Engineering in the Bunker

Utilities and Cable routing
Remote handling

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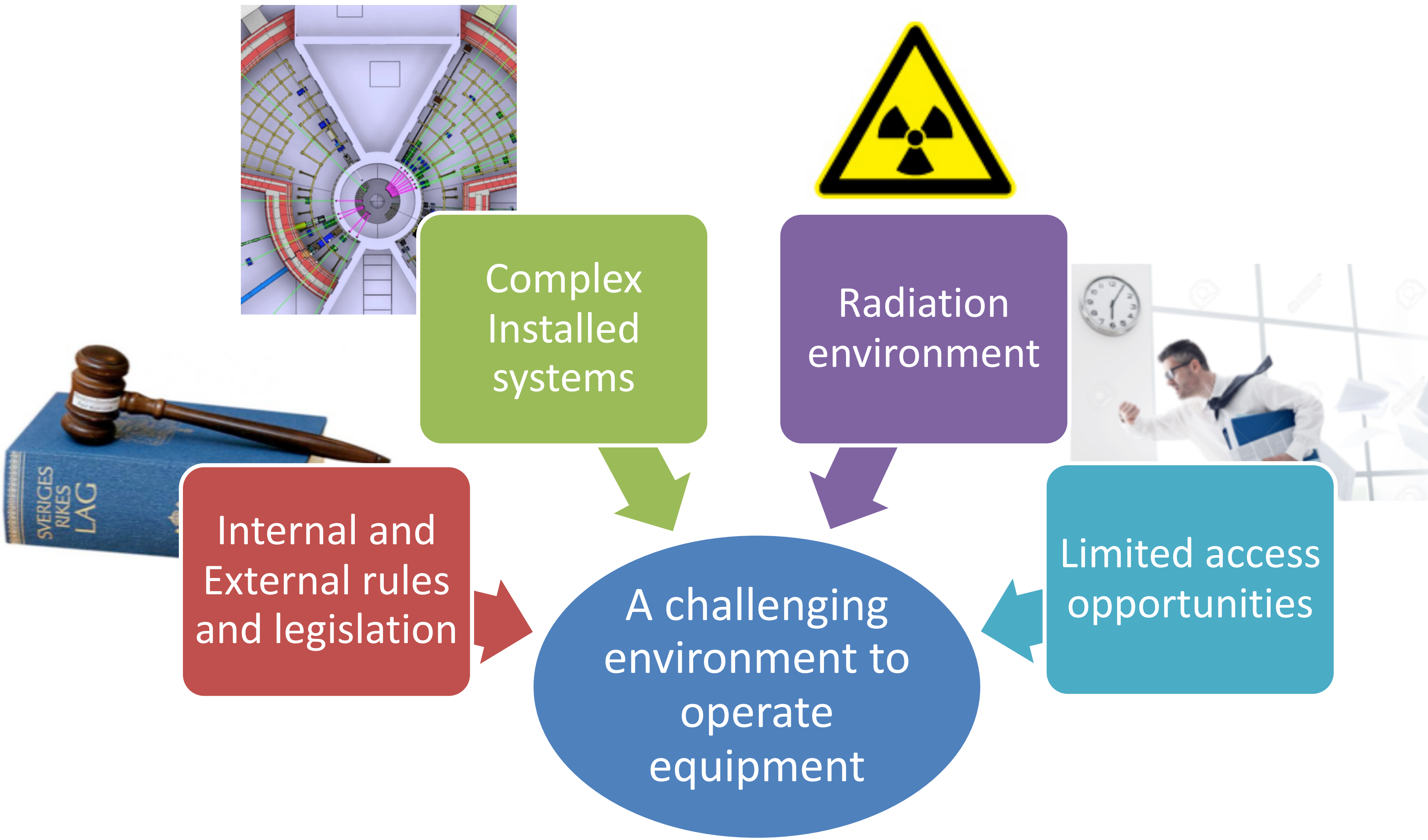
www.europeanspallationsource.se
15 February, 2018

ESS unique source, with unique boundary conditions.



Strategy

Proposed strategy

- Zero equipm
- E
- M
- Ro

s

Reality check !

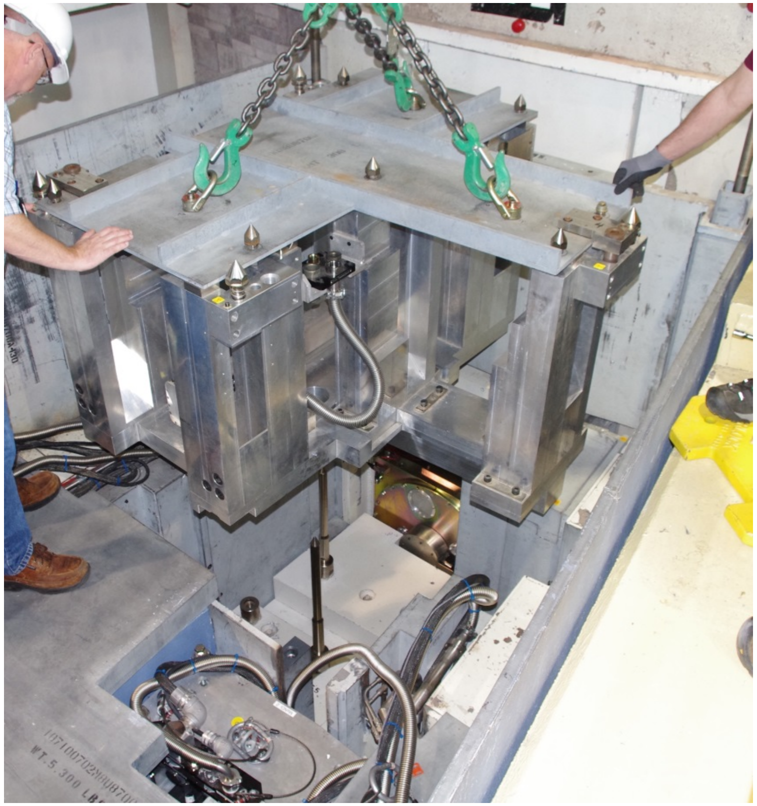
Real plan

Do a little bit of each ….

….. and a little engineering magic

Lessons learned

- SNS (1-1.4MW)
  - Critical systems prepared for remote handling
  - Activation levels increasing (10 years of operation)
- J-PARC (~0,5MW)
  - Critical systems designed for remote handling
  - Maintenance equipment handled remotely
- ISIS (~200KW)
  - No RH compatibility on instrument component
  - Still manageable after 30 years
- JET (Joint European Torus)
  - Forced to retrofit RH components
  - 3-5 times longer handling time on upgraded equipment compared to original RH designs

