Study of shape transitions in the neutron-rich Os isotopes

Nuclear Structure Physics with Advanced GammaDetector Arrays

P.R. John[1],
V. Modamio[2], J.J. Valiente-Dobón[2], D. Mengoni[1], S. Lunardi[1], T. Alexander[3], G. de Angelis[2], N. Ashwood[4], M. Barr[4], D. Bazzacco[1], P.G. Bizzeti[5], A.M. Bizzeti-Sona[5], S. Bottoni[6], M. Bowry[3], A. Bracco[6], F. Browne[7], M. Bunce[3], A. Gadea[8], F. Camera[6], L. Corradi[2], F.C.L. Crespi[6], E. Farnea[1], E. Fioretto[2], A. Gottardo[2], Tz. Kokalova[4], W. Korten[9], A. Kusoglu[10], S. Lenzi[1], S. Leoni[6], C. Michelagnoli[1], T. Mijatovic[11], G. Montagnoli[1], D. Montanari[2], D.R. Napoli[2], Zs. Podolyák[8], G. Pollarolo[12] ,F. Recchia[1], O.J. Roberts[7], E. Sahin[2], M.-D. Salsac[9], F. Scarlassara[1], M. Sferrazza[13], A.M. Stefanini[1], S. Szilner[11], C.A. Ur[1], J. Walshe[4], C. Wheldon[4]

[1]Dipartimento di Fisica e Astronomica and INFN, Sezione di Padova, Italy.[2]INFN, Laboratori Nazionali di Legnaro, Italy.[3]Department of Physics, University of Surrey, United Kingdom.[4]School of Physics and Astronomy, University of Birmingham, United Kingdom.[5]Dipartimento di Fisica and INFN, Sezione di Firenze, Italy.[6]Dipartimento di Fisica and INFN, Sezione di Milano, Italy.[7]University of Brighton, United Kingdom.[8]Instituto de Fisica Corpuscular, CSIC, Valencia, Spain.[9]CEA/Saclay, IRFU/Service de Physique Nucleaire, Gif-sur-Yvette, France.[10]Istanbul University, Turkey.[11]Institut Ruder Bošković, Zagreb, Croatia.[12]Dipartimento di Fisica and INFN, Sezione di Torino, Italy.[13]University of Brussels, Belgium.

Outline

The neutron-rich W, Os and Pt isotopes

- Existence of Isomers
- Different shapes in their ground-state prolate, oblate, triaxial, and spherical
- Shape transitions
- Region is a crucial testing ground for nuclear models

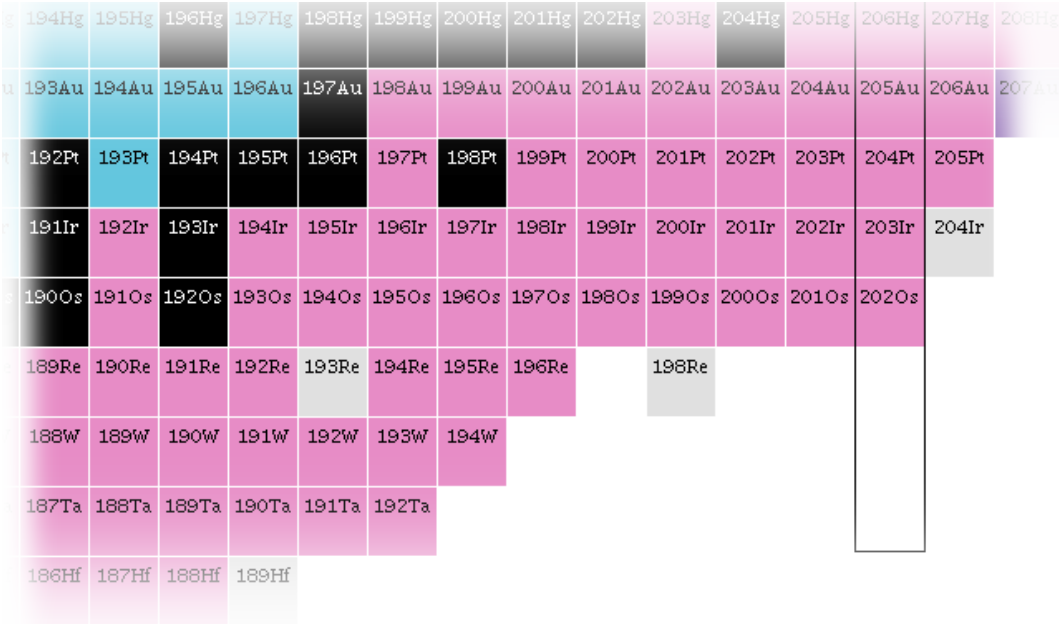

Chart taken from: Nuclear Data Database NUDAT 2, http://www.nndc.bnl.gov/nudat2.

- Region studied using both stable and radioactive beams: **No spectroscopic information about ^{196}Os**

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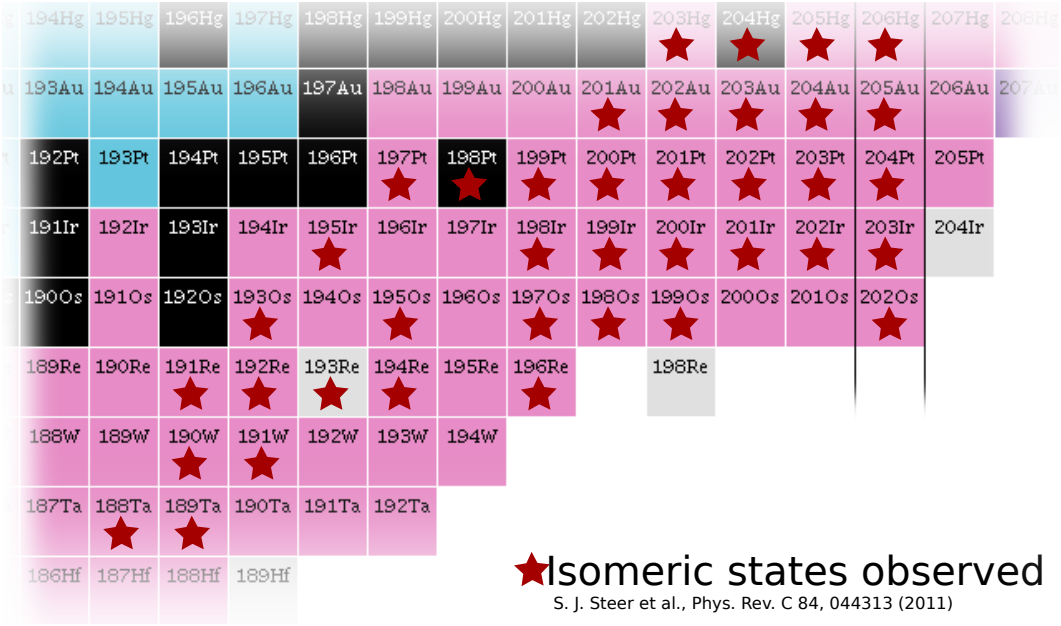

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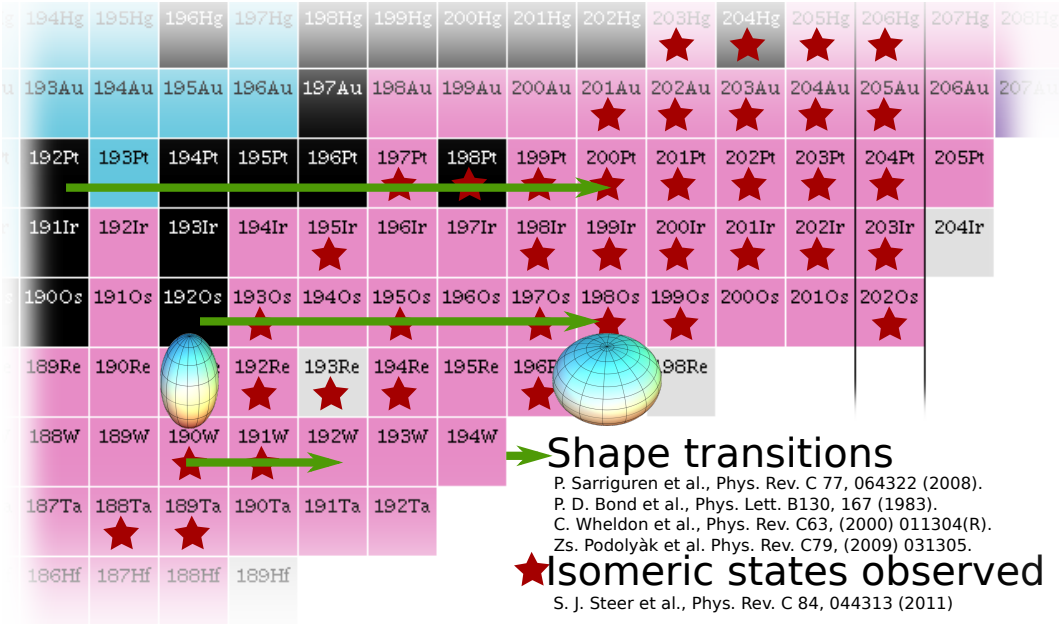

