

ISOLDE@CERN: near and long-term future

S. Gilardoni (EN/STI)

In collaboration with:

J.A. Rodriguez, E. Siesling (BE/OP)

G. Neyens, K. Johnston (EP/SME)

R. Heinke (EP/UIS)

M. Calviani, R. Catherall, S. Rothe, A. P. Bernardes, J. Voltaire (EN/STI)



ISOLDE : a successful long history

From CERN Convention: 1953

The Organization shall, [...], confine its activities to the following:

- the organization and sponsoring of international co-operation in nuclear research, including co-operation outside the Laboratories; this co-operation may include in particular:
 - work in the field of theoretical nuclear physics;
 - the promotion of contacts between, and the interchange of, scientists, the dissemination of information, and the provision of advanced training for research workers;
 - collaborating with and advising other research institutions;
 - work in the field of cosmic rays.

Dec 1964: CERN approves the online separator project



1972: SC Improvement Program – doubles the intensity

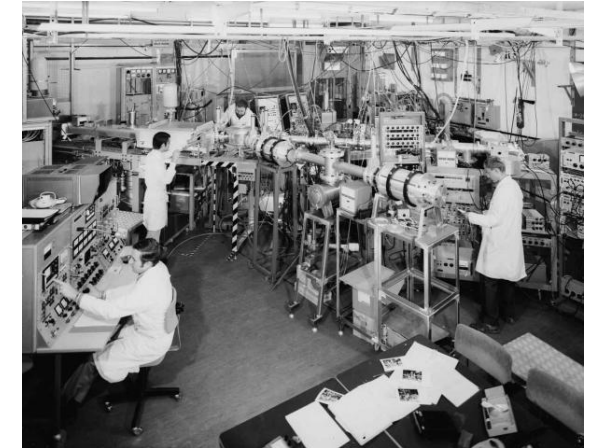
May 1966: Synchro-Cyclotron shuts down for ISOLDE construction



June 1983: ISOLDE III approved – two-stage high resolution separation using two magnets



Oct 1967: First proton beams at ISOLDE



**Dec 1990: The Synchrocyclotron beam ends
New ISOLDE facility → Online in 1992@PSB**



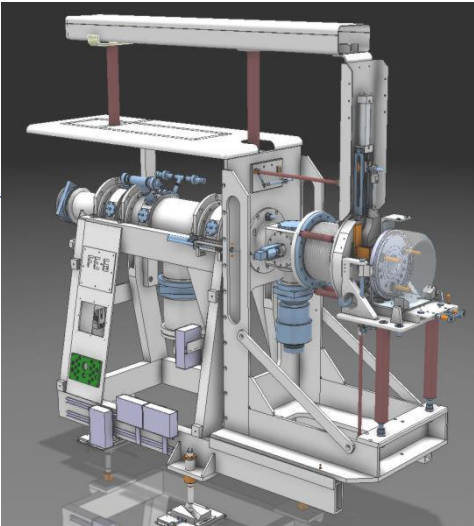
Future of ISOLDE : a proposed roadmap

- Goal: secure the future of ISOLDE leadership as flagship facility for nuclear physics:
 - Combined effort between different programs: CONS, Operation, EPIC
 - Different horizons : up to LS4 for EPIC, starting now for all the others
- Staged approach:
 - Intermediate upgrade/consolidation steps bringing improvement to the operability of the facility together with new physics potentials
 - Each step studied to be potentially compatible with financial situation
 - Mayor interventions can happen only during LS or extended
- Strategy since the beginning for EPIC:
 - Consider global optimization of resources with other programs
 - Avoid same path as for TSR, discussion within ATS sector since first EPIC days.
- Opening synergies with other experimental programs (AD, n_TOF)
→ See Doser's and Mengoni's presentations

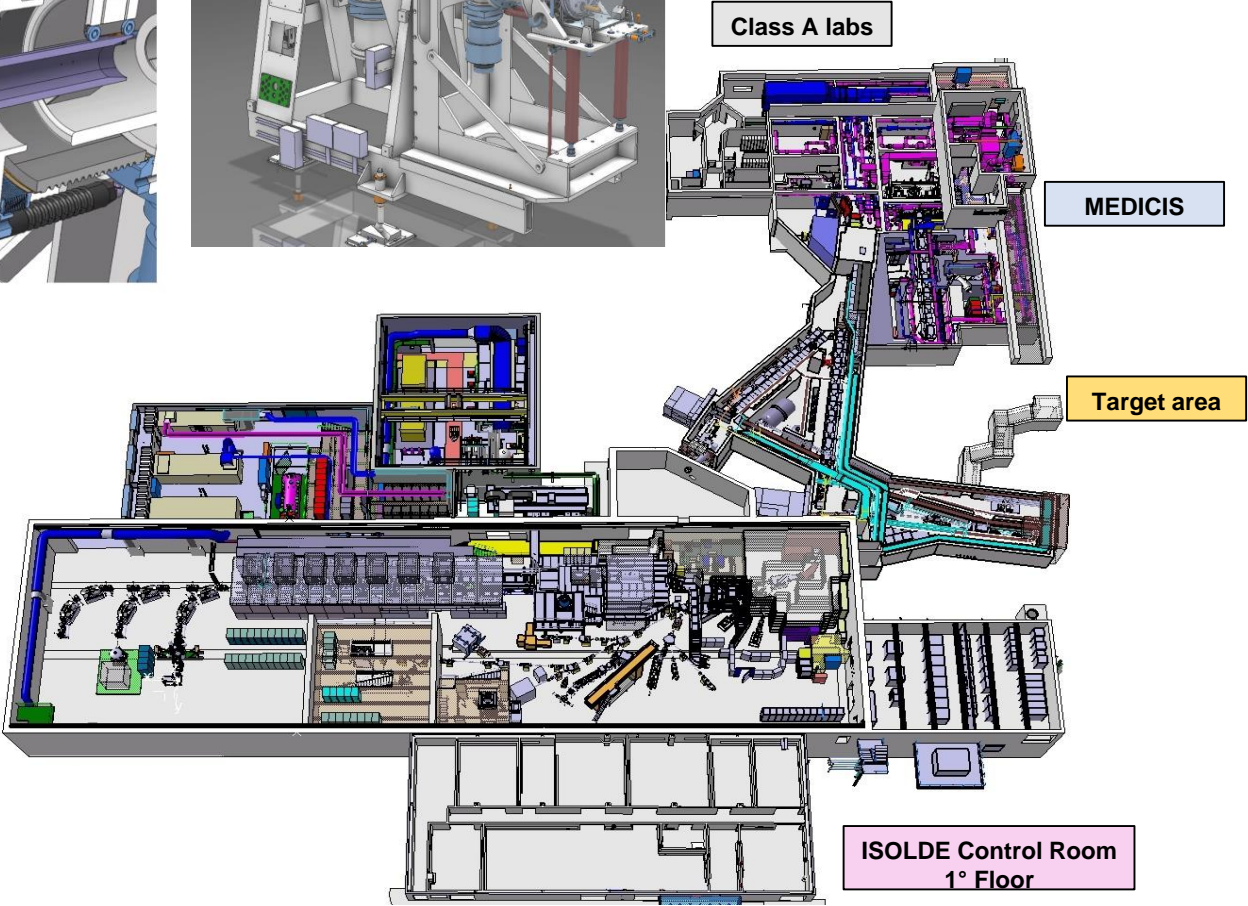
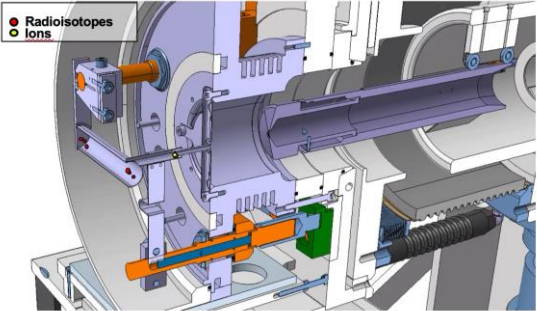
ISOLDE



