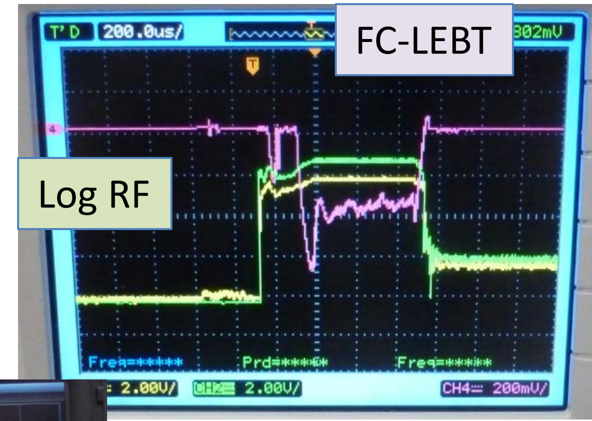
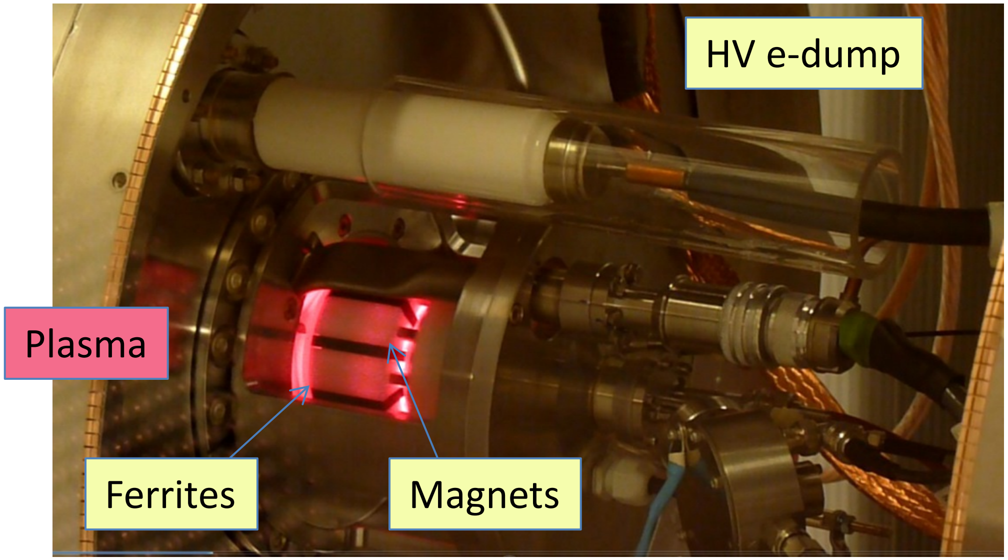

Cs-Laboratory
357
Welcome to CERN
Production
Metrology
72
102
Cleaning
Linac4 ion source
400
6
Controls
Magnets
Ion source test stand
152
9
Assembly PG
169
Leak test
Route RUTHERFORD
Route WEISSKOPF
Route BECQUEREL

Linac4 ISWP review, Nov. 14th 2013
Overview and status

- Short introduction
  - Deliverables as defined in the June 2010 Review
  - Modification to the ISWP boundary conditions
- Status
  - Ancillary equipment, adaptability in the design
  - Challenges / findings
  - Ion source prototypes test results
  - Simulation / Publications / reports
- Outlook
  - From project WP to operation
    - *Towards 98% reliability …*

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





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

J.P. Corso, J. Coupard, M. Wilhelmsson, F. Fayet, D. Steyeart, E. Chaudet, Y. Coutron, A. Dallocchio, P. Moyret, S. Mathot, Y. Body, R. Guida, P. Carriè, A. Wasem, J. Rochez, D. Aguglia, D. Nisbet, C. Machado, N. David, S. Joffe, P. Thonet, J. Hansen, N. Thaus, P. Chigggiato, A. Michet, S. Blanchard, H. Vertergard, M. Paoluzzi, M. Haase, A. Butterworth, A. Grudiev, R. Scrivens, M. O'Neil, P. Andersson, S. Bertolo, C. Mastrostefano, E. Mahner, J. Sanchez, I. Koszar, U. Raich, F. Roncarlo, F. Zocca, D. Gerard, A. Foreste, J. Gulley, C. Rossi, G. Bellodi, J.B. Lallement, M. Vretenar, A. Lombardi

Thank you all ☺

Students & Fellows

Matthias	Kronberger	SLHC-Fell.	CERN
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

L4IS-historical Introduction

- 2005: Decision to copy the DESY RF volume source (reliable, no Caesium)
- 2008: SLHC: EU-project towards a plasma generator upgrade from Desy to 50 Hz, 100 kW 2MHz RF driven 5% duty factor.
- 2009: DESY-type source completed, equipped with CERN power supplies and RF generator.
- May 2010: tests show that it cannot operate at 45 kV nominal voltage. The 45 keV co-extracted electron beam is focussed; it vaporizes the electron dump and induces HV-sparks.
- End 2010: launched crash programme to build an improved source of CERN design operating in volume mode but upgradable to surface (Cs-based) production.
- March 2011 completion of the SLHC WP.
- June 2011 Linac4 IS-review https://indico.cern.ch/conferenceDisplay.py?confId=129870

The Linac4 Ion source work package (ISWP-2011) was tailored to meet:

- The 3 MeV test dead line
- The commissioning with beam in the tunnel

Implies: Parallelized design-simulation-purchase of raw material

WPIS Time table

Date	L4-IS 3 MeV test stand	L4-IS -tunnel Bldg. 400	L4-IS upgrades	sLHC Plasma Generator test stand	H- IS test stand	Cs Laboratory
2010			Minimal dump, protons	RF and plasma diagnostics		Design
2011	protons, ~~*mini H- pulse*~~		**Rev. world's IS** **Rev. WPIS June**	Gas Dynamics, Upgrade to HT	Design, production	
2012			Multistage and e- dump		Test and commissioning	
2013	Move to L4-building 400	Commissioning in L4 building	New HT-supply & extraction		Operation	Surface source Proto.
2014		Operation, Upgrade, control	Spare parts		Operation	Test of prototype
2015					Move test stand to 152	

2011 Review

3MeV & L4 milestones vs. ISWP actions

	date	L4-milestone	ISWP action
3MeV	April 2012	3MeV test Protons	Protons
	May-Aug 2012	LEBT June 2012 H^- beam July 2012	New front-end installation and commissioning Installation of proto #1 at the 3MeV test stand
	Sept-Dec	3MeV test H^-	H^- 30 mA
IS-test stand	Oct-Dec 2012		Ion source test stand commissioning
Linac4	Jan 2013		Installation source in L4
	Tbc.		Test IS exchange procedure (proto #1)
	Dec 2013	Decision to connect	
	Feb 2014		Installation of proto #2 in linac4
	April 2014	L4-160 MeV commissioning completed	20 mA required at the end of the linac4 (40 mA at the source)
	… 2015	LSS2 or long MD	Installation of proto #3

WPIS H^- Ion source: staged approach, 2 units each + spare

	#1 Volume source	#2 Surface source	#3 Magnetron
Operational experience Achieved H^- current	DESY 30 mA	SNS 50 mA	BNL 80 mA
Plasma Heating process	2 MHz RF Ext. antenna	2 MHz RF Int. & Ext. antenna	Arc discharge
Cesiation		Cs-chromate Single deposition:	Cs metal Constant flow
Cs-Oven test stand		Nov. 2011	Nov. 2011
Electron / H^- ratio	10-100	10	0.5 - 1
357 Plasma test stand (operational)	→ Sept. 2012	2013	2014-2015
3MeV test stand (until Dec-2012) (operational, Bldg. 152)	Jul. 2012- Dec-2012		
IS test stand (Bldg. 357)		2013	2014
Linac4, building 400	Jan 2013	Oct 2013	2015

Summary of the L4-WPIS changes

- Delayed move into the tunnel, RFQ tests in 152 until June 2013.
- Cancellation of the DESY source 45 kV proton commissioning of the RFQ
- Decision to not build an ion source test stand in building 357.
  - Should allows commissioning of the source and LEBT equipment in the tunnel before moving the RFQ
  - Saves the 2015-foreseen move of the test stand from 357 to 152
  - The tunnel is not the best place for IS-R&D: effectively no IS-test-stand between January and July 2013 but beam delivery to RFQ commissioning.
- Decision to consider IS-03 (Magnetron) as an option "*to be confirmed at a later stage*".
  - To minimize delays if the option would be selected, decision to maintain a minimal task with the following deliverables:
    - Insource BNL's drawings and produce a 3D Cathia model and production drawings
    - Produce a magnetron plasma generator and test it at BNL

Status

14th November 2013

1) Repaired insulator + 1 bar SF6
2) Mount backup option (DESY plasma generator) on IS01 Front end + extraction & e-dumping system

12 mA 45 kV H^- beam available:
@ IS-TS Nov. 12th 2013
IS02 before cesiation *tbc*.

15 mA 45 kV H^- beam available:
@ 3MeV TS since February 2013
@ Linac4 since September 2nd 2013
IS01 + DESY PG

				L4-ISWP		
	drawing ***SPLNFHR ...***	_	D	E	F	G
	units produced :	DESY	SLHC	IS01	IS02	*IS03*
Design / Eng. / Prod.	Frontend, support Pumping port	o		2	-	-
	Main insulator	o		2	x	x
	Extraction optics	o		2	x	x
	Plasma Generator	1	o	2	2	1
	Flange	o		2	2 + x	x
	RF-Transfo-Matching	o	o	2	-	-
	Handling-gear	o		1	x	x
IS-TS 152	IS-test stand 152	o		1		
	LEBT	o		1		
	Photometry Spectroscopy		1	1		
	RF-Amplifier 100kW 50Hz		1			
L4-IS 400	L4 faraday cage 400			1		
	LEBT			1		
	RF-Amplifier 100kW 2Hz	1				
Ancillaries	Pumping system	o		2		
	RGA		1	1		
	Pulsed HV + cw Einzel			2		
	Arc Discharge					x
	H2-distribution IS+LEBT			2		
	Cs-Oven				2	x
	Cs-test stand 357		Optics TS	HV + Piezo	1	
	Mag-meas. Unit 6		1			

o : obsolete
x : mandatory work

Produced and sucessfully teste
Produced being tested
Partially/not yet designed
Produced but Failed

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

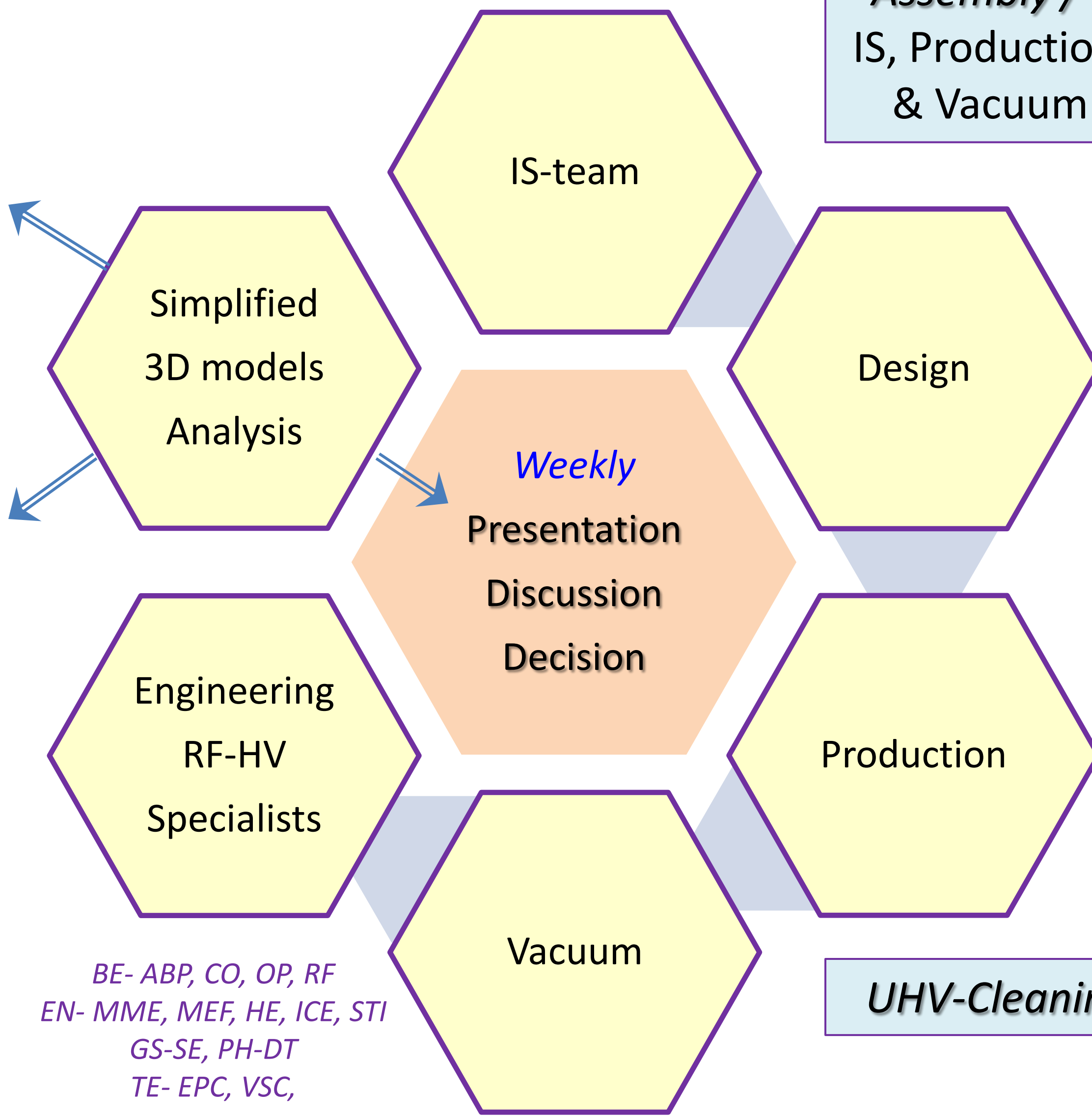
- Plasma heating
- Light emission

Collaborations

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

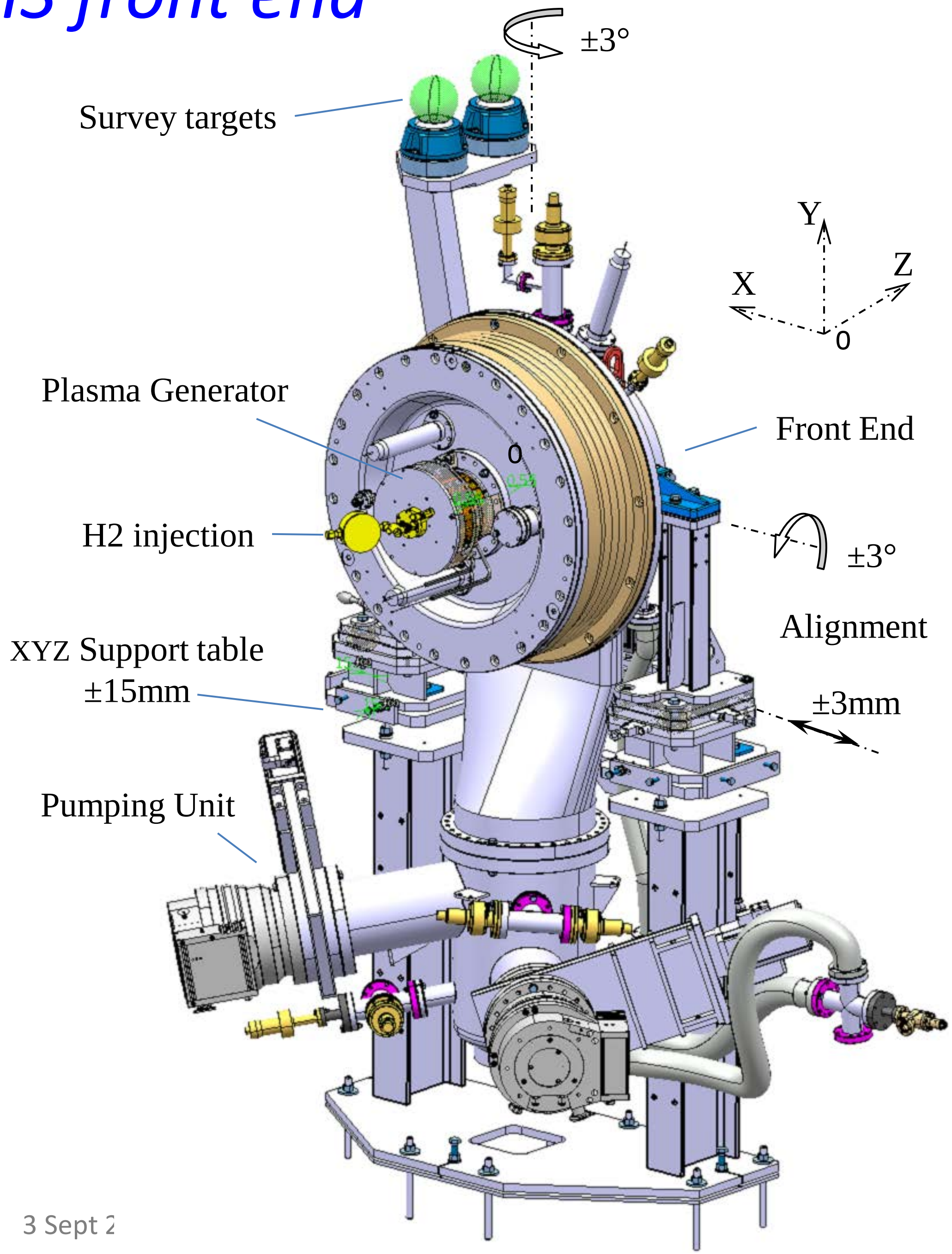
Assembly / leak test

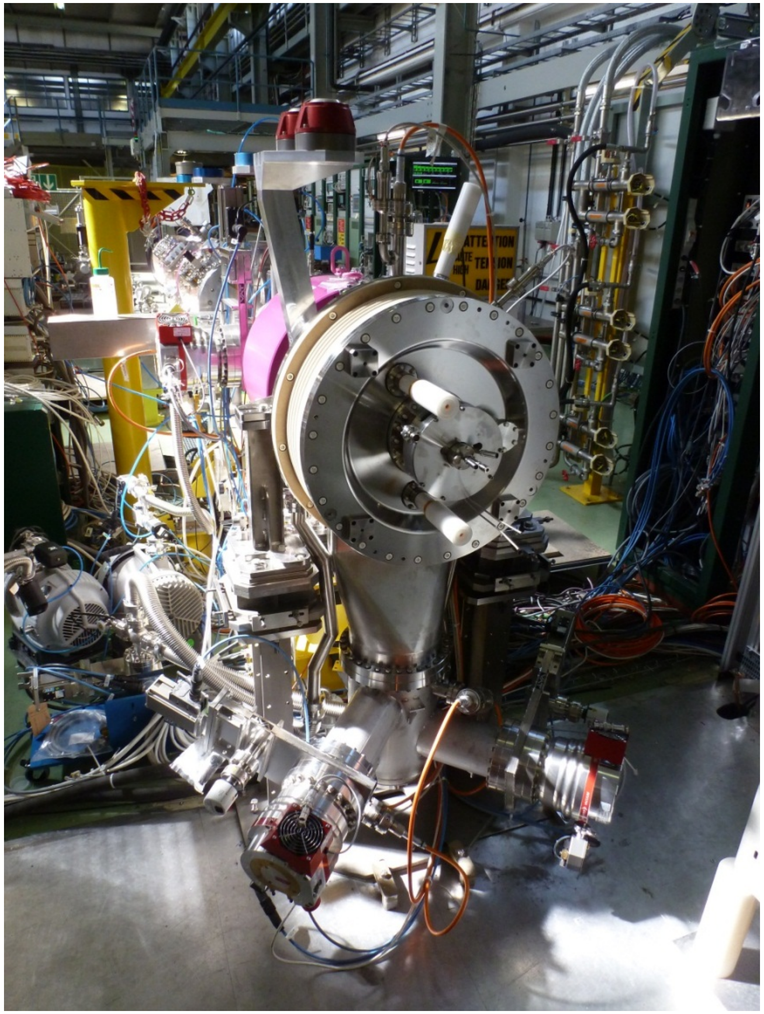
IS, Production, Design & Vacuum -teams



UHV-Cleaning

IS front end





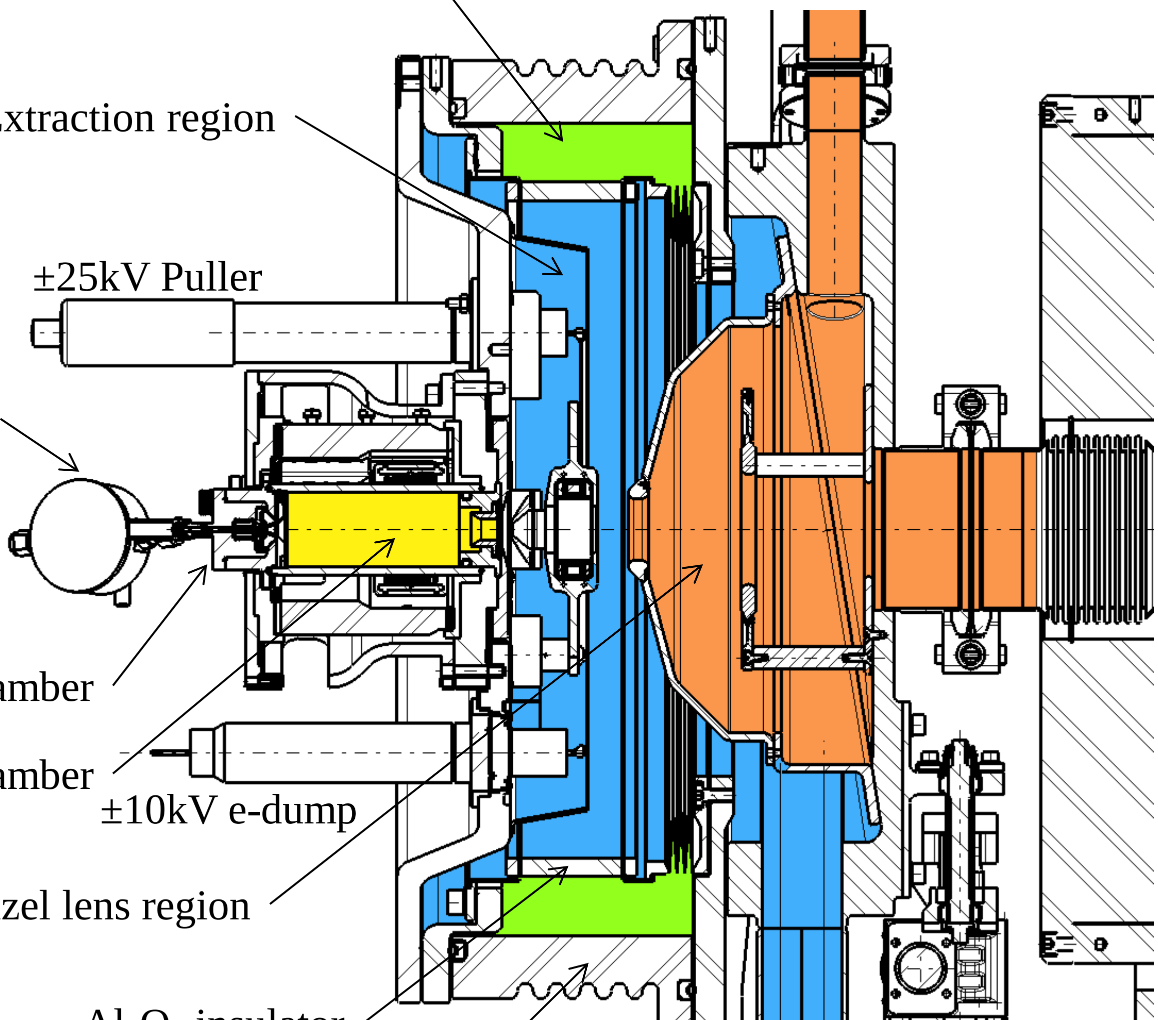
- Alignment table (Survey)
- Beam based alignment options:
  Horiz. displacement & dϕ, dω

