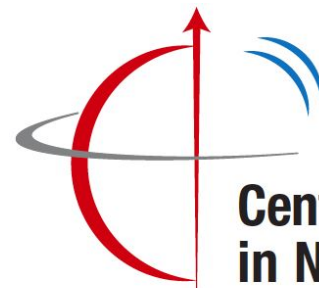# Nuclear Structure Studies with Pelletron, CEBAF, and EIC

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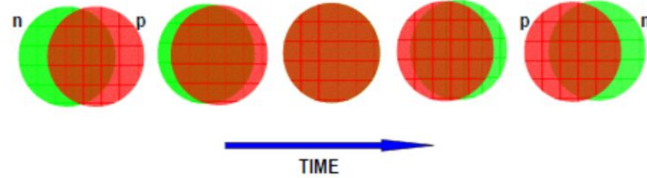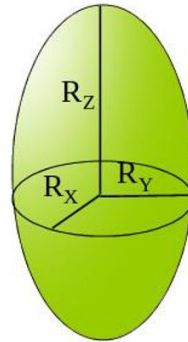**Center for Frontiers in Nuclear Science**

Nuclear Structure Studies with Pelletron

Thesis: *Hot giant dipole resonance studies in A~ 130-15 nuclei*

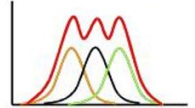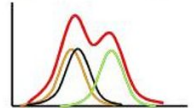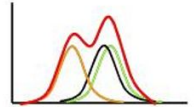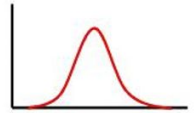**Institute:** *Tata Institute of Fundamental Research, Mumbai*

TIME

- Width: the damping mechanism inside nucleus
- Constraining the iso-vector component of nuclear force

Nuclear shape from GDR Lineshape

- Spherical
  $$R_X = R_Y = R_Z \rightarrow w_X = w_Y = w_Z$$

- Prolate
  $$R_X = R_Y < R_Z \rightarrow w_X = w_Y > w_Z$$

- Oblate
  $$R_X = R_Y > R_Z \rightarrow w_X = w_Y < w_Z$$

- General Ellipsoid
  $$R_X \neq R_Y \neq R_Z \rightarrow w_X \neq w_Y \neq w_Z$$

E_γ

Nuclear shape evolution as a function of angular momentum and excitation energy
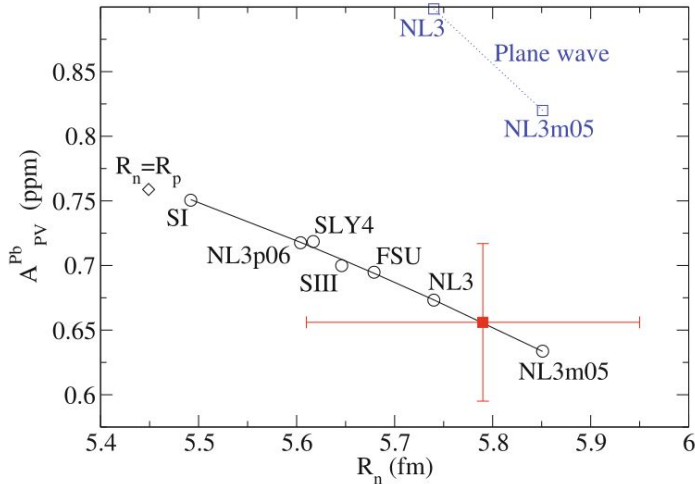
CEBAF: PREX-II/CREX (Pb/Ca Radius EXperiment)

- Parity-violating electron scattering asymmetry $\quad A_{PV} = \dfrac{\sigma_R - \sigma_L}{\sigma_R + \sigma_L}$

$$A_{PV} \approx -\frac{G_F Q^2 Q_W}{4\pi\alpha\sqrt{2}Z}\frac{F_W(Q^2)}{F_{ch}(Q^2)}$$

