The 5th International Conference on

"COLLECTIVE MOTION IN NUCLEI UNDER EXTREME CONDITIONS"

September 14-18, 2015 Kraków, Poland

Organized by IFJ PAN Kraków and coorganized by UJ Kraków, AGH Kraków, UW Warszawa and Foundation for AGH

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Invited Speakers

Naftali Auerbach (Tel Aviv)
Sonia Bacca (TRIUMF)
Baha Balantekin (Wisconsin-Madison)
Sudhee R. Banerjee (Kolkata)
Didier Beaumel (IPN Orsay)
Roelof Bijker (ICN-UNAM Mexico)
Konstanze Boretzky (GSI)
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Anna Corsi (Saclay)
Nguyen Dinh Dang (RIKEN/Hanoi)
Jacek Dobaczewski (UW Warszawa)
Bogdan Fornal (IFJ PAN Kraków)
Dieter Frekers (Muenster)
Yoshitaka Fujita (Osaka)
Sydney Gales (IPN Orsay/Bucharest)
Magne Guttormsen (Oslo)
Muhsin Harakeh (Groningen)
Mikhail Itkis (JINR Dubna)
David Jenkins (York)
Nasser Kalantar-Nayestanaki (Groningen)
Elias Khan (IPN Orsay)
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Haizhao Liang (RIKEN)
Ismael Martel (Huelva)
Indranil Mazumdar (TIFR Mumbai)
Chiara Mazzocchi (UW Warszawa)
Jie Meng (Beijing)
Witold Nazarewicz (MSU/UW Warszawa)
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Nils Paar (Basel/Zagreb)
Paul-Gerhard Reinhard (Erlangen)
Gencho Rusev (Los Alamos)
Domenico Santonocito (LNS Catania)
Masaki Sasano (RIKEN)
Deniz Savran (GSI)
Haiko Scheit (TU Darmstadt)
Noritaka Shimizu (Tokyo)
Artemis Spyrou (MSU)
Atsushi Tamii (Osaka)
Thomas Roger (GANIL)
Calin A. Ur (Bucharest)
Mikhail Urin (Moscow)
Marine Vandebrouck (GANIL)
Yanlin Ye (Beijing)

COMEX5

comex5.ifj.edu.pl

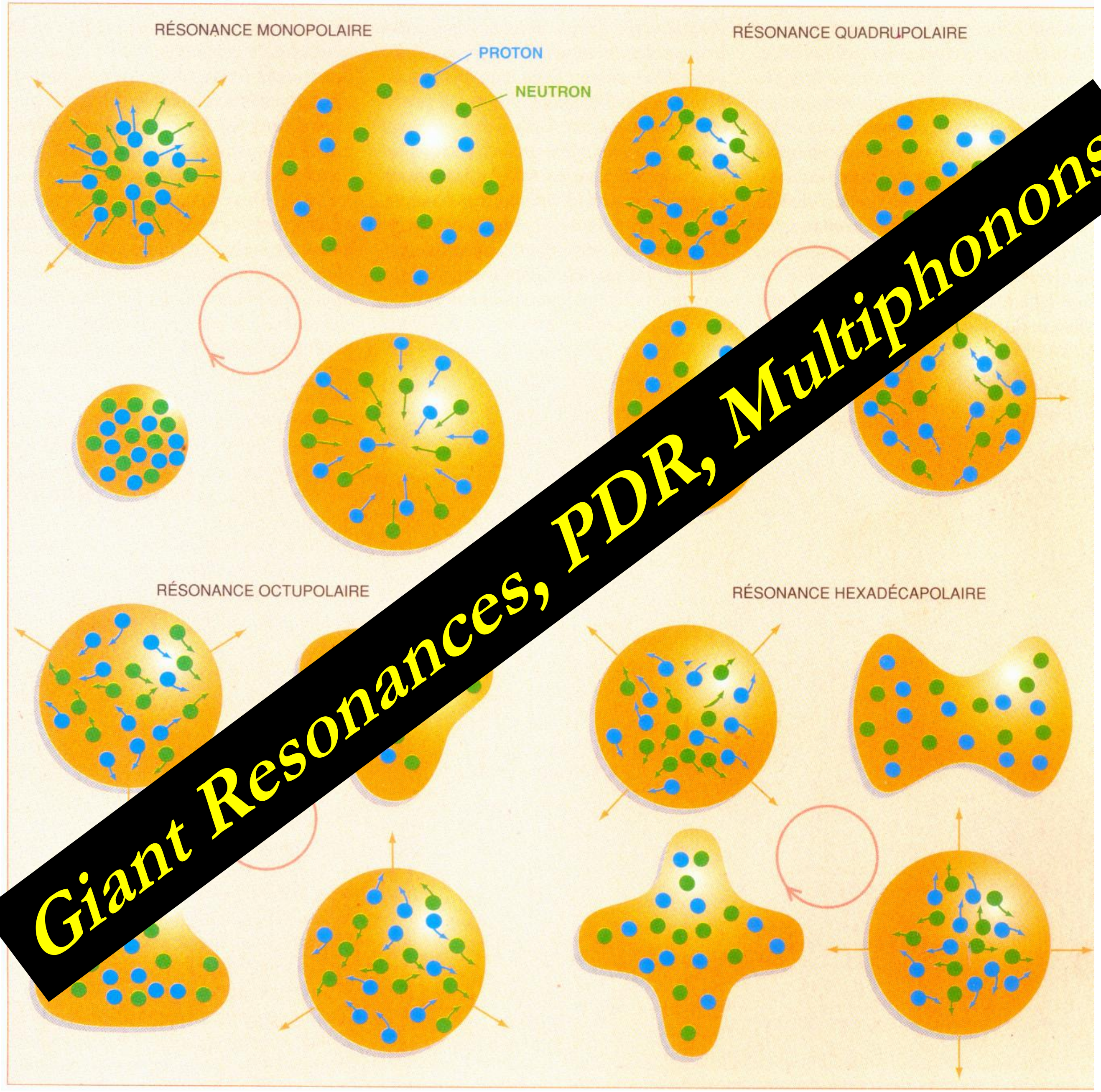
COMEX 5 OUTLOOK

The main topics of COMEX5 conference are:
- Giant resonances in cold and hot nuclei,
- Collective and new excitation modes in nuclei,
- Spin and isospin modes,
- Multi-phonon excitations, clustering and pairing effects in excitations,
- Studies of the decay of highly excited states,
- Applications in astrophysics,
- Novel instrumentation and novel methods,
- New facilities.

Future prospects

Physics of Collective Modes under Extreme Conditions

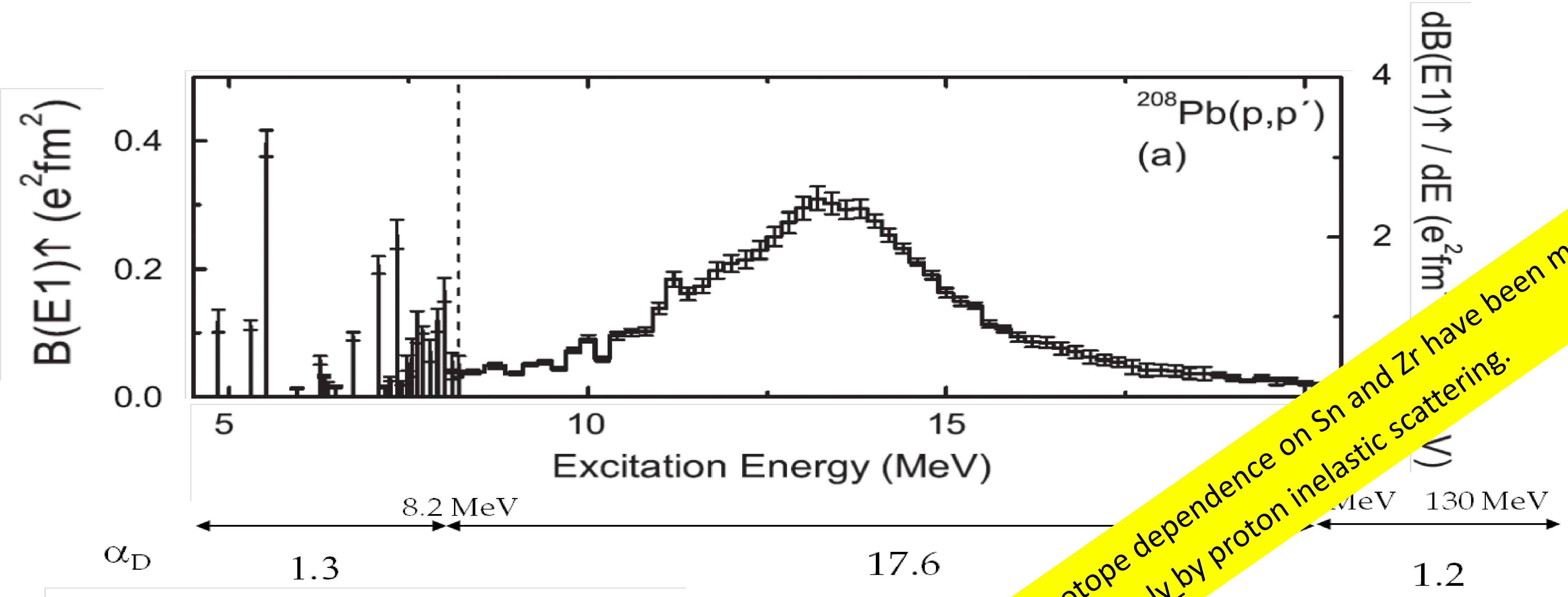
Giant Resonances, PDR, Multiphonons



Huge added value of High resolution and Polarized beams

A.Tamii et al (RCNP Osaka) PRL (2011)107,062502

E1 Response of ^{208}Pb and α_D

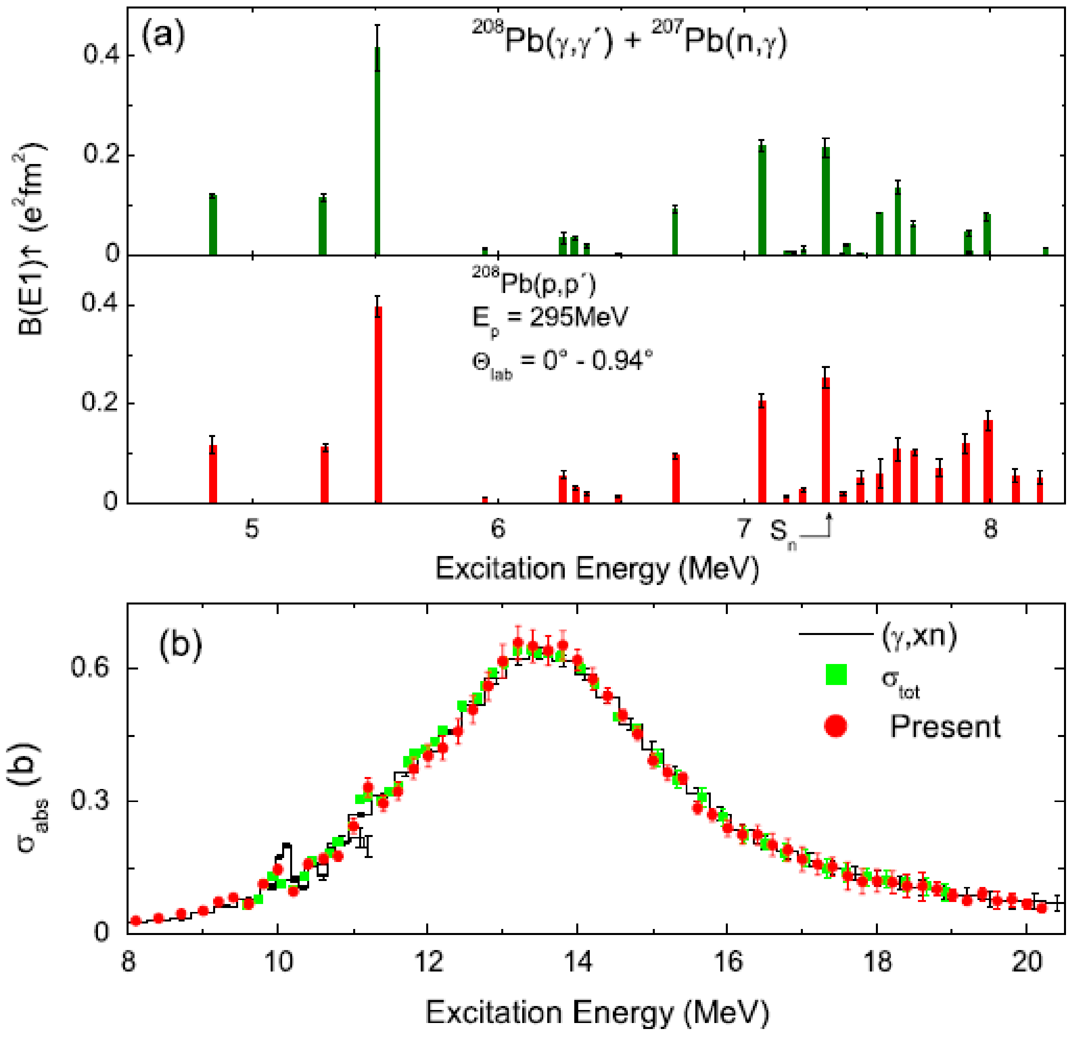


- Isotope dependence on Sn and Zr have been measured precisely by proton inelastic scattering.

