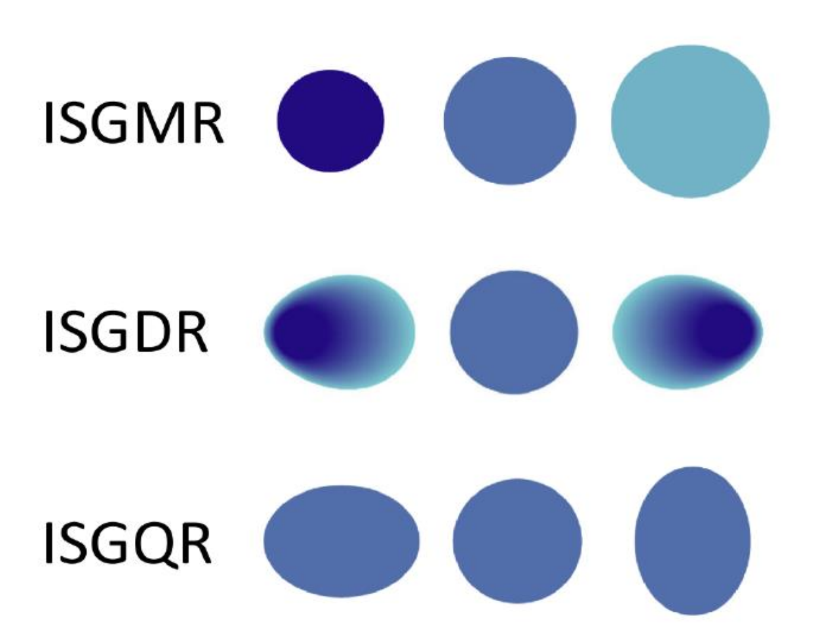
Giant Resonances Active Target



Alex Antony Arokiaraj, 17 October 2018

Compressibility

$$\frac{E}{A}(\rho) = \frac{E}{A}(\rho_0) + \frac{1}{18}K_\infty\left(\frac{\rho-\rho_0}{\rho_0}\right)^2 + \dots,$$

$$\chi = -\frac{1}{V}\left(\frac{\partial P}{\partial V}\right)^{-1}$$

$$K_\infty = 9\rho_0^2 \frac{d^2(E/A)}{d\rho^2}\bigg|_{\rho_0}$$

$$\chi^{-1} = \rho^3 \frac{d^2(E/A)}{d\rho^2}$$

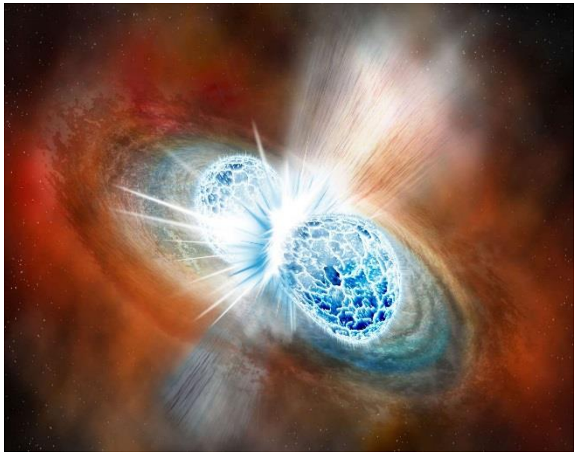
$$K_\infty = k_F^2 \frac{d^2(E/A)}{dk_F^2}\bigg|_{k_{F0}}$$

$$K_\infty = \frac{9}{\rho_0}\chi^{-1}$$

$2.2 * 10^9$ Pa

$1.6 * 10^{11}$ Pa

$6.6 * 10^{33}$ Pa



Giant Resonances

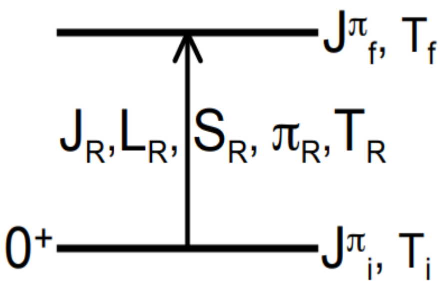
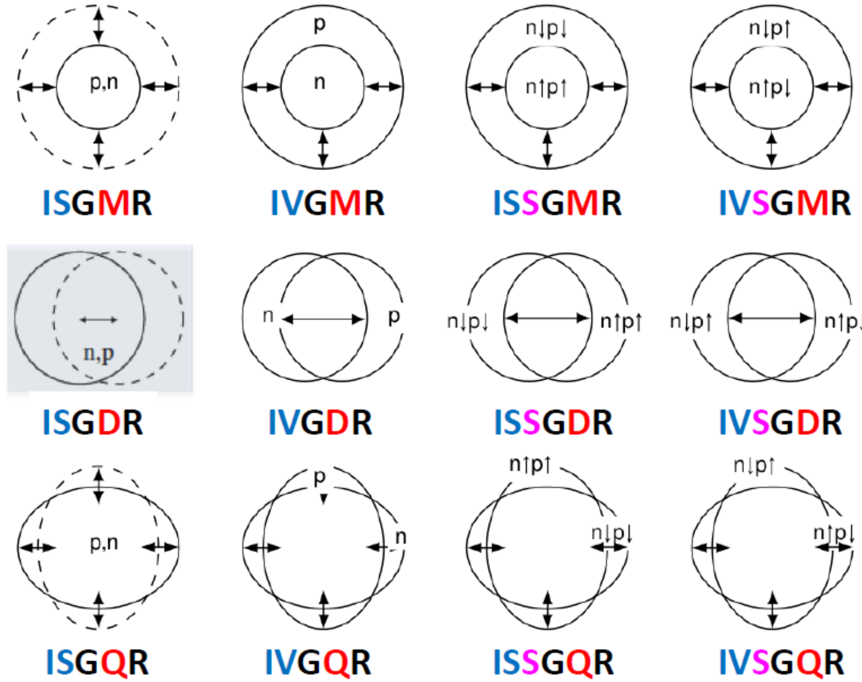


