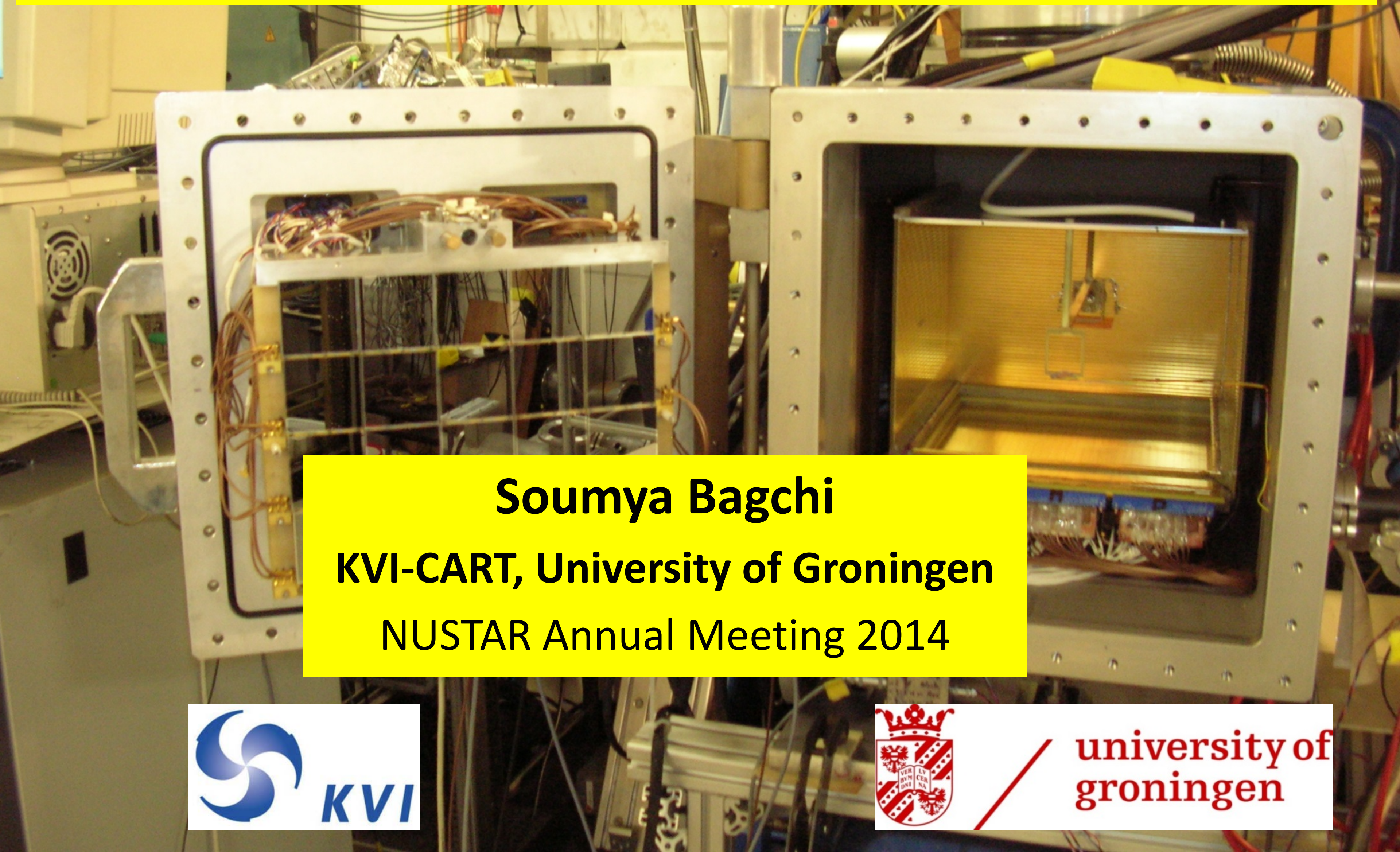
Study of compression modes in ^{56}Ni with the active target MAYA



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NUSTAR Annual Meeting 2014

KVI

university of groningen

Outline

- Introduction to Giant Resonances
- Importance of compression modes in nuclei
- Experimental Setup
- Results
- Summary and outlook

Giant Resonances (GR)

Isoscalar

In phase

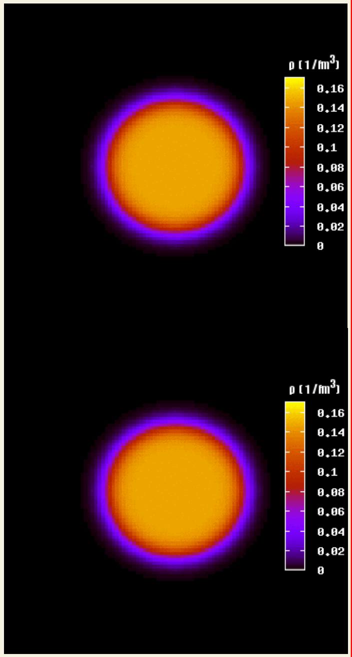
Isovector

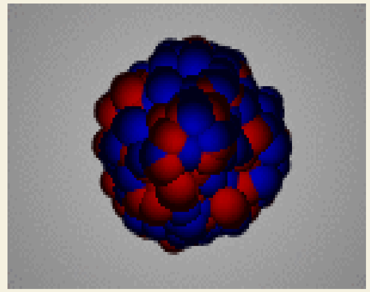
Out of phase

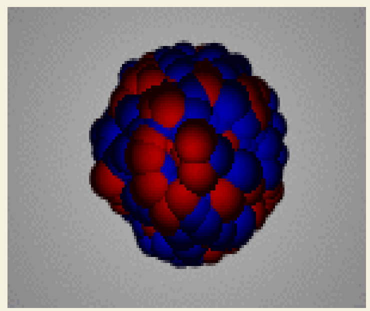
Compression modes

Monopole
L = 0
(GMR)

Dipole
L = 1
(GDR)







Giant Resonances (GR)

Compression modes

Isoscalar

In phase

Monopole
L = 0
(GMR)

Dipole
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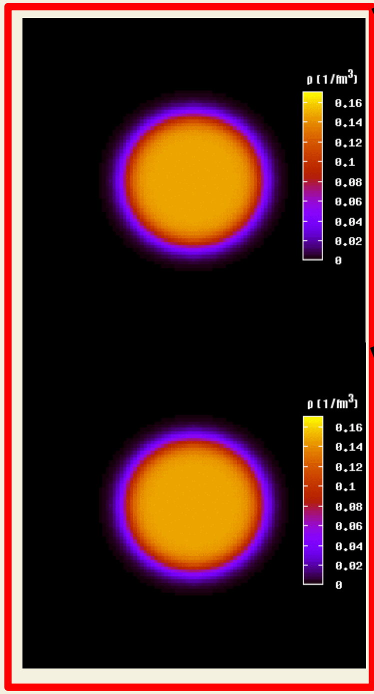
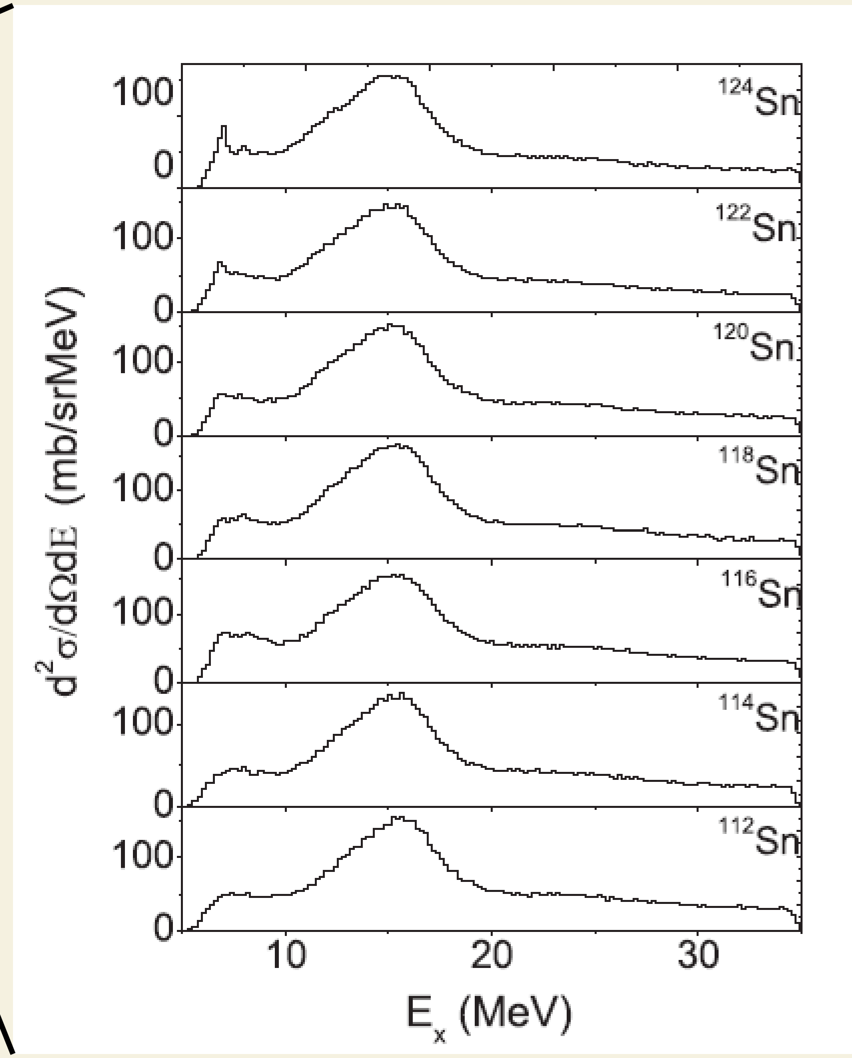


