ISOLDE and n_TOF Consolidation

Richard Catherall
ISOLDE Technical Coordinator
EN-STI

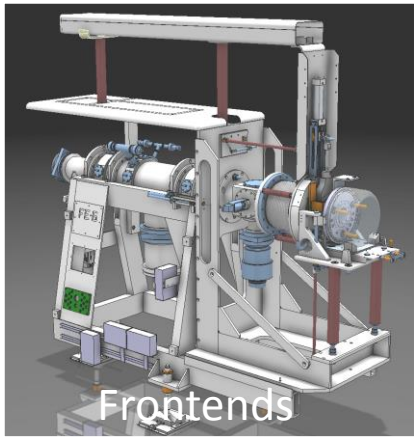
Chamonix 2014 workshop

Introduction

- Consolidation driven by the following criteria:
  - Operation and performance of the facility
  - Aging
    - Radiation damage, corrosion, mechanical failures
  - Difficulty to repair due to high dose rates and contamination
  - Safety
    - Radiation protection

- Issues identified and addressed in HIE-ISOLDE Design Study
  - Arrival of Linac 4 and a potential increase in p-beam intensity
    - 2 GeV upgrade of Booster ISOLDE?

Introduction



RILIS

REX Low energy

Beam dumps shielding

Off-line separator

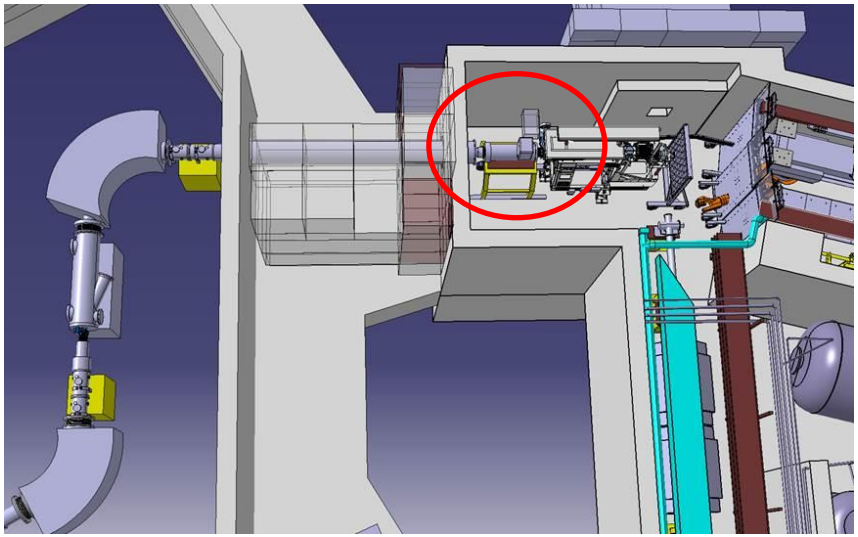
Magnets Vacuum High voltage CV controls Safety

Frontends

- Both Frontends should be replaced during LS2
- Frontend lifetime: 6 – 8 years
  - HRS operational since March 2010
  - GPS since March 2011
- A failure of one Frontend during the operational period will reduce the physics program by 50%
- Construction of 1 spare on-line Frontend

- Take advantage of replacement to develop a new generation of Frontends requiring a minimum number of interventions
  - E.g. - Modify extraction electrode system

Vacuum TE-VSC



- Replace first beam line chamber
- Extension of exhaust gas containment
  - Addition of a third tank
  - ISOLDE pumping is stopped when the tanks are full
  - Not always possible to release gases due to a lack of decay time
- Replace beam line turbo pumps

