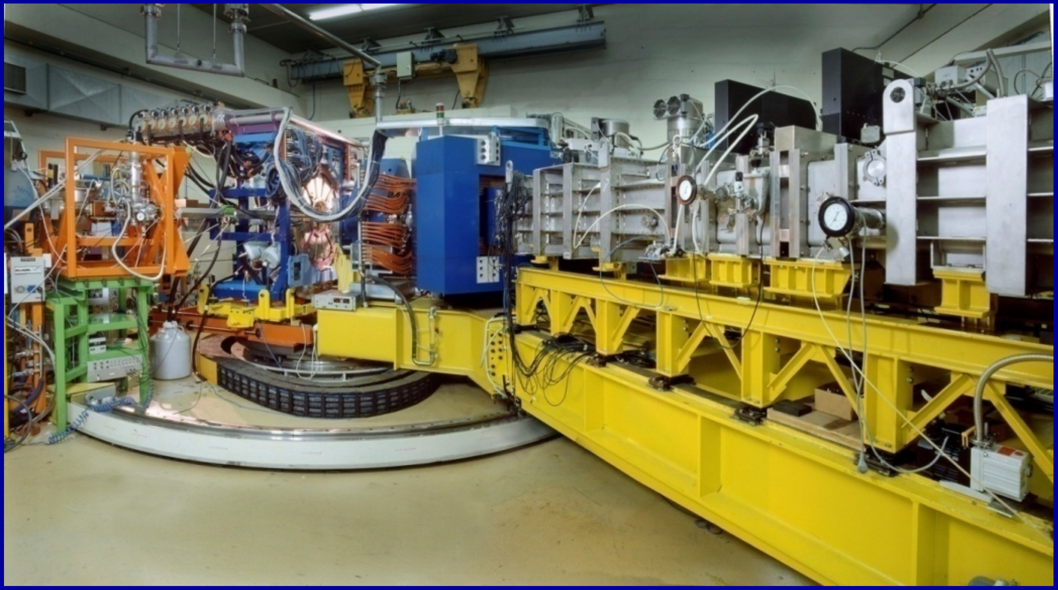
PRISMA:
performance and recent upgradings

L.Corradi (LNL)

On behalf of the Prisma Collaboration



Agata Week
Zoom meeting, March 17, 2021

characteristics

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 6.5 m

Energy acceptance ± 20%

Momentum acceptance ± 10%

Maximum $B\rho$ = 1.2 Tm (ME/q^2 = 70 MeV amu)

Dispersion 4 cm/% $\Delta p/p$

Mass resolution 1/300 FWHM

Aberrations correction via software

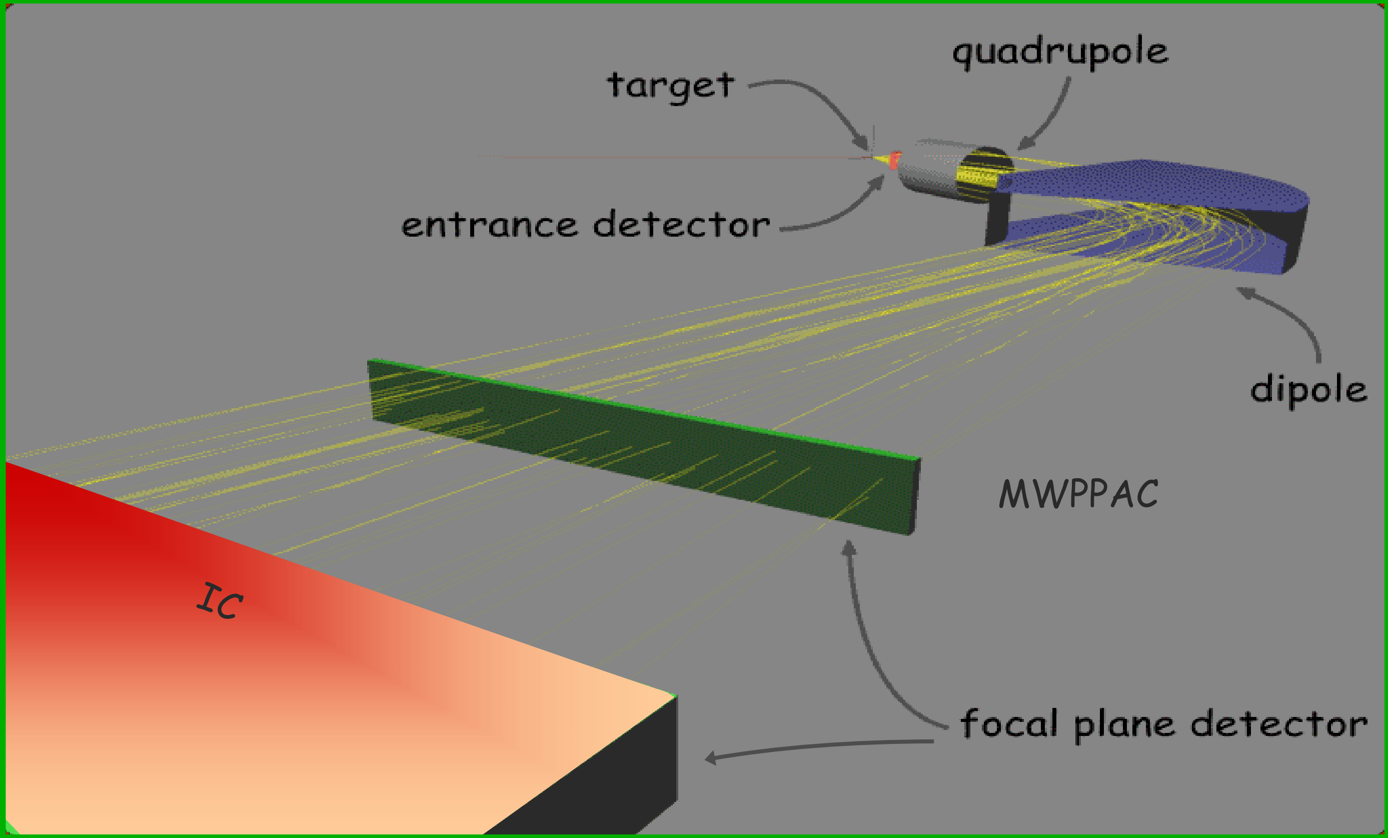
MCP and MWPPAC x,y position resolutions 1 mm

MCP and MWPPAC timing resolutions ~ 350 ps

IC Energy resolution ~ 1%

Nuclear charge resolution $\Delta Z/Z \sim 1/60$

PRISMA spectrometer – trajectory reconstruction



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

A physical event is composed by the parameters:

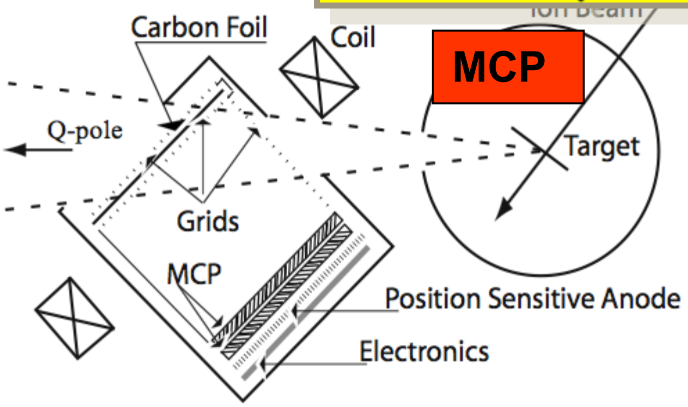
- **position at the entrance** — **x, y**
- **position at the focal plane** — **X, Y**
- **time of flight** — **TOF**
- **energy** — **DE, E**

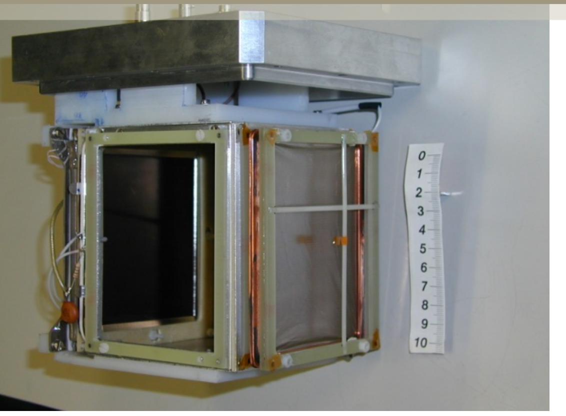
$$B\rho = A \cdot \frac{v}{q} \propto X$$

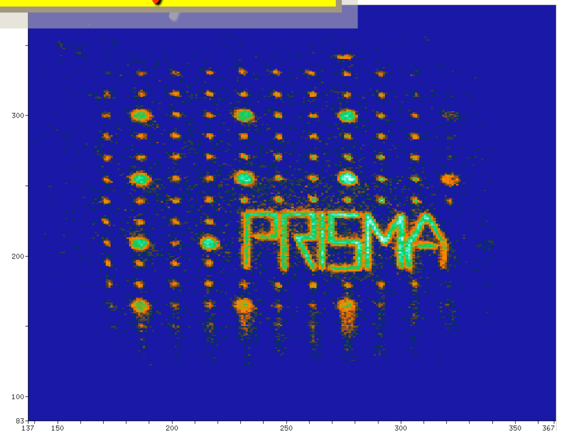
$$q = \frac{2}{S(\theta,\phi)} \cdot \frac{E \cdot T}{B\rho(\theta,\phi)}$$

