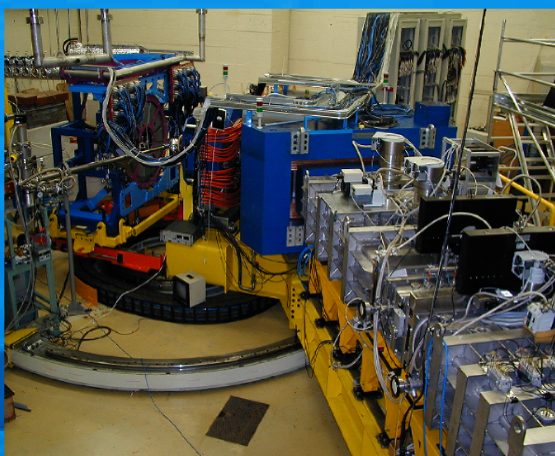
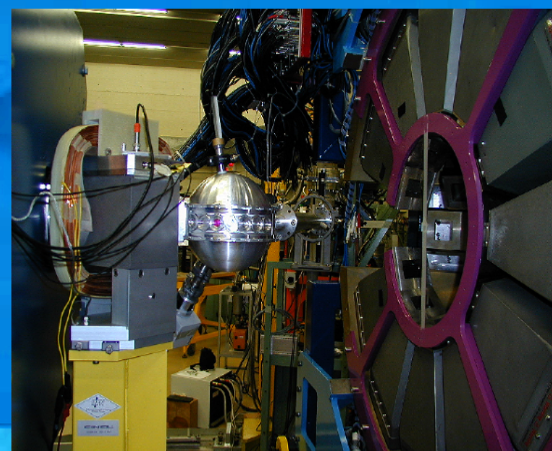
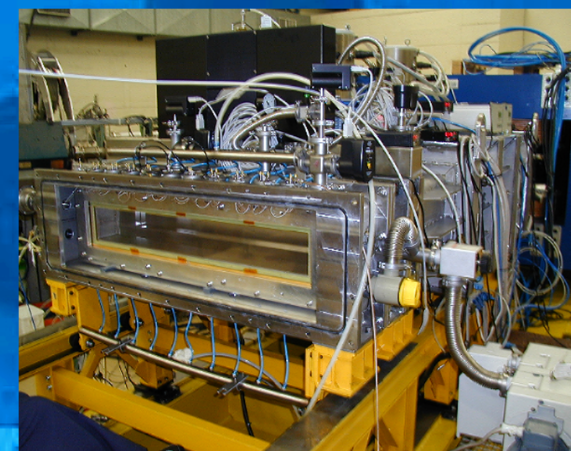
Binary Reactions Explored with PRISMA+CLARA







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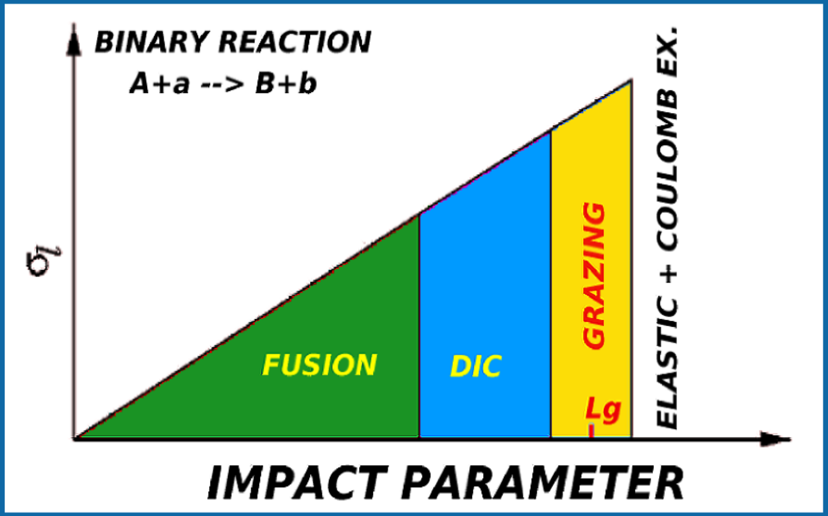
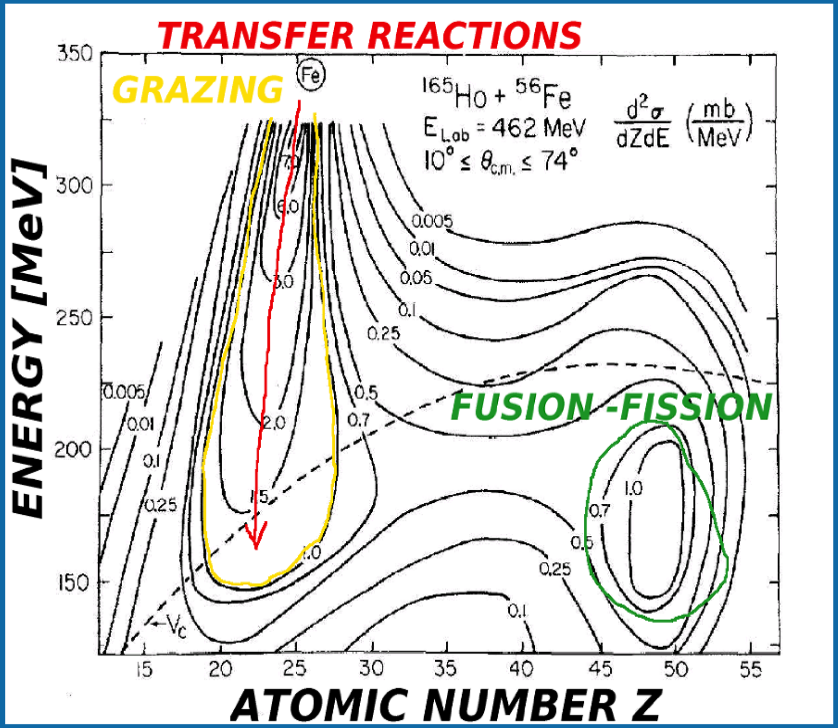
IX International Conference on Nucleus Nucleus Collisions

Reaction mechanism in the grazing regime





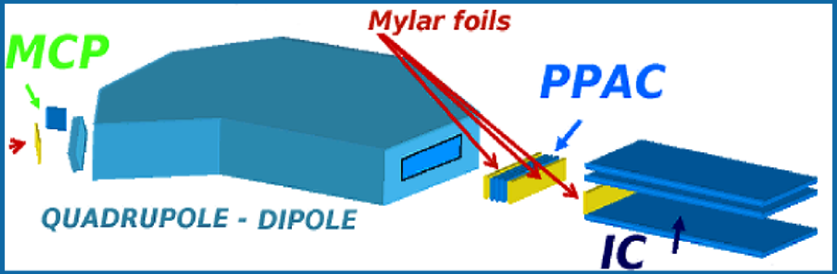
In the grazing regime, where quasi-elastic processes cover ~ 60-80 % of the total flux, we aim to study :

- ***the isotopic distribution***
- ***the role of single particle and pair transfer modes***
- ***transition from quasi-elastic to deep-inelastic***

