Status of the ELENA Electron Cooler

G. TRANQUILLE (ON BEHALF OF ALL THE TEAM)

Status of the ELENA electron cooler

- Cooler parameters
- Design
- Magnetic system
- Vacuum system
- Tentative installation schedule

- Electron cooling essential in ELENA to counter emittance blow-up caused by the deceleration process.
- To prepare bunches with sufficiently low emittance for extraction to the experiments via the long electrostatic extraction lines.
- Cooling needed at 2 momenta: 35 MeV/c and 13.7 MeV/c.
- Expected emittances prior

  to cooling:

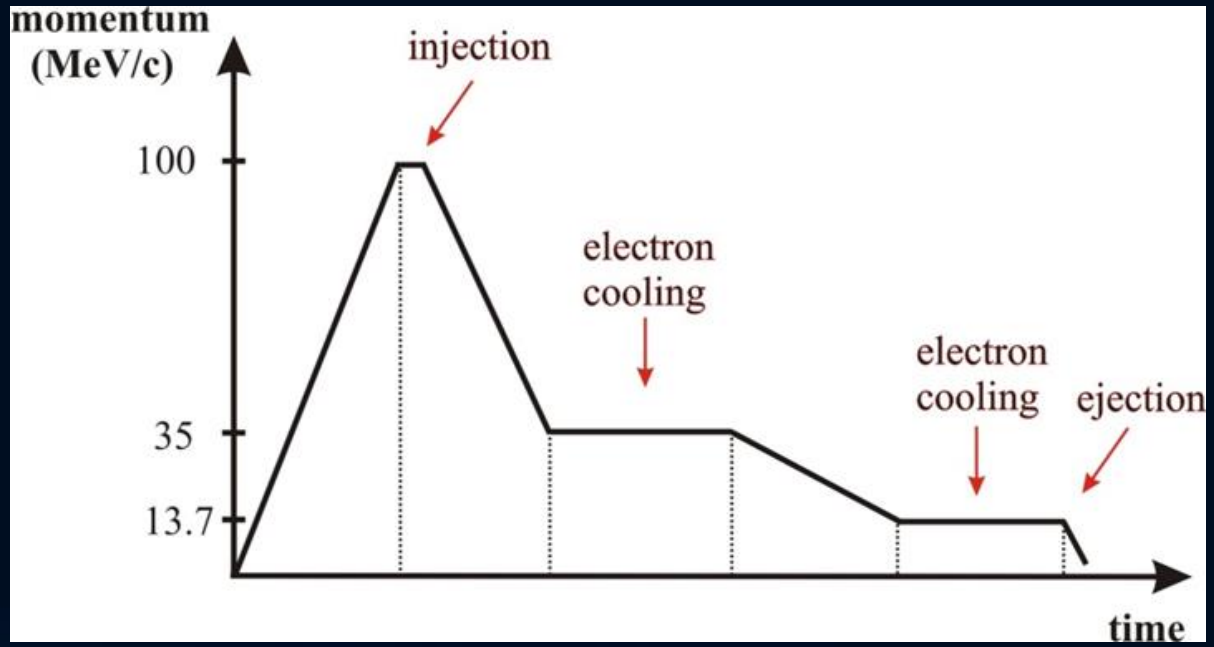
  @ 35 Mev/c:

  $\varepsilon \sim 50\ \pi$ mm mrad

  $(\Delta p/p) = \pm 2 \times 10^{-3}$
- Needed emittances at extraction:

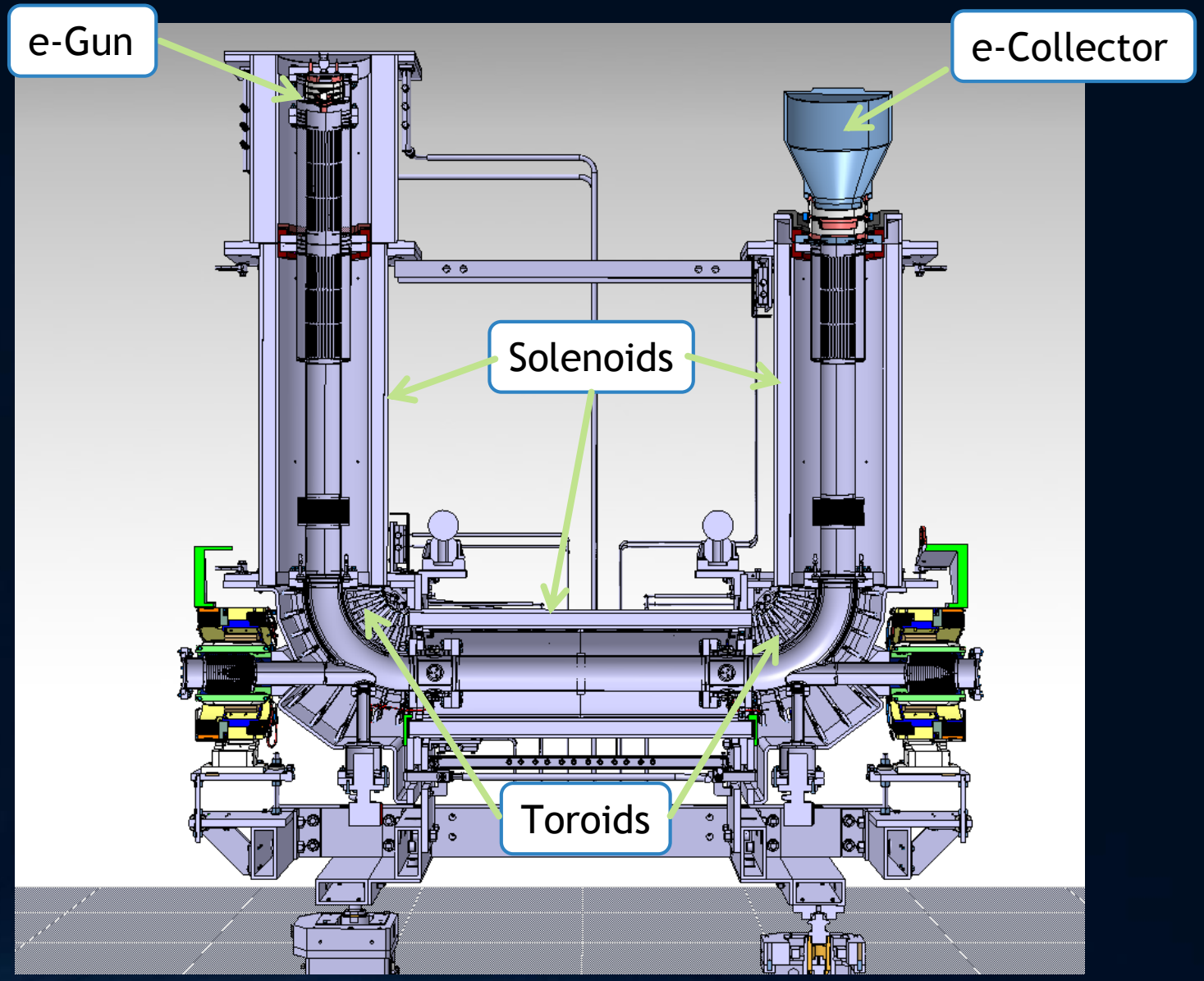
  $\varepsilon \leq \sim 3\ \pi$ mm mrad

