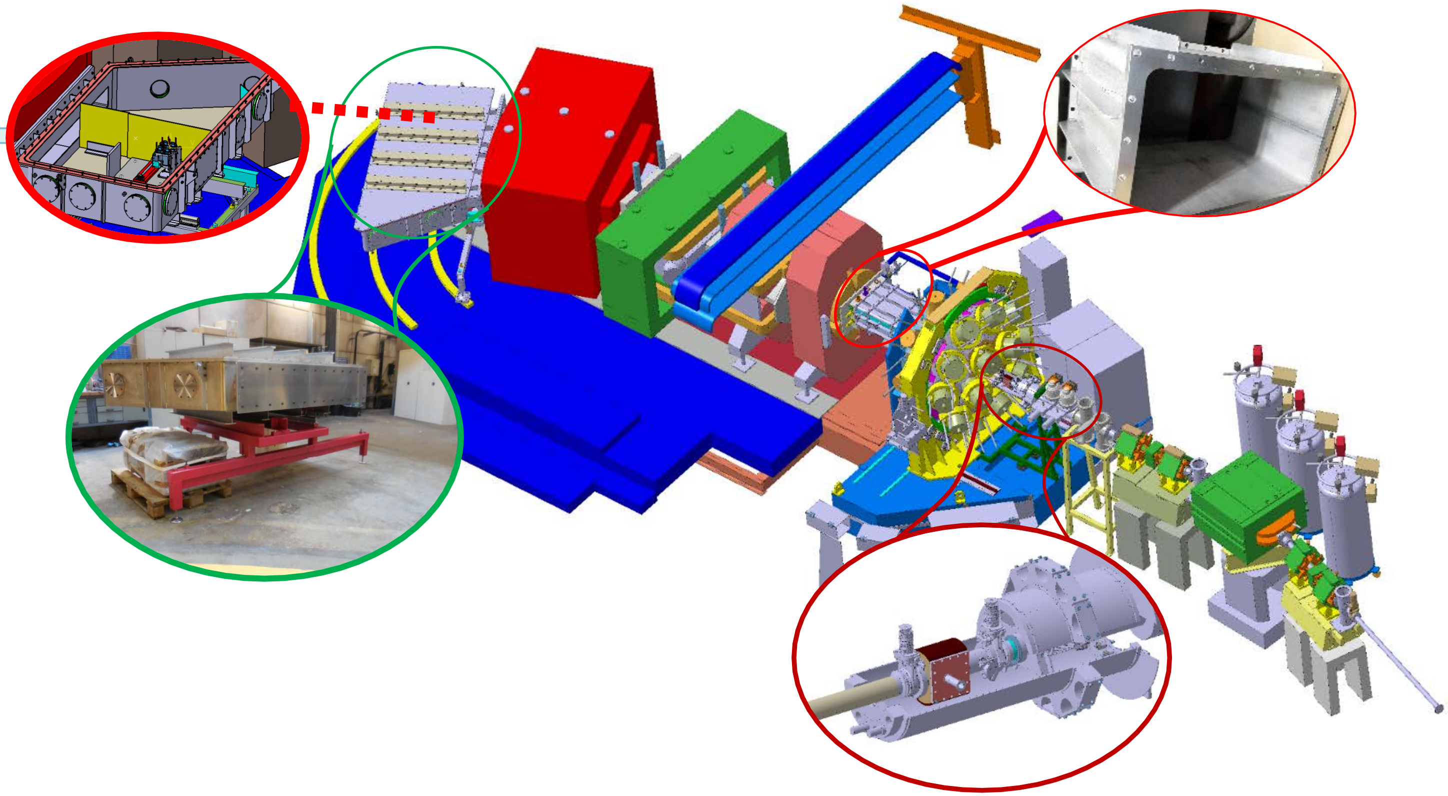


The VAMOS Gas-Filled Mode

Ch.T for the VAMOS-GFS Collaboration

CEA IRFU SPhN/SIS/SEDI

GANIL

AGATA Collaboration meeting, VENICE, June 30th-July 1st

Objectives of the VAMOS Gas-Filled mode

- Study of exotic nuclei using high resolution spectroscopy (AGATA) and fusion-evaporation reactions
  - Low cross sections (few nb to μb)
  - Channel of interest lost in a huge background (fission, other F-E channels, etc).

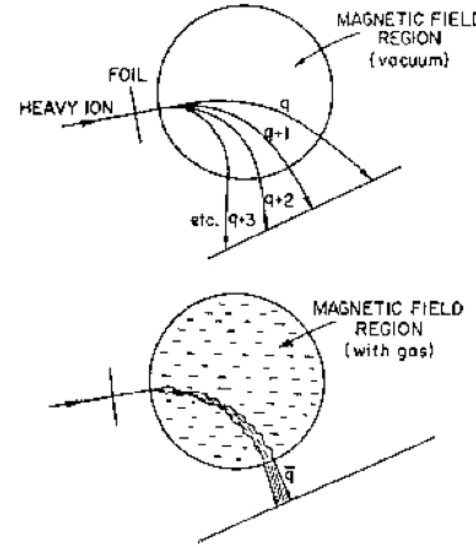
→ Need to tag the nuclei of interest
  - Physical separation using a zero degree separator / spectrometer
  - Recoil Tagging technique (kinematic conditions using focal-plane detectors)
  - Recoil Decay Tagging : kinematic condition + characteristic decay (alpha, fission).

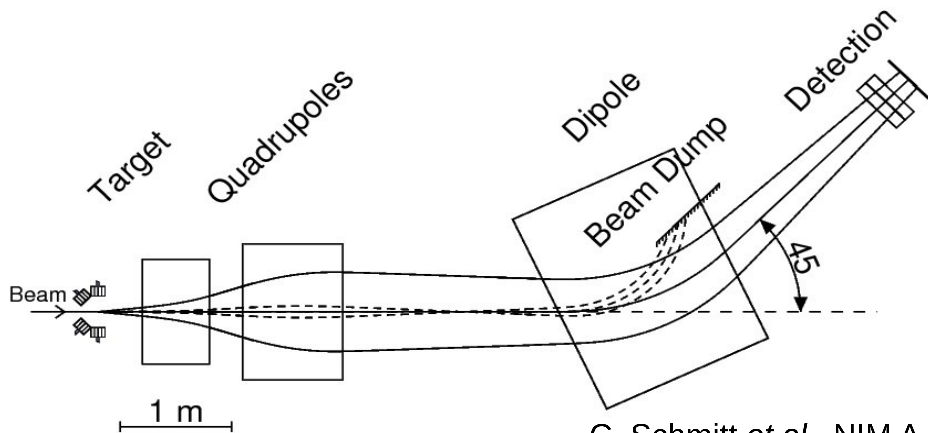
→ upgrade of the VAMOS vacuum spectrometer as a gas-filled separator

- No other place foreseen for the coupling of AGATA with a zero degree separator
- Longer term : EXOGAM2, PARIS, radioactive Spiral2 Phase2 beams, etc.

