EPIC workshop summary talk

Kieran Flanagan

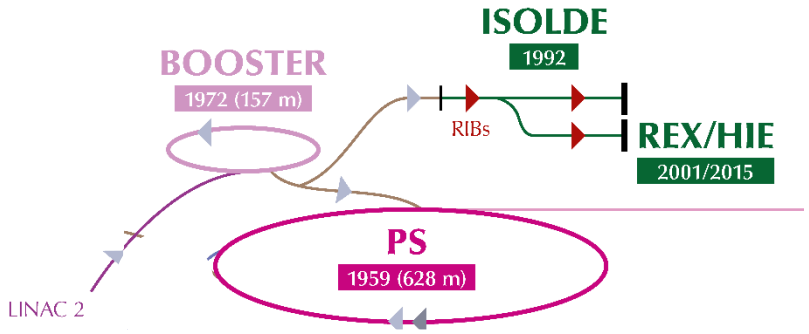
University of Manchester

Outline

- Background of the EPIC project.
- Goals of this workshop
  - Initiate thinking and discussions on the future of ISOLDE
  - Set-up working groups based on parallel sessions
  - Prepare goals and timeline for conceptual / technical design reports (including physics cases)
  - Prepare fund raising for sub-projects
- Major Components of EPIC
- Physics Opportunities
- Outlook

Contributions to the slides from all speakers (thank you)

a Radioactive Ion Beam (RIB) facility at CERN



~ 2/3 of Booster protons were used by ISOLDE in 2018

UNIQUE worldwide thanks to 1.4 GeV protons

More than 50 years of experience in production of radioactive isotopes

Since 2001: re-acceleration of RIB's with REX and HIE-ISOLDE (NC and SC Linac)

- > 1000 isotopes available already (of 3000 known) (60 keV – 10 MeV/u)
- > 70 different elements
- > **10 different permanent experimental set-ups (and new ones coming)**
- More than **45 experiments** for more than 500 users / year

  (> 900 registered ISOLDE users from 43 countries)

EPIC
Exploiting the Potential of ISOLDE at CERN

The ISOLDE Collaboration input to ESPP update

Gerda Neyens, ISOLDE Collaboration Spokesperson
Richard Catherall, ISOLDE Technical Coordinator (soon Joachim Vollaire)
Bertram Blank, Chair of the ISOLDE Collaboration (soon Kieran Flanagan)
Karsten Riisager, Chair of the ISOLDE and n-TOF (INTC) program committee

Major components of EPIC

- Take advantage of LHC Injector Upgrades (LIU)
  - Increase of p-intensity (x2)
  - Increase of PS-BOOSTER p-energy (1.4 to 2 GeV)
- **Parallel beam operation** by installing additional target stations
- Higher quality beams for **improved RIB beam purification**
- Upgrade REX-ISOLDE
- A new compact storage ring
- A new experimental hall for new experiments.

Capacity and Capability

- Components of EPIC broadly break down into two topics.
- The aim is to increase both.
- Capability
  - This is defined by the users in terms the isotopes, yields and beam cleanliness required for experiments (>10^4pps of ^{32}Mg delivered to ISS)
- Capacity
  - Number of experiments that can be performed (both in terms of space for new experiments and facility operation).

2 GeV and Intensity upgrade

- Talks by **Sebastian Rothe** (targets), **Marco Calviani** (beam dumps), **Wolfgang Bartmann** (BTY line), **Joao Pedro Ramos** (impact on radioactive beam intensities)
- Beam dumps need to be exchanged.
  - Material does not conform standards
  - Unknown condition and signs of corrosion
  - Required for Energy and Intensity upgrade

- Beam dump exchange will be complex process and if approved will take place in LS3

- Upgrading BTY line to transfer 2 GeV protons to ISOLDE
  - It is feasible and there are two potential routes
  - Will require statement from ATS Sector management before studies can commence.