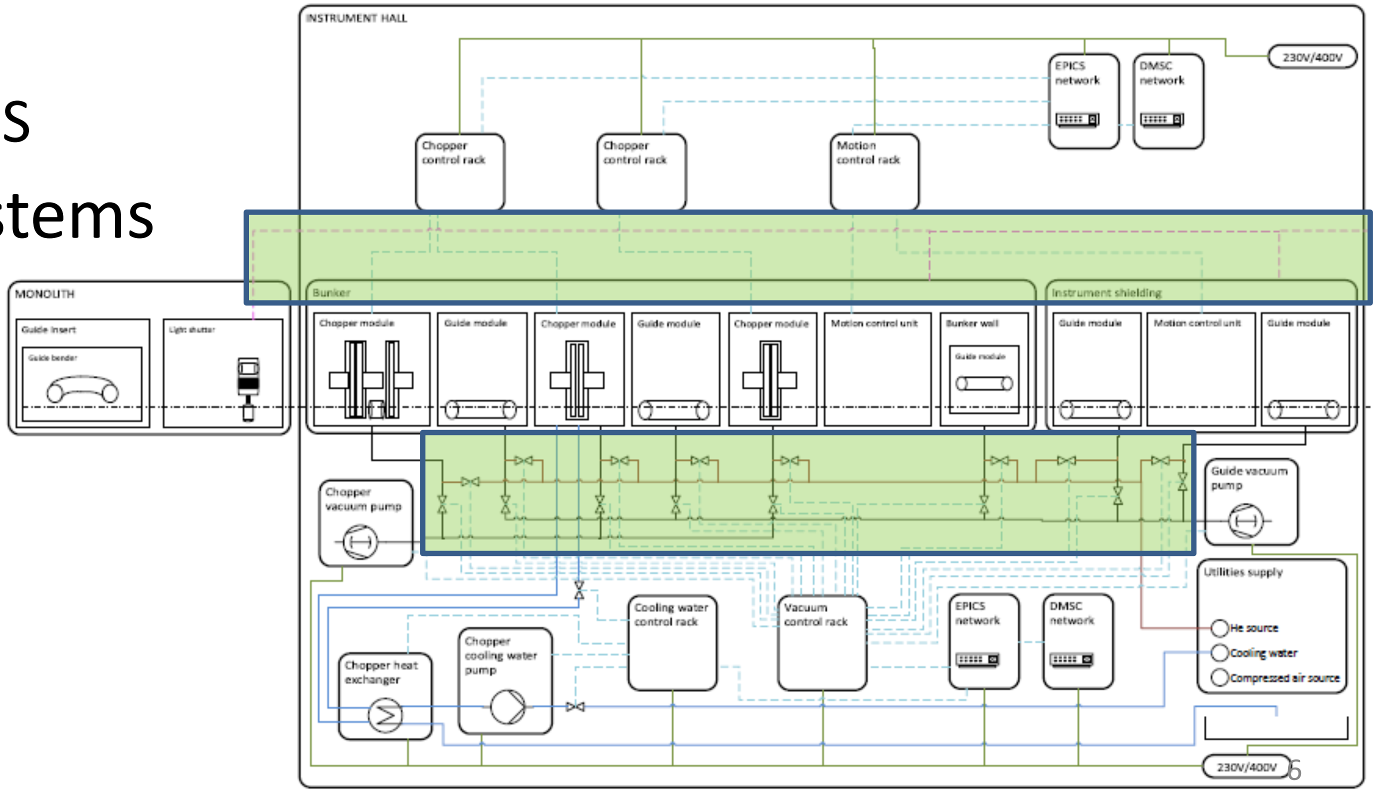


Large (dual beamline) RH module at SNS

There and back again …..
Utilities routing in the bunker

Scope

- Instrument
  - power & control
  - Cooling
  - Vacuum
  - PSS / MPS
- Bunker systems
  - Power
  - Lighting
  - PSS
  - Fluids



Utilities
Why ?

But isn't this part of instrument scope ? YES !!!

But ….

- There are at least 8 different stakeholders (6 internal)
- Many constraints
- Access to equipment / Compatibility with RH
- Operability
- Difficult to understand environment
- In short it's a messy issue!

Or wouldn't you rather find cable trays pre-installed and you just use them ?

If so lets talk !

Utilities routing plan for a plan

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Requirements → Concept → Solution development → Generic solution

Requirements

Needs

- Electrical power
- Signal
- Vacuum
- Cooling
- PSS / MPS

Constrains

- Access
- Grounding
- Fire
- Radiation

Concept

An illustration to explore parameter space and for discussion with stakeholders

Solution development

Exploring options
Evaluating solutions
Meeting needs & constraints

Generic solution

Making decisions
Defining solutions
Getting agreement

Output

A generic concept based on a toolbox of solutions which can be tailored to specific instrument needs

Cabling and utilities
Route (s)

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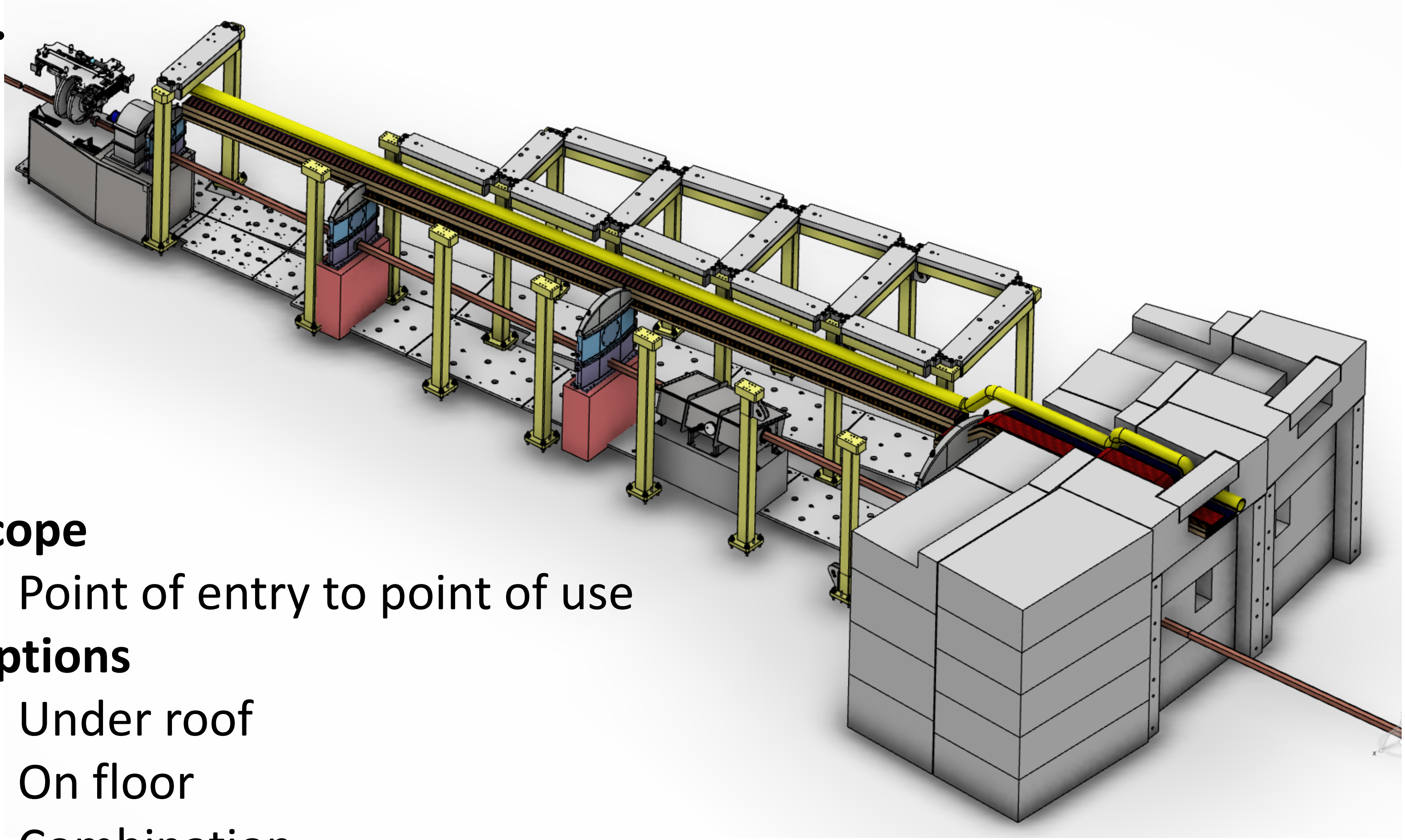


