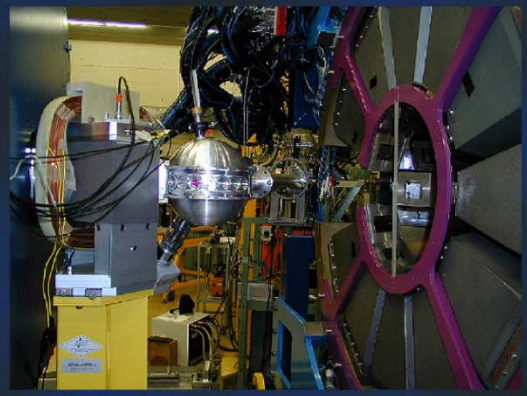
Nucleon-nucleon correlation effects in multinucleon transfer reactions



Suzana Szilner

Ruđer Bošković Institute, Zagreb, Croatia

Ruđer Bošković

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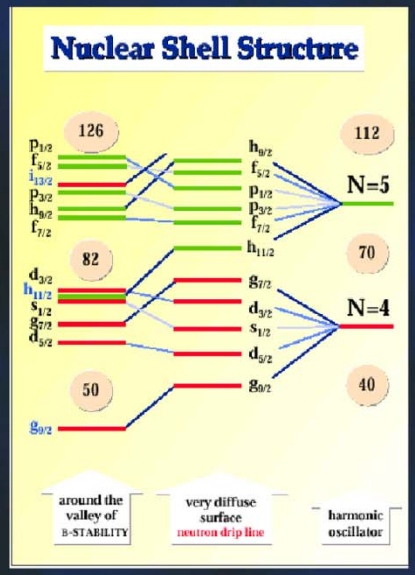
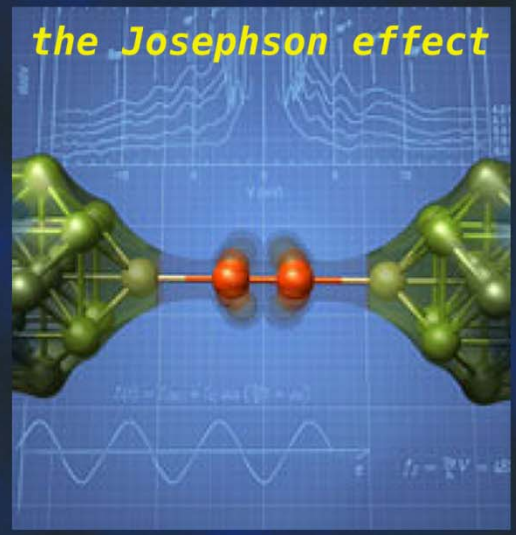
Why transfer reactions?

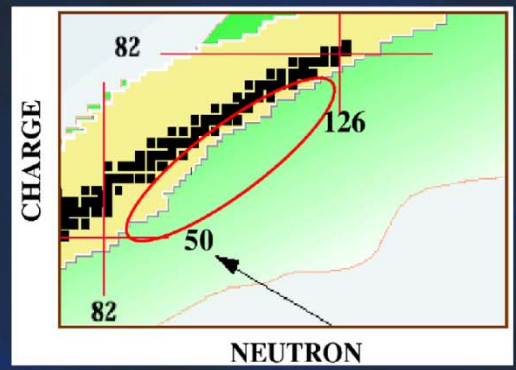
a study of the properties near shell closure

a study of the residual interaction (pairing)

a tool for the population of neutron rich nuclei







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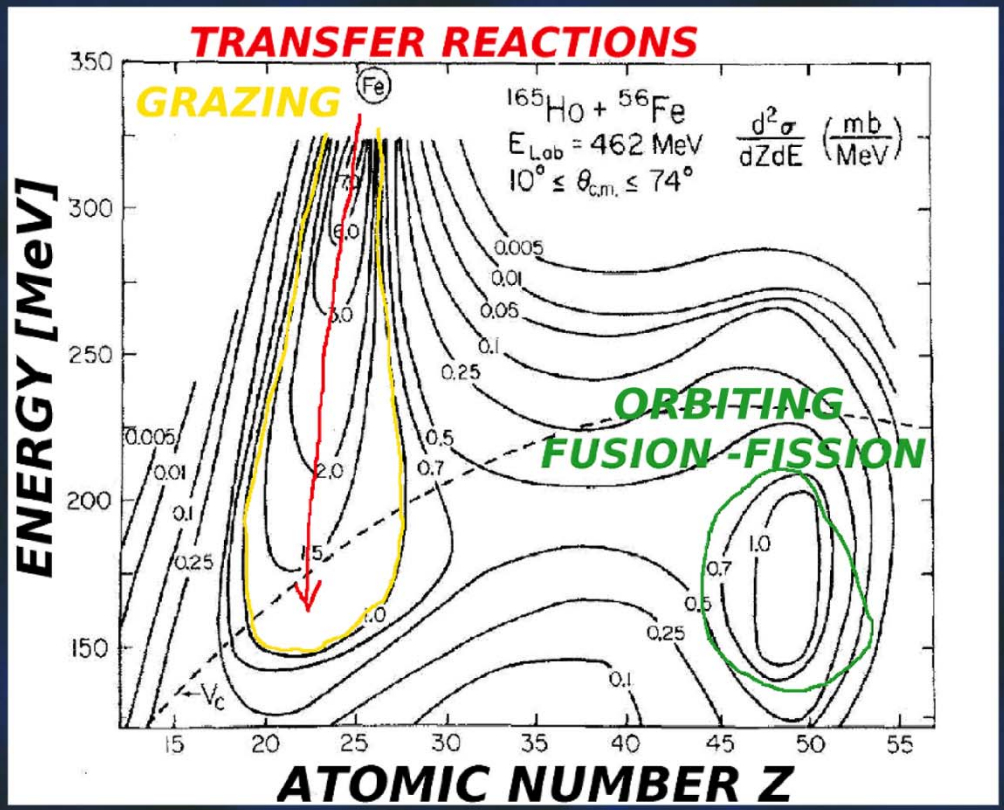
Basic properties of transfer reactions



- binary reactions

  grazing regime 70% of c.s.

- for stable nuclei (opt. Qval)

  neutron pick-up

  proton stripping

How the reaction cross section is shared between the different final mass partition?

Which are the degrees of freedom that influence the evolution of reaction (deformation, single, and pair transfer modes)?

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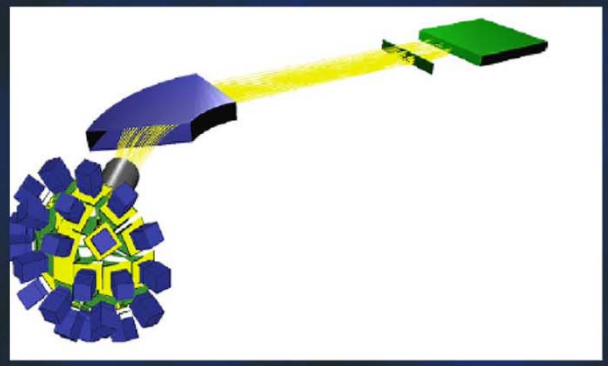
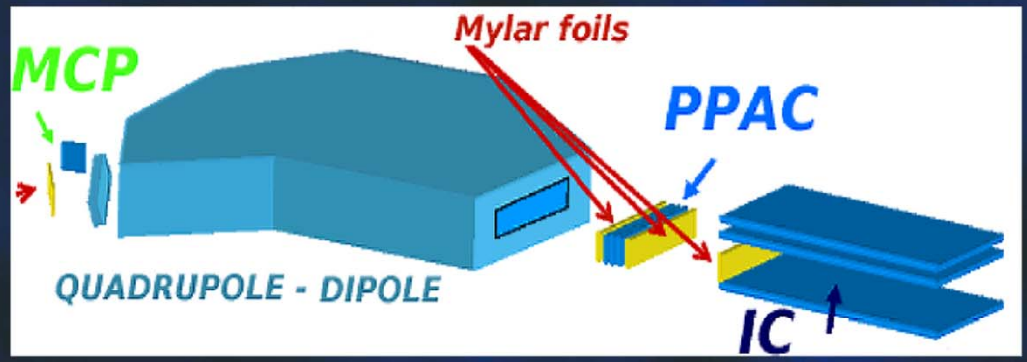
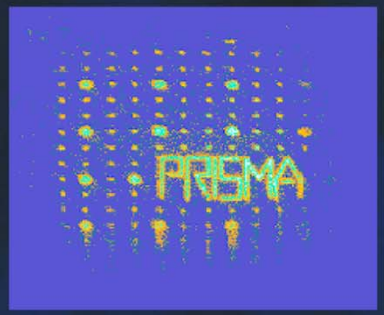
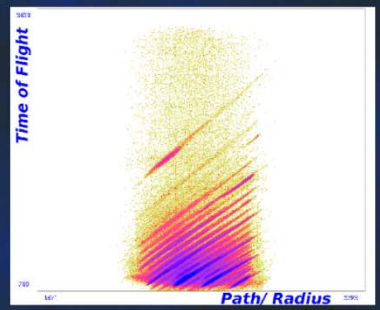
PRISMA+CLARA

