

HEL program and planning

A. Rossi on behalf of the HEL project

CERN – October 19th to 21st 2021



The 11th HL-LHC Collaboration Meeting will be held in digital format and will take place from 19 to 22 October 2021. This on the results of key HL-LHC prototype tests, to highlight the format was chosen after consultations with all collaboration partners and tries to address the preferences of all HL-LHC to pandemic restrictions, and to update all collaborators on the collaborators given the persisting travel restrictions and latest schedule changes. limitations for social gatherings due to COVID-19.

package parallel sessions, this meeting will serve as a technical update forum for the 5th Cost and Schedule Review, which is scheduled for 8-10 November 2021.



The main objectives will be to update all HiLumi collaborators progress made in the last year when all work still had to adapt

This year, all HL-LHC collaborators will be invited to Based on the traditional programme with plenary and work follow the presentations 100% remotely. Participation in the meeting is by invitation only, and registration is mandatory and without fee.

CERN - Organizing Committee

- Oliver Brüning Project leader
- Markus Zerlauth Deputy Project leader
- Cécile Noels Project Office
- For more details and registration www.siteweb-hilumi.ch

The HEL-based collimation concept



- <u>Active</u> halo depletion: control diffusion speed, selective by amplitude.
 - Electron beam equivalent to non-material scraper; small kick per turn \rightarrow safe device
 - Does not need to be in IR7: enhanced diffusion brings losses in IR7
 - Constraints from tight transverse aperture determine the requirement on the small electron beam size.

Hollow Electron Lens in HL-LHC baseline after C&SR 2019, as in-kind contribution



WP5.3 Scope

- 2 Hollow Electron Lens units to be installed in IR4 during LS3 plus spares components for a full 3rd unit
- Main deliverables from BINP
 - Electron gun and collector
 - Beam instrumentation
 - Vacuum system
 - Magnetic system (solenoids, correctors, compensation dipole)
- Main deliverables from UK-CI: BGC
- Main deliverables from CERN
 - Magnet detection/protection and powering
 - Cryogenics
 - HV powering and anode pulse generator
 - Design of BPM, gun and collector
 - Ancillaries (cables, water cooling, controls including vacuum …)
- Final tests and installation in collaboration



WP5.3 WBS

WP5.3.1	Magnet System	TE-MCS A. Foussat
WP5.3.2	Magnet Protection	TE-MPE M. Wozniak
to go to WP9	Cryogenics	TE-CRG G. Ferlin
WP5.3.3	Vacuum	TE-VSC G. Bregliozzi
WP5.3.4	Powering	SY-EPC M. Martino
WP5.3.5	Modulator	SY-ABT E. Carlier
WP5.3.6	Electron Gun & Collector	SY-BI A. Rossi
WP5.3.7	Instrumentation (BPM, BGC, BLM)	SY-BI M. Wendt, R. Veness, C. Zamantzas
WP5.3.8	Electron Beam Test Stand	SY-BI A. Rossi
WP5.3.9	Survey & Alignment	BE-GM J-F. Fuchs
WP.5.3.10	Utilities & facilities	SY-BI A. Rossi
to go to WP15	Integration & Tunnel infrastructure modification & Installation	J. Oliveira (EN-ACE)
	Design by D. Perini & A. Kolehmainen EN-MME	







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HEL main specifications

Property	Specification			
Design current (cathode 4/8 mm radii)	5.0 A ± 0.5 A	Stability over a pulse and from pulse to pulse 0.5%		
Interaction region length (at min. inner beam radius)	3 m	90% halo depletion in 5 min		
Min/max inner radius at 7 TeV	1.1/2.2 mm ± 0.01 mm	3.6/7.2 LHC beam sigma (280 m β) ± 1%		
Electron beam position range	± 4 mm	 ± 2 mm for LHC orbit variations, misalignment + 2 mm for set up purposes 		
Electron beam angle range	± 2 mm / 3 m	For LHC orbit variations		
Position stability fill to fill and pulse to pulse	0.03 mm	1% of LHC beam sigma at 7 TeV		
Rate of position change	0.1 mm / s	-		
Electron pulse length	1.2-86 μs	To leave witness batches		
Maximum number of pulses for LHC turn	3			
Electron beam rise time	< 200 ns	To inject between SPS batches		
Tolerated integrated dipole kick in the core	1 nrad	 Tight requirements on e-beam : symmetry entrance / exit of e-beam trajectory Electron density distribution Smooth trajectory 		



Functional specifications of overall HEL device (EDMS No 2514085)

- Missing more detailed study on e-beam optics and magnetic layout/map
- Functional specifications of HEL Magnets (EDMS No 2515452) drafted
 - Interfaces specifications almost complete (drawings missing)
 - In review (Hollow E-Lens Magnet System Review https://indico.cern.ch/event/1061478/)
- Functional specifications of HEL High Voltage System (EDMS No 2265586) in eng. check
 - Technical specifications already on going. Safety will be included in each of the HEL TS documents
- Functional specification of HEL Pulse Generator (EDMS No 2265592) in eng. check.
 - Technical feasibility analysis completed \rightarrow internal to CERN



