Update on the injection region

Awake collaboration meeting, CERN

16/10/2025

Michele Bergamaschi

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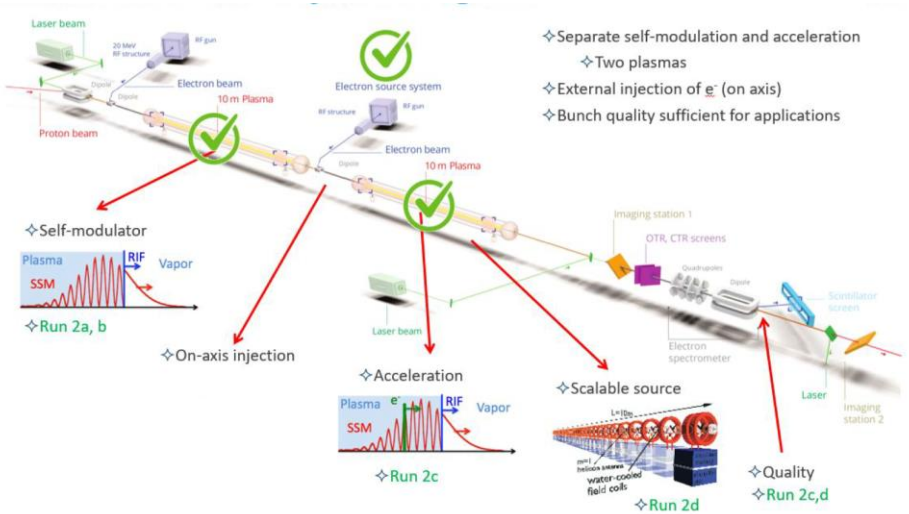
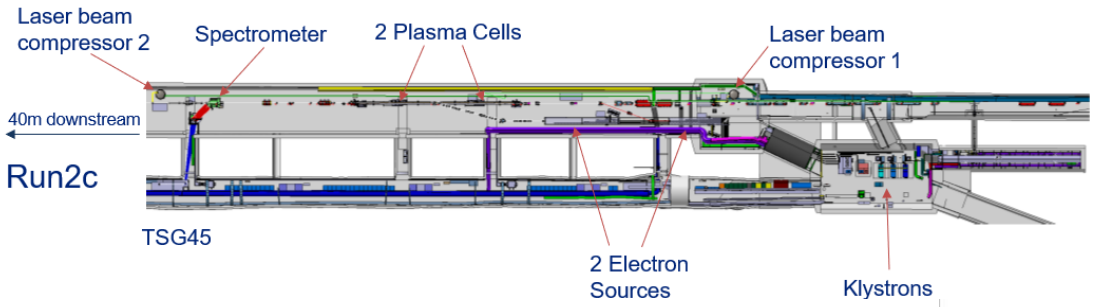
- Work ongoing for Injection region for Run 2c
- Conceptual design phase
- Feasibility study design phase
- Integration studies
- Summary

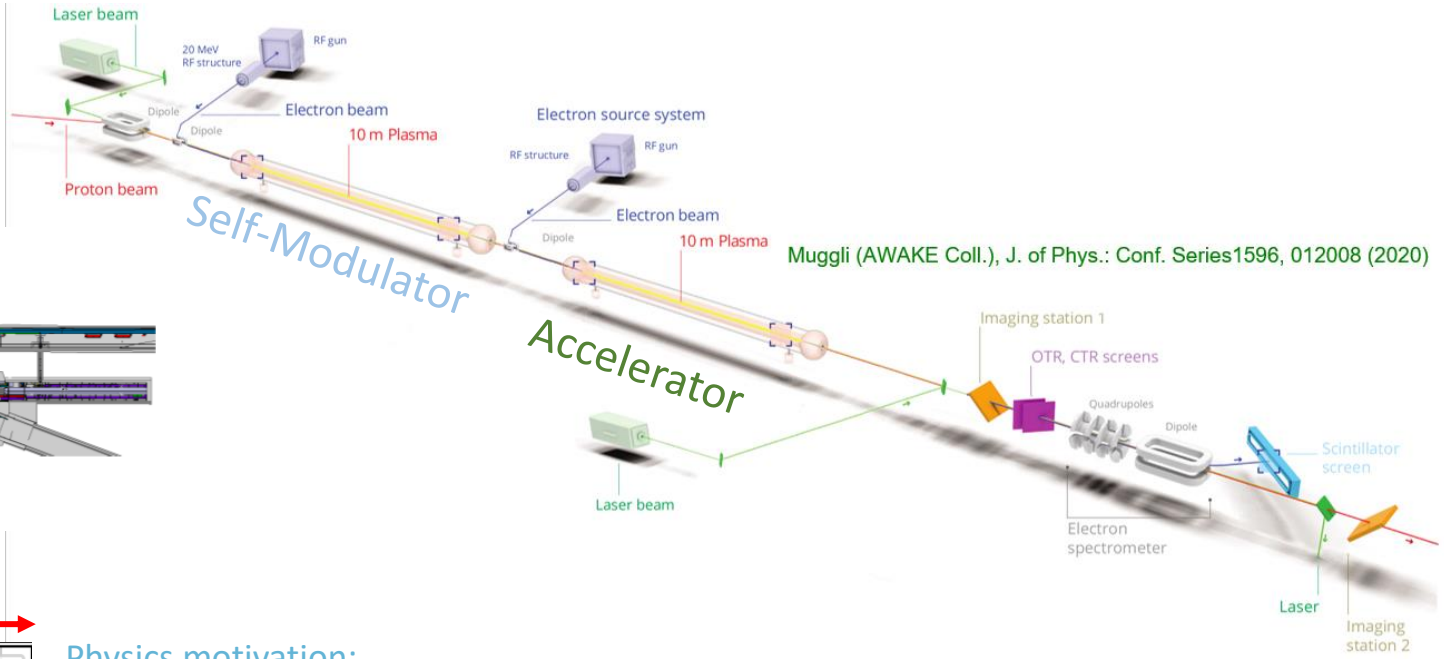
Work ongoing for Injection region for Run 2c

- Discussion has started this year for the design of the injection region for Run 2c:
  - Physics motivation is guiding the design, though technical constraints are several because of the complexity of the area
  - Conceptual design phase started in Jan 2025 (MPP with GWA)
  - Discussion to understand limitations has started with CERN: vacuum, e-beamline, magnets, integration, instrumentation dedicate Injection region meeting regularly taking place

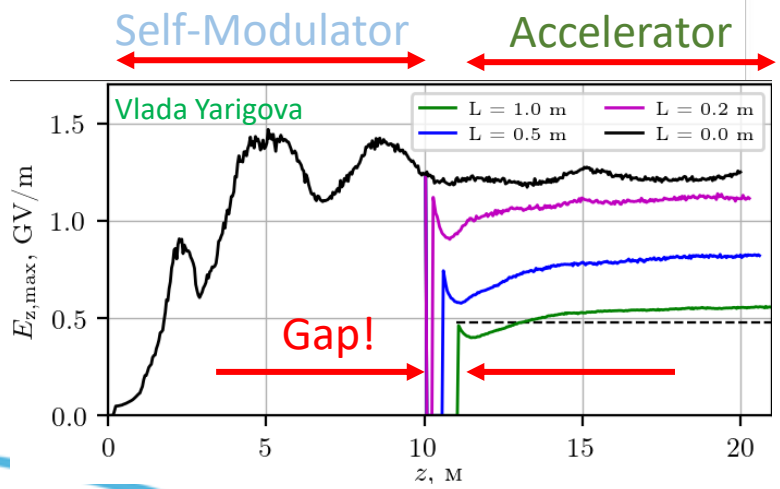


Work ongoing for Injection region for Run 2c





Muggli (AWAKE Coll.), J. of Phys.: Conf. Series1596, 012008 (2020)