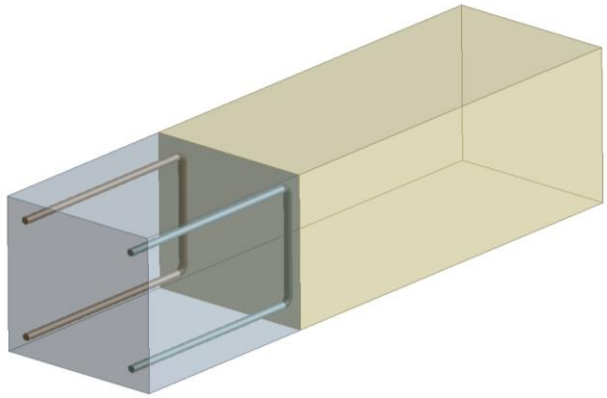
ISOLDE Beam Dumps

- Replace/modify the ISOLDE beam dumps
  - At the limit of operation in terms of thermal and compressive stresses
  - Simulations done on assumed properties show that limits are exceeded for certain p-beam conditions
  - A failure of the beam dump would stop the ISOLDE physics program for >12months
  - Prevent any increase in p-beam intensity and energy
- Should be replaced/modified during the LS2 period
  - 2 options considered

ISOLDE Beam Dumps

Option 1

- Insert a PSB like water-cooled beam dump in front of existing beam dumps.
  - Advantages:
    - Cheaper option
    - Based on known design
    - “easier” access
  - Disadvantages
    - Implementation and maintenance of a cooling system
      - Activated water
    - Contribution to target area air activation and consequent release to atmosphere.
    - High dose rate for installation



