Status of the activities for LS1 and HIE-ISOLDE Design Study

Alignment
VITO Beam line modification

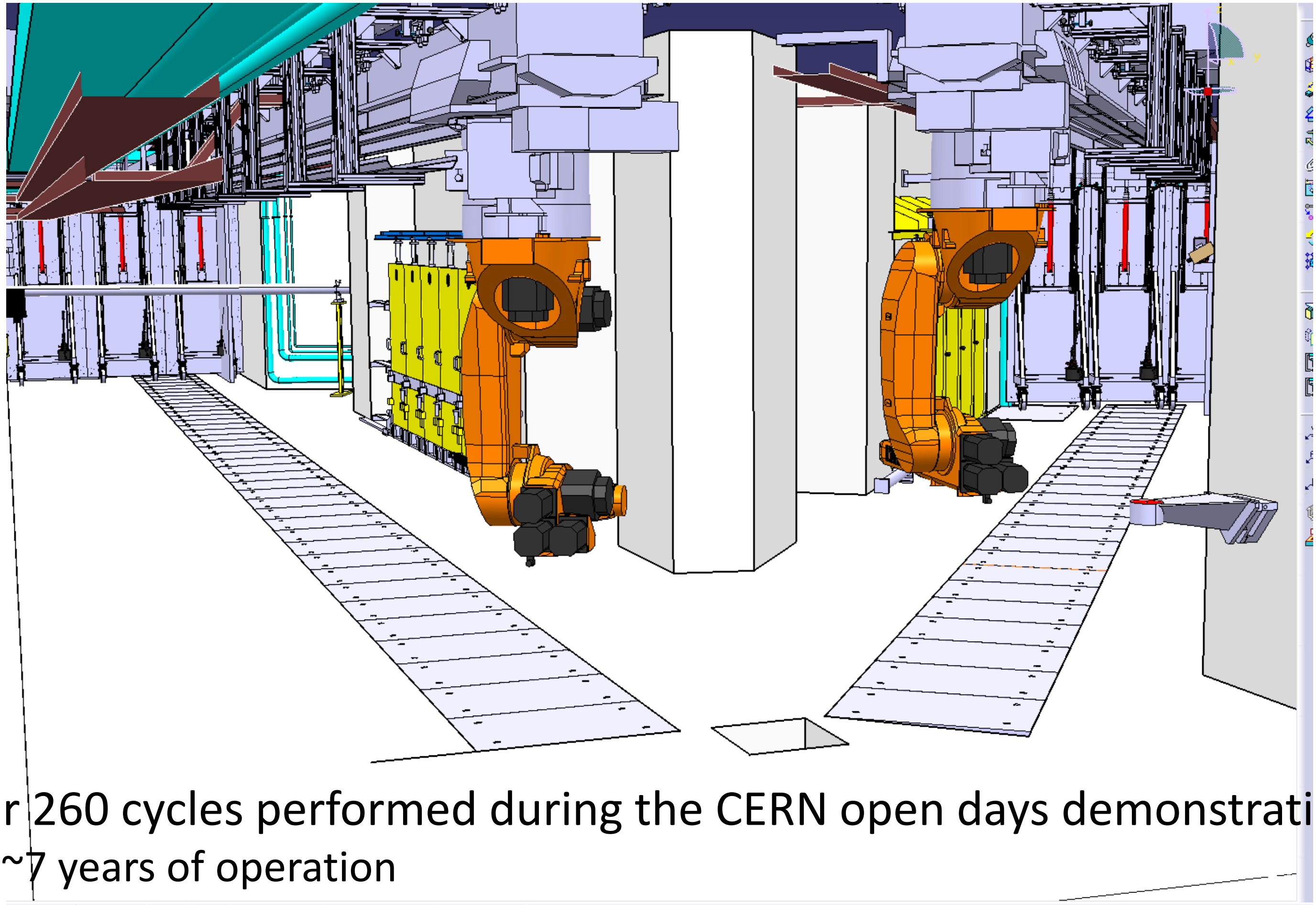
Richard Catherall
EN-STI-RBS

ISOLDE Collaboration Committee
22nd October 2013

LS1 Activities

- Target area
  - Robots
  - PAD/MAD
  - Medicis
  - Hot Cell
- Hall
  - REX
  - TSR@ISOLDE
  - RILIS

Robots

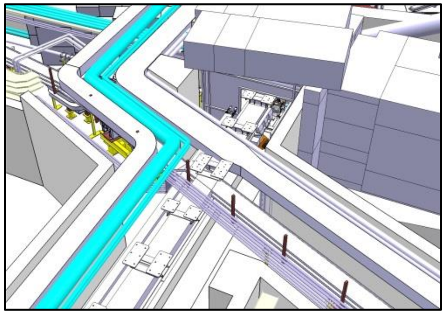


- Over 260 cycles performed during the CERN open days demonstration
  - ~7 years of operation
  - No faults
  - But…

M. Vagnoni, J-L Grenard

Phase III – Services modification

Overview of the situation



MAIN TASKS TO BE CARRIED OUT

☐ Dismantling and installation of new CV pipes and ducts

☐ Dismantling and installation of new electrical cables and cable trays

RADIOPROTECTION ASPECT

☐ Higher collective and individual doses than expected

2313 H.µSv
ALARA Committee

March 2013

→ Factor 3 →

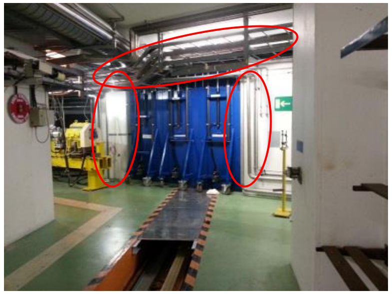
7181 H.µSv
New estimation

September 2013

☐ Main reason for higher dose rates in the area:

→ Activation of certain equipment and material near the Faraday Cages on both GPS and HRS sides

- ✓ Ducts, pipes
- ✓ Concrete walls
- ✓ Cable trays



CONSEQUENCES

☐ Major increase of the collective dose concerning phase 3 near the GPS Faraday cage

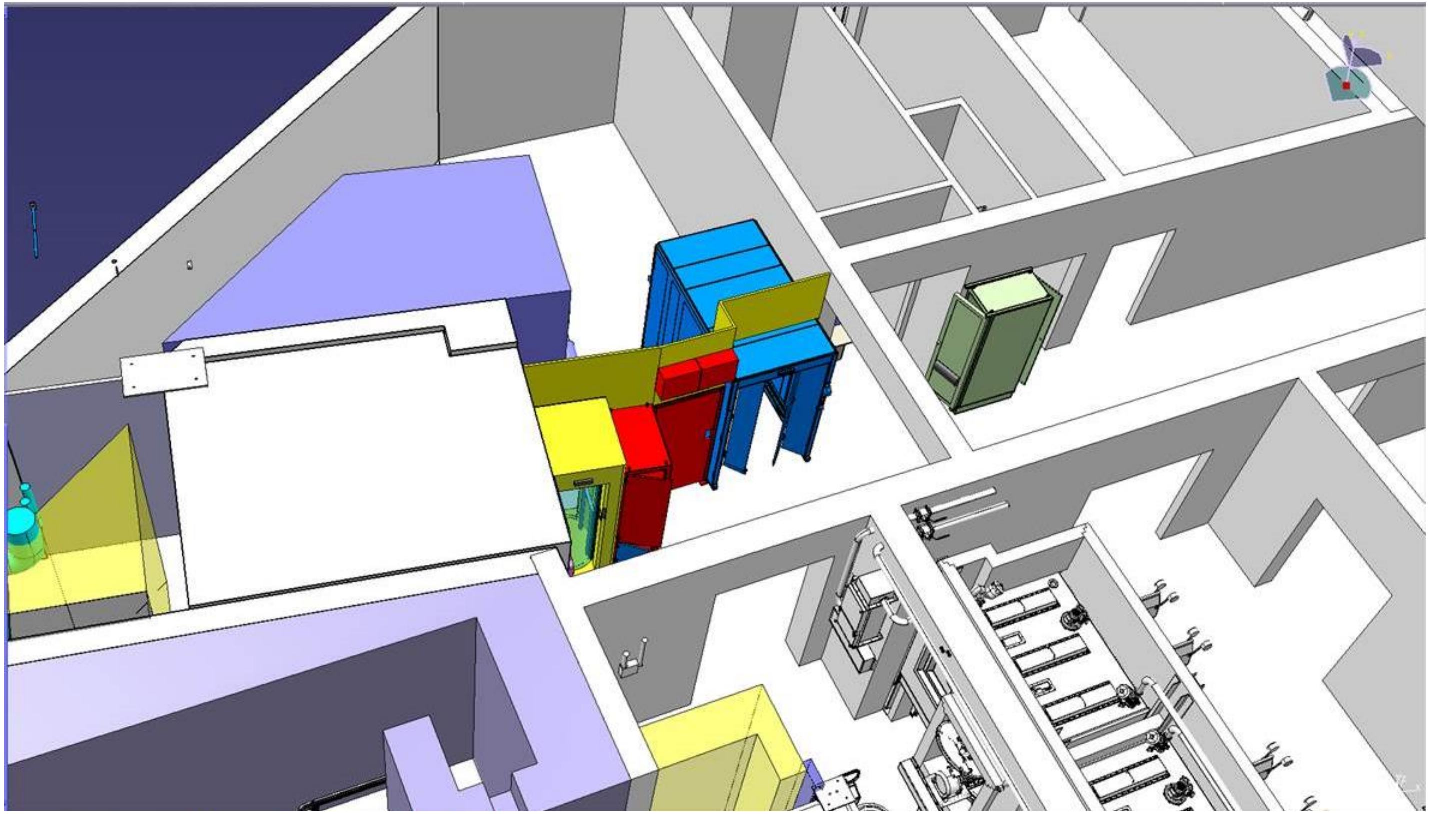
Phase III – Services modification

Overview of the situation

ADDITIONAL CONTROL MEASURES IMPLEMENTED

- ☐ Use of a saber saw to reduce the time of intervention and to maintain a safe distance from the cutting points
- ☐ Installation of a lift truck to allow the mechanical support of the ducts and pipes during cutting work, thus avoiding human intervention for the handling
- ☐ Phasing of the work in order to dismantle the hot points first
- ☐ Limitation of the individual dose to 600 µSv

PAD/MAD Installation



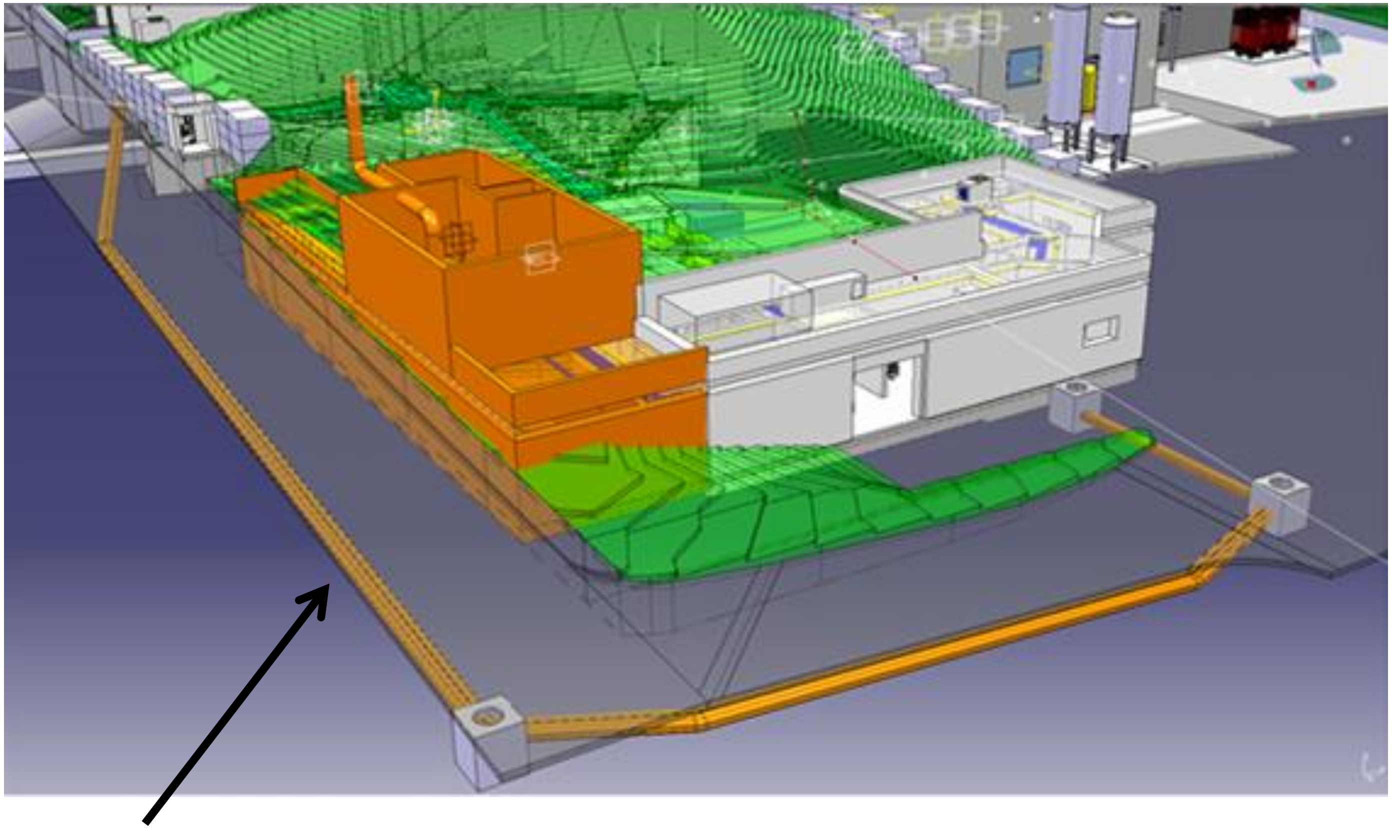
- Will be installed in January
  - Gives more time for installation of robots
  - Allows for the modification of the corridor for future hot cell
  - Safety chain checks start in February

Groundbreaking

September 4th 2013

T. Stora

Building



New services for Bld 179 done.
Earth removal started.
“cold building” finished in Feb 2014 (1 month shift).

