The ISOL@MYRRHA project

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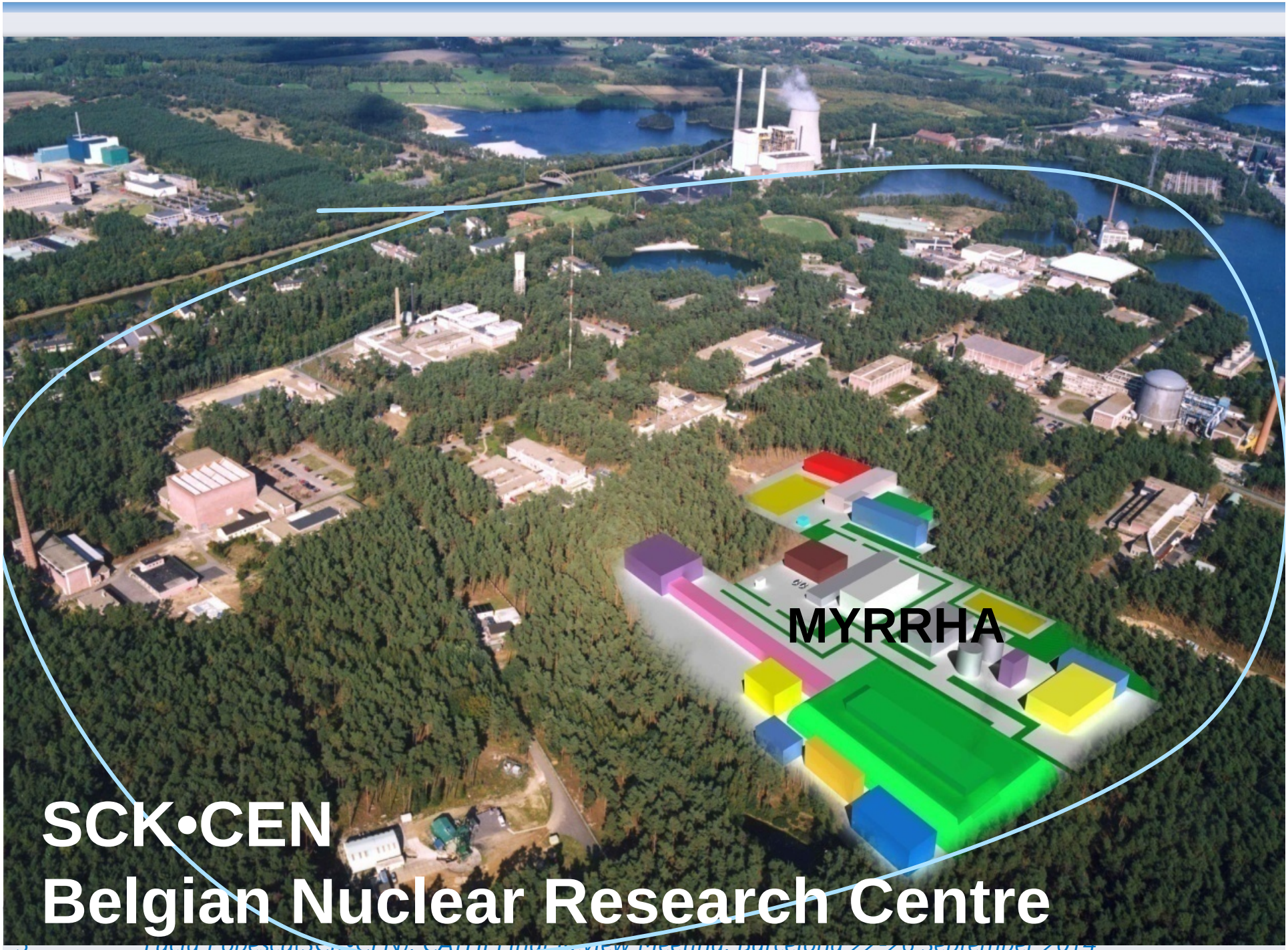
Outlook

- Introduction: SCK•CEN & the MYRRHA project
- ISOL@MYRRHA
  - Concept
  - Technical design
  - Applications
- Summary



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Belgian Nuclear Research Centre

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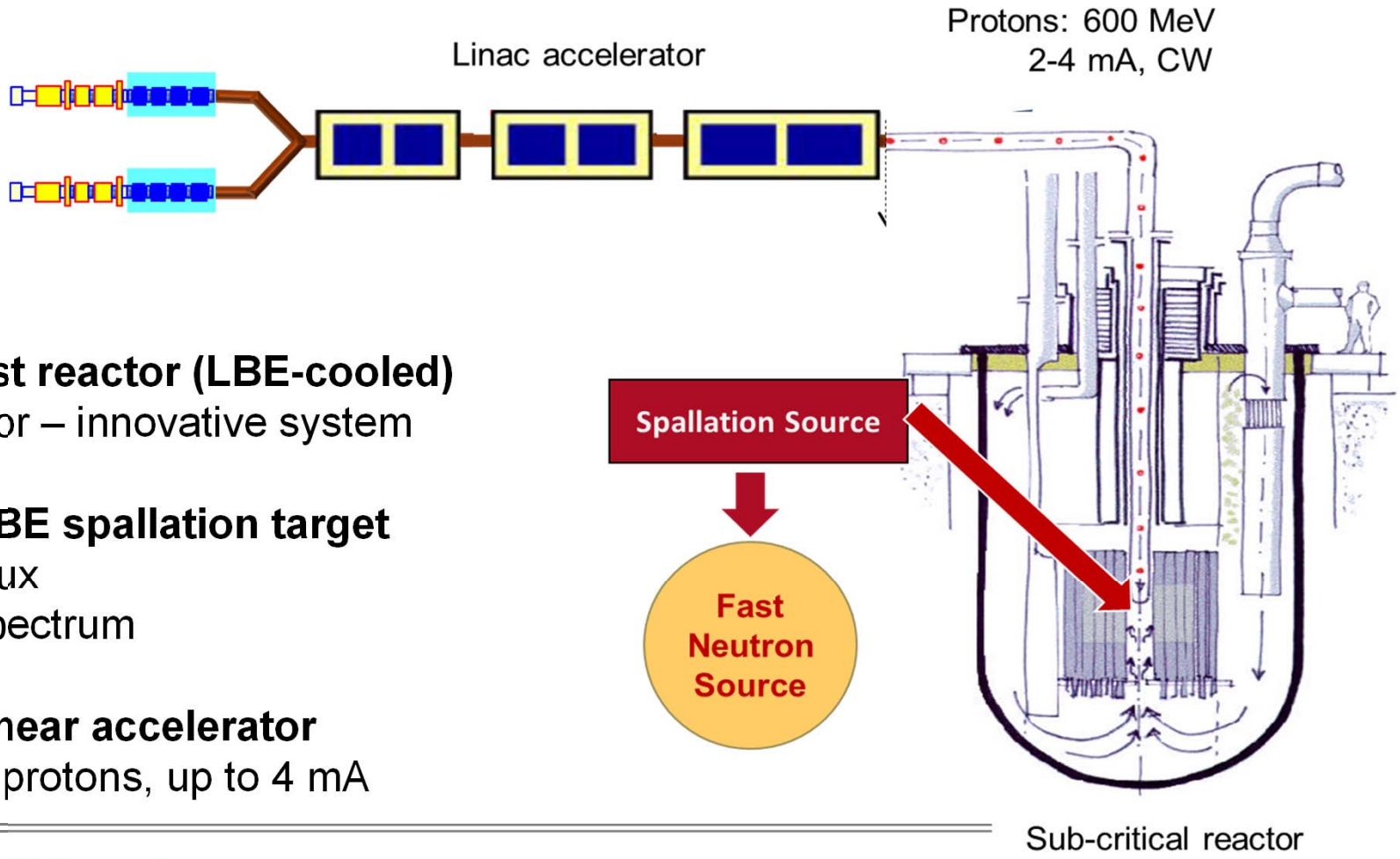
STUDIECENTRUM VOOR KERNENERGIE
CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE

