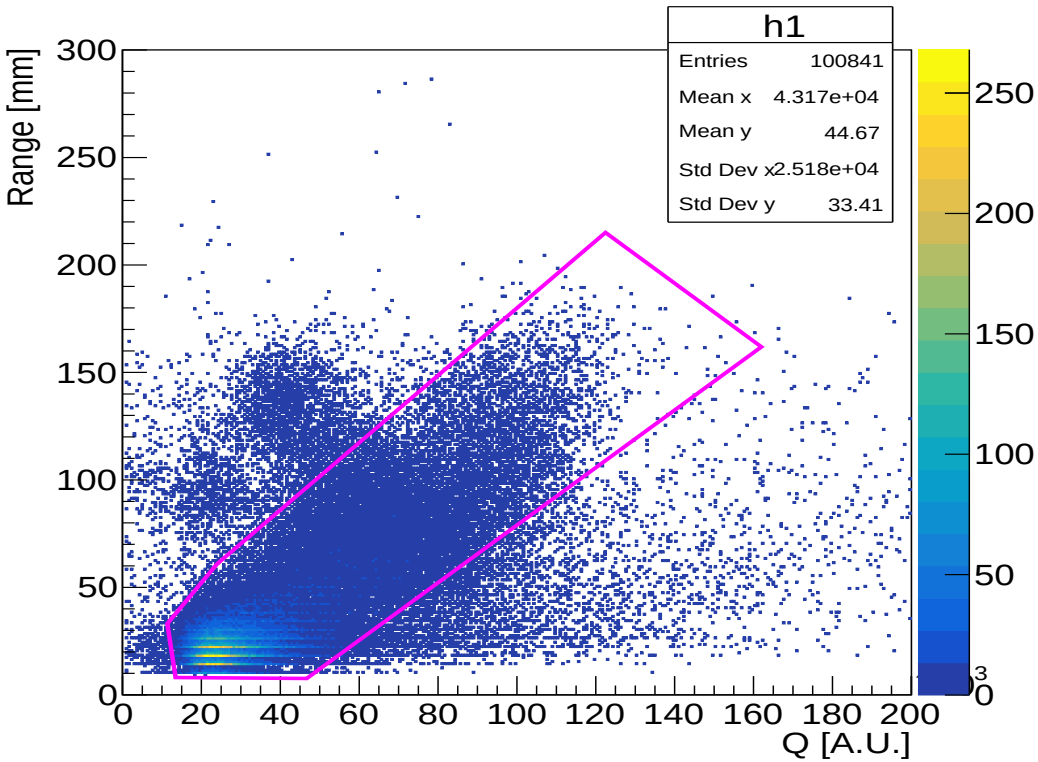


Fig credits: Marine Vandebrouck

e780 PRELIMINARY online analysis – $^{68}Ni(\alpha,\alpha')^{68}Ni^*$

Kinematics curve

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

