Protons on actinide targets

Nuclear Structure

Rituparna Kanungo

Saint Mary's University

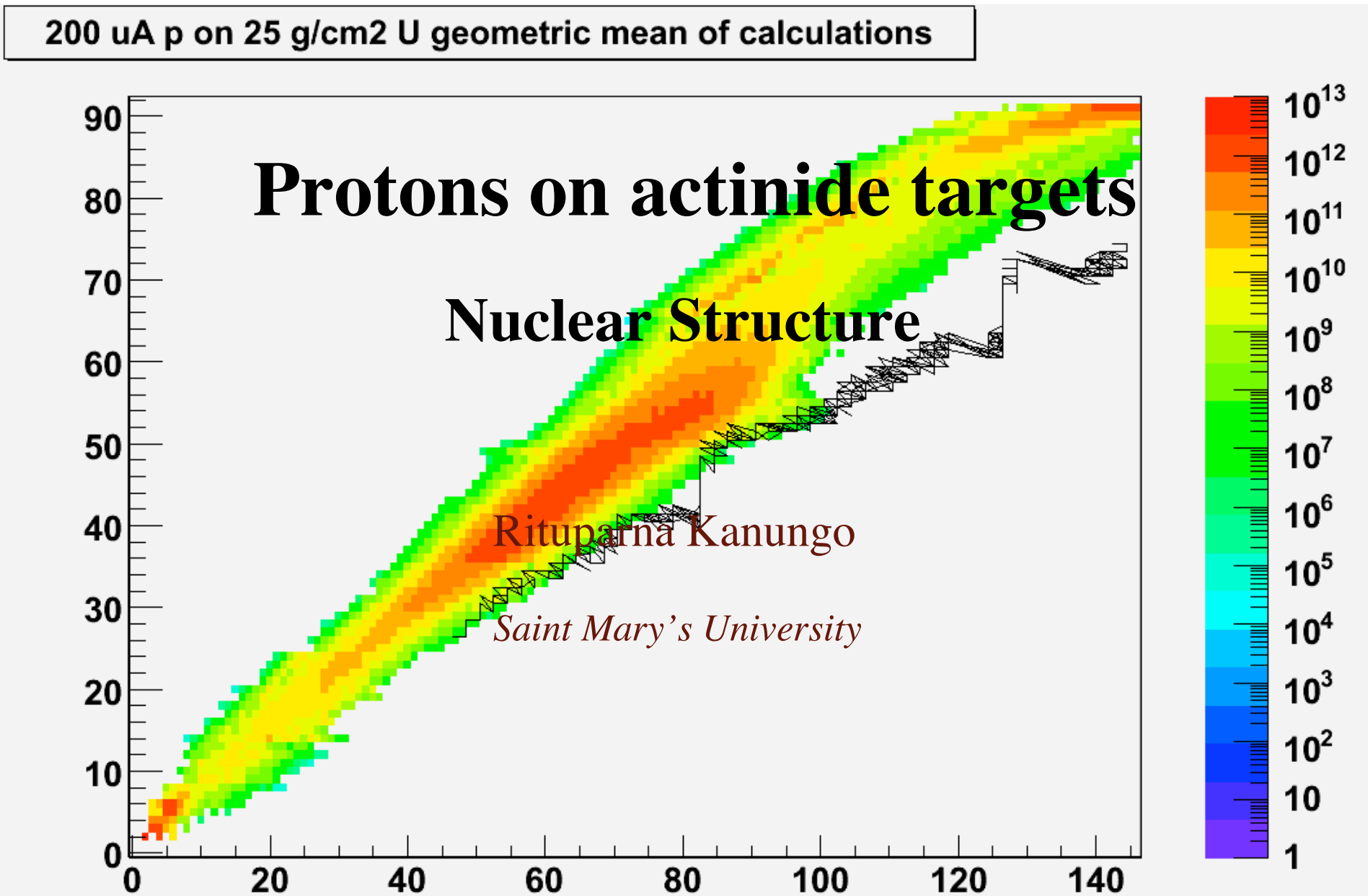


Figure courtsey :
M. Dombsky and G. Hackman

