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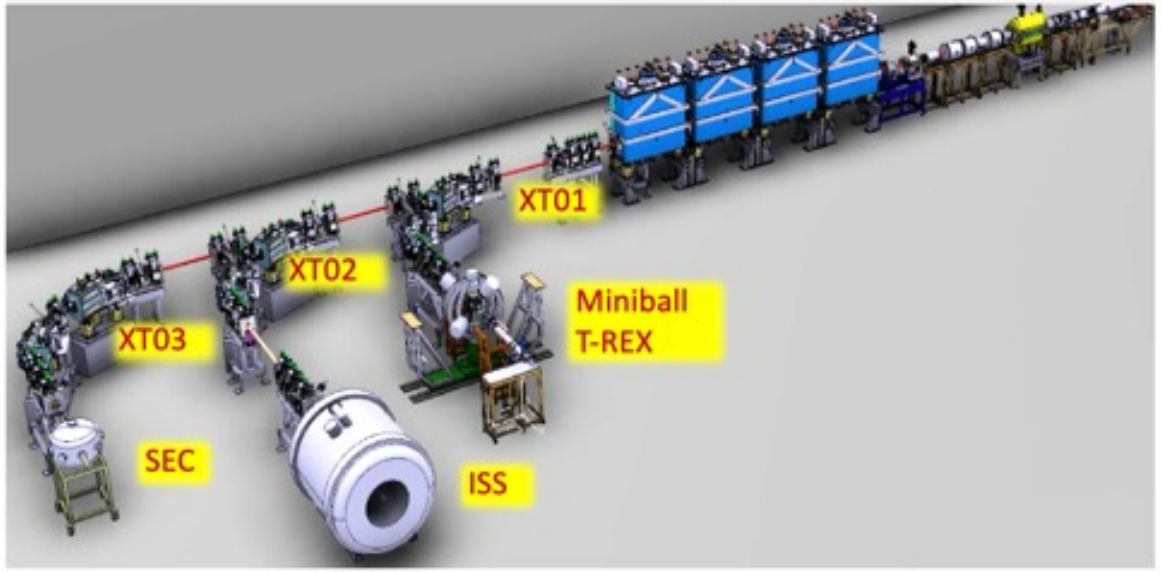
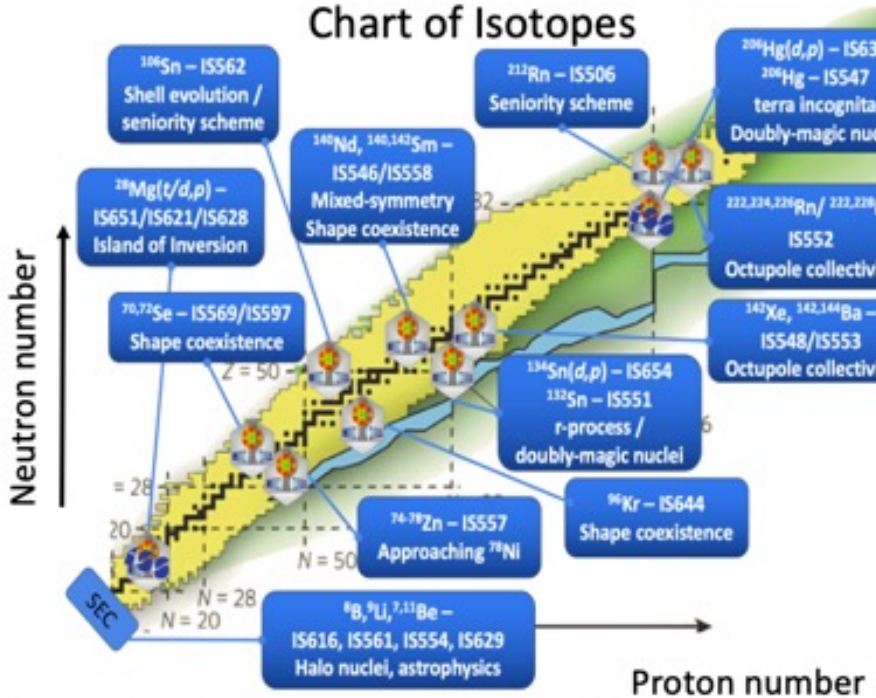
# THE HIE-ISOLDE FACILITY AT CERN

**World-leading facility in radioisotope production and acceleration**

- Large range of radioactive beams: from $^{6}$He – $^{234}$Ra
- > 1000 isotopes, > 70 elements
- Wide energy range 0.45 -~ 10 MeV/A




*Recent physics cases investigated at HIE-ISOLDE (L. Gaffney, ISOLDE EPICS Workshop 2019).*

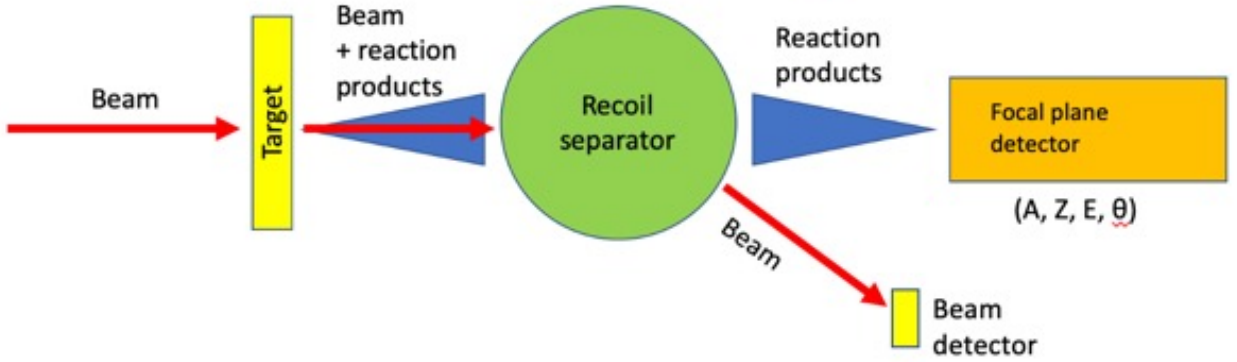
**Nuclear Physics:** Study of nuclear structure, reaction dynamics, and decay modes of radioactive nuclei. Societal applications.

