PURESAFE
Preventing hUman intervention for IncREased SAfety inFrastructures Emitting ionizing radiation

RP 9

Study of a logistic concept for Super-FRS RH components

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Project: 06/2012 – 01/2015

Background Information

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- Supervisor: Dr. Helmut Weick
- Organisation: GSI Helmholtz center for heavy ion research

- University: Tampere University of Technology, Finland
- PhD Supervisor: Prof. Jouni Mattila

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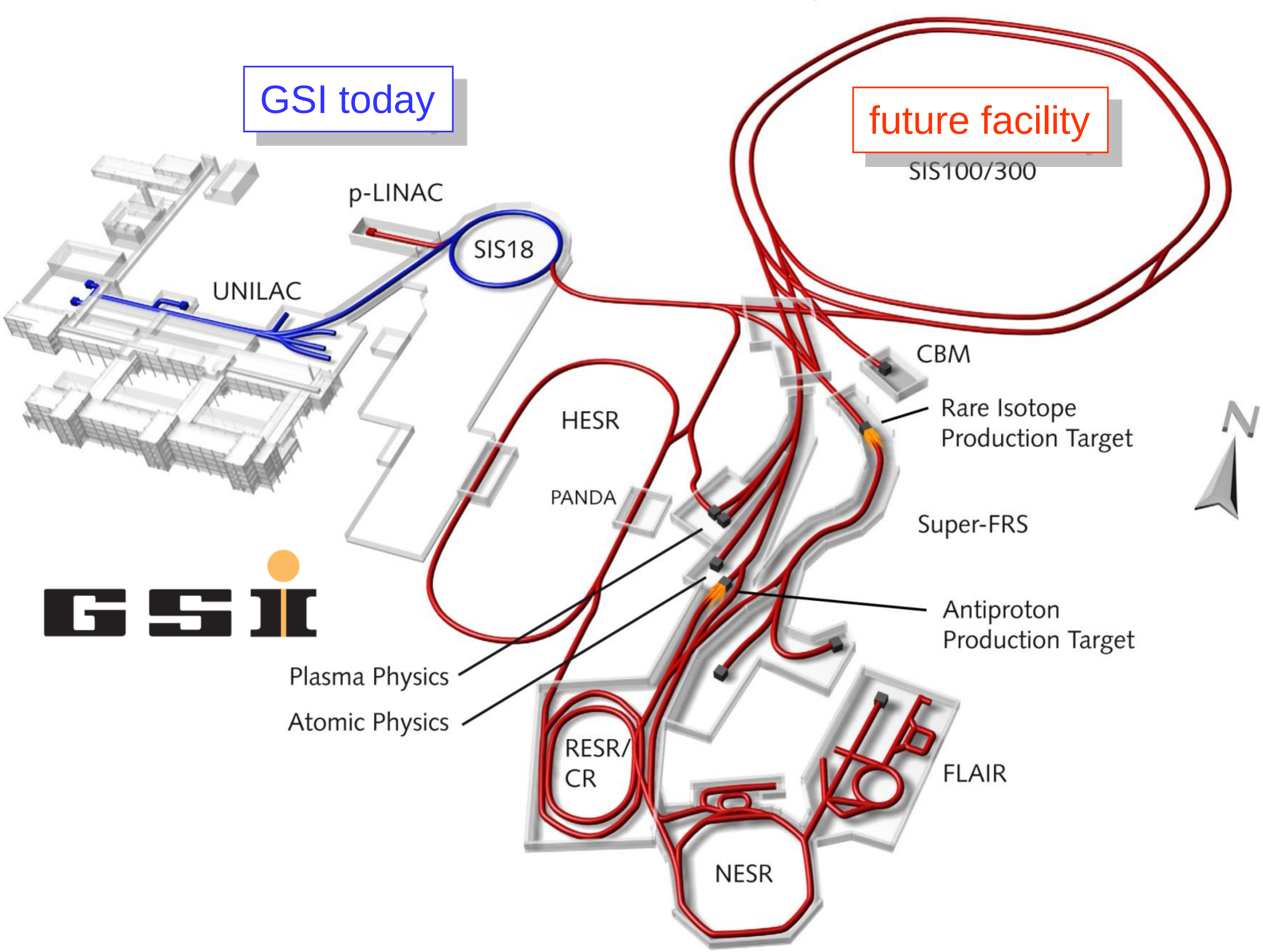
Research Goals

- Setting up requirements; compilation of RH components to be transported
- Review of existing components designs; identification of features that have to be adapted for Super-FRS needs.
- Flask dimensioning and requirements.
- Investigation of intervention scenarios.
- Analysis and validation of costs
- Documentation of the progresses in internal reports, scientific papers, and final dissertation

