The PRISMA spectrometer: what we learned so far

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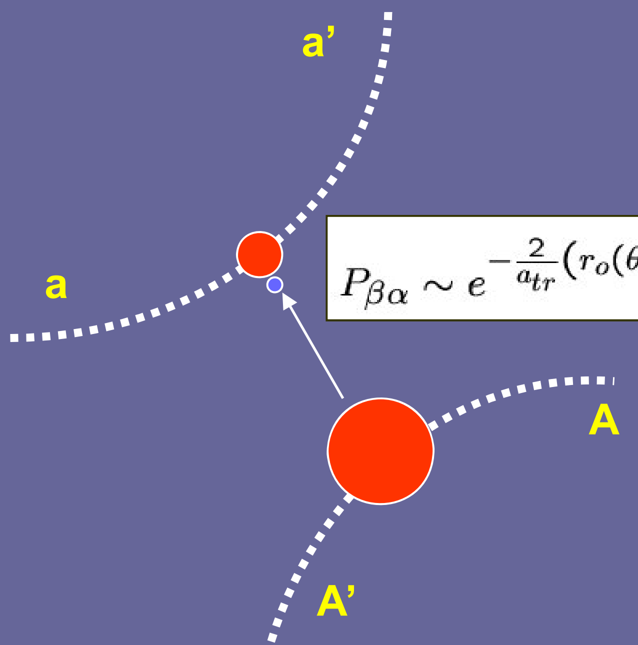
IRIS Workshop, GSI, March 1, 2010

Transfer reactions among heavy ions



$$P_{\beta\alpha} \sim e^{-\frac{2}{a_{tr}}(r_o(\theta)-R_o)}$$

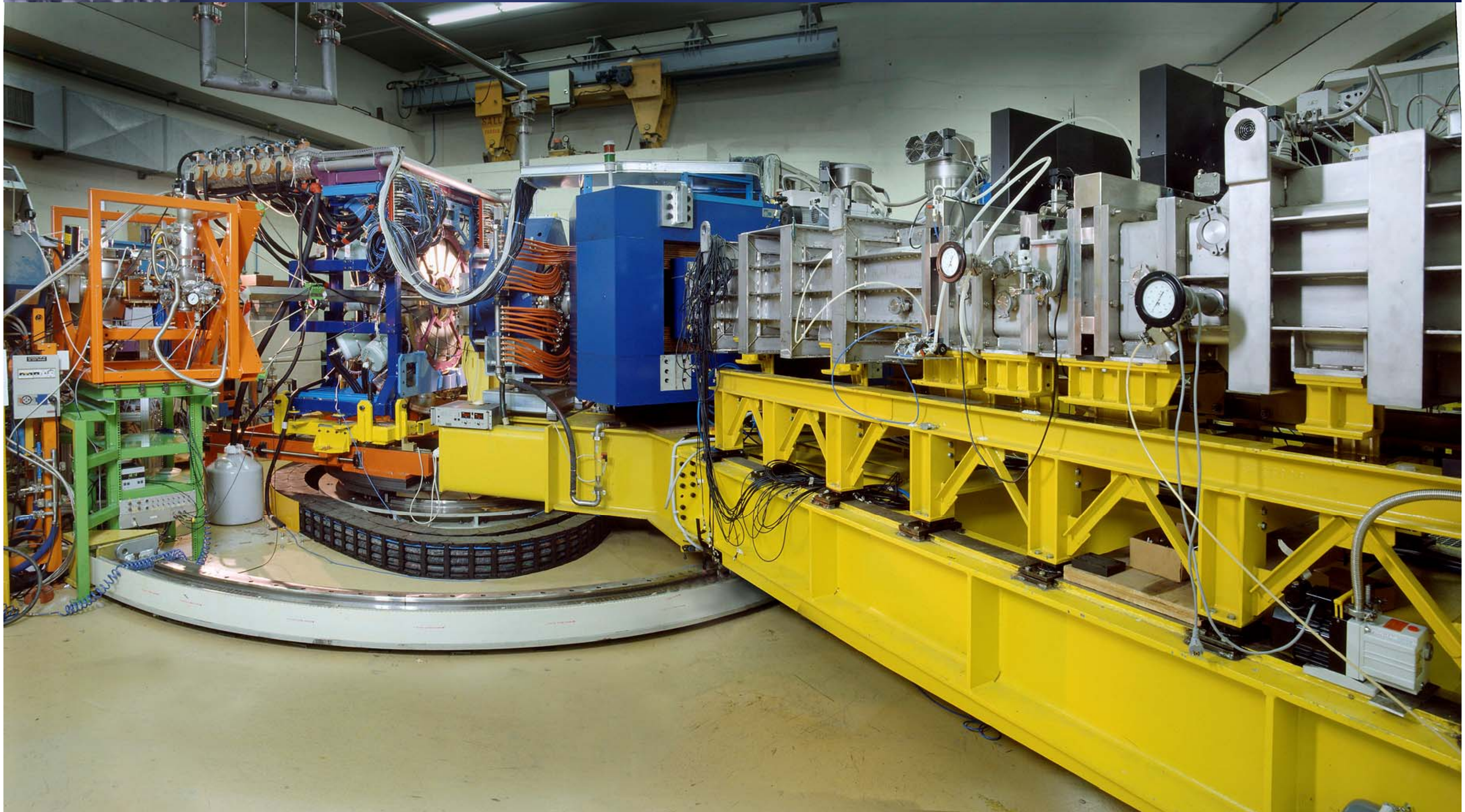
probing single particle aspects and nucleon-nucleon correlations

transition from quasi elastic to deep inelastic processes

connection with other reaction channels (near and sub barrier fusion)

population of neutron-rich nuclei

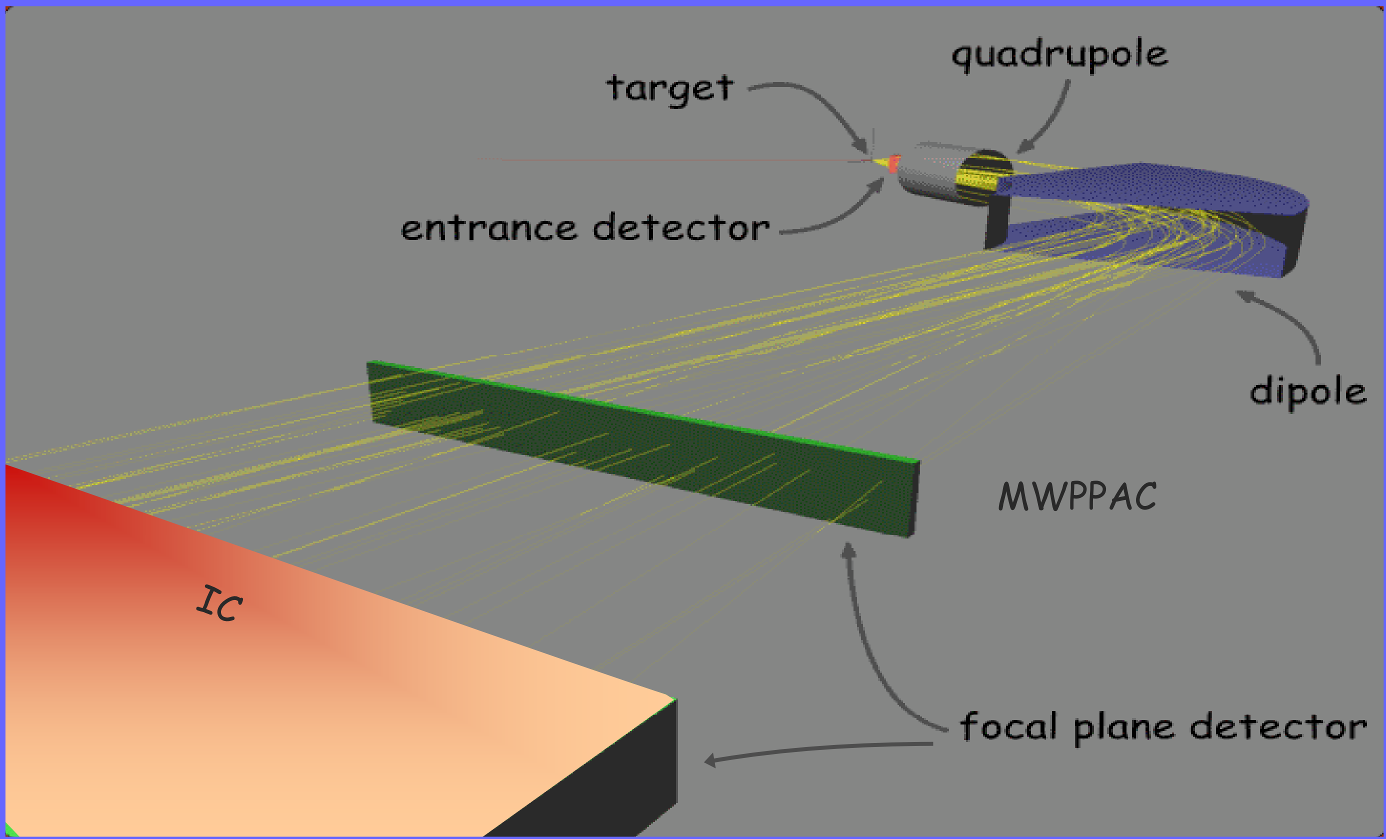
THE PRISMA SPECTROMETER + CLARA GAMMA ARRAY



PRISMA spectrometer – design characteristics

Angular acceptances	$\Delta\theta \sim \pm 6^{o}$ $\Delta\phi \sim \pm 11^{o}$
Solid angle	$\Delta\Omega \sim 80$ msr
Distance target-FPD	7 m
Energy acceptance	± 20%
Momentum acceptance	± 10%
Maximum rigidity	$ME/q^2 = 70$ MeV amu
Dispersion	4 cm/%
Energy resolution	1/1000 (via TOF)
Mass resolution	1/300 FWHM (via TOF)
Aberrations correction	via software

PRISMA spectrometer – trajectory reconstruction



$$T = \frac{S(\theta,\phi)}{v}$$

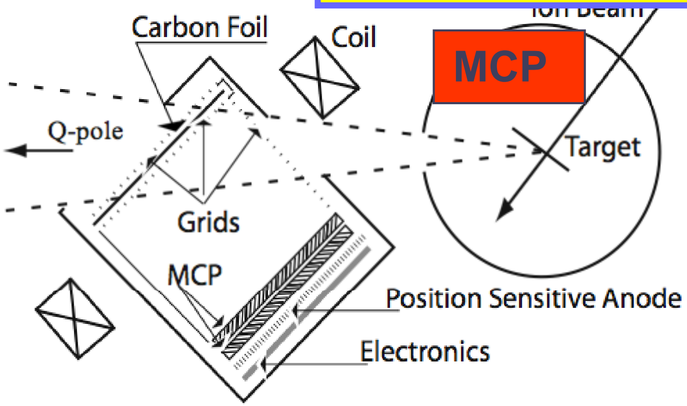
$$B\rho = A \cdot \frac{v}{q} \propto X$$

