INTERNATIONAL CENTRE *for* THEORETICAL SCIENCES

ICTS

TATA INSTITUTE OF FUNDAMENTAL RESEARCH

Advances in Nuclear Physics

Summary and Concluding Remarks

Ambar Chatterjee

BARC

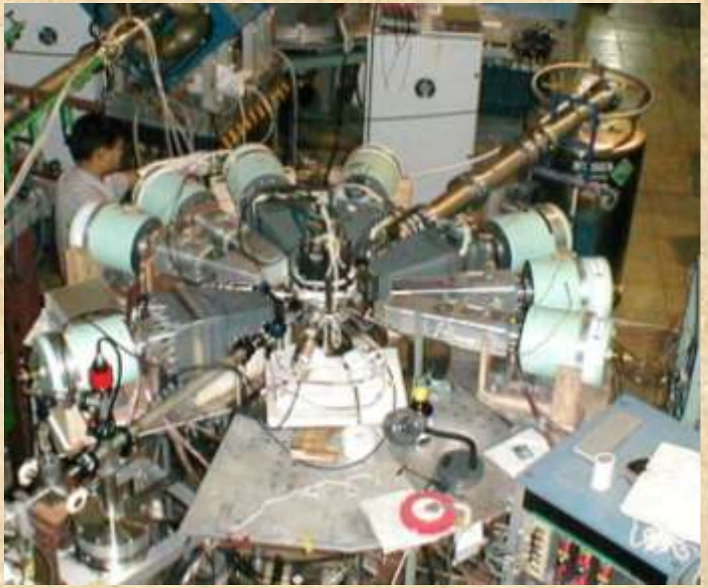
Opportunities and Avenues in Mainstream Nuclear Physics

Facilities and Perspectives (India)

- BARC-TIFR Pelletron – Linac at Mumbai
- IUAC Pelletron – Linac at New Delhi
- K120 Cyclotron at Kolkata
- K500 S Cyclotron at Kolkata
- RIB Facility at Kolkata
- Neutrino Observatory at Pottipuram, Tamil Nadu

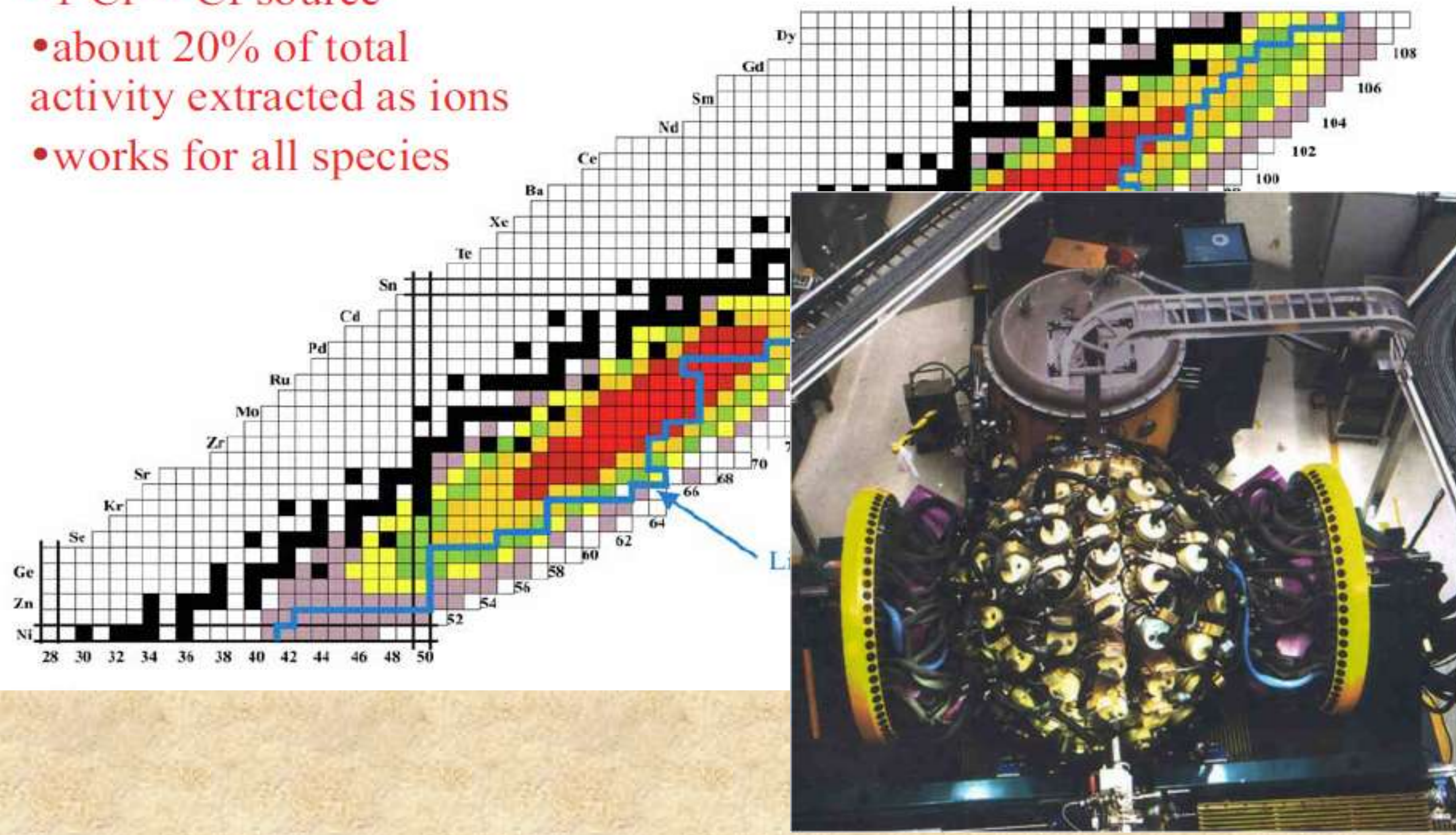
Opportunities for Collaboration

- Gammasphere, CARIBU/ATLAS at Argonne
- FAIR – GSI (2018) NUSTAR, R3B, EXL
- RIKEN
- GANIL SPIRAL2
- ANU



