Approaching the p-process path:

α-scattering of radioactive Sn nuclei

Francisco G. Barba

HIE-ISOLDE Physics Workshop 2023

Thursday, 25th May 2023

Outline

Motivation

- p-nuclei and α-nuclear potentials

IS698 Setup

- Beam, target and detectors

Preliminary results

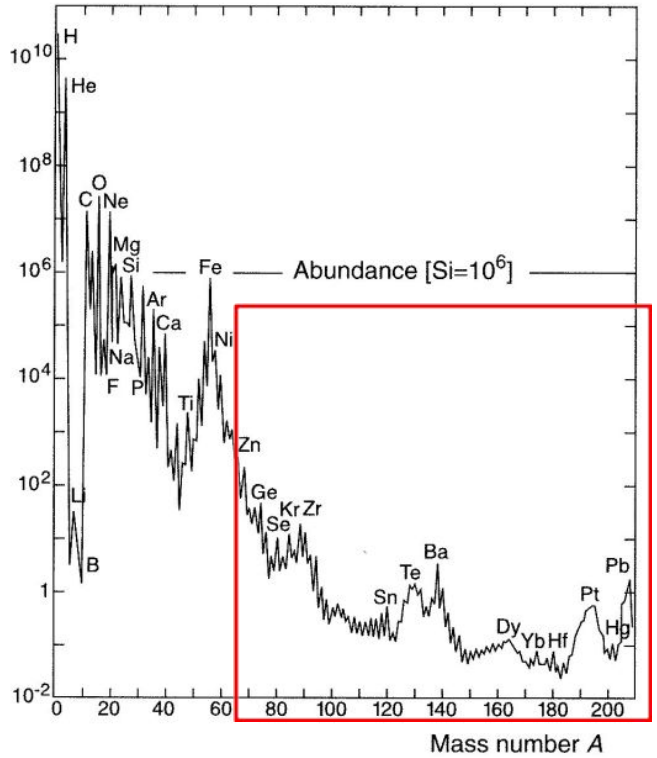
- Pilot beam
- Target behaviour
- Preliminary cross section

Outlook on future experiments

Motivation

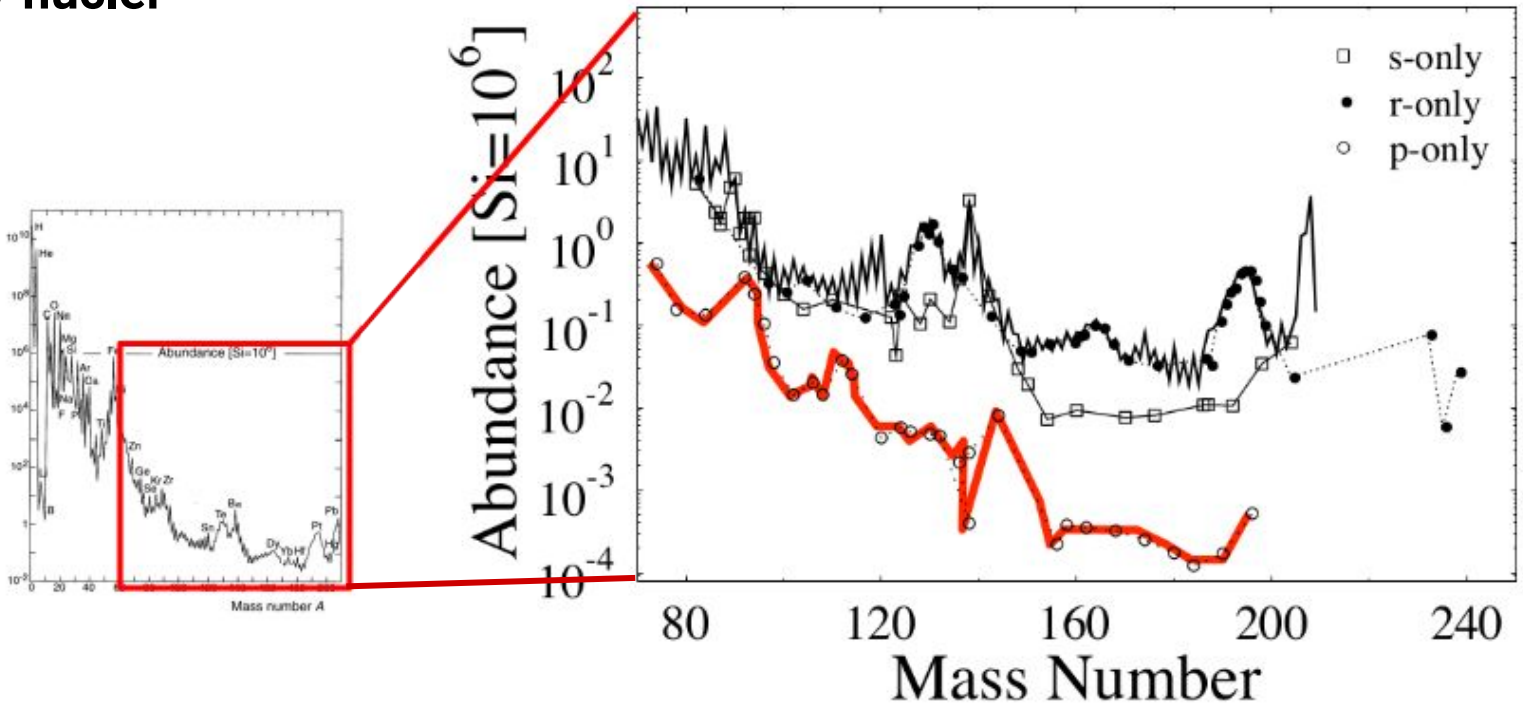
Solar Abundance Distribution (SAD)

- Bulk of elements:
  - BBN
  - Fusion phase
- Heavy elements:
  - **Neutron capture** processes