  $(\Delta p/p) \leq \pm 1 \times 10^{-3}$



- Operate at very low electron energies (down to 55 eV).
- Operate at very low magnetic field to minimize disturbance to circulating low energy antiprotons – 100 Gauss in the cooler.
- Extremely good vacuum.
- Adiabatic expansion of electron beam to reduce transverse temperatures.
- Very good field quality – especially in the cooler solenoid ($B_t/B_{||} < 5 \times 10^{-4}$).
- Orbit correctors and solenoid compensators.

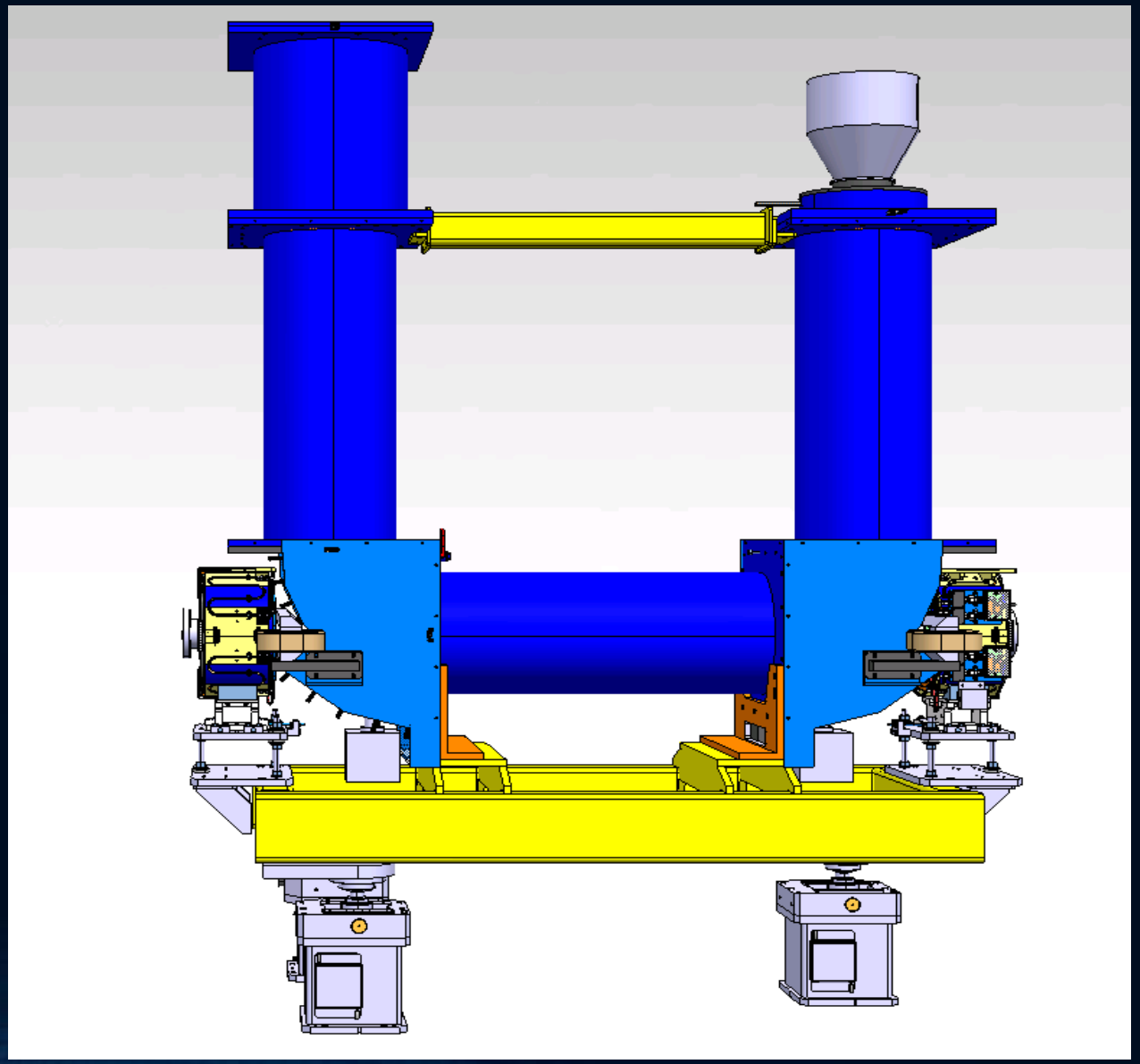
Momentum (MeV/c)	35	13.7
β	0.037	0.015
Electron beam energy (eV)	355	55
Electron current (mA)	5	2
Electron beam density (m^{-3})	1.38×10^{12}	1.41×10^{12}
B_{gun} (G)	1000	
B_{drift} (G)	100	
Expansion factor	10	
Cathode radius (mm)	8	
Electron beam radius (mm)	25	
Twiss parameters (m)	β_h=2.103, β_v=2.186, D=1.498	
Flange-to-flange length (mm)	2330	
Drift solenoid length (mm)	1000	


