New HEL parameters

- Here is a set of proposed parameters. Given the present knowledge, I think they are a good conservative baseline. Of course we need numerical simulations, including the bends -- more comments on this later.
- 5 T in main solenoid
- S shape, with dipole corrector
- rout = 1.94 mm, rin = rout/2, as it is now. Increasing the proton beam size would help a lot, but at this point I assume we don't have much freedom in the choice of beta functions.
- 0.2 urad max kick in continuous mode (where we can tolerate more profile distortions), 0.1 urad max kick in pulsed mode (when we need a more symmetric e-beam). This may imply a reduction of performance compared with the present 0.4 urad. Of course, the translation from maximum kick to cleaning rate is complex, because it depends on the details of halo population and machine configuration (lattice, nonlinearities, diffusion, etc.). This has always been a tricky point, and we need to decide with Stefano if the specifications should be in terms of the range of kicks or halo removal rates, or both.
- e-beam 15 keV, 2.9 A. We have some freedom in the choice of the combination (V, I), with the constraint that V should be high enough to ensure transmission of the dense e-beam through the beam pipe. Even if we decide to eventually go to a lower perveance, the cathode development program still makes sense, because we need to know the current-density reach and to demonstrate the required current. We can have a fixed, high-perveance gun and lower the cathode-anode voltage for extraction, while keeping the full kinetic energy in the overlap region where the beam pipe is grounded, as it done in RHIC (e.g., cathode at -15 kV, anode pulsed between -15 kV and -5 kV, beam pipe grounded).

$$g = \frac{v_d \tau}{2\pi r_{\max}},$$

$$\vartheta(r) = \frac{2I_e(r) \cdot L(1+\beta_e\beta_p)}{r\beta_e\beta_p c^2 (B\rho)_p},$$ angular kick experienced by a proton at radius r traversing a hollow electron beam enclosing current $I_e(r)$ in an interaction region of length L

$$g = \frac{\vartheta_{\max}(B\rho)_p \beta_p}{2\pi r_{\max} B\beta_e \cdot (1+\beta_e\beta_p)} \leq 0.2$$

Measure of slipping between layers?

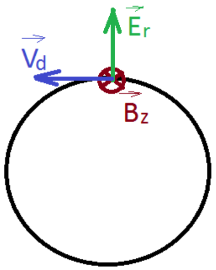
$$\frac{\omega_{plasma}}{\omega_e} = \frac{1}{B}\sqrt{\frac{m_e I_e}{\pi\left(r_{\max}^2 - r_{\min}^2\right) v_e \varepsilon_0 e}} \leq 0.015$$

Measure of exchanges between layers

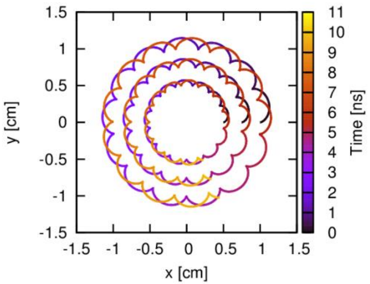
Effect of drift velocity

- Larmor motion: electrons rotating along the magnetic line with longitudinal velocity $v = \sqrt{2e/m_e U}$

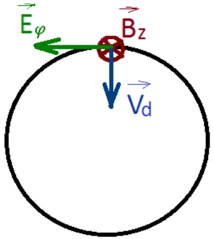
- Drift velocity derives from the ExB (e-beam electric field significant for large e-currents) $\vec{v}_d = \frac{\left|\vec{E} \times \vec{B}\right|}{B^2}$