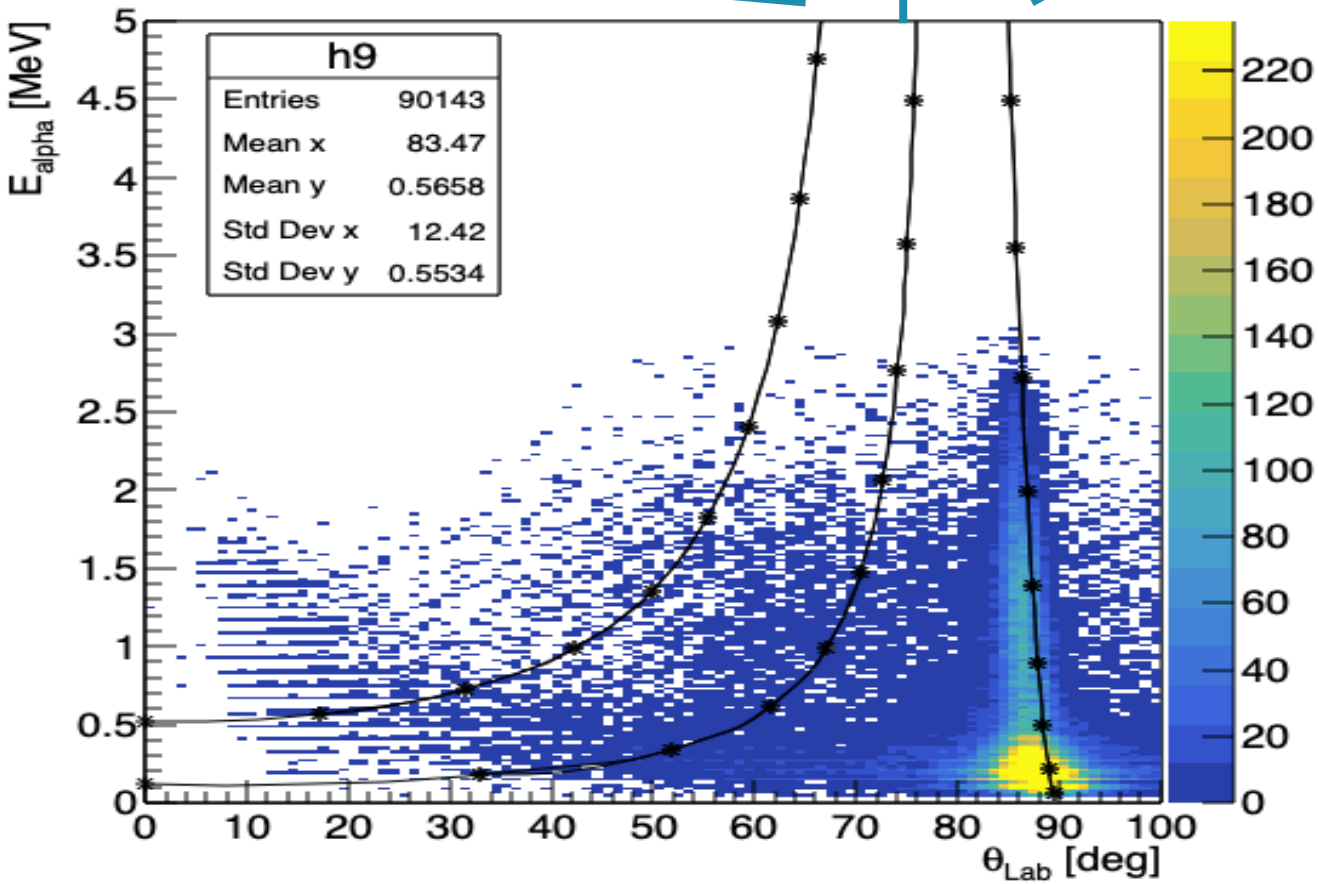


Fig credits: Marine Vandebrouck

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

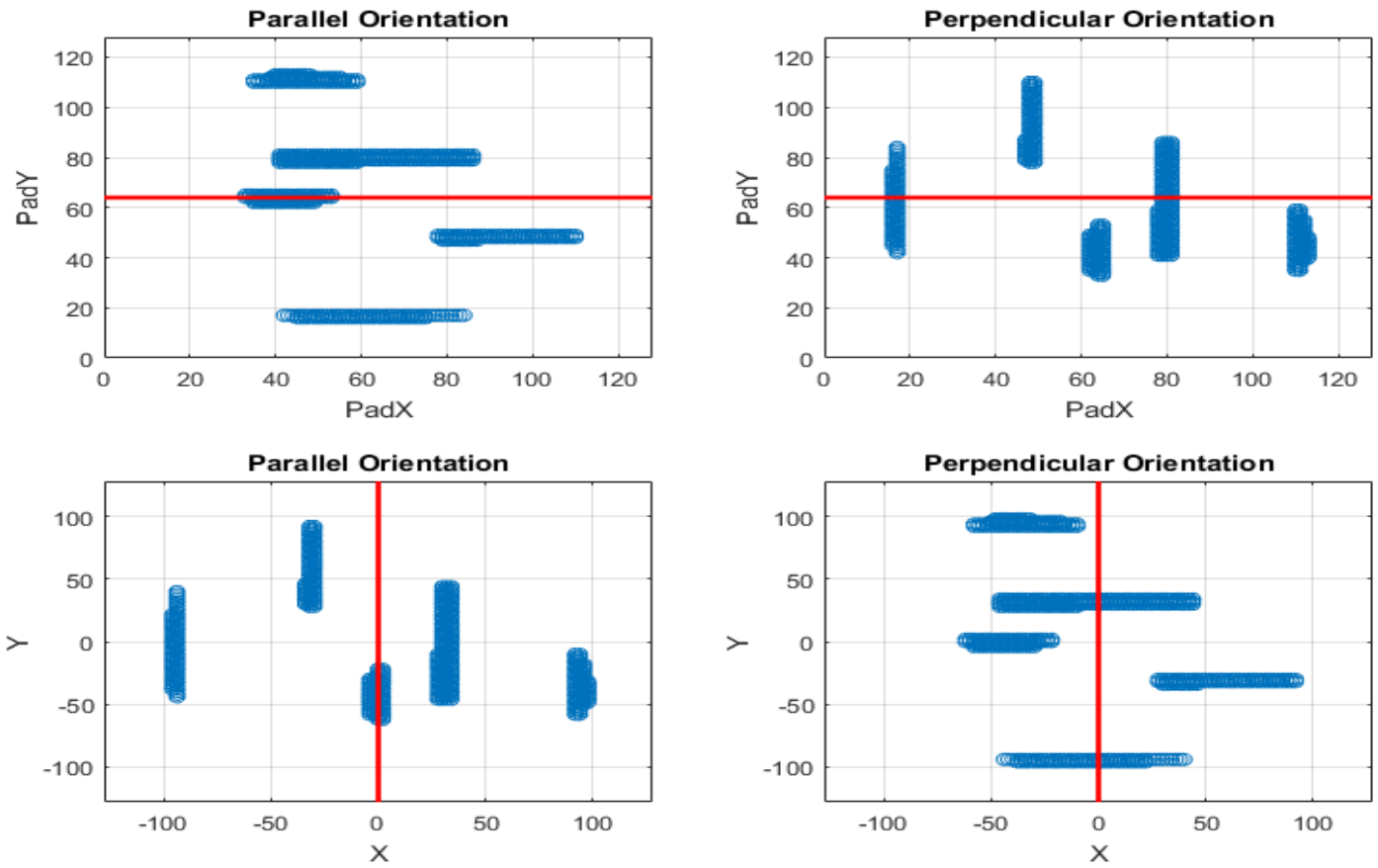
3. Identification of Clusters using density based spatial clustering approach.