**Recoil Separator** → extend the ISOLDE physics program

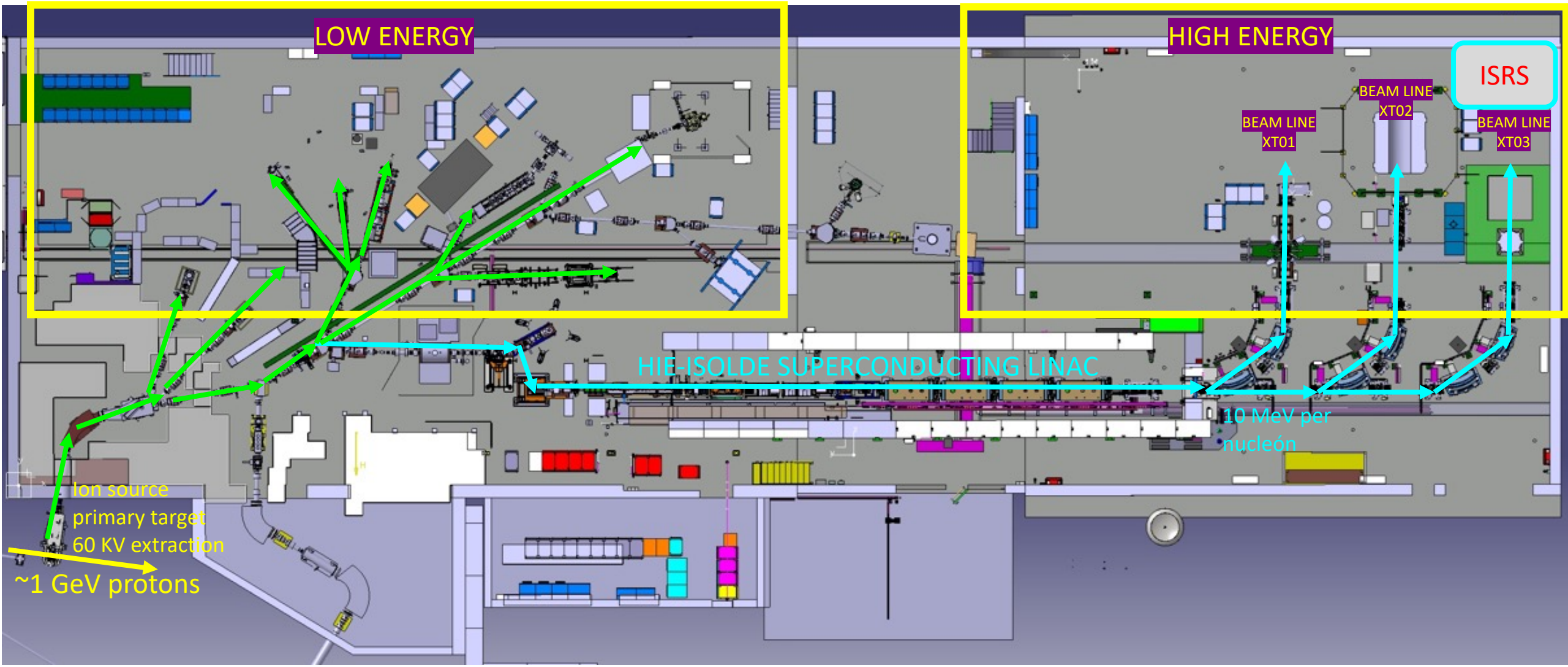
**ISOLDE SUPERCONDUCTING RECOIL SEPARATOR: ISRS**