- Overall design well advanced
 - Integration and installation
 - Cryogenics
 - Magnets specs reviewed
 - Magnet circuits and quench protection defined
 - Powering
 - Gun prototyped, being tested
 - Collector design complete
 - Beam instrumentation prototyped, being tested



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Integration and installation



Cryogenics

- Service module designed
- Pressure analysis for magnet system complete (4.5barA)





Circuits and quench protection

- Recovering 120A&600A PC from LHC – circuit analysis completed
- Energy extraction required for main solenoids only, full study complete



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WP5.3 Main achievements (key technology demonstration)

Scandia-doped W cathode electron gun

- Scandia-W cathode produced 5A at FNAL (G. Stancari)
- HEL e-gun prototype CHG-16-sc-e BIS validated electrically at e-beam test stand (no HV break-down)
- Current extracted at E-Lens Test Stand







Collector

- Collector design completed
- Waiting for validation from e-beam transport simulations before production is launched





WP5.3 Main achievements (key technology demonstration)

- Version for LHC measurements to be tested at EBTS – Q1/2 '22, at LHC in 2023.
- Gas curtain 9x0.3mm at 10¹⁶ N₂/m³
- Design to fit in tight HEL space in progress



BGC (e- and hadron beams)





Stripline BPM (e- and hadron beams)

 Numerical simulations and laboratory measurements demonstrate the feasibility of measuring both ~ DC ebeam and bunched LHC beam, with < 2um difference



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WP5.3 Open points: e-beam optics and magnet layout

Courtesy of D. Nikiforov and BINP team **Electron beam optics** 0.1nrad residual kick LE EBeam trajectories, initial R_b=8mm Plane position / mn Magnetic shielding is excluded from simulation Due to magnetic field lines Collector and part of the vacuum hamber are excluded from distortion in the middle gap, the ulation to see the size of the full uncentered beam deflection Magnetic model required am at the entrance of the collec was observed for specs work done in Long corrector current - 5 A Long corrector current -15 A ΔY = 370 um To inject R_{beam in main solenoid} = 8mm collaboration with **BINP** Collector entrance should be D~120mm (min = 230 un Collector entrance should be moved towar the collector solenoid Trajectione Origin: Directo Servete SC/201 Servet Allocation Directo Allocation *Adriana Rossi, 11th HiLumi Collaboration Meeting 20th October 2021 Z, mm

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WP5.3 Roadmap

- Complete studies to define magnetic layout in collaboration with BINP
- Finalise magnet functional specifications and interfaces technical specifications
- Complete all procurement documentation to pass the baton to BINP . . .
- Continue tests at CERN Electron Beam Test Stand (NC magnets)
 - Electron gun
 - Collector (prototype still to be built)
 - BPM
 - BGC
 - Pulse Generator
 - HV system (powering and controls)





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In-kind status and effect of planning

Hollow Electron Lens: Overall Planning	2021	2022	2023		2025	2026	2027
Magnet System					WOUC M		
CERN Functional Design	VTE V	magnet design review				annin_	
Magnetic layout	Magnetic layout		Integrated functional design review				af Durr
Manufacturing Design BINP				Review of BINP translat	ion, production readine	SS	
Material procurement							
First of in-kind HELO			HEL O				
Series HEL1, HEL2					HEL1,2		
Cold power surface tests at BINP							
HEL Assembly - cold magnet commissioning CERN							
Gun, Collector							
Gun design, prototyping and tests @ CERN EBTS	1		🔷 🖓 Gun	design validated			
Gun drawings & production @ BINP							
Gun testing @ CERN EBTS							
Collector design, study, proto, tests @ CERN EBTS of	prototyping	tests at EBTS	Collector design validat	ed			
Collector drawings & production @ BINP							
Collector testing @ CERN EBTS							
Tunnel infrastructure for HEL ready- Cable , rack an	nd electronic						
Instrumentation							
BPM studies, prototyping and tests @ CERN EBTS			BPM desig	n validated, ready for BI	IP		
BPM drawings & production @ BINP + tests @ CERN							
BGC design, prototyping, tests @ UK-CI&CERN, final					🕴 🕴 🕴 BGC rea	ady for BINP	
Tunnel infrastructure for HEL ready- Cable , rack an	nd electronic						
Modulator							
Modulator design and test @ CERN EBTS desig		sign and prototyping	test	s at EBTS 🛛 🗘 Modu	ılator design validated, ı	ready for BINP	
Modulator production at BINP ?							
Modulator testing @ CERN EBTS							

Assumptions for production schedule at BINP based on capabilities estimated by CERN experts!





Thank you for your attention