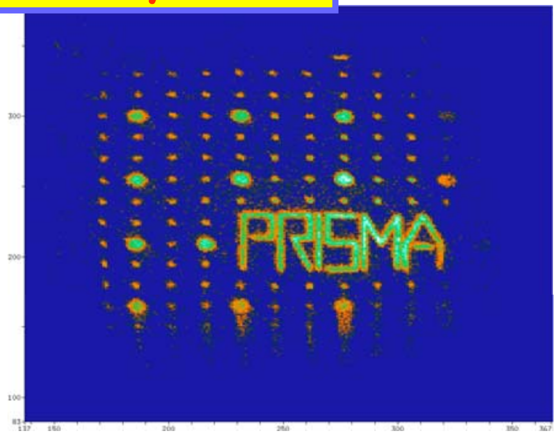
$$q = \frac{2}{S(\theta,\phi)} \cdot \frac{E \cdot T}{B\rho(\theta,\phi)}$$

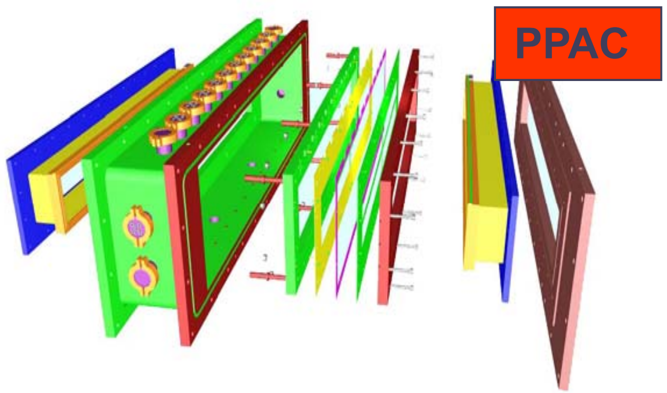
A physical event is composed by the parameters:

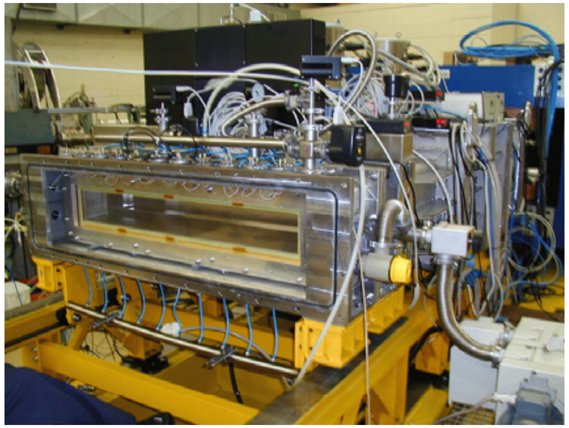
• position at the entrance	x, y
• position at the focal plane	X, Y
• time of flight	TOF
• energy	DE, E

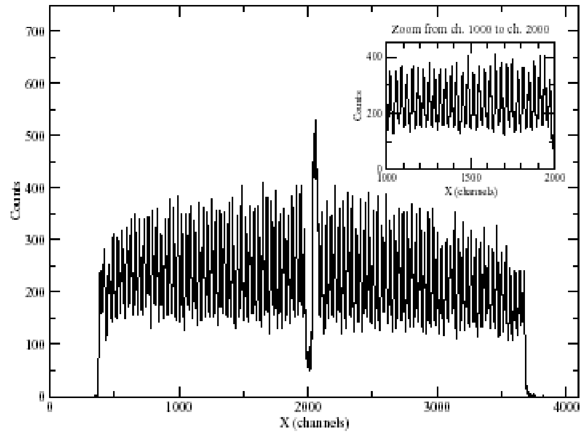
PRISMA spectrometer – a complex detector system

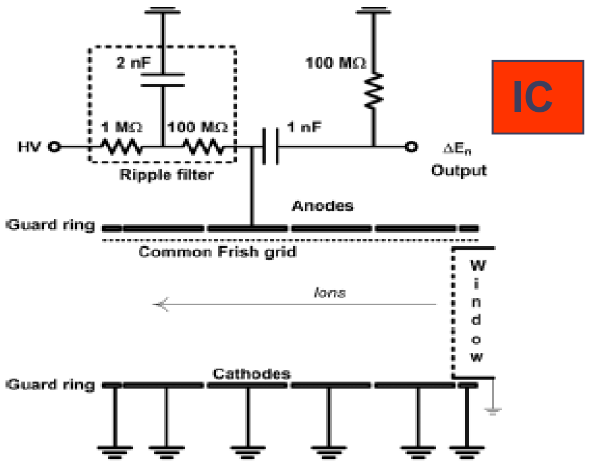


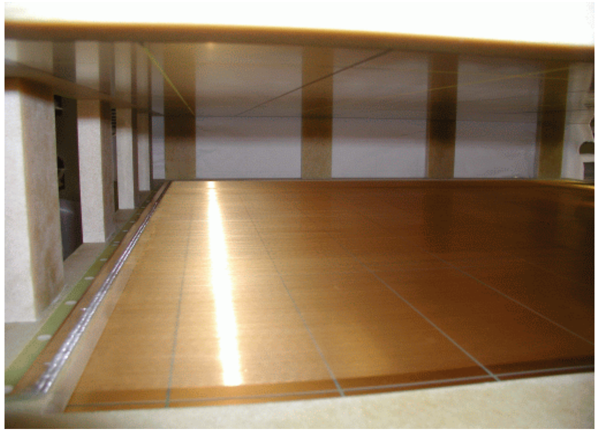


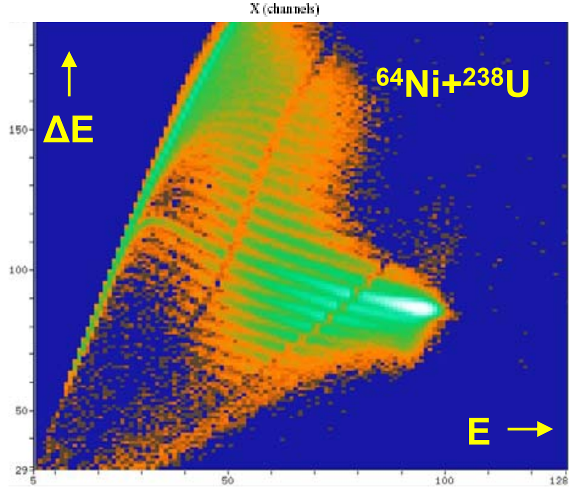




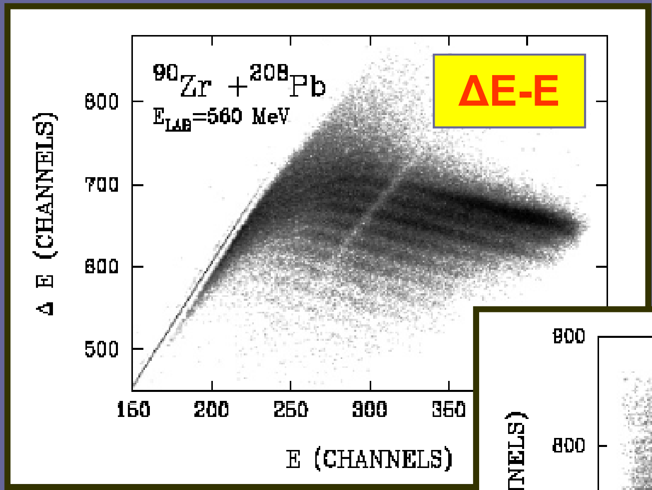




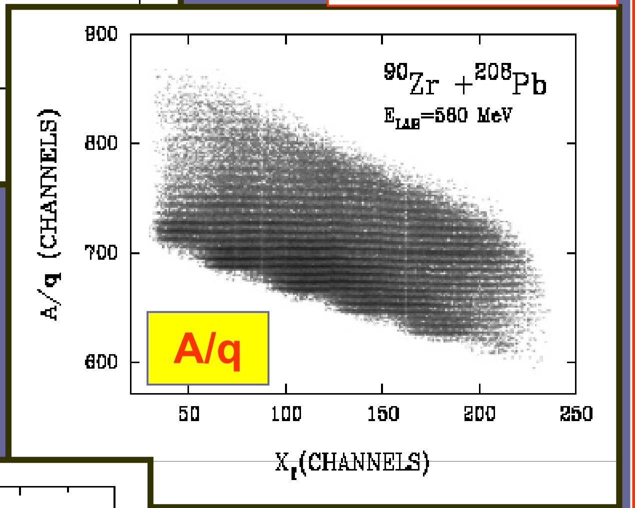




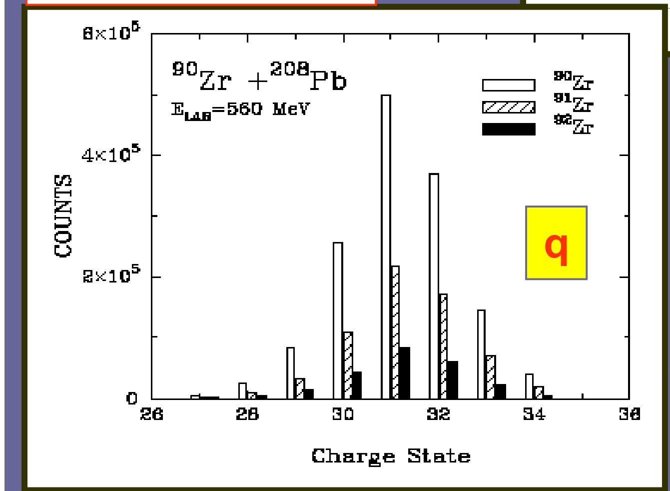
PRISMA spectrometer – trajectory reconstruction

