Accelerator Beam Physics Group
BE department

BEAM CHARACTERIZATION IN LINAC4

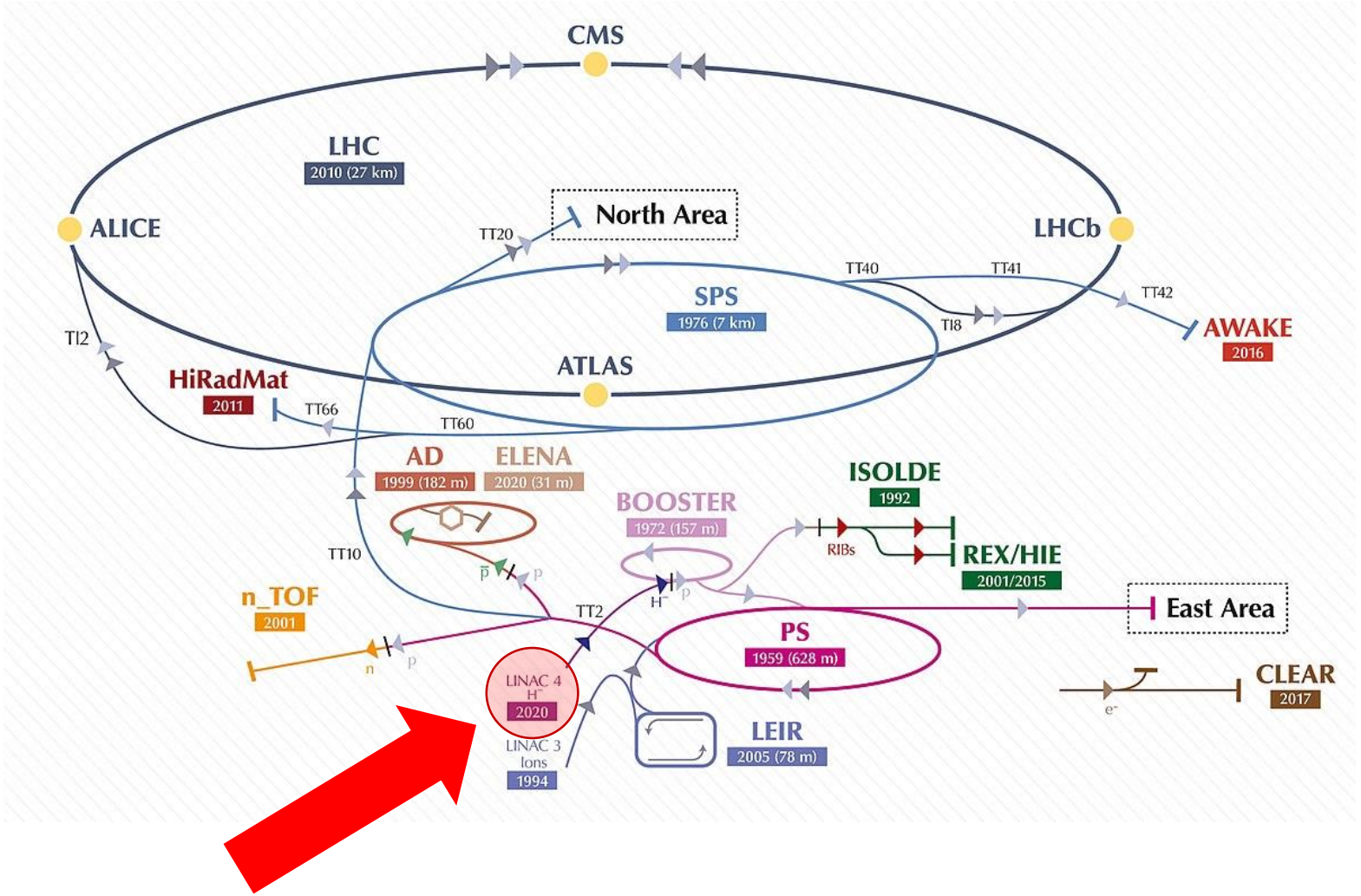
Minh Au (minh.au@cern.ch)
Supervisor: Alessandra Lombardi (BE-ABP HSL)
With the Support of: Jonathan Bollig, Edgar Sargsyan, Jone Etxebarria Erdoiza

