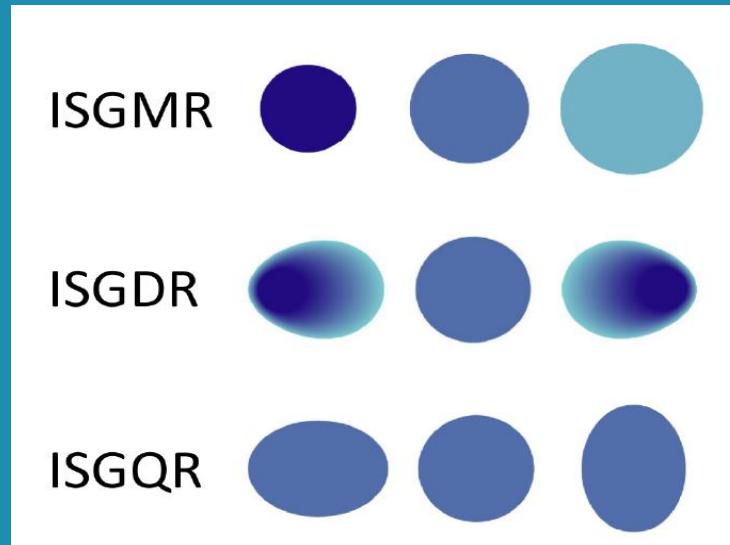


Searching for isoscalar resonances in ^{68}Ni with ACTAR TPC



Alex Antony Arokiaraj

Supervised by:

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Dr. Marine Vandebruck, CEA, France

Structure

- Motivation
- Experiment
- Analysis
- Outlook

Motivation: Giant Resonances

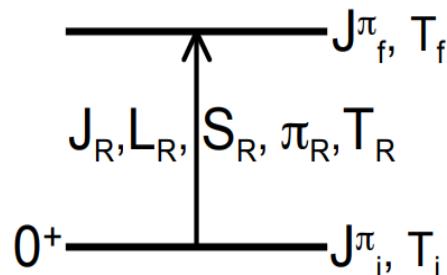
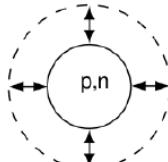
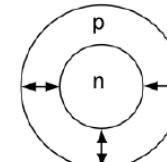


Fig courtesy: Elias Khan

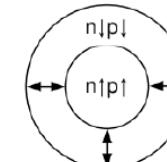
$\Delta L = 0$
Monopole (M)



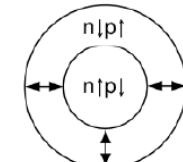
ISGMR



IVGMR

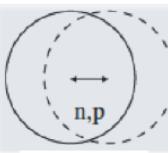


ISSGMR

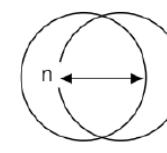


IVSGMR

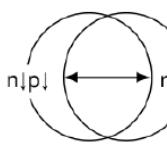
$\Delta L = 1$
Dipole (D)



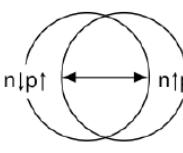
ISGDR



IVGDR

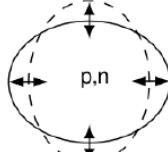


ISSGDR

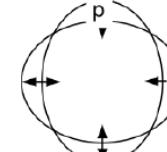


IVSGDR

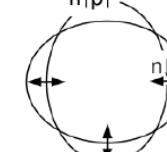
$\Delta L = 2$
Quadrupole (Q)



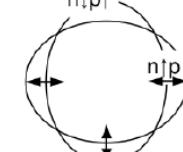
ISGQR



IVGQR



ISSGQR



IVSGQR

Multipole Decomposition Analysis

Inelastic scattering – alpha probe

$\Delta T = 0$
Isoscalar (IS)
 $\Delta S = 0$
Electric

$\Delta T = 1$
Isovector (IV)
 $\Delta S = 0$
Electric

$\Delta T = 0$
Isoscalar (IS)
 $\Delta S = 1$
Magnetic (S)

$\Delta T = 1$
Isovector (IV)
 $\Delta S = 1$
Magnetic (S)

Fig courtesy: Bagchi 2015 PhD Thesis

Motivation: Physical Interpretation of Angular Distributions

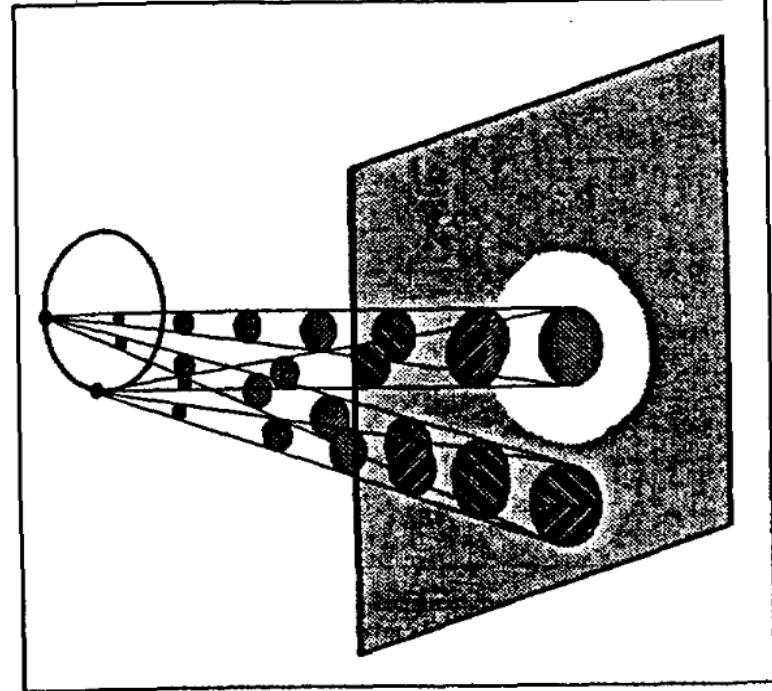
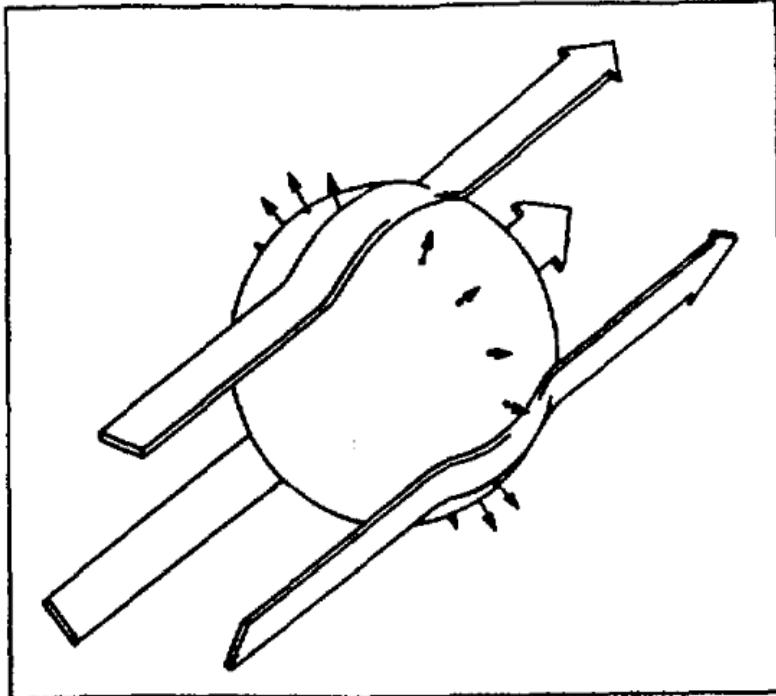