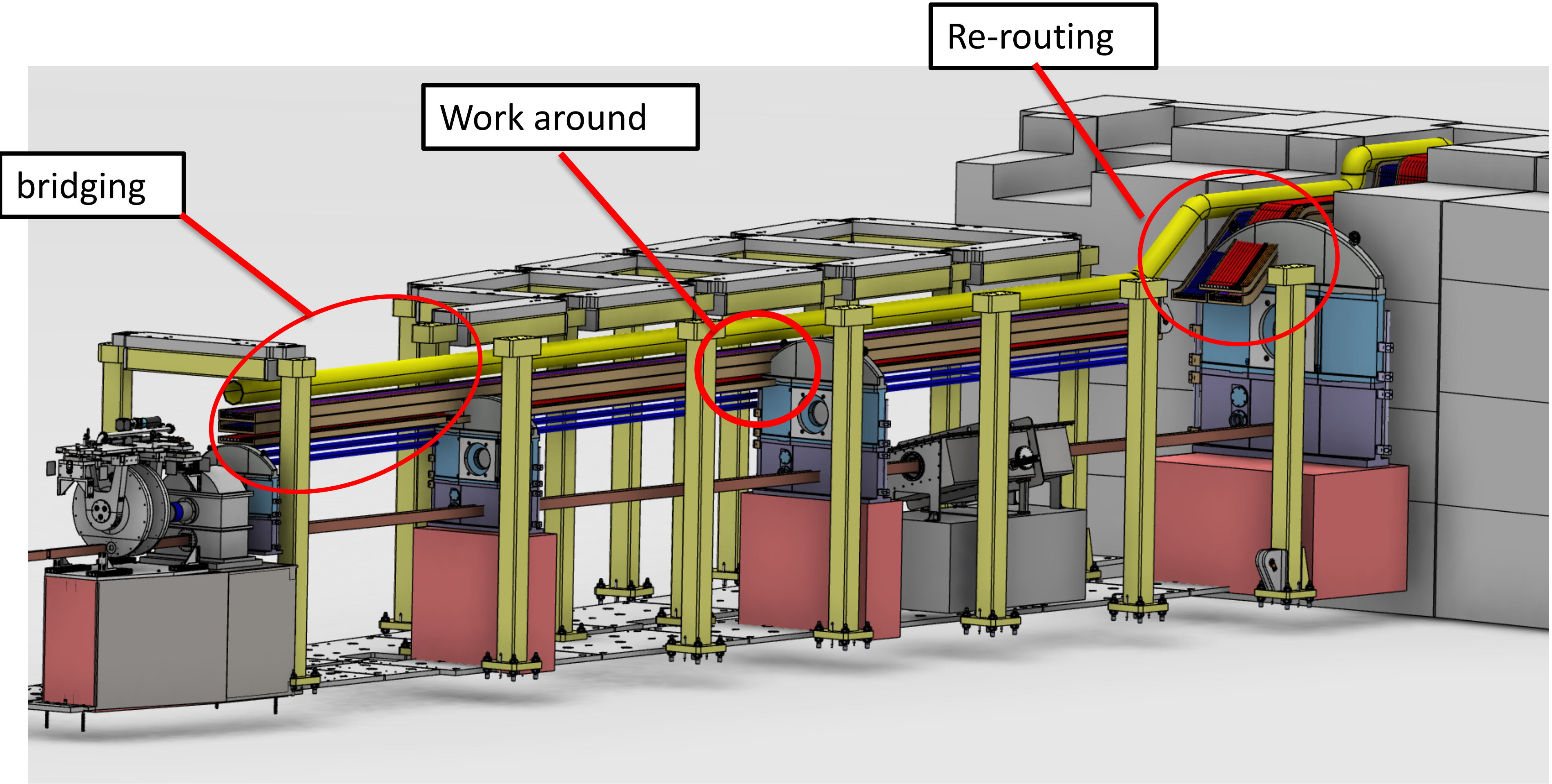
Scope

- Point of entry to point of use

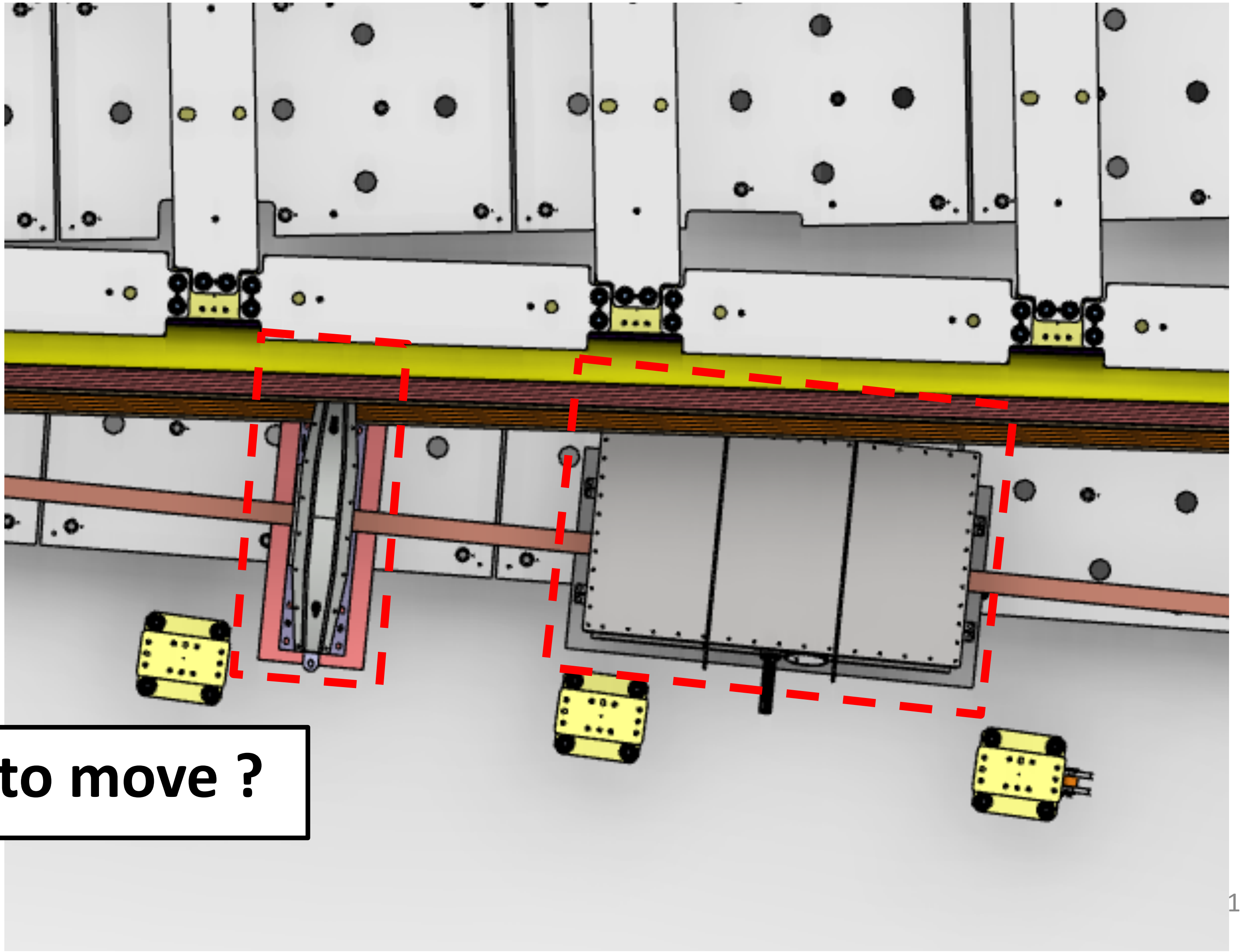
Options

- Under roof
- On floor
- Combination

Issues
Clashes



Issues extraction

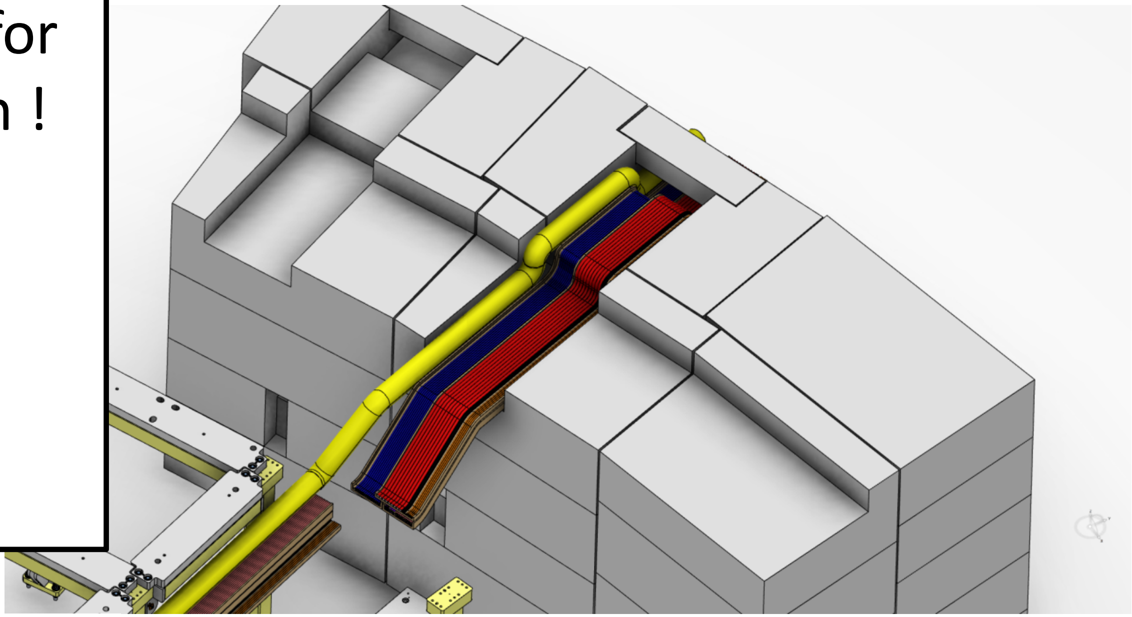


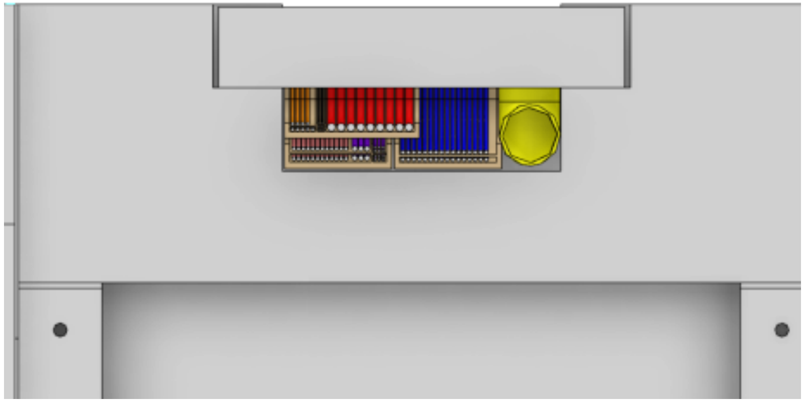
Room to move ?

Cabling and utilities feed throughs

- Sufficiently spacious for needs and installation !
- Accessible
- Radio quiet

Modular





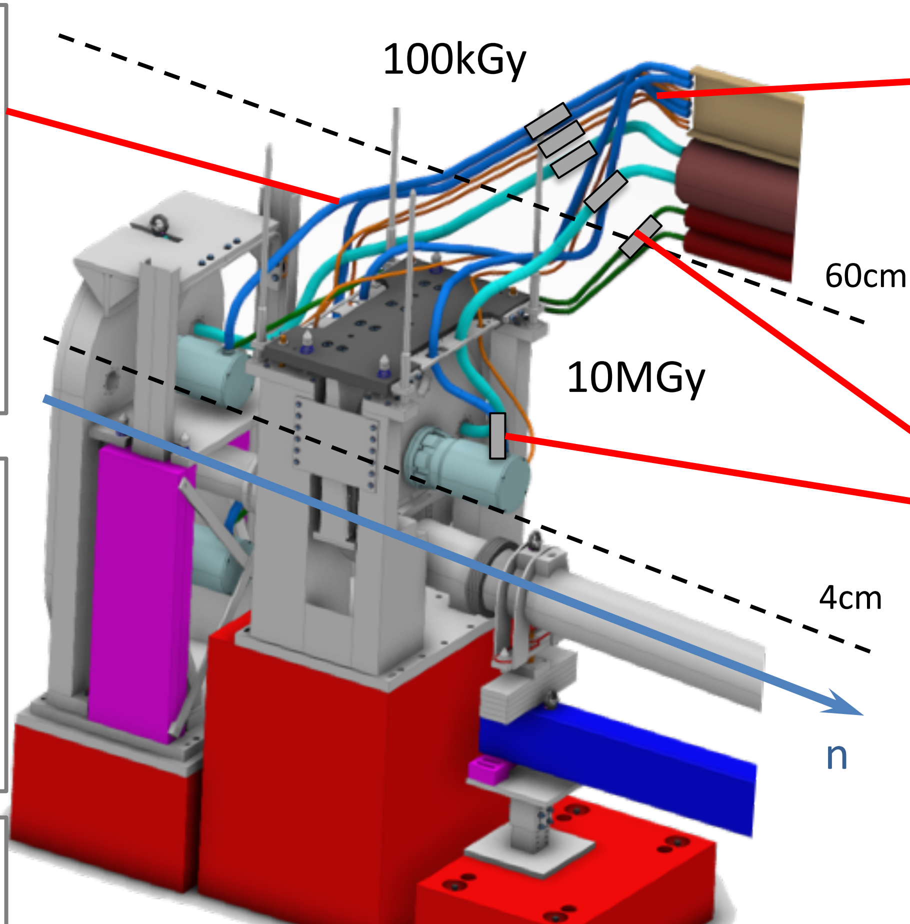
Radiation damage
Use of hardened components

Cables
Radiation spec cables:
Huber Suhner RADOX 125
(3 MGy)

AXON Polyimide TPI
(20MGy)

Sensors
Vibration Sensor:
Vibro-Meter CA901
(10 MGy)

Switches
Mechanical limit switch:
Crouzet 83151 **(10 MGy)**



MORE INFORMATION IN RH
DOCUMENT ESS-0042943

Cables
Standard cables, PU isolated
(100 kGy, **to be tested!**)

Connectors
Push-Pull, RH ability:
Lemo B-series (Materials:
SS AISI 303 + PEEK plastics)
(10 MGy, to be confirmed!)

Positioning Motors
Stepper motors:
Phytron VSS **(1 MGy)**

Brushless DC motors:
Wittenstein MRSR **(10 MGy)**

Deployment
a graded approach

MGy	6.05m–7m	7m–8m	8m–10m	10m–12m	12m–
Standard EPDM O-ring (max. 250kGy)	100	86	71	44	10
Rad Hard EPDM O-ring (max. 20MGy)	10	8.6	7.1	4	1
Aluminum Gasket (> 20MGy)	200	170	140	81	20