Fig courtesy: Elias Khan

ΔL = 0
Monopole (M)

ΔL = 1
Dipole (D)

ΔL = 2
Quadrupole (Q)



ΔT = 0	ΔT = 1	ΔT = 0	ΔT = 1
Isoscalar (IS)	Isovector (IV)	Isoscalar (IS)	Isovector (IV)
ΔS = 0	ΔS = 0	ΔS = 1	ΔS = 1
Electric	Electric	Magnetic (S)	Magnetic (S)

Multipole Decomposition Analysis

Inelastic scattering – alpha probe

Fig courtesy: Bagchi 2015 PhD Thesis

Impetus for GR measurements

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

Macroscopic Approach

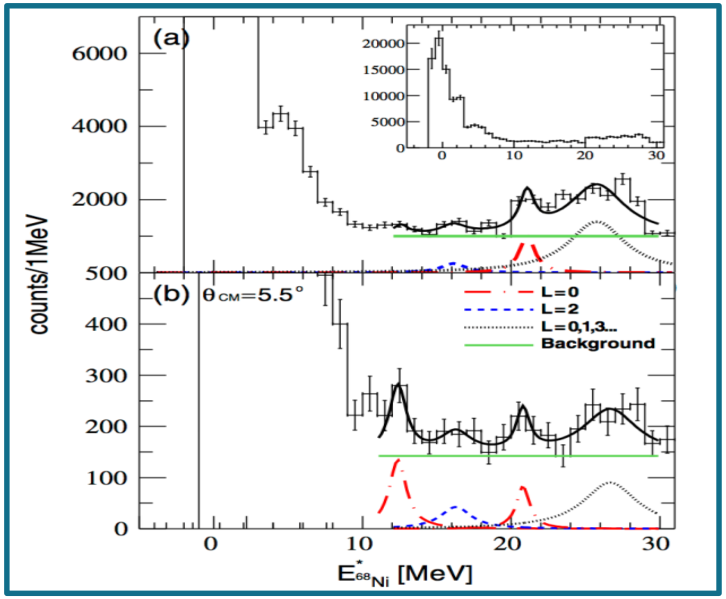
K_∞ = 100-400 MeV *J.P. Blaziot et.al 1995*