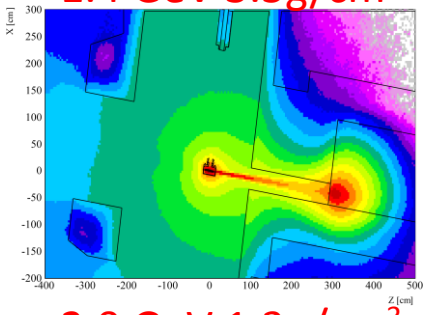
2 GeV and Intensity upgrade

- Increase of p-intensity (x2)

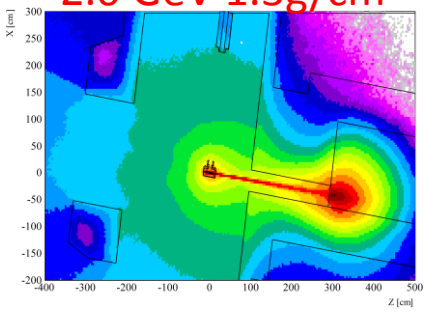
- The yield will scale with intensity
- This will also increase the target dose and frontend dose
- Peak power and shocks may impact on target lifetime.

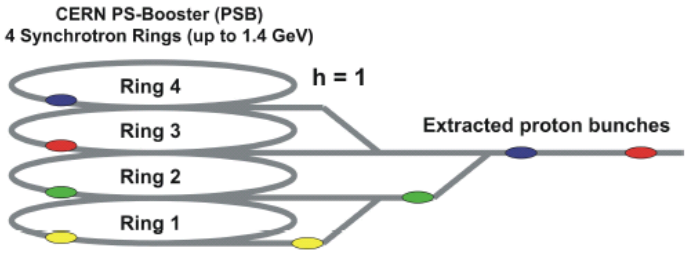
Fluence mapping (All paticles)

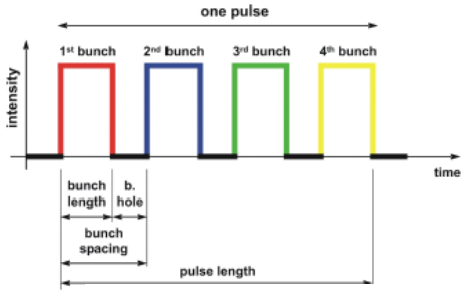
1.4 GeV 3.5g/cm^3



2.0 GeV 1.3g/cm^3







2.3 µs in NORM

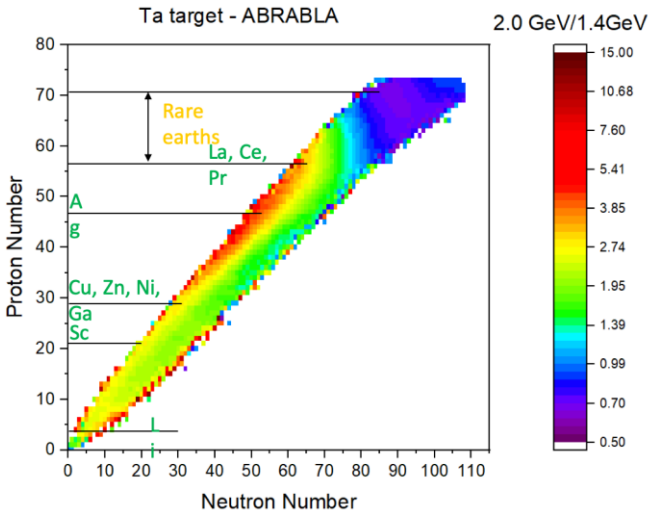
16 µs in STAG

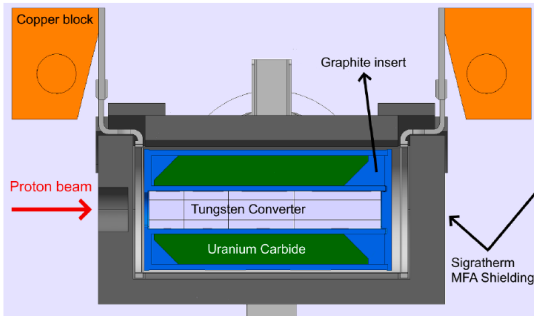
- STAGISO (at full intensity) should be used as standard.
- Higher beam energy combined with target development may help reduce dose and increase target and frontend lifetime at higher intensities.