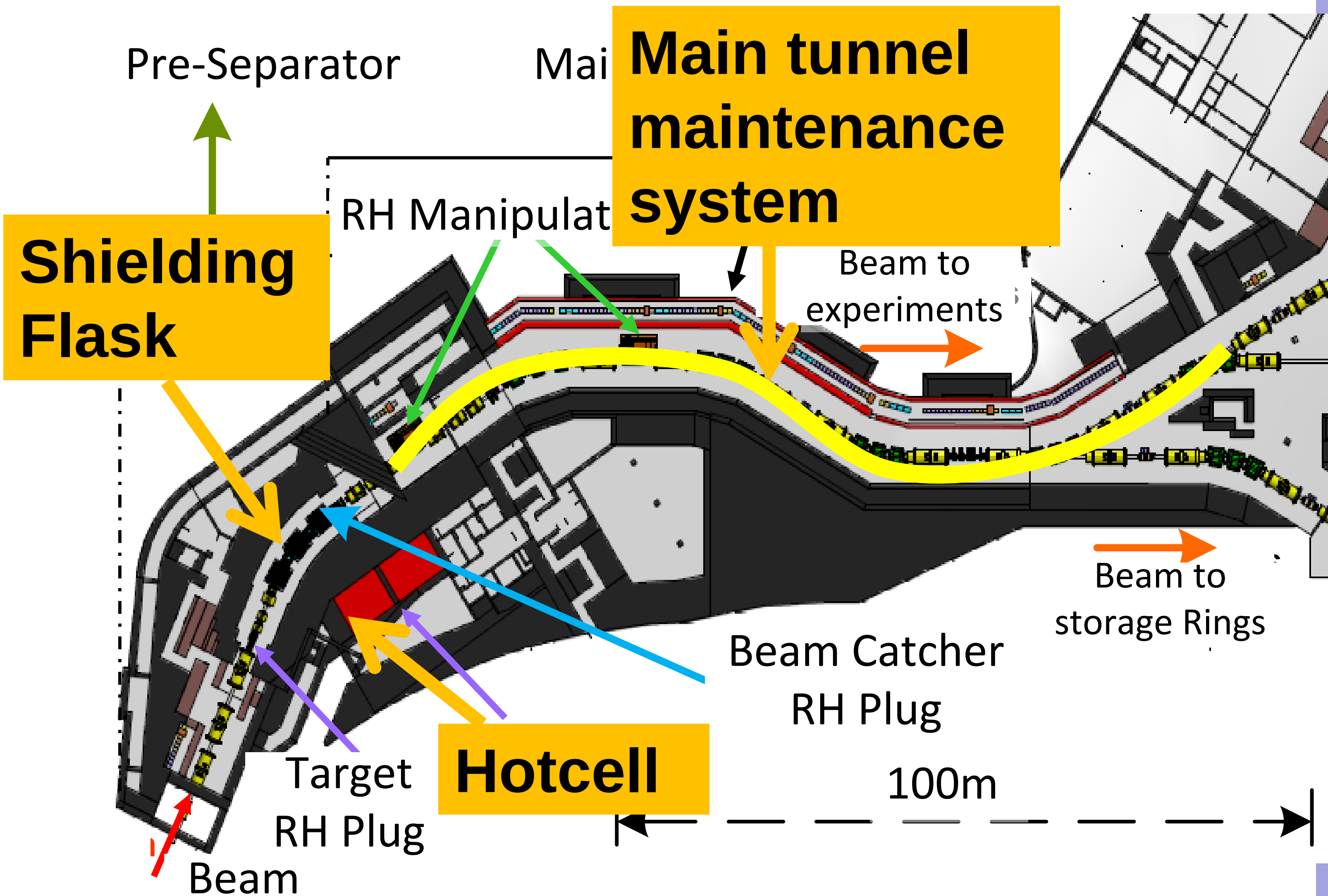
Project Selected

- Develop Logistic Concept for Super-FRS main tunnel RH system

Project Selected



FAIR Gmbh


Pre-Separator
Mai
Main tunnel maintenance system
RH Manipulat
Shielding Flask
Beam to experiments
Beam to storage Rings
Beam Catcher RH Plug
Target RH Plug
Hotcell
100m
Beam