Fig courtesy: P. Chomaz

Schematic picture of diffraction of different wavelets at the periphery of the nucleus performing a monopole vibration

Motivation: Incompressibility of Nuclear Matter

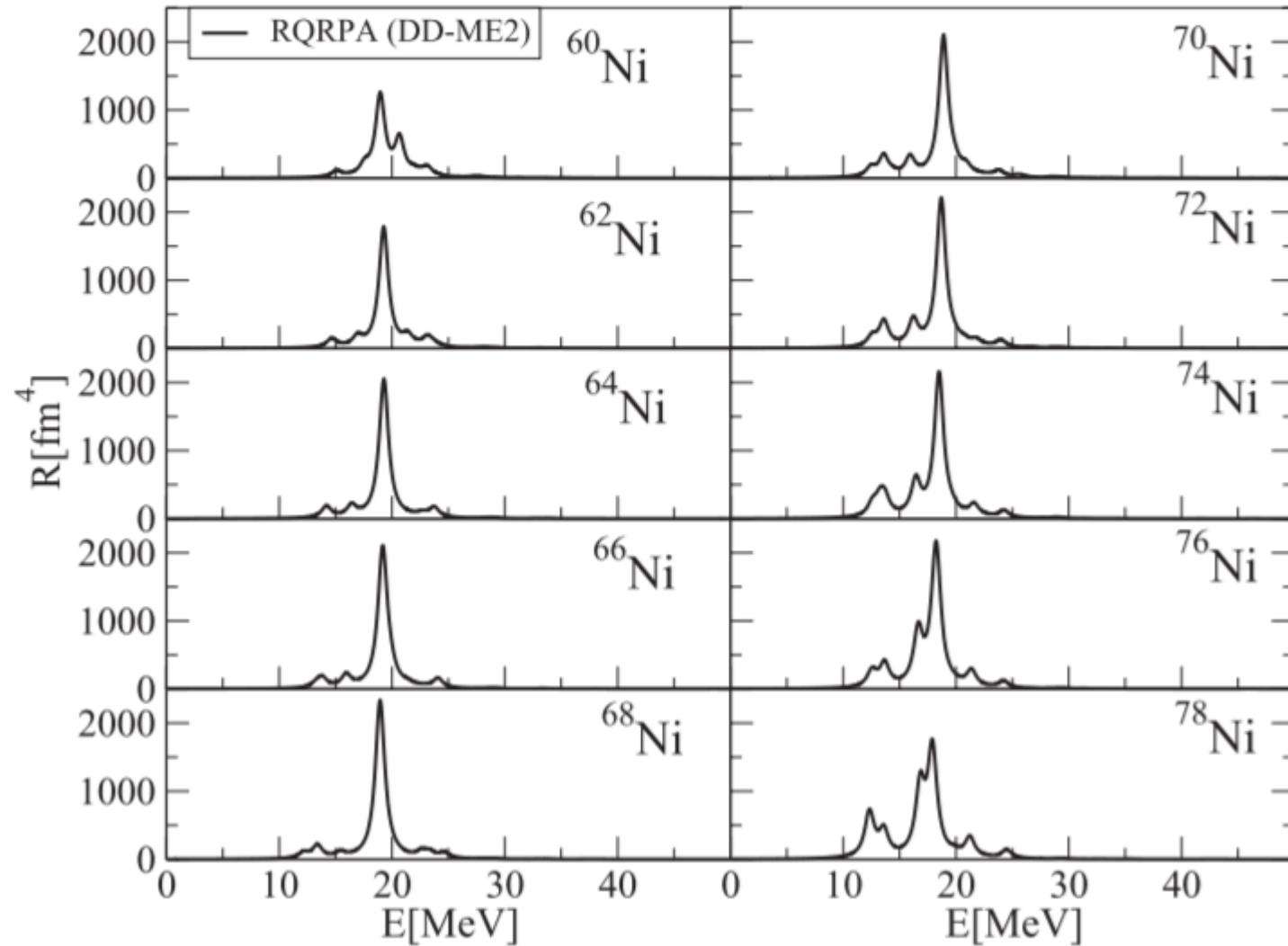
$$E_{ISGMR} = \hbar \sqrt{\frac{K_A}{m \langle r^2 \rangle}}$$

$$E_{ISGDR} = \hbar \sqrt{\frac{7}{3} \frac{K_A + \frac{27}{25}\epsilon_F}{m \langle r^2 \rangle}}$$

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

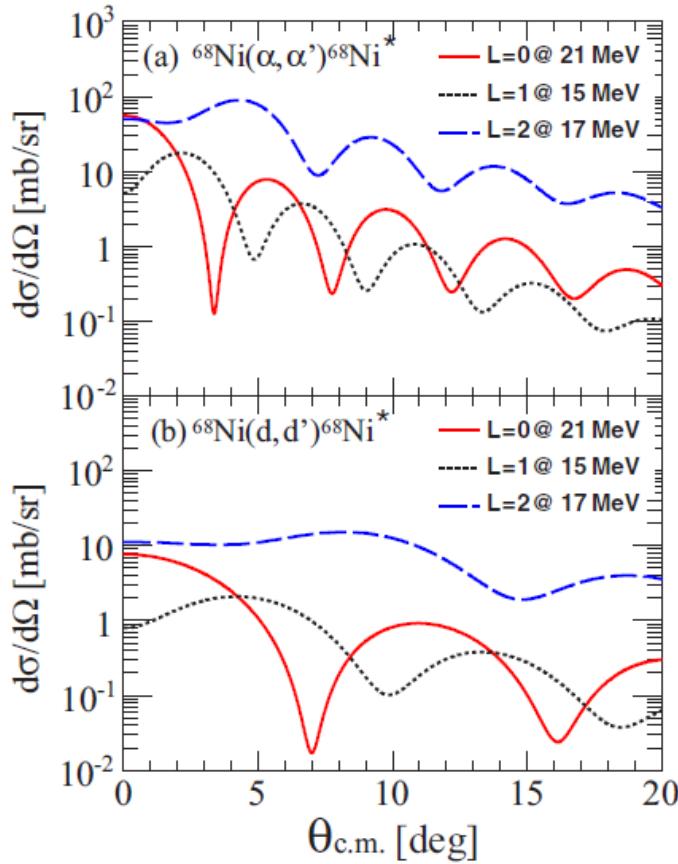
- Fully Consistent RPA (Random Phase Approximations)
- Provides at the same time K_∞ , E_{ISGMR}
- $K_\infty = 240 \pm 10$ MeV, ^{208}Pb B.K.Agrawal et.al 2003
- $K_\infty = 230 \pm 40$ MeV, $^{208}\text{Pb}, ^{120}\text{Sn}$ Khan et.al 2013

