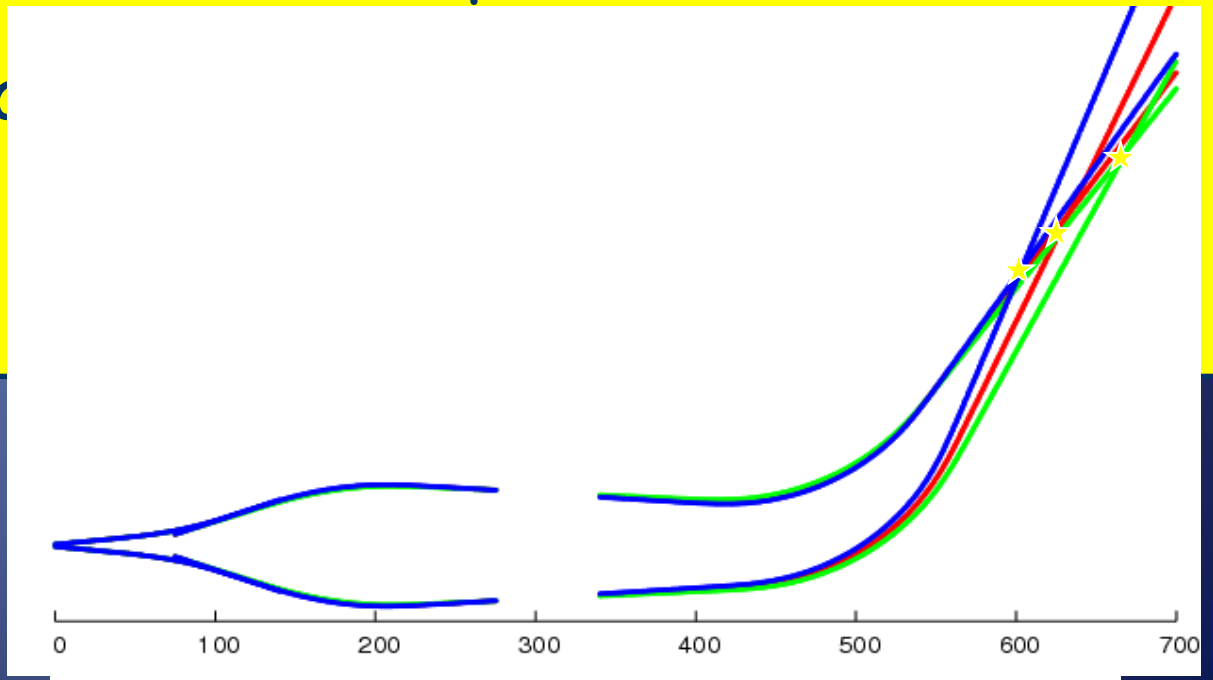
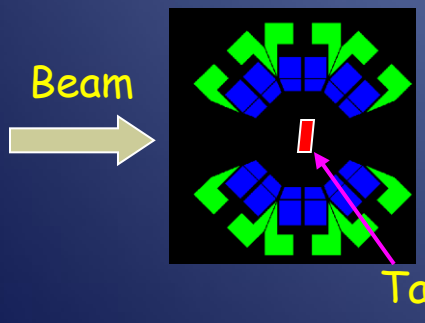
From VAMOS to VAMOS++

VARIABLE MODE SPECTROMETER

Essential for nuclear structure and reaction studies

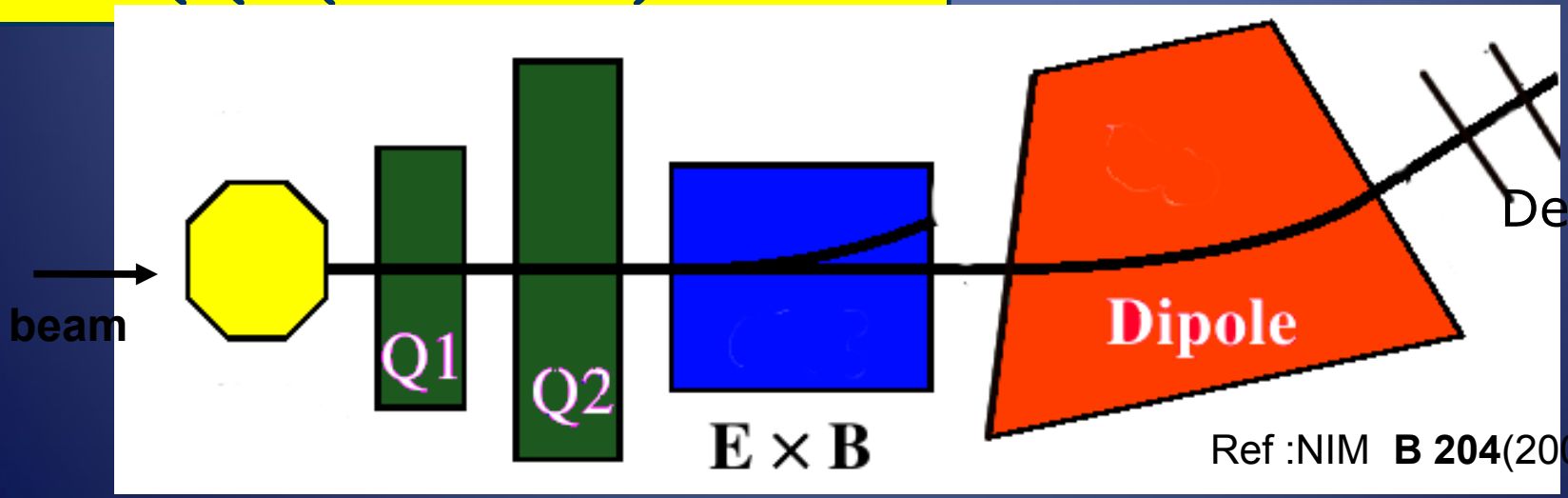
- ✓ Identification of reaction products
- ✓ Large accepta
- ✓ Coupling with MUST2 …)





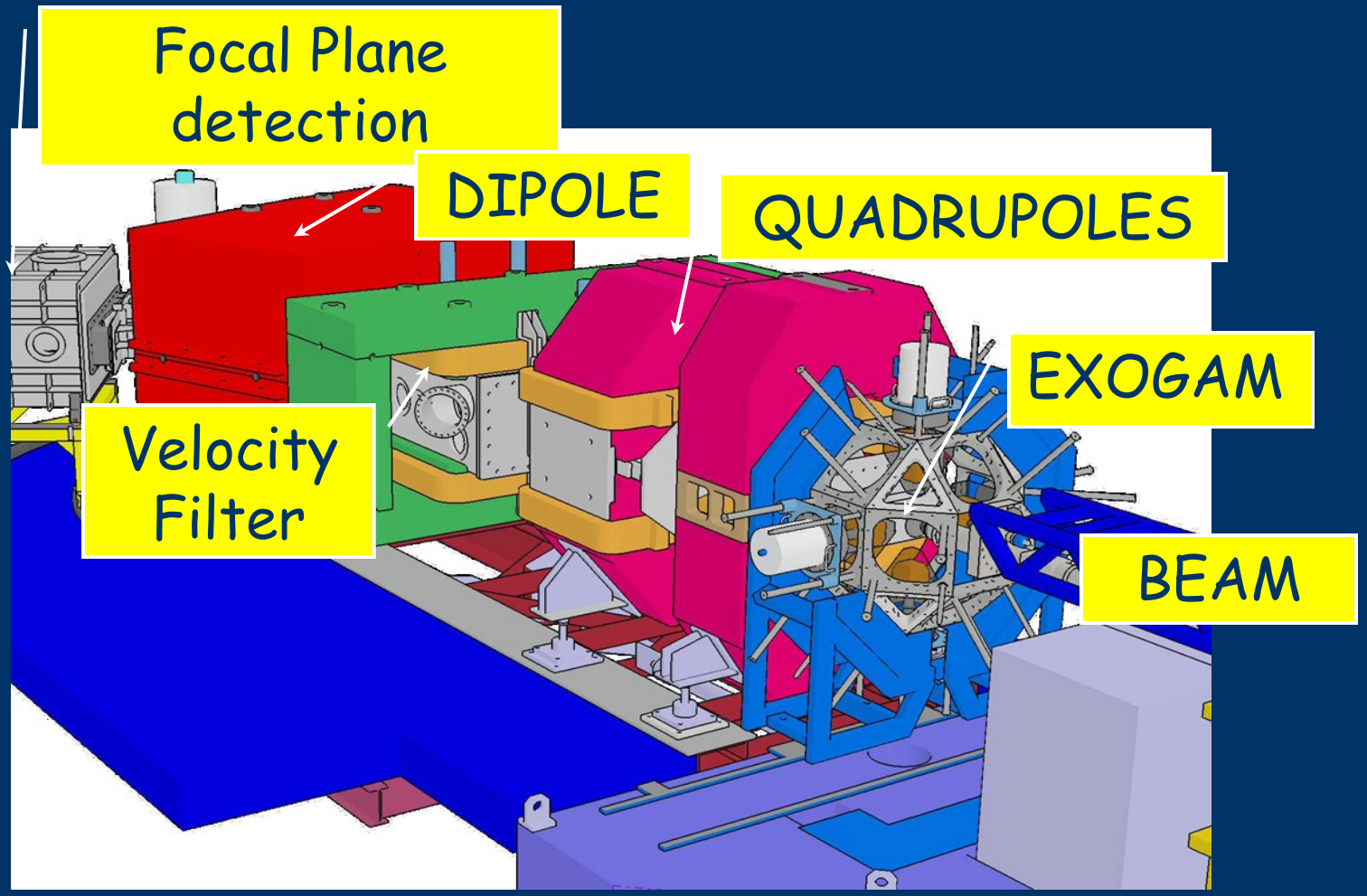
Variable Mode Operation

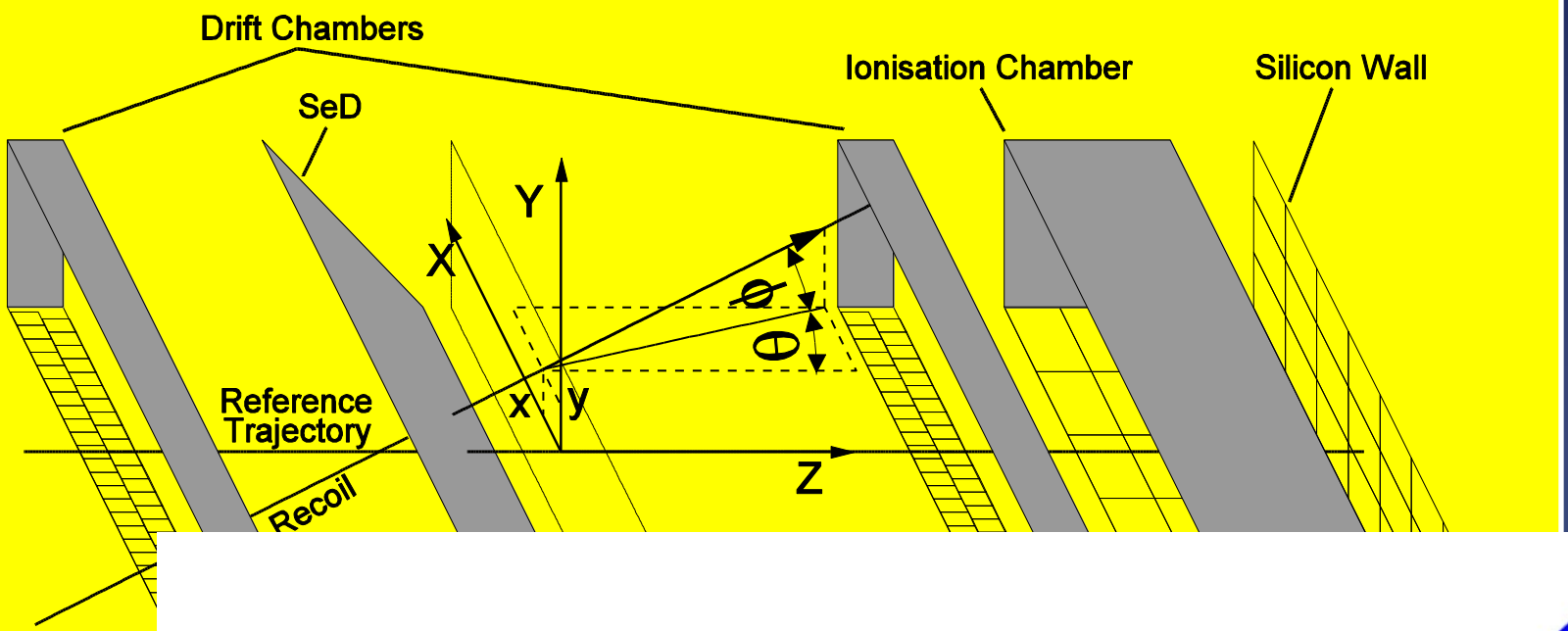
- ✓ QQ – Focusing Mode
- ✓ QQD – Spectrometer
  - ➢ Variable Dispersion
- ✓ Recoil Separator
  - ▪ QQF(D)
  - ▪ QQD (Gas filled)



