HEL test stand update

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BGC Collaboration Meeting – March 2020 - CERN

Outline

I. Parameters of Electron Beam for Hollow Electron Lens

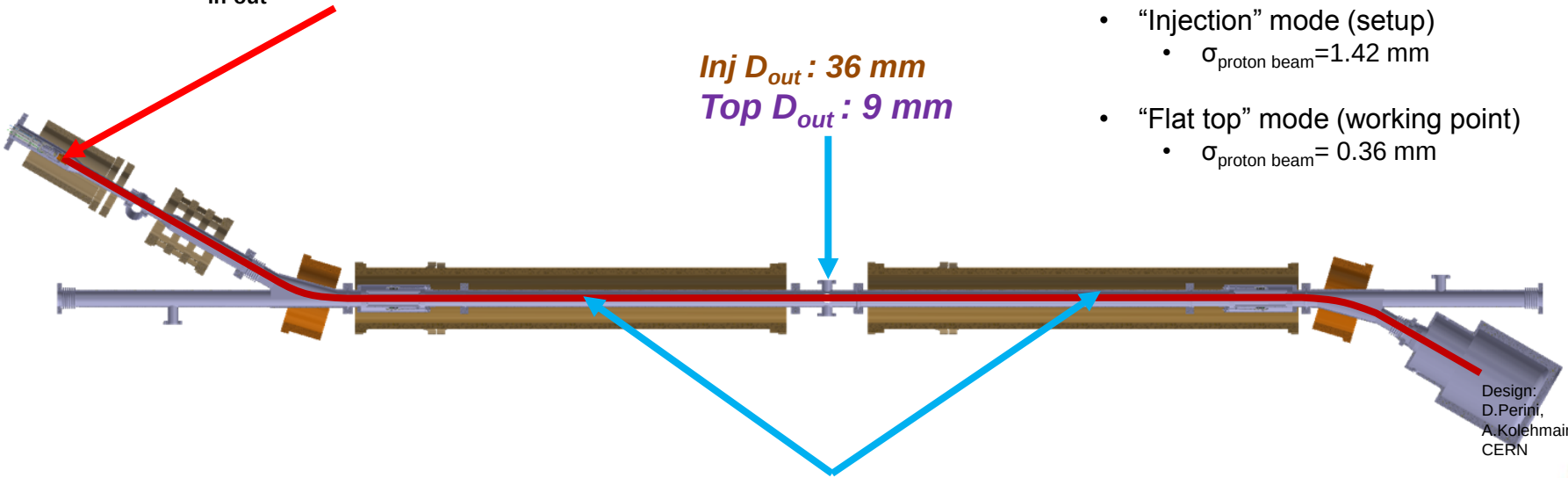
II. Parameters of Electron Lens Test Stand

III. Schedule and planning for Electron Lens Test Stand

I. Hollow Electron Beam Parameters

HEL: size of the beam

E-gun cathode:
$D_{in\text{-}out}$ = 8.05 – 16.1 mm



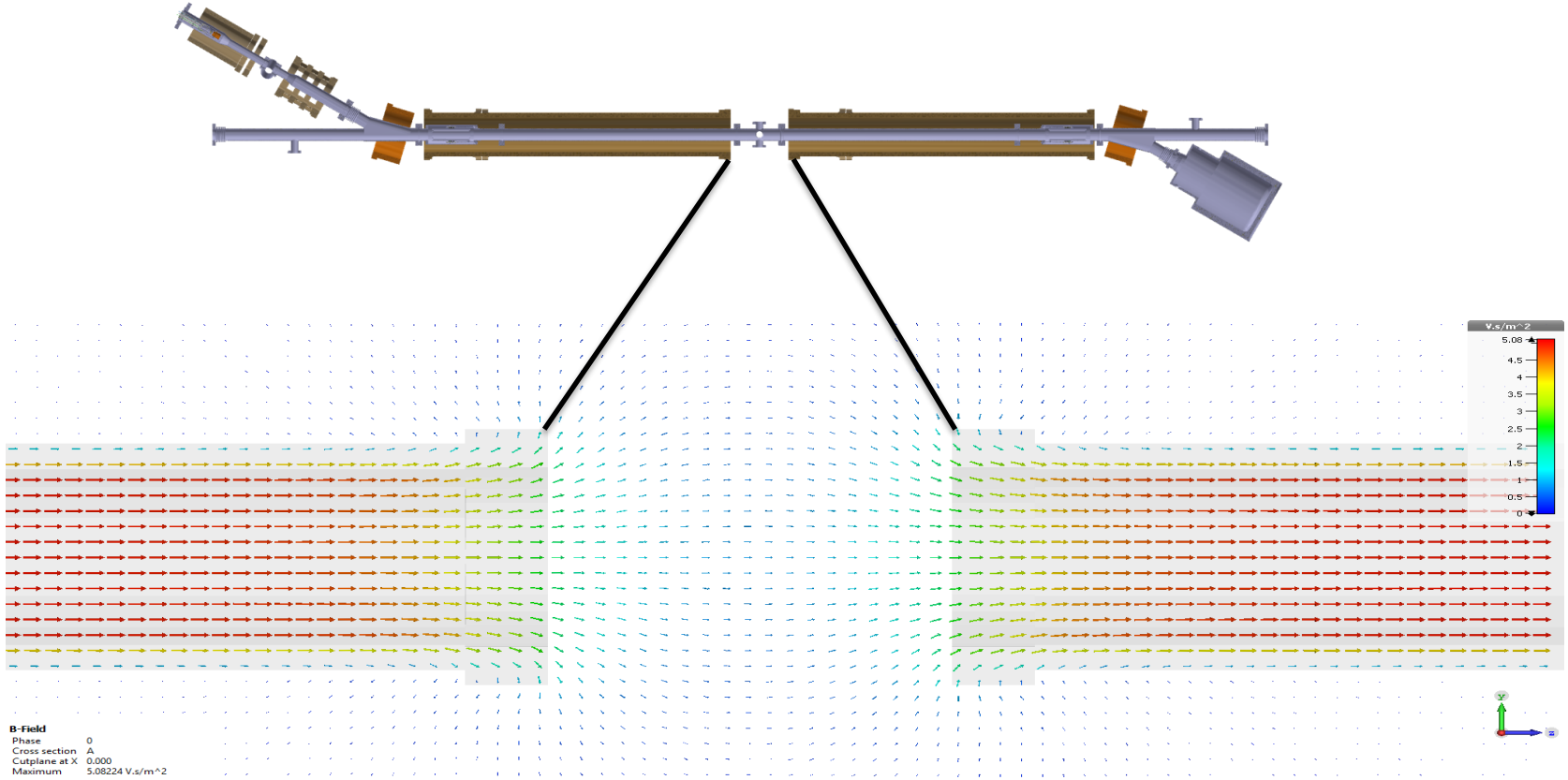
Injection mode:
$D_{in\text{-}out}$ = 8.58 - 17.15 mm

