How to standardize experiments within HEARTS?

The GSI perspective – now including the feedback

Online, 12.04.2023

related to:
WP4 Task 4.4 and D4.4
WP6 Task 6.1 and D6.1
WP8 Task 8.1 and D8.1

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GSI Biophysics

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Disclaimer / Consideration

- The goal of this presentation is start a discussion. All ideas/proposed solutions are up for discussion.
- The discussion is tailored for the GSI part of the project but significant parts can be directly used for CERN as well.
- NSRL is our internal benchmark, but it is important to understand that there are significant differences e.g.
    - NSRL is a pure user facility. Everybody working at NSRL is either doing beamline development or user service
    - GSI is rather a science facility.

  ➔ The level of direct support we can offer will most likely be smaller
- Beam time is very limited and must be used very efficiently, thus universal, simple and practical interfaces are needed
- The “standard” we try to find doesn’t need to fit all possible experiments, only most. Non-standard experiments will, of course, still be possible if necessary.

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Topics / Flow

Part 1

Technical parameters

- Beam parameters
- Variable shielding / range shifter
- Target station

Points added due to the feedback (via the discussion afterwards or via email by TAS) are added in green to the following slides.

Part 2

Proposed workflow

- first contact point of users via webpage
  - user guide
  - FAQ
  - contact/beam request
- assignment of liaison scientist
- experiment scheduling / planning
- on-site dry-run
- beam exposure
- test report

Part 1
Beam parameters

	GSI	comments
Energies	80-1000 MeV/u	Typically 2-3 energies
Ions	H to U	typically C, Fe, U *
Intensity range	500 – 10^9 per spill	Depends (a bit) on the ion species
Extraction	Slow 1-10 s (quadrupole resonance)	Optional slow RF-KO (1 – 10 s), Fast kick out extraction (<1µs)
Spill length	0.2 – 10s	
Spill pause	< 2s	Variable duty cycle
Delivery	Scanning	Arbitrary shapes
Max area	Up to 20 x 20 cm^2	< 5 x 5 cm^2 for uranium
Uniformity	Better than +-5%	
Beam microstructure	Important?	Can be improved with RF-KO

Note:
Every change to the accelerator settings during beamtime take at least 30 min and can take up to hours

Ions are not offered at the same time

beam

beam

Proposal:

- One high energy → Shoot through/Bio
- One low → BP scanning

- One high intensity > 10^6 per spill
- One low intensity ≈ 5000 per spill

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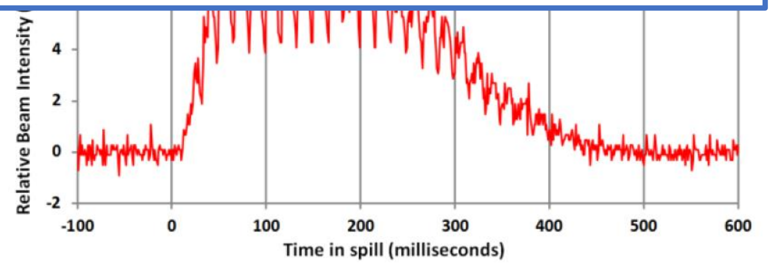

* additional ions like protons, helium might be available

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Spill paus		
Delivery		
Max area		
Uniformit		
Beam mic		

TAS:

- Crucial to deliver defined LET values between 1 to 60 MeV/cm²/mg
  → Pick 5 critical LET values (to be discussed and agreed upon)
- 5x5cm² spot (Uranium) is small for board level testing
  → The board can also be moved to cover a larger area, just not at the same time.
- Defined time for change of ions is important.
  → **There is no offer of multiple ions at the same time.** Different ions are only available in different slots (possibly weeks apart). Different LET values can be achieved with different energies of the same ion.