4. Identification of track orientation using principal component analysis – Bailey 2016 – Weighted EMPCA using weighted expectation maximization

5. Weighted 3D Charge projection

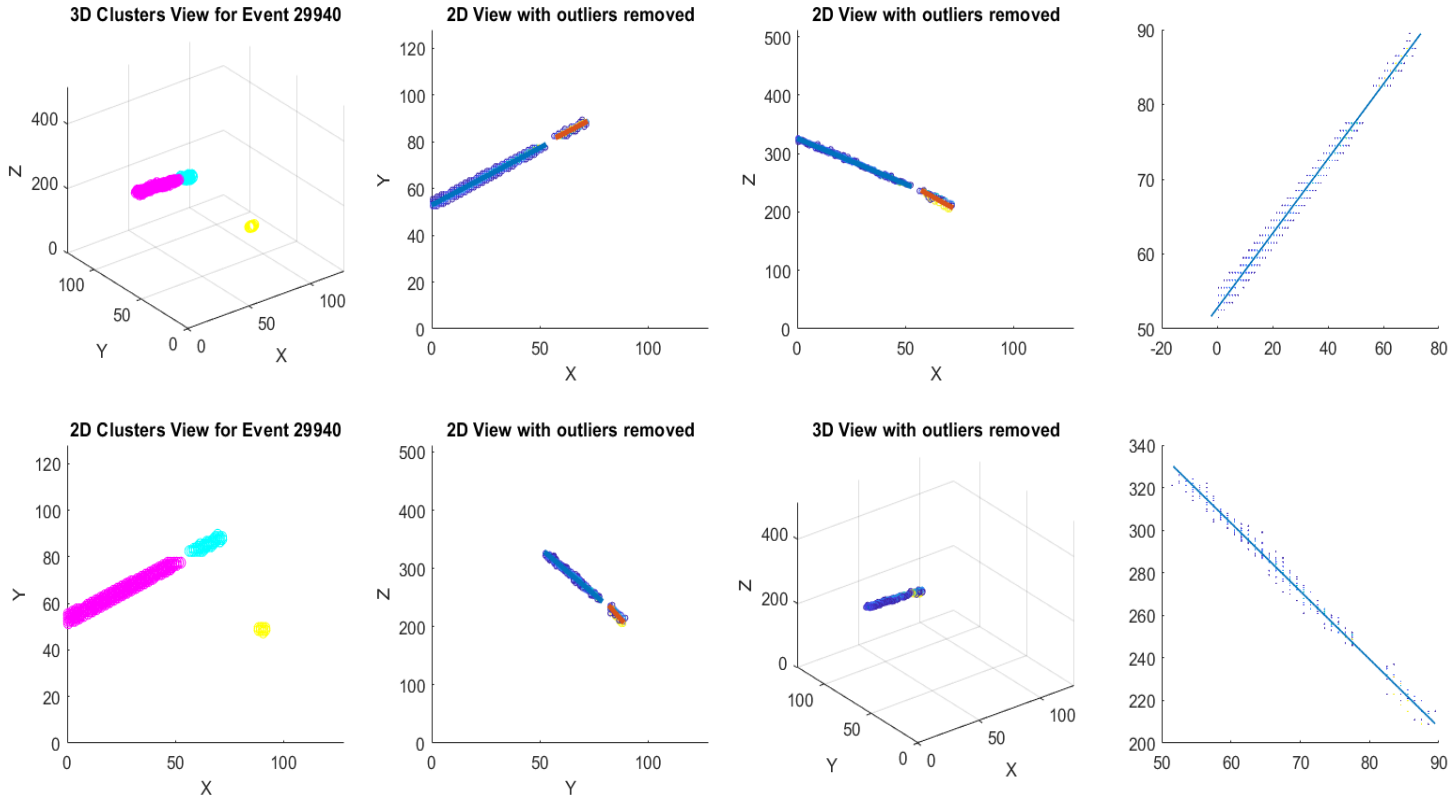
e780 – OFFLINE ANALYSIS – Tracking Algorithms