Physics motivation:

- Accelerating gradient: 1GeV/m
- Energy gain 4-10GeV over 10m
- Minimize the gap length (between the two plasmas) to maximize the accelerating gradient in the accelerator
  - Gap -> defocusing of p^+
  - Lower accelerating gradient in the accelerator

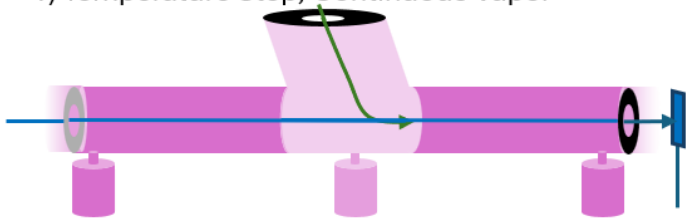
- Essential for the success of Run 2c

Slide from P. Muggli talk at PEB

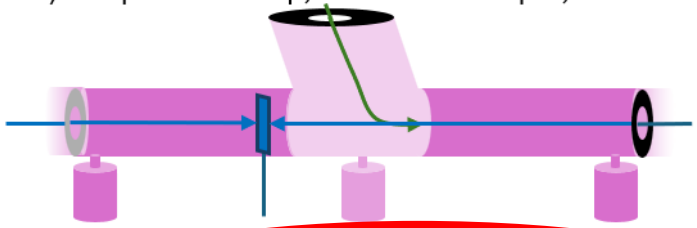
Conceptual design phase

Continuous vapor concepts (1, 5, 6)

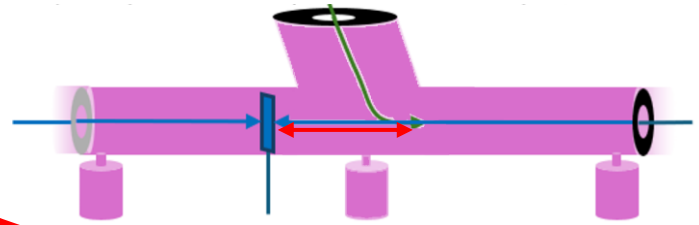
1) Temperature Step, Continuous Vapor



5) Temperature Step, Continuous Vapor, two laser beams

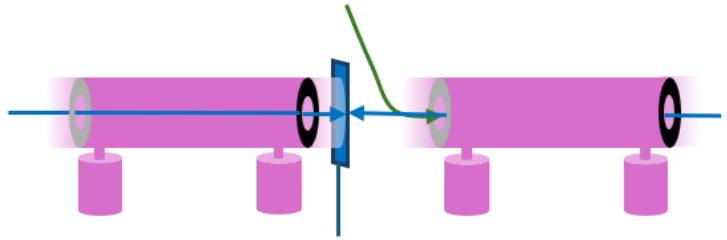


6) Temperature Step, Continuous Vapor, two laser beams, Uniform

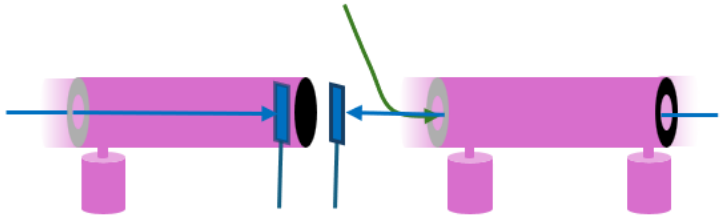


Discontinuous vapor concepts (1, 5, 6)

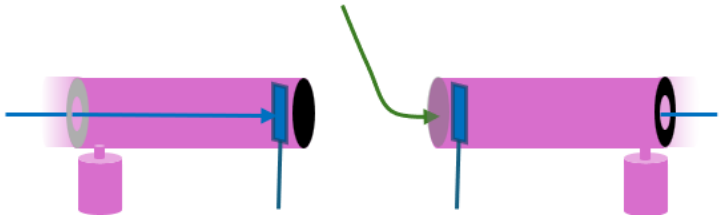
2) Two Open Sources



3) One Open, One Closed Source

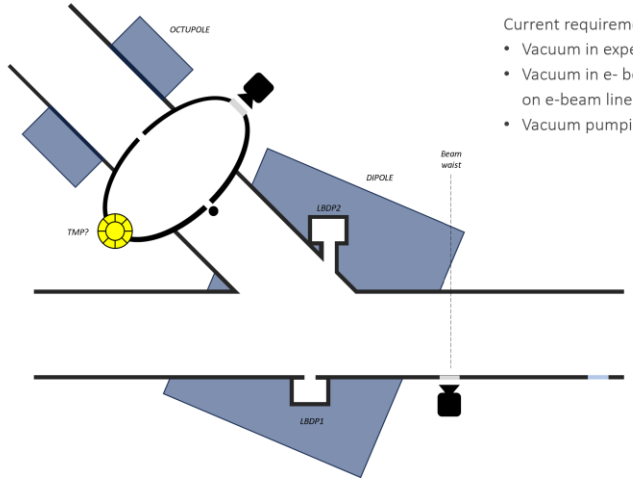


4) Two Closed Sources



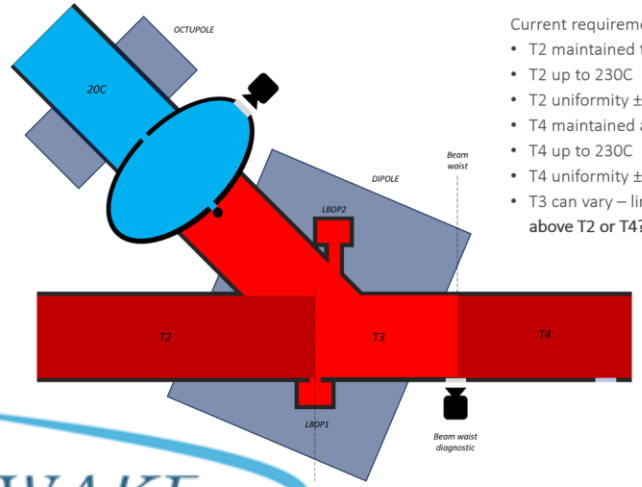
Conceptual design phase

Vacuum – General & geometric requirements



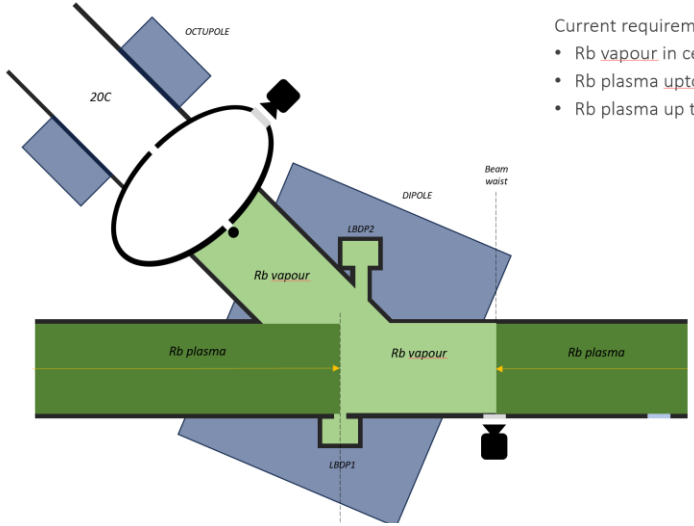
Current requirements:
- Vacuum in experiment ~1e-6 mbar
- Vacuum in e- beam line <1e-8mbar (**TBC**) from **TBD** on e-beam line
- Vacuum pumping included on central chamber (**TBD**)

