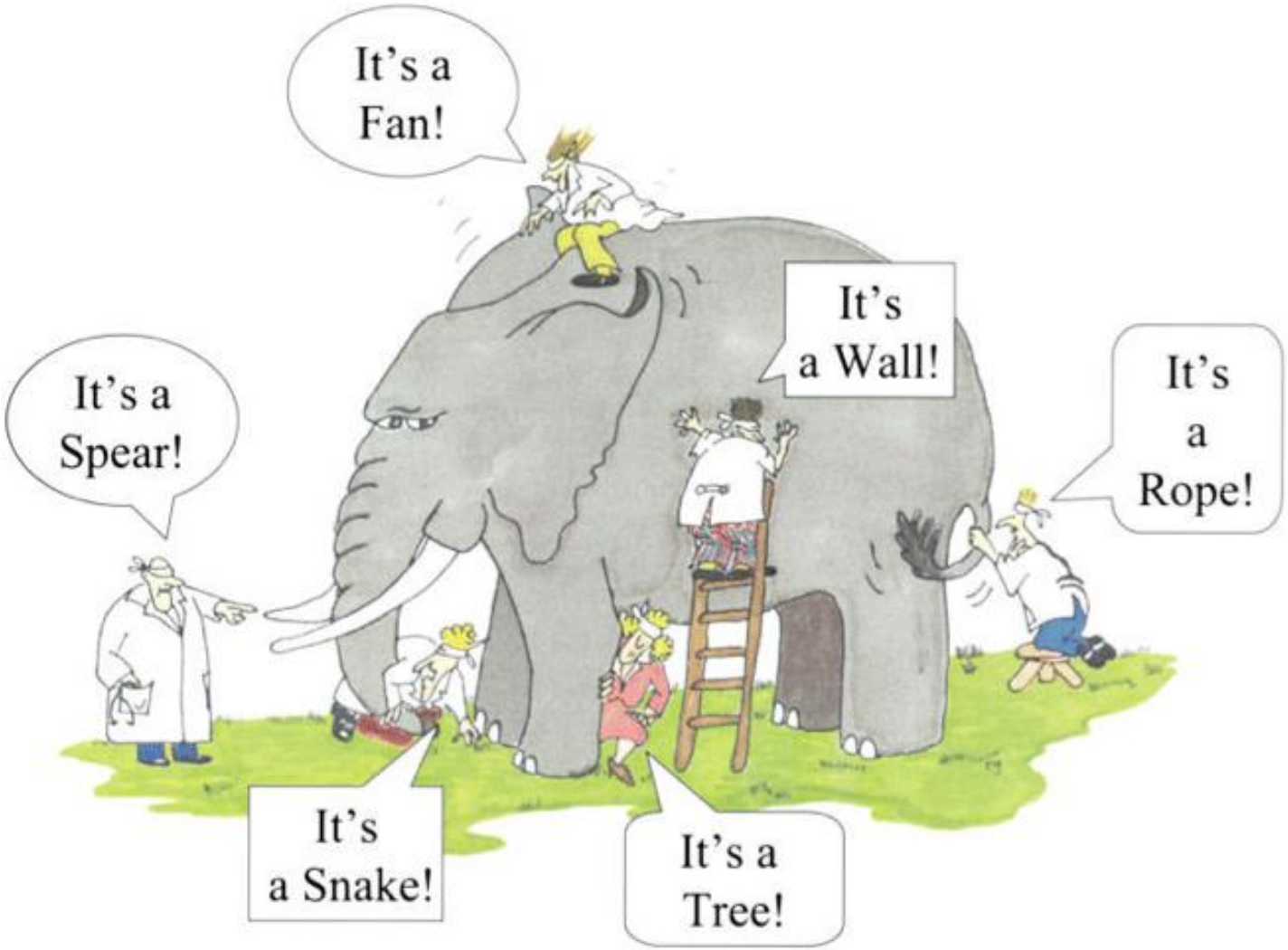
A workshop on neutron guide engineering

Or some personal ideas you might consider when approaching the engineering of long guide systems at the ESS….