Motivation: Soft Modes



E.Khan et.al PRC (2011)

Experiment: Constraints



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

Experiment: ACTAR TPC, GANIL

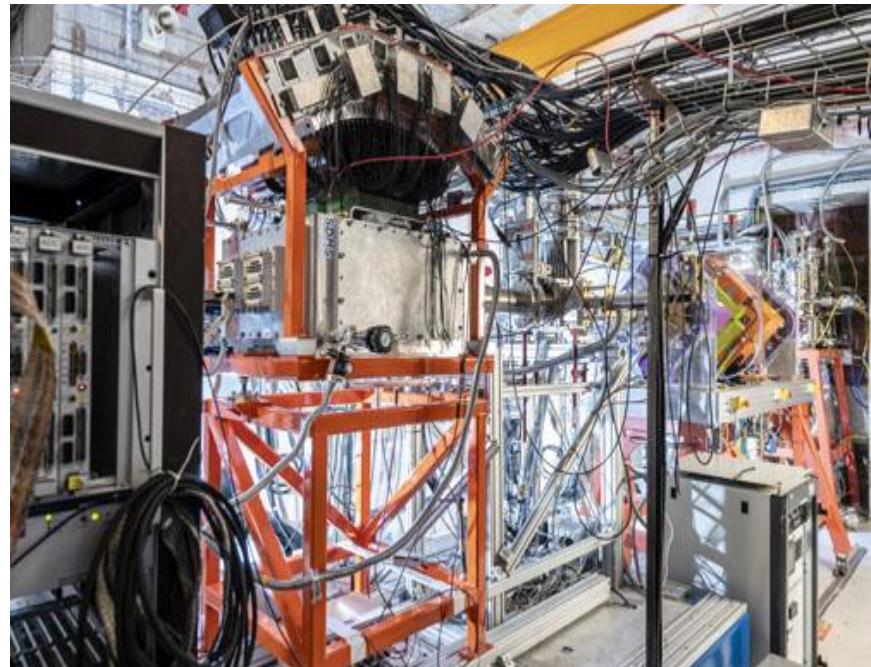
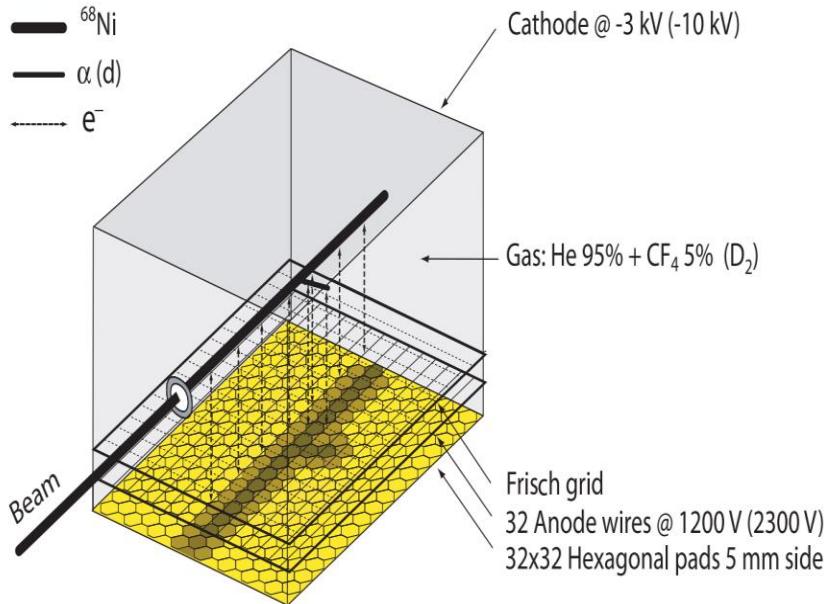


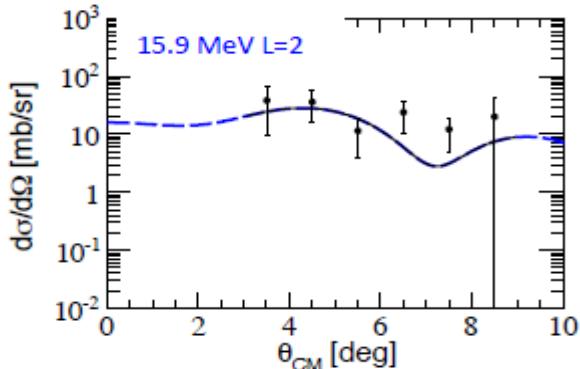
Fig courtesy: Marine Vandebrouck

B.Mauss et.al NIM (2020)

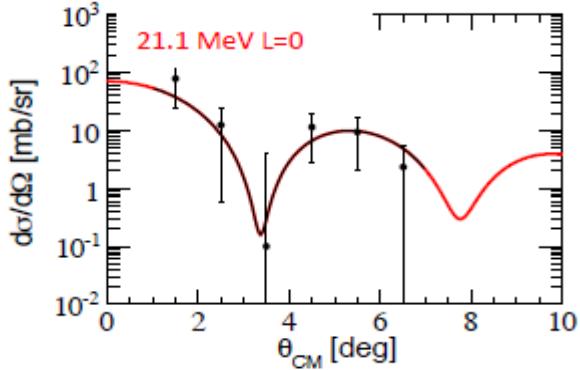
High resolution pads – 2 mm * 2mm as compared to MAYA