Thermal – General & geometric requirements



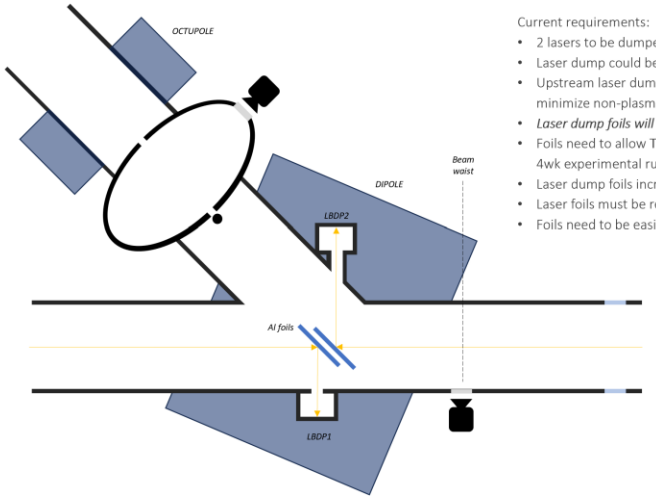
Current requirements:
- T2 maintained to upstream beam dump
- T2 up to 230C
- T2 uniformity ±0.5C (**TBD**)
- T4 maintained after beam waist
- T4 up to 230C
- T4 uniformity ±0.25C (**TBD**)
- T3 can vary – limits **TBC (+5C above Rb flask; 10C above T2 or T4?)**

Rb – General & geometric requirements



Current requirements:
- Rb vapour in central section
- Rb plasma upto upstream laser dump
- Rb plasma up to beam waist from downstream

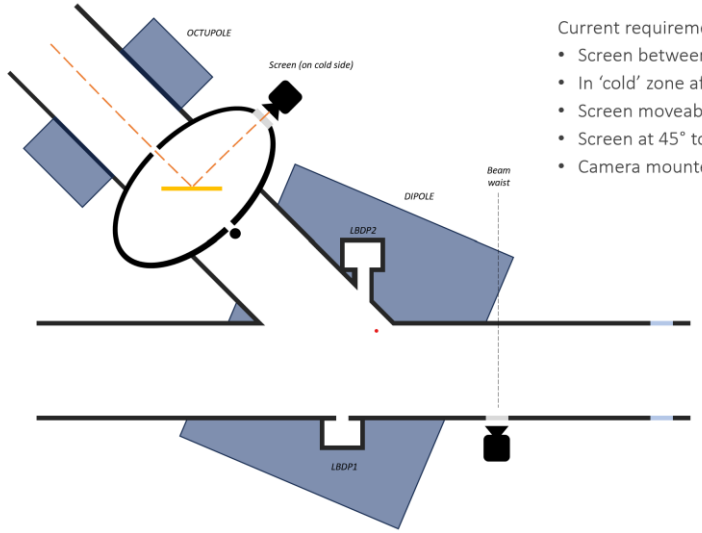
Laser dump – General & geometric requirements



Current requirements:
- 2 lasers to be dumped
- Laser dump could be a single foil or pair (independent dumps?)
- Upstream laser dump to be as close as possible to e-beam to minimize non-plasma gap
- *Laser dump foils will be located inside dipole field*
- Foils need to allow **TBD** laser hits before replacement (minimum 1 4wk experimental run – 50k hits?)
- Laser dump foils incrementally moveable
- Laser foils must be removable off beamline axis
- Foils need to be easily replaceable

Conceptual design phase

Screen Diagnostic – General & geometric requirements

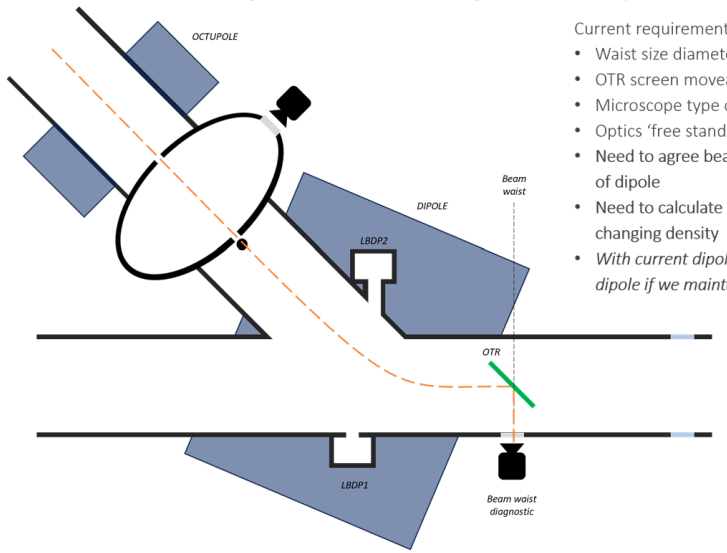


Current requirements:

- Screen between last octupole and dipole
- In 'cold' zone after aperture plate
- Screen moveable in and out of e-beam
- Screen at 45° to e-beam
- Camera mounted to experiment or 'free standing'

GWA Technology

OTR Beam Waist Diagnostic – General & geometric requirements

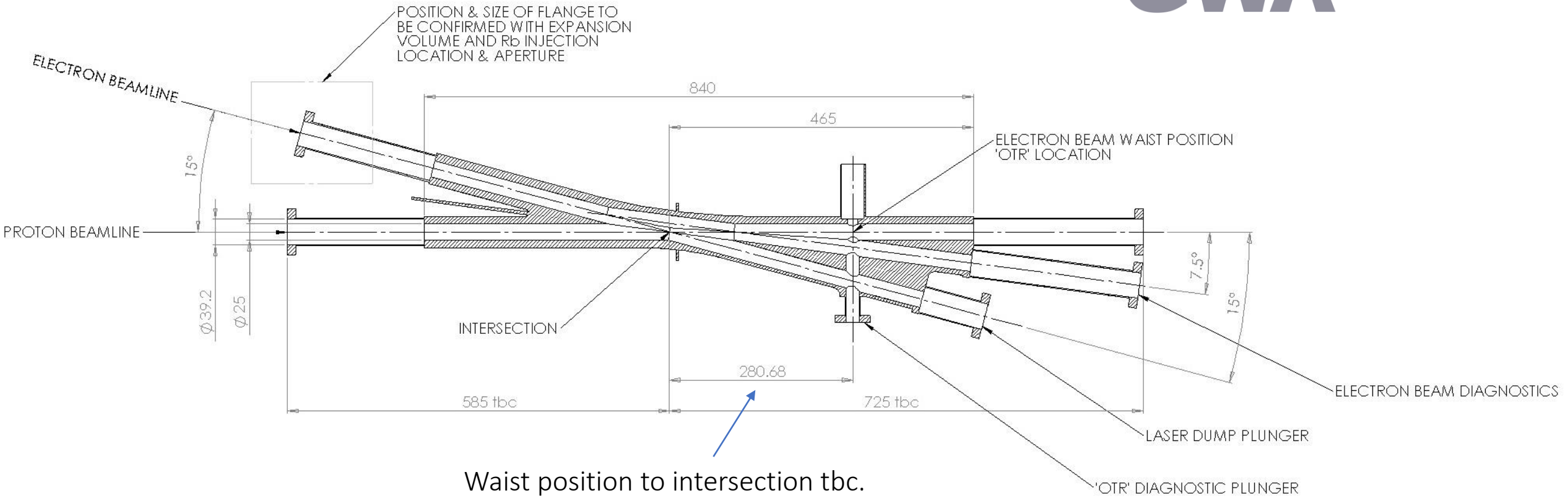


Current requirements:

- Waist size diameter requiring imaging is ~5µm dia
- OTR screen moveable in and out of e-beam
- Microscope type optics required
- Optics 'free standing'
- Need to agree beam waist nominal position from centre of dipole
- Need to calculate waist position movement in z with changing density
- *With current dipole the OTR screen will be inside the dipole if we maintain non-plasma gap < 300mm*

GWA Technology

Feasibility study design phase



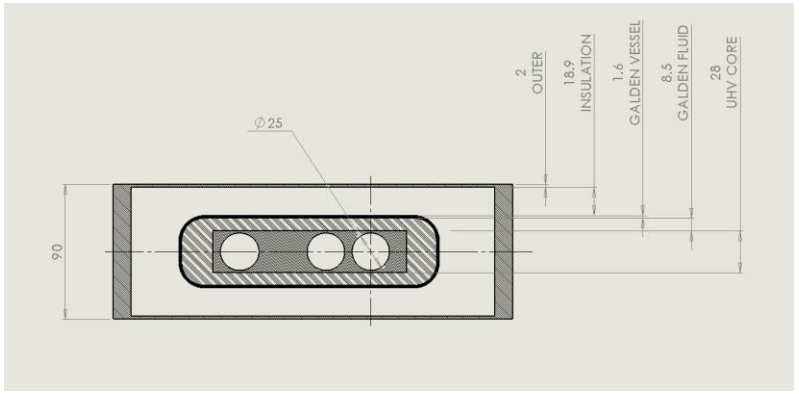
Waist position to intersection tbc.
This dimension has been manipulated to achieve <300mm waist to laser dump (non-plasma gap) for thermal simulation and may not be achievable.

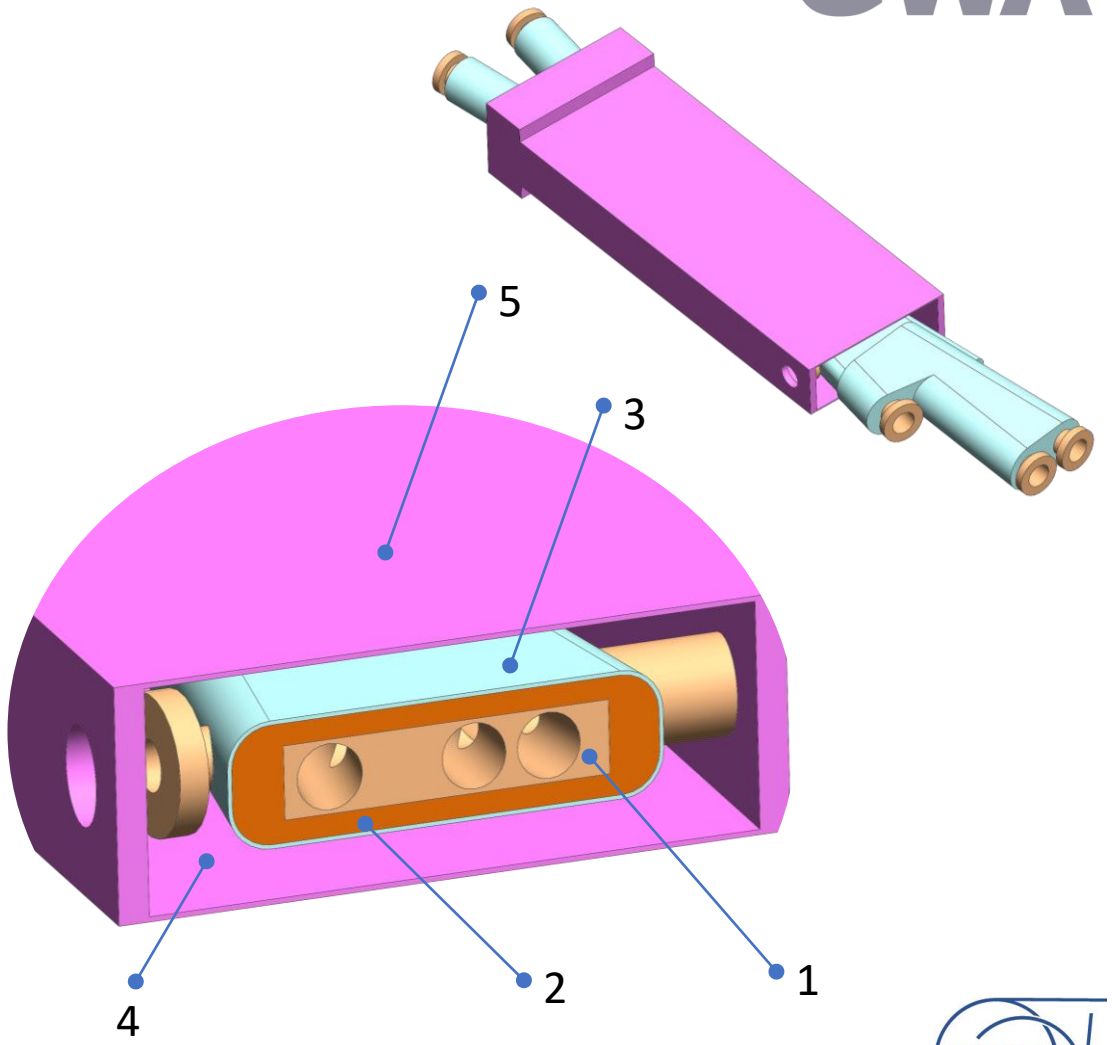
Feasibility study design phase

Y-Piece core elements

There are 5 basic elements to the Y-piece construction:

1. Inner UHV fabrication
2. Heated Galden fluid
3. Outer Galden jacket
4. Insulation layer (not shown)
5. Outer skin

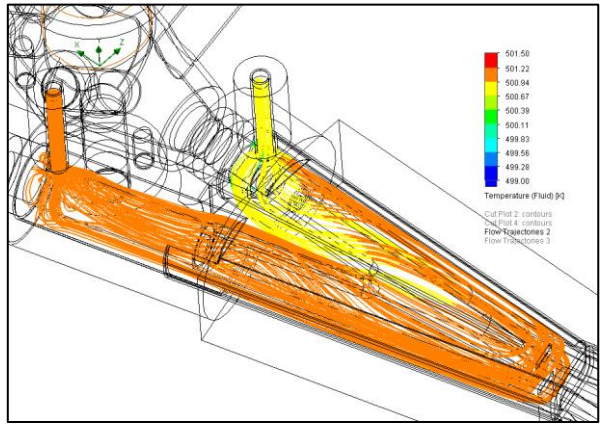


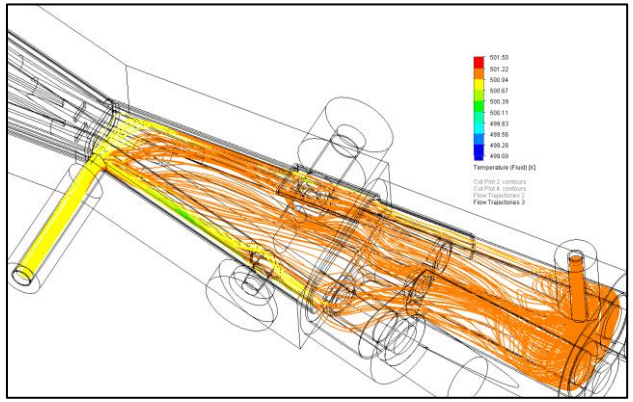


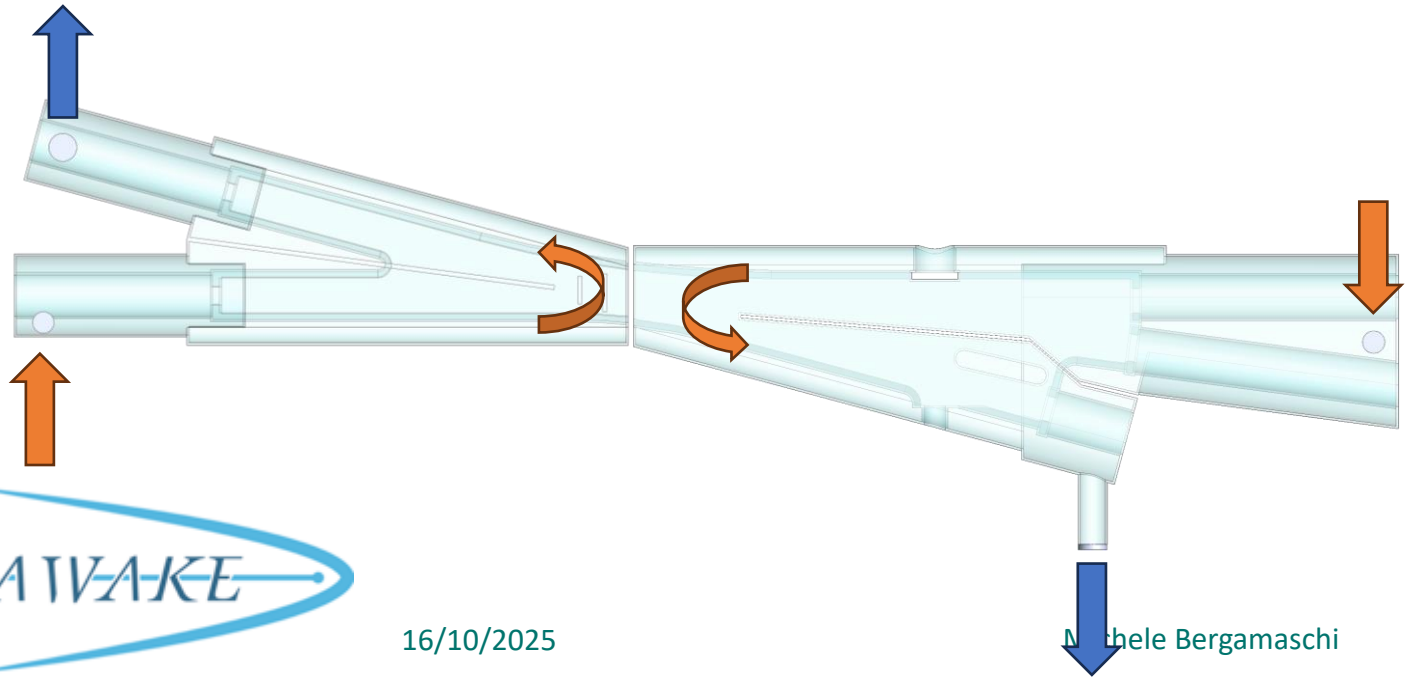
Feasibility study design phase

Thermal simulations

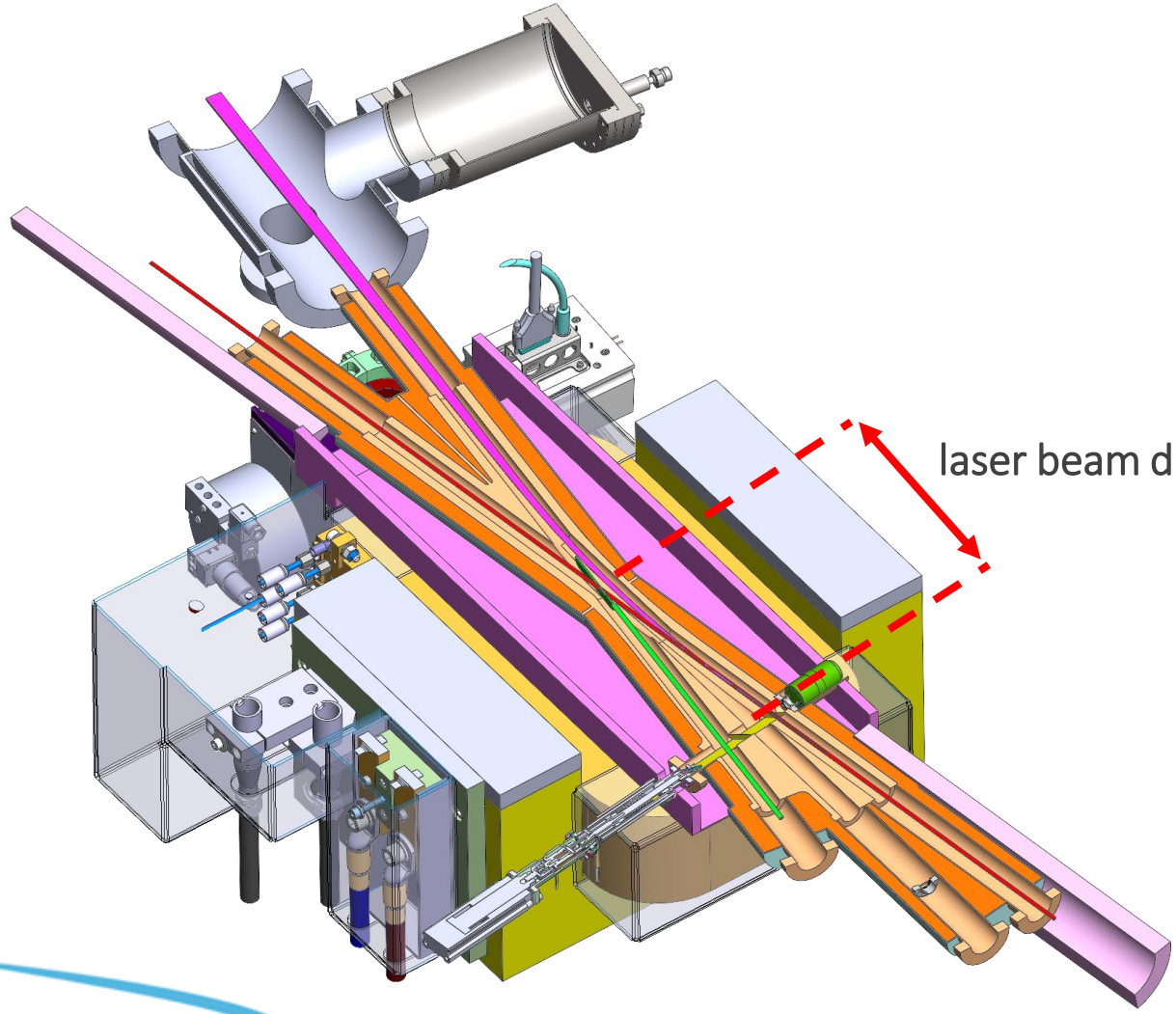
- Current simulation suggests ±0.5C uniformity is possible => Supports density uniformity requirements
- Outer insulation surface temperature of y-piece <50C => Unlikely to impact dipole reliability/performance
- Beamline temperature profile lumpy => more investigation/refinement of design needed
- Model uses temperatures, flow rates and materials similar to run 2b => Lowers technical risk



