Report on design of test stand and beam instrumentation

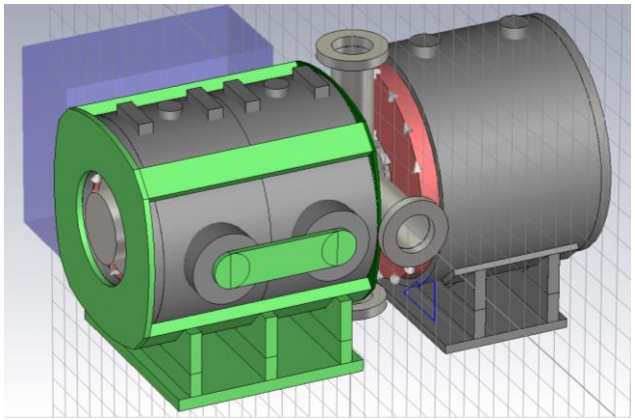
Test stand at CERN

- Foreseen for ARIES studies WP16 – **Intense, RF modulated E-beams (IRME):**
  - Design and build a test stand for testing gun including instrumentation suitable for measuring the transverse and longitudinal profiles of the RF modulated electron beam
  - Measure the properties of the RF modulated electron beam created by the gun using this test stand

  [50x70mm oval e-beam, 5-10A, 22kV]
- Can be used for:
  - Studies high intensity e-gun for **Beam-Beam Long Range compensation:**
    - Few mm round e-beam, up to 20A, **20-35kV**
    - Modulation at 40MHz for BPM measurements
  - Test Gas Curtain Monitor
  - If **HEL-HL-LHC** becomes baseline:
    - Characterise e-guns
    - Validate, commission modulators
    - Test beam instrumentation, modulators, interlocks,

HiLumi HL-LHC PROJECT

Test stand development at CERN:

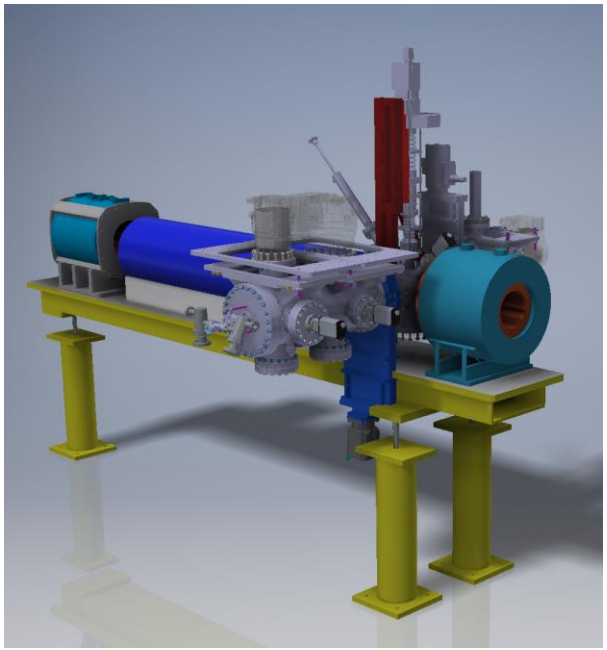


Gun solenoid (twins), collector solenoid, prototype of diagnostic box (pin-hole Faraday cup + YAG screen monitor).

Purpose of the first stage:

- Preparation:
  - Commissioning hardware (magnets, vacuum, HV system, control, etc.)
  - Safety and technical aspects of operation
  - Commissioning diagnostic procedures (current, profile, position)
- Measurements:
  - Electron gun tests: characterization
  - Electron gun: anode modular
- Preparation for upgrade

Test stand development at CERN. Upgrade.

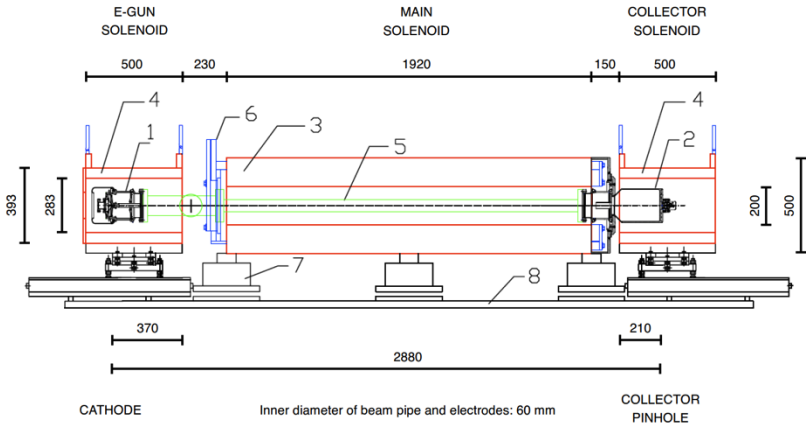


Purpose and measurements of stage 2:

- Allow drift and see beam deformations/rotations/… computer model validation
- Study electron beam dynamics in regime close to virtual cathode
- Study electron beam dynamics with compression

- Test Beam Position Monitor ‘shoe-box’ or ‘strip-line’ with very HF modulation
- Test effect of very HF modulation (<10% current) on beam dynamics (microbunching?) for HEL

E-lens test stand at FNAL



https://cdcvs.fnal.gov/redmine/projects/elens/wiki/Test_Stand

Operational, up to 10 kV, 8μs x 1Hz pulses (or higher at < 5A)

Used to test CERN guns, will be used for testing guns for space-charge compensation at IOTA ring.