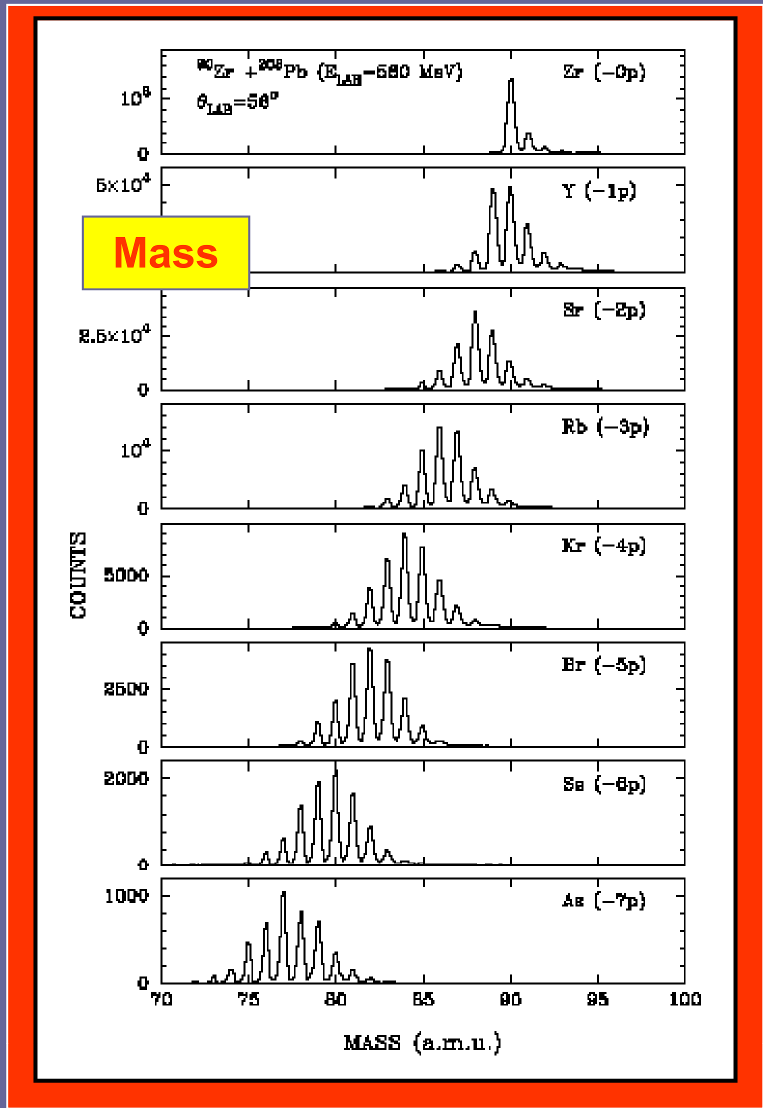


$$B\rho = A \cdot \frac{v}{q} \propto X$$

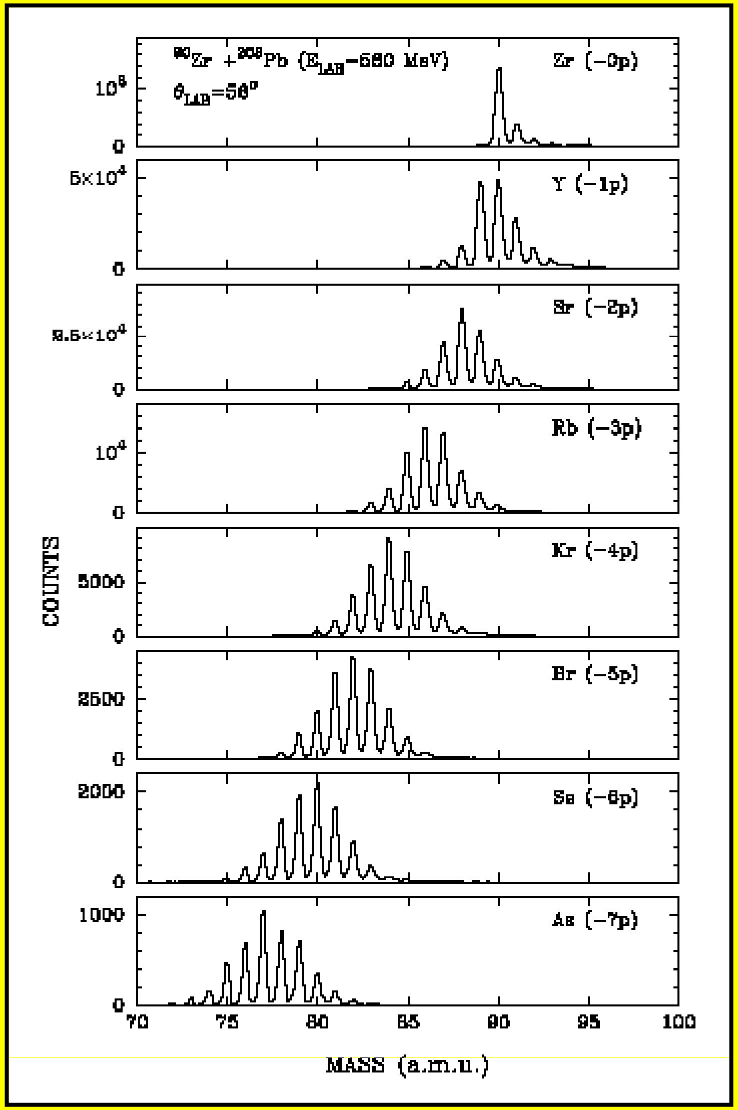


$$q = \frac{2}{S(\theta,\phi)} \cdot \frac{E \cdot T}{B\rho(\theta,\phi)}$$



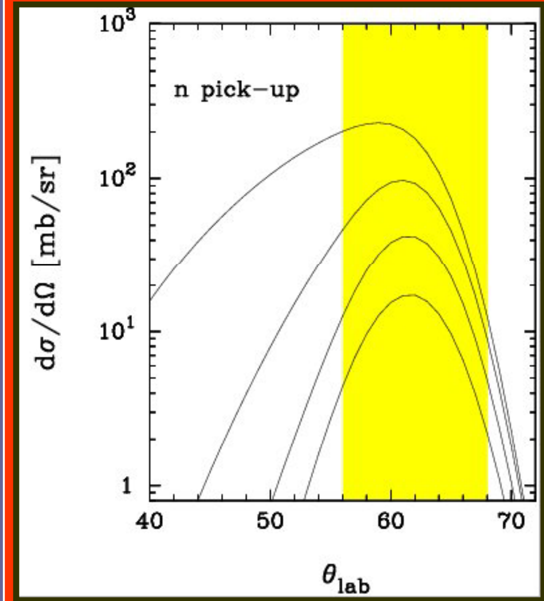


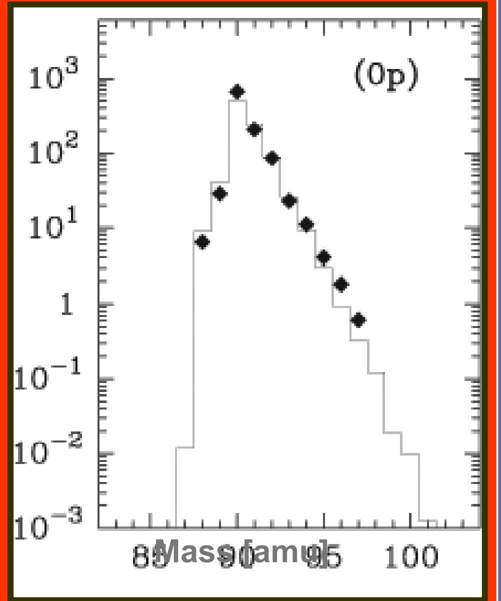
Multineutron and multiproton transfer channels near closed-shell nuclei



$^{90}Zr + ^{208}Pb$ E_{lab}=560 MeV

pure neutron pick-up channels

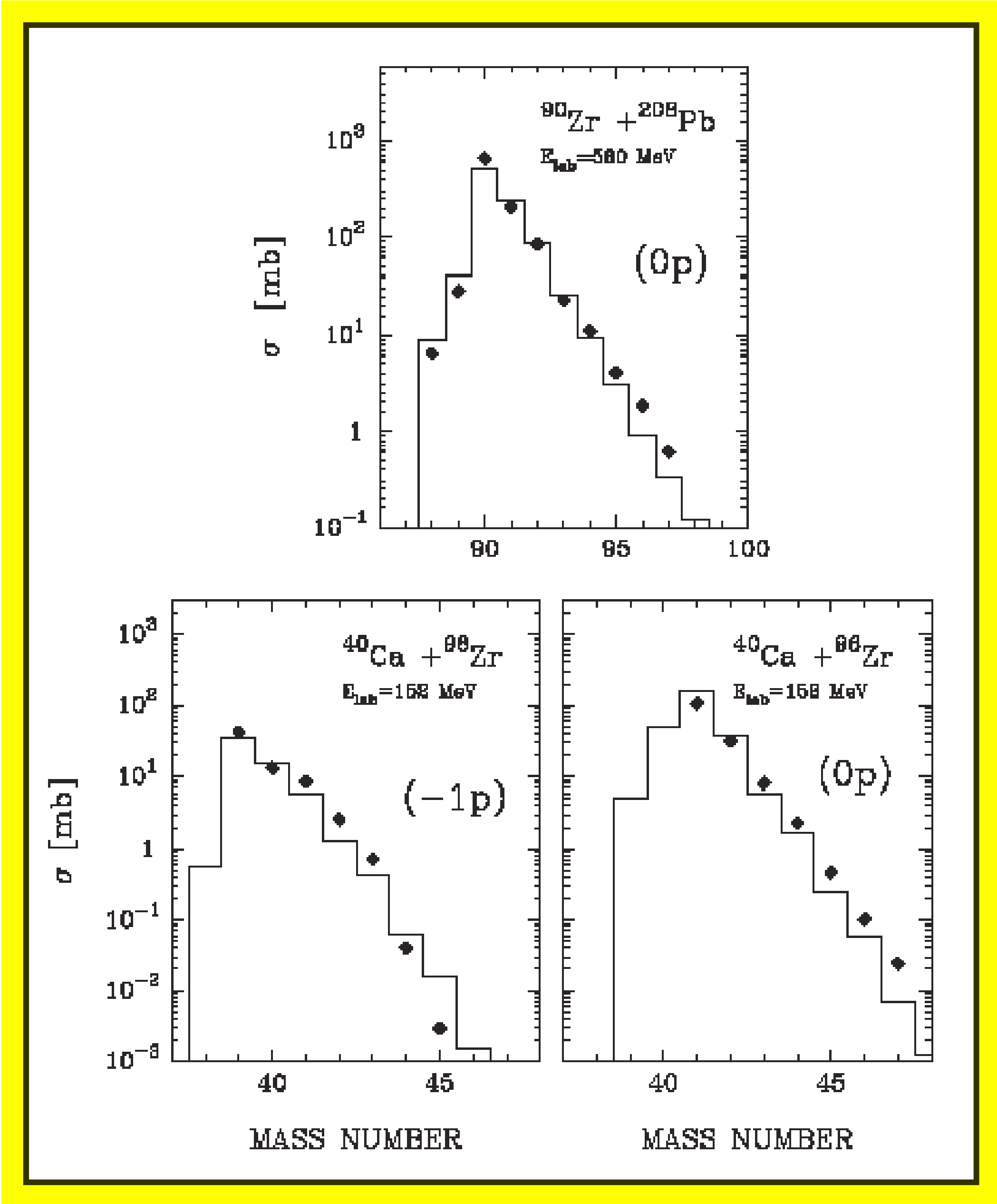




PRISMA spectrometer data

GRAZING code calculations (G.Pollarolo)

