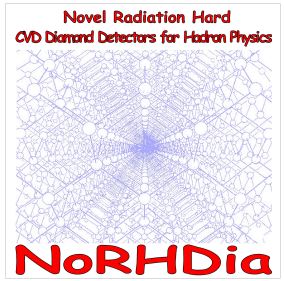

Mapping single-crystal diamond with ^{12}C micro beams

Run Feb 2005

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GSI Darmstadt

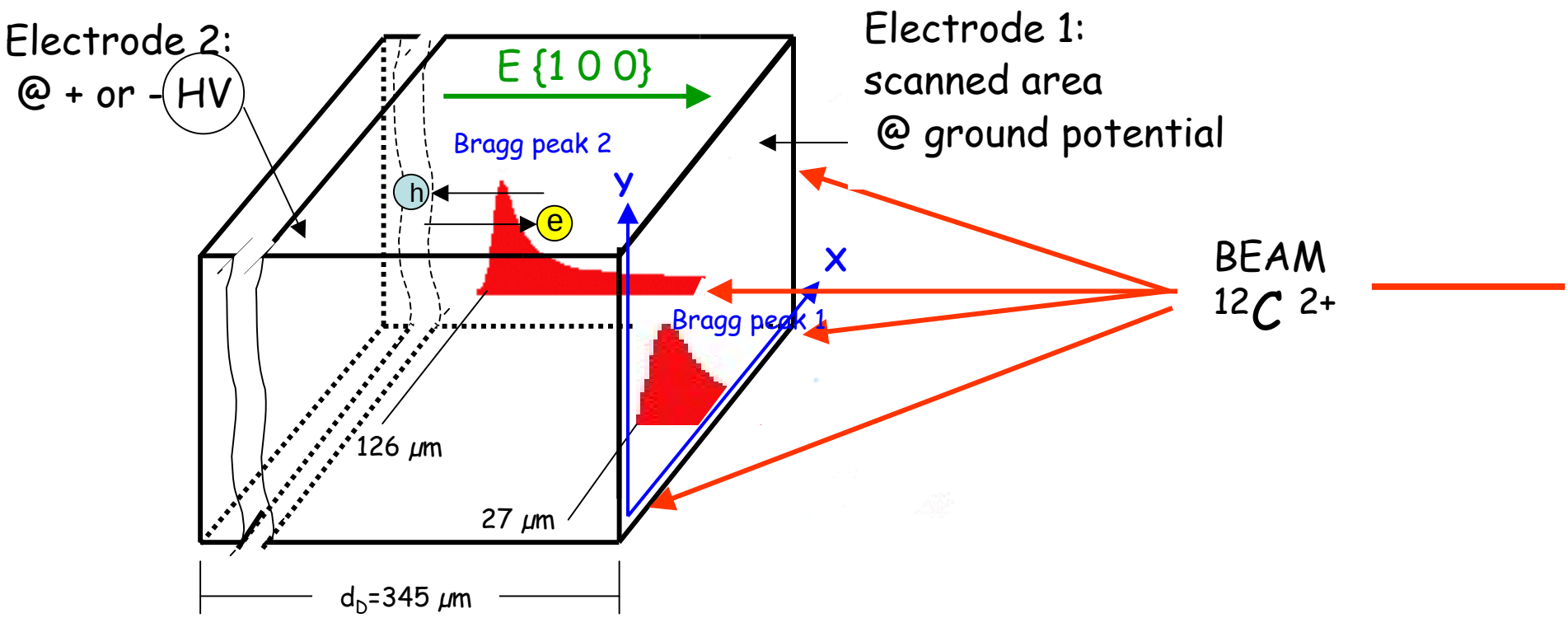
Outline

- Introduction
- Experimental Setup
- Description of experiments done/ Calibration
- Principle of data treatment: example $\Rightarrow$ PC-CVD
- SC-CVDD maps
- Energy resolution for stopped HIs
- SRIM Calculations
- Conclusions and Outlook

Introduction

➡ Spectroscopy at Bragg-Peak

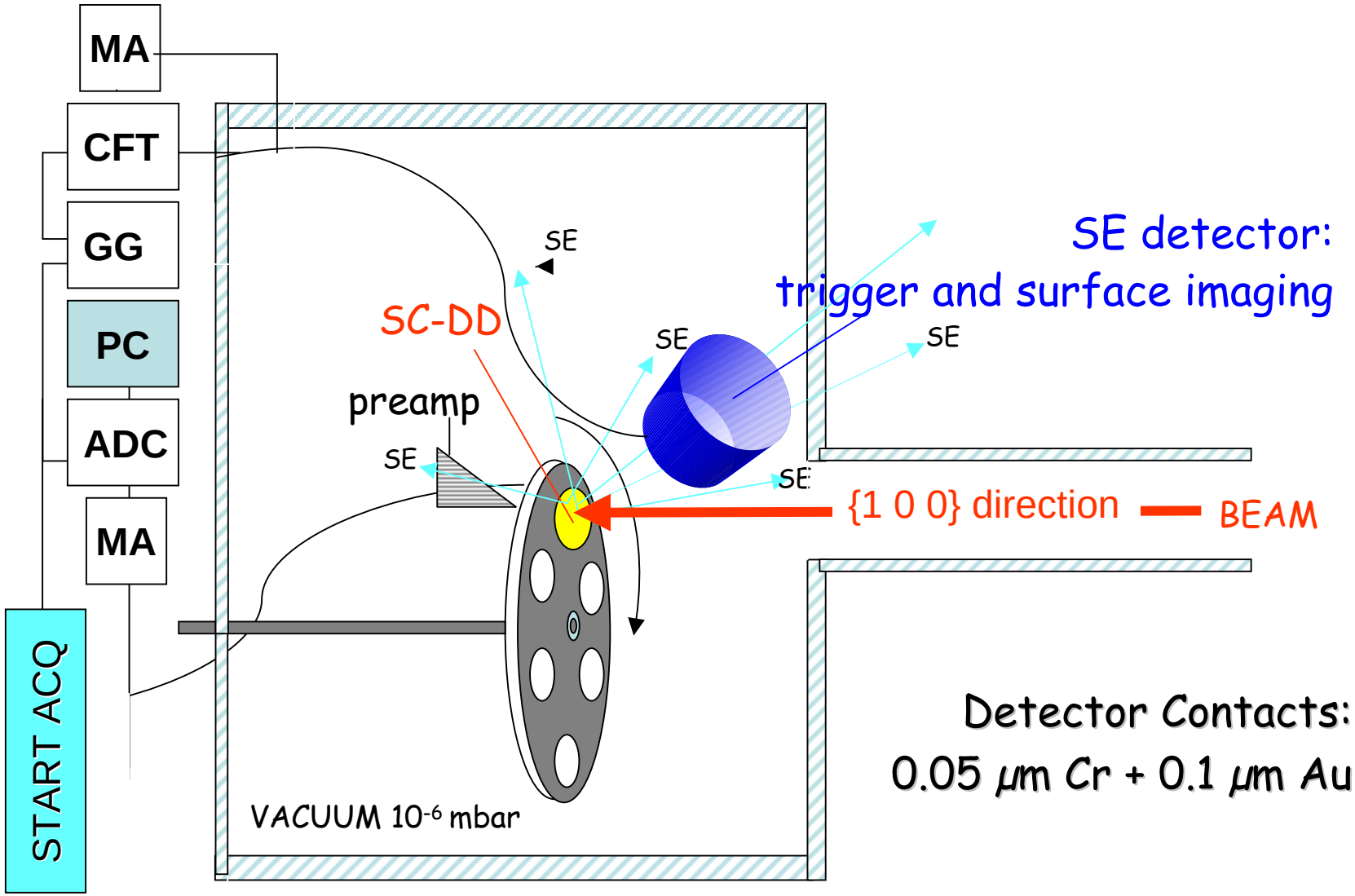
➡ XY scanning and Tuning of the beam energy



Measured Parameter : Amplitude ~ $E_{meas}^{deposit}$ ~ Q_{meas}

Quality parameter: Peak_E and ΔE(FWHM)/E

Experimental Setup



Description of measurement I

- Ion Beam $\Rightarrow$ $^{12}C^{2+}$ of two different energies
  - E_{low} = 3.6 A MeV ; E_{high} = 9.515 MeV/amu
- Irradiated areas $\Rightarrow$ 140 x 93 μm^2; 93 x 60 μm^2

Ranges in "Diamond": ^{12}C, ρ = 3.52 g/cm^3

for the reaction $\Rightarrow$ ^{12}C (^{12}C, ^{12}C) ^{12}C

27 μm 126 μm

Mistake: $\Rightarrow$ we irradiated not exactly the same region!

Description of measurement II

- Beam contaminations with ions of same velocity and A/Q of primary beam (if any) can be used for precise energy calibration:

$^{12}C^{2+}$ corresponds to $^{18}O^{3+}$

(Private communication accelerator people:
≈ 0.6% of $^{18}O^{3+}$ ⇒ is known for this case!)