T. Stora

Earth Removal

T. Stora

External partners

External partners :

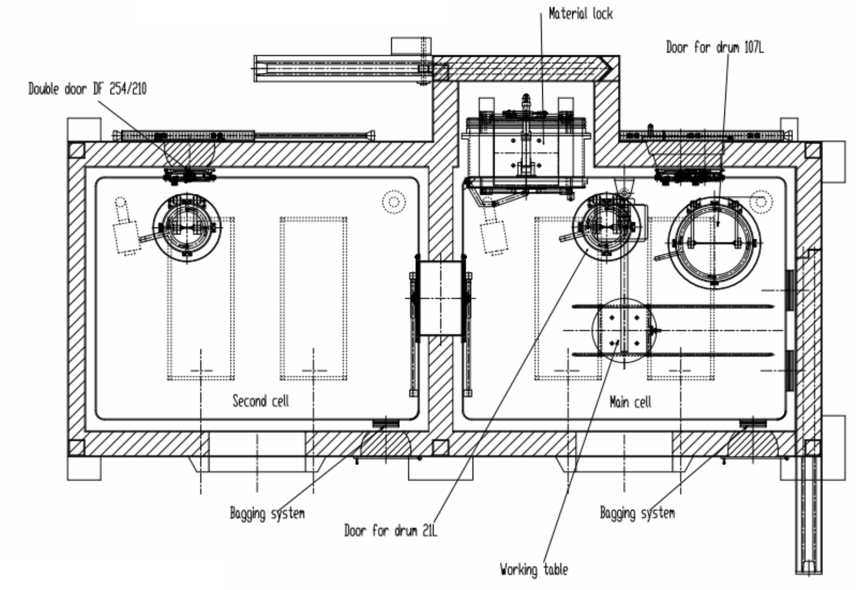
Dr. Forni (**Clin. Carouge**)
L. Vouga, Prof. P. Morel, Prof. L. Buehler, Prof. Y. Seimbille, Prof. O. Ratib (**HUG**, Geneva), Prof. D. Hanahan (**ISREC-EPFL**, Lausanne)
Prof. J. Prior, Dr. F. Buchegger (**CHUV**, Lausanne)
Prof. M. Huyse, Prof. P. van Duppen (**Univ. Leuven**)
Prof. S. Lahiri (SINP, **Kolkata**)
Prof. Piperkova (Nat'l oncology hospital, **Sofia**)
Prof. Dos Santos (FCUL, **Lisbon**)

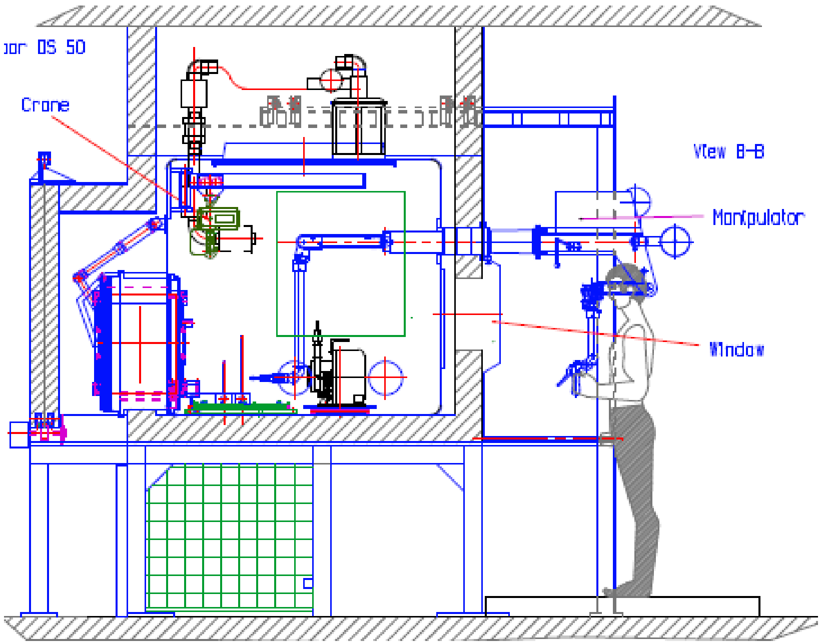
Budget so far : (CERN+external+in-kind) : 3.2 MiCHF
New in-kind + grant requests underway

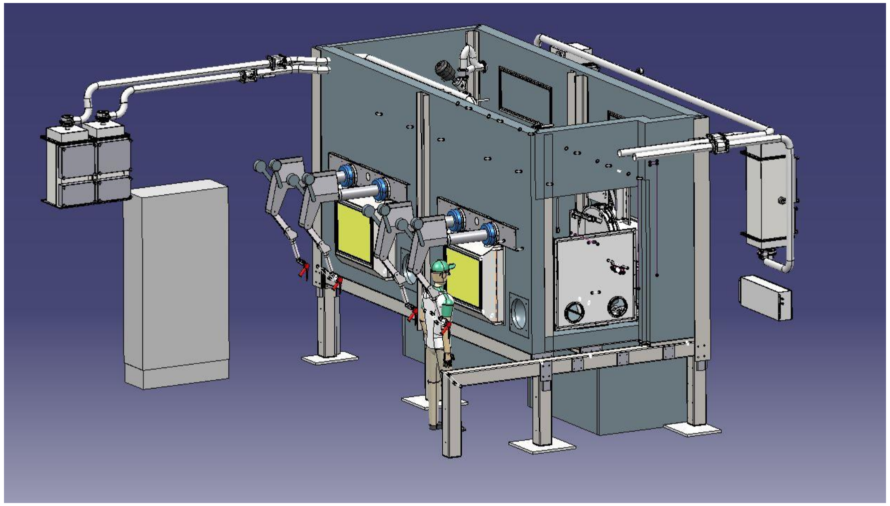
PHASE I Commissioning : No beam (end 2015)
PHASE II Start up with light targets for retour d'experience (2016)
PHASE II B Production with light targets (mid 2016)
PHASE III Extending to heavy targets up to Tantalum (tentative end 2016)
PHASE IV Collection of short lived alpha emitters (149Tb) (tentative 2017)
PHASE IVB Operation with Lasers
PHASE V Operation with Uranium targets/possible proton beam upgrade (tentative 2018)

T. Stora

Hot cell layout







- Production on schedule
- Factory acceptance tests planned for December 2013
- Modification of building 179 to start in next few weeks

REXEBIS and REXTRAP

1. Scheduled electron cathode tests for autumn 2013 postponed to spring 2014

    Due to lacking infrastructure (water, LHe, controls etc).

2. Repair of REXEBIS magnet cryostat initialized

    Present LHe holding time 6 days and could fall abruptly (nominal 14 days).
    Last repaired 2005 by external firm Ice Oxford; this time in-house repair.
    Major and risky job; complete EBIS needs to be dismantled.
    Goal: EBIS re-assembled by March 2014.

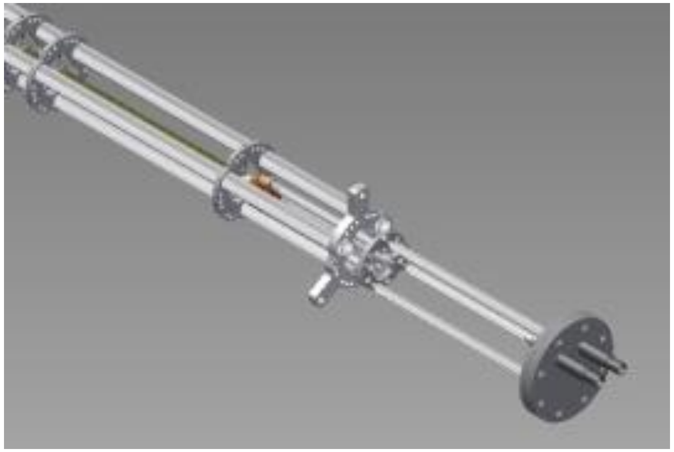
3a. Incomplete and incorrect drawings of REXEBIS now redone in 3D

b. Production of spare collector (critical EBIS part), gun and inner structure

    Spin-off from TwinEBIS

4. Modification of injection FC for REXTRAP

    Inherent design error mitigated; new version being evaluated.



F. Wenander

TwinEBIS test setup

* Labview system for DC control and vacuum readout finished.

* Bakeout system, power supplies, HV gun rack installed.

* Remaining mechanical internal parts in production.
(act as spares for REXEBIS)

* Vacuum control system (FPGA) in production. Assistance P. Fernier.

* M. Breitenfeldt COAS during autumn 2013 => major push!

Long-term goals:

0. Spare for REXEBIS
1. Higher electron current
2. Better cathode lifetimes
3. Test-bench for EMILIE project
4. Optimization of extracted ion pulse

EBIS team: M. Breitenfeldt, J. Thiboud

Funding of EBIS development activities

Good progress thanks to excellent members at the team!

1. Struggling to extend A. Shornikov's presence at CERN. His CATHI fellowship is ending 30/6-2014.

2. Can only fund M. Breitenfeldt to Feb 2014. TwinEBIS activities will thereafter be reduced.

* ENSAR-2 application submitted for continuation of the charge-breeder upgrade development. Approval, granted funding and starting date unknown.

* Open for external contributions and suggestions how to prolong 1 and 2 above.

TSR@ISOLDE integration study

* Preliminary results presented at IEFC 31/7-2013
* Final report submitted to Director of accelerators and department leaders 28/8-2013
* Full presentation and executive summary can be obtained upon request (F. Wenander)

TSR elements evaluated by CERN specialists
In general a positive response and supportive response from the CERN groups

Two approaches
1. CERN homologation (full-fledged ‘standardization’)
2. Keep-system-as-is (low-budget option with minimal changes)

Next steps
* Awaiting feedback from CERN management
* TSR@ISOLDE workshop at CERN 14 Feb 2014

E. Piselli, E. Siesling, F. Wenander

TSR@ISOLDE integration study

* The radiological concern of importing the ring is minimal.
* Well advanced civil engineering plan with associated infrastructure exists.
* No technical show stoppers for the implementation – standard solutions identified.

CERN integration proposal

a. The first cost and manpower estimate, should cover most/all parts of the move and are believed to be conservative. The CERN support groups claim that the cost of some WPs can be reduced if the allocated budget so requires. However, no contingency included.

b. Most CERN groups have insisted on hardware changes and CERN standardization and discourage a 3 years transition period with temporary solution as that would inflate the costs.

Total cost and manpower for transfer and integration into a CERN facility:

15.2 MCHF ***27.5 FTE (man year)***

Keep-system-as-is

a. Would need to keep all subsystems as they are since many are interlinked with the control system.

b. Would have limited or in some cases no support by CERN groups; longer dependence on MPIK Heidelberg.

c. Power converters, vacuum, magnets, RF and e-cooler could in principle be imported as such.

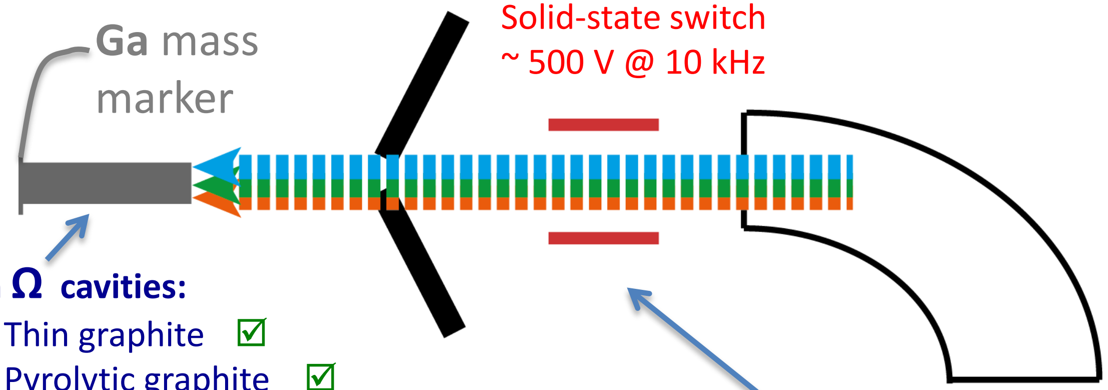
d. Improved electrical ring safety is mandatory if the ring is imported as is.