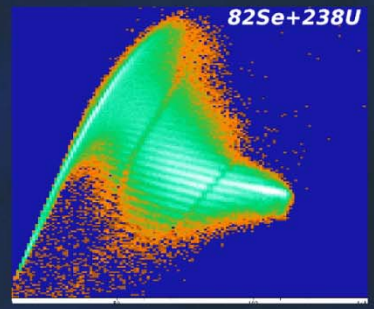
S.Beghini et al, NIM A551,364(2005)
G.Montagnoli et al, NIM A547,455(2005)

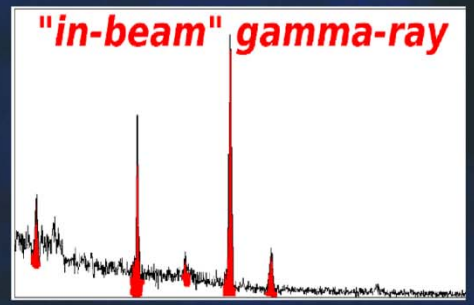












A "raw" physical ***event*** is composed by a few parameters:

position at the entrance	x, y → (θ, ϕ)
position at the focal plane	X, Y
time of flight	ToF
energy and energy loss	ΔE, E
coincident γ-rays	Eγ

Result → A, q, E, Z for the analyzed ions
→ Doppler-corrected γ-ray spectra

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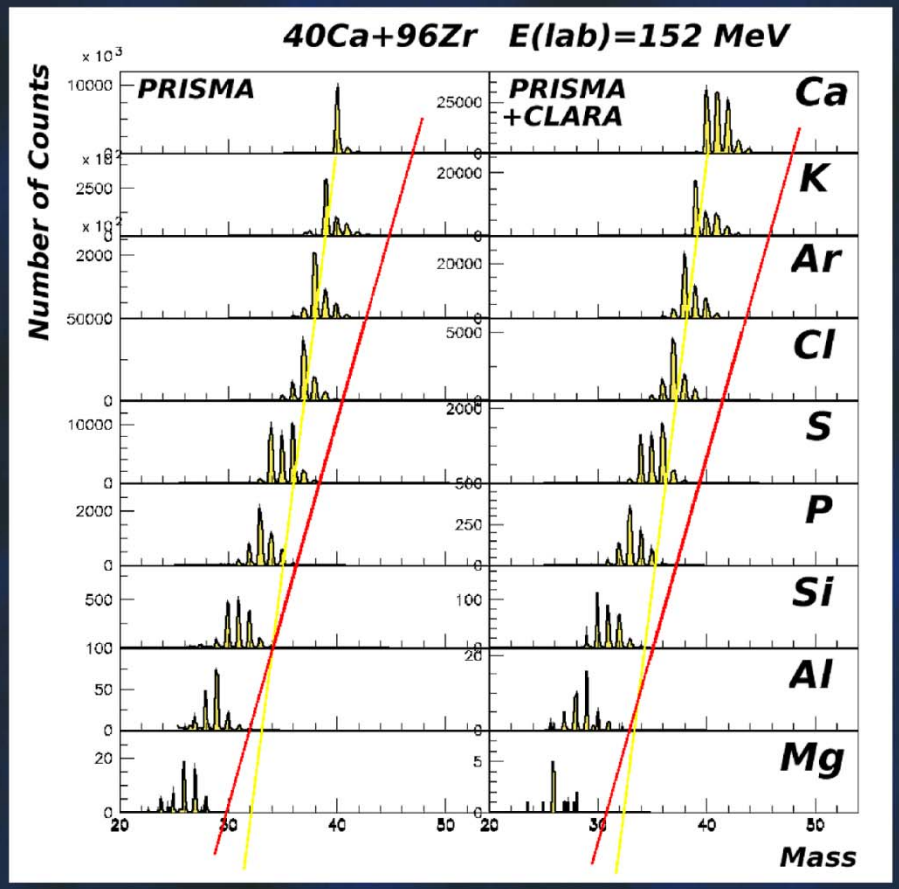
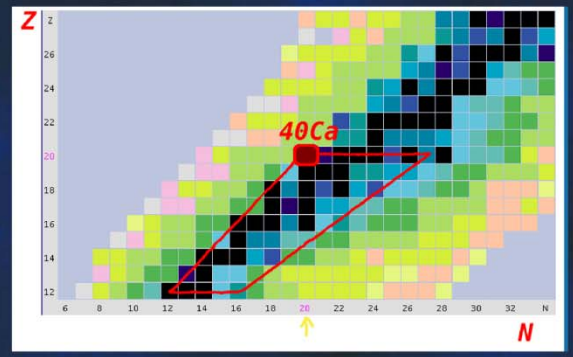
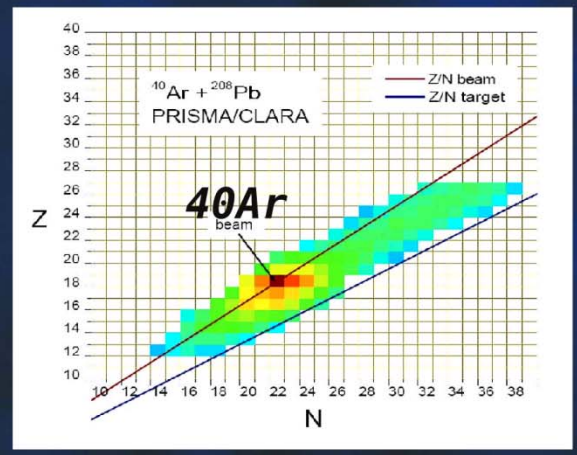
Phenomenology of MNT







- The system does not reach charge equilibration
- The population in the (N,Z) plane is defined by Q-opt
- +1n channel is stronger than -1p; -1p is as strong as -2p
- The evaporation strongly influences the final isotopic distribution

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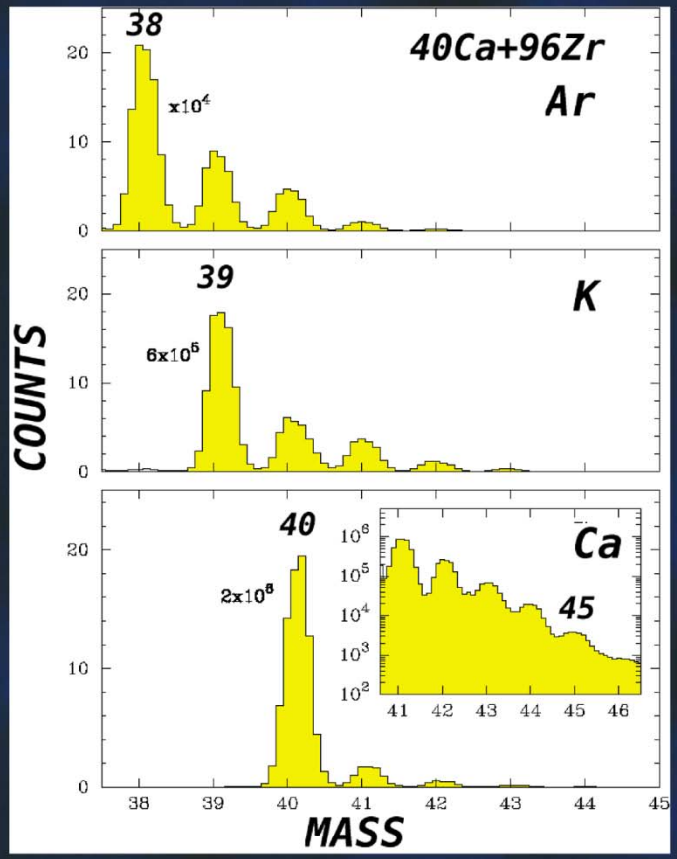
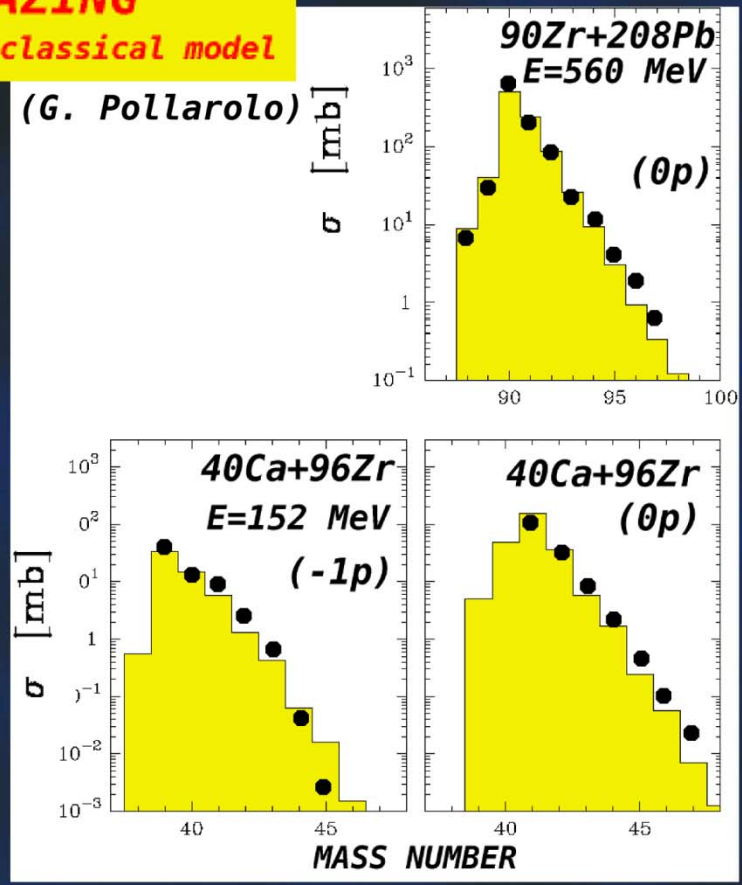
Comparison with GRAZING model