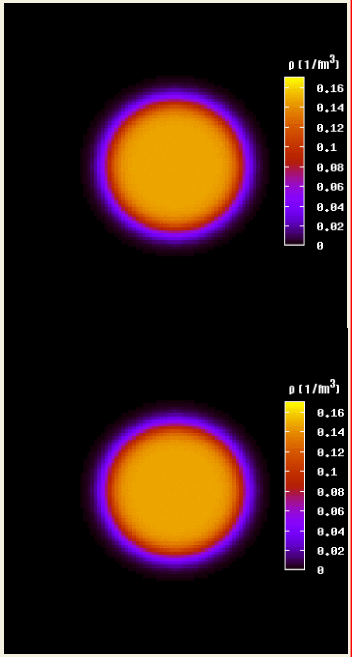


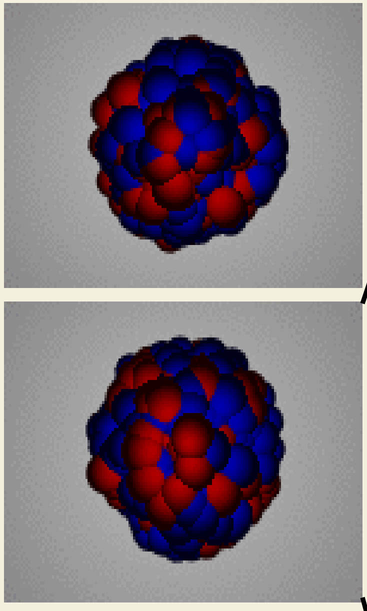
[T. Li., *et al.,* PRC **81**, 034309 (2010)]

Giant Resonances (GR)

Compression modes

	Isoscalar In phase	Isovector Out of phase
Monopole L = 0 (GMR)		
Dipole L = 1 (GDR)		



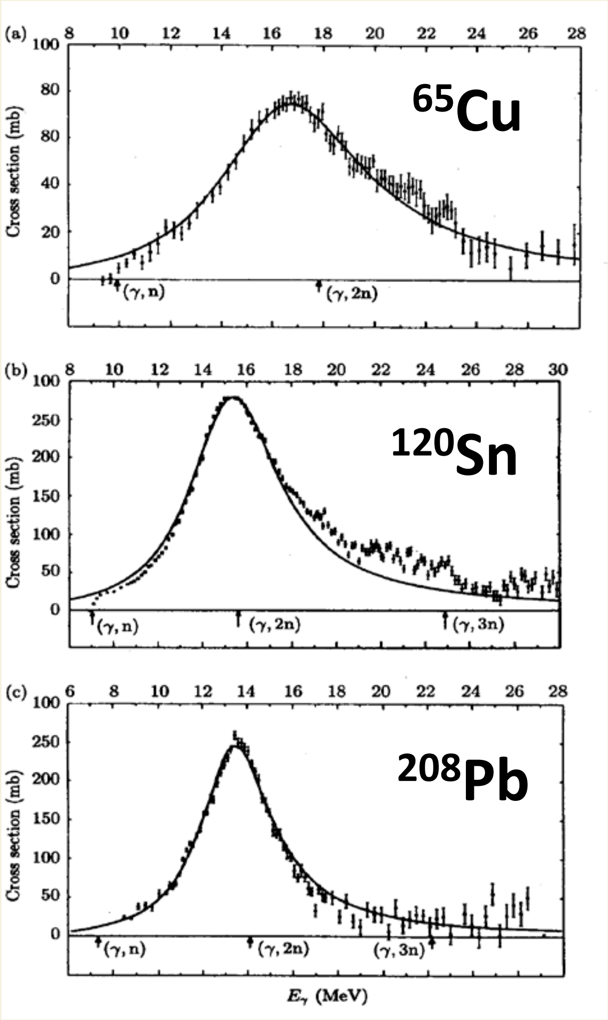


Macroscopically:

- Excitation Energy
- Width

Photo absorption cross sections

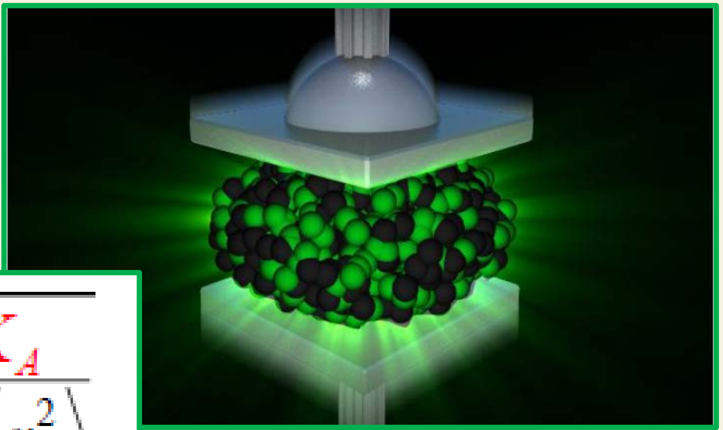
Berman and Fultz, Rev. Mod. Phys. 47 (1975) 47

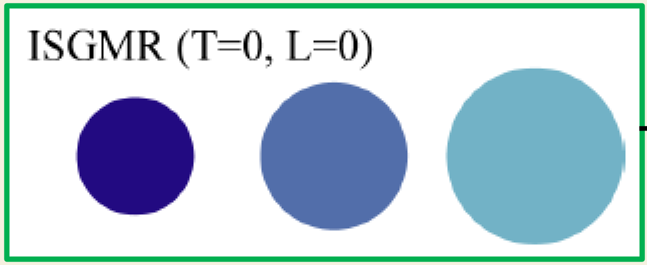


Nuclear Incompressibility

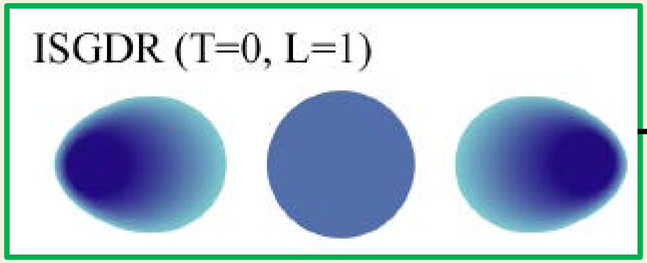
Incompressibility:

Measure of the resistance of matter to uniform compression





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



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

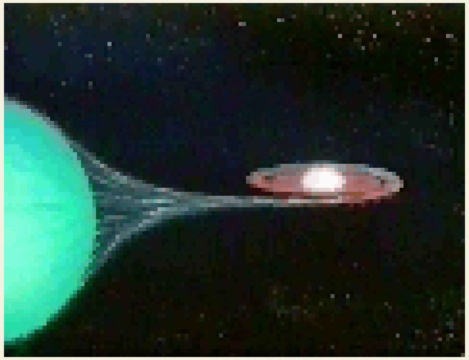
$$K_A = K_\infty + K_{Surf}\,A^{-1/3} + K_\tau\left(\frac{N-Z}{A}\right)^2 + K_{Coul}\,Z^2\,A^{-4/3}$$

Why study nuclear incompressibility?

➢ Key input to the EoS of the nuclear matter

EoS of the nuclear matter is important for studying:

- Core collapse and supernovae explosion
- Formation of neutron star
- Collisions of heavy ions



Why Ni?