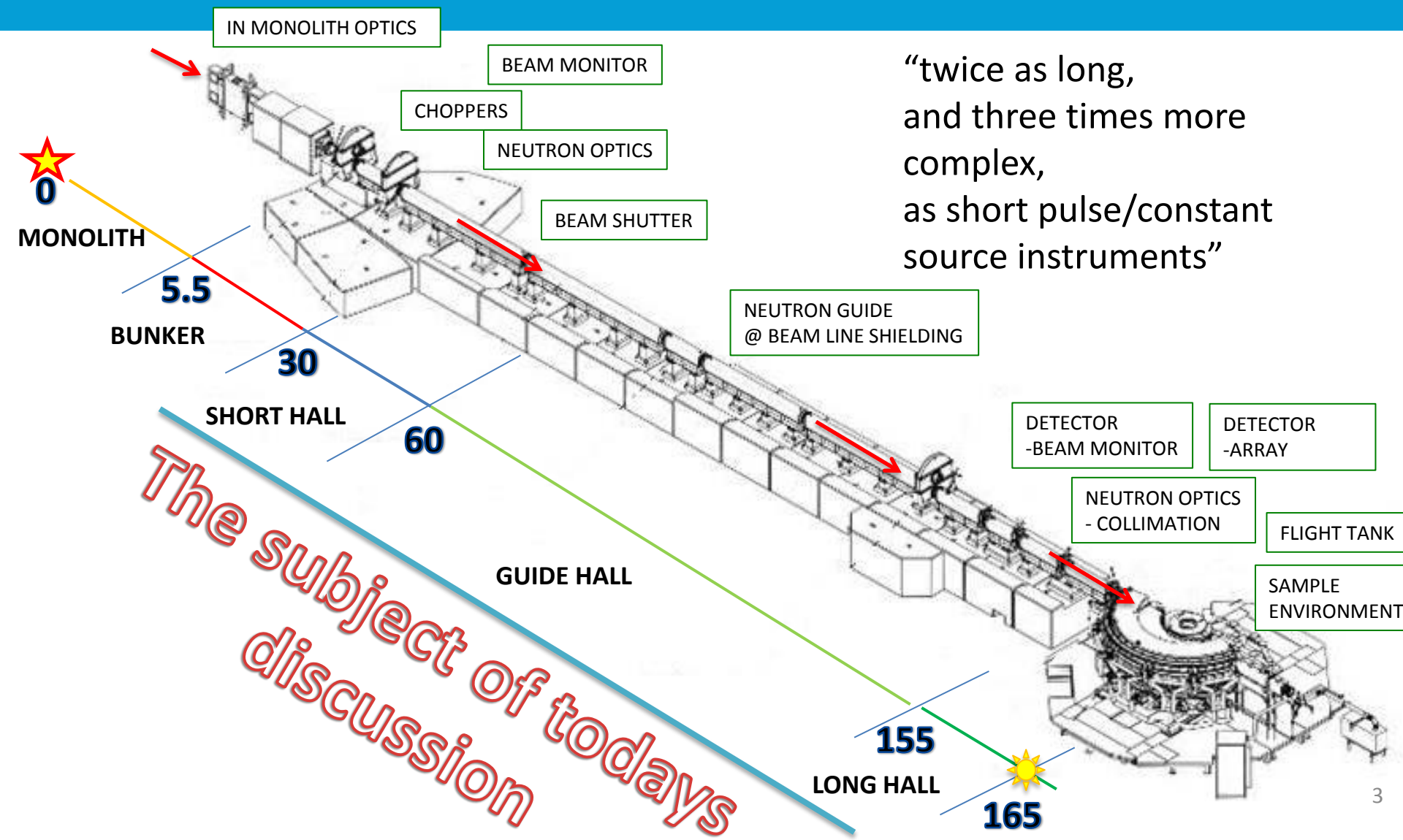
IKON 14 Feb 2018

I.Sutton ESS, NSS Technical coordination

Seeing beyond the details …
to capture the (elephant) big picture.



ESS instruments



"twice as long,
and three times more
complex,
as short pulse/constant
source instruments"

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Lets be clear about this ….

My

Assumptions, Presumptions

& Subjectivity

Assumption about you

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Performance IS important to you !

- Real performance (not paper performance)
  - Day one performance
  - ‘Real life’ day 1000 performance

Cost IS a constraint

- Full life time costing
  - Construction
  - installation
  - Operation
  - Decommisioning

Assumptions from me

Base assumption

- Alignment is correlated to Performance
- The settlement will affect alignment

Thus to maintain performance ;

- Engineer systems tolerant to settlement
- Facilitate corrective maintenance (re-alignment)

- Alignment will be conducted using laser tracker

Hence our stated objective becomes

"To establish engineering solutions, which maintain guide performance in service though, tolerance to settlement and facilitating corrective maintenance, at the lowest total lifetime costs "

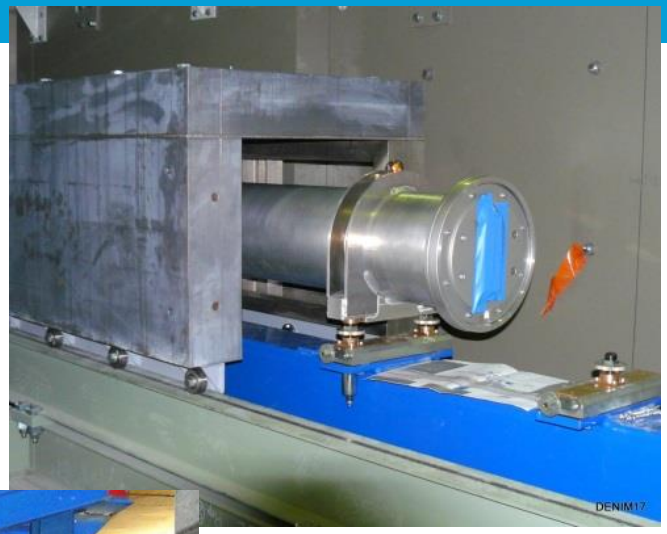
… having defined our objective we can explore potential solutions …

Consider the system as a whole

Cradle to grave costing

Hardware
- Optics
- Pressure housing
- Support
- Shielding

All phases
- Installation
- Alignment
- Maintenance
- Disposal



H14 Guide shielding ‘railway’

Within the specific context of Long guide system

Specific drivers

Length !!!!!

- Cost scales ~linearly with length !
  - Reduce costs per meter
- Misalignment is cumulative & scales linearly (or worse)
  - Engineer in stability
- Building to building movement
  - 2 feed-throughs

Some (a very little) Context

The road to here …

Historical Context

Generation I ‘1960-90’

Evacuated glass & strong-back

Generation II ‘1980 -’

Evacuated housing

Generation II ‘2000 –’

Simple ‘unit housing’ & Strong-back

State of the art Systems

Competing approaches

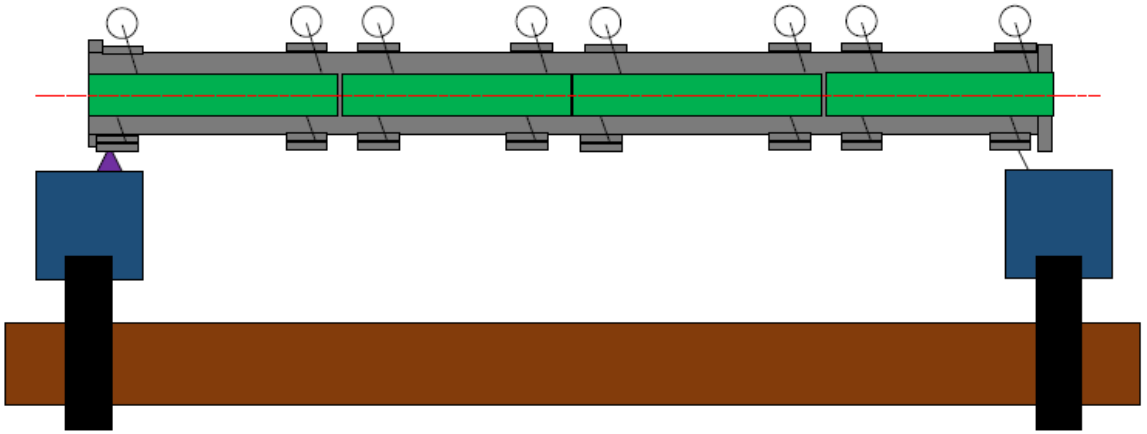
1. Simple unit & strong back

2. ‘Stiff housing’