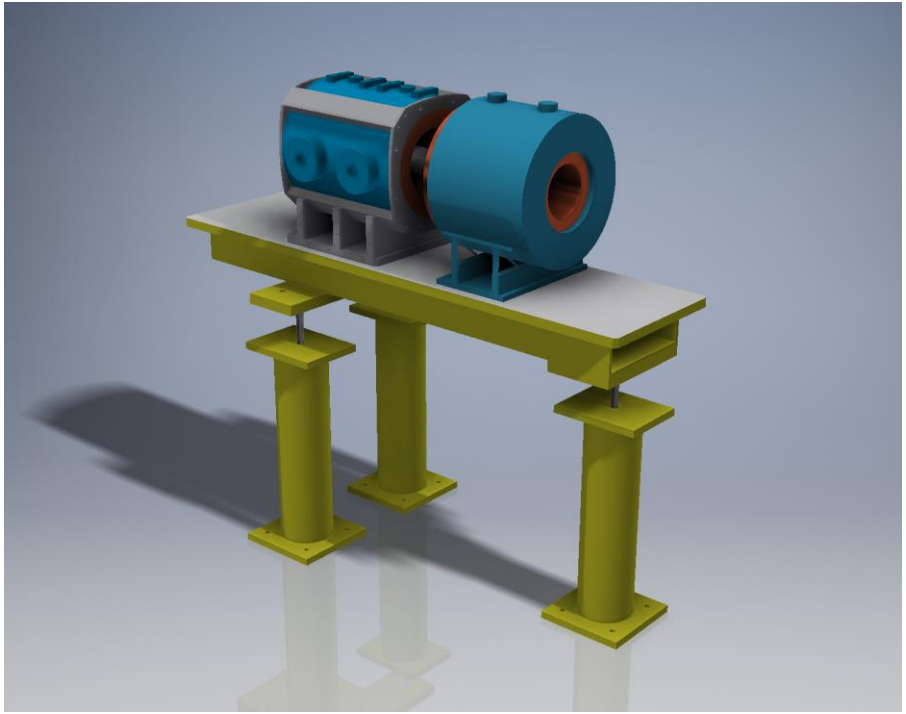
Could be used to test HF modulators.

Diagnostics: pin-hole FC in collector

Simulations and computer codes

- Reliable and verified simulation technics and models are required
- Computer codes that will be used for simulation for electron gun and beam dynamics:
  - CST particle studio
  - WARP
  - Results of gun simulations using TRACK and UltraSAM (2D codes) are available
  - BENDER

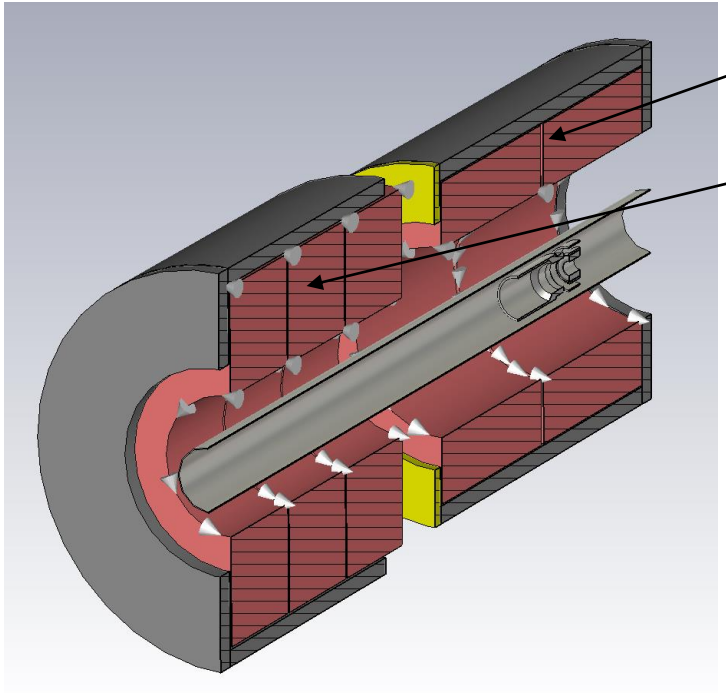
Current status: solenoids



- Solenoids (gun & collector) were recuperated
- Alignment support was recuperated
  - Alignment tables for solenoids are in production