GRAZING
semiclassical model
(G. Pollarolo)



GRAZING:A.Winther, NPA572 (1994) 191; NPA594 (1995) 203

htpp:/www.to.infn.it?~nanni/GRAZING

S.Szilner et. al,PRC 76 (2007) 024604

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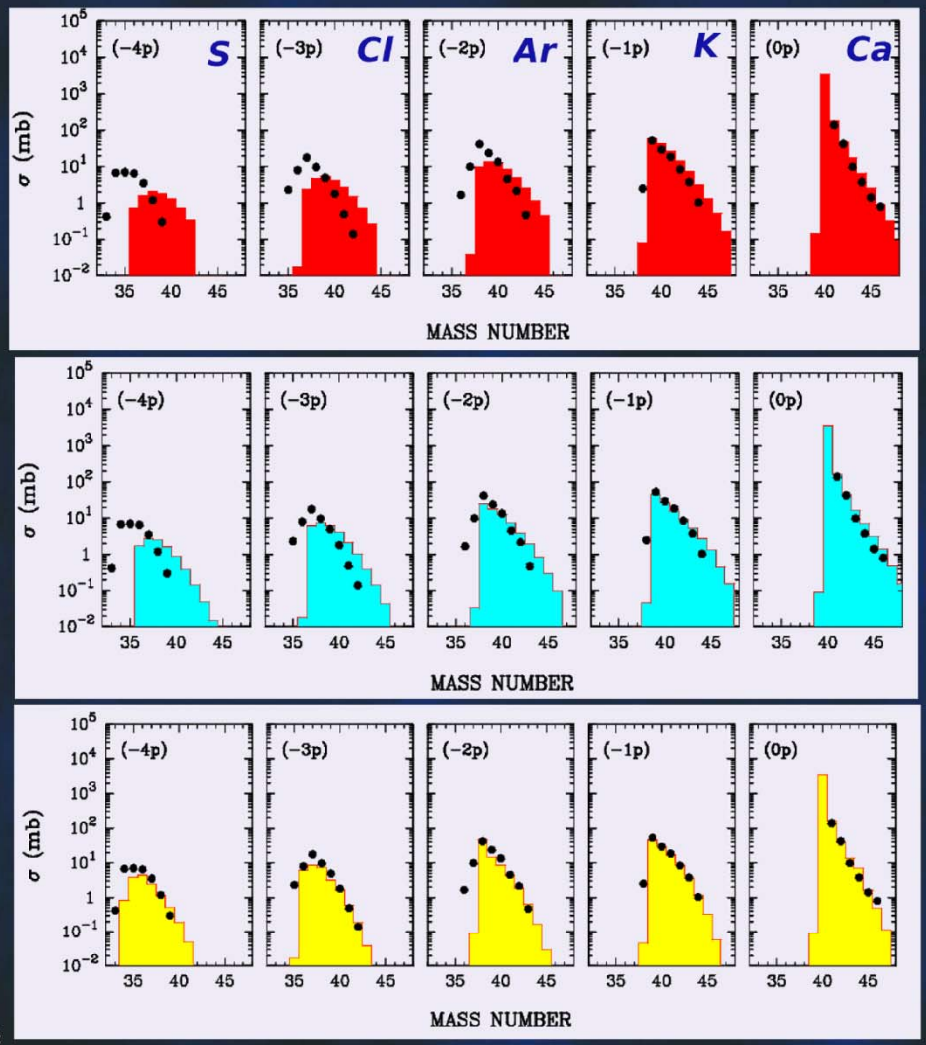
Cross sections and comparison with calculations



successive transfer

$$c_{\alpha\beta} = -\frac{1}{\hbar^2}\sum_{\gamma}\int_{-\infty}^{+\infty} dt f_{\alpha\gamma}^{(1)}(\vec{R}(t))e^{-i(Q_{\alpha\gamma}-Q_{\alpha\gamma}^{opt})t}$$
$$\int_{-\infty}^{t} dt' f_{\gamma\beta}^{(1')}(\vec{R}(t'))e^{-i(Q_{\alpha\gamma}-Q_{\alpha\gamma}^{opt})t'}$$

+simultaneous transfer

$$c_{\alpha\beta} = \frac{1}{i\hbar}\int_{-\infty}^{+\infty} dt f_{\alpha\beta}^{(2)}(\vec{R}(t))e^{-i(Q_{\alpha\beta}-Q^{opt})t}$$

$f_{\alpha\beta}^{(2)}(R) = \beta_{pair}\frac{dV_{OPT}(r)}{dA}$ **PAIR FORM FACTOR**

+evaporation

CWKB calculation by G. Pollarolo

40Ca+208Pb E(lab)=249 MeV
S.Szilner et al, PRC 71, 044610 (2005)

Complex WKB theory

E.Vigezzi and A.Winther, Ann.of Phys. 192, 432 (1989)

