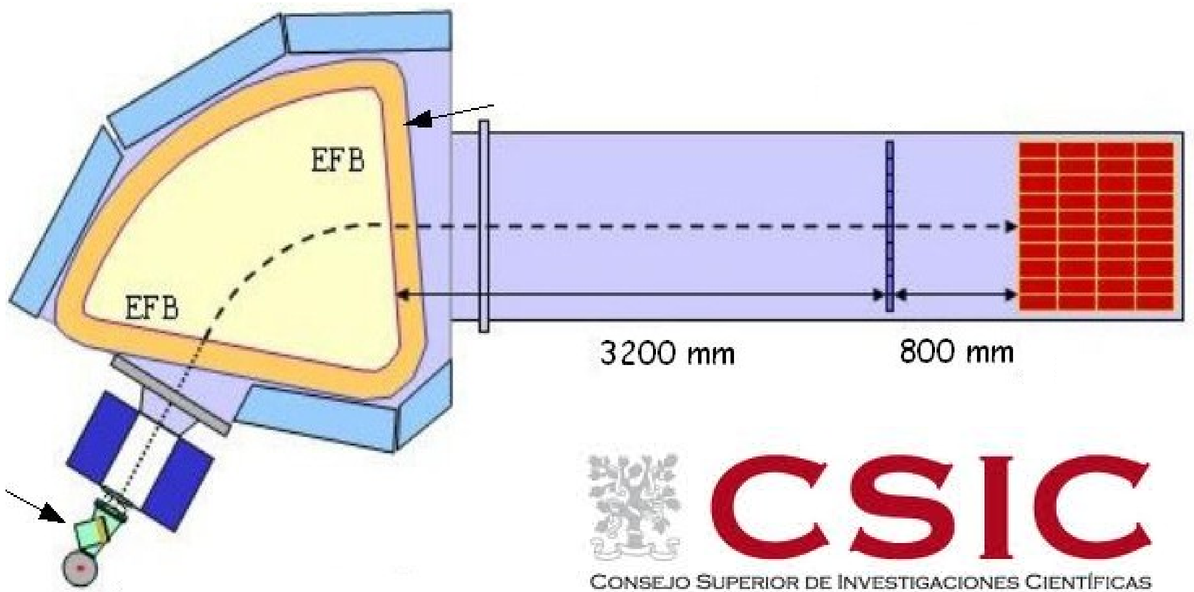
The PRISMA Ion-Tracing Spectrometer coupled with Large Ge arrays for Nuclear Structure Studies: The CLARA-PRISMA and AGATA-PRISMA setups

A.Gadea (IFIC, CSIC-University of Valencia)

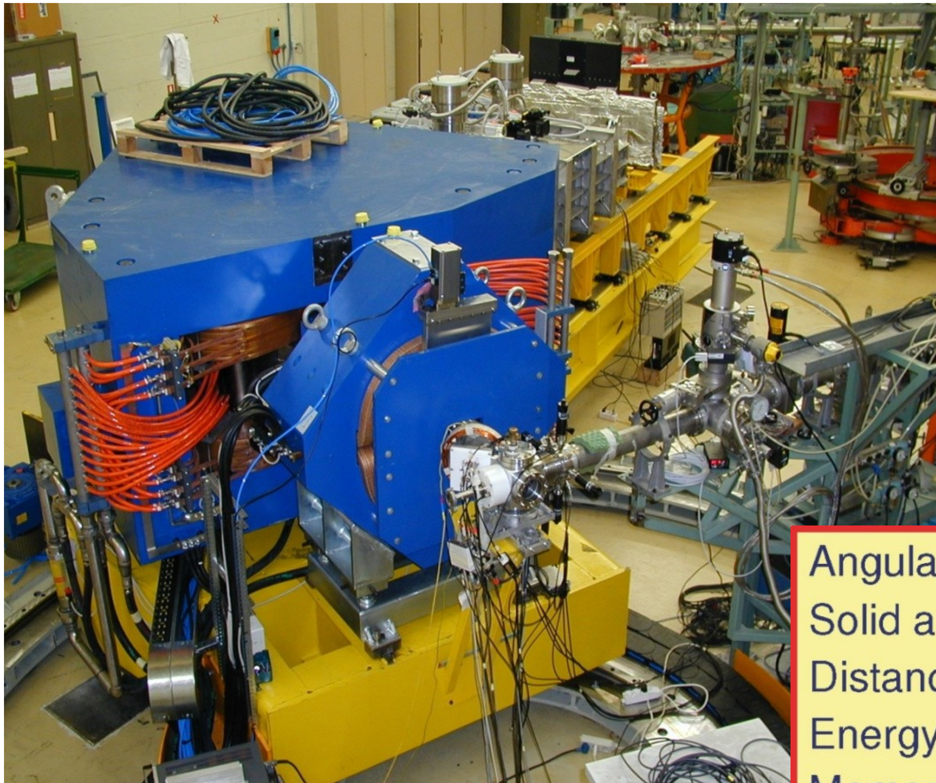


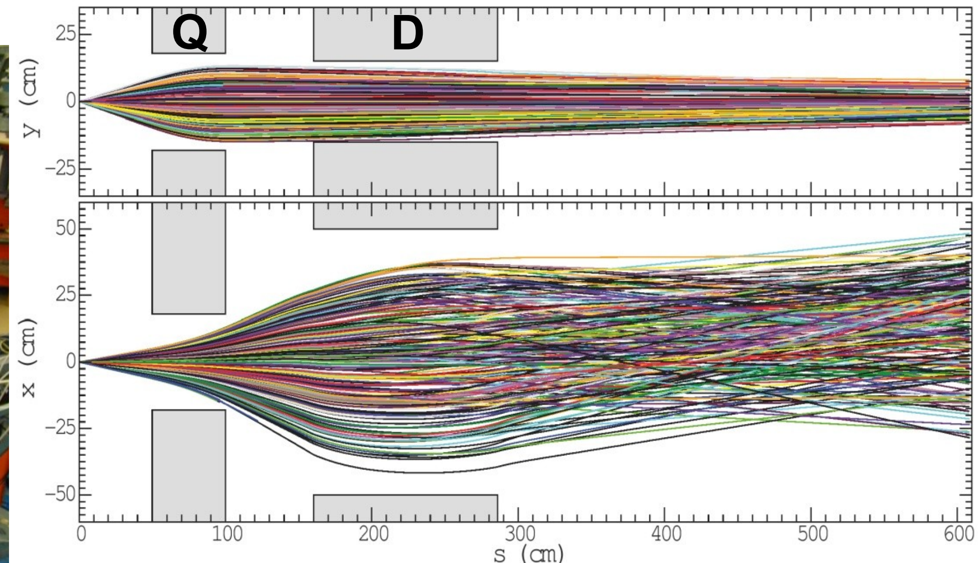
AGATA
ADVANCED GAMMA TRACKING ARRAY

CSIC
CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

IFIC
INSTITUT DE FÍSICA CORPUSCULAR

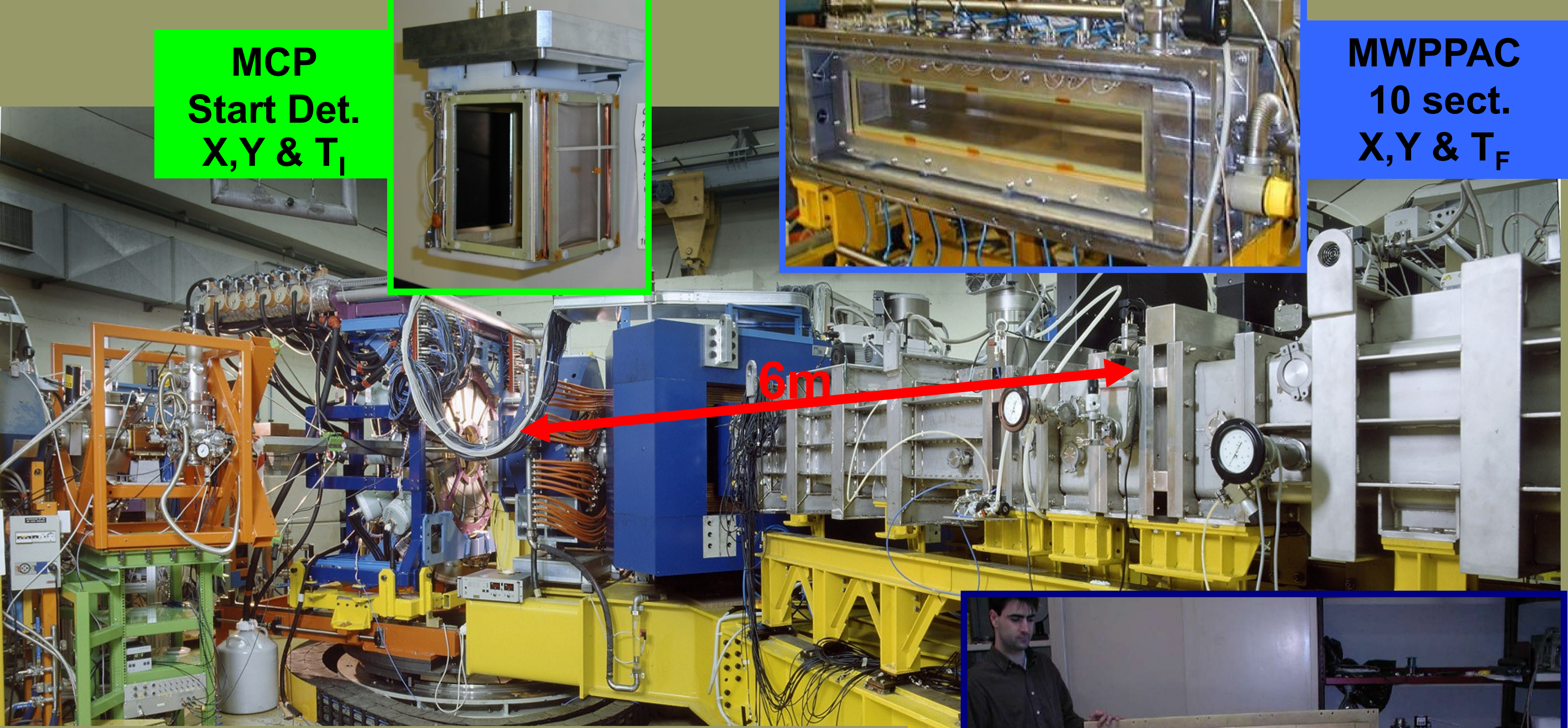
PRISMA Ion Tracing Spectrometer





Angular acceptances	$\Delta\vartheta \sim \pm 6^{o}$, $\Delta\varphi \sim \pm 11^{o}$
Solid angle	~ 80 msr
Distance target-FPD	7 m
Energy acceptance	± 20%
Momentum acceptance	± 10%
Maximum rigidity	ME/q^2 = 70 MeV amu
	$B\rho$ = 1.2 T m
Dispersion	4 cm/%
Energy resolution	1/1000 (via TOF)
Mass resolution	1/300 FWHM
Aberrations correction	via software

A. Stefanini et al., NPA701 (02) 217c.



MCP
Start Det.
X,Y & T_I

MWPPAC
10 sect.
X,Y & T_F

Ionisation Chamber
10x4 sect.
ΔE - E

PRISMA: Large acceptance tracking Magnetic Spectrometer Q-D

Designed for the HI-beams from XTU-ALPI

Ω = 80 msr

$\Delta Z/Z \approx 1/60$ (Measured) IC

$\Delta A/A \approx 1/190$ (Measured) TOF

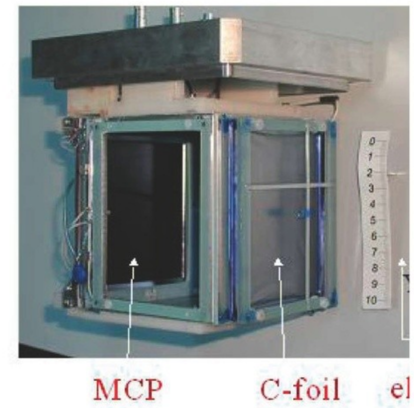
Energy acceptance ±20%

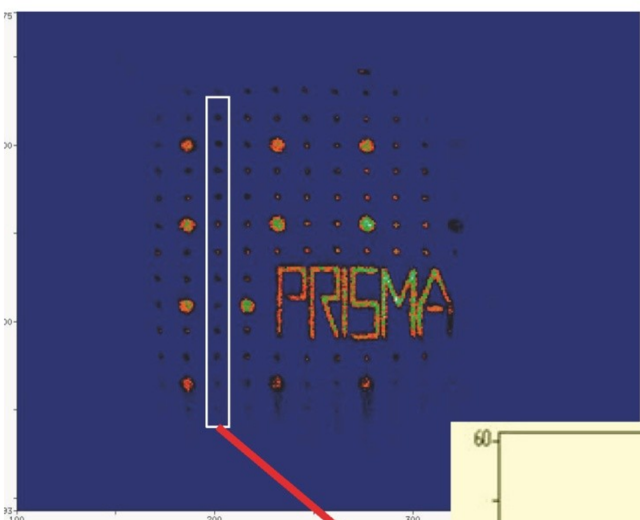
Max. Bρ = 1.2 T.m.

MCP Start Detector

- Micro Channel Plate
- 8x10 cm² sensitive area
  (covering a solid angle of 80msr)
- timing resolution for TOF ~ 350 ps
- particles enter with an angle of 135°

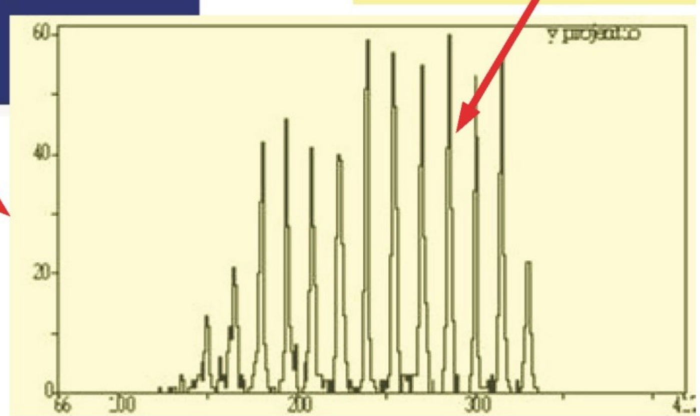
- d_{TARGET}=25 cm
- C-foil 20μg/cm² thick
- E_{acc}=30-40 kV/m
- B~120 Gauss

