Diamond DDBA Vacuum Overview

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On behalf of ....

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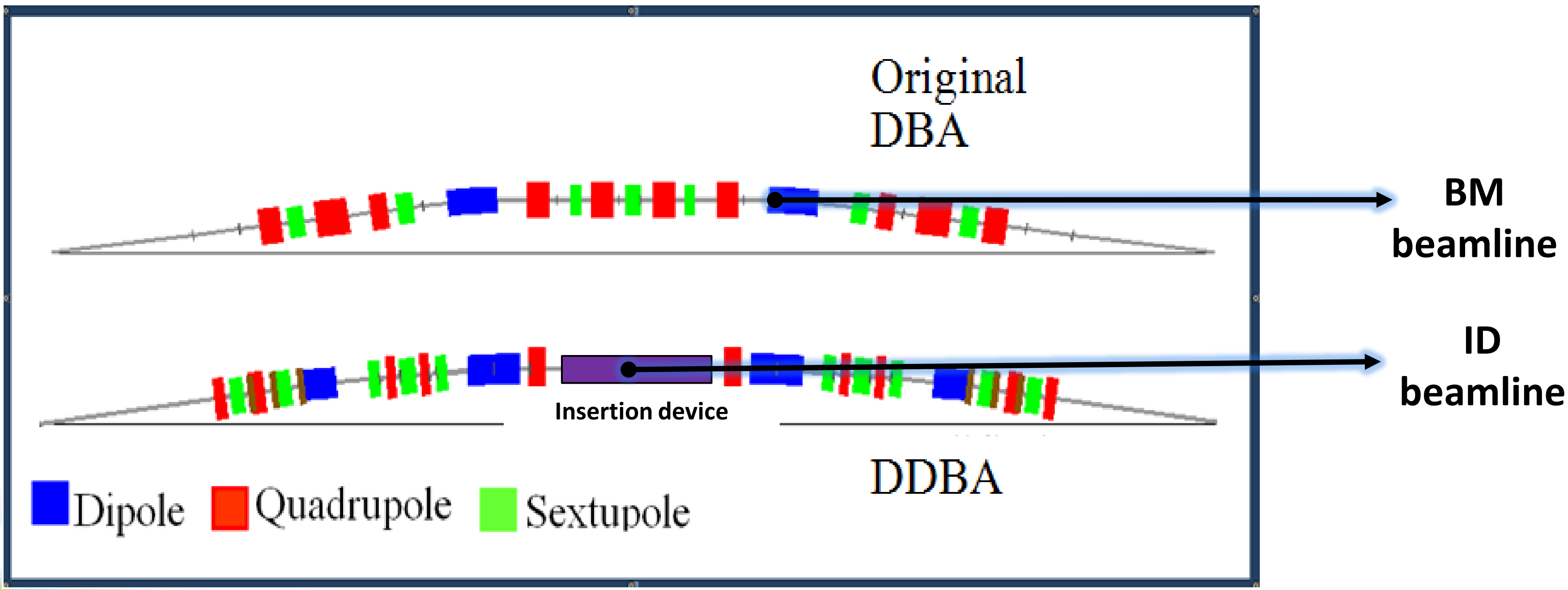
Motivation

Need for additional insertion devices → Double Double Bend Achromat (DDBA) concept: Replace one or two "DBA" cells with a new "DDBA cell" creating a new mid-cell straight section for an Insertion Device, thus converting a BM beamline into an ID beamline.



+ Development of technology needed for a possible future major upgrade, Diamond-II

Timescales

The plan:

Install one cell of DDBA in summer 2016 in an 8-week shutdown.

which implies:

Completing reference designs and issuing Vacuum Vessel Calls for Tender in February 2014.