Top mode:
$D_{in\text{-}out}$ = 2.17 - 4.35 mm

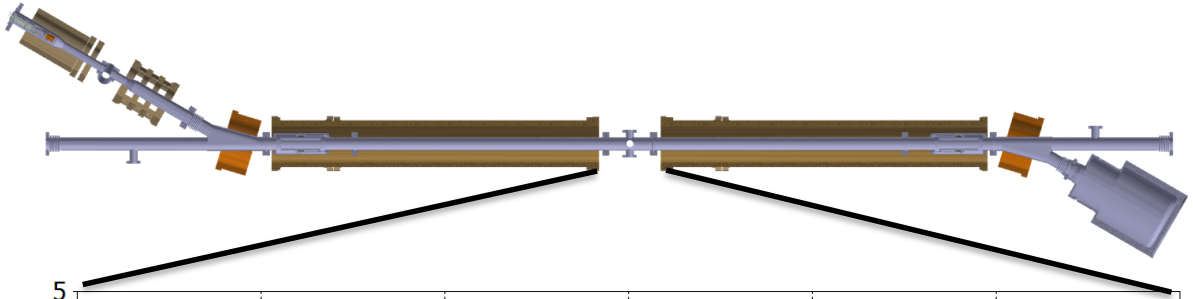
HEL application:

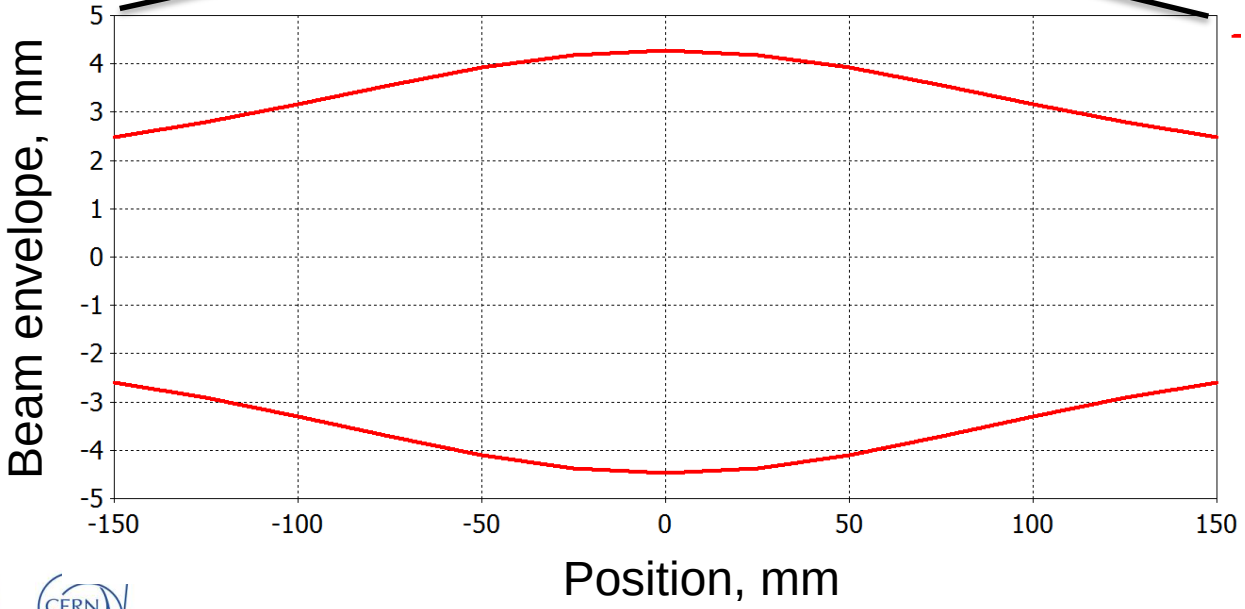
- "Injection" mode (setup)
  - $\sigma_{proton\ beam}$=1.42 mm
- "Flat top" mode (working point)
  - $\sigma_{proton\ beam}$= 0.36 mm