Ref :NIM **B 204**(2003)146

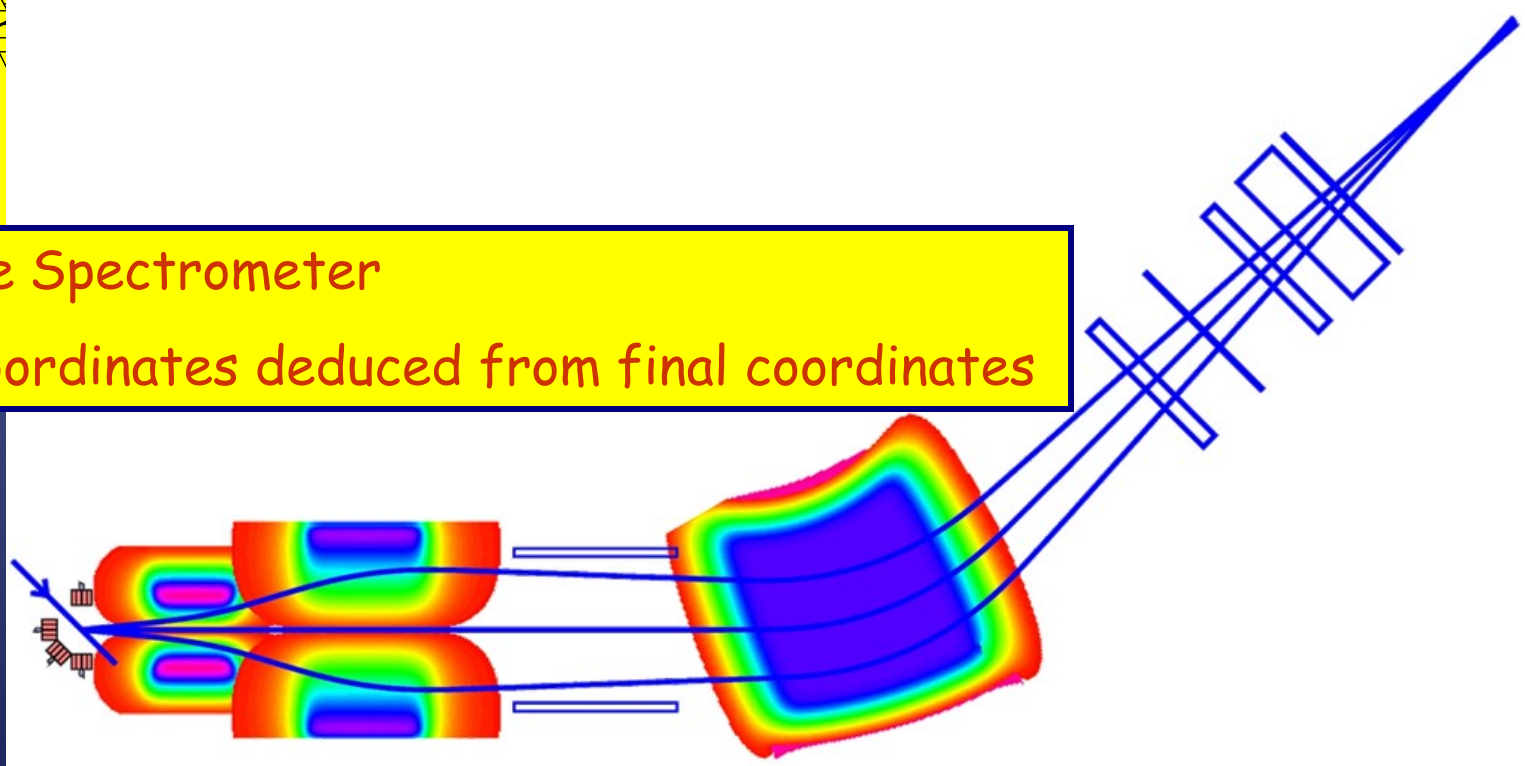
VAMOS Spectrometer Schematic View



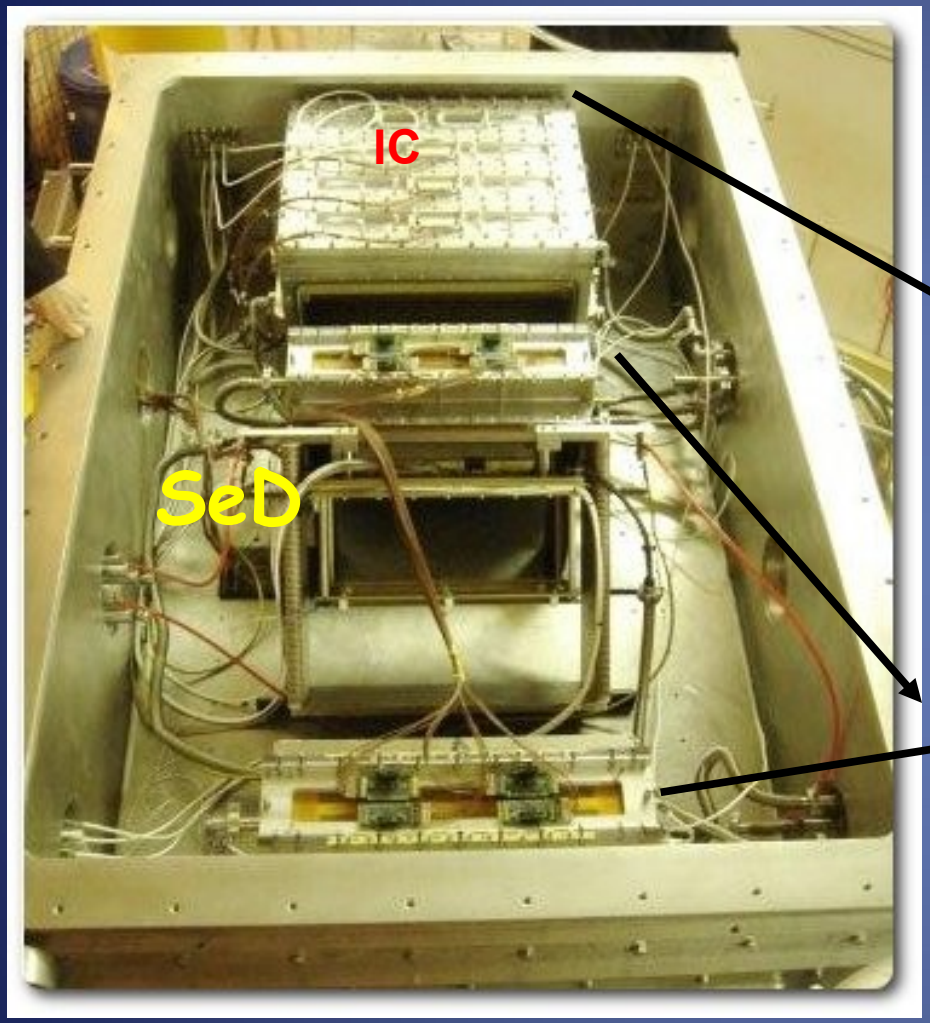


Software Spectrometer

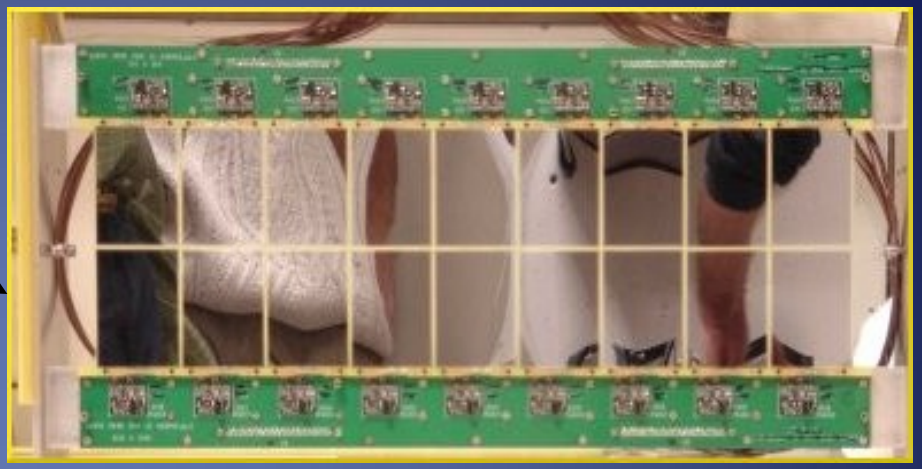
Initial coordinates deduced from final coordinates



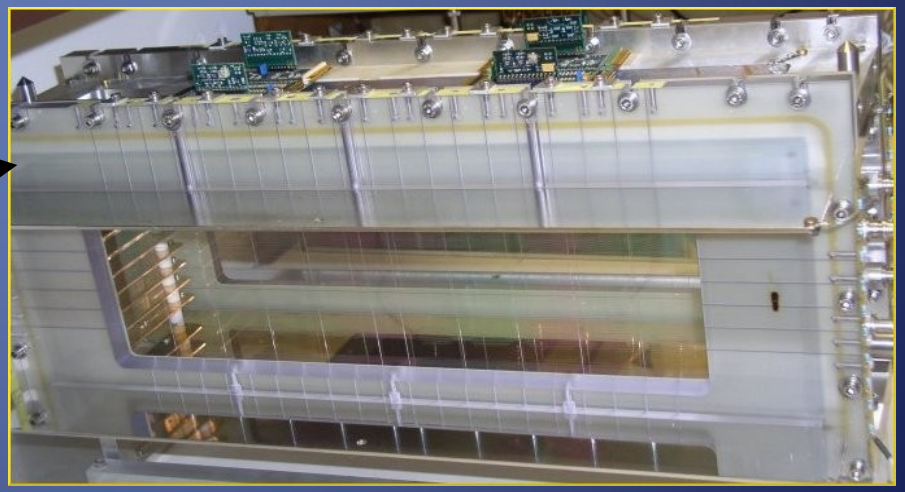
Focal Plane Setup



beam

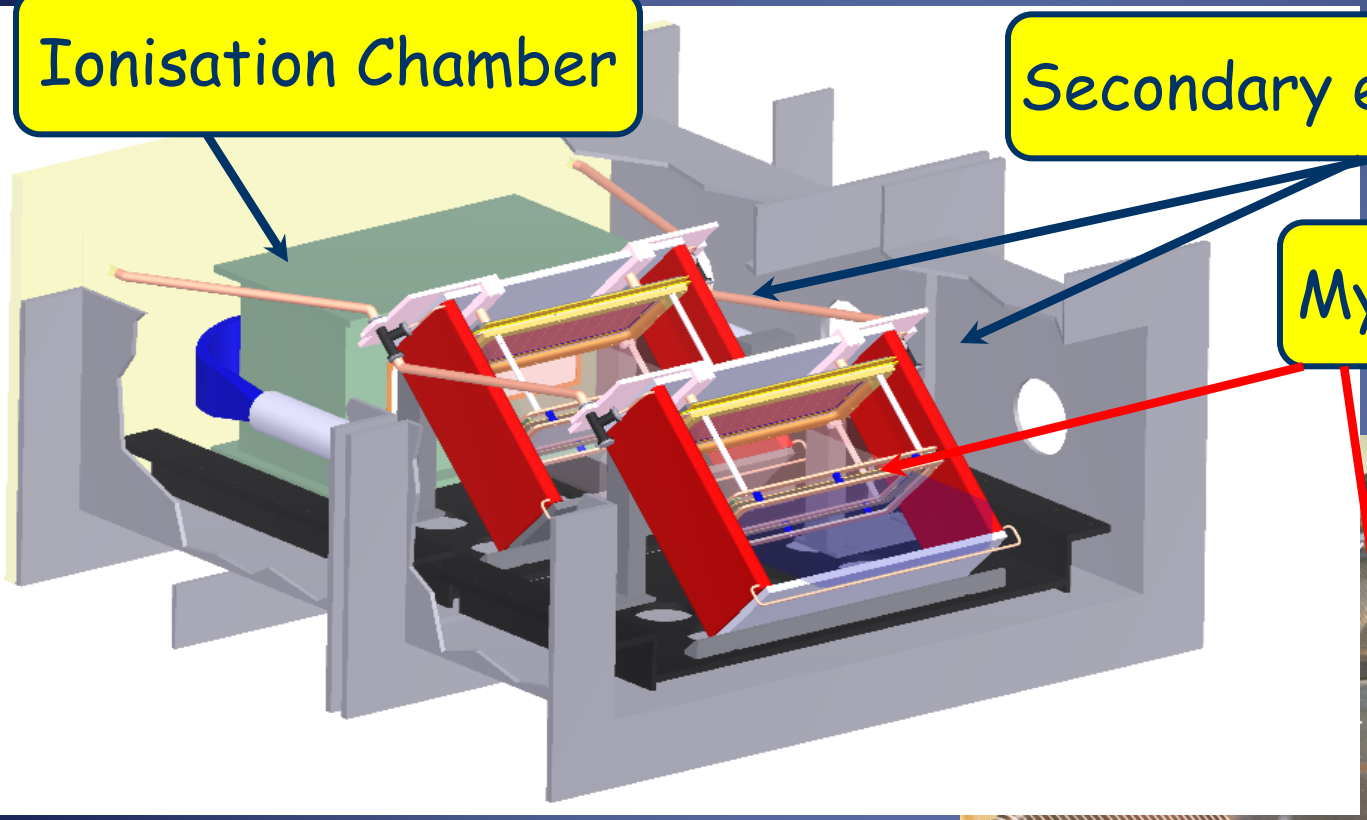


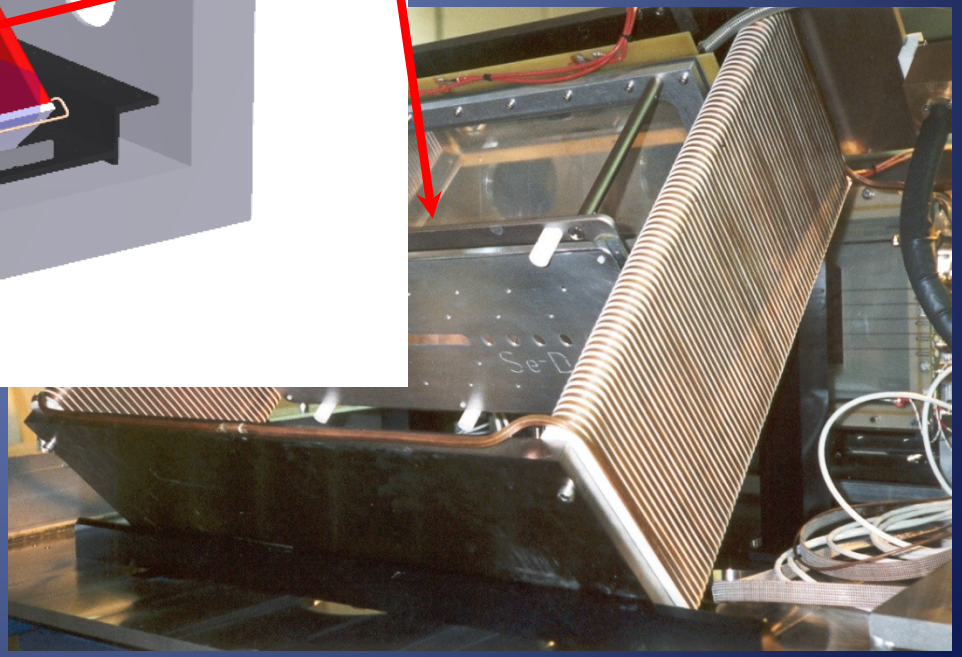
Si Wall



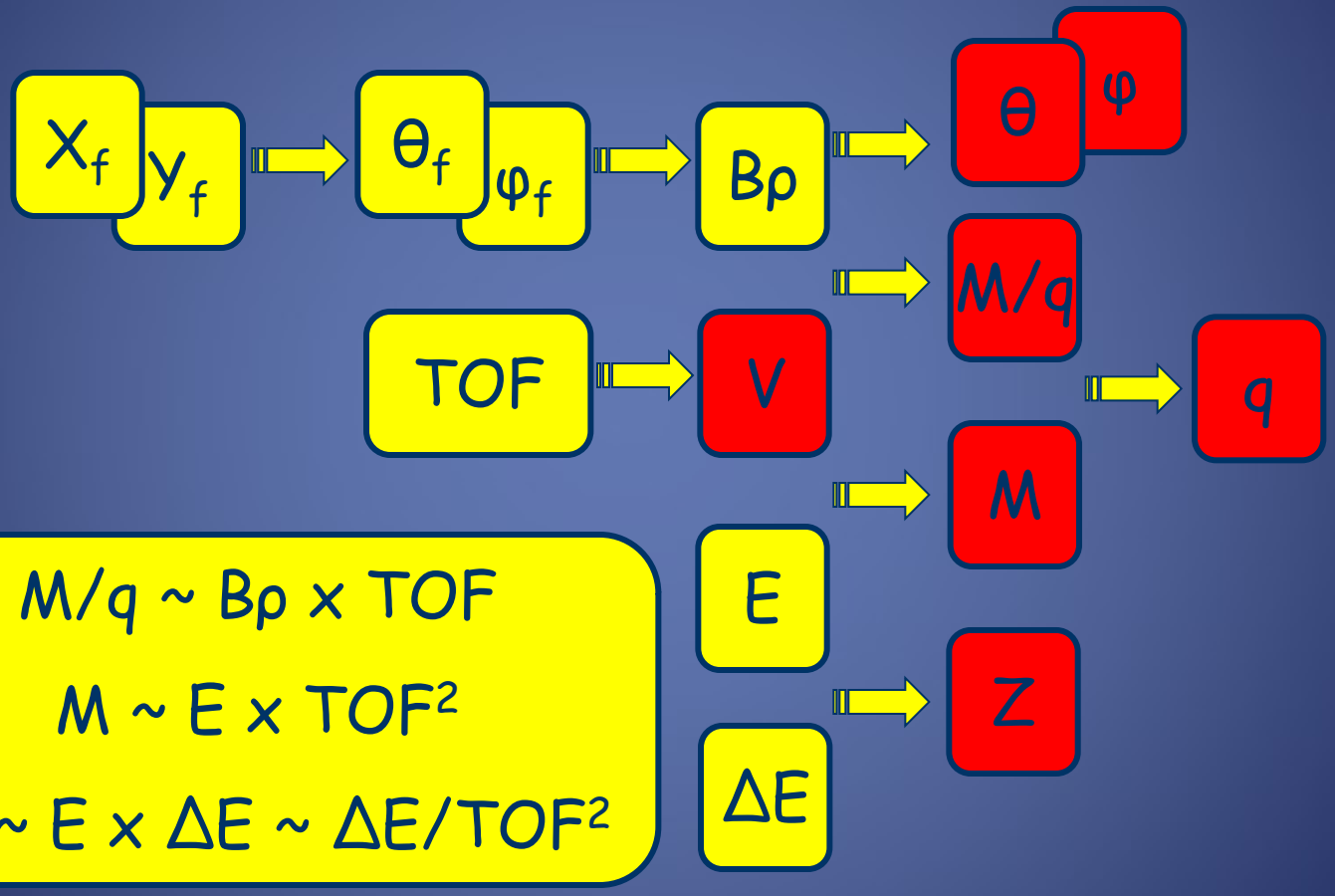
Drift Chamber

Heavy/Slow Ion Detection



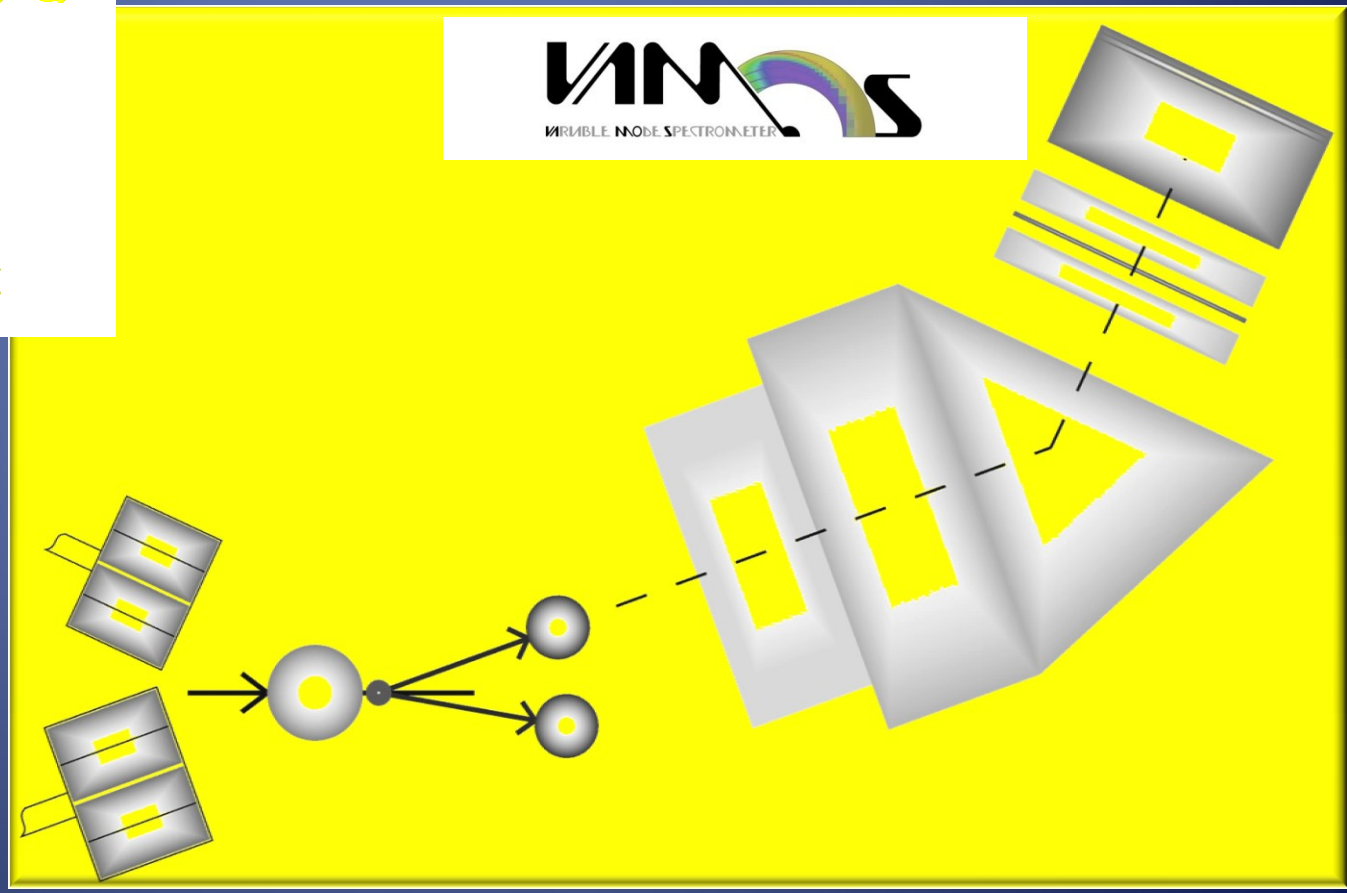


VAMOS Measurement
(Software Spectrometer)

