NEG coating of ELETTRA dipole chambers

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ELETTRA-CERN Project update

Outline:

- ✓ Project overview
  - ELETTRA 2.0
  - Dummy chambers
  - Coating requirements

- ➢ Coating strategy

- ➢ Experimental updates

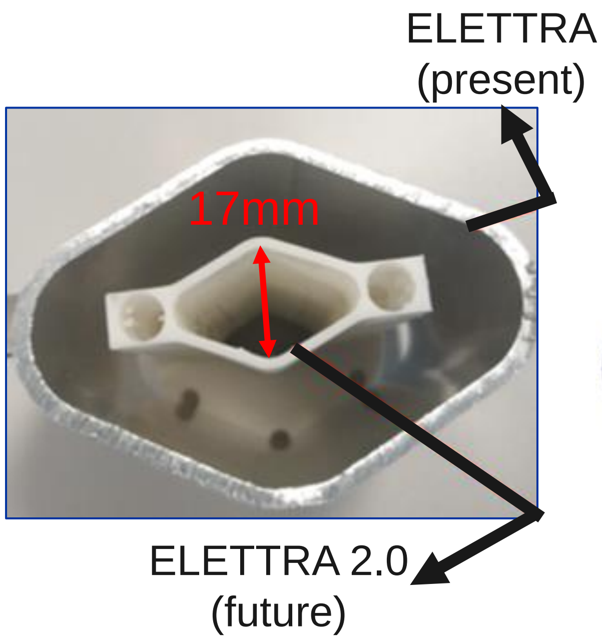
- ➢ Conclusion

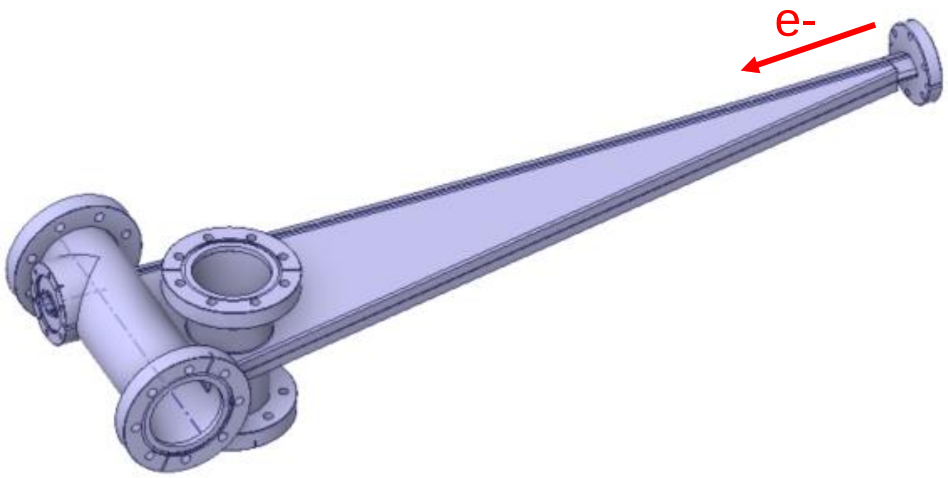
ELETTRA 2.0

- Elettra Sincrotrone Trieste
  - **Synchrotron light** source – 34 beamlines
  - From IR to Hard X-Rays for:
    - Solid state physics
    - Biology
    - Environmental science

elettra.eu

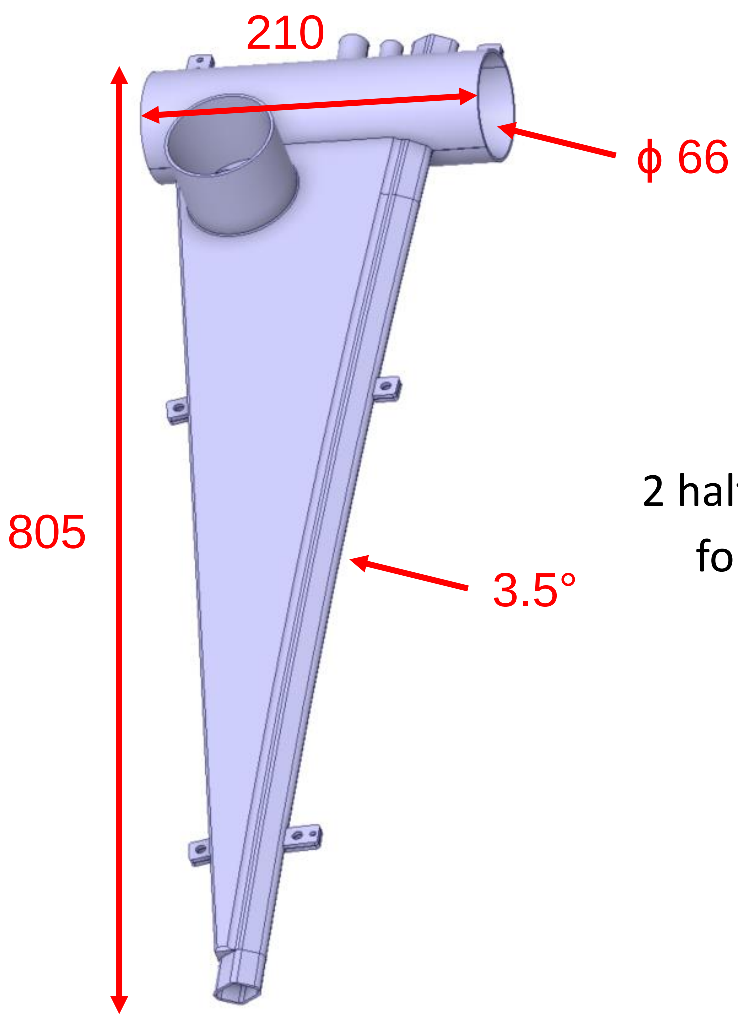
- Elettra 2.0
  - **Arcs** upgrade – 72 St.St. chambers
    - **Outsource** NEG coating
  - Horizontal **emittance** reduction by 49 times (0.25 nm rad)
  - Update UHV System – **smaller** diameters for higher magnetic fields
  - **NEG** coating for
    - Distributed pumping
    - Low PSD yields



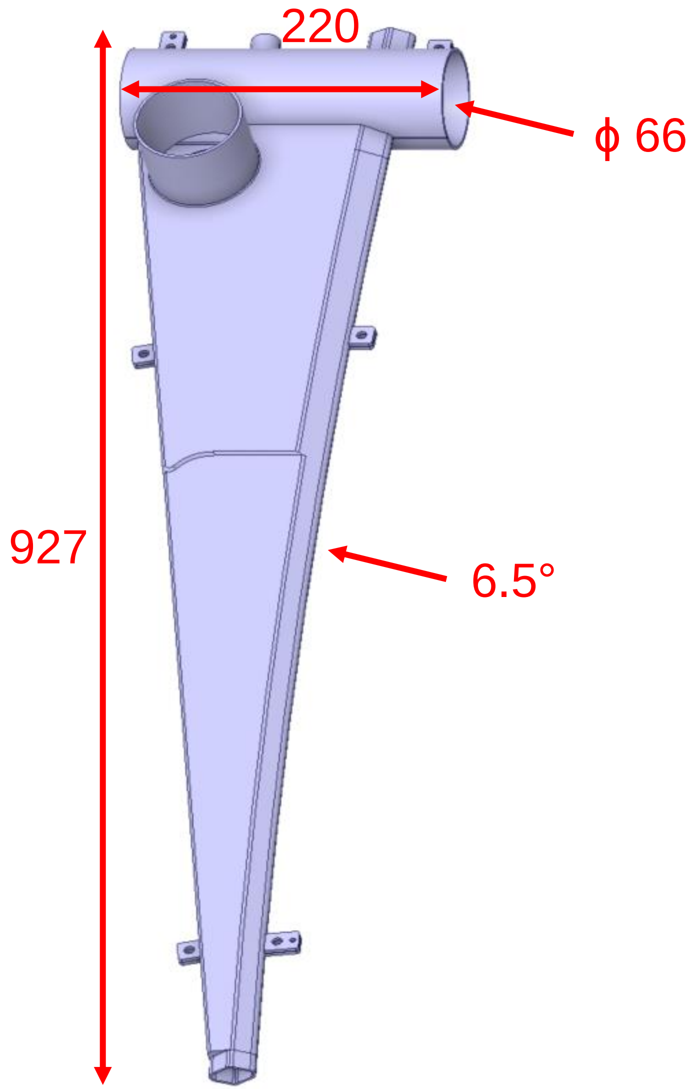


Dummy chambers (2 types)

- With synchrotron light extraction (**wLE**)
- Without synchrotron light extraction (**woLE**)