L.Corradi et al, J.Phys G36(2009)113101 (Topical Review)

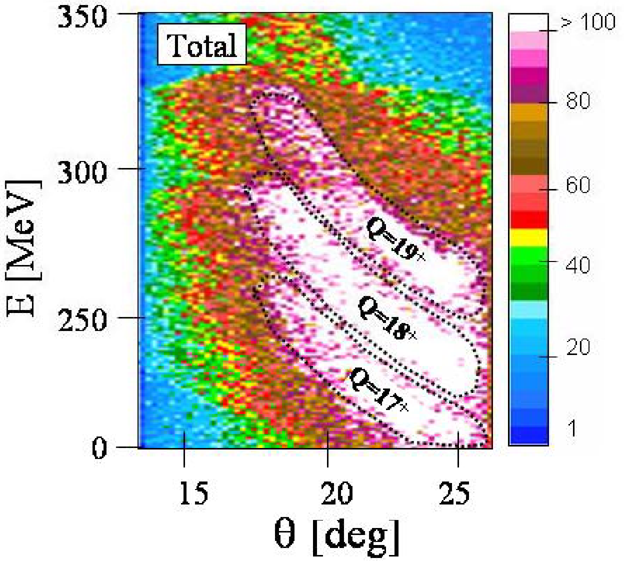


Total cross sections

successive transfer

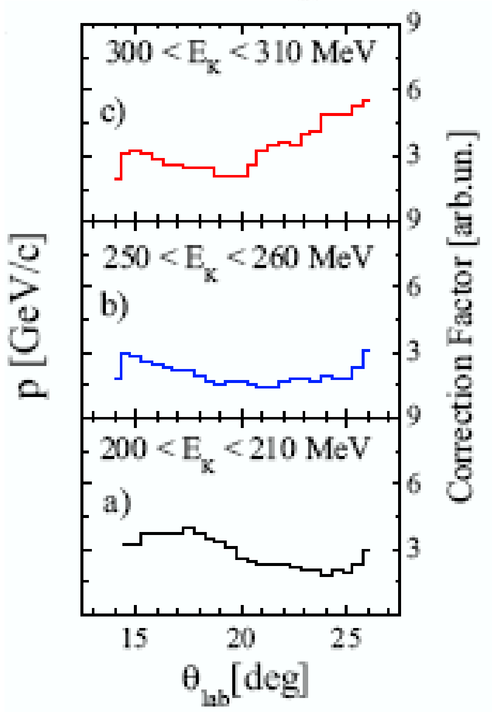
$$c_{\alpha\beta} = -\frac{1}{\hbar^2}\sum_{\gamma}\int_{-\infty}^{+\infty} dt\, f^{(1)}_{\alpha\gamma}(\vec{R}(t))\, e^{-i(Q_{\alpha\gamma}-Q^{opt}_{\alpha\gamma})t} \int_{-\infty}^{t} dt'\, f^{(1')}_{\gamma\beta}(\vec{R}(t'))\, e^{-i(Q_{\alpha\gamma}-Q^{opt}_{\alpha\gamma})t'}$$