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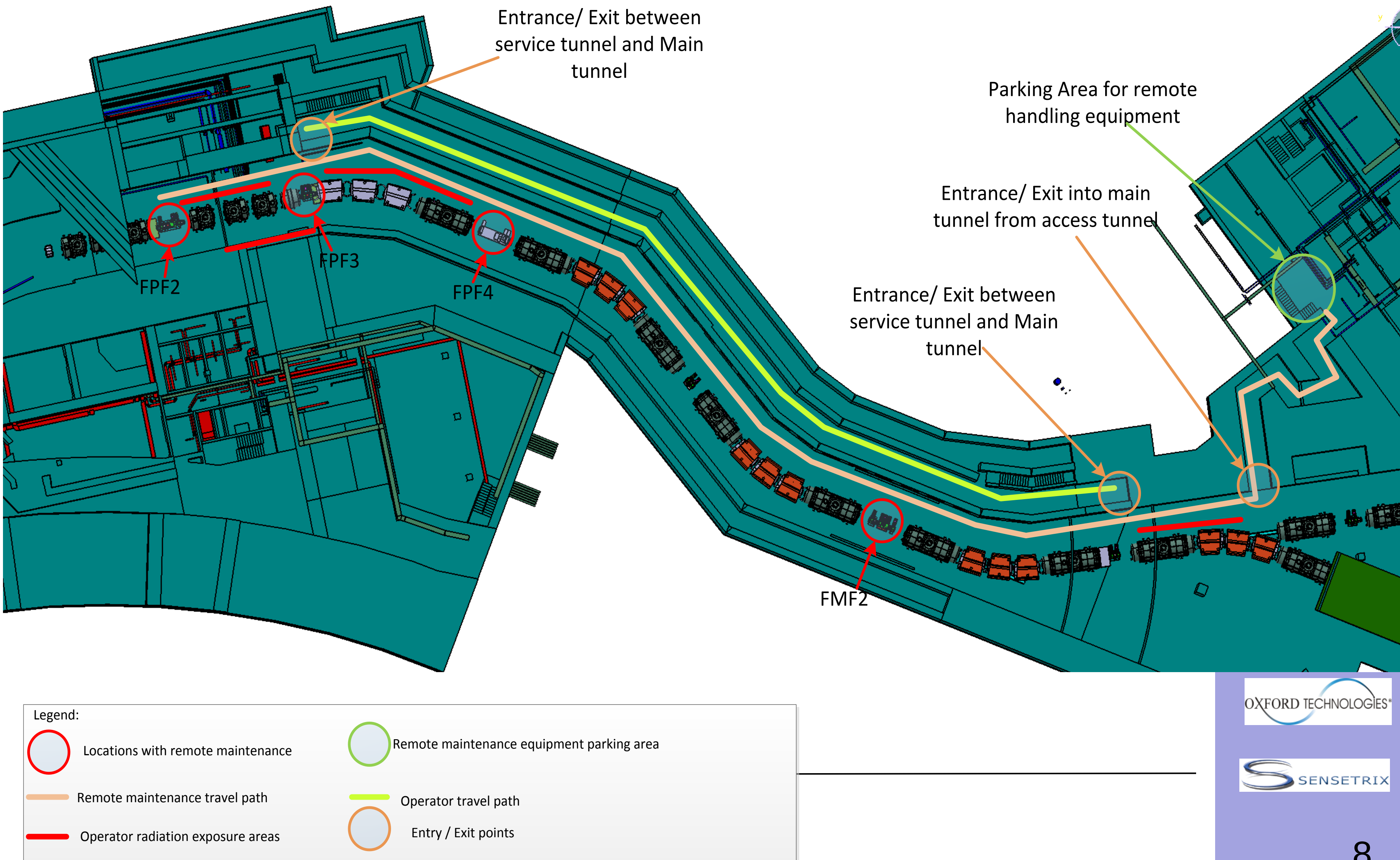
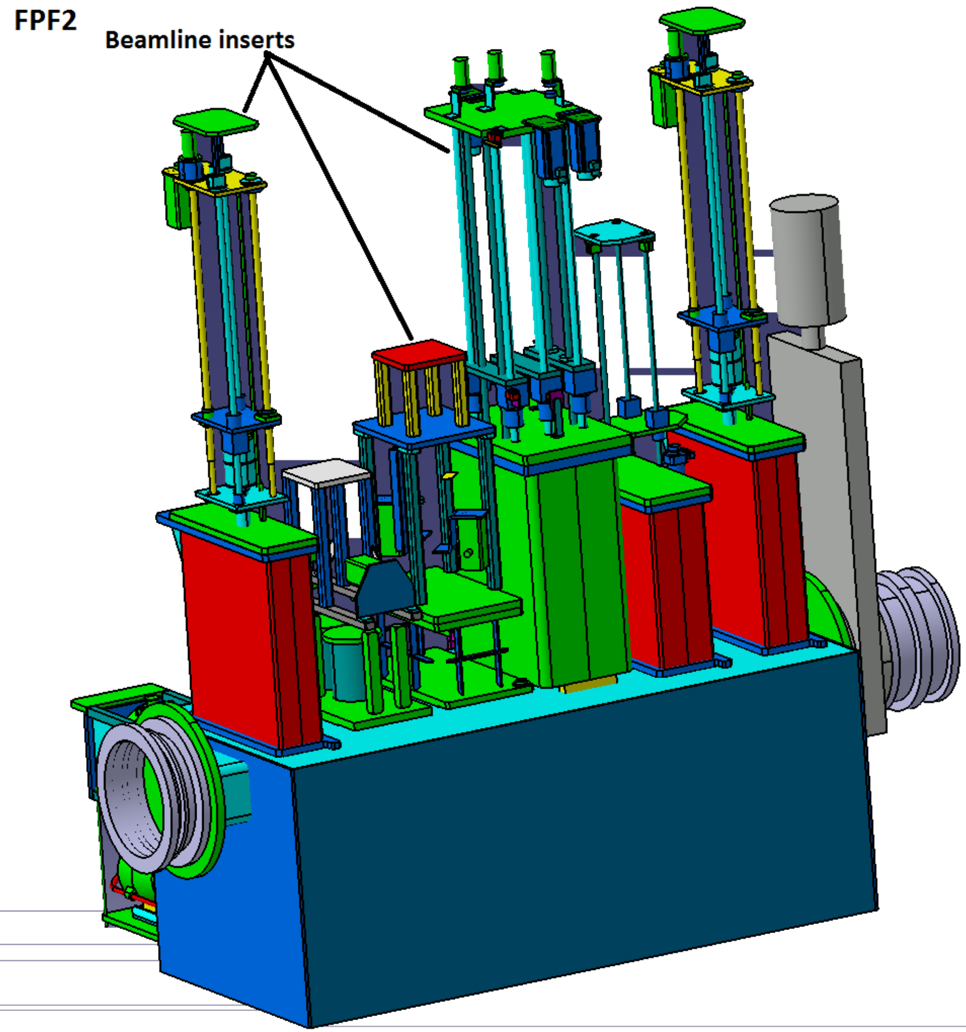
Project Selected



