

Electron Lens Test Stand Introduction

A. Rossi

Status and Future Plans of the Electron Lens Test Stand, 1 July 2019



Electron Lens Test Stand Motivations

The Electron Lens Test Stand was built

- to characterize and test:
 - **electron gun and modulator** for **ARIES** project, WP16: Intense, RF Modulated E-Beams (Electron Lenses for Space Charge Compensation)
 - **electron gun, modulator, instrumentation (BGC and BMP), control system, infrastructure** for **HL-LHC** WP5: Hollow Electron Lens for Halo Diffusion Enhancement
- to validate simulation codes on e-beam dynamics



ARIES WP16: Intense, RF Modulated E-Beams

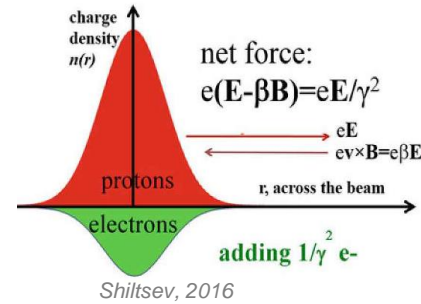
- JRA activity with four collaborators: CERN, GSI, IAP, RTU
- Manufacturing of an RF modulated electron gun for application in electron lenses
 - High electron currents $\sim 10\text{A}$
 - RF modulated at $\sim 5\text{MHz}$
 - Variable transverse and longitudinal beam profiles
 - Different cathode shapes
- Operation of a test stand for the RF modulated electron gun
 - Normal conducting solenoids for beam transport
 - Capabilities for testing different vacuum chamber geometries
 - Instrumentation for probing transverse and longitudinal electron beam profiles



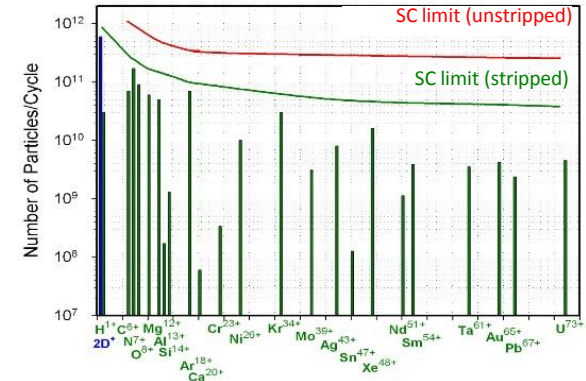
Electron Lenses for Space Charge Compensation

- GSI: Electron Lens for Space Charge Compensation (SCC)
 - Upgrade of SIS18 to increase intensity
 - Partial compensation of space charge tune spread
 - Bunched ion beams requiring longitudinal e-beam modulation
 - Matching of transverse profile to flat ion beam
 - Electron currents about 10 A
 - Modulation bandwidth about 5 MHz