Motivation

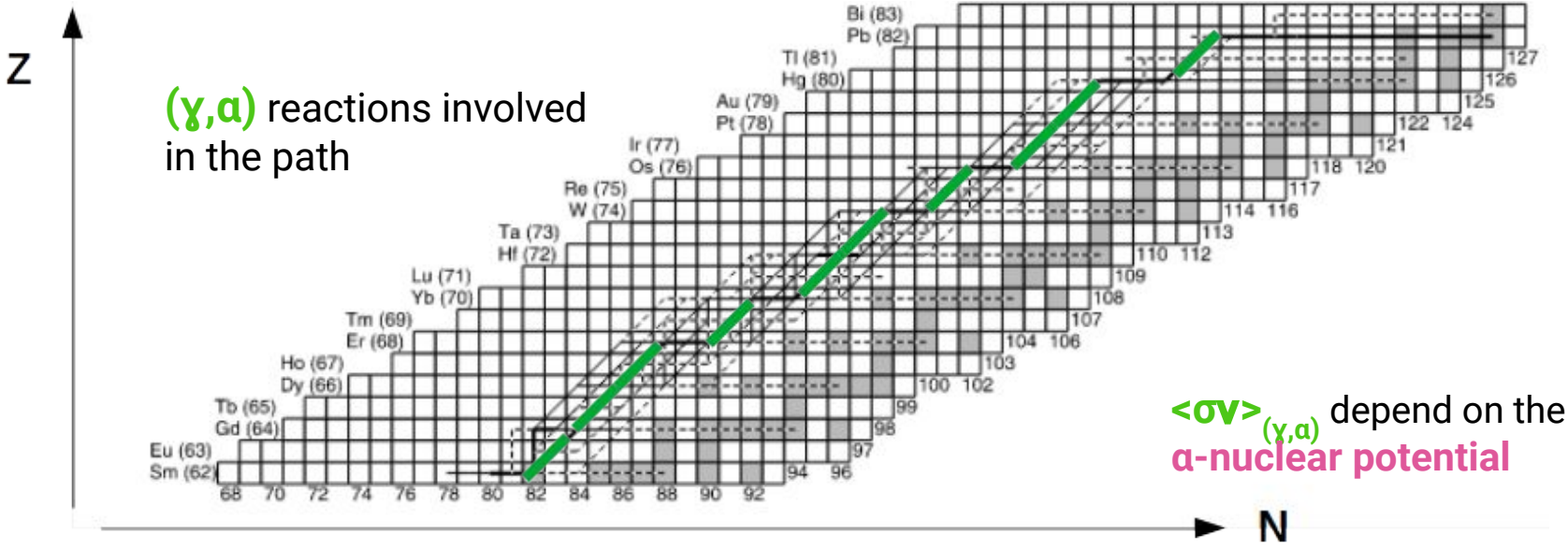
p-nuclei



Motivation

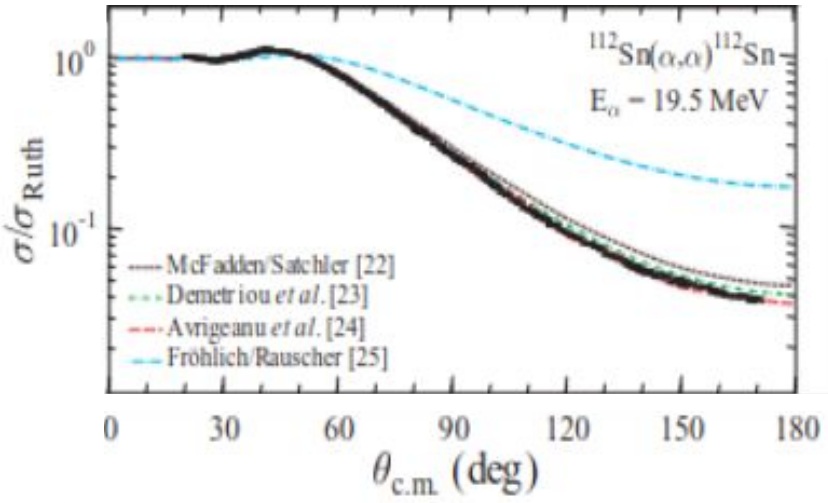
Sensitivity studies of gamma Process

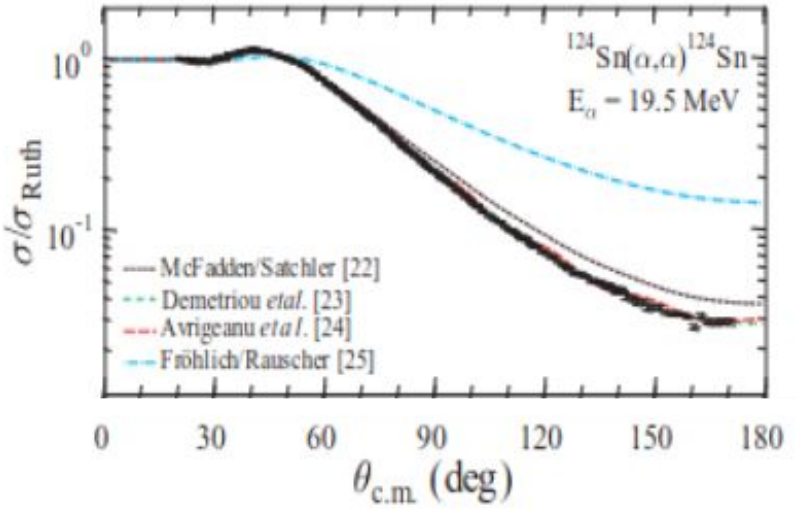
W. J. Rapp et al., Astrophys. J 653, 474 (2006)



Motivation

α-nuclear potentials: elastic scattering



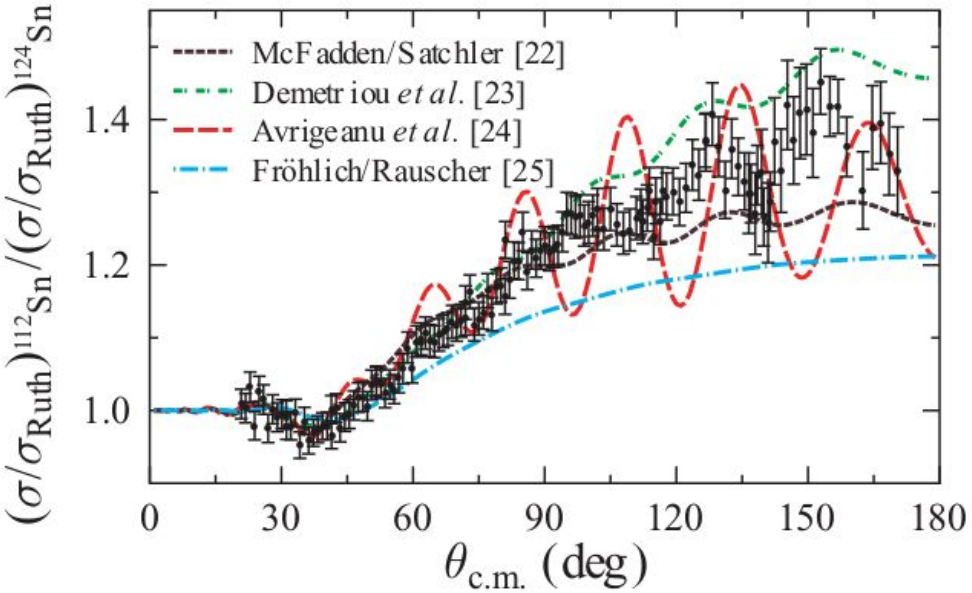


D. Galaviz et al, PRC71, 0650802 (2005)

Motivation

α-nuclear potentials: elastic scattering

Mass dependence in stable Sn isotopes



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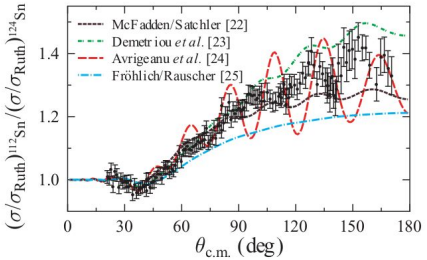
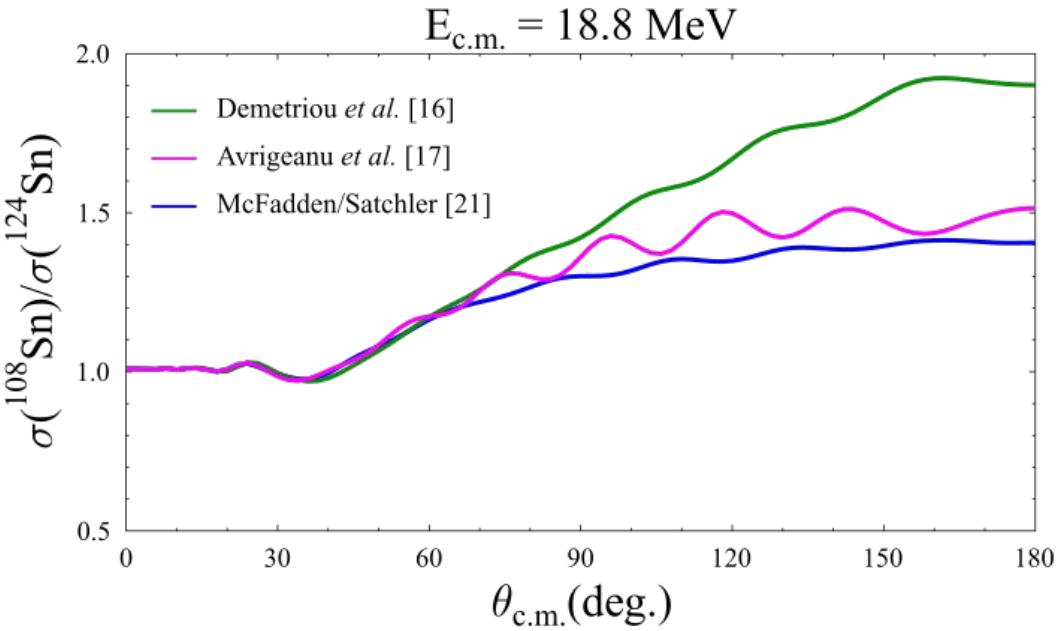


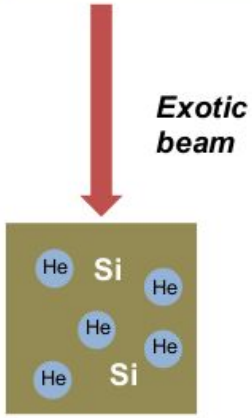


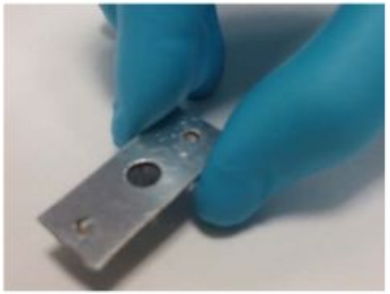
Motivation

Magnetron Sputtering
Si/He thin films

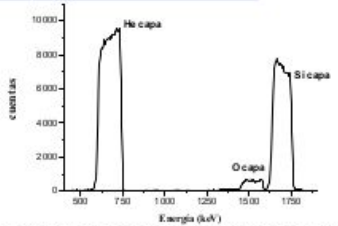
Elastic Scattering in
inverse kinematics

	GODINHO et al. (MS)	Vanderbist et al. (Ionic Implant.)	Raabe et al. (Ionic Implant.)	Ujic et al. (Ionic Implant.)
Metal (10^{15} at/cm^2)	9250 (Si)	1200 (Al)	4200 (Al)	1200 (Al)
He (10^{15} at/cm^2)	4060	275	270	130
O (10^{15} at/cm^2)	700	60	100	??

