LHC Injectors and Experimental Facilities Committee Workshop
Linac4 Source

The numerous contributions of the Linac4 ion source and sLHC teams and international colleagues is gratefully acknowledged

Abstact

According to the Linac 4 design parameters, the H^- source is expected to deliver 400 us pulses with an average current of 80mA at 45 KeV, at a frequency of 1 Hz.

The RF driven volume source presently installed at the 3 MeV test stand has been conceived as an upgrade of the 35 KeV, 50mA source used at DESY. The commissioning at 35 KeV has been completed and the problems encountered for the 45 KeV H^- upgrade will be discussed.

The source has been now converted to a 45 KeV proton source and will be used for the RFQ and chopper commissioning.

In the frame of the plasma generator work package within the SLHCPP EU-project, a 50Hz, 1.2 ms, 100kW, 2MHz RF test stand was developed and a multi kW plasma generator derived form the DESY volume source was designed, produced and tested.

A crash program has been initiated to provide a new Linac4 source design. The new source development compatibility with the different Linac4 installation scenarios, the needed resources and main road map will be described in detail.

Linac4 Source

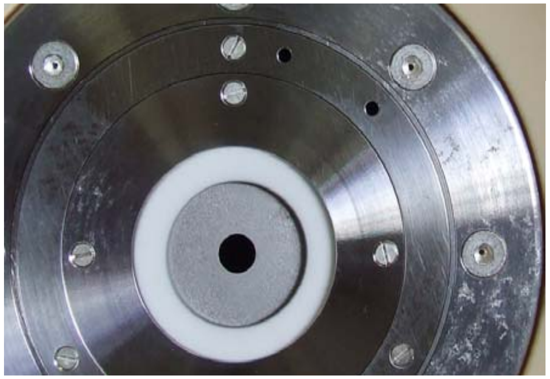
- DESY vs Linac4 and SPL ion source parameters
- Copy of the Desy ion source at the 3 MeV test stand: Commissioning findings
- WPIS amendment proposal August 2010
- A brief review of H^- accelerators ion sources
- sLHCPP 7.1 Plasma Generator commissioning
- WPIS February 2011 vs. LS1 schedule

DESY, Linac4 and SPL ion source parameters

H^- ion source stages		DESY	Linac4 Oct-2010	*Linac4 Dec-2012*	Nominal June-2015	SPL-PG	L4 / DESY
Repetition rate	Hz				2	50	
HT	kV	35	35	45	45		128%
RF-power	kW	30	30	80	100	100	333%
RF-pulse	J	4.5	15	40	70	120	15.56
H- current	mA	30	20	30	60-80		267%
Pulse duration	ms	0.15	0.5	0.5	0.7	1.2	467%
Co-extracted electrons *	A		2	3	5		
e-dump power *	J		35	68	158		

(*) Assuming dump at ground, the volume source's e/H^- of 50,
Cs sources have e/H^- ratio of typically 2-10.

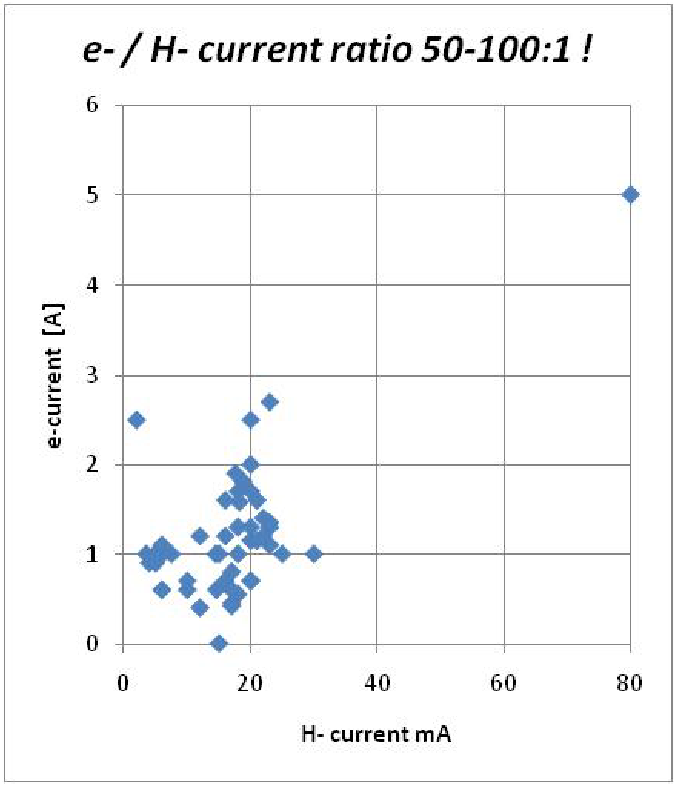
Copy of the DESY ion source at the 3 MeV test stand: Commissioning findings



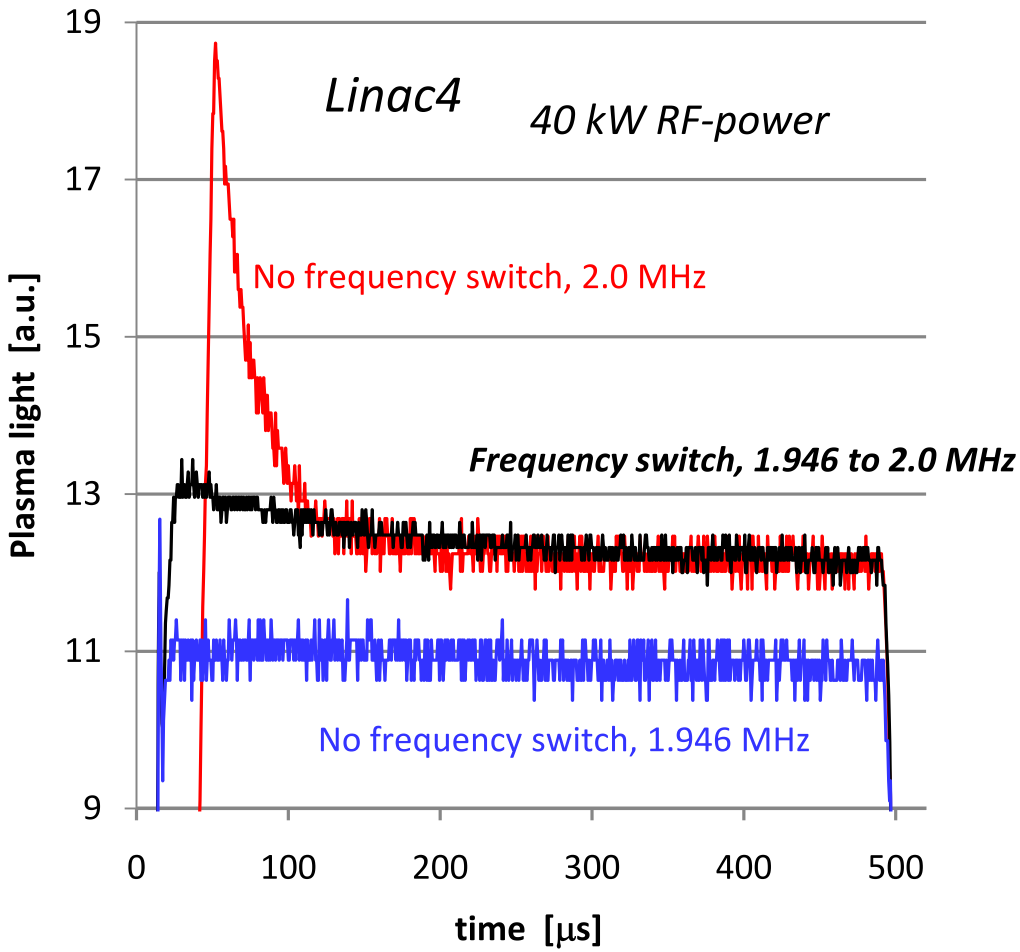
Present Show stopper

- E-dump energy: *2 orders of magnitude reduction mandatory*
- High voltage
  - Sparks (2 μF > 2 kJ)
  - Antenna air ionization
  - Internal capacities (sparks to H2-line)

- Thermal load
- Alignment, tuning flexibility
- Spare parts policy (*fast IS-exchange*)
- Emittance is nominal at low current and is expected to increase
- HT power supply requires upgrade for 2 Hz operations



L4-IS achievement: *RF frequency switch*



O. Midttun,
R. Scrivens,
D. Kuchler,
M. Paoluzzi,
M. O'Neil,
C. Mastrostefano

Action plan August 2010,

draft Schedule & Resources: *34 FTE, 4.5 MCHF*

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	Operation, p, 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	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	

	mY	*fraction*	*kCHF*	*hours*
total Manpower	33.9			
staff	20.3	60%		
Fellows	*13.6*	40%, 36%	1632	
FSU+MME		18%	791	15500
hardware		46%	2064	
total cost			4487	

Resources' profile		*2011*	*2012*	*2013*	*2014*	*2015*
Hardware 2.1 MCHF Design office 0.8 MCHF fellows 1.6 MCHF	kCHF	1062	1637	958	494	336
		24%	36%	21%	11%	7%
Staff 20.3 FTE fellows 13.6 FTE	FTE	7.9	11.1	7.4	4.7	2.8
		23%	33%	22%	14%	8%

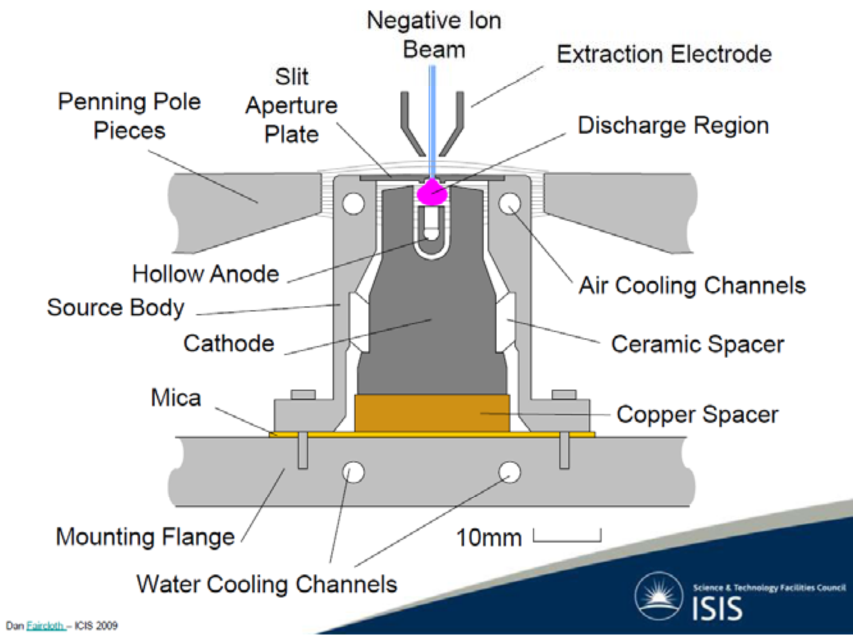
Cesiated H^- ion sources,

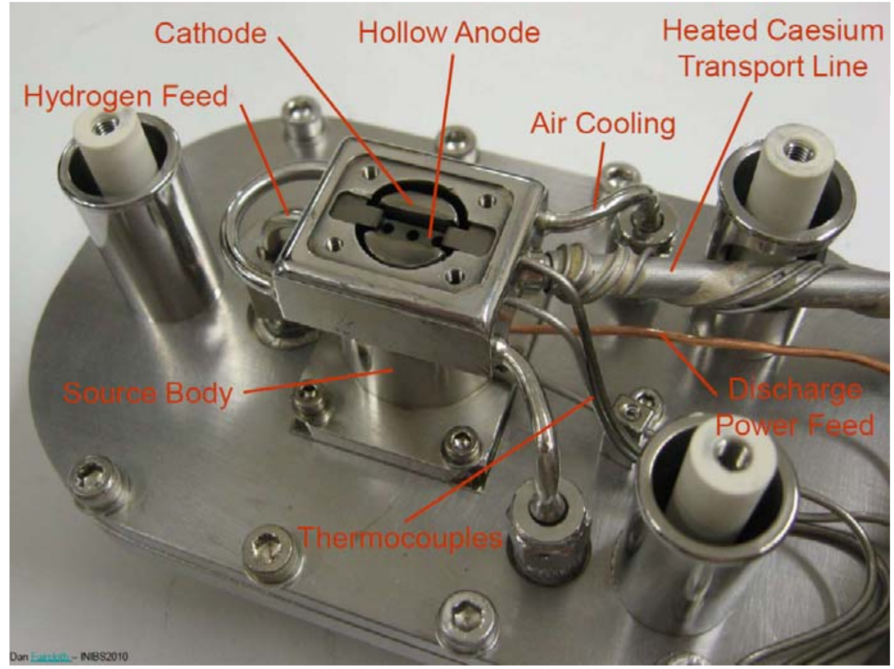
Data extracted for specific operation conditions on: Cs-injection rate, H^- current, emittance, HV, repetition rate and life time

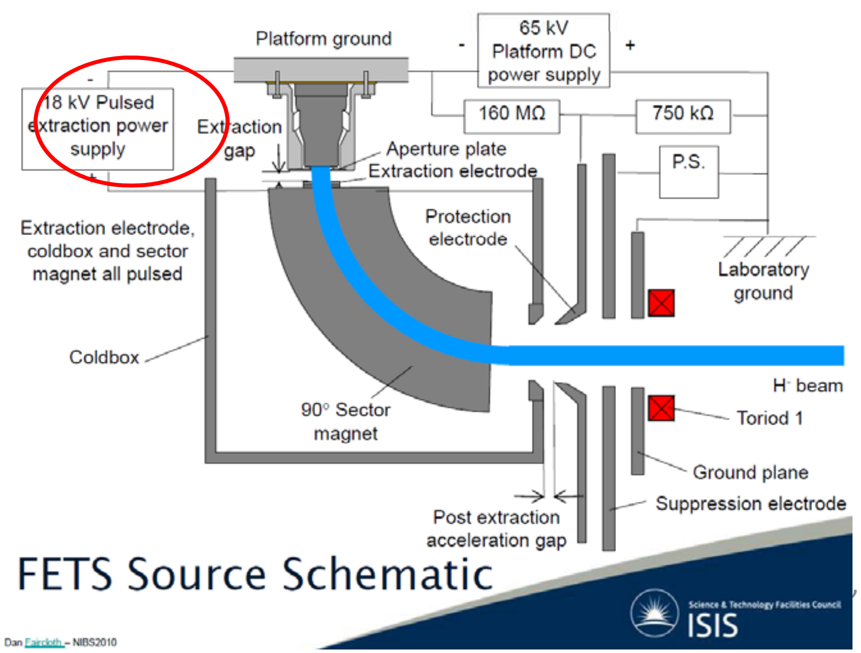
	Cs consumption	*mg/day*	*H^- mA, μs, mmmRad*	*Rate, Life time*
LANL	20 g/ 30 days	600	40 mA, 1000 μs, *0.13* π, 80 keV	120Hz,
DESY	1 mg/day	1	25 mA, 150 μs, *0.25* π, 35 keV	6 Hz, 6 month
J-parc	LaB6, W	No ALARA	36 mA, 500 μs, *0.25* π, 50 keV 60 mA	25 Hz, 500 h
SNS SNS goal	30 mg / 40 days 3 mg	0.75 <0.1	56 mA/85%, 1000 μs, *0.2* π, 50 keV	60 Hz, 5 weeks
RAL	3 g/month	100	35-80 mA, 800 μs, *0.3* π, 65 keV	50 Hz, 1 month
BNL	< 0.5 mg/h	< 12	90-100 mA, 700 μs, *0.4* π, 35 keV	6 Hz, 3-9 month