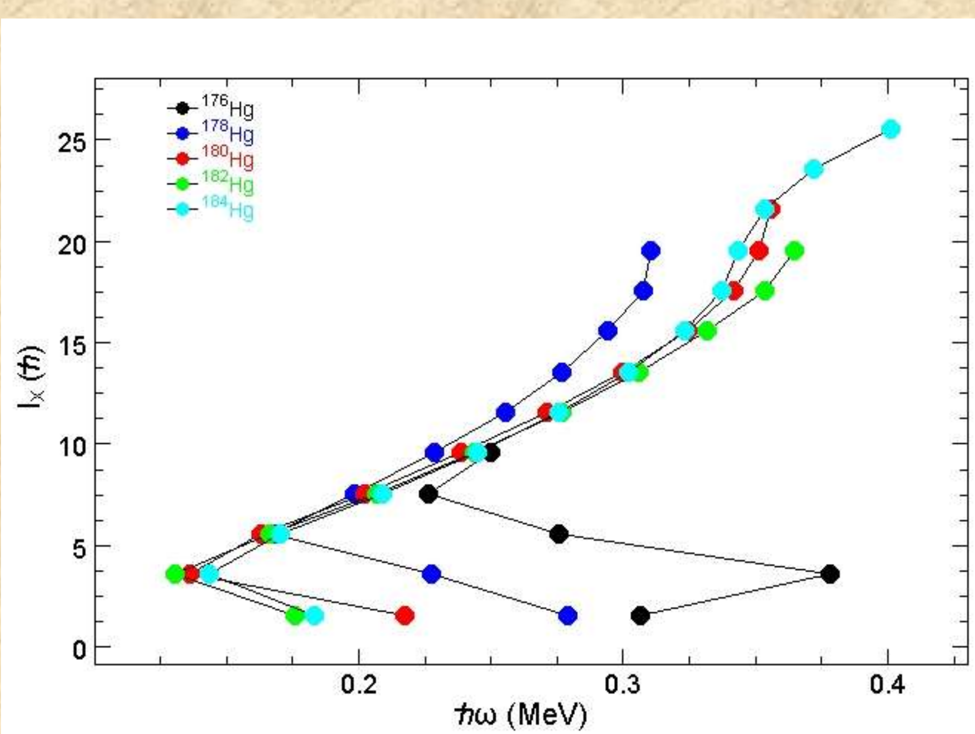

M.Carpenter
CARIBU and GAMMASPHERE

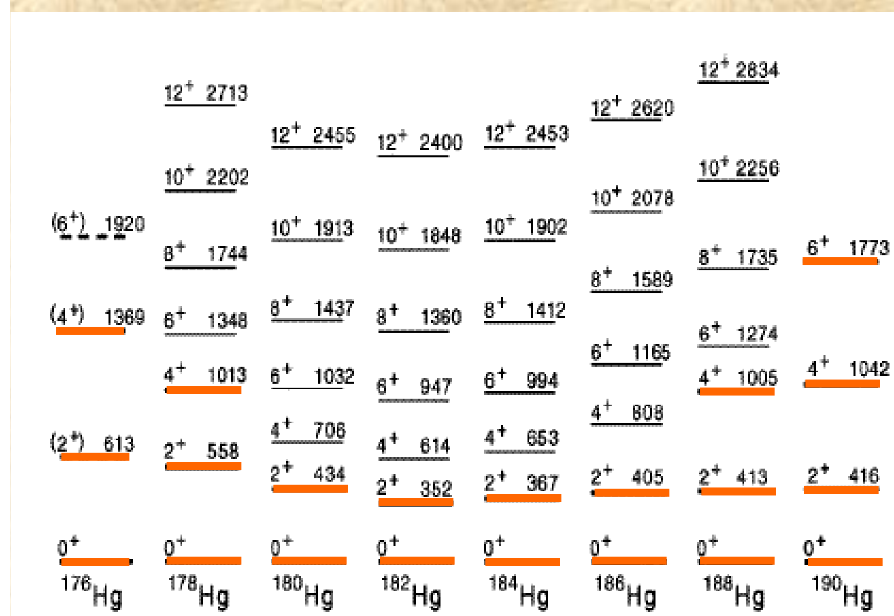
- 1 Ci ^{252}Cf source
- about 20% of total activity extracted as ions
- works for all species



