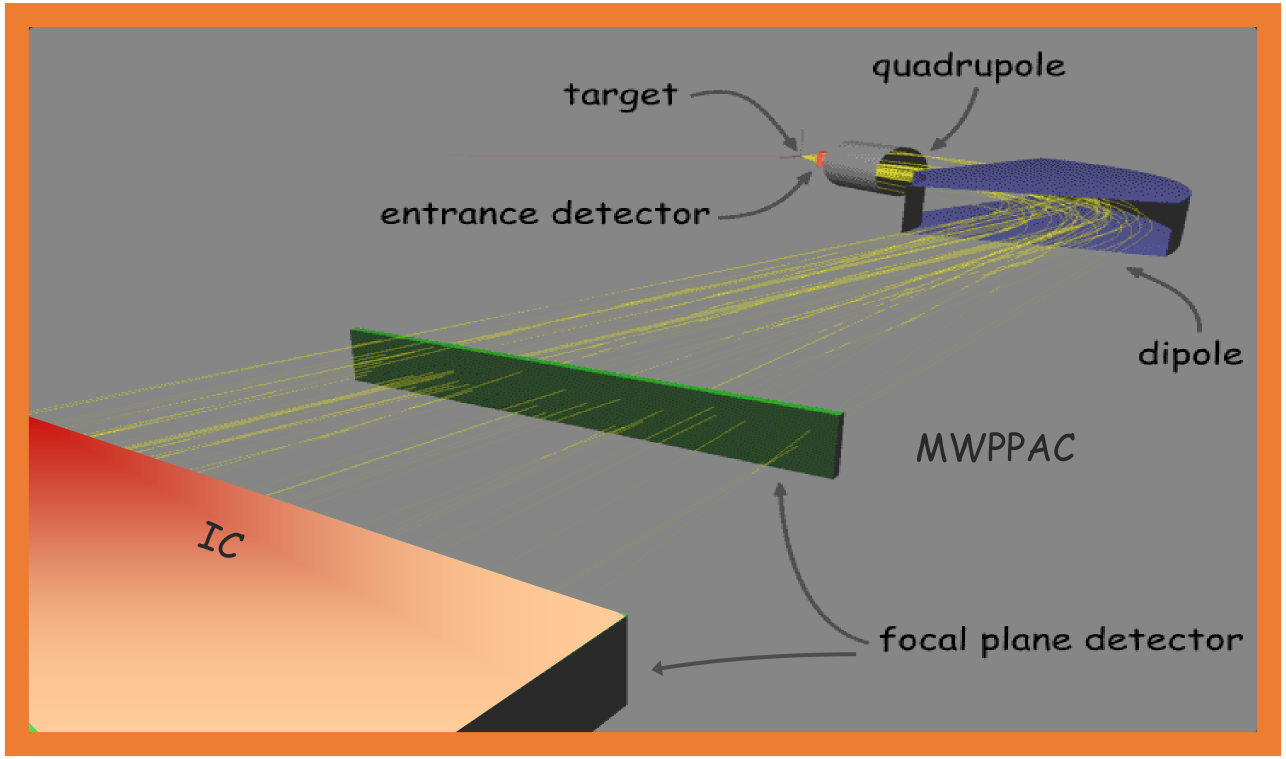
PRISMA
Performance and recent upgrades

F. Galtarossa and L. Corradi
on behalf of the PRISMA collaboration

AGATA pre-PAC meeting
8-10 November 2021

Trajectory reconstruction

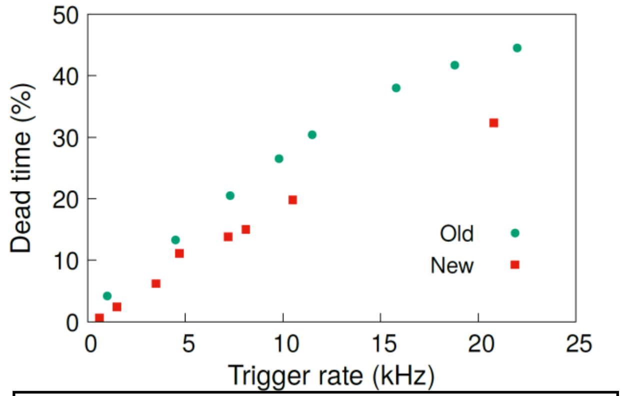


A physical event is composed of:

- Entrance position (x,y) -> (θ,ϕ) — MCP detector
- Position at the focal plane (x',y') — MWPPAC detector
- Time-of-Flight (ToF) — Δt MCP-MWPPAC
- Energy (ΔE-E) — Ionization Chamber

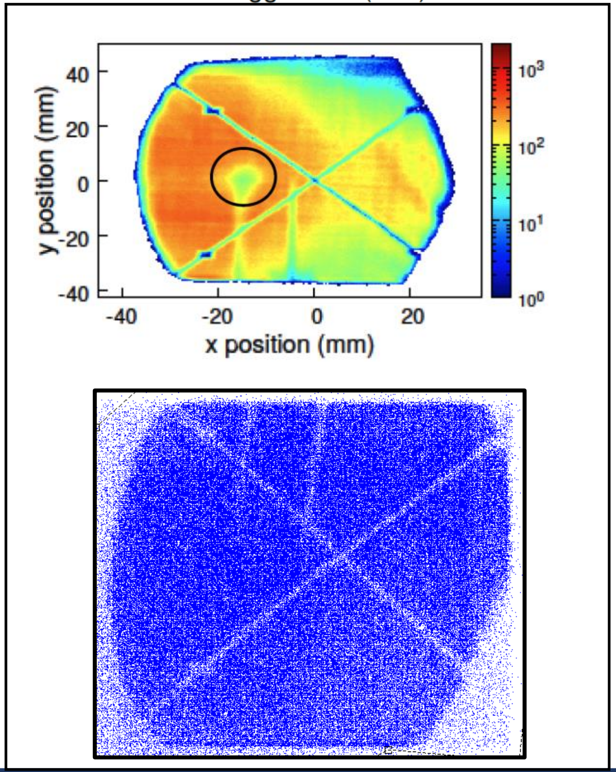
Solid angle ΔΩ	~ 80 msr
Angular acceptances	Δθ ≈ ±6°; Δφ ≈ ±11°
Energy acceptance	±20%
Momentum acceptance	±10%
Mass resolution	ΔA/A ≈ 1/300
Nuclear charge resolution	ΔZ/Z ≈ 1/60
Maximum Bρ	~ 1.2 Tm
Dispersion	Δp/p ≈ 4 cm/%
Distance target-FPD	~ 6.5 m
IC Energy resolution	~ 1%
MCP and MWPPAC x,y position resolutions	~ 1 mm
MCP and MWPPAC timing resolutions	~ 350 ps
Maximum rate at the FP	~ 3 kHz
θ_{PRISMA} (AGATA standard position)	20° < θ < 88°
θ_{PRISMA} (AGATA close position)	35° < θ < 88°

Upgrades and recent tests



Hardware:

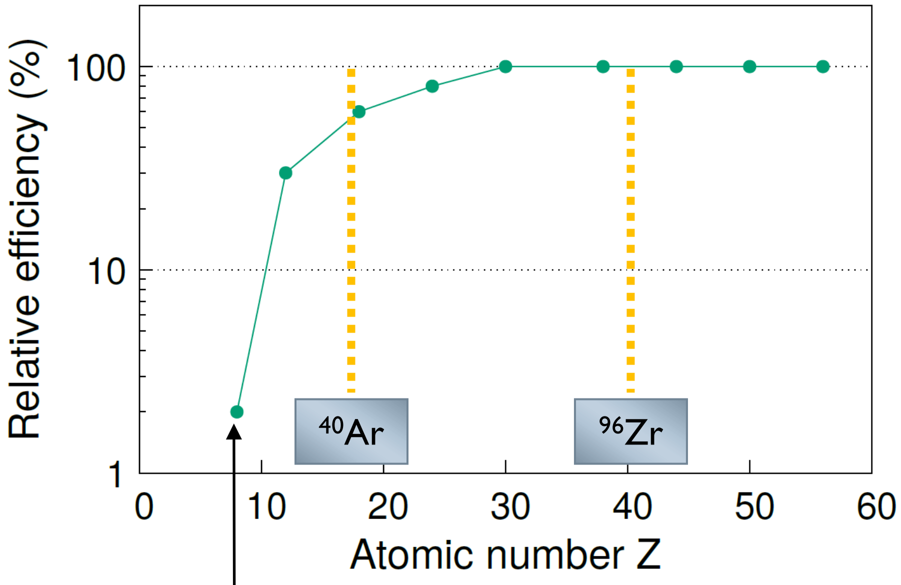
- Mesytec preamplifiers and amplifiers for the IC;
- Modification of the read-out, dead time reduced significantly;
- Fixed problem of efficiency on the entrance MCP detector;
- New more efficient MWPPAC (tests to be completed);
- Determination of the the y position of the incoming ions in the IC.



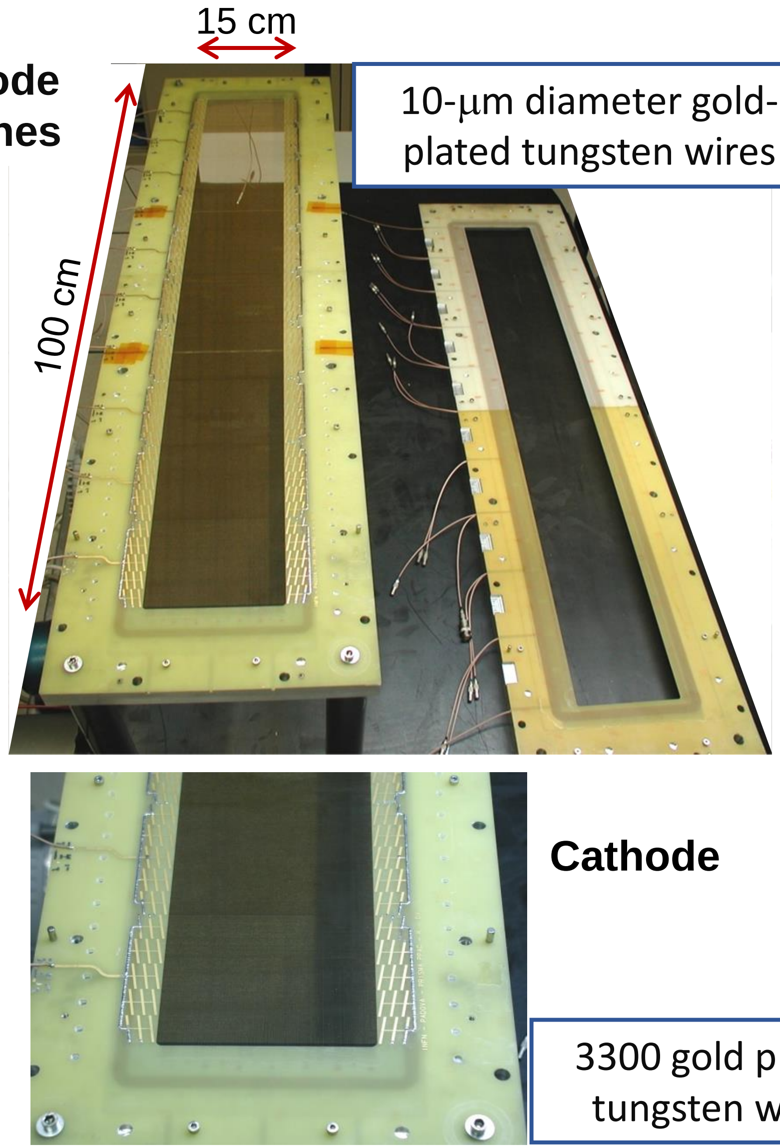
Software:

- Updated the PRISMA libraries and integrated them in the AGATA software;
- Two data frames with raw and pre-analyzed data for a quick check of the correct coincidence PRISMA-AGATA during the experiment.

