Linac4 H^- sources: Highlights 2013 & objectives

Mandate: *80 mA H^- within norm. emittance of 0.25 π·mm·mrad required intermediate stages:*

Lina4 IS#	**#1 Volume source**	**#2 Surface source**	**#3 Magnetron**
Operational experience *H^- current*	DESY 30 mA	SNS 50 mA	BNL 80 mA
H- production mode	$H_2^* + e \rightarrow H^- + H_0$	H_0 on cesiated surface $\rightarrow H^-$	Complex mix
Plasma Heating process	H_2-plasma 2 MHz RF Ext. antenna	H_2-plasma 2 MHz RF Int. & Ext. antenna	H_2-Cs plasma Arc discharge
Cesiation		Cs or Cs-chromate Single deposition: 100 mg/y	Cs metal Constant flow 5 g/y
Electron / H^- ratio	20-50	10	0.5 - 1

… and a proton source compatible with linac4, 80 mA or more…

Organization of the ISWP

Simulation - Measurements

Bi-Weekly meeting

- Beam-optics *IBSimu*
- Pulsed H_2 injection
- High voltage, B-field (Opera)
- Thermal equilibrium
- RF-field (ANSYS HFSS)
- Photo- Spectrometry

Simulation Plasma

Bi-Weekly video meeting with KEIO university

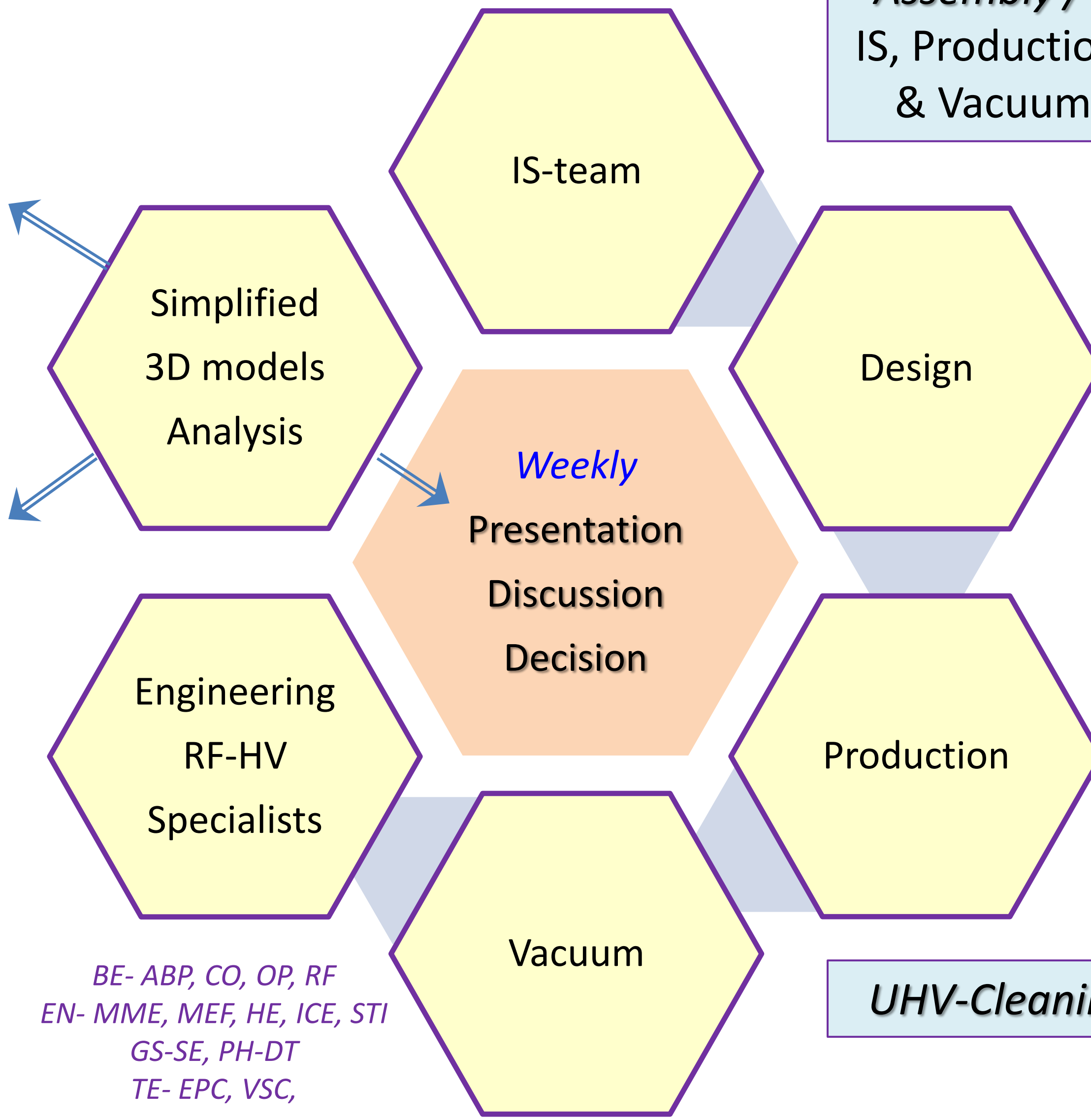
- Plasma heating
- Light emission

Collaborations

BNL, IPP, SNS, RAL, J-PARC, Uni. Orsay, Uni. Jyvaskyla

Assembly / leak test

IS, Production, Design & Vacuum -teams



UHV-Cleaning

Linac4 IS Collaborations	
IPP Garching	U. Fantz
University of Jyvaskyla	O. Tarvainen, T. Kalvas
SNS	M. Stockli
KEIO University	A. Hatayama 畑山明聖
IPGP Orsay	T. Minea
ISIS	D. Faircloth
BNL	J. Alessi
J-PARC	A. Hueno