VAMOS-GFS test 2009

^{40}Ca (196MeV) + ^{150}Sm → $^{190}Pb^*$ (σ_{ER} ~ 50mb)



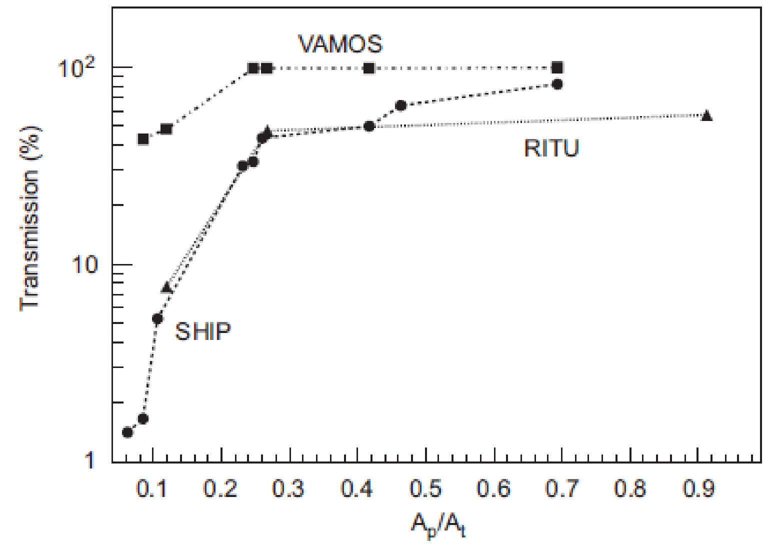


C. Schmitt *et al.*, NIM A 621 (2010) 558

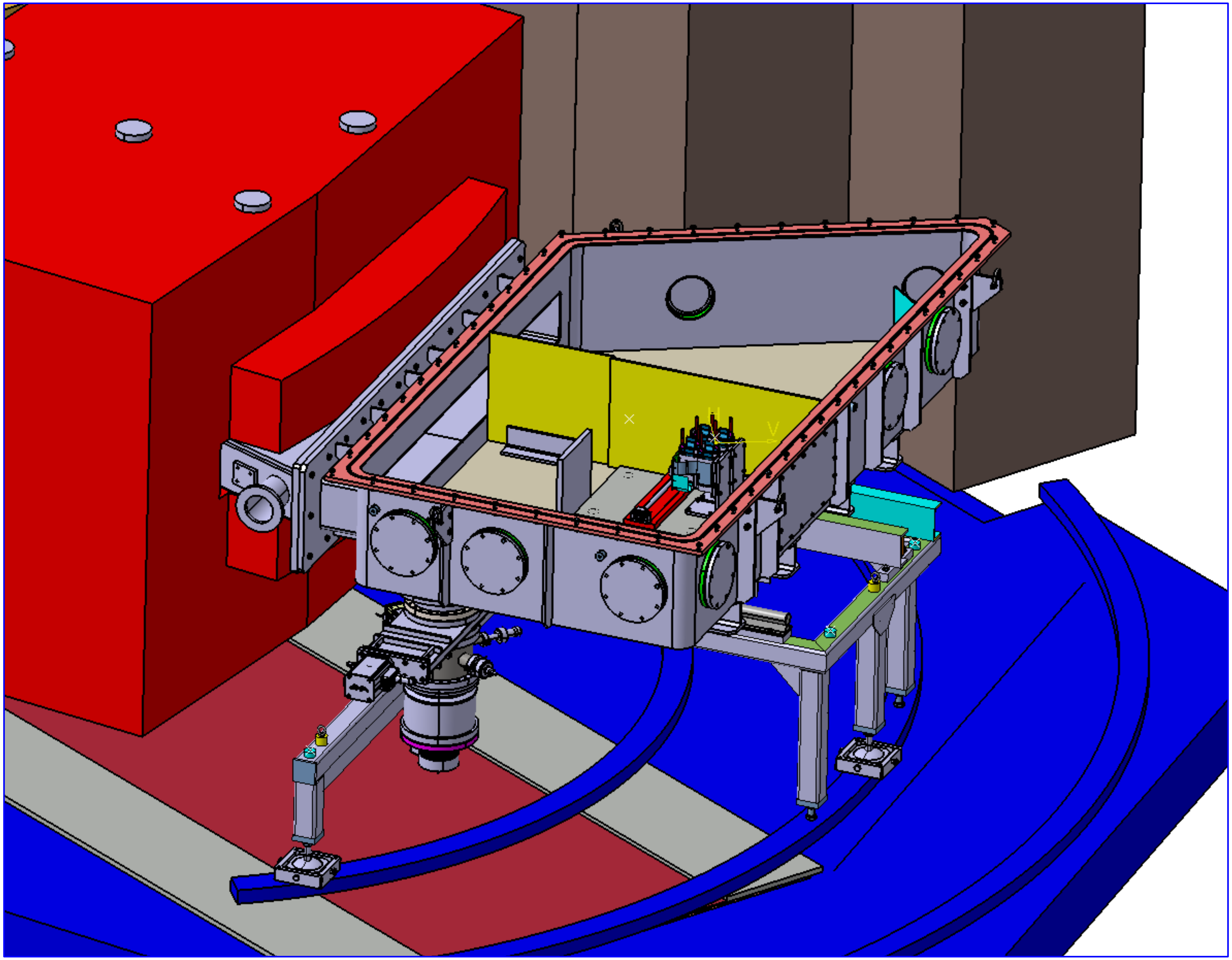
Transmission :
- 95 % for *xn* channels
- 80% for α, p channels

Rejection > 10^{10}

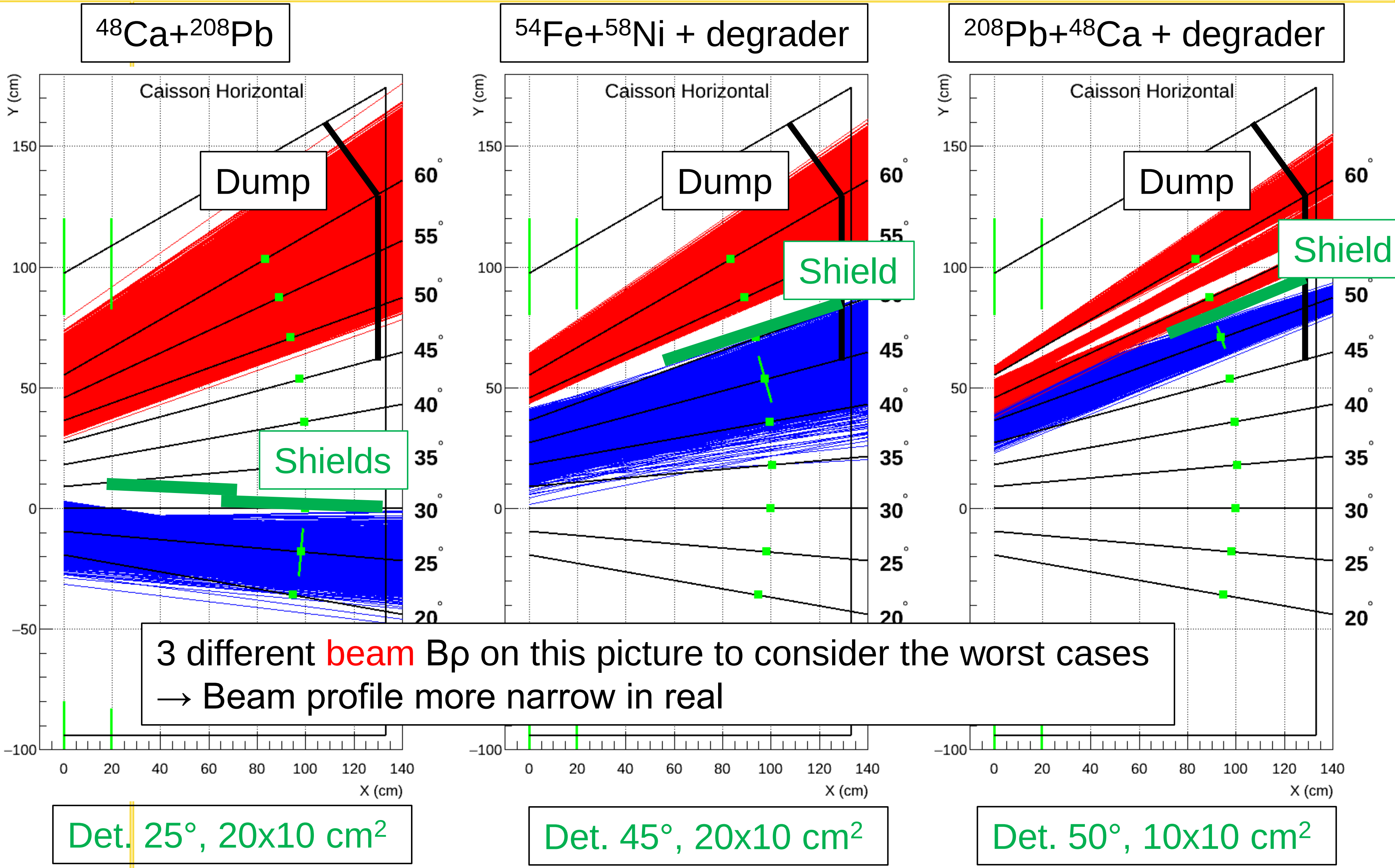
- Up to Bρ = 2.1 - 2 .2 Tm if VAMOS pushed back