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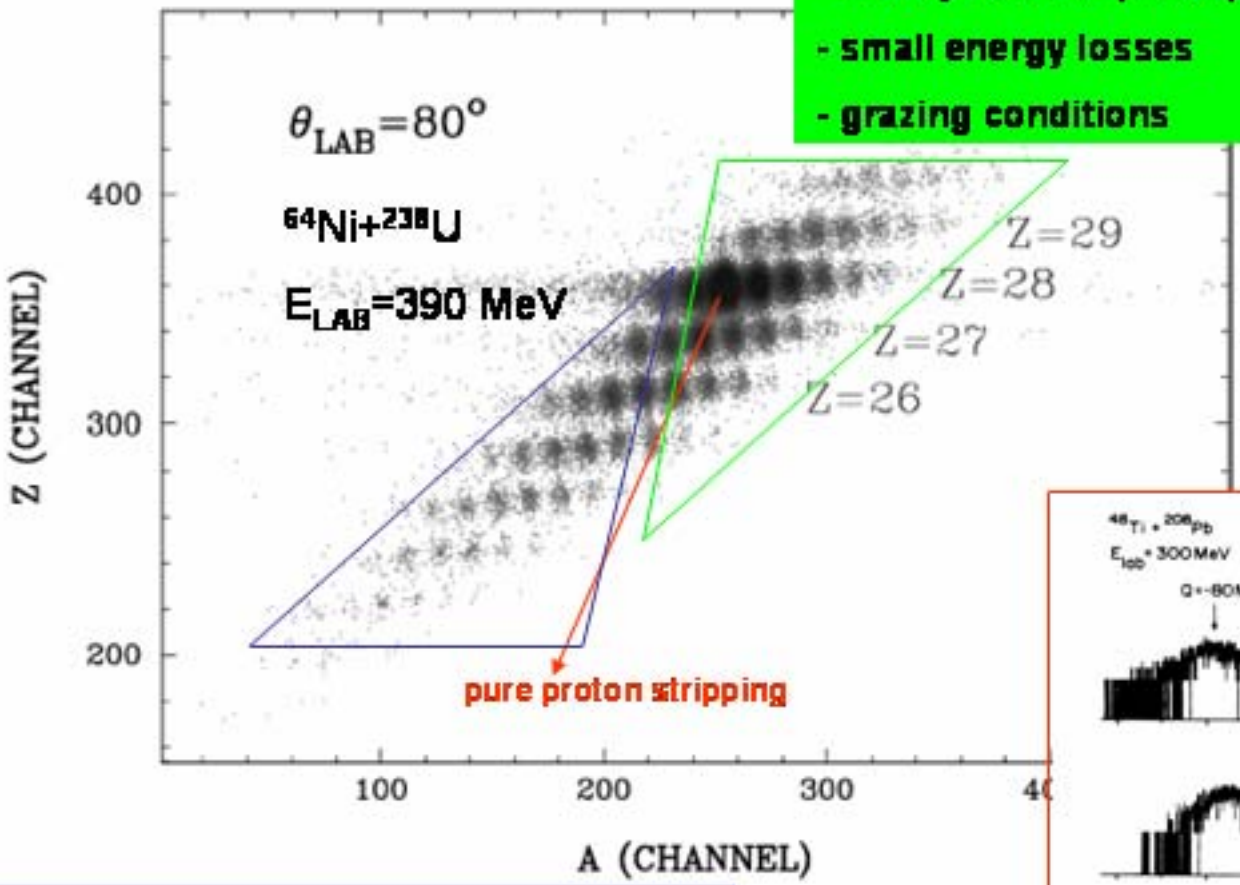
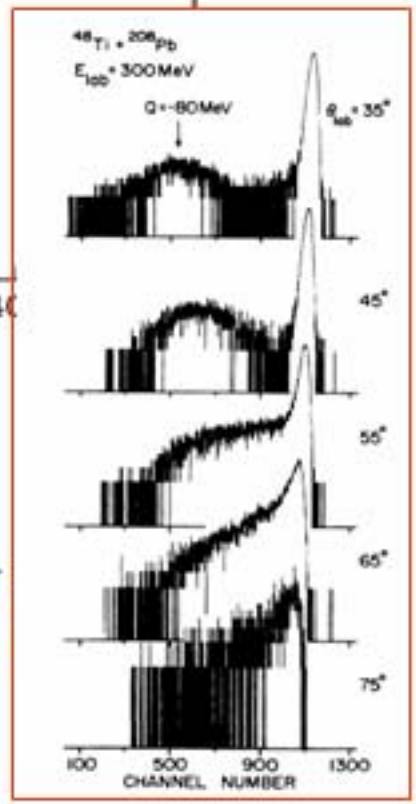
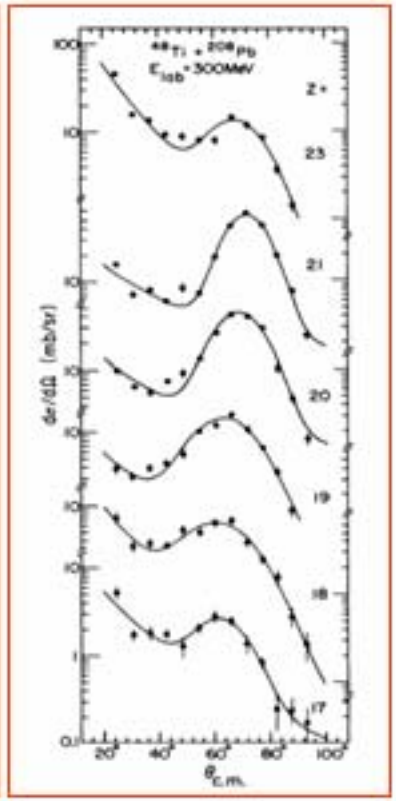
- quasi elastic processes (governed by F(r) and Qopt)
- mainly neutron pick-up and proton stripping
- small energy losses
- grazing conditions



- transition to deep inelastic processes
- also neutron stripping - proton pick-up
- nucleon evaporation effects
- large energy losses
- deviation from grazing conditions