Shape Co-Existence in Hg isotopes

Systematics of Yrast Bands in Hg Isotopes

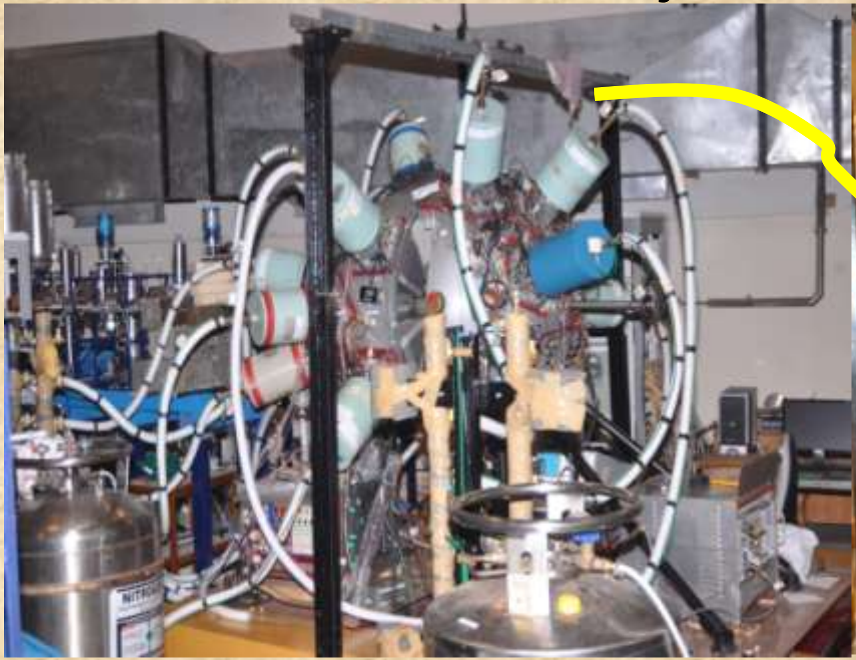




R.Palit

DDAQ with INGA

Detector Array



DSP DAQ

Host PC

PC for Storage & Analysis

Detectors -> DSP cards -> PCI Bridge -> PC-> Gigabit -> PC

Prof. J. Gerl

FAIR – The Facility

Primary Beams

- 10^{12}/s; 1.5-2 GeV/u; $^{238}U^{28+}$
- Factor 100-1000 over present in intensity
- $2(4) \times 10^{13}$/s 30 GeV protons
- 10^{10}/s $^{238}U^{73+}$ up to 25 (- 35) GeV/u

Secondary Beams

- Broad range of radioactive beams up to 1.5 - 2 GeV/u; up to factor 10 000 in intensity over present
- Antiprotons 3 - 30 GeV

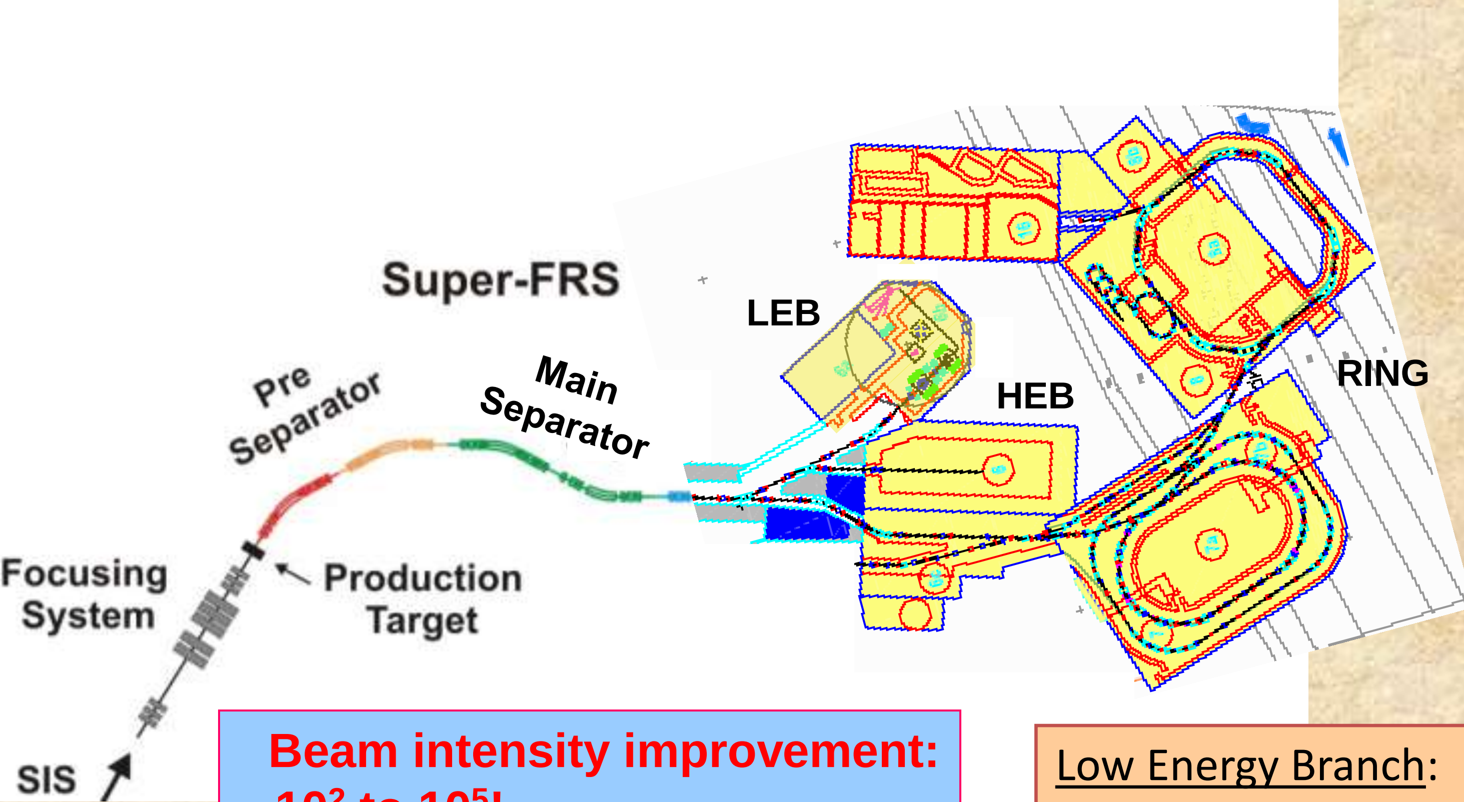
Storage and Cooler Rings

- Radioactive beams
- e – A collider
- 10^{11} stored and cooled 0.8 - 14.5 GeV antiprotons

Key Technical Features

- Cooled beams
- Rapidly cycling superconducting magnets

NUSTAR



Beam intensity improvement: 10^2 to 10^5!