e-Gun
e-Collector
Solenoids
Toroids

Concept overview of Magnets Elements

- Magnets
- Supporting system

tesla

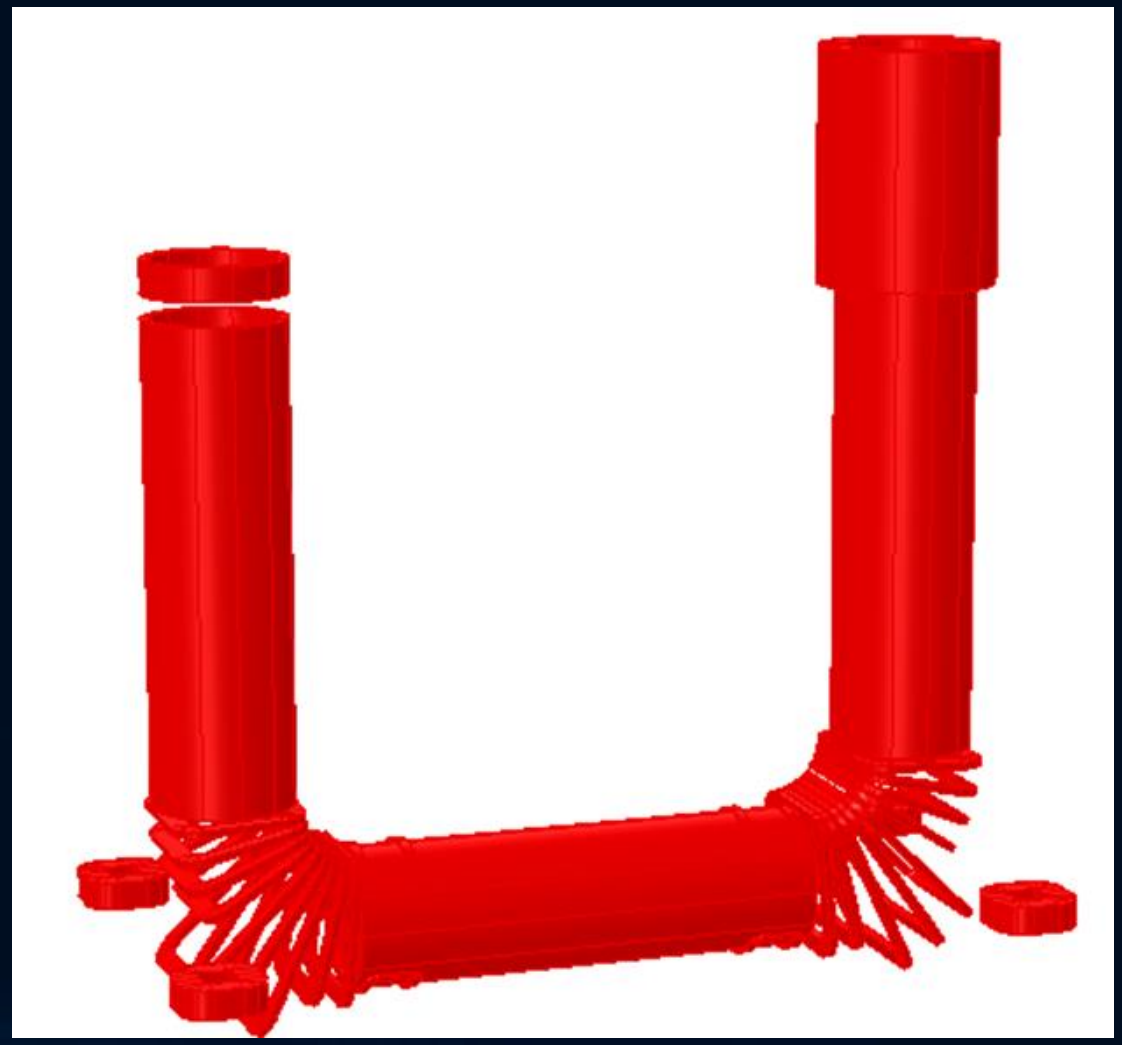


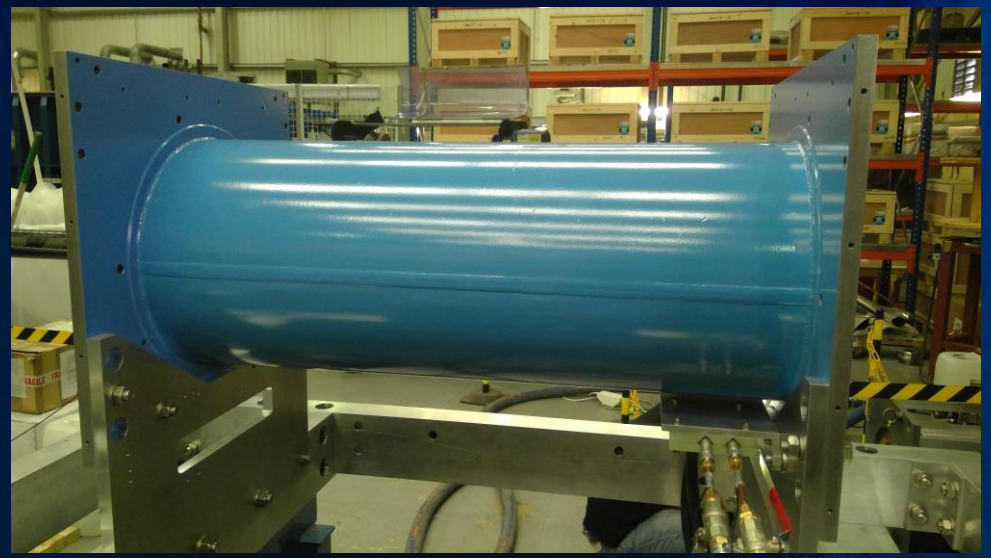
Magnetic system components

- Main cooler solenoid
- Gun solenoid
- Collector solenoid
- Expansion solenoid
- Squeeze coil at collector
- 2 x Toroid section consisting of