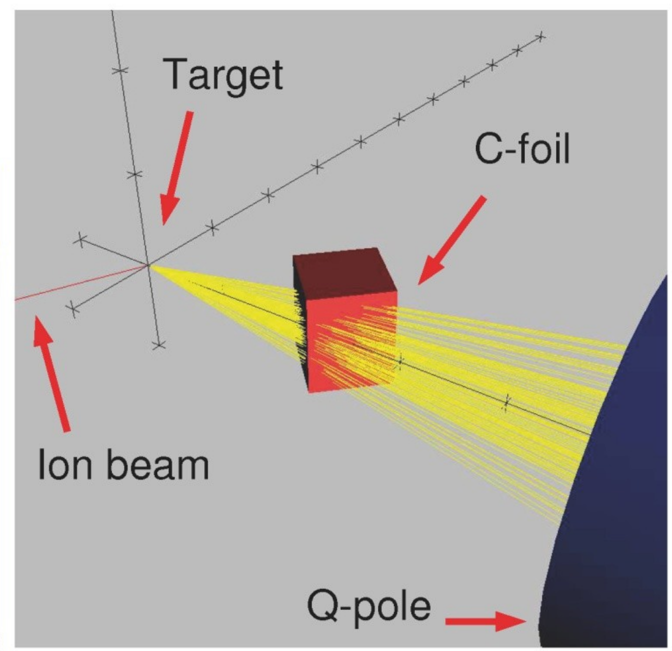




hole diameter 1 mm

1.1 mm FWHM



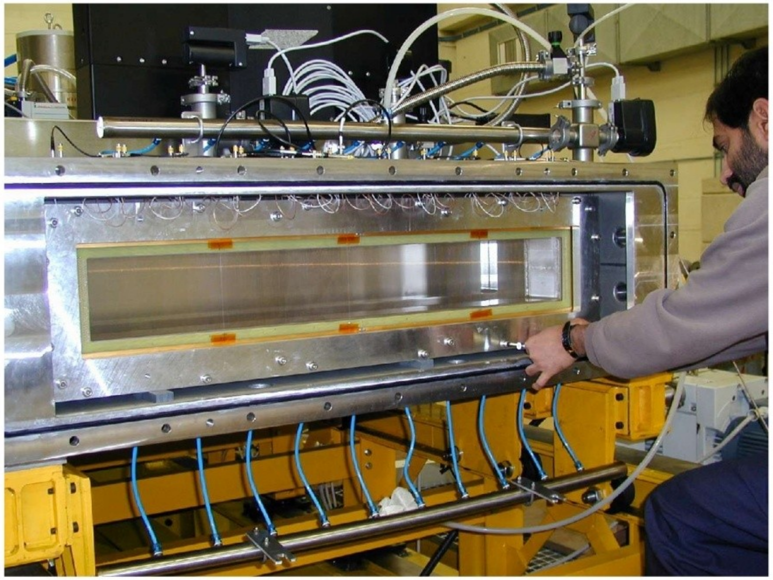


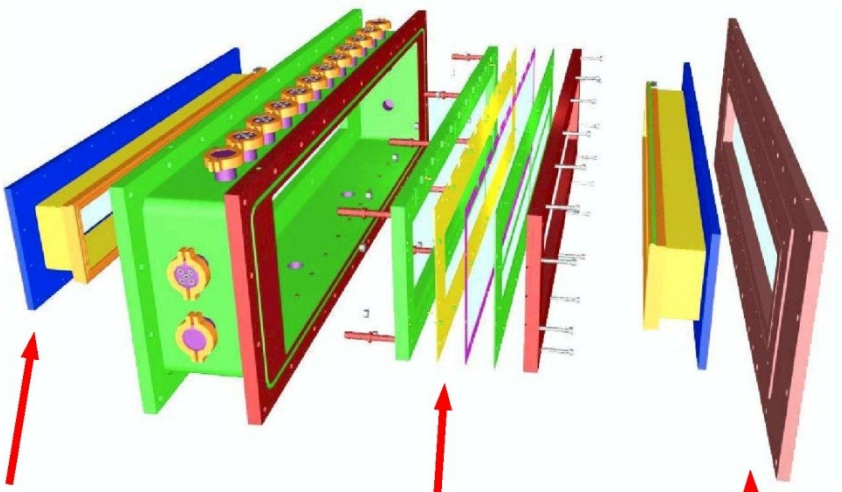
3 signals

G.Montagnoli et al. NIM A547, 455 (05)

Focal Plane Detectors: MWPPAC

- MWPPAC
- active area 1m x 13 cm
- 10 independent sections
- ΔX ~ 1mm, ΔY ~ 2mm (FWHM)
- stop signal for TOF





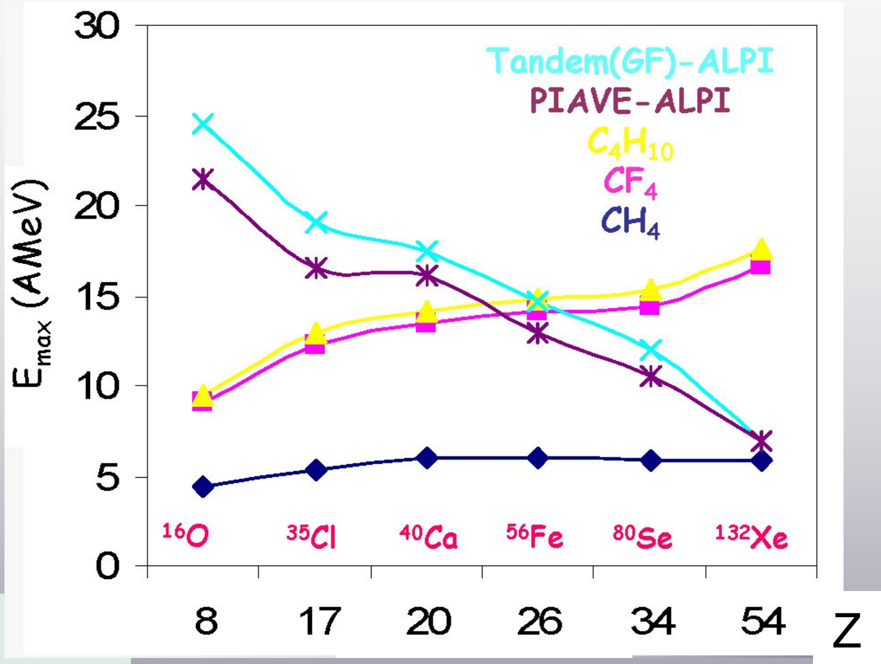
- Filling gas: C_4H_{10}
- Filling pressure: 7 mbar

10 x 3 signals (X_l, X_r, timing)

2 signals (Y_u, Y_d)

S.Beghini et al. NIM A551, 364 (05)

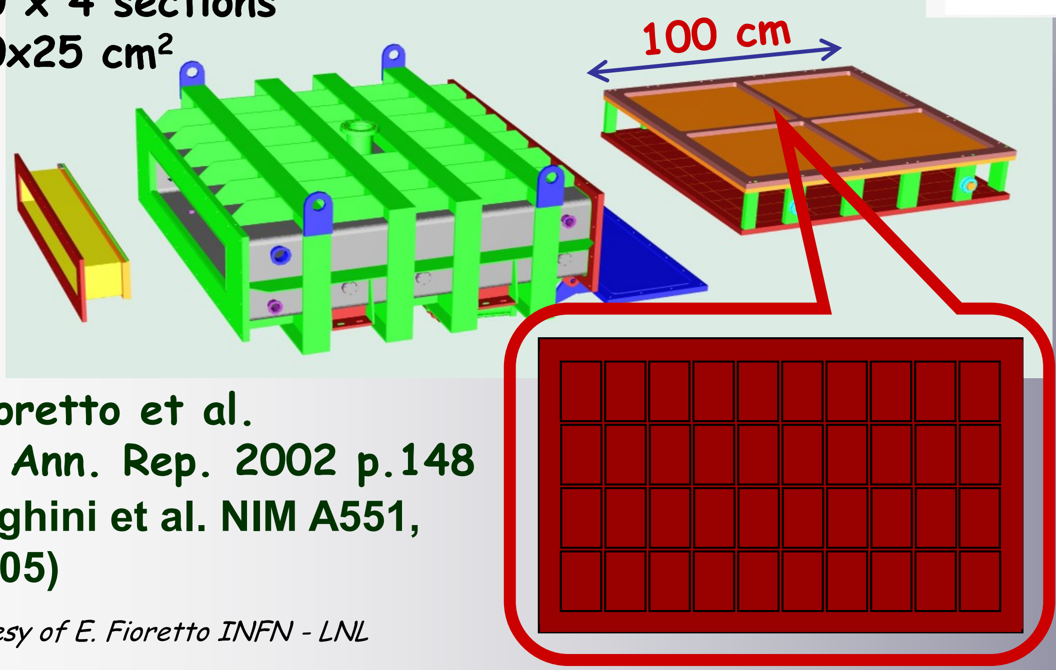
The Focal Plane Detector: IC



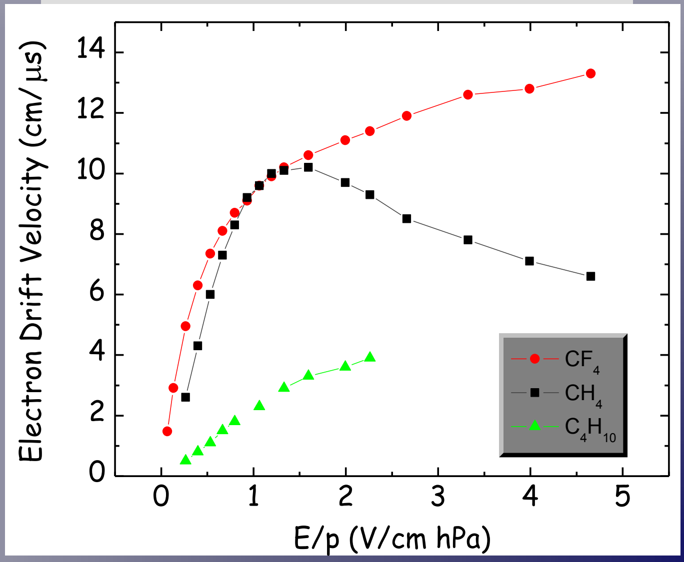
Maximum working pressure 100 hPa

10 x 4 sections

10x25 cm^2



Electron Drift Velocity

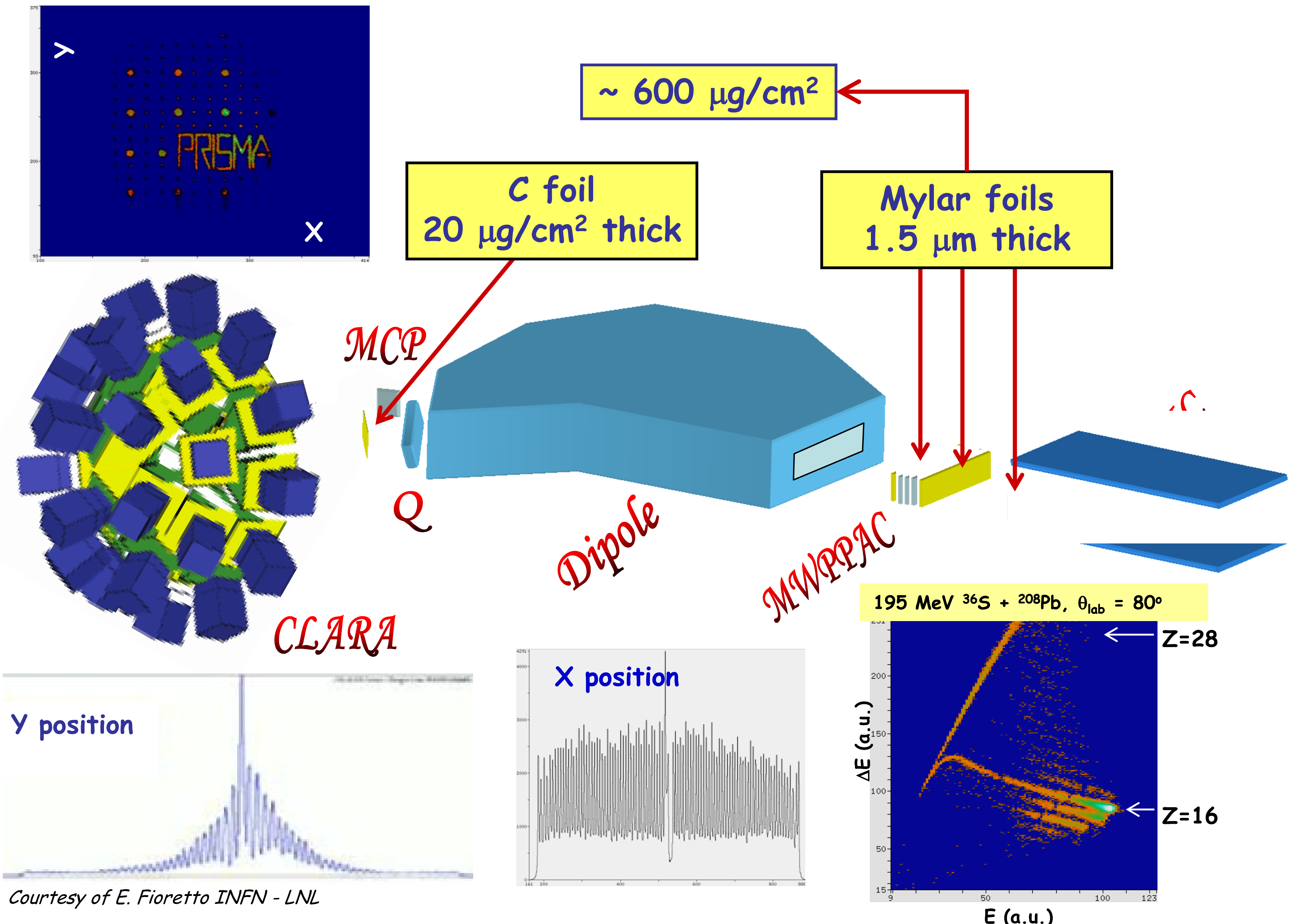


E.Fioretto et al.
LNL Ann. Rep. 2002 p.148

S.Beghini et al. NIM A551, 364 (05)