Low Energy Branch:

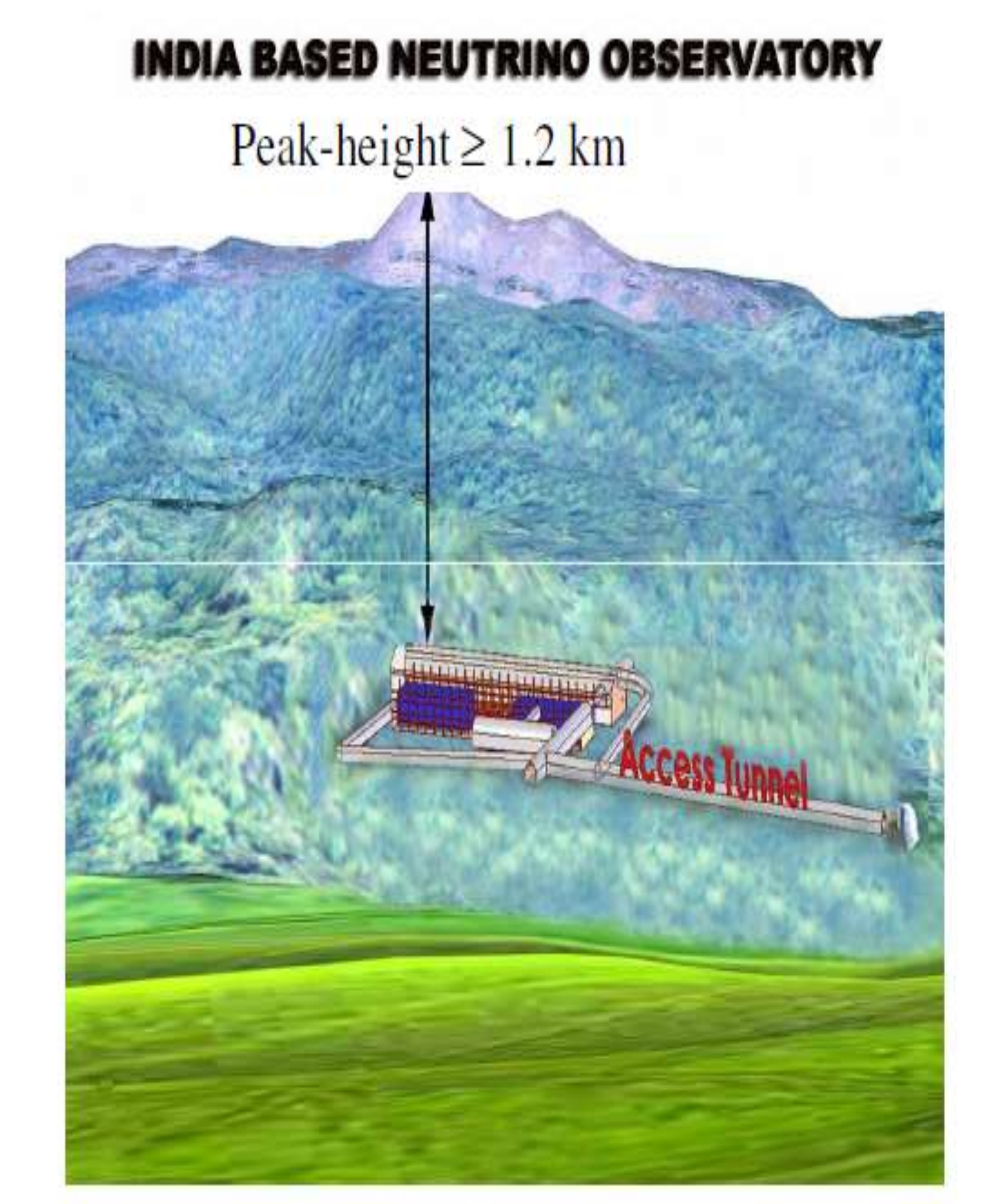
HISPEC, DESPEC, MATS, LASPEC

High Energy Branch:

R3B

Ring Branch:

EXL, ILIMA, ELISE

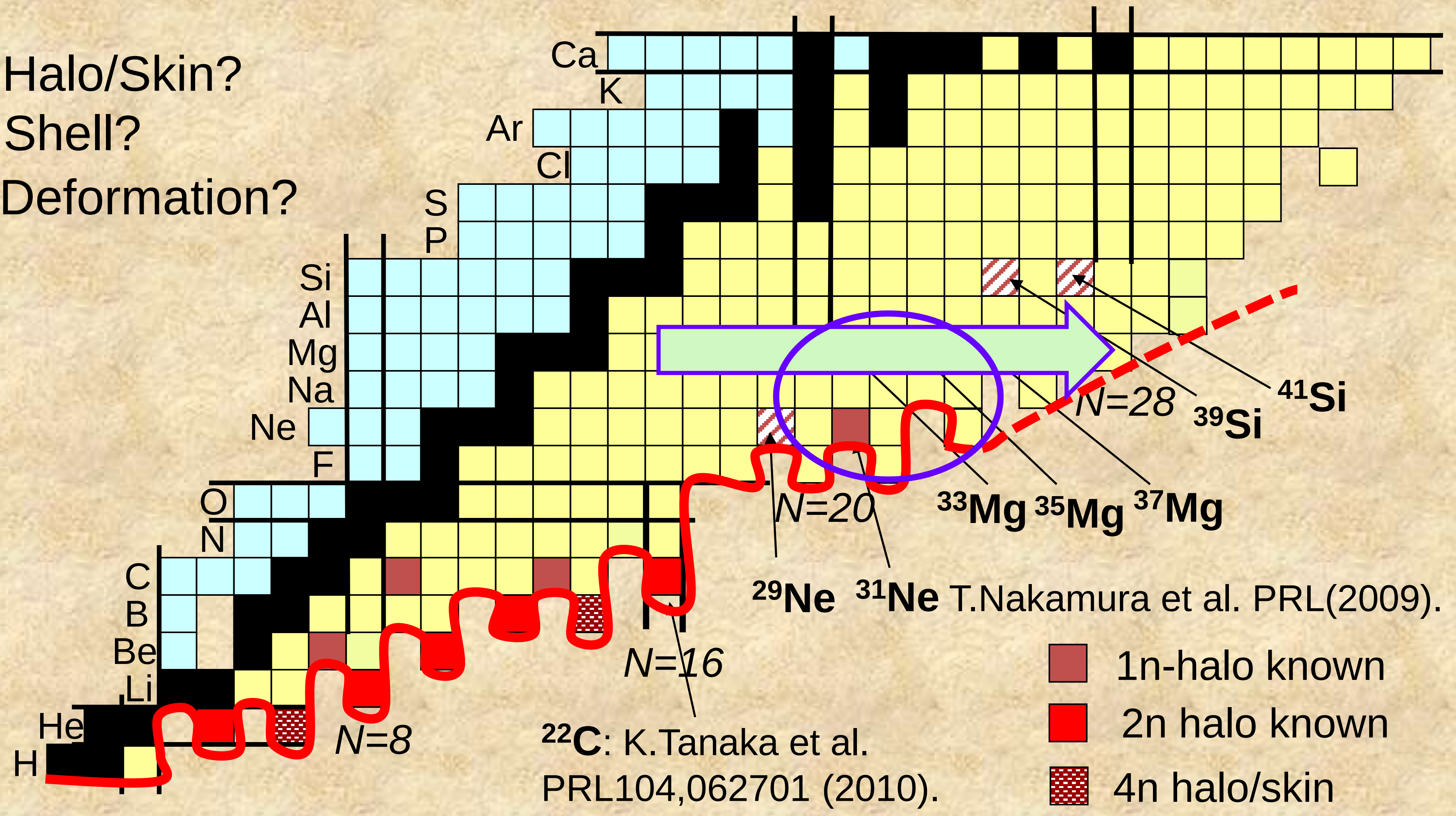


Pottipuram
Tamil Nadu

Takashi Nakamura

Coulomb/Nuclear Breakup

Halo/Skin?
Shell?
Deformation?



P.K.Pujari Target Preparation:
E.g.: Polymer Assisted Deposition

Spin coater and target wheel

- **Spin coating of metals chelated to a multi-dentate aqueous polymer (polyethylenimine(PEI))**

- **Annealing of spin-coated films yields a crack-free, uniform and homogenous metal oxide film**

- **PAD reapplication can produce film of desired thickness**

S.Santra: Weakly bound stable projectiles

Low breakup threshold

Stable ions

$^6Li \rightarrow \alpha + d$, $S_{\alpha d}$=1.48 MeV,

$^7Li \rightarrow \alpha + t$, $S_{\alpha d}$=2.47 MeV,

$^9Be \rightarrow \alpha + \alpha + n$, $S_{\alpha n}$=1.57 MeV,

Unstable ions

$^6He \rightarrow \alpha + 2n$, $S_{\alpha 2n}$=0.97 MeV,

- Study simulates reactions involving RIBs
- Synthesis of superheavy element by fusion of nuclei near neutron drip line
- Extrapolation to low energy capture cross section → Astrophysical interest

Advantage→Stable and large intensity

Multi-nucleon transfer and their effect on the mechanism of near barrier fusion reaction

Samit Mandal

- Multinucleon transfer reaction around Coulomb barrier
- Effect of multinucleon transfer channel on fusion cross section
- Effect of pairing correlation on multinucleon transfer reaction mechanism
- Relative importance of ground state and excited state transfer strength

Tom Aumann: R3B

Quasi free scattering with RIB

Pygmy Dipole

❑ Single Particle Structure

❑ Nucleon – Nucleon correlations

Many components of R3B Setup

- Si Tracker
- NeuLAND
- CALIFA – Charged Particle Detector
- R3B GLAD: Superconducting Dipole