CERN

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Thank you all ☺

Students & Fellows

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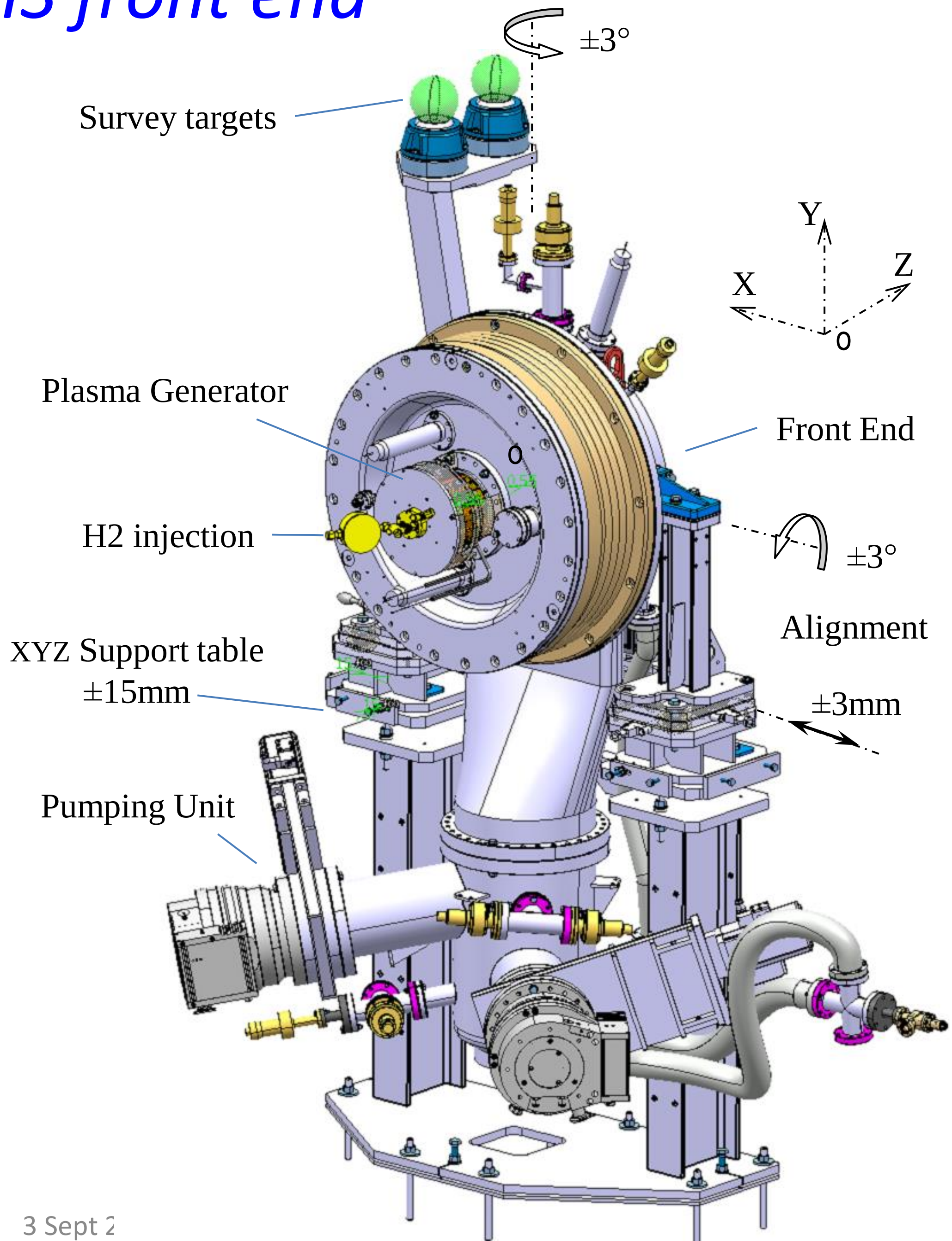
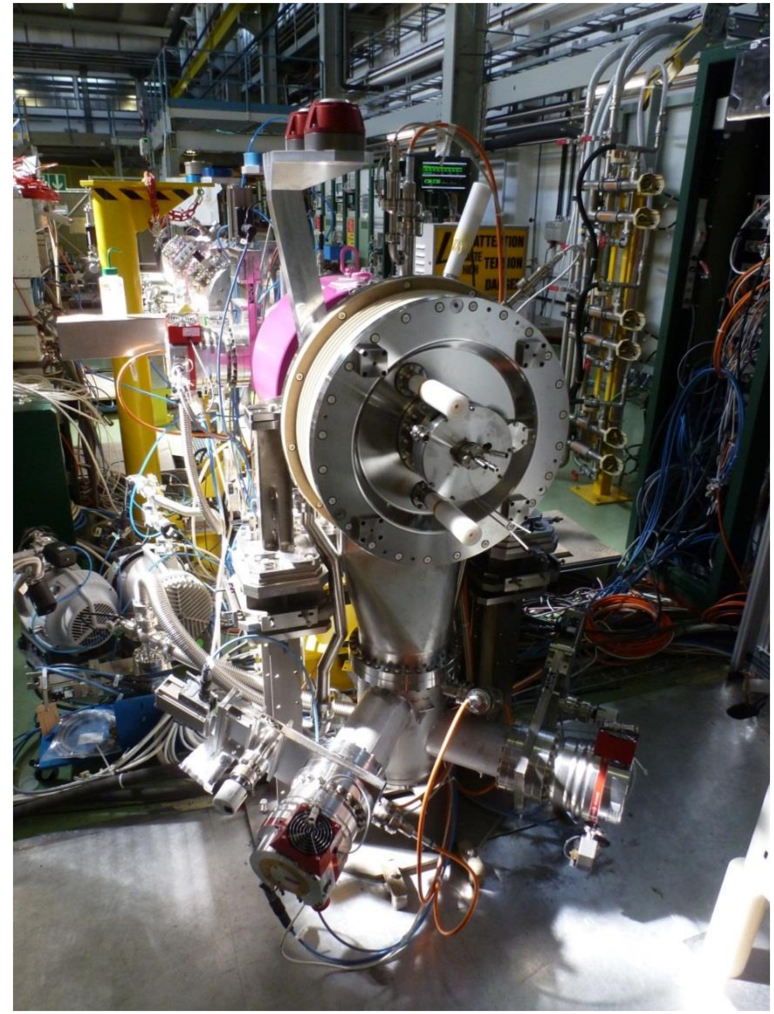
Claus	Schmitzer	SLHC-PhD.	
Oystein	Midttun	PhD.	
Stefano	Mattei	Tech-Fell.	
Hugo	Pereira	Fell	
Jose	Sanchez	Dipl, Tech-Fell.	
Jaime	Gil Flores	Tech-Fell.	
Chiara	Pasquino	Tech-Fell.	
Cristhian	Valerio	PhD.	
Sylvia	Izquierdo	Tech-Fell.	
Mahel	Devoldere	Tech-Fell.	
Marco	Garlasche	Fell.	
Serhiy	Mochalsky	Fell.	LPGP Orsay
Taneli	Kalvas	PhD.	Jyvaskyla Univ.
Masatoshi	Ohta	太田雅俊	Keio Univ.
Masatoshi	Yasumoto	安元雅俊	
Kenjiro	Nishida	西田健治朗	
Takanori	Shibata	柴田崇統	
Takashi	Yamamoto	山本尚史	