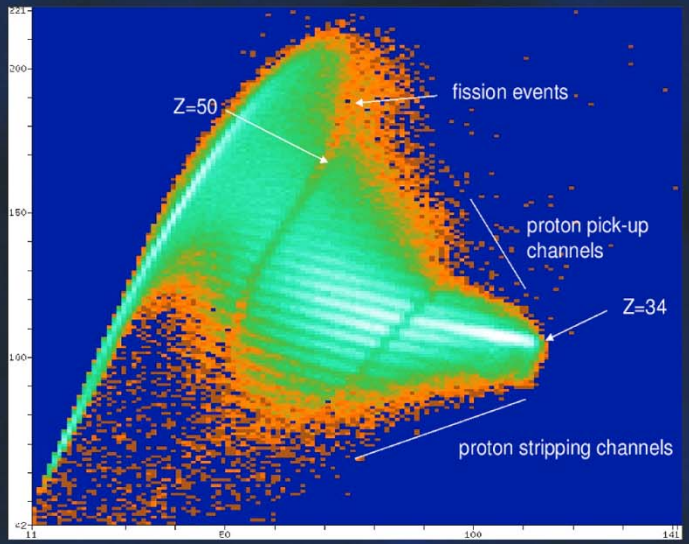
more pronounced at forward angles



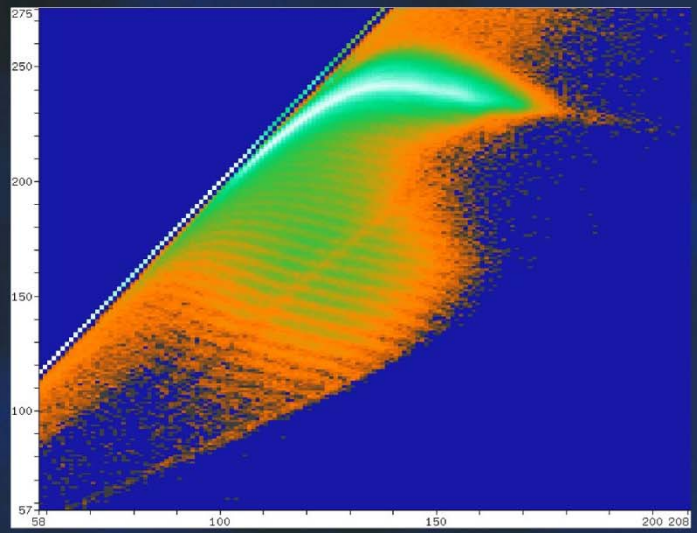


QUASI-ELASTIC, DEEP-INELASTIC AND FISSION EVENTS

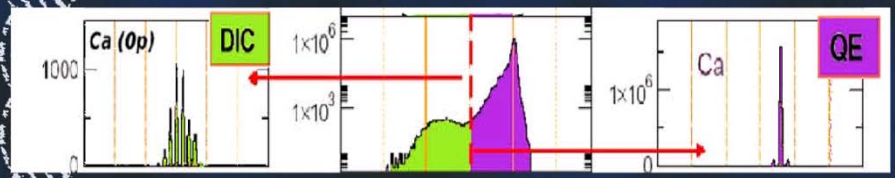
82Se+238U E(lab)=505 MeV

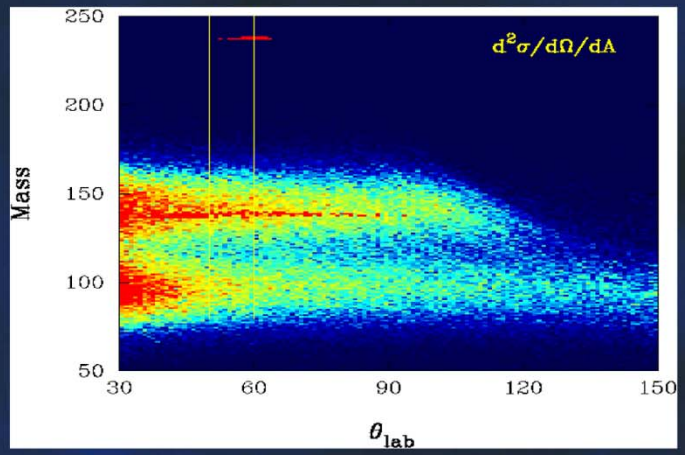


136Xe+238U E(lab)=960 MeV



48Ca+238U





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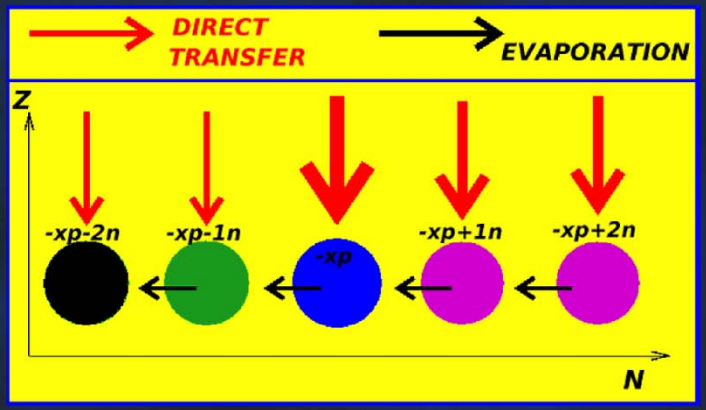
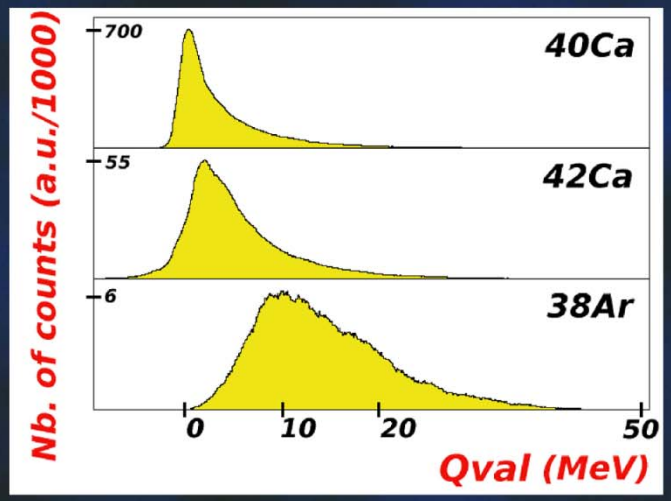
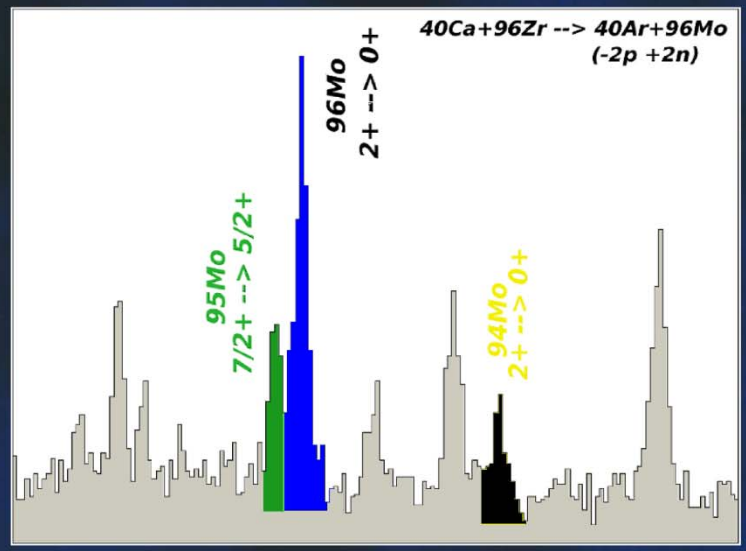
Effects of EVAPORATION







binary reaction --> heavy partner

Final fragments are produced at high ecitation energy

Projectile-like fragment is detected --> binary reaction --> Doppler correction for target-like

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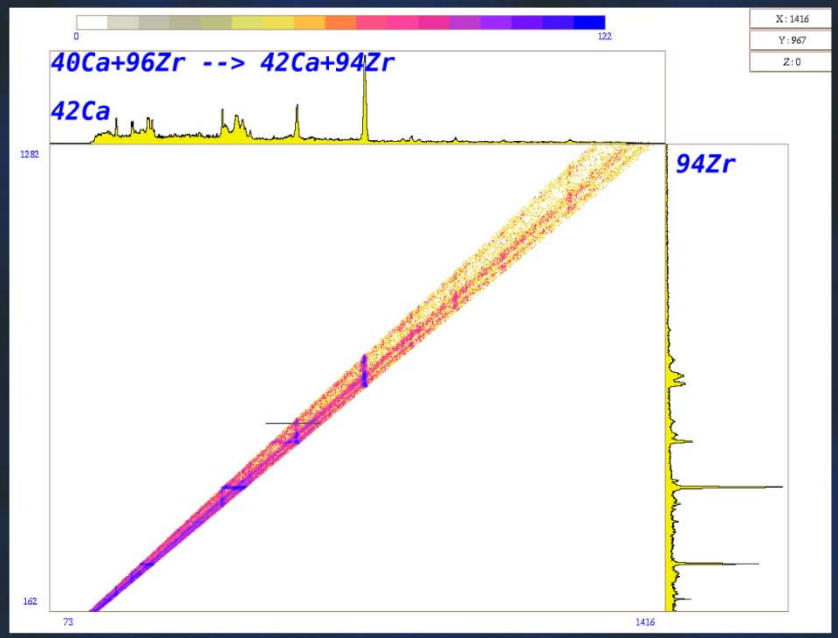
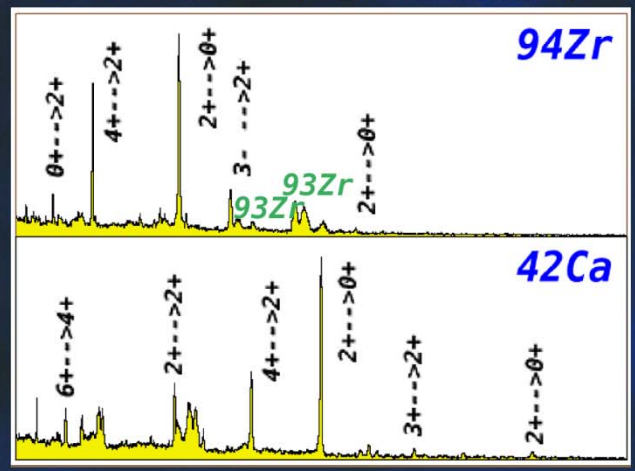
Effects of EVAPORATION

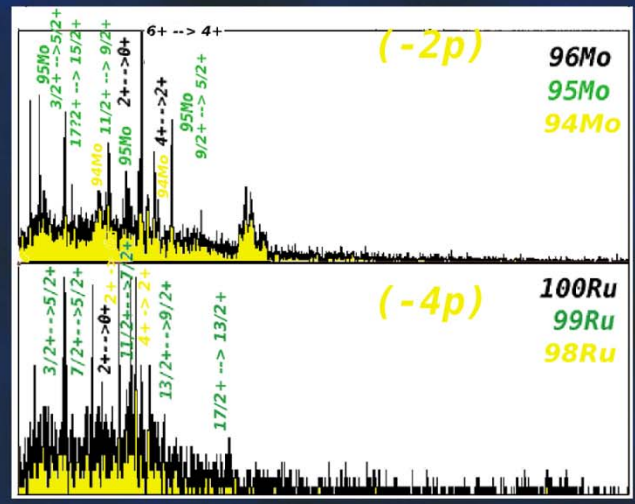


42Ca+94Zr (+2n channel)



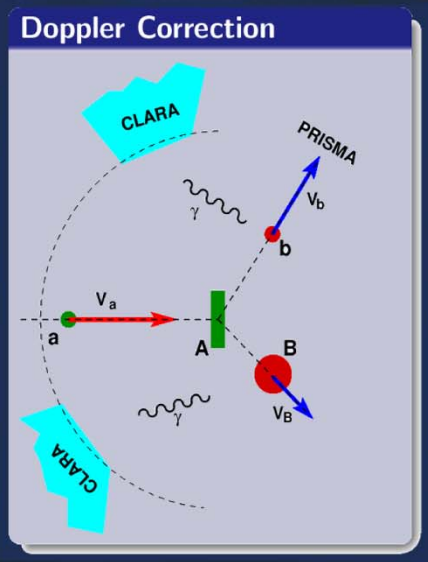
94Zr 91%
93Zr 9%

"target like"