MYRRHA: EXPERIMENTAL ACCELERATOR DRIVEN SYSTEM

A pan-European, innovative and unique facility

MYRRHA

MYRRHA –ADS concept



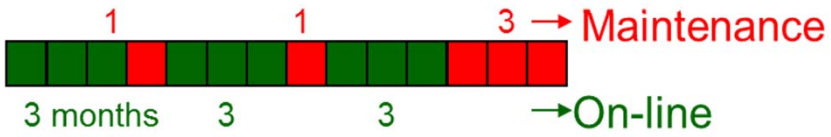
subcritical fast reactor (LBE-cooled)
lead fast reactor – innovative system

high-power LBE spallation target
high neutron flux
fast neutron spectrum

high-power linear accelerator
CW, 600-MeV protons, up to 4 mA

Operation: - ADS mode

- critical mode



MYRRHA -Applications

Fuel research
in entire reactor

Material research
in large volumes

Fission GEN IV

Highly representative conditions
below the target

Improved conditions
in dedicated positions

Fusion

Transmutation
in entire reactor

Waste

Multipurpose
h**Y**brid
Research
Reactor for
High-tech
Applications

High energy LINAC
600 MeV – 1 GeV
Long irradiation time

Fundamental research

ISOL@MYRRHA

Radio-isotopes

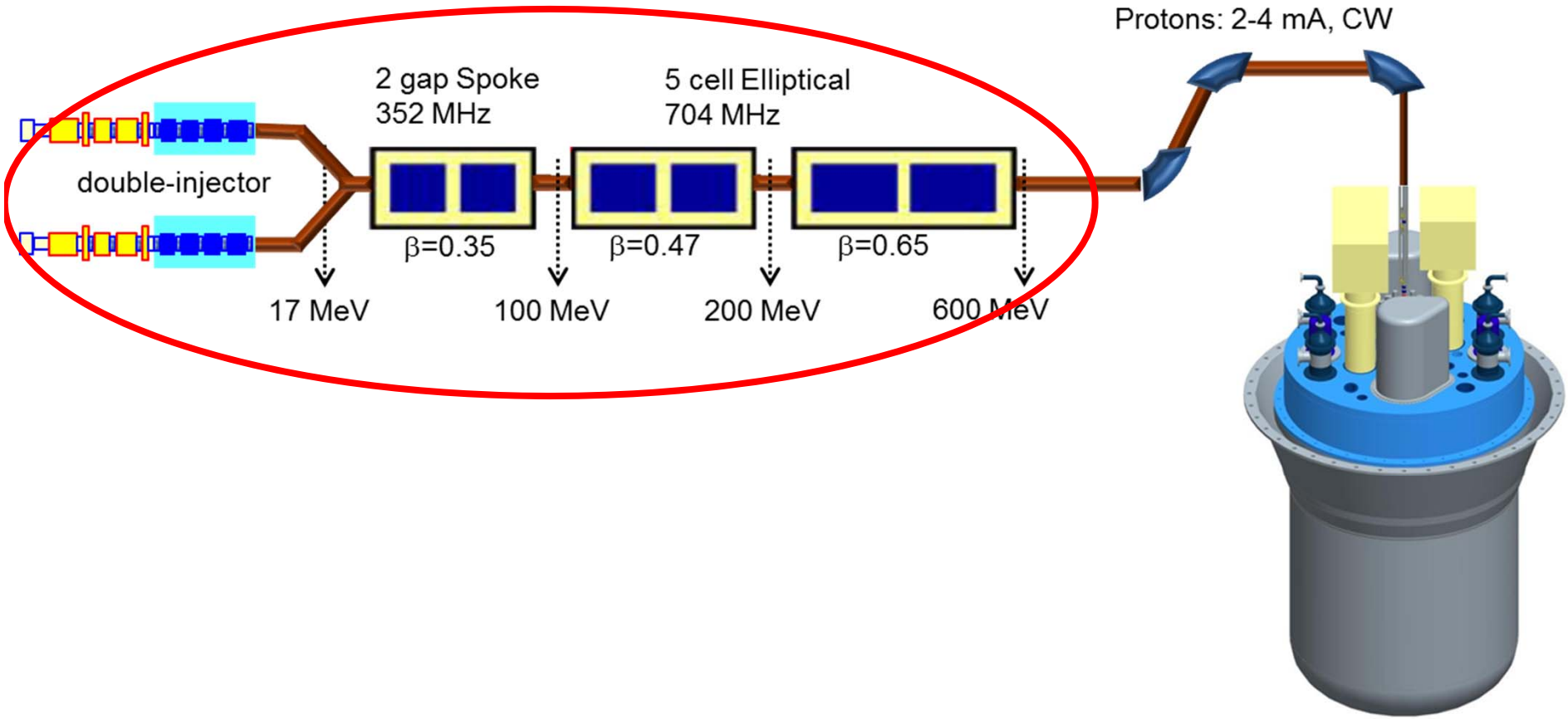
Tc-99m
in dedicated positions

Silicon doping

Large ingots
outside of reactor core

MYRRHA accelerator

Collaborative efforts within MAX FP7 project:
CNRS, ACS, ADEX, CEA, EA, FE-UCP, IAP, INFN, KUL, SCK•CEN, TED



MYRRHA Accelerator Challenge

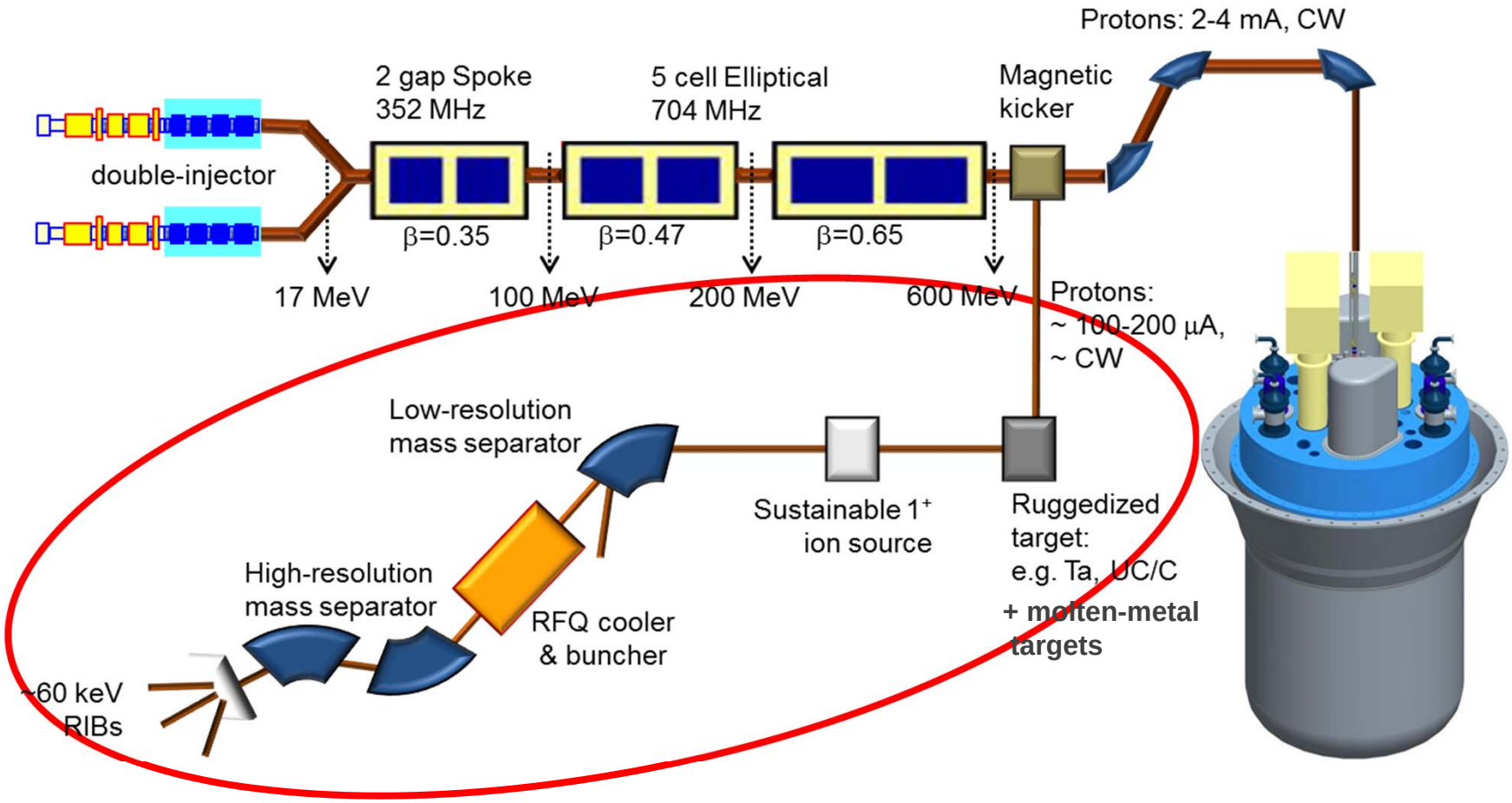
fundamental parameters (ADS)	
particle	p
beam energy	600 MeV
beam current	4 mA
mode	CW
Mean time between failures	> 250 h

challenge !