Courtesy of E. Fioretto INFN - LNL

PRISMA detectors: present configuration

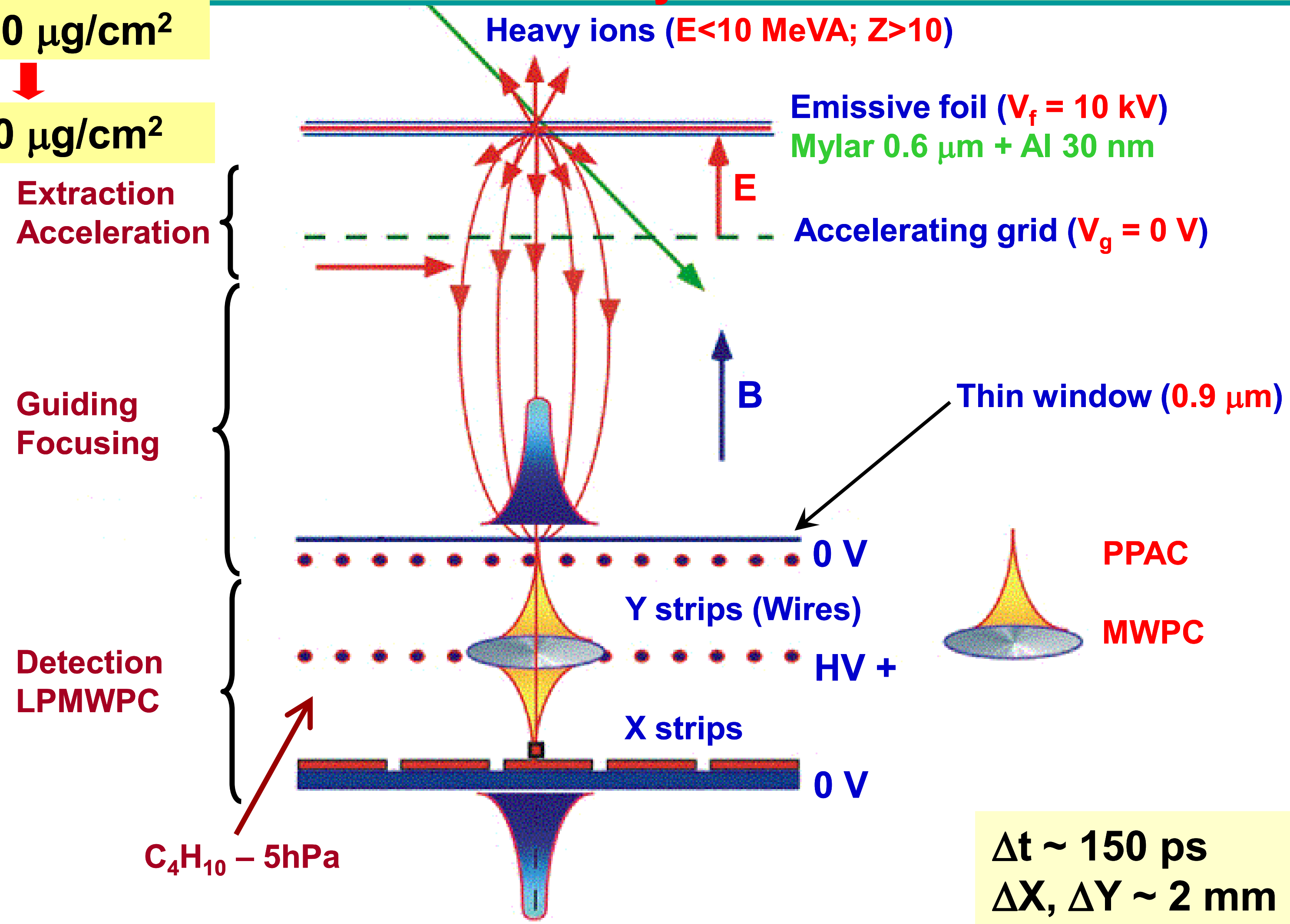


New FPDs for low energy heavy-ions

Secondary electron detector under production at University of Manchester

~ 420 μg/cm²

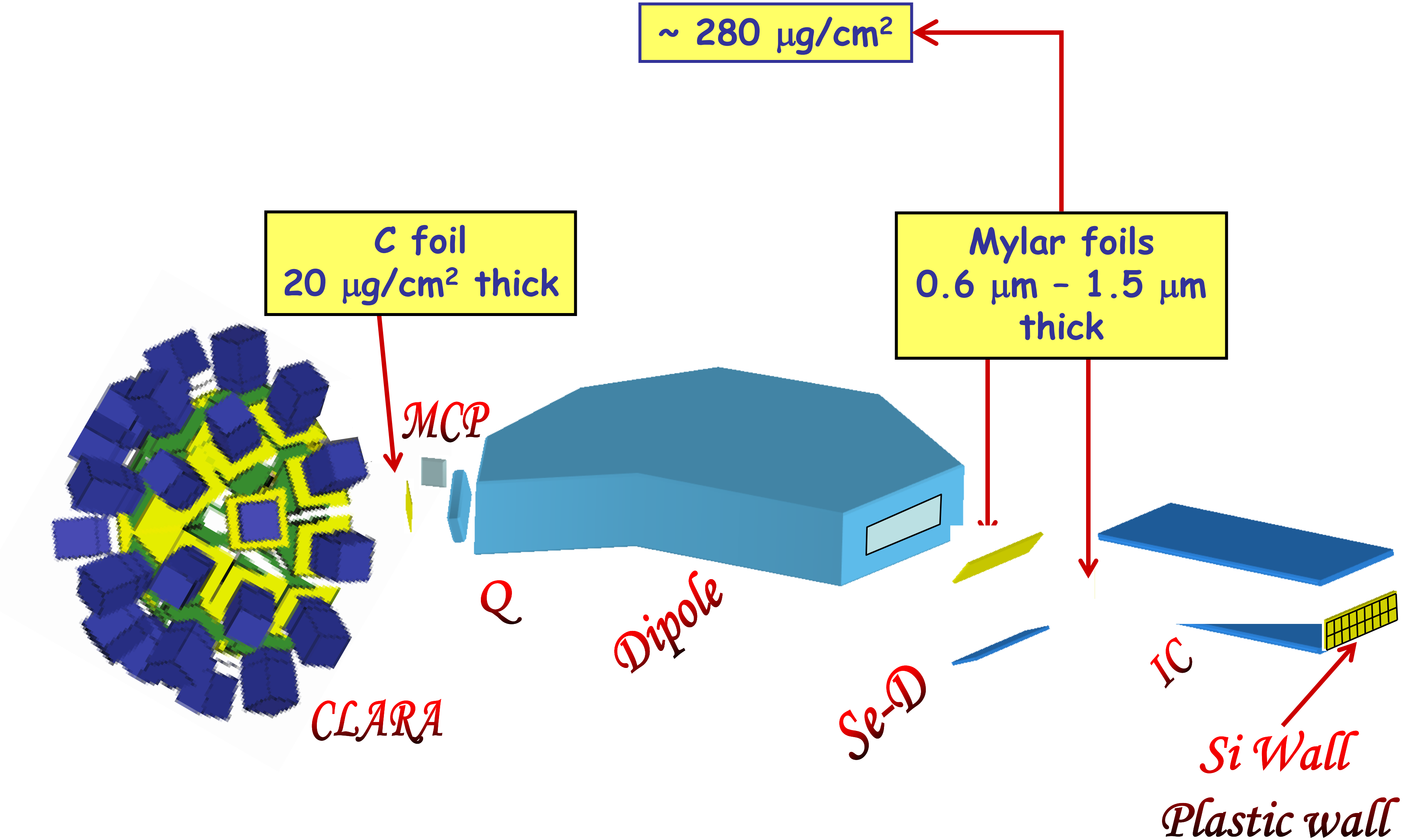
~ 80 μg/cm²



Δt ~ 150 ps
ΔX, ΔY ~ 2 mm

Courtesy of E. Fioretto INFN - LNL

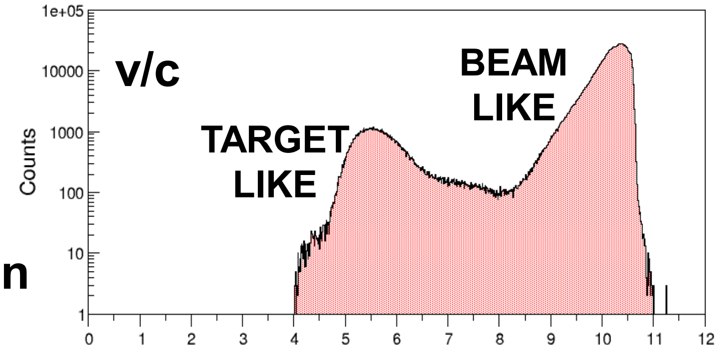
PRISMA detectors for light Ions and low energy heavy ions: SeD under development

