Hollow Electron Lens Harware kick-off meeting

Adriana Rossi BE-BI

Motivation for HEL in HL-LHC

Depletion of halo below collimator opening

- The angular kick θ experienced by a proton at radius r traversing a hollow electron beam enclosing current I_{er} over region of length L

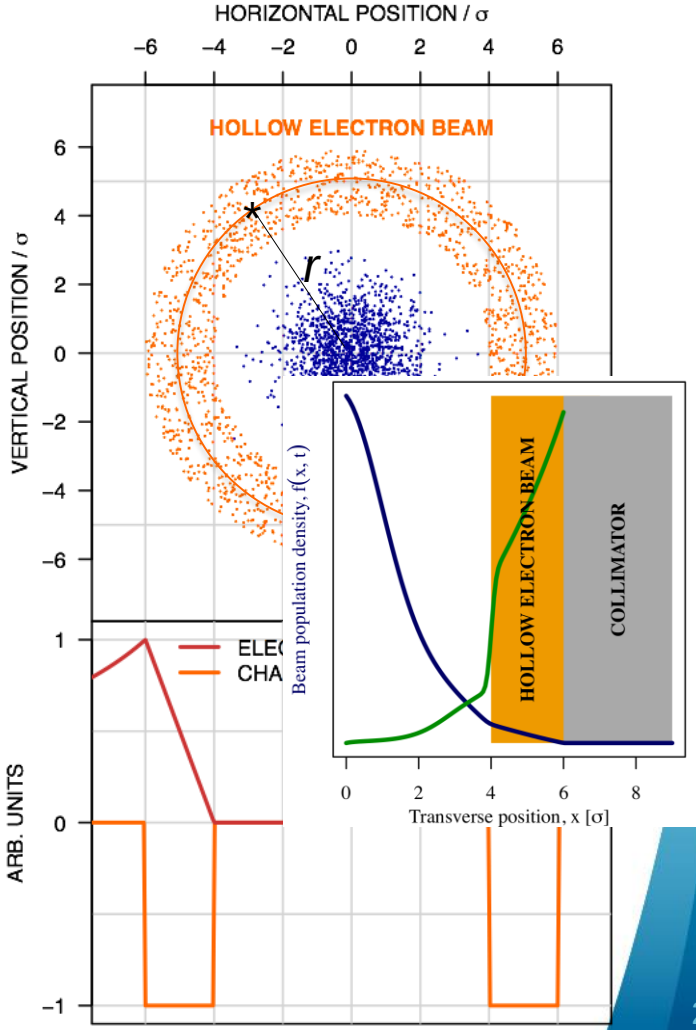
For conter-propagating e- p+

$$q = \left(\frac{1}{4\pi\varepsilon_0 c^2}\right)\frac{2I_{er}L}{r(Br)_p}\frac{(1+b_p b_e)}{b_p b_e}$$

- e-beam from 4 to 6 sigma ≈ radii from 1.2 to 1.8 mm over a distance ~3m

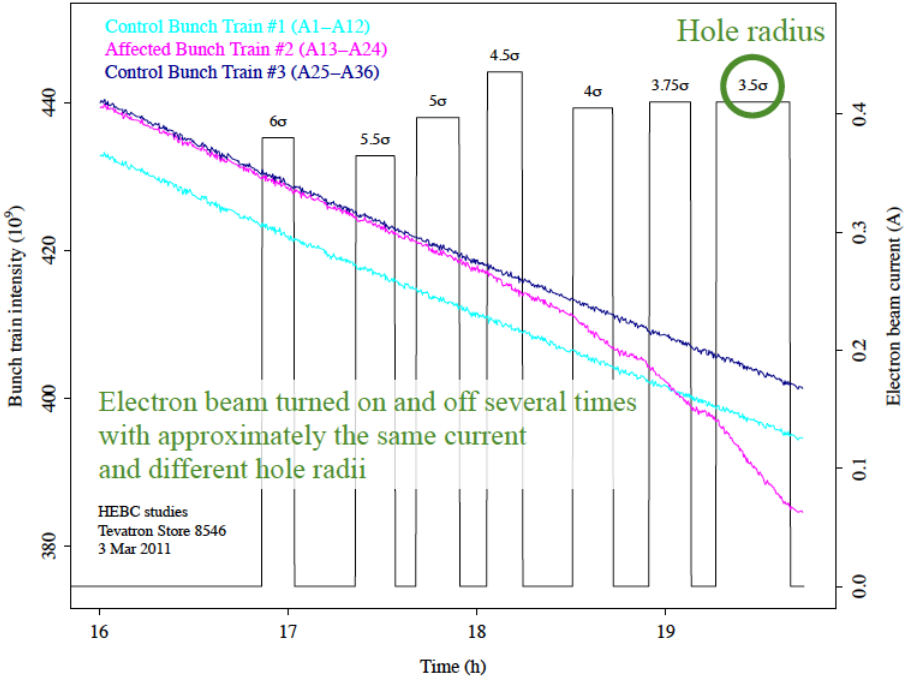
$$r = r_{egun}\sqrt{\frac{B_{egun}}{B_{main}}}$$