- Incompressibility value (K_∞) obtained from isotopic chain of

  Pb: 240 $\pm$ 10 MeV [G. Colò *et al.*, PRC **70**, 024307 (2004)]

  Sn and Cd: 210 – 215 MeV

  [T. Li., *et al.*, PRC **81**, 034309 (2010)]

  [D. Patel., *et al.*, Phys. Lett. B **718** (2012) 447 – 450]

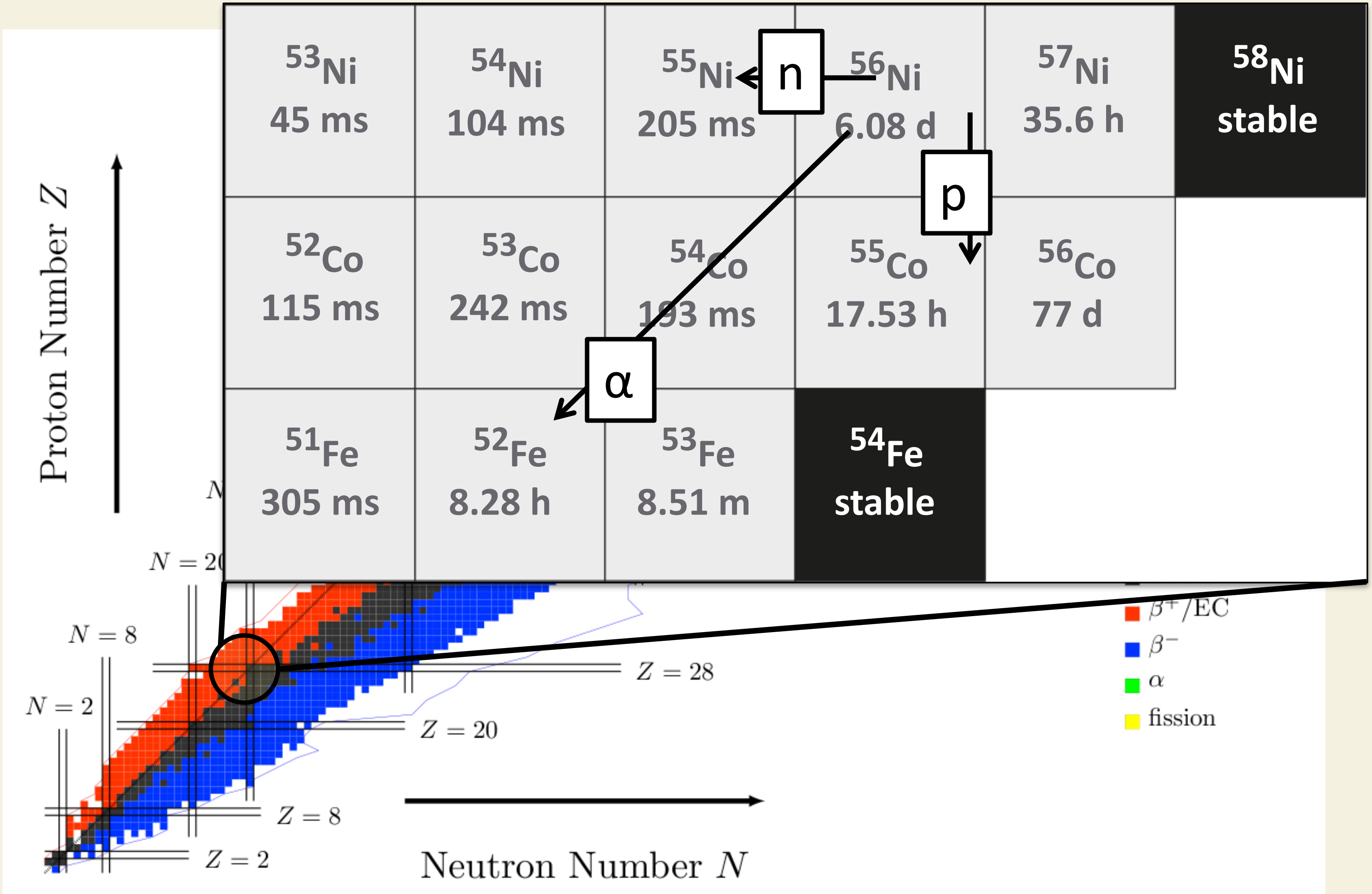
- Why is there a discrepancy in K_∞ values between Sn/Cd and Pb?

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

➢ Need to study for a series of isotopes of a nucleus

^{56}Ni

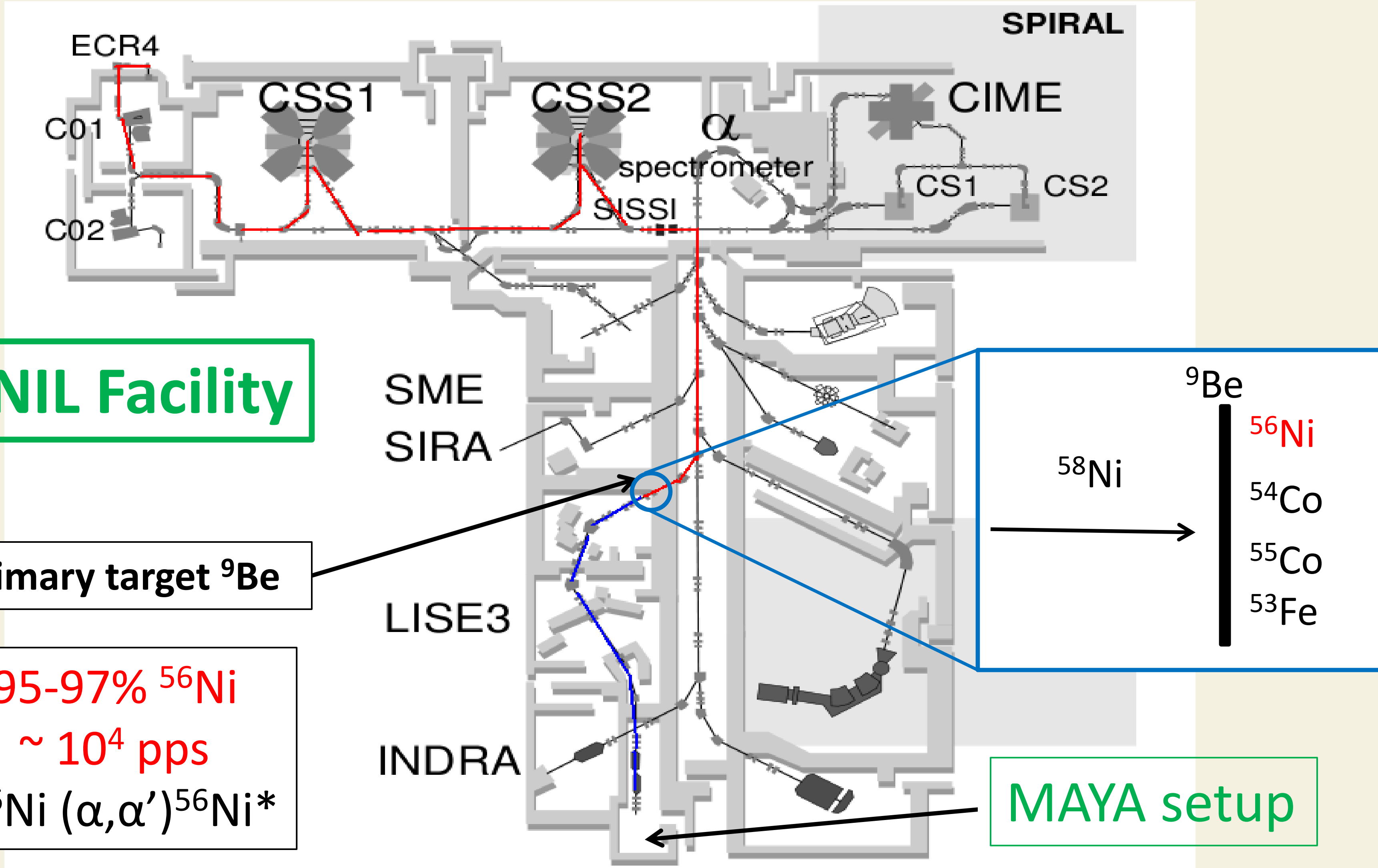
^{58}Ni
^{60}Ni
^{68}Ni



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

Primary Beam: ^{58}Ni at 75 MeV/u → Primary Target: ^{9}Be (thickness 500 μm) → Secondary Beam: ^{56}Ni at 50 MeV/u

GANIL Facility



95-97% ^{56}Ni

~ 10^4 pps

^{56}Ni (α,α')^{56}Ni*

Challenges with exotic beams:

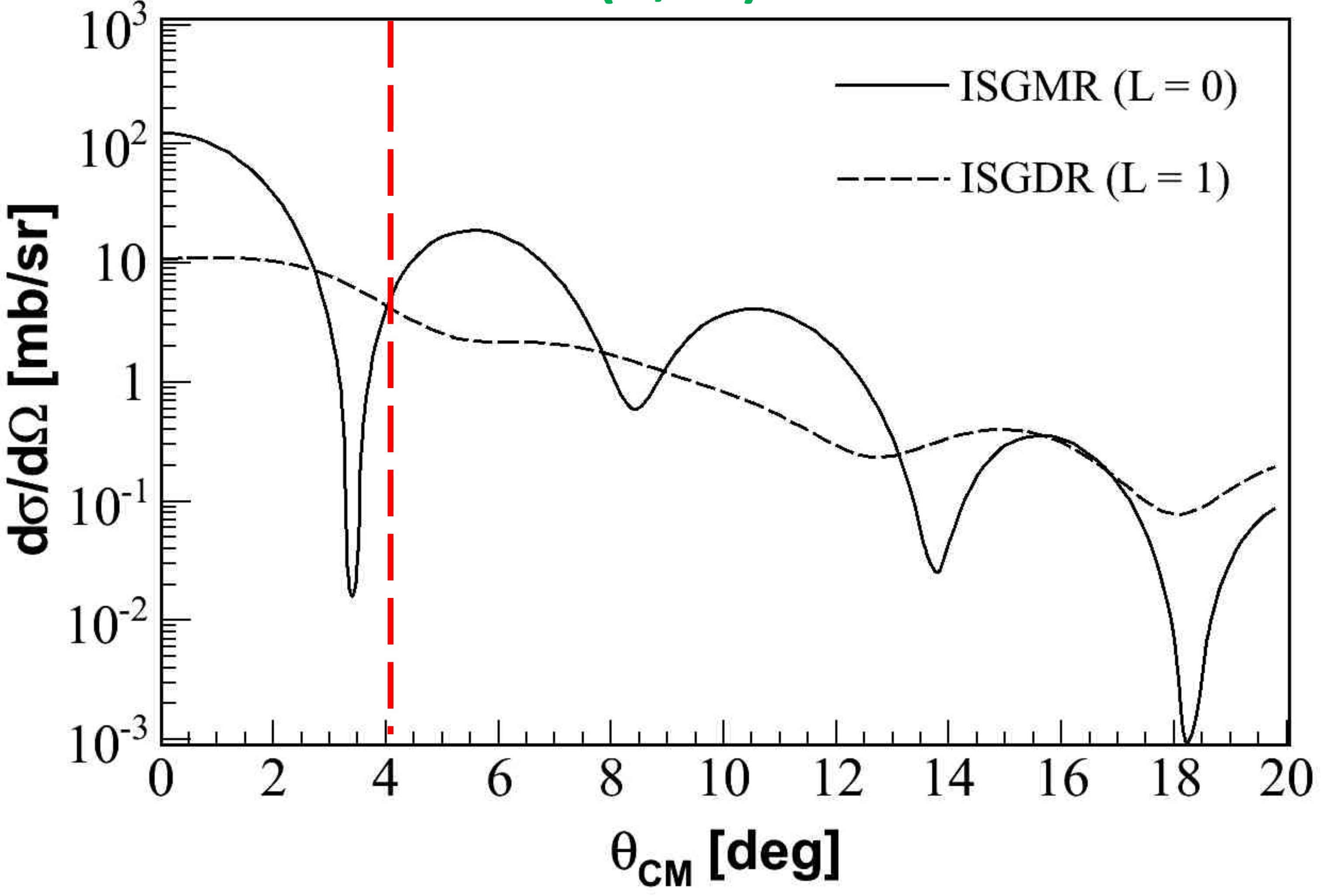
- Intensity of exotic beams is very low (~10^4 – 10^5 pps)
- To get reasonable yields thick target is needed
- Very low energy (~ sub MeV) recoil particle will not come out of the thick target

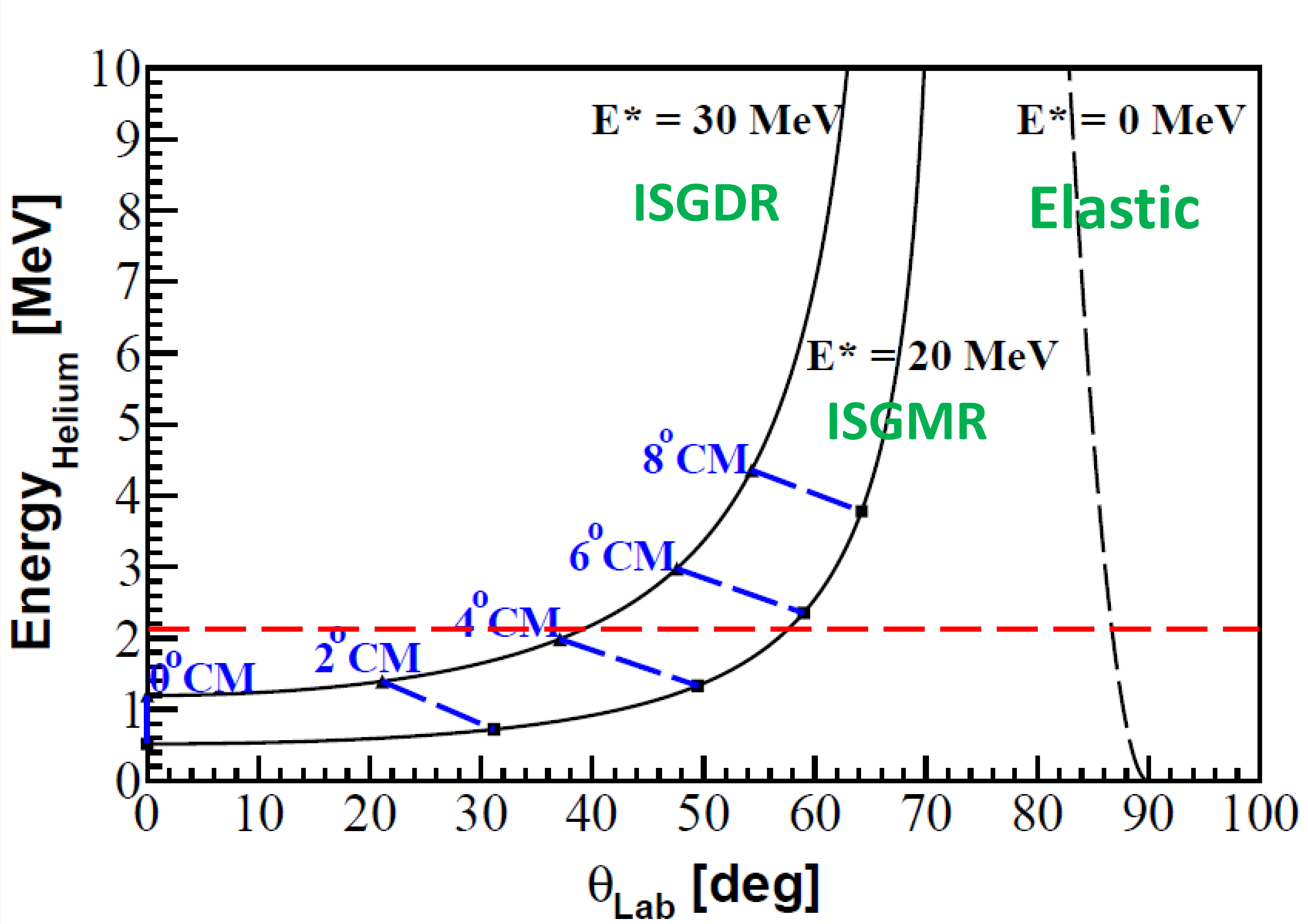
⟶ **Active target:** Detection takes place at every point of the target (**Detector and target are the same**)

- Good angular coverage
- Effective target thickness can be increased without much loss of resolution
- Detection of very low energy recoil particle is possible