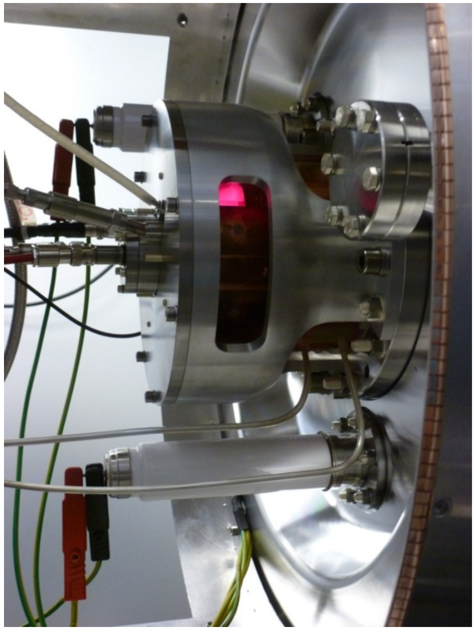
Quick exchange in case of failure:

- Pumping port
- Front end

“Plug & play” Plasma Generator and beam formation region

IS01





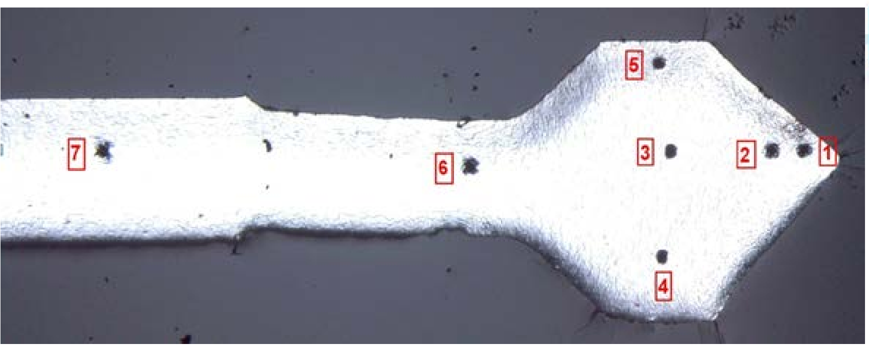
H_α light diffusing through
The Al_2O_3 Chamber

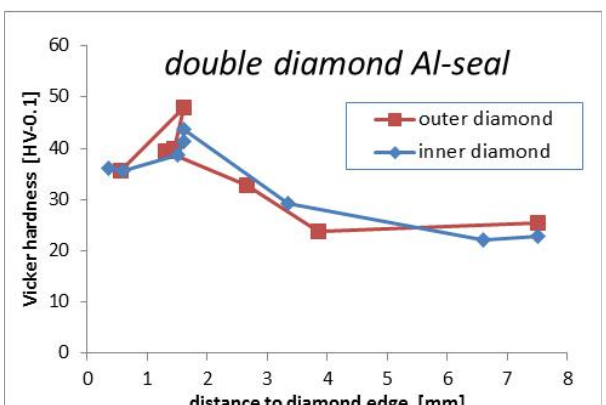
Exchangeable:

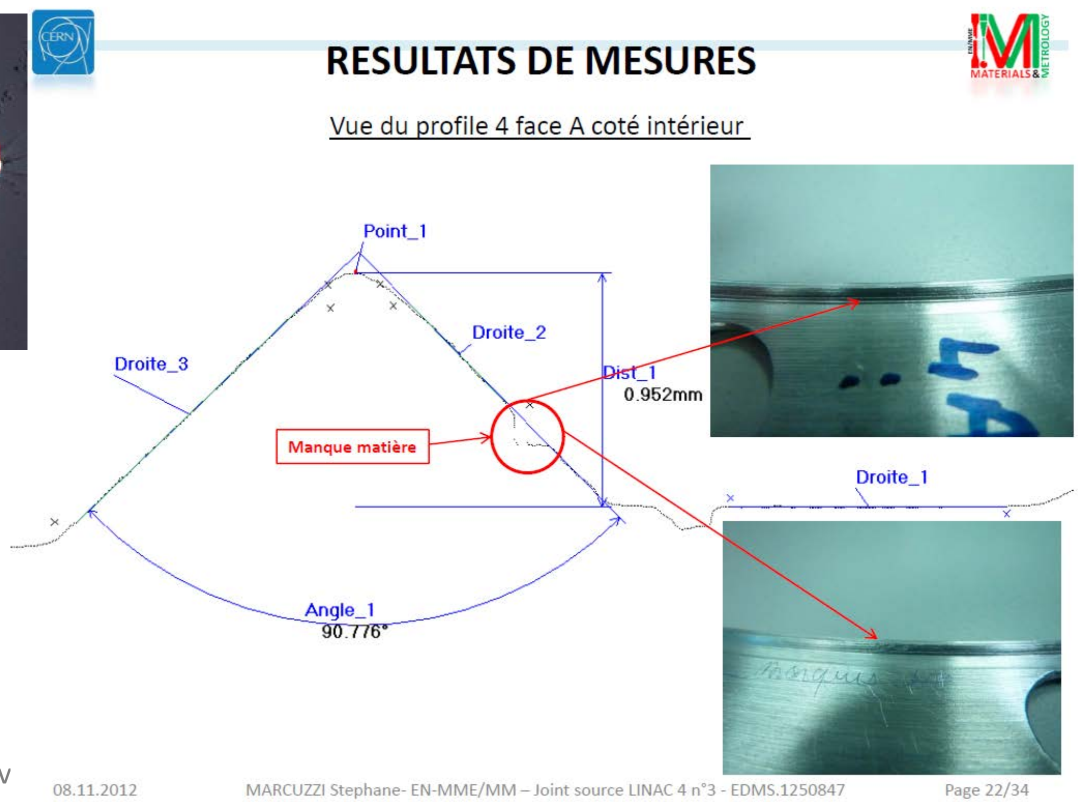
- Plasma Generator
- Flange + Extraction Optics
- Ground electrode
- Einzel lens
- Insulators

Al-2-diamond sealing issue

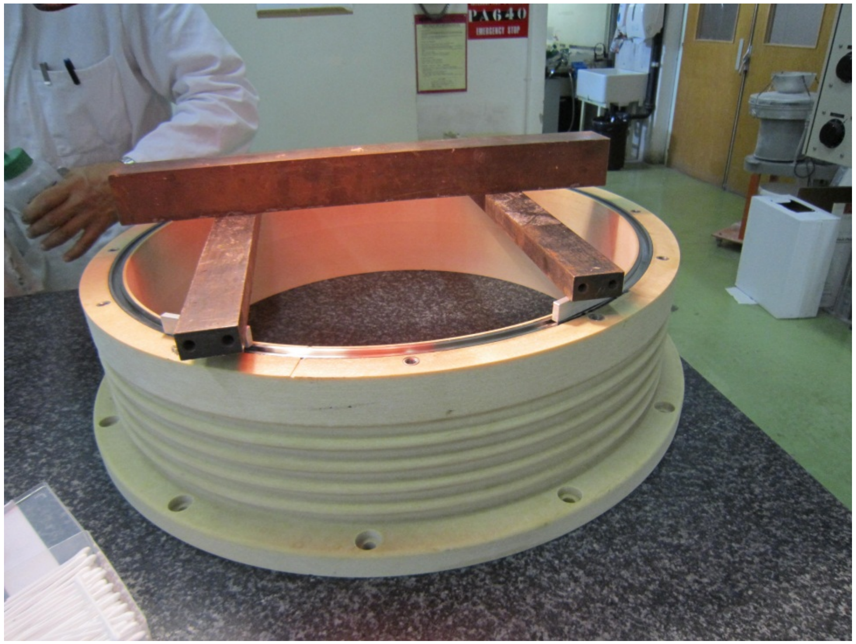
- *Apart from 2 units all other are non conform.*
- Other producer failed → *Successfully achieved by CERN's central workshop*
- Test with double helicoflex under way
- Investigation of Front end modification
  - Double knifes for Cu excluded (2×400 N/mm)
  - Groove for helicoflex or O-ring + knife edge Al

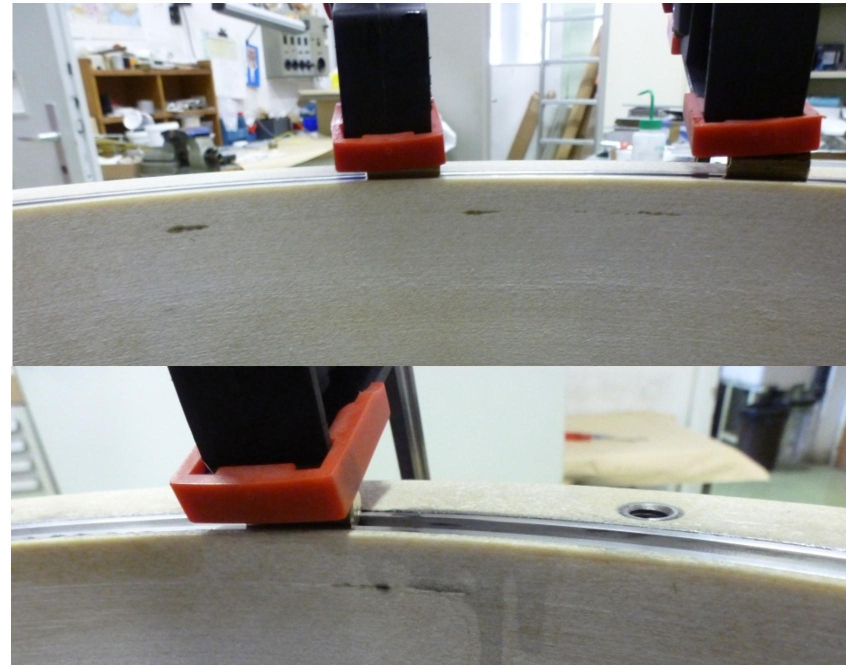






Epoxy-Glass fibre (EPGM) Insulator



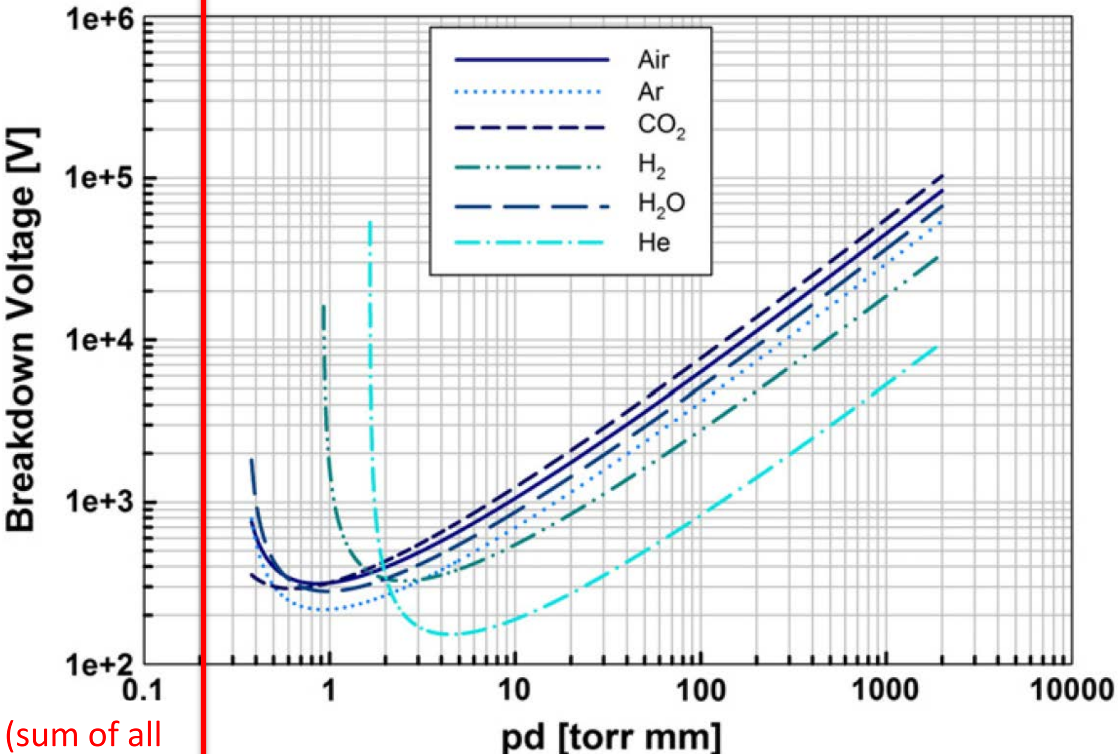


Lessive NGL 17.40 spec. ALU III avec ultrasons pendant 5 h
Rinçage avec eau déminéralisée + alcool
Séchage à l'air comprimé
Etuvage à 60 °C.

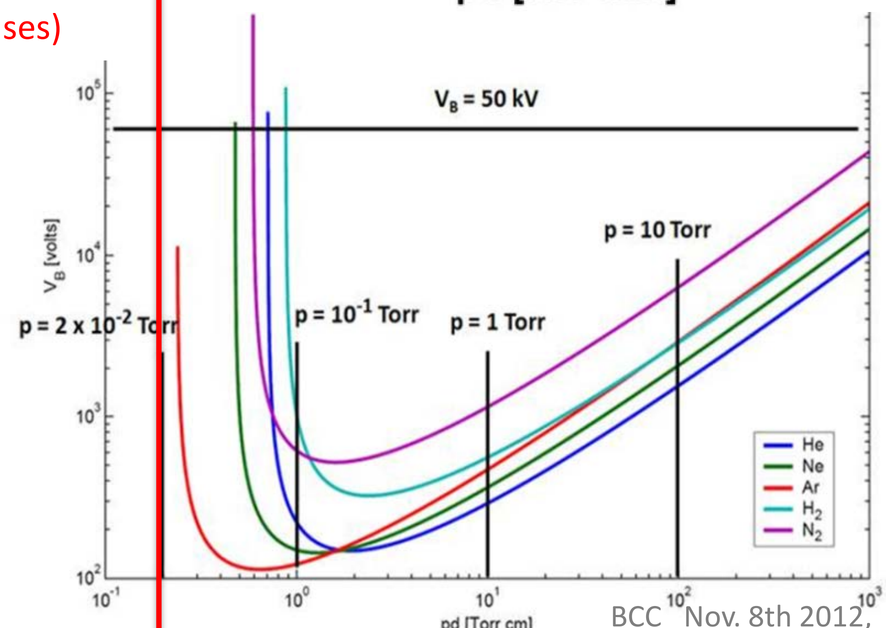
Outgassing & limited pumping speed:

- Received leaky, was sent back for removal of the SS-groove.
- Very crude repair generated cracks in epoxy glued at the factory.
- SS-grooved tightly glued in house.
- $2.1\ 10^{-2}$ mbar in the secondary vacuum instead of $\sim 10^{-5}$
- Paschen criteria checked before HT tests,
- Outgassing rate: O($2\ 10^{-2}$) mbar l/s **>>** RGA measurement needed

Secondary pumping: RGA on EPGM samples Pashen curves from representative gases



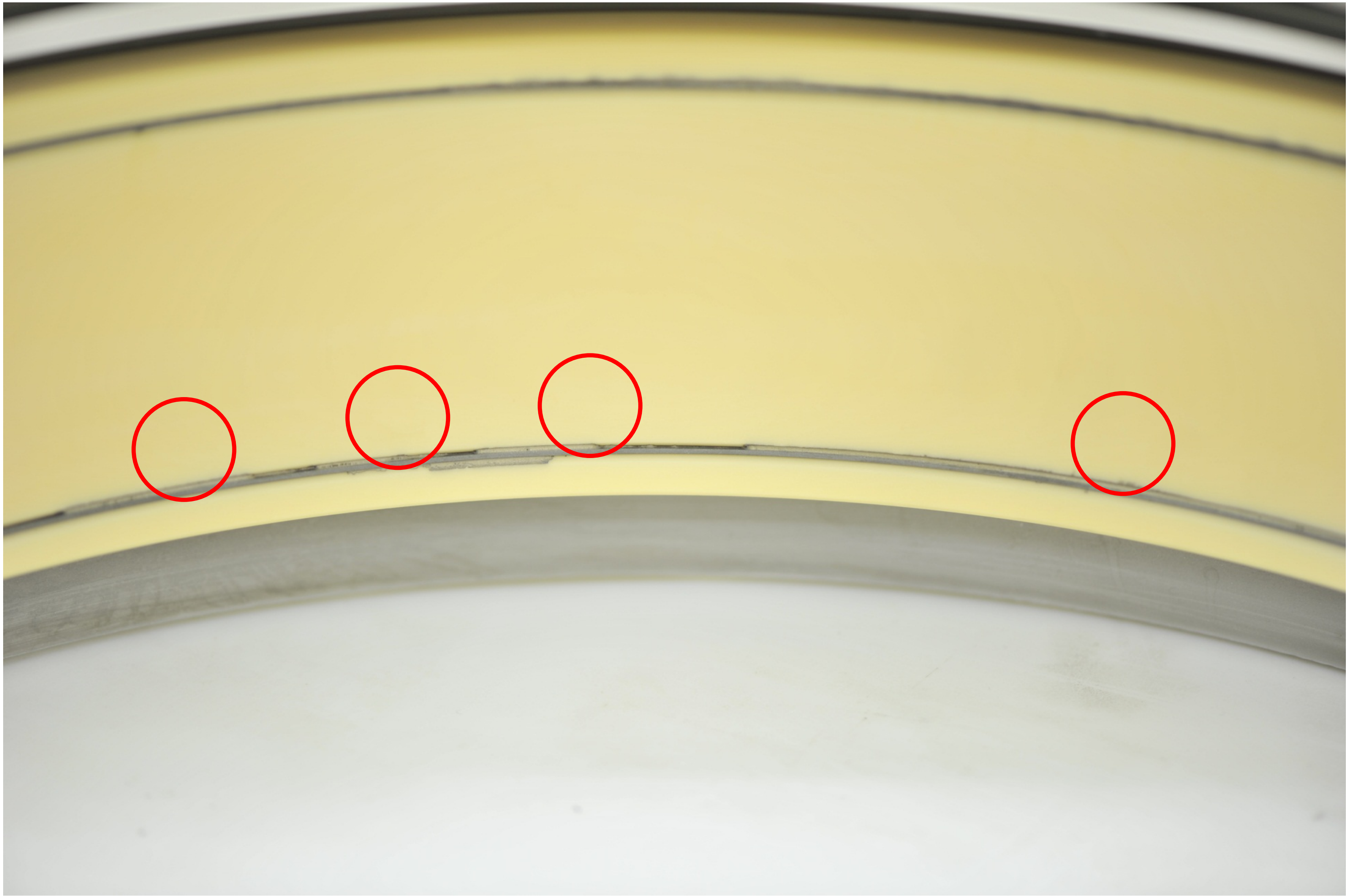
pd (sum of all gases)



! Very Close to H_2O breakdown conditions
→ *Successfully solved via 1 bara SF_6*