- Electron beam hollowed =>
  core ≈ not affected (in field-free region)
  + no effects on impedance
- Margin for beam jitters / CC failure



Review of the need for hollow e-lenses for the HL-LHC (CERN, 6-7 October 2016)

- https://indico.cern.ch/event/567839/
- Successfully demonstrated at Tevatron (Stancari)
- Review conclusions:
  - A hollow e-lens will mitigate CC failures (large betatron oscillations) if < 2 σ
  - HL-LHC less sensitive to transients due to small variations of orbit, tune and other parameters
  - **Implement active beam halo control using a hollow e-lens**

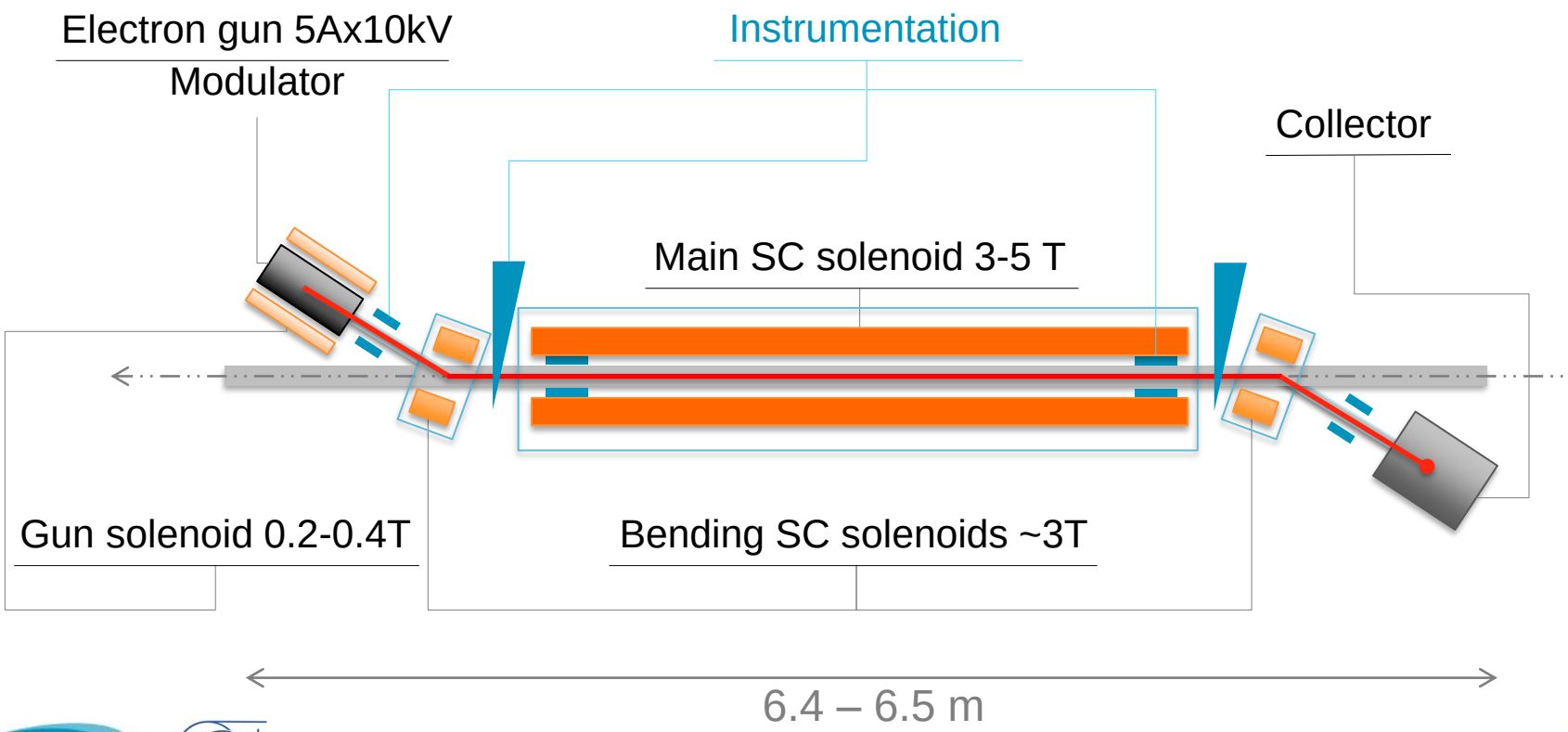


Review of the HEL concept readiness for integration into the HL-LHC baseline (O. Bruning) wk42

Review if CERN has all information at hand to estimate the individual cost items for the hollow e-lens and to prepare a tentative production schedule (including potentially required prototype developments and R&D milestones) for implementing