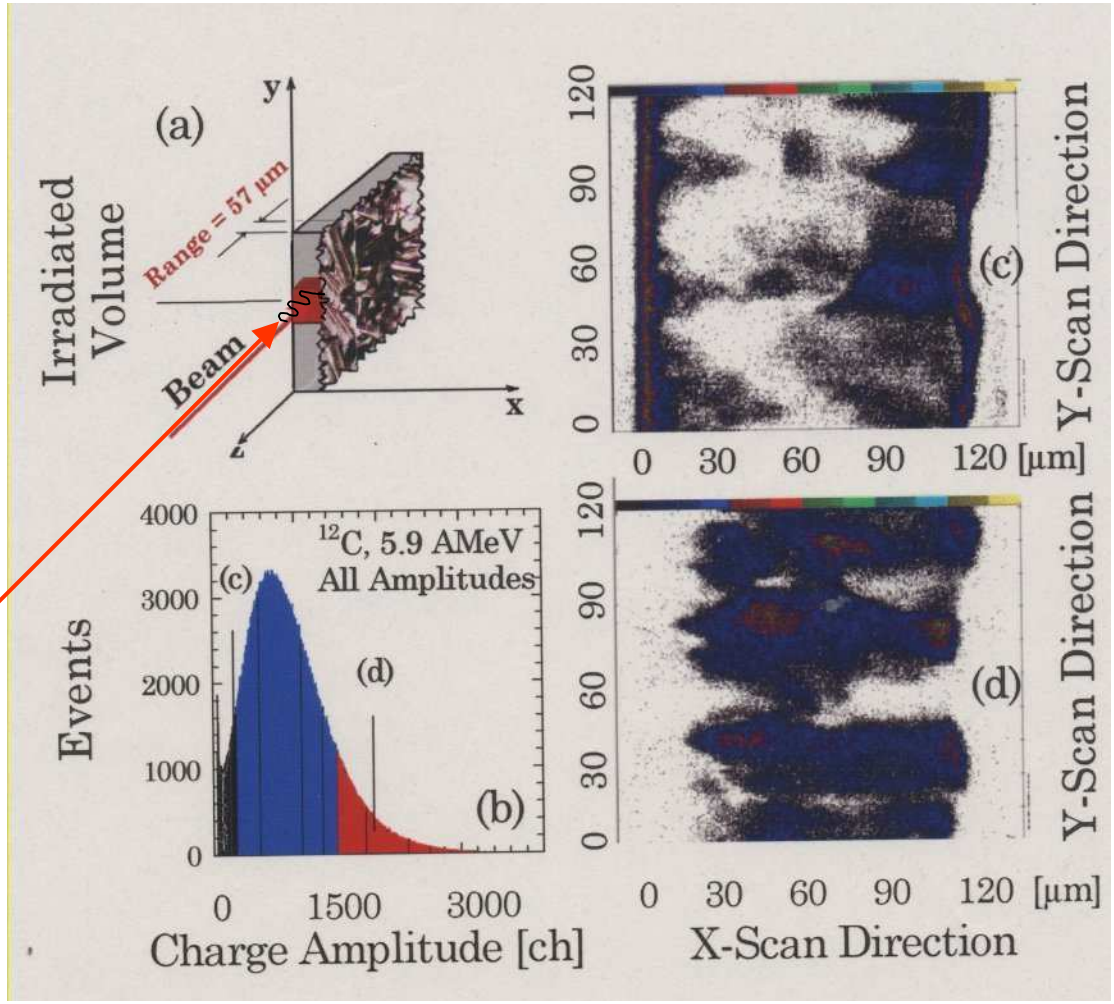
Big Advantage ⇒ reaction $^{12}C\,(^{18}O, ^{18}O)\,^{12}C$