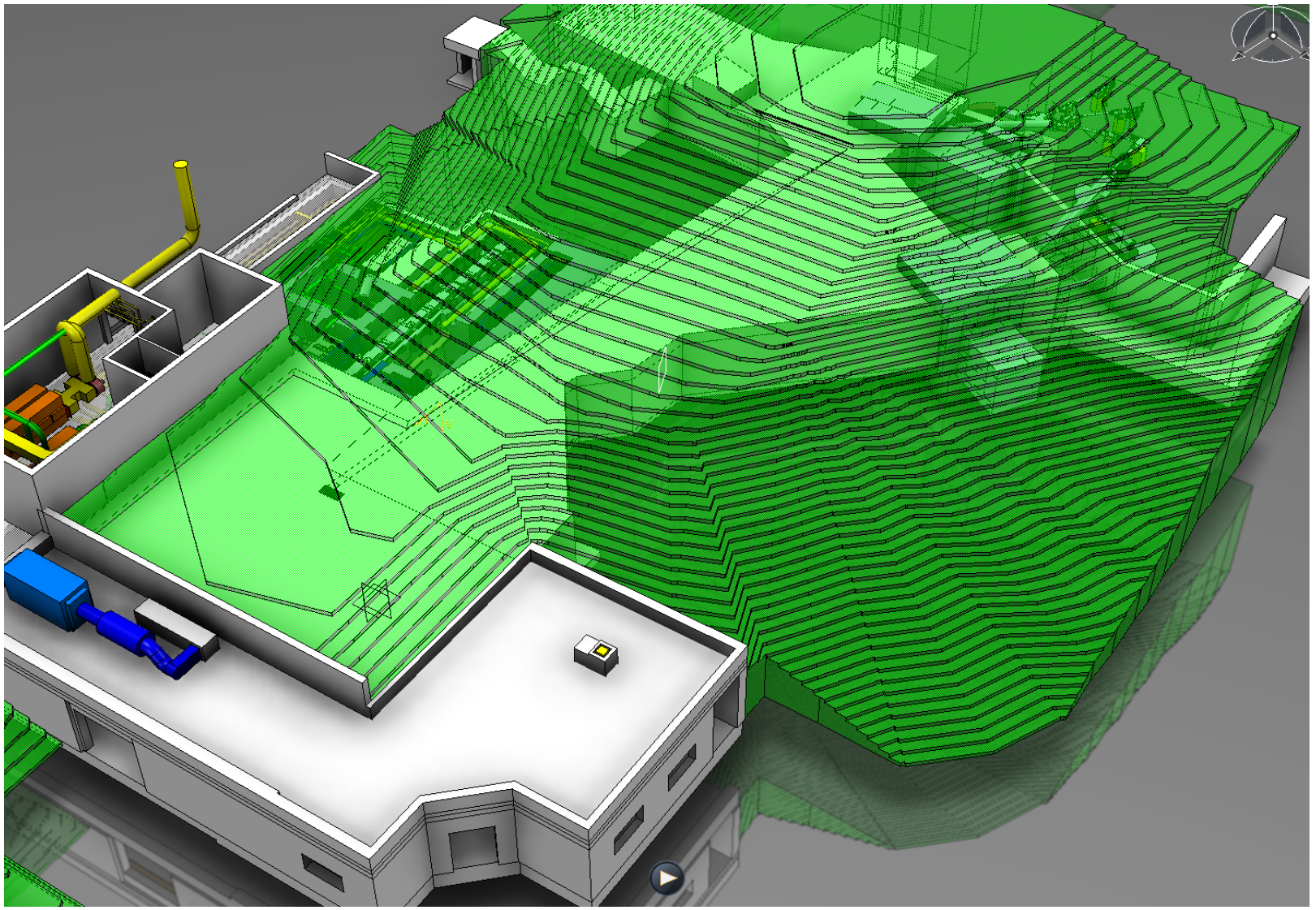
ISOLDE Beam Dumps
Option 2

- Replace existing beam dumps
- Advantages
  - Low dose rate for installation
  - Take advantage to improve shielding (see next slides)
  - Reduction in air activation through new design
- Disadvantages
  - Removal, storage and replacement of ~3500m^3 of earth, about half of which is activated.
  - Handling and storage of radioactive beam dump
  - Still require cooling and its associated disadvantages

Shielding

- Further shielding required to attenuate dose rates observed during operation and under certain conditions:
  - 2uA of p-beam on thick ISOLDE targets (>50gcm-2)
  - Identified by RP in https://edms.cern.ch/document/1142606/1 **CERN-DGS-2010-006-RP-SN**
  - Impact of p-beam intensity and energy increase on radiation dose rates outside the CERN perimeter to be assessed
- Can be combined with an upgrade of the ISOLDE beam dumps
- Requires major excavation work of activated earth

Shielding

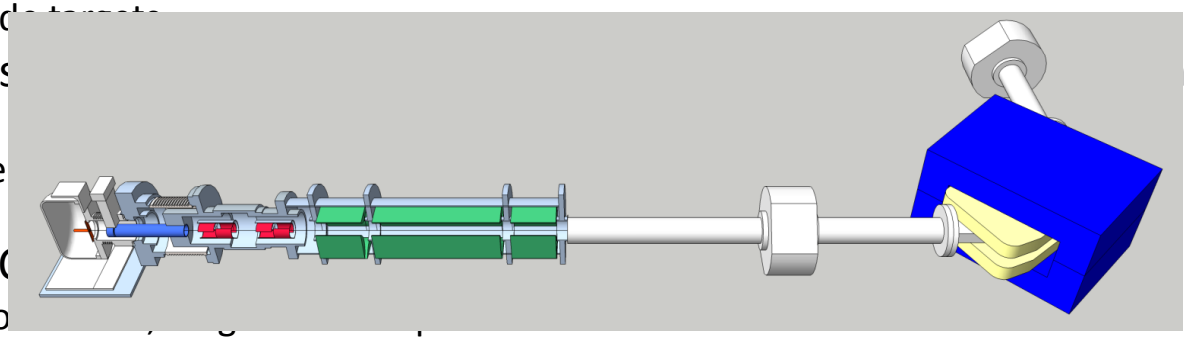


Off-line Separator

- Construction of a dedicated off-line separator in the Class A laboratories

- Prior to 2005 and the commissioning of the Class A laboratories at the ISOLDE Facility, all targets (non-actinide and actinide (UC_2-C)) underwent off-line testing in the ISOLDE laboratories in building 3 prior to operation on-line.
  - Target characterization, stable beam mass scans, ionization efficiency measurements..etc