the e-lenses during LS3 and to assure sufficient space and infrastructure in the designated areas for the installation of the hollow e-lenses during LS3.

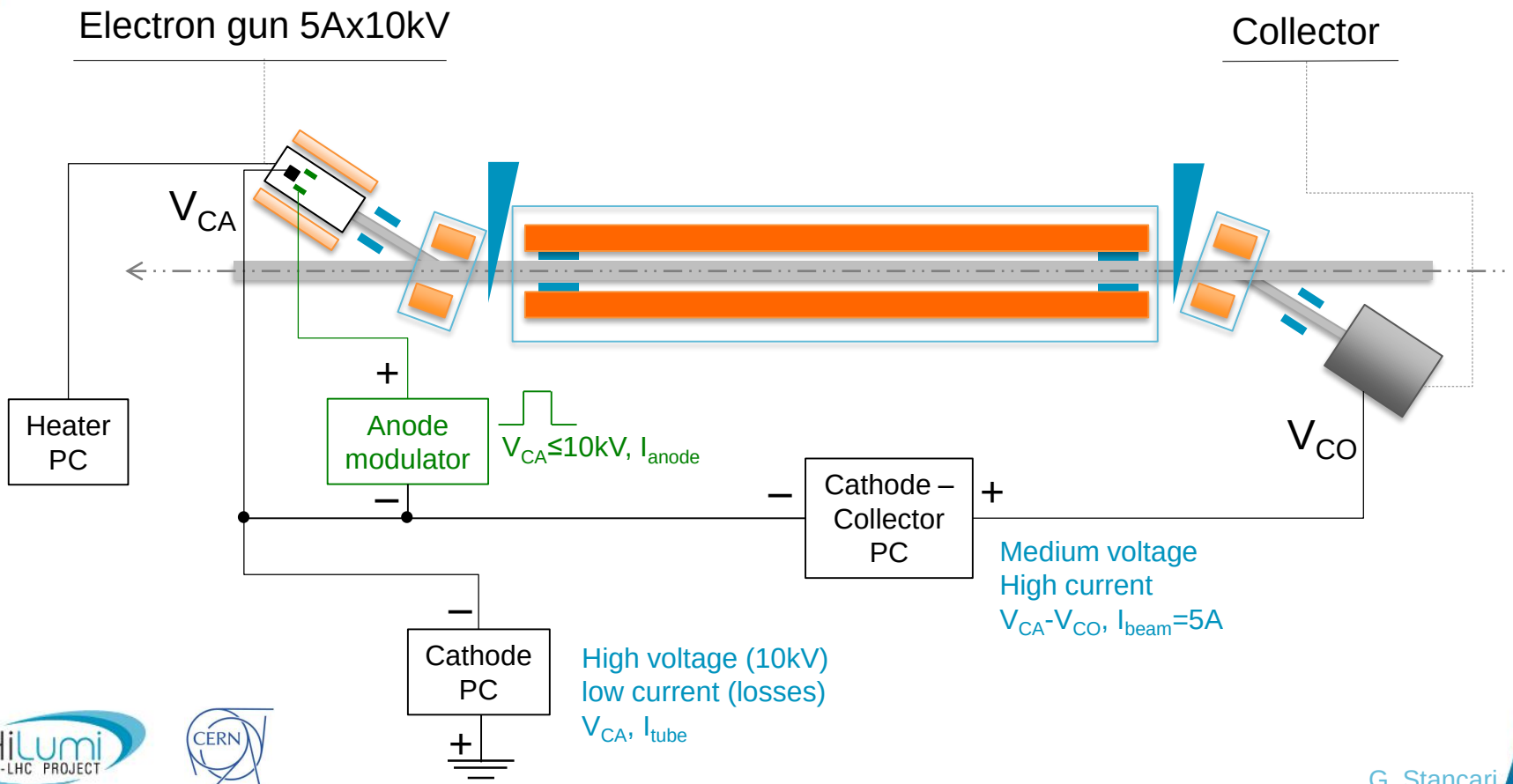
- Is CERN ready to:
  a) estimate **the total cost** and resource requirements for the e-lenses (including the technical development)?
  b) reserve **sufficient space for the e-lenses in IR4**?
  c) specify the **technical infrastructure** needs in IR4 to avoid future iterations on key services at a later stage?
  d) identify which **components of the e-lenses need to be produced in-house and which components could be outsourced**?
- Have all the implied technical groups identified the required resources for implementing the e-lens development (including the required technical development for finalising the technical design by the end of LS2) and integration (for the e-lenses installation in LS3 and operational exploitation as of the start of Run4)?