Development of a new more efficient MWPPAC



Due to the attenuation of the low anode signals by the delay lines

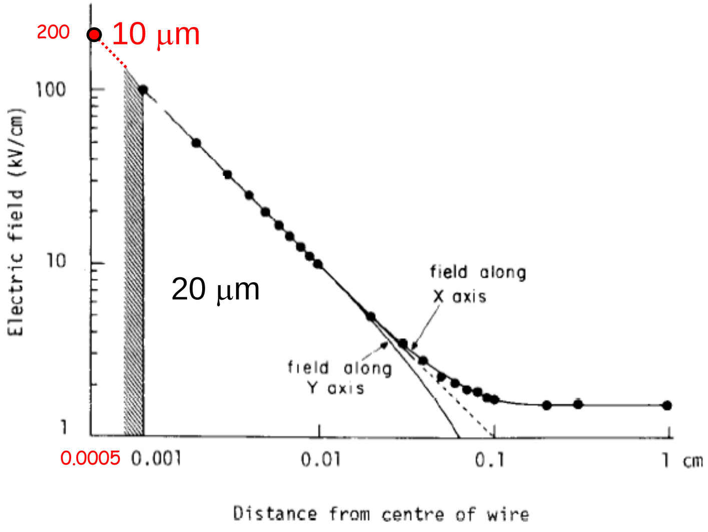


Anode planes

10-µm diameter gold-plated tungsten wires

Cathode

3300 gold plated tungsten wires

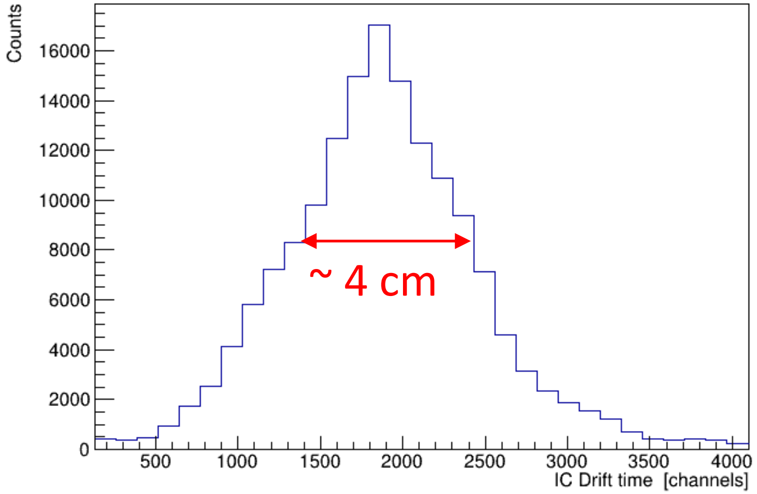


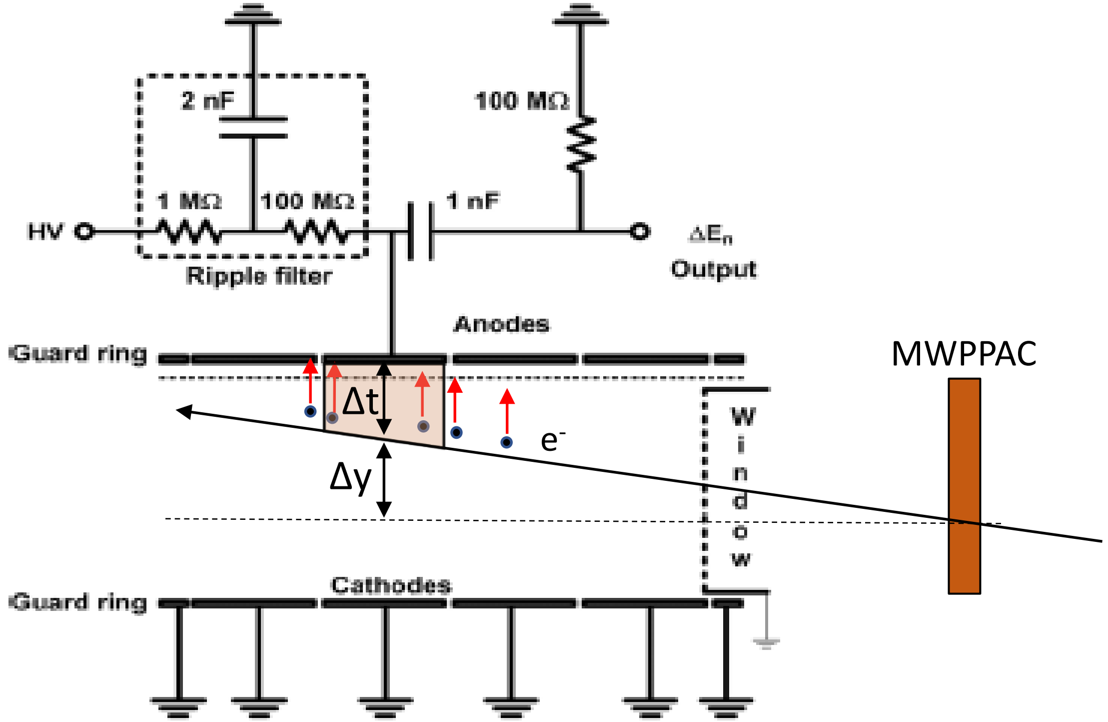
Detector efficiency improved from few % to about 43% for ^{16}O @ 50 MeV

y position determination in the IC

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

start: MWPPAC cathode
stop: IC anode





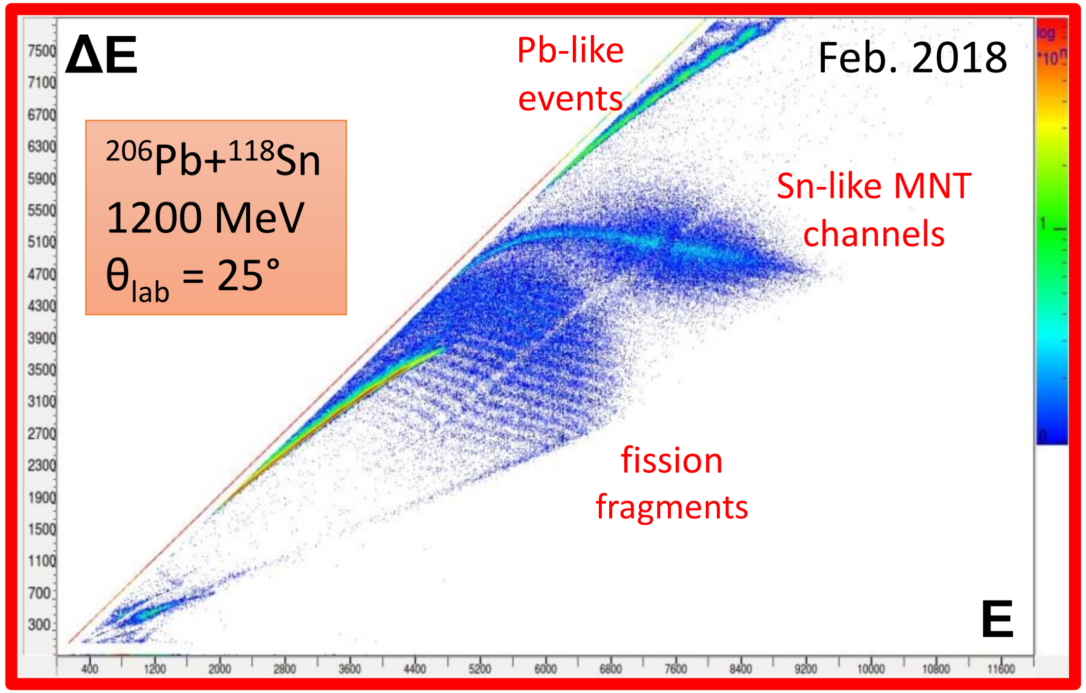
The time difference between MWPPAC and IC anode essentially reflects the electrons drift time inside the chamber (v ~ 10 cm/µs)

Having a y coordinate should help in improving the Z resolution of the IC and better control the ion trajectories

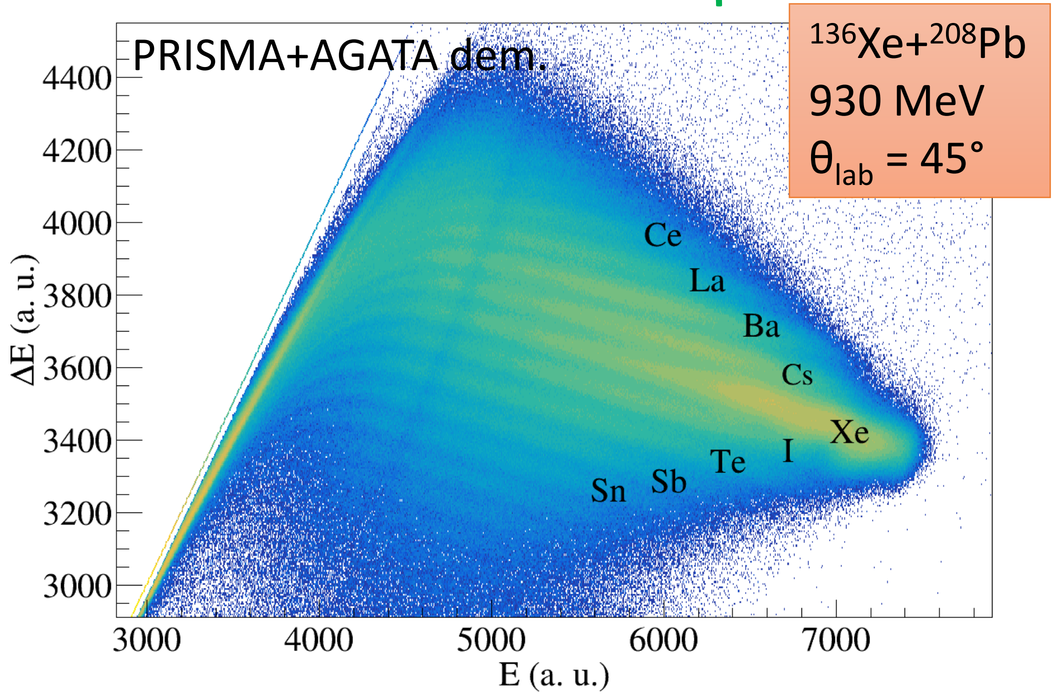
Nuclear charge identification

$\Delta E/E < 2\%$
$Z/\Delta Z \sim 60$ for Z=20

No condition on γ



Condition on γ



For a good identification in Z, ions entering PRISMA must have energies higher than ~ 3-4 MeV/u on average, depending on Z.

