Fast Wire Scanner Prototype Mechanical Design

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For the FWS Study Group

Particular thanks to Nicolas Chritin for the CAD models, B.Salvant for the RF studies and J.Herranz for the magnetic lock design

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  - Integration into SPS and other machines
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  - Bearings
  - Motor assembly
- **RF and impedance**
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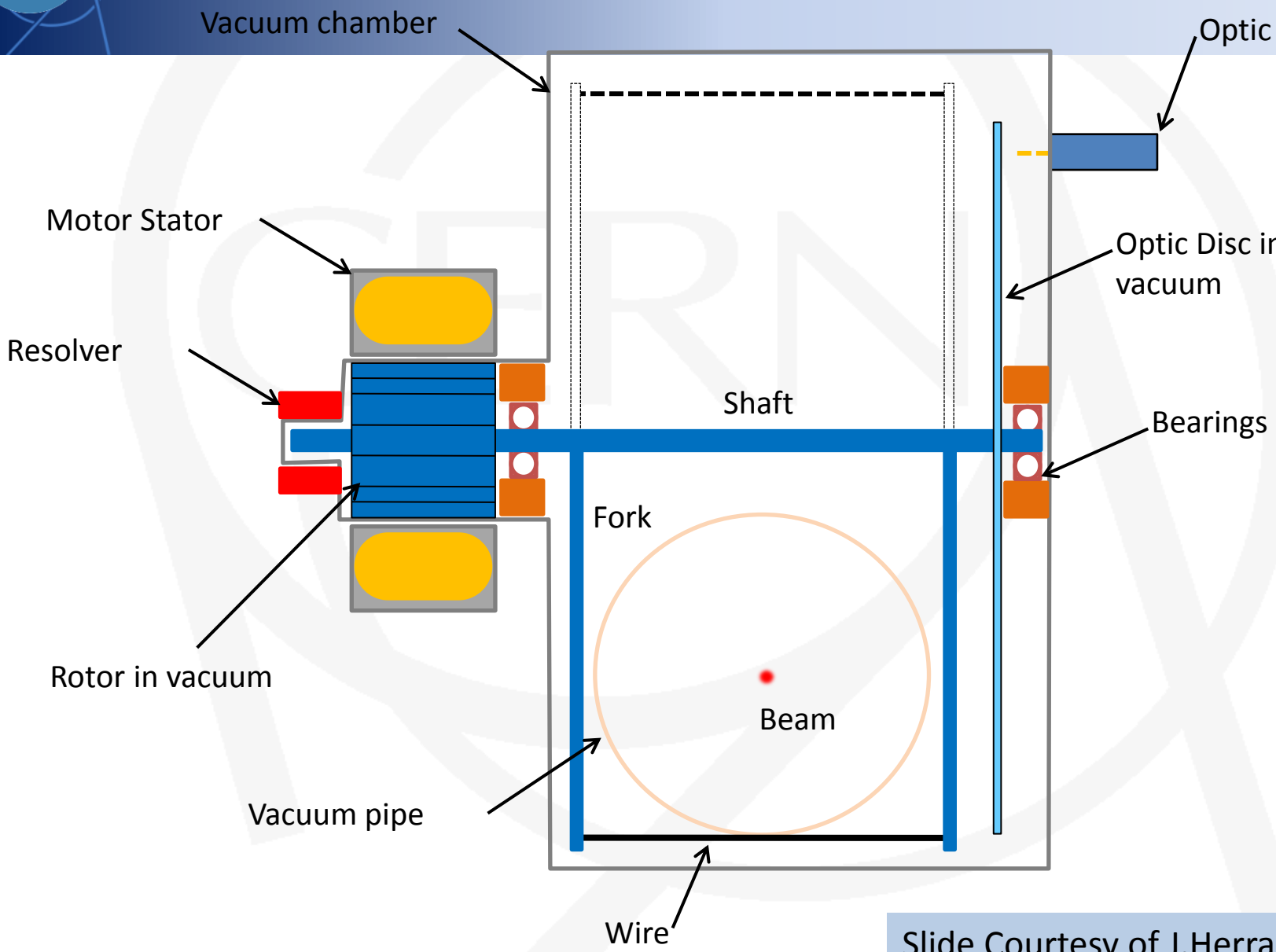
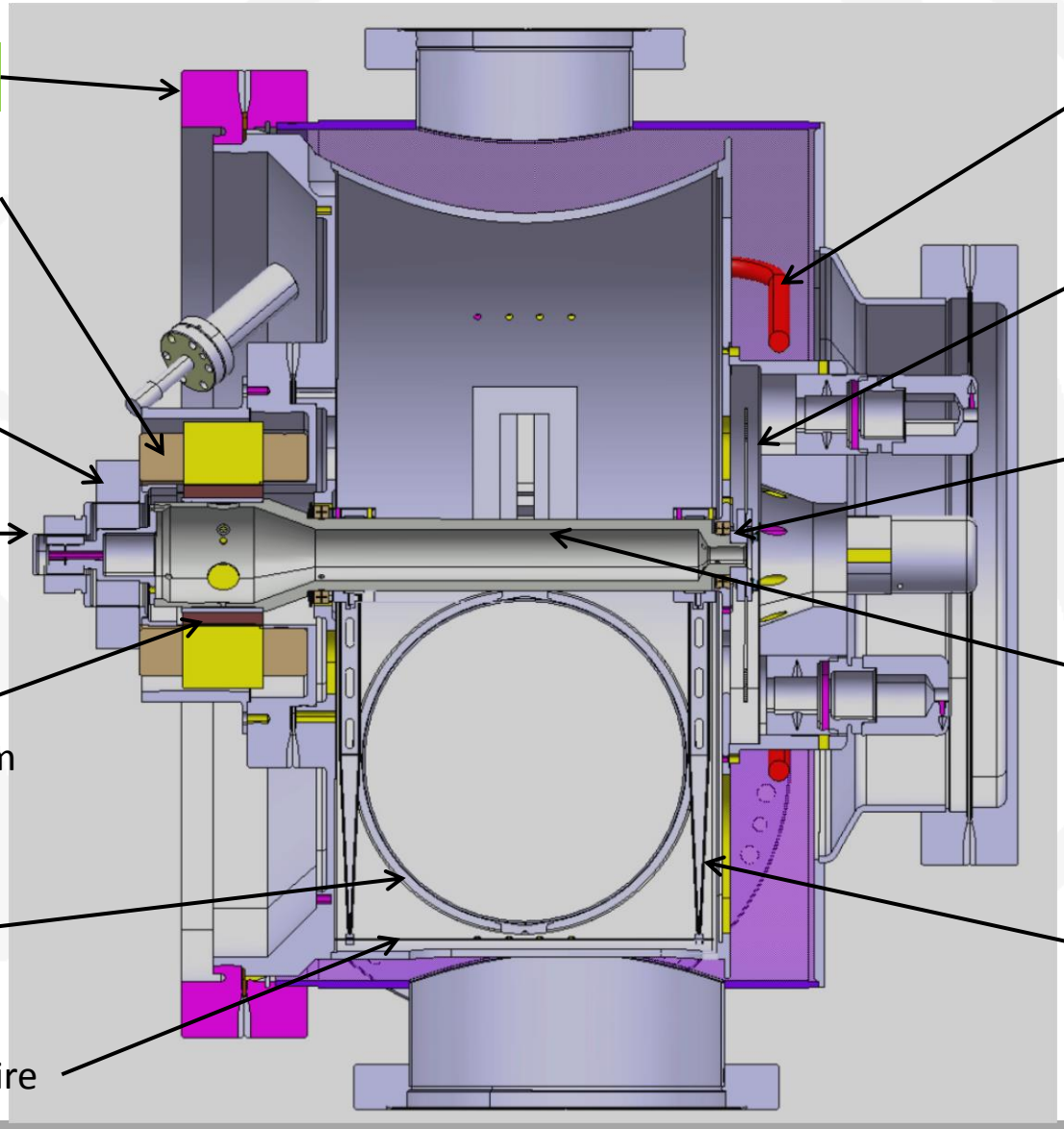
  - Solutions and studies in progress
- **Vacuum**
- **Conclusions and Future Work**