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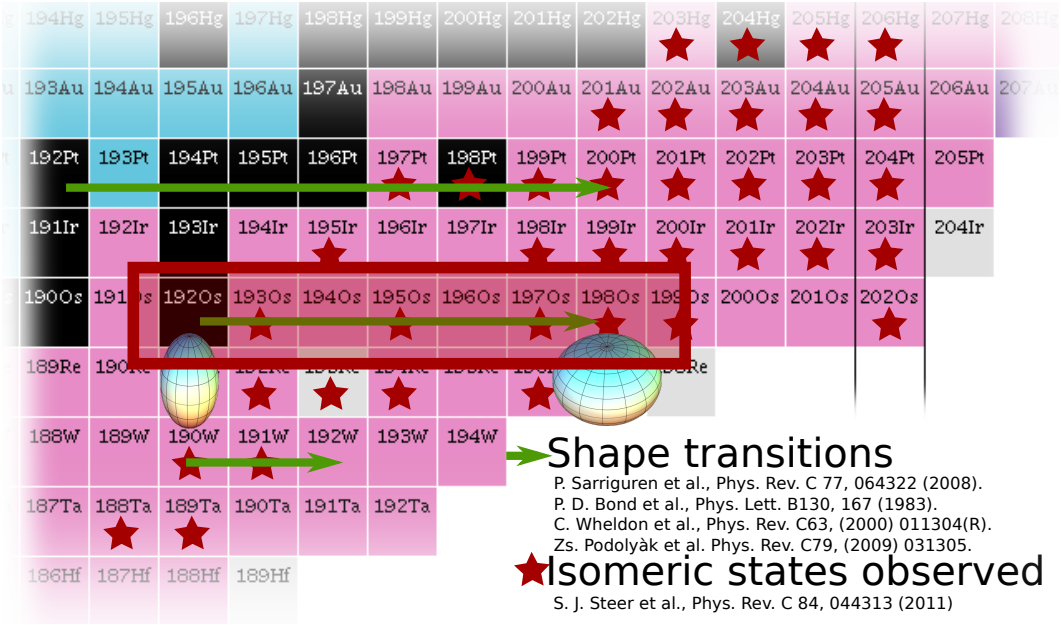

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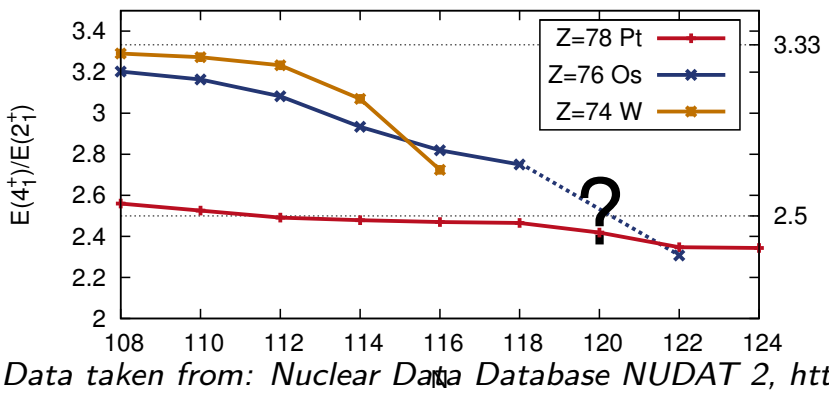
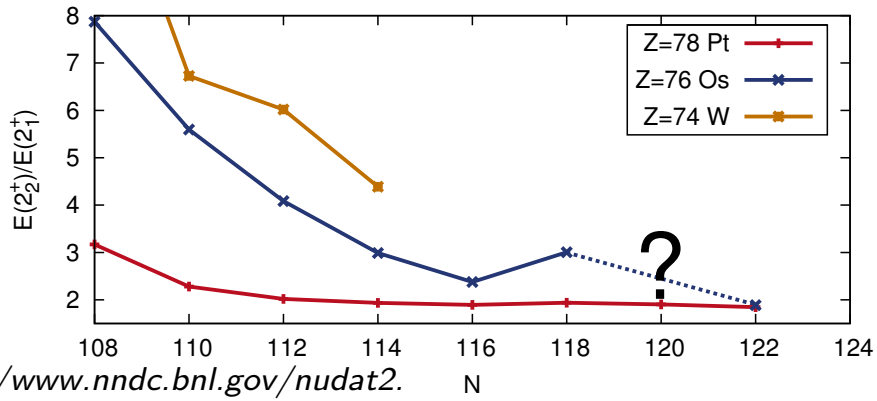
Shape transitions in the neutron-rich W, Os and Pt isotopes

W Sudden prolate to oblate shape transition predicted for A=190-192
P. Sarriguren et al., Phys. Rev. C 77, 064322 (2008).

Pt Transition region starts with A=192 and persists till A≈200 with γ-soft ground states
T. Möller, HK 20.8. P. D. Bond et al., Phys. Lett. B130, 167 (1983).

Os Prolate deformed groundstate of ^{194}Os, oblate deformed groundstate for ^{198}Os found.
C. Wheldon et al., Phys. Rev. C63, (2000) 011304(R). Zs. Podolyák et al. Phys. Rev. C79, (2009) 031305.



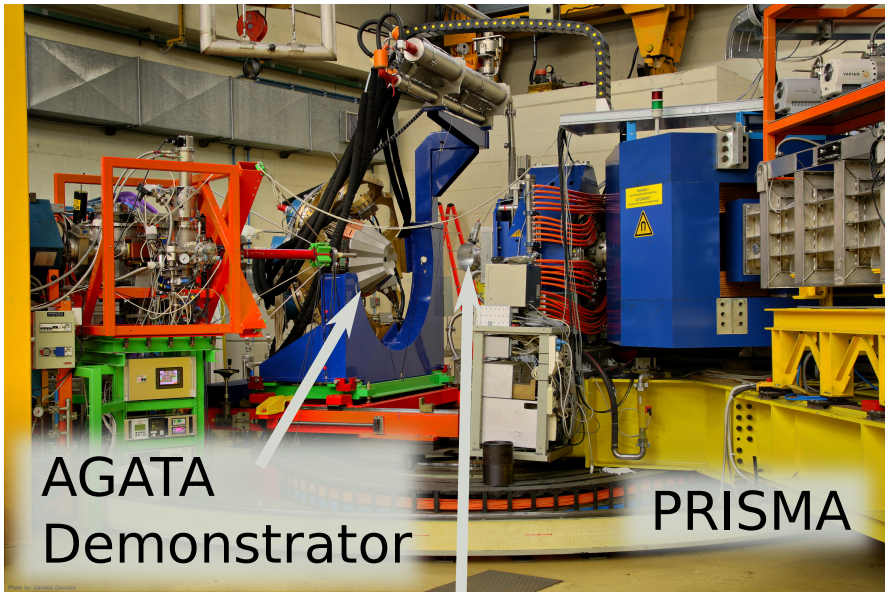


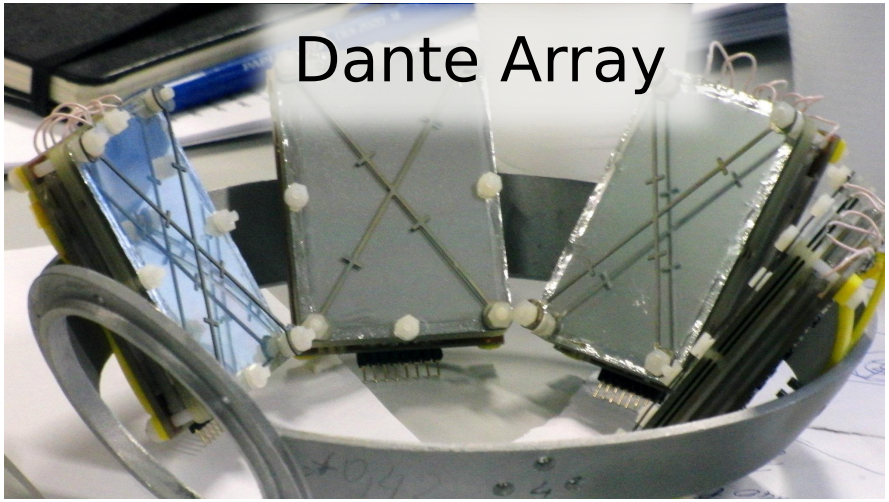
Data taken from: Nuclear Data Database NUDAT 2, http://www.nndc.bnl.gov/nudat2.

Setup

The experiment was performed at LNL, Italy using

- a 426 MeV ^{82}Se beam
- a 2 mg/cm^2, self-supporting ^{198}Pt target
- AGATA Demonstrator (5 Cluster)
- large-acceptance magnetic spectrometer PRISMA@57° **detecting the lighter beam-like recoils**
- DANTE heavy ion detector (for additional particle-particle-γ-γ coincidences without particle identification)