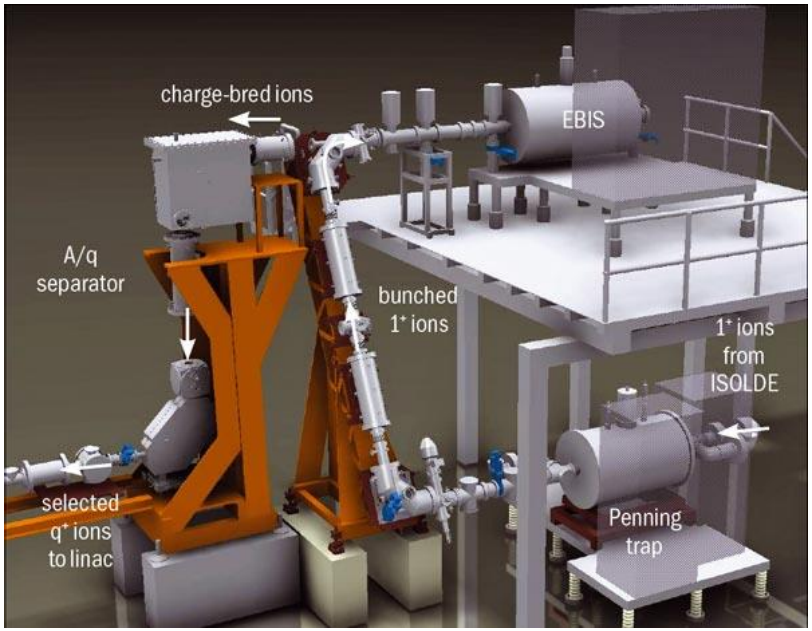
- Since 2005
  - All radioactive source handling (including actinide target preparation) is done in the Class A laboratories.
  - To avoid cross contamination, only non-actinide targets continue to be tested in building 3
  - A second dedicated off-line separator is required in the Class A laboratories for the testing of actinide targets
- The risk is [illegible] of a physics run
  - 2 wee[illegible]
- Spin off: [illegible]
  - ^{7}Be co[illegible]



Necessary and not approved not necessary necessary and approved part in HIE-ISOLDE

REX-ISOLDE

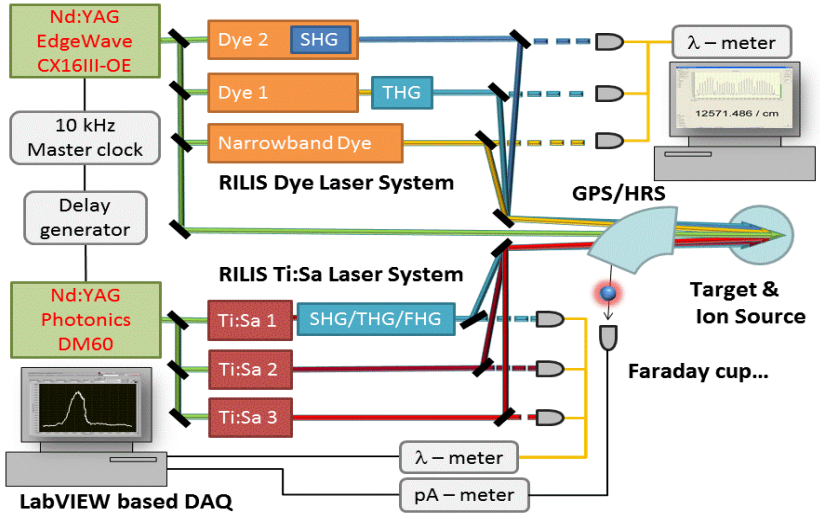
- The low energy part of REX cools, bunches and ionizes to a multi-charged state the singly-charged ion beams from ISOLDE before injecting into the REX-Linac
- REX-ISOLDE provides ~ 200 x 8 hour shifts per year of physics to the ISOLDE community
- Consolidation implies replacement of critical components for the REXTRAP and REXEBIS
  - Request 300kCHF over a period of 3 years
    - 2016-2017-2018
  - May be integrated into a project to replace with an upgraded REXEBIS