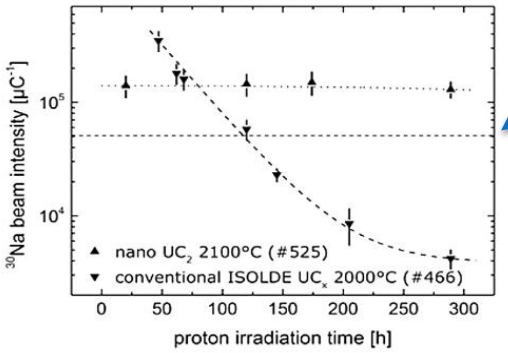
2 GeV and Intensity upgrade

- Increase of PS-BOOSTER p-energy (1.4 to 2 GeV)

- Exotic n-deficient isotopes (largest increase):
  - $Z_{isotope} = Z_{target} - (10 \text{ to } 30)$
  - Factors of 2 to 40 have been seen
- Low Z isotopes (fragmentation):
  - Increase in factors of 2 to 4
- For neutron induced fission there is potentially higher contamination induced by scattered protons (but they will also scatter less) requires design considerations.
- Sintering of targets will limit the time that that short-lived species can be studied.



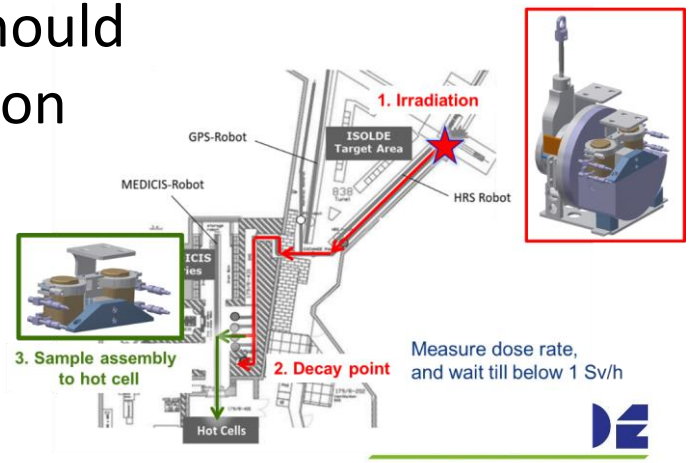




DB

2 GeV and Intensity Upgrade

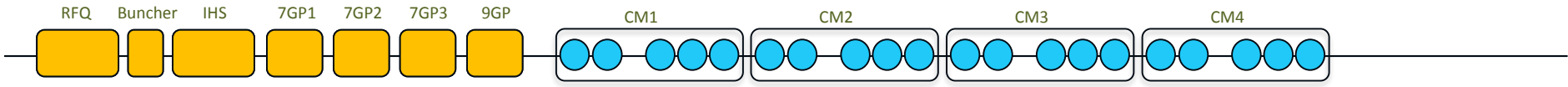
- The user community was clear we should maintain both energies (1.4 and 2 GeV).
- Justification will requires input from users on key beams, intensity and purity, where the gain for running at 2 GeV is compelling.
- The impact on operation of higher intensity and higher energy will require a combined analysis to assess impact to both target and frontend lifetime.
- The upgraded (and new) target stations should have consideration for systematic irradiation tests and MEDICIS.



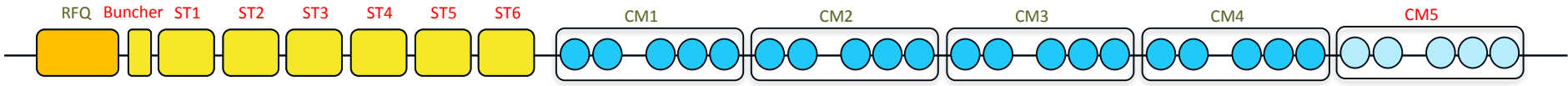
Upgrade of REX-ISOLDE

Alberto Rodriguez (technical) Joakim Cederkall (physics)

REX/HIE-ISOLDE today:



Room temperature upgrade of REX + fifth high-beta cryomodule:

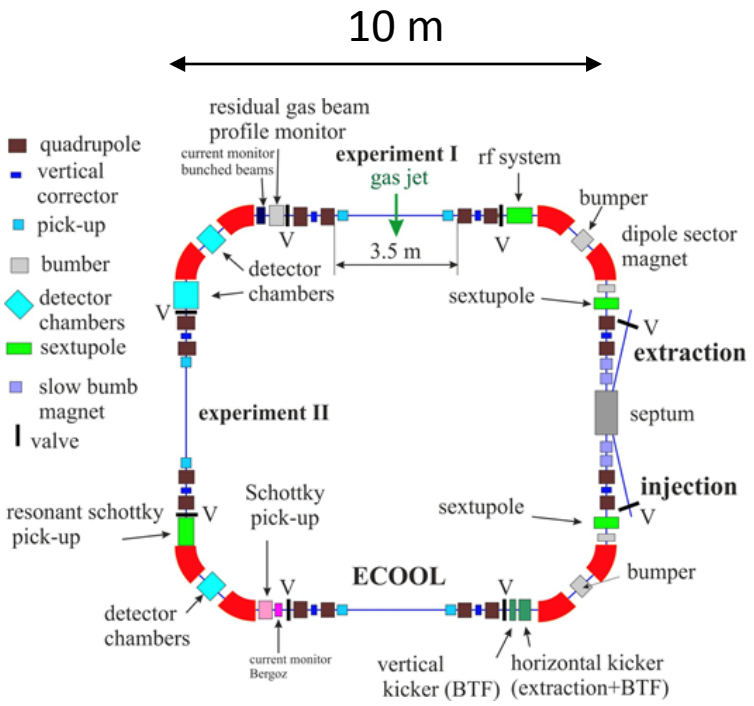


- Ideally 10 MeV/u for all masses
  - Some experiments not possible at lower energies.
- Priority from the users to allow A/Q to be extended to 5.5
- Upgrading of the EBIS:
  - Higher charge states and faster breeding time.
  - Will help reduce pressure on the accelerator
- Production of a bunched of beam for TOF measurements

A new compact storage ring

- Stored radioactive beams have many advantageous

- ❑ Uniqueness: injection at the required energy (fast – shorter lifetimes accessible)
- ❑ Can be used multiple times in an in-ring detector (luminosity increase!)
- ❑ Can be cooled to deliver excellent quality beams to external experiments for high-precision studies



Talks:

- ✓ Manfred Grieser (a new design)
- ✓ Yuri Litvinov (physics)

New Low Energy Physics Opportunities

Magdalena Kowalska

- Weak Interaction Studies (^{10}C, ^{23}Mg, ^{35}Ar, (^{98}In reachable?))\
- Nuclear-structure: Shell Structure (^{100}Sn), p-emitters (n-deficient lanthanides)
- Nuclear astrophysics: rp process: ^{56}Ni and ^{100}Sn regions

- Several new low-energy experimental set-ups in preparation or proposed (posters)

- ❑ **GANDALF (**atomic spectroscopy of radioactive elements)
- ❑ **MIRACLS** (ultrapure beams production and laser spectroscopy) V. Lagaki
- ❑ **MR-TOF** (for beam characterization and purification) M. Vilen
- ❑ **PUMA** (interactions between exotic matter and antiprotons) F. Wienholtz
- ❑ **MULTIPAC** (Large superconducting magnet for PAC for materials studies)
- ❑ **Trap for RaF molecules** (eEDM and other symmetry violations)

New Opportunities at HIE-ISOLDE

Liam Gaffney

HIE-ISOLDE physics at full 10 MeV/*u* energy

- Crucial to fully exploit existing and future experimental setups.
- Large angular momentum transfer cross section improve 10-100 times.
- A sliding scale of new physics cases, more exotic reactions

HIE-ISOLDE physics with 2 GeV upgrade

- Specific cases where the p^+ energy improves HIE-ISOLDE physics.
- Examples around ^{100}Sn, island of inversion and N=126.
- Increased yields extend systematics or bring new reactions in to play.

Several new high-energy experimental set-ups in preparation or proposed (posters)

ISS experiments (D. Sharp, S. Bennet)

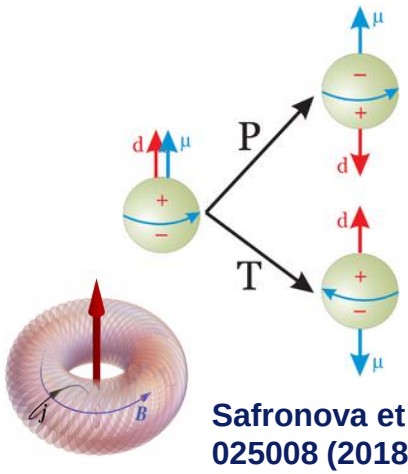
Miniball (T. Kroll)

HIE-ISOLDE Superconducting Recoil Separator (I. Martel)

