

The HIE-ISOLDE Superconducting Recoil Separator

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16. ESS-BILBAO, Bilbao, Spain.

17. Univ. Aarhus, Denmark.

18. Cockcroft Institute, Daresbury, United Kingdom.

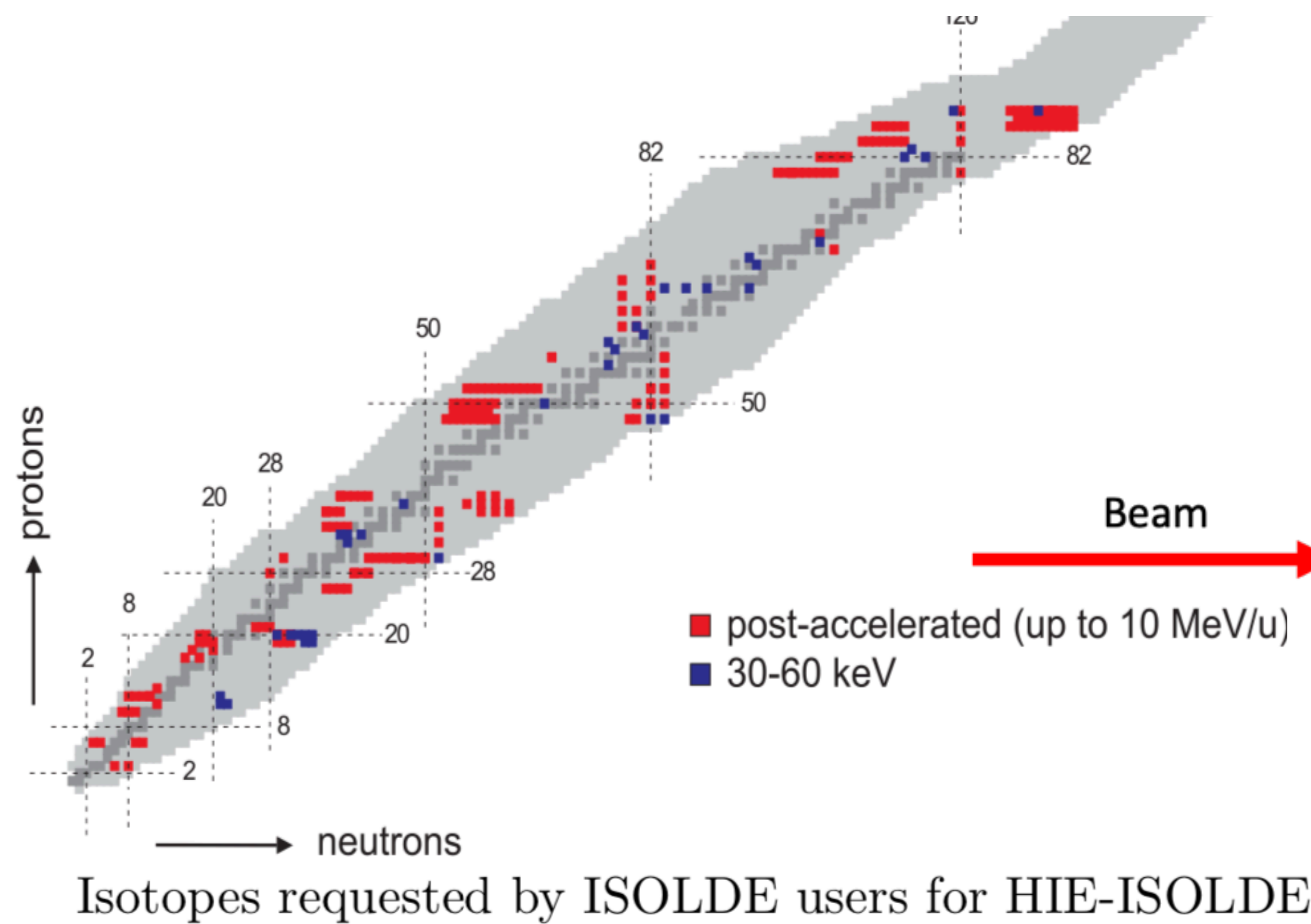
19. Univ. West Scotland, United Kingdom.