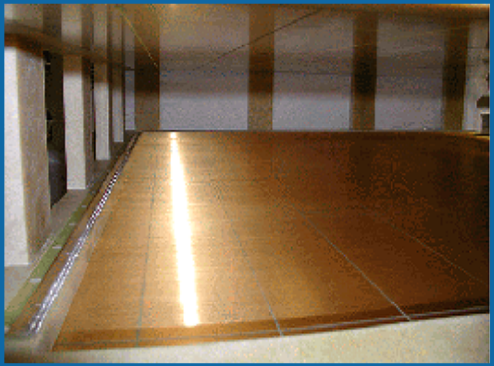
PRISMA+CLARA provides an ideal tool for exclusive gamma-particle coincidence measurements

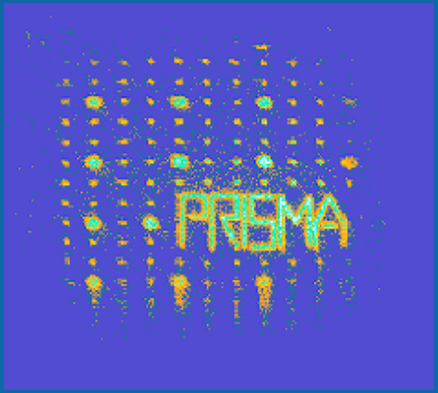
The Magnetic Spectrometer PRISMA

MCP (START detector)



SEGMENTED IONIZATION CHAMBER

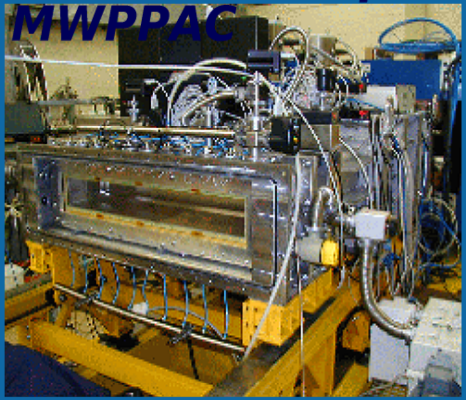


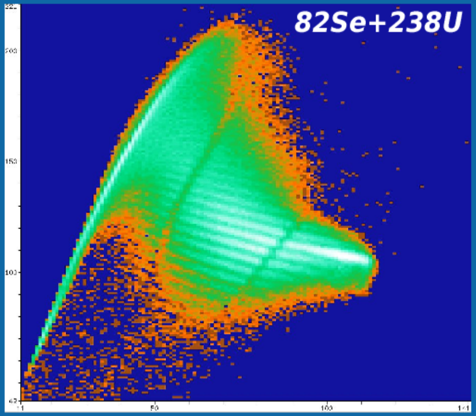


X,Y, TOF-start

X,Y,TOF-stop

MWPPAC





Angular acceptances	$\Delta\theta \approx \pm 6^\circ$ $\Delta\varphi \approx \pm 11^\circ$
Solid angle	$\approx$ 80 msr
Distance target - FPD	7 m
Energy acceptance	$\pm$ 20%
Resolving power	$p/\Delta p \approx 2000$
Mass resolution	1/270 (measured)
Energy resolution	1/1000 (via ToF)
Z resolution	$\leq$ 1/60 (measured)
Count rate capability	up to 2×10^5 sec^{-1}

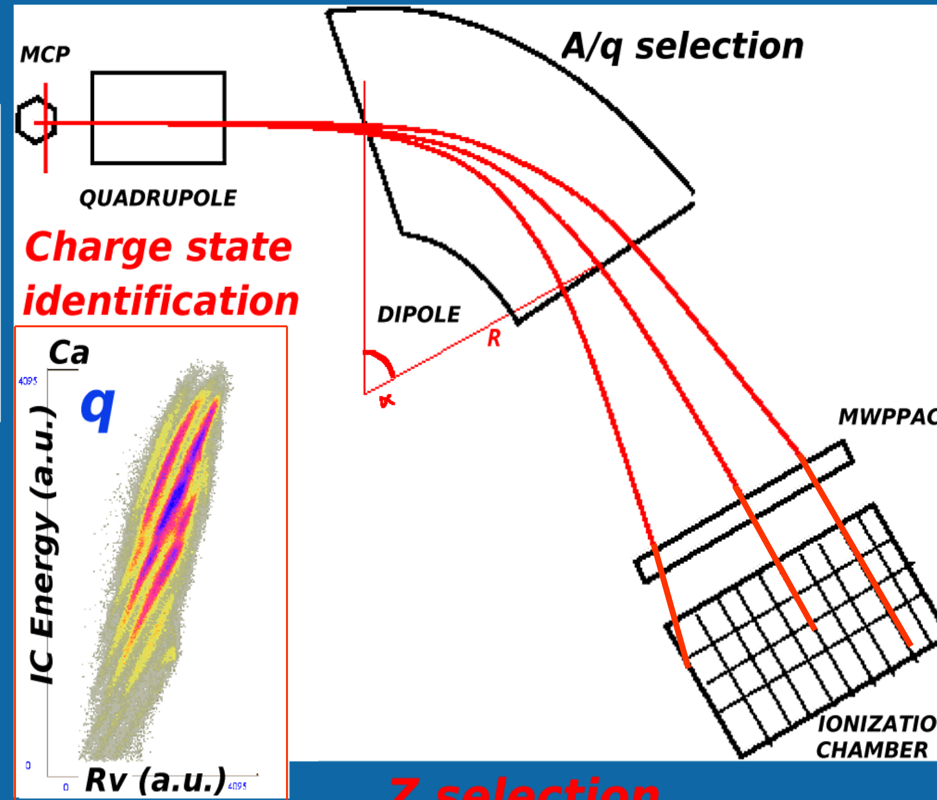
S.Beghini et al, NIM A551,364(2005)
G.Montagnoli et al, NIM A547,455(2005)

Ion Trajectory Reconstruction

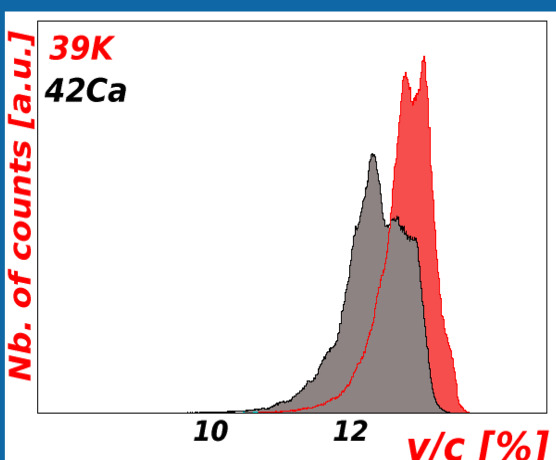
A "raw" physical *event* is composed by a few parameters:

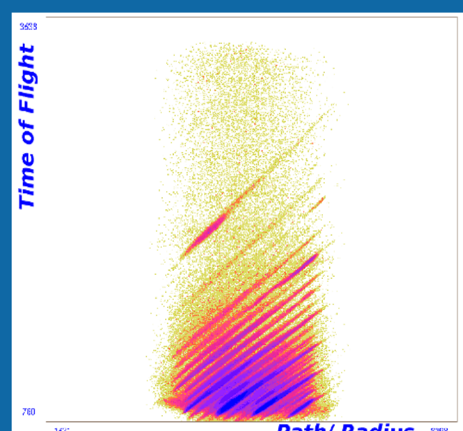
position at the entrance	$x, y \rightarrow (\theta, \phi)$
position at the focal plane	X, Y
time of flight	ToF
energy and energy loss	ΔE, E
coincident γ-rays	$E\gamma$