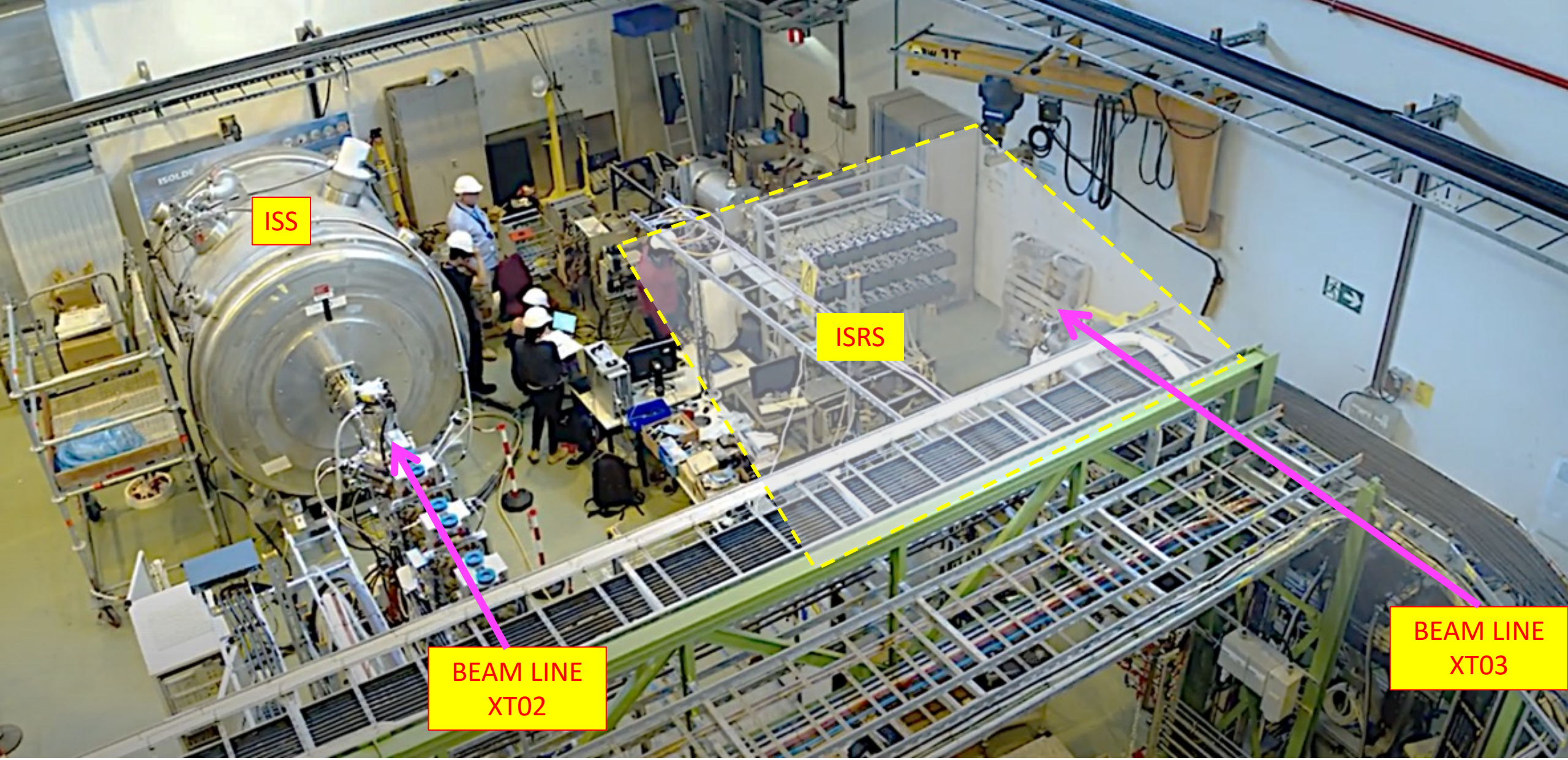
## Recoil Separators

- Separate/analyse forward focussed reactions products (θ ~ 0°) from the primary beam.



# ISOLDE FACILITY AT CERN




ISS
ISRS
BEAM LINE
XT02
BEAM LINE
XT03

CERN-INTC-2021-021 / INTC-I-228
20/01/2021

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

Letter of Intent to the ISOLDE and Neutron Time-of-Flight Committee

# Design study of a Superconducting Recoil Separator for HIE-ISOLDE

January 20, 2021

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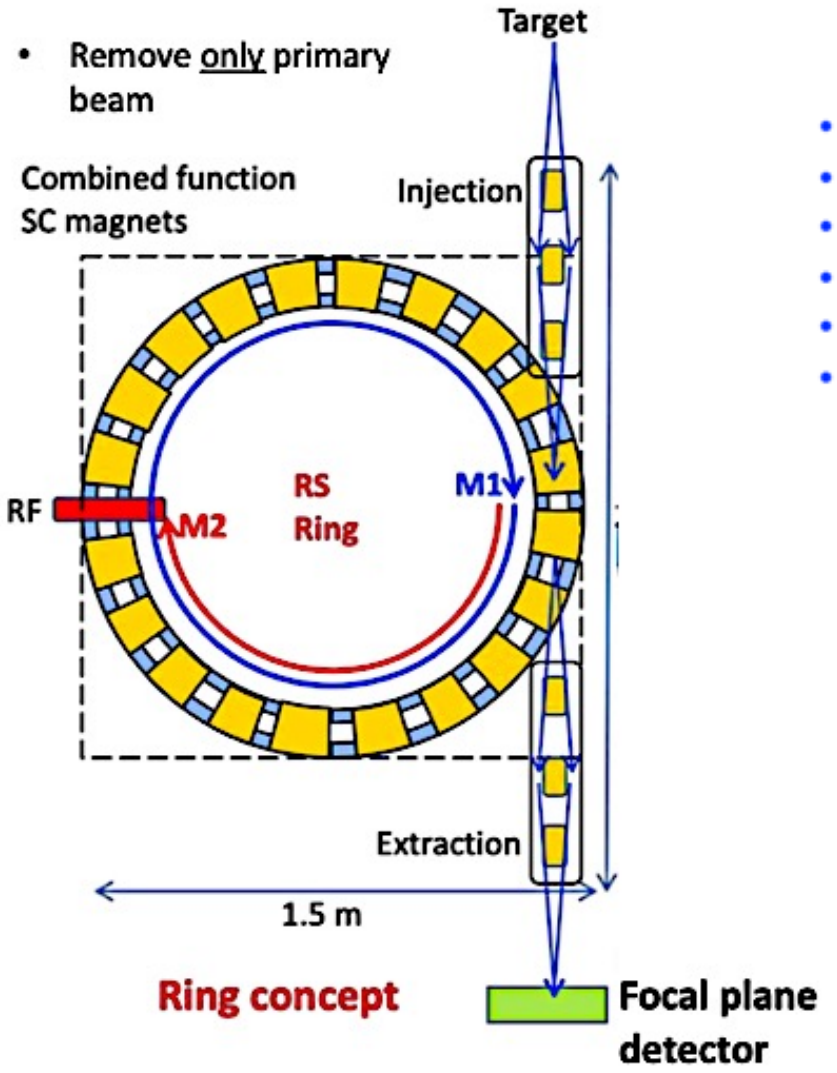
**Abstract**

The HIE-ISOLDE facility at CERN delivers presently the largest range of low-energy radioactive beam available worldwide. The relevant features of the atomic nucleus are investigated by Coulomb excitation, transfer, deep inelastic and fusion-evaporation reactions. These studies can benefit from the use of a high-resolution spectrometer which selects and quantifies the beam-like reaction fragments from the intense primary beam. The collaboration has carried out preliminary design studies to assess the feasibility of developing a compact superconducting recoil separator. In this LoI the collaboration is requesting the endorsement of the INTC to commit resources to continue with a proof-of-concept project and participate in national and EU funding programs.