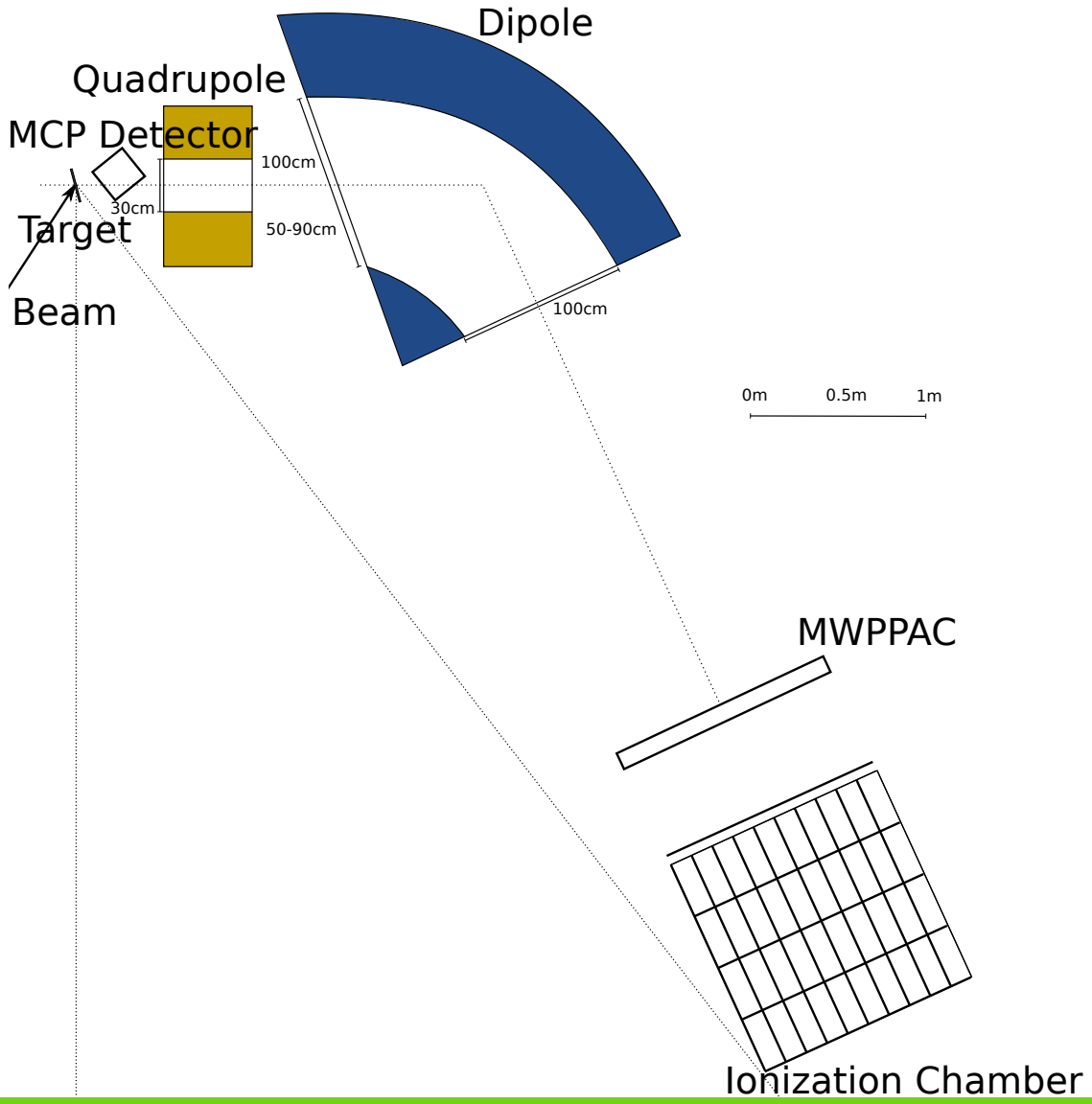
Particle Identification using PRISMA

Measure

- Entrance and exit position
- Time of flight
- Energy loss
- Total energy

Reconstruct

- Trajectory
- Velocity vector
- Z, A, q



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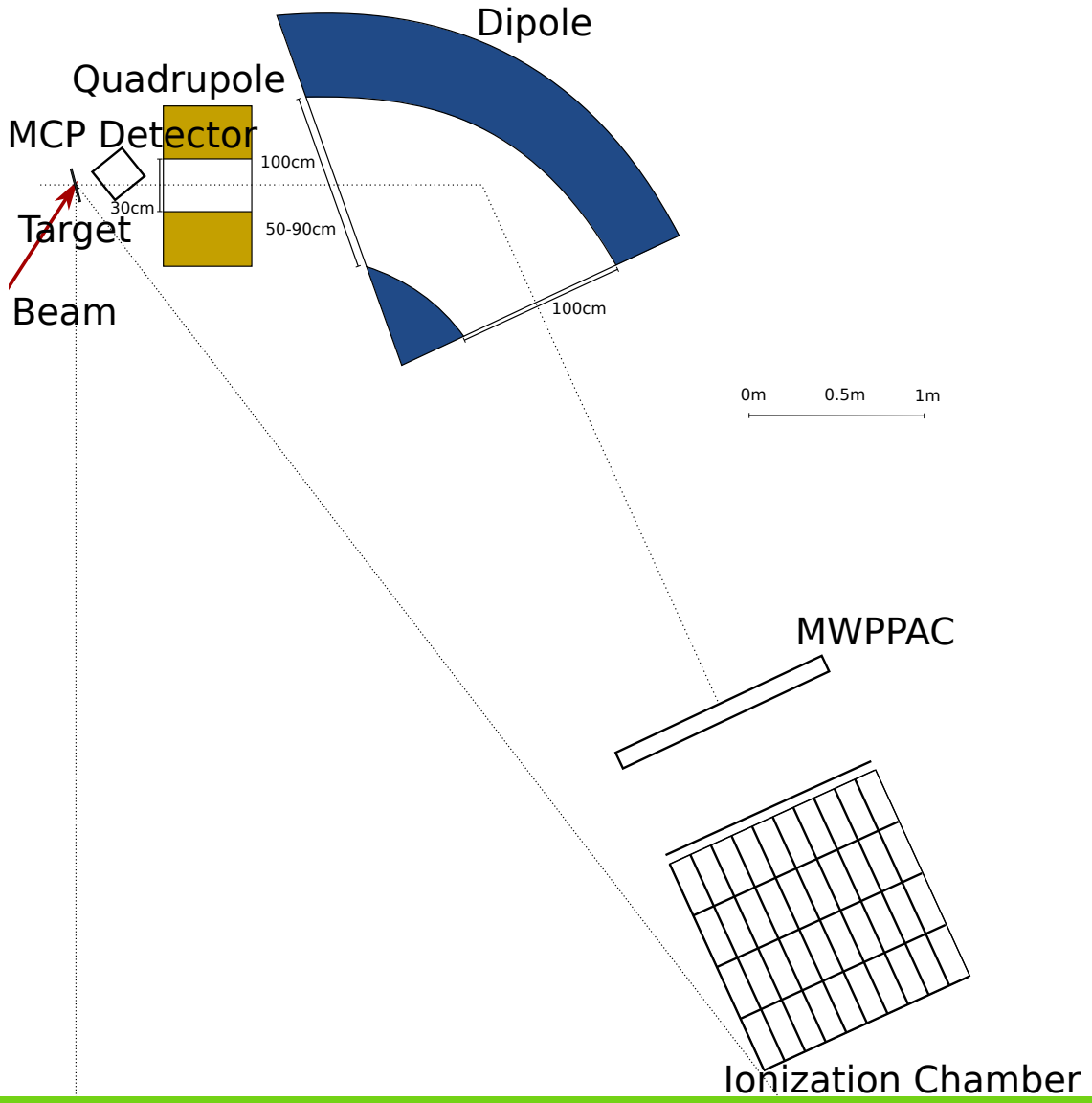

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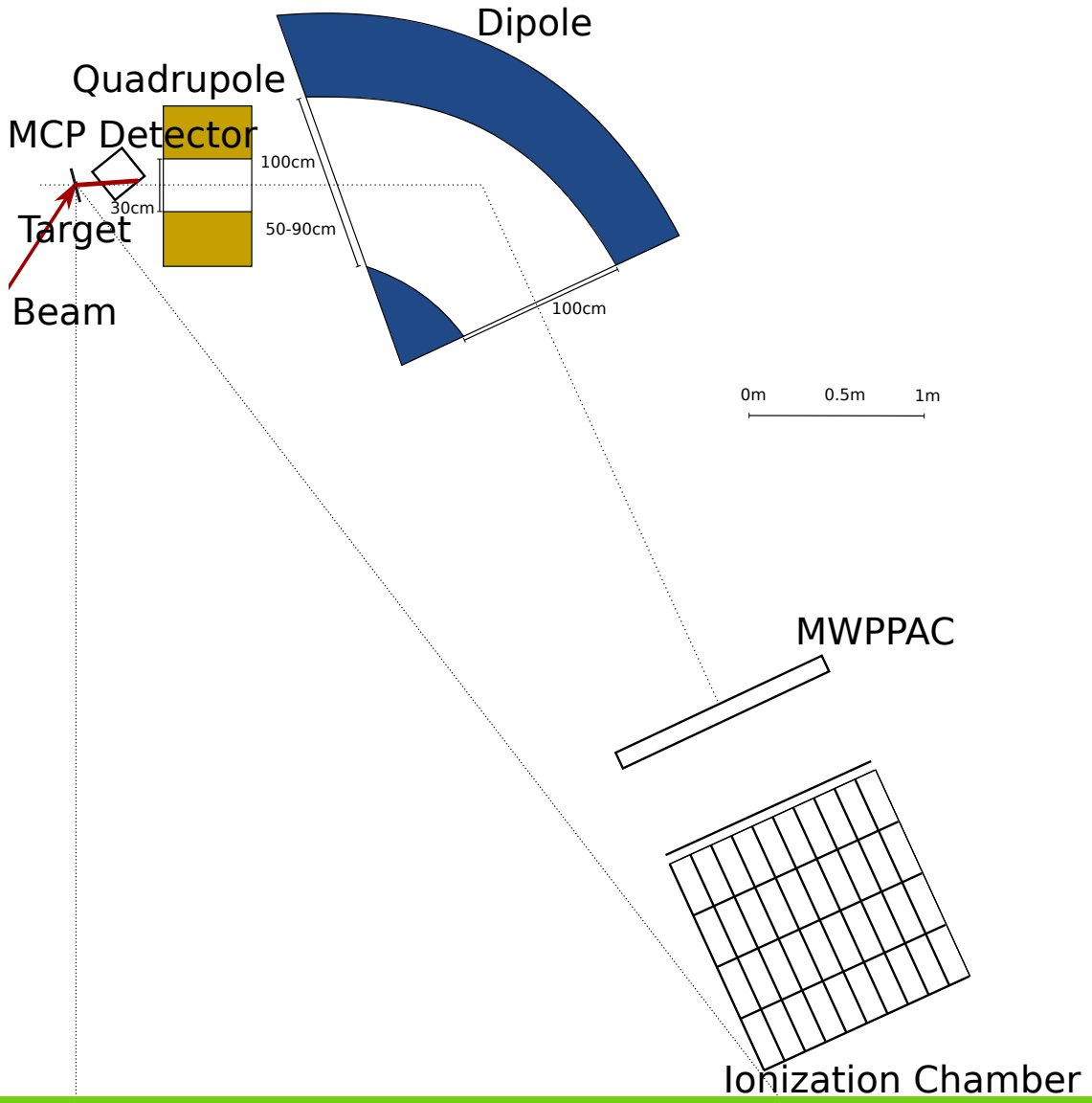