Minh Au
minh.au@cern.ch

Table of Contents

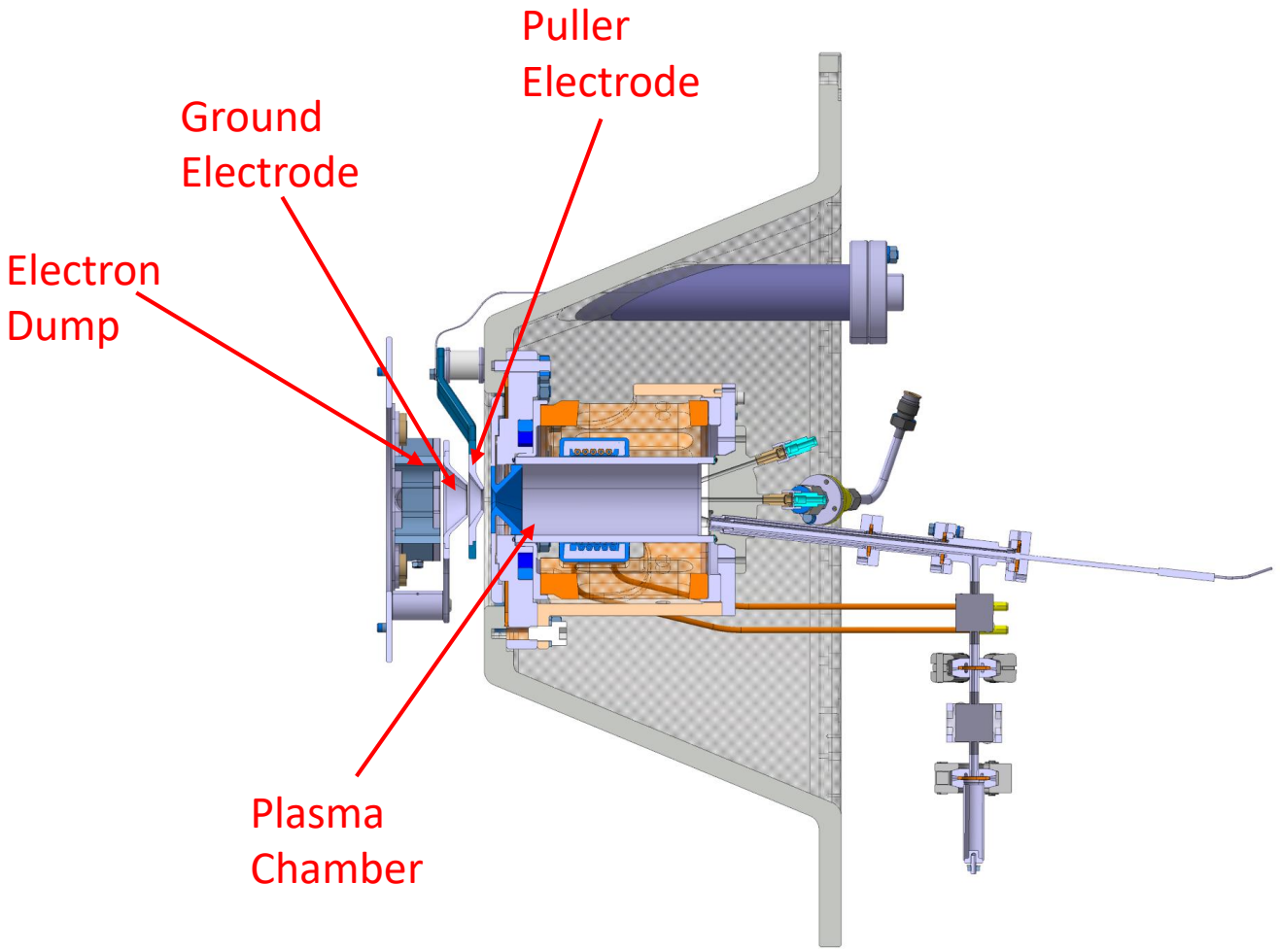
Minh Au
minh.au@cern.ch

LINAC4 as the Injector



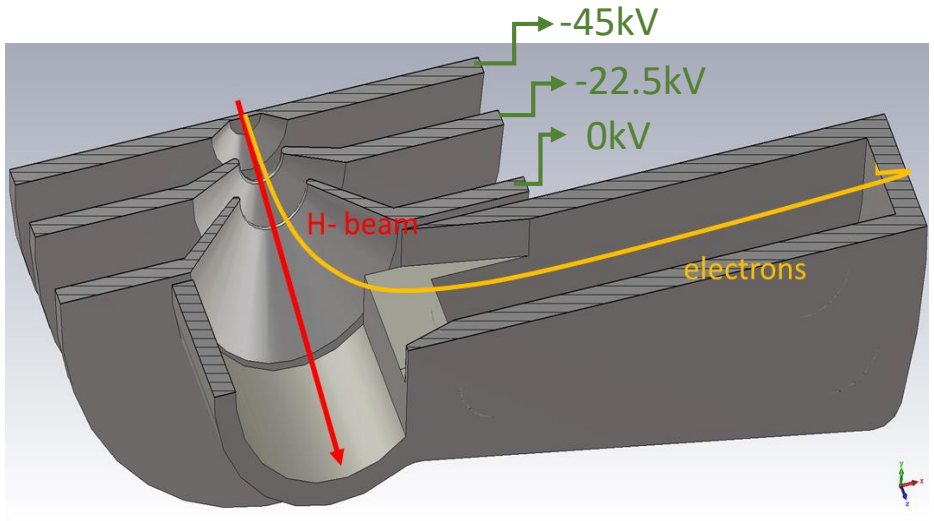
Minh Au
minh.au@cern.ch

LINAC4 Ion Source