Experiment: Benchmark – Previous measurements with MAYA

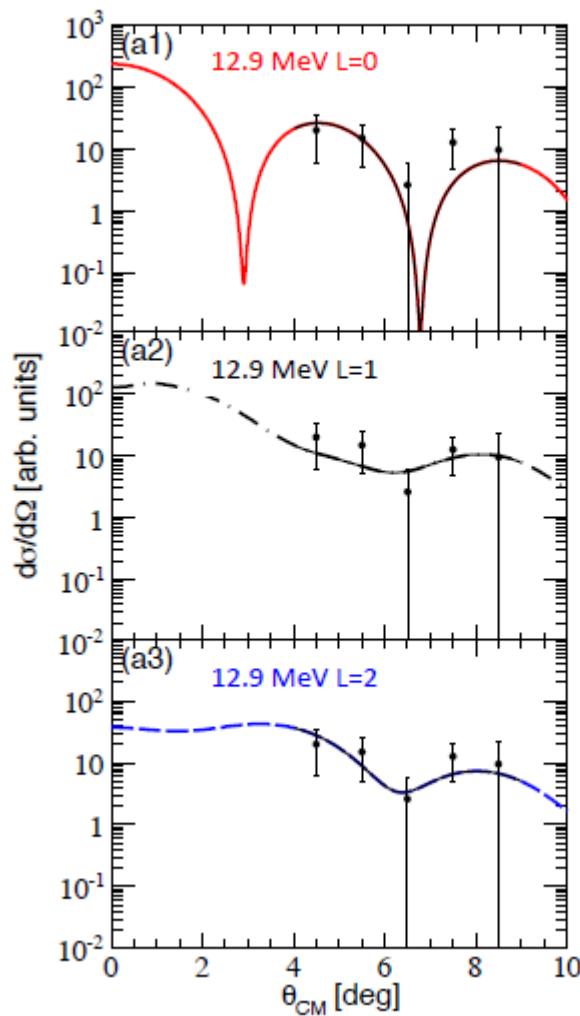
ISGQR



ISGMR

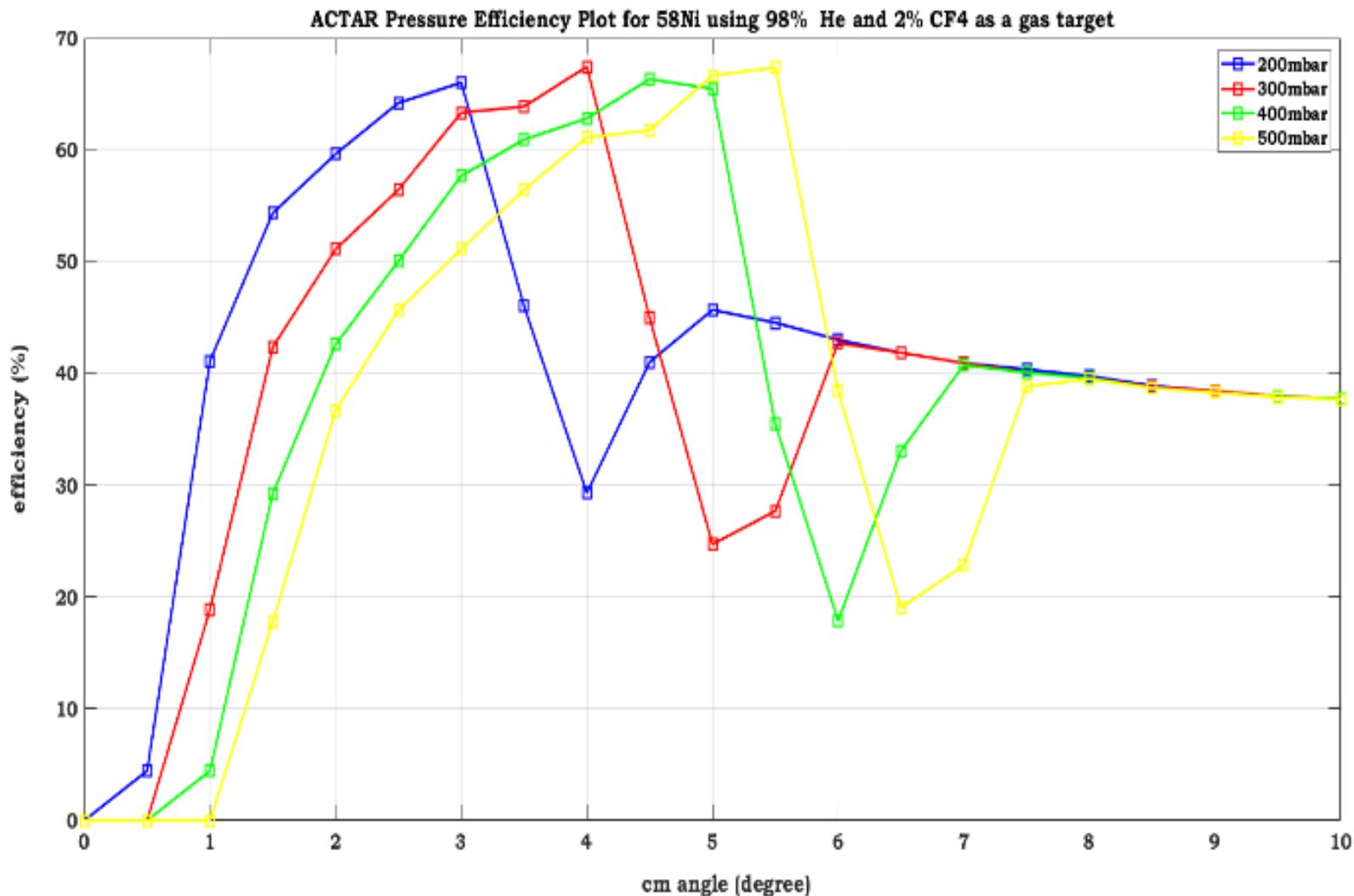


M.Vandebruck et.al PRC (2015)



Soft
ISGMR ?