Rotation velocity, larger at larger radius



Courtesy of Daniel Noll

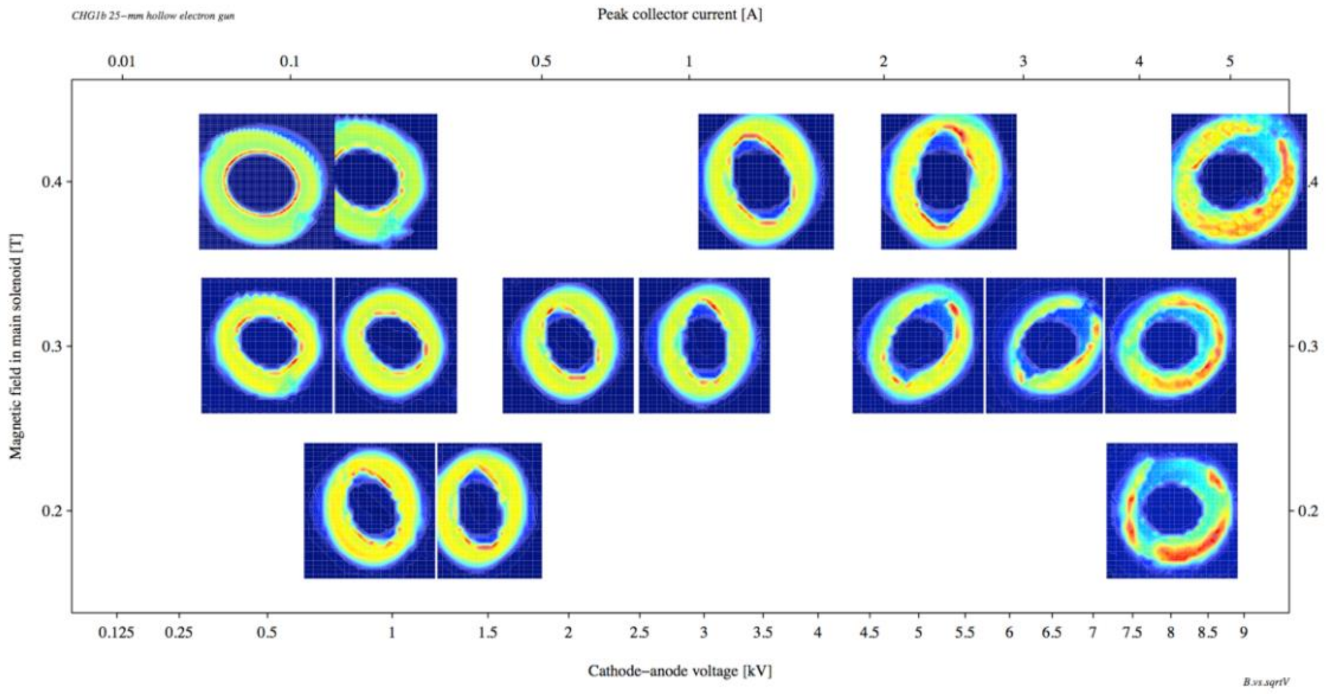


$\omega = v_d / r$ Circular beam frequency

$$\Phi(z, r) = \frac{z \cdot v_d}{r \cdot \sqrt{2\eta U}}$$

In case of <u>non</u> azimuthally uniform beam there could be an angular component of the electric field causing beam to tilt by Φ.

