Overview of GBAR antiproton trap

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GBAR antiproton trap

Functional requirement

- Receive and catch the antiproton bunches from ELENA with GBAR decelerator
- Cool antiprotons and reduce the size of the beam
- Catch additional bunches while manipulating beam size
- Inject to GBAR reaction chamber
- Recapture unused antiprotons from the reaction chamber

Input

- Antirptoton energy : 1-6keV (300 eV ΔE)
- # Antiprptons/cycle : 4 x 10^6
- Emittance : 40 π mm mrad
- bunch length : ~ 270 ns
- cycle time : 110s

Output

- Antirptoton energy : 10-100 eV(15 eV ΔE)
- # Antiprptons : 1 x 10^7
- Radial beam size : 1 mm
- bunch length : ~ 100 ns

Goal of this workshop

- Specification of the solenoid magnet

  Bore diameter

  Maximum magnetic field

  Cold bore or warm bore ?

- Electrodes dimension

  Number of potential wells – 2 enough ?

  Total electrode length

- Upstream and downstream interface

  Injection beam well defined ?

  Beam extraction - buncher needed ?

- Vacuum system, control system, detectors, etc…

GBAR antiproton trap- Cold bore vs Warm bore

Issue 1 : Operation (Access to the electrodes)

Warm bore (ALPHA, CUSP, MUSASHI-2)
Cooling/warming UHV pipe while keeping magnet cold

Cold bore (MUSASHI-3)
Cooling and warming of UHV pipe with magnet at the same time
But with a **poor thermal connection** between magnet and UHV pipe
satisfying
- the bore can be heated up within 10 hours (from 4K to 300K),
- but we do not need any availability for baking,
- although the bore and the magnet do not need to be thermally isolated, we need to come back the 4K after heating up as early as possible.
- Though the temperature of the magnet becomes around 40K when the bore is at RT, we can come back to 4K within 12hours or so.

Issue 2 : Detector location

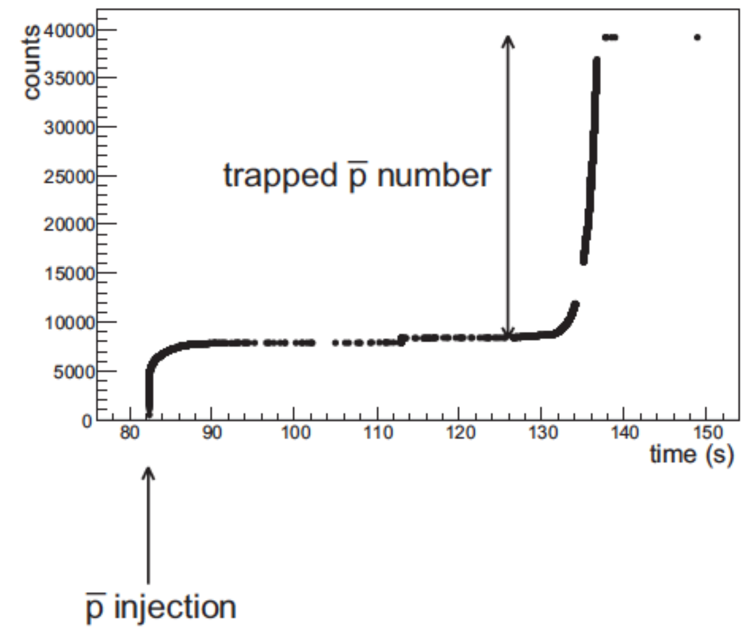
Between the magnet and UHV pipe : ALPHA
Outside the magnet : MUSASHI

GBAR antiproton trap- Cold bore vs Warm bore

Issue 2 : Detector location

Outside the magnet : MUSASHI

2m long, 4x6 Plastic scintillator



1.2×10^6 pbar → x 3% →36,000 count

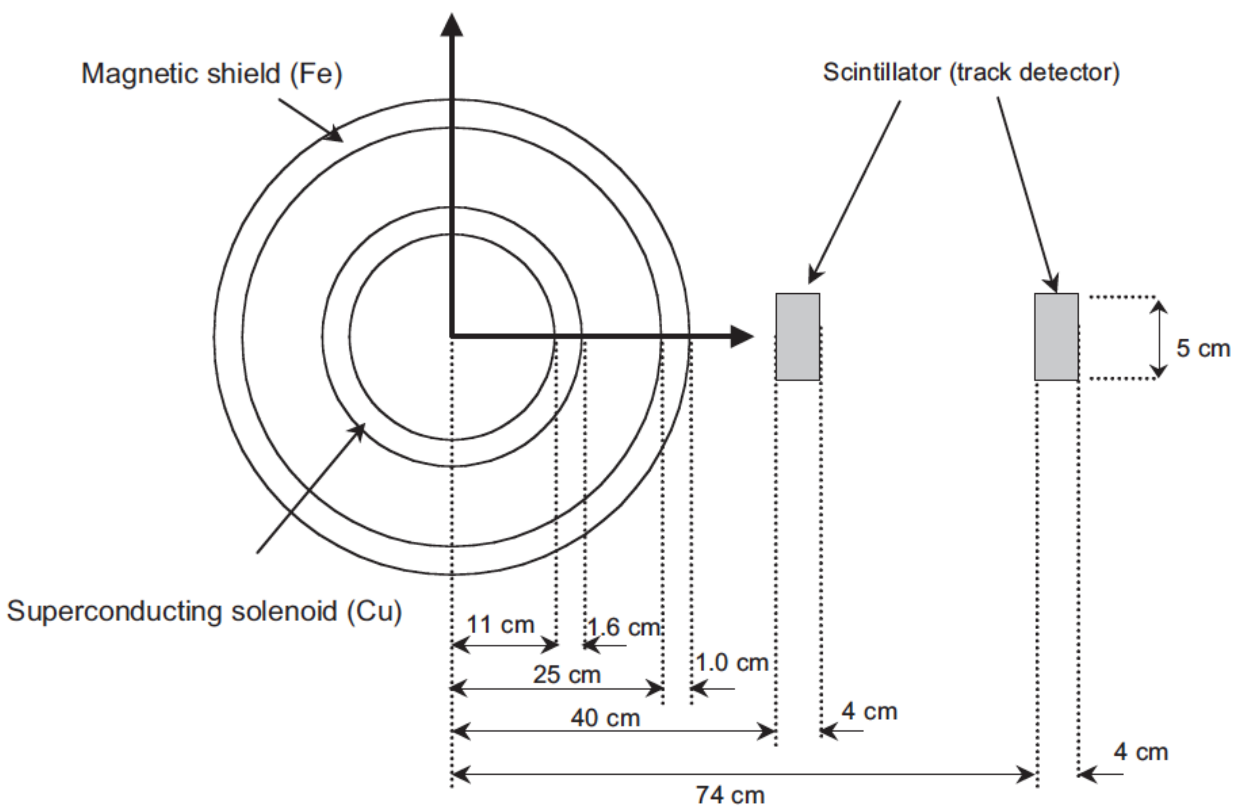
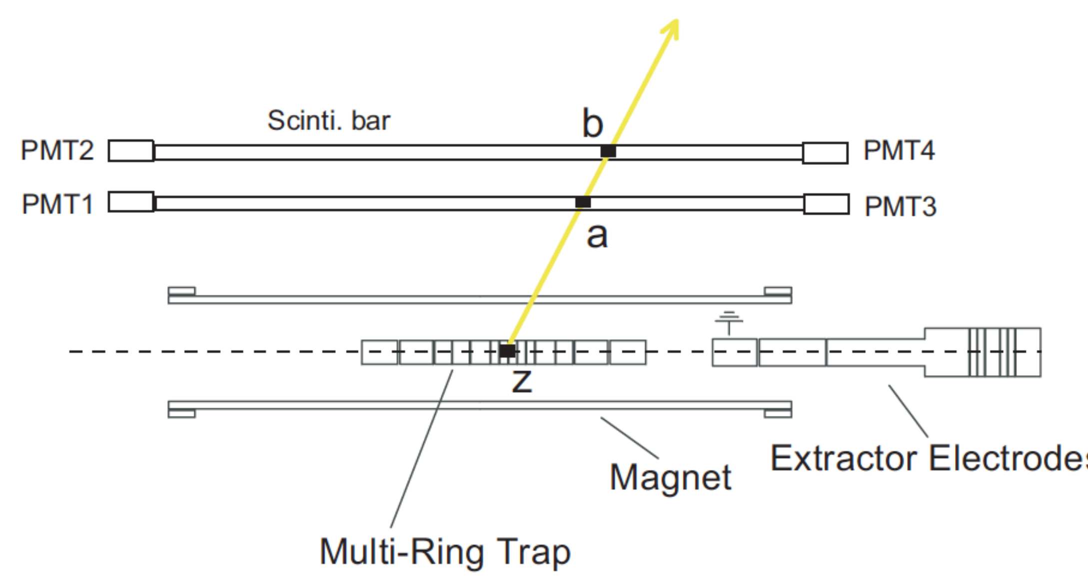


Figure 2.25: Configuration of track detector along the superconducting solenoid.