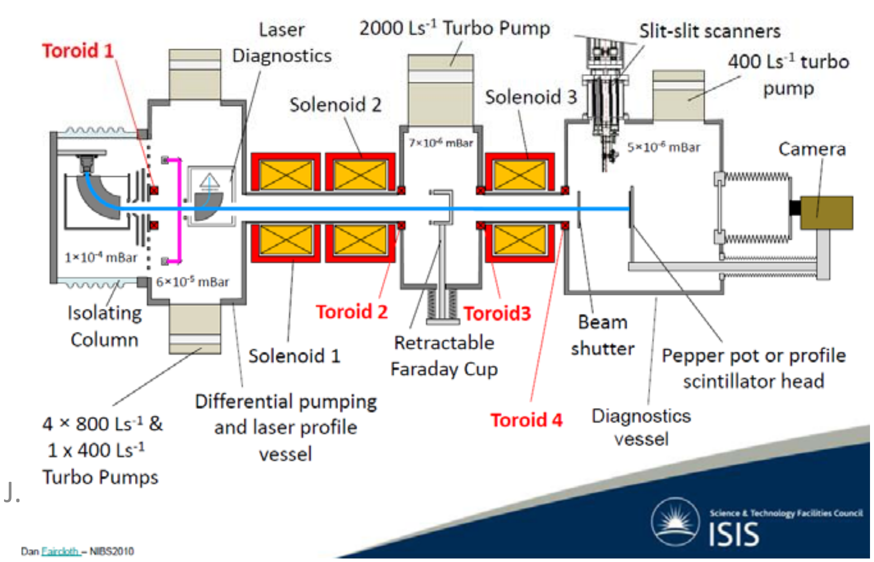
RAL Penning H⁻ ion source

Courtesy form: D. Faircloth,
Presented at NIBS 2010 Takayama









BNL's Magnetron surface plasma H^- ion source

- Pulsed H_2 injection
- IS-exchange : 8h
- Life time: 6 month
- Slow buildup of CsOH will gradually block the hydrogen inlet

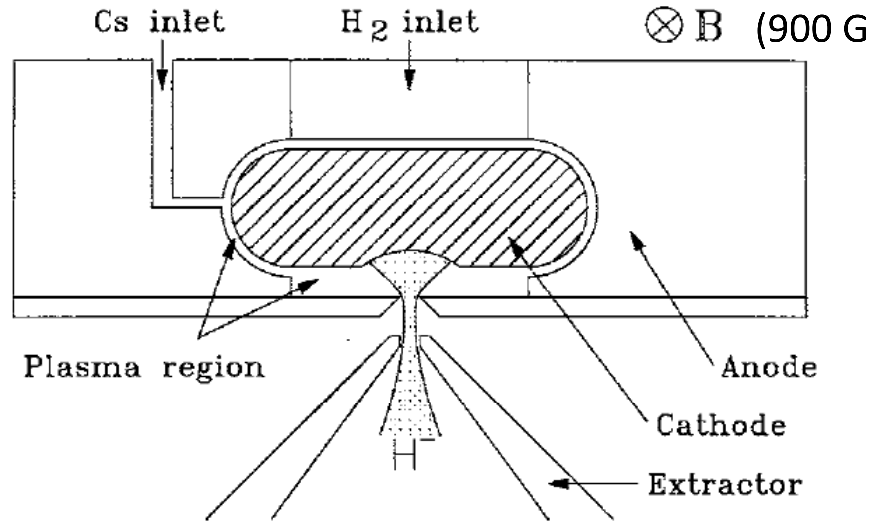


FIGURE 1. Schematic of the magnetron source.

TABLE 1. Typical running parameters

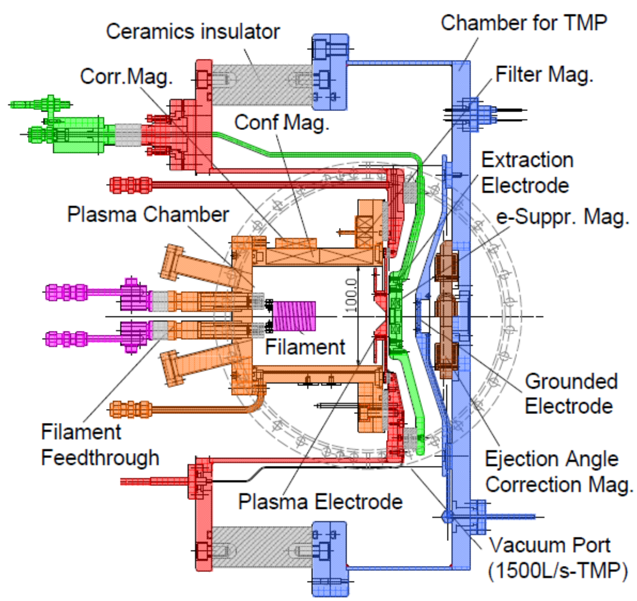
H- current	90-100 mA
J (H-)	1.5 A/cm^2
Extraction voltage	35 kV
Electron/H-	0.5- 1.0
Arc voltage	140 – 160 V
Arc current	8 – 18 A (see note)
Rep rate	7.5 Hz
Pulse width	700 µs
Duty factor	0.5 %
rms emittance	~ 0.4 π mm mrad
Cs consumption	< 0.5 mg / hr
Gas flow	~ 2 sccm

Ref: **Performance of the Magnetron H- Source on the BNL 200 MeV Linac ,** James G. Alessi, *20th ICFA Advanced Beam Dynamics Workshop on High Intensity and High Brightness Hadron Beams, edited by W. Chou, Y. Mori, D. Neuffer, and I.-F. Ostiguy, 2002*

J-Parc double helix cathode, ion sources

J-PARC present ion source

NIBS2010 @Takayama, Japan



Plasma chamber:

- Material: Cu (OFC)
- Size: 100mm in diameter 133mm in length
- **Cesium: Free**

Filament:

- Material: LaB_6
- Type: Double helix
- It was originally developed and has been used at KEK-PS

Beam extractor:

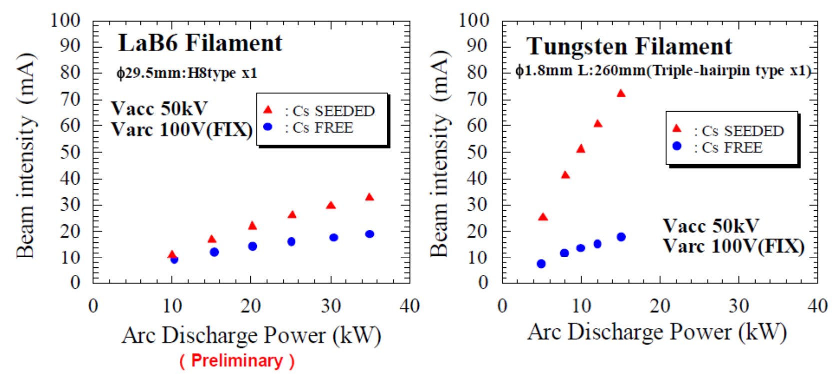
- Number of electrode: 3
- Ejection angle correction magnet (@ exit flange)

Basic structure of the ion source is not changed since the operation was started.

Courtesy form: H. Oguri, K. Ikegami, K. Ohkoshi, Y. Namekawa, A. Ueno Presented at NIBS 2010 Takayama

Results of cesium seeded experiment

NIBS2010 @Takayama Japan



In the Cs-free condition, the maximum H^- ion currents were around 18 mA for the cases with the LaB_6 and the W filament.

In the Cs-seeded condition, the H^- ion current increased by about 4 times for the case with the tungsten filament, however, by less than 45 % for the case with the LaB_6 filament.

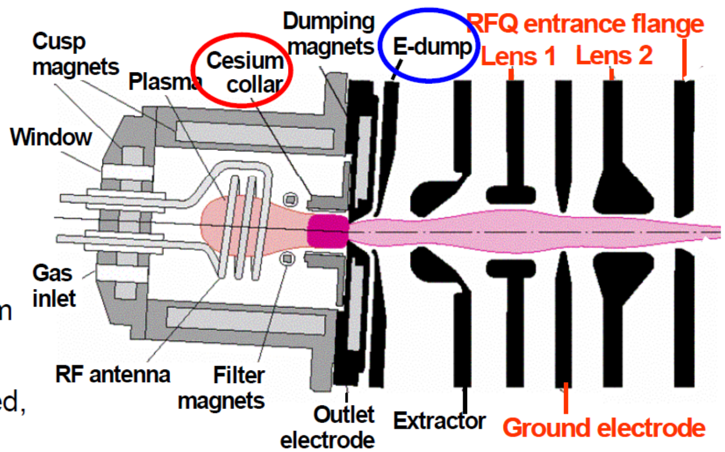
SNS H^- ion source, RF internal antenna

Courtesy form: M. P. Stockli,
Presented at NIBS 2010 Takayama

Cs-chromate + Al-Zr getter

The SNS Baseline H^- Source

- LBNL developed the SNS H^- source, a cesium-enhanced, multicusp ion source.
- Typically 250 W from a 600-W, 13-MHz amplifier generate a continuous low power plasma.
- The high current beam pulses are generated by superimposing 30-70 kW from a pulsed, 80-kW, 2-Mz amplifier.



- **After significant modifications, the SNS H^- source now routinely produces the 38 mA LINAC beam current required for 1-1.4 MW beams!**
- **The source service cycle has been increased from 2 weeks in 2008, to 3, and to 4 and 5 weeks without seeing old-age signs or failures.**
- **We have demonstrated 56 mA MEBT pulse current and 59 mA MEBT peak current, which is sufficient for 2-3 MW beam power.**

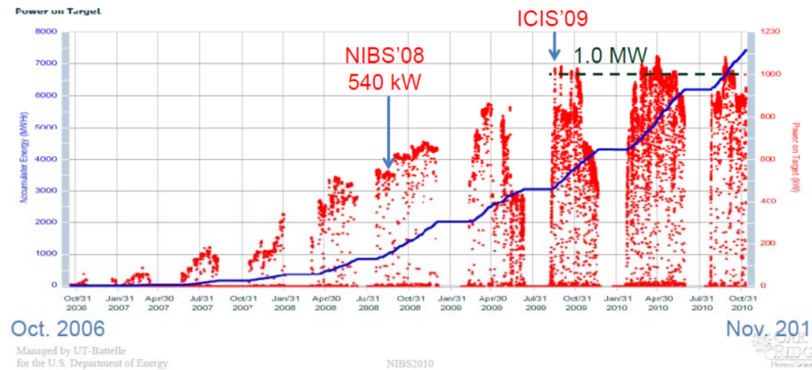
An initial injection of ~3 mg Cs is sufficient for >5 weeks of persistent, ~50 mA H- beams.

The SNS Beam Power Ramp-up

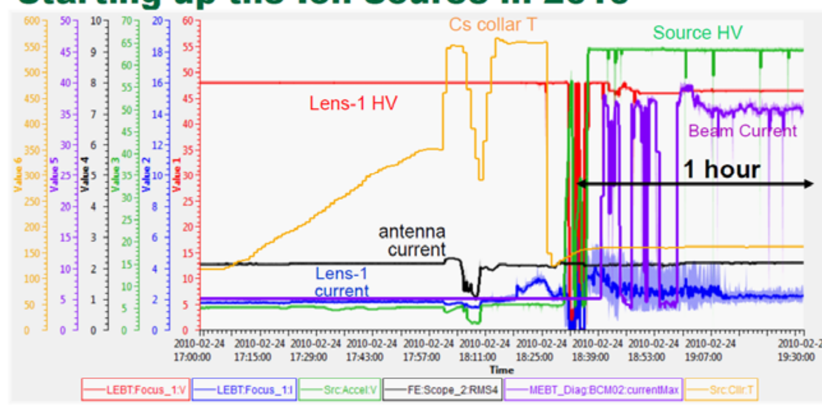
In Sep. 2009, the SNS beam power on target reached 1-MW milestone.

The 1-MW operation parameters:

- Beam energy: 0.925 GeV
- Beam current: 38-42 mA
- Duty factor: 4.8% (60Hz, 0.80ms)
- Chopper beam-on fraction: ~0.6
- Average current: ~ 1.1mA



Starting up the Ion Source in 2010

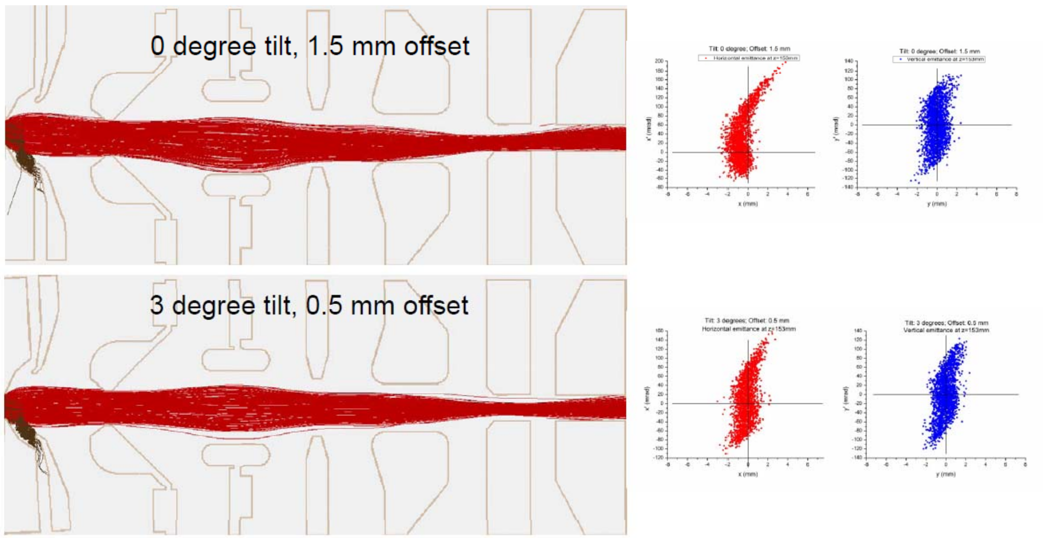


- Reducing the initially released Cs to ≤5 mg has reduced the time of severe arcing to <1 hour. Occasionally, the severe arcing causes extensive damage that requires replacing the source and/or other components.