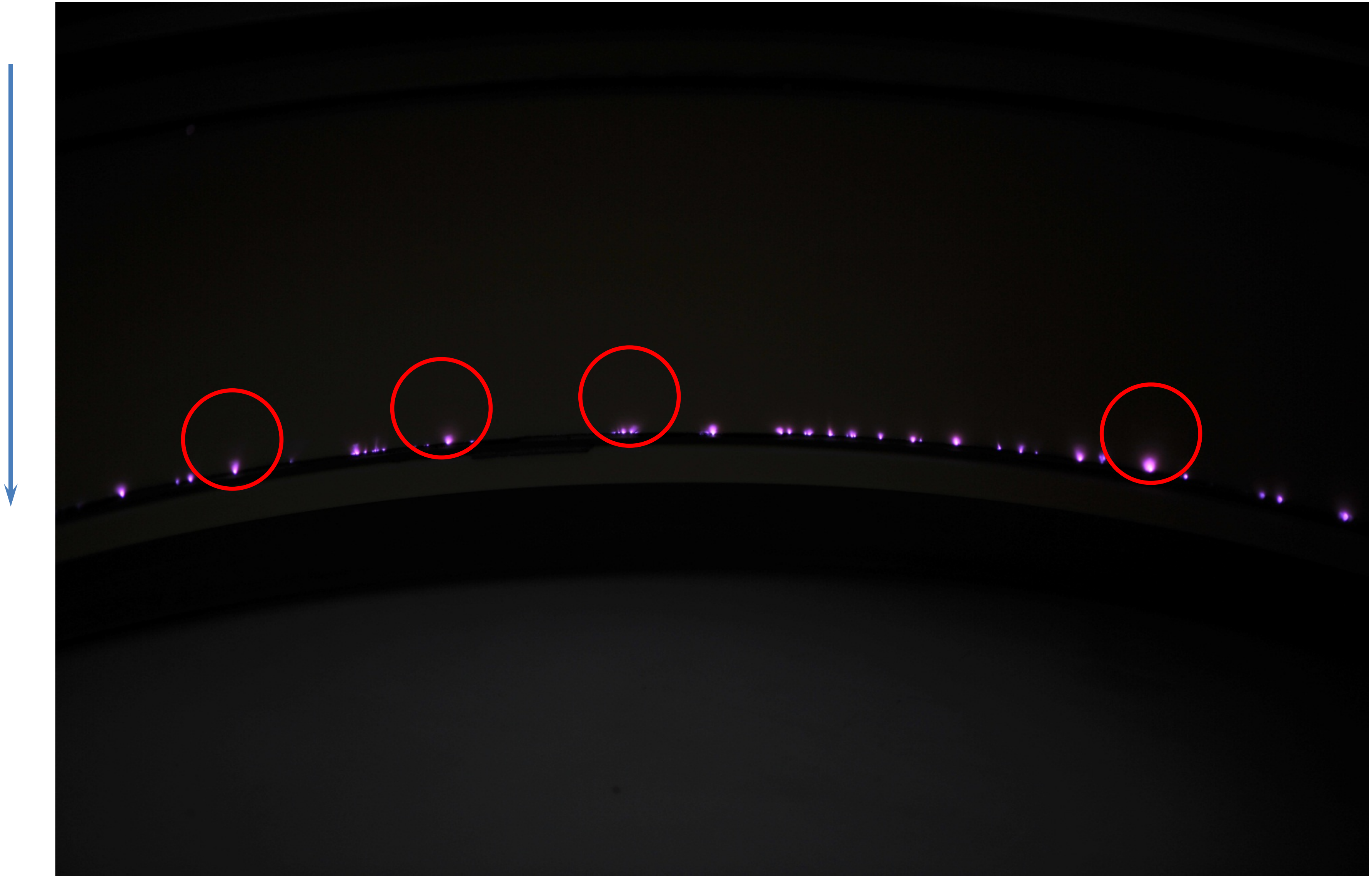
		Sample 1	Sample 2	
7 Highest /all		98.2%	98.8%	
	m			
H	1	8.20E-08	1.93E-07	1.6%
H2	2	3.24E-08	6.13E-08	0.6%
O	16	1.13E-07	3.88E-07	3.0%
OH	17	6.77E-07	2.95E-06	21.6%
H2O	18	2.15E-06	9.85E-06	71.3%
CO-N2	28	1.60E-08	6.24E-08	0.5%
CO2	44	5.46E-09	2.79E-08	0.2%

Al2O3 main (45 kV) insulator



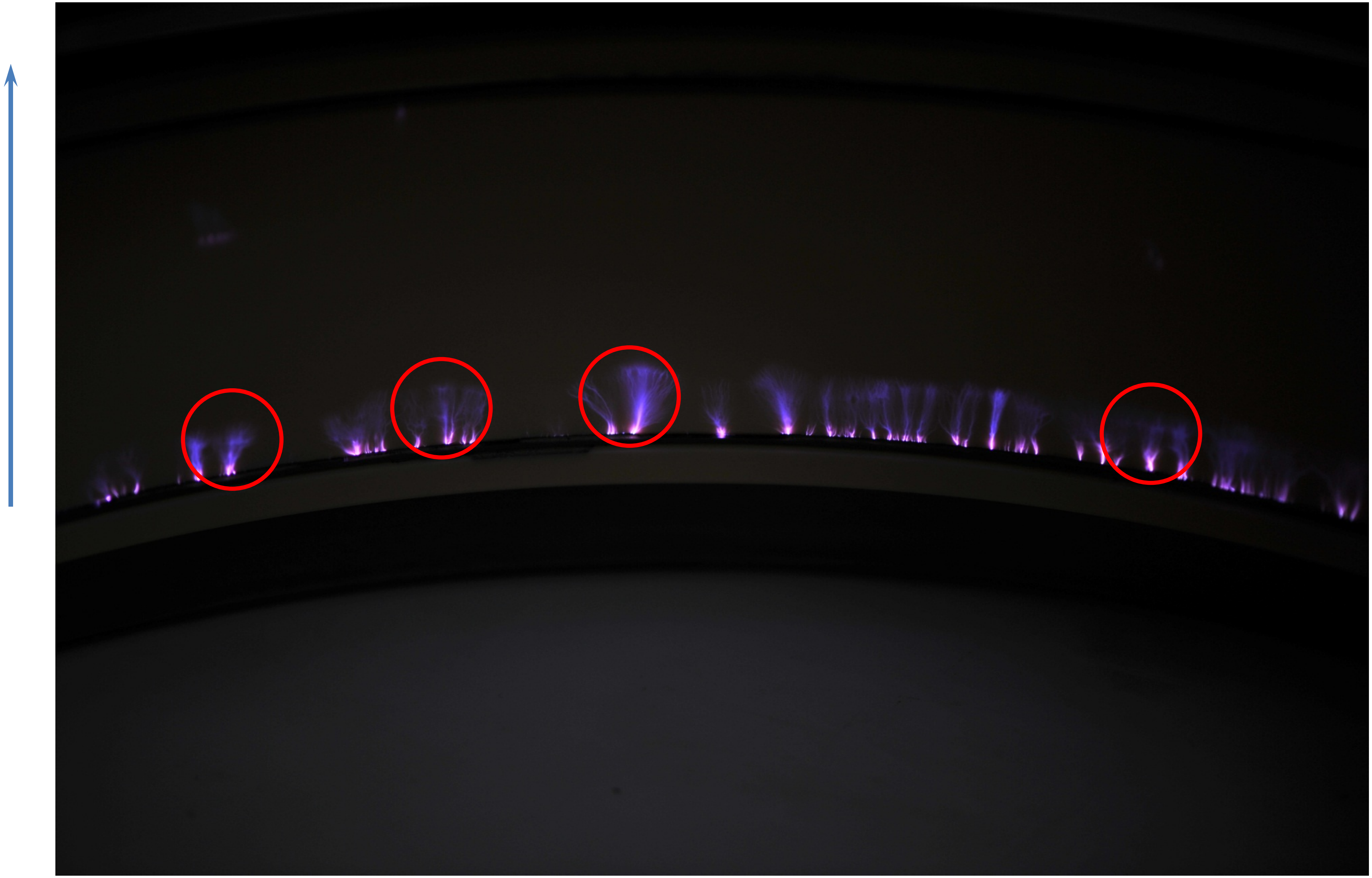
H⁻ source polarity

5 kV/cm

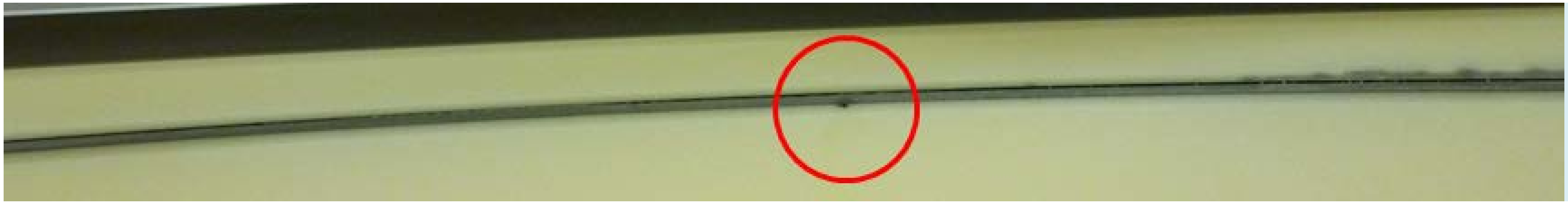


Proton source polarity

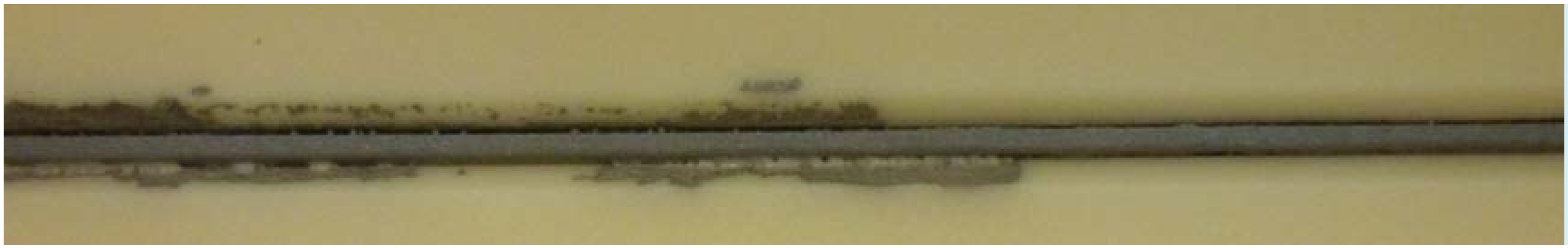
5 kV/cm



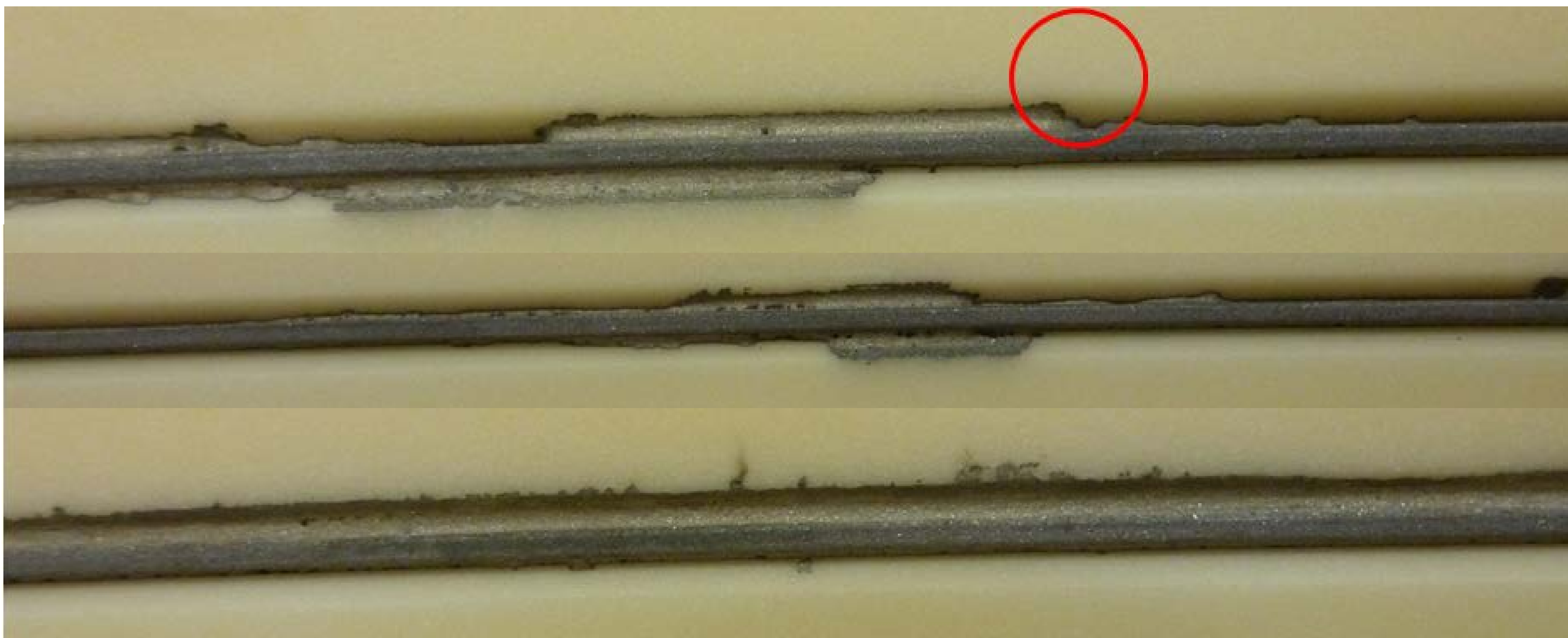
Active brazing Al2O3 insulator



Bellow Int.

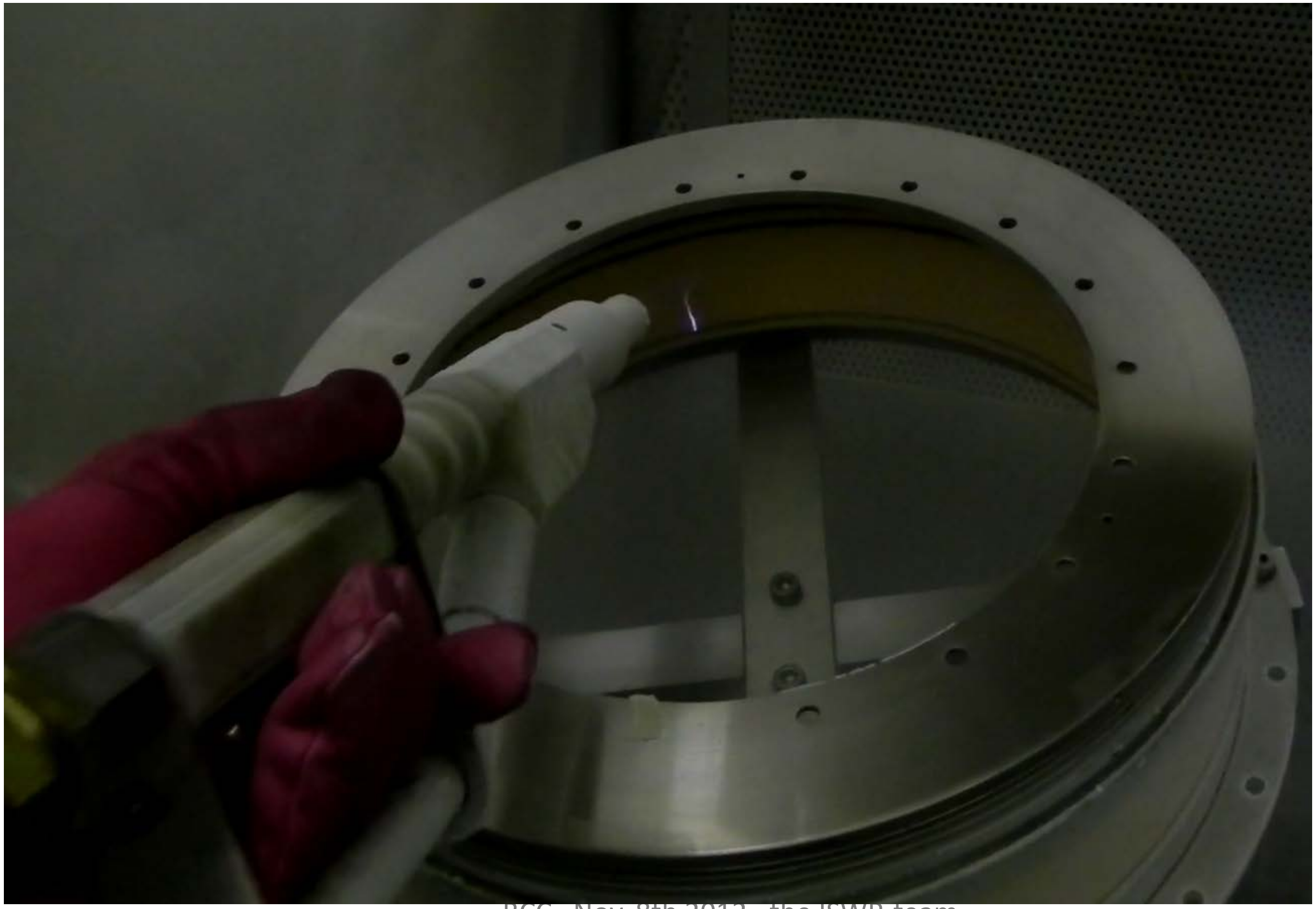


Bellow ext.

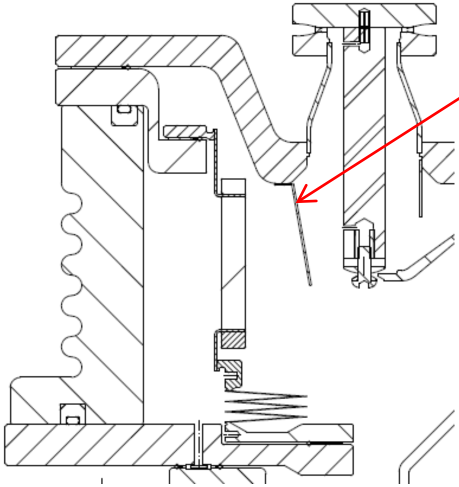


Dry ice cleaning of Al2O3 insulator

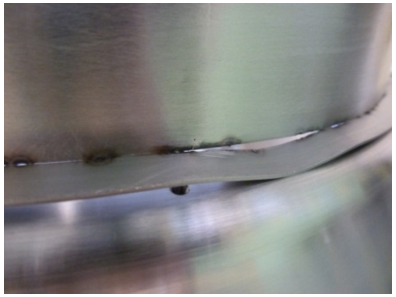
Time evolution of the HT drain current could be related to air reactive contamination.
Cleaning with alcohol reduced drain current
CO_2 dry ice (3mm beads) blasting under Nitrogen followed by drying at 60 deg.C.
The 30 kV HV tests then showed a non-measurable current drain (<0.1μA).
Surface contamination existed and is likely removed



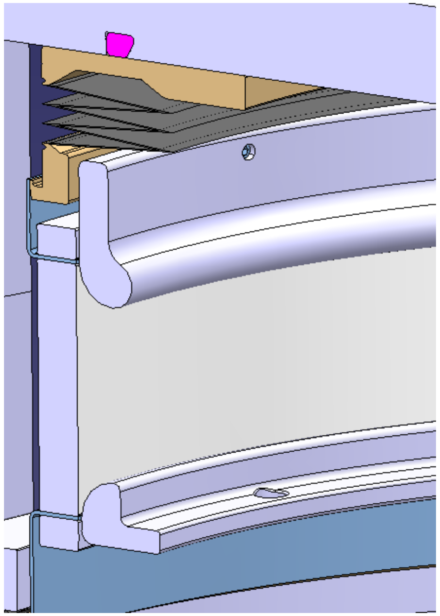
2D Electrostatic Simulation of FE-Insulation

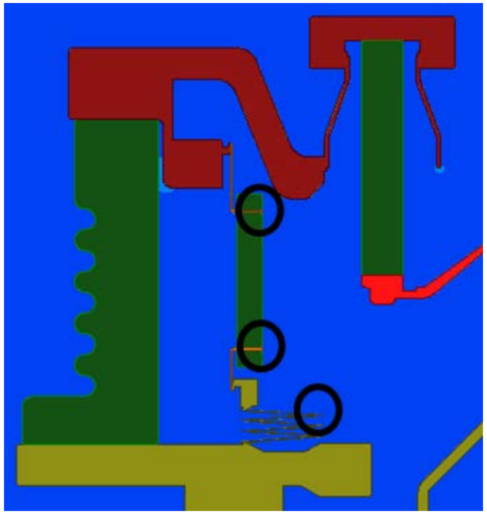


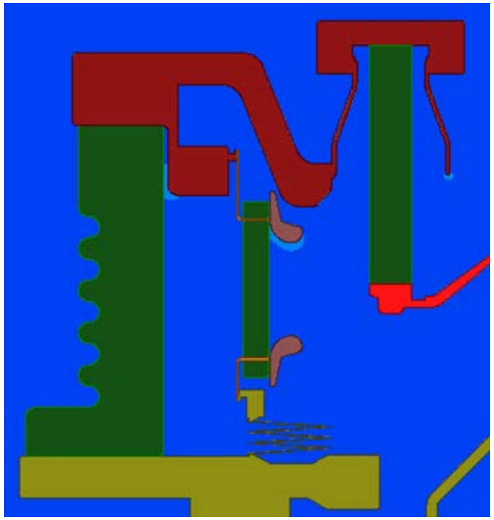
Screen shielding form Cs-vapour
→ *Removed*



Protrusions induced field emission spots and cracks lead to high fields
→ *Successfully shielded*