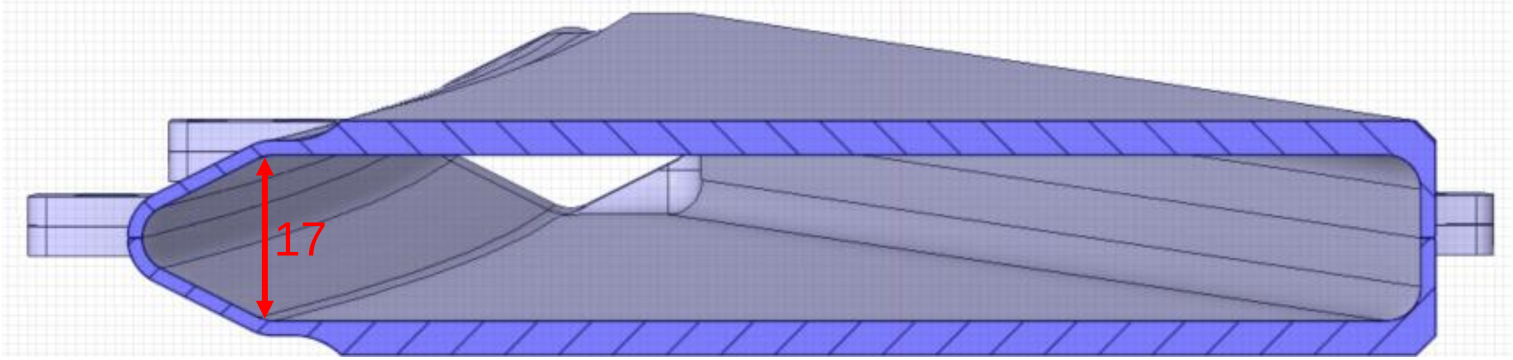


2 half shells per type for prototyping



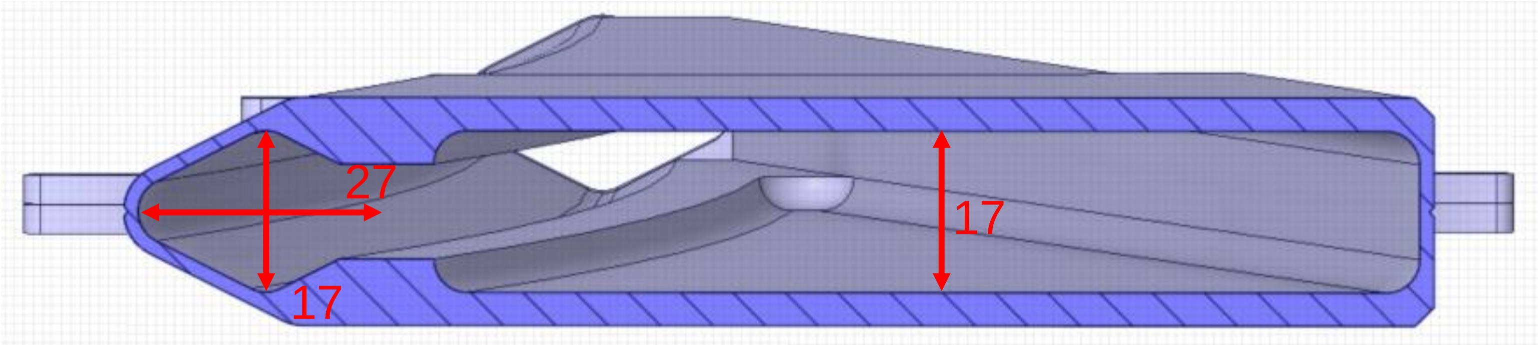
Dummy chambers cross section

- With synchrotron light extraction (**wLE**)
  - Open volume



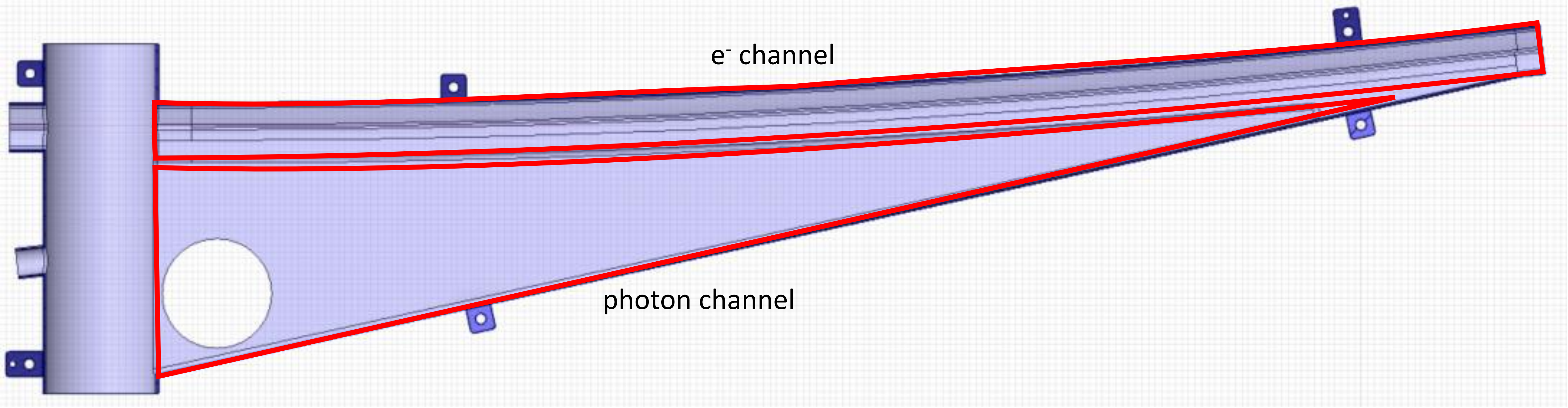
e^- side photon side

- Without synchrotron light extraction (**woLE**)
  - Partially closed volume

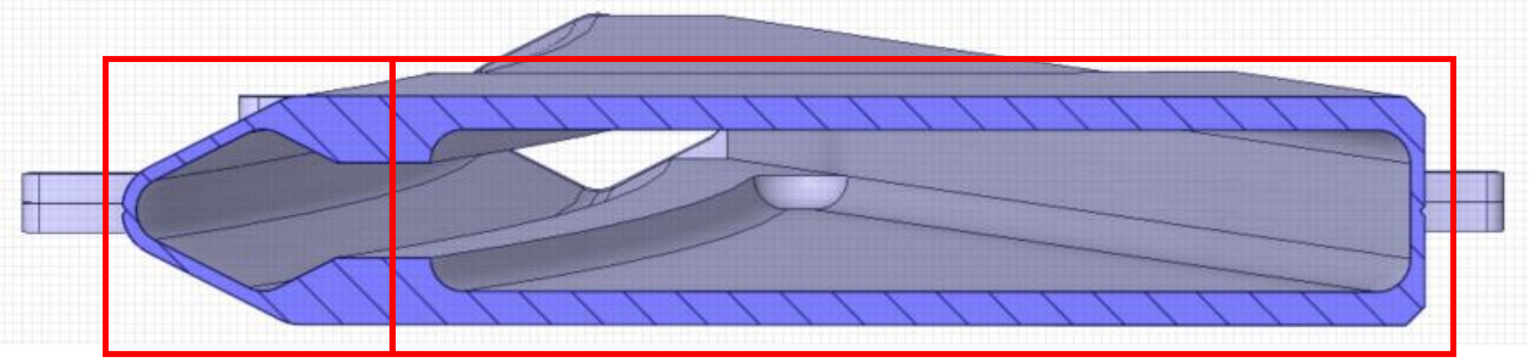


e^- channel photon channel

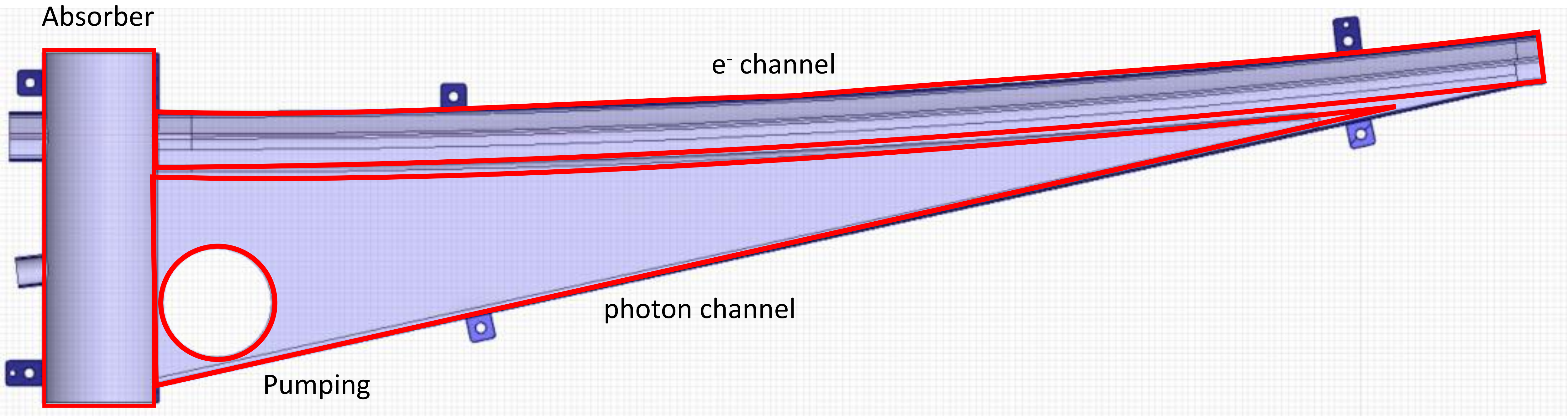
Coating requirements



- e- channel
  - 0.2 < Thickness < 0.5 µm – impedance limited
  - High coverage
- photon channel
  - 0.2 < thickness < 1.5 µm
  - High coverage – PSD limited



Coating requirements



➢ Absorber area

- High coverage – PSD limited
- 2nd coating run

➢ Pumping ports

- High coverage – PSD limited
- 2nd coating run

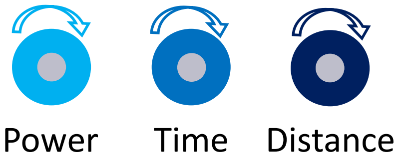
ELETTRA-CERN Project update

Outline:

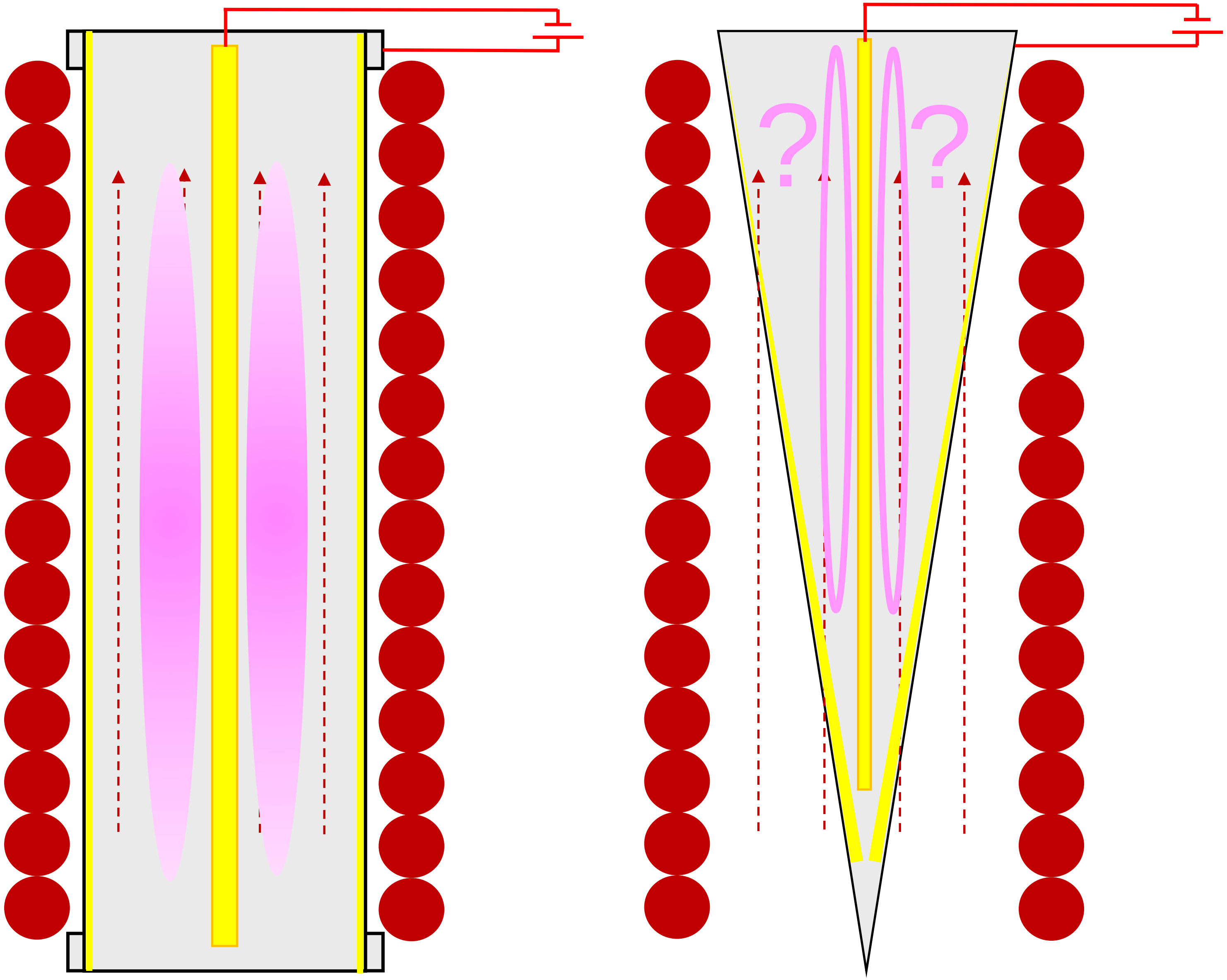
- ➢ Project overview
- ✓ Coating strategy
  - Coating principle
  - Short plasma confinement
  - Target translation in UHV
- ➢ Experimental updates
- ➢ Conclusion