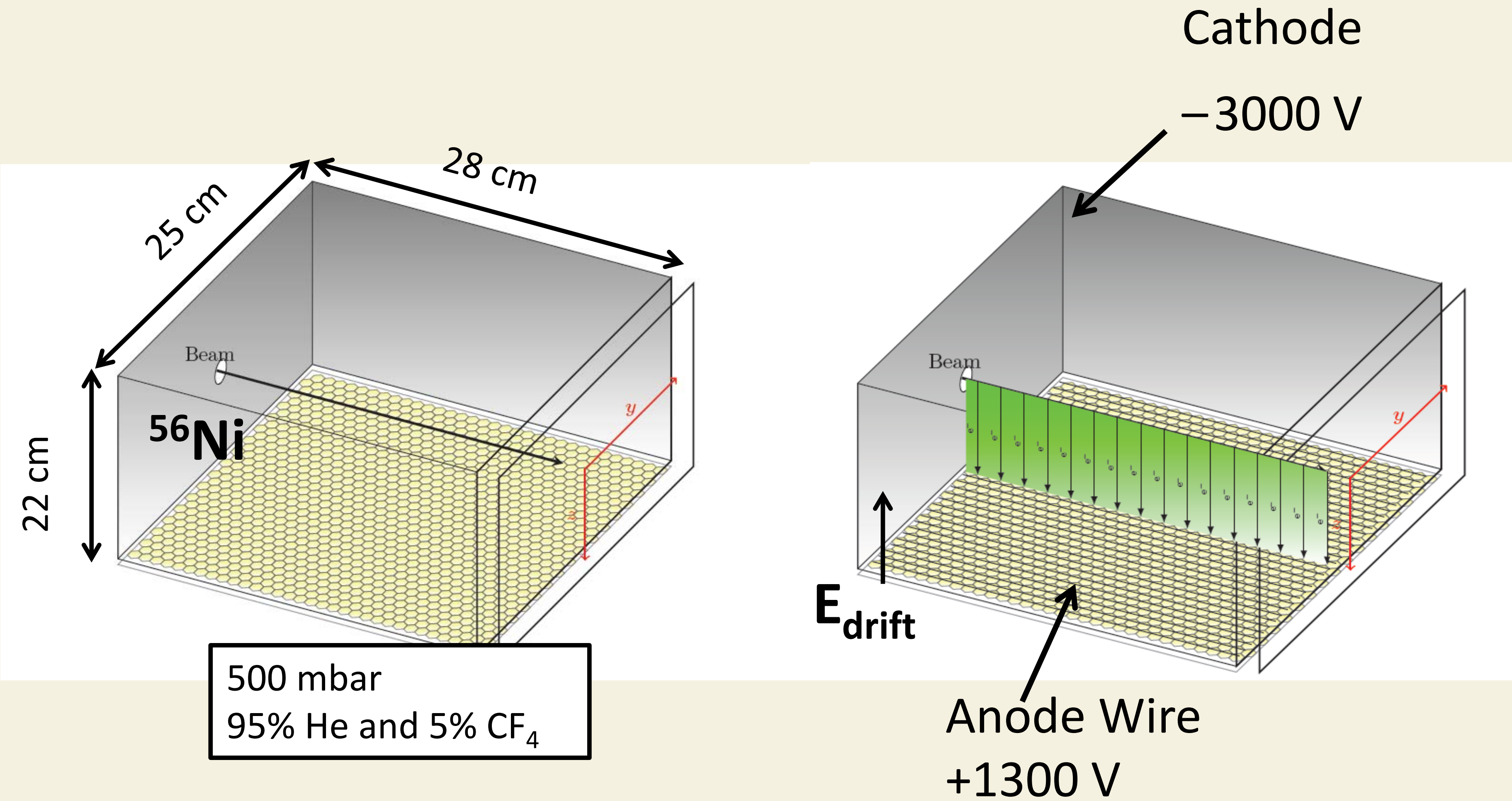
Angular distribution: DWBA

$^{56}Ni\ (\alpha, \alpha')\ ^{56}Ni^*$

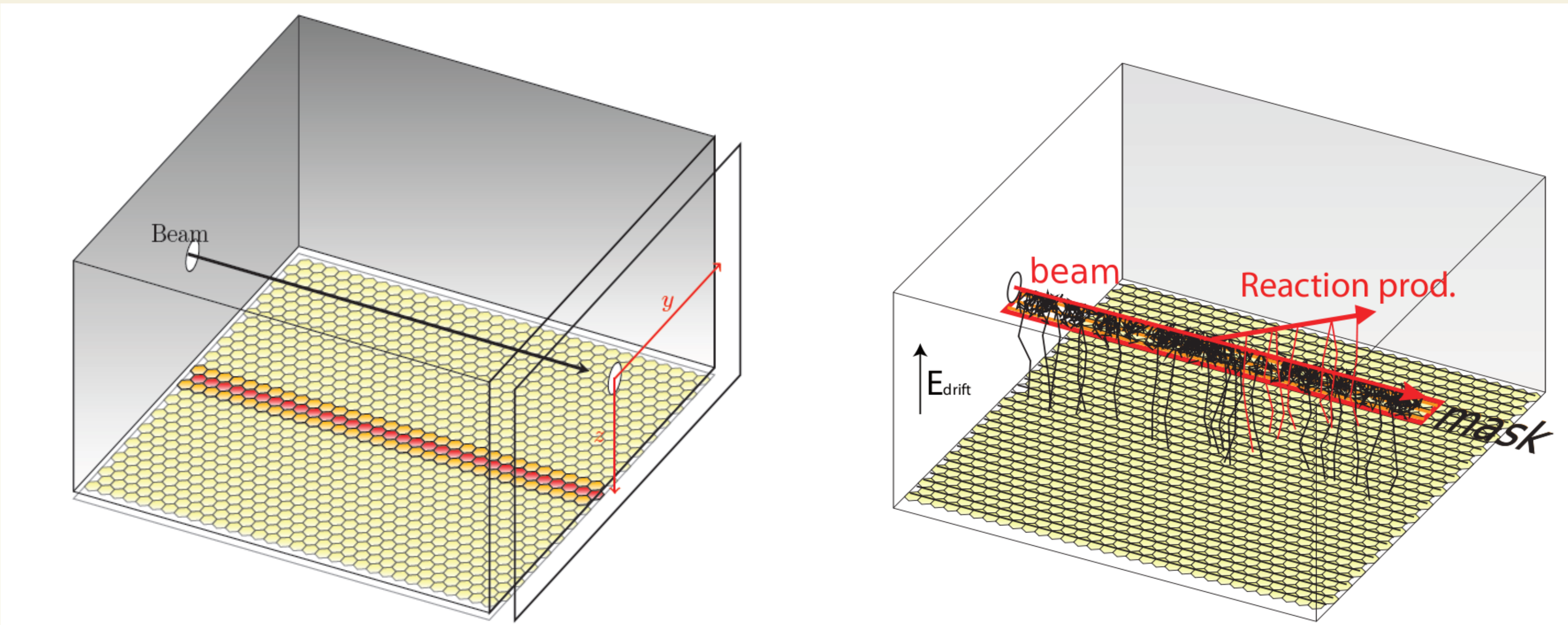



E* = 30 MeV
E* = 0 MeV
ISGDR
Elastic
E* = 20 MeV
ISGMR
8° CM
6° CM
4° CM
2° CM
0° CM
Energy$_{Helium}$ [MeV]
θ_{Lab} [deg]
0
1
2
3
4
5
6
7
8
9
10
0
10
20
30
40
50
60
70
80
90
100