$$\alpha_D \equiv \frac{\sigma_{-2}}{2\pi^2}\cdot\frac{\hbar c}{e^2} = \sum \frac{\sigma_{\rm abs}(E_x)}{E_x^2}\cdot\frac{\hbar c}{2\pi^2 e^2}$$

in total 20.… .6 fm^3/e^2

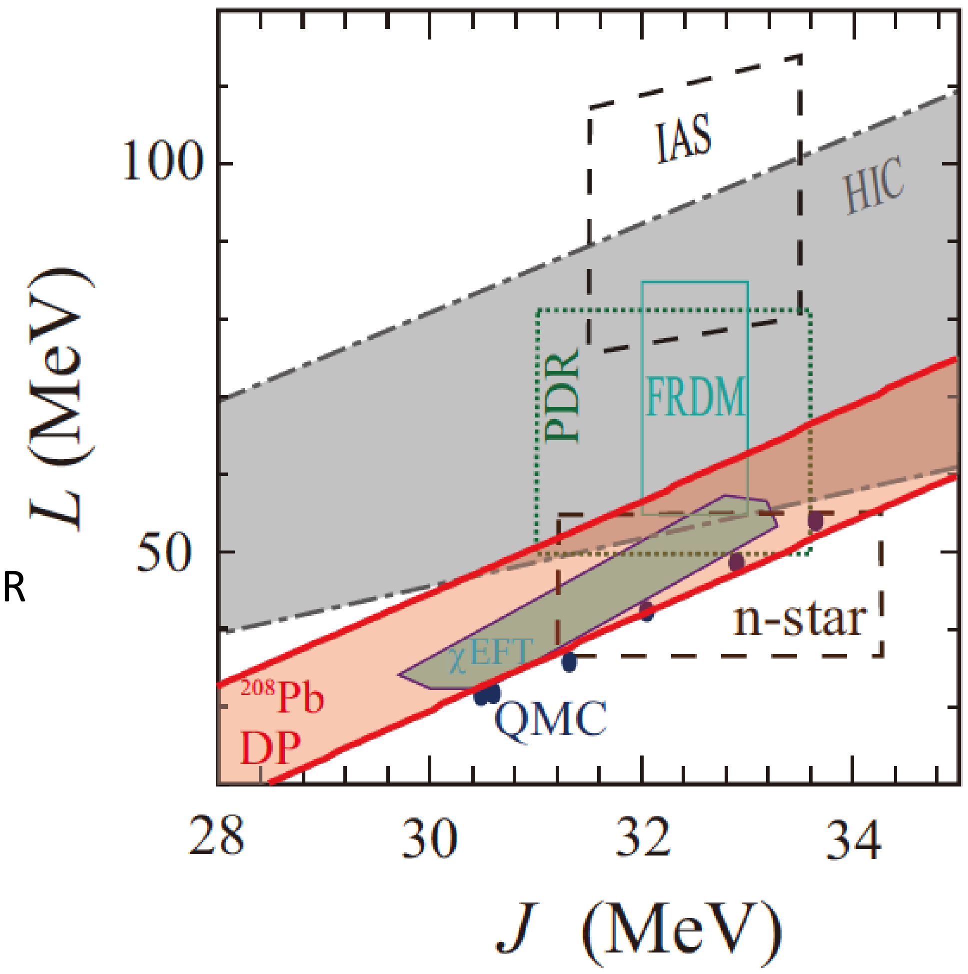
Constraints on *J* and *L* by the ^{208}Pb Dipole Polarizability



Low-Ex

Electric dipole (E1)

GDR



DP: Dipole Polarizability
HIC: Heavy Ion Collision
PDR: Pygmy Dipole Resonance
IAS: Isobaric Analogue St
FRDM: Finite Range Droplet
Model (nuclear mass analysis)
n-star: Neutron Star Observation
χEFT: Chiral Effective Fiel
Theory

A. Tamii *et al.*,
PRL 107 (2011) 062502

A. Tamii et al., EPJA**50**, 28 (2014)

Hot Topic :Pygmy resonances   Anwers and many more questions

We need different probes !

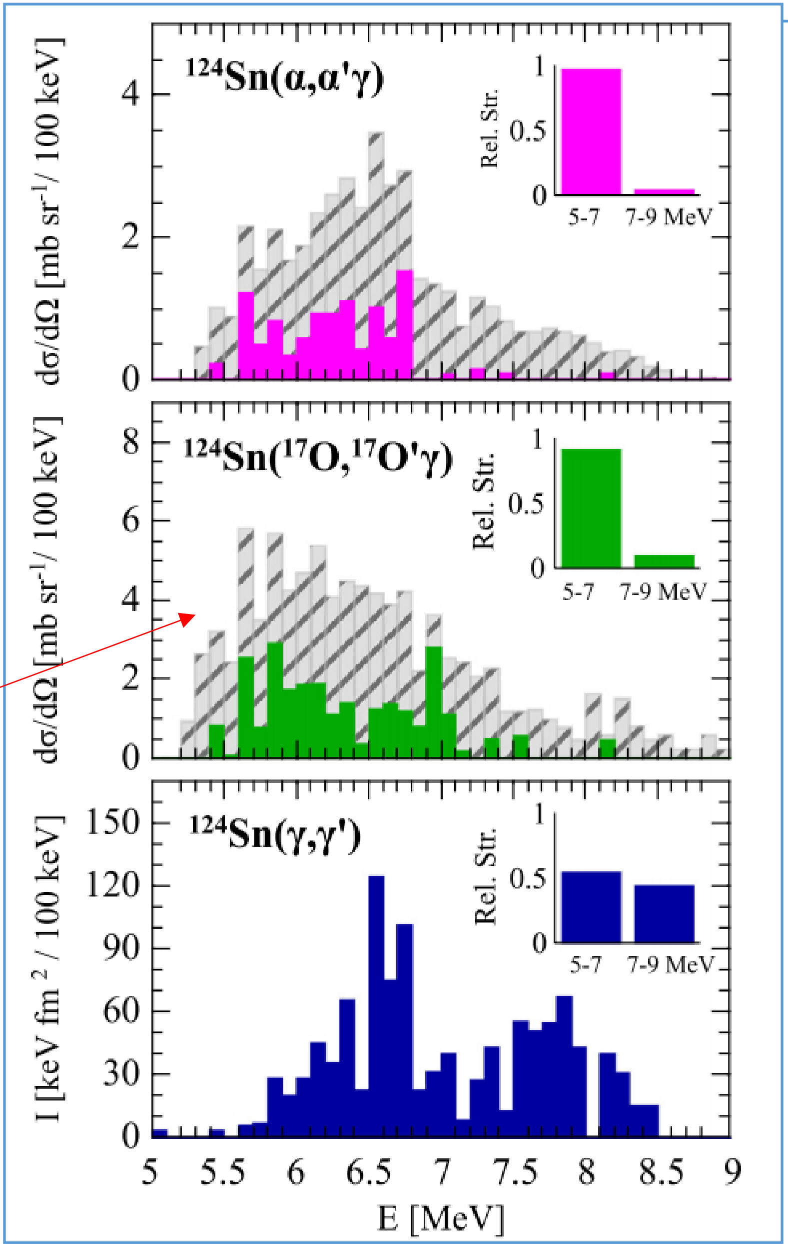
Isoscalar or isovector?

Comparison : ^{17}O, alpha and Gamma scattering

The splitting of the PDR region becomes even more evident with integratation of the strength into two regions, 5–7 and 7–9 MeV

IS nature of the PDR due to outermost nucleons ,neutron skin. The r_{np} is correlated with J and L. Interesting to study the properties of the neutron skin

More experimental information's on Transitions densities
Decay pattern , branching ratio with NRF
Transition region from bound to unbound ELI-NP !!

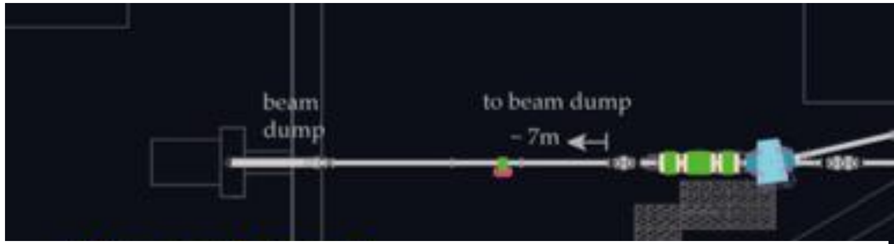


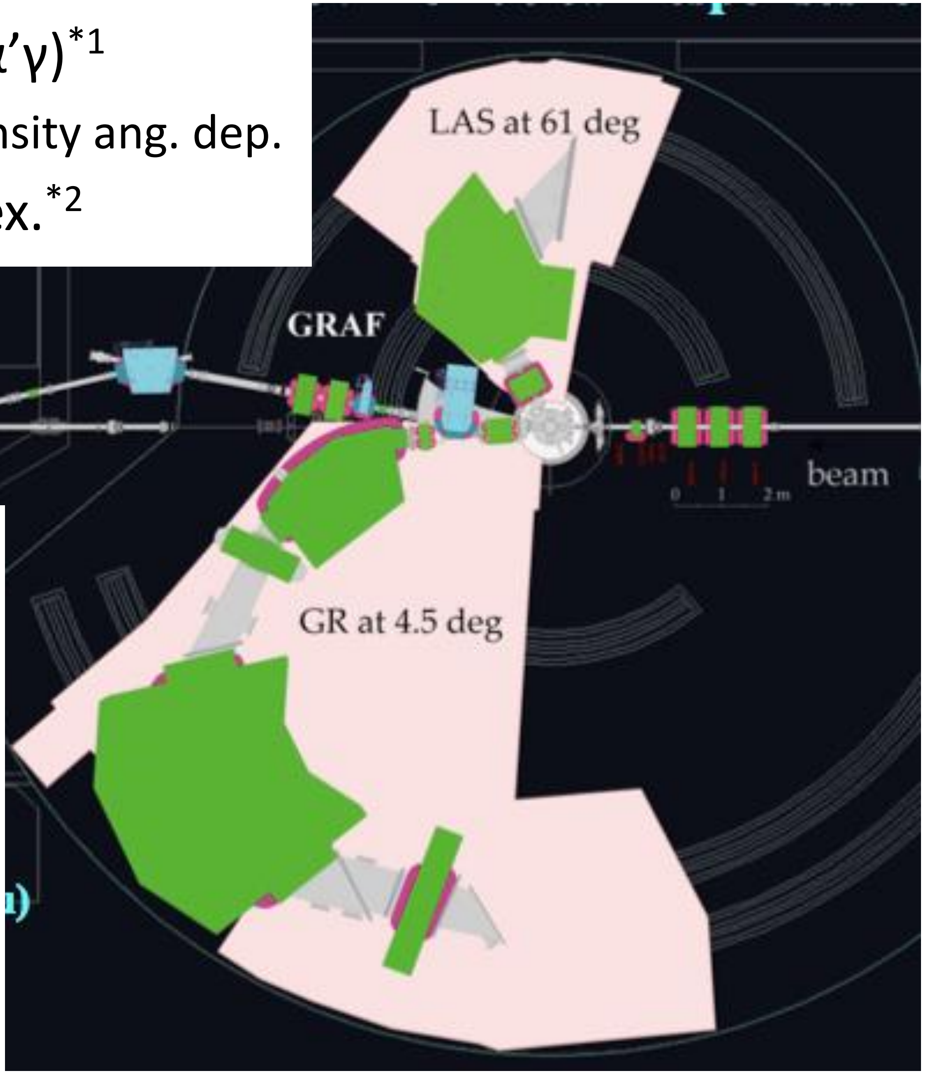
Harakeh
Bracco
Tamii
Savran
…………

Future

CAGRA+GR Campaign Exp. in 2016

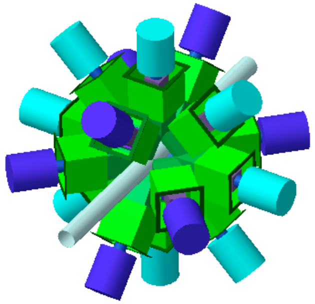
- Study on PDRs by (p, $p'\gamma$) and (α,$\alpha'\gamma$)*1
  isospin/surface property, transition density ang. dep.
- (^{6}Li,^{6}Li'γ) for IV spin-flip inelastic ex.*2