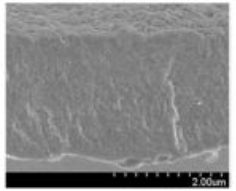




Self-supported Si:He target



RBS spectrum of Si:He target using 2,0 MeV protons and 165° scattering angle

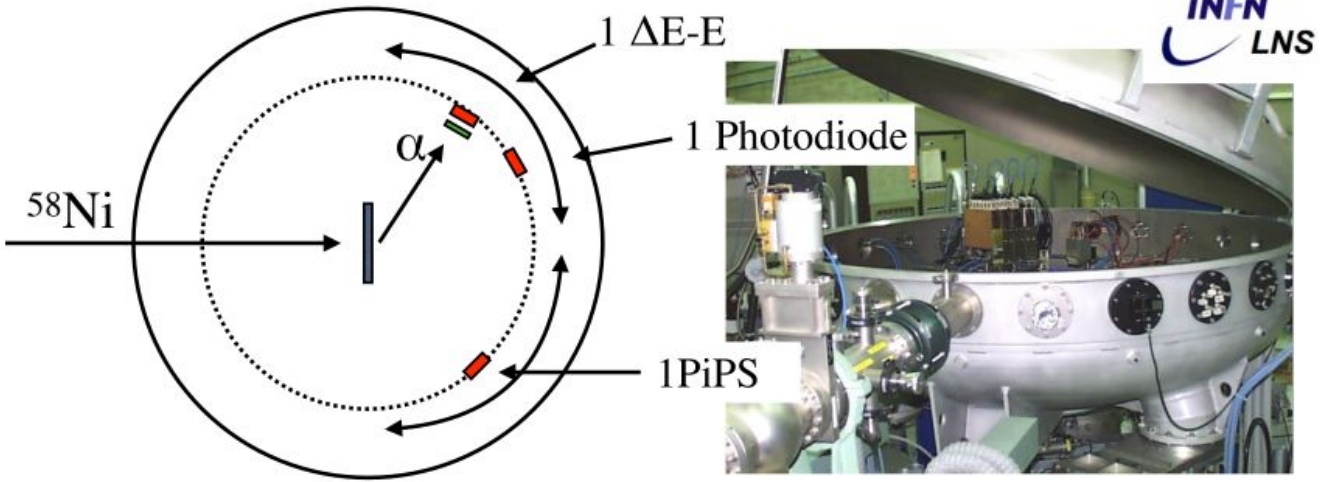


SEM corss section of the Si:He target

V. Godinho *et al.*, ACS Omega 2016, 1 (6), 1229 (2016)

Motivation

- Performed at INFN/LNS
- Developed in the framework of an stable beam experiment proposed at the CT2000 scattering chamber



Motivation

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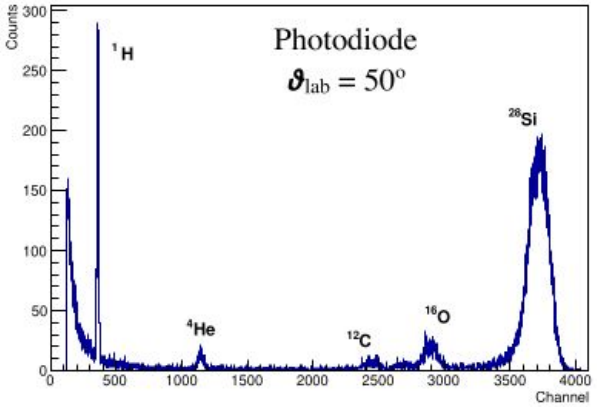
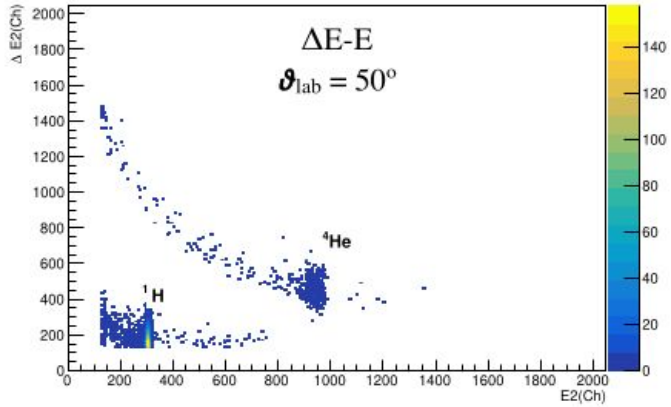
$^{4}He(^{58}Ni,\alpha)^{58}Ni$ @ 150 MeV