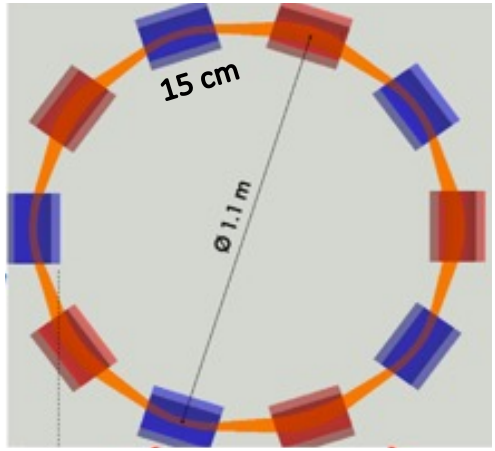
# THE ISRS CONCEPT: A "MINI"-PARTICLE STORAGE RING

*C. Bontoiu, J. Resta, V. Rodin, I. Martel, C. Welsch*, Nucl. Inst. Meth. A 969 (2020)164048



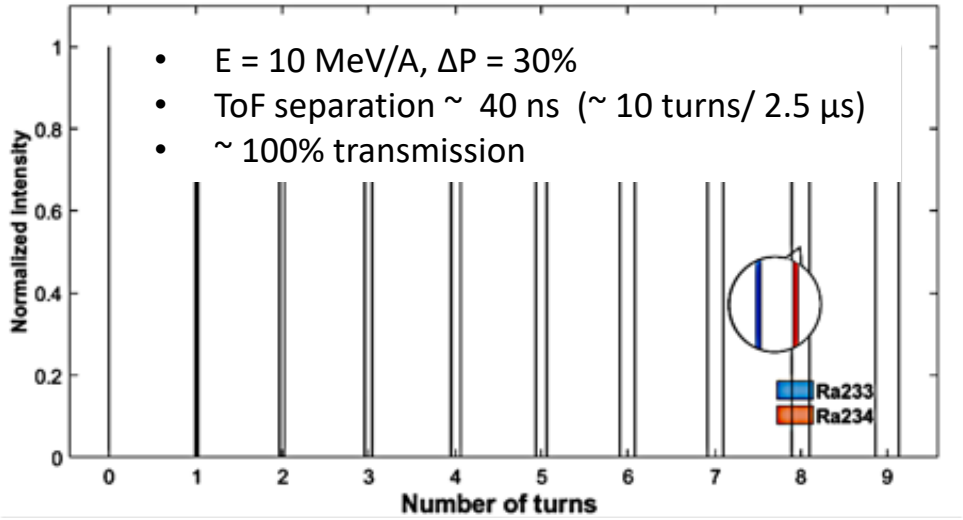

- Fixed Field Alternating Gradient → accepts large divergence and momentum spread
- Superconducting magnets → reduced size, mass, large fields
- Multifunction magnets (dipole, quad., sext.) → compact magnets
- Canted Cosine Theta (CCT) → reduce field errors, easier design/ fabrication
- Iron free (magnetic shield) → reduced thermal mass, weight, non-linearities
- Cooling by cryocoolers → easier operation, displacement (rotation)