missing pads



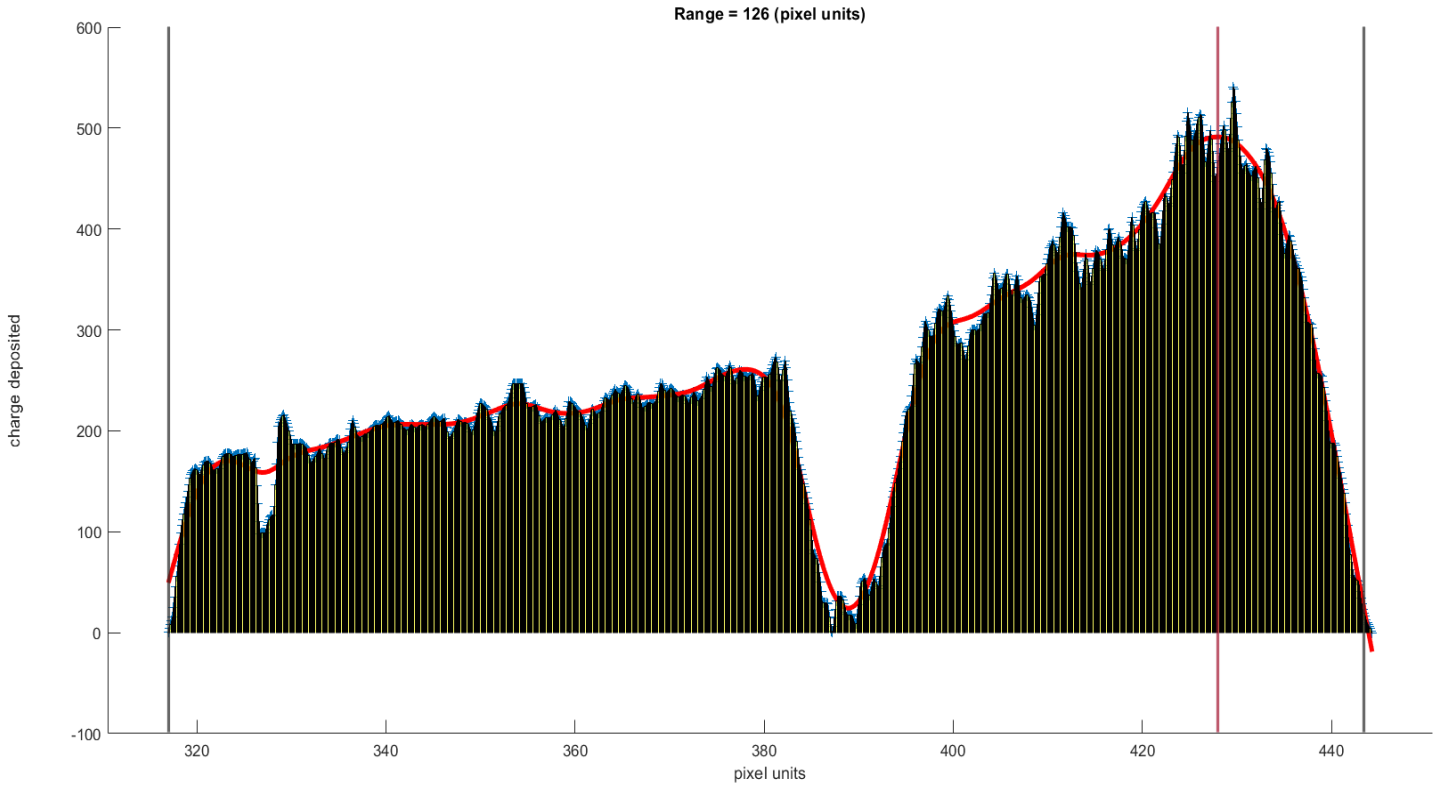
e780 – OFFLINE ANALYSIS – Tracking Algorithms