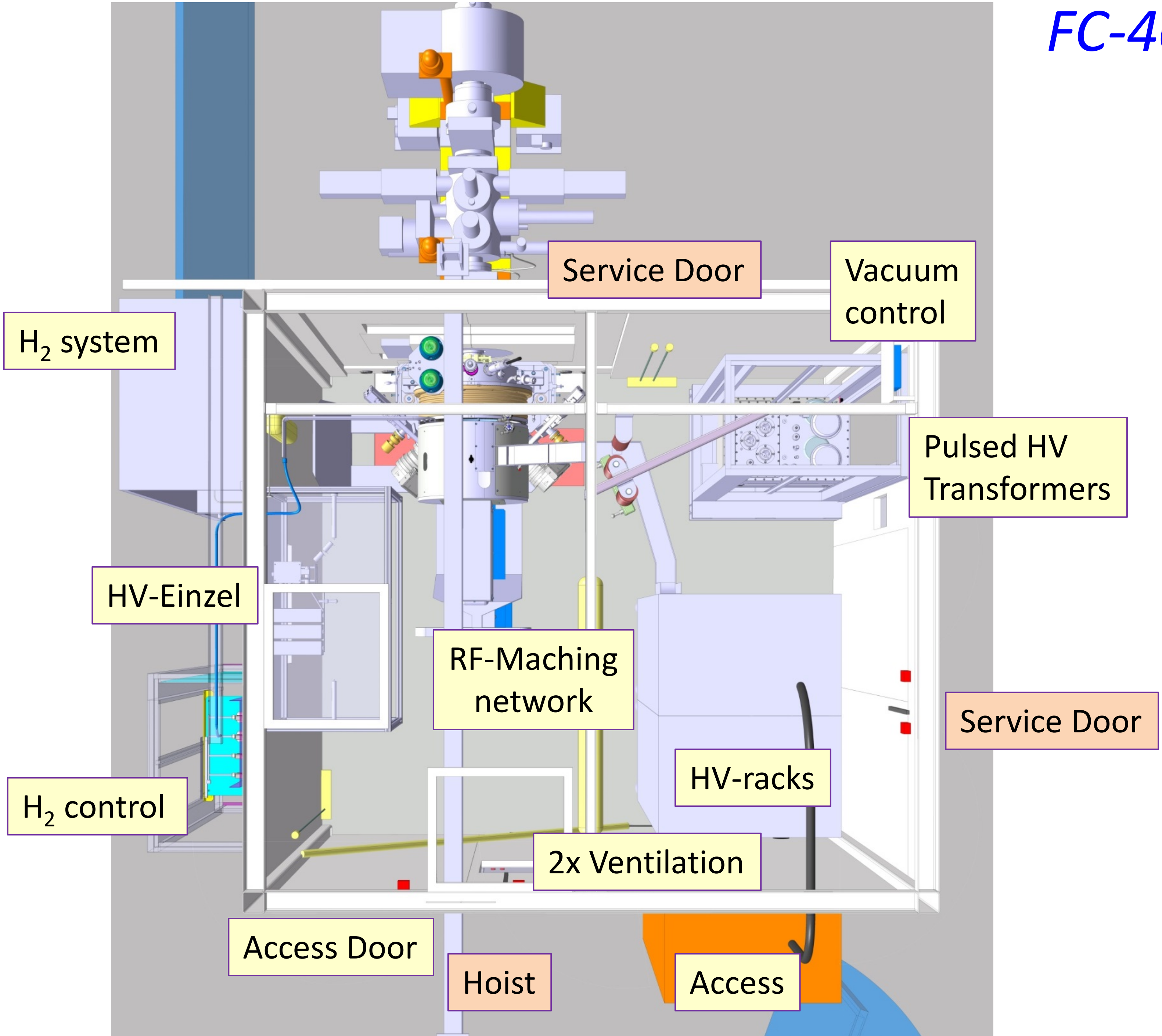






1 ceramic was sent back to remove protrusions by grinding
→ *Successfully passed HV tests*

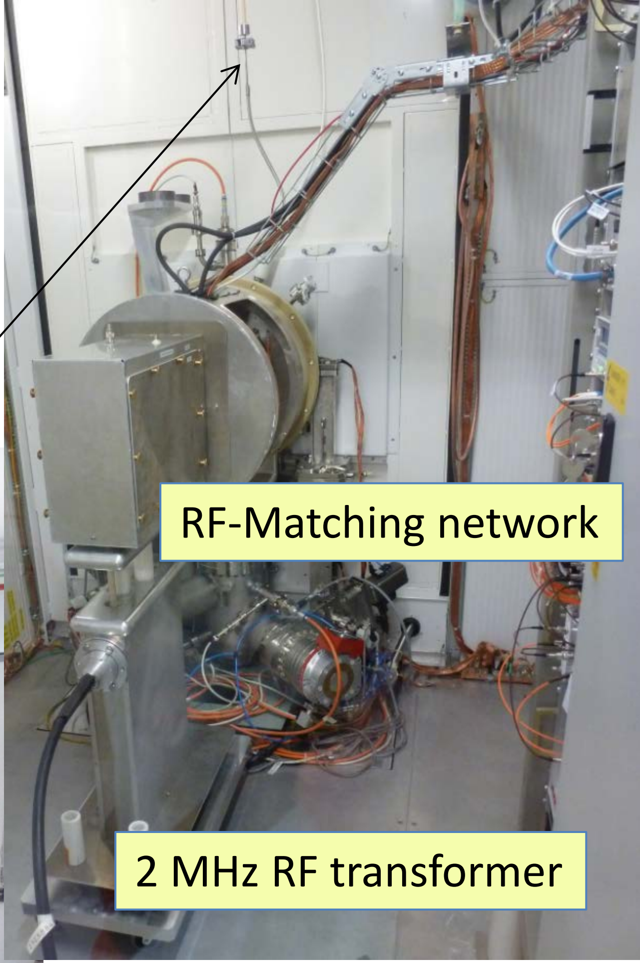
FC-400

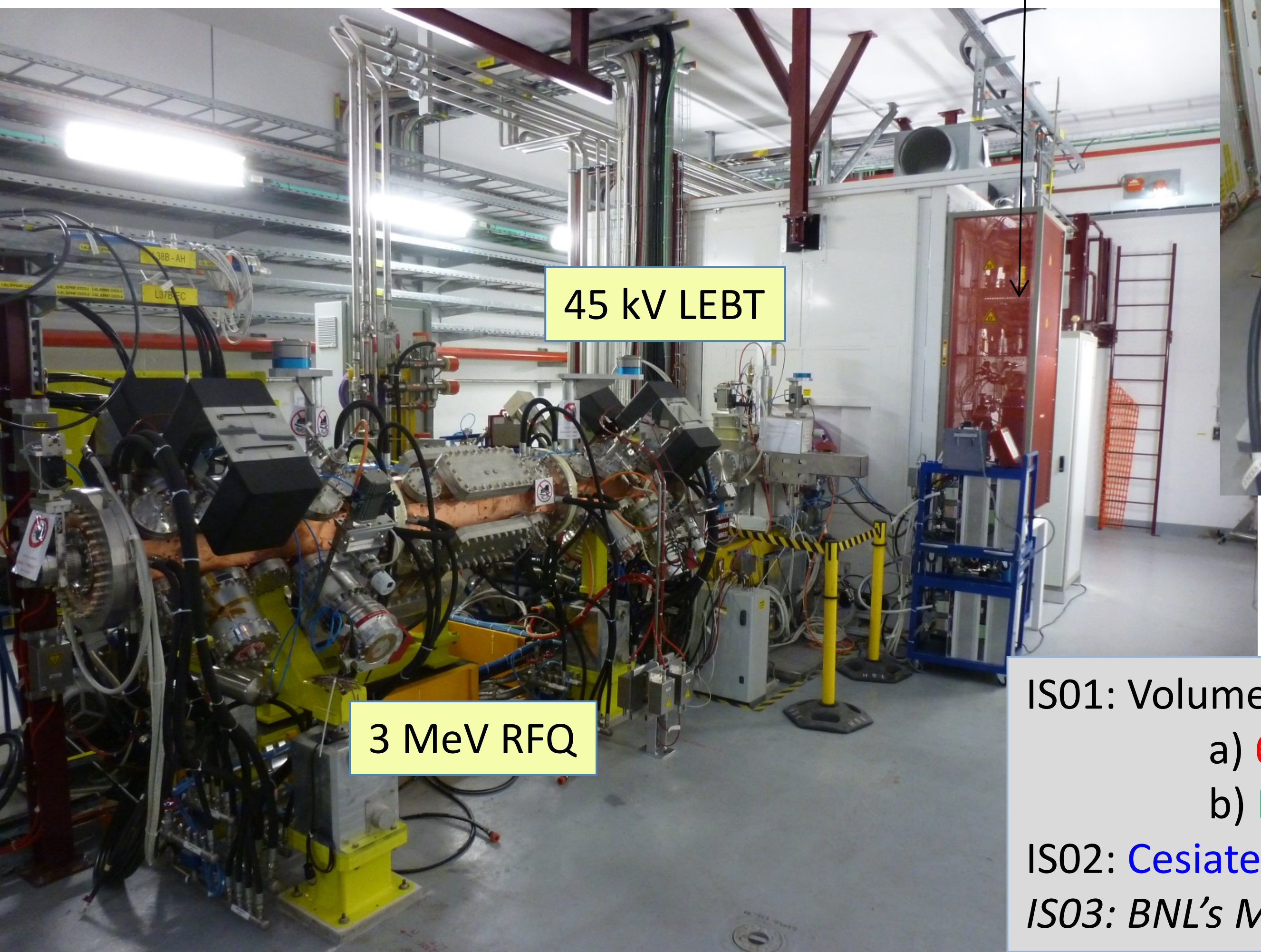


Service Door
Vacuum control
H_2 system
Pulsed HV Transformers
HV-Einzel
RF-Maching network
Service Door
HV-racks
H_2 control
2x Ventilation
Access Door
Hoist
Access

Linac4 tunnel Sept. 2013

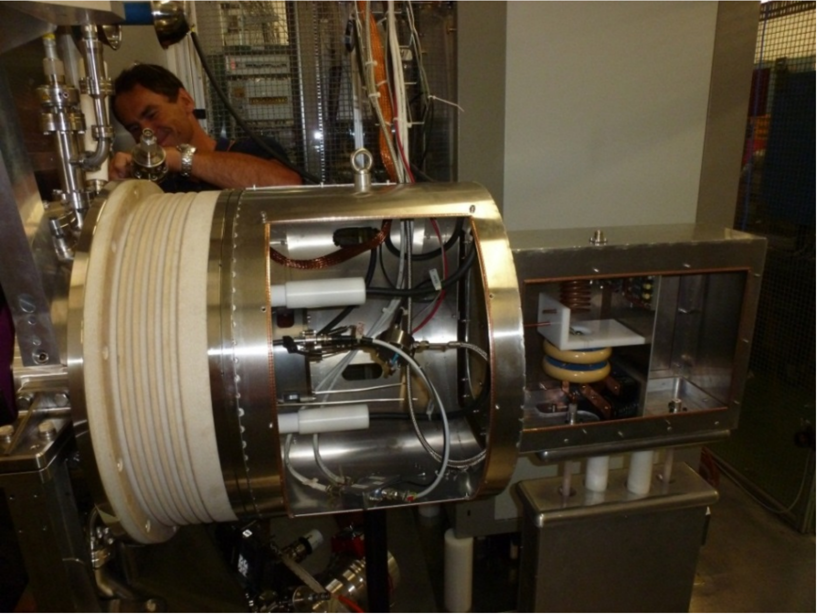
- Installation of the LEBT, RFQ and Chopper line
- Commissioning with a 45 kV 20 mA class volume source based on the DESY plasma Generator)





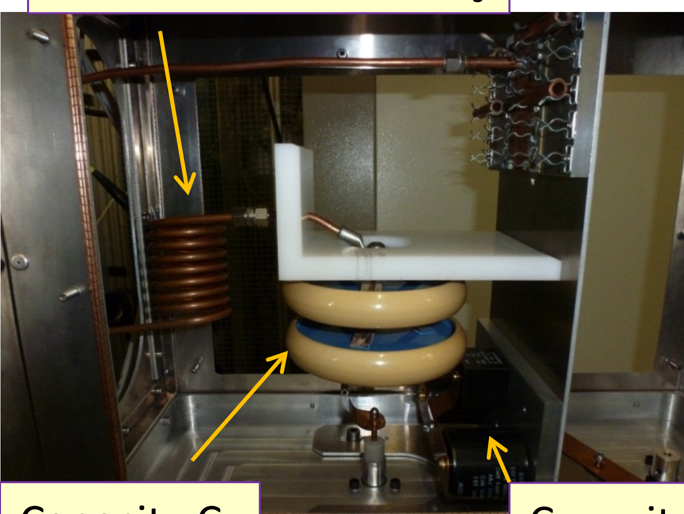
IS01: Volume 20 mA
a) 60-100 kW plasma Generator
b) DESY Plasma Generator
IS02: Cesiated surface 40-50 mA
IS03: BNL's Magnetron (tbc.)

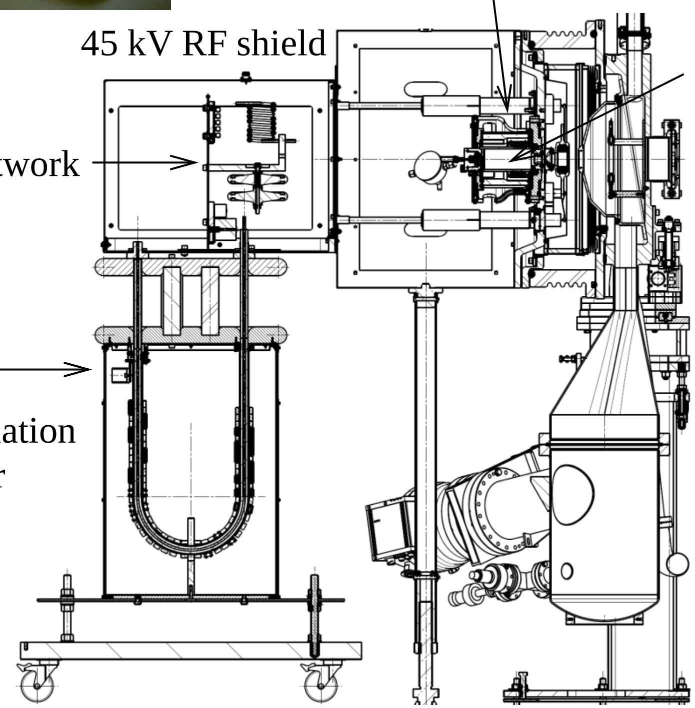
RF-Insulation transformer & Matching Network



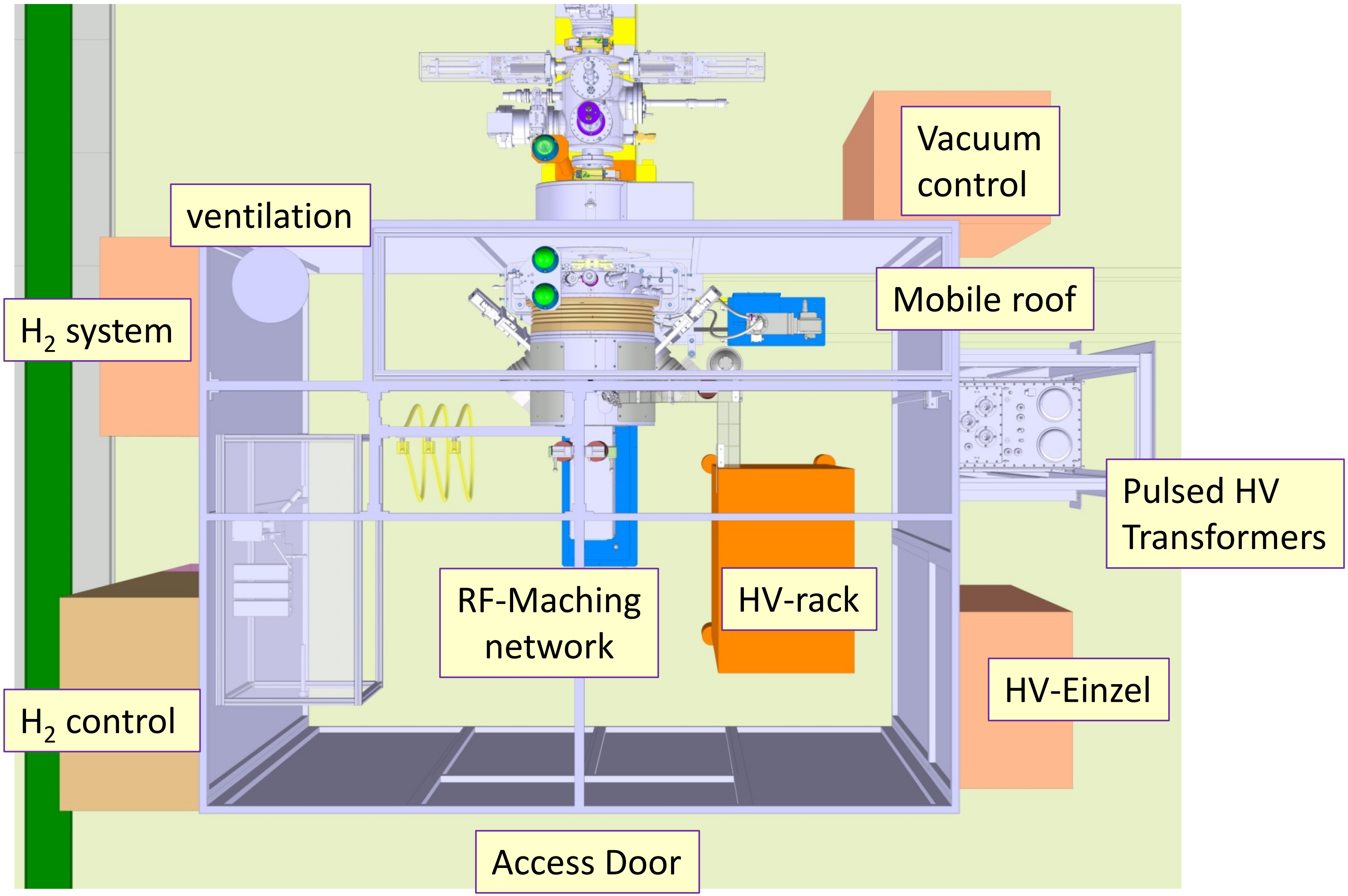
Exchangeable:

- C_p, C_s, L_s measured for each Plasma Generator or solenoid antenna (3-6 turn) → f_o at 1.95 MHz
- Pole fixed to -45 kV potential (HV-flange) either close to extraction hole of at the middle of the plasma chamber



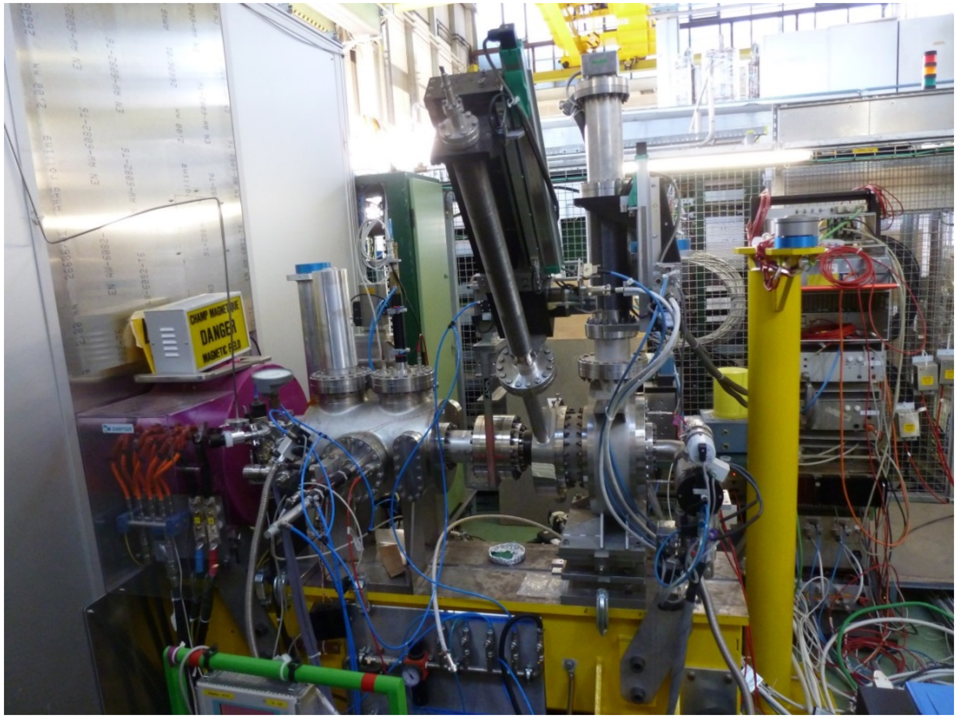


FC-152



Vacuum control
ventilation
Mobile roof
H_2 system
Pulsed HV Transformers
RF-Maching network
HV-rack
HV-Einzel
H_2 control
Access Door

IS-test stand

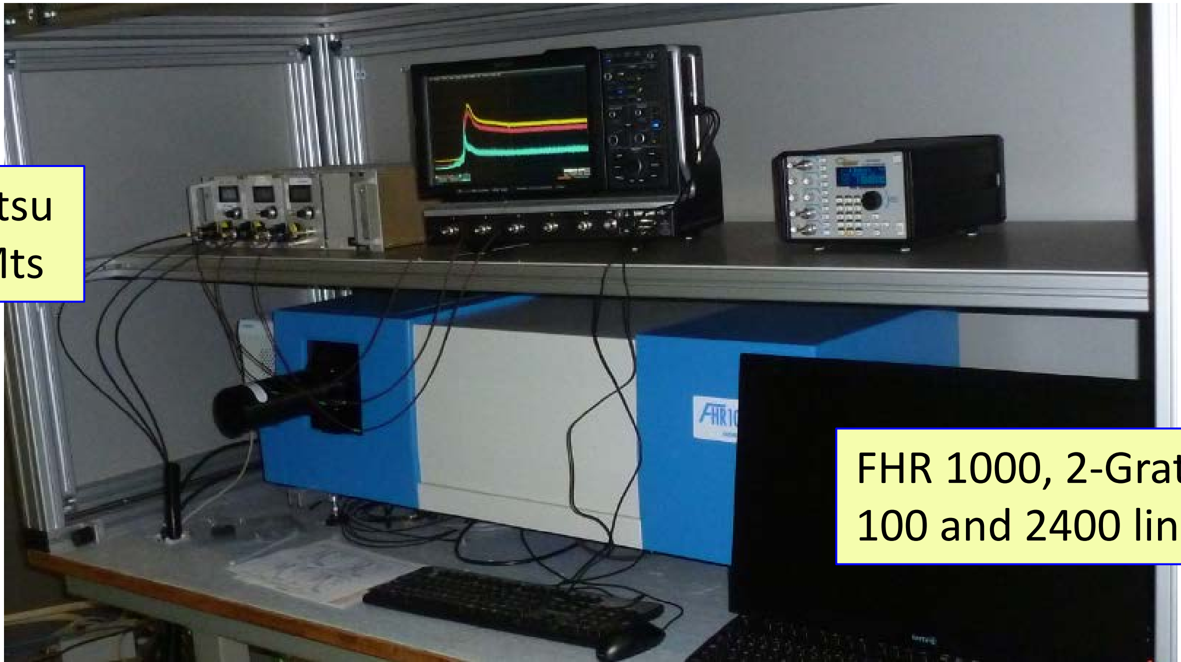


Equipped identically to the first half of Linac4's LEBT :

- Solenoid
- Faraday cup
- H-V grids
- Beam current transformer
- Gas-density regulation

Plasma and beam diagnostics :