Principle of data treatment

PC-CVDD, irradiated with ^{12}C, 5.9 AMeV ⊥ to the growth direction

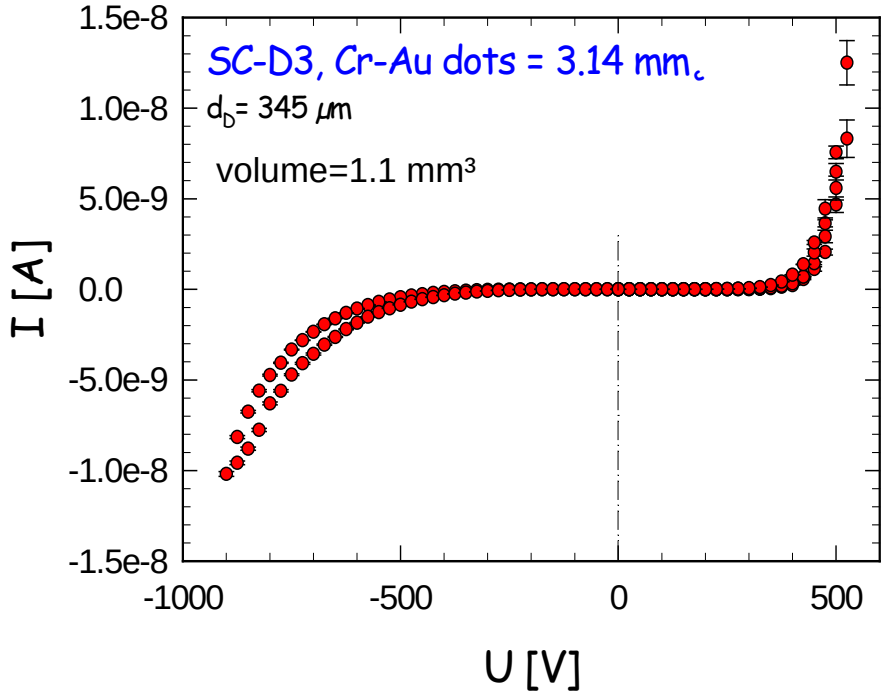
cleaved,
"as grown" sample,
d = 120 µm

scanned beam

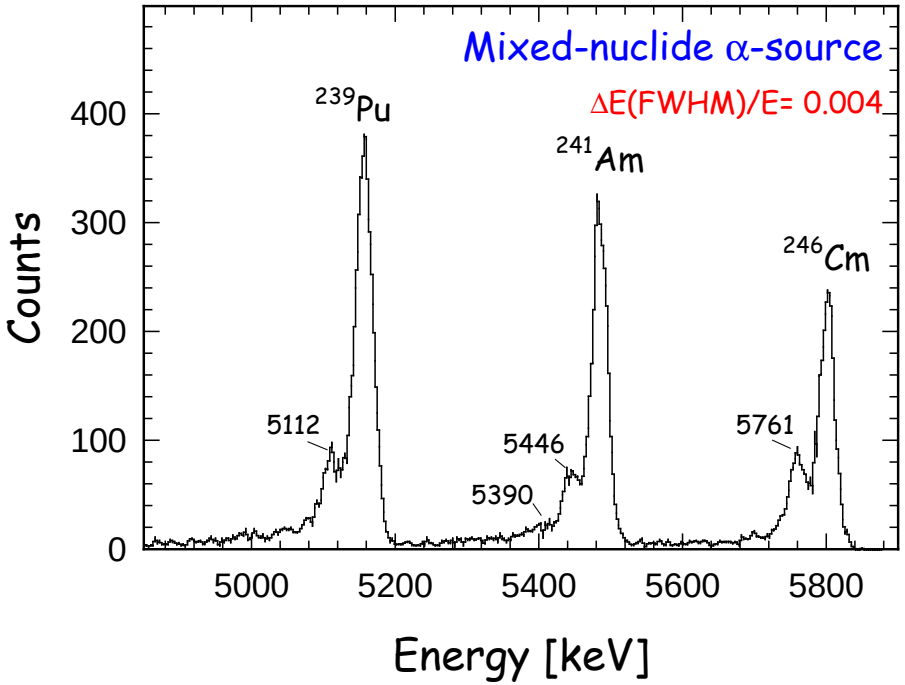


Characteristics of the sample to test: E6-D3, d =345 µm, sandwitch-dot ∅ 2 mm

1. IV Behaviour

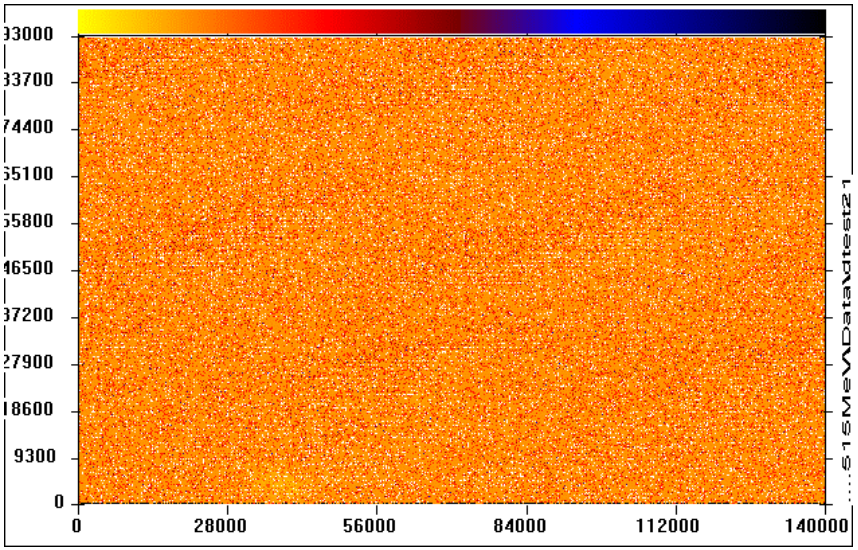


2. Energy Resolution



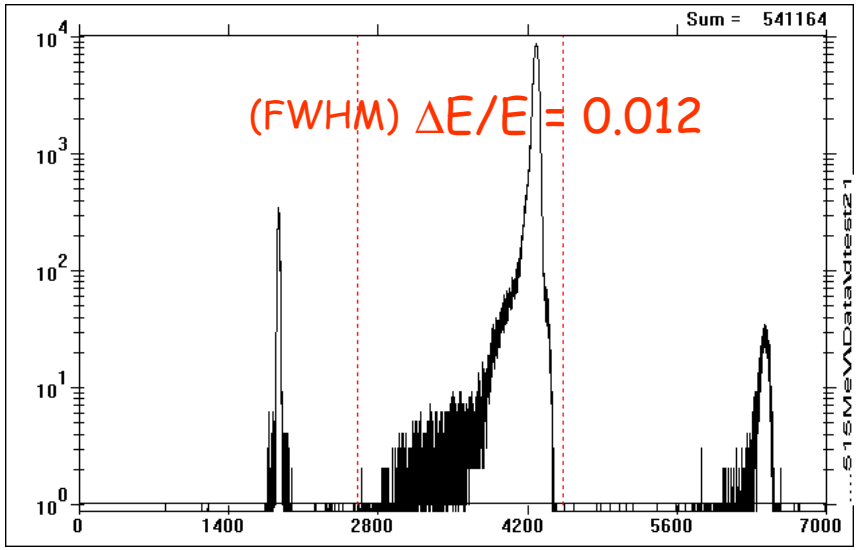
Collected-charge maps: ^{12}C, 3.6 AMeV Detector @ - 400 V (all data)

E_1 = 3.6 AMeV



Map
at 27 ± 10 μm depth
(all ^{12}C data)

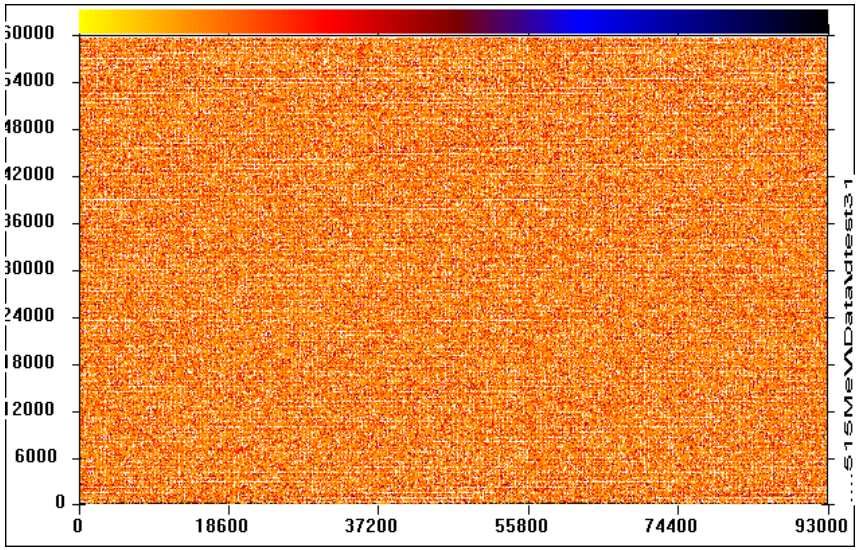
E_1 = 3.6 AMeV



Energy spectrum
at 27 ± 10 μm depth
(all ^{12}C data)

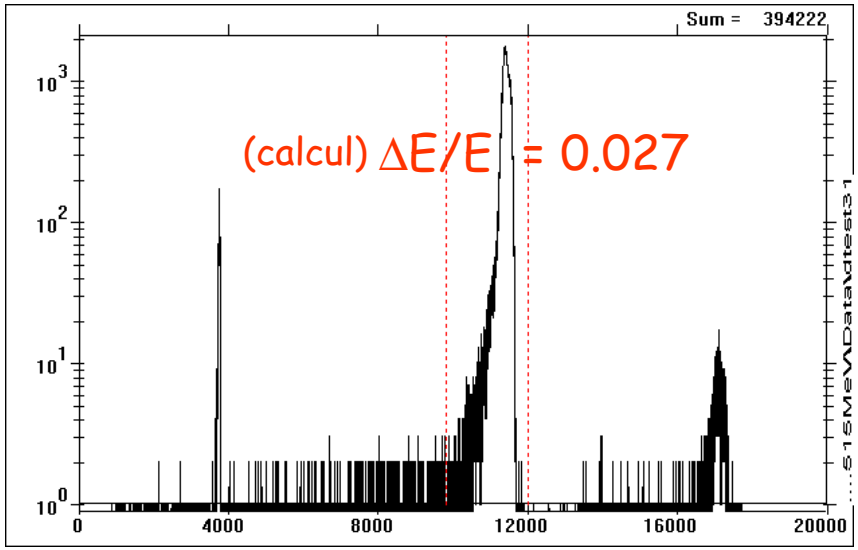
Collected-charge maps: ^{12}C, 9.515 AMeV Detector @ - 400 V (all data)

E_2 = 9.515 AMeV



Map
at 126 ± 7 µm depth
(all ^{12}C data)