Methodology - Conceptual Design



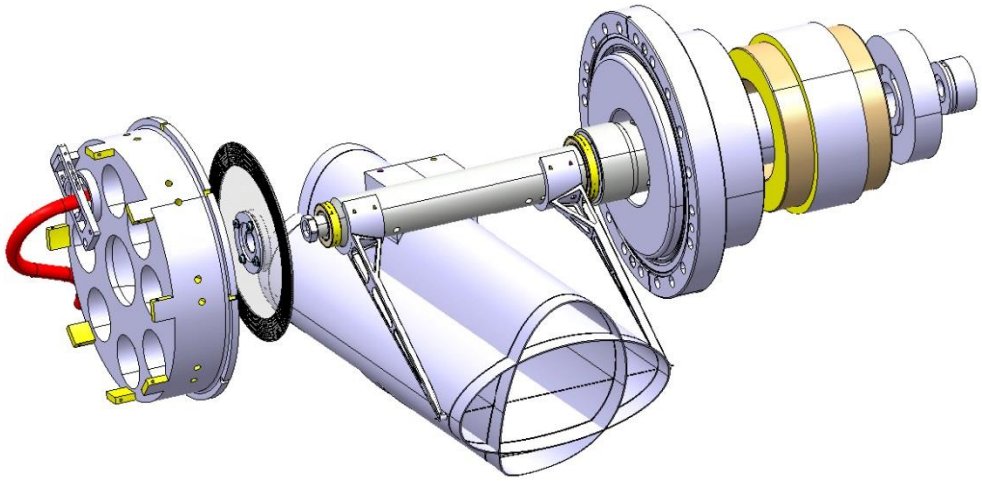
Slide Courtesy of J.Herranz Alvarez

From Schematic to Design



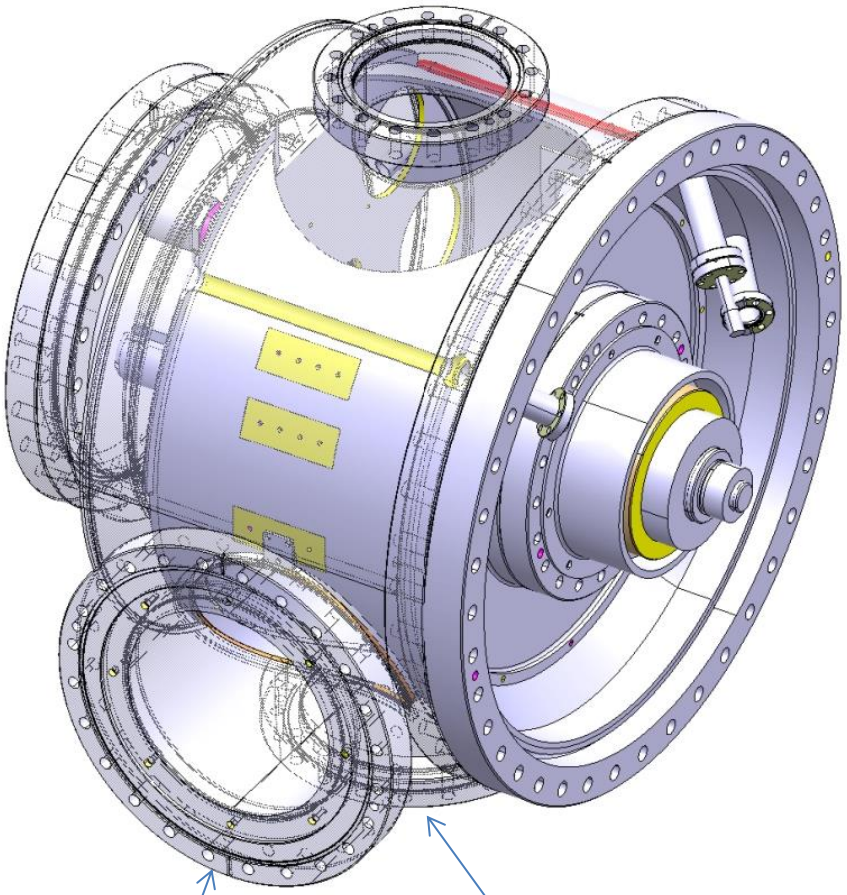
Modulable Design Concept

Machine	Scan aperture (mm)	RF Screen	Bakeout	Space Constraint
PS Booster	146x70	N	N	Axial, Transverse
PS	146x70	N	N	Axial
SPS	152x83	Y	N	-
LHC	65x65	Y	Y	Transverse



- Design is based around the largest aperture scan required (SPS, H & V)
- Forks and RF screen can be replaced to produce variants for other machines or locations. Other components will remain unchanged