The goal of this work is to minimize Cs-related arcing to improve source availability and shorting source start-ups!

SNS-simulation of tilt angle and new LEBT

Toward the MW – optimizing ion source tilt and offset



Beam simulation with and without 3 degree tilt

According to this simulation, the beam should be better aligned and transported through the LEBT when the source is at 3 degree tilt. Further work is needed to understand the discrepancy between the simulation and the reality.

18 Managed by UT-Battelle for the U.S. Department of Energy NIBS2010

Courtesy form: B. Han
Presented at NIBS 2010 Takayama
THE NEW LEBT FOR THE SPALLATION NEUTRON SOURCE POWER UPGRADE PROJECT
B. X. Han and M. P. Stockli, SNS, ORNL, Oak Ridge, PAC07, Albuquerque, New Mexico, USA

April May, 3D simulation
T. Kalvas's simulation code including effect of the e-beam

Outcome of H^- accelerators ion sources review

- Review of world's accelerators H^- ion sources completed (Feb)
  - RAL-ISIS
  - BNL Magnetron + Cs metal
  - JPARC
  - SNS inductive RF internal or external antenna + Cs Chromate
  - DESY inductive RF external antenna
- *No H^- ion sources within specified emittance @ nominal beam intensity !*
- Options for Linac4:
  1) L4-inductive external antenna + Cs
     - > 1 MCHF already invested
     - Existing know how, intrinsic flexibility
  2) Upgrade of BNL's magnetron to 45 kV as Risk mitigation
     - Simple and reliable for BNL operations @ 6Hz

Summary:

- August 2010 ISWP resource envelope accepted as 0-baseline.
- ISWP Review confirmed for June 2011
- Pulsed extraction & BNL-IS Mittigation added to the 0-baseline

Mandatory R&D for best Linac4 IS-candidates

function	RF-source	BNL Magnetron
Pulsed gas injection	R&D	R&D
Pulsed HT power supplies	R&D	R&D
Pulsed discharge	Ignition, 20A, 1 kV + R&D on uncorrelated ignitions	Discharge, 400-150 V, 15A, R&D
Cesium injection	Cs-Chromate Single injection	Cs-metal cw flow
H-plasma	Inductive coupling, ignition	Cs-Mo-H plasma & metallurgy
Life time extrapolated to L4	5 weeks, 60 Hz > 3 years	6 month, 6 Hz > 1.5 years
Risks , mitigation	60 to 1-2 Hz, thermal control	6 to 1-2 Hz, heating
Tuning	RF pulse and frequency Gas pressure	Arc power, Gas pressure
Extraction	Multistage 65 kV to 45 kV	Single 35 kV to multi 45 kV

Both system require very similar development at CERN, namely:

Pulsed power supplies
Thermal control
Cs-ovens
3D Simulation of extraction

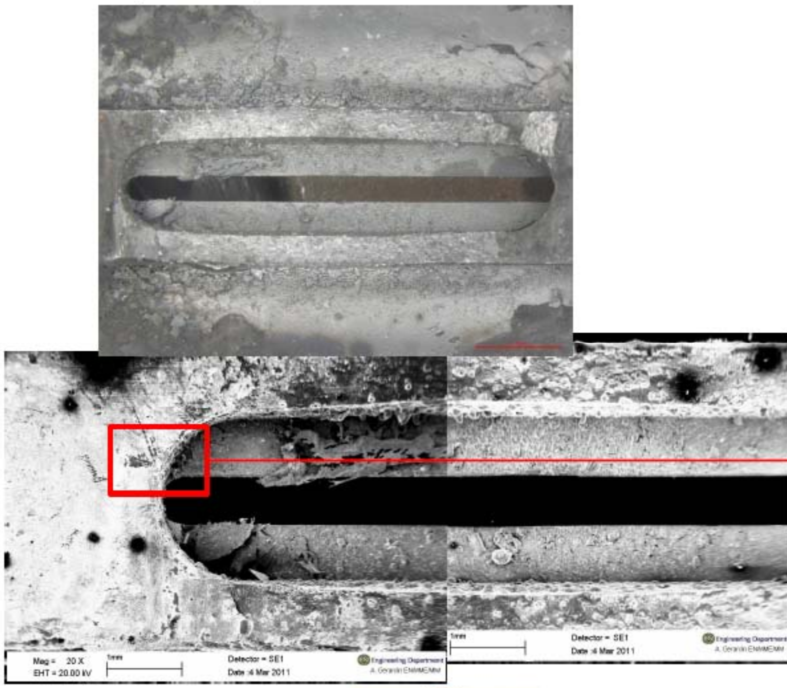
Test stand design:
compatible to RF & Magnetron sources and also to the sLHC PG or DESY-IS

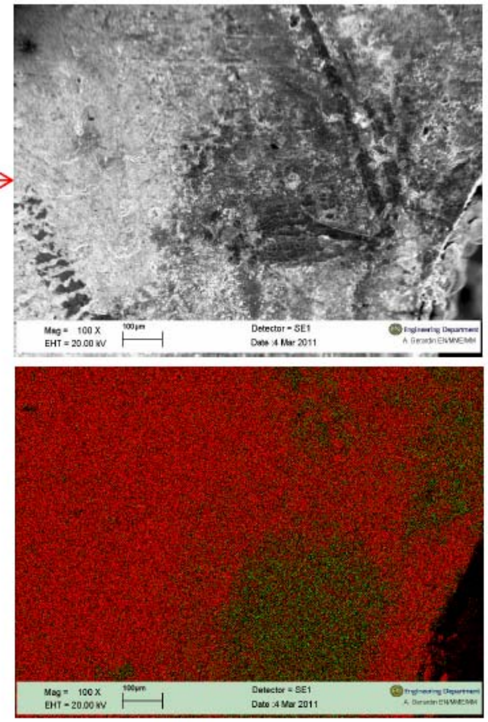
First investigations on arc discharge driven metallic Cs H^- ion sources

Engineering Department

SEM observations:

aperture plate inner surface





EDX mapping:
Red: Mo
Green: Cs

MME Mechanical & Materials Engineering

Probe: ISIS' best ion source courtesy of D. Faircloth RAL
Metallurgy: S. Sgobba & A. Gerardin

Sputtering and Mo-deposition under H2-vapours

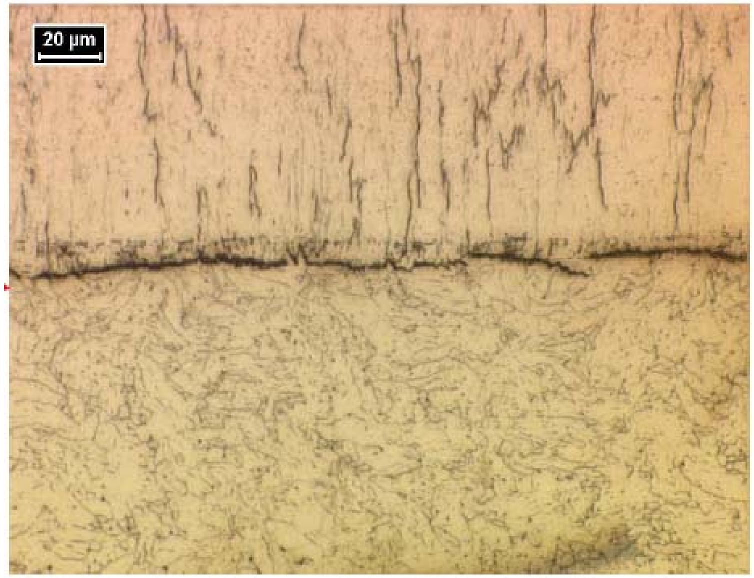
EN Engineering Department

SEM observations:

Cathode tip: sample 2 section analysis

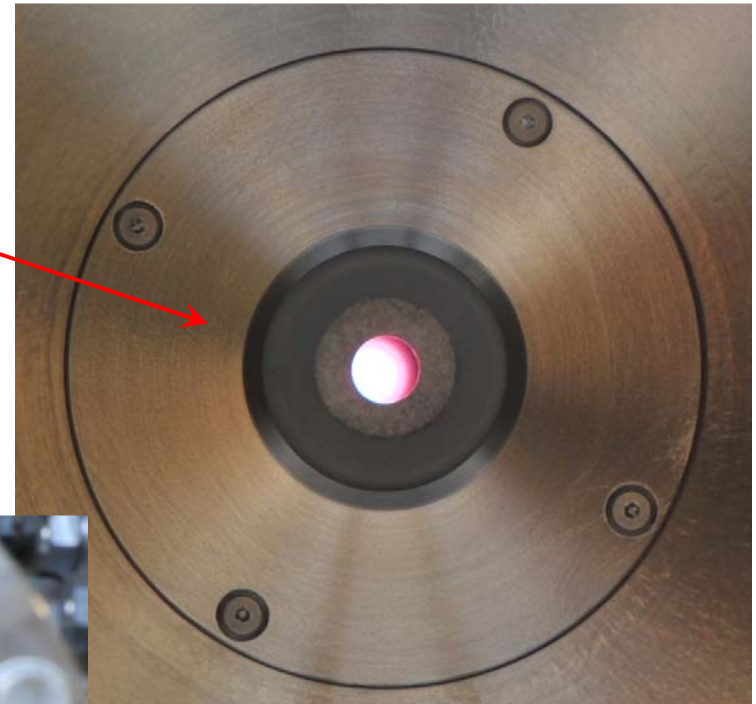
Cs Sputtering of Mo
epitaxial Mo-growth under H2 atm.
Generation of brittle Mo-flakes