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

Microscopic Approach

- 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*

Previous Experimental works

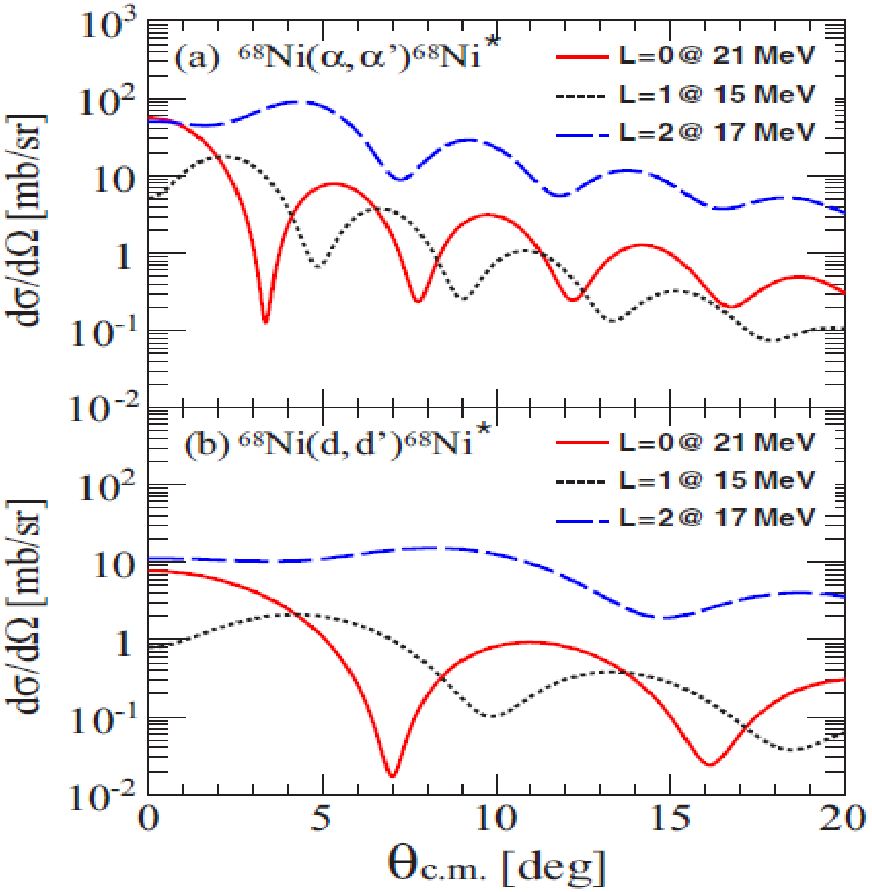


$$\frac{\delta K_\infty}{K_\infty} \sim 2\frac{\delta E}{E}$$

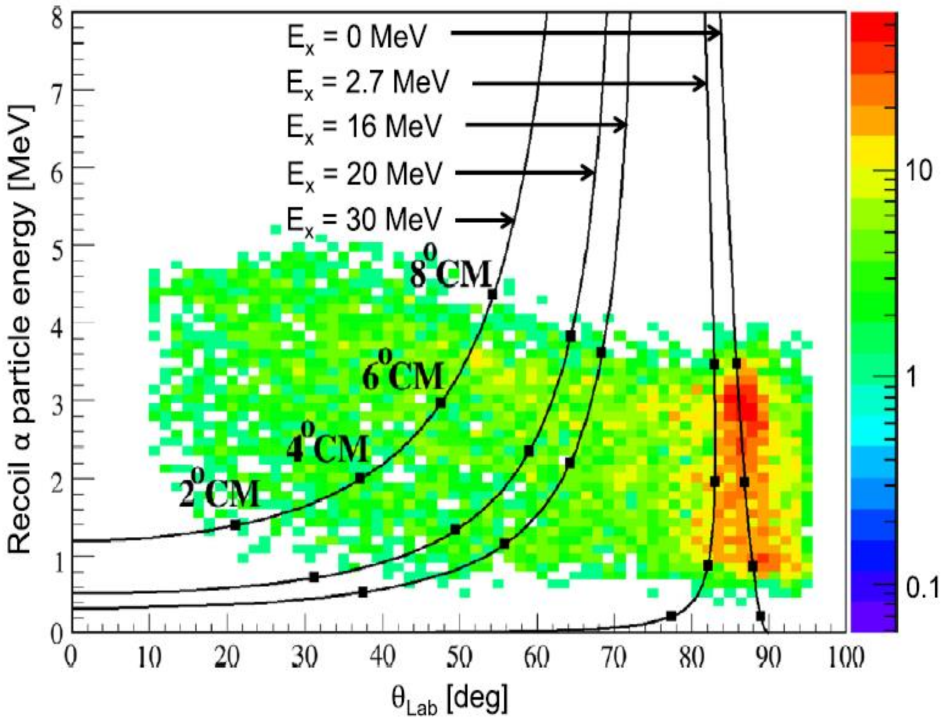
Error of 0.5 MeV translates into a 10MeV error on K_∞

Element	Beam Energy	Work	Measurements	Target
^{56}Ni	50 MeV/A	*Monrozeau et.al 2008*	E_{ISGMR} = 19.3 ± 0.5 MeV E_{ISGQR} = 16.2 ± 0.5 MeV	MAYA
^{68}Ni	50 MeV/A	*Vandebrouck et.al 2015*	E_{ISGMR} = 21.1 ± 1.9 MeV E_{ISGQR} = 15.9 ± 1.3 MeV	MAYA
^{56}Ni	50 MeV/A	*Bagchi et.al 2015*	E_{ISGMR} = 19.1 ± 0.5 MeV E_{ISGDR} = 17.4 ± 0.7 MeV	MAYA

Limiting Factors



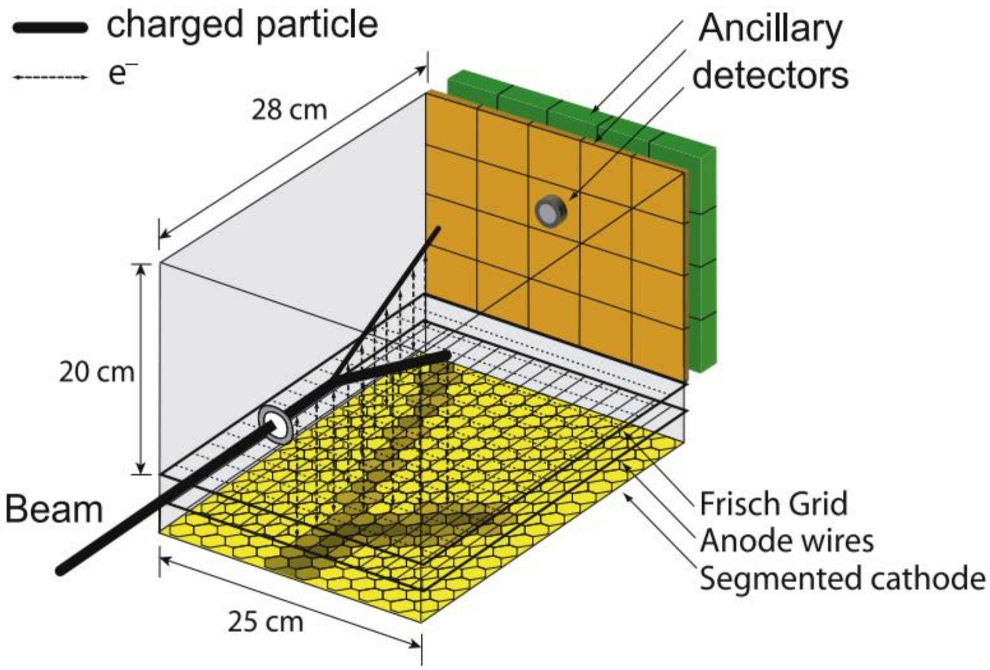
Angular distribution prediction calculated in the DWBA approximation