- 8 Power converters (45 V – 140 A) from DELTAELECTRONIKA were delivered at CERN
  - 560 A for gun solenoid (up to 0.3T)
  - 560 A for collector solenoid (up to 0.5T)

CST model of the solenoids



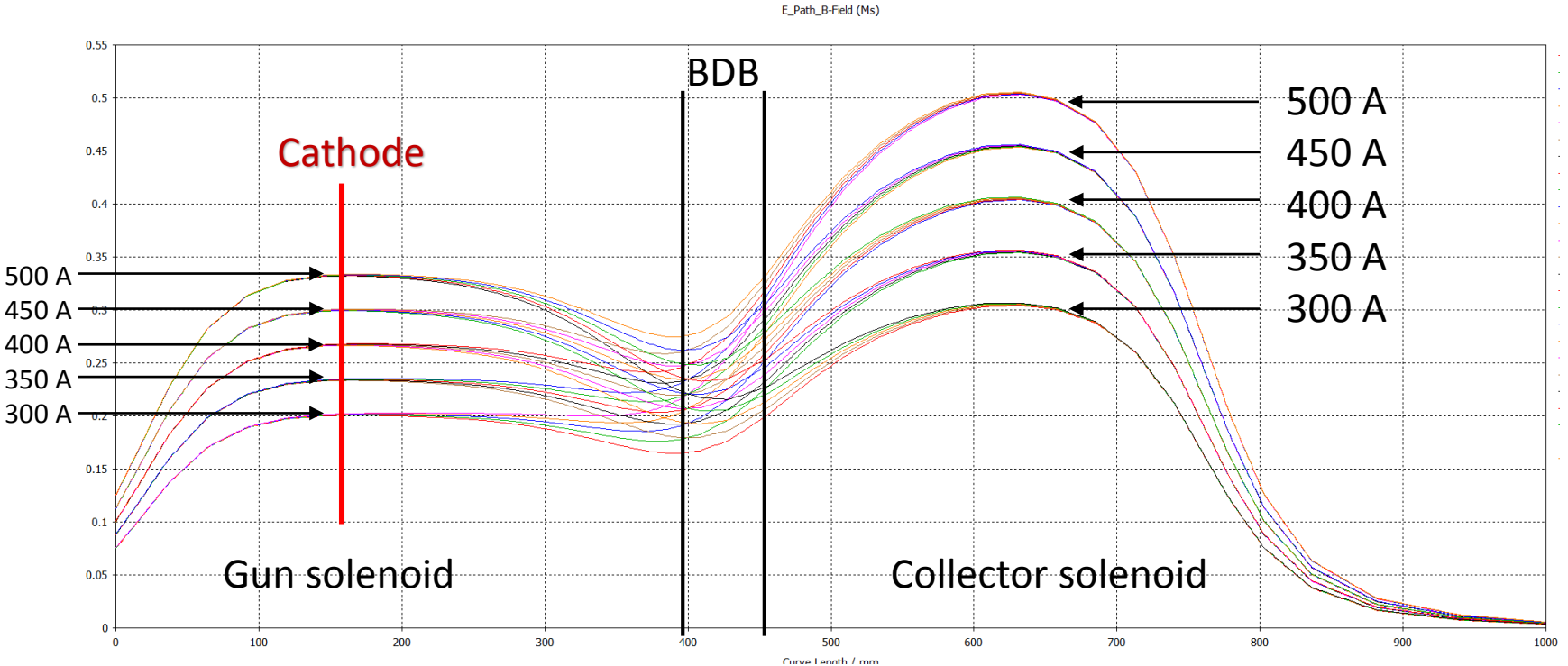
Gun solenoid (2 coils)

Collector solenoid (3 coils)

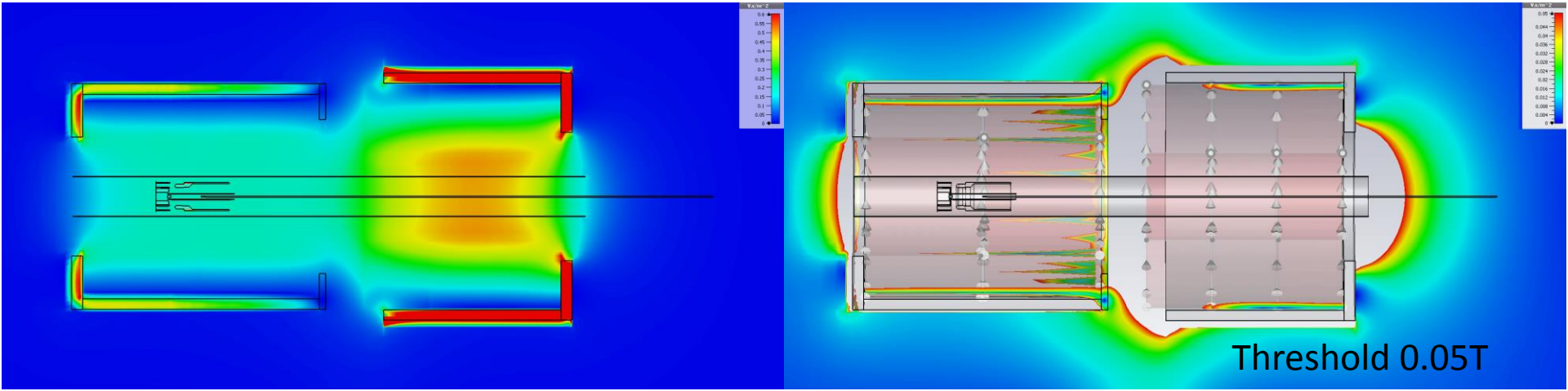
B field depending on current is calculated