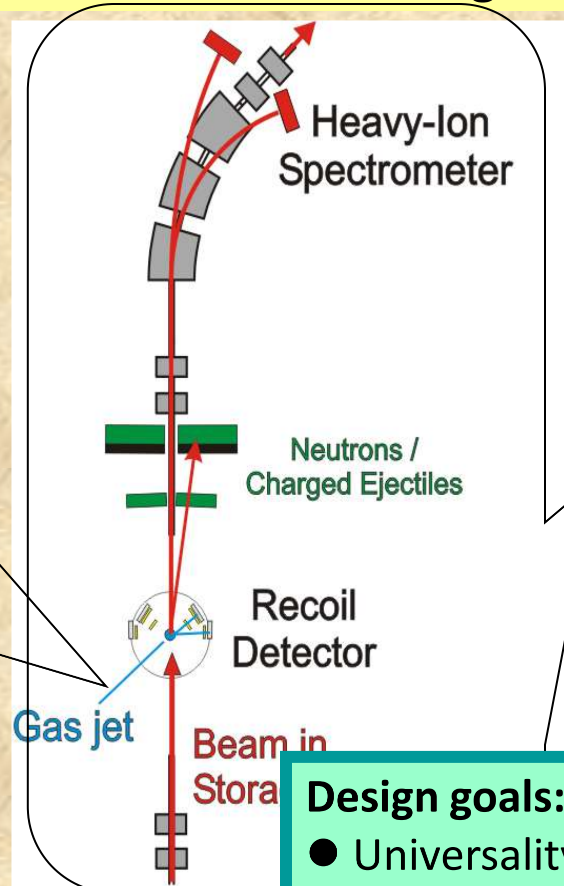
Peter Egelhof

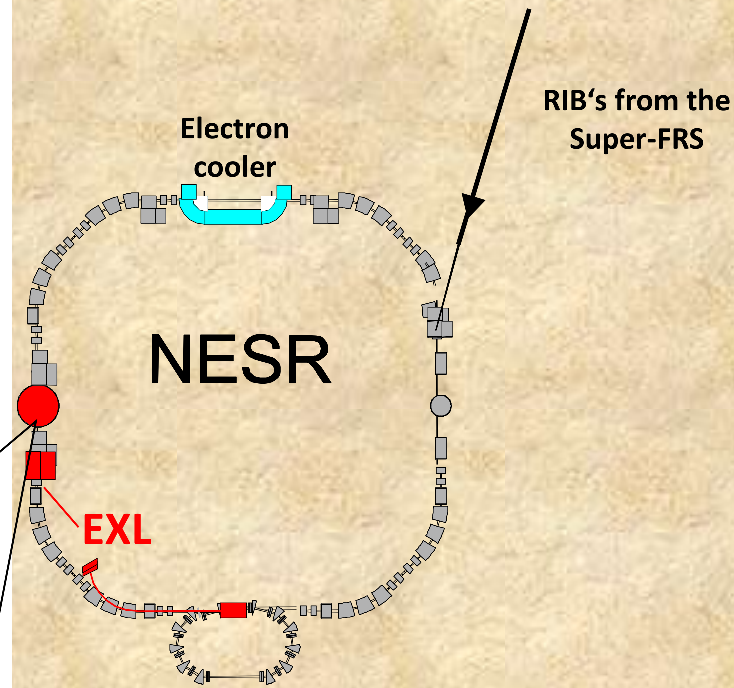
Intermediate Energy Elastic Proton Scattering
- a Tool to Study the Radial Shape of Halo Nuclei

light isotopes with halo-structure: ^{6}He, ^{8}He, ^{11}Li, ^{14}Be, ^{8}B, ^{17}C(?)

- R^{3}B: Reactions with Relativistic Radioactive Beams
  ⇒ High Energy Branch
- EXL: EXotic Nuclei Studied in Light-Ion Induced Reactions at the NESR Storage Ring
  ⇒ Ring Branch
- ELISe: ELectron Ion Scattering in a Storage Ring e-A Collider
  ⇒ Ring Branch

EXL: EXotic Nuclei Studied in Light-Ion Induced Reactions at the NESR Storage Ring





Detection systems for:

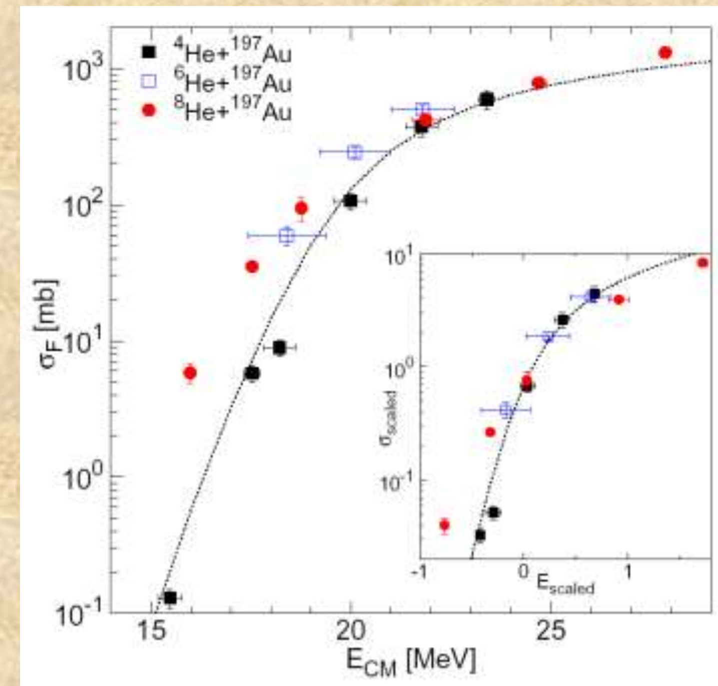
- Target recoils and gammas (p,α,n,γ)
- Forward ejectiles (p,n)
- Beam-like heavy ions

Design goals:

- Universality: applicable to a wide class of reactions
- High energy resolution and high angular resolution
- Large solid angle acceptance
- Specially dedicated for low q measurements with high luminosity (> 10^{29} cm^{-2} s^{-1})