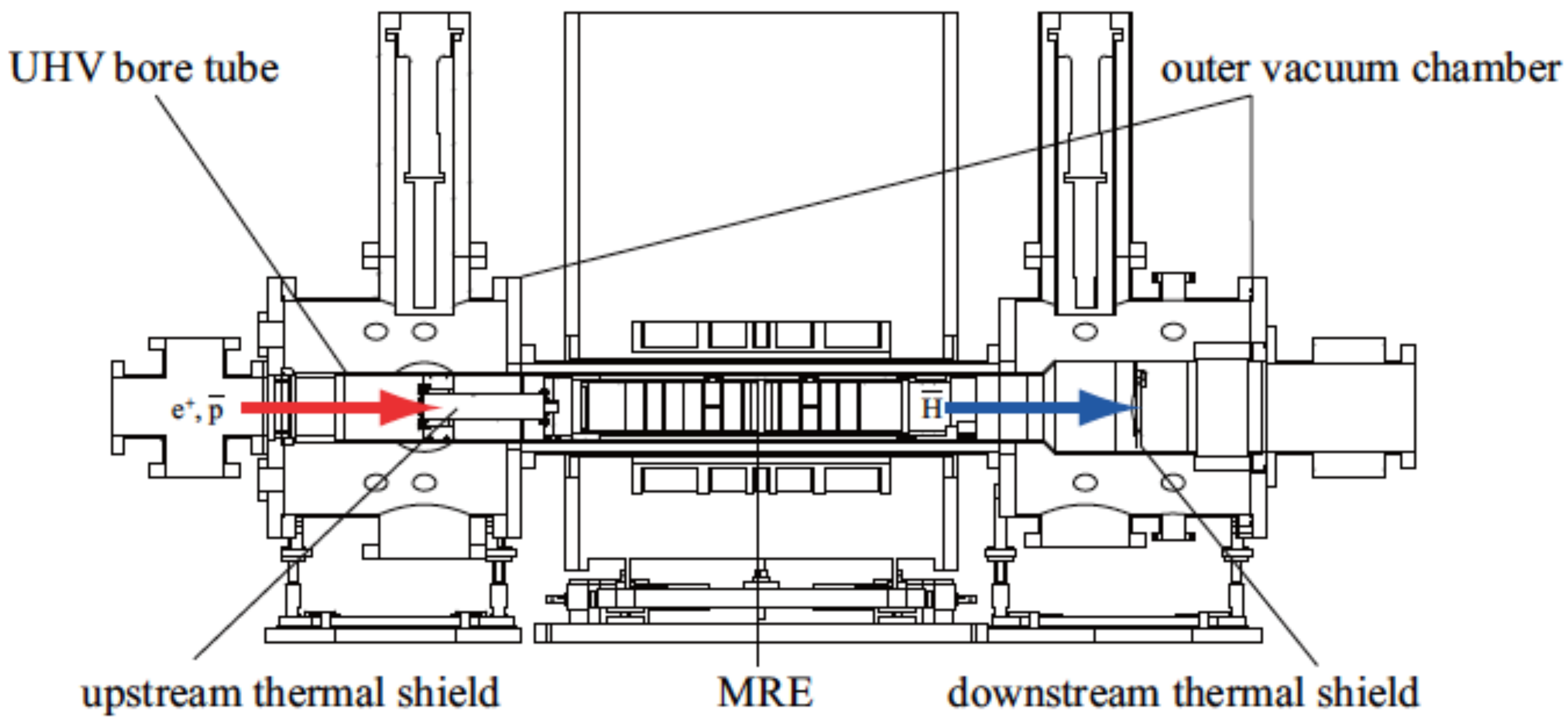


N.Kuroda Ph.D. Thesis

Cold bore vs Warm bore

Three choices

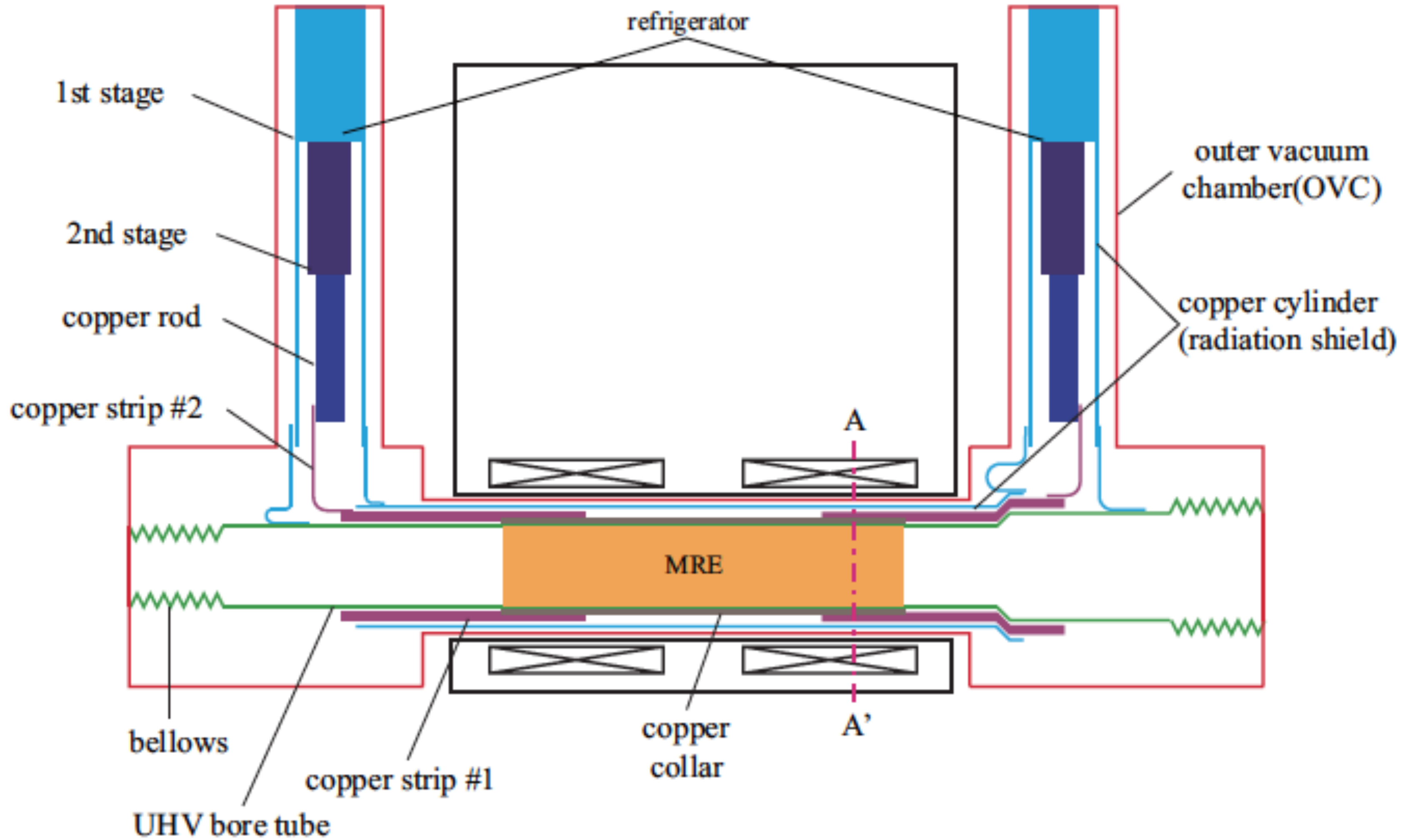
1. Cold bore with poor thermal connection between magnet bore and vacuum pipe
2. Warm bore with enough space for detectors
3. Warm bore with minimal space between magnet bore and vacuum pipe