PRISMA spectrometer – a complex detector system

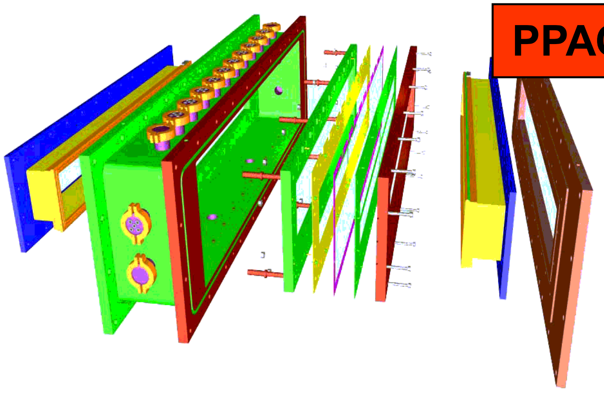
MCP

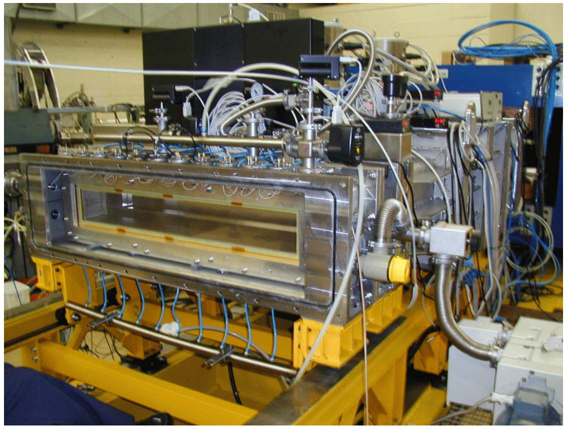


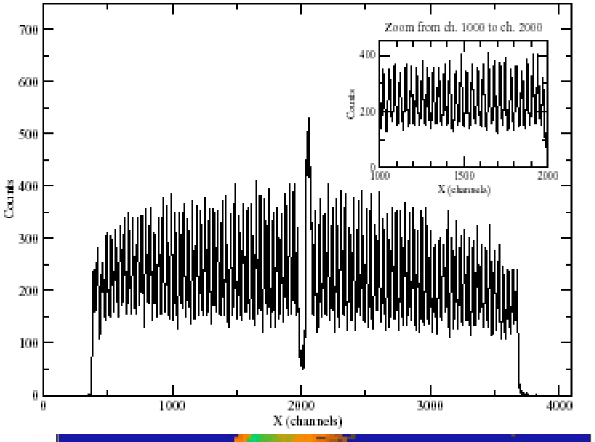




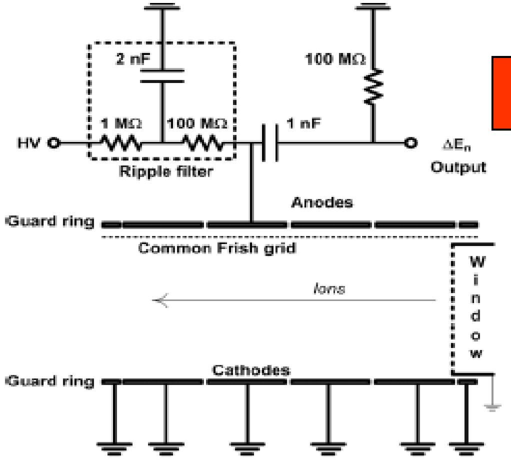
PPAC

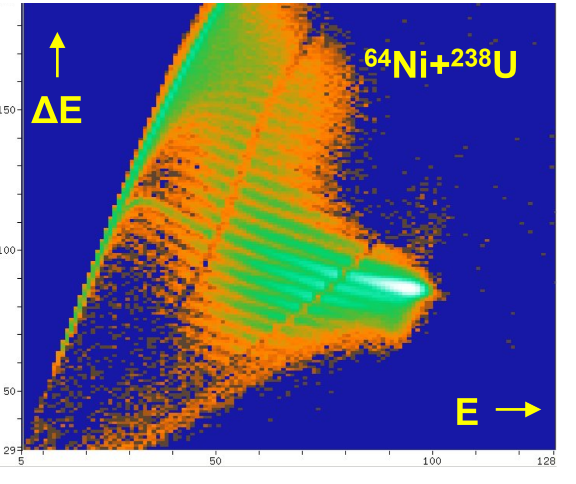






IC





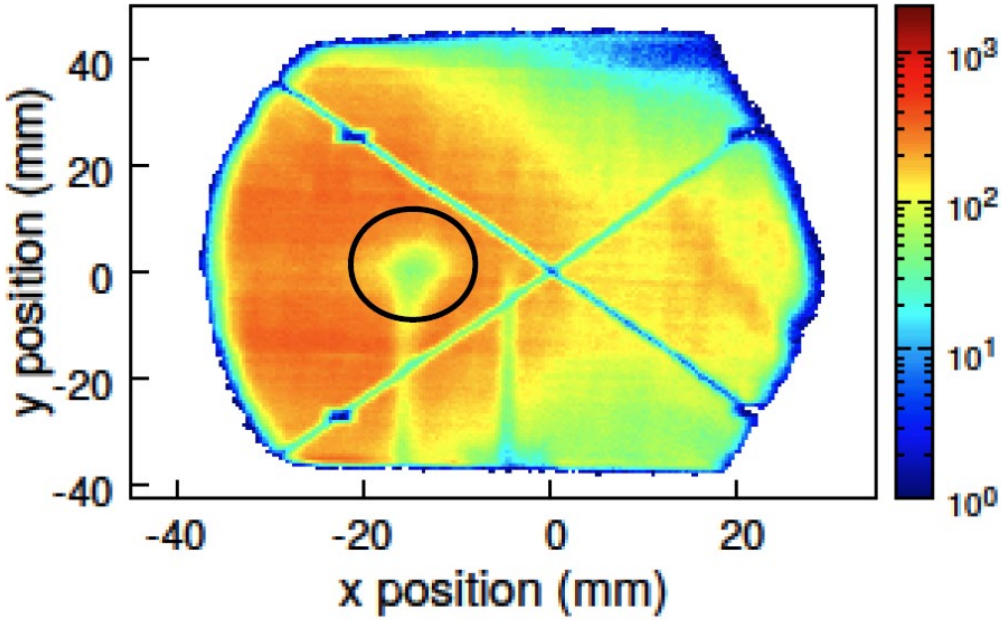
Recent upgradings

Development of a new MCP detector with a new delay line

Development of a new MWPPAC with a more efficient anode

First test of the Y position determination of the IC via drift time method

In beam tests of the new MCP



Latest experimental campaigns unveiled a region of the detector with reduced efficiency.

This was attributed to:

- low tension of some gold-plated tungsten wires of which is composed the position-sensitive anode
- overlapping of near wires

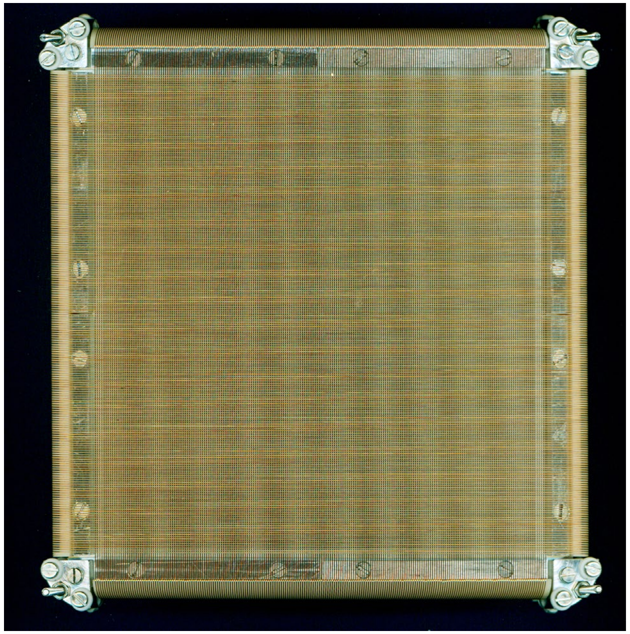
A new position-sensitive anode has been assembled and mounted and two days of beam time were allotted during the last PAC meeting for the test of the new configuration.