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

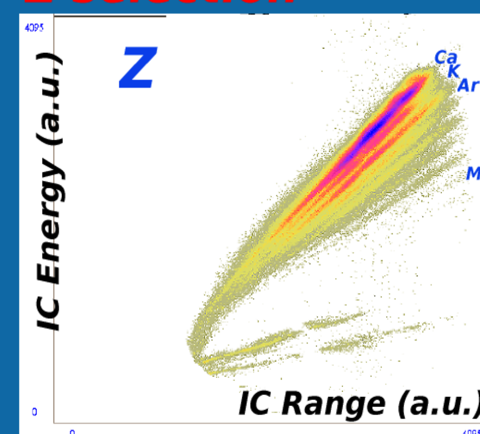


Velocity distribution

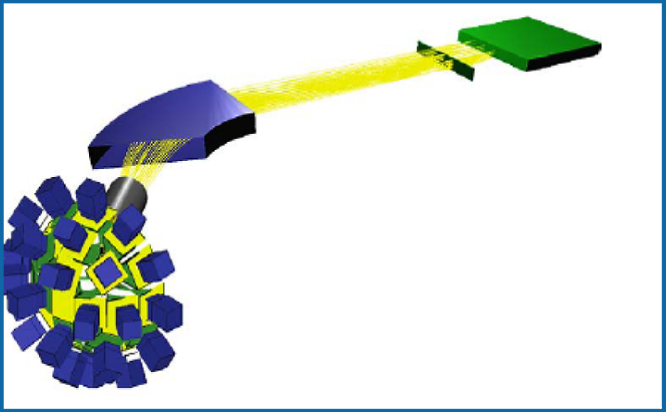


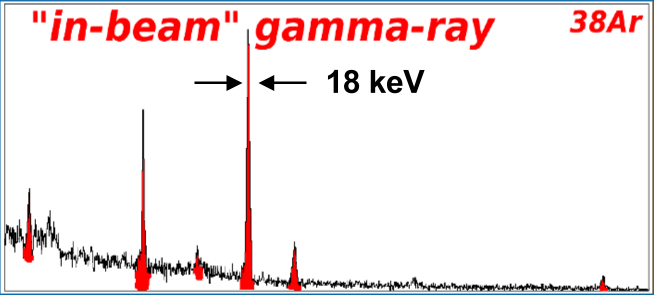


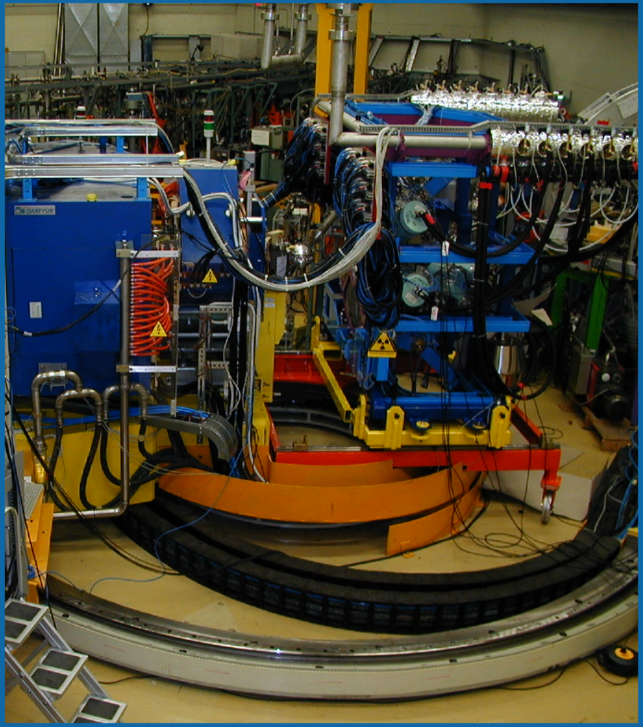
Z selection

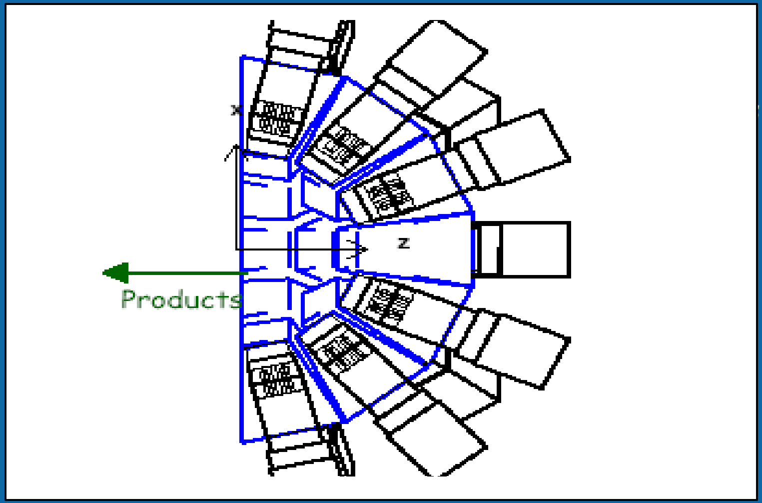


CLARA - Clover Array



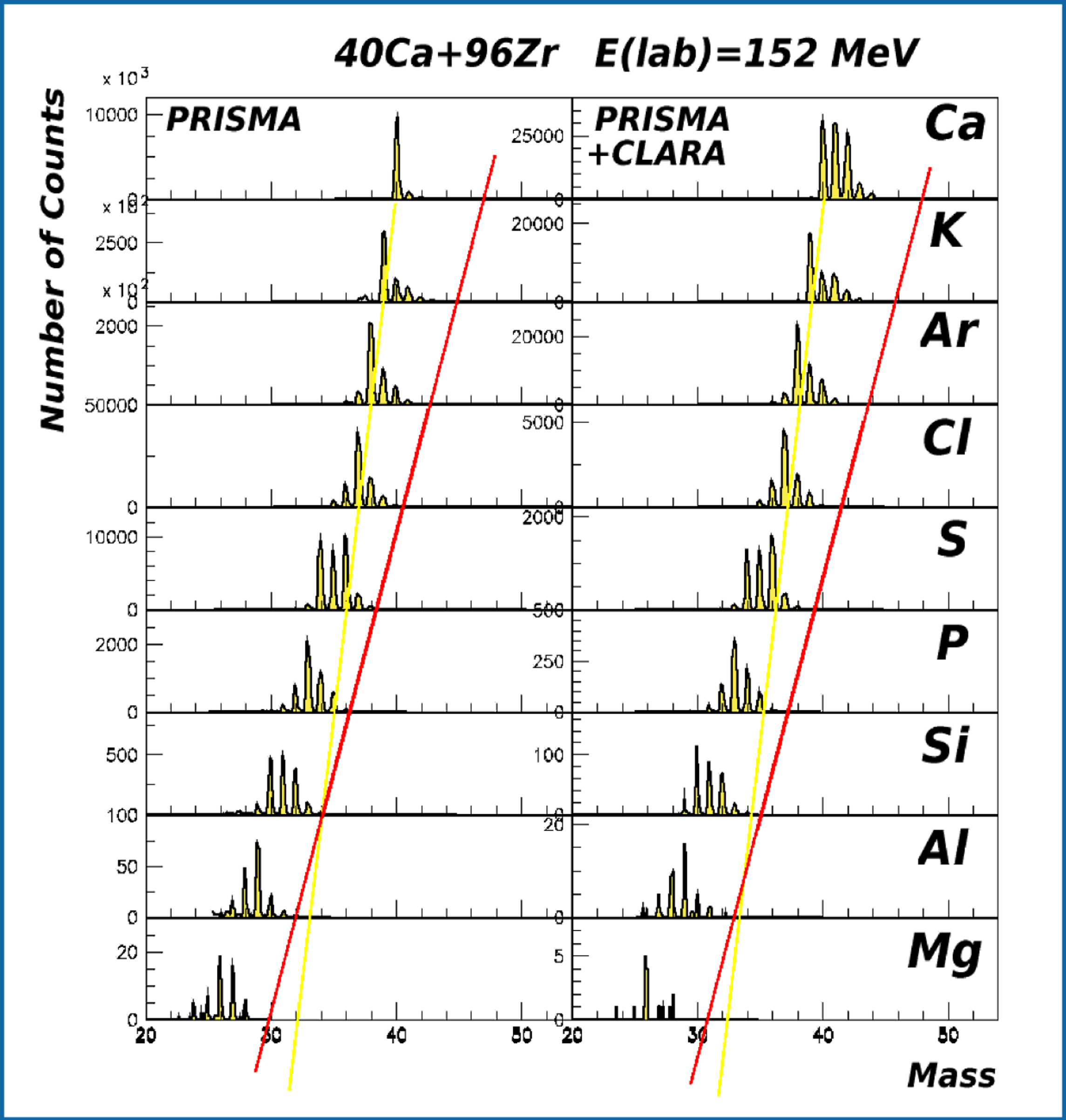


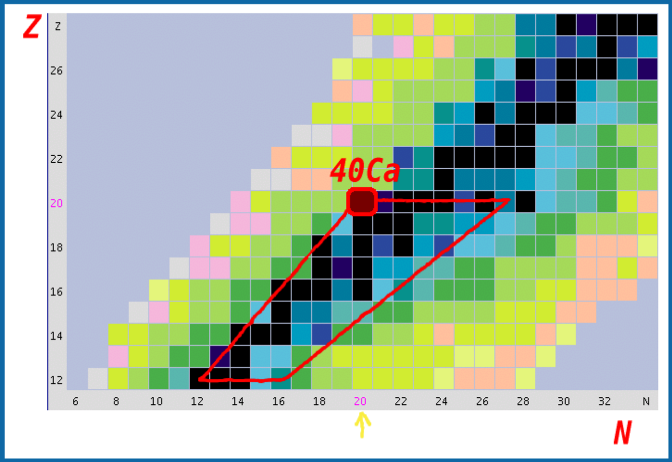




24 to 25 Clovers setup
Efficiency ~ 3 % @ 1.3 MeV
Peak/Total ~ 45 %
Position θ = 103°–180°
FWHM ~ 10 keV
for E_γ = 1.3 MeV @ v/c = 10%

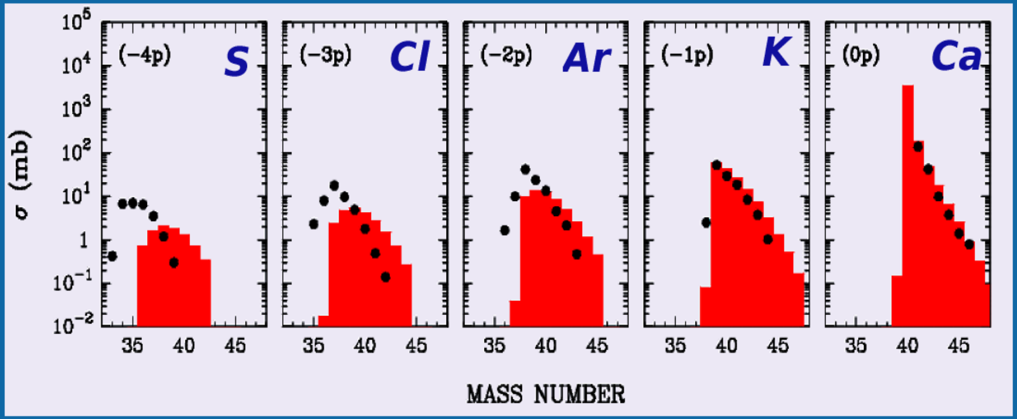
Phenomenology of MNT





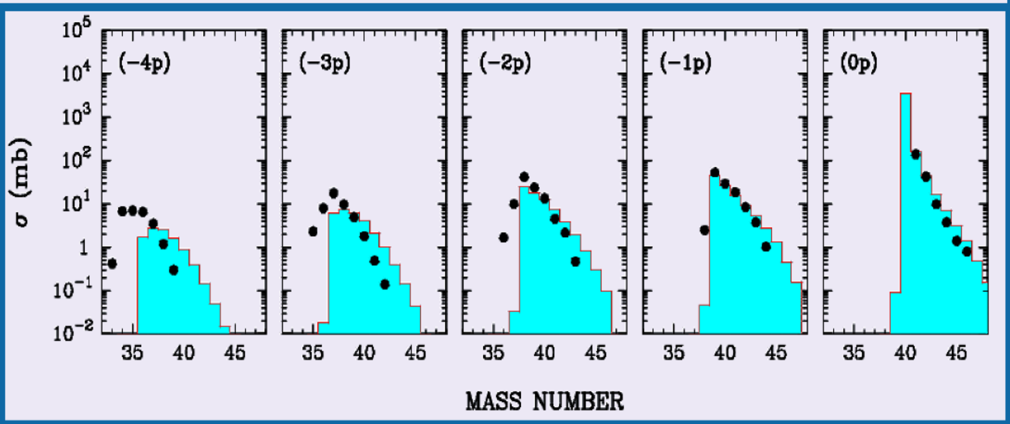