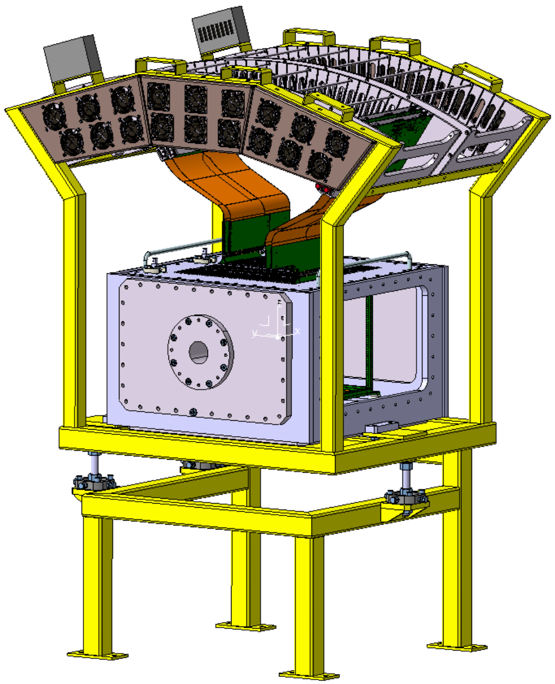
Vandebrouck et.al 2015

Fig courtesy: Bagchi 2015 PhD Thesis

MAYA & ACTAR TPC

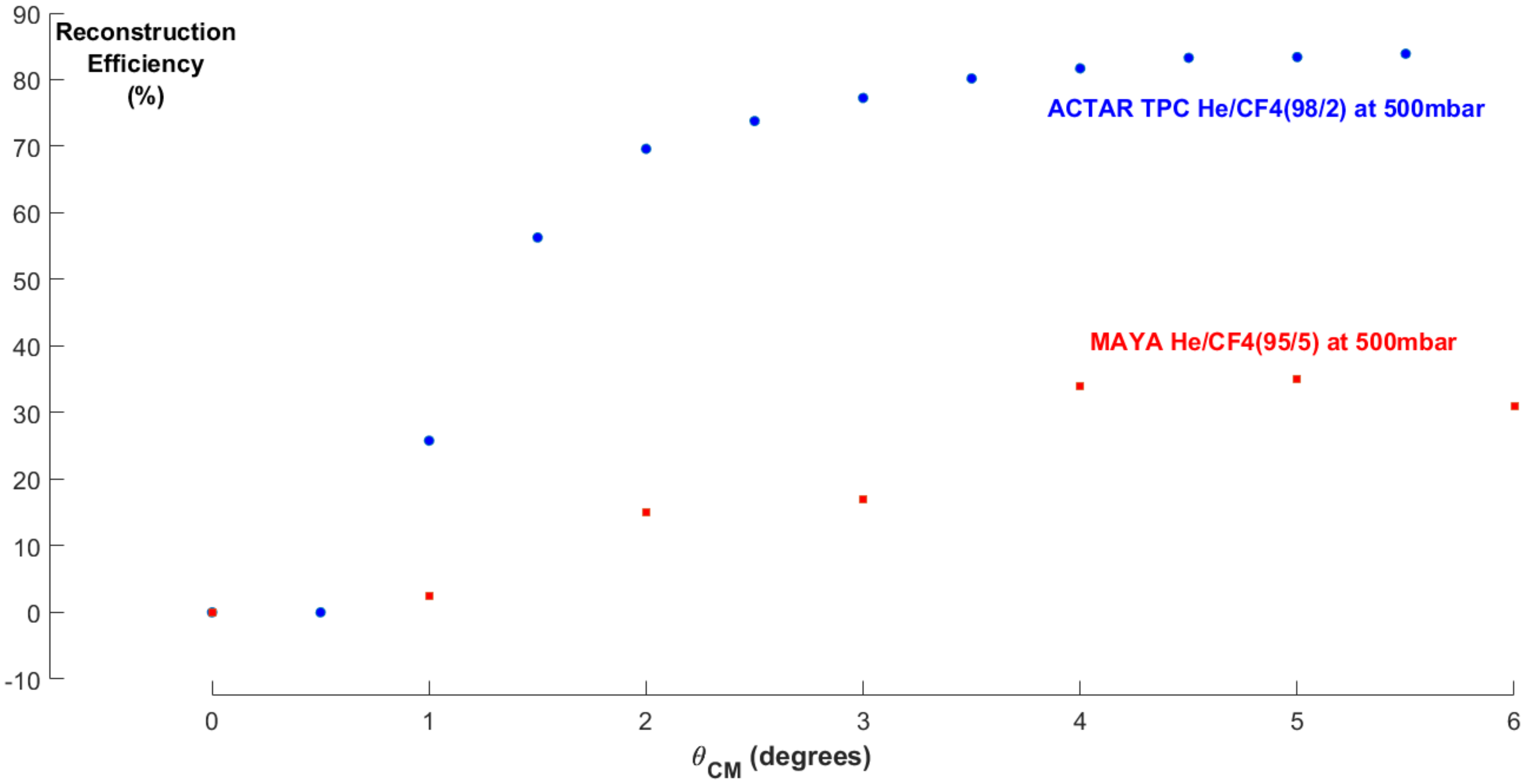


35×35 hexagonal pads with 5 mm sides