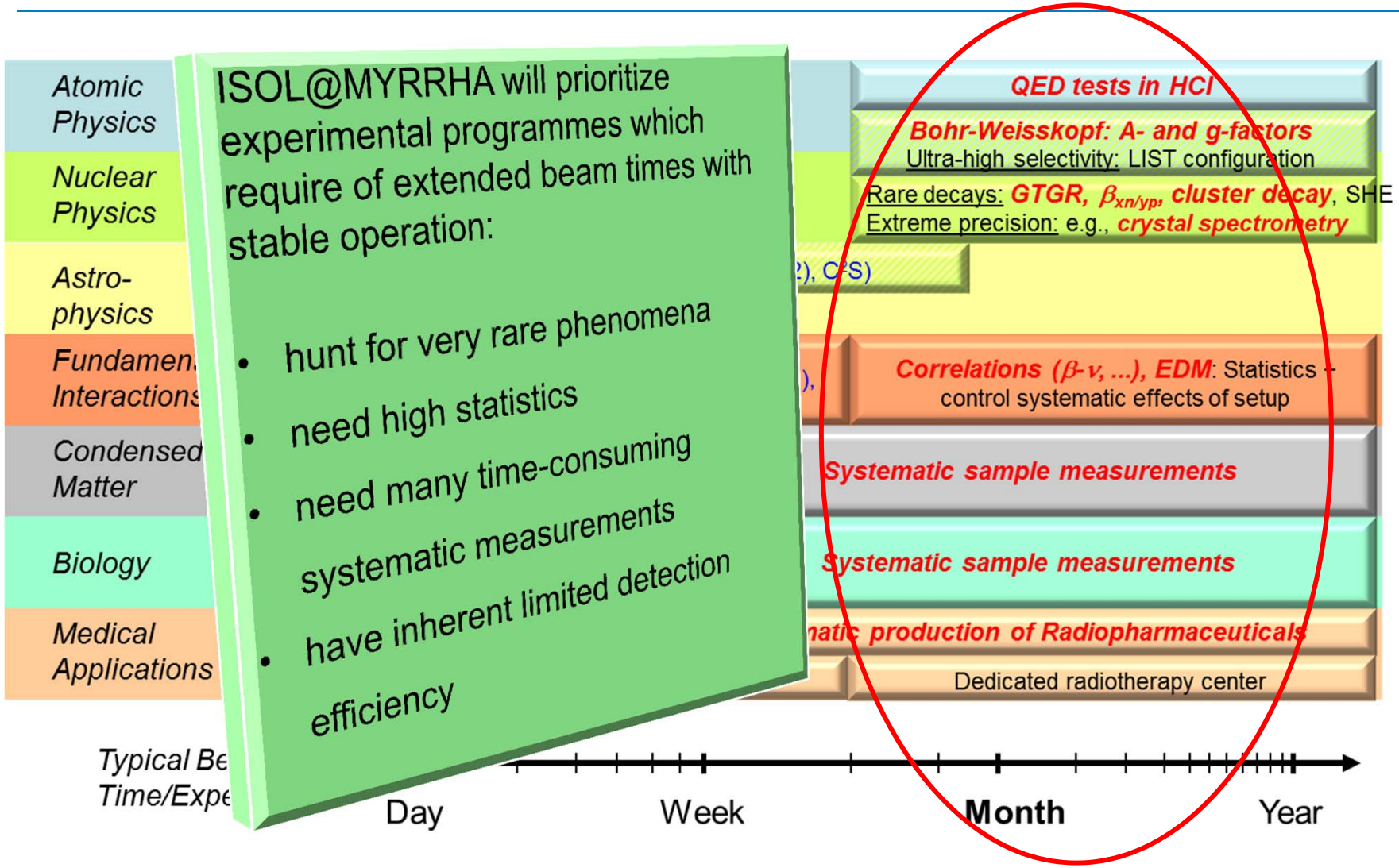
failure = beam trip > 3 s

implementation	
superconducting linac	
frequency	176.1 / 352.2 / 704.4 MHz
reliability = redundancy	double injector
	"fault tolerant" scheme

ISOL@MYRRHA concept



ISOL@MYRRHA Applications



Courtesy of *D. Pauwels* (KUL & SCK•CEN)

ISOL@MYRRHA Project

- ISOL@MYRRHA Feasibility Study (pre-conceptual design and scientific case) carried out within BriX-IAP6 (2007-2012)

- Technical & Scientific report submitted to NuPECC

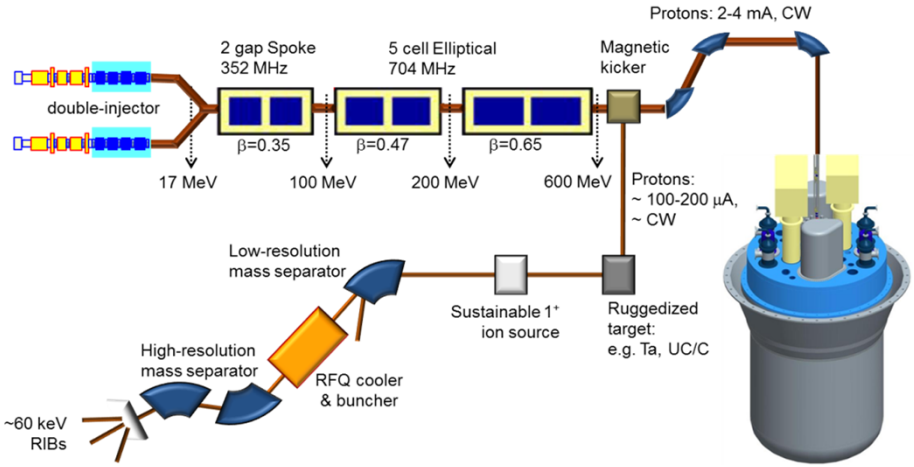
  ➔ 2010 – Technical Design of ISOL@MYRRHA included in the long-range plan of NuPECC

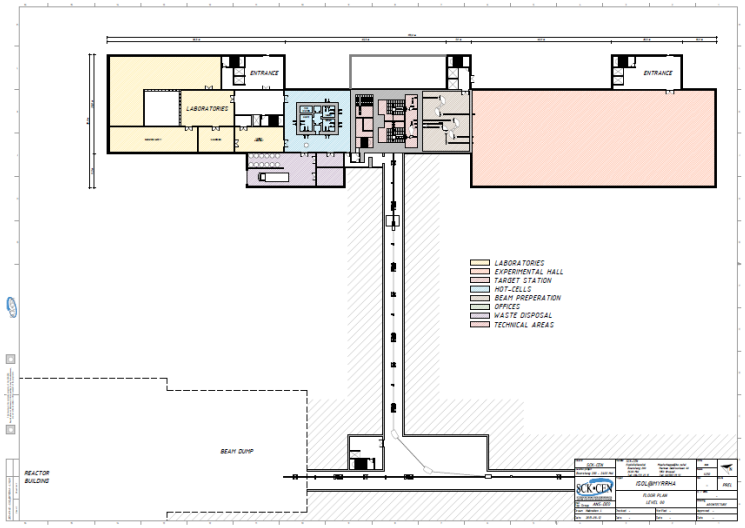
- Detailing the Design, updating the Scientific Case and building the Users Group through a series of topical workshops - BriX-IAP7 (2012-2017)

- Belgian Consortium – created in 2013

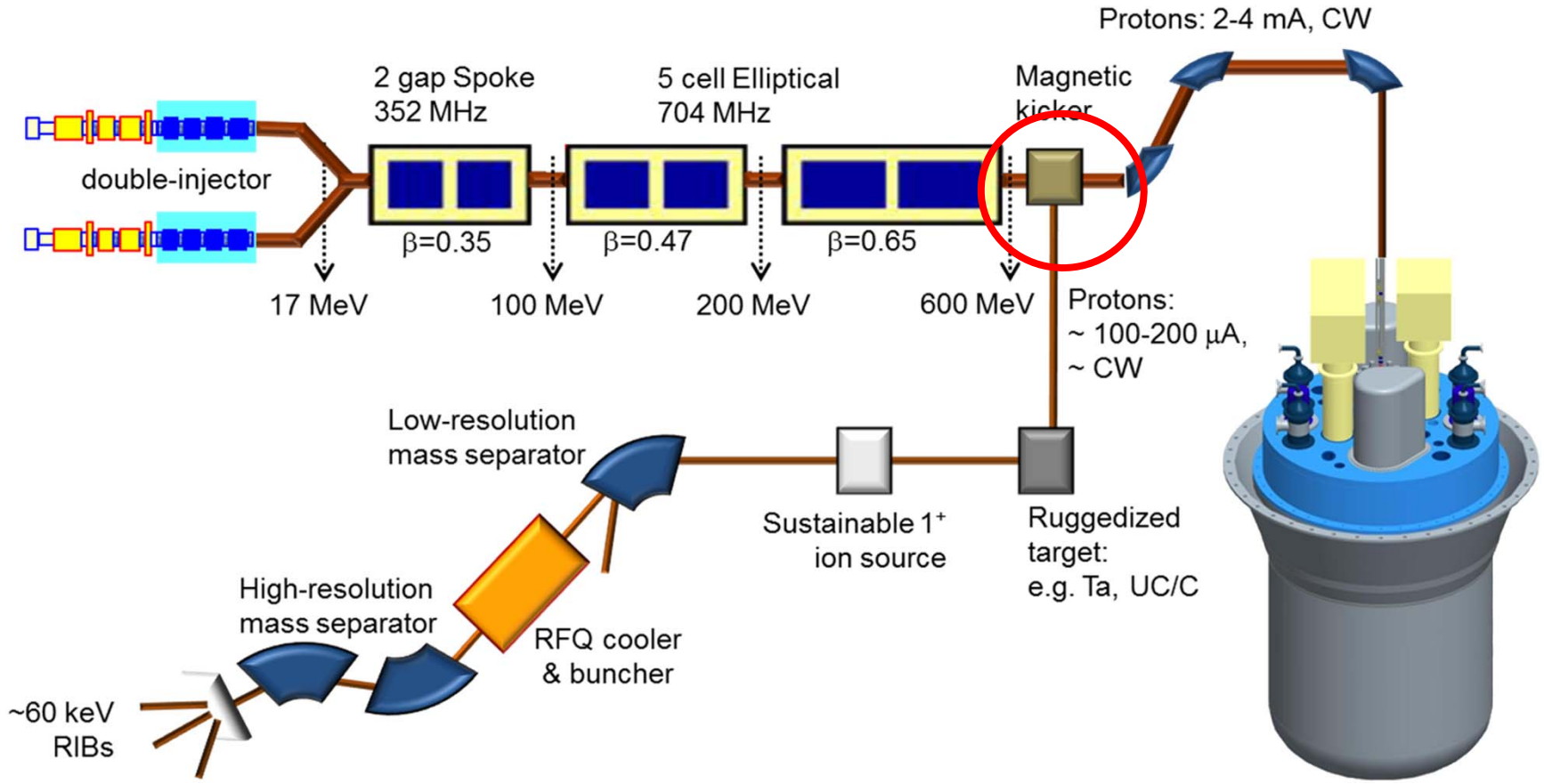
  - Aim:
    - Coordinated RTD programme – ISOL developments
    - Joining EURISOL collaboration (MOU signed in July 2014)