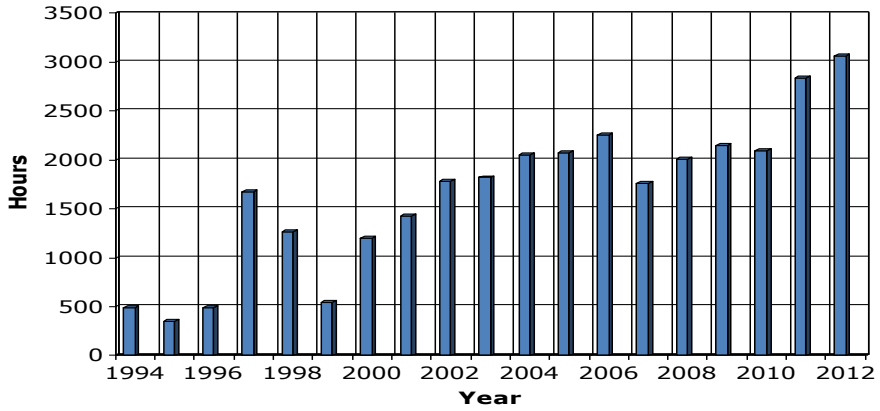


Necessary and not approved not necessary necessary and approved part in HIE-ISOLDE

RILIS

- RILIS is the Resonance Ionization Laser Ion Source, used to improve the selectivity of the ion sources in ISOLDE.
- 70% of the beams in ISOLDE are produced using RILIS.
- Nd:YAG lasers have limited lifetime, and need to be replaced after about 15000 hour of operation (say, every 5 years).
- We already see signs of degradation (output power reduced) of the YAG lasers (bought in 2007/2008), so it is time to replace them.





Impact of laser failure on operation

- Spare lasers are used to replace faulty units

  ~ 2 failures per operation year, tending to increase with the age of lasers

  Spare units are becoming old, performance degrading

  Cost of repair is high as the warranty has expired

- More RILIS beams are available after LS1
  - More requests for RILIS from ISOLDE users
  - Duration of runs will increase

Budget request for consolidation of RILIS lasers

- Request 2013

Laser model	Application	Year of purchase	Number	Estimated price/unit, kCHF
Lumera Blaze 532-40-HE	Highly efficient non-resonant ionization	2014	1	110
EdgeWave Innoslab CX16III-OE + warranty extension	Pumping of dye lasers and non-resonant ionization	2015	1	220
Photonics DM60 or similar	Pumping of TiSa lasers	2015	1	75

- Spending profile - was not approved

Status / kCHF	2014	2015	Total
requested	110	295	405

Current status of RILIS consolidation

- **Lumera laser** ⟶ purchased in 2014

  Funding gathered from other sources:

  Marie Curie ITN CATHI (50%) + STI operation (50%)

- **Photonics laser** ⟶ price increased to 105 kCHF
- **Updated budget request**

Status / kCHF	2014	2015	Total
requested		325	325

RILIS lasers require a recurrent consolidation every 5 years

~ 435 kCHF in 2020

Necessary and not approved not necessary necessary and approved part in HIE-ISOLDE

ISOLDE Magnets

- Supply of spare magnets and coils for both ISOLDE and REX ISOLDE
- Any failure of the magnets would result in considerable down time of the machine
  - During operation the repair of 1 separator magnet would stop all operation due to access restrictions