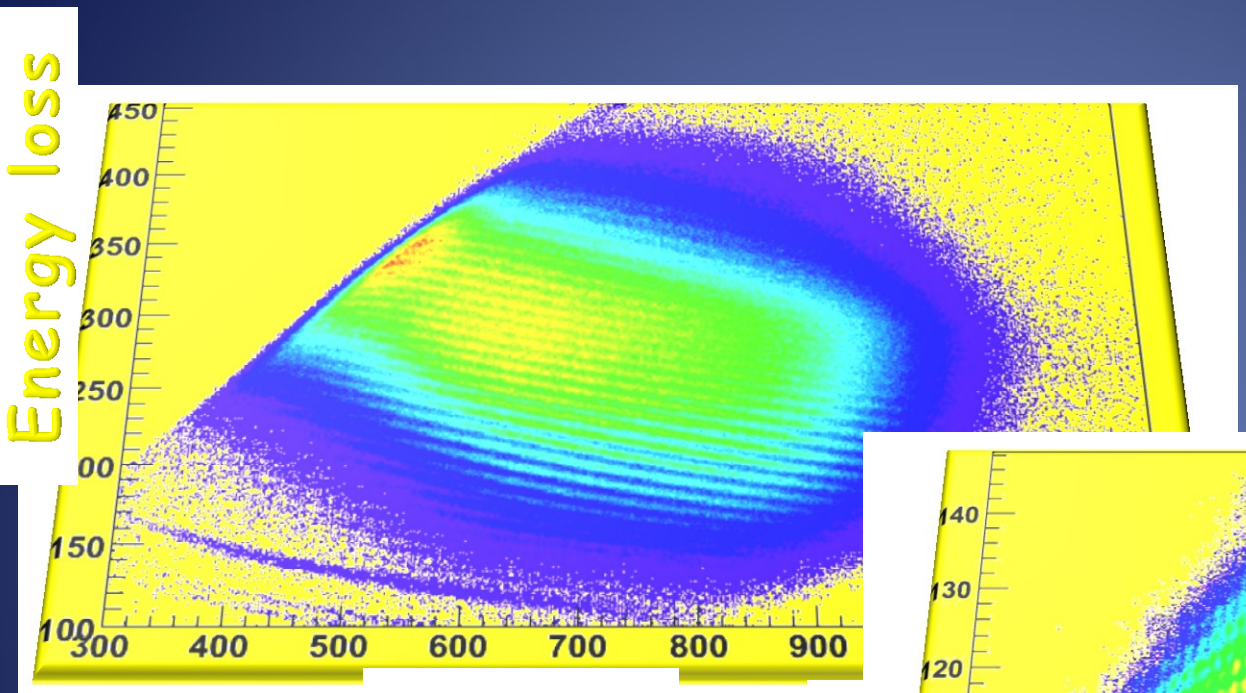


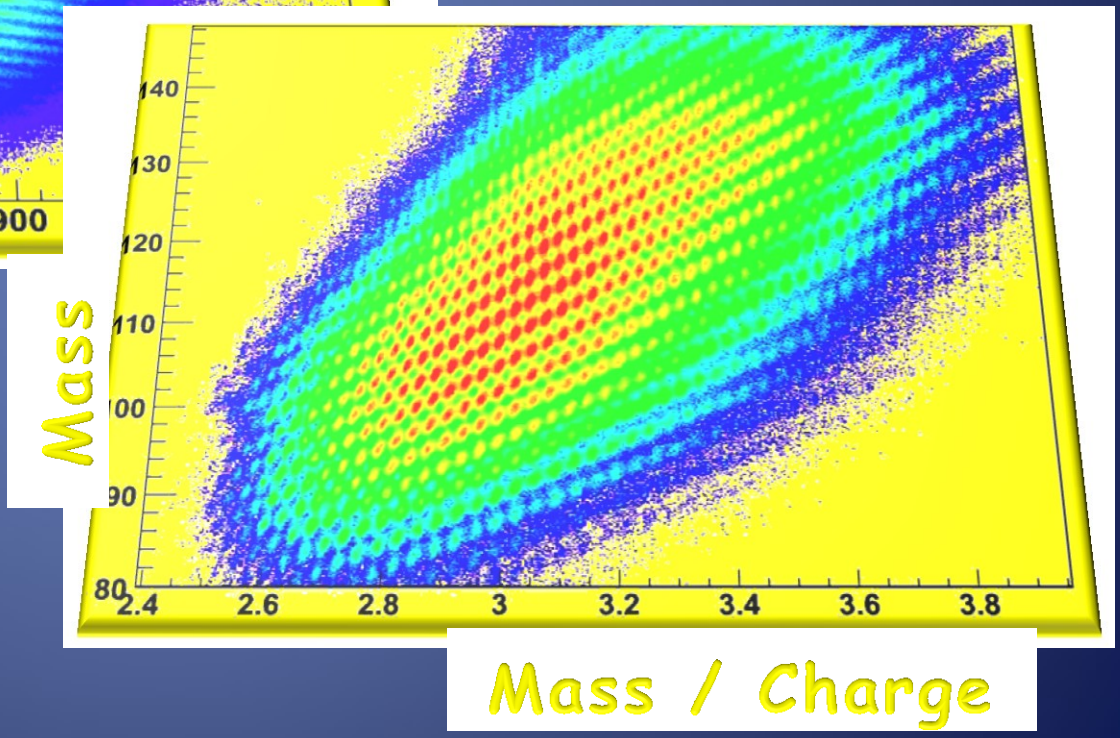
Isotopic Yields of Fission Fragments

- Beam:
  - ^{238}U
  - 6.15 MeV/u
- Target
  - ^{12}C
  - 20 $\mu g/cm^2$



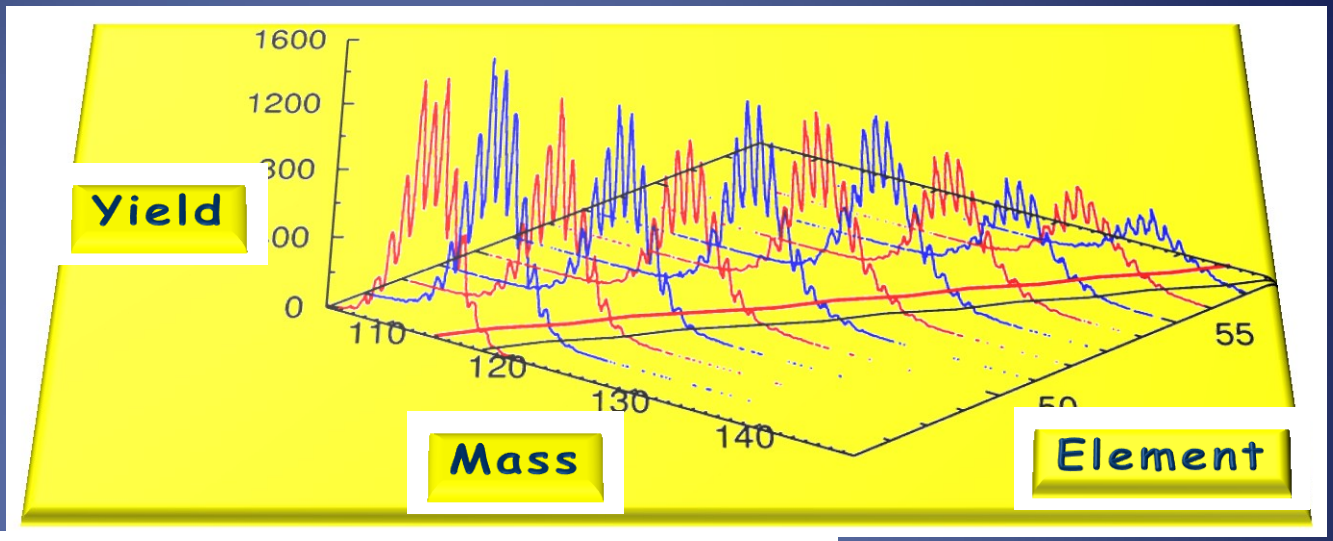
Identification: U + C

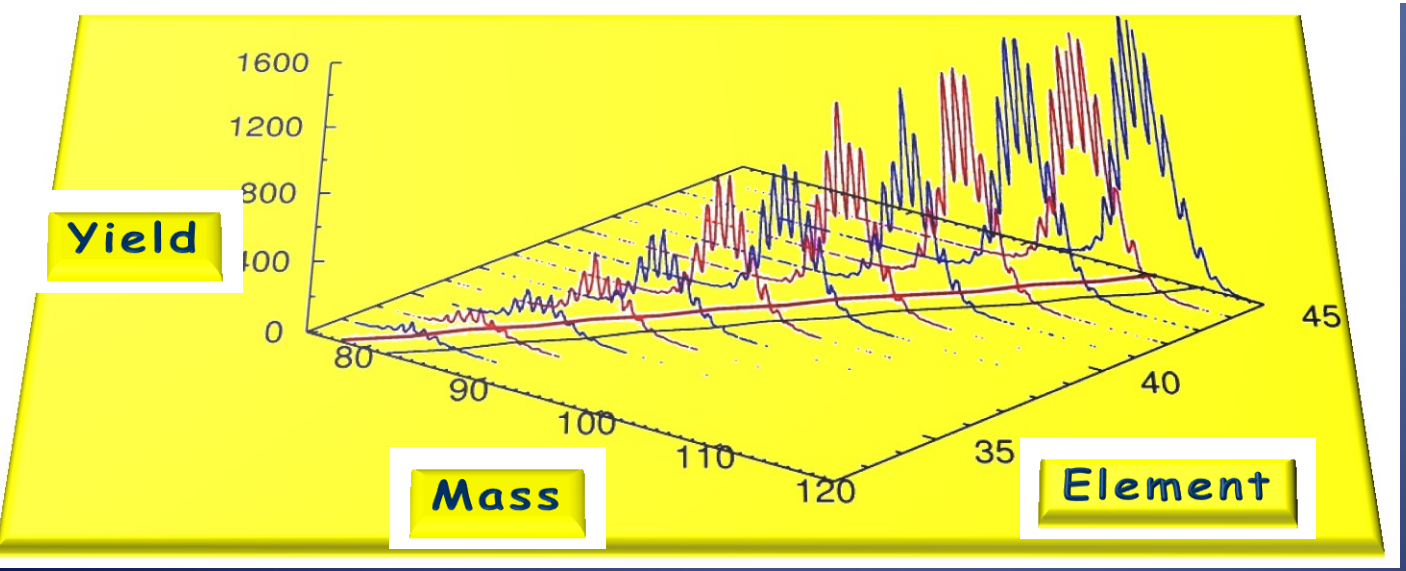




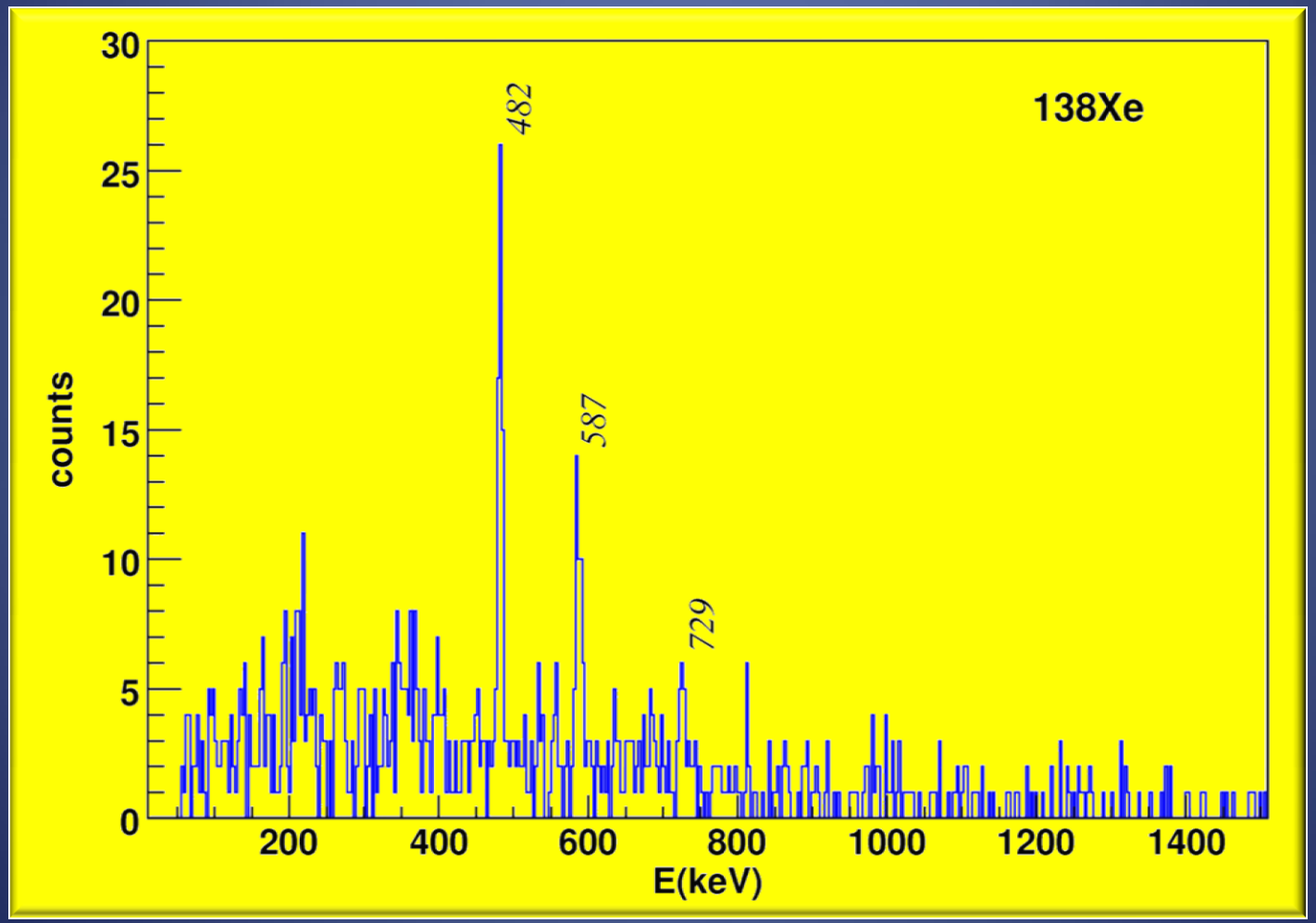
M. Caamaño, F. Rejmund, K.H. Schmidt et al., ongoing analysis (April 2008)

