Gamma spectroscopic studies using deep-inelastic reactions

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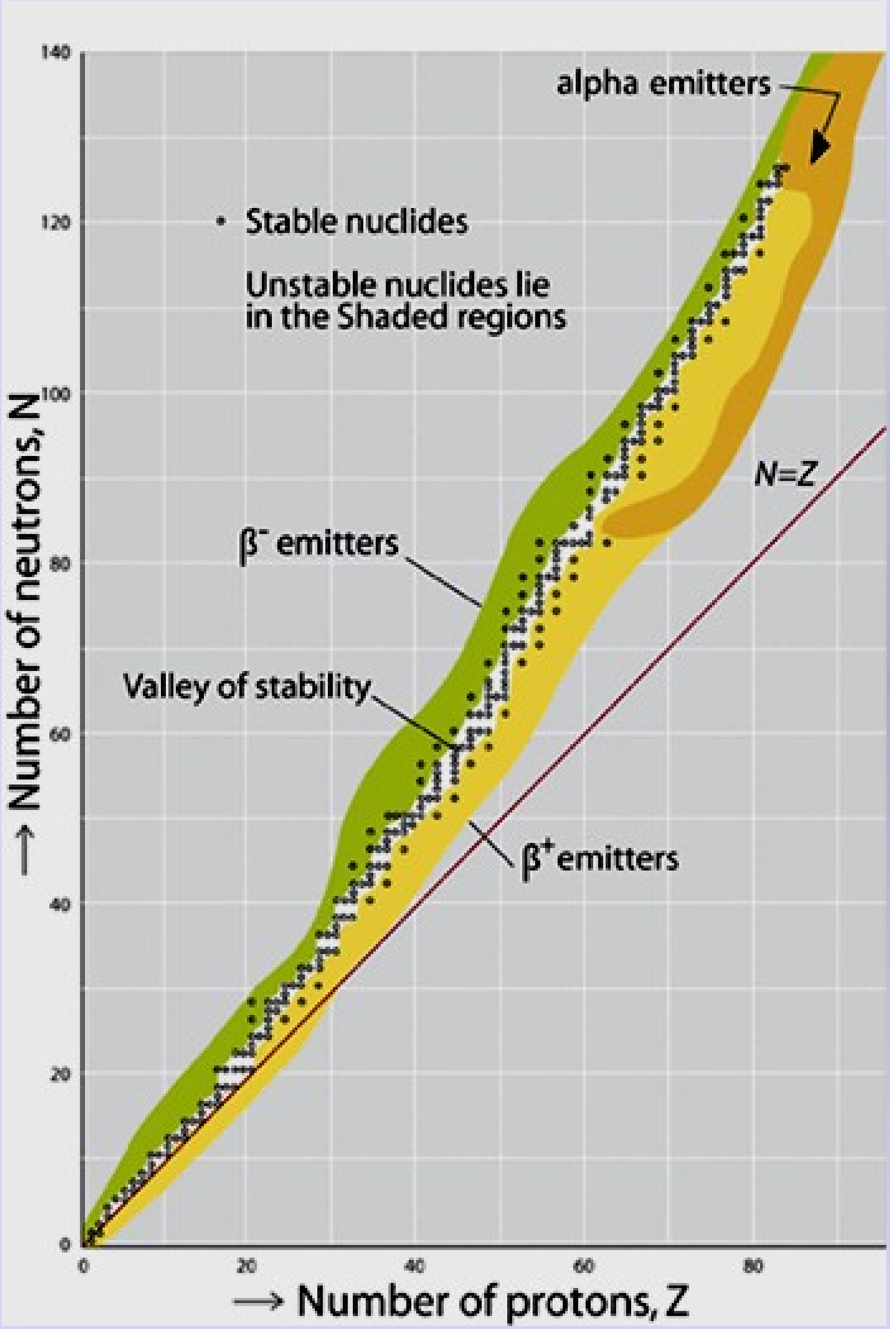


The valley of stability in heavy nuclei proceeds, on an average, by adding more neutrons than

Compound nucleus

The additional evaporation of several neutrons from the initial compound nuclear state increases the neutron deficiency.

(HI, xnγ) reaction lead to neutron deficient nuclei.