S.Szilner et al,
Phys.Rev.C76(2007)024604

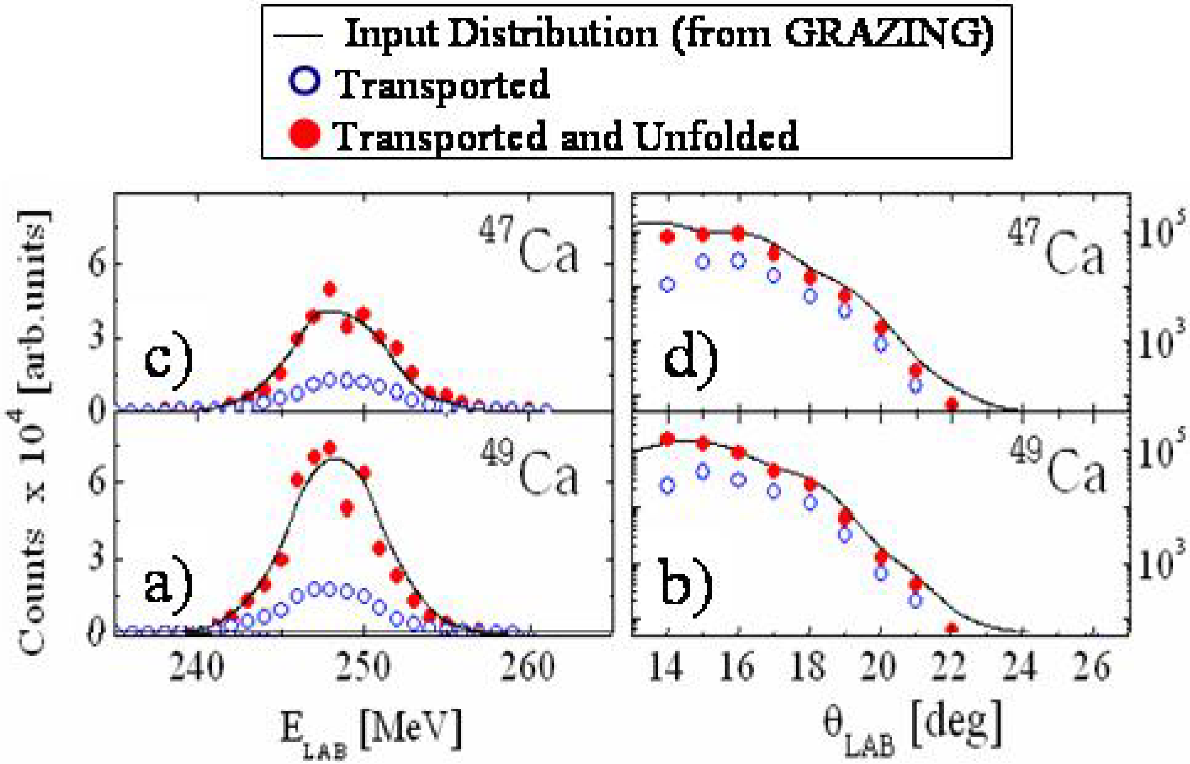


PRISMA simulations of ion transport

Correction factors derived from bidimensional E-θ uniform input distributions



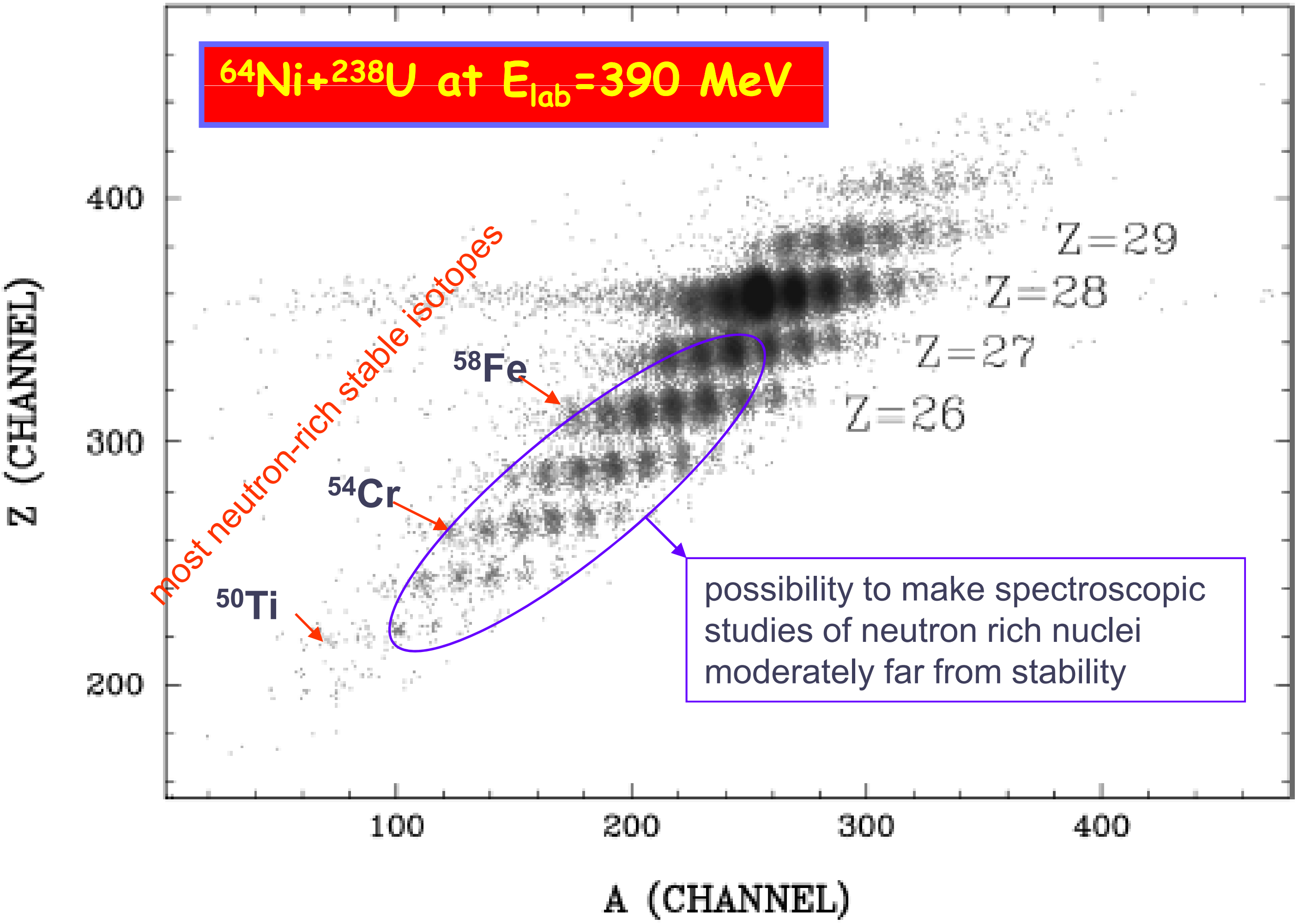
$^{48}Ca+^{64}Ni$ E=270 MeV



D.Montanari et al, Dubrovnik09

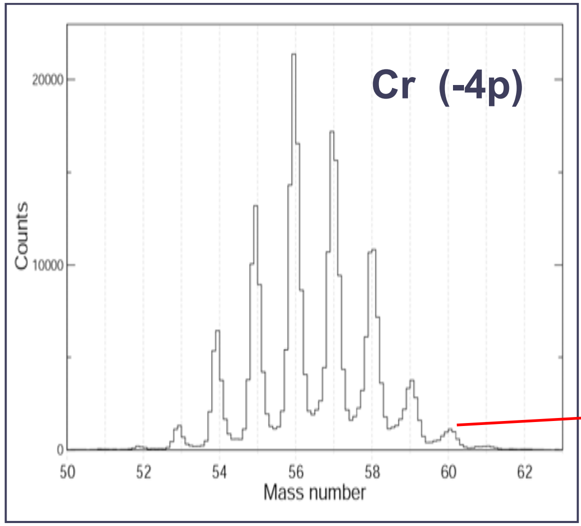
Grazing calculations by G. Pollarolo

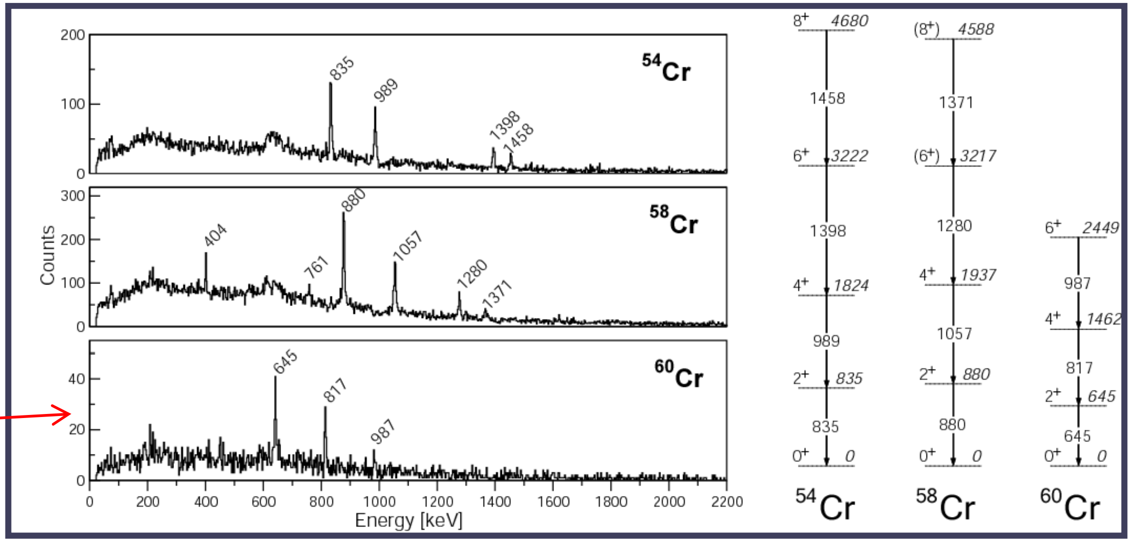
Population of neutron rich nuclei : point of view of nuclear spectroscopy



L.Corradi et al, Phys.Rev.C59(1999)261

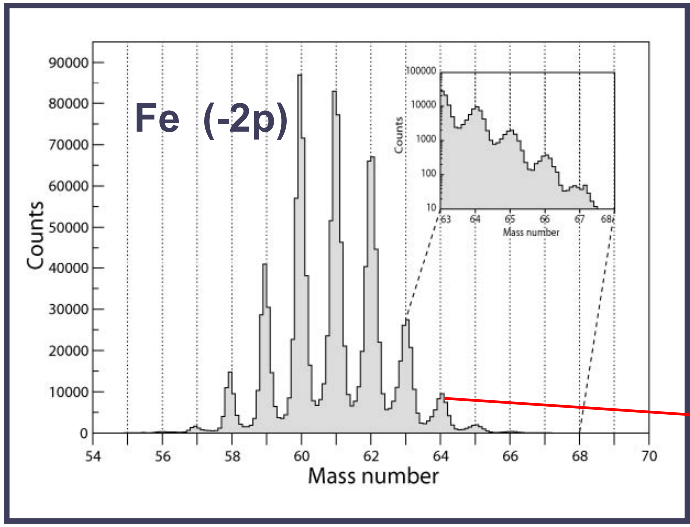
Softness in Cr and Fe isotopes populated in $^{64}Ni+^{238}U$ at E_{lab}=404 MeV

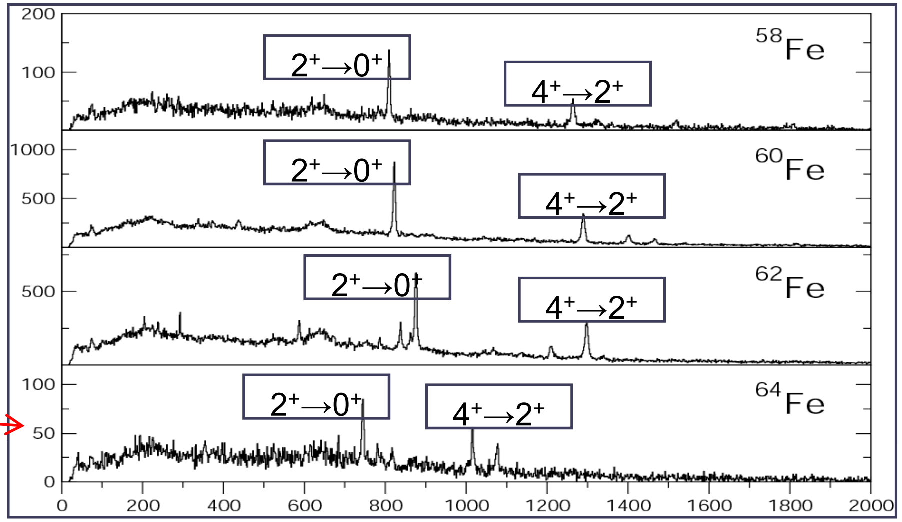




gating on mass

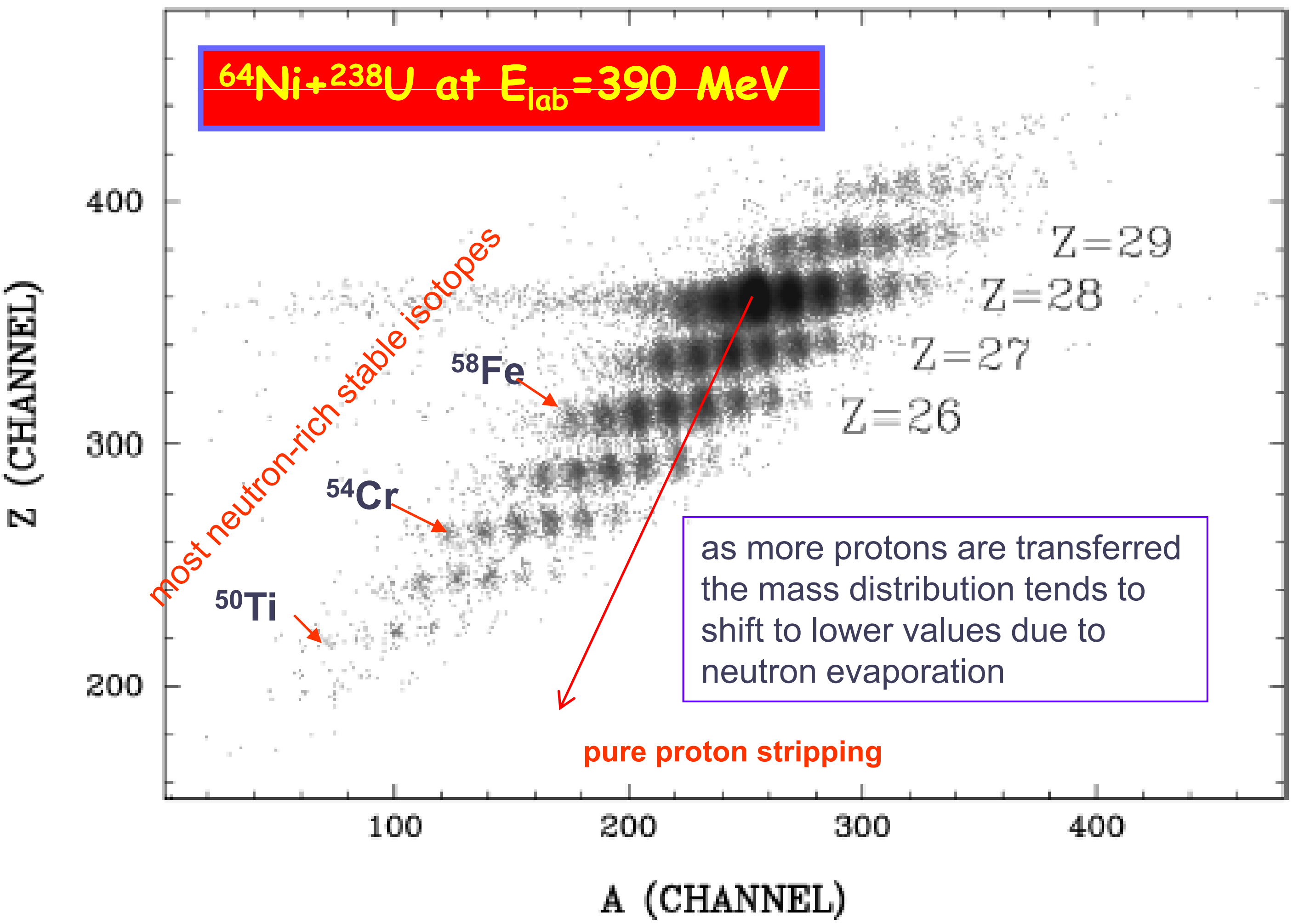
N.Marginean et al., Phys. Lett. B 633(2006)696