Hollow Electron Lens

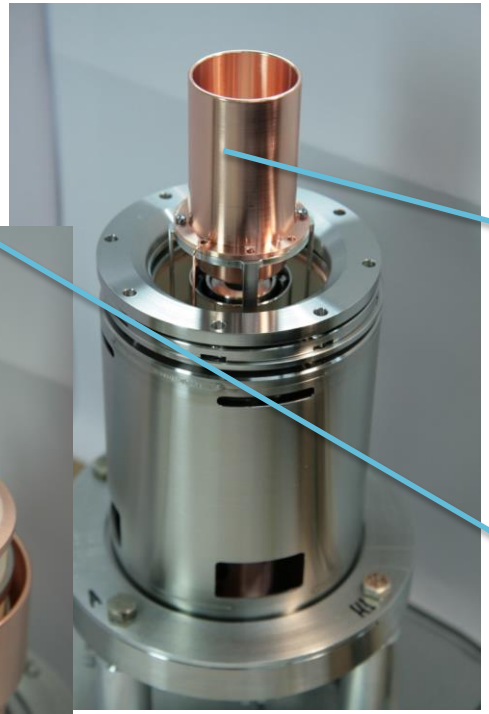


See Diego Perini for magnetic/mechanic design and Marta Alcaide Leon for integration