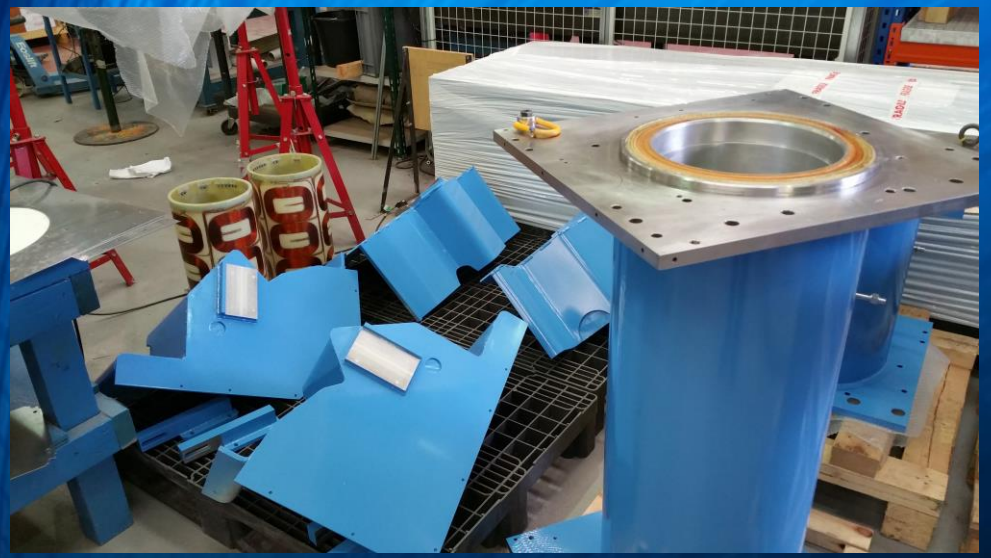
  9 racetrack coils each
- Various corrector coils to

  ensure good field quality
- Orbit correctors
- Solenoid compensators





Standard solenoid on measurement bench

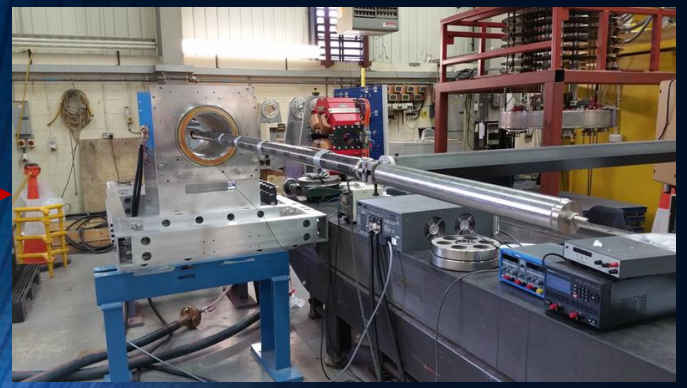


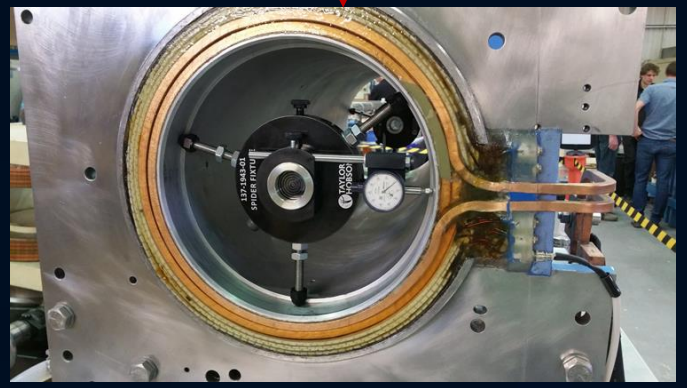
Shielding, standard solenoids and expansion solenoid

Toroid assembly

Magnetic measurement the ELENA Electron Cooler

- Lakeshore Model 460 Gaussmeter with 3-axis HSE probe (1 mG resolution in range up to 300 G, accuracy of ±0.1%).
- Probe holder with mirror for precise alignment. Has 4 possible rotational positions with 3 mounting points (0, 10 and 25 mm).
- Counter balanced carbon fibre tube to hold probe holder.
- Probe carrier and tube driven and positioned with a CMM arm with ±0.5 mm accuracy.
- Precise probe alignment made with an autocollimator and spider fixtures.