0m, 6.05m, 7m, 8m, 10m, 12m

60cm, 4cm, 2.8cm

Moderator

Neutron beam size 6x6cm

n

Requirement Specs ESS-0059912

Wrap up

Key dates

- Concept for comment — end February
- Generic design by — end April

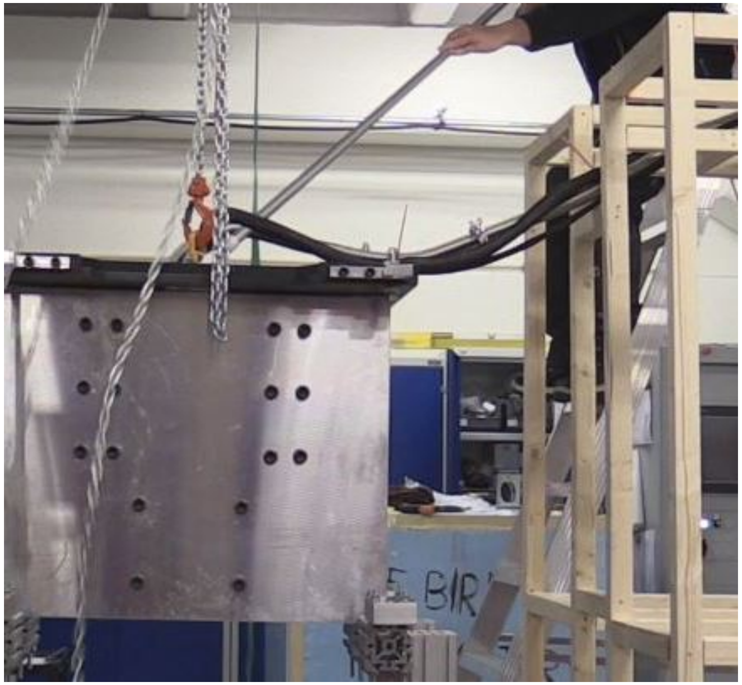
Contact

- Talal Osman

- Means of contact
- Confluence
  - https://confluence.esss.lu.se/x/moAVBw

Remote handling,
Strategy and Best practices

What is remote handling



ESS chopper extraction test

FRM-II Guide replacement
Image courtesy of E. Calzada

ISIS Long tool test
Image courtesy of P. Galsworthy

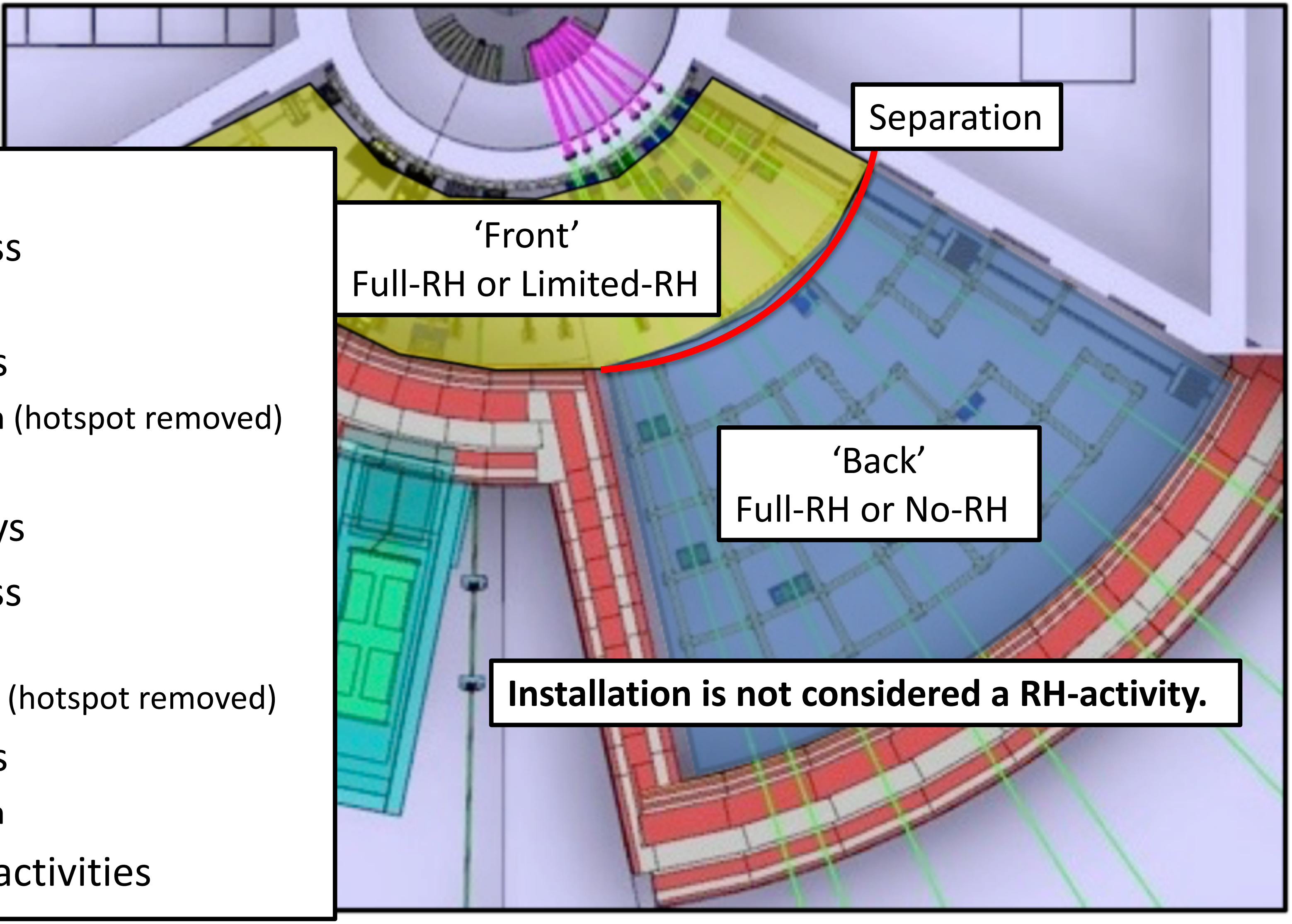
Implementation

After 48-72hrs

- Front access
  - RH only
- Rear access
  - Hands on (hotspot removed)

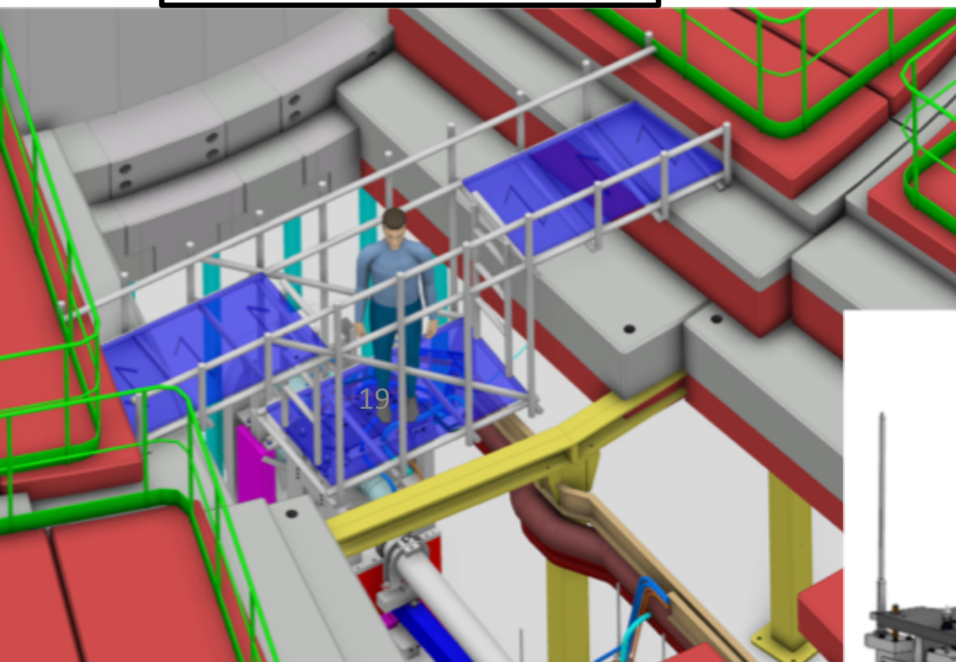
After 10-15days

- Front access
  - RH only
  - or Hands (hotspot removed)
- Rear access
  - Hands on
- Restricted activities

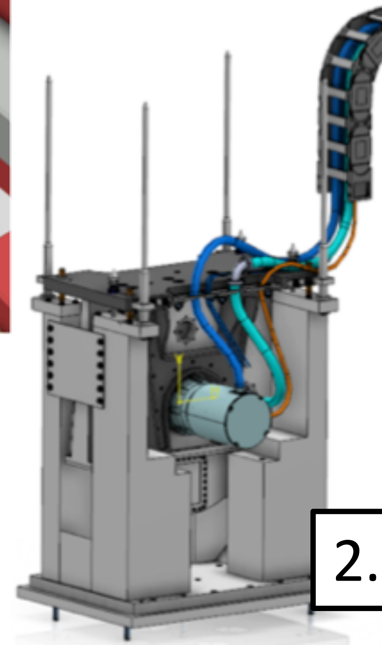


Remote handling
Simple as 1, 2, 3 …. (?)