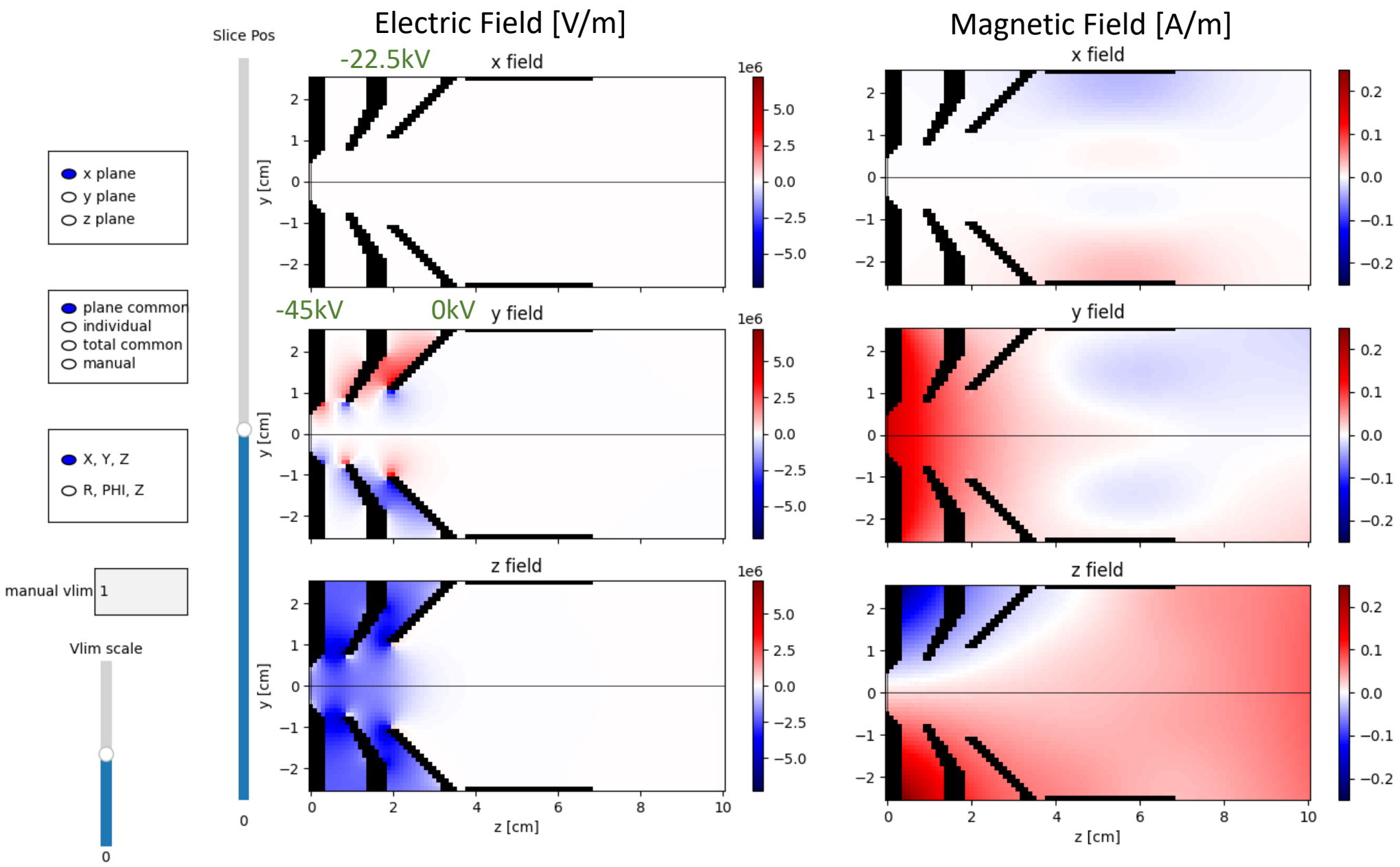
The relative strength between electric and magnetic field decides **beam quality**

Goal: Combine different **E** and **B** fields to simulate beam extraction systems