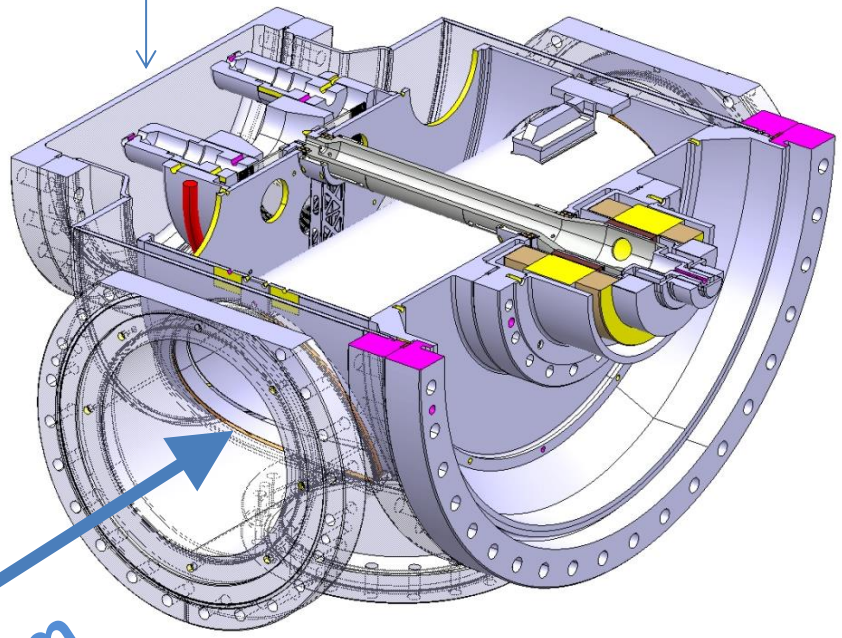
Standard Vacuum Tank



CONFLAT flanges throughout

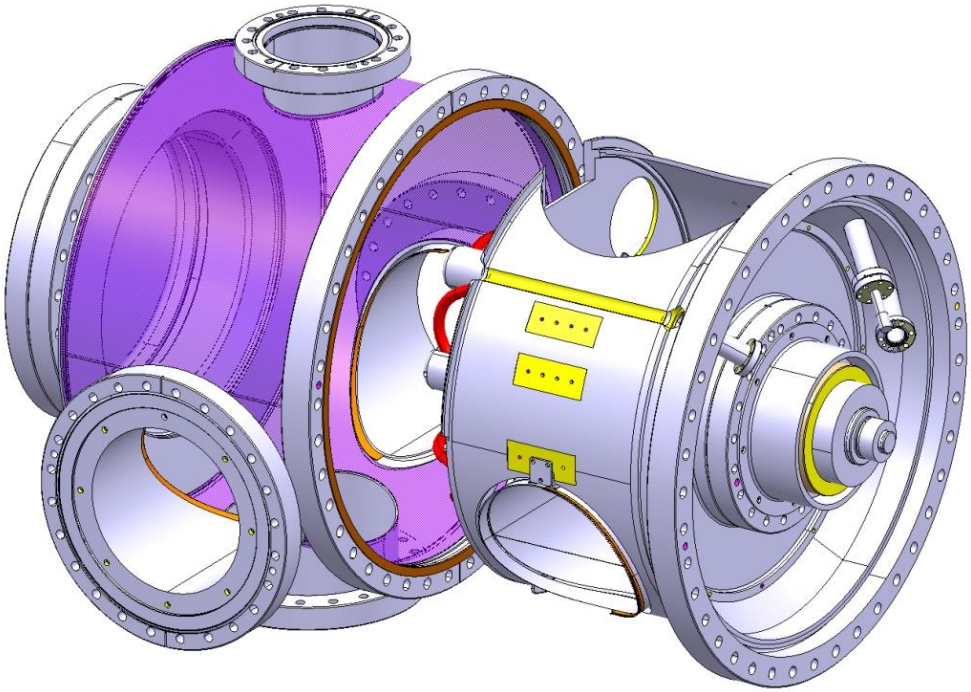
Ports for vacuum equipment

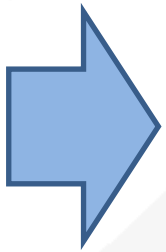
Additional port to access optical system (possibly removed after prototype)

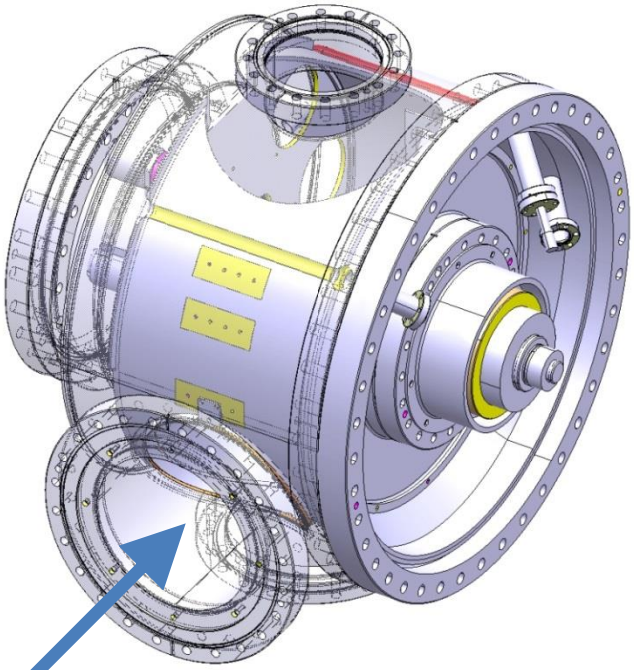


Beam

Installation in Vacuum Tank



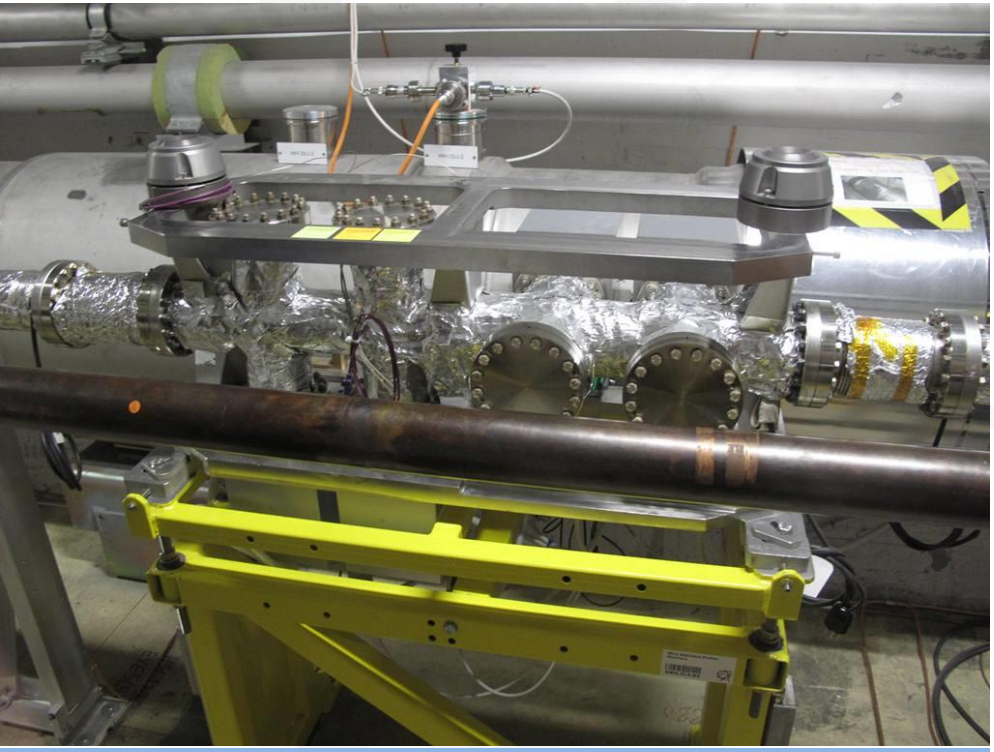




Install calibrated scanner module

Beam

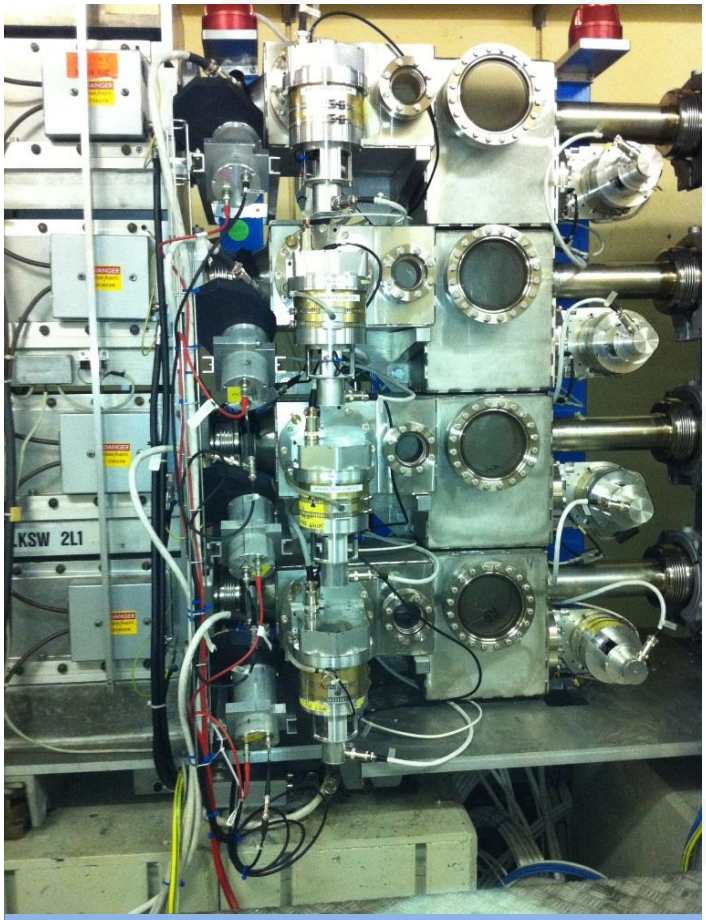
Integration Issues



LHC has plenty of longitudinal space, but cryo-line limits lateral space on one beam line