20. Univ. Jyvaskyla, Finland.

21. IMIS Univ., Riyadh, Saudi Arabia.

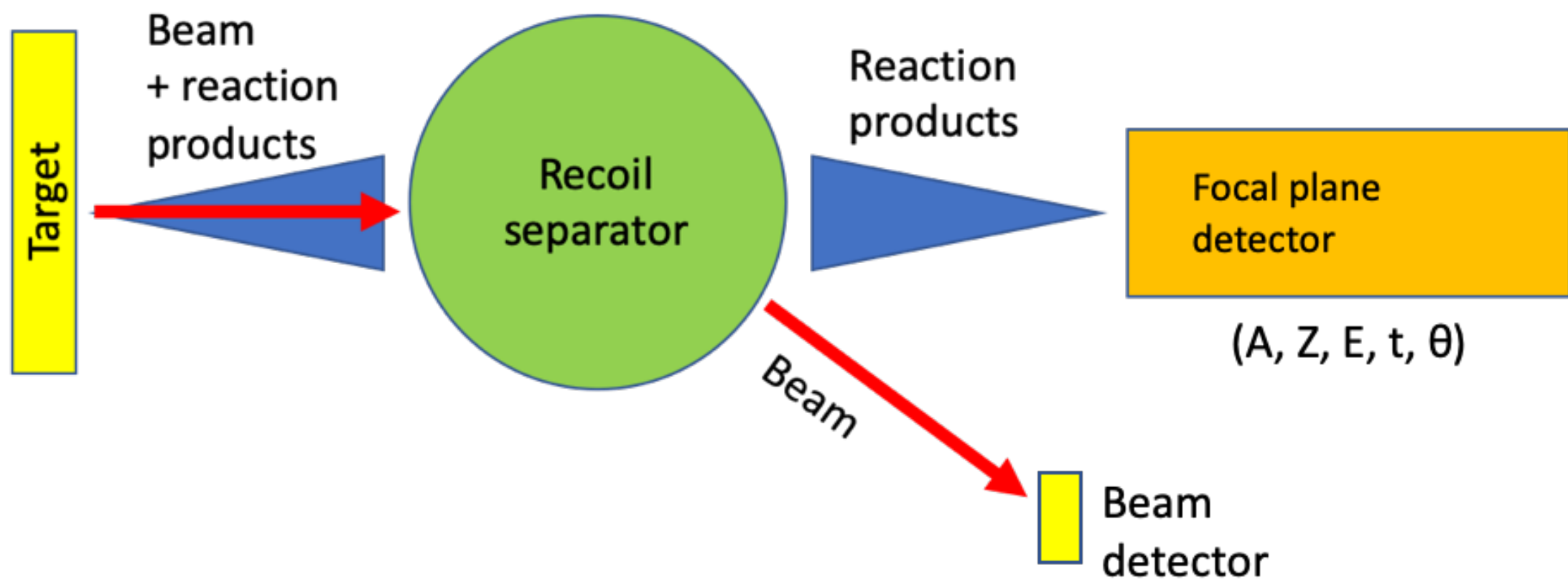
Introduction

The HIE-ISOLDE facility at CERN (Geneva, Switzerland) [1] produces a large variety of radioactive beams from ⁶He to ²³²Ra at 0.45-10 MeV/u. This energy range is ideal to study nuclear structure, low-energy dynamics and astrophysics.



Recoil separators

An important experimental problem is the separation of the primary beam from beam-like reaction fragments produced in heavy ion reactions.



Physics Program

The White-Book of the facility, addressing the relevant physics cases is presently in preparation. This will define the technical requirements,