Coating Principle

- **Magnetron Sputtering**
  - Vacuum chamber = **substrate**
  - **Target** of coating material
  - **Plasma** discharge
  - Uniform film growth



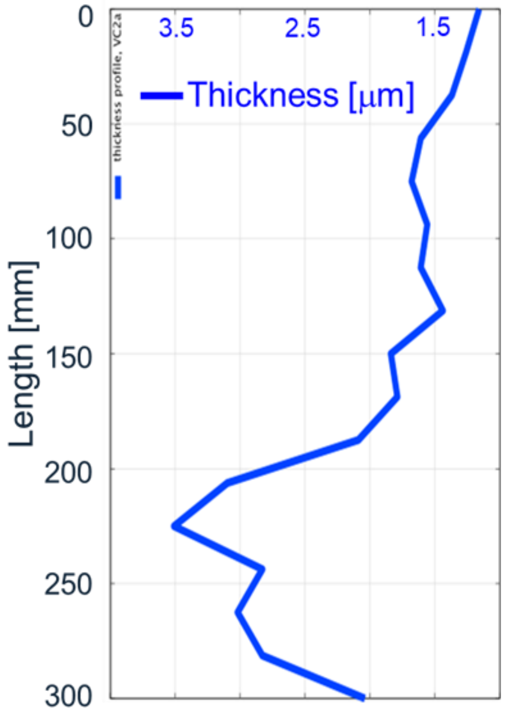
- **ELETTRA geometry**
  - Plasma inhomogeneity at narrow region
  - Non-uniform coating
    - Plasma difference
    - Change in coated surface



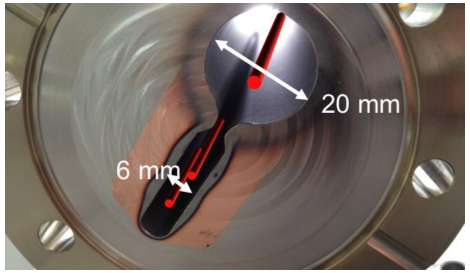
Short plasma confinement

➢ Previous similar coating

- **Whole cathode** active
  - Only overall control
- Local **inhomogeneities** possible



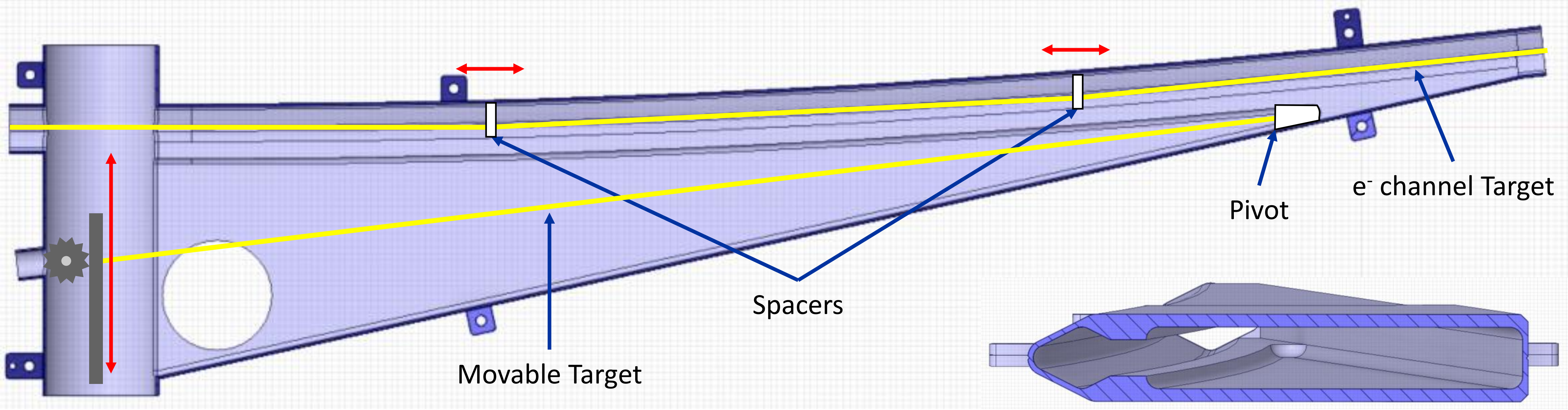
MAX IV
antechamber



➢ Advantages of short plasma

- **Power** in specific position
  - Localized film growth
- Control of **time** per position
  - Homogeneity
- Local cathode-substrate **distance**
  - Cross section adaptation

Dipole woLE – target arrangement



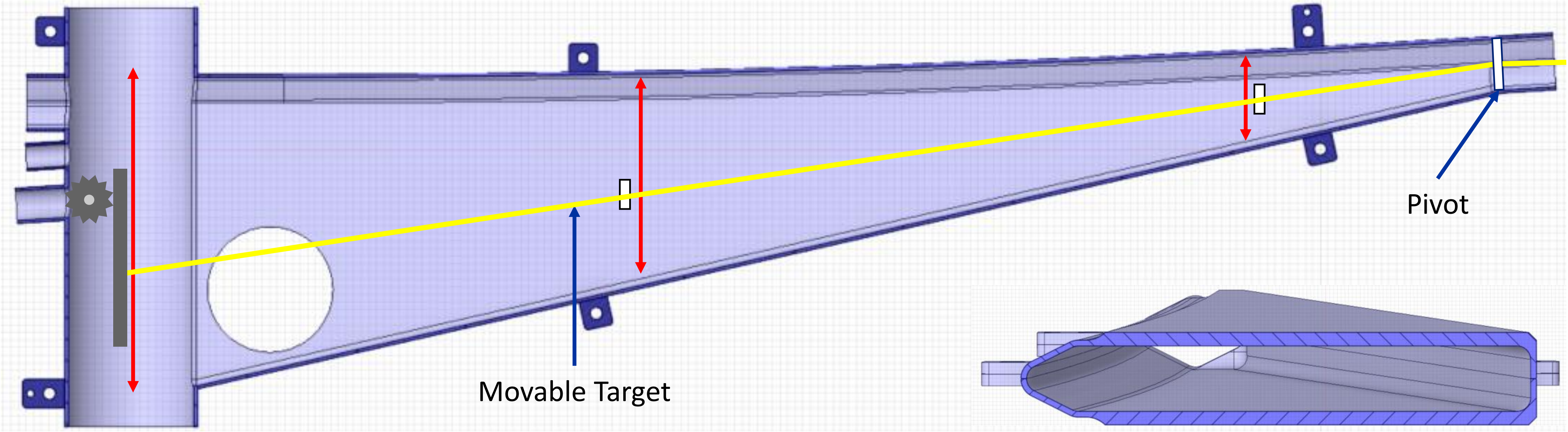
➢ woLE Coating approach:

- Bent target for e^- channel
- Translational spacers on fixed target (**longitudinal translation**)
- Pivoting target for photon channel (**transversal motion**)

➢ woLE Coating challenges:

- Spacers = insulated + no-scratch movement
- Pivoting mechanism
- Minimize shadow from pivoting centre
- UHV motion system from top

Dipole wLE – target arrangement



➢ wLE Coating approach:

- Pivoting target through full section (**transversal motion**)
- Bending spacers for 3° angle
- No hindrance on the side

➢ wLE Coating challenges:

- Spacers = insulated + no-scratch movement
- Pivoting mechanism
- UHV motion system from top

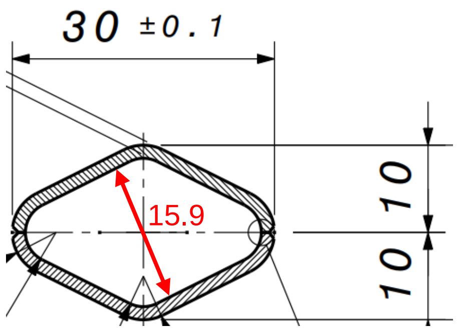
ELETTRA-CERN Project update

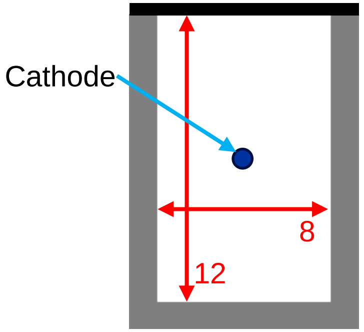
Outline:

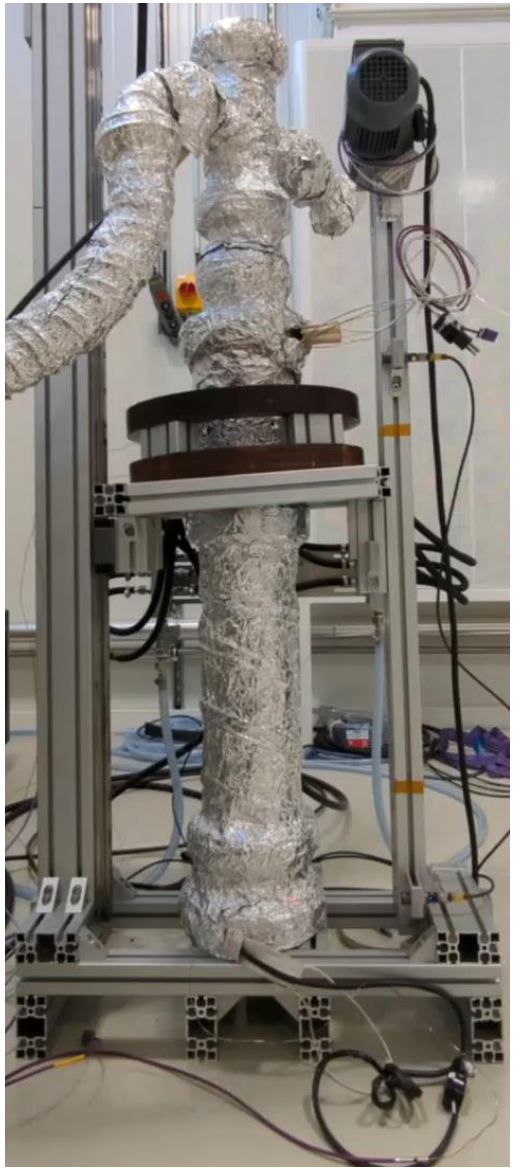
- ➢ Project overview
- ➢ Coating strategy
- ✓ Experimental results
  - Optimization of thickness uniformity
  - Coating system implementation
- ➢ Conclusion

Optimization of thickness uniformity

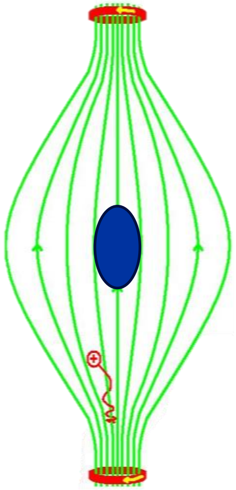
- Plasma study in narrow volumes
  - Create narrow chamber + sample
  - **U-shaped** alu profile, capped with **stainless steel sample**







