

# Electron Gun/Collector + individual systems tests and summary on resources for the Electron Beam Test Stand

A. Rossi, D. Perini, A. Kolehmainen, S. Sadovich

HL-LHC Hollow Electron Lens (production) kick-off meeting – 13 April 2021

### Scandia-doped W cathode electron gun Cathode ID 8.05 – OD16.1 mm, 5 A at 10 kV extraction voltage

HEL e-gun prototype CHG-16-sc
Successfully tested (5A x 10kV)
Body too big to fit gun solenoid



Successfully tested at FNAL Now delivered to CERN

courtesy of G.Stancari



- HEL e-gun prototype CHG-16-sc-e
- Failed test at test stand (leakage current through ceramic insulator).
- Measurements indicate causes as low resistivity of ceramics and too a high T when filament hot

First HEL prototype design 2019: D.Perini, A.Kolehmainen CERN

# Scandia-doped W cathode electron gun

HEL e-gun prototype CHG-16-sc-e BIS



- Issued from trying to better dissipate heat of ceramics.
- Use Alumina and pre-treatment
  - Complete design including back pumpingProduced, being assembled, ready end April – beg. May 2021.
  - Will be first tested at gun-test-facility for electrical and T performance, then characterised in electron beam test stand

Plan to exchange ceramics in HEL e-gun prototype CHG-16-sc-e and adapt design to HEL (include back pumping) to have a simpler and sturdier design. Tests foreseen in second half 2022.



## **E-lens test stand**



Dedicated E-GUN test stand Outgassing of the gun (RGA and pressure gauge) Gun temperature (viewport) HV breakdown NO measurements of electron current





# **HEL Collector**

Mechanics/cooling to withstand max 5 A x 15 kV power

Biasing to reduce outgassing and secondary electrons, recover power, improve efficiency

- Collector design completed, ready for prototyping
- $\checkmark$  To be verified with simulations, before proceeding:
  - $\stackrel{-}{\sim}$  Collector solenoid sufficient to shrink e-beam through extraction arm.
  - Collector efficiency with biasing (retarding and repelling) electrodes
  - 🖓 Vacuum performance





- Prototype ready  $\sim$  9 month after launching production.
- <sup>5</sup> To be tested at CERN (test stand)
  - Will allow tests with full current for BGC and anode modulator