1. Vertical access



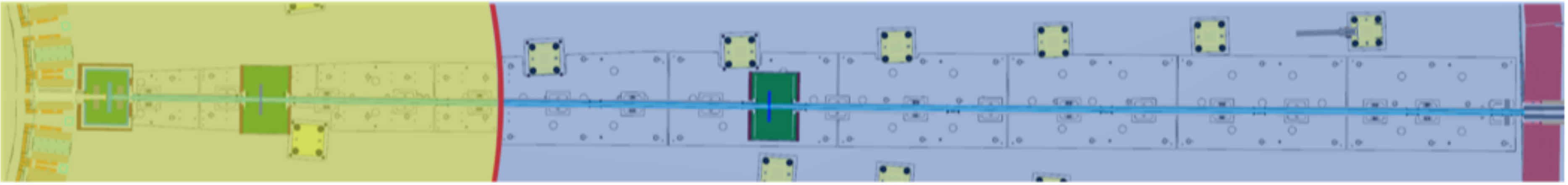
3. Long manual tools



2. RH Ready equipment

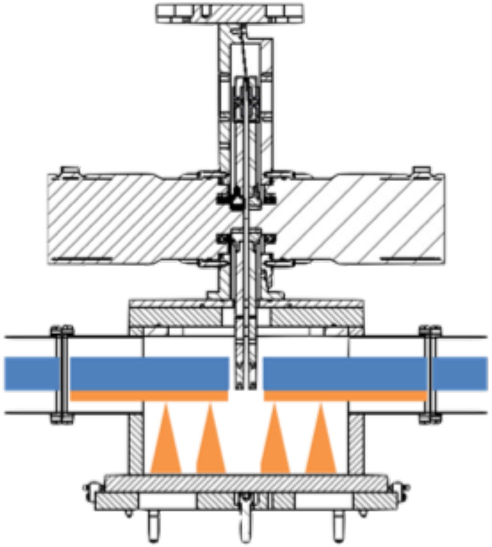
Worked example - Bifrost

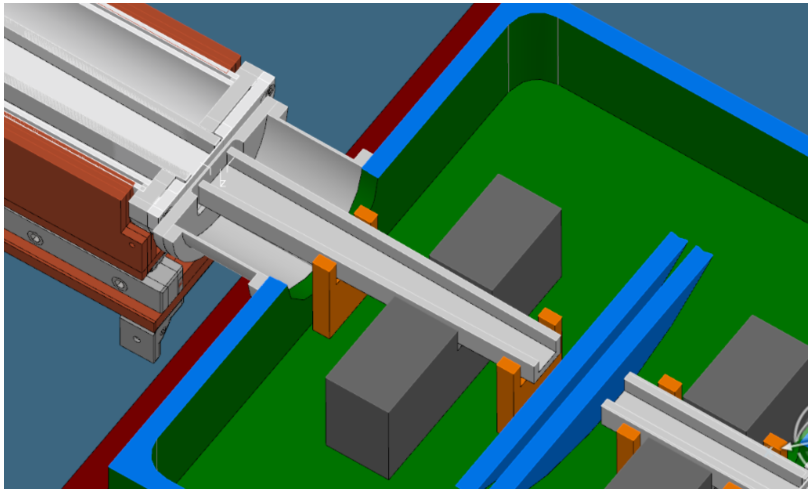
2x Guide modules – Limited RH R11.5 **Guide modules – No RH**

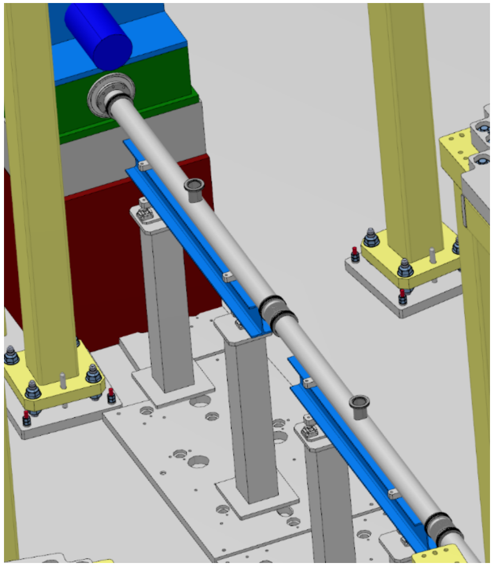


2x chopper modules, Horizontal split variant
Chopper assembly – Full RH
Lower enclosure with guide sections – Limited RH

Chopper module, Horizontal split variant
Chopper assembly – Full RH
Lower enclosure with guide sections – No RH

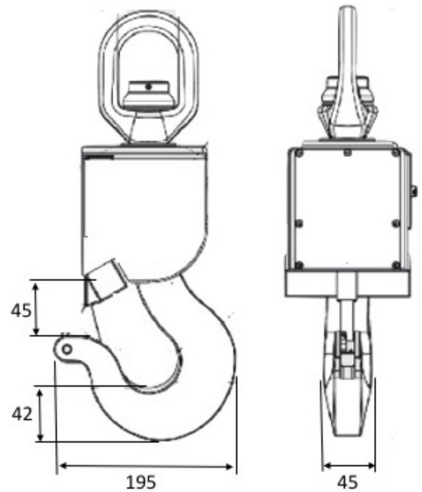




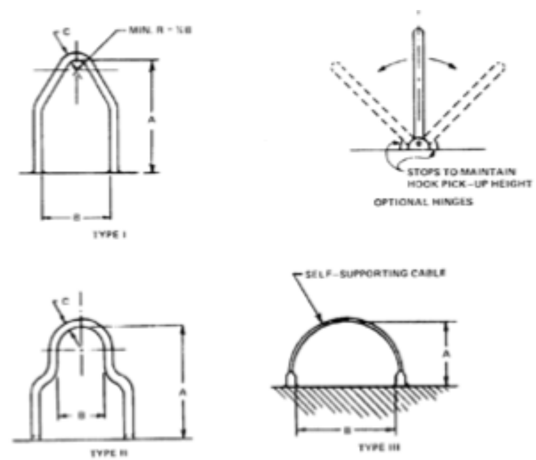


Lifting, grappling and handling

- Module weight <5000kg
- Simple operations (One operation at a time)
- Single directional lifting (vertical extraction path)
- Guided single point lifting where possible
- Multiple point lifting acceptable in special cases.



5 tone hook interface



Single point lifting examples

RH engagement test

Design Strategy:

Standard ESS concepts.
Instrument realisation and supply.

Supply type:

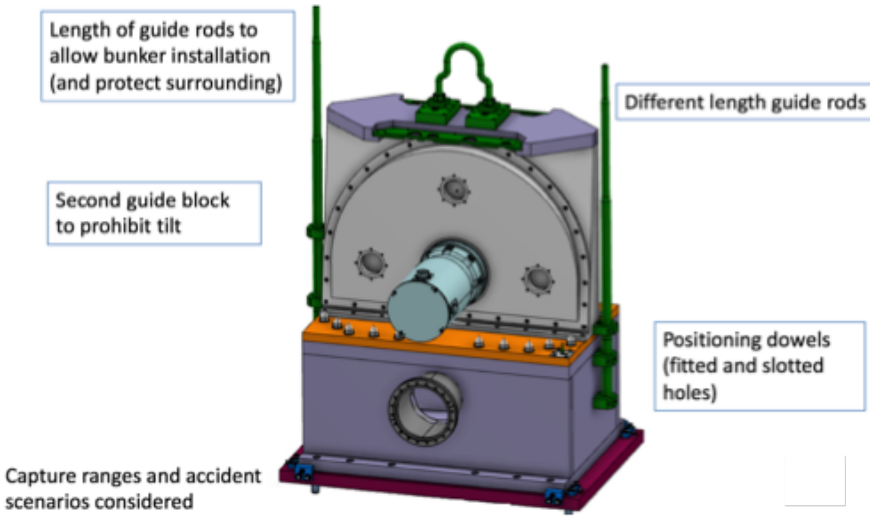
Conceptual design drawings and specifications.