- Short plasma confinement along z-axis
  - Investigation of **magnetic bottling**
    - Plasma ignition in low field region
  - Investigation of **diverging** magnetic field



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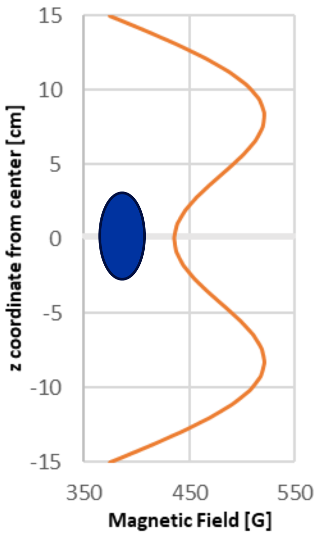
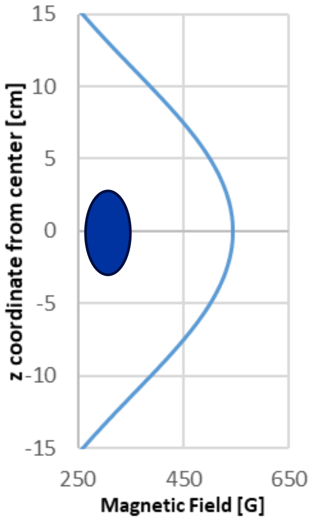
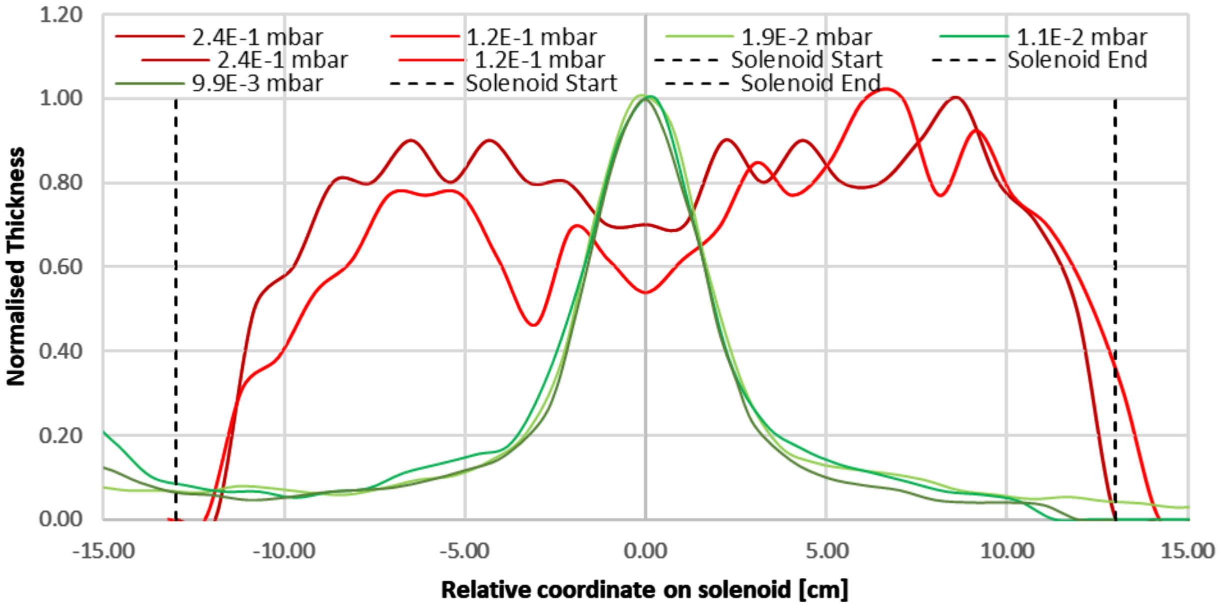


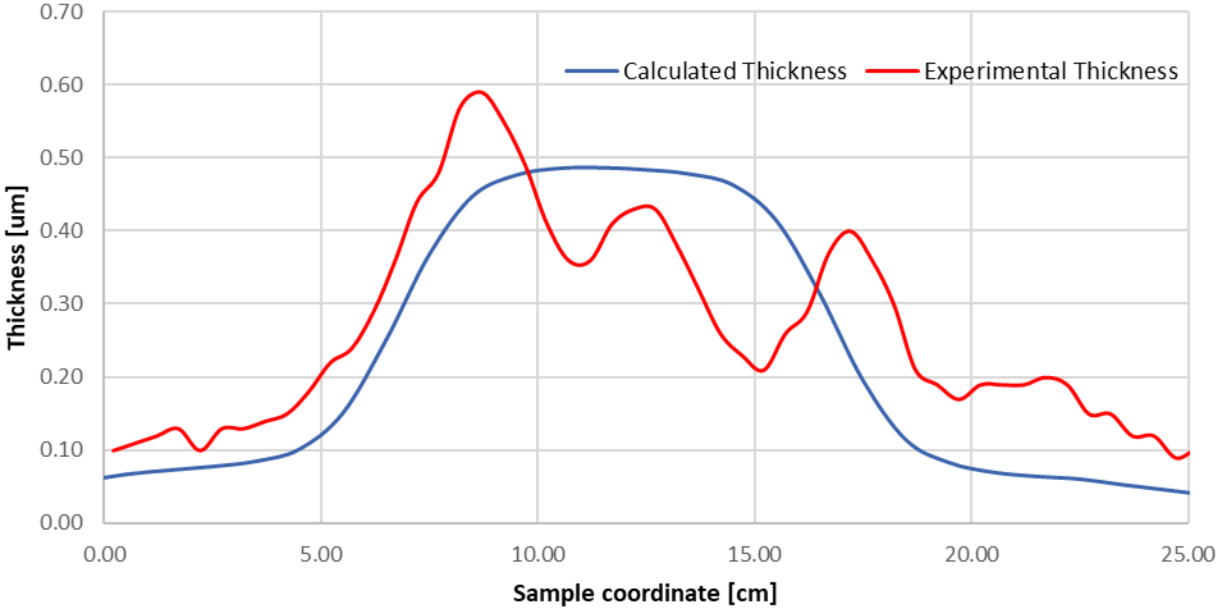


Thickness uniformity – Bottling

- Static analysis
  - 2 regimes
    - **High** Pressure = Broad & flat – solenoid **length**
    - **Low** Pressure = Narrow & gaussian – solenoid **centre**

- Dynamic analysis
  - 2 ideas for coating 10 cm at ≈0.45 µm:
    - Continuous scanning





Thickness uniformity – Bottling

Static analysis

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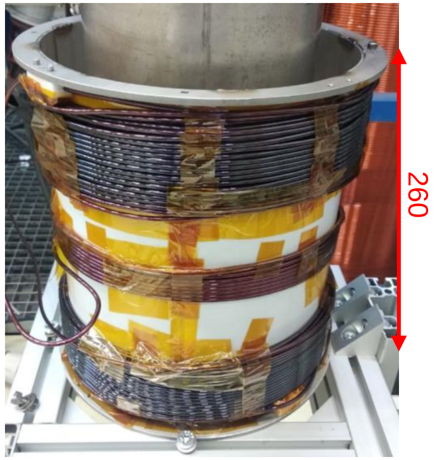
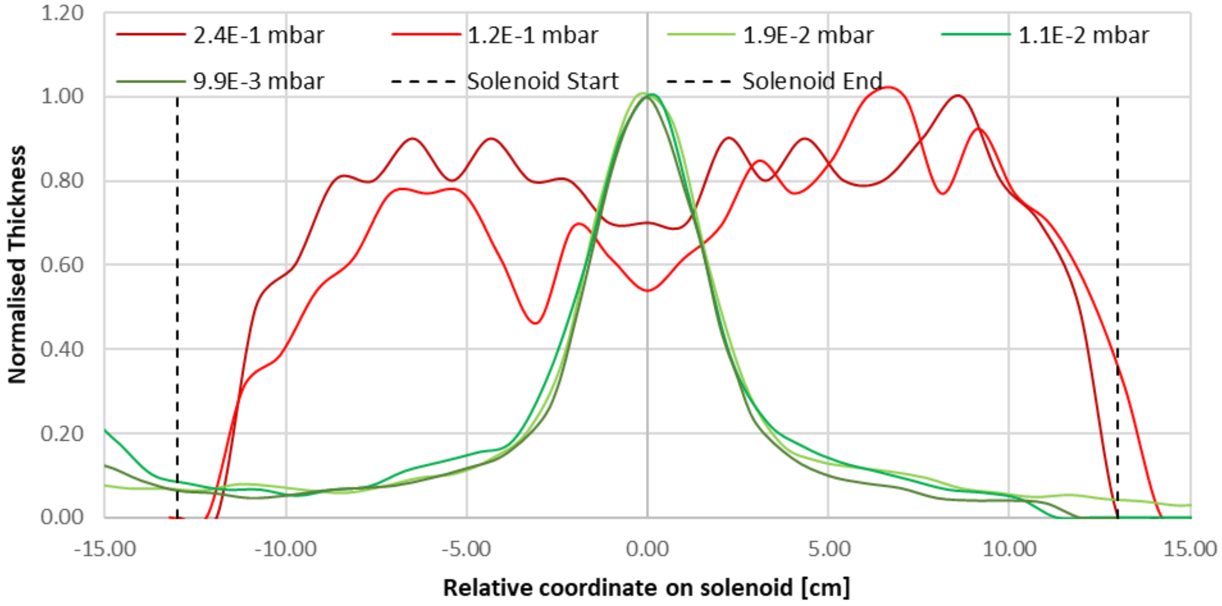
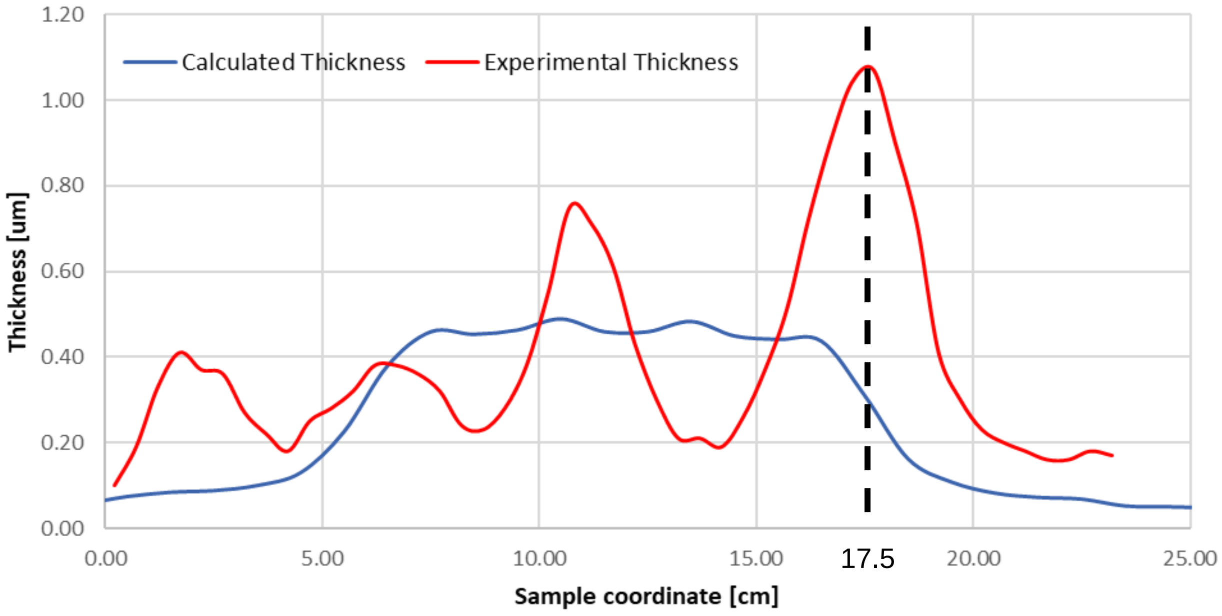