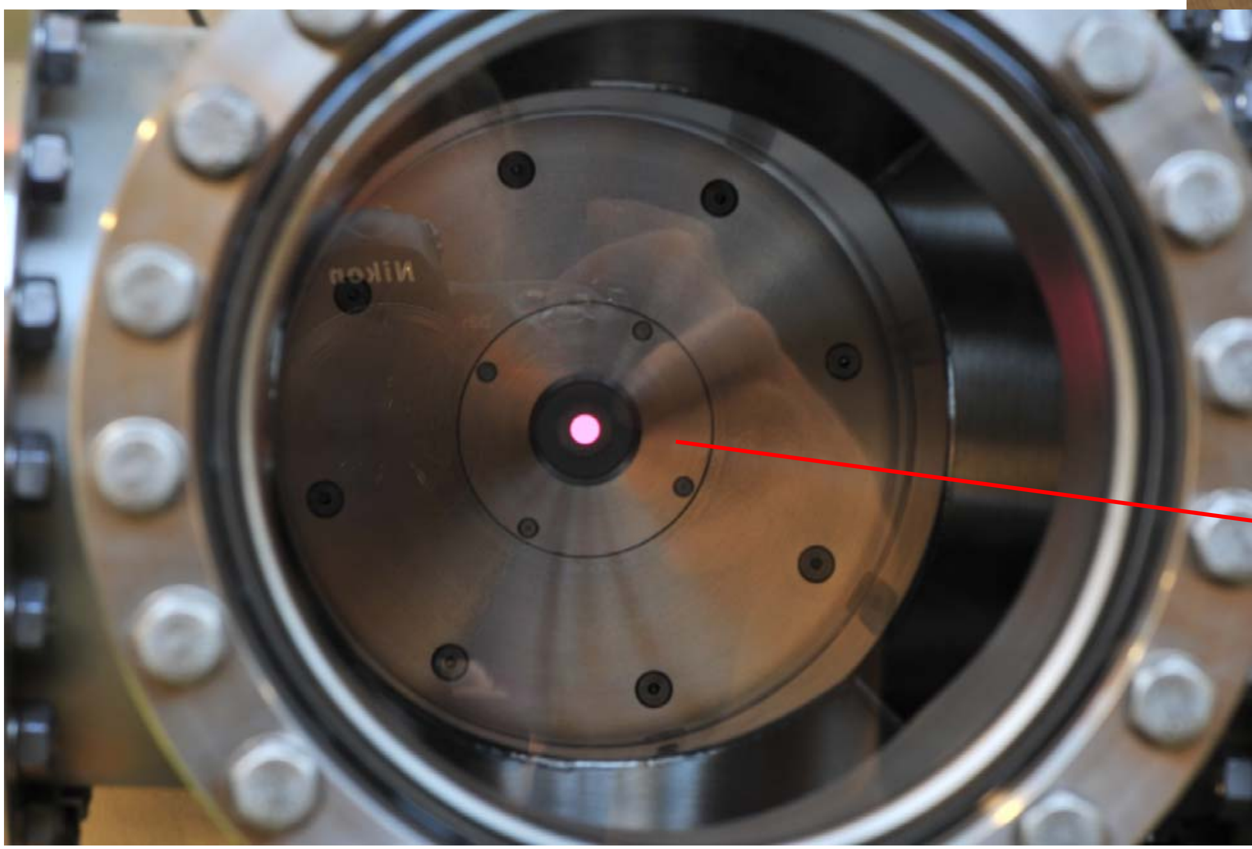
MME Mechanical & Materials Engineering

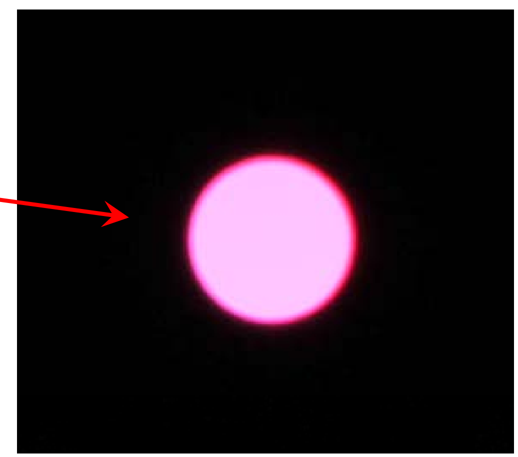


sLHC Plasma Generator's 1st Spark gap Ignition & 1st RF-H-plasma

1st November 2010



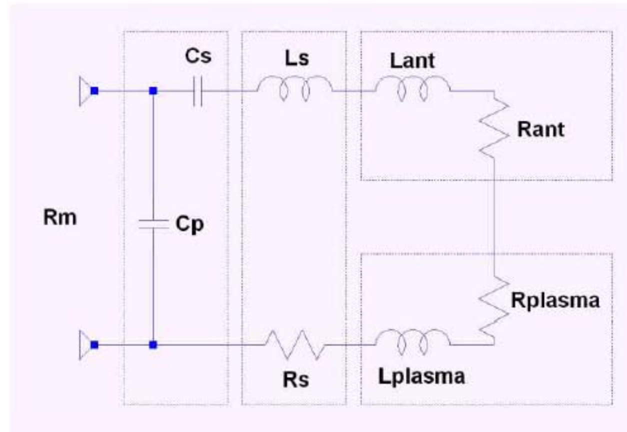


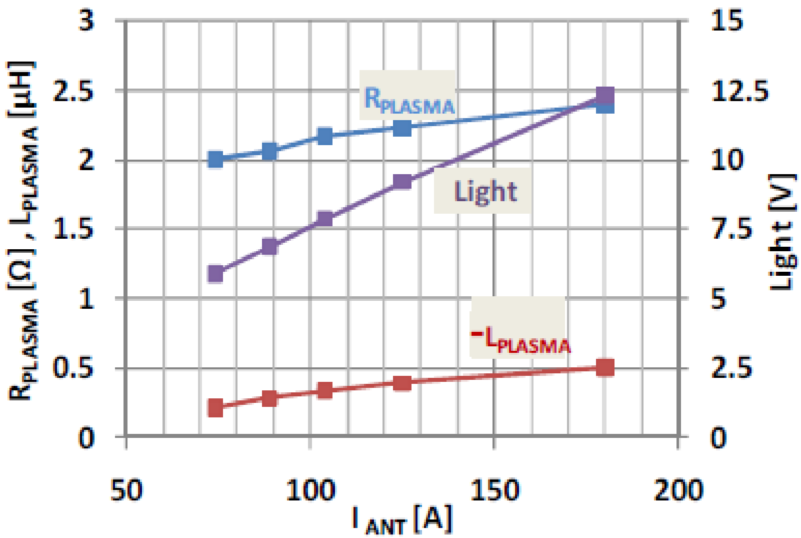


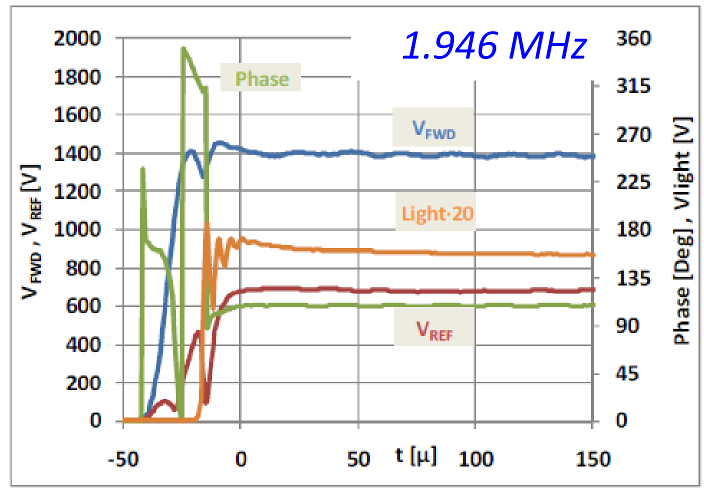
CERN LINAC4 H- Source and SPL plasma generator RF systems, RF power coupling and impedance measurements

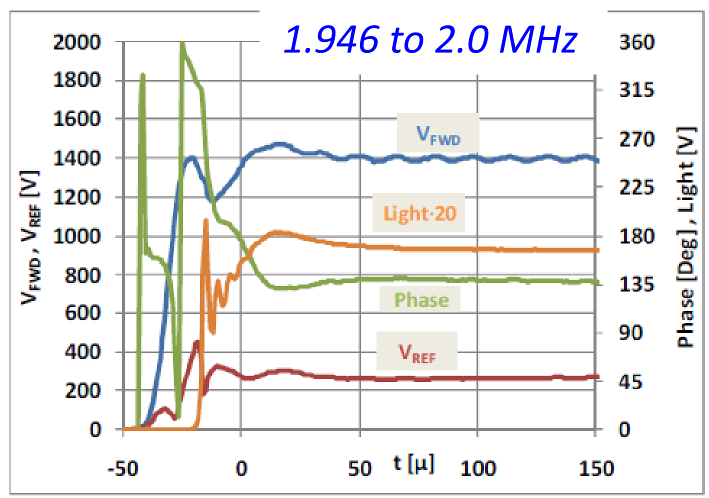
M. M. Paoluzzi, M. Haase, J. Marques Balula, D. Nisbet, NIBS-2010 Takayama

sLHC 7.1 Plasma diagnostics: via RF matching network



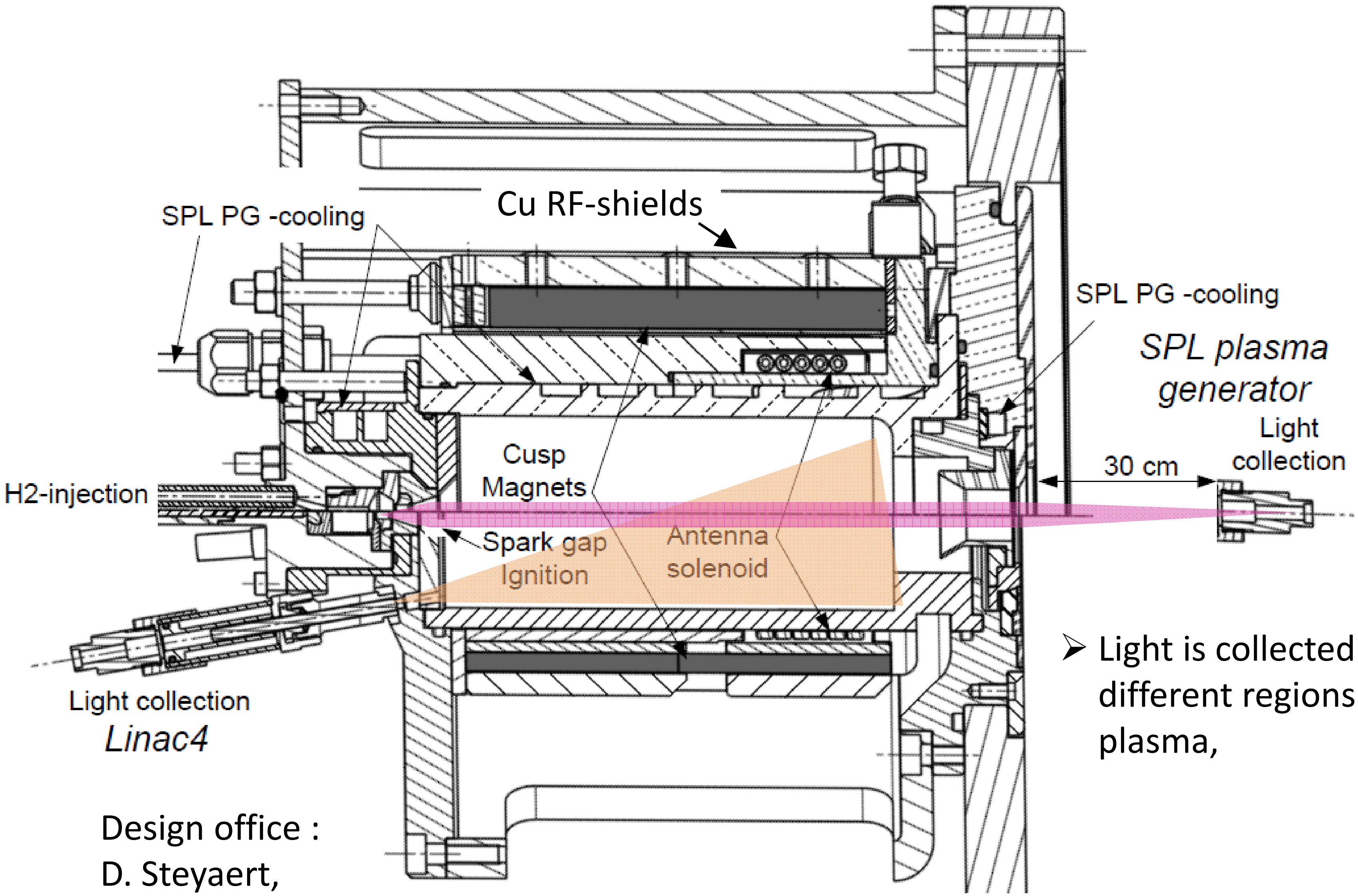






Parameter	H^- Source	SPL Plasma generator
L_{ANT}	3.2 μH	2.53 μH
R_{ANT}	0.4 Ω	0.2 Ω
L_S	1.98 μH	2.27 μH
R_S	0.5 Ω	0.16 Ω
C_S	1.61 nF	1.505 nF
C_P	6.5 nF	6.3 nF
Q	~70 no plasma	~170 no plasma
	~30 with plasma	~150 with plasma
Cable Z_0	50 Ω	50 Ω
Cable length	32.2 ns	30.0 ns