System level
- architecture

Comparative merits

Exhibit C
Stiff housing

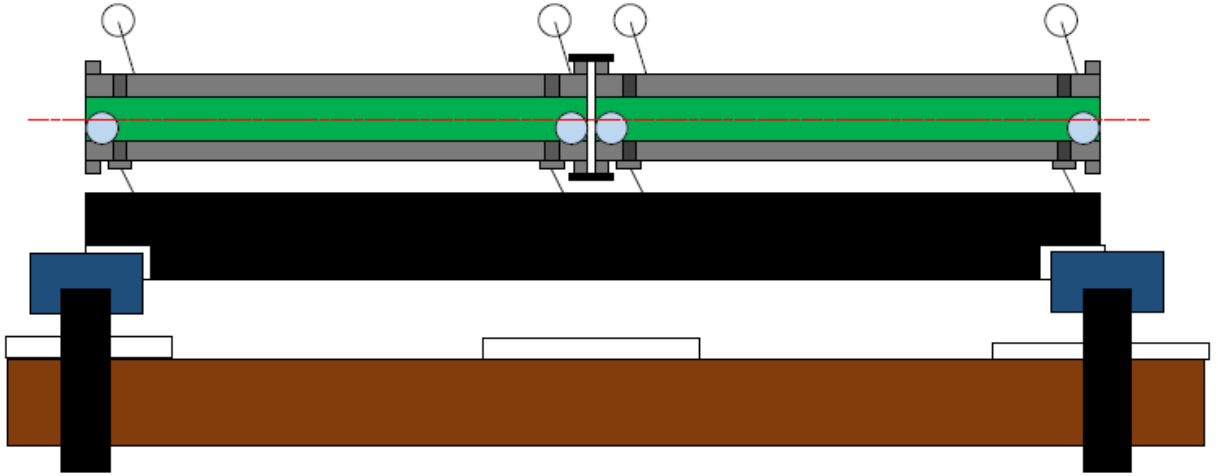


Features
- Self supporting
- Alignment devices incorporated in housing

For
- Easily available
- Customizable
- Cheaper supports

Against
- Movement under vacuum

Exhibit B
Simple/unit/strongback

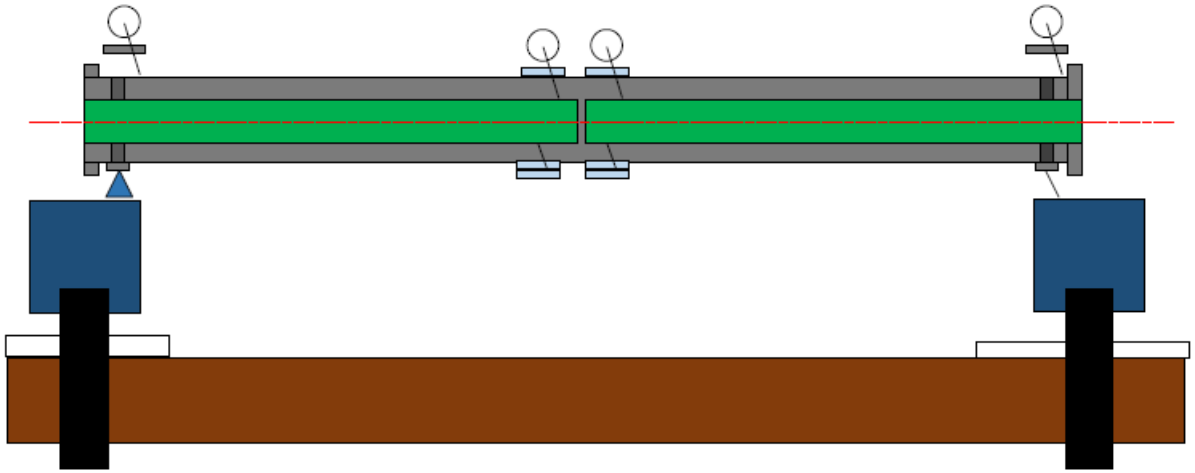


Features
- Support beam
- Optics fixed
- Rigid

For
- If standardized cheap
- Rigid
- Alignment under vacuum

Against
- Long guide sections
- Support beam cost

Exhibit A
Stiff housing II



Features
- Self supporting
- Guide is fixed

For
- If standardized cheap
- Rigid
- Alignment under vacuum

Against
- Long guide sections

?

As yet untried
but why not ?

Evaluation

	Alignment accuracy	speed of alignment / in lab	speed of alignment / on site	Manufacture cost - housing	Manufacture cost - optics	Ease of re-alignment	Repair costs	Vacuum leak rate	Tolerance to ground moveme	Ease of inspection	Total
Stiff housing Evo	3	2	4	4	3	3	2	5	3	3	32
Unit strong-back	5	3	4	3	3	5	3	3	3	5	37
Stiff housing	1	5	1	2	5	1	4	3	2	1	25

Unit Strong or Stiff housing Evo most favourable

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Sub System level
Drill down to the engineering details

Optics

Recommendation

Use the longest feasible guide section.

Why ?

Because alignment require skill, equipment & controlled conditions – i.e. suppliers lab!

Benefits

- Lower cumulative alignment error
- unit – unit & section - section
- Cheaper housing
- Cheaper installation

Housings

Materials

Unit housings

- Aluminium alloy (Passivated)

Stiff housings

- Low alloy steel (Epoxy painted inside & out)

Length 2 or 4m

Cost drivers

- Machining (flanges, windows, alignment bosses)
- Welding
- Surface finishes (painting)

Vacuum

Recommended operating vacuum

1x10e-1 mbar (5x10e-2)