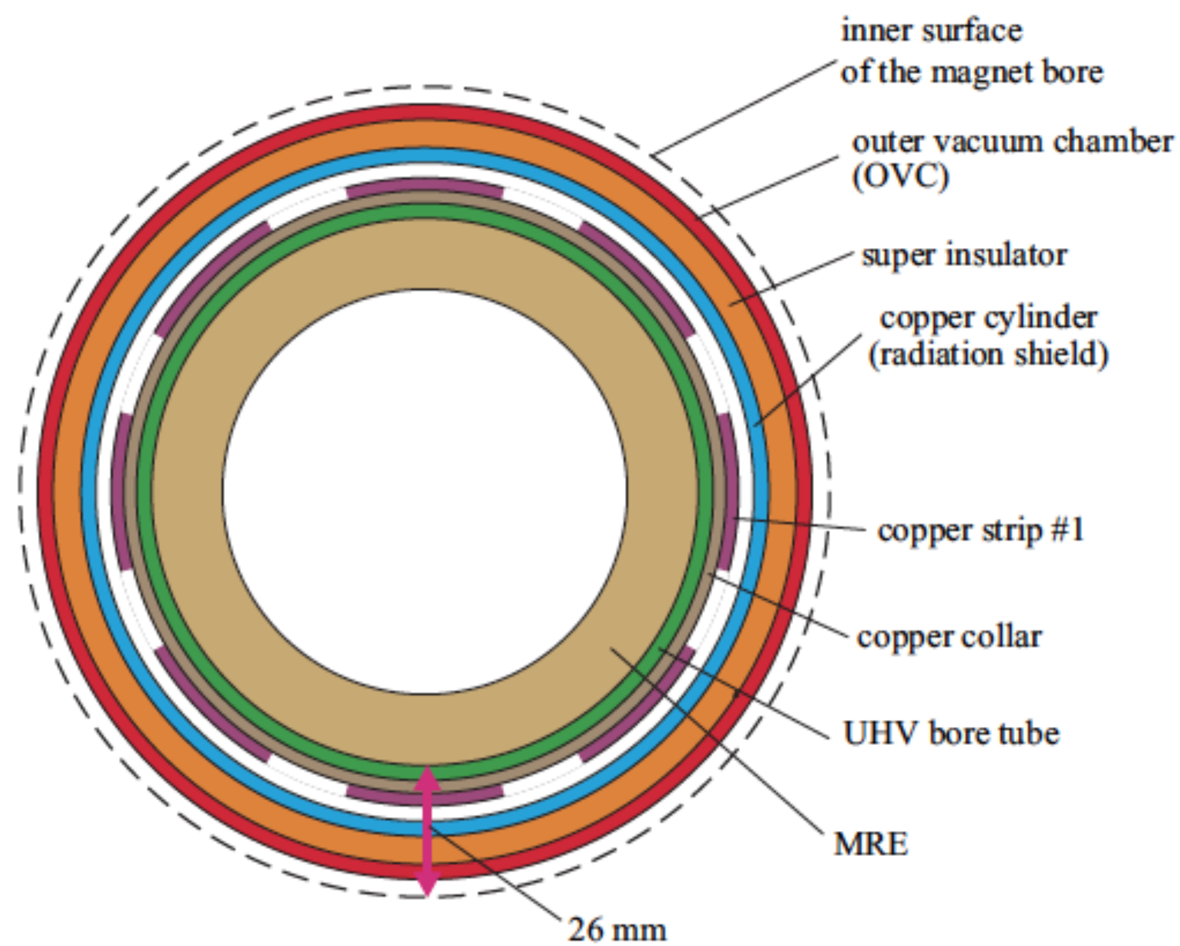


CUSP Trap

CUSP Trap

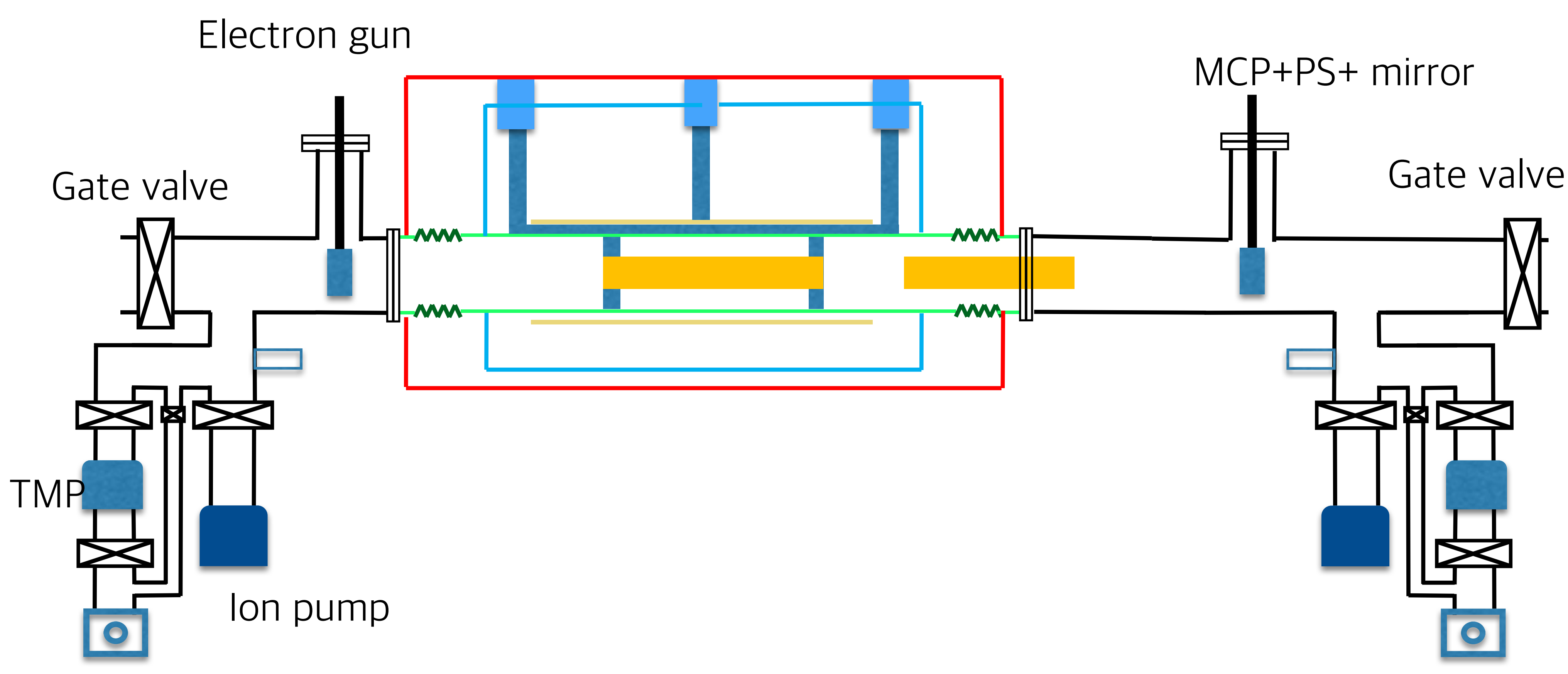
Enomoto Thesis



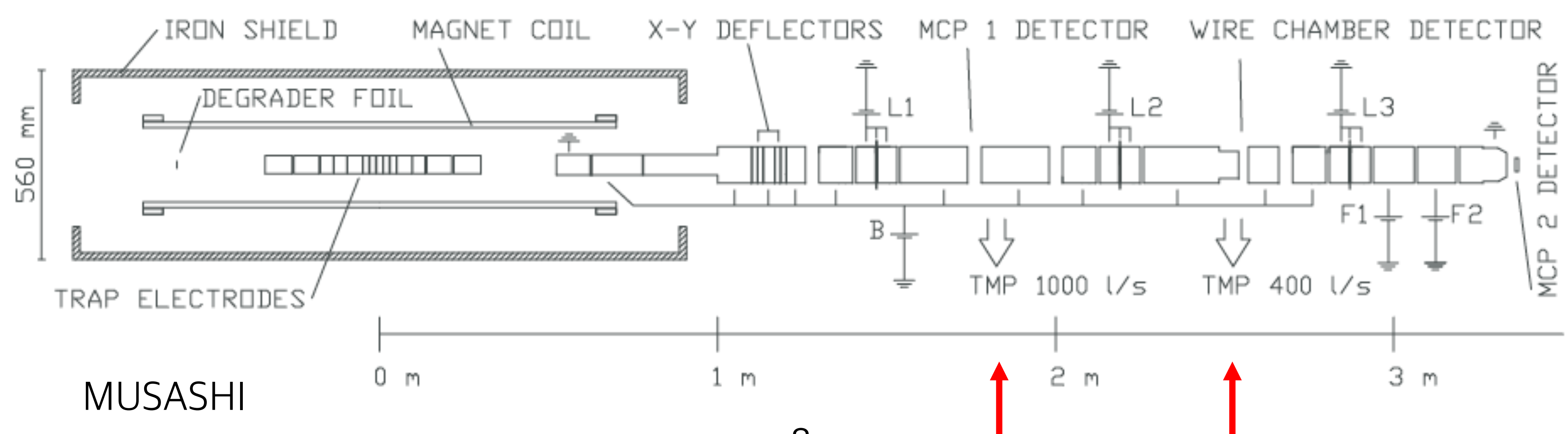