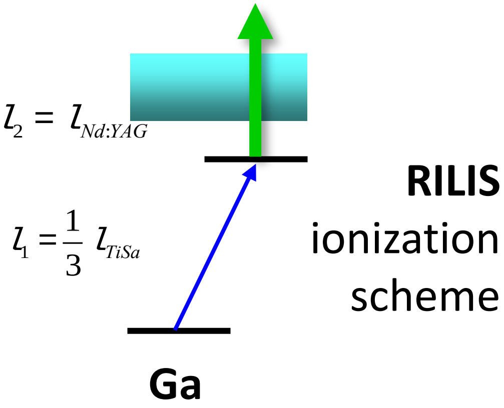
The approximate cost and manpower need for the Keep-system-as-is scenario are:

11.8 MCHF ***17.1 FTE (man year)***

The cost saving might appear low but it should be kept in mind that:
** The main cost drivers for a TSR at ISOLDE are the injection line, buildings and infrastructure.*
** Some spares, complementing parts and replacement parts are absolutely necessary.*
** Includes the mandatory electrical protection of magnets connections.*
** Includes sensitivity improvement of the beam diagnostics.*

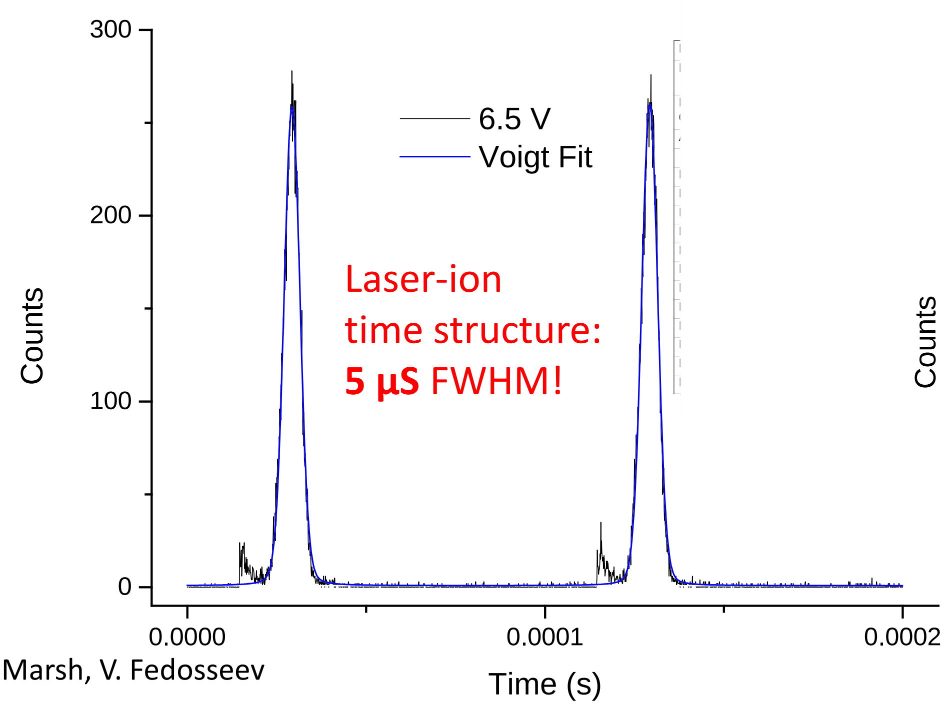
Narrow laser-ion bunch width + micro beam gate tests





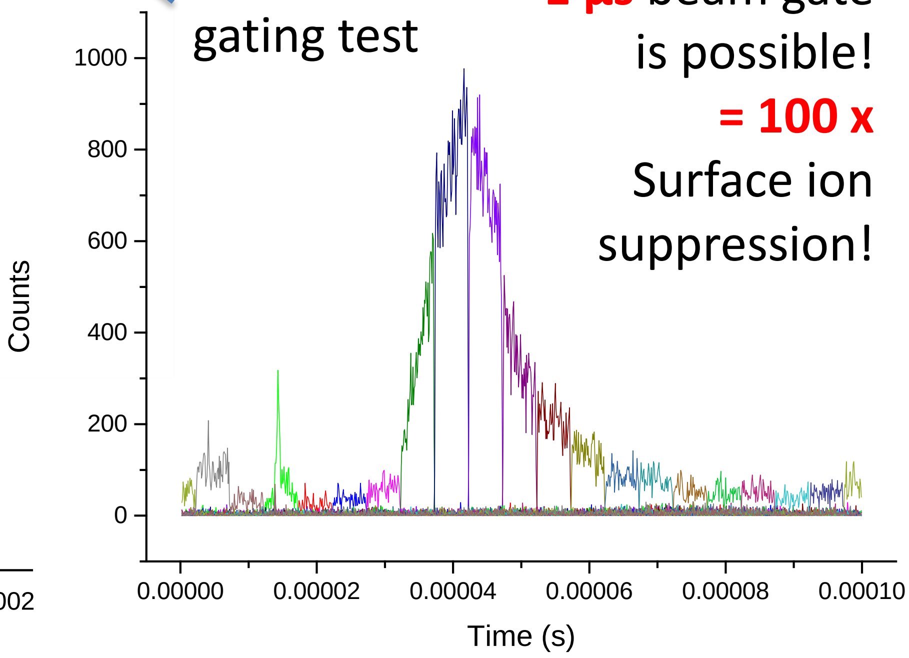
High Ω cavities:

1. Thin graphite ☑
2. Pyrolytic graphite ☑
3. Sigradur 'glassy' graphite ☐
4. Pulsed heating for higher voltage ☐



Laser-ion time structure: **5 µS** FWHM!

B. Marsh, V. Fedosseev



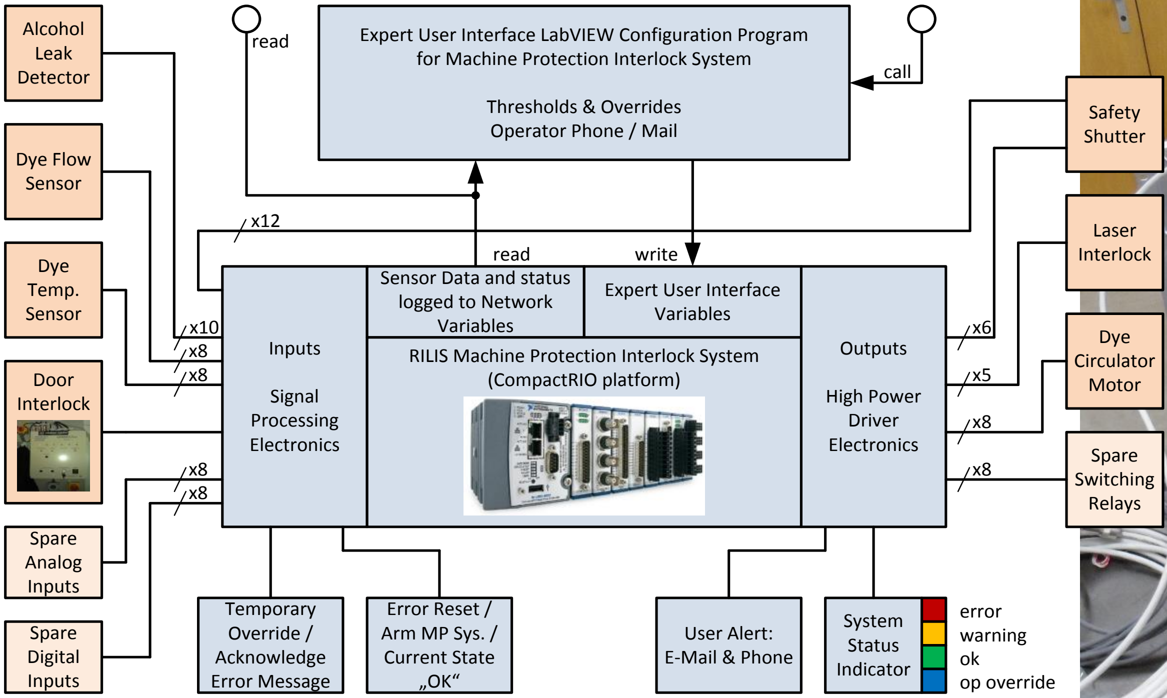
5 µs beam gating test

1 µs beam gate is possible!

= 100 x

Surface ion suppression!

RILIS machine protection: built and b



- Hardware to control multiple laser interlocks and shutters is assembled by STI-ECE
- Laser dye leak detection
- Offline testing has begun
- Installation in January 2014

Preparation for **‘on-call’** RILIS operation

B. Marsh, V. Fedosseev

Overview

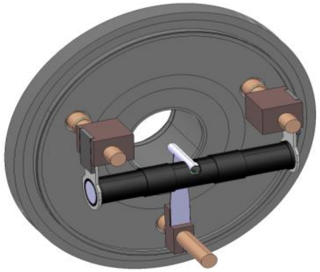
- Different Technical Advances
  - Targets
  - Front End
  - Beam Quality
    - REX EBIS
    - Off-line
    - HRS
  - Infrastructure
    - Ventilation

- Time line
  - The Design Study report
  - REX-EBIS planning
  - Implementation

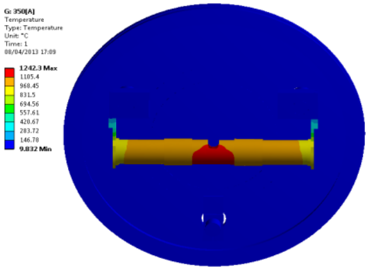
- HIE-ISOLDE workshop: The Technical Aspects

Targets: RIB Intensity Increase

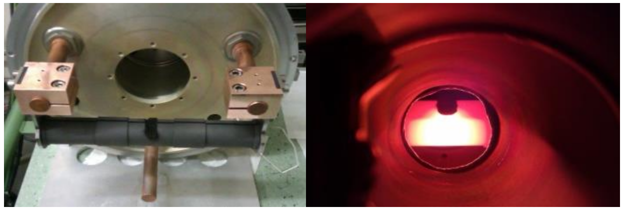
- Separated heating and containing design: electro-thermal study, prototype and experimental tests



CATIA model

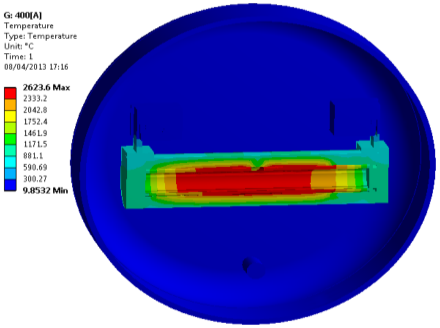


Graphite container simulations

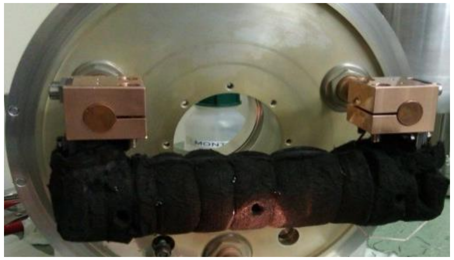


Bare Graphite heater

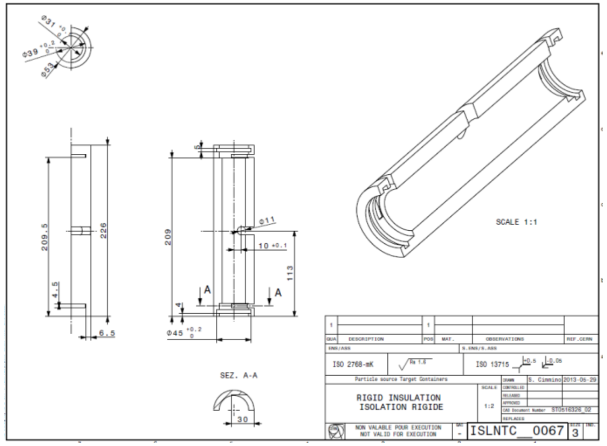
CATIA model



Sigratherm screen simulations

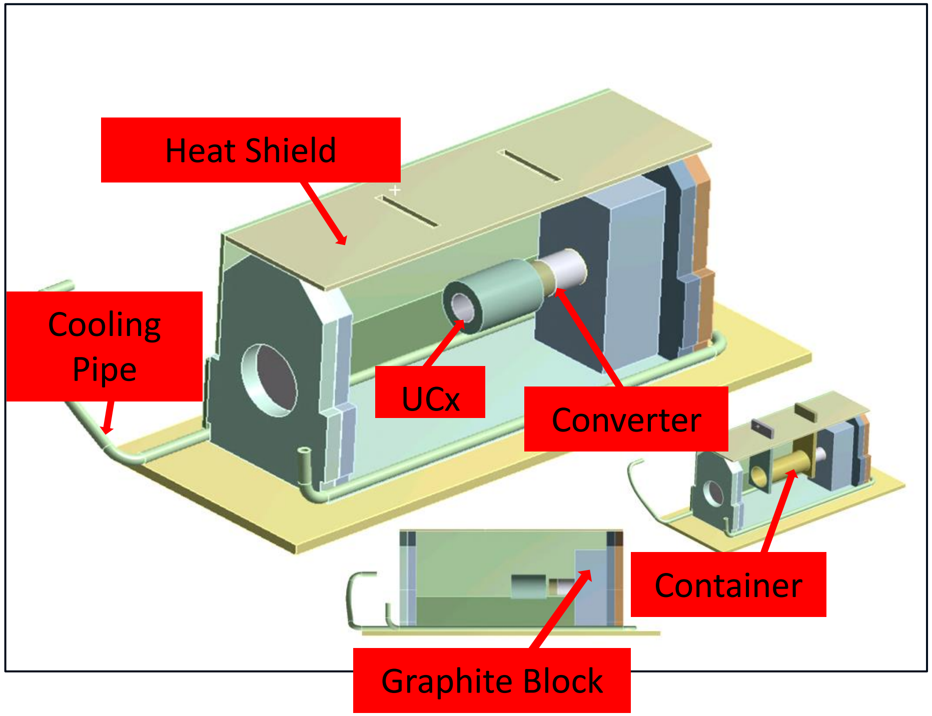


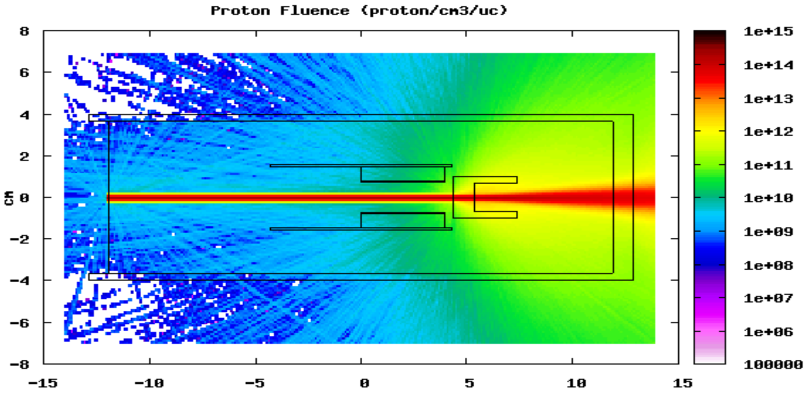
Graphite heater with Sigratherm screen

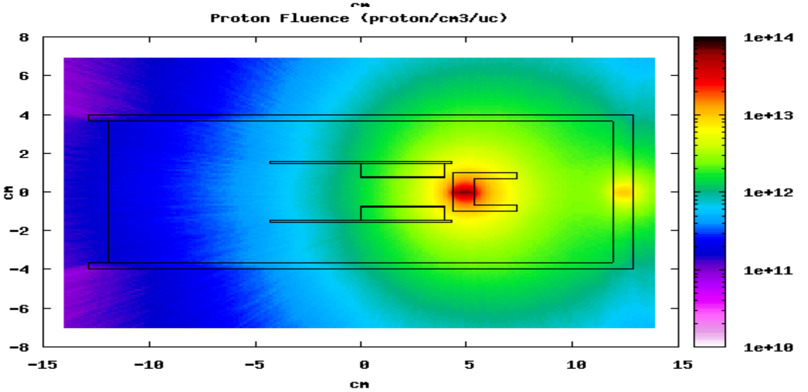


Targets: RIB Purification

- Neutron spallation source design study:

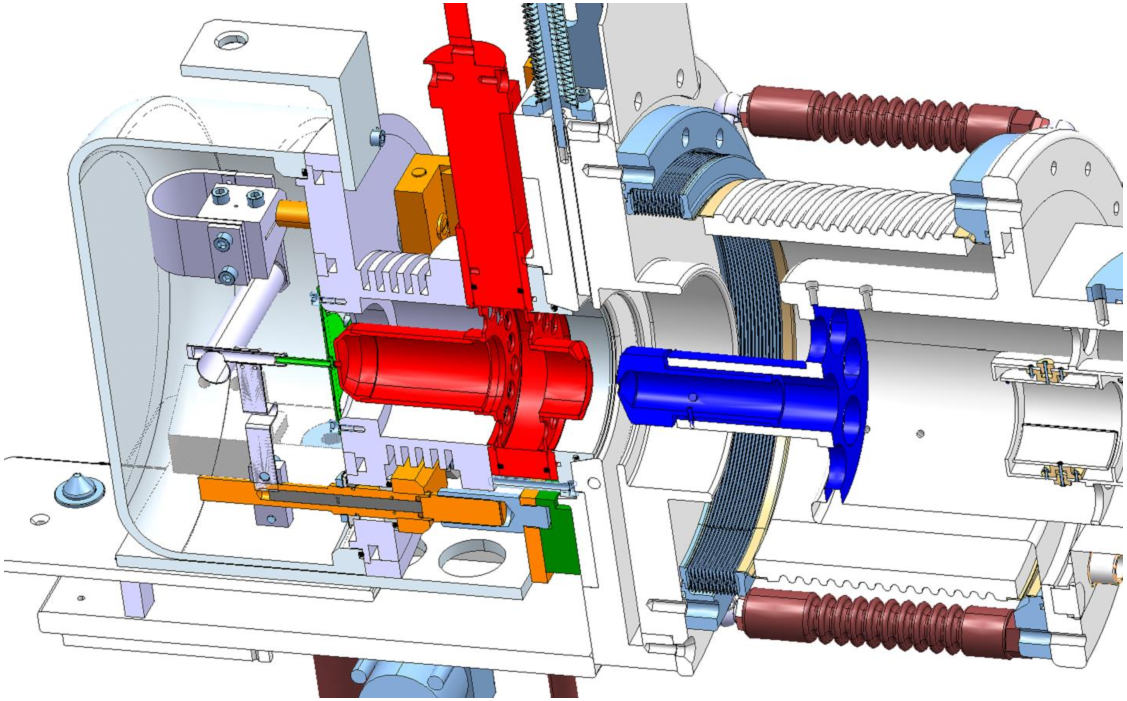






Online tests at TRIUMF in 2014.
Energy: 500 MeV;
Intensity: 100uA.

Front End: Pre extraction prototype

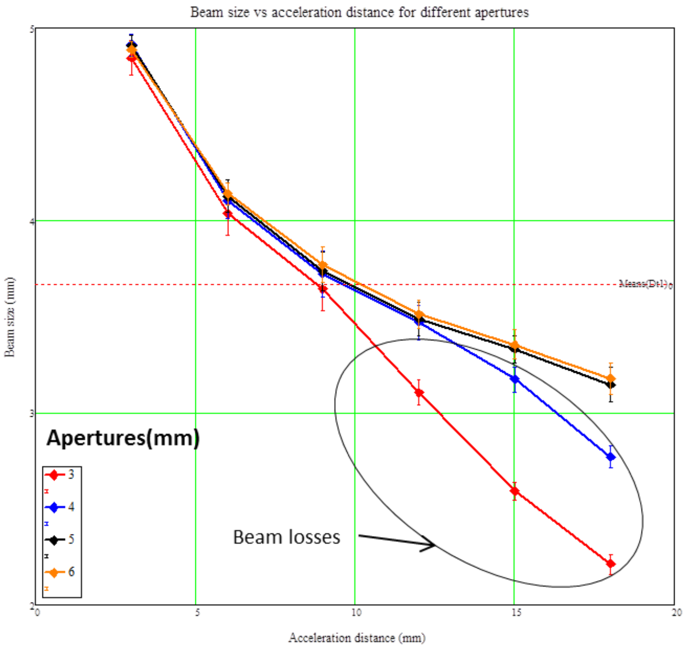


- Without electrode movement mechanism
- Electrode head exchanged with target unit without human intervention
- Intermediate voltage works as focalization lens
- Intermediate electrode customizable for each target unit

60 kV
57 kV
Ground

J. Montano

Front End: Geometrical optimization



… A numerical optimization of the geometry has been performed. The criteria were mostly based on extracted beam quality and minimum losses

… prototypes have been constructed and are under experimental tests to validate the results

J. Montano

Charge breeder upgrade for HIE-ISOLDE

Design parameters

	HIE-ISOLDE / TSR@ISOLDE charge breeder	REXEBIS
Electron energy [kV]	150	5
Electron current [A]	2-5	0.2
Electron current density [A/cm^2]	1-2x10^4	100

New EBIS – High Energy Compression and Current (HEC^2) EBIS

Main challenge – produce the high compression electron beam

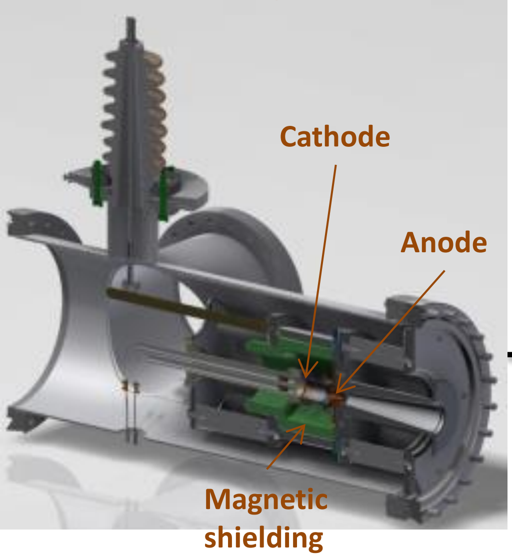
Goal – have a reliable design of the HEC^2 electron gun at earliest possible stage

Realization – in a joint effort with BNL, based on BNL design and infrastructure (BNL Test-EBIS), partly funded and manned by CERN

EBIS team: CATHI fellow A. Shornikov

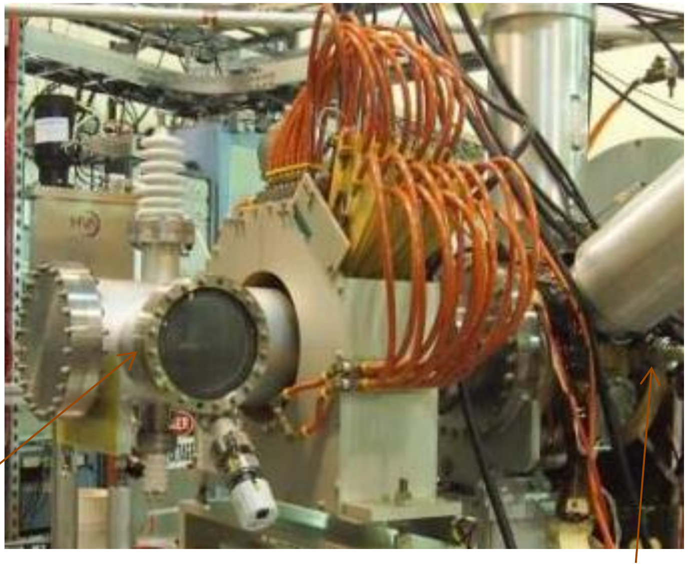
Charge breeder upgrade for HIE-ISOLDE

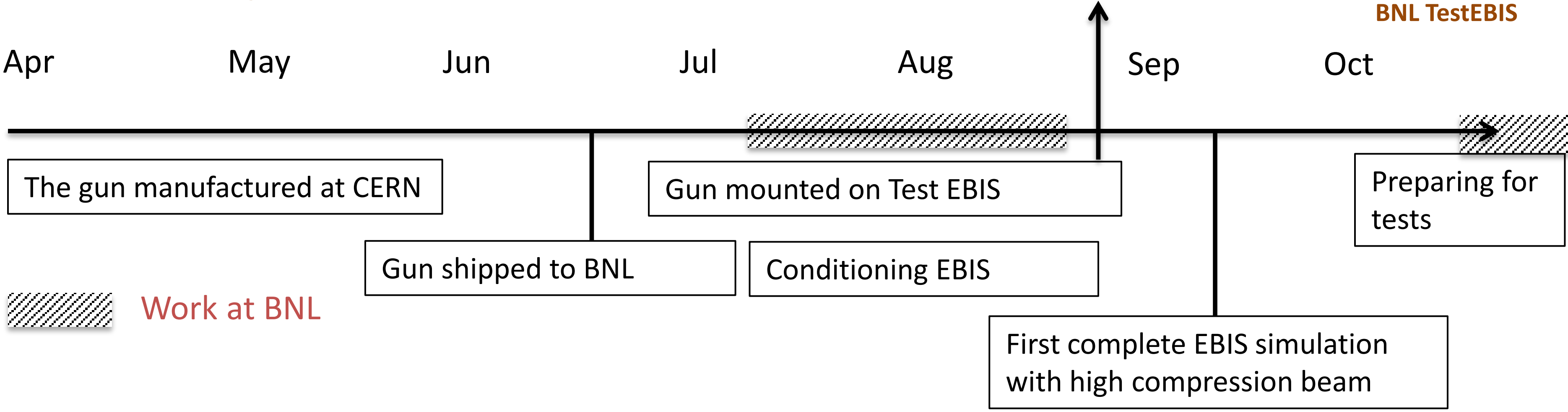
HEC2 gun



Progress since April

HEC2 gun at TestEBIS





The gun manufactured at CERN

Gun shipped to BNL

Gun mounted on Test EBIS

Conditioning EBIS

First complete EBIS simulation with high compression beam

Preparing for tests

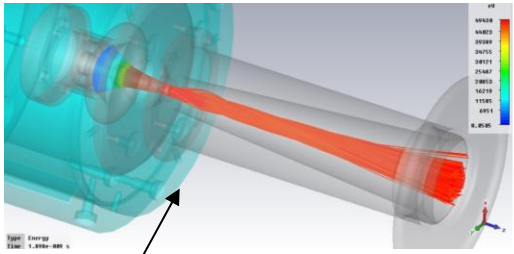
▨ Work at BNL

EBIS team: CATHI fellow A. Shornikov

Electron beam simulations

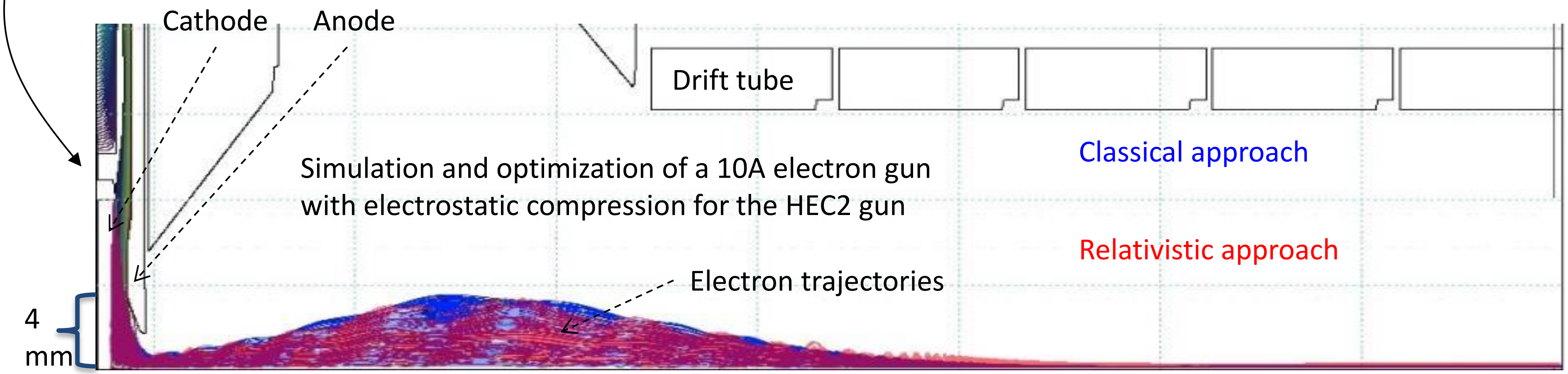
*Major effort benefiting: HEC2 gun design and verification
REXEBIS current increase

* So far mainly 2D results using Field Precision software
* Complete BNL TestEBIS with HEC2 gun simulated – major feat!



