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

COMEX5

Neutron-skin thickness and symmetry-energy constrains from the study of the anti-analog giant dipole resonance

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Excitation of the Isovector Giant Dipole Resonance by Inelastic α Scattering and the Neutron Skin of Nuclei

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(Received 2 November 1990)

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Excitation of Isovector Spin-Dipole Resonances and Neutron Skin of Nuclei

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Physics Letters B 720 (2013) 428–432

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Anti-analog giant dipole resonances and the neutron skin of nuclei

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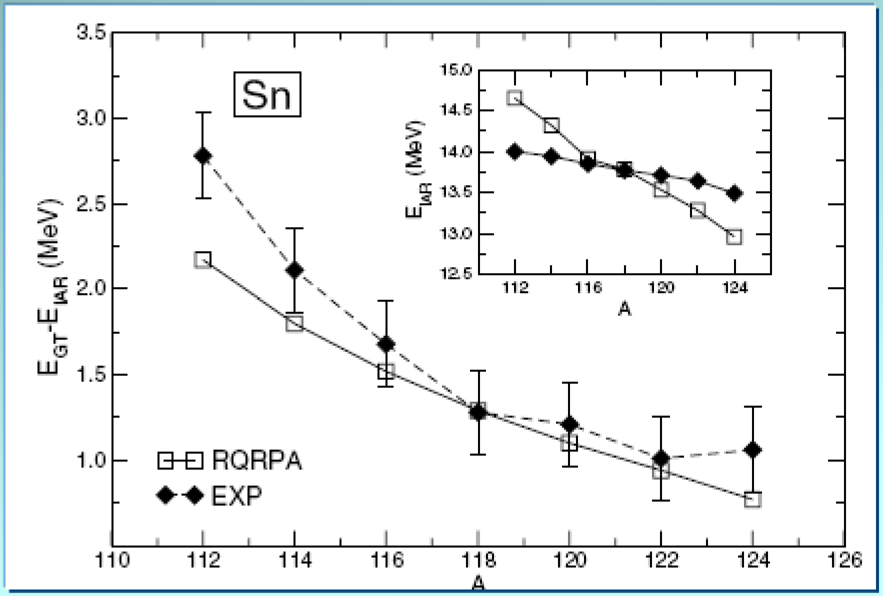
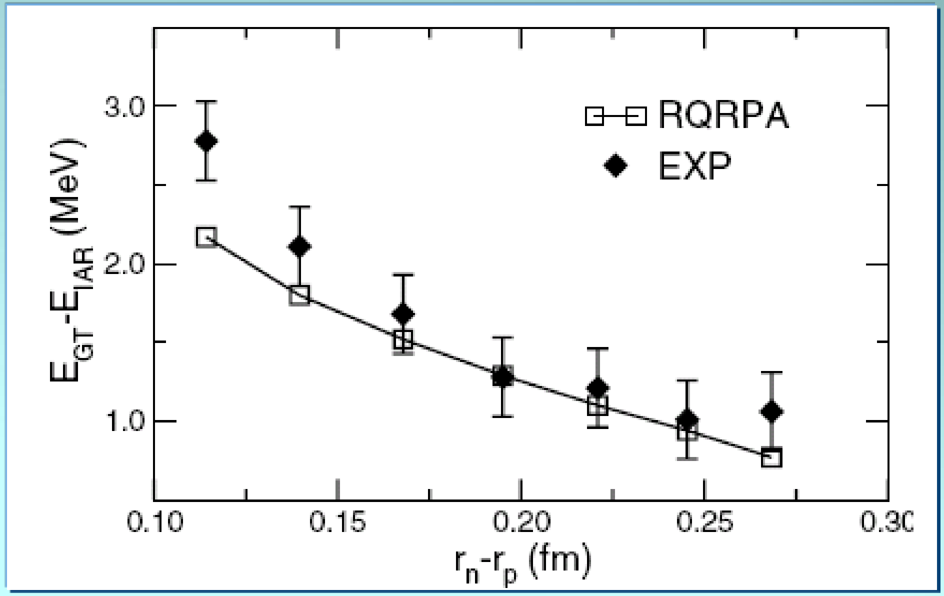
Spin-Isospin Resonances and the Neutron Skin of Nuclei

(D. Vretenar et al., PRL 91 (2003) 262502.)

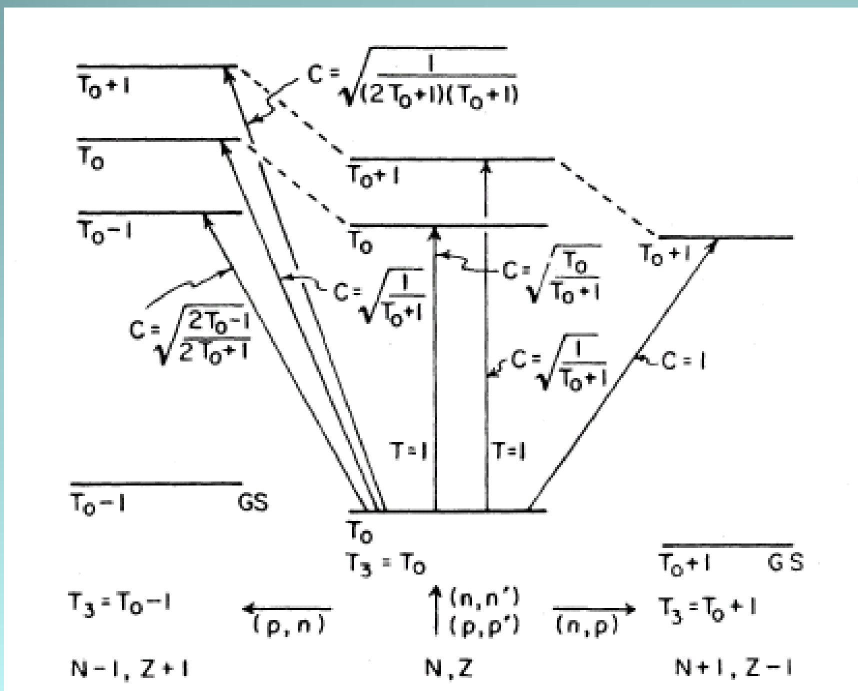
Excitation in charge-exchange reactions :(^{3}He,t), (p,n)



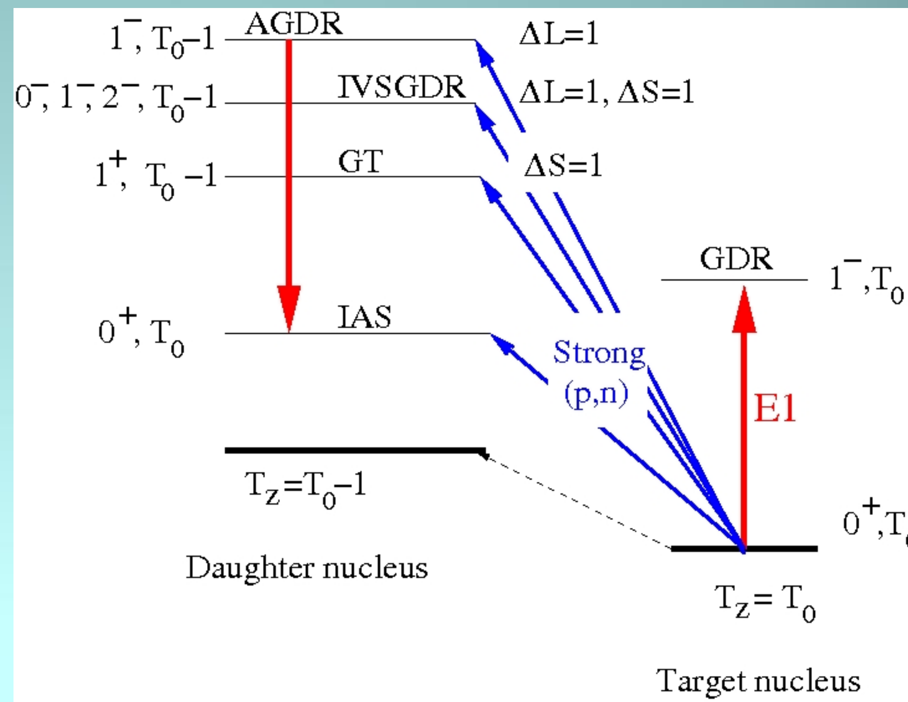


The Anti-analog Giant Dipole Resonance (AGDR): a new way to study the neutron-skin

(A. Krasznahorkay et al., Phys. Lett. B720 (2013) 428)