Separate magnet bore and vacuum pipe :
~ 52mm increase of magnet bore diameter

Conceptual Layout

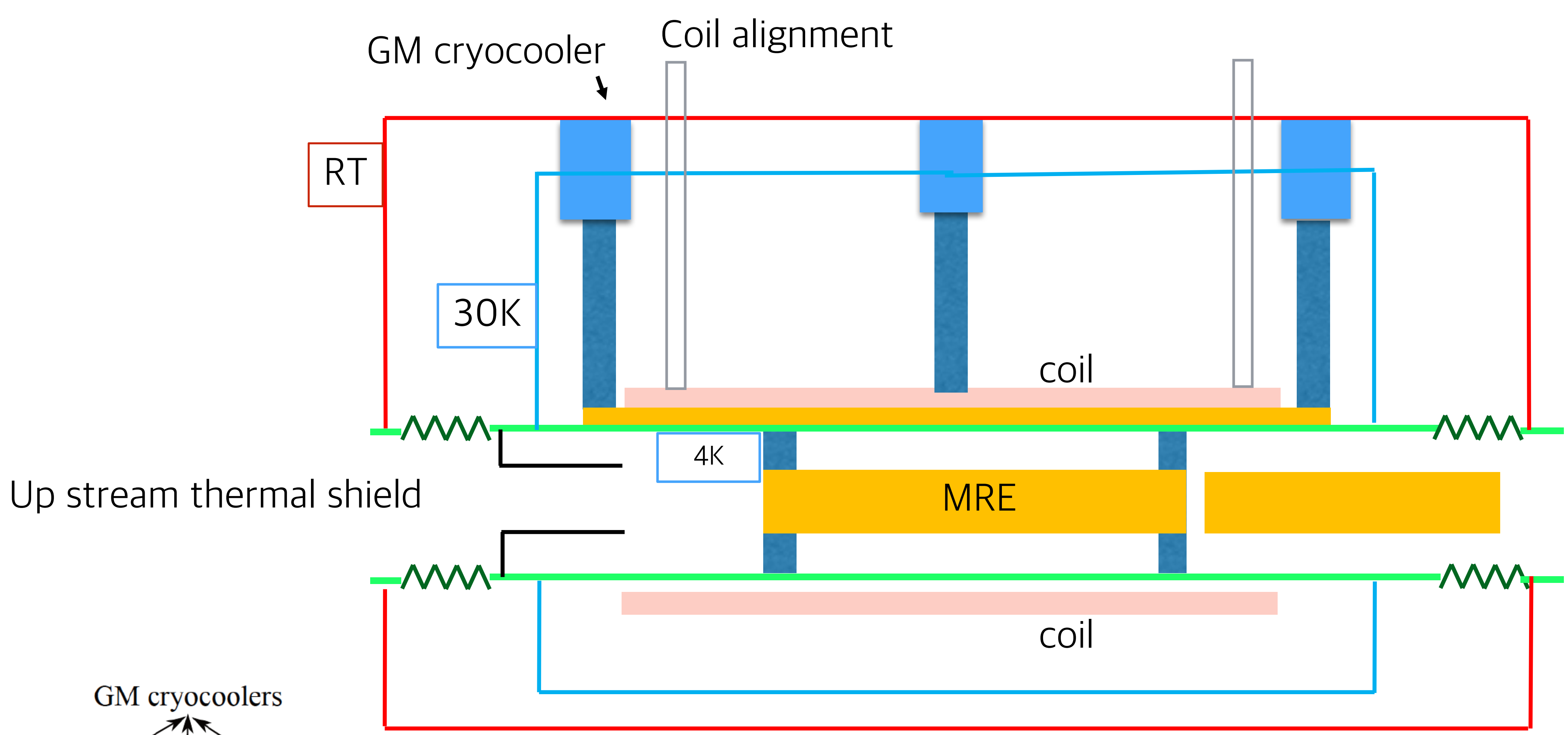


Schematic : not in scale



MUSASHI

Cryogenics