PS is limited in longitudinal space

Integration Issues

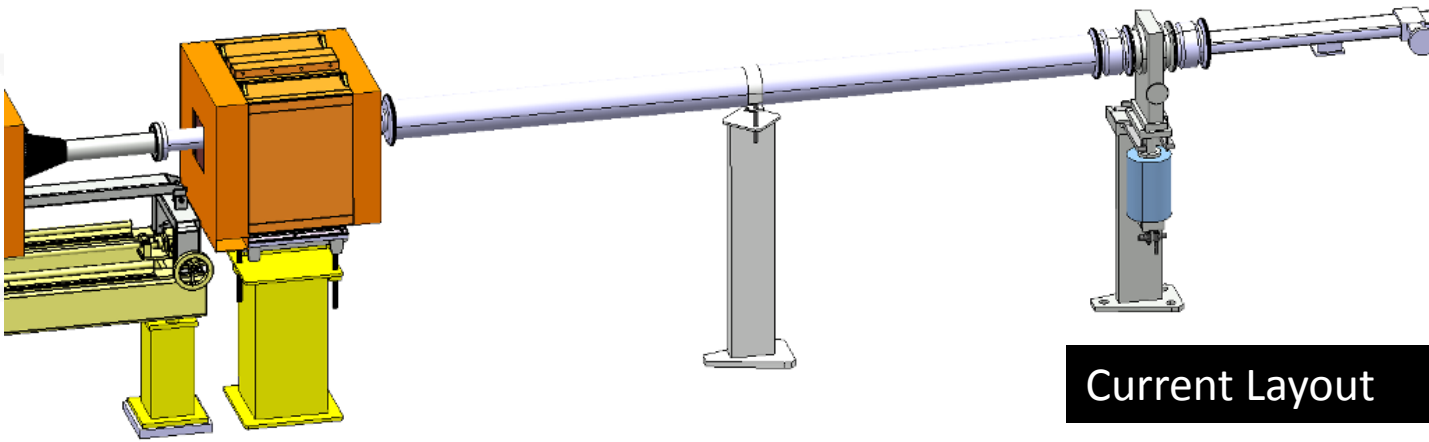


Booster has 4 lines superposed.

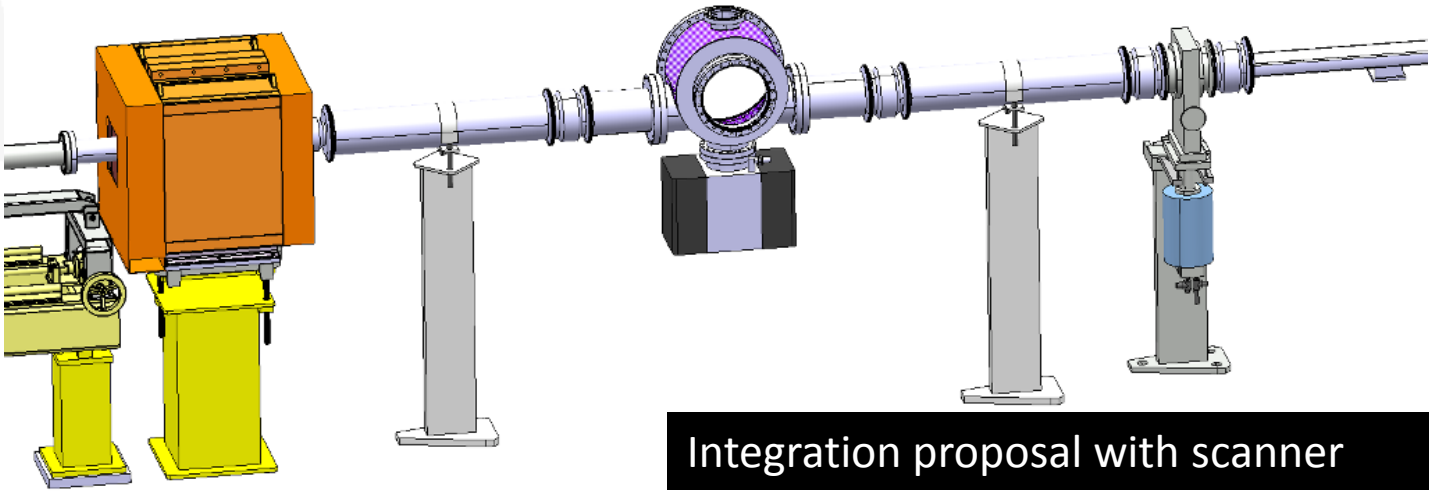
- There does not appear to be an integration solution that allows one common vacuum tank to be integrated that can scan all apertures required for machines at CERN
- For the moment, integration into the Booster is not considered
- A modified design using as many components as possible can be studied at a later date

Integration in to SPS

Prototype is integrated in to the SPS ring.
Advantages:
-LHC-type beams
-No bakeout
-Plenty of space,
-Relatively easy access,