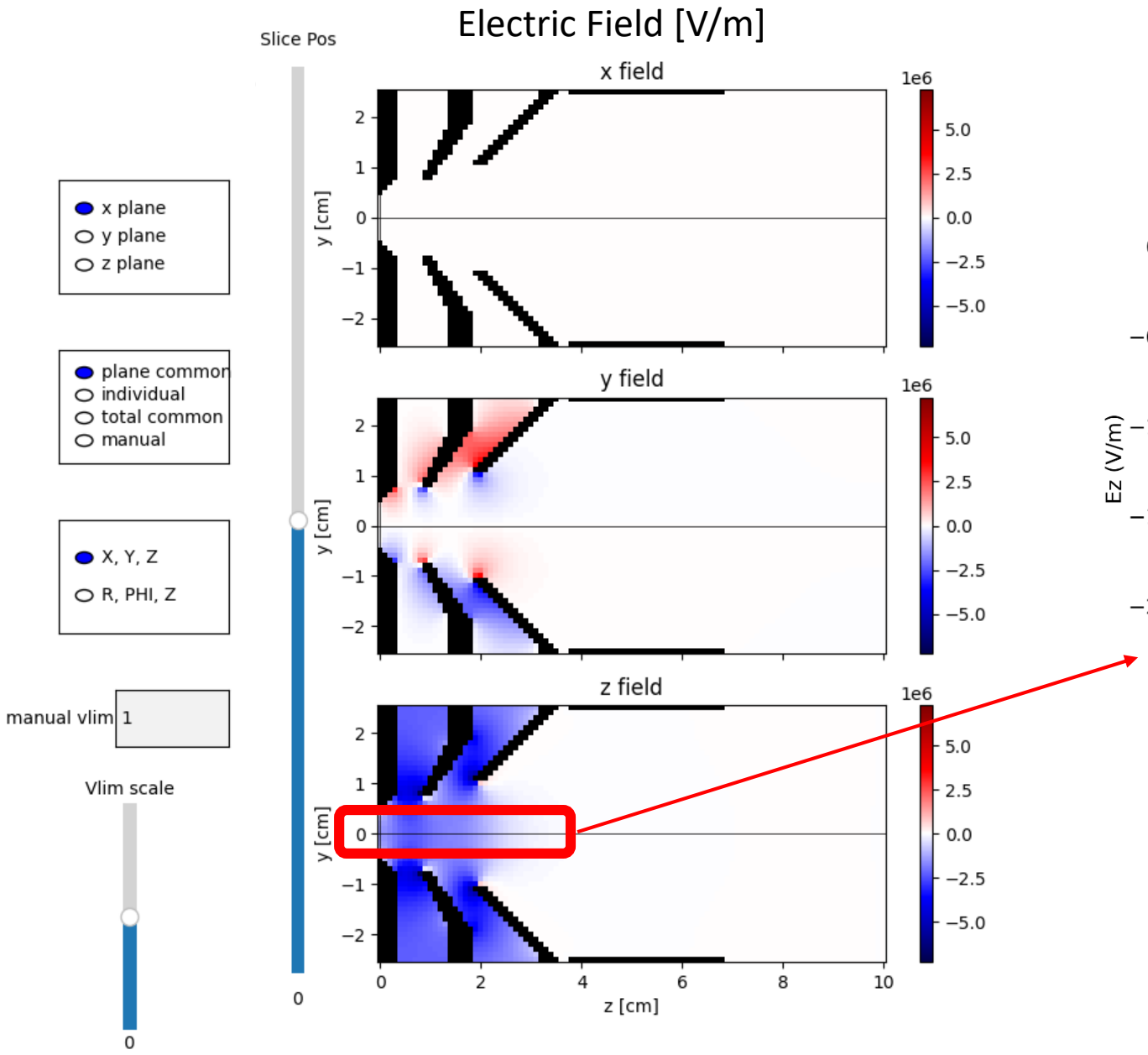


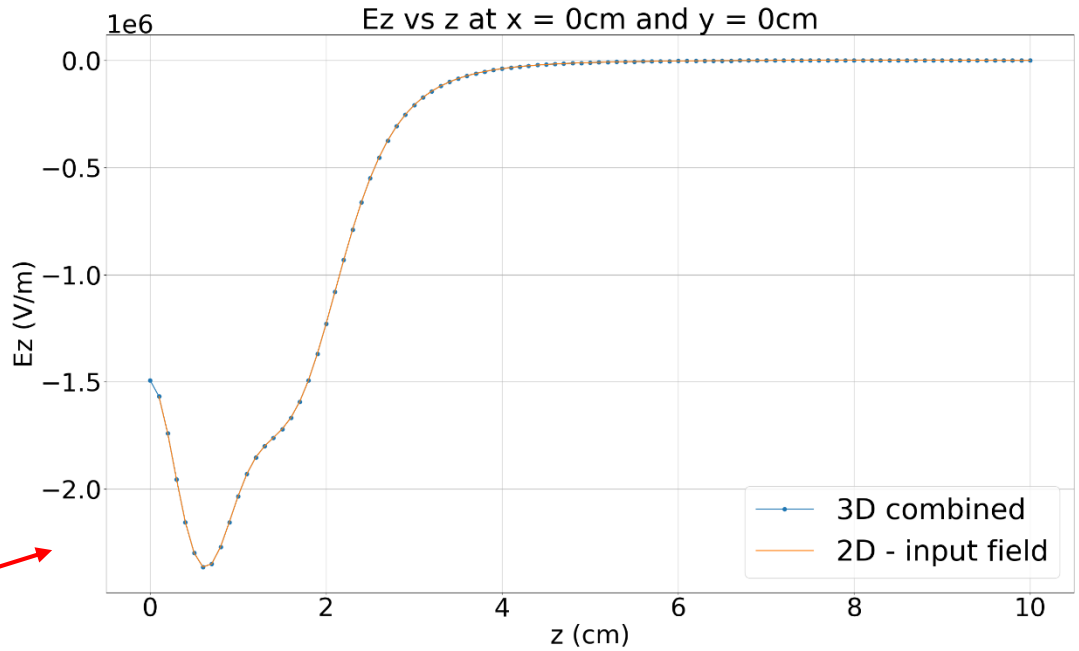
Minh Au
minh.au@cern.ch

Combiner Results – IS04



Minh Au
minh.au@cern.ch

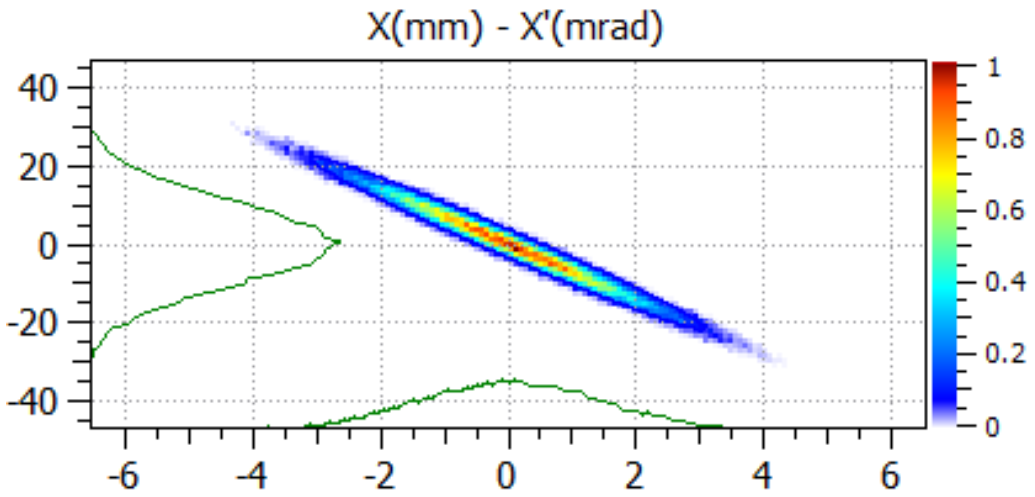