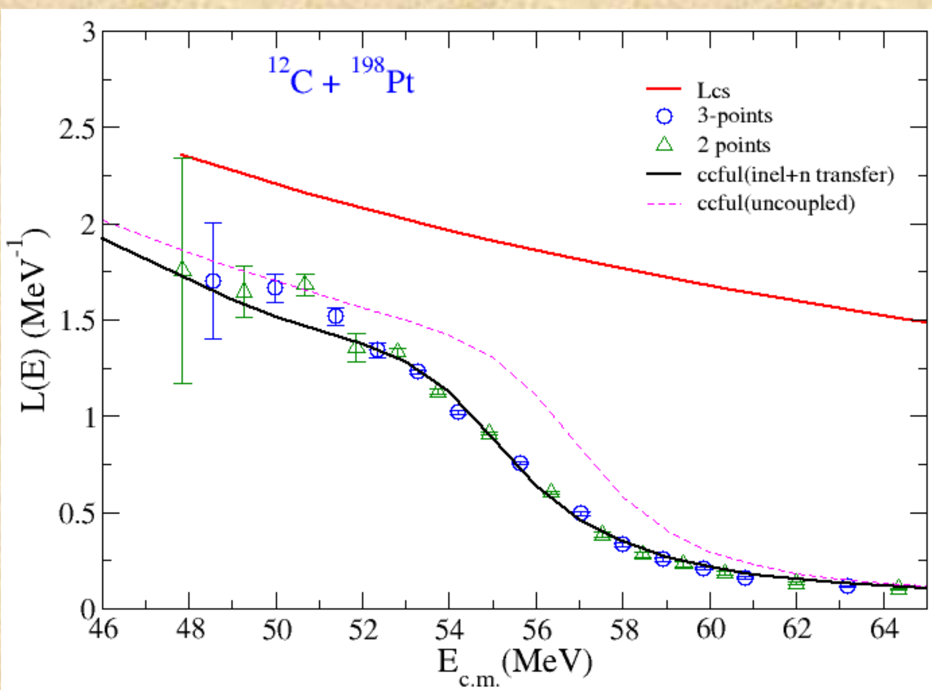
Tunneling in He isotopes

At deep sub barrier energies
No pronounced fusion hindrance for asymmetric systems
with weakly bound and stable projectile:
^{6}Li, ^{12}C, ^{7}Li + ^{198}Pt



$\sigma_{fus}(^{6,8}He > \sigma_{fus}(^{4}He)$

$\sigma_{fus}(^{6}He) \sim \sigma_{fus}(^{8}He)$



Level Structure of $^{32,34}P$: What do we learn about the $f_{7/2}$ –$p_{3/2}$ energy gap ?

Sandeep. S. Ghugre

1876-keV transition de-exciting 2305-keV level in ^{34}P confirmed as mixed transition with a plausible M2/E3 admixture.

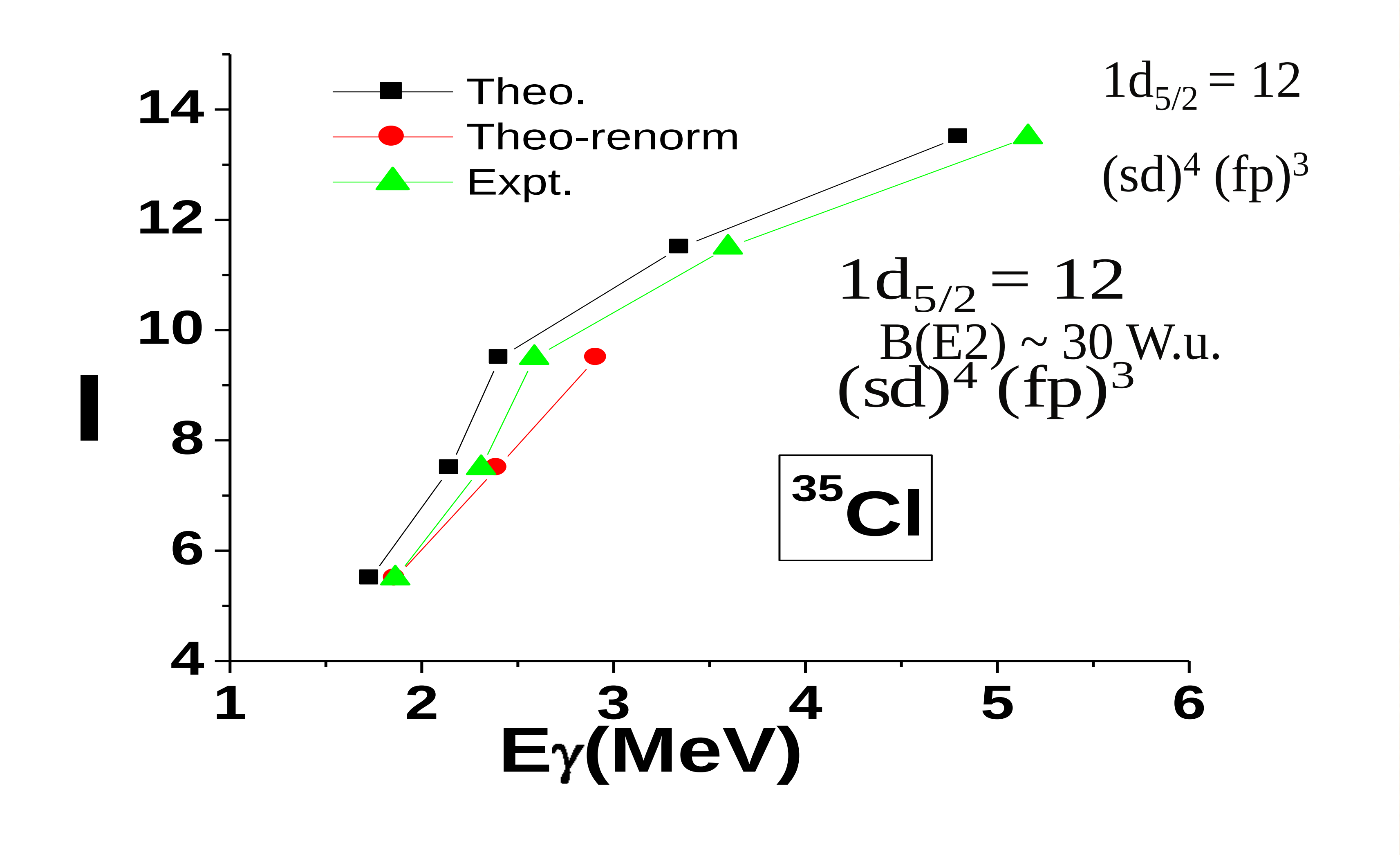
Shell model calculations

- Reproduced low-lying positive and negative parity states.
- No lowering of single particle energy cf other workers.