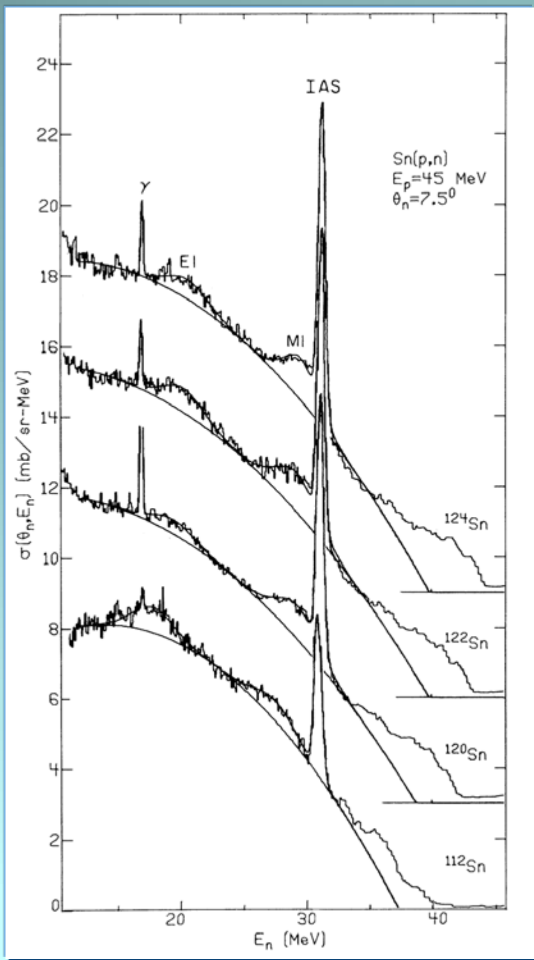


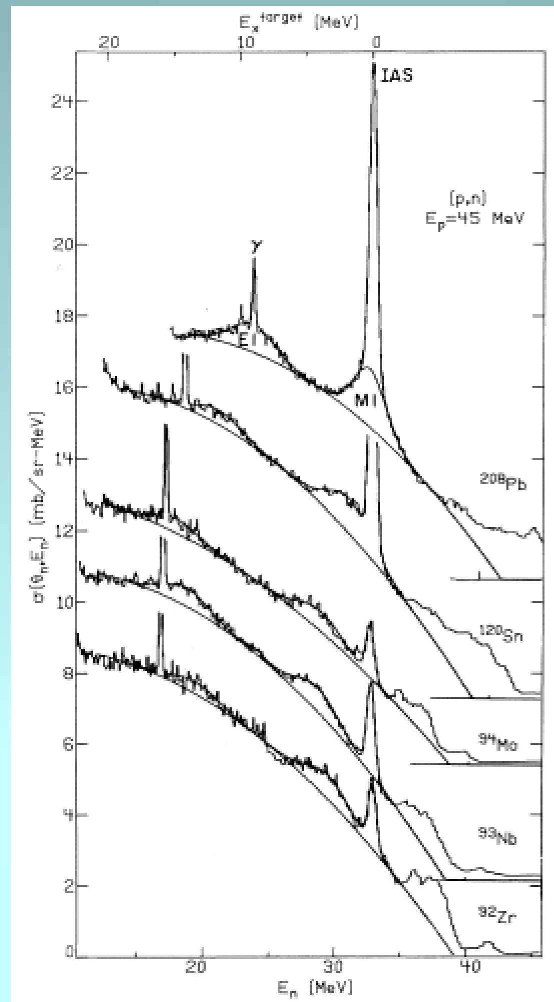
Isospin Clebsch-Gordan coefficients for (p,n) and (n,p) reactions (F. Osterfeld, Rev. Mod. Phys. , 64, (1992), 491)

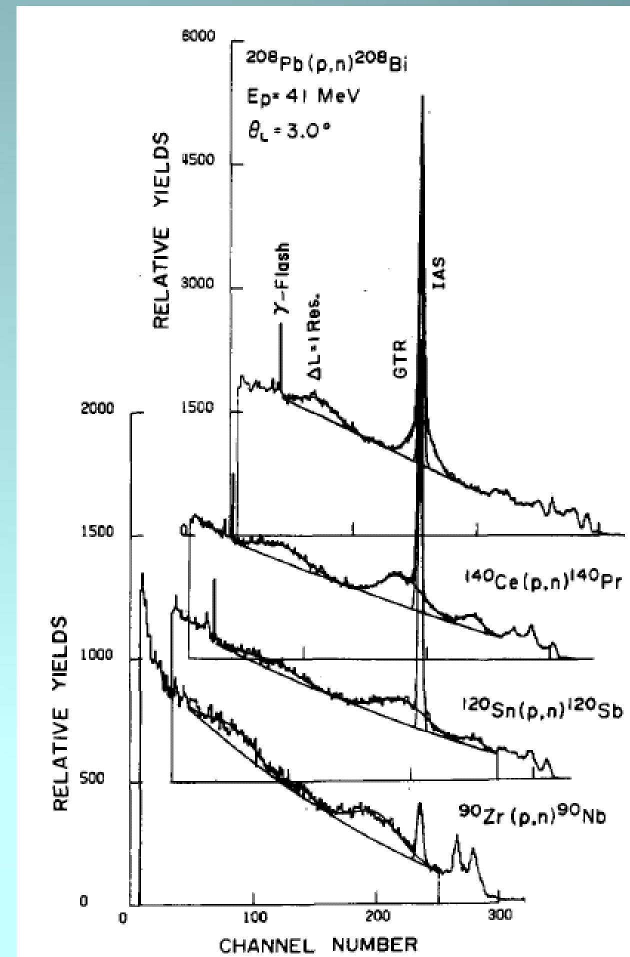


Strongly favored giant resonances excited in (p,n) reactions

The Anti-analog Giant Dipole Resonance (AGDR): previous experimental results



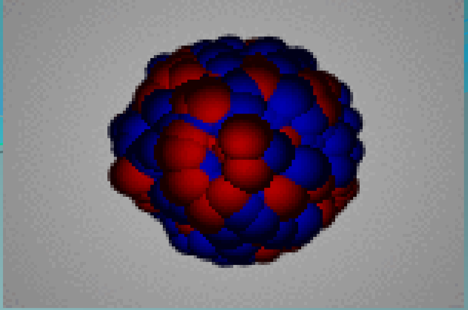


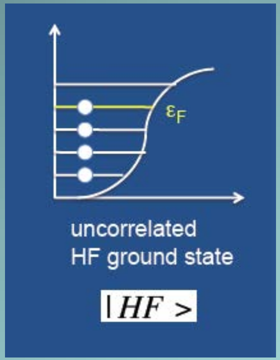


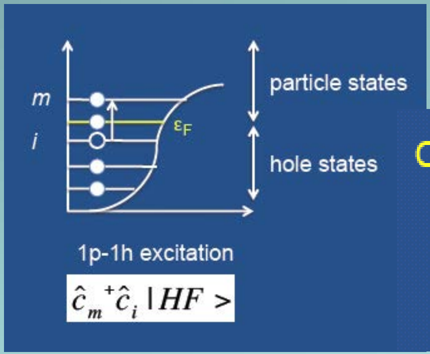
Sterrenburg et al., Phys. Rev. Lett. 45, 1839 (1980). L= 7 m.