We believe this is challenging but achievable

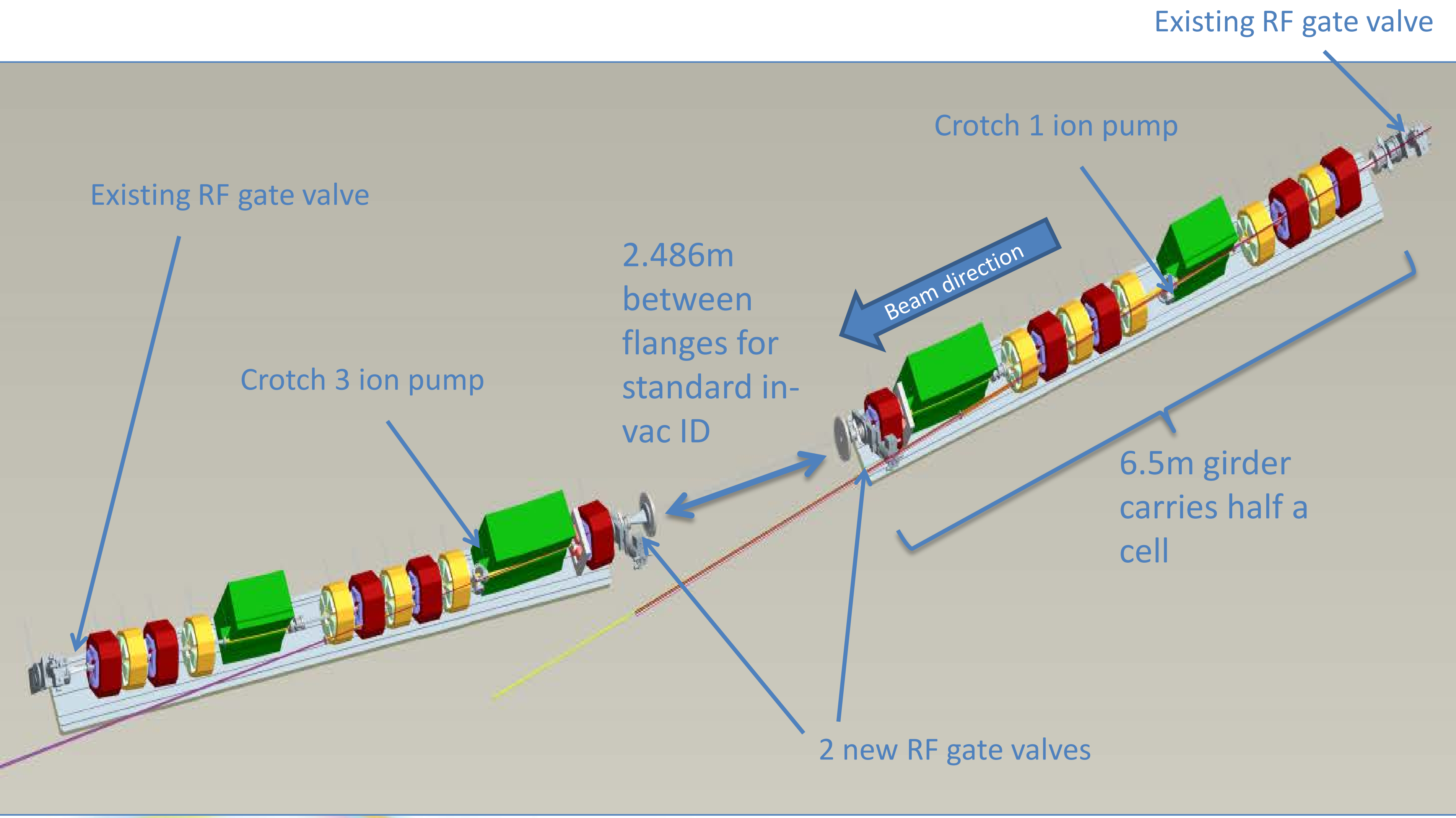
Vacuum requirements

- CO equivalent $p \leq 10^{-9}$ mbar with stored beam
- Beam compatible: Impedance, Beam stay clear, RF heating, DC/AC magnets, SR heat loads ...
- No pressure bursts or particles to trip beam
- Installation + conditioning $\leq$ 8 weeks downtime