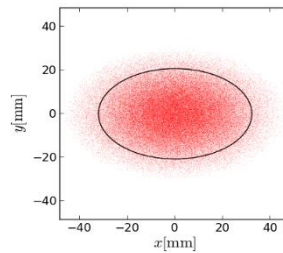
Transverse profile matching



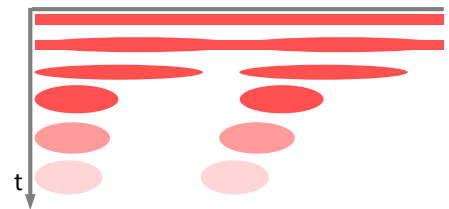
SIS18: Present ion intensities



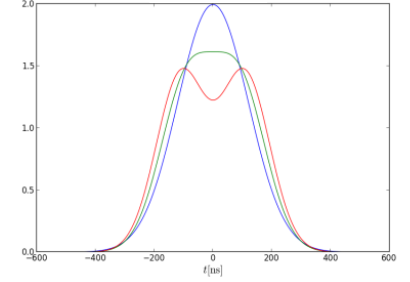
SIS18: Flat beam



SIS18: Bunches during cycle



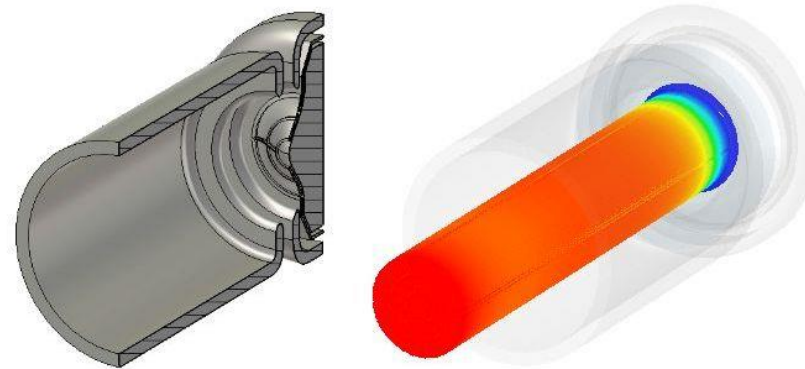
longitudinal profile



SCC Gun with Grid Modulation

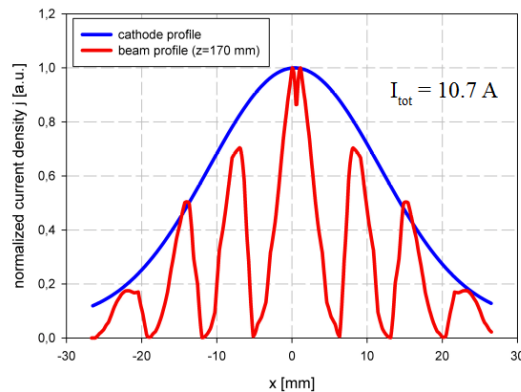
- Reduced power dissipation over anode modulation
- Losses on grid need to be considered
- Higher extracted currents required (10 A \rightarrow 16 A)
- Heat load on grid estimated to be safe for tungsten
- Tests using a Tungsten prototype foreseen at IAP
- Tungsten cathode and grid received
- Integration into spare volume ion source planned
- Ion source's filament used for indirect heating
- Preparations under way

SCC gun layout and simulation of extraction

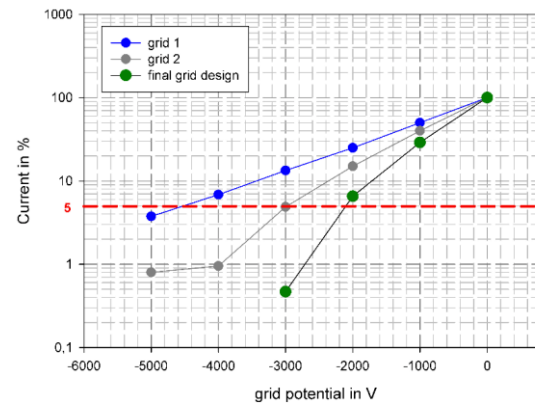


SCC Gun Requirements (Preliminary)	
Extracted current	10 A
Hor./vert. beam size	35 mm/20 mm
Cathode radius	\sim 30 mm
Gun solenoid field	\sim 0.5 T
Extraction Voltage	$>$ 25 kV
Grid voltage	\sim 3 kV
Dissipated power	\sim 3 kW
Modulation bandwidth	5 MHz

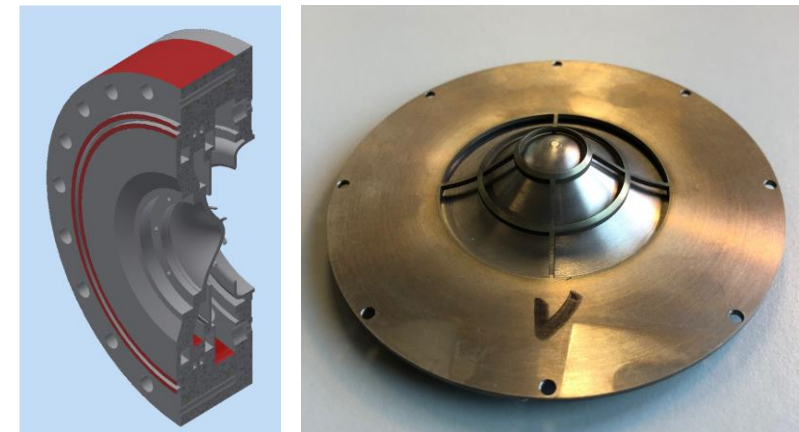
Final grid design and simulated beam profile