Mass Distributions

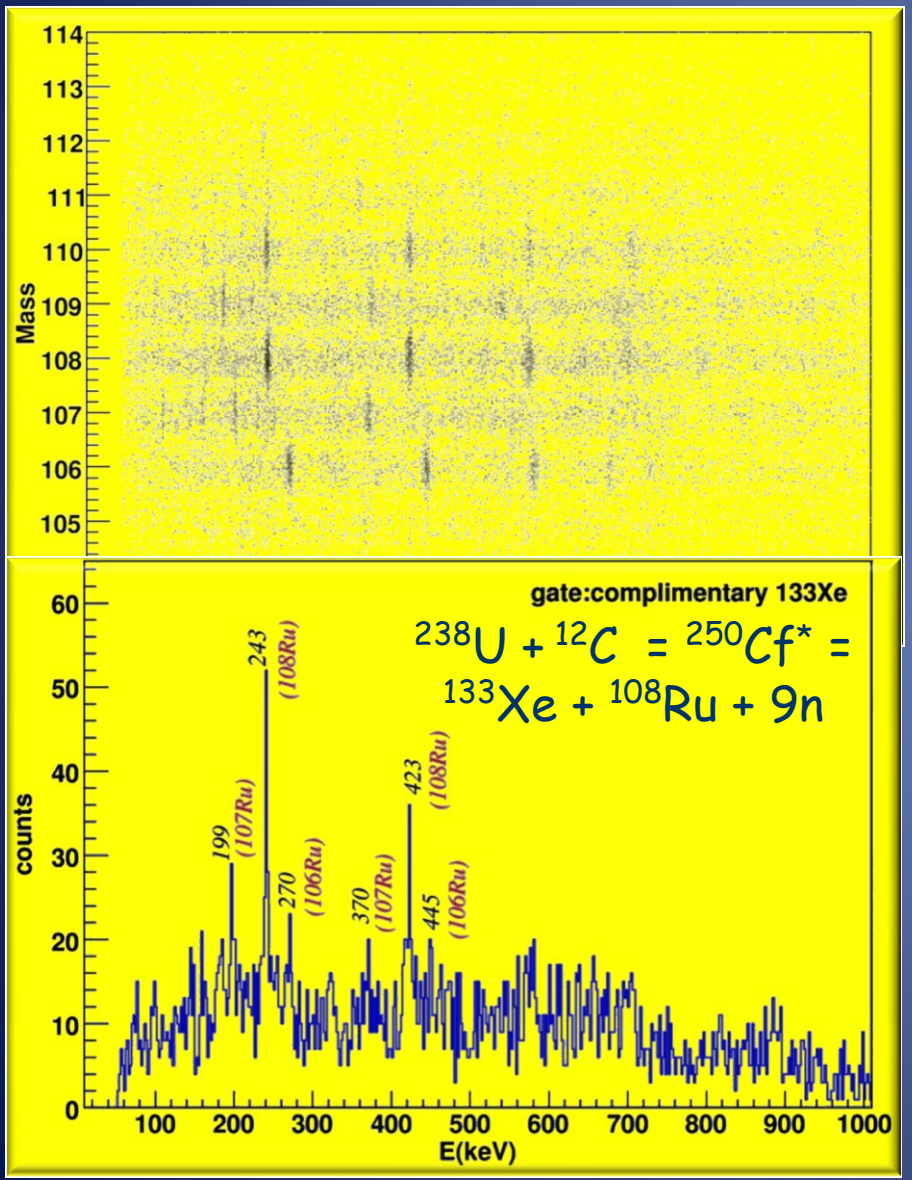




Isotopically identified fragments ^{138}Xe

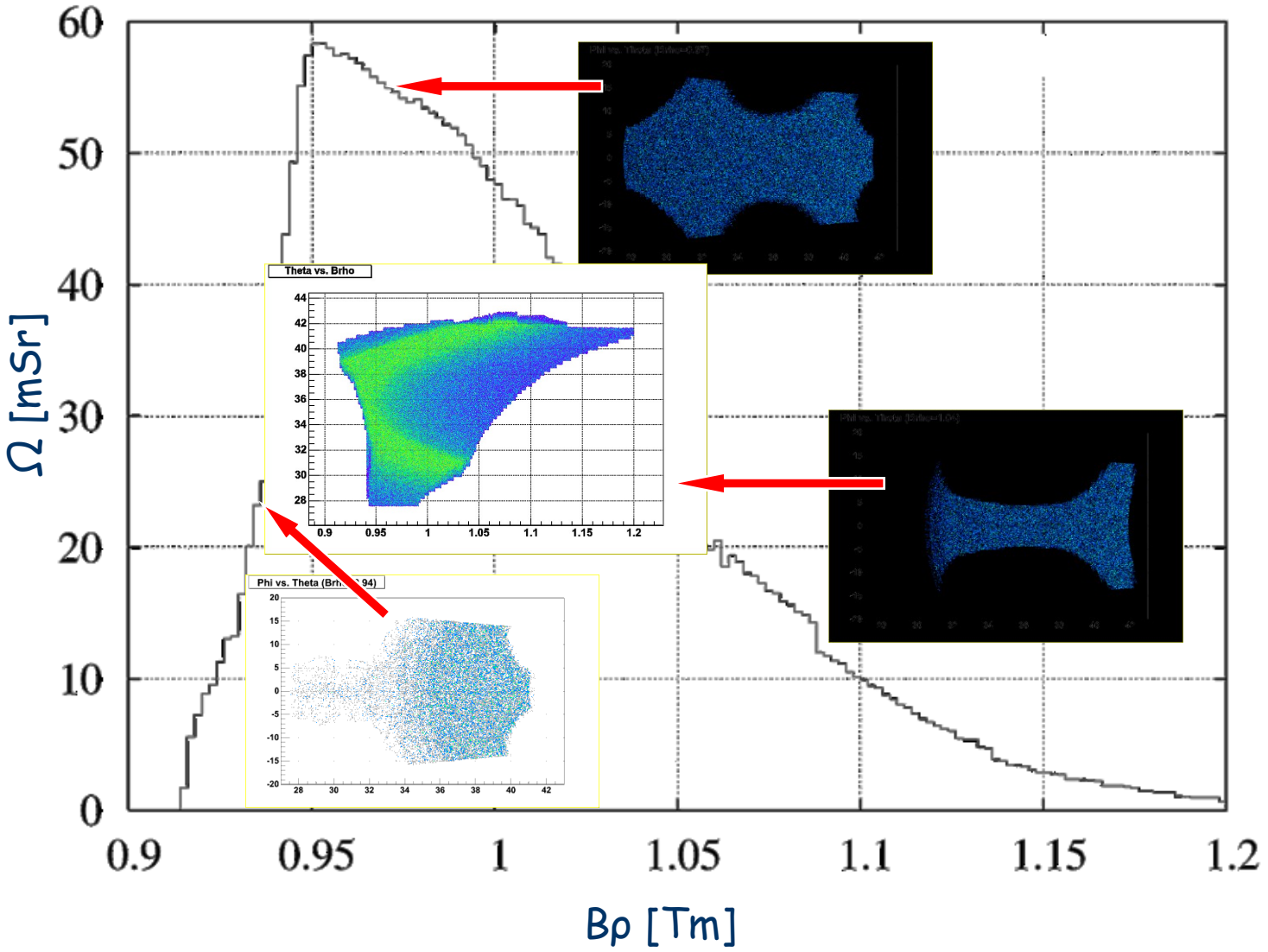


Light Fission Fragment

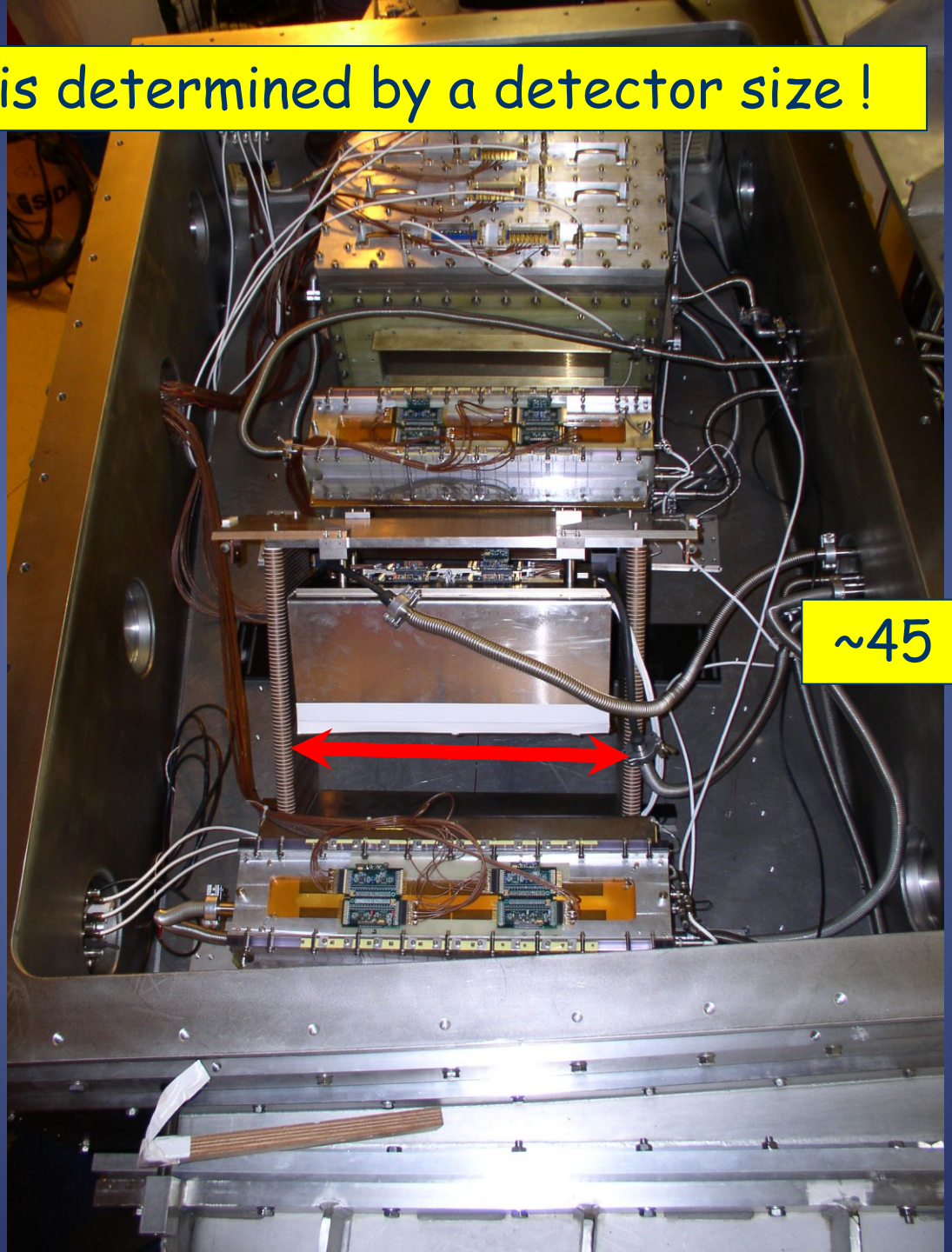


- dE-E gate on Ru (Z=44)
  - Measured Mass
  - Measured Energy of γ-ray
  - Doppler correction using measured V
- Gate on ^{133}Xe (Z=54)
  - Measured Energy of γ-ray
  - Doppler correction using V deduced for the partner

Acceptance of VAMOS

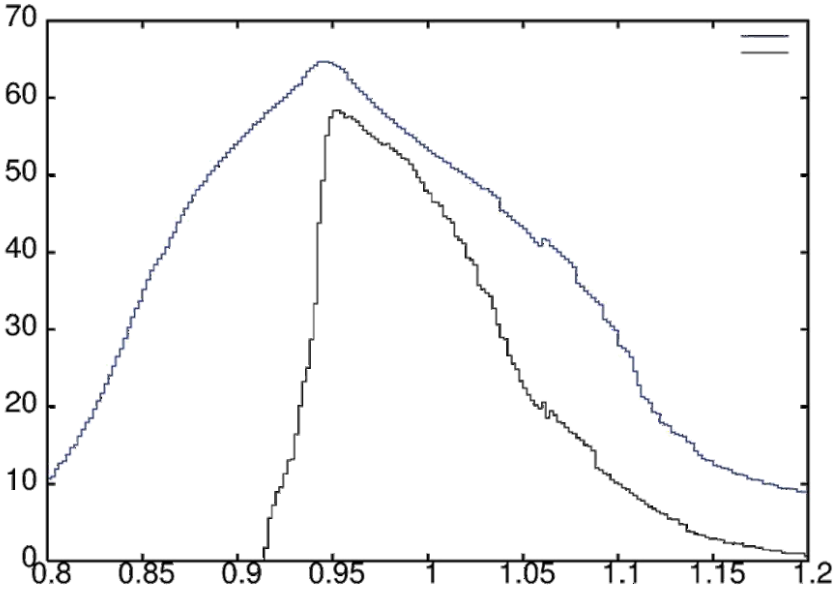


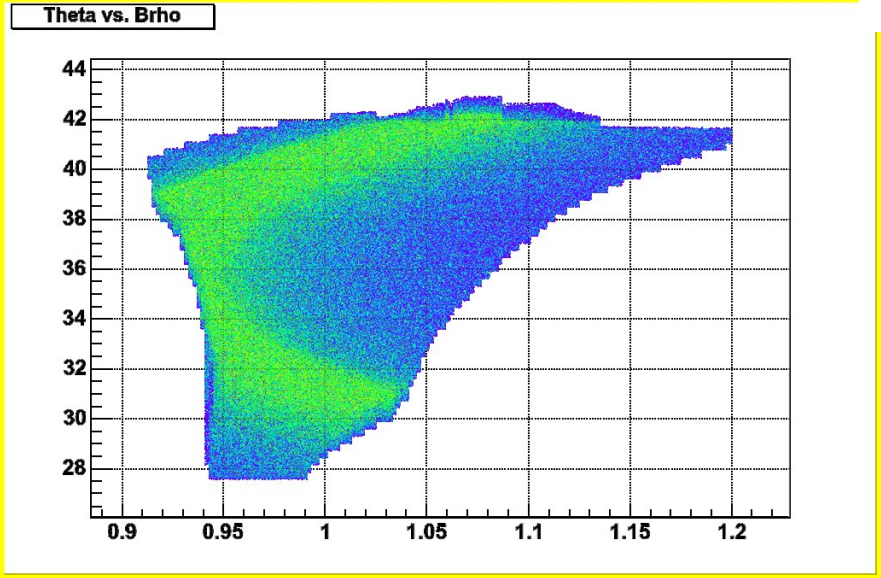
Acceptance is determined by a detector size !

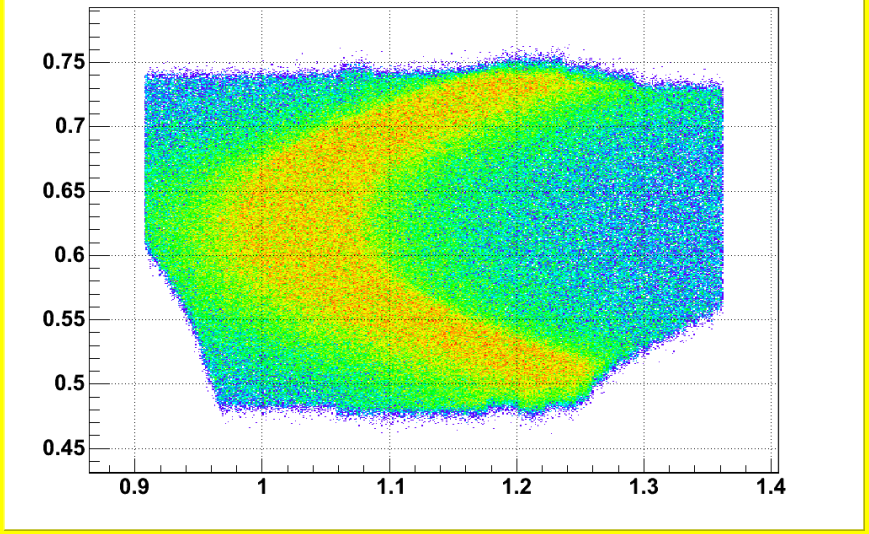


Proposed improvement

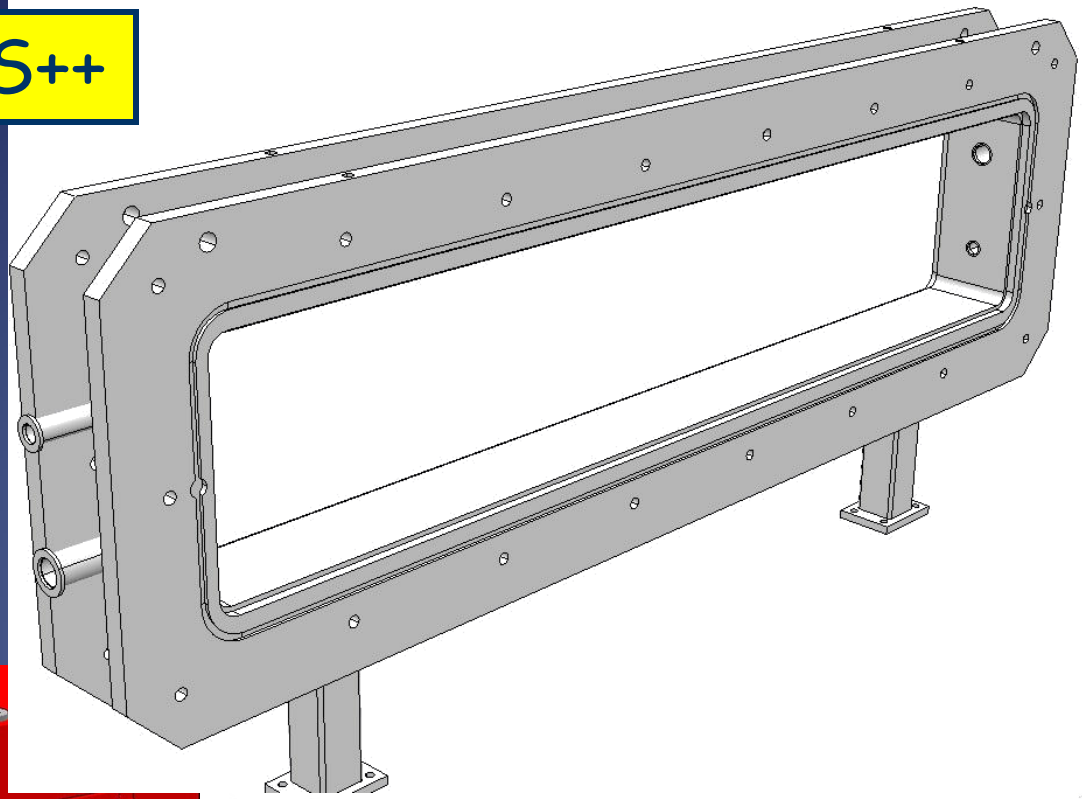
By doubling of size of the focal plane detection