Plasma light capture

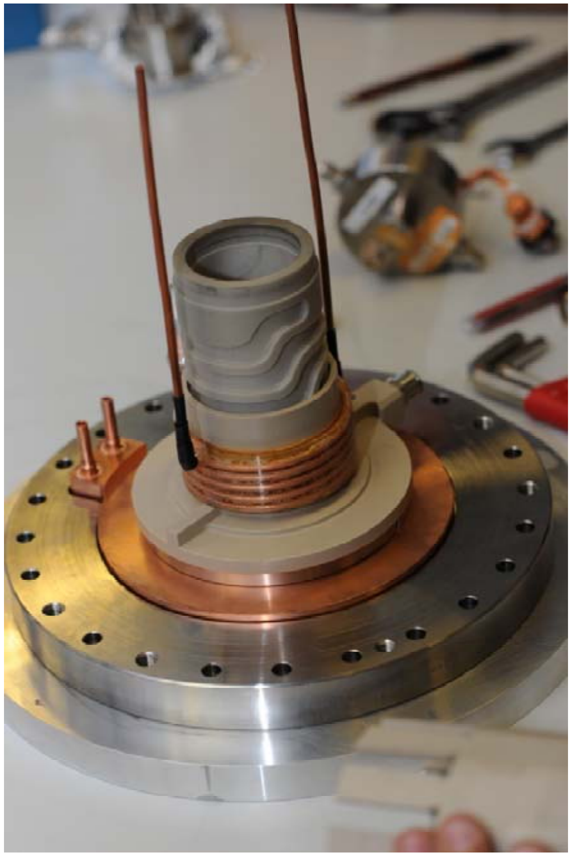


- Light is collected on different regions of the plasma,

Design office :
D. Steyaert,
E. Chaudet

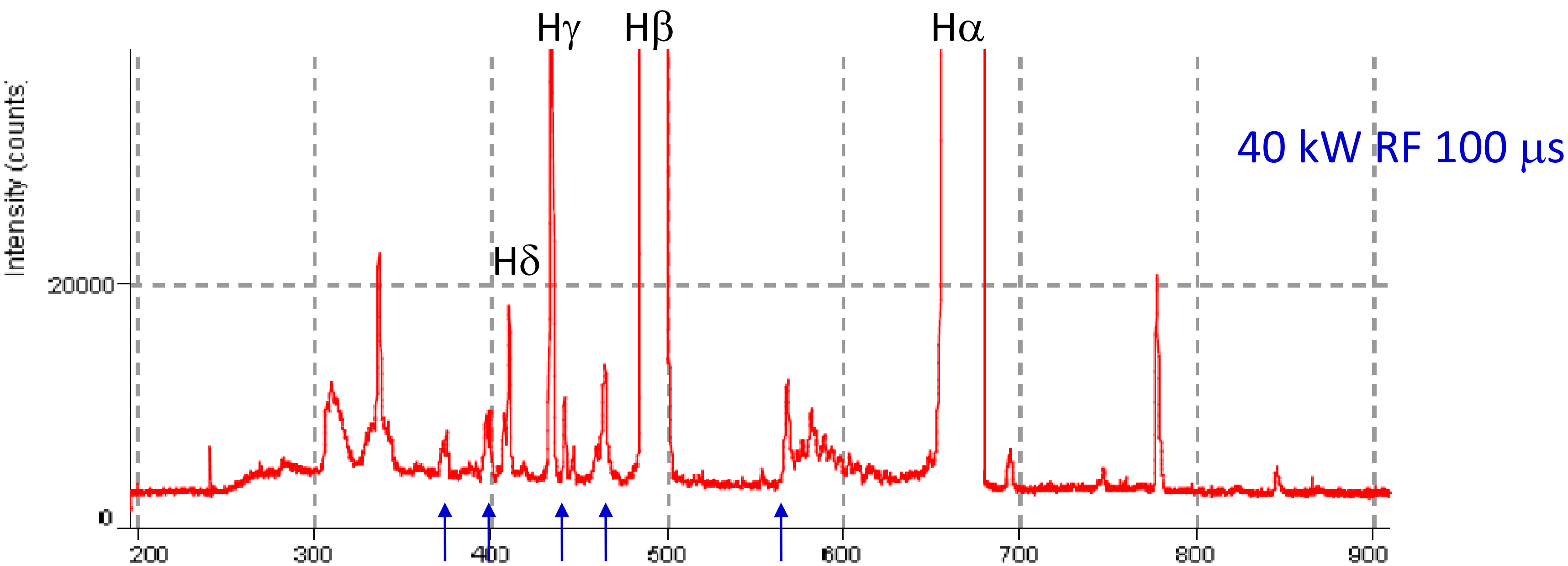
sLHC plasma generator prototype

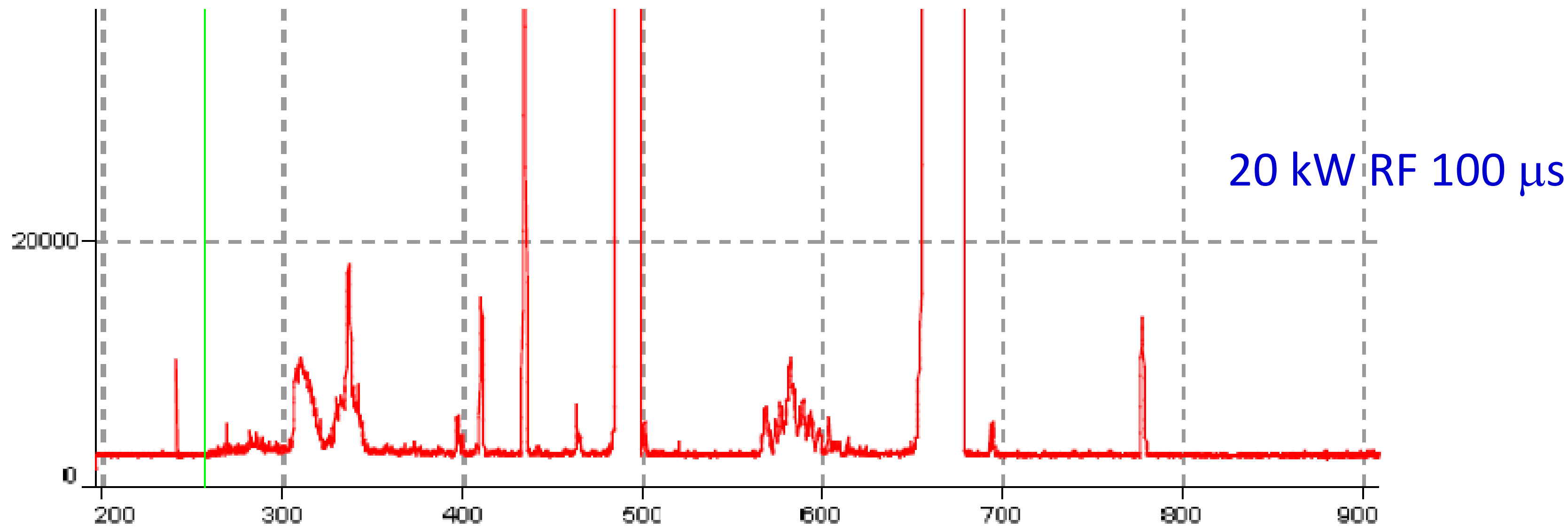
P. Moyret & G. Favre
EN-MMe



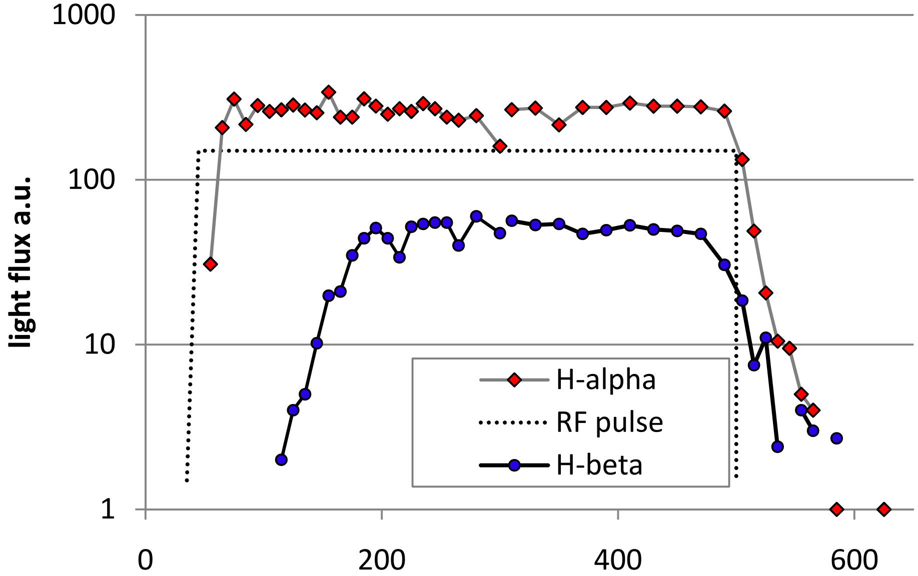
Tight fit is good for team spirit

sLHCPP 7.1 Optical emission spectroscopy



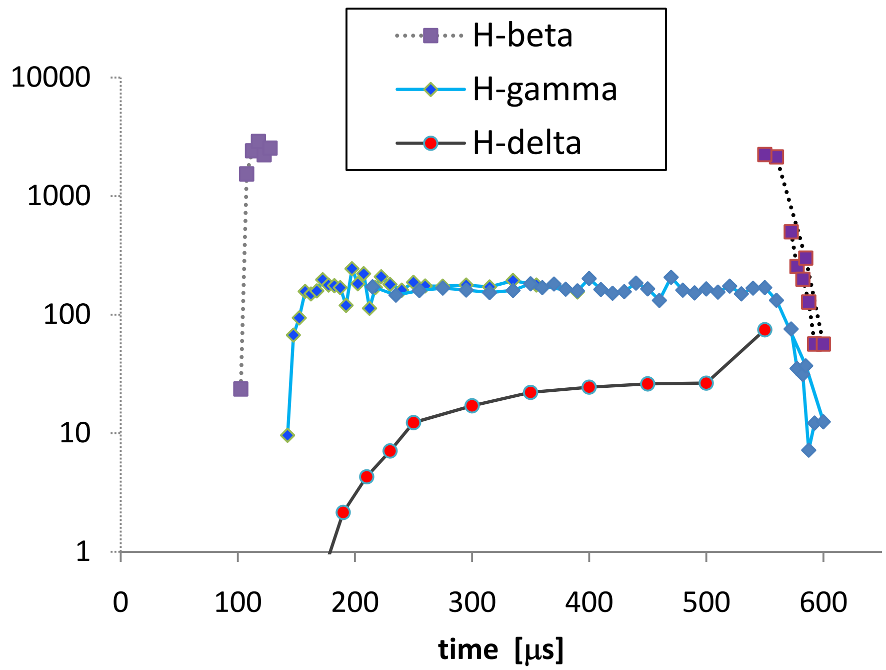


Hydrogen Balmer lines



Plasma Generator (*)

For the sLHC PG &Linac4 IS Optical Emission Spectroscopy is the best and only direct characterization method



Linac4 ion source

	Ratio to previous line	Delay µs	10-90 rise time µs
Hα	1		< 3
Hβ	8-15*	80*	< 5, <40*
Hγ	15	40	< 10
Hδ	8-15	40	< 50

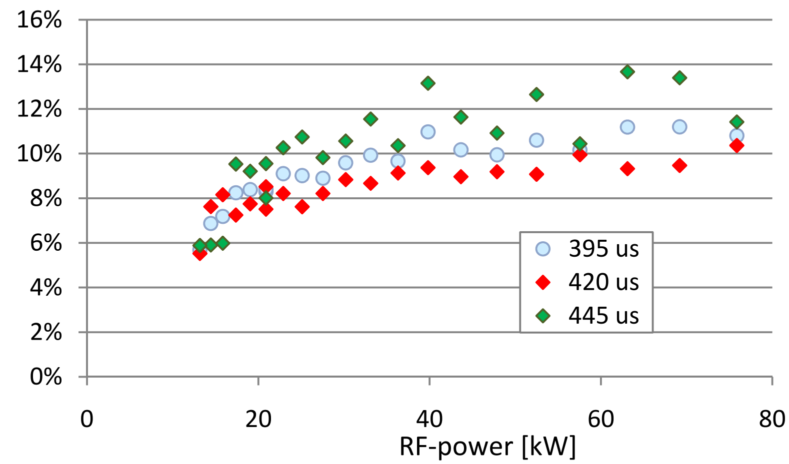
IS Hydrogen plasma characterization: The ratio Hβ/Hα

- At IPP Garching, CR-models are applied to ITER ion sources to characterize the plasma, We extract H^- ions before equilibrium is reached.
- Are the basic assumptions of these models valid 200 μs after the start of an RF pulse **?**

Linac4 ion source

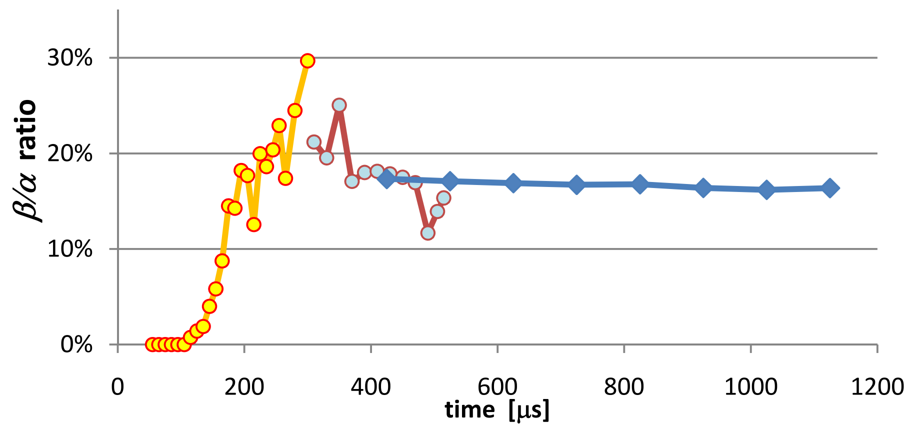
The ratio Hβ/Hα increases with RF power from 6-12%

The lines intensity increases with RF-power



sLHC-Plasma Generator

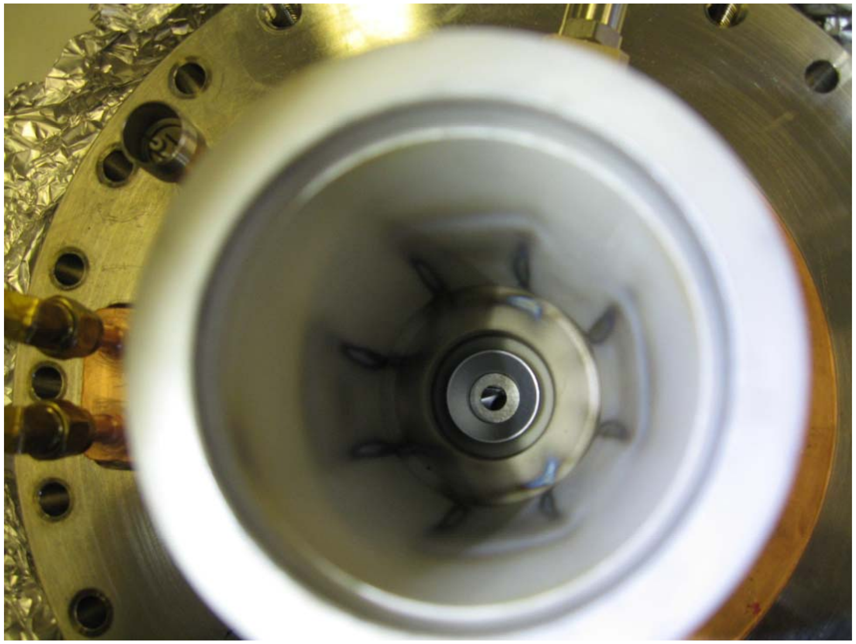
The ratio Hβ/Hα (18%) is almost stable after 150 μs (slope ~ 1%/ms)

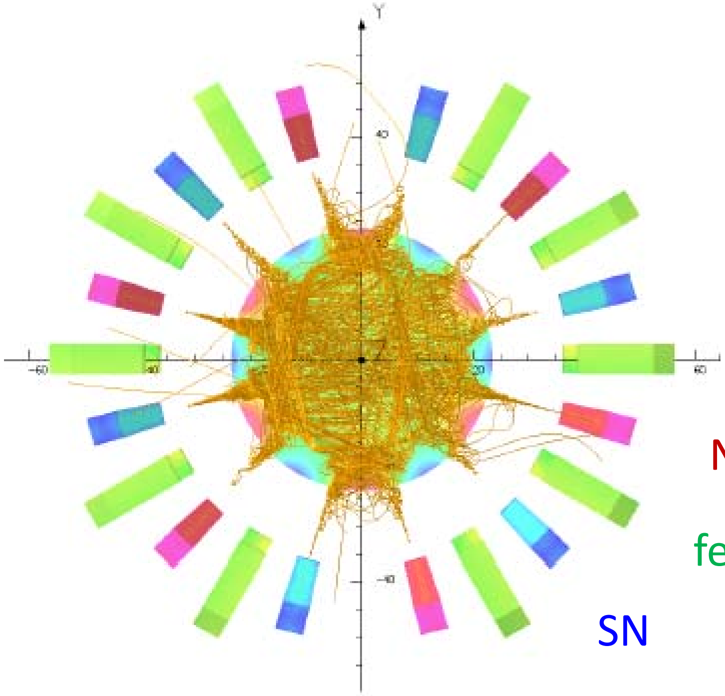


Electron – multicusp confinement

12-pole NS config. Simulation C. Schmitzer)

electron-loss lines





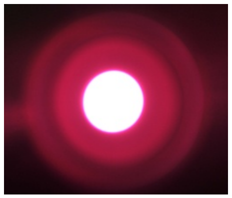
NS

ferrite

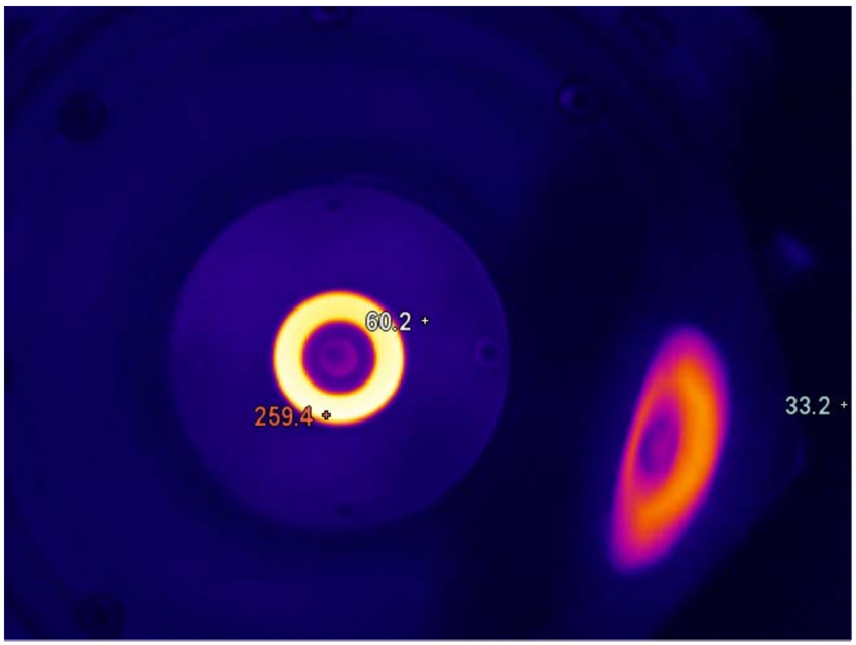
SN

8-pole Halbach config. Proposed by D. Kuchler

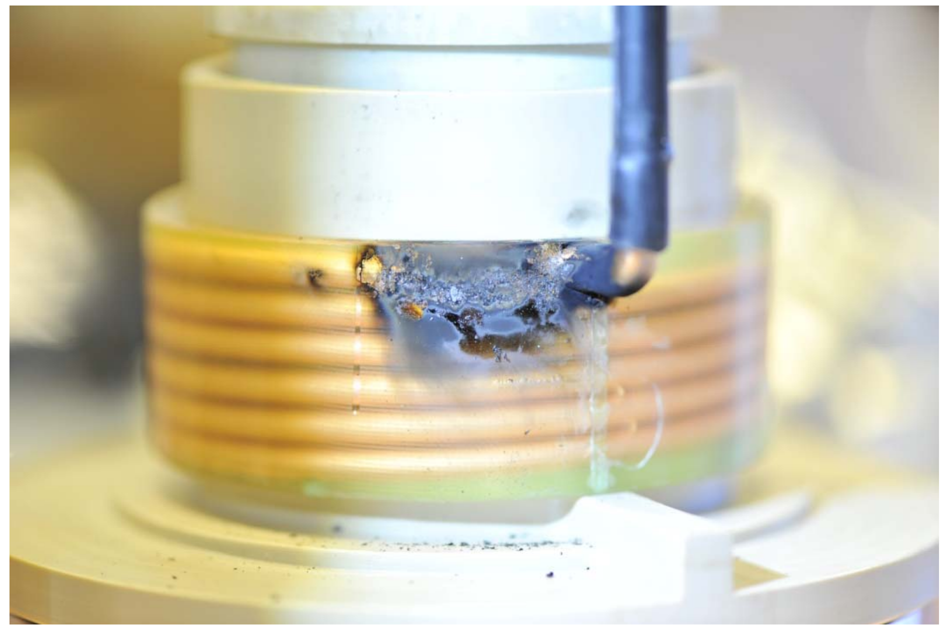
Visible and Infra red views at high power, temperature measurement