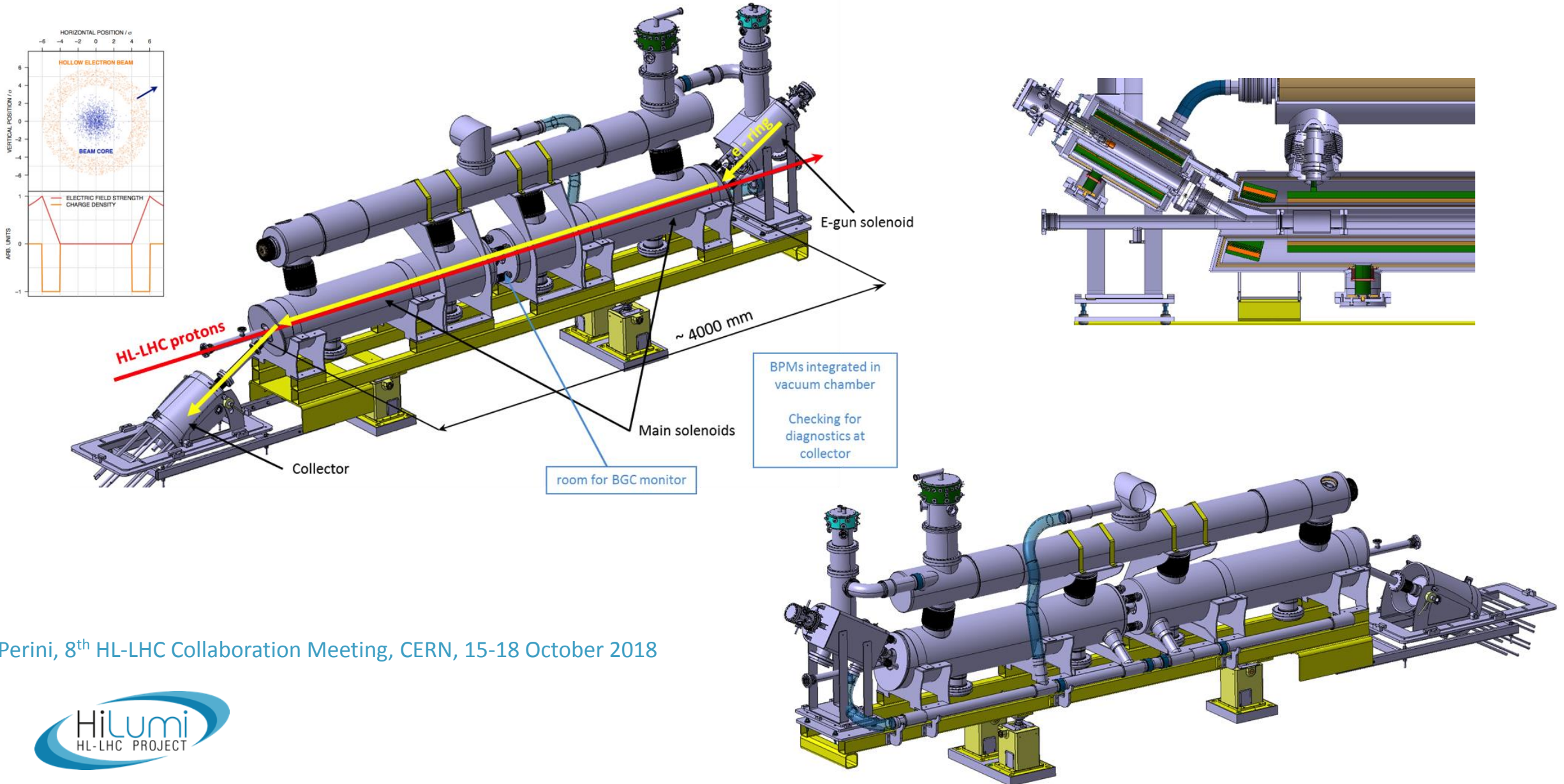
Current vs. voltage for three grid designs