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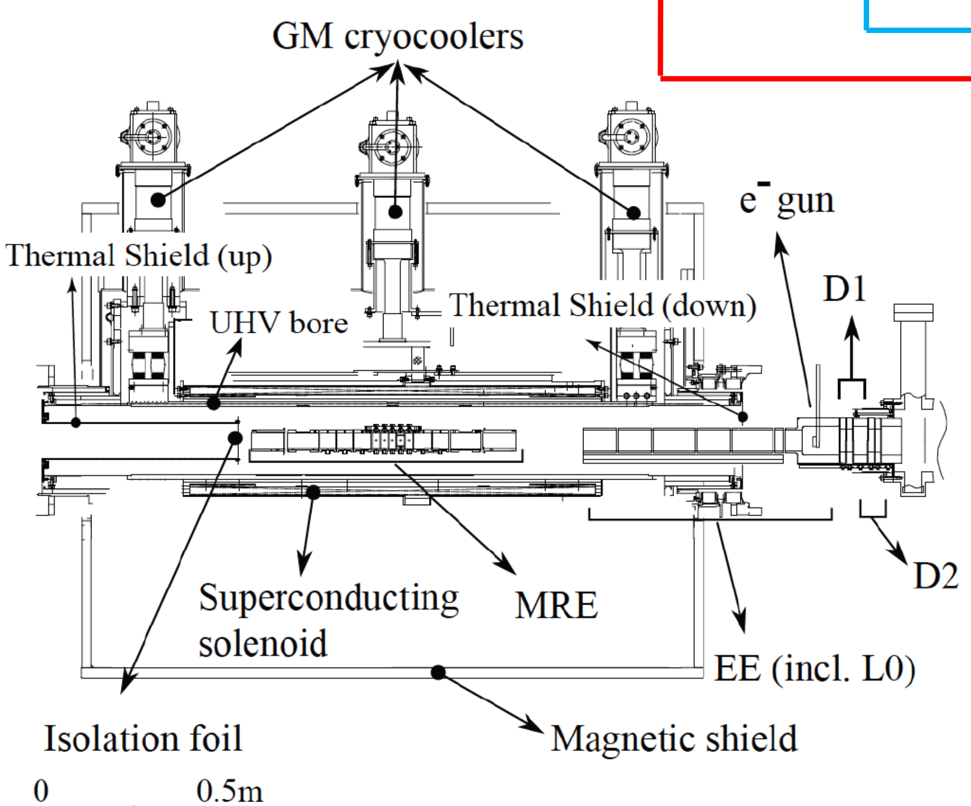
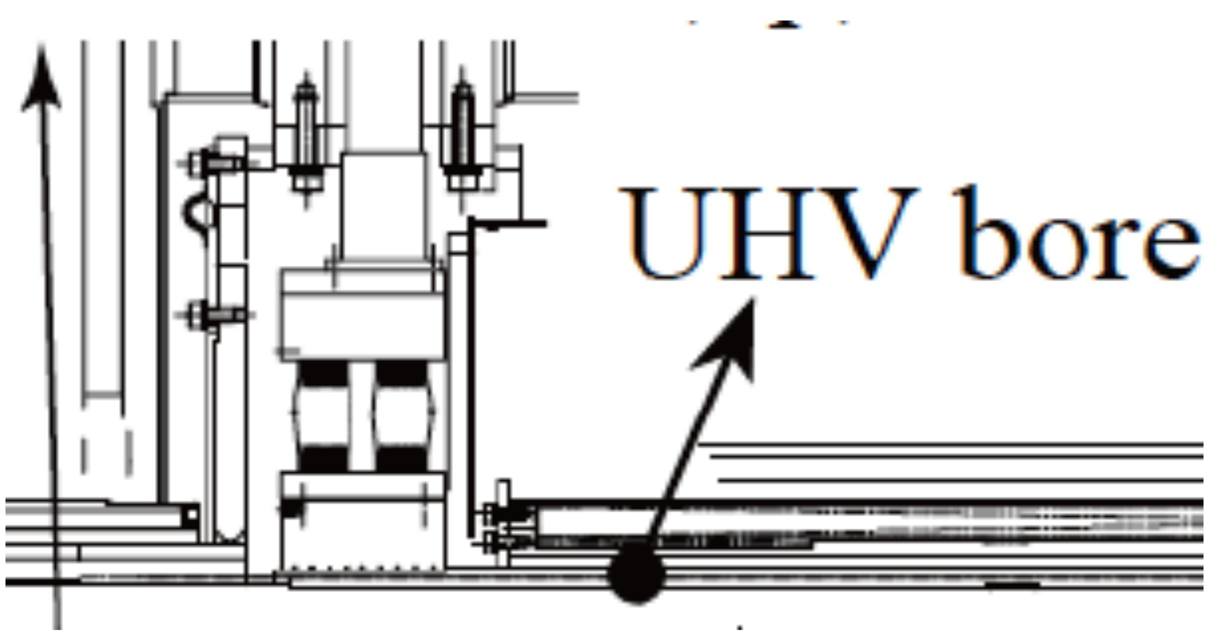
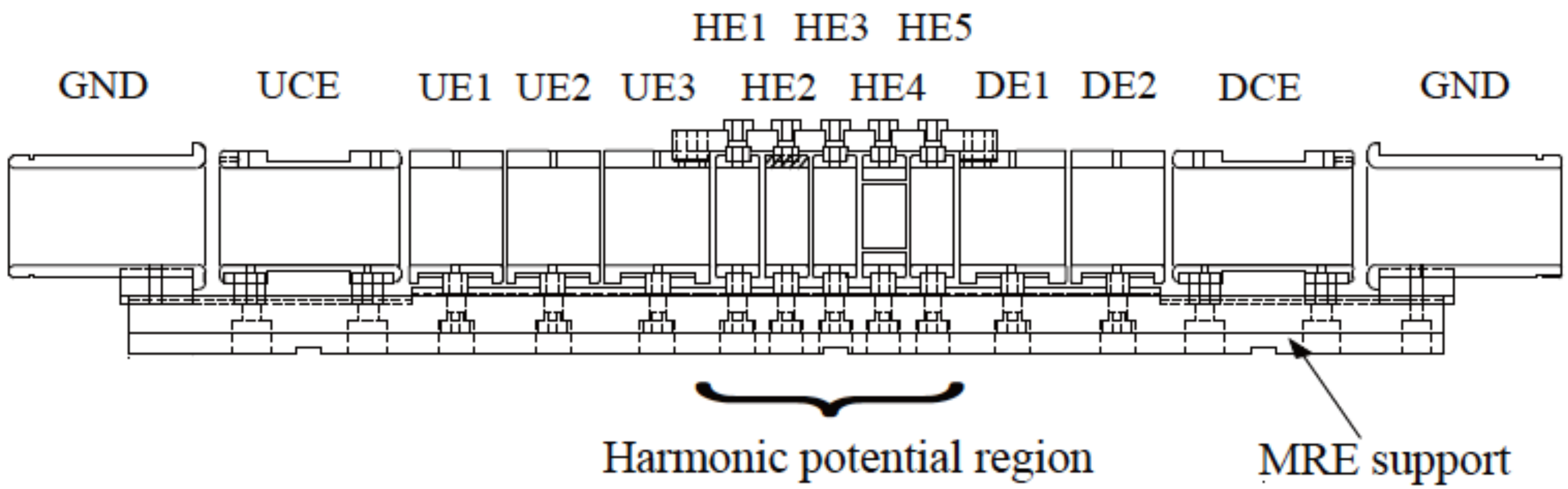