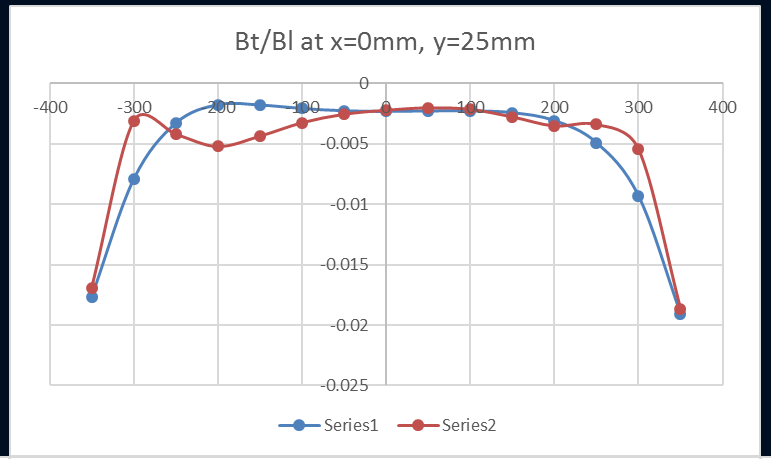


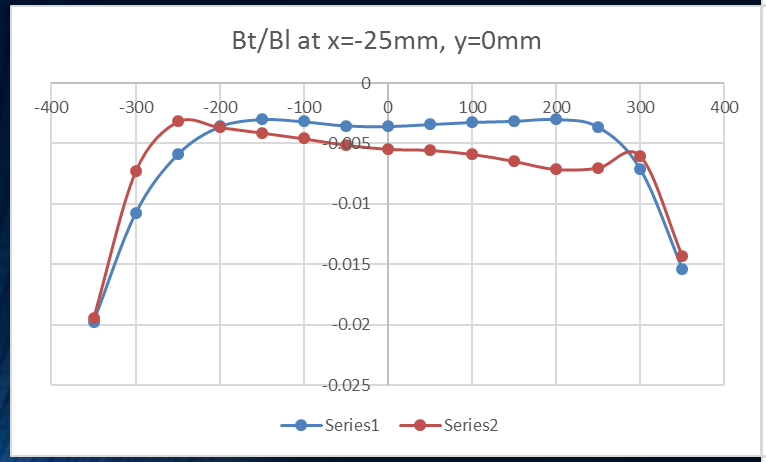


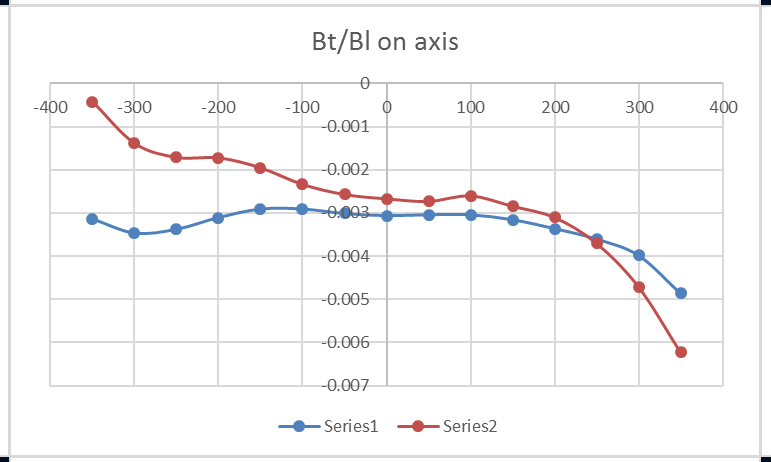
- Measure each standard solenoid to determine how to place the solenoids during assembly ($B_t/B \leq 5x10^{-3}$).
- Check the magnetic model proposed by TESLA Engineering (saddle coils, circular coils, fine-tune coils…).
- $B_t/B \leq 5x10^{-4}$ in the centre of the drift solenoid (50 mG).
- Field map of the electron cooler.

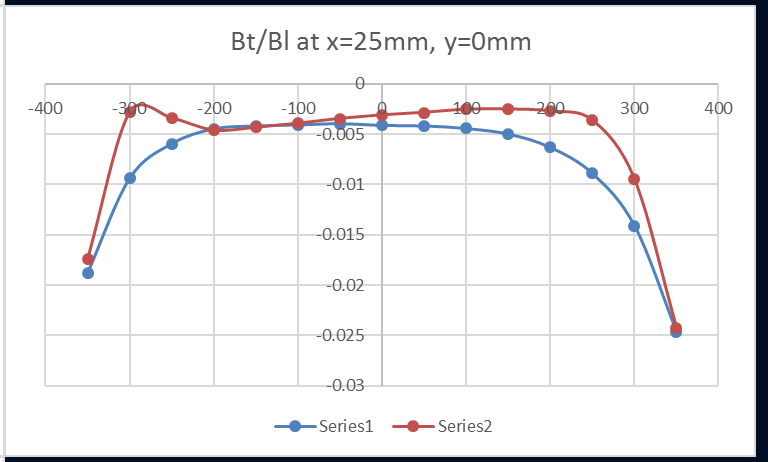
Influence of circular coils on Bt/Bl
For SS#4

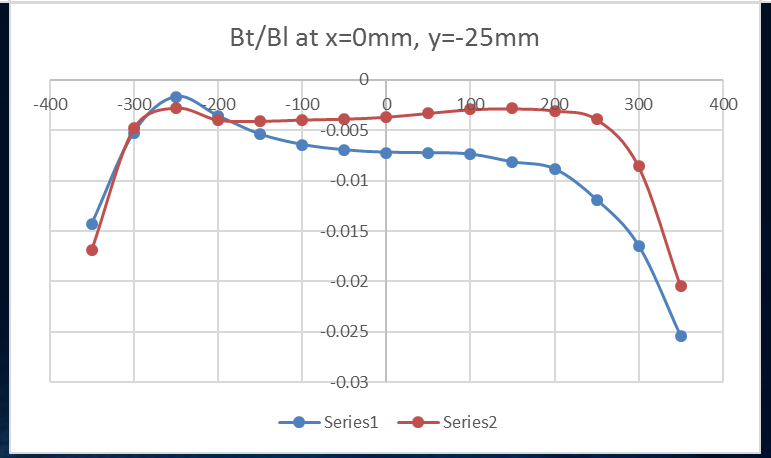
Bt = sqrt(Bx^2 + By^2)