What need maintenance?



26 beamline inserts requires maintenance

FPF	Chamber Dimension Length, width, height/mm	Beamline insert
2	3352*970*1280	Beamstop Single detector X-slits Scintillator detector Degrader discs Degrader wedges and plates Detector space (reserved) Single detector
3	990*720*1130	Y-slits XY-single
4	3552*970*1130	XY-detectors PDC detector Reserved space Y-slits Secondary target X-slits TOF-Detectors XY-detectors
FMF	Chamber Dimension Length, width, height /mm	Beamline Insert
2a	1190*970*1130	XY-detector Xslits
2b	1195*720*280	Y-slits Degrader discs Degrader wedges and plates Finger detector
2c	1154*660*1130	TOF Detector XY-Detector

Systems Engineering

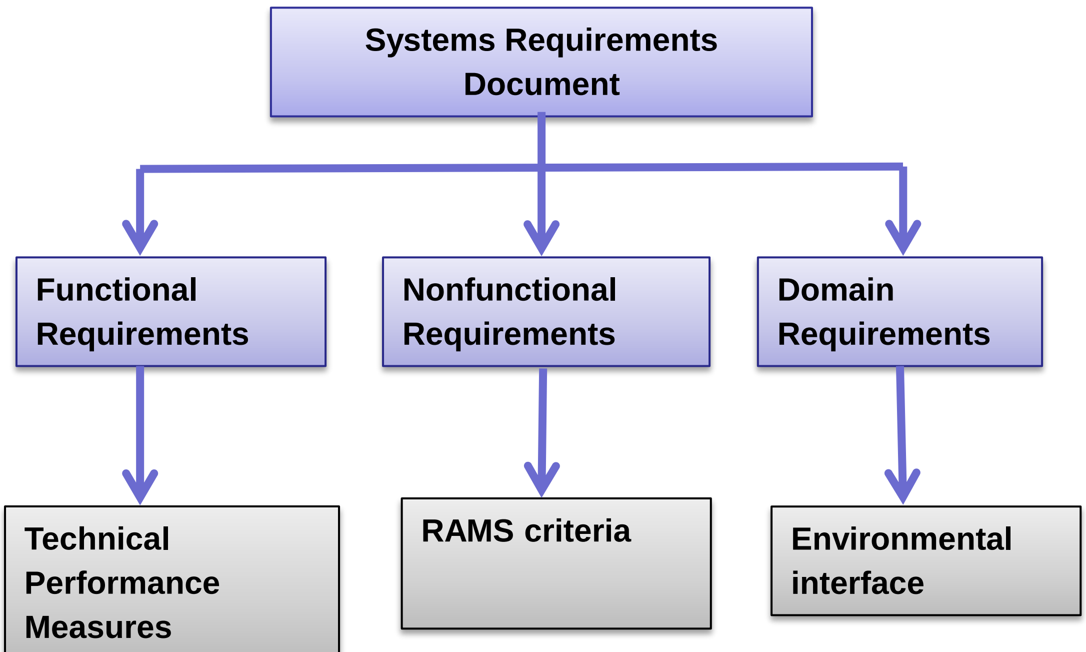
application

Requirements and components

S.No.	Remote maintenance system design requirements
1.	Remote and Safe manipulation
1.1.	Removal and installation of connector plates
1.2.	Removal and installation of heavy **beamline insert up to 750kgs**
1.3.	Safe environment for operator
1.4.	Longest beamline **insert to be handled 2080mm**
2.	**Remote inspection of surroundings**
3.	Transport of activated parts (within tunnel)
4.	Transport of activated parts (to main hotcell)
5.	Remote maintenance on beamline insert
5.1.	Minor repairs
5.2.	Major replacements and repairs
5.3.	**Transport and Disposal** of activated components
6.	**Suitable remote handling lifting point 2295mm** (Critical for lifting interface design and connector plate design position for beamline inserts)
7.	Parking space maximum width for remote maintenance equipment 3047mm (Critical for remote handling system parking interface design)
8.	Remote maintenance equipment must be prevented from becoming activated itself