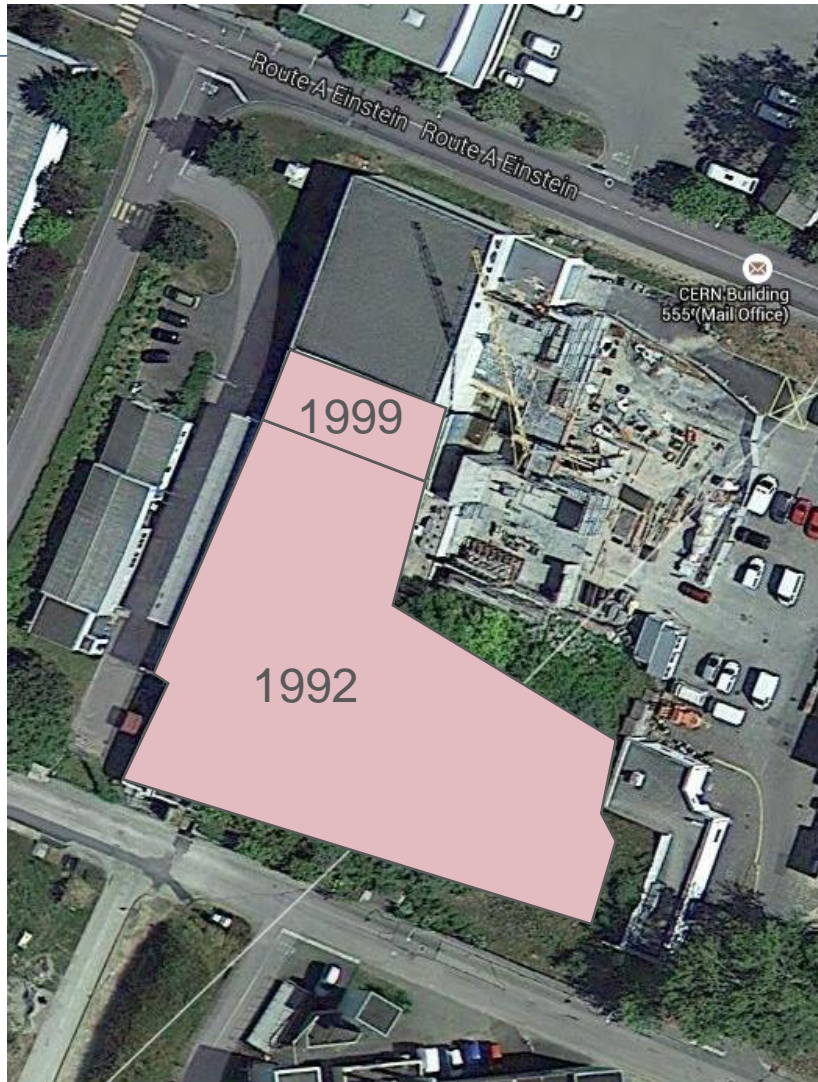
Front-ends



Targets

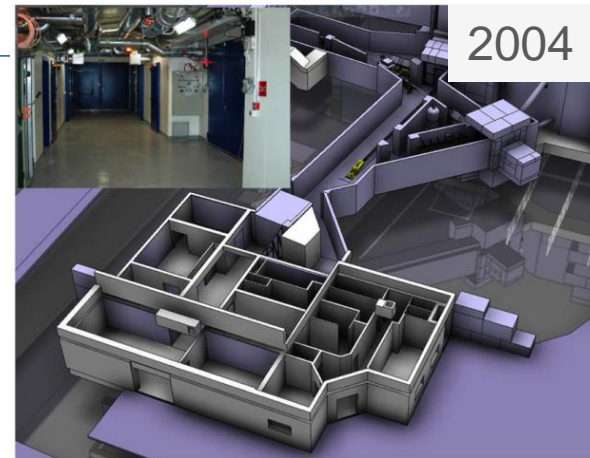
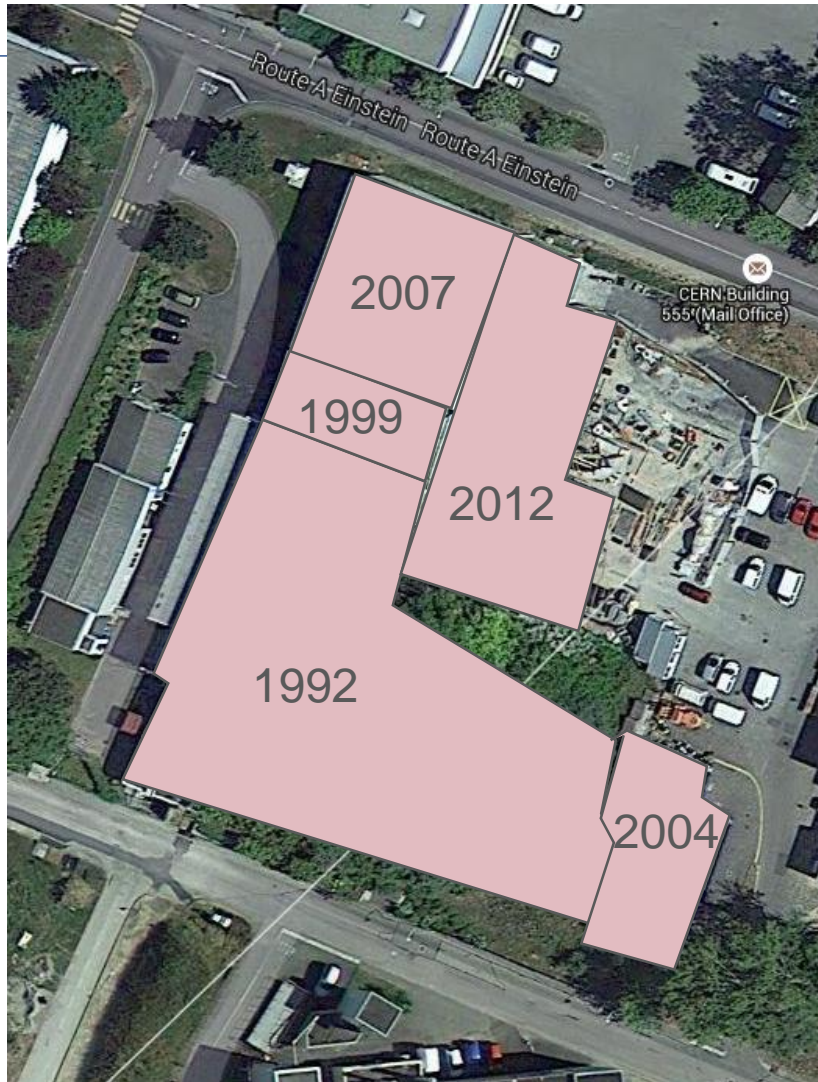