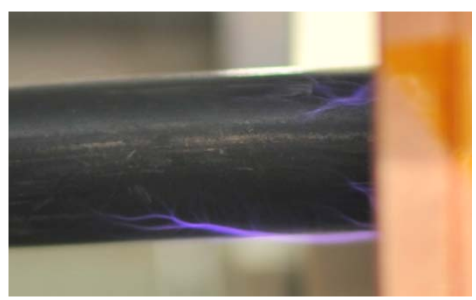
sLHC's best today: 50 kW, 1.2 ms at 50 Hz (3 kW av.)
100 kW, 1.2 ms at 1 Hz

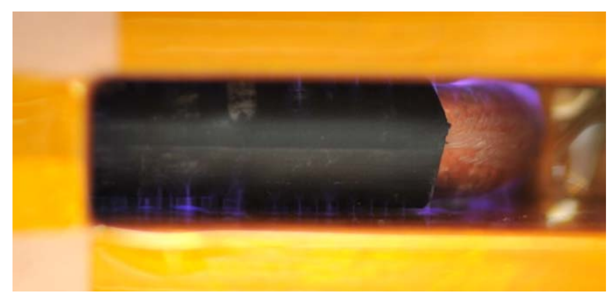


Mould, epoxy type reviewed



Th-simulation by M. Kronberger



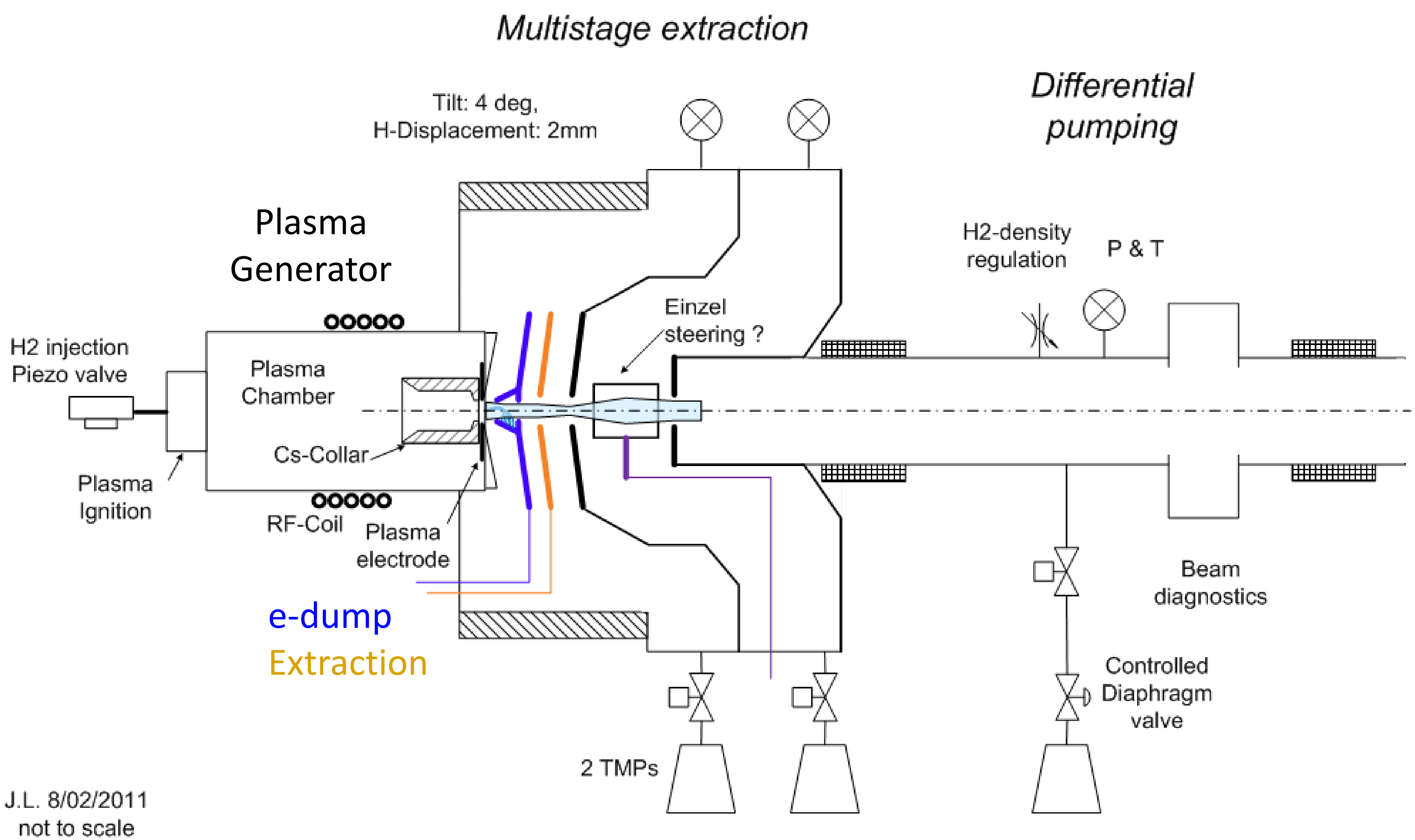


ISWP coordination, scheduling

ID		Task Name
1		**3MeV test stand milestones relevant for ISWP**
6		
7		**Linac4 project milestones relevant for ISWP**
10		**357 Test stands**
22		IS-WP review
23		
24		**Safety**
42		
43		**Power supplies**
104		
105		**RF-components**
108		
109		**Mechanical design and production**
247		
248		**Simulation**
257		
258		**Beam Diagnostics 357**
265		
266		**Trigger timing controls**
276		
277		**Vacuum systems and vacuum control**
311		
312		**H2, Ar and N2 distribution**
337		
338		**Magnets**
363		
364		**Electronics**
367		
368		**Measurements**
376		
377		**Travel, collaboations**
385		
386		**L4IS-WP-start**
583		
584		Linac4 ISWP completed

ID		Task Name
109		**Mechanical design and production**
110		**Linac4- 3MeV test stand**
111		**Pre-LEBT and HT insulator Lina4**
120		**Linac4-tunnel**
121		Design
122		drawings, Procurement
123		**Production faraday cage**
127		**IS Test stand 357**
128		**Pre-LEBT and HT insulator IS-TS 357**
136		**LEBT support**
140		**Plasma test stand 357 available**
141		False floor
142		Move of plasma test stand to new location
143		**Cs-Oven test stand 357**
144		integration, Design
145		**Test vacuum Chamber**
149		**RF driven Plasma Generators**
150		**Plasma Generator sLHC + Cesiation 2Hz**
163		**Plasma Generator proto 01**
175		**Plasma Generator proto 02 i.e. SNS unit**
187		**Plasma Generator proto 03, L4**
199		**Plasma Generator proto 03, L4 spare unit**
211		**RF-Matching network for each PG**
223		**Magnetron source BNL**
224		Drawing 3D model
225		Metallurgy, Cs-Mo,H2 (samples form old ISI and BN
226		Arc, arc-plasma simulation, characterization
227		**Metallic Cs-Oven**
230		**Plasma Generator BNL 01**
238		**Plasma Generator BNL 02**

Diff. Pumping, Insulator, Tilt and Alignment



G. Vandoni

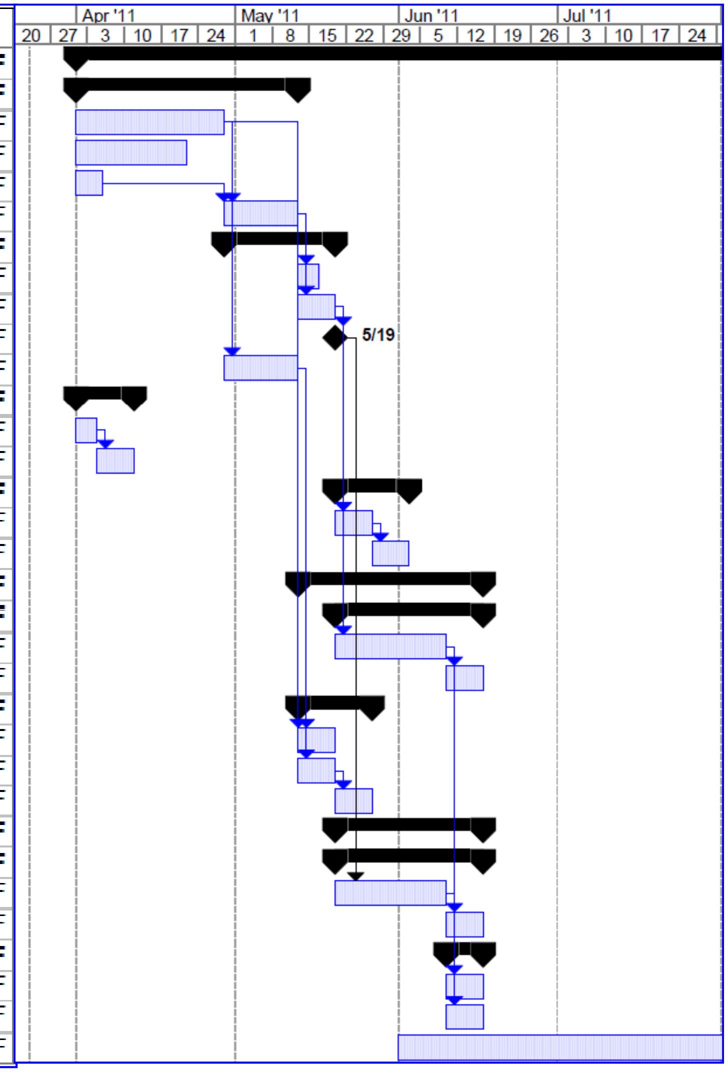
WPIS Vacuum

1) 3MeV test stand upgrades:
   a) LEBT Density regulation (2-5%), 10^{-8}-10^{-4} mbar at 25 deg.C, measurement integration time > 1s, regulation loop time constant > 1 min). time resolved pressure (5ms) temperature (1 min) monitoring for failure analysis.
   b) Based on pulsed IS flow 1-5 10^{-3} mbar l/s per pulse and apertures size (5-20 mm), pre study of the differential pumping effectiveness.
   c) Beam extraction chamber's Differential pumping system (2+1 TMP).
2) 357-Plasma Generator test stand: Modification.
3) 357-Cs-Oven test stand: design, produce and commissioning of pumping system (1 TMP compatible with Cs vapours)
4) 357-Ion-source test stand: identical to linac4's source +LEBT
   a) LEBT: produce and commissioning of pumping system (1 TMP+ diaphragm + H2 injection)
   b) LEBT Density regulation, 10^{-8}-10^{-4} mbar at 25 deg.C, measurement integration time > 1s, regulation loop time constant > 1 min)
   c) Beam extraction chamber's Differential pumping system (2+1 TMP).
5) Control's rack, cabling, Operation and maintenance of the 357 test stands and Linac4 components
6) Spare parts: 10% + at least 1 unit of each item

The gauges shall be calibrated for H2, the pressure and density measurements shall be monitored in a database and accessible.

ISWP-Vacuum cost and duration *(schedule integration pending)*

Task Name	Total Cost
Vacuum systems and vacuum control	**280 kCHF**
Vacuum system study and specification (June 2011)	**10 kCHF**
LEBT density regulation: pre-study and specification (cat2/cat3 FTE)	10 kCHF
Diff-pumping study (cat2 FTE)	0 kCHF
Specification of TMP compatible with Cs vapours (cat2/3)	0 kCHF
Pumping & diagnostics equipment definition (cat3 FTE)	0 kCHF
Vacuum equipment Procurement	**225 kCHF**
Cabling and controls cat3	25 kCHF
conventional pumping & diagnostics equipment, 1st lot, cat3	95 kCHF
conventional pumping & diagnostics equipment, 2nd lot, cat3	95 kCHF
gas injection regulation, temperature measurement, cat2/3	10 kCHF
Plasma test stand 357 new vacuum cabling July August 2011	**2 kCHF**
DIC for vacuum (cat3)	0 kCHF
cabling and tests for vacuum (FSU)	2 kCHF
Vacuum for the Cs-Oven test stand 357 July August 2011	**4 kCHF**
installation, incl controls	2 kCHF
tests and commissioning	2 kCHF
Vacuum for the Ion source test stand 357 (Sept-Nov 2011)	**17 kCHF**
Ion source pumping 357	**8 kCHF**
installation, incl controls and PVSS	6 kCHF
tests and commissioning	2 kCHF
LEBT pumping 357	**9 kCHF**
controls for the gas regulation loop	5 kCHF
installation, incl controls and PVSS	2 kCHF
tests and commissioning	2 kCHF
Vacuum for the Ion source test stand 3MeV (Mars 2012)	**12 kCHF**
Ion source pumping 3 MeV	**8 kCHF**
installation, incl controls and PVSS	6 kCHF
tests and commissioning	2 kCHF
LEBT pumping 3MeV	**4 kCHF**
installation, incl controls and PVSS	2 kCHF
tests and commissioning	2 kCHF
Vacuum operation at b.357 cost per year	10 kCHF