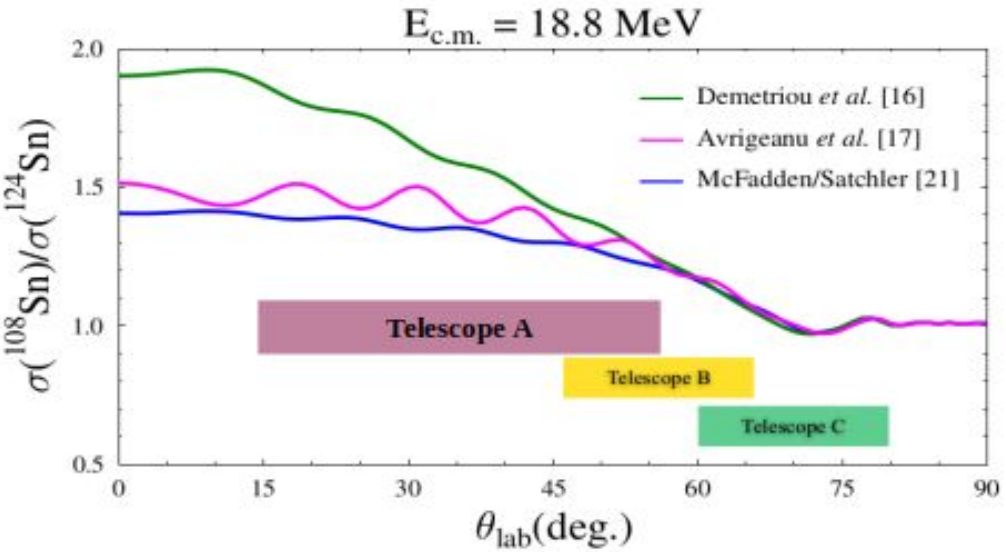




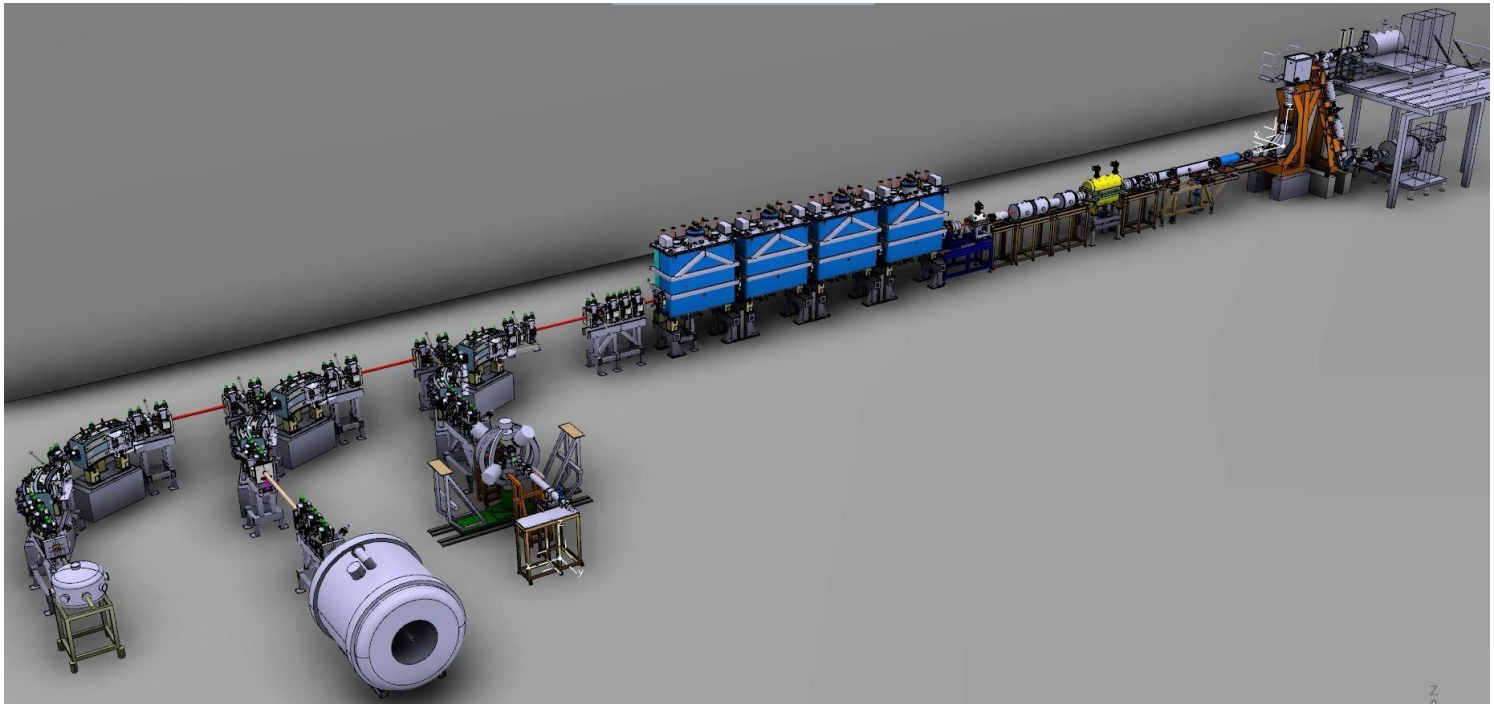
IS698 Proposal

Measurement of the $^{4}He(^{A}Sn, ^{4}He)^{A}Sn$ in inverse kinematics at the same $E_{c.m}$

mass dependance of **α-nuclear potentials** along the Sn isotopic chain



Setup



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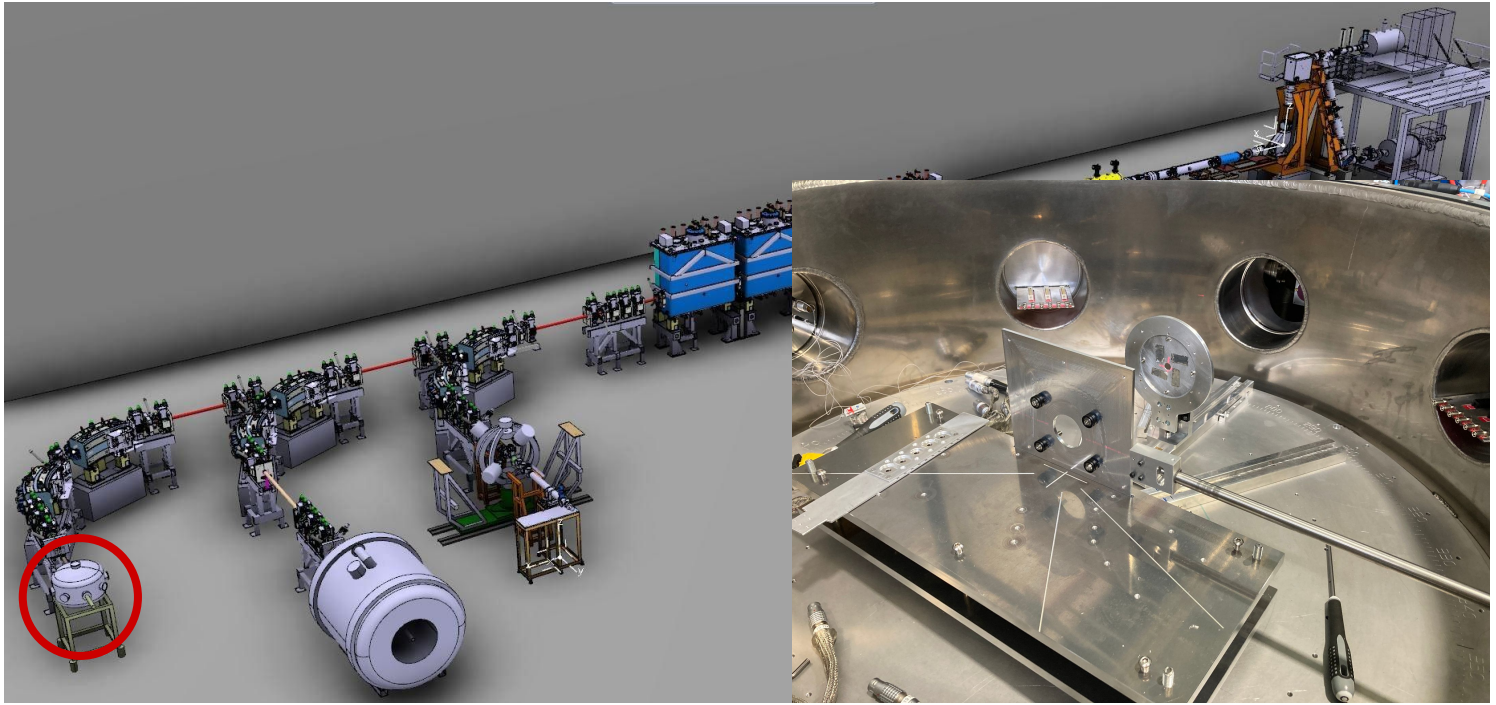

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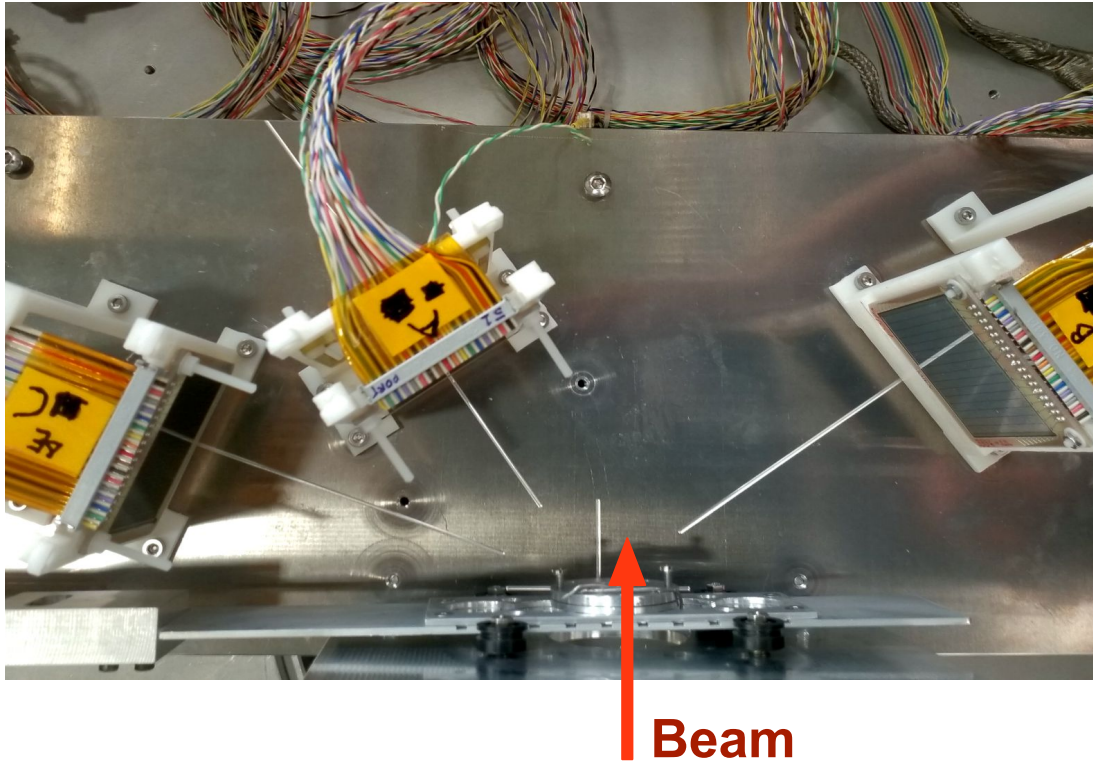
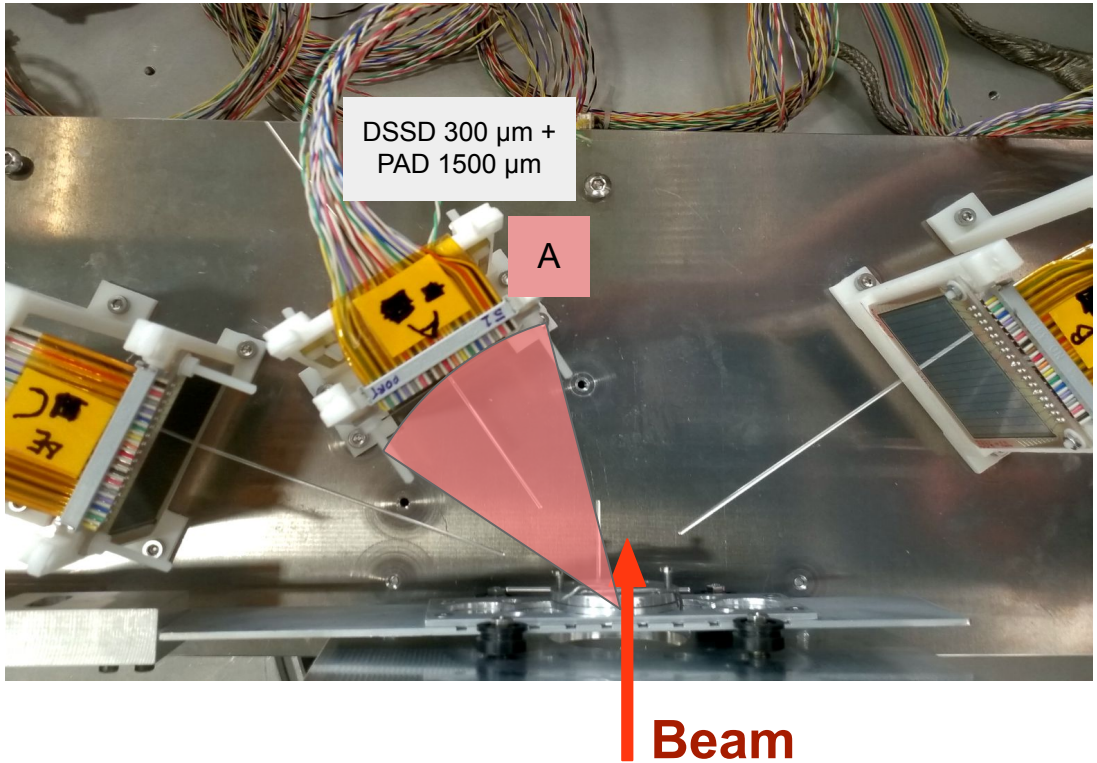