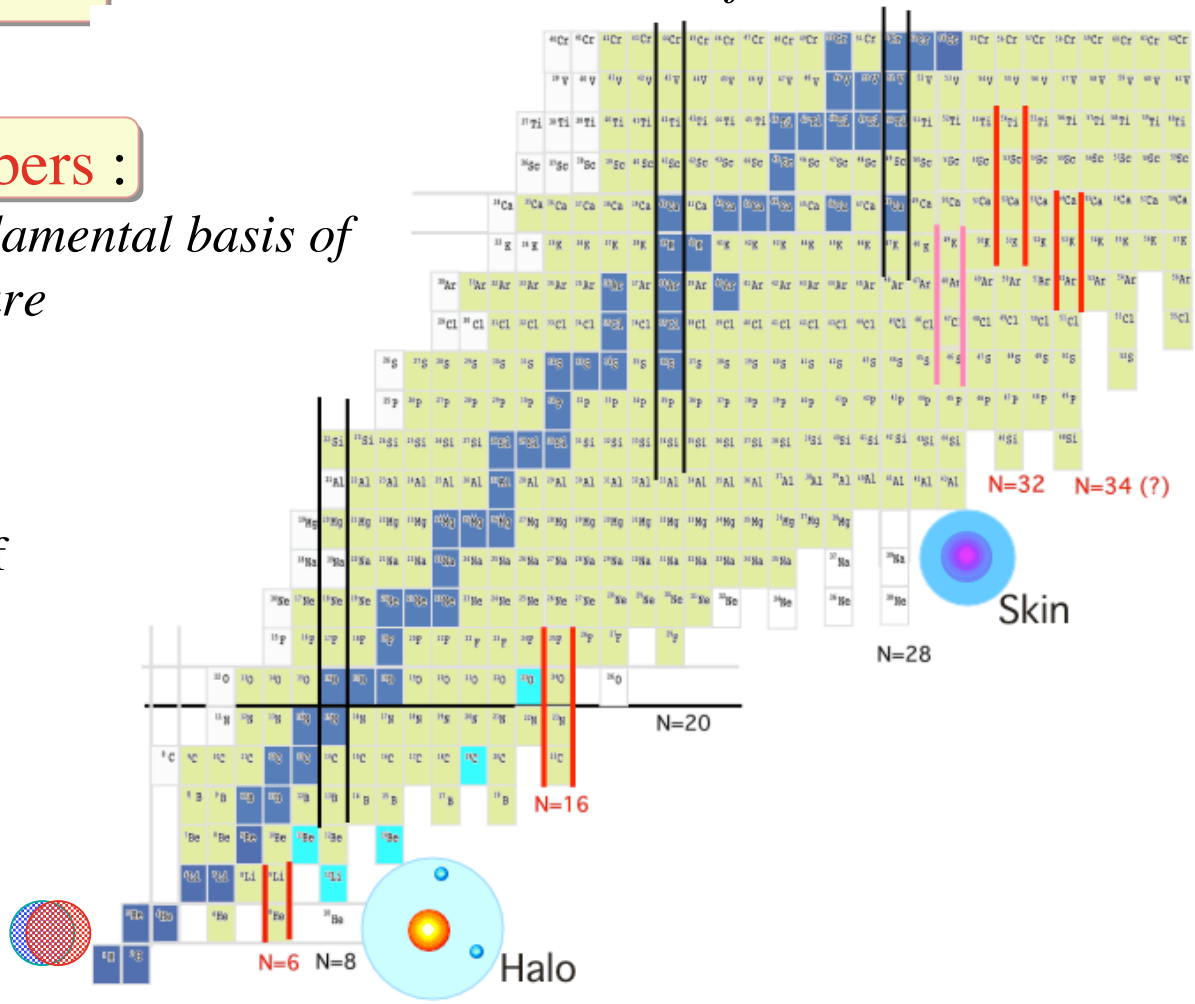
Nuclear structure : RIB opens a new era

Nuclear Halo, Skin : *A renaissance in our view of the nucleus*

New magic numbers :