From a concept to a technical design





Proton-beam extraction towards the ISOL section



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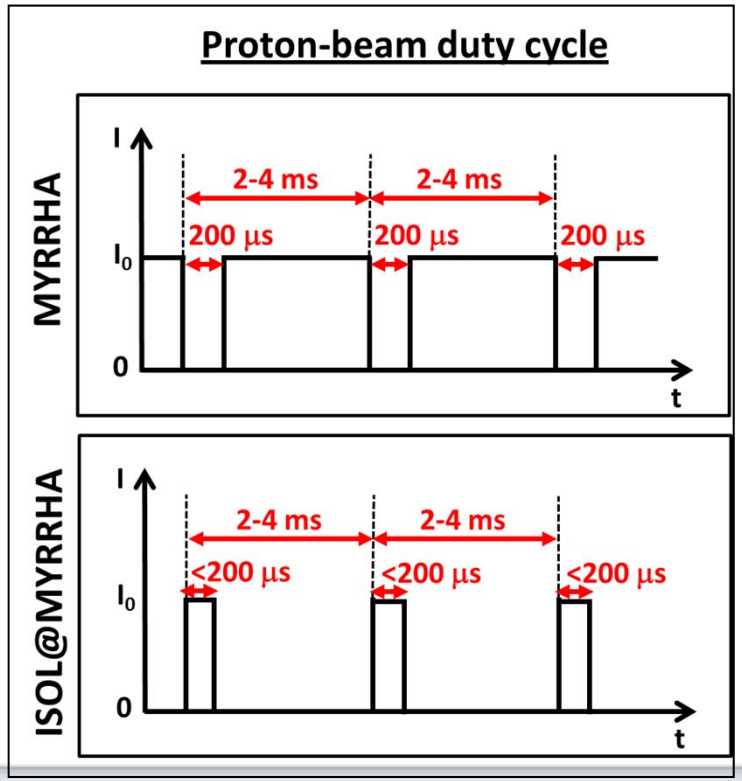
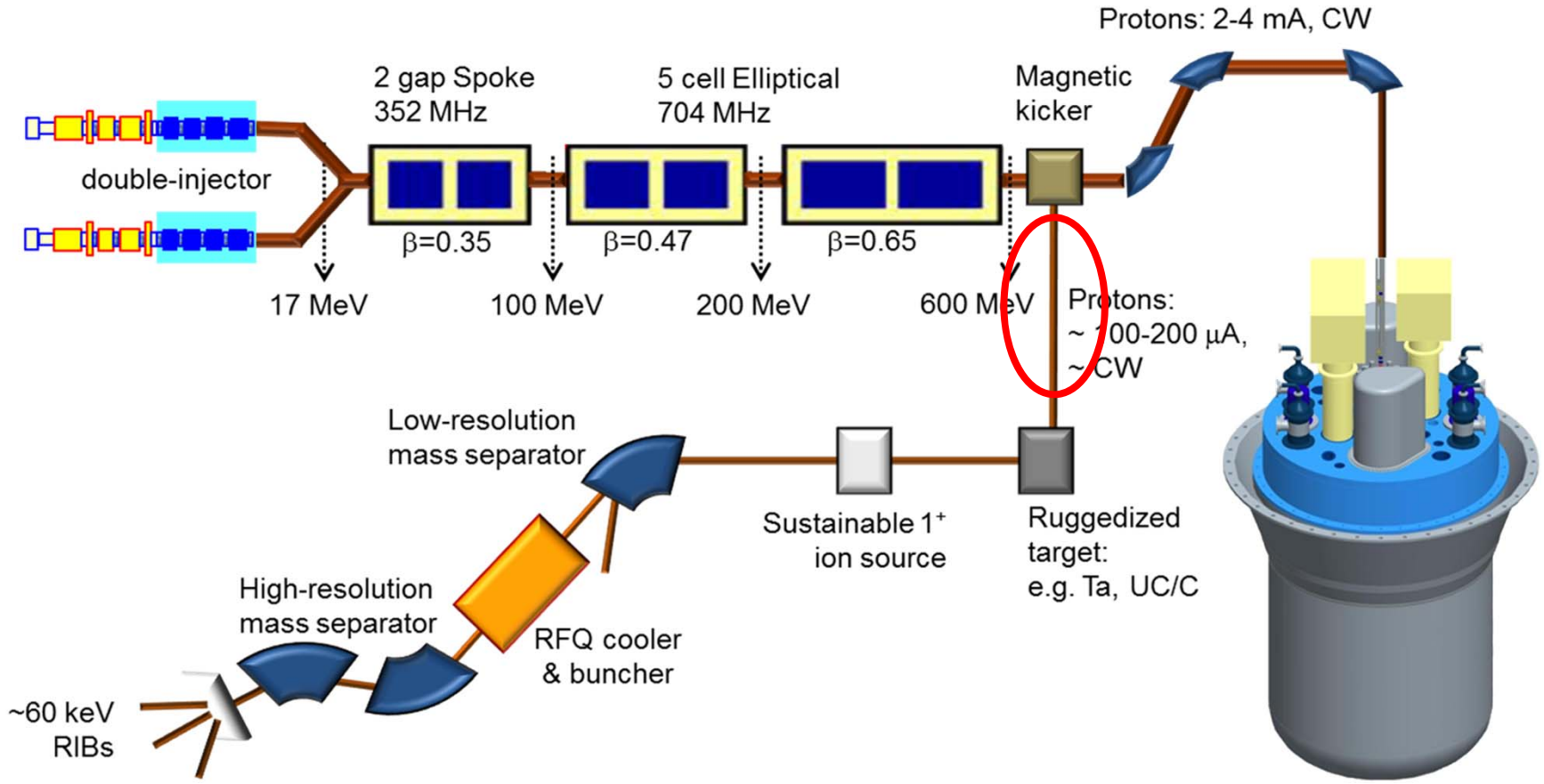


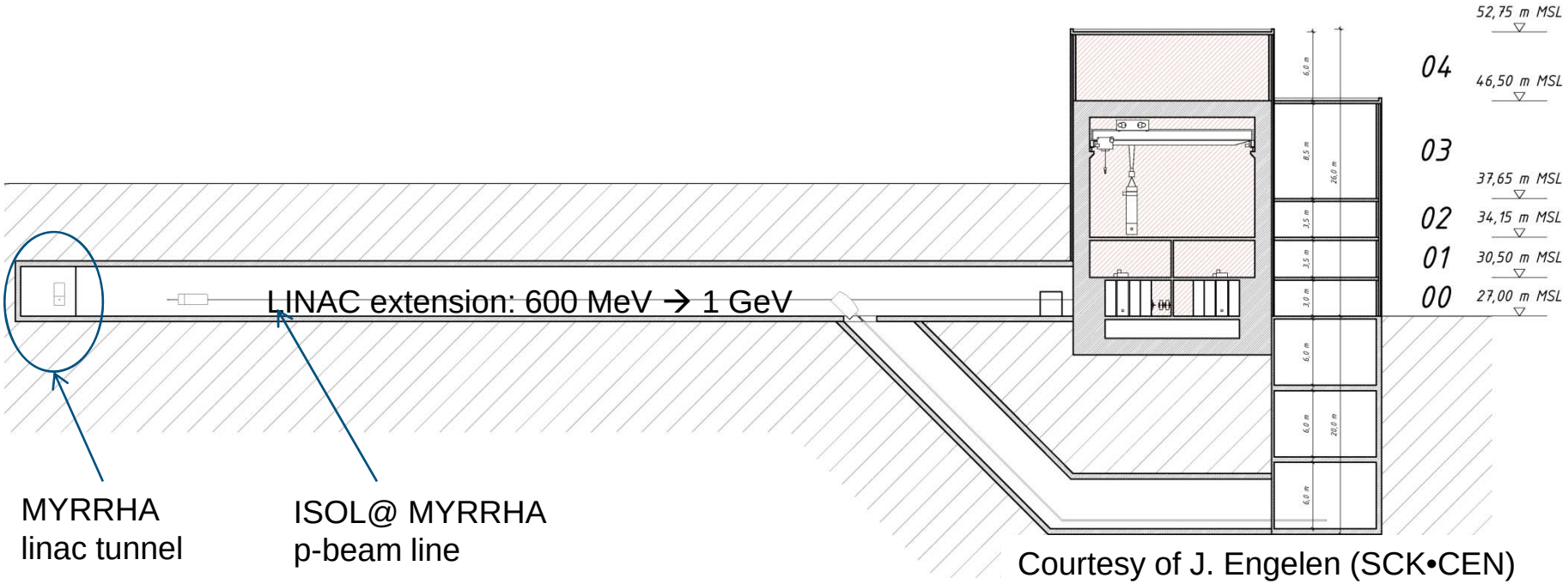
Courtesy of D. Vandeplassche (SCK•CEN)