Setup

Telescope A
19º to 51º



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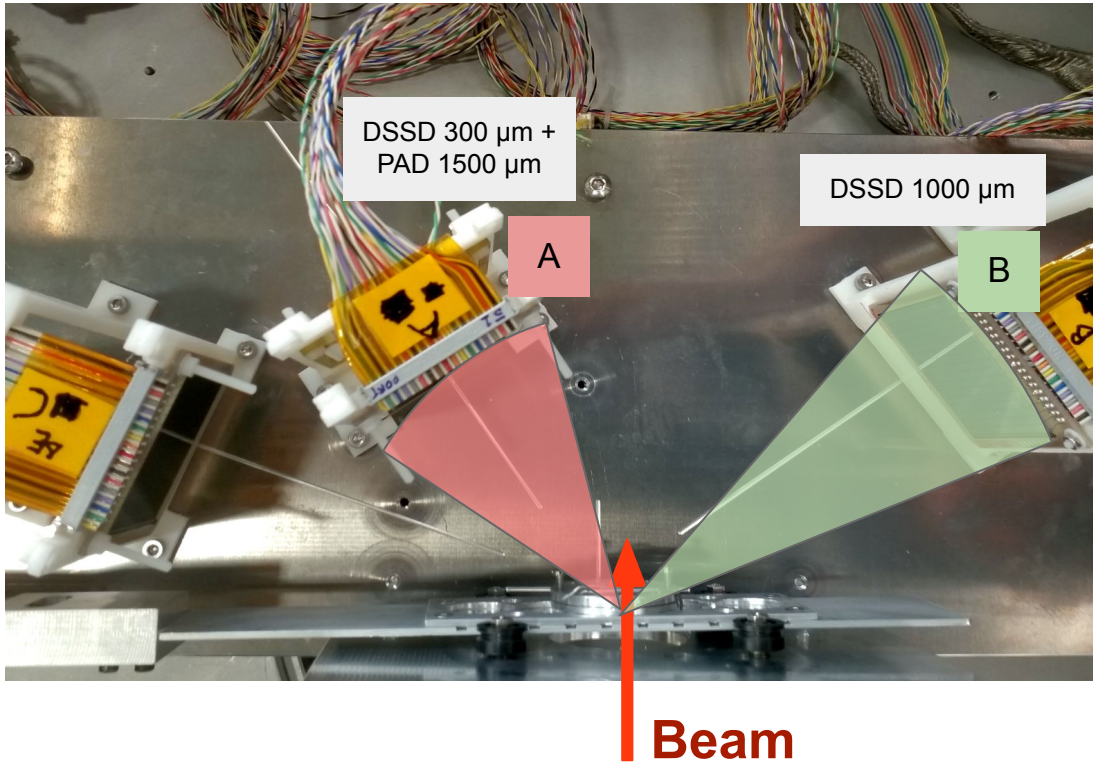
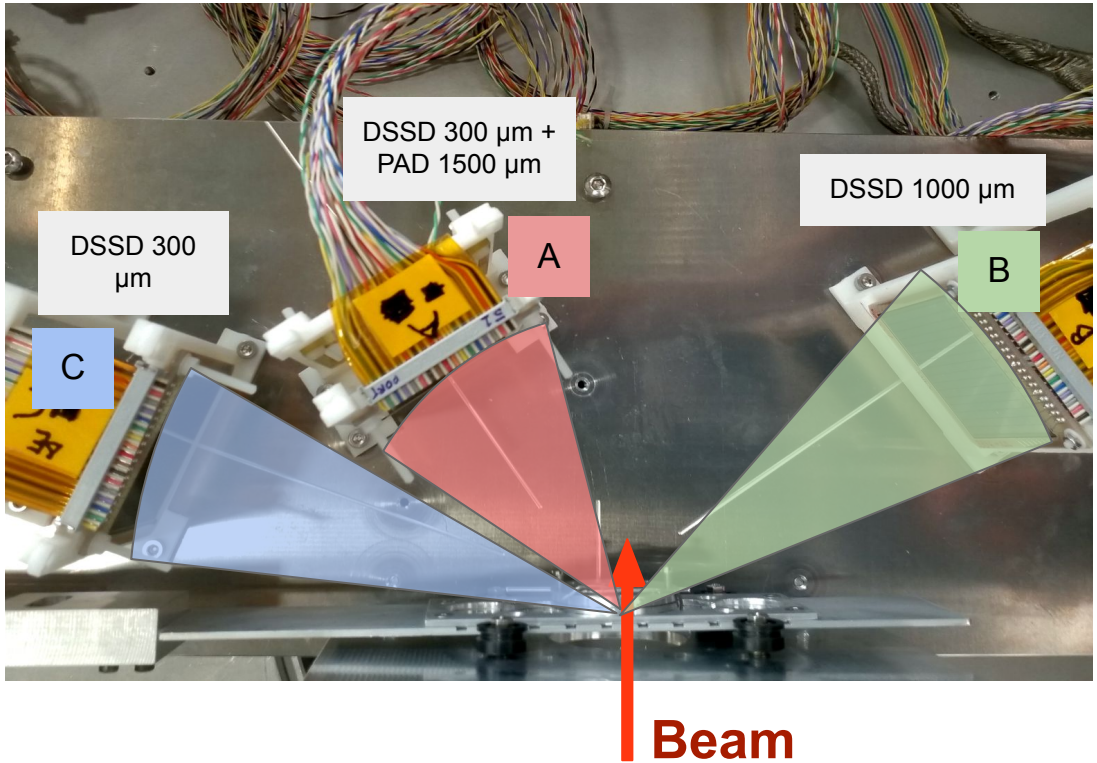