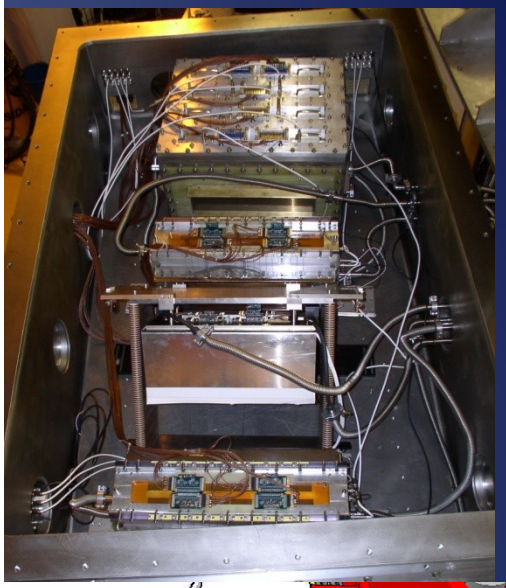


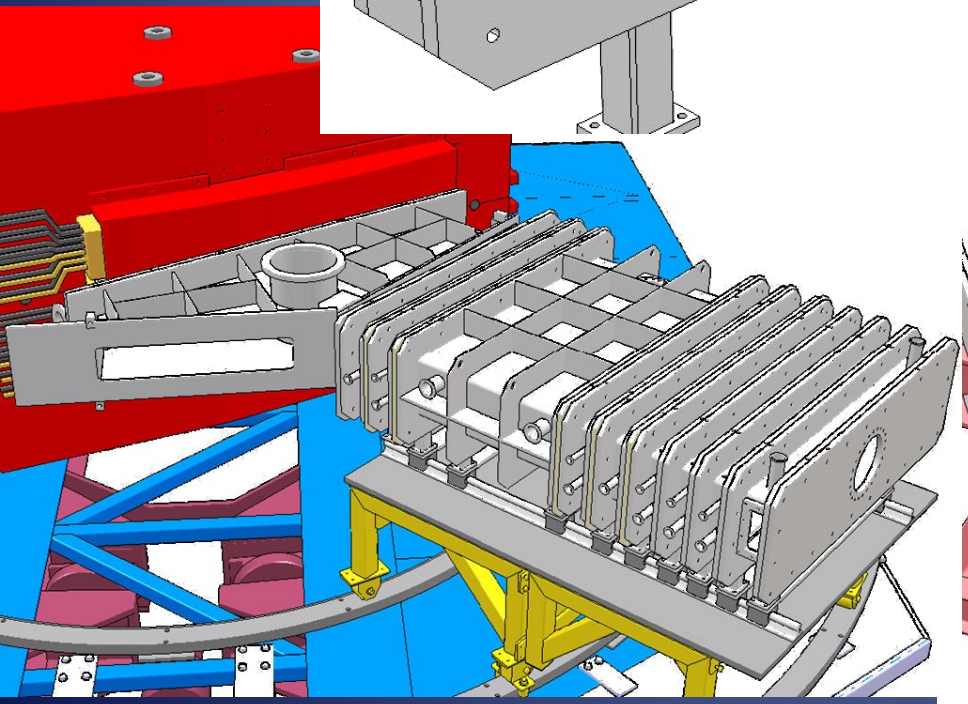


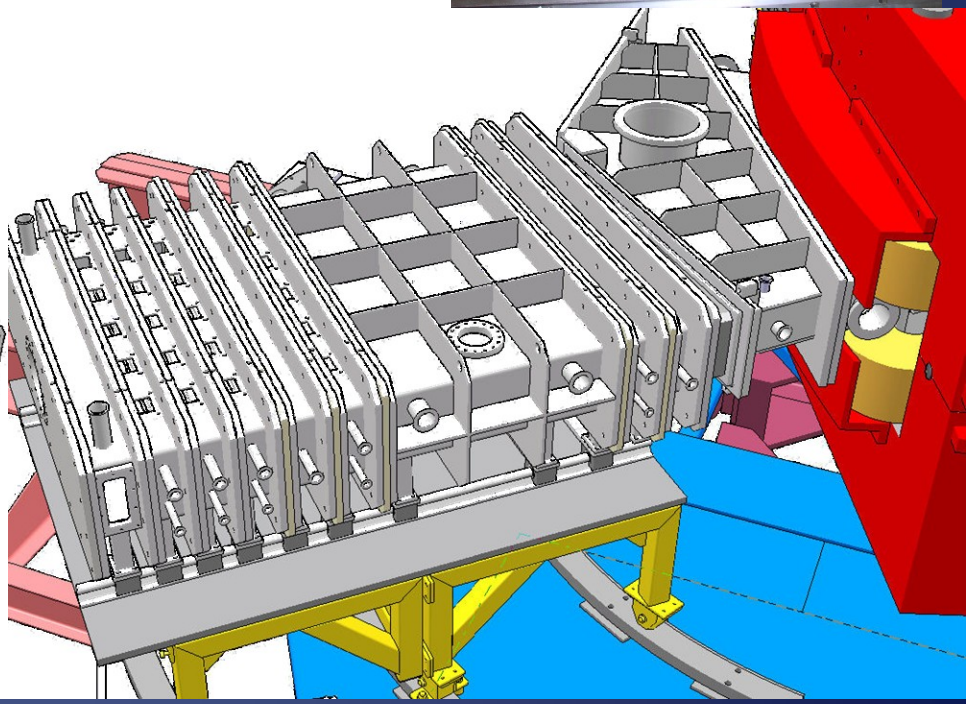


VAMOS++

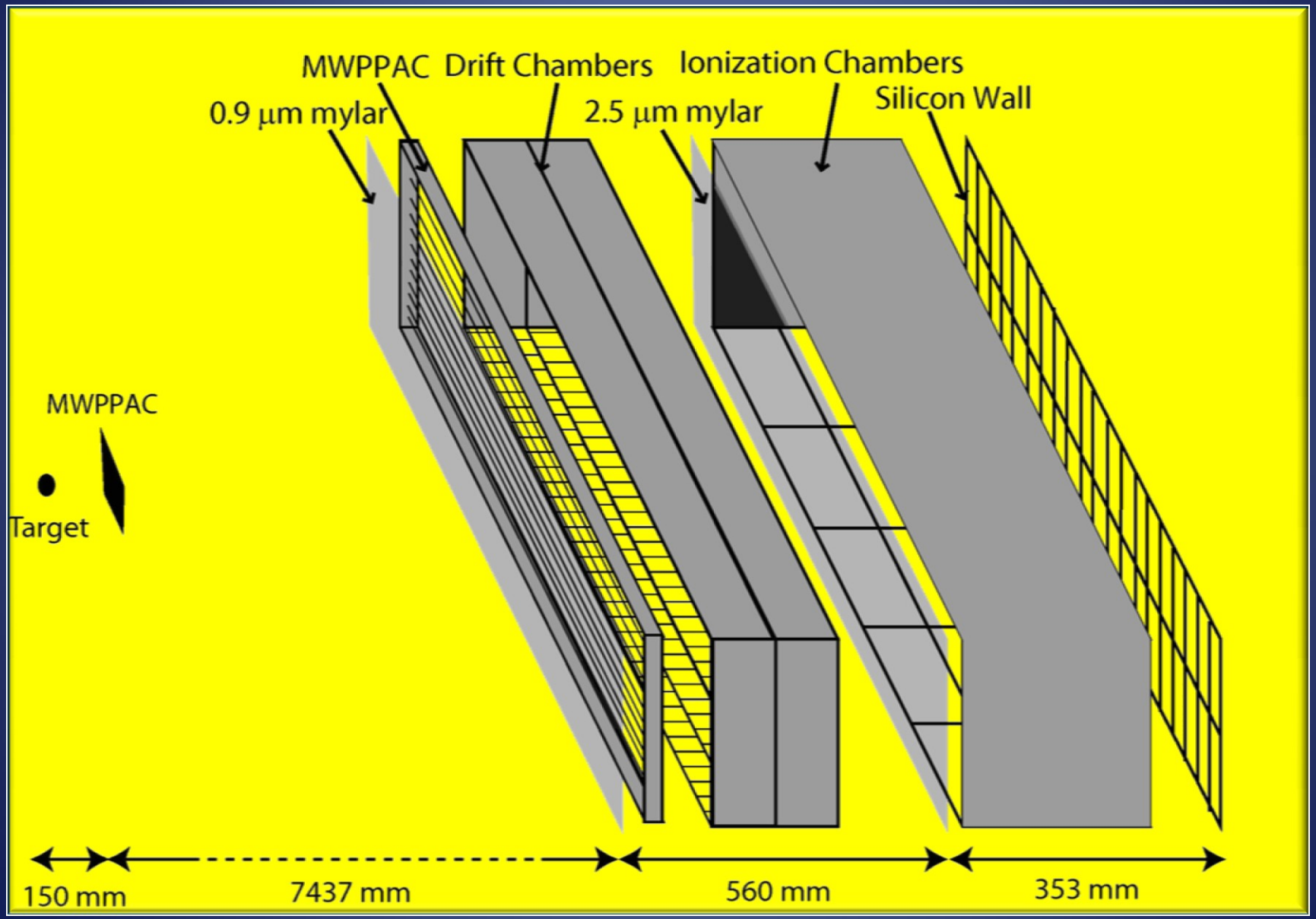




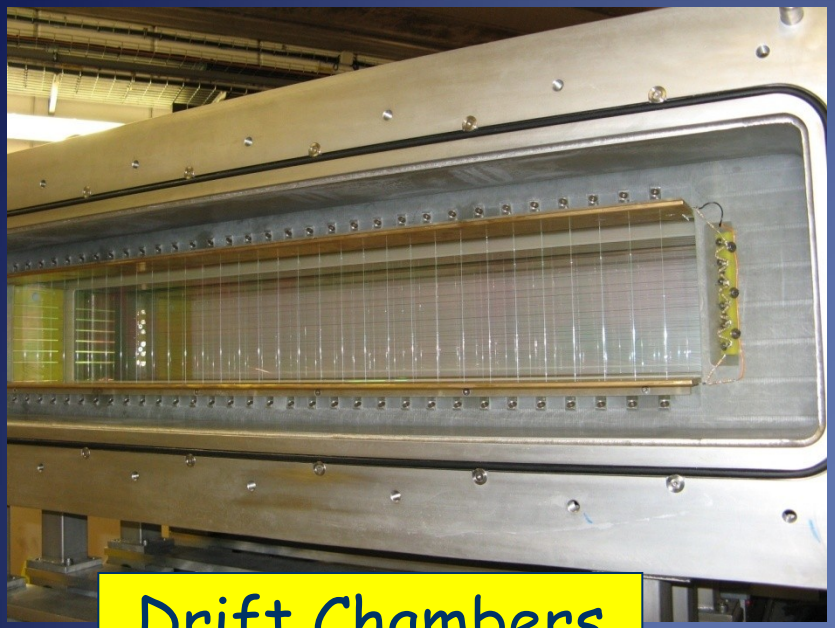




VAMOS++

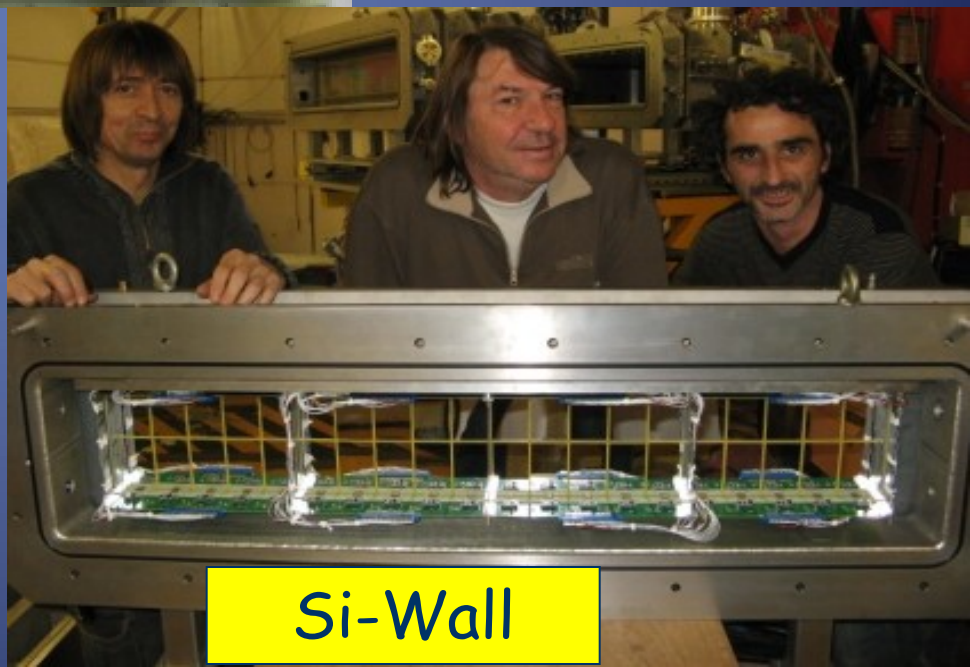

MWPPAC
Drift Chambers
Ionization Chambers
0.9 μm mylar
2.5 μm mylar
Silicon Wall
MWPPAC
Target
150 mm
7437 mm
560 mm
353 mm