HEL: size of the beam



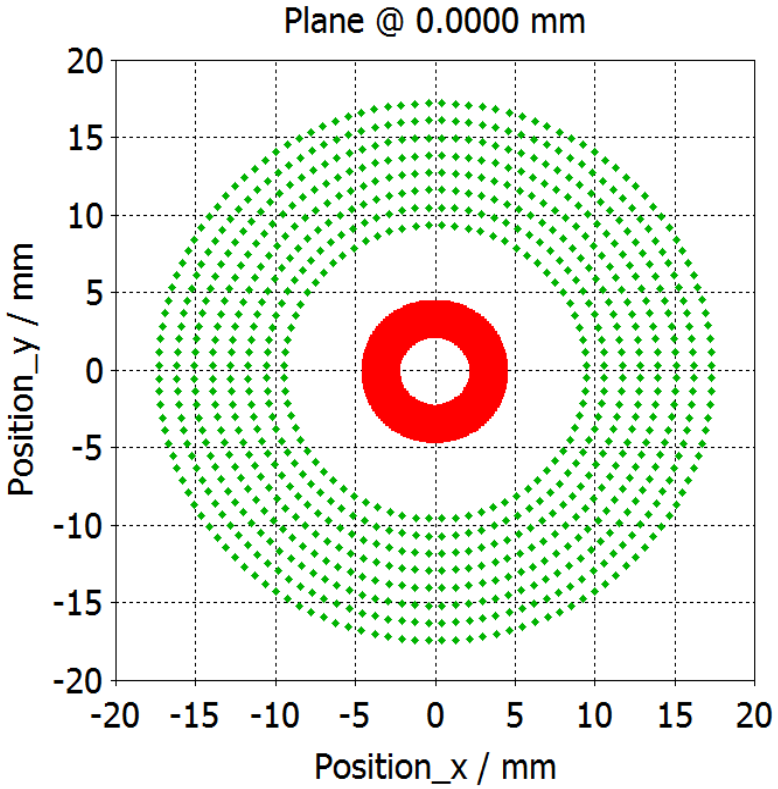
HEL: size of the beam





- **at “flat top”**
  Proton beam is centred

HEL: size of the beam

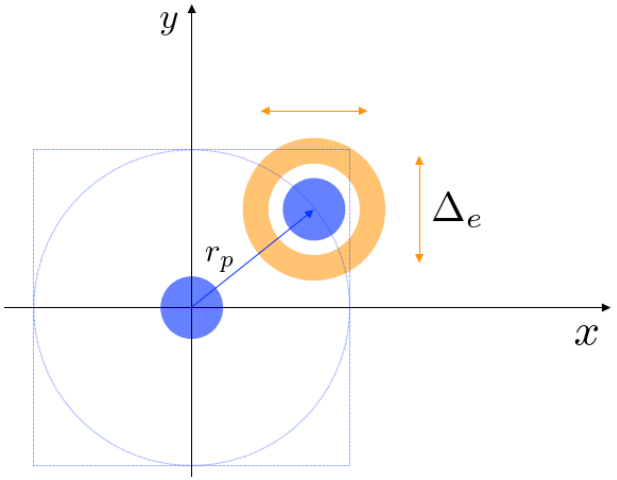


Cross-section at Z=0 (middle of the gap)

Proton beam is centred X=0 ; Y=0

Flat top mode
Injection mode

HEL: size of the beam



Minimum requirement for "7TeV" setting up: $\Delta_e = \pm 2$mm

Ideal proton orbit:

$r_p = 0 \rightarrow \Delta_e = \pm 2$ mm would suffice.

Reference LHC case:

$r_p = \pm 2$mm $\rightarrow$ **$\Delta_e = \pm 4$ mm**

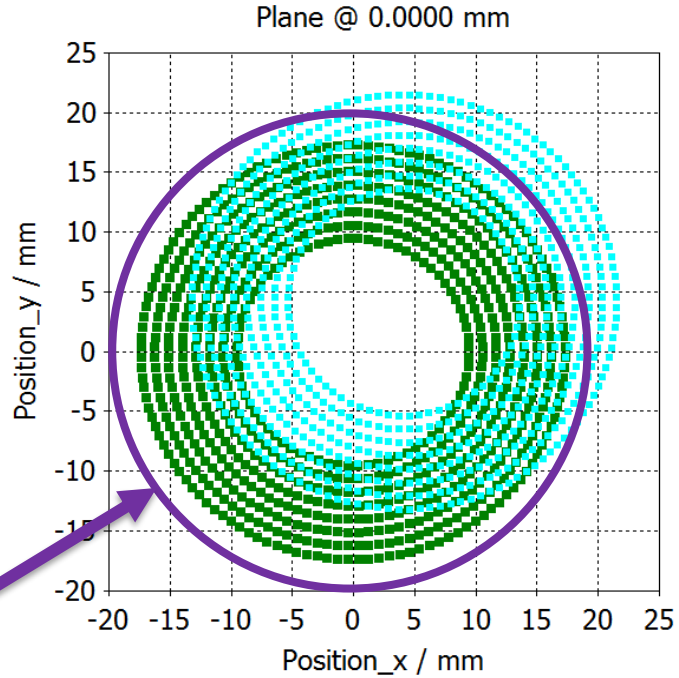
S. Redaelli, 122nd ColUSM, 22/11/2019

Cross-section at Z=0
(middle of the gap)