Physics cases

- Direct reactions

• Transfer

• Coulex

• Deep inelastic
- Fusion-evaporation

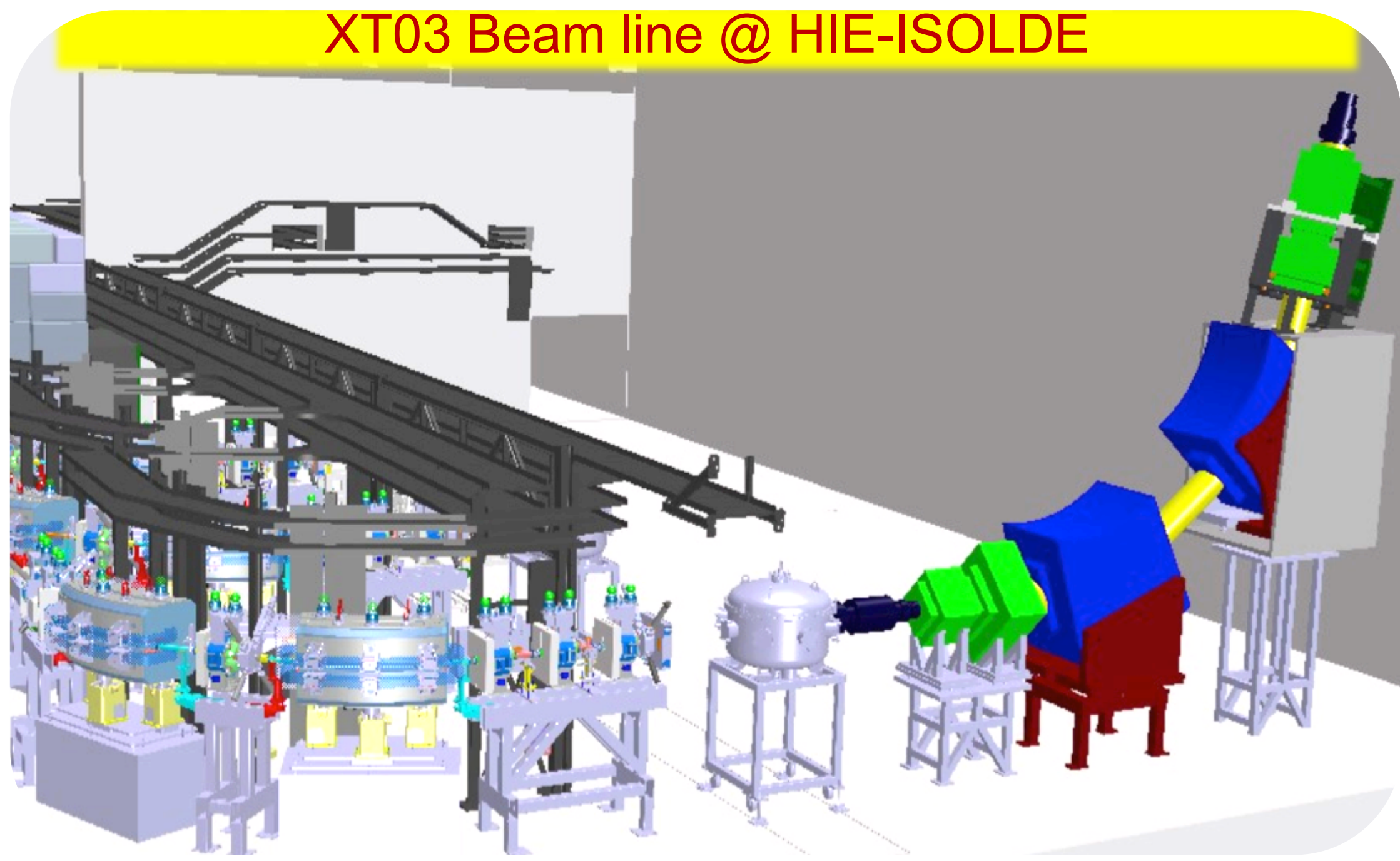
• Astrophysics

• Focal plane decay

• Beyond HIE-ISOLDE

Profit from existing detectors

- MINIBALL, SEC, ISS



Traditional ToF system based on warm magnets

- Previous initiative → HIFI
- Space constraints at HIE – ISOLDE HALL (~6m) translates into poor mass resolution for masses > 50.
- Look for compact alternative solution