Isolde evolution - expansion



REX-
ISOLDE

Isolde evolution - expansion

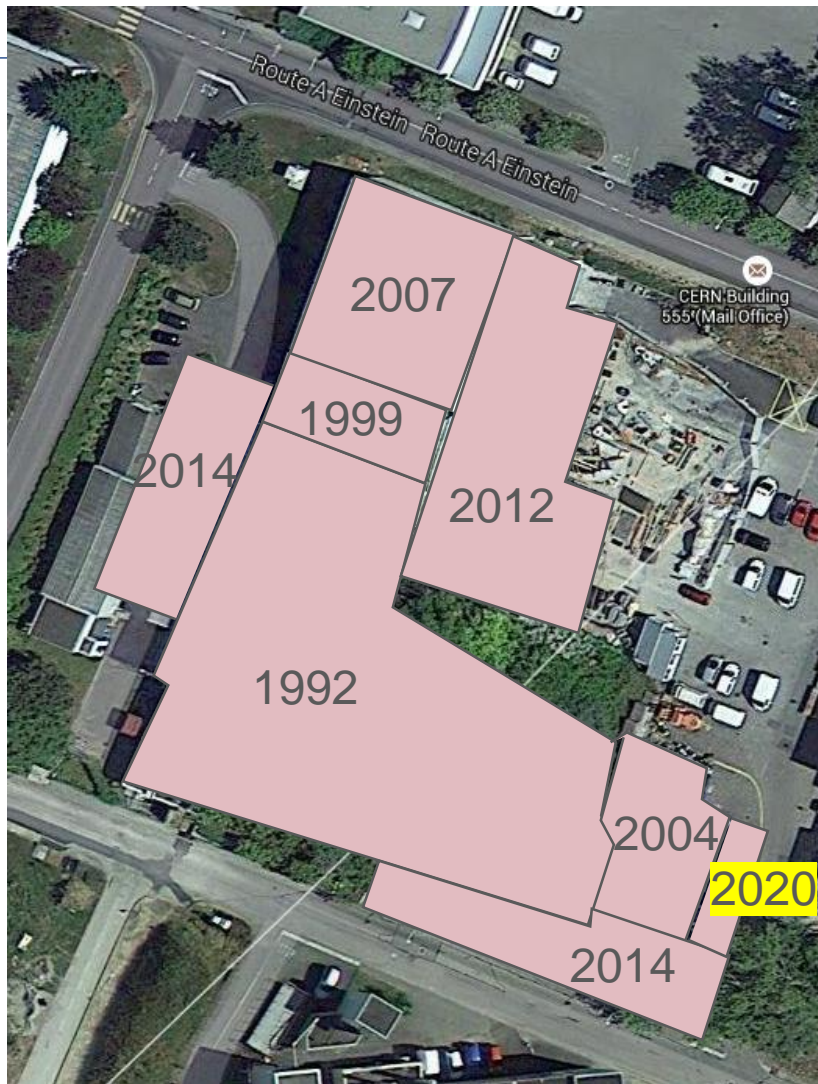


Class A radioactive laboratory



HIE ISOLDE on line 2015

Isolde evolution - expansion



User and Operations facility building

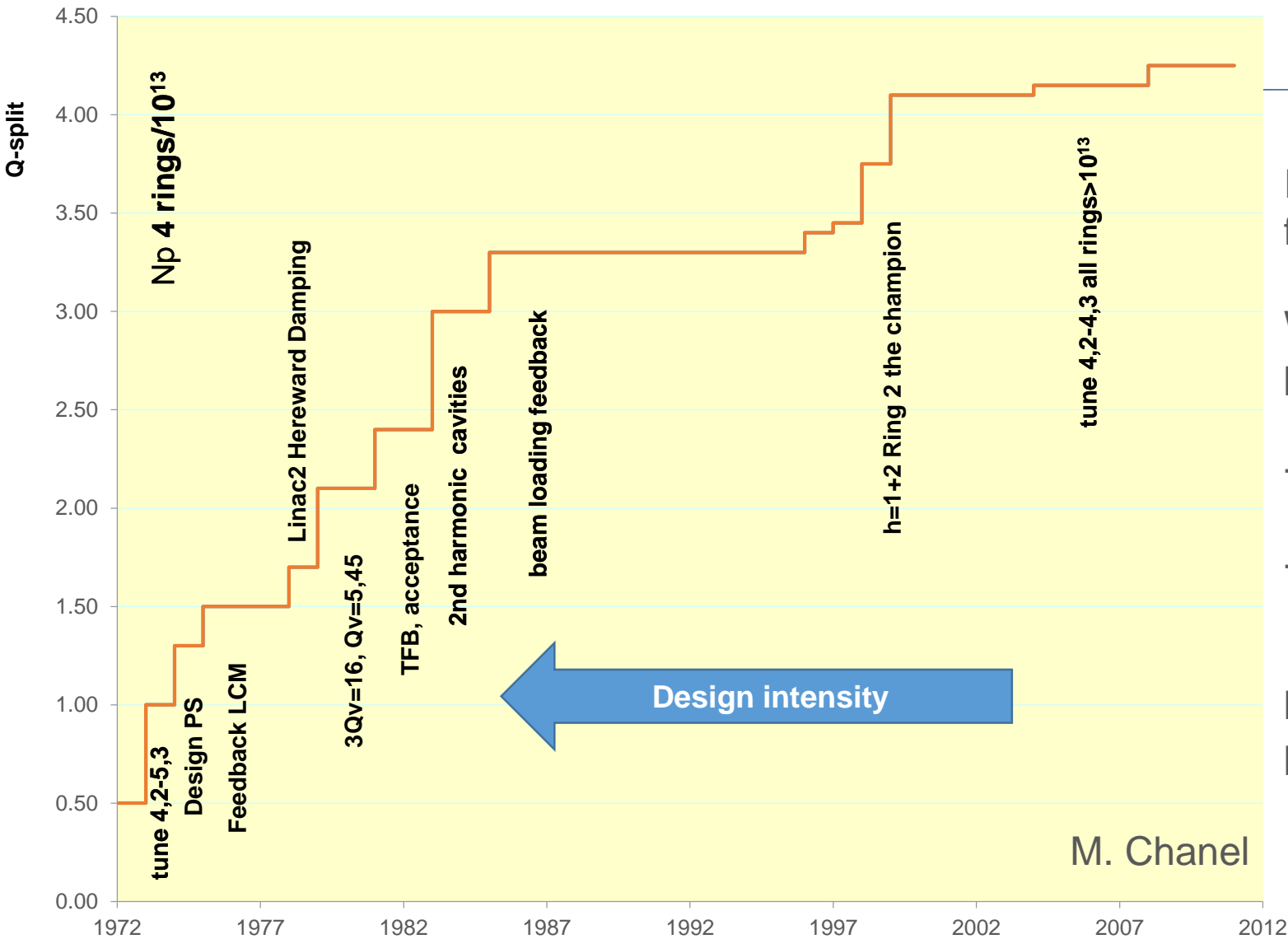


Groundbreaking MEDICIS building



NANO-lab building

PSB evolution



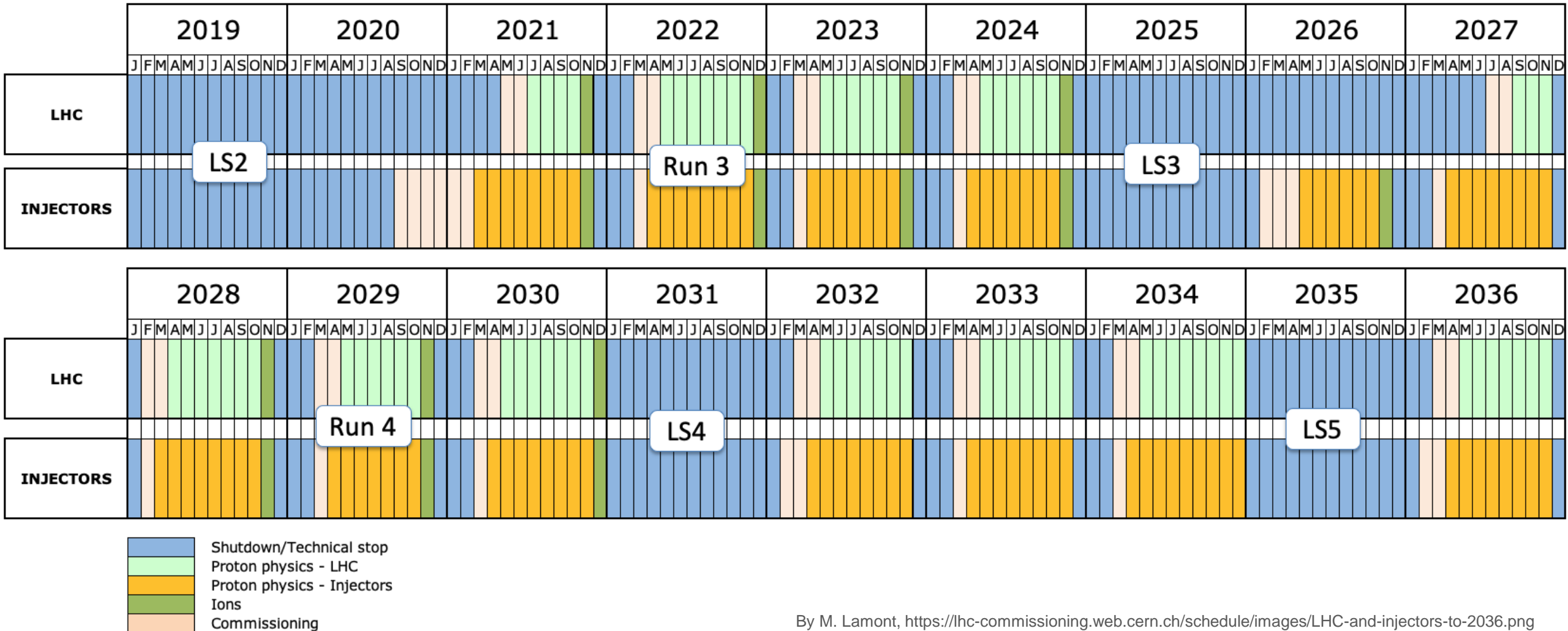
ISOLDE matching proton beam evolution following PSB performance improvements

With LIU (LHC INJECTOR UPGRADE) post LS2 for PSB:

- 2 GeV beams → all users except ISOLDE
- Potentially higher intensity

ISOLDE consolidation/upgrade considering potential offered by L4+PSB@2GeV

Draft of future CERN accelerator plan



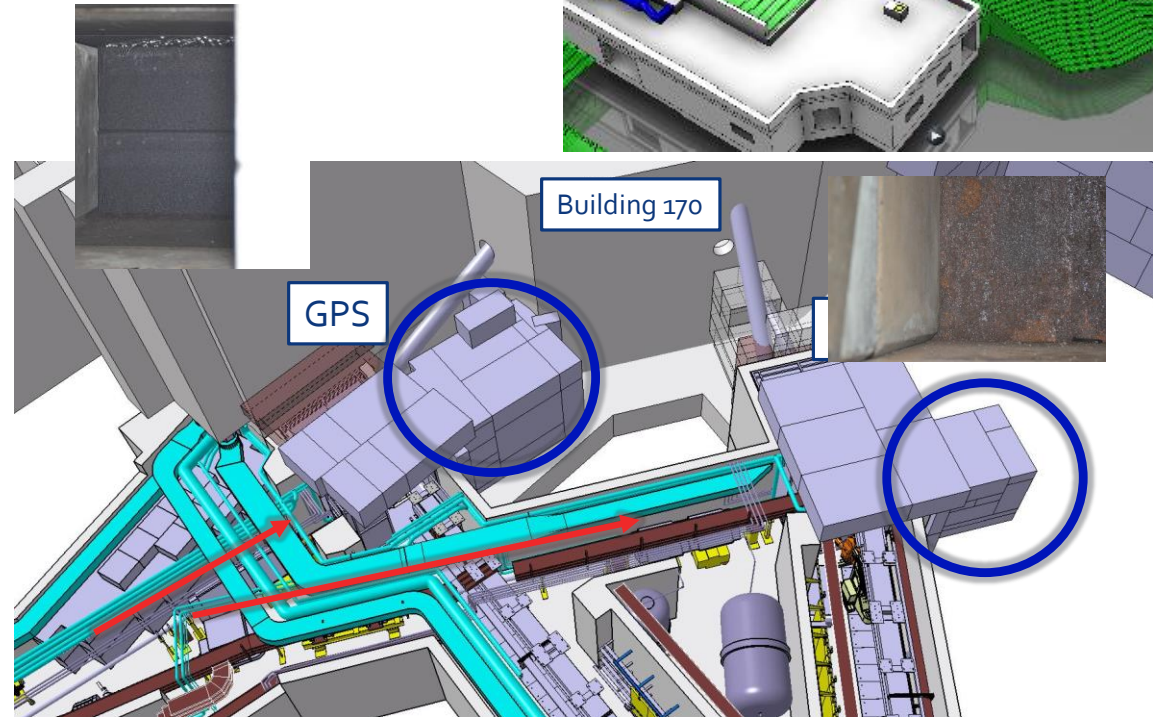
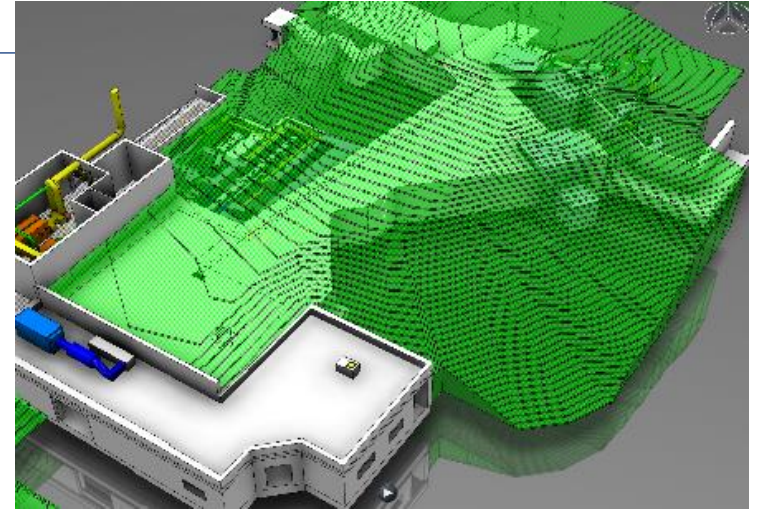
By M. Lamont, <https://lhc-commissioning.web.cern.ch/schedule/images/LHC-and-injectors-to-2036.png>



ISOLDE target areas consolidation : up to LS3

High priority consolidation items:

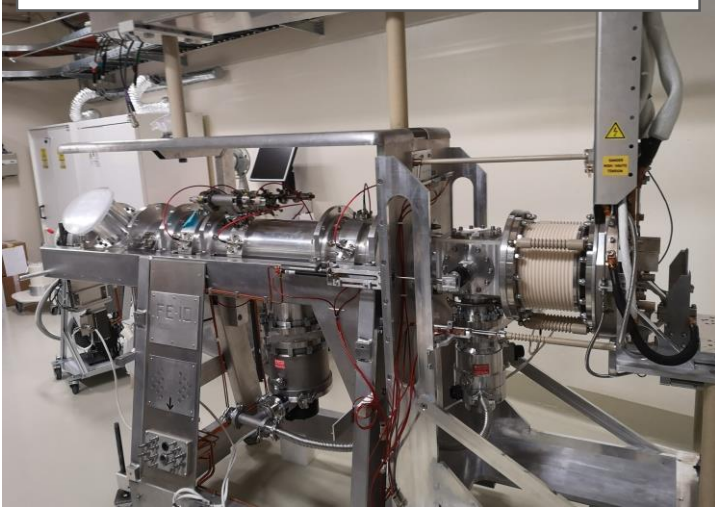
- Renovation of beam-dumps at end of life-time (signs of rust)
- Replacement of Front-end after few years of operation
 - FE lifetime given by integrated dose.
- ISOLDE RILIS Lasers regular replacement



Frontend exchange

- Front-end exchange is a major work requiring an LS both for cooldown as for installation
- Design of new generation starting after beginning of operation
- Typical FE lifetime is 4 – 8 years depending on dose cumulated (seal, HV, etc...) → Next LS3
- Identified need for larger Faraday cage to easy interventions/maintenance (ALARA)

FE10 completion in Build. 179



Frontend delivery team (with masks)



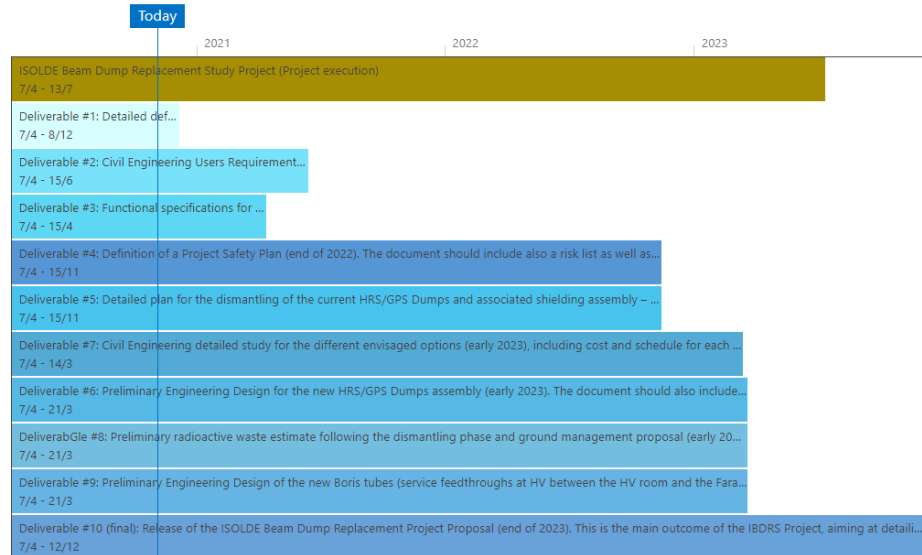
Passing the chicane



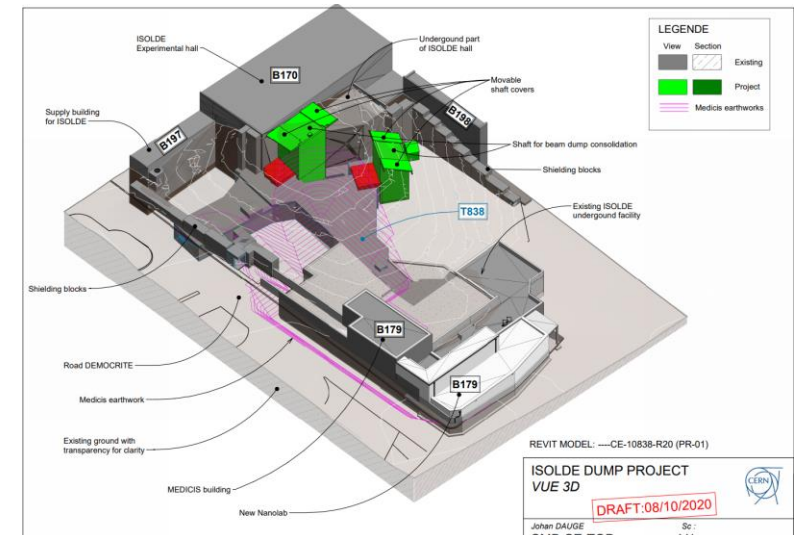
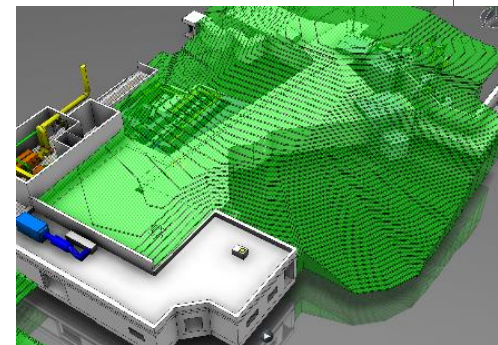
ISOLDE Beam Dump Replacement Study

IBDRS Isolde Beam Dump Replacement Study

Roadmap



- Ana-Paula Bernardes nominated Project Leader
- See her presentation



- New beam dump system compliant with modern standard for operation and RP
- Opportunity to implement solutions to overcome some current limitations (space, accessibility, intensity, energy...)