Timeline:

March

Safe alignment of module

- Design to avoid wedging and jamming and lock one degree of freedom at a time.
- Use guide rods when visibility is good room for stiff rods. Otherwise rollers are preferred.
- Avoid leaving alignment features under load when in-situ.
- Important to place dowels correctly.
- Place survey interfaces close to adjustment locations.
- Specific strategy for positioning of guide sections (See Iain's talk on Thursday.).



Design Strategy:

Defined requirements and materials.
Base range of components.

Supply type:

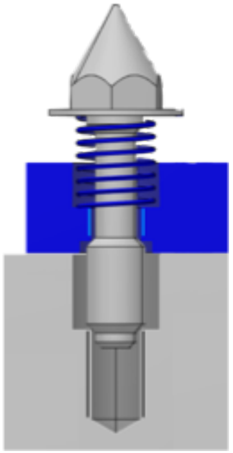
Defined base set of components.
Additional components added to approved list when identified by instrument teams.

Timeline:

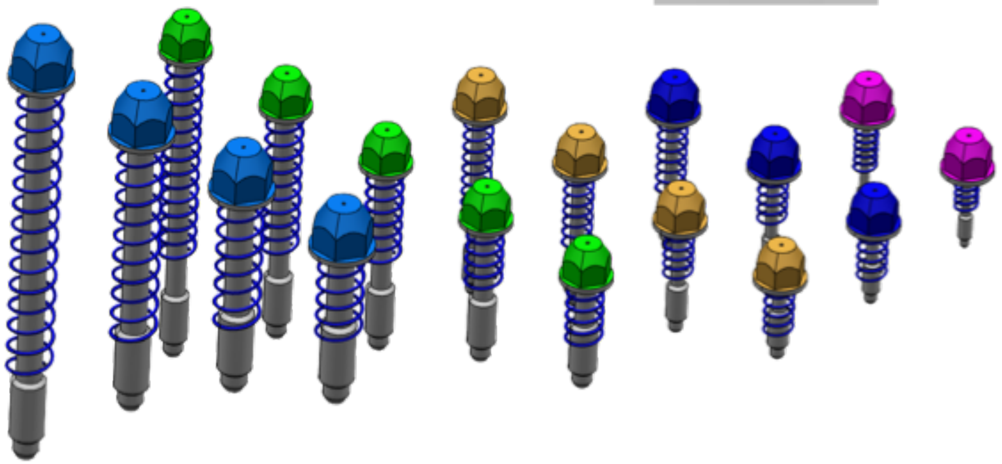
April

Fasteners

- Remote handling fasteners for remote handling interfaces.
- Few bolts as possible.
- Few sizes as possible.
- Captive pop up design.
- Titanium screws.



Material	Standard	Price coeficient
Low cobolt (<0,2%) stainless steel	1.4404 / 316L	3,6
Titanium Alloy	Ti6Al4V	2,2
Aluminium alloy	7075	0,7
Stainless steel	1.4404 / 316L	1



Design Strategy:

Standard ESS design.
Instrument supply.

Supply type:

Full range design, drawings and specifications

Timeline:

February

Clamp and bellow

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- Development with ESS vacuum group.
- Promising commercial clamp solutions employed at CERN.
- Only required in Yellow zone.

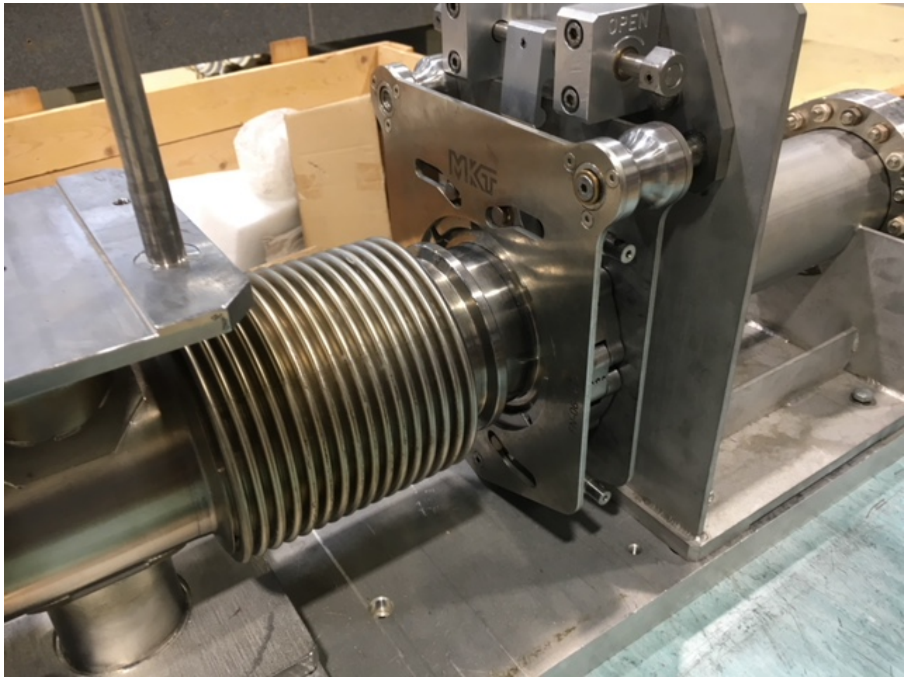


Image courtesy of CERN

Design Strategy:

Standard ESS design. Instrument supply.

Supply type:

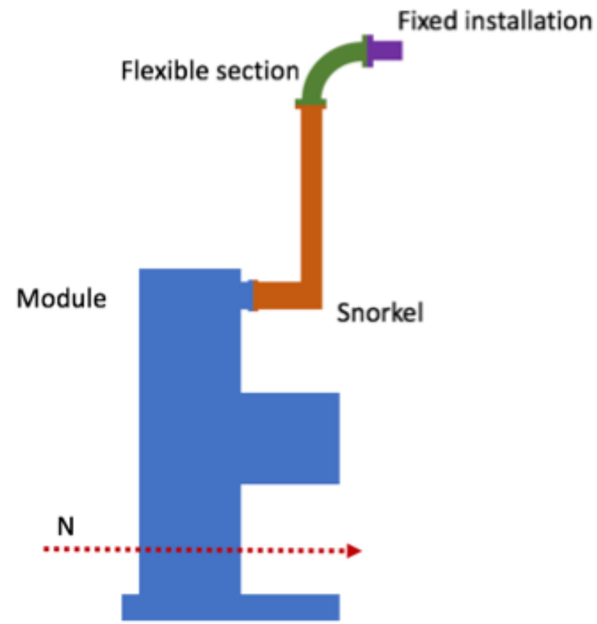
Full range design, drawings and specifications

Timeline:

August

Connectors

- Utilities routed in three sections
  - Self supporting snorkel
  - Flexible section
  - Fixed section
- Bundling of connectors
- Push-pull type connectors



Design Strategy:

Defined requirements and materials. Base range of components.

Supply type:

Defined base set of components. Additional components added to approved list when identified by instrument teams.

Timeline:

June

Other areas of best practice

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- Failure analysis
  - RH features shall not be damaged in any failure scenario.
- Viewing and visibility
- Identification
- Activation
- Decontamination

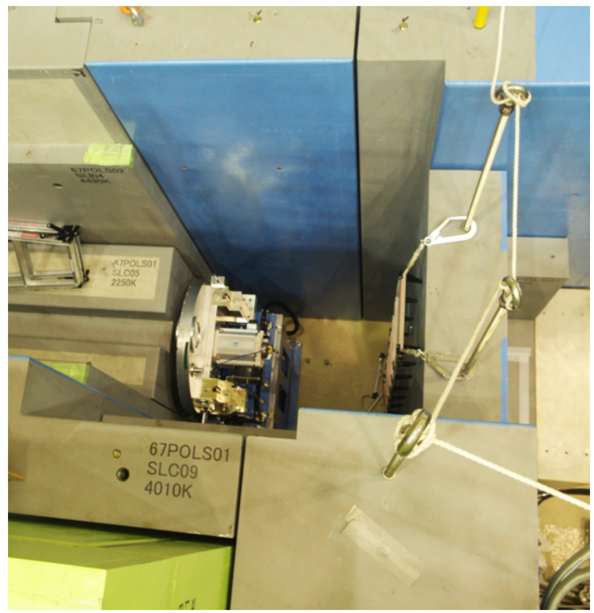


Image courtesy of J-PARK

<u>Design Strategy:</u>

Rules and guidelines only.