Allows to break the symmetry (e.g. misalignments)

* Preliminary 3D simulation results using CST Microwave Studio obtained
* Cluster simulations using up 128 cores and 1 TB memory in the pipeline



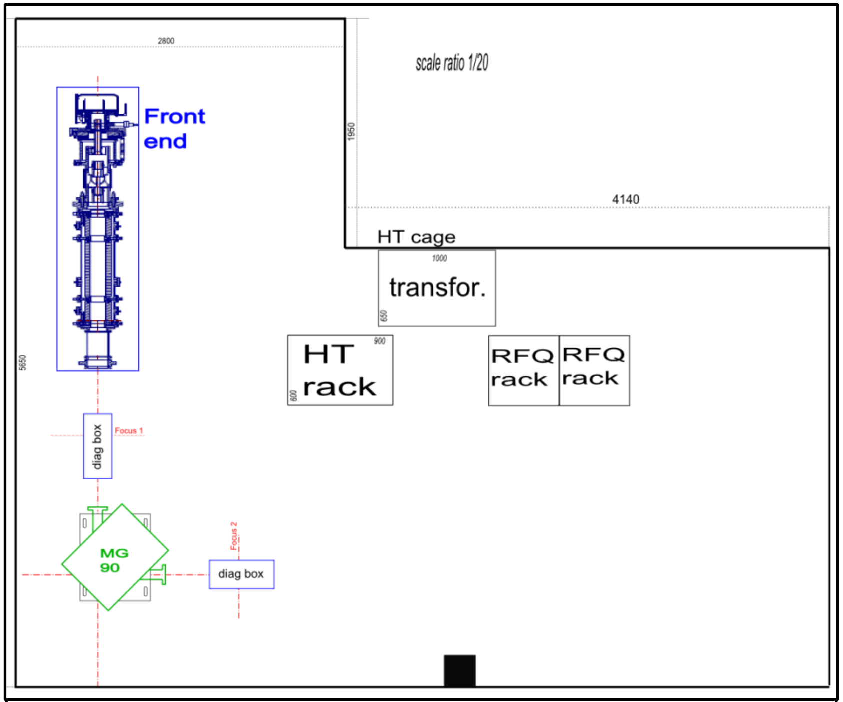
Simulation and optimization of a 10A electron gun with electrostatic compression for the HEC2 gun

Results: Limited beam scalloping
$>2E4\ A/cm^2$ in full field
optimization of collector potential and geometry in process

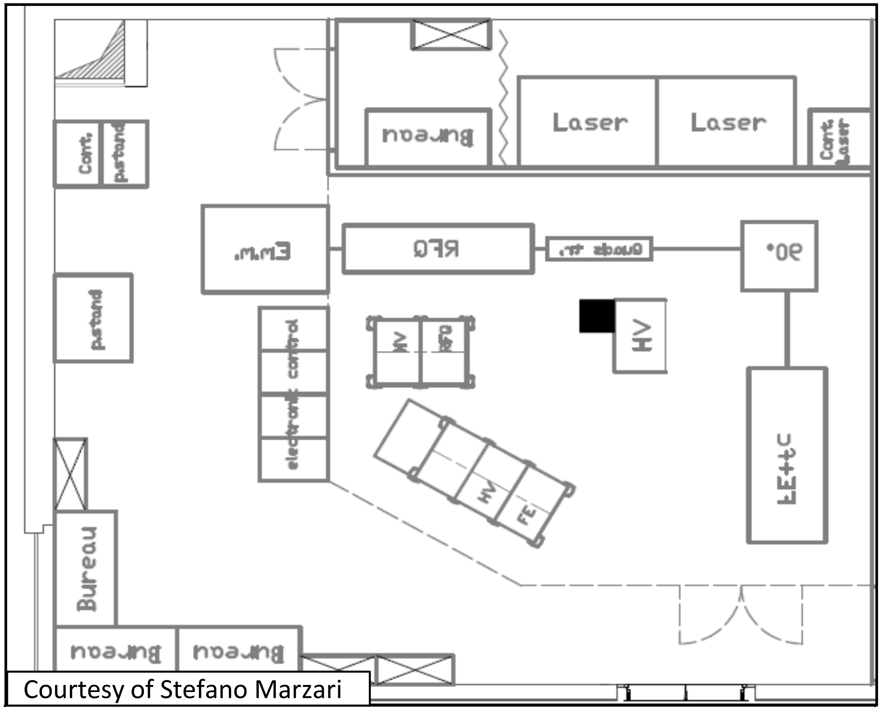
EBIS team: PhD R. Mertzig

ISOLDE offline separator #2

Purpose: testbench for the validation of principles regarding the High Resolution Separator upgrade



ISOLDE offline #2 (current status)



Courtesy of Stefano Marzari

Foreseen layout of ISOLDE offline #2

- ✓ Detailed definition of experimental setup
- ✓ Dipole characterization
- ✓ Magnetic field mapping

- ✓ Ion source characterization
- ✓ Separation test
- ✓ RFQCB test

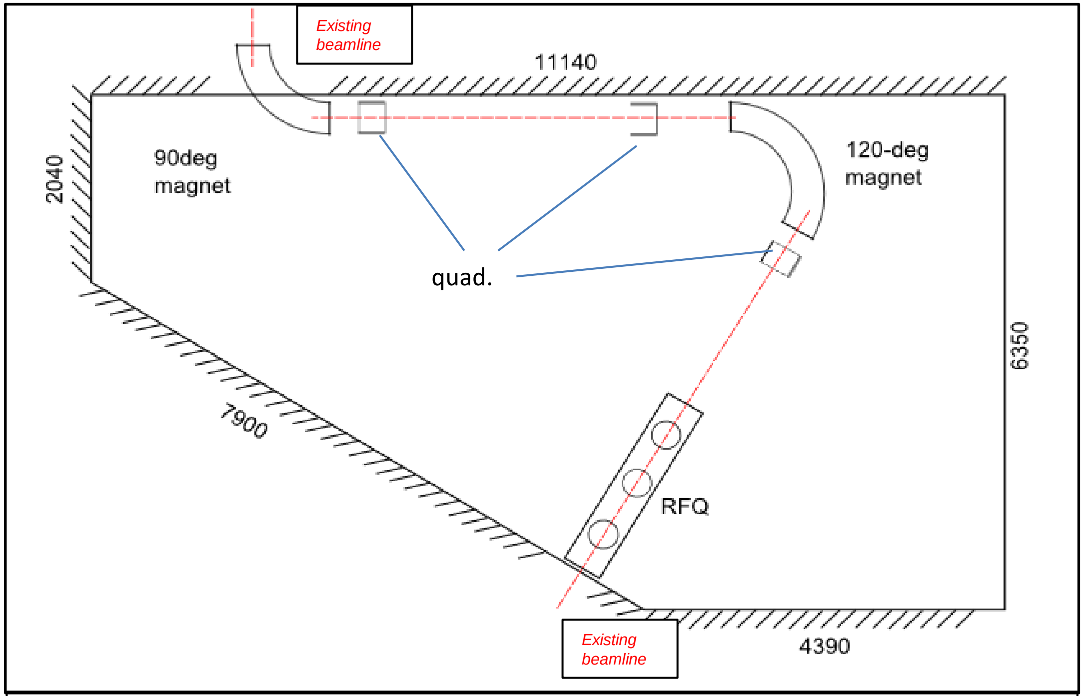
Status on 11/10/2013 : FE and MG90 operational, RFQ under assembly

M. Augustin

High Resolution Separator (HRS) upgrade design study

Moving of Radio Frequency Beam Cooler (RFQBC) foreseen more upstream of beamline, in the separator room.

➔ Constraints regarding the available space in separator room and regarding the positioning of already existing beamlines upstream and downstream

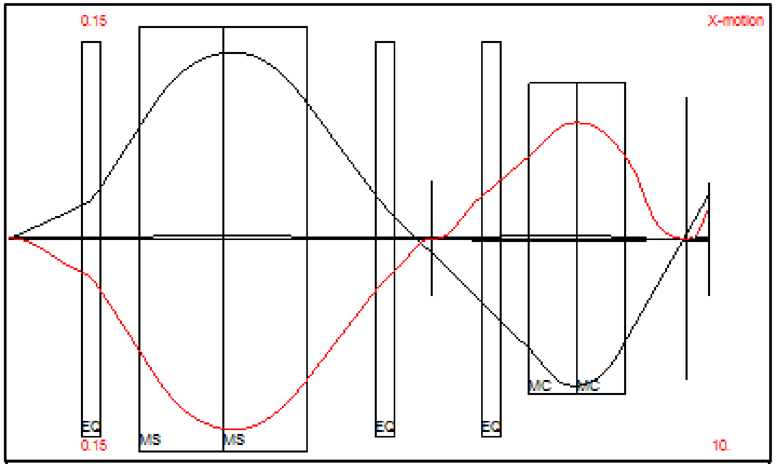


Layout proposal schematic

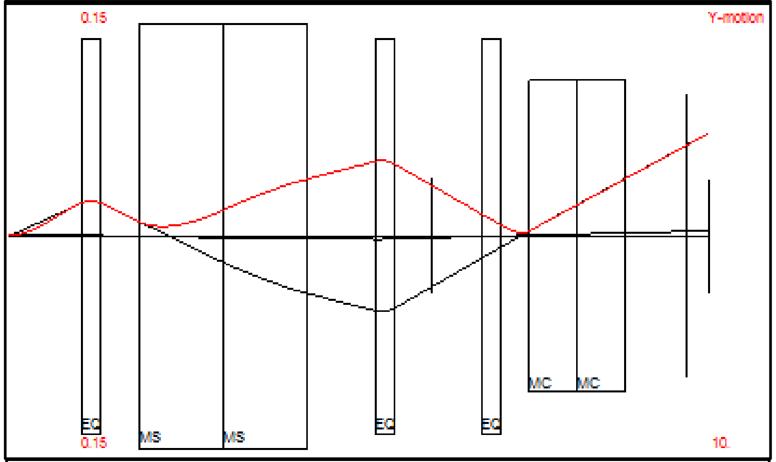
- ✓ Low beam emittance at exit of RFQBC
- ✓ Beam shaping before magnetic stages with quadrupoles
- ✓ 120º dipolar separator magnet (including quadrupolar and sextupolar components)
- ✓ 90º dipolar separator magnet

M. Augustin

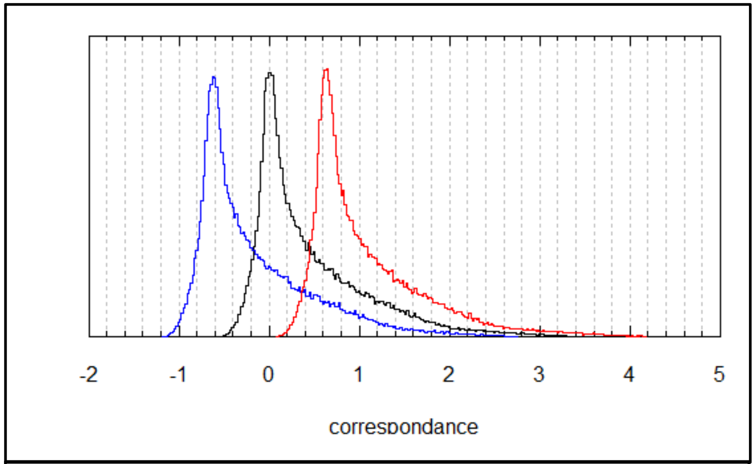
High Resolution Separator (HRS) upgrade design study



© COSY simulation of HRS proposed layout : x-axis



© COSY simulation of HRS proposed layout : y-axis



Separation power computation with © Octave

- ✓ Considered mass M=100
- ✓ $\Delta M/M = 2.10^{-4}$
- ✓ Computation performed at 3rd order

Next steps :