U. Raich

WPIS Beam diagnostics

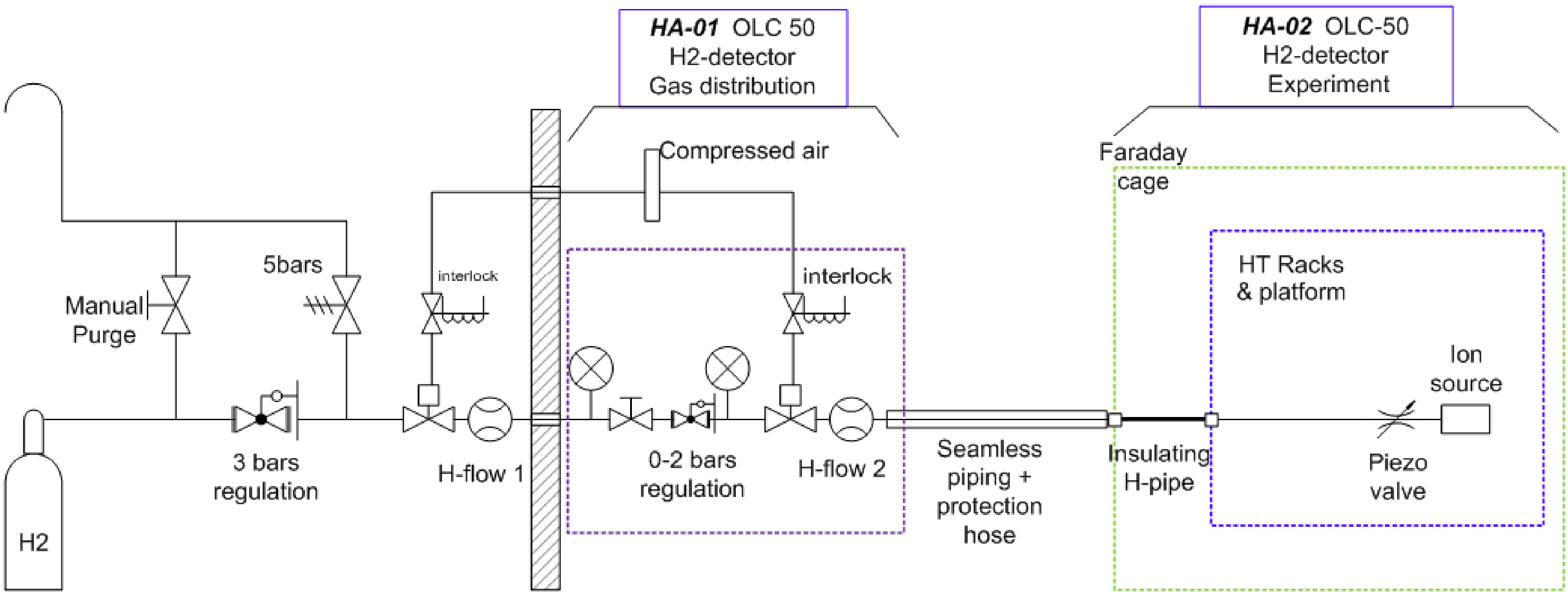
(schedule integration pending)

- Emittance meter
- Faraday cups
- x-y Beam profile monitor
- Beam energy (and plasma potential via Retardation method)

ID	Task Name	Total Cost
258	**Beam Diagnostics 357**	**480 kCHF**
259	**Emittance meter (tuned for frequent use)**	**330 kCHF**
260	Mechanics	250 kCHF
261	Electronics	80 kCHF
262	Faraday cups 357 (2 units floating up to 5 kV)	20 kCHF
263	Beam profile measurement (10x10 x-y meas grid)	80 kCHF
264	Retardation Beam energy	50 kCHF

H2 injection

M. Wilhelmsson



H- test stand at building 357 proposition:

The amount of explosive gas is minimized in the HT ion source set up as follow:

- 2 flow meters, 2 interlocked pneumatic valves
- OLC50 flammable gas detectors with hood on the low pressure gas distribution
- OLC50 flammable gas detectors with hood on the experimental area
- Seamless tubing up to the faraday cage
- Insulating tubing from the farday cage to the HT racks-platform

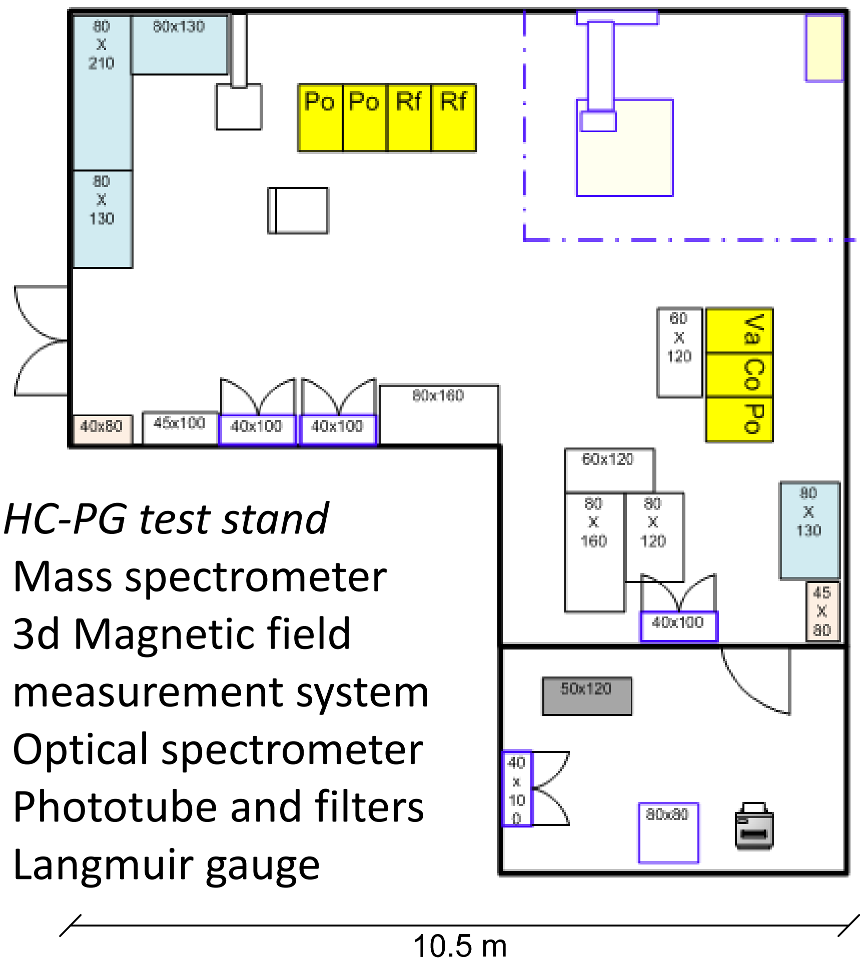
Interlock system : Presence of 10-20% LEL or H2 flow > nominal.

*This shall also be considered for the **Linac4 ion source,** and merged with the Linac4 LEBT*

357-R-005 Test stand

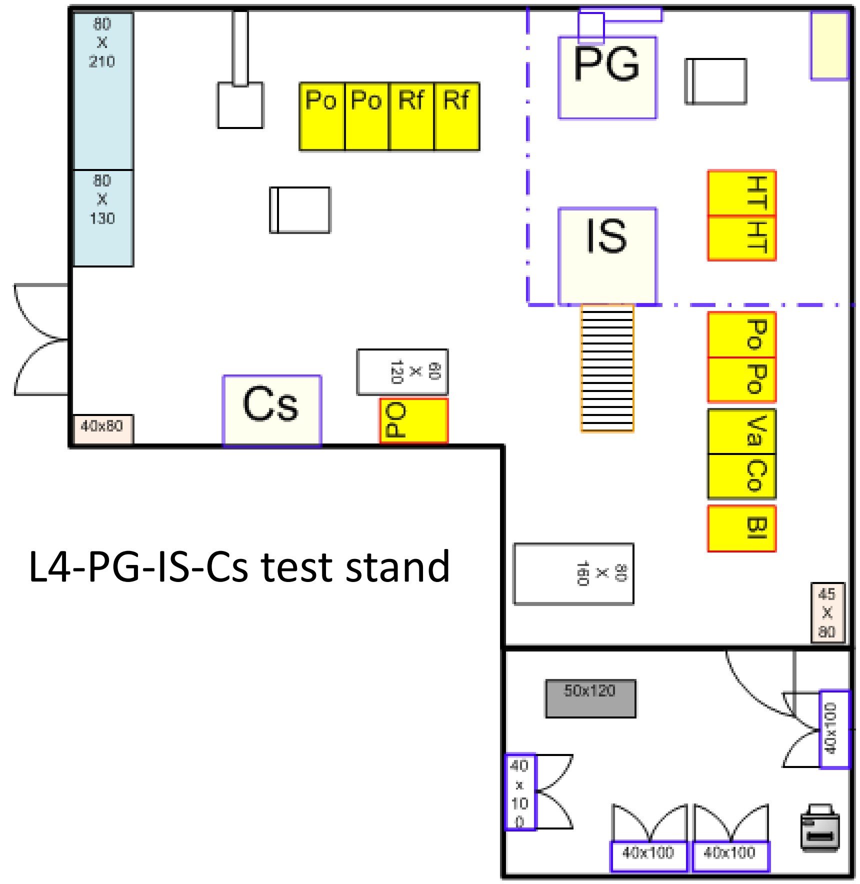
Quite Crowded,
Missing space for Cs-lab
Challenging handling of equipment
Integration study required

Demineralized Water cooling
and SPL RF-generator



sLHC-PG test stand

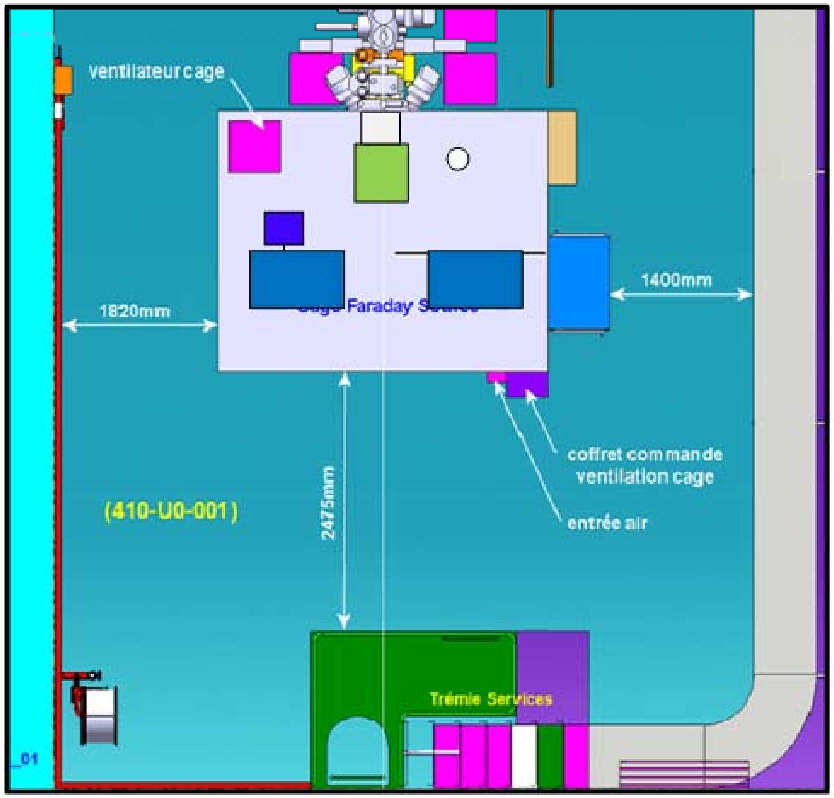
- Mass spectrometer
- 3d Magnetic field measurement system
- Optical spectrometer Phototube and filters
- Langmuir gauge

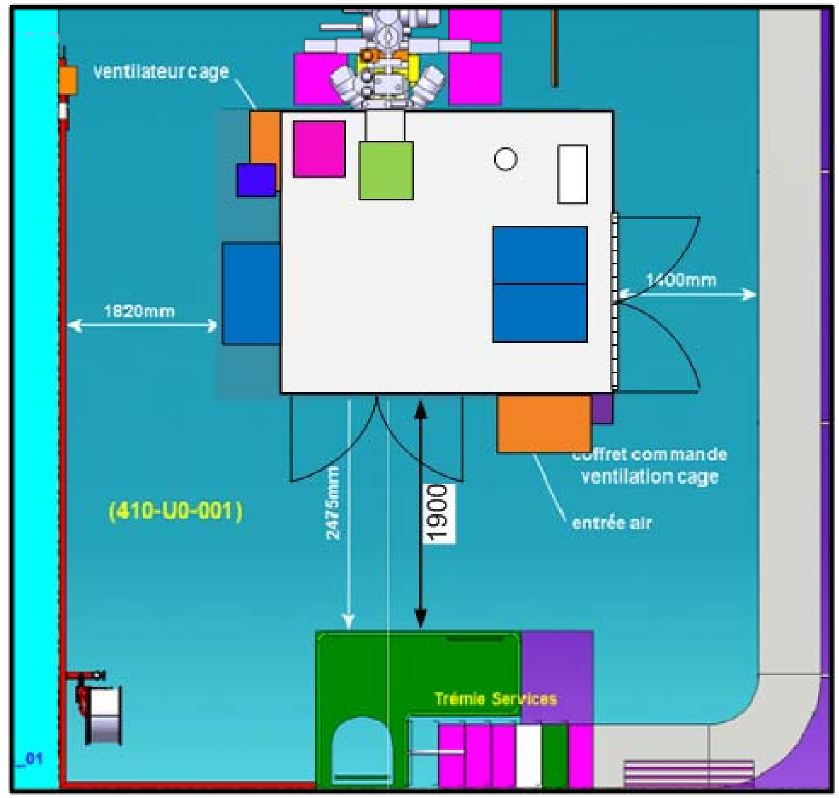


L4-PG-IS-Cs test stand

Modification of Faraday cage

Gain in accessibility mandatory for “fast” ion source exchange and space for pulsed HT-transformers