- Identification of clusters, track orientation, cluster merging for tracks with holes



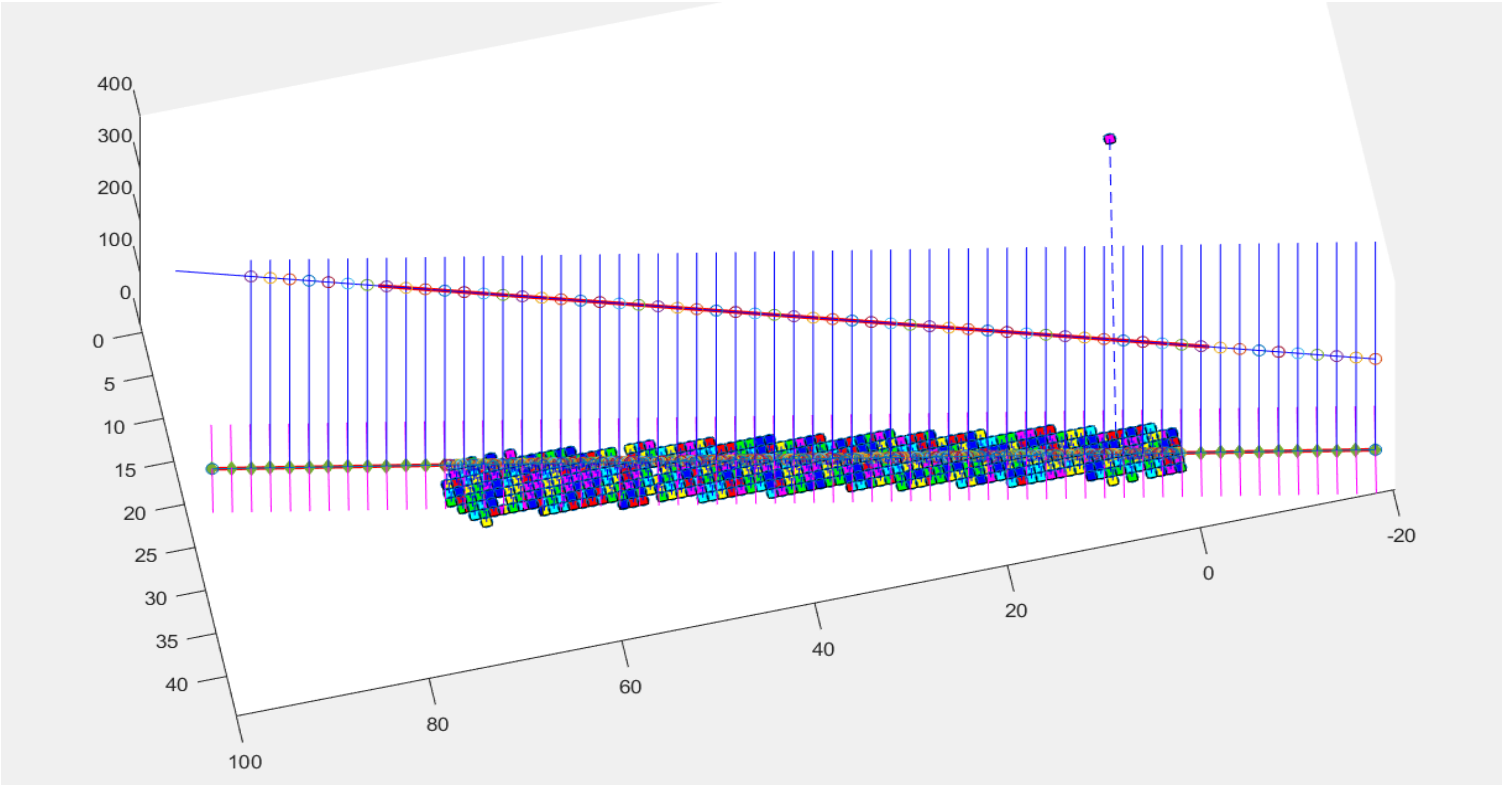
e780 – OFFLINE ANALYSIS – Tracking Algorithms

- Charge profile with hole corrections



e780 – OFFLINE ANALYSIS – Tracking Algorithms

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

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Thank you for your attention