B field map during solenoids commissioning using XYZ scanner and Hall probe

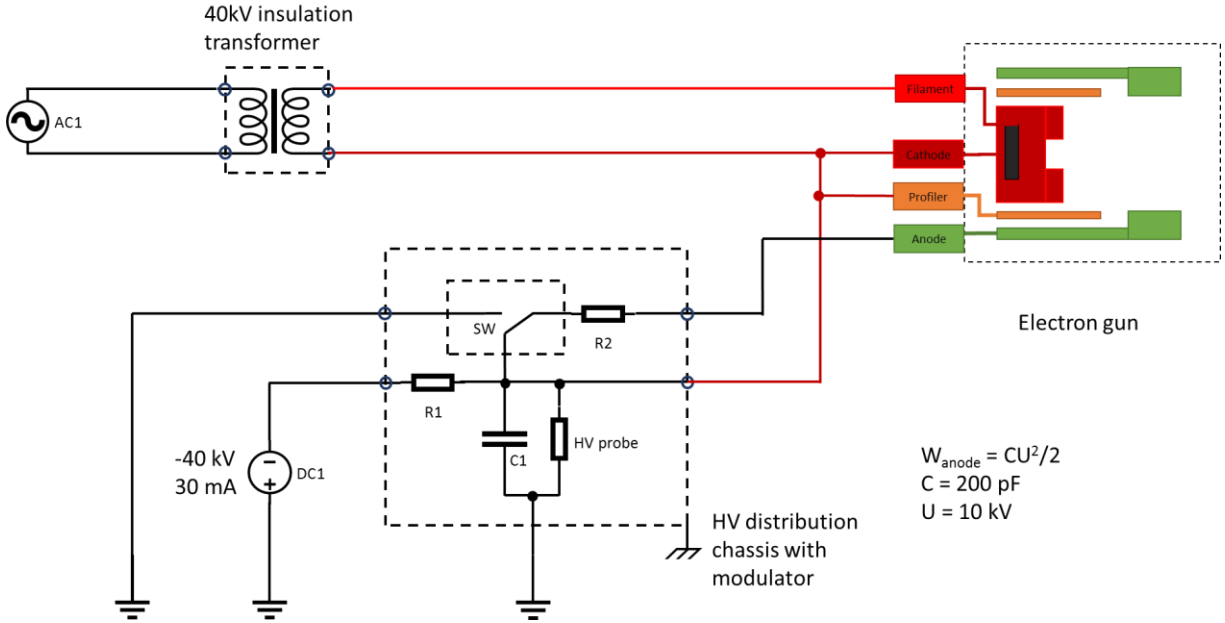
Magnetic field along Z axis for different currents in the test bench