Focal plane chamber

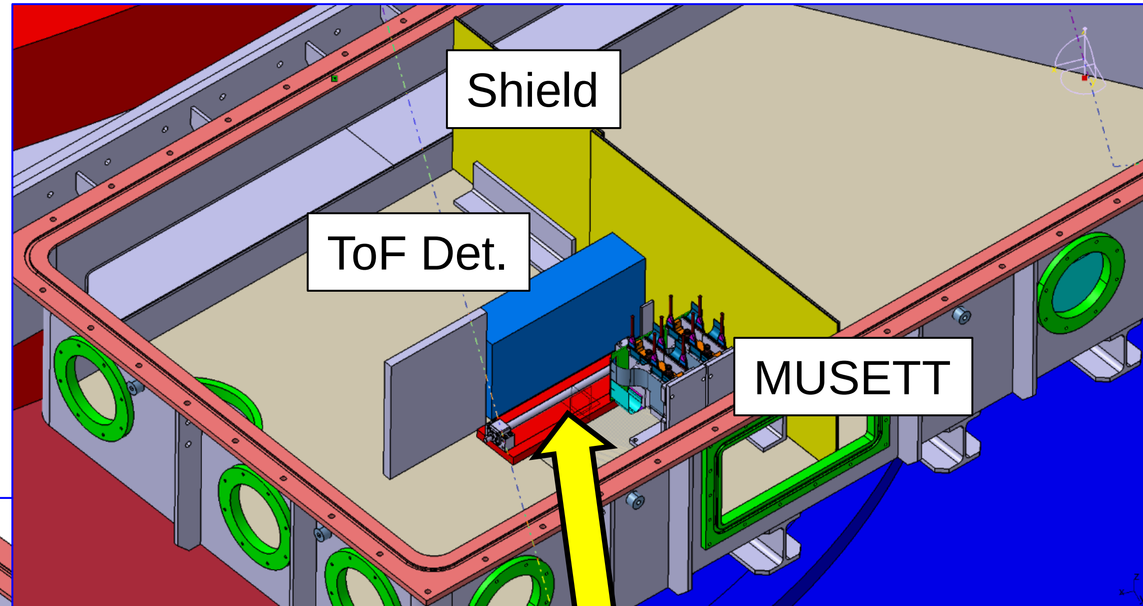


VAMOS-GFS : a versatile device



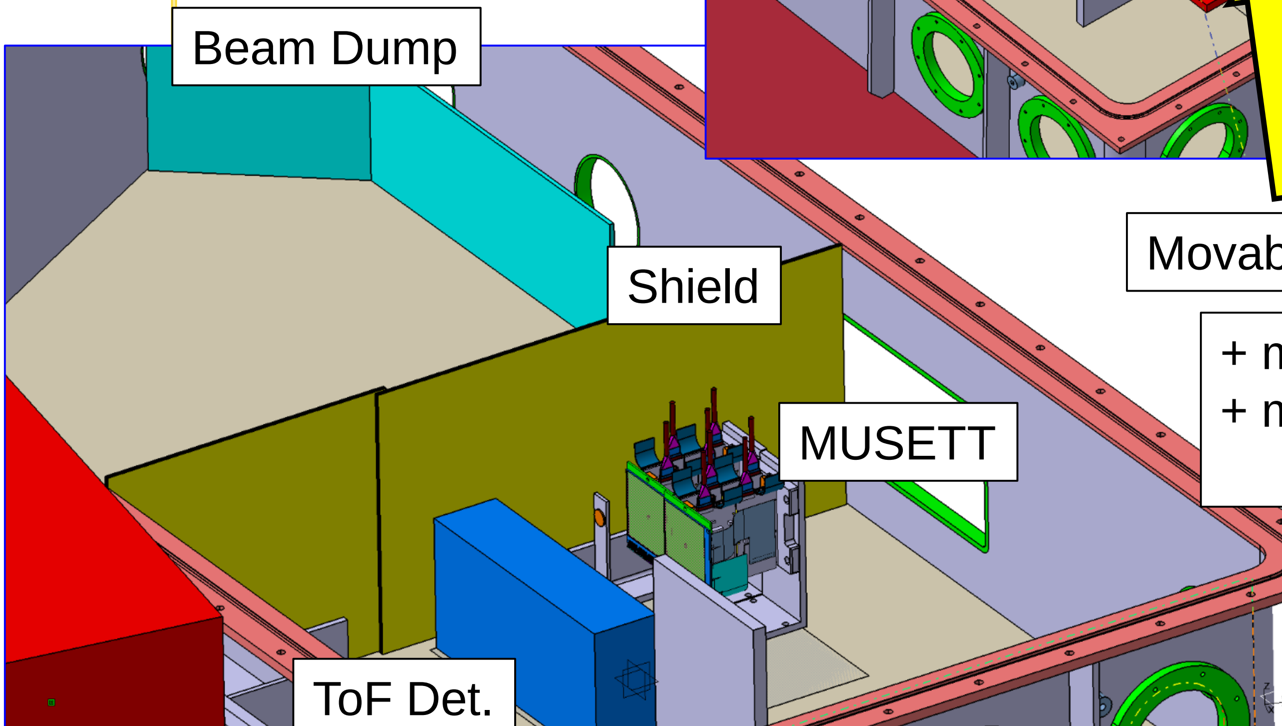
3 different beam Bρ on this picture to consider the worst cases
→ Beam profile more narrow in real

Equipment (30° case)