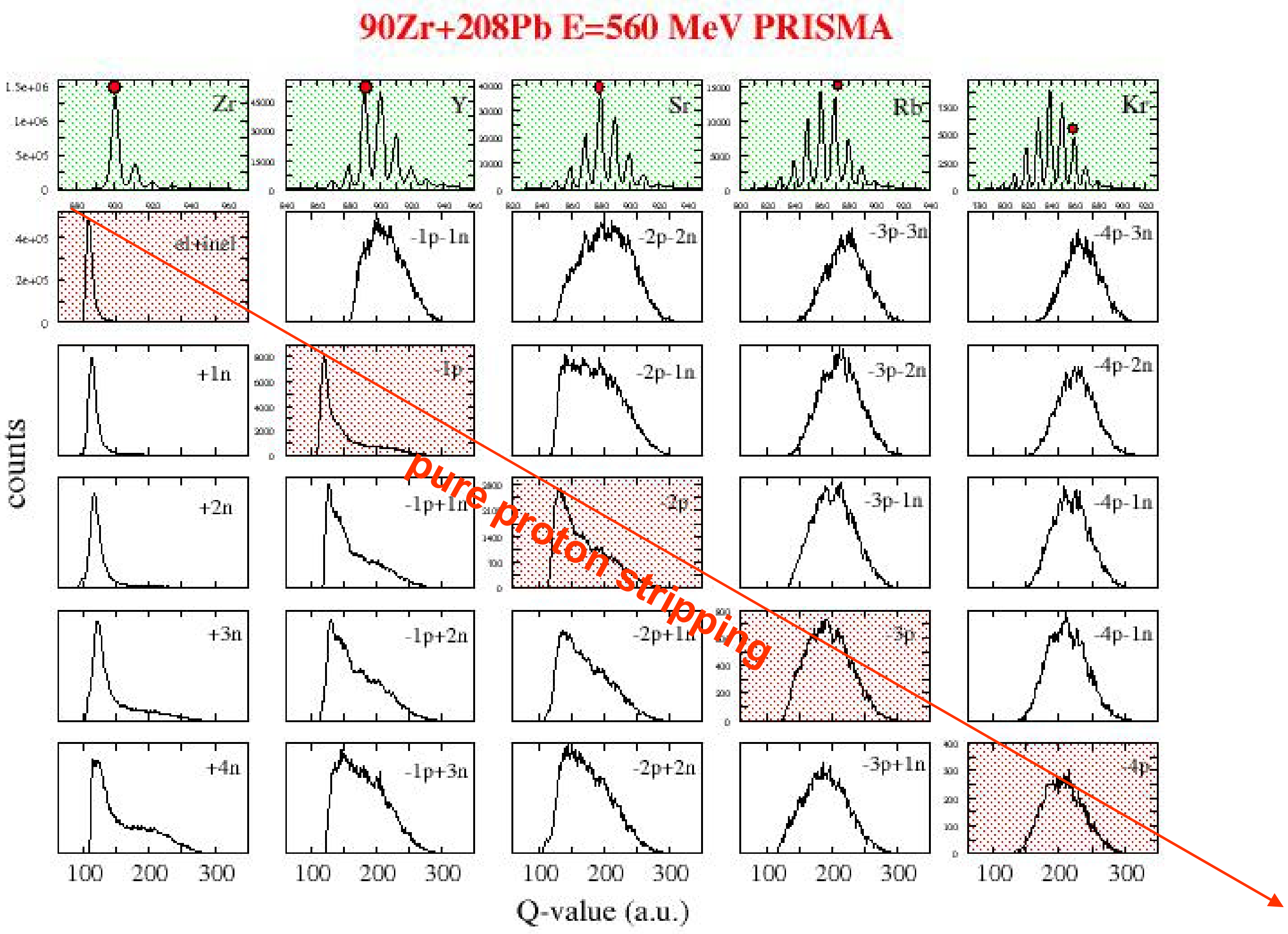
S.Lunardi et al., Phys. Rev. C 76(2007)034303

Population of neutron rich nuclei : point of view of reaction mechanism

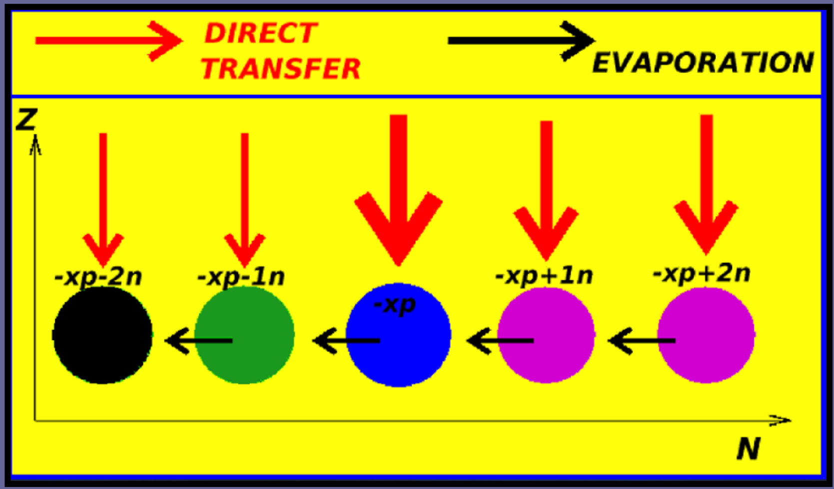


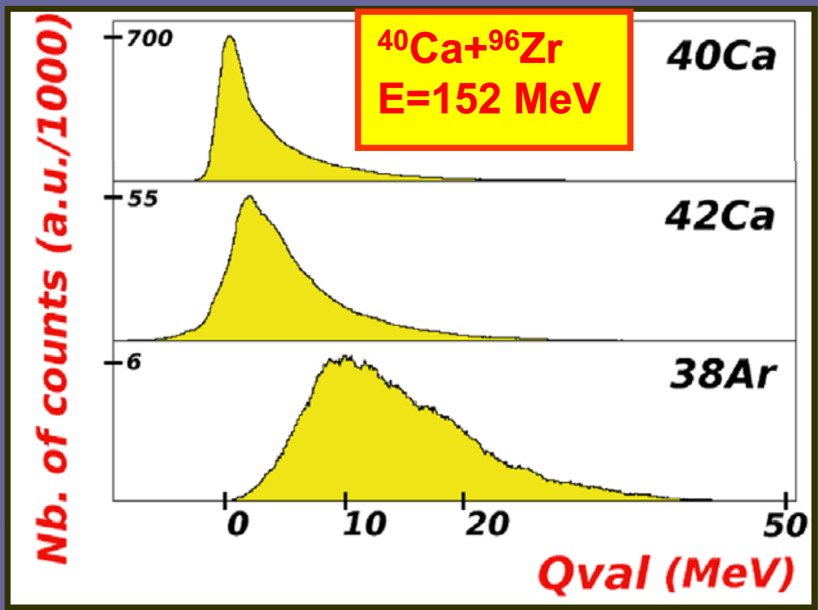
L.Corradi et al, Phys.Rev.C59(1999)261

TKEL distributions – transition from QE to DIC processes

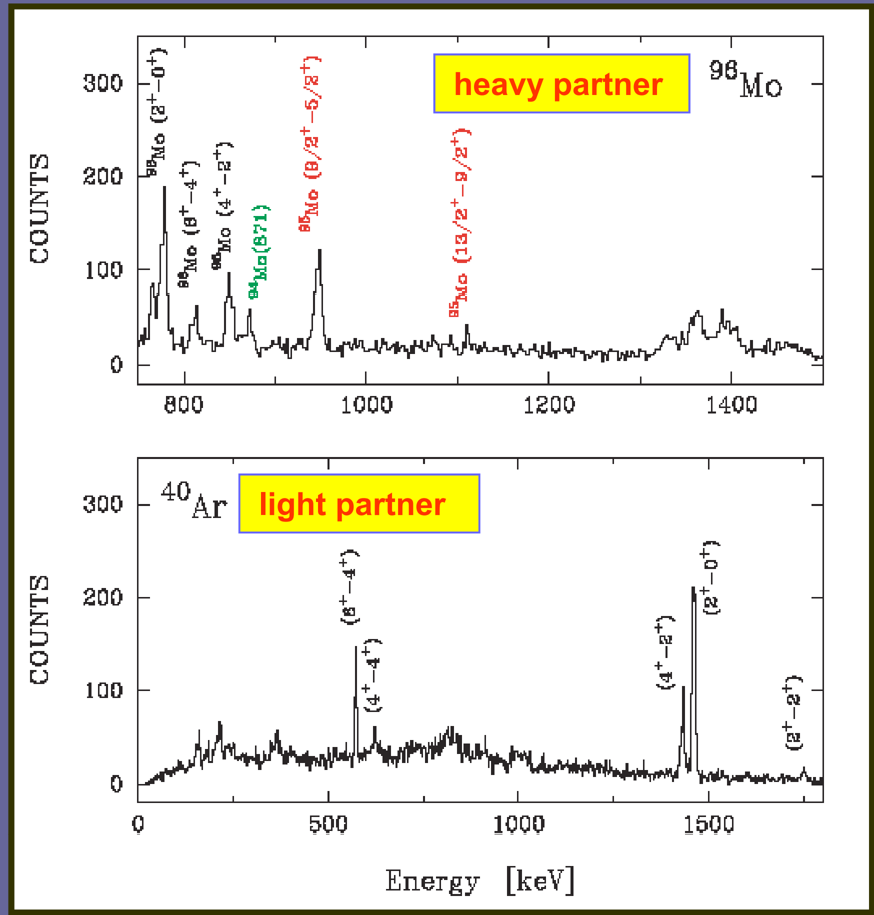


Evaporation processes in multinucleon transfer reactions





Direct identification with PRISMA+CLARA



Some few remarks on PRISMA

- mass determination via tracking procedure with low energy heavy ions

- powerful tool to perform spectroscopic studies in moderately n-rich nuclei populated via MNT processes and to investigate the population pattern to specific final states

- possibility to extract with high efficiency A,Z yields in reactions with heavy ions . Cross section determination is feasible but care has to be taken with spectrometer transmission

4 recent (major) interesting achievements with PRISMA

- Elastic scattering (using coincident gamma rays)