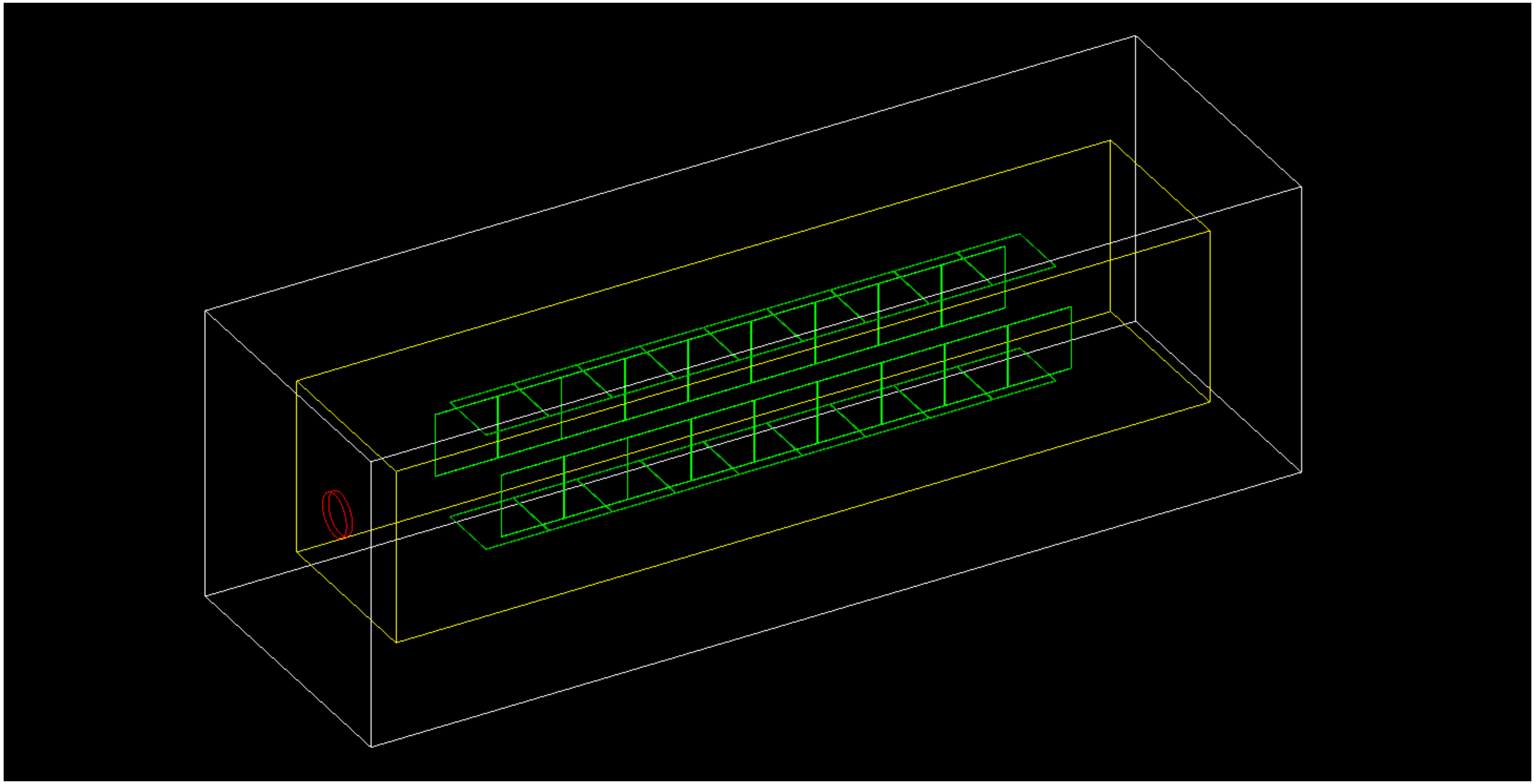
From 1 MeV to 100 KeV improvement in energy resolution

Improvements through ACTAR

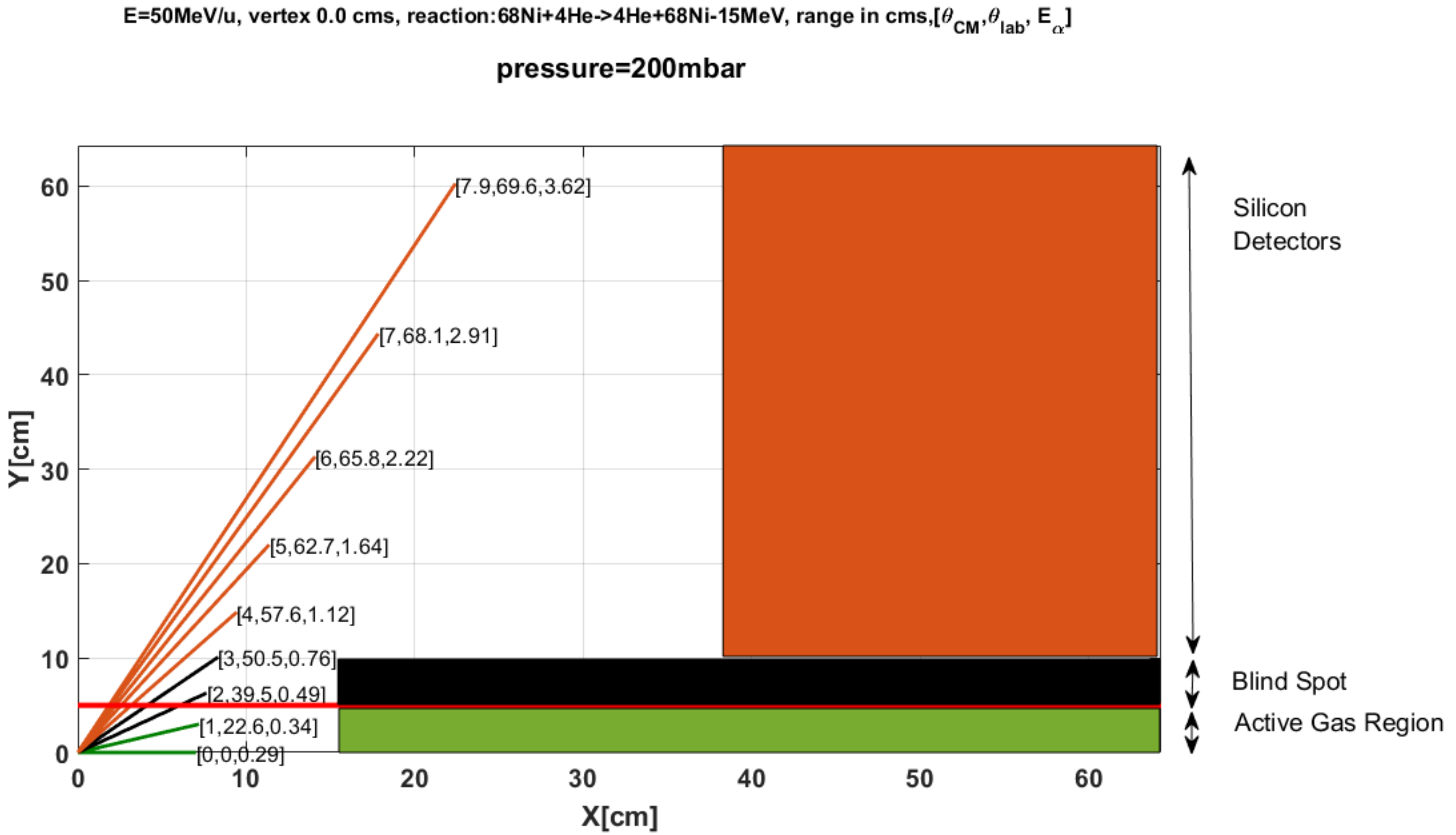


MAYA calculations by B.Mauss (GANIL)