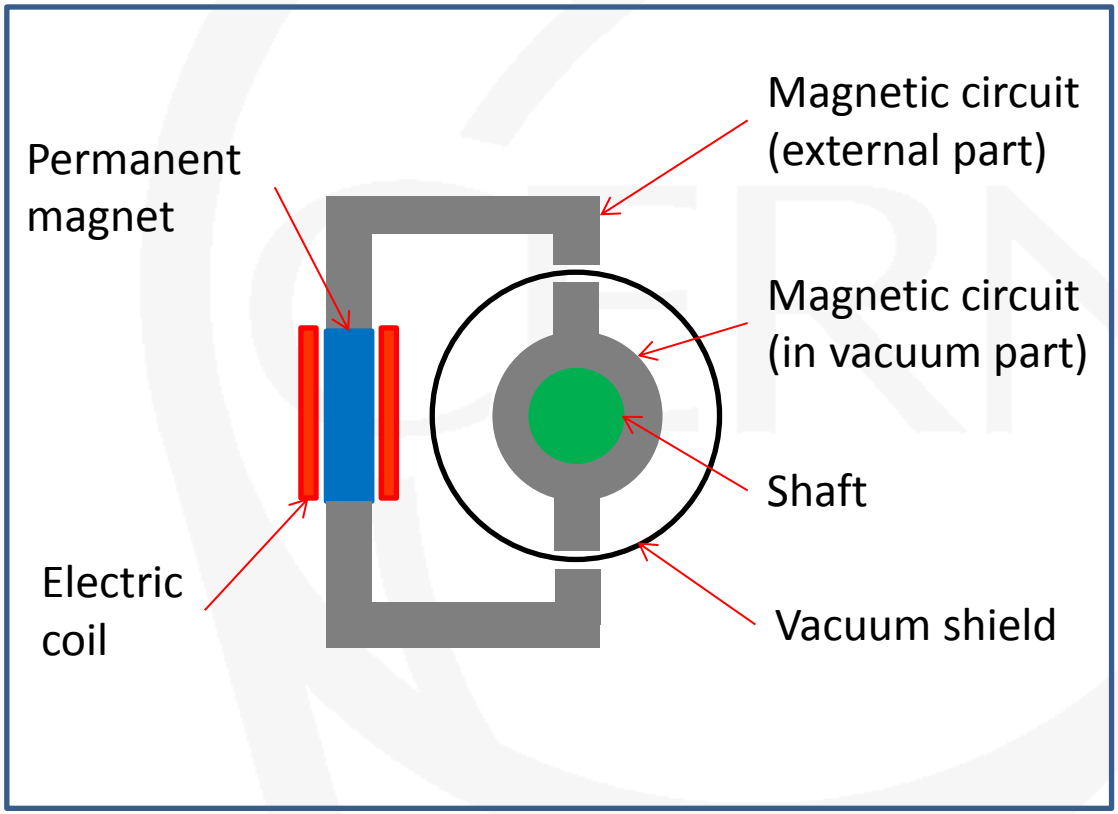


Current Layout

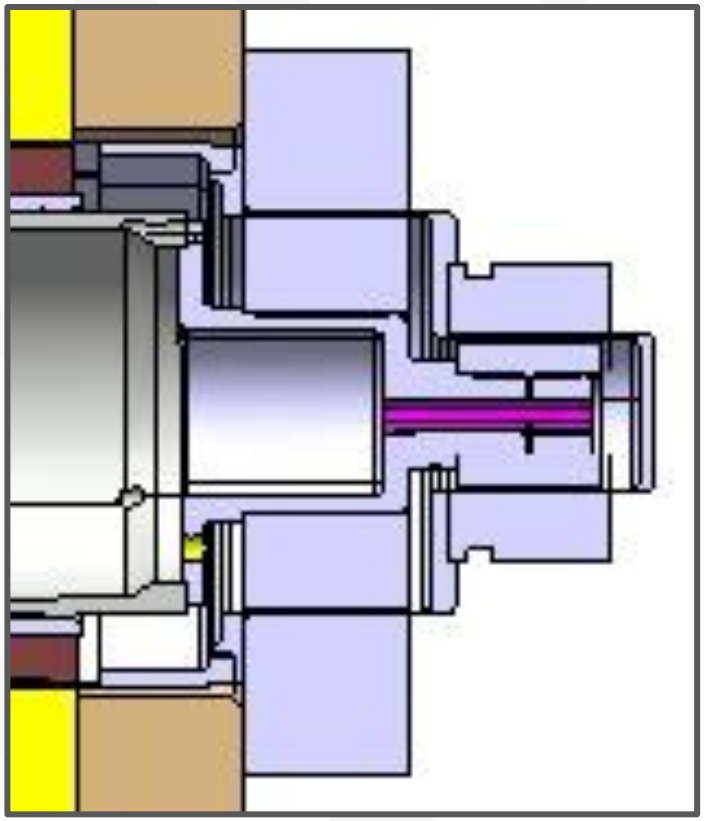


Integration proposal with scanner

Magnetic movement locking system conceptual design



Conceptual design



Location in the prototype

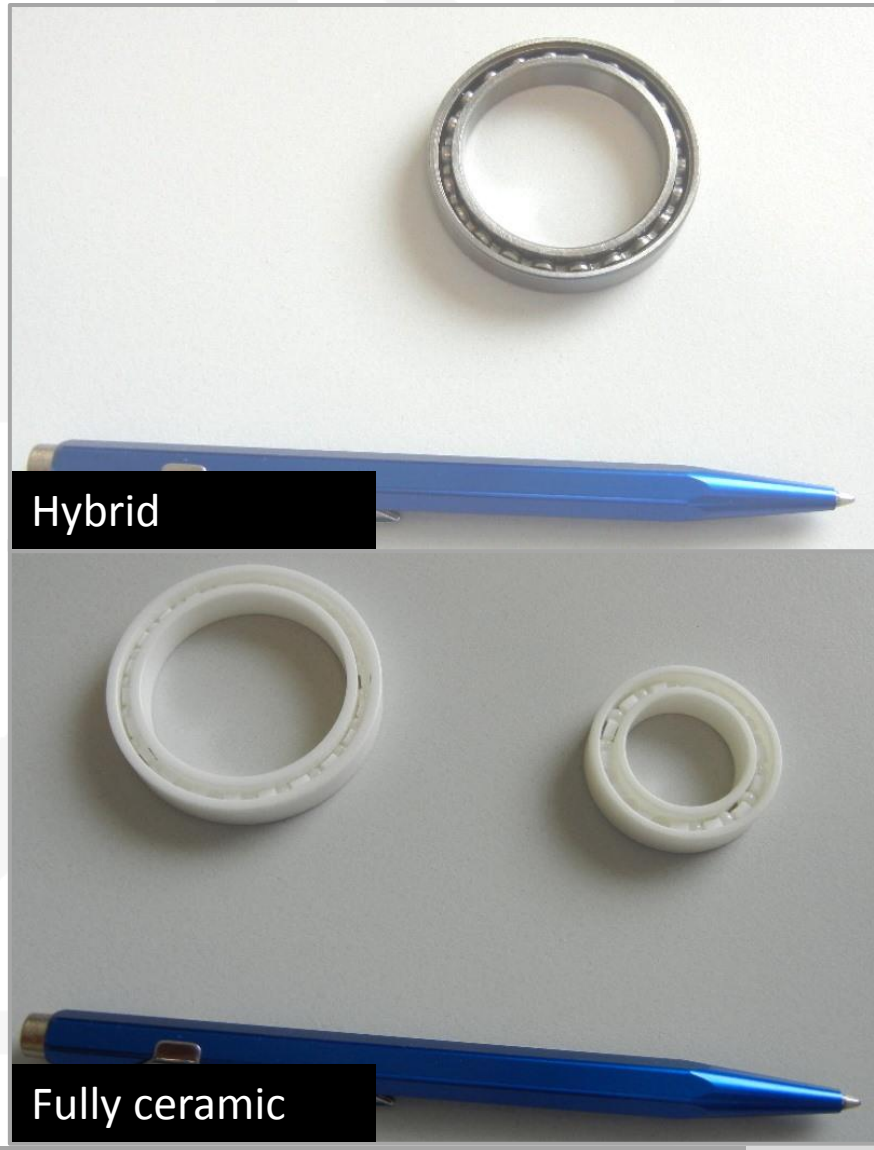
Courtesy of J.Herranz Alvarez

Bearings

- **Requirements**
  - In-vacuum operation
    - Low outgassing, so limited or no lubrication
    - Resistant to bakeout temperatures (for LHC)
    - Risk of ‘cold welding’
  - Low (non-systematic) lateral run-out
  - Low loads – at lower limits of working ranges
    - Should have no problems of wear or heating…
    - … but will need to verify slip or run-out
  - Intermittent operation
  - Small quantities
    - Suppliers not interested in R&D