- DN 50 (TBC) port every 2nd housing
- Vacuum sensor on housing probably OK

Balance cost / performance

- Engineering achievable and cheap, maintainable

Leak rates

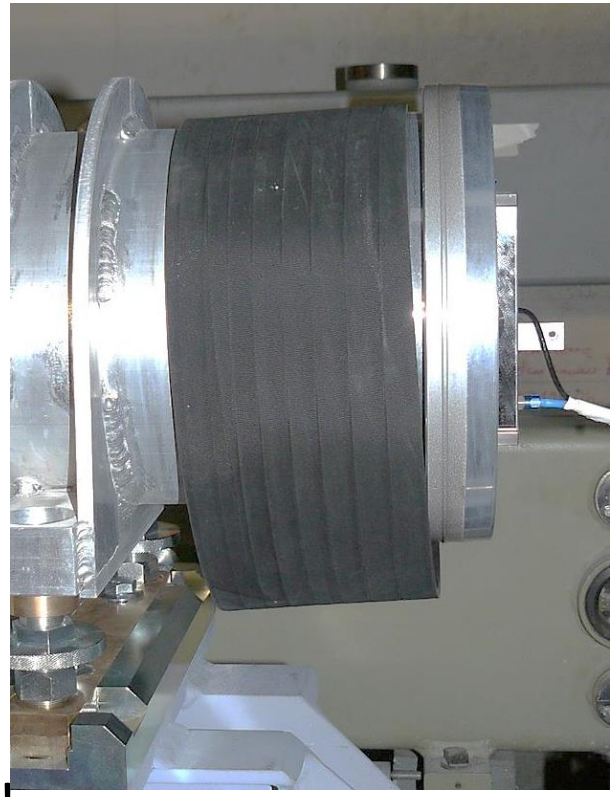
- 10e-7 mbar/ltr/sec (?)

Sealing
housing to housing

My recommendation

- Use rubber bellows where you can
- Metal where you must (welded spire)

- Use EPDM (EP8571) commercial or nuclear grades



Advantages of rubber

- If you standardize on flanges they are cheap !
- They are flexible – reducing alignment error
- ‘ILL’ design or FRM-2 (FRM2 is more robust)

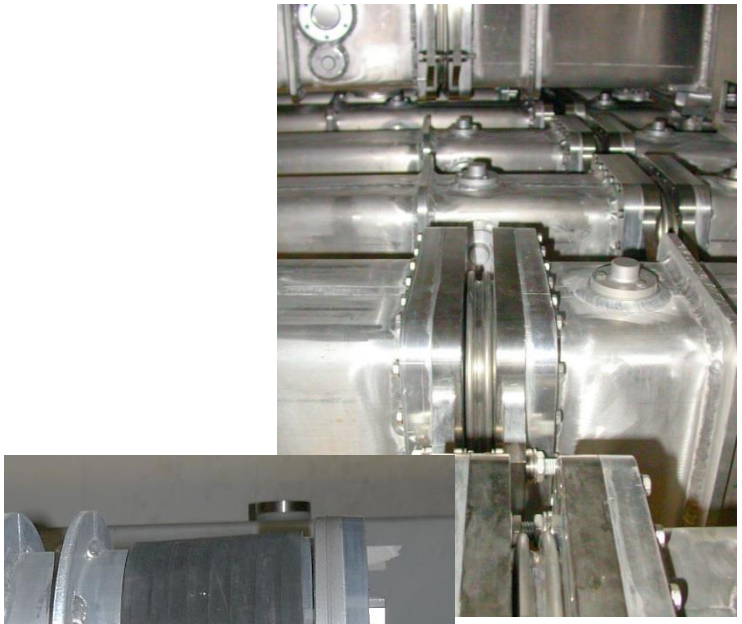
Sealing
housing to housing

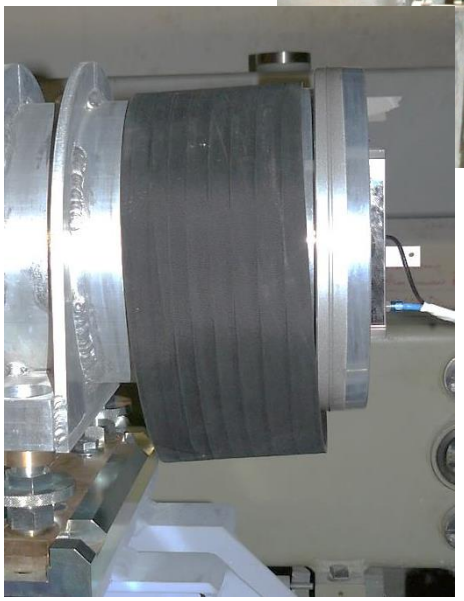
Required to accept

- Installation tolerances
  - Range : mm's & degrees
- Movement
  - Rotation
  - Vertical movement
  - Horizontal
  - Twist
  - Range :mm's & degrees

Options

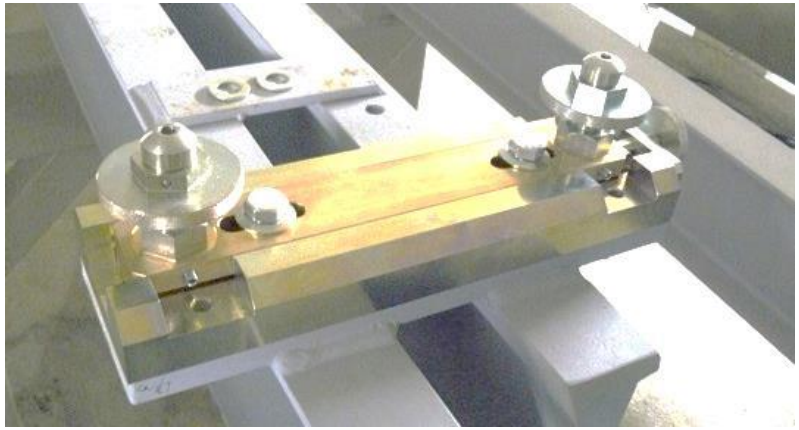
- Metal bellow & Rubber sleeves





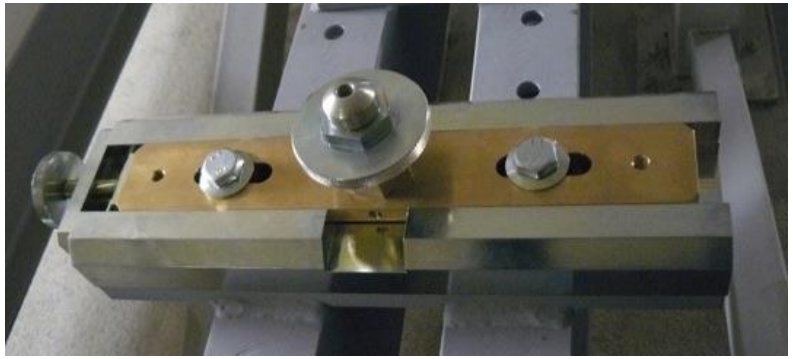
Alignment features

- 3 points on each housing
  - Front fixed
  - Rear floating
- Not hyper static
- High rigidity required (vac loads)
- Bolt down