Profile evolution

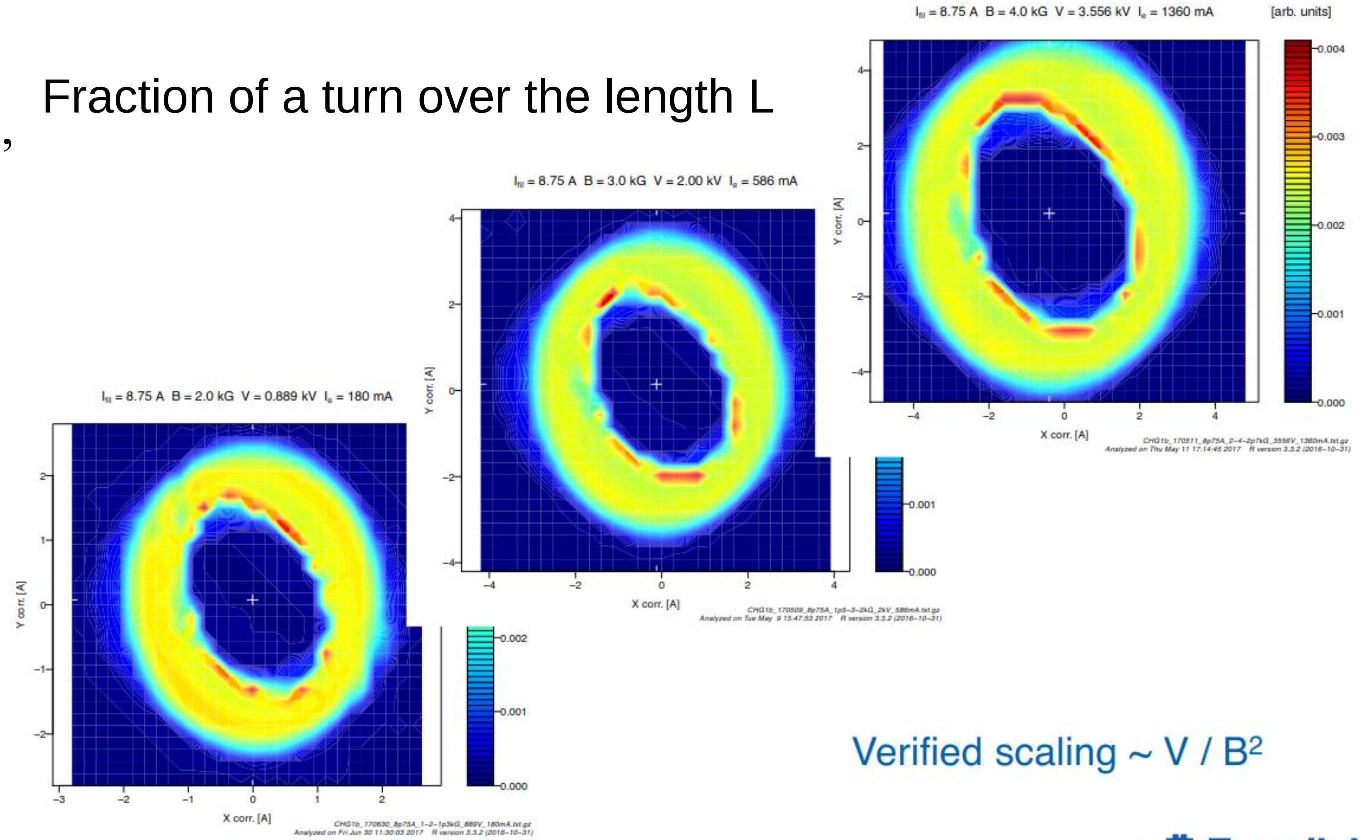


Profile scaling

$$g = \frac{v_d \tau}{2\pi r_{\max}},$$

Fraction of a turn over the length L

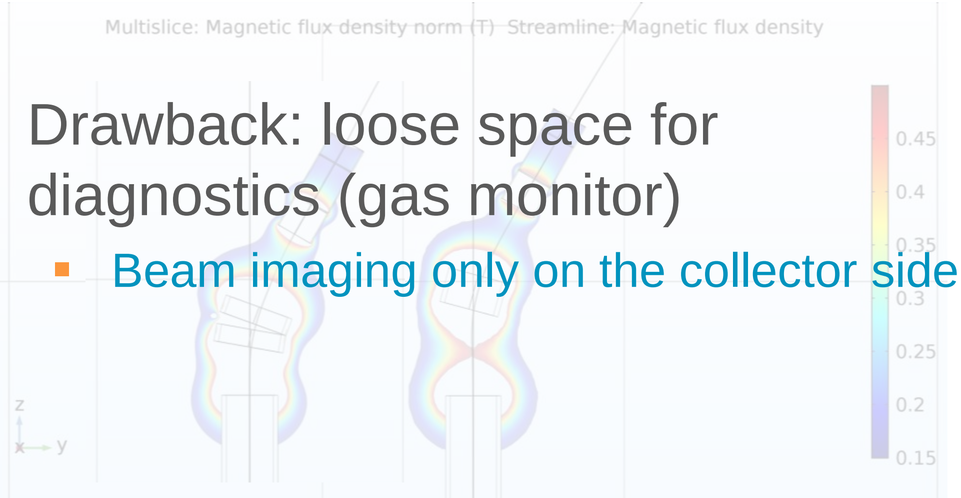
$$\vec{v}_d = \frac{\left|\vec{E}\times\vec{B}\right|}{B^2}$$



Verified scaling ~ V / B^2

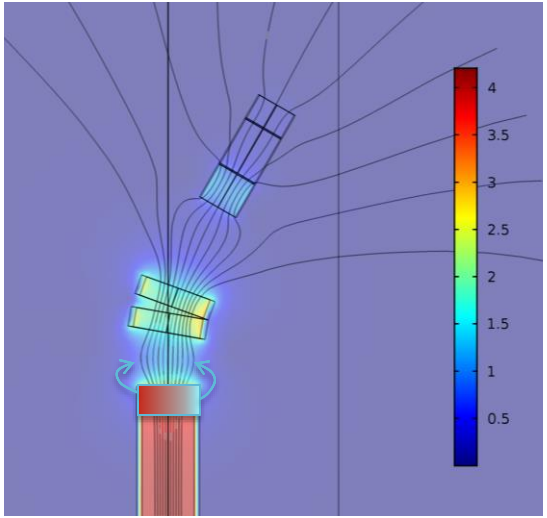
Improving magnetic field at injection

- Make the filed on the injection arm more uniform (to minimise deformations and transfer from longitudinal to transverse velocity)



- Drawback: loose space for diagnostics (gas monitor)
  - Beam imaging only on the collector side

Courtesy of Carlo Zanoni



White is off scale, high B