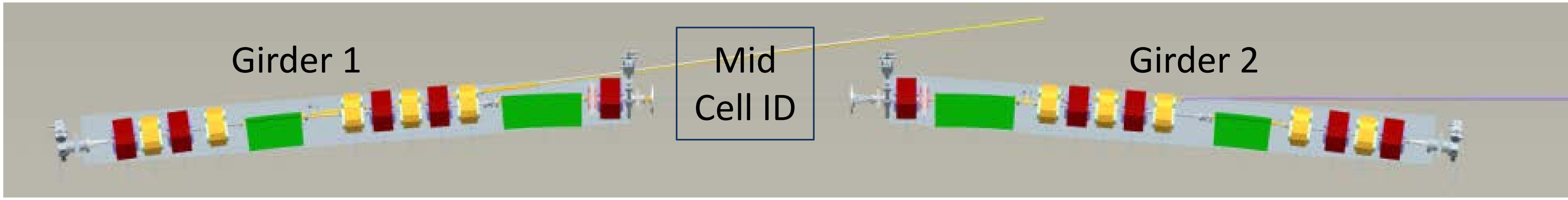
Decisions taken

- Narrow bore vacuum vessels (typically 18 x 27 ellipse) and dense magnetic lattice
  - → low conductance
  - → distributed pumping
  - → NEG coating (as near 100% as possible) + ion pumps to pump high gas loads, inert gases and hydrocarbons
- Not planning to build in-house NEG coating facility – coating by industry, other labs, CERN
- Design for in-situ NEG activation
- Vacuum vessels
  - Copper - high power densities
  - Stainless steel – lower power densities, corrector magnets, bellows, BPM units
- Complete replacement girders built up and NEG activated outside the storage ring and installed without venting