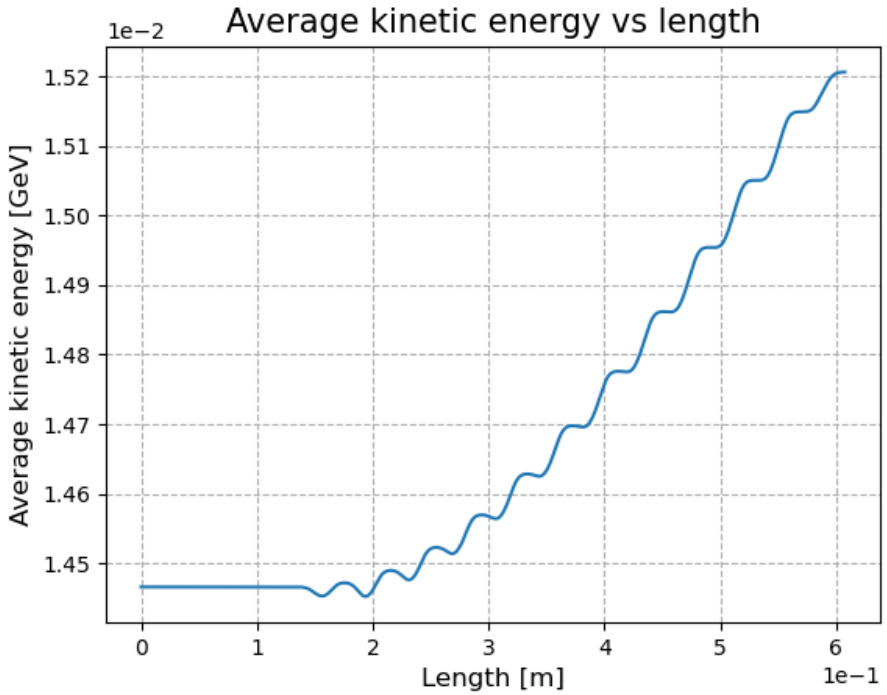


Minh Au
minh.au@cern.ch

TRAVEL – Particle Tracking in Electric Field Map

- Simulate particle trajectory using input beam and various elements of the structure