**First optimization (10 multifunction magnets)**



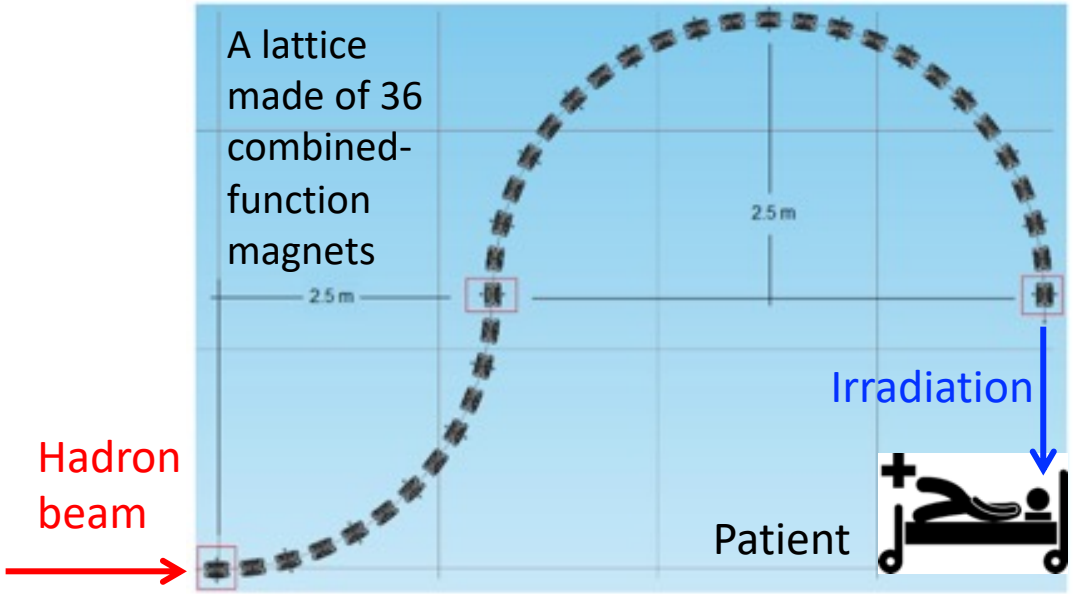

$^{2}\mathrm{H}(^{233}\mathrm{Ra},\ ^{234}\mathrm{Ra})\mathrm{H}$

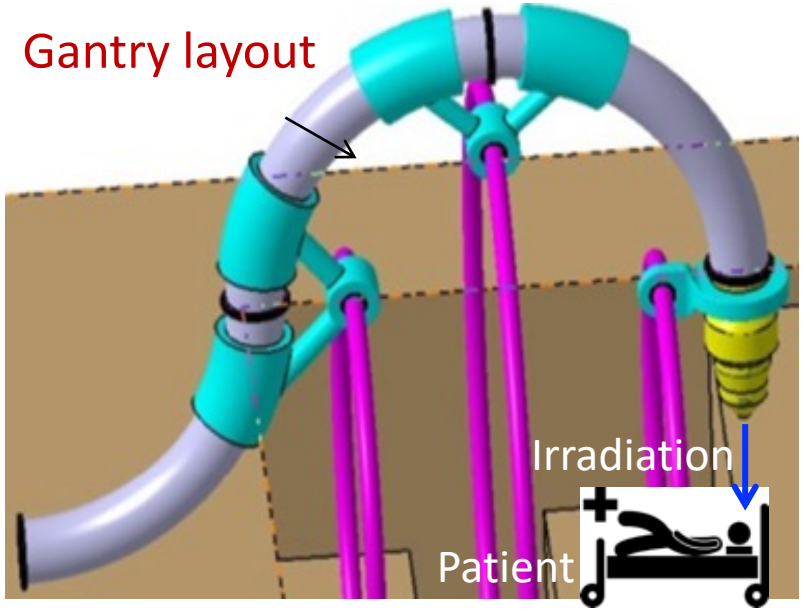
- E = 10 MeV/A, ΔP = 30%
- ToF separation ~ 40 ns (~ 10 turns/ 2.5 μs)
- ~ 100% transmission



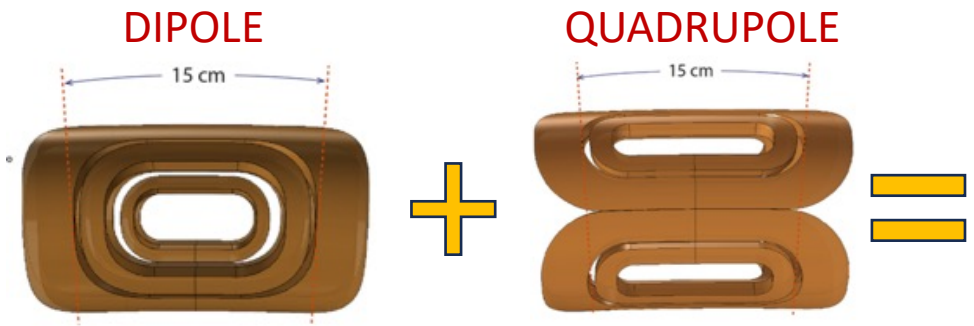
# ISRS CONCEPT → BASED ON PREVIOUS STUDIES OF SUPERCONDUCTING GANTRIES

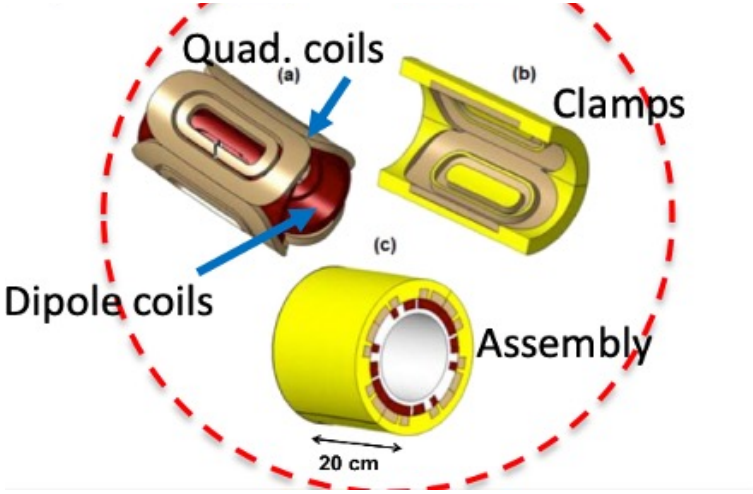
*"Design of a superconducting gantry for protons", C. Bontoiu, J. Sánchez, R. Berjillos, J. Pérez, I. Martel.* IPAC2015, TUPWI014




Multifunction coils (racetrack→ LHC)



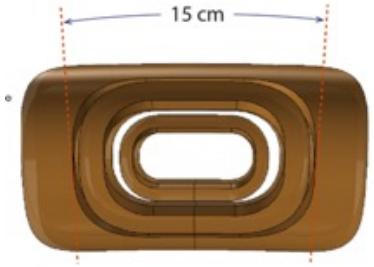
# NESTED multifunction superconducting magnets

RACETRACK

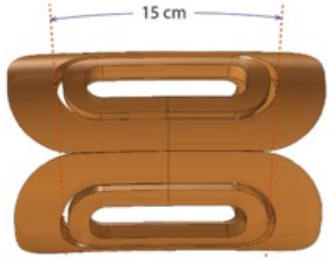
Multifunction coils
(Racetrack→ LHC)

*C. Bontoiu, et al.*
IPAC2015, TUPWI014

DIPOLE




QUADRUPOLE

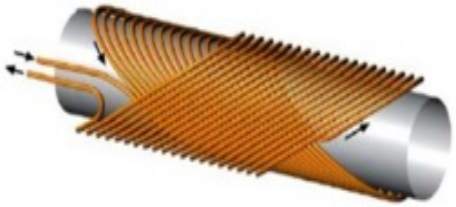



STRAIGHT

Canted Cosine
Theta (CCT) coils

Wei Wu 2020 J. Phys.: Conf. Ser. 1401; L. Zhou et al., Shock and Vibration 2021, 8895136

DIPOLE



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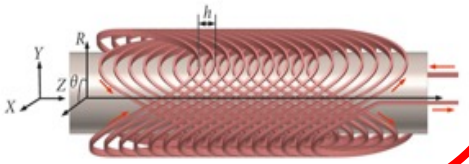
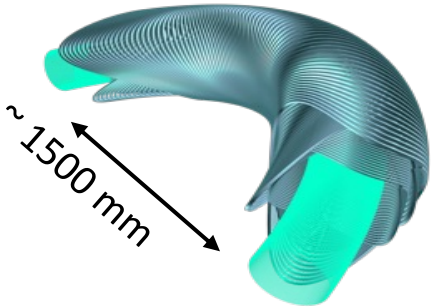