Experiment: Upgrade – Capabilities of ACTAR TPC



Experiment: e780 @ GANIL



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

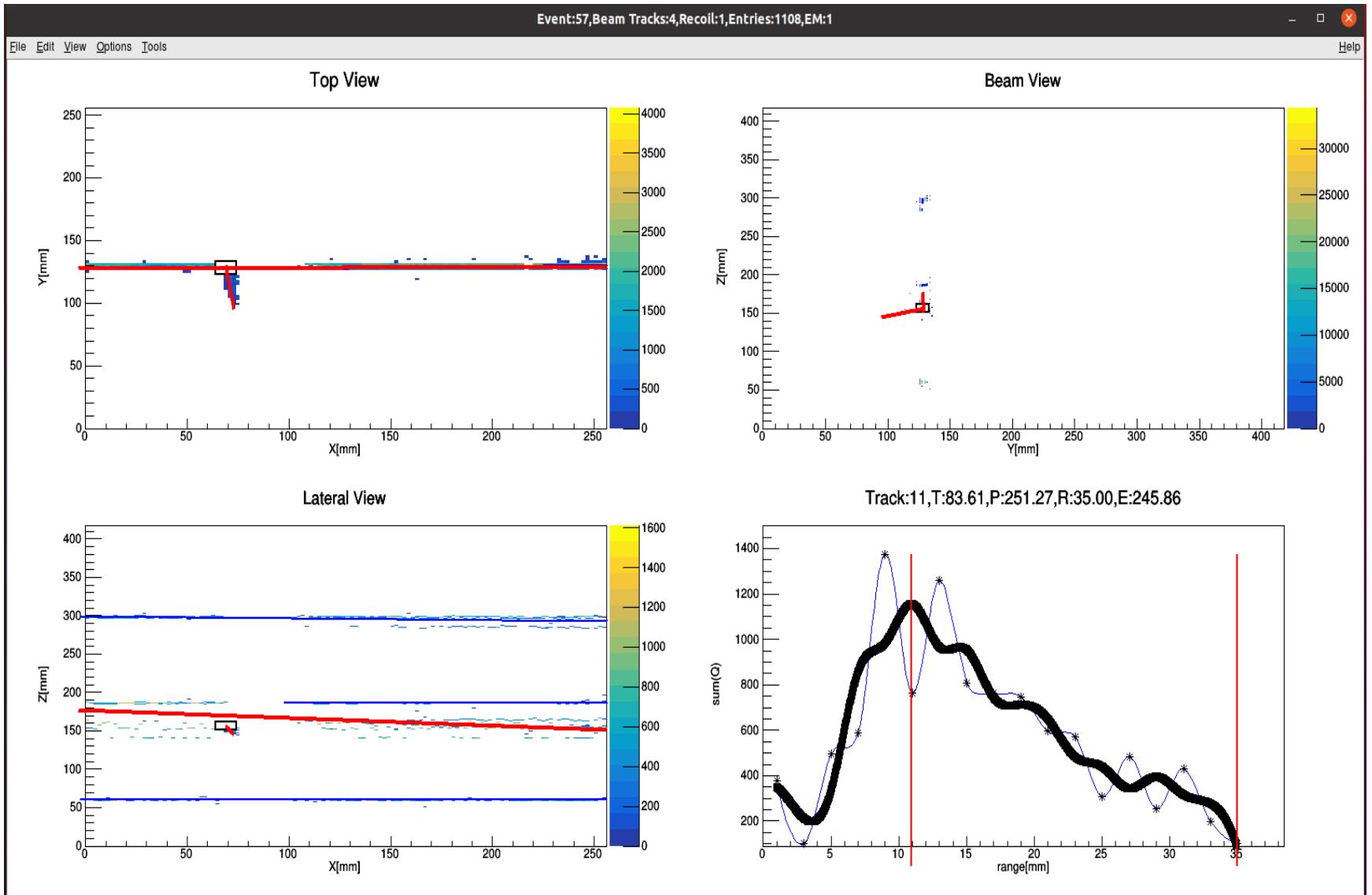
Analysis: iTracks

- Particle Identification tool for analyzing the images from active targets
- Unsupervised Learning Techniques employed to isolate the tracks
- Available on github page <https://github.com/alexantonyarokiaraj/iTracks>
- Customized to run on distributed environments – based on Apache Spark
- Process rate: 2 secs/image on single core. With 100 cores - 7 million images processed in 2 days

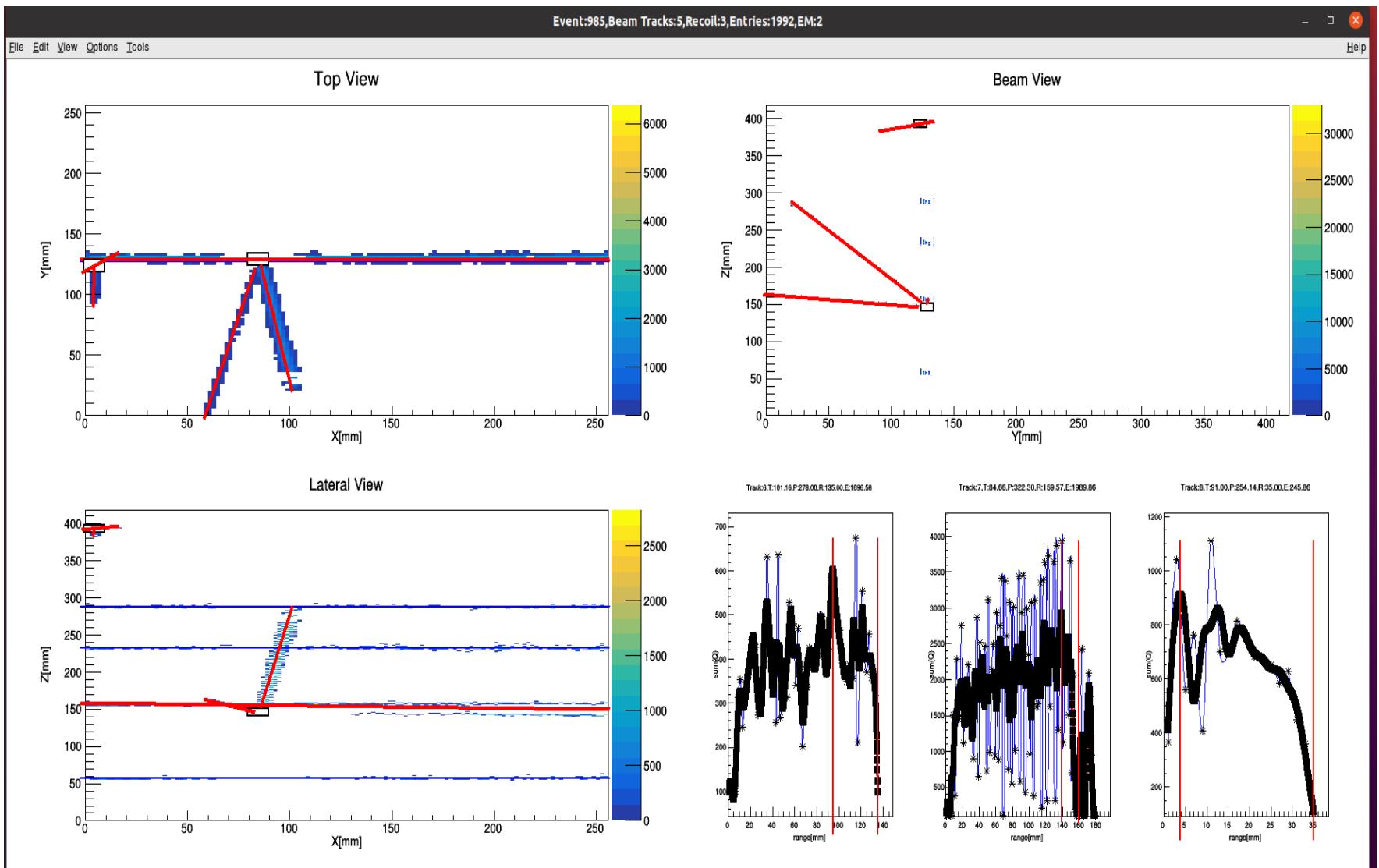
The Tool gives the following output parameters

1. Number of identified tracks – separated into projectile and ejectile tracks
2. Reaction Vertices
3. Kinematic Parameters – Lab Angle, Phi Angle, Range, Energy, Center of mass Angle and Excitation Energy