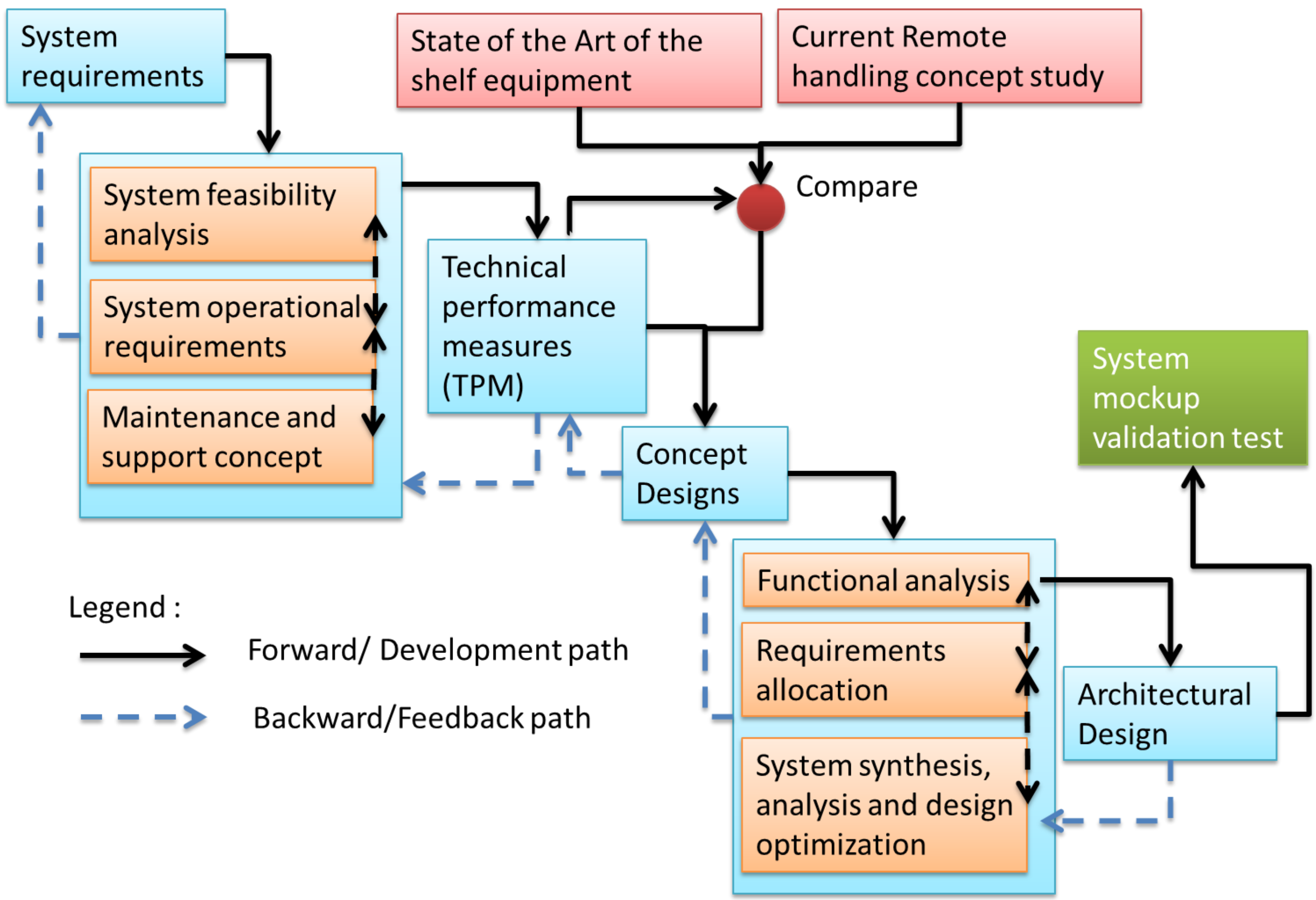
RH equipment logistics

- Functional performance
- Reliability