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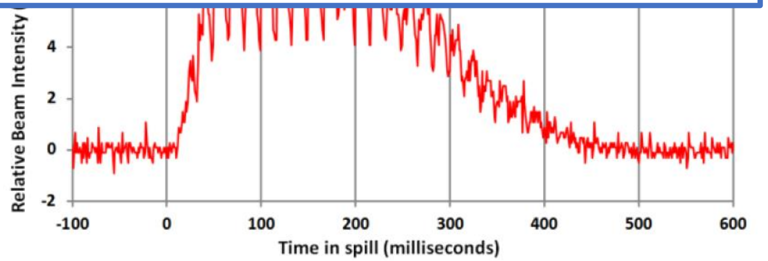
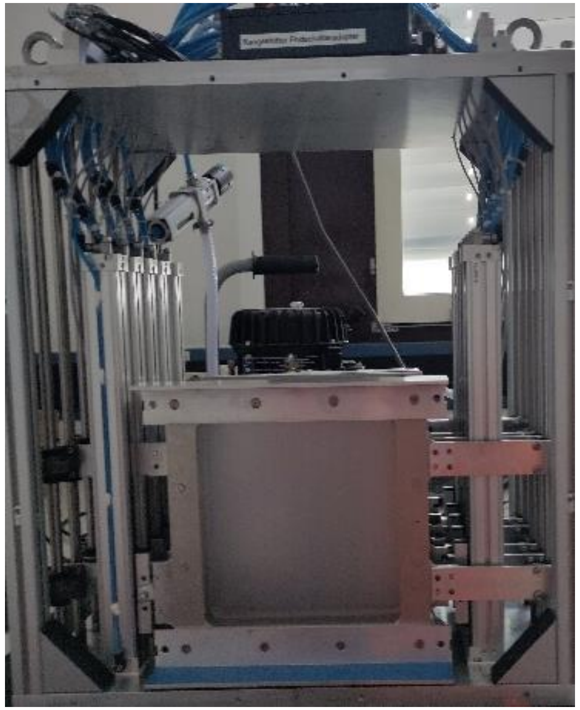


Part 1

Variable shielding handler/ Variable depth Bragg Peak Range shifter



“Old” binary Range shifter

- modular version of the cave A binary range shifter
- 4 modules → 8 plates
  - module
    - 2 plates, two sets of pneumatic linear motors
    - max size 20 x 20 cm^2
    - max weight ≈ 10 kg
- modules can be used individually or combined
- standardized frames for “fast” plate exchange
  - CAD available for users in case of non-standard configuration

- Standard plate-sets for
  - shielding (aluminum, PE) → thicker
  - peak finding for electronics → binary, thinner

Note:
NSRL uses 2 target wheels which offers some geometrical benefits but is far less flexible/useful for different settings

PE and PMMA are okay materials for electronics irradiation as a degrader, as light fragments do not influence measurements much. **Awaiting further feedback from industry.**

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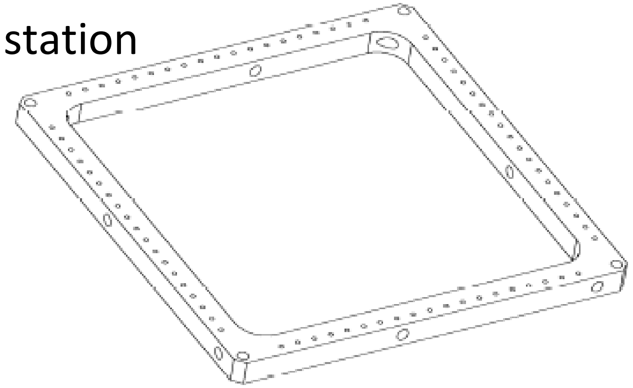
Target station / Target station interface

CERN target station and holder



- Based on linear axes with hybrid steppers
  - every point within the frame reachable via scanner and/or motor
- Distortion corrected and calibrated target camera (OpenCV)
  - Front or back
- Distortion corrected Target laser
- Remote movement (z → beam direction)
  - x / y → standard
  - + 1D-Rotation to be incorporated ~~optional~~

