EPIC workshop Feedback and follow-up

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Outline

- Major Components of EPIC
- Goals and outcome of the 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
- Physics Opportunities
- Outlook
- Input for the MTP 2021-2025
- Fund raising status

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.

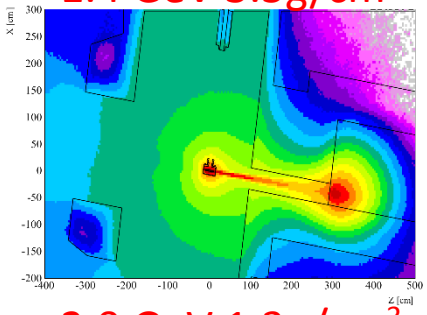
2 GeV and Intensity upgrade

- Increase of p-intensity (x2)

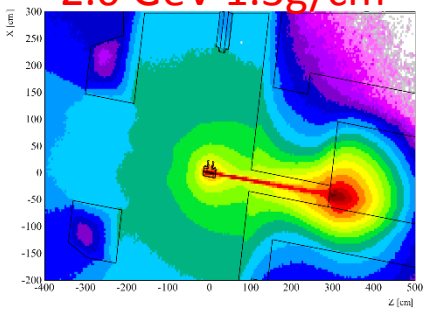
- The yield will scale with intensity
- This will also increase the target dose and frontend dose
- Peak power and shocks may impact on target lifetime.

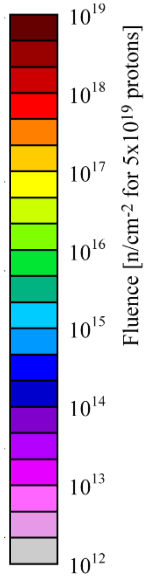
Fluence mapping (All paticles)