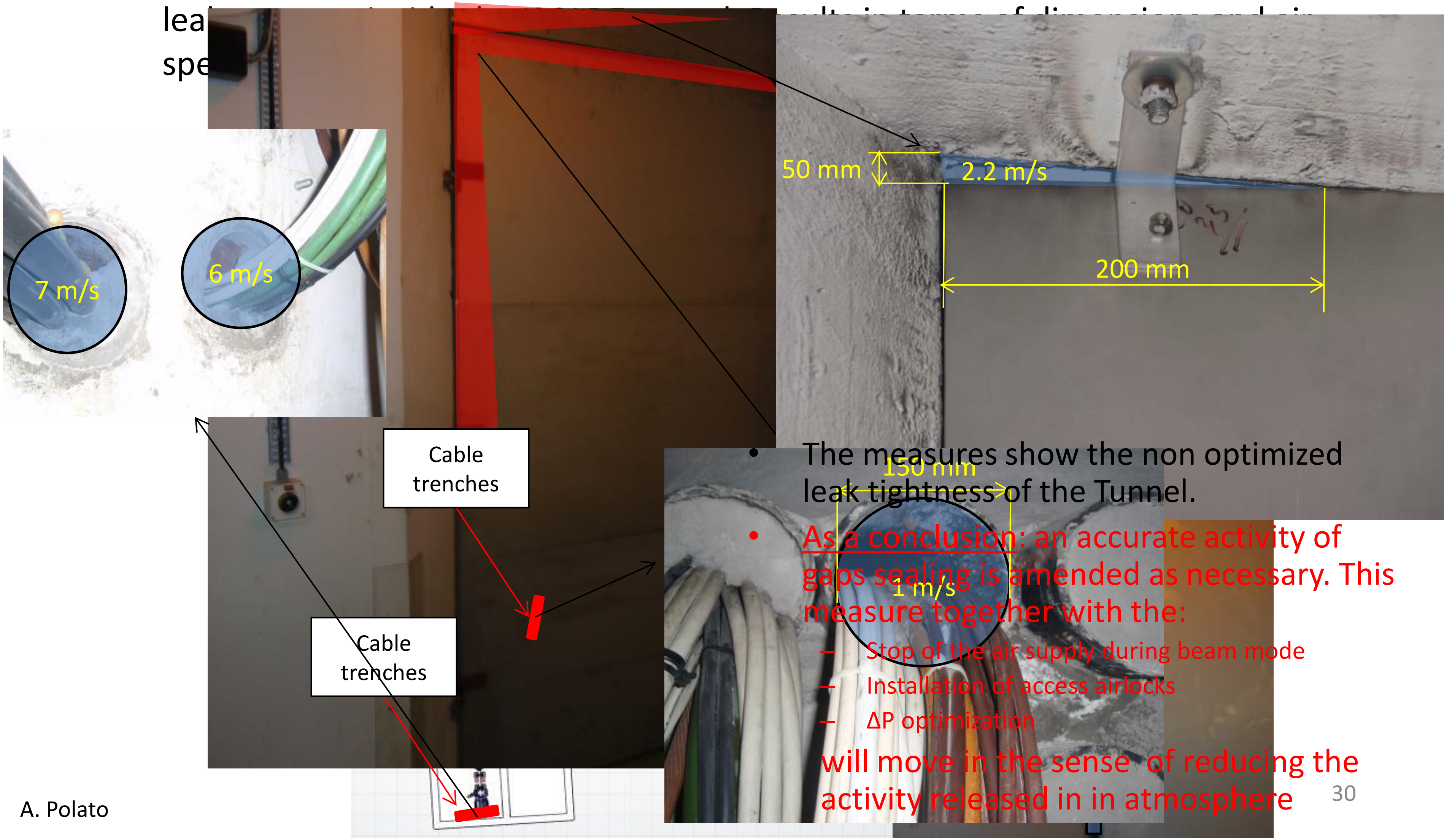
- ➢ Tuning for compensation of aberrations at 3rd order on MG120
- ➢ Tuning of quadrupole and sextupole components on MG90 °
- ➢ © Opera simulations of MG120°

M. Augustin

Ventilation

Tunnel and HT Room surveys to measure existing air Leaks

- On-field activity to measure the entities and positions of the main sources of air
lea
spe



- The measures show the non optimized leak tightness of the Tunnel.
- As a conclusion: an accurate activity of gaps sealing is amended as necessary. This measure together with the:
  - Stop of the air supply during beam mode
  - Installation of access airlocks
  - ΔP optimization

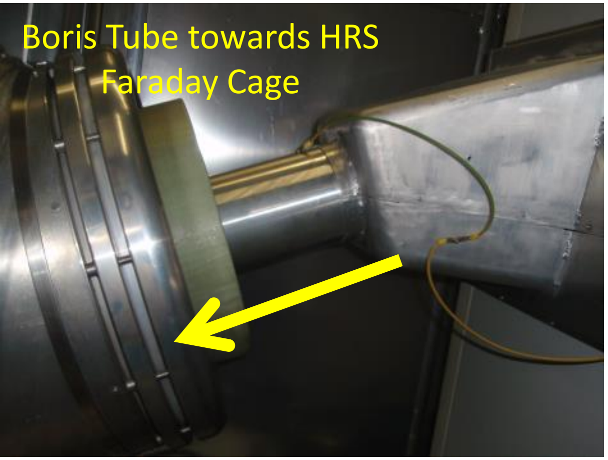
will move in the sense of reducing the activity released in in atmosphere

Ventilation

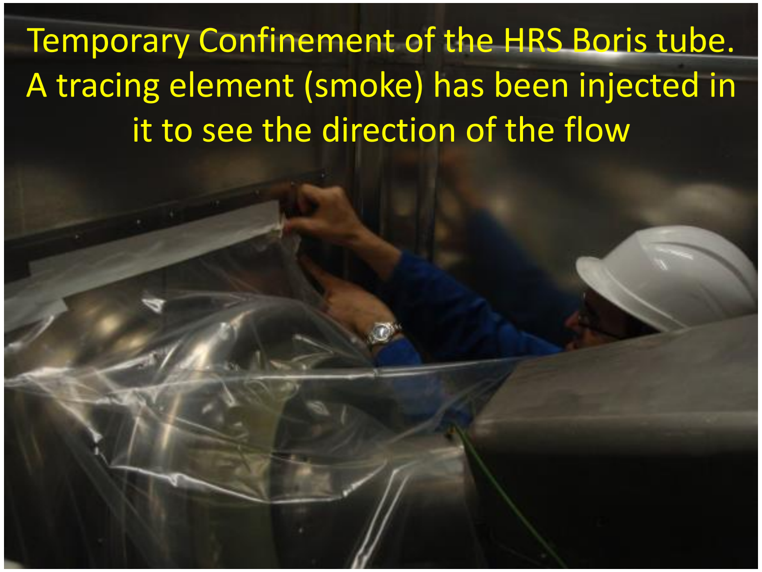
Tunnel and HT Room surveys to measure existing air Leaks

- Verification of the correct pressure cascade between HT room and ISOLDE Tunnel, to confirm that the traces of activation in the HT Room are not caused by an air backflow (but most probably by direct radiations in the room)

Boris Tube towards GPS Faraday Cage



Boris Tube towards HRS Faraday Cage



Temporary Confinement of the HRS Boris tube. A tracing element (smoke) has been injected in it to see the direction of the flow

SMOKE TEST MOVIE

(INTERNET CONNECTION AND MOVIE PLAYER NEEDED)

- The test showed that the tracing element was flowing towards the Faraday Cage, hence no air backflows are present (in accordance with the initial evaluations) ✓
- As a conclusion: due to the contamination present in the room, a confinement system of the HT room vs. the Instrumental hall will be proposed in the Design Study

Precious help from:  H. Sabri  A. Garcia

The Design Study Report

- Document describing all the issues addressed throughout the design study period
- High Intensity
  - Targets; thermal analysis, design and materials
  - Front ends
  - High voltage
  - Operation
- Infrastructure
  - Beam dumps
  - Radiation protection
  - Ventilation and cooling
  - Vacuum
- Beam Quality
  - HRS magnet design
  - RFQ Cooler
  - New REX-EBIS
- Cost Summary and Planning

Report: Deliverable for the Autumn 2014

Tentative tasks and timeline for breeder upgrade

		Phase	Part	Task
2013-2014	A	Gun gen1	Gun	Demonstrate >1.5E4 A/cm^2 in trapping region.
	B	Gun gen1	Collector	Suppress backscattered electrons.
	C	Gun gen1	Trap	Detect low level RF that will inhibit cryogenic operation.
2015-2016	D	Gun gen2	Gun	Suppress discharges at gun to allow for cw operation.
	E	Gun gen2	Collector	Extract the ion beam.
	F	Gun gen2	Collector	Suppress backscattered electrons for cw beam.
	G	Gun gen2 HV	Gun	Allow e-beam acceleration to 150 keV.
2015	G	Concept	Surroundings	Shield 5 T magnet stray field.
	H	Concept	Vacuum	Attain vacuum performance with either warm or cryogenic concept.

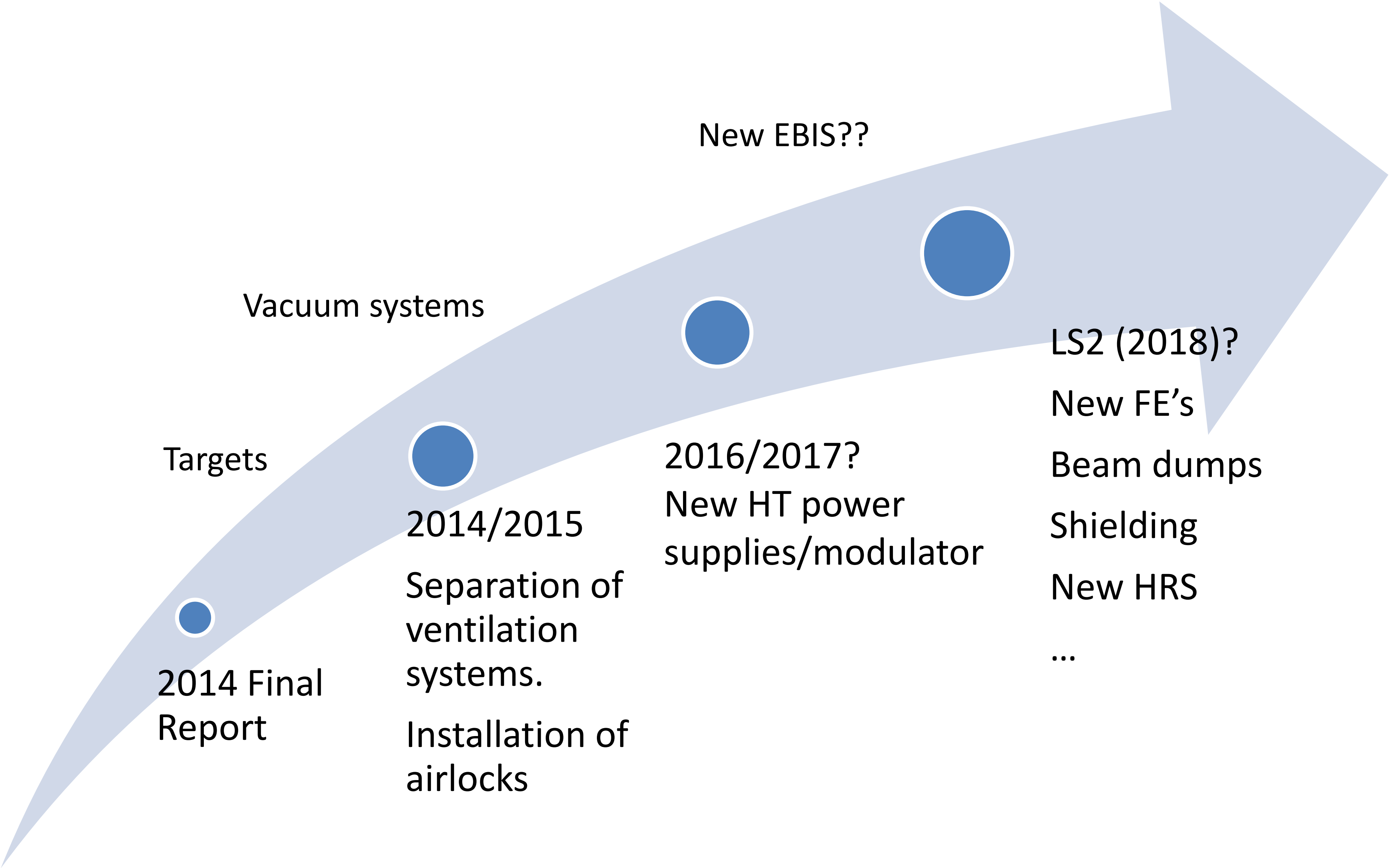
Conditions for above:

1. Continued collaboration with BNL
2. A. Shornikov following the project
3. ENSAR2 application granted and fully funded

By end of 2016 all critical items could be verified -> solid foundation for design.
Thereafter a 2 years realization phase would follow (manpower and cost tbd).

F. Wenander

Implementation



Targets

2014 Final Report

Vacuum systems

2014/2015

Separation of ventilation systems.

Installation of airlocks

New EBIS??

2016/2017?
New HT power supplies/modulator

LS2 (2018)?

New FE's

Beam dumps

Shielding

New HRS

…

HIE-ISOLDE WORKSHOP
The Technical Aspects

28th-29th November 2013, Globe of Science and Innovation, CERN, Geneva, Switzerland

Scientific Advisory Committee:

- Richard Catherall
- Maria Garcia Borge
- Thomas Otto
- Thierry Stora
- Walter Venturini Desolaro
- Didier Voulot
- Fredrik Wenander

Local Organizing Committee:

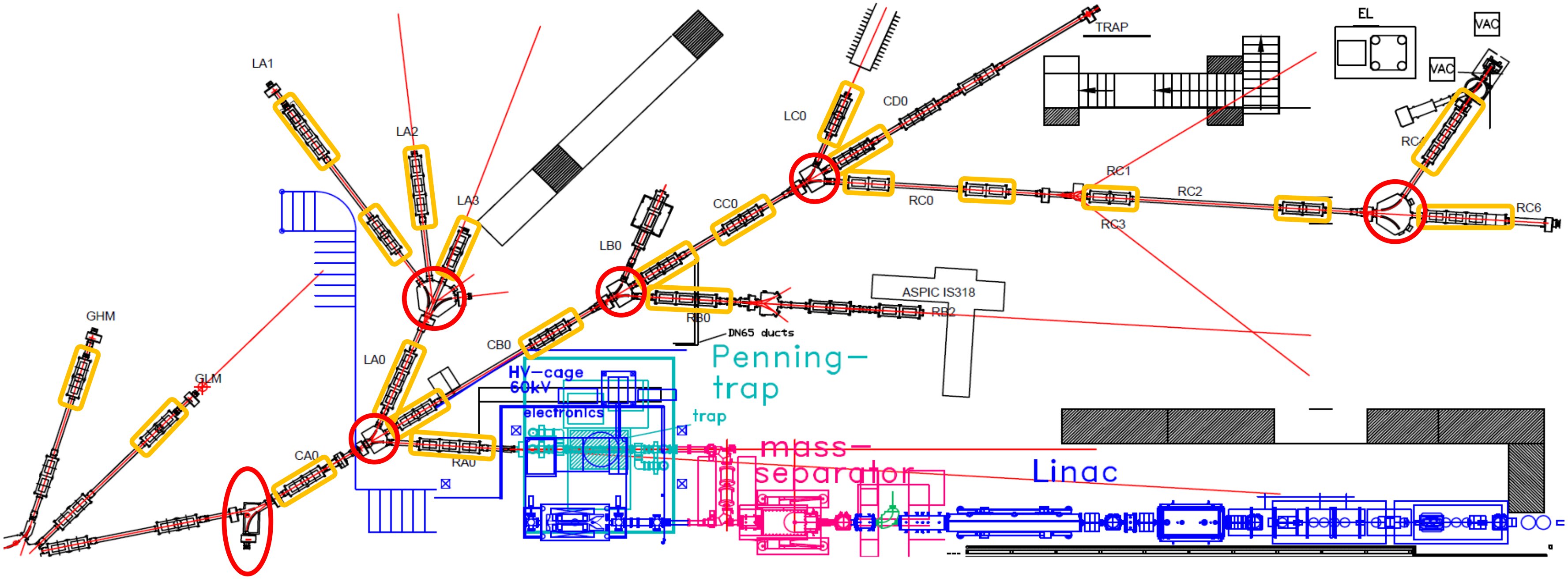
- Richard Catherall (Chairman)
- Michal Czapski
- Geraldine Jean
- Yacine Kadi
- Ayse Karatepe
- Annelie Rasmussen

Conference Page:
http://indico.cern.ch/e/HIE-Isolde-Workshop

Enquiries and Correspondence:
en-dep.workshops@cern.ch

FP7-PEOPLE-2010-ITN project CATHI (Marie Curie Actions - ITN), Grant agreement no PITN-GA-2010-264330.