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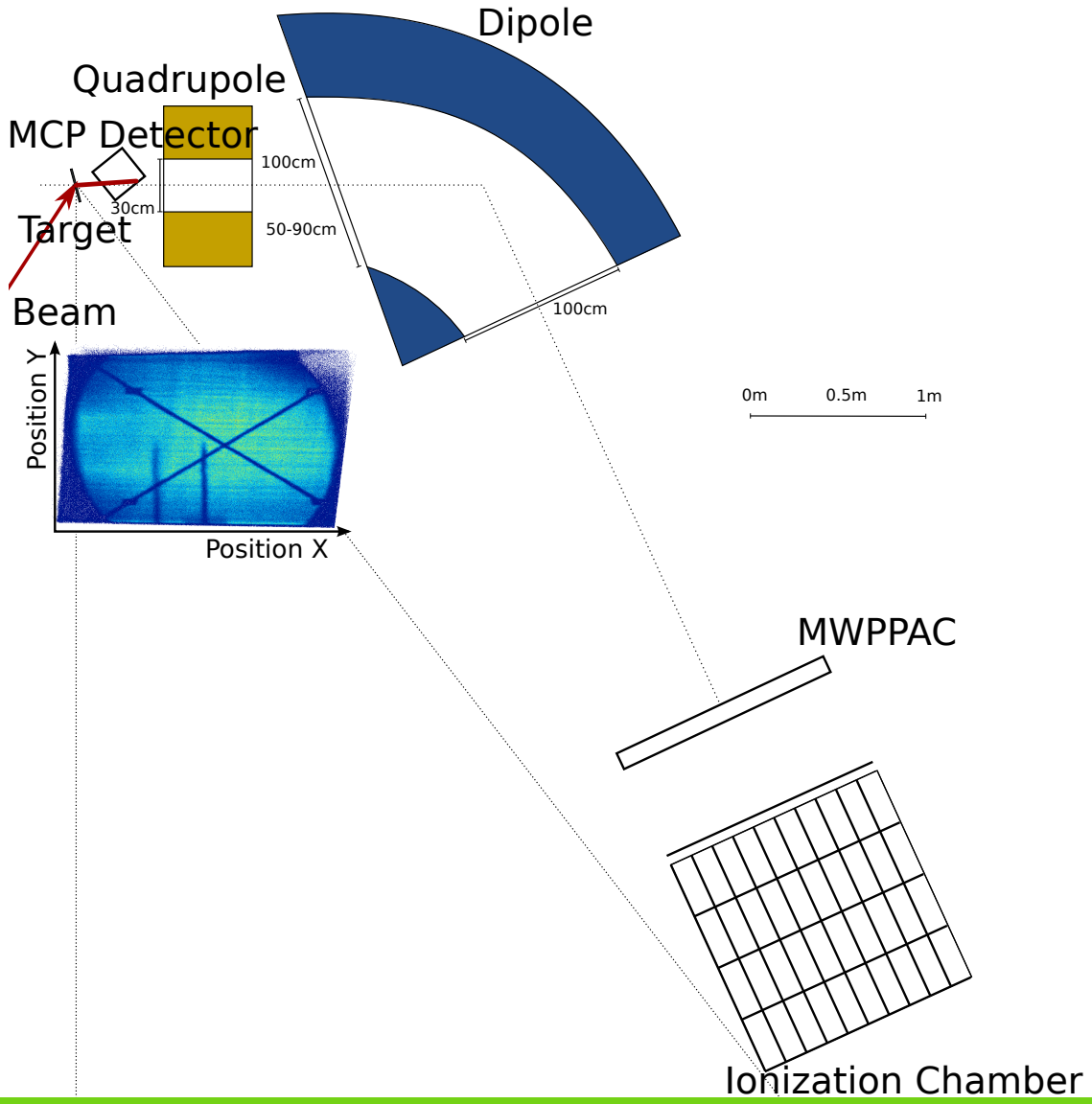

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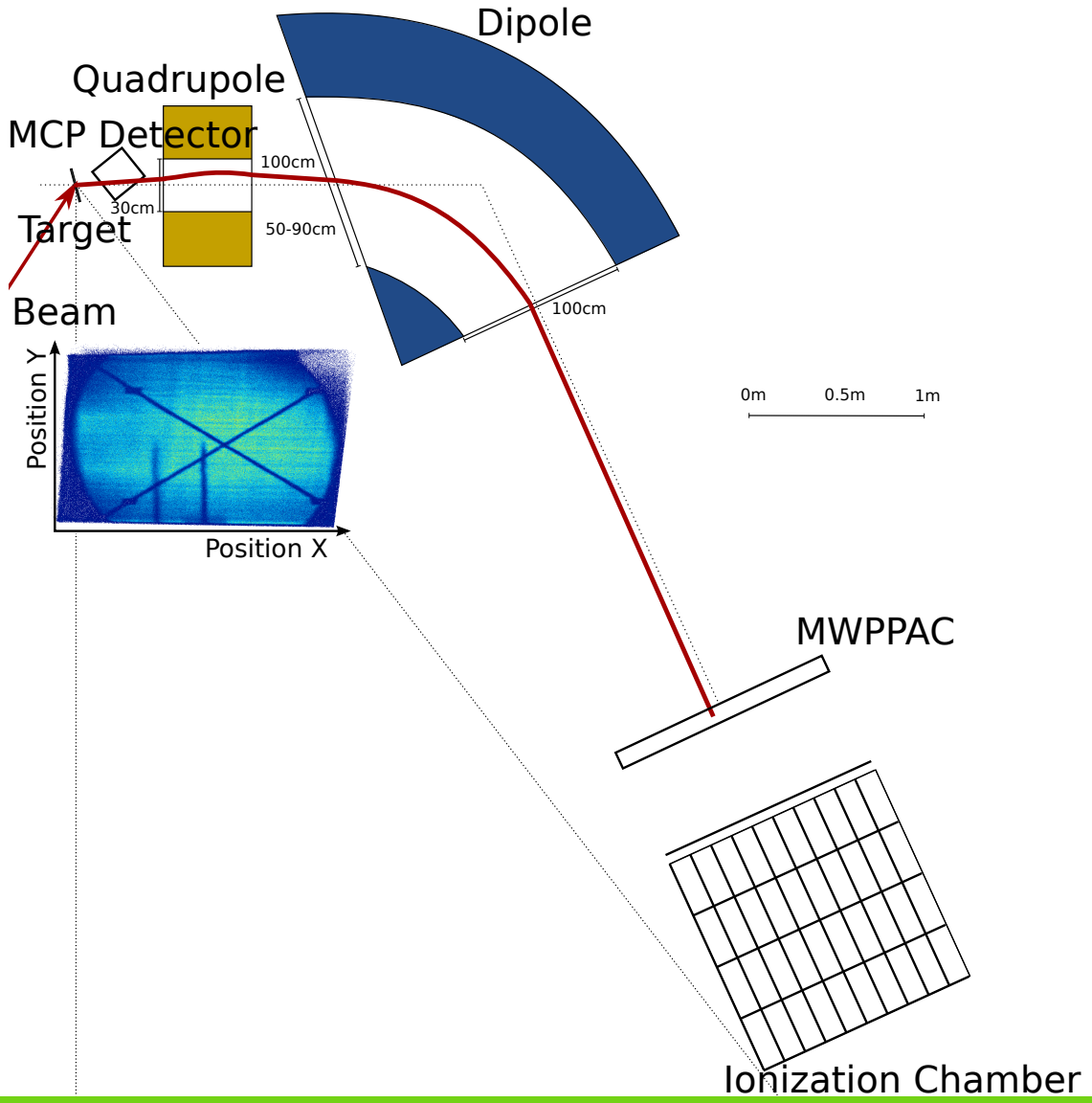