S. Nishihara et al., Phys. Lett. B 160, 369 (1985). L= 18 m.

Theoretical results





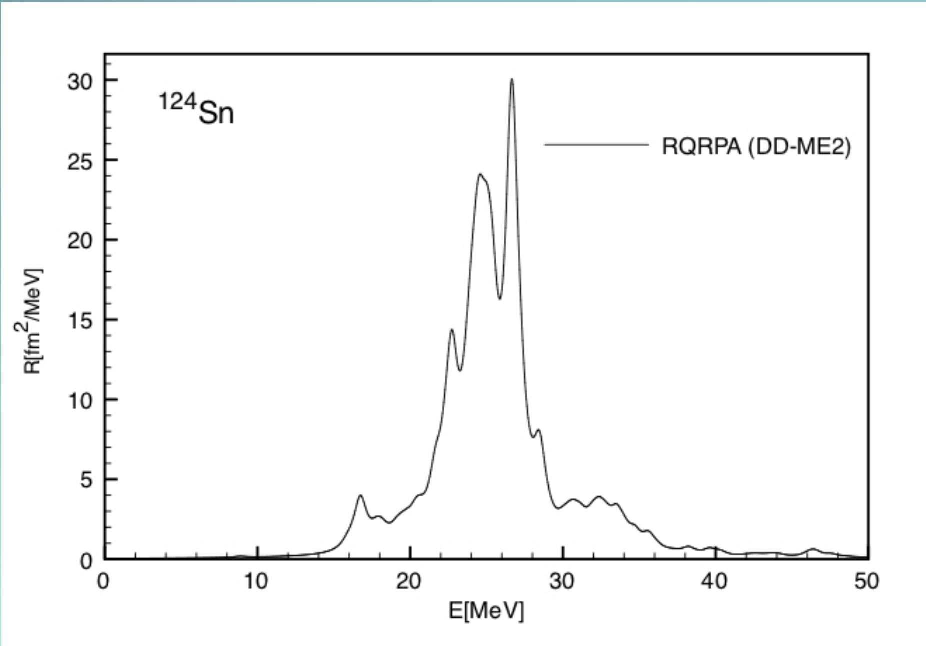


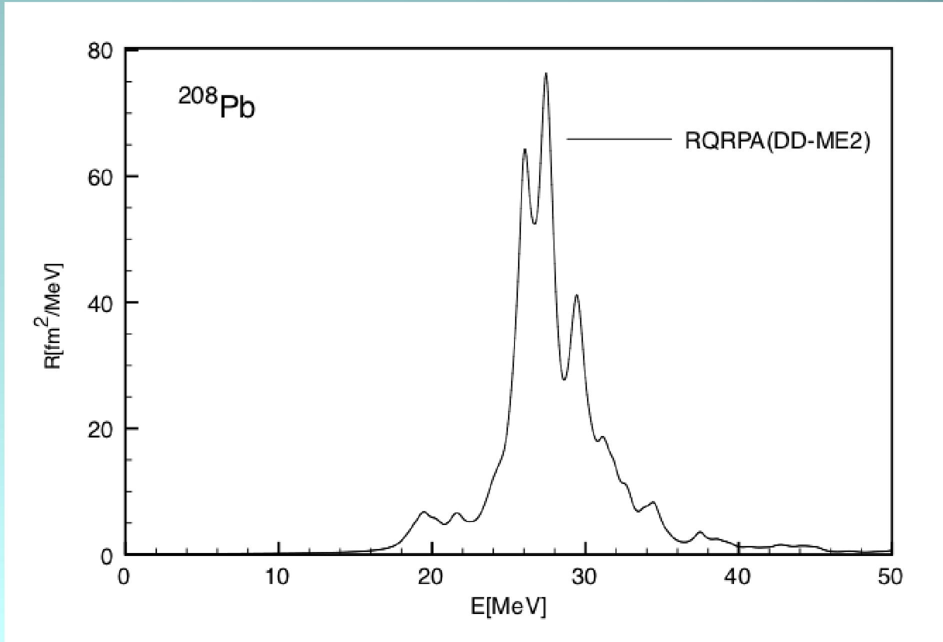
Collective vibration = coherent superposition of large number of p-h excitations

$$|\nu_{RPA}> = \sum_{m,i} A^{\nu}_{mi}(\hat{c}_m^{+}\hat{c}_i)\,|HF>$$

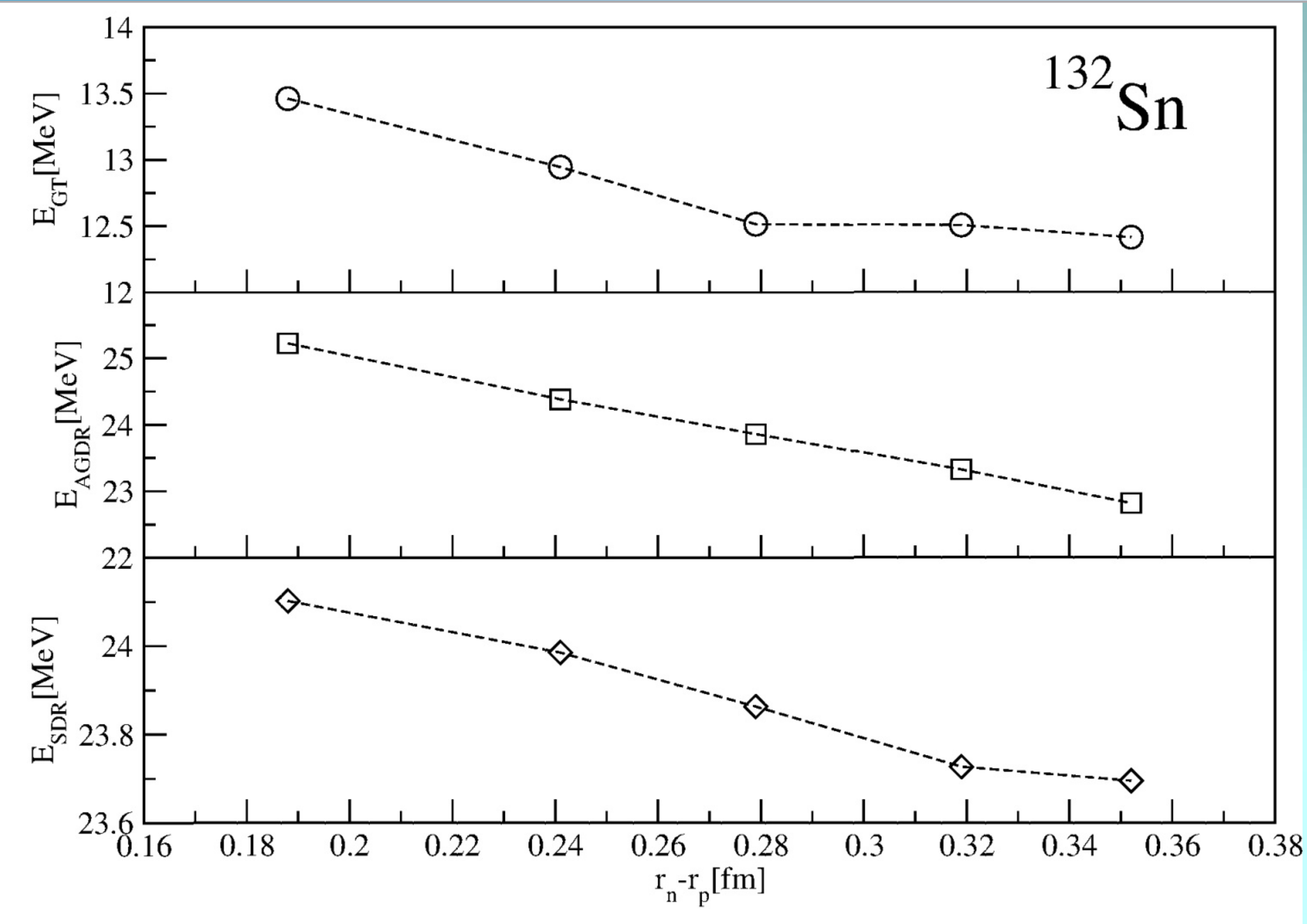
- Fully self-consistent relativistic proton-neutron quasiparticle random phase approximation (pn-RQRPA) based on the Relativistic Hartree-Bogoliubov model (RHB) [Vretenar & Paar].
- density-dependent meson-exchange (DD-ME) interactions

AGDR strength distributions





The energy of the GT, AGDR and SDR relative to the IAS as a function of the neutron-skin thickness