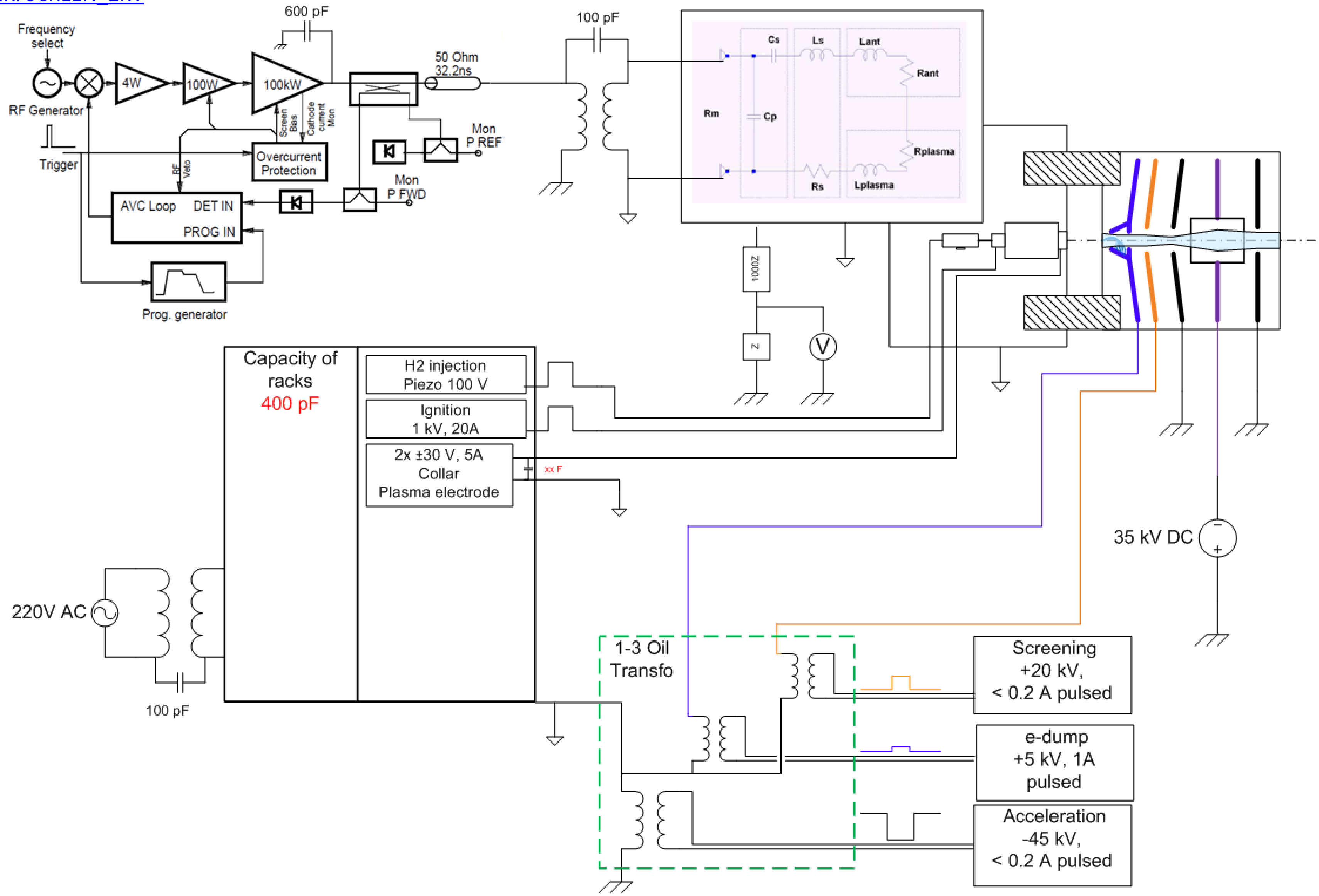




H2 gas system out of HT cage and common to LEBT and IS

RF-generator power supplies:
L4L.RFANODE_22KV
L4L.RFGRID_550V
L4L.RFSCREEN_2KV

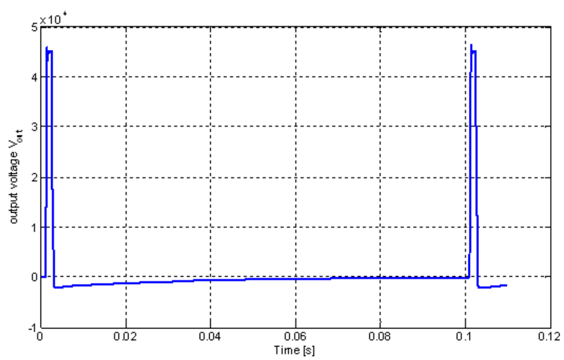
WPIS Power supplies

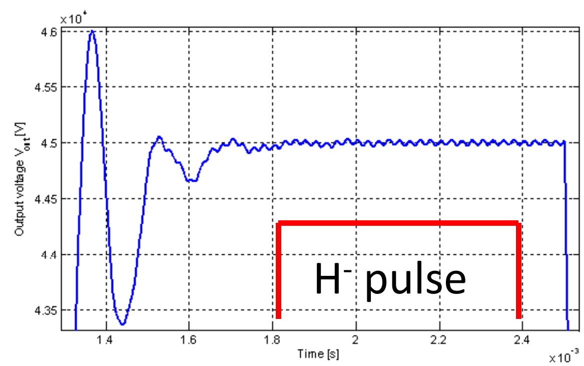


WPIS Power supplies

D. Nisbet
D. Aguglia

Name, location		Responsible Group	type	Voltage, polarity	Load [A]	load duration [ms]	Pulse duration [ms]	Rep. rate [Hz]	357 test facility's test PG	Cs	IS	3 MeV Linac4	Spares	Status total	avail.	need
Acceleration, HT racks	Gnd + transfo	TE/EPC	R&D	-45 kV	0.2	0.7	2-5	2			1	1	1	3		3
Extraction	Gnd + transfo	TE/EPC	R&D	20 kV	0.2	0.7	2-5	2			1	1	1	3		3
Electron dump	Gnd + transfo	TE/EPC	R&D	4 kV	2	0.7	2-5	2			1	1	1	3		3
Insulation transformer	Gnd	*	commercial								1	1	1	3	1	2
Einzel lens	Gnd	TE/EPC	commercial	-40 kV	0.2	0.7	cw				1	1	1	3		3
Collar	HT-racks	*BE/ABP*	CERN	+/- 30 V			cw		1			1	1	3	2	1
Plasma electrode	HT-racks	*BE/ABP*	CERN	+/- 30 V			cw		1			1	1	3	2	1
Ignition	HT-racks	*BE/ABP*	R&D	+ 1 kV	20	0.1	0.1	2	1			1	1	3	2	1
Arc discharge	Gnd + transfo		R&D	400 /150 V	20	1					1			1		1
Cs-Cromate Oven	HT-racks		R&D							1		1		2		2
Cs-metal Oven	HT-racks		R&D							1				1		1
LEBT solenoid	Gnd	TE/EPC	commercial		350		cw				2	2	1	5		5
LEBT steerers	Gnd	TE/EPC	commercial		10		cw				4	4	1	9		9
LEBT pre chopper	Gnd		R&D			0.1					1	1	1	3		3
HT- for RF amplifier	Gnd	TE/EPC	CERN	20 kV	2		cw				1	1	1	3	2	1
HT- for commissionning	Gnd		CERN	-50 kV	0.05		cw				1	1		2	1	1

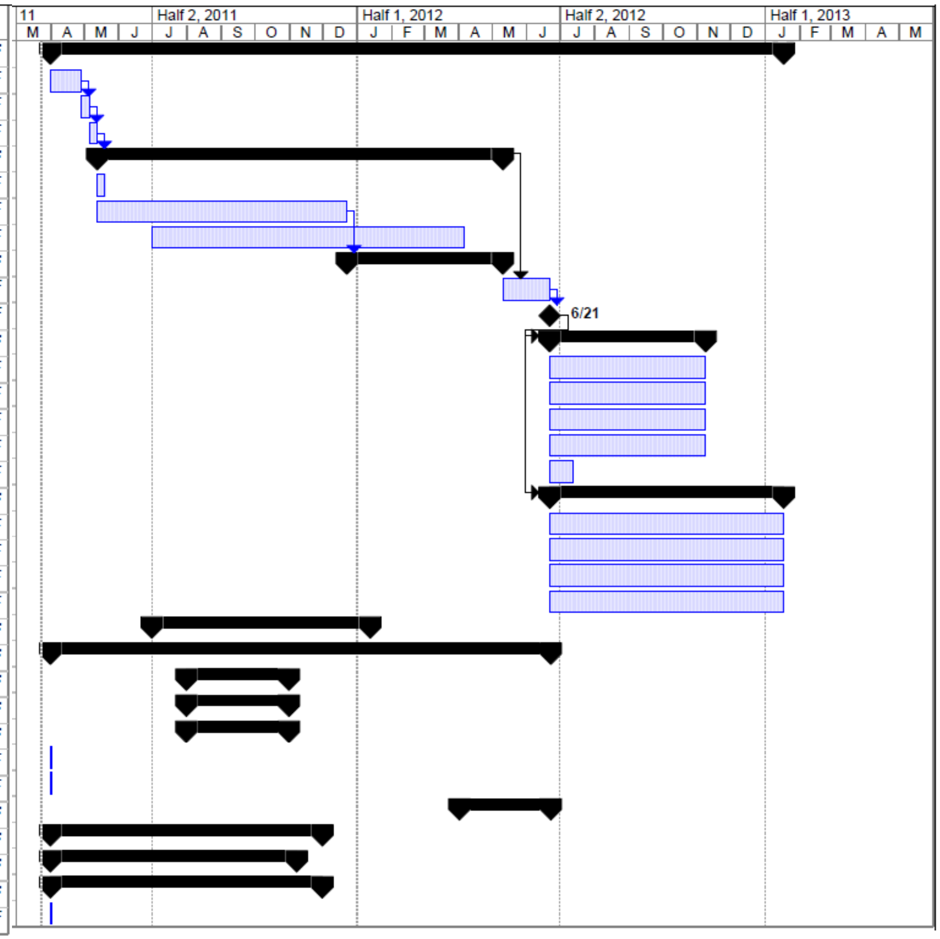




WPIS – power Draft schedule and cost

(schedule integration pending)

ID	Task Name	Total Cost
43	**Power supplies**	**1,070 kCHF**
44	Pulsed power supplies and transformer simulation	0 kCHF
45	Cabling 3MeV test stand	0 kCHF
46	Cabling Linac4	0 kCHF
47	**Pulsed power supplies Linac4**	**350 kCHF**
48	Specification	0 kCHF
49	procurement set 1 + spares	0 kCHF
50	procurement set 2 remaining items +Spares	100 kCHF
51	**fabrication et commissioning**	**250 kCHF**
56	Test and decision on extraction system	0 kCHF
57	HT-prototypes tests successful	0 kCHF
58	**Pulsed power supplies 357**	**250 kCHF**
59	e-dump pulsed power supply	50 kCHF
60	Extraction pulsed power supply	50 kCHF
61	HT 45 kV pulsed power supply	50 kCHF
62	HV-pulsed power supply Oil-transformer	100 kCHF
63	Cabling 357	0 kCHF
64	**Pulsed power supplies spares**	**250 kCHF**
65	e-dump pulsed power supply	50 kCHF
66	Extraction pulsed power supply	50 kCHF
67	HT 45 kV pulsed power supply	50 kCHF
68	HV-pulsed power supply Oil-transformer	100 kCHF
69	**Arc discharge pulsed power supply (magnetron**	**110 kCHF**
73	**cw-power supplies**	**40 kCHF**
74	**Einzel lens cw power supply reutilieser 50 kV existante +1 +1 spare**	**20 kCHF**
78	**Cs-Chromate oven power supply**	**0 kCHF**
82	**Cs-Metal oven power supplies**	**0 kCHF**
86	Collar power supply	10 kCHF
87	Plasma electrode power supply	10 kCHF
88	**HT-power supply for RF-amplifier (spare)**	**0 kCHF**
90	**Magnets and stirrers**	**70 kCHF**
91	**Solenoids 4 u + 1 spare (350 A cw)**	**60 kCHF**
97	**Stirrers 10 u + 1 spare (10 A)**	**0 kCHF**
103	Racks 6x	10 kCHF



I. Kozsar
BE-OP

WPIS Controls, Monitoring

Controls: Settings and readout of effective value

- Power supplies: All currents and voltages (time)
- RF Amplifier:
  - Power setting (time), frequency shift
  - Injected, reflected power
  - Current and voltage phase, Power deposited into the plasma
- Plasma generator: OES-intensities: Hα, Hβ, Hγ (time)
- Gas injection, settings pulse (time), H2-Pressure
- Vacuum: Pressure of differential pumping tanks (time)
  - H2 Density of LEBT
- Timing signals

Controls panel software by OP team not yet discussed but necessary

Collaborations, sLHC & linac4 IS

Creative manpower was required to address missing staff and expertise; Students, PhDs & Project associates and collaboration to external institutes the list below is our way to address it.

- SNS: Visit J. Lettry to SNS (April), ion source exchange, operation of external antenna SNS ion source on test stand
  - Visit R. Welton to CERN April-May tbc.
- IPP Garching (*sLHC*): Seminar U. Fantz at CERN,
  - Visit J. Lettry, M. Kronberger (February):
    - Visit Cs-laboratory and ITER ion source
    - Emission spectroscopy and Cs-density diagnostics
    - Interpretation of emission spectroscopy via CR models
- Rutherford Appleton Laboratory, ISIS ion source
  - Visit D. Faircloth December (eddy current shielding), february-March high power operation of SPL plasma Generator
  - Visit J. Lettry to RAL (January), ion source operation and exchange, new test stand.
  - Arc discharge plasma simulation
- Prof. Akiyoshi Hatayama, (KEIO university, Japan)
  - Simulation of e-heating in Hydrogen plasma, undefined schedule, upgrade from arc discharge to external antenna.
- S. Mochalskyy (Orsay & Cadarache), 3D-simulation of the plasma in the CERN linac4 ion source (Plasma parameter measurement pending).
- O. Tarvainen &T. Kalvas(University of Jyvaskyla) *sLHC & Linac4*
  - UV-VUV Lyman lines emission spectroscopy on sLHC plasma. 2 weeks plasma (April tbc.).
  - T. Kalvas code for simulation of multistage extraction with co-extracted electrons (1 month)
- BNL, James Alessi, visit R. Scrivens and F. Wenander (Feb. 2011)

Conclusion and outlook

- WPIS review is scheduled *June 2011*
  - Resources presented by tasks representatives
  - Extraction simulation April May
  - Draft differential pumping design
  - Report on : Resources (cost and manpower), Feasibility, schedule, Optimization and Risk mitigation
- WPIS February 2011 vs. LS1 schedule: The likelihood of matching the LS1 schedule is part of the of the review's report. At this stage it is premature to conclude but the goal is quite challenging
- Installing a new extraction system, new power supplies and a new source mid 2012 is challenging but leaves 5 month for debugging and commissioning of the prototype *This is our baseline*.
- Developing prototype, producing a test stand and in parallel multi collaboration for simulation … senior physicists welcome to share the honor
- L4 will only move after (successful) H^- tests

Acknowledgments, & thank you

Davide Aguglia, Sebastien Bertolo, Andre Castel, Elodie Chaudet, Jean-Francois Ecarnot, Hugo Estevao, Gilles Favre, Fabrice Fayet, Jean-Marie Geisser, Matthias Haase, Alexandre Habert, Jan Hansen, Stephane Joffe, Matthias Kronberger, Didier