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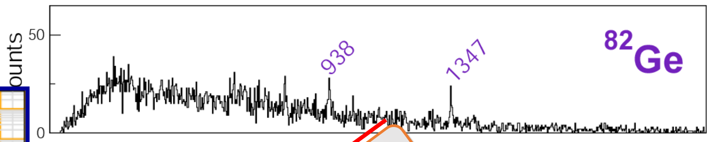
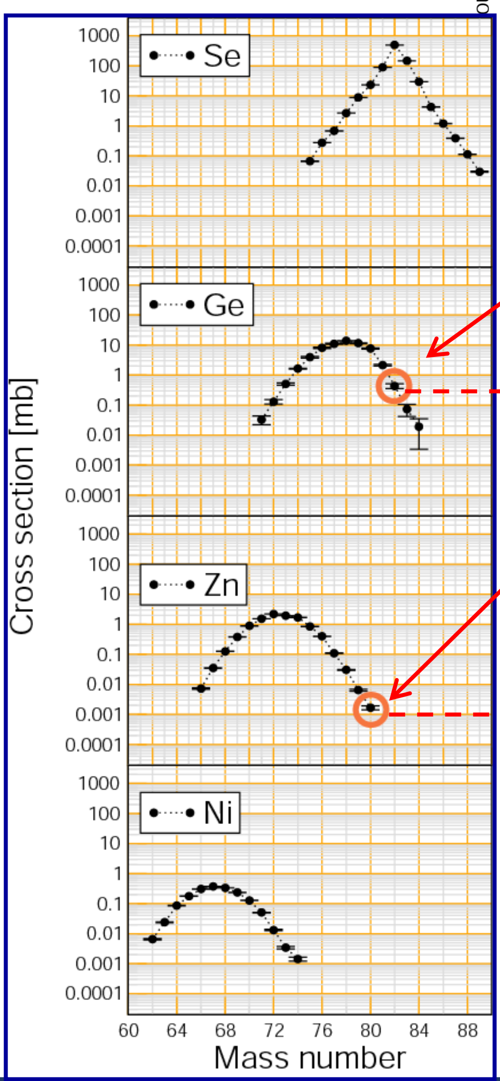
Compute carefully the energy losses in target (accounting for possible tilting angle), backing, degrader.