8+19+50=77

IS front end





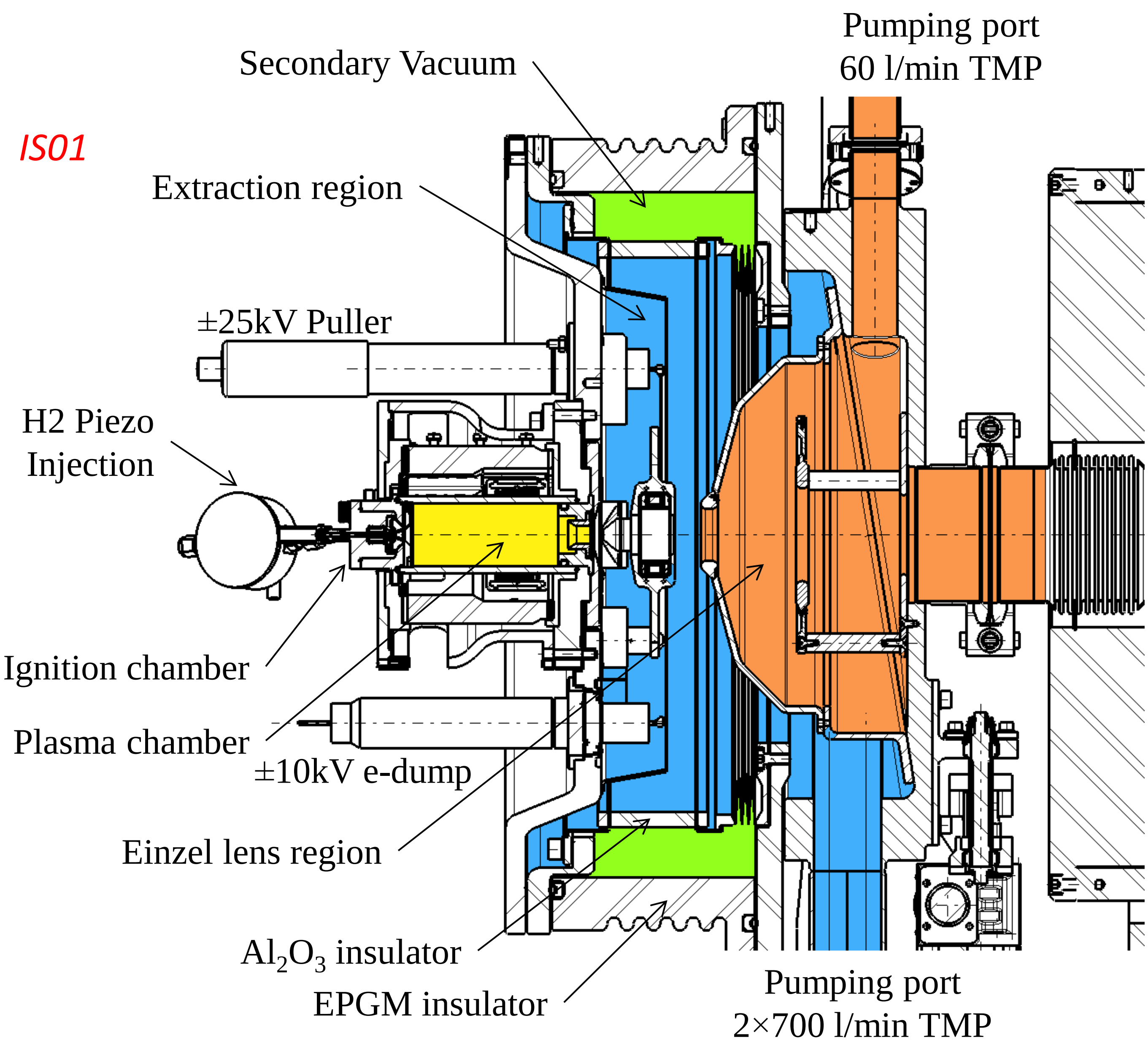
- Alignment table (Survey)
- Beam based alignment options:
  Horiz. displacement & $d\phi$, $d\omega$

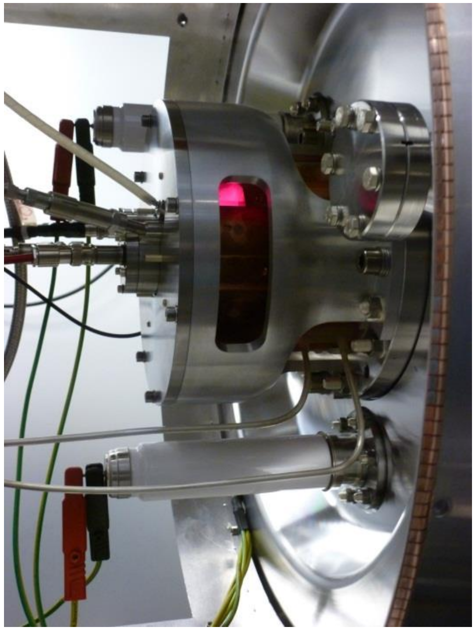
Quick exchange in case of failure:

- Pumping port
- Front end

“Plug & play” Plasma Generator and beam formation region

IS01





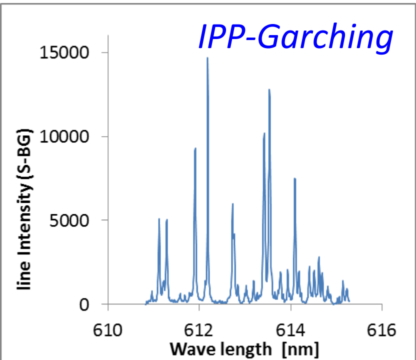
H_α light diffusing through
The Al_2O_3 Chamber

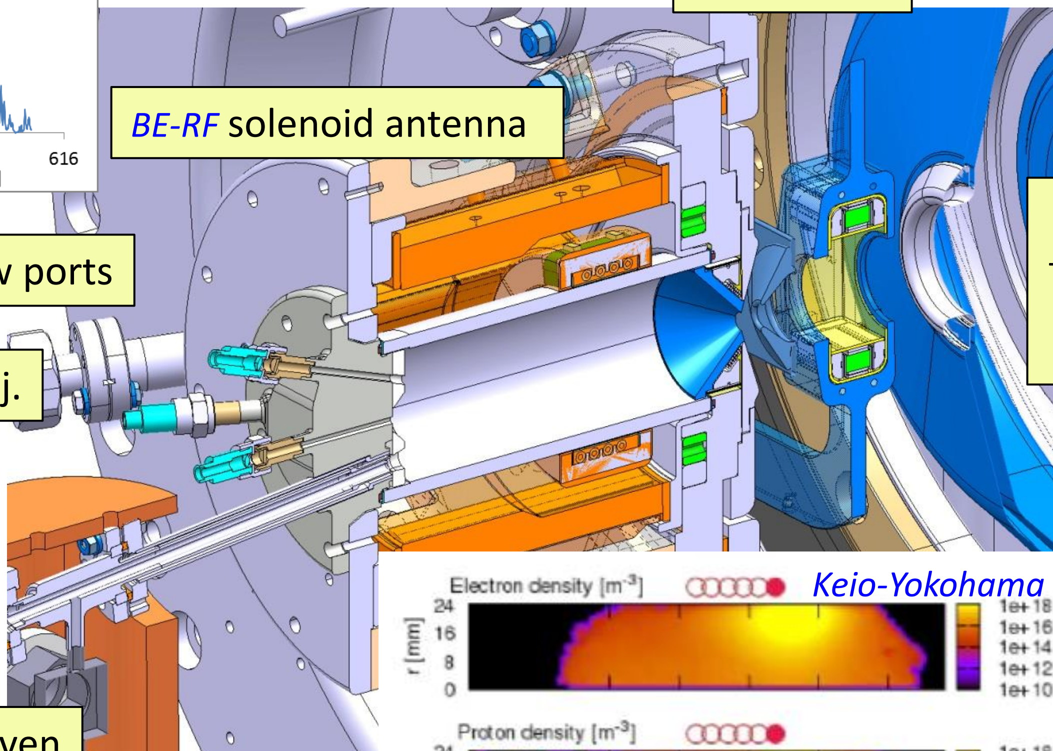
Exchangeable:

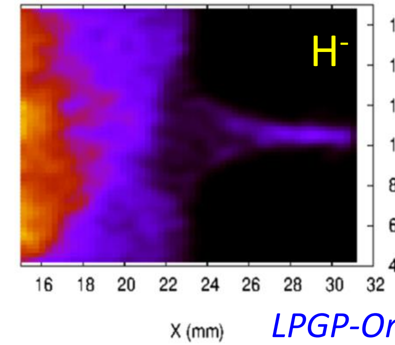
- Plasma Generator
- Flange + Extraction Optics
- Ground electrode
- Einzel lens
- Insulators

ABP-HSL's Cesiated surface Linac4 H^- source:
How does it work ? Who made it possible ?

77 Identified contributors,
8 external institutions
19 TS, PhD & fellows (22 FTE)

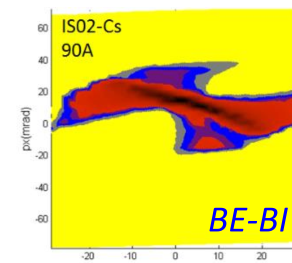


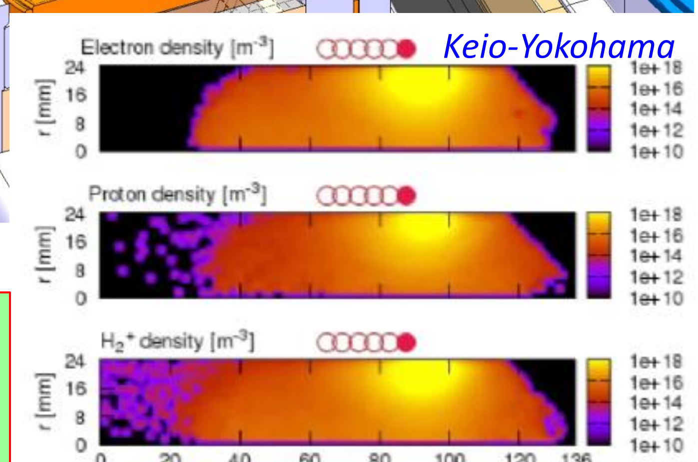


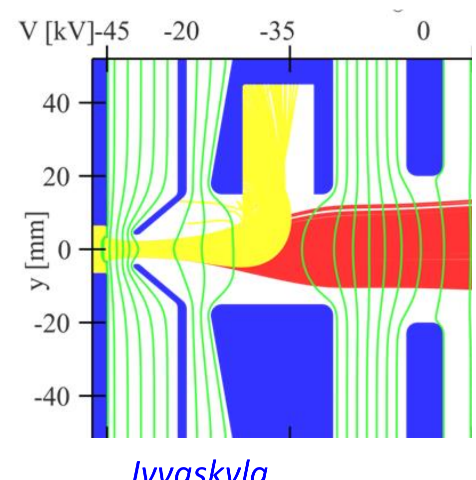


Pulsed HVs
-45 kV source
25 kV puller
10 kV dump

TE-EPC



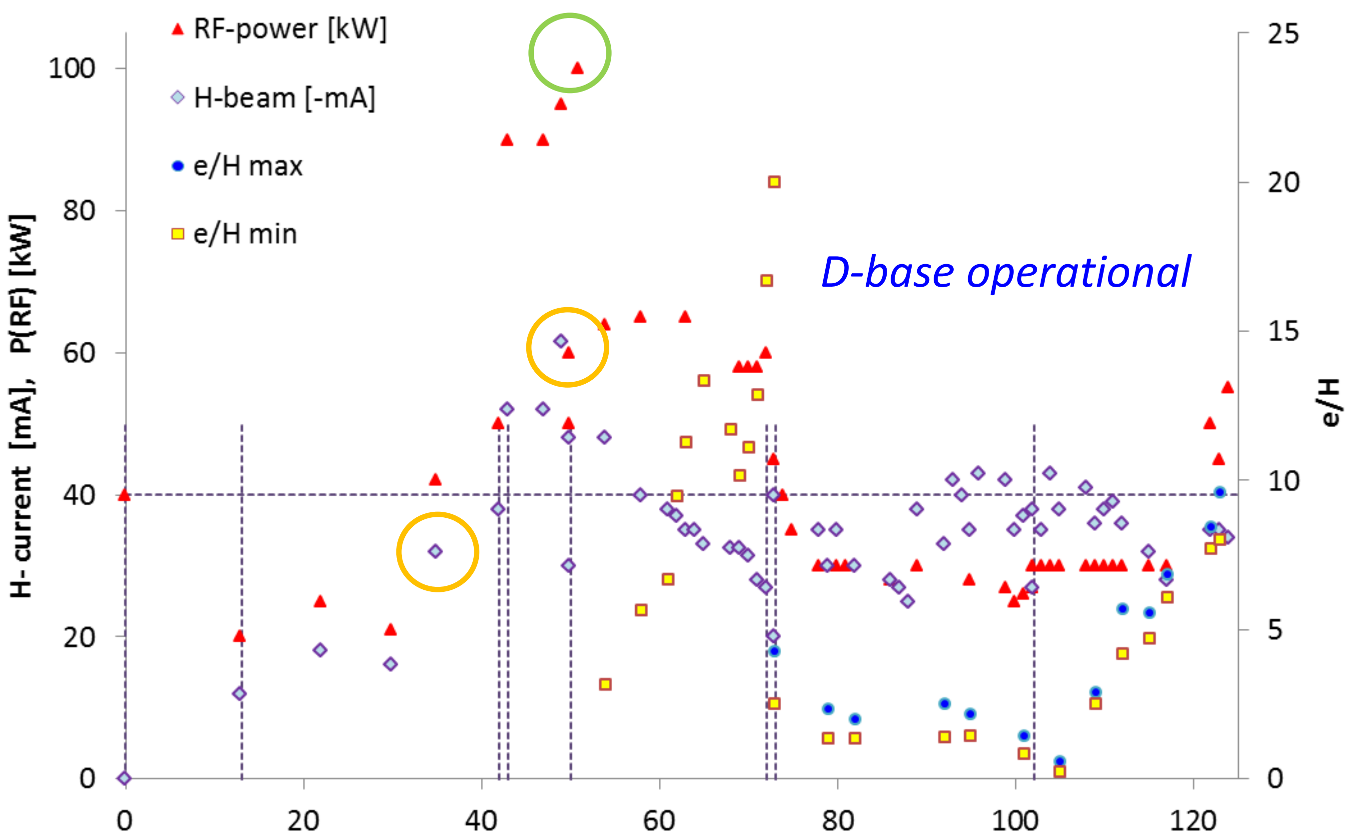




Most physics processes within this H^- source are simulated, now entering engineering phase

IS02 Accumulated experience in conditioning & H^- Production:

- Plasma Generator cond.: 10 days
- Volume production: 30 days
- Cesiated surface: 80 days



Notes on IS02:

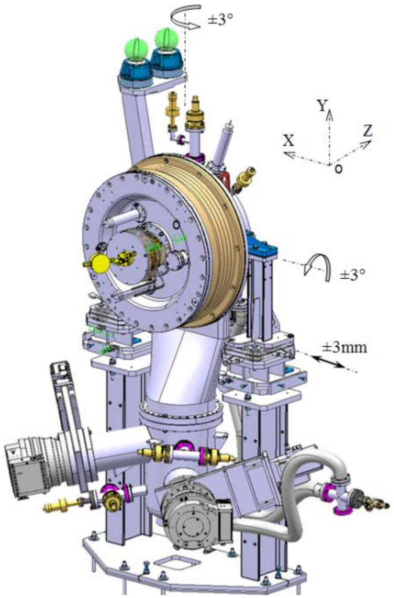
- Volume production 30 mA
- Cesiated 60 mA
- Cs-shortage: Strong anti-correlation between H^- current and e-current
- Improvement of e/H few hours after cesiation
- Holds 100 kW RF

2013 highlights

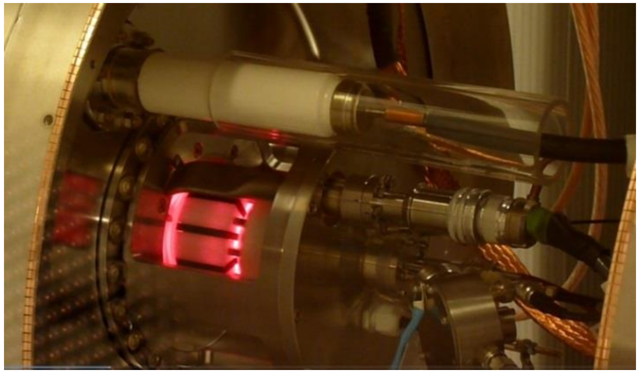
The very tight schedules of the 3MeV TS (mid. 2012) & L4-commissioning (sept.2013) is Matched

Flexible *front end* produced is suited for unprecedented IS-diversity :

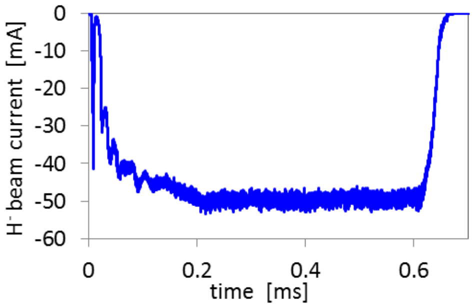
- Direct extraction of H^- from the RF-H_2 plasma volume (Desy *Volume IS **20** mA*)
- Extraction of H^- emitted form from a cesiated Mo-surface after impact of RF-H_2 plasma produced H_0 or p (SNS *Surface IS **50** mA*)
- Extraction from an arc discharge induced Cs-H plasma (BNL's *Magnetron **100** mA*)
- Proton source (p, H_2^+, H_3^+)