Tungsten prototype for heat load tests



Hollow Electron Lens



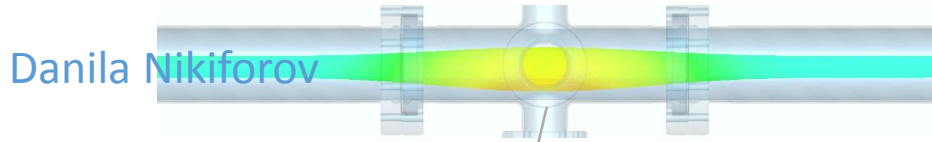
D. Perini, 8th HL-LHC Collaboration Meeting, CERN, 15-18 October 2018

HEL Parameters		Value or range
Proton beam optics at HEL	β [m]	280
Length of interaction	L [m]	3
Desired transfer scraping radius (3 to 6 beam σ @ $\varepsilon = 3.5\mu\text{rad.m}$)	$r_{e\text{-beam}}$ [mm]	1.1 – 2.2 @ 7TeV 4.3 – 8.6 @ 450GeV
Electron beam current	I [A]	5
Cathode radius	r_{cathode} [mm]	4 – 8
Gun extraction and modulation voltage (cathode-anode)	[kV]	10
Acceleration voltage (cathode to ground)	[kV]	15
Collector voltage	[kV]	In study
Modulator rise time	[ns]	200
Modulation repetition rate	[kHz]	35 *
Magnetic field at gun	[T]	3.45 @ 7TeV / 0.22 @ 450GeV
Magnetic field at bend	[T]	3.5
Magnetic field at main	[T]	3 @ 7TeV / 5 @ 450GeV
Magnetic field at collector?	[T]	In study



* See Sergey's presentation for more details on modulation

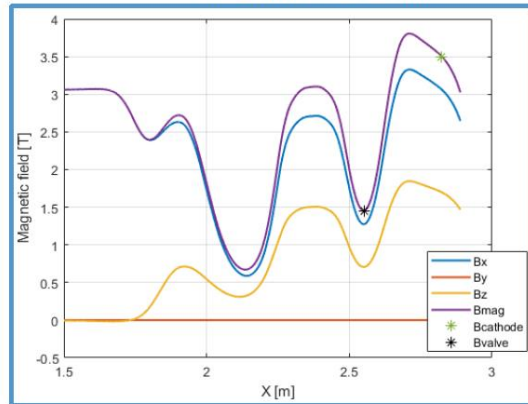
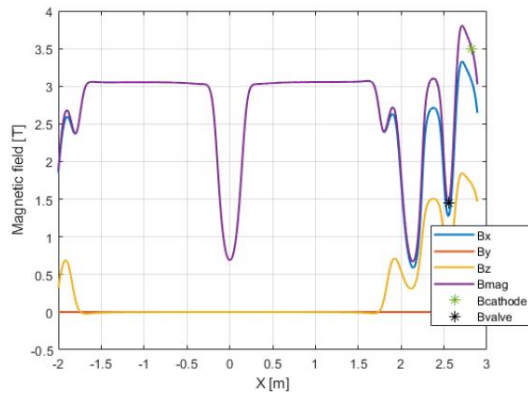
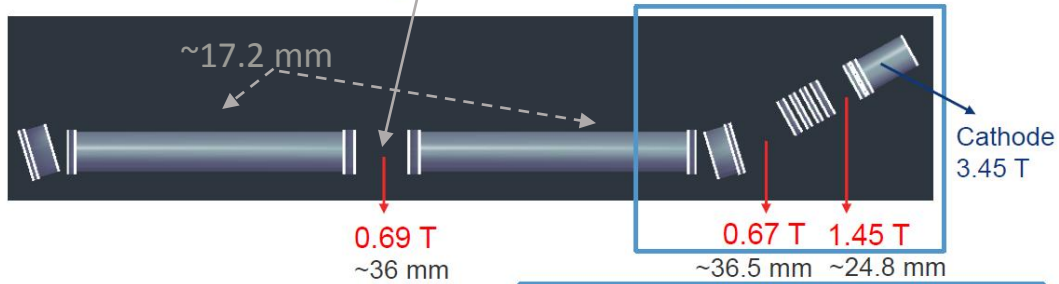
HEL Magnetic Configuration and Beam Size