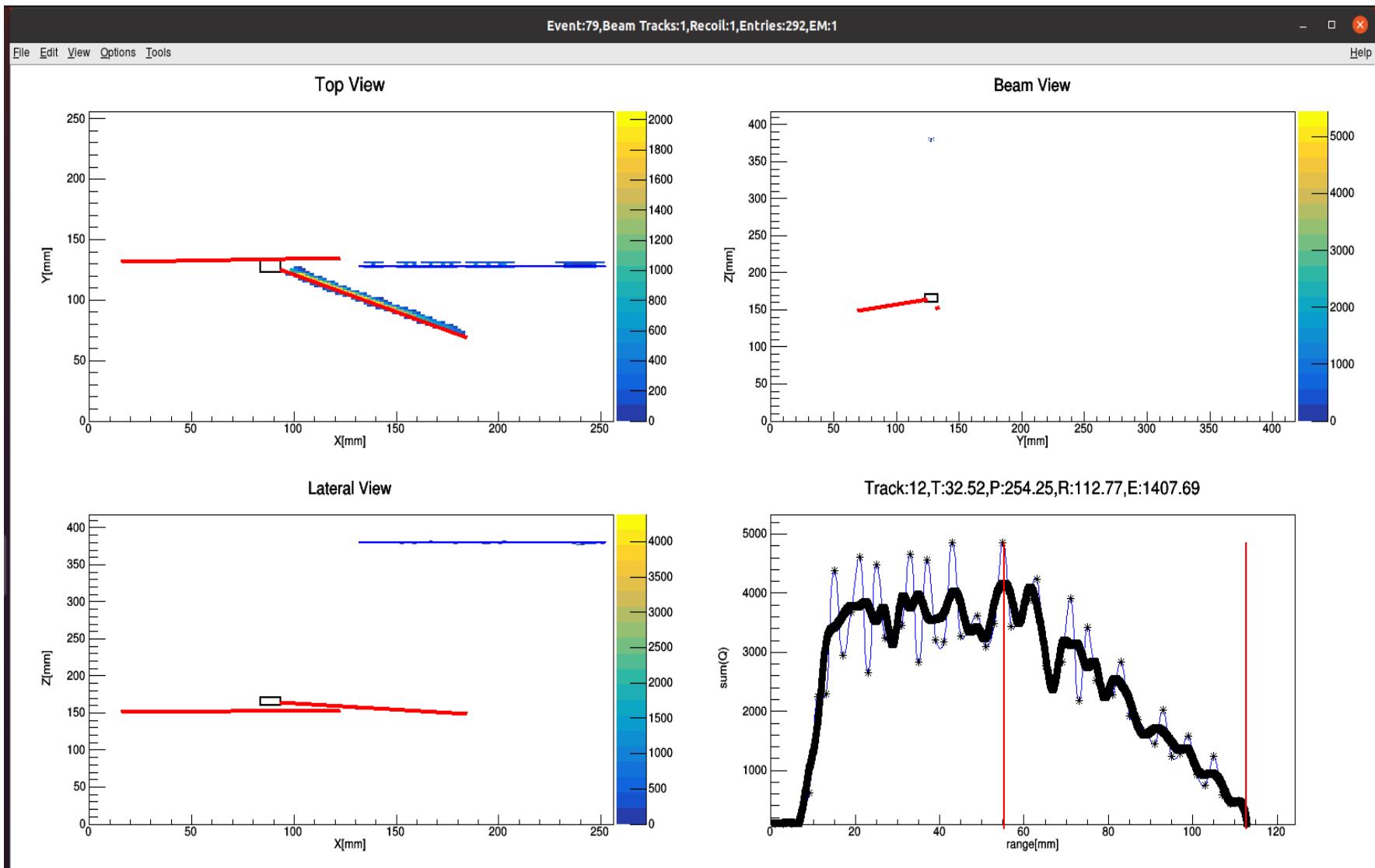
Analysis: iTracks - Samples



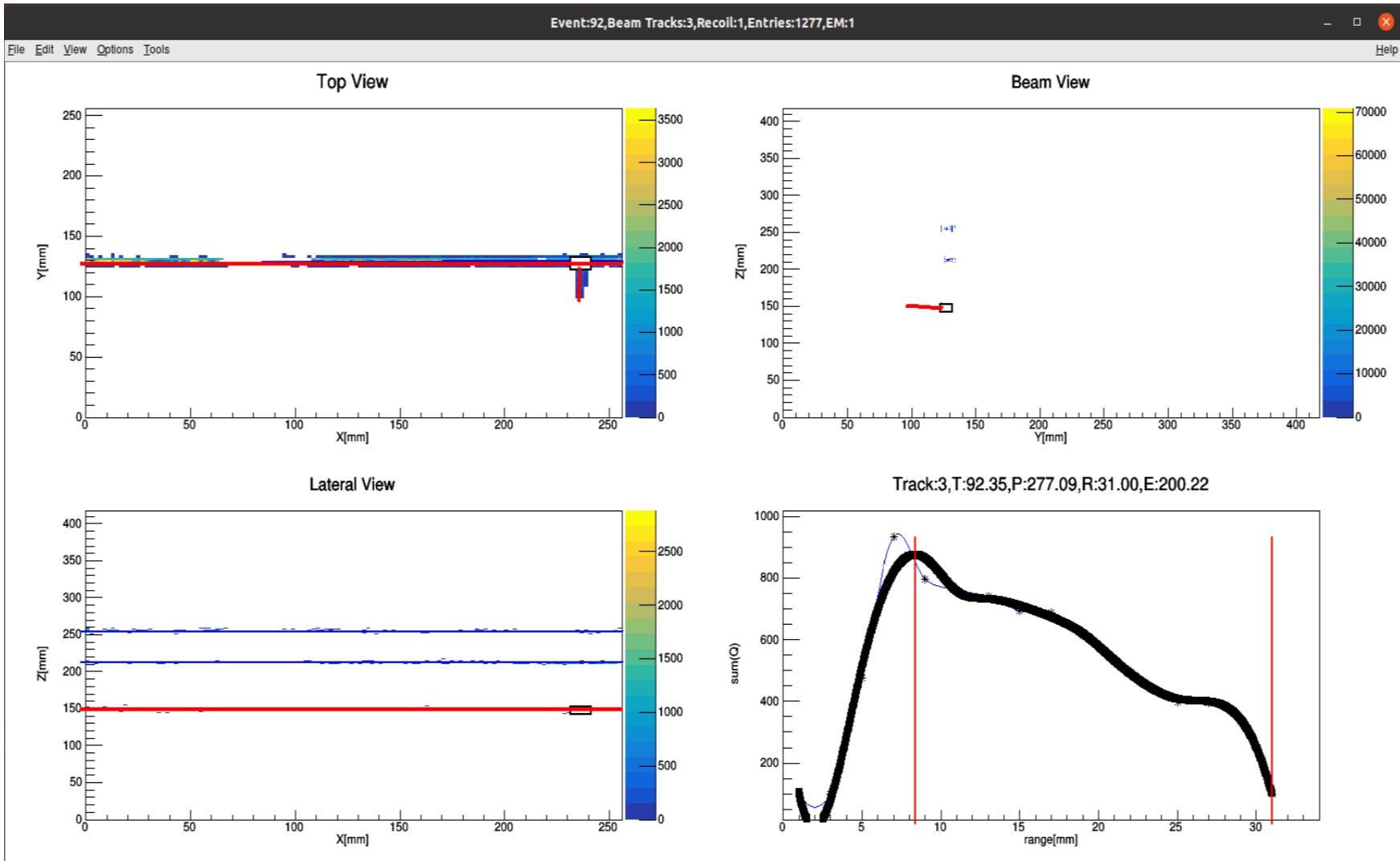
Analysis: iTracks - Samples



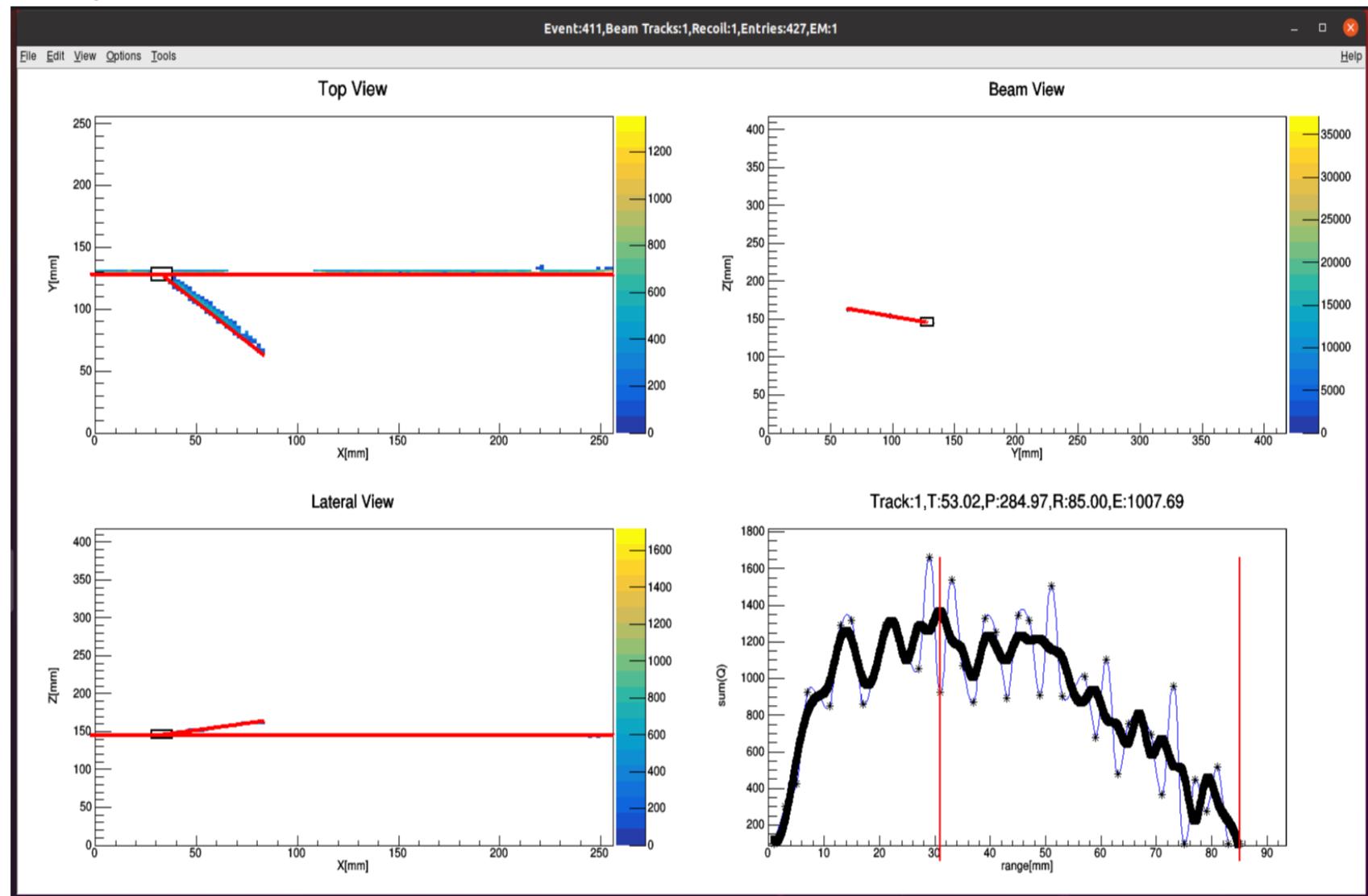
Analysis: iTracks - Samples