Dynamic analysis

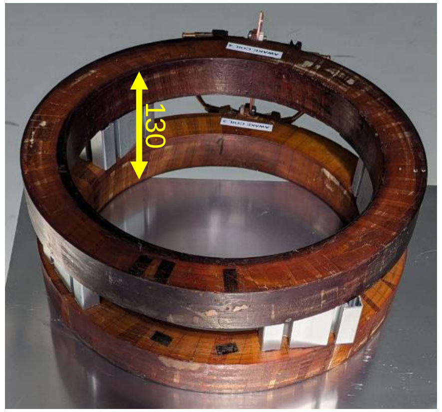
- 2 ideas for coating 10 cm at ≈0.45 μm:
  - Continuous scanning
  - Multi-static at fixed distance
- **Plasma Pinning** on previous coating positions



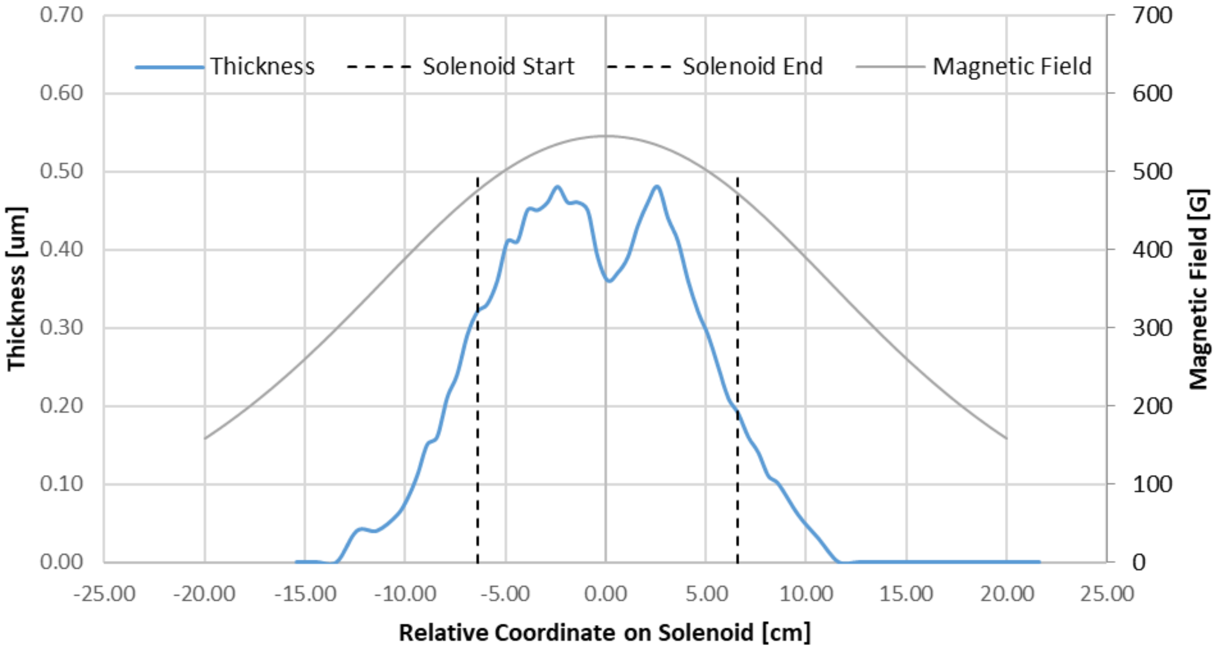


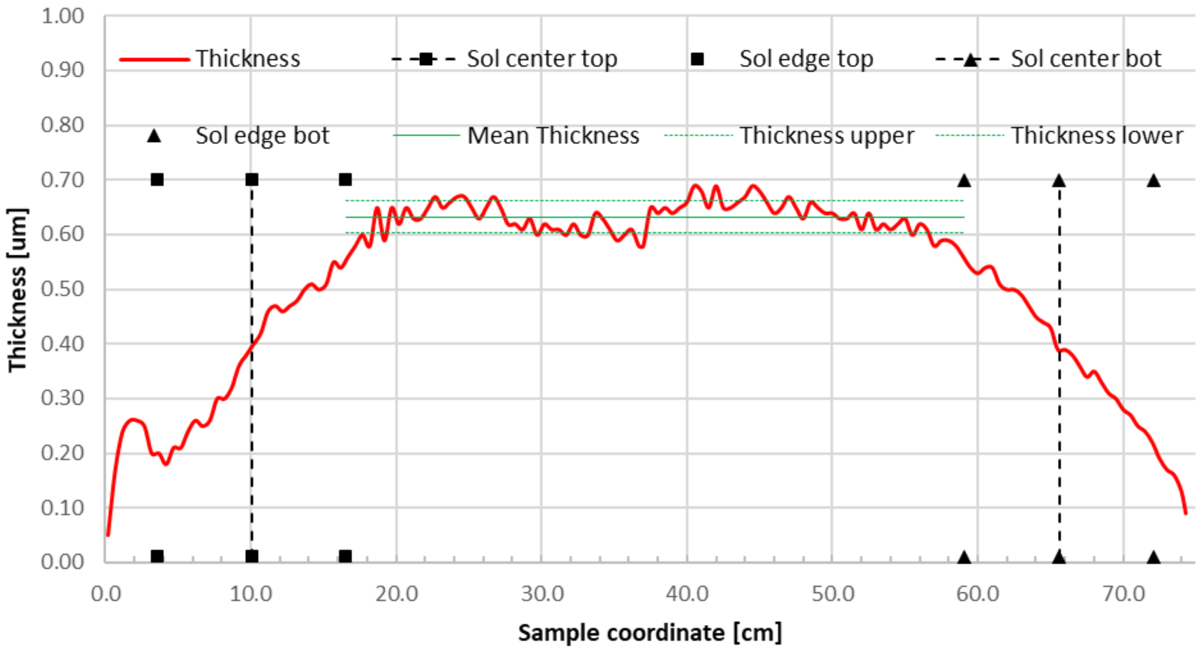
Thickness uniformity – Diverging

- Static analysis
  - Broad & fairly flat profiles
  - Coherent with magnetic field and solenoid positioning



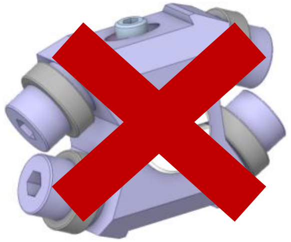
- Continuous scanning analysis
  - Continuous coating over 55 cm - (10h) successful
  - 1 solenoid length of non-homogeneity
  - Homogeneous profile over 30 cm – (**0.63 ± 0.03 µm**)

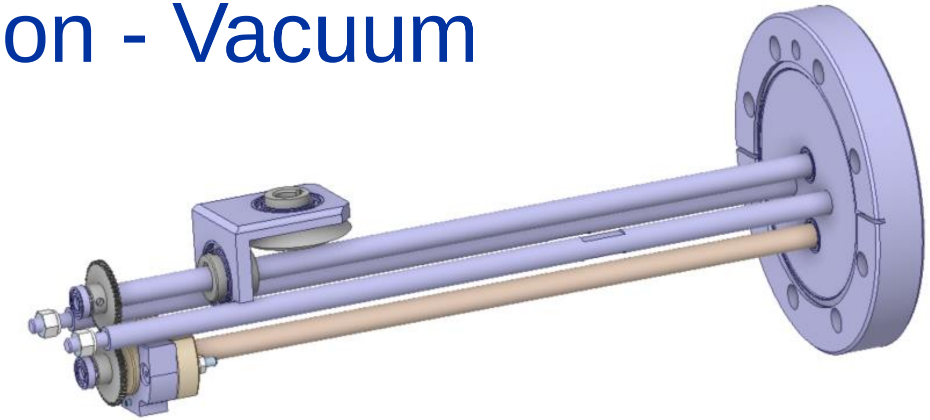


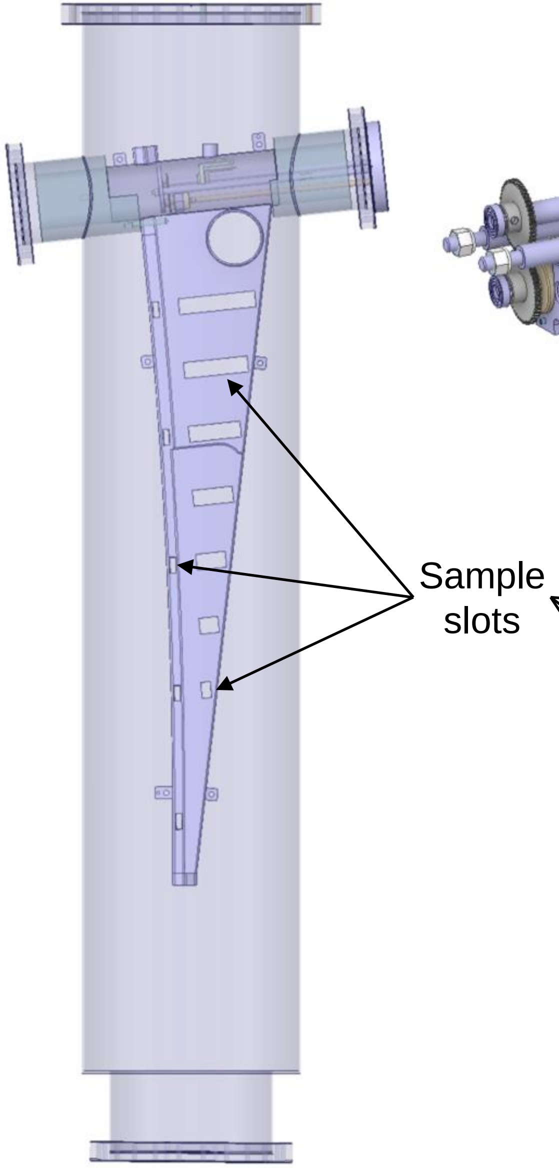


Coating system implementation - Vacuum

- Vacuum for half-shells coating
  - Vacuum vessel to host shells
  - Adaptation components for support
  - Design of top flange for feedthroughs
- Cathodes manipulation in UHV (MME collaboration)
  - Vertical translation
    - Movable spacers on bearings
  - Horizontal translation
    - Access from top flange
    - UHV compatible components