CAGRA(Clover Ge Array)

for γ-coincidence measurements



also plans for $LaBr_3$ detectors

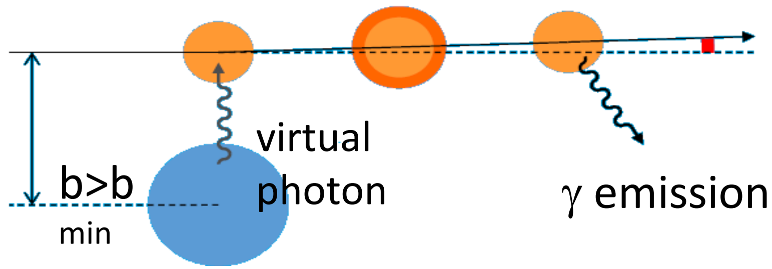
*1 A. Bracco, F. Crespi, V. Derya, M.N. Harakeh, T. Hashimoto, C. Iwamoto, P. von Neumann-Cosel, N. Pietralla, D. Savran, A. Tamii, and A. Zilges *et al.*

*2 S. Noji, R.G.T. Zegers *et al.*,

Relativistic **Virtual photon scattering (GSI-RIKEN)**

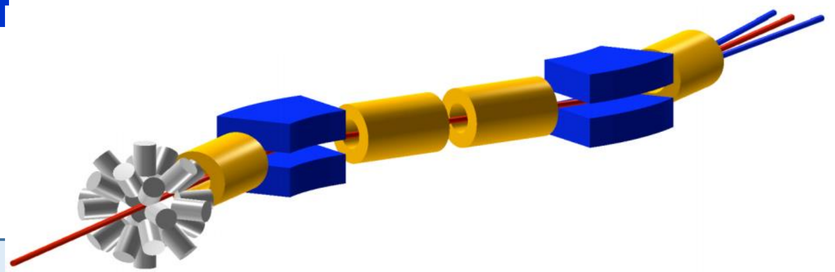
Extension to unstable “exotic” n-rich nuclei

high selectivity for dipole E1 excitation

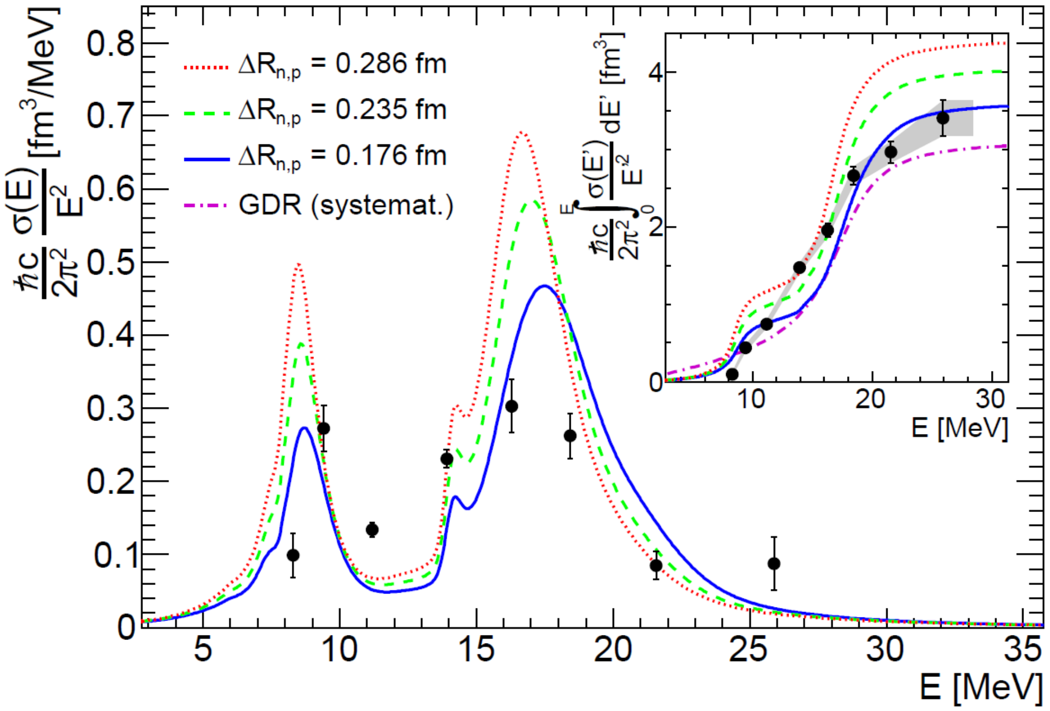


LAND-R^{3}B -AGATA at GSI

BIG RIPS-DALI2 @ RIKEN



Inverse Energy-Weighted Dipole Strength and Dipole Polarizability in ^{68}Ni



AGATA+LaBr3:Ce

GSI
400 MeV/u ^{64}Fe + ^{208}Pb (October 2012)
430 MeV/u ^{62,64}Fe + ^{197}Au (April 2014)

DALI2+LaBr$_3$:Ce

Riken
280 MeV/u ^{70}Ni + ^{197}Au (October 2014)
280 MeV/u ^{72}Ni + ^{197}Au (future)
…

Low momentum collective modes: hadronic scattering

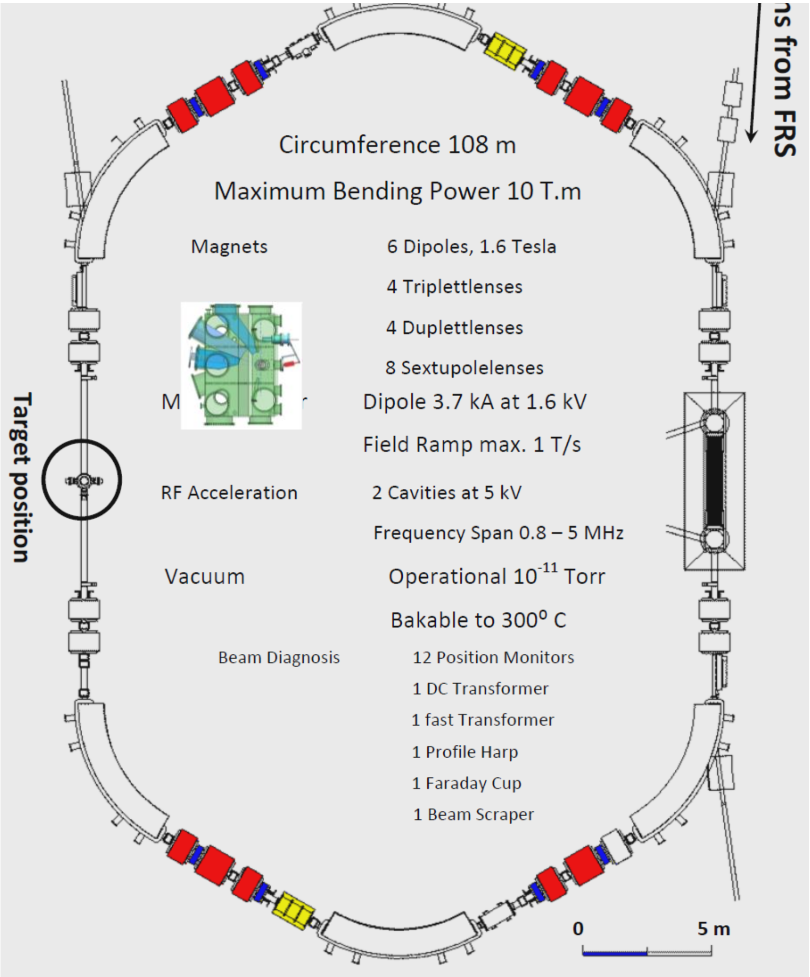
Experiments in storage rings and with active targets -

Experimental storage ring at GSI

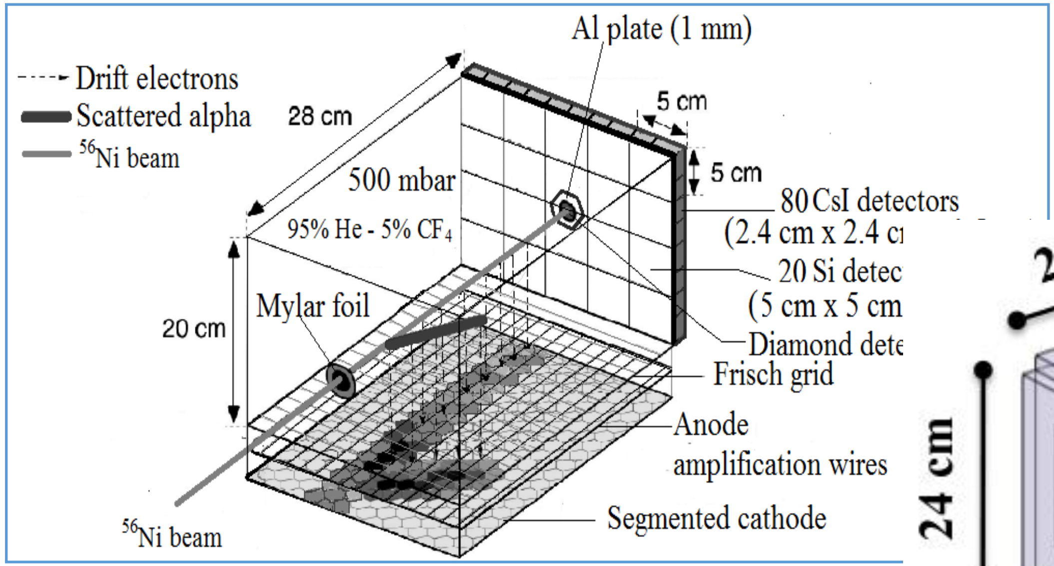
Luminosity: $10^{26} - 10^{27}$ $cm^{-2}s^{-1}$