96Mo 66%
95Mo 24%
94Mo 18%

100Ru 2%
99Ru 42%
98Ru 56%



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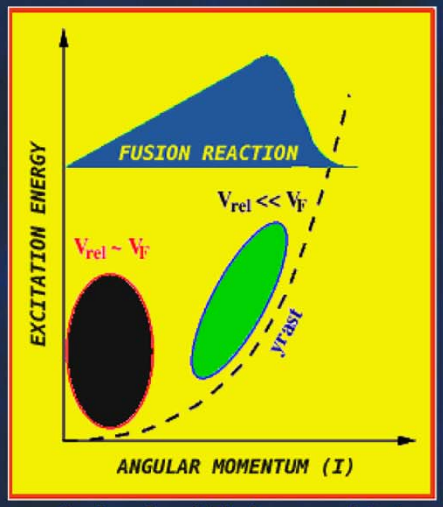
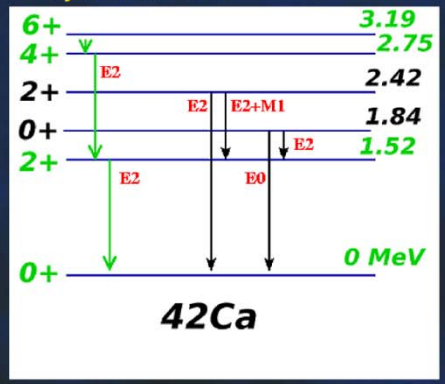
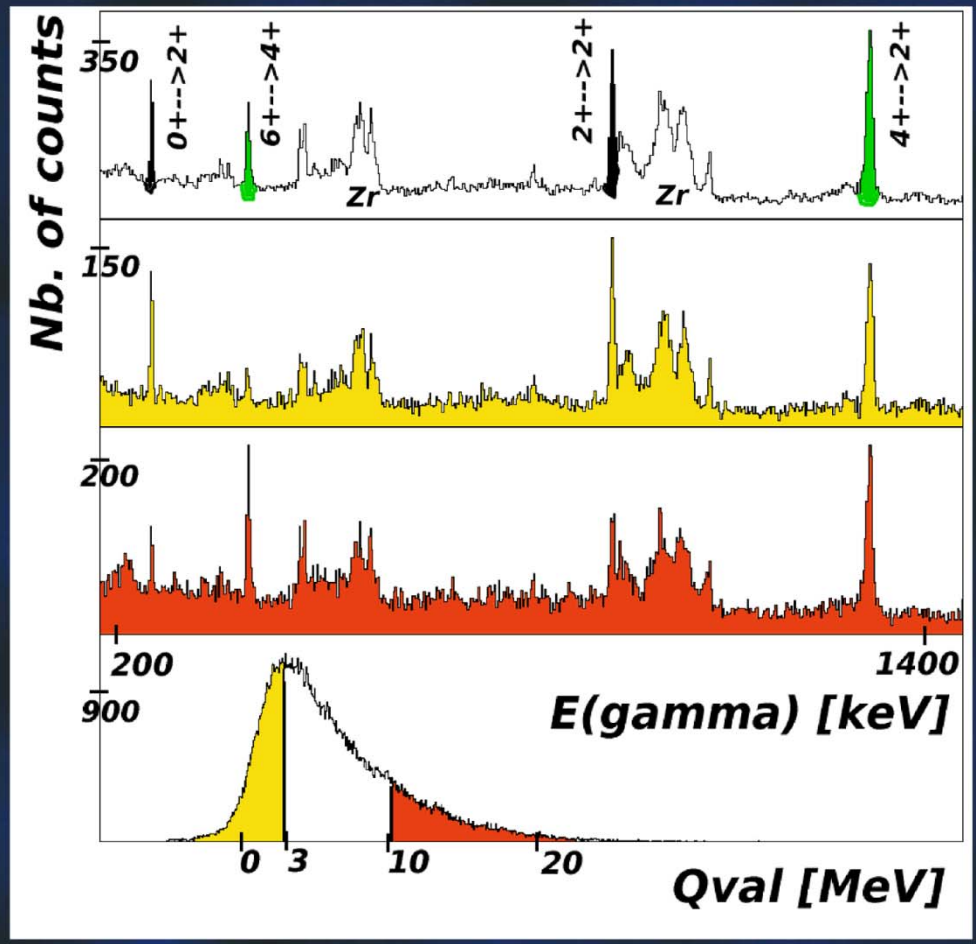
Selectivity in angular momentum



Regions in a (I,E) plane populated by MNT reactions



42Ca (+2n channel)



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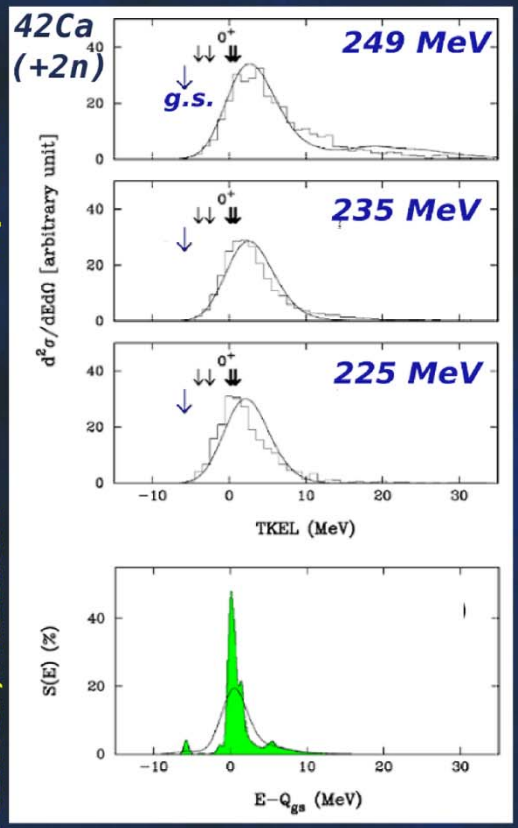
Population of PAIRING-VIBRATIONAL states