- The system does not reach charge equilibration
- The population in the (N,Z) plane is dictated by Q-optimum
- +1n channel is stronger than -1p; -1p is as strong as -2p (sequential - pair transfer)
- Evaporation strongly influences the final isotopic distribution

Cross sections and comparison with calculations



successive transfer

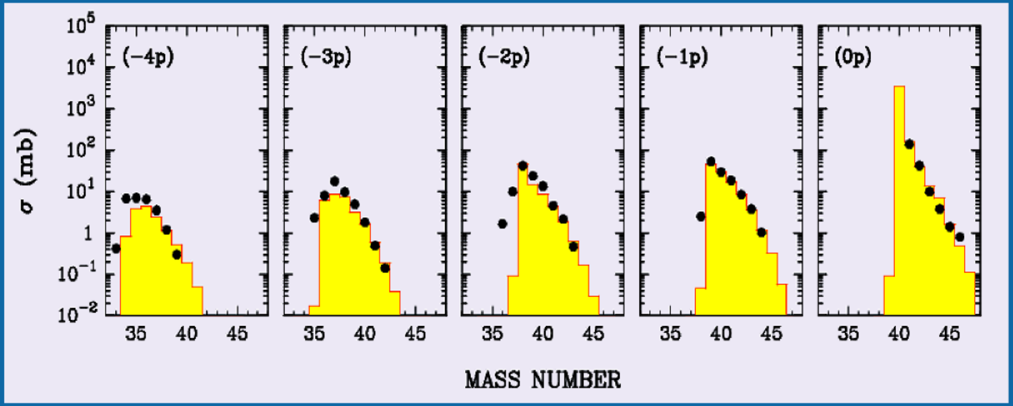
$$c_{\alpha\beta} = -\frac{1}{\hbar^2}\sum_{\gamma}\int_{-\infty}^{+\infty} dt\, f^{(1)}_{\alpha\gamma}(\vec{R}(t))\, e^{-i(Q_{\alpha\gamma}-Q^{opt}_{\alpha\gamma})t} \int_{-\infty}^{t} dt'\, f^{(1')}_{\gamma\beta}(\vec{R}(t'))\, e^{-i(Q_{\alpha\gamma}-Q^{opt}_{\alpha\gamma})t'}$$