Detector B
44º to 66º

Setup

Telescope A
19º to 51º



Detector B
44º to 66º

Detector C
60º to 80º

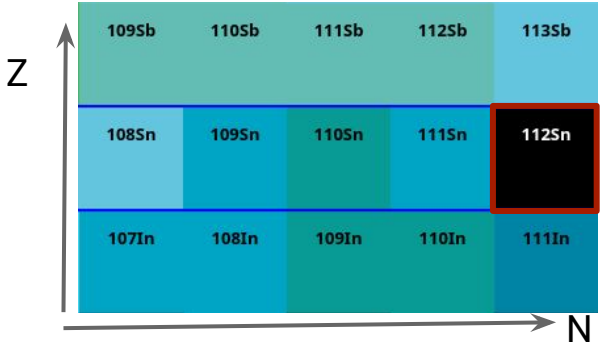
Setup

Pilot Beam **E_{Beam} = 4.9 MeV/u**

Cocktail of ^{12}C, ^{16}O, ^{20}Ne and ^{32}S

Sn Beam **E_{Beam} = 4.9 MeV/u**

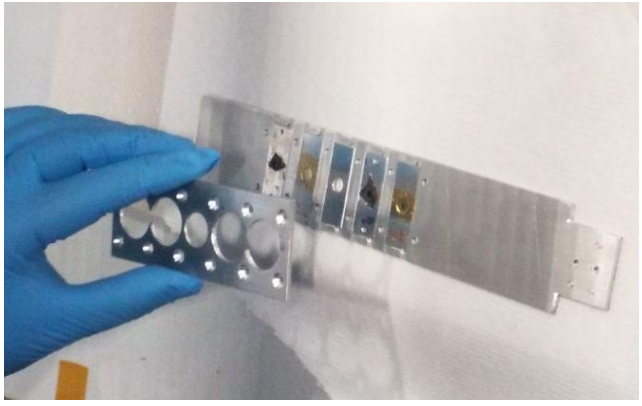
^{112}Sn with i ≈ 30 pA



Targets

^{197}Au with ≈ 300 µg/cm²

^{4}He with ≈ 2 x 10^{18}atoms/cm²



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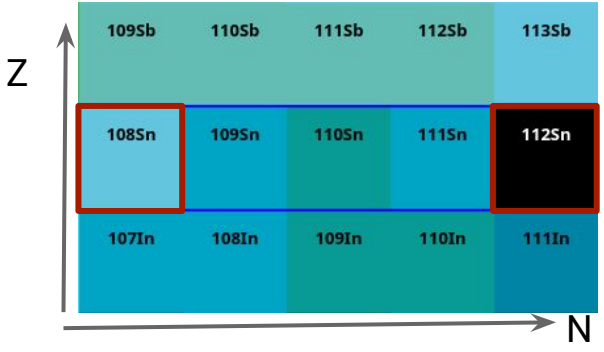
^{112}Sn with i ≈ 30 pA ^{108}Sn with i ≈ 50 pA



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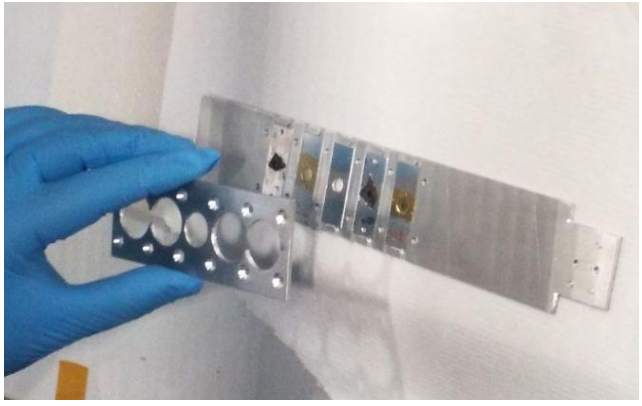

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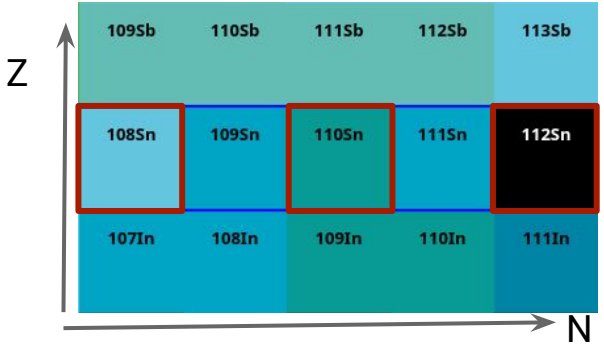

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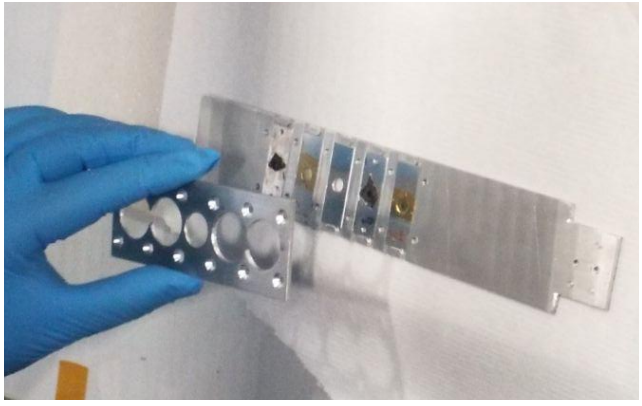

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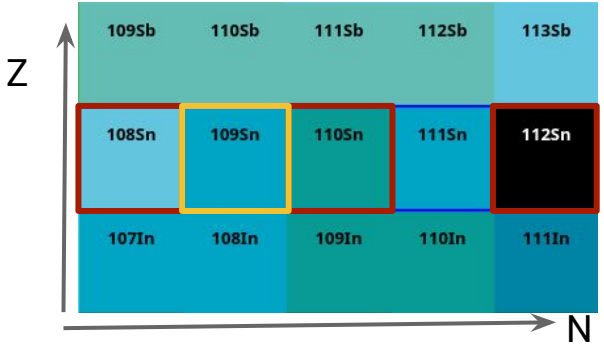
^{110}Sn with i ≈ 80 pA ^{109}Sn with i ≈ 90 pA



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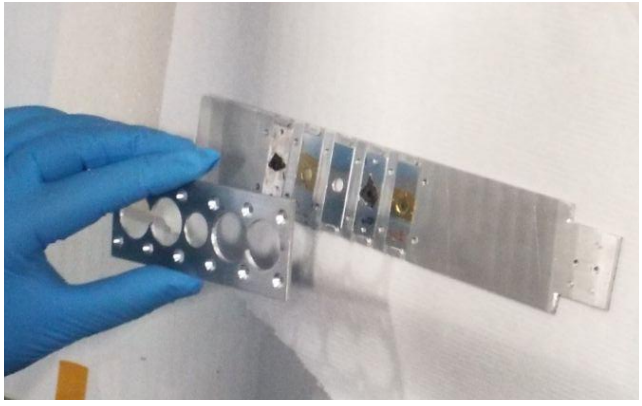

Setup

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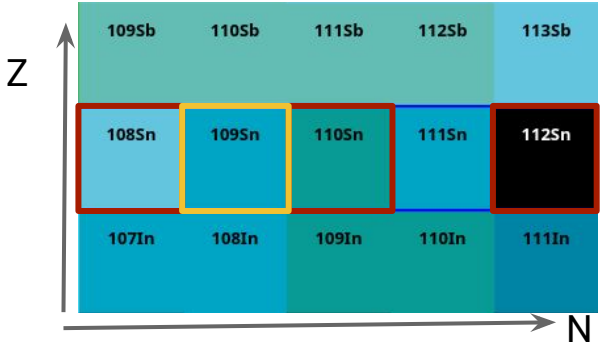
Cocktail of ^{12}C, ^{16}O, ^{20}Ne and ^{32}S

Sn Beam E_{Beam} = [illegible] eV/u

^{112}Sn with i [illegible] with i ≈ 50 pA

^{110}Sn with i ≈ [illegible] ^{9}Sn with i ≈ 90 pA

23 Shifts



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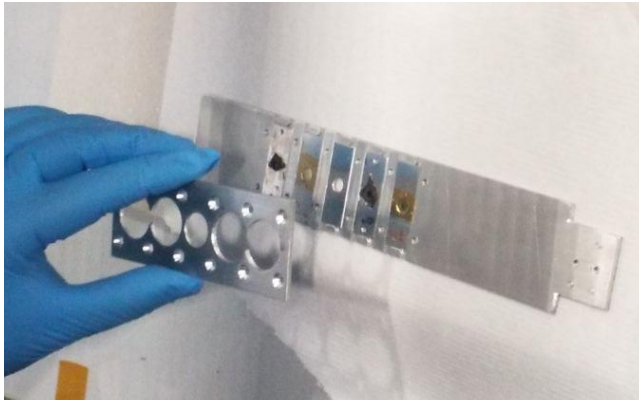
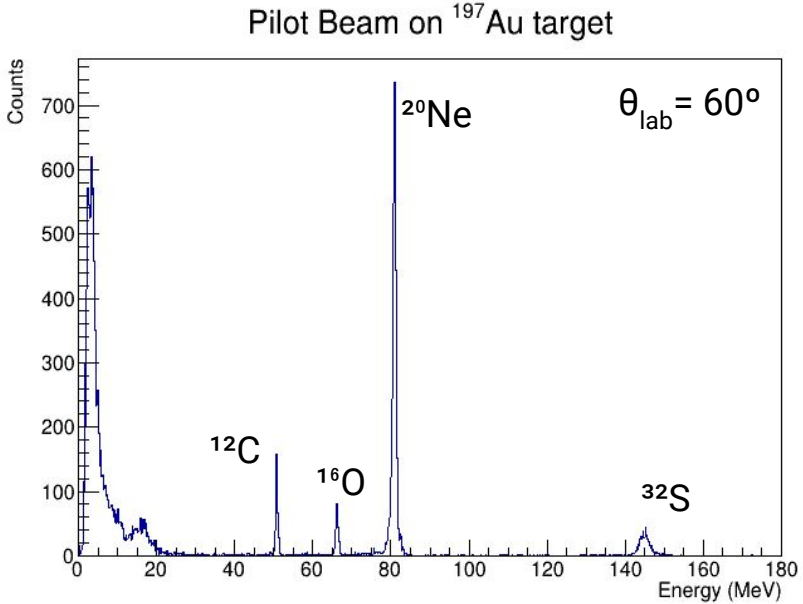
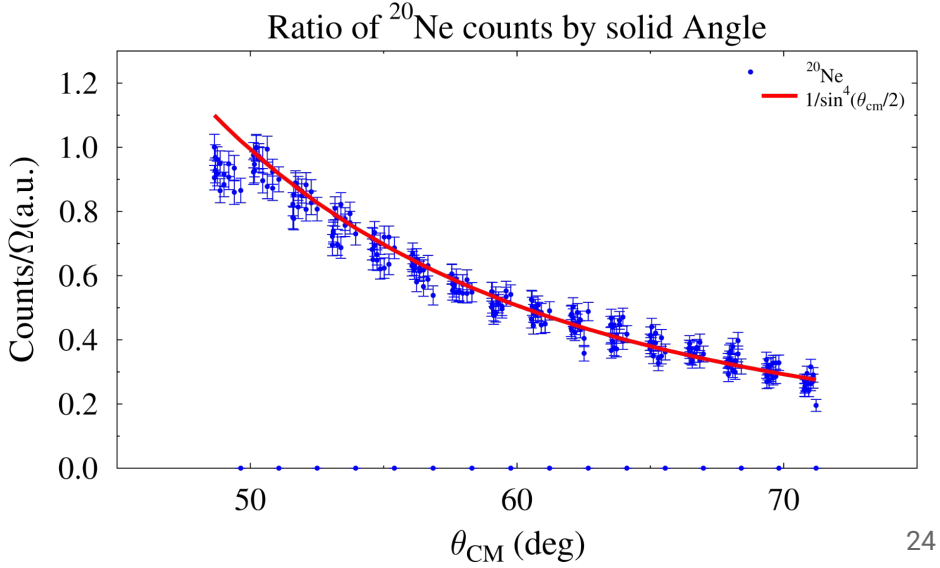