Magnetic field on X=0 plane for 300A in GS and 500A in CS

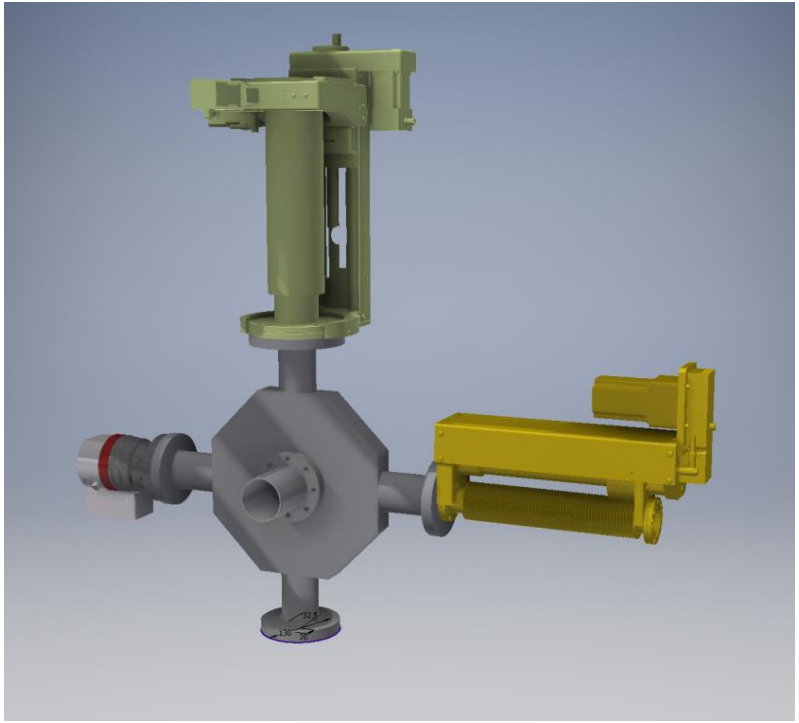


HV schematic



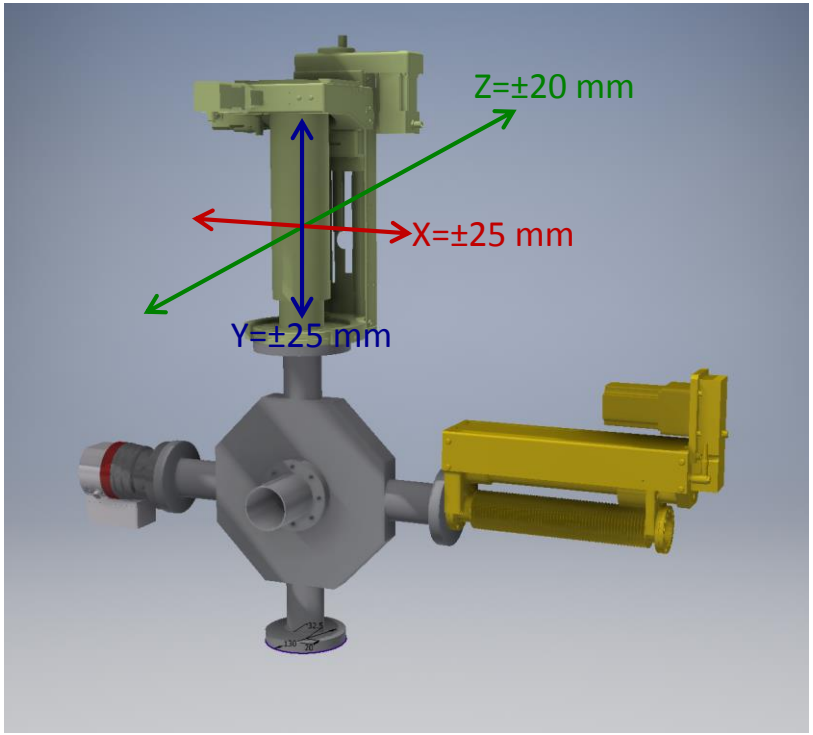
- Operation in pulsed mode
- BELHKE HV switch (HTS 401-10-GSM) for anode modulation
- Faraday Cage during upgrade
- ¿ Requirements (V, I) for filament for GSI gun ?
- ¿ Requirements of the pulse (rise time, duration) for GSI gun ?

Beam diagnostic box

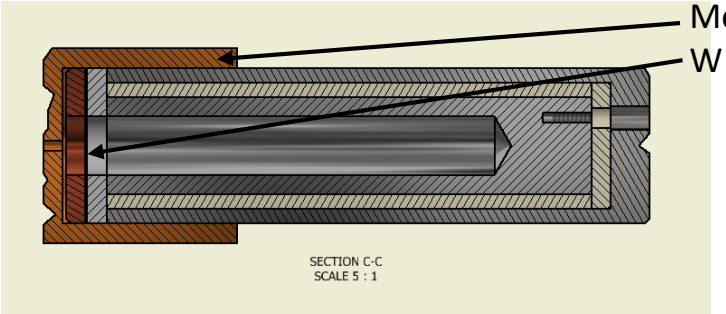


- Beam diagnostic box includes:
  - XYZ scanner with Faraday Cup
  - YAG:Ce screen
  - Port for vacuum pump