In beam tests of the new MCP

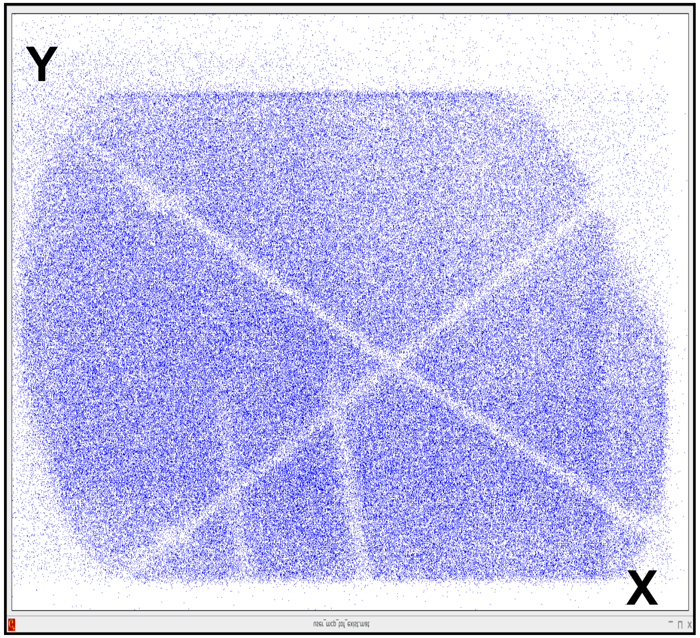
8-9 February, 2021 - ^{58}Ni @ E=225 MeV

In the new configuration the efficiency of the entrance detector of PRISMA turned out to be about 90% and no low efficiency region was evidenced in the X-Y scatter-plot

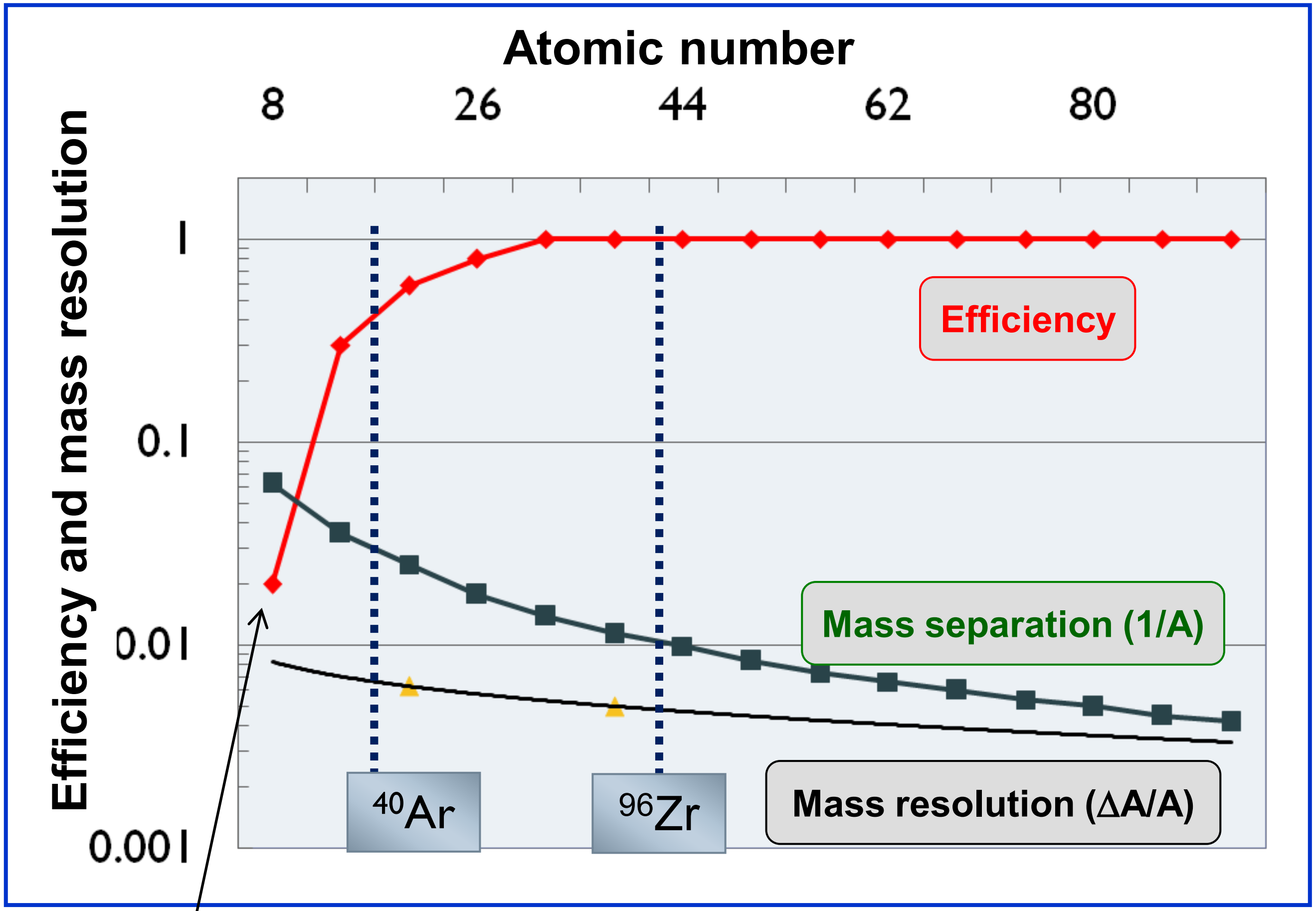
new delay line



MCP X-Y scatter plot



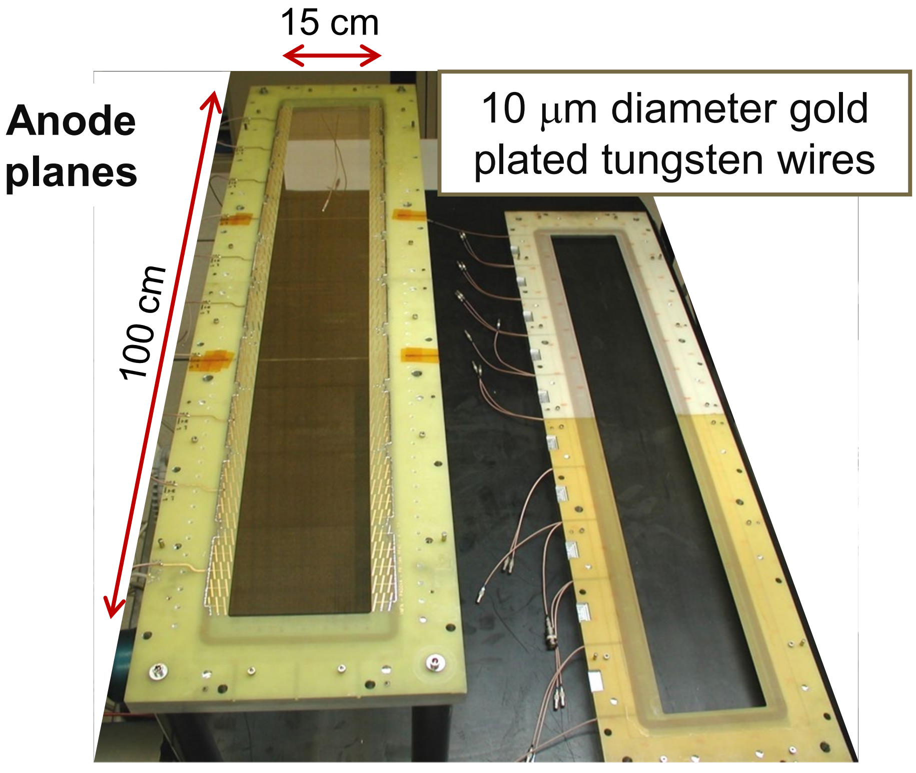
PRISMA spectrometer : MWPPAC detector at focal plane

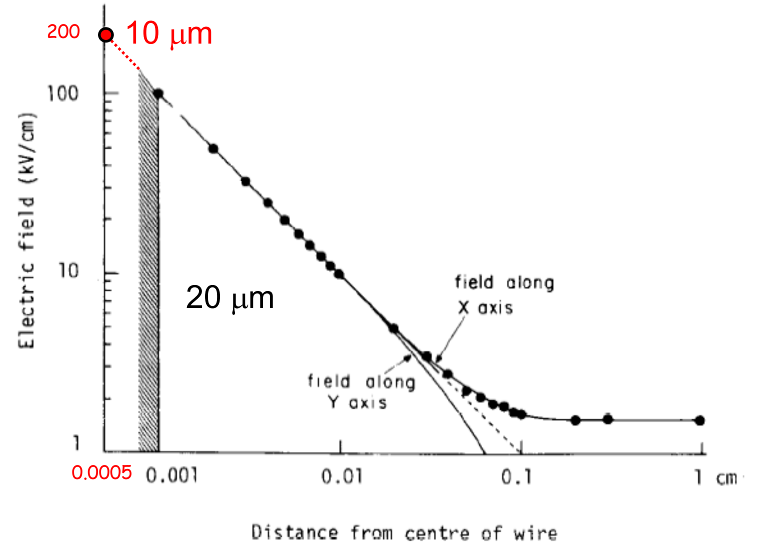


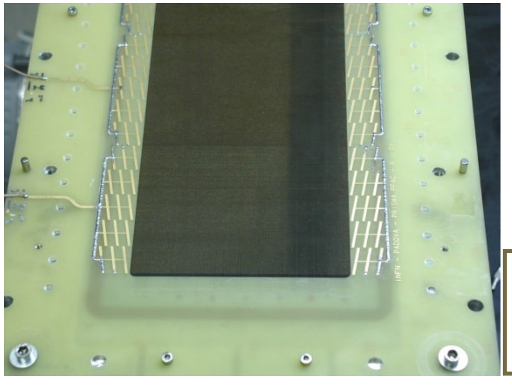
Attenuation of the X anode signals produced by the delay lines