- Interface
- Cost Effective

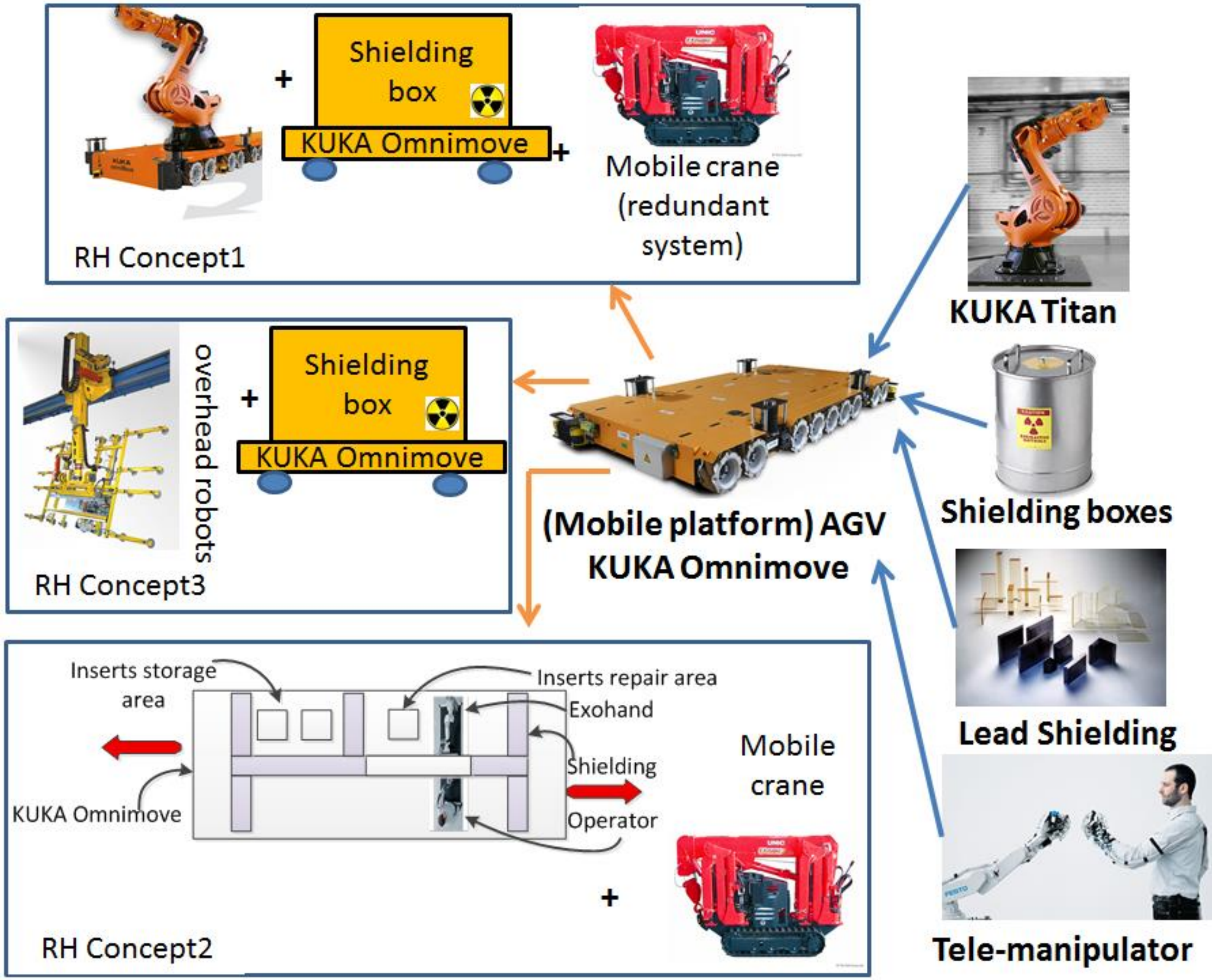


Research Approach (Systems Engineering)