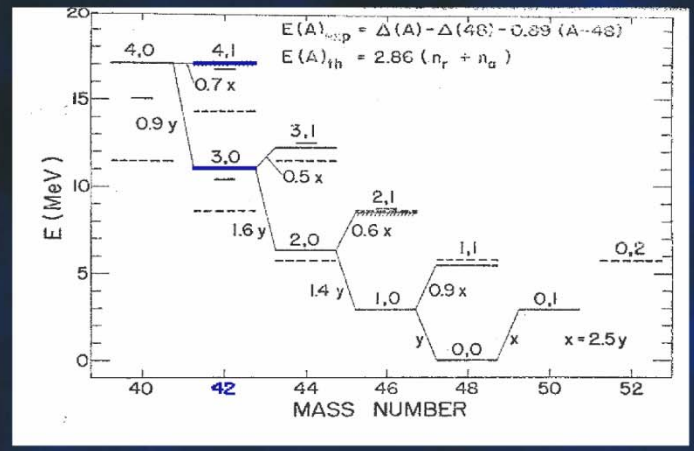


exp+CWKB

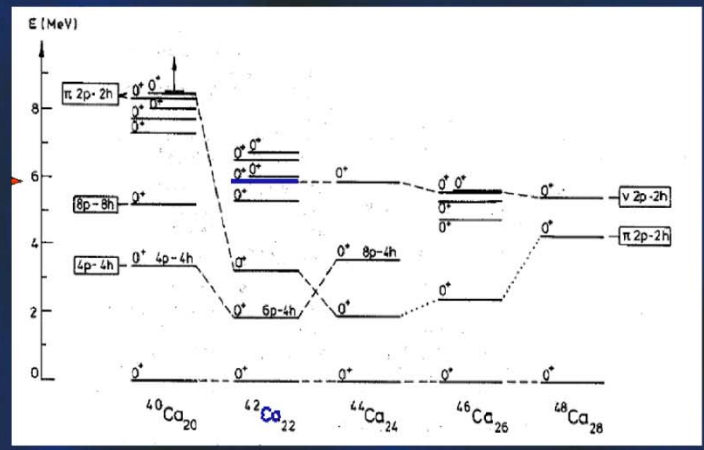
shell model
E.Caurier,F.Nowacki

S.Szilner, EPJA 21 (2004) 87

PAIRING-VIBRATION MODEL



0+ states in 40 - 48 Ca



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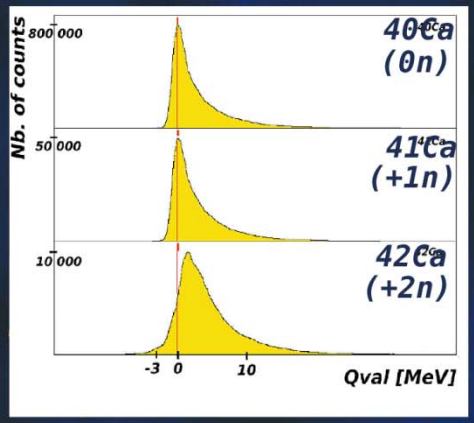
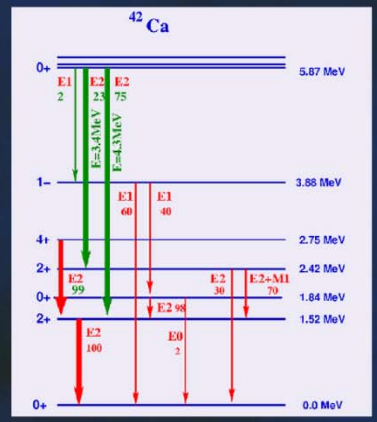
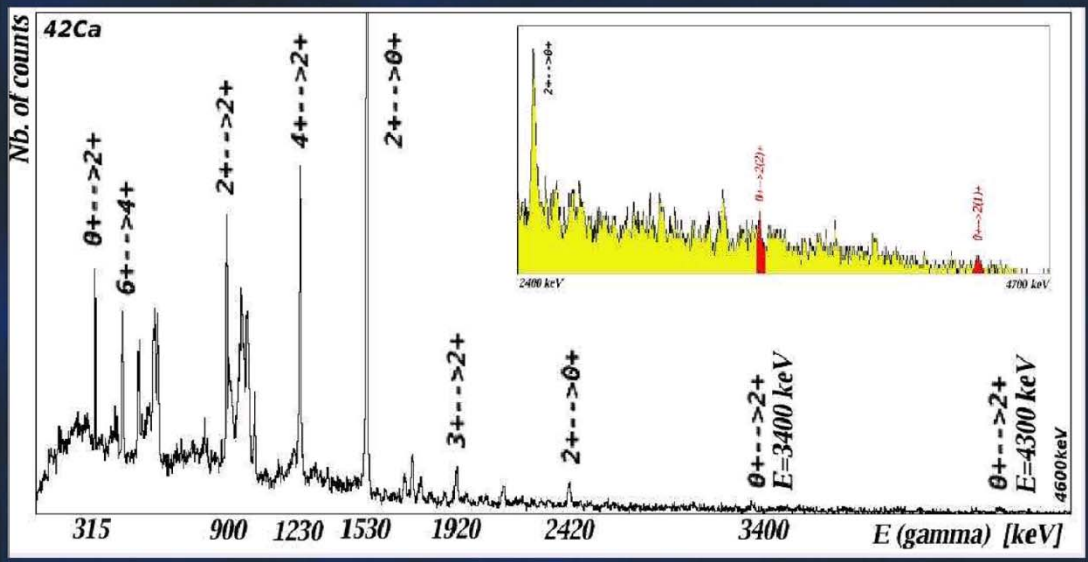
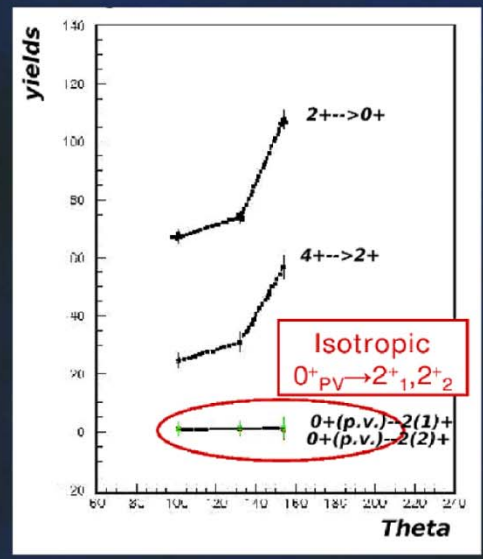
Population of PAIRING-VIBRATIONAL states









S.Szilner, PRC 76 (2007) 024604

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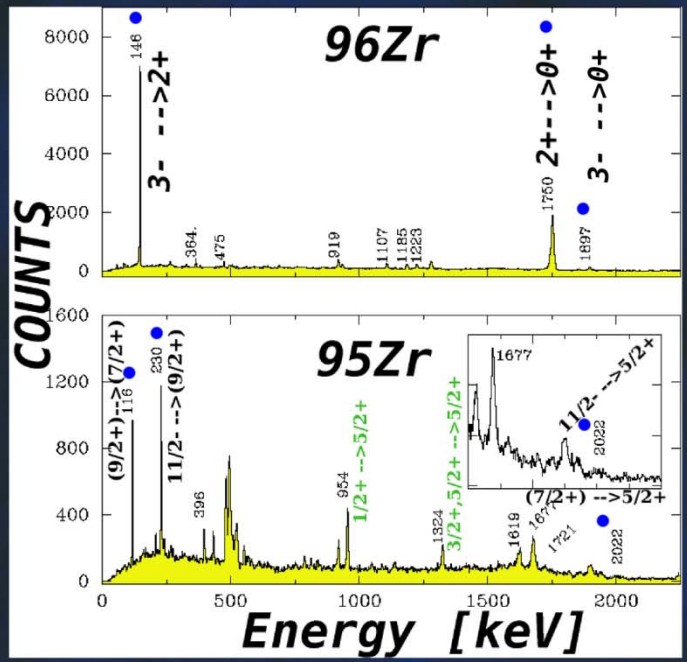
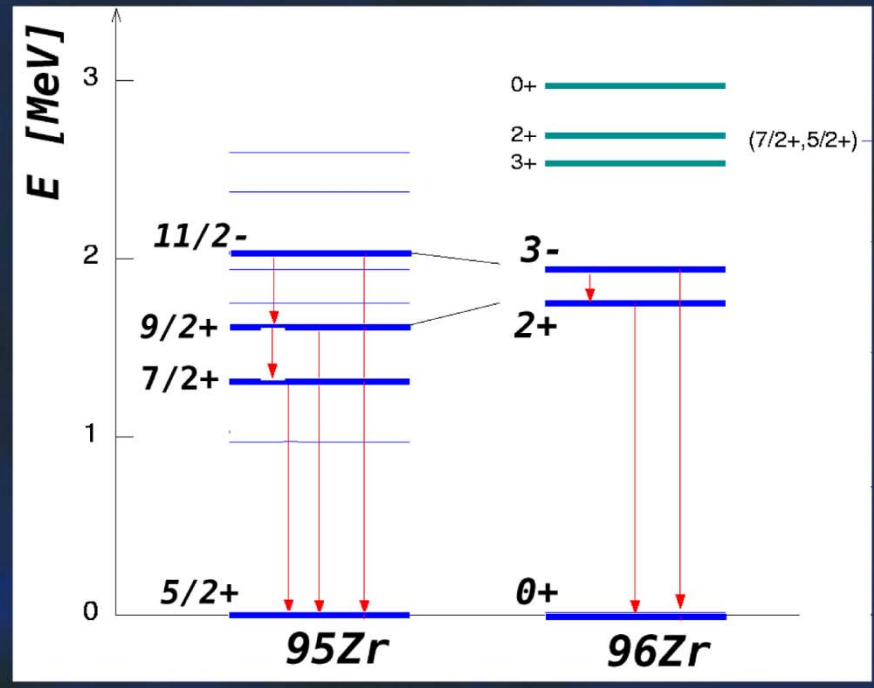
Population of particle-boson states





$$(d_{5/2})^- \otimes 3^- \rightarrow 1/2^-, 3/2^-, ..., 11/2^-$$
$$(d_{5/2})^- \otimes 2^+ \rightarrow 1/2^+, 3/2^+, ..., 9/2^+$$