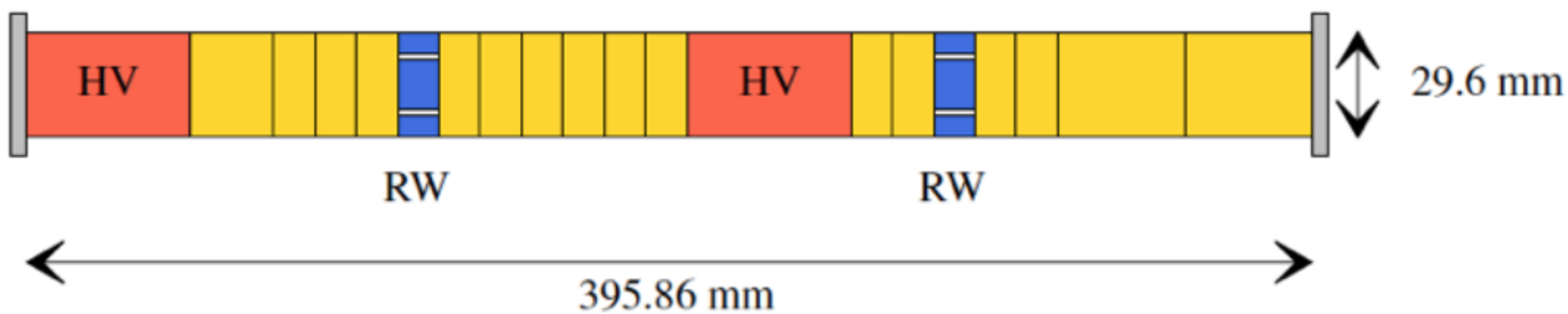


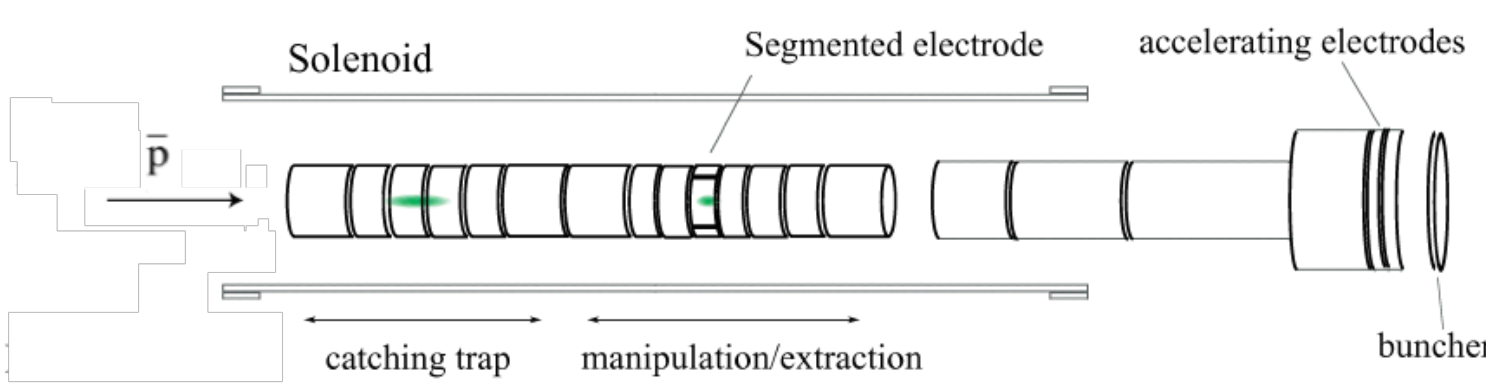
Electrodes

MUSASHI



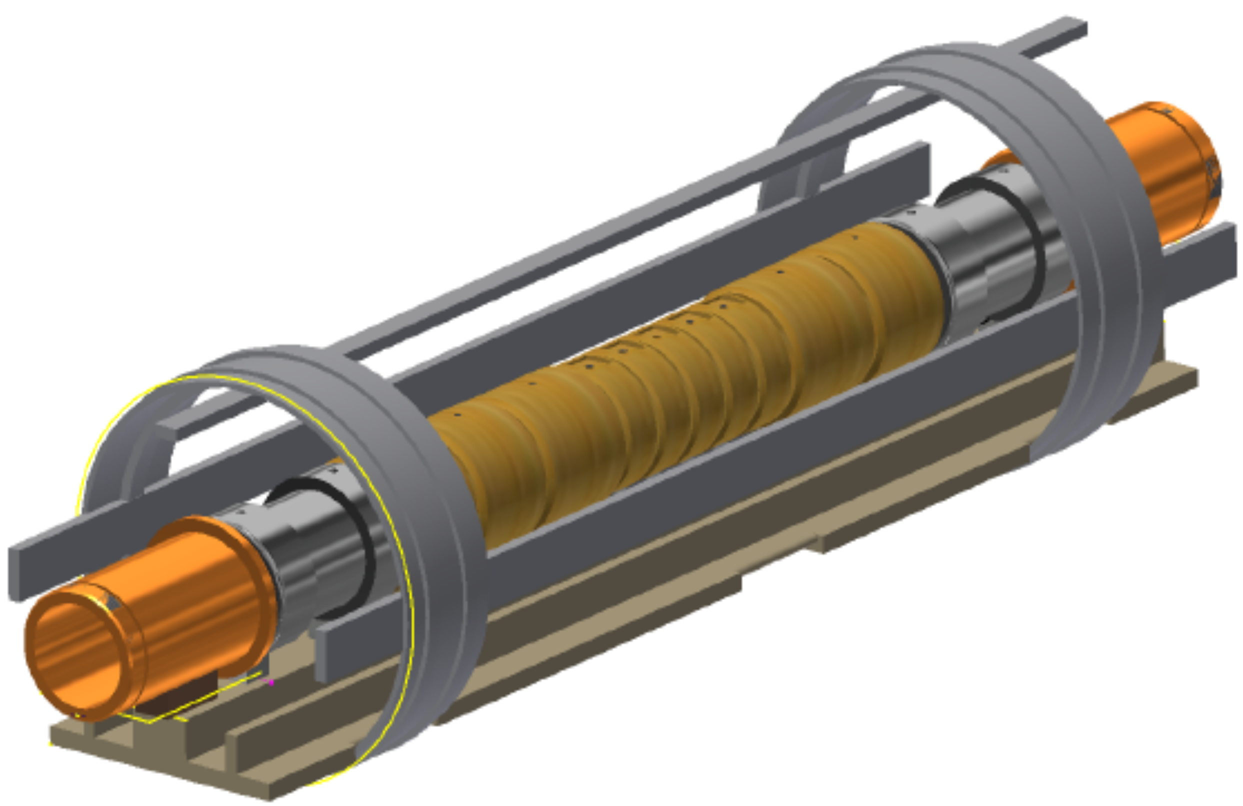
ALPHA-2

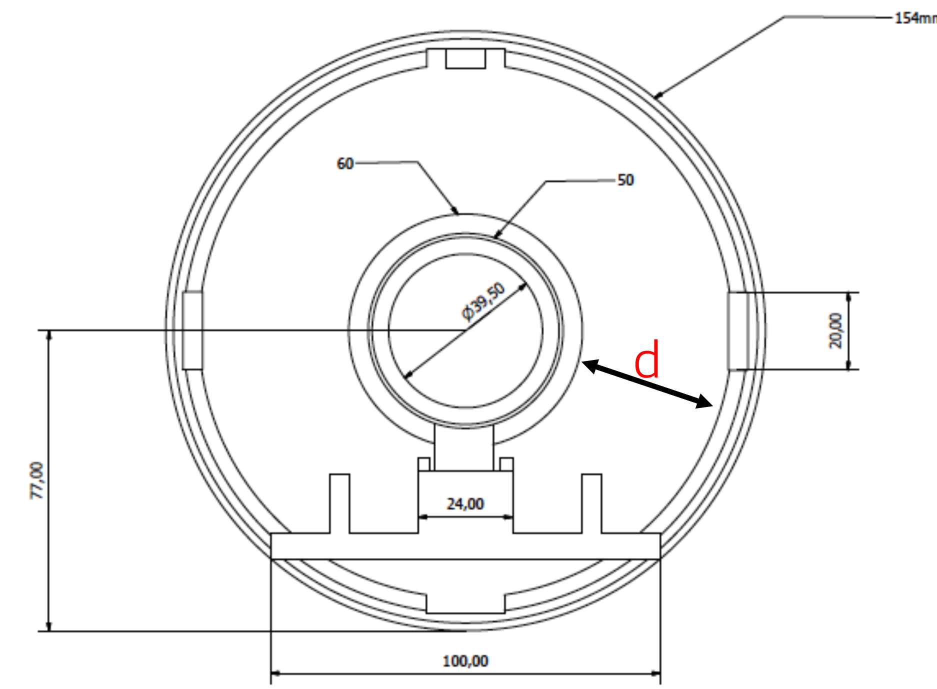


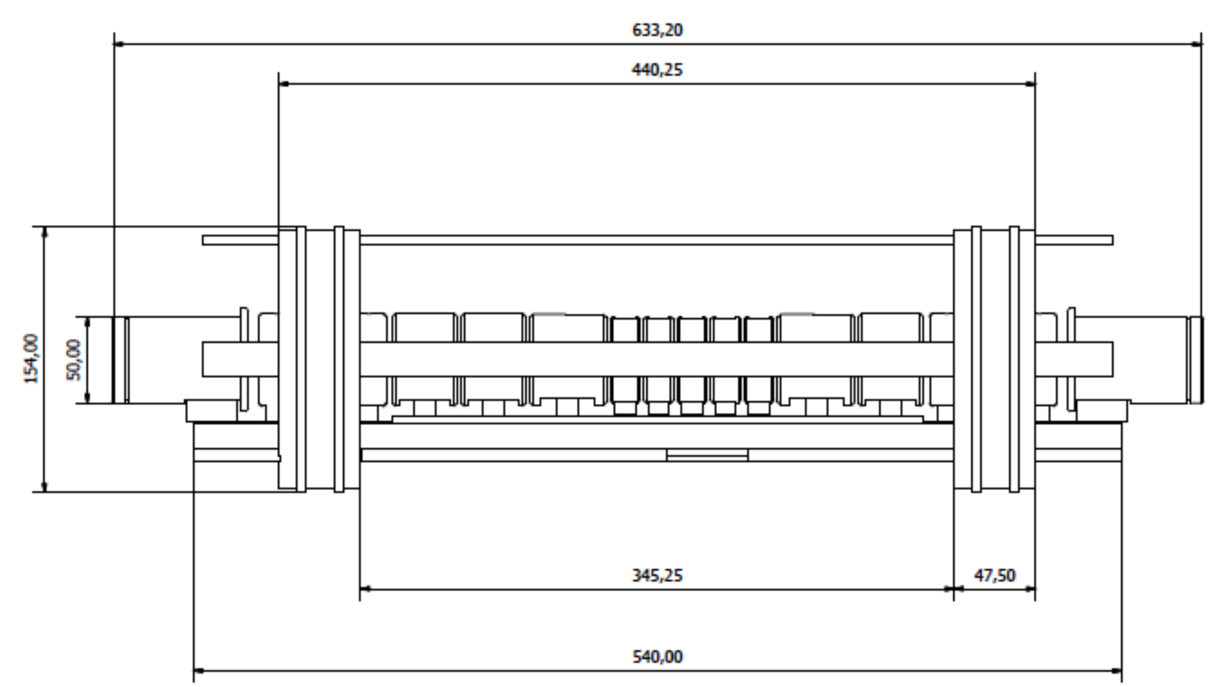


GBAR antiproton trap-Electrode

Design basis : starting from MUSASHI trap







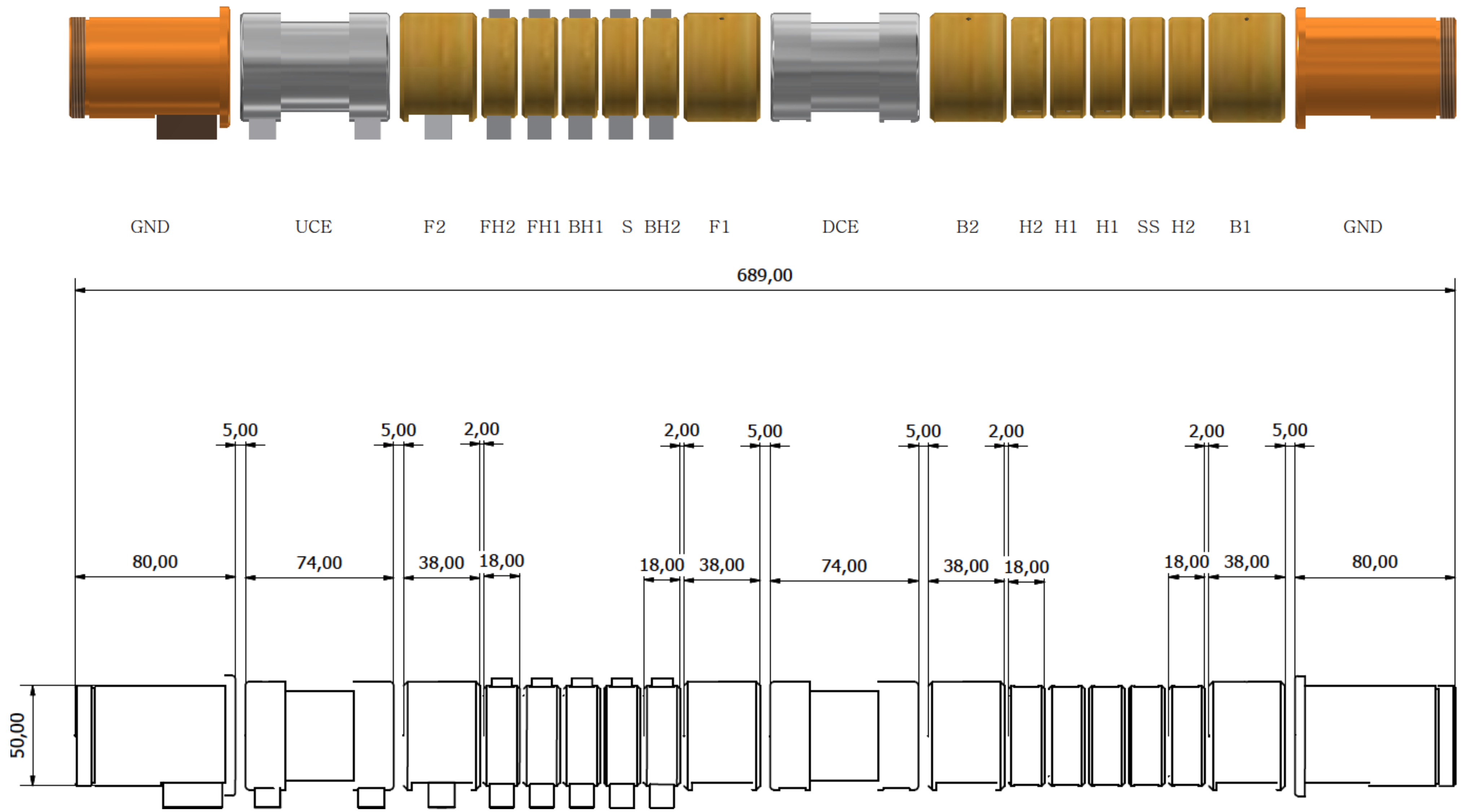
Additional requirement:

two potential wells with rotating wall

Q: can we reduce the gap d? How much ?

GBAR antiproton trap-Electrode

Minimal modification from MUSASHI trap



Length 689 mm : 55.8 mm longer than MUSASHI (633.2 mm)