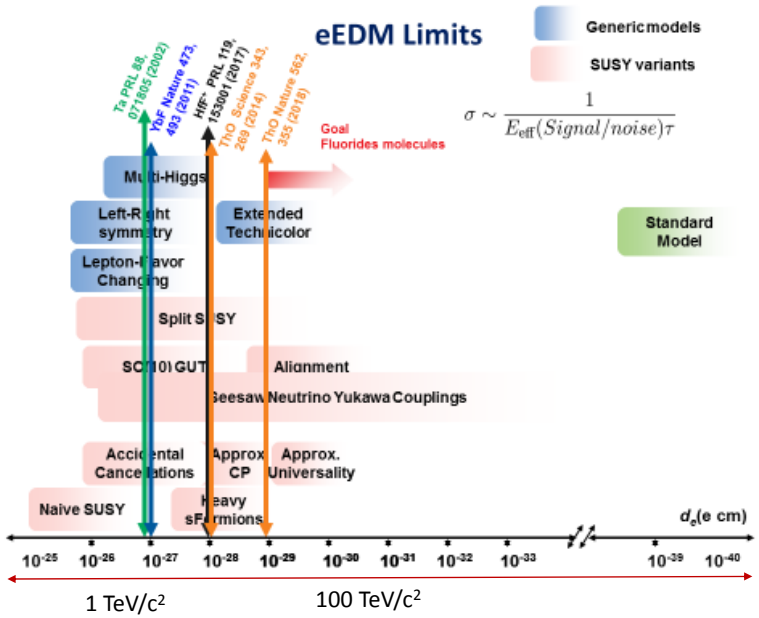
Opportunities for New Physics searches using exotic molecules and atoms

Ronald Garcia Ruiz

- Fundamental Symmetries
  - eEDM (Physics BSM) , CPT, Dark Matter
- Nuclear physics (electroweak sector)
  - Anapole moments: AM
  - Magnetic Quadrupole moments
  - Schiff moments



Safronova et al. Rev. Mod. Phys. 90, 025008 (2018)



$$\sigma \sim \frac{1}{E_{\mathrm{eff}}(Signal/noise)\tau}$$

- Radioactive atoms and molecules potentially provide a sensitive laboratory to contribute to these searches.
- High precision studies will require
  - High yields
  - Long measurement times
  - High stability laboratory space
- Positive response from community