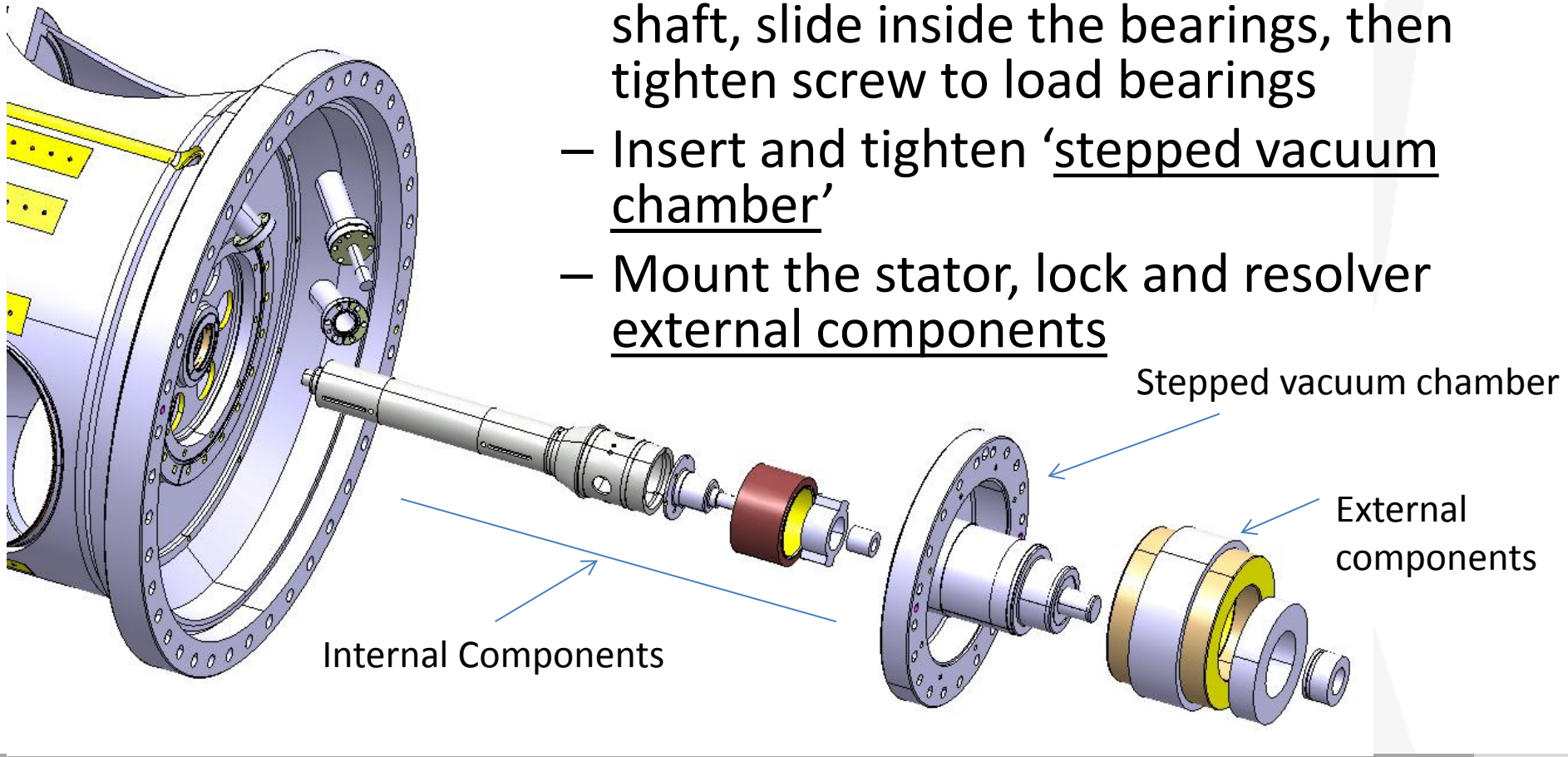
Bearing Options

- **Bearing options**
  - Hybrid bearings: Stainless steel bearing races with Ceramic (Si_3N_4) balls
  - Fully-ceramic bearings: Ceramic races and bearings (ZrO_2)
- **Lubrication**
  - Prefer to run ‘dry’ for vacuum reasons, should be possible for these materials
  - Will test both outgassing and performance
- **Design**
  - The shaft is designed with an axial pre-load provided by spring washers to minimise run-out
  - Two different sized bearings are used to allow installation of the shaft sub-assembly into the support



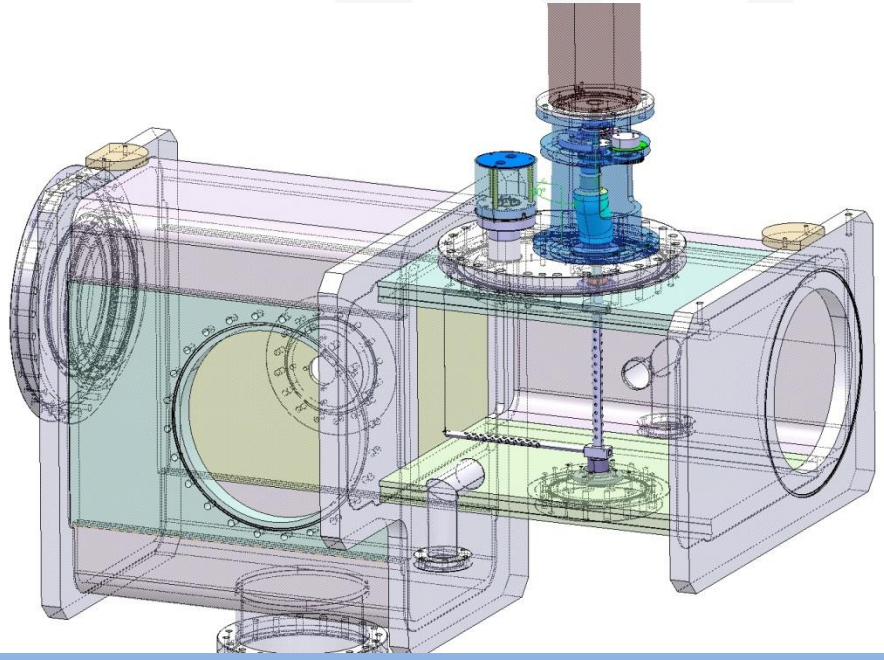
Motor Assembly

- **Assembly in 3 stages**
  - Mount rotor, along with lock and resolver internal components on the shaft, slide inside the bearings, then tighten screw to load bearings
  - Insert and tighten 'stepped vacuum chamber'
  - Mount the stator, lock and resolver external components



Heating Issues in Existing SPS Rotary Scanners

Some existing scanners show signs of heating



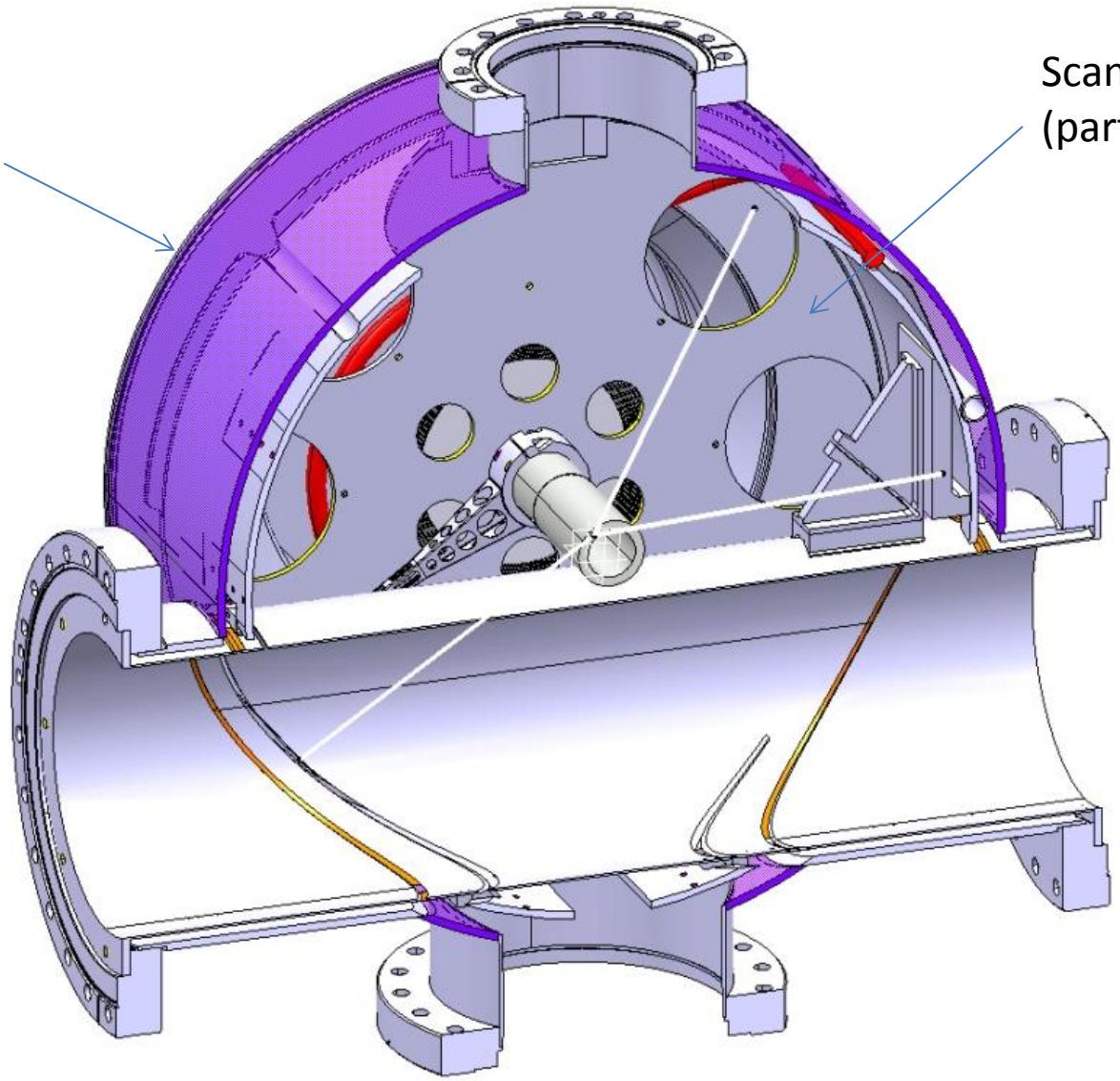
3D model of scanner and tank has been re-created to allow analysis and possible modification