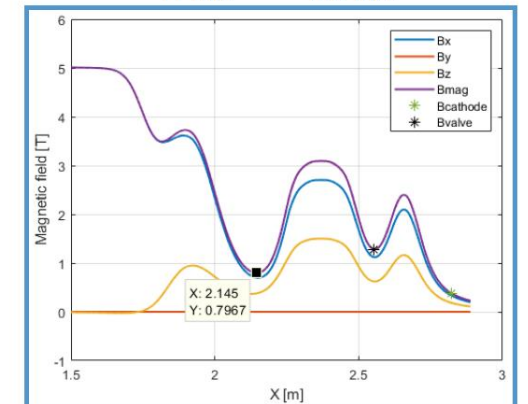
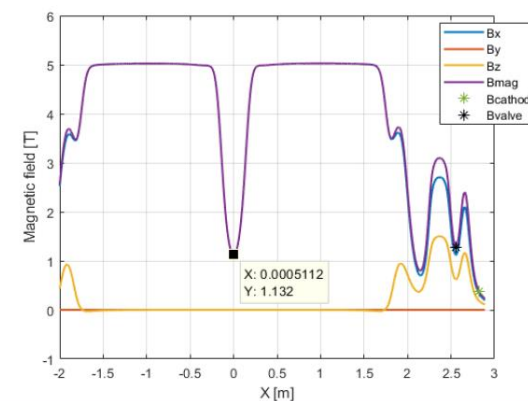
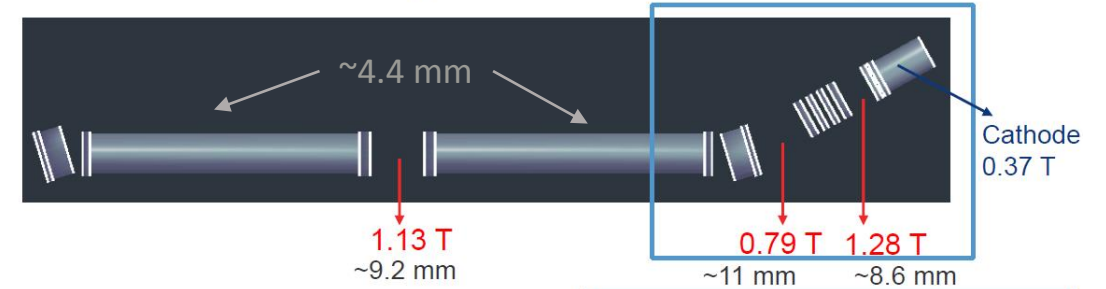
Danila Nikiforov