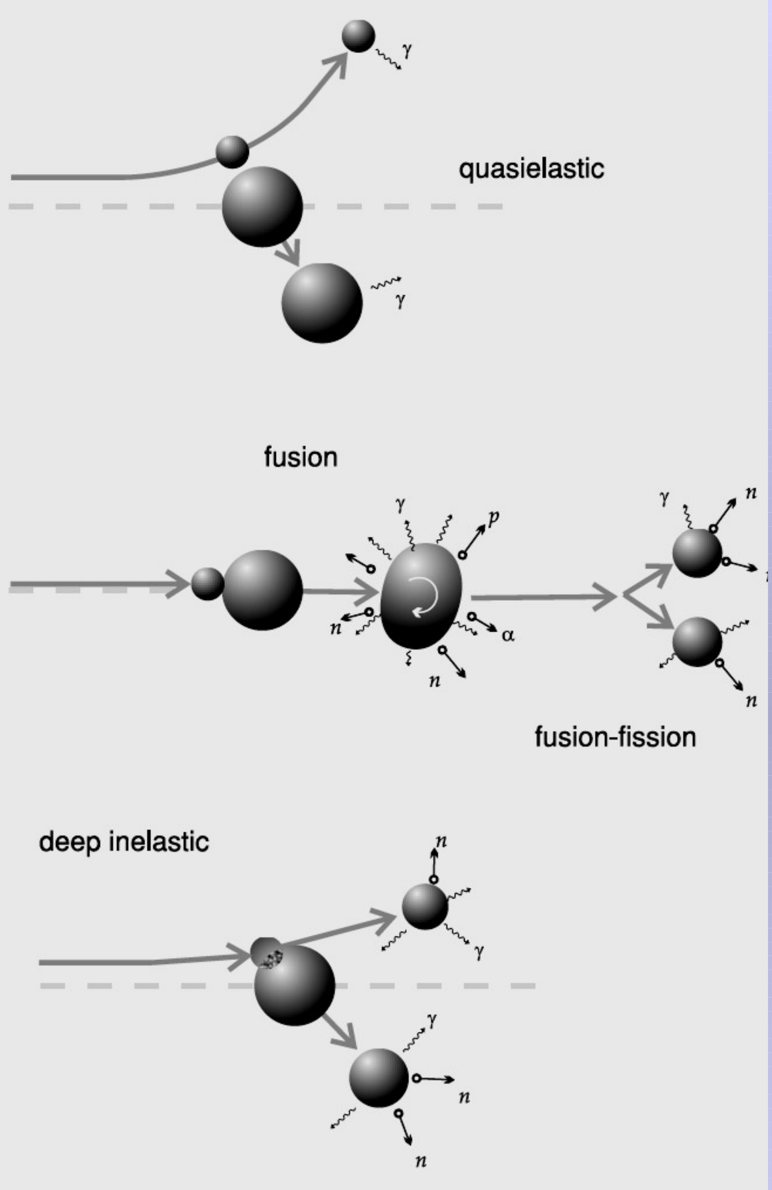
Neutron rich nuclei are much more difficult objects to reach through in beam spectroscopic studies.

Apparent asymmetry of information in the chart of nuclei

Neutron rich nuclei can be produced only with the use of complex nuclear reaction.

Moderate size gamma detector arrays allows to initiate studies of nuclei produced in deep- inelastic heavy ion reactions.

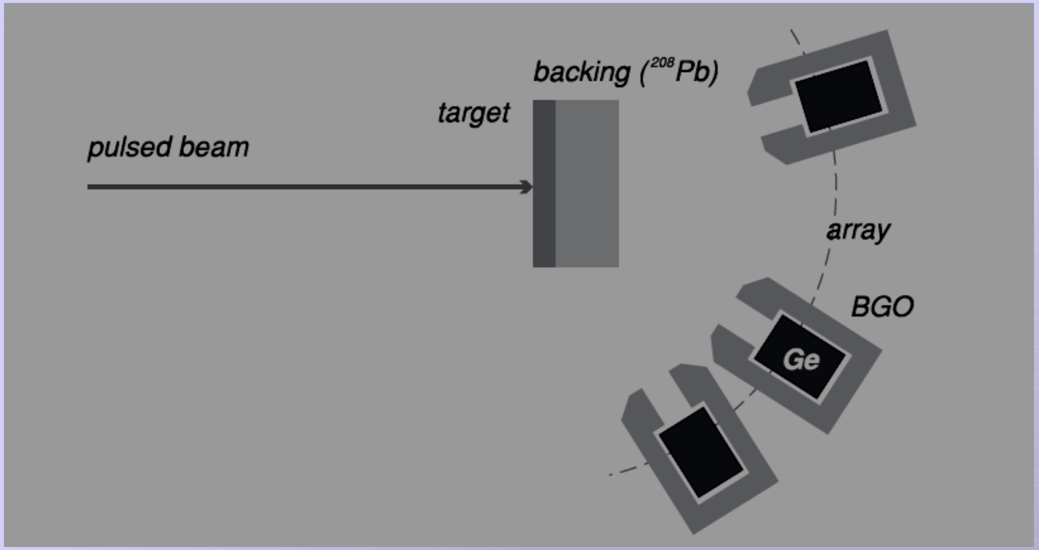
Technique of gamma coincidence data analysis is almost identical in deep-inelastic heavy ion reactions



Weakly excited final nucleus: Coulomb excitation, nuclear inelastic scattering, few nucleon transfer reaction.

Fusion reaction : compound nucleus with high angular momentum: subsequent evaporation of particles and high multiplicity of gamma rays. At the limiting values of angular momentum the compound nucleus cannot sustain the rotation and undergoes fission.

Intermediate impact parameter between the peripheral and central collisions: large transfer of mass, energy, angular momentum takes place



Thick target with suitable backing.

Heavy ion beam of energy ~ 2 times the Coulomb barrier.

Gamma coincidence to be measured in lowest possible fold

Beam pulsing is to be used to separate prompt in-beam events from those arising in and/or radioactive decays.

Detailed analysis of the good statistics gamma coincidence data provides the only selective power.

Data analysis involves only discrete gamma lines: gamma lines that are emitted from the stopped product nuclei.