Note: No signs of heating observed in 416V, which has a transition added in the chamber

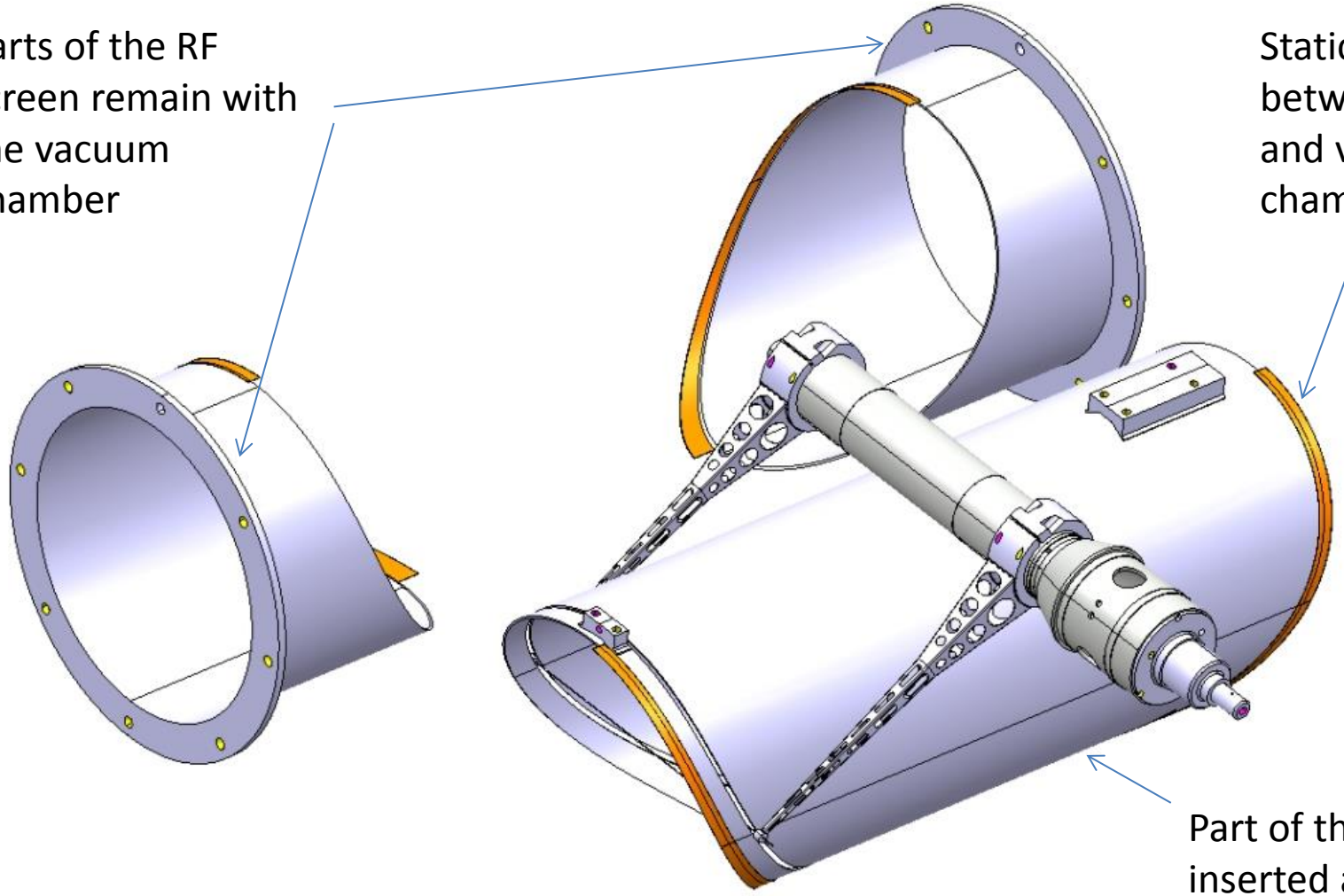
Overview of RF Design

Permanently installed vacuum chamber

Scanner module (part-view)