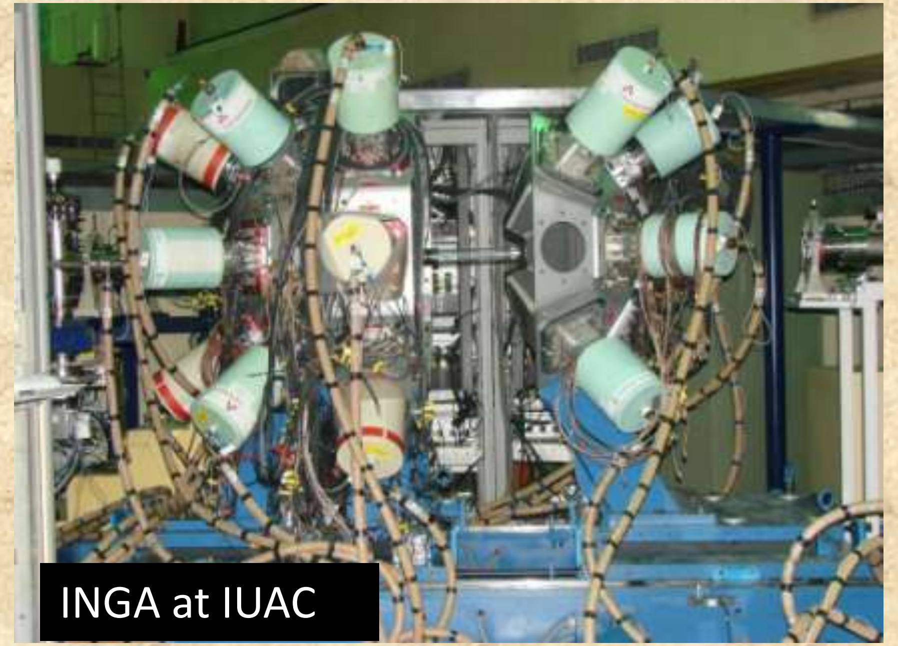
Shell model is successful in explaining the overall Structure with certain interesting exceptions

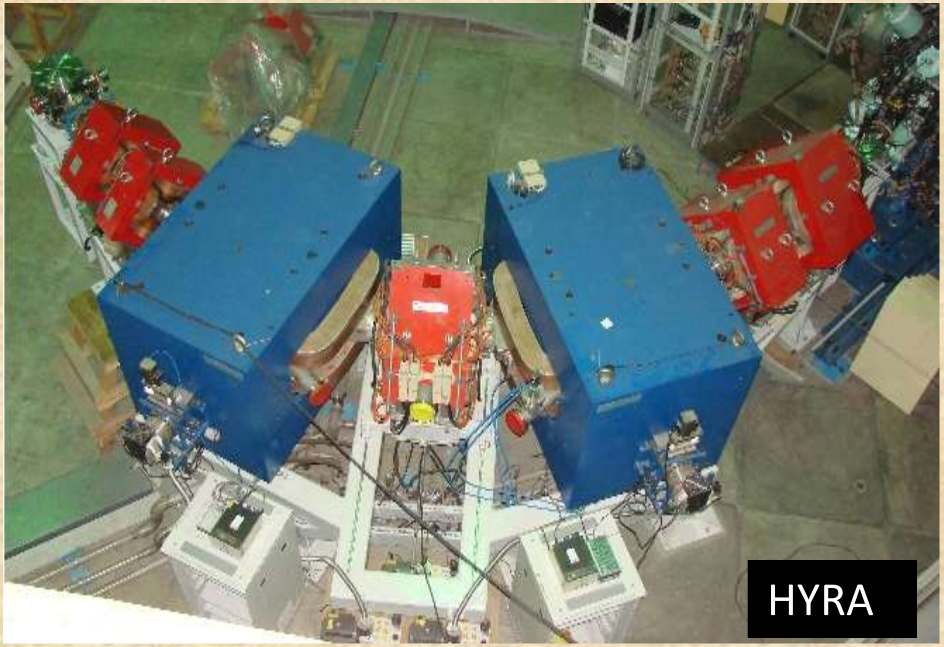
Shell Model studies

M.Saha Sarkar



R.P.Singh: Nuclear Structure through Coulomb Excitations





Experiments

Study of proton rich Sn isotopes
Collaboration with group at GSI

Investigation of Tetrahedral symmetry
Collaboration with LNL,Warsaw,Tetranuc

$B(E2, 2_1^+ \rightarrow 0_{gs}^+)$ in ^{112}Sn at IUAC

Tetrahedral Symmetry
Expt at LNL

Sarmishta Bhattacharya:

Single Particle and collective excitations in transitional nuclei

Role of intruder and Triaxiality

Experiments with INGA

Development of collectivity going towards neutron rich nuclei

S.Triambak

Isospin symmetry in Nuclear Physics: Precise Comparison of theory with experiment