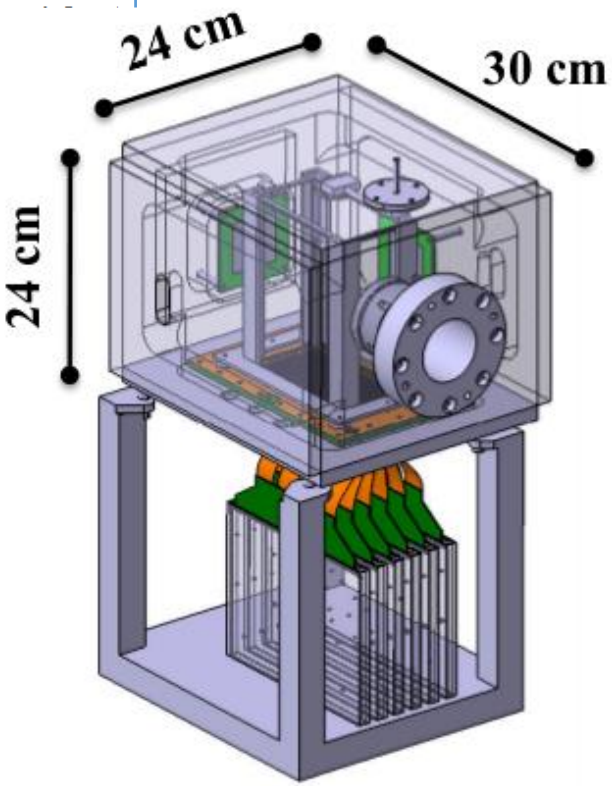
INVERSE Kinematics

Stable and unstable beams



ESR ring and EXL



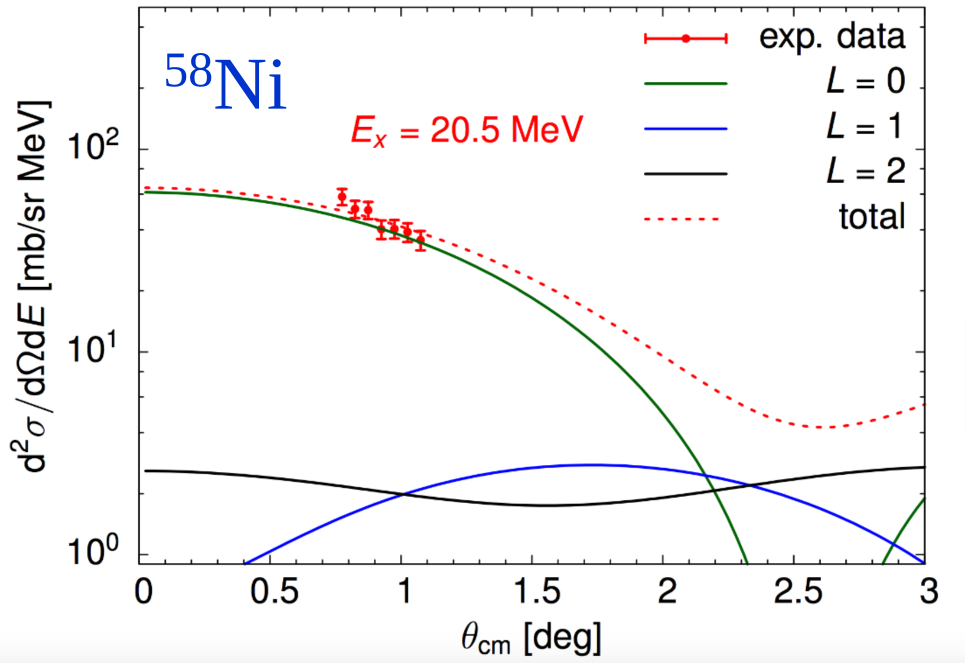


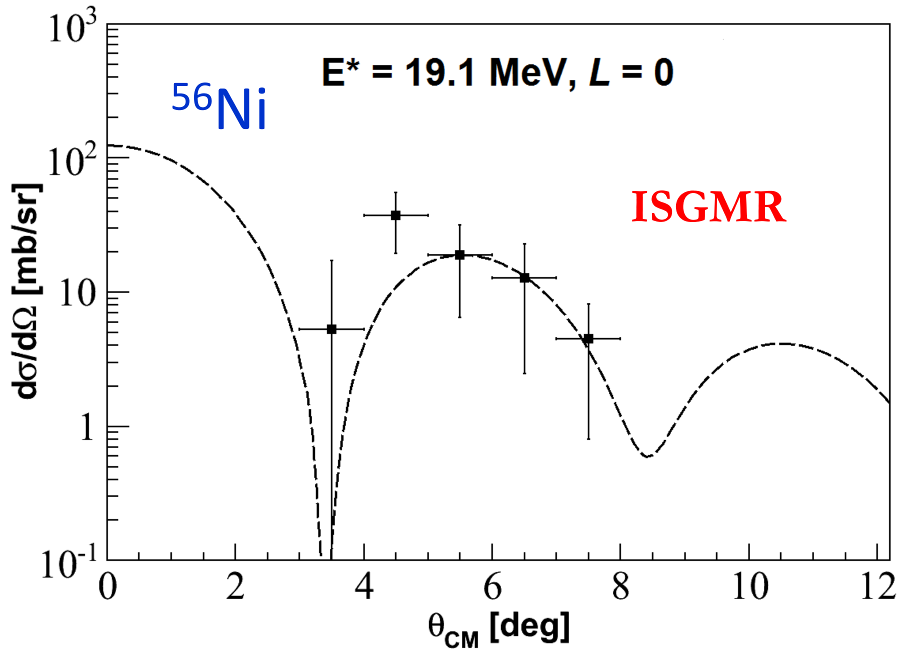
MAYA active target

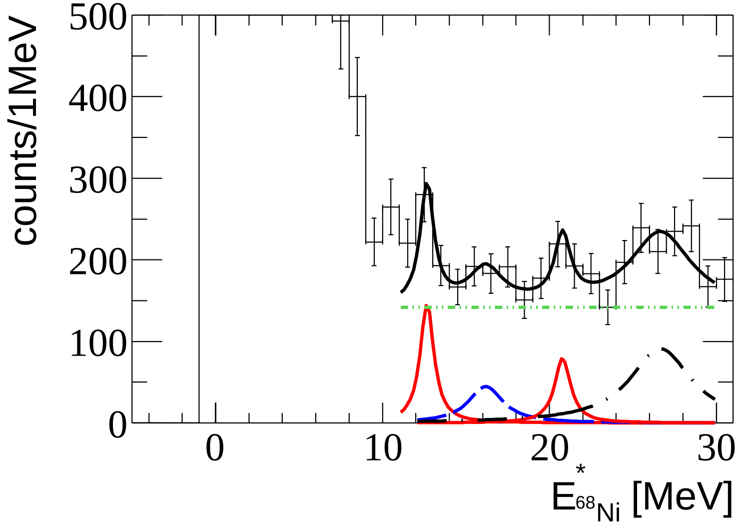
And

New generation ACTAR

Innovative experimental methods and tools







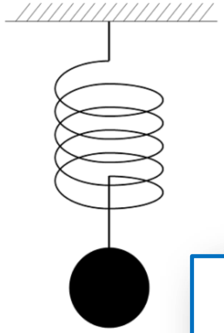
Monopole mode in ^{58}Ni and ^{56}Ni: ring vs. active target

Isovector charge-exchange modes

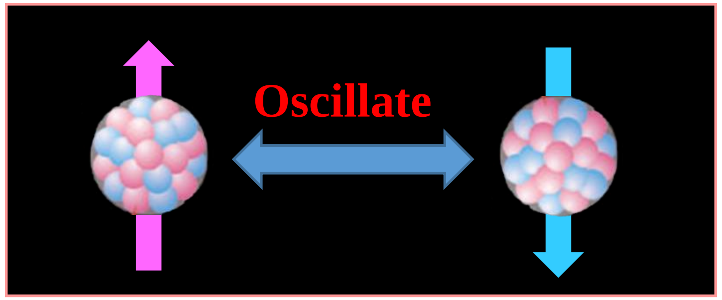
Gamow-Teller Giant Resonance

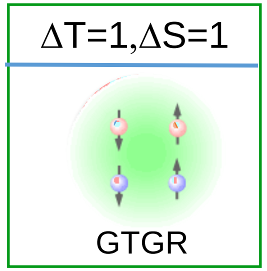
GT operator : $\sigma t^{\pm}$ ($\sigma\tau^{\pm}$)

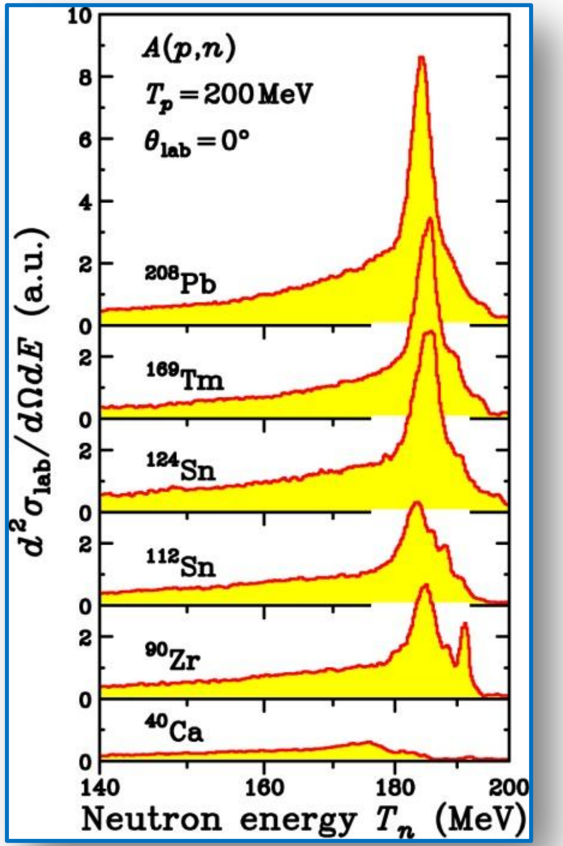
Spin   Iso-spin



$$\omega = \sqrt{\frac{k}{m}}$$





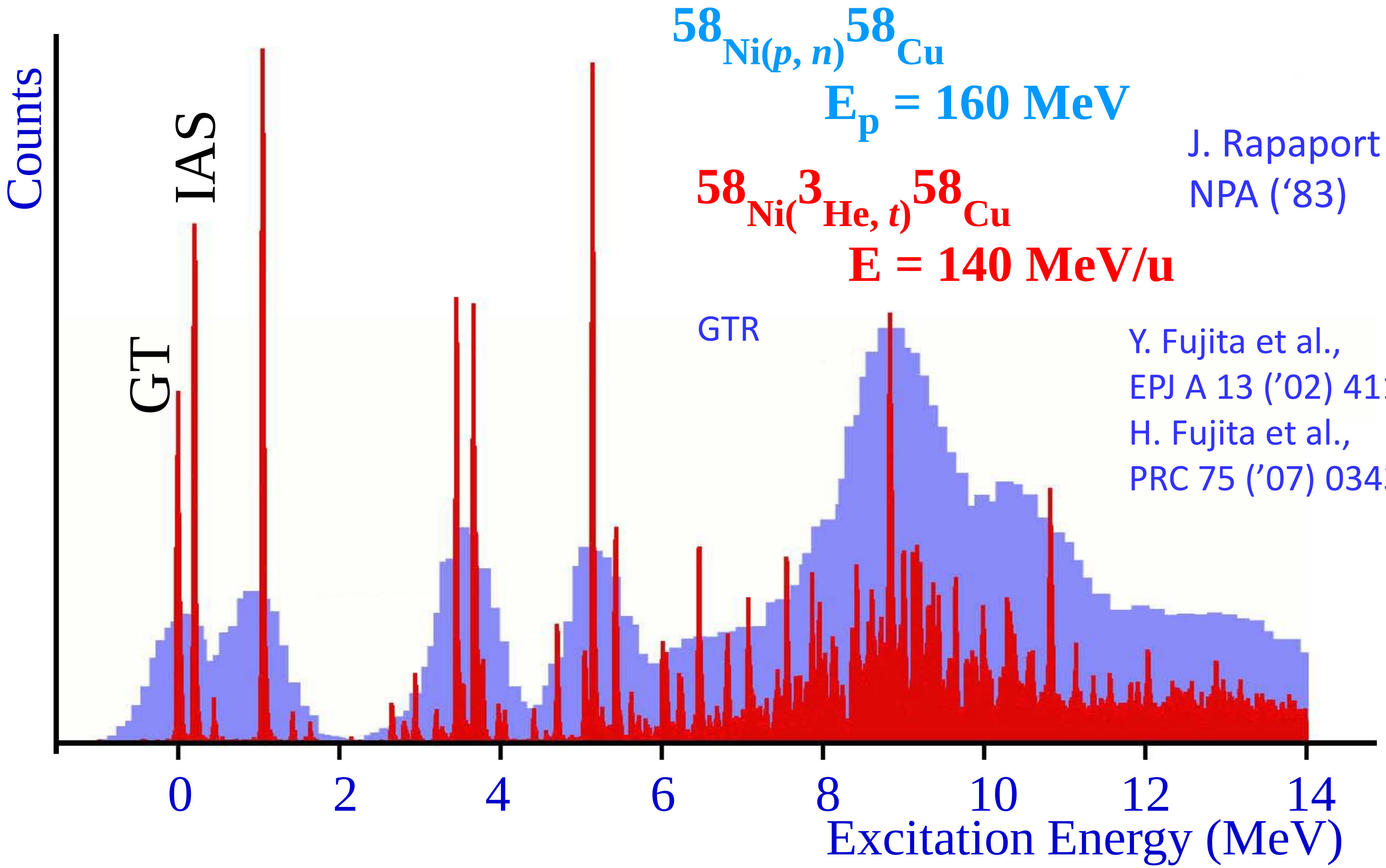


Spin: up ←→down
Isospin: p ←→ n

Purely quantum mechanical oscillation.

Comparison of (p, n) and (^{3}He,t) 0° spectra

Key : Resolution!