ISOLDE operability: more time to users

	Sum of Shifts remaining for Run3	Number of experiments
Number of shifts remaining after status report review	485	34
Grand Total of shifts now on books at ISOLDE	1015,5	66

- Parallel operation of the two front-ends (see Rothe's presentation):
 - Setting up of one experiment on one FE while a second is running on the other
 - Consider real alternating operation running HRS and GPS at later stage
- Nano-material based targets potential gains:
 - Improve target lifetime → reduce target exchange and number of targets
 - Improve yields
 - Offer new short-live isotopes

Nano-Laboratory Construction

March

June

November

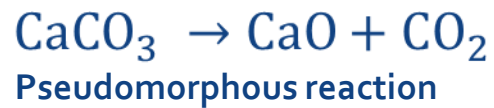
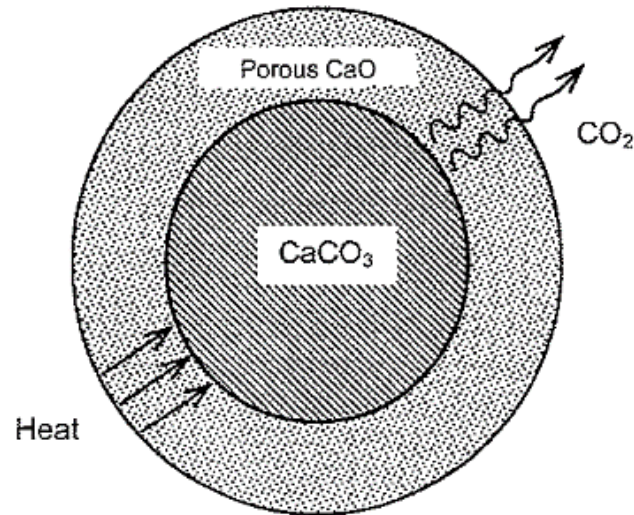


Existing Building 179

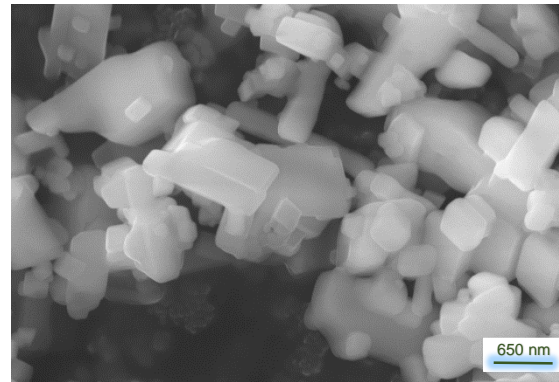
- New laboratory will offer more space and a modern infrastructure (fully enclosed process requiring less transfer of radioactive powder) for production of UCx pills (including pills from nano-material powders)
- Storage area for radioactive material (hot cell for ISOLDE and MEDICIS targets dismantling)
- Operation will start in 2021

Nano-target: Calcium Oxide example

800°C – 2 h
Vacuum (base P=10⁻³ mbar)

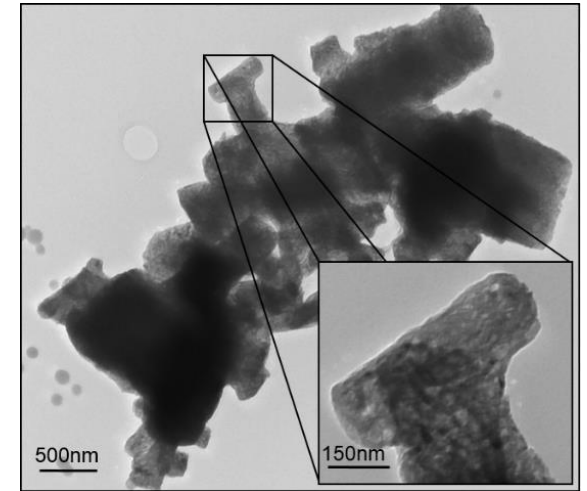


CaCO₃

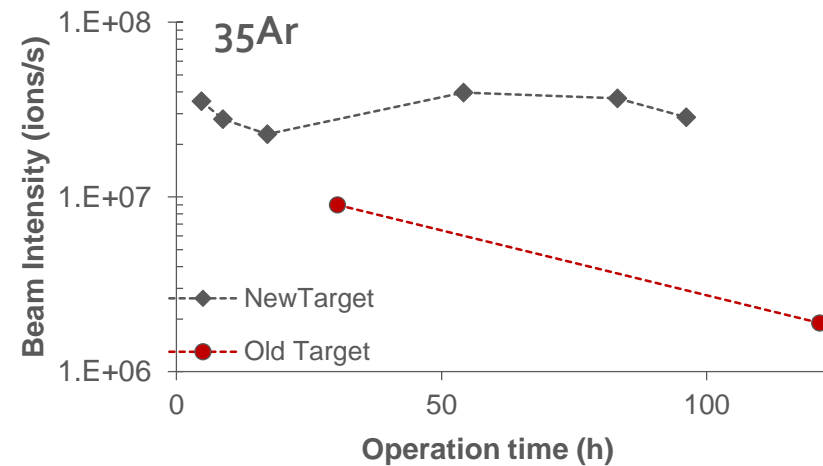


Grain size ~1 μm

CaO



Grain size ~40 nm



Operation temperature reduced
to keep nanostructure

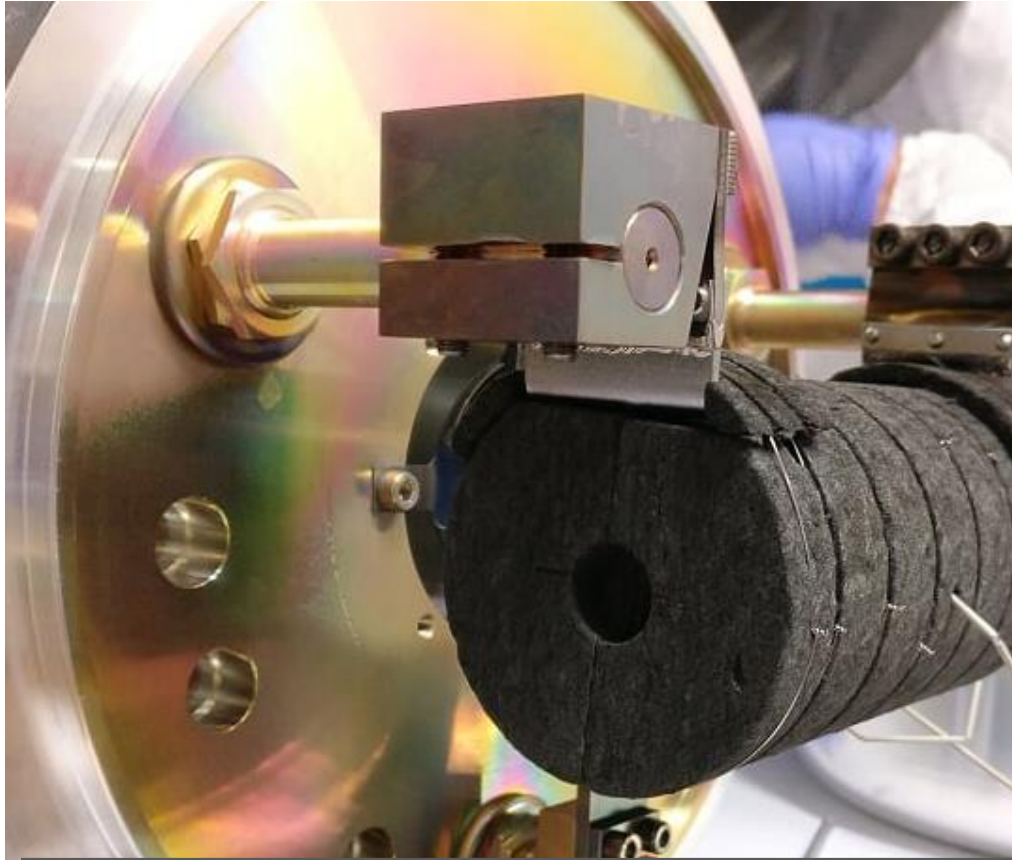
J.P. Ramos, et. al., Ceramics International 41 (6) (2015), 8093-8099.