Cross section sensitivity



PRISMA+CLARA



~ 0.6 mb

Nuclear structure studies

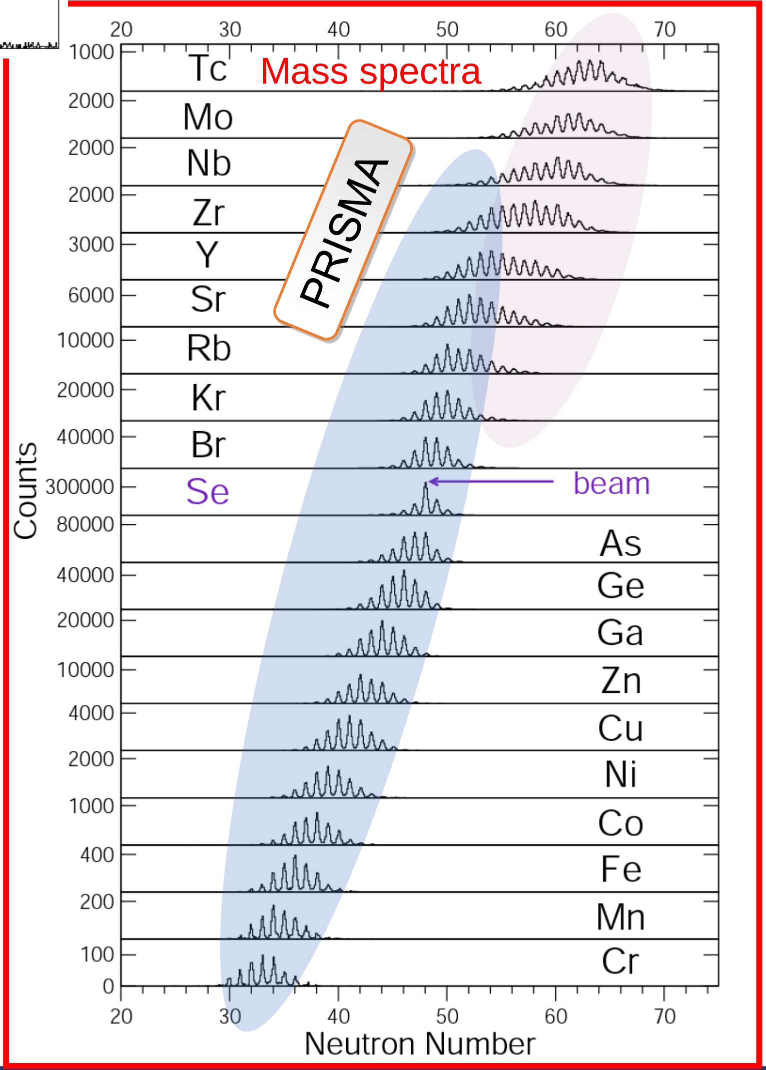
^{80}Zn

~2 μb

Nuclear dynamics studies

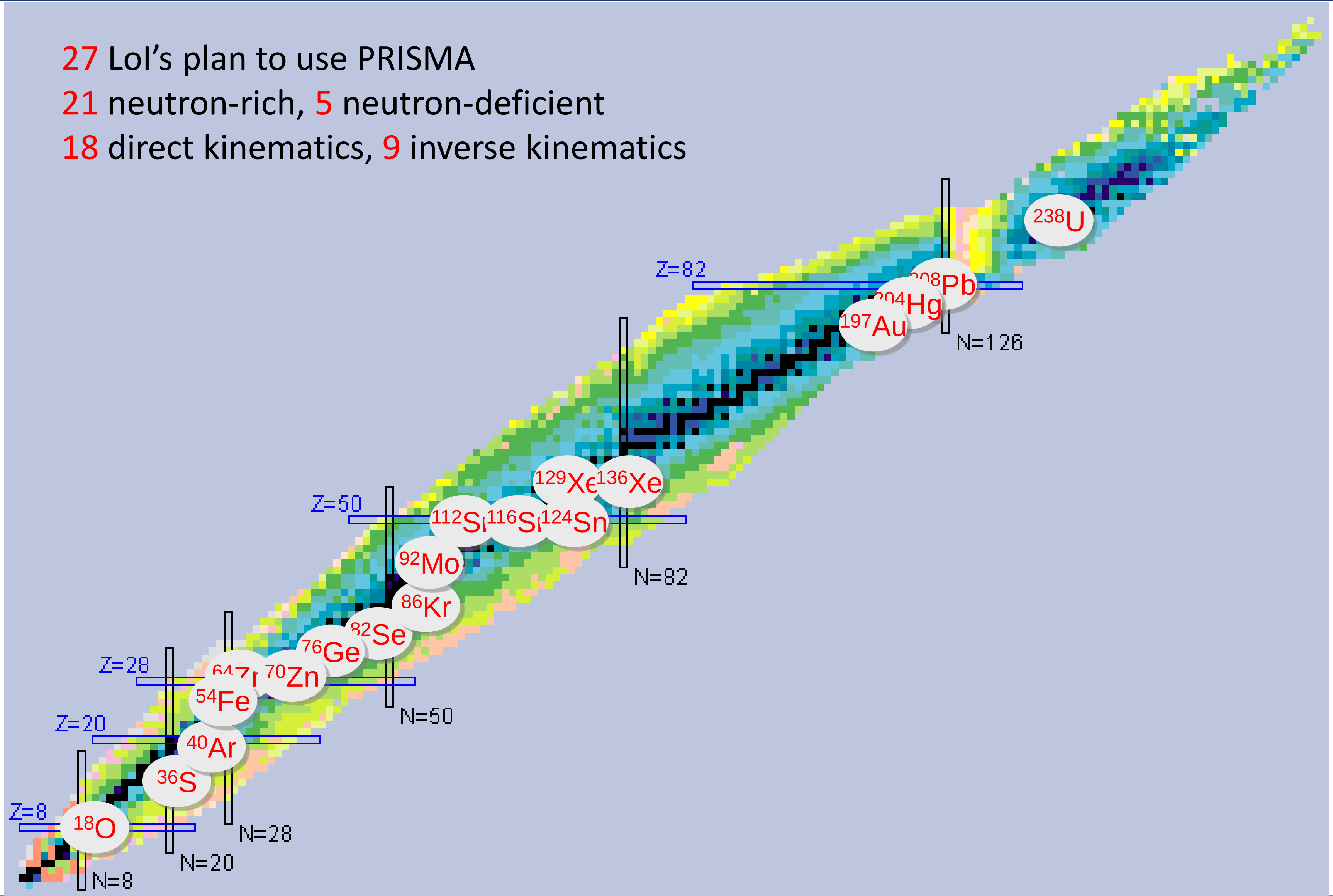
PRISMA @ 64°

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



LoI’s for PRISMA and required beams

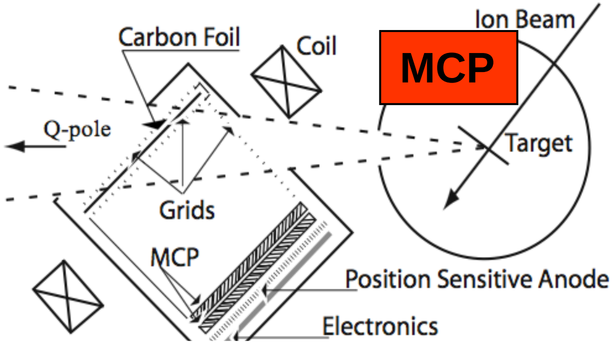
27 LoI’s plan to use PRISMA
21 neutron-rich, 5 neutron-deficient
18 direct kinematics, 9 inverse kinematics

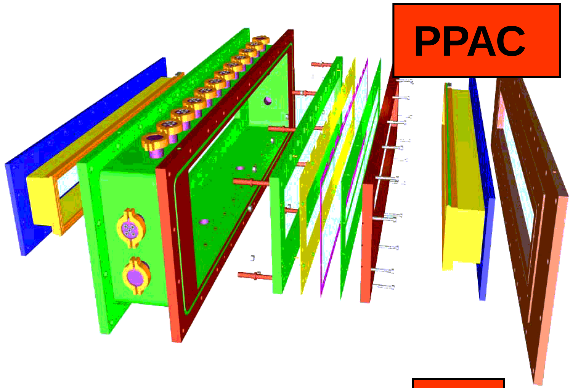


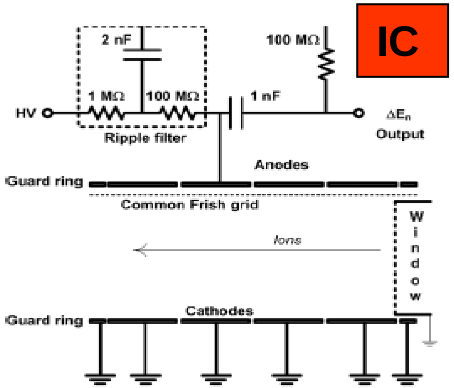
Summary

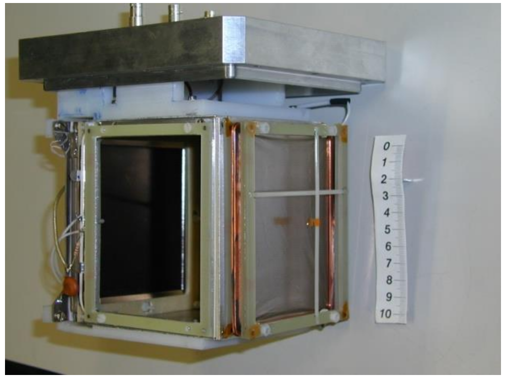
- PRISMA has been so far operated in standard configuration for **MNT** studies;
- In many years of experience the optimum performance has been achieved for the detection of ions with **30 < A < 130** at **3-6 MeV/u**, at angles θ_{lab} **> 20º** and with max **1-3 kHz** trigger rate at the focal plane;
- With the newly developed MCP and MWPPAC we will be able to efficiently detect also light ions in the range **6 < Z < 14**;
- For **A > 130-140** the mass separation becomes rapidly a problem;
- The mechanically allowed angular ranges for PRISMA coupled to AGATA are **20º < θ < 88°** for AGATA in **standard position** and **35º < θ < 88°** for AGATA in **close-up position**.
- PRISMA sensitivity limit is in the **few μb** range.