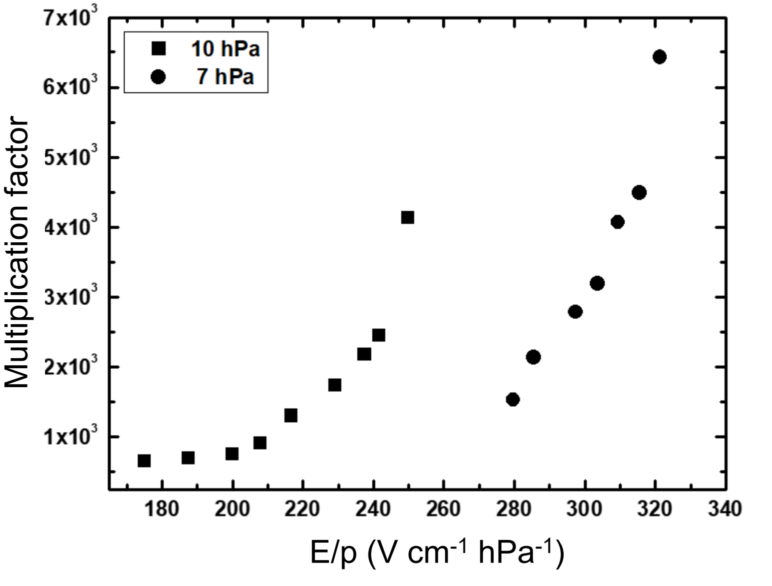
PRISMA : development of a more efficient MWPPAC

E.Fioretto



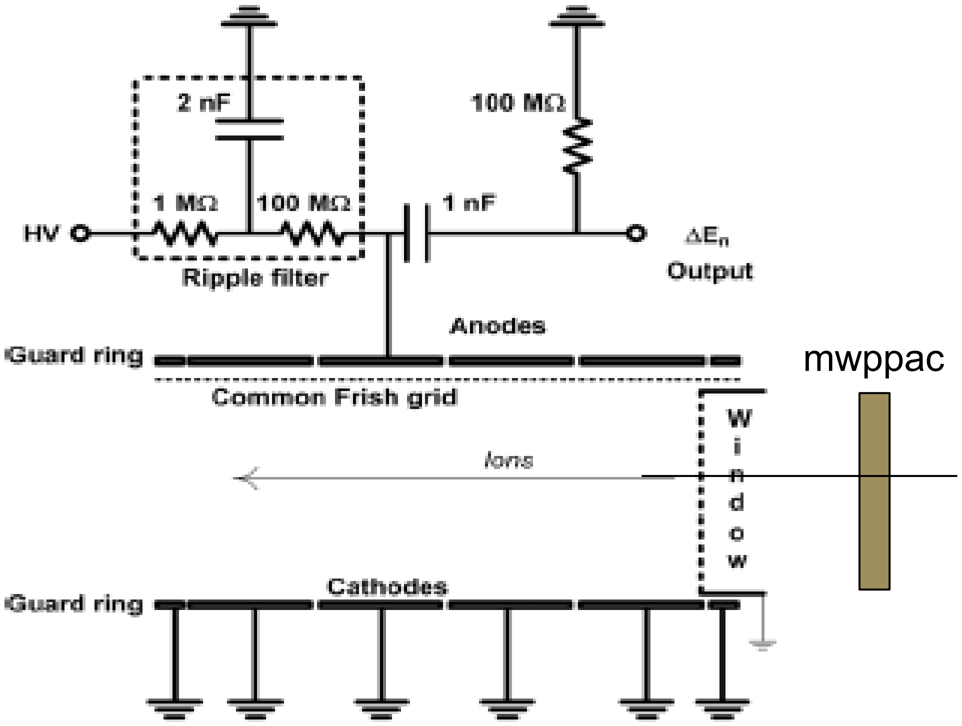






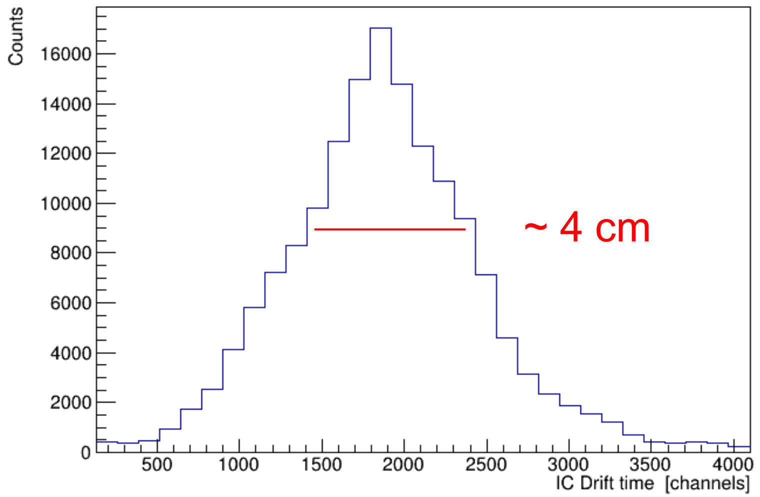
Detector efficiency improved from less than 1% to about 43% for ^{16}O @ 50 MeV