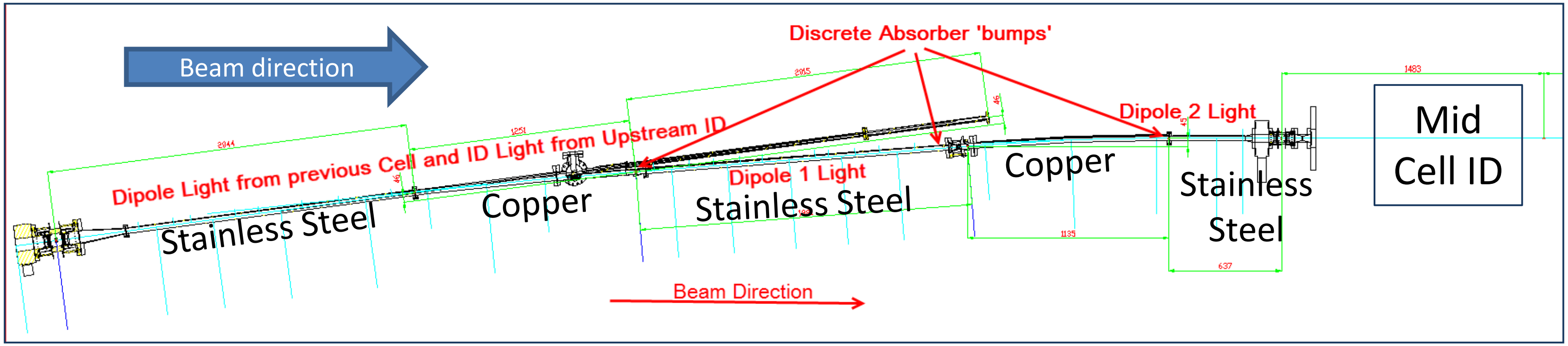
General Layout



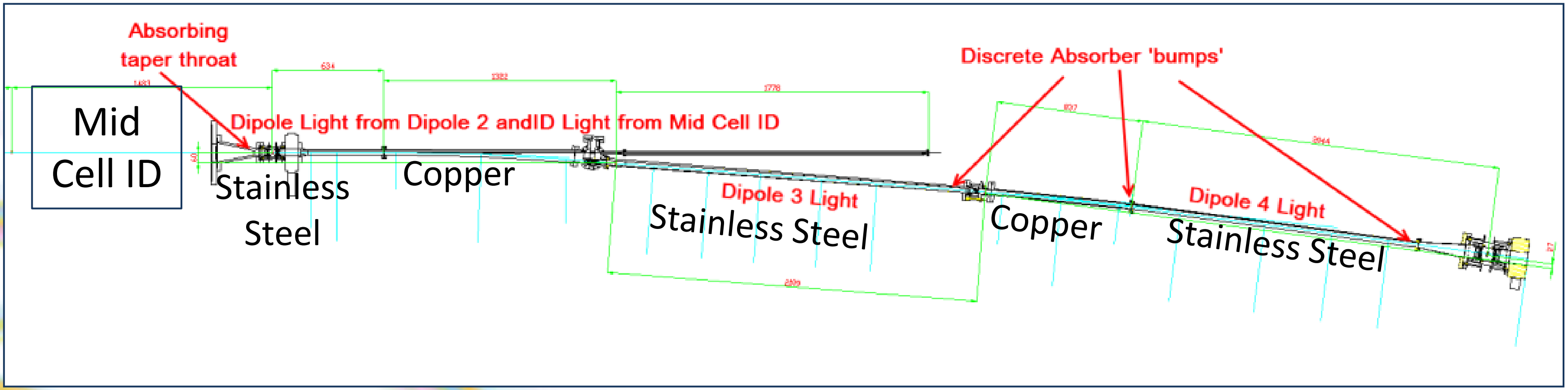
Vessel Overview



Cell Entry Vessel String (Girder 1)



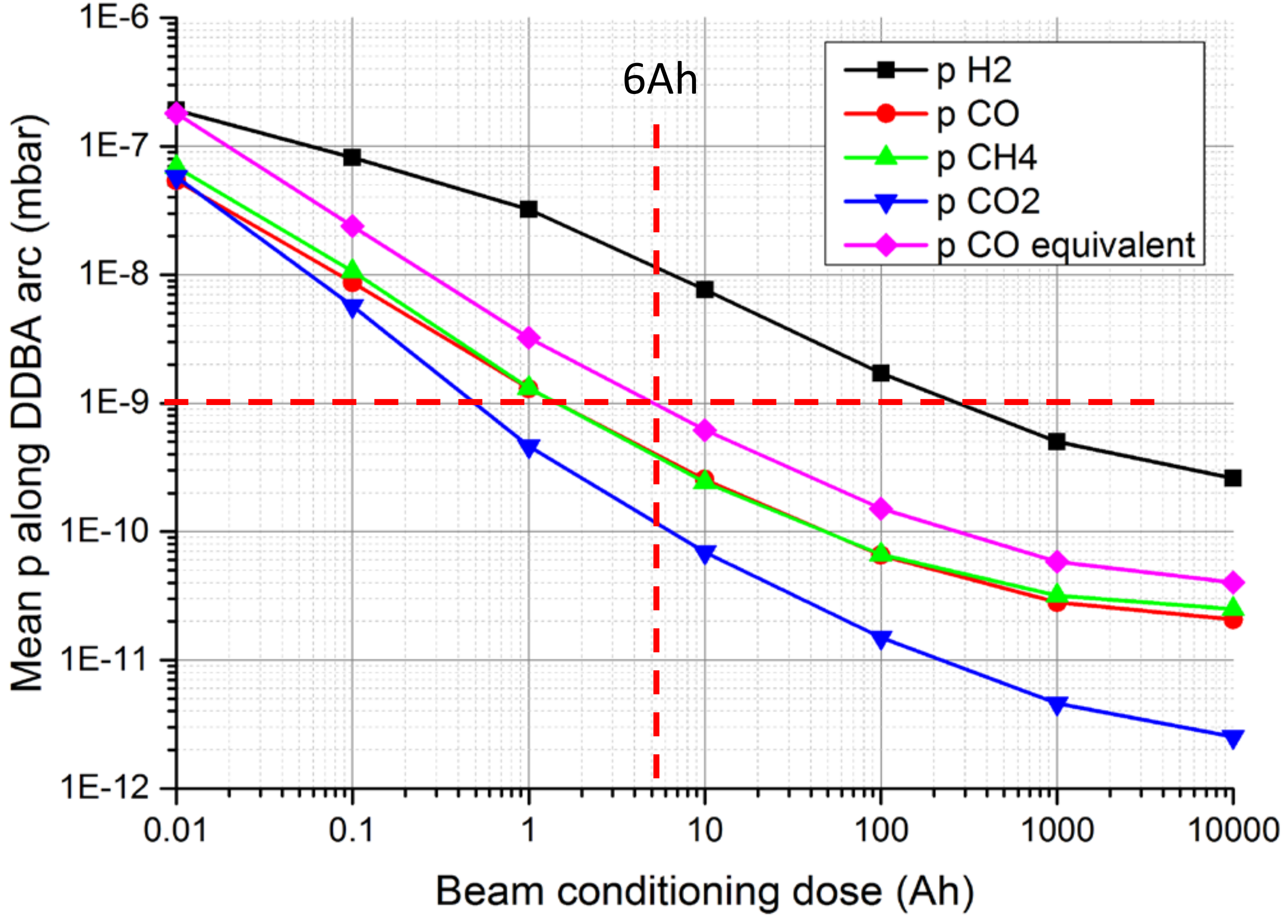
Cell Exit Vessel String (Girder 2)