simple one-loop radiative correction

$$\text{eEDM scale} \sim \frac{\alpha m_e e\hbar}{\pi M_S^2 c} \sin\theta_{CP}$$

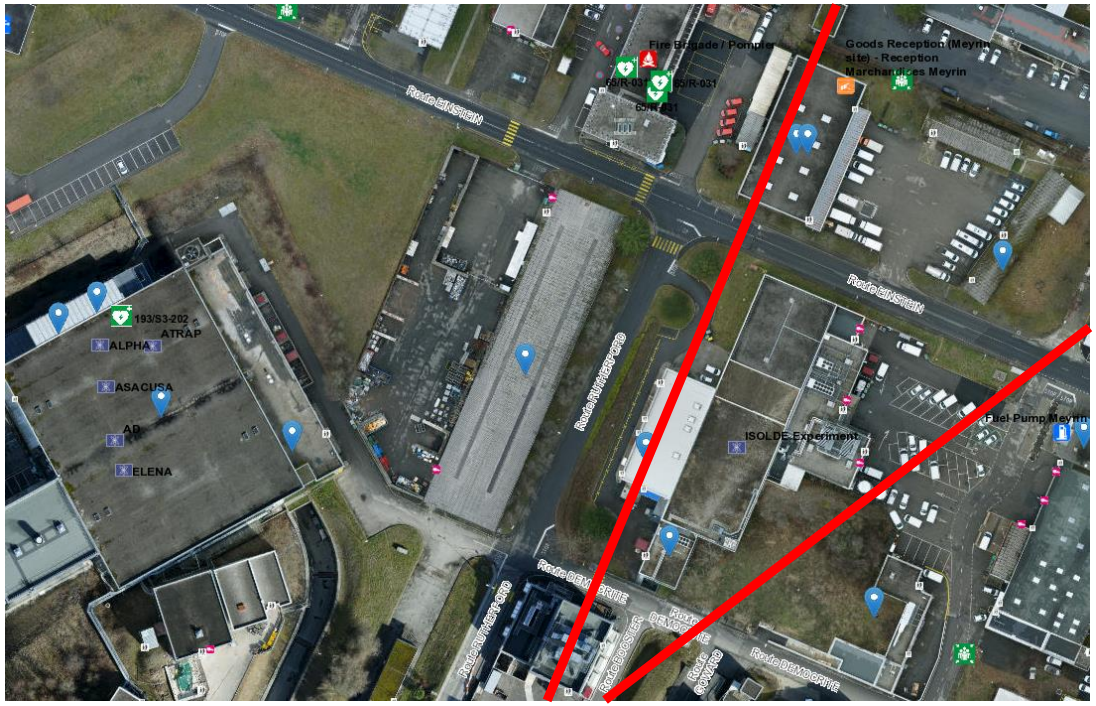
Working groups

Opportunities with **low-energy beams** Magda Kowalska	Opportunities with **HIE-ISOLDE beams (+Storage Ring)** Liam Gaffney	**HI-SRS** Working group Ismael Martel	**Applications** of RIB's (solid state, biochemistry, irradiations, medical, …) Karl Johnston	**Technical** Working group (design, layout, pre-studies, …) Joachim Vollaire

- Commenced the process of brainstorming yesterday
- Parallel operation but with no compromise on beam quality

Challenges for Expanding ISOLDE

Service Tunnel



FR/CH Border

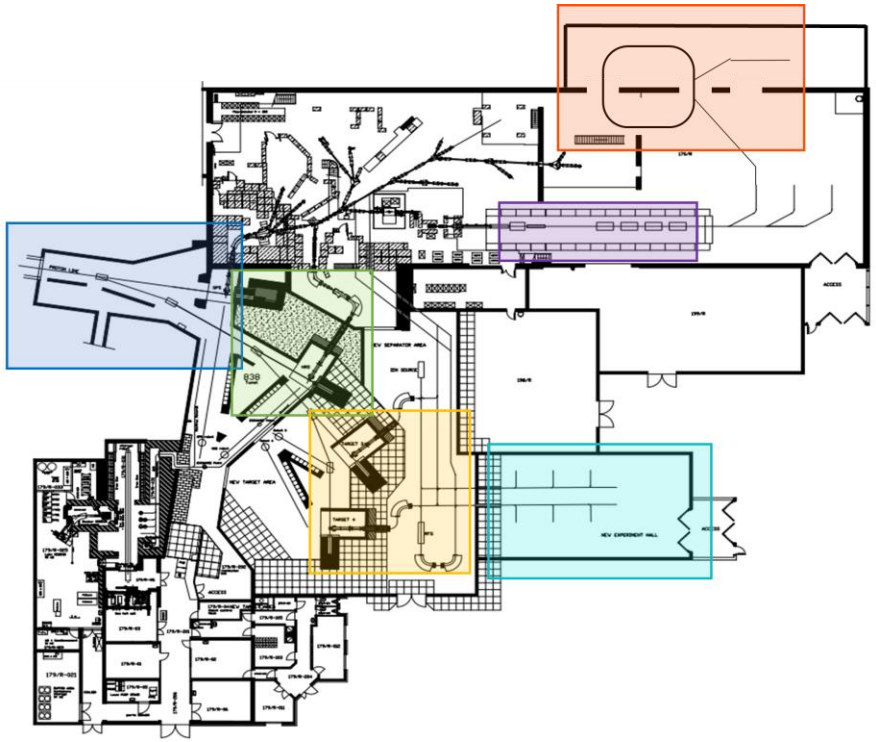
Position of ISOLDE makes expansion of the hall or target station difficult.

French/Swiss border places limits on distances to nearest building.