Cathode $\varnothing \sim 8-16$ mm

HEL – New configuration @ Injection

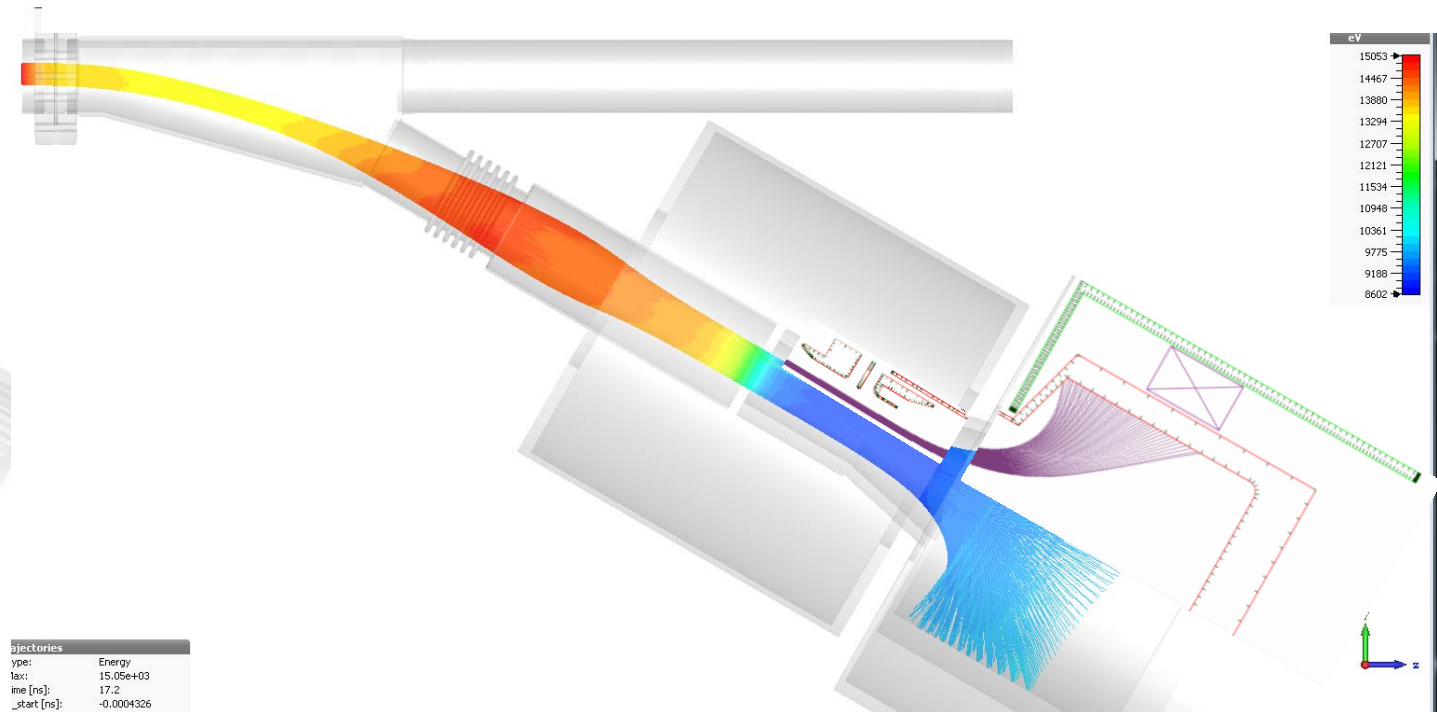
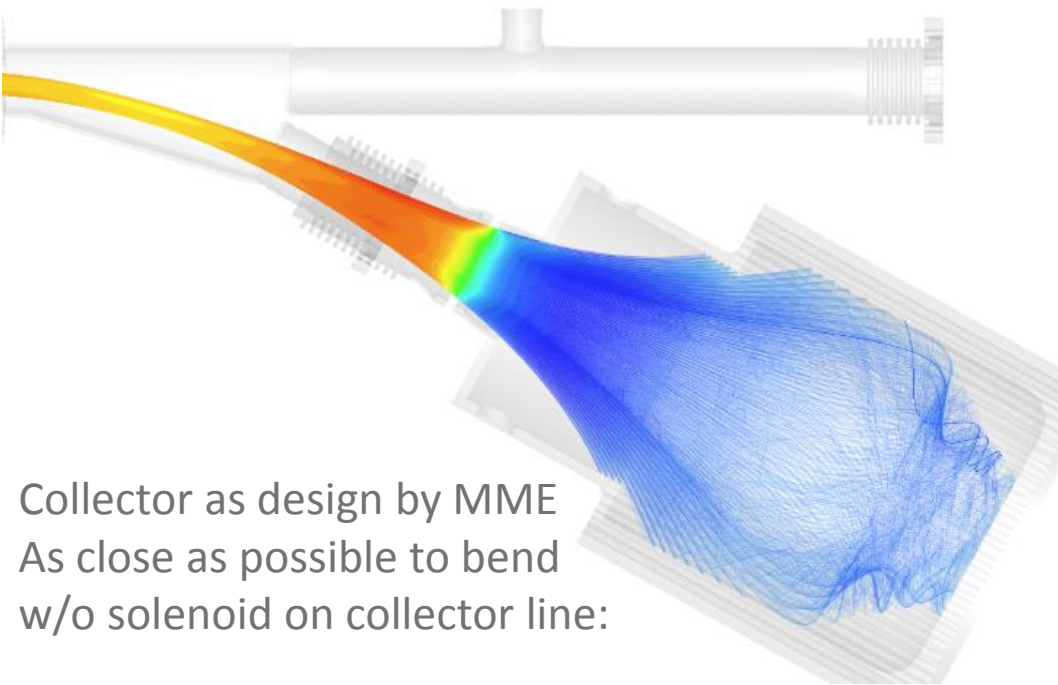