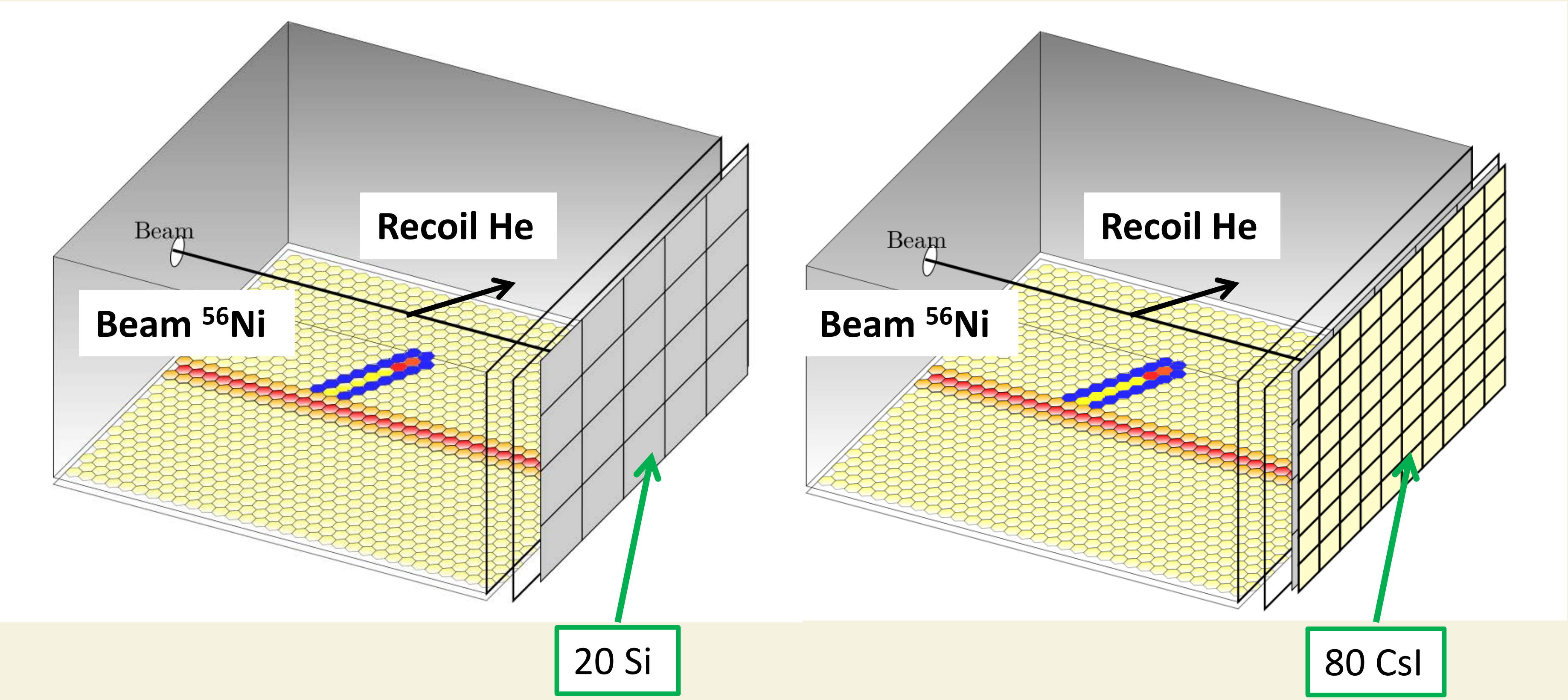
MAYA setup

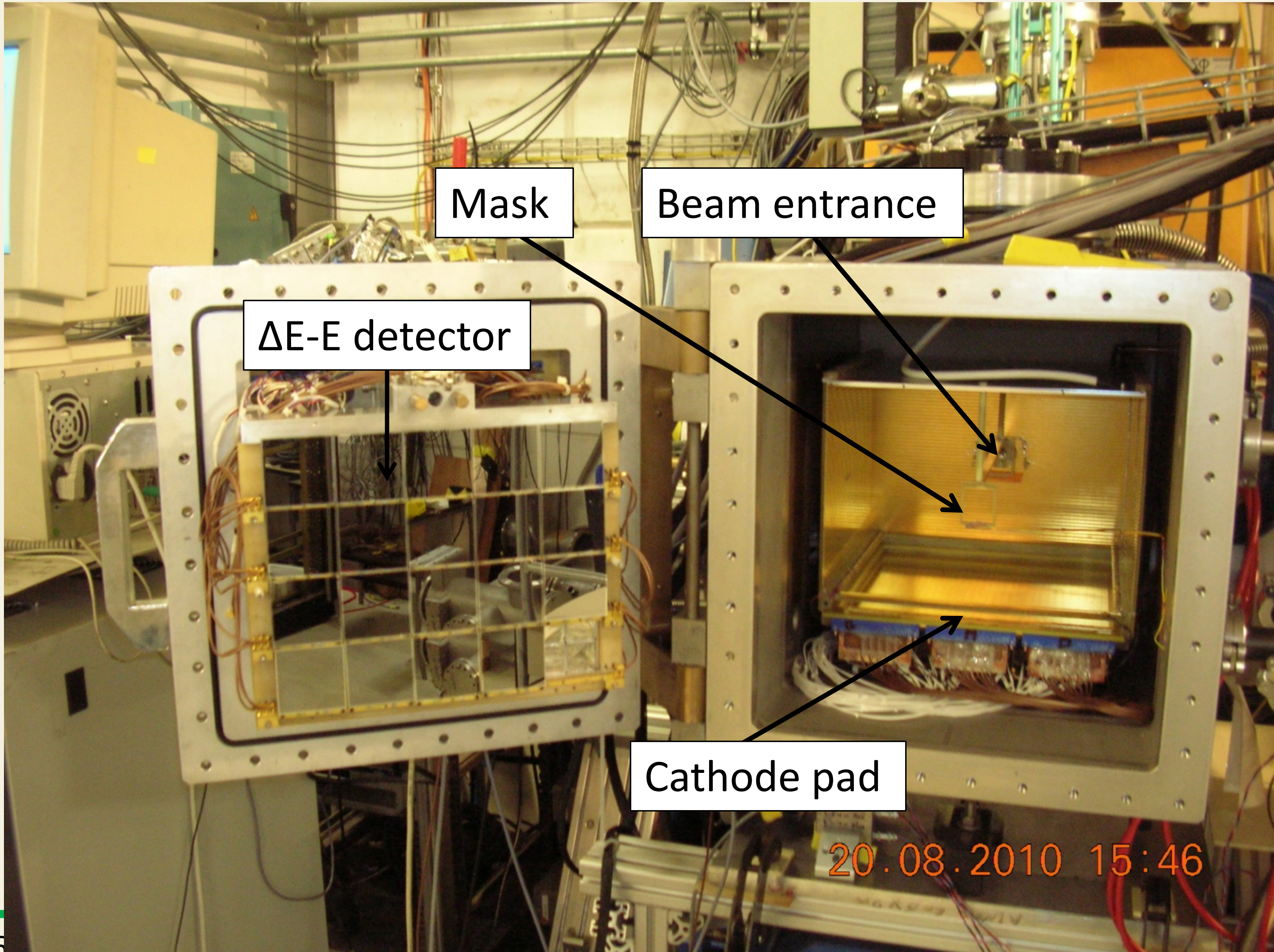

28 cm
25 cm
22 cm
Beam
^{56}Ni
y
z
500 mbar
95% He and 5% CF_4
Cathode
−3000 V
Beam
y
z
E_{drift}
Anode Wire
+1300 V