Movable α source

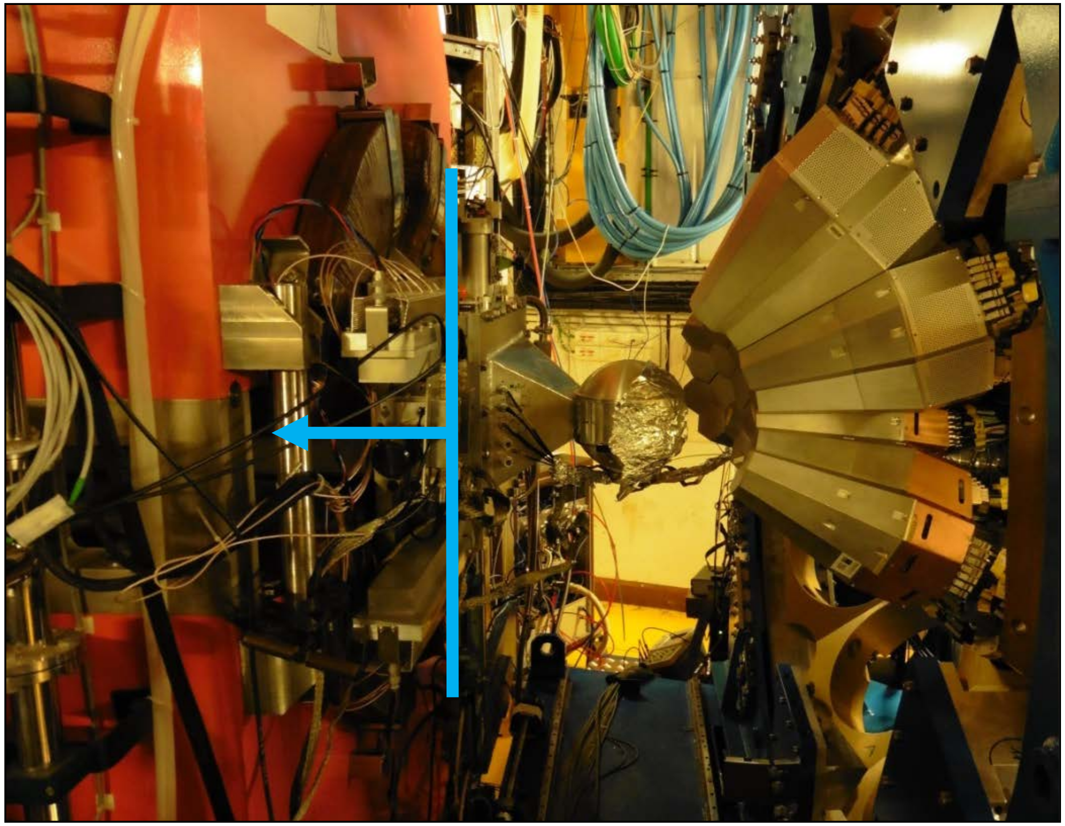
+ movable mask after dipole
+ movable mask in front gas-detector

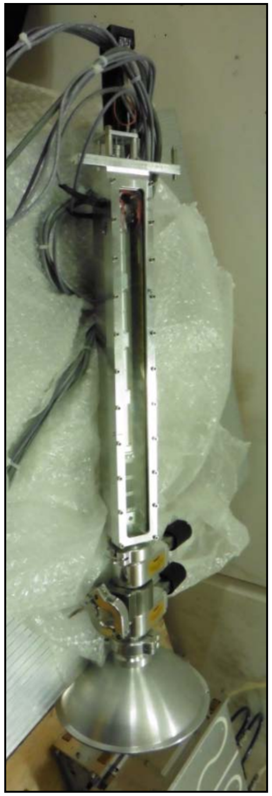


Caisson

Target Chamber

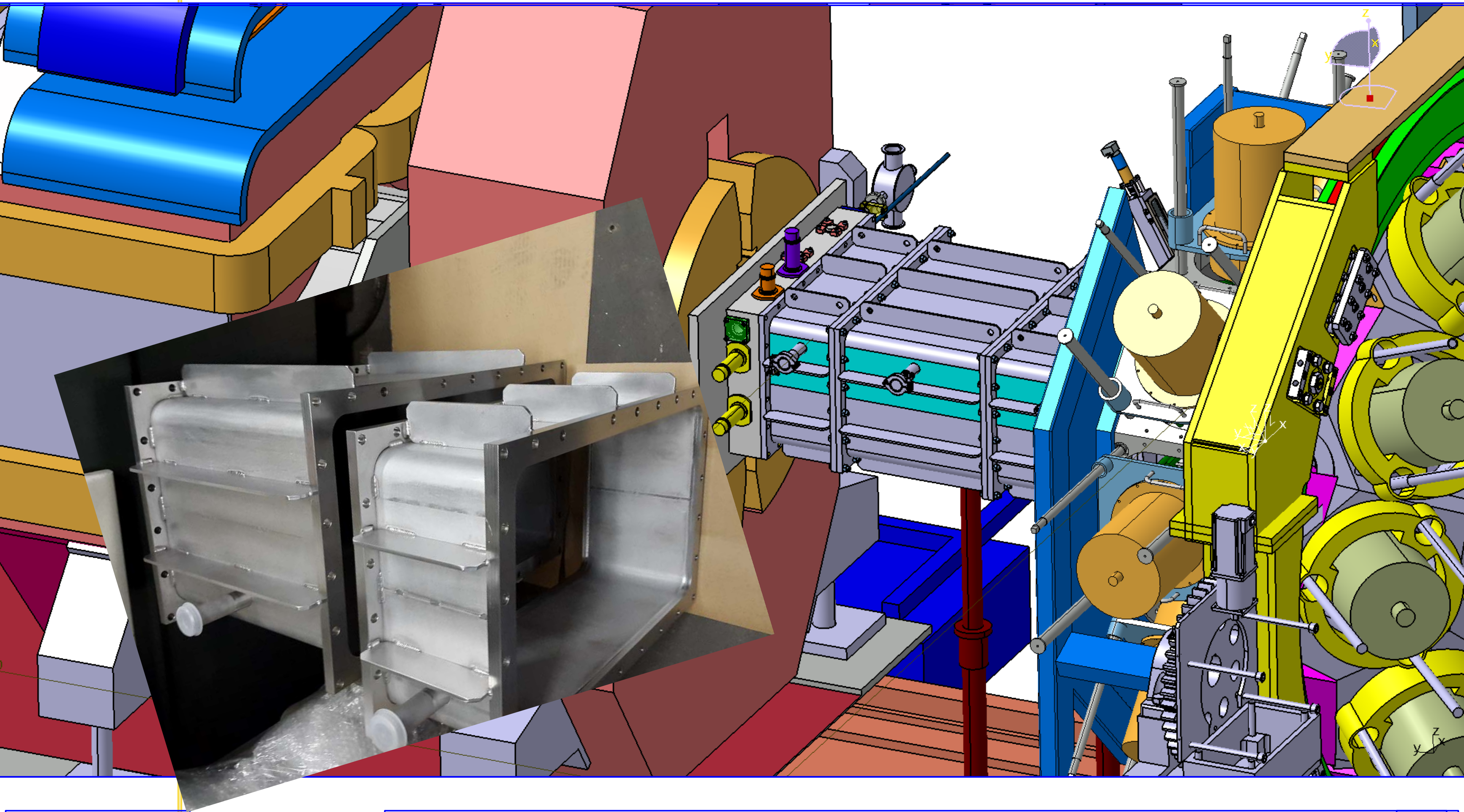
- → AGATA
- → Need adaptation to push VAMOS back 20-100 cm to fit with highest Bρ (Q2 current limitation; also helps to reduce beam scattering).