Superconducting Recoil Separator

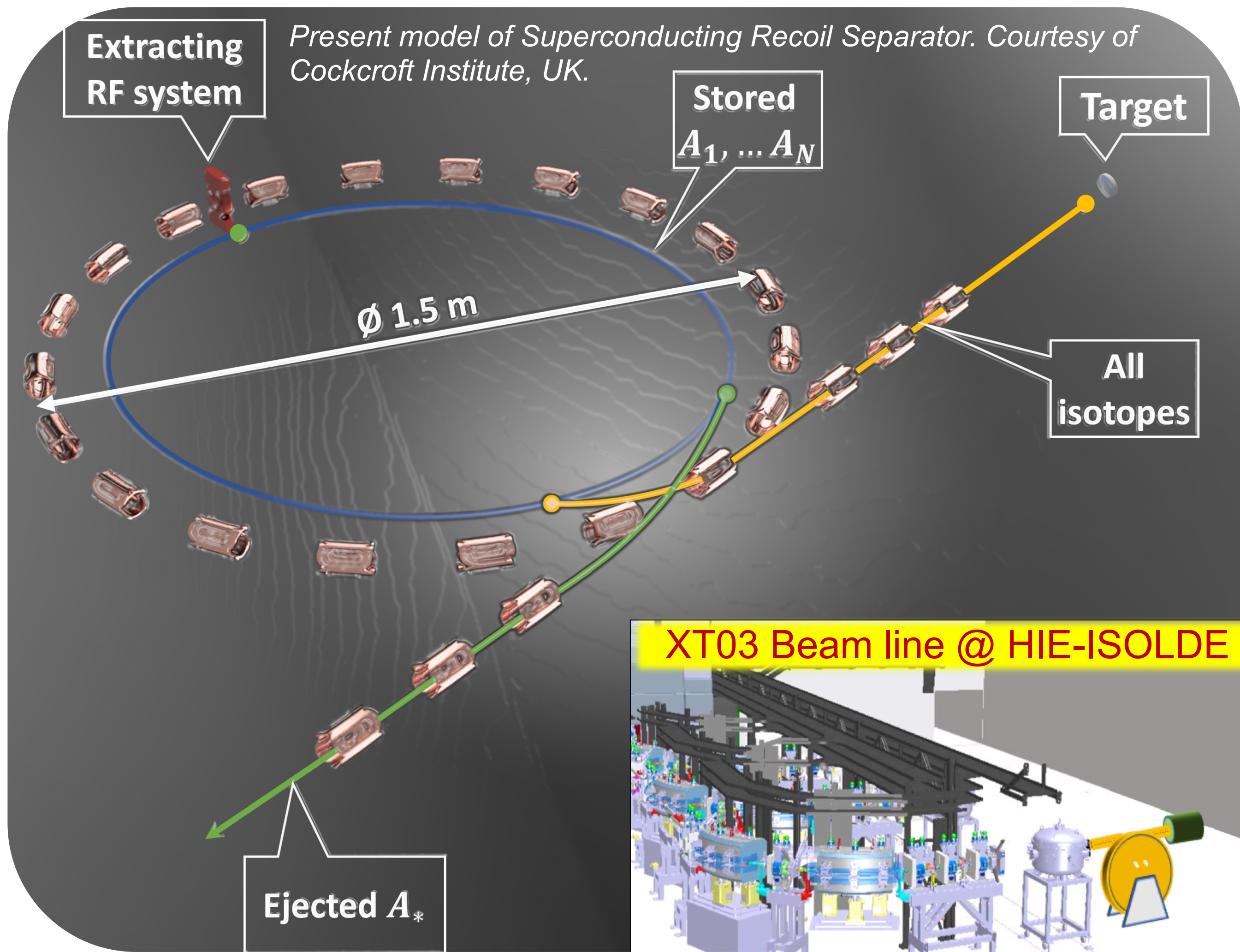
To meet the physics program needs, a high-resolution recoil separator based on a **compact superconducting (SC)** mini-ring storage system has been proposed [2].

A proof-of-concept preliminary design features a $\Phi = 1.5$ m diameter ring built up of **multifunction SC magnets** [3] of $\delta = 25$ cm length (MFSCM) in a **Fixed-Field Alternating-Gradient (FFAG)** configuration. The MFSCMs should be able to withstand magnetic fields as high as 4 to 6 T. **HTS** materials and **cryocooler** systems are being considered in the design. Preliminary beam dynamics studies are ongoing (J. Resta –López, Cockcroft Institute, UK) [4].

Reaction fragments circulate up to $\tau \sim 1 \mu s$ being differentiated by their cyclotron frequency. Various techniques of operation are under study. **In the simplest mode**, the ions are extracted, identified and quantified in a focal plane detector by **Time-of Flight (ToF)** and **Energy Loss** in Gas - Si detectors. **Digital Pulse Shape Analysis (DPSA)** techniques will help to deal with the most challenging cases.

Simulations

$d(^{233}\text{Ra}, ^{234}\text{Ra})p @ 10 \text{ MeV/u}$
 $^{233}\text{Ra}, ^{234}\text{Ra}$ -ToF separation $\sim 40 \text{ ns}$ (10 turns)