MAYA setup

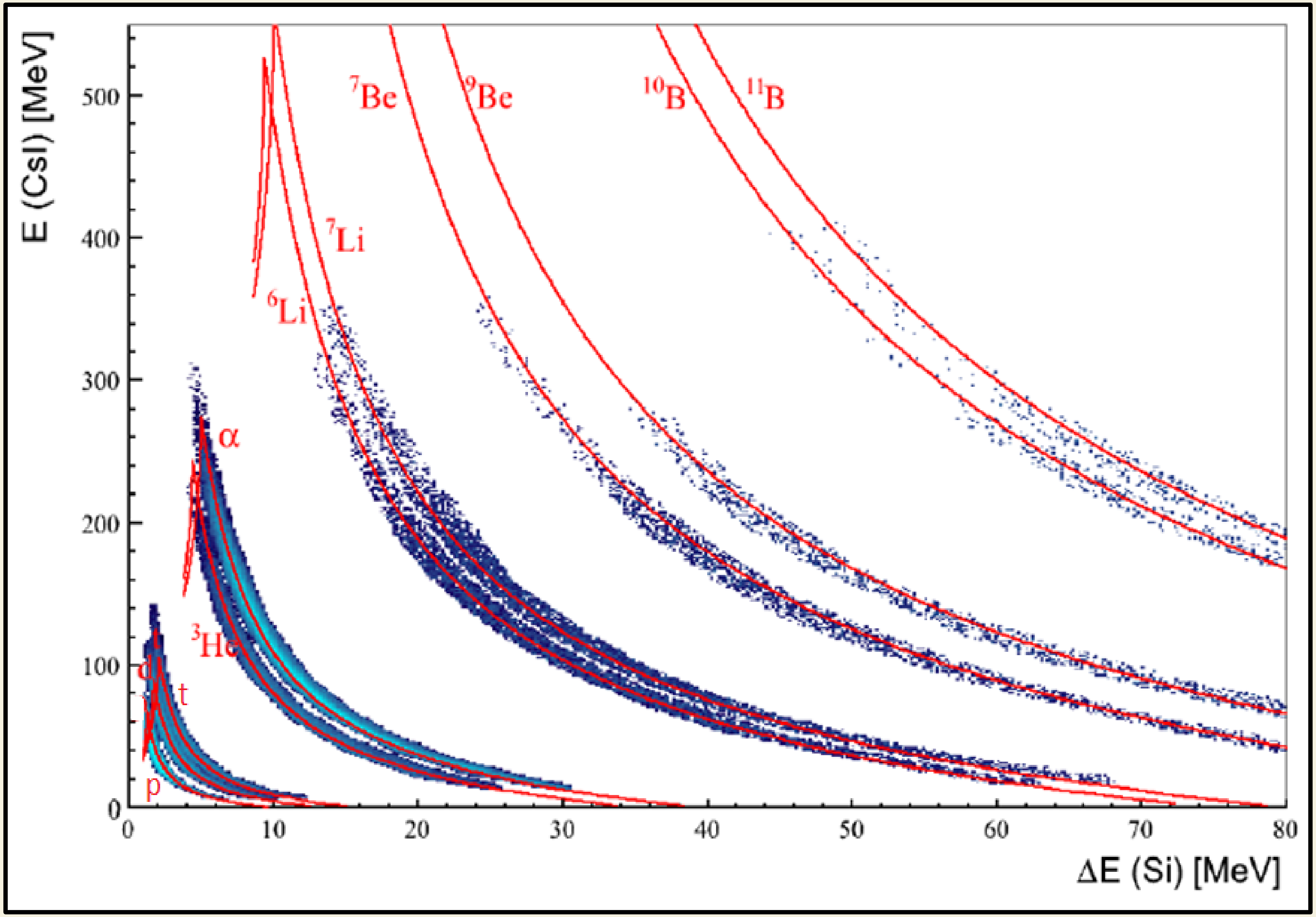


Si/CsI Telescope in MAYA

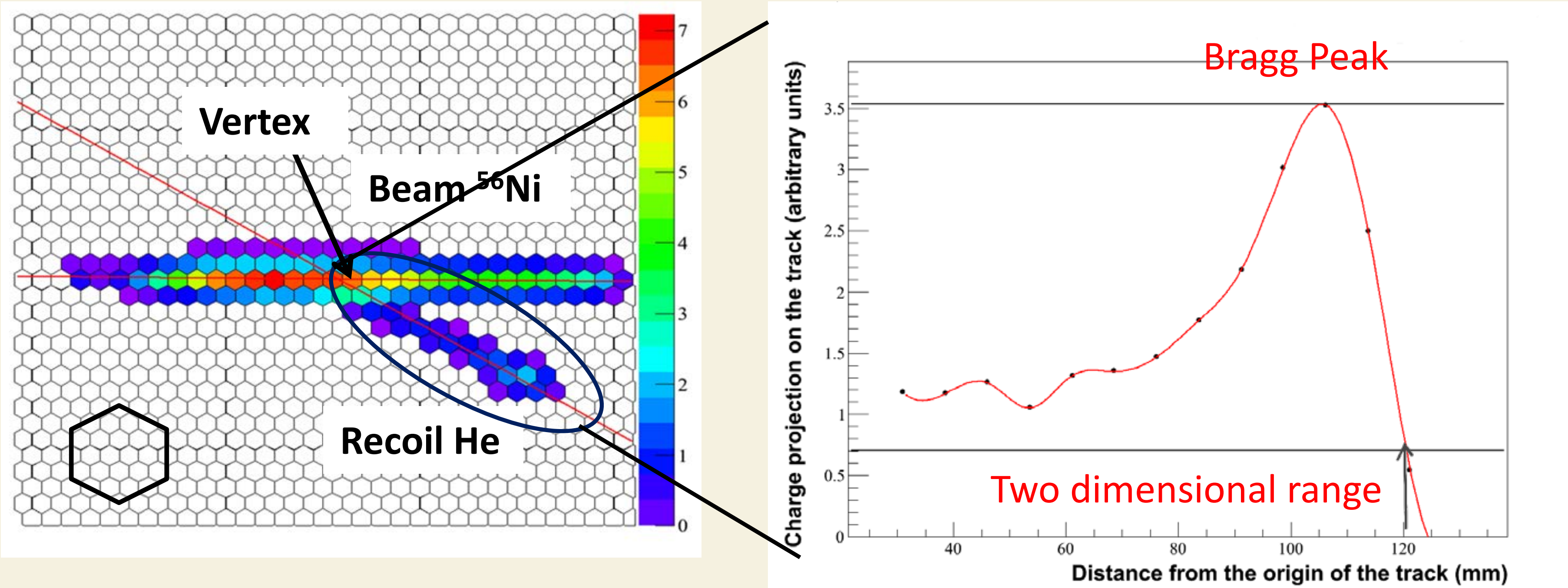



Mask
Beam entrance
ΔE-E detector
Cathode pad
20.08.2010 15:46

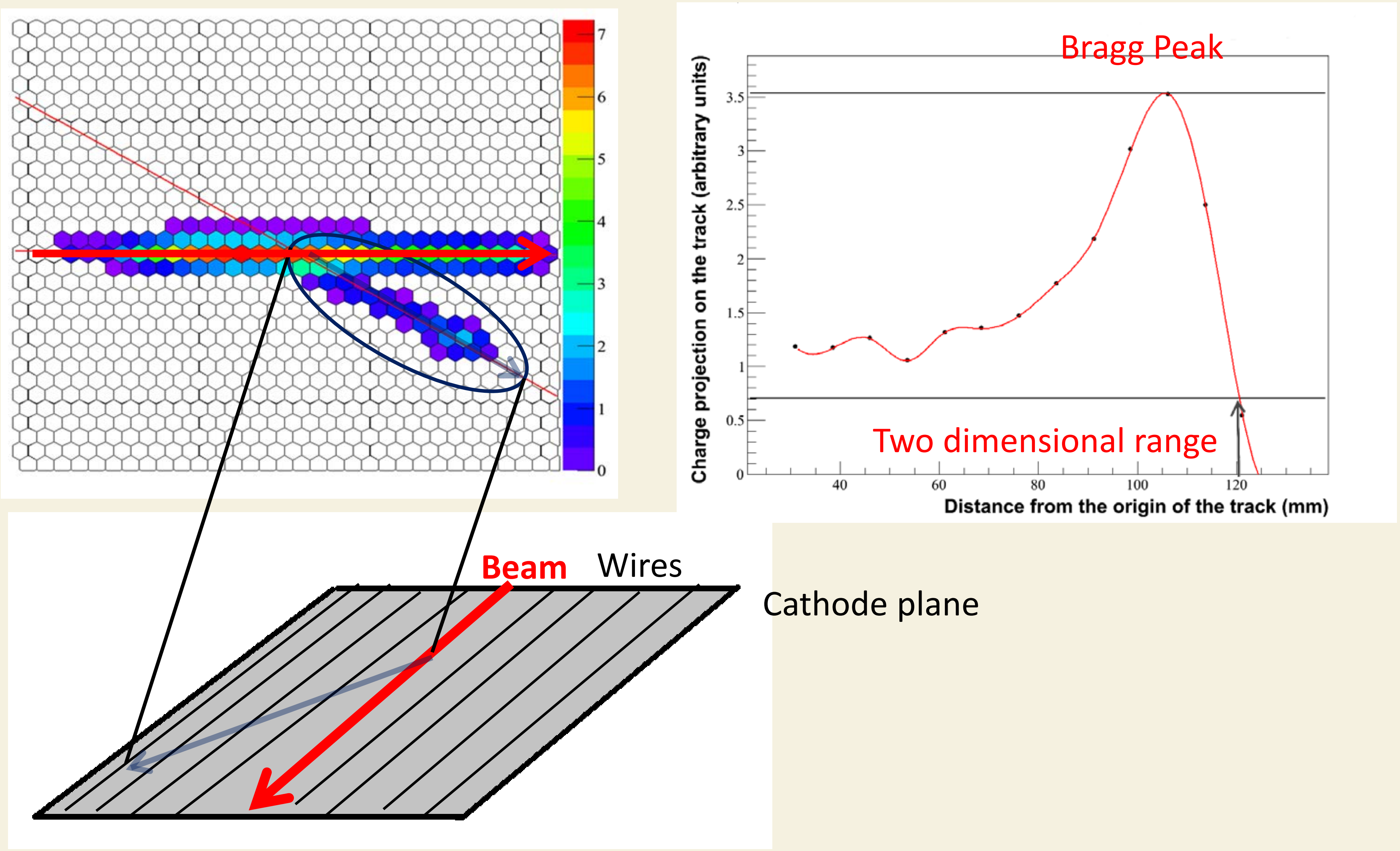
Particle Identification in forward ΔE-E telescope