Q: Can we reduce lengths of GND and HV electrodes ? How much ?

Is B2 needed ?

Extraction Electrodes (MUSASHI)

The basic requirement of the extraction beam line

(1) to transport the cooled antiprotons from the MRT to the target area with a minimum of loss,

(2) to focus the beam at the target with a minimum spot size,

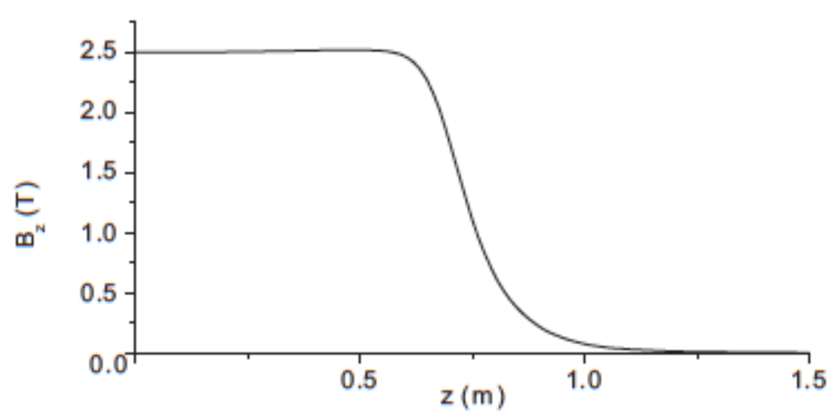
(3) to enable differential pumping with a pressure difference of more than six orders of magnitudes between the trap area and the target area,

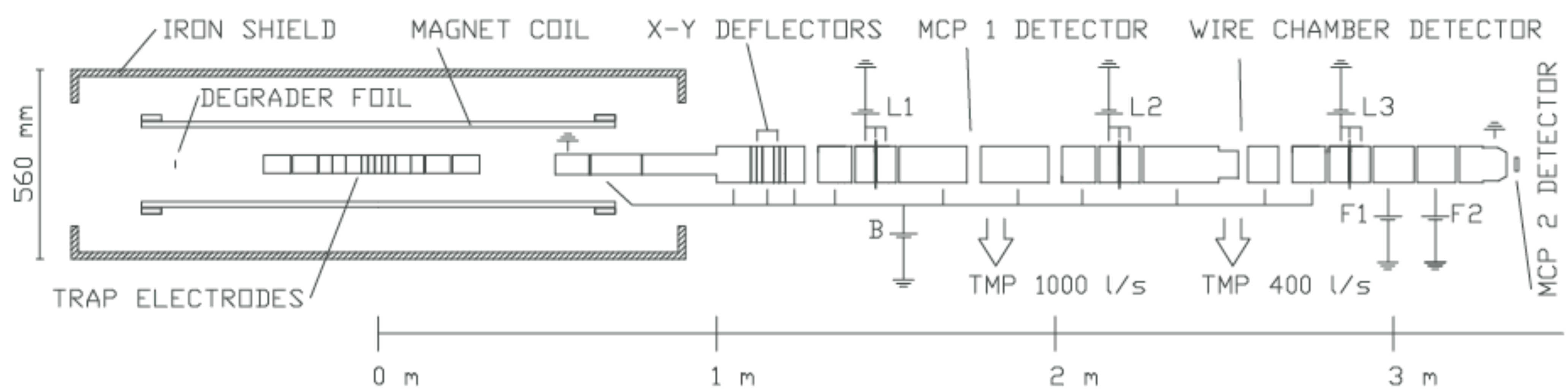
(4) to provide a variable beam energy at the target from 10 eV to 1000 eV, and