Detectors



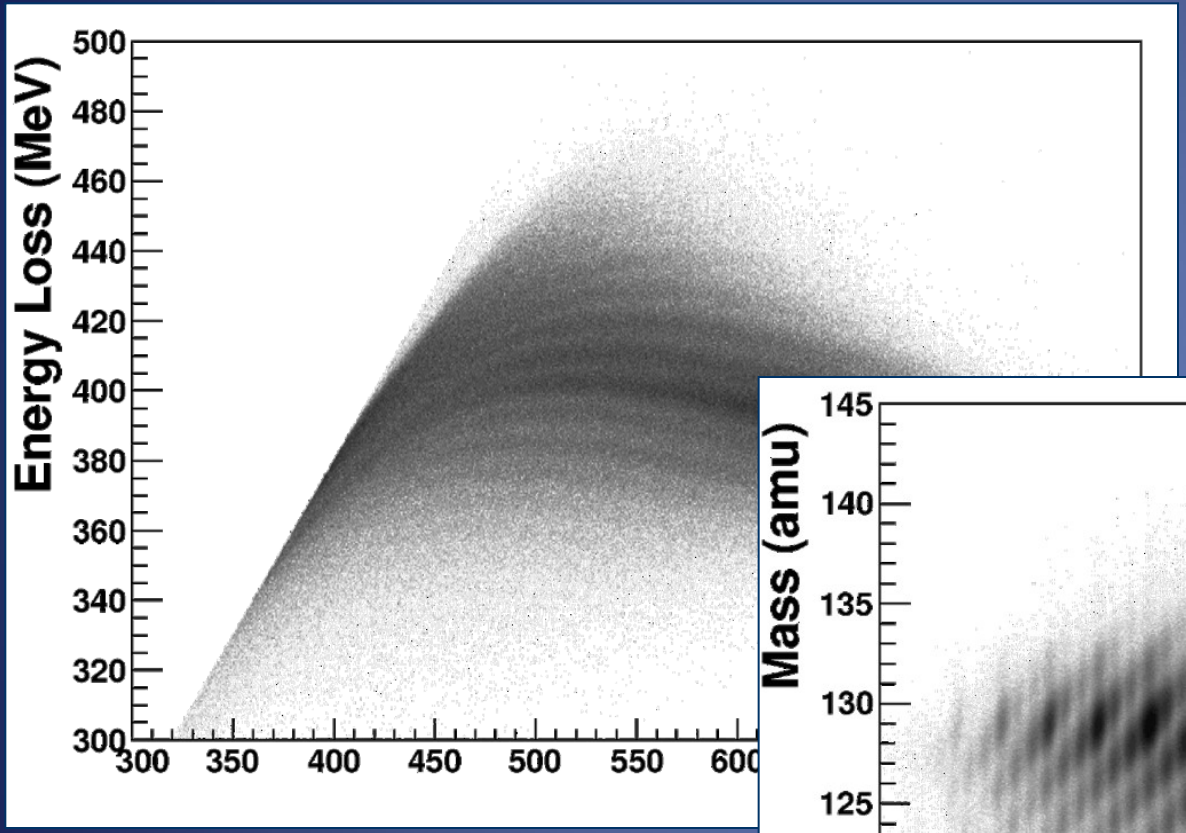
Drift Chambers

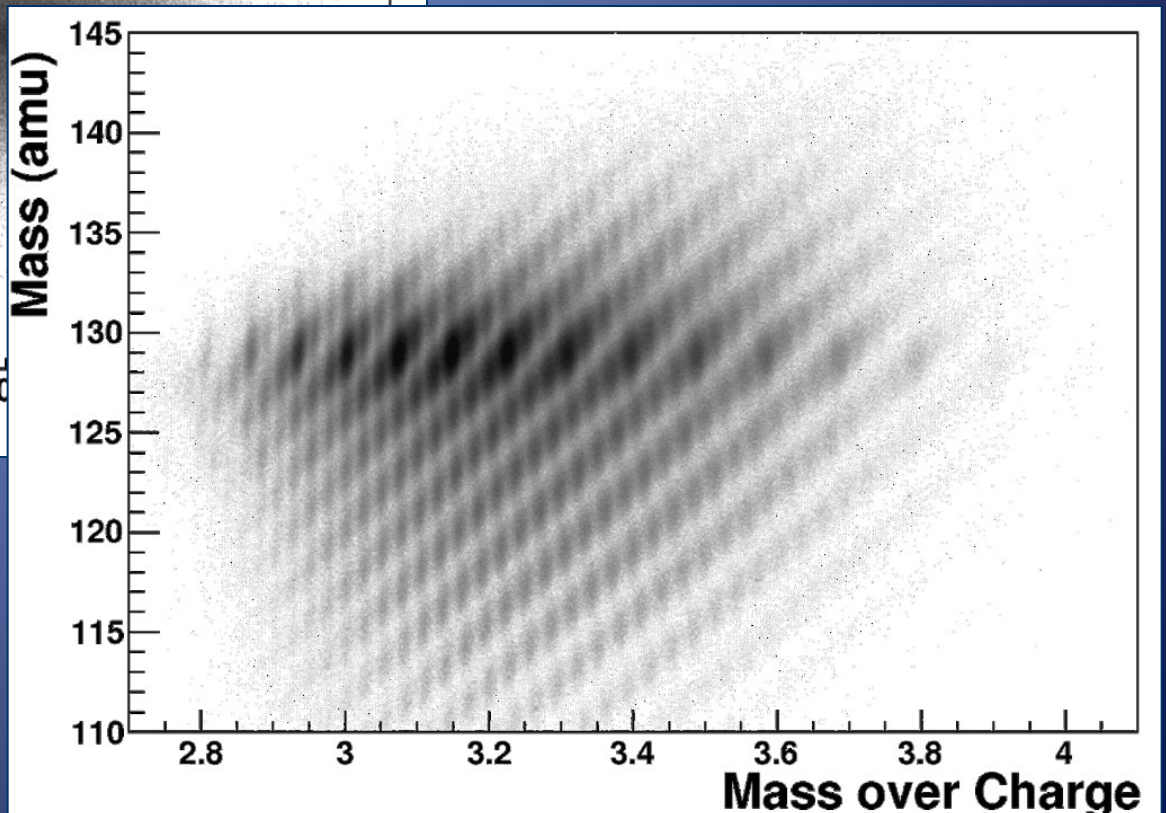
MWPPACs



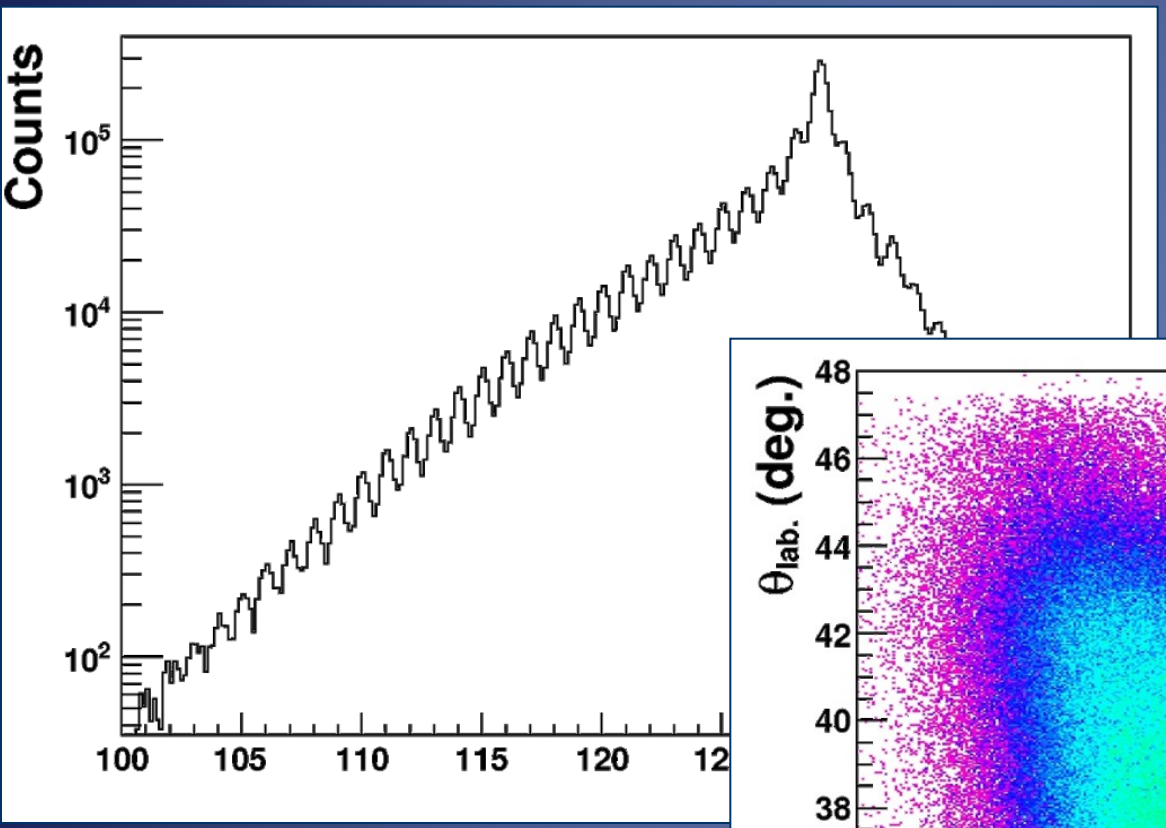
Si-Wall

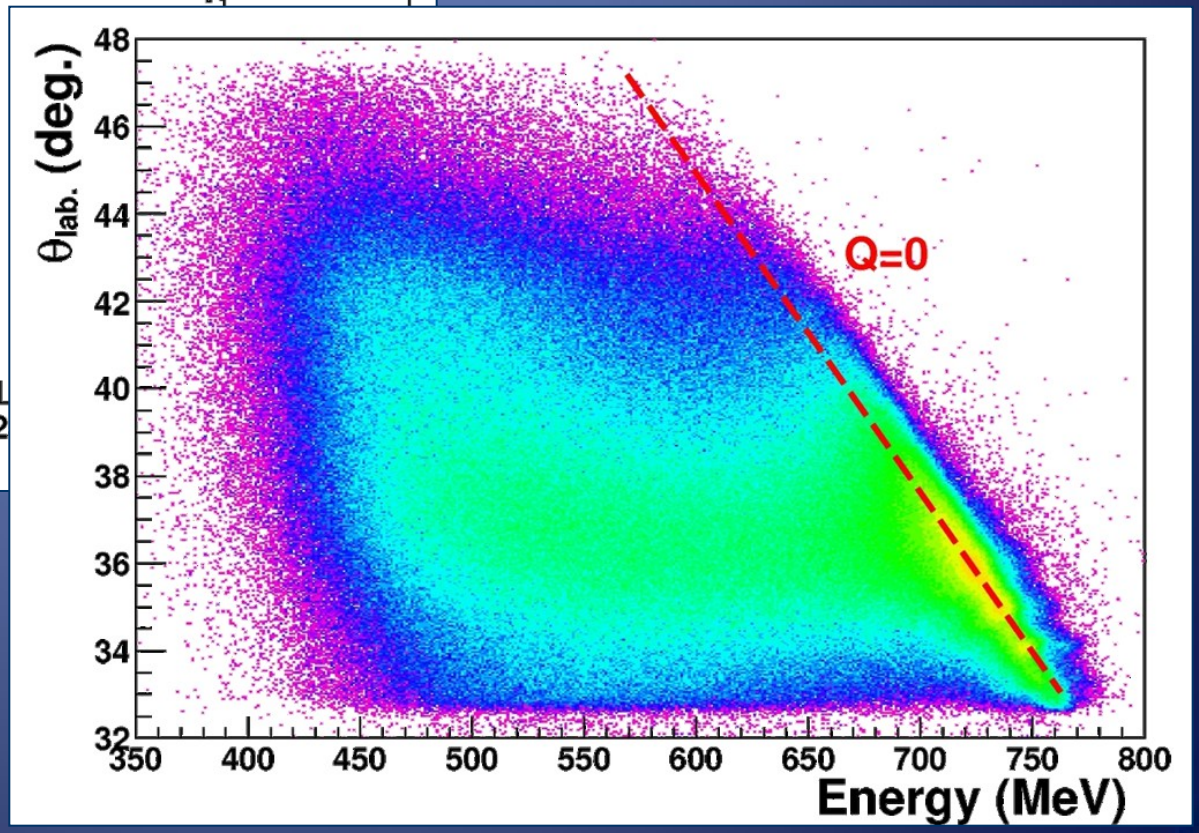
^{129}Xe @ 7.5 MeV/u + ^{197}Au
VAMOS at 40°



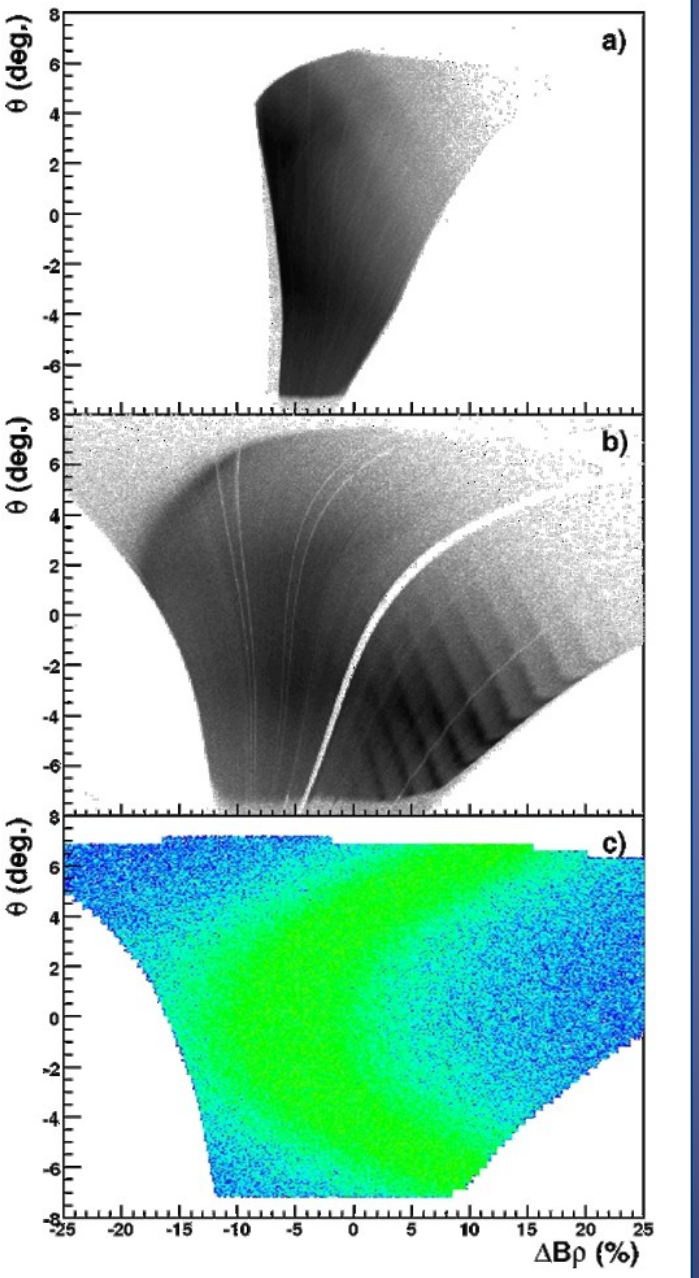


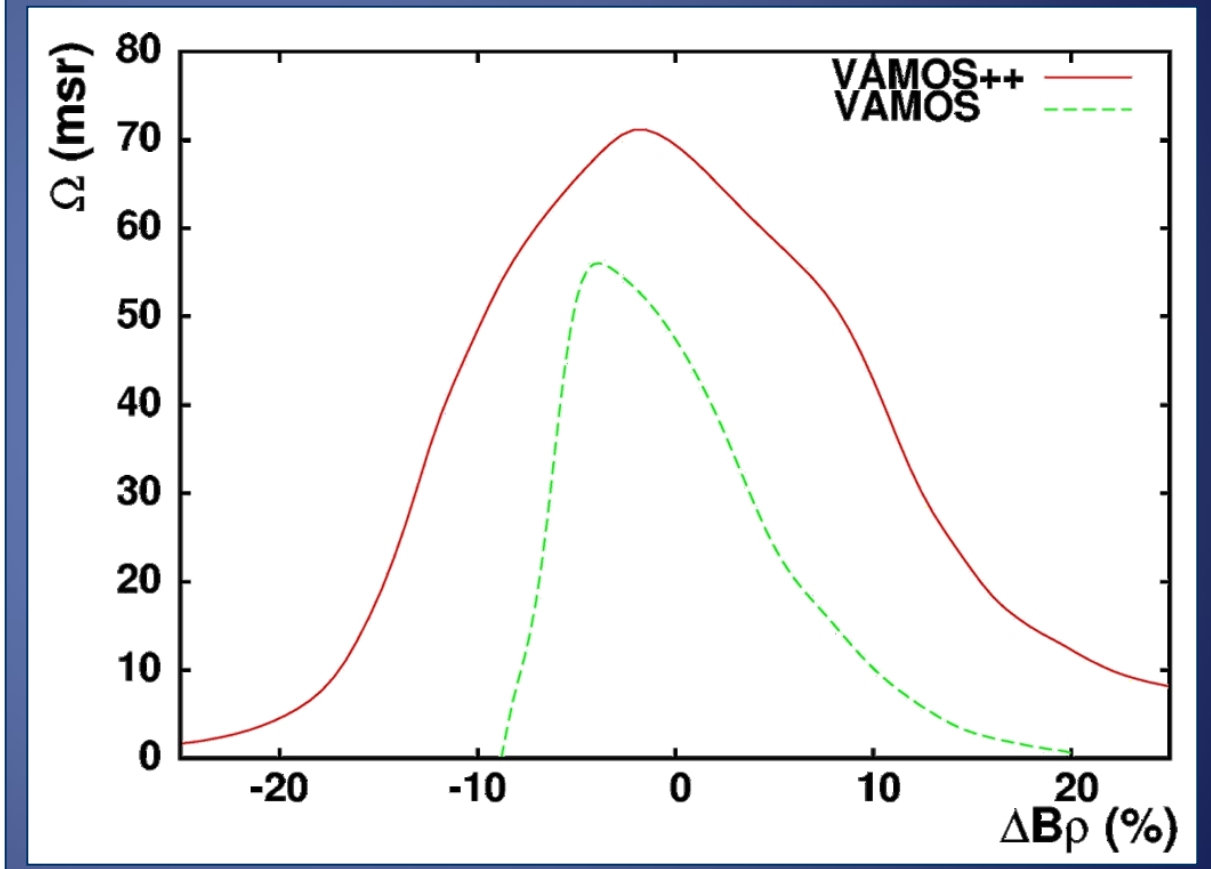
^{129}Xe @ 7.5 MeV/u + ^{197}Au
VAMOS at 40°





Acceptance

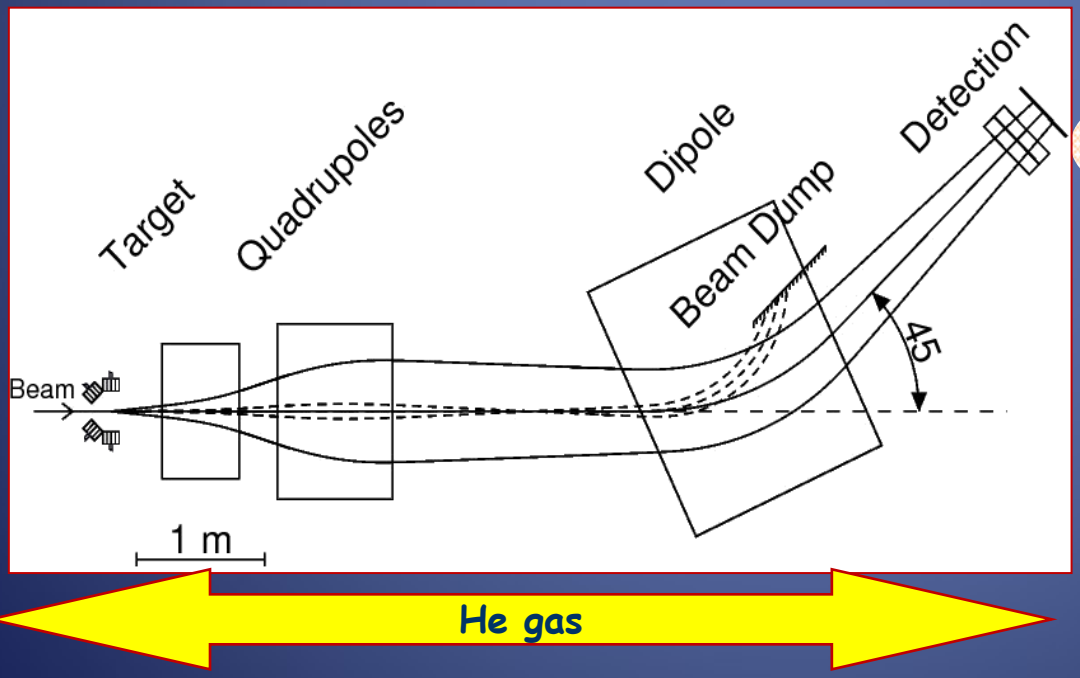




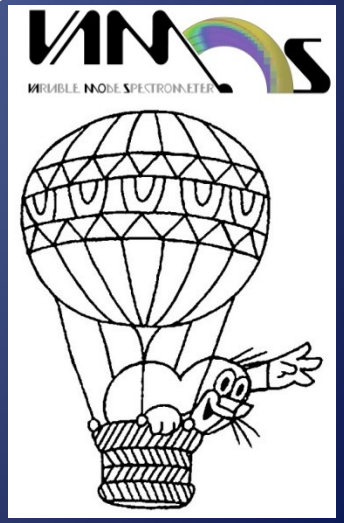
Gas Filled version

- ✓ C foil before the target for vacuum/gas separation
- ✓ He gas-filling ~(0.2–1.3) mbar
- ✓ beam dump (Ta plate)

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

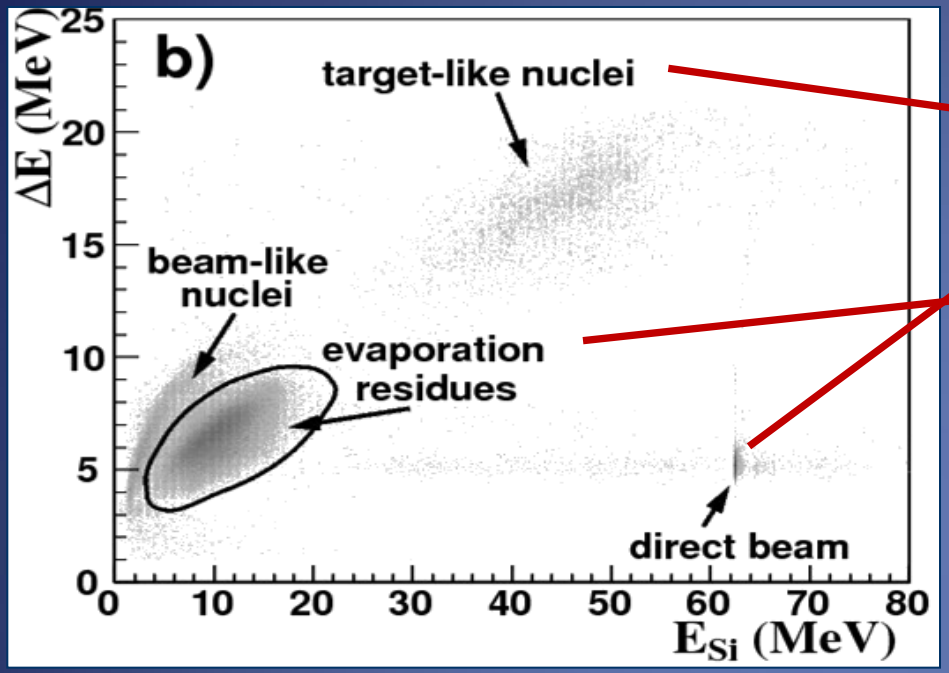


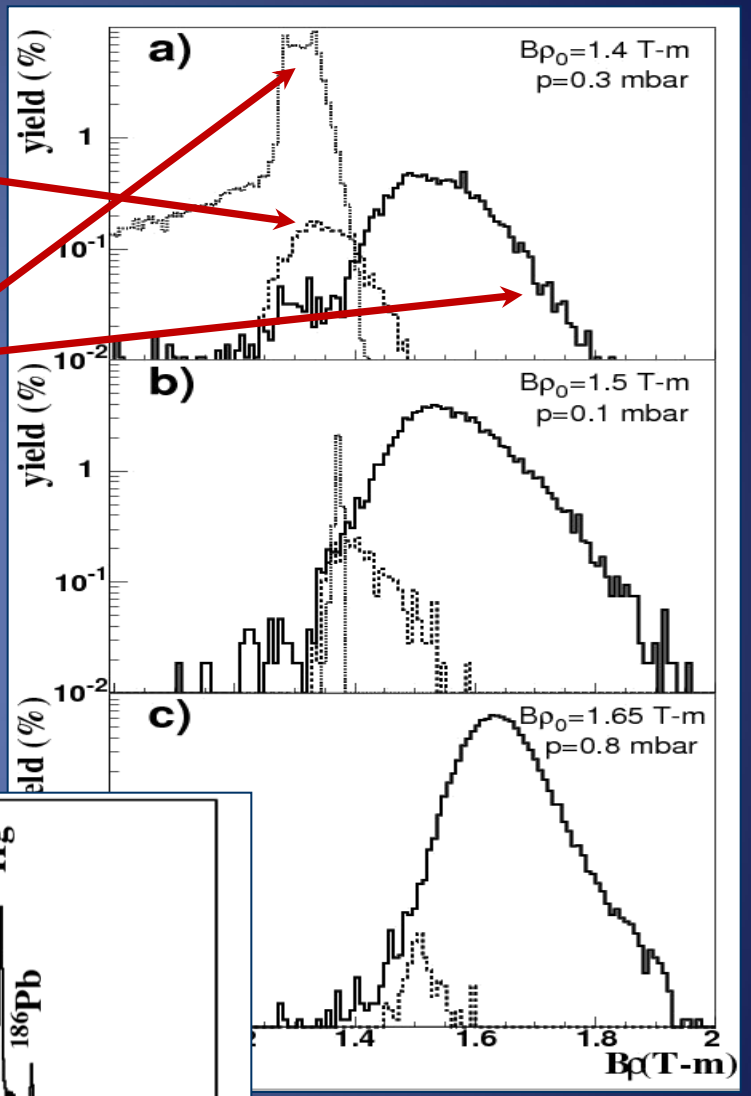
x, y, ΔE, E, T_{of}

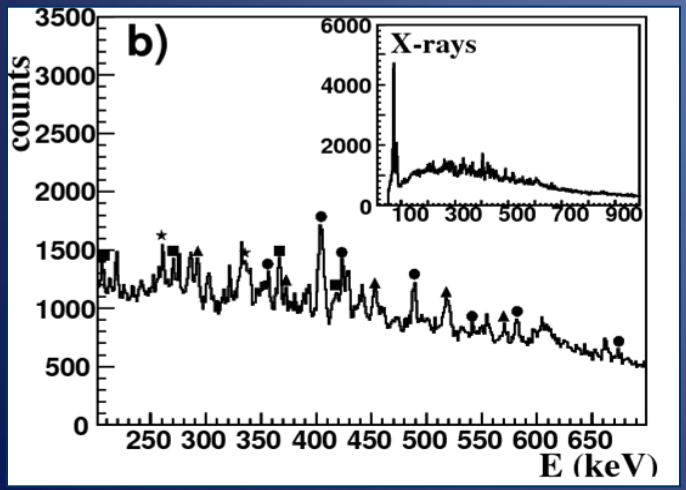


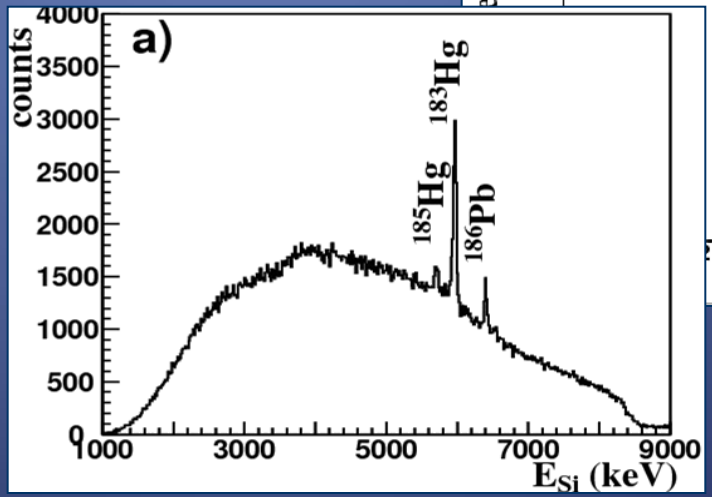
Ch.Schmitt et al., NIMA621(2010)558

Spectra


b)
target-like nuclei
beam-like nuclei
evaporation residues
direct beam
ΔE (MeV)
E_Si (MeV)


a)
Bρ0=1.4 T-m
p=0.3 mbar
b)
Bρ0=1.5 T-m
p=0.1 mbar
c)
Bρ0=1.65 T-m
p=0.8 mbar
yield (%)
Bρ(T-m)


b)
X-rays
counts
E (keV)


a)
183Hg
185Hg
186Pb
counts
E_Si (keV)