Proton-Beam Transport to ISOL@MYRRHA



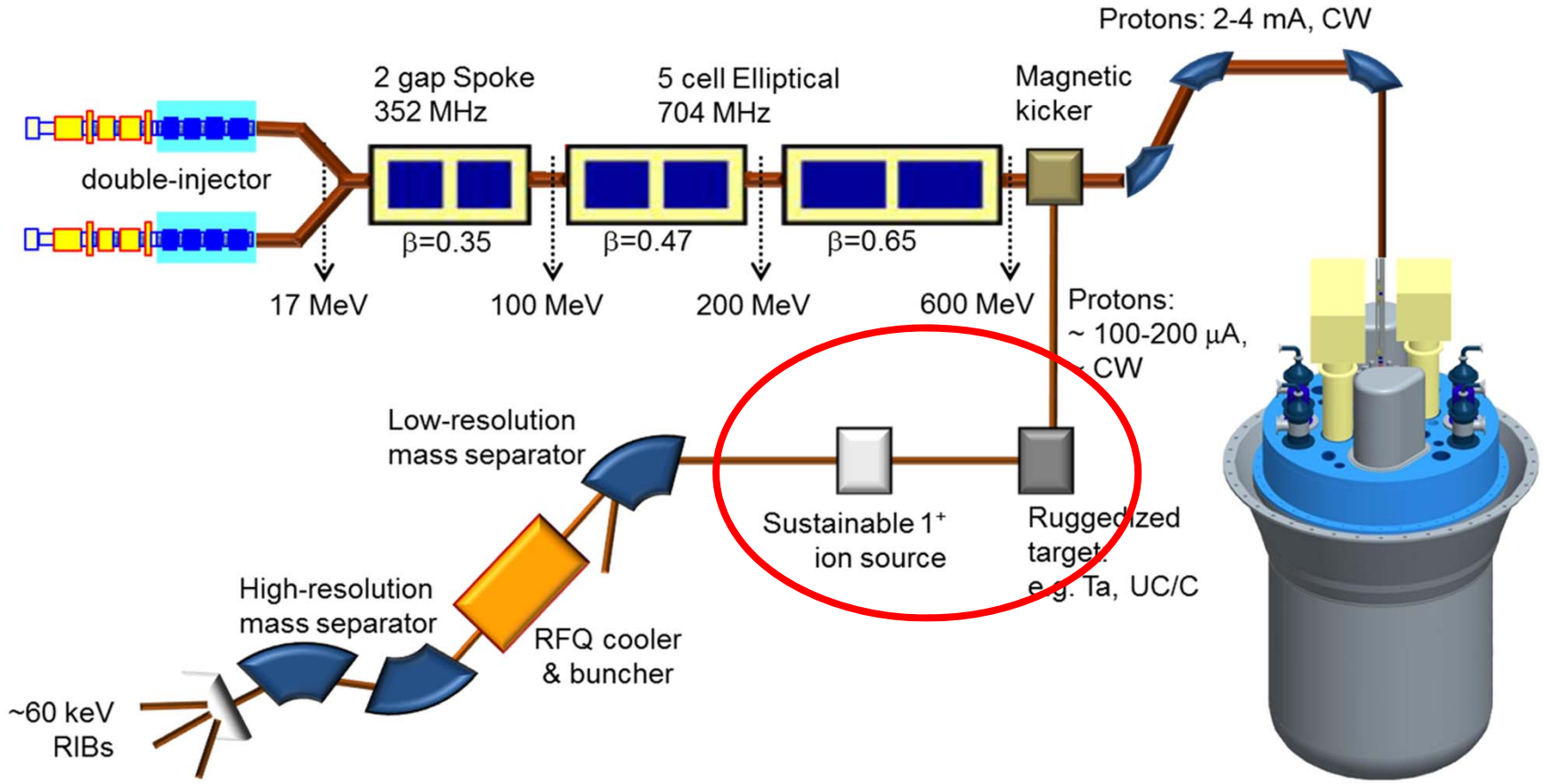
Proton-Beam Transport to ISOL@MYRRHA

- Achromatic beam transport
- Options kept open for later upgrades:
  - Energy upgrade (600-MeV → 1-GeV protons)
  - MW target station
- D-magnets design for 600-MeV, 800-MeV and 1-GeV protons



Courtesy of J. Engelen (SCK•CEN)

RIB production facility



RIB production facility

- Concept 1: two target stations

  - Advantages:

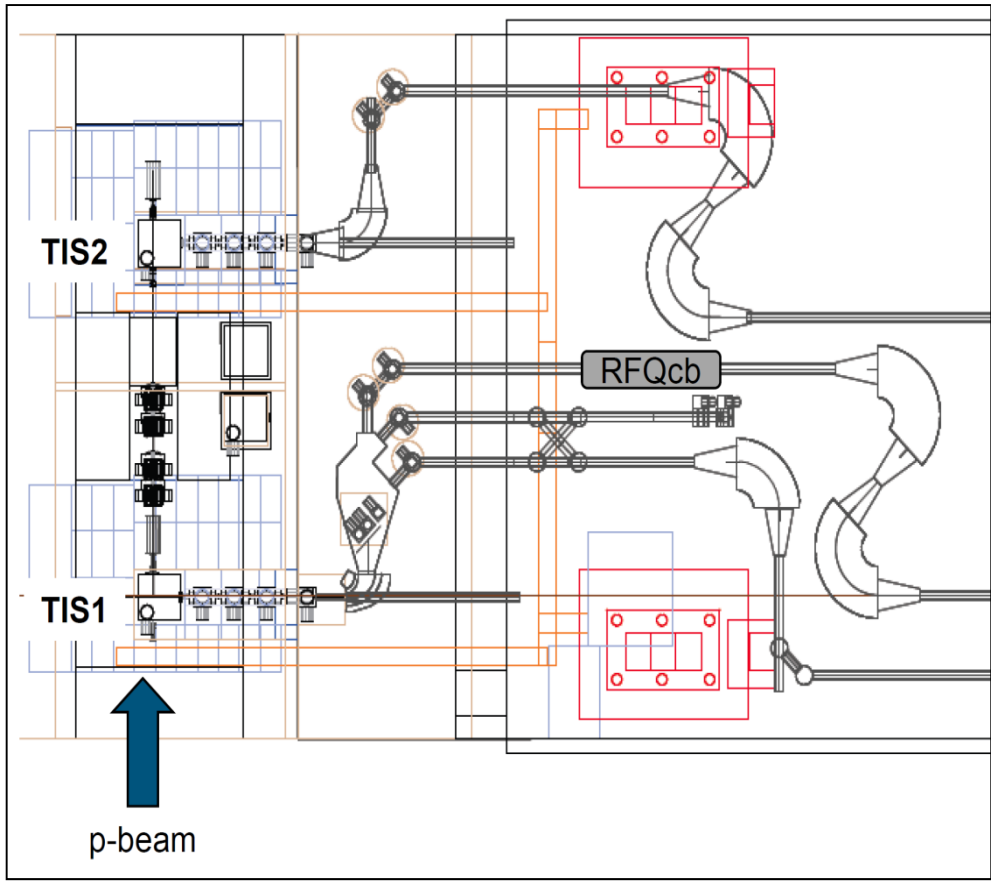
➢ *maximize the use of p-beam*

➢ *multi-user facility (delivery of two different RIBs at the same time)*

➢ *Possibility for target development at TIS2 during exploitation of TIS1*

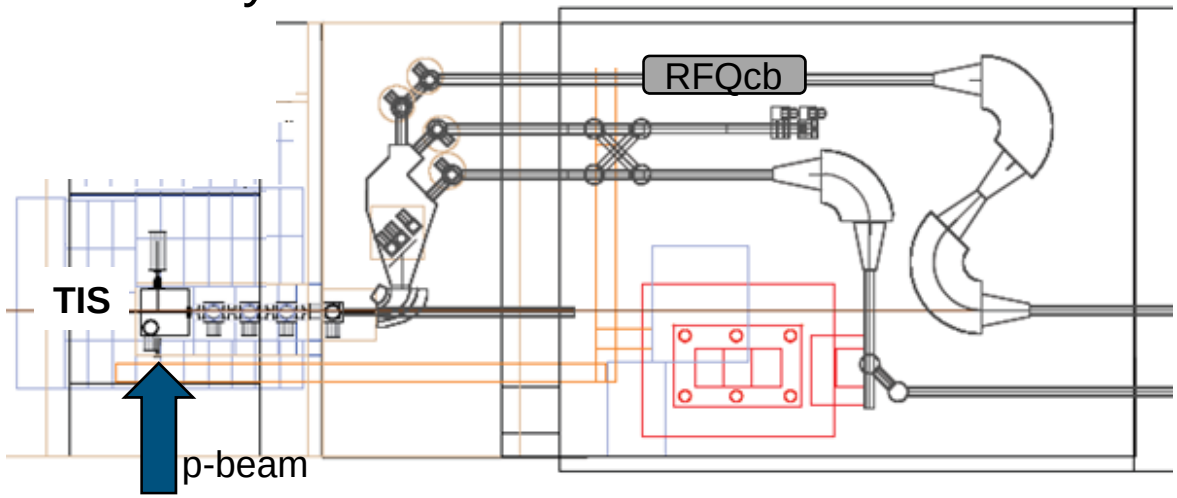
  - Challenge:

➢ *Large beam spread after TIS1 → re-focusing elements exposed to high dose => decreased reliability*



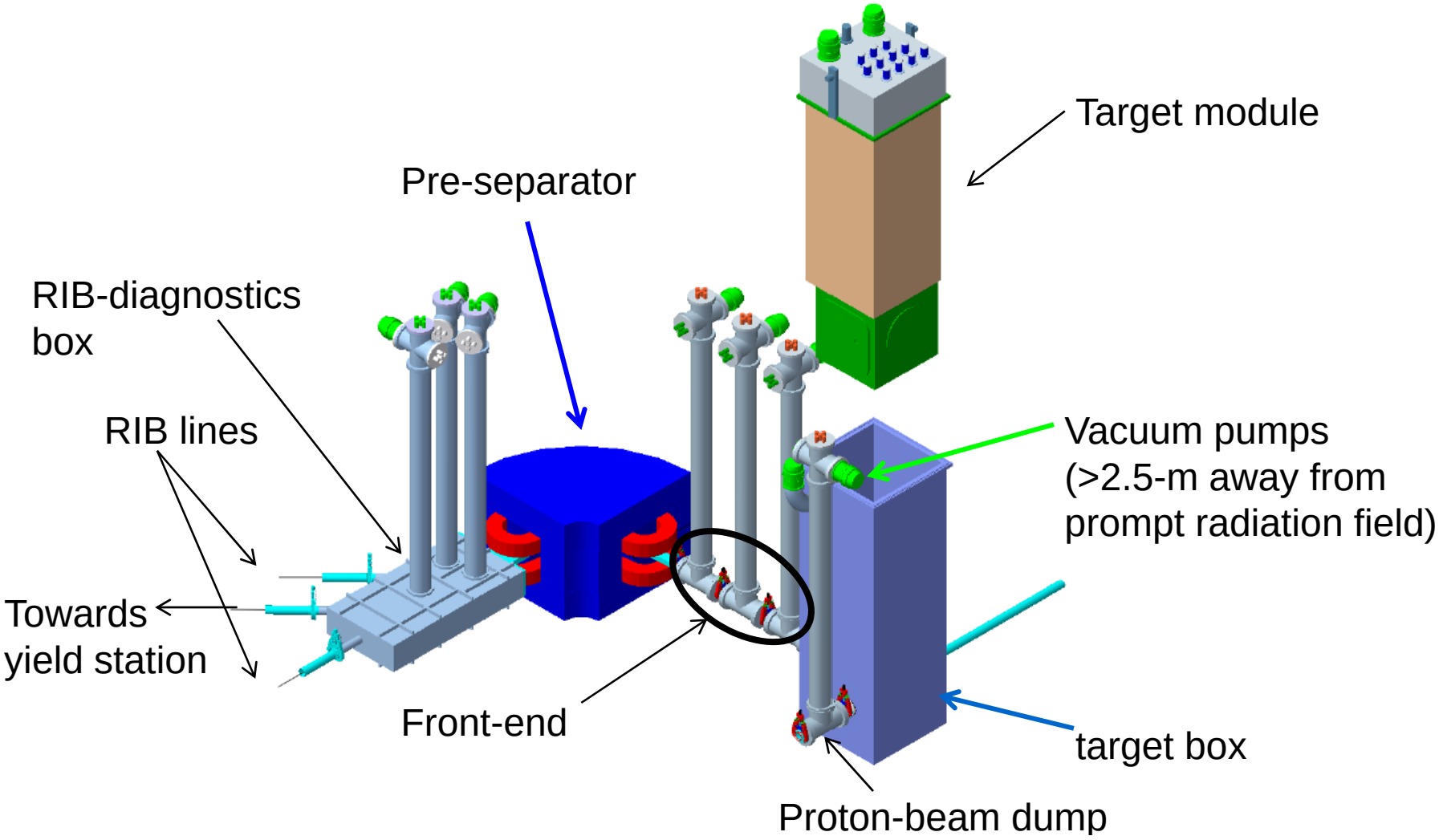
RIB production facility

- Concept 2: one target station only



- Drawback:
  - *Single-user facility*
    or
  - *2 very similar RIB's*
- Advantages:
  - *Beam Dump immediately after target*
    - *Better shielding with less material – diminished costs*
  - *No components exposed to high rad. dose*
    - *Increased reliability*
    - *Diminished maintenance periods, waste & operating costs*
- Potential upgrade:
  - *p-beam split and simultaneous irradiation of two targets at ½ power*

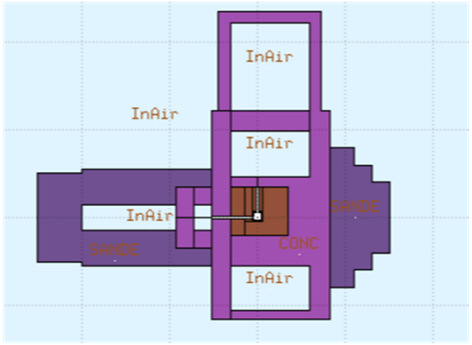
Target Station Conceptual Design

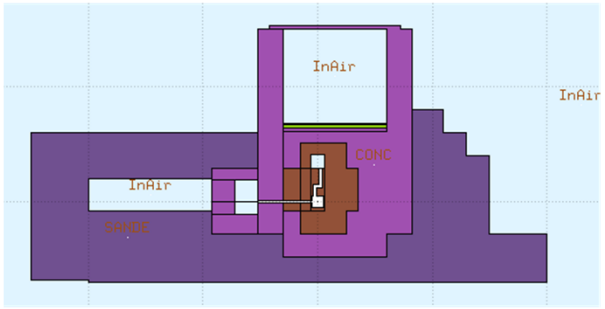


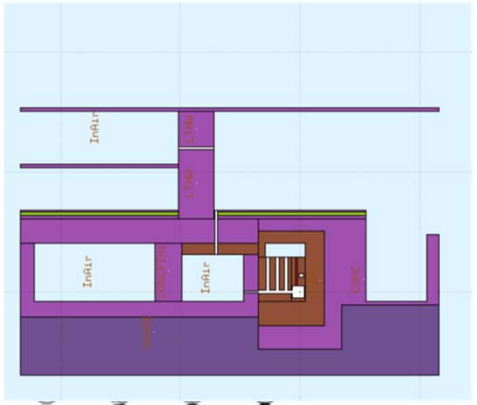
Courtesy of P. Bricault (TRIUMF, SCK•CEN)

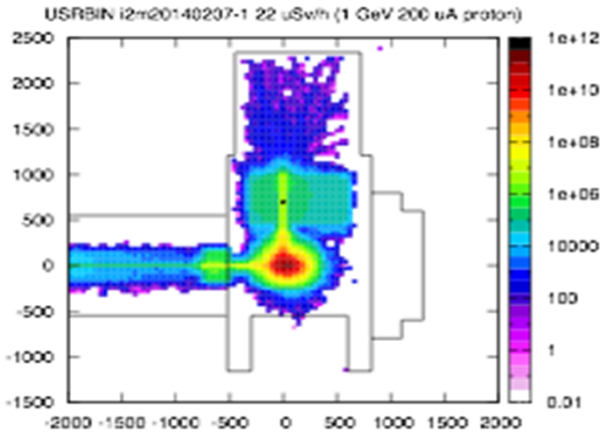
Shielding of the target station

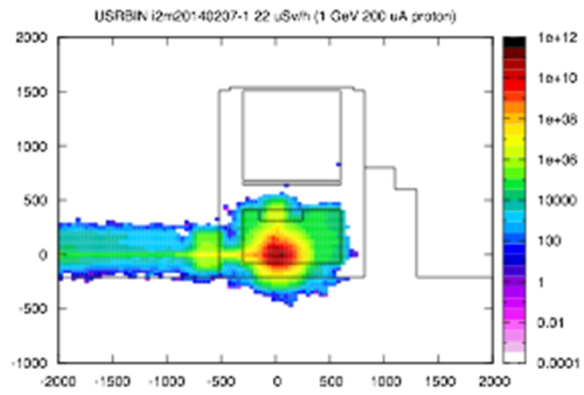
- Calculations performed for the different developed concepts
- Shielding and design adapted in order to solve several issues
- The work is ongoing