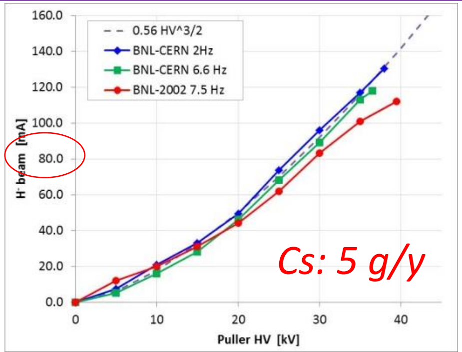
Sept. 2nd 2013: 1st H^- beam in linac4



Dec. 13th 2013: First 50 mA pulse of the cesiated surface prototype



Oct. 9th 2013: Nominal Linac4 beam tested @ BNL, 2 & 6.6 Hz



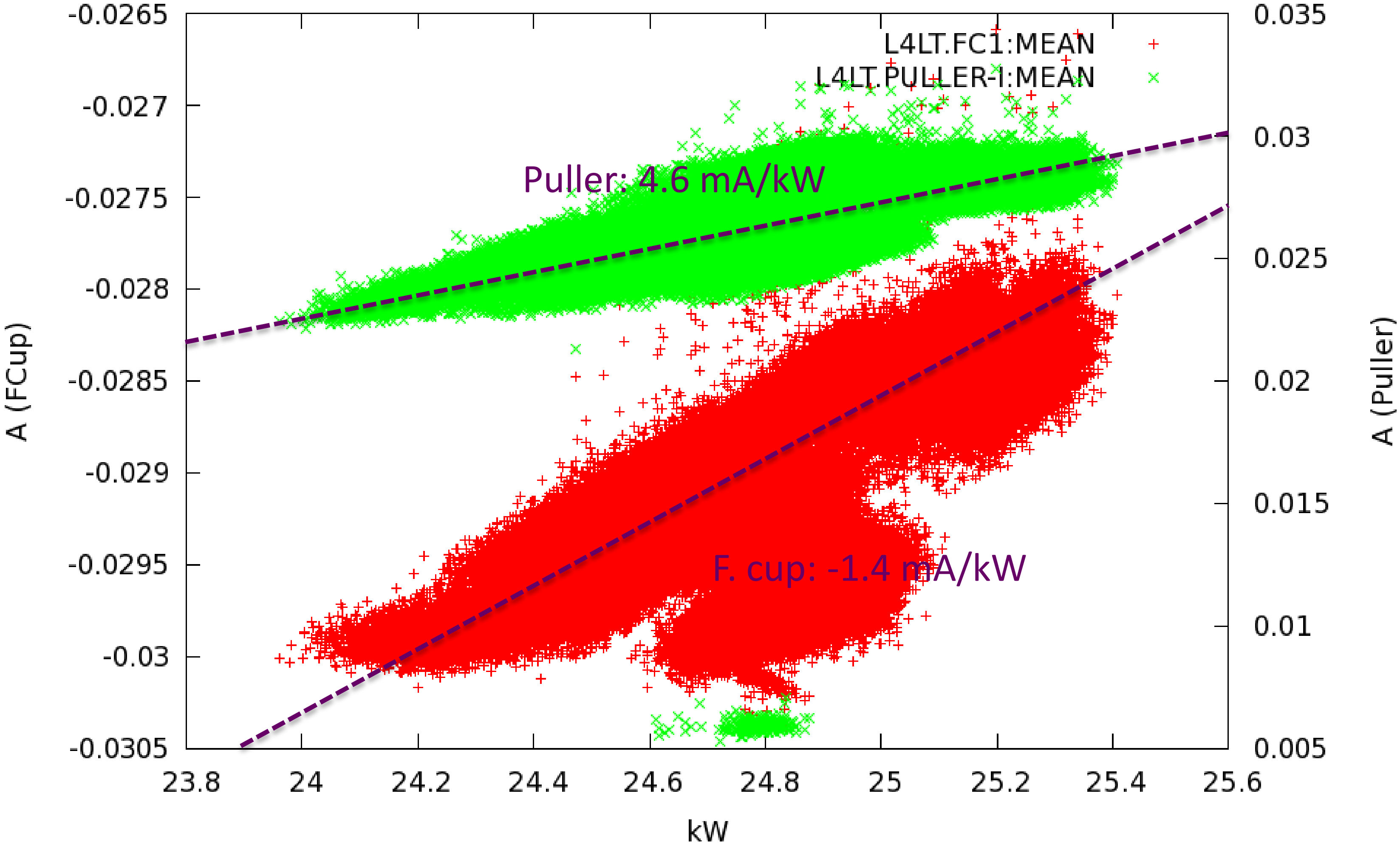
Objectives:
1) reliability   2) p-source   3) beyond 40 mA

2014-15

- Stabilization of the H^- current
- Increasing the availability to 99 % between technical stops
- Optimizing mean time between maintenance
- Demonstrate reactions to breakdowns via timing and operation procedures
- Produce and test a proton source based on existing plasma generator
- Produce and test the On-axis magnetron at 0.8 Hz at the IS-test stand
- *Tilted magnetron with Cs condensation*

CERN Magnetron: APT flow, Deliverables	*Date*
Refurbished magnetron prototype with Temperature-controlled anode (On-axis no-flange)	2014
Beam optics available, Design completed raw material ordered, Arc supply ordered	2015
Production completed tests launched, decision for corr.-QP	2016
Proto flange (+spare Magnetron) available for L4 testing	2017

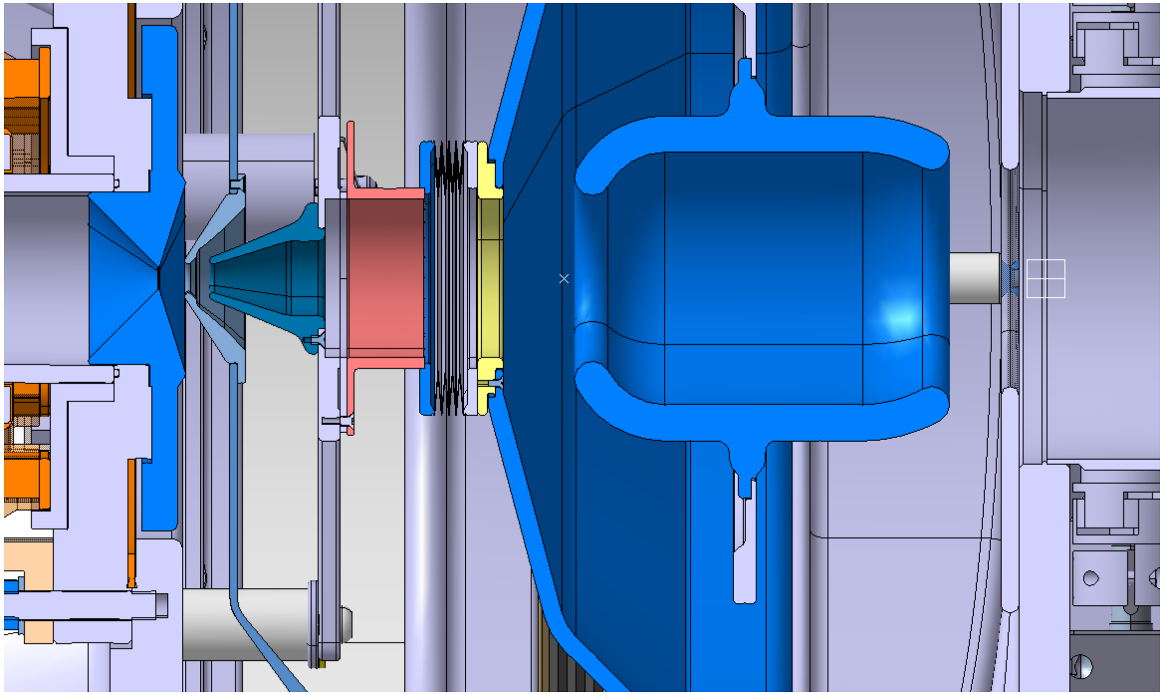
DB-correlations: Puller & H^- beam currents vs. RF-power



The Rf-amplifier is facing the entrance door, its power is correlated to the room temperature