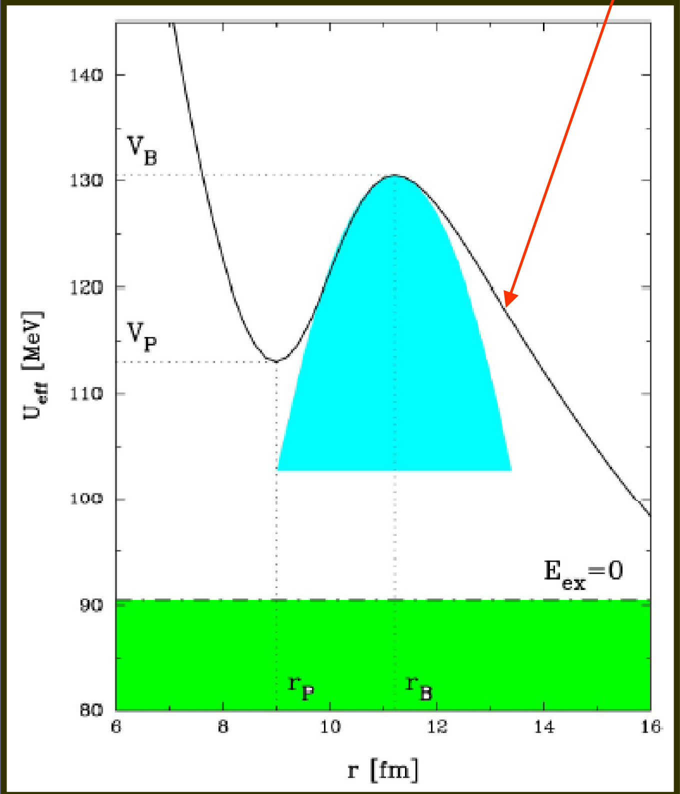
- Sub barrier transfer reactions
(forward angle detection in inverse kinematics)

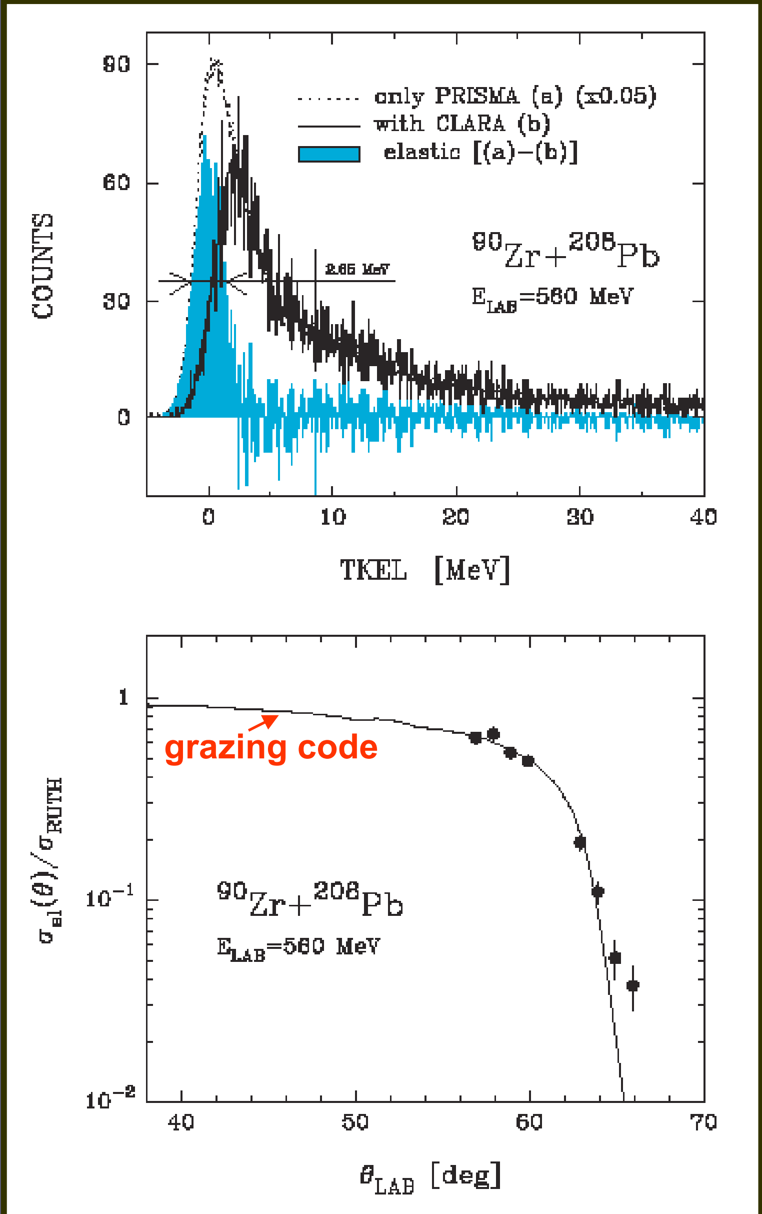
- Lifetime measurements
(use of degrader foils)

- Studies of very neutron rich nuclei
(detection of fission products with high efficiency)

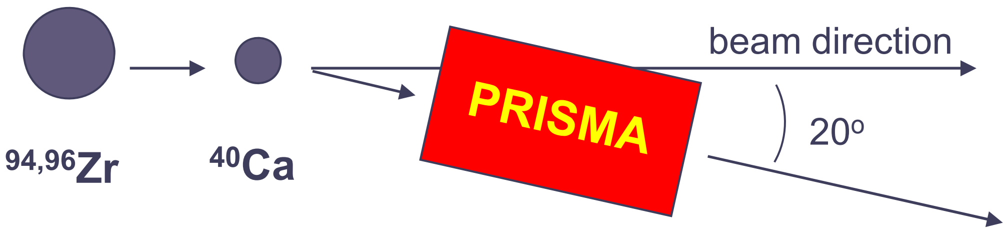
Elastic scattering – using Prisma and Clara information

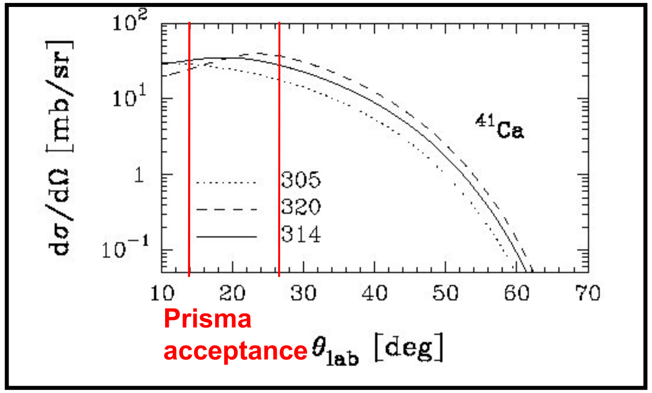
elastic scattering is the first important ingredient for nuclear reaction studies. It provides information on the (outer part of) nuclear potential



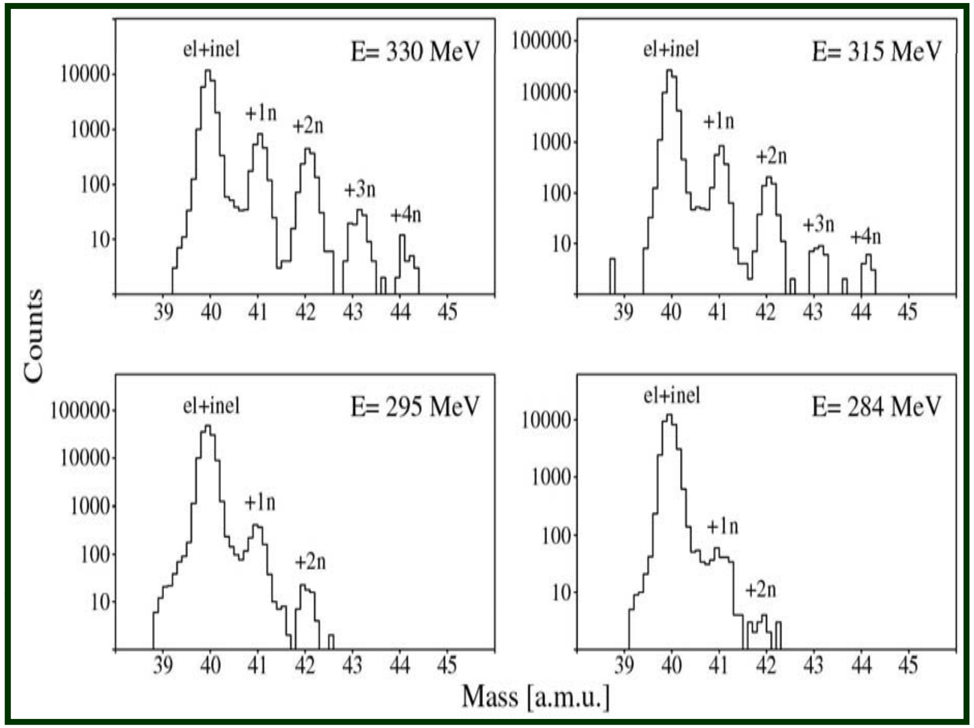


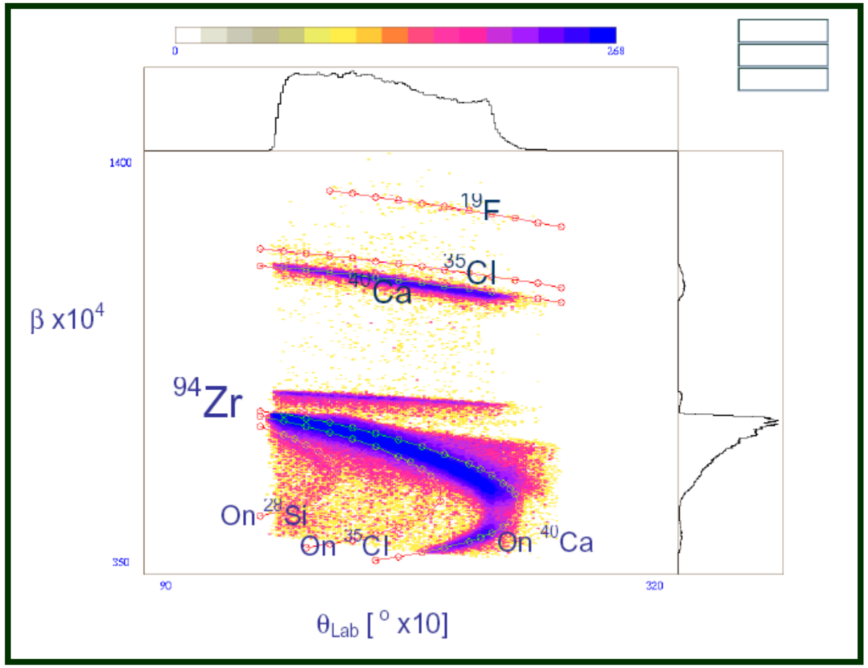
Detection of (light) target like ions in inverse kinematics with PRISMA