HL-LHC Hollow Electron Lens (production) kick-off meeting – 13 April 2021

# **Detailed EBTS planning being drawn**

Electron Beam Test Stand: Planning									2021	2022				2023						
		ing								1	1 2 3 4 5 6 7 8 9 0 11 12	1 2 3	4 5 6	789	0 11 12	123	4 5	5 7 8	9 10 11 1	12
		Man / day	man	da y:	comments	jea n Al	l ex Stép	häreehriSei	ga <mark>y QP ML</mark>	XEI								1	1	
item Com	nissioning EBTS stage 1b																			
1	E-Gun v0, diagnostics	20	1	20	Sergey, 2nd person for safety, could be someon	ne working	in the bu	ilding 20					I I		1			1		
2	Mechanical work	20	2	10	Stephane (5), technician (5)		10	10									8			
3	Documentation / Manual / Software Control	15	1	15	Sergey			1	5								8			
Insta	llation EBTS stage 2 (with non-cooled collector = limit of average	e-current to	0.5	mA)														1		
4	EBTS-2 installation: E-Gun v0, BPM, Solenoids, Power converte	rs, non-coo	led c	plie	top y (3), Jean (7), Stephane (10), technician	(10) 7	10	10 3									8			
5	Bakeout equipment installation + leak testm 40-30 (1200CHF)	-											1 1				8	1	1	
6	Bakeout	1	1	1	XEI technician (1)			1					1 1		1		1	1	1	
7	Solenoids comissioning	10	2	5	Sergey (5), Jean (5)	5		-					1 1				1	1	1	
8	BPM commissioning	2	2	1	Sergey (1), Manfred (1)			1	1				8 8				8		1	
Meas	urements with beam at 5A. 10us. 10 Hz (E-Gun v0 then v2. BPM)	0.5mA											1 1		1		1	1	1	
9	E-Gun v0 Extracted current as function of T and V L and B	30	2	15	Activation of gun. XEI technician (15), Sergey (1	15		15 1	5				1 1		1		8	1	1	
10	BPM studies as function of Land B (size of the heam)	30	2	15	Sergey (15), Manfred (3), Georgeos (12)			1	5 15				1 1				1	1	1	-
11	E. Gun v2 and BGC (for LHC) Installation (reshuffling of colonoid	<b>1</b> c) 20	2	10	Serrey (2) Jean (7) MJ (CI (10)	7			10				I I					1	1	
12	Look test	20	1	1.0	anger (an jean (a), mer er (20)				10				1 1					1	1	-
12	Pakoaut	2	1.	1	VELANA AND AND AND AND AND AND AND AND AND			2					1 1				1	1	1	-
14	E Cup v2 Everented surrent as function of T and V	40	1	2	Farmer (20) / 22	10		10 0									8			-
14	E-GUILV2 EXUACTED CUFFERE AS FUNCTION OF LAND V	40	2	20	aeigey (20) / //	10		10 2	°				<u>                                     </u>		-		1	1	1	-
10	DBC CONTINUSSIONING	10	2	°				+  .	10				I I		1					-
10	BPM tests	30	2	15	sergey (15), Manfred (3), ?? (12)			1	5 15				I I				8			_
17	BGC (for LHC) tests	80	2?	40?	operator-XEI (40?), CI-UK + ML + PM teams ?			40	40				I I		1					_
		1	1	123	Total 20	021 % 0 00	0.09	0.38 0.4	8 0.13 0.26	1.07					1		8			
Insta	llation EBTS stage 2 (cooled collector = average e-current up to 5	4)								. 1										
18	HEL prototype collector: design / fabrication HV protection	20	1	20	Jean (20)	20														
19	Power converters in FC: cabling and control crates	20	2.5	8	Alex (4), Stephane (8), technician (8)		4 8	8									8		1	
20	E-Gun v3 installation	2.5	2.5	1	Sergey (0.5), Technician (1), Jean (1)	1		1 0											1	
21	HEL prototype collector installation and power converters in Fa	arada 90Cage	<b>e</b> 3	10	Sergey (5), Alex (5), Stephane (5), technician (1	10), Jósan (5	5 5	10 5												
22	Safety inspection/ documentation	12	2	6	Sergey (10), Alex(2)		2		0	-								1	1	-
23	Bakeout equipment installation + leak testm 40-30 (1200CHF)	-																1	1	
24	Bakeout	2	1	2	XEI technician (2)			2									1	1	1	-
	Gun activation	30	2	15	Activation of our XEL technician (15) Serger (1			15 1									1	1	1	-
25	Commission of aun/collector (Gun: beating, Collector: HV breakdown	20	2	10	Serrey (4) lean and/or Alex? (16			•	-								8		8	-
Moor	uroments with beam at EA, with seeled biased collector (no VAG	(roon)	-	10	Sergey (4), Jean and/ of Alexi (10								1 1		1		1	1	1	
26	Tosts of the E gun and HV system stability	20	2	10	Serrey(10) Alex (10)		10								Gun de	sign valida	ed read	vitor BINP	1	-
20	Cellector officiency measurements	20	2	10	Sergey(10), Alex (10		10								Guirde	Collector	docion v	Wated re	why for PIN	ALD.
27	collector enciency measurements	20	2	10	Sergey(10), Alex (10)		10	1								Collector	Sesign vi	similated, re	and y for bit	
28	BPM	40	2	20	QP ?			2	0 20							BGC for I	MC ready	Br LHC in	stallation	
29	BGC for LHC	80	2	40	ope. pr-XEI ? / UK + ML PI dms ?			40	40							DOC IOI L	ac ready	a circ ii	Sometion	
					Total 20	022 % OHE	0.13 0.0	6 0.33 0.	32 0.09 0.17	7 1.02					1			1	1	_
De-in	stallation of BGC, addition of e-beam diagnostics + gun modulato	r + final HE	LH	PC				ь I	1 1									1	1	
30	BGC instrument removal for LHC installation	4	2	2		1		2	1				I I				1	1	1	_
31	HEL HV power converter installation	10	2	X	EPC ? Tbc (otherwise Stéphane (5) + Wil (5))		5	5					I I					1	1	
32	Gun modulator connection	2			RF/ABT								1				1	1	1	
33	2nd YAG screen installation at BGC location, vacuum pumps in	stallation	2	2	Sergey (2) Jean (2)	2		2					1							
34	Leak test firm 40-30 (600CHF)	-																		
35	Bakeout	2	1	2	XEI technician (2)			2					1 1							
36	Commissioning	14 (BI)	2	7				10 4											1	
Meas	urements with nominal beam parameters (5A, 1-86us. 33kHz)	1															8			
37	Gun Modulator tests including FESA class and control system	20	1	20	Assistance from XEI is required (setup/tests)			15 5											1	
38	BPM	20	1	20				1 [	20				1 1		1			BPM de	sign validat	ted, rea
39	Tests with PC and control system	20	1	20					20				1 1							
Insta	liation of BGC prototype for HEL and tests	20	1	1																
40	BGC for HI-I HC prototype installation	10	2			5		<					1 1						1	
41	Look tests	10	1	1		2													1	-
41	Leak tests	1	1	1	VEL-Colore (2)			-											1	-
42	Bakeout	2	1	2	XEI tecnnician (2)			2									8	8		4
43	BGC commissioning	10	2?	5	and the second				10				I I		Ĭ		8			_
44	BGC tests	120	3	40				40	80				I I		i		8			
45	Tests with PC and control system	40	1	40				40							i		8			
				171	Total 20	028 % 0.00	0.02	0.52 0.0	5 0.17 0.39	0.62			I I				1			
E-Gu	n developmätatment heating, HV breakdown, outgassing, measurements	of light																		
46	Tests of the E-gun v2	10	2	5	Sergey (3), Jean (7)	7		3					I I		l l		8	8	8	
47	Tests of the E-gun v3 (i.e. v1 upgraded)												1 1		1				1	

Manpower for test stand support, gun, collector, modulator and BPM has been estimated (see R. Veness's talk)



# Conclusion

### Electron gun:

- Extraction of 5A x 10kV from small cathode demonstrated already in 2017
- Open point: design gun that fits into space and has sufficient insulation (temperature + material choice)
- $\checkmark$  Programme well defined and resources available
- Collector:
  - Design to specification completed
  - Open point: verify efficiency, vacuum and collector solenoid
  - $\checkmark$  Tests to validate foreseen, and resources available

#### 주 Test stand:

- $\checkmark$  Planning to accommodate multiple testing being worked out
- Condition of the second sec
- External tests after 2023 (UK-CI and BINP) for validation of in-kind requires additional manpower from contributing institutes UK-CI ends in 04/2025
- Detailed description of WBS is needed to fully evaluate support resources



# **15-mm (0.6-in) hollow e-gun (HG06) used in Tevatron**





FERMI NATIONAL ACCELERATOR LABORATORY

#### - 03 September 2020

#### 15-mm (0.6-in) hollow e-gun (HG06) used in Tevatron





20 10