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Exploratory study for the production of Sc beams at the ISOL facility of MYRRHA

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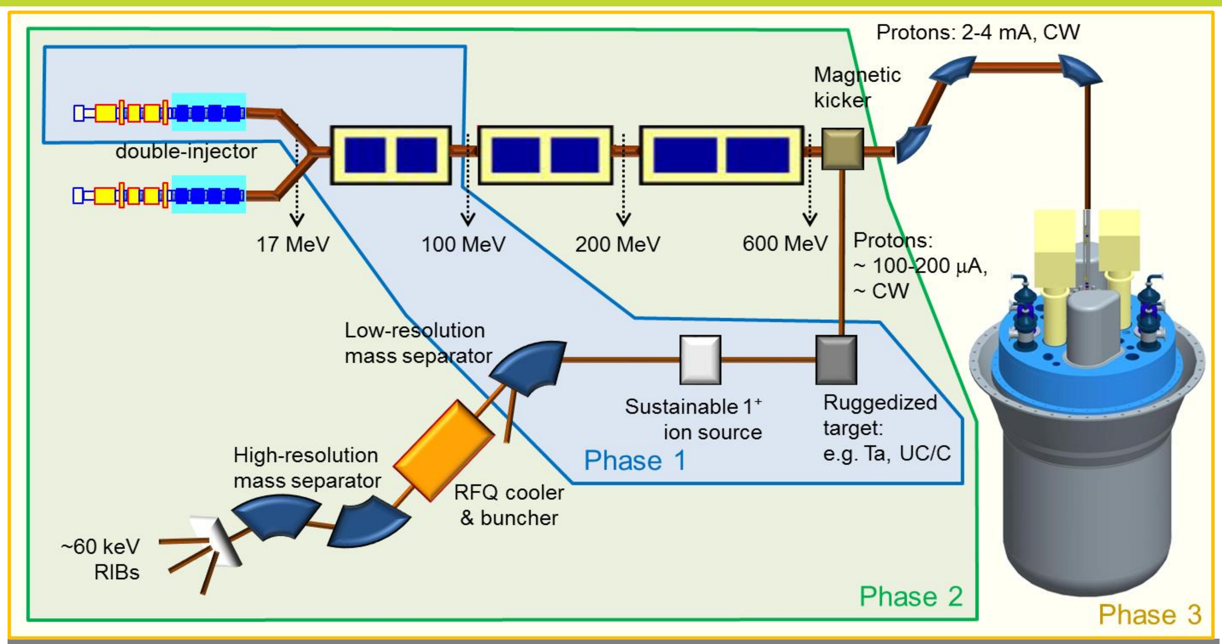
Introduction

For several years, SCK•CEN has been working on the MYRRHA project, for the realisation of an Accelerator Driven System (ADS). Its proton beam will also advantageously serve an ISOL facility, where stability and high intensity can be real assets for radio-isotope production.
The project will be implemented in 3 phases, two of which are relevant to the ISOL@MYRRHA project. In the first phase, the 100 MeV section of the Linac will be deployed and coupled to a Proton Target Facility (PTF) hosting an ISOL system. It will provide access to many different Radio-active Ion Beams (RIBs) that are of interest for both physics and medical applications.



Phased Implementation

Motivation

Isotopes ^{41,40}Sc can be of interest for the physics community, as the former is a good candidate for beta decay spectroscopy, while the latter undergoes beta-delayed alpha and proton emission.
For the medical community, ^{47,44}Sc can constitute a "theranostic pair", with the former for treatment purposes and the latter for imaging.
The purpose of this poster is to describe the design optimisation process that is currently being applied in order to determine targets for production of these isotopes.