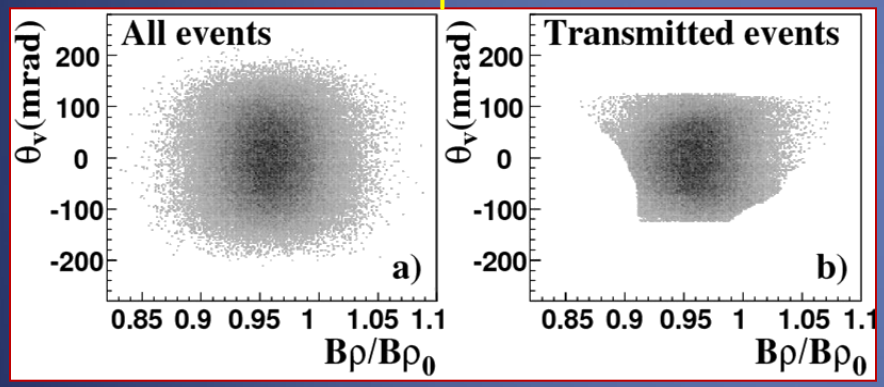
Performances

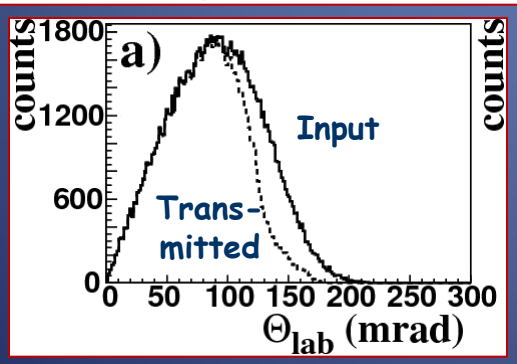
Optimal conditions : **$B\rho_0$=1.65Tm and p ~ 1mbar** (with present simple set-up
Beam rejection factor > 10^{10}

No direct beam on the detectors for $1{\cdot}2{\cdot}10^{10}$ ^{40}Ca per sec sent in VAMOS

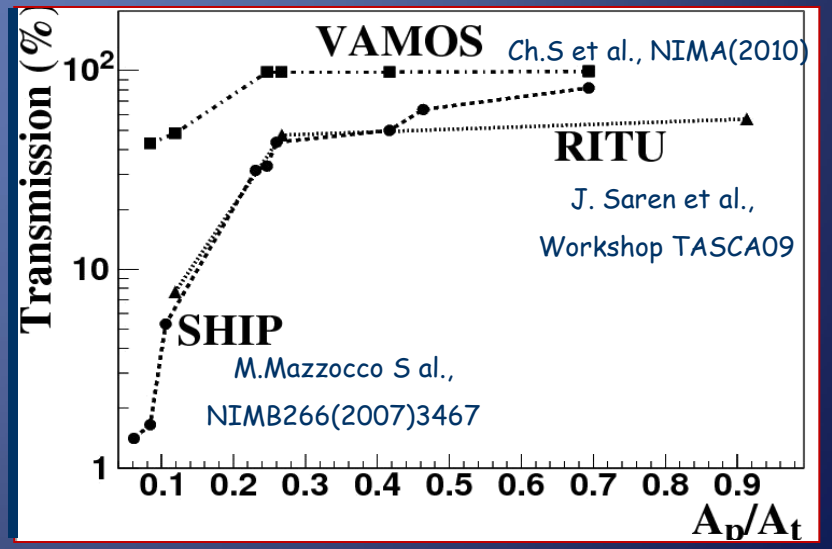
Transmission (from ion-optical calculations)

α3n evaporation channel





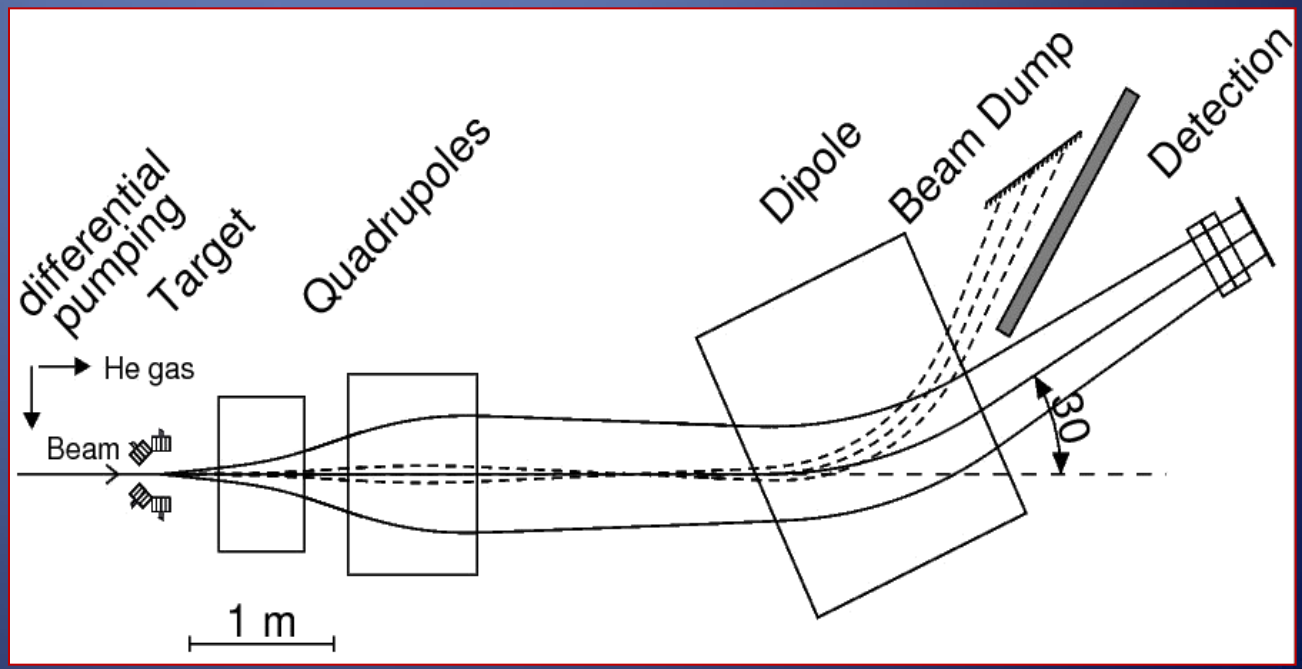
Large ϑ aperture
Big detectors



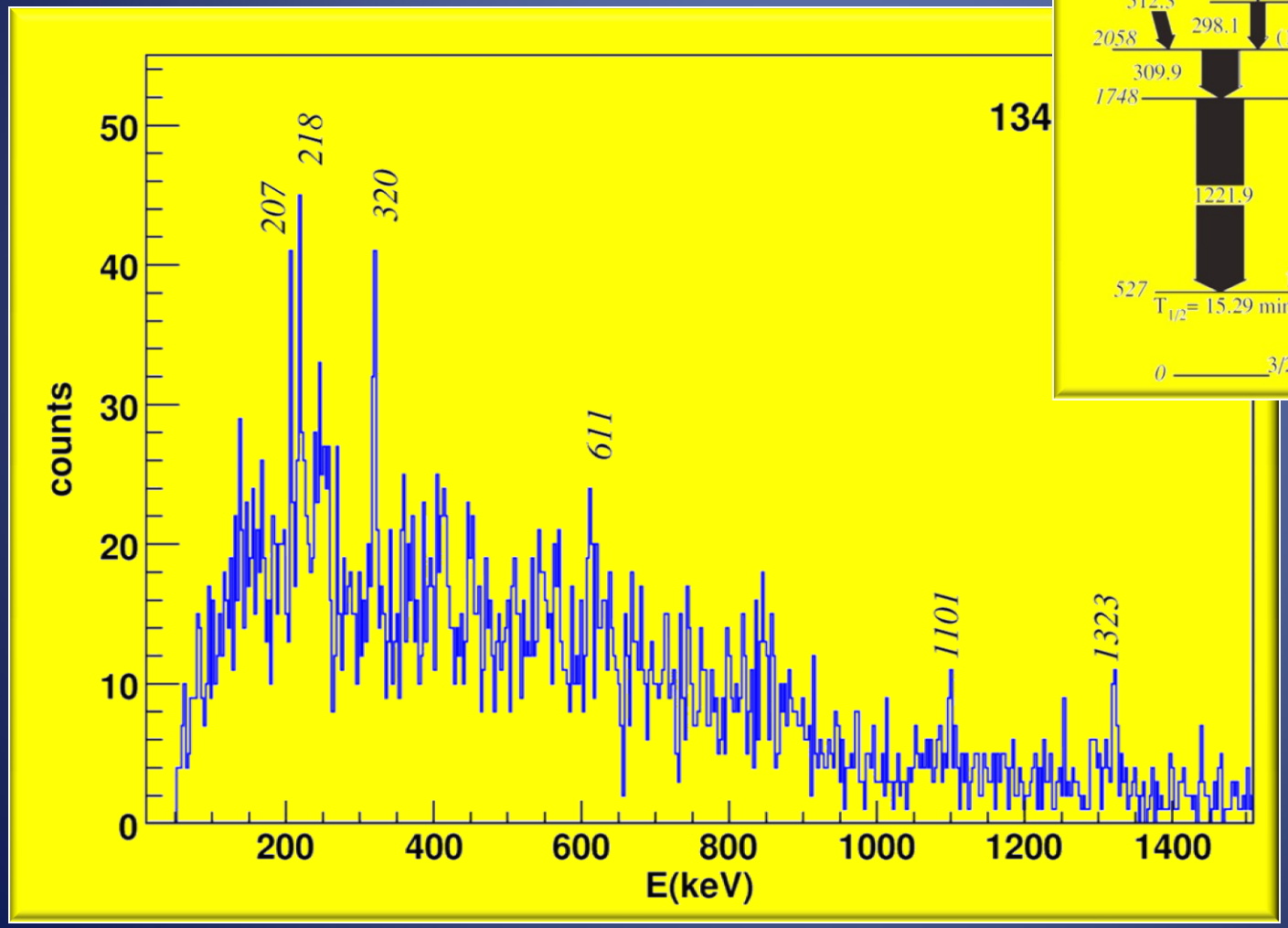
Improvements towards physics experiments

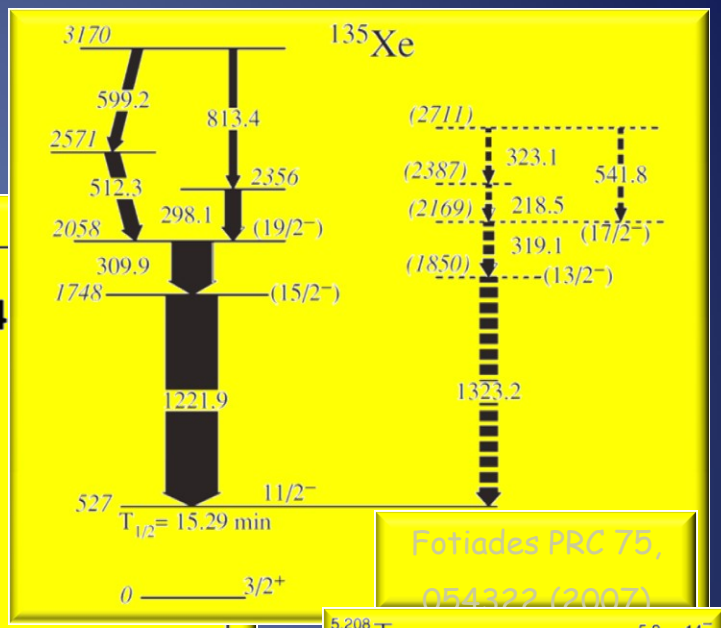
- ✓ **Beam dump behind VAMOS and shielded** (↓ scattering from there)
- ✓ **Differential pumping system** (↓ γ-background)
- ✓ **Recoil Decay Tagging with MUSETT** (ER-decay correlation)