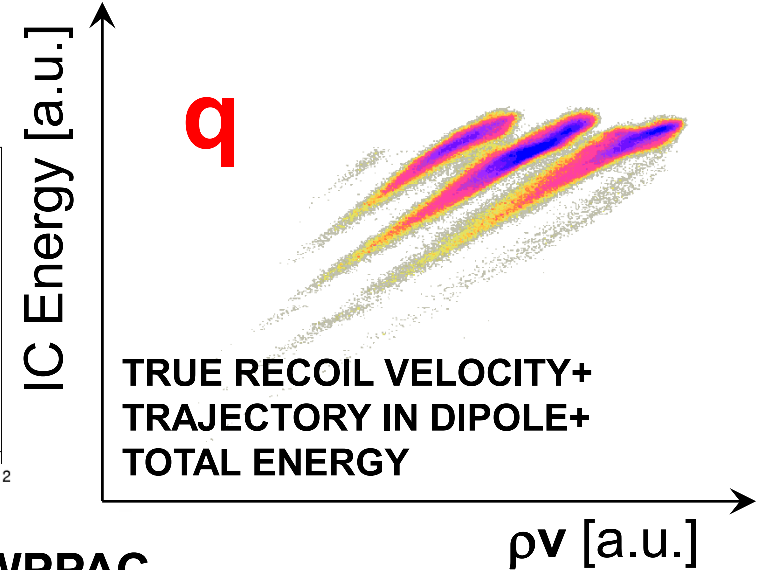


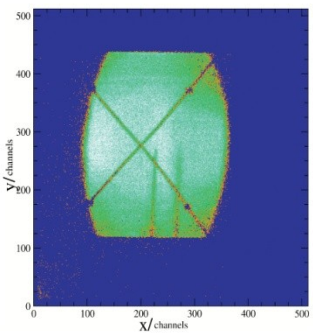
Courtesy of E. Fioretto INFN - LNL

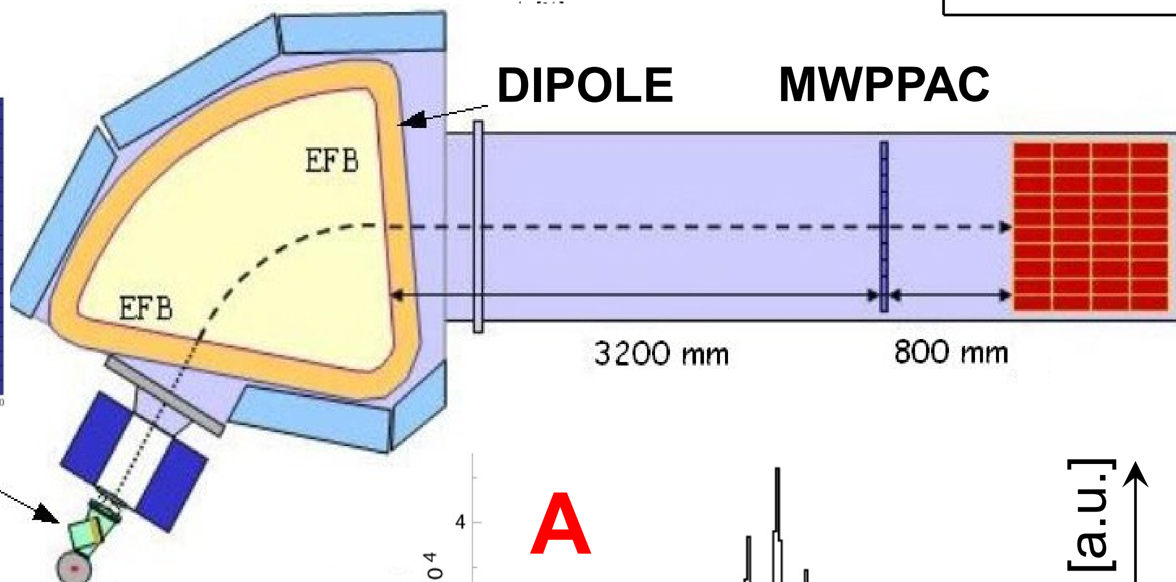
Tracking on PRISMA

A/q
- **true recoil velocity**
- **trajectory in dipole**





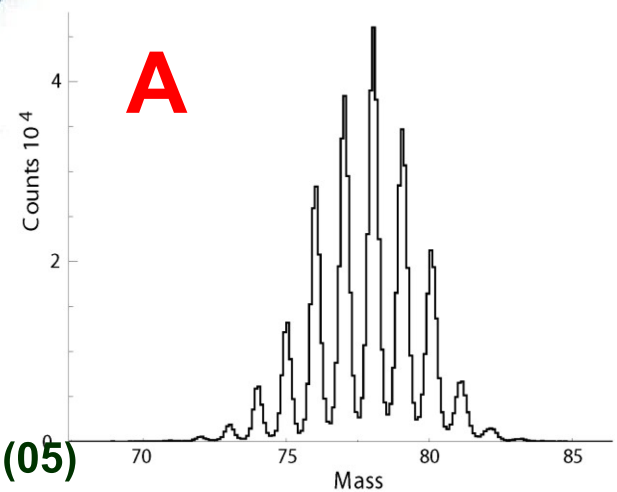


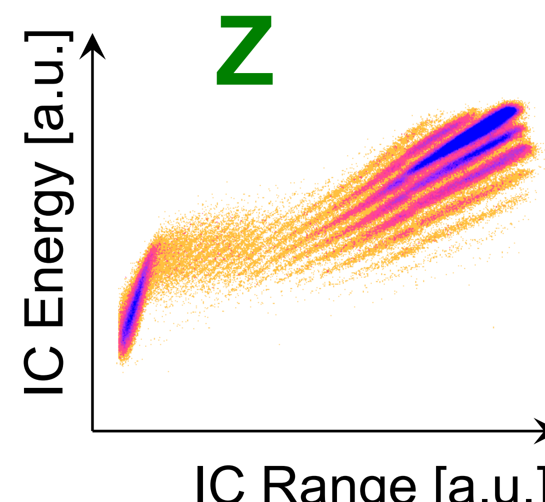


IONIZATION CHAMBER
5‰ Energy resolution

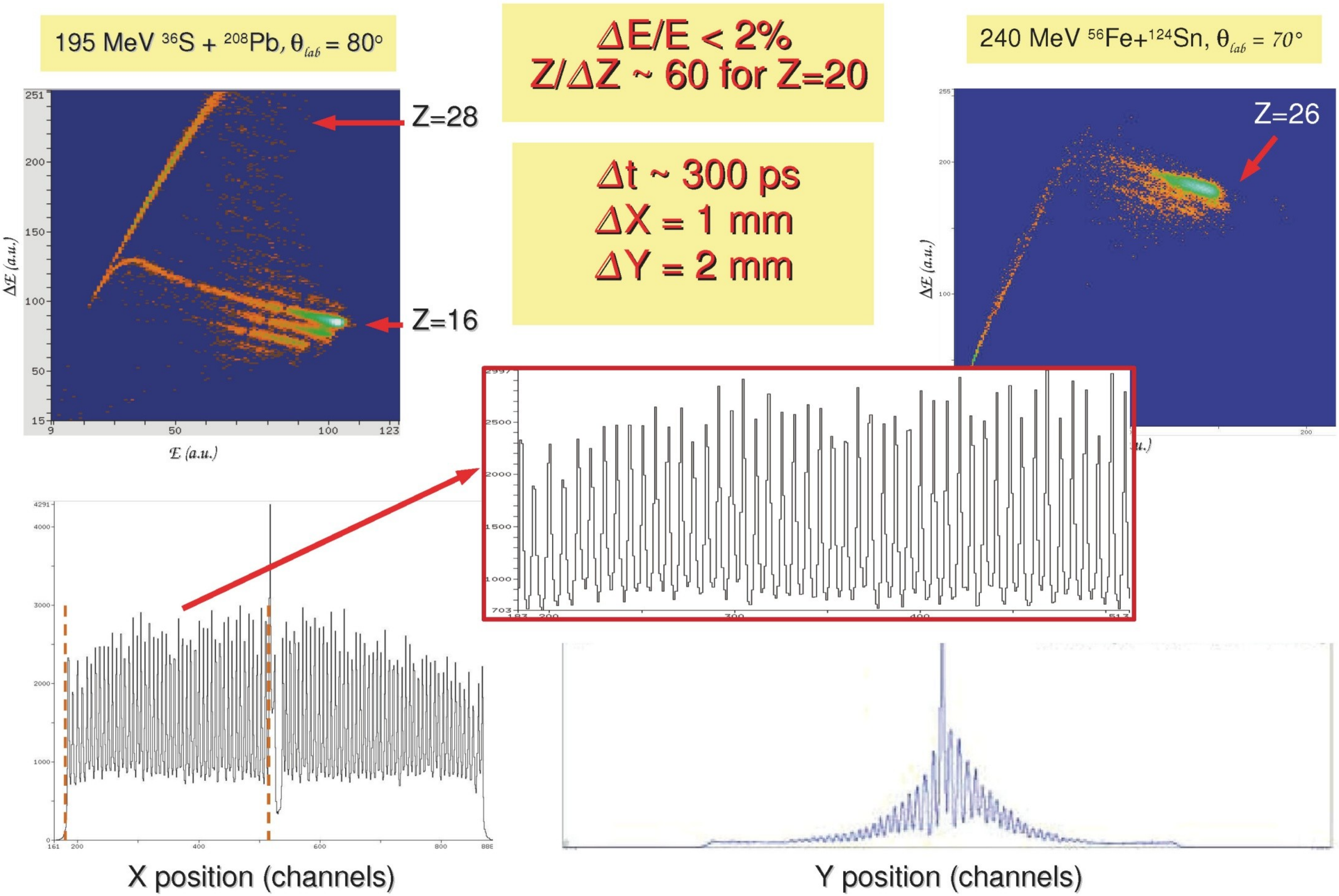
MCP Start Detector

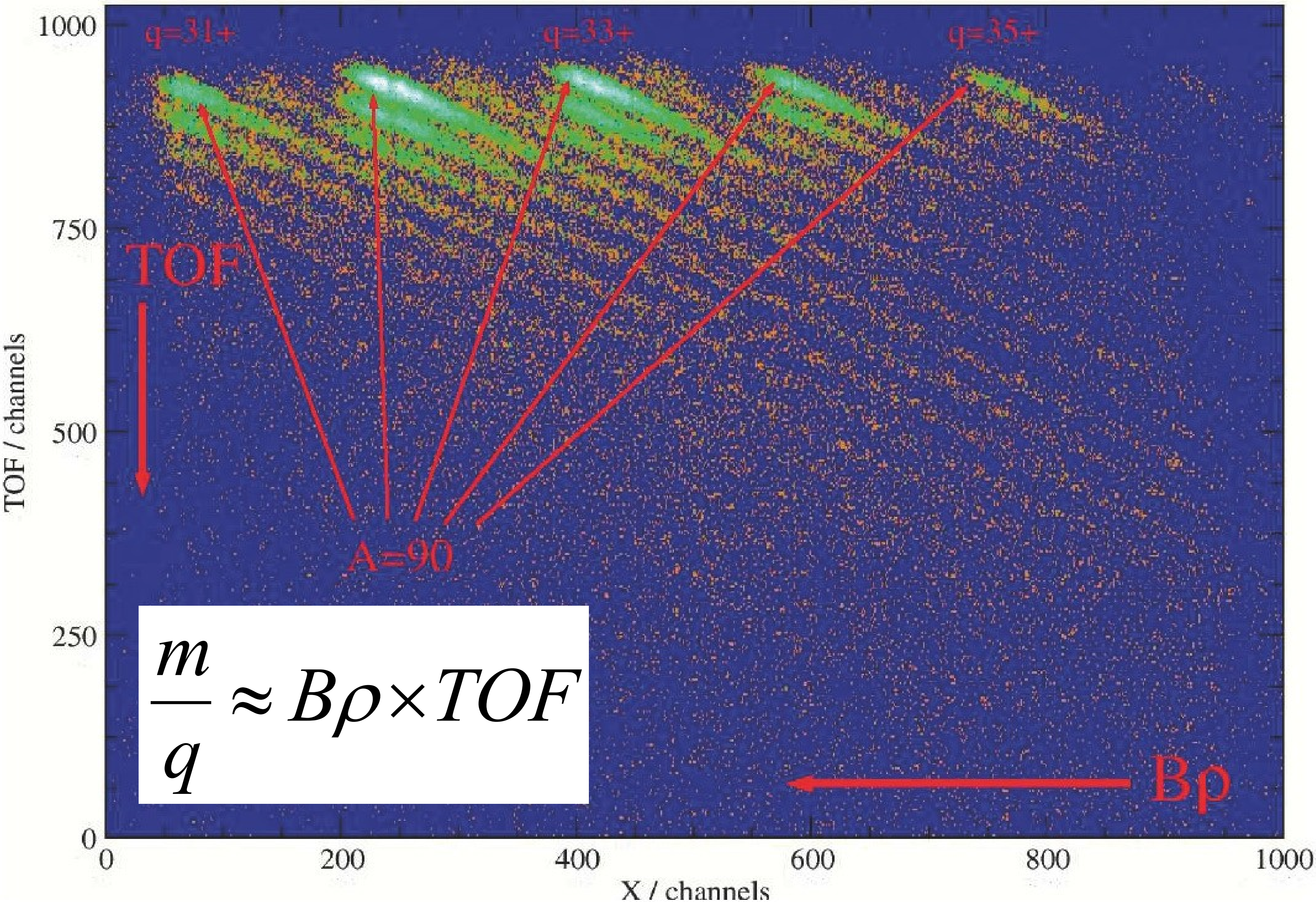
MCP-MWPPAC
ΔTOF=0.5 ns





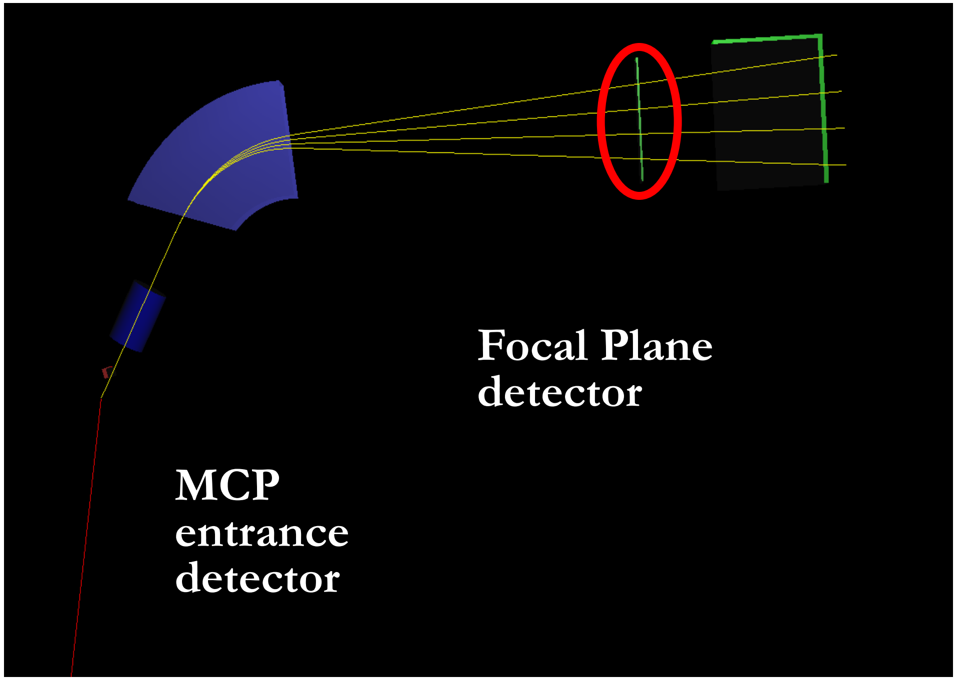
S.Beghini et al. NIM A551, 364 (05)
G.Montagnoli et al. NIM A547, 455 (05)


195 MeV 36S + 208Pb, θlab = 80°
ΔE/E < 2%
Z/ΔZ ~ 60 for Z=20
240 MeV 56Fe+124Sn, θlab = 70°
Z=28
Z=16
Z=26
Δt ~ 300 ps
ΔX = 1 mm
ΔY = 2 mm
ΔE (a.u.)
E (a.u.)
X position (channels)
Y position (channels)

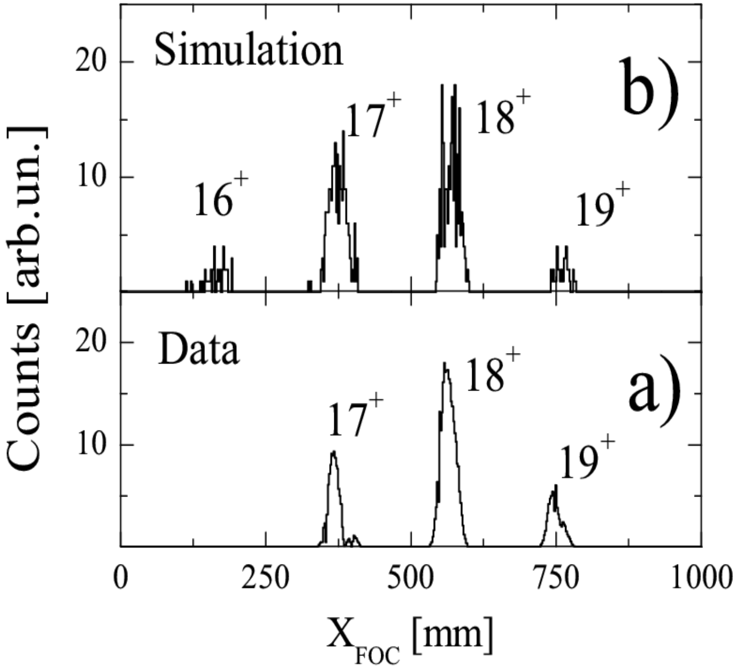

q=31+
q=33+
q=35+
TOF
A=90
Bρ
$\frac{m}{q} \approx B\rho \times TOF$
TOF / channels
X / channels
1000
750
500
250
0
200
400
600
800

Monte Carlo Simulation of the PRISMA Response Function

Monte Carlo simulation based on the ray tracing code originally developed by A. Latina and E. Farnea
The charge states transported in the simulation have to be the same as in the experiment



48Ca Charge States



D.Montanari et al. EPJA (11) in press

Courtesy of D.Montanari INFN-Milano

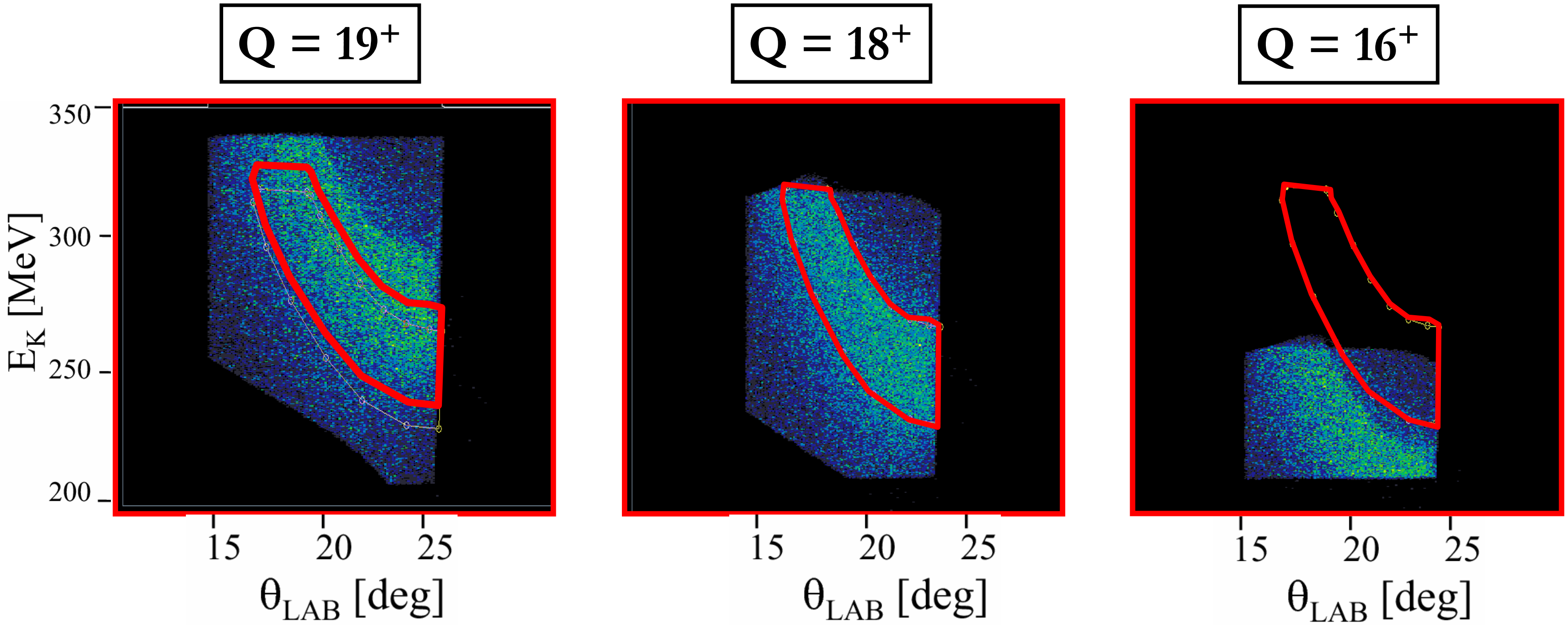
Response for an Uniform Distribution for 48Ca

Transport in PRISMA of a uniform distribution in (E_k,θ,ϕ)

E_K = [200, 400] MeV

ϑ = [10°, 40°]

φ = [-40°,40°]

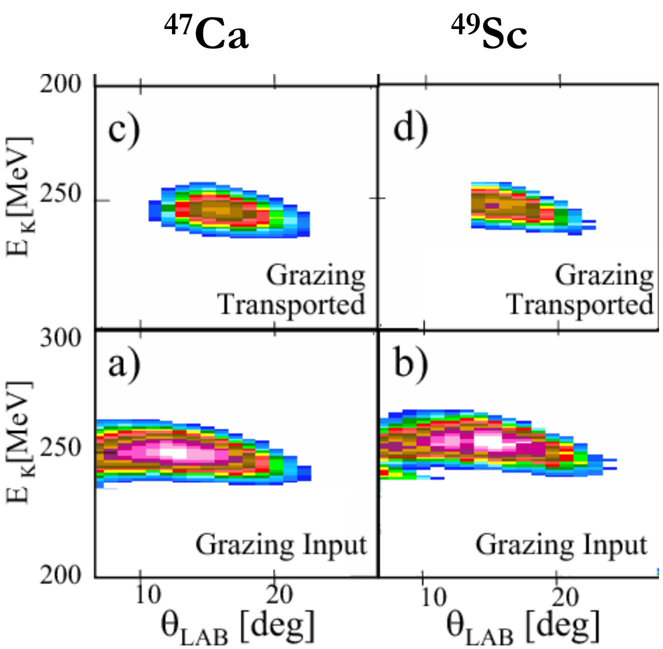


D.Montanari et al. EPJA (11) in press

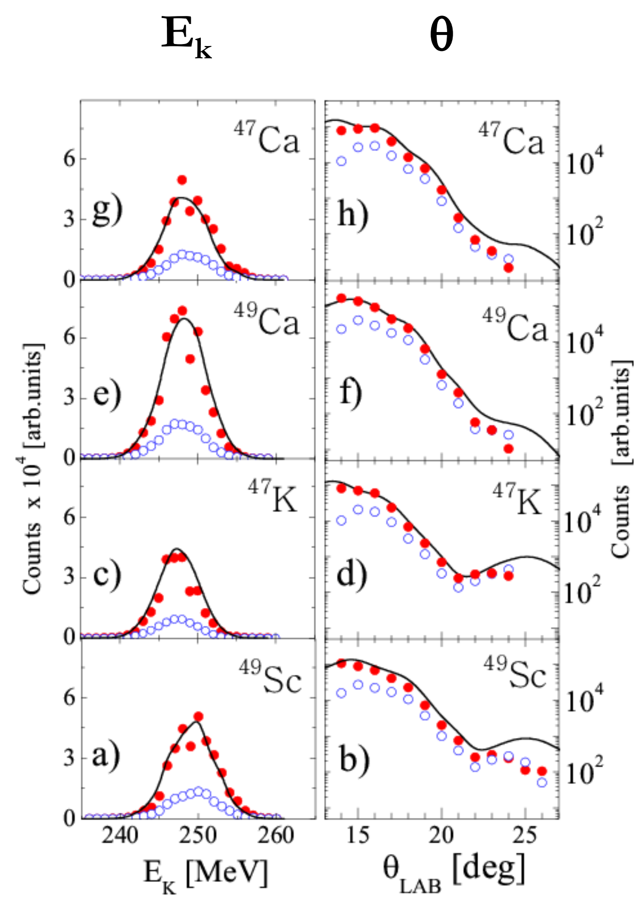
Courtesy of D.Montanari INFN-Milano

Calculated PRISMA Response
with INPUT theoretical distributions

$$(d\sigma/d\Omega dE)_{GRAZING} \leftrightarrow (d\sigma/d\Omega dE)_{GRAZING\text{-}Transp} * f(E,\theta)$$



GRAZING model:
(A.Winther,
Nucl.Phys.A594
(1995)203)



GRAZING input (solid line)

GRAZING-Transp (open circle)