Neutron skin thickness: $\Delta R_{np} = R_n - R_p$

- Symmetry energy - Neutron star structure, heavy ion collision
- Constrain the isovector contributions to the nuclear EDF
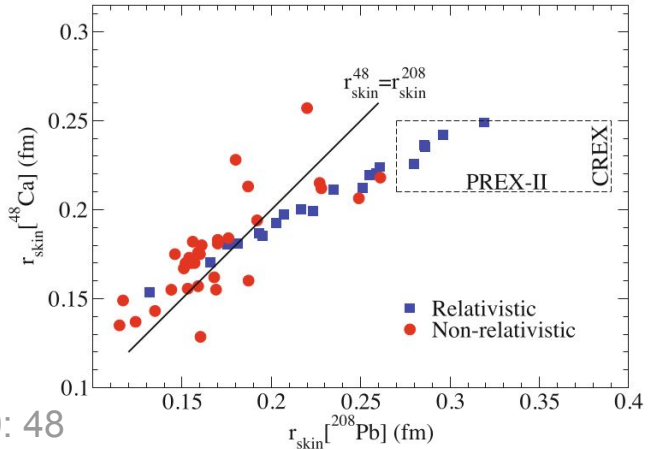
PREX-I result: $A_{PV} = 0.656 \pm 0.060 \pm 0.014 \text{ppm}$ $\quad \Delta R_{np} = 0.33^{+0.16}_{-0.18}\text{fm}$

Goal of PREX-II/CREX

$$\Delta R_{np}^{Pb} \approx \pm 0.06 \text{fm}$$

$$\Delta R_{np}^{Ca} \approx \pm 0.02 \text{fm}$$

3

PREX/CREX: Q^2 measurement

- Asymmetry is a strong function of Q^2: $\frac{dA_{PV}}{dQ^2} \approx 30\frac{\text{ppm}}{GeV^2}$
- Need to measure the small scattering angles very precisely
- Nuclear recoil method with a water cell target is used to get this precision
- Tracking using GEM detectors
  - CODA based GEM DAQ development
  - Working on tracking software development

- ❖ Detector R&D
- ❖ Error estimation from inelastic excitation of the target

MӨLLER - Physics beyond Standard model

- Measure the A_{PV} ~ 33 (0.7) ppb in the e-e scattering
- Unprecedented sensitivity: amplitude ~ $0.001G_F$
- Best contact interaction reach at low Q^2 in the foreseeable future ~ 7.5 TeV

- Detector R&D
- Simulation
- Shield design

Layout of the experiment
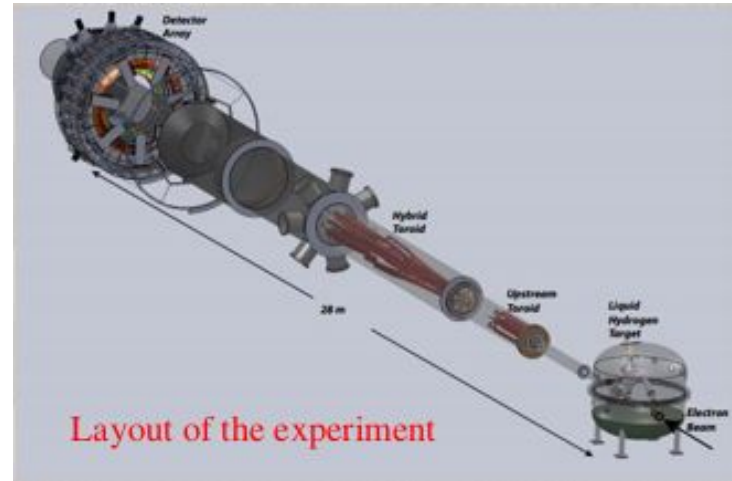
Nuclear structure studies with EIC!!

- ❖ All the studies I'm carrying out at JLab will be relevant for any precise experiment in the future.
- ❖ The exact physics cases need to be explored

Thanks