How to standardize experiments within HEARTS?

The GSI perspective

Online, 08.02.2023

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.

HEARTS

Topics / Flow

Part 1

Technical parameters

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

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

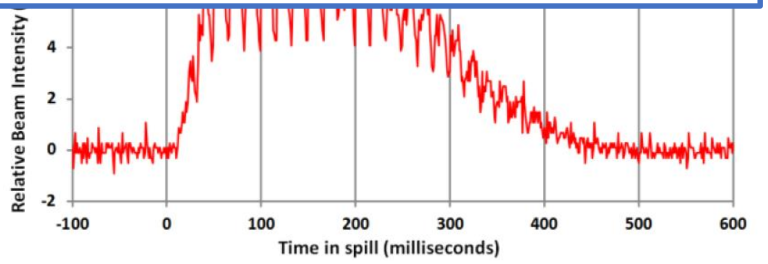
beam

beam

Proposal:

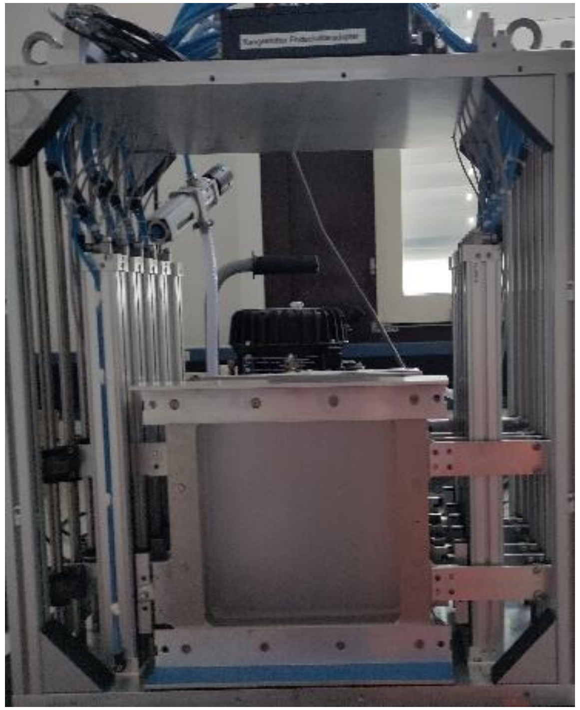
- One high energy → Shoot through/Bio
- One low → BP scanning

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



* additional ions like protons, helium might be available

Variable shielding handler/ Variable depth Bragg Peak Range shifter



“Old” binary Range shifter

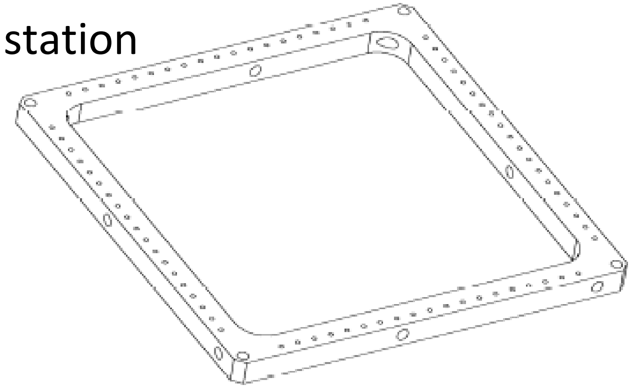
- modular version of the cave A binary range shifter
- 4 modules → 8 plates
  - module
    - 2 plates, two sets of pneumatic linear motors
    - max size 20 x 20 cm^2
    - max weight ≈ 10 kg
- modules can be used individually or combined
- standardized frames for “fast” plate exchange
  - CAD available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

Part 1
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 optional

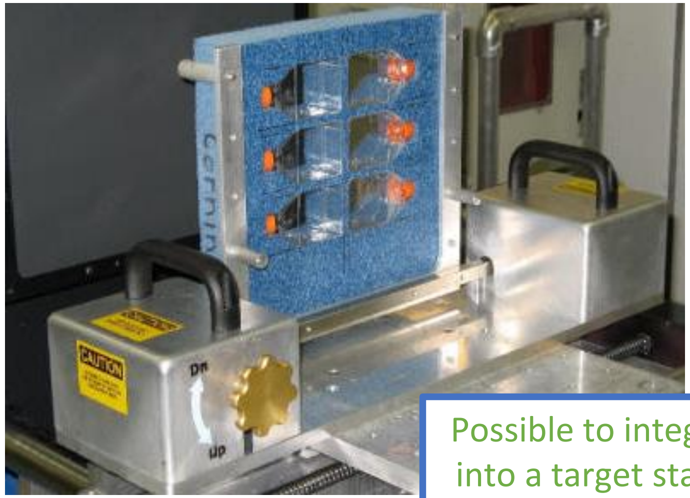
Note: Entering the cave takes a minimum of ≈ 10 min