Extensions

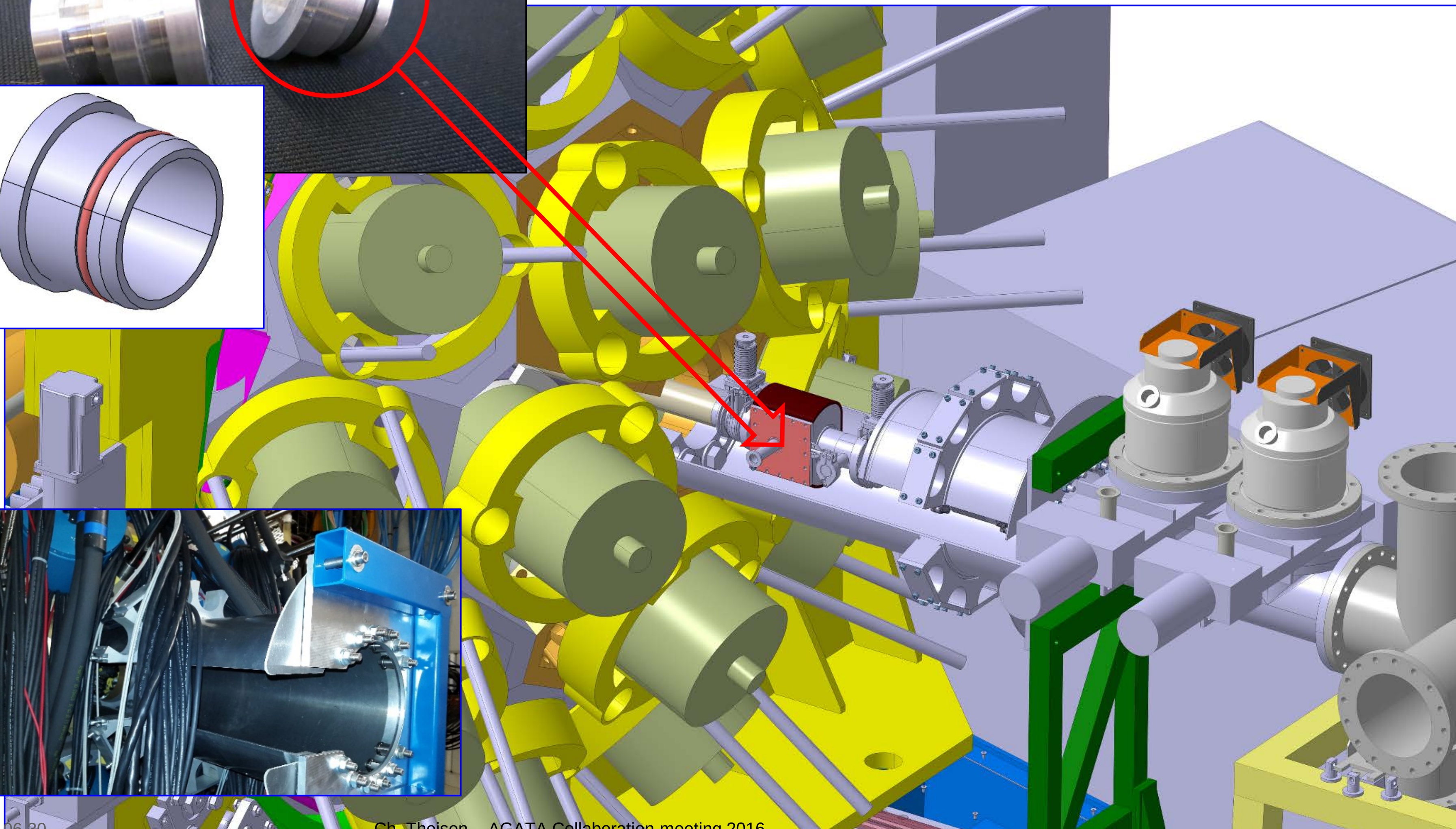
1000 mm



C Window

JYFL C foils frames

Inspired from 2009 test & RITU@JYFL
Design almost finished



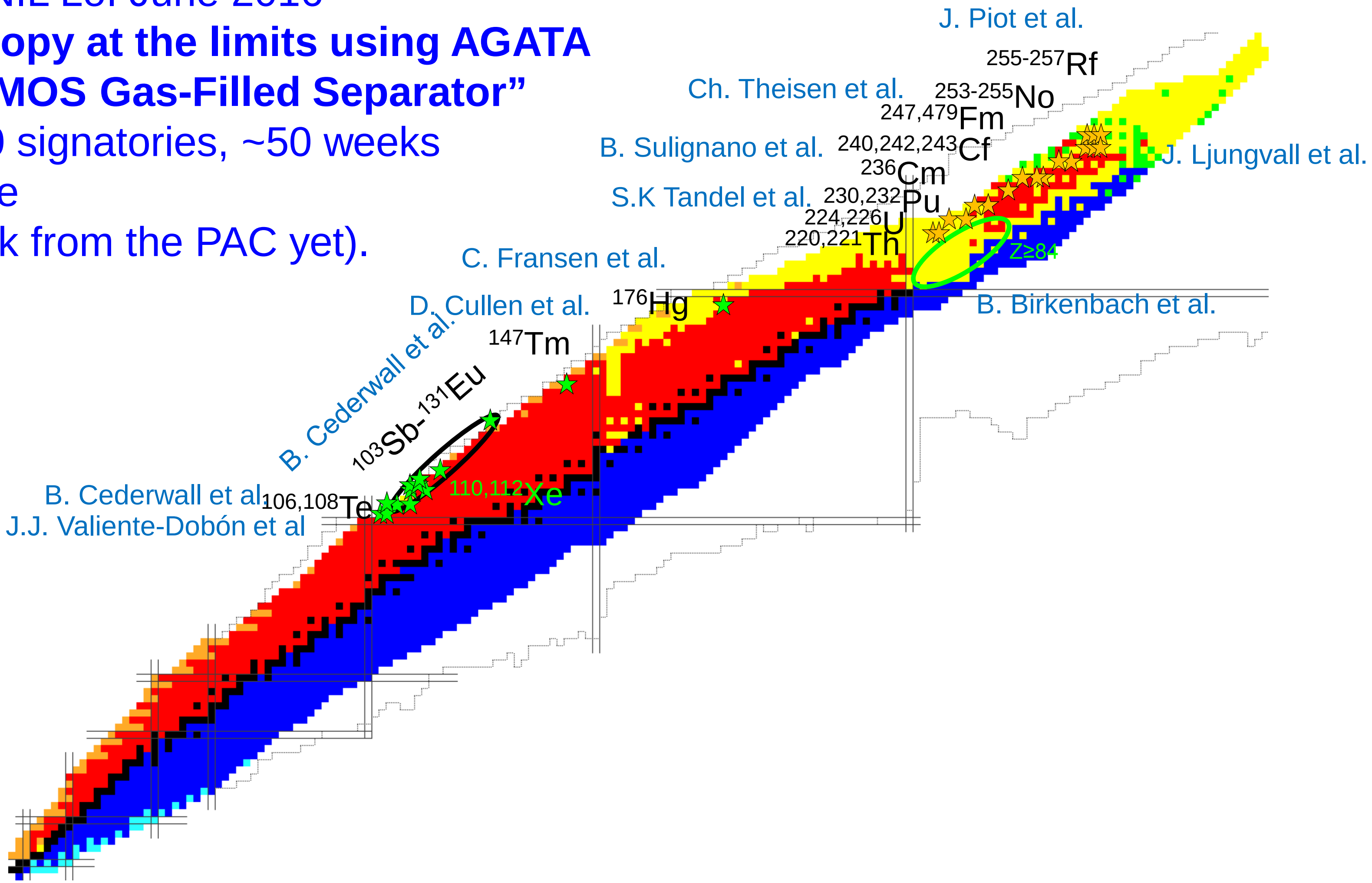
Physics case

- AGATA LoI 2013
- AGATA LoI 2016
- PAC GANIL LoI June 2016

“Spectroscopy at the limits using AGATA and the VAMOS Gas-Filled Separator”

31 labs, 180 signatories, ~50 weeks of beam time

(no feedback from the PAC yet).