Hollow Electron Lens

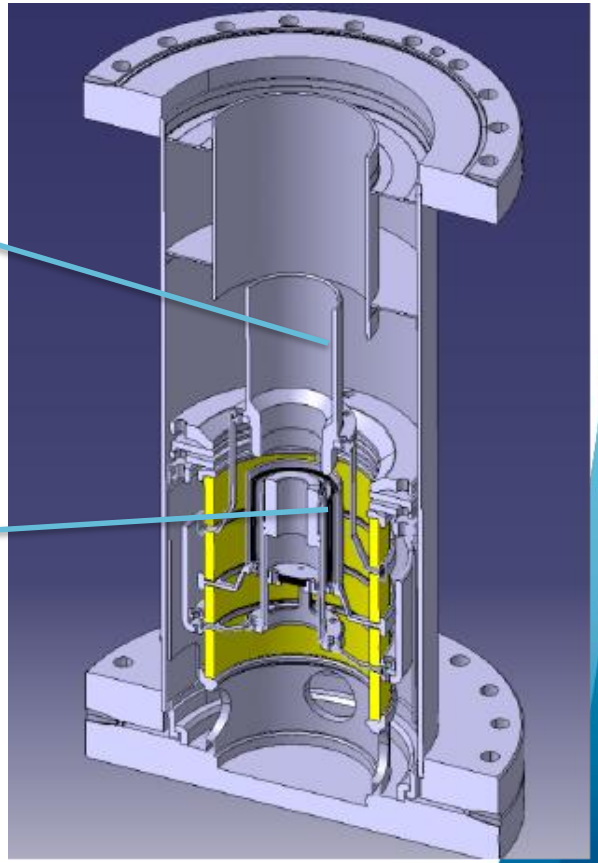


CHG1 built at CERN, based upon Fermilab design



Anode

Hollowed cathode

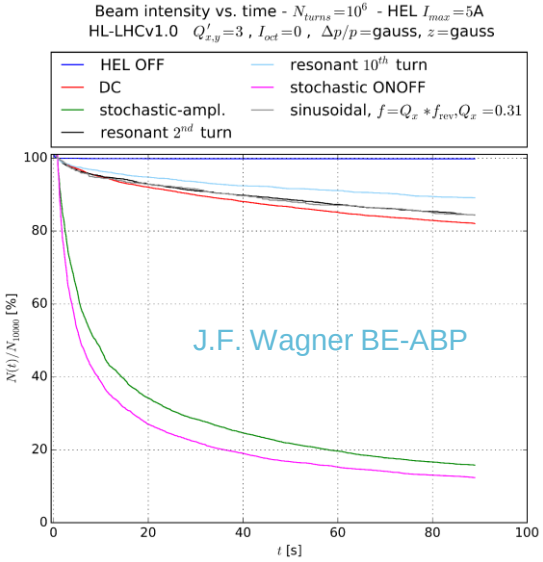


Specifications

- Electron gun
  - 5A (for kick) x 10 kV (to transport electrons)
  - Ring from 1.2 to 1.8 mm with B_{main} ~ 4T
    ➔ r_{egun} ≈ 5.5 – 8.3 mm (under design)

$$r = r_{egun}\sqrt{\frac{B_{egun}}{B_{main}}}$$

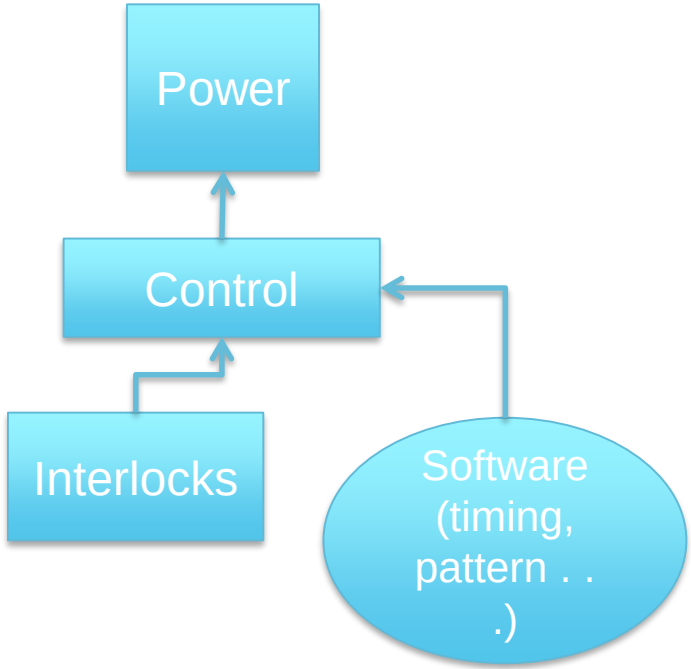
- Anode modulator
  - 0 – 10 kV
  - 3 per revolution = 33 kHz to be able to leave a fraction of beam intact and keep flexibility.
  - 200ns rise time



Specifications

- Anode modulator
  - 0 – 10 kV
  - 3 per revolution = 33 kHz to be able to leave a fraction of beam intact and keep flexibility.
  - 200ns rise time

  - LINAC4 H^- chopper? BE-RF
  - Kickers? TE-ABT



Fermilab electron-lens test stand layout

dimensions in mm