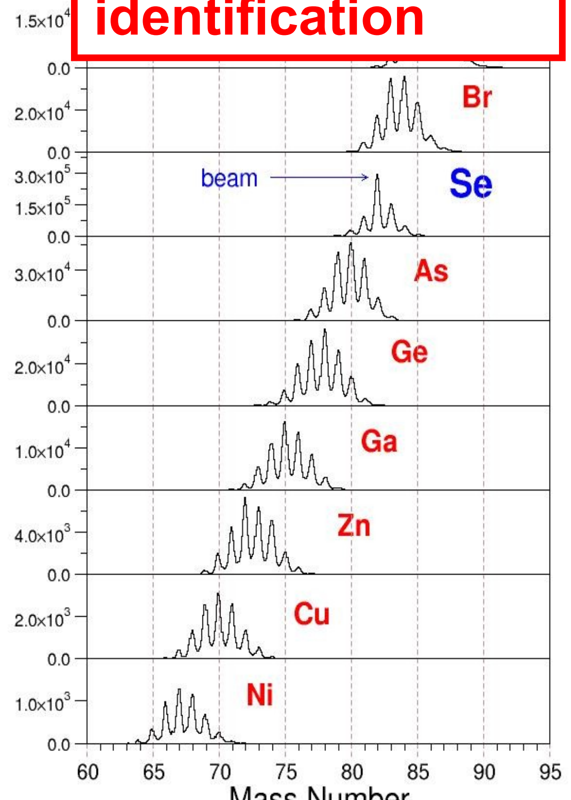
GRAZING-Transp * f(E,θ) (filled circle)

D.Montanari et al. EPJA (11) in press

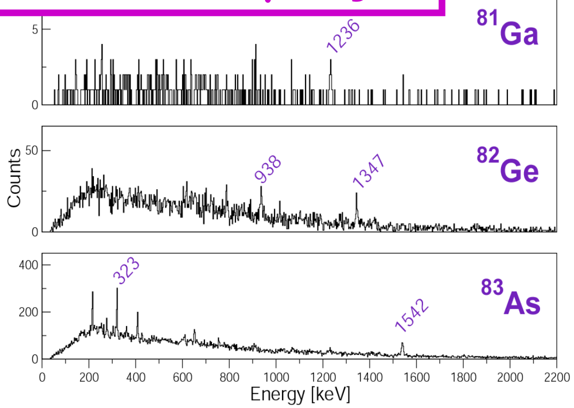
Courtesy of D.Montanari INFN-Milano

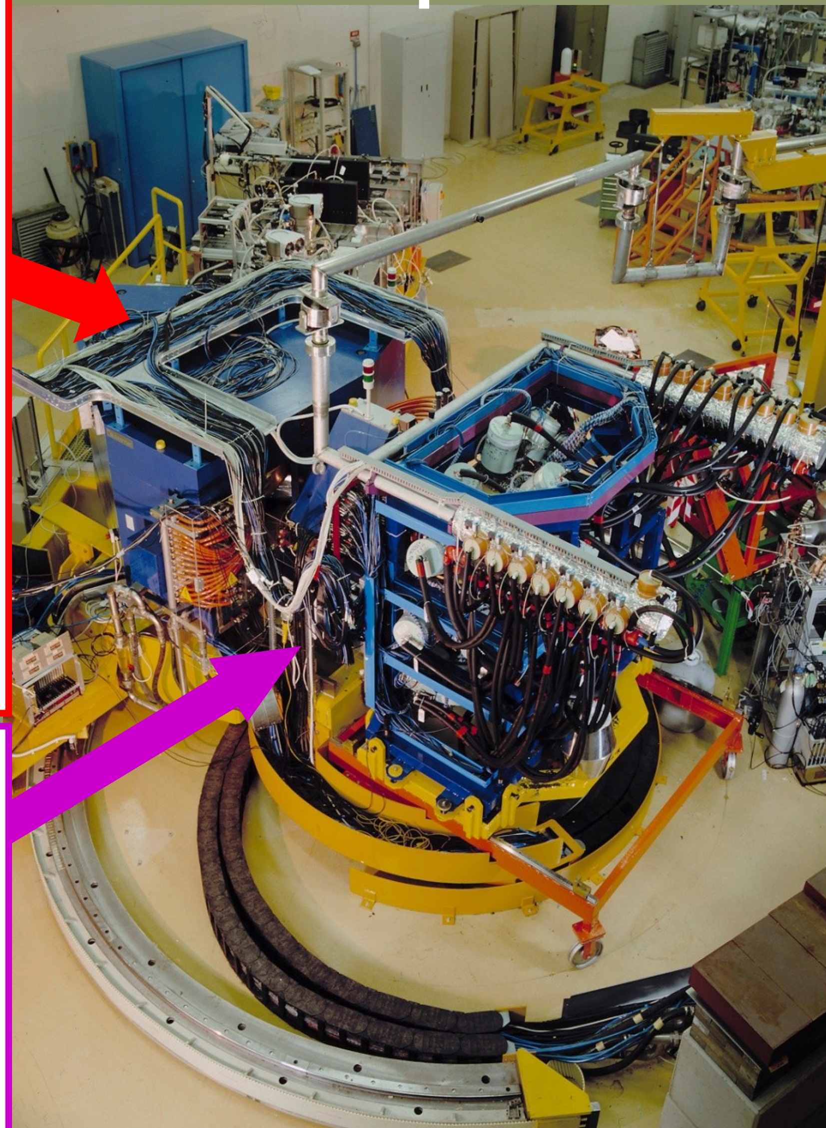
CLARA-PRISMA at LNL
Clover Detector array
PRISMA Spectrometer

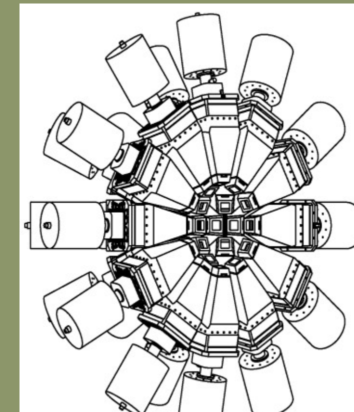
A & Z identification

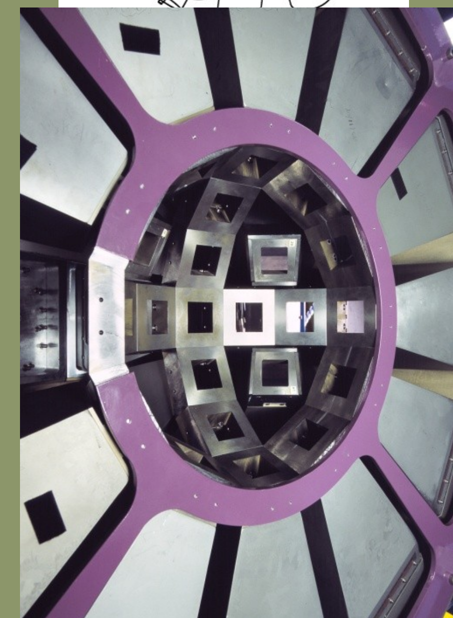


"in-beam" γ-ray







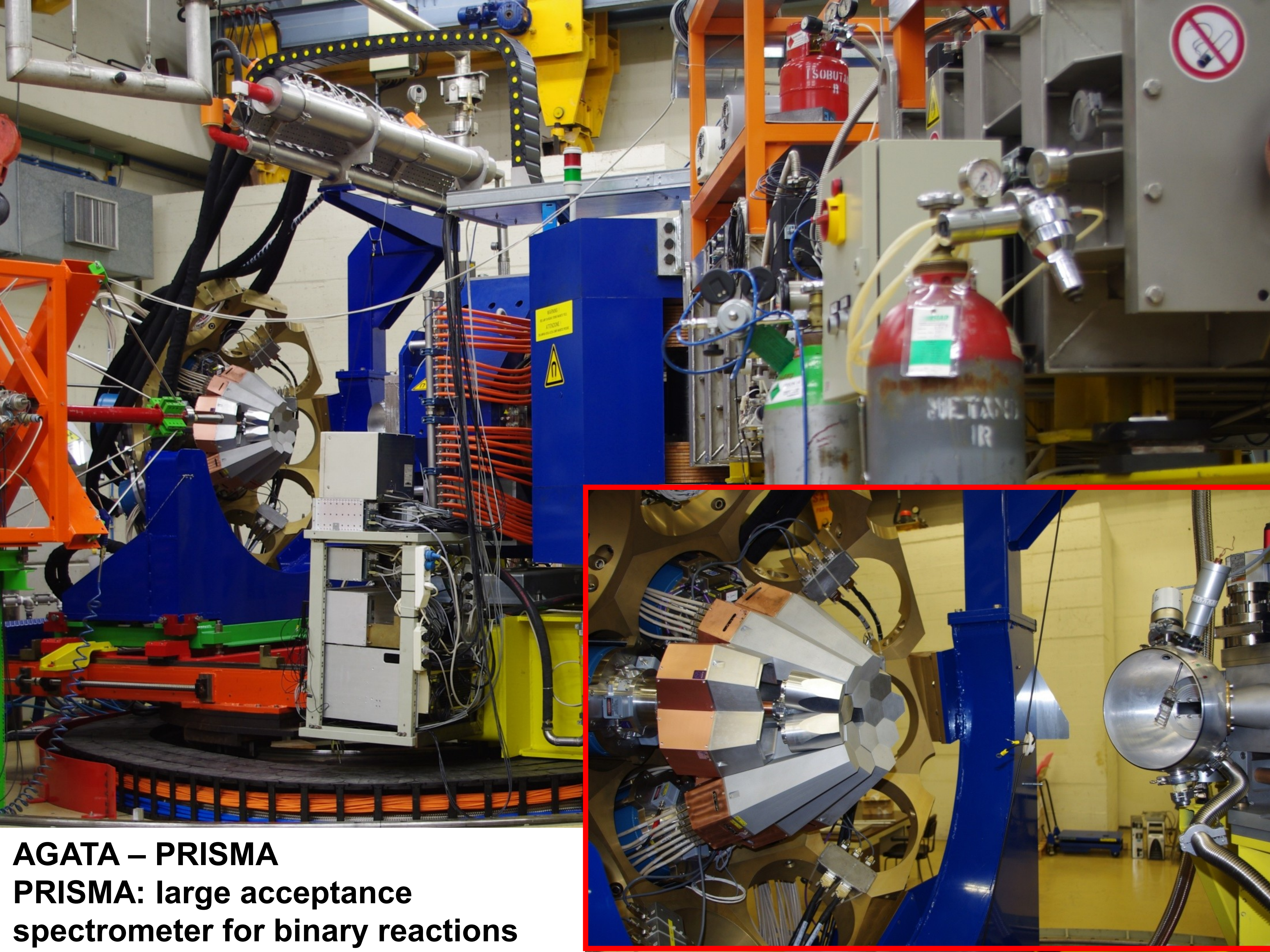


25 Euroball Clover detectors (GammaPool)

Performance at Eγ= 1.3MeV

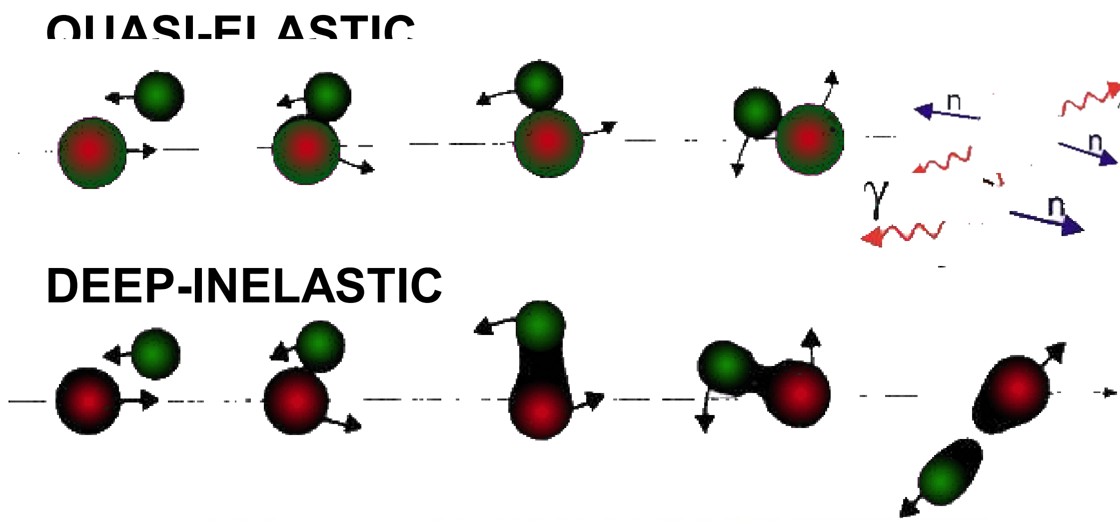
- Efficiency ~ 3 %
- Peak/Total ~ 45 %
- FWHM < 10 keV (at v/c = 10 %)

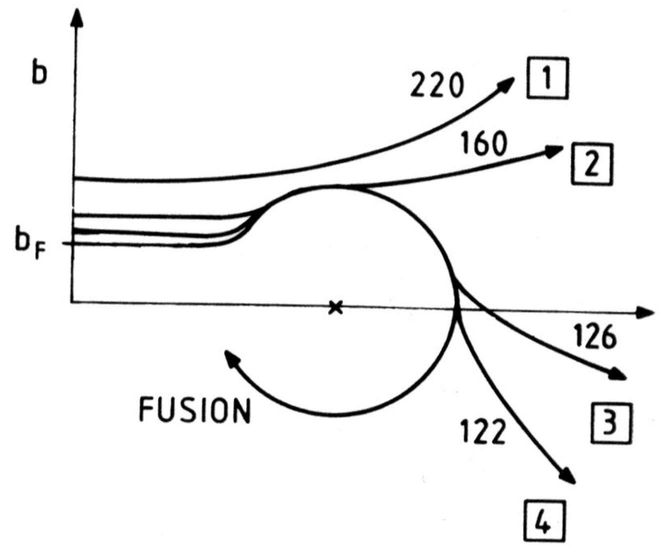
A. Gadea et al., EPJA20 (04) 193



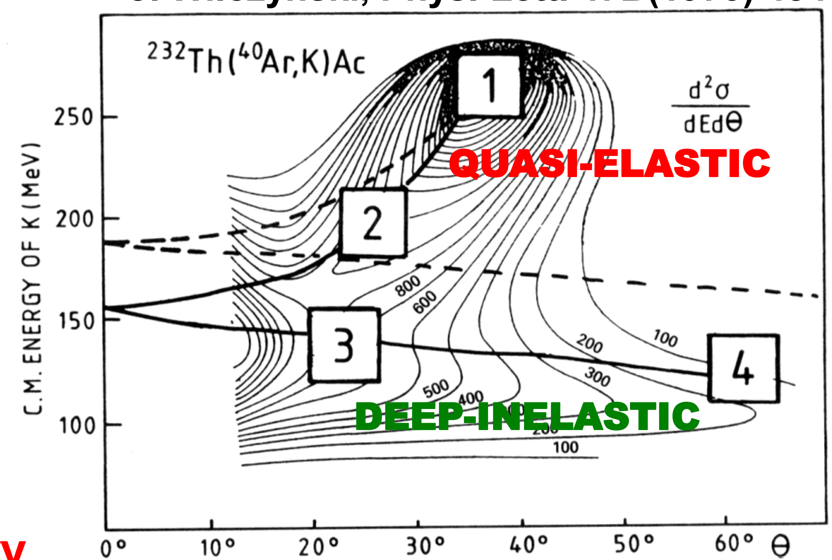
AGATA – PRISMA
PRISMA: large acceptance spectrometer for binary reactions

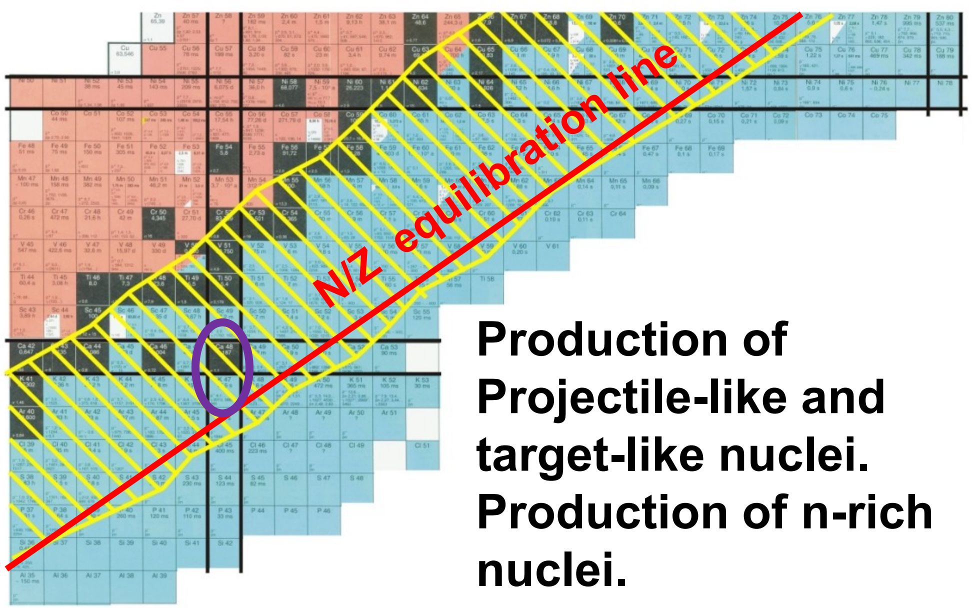
GRAZING and DIC REACTIONS





J. Wilczynski, Phys. Lett. 47B(1973) 484

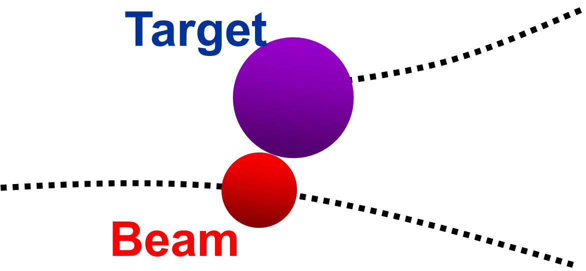




Production of Projectile-like and target-like nuclei. Production of n-rich nuclei.