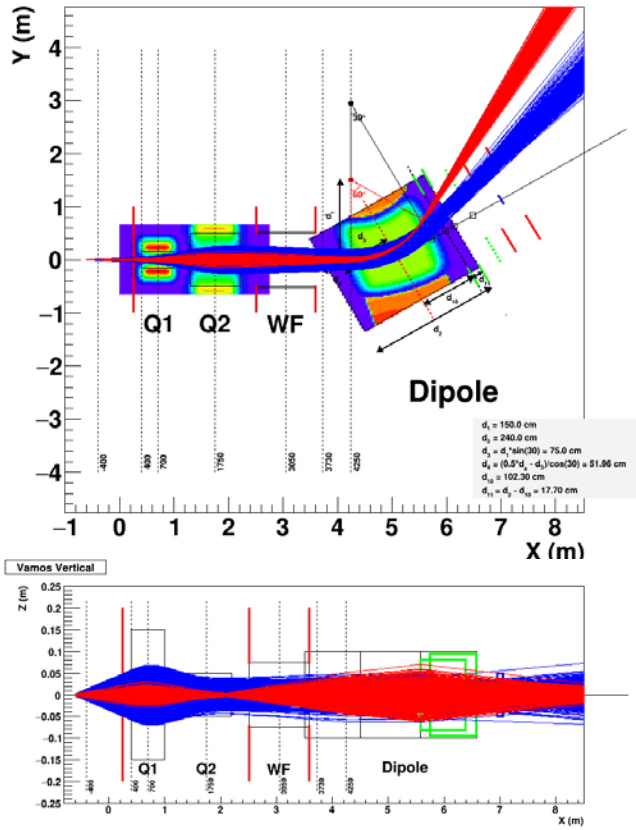
^{100}Sn region

- J.J. Valiente-Dobón, E. Clément, A. Gadea *et al.*

  Spectroscopy of neutron-deficient N~Z nuclei around ^{100}Sn

- B. Cederwall, T. Bäck *et al.*

  Lifetime measurements of excited states in Te and Xe isotopes near the N=Z line.



^{54}Fe+^{58}Ni $\rightarrow$ ^{110}Xe + 2n with degrader

Target =
1 mg/cm^2 ^{58}Ni
Degrader =
1 mg/cm^2 Mg

Detection 45°
Vamos -60 cm
Foc recoils at 9m

Transmission
2n channel : 72 %
4p channel : 57 %
α2p channel : 29 %

Proton dripline, Hg, Th

- B. Cederwall *et al.*

  Recoil-decay tagging spectroscopy along the proton dripline above ^{100}Sn; from Sb to Eu.

  ^{103,104}Sb, ^{105,106}Te, ^{110}Xe, ^{111,112}Cs, ^{113}Ba, ^{117}La, ^{130,131}Eu

- D.M. Cullen, B.S. Nara Singh *et al.*

  Lifetime measurements to determine the deformation of proton-emitting nuclei.

  ^{92}Mo(^{58}Ni, 1p2n)^{147}Tm + degrader

- Ch. Fransen *et al.*

  Shape coexistence in neutron deficient ^{176}Hg: First measurement of E2 transition strengths in the yrast band.

  ^{56}Fe(^{124}Xe,4n)^{176}Hg + Mg degrader

- S.K. Tandel *et al.*

  Evolution of octupole and quadrupole collectivity in Th isotopes.

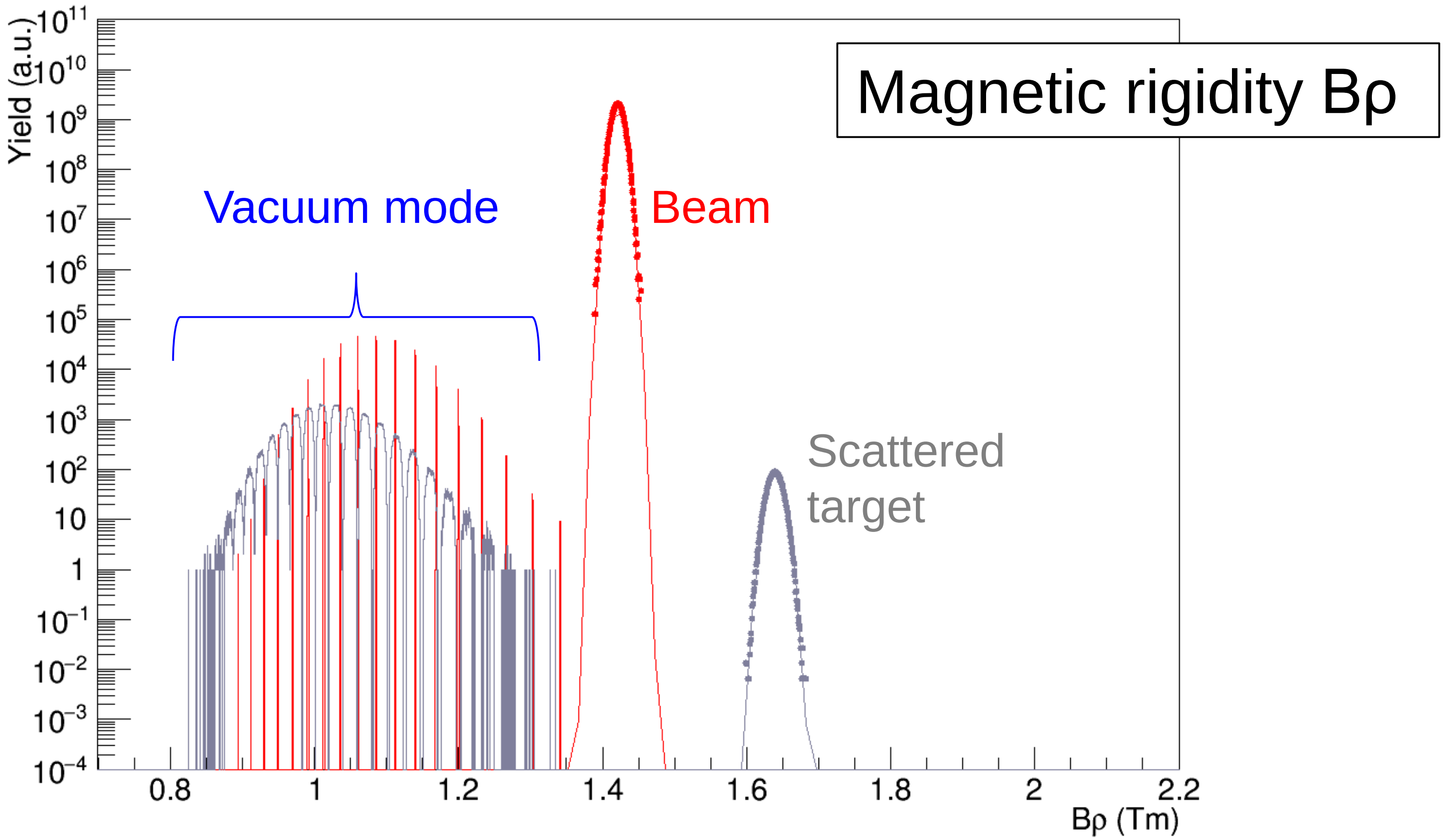
  ^{176}Yb(^{48}Ca,3-4n)^{220,221}Th + degrader

Actinides, MNT

- B. Birkenbach *et al.*

  Prompt gamma-ray spectroscopy of heavy nuclei in the Z ≥ 84 mass region after multinucleon transfer and deep-inelastic transfer reactions.