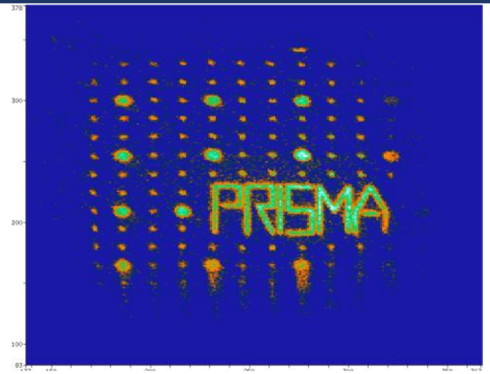
PRISMA detectors

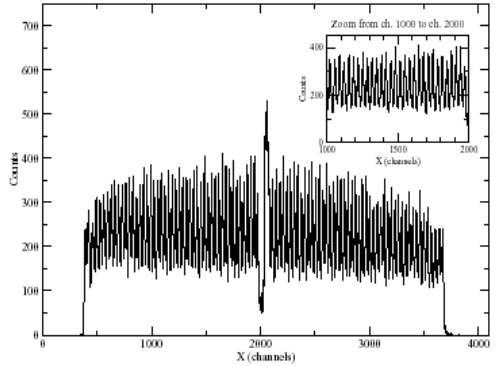


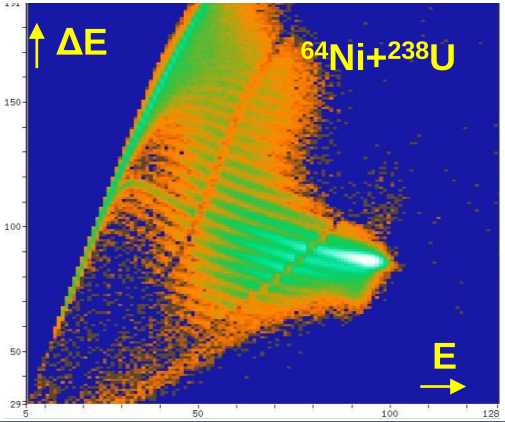












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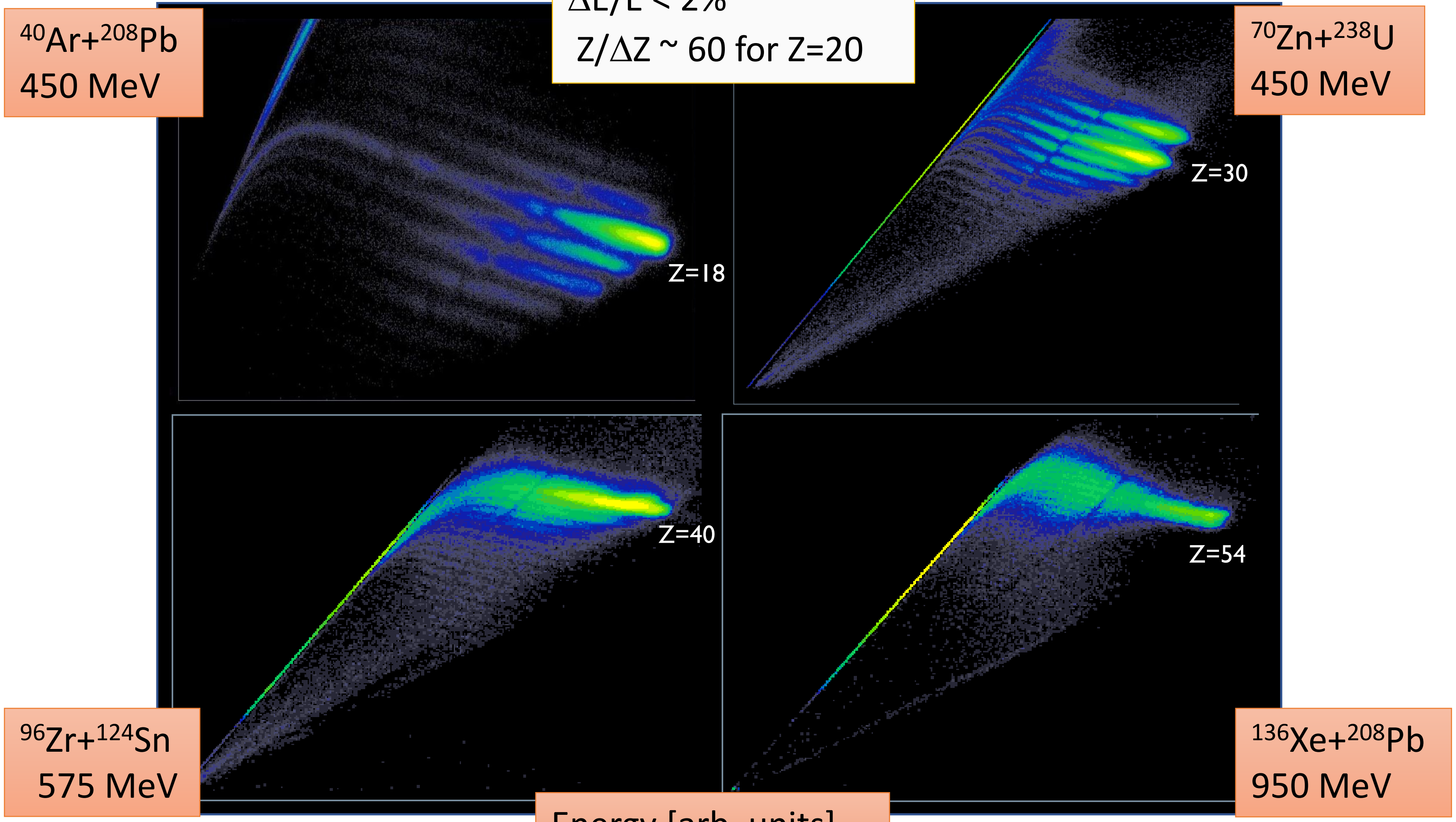


Energy [arb. units]

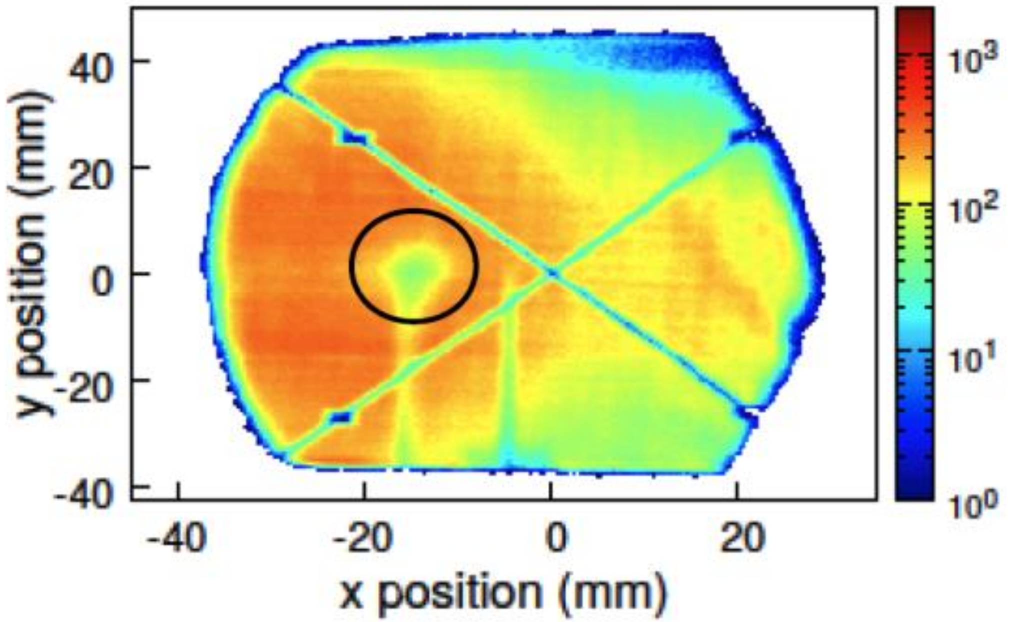
In-beam tests of the new MCP

The last 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 the position-sensitive anode is composed;
- overlapping of near wires.