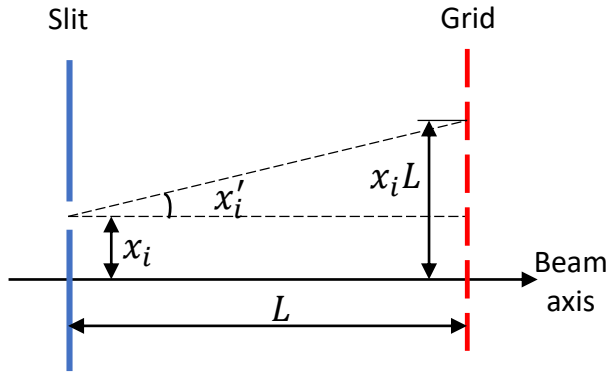


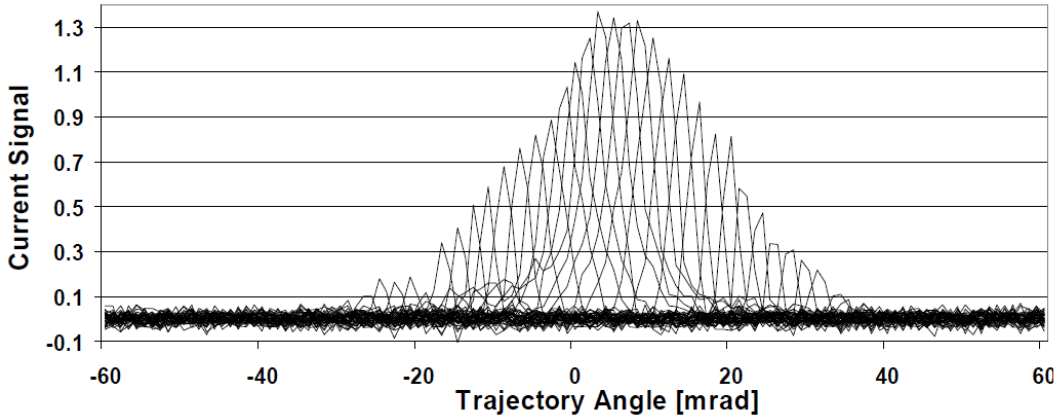
Particles traveling through an IH cavity

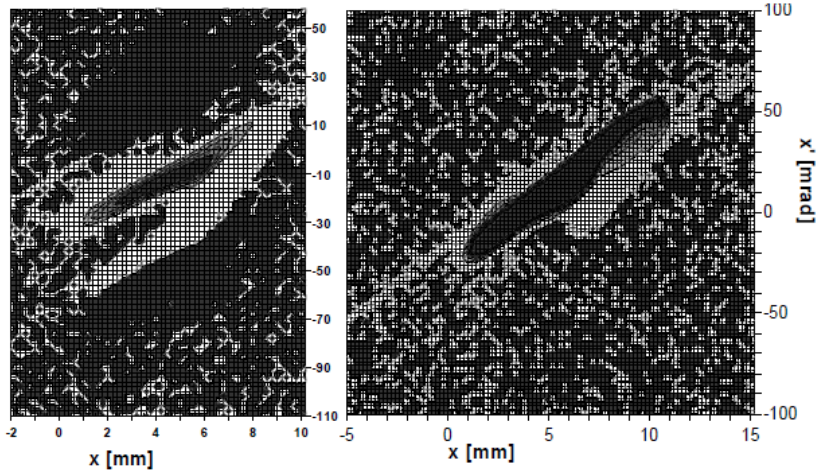
Minh Au
minh.au@cern.ch

Emittance analysis: SCUBEEx

- Beam emittance is measured at the test stand with **Slit – SEM Grid**
- Further outside the beam core, the particle flux drops to pure background, assumed to consist of only two components: the **noise** and the **bias**
- Applying a **simple threshold underestimates the emittance**
- SCUBEEx – Exclude data far from the beam core:
  - Analyze and calculate Twiss parameters from moderately thresholded data
  - Estimate the elliptical exclusion
  - Determine bias from **beam-free background** data