Consequence of thick target experiment: integration of initial beam energy : undesired enhancement of quasi-elastic process e.g. Coulomb excitation

Gamma cross coincidence identification

1988: $^{60}Ni + ^{92}Mo$, $E_{lab} = 255$ MeV

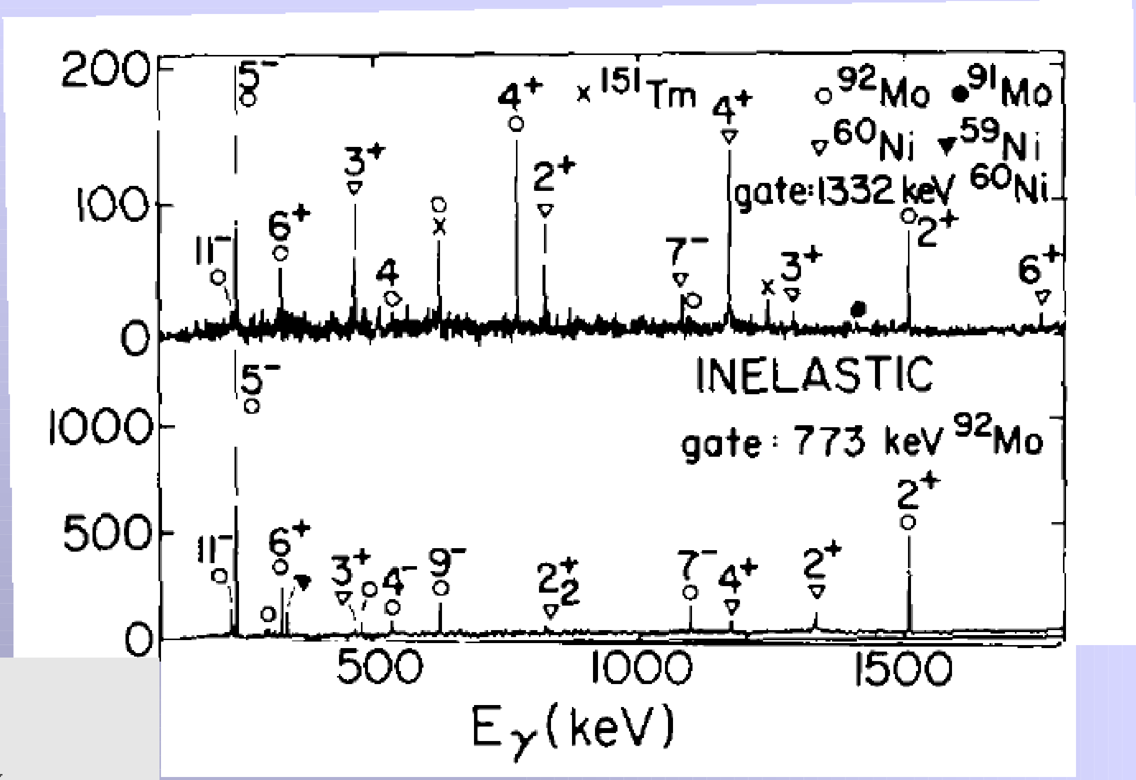
Detector system: 12 Compton-suppressed Ge detectors

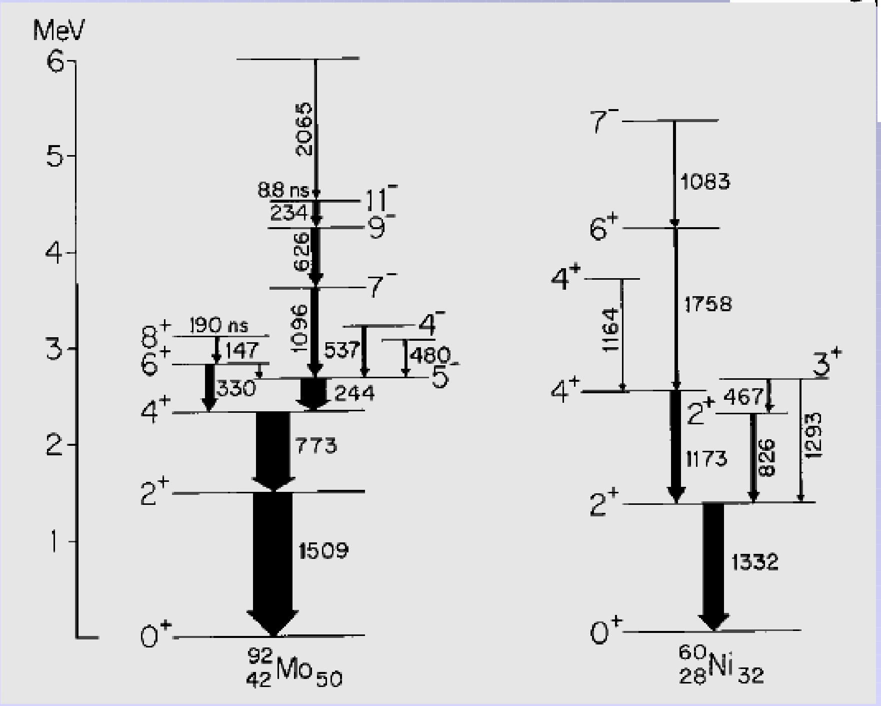
Target: Thick Pb backing

Apart from the fusion evaporation residues, the data were found to also include many events arising from inelastic and transfer reaction products.