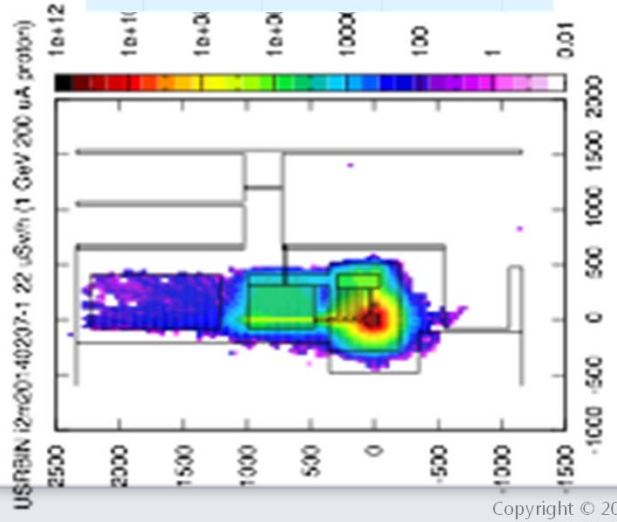




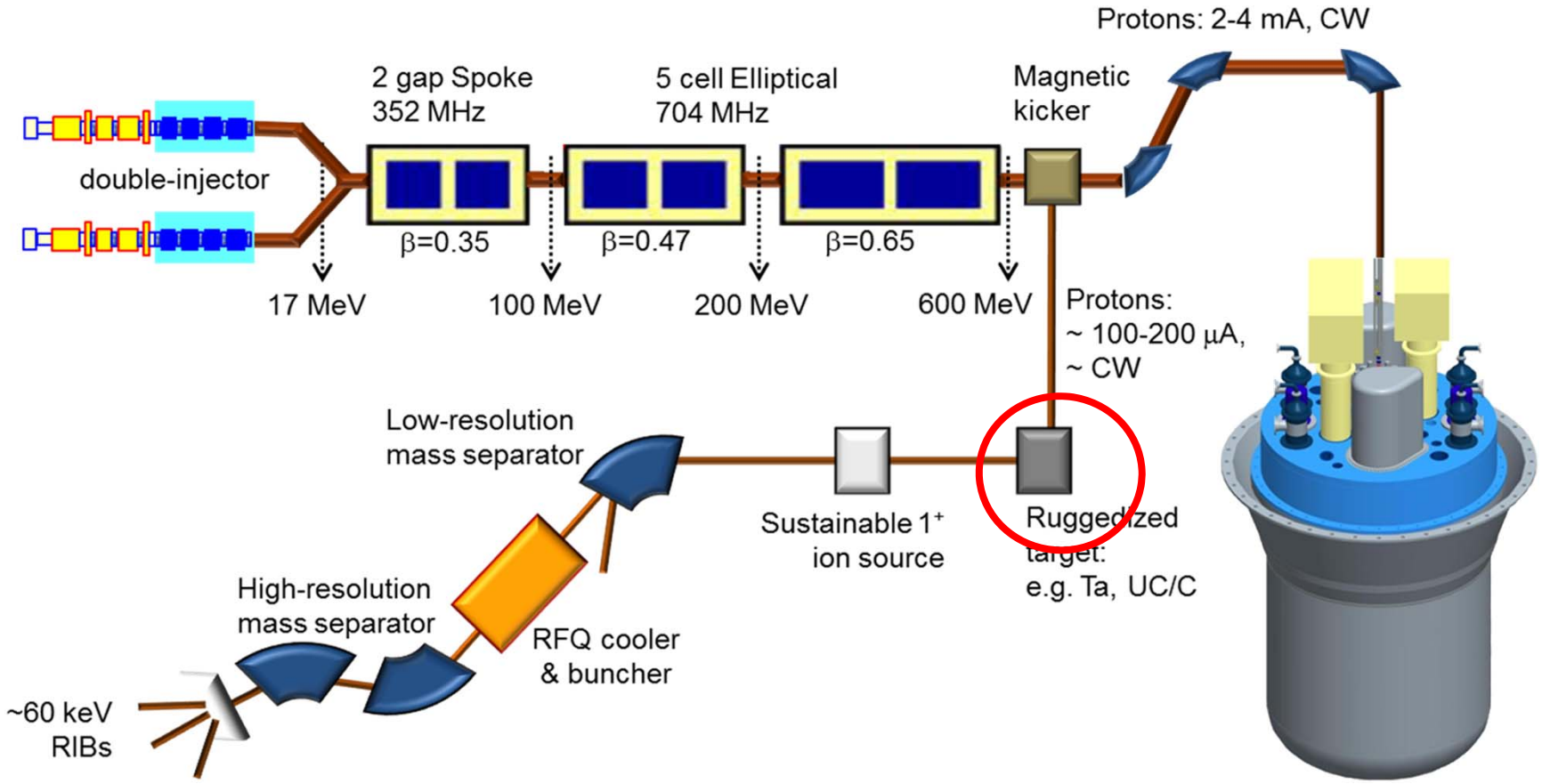








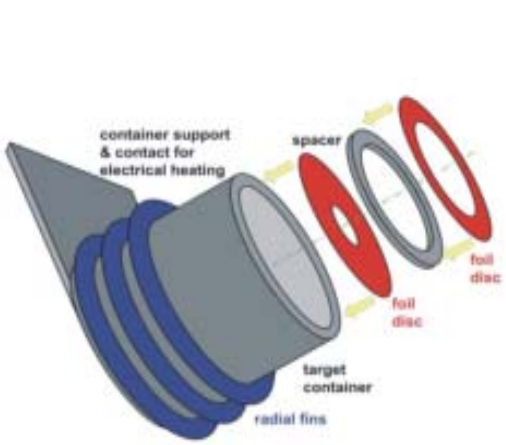
Targets

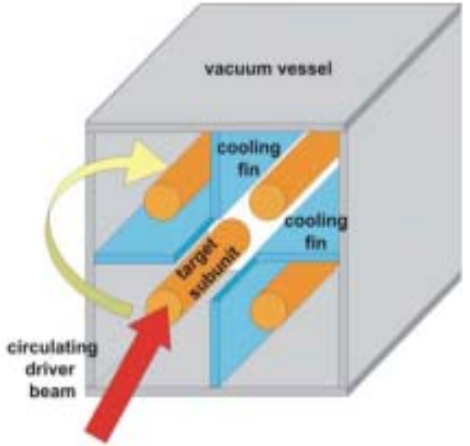


High-Power Targets

- Solid targets based on ISAC design
  - refractory metal foils (e.g., Ta, Nb, Ti)
  - carbide powders on a graphite sheet (e.g., ZrC/C, SiC/C)
  - UCx/C should run at full power at ISOL@MYRRHA

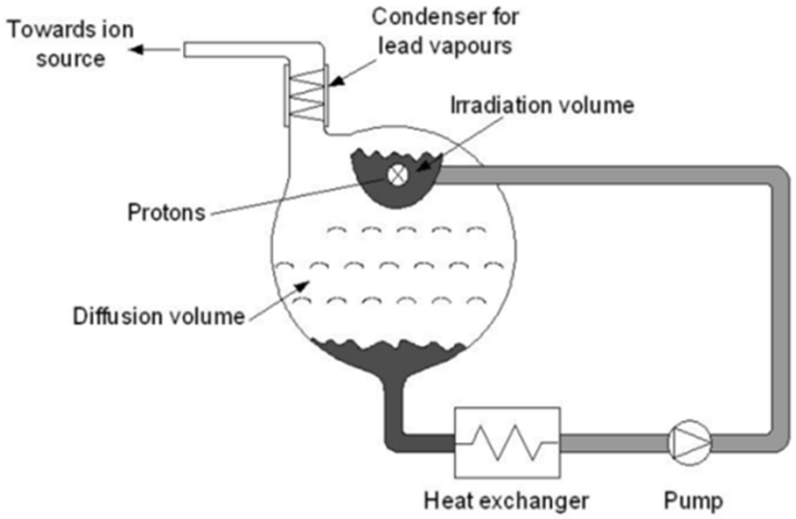
- Evaluating
  EURISOL 100-kW solid target