MNT channels have been measured down to 25 % below the Coulomb barrier

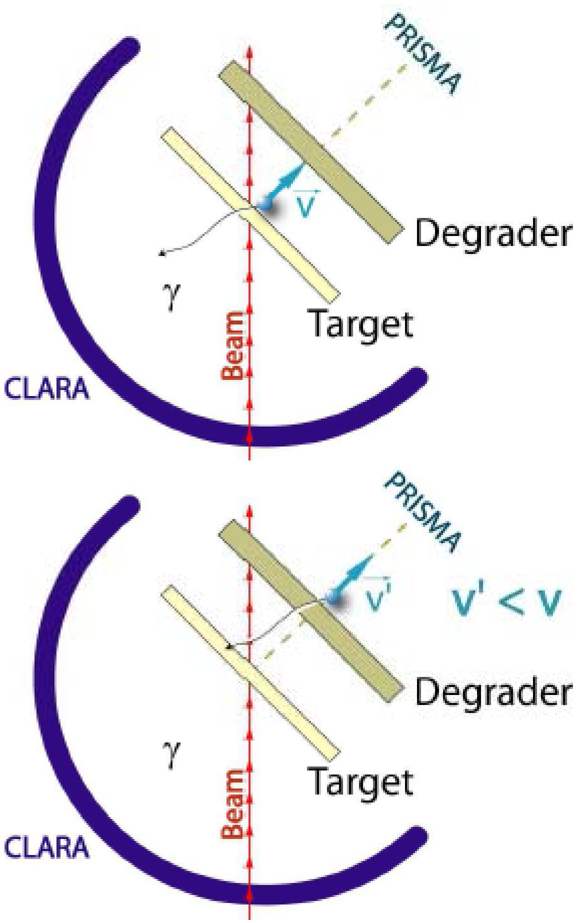


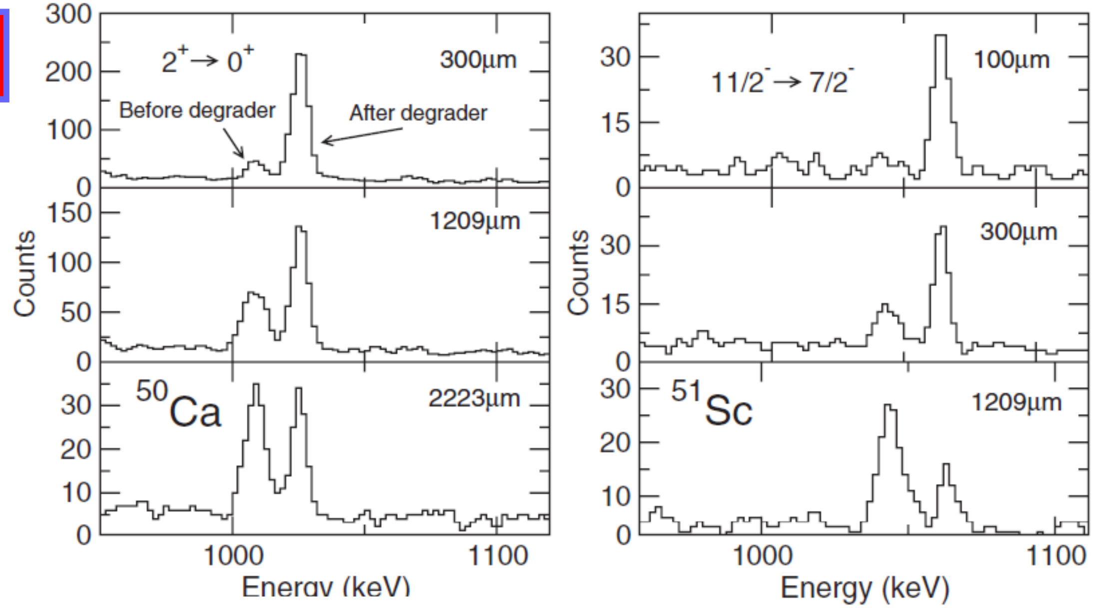


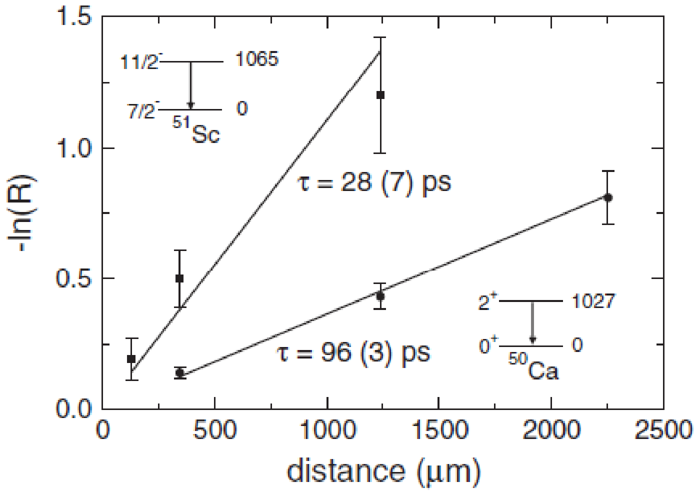
L.Corradi et al, LNL exp. March 2009

Lifetimes measurements in $^{48}Ca + ^{208}Pb$ at E_{lab}=310 MeV

Differential Plunger Method



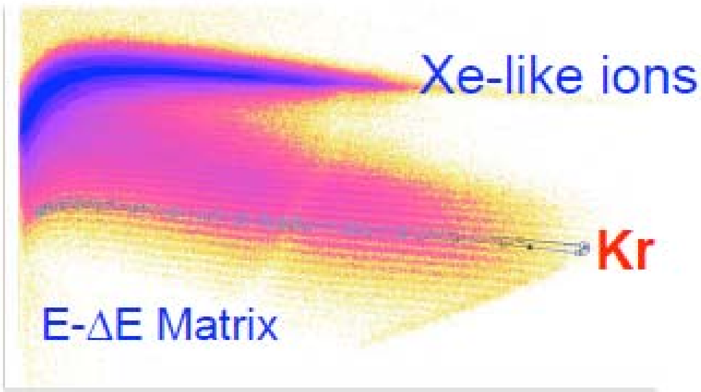


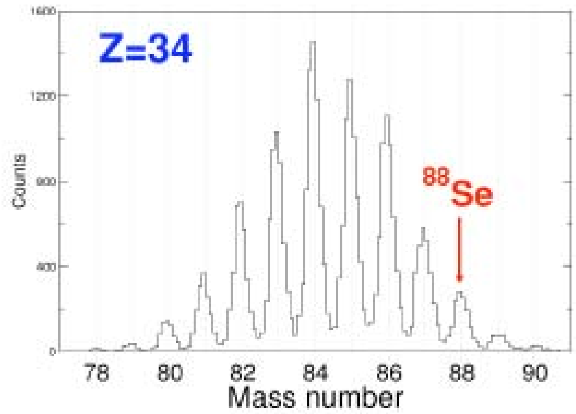


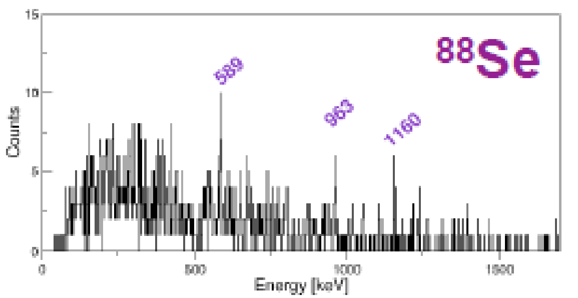
comparison of deduced B(E2) with large scale shell model calculations

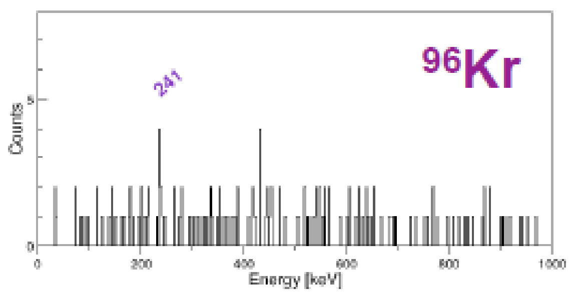
J.J.Valiente-Dobon et al, PRL102(2009)242502

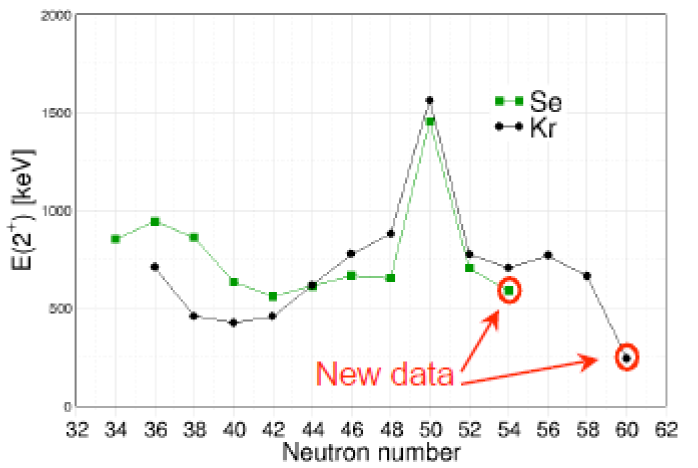
Neutron rich nuclei produced in the fission of ^{238}U in $^{136}Xe+^{238}U$ at E_{lab}=990 MeV











N.Marginean et al., Phys. Rev. C80(2009)021301(R)

L.Corradi[1], S.Szilner[3], G.Pollarolo[4], A.M.Stefanini[1], S.Beghini[2], S.Courtin[7], G.de Angelis[1], E.Farnea[2], E.Fioretto[1], A.Gadea[5], F.Haas[7], D.Jelavec[3], D.Lebhertz[7], S.Lenzi[2], S.Lunardi[2], N.M.Marginean[6], P.Mason[1], D.Mengoni[2], G.Montagnoli[2], D.R.Napoli[1], F.Recchia[2], M.-D.Salsac[7], F.Scarlassara[2], N.Soic[3], C.Ur[2], J.J.Valiente-Dobon[1], F.della Vedova[2]

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[6]IFIN-HH, Bucharest, Romania

[7]IReS, Strasbourg, France