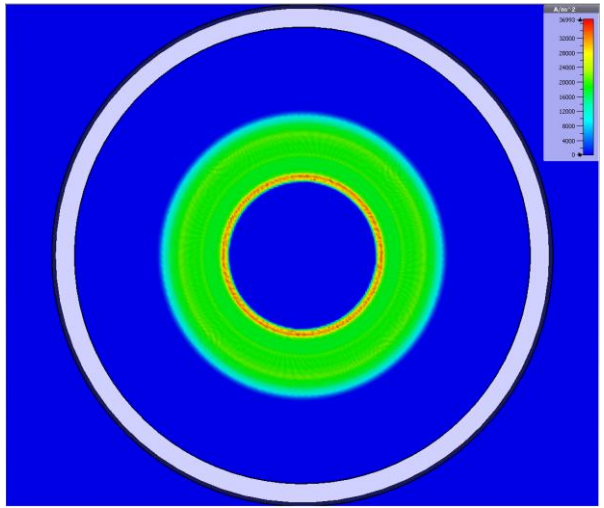
BDB: Faraday Cup



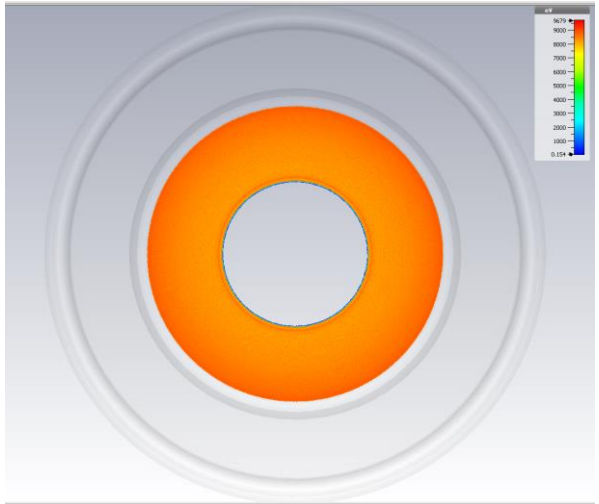
- Pin hole Faraday Cup



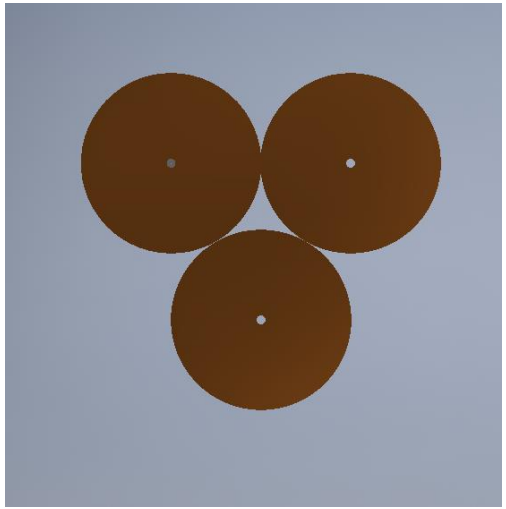
BDB: Faraday Cup



Current density



Energy density

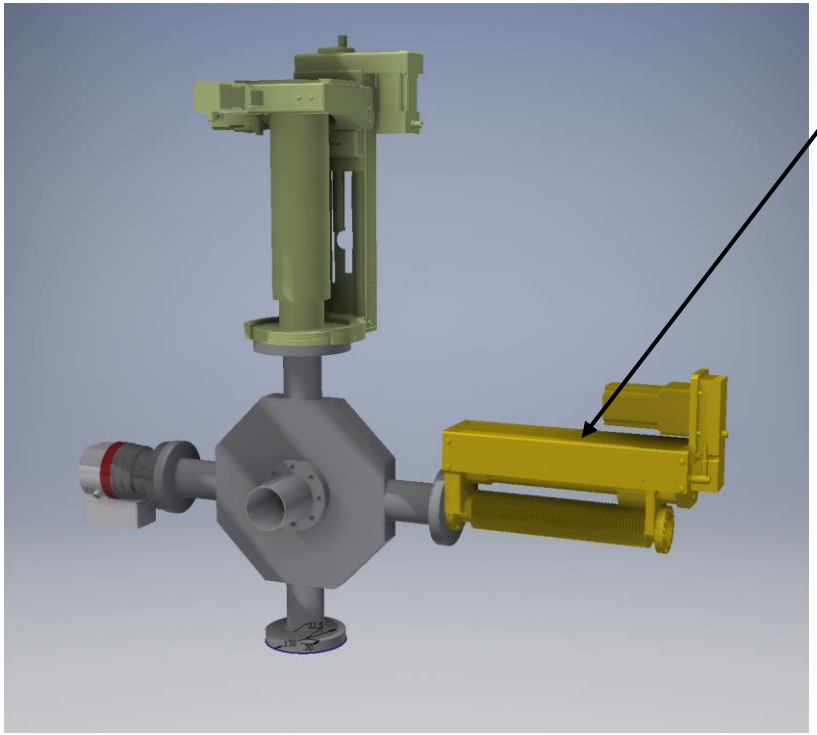


FC array on one actuator:

- Decrease time for scan
- Different apertures

*Design of FC with HV repeller is under development

BDB: YAG:Ce screen

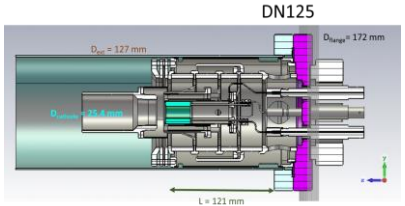


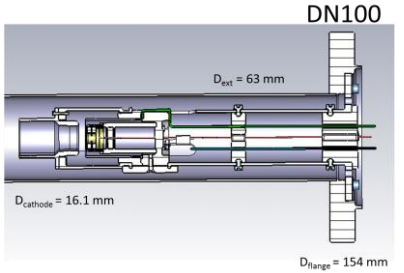
- Actuator with YAG:Ce screen
  - 3 screens (D=50 mm) are delivered at CERN
  - Beam profile in one pulse
  - Fragile (can be destroyed after one long pulse)
  - Requires view port on the collector side

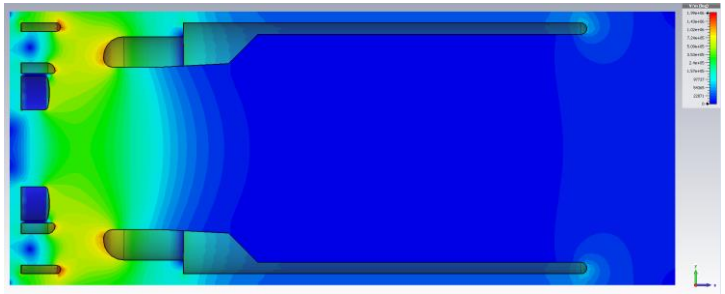
Stage 1: measurements

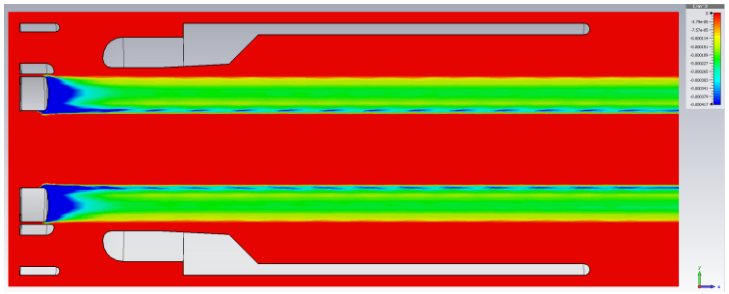
- Gun characterization
  - Measurements like in FERMILAB, but without 2 m drift for 25.4/16.1mm guns
  - Comparison experimental results with CST/WARP/TRAK/UltraSAM (to use output beam profile distribution as inputs for beam dynamics simulation)

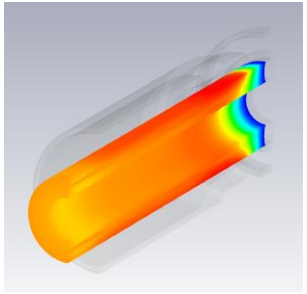
- Anode modulator
  - 33 kHz at full range (0 V – -10kV), 200pF at 10kV at 33 kHz…
  - ~MHz at % level (beam modulation for BPM)
  - **Test modulator but not the beam/BPM*