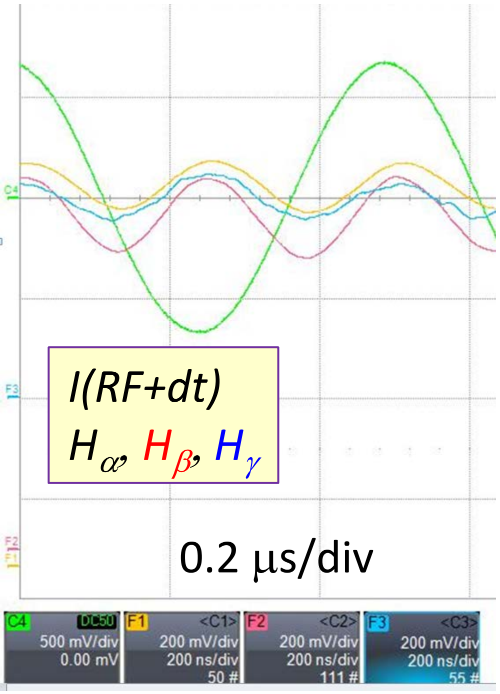
- Optical photometry
- Spectrometer
- Emittance meter



3 Hamamatsu
10 MHz PMts

FHR 1000, 2-Gratings
100 and 2400 lines/mm

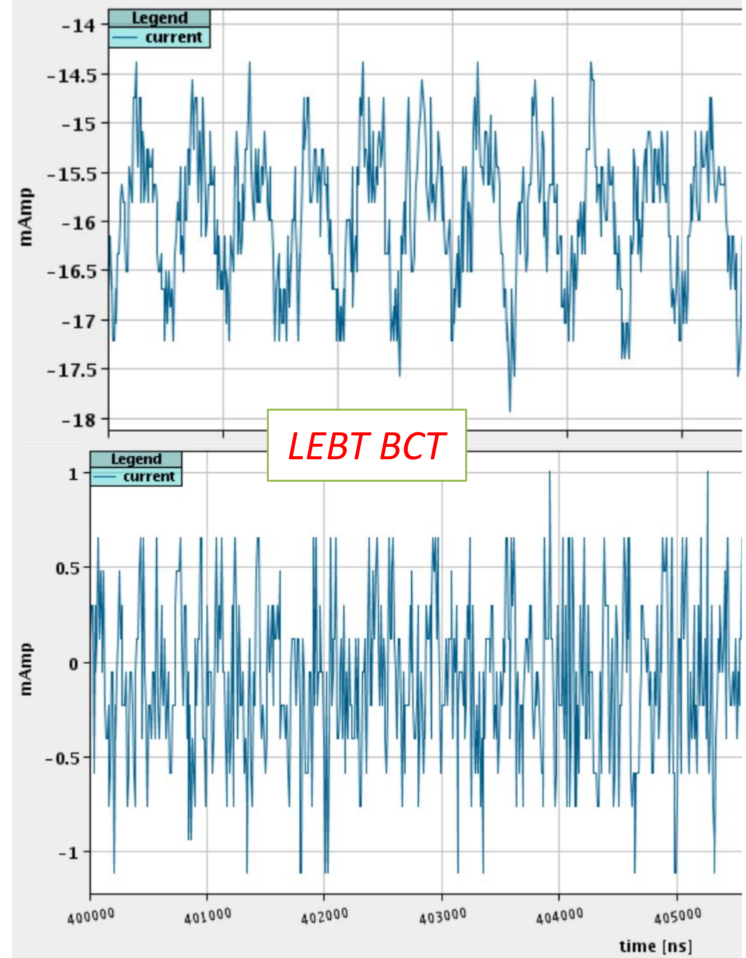
Plasma light & H^- beam



4 MHz fine structure observed in the plasma light emission, O(10-15%) peak to peak .

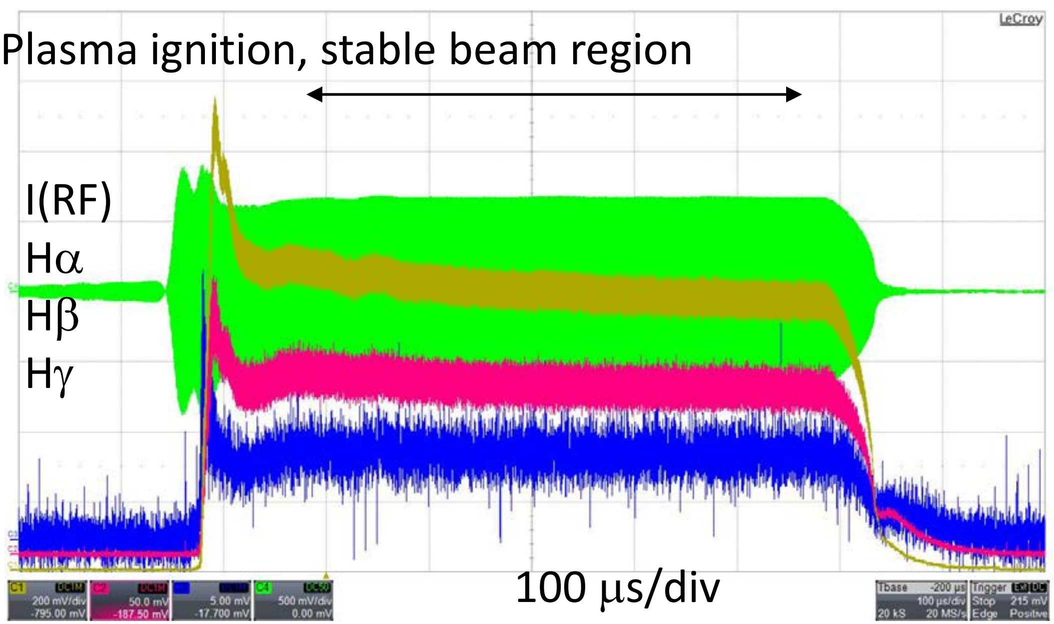
2 MHz H^- beam fine structure observed in the Volume source equipped with the DESY PG: O(20%) peak to peak fluctuation of the H^- beam intensity (Av.: 16 mA)

2MHz ripple observed by M. Sordet, J. Tan *BPM-ToF* system

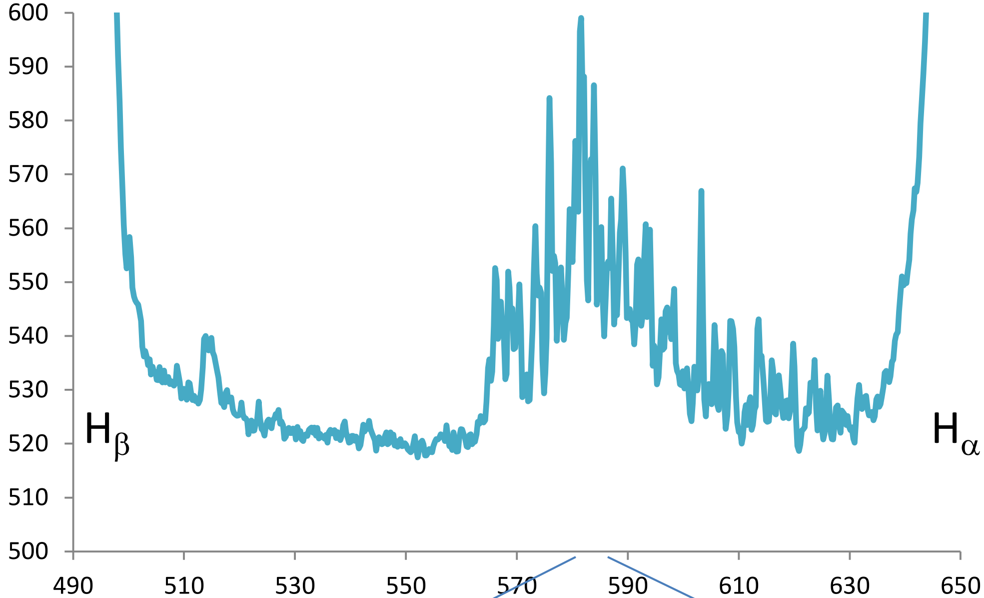


LEBT FC intercepting the H^- beam

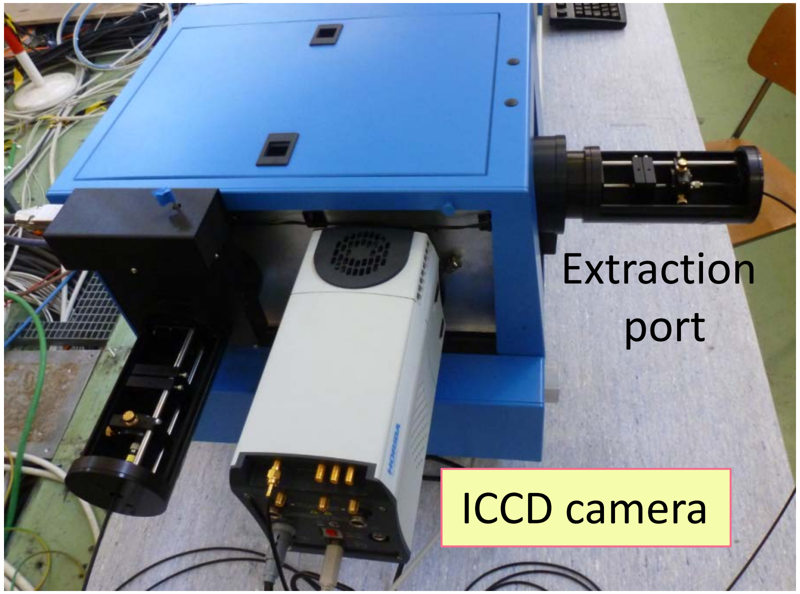
Courtesy: U. Raich 27/3/13



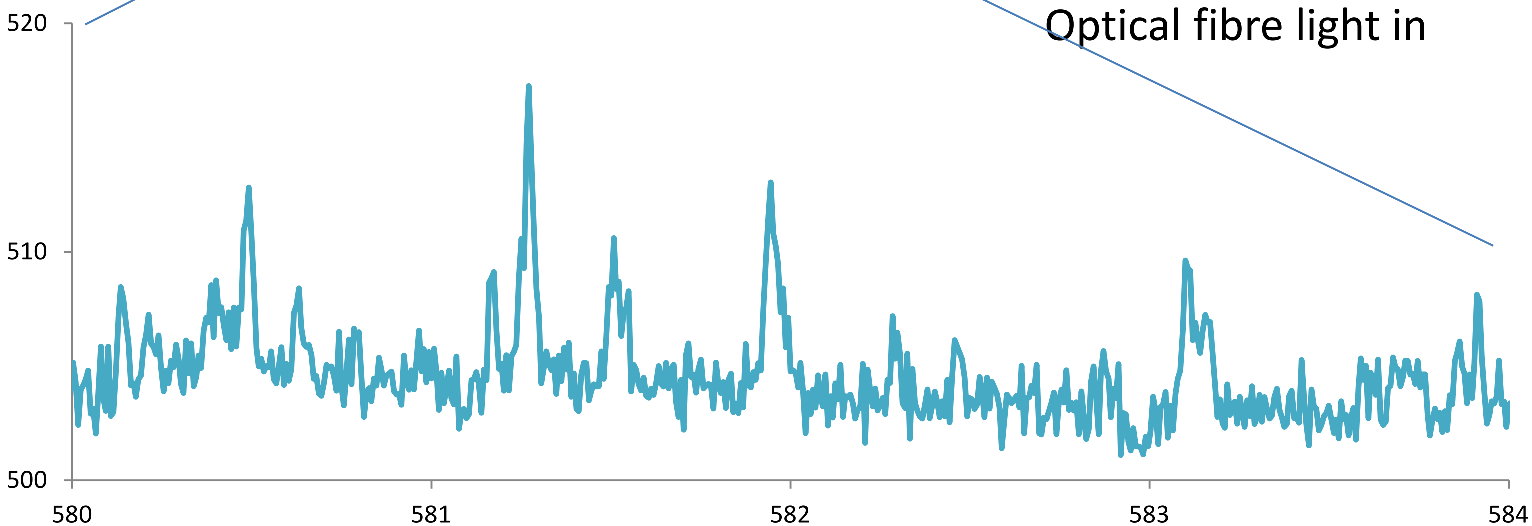
Optical Emission Spectrometry



100 lines/mm



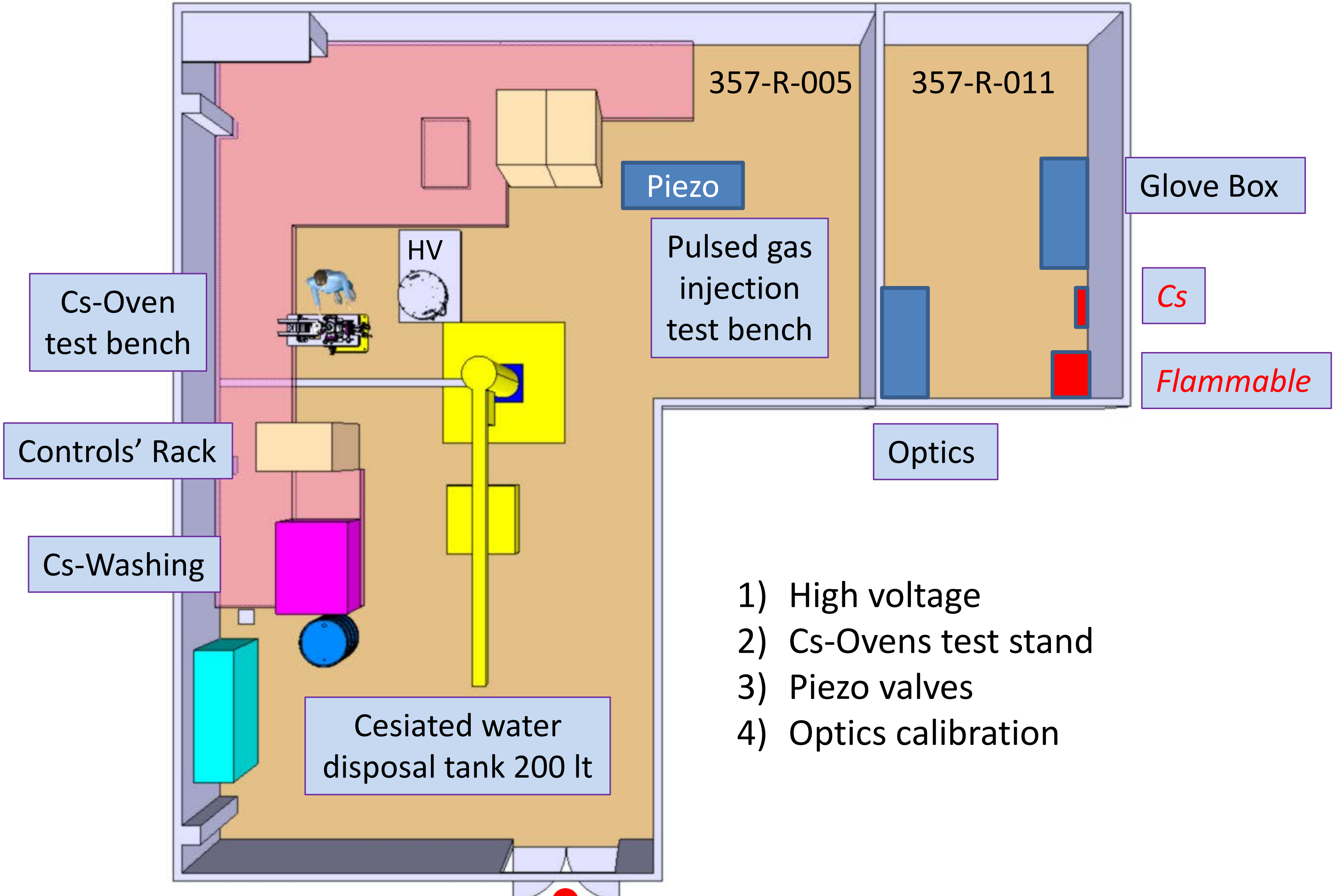
Optical fibre light in



2400 lines/mm grid

Operational & eagerly awaiting plasmas

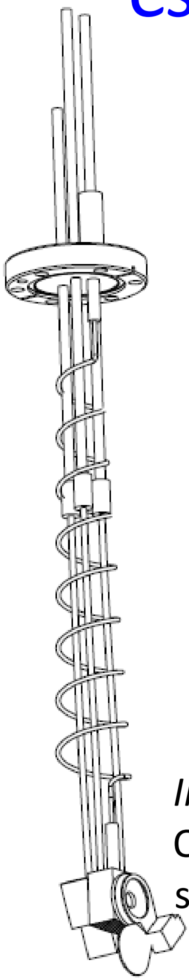
Linac4 IS: 357 test stand



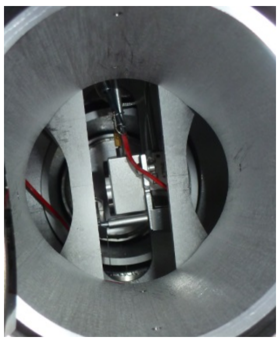
1) High voltage
2) Cs-Ovens test stand
3) Piezo valves
4) Optics calibration

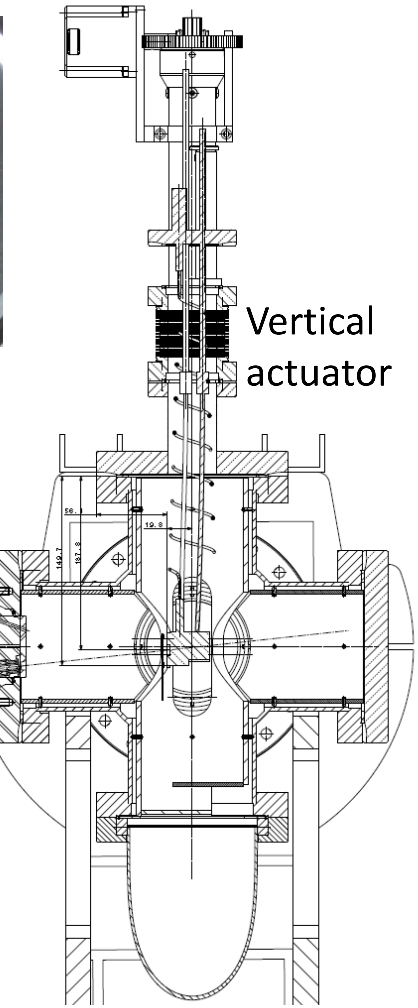
Cs-test stand 357

- *Cs-Oven filling*
- *Flow and angular distribution of the Cs-atomic beam*
- *Cleaning of cesiated components*