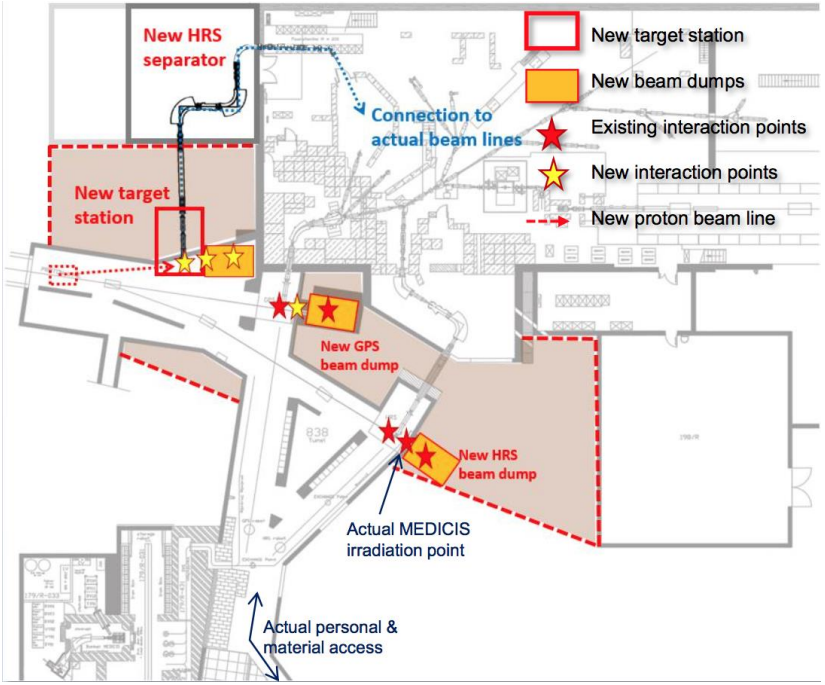
Service tunnel blocks and expansion of the hall towards the Jura.

Initial Suggestions

2018: Richard Catherall and Tim Giles



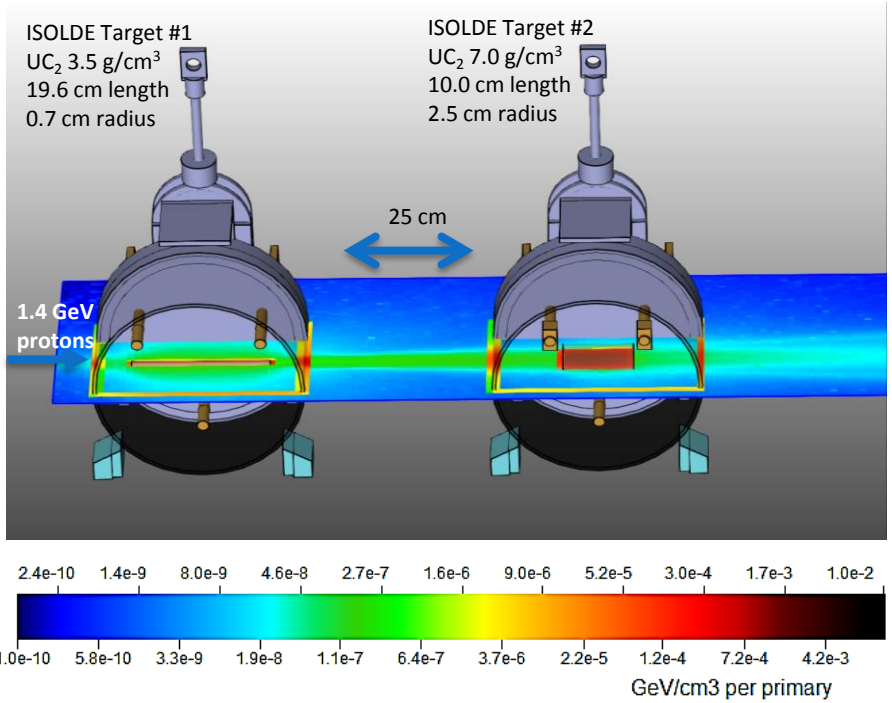
2019: Old control room option



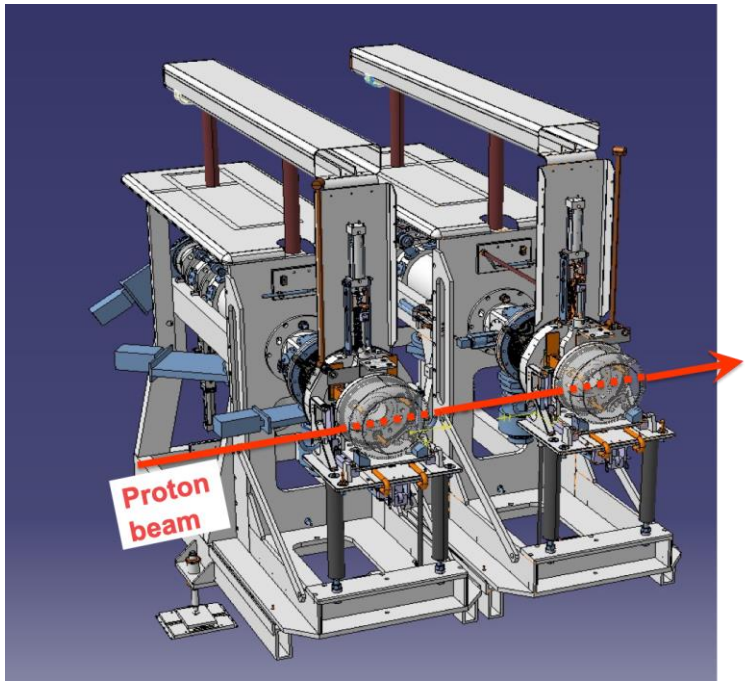
- Technical discussion highlighted challenges associated with exchanging HRS and GPS
- Border and cryoplant makes an extension into the car park and additional target stations next to MEDICIS (2018 design) challenging.