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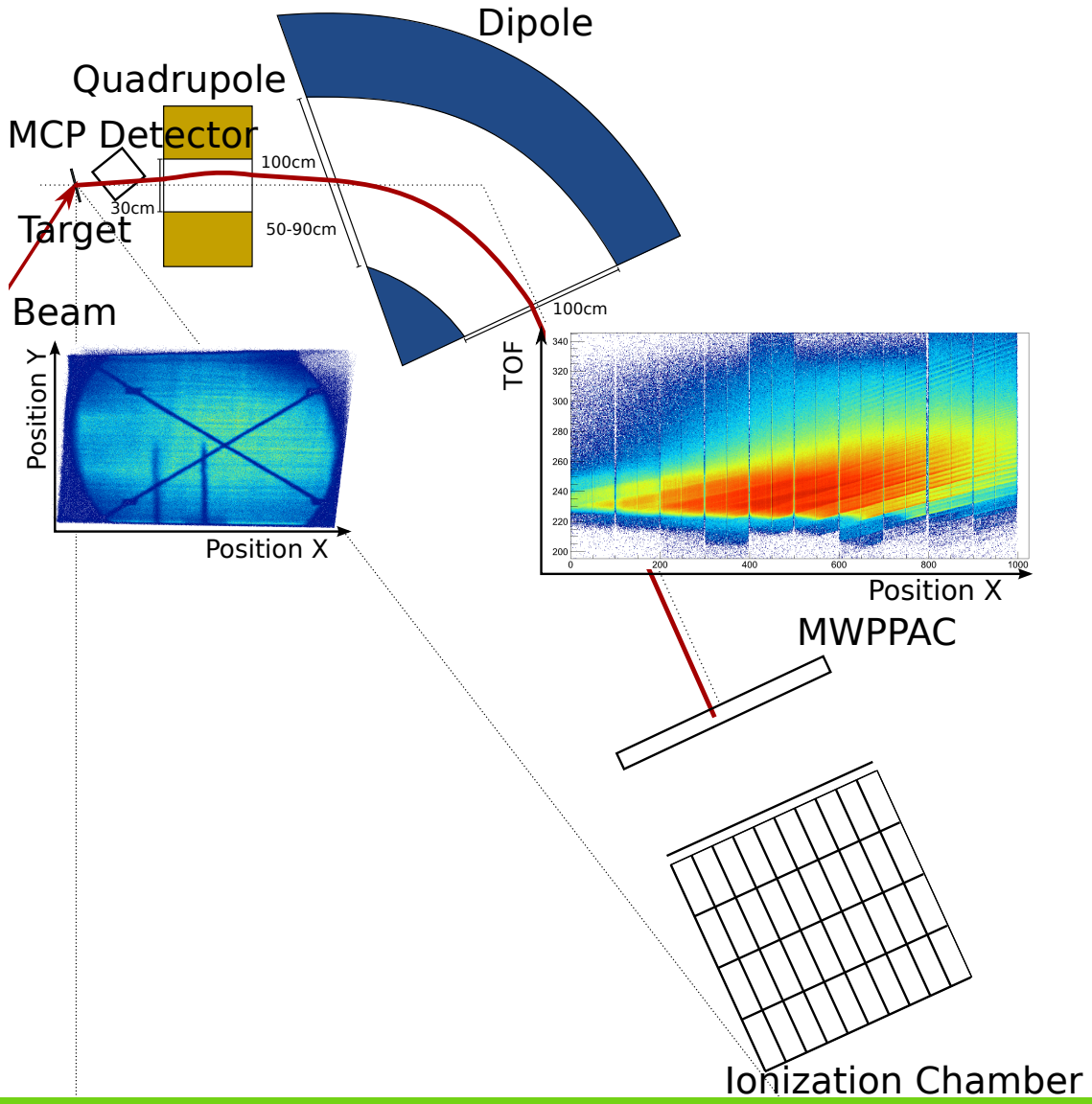

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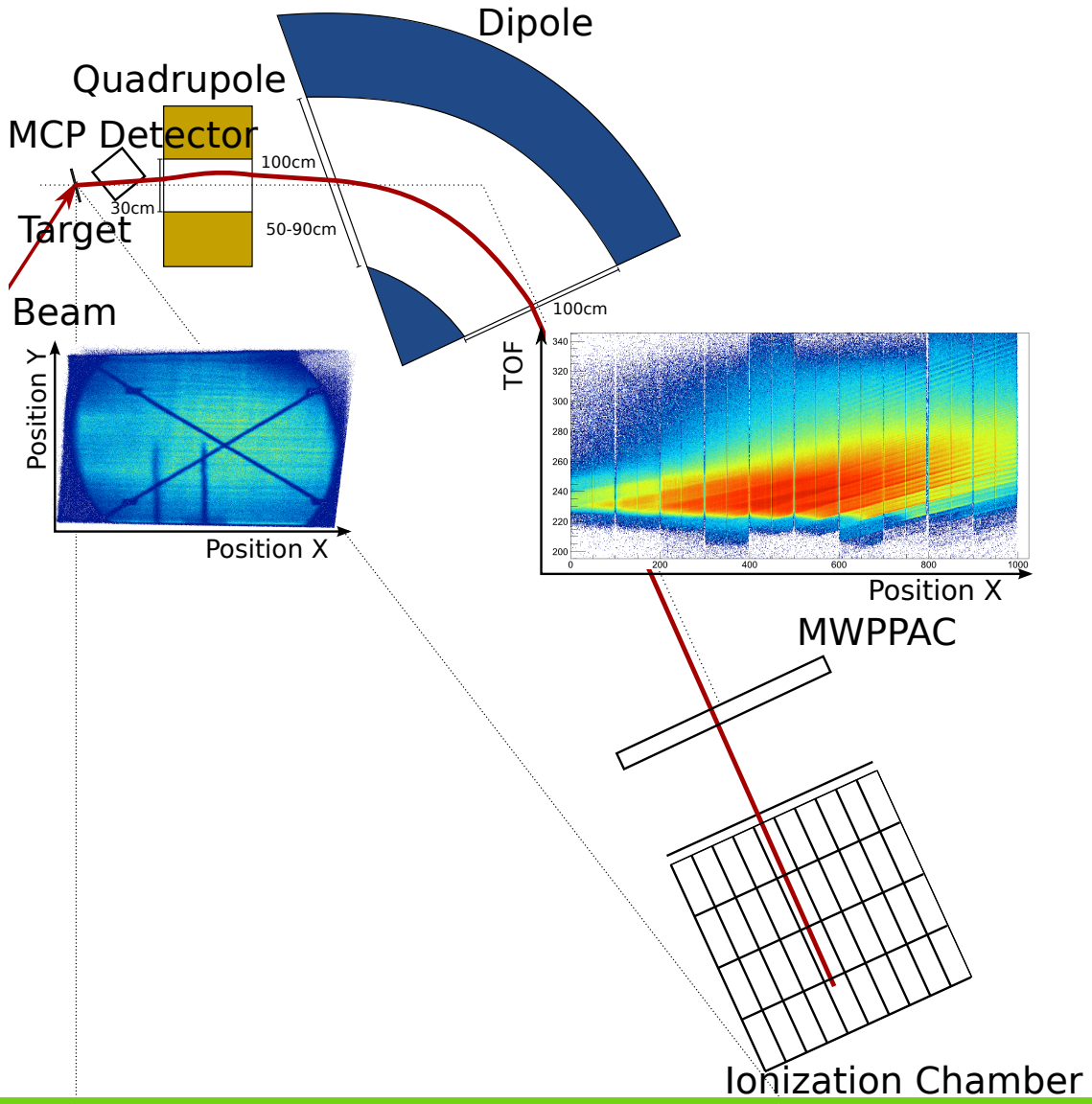

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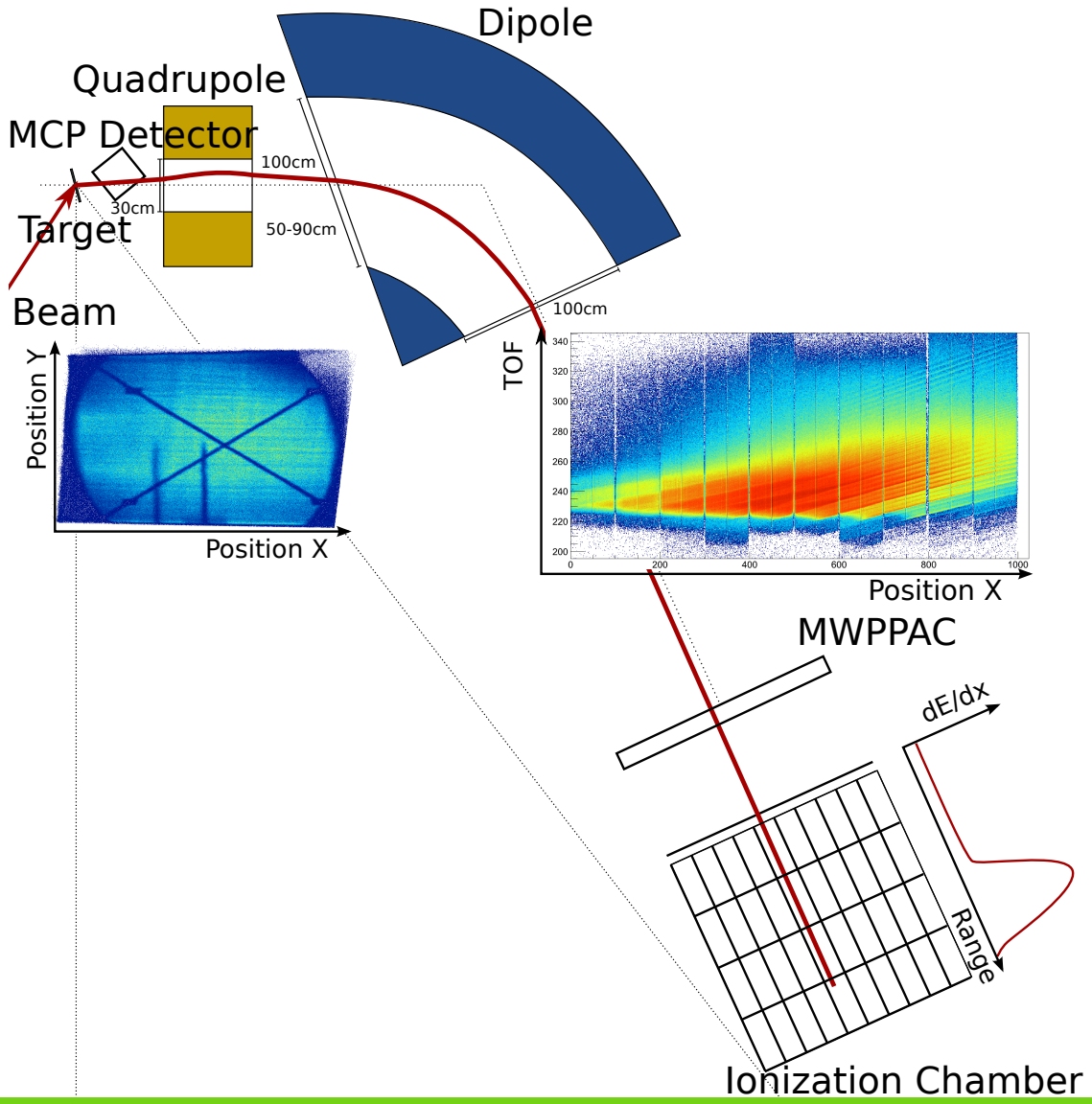