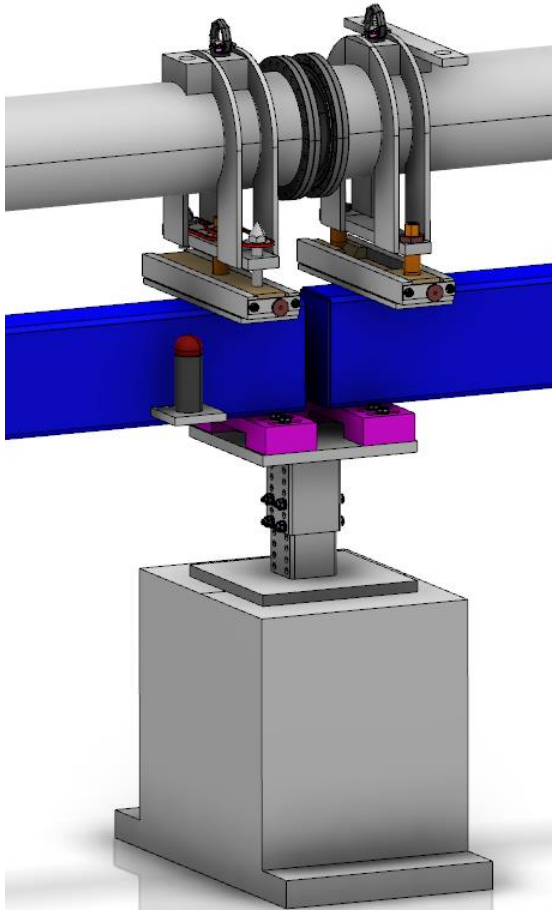


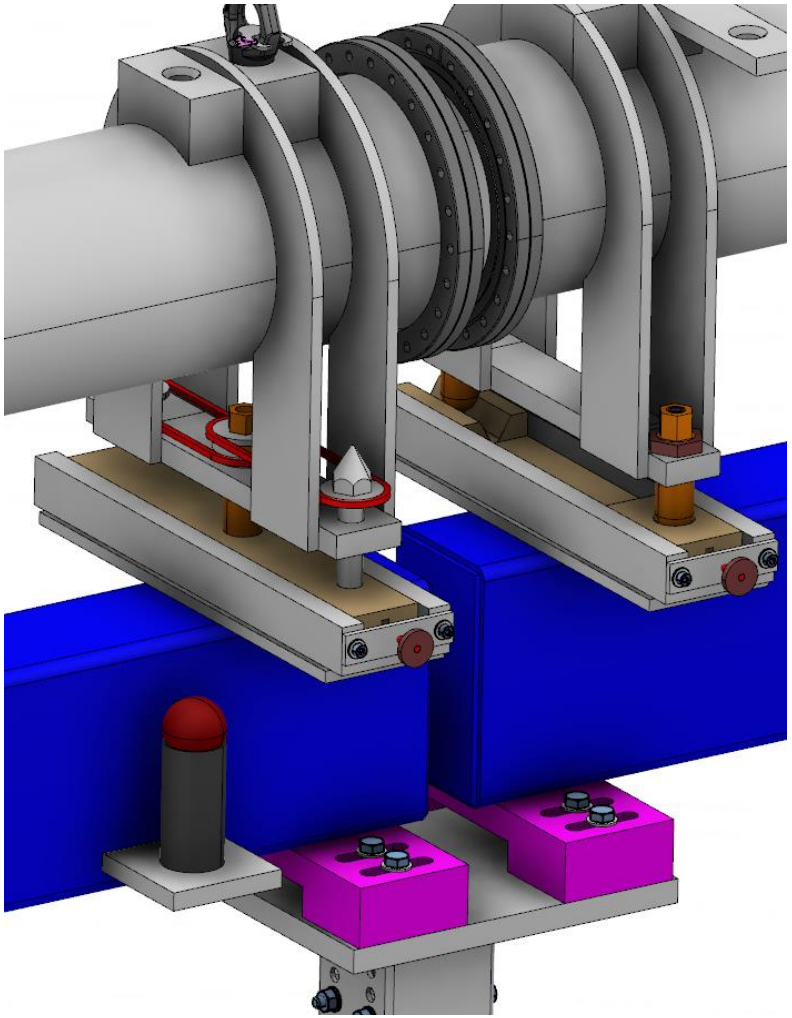
Real life considerations

- Be ready for partial installations & align alignments
- Think Installation flexiblity
- Be ready to vacuum test in sections (brace, brace, Brace!)



Alignment features some ideas





Active alignment

Monitoring

Knowing when to intervene.

- Monitor support movement
- Tech exists on X-ray beamlines

- Use at on critical beamlines or interfaces
  - Remote adjustment ?
  - Over illumination

- If in doubt leave space and retrofit if required !

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System level
Putting it together

Putting ideas into practice … does it still work ?