Double front end

M. Lozano

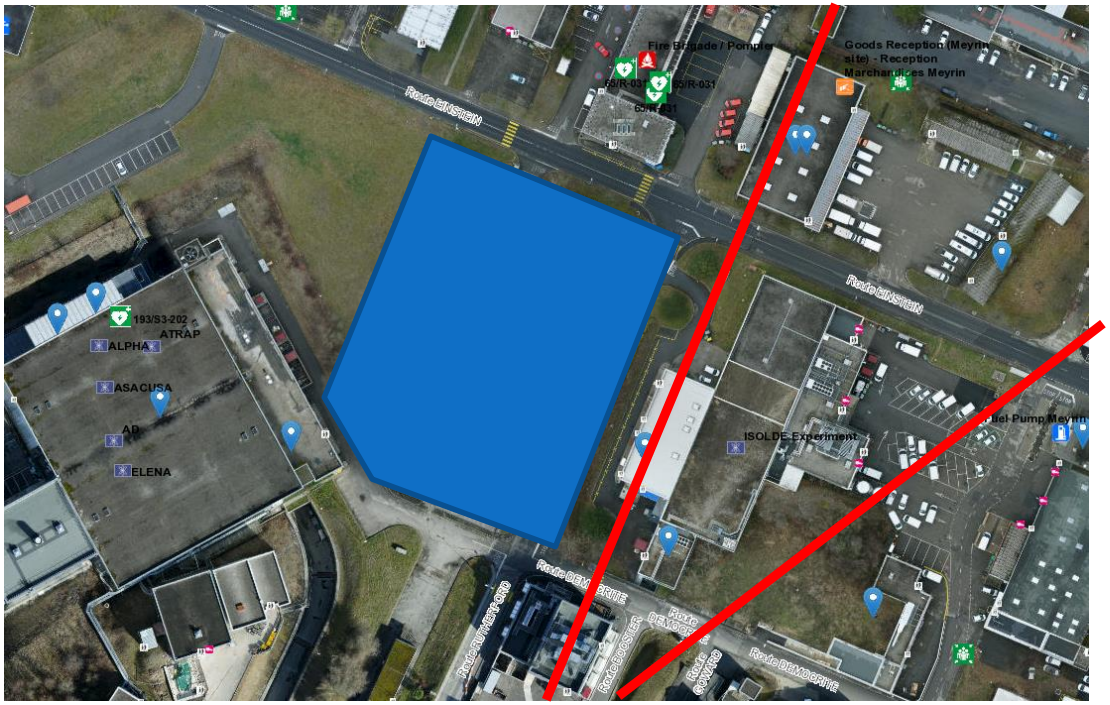


FLUKA Simulation: Ch. Duchemin



- Two targets installed in series in a single front-end area profiting from the full proton current simultaneously.
- Significant cost reduction in civil engineering
- Overall RIB production would increase significantly.

Dream bigger



15 year time-line

- A new low energy building: provide space for new experiments, clean rooms for surface science, multi-user facility.
- Potential for more exotic experiments (electron scattering, p-bar etc)
- Allows existing hall focus on high energy RIB production and provides space for more experiments there.

Summary and Outlook

- There has to be realism but this can come later (don't be too conservative at this stage)
- Start to imagine what we could achieve-> game changing.
- Working groups have been setup to now collect ideas and begin to create a plan.
- The Group for the Upgrade of ISOLDE will collect ideas and priorities.
- The next step is to initiate the process of preparing a conceptual design report (CDR) and seek funding.