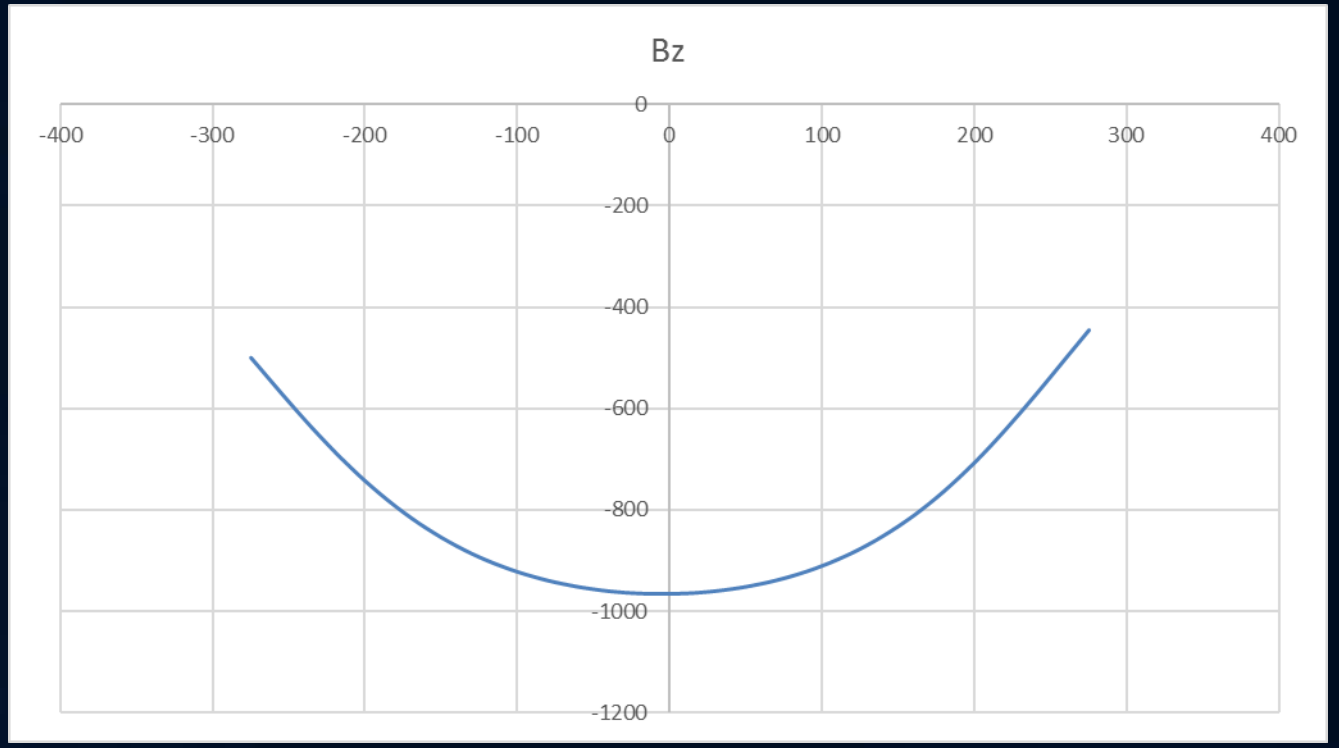




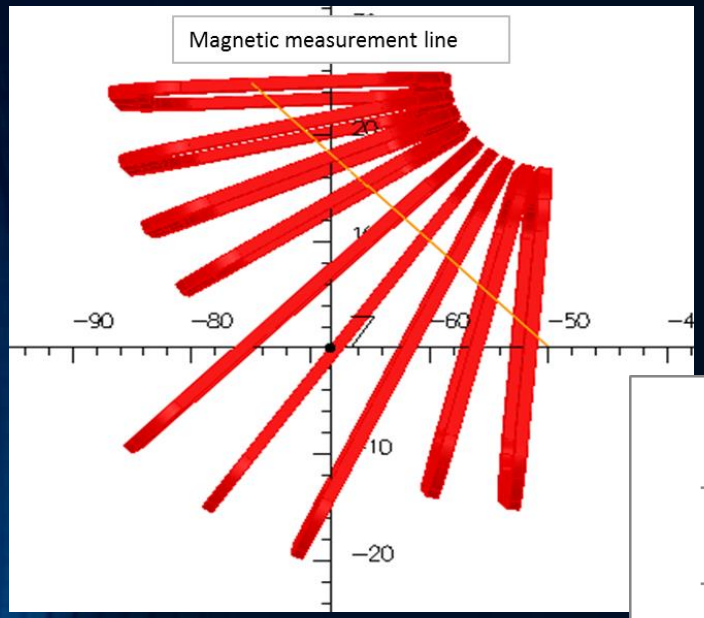


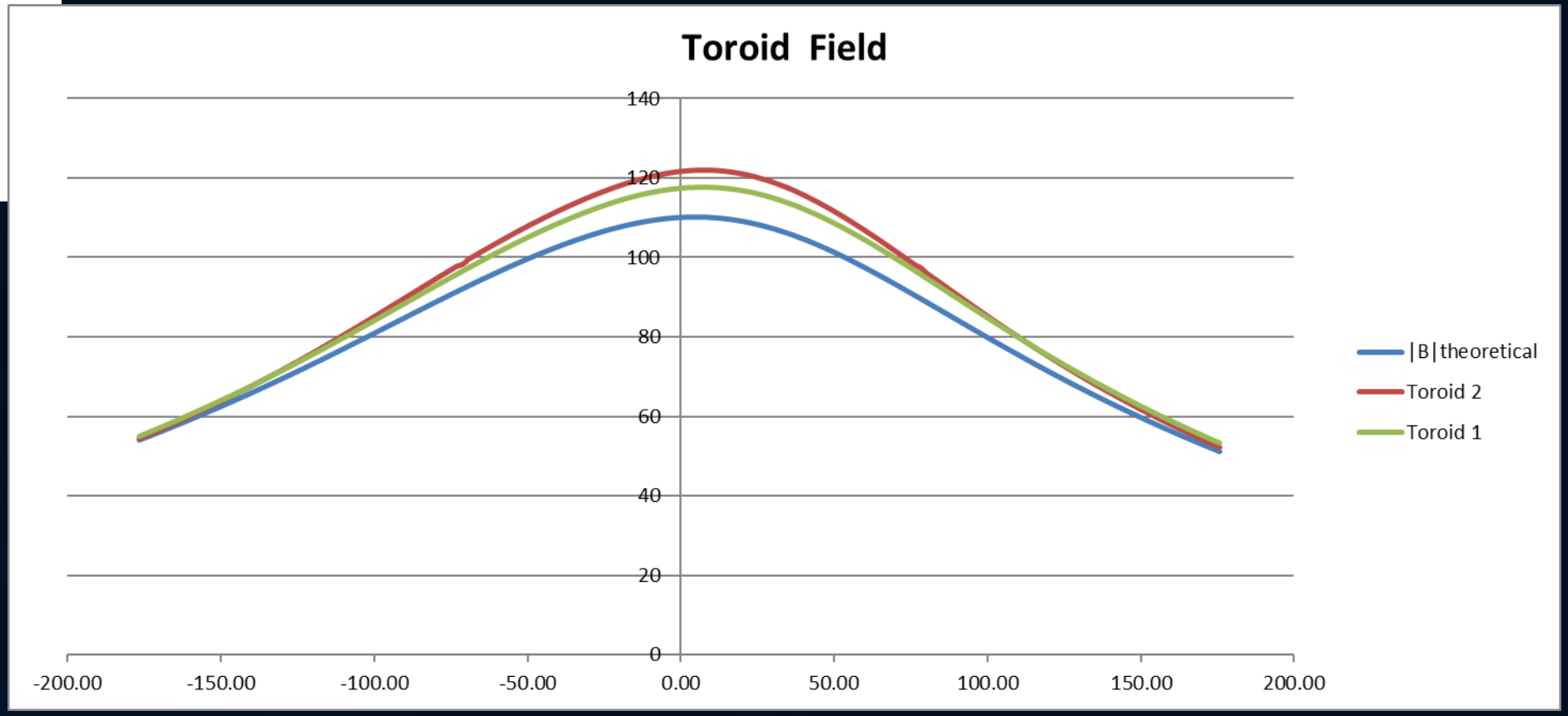


Expansion solenoid



Toroid


Magnetic measurement line
20
10
−20
−90
−80
−60
−50


Toroid Field
140
120
100
80
60
40
20
0
-200.00
-150.00
-100.00
-50.00
0.00
50.00
100.00
150.00
200.00
|B|theoretical
Toroid 2
Toroid 1

Where are we with the magnet measurements?