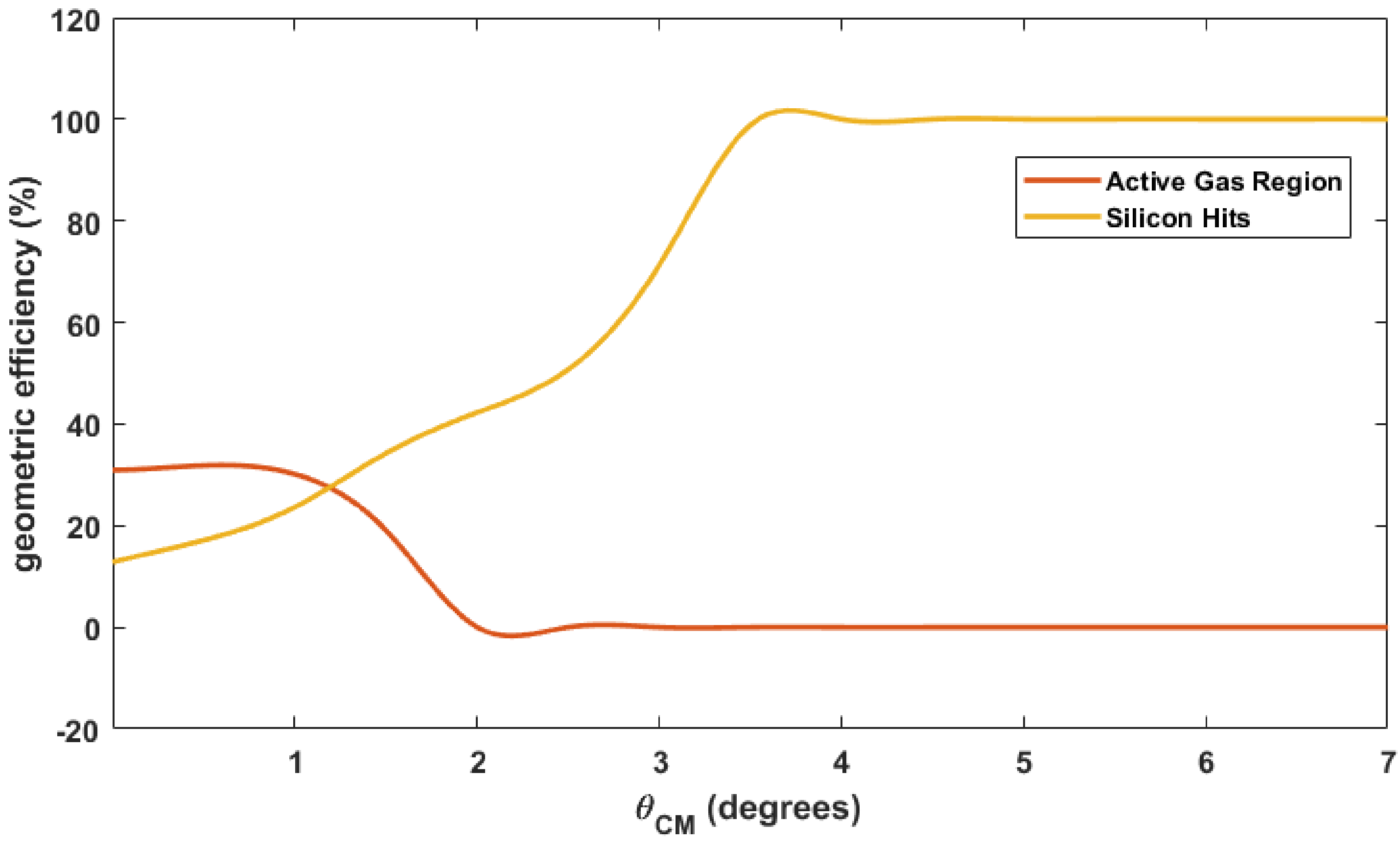
Giant Resonances Active Target



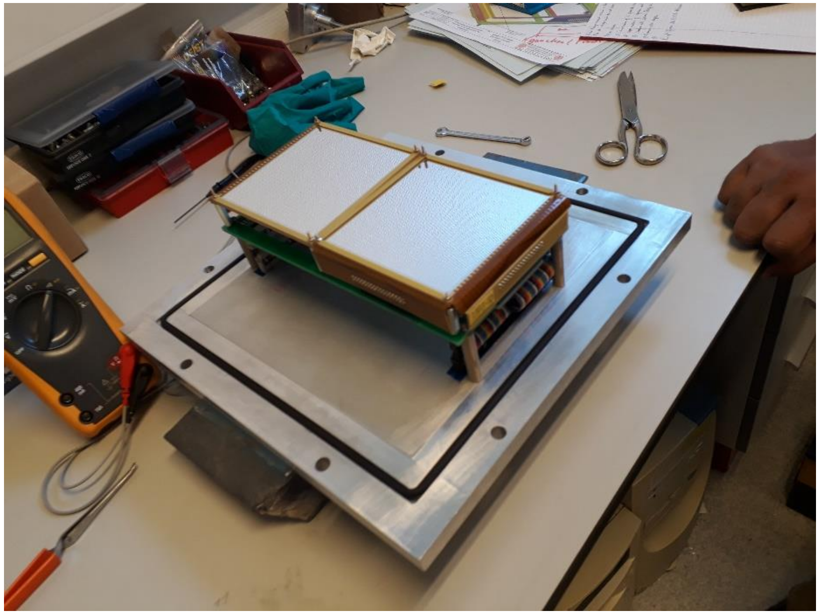
Looking beyond ACTAR, a dedicated active target for resonances