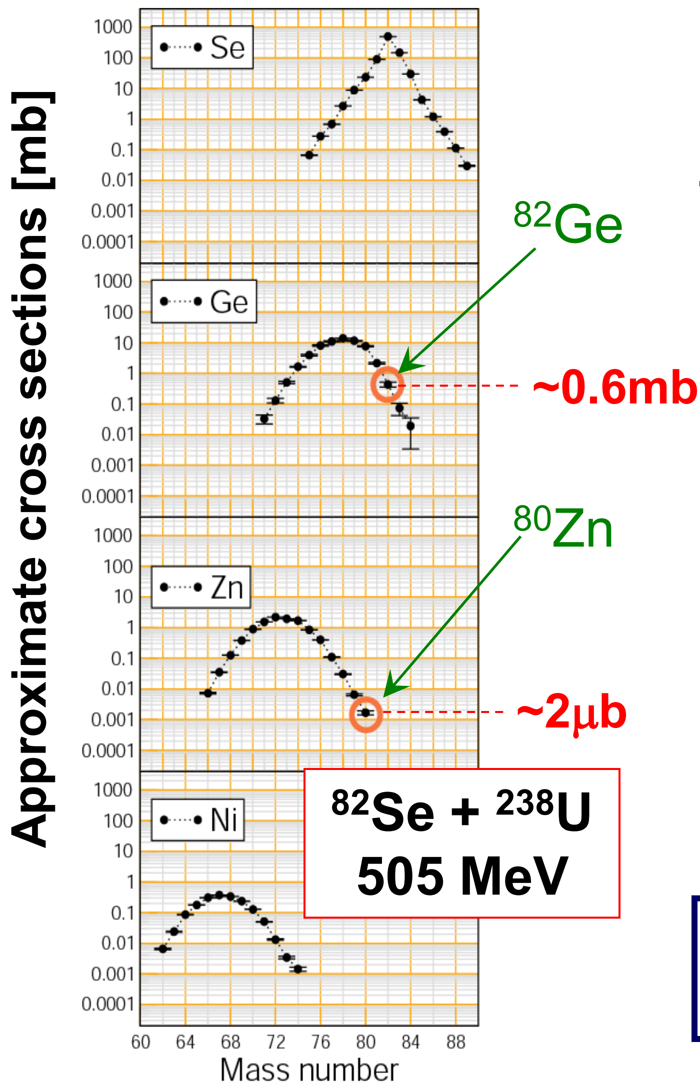
Identification of products with complementary detectors or by γ-spectroscopy of the partners is required

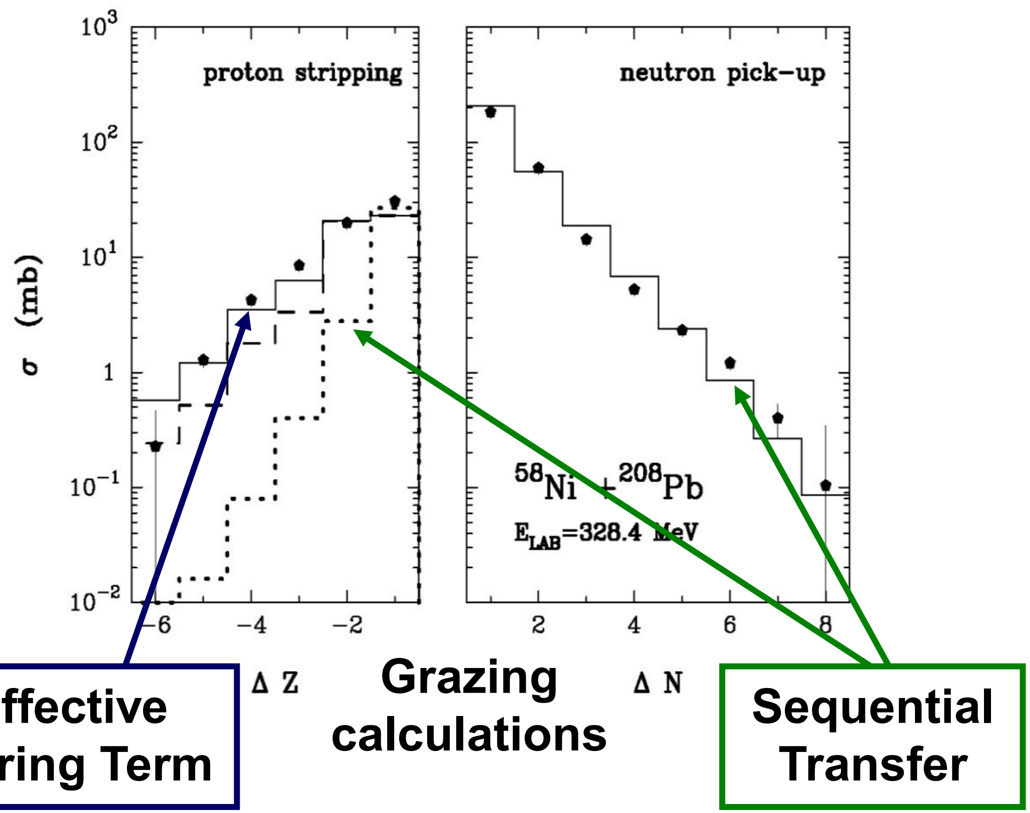
Grazing reactions transferring several nucleons, a tool to study neutron-rich nuclei



Deep-inelastic reactions used since thick target pioneering work of R.Broda et al. (PLB 251 (90) 245)

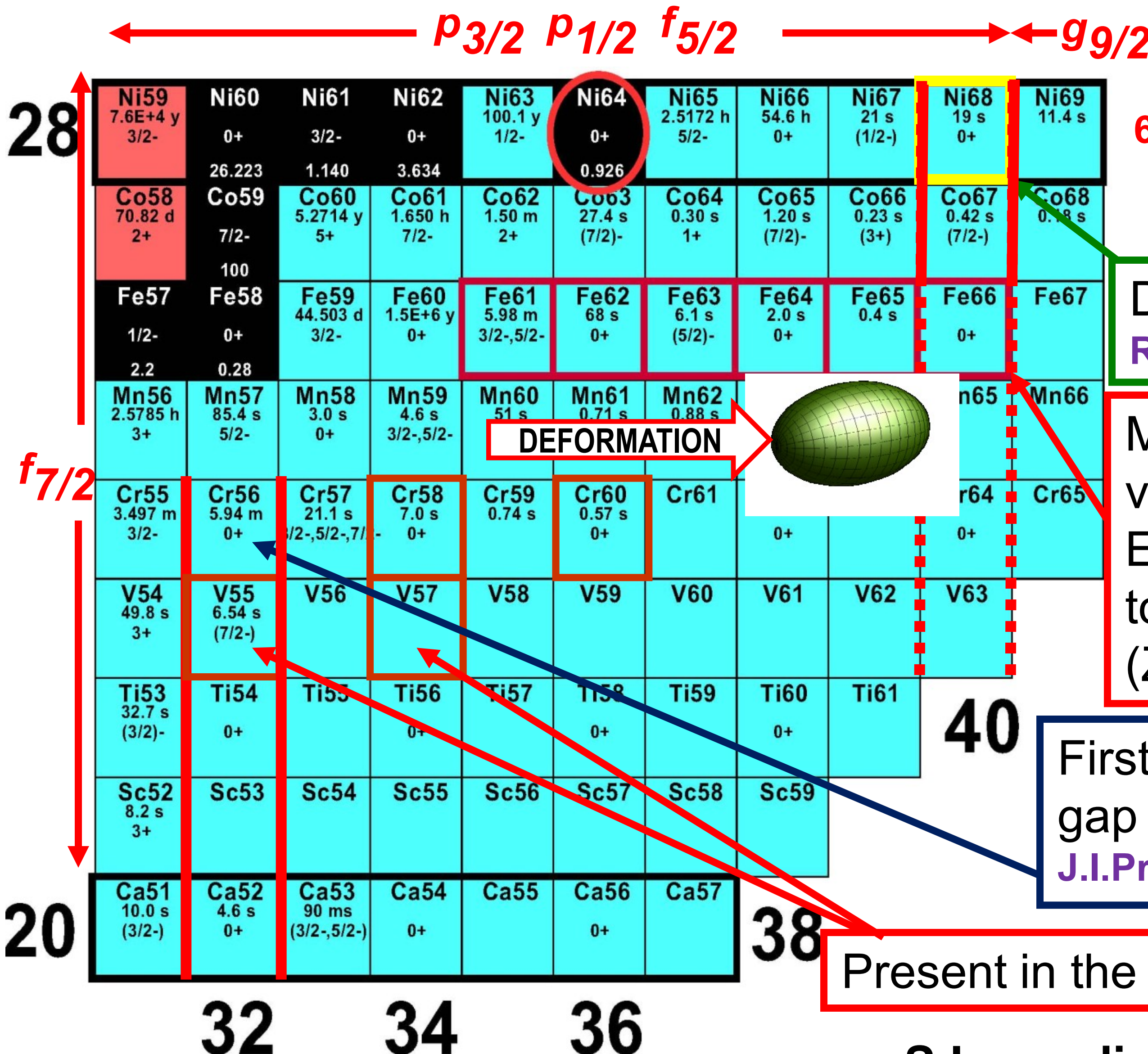
Use of Multinucleon-transfer at the grazing angle triggered by the LNL reaction mechanism group.





L.Corradi et al., Phys.Rev.C59 (99)261, Theory: G.Pollarolo

N=28-40 neutron-rich A~50-70 nuclei



^{64}Ni (400 MeV)+ ^{238}U

CLARA-PRISMA θ_G = 64°

Doubly magic character
R.Broda et al., PRL 74 (95) 868

Magic Character of N=40 vanishes for Z<28.
Evolution of the collectivity towards N=40 in the Fe (Z=26) isotopes

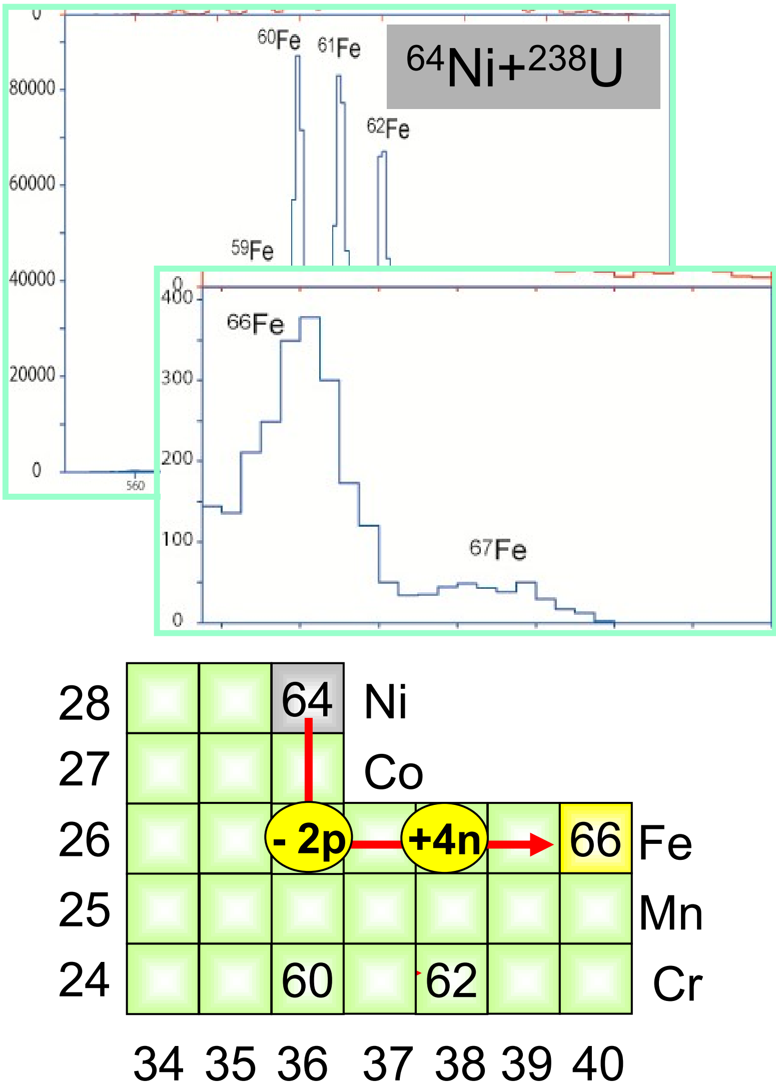
First indication of N=32 shell gap in Cr isotopes
J.I.Prisciandaro et al PLB510(01)17

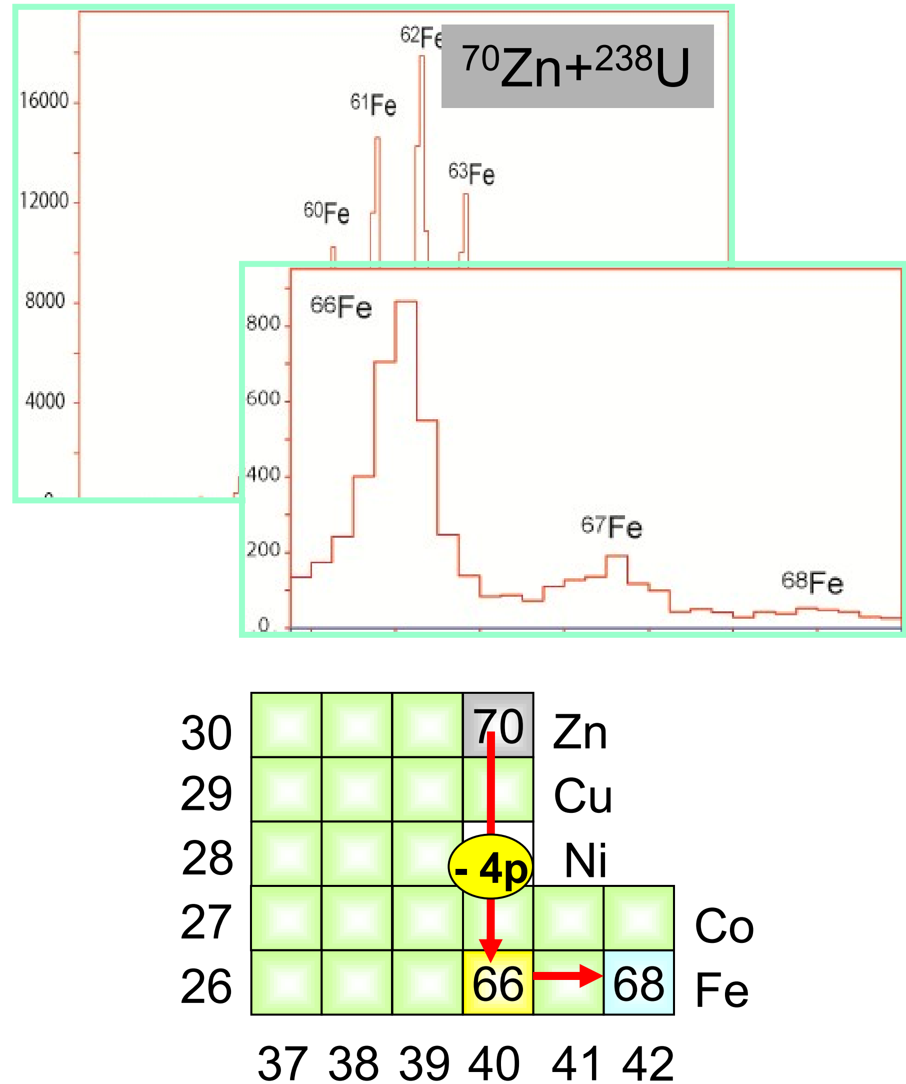
Present in the in the 1πf7/2 band in ^{55,57}V