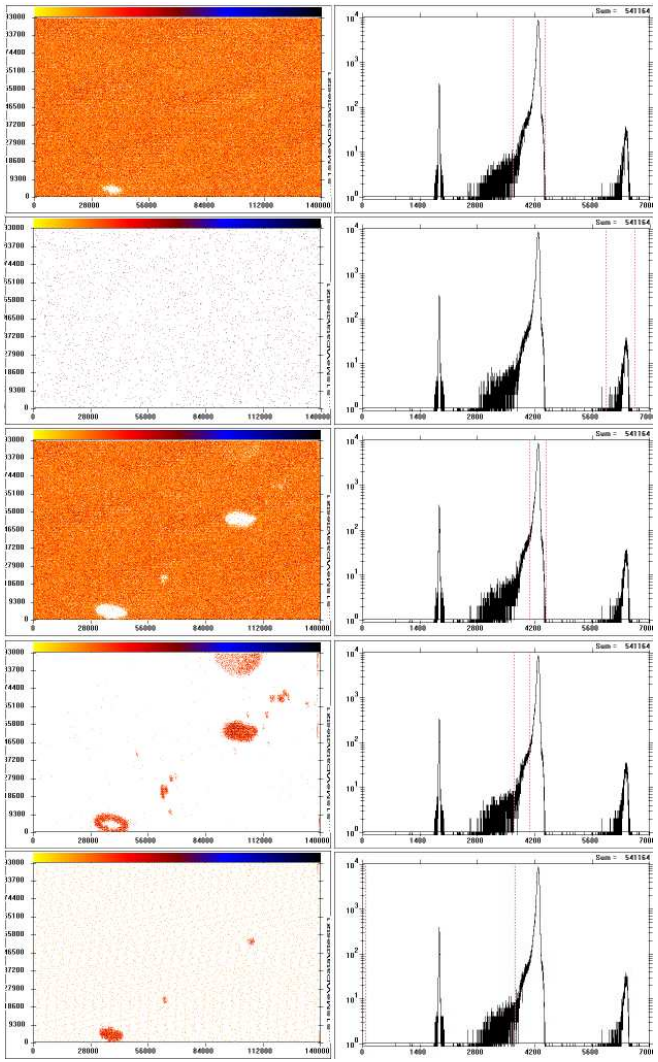
E_2 = 9.515 AMeV



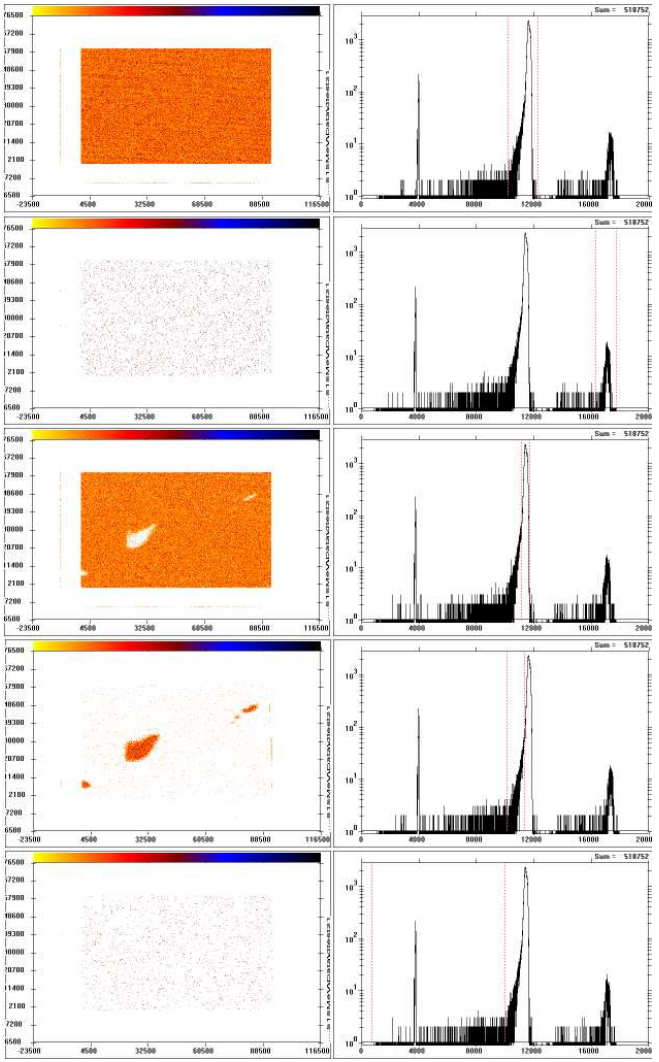
Energy spectrum
at 126 ± 7 µm depth
(all ^{12}C data)