Mutation of the fundamental basis of nuclear shell structure

Change in ordering of nuclear orbitals

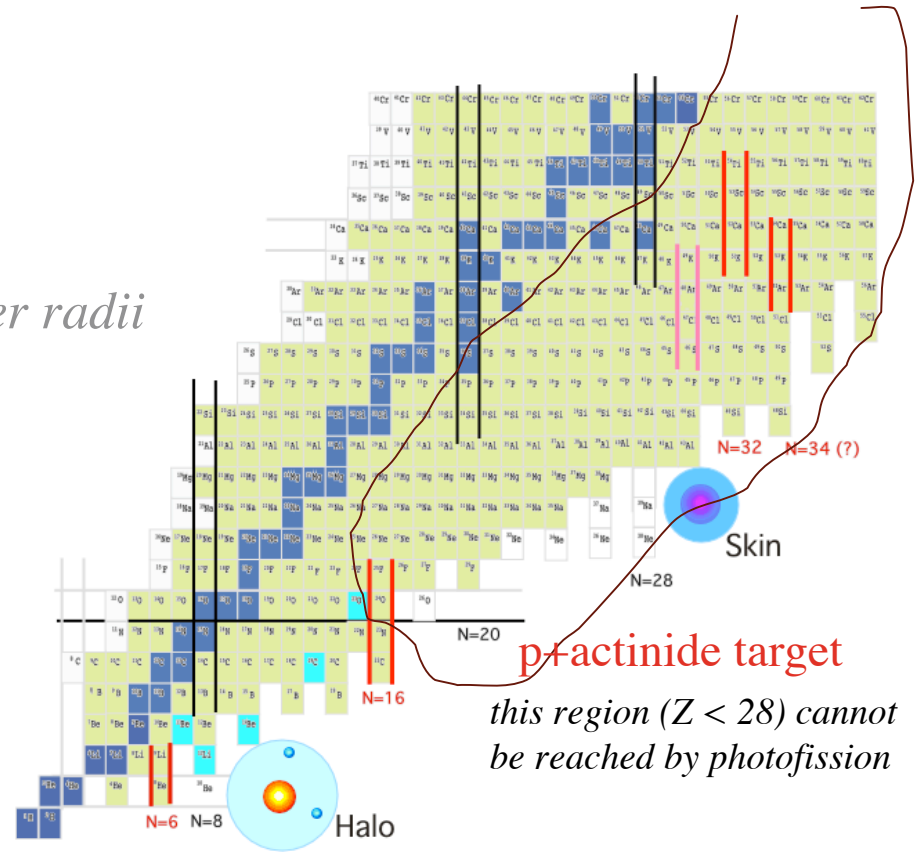


Nuclear structure potential at ISAC

with proton induced reactions on actinide targets

Access to very neutron-rich nuclei (A/Z ~ 2.7- 3)

- **Evolution of shell structure**
  - Excited states : *Coulex, inelastic scattering*
  - Nuclear orbitals : *transfer reactions*
  - Masses
  - Beta decay
- **Nuclear skin**
  - Charge radii *and matter radii*
- **Soft dipole resonance**
  - Inelastic scattering
    New collectivity, effect on fusion
- **Nucleon correlation**
  - Pair transfer