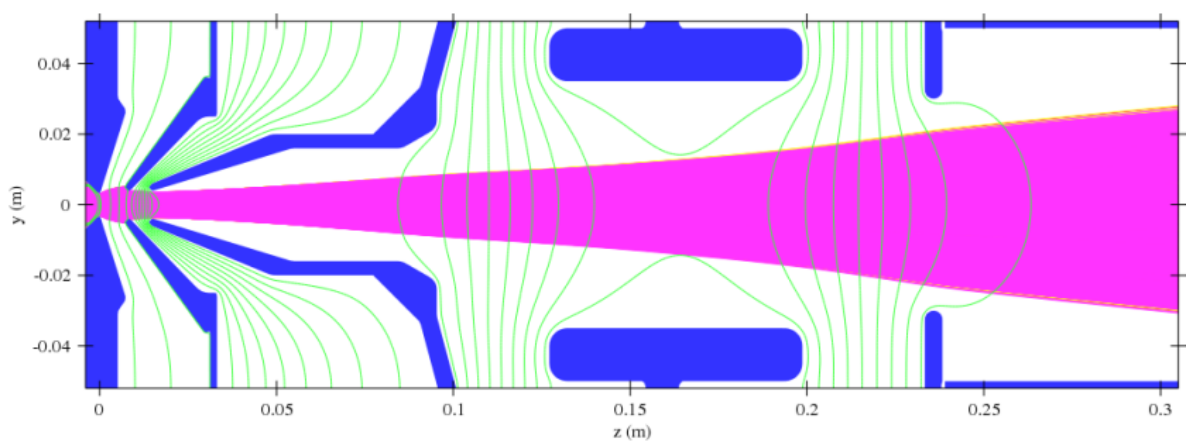
Proton, H_2^+, H_3^+ source

IS01 PG +45 kV



Puller 35 kV

Einzel lens -35 kV

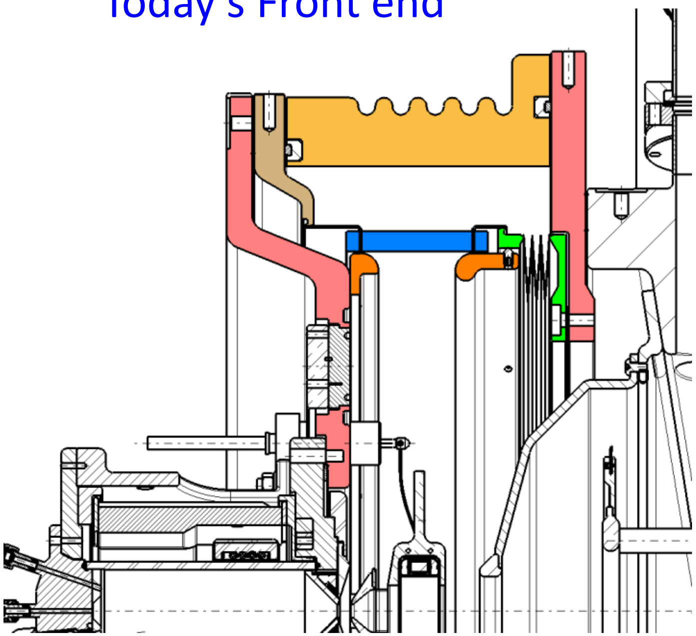


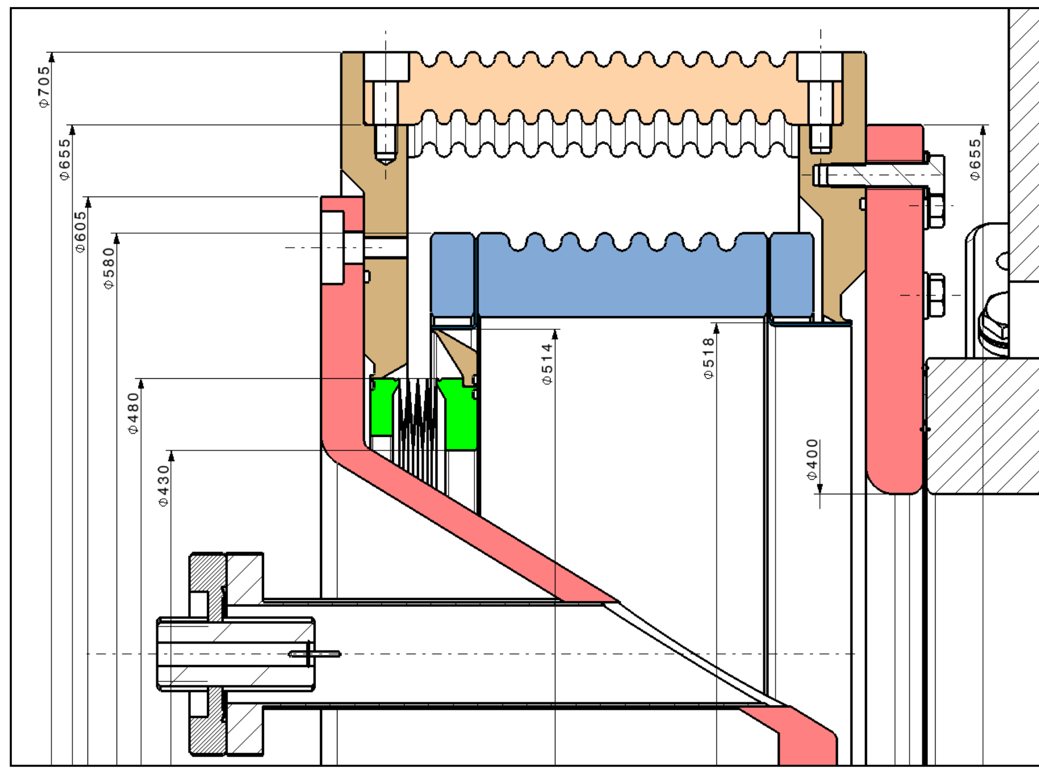
- Boundary: compatible with existing front end.
- Iteration between design and beam simulation on-going

Modification of the Is-Front end: Large ceramic insulator

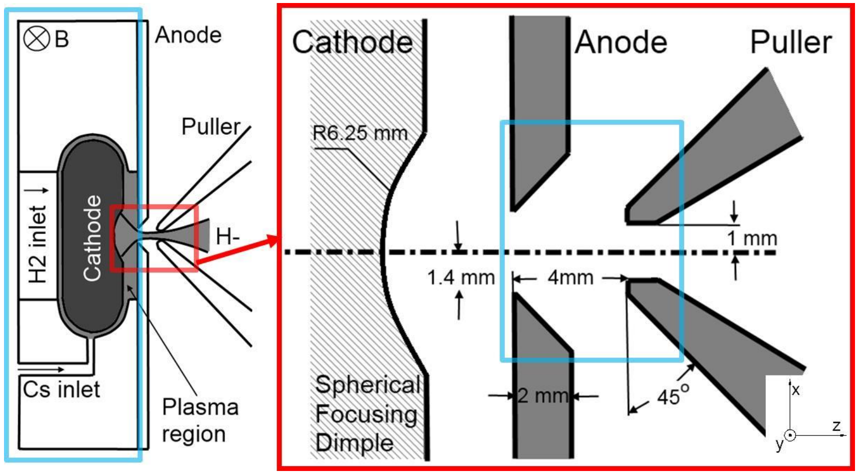
Delivery:
Ceramic insulator: March-April 2015
Deep flange
Mtl. End Nov,
Machining end January 2015