J. Rapaport et al.
NPA ('83)

Y. Fujita et al.,
EPJ A 13 ('02) 411.
H. Fujita et al.,
PRC 75 ('07) 034310

GT states in A=42-54 T_z=0 nuclei

Collective excitation formed by the attractive IS residual interaction

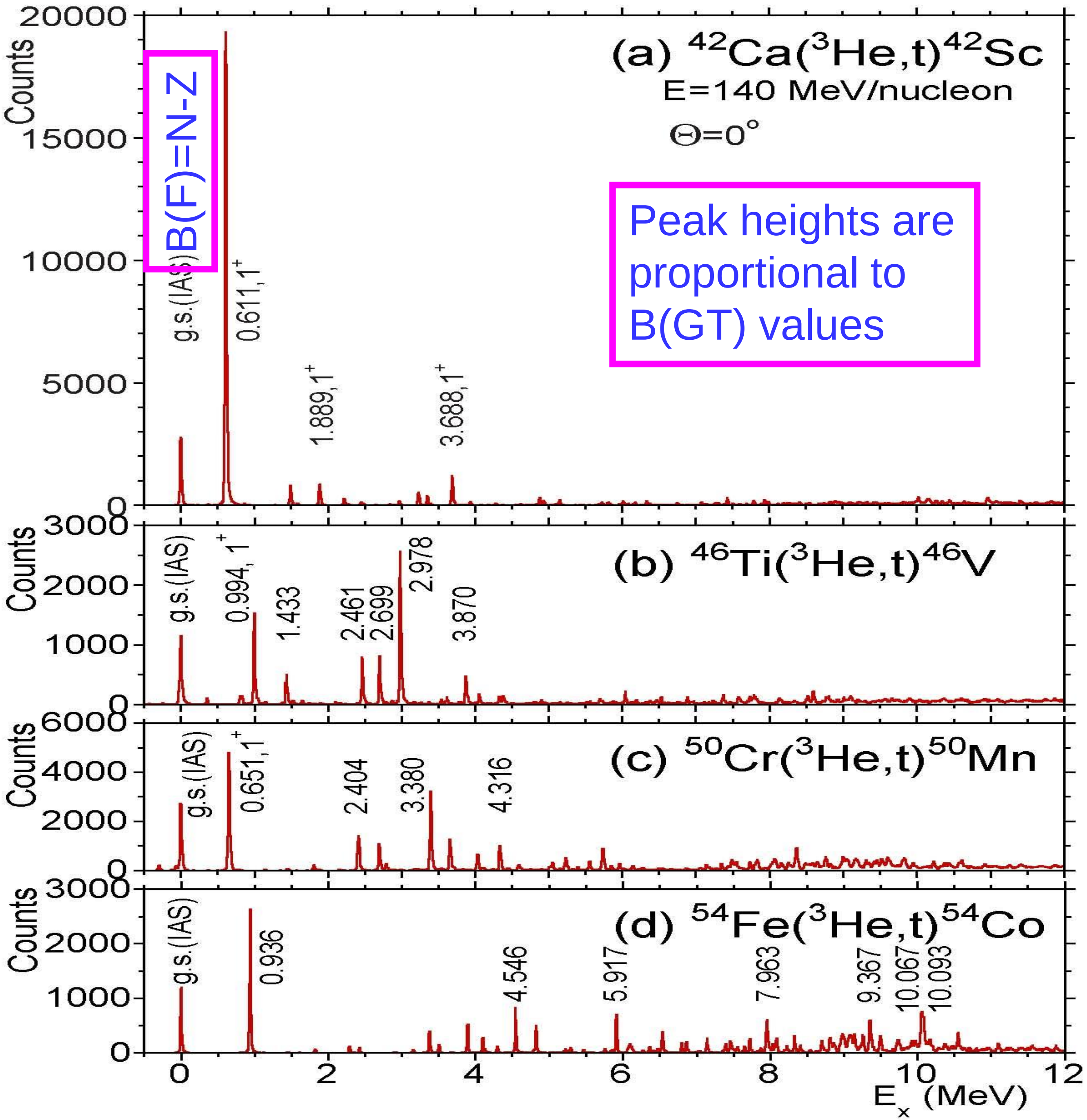
Y. Fujita et al.
PRL 2014
PRC 2015

T. Adachi et al.
PRC 2006

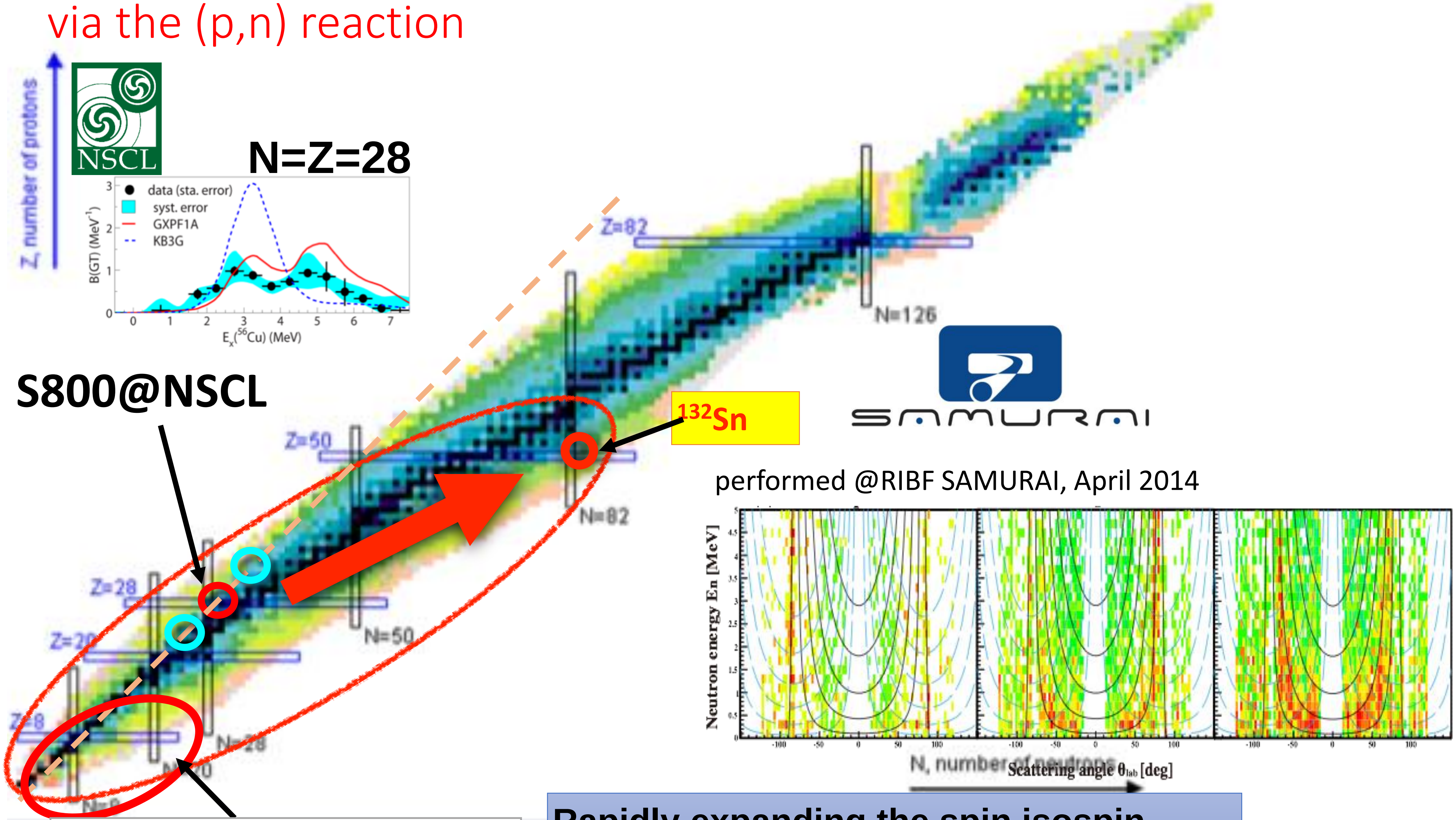
Y. Fujita et al.
PRL 2005

T. Adachi et al.
PRC 2012

Collective excitation formed by the repulsive residual interaction



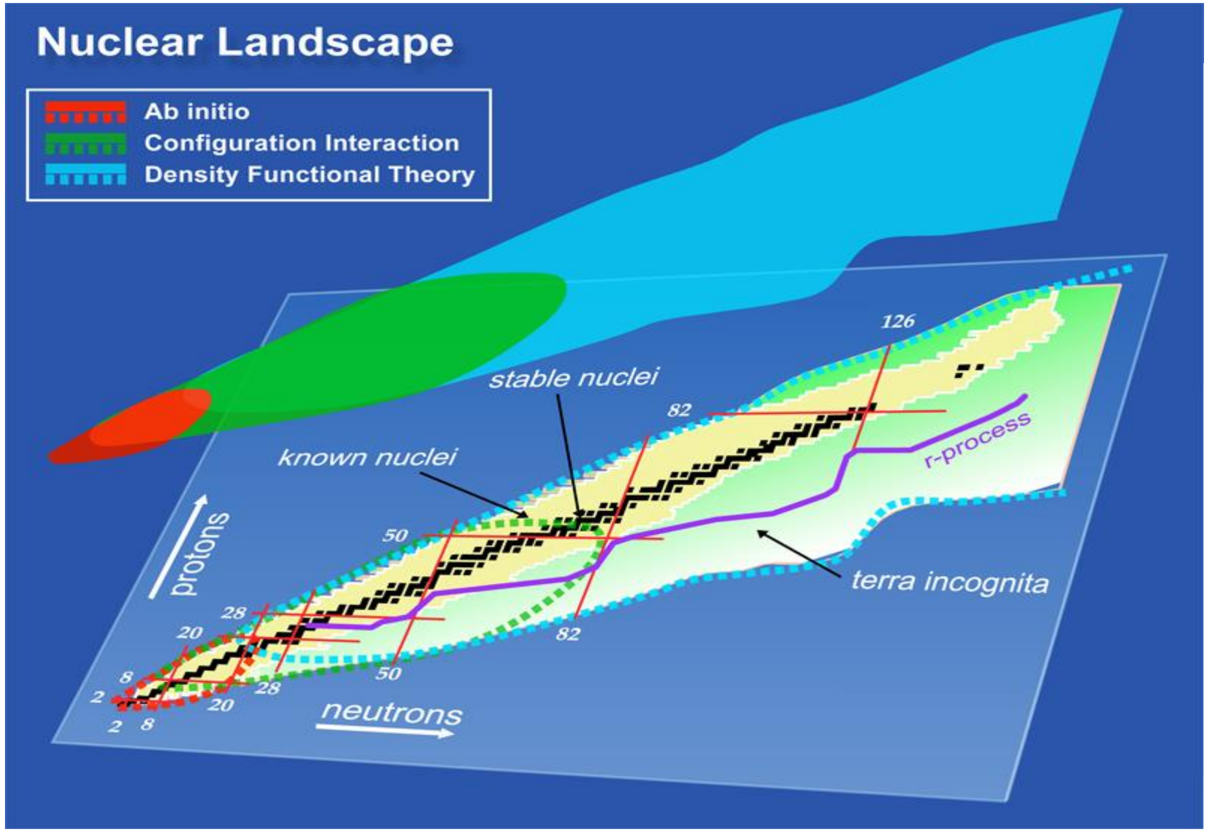
Spin-isospin responses in unstable nuclei
via the (p,n) reaction



^{12}Be, ^{8}He (SHARAQ), ^{11}Li, ^{14}Be (SAMURAI), ^{16}C(p,n) (S800)

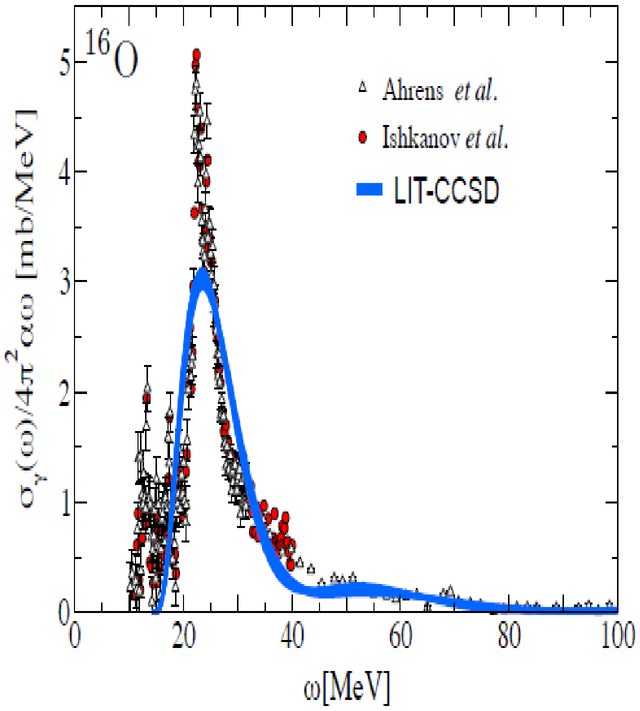
Rapidly expanding the spin isospin giant resonance studies