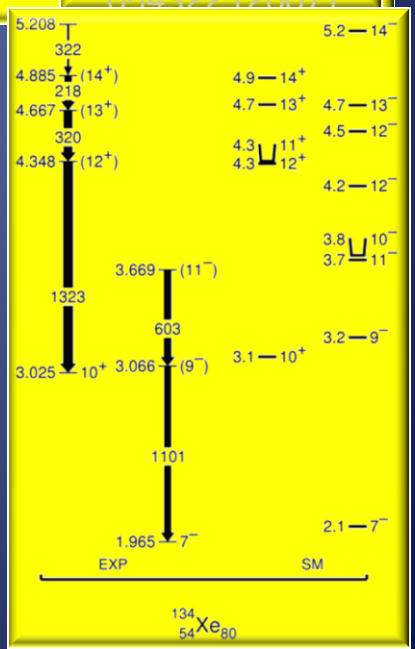
Larger beam rejection and transmission

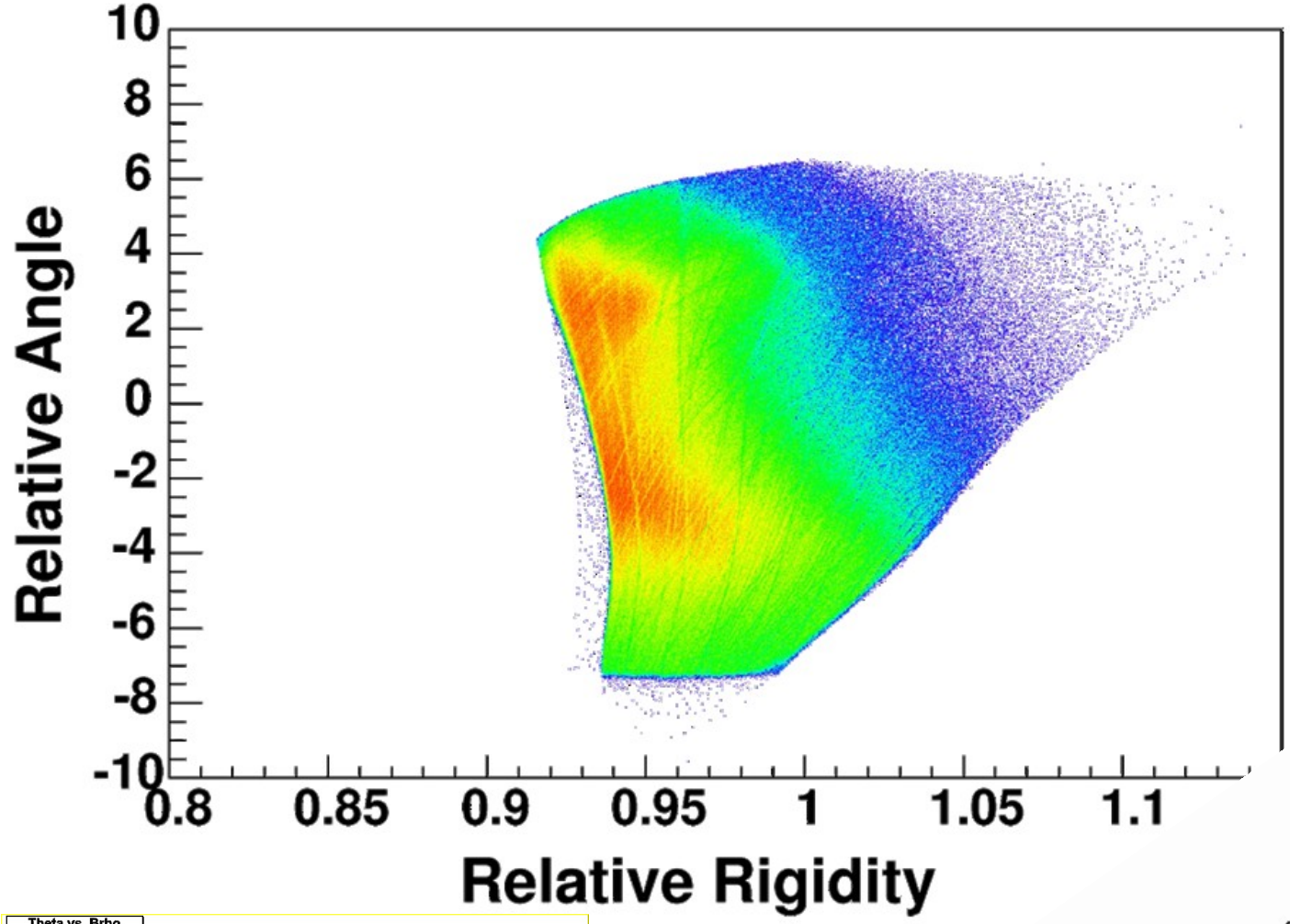


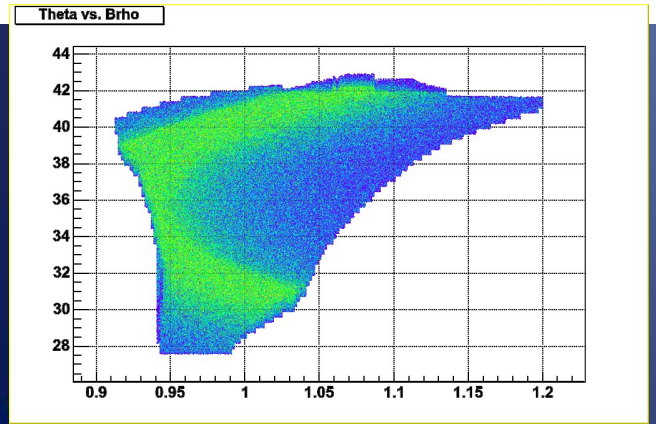
The spectrum of ^{134}Xe

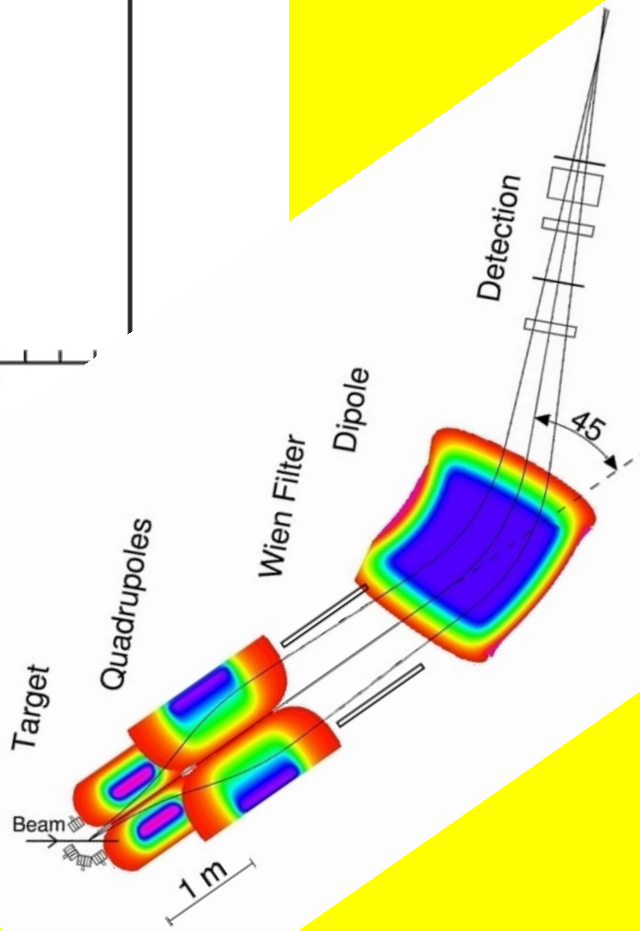


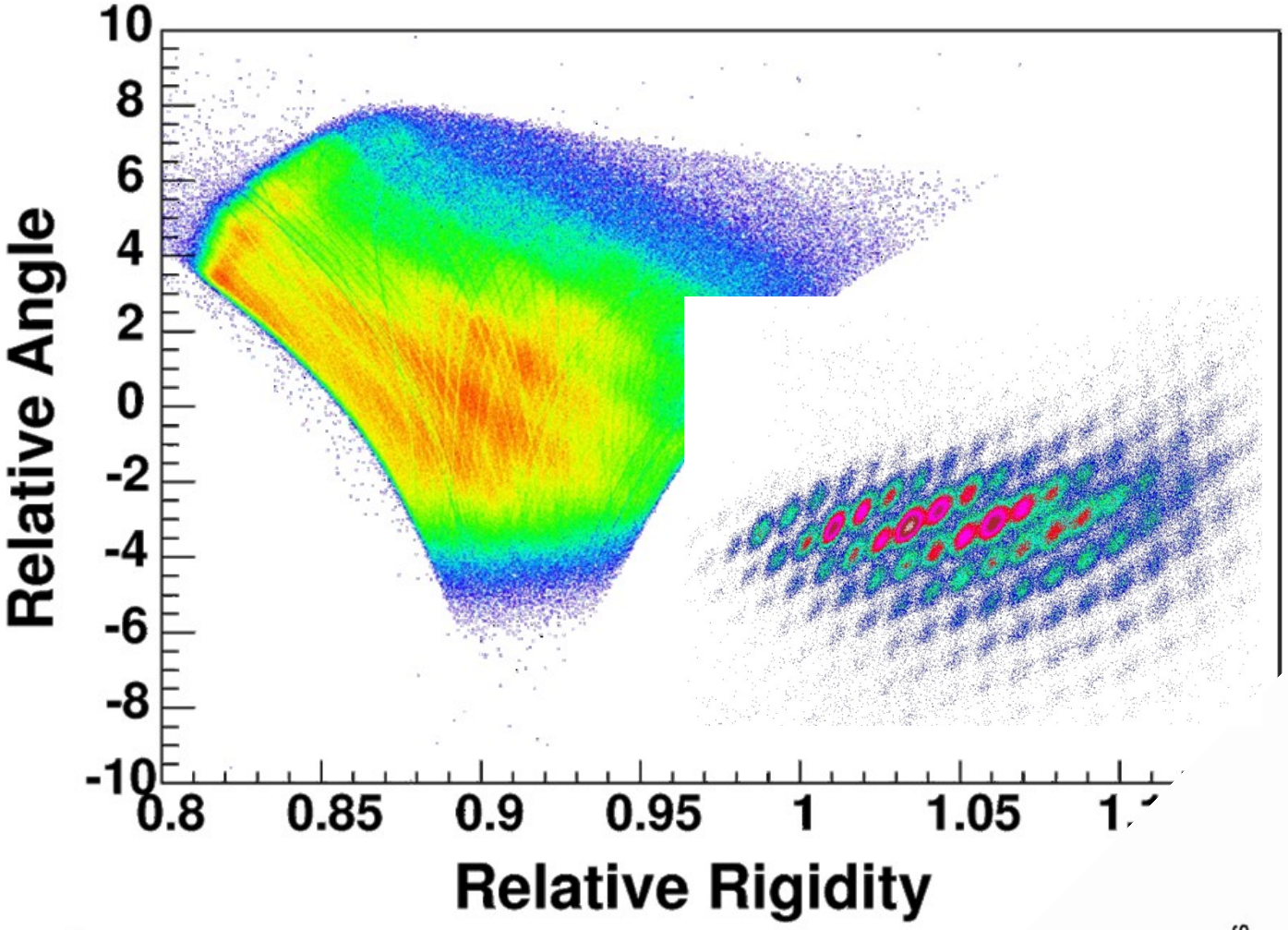


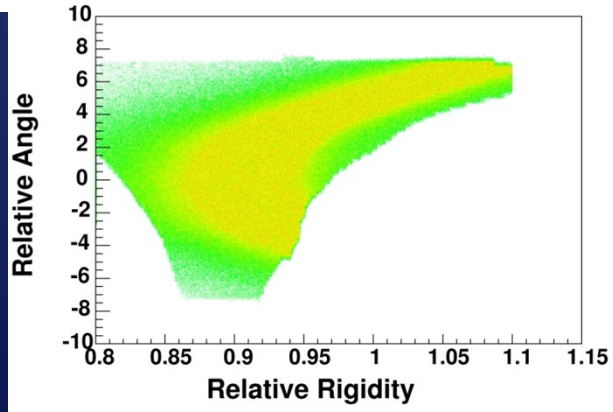


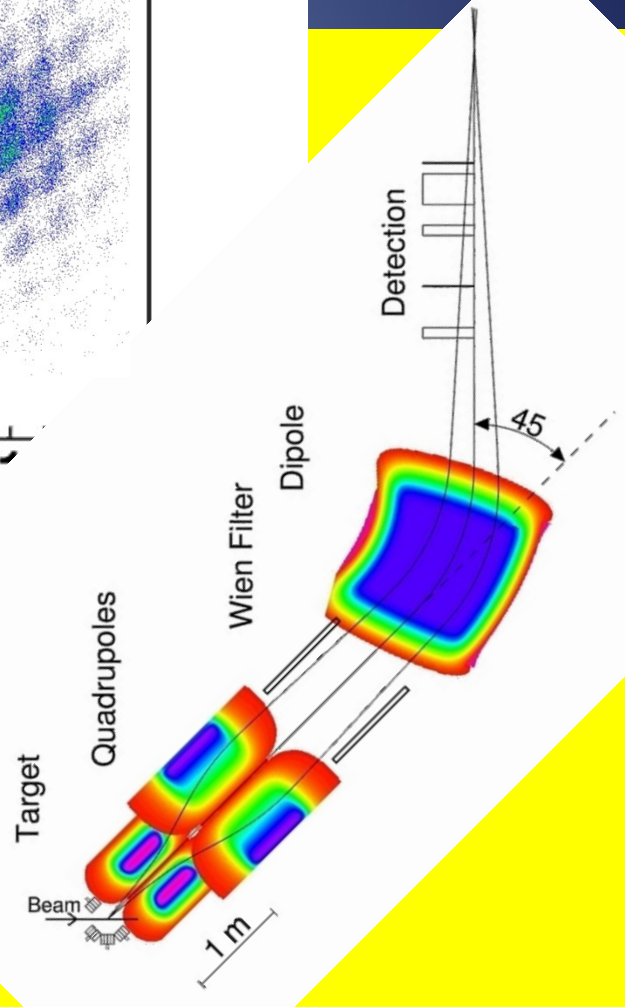

Relative Angle
10
8
6
4
2
0
-2
-4
-6
-8
-10
0.8
0.85
0.9
0.95
1
1.05
1.1
Relative Rigidity

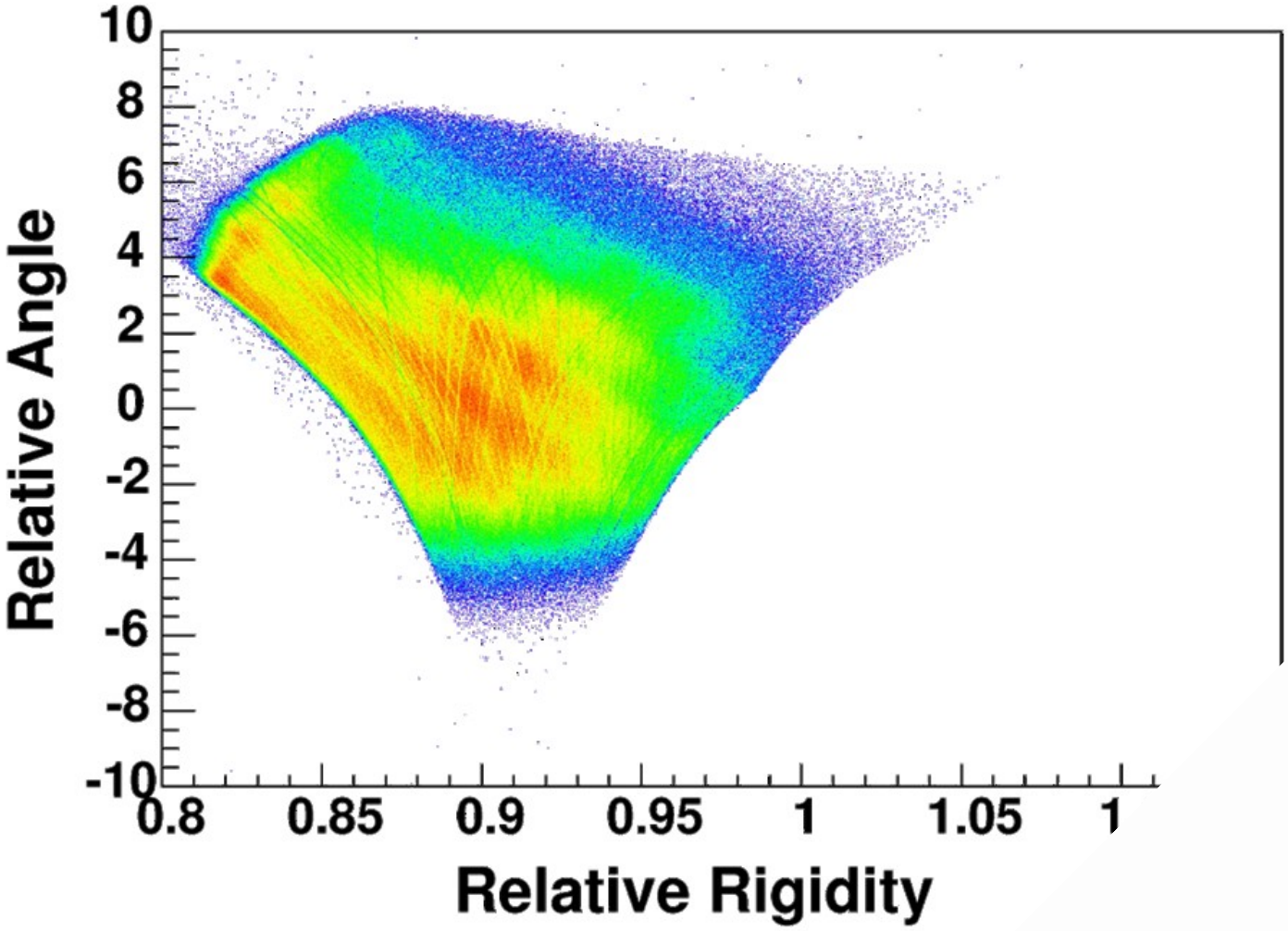

Theta vs. Brho
44
42
40
38
36
34
32
30
28
0.9
0.95
1
1.05
1.1
1.15
1.2

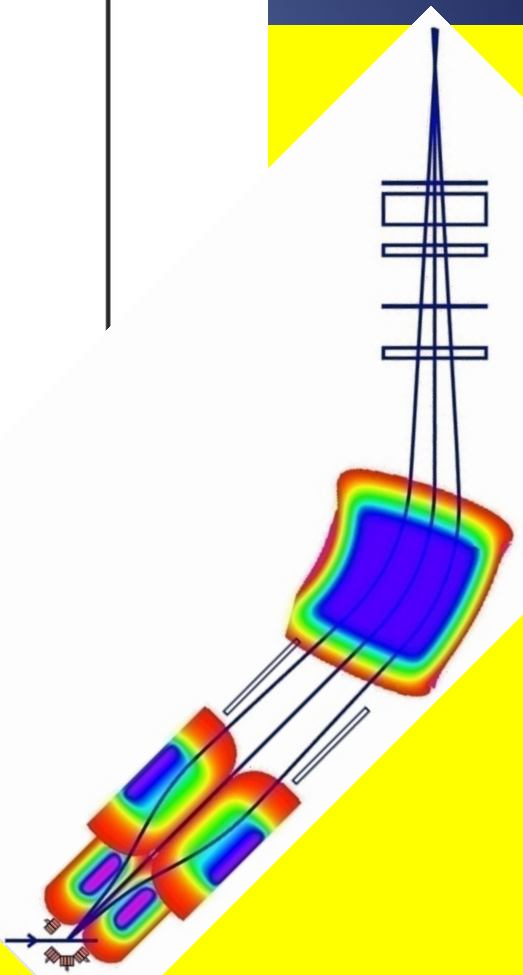

Detection
Dipole
Wien Filter
Quadrupoles
Target
45
Beam
1 m

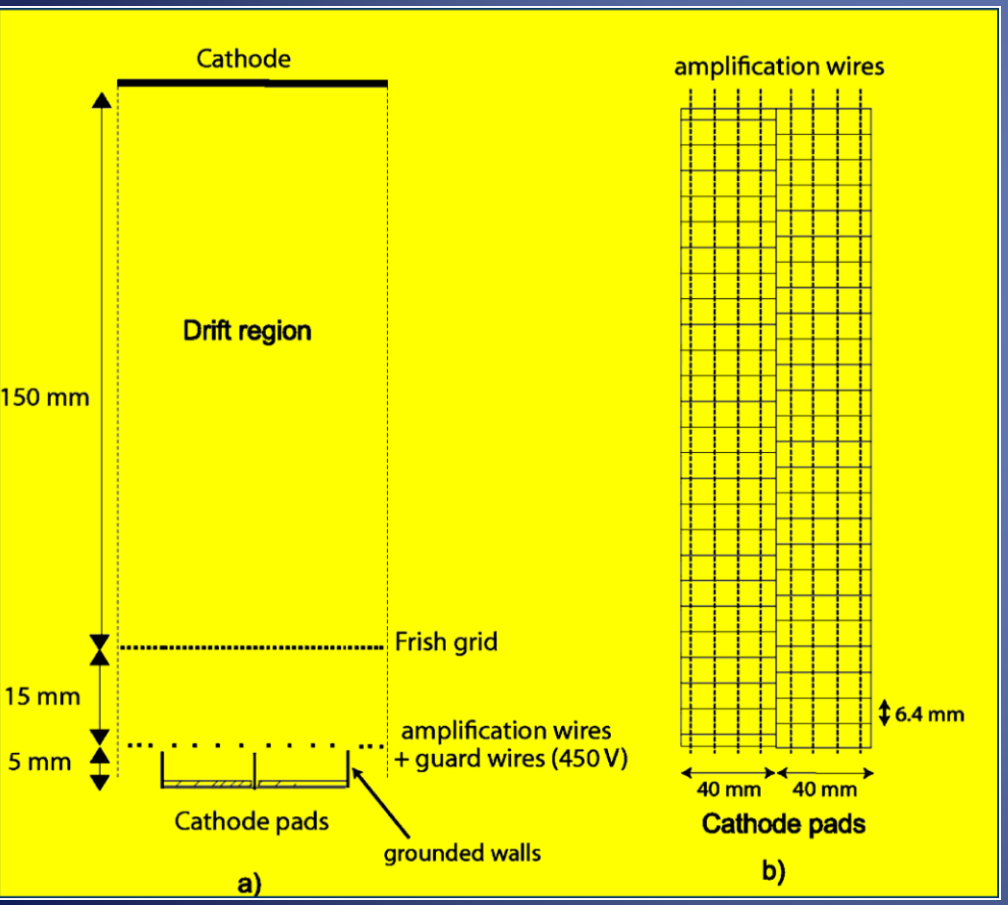

Relative Angle
Relative Rigidity
10
8
6
4
2
0
-2
-4
-6
-8
-10
0.8
0.85
0.9
0.95
1
1.05


Relative Angle
Relative Rigidity
10
8
6
4
2
0
-2
-4
-6
-8
-10
0.8
0.85
0.9
0.95
1
1.05
1.1
1.15


Detection
45
Dipole
Wien Filter
Quadrupoles
Target
Beam
1 m


Relative Angle
10
8
6
4
2
0
-2
-4
-6
-8
-10
0.8
0.85
0.9
0.95
1
1.05
1
Relative Rigidity




Cathode
Drift region
150 mm
Frish grid
15 mm
amplification wires
+ guard wires (450 V)
5 mm
Cathode pads
grounded walls
a)
amplification wires
6.4 mm
40 mm
40 mm
Cathode pads
b)