J.P. Ramos, et al., NIMB 320 (2014), 83-88

J.P. Ramos, Master Thesis, Univ. Aveiro/CERN (2012)

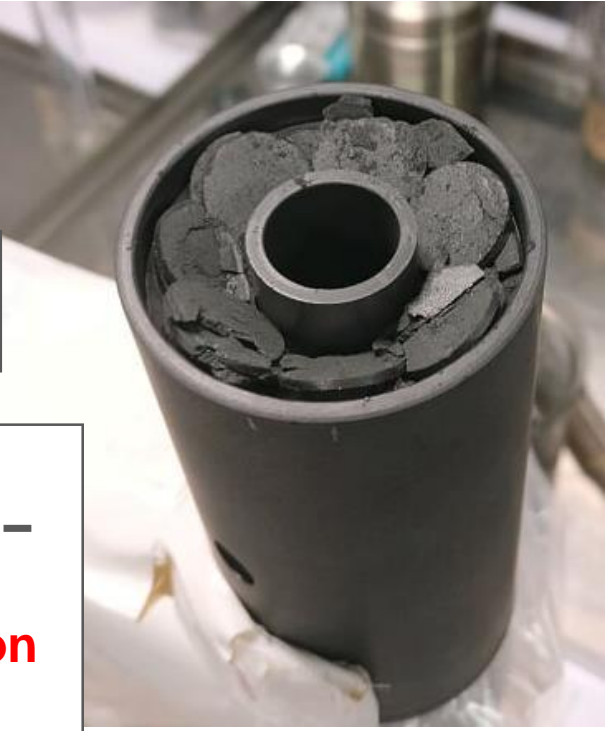
J. P Ramos

ISOLDE target development: Proton-to-neutron converter

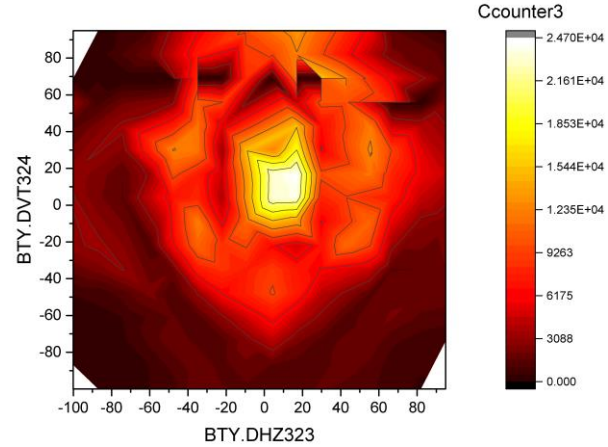


Successfully tested
at ISOLDE

Rb and Cs isotopes
have been measured –
T1/2 down to 30 ms
seen at the tapestation
(>101Rb, >150Cs)



2nd half of beam time:
• Laser beams (Ga, Zn, Ni, In, Te)



Proton scan with ¹⁴⁵Cs

Physics → what we do with that

- Run more / longer experiments per year
 - Fulfil high demand for beam time
- Better quality beams, e.g. around ^{132}Sn (intensity/purity)
 - Region of interest for astrophysics r-process path (link to origin of elements, neutron-star mergers, gravitational waves)
- Faster release
 - Shorter lived (thus more exotic) isotopes
 - Those are typically of highest interest (astrophysics, nuclear modelling, ...)

Improving beam purity

- Some exotic beams are produced only a few isotopes/second in a background of more than 1.000.000/s isobars.
 - Current isobar selection using HRS is about 1/2000
 - Separation of isotopes with same number of nucleons is impossible
 - Purification of 1/20000 is needed
- Development of a fast MR-TOF mass spectrometer (talk by M. Vilen)
- Improving purification is essential in case of upgrade to 2 GeV

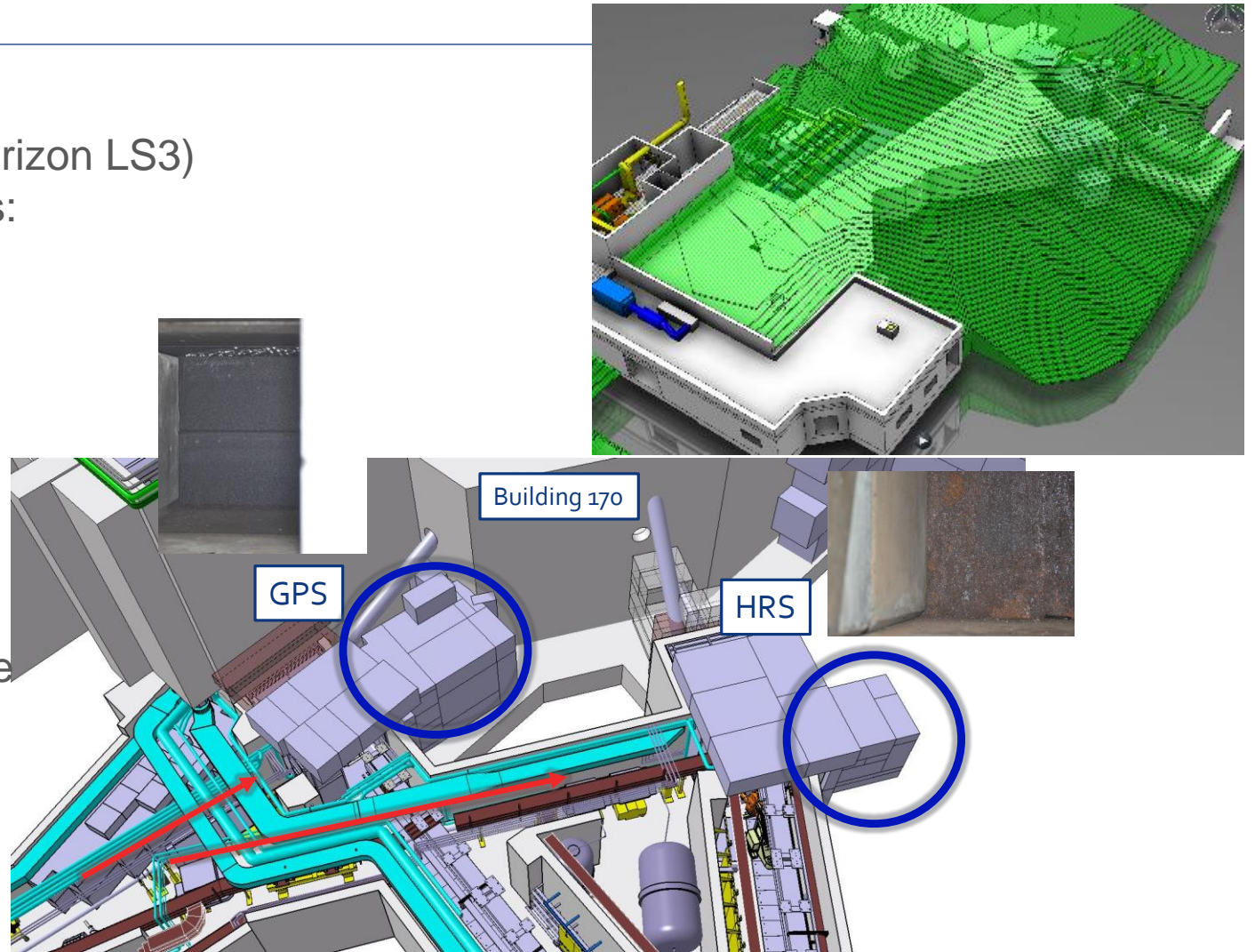
ISOLDE upgrade : EPIC – Medium term

Medium-term facility upgrade (possible horizon LS3)
to fully profit from LIU-PSB improvements:

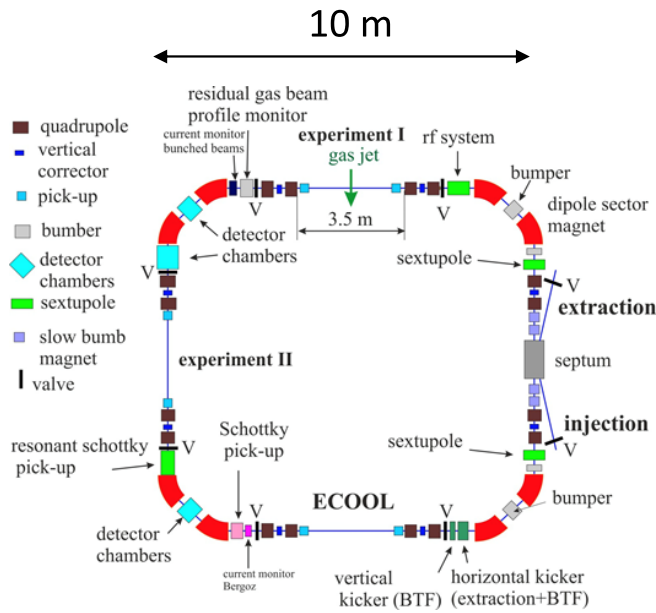
- ISOLDE @ 2 GeV
- Increased POT

Upgrade needed :

- Rebuilding of PSB-ISOLDE transfer line
- Rebuilding of ISOLDE beam dumps
- Validate new targets and future FEs

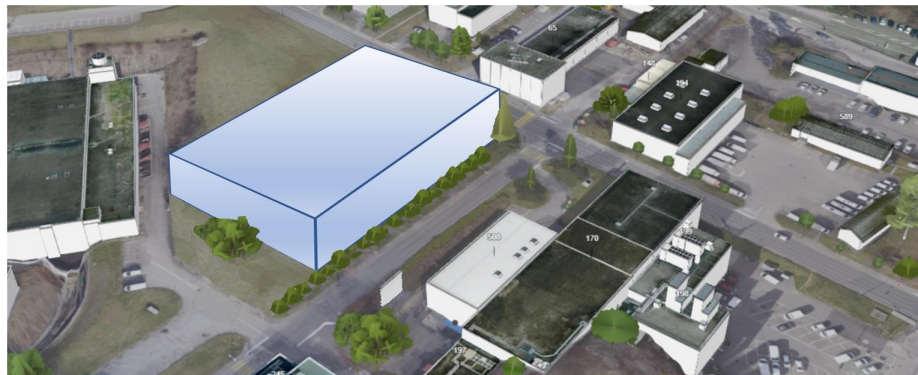
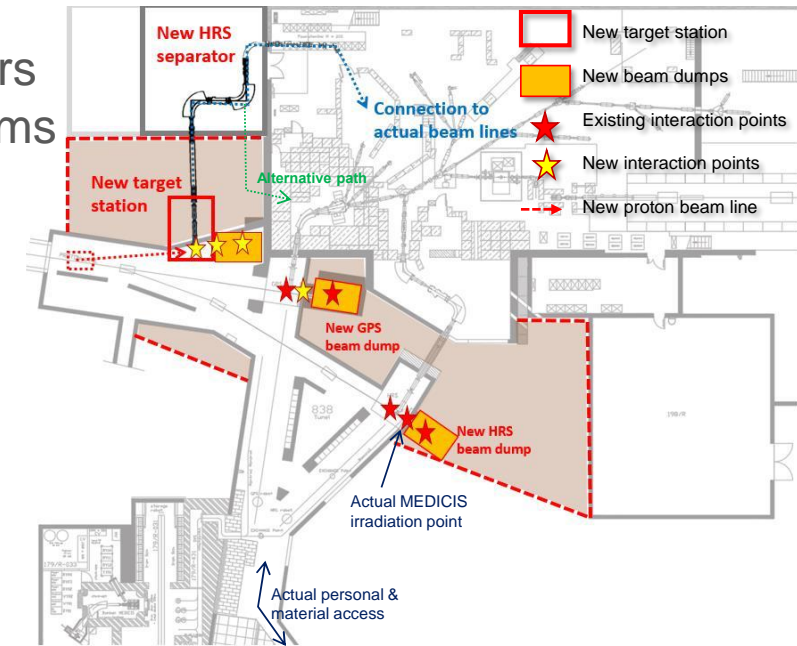


ISOLDE upgrade : EPIC – long-term (>LS3)



Goal:

- increase integrated intensity to final users
→ 1-2 new Front-Ends with RILIS systems
- increase possible experiments
→ New experimental hall
- New physics opportunities
→ Isotope storage ring



Reasons for a new ISOLDE hall and target stations

- No-more expansion of the existing ISOLDE experimental hall possible
- An overfull existing ISOLDE experimental hall and growing demand for new experimental stations: 2 out of 5 new by the RB endorsed experiments will have difficulties to be housed in the existing hall
- Need for higher efficiency and higher quality beams: parallel physics from new target stations and infrastructure with high-resolution separation

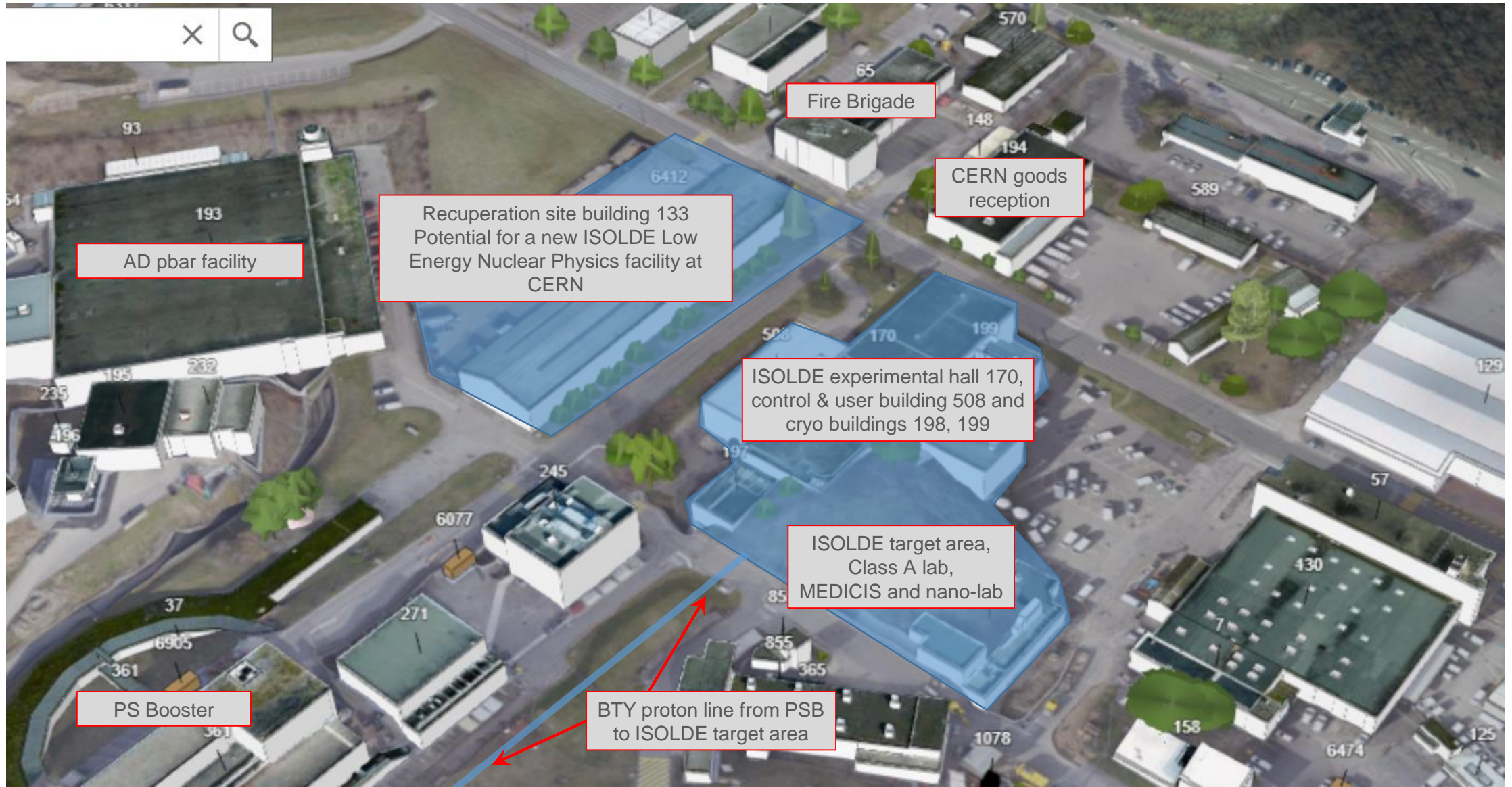
Proposed solution

- A new Low Energy Nuclear Physics experimental hall with its own underground target stations at CERN making use of existing tunnel structures (TT70) to transport the proton beam from PSB
- Present experimental hall 170 and target-zone fully available for HIE ISOLDE post-acceleration experiments, MEDICIS as well as Class A and nano-lab target and ion source development
- Opens the possibility to add a future storage ring in the existing Low Energy hall after the existing Low E experiments have been moved to the new hall and the space becomes available
- **Opens the possibility to connect to the AD (and n_ToF), enabling promising future physics**
- **Construction and installation of the new hall and target stations can be carried out in parallel with physics at the existing ISOLDE facility securing nuclear physics at CERN.**