General position dependence of the E-spectra

E1 = 3.6 AMeV

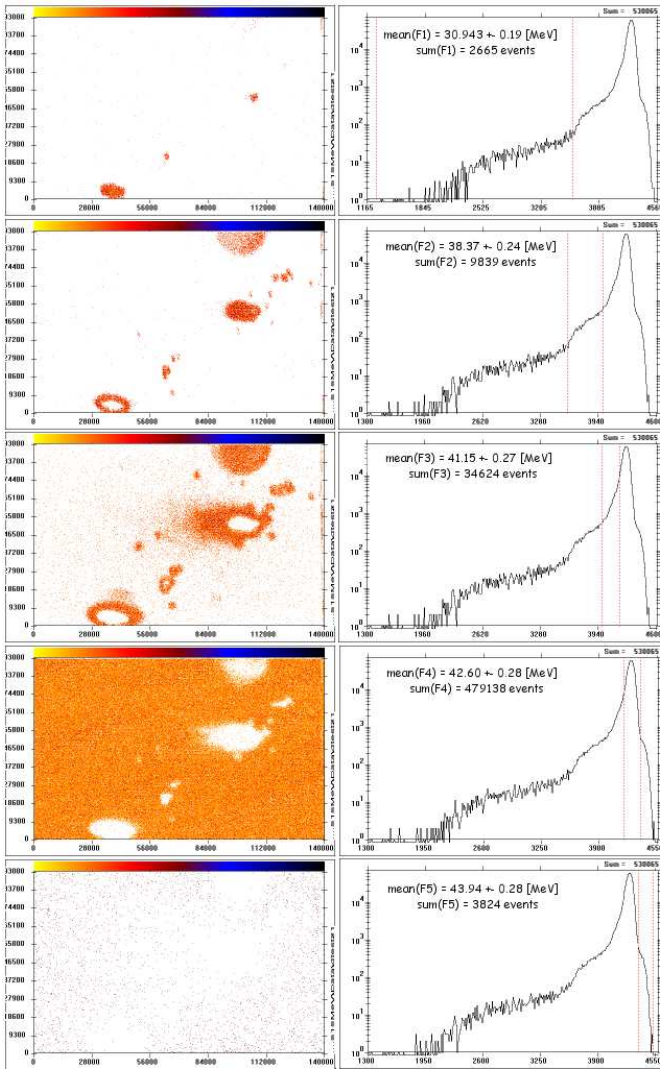


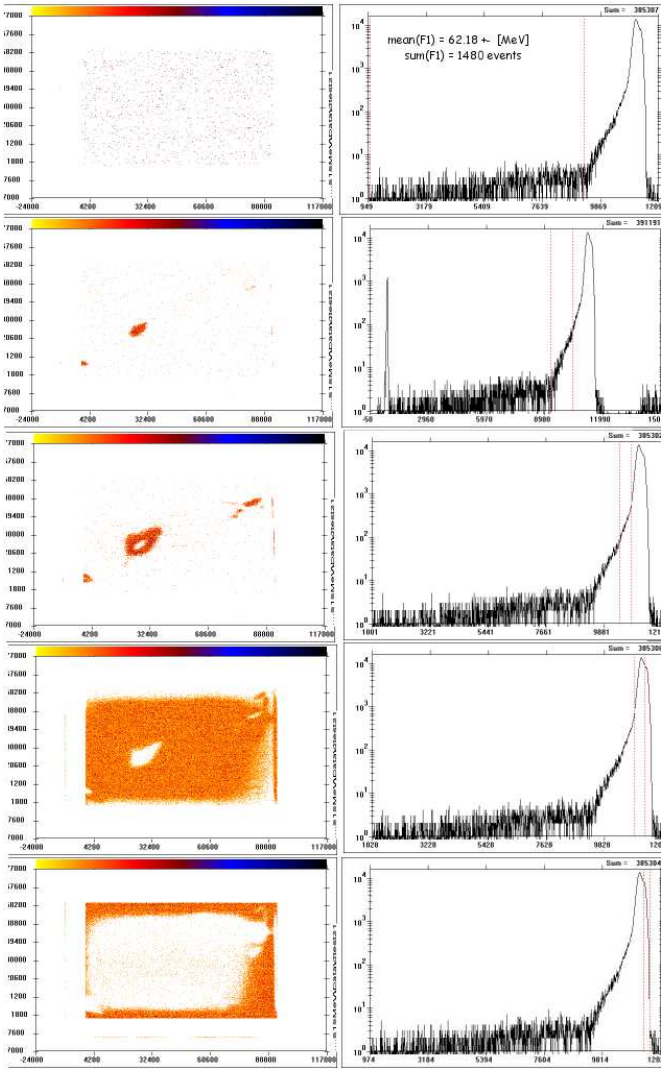
E2 = 9.515 AMeV



Scanning the energy spectra step by step

3.6 AMeV (ΔE_corr)

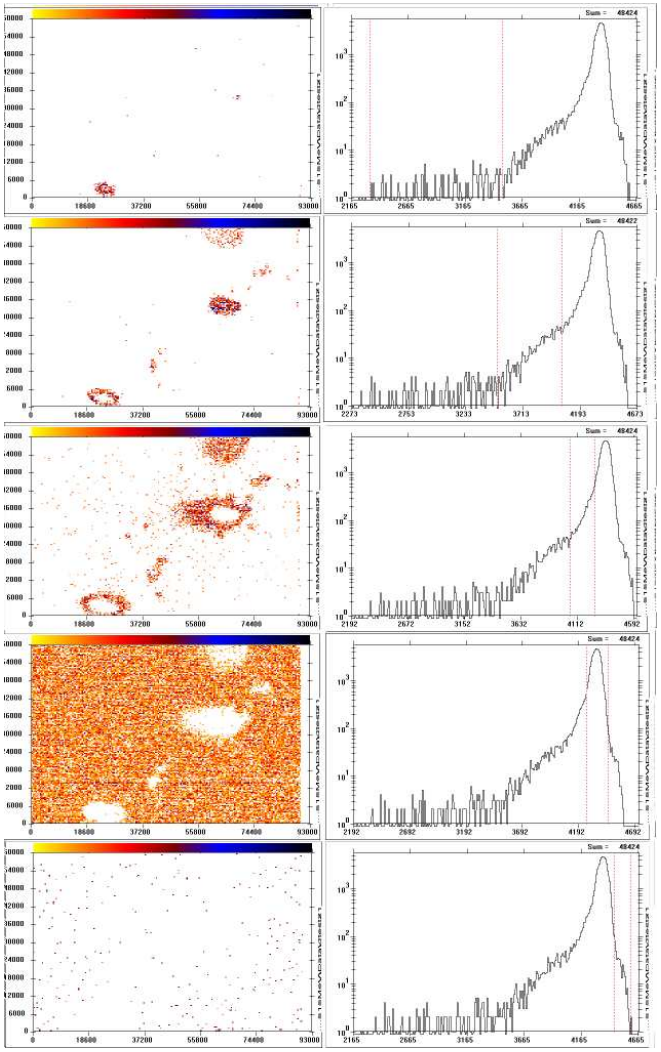


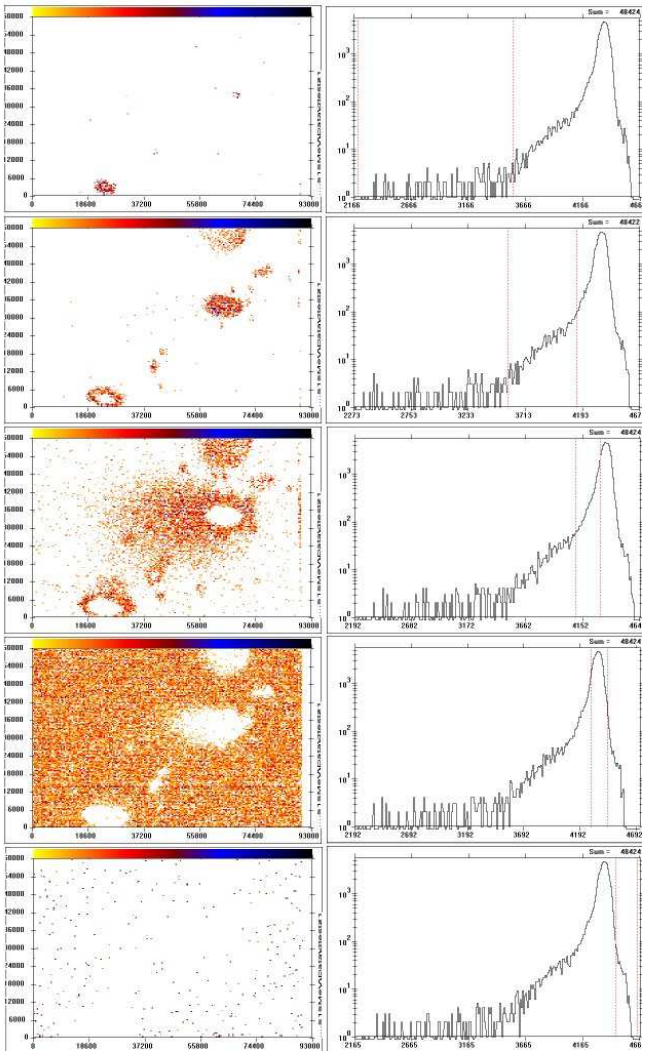


9.515 AMeV-Zoom (ΔE_corr)

Radiation damage/Micro Pumping ?

Scan 1

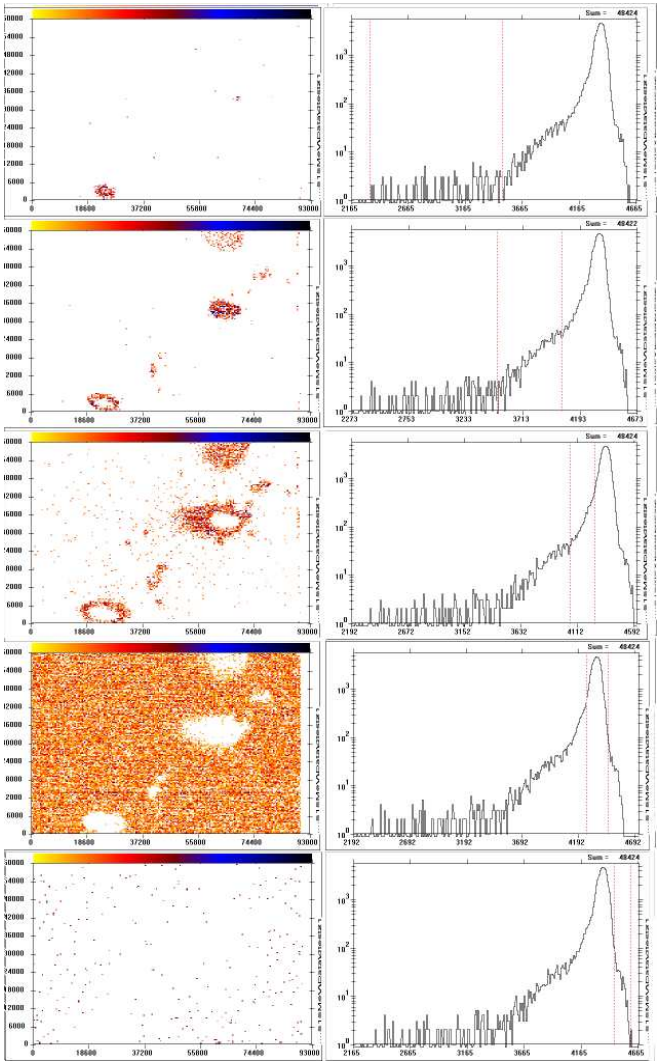


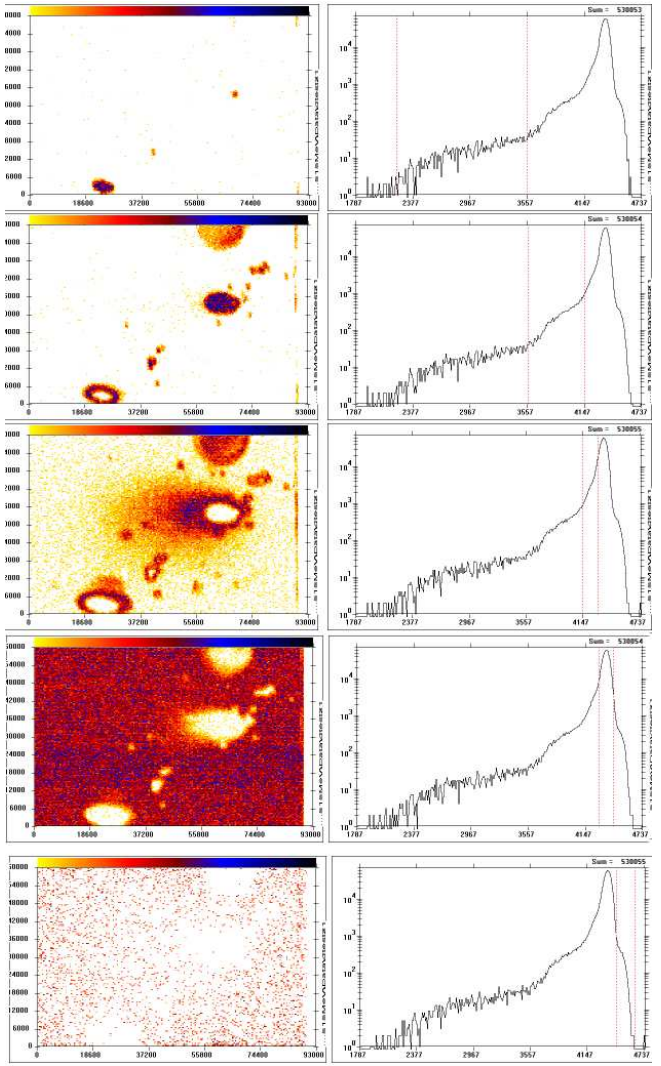


Scan 11

Radiation damage/Micro Pumping ?