The green light to go ahead with the magnet construction was only given in June 2015

Three iterations needed before the measurement system was deemed to have the correct performance

All standard solenoids measured with circular coils powered
- Selection of "drift solenoid"

Expansion solenoid measured
- Has to be re-measured as the shielding end-plate was not in place

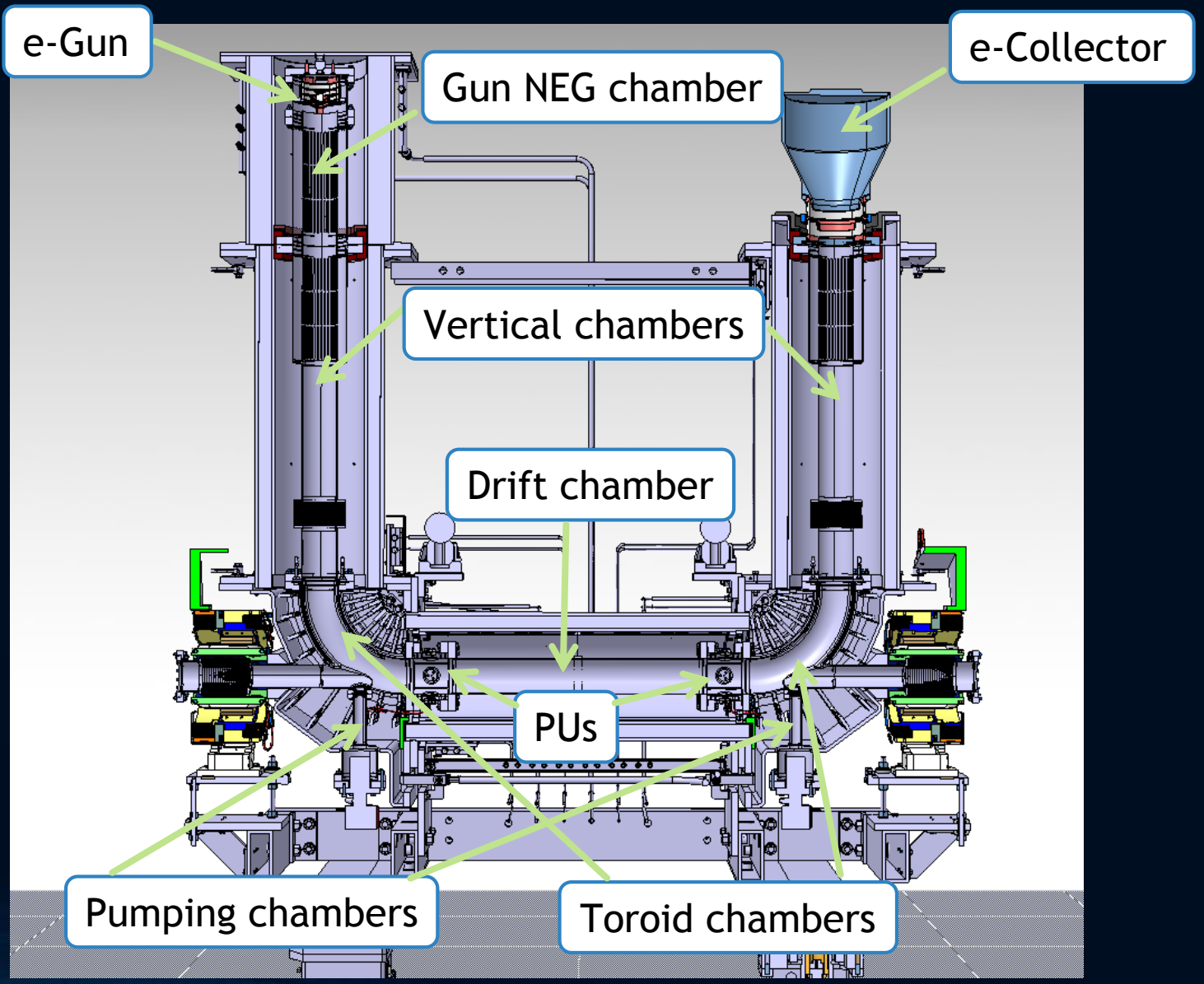
Toroids partially measured

Compact correctors measured at CERN
- High B2 component due to parallelism error – will be corrected