SLOT	DESIGN	What?	How much (kCHF)	Comments?
GPS.MAG70	PXMDSEAHWC	Spare coils	100	Any repair would currently need to be made insitu as there is no provision to remove the magnets from the line, considerable down time still expected!
HRS.MAG60	PXMDSFACWC	Spare coils	100	Any repair would currently need to be made insitu as there is no provision to remove the magnets from the line, considerable down time still expected!
HRS.MAG90	PXMDSGACWC	Spare coils	100	Any repair would currently need to be made insitu as there is no provision to remove the magnets from the line, considerable down time still expected!
XSEP.MD100	PXMBXCAHWC	Spare magnet	120	Considering solid yoke construction a new magnet would be recommended
MQT1 + MQT2	PXMQTACFWC & PXMQTADFWC	Spare magnets	60	Considering solid yoke construction a new magnet would be recommended
MQT3	Not in Database	Spare magnets	100	Design makes coil replacement difficult, considerable down time expected!
MQT4 + MQT5.2	PXMQTABFWC & PXMQTAAFWC & PXMQTAEFWC & PXMQTAFFWC	Spare magnets	60	Considering solid yoke construction a new magnet would be recommended
			640	+ 160 (2 FTE) = 800 KCHF

Necessary and not approved not necessary necessary and approved part in HIE-ISOLDE

High Voltage

- Replace the four 60kV Astec power supplies.
- Independent of the new modulator development within the HIE-Design Study

- Present Astecs nearing the end of life and failure rates may become unacceptable between now and the installation of the new modulator (circa 2018?).

- The Market Survey is nearing completion and with tender planned for next year.
- Allocated expenditure of 93kCHF in 2015 and 100kCHF in 2016.

CV

- Modification of the ventilation controls for the original ISOLDE Facility after separation of the Class A laboratories
  - Tunnel, HT room, control room and “old” hall
- Should be synchronised with the coupling of the MEDICIS ventilation with the Class A labs
  - Shutdown 2014/2015?
- Requires modification of an old and obsolete ventilation control system

Safety (First)

- Request 120kCHF/year in order to cope with ALARA and planned interventions in sensitive areas.
  - Assistance and follow-up of interventions.
- Preparation of risk analysis associated with operation and intervention.

Consolidation Expenditure Request

WU/kCHF	2015	2016	2017	2018	2019	2020	Groups
Frontends x2 Spare Frontend		300	300		50	300	**EN-STI-RBS** BE-BI TE-VSC
Beam dumps O1 O2				1000 ?	?		**EN-STI-TCD** GS-SE? DGS-RP
Shielding				?	?		**GS-SE** DGS-RP
Off-line	400	400					**EN-STI-RBS**
REX		100	100	100			**BE-ABP**
RILIS	325					400	**EN-STI-LP**
Magnets	200	300	300				**TE-MSC**
Vacuum		70	60	160	60	60	**TE-VSC**
High Voltage	93	100					**TE-ABT-EC**
CV controls	?						**EN-CV**
Safety	120	120	120	120	120	120	**EN-STI**

Approved ISOLDE Consolidation Budget

WU kCHF	2014	2015	2016	2017	2018
IS Consolidation	224	115	220	220	220

- Used for small operational consolidation
- Pumps
- Test stands
- Cables
- Auxiliary equipment

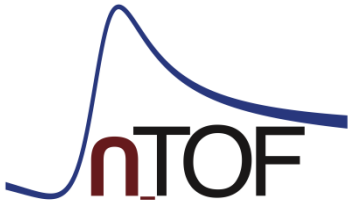
Risk Register

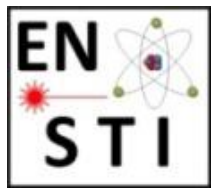
WU Name	Probability of Failure (P)	Impact on Scientific Objectives (Io)	Impact on reputation (Ir)	Financial Impact of failure (If)	Safety Impact (Is)	Risk Score (Rs)
Frontend and first stage beam line	4	4	3	2	1	16
Beam dumps	3	5	3	2	1	15
Shielding	1	4	2	3	4	4
Class A off-line separator	4	2	2	1	1	8
REXEBIS and REXTRAP	3	4	3	1	1	12
RILIS	3	4	3	2	1	12
Ventilation controls	3	4	3	2	1	12
HT	3	4	3	1	1	12
magnets	2	5	3	2	1	10
vacuum	2	2	1	1	1	4