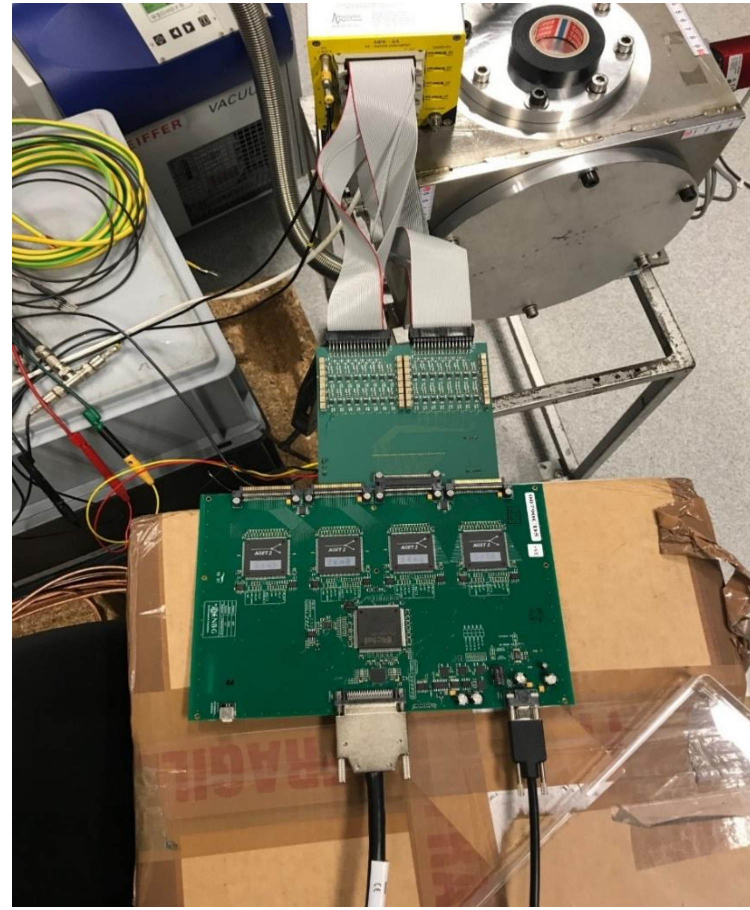


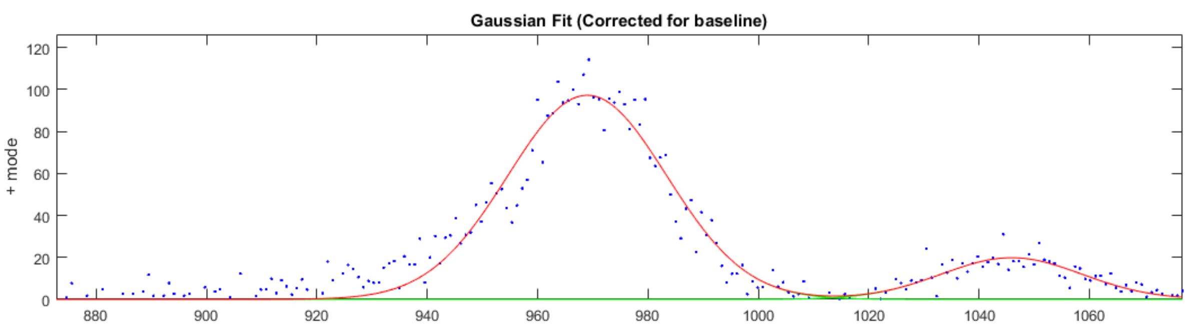
Improved Statistics



DSSSD

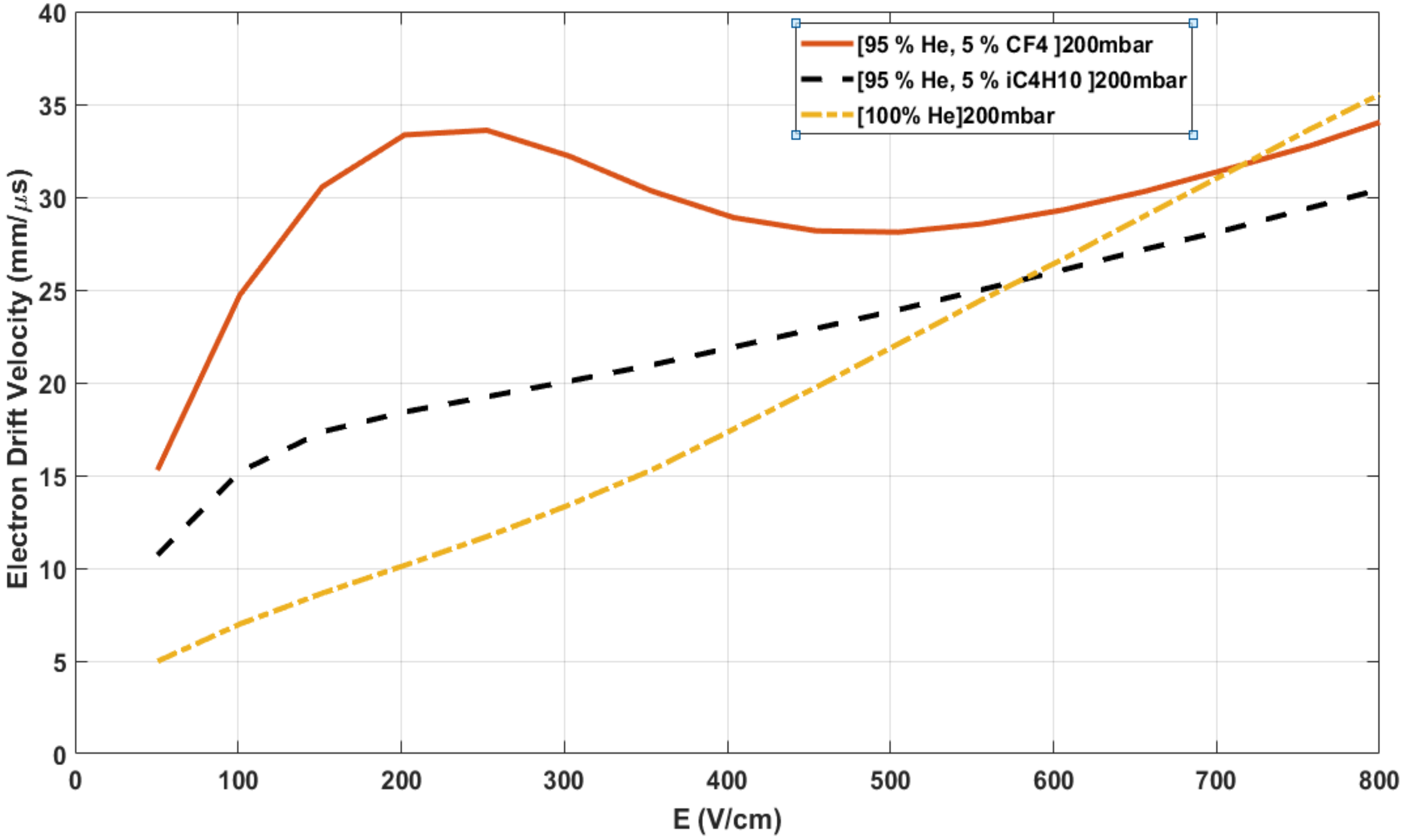




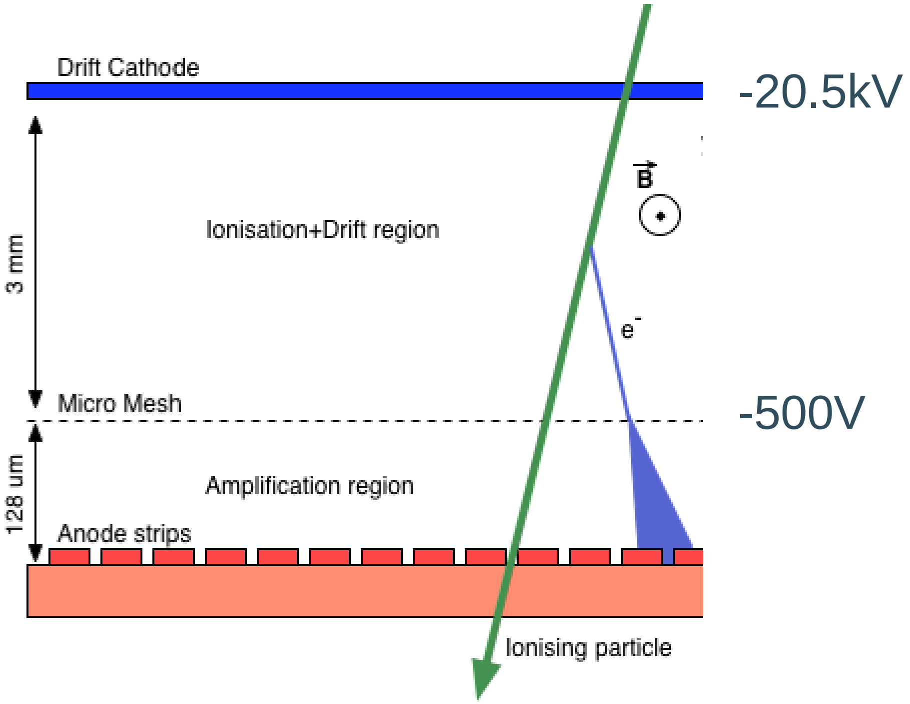


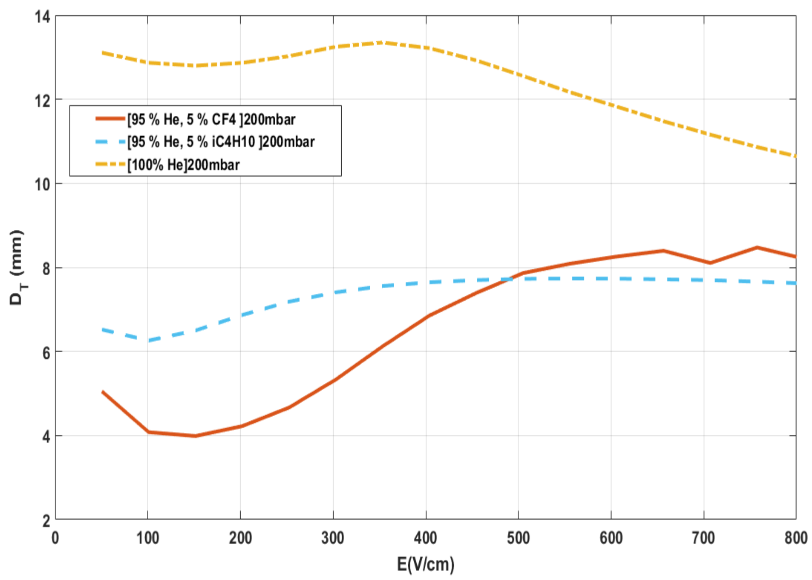
Analog
FWHM: 30 keV
GET
FWHM: ~ 100KeV

Operating Parameters of the setup



Operating Parameters of the setup





Conclusions

- Giant Resonances Active Target (GRAT) is a better experimental tool to study the resonance reactions involving low momentum transfer in inverse kinematics.
- Error on nuclear matter compressibility can be reduced from 10 MeV to approximately 0.2 MeV
- Other interesting phenomena such as pygmy resonances can also be studied in great detail.

Thank you for your attention

Backup slides