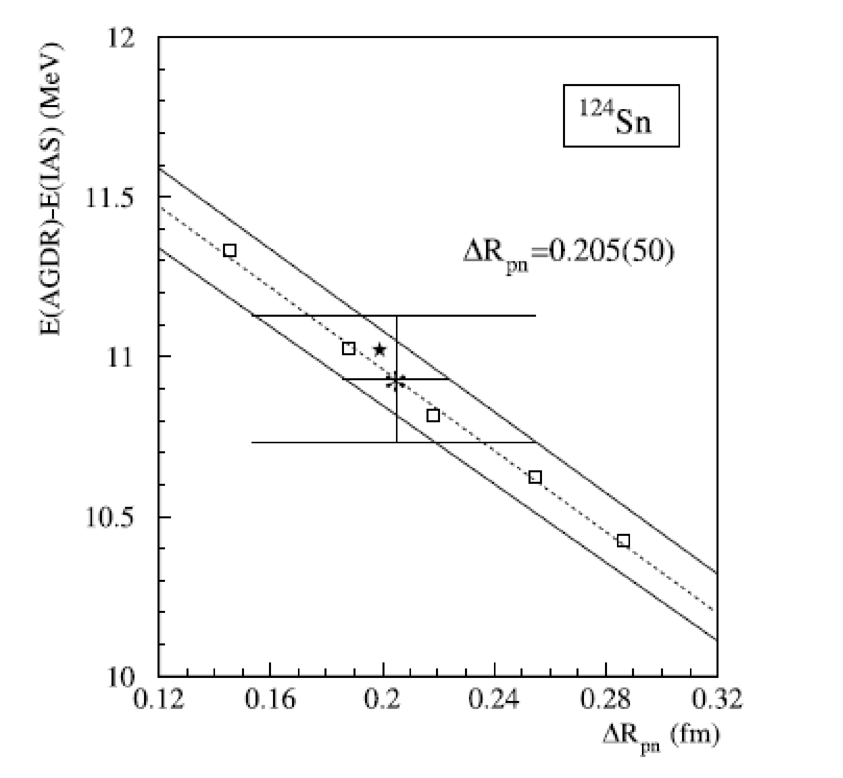


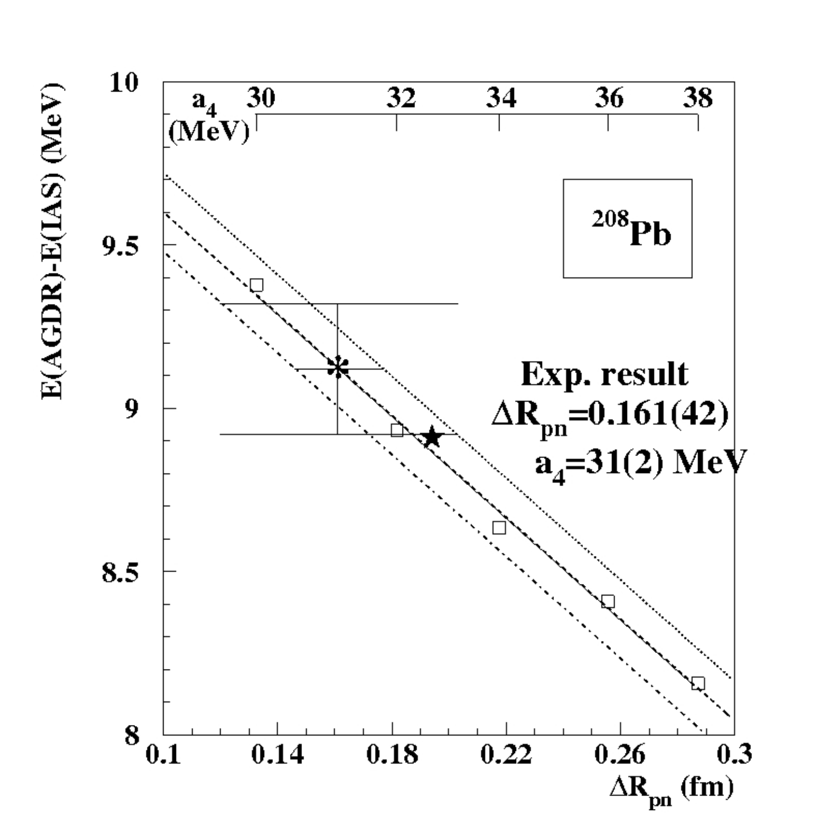
ΔE=1 MeV

ΔE=2 MeV

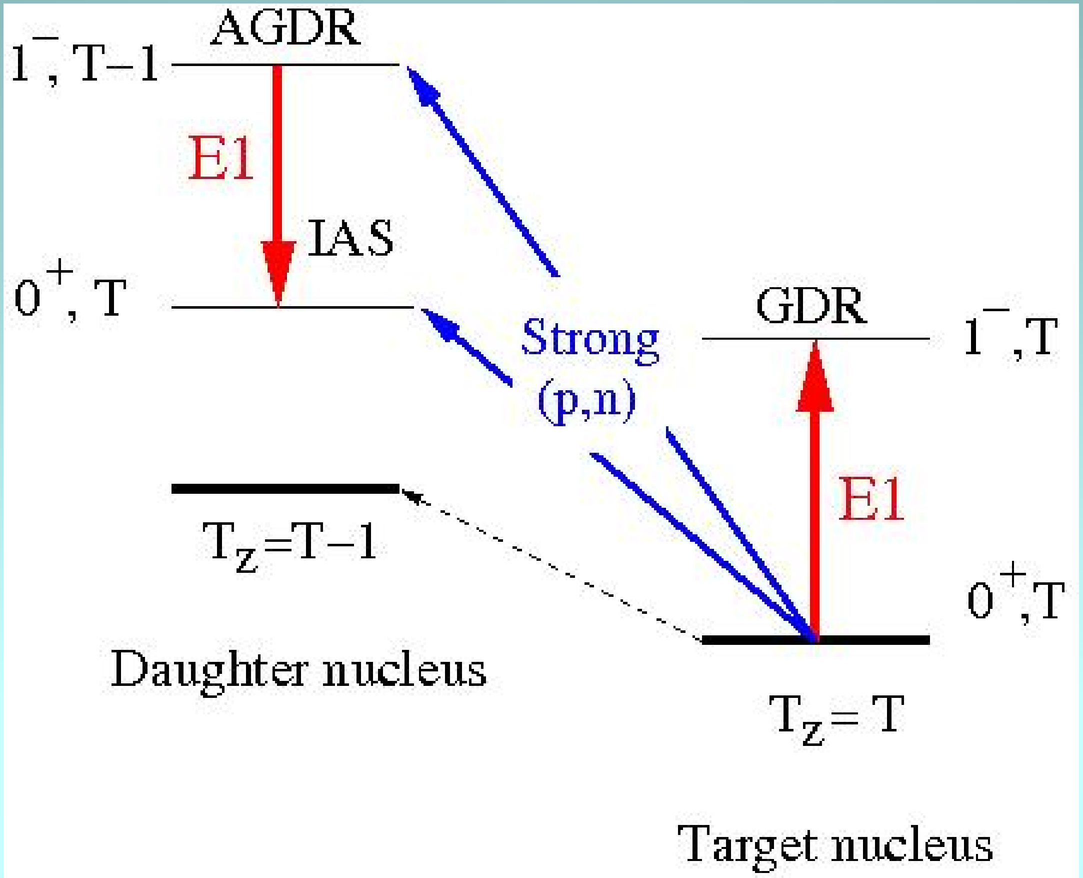
ΔE=0.4 MeV

The theoretical values E(AGDR)–E(IAS) are plotted as a function of the corresponding ground-state neutron skin thickness R_{pn}, and compared to the experimental value E(AGDR) – E(IAS).