Y position determination of the IC via drift time method



TAC drift time spectrum taken in tests with ^{58}Ni @ 225 MeV

start: MWPPAC cathode
stop: IC anode

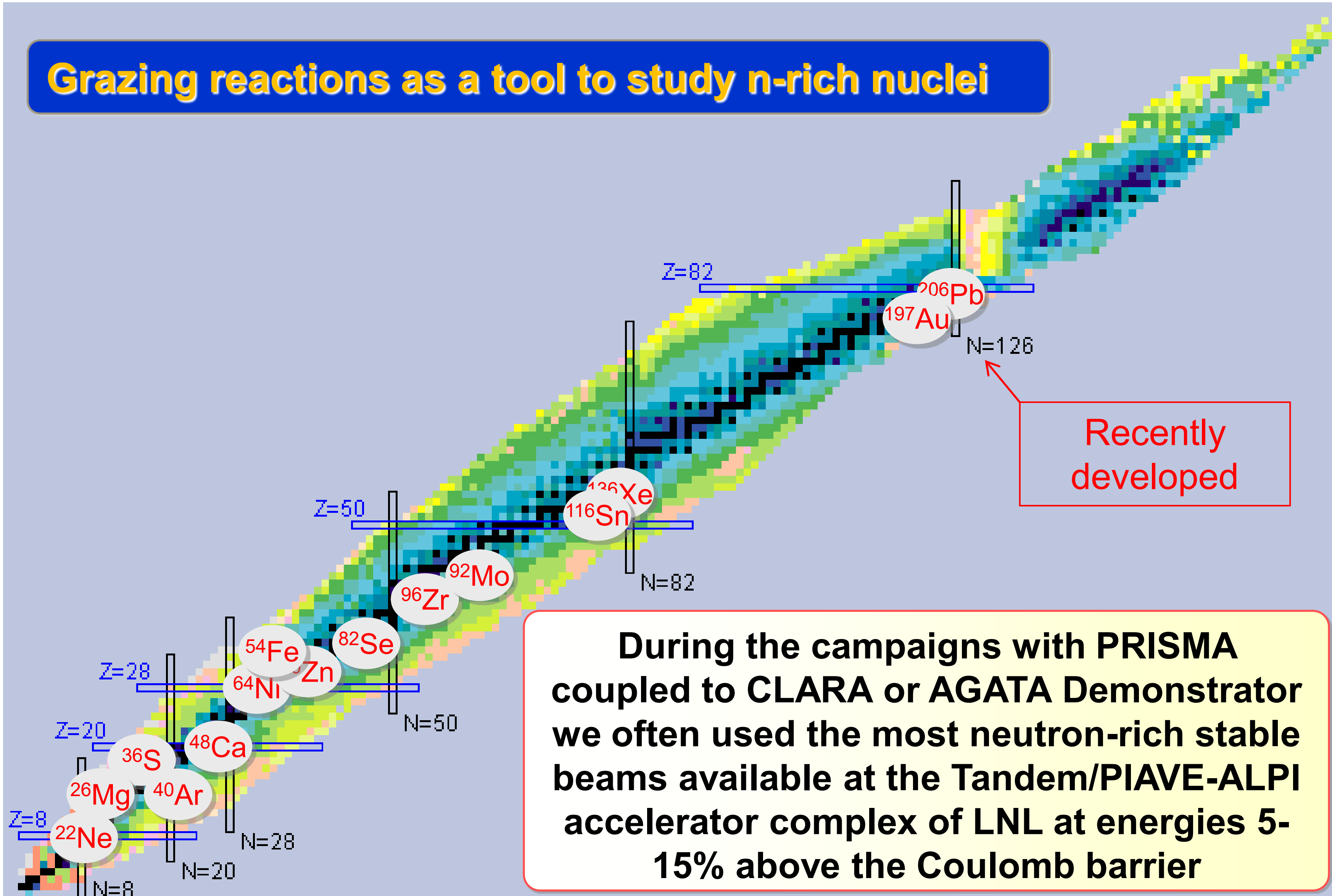


Having a Y coordinate should help in improving the Z resolution of the IC

performance

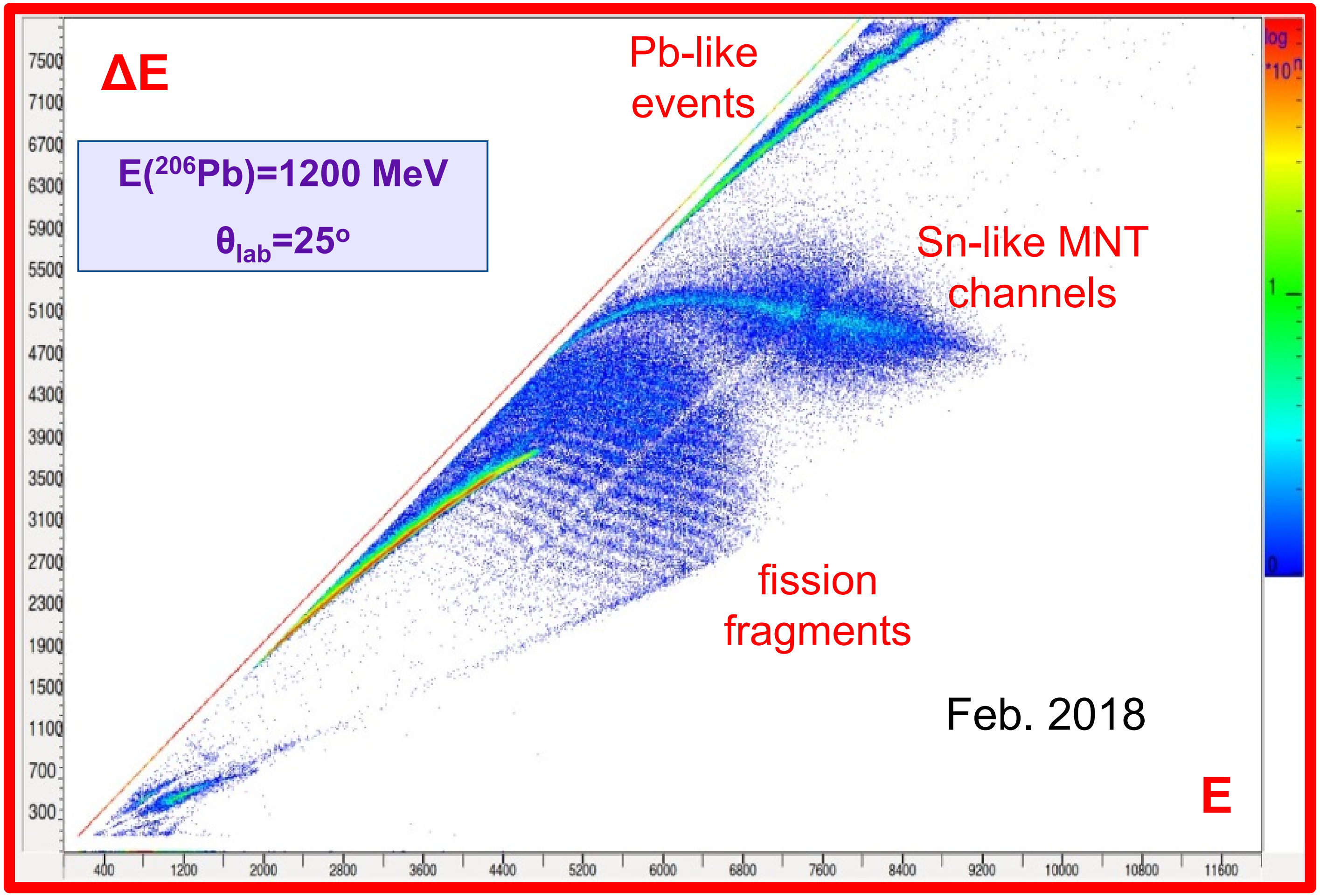
Beams accelerated for experiments with PRISMA

Grazing reactions as a tool to study n-rich nuclei



During the campaigns with PRISMA coupled to CLARA or AGATA Demonstrator we often used the most neutron-rich stable beams available at the Tandem/PIAVE-ALPI accelerator complex of LNL at energies 5-15% above the Coulomb barrier

Nuclear charge identification in the $^{206}Pb+^{118}Sn$ reaction



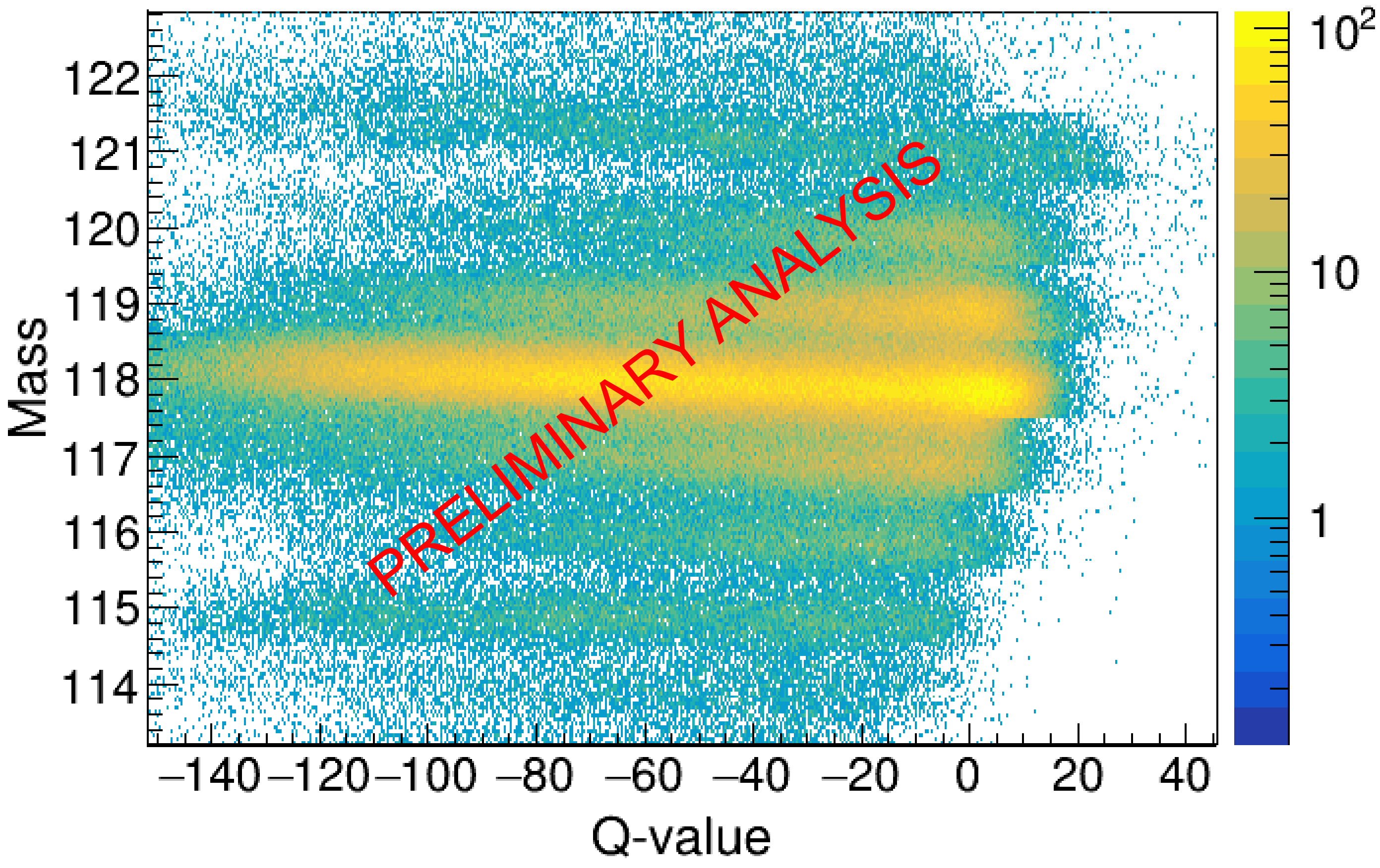
PRISMA was optimized for the detection of MNT channels but one can also observe a large yield for fission fragments, showing more clearly the obtained good Z-resolution

Mass identification in the $^{206}Pb + ^{118}Sn$ reaction

$E(^{206}Pb) = 1200$ MeV

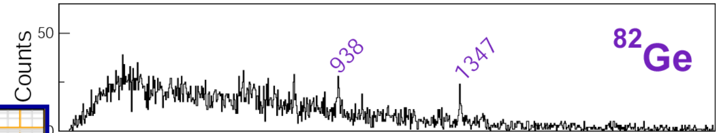
$\theta_{lab} = 35^o$

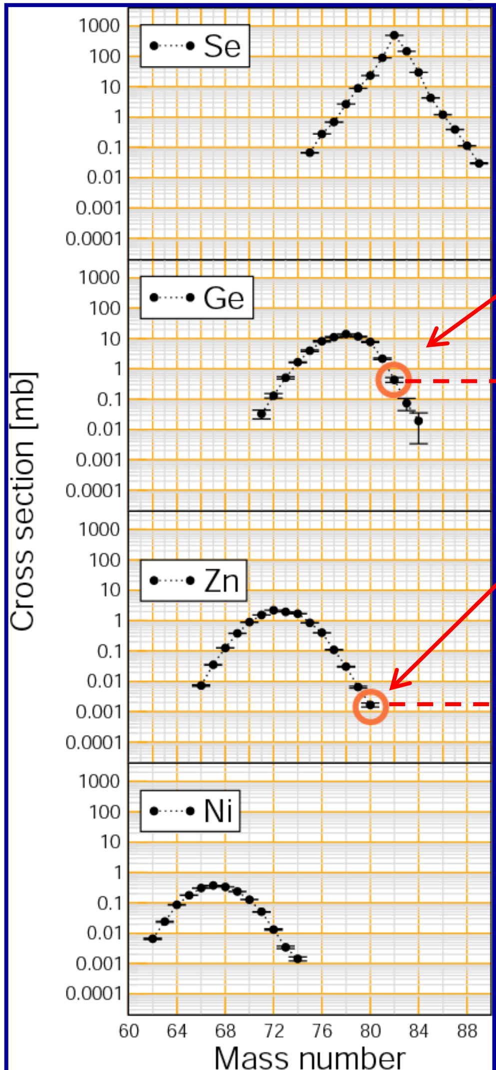
pure neutron transfer channels (Z=50)