Injection mode

Beam is centred

Beam with offset Y=+2mm X=+2mm

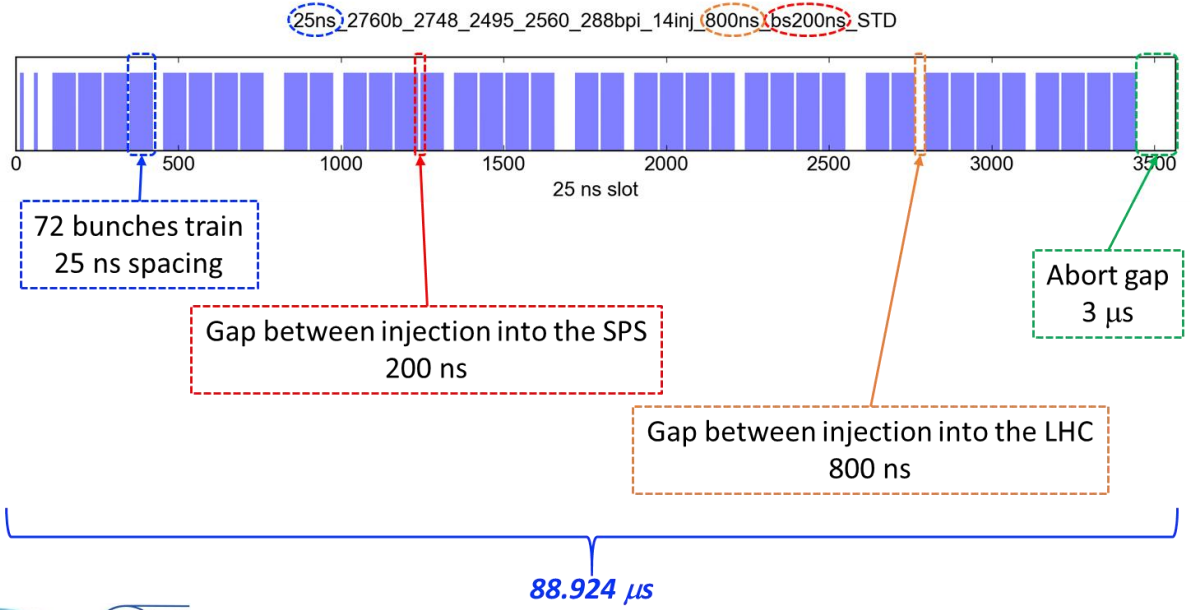


Region of interest:
D=40mm

HEL: beam current

HL-LHC filling pattern

Baseline HL-LHC filling pattern:



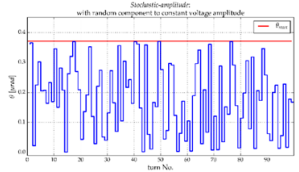
ColUSM#116 - E-BEAM joint meeting
D. Mirarchi, S. Redaelli
Powering scheme for HEL

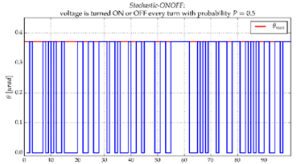
HEL: beam current

Possible working mode

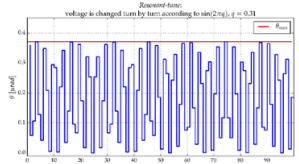
1. **continuous (DC)**

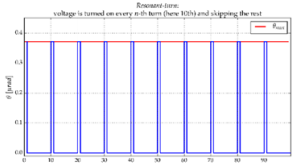
2. **Stochastic:**
   - Stochastic-amplitude:
   - Stochastic-ONOFF:



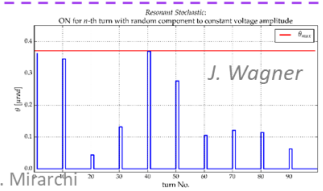


3. **Resonant:**
   - Resonant-tune:
   - Resonant-turn:





4. **Stochastic-amplitude + Resonant-turn**



Average current

≈5A for DC mode

≈3A for stochastic

≈5/turn for resonant-turn mode

II. Electron Lens Test Stand Parameters

E-lens test stand at CERN

Hollow Electron Lens (HEL) at HL-LHC

- Gun measurements (5A, 10kV extraction, 15kV energy):
  - Electron gun tests: characterization (current as function of temperature and extraction voltage, profile measurements)
  - Anode modular (200ns rise time, up to 86us)

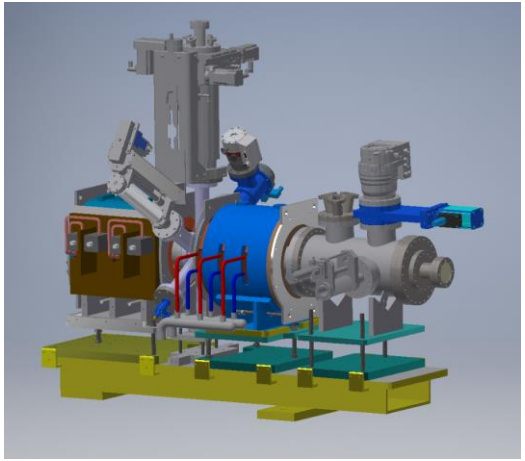
- Diagnostics for electrons and hadrons:
  - Beam Gas Curtain Monitor
  - Beam Position Monitor

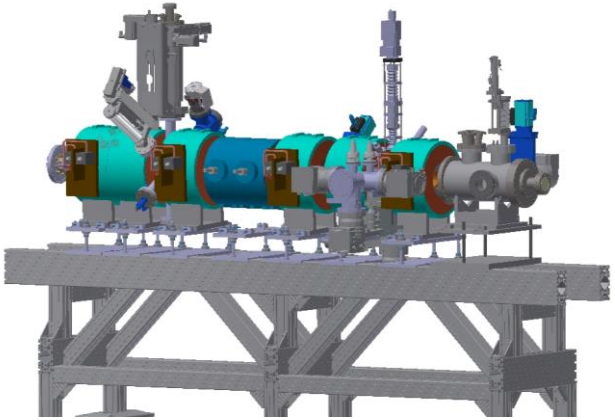
WP16: Intense, RF modulated E-beams (IRME) in the framework of the ARIES* project:

- Designing and manufacturing an RF modulated electron gun for space charge compensation (~10A, 30kV extraction voltage, ~1MHz modulation) and its power modulator
- Measuring properties of RF modulated electron beam

*ARIES – Accelerator Research and Innovation for European Science and Society

E-lens test stand at CERN





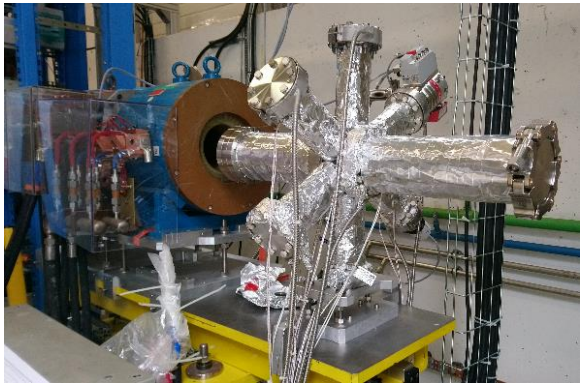
Stage 1 (gun prototype and diagnostics):