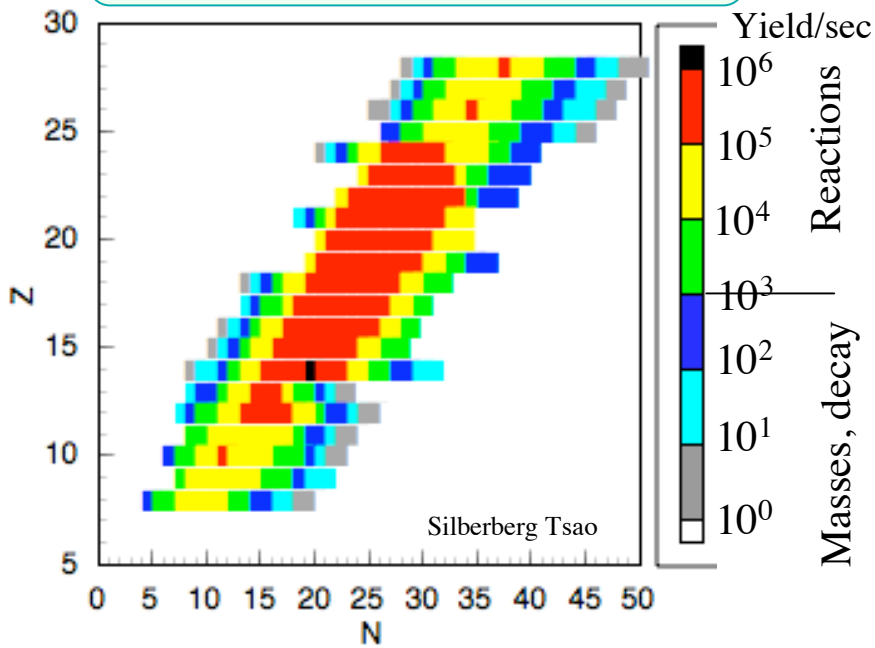


Much of nuclear astrophysics (r-process, neutron-star) relies on nuclear structure of neutron-rich nuclei. These issues are therefore important for heavier nuclei as well.

Expected *first* reach with protons on actinide targets

Z= 8-28 is only shown

Yield with Actinide target for accelerated RIB with 20μA protons



In-target production yields@ 20μA reduced by 10^{-5}

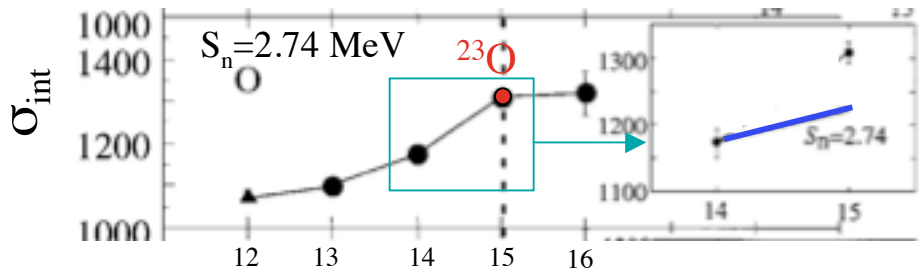
- Efficiency of extraction out of target + ion source is assumed to be ~ 10^{-4}
- Transmission for accelerated beams ~ 10%

- Development of cryogenic reaction targets are being planned to achieve an order of magnitude increase in reaction yield. -- *IRIS*
- Beam identification before reaction target to detect for isobaric beam contaminants. -- *IRIS*

Nuclear halo and new magic number

New magic number : N=16

A. Ozawa et al., PRL 84(2000)5493



Unsolved question :

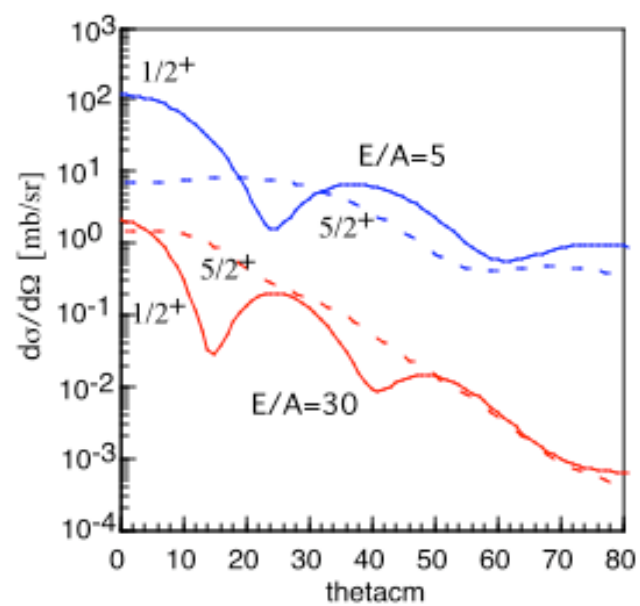
The large cross-section is not explained by ^{23}O (1/2$^+$)

What is spin of ^{23}O ?