DDBA beam conditioning (1D calc)

May be somewhat over optimistic:

- Literature values for NEG outgassing, PSD and sticking probabilities – no saturation
- Neglects indirectly irradiated surfaces
- 1D model oversimplifies crotch region



I_{beam} = 300mA, S_{crotch} = 100l/s

In situ NEG activation

In-situ (DDBA, SIRIUS, ESRF, SOLEIL ....)	Ex-situ (Max IV)
Larger magnet pole gap	**Smaller magnet pole gap**
Faster recovery from intervention or accident or NEG saturation	Slower recovery – reactivation has to be done ex-situ
Can install vessel-by-vessel – DDBA max vessel length ca 2 m	Needs long lifting frames (7 - 8m) – cannot vent once activated
Thermal expansion (Cu/StSt ΔT 200°C 3mm/m) need larger RF bellows travel	**Smaller bellows range for alignment**

Will most likely use Kapton bakeout heaters using CERN technology – may be difficult with complex vessels, concave cross section ...

Also considering thermally sprayed oxide / metal heaters but technology of applying these is too crude at the moment

Proceedings of 2005 Particle Accelerator Conference, Knoxville, Tennessee

ULTRATHIN POLYIMIDE-STAINLESS STEEL HEATER FOR VACUUM SYSTEM BAKE-OUT

Christian Rathjen, Sébastien Blanchard, Bernard Henrist, W. Koelemeijer, B. Libera, P. Lutkiewicz, CERN, Geneva, Switzerland

Vessel and NEG coating strategy

- Develop vessel reference designs
- Review coating challenge vessel by vessel
  - Easy to coat vessels can be done by industry
  - More challenging vessels will need significant R & D and may need to be done by CERN or other labs
- Competitive tender for half cell prototype vessels and coatings with option to proceed to production sets
- Set up collaborative agreement with CERN
  - Coating and in situ heaters advice and support
  - R & D (and production if necessary) where beyond scope of industry
  - Qualify industrial partner(s) and their processes
- Set up small lab facility at Diamond for simple transmission / sticking probability measurements

Build and installation strategy

- Fully tested and qualified NEG coated vessels delivered from the supplier(s)
- Assembled on to girders with vacuum equipment and integrated with magnets
- On girder pump down, bakeout and NEG activation
- Installation in the storage ring tunnel under vacuum without venting
- Connect up to adjacent vacuum sections (bake these if necessary)
- Open gate valves
- Inject beam and carry out beam vacuum conditioning

Some possible discussion topics

NEG coating
- How well can industry deliver – plant, know-how, recipes, capacity, cost, timescales ... ?
- Lab and industry over / under capacity in different regions / worldwide
- Qualification of supplier, etching, cleaning, coating plant and process, acceptance tests
- Applying to different vessel geometries / multi-materials / brazed joints
- Controlling thickness and uniformity - vacuum performance, number of regeneration cycles, beam impedance - aim at 0.5 to 1.0 µm
- How to treat BPM buttons, RF bellows and contacts
- Max continuous operating T of NEG coating illuminated by SR?

In situ thin bakeout heaters
- Minimum vessel to pole gap, expected pole temperature
- Complex vessel geometries including concave sections and side ports
- Radiation damage (more of an issue for Al vessels)

RF flange joint design (small cross sections)
- Impedance
- Alignment
- Vacuum integrity

RF contact designs and materials
- Compatible with beam impedance/losses, thermal expansion etc
- Optimised for NEG coating