13 binary reaction channels were identified.

Population of states in ^{92}Mo target and ^{60}Ni beam

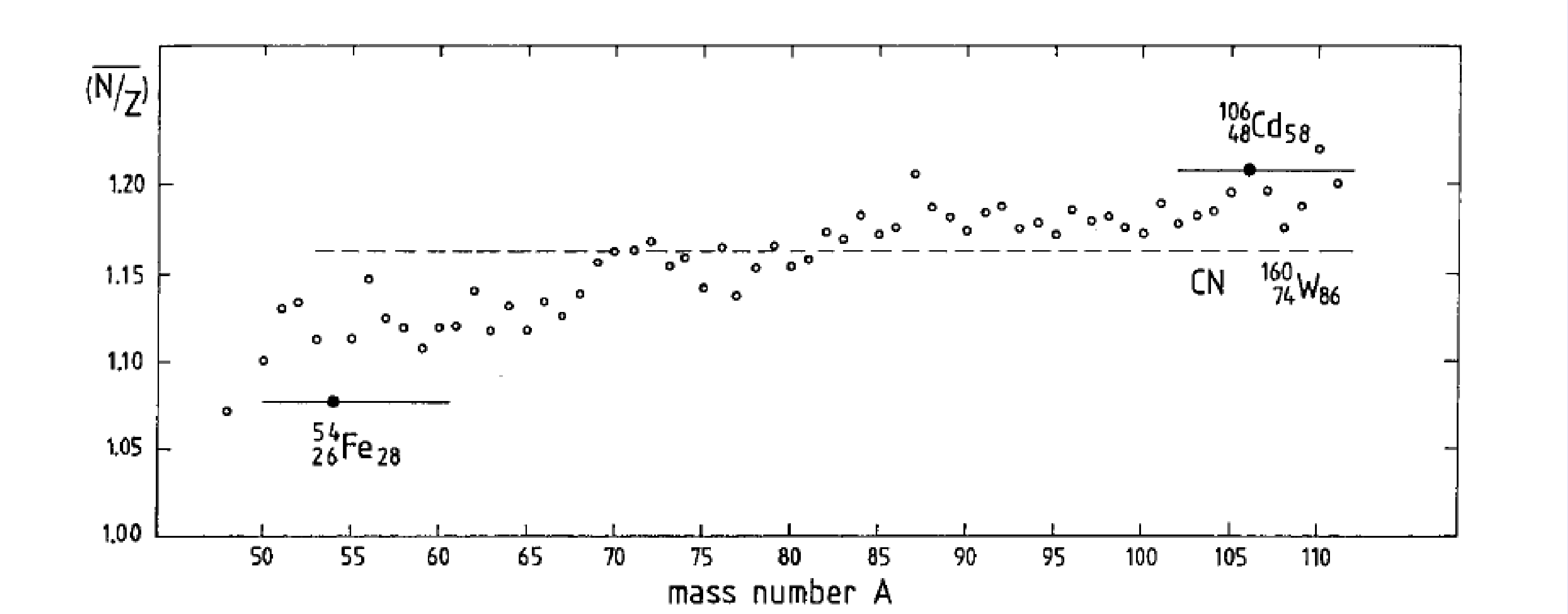




Cross coincidence between gammas from two excited nuclei in the exit channel

Possibility of deep-inelastic reactions for yrast spectroscopy.

$^{54}Fe+^{106}Cd$; OSIRIS multi-detector array



The variation of N/Z ratio extracted for each mass for all binary reaction products.

Very complete analysis of gamma coincidence data: path to study hard to reach nuclei

Spectroscopic studies of **Light nuclei**

Experimental difficulties using deep inelastic reaction

Strong dominance of the fusion reaction channel in collisions involving beams of light nuclei produces a high background of undesired gamma coincidence events.

Use of gamma multiplicity filter: selection of low gamma fold events which reduces significantly high multiplicity coincidences arising from the fusion evaporation reaction products.

^{37}Cl+^{160}Gd, Beam energy ~170 Mev

Neutron rich *sdf* shell nuclei

PRC 49, 2413(1994)

Detector system:

12 Compton suppressed HPGe

+ 50 element BGO array

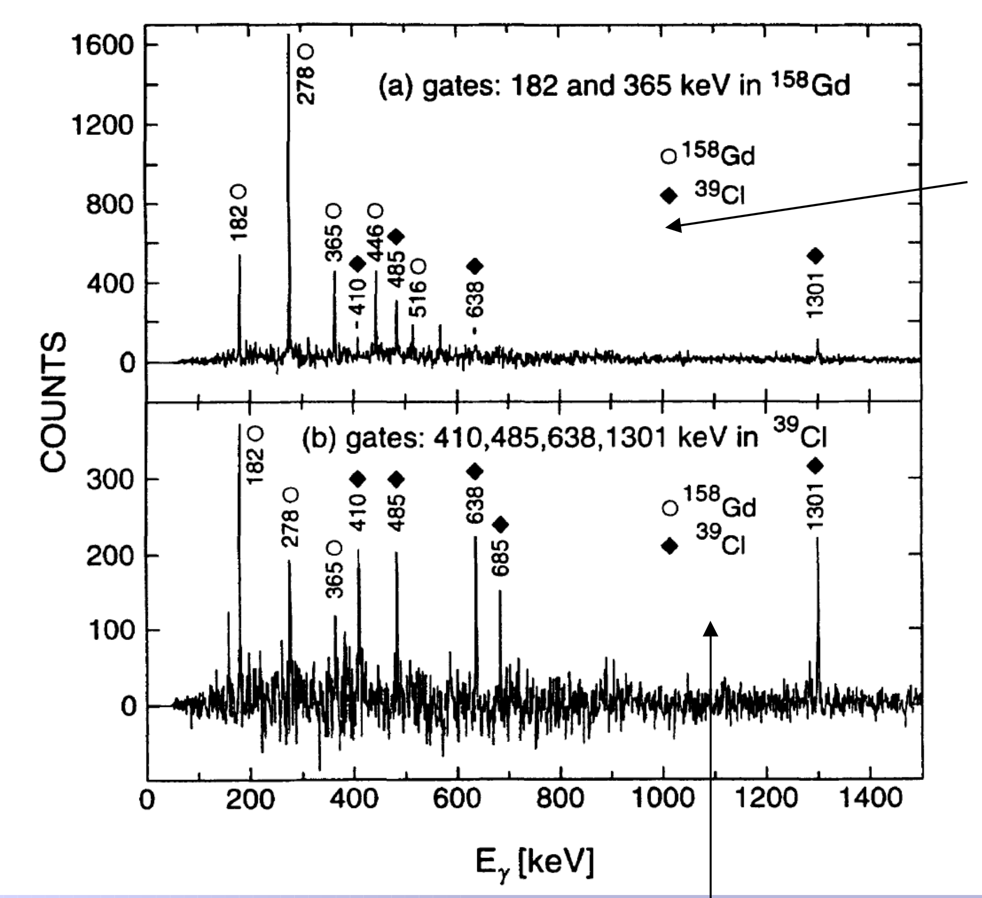
events

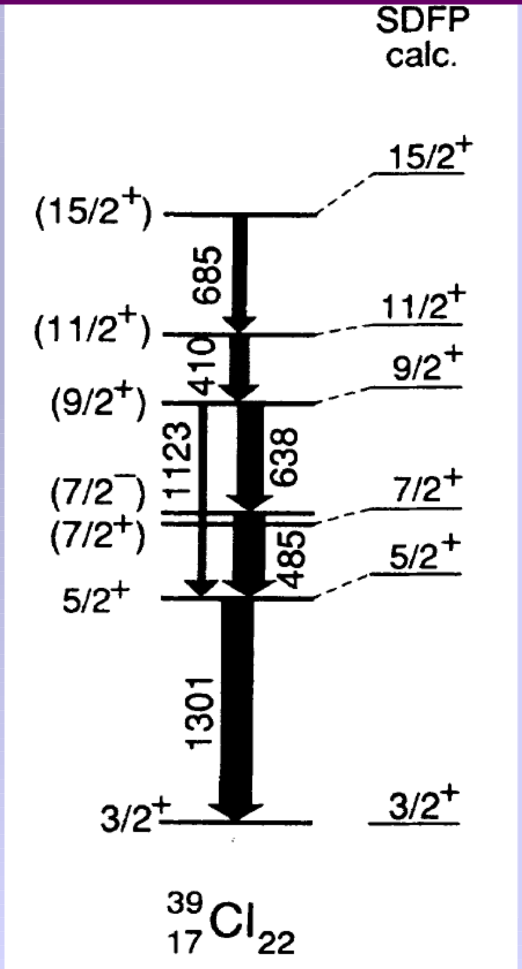
Analysis of the lower multiplicity subsets of the γ-γ data

information about the yrast states in targetlike and projectilelike reaction products.

For many product nuclei near ^{160}Gd, yrast gamma cascades were already known upto high spins, but much less was known about the gamma rays in the less accessible nuclei around ^{37}Cl.

Known ^{39}Cl γ-rays appeared in coincidence with the yrast cascade of γ rays of ^{158}Gd.

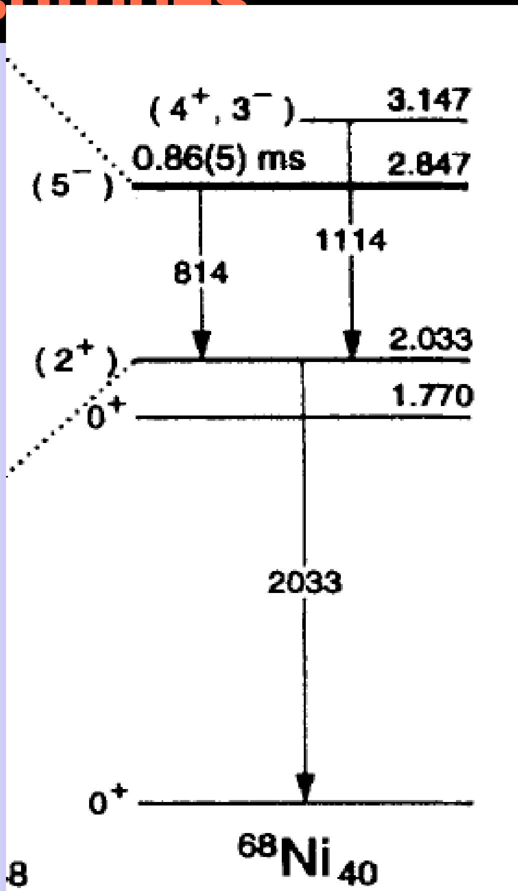




Gating on ^{39}Cl transitions sharply enhanced the prominence of the ^{39}Cl coincidence peaks.