- 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

Part 1
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)

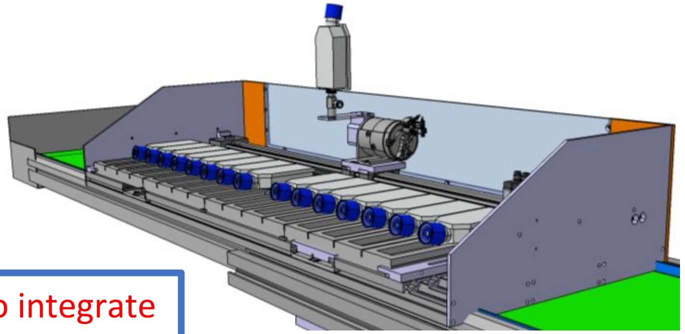
T25 Flask



Possible to integrate into a target station

NSRL remote sample flipper

Well plate

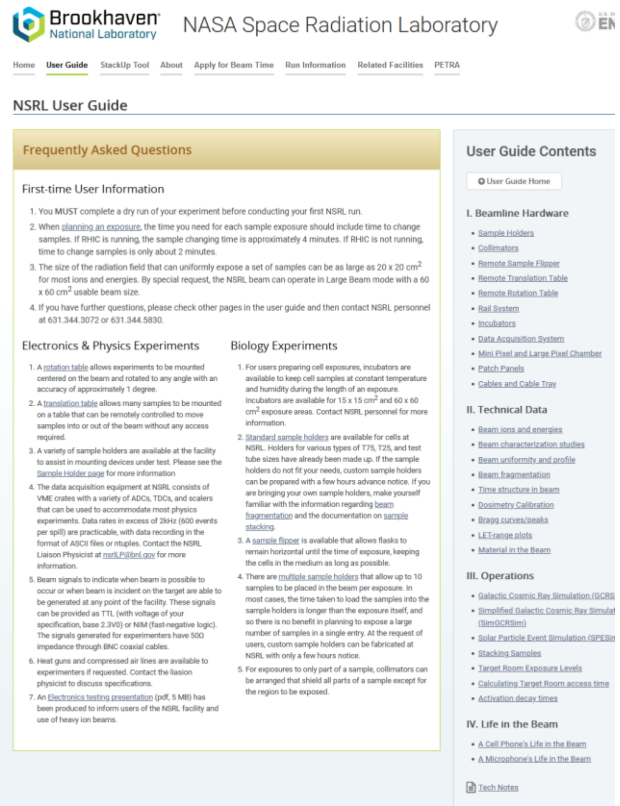


GSI Flask exchanger

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

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

Part 2
HEARTS website – facility user guide



Brookhaven National Laboratory NASA Space Radiation Laboratory

Home | User Guide | StackUp Tool | About | Apply for Beam Time | Run Information | Related Facilities | PETRA

NSRL User Guide

Frequently Asked Questions

First-time User Information

1. You MUST complete a dry run of your experiment before conducting your first NSRL run.
2. When planning an exposure, the time you need for each sample exposure should include time to change samples. If RHIC is running, the sample changing time is approximately 4 minutes. If RHIC is not running, time to change samples is only about 2 minutes.
3. The size of the radiation field that can uniformly expose a set of samples can be as large as 20 x 20 cm^2 for most ions and energies. By special request, the NSRL beam can operate in Large Beam mode with a 60 x 60 cm^2 usable beam size.
4. If you have further questions, please check other pages in the user guide and then contact NSRL personnel at 631.344.3072 or 631.344.5830.