Courtesy of S.Szilner and J.Diklic

Cross section sensitivity





PRISMA+CLARA

Nuclear structure studies

~ 0.6 mb

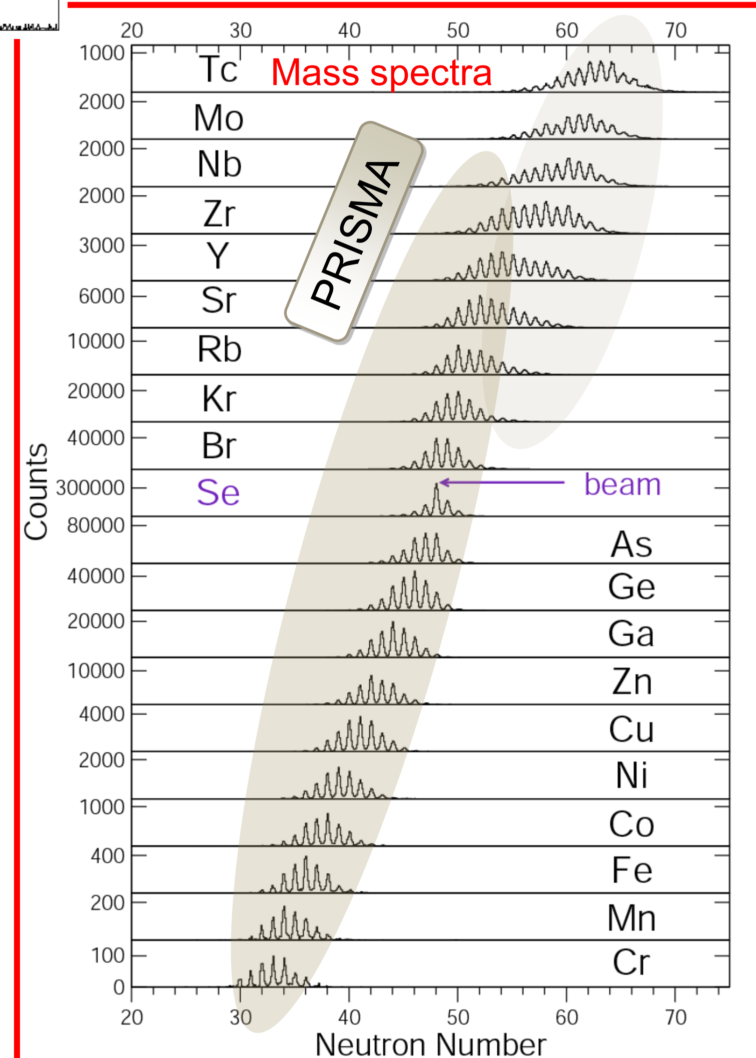
^{80}Zn

Nuclear dynamics studies

~2 μb

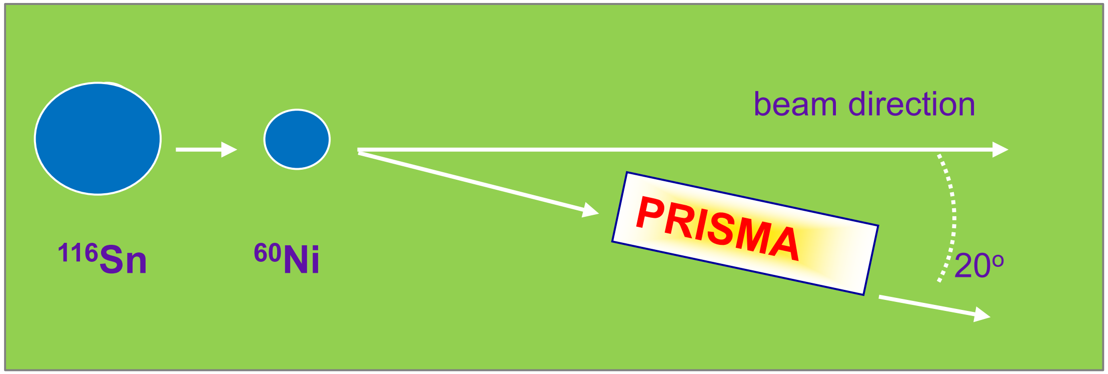
PRISMA @ 64°

^{82}Se+^{238}U @ 505 MeV



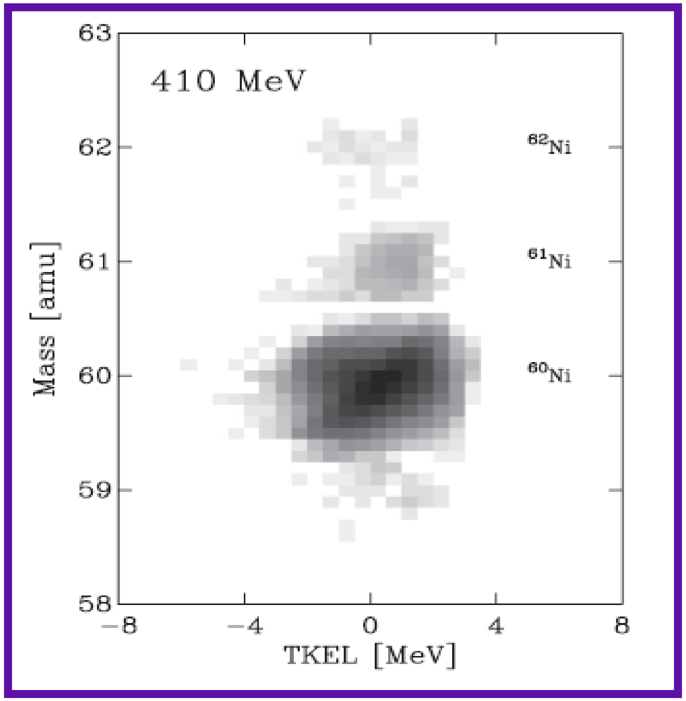
recent achievements

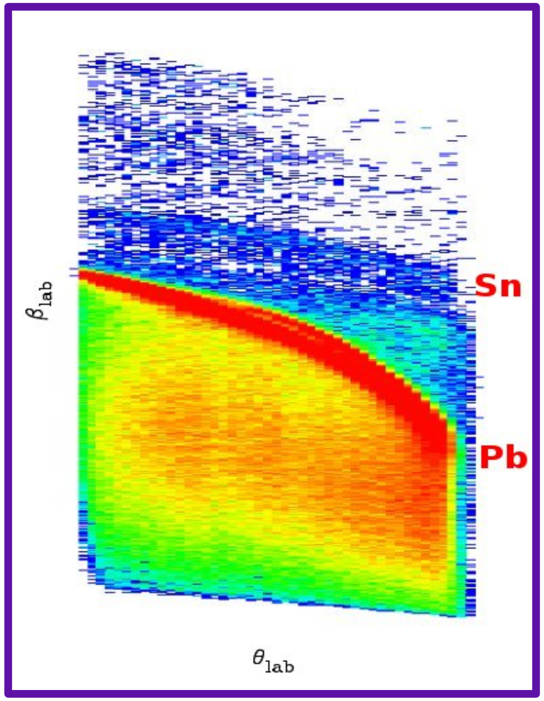
Nucleon-nucleon correlations studied with PRISMA



$^{96}Zr+^{40}Ca$, $^{116}Sn+^{60}Ni$, $^{92}Mo+^{54}Fe$, $^{206}Pb+^{116}Sn$ direct + inverse kinematic, PRISMA and PRISMA+CLARA/AGATA/LaBr (7 experiments)

$^{96}Zr+^{40}Ca$: S. Szilner et al., Phys. Rev. C 76 (2007) 024604; L. Corradi et al., Phys. Rev. C 84 (2011) 034603
$^{116}Sn+^{60}Ni$: D. Montanari et al., Phys. Rev. Lett. 113 (2014) 052501; D. Montanari et al., Phys. Rev. C 93 (2016) 054623
$^{92}Mo+^{54}Fe$: T. Mijatovic