+simultaneous transfer

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

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



+evaporation

CWKB calculation by G. Pollarolo

Complex WKB theory

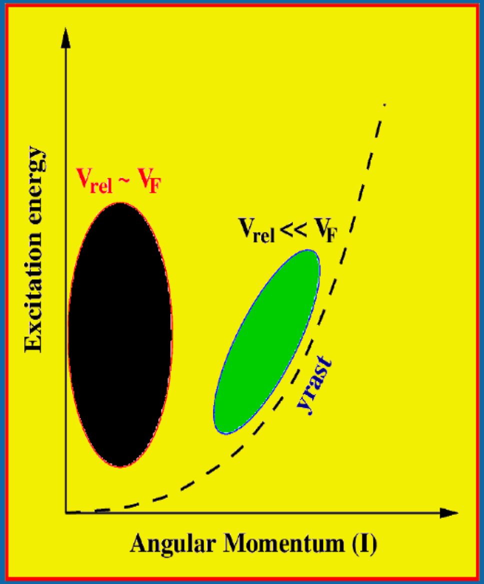
E.Vigezzi and A.Winther, Ann.of Phys. 192, 432 (1989)

40Ca+208Pb E(lab)=249 MeV

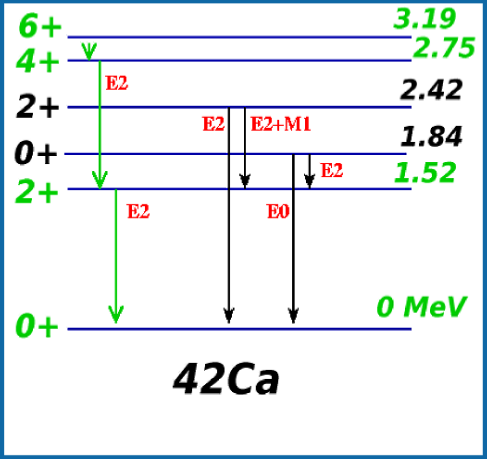
S.Szilner et al, PRC 71, 044610 (2005)

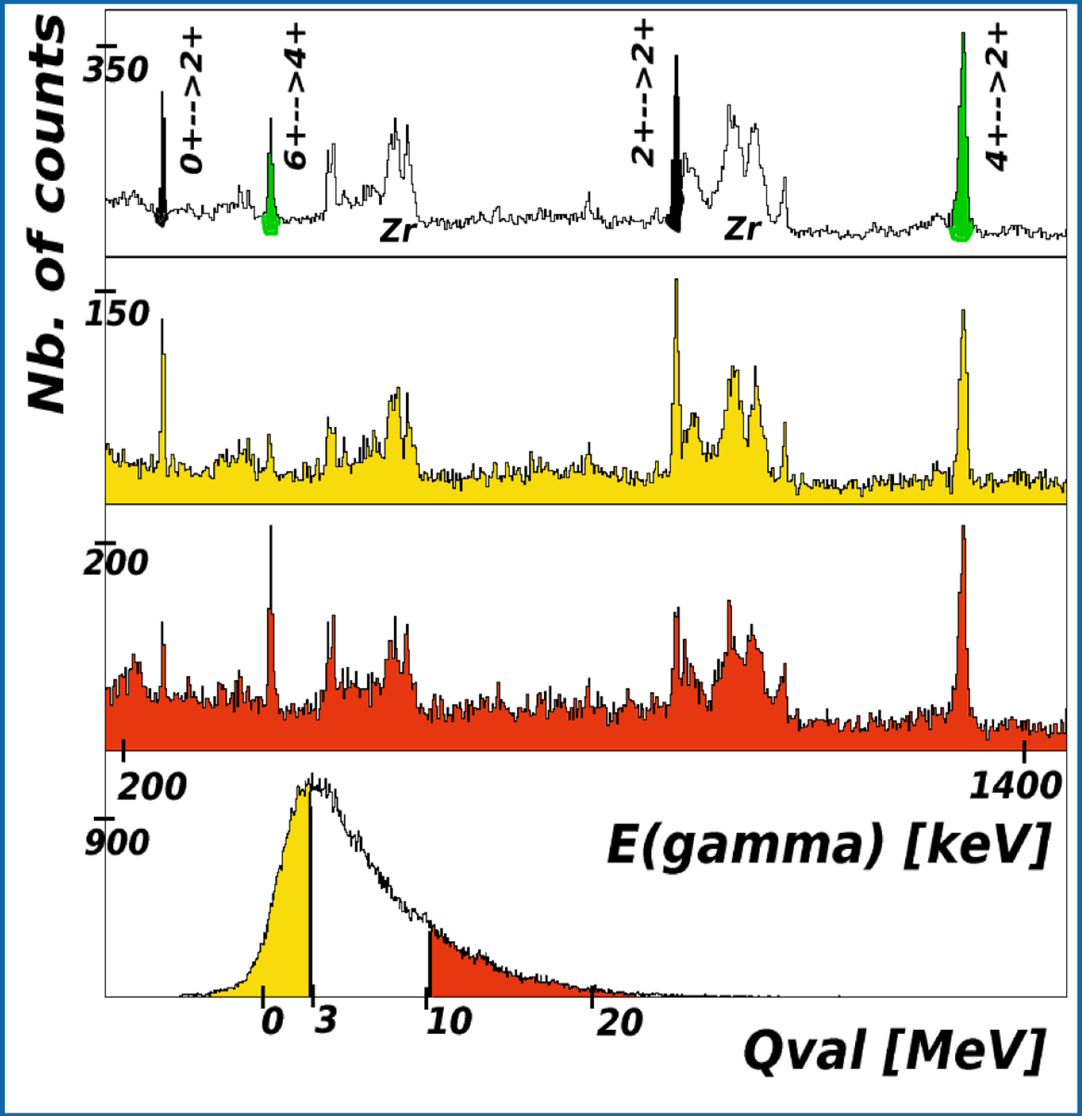
Selectivity in angular momentum

42Ca



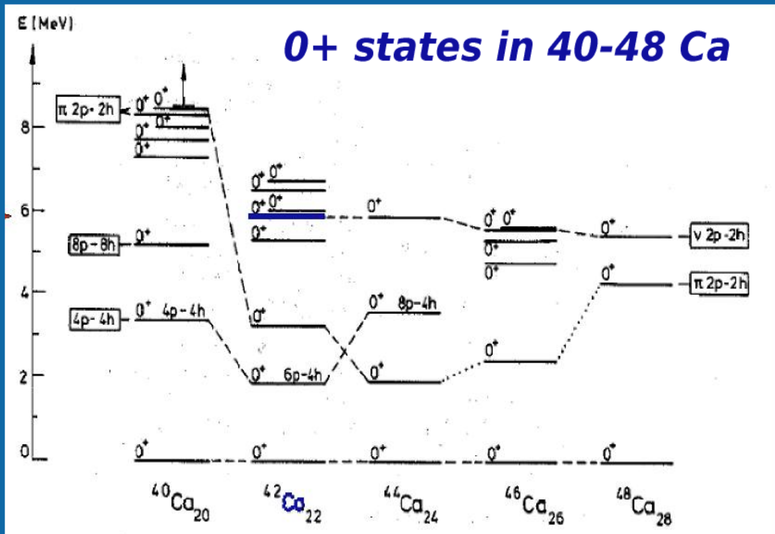
Regions in a (I,E) plane populated by MNT reactions