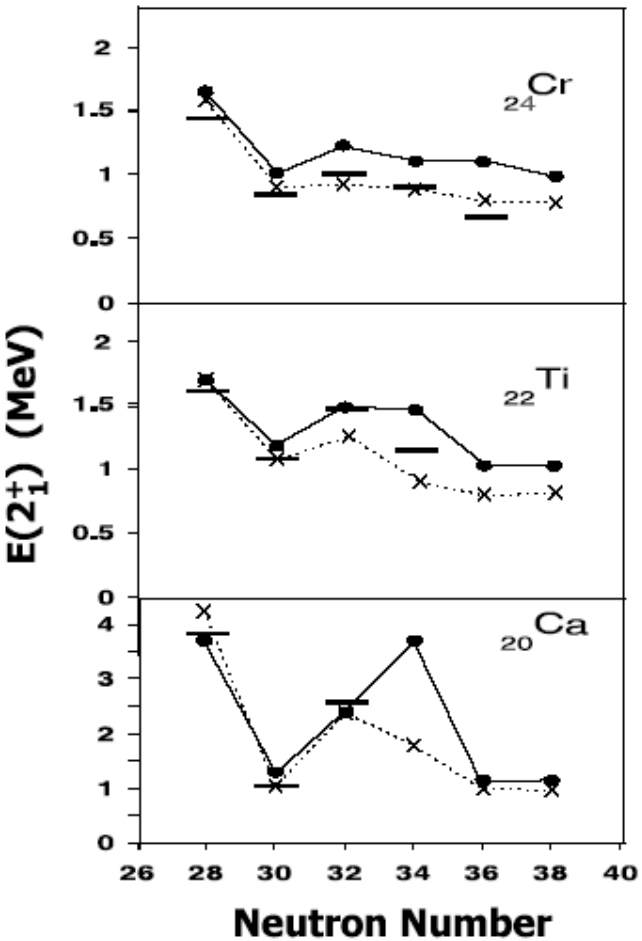
^{22}O(d,p)^{23}O at ISAC can address this question

^{22}O ; 1000/s : *20uA*

To be proposed



New shell closures N=32 and N=34 (?)



EXP — S.N. Liddick et al., PRL 92 (2004) 072502
GXPF1 ● M. Honma et al., PRC 95 (2002) 061301
KB3G × A. Poves et al., Nucl. Phys. A 694 (2001) 157

- The first 2^+ state in neutron-rich Ca isotopes

  Coulomb excitation below barrier

  @ TIGRESS

  R.A.E Austin : S993 *approved proposal*

- Masses of neutron-rich Ca isotopes

  @ TITAN

  H. Savajols, J. Dilling : S1112 *approved proposal*

Other approved proposals

- Probing Shell Structure with β and βn-delayed γ spectroscopy (^{26}Na, ^{32}Na, ^{20}N, ^{22}N)