Note: Entering the cave takes a minimum of ≈ 10 min

- One frame per “experiment”
- Frame design based on CERN holder
  - Inner opening > 20 x 20 cm^2 (RADEF and GANIL allow for up to 25 x 25cm^2 boards)
  - Laser markers (back and/or front)
  - Material: aluminum or reinforced plastic
- Common frame between CERN and GSI

Target station / Target station interface Bio

- Biology irradiations typically use:
  - T25 or T12.5 Flasks in sets of three or six per dose
  - Well plates
- Cells inside the flasks prefer to stay inside the medium
  a. Fill the flasks completely
  b. Only position them upright for a short time (<20min, depends on the experiment)

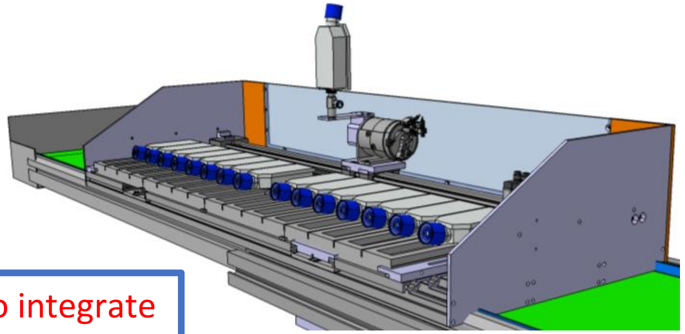
Proposal:
- Utilize a system, which flips flasks into an upright position only for irradiation and positions them horizontally otherwise (based on the GSI flask exchanger).
- System should accept at least three, better six, T25 flasks at the same time and also be compatible with well plates

T25 Flask

Well plate

Possible to integrate into a target station

NSRL remote sample flipper



More complicated to integrate into a target station, prototype exists at GSI already

GSI Flask exchanger

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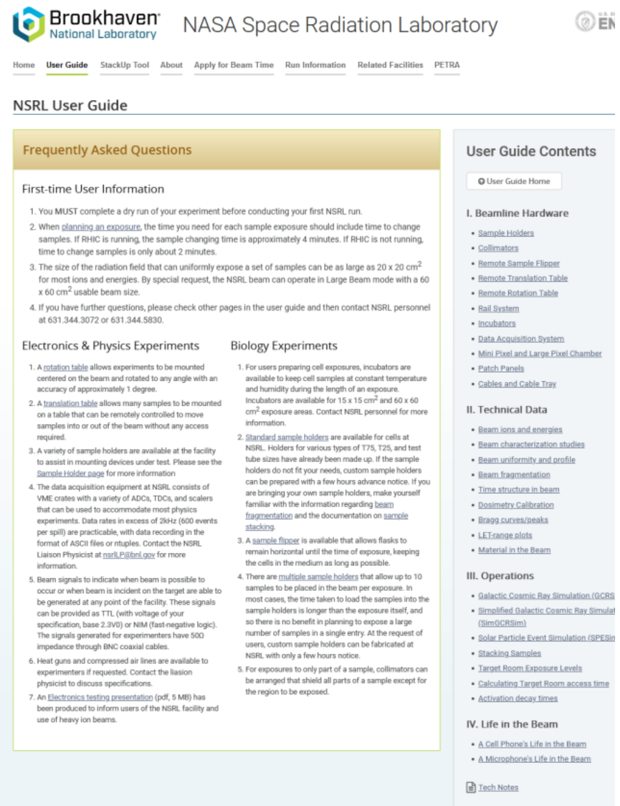
Part 2
HEARTS website – facility user guide



Similar to the NSRL user guide (https://www.bnl.gov/nsrl/userguide/)

- Short explanation of basic physics with relevant examples
  - Scattering/fragmentation/etc.
  - Shared GSI/CERN
- Explanation of irradiation room + CAD
  - Space, cables, etc.
- Explanation of beamline + CAD
- Explanation of dosimetry/beam monitoring
- Explanation of Shielding exchanger + interface CAD
- Explanation of target station + interface CAD
  - In case of bio → standardized flasks/etc.
- Explanation of preparation/dry run
- Resource/tools (Lise++, etc.)
  - Shared GSI/CERN

Generally liked by everyone
Started with information collection and writing a first draft.