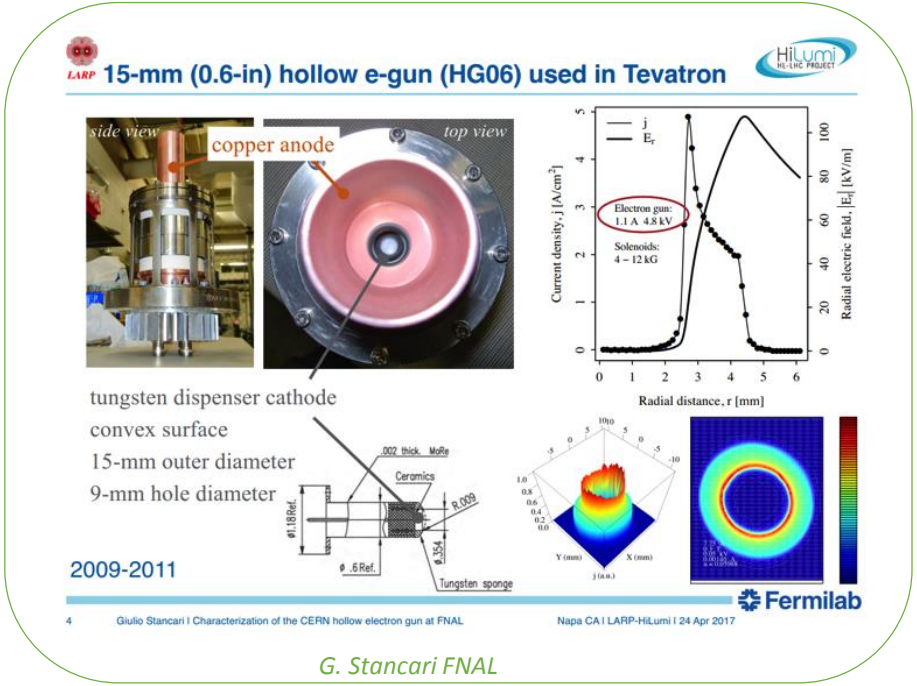




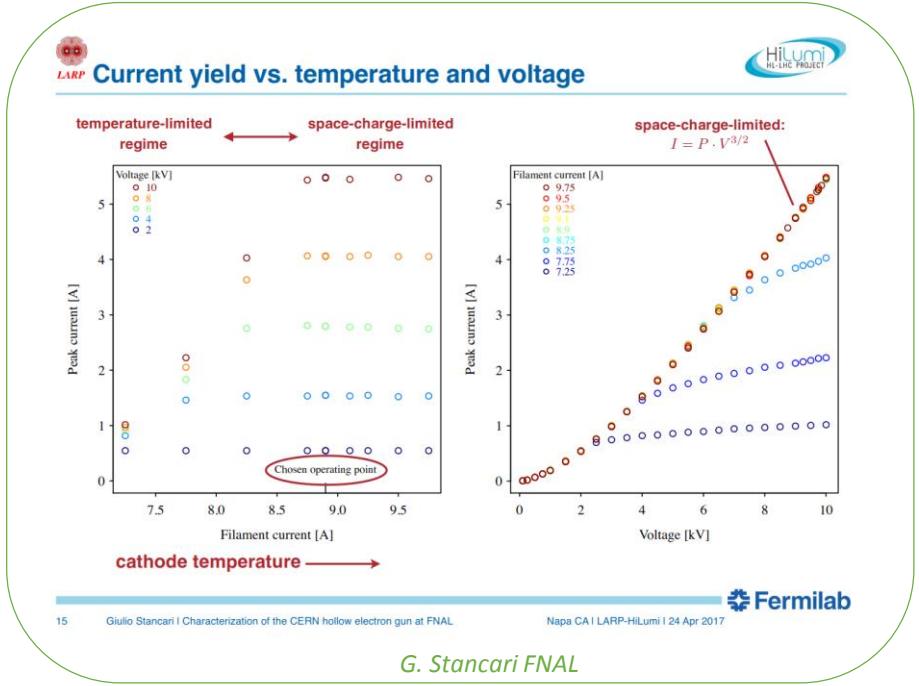


FNAL test stand: measurements

- Electron gun characterization

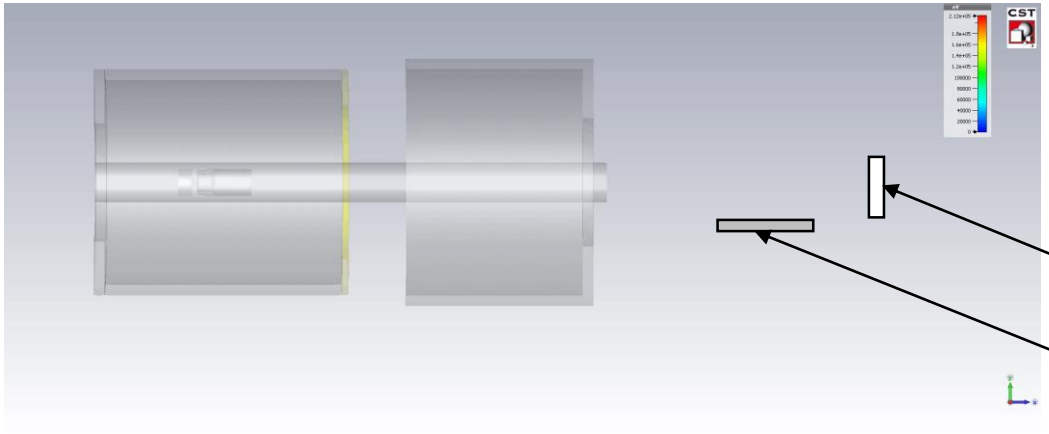


G. Stancari FNAL



G. Stancari FNAL

Collector



- View port for YAG:Ce screen
- Faraday Cup with repeller and view port as collector (no water cooling)
- To finalize design simulations with GSI gun are required
- ¿ Resolution 1 Gs/s ?

Summary and outlook

- A test stand at CERN is being constructed in a phased approach:
  - Stage 1 (Gun Solenoid – Diagnostic box – Collector solenoid) can be used for:
    - E-gun characterization both for HL-LHC HEL (in parallel or after FNAL) and SIS18 SCC lens;
    - Benchmark simulation codes (CST, WARP, TRAK, UltraSAM)
    - E-gun studying for BBLR compensation;
    - Test anode modulator
    - Test and commission BGC
  - Stage 2 (+ drift solenoid) is needed to:
    - Test RF modulation for SIS18 SCC lens;
    - Test BPM for electrons (HF or LF modulation);
    - Investigate electron beam dynamics and benchmark simulation codes (CST, WARP, …)
- Issues:
  - Cooling water in the building 236