Theory from evolution to revolution

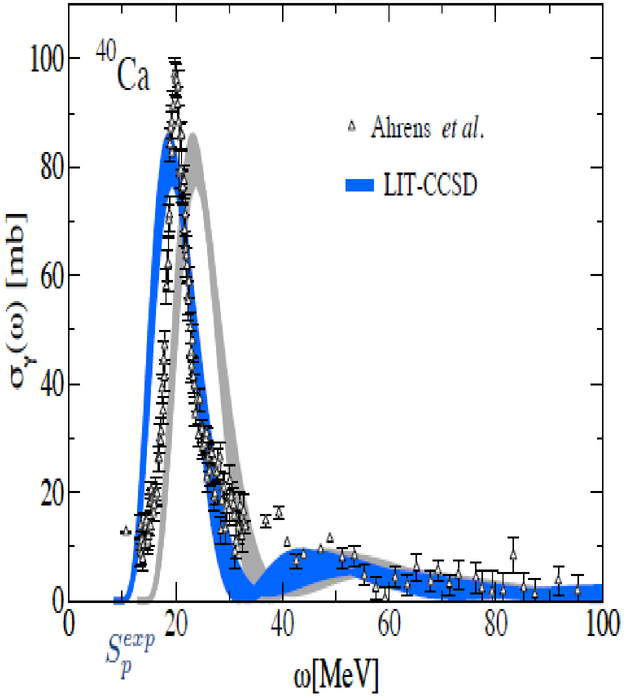


Challenge: develop new ab-initio methods that can extend the frontiers to heavier nuclei

S.B. *et al.*, PRL **111**, 122502 (2013)



S.B. *et al.*, PRC **90**, 064619 (2014)

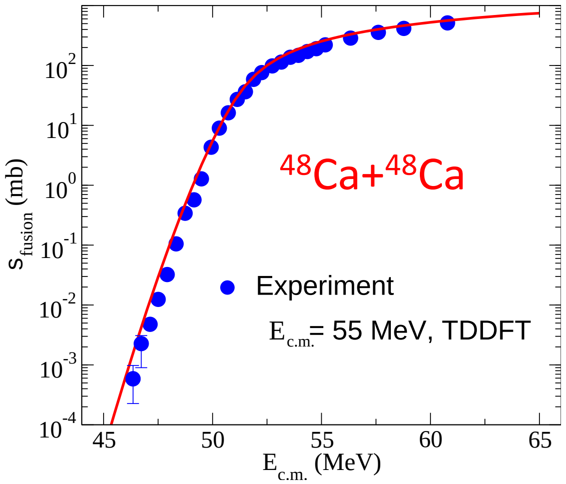


V. Nazarewicz,S.Bacca

The position of GR described form first principles for the first time

Nuclear Theory from evolution to revolution

Fusion cross sections from TDDFT
R. Keser et al., PRC 85, 044606 (2012)



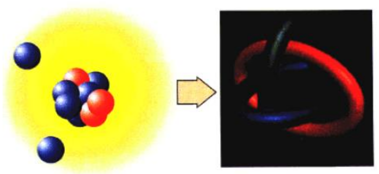
Nuclear states and Clusters

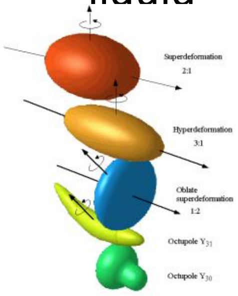
Halo

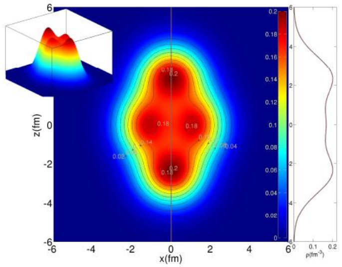
Quantum liquid

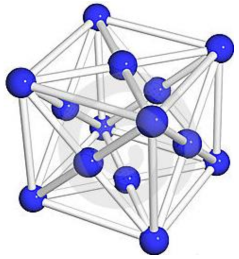
Cluster

Crystal

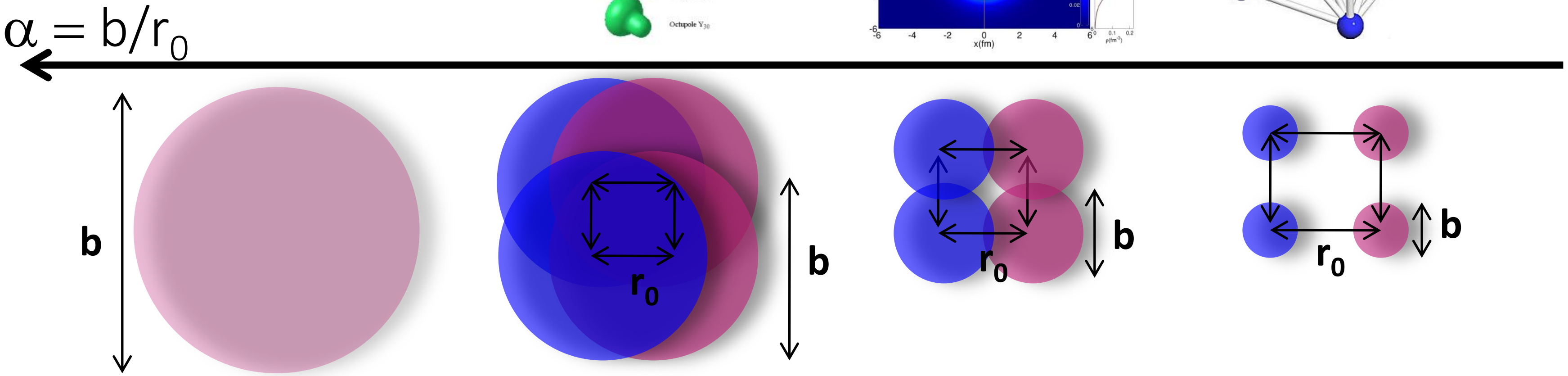






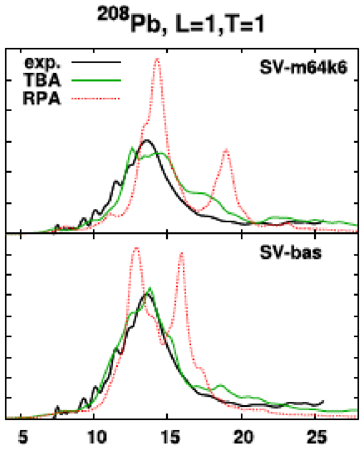


E.khan



Fully microscopic calculations beyond mean field studies are now available –No free parameters!!

Skyrme RPA+PVC
Y. Niu *et al.*, PRL 114, 142501 (2015).
Y. Niu *et al.*, PRC 90, 054328 (2014).
Skyrme TBA
N. Lyutorovich et al., PLB 749, 292 (2015)
Covariant TBA
E. Litvinova *et al.*



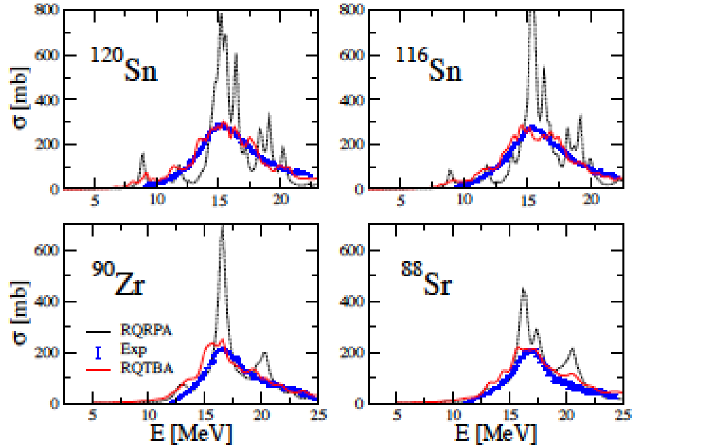
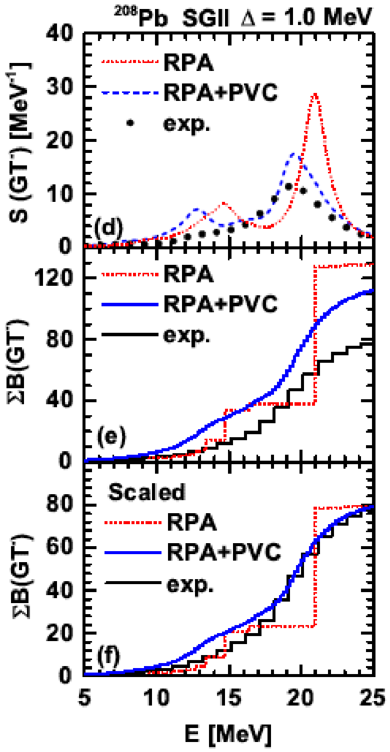
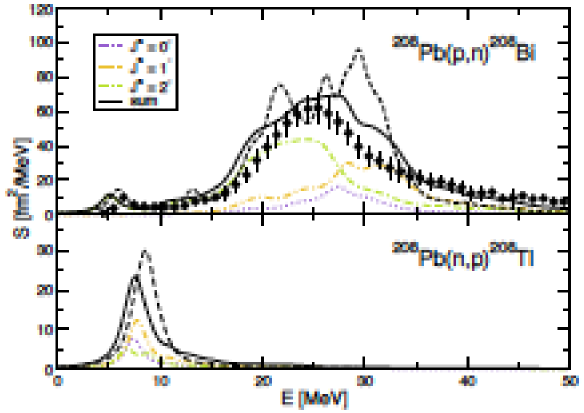
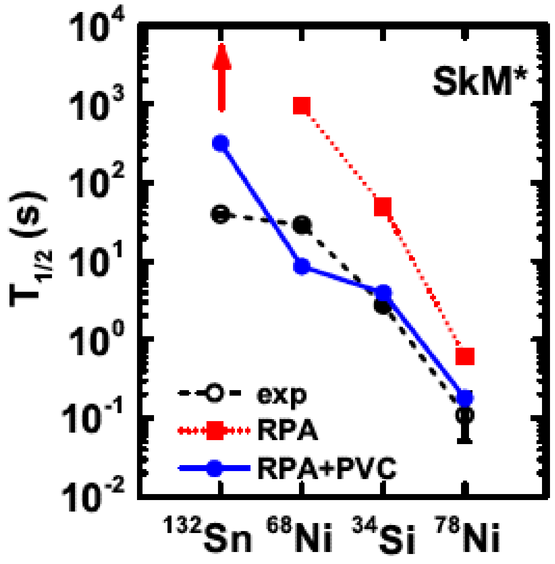


Fig. 1. Total dipole photoabsorption cross section in stable medium-mass nuclei.

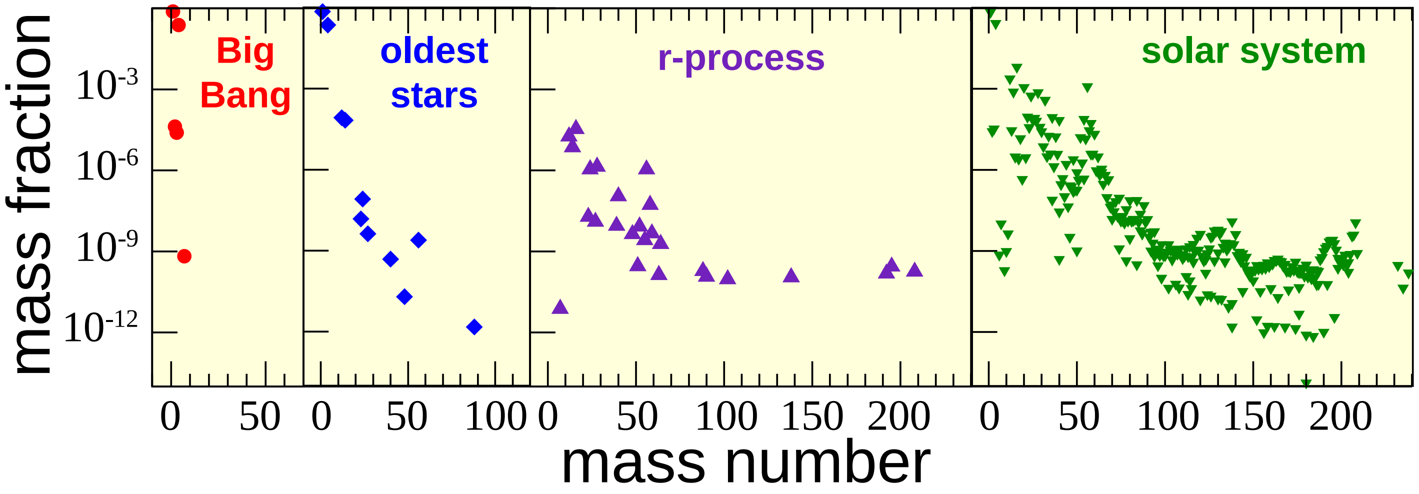


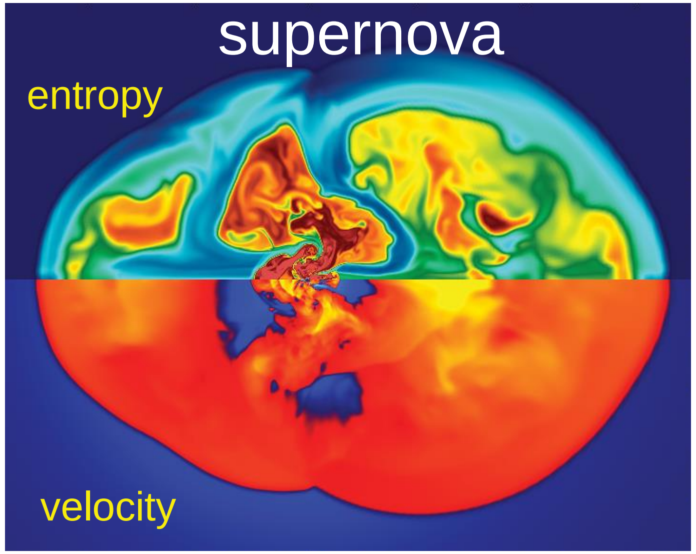
IV Dipole (above)
GTR, SDR, β-decay (below)