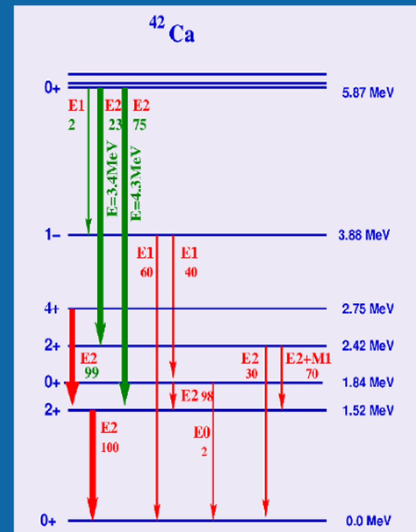


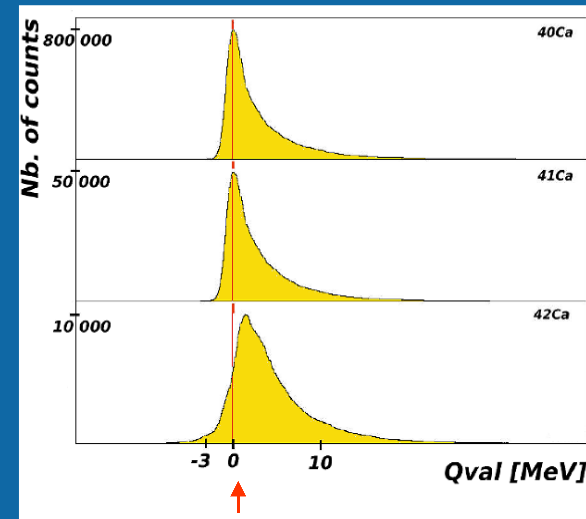


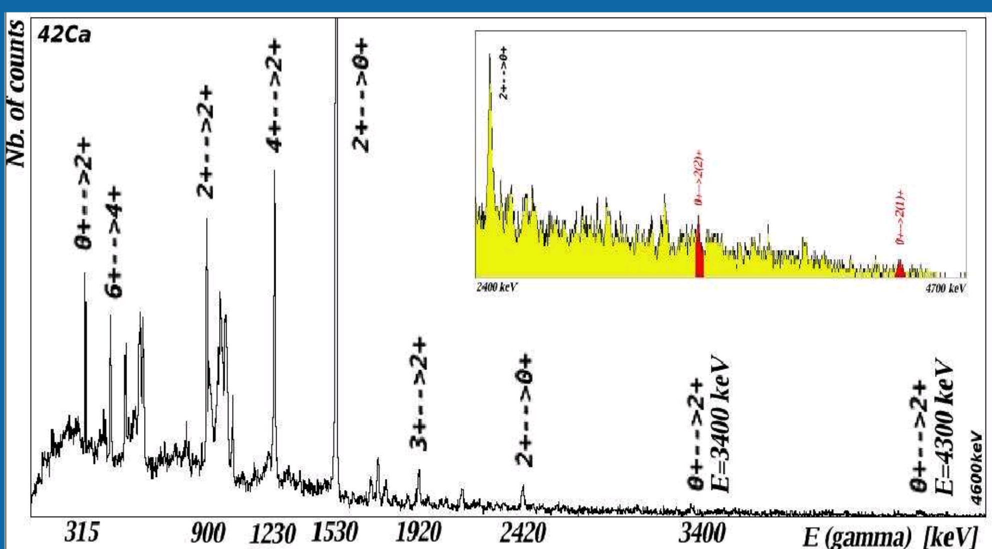
TKEL distributions as a selection tool

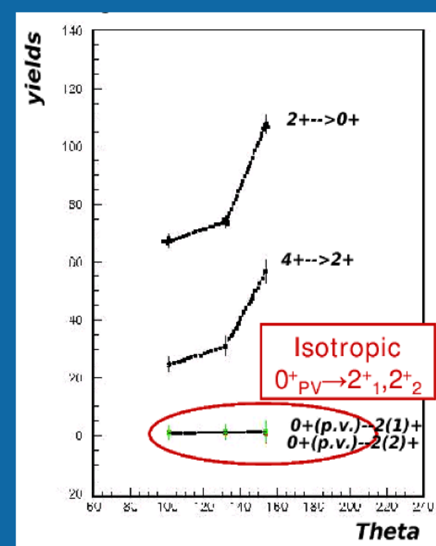
Population of PAIRING-VIBRATIONAL states