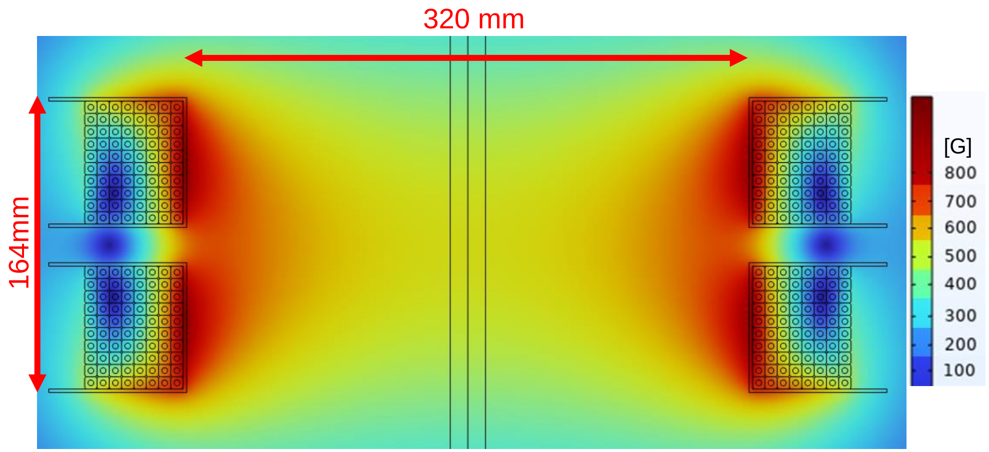


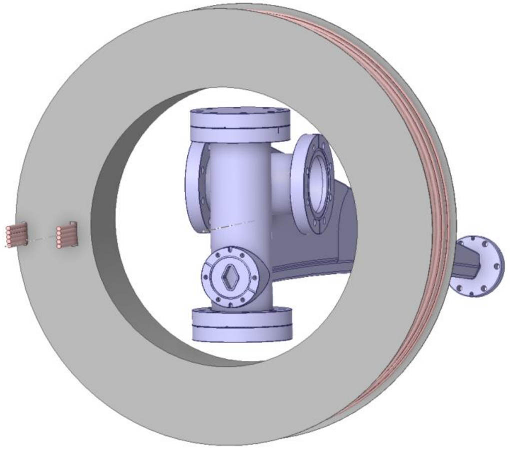


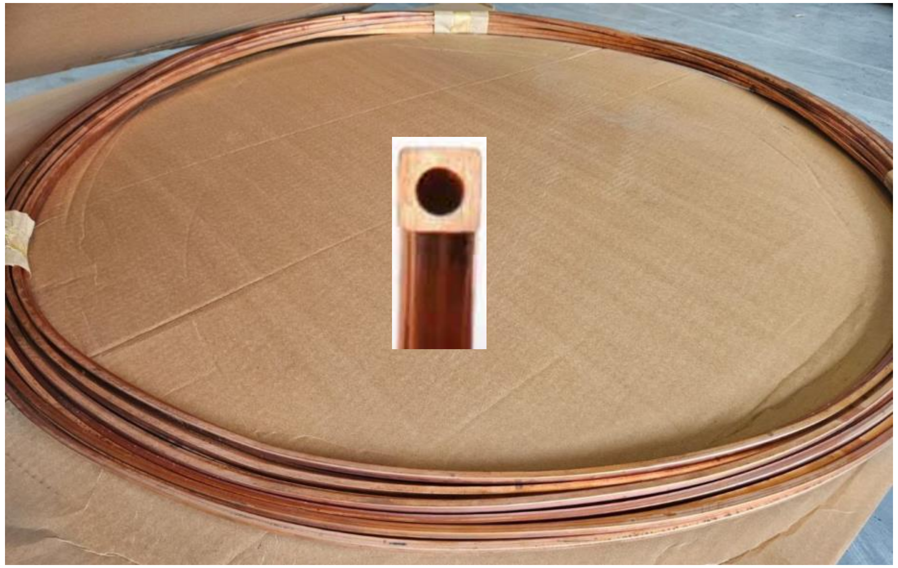
Coating system implementation - Solenoid

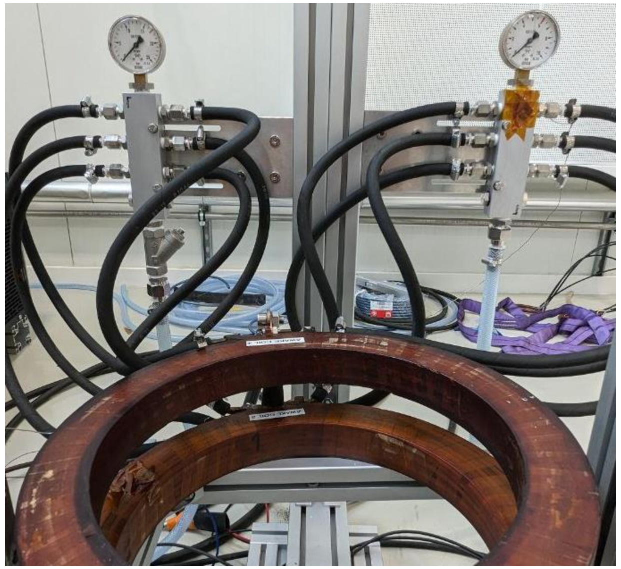
➢ High field short solenoid

- Self-produced due to time constraints
  - Hollow conductor – water cooled
  - Copper bought from MSC-NCM
  - Deoxidized in b.107 – Kapton adhesion
- 320 mm diameter to pass through real chambers
- Water cooling circuit developed









ELETTRA-CERN Project update

Outline:

- Project overview
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- Experimental updates
- ✓ Conclusion
  - Summary
  - Schedule

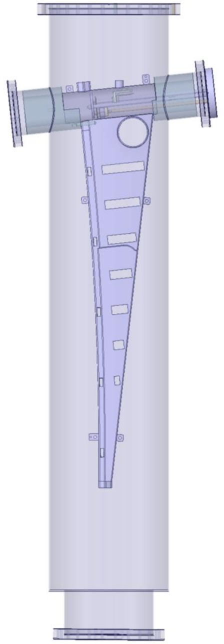
Conclusions

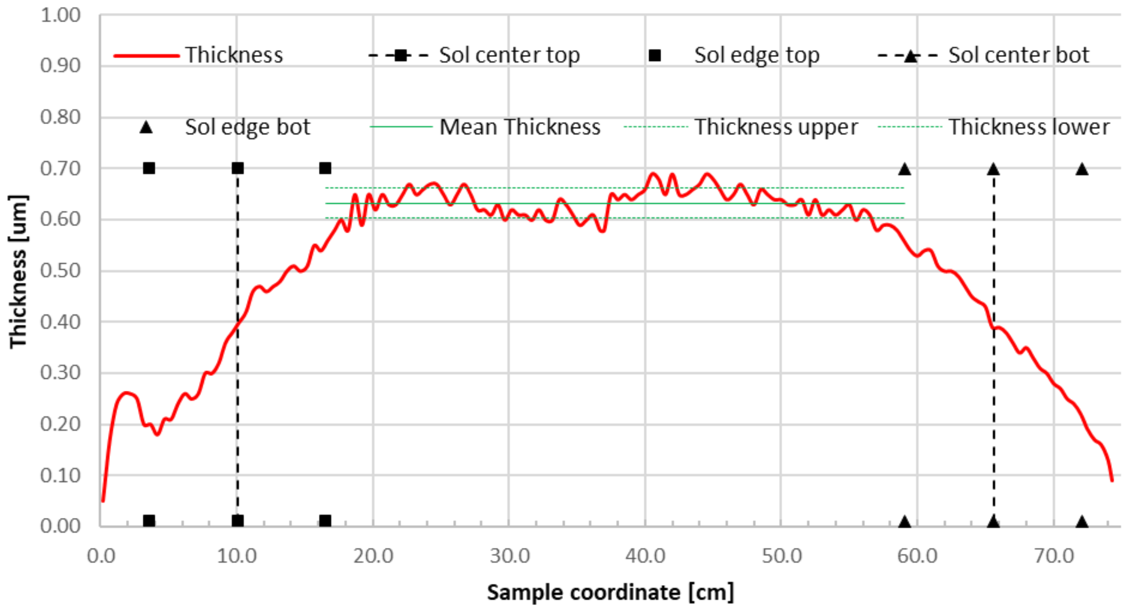
➢ Summary

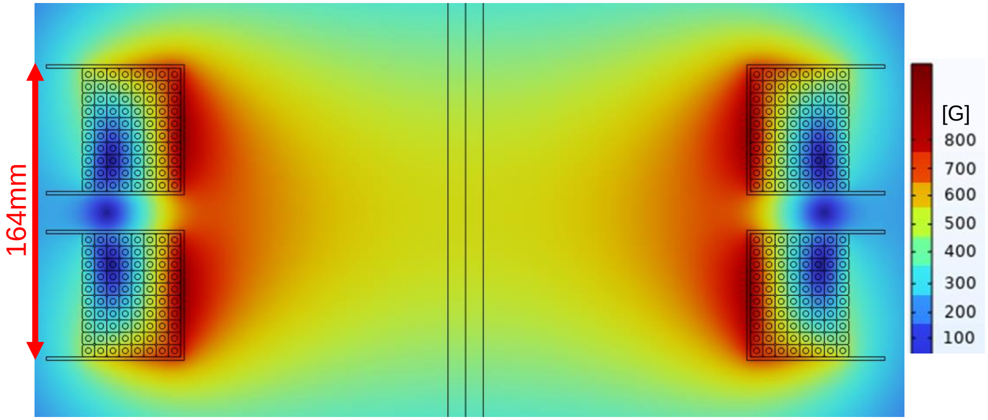
- Satisfying coating over 30 cm
- Solenoid design almost completed
- Vacuum for dummy coating almost completed
- UHV translation system ongoing

➢ Schedule

- 2023 = complete full coating system
- 2024 = finalize recipe for dipoles







Time Frame	Milestones	Deliverables
Q3 2023	Start tests on **half chambers**	Validate coating in alu profile
Q4 2023	Production of final **solenoid**	
Q1 2024	Parameters **optimization** for dummy coating	**Report** on coating parameters
Q2 2024	**Half shell** complete coating (optional: real chamber?)	NEG technology to industry