CURVED

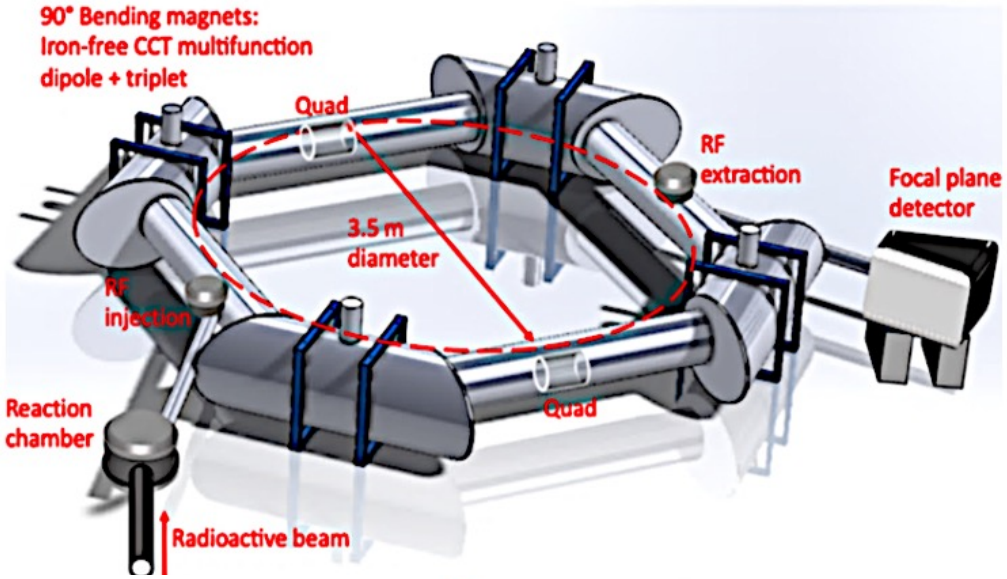
90° CCT curved
magnets

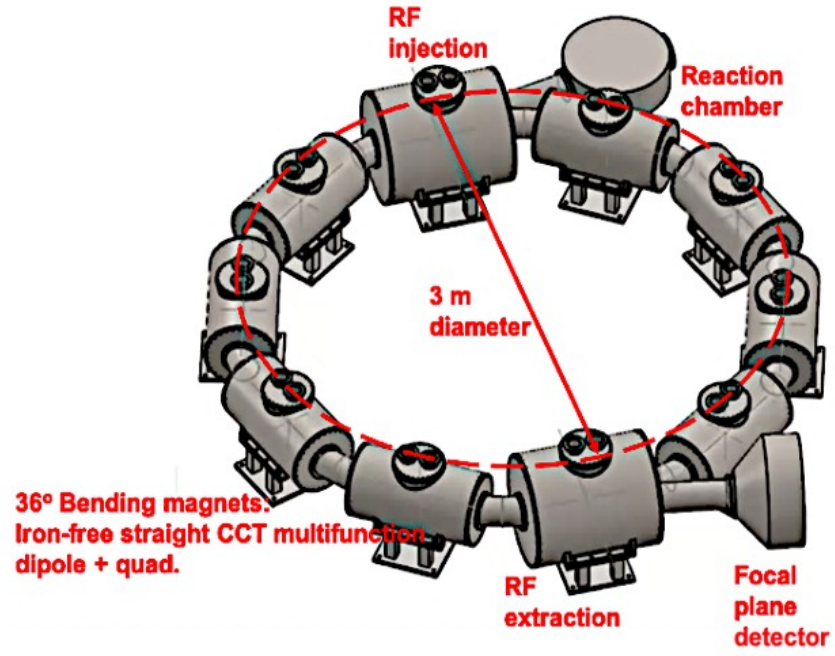
G. Kirby et al., IEEE
Tran.App.Sup. 23(2022)1-5