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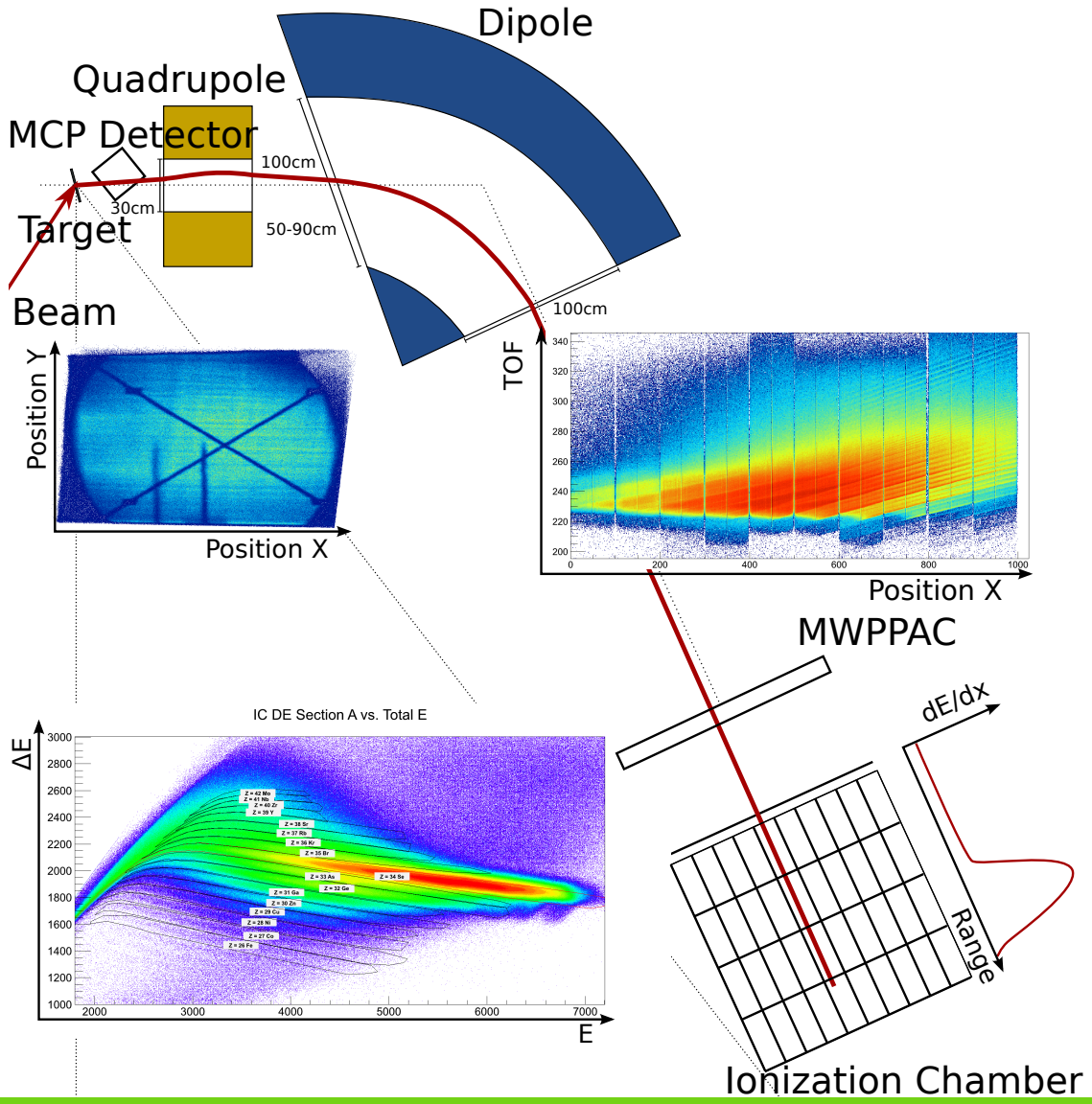

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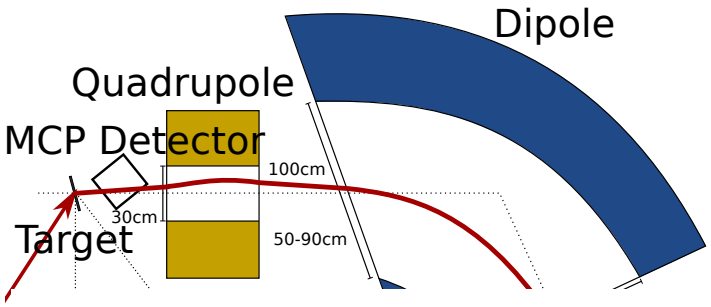
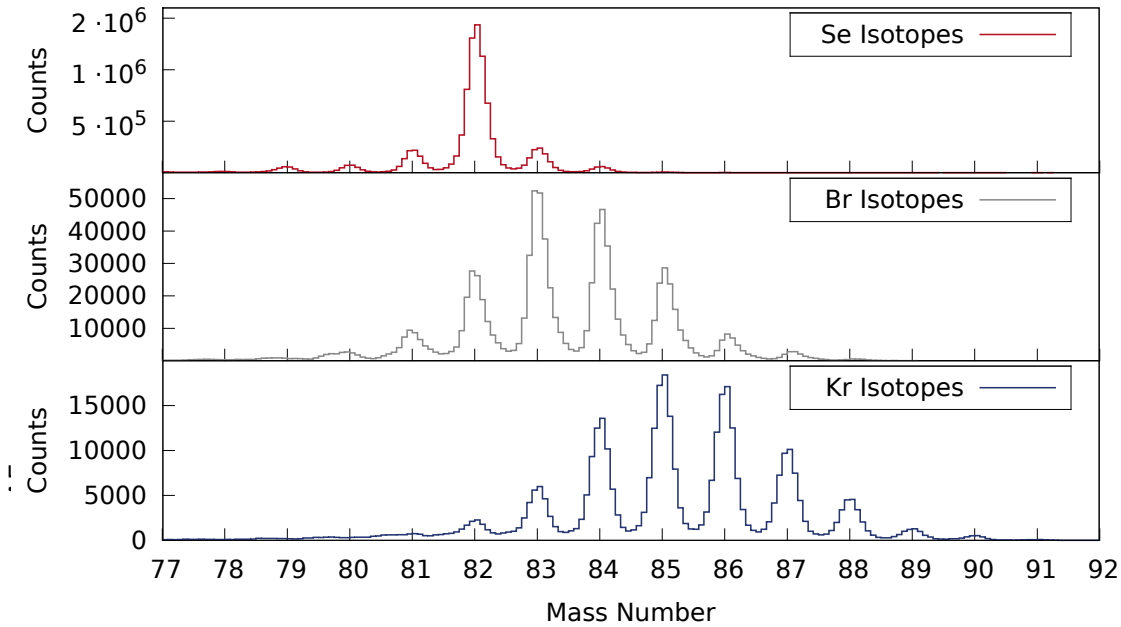
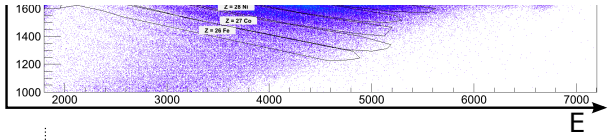
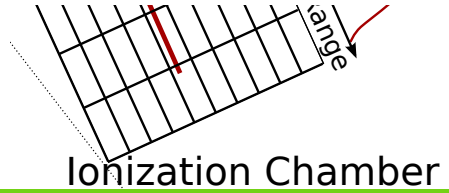