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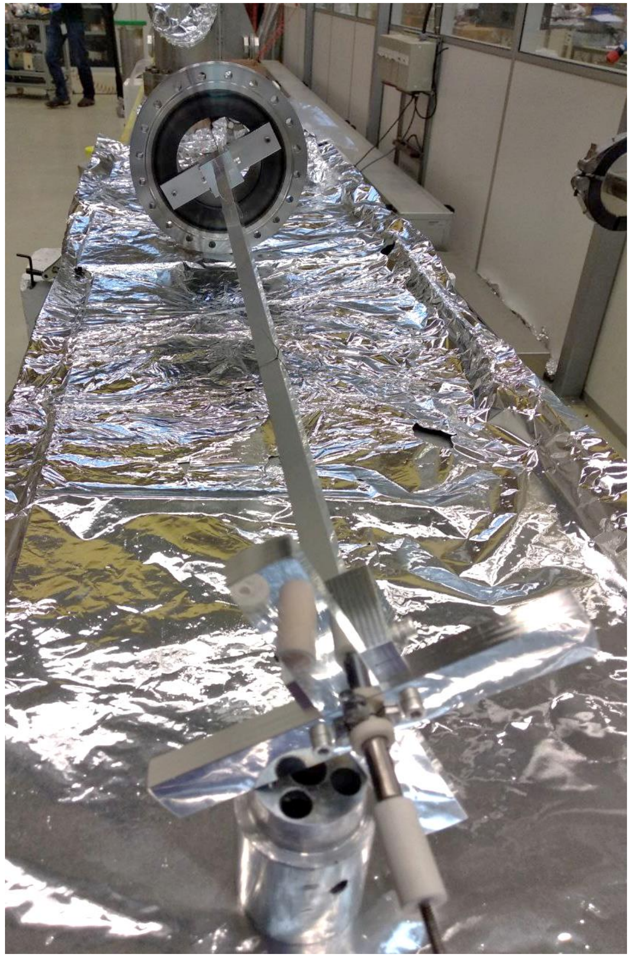
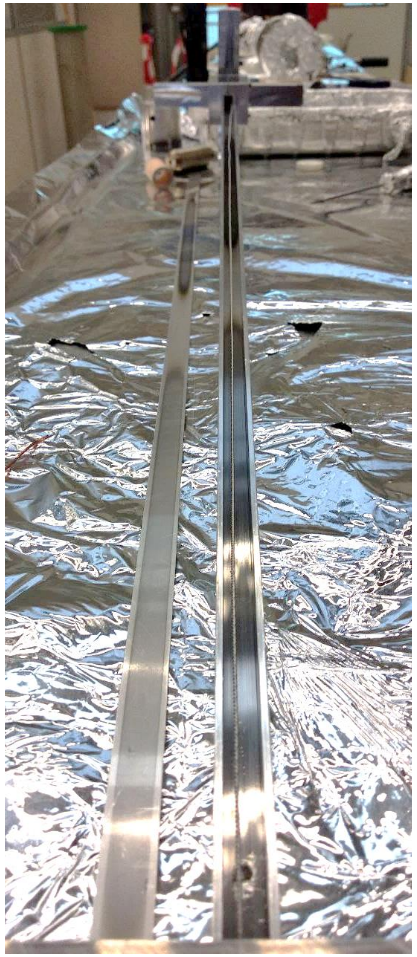
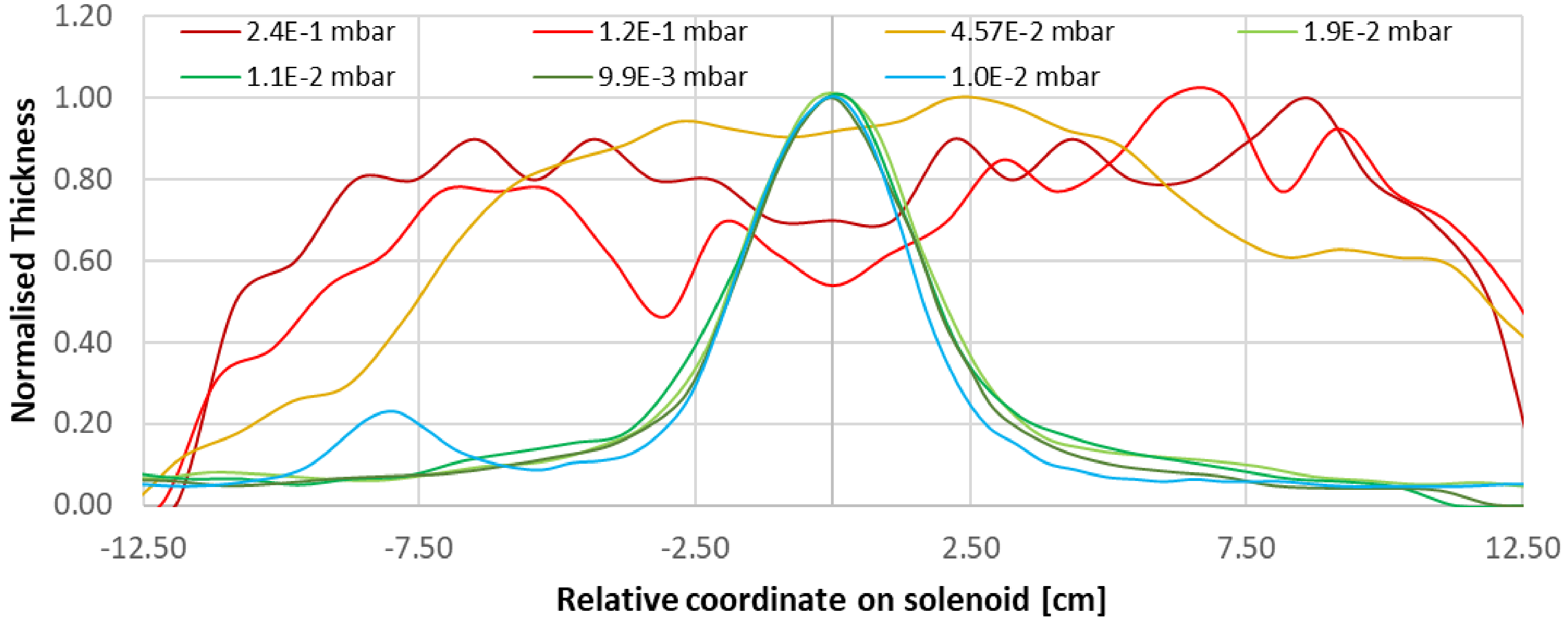
APPENDIX – Coating study system