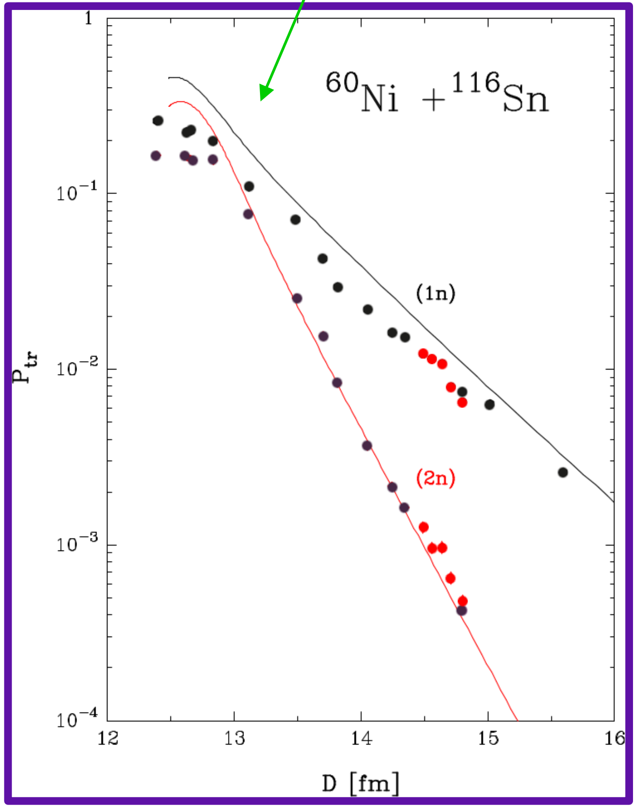




G.Potel, F.Barranco, E.Vigezzi and R.A.Broglia PRC103(2021)L021601

Correlation length

$$\xi = \frac{\hbar v_F}{\pi\Delta} \approx 13 \text{ fm}$$

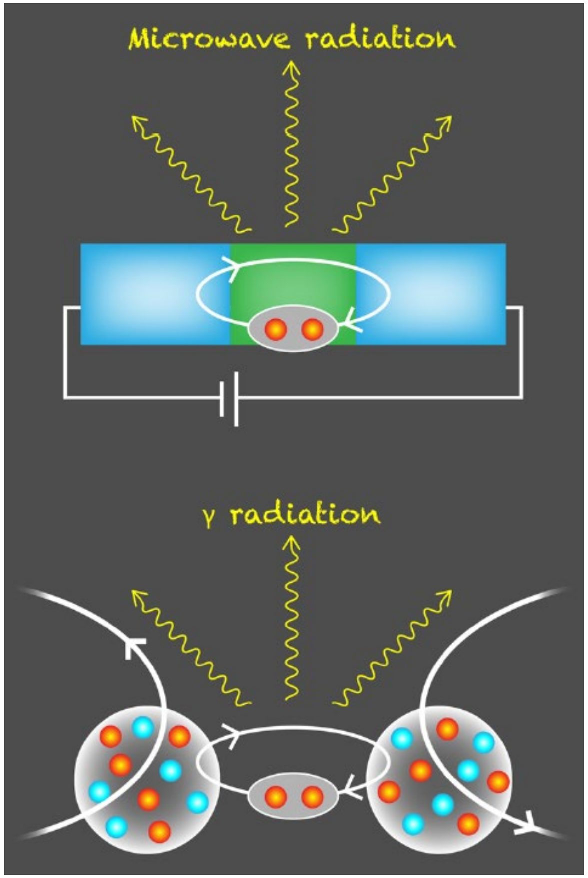


D.Montanari, L.Corradi, S.Szilner, G.Pollarolo et al, PRL113(2014)052501; PRC93(2016)054623

The Tiniest Superfluid Circuit in Nature

A new analysis of heavy-ion collision experiments uncovers evidence that two colliding nuclei behave like a Josephson junction—a device in which Cooper pairs tunnel through a barrier between two superfluids.

By Piotr Magierski



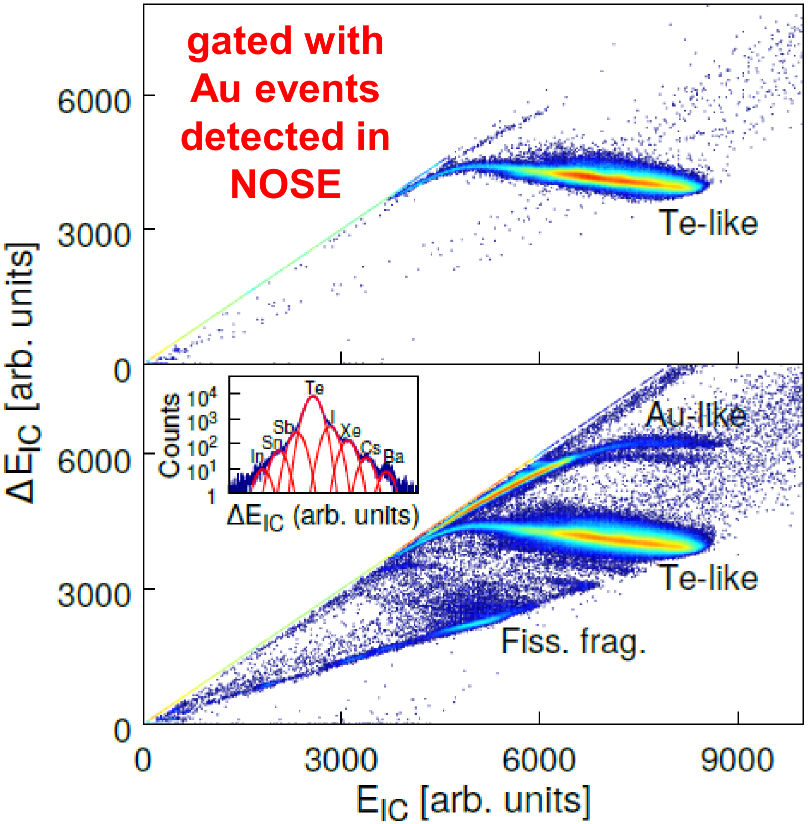
(PRC editor's suggestion)

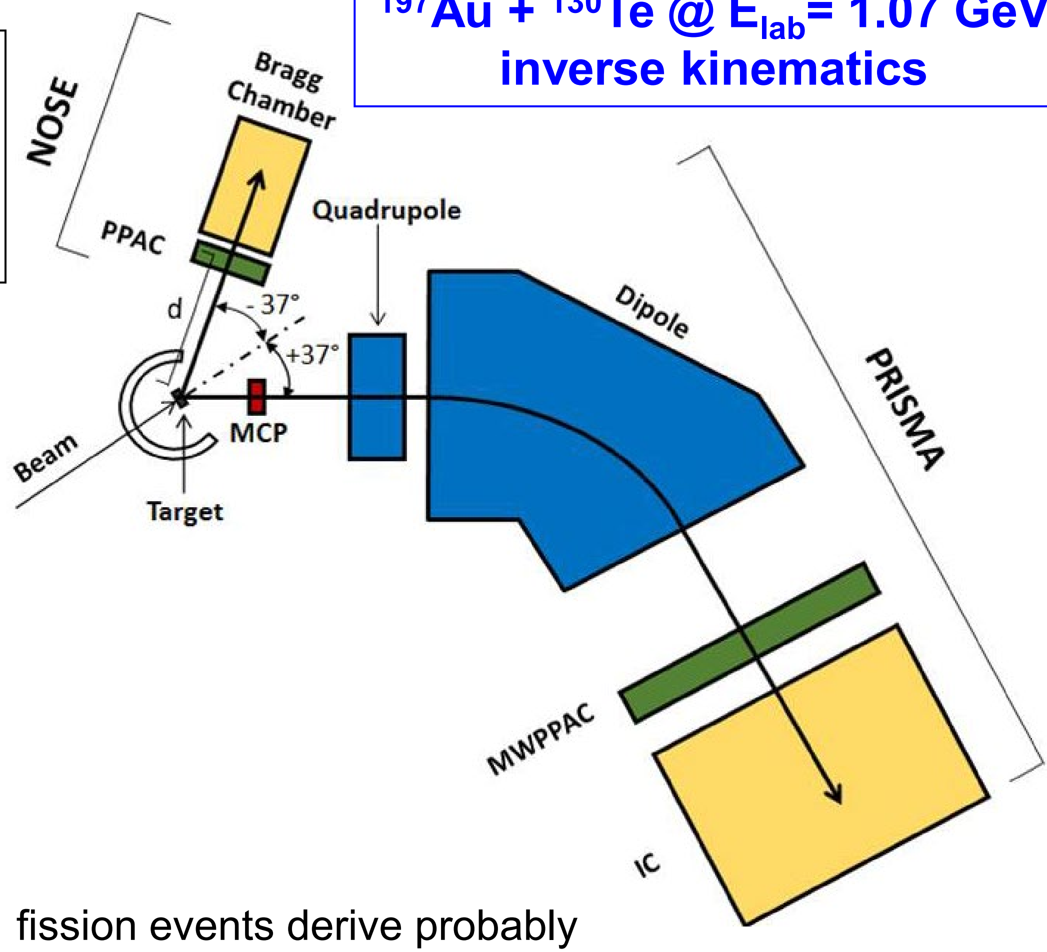
Ongoing “removal work”

The $^{197}Au+^{130}Te$ experiment with the PRISMA spectrometer

PRISMA spectrometer used in high resolution kinematic coincidence with a second time-of-flight system (NOSE)