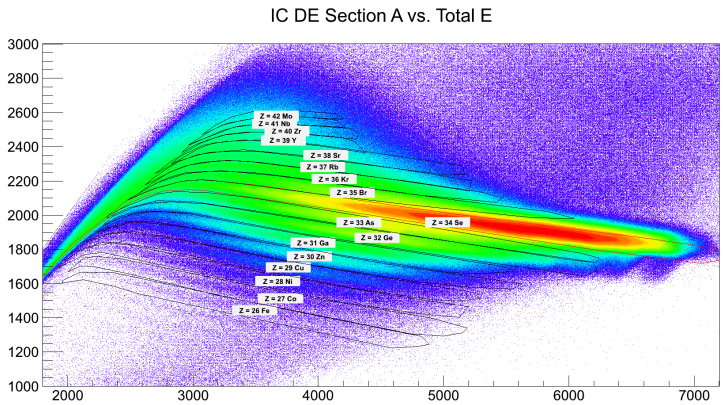


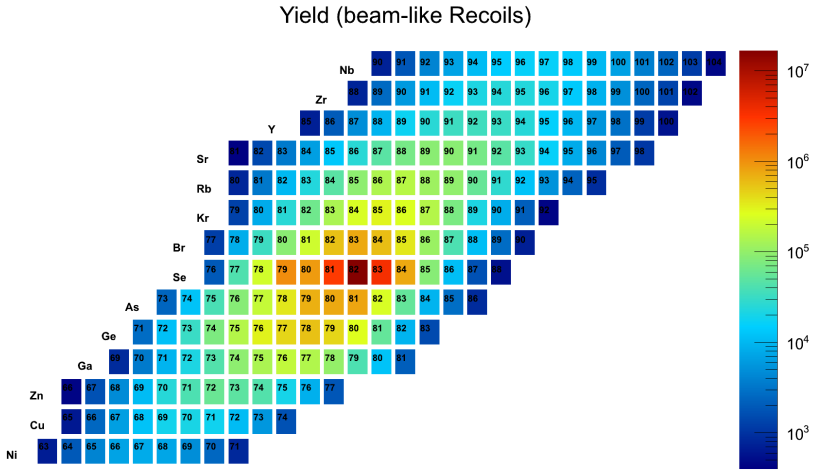




Particle Identification using PRISMA

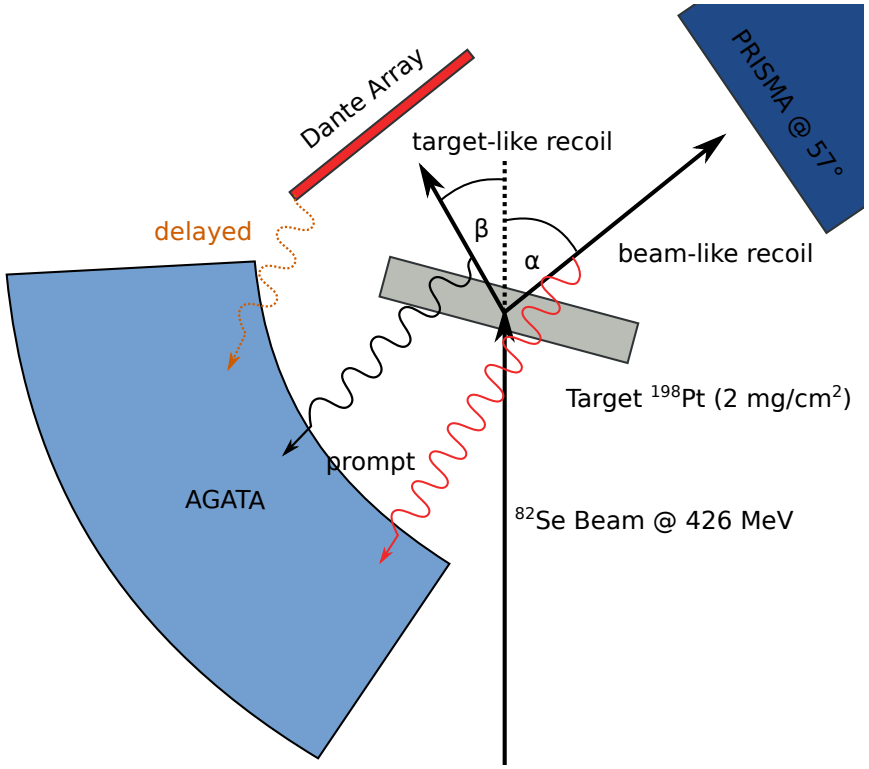
- Event by event particle identification using PRISMA
- Only the lighter beam-like fragment is unambiguously identified
- Event by event Doppler correction for the beam-like ions
- Heavier ions of interest are partly detected in the DANTE array
- Need to reconstruct angle and velocity of target-like ions





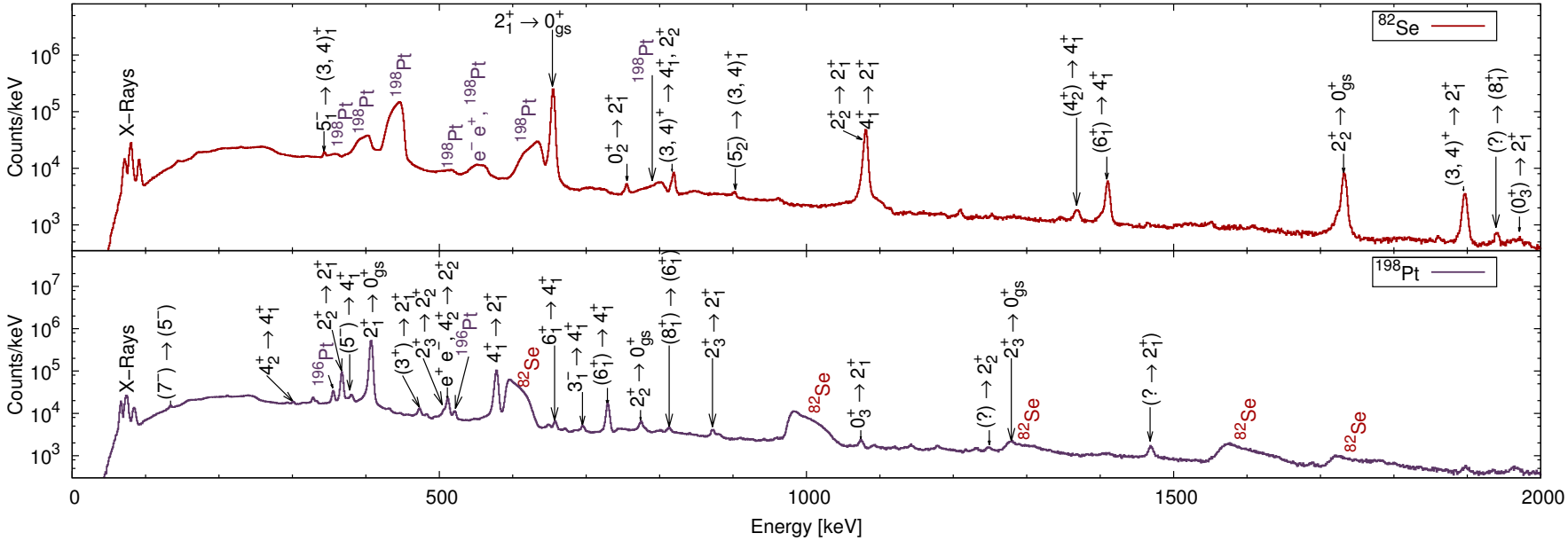
Doppler Correction using the Binary Partner Method

- Reconstruct the velocity vector of the un-detected heavier ion event by event using
  - Relativistic two-body reaction
  - Exact masses
  - Q-value of reaction
  - Energy loss in the target for all participants
  - **Assumption: No particle evaporation**
- Target-like recoil is stopped in the reaction chamber ⇒ Possibility to measure decay of isomers



Preliminary Spectrum of ^{82}Se and ^{198}Pt

- Good Doppler correction with
  - FWHM of 6.21 keV for the $2_2^+ \rightarrow 0_{gs}^+$ of ^{82}Se at 1731.5 keV (3.59‰)
  - FWHM of 4.18 keV for the $2_1^+ \rightarrow 0_{gs}^+$ of ^{198}Pt at 407.21 keV (1.02%)

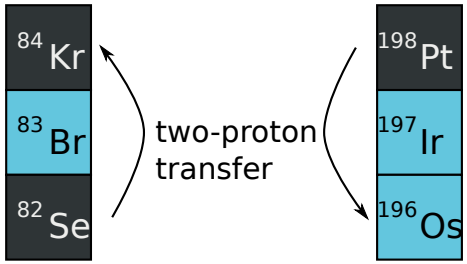


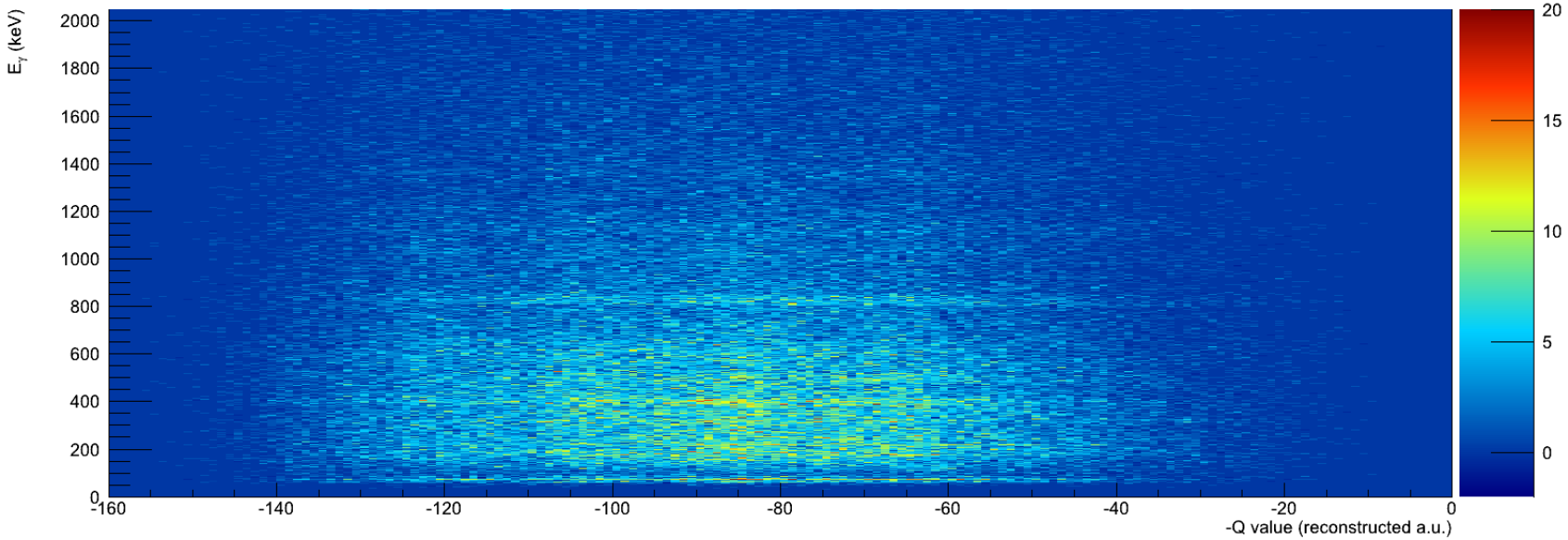
Transitions tentatively assigned based on previously reported gamma ray energies.
H. Xiaolong,Nuclear Data Sheets 110, 2533 (2009). J. K. Tuli, Nuclear Data Sheets 98, 209 (2003).