RF Screens and Forks

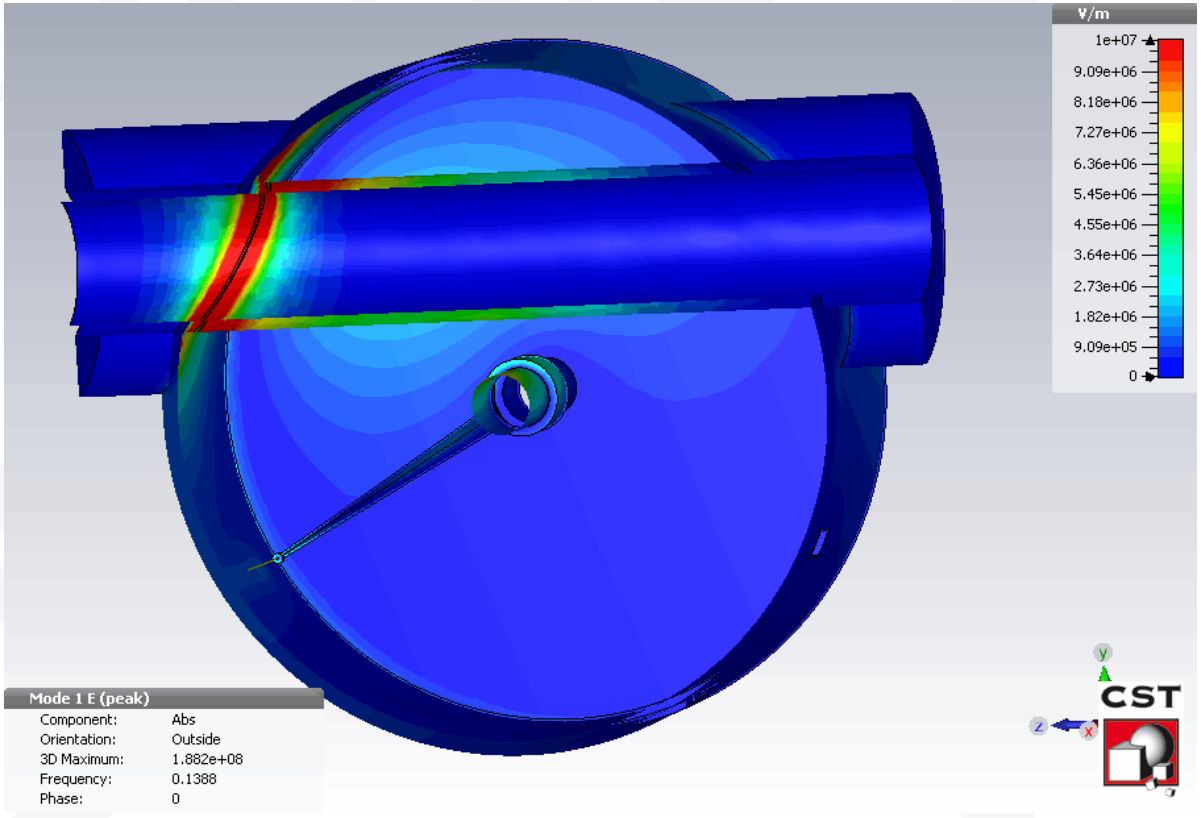


Ongoing Simulations

- Significant low frequency mode due to the longitudinal gap:
  - Shunt impedance (longitudinal): 250 kOhm
  - Quality factor: 2500
  - Frequency: 140 MHz

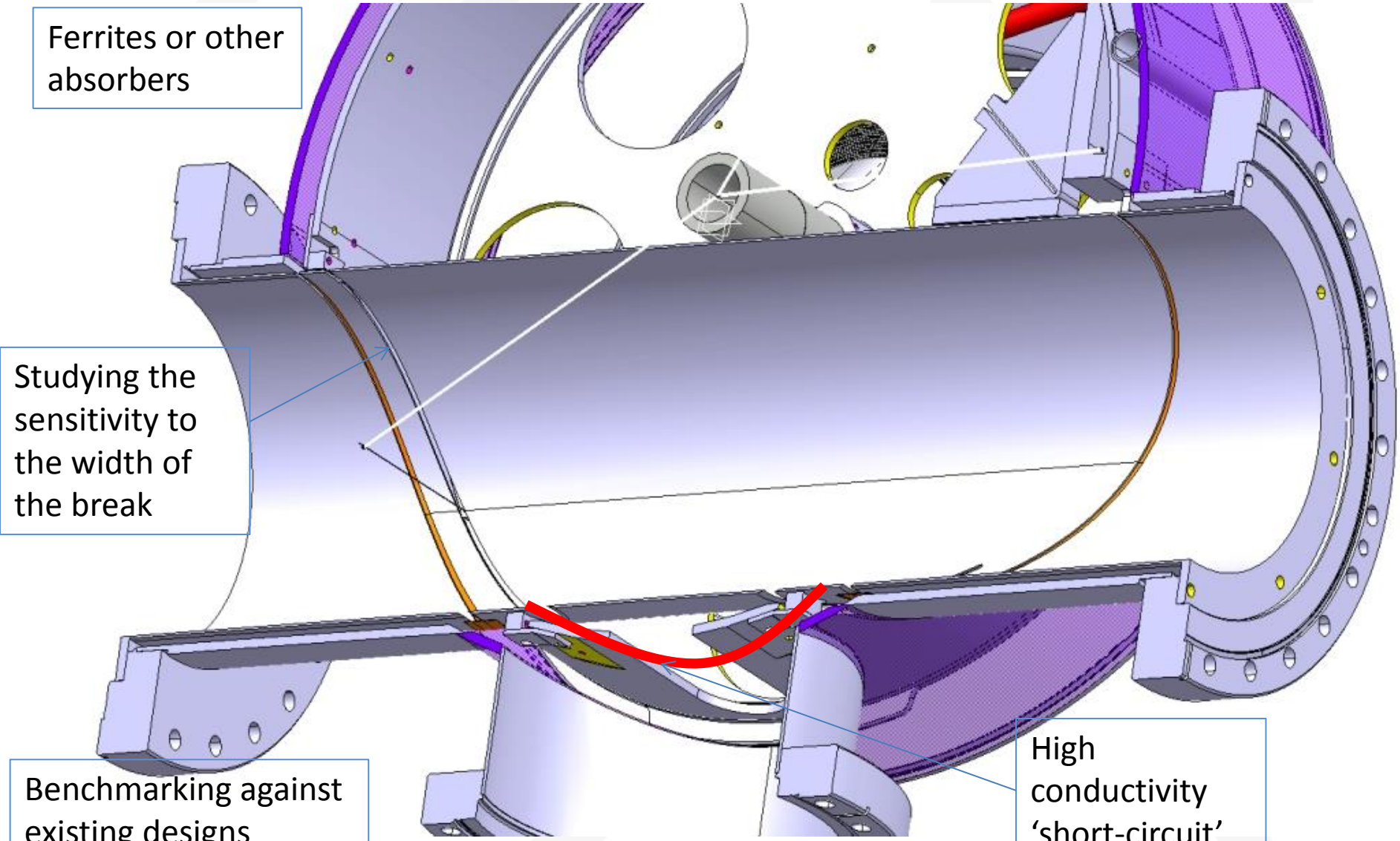
- Quite worrying as is (for longitudinal coupled bunch instabilities)

- Possibility to use ferrites (like in wall current monitor) or mode couplers to damp the mode



Slide courtesy of B.Salvant / CERN

Options Studied to Mitigate RF Issues



Vacuum Issues

- **Bakeout**
  - SPS and PS are not baked
  - Designed for eventual installation in LHC, fully-baked to 200°C for NEG activation
    - Structural materials all UHV compatible
    - Rotor magnets (Sm_2Co_{17}) and coils limited, so agreed 150°C bakeout for motor region (differential bakeout with thermocouple control)
- **Outgassing**
  - Rotor magnets (sintered) under test
  - Bearings (with/without dry lubricants) under test
  - Optical components 'UHV compatible' but will be tested
  - Tests of 3D machined forks will be done

Project Status and Schedule

- **'Laboratory model'**
  - Components required to produce a working scanner are now being manufactured at CERN
    - Assembly and functional testing at CERN summer/autumn 2013
  - Vacuum tank and RF screen details being finalised
    - RF screen could still be modified
- **Prototype for the SPS**
  - Build a new scanner using feedback from the laboratory tests for installation in the SPS late spring 2014, for operational tests post-LS1
  - The *schedule fall-back solution* is to install the 'laboratory model' vacuum chamber in the SPS
- **Series manufacture**
  - Assuming testing in the SPS is successful, a series (with modifications from the prototype) would be manufactured for installation in the PS, SPS and LHC in LS2

Conclusions

- **Status**
  - Mechanical design of a scanner is complete and a prototype is in production
  - It is designed for integration into the SPS, but also with a view to future integration into the PS and LHC
- **Main mechanical design issues for test in the lab**
  - Assembly and mechanical operation
  - Bearing operation and tolerances in air and vacuum
  - Fork displacements
  - RF testing with baseline screen
- **Future work (for the SPS prototype)**
  - Correct the design based on test results from the different sub-systems
  - Design refinements to improve installability, maintainability etc.