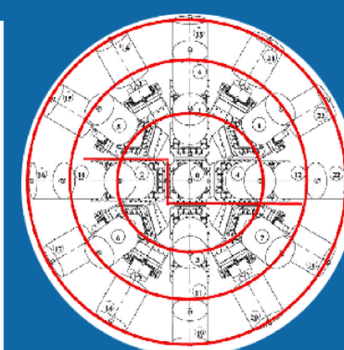






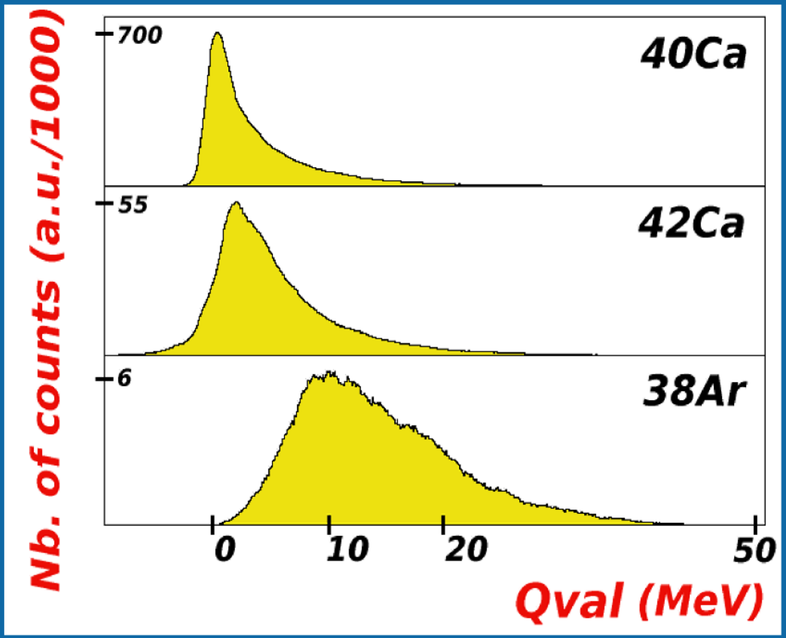


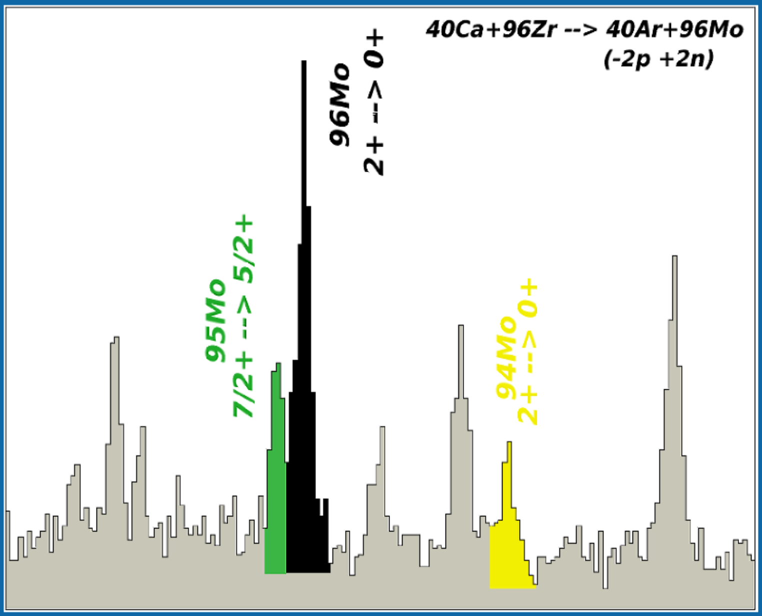




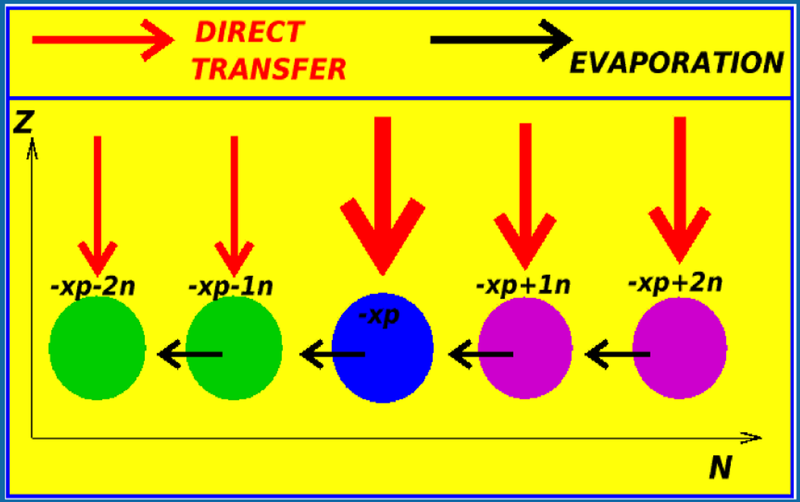
Angular Distribution of $4^+ \rightarrow 2^+$ and $2^+ \rightarrow 0^+$ transitions indicates: $\sigma/J \sim 0.3$