Reconstructing Q-Value

- Two-Proton transfer channel
- Neutron evaporation for beam-like and target-like fragments leads to a misinterpretation of the measured gamma rays
- Reconstruct Q-value based on momentum conservation

A.B. Brown et al., Phys. Rev. 82, 159 (1951)





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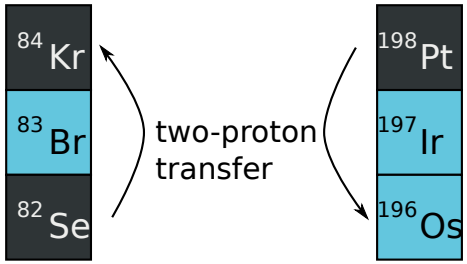
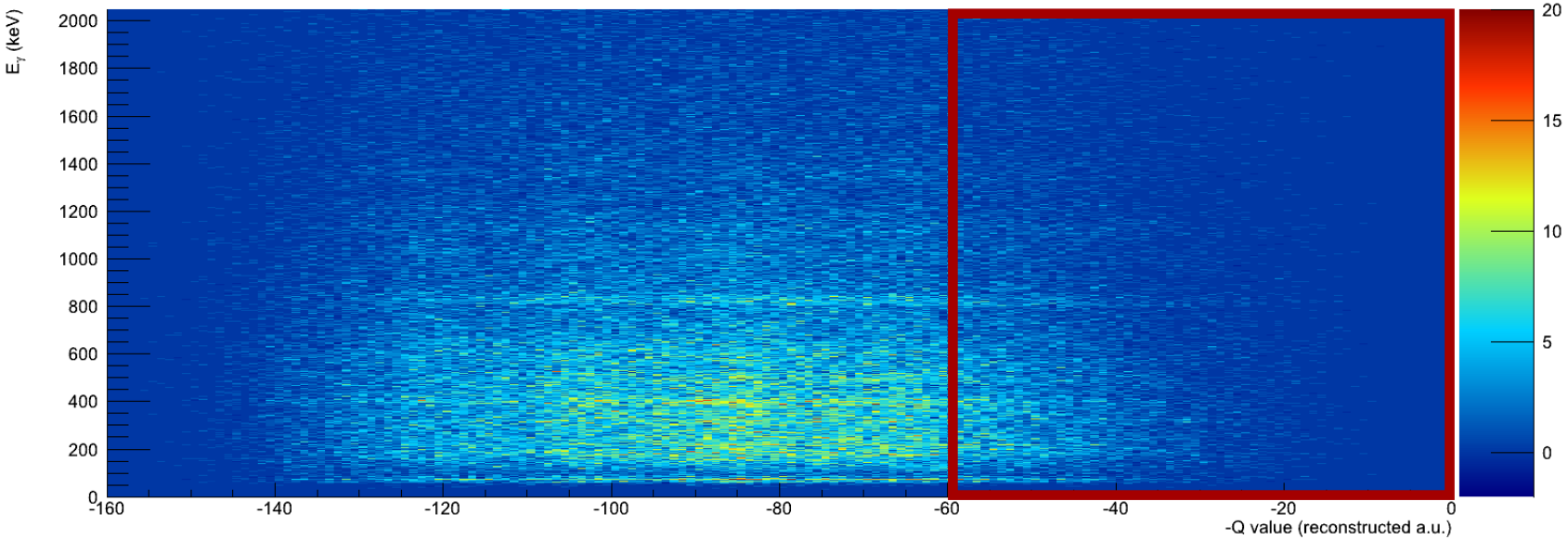
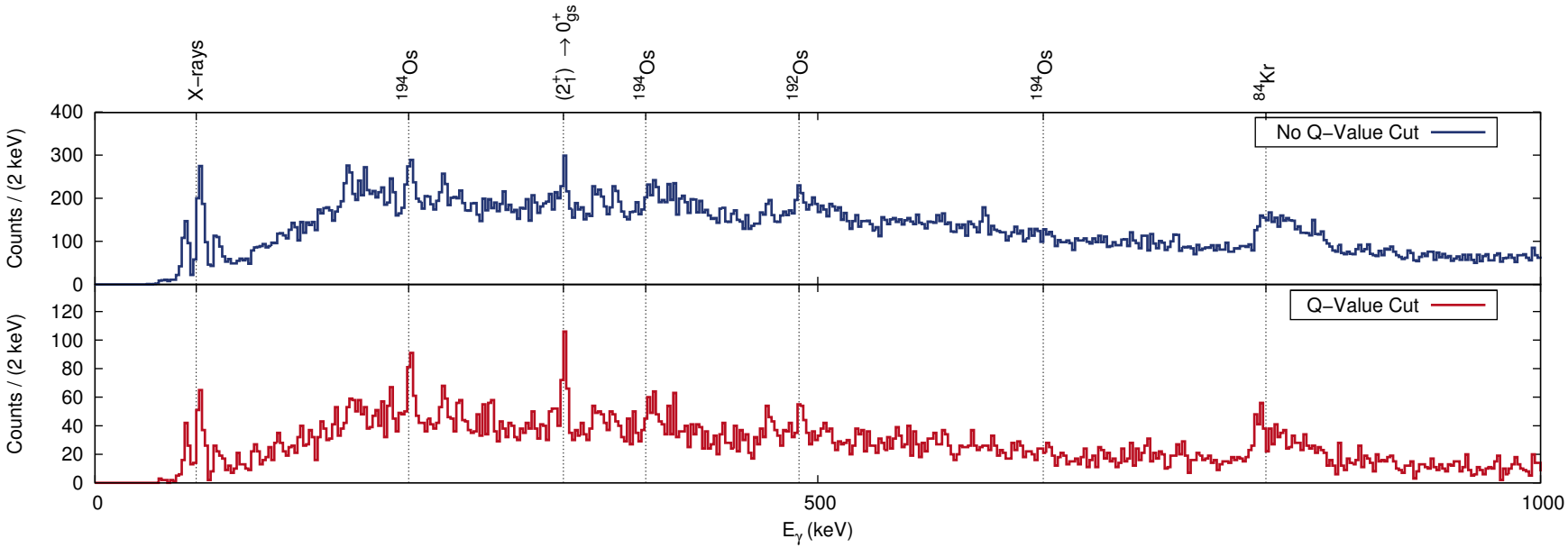




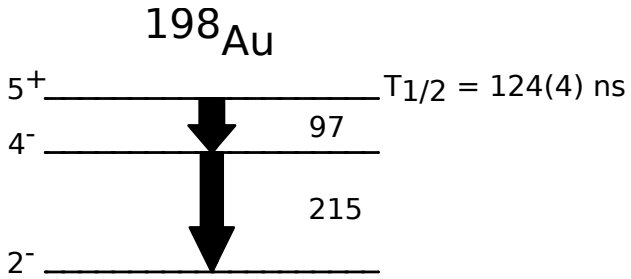
Spectra for ^{196}Os

- Cut on the reconstructed Q-value reduces contribution of nuclei produced by neutron evaporation
- Transition ($2_1^+ \rightarrow 0_{gs}^+$) was observed for the first time
- Statistics is high enough for $\gamma - \gamma$ coincidences



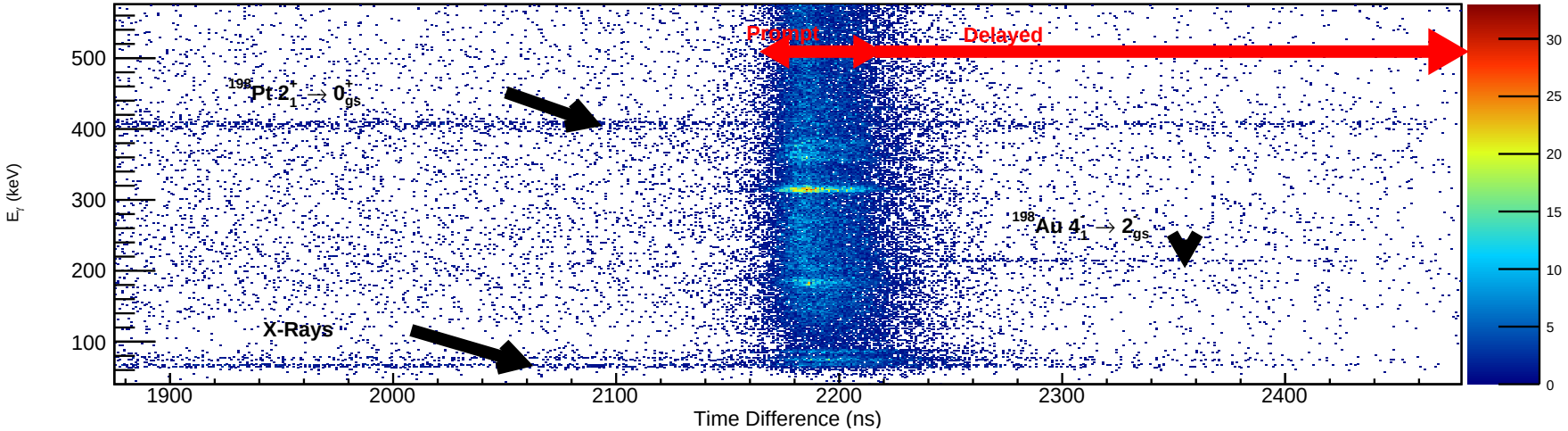
Delayed Gamma Ray Spectroscopy

- No collimators and BGOs for AGATA ⇒ higher sensitivity for gamma rays emitted from stopped ions out of target position.
- Careful time alignment of all 555 channels
- Tagging of isomer by binary partner



J.C. Cunnane and P.J.Daly, Phys. Rev. C6 (1972) 1407.

Example: Gate on ^{82}As *(binary partner ^{198}Au)*



Conclusions and Outlook

- A multi-nucleon transfer reaction was used to populate medium-to-high spin states in the neutron-rich nuclei around $A = 190$.
- Reconstructing the velocity vector for the undetected heavier target-like fragment provides a good Doppler correction ($\approx 1\%$).
- A cut on the reconstructed Q-value reduces contribution in the spectra due to nuclei produced by neutron evaporation.
- This experiment provides for the first time spectroscopic information on ^{196}Os and will help to elucidate the shape evolution in the neutron-rich Os nuclei
- Data analysis still in progress. Especially $\gamma - \gamma$ (prompt - delayed).
- Additional Experiment at VAMOS and Exogam (April 2012).

Thank you for your attention