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How much support is necessary/wanted by industry?

Note: Beam exposure, etc. will always be performed by GSI/FAIR staff

Possibilities for support

- Regulatory requirements (e.g. radiation protection, biological lab safety, required GSI instructions, etc.)
- Experimental planning?
- MC simulations or other forms of calculations

  Discussion Result: Provide LET Spectra at the top of the package of the DUT. Inside the package is the users responsibility.
  TAS Feedback: MC simulations for beam transport and LET determination through a large and complex amount of shielding
  → **Both points agree with each other**

- Non-standard holders etc.
- Fully perform the testing (no industry partner) on-site
- Use of GSI/FAIR experimental equipment e.g. power supplies

  Generally no extra equipment is needed. Only in case of failures it would be good to have.

Workflow for onsite access for experimenters

- Apply for guest status at GSI
  - Fill online registration forms
  - Sign Home institute declaration
  - Perform general GSI safety instructions online
- If access to the cave is needed:
  - Further online safety instructions
  - Medical certificate
  - Apply for TLD dosimeter (or Barcode if neutron sensitive dosimeter is available)
  - Safety instructions on site
- Possibly apply for access to the Internet* or even to the GSI network / clusters

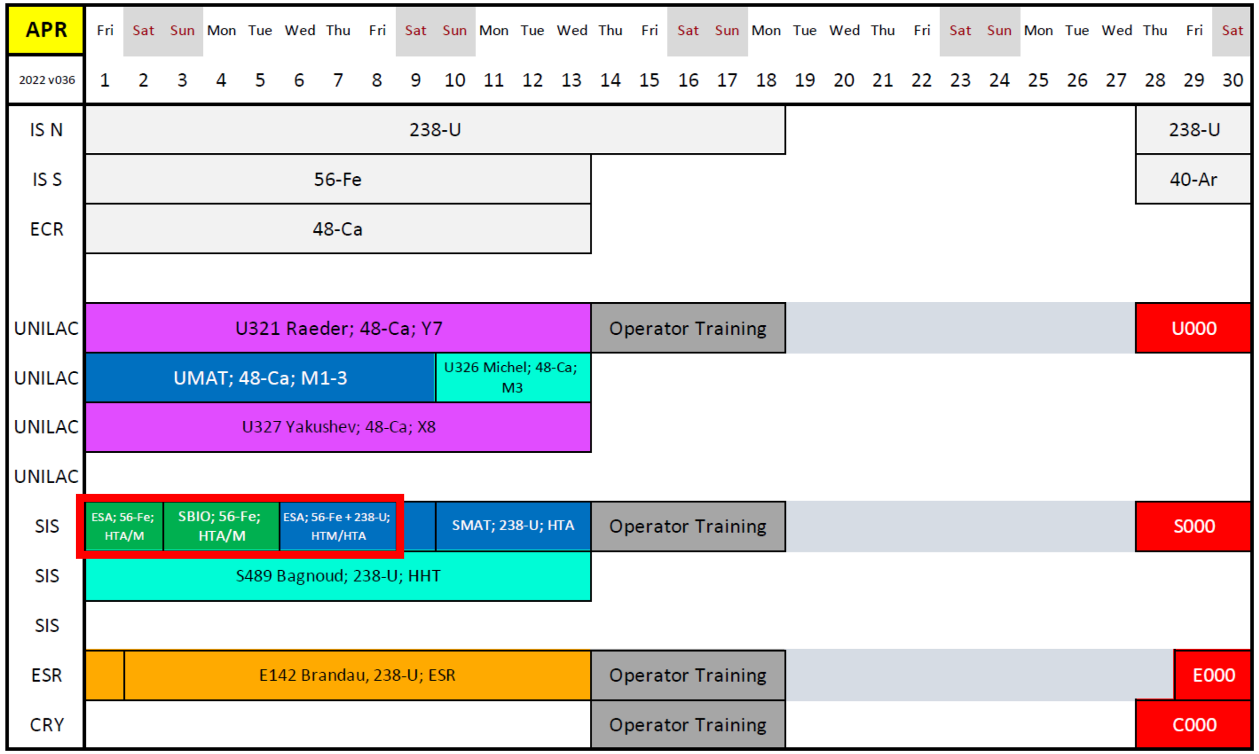
The application for a guest status process is required for everyone coming to GSI