Separation your loads

Use what we have

- Piles
- Decoupled floor

Ties the piles

What

- Cut / level / shim
- Rigid Traversal tie bar
- Bolt / Glue

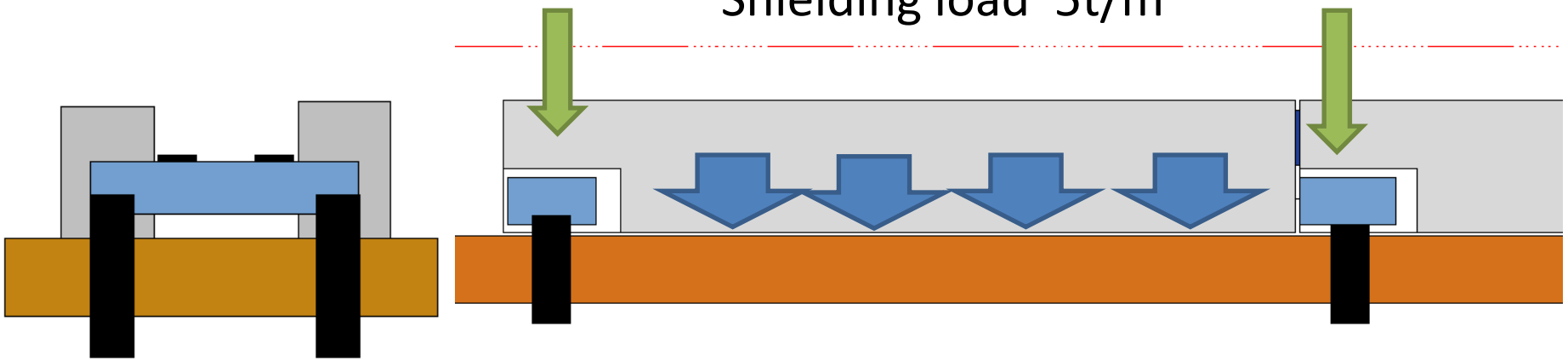
Why

- Increased rigidity (sway)
- Spread load

Shielding base

Equipment load 500kg / point

Shielding load 5t/m



What

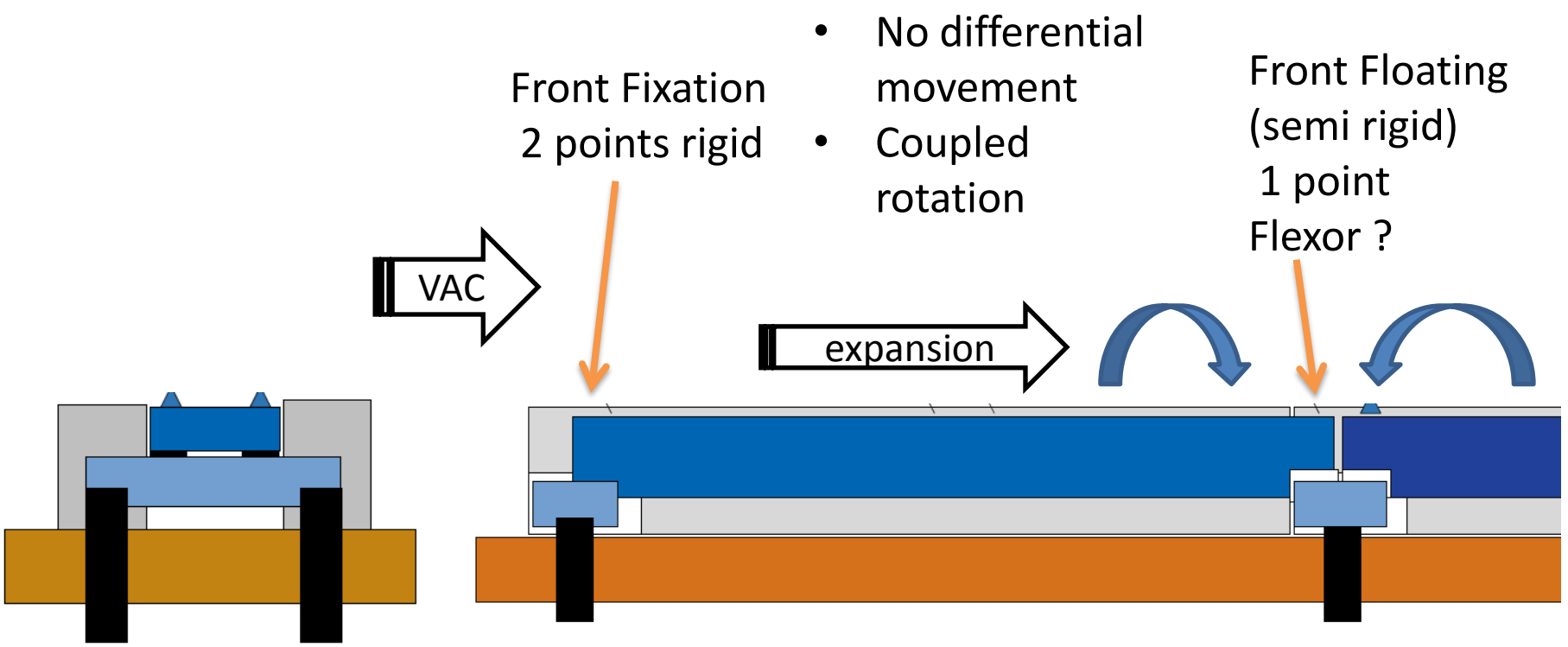
- Install thick (concrete) base beams
- Both sides of beamline

Why

- Spread load of shielding
- Standardized / cheap
- Mid height

ILL a time ago

Install spans (beam or rigid housing)



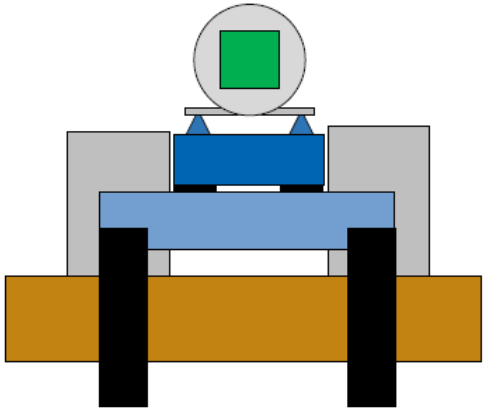
What

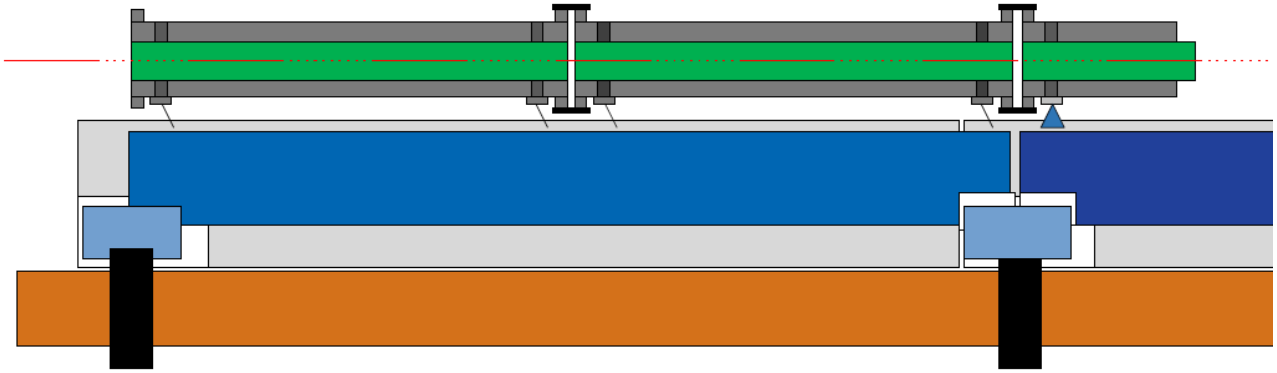
- Install spanning element
- Rough align