Scan 1

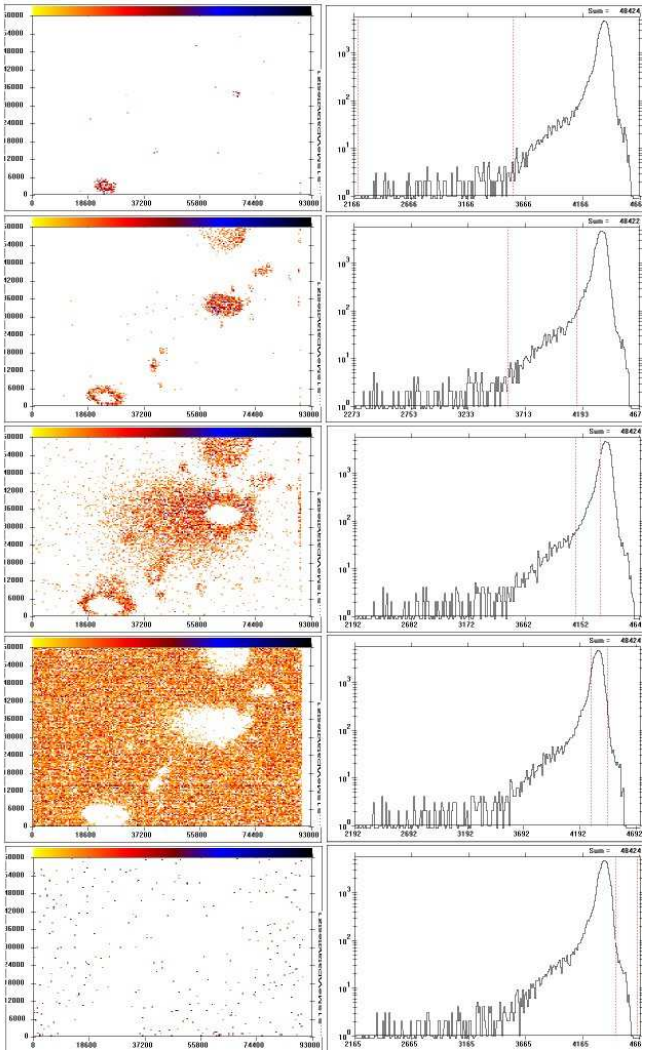


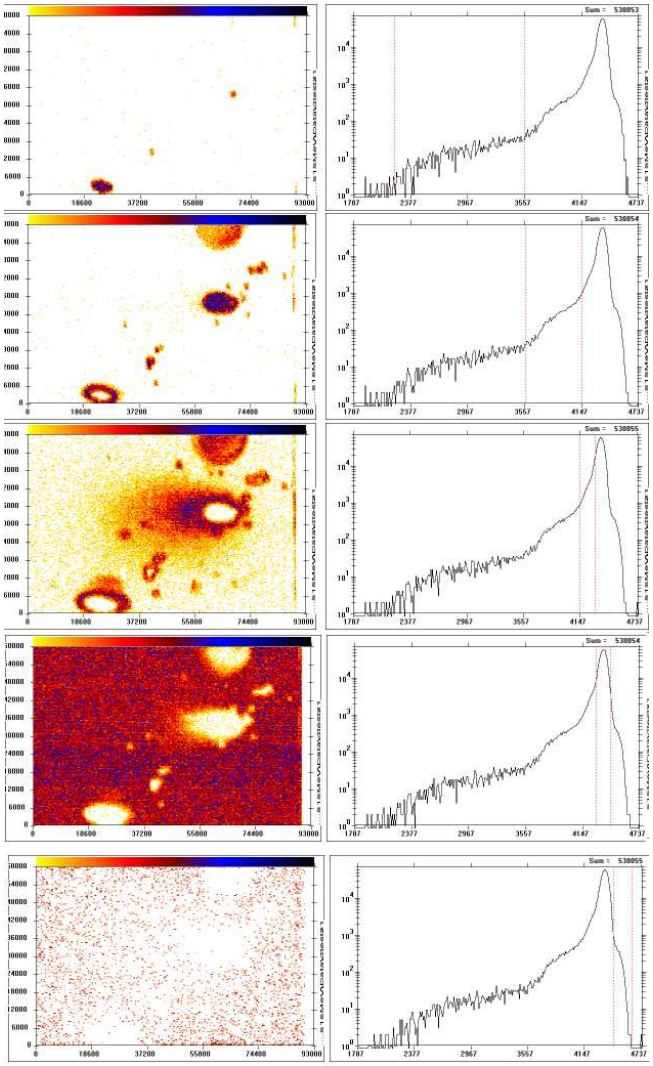


Scan all data

Radiation Damage/ Micro Pumping ?

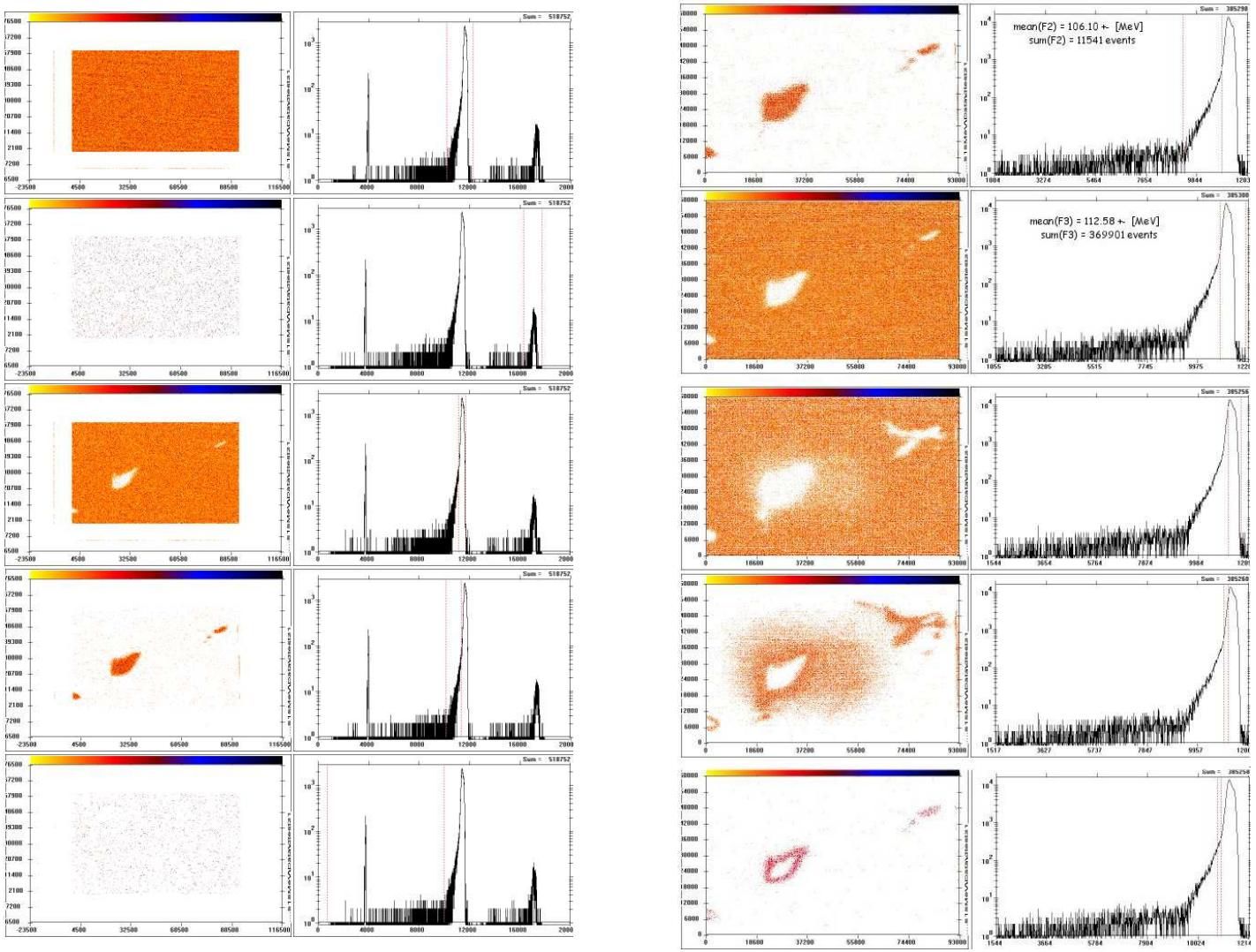
Scan 11





Scan all data

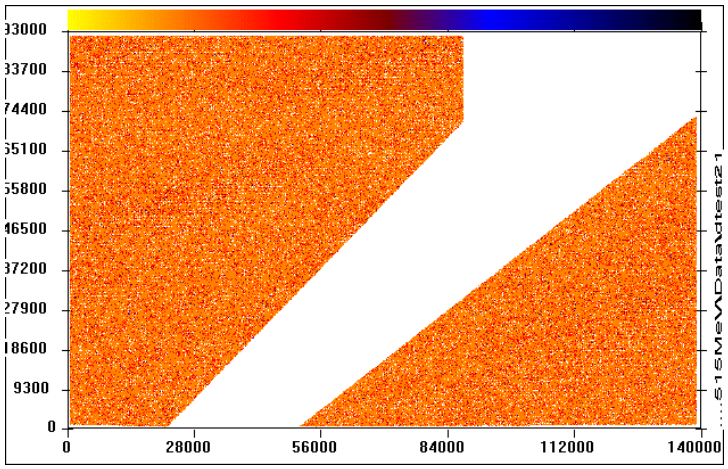
A closer view to the spots of E_2 = 9.515 A MeV