The rules for getting access to the cave follow German radiation protection laws and cannot be changed.

Guides for all registration processes are available on the GSI webpages

* in case the user cannot access eduroam

Part 2
Experiment scheduling / planning



(1) only if parallel operation possible /// (2) only block mode

Available at
https://www.gsi.de/fileadmin/beamtime/2022/BTS2022_v042.pdf

- Influencing when a specific beamtime block is scheduled is really difficult
- Specific user wishes for dates are essentially impossible

- Scheduling within a specific beamtime block is up to us → degree of flexibility

The beam time block is fixed and the time slots must be accepted by the users

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Part 2
On-site dry run / Target preparation

example

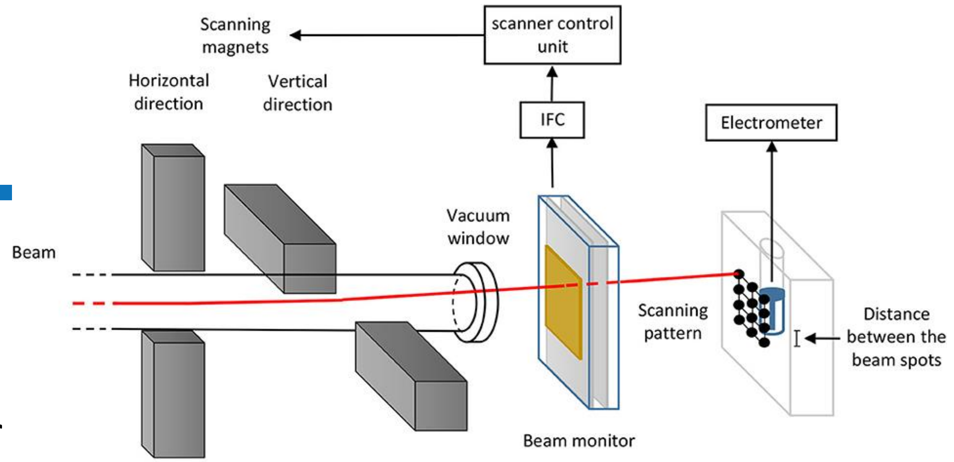
Goal: time optimization

- Minimizing the setup time (likely, there are other experiments right before and afterwards)
- Every experiment gets one cart to place electronics
  - For larger equipment tables with wheels are an option*
- If possible, every experiment should perform a dry run outside of the cave

- Proposed process
  - Prepare experiment on cart
  - Test outside of cave
  - Move fully tested experiment to cave
  - Irradiate
  - Bulk remove

*Maximal size needs to be investigated for the maneuverability through the labyrinth and cave.