Why

- Reduce uncertainty

Install guide & align

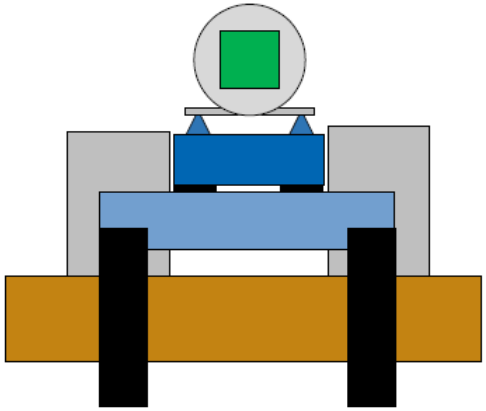


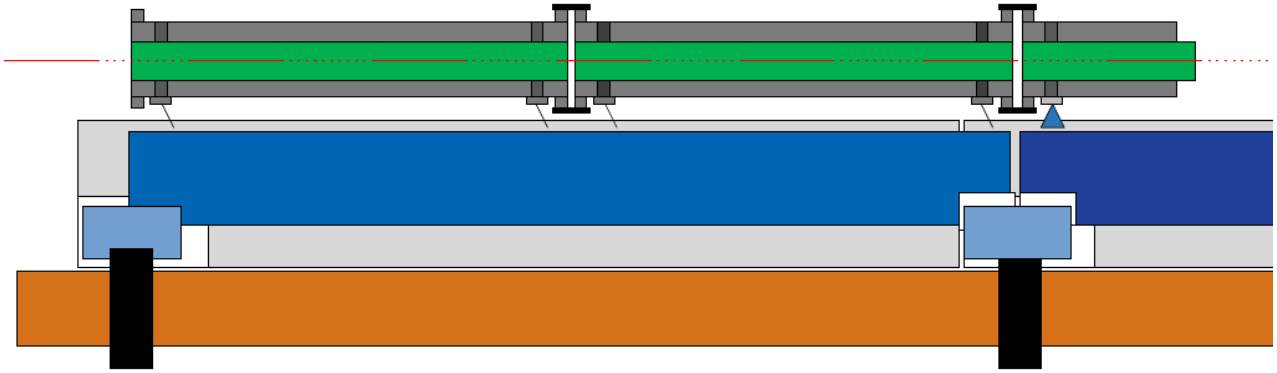


What

- Install guide
- Precise alignment

Install guide & align

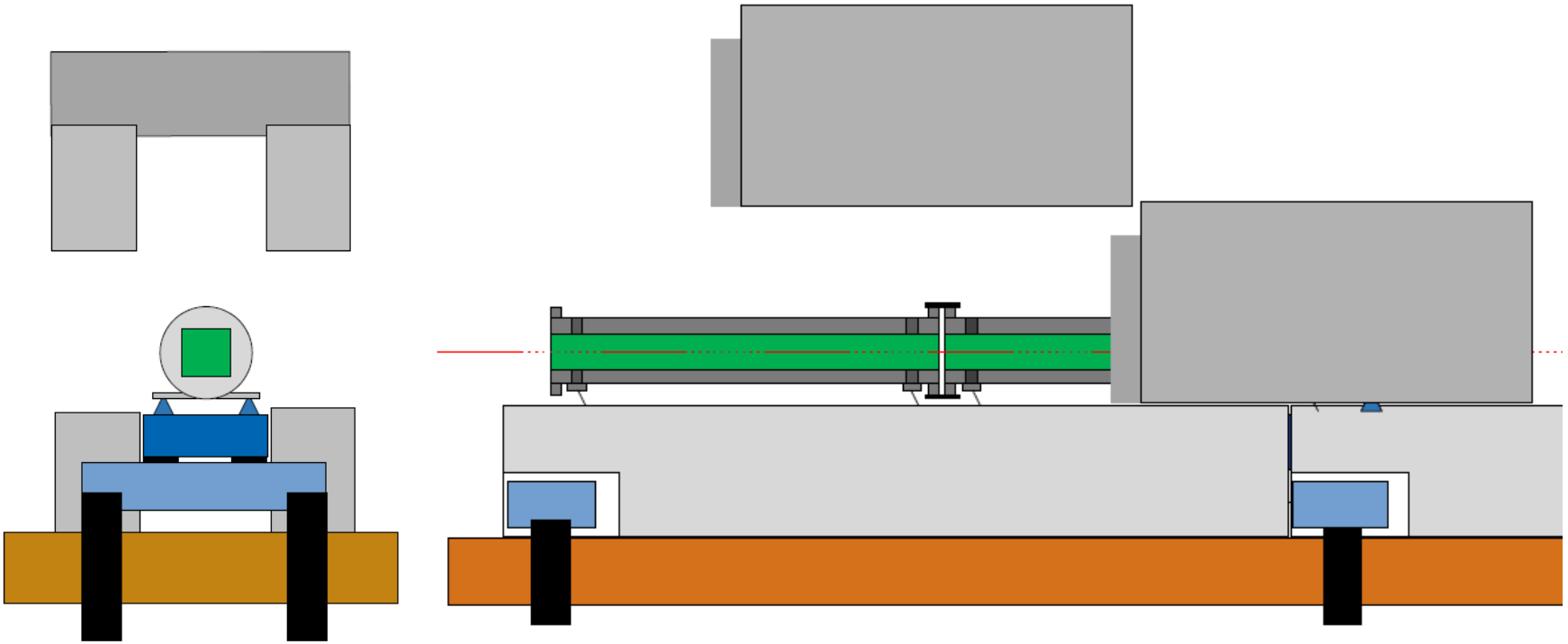




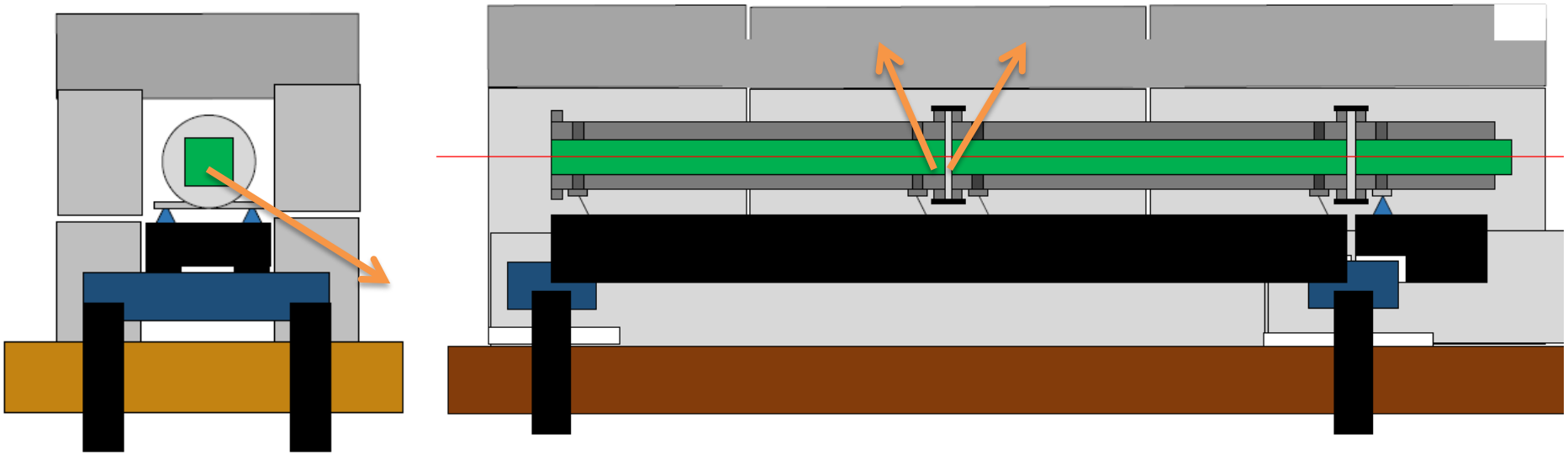
What

- Install guide
- Precise alignment

Install upper shielding



Integrated concept ?
Some thoughts

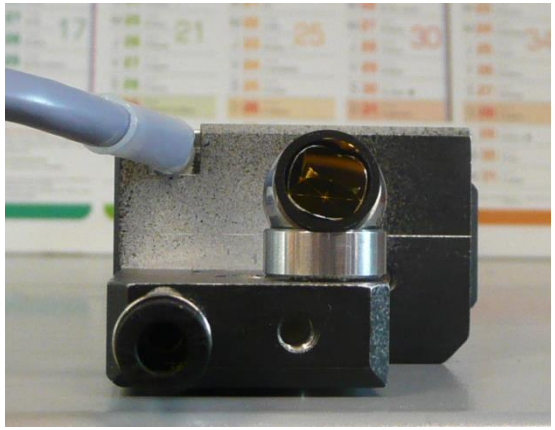


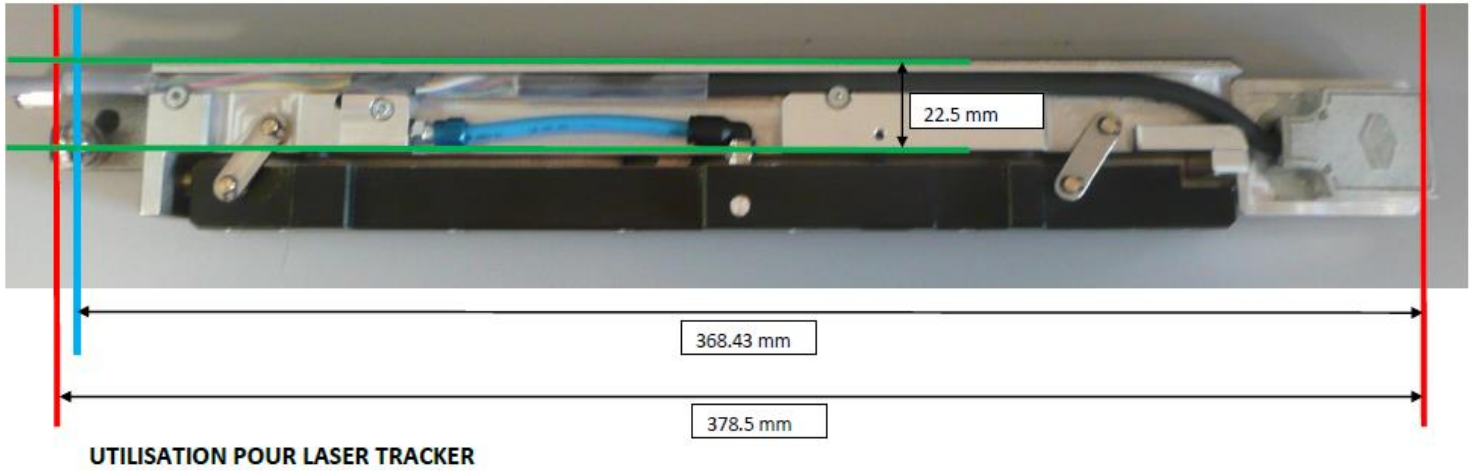
- lower shielding is static (not removed for maintenance)
- Reduced shielding requirement downwards ?

- Standardised components ?
- Concrete = cheap near standard parts

Alignment mouse

- Through wall alignment
- Independent validation
- Pre alignment





Recommendations

Construction

- Separate your loads
- Design to be installed / maintained

Alignment

- Best done in the lab
- Purchase the longest sections of guide practical (1-2.5m)
- For best in service results align the housing not the guide

Housings

- One guide one housing (if you can)
  - Cheap /Quick & easy to install / Alignment under vacuum

- Aluminium cheaper than steel

Thanks to

A cast of hundreds

My colleges at ESS & ILL

But also PSI,FRM2,FZJ,LLB

Suppliers

- Swiss neutronics
- S-DH
- Mirrotron

Special thanks to
ILL H17 / H14 Engineering team

NBOA
DELIVERed to Site …..