HEL – New configuration @ flat top



Current studies for collector design at injection

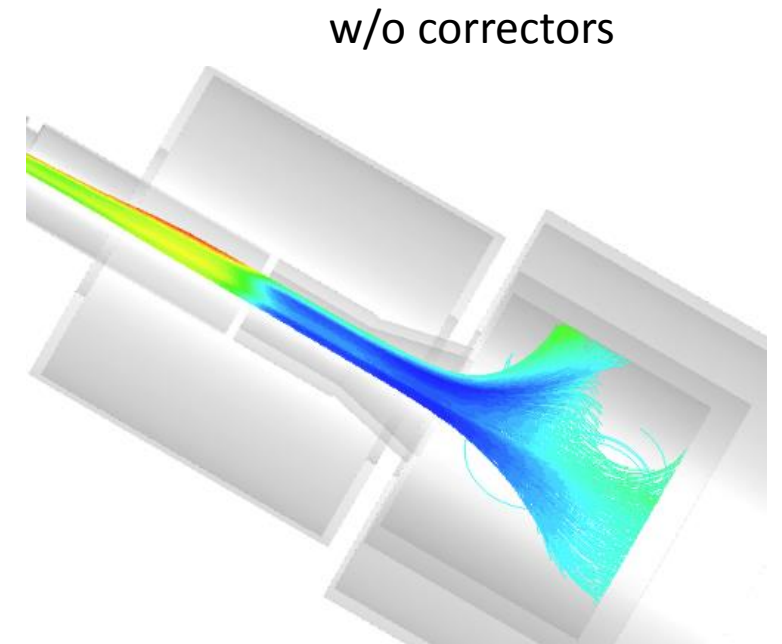
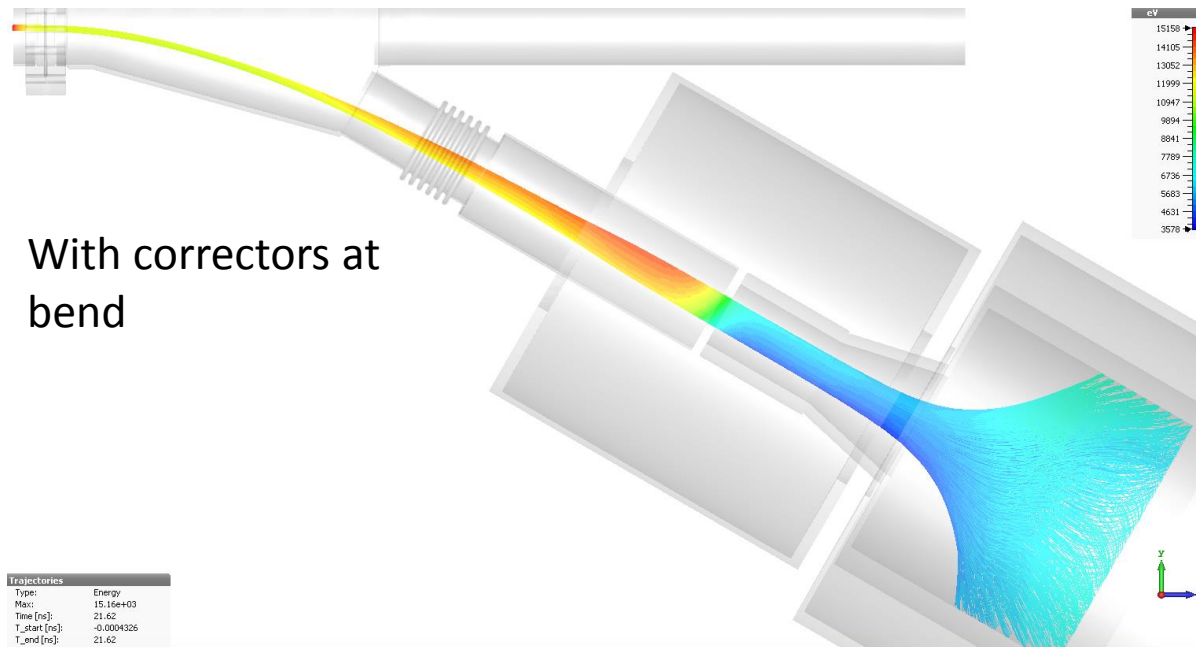
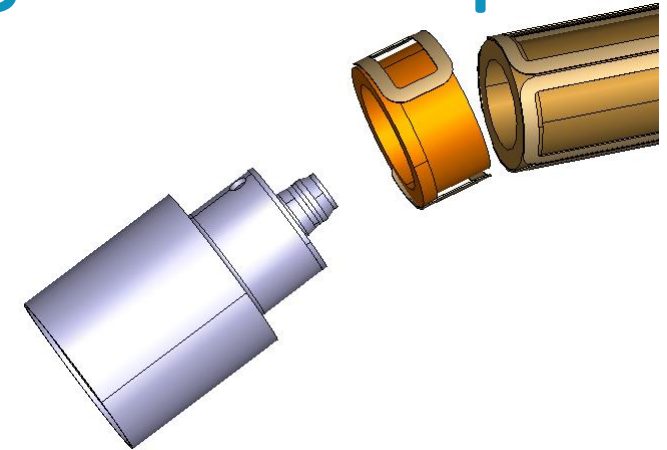
Collector with additional solenoid magnet (warm 1.5kA!)
And repeller electrodes, as proposed by Danila