S.Lunardi, S.M.Lenzi, S.Freeman

Beyond N=40 in Fe isotopes

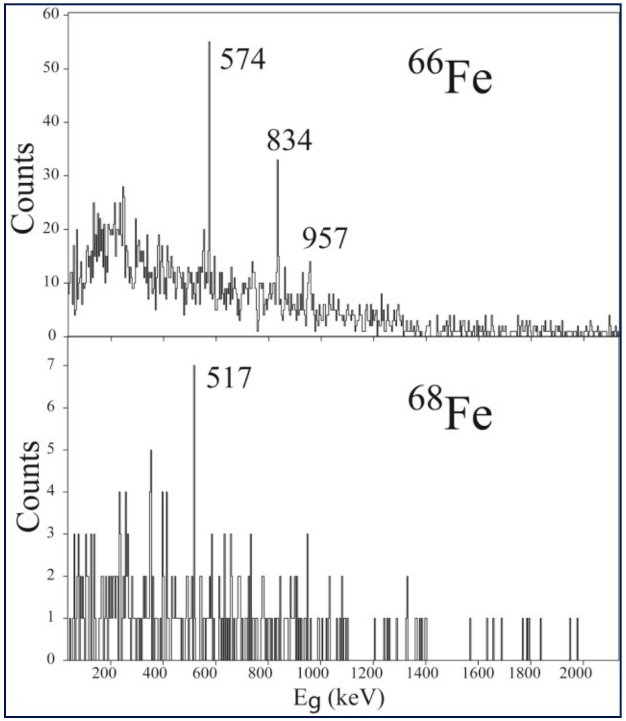
Comparison ^{64}Ni and ^{70}Zn onto ^{238}U



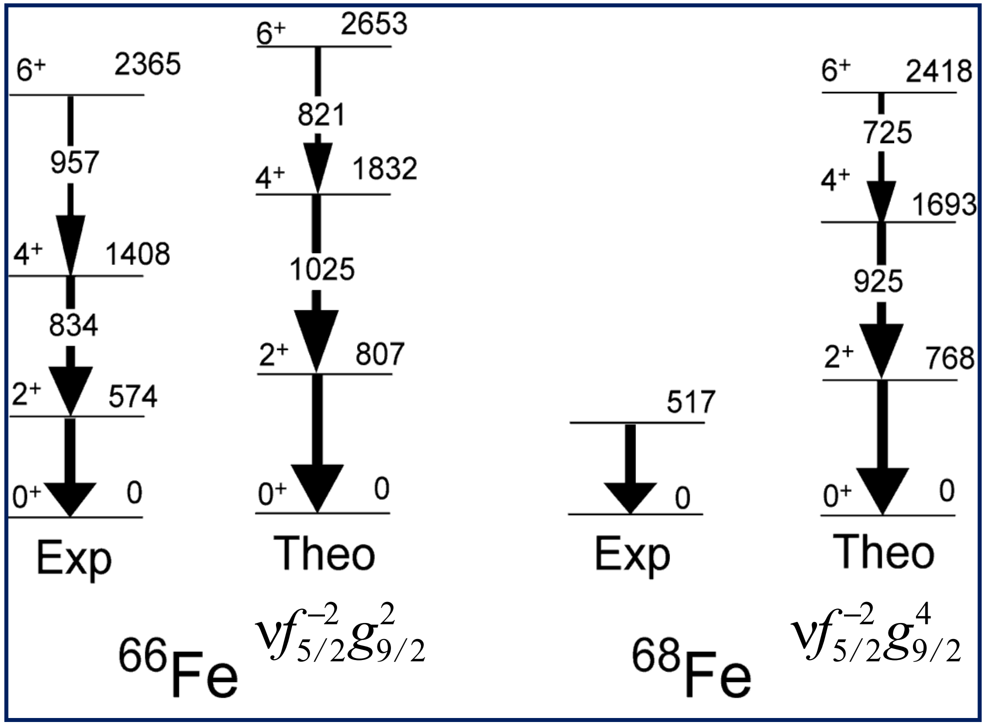


N=40 and N=42 Fe isotopes

^{70}Zn@460MeV onto ^{238}U



N=40 N=42



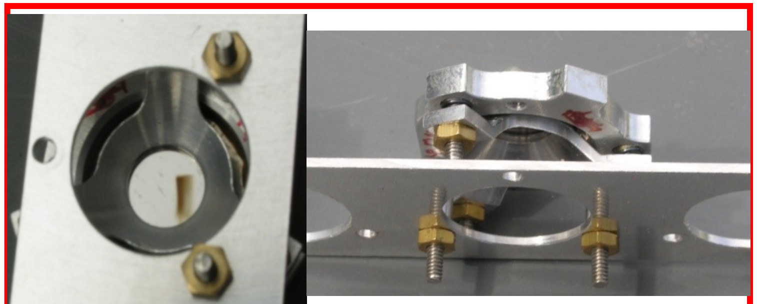
The experimental level schemes are more quadrupole-collective than the calculated ones.

Quadrupole collectivity can be produced by including the $d_{5/2}$ shell in the model space (A. Zuker et al., PRC52 R1741 (1995)).

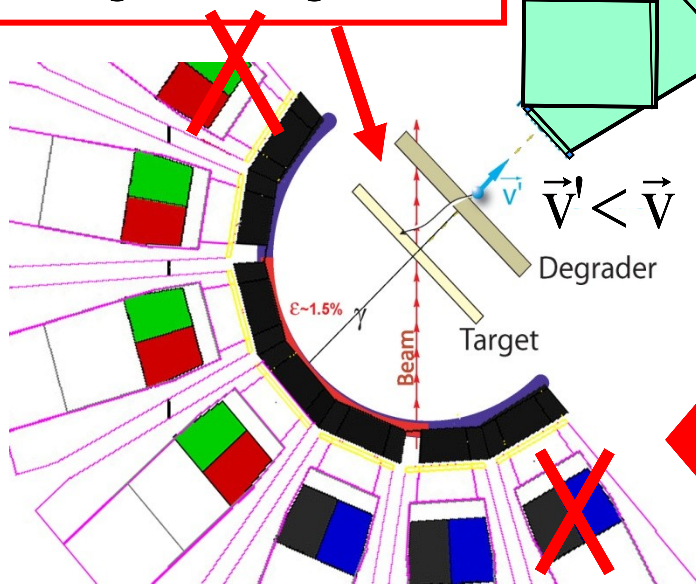
S.M. Lenzi et al., LNL Annual Report 2007 and to be published

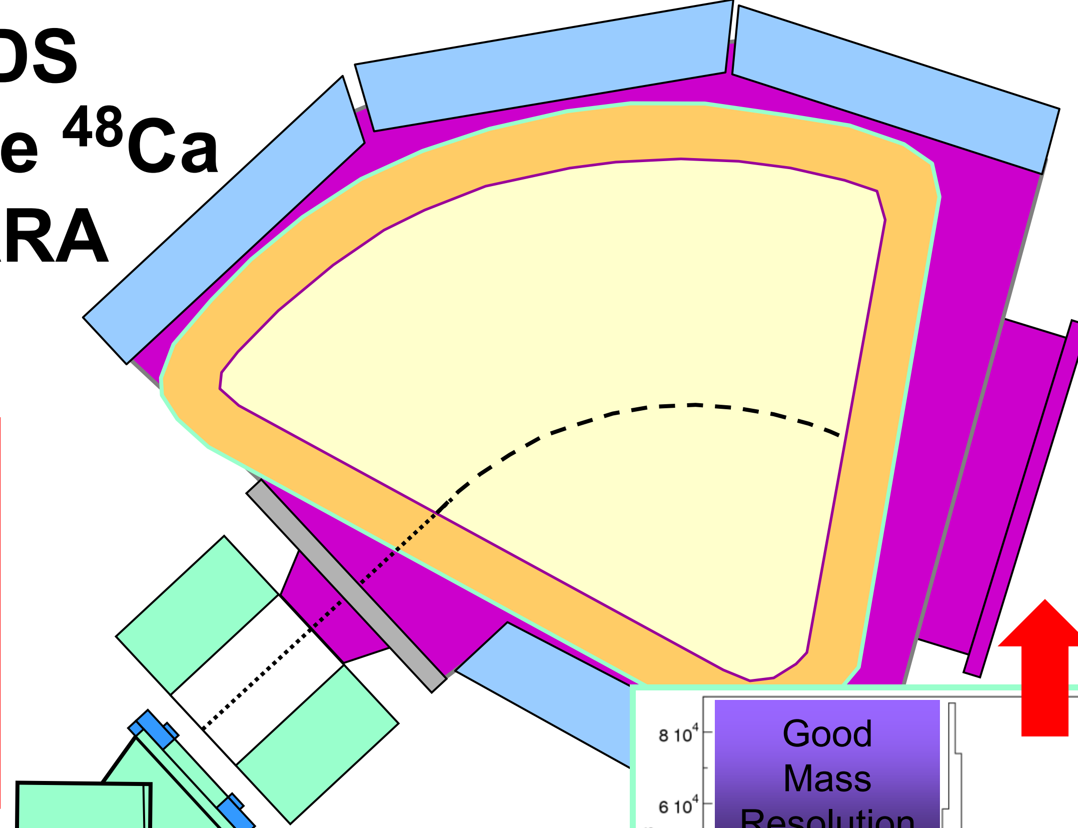
Differential RDDS Measurement in the ^{48}Ca region with CLARA

D.Mengoni, J.Valiente, A.Gadea, A.Dewald

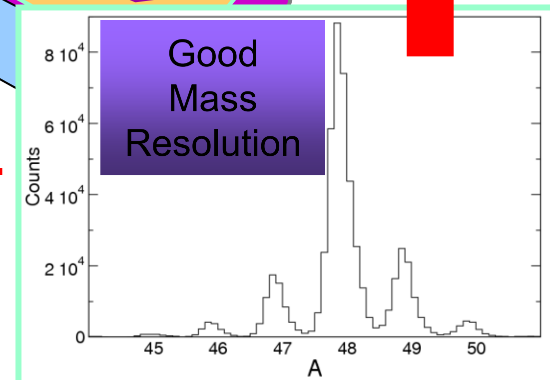


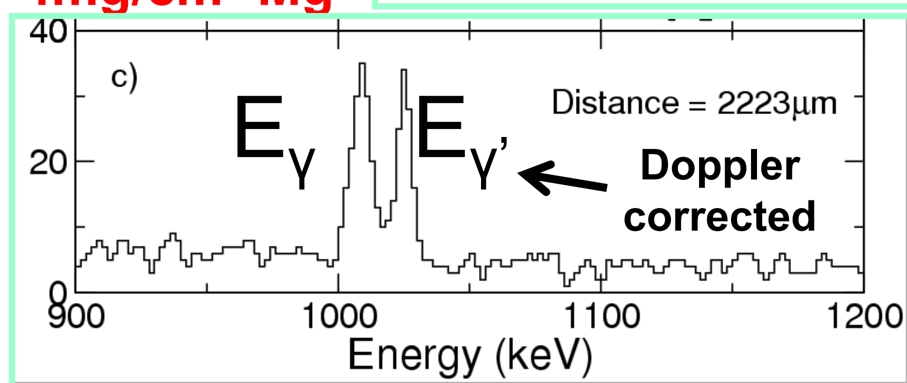
Differential Plunger for angles ≠ 0°



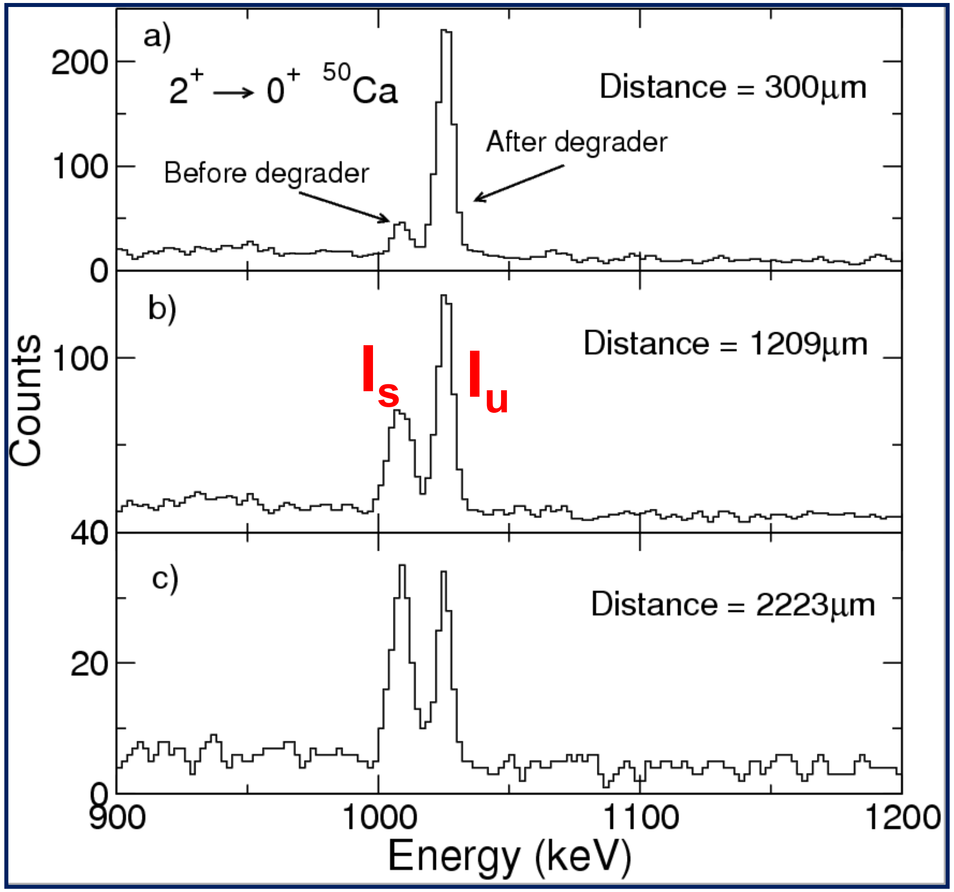


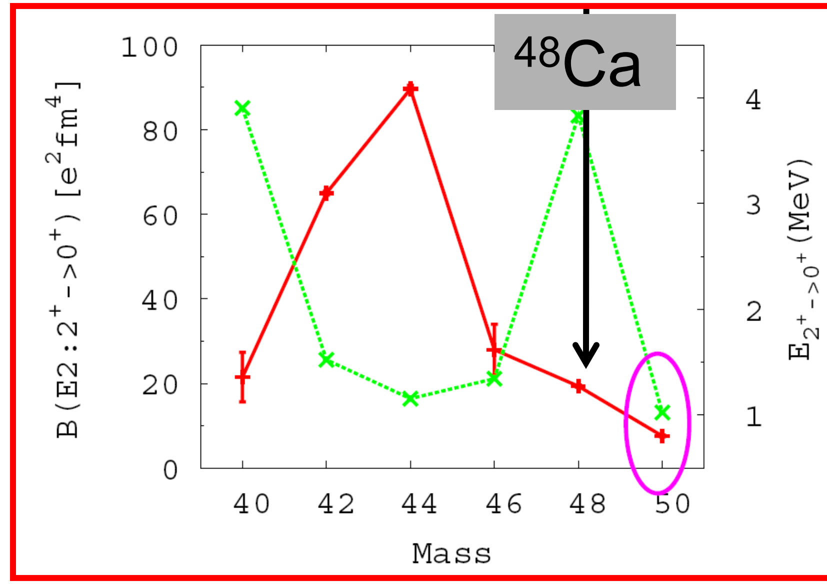
^{48}Ca 310MeV + 1mg/cm^2 ^{208}Pb
Degrader 4mg/cm^2 Mg