Preliminary Results

Experimental Data





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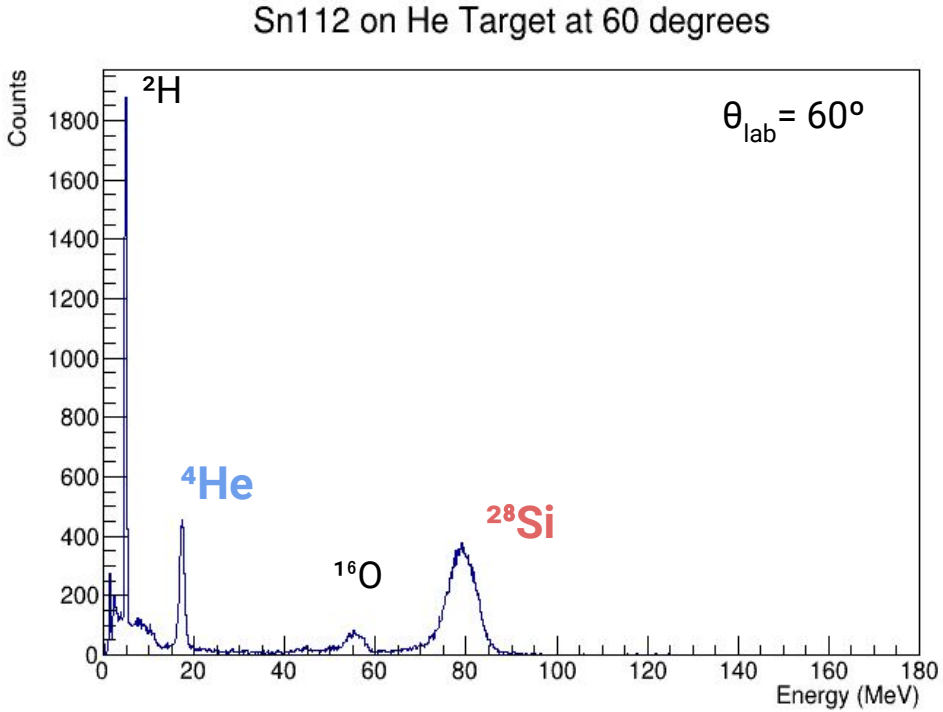
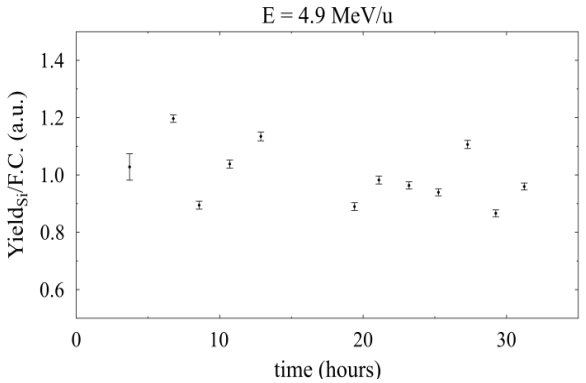


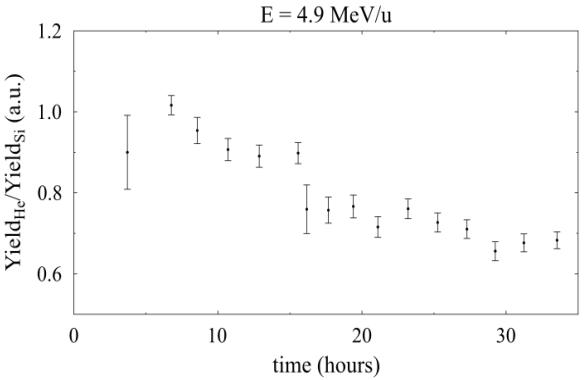
Preliminary Results

Amount of He over time

Si amount rather constant

He amount decreases





Preliminary Results

Amount of He over time

Si amount rather constant

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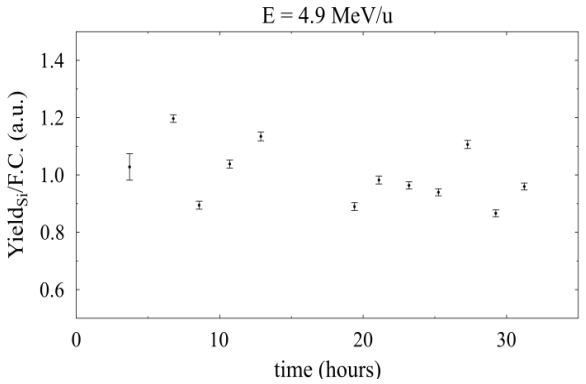
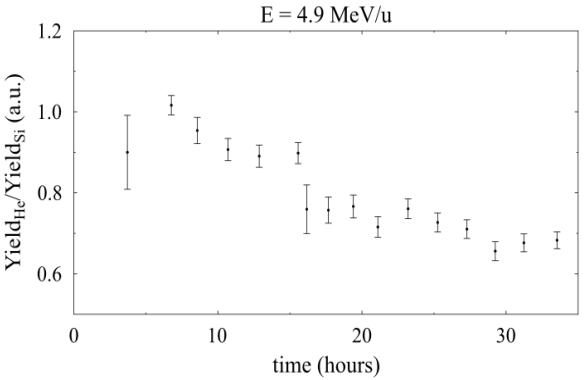
Need to account the different amount of He on each run

★ **Normalize the integral of He to the ratio He/Si at 60°**





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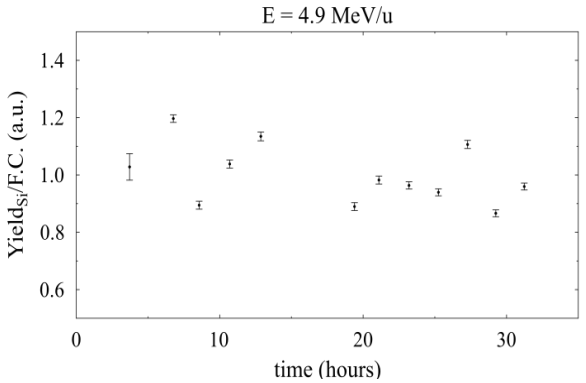
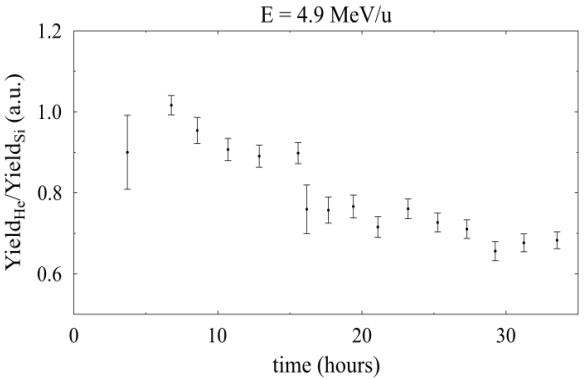
$$\alpha_i = \frac{N^i_{He}(60°)}{N^i_{Si}(60°)} \frac{N^0_{Si}(60°)}{N^0_{He}(60°)}$$