State of the Art

Currently, other facilities such as ISAC and ISOLDE have been able to produce and successfully extract RIBs of Sc from metallic targets of Ta and Ti:

- ISAC $^{(50g-52g)}$Sc e.g. 4.1 E5 isotopes/s of ^{50g}Sc from Ta target
- ISOLDE $^{(42-44,\ 46-48,\ 50,\ 52)}$Sc e.g. 3 E7 isotopes/s of ^{47g}Sc from Ti target

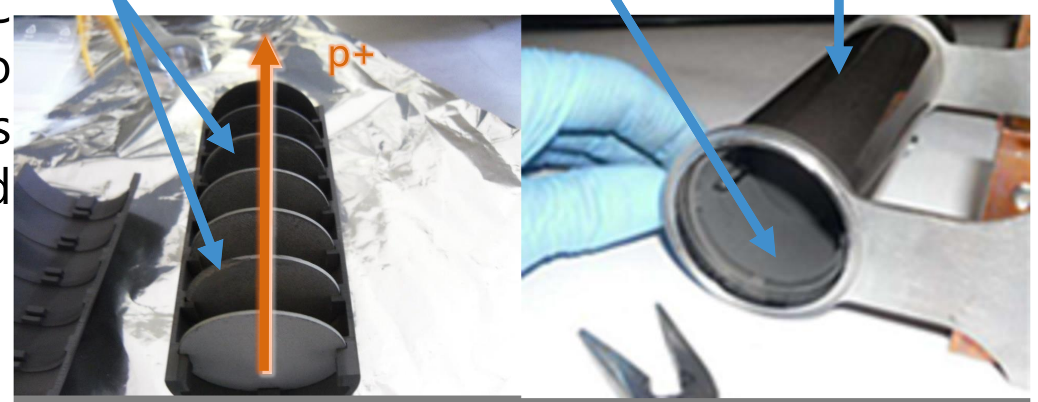
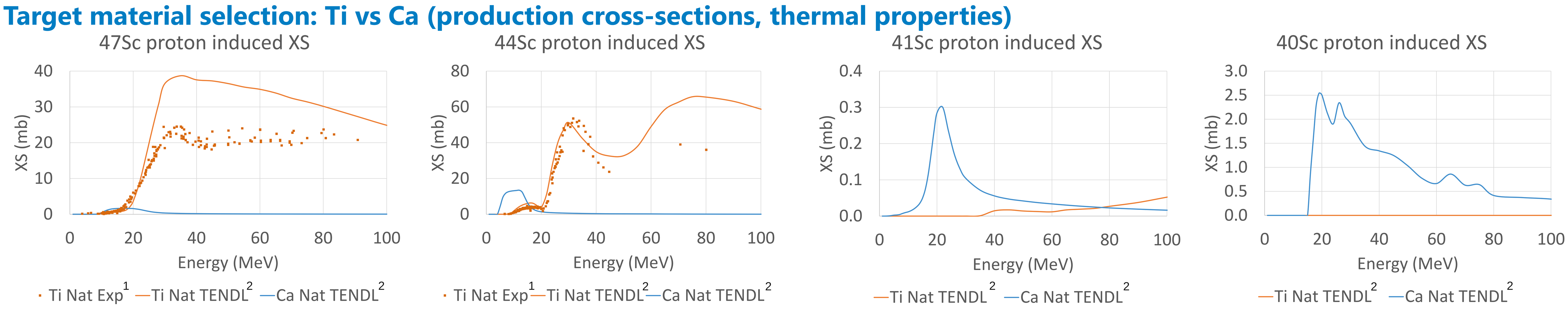


Illustration of an ISOL target
SPES Target (INFN Legnaro, Italy)
A future target concept that will be used for the 100 MeV PTF would be similar to this one

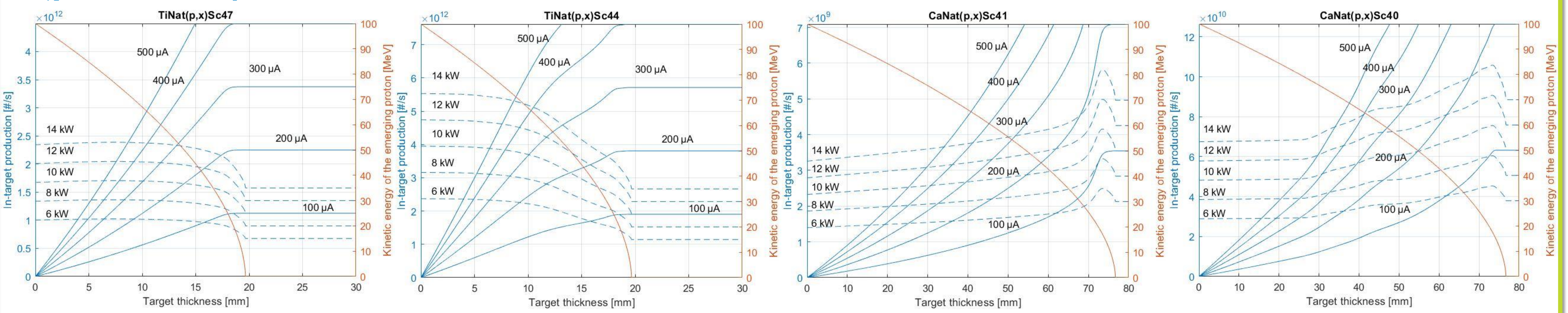
Target material selection: Ti vs Ca (production cross-sections, thermal properties)