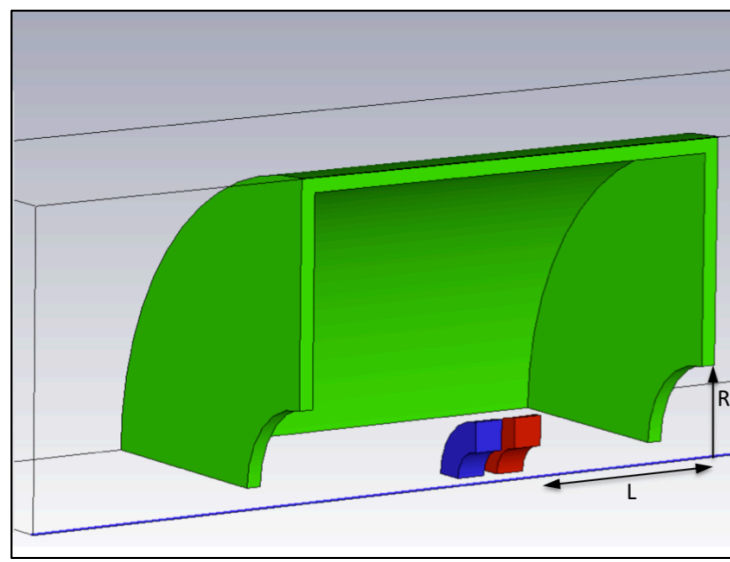


HI – SRS Working groups

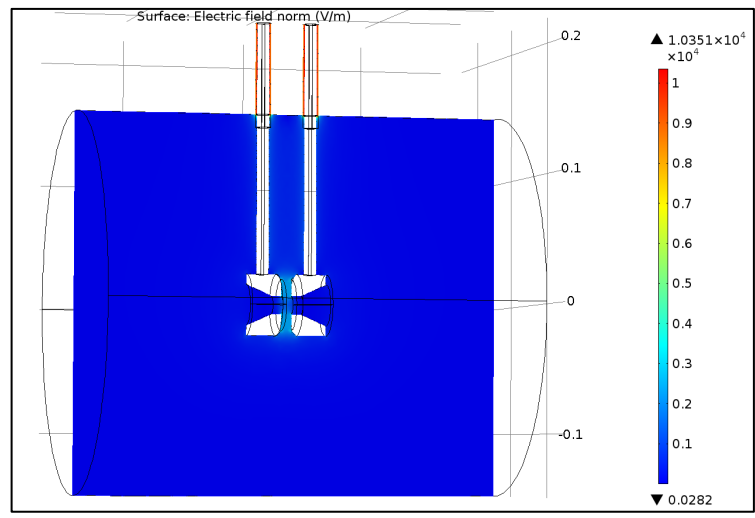
WP1	Project Coordination and Management	WP5	Construction of prototypes
WP2	System specifications and selection of technologies	T5.1	Beam transport line
T2.2	Physics case/White book	T5.2	Multiharmonic buncher
T2.3	Conceptual design and critical components	T5.3	Solid State Power Amplifier
WP3	Design study of the spectrometer	T5.4	Multifunction magnets
T3.1	Beam dynamics FFAG	T5.5	Magnetic probes
T3.2	Charge breeder development	T5.6	Magnet test bench
T3.3	Beam transport (SEC)	T5.7	Cryostat, cryogenic system, control
T3.4	Multiharmonic buncher	T5.8	Integration/preliminary test
T3.5	Solid State Power Amplifier	WP6	Local systems, integration and installation
T3.6	Re-buncher	T5.1	Standard beam instrumentation
T3.7	RF and LLRF systems	T5.2	Vacuum systems
T3.8	Superconducting multifunction magnet design	T5.3	Integration mechanical systems
T3.9	Magnetic probes	T5.4	Installation
T3.10	Magnet test bench design	T5.5	Safety
T3.11	Injection/extraction system	WP7	Prototype evaluation
T3.12	Cryostat, cryogenic system, control	T7.1	Testing plan and initial machine studies
T3.13	Standard beam instrumentation	T7.2	Integration control systems
T3.14	Specialized beam instrumentation	T7.3	Hardware commissioning
T3.15	Safety: machine protection	T7.4	Stable beam commissioning
T3.16	Safety: personal protection	T7.5	Radioactive beam commissioning
T3.17	Budget and timeline	T7.6	Initial operations
WP4	Design study of physics detectors	T7.7	Data acquisition software
T4.1	Focal plane detectors and ancilliary systems	T7.8	Data analysis
T4.2	Control system and DACQ for physics detectors	WP8	Exploitation and dissemination

Multiharmonic buncher

A bunch spacing of 100 - 500 ns is needed for operating the spectrometer in ToF mode. This can be achieved by using a multi-harmonic buncher (MHB) and a dedicated EBIS extraction mode. A single-gap, grid-less MHB, similar to ATLAS in ANL [5], is being developed from previous studies [6].



Model of M. A. Fraiser [5], CERN (Switzerland).



Present MHB model. Courtesy of ESS-Bilbao, Spain.

References

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[4] J. Resta - López et al., Nucl. Inst. Meth. (in preparation).

[5] P.N. Ostroumov et al., PAC’07, WEPMN091(2007)2242.

[6] M. Fraiser et al. LINAC2014, THPP030.