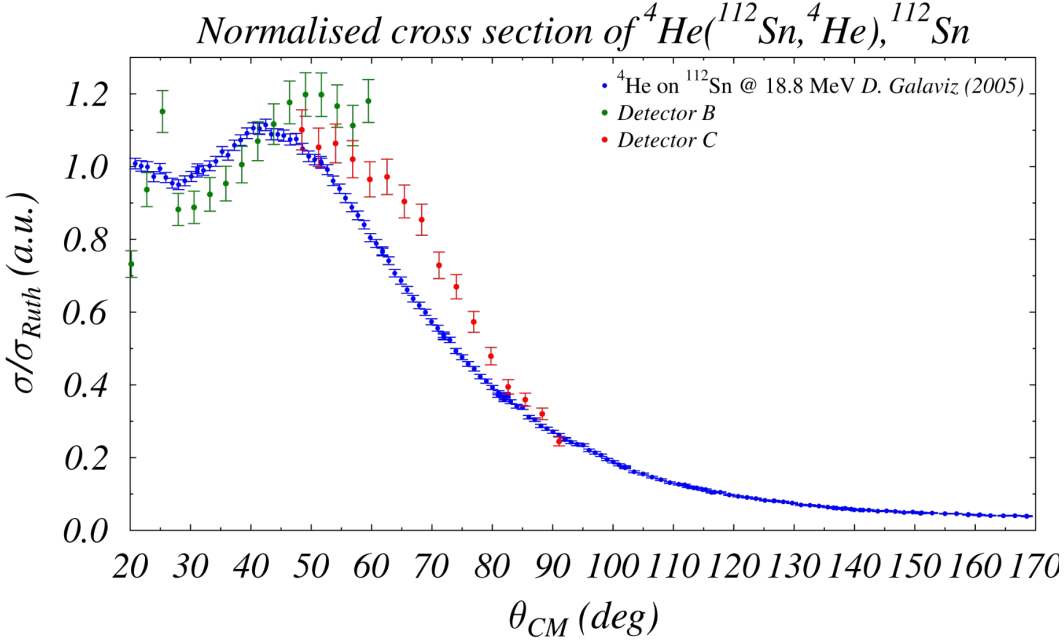




Preliminary Results

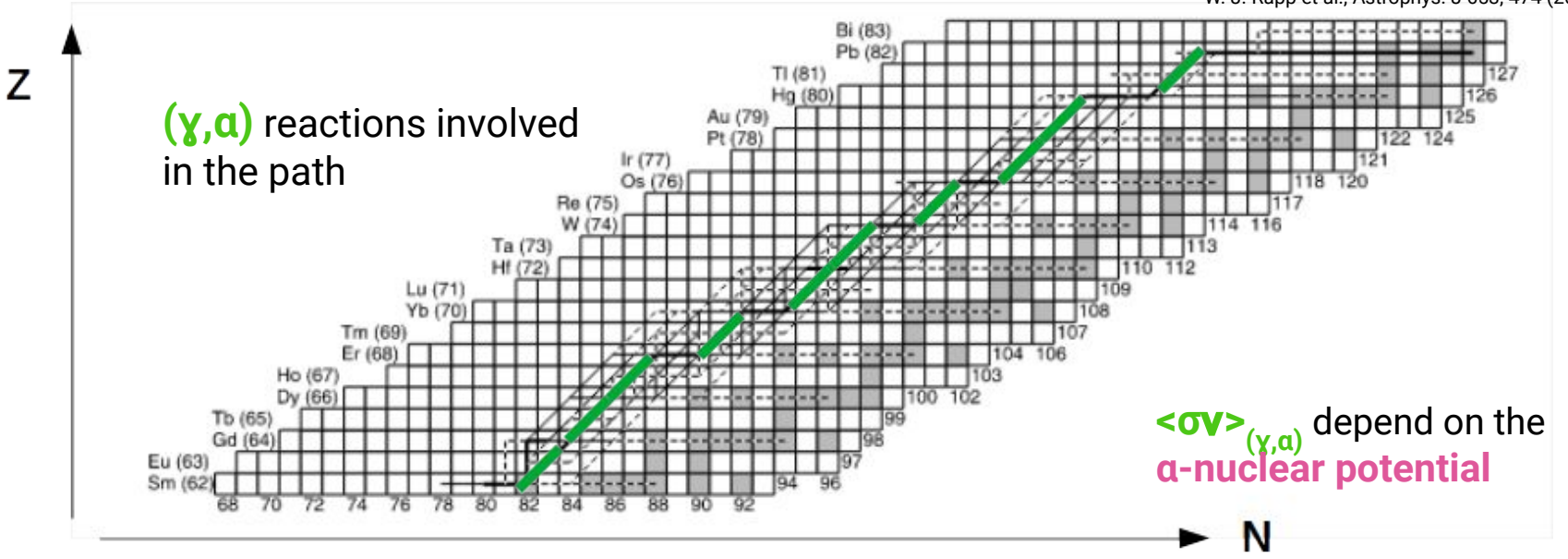
^{4}He(^{112}Sn,^{112}Sn)^{4}He @ 18.9 MeV (CM)

$$\frac{d\sigma_{He}}{d\Omega}(\theta) = \sum_i \left(\frac{N^i_{He}(\theta)\alpha_i}{N^i_{Si}(60^\circ)} \right) \left(\frac{d\sigma_{Si}}{d\Omega}(60^\circ) \right)_{Ruth}$$



Outlook for future experiments

W. J. Rapp et al., Astrophys. J 653, 474 (2006)



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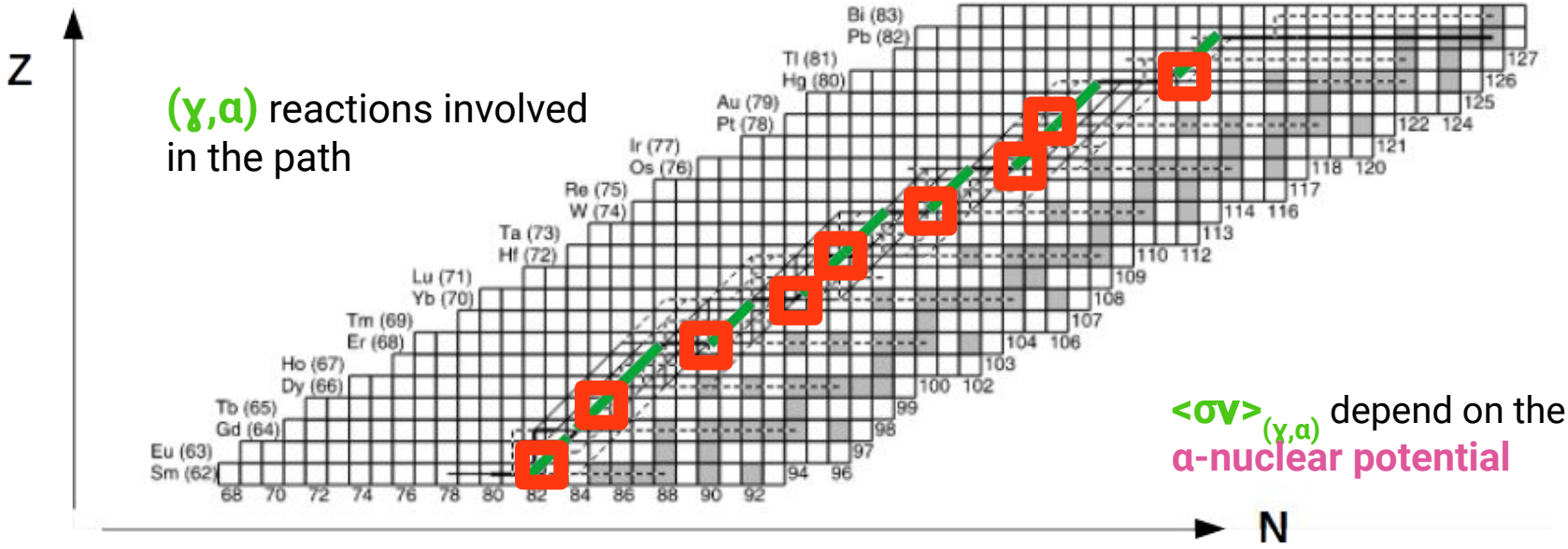

Acknowledgements

RENASCER Project: CERN/FIS-PAR/0009/2021
SCORE Project: EXPL/FIS-NUC/0364/2021