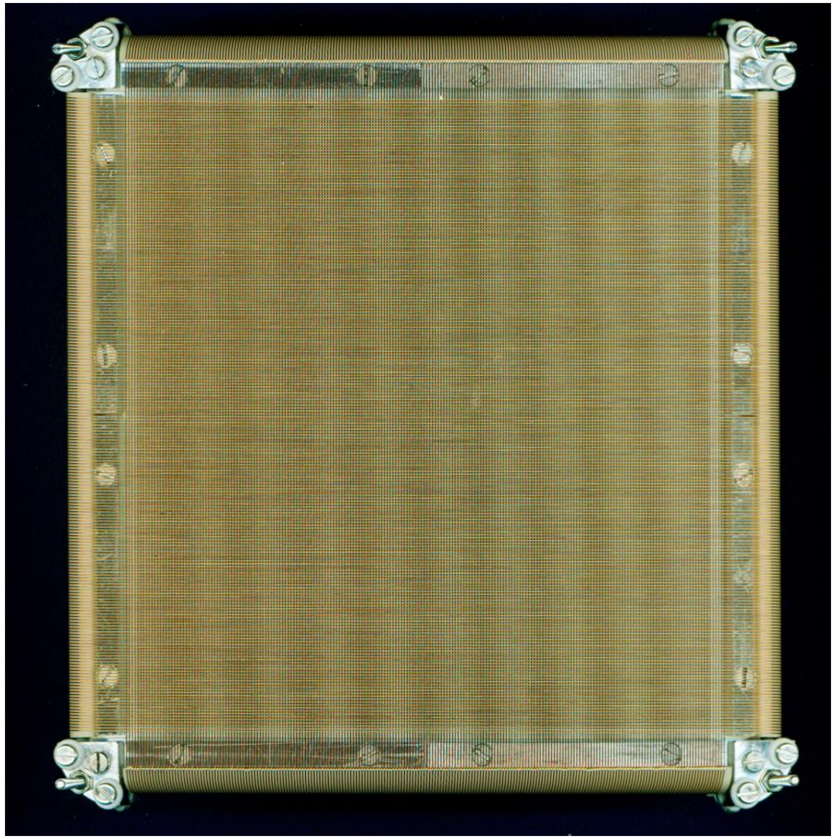
A new position-sensitive anode has been assembled and mounted and two days of beam time were allotted during the last PAC meeting for the test of the new configuration.

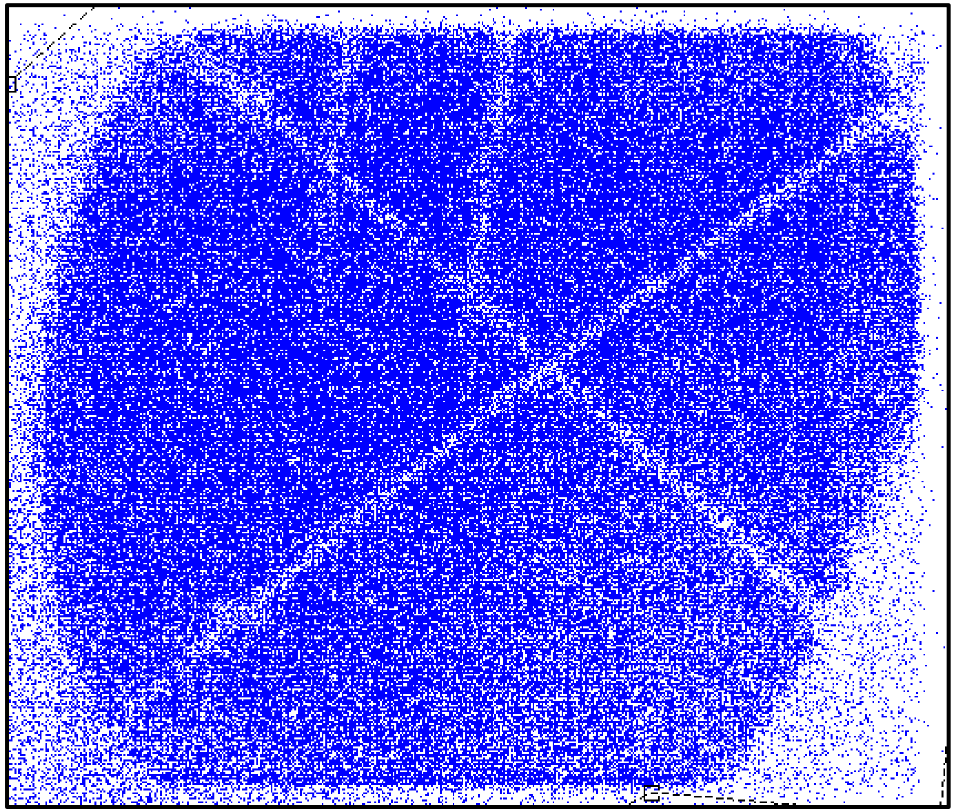


In-beam tests of the new MCP

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

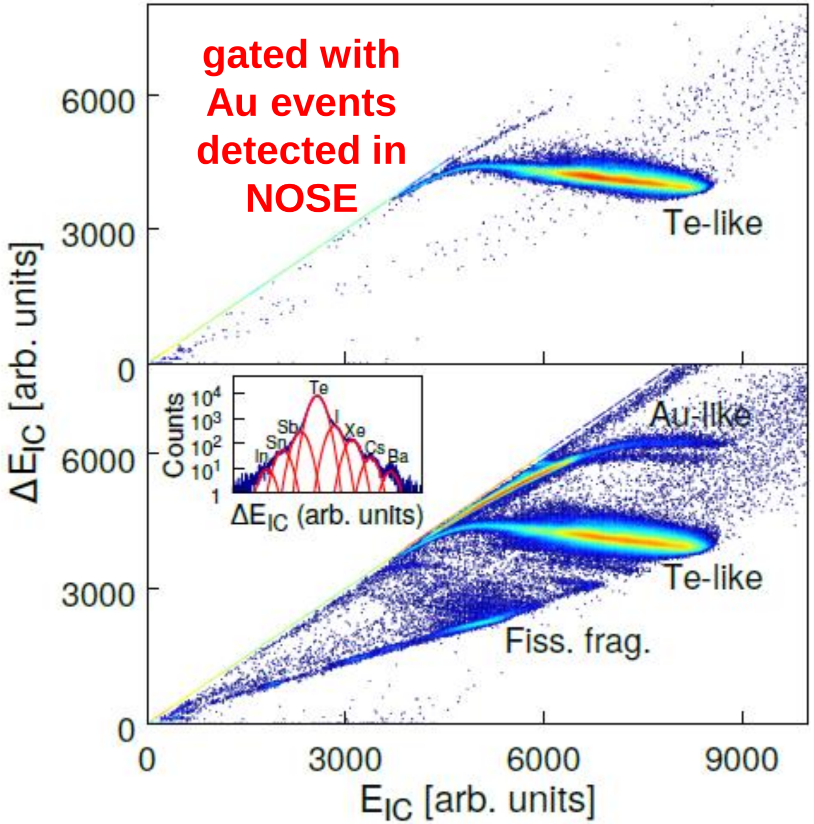
- In the new configuration the efficiency of the entrance detector of PRISMA turned out to be about 90% and no low efficiency region was evidenced in the X-Y scatter-plot