Effects of EVAPORATION





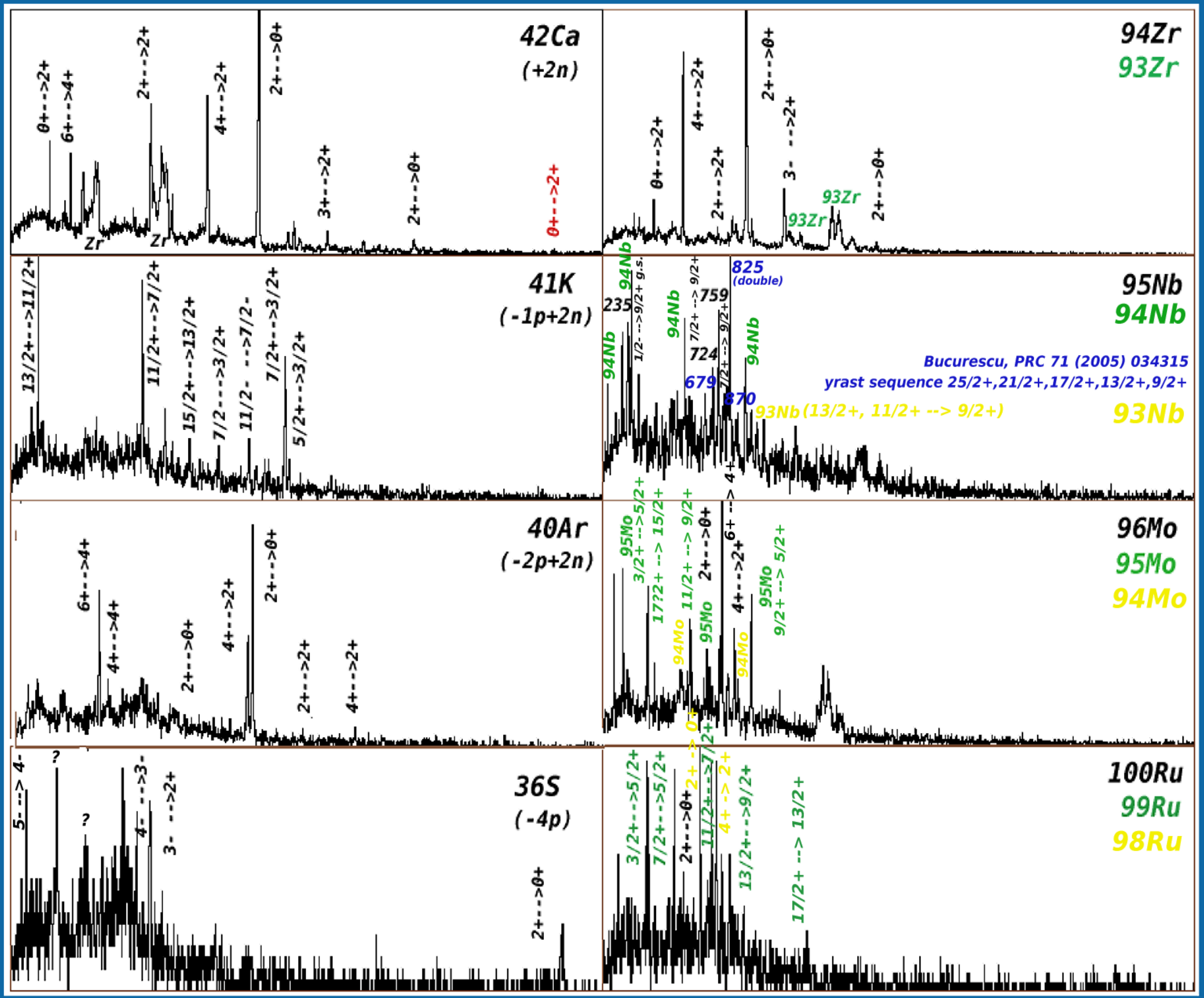
Binary reaction --> heavy partner



Final fragments are produced at high ecitation energy

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

40Ca+96Zr E(lab)=152 MeV



94Zr 91%
93Zr 9%

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

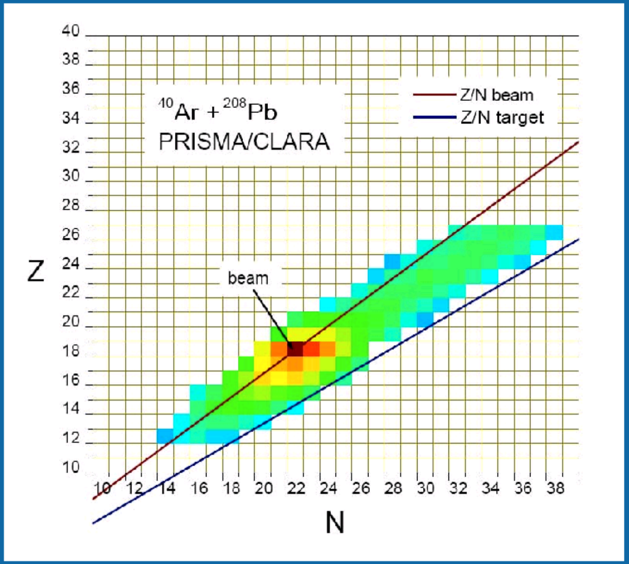
100Ru 2%
99Ru 42%
98Ru 56%

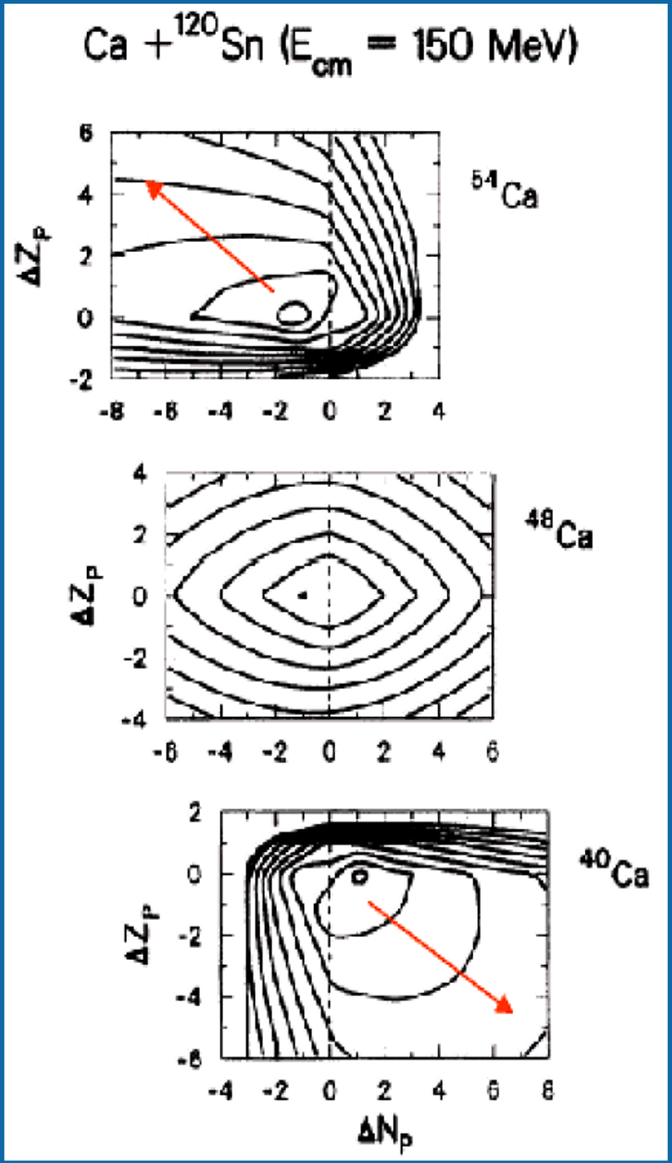
projectile-like

target-like

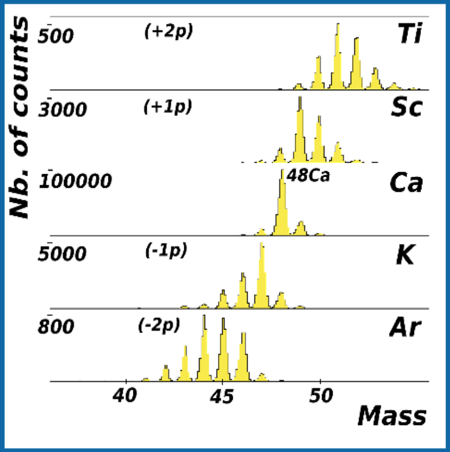
Summary and outlook

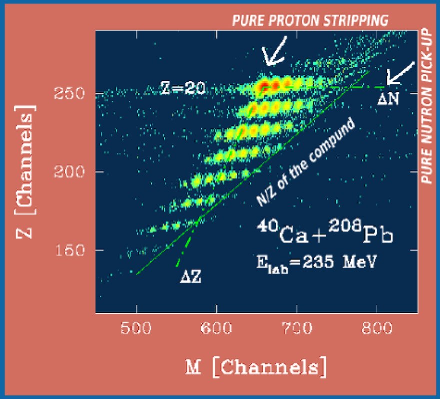
PIAVE+ALPI beam test
40Ar+208Pb, N.Marginean





48Ca+238U, R. Broda



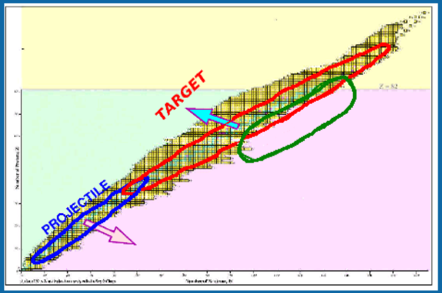


C.H.Dasso, G.Pollarolo, A.Winther
PRL 73, 1907 (1994)

40Ca+208Pb

STABLE beams: neutron-rich projectile-like and proton-rich target-like

Neutron-rich nuclei only by using NEUTRON-RICH RADIOACTIVE beams on heavy targets



^{36}S+^{208}Pb Search for excited states in neutron rich Mg,Si,S

X.Liang (Paisley), F.Asaiez (Orsay)

^{64}Ni+^{238}U Spectroscopy of deformed neutron rich A~60 nuclei

S.Lenzi (Padova), S.Freeman (Manchester)

^{82}Se+^{238}U Nuclear spectroscopy of neutron rich nuclei in the N=50 region

G.de Angelis (LNL), G.Duchene (Strasbourg)

^{90}Zr+^{208}Pb Pair transfer effects in ^{90}Zr+^{208}Pb

L.Corradi (LNL)

^{54}Fe+^{50}Cr Identification of the 6^{+} state in ^{54}Co

A.Gadea (LNL)

^{32}S+^{58}Ni Excited states in ^{31}S

N.Marginean, D.R.Napoli (LNL)

^{24}Mg+^{24}Mg Resonances in ^{24}Mg+^{24}Mg and molecular states in ^{48}Cr

F.Haas (Strasbourg)

^{40}Ca+^{96}Zr Decay properties of pairing vibration states populated in transfer reactions

S.Szilner (Zagreb)

^{40}Ca+^{90,96}Zr Large angle scattering of ^{40}Ca+^{90,96}Zr

G.Montagnoli,A.Stefanini (LNL)

^{48}Ca+^{238}U Shell model states in neutron rich nuclei near ^{48}Ca

R.Broda (Crakow)

^{82}Se+^{170}Os Collective and symmetry studies around the ^{170}Dy valence maximum

P.Regan (Surrey)

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