Electronics & Physics Experiments

1. A rotation table allows experiments to be mounted centered on the beam and rotated to any angle with an accuracy of approximately 1 degree.
2. A translation table allows many samples to be mounted on a table that can be remotely controlled to move samples into or out of the beam without any access required.
3. A variety of sample holders are available at the facility to assist in mounting devices under test. Please see the Sample Holder page for more information
4. The data acquisition equipment at NSRL consists of VME crates with a variety of ADCs, TDCs, and scalers that can be used to accommodate most physics experiments. Data rates in excess of 2kHz (600 events per spill) are practicable, with data recording in the format of ASCII files or ntuples. Contact the NSRL Liaison Physicist at nsrlLP@bnl.gov for more information.
5. Beam signals to indicate when beam is possible to occur or when beam is incident on the target are able to be generated at any point of the facility. These signals can be provided as TTL (with voltage of your specification, base 2.3V0) or NIM (fast-negative logic). The signals generated for experimenters have 50Ω impedance through BNC coaxial cables.
6. Heat guns and compressed air lines are available to experimenters if requested. Contact the liasion physicist to discuss specifications.
7. An Electronics testing presentation (pdf, 5 MB) has been produced to inform users of the NSRL facility and use of heavy ion beams.

Biology Experiments

1. For users preparing cell exposures, incubators are available to keep cell samples at constant temperature and humidity during the length of an exposure. Incubators are available for 15 x 15 cm^2 and 60 x 60 cm^2 exposure areas. Contact NSRL personnel for more information.
2. Standard sample holders are available for cells at NSRL. Holders for various types of T75, T25, and test tube sizes have already been made up. If the sample holders do not fit your needs, custom sample holders can be prepared with a few hours advance notice. If you are bringing your own sample holders, make yourself familiar with the information regarding beam fragmentation and the documentation on sample stacking.
3. A sample flipper is available that allows flasks to remain horizontal until the time of exposure, keeping the cells in the medium as long as possible.
4. There are multiple sample holders that allow up to 10 samples to be placed in the beam per exposure. In most cases, the time taken to load the samples into the sample holders is longer than the exposure itself, and so there is no benefit in planning to expose a large number of samples in a single entry. At the request of users, custom sample holders can be fabricated at NSRL with only a few hours notice.
5. For exposures to only part of a sample, collimators can be arranged that shield all parts of a sample except for the region to be exposed.

User Guide Contents

User Guide Home

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

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

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

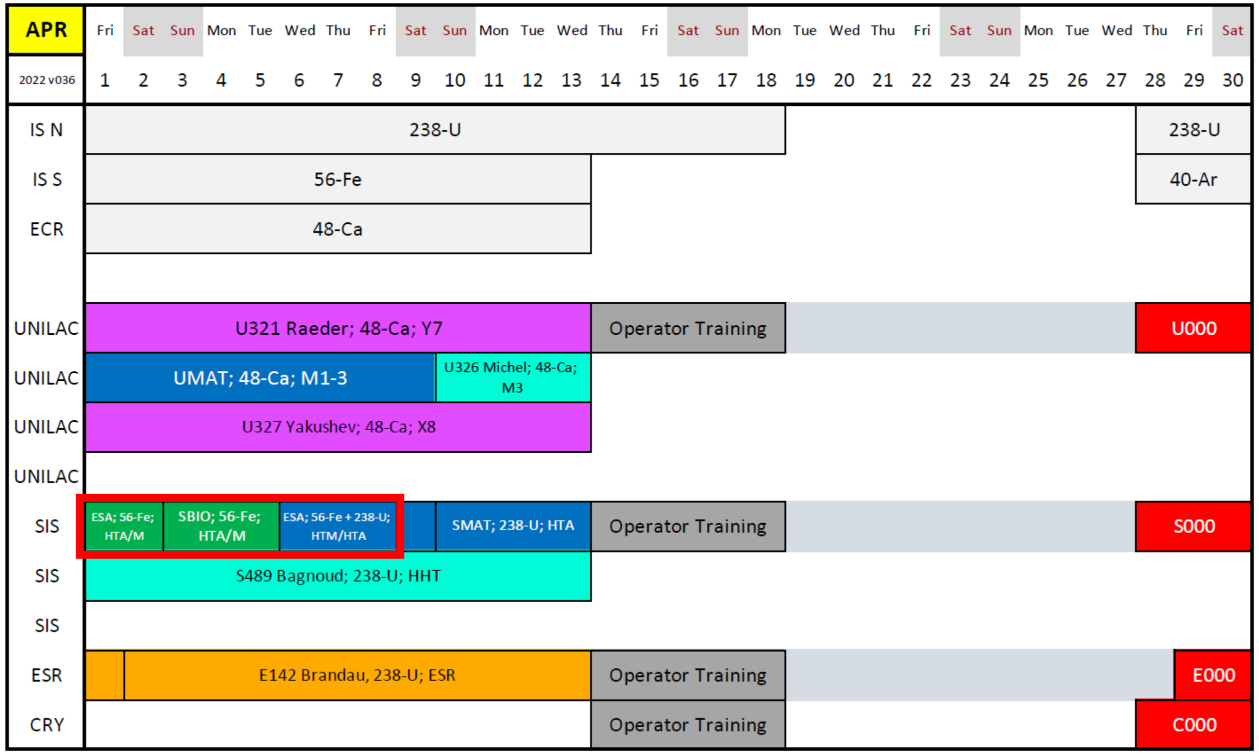
The application for a guest status process is required for everyone coming to GSI