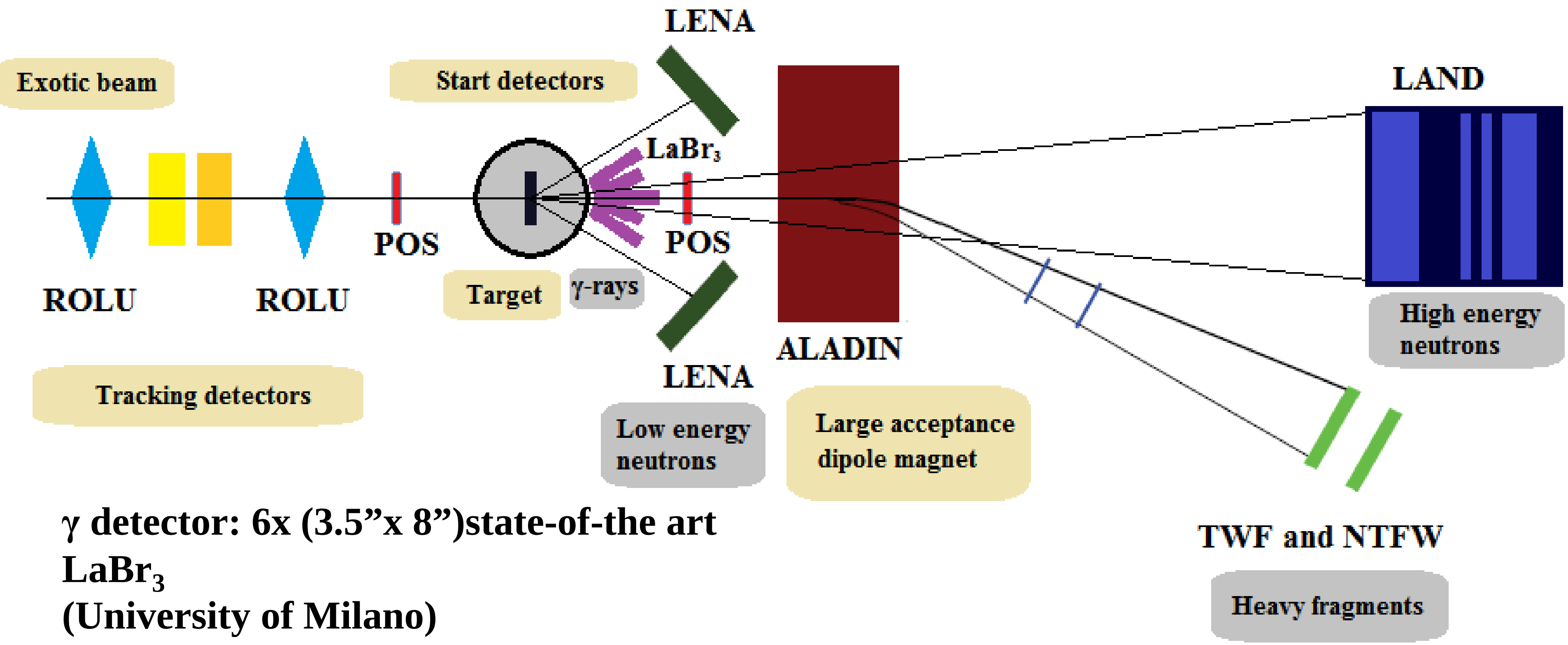


Excitation and γ-decay of the AGDR



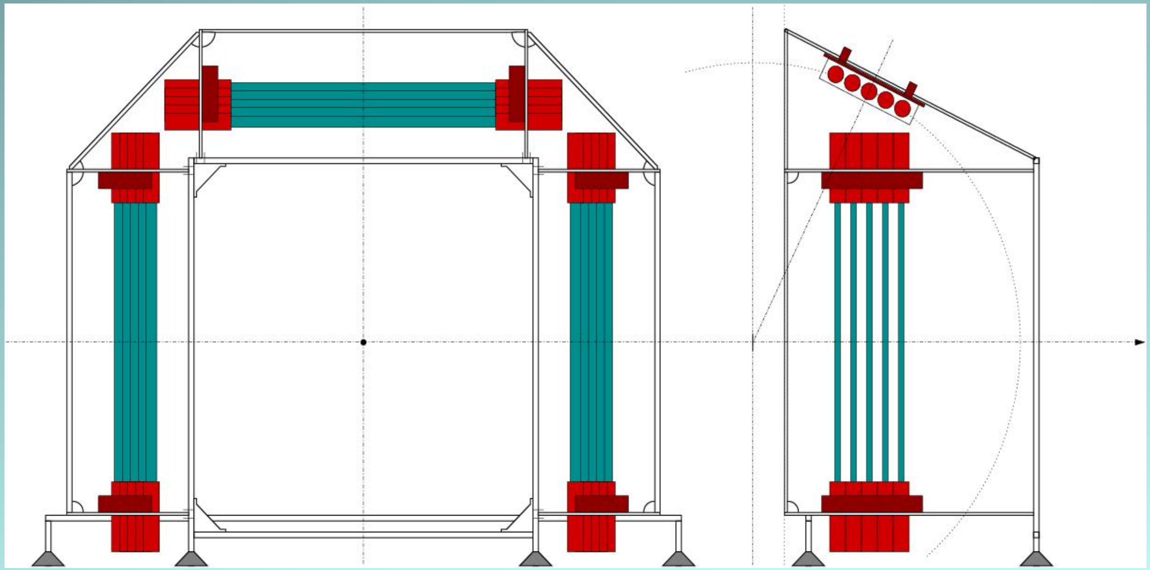
Experiment S408 at GSI

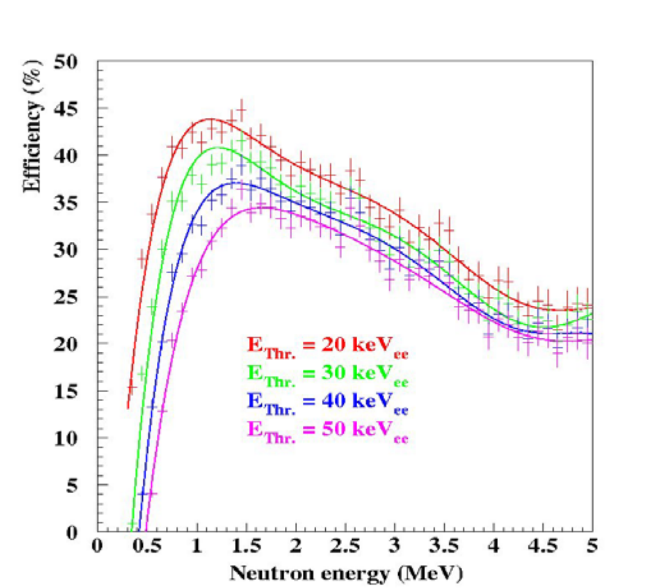
p(^{124}Sn,n) E = 600 AMeV



γ detector: 6x (3.5"x 8")state-of-the art LaBr$_3$
(University of Milano)

Geometrical arrangement and characteristics of ELENS (LENA)

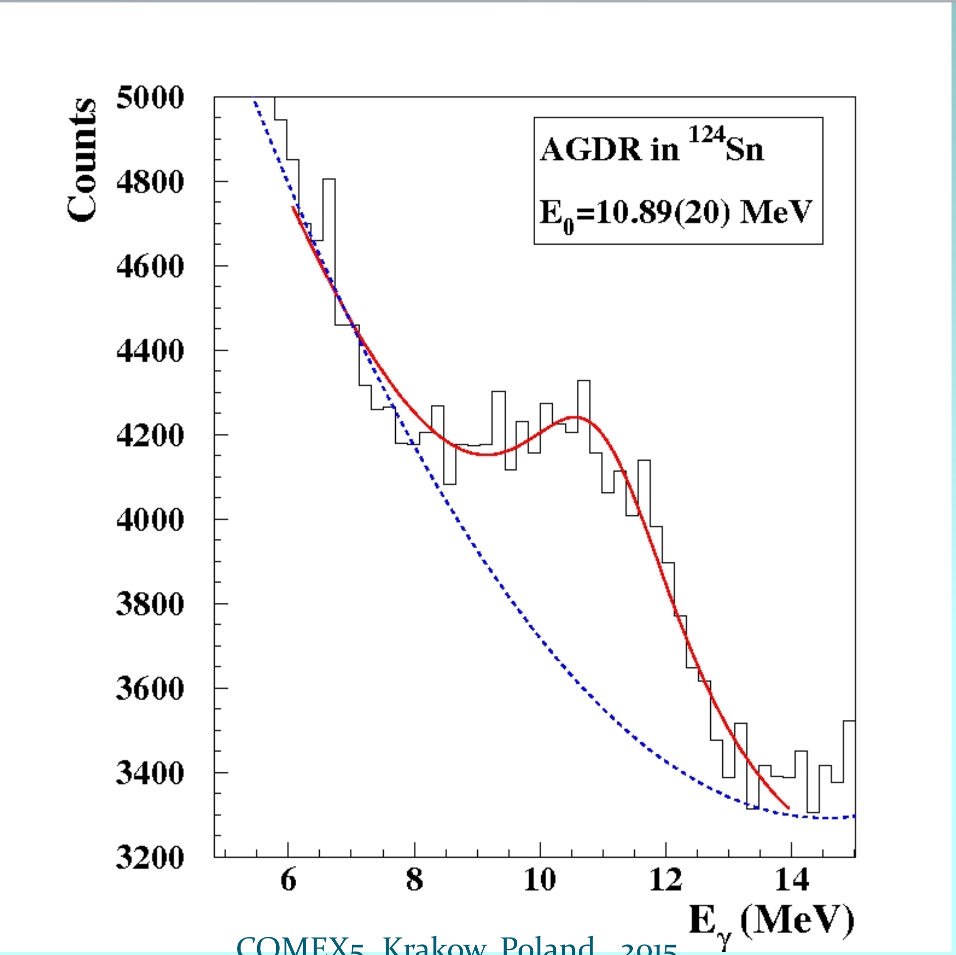




Time resolution (FWHM)	< 0.8 ns
Angular resolution(L= 1 m)	< 1°
Energy resolution (E_n = 1 MeV)	< 10 %
Detection efficiency (E_n= 0.5 - 5 MeV)	20 - 40 %