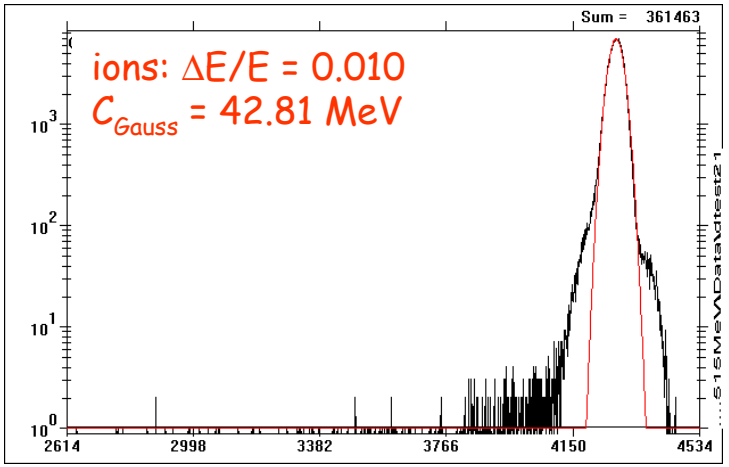


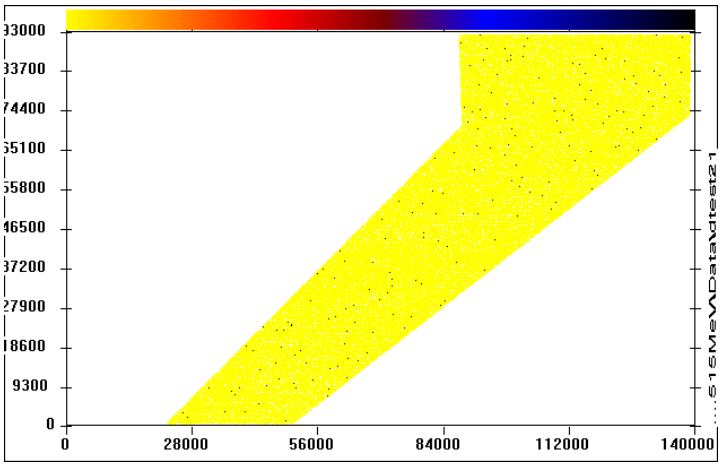
Energy Resolution: ^{12}C, 3.6 AMeV

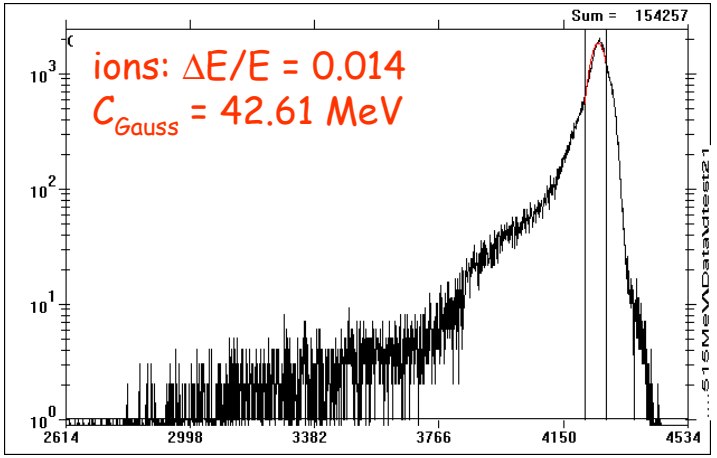
Energy deposit E1* = 42.91 MeV

(@ FWHM)





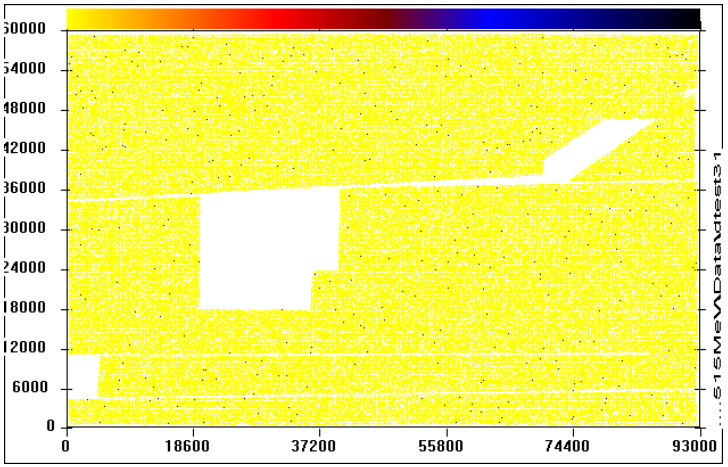


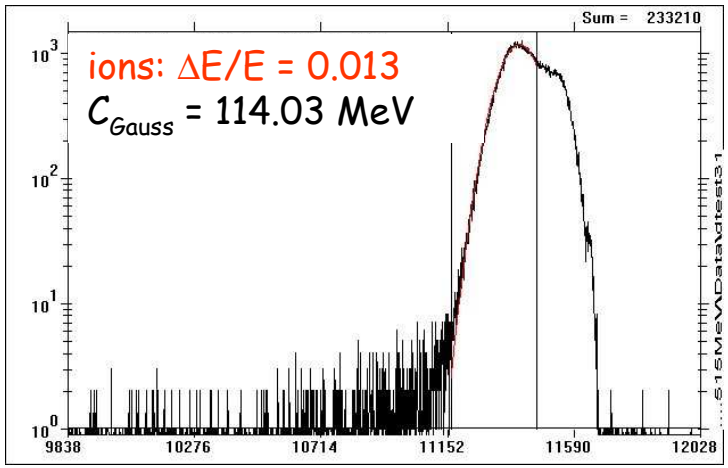


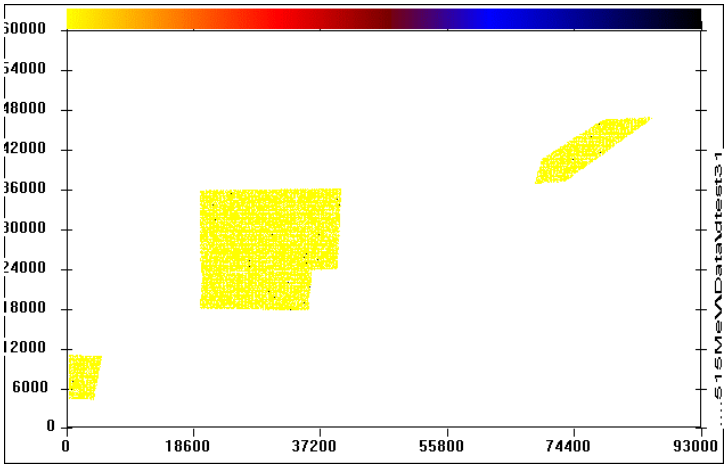
Energy Resolution: ^{12}C, 9.515 AMeV

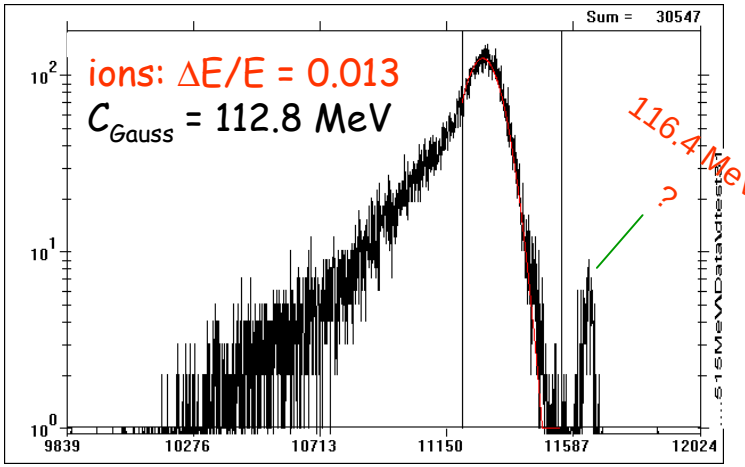
Energy deposit E2* = 114.013 MeV

(@ FWHM)