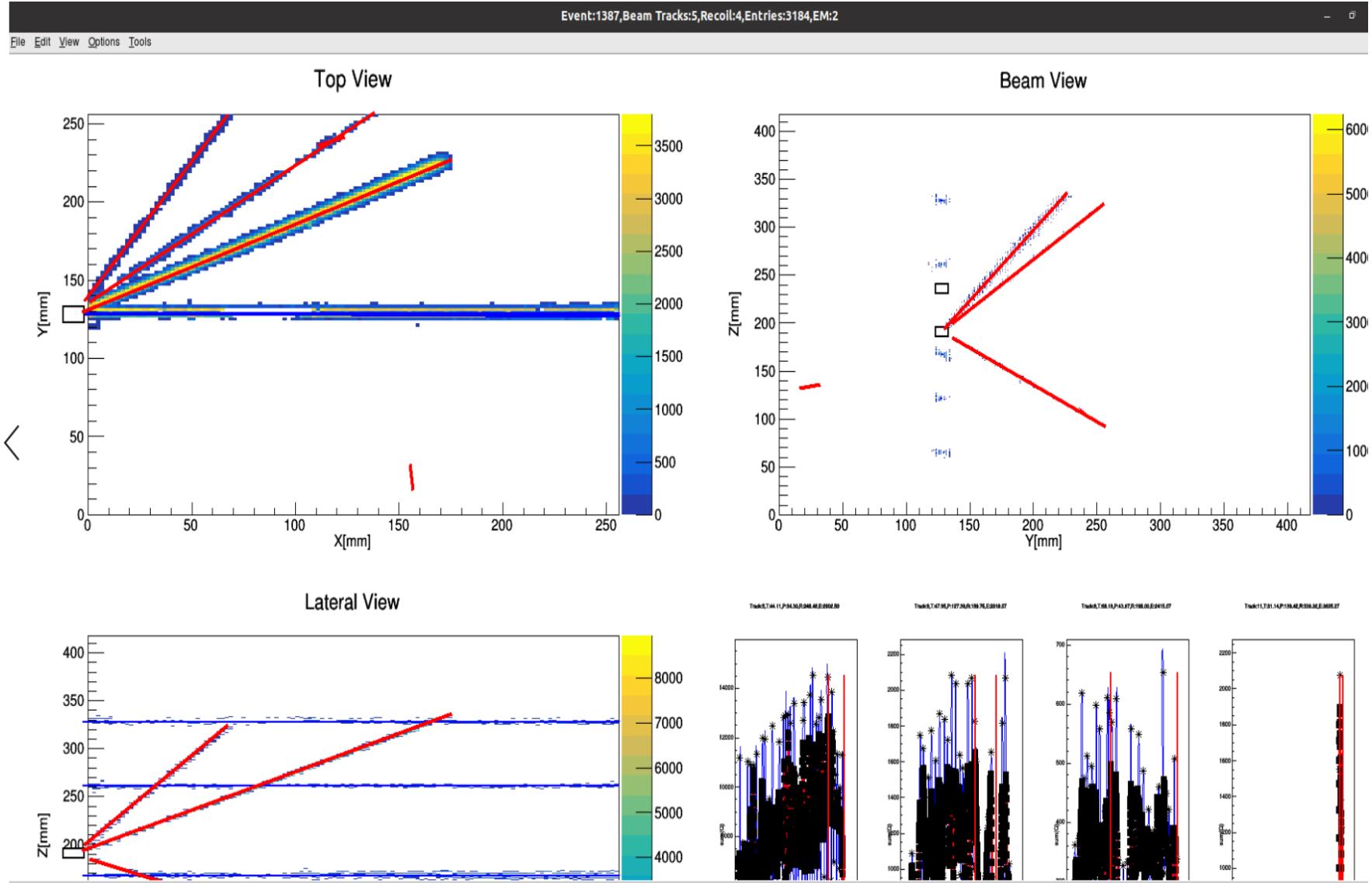
Analysis: iTracks - Samples



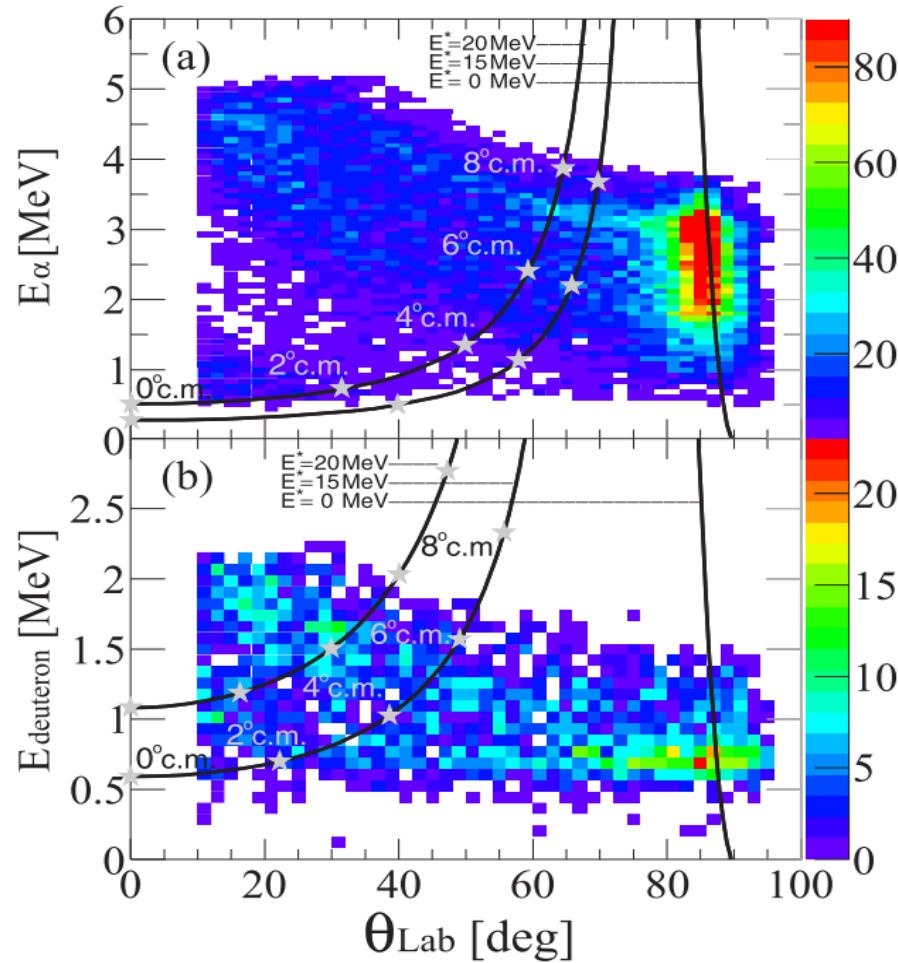
Analysis: iTracks - Samples



Analysis: iTracks - Samples

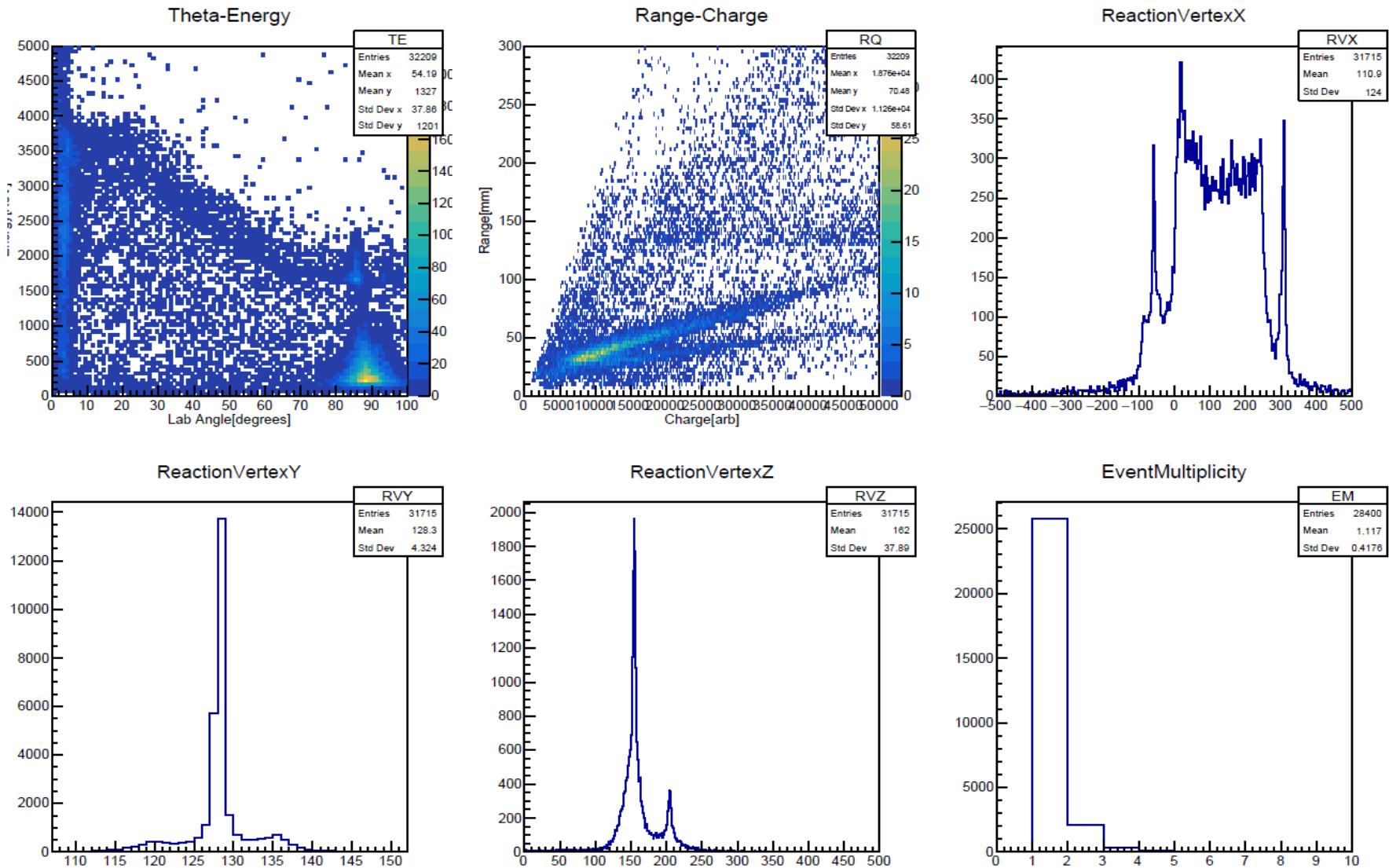


Results: Benchmark



M.Vandebruck et.al PRC (2015)

Results: iTracks - Output



Outlook

- Next - Event Selection
- Next – Correction using Simulations
- Validation of ^{58}Ni and the search on ^{68}Ni
- A better understanding of the soft modes in neutron rich nuclei.