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

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
- 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

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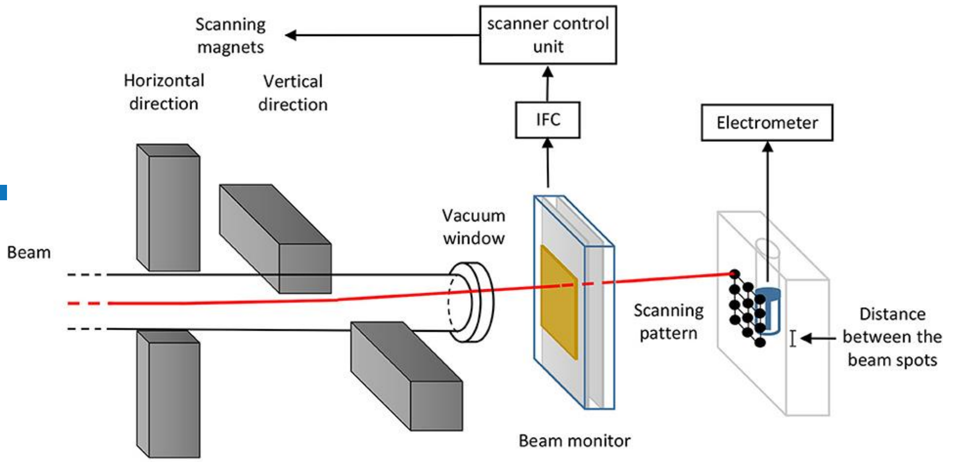
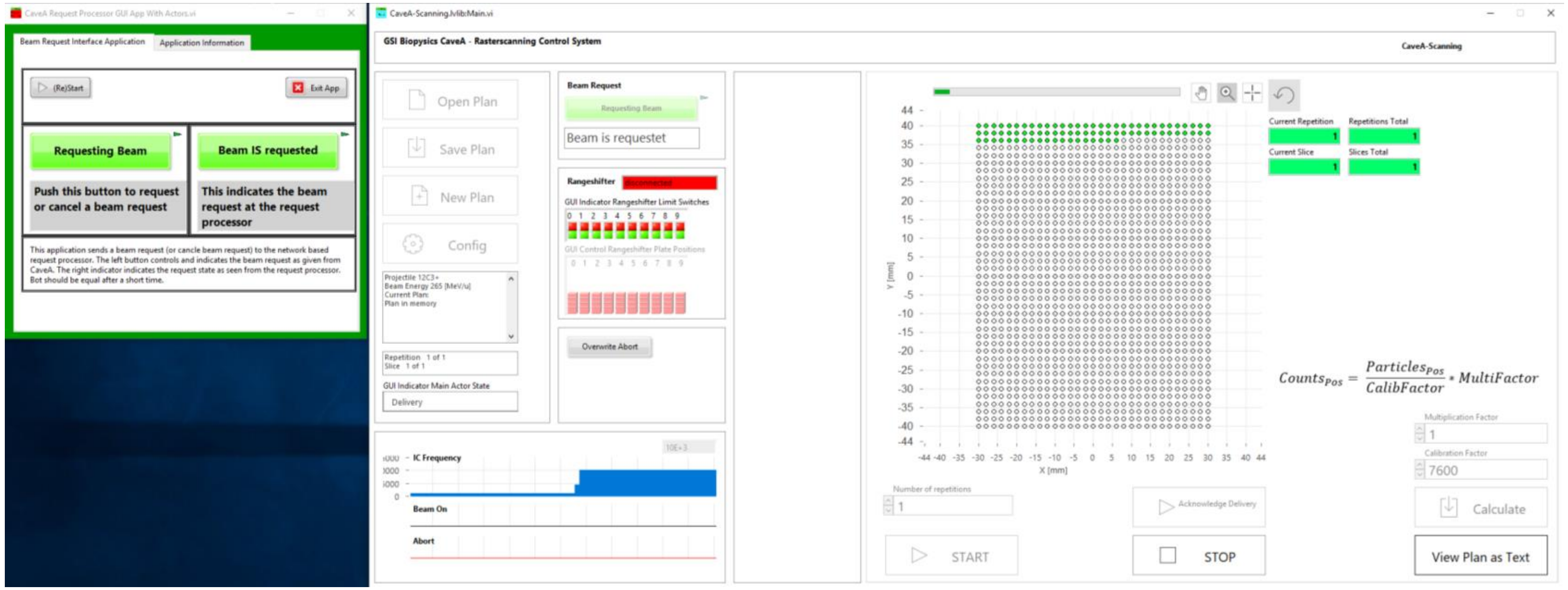
Part 2
Beam exposure