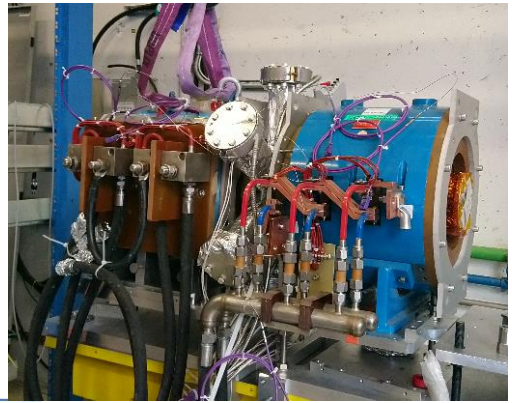
- Current yield as function of temperature of the filament and extraction voltage
- Profile of the electron beam after 250 mm of drift
- Anode modulator: rise time and fall time

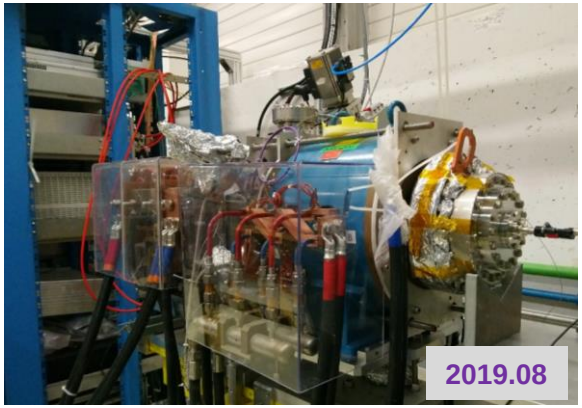
Stage 2 (full working version):