^{197}Au + ^{130}Te @ E_{lab}= 1.07 GeV inverse kinematics

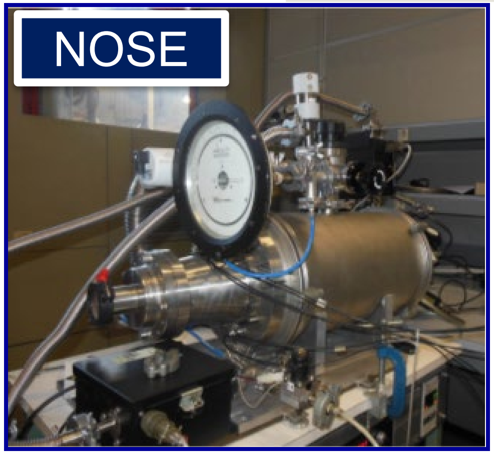


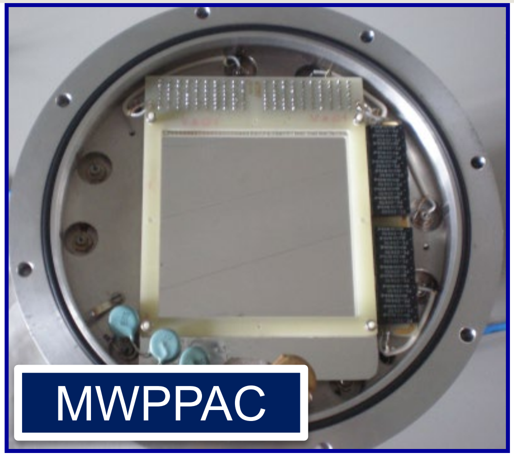


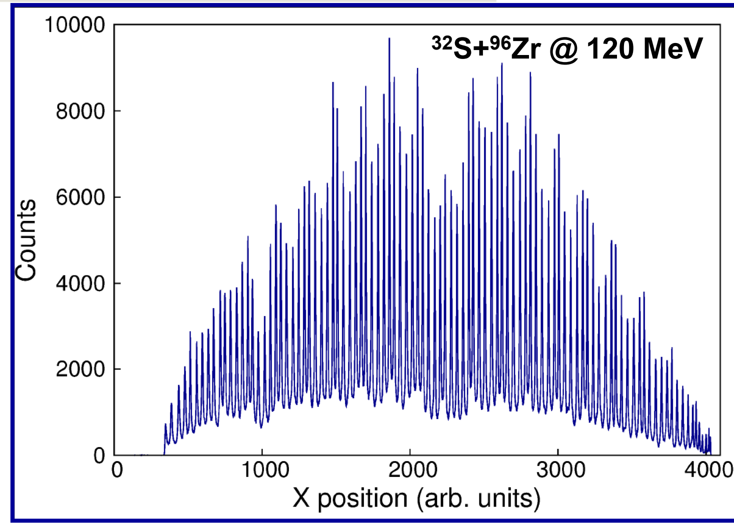
fission events derive probably from transfer induced fission or quasi fission

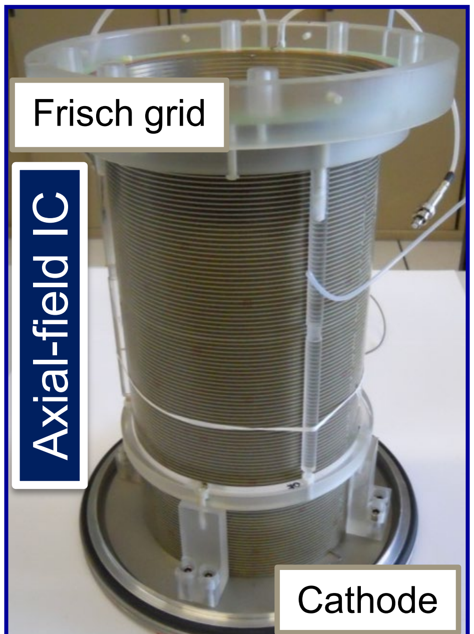
F.Galtarossa et al., Phys. Rev. C97(2018)054606

NOSE: an ancillary detector coupled to PRISMA

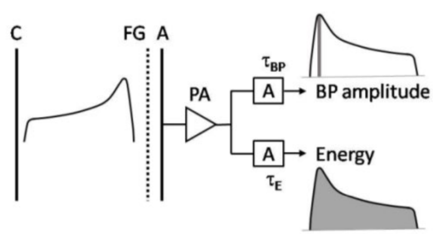




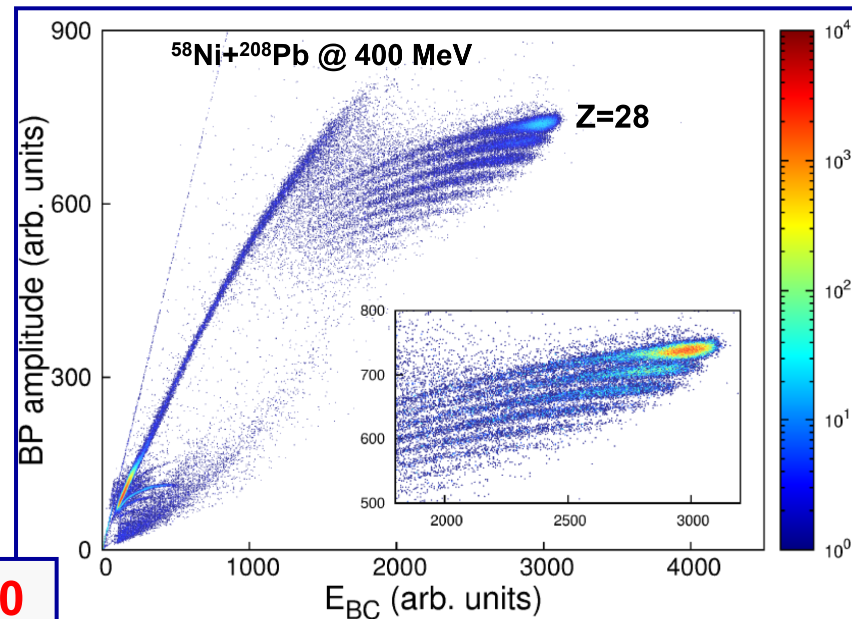




Bragg Curve Spectroscopy



E. Fioretto et al., NIM A 899 (2018) 73

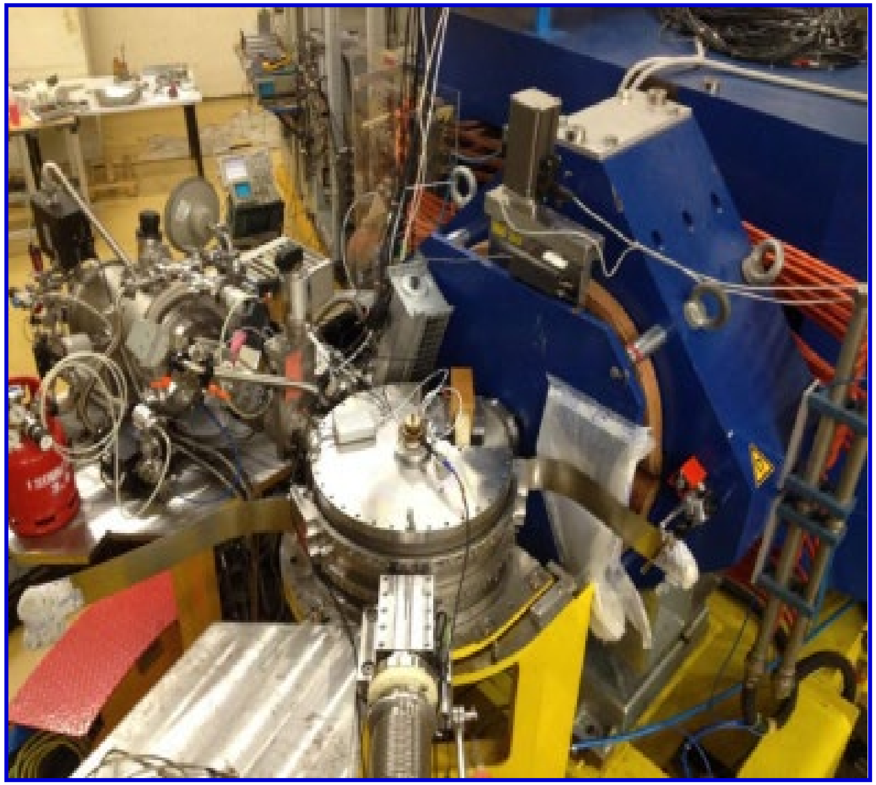


$\Delta Z/Z \sim 1/60$

E. Fioretto – NN2018, Japan, Dec. 2018 and NIMA899(2018)73

The PRISMA spectrometer coupled with NOSE and the LaBr array

NOSE mounted on the PRISMA sliding seal scattering chamber (year 2016)



NOSE + LaBr array mounted on the PRISMA scattering chamber with a new cover (year 2018 - present)

NOSE already removed

To summarize

PRISMA has been so far operated in standard configuration for MNT studies

In many years of experience optimum performance has been achieved for the detection of ions with $30 < A < 130$ at 3-6 MeV/A, at angles $20^o < \theta_{lab}$ and with max 1-3 kHz trigger rate at the focal plane

With the newly developed MCP and MWPPAC we will be able to efficiently detect also light ions in the 6-14 Z range

For $130\text{-}140 < A$ mass separation becomes rapidly a problem. Overlapping A/q is a yet unsolved (or unsolvable ?) issue

To get total cross sections for MNT it is generally sufficient the yield information together wih a proper normalization procedure. To get $d\sigma/d\Omega$ one needs to correct via simulations

PRISMA sensitivity limit is in the few μbarn range