(See Erwin's talk)

Present/future situation of the ISOLDE area



A New ISOLDE experimental hall and target stations

a new ISOLDE Low Energy Nuclear Physics experimental hall (50x72m)
With underground target stations
making use of existing tunnel
structures (TT70) for the proton beam
from PSB

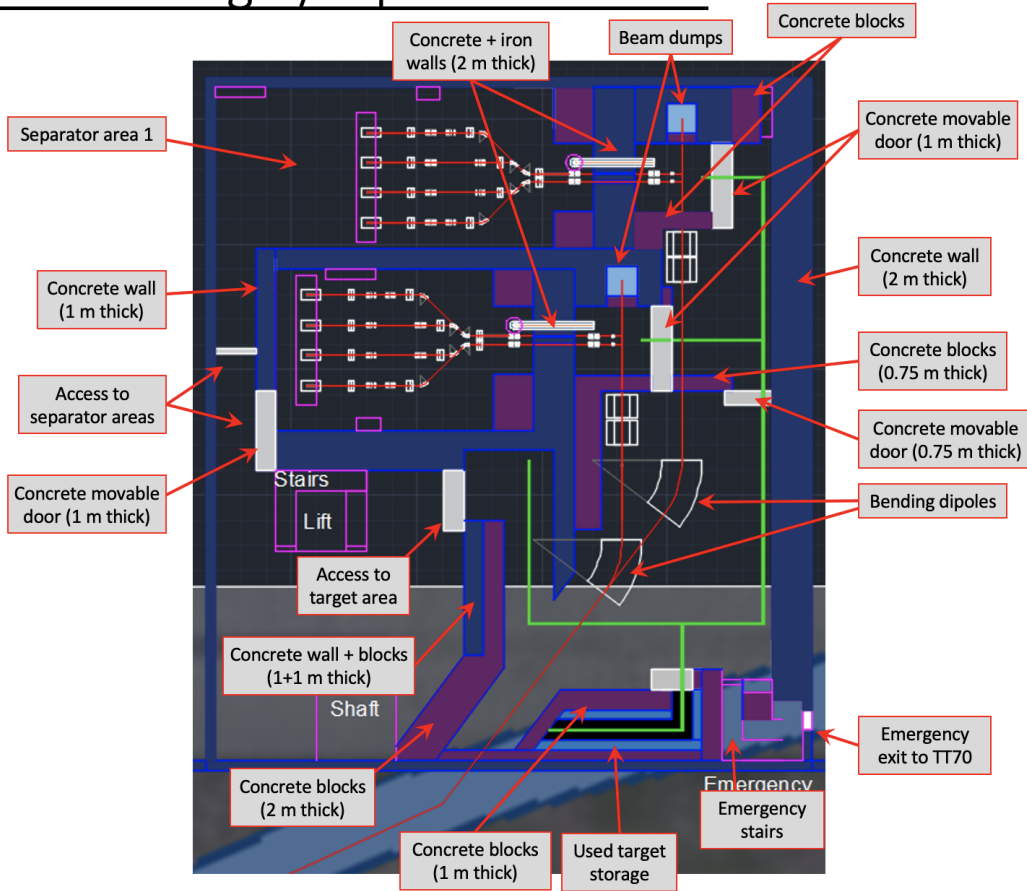
AD pbar facility

ISOLDE experimental hall 170,
control & user building 508 and
cryo buildings 198, 199

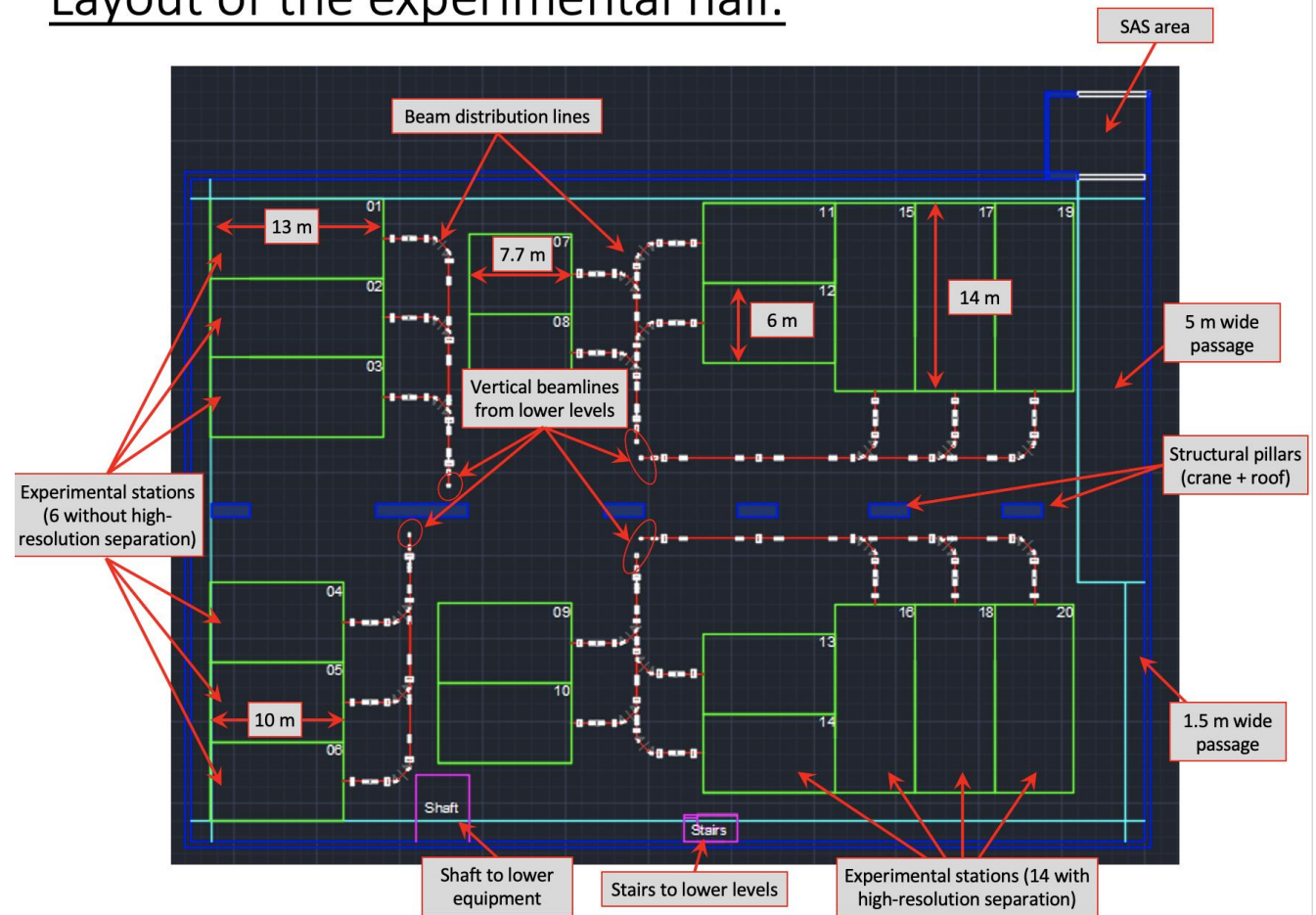
Access to the underground areas

Concept for a new ISOLDE Hall

Layout of Target/Separator Zones:



Layout of the experimental hall:



Conclusion

- Rich possible improvement program following the long-term tradition of the ISOLDE community/facility
- Clear need for physics community to keep/improve ISOLDE capabilities in producing a large variety of isotopes, but also need in increase integrated time to users
- Staged proposed approach with clear improvements in facility operability and physics potentials
 - Secure long term facility operation without forgetting potential given by post LIU PSB (FEs, dumps, new faraday cages, targets, etc..)
 - Explore possible funding schemes for each upgrade step outside CERN
- Explore synergies with other CERN physics programs
 - n_TOF, AD for example
- To be done:
 - Continue working on technical proposals with horizon LS3 and LS4
 - evaluate impact on facility future operational costs wrt to proposed upgrades



Thank you for your
attention!