- E-gun measurements from Stage 1
- BGC
- BPM
- Beam dynamics studies

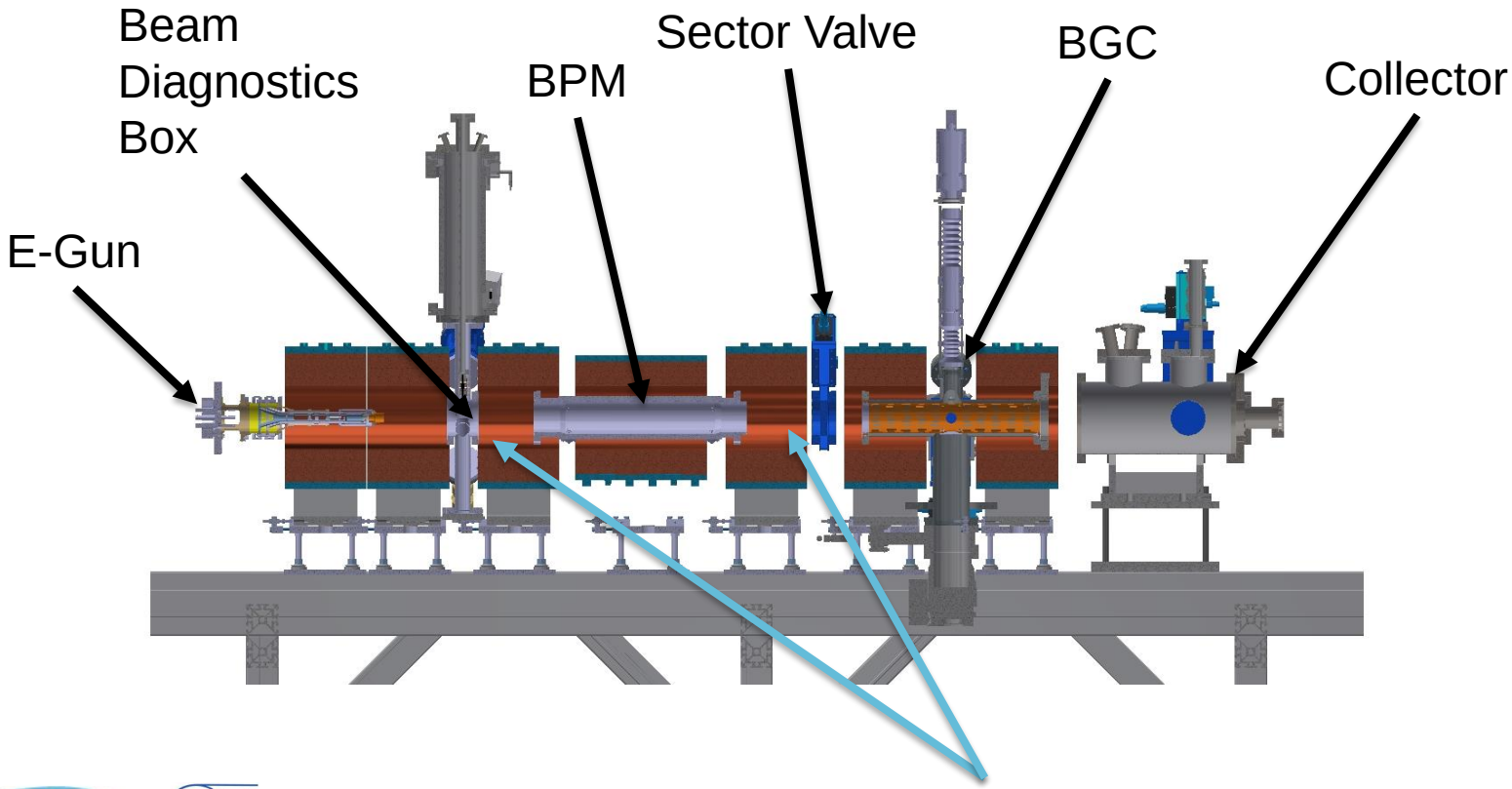
E-Lens Test Stand: Assembling



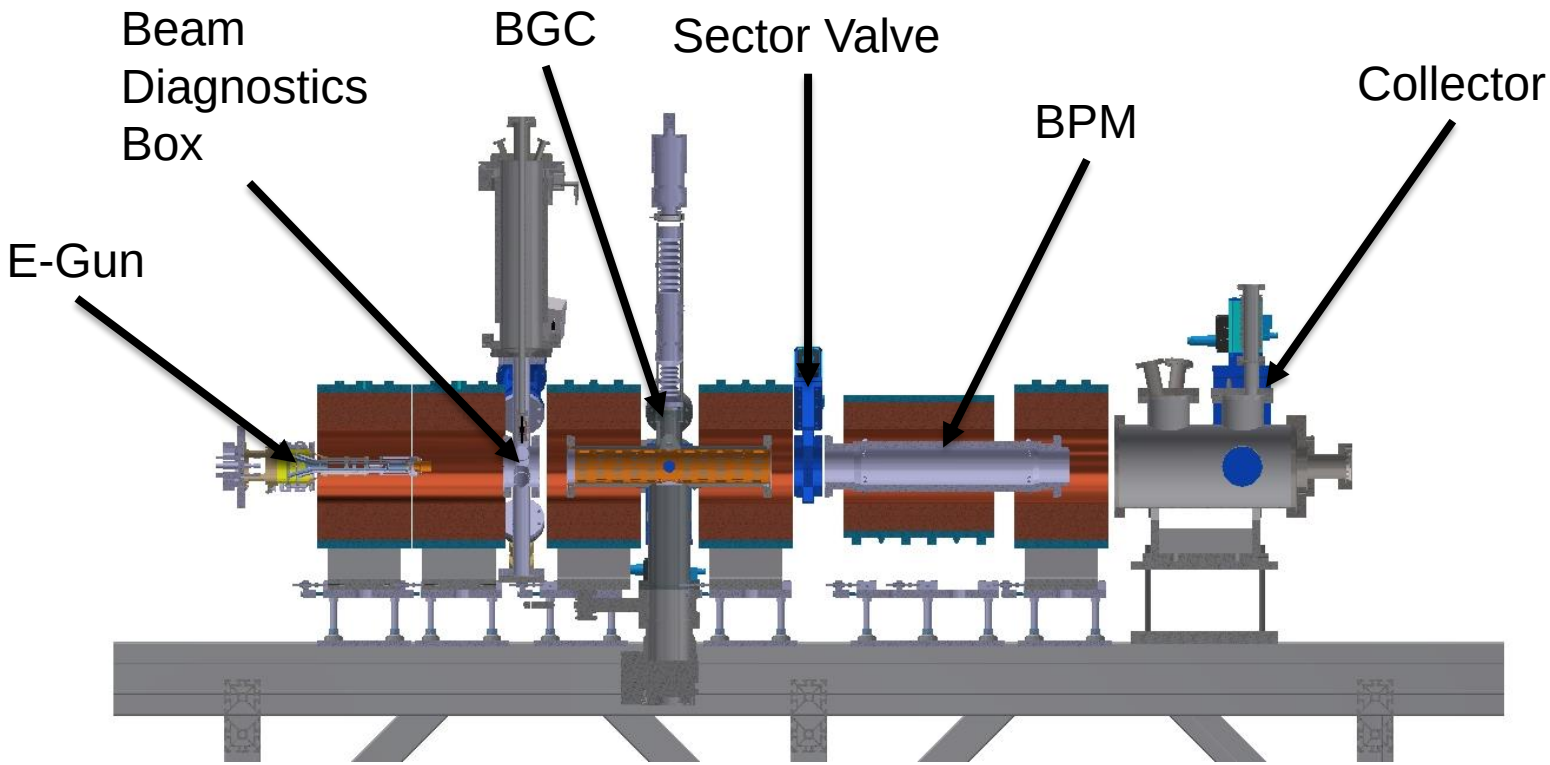




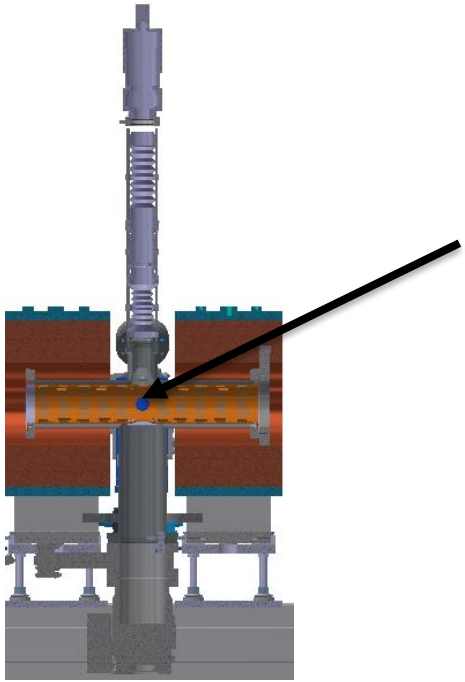
E-Lens Test Stand: current design v1



E-Lens Test Stand: current design v2

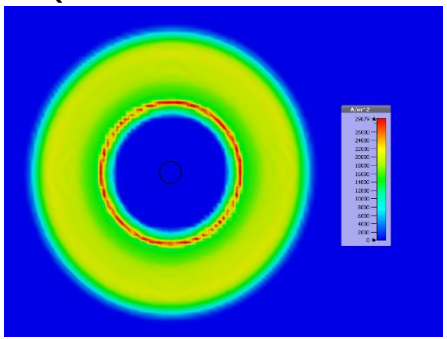


E-Lens Test Stand: E-Beam properties



E-Beam:

- Hollow Beam D_{out} >= 16mm
- Steering +- 5mm
- Energy >=10 keV
- Pulsed mode: 100us at 5A at 10 Hz ≈ 5mA average
  - Limited by passively cooled collector
  - Repetition rate can be increased using water-cooled collector up to HEL nominal parameters (Anode Modulator is also needed)