Marco Calviani

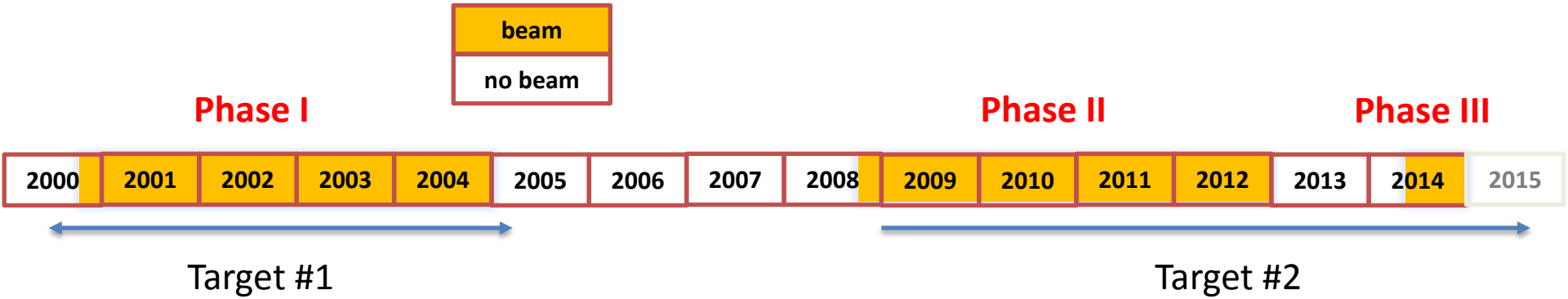
Chamonix 2014 workshop

N_TOF CONSOLIDATION REQUESTS





n_TOF facility milestone

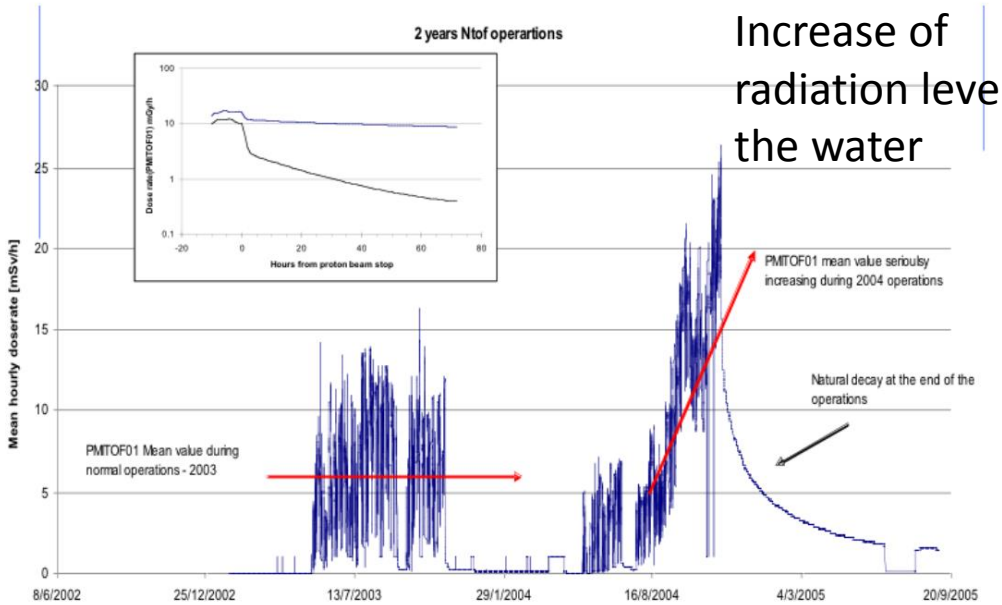


- 1998-2001: preparation and commissioning
- 2002-2004: **phase I** data taking (target #1)
- 2005-2007: spallation target upgrade
- 2008: first proton on target #2
- 2009-2012: **phase II** data taking (target #2)
- 2010: EAR1 upgrade and borated water moderator
- From 2014: **phase III** data taking (target #2) and EAR2 operation