Super-FRS RH main tunnel RH systems engineering framework



Concept solutions



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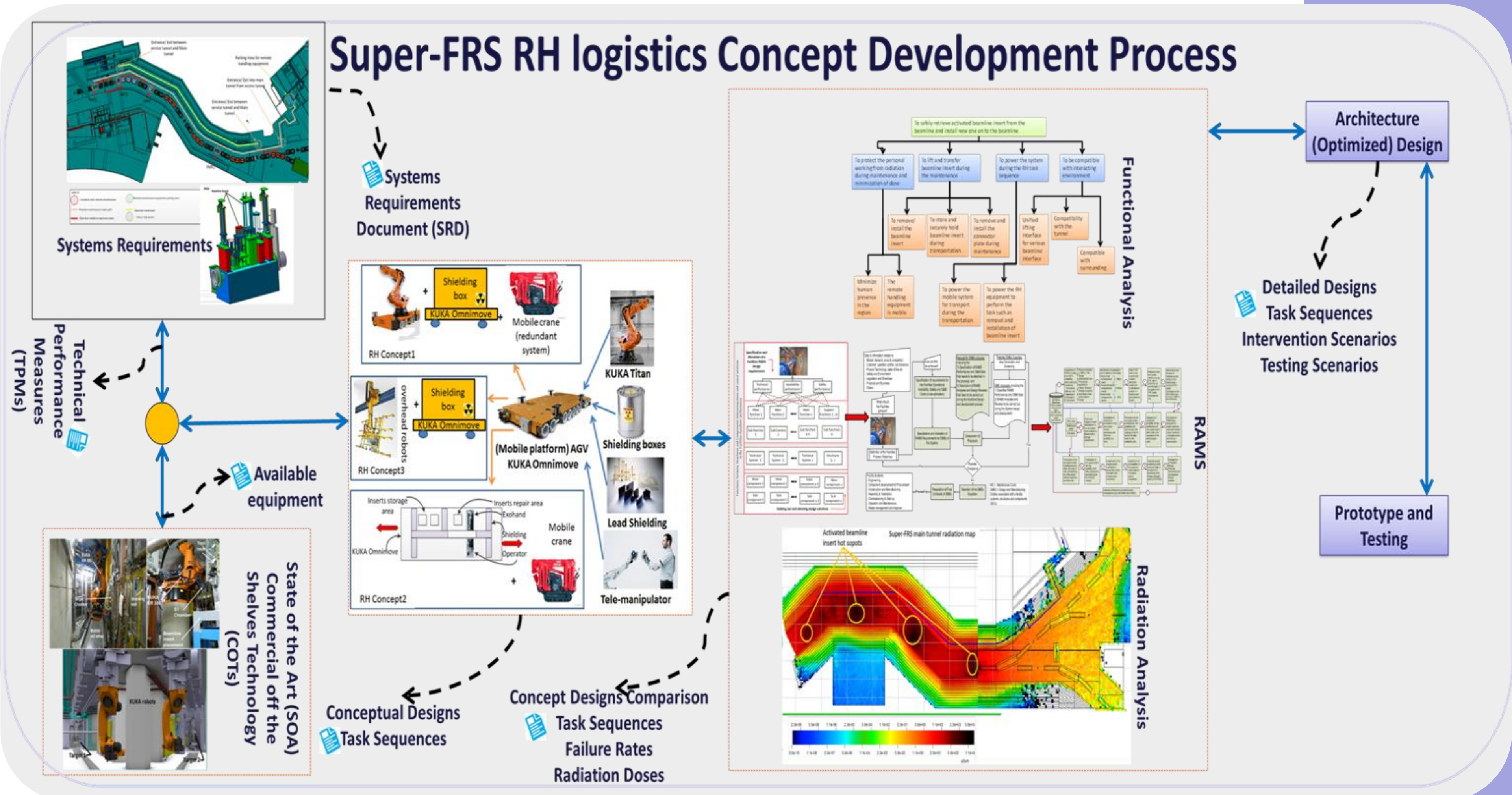
Developed Concepts

Activated waste Handling Systems for Super-FRS and FAIR

CERN

Super-FRS RH Concepts

Concept 1	Concept 2	Concept 3
• Six axis (KUKA titan [15]) robot to perform remote manipulation. • Mobile platform (KUKA omnimove [16]/ AGV) that can transport robot in-between parking position to maintenance region. • Mobile shielding container to transport activated beamline inserts. • Power supply, navigation and parking system.	• Tele-manipulator to perform mobile manipulation and inspection on beamline inserts. • Mobile platform (KUKA omnimove/ AGV) that can transport robot in-between parking position to maintenance region. • Remotely operated mobile crane to transfer beamline insert in between mobile platform and beamline. • Shielding wall to protect human presence. • Power supply, navigation and parking system	• Overhead crane with telescopic robot to lift the beamline insert. • Mobile shielding container to transport activated beamline inserts. • Power supply, navigation and parking system.


Super-FRS RH logistics Concept Development Process
Systems Requirements
Systems Requirements Document (SRD)
Technical Performance Measures (TPMs)
Available equipment
State of the Art (SOA) Commercial off the Shelves Technology (COTs)
RH Concept1
Shielding box
KUKA Omnimove
Mobile crane (redundant system)
KUKA Titan
RH Concept3
overhead robots
(Mobile platform) AGV KUKA Omnimove
Shielding boxes
Lead Shielding
Tele-manipulator
RH Concept2
Inserts storage area
Inserts repair area
Exohand
Shielding
Operator
Mobile crane
Conceptual Designs
Task Sequences
Concept Designs Comparison
Task Sequences
Failure Rates
Radiation Doses
Functional Analysis
RAMS
Radiation Analysis
Activated beamline insert hot spots
Super-FRS main tunnel radiation map
Architecture (Optimized) Design
Detailed Designs
Task Sequences
Intervention Scenarios
Testing Scenarios
Prototype and Testing

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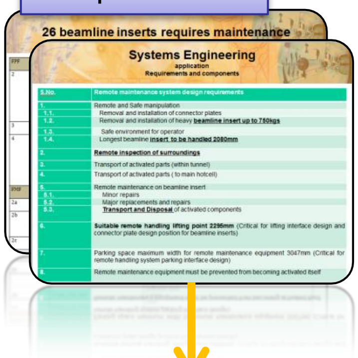
Requirements