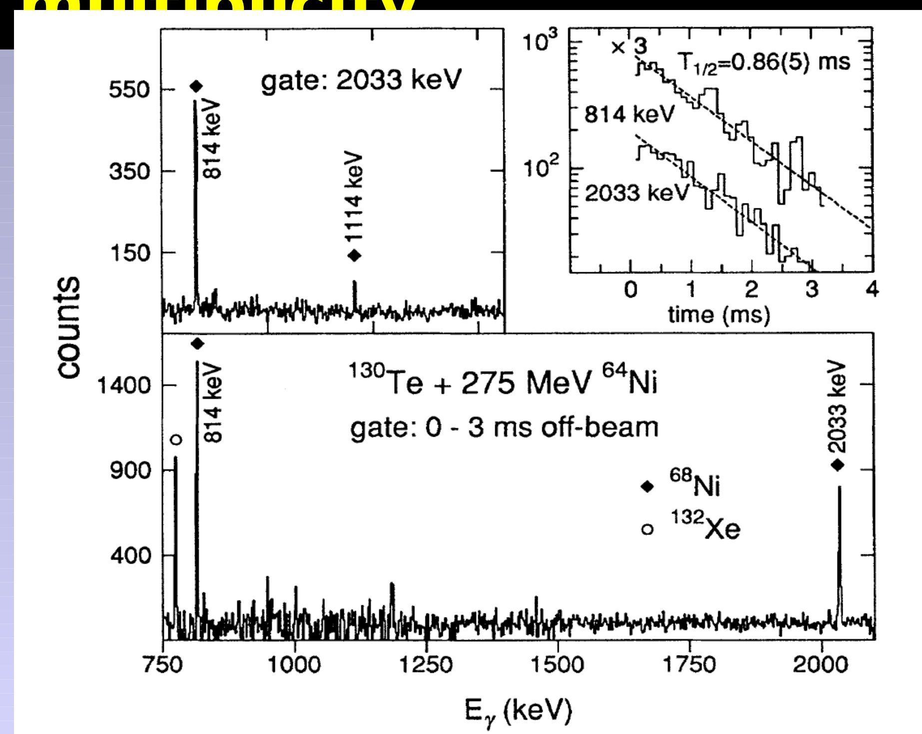
Neutron rich Ni isotopes

Phys. Rev. Lett 74, 868 (1995)



^{130}Te+^{64}Ni, Beam energy 275 MeV

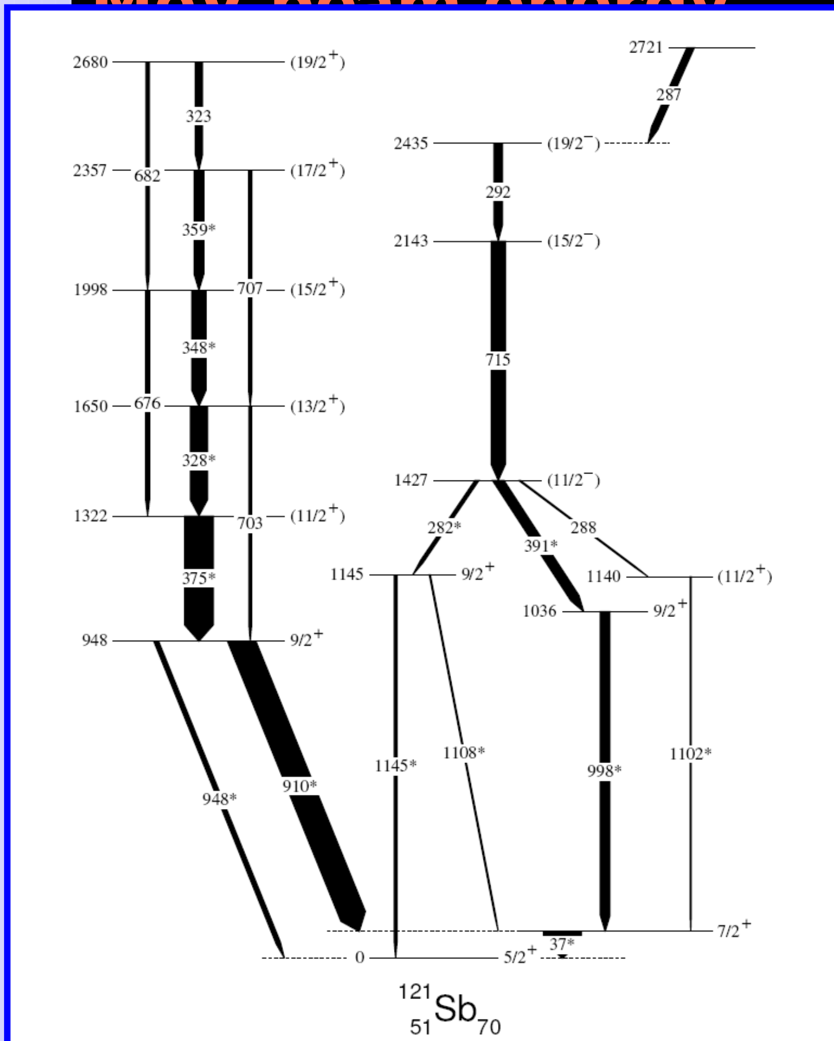
γ-γ coincidence data was stored without any restriction on the multiplicity