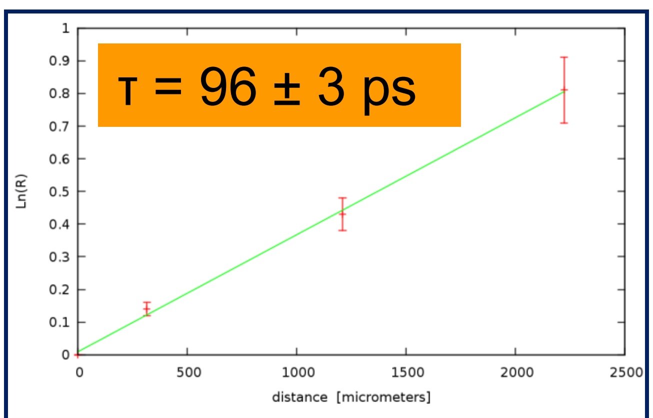


Lifetime of the 2^+ in ^{50}Ca

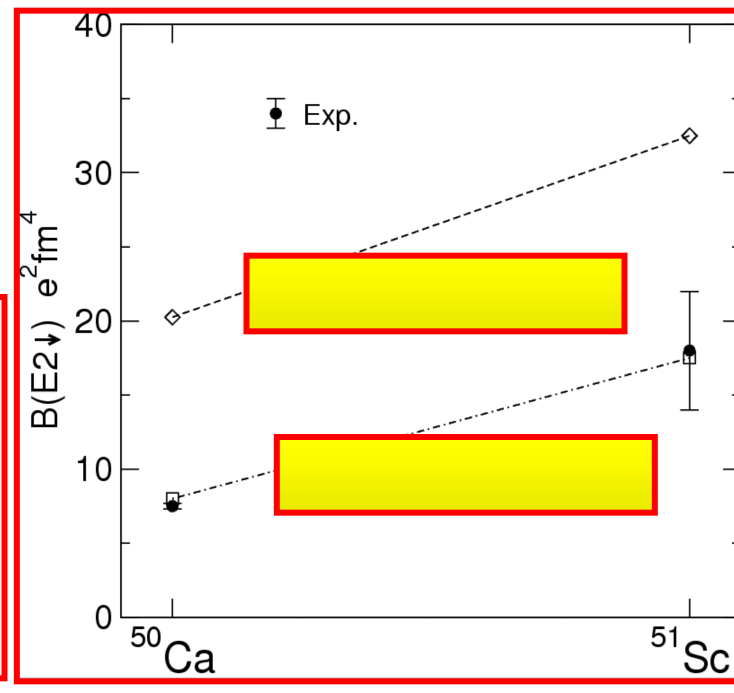




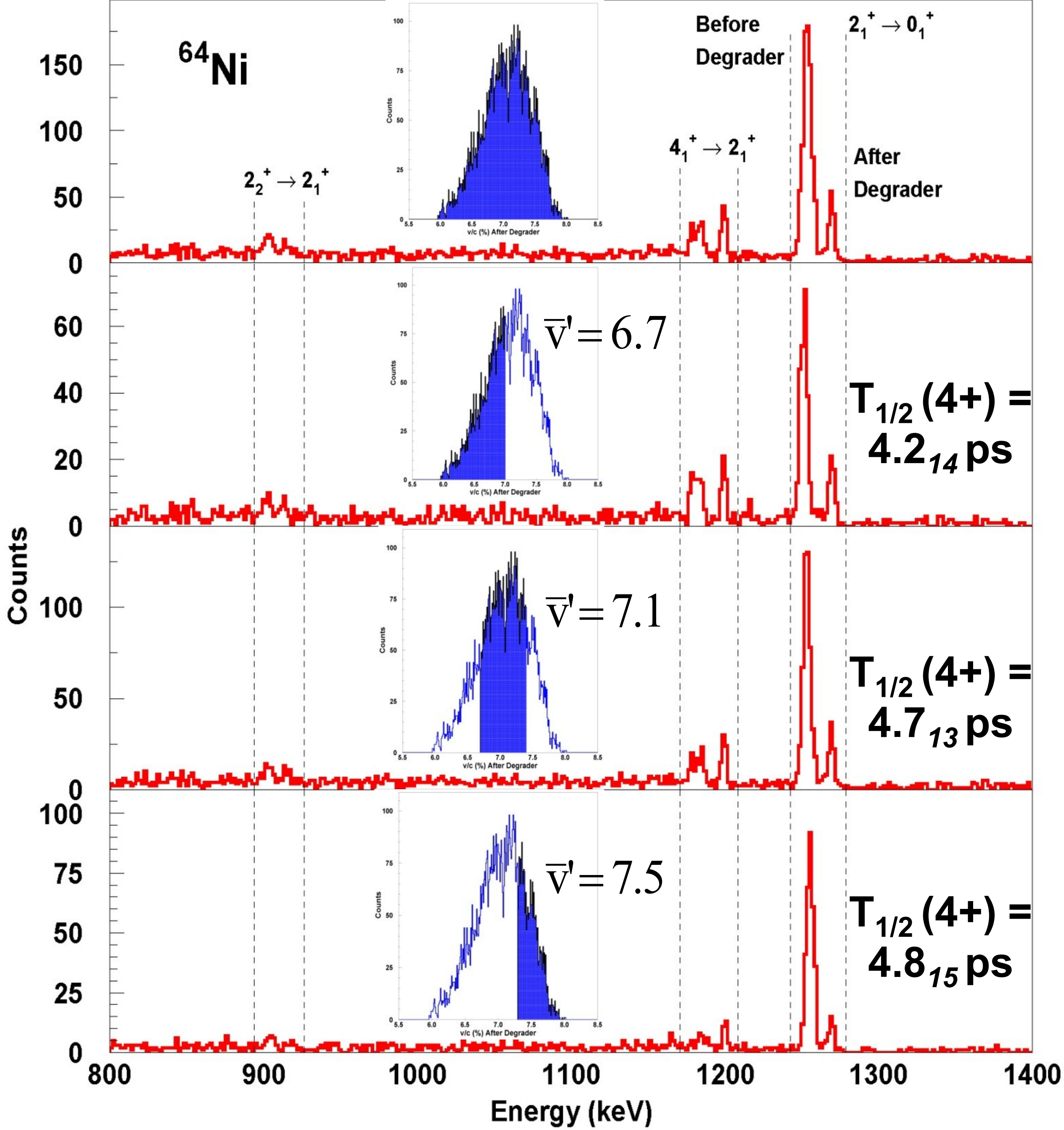
J.J. Valiente-Dobón et al. PRL 102 (09) 242502.

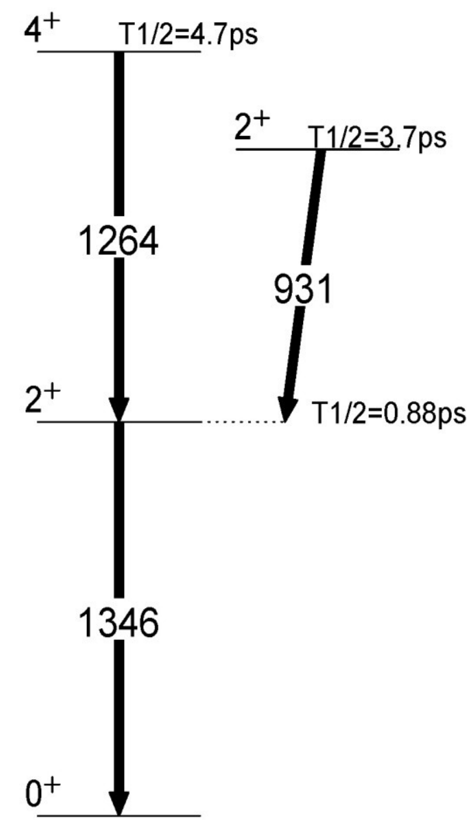


The obtained effective charges (IS) are different to the ones obtained nearby N≈Z (IS+IV) → Possible isospin dependence of the effective charges.

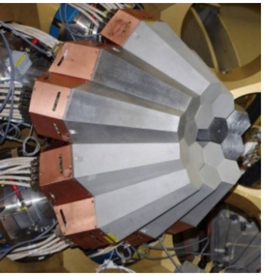


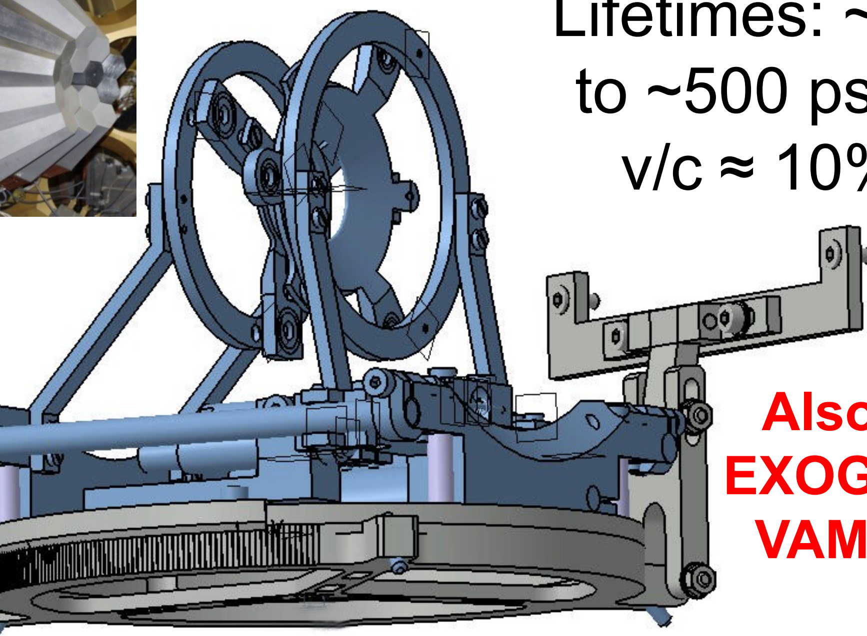
^{64}Ni Inelastic Scattering





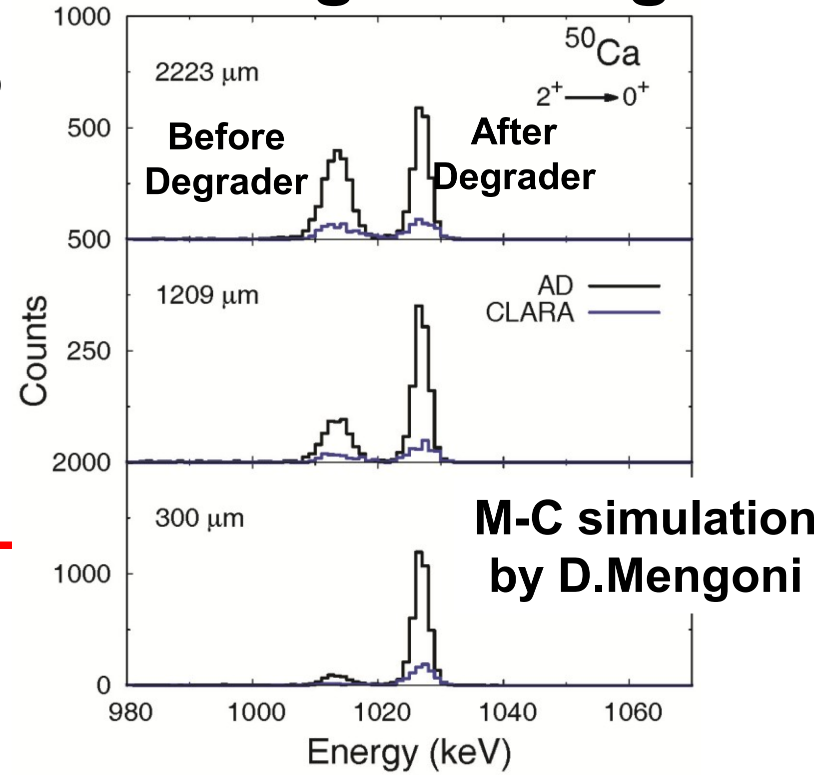
Differential RDDS Measurements at the AGATA – PRISMA setup with the Cologne Plunger





Lifetimes: ~0.5 to ~500 ps at v/c ≈ 10%

Also at EXOGAM-VAMOS



Cologne plunger setup for RDDS measurements in grazing reactions

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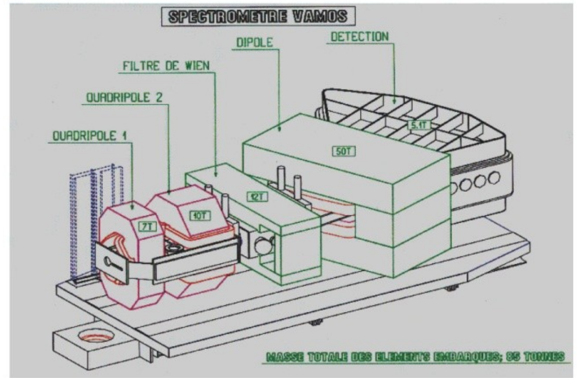
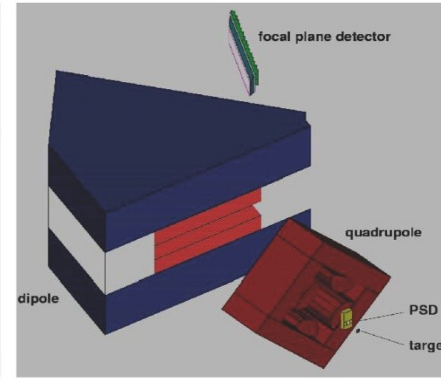
Table 1: Specifications of the Cologne differential plunger for the use in grazing reactions.

Target-degrader separations:	0–10 mm
Precision of the target-degrader separation setting (motor):	0.1 µm
Inductive transducer resolution:	0.01 µm (0–40 µm range), 0.1 µm (0–200 µm range), 1 µm (0–5 mm range)
Maximum rotation against the beam axis:	45 degrees*

SPECIFICATIONS OF ION TRACING SPECTROMETERS





	PRISMA	VAMOS	MAGNEX
Solid Angle (msr)	80	100	52
Target-FPD (m)	7	7.3	5.8
Dispersion (cm/%)	4	2.5	3.8
Momentum acceptance	±10%	±5%	±10%
Max Rigidity T•m	1.4	1.6	1.8

Summary and outlook:

- PRISMA is a Ion Tracing Spectrometer for Heavy Ions with large acceptance (80 msr).

- Coupled with Large Ge arrays it has been a very useful tool to study moderately neutron-rich nuclei produced by Grazing reactions

- PRISMA can be use for any binary reaction with stable beams and RIBs. Any facility will benefit from such instrument

- Drawback: complexity of the response function in case cross section measurements are performed