- Beam too big at collector entrance
- Care to be taken for collector width/depth to avoid magnetic bottle

Current studies for collector design at flattop

Main corrector parameters		
Coils (1.05x1.65 mm)	Current per coil	Field
54 (three layers)	400 A	300 Gs



Summary

- The Electron Lens Test Stand is funded by the ARIES and HL-LHC projects.
- Wide range of parameters → long integration

Parameters at test stand	SCC	HEL
Electron beam current [A]	10	5
Cathode radius [mm]	15	4 – 8
Gun extraction and modulation voltage (cathode-anode) [kV]	30	10
Modulator rise time	?	200
Modulation repetition rate [Hz]	5M	35k *

- Scope of this meeting: present status of the test stand with geometry and characteristics and tests for the HL-LHC project.

SCC Gun Modulator

- Goals
 - Modulator for grid of SCC gun
 - Full modulation requiring 3 kV at 0.1 A
 - Bandwidth ≥ 10 MHz
 - Frequency range 0.4 to 1 MHz
- Status @ Y2
 - Improved prototype built for proof-of-concept
 - Signal generator for sweeping different wave forms over frequency range implemented
 - Tests at IAP next week
- Proof-of-concept experiment (IAP)
 - Modifications to set-up for proof-of-concept experiment for reduced stray capacitances

*Work performed by P. Apse-Apsitis,
I. Streiks, J. Van De Pol*

Working prototypes of signal generator and modulator



Frequency sweep of Gaussian double bump profile