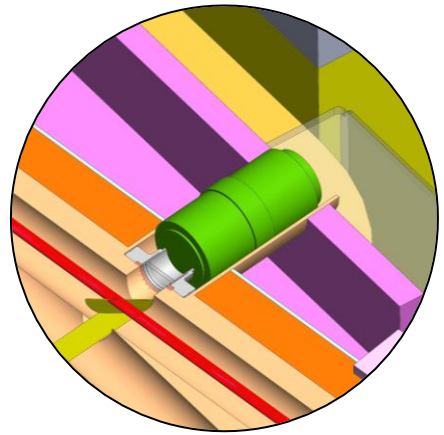




Feasibility study design phase



Waist Diagnostic

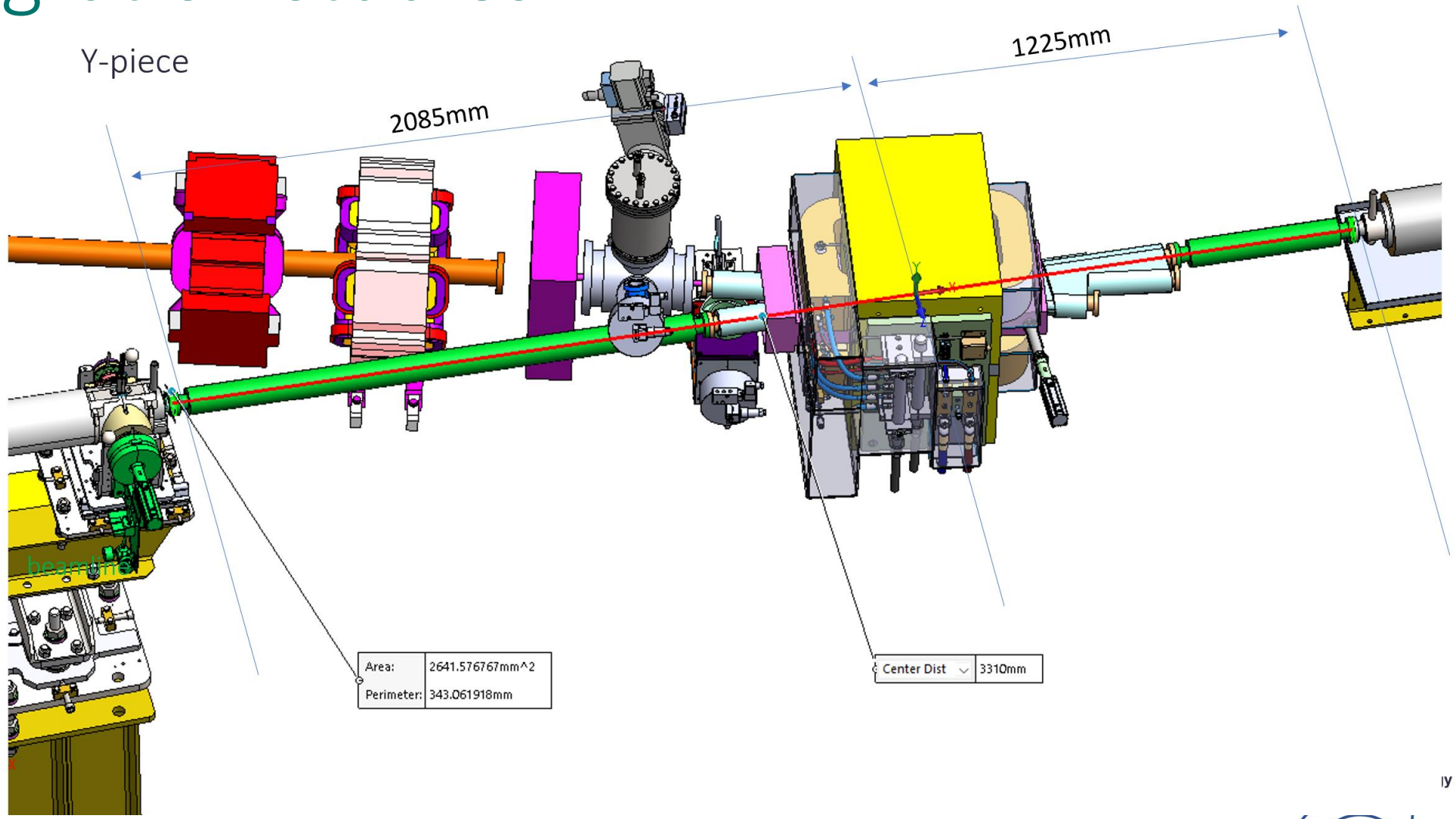


Challenging goals -> measure waist size ~5µm inside vapor source

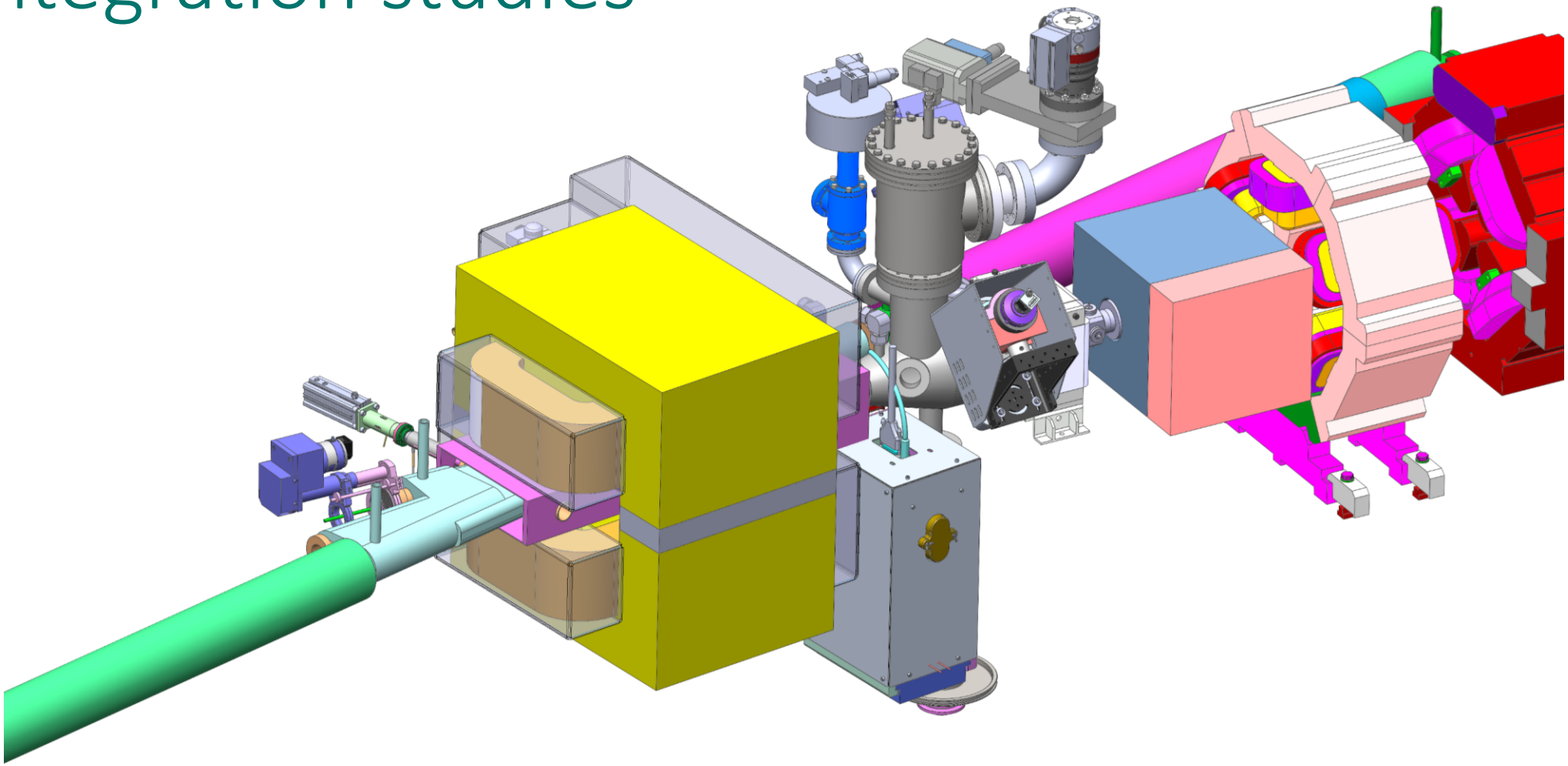
Long Working Distance Microscope Objectives Lenses – optics size could be an issue