The origin of elements

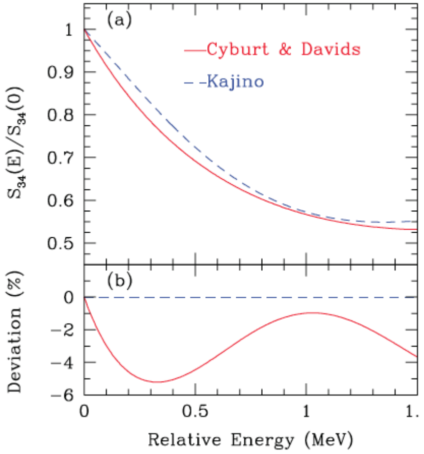




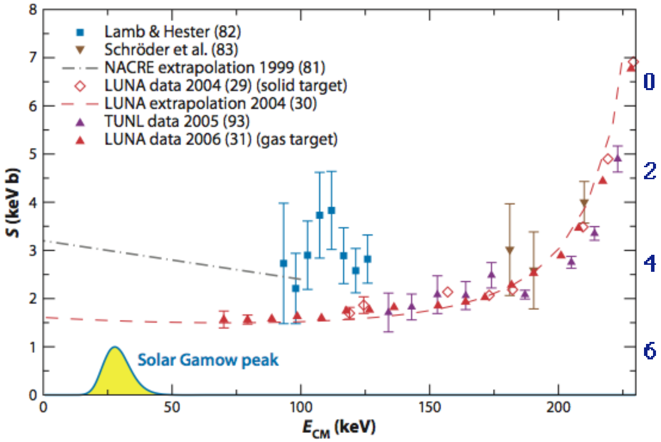
Possible sites for the r-process

Nuclear reactions and astrophysics

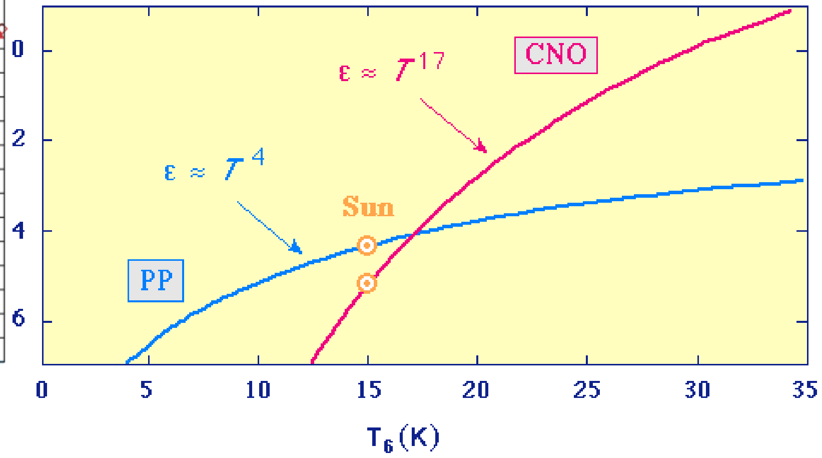
Source	Percentage Error
Diffusion coefficient of SSM	2.7%
Nuclear rates [mainly $^7Be(p,\gamma)^8B$ and $^{14}N(p,\gamma)^{15}O$]	9.9%
Neutrinos and weak interaction (mainly θ_{12})	3.2%
Other SSM input parameters	0.6%



$^3He(\alpha,\gamma)^7Be$



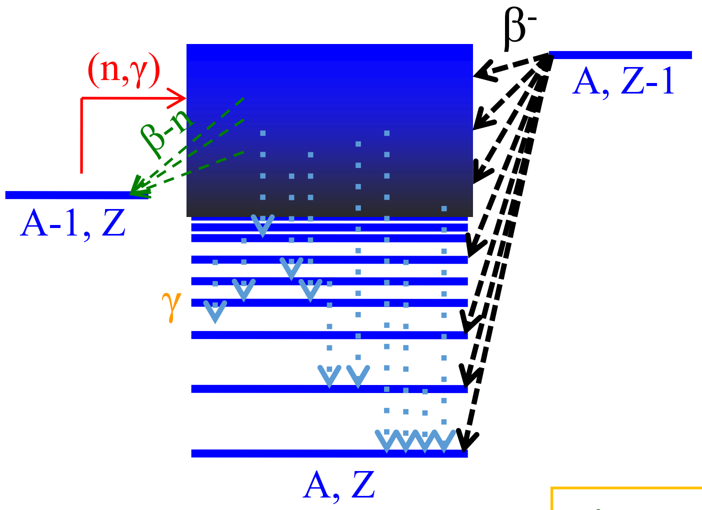
$^{14}N(p,\gamma)^{15}O$

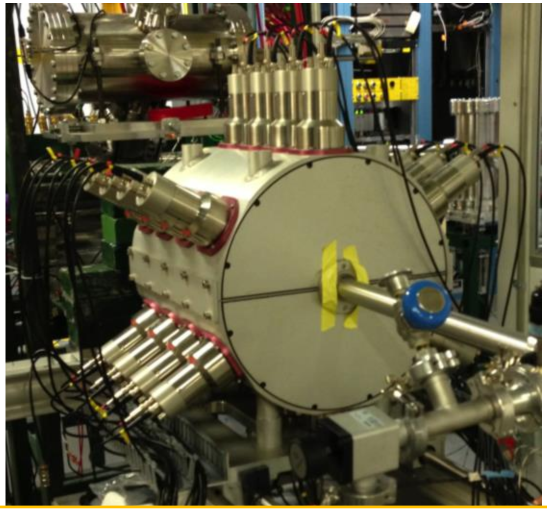


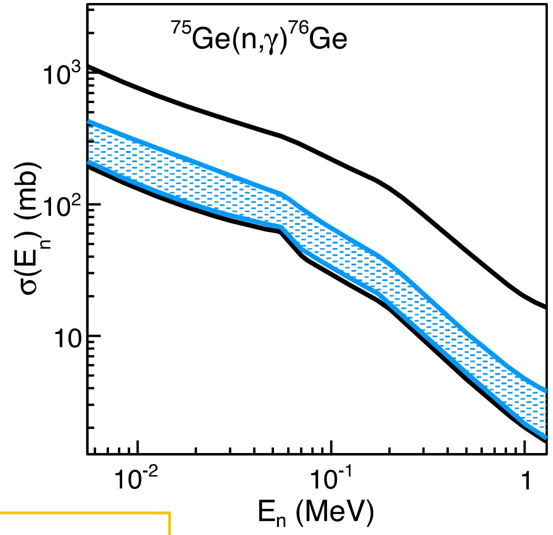
Constraining (n,γ) reaction cross sections for astrophysical applications

A. Spyrou, MSU

- New technique for constraining (n,γ) reaction rates on unstable nuclei.
- Current neutron-capture rate uncertainty in many cases is more than a factor of 100.
- Technique uses β decay to populate the same nucleus as an (n,γ) reaction and determine its level density and γ-strength function. (n,γ) cross section is calculated using these measured quantities.
- Uncertainty of extracted (n,γ) reaction rates is ~ factor of 2-3. Makes measurements on relevant short-lived nuclei possible.







The Summing NaI (SuN) detector at NSCL.

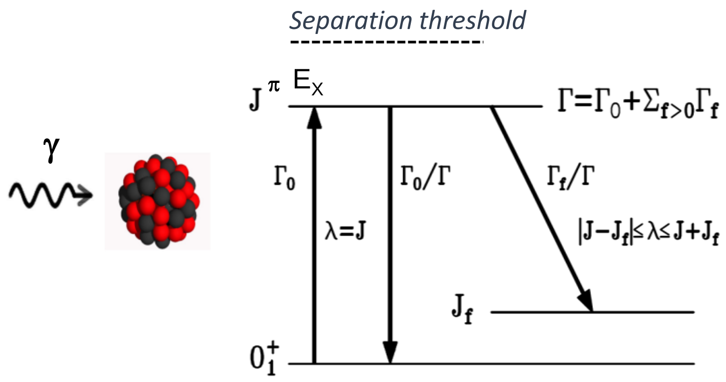
A. Spyrou et al., PRL 113, 232502 (2014)

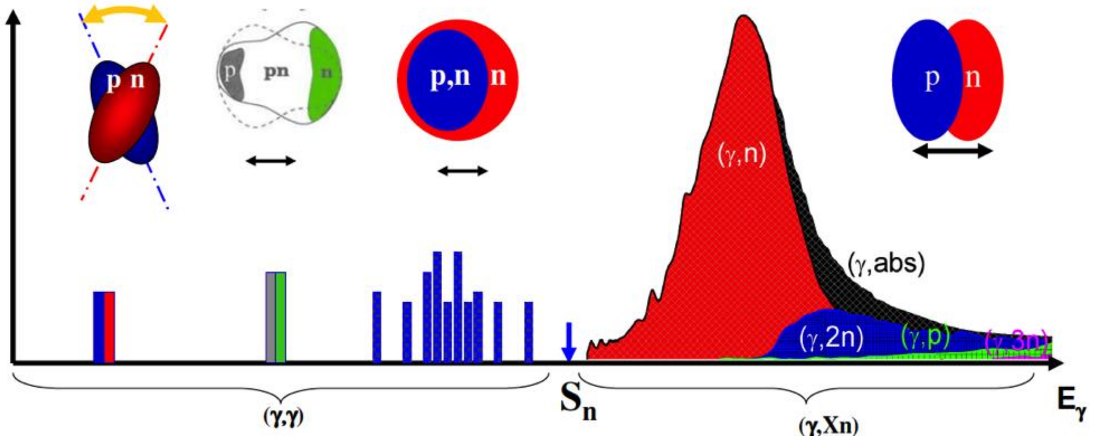
Nuclear Resonance Fluorescence (NRF)

C.A.Ur (ELI-NP)   A.Zilges (Univ of Cologne)

Special properties of ELI-NP photon beam for NRF:

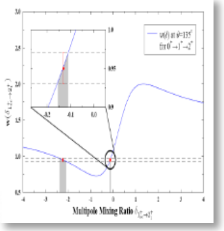
- very high intensity
- (10^4 photons/(s·eV))
- narrow bandwidth
- (down to 0.5%)
- high degree of
- polarization (> 99%)
- small beam diameter
- (mm range)
- low duty factor (100 Hz)



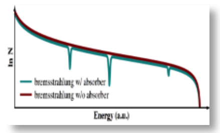


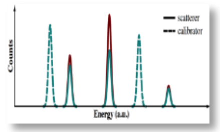
Availability frontier
(access to rare isotopes)

Sensitivity frontier
(weak channels)



Precision frontier
(high statistics)