Part 2
Beam exposure



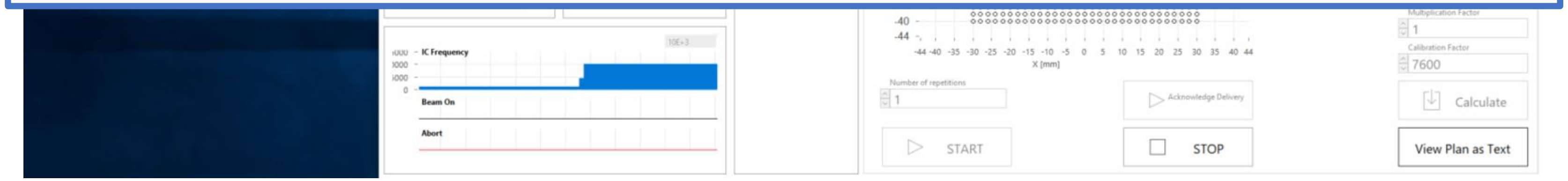
Cave A Scanning system

Information, which has to be supplied for the irradiation process

- Desired beam intensity
  - Can also be adjusted during the experiment, but takes time (larger steps take more time)
- Irradiation areas (positions on the DUT and sizes)
  - Used for setting up the scanning system
  - Easily adjustable during the experiment in case more or less are needed
- Desired total number of ions / cm² (for each irradiation area)
  - Easily adjustable during the experiment in case more or less are needed

Beam scanning is different to a standard beam spot
→ Influence needs to be investigated

Request to start and stop the beam with user provided signals (e.g. standard TTL)
→ Needs to be checked with the GSI safety department
Note: The signal can only be a request to start the beam at the next possible time slot and not an immediate start due to the multi-user operation at GSI (and CERN).



Cave A Scanning system GUI

Part 2
Online information for users

- Not connected to the internet (data protection concerns)
- To be investigated if remote access is possible (e.g. tunnel or similar)

Goal: Supply information to users

Show live data about the irradiation

- Beam type & energy
- Status / Progress of the beam application via scanning
- Ions / spill, avg. # Ions for last N spills, Ions / cm^2 / s, etc.
- DUT positioning picture
- Target station data (X & Y position, etc.)
- Information about other instrumentation (e.g. shielding)

What other kind of data would be needed here?

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Part 2
Beam exposure – additional signals for users during exposure

E.g. time resolved pulses of the beam monitoring detectors

- What standard? NIM/TTL 5V/24V

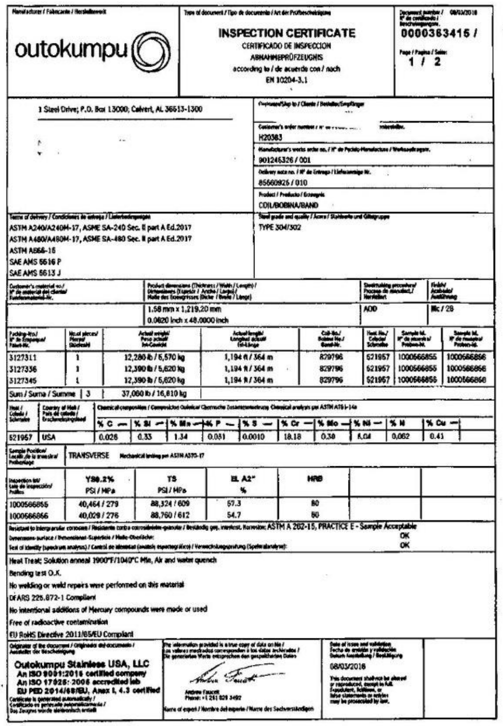
Will these signals recorded by the user or by us and we only provide a timestamp or a synchronization pulse?

- Beam start and stop signals for DAQ synchronization
- User triggered logging:
  - Is a good idea to allow a synchronization with the user DAQ.
  - One needs to decide on a common logging format (e.g. xml) and the information content (which signals and/or other data).

Note: The amount of recorded information in different systems of the irradiation room/accelerator is extremely high

Define a set of information of interest for most experiments

Part 2
Test/Summary sheet/Logbook



Possible options:

- Standardized test report per sample
- Scan of Logbook
- E-Log

- Possible information
  - Beamspot
  - Field
  - Planned exposure
  - …

Note: The amount of recorded information in different systems of the irradiation room/accelerator is extremely high

Define a set of information of interest for most experiments

Did we miss any crucial points?