Today's Front end



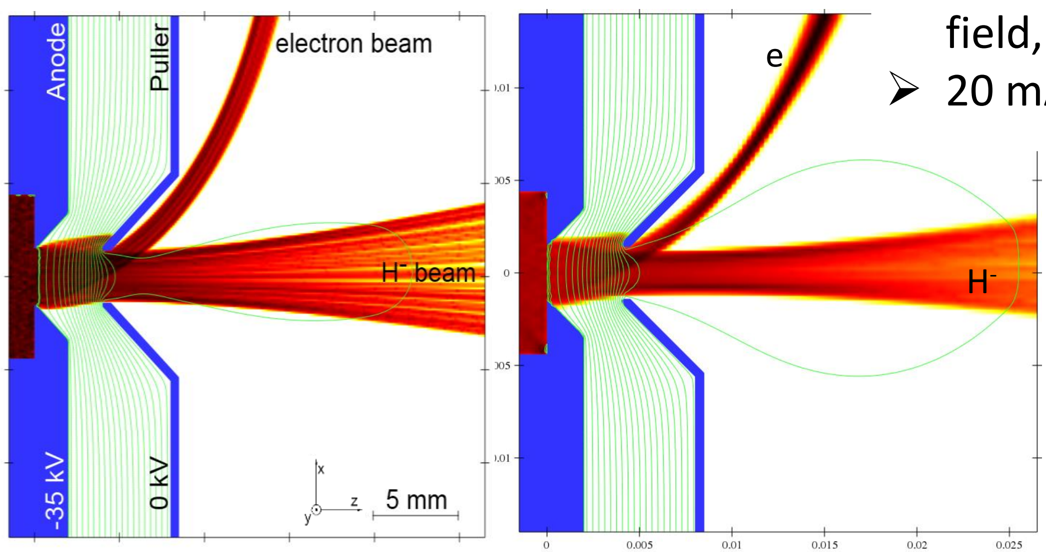


Simulation of BNL's Magnetron with IBSimu



-35 kV

-45 kV



IBSimu settings:

- H^- beam current density is set to 1.6 A/cm2, resulting in a current of 100 mA.
- Electron to H^- ratio = ½ (50 mA)
- A 3-D magnetic field map created in OPERA from the known magnet geometry and adjusting the field to a peak of 900 G.

Results:

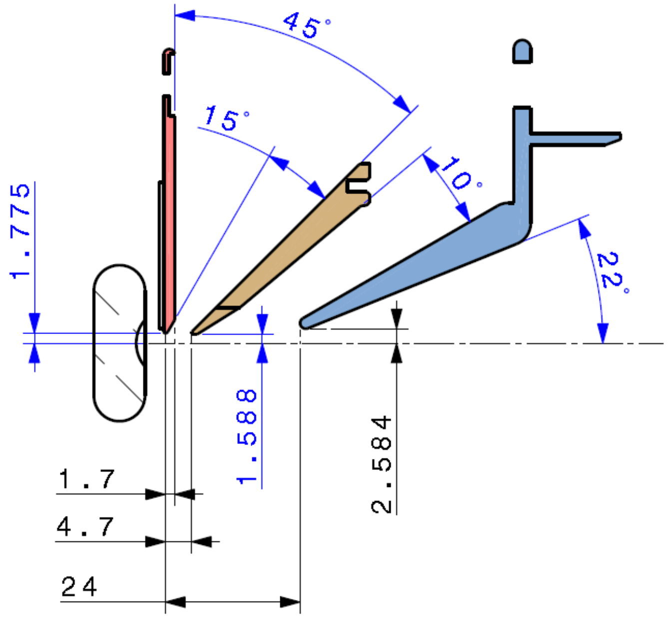
- The H^- beam is transported through the puller at close to 100% efficiency.
- 60 % of the co-extracted electrons (30mA), which trajectories are bent by the magnetic field, are dumped on the puller electrode tip.
- 20 mA e-beam passes the puller electrode.

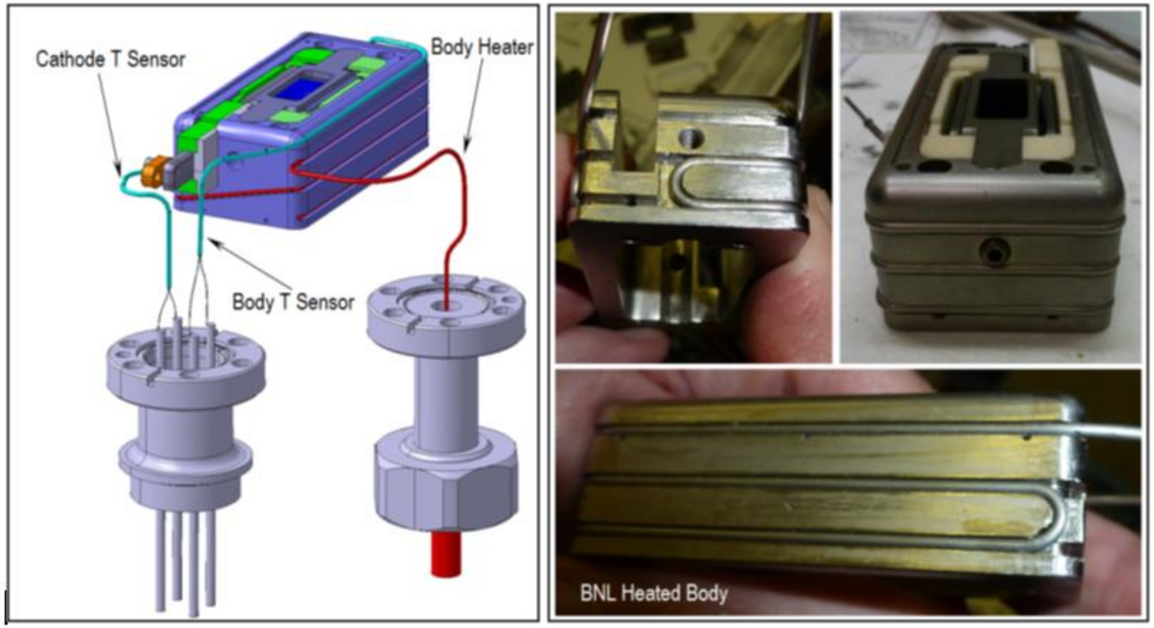
1) J. Lettry, J. Alessi, D. Faircloth, A. Gerardin, T. Kalvas, H. Pereira, and S. Sgobba, Investigation of ISIS and BNL ion source electrodes after extended operation, Review of Scientific Instruments 83, 02A728 (2012).
2) H. Pereira, J. Lettry, J. Alessi and T. Kalvas, *Estimation of Sputtering Damages on a Magnetron H^- Ion Source Induced by Cs^+ and H^+ Ions*, *AIP Conf. Proc.* 1515 (2013) pp.81-88.

Magnetron: BNL-test Post mortem, Status and outlook

https://edms.cern.ch/document/1352150/1

2 stage extraction: Puller at 30 kV





- Heated Anode body mandatory for 0.8Hz operation designed and ready for production
- W-tip and broken isulator ceramics will be replaced.