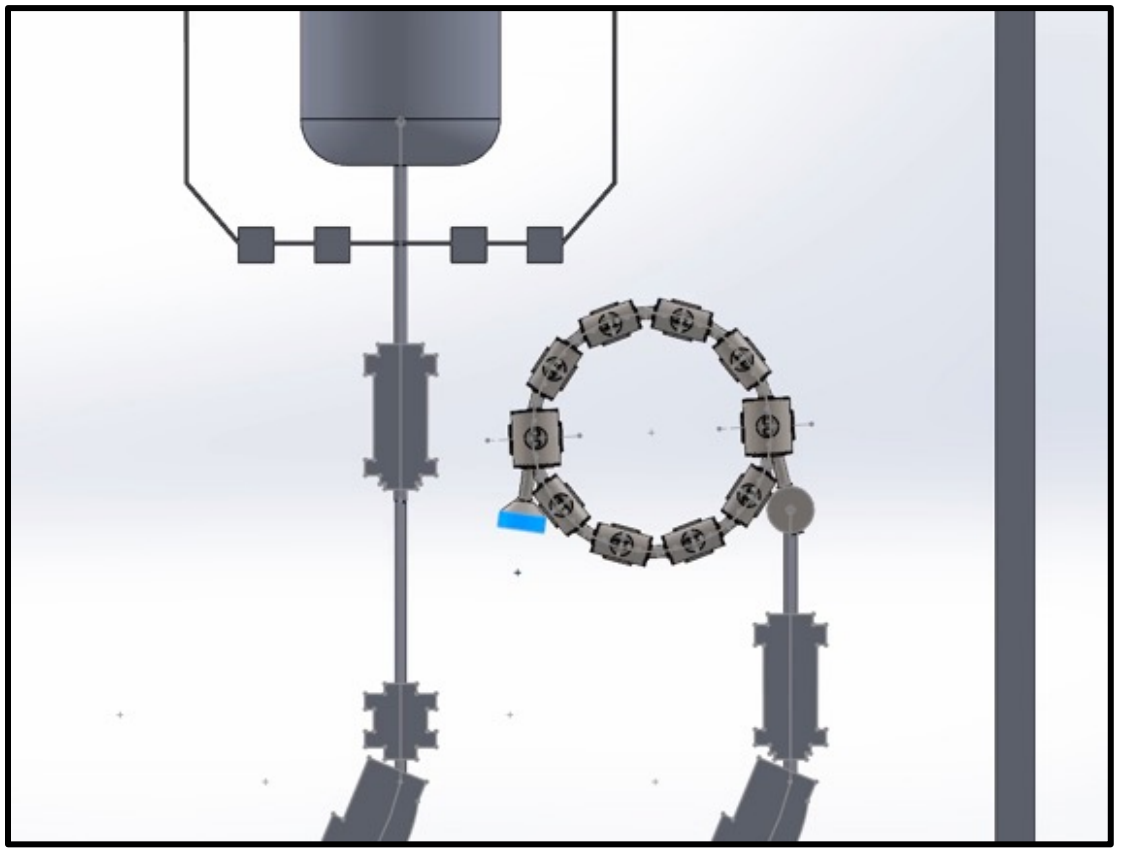



Single 90° sector
with dipole function
(FUSILLO, CERN)

# POSIBLE ISRS CONFIGURATIONS



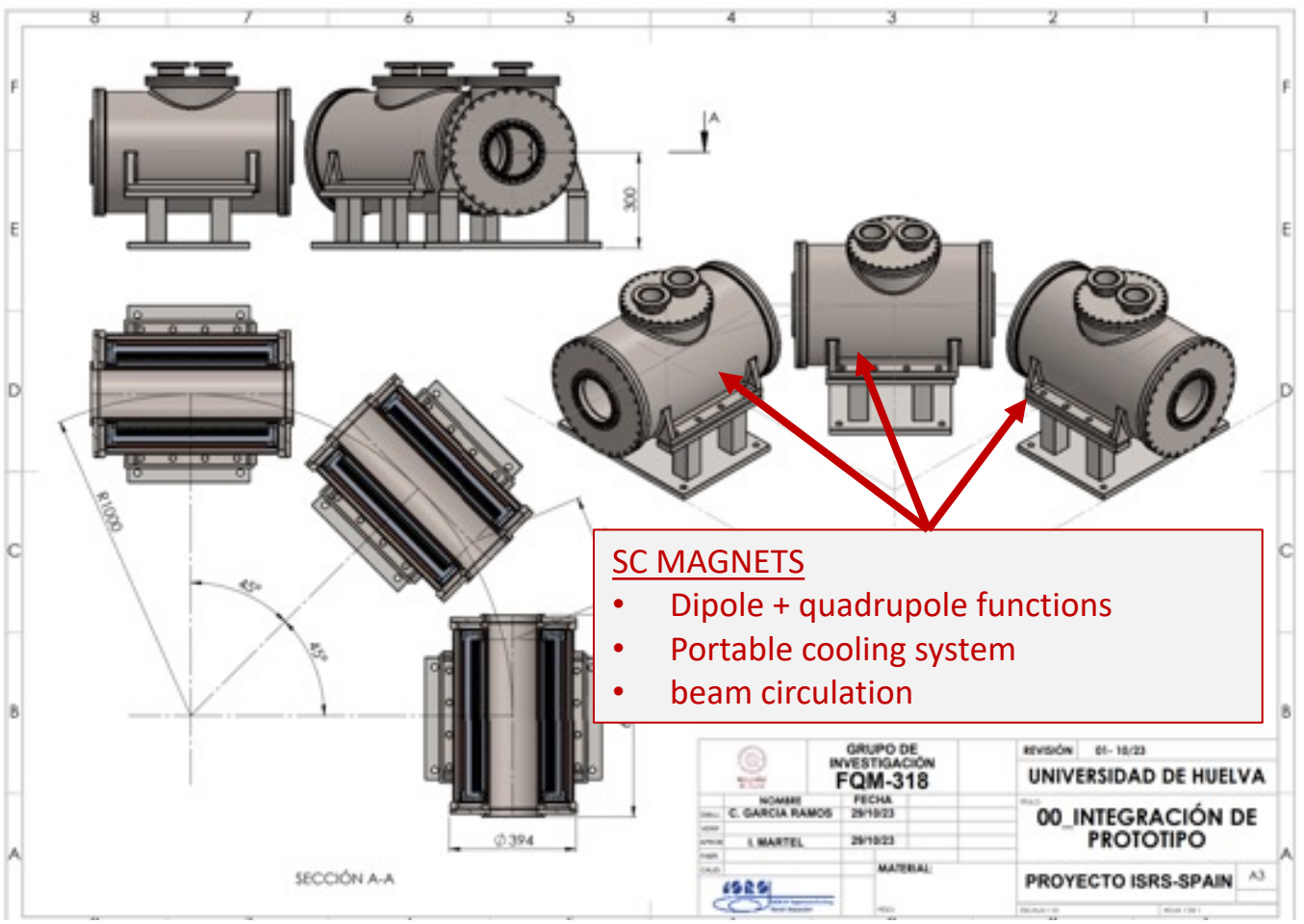



**December 2021:** Spanish Ministry of Science and Innovation grants 6 M€ to the Spanish Institutions participating in CERN experiments.