  $^{136}Xe + ^{207}Pb \rightarrow$ MNT at 0 degree (target like)



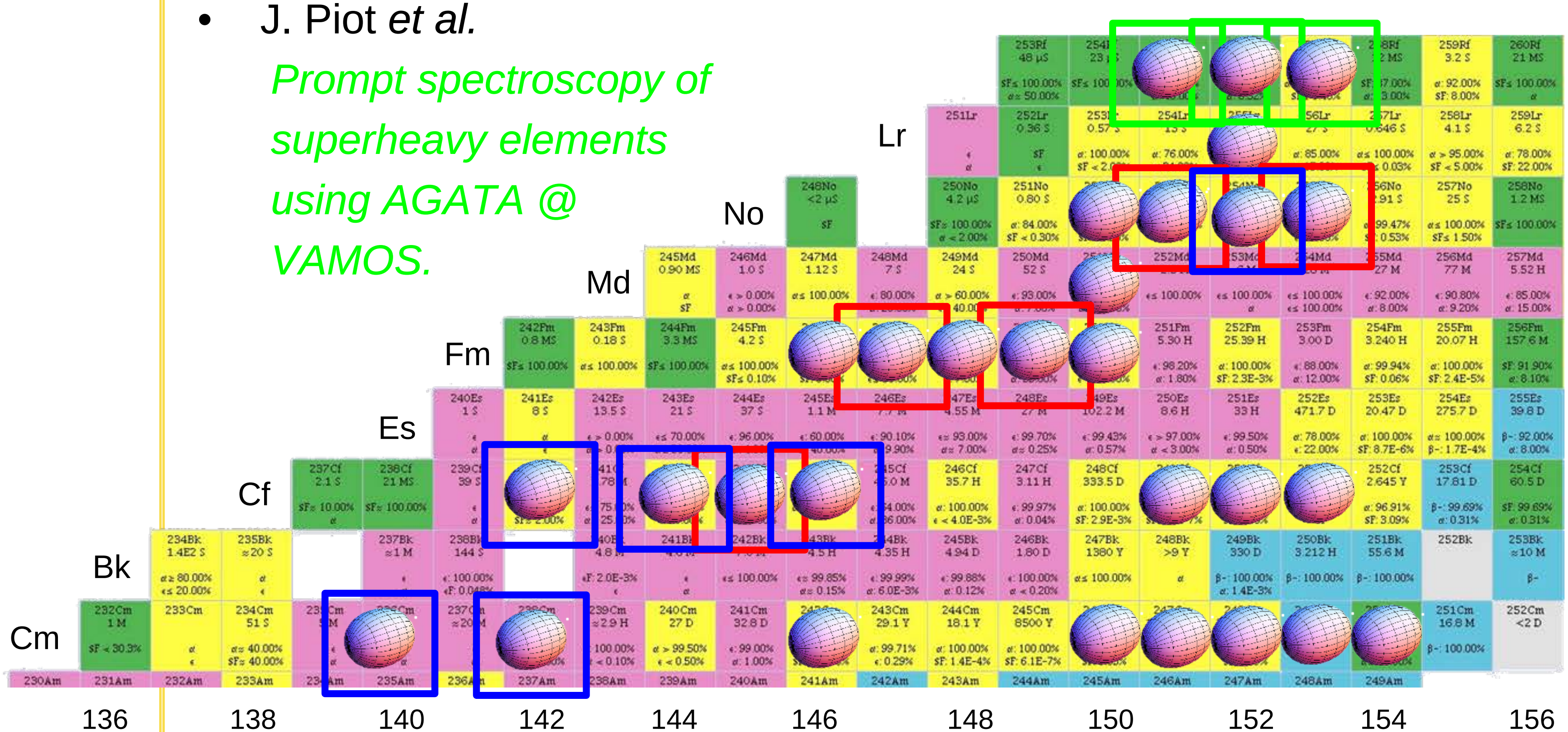
VHE/SHE

- B. Sulignano *et al.*

  K-isomers in even-even actinide nuclei.
- Ch. Theisen *et al.*

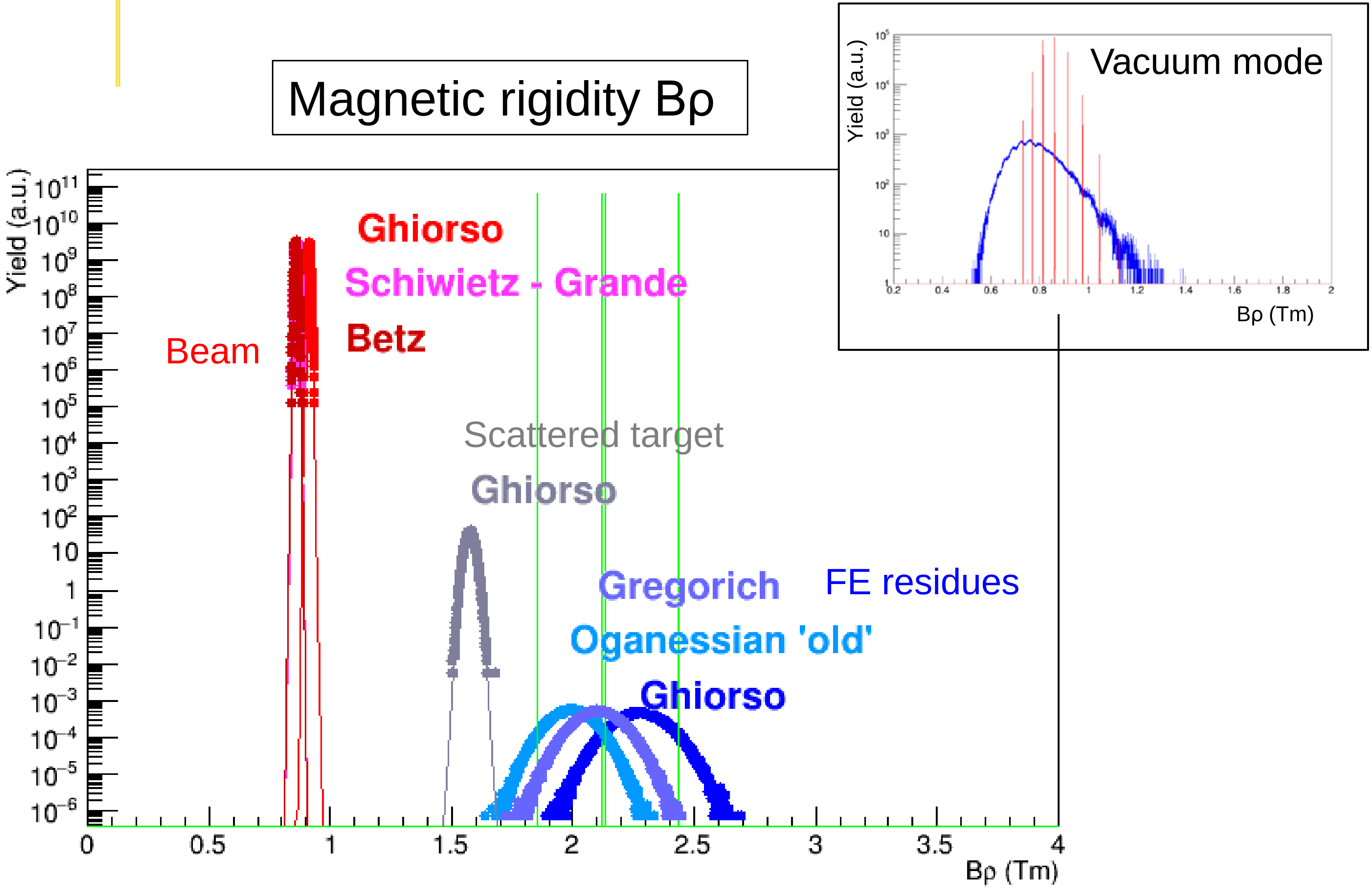
  Spectroscopy of the heaviest odd actinides.
- J. Piot *et al.*

  Prompt spectroscopy of superheavy elements using AGATA @ VAMOS.