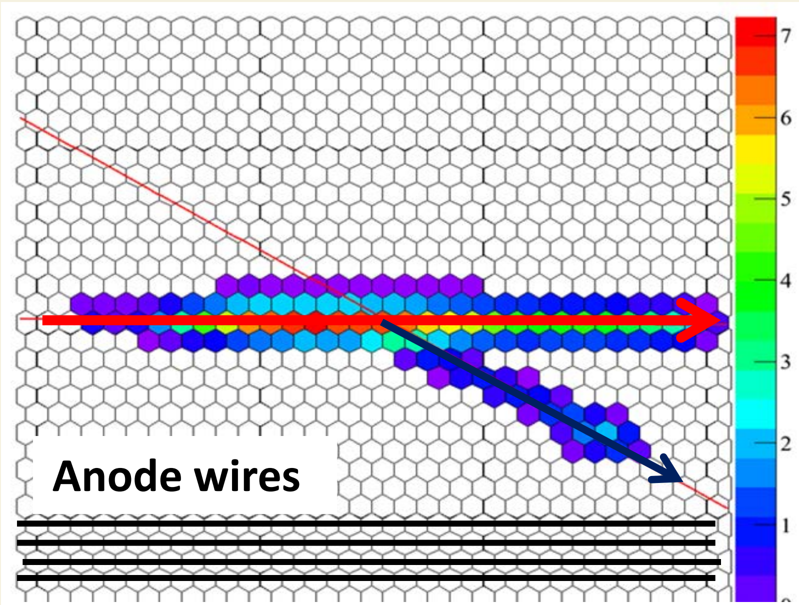
Kinematics reconstruction

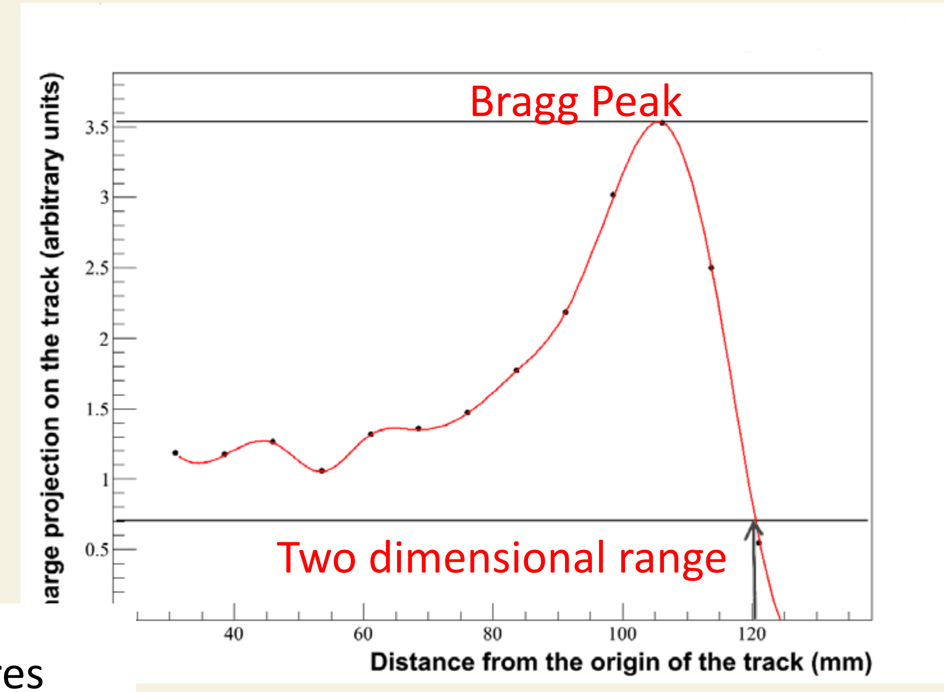


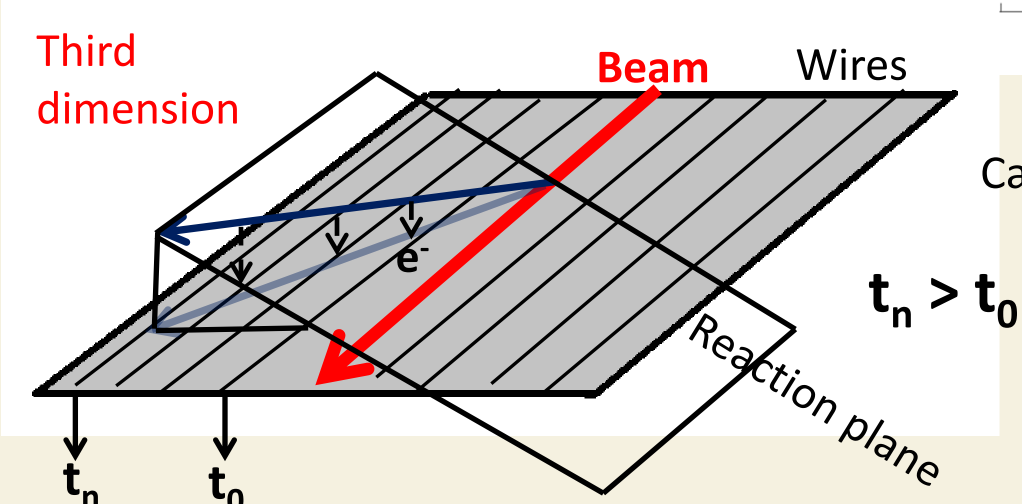
Kinematics reconstruction



Kinematics reconstruction



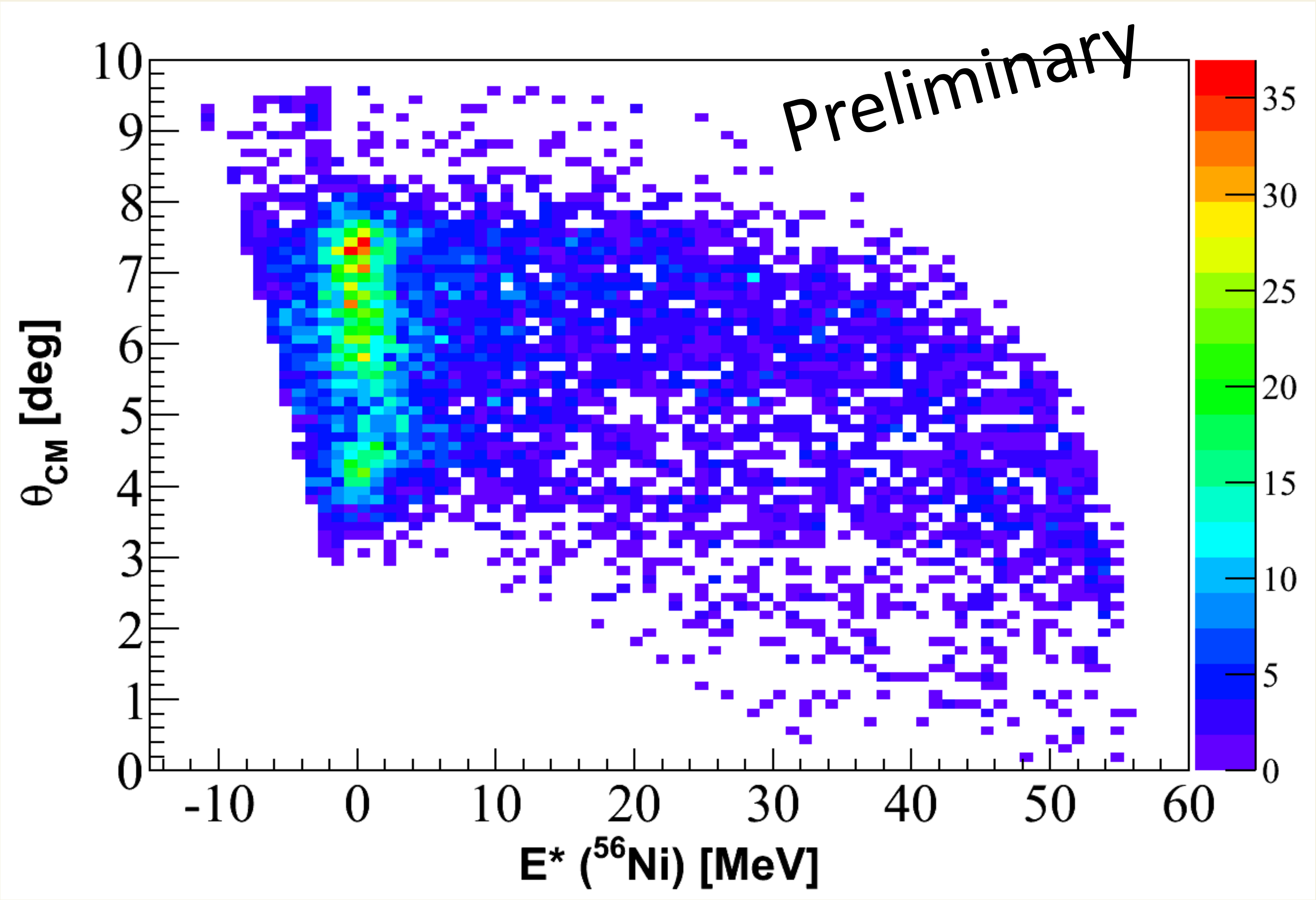




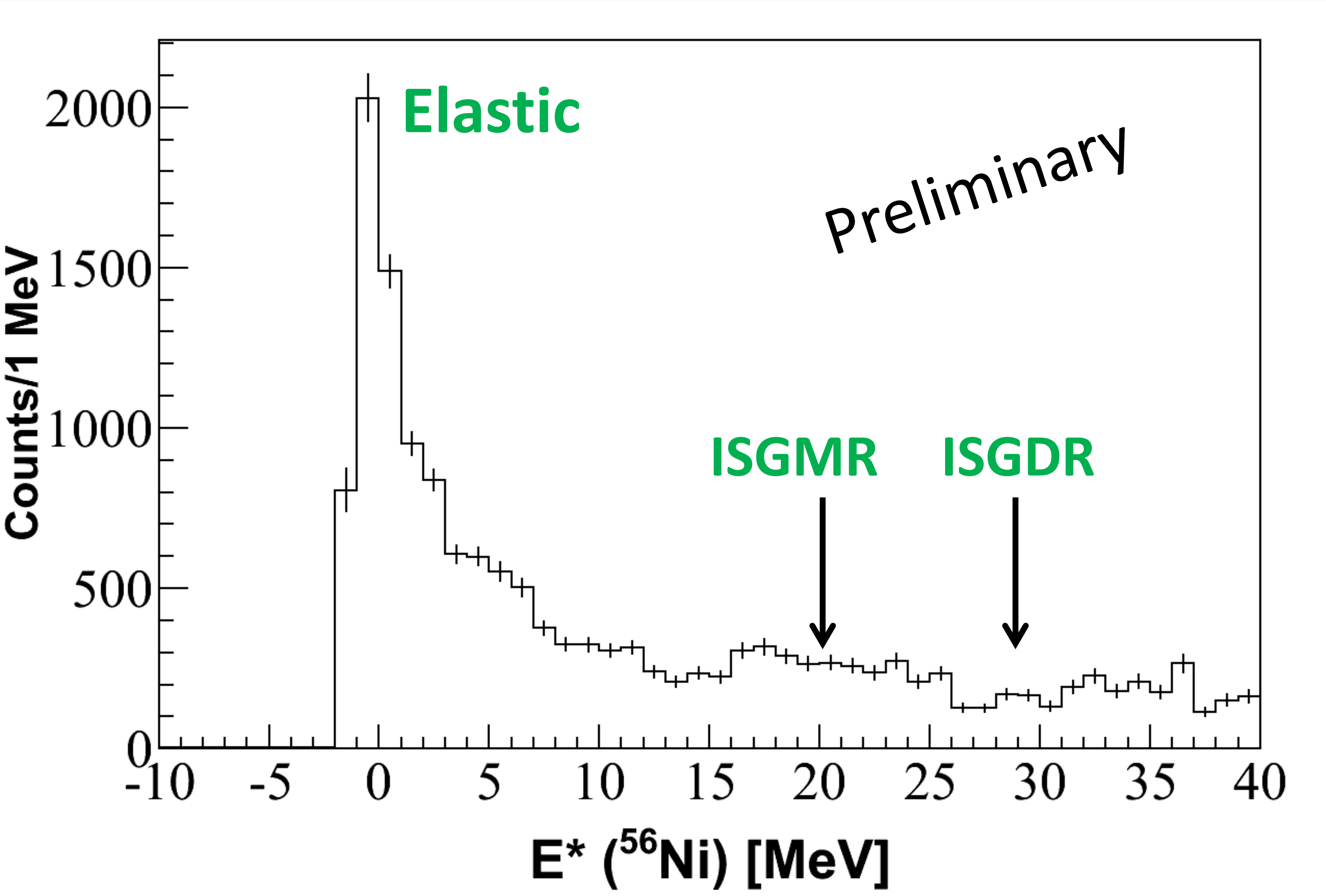
$t_n > t_0$ ➔ Track is going in the upward direction

Range ⟶ Energy

Angular Distribution



Excitation energy of ^{56}Ni



Summary

- Compression modes in ^{56}Ni are studied.
- Active target has been used to study the compression modes.
- Preliminary results are shown.

Outlook

- Excitation energies of the compression modes will be determined.
- Angular distributions of ISGMR and ISGDR will be studied.
- Nuclear incompressibility will be measured from the excitation energies.

ENSAR

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