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 / cm^2 (for each irradiation area)
  - Easily adjustable during the experiment in case more or less are needed



Cave A Scanning system



Cave A Scanning system GUI

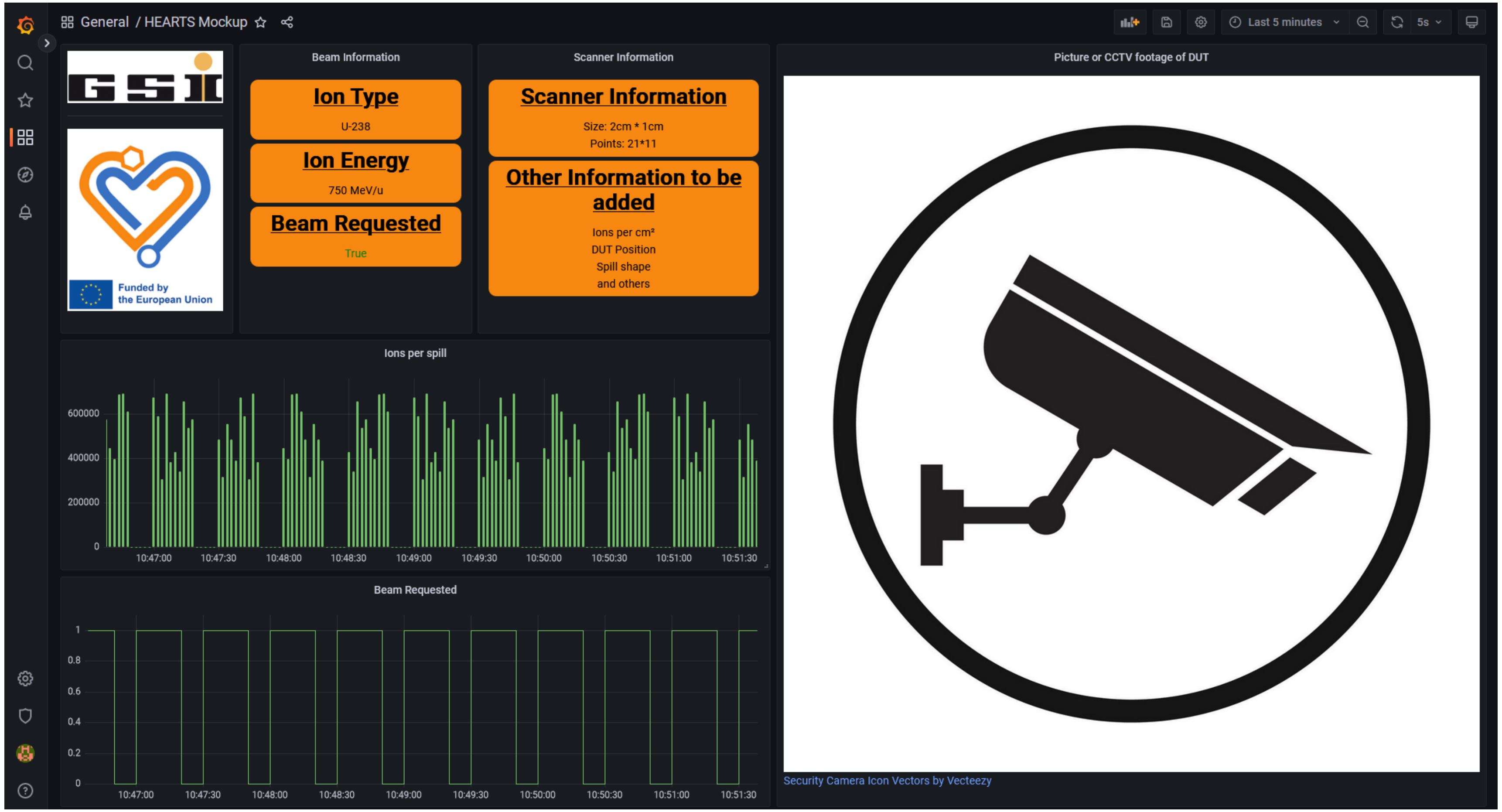
Part 2
Online information for users

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?



HEARTS

Beam exposure – additional signals for users during exposure

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

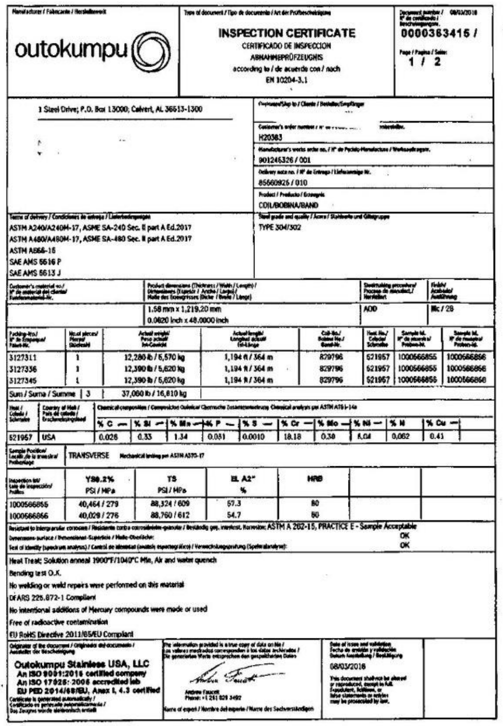
- What standard? NIM/TTL 5V/24V

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

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



outokumpu

INSPECTION CERTIFICATE
CERTIFICADO DE INSPECCION
ABNAHMEPRÜFZEUGNIS
according to / de acuerdo con / nach
EN 10204-3.1

0000363415 /
1 / 2

1 Steel Drive; P.O. Box 13000; Calvert, AL 36613-1300

H20383
901246326 / 001
85660926 / 010
COIL/BOBINA/BAND

ASTM A240/A240M-17, ASME SA-240 Sec. II part A Ed.2017
ASTM A480/A480M-17, ASME SA-480 Sec. II part A Ed.2017
ASTM A666-15
SAE AMS 5516 P
SAE AMS 5513 J

TYPE 304/302

1.58 mm x 1,219.20 mm
0.0620 inch x 48.0000 inch