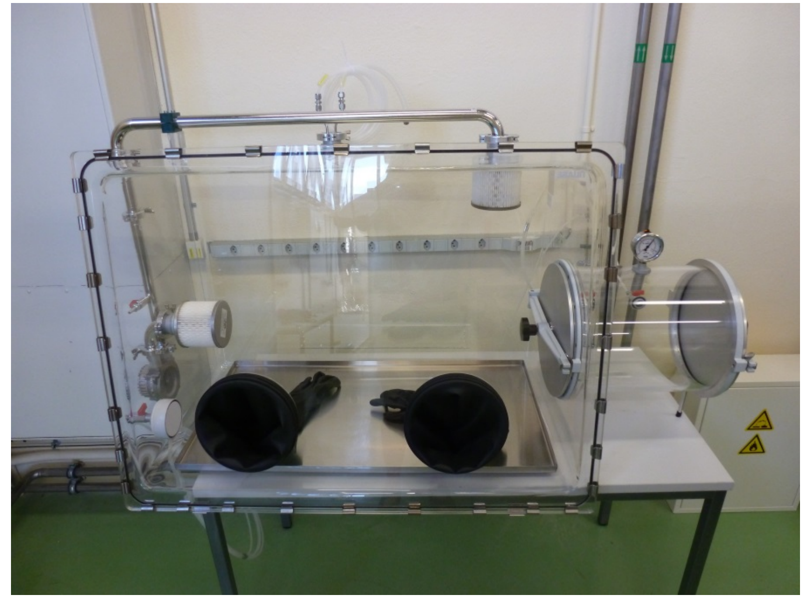


Inficon Quartz sensor





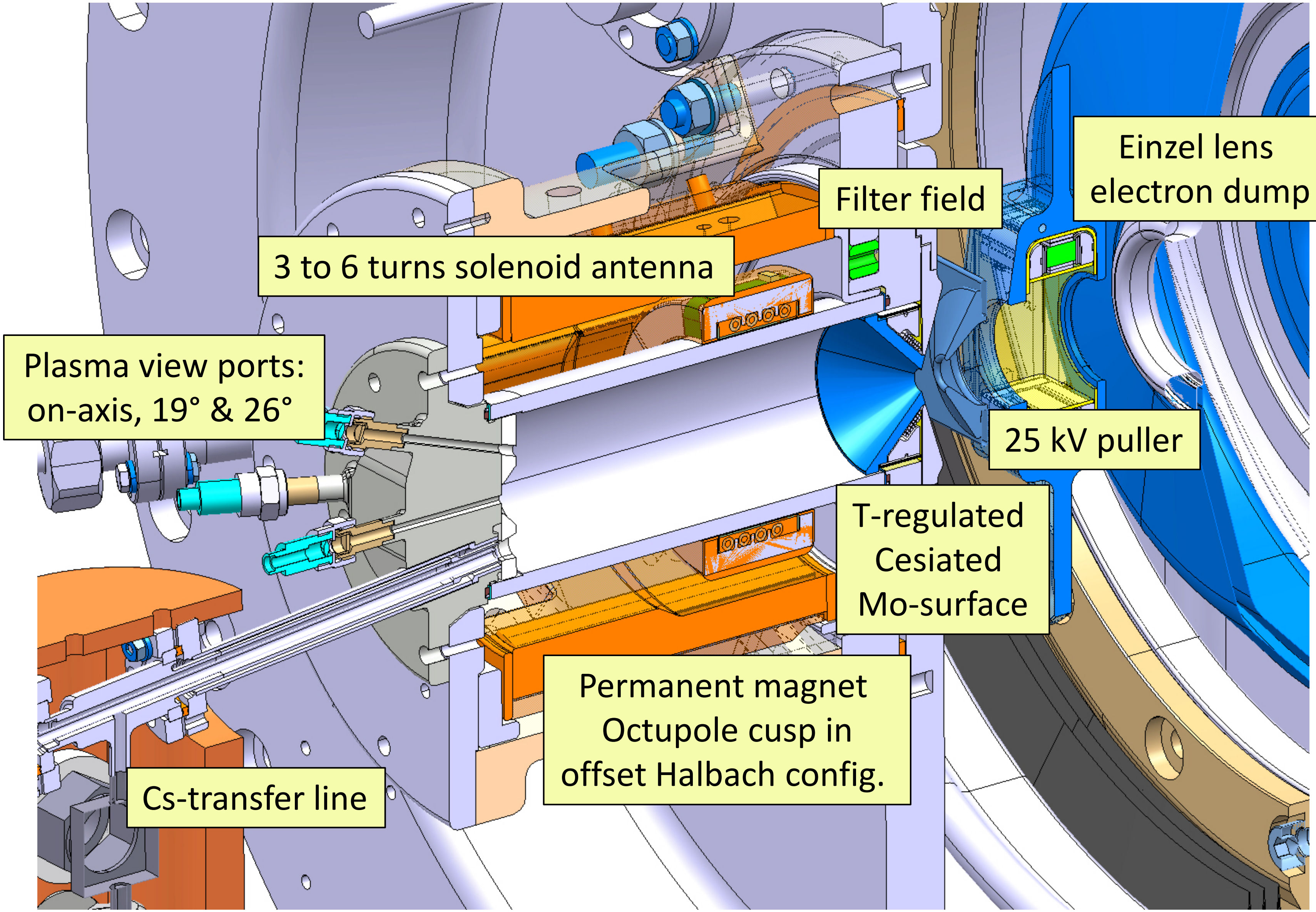
Vertical actuator



Inert gas glove box & antechamber

Industrial washing system

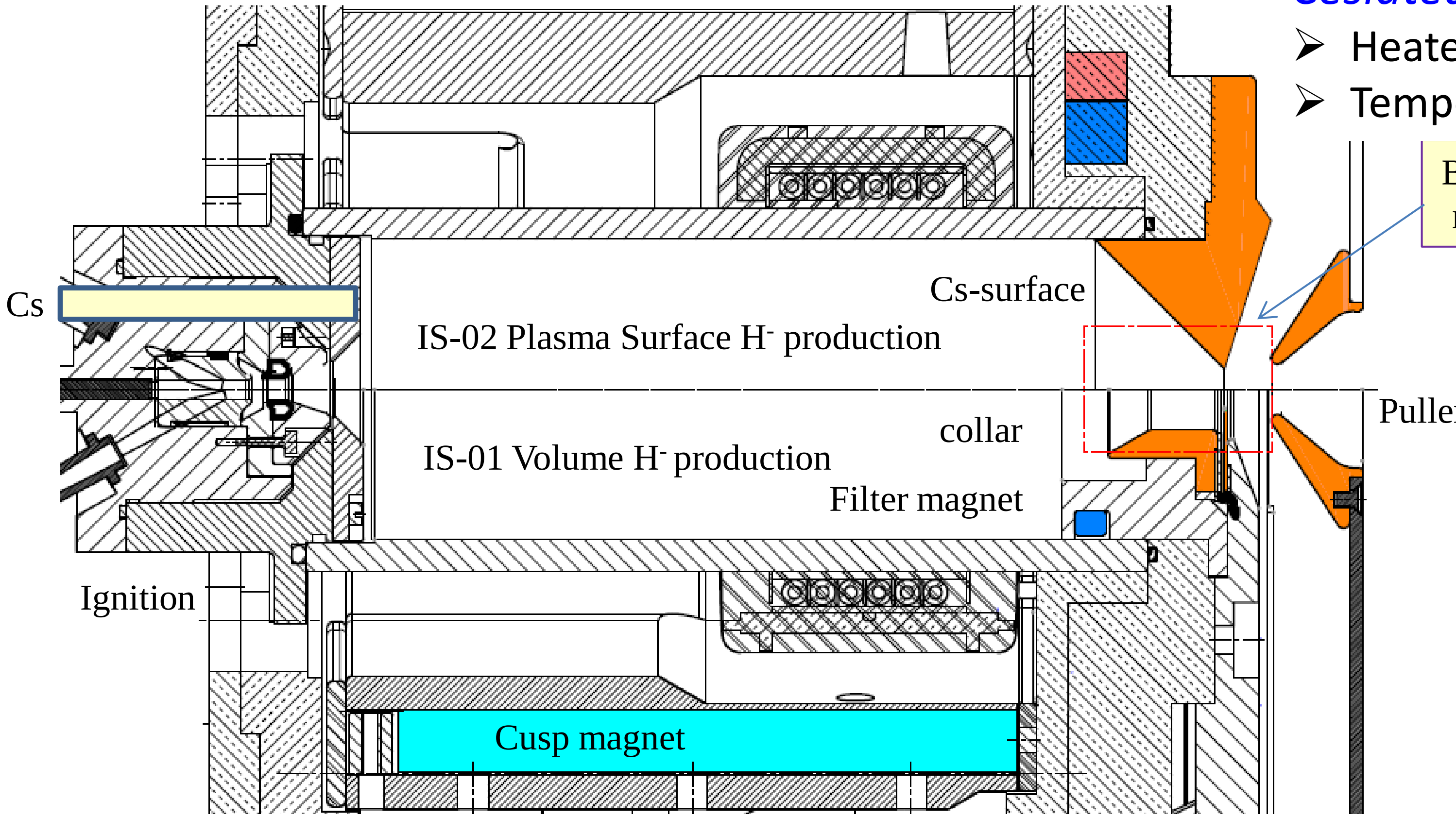
IS02 plasma Generator



Plasma Generator design: IS01 vs. IS02

Cesiated surface:

- Heater design
- Temperature regulation

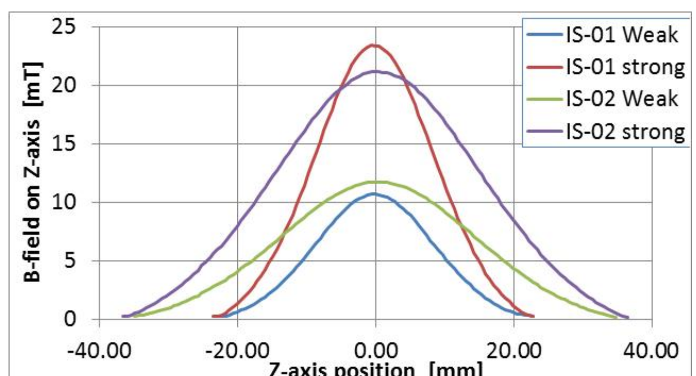


Beam optics:

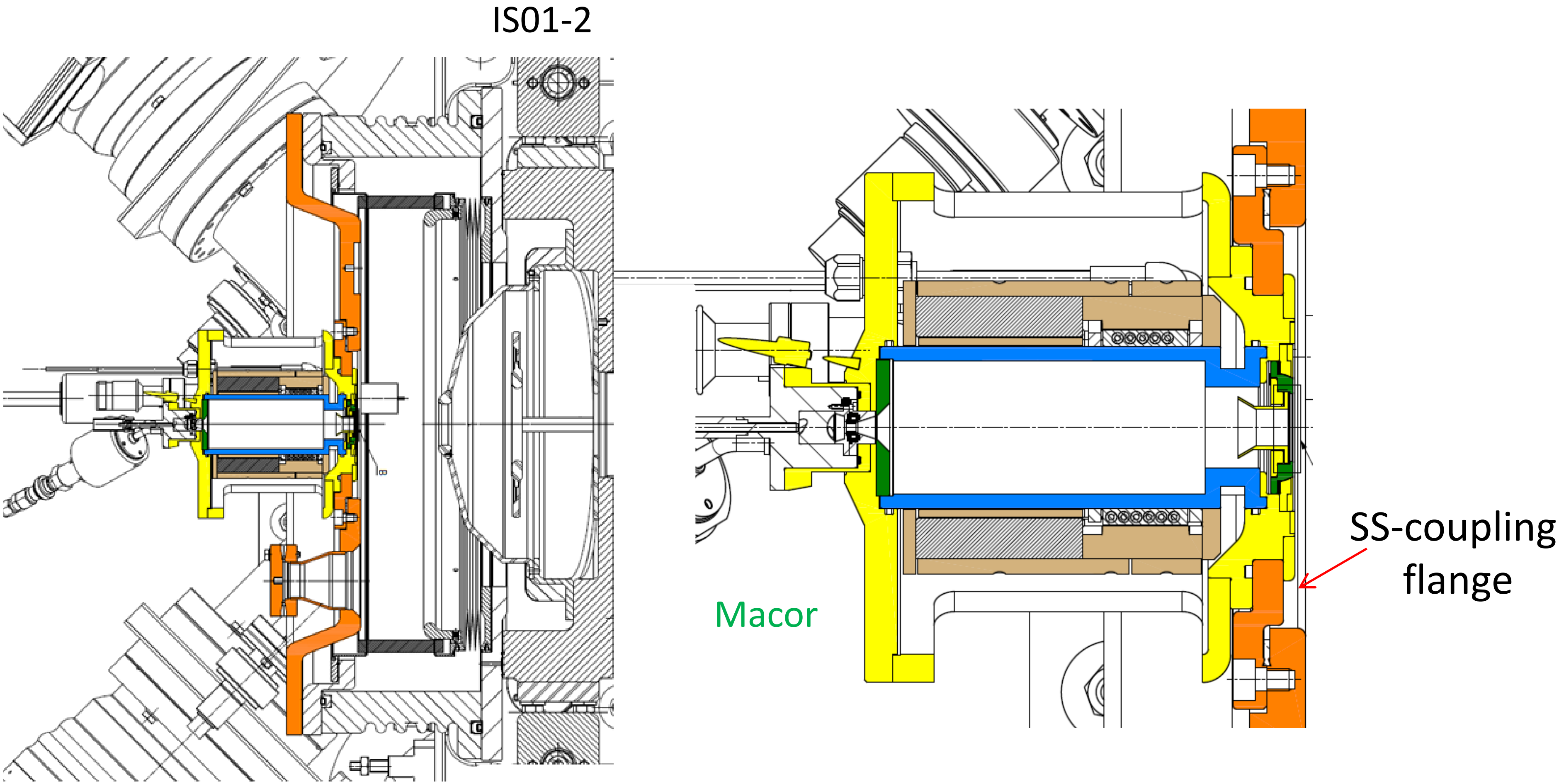
- Dumping of coextracted electrons
- Minimize emittance

Caesium:

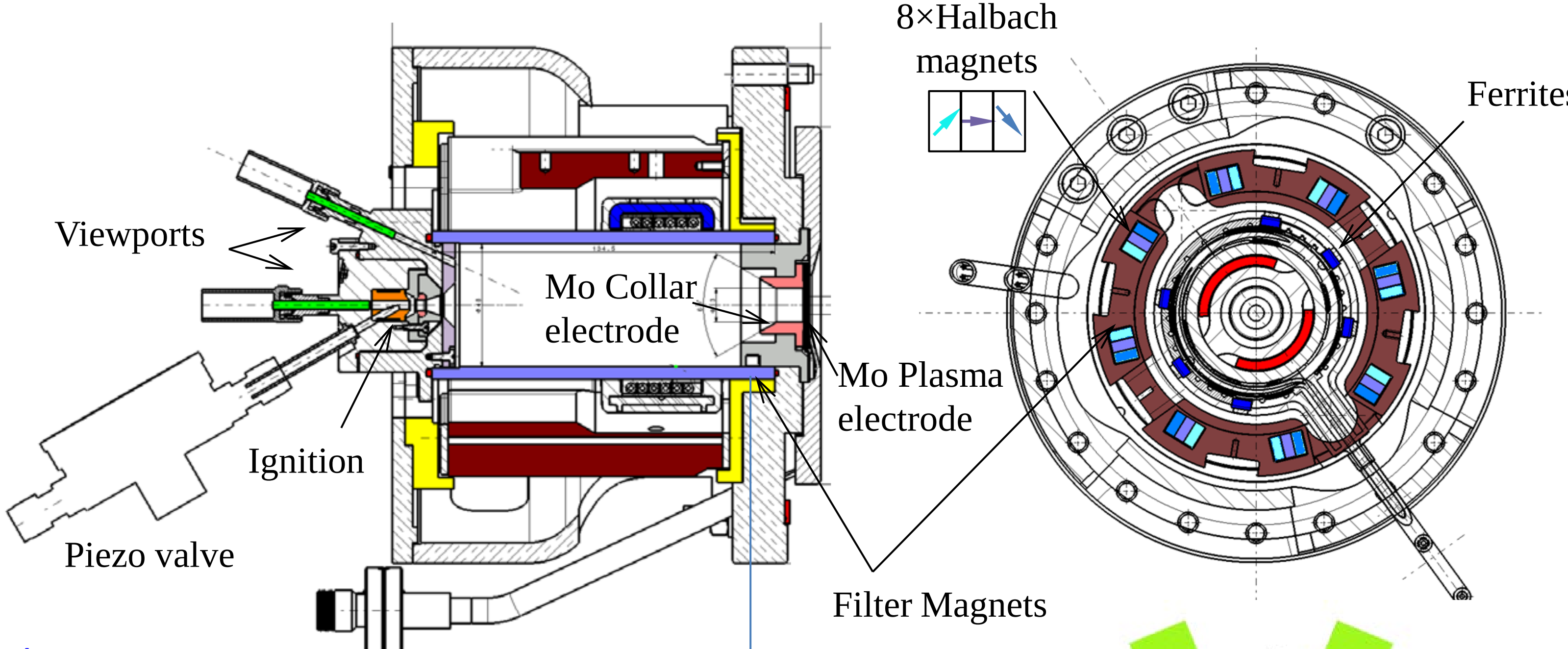
- Oven production
- Test stand commissioning
- Flow calibration
- Cleaning procedure (mg range)