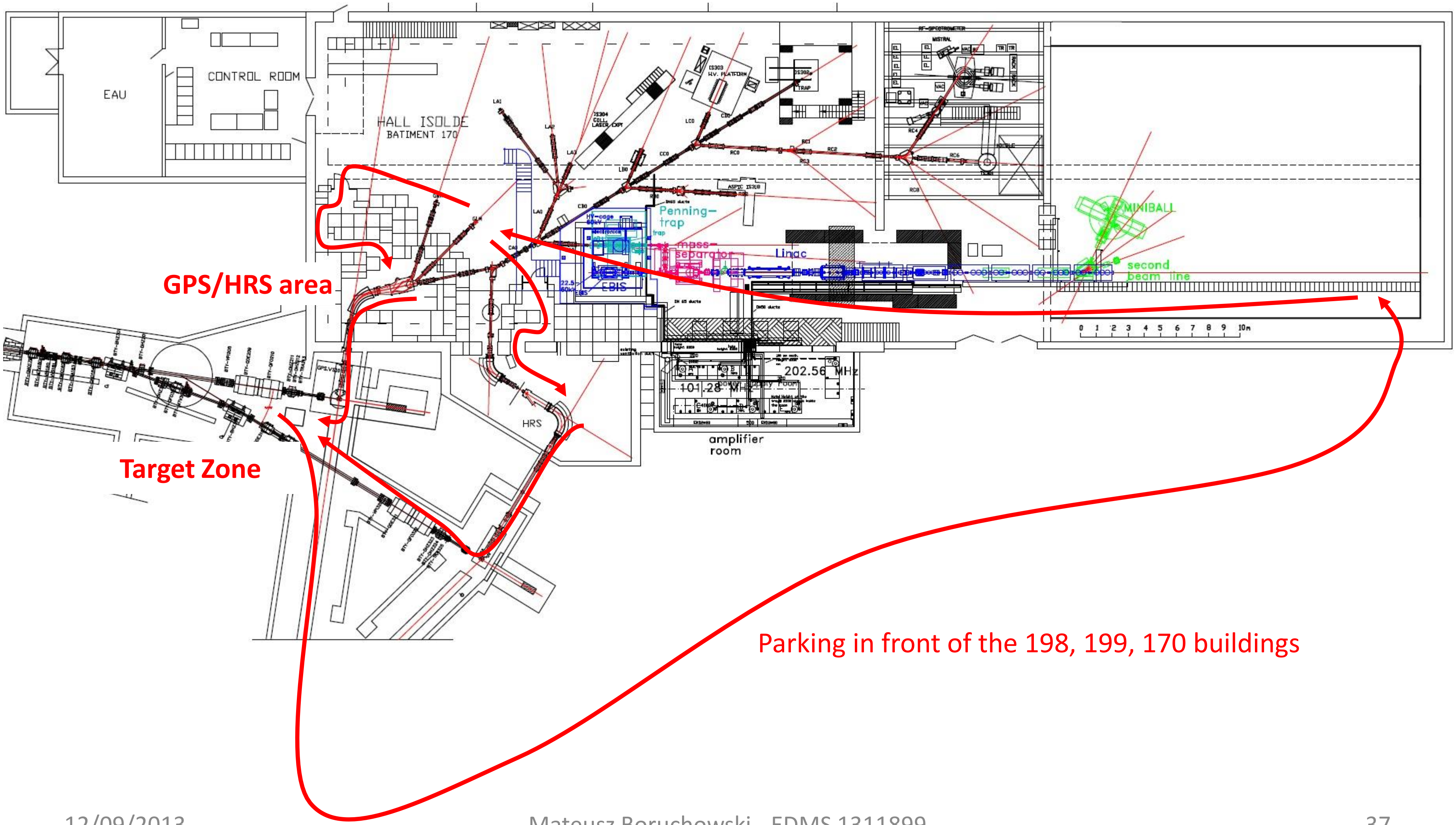
Range of the measurement done by SU-EXP – quadroples and switchyards



▭ **Quadruples**

○ **Switchyards**

Range of the measurement done by SU-EXP – levelling travers

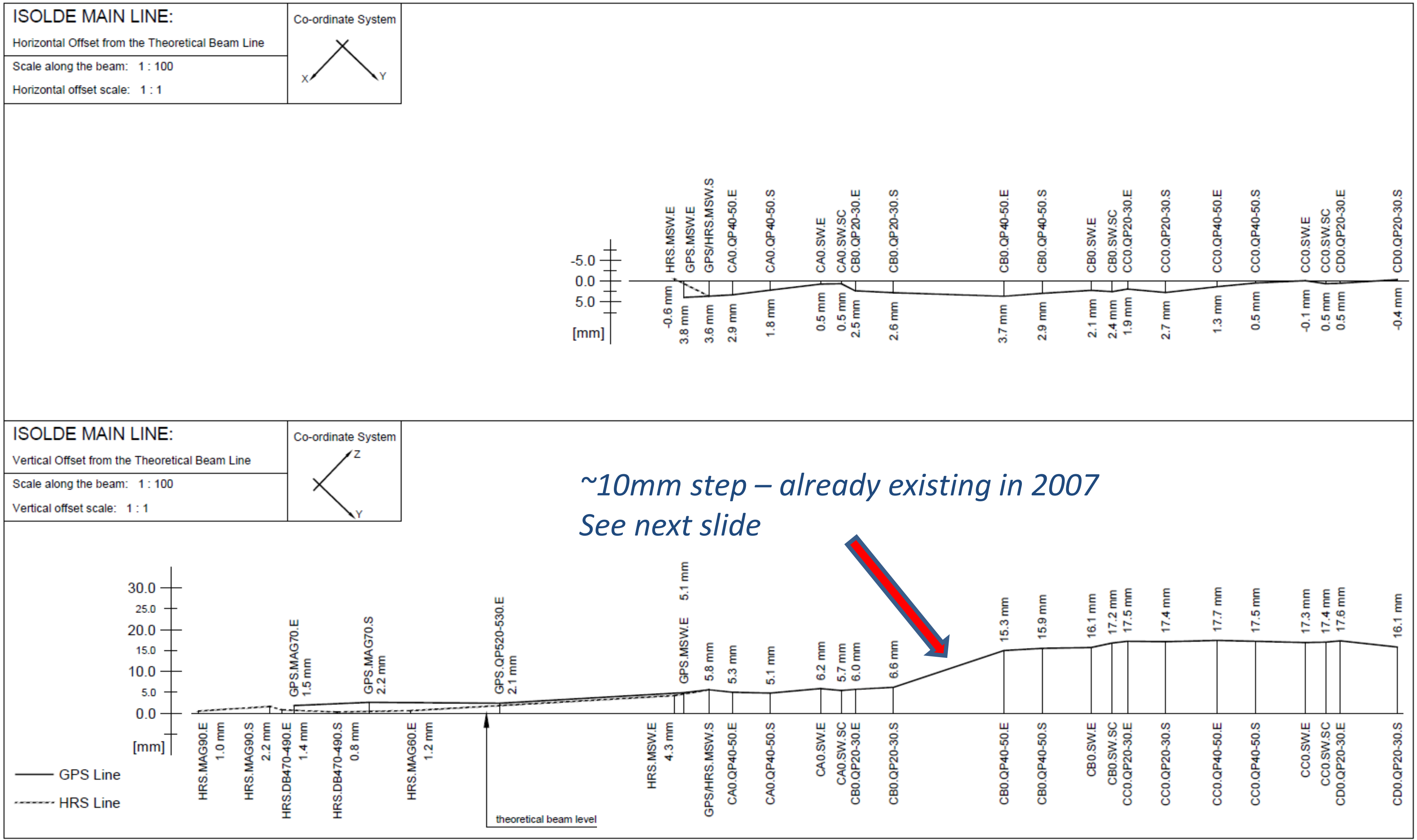


GPS/HRS area

Target Zone

Parking in front of the 198, 199, 170 buildings

Results: Central Line - graphs



~10mm step – already existing in 2007
See next slide

Results: Central Line - numbers

Horizontal and vertical offsets are given to the theoretical beam line. Positive sign of the horizontal offset means that, the measured point is on the right from the theoretical beam line (looking downstream). Positive sign of the vertical offset means that, the measured point is above the theoretical beam line. Nominal position in XYccs of each line has been taken from the autocad drawing of Isolde/Hie-Isolde provided by Didier VOULOT. Nominal position in H has been determined according to the same drawing as well as the calculated slopes.

REMARK: Final values of the offsets might change slightly after recalculation according to the optic files which will be provided by Isolde Team

Name	Horizontal offset [mm]	Vertical offset [mm]	Name	Horizontal offset [mm]	Vertical offset [mm]
HRS.MAG90.E	---	1.0	CB0.QP20-30.E	2.5	6.0
HRS.MAG90.S	---	2.2	CB0.QP20-30.S	2.6	6.6
HRS.DB470-490.E	---	1.4	CB0.QP40-50.E	3.7	15.3
HRS.DB470-490.S	---	0.8	CB0.QP40-50.S	2.9	15.9
HRS.MAG60.E	---	1.2	CB0.SW.E	2.1	16.1
GPS.MAG70.E	---	1.5	CB0.SW.SC	2.4	17.2
GPS.MAG70.E	---	2.2	CC0.QP20-30.E	1.9	17.5
GPS.QP520-530.E	---	2.1	CC0.QP20-30.S	2.7	17.4
HRS.MSW.E	-0.6	4.3	CC0.QP40-50.E	1.3	17.7
GPS.MSW.E	3.8	5.1	CC0.QP40-50.S	0.5	17.5
GPS/HRS.MSW.S	3.6	5.8	CA0.SW.E	0.5	6.2
CA0.QP40-50.E	2.9	5.3	CA0.SW.SC	0.5	5.7
CA0.QP40-50.S	1.8	5.1	CD0.QP20-30.E	0.5	17.6
CA0.SW.E	0.5	6.2	CD0.QP20-30.S	-0.4	16.1
CA0.SW.SC	0.5	5.7			

Results: Left Lines – numbers

LA1, LA2, LC0

Name	Horizontal offset	Vertical offset
	[mm]	[mm]
LA0.SW.SGG	-3.8	6.9
LA1.QP20-30.E	-1.9	7.6
LA1.QP20-30.S	-1.0	7.8
LA1.QP40-60.E	0.6	8.2
LA1.QP40-60.S	0.7	8.2
LA0.SW.SG	-0.7	7.1
LA2.QP20-40.E	-0.8	7.6
LA2.QP20-40.S	-0.1	8.6
CC0.SW.SG	1.9	17.5
LC0.QP20-30.E	1.6	15.4
LC0.QP20-30.S	1.4	17.0

LA0, LA3

Name	Horizontal offset	Vertical offset
	[mm]	[mm]
CA0.SW.SG	-0.7	5.5
LA0.QP20-40.E	-0.9	6.2
LA0.QP20-40.S	-0.3	6.6
LA0.SW.E	-0.7	7.9
LA0.SW.SC	0.3	6.8
LA3.QP20-30.E	-1.9	6.7
LA3.QP20-30.S	-2.6	8.3

Alignment

- The following reasons contributed to the decision not to re-align the beam line during the LS1 period:
  - Consecutive delays:
    - Cleaning had to be done, Absence of J. Thiboud
  - The current workload on-going at ISOLDE is already a cause for concern with respect to the start up next year.
  - The clash with HIE-ISOLDE work in the hall
    - Especially near the platform
  - The uncertainty in improvement of beam transport
  - REX
- Counter measures
  - Will open 1 or 2 switchyards to better understand their alignment
  - Implement automatic beam tuning
    - Resources

Technical and Safety Review of the RB0 upgrade (VITO line) held on September 3, 2013.