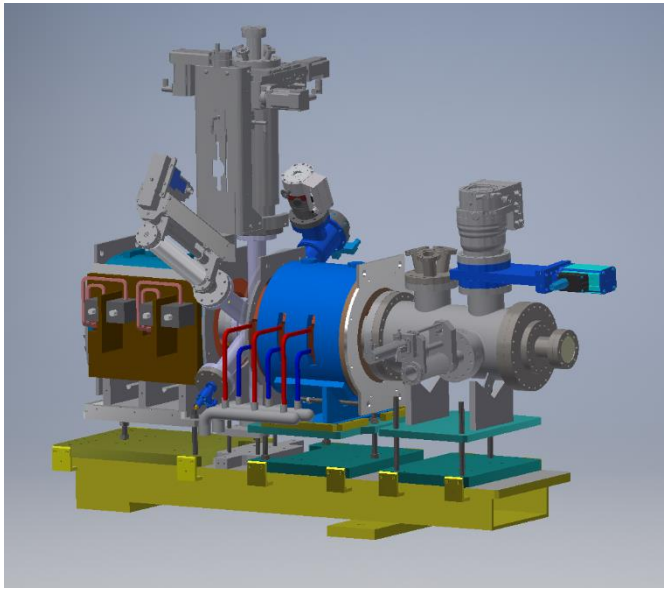


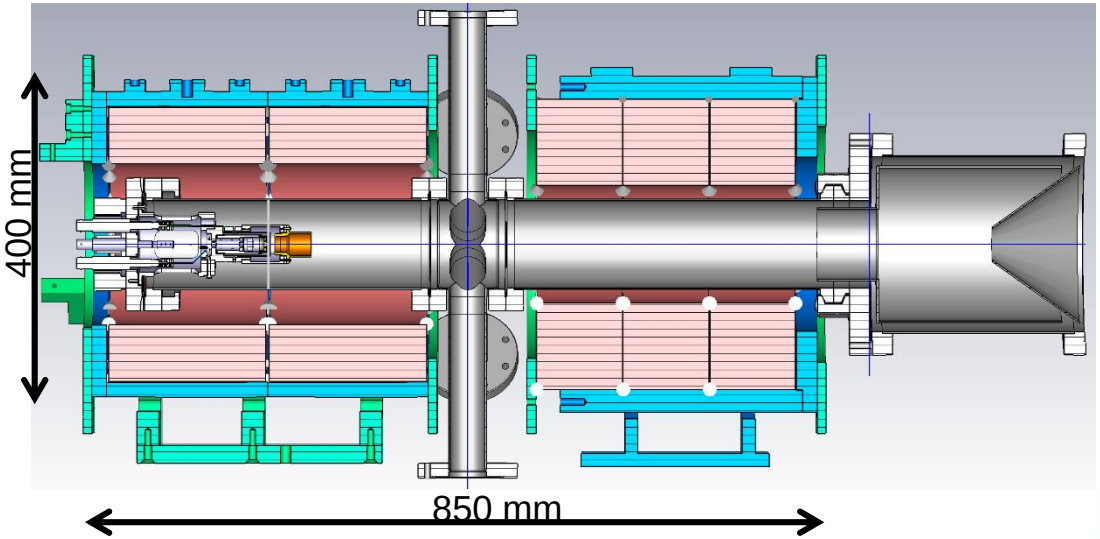
III. Schedule and planning

- Move Test Stand at new position and install working version of the gun (tested at FNAL) – 2 months
  - Safety check
    - Gun and Instrumentation tests (YAG and FC)
    - Check light reducing using orifices
- Additional solenoids recuperation – 7 months
  - Solenoids, [BPM] and BGC installation (1.5 rack is reserved for BGC needs)
  - Safety check
    - Measurements and tests with BGC
- ARIES
  - Measurements in terms of ARIES project – TBD
- 2020-…
  - BGC without optical system is a “black box” for e-beam:
    - –remove BGC vacuum chamber
    - –install YAG screen into BGC vacuum chamber
    - –optical system

Spare slides

E-Lens Test Stand – stage 1

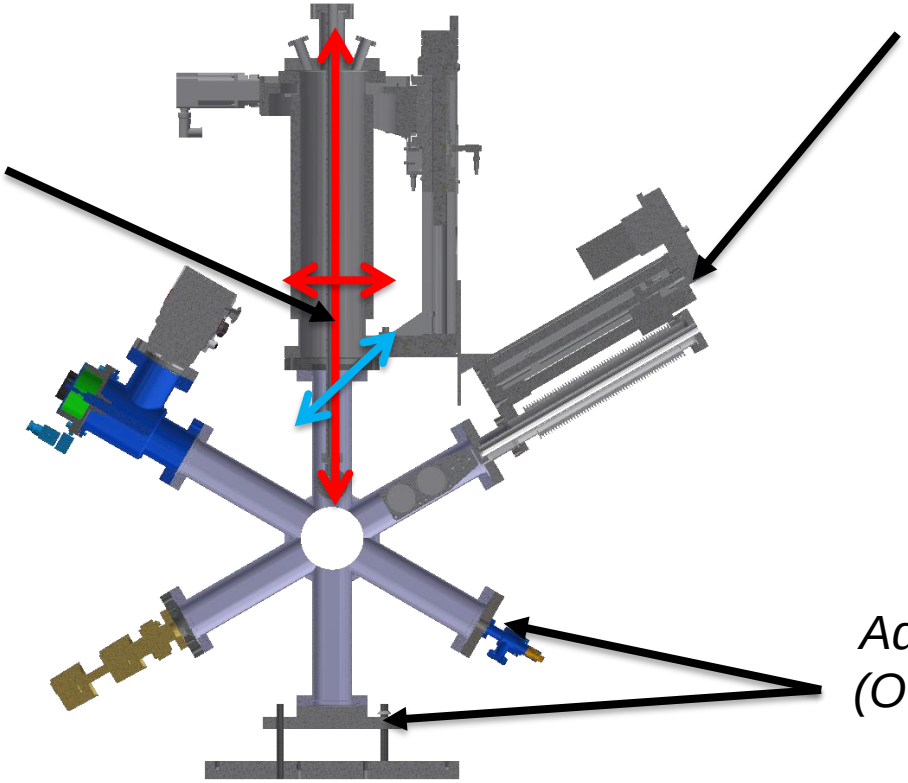




Parameters of the E-lens test stand :