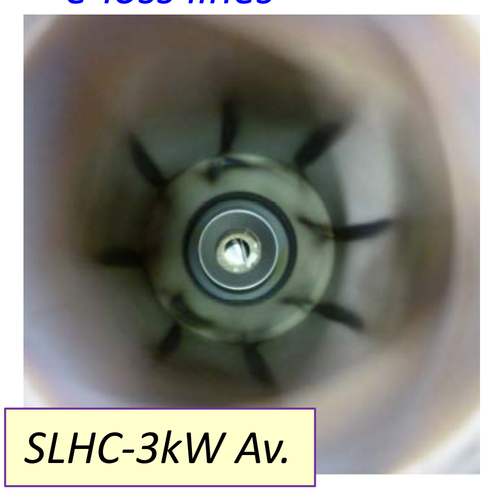
Mounting the DESY PG on IS01-2 flange

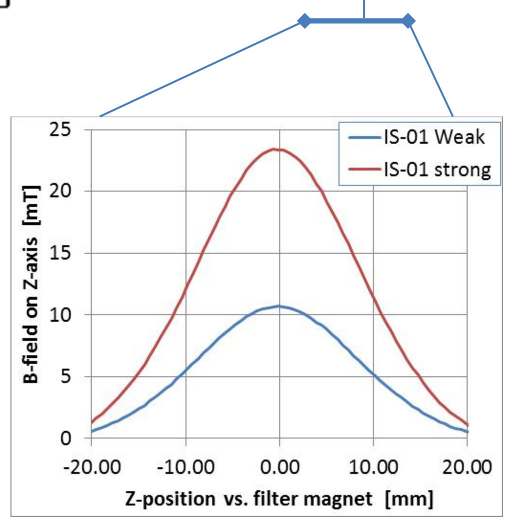


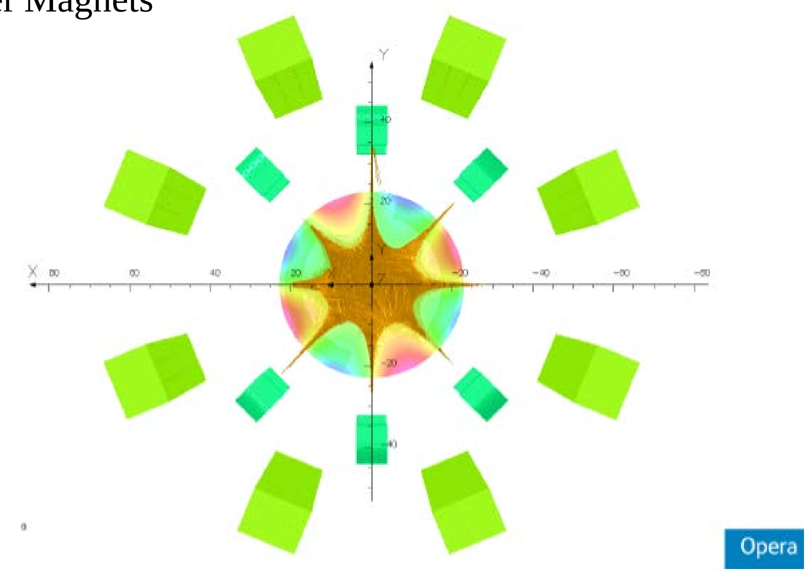
Permanent magnets configuration IS01-02



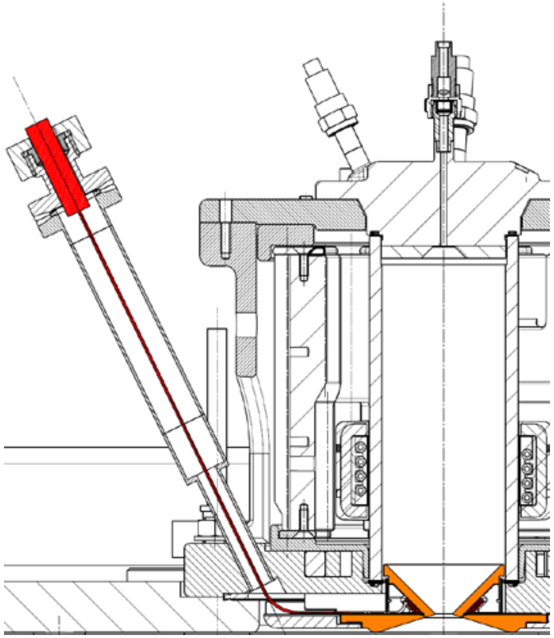
e-loss lines

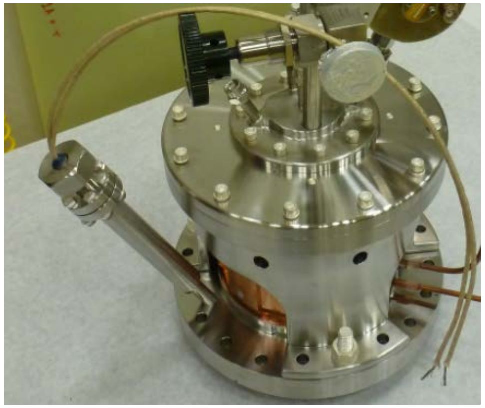


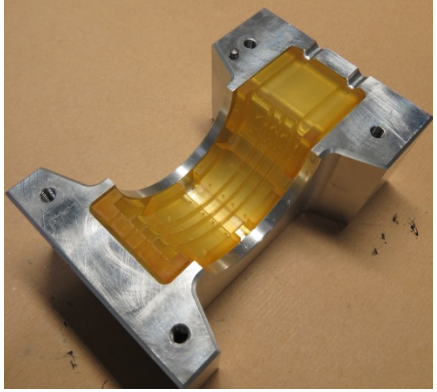




Temperature control of the Cesiated Mo-surface



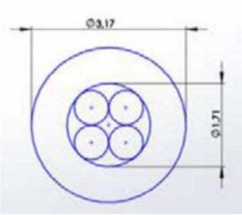


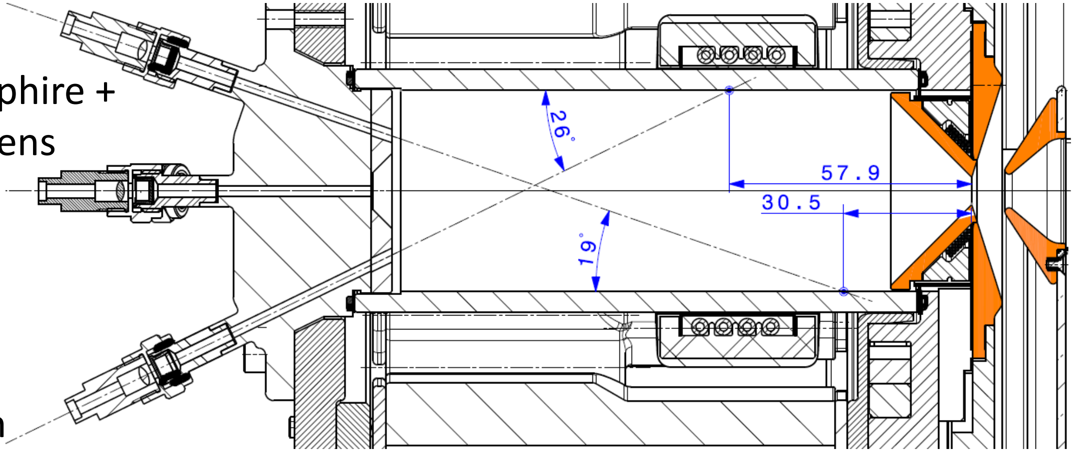


3D-printing of the solenoid Epoxy mould

Implementation of the on-axis, 19° & 26° Optical view ports

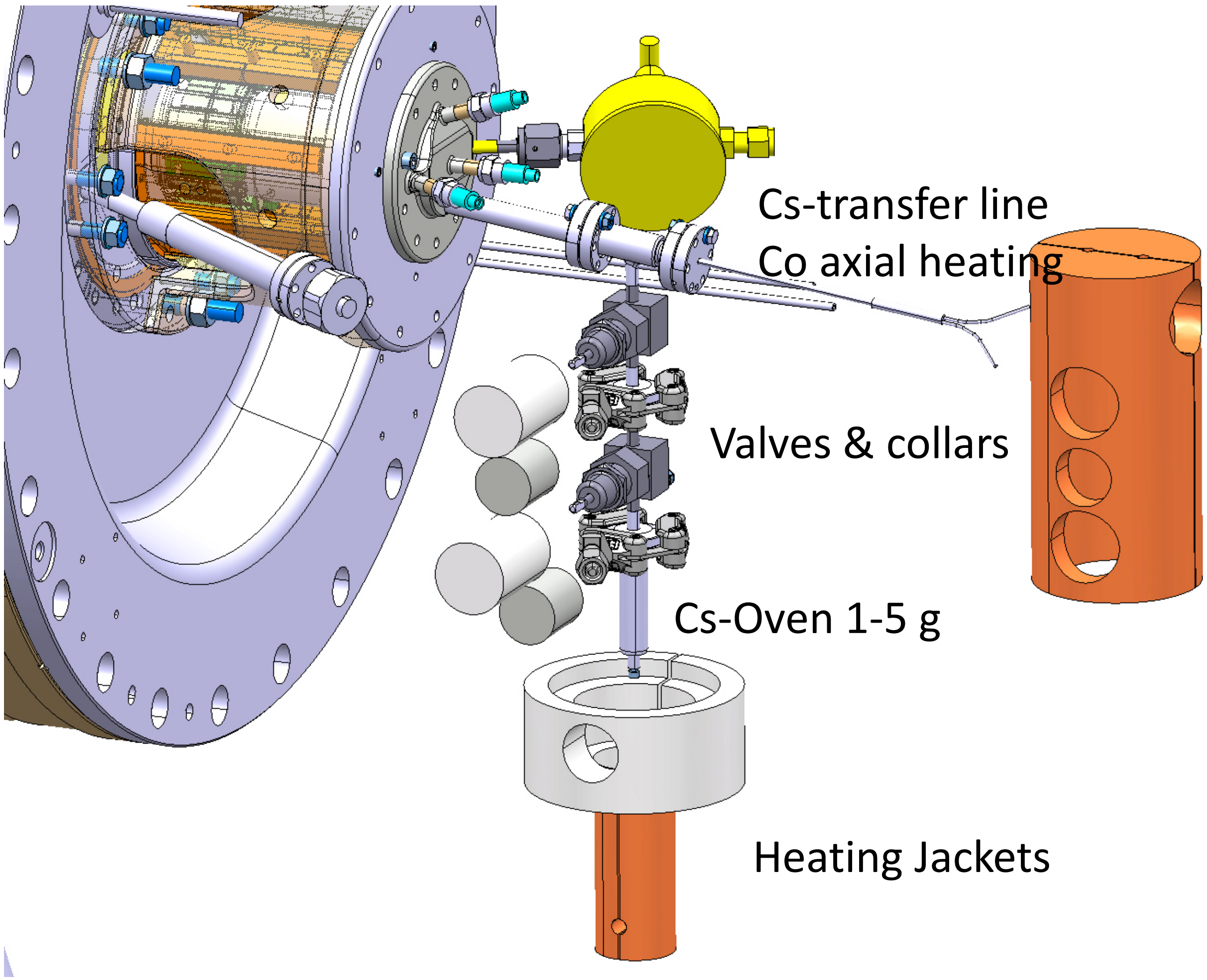
Brazed sapphire + Quartz lens

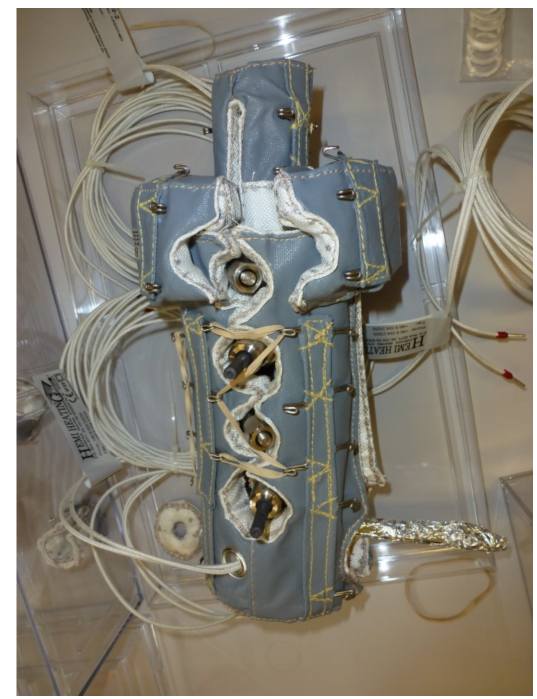




4 fibers (600µm core, 660µm clad, 710µm polyimide coating) inside of a SMA connector

Cs-Oven





Two valves allow refilling without breaking the vacuum

List of all tests at ISTS-152 and operation in L4-400

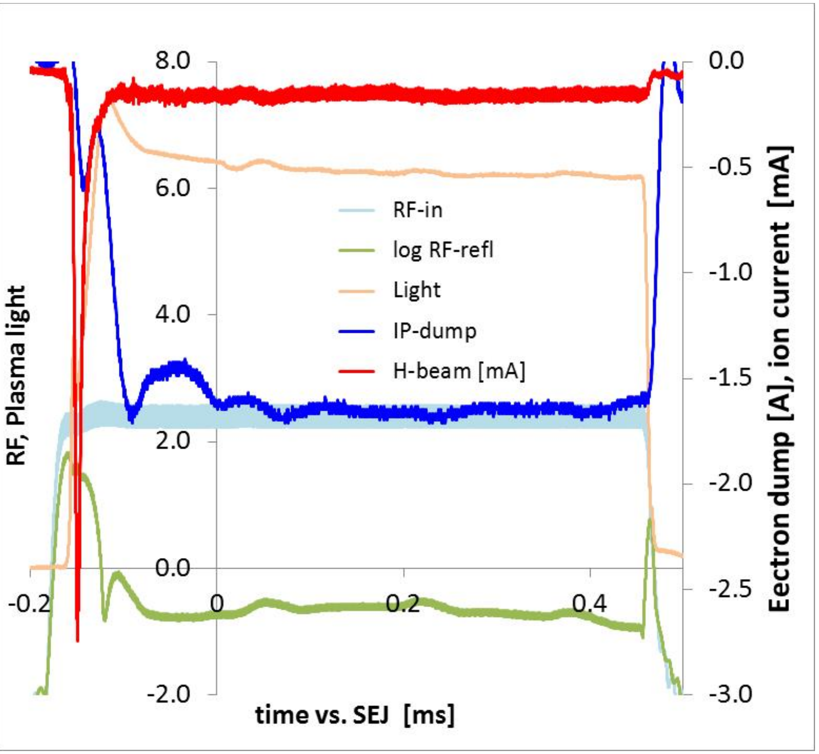
3MeV Test Stand → Ion Source Test Stand (July 2013)

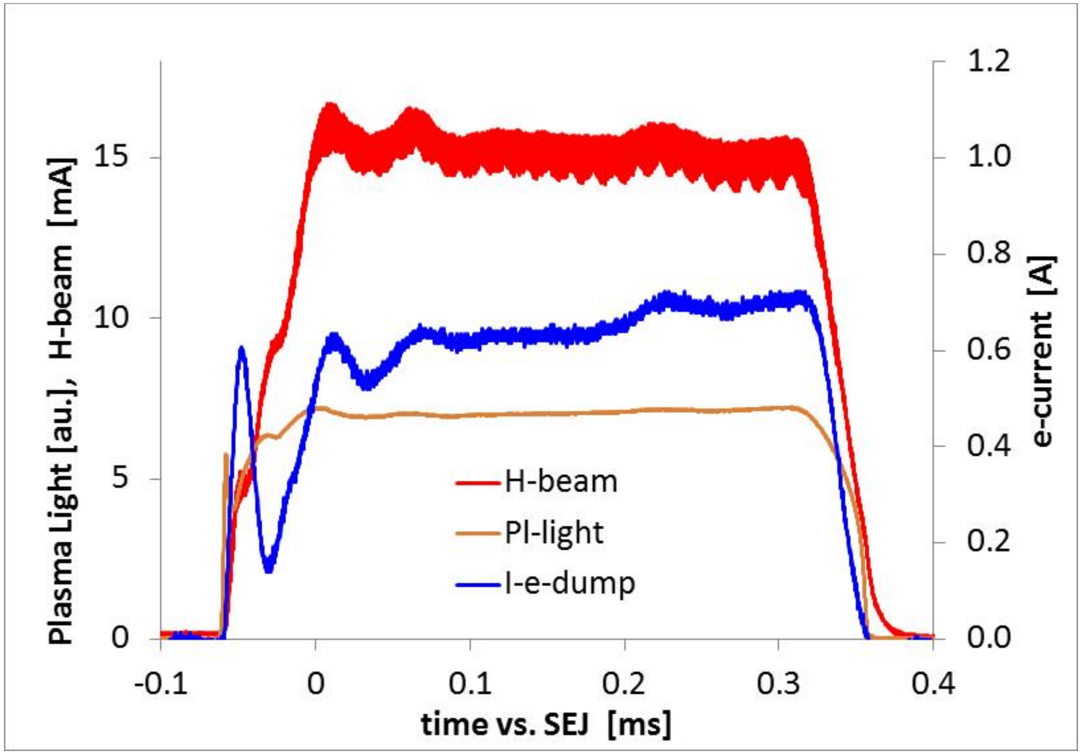
- DESY source in 35kV H^- and protons → mid 2012
  - Emittance measurements
- IS01 6-turns 2 polarities 45 kV H^- and protons → end 2012 and June 2013
  - Variation of all parameters: RF-frequency & power, Gas pressure, collar and plasma electrode potentials, Filter field strength, Macor instead of Al^2O^3, short circuit of the plasma electrode
- IS01+DESY-PG 45 kV H^- and protons Feb-June 2012 (OM presentation)
  - One Emittance measurement
- IS02 uncesiated 4-turn 45 kV H^- from Oct. 2013 (OM presentation)

L4-Tunnel

- IS01+DESY-PG 45 kV H^- Sept 2nd 2013 …

IS-01 PG vs. Desy PG



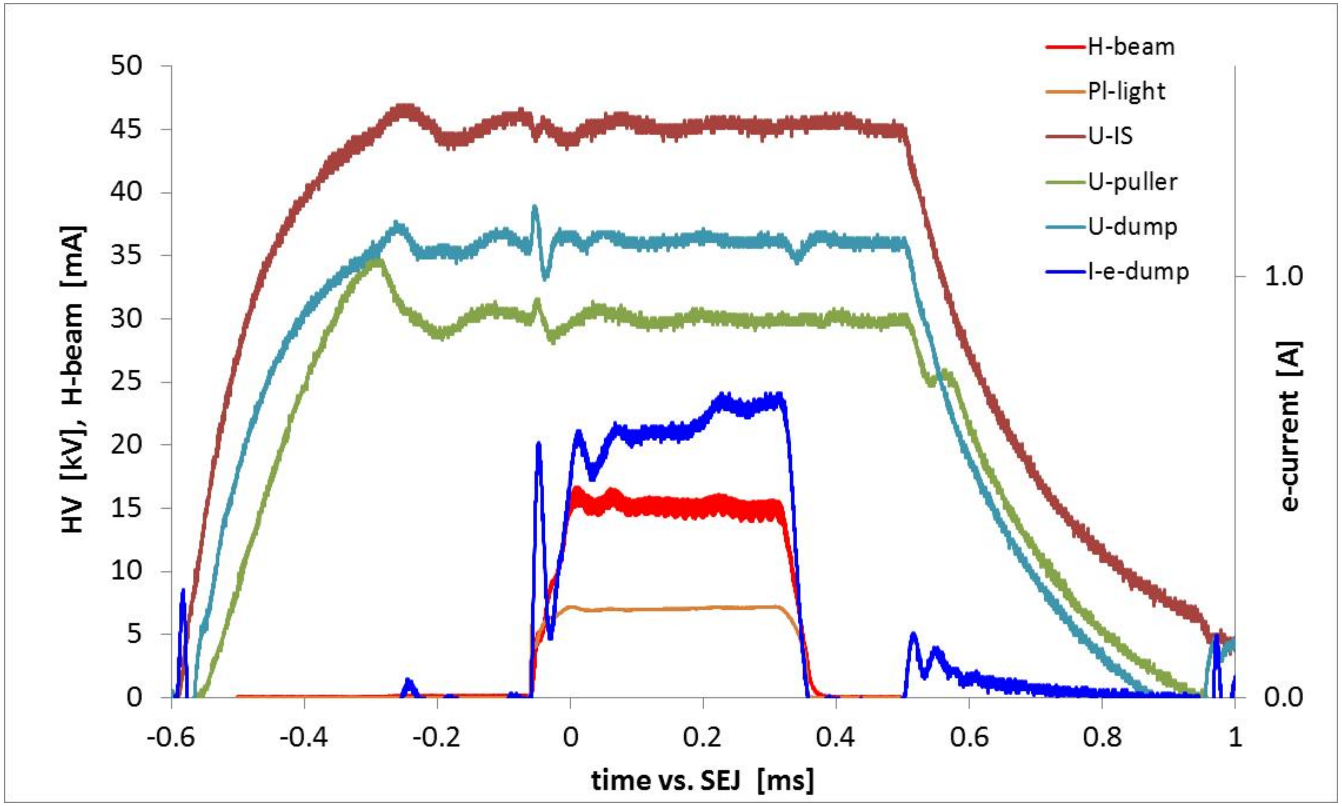


Plasma Generator:	IS01 6-turn	Desy + IS-01 Optics & e-dump
RF-coupling	Excellent	Good
45 kV H^- beam current	3 mA & stops after 40 μs	16-22 mA
Electron-dump current	1.5-3 A	0.6 A
Plasma Light	Normal	Normal

- Electron dumping operational up to 3A !,
- Higher e-current when fixing the potential of the solenoid at the middle of the plasma chamber

→ 3-5 turns solenoid & mobile antennas

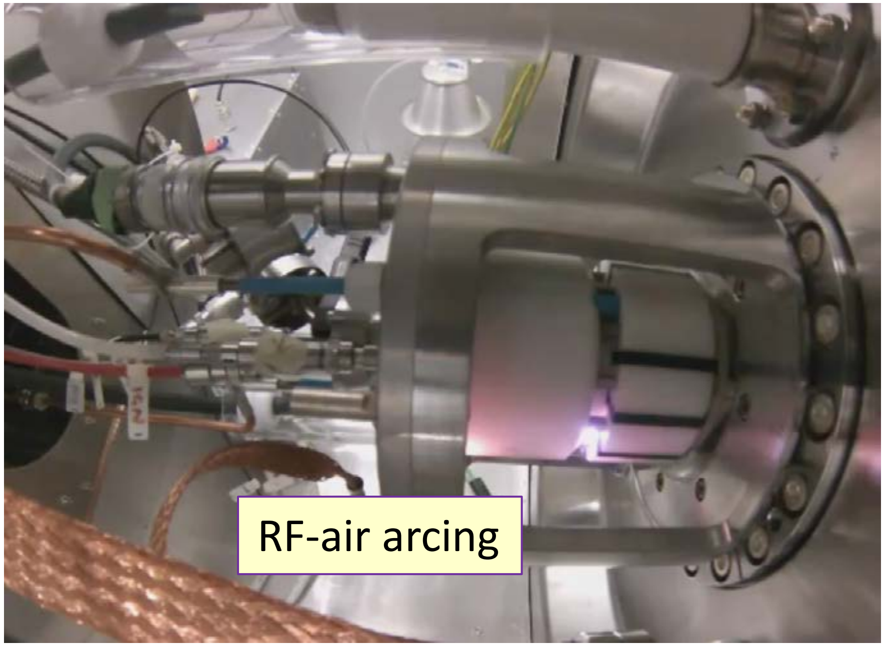
Response of the Pulsed HV under dynamic load: 0.6 A electrons & 16 mA H⁻

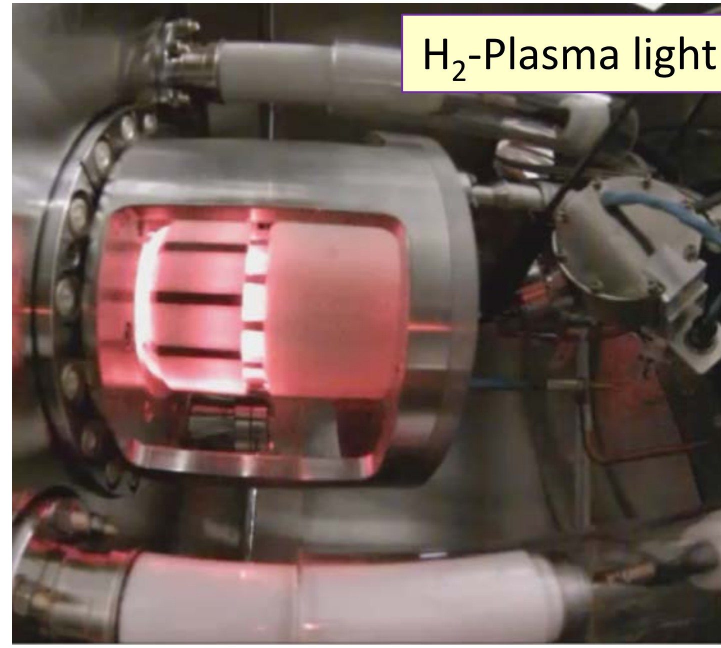


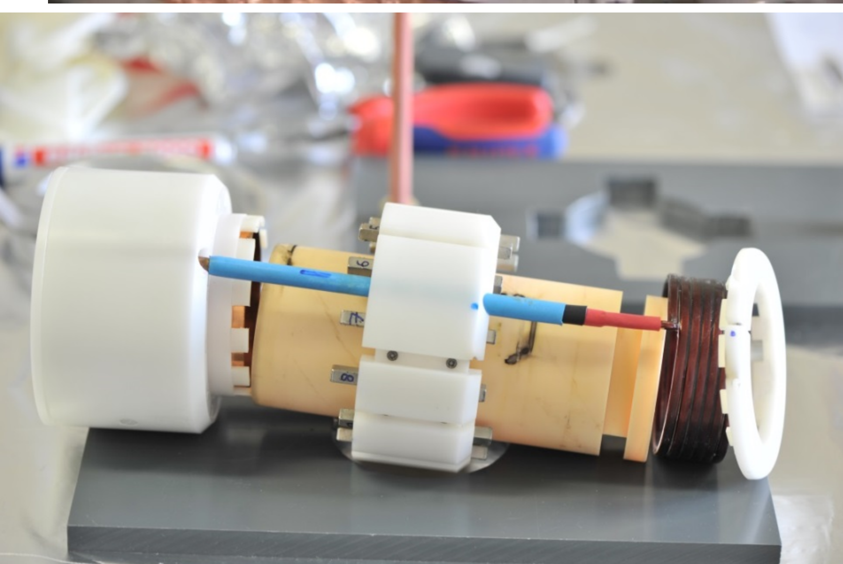
Pulsed HV system:

- Beam energy fluctuation meets Specification, further improvement expected with new controls electronics (end 2013)
- ± 0.5 kV stability throughout the beam pulse
- Detects over-currents and stops discharges. No traces of arcs on the electrodes
- Up to 3 A electron current successfully dumped at 10 keV on the e-dump, detailed analysis in O. Midttun's presentation

IS01+DESY PG: after 1 year integrated operation time (no maintenance) → RF-induced arcing in air