1: https://www.oecd-nea.org/janis/ 2: https://tendl.web.psi.ch/tendl_2017/tendl2017.html

Ti is superior for the long-lived isotopes, whereas in the case of ^{41}Sc the choice is more nuanced, with finally Ca being ideal for ^{40}Sc production.
Ti-C has a much higher maximum operating temperature than Ca-C, allowing greater current on target (for a similar geometry).

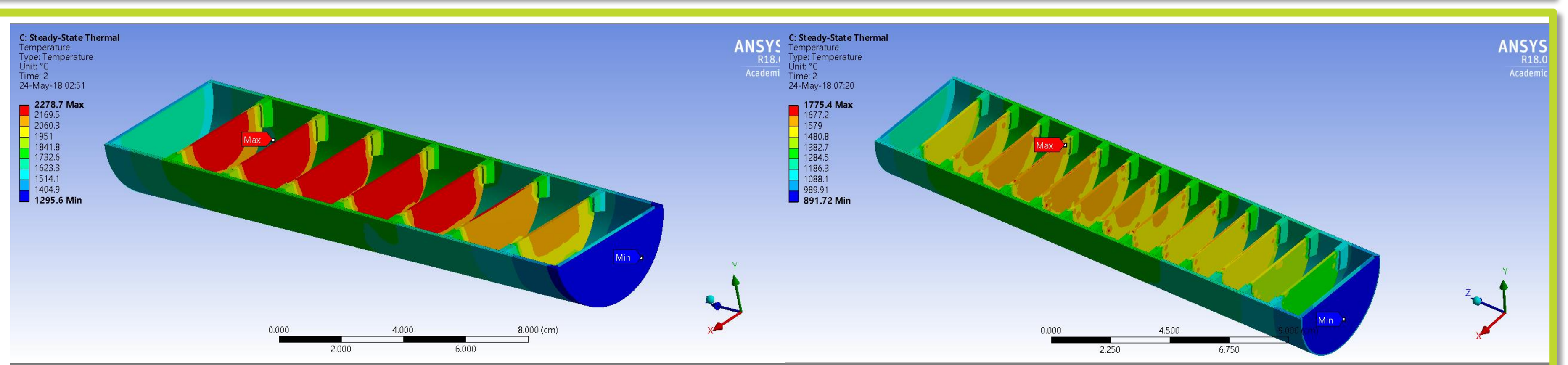
Target-thickness optimisation



Determination of an optimum in thickness where production is maximal, accounting for power and current limitations, by the means of a 1-D analysis using the TENDL cross-sections shown previously. The intersection of the regions below power and current defines a permissible design region, with the maximum of that region being the optimum in terms of production. The optimal thickness is then used to create a model for a full Monte Carlo simulation of the design, where scattering can be taken into account, which is essential for the subsequent thermal analysis.

Target thermal analysis

Buffer discs placed at either end of the container to separate the inner target volume from the "cool" edges. Optimal spacing between the discs will better spread the heat load and also improve uniformity.
Increasing temperature uniformity aids effusion processes and lessens thermal stress.



Ti-C based target for ^{47,44}Sc Ca-C based target for ^{41,40}Sc

Summary

The concepts under investigation are an exploration of the possible optimisation routes for targets that could be used at the PTF at SCK•CEN. For the longer-lived Sc isotopes, greater current and lower thickness would give better results, while the converse is true for the shorter-lived isotopes. In order to complete the study, more in-depth mechanical simulations, release simulations and experimental measurements are required and are planned for the near future.

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