(5) to be able to deliver the antiprotons both as a dc beam

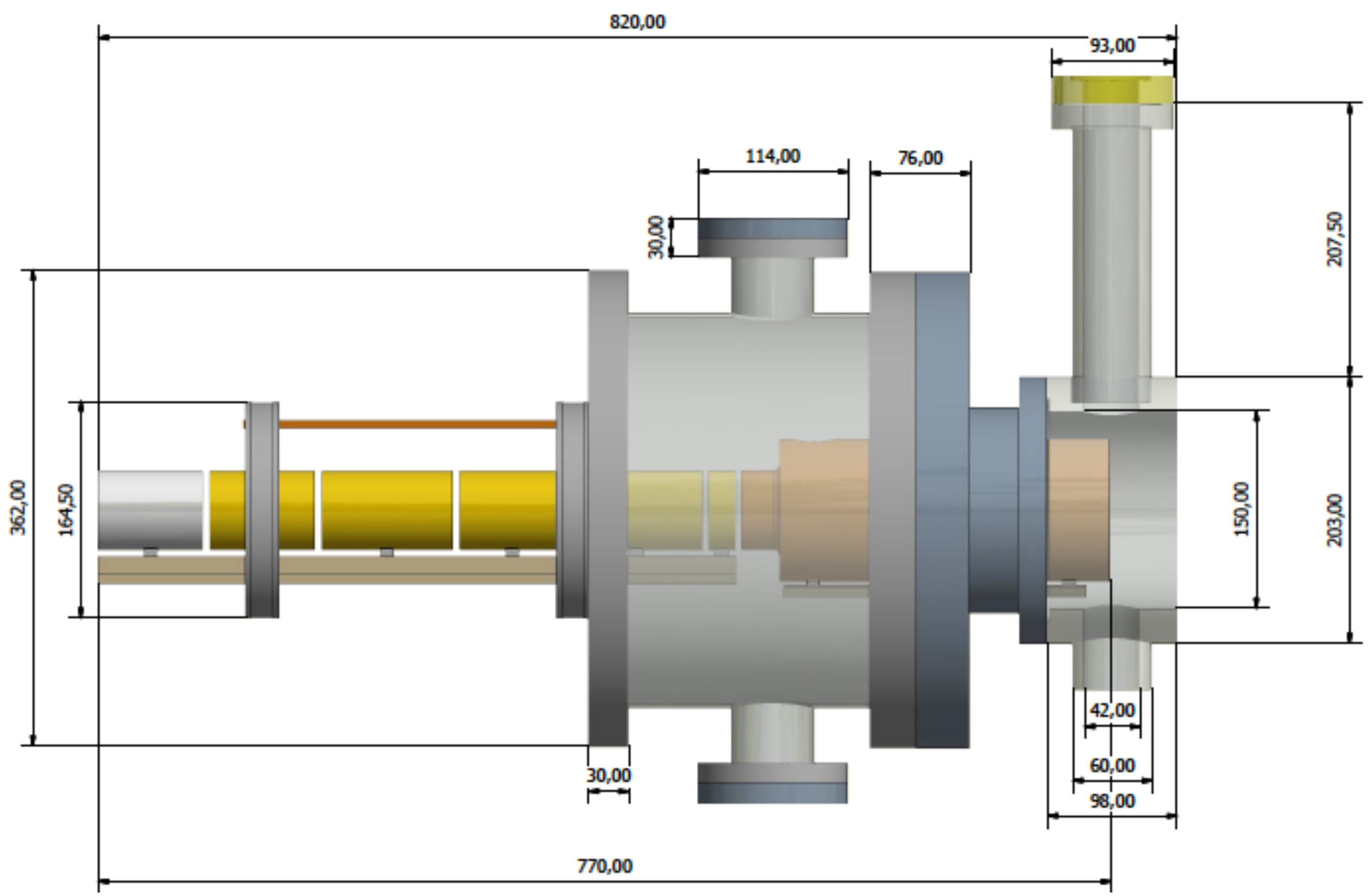
(6) and as a pulsed beam of a few microseconds duration. → 100 ns !

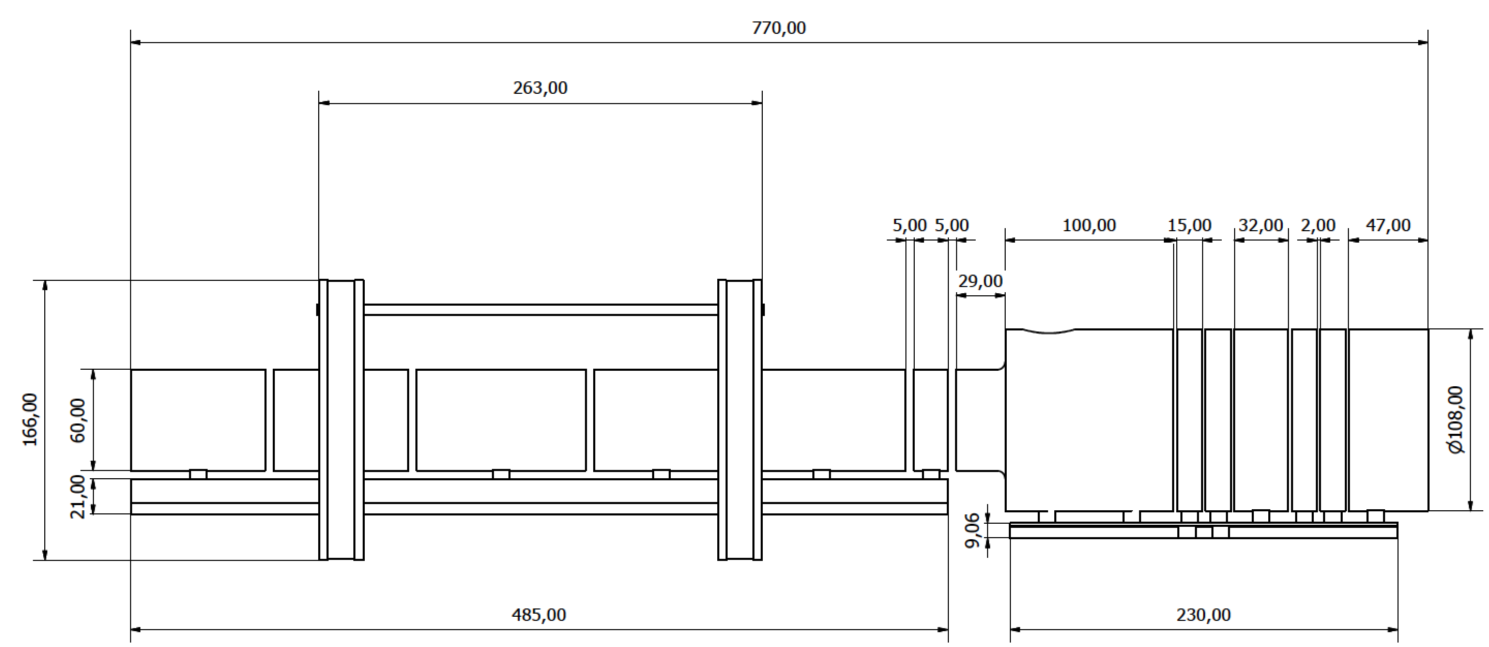
MUSASHI





Extraction Electrodes





Magnet specification

Central field	2 – 5 T
Bore diameter	200 mm
Coil inner diameter	200 mm
Uniform region(<0.1%)	500 mm
Coil length	1000 mm
Cooling method	GM cryocooler
Magnetic shield	5 mT (r=0.5m, z=1.5 m)

Cold bore with poor thermal coupling between coil and vacuum pipe

Schedule

이름	시작일	종료일	기간
Magnet	16. 10. 3	18. 1. 5	330
Magnet design	16. 10. 3	16. 12....	60
Magnet order	16. 12. 26	17. 2. 3	30
Magnet Fabrication	17. 2. 6	17. 10....	180
Magnet comissioing	17. 10. 16	18. 1. 5	60
Electrodes	16. 10. 3	17. 7. 21	210
Electrodes design	16. 10. 3	17. 2. 3	90
Electrodes fabrication	17. 2. 6	17. 4. 28	60
Power supply	17. 2. 6	17. 4. 28	60
Electrodes test	17. 5. 1	17. 7. 21	60
Vacuum system	16. 10. 3	17. 11....	290
Vacuum system design	16. 10. 3	17. 2. 3	90
Vacuum chamber fabrication	17. 2. 6	17. 4. 7	45
Vacuum pump purchase	17. 2. 6	17. 9. 1	150
Scroll pump	17. 2. 6	17. 4. 7	45
TMP	17. 2. 6	17. 7. 21	120
Cryopump	17. 4. 17	17. 9. 1	100
Vacuum test 1	17. 4. 10	17. 5. 5	20
Vacuum test 2	17. 7. 24	17. 9. 1	30
Vacuum test 3	17. 9. 4	17. 11....	50
System Integration	18. 1. 8	18. 11. 9	220
Magnet+Vacuum System	18. 1. 8	18. 2. 16	30
Electron commissioing	18. 2. 19	18. 4. 13	40
Move to CERN	18. 4. 16	18. 5. 25	30
Installation	18. 5. 28	18. 7. 6	30
comissioning	18. 7. 9	18. 11. 9	90