Integration studies

Y-piece



Integration studies

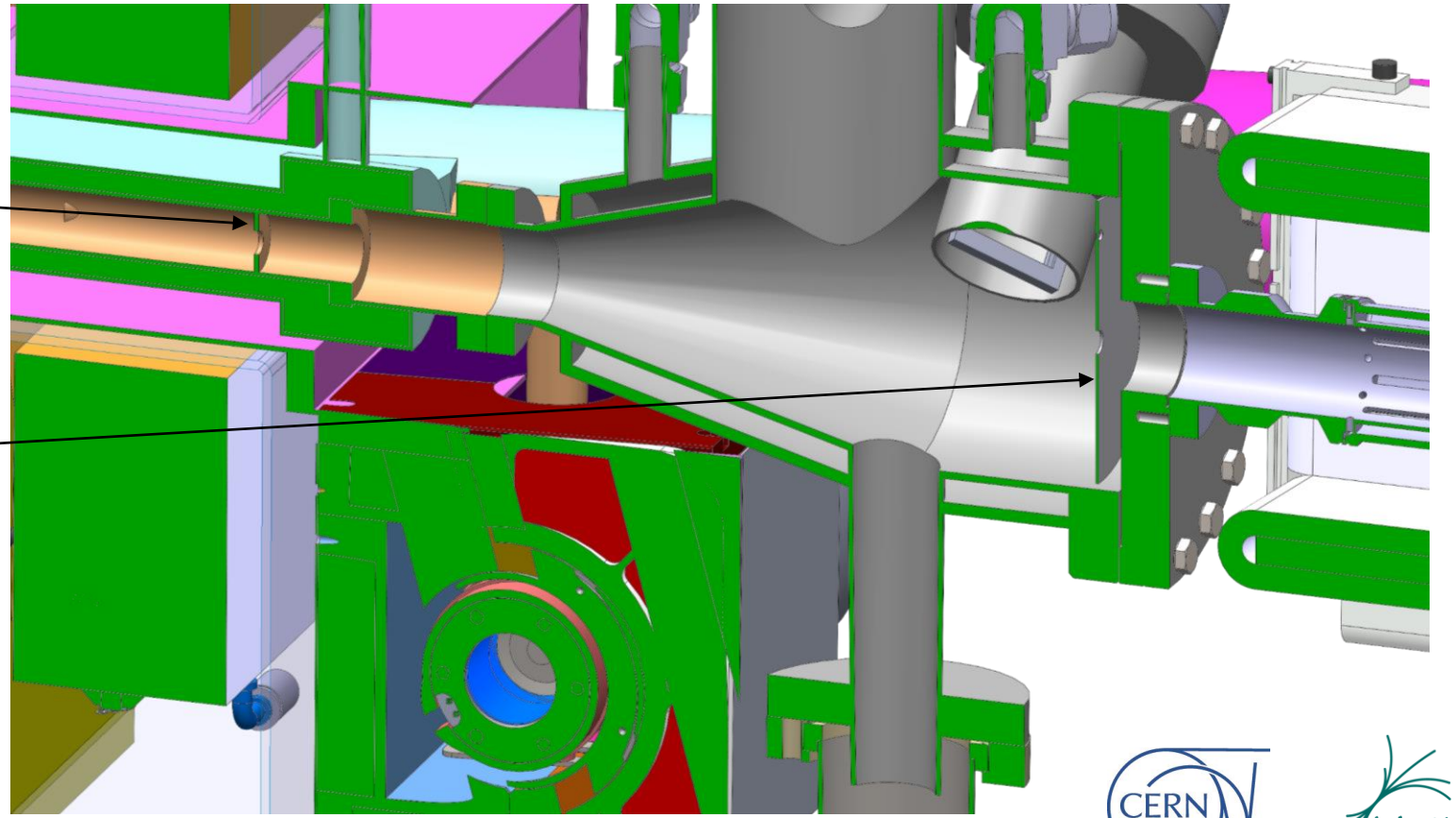


Integration studies

Expansion volume

Aperture plate buried inside Y piece leg

Aperture plate at rear of chamber (e-beam Rb limiter)