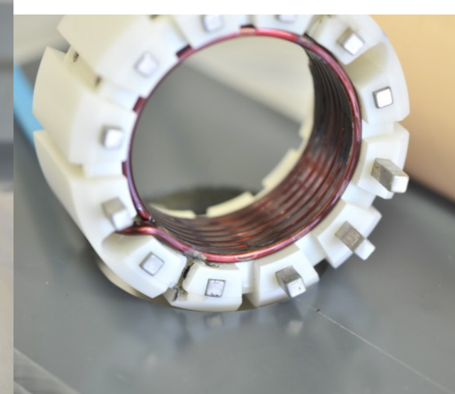


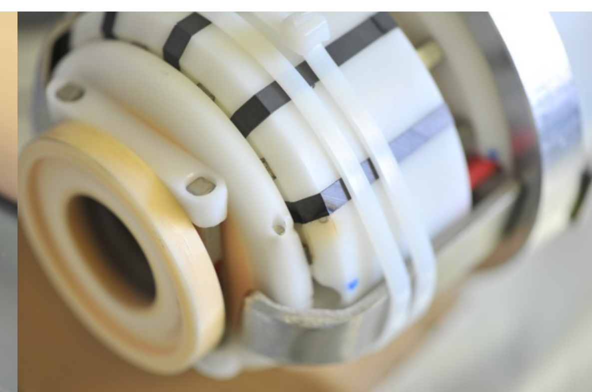


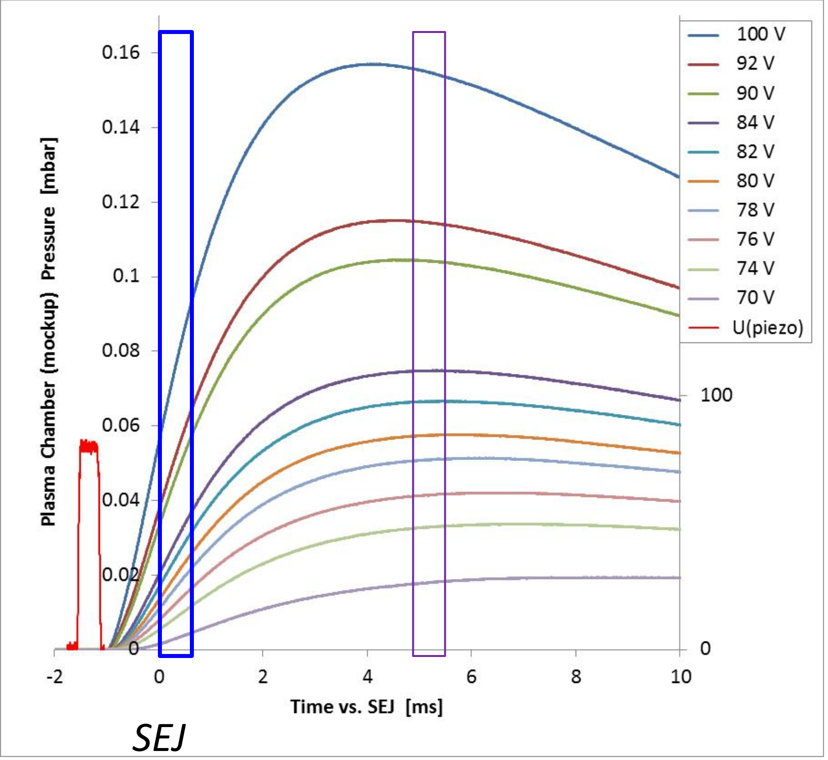


Burned wire insulator and molten magnet housing

Repaired and now operated below 20 kW RF

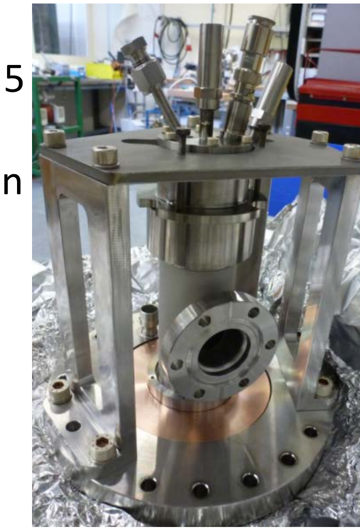




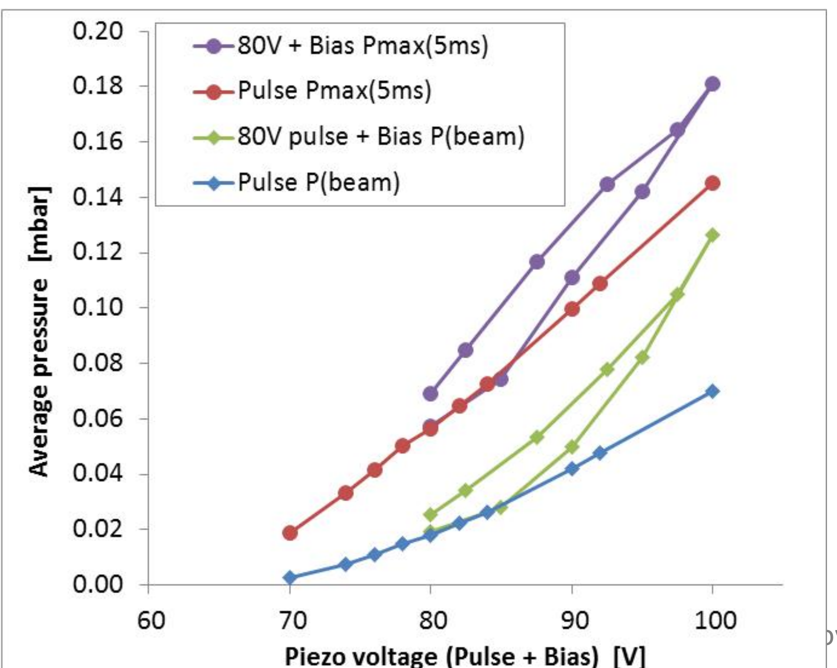


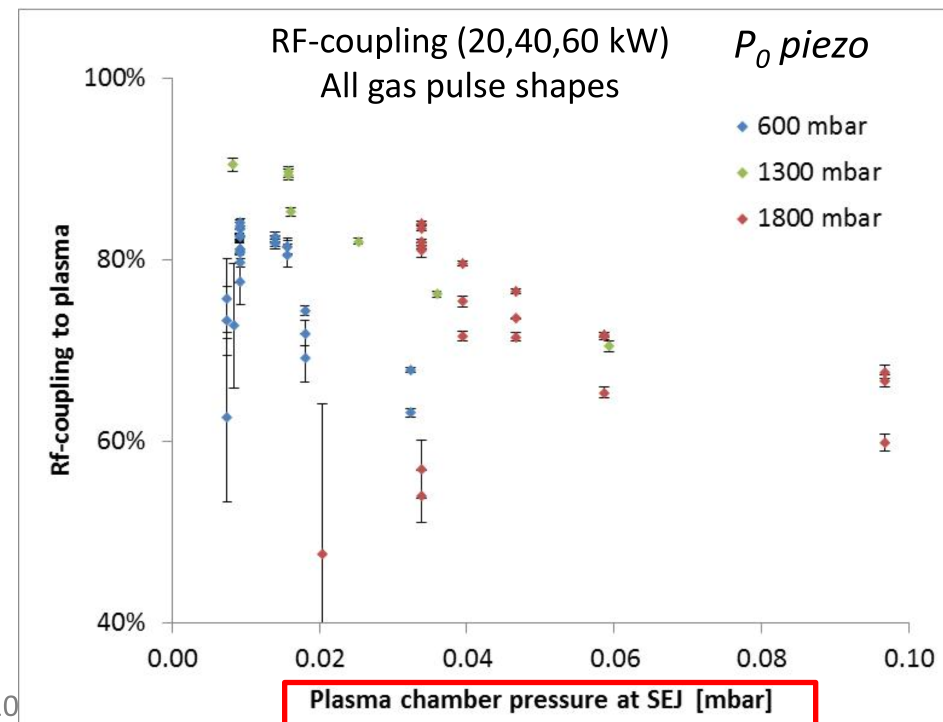
Mock-up pressure meas.

The pressure in the plasma chamber during ignition and H^- pulse depends on 5 piezo valve operation parameters:
P_0, delay, bias, pulse voltage and duration



- ✓ *These partial derivatives are measured.*
- ✓ *RF-power profile ramp minimizes AVC's overshoot*
- ✓ *Rf-inductive plasma ignition (No spark-gap) operational*





Simulations & benchmarking of measurement

The Linac4 ion source team produced 24 conference papers, all published or accepted for publication from 2010 to 2013. Improving our basic understanding of H^- ion source physical processes and developing measurement techniques of predictable observables is mandatory to address technical challenges and to identify the direction of development towards 98% reliability

H_2-injection dynamics	→	1) Neutrals at ignition ↔ *P-meas.*
RF-field & Plasma conductivity	→	2) **E** and **B** fields
1+2 → PIC Plasma heating Keio	→	3) e-density and EEDF
3 → CR-model	→	4) *H_0 density … flux*
		5) Light emission ↔ *OES-P observable*
4 → Beam formation ONIX	→	6) electron & H^- beam, emittance
6 → Beam transport IBSimu	→	7) emittance ↔ *OES observable*
7 → Beam neutralization		

NIBS 2010 Takayama

- J. Lettry, S. Bertolo, A. Castel, E. Chaudet, J.-F. Ecarnot, G. Favre, F. Fayet, J.-M. Geisser, M. Haase, A. Habert, J. Hansen, S. Joffe, M. Kronberger, D. Lombard, A. Marmillon, J. Marques Balula, S. Mathot, O. Midttun, P. Moyret, D. Nisbet, M. O'Neil, M. Paoluzzi, L. Prever-Loiri, J. Sanchez Arias, C. Schmitzer, R. Scrivens D. Steyaert, H. Vestergard, M. Wilhelmsson, Measurement of optical emission from the hydrogen plasma of the Linac4 ion source and the SPL plasma generator, *AIP Conf. Proc.* 1390 (2011) pp.245-254.
- M. Paoluzzi, M. Haase, J. Marques Balula, D. Nisbet, CERN LINAC4 H- Source and SPL plasma generator RF systems, RF power coupling and impedance measurements, *AIP Conf. Proc.* 1390 (2011) pp.265-271.
- M. Kronberger, E. Chaudet, G. Favre, J. Lettry, D. Küchler, P. Moyret, M. Paoluzzi, L. Prever-Loiri, C. Schmitzer, R. Scrivens, and D. Steyaert, Magnetic Cusp Configuration of the SPL Plasma Generator, *AIP Conf. Proc.* 1390 (2011) pp. 255-264.

ICIS 2011 Giardini Naxos

- 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).
- Ø. Midttun, T. Kalvas, M. Kronberger, J. Lettry, H. Pereira, C. Schmitzer, and R. Scrivens, *A New extraction system for the Linac4 H- ion source,* Review of Scientific Instruments 83, 02B710 (2012).
- C. Schmitzer, M. Kronberger, J. Lettry, J. Sanchez-Arias, and H. Störi, Plasma characterization of the SPL plasma chamber using a 2 MHz compensated Langmuir Probe, Review of Scientific Instruments 83, 02A715 (2012).
- J. Lettry, U. Fantz, M. Kronberger, T. Kalvas, H. Koivisto, J. Komppula, E. Mahner, C. Schmitzer, J. Sanchez, R. Scrivens, O. Midttun, P. Myllyperkiö, M. O'Neil, H. Pereira, M. Paoluzzi, O. Tarvainen, D. Wünderlich, Optical Emission Spectroscopy of the Linac4 and SPL Plasma Generators, Review of Scientific Instruments 83, 02A729 (2012).

NIBS 2012 Jyvaskyla

- 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.
- H. Pereira, D. Faircloth and J. Lettry, *Operation and thermal modeling of the ISIS H- source from 50 to 2 Hz repetition rates*, *AIP Conf. Proc.* 1515 (2013) pp.114-120.
- S. Mochalskyy, J. Lettry, T. Minea, A. F. Lifschitz, C. Schmitzer, O. Midttun, D. Steyaert, *Numerical modeling of the Linac4 negative ion source extraction region by 3D PIC-MCC code ONIX*, *AIP Conf. Proc.* 1515 (2013) pp.31-40.
- J. Lettry, D. Aguglia, Y. Coutron, A. Dallochio, H. Perreira, E. Chaudet, J. Hansen, E. Mahner, S. Mathot, S. Mattei, O. Midttun, P. Moyret, D. Nisbet, M. O'Neil, M. Paoluzzi, C. Pasquino, J. Sanchez Arias, C. Schmitzer, R. Scrivens, D. Steyaert, J. Gil Flores, *H^- Ion Sources For CERN's Linac4*, *AIP Conf. Proc.* 1515 (2013) pp.302-311.
- C. Pasquino, P. Chiggiato, A. Michet, J. Hansen, J. Lettry, *Vacuum simulation and characterisation for the LINAC4 H^- source*, *AIP Conf. Proc.* 1515 (2013) pp.401-408.
- E. Mahner, J. Lettry, S. Mattei, M. O'Neil, C. Pasquino, C. Schmitzer, *Gas injection and fast-pressure-rise measurements for the Linac 4 H− source*, *AIP Conf. Proc.* 1515 (2013) pp.425-432.
- S. Mattei, M. Ohta, A. Hatayama, J. Lettry, Y. Kawamura, M. Yasumoto, and C. Schmitzer, RF Plasma modeling of the Linac4 H- ion source, *AIP Conf. Proc.* 1515 (2013) pp.386-393.
- Ø. Midttun, T. Kalvas, M. Kronberger, J. Lettry, R. Scrivens, *A magnetized Einzel-lens electron dump for the Linac4 H- ion source*, *AIP Conf. Proc.* 1515 (2013) pp.481-490.

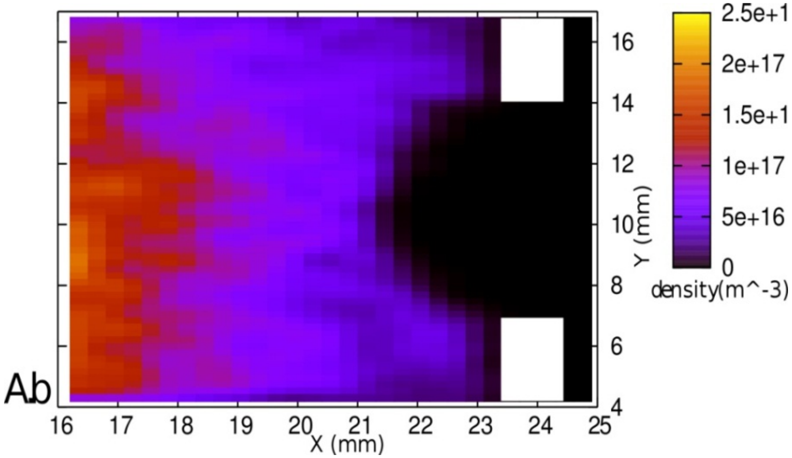
ICIS 2013 Chiba *accepted for publication in AIP Conf. Proc.*

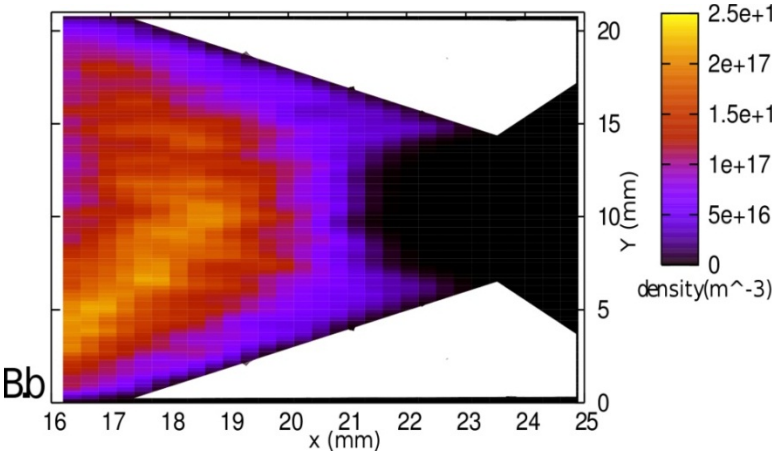
- J. Lettry, D. Aguglia, P. Andersson, S. Bertolo, A. Butterworth, Y. Coutron, A. Dallocchio, E. Chaudet, J. Gil-Flores, R. Guida, J. Hansen, A. Hatayama, I. Koszar, E. Mahner, C. Mastrostefano, S. Mathot, S. Mattei, Ø. Midttun, P. Moyret, D. Nisbet, K. Nishida, M. O'Neil, M. Otha, M. Paoluzzi, C. Pasquino, H. Pereira, J. Rochez, J. Sanchez Alvarez, J. Sanchez Arias, R. Scrivens, T. Shibata, D. Steyaert, T. Yamamoto, *Status and Operation of the Linac4 Ion Source Prototypes*.
- Ø. Midttun, J. Lettry, and R. Scrivens, *Measurements of Linac4 H- Ion Source Beam with a Magnetized Einzel Lens Electron Dump*.
- R. Scrivens, G. Bellodi, O. Crettiez, V. Atanasov Dimov, D. Gerard, E. Graneman Souza, R. Guida, J. Hansen, J.-B. Lallement, J. Lettry, A. Lombardi, Ø. Midttun, C. Pasquino, U. Raich, B. Riffaud, F. Roncarolo, C. A. Valerio-Lizarraga, J. Wallner, T. Zickler, *Linac4 Low Energy Beam Measurements with Negative Hydrogen Ions*.
- C. A. Valerio-Lizarraga, J.-B. Lallement, I. Leon-Monzon, J. Lettry, Ø. Midttun, R. Scrivens, *Space Charge Compensation in the Linac4 Low Energy Beam Transport Line with Negative Hydrogen Ions*.
- A. Grudiev, J. Lettry, S. Mattei, M. Paoluzzi, and R. Scrivens, *Numerical Simulation of Electromagnetic Fields and Impedance of CERN LINAC4 H- Source taking into Account the Effect of the Plasma*.
- S. Mattei, M. Ohta, M. Yasumoto, A. Hatayama, J. Lettry, A. Grudiev, *Plasma ignition and steady state simulations of the Linac4 H- Ion Source*.
- M. Ohta, S. Mattei, M. Yasumoto, A. Hatayama and J. Lettry, *Numerical Study of the Inductive RF-discharge Initiation for the Linac4 H- Ion Source*.
- T. Yamamoto, T. Shibata, M. Ohta, M. Yasumoto, K. Nishida, A. Hatayama, S. Mattei, J. Lettry, K. Sawada and U. Fantz, *Modeling of Neutrals in the Linac4 H- Ion Source Plasma; Hydrogen Atom Production Density Profile and H_α Intensity by CR Model*.
- K. Nishida, S. Mochizuki, M. Yasumoto, M. Ohta, J. Lettry, S. Mattei, and A. Hatayama, *Equivalent Circuit of RF-Plasma with The Transformer Model*.

ONIX PIC-simulation of the plasma-beam formation:

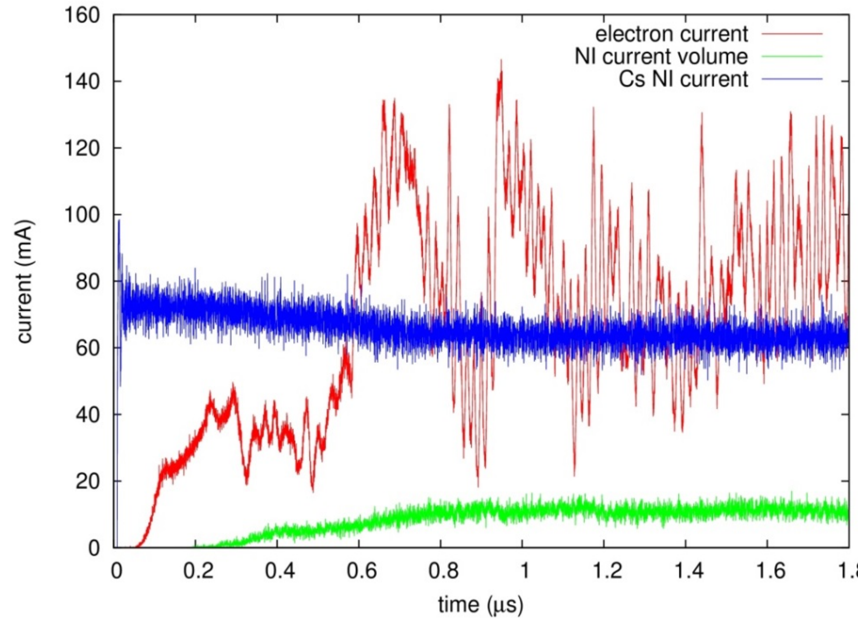
P-density: O(10^{18}) m^{-3}

IS01 & IS02 steady state H^+ density

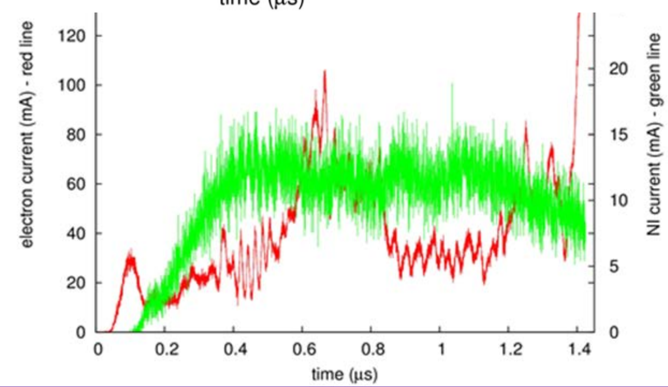




S. Mochalskiy, Collaboration with LPGP Orsay France



IS02 No-Cs
Tested Nov.12th



13 runs @ 2weeks & 20 cpus:

- *IS01, (volume production), IS02, Vol. & Surface*
- *Sensibility study: H^- prod. Rate (1-7 kA/m^2), filter field strength, Super particles density, **plasma density** (5×10^{17}-2×10^{18} m^{-3}) and electron to H^- ion ratio (5:5-1:10)*
- *positive and negative ion extraction*

Conclusion outlook

1) The ISWP could meet RFQ driven deadlines, a 15 mA, 45 kV H^- commissioning beam is available in the linac4.
2) However, the intensity and beam emittance are not met. The IS01 optics emittance is limited by volume source e/H ratio requiring design of high current low energy e-dumping.
3) Two sets of prototypes were produced, more time is required to conclude on their performances and potential.
4) All ancillary systems are operational, all of them require improvements in reliability, controls (GUI) and monitoring.
5) The availability of the test stand was O(20%) over the last 4 month… many valid explanations, but 98% is very far. Numerous specialist needed, all of them very busy, all found a slot within the next few days.
6) Simulation of the key processes (i.e. H_2-injection, RF, plasma heating) are at a level where engineering and optimization could start.

		L4-ISWP		
	drawing ***SPLNFHR…***	**E**	**F**	***G***
	units produced :	IS01	IS02	*IS03*
Design / Eng. / Prod.	Frontend, support Pumping port	2	-	-
	Main insulator	2	x	x
	Extraction optics	2	x	x
	Plasma Generator	2	2	1
	Flange	2	2 + x	x
	RF-Transfo-Matching	2	-	-
	Handling-gear	1	x	x
IS-TS 152	IS-test stand 152	1		
	LEBT	1		
	Photometry Spectroscopy	1		
	RF-Amplifier 100kW 50Hz			
L4-IS 400	L4 faraday cage 400	1		
	LEBT	1		
	RF-Amplifier 100kW 2Hz			
Ancillaries	Pumping system	2		
	RGA	1		
	Pulsed HV + cw Einzel	2		
	Arc Discharge			x
	H2-distribution IS+LEBT	2		
	Cs-Oven		2	x
	Cs-test stand 357	HV + Piezo	1	
	Mag-meas. Unit 6			

Thank to all contributors, great motivated IS-team

Major contributions from IS-team students and fellows

				2.0				6.0				7.8				6.0				2.5				2.0			
				2010				2011				2012				2013				2014				2015			
Matthias	Kronberger	CERN	Th-load-Beam optics			0.25	0.25	0.25	0.25	0.25																	
Claus	Schmitzer		Langmuir, RF-coupling			0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25													
Oystein	Midttun		Beam optics, operation			0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25							
Stefano	Mattei		Plasma modeling								0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25							
Hugo	Pereira		Cesium Lab. Sputtering					0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25										
Jose	Sanchez		Meas. B-field, FPGA RF			0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25										
Jaime	Gil Flores		Controls, database									0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25								
Chiara	Pasquino		H2-injection							0.25	0.25	0.25	0.25														
Cristhian	Valerio		LEBT space charge								0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25								
Sylvia	Izquierdo		H2-distr controls										0.25	0.25													
Mahel	Devoldere		FE engineering							0.25																	
Daniel	Fink		Spectro / beam																	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
			Plasma / Cesiation																								
Marco	Garlasche		IS02 engineering													0.13	0.13	0.13	0.13								
Serhiy	Mochalsky	LPGP Orsay	Beam formation										0.25	0.25													
Taneli	Kalvas	Jyvaskyla Univ.	Beam Optics					0.25																			
Masatoshi	Ohta	Keio Univ.	Plasma Modeling						0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25							
Masatoshi	Yasumoto								0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25							
Kenjiro	Nishida												0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Takanori	Shibata		Neutrals transport						0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13							
Takashi	Yamamoto												0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13