Mounting of the full assembly on-going

Vacuum Elements

- Vacuum system
- Gun & Collector



Gun NEG chamber

Vertical chambers

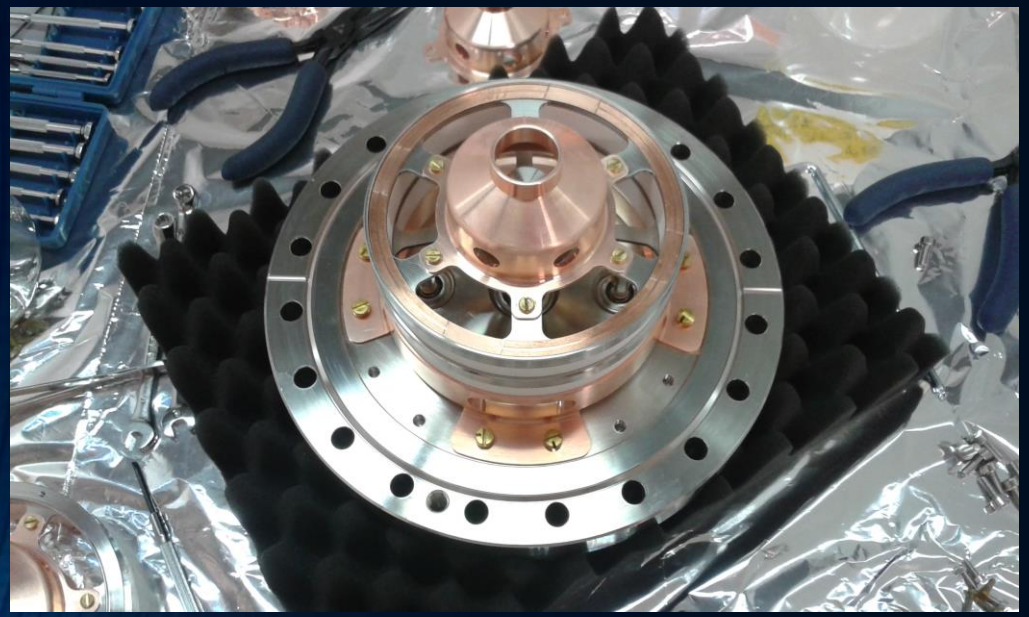
Toroid chamber

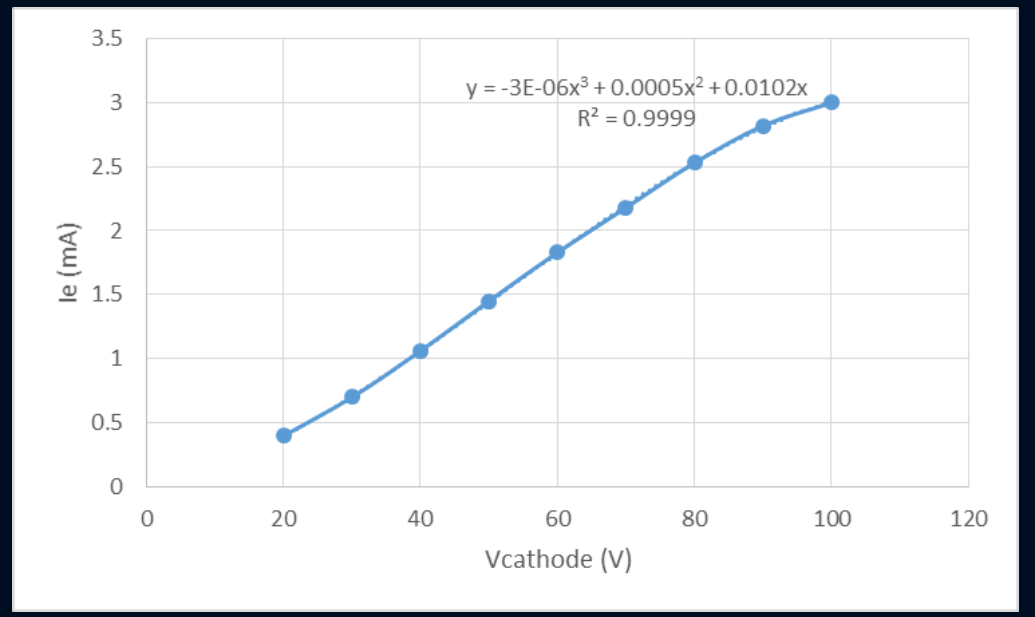
Drift chamber

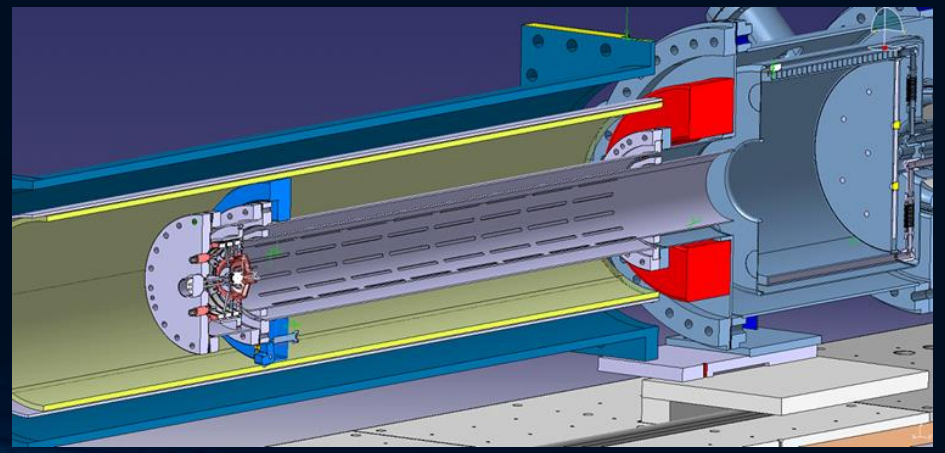
Pumping chambers

Collector

The electron gun







element	NEG	VSC	
Electron gun	n/a	✗	Undergoing test on the ecool test stand
Collector	n/a	✓	Ready
Gun NEG chamber	strips	✗	Final acceptance test in March
Vertical chambers	strips	✗	Final acceptance test in March
Toroid chambers	✗	✗	Electrodes to be mounted after NEG coating
+ electrodes	✓	✗	Final acceptance test in March
Drift chambers	✓	✗	Final acceptance test in March
Pumping chambers	✓	✗	Final acceptance test in March
PU	✗	✗	Mounting and electrical tests still to be done

Tentative schedule

IF ALL GOES WELL

finish all magnetic measurements – end February
dismount and ship magnet system and frame to CERN – end March

all vacuum activities can only start after week 10
- NEG coat toroid chambers
- mount electrodes in toroid chambers
- Pus mounted and tested
- final vacuum acceptance tests (complete assembly or individual elements?)

At the earliest we will be in a situation to start mounting the cooler in May
- 2 weeks for the assembly
- move into the ring and connect
- bake-out
- connections (wic, water & electrical)
- tests

} 1 month

QUESTIONS/COMMENTS?

Influence of transverse temperature on the cooling (BETACOOL)