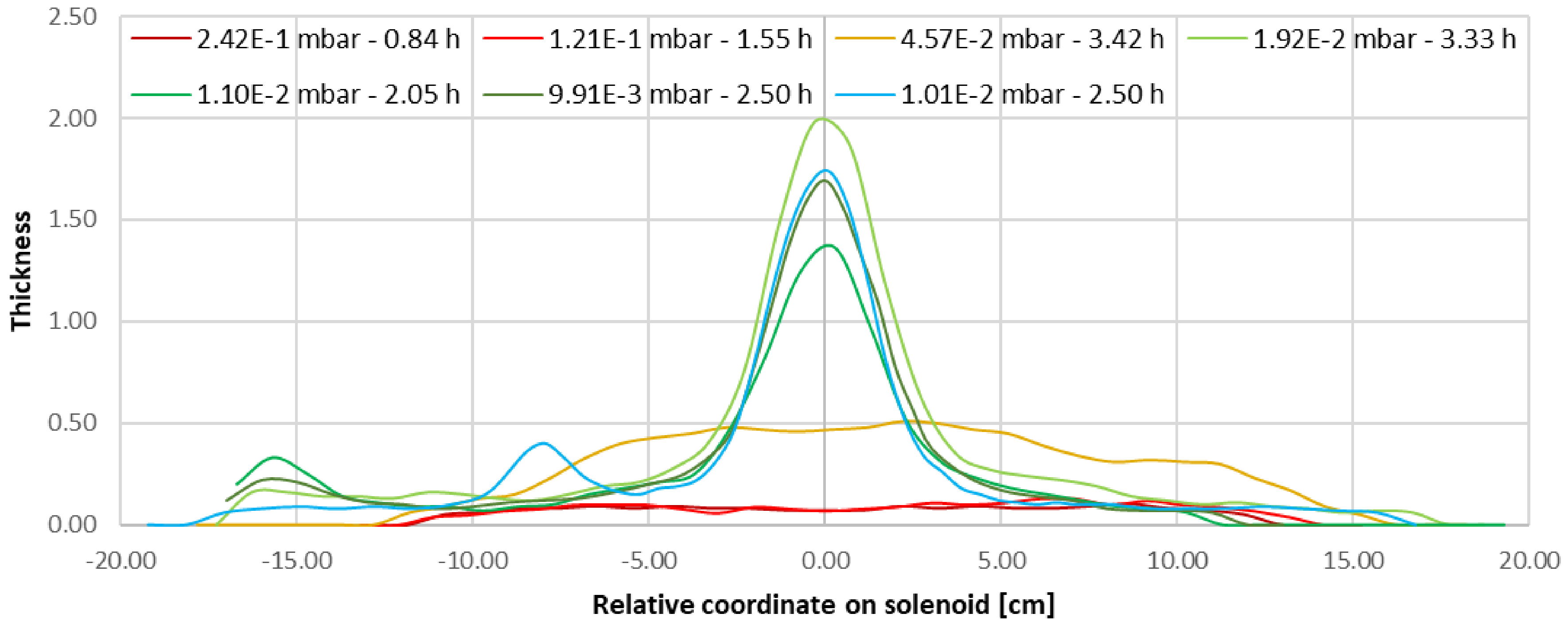




APPENDIX - Bottling results normalised



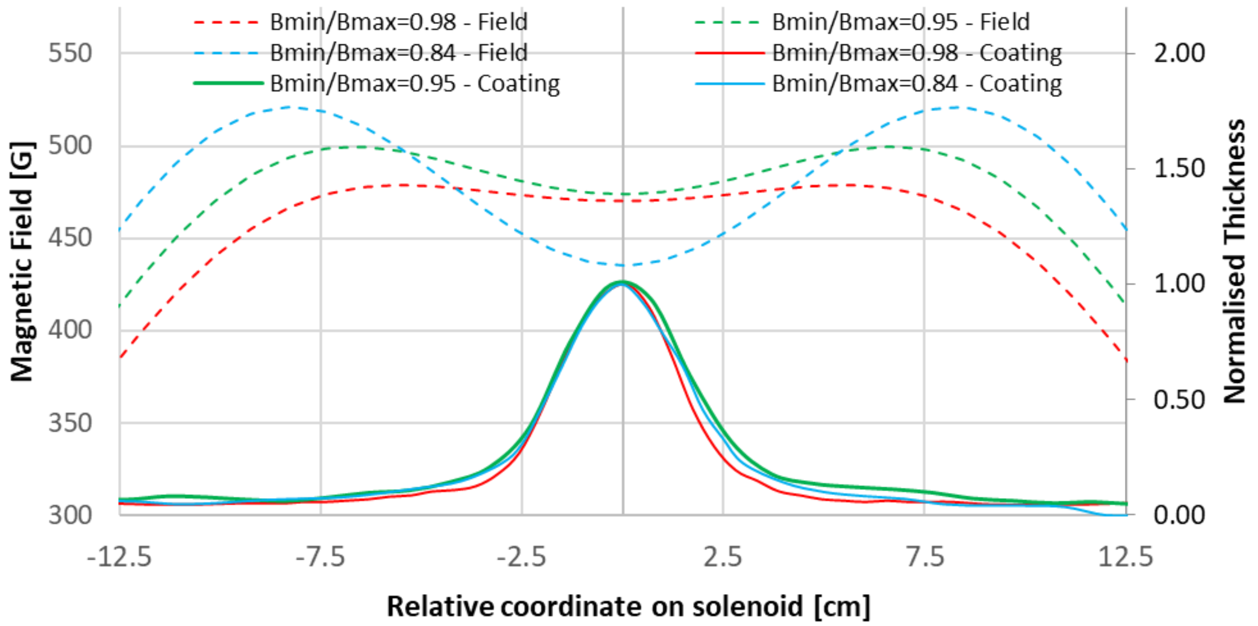
APPENDIX - Bottling results absolute



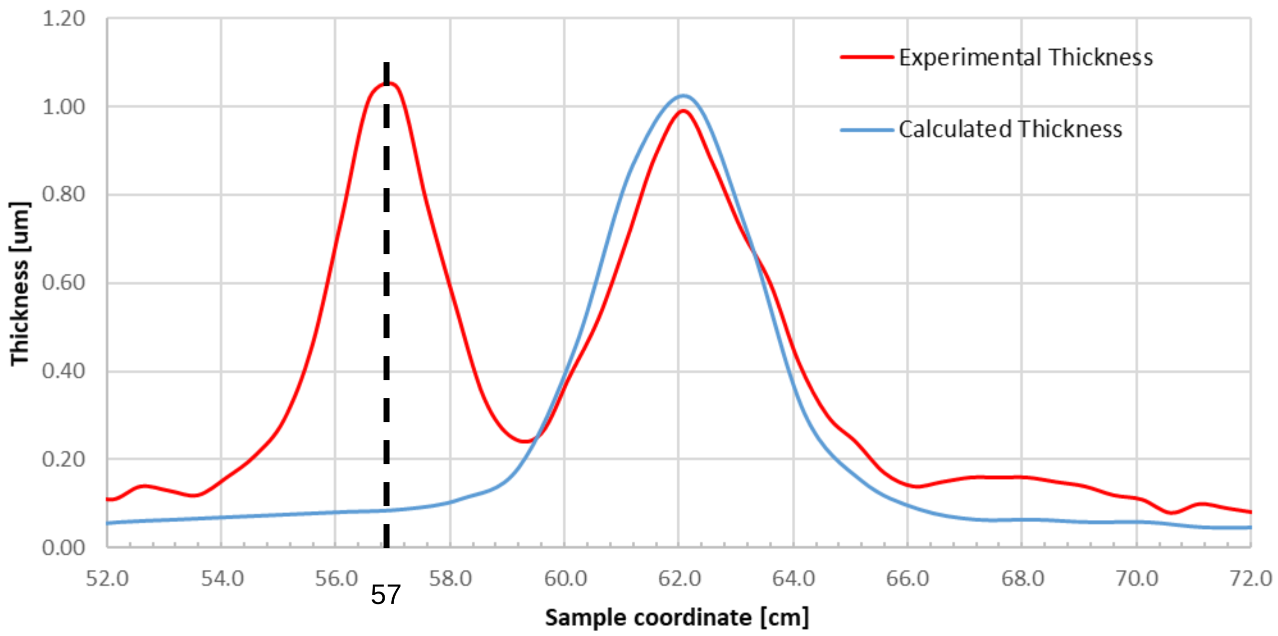
APPENDIX – Magnetic Bottling analysis

- No visible effect of change in magnetic profile
  - Probably not bottling

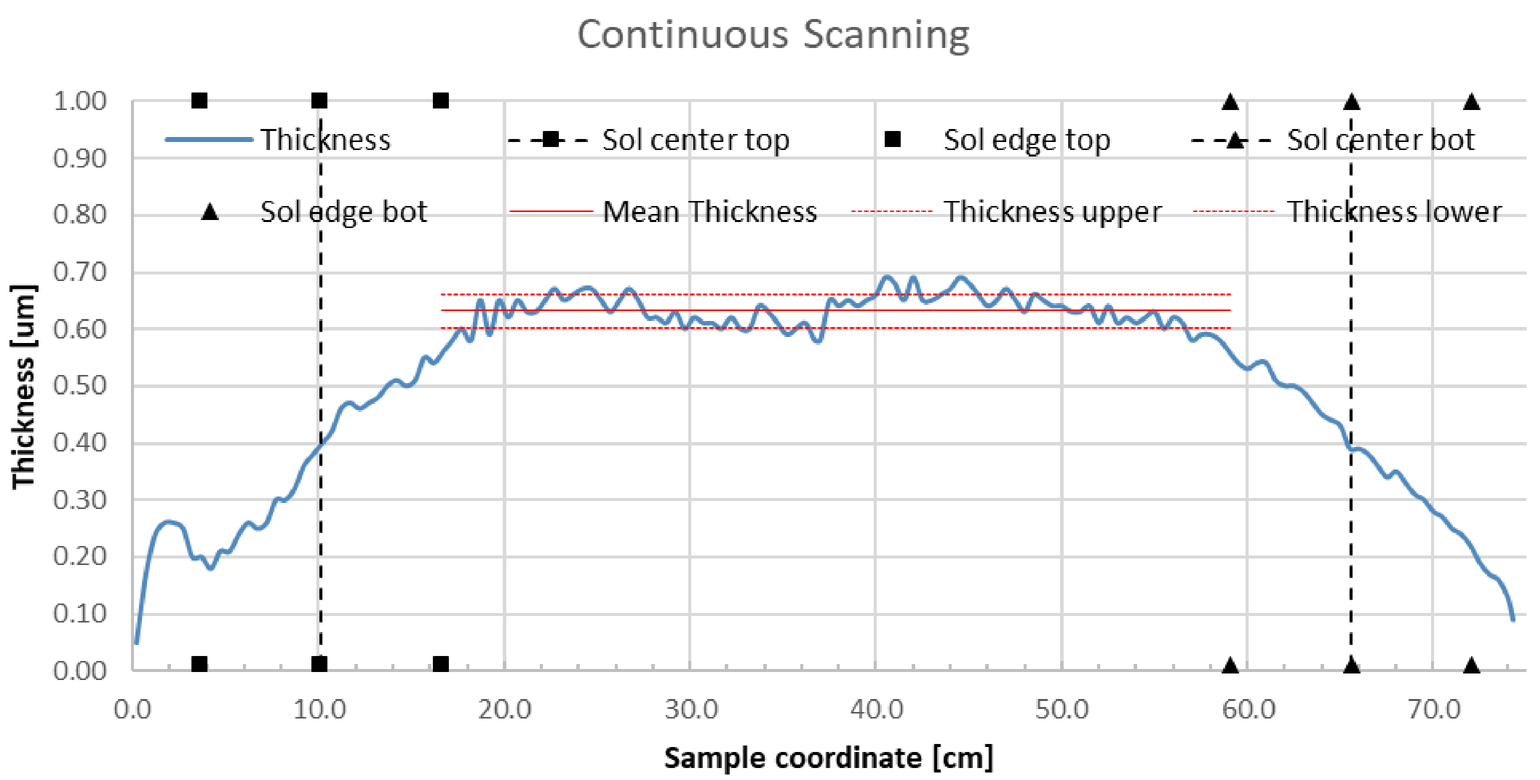
$$\sin \theta_{\text{crit}} = \sqrt{\frac{B_{\text{min}}}{B_{\text{max}}}}$$



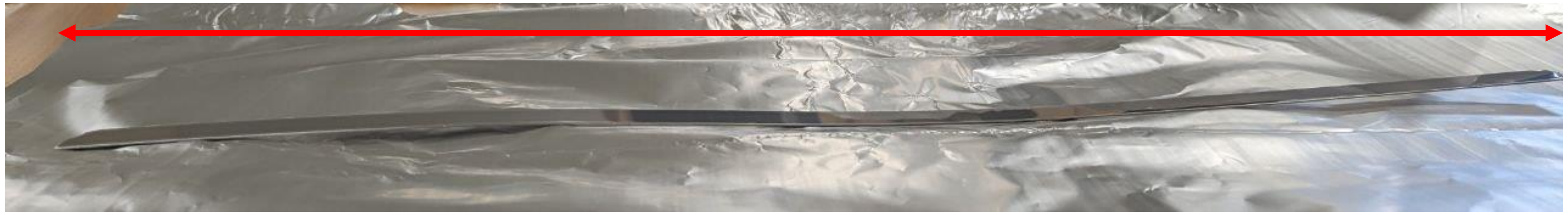
APPENDIX - Bottling results – plasma escape



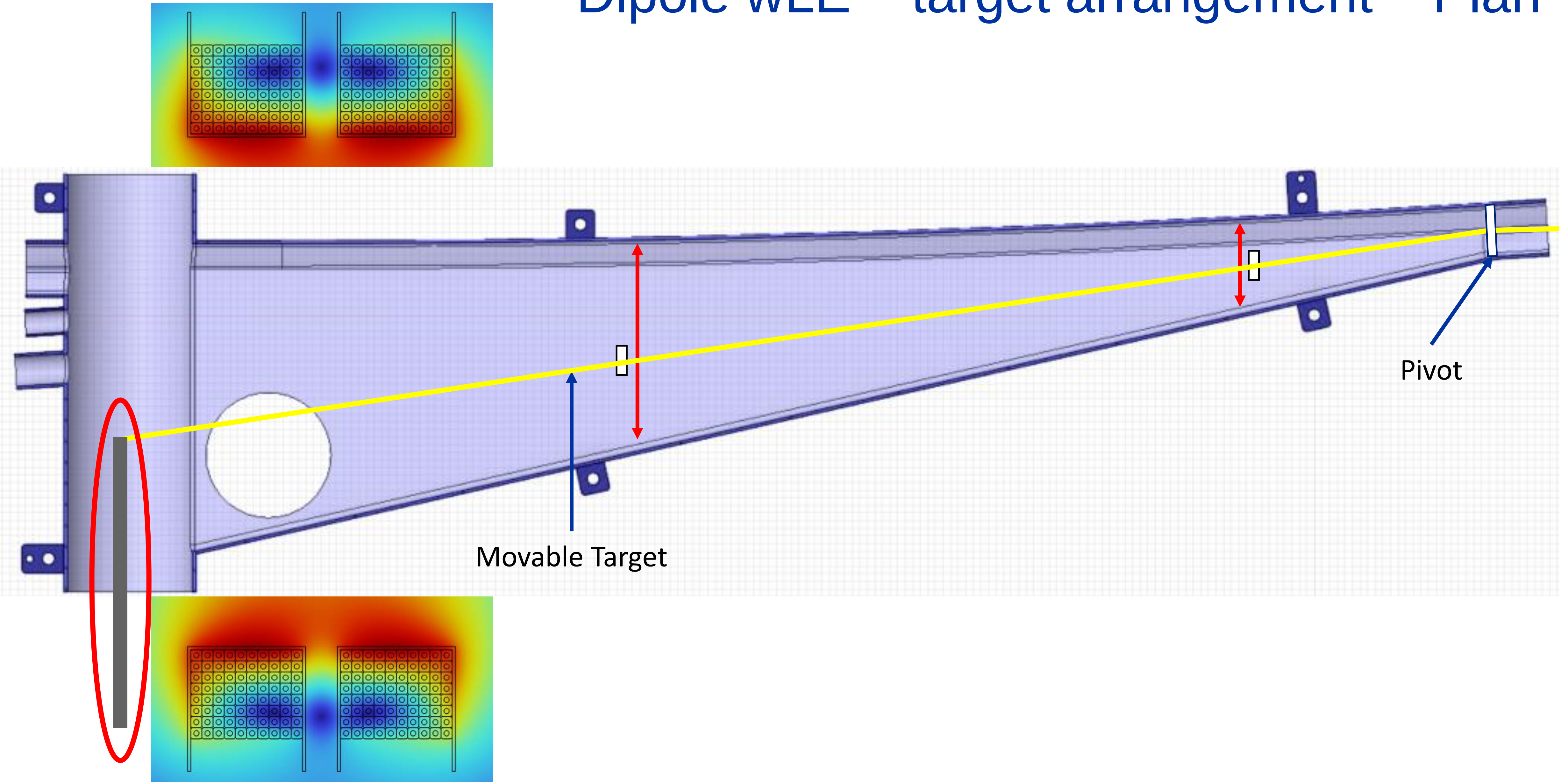
APPENDIX – Diverging solenoid results



0 - 37 cm



Dipole wLE – target arrangement – Plan B



Dipole wLE – target arrangement – Plan C