  F. Sarazin, G. Hackman S955 *[8pi]*

- Shells Evolution in Neutron-Rich *sd*-shell Nuclei with Near 20

  C. Wu S1075 *[TIGRESS]*

- Search for negative parity states in ^{27}Na

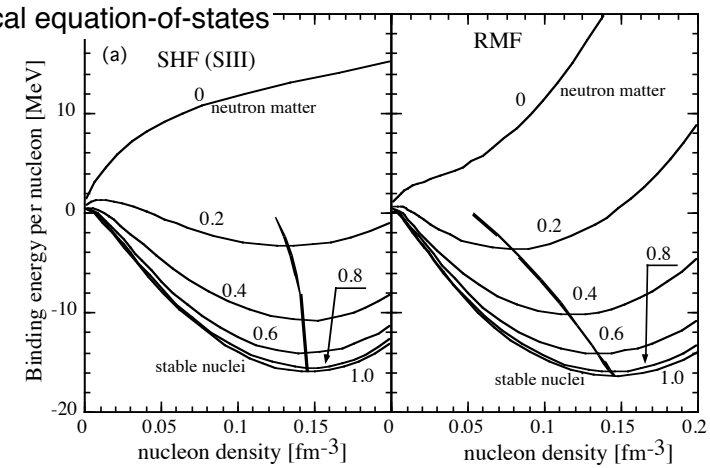
  W.N. Catford S1107 *[TIGRESS]*

Charge radii : neutron skin

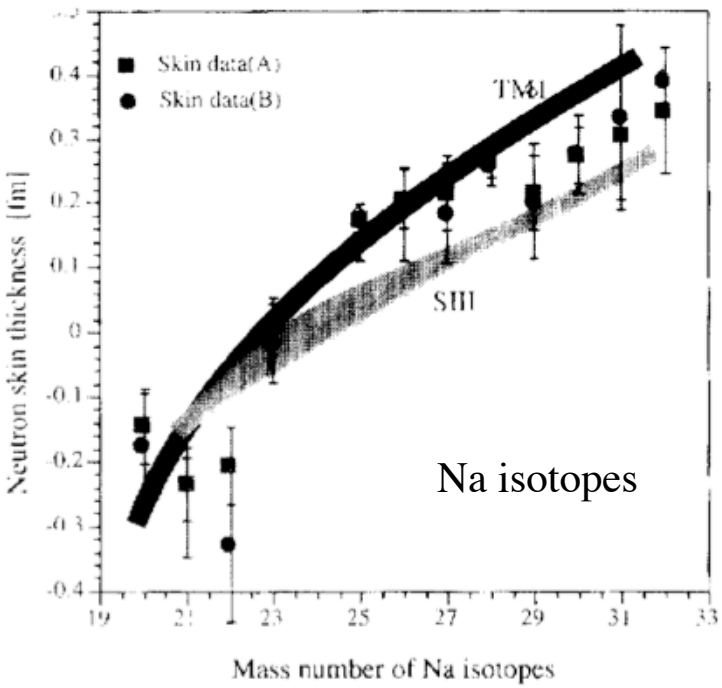
Neutron skin : Constraining the EOS of asymmetric nuclear matter

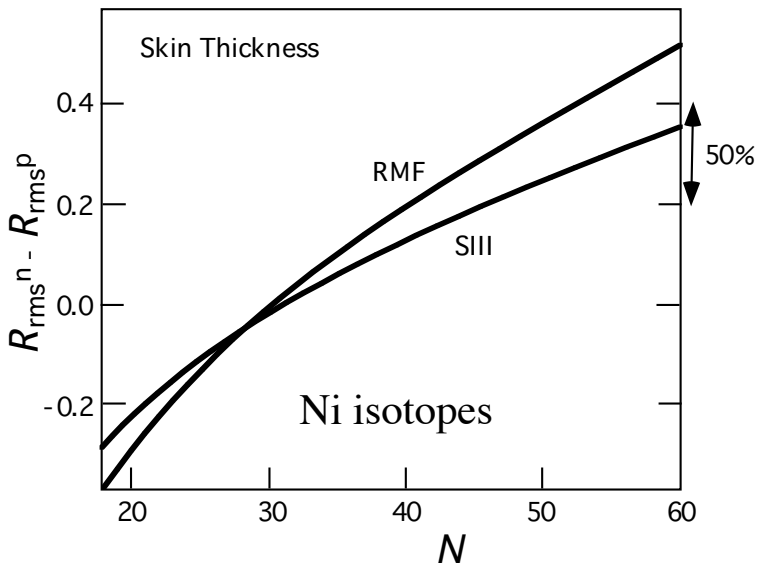
(density dependence of symmetry energy)

Two typical equation-of-states



Discrimination between different theoretical models





K. Oyamatsu,et al, Nucl. Phys. A 634(1998)3

Summary

Proton induced reactions on actinide targets extends our reach to very neutron-rich light and medium heavy nuclei that are not accessible with photofission.

The beam availability at ISAC bears excellent promise to produce significant **immediate impact** on evolution of nuclear structure in neutron-rich nuclei

ISAC is presently making important contributions to the understanding of nuclear halo and shell closures for light neutron-rich nuclei.

Halo-08 workshop
March 27-28, 2008

The complementary capabilities with protons and photofission will make ISAC a premier facility for high-intensity, good-quality beams of neutron-rich nuclei.