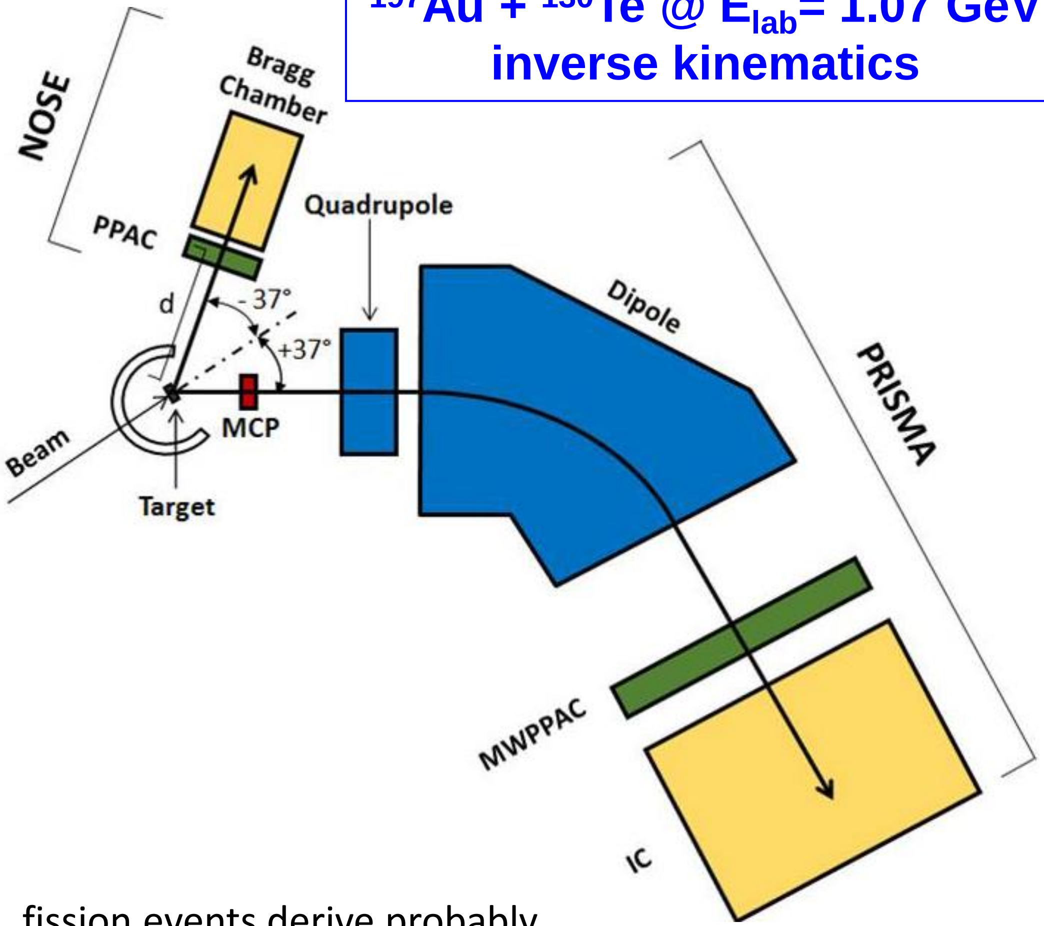


The $^{197}Au+^{130}Te$ experiment

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



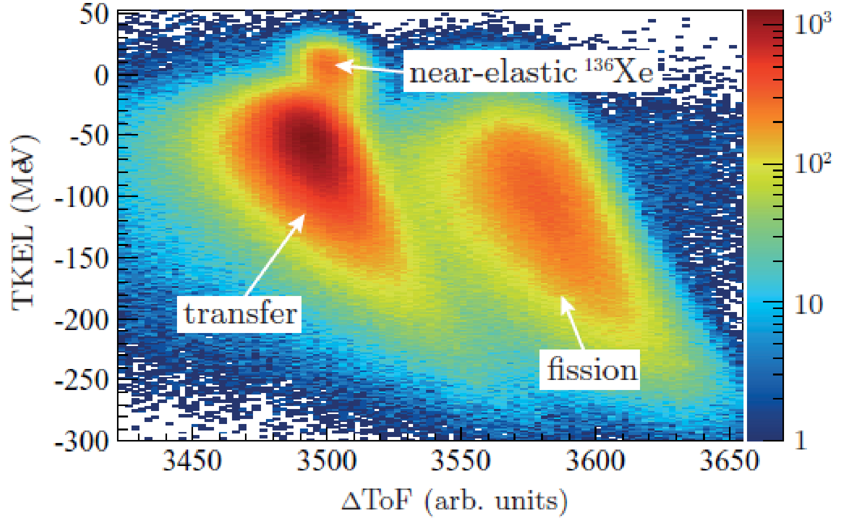
$^{197}Au + ^{130}Te$ @ E_{lab}= 1.07 GeV inverse kinematics

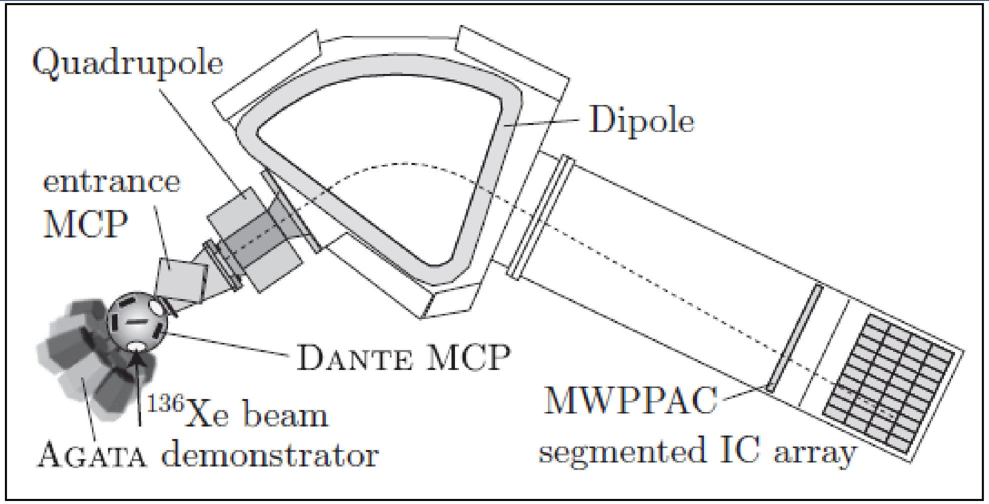


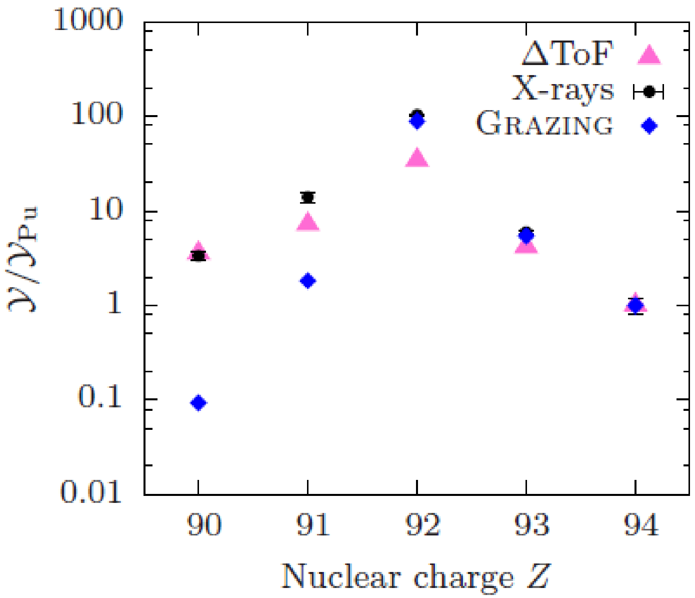
fission events derive probably from transfer induced fission or quasi fission

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

The $^{136}Xe+^{238}U$ system at E_{beam} = 1 GeV







via a kinematic coincidence PRISMA-DANTE one could extract the yield of mass integrated actinide nuclei, which turns out to be in good agreement with that derived from X-ray analysis

A.Vogt et al., PRC92(2015)024619