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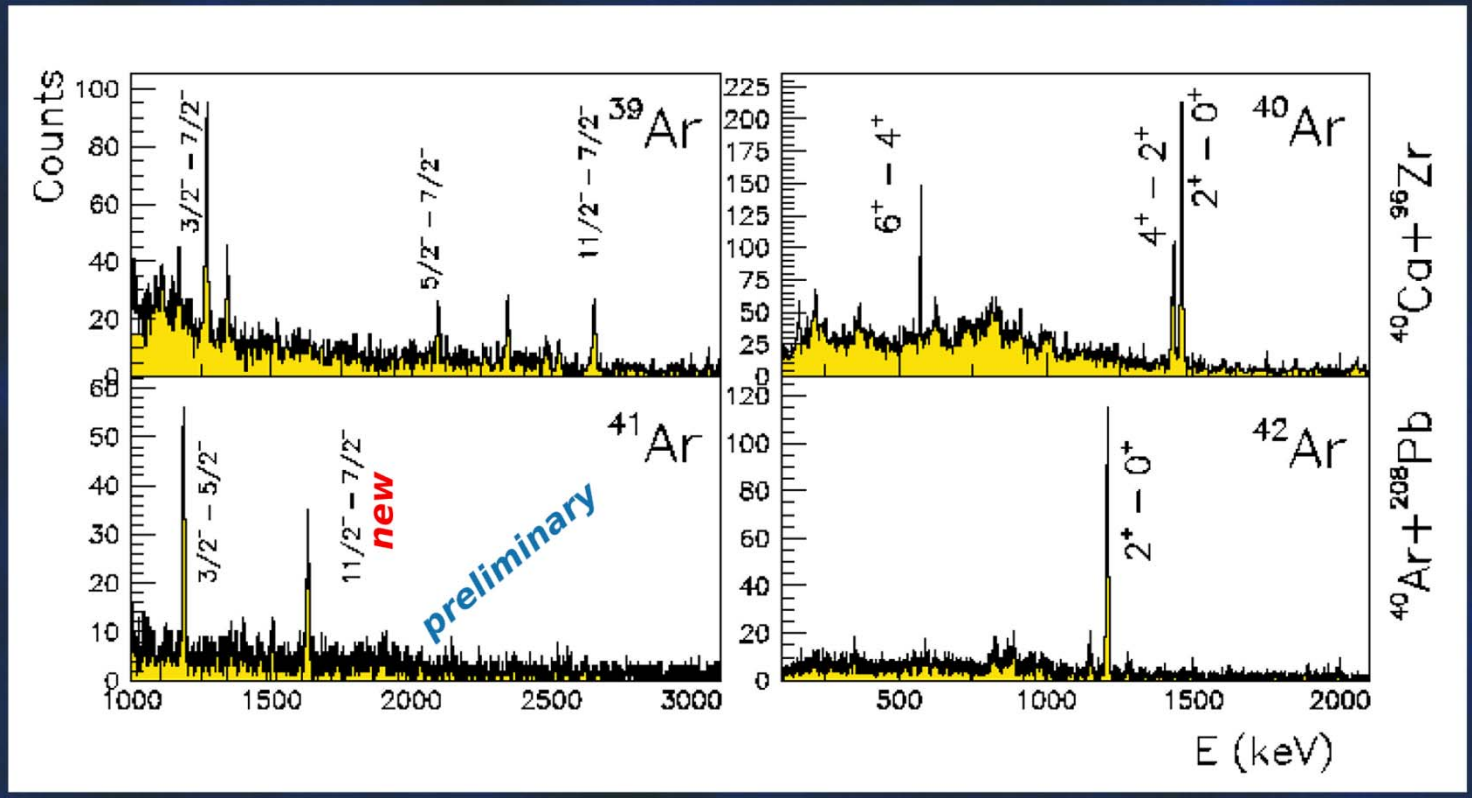
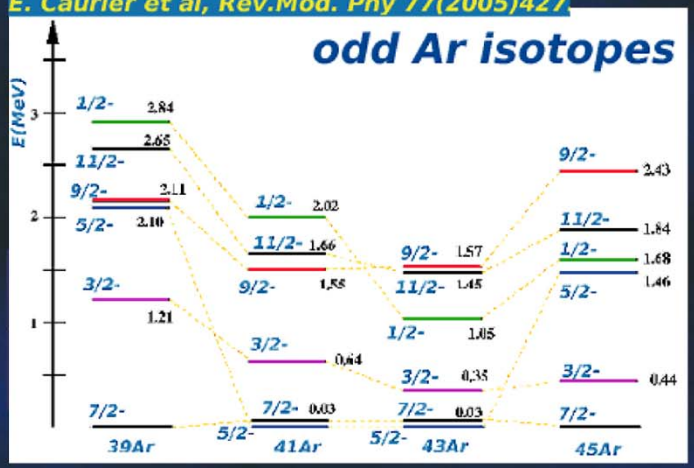
Population of particle-boson states



E. Caurier et al, Rev.Mod. Phy 77(2005)427



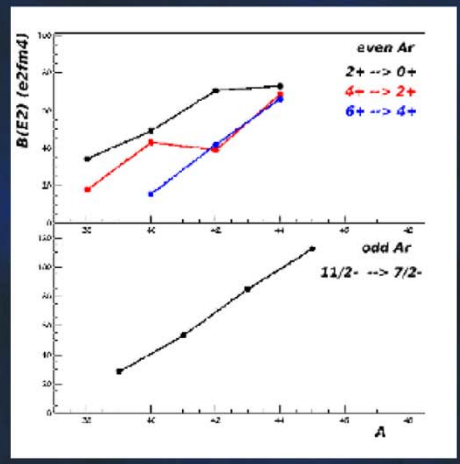
SHELL MODEL:

p -sd, n-sd & fp shells

16O core

cal: D. Lebhertz

2+ x f7/2 --> 11/2-, ...



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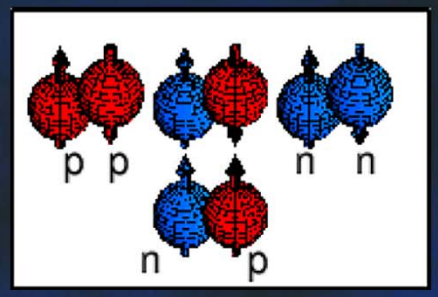
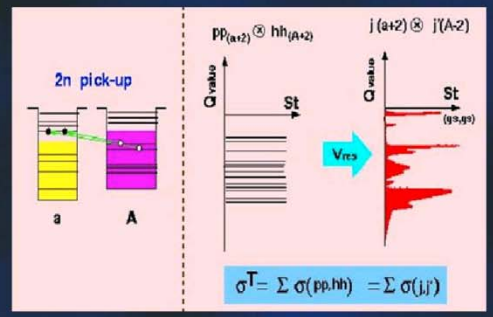
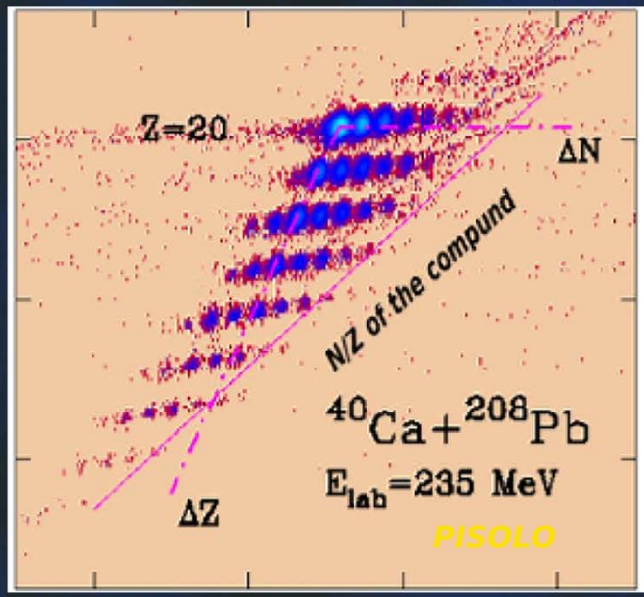
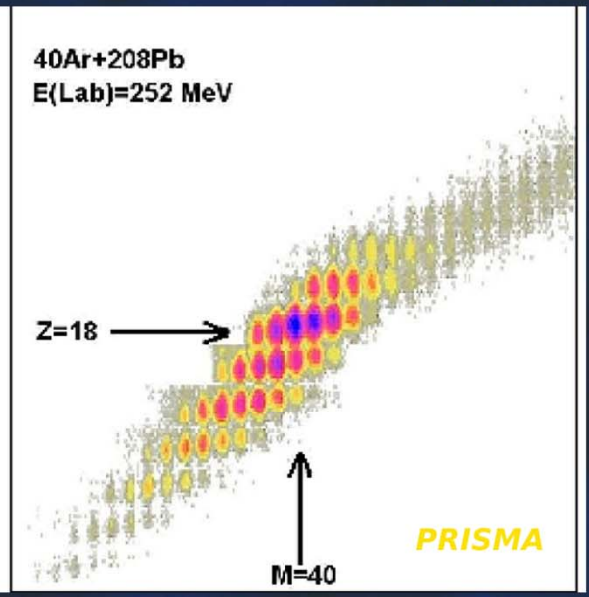
Nucleon-nucleon correlations

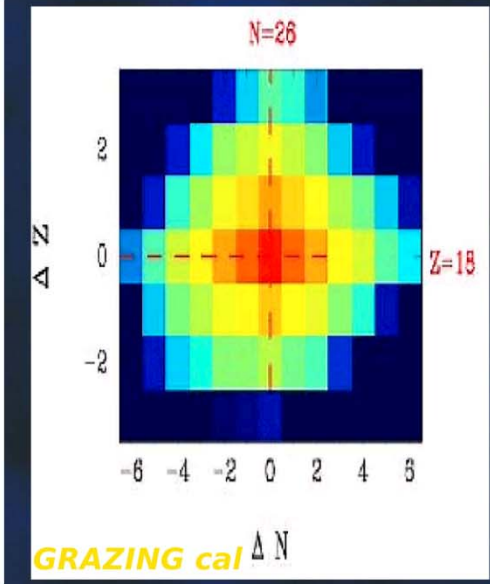




target:208Pb beam:40Ca 40Ar 44Ar







Z (channels)

M (channels)

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