Detector system: GASP

Eur. Phys. J. A 24, 39 (2005)

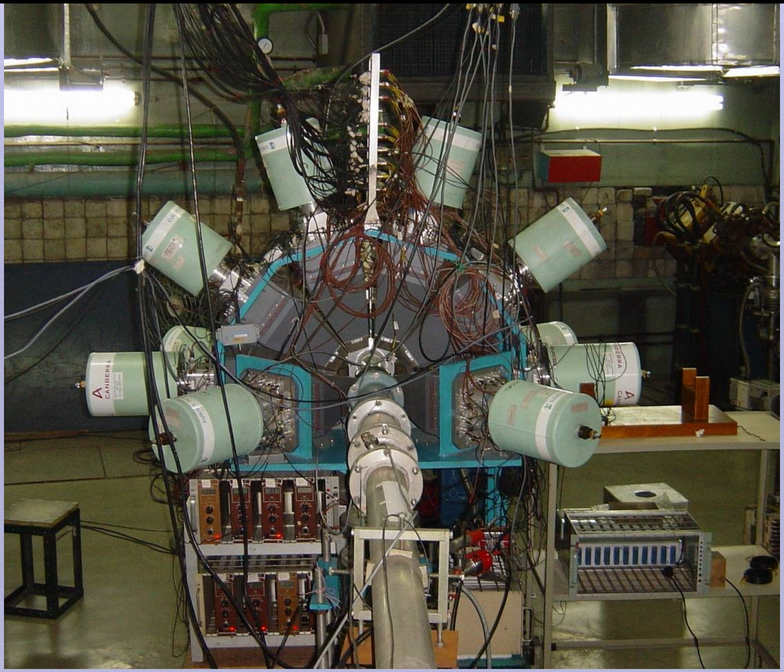
^{121}Sb isotopes is produced as fission fragments obtained in the fusion reaction ^{31}P+^{176}Yb at 152 MeV beam energy



Detector system: EUROBALL IV

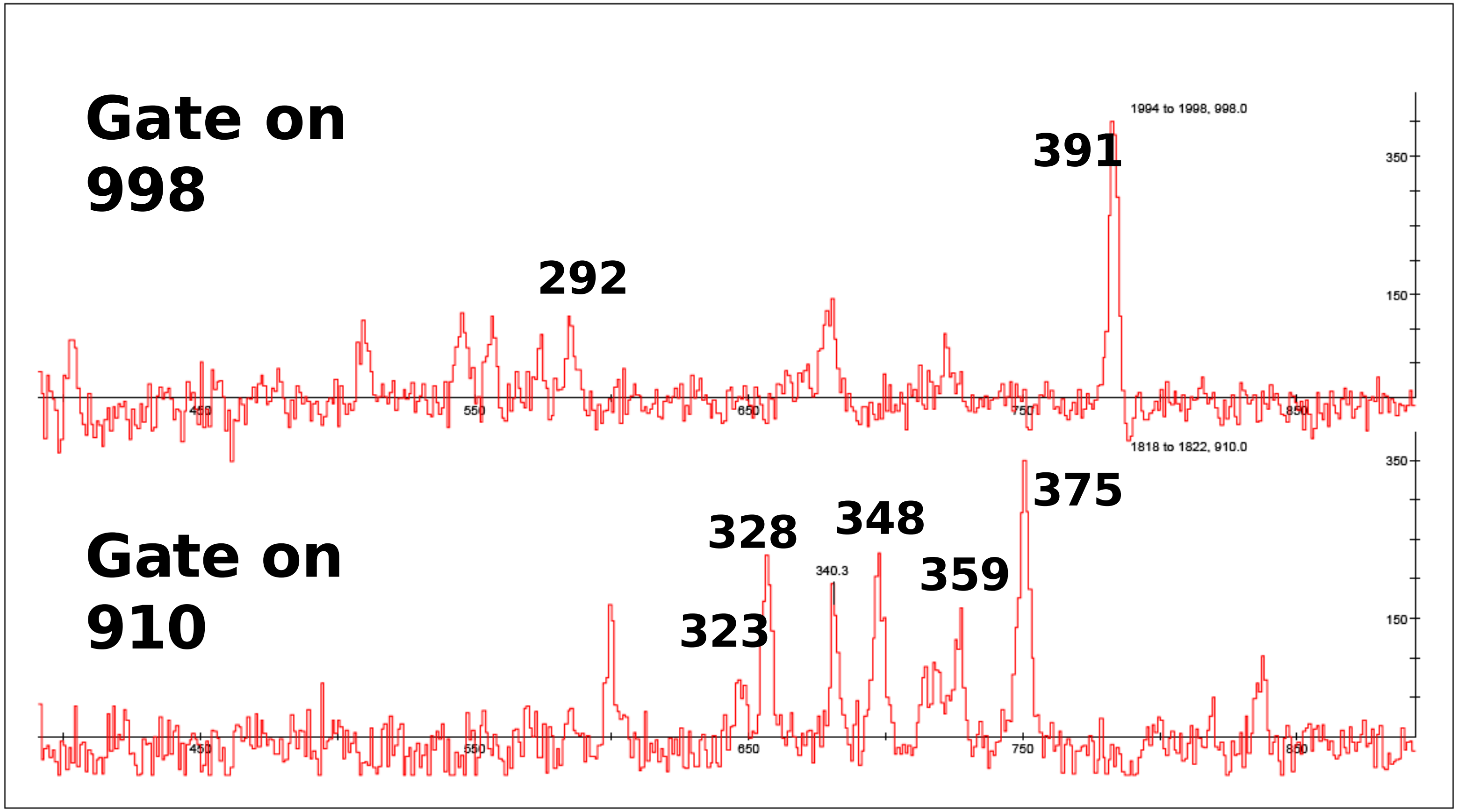
15 Cluster germanium detector 26 Clover detector 30 tapered single crystal Ge detector 210 BGO inner ball