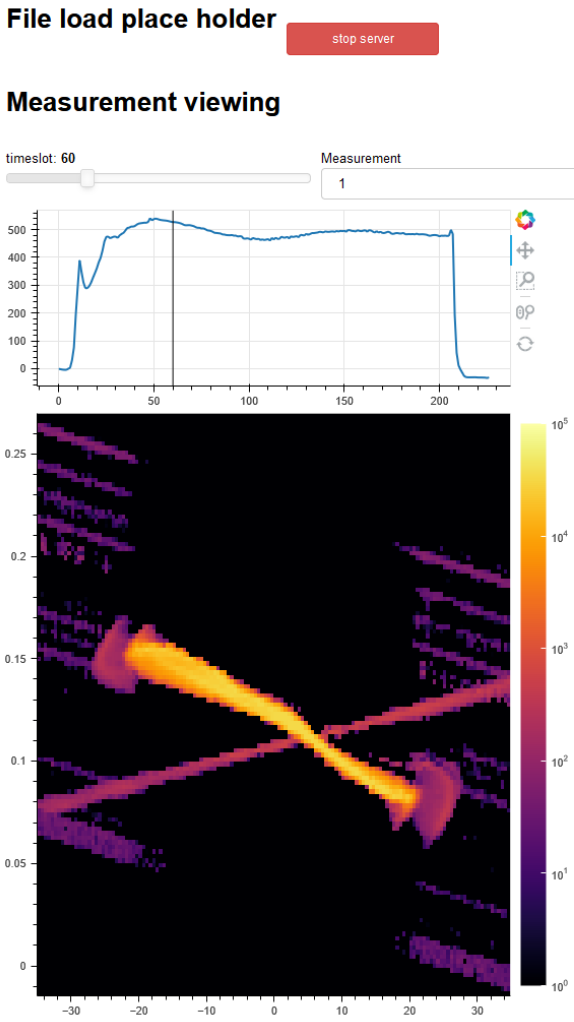


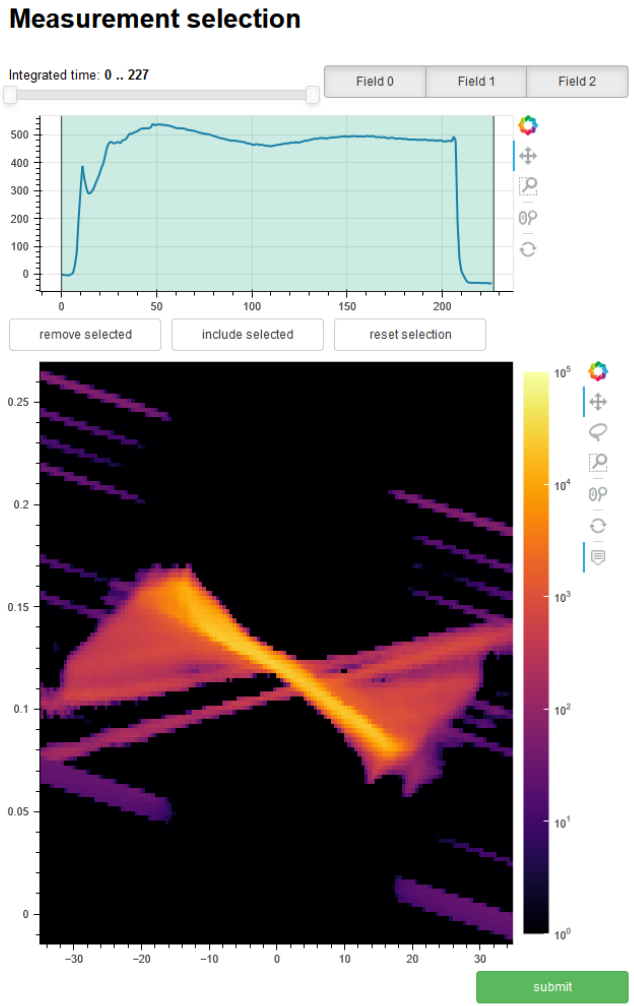


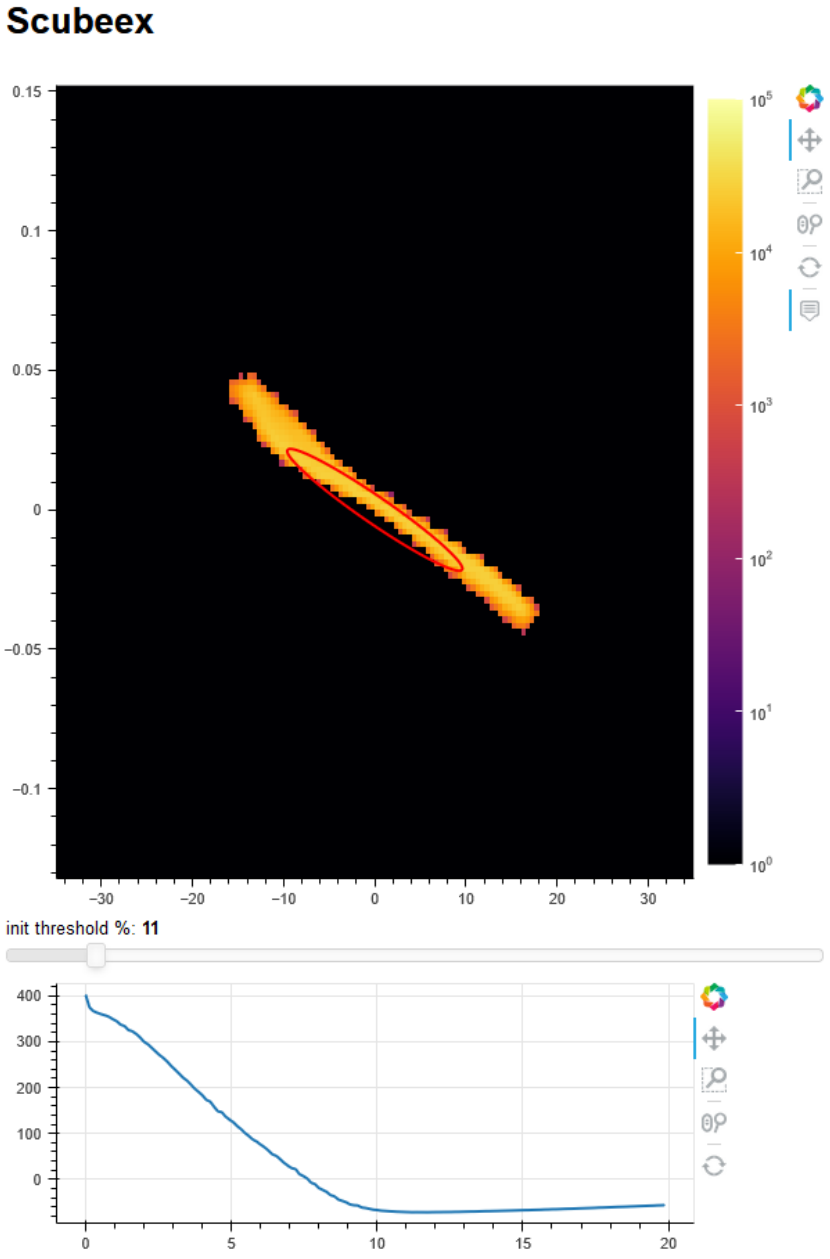


Minh Au
minh.au@cern.ch

Current Progress







Minh Au
minh.au@cern.ch

Future Works

- Complete SCUBEEx analysis and the application interface
- Manual selection of excluded data – particularly useful to exclude H0 line
- Generate beam distribution from the analyzed data in DST, DAT (PATH/TRAVEL) and TXT (PATH/TRAVEL) formats
- Allow users to load, display and analyze/calculate (RMS, N x RMS, N% emittances, Twiss parameters) beam distributions in DST, DAT, and TXT formats

Minh Au
minh.au@cern.ch

References

- Bazak, Betzalel & Weissman, L.. (2008). Minimum ellipse emittance analysis with SCUBEEx code. Journal of Instrumentation. 3. T02001. 10.1088/1748-0221/3/02/T02001.
- Stockli, Martin & Welton, R. & Keller, R.. (2004). Self-consistent, unbiased root-mean-square emittance analysis. Review of Scientific Instruments. 75. 1646-1649. 10.1063/1.1695649.
- Stockli, Martin & P, Martin. (2006). Measuring and Analyzing the Transverse Emittance of Charged Particle Beams. AIP Conference Proceedings. 868. 10.1063/1.2401393.

Minh Au
minh.au@cern.ch

Details: Exclusion analysis (SCUBEEx)

- Current evaluation of RMS emittance parameters takes into account statistical excursions and artifacts that are **unlikely to contain any real current signal**
- Exclude data far from the beam core:
  - Analyze and calculate Twiss parameters from moderately thresholded data
  - Estimate the elliptical exclusion
- The **average current measured outside the exclusion ellipse levels off** as soon as all real current signals are included (dashed curves on the plot)
- Determine bias from **beam-free background** data
- After subtracting the bias, the fraction of the beam inside the exclusion ellipse reaches unity for the same smallest ellipse size where the average outside current starts to level off (solid curves on the plot)
- SCUBEEx works best for beam distributions with **strong elliptical core**
- SCUBEEx should not be used for data with ghosts and artifacts because the incorrect bias subtraction can be very misleading