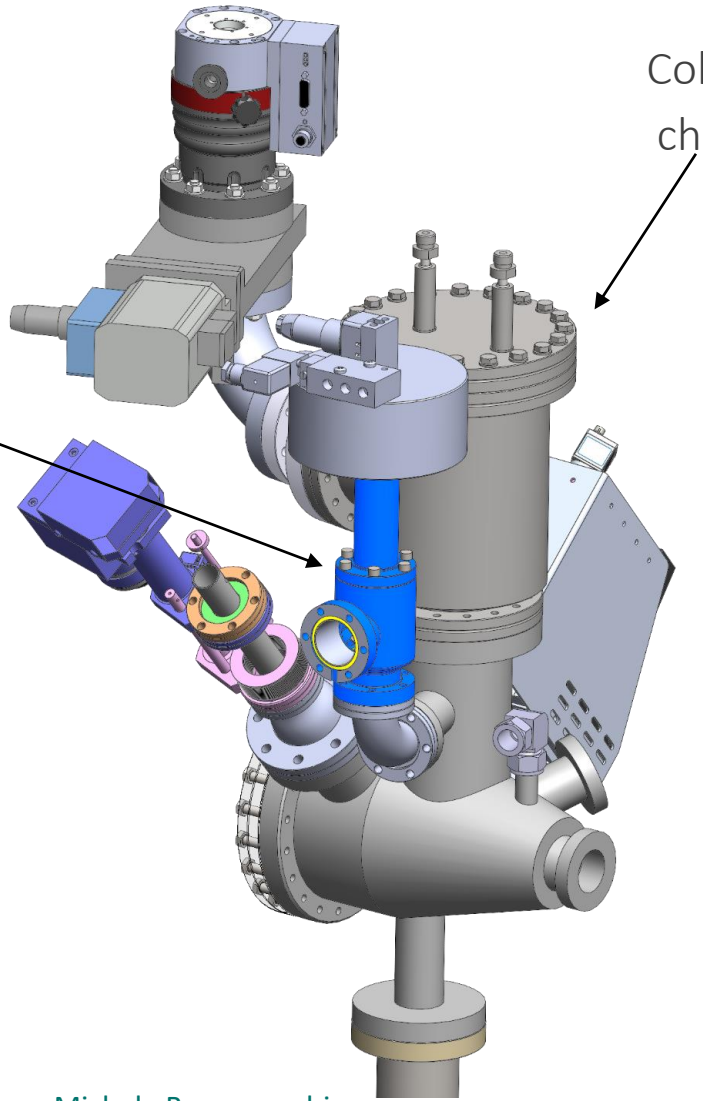


Integration studies

Expansion volume

Provision for argon feed orientated for best Rb melt/collection

Cold trap and VPG orientated on chamber orientated for best Rb melt/collection

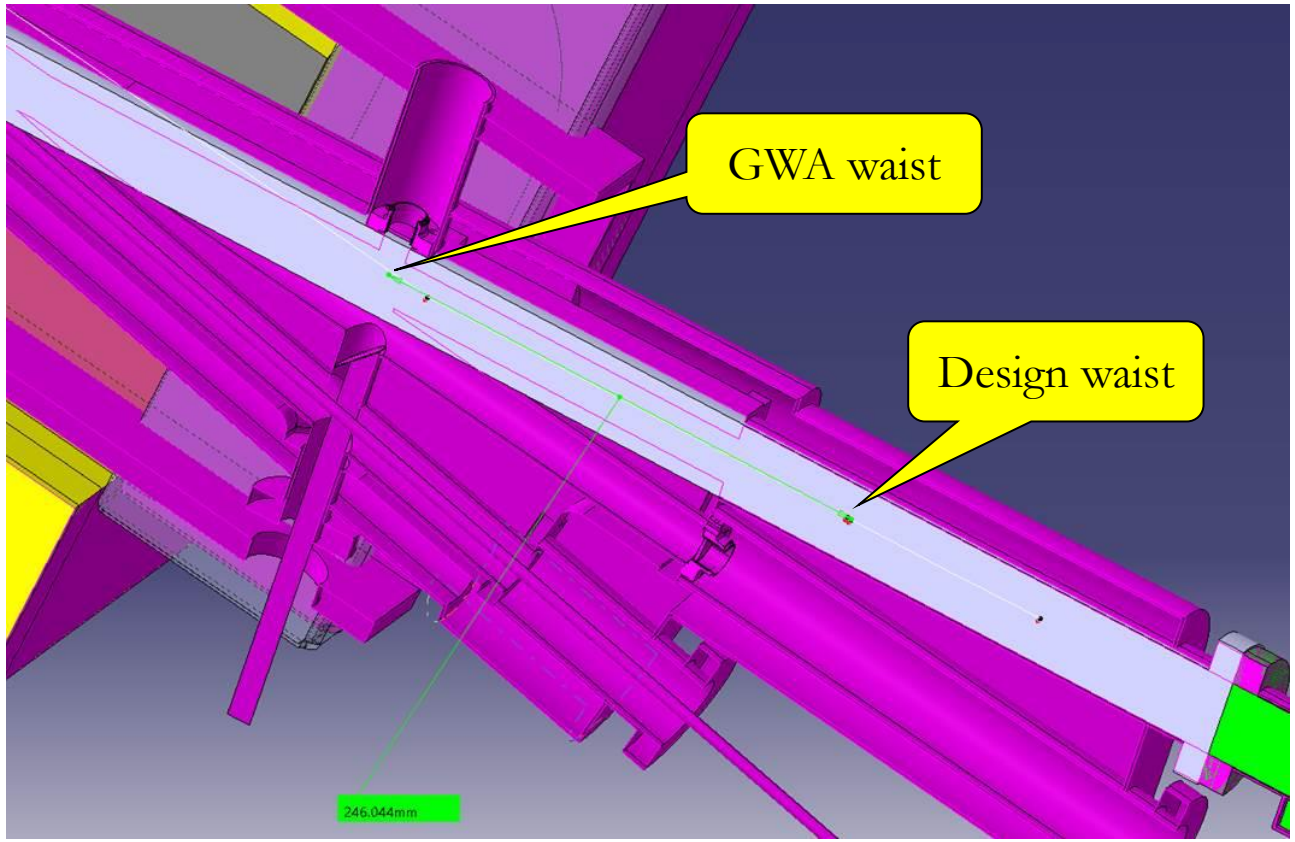


Integration studies

In Progress

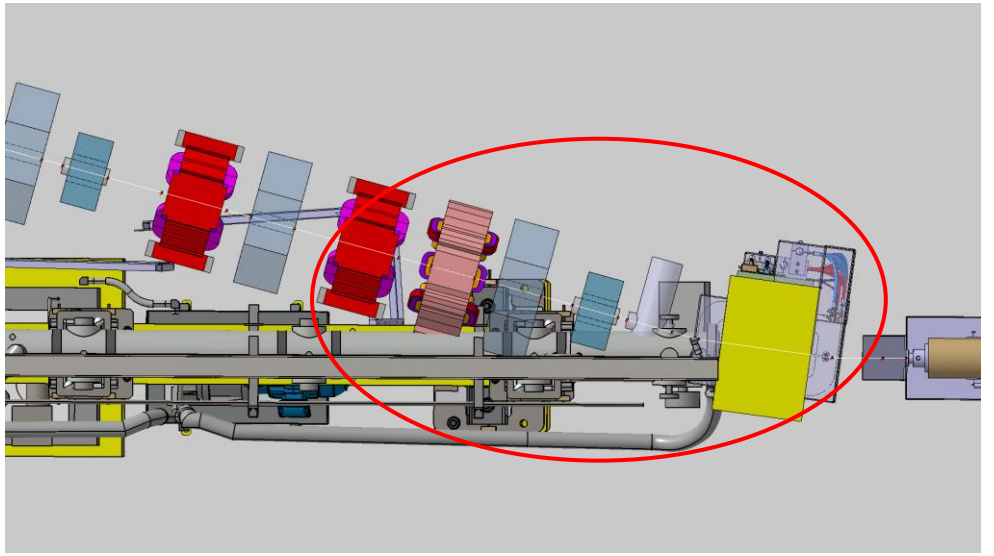
Waist position

- Position of beam waist to be resolved
- GWA waist position supports <300mm non-plasma gap for best Physics
- Design waist increases non-plasma gap to ~550mm



Summary

- Understanding with SY-ABT if 150MeV beam waist can be moved closer to dipole to minimize gap
- Integration studies ongoing for tunnel and magnets location on 150 MeV line – source interaction points
- Defining presence on e-beam dump and valves on 150 MeV compatible with new expansion volume with TE-VSC



Picture from F. Galeazzi

Summary

- First thermal estimate studies suggest injection region source can be built inside 100mm gap dipole, dipole split for assembly necessary - Confirmed by TE-MSC experts
- Feasibility of laser beam dumps inside/close to dipole magnet is been investigated and will be crucial to minimize gap in the plasma
- Understand use of diagnostic presence in injection area for tuning and accurate delivery of 150MeV at injection point
  - Commissioning strategy of 150MeV-beamline under discussion to access which diagnostics are essential (screens, BPM, OSR, timing etc) near/inside the injection region
  - Possibility of having a "simple" vacuum chamber for commissioning of the diagnostics
- BE-ICS group involvement under discussion for control system design and support for Run2c-> no technical challenge

Thank you for your attention