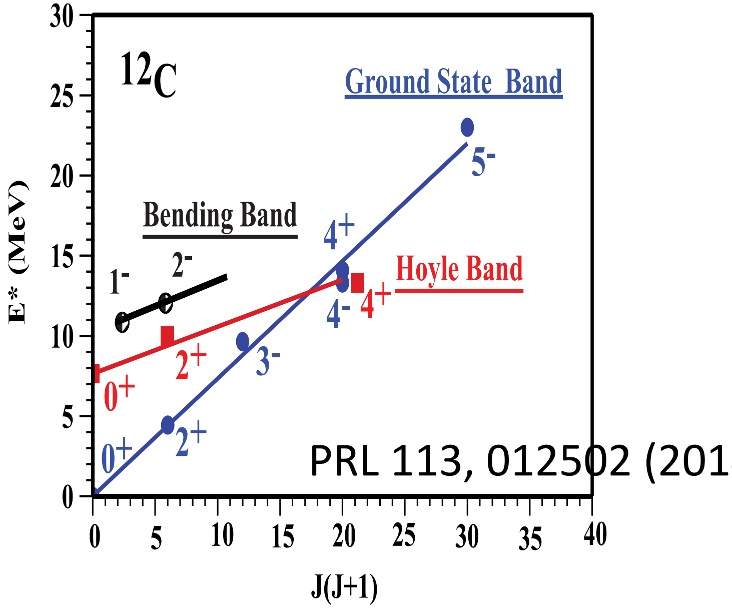


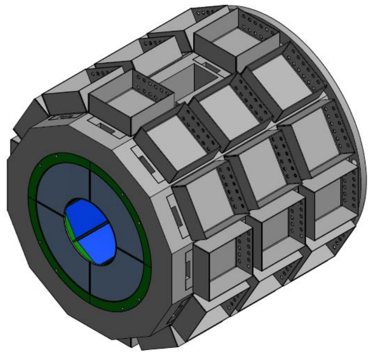
Electromagnetic Dipole Response in Nuclei

Nuclear Structure and Astrophysics @ ELI-NP

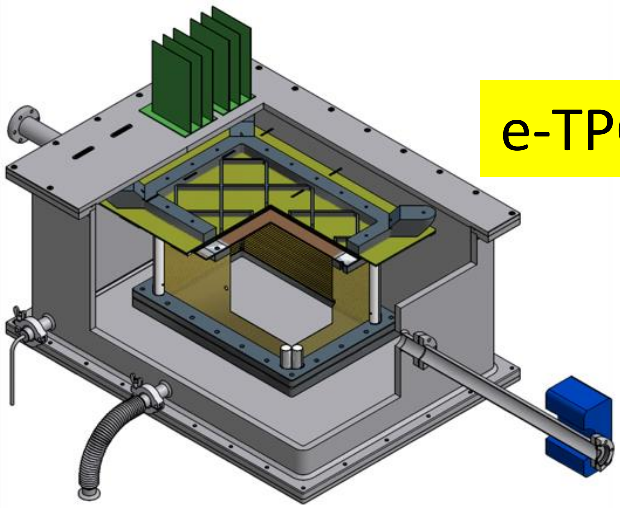
Physics case:

- Nuclear structure – clustering in light nuclei: ^{12}C, ^{16}O;
- Nuclear astrophysics: **^{16}O(γ,α)^{12}C**, ^{22}Ne(γ,α)^{18}O, ^{19}F(γ,p)^{18}O, ^{24}Mg(γ,α)^{20}Ne, the *p*-process (with the high energy γ beam in E8 experimental hall);
- International collaboration: Italy (INFN-LNS), Poland (Univ. Warsaw),USA (U. Chicago, U. Yale, U.Conn), Romania



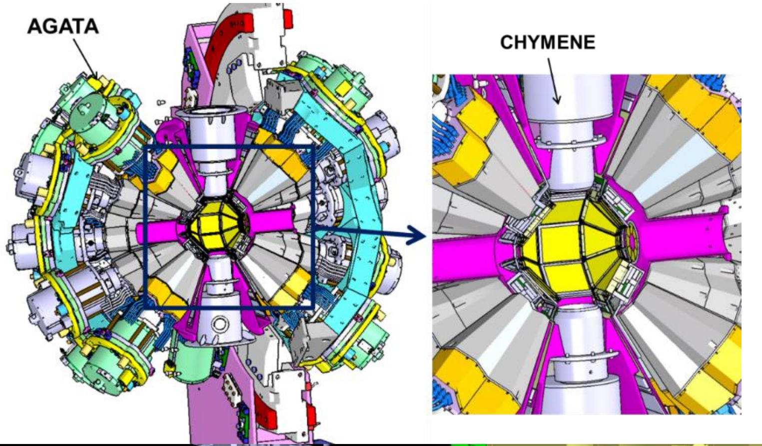


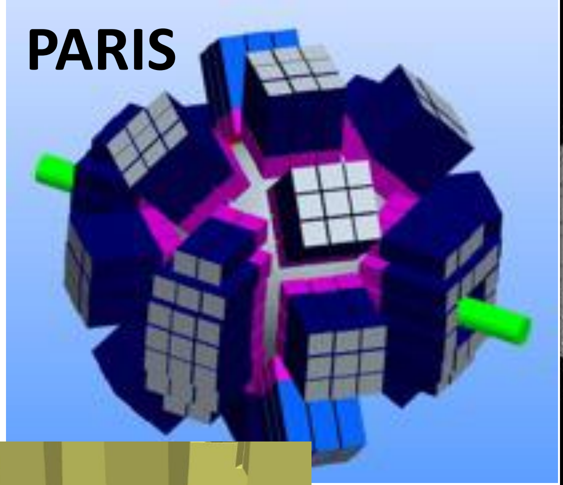
Si SSD Barrel

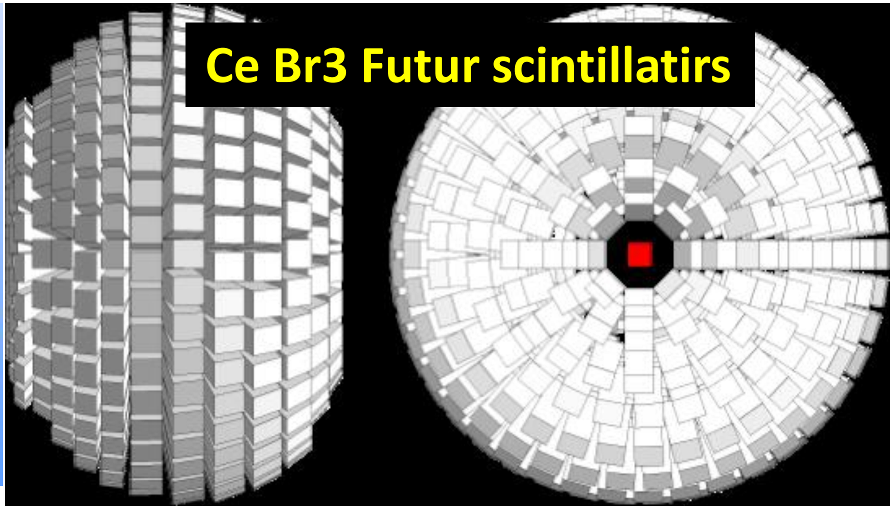


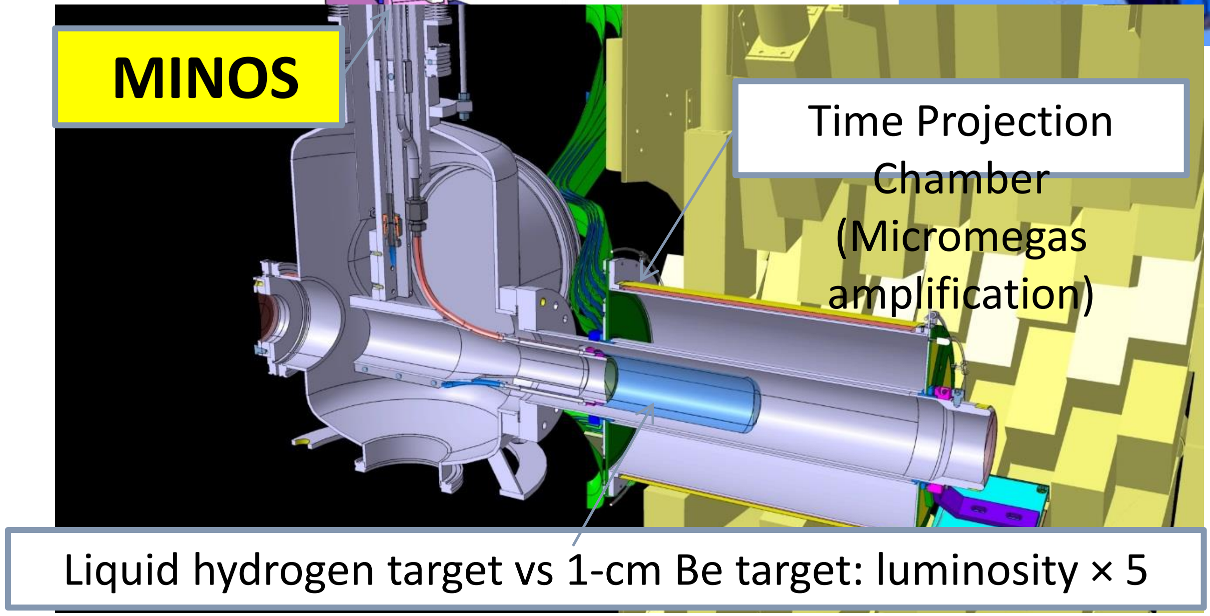
e-TPC

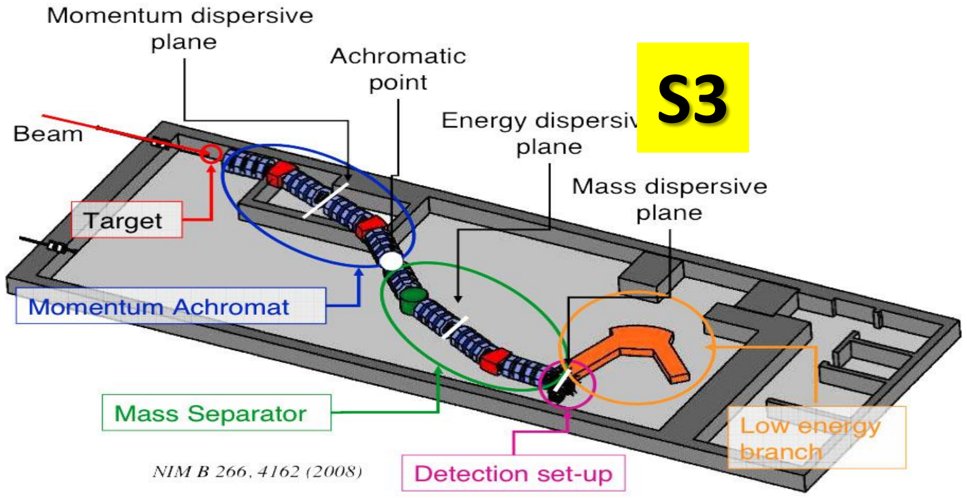
Amazing Development of innovative instruments!!


AGATA
CHYMENE


PARIS


Ce Br3 Futur scintillatirs


MINOS
Time Projection Chamber (Micromegas amplification)
Liquid hydrogen target vs 1-cm Be target: luminosity × 5


S3
Momentum dispersive plane
Achromatic point
Energy dispersiv plane
Mass dispersive plane
Beam
Target
Momentum Achromat
Mass Separator
Detection set-up
Low energy branch
NIM B 266, 4162 (2008)

TNA EU Facilities
+ ESFRI Facilities
The ISOLDE facility
CERN ISOLDE HIE-ISOLDE INTC ISCC IMS Schedule
+HE –ISOLDE is starting
Jyvaskyla
KVI
ENSAR 2
Facilities
INSTITUT DE PHYSIQUE NUCLÉAIRE ORSAY
AGENDAPARTAGÉ
IPNMAIL
INTRANETIPN
ALTO
GANIL-SP1
GANIL
GSI
INFN LNS & LNL
and SPES RIB
National Laboratory of Cyclotrons
in Poland
Heavy Ion Laboratory
University of Warsaw
Cyclotron Center Bronowice
at the Institute of Nuclear
Physics
Isochronous
cyclotron K=160
Cyclotron PROTEUS
C-235
IFIN-HH
eli
Nuclear Physics

The frontiers of nuclear science today require new tools, technologies, and accelerators. The quest is to understand the origin, evolution, and structure of the visible matter in the universe. Photons ,Stable and Radioactive Ion Beams are central to this quest worldwide.

(associated to impressive innovation in instrumentation)

Backed by a strong development in nuclear theory

The 5th international conference on
"COLLECTIVE MOTION IN NUCLEI
UNDER EXTREME CONDITIONS"

COMEX5

Crakow September 13-18,2015

Thanks to all contributors to this outlook talk
A.Bracco, B. Balantekin,K. Boretsky, R. Casten, G.Colo,J.Dobaczweski, B.Fornal, D.Freekers, M.Itkis, M.N. Harakeh, V. Nazarewicz,E.Khan, N.Kalantar, A. Krasznahorkay, Ch.Mazzocchi,M. Sasano, D. Savran,N. Shimizu,A, Spyrou,A.Tamii, M.Tataki, C.A. Ur, M.Vandebrouck, R.Zegers, A.Zilges+ ………………..

Dziękujemy za cierpliwość

See you in 2018 at COMEX6 -Capetown

END