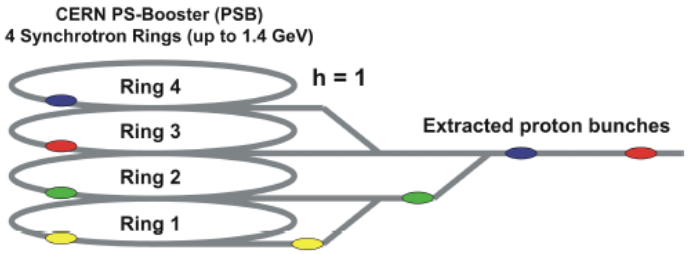
1.4 GeV 3.5g/cm^3

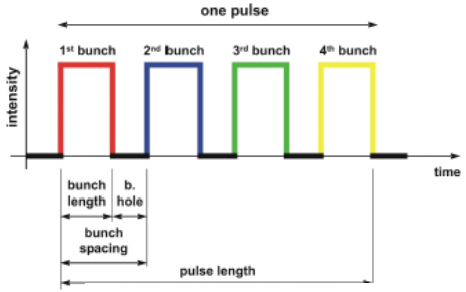


2.0 GeV 1.3g/cm^3









2.3 µs in NORM

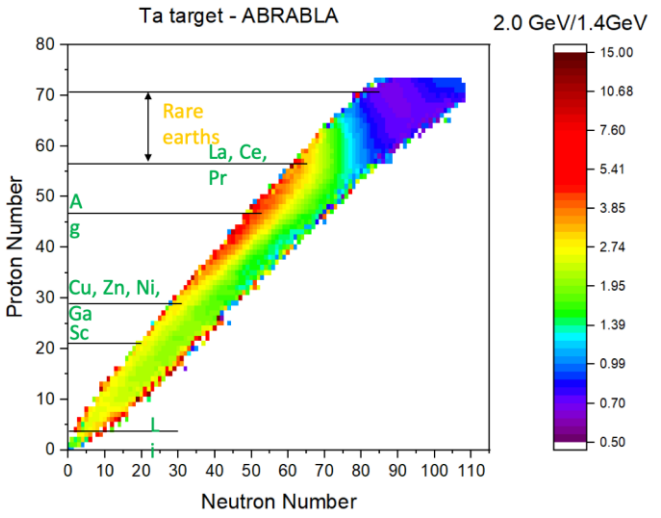
16 µs in STAG

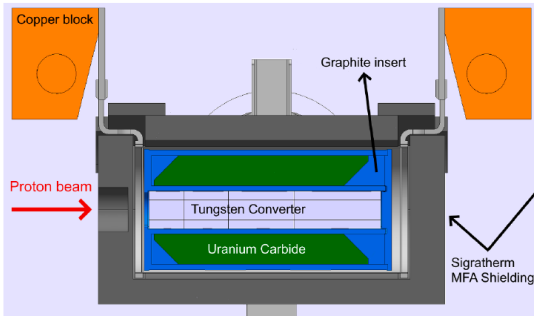
- STAGISO (at full intensity) should be used as standard.
- **Higher beam energy combined with target development may help reduce dose and increase target and frontend lifetime at higher intensities.**

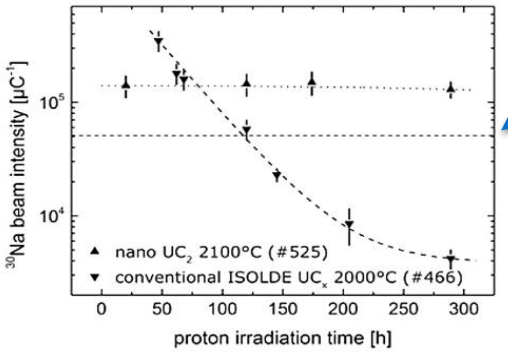
2 GeV and Intensity upgrade

- 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 short-lived species can be studied**.



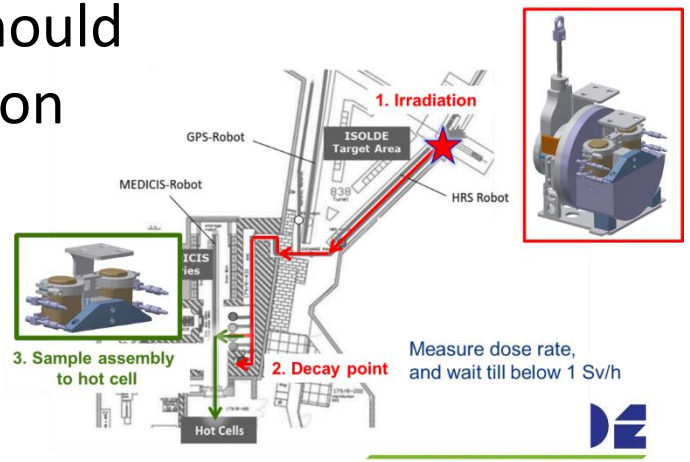




DB

2 GeV and Intensity Upgrade

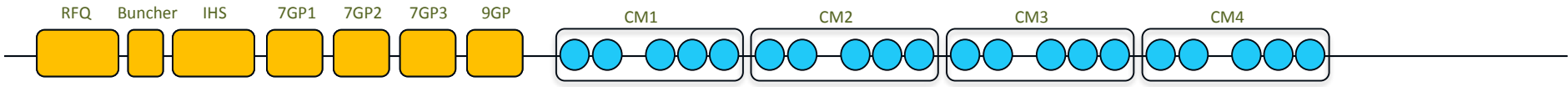
- The user community was clear we should maintain both energies (1.4 and 2 GeV).
- Justification will requires input from users on key beams, intensity and purity, where the gain for running at 2 GeV is compelling.
- The impact on operation of higher intensity and higher energy will require a combined 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.



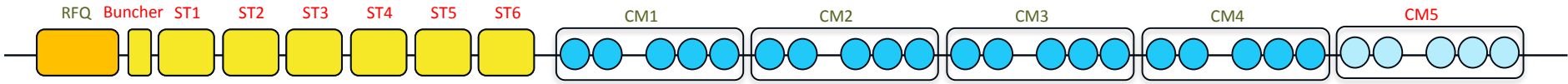
Upgrade of REX-ISOLDE

Alberto Rodriguez (technical) Joakim Cederkall (physics)

REX/HIE-ISOLDE today:



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

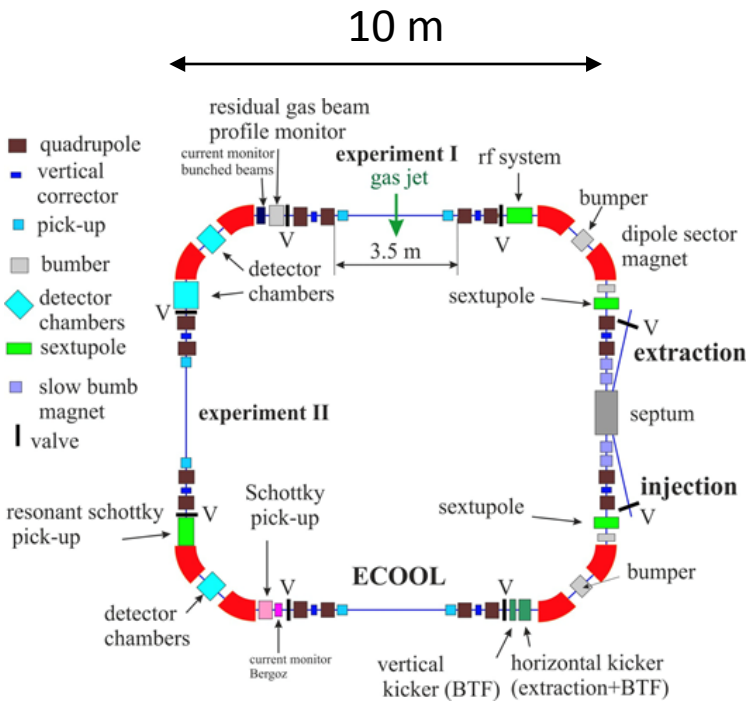


- Ideally 10 MeV/u for all masses
  - Some experiments not possible at lower energies.
- **Priority from the users to allow A/Q to be extended to 5.5**
- Upgrading of the EBIS:
  - Higher charge states and faster breeding time.
  - Will help reduce pressure on the accelerator
- Production of a bunched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

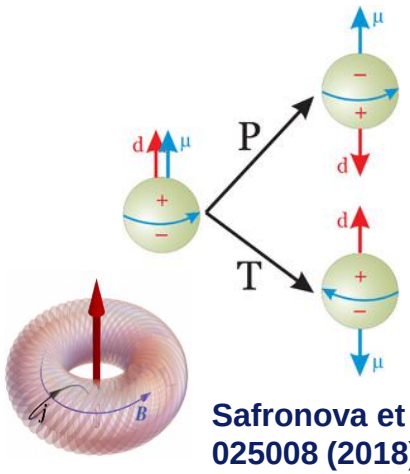
Miniball (T. Kroll)

HIE-ISOLDE Superconducting Recoil Separator (I. Martel)

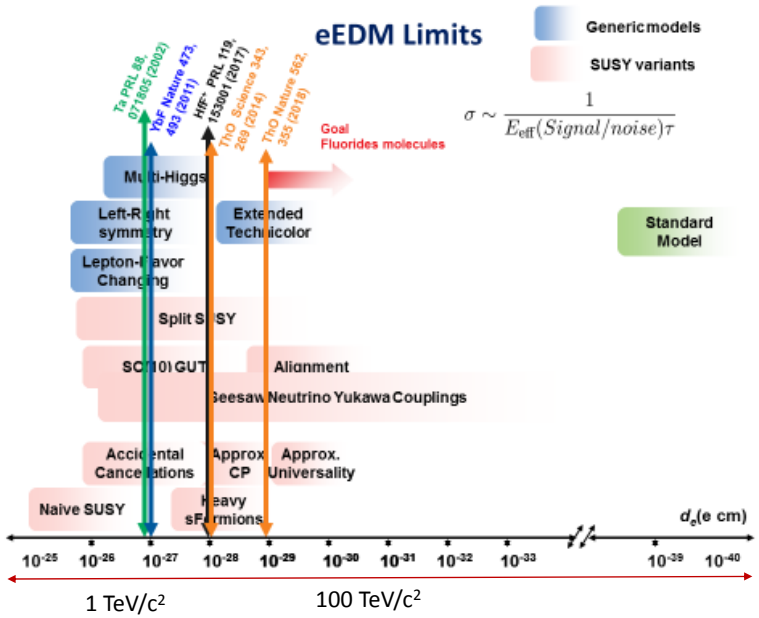
Opportunities for New Physics searches using exotic molecules and atoms

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)



simple one-loop radiative correction

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

- 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

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

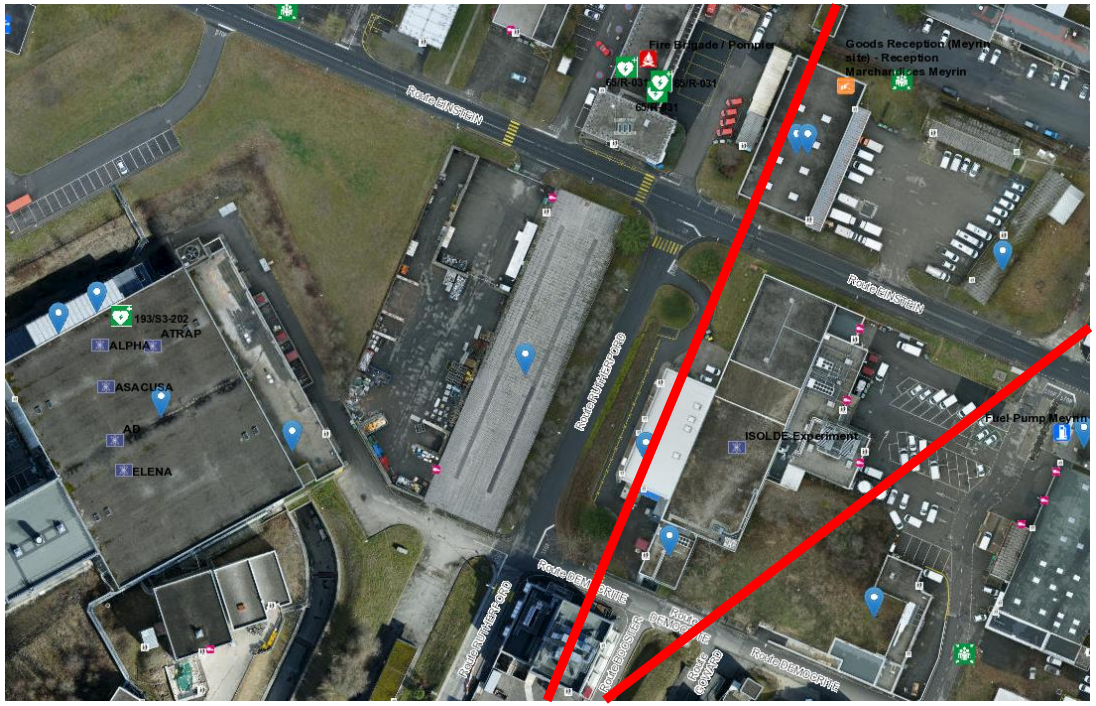
- Commenced the process of brainstorming yesterday
- Parallel operation but with no compromise on beam quality

Conclusions from working groups

Requested Upgrade	Priority of WG Low Energy Experiments	Priority of WG Applications with RIB's	Priority of WG HIE-ISOLDE	Priority of WG Technical Groups
Proton Intensity upgrade (new beam dumps)	2	3		
Improved beam purity	1	3	5	
Spare target for every experiment	1			
Parallel operation by pulsing central beam line	1	2	2	2
Parallel operation by adding a new target station(s), including new HRS and additional beam purification	3	4	3	5
2 GeV upgrade	4*	1		1
A dedicated irradiation station in one of the target area's (small samples)		5		
Room Temperature upgrade of REX (including a buncher)			1	
Storage Ring			4	
STAGISO with 4 rings (less stress on targets)				3
Discrete energies from PSB between 1.4 and 2 GeV for some period				4
Better ancillary labs (e.g. Laser)	3/4			

Challenges for Expanding ISOLDE

Service Tunnel



FR/CH Border

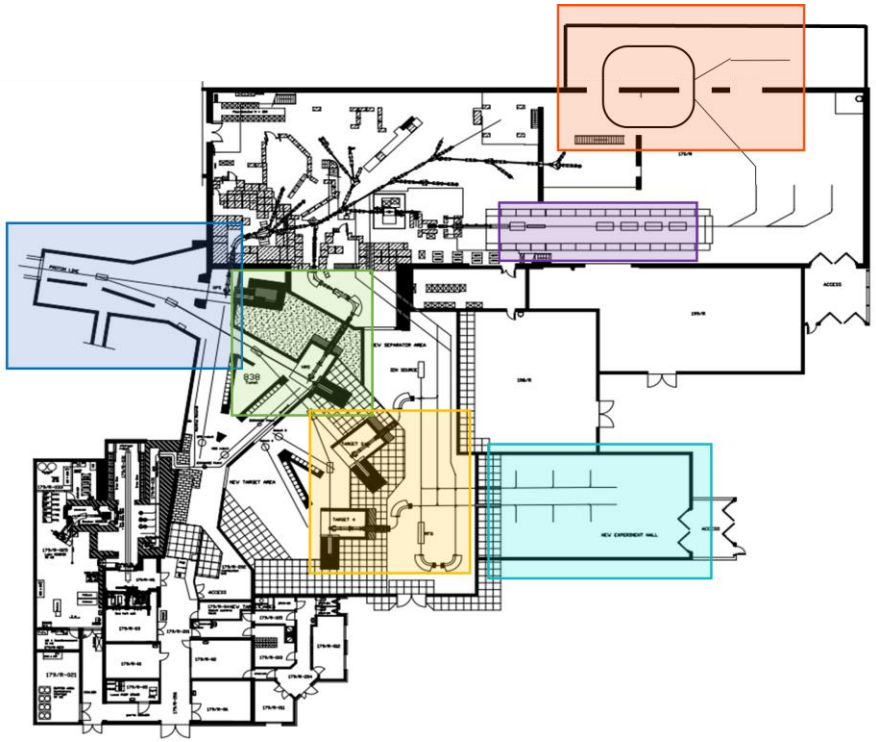
Position of ISOLDE makes expansion of the hall or target stations area difficult.

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

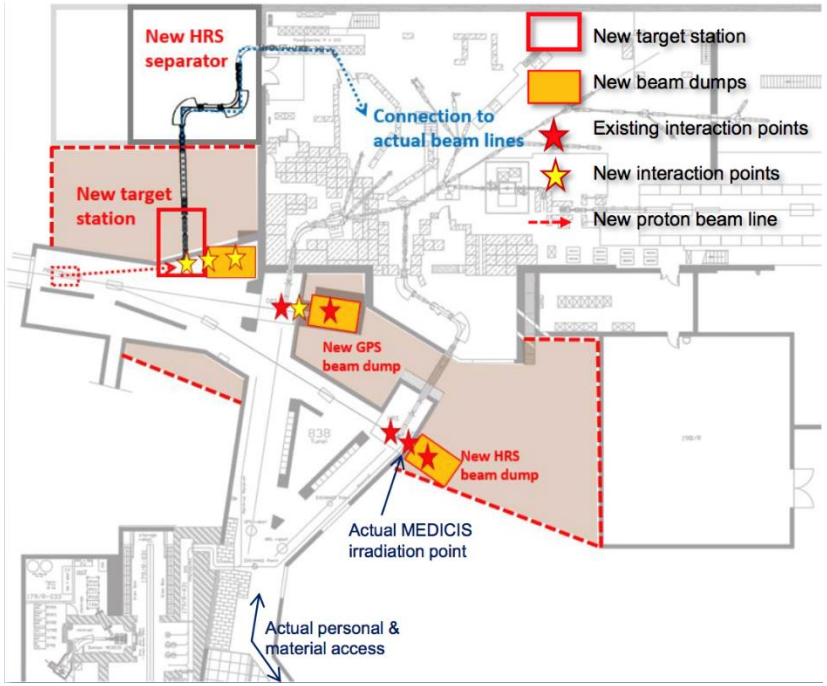
Service tunnel blocks an expansion of the hall towards the Jura.

Initial Suggestions

2018: Richard Catherall and Tim Giles



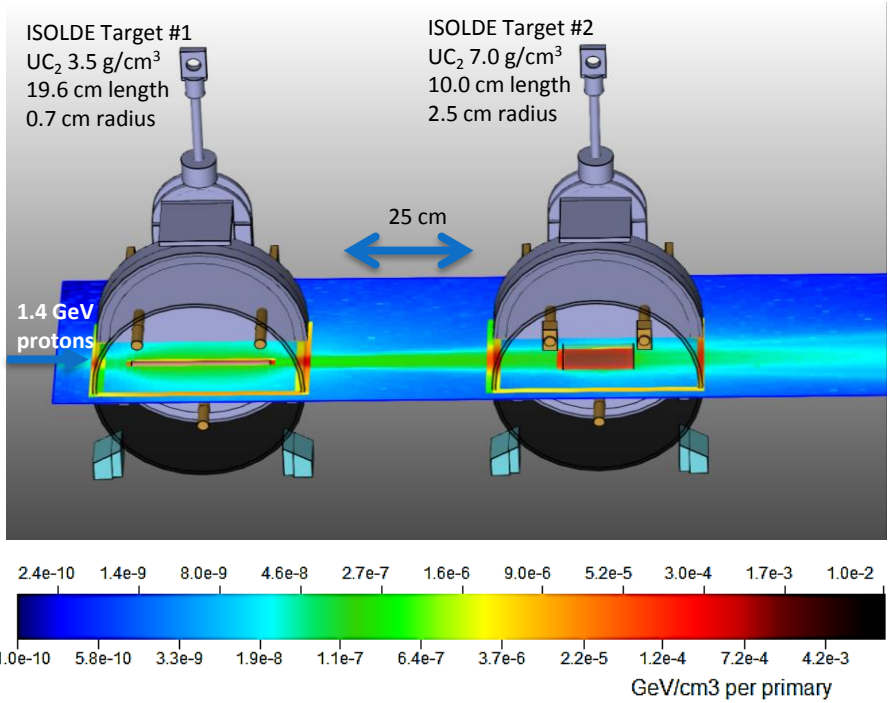
2019: Old control room option



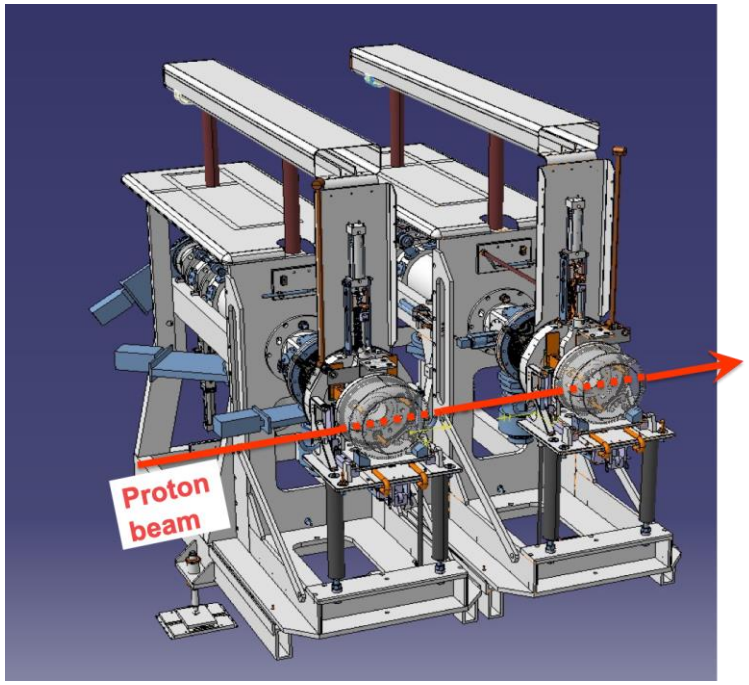
- Technical discussion highlighted challenges associated with exchanging HRS and GPS
- Border and cryoplant makes an extension into the car park and additional target stations next to MEDICIS (2018 design) challenging.

Double front end

M. Lozano

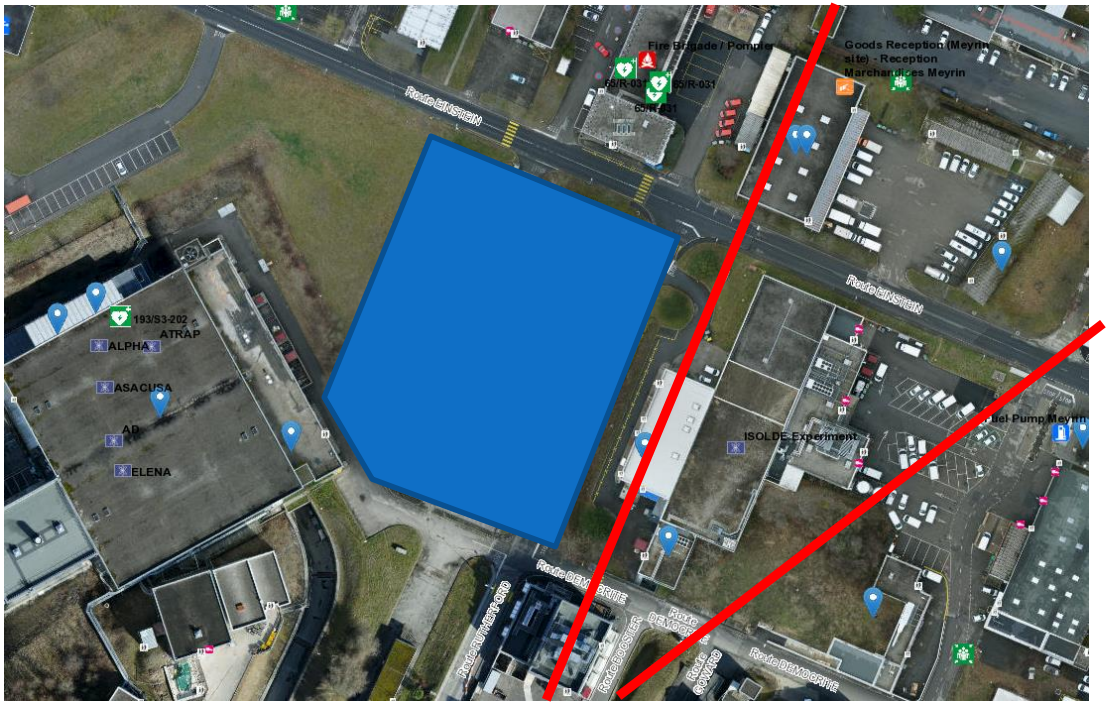


FLUKA Simulation: Ch. Duchemin



- 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 from workshop

- 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.

Recommendations for MTP 2021-2025

- **Near-future (up to LS3) upgrade priorities:**

1. Higher proton intensities on the ISOLDE Target (new beam dumps, better shielding of FE's, any other RP requirements to be studied to be installed in LS3)
2. Parallel operation by switching between different RIB beams at CAO (study to be funded asap)
3. Room-temperature upgrade of the REX-ISOLDE, including a buncher (and chopper?) (study to be funded asap)
4. Better beam purification options in current ISOLDE hall (e.g. MR-TOF, better HRS, …) (development ongoing in EP, once proof-of-principle is realized, funding for an ISOLDE MR-TOF construction)
5. Study for adding new target station(s) with improved beam purification options and to send beams from two target stations in parallel to the low-energy and HIE-ISOLDE beam lines

Recommendations for MTP 2021-2025

- **Outcome from discussion with S. Giraldoni, J. Vollaire, R. Catherall, G.N.**

What could be the best strategy for the MTP, also considering the CERN situation.

1. High-intensity upgrade (beam dumps and better shielding)
2. Parallel operation by switching RIB beams at CAO
3. 2 GeV + beam purification
4. 2 new front ends study

Open questions

1. 2 GeV upgrade ?

- Users are worried about higher contamination.
- What about beam intensity reduction if we stay at 1.4 GeV ?
- Needs further study / information to users ?

2. Can better beam purification be realized in the current ISOLDE hall ?

3. How to deal with increasing demand for place in the hall ?

4. How to deal with strong RP rules around GLM/GHM ?

FUND RAISING

- Start with funding through national initiatives (can be for sub-projects)
  - Univ. Uppsala: study for parallel operation at CAO, storage ring, …