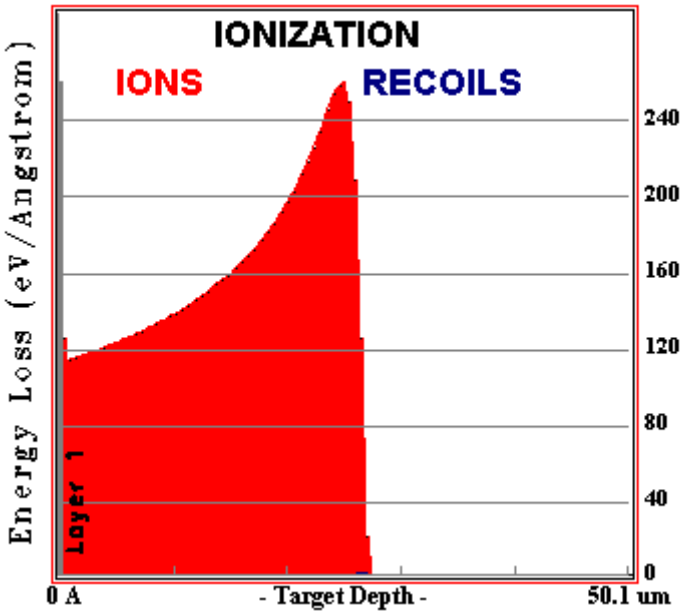




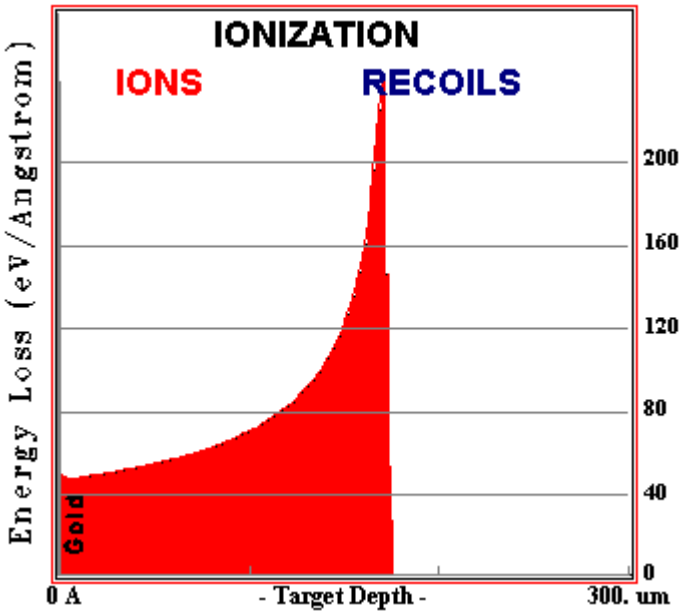


SRIM2003 Calculations $^{12}C(^{12}C\ ^{12}C)\ ^{12}C$

3.6 AMeV



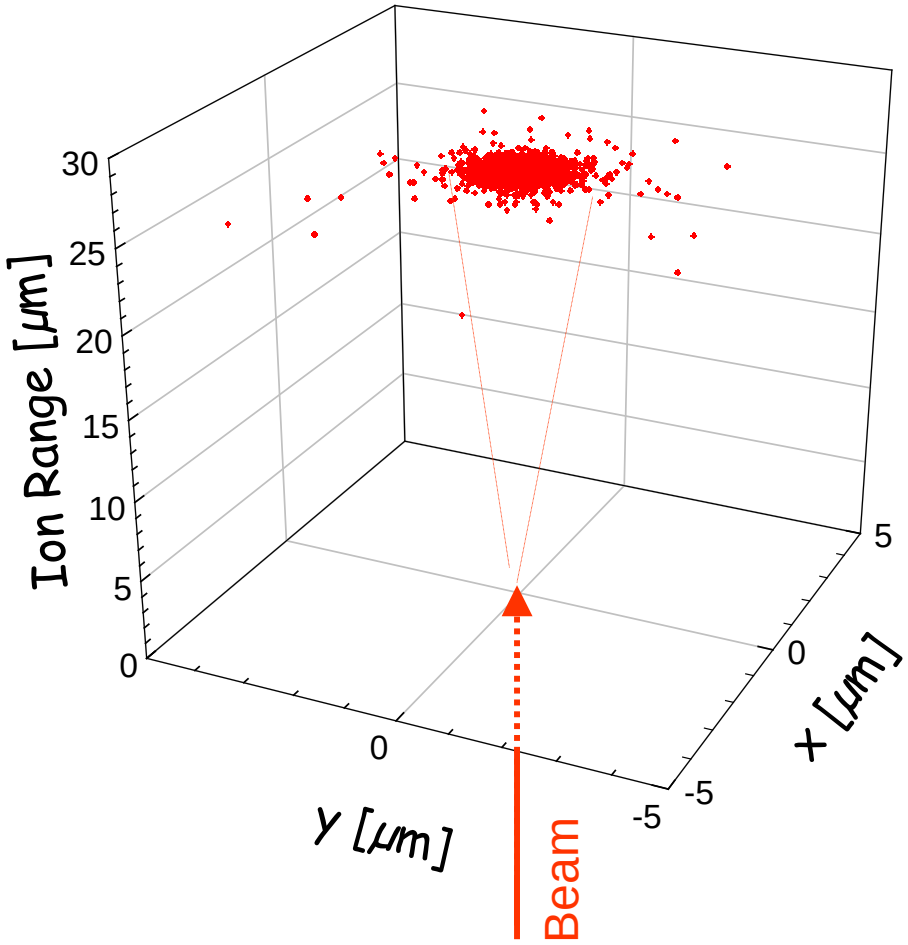
11.4 AMeV



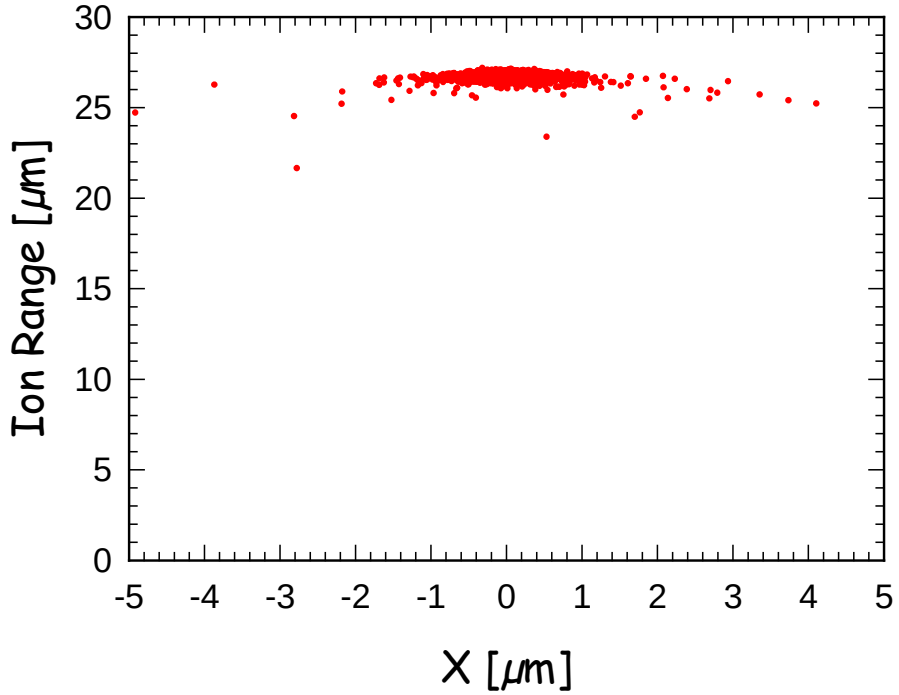
Ion Range and Spread (SRIM2003) :

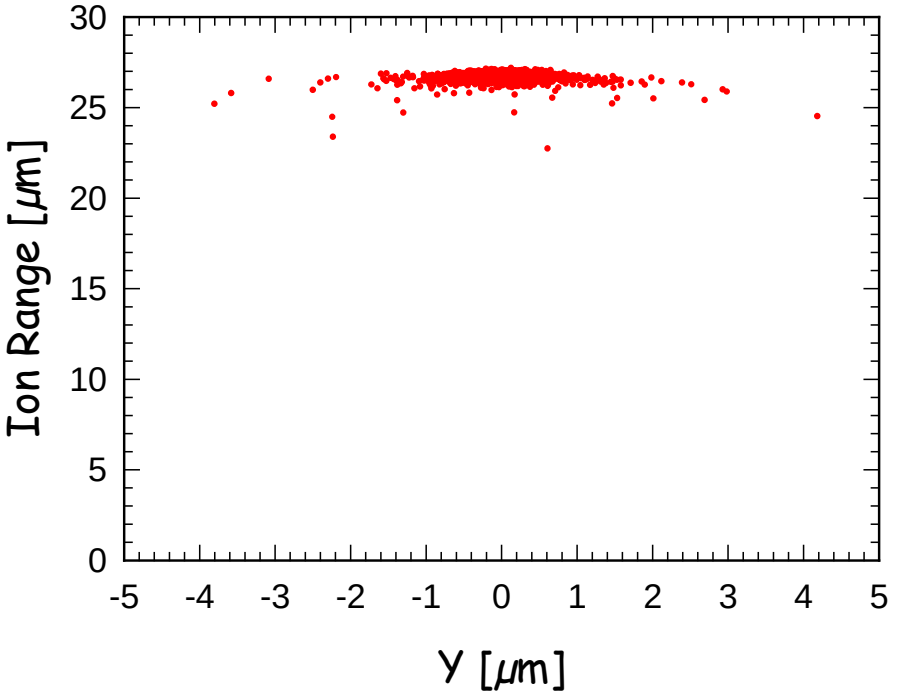
10^4 events $\Rightarrow$ $^{12}C(^{12}C\ ^{12}C)\ ^{12}C$; E = 3.6 AMeV

after 0.1µm Au + 0.05 µm Cr + 300 µm ^{12}C (ρ=3.52 g/cm^3)



Projected Ion Range





Conclusions and Outlook from this ⇒ PRELIMINARY Analysis

- For a real HI beam ⇒ SC-CVDD is homogeneous
  - Spectroscopic Grade (SG) material.
- Limits of ΔE microbeam investigations:
  - Missing energy difficult to be localized along the particles track, except in case of high-resolution surface imaging (SE-D).
- The experiment (+ setup) must be improved
- A lot more analysis is needed to understand all pecularities observed.
- However, Micro-Beams are a powerful tool for SC-DD characterisation