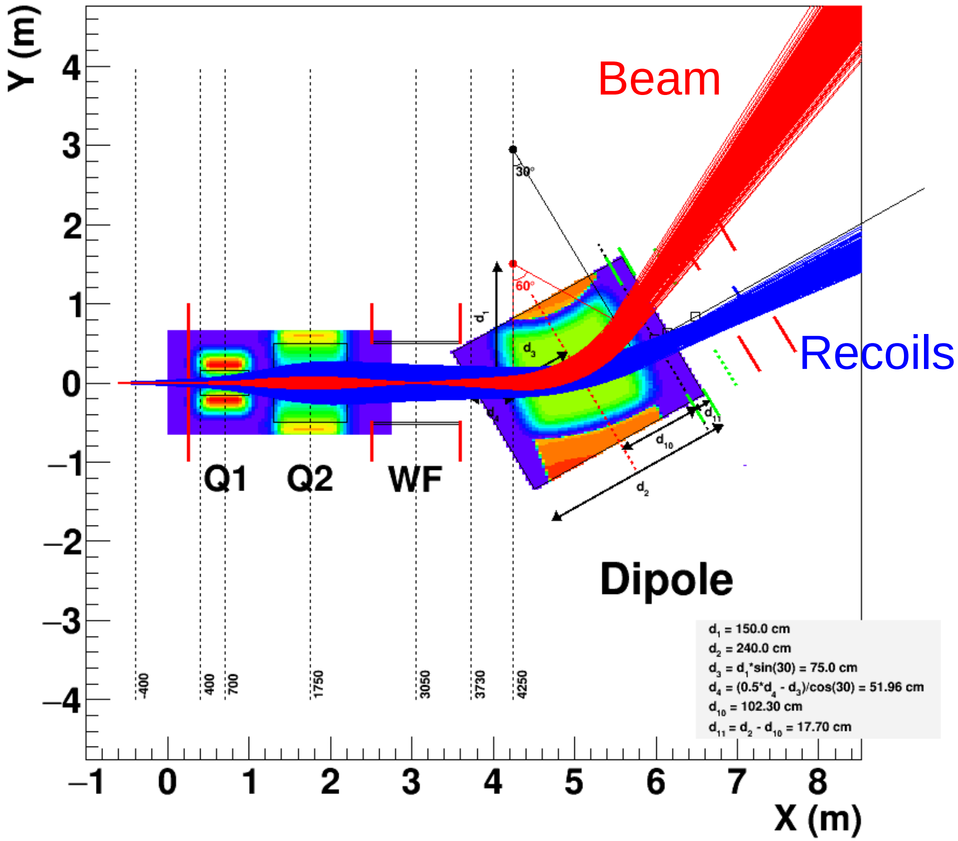


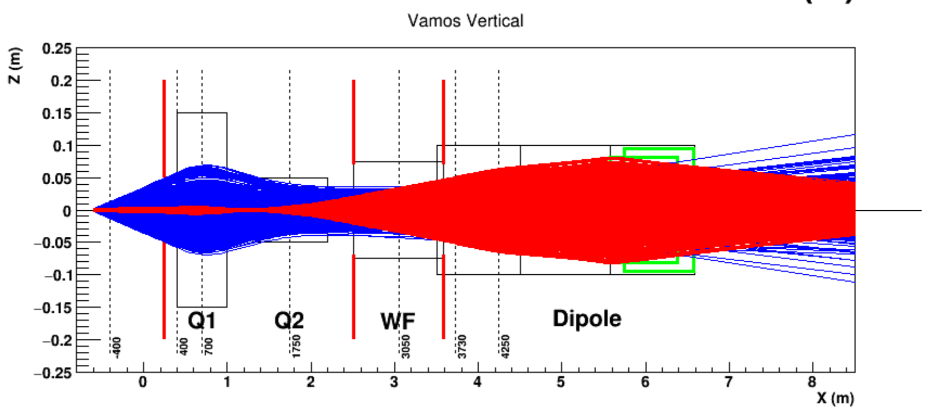
$^{224,226}U + ^{228,230,232}Pu$

$^{48}Ca + ^{208}Pb \rightarrow ^{254}No + 2n$



$^{48}Ca + ^{208}Pb \rightarrow ^{254}No + 2n$





Detection 25°
Vamos -60 cm
Foc recoils at 9m

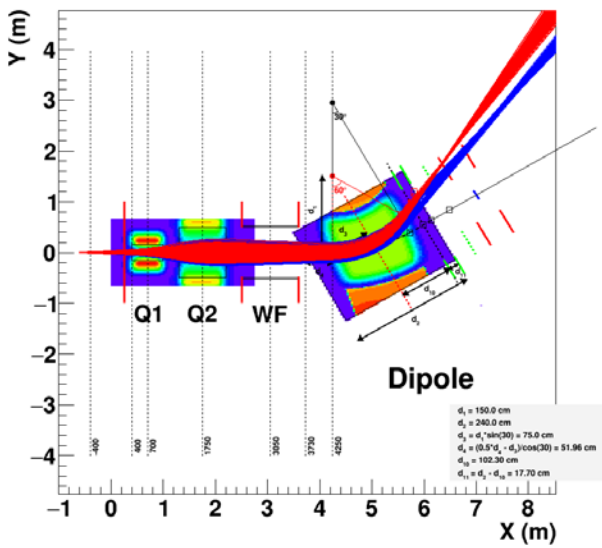
Transmission
recoils : > 60 %

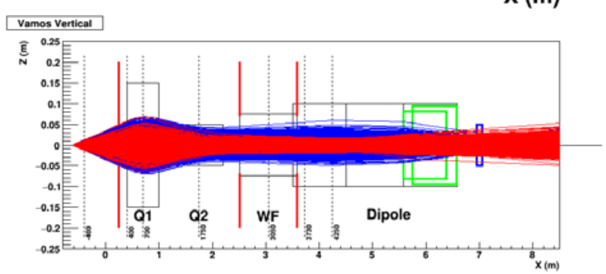
^{254}No lifetimes

- J. Ljungvall *et al.*

  Lifetime measurements of excited states in the ground state band in ^{254}No using the AGATA, VAMOS gas-filled setup and the focal plane MUSETT.

^{208}Pb + ^{48}Ca $\rightarrow$ ^{254}No + 2n with degrader





Target =
2 mg/cm^2 ^{197}Au
0.5 mg/cm^2 ^{48}Ca +
0.5 mg/cm^2 ^{197}Au +
Degrader = 5 mg/cm^2 Au
(Mg is better)

Detection 50°
Vamos -60 cm
Foc recoils at 9m

Transmission recoils ~80 %

Summary

- VAMOS-GFS principle established in 2009
- Design constrained by detailed simulations
  - Mechanics : caisson and extensions ready
  - Design upstream beam line with C window almost finished
  - Detection existing or being designed
- We should be ready in 2017
- Great opportunities from ^{100}Sn to SHE regions
- Ganil PAC 2016 : LoI being evaluated
- Campaign vs other devices ?
- Competition with GAMMASPHERE+ AGFA @ ANL

VAMOS-GFS Team

MECHANICS: P. Girardot, A. Raut, Ph. Daniel-Thomas, P.Gangnant, P. Contrepois, P. Graffin et al.

MUSETT : E. Monmarthe, B. Sulignano et al.

MUSETT EDAQ : C. Houarner, L. Legeard, C. Maugeais, F.Saillant et al.

GAS Detector : G. Frémont et al.

VAMOS : J. Goupil, A. Lemasson et al.

AGATA : E. Clément, L. Menager, J. Ropert, et al.

SIMULATIONS & OPTICS : Ch.T, J. Saren (JYFL), B. Jacquot, Ch. Schmitt

PLC : J. Cacitti

+ JYFL RITU team for help and advices

Contacts : Ch. Theisen / Ch. Schmitt

Thank you