AOD
2B

3127311	1	12,280 lb / 5,570 kg	1,194 ft / 364 m	829796	521957	1000566855	1000566856
3127336	1	12,390 lb / 5,620 kg	1,194 ft / 364 m	829796	521957	1000566855	1000566856
3127345	1	12,390 lb / 5,620 kg	1,194 ft / 364 m	829796	521957	1000566855	1000566856
Sum / Suma / Summe	3	37,060 lb / 16,810 kg					

		% C	% Si	% Mn	% P	% S	% Cr	% Mo	% Ni	% N	% Cu
521957	USA	0.026	0.33	1.34	0.031	0.0010	18.18	0.30	8.04	0.062	0.41

TRANSVERSE

	YS0.2% PSI / MPa	TS PSI / MPa	EL A2" %	HRB
1000566855	40,464 / 279	88,324 / 609	57.3	80
1000566856	40,029 / 276	88,760 / 612	54.7	80

ASTM A 262-15, PRACTICE E - Sample Acceptable
OK
OK

Heat Treat: Solution anneal 1900°F/1040°C Min, Air and water quench
Bending test O.K.
No welding or weld repairs were performed on this material
DFARS 225.872-1 Compliant
No intentional additions of Mercury compounds were made or used
Free of radioactive contamination
EU RoHS Directive 2011/65/EU Compliant

Outokumpu Stainless USA, LLC
An ISO 9001:2015 certified company
An ISO 17025: 2005 accredited lab
EU PED 2014/68/EU, Anex I, 4.3 certified

08/03/2018

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?