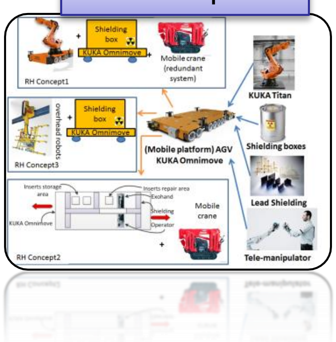


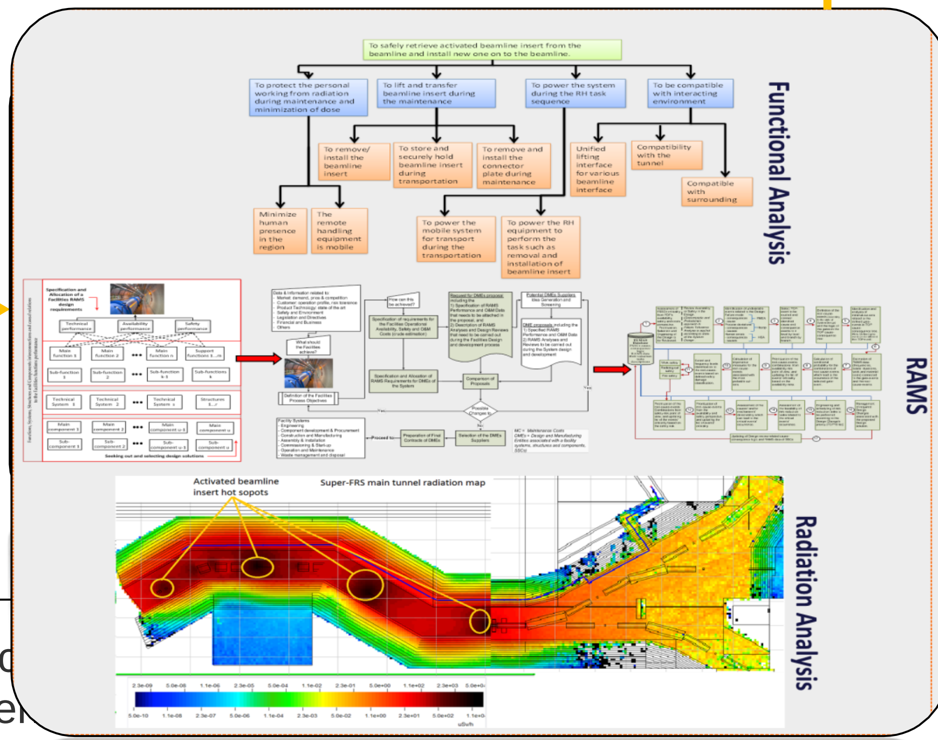
State of the art

Optimized Solution

TPMs

Concepts





Best of three
Future work

- None of the three concepts fulfills 100% of requirements. But fulfills the performance requirements. Modification to each solution is required
- Evolution of the system over course of 30-40 years has to be taken into consideration
- Recoverability and maintainability are also key issue that needs to be addressed
- Onboard electronics needs to be reduced or protected during operation
- Criteria to select the RH equipment for Super-FRS
- Concept three in the analysis has been better than others two but cost and R&D to Super-FRS system is higher.
  - Cost to change the Super-FRS tunnel and beamline interfaces will be larger
  - Additional tele-operation capabilities will improve the ability of the system to perform remote maintenance

Results

- Systematic approach with specific steps to develop RH logistic concepts
- RH equipment compatible to conduct remote maintenance
- RH task sequences for conduct remote maintenance
- Functional, FMEA and Radiation analysis
- Cost estimates for the RH components
- Criteria to select the RH equipment for Super-FRS

Collaboration & Interaction

- PURESAFE Collaboration (RP2 and RP1)
  - RP2: collaboration include the development of intervention scenarios for the RH task sequence
  - RP1: RAMS analysis for the Super-FRS task sequence ongoing
- PURESAFE partner institution interactions
  - CERN (two months of secondment)
  - OTL (one month secondment)
  - TUT (two months secondment)
- PhD Studies Tampere University of Technology
  - Prof. Jouni Mattila
- Private Sector (KUKA robotics, Hager-GmbH, Getinge Group, Westinghouse, etc)
- Research Institutes (JPARC, PSI, Differ, HiT, GANIL)

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Summary

- PURESAFE projects knowledge developed can be implemented at Super-FRS (tele-operation, augmented reality, configuration management, and intervention planning)
- Developing remote handling requires resources and manpower since it is time consuming
- Systems engineering approach increase the understanding of RH problems within complex system
- The new tools adopted in this research needs development, so they can be used on much higher level
- Open mind to developing such solution is very important
- Sometime remote handling is not the one of important aspect with in the facility design. But it becomes important during as beam intensities increases with time.
- Particle accelerator facilities will evolve hence it is strategic decision to select RH equipment

Thanks for your attention

Questions Comments