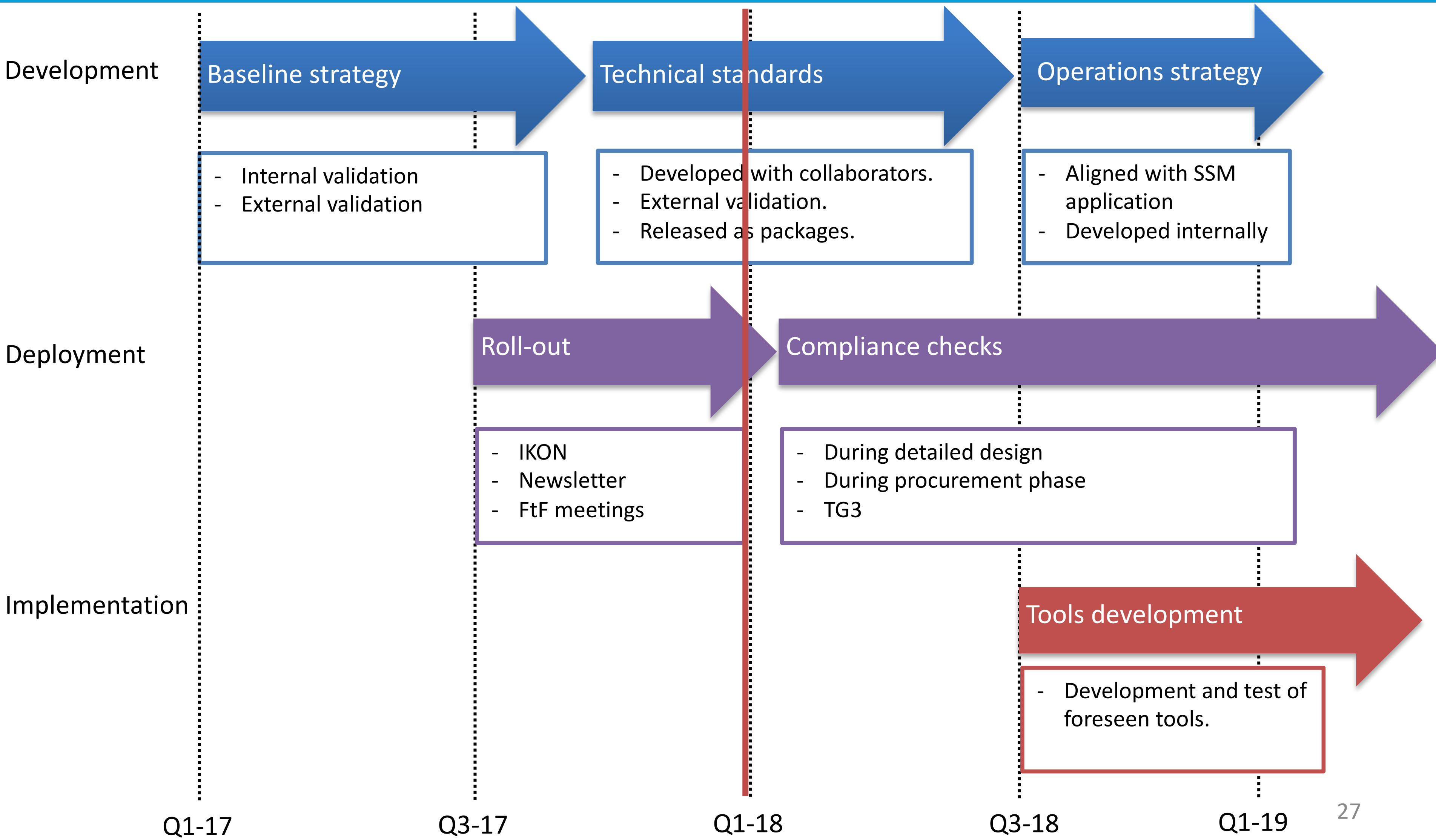
<u>Supply type:</u>

Written rules and guidelines. Specific implementations will be shared through confluence page.

<u>Timeline</u>:

June 2018

RH Deployment plan



More and detailed information in: ESS-0042943

Living database on:
https://confluence.esss.lu.se/display/SD/NSS+Remote+handling+Homepage

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Thank you for your attention

Questions?

Extras

Dose on personnel – chopper example

Whole body dose @ about 30 cm [μSv/h]						
Delay following beam shutdown	Material	1h	1 day	3 days	7 days	1 year
Guide upstream of the 1st chopper	Aluminium (5083)	200	<3	<0.5	<0.5	<0.5
Guide downstream	Aluminium ?	<25	<3	<0.5	<0.5	<0.5
Collimator (streaming)	Copper	<50	<25	<3	<3	<3
Chopper (no steel)	Aluminium housing / Alu rotor	300	<50	<3	<0.5	<0.5
Heavy shutter	Tungsten / no housing	1000	100	<50	<25	<25
T_0 chopper (Tungsten hammer)	Tungsten / steel housing	1000	100	<50	<25	<25
Inside rear bunker wall (with lead)	Lead /PolyConcrete/ Steel	<3	<3	<3	<3	<0.5

Contact dose [μSv/h]						
Delay following beam shutdown	Material	1h	1 day	3 days	7 days	1 year
Guide upstream of the 1st chopper	Aluminium (5083)	1000	50	<3	<3	<3
Guide downstream	Aluminium ?	40	<3	<3	<0.5	<0.5
Collimator (streaming)	Copper	1000	200	<25	<25	<25
Chopper (no steel)	Aluminium housing / Alu rotor	15000	200	<25	<3	<3
Heavy shutter	Tungsten / no housing	20000	1000	500	<100	<100
T_0 chopper (Tungsten hammer)	Tungsten / steel housing	20000	1000	500	<100	<100
Inside rear bunker wall (with lead)	Lead /PolyConcrete/ Steel	<3	<3	<3	<3	<0.5

Note all calculations assume **idealized configurations** and ignore effects of trace material impurities
Exposition prior to shutdown is assumed to be **100 days at full rated power (5MW)**

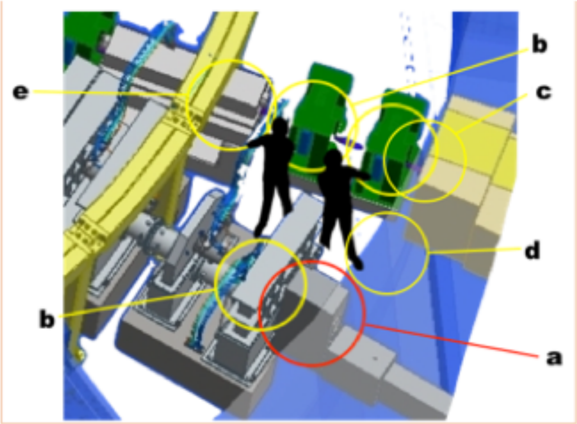

Figure 4 - Front end work

The workers receive the following dose,

a) Contact dose from T0 Chopper – 500μSv/h
a) Contact dose from two sections of guide – 6μSv/h (3μSv/h each)
b) Proximity dose (30cm) from three choppers – 9μSv/h (3μSv/h each)
c) Proximity dose (30cm) from one heavy shutter – 50μSv/h
d) Proximity dose (30cm) from bunker rear wall – 3μSv/h
e) Proximity dose (30cm) from copper collimator – 3μSv/h

Total dose adds up to 571μSv/h.

Integrated dose adds up to 95mSv per year for the maintenance of choppers

Facility limit of 2mSv/year on staff

48 man chopper group

Comparable results on other technology fields

RH classification process

Graphical illustration of the ESS process for Remote Handling Classification of instrument modules. ESS-0042943