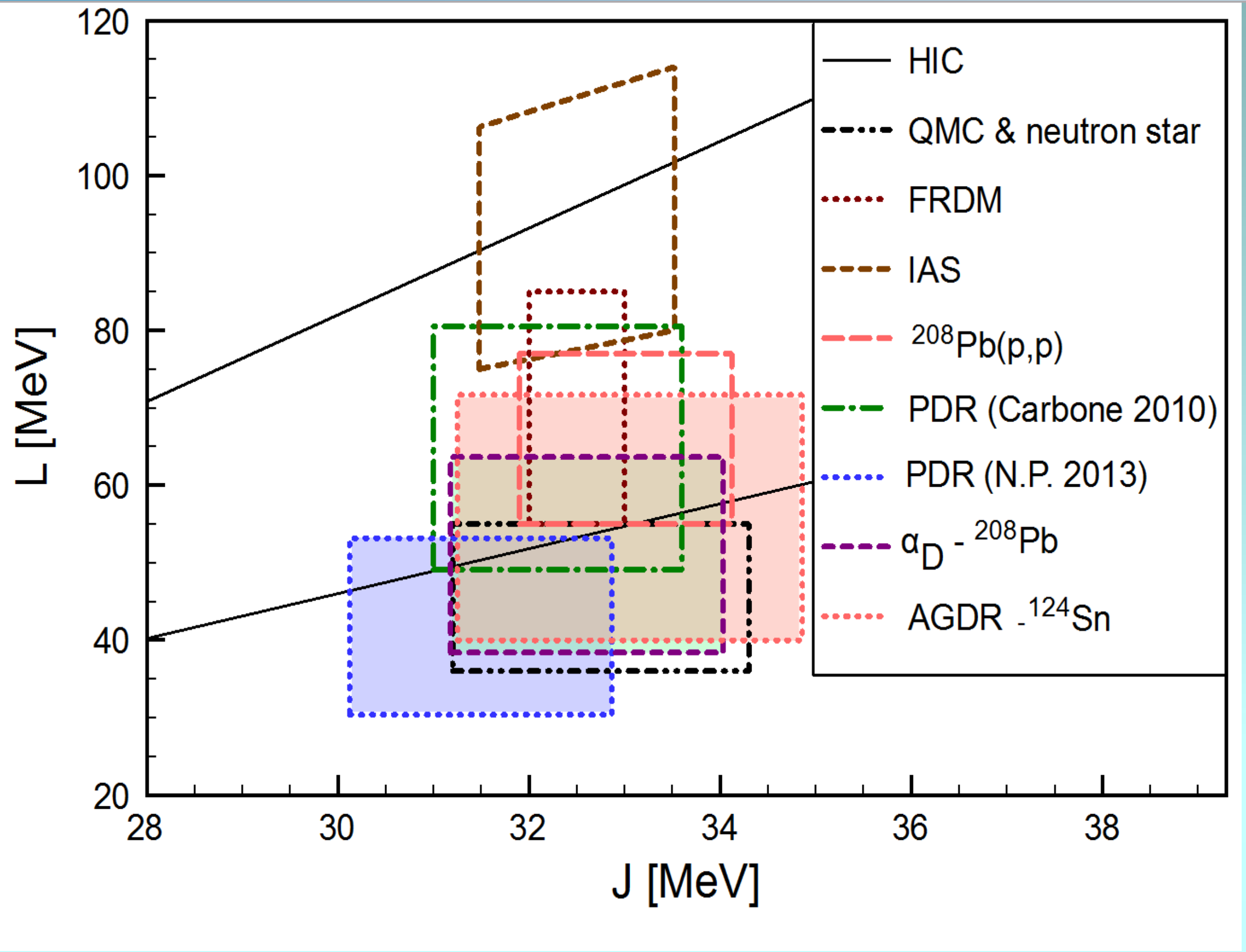
L. Stuhl et al.,
NIM, 736 (2014) 1.

γ-ray spectrum measured in coincidence with the neutrons ($0.5<E_n<3.5$ MeV and $66^\circ<\Theta_{LAB}<68^\circ$)



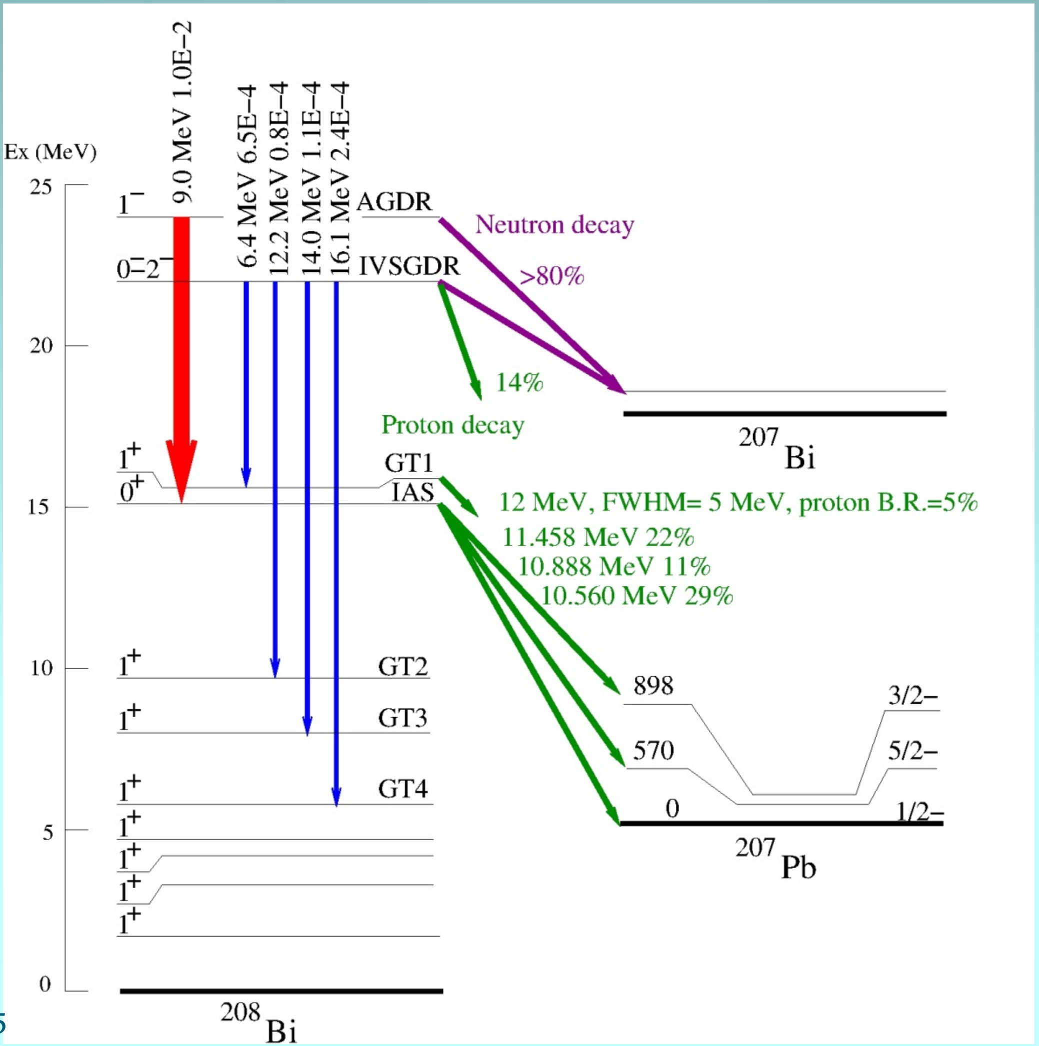
E(GDR) = 15.19
FWHM(GDR)=4.81

Constraining the symmetry energy at saturation density and slope of the symmetry energy from various approaches



Also see M. B. Tsang et al., PRC 86, 015803 (2012)

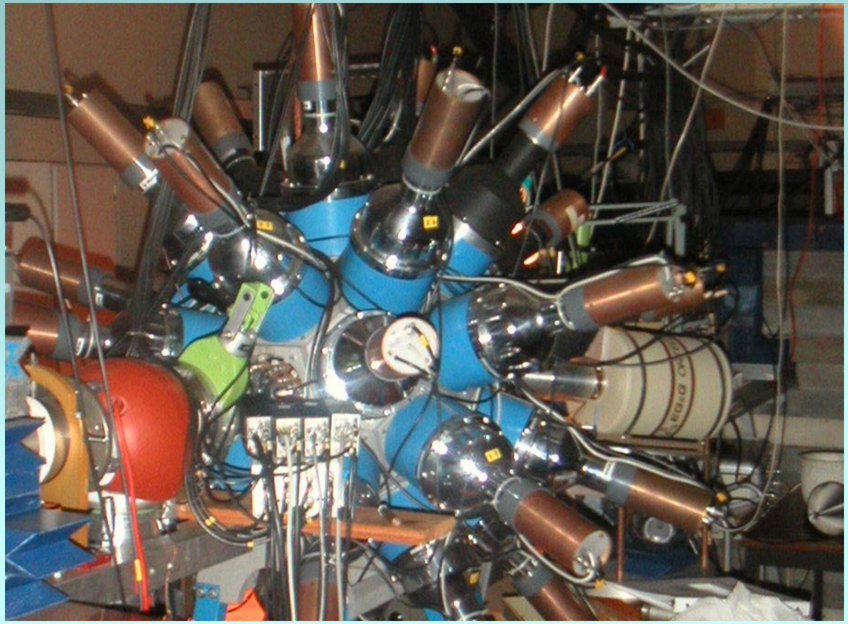
Study the AGDR in the ^{208}Pb(p,nγp)^{208}Bi reaction at Ep= 30 MeV