Indian National Gamma Array at VECC



Detector System: 8 Compton suppressed Clover Detectors

2 segmented LEPS detector.



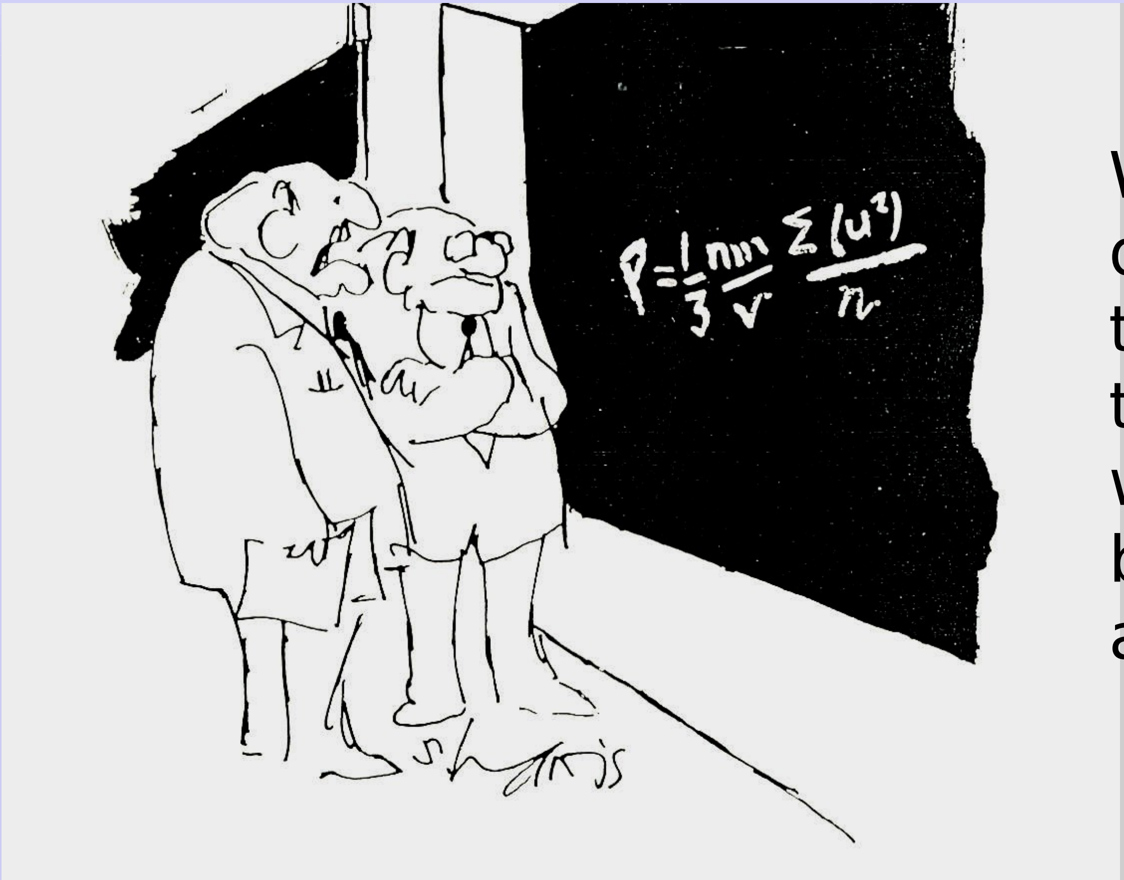
$^{40}Ar+^{121}Sb$, Beam energy ~ 280 MeV

All the known lines of ^{121}Sb are clearly visible

Conclusion:

Deep in-elastic heavy ion reaction can be used to study hard to rich nuclei at beam energy of 5-10 MeV/A

A moderate size detector array, like INGA with 24 clover detector along with a BGO multiplicity filter will be suitable for such type of studies.



What is most depressing is the realization that everything we believe will be disproved in a few years

Thank You