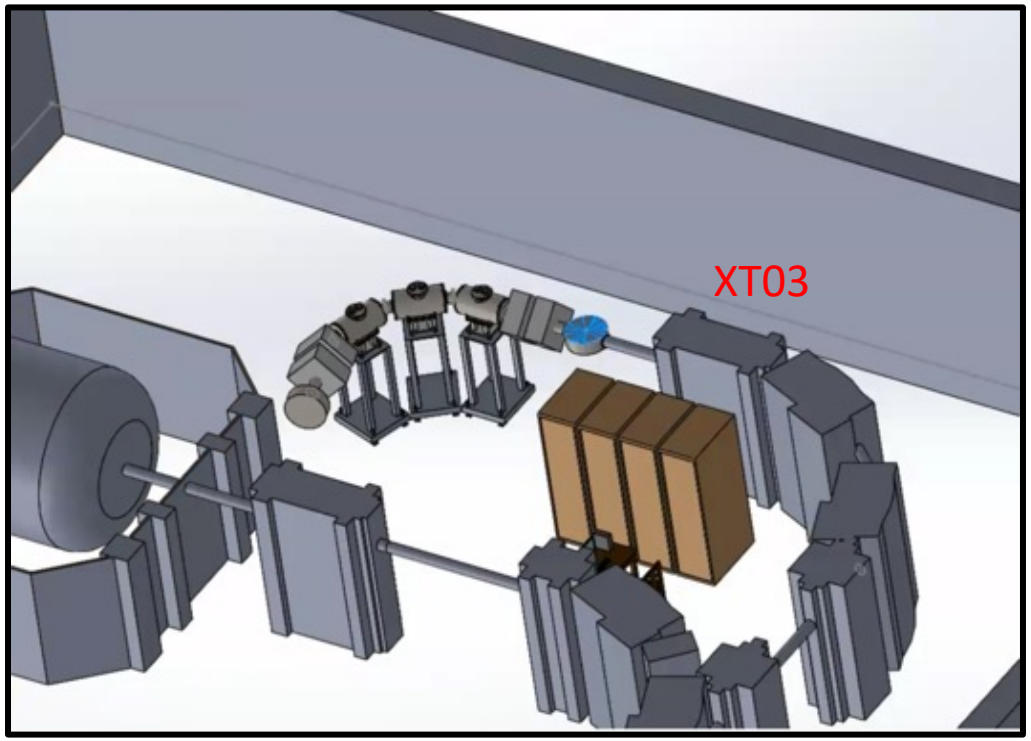
**ISOLDE ISRS**: 3 M€ for R&D activities. -> protype of STRAIGHT CCT magnets + test bench. Delivery: end of 2025.

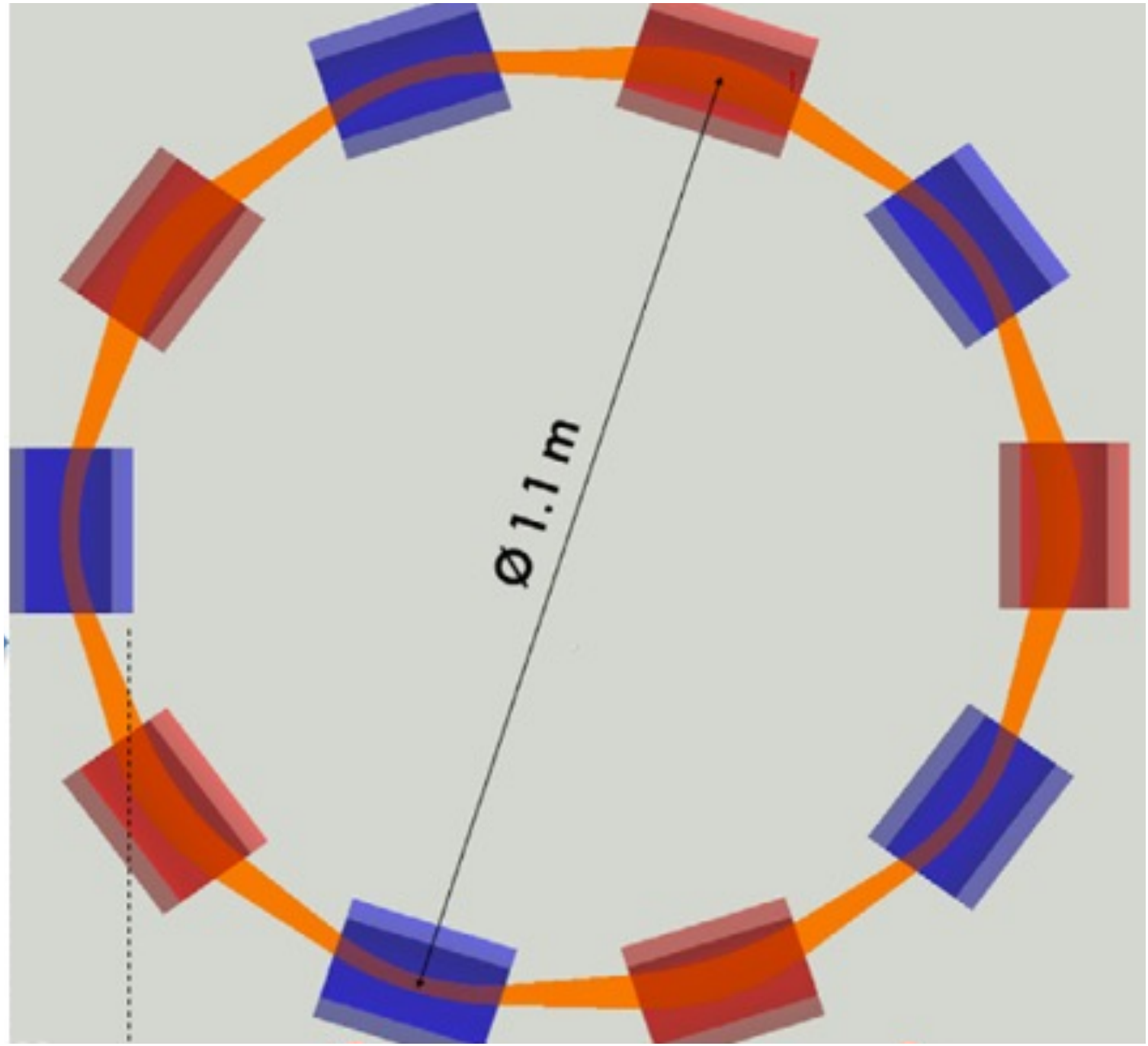
# MAGNET TEST BENCH




SC MAGNETS

- Dipole + quadrupole functions
- Portable cooling system
- beam circulation




Ø 1.1 m

## Summary

- Superconducting spectrometer for ISOLDE/CERN: ISRS
- R&D project to study ISRS funded
- Public tendering to provide one or more units of CCT straight magnets
- Multifunction: Dipole + quad functions
- Cryocooling: Portable system, compact easy maintenance/operation