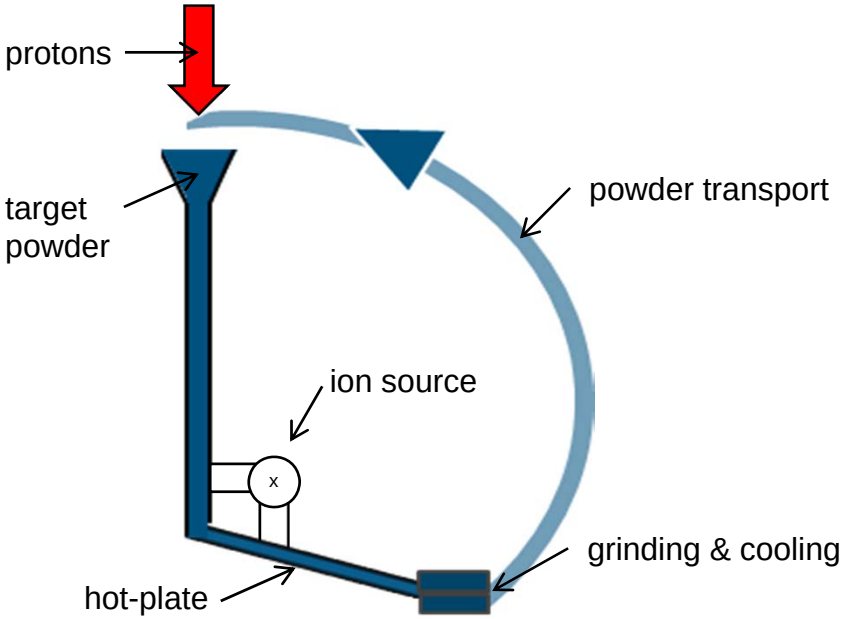


Innovative high-power targets

- Pb-Bi loop - production of short-lived volatile elements



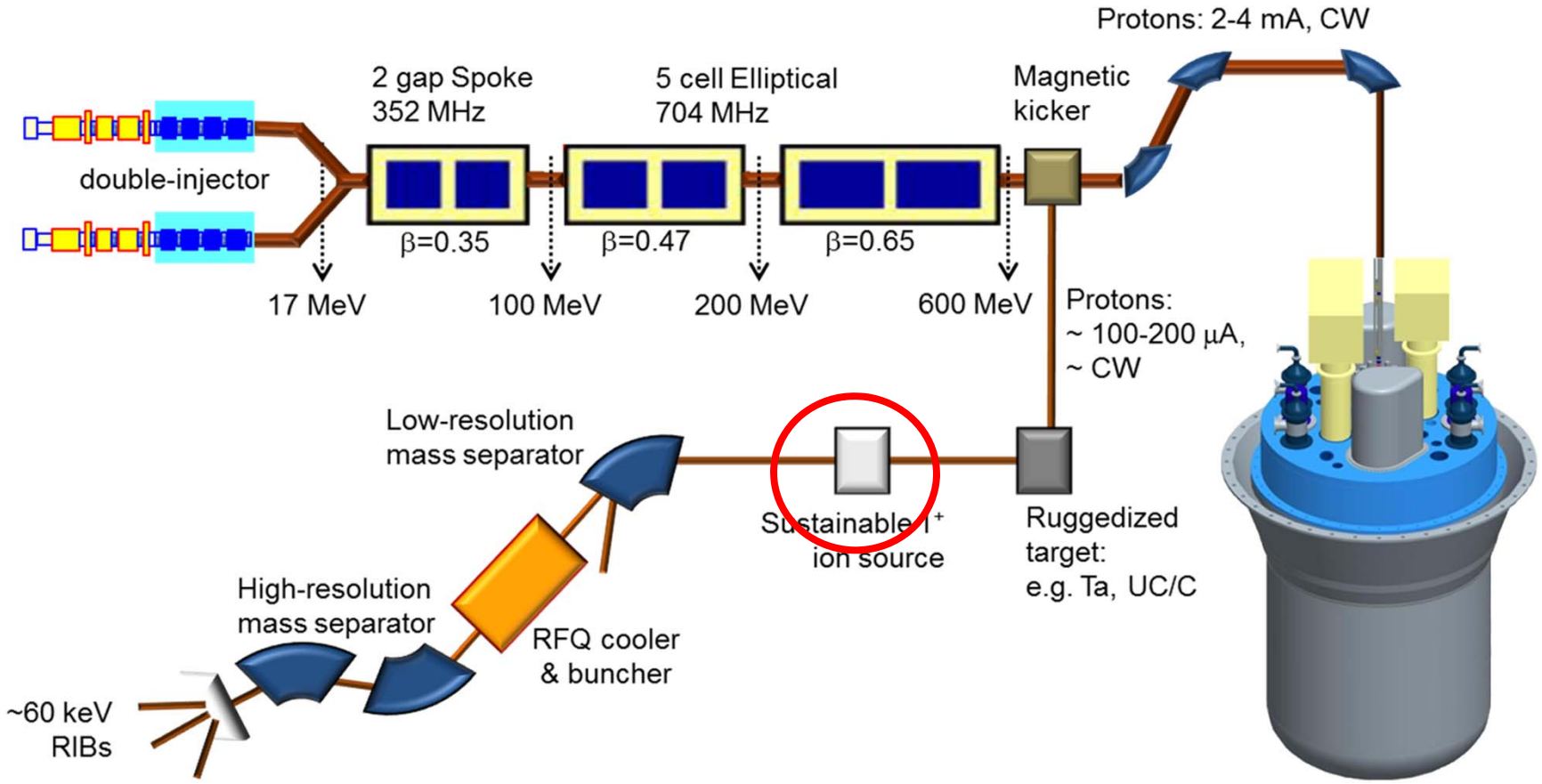
- Circulating-powder loop



EURISOL → **LIEBE project**

The two concepts allow further increase of beam intensities

Ion sources

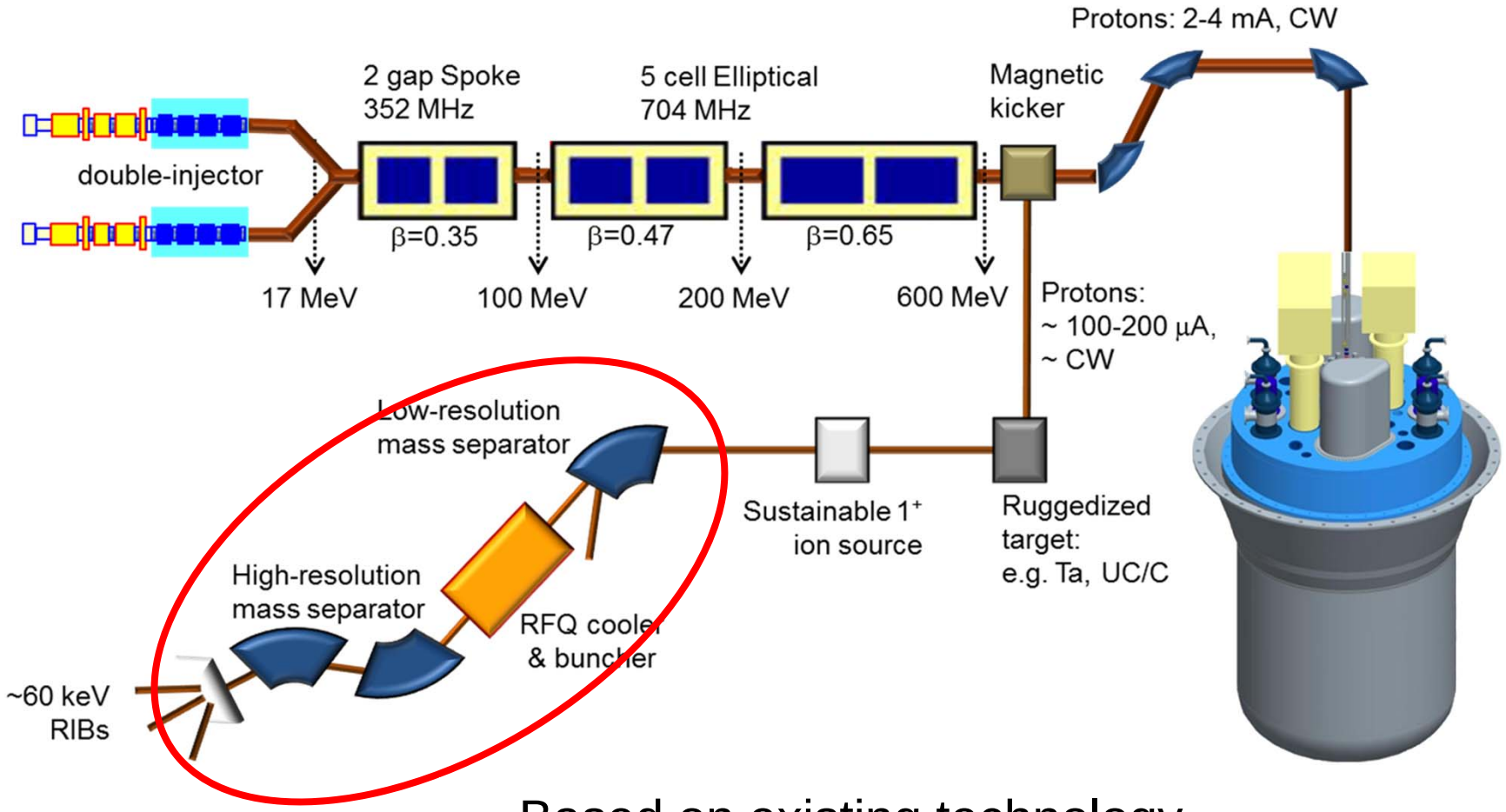


Ion sources

In view of the long beam times, the ion sources should have a reliable operation over at least three months without efficiency degradation

- 3 types considered:
  - ECR 1+: for gaseous elements (noble gases, C, N, O,…)
  - Surface ion source (hot cavity): for beams of alkaline and earth alkaline elements
  - RILIS : for elements with intermediate ionization potentials

Mass separation



- Based on existing technology
- Pre-separator design under work

Summary

- ISOL@MYRRHA - extension of the MYRRHA-ADS, sharing the p-beam with the nuclear reactor
- Focus on experimental programmes which need extended beam times with stable operation *(experiments which hunt for very rare phenomena, need high statistics, need many time-consuming systematic measurements, have inherent limited detection efficiency)*
- Current ISOL@MYRRHA Design envisages 1 target station (600-MeV <200 μA protons) and a high-resolution mass purification system => high-purity RIBs ~100 times more intense than today at ISOLDE
- Options kept open for potential upgrades:
  - 600-MeV → 1-GeV proton-beam driver
  - MW-target station

Acknowledgements

SCK•CEN Contributors

- S. Vanmaercke
- D. Vandeplassche
- A. Stankovskiy
- L. Sexton
- M. Schyns
- P. Schuurmans
- R. Salemme
- L. Popescu
- D. Pauwels
- D. Houngbo
- J. Engelen
- P. Bricault

Collaborators

BriX

TRIUMF

ISOLDE

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EURISOL
Consortium

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