Technical review panel:

1. Tim Giles (optics and beam lines)
2. Gerrit Jan Focker (beam instrumantation)
3. Ana Paula Bernardes (safety)
4. Jean Christophe Gayde (survey)
5. Erwin Siesling (integration)
6. Didier Voulot (TSO and REX compatibility)
7. Giovanna Vandoni (vacuum)
8. Joachim Vollaire (radiation protection)
9. Maria Garcia Borge (physics)
10. Richard Catherall (chairman, ISOLDE technical coordination)

Upgrade approved by the Technical committee

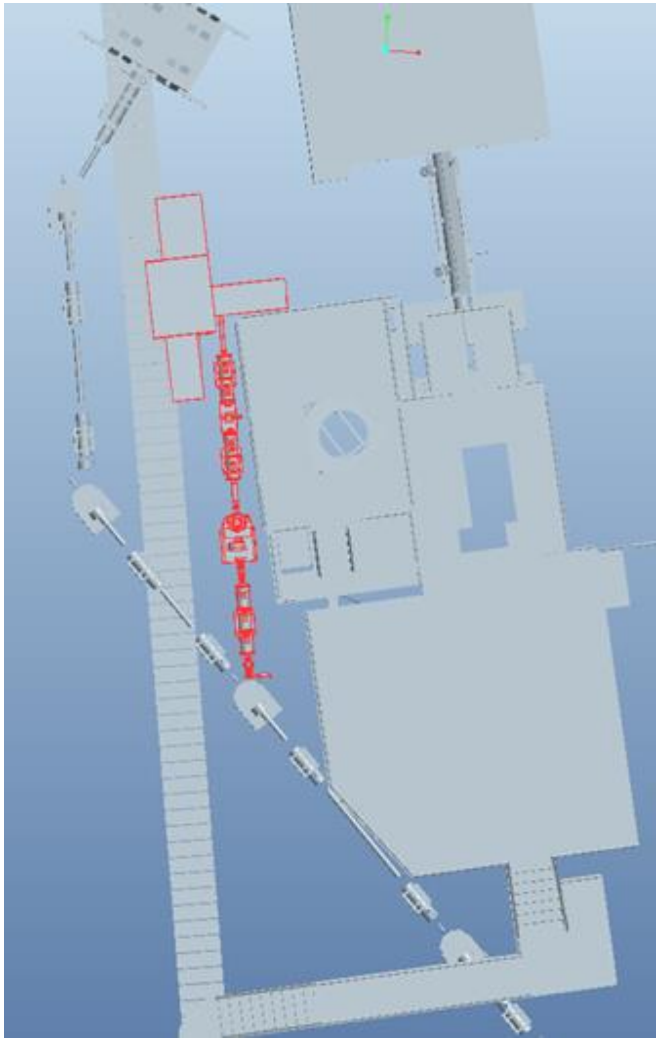
INTC committee:

- Physics cases endorsed (26 June 2013)
- 3 proposals, 2 LoIs submitted in September 2013

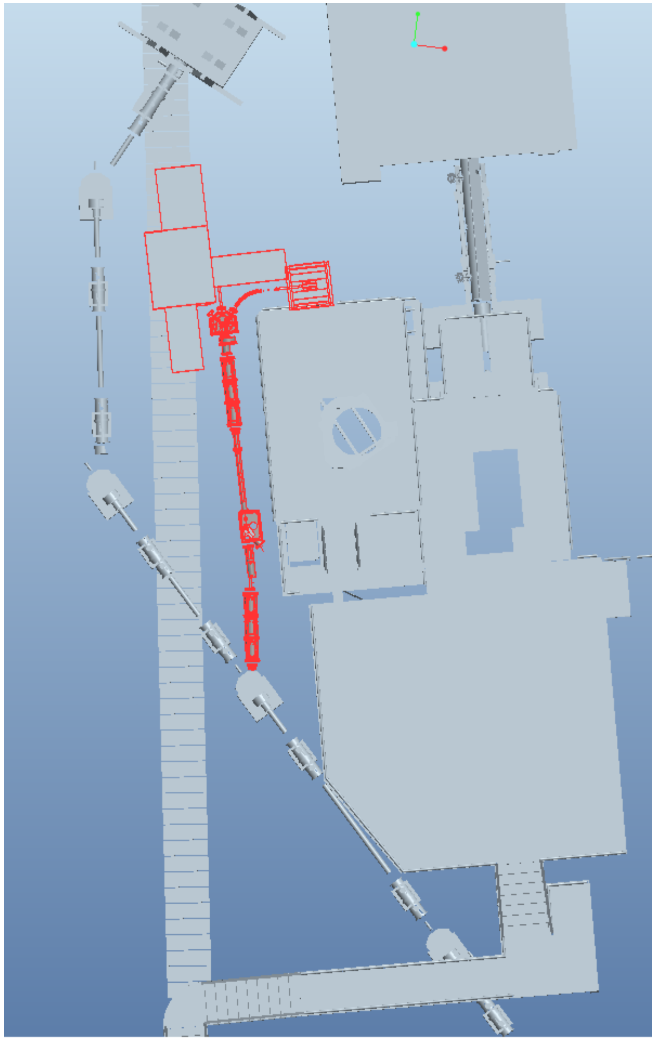
Physics endorsed by the INTC committee

ASPIC → VITO (upgrade, not a new beam line!)

ASPIC



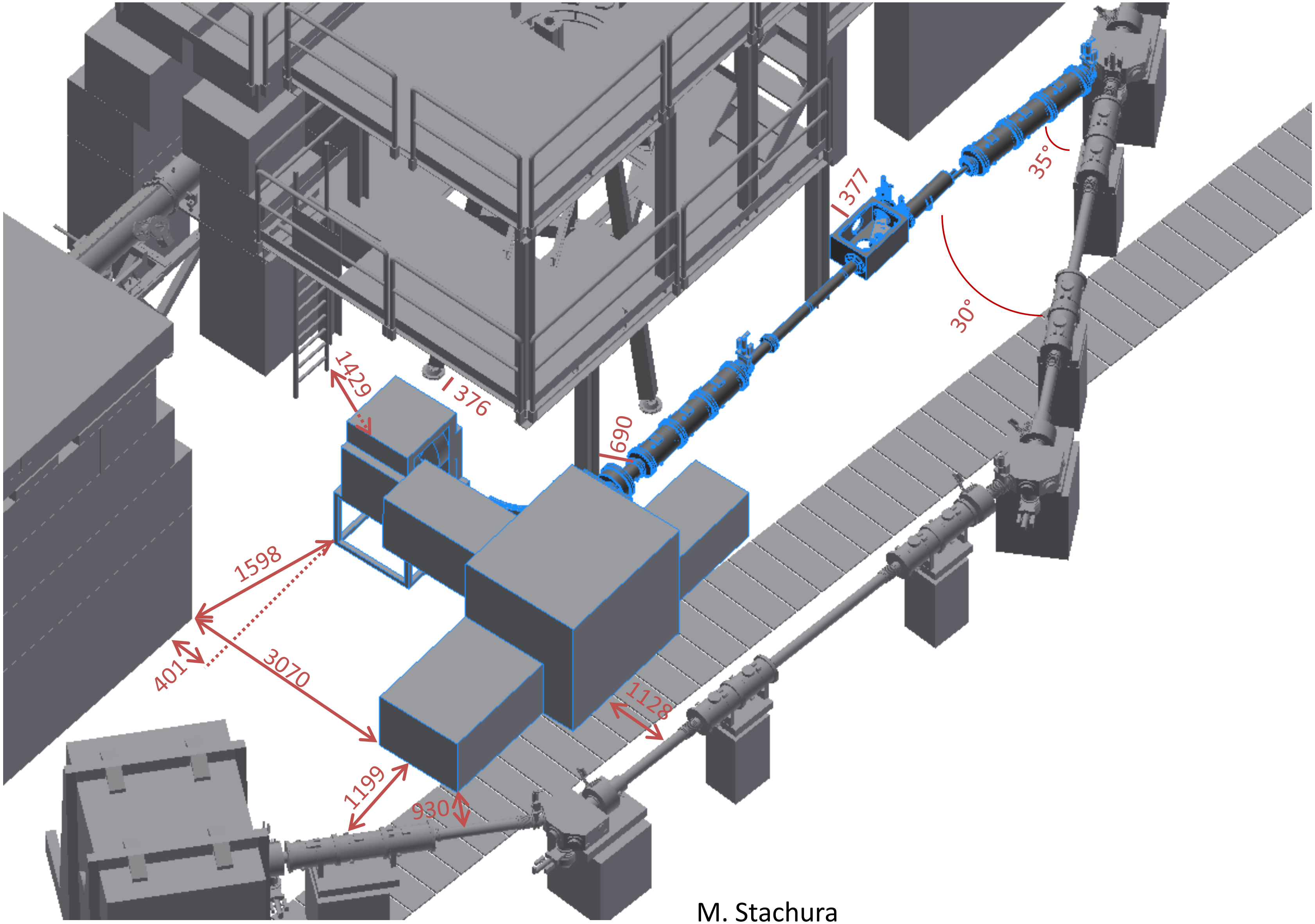
ViTO



M. Stachura

Space around the experiment

Access and escape routes (all dimensions respected)



M. Stachura

Radiation

From Joachim Vollaire:

“RP requests to be present when the first manipulation of the beamline takes place, in particular when the vacuum beam pipe will be opened. The standard safety file, as it is known from other ISOLDE beamlines needs to be filled in and submitted but **other than that no additional steps are required before the physical start of work at the beamline. I don’t see an impact from a radiation protection standpoint in a slight modification of the beam line optics.** “

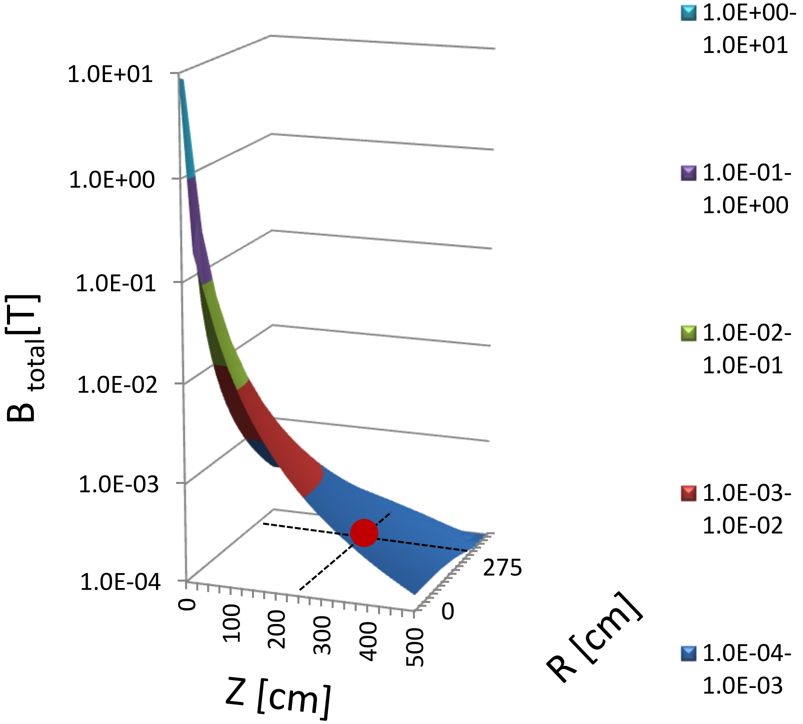
FLUKA simulations done for:

^{8}Li, ^{21}Na, ^{23}Mg, ^{31}Mg, ^{33}Mg, ^{33}Na, ^{35}Ar, ^{58}Cu, ^{73}Se, ^{74}Cu, ^{77}Br, ^{80}Br, ^{111}Ag, ^{111}Cd, ^{111}In, ^{140}La, ^{147}Ga, ^{172}Lu (with and without shielding and for 1ms and 1wk of cooling period).

- Whenever listed in SR 814.501, accumulated amount is below 1LA.
- The new monitoring system will cover more precisely this part of the hall.
- Most of the accumulated activity will be removed during / after irradiation.
- Very small quantities of radioactivity will be handled.
- The requested isotopes and their isobaric contaminants – mostly short-lived.

Magnetic Field

- Minimal influence on HIE-ISOLDE, REX, TAS, WITCH and ISOLTRAP
- Local field of Max. 0.3 T
- Magnetic field of WITCH: members of WITCH in VITO collaboration, willing to switch off the magnet for the time of β-NMR experiments
- Magnetic field of REX: not an issue for beam transport at VITO



M. Stachura

Based on WITCH 9T Stray Field

(provided by M. Breitenfeldt)

9T – max magnetic field

6T – magnetic field during experiments

3T – when WITCH on standby

VITO pumping zone: 10^{-4} T

Alternative location of the VITO beam line

Alternative location:

- RC lines (behind NICOLE or RC2 → switchyard → VITO line) – possible conflict with on-going works

Disadvantages:

- Setting up a new line
- Large budget required
- At least 8.5 m of free space required
- Problems with lasers: smaller focusing on larger distances, lower laser power due to larger amount of optics, bigger vibration of the laser beam, considerable additional budget
- Beam tuning more difficult (ideally 4 mm beam at the entrance of the β-NMR setup)
- RC region is currently space for low background experiments (permanent decay station), which is not compatible with PAC type of ion implantations
- If moving becomes necessary then rather upstream (GLM, GHM), old control room access less critical, zone of higher background

VITO Beam line

- SUMMARY
  The panel would like to congratulate the VITO Collaboration on their excellent preparation in anticipation of this review and the quality of their presentations. It is clear that the proponents have thoroughly investigated both the installation and integration of this modified beam line. From a technical point of view, no justified objections to this installation were raised. The availability of a dedicated beam line for laser-induced nuclear orientation along with ASPIC and B-NMR set-ups can only be of benefit to the physics program at ISOLDE. The panel recommends that the ISCC and INTC support this initiative by the VITO Collaboration.

- Only 38 weeks to go before protons to ISOLDE!
- Thank you for your attention