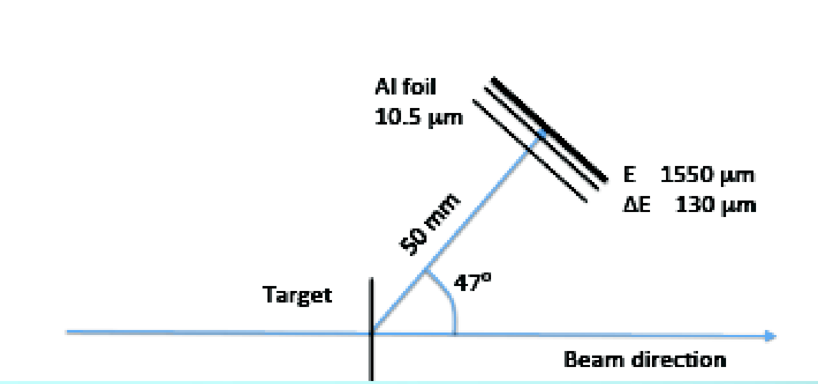


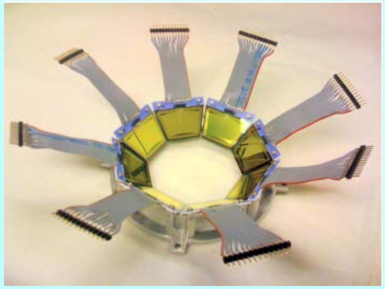
Experimental set-up we used in Oslo

CACTUS:

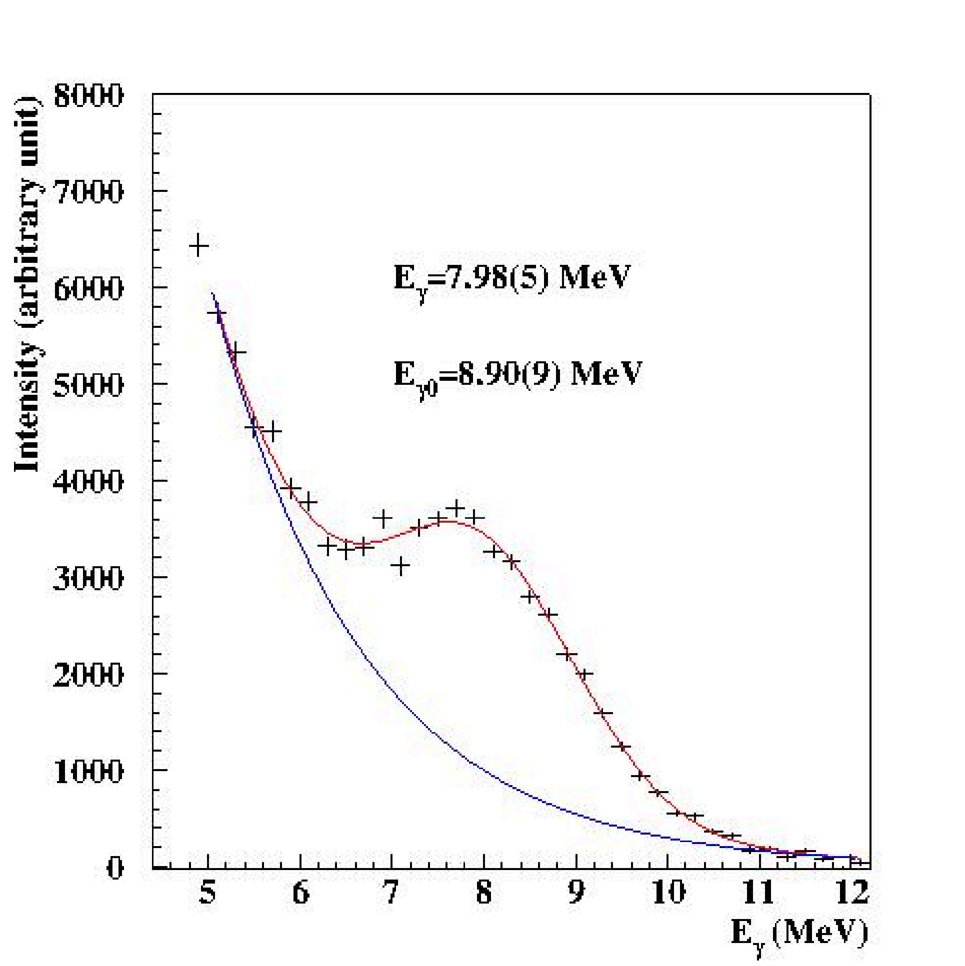
28 NaI 5”x5” and SiRI telescopes



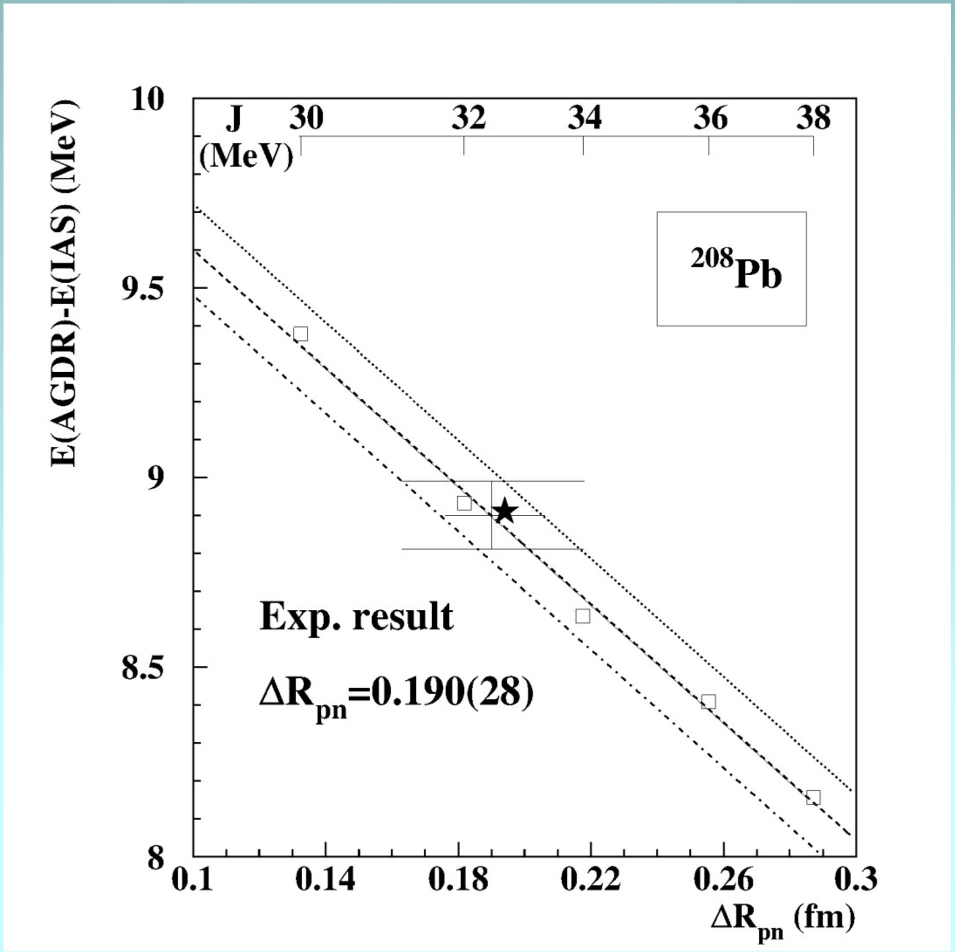




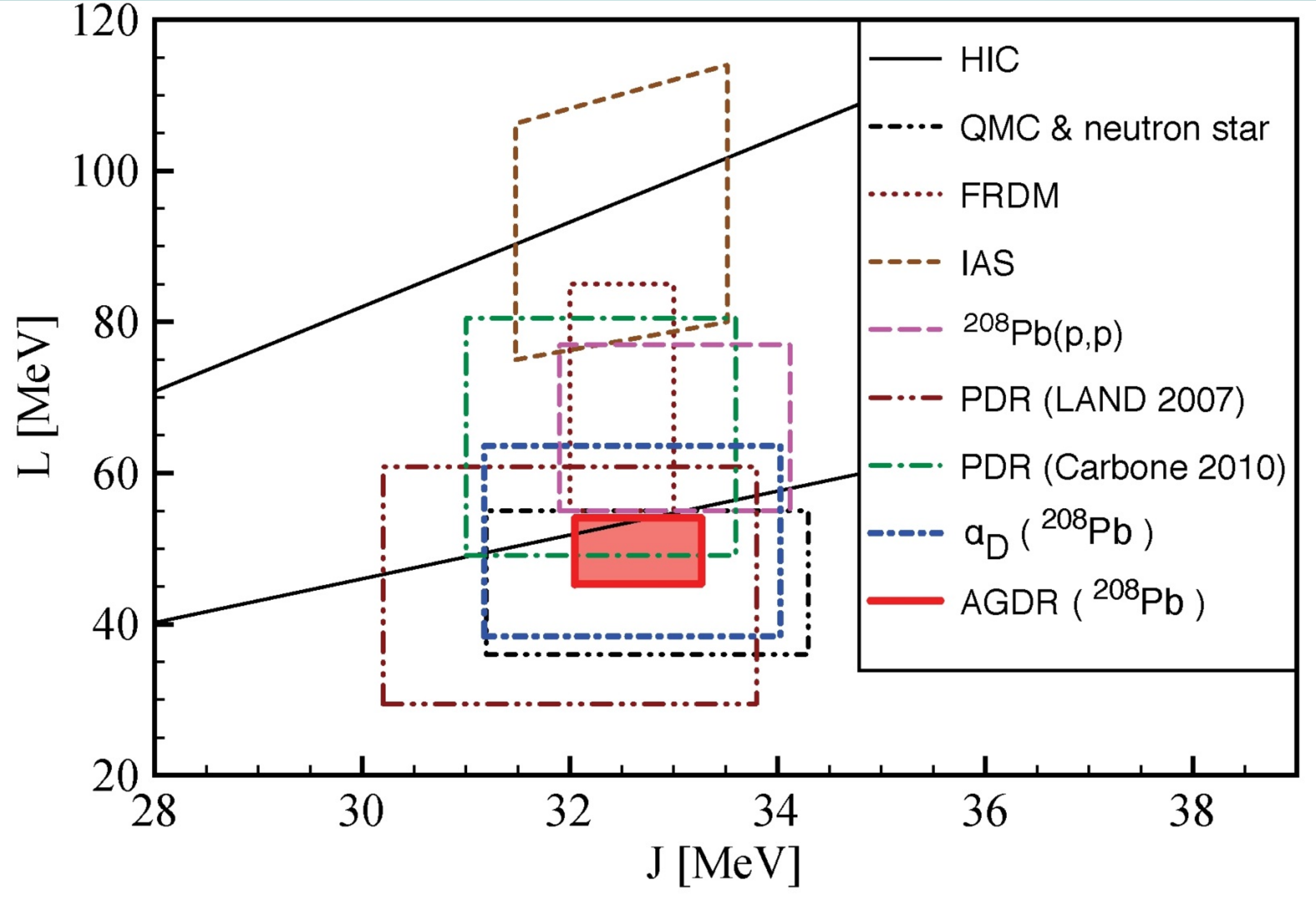
γ-energy spectrum measured in coincidence with the protons



Determination of the neutron-skin thickness

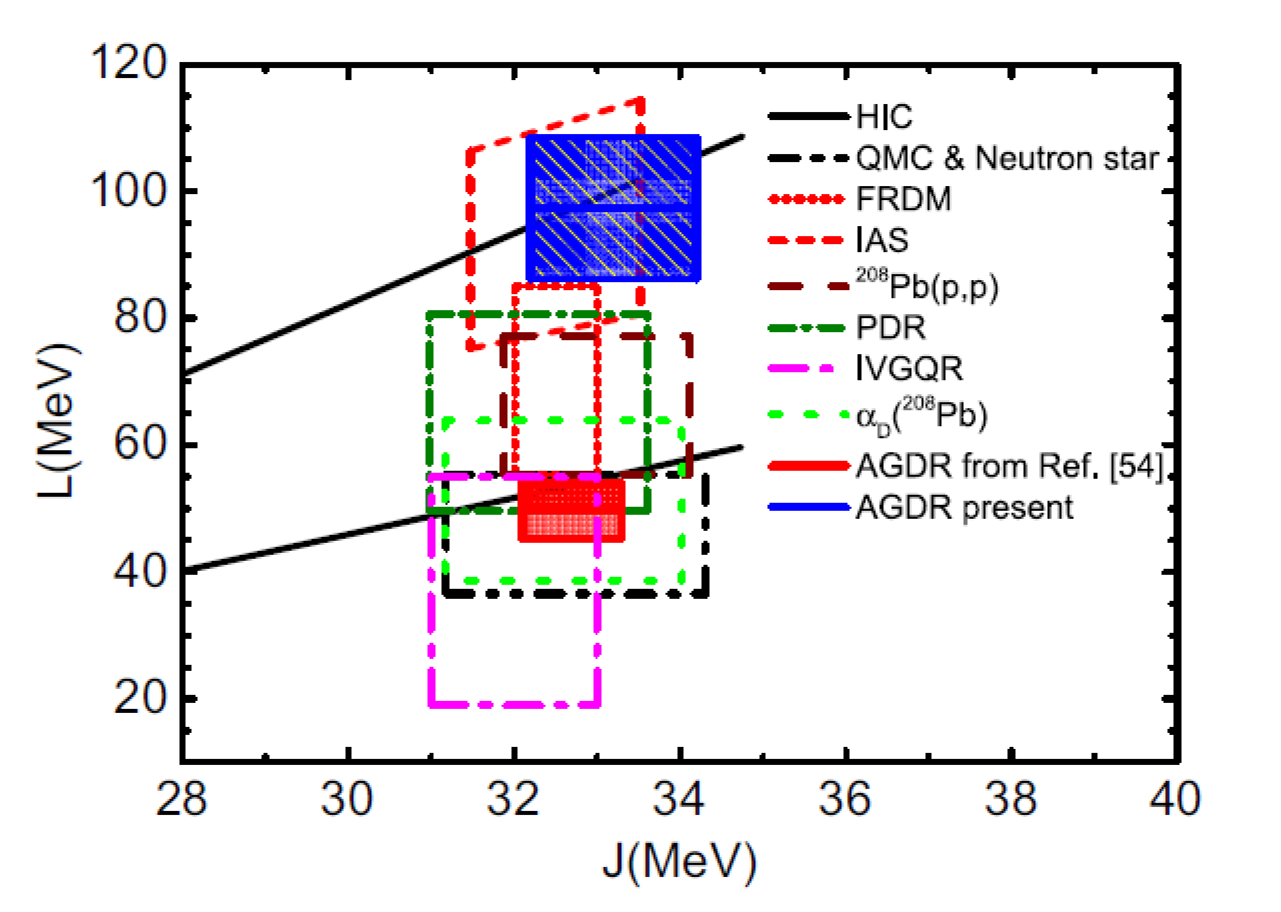


Constraining the symmetry energy and slope of the symmetry energy from various approaches

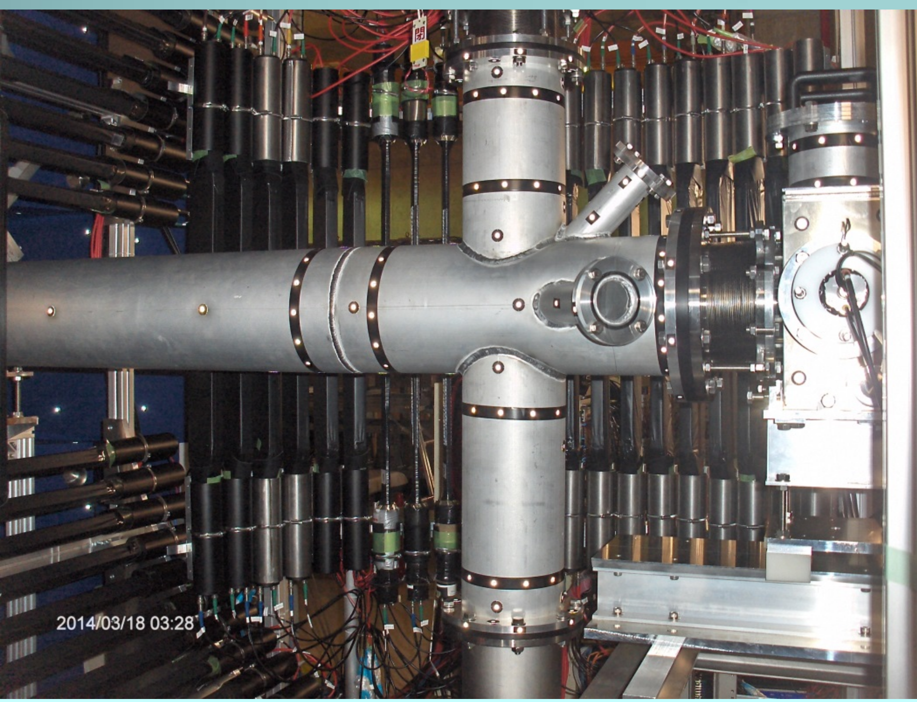


An alternative description…

Li-Gang Cao, X. Roca-Maza, G. Coló, H. Sagawa, Phys. Rev. C92, 034308 (2015)



The WINDS+ELENS detectors in front of the Samurai magnet Exp:NP1306 (2014) $^{132}Sn(p,n)$



Conclusions

A new method was introduced to measure the neutron-skin thickness

We can get information not only for the symmetry energy J, but also to its slope parameter L, which is badly constrained yet.

AGDR studies in RIB's (RIKEN)

Thank you for your attention