- Gun Solenoid 0.3 T (at 450 A)
- Collector Solenoid 0.45 T (at 450 A)
- Gun acceleration voltage up to 40kV
- Pulsed mode of operation

E-Lens Test Stand: Diagnostic box

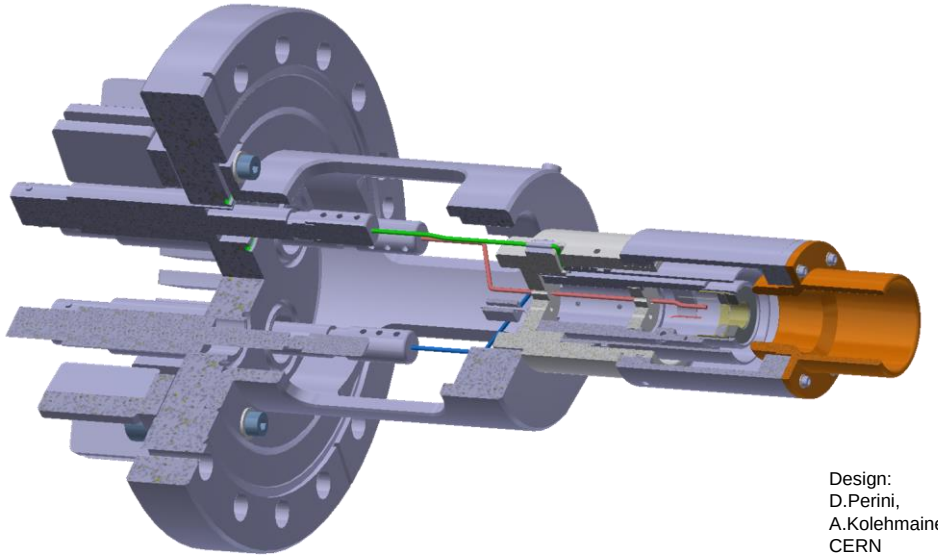


3D (X,Y,Z)
Movable Pin-hole
Faraday Cup

YAG:Ce screen

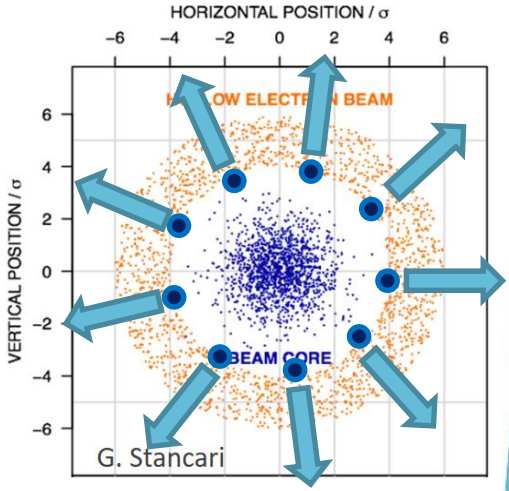
Additional ports (OTR, Langmuir probe)

E-Gun



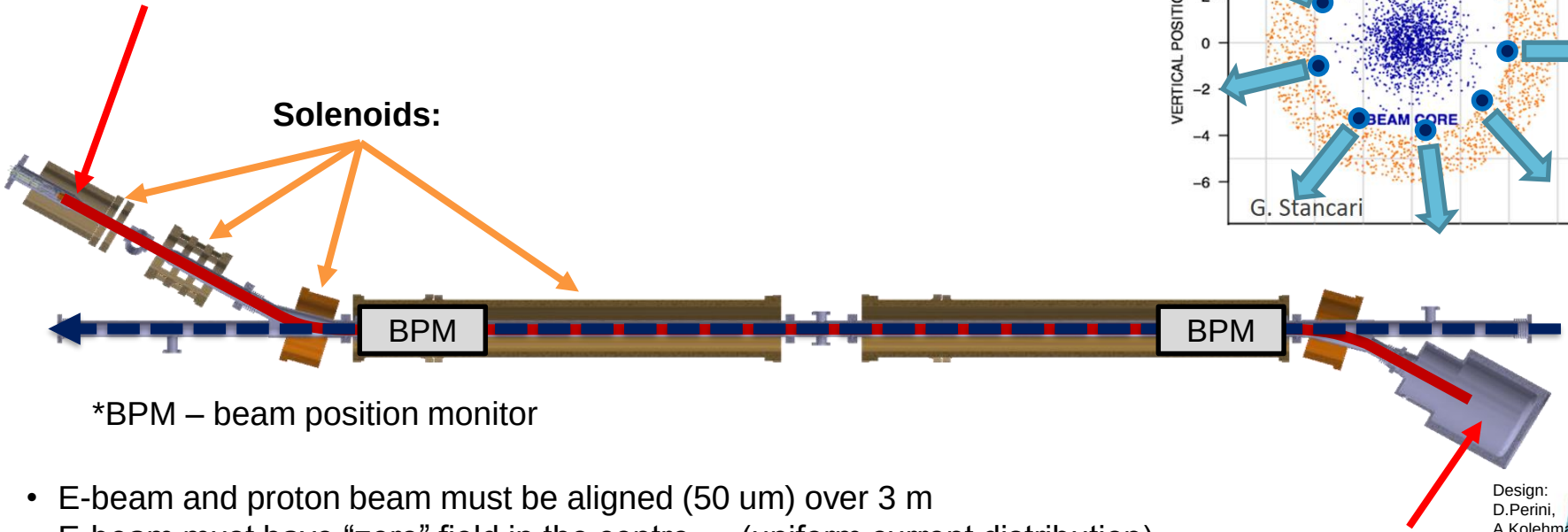
Design:
D.Perini,
A.Kolehmainen
CERN

Hollow Electron Lens (HEL)



Electron gun:

Solenoids:



*BPM – beam position monitor

- E-beam and proton beam must be aligned (50 um) over 3 m
- E-beam must have “zero” field in the centre → (uniform current distribution)
- Rise time and fall time < 200ns

Design:
D.Perini,
A.Kolehmainen
CERN

HEL: size of the beam