n_TOF target evolution

- 2000-2004 → target #1
  - Solid lead target in a water bath
  - Operation stopped due to leakage of spallation products in the cooling water

Damaged and oxidized target #1

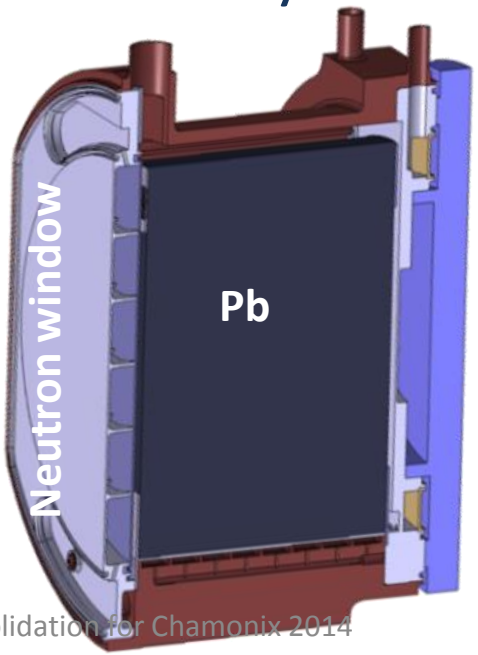


Increase of radiation levels in the water

2004

n_TOF target evolution

- 2008-now → target #2
  - Monolithic water-cooled Pb target in pressurized vessel
  - Optimized target with separated cooling/moderator loops
  - Fully controlled water chemistry



Target #2 lifetime

- Lifetime of target #2 critical parts estimated to be **~10 years**, based on dedicated corrosion tests
  - Repair not possible (due to design and high expected dose rate O(100 mSv/h))
- **Risks if exchange not performed during LS2:**
  1. Spill of highly radioactive water in the target pit
  2. Increased contamination of the water loop
  3. Long physics stop if failure occurs between LS2 and LS3

n_TOF target #2 inspection

- External inspection performed in April 2014
- Surface oxidation stains have been observed, due to humid atmosphere
- Similar/worse expected inside the loop

Consolidation needs

1. Design and construction of a new neutron spallation target (#3)
   - 1.3MCHF
2. Dismantling of the target #1 cooling station (in FTN tunnel)
   - 2018 (200kCHF)
3. Consolidation of EAR1 sweeping magnet power supply
   - 2017 – 2018 (200kCHF over 2 years)

WU Name	Probability of Failure (P)	Impact on Scientific Objectives (Ip)	Impact on reputation (Ir)	Financial Impact of failure (If)	Safety Impact (Is)	Risk Score (Rs)
n_TOF spallation target exchange	2	5	3	3	1	**10**
target #1 cooling station removal	1	1	2	N/A	3	3
Sweeping magnet power supply consolidation	3	2	2	1	1	6

Target failure can jeopardize >1 year of physics

Necessary and not approved not necessary necessary and approved part in HIE-ISOLDE

N_TOF consolidation requests

Request / kCHF	2014	2015	2016	2017	2018	Total
Design and construction of a new neutron spallation target	0	250	500	350	200	1300
Dismantling of the target #1 cooling station	0	0	0	0	200	200
Consolidation of EAR1 sweeping magnet power supply	0	0	0	100	100	200
Total/year	0	250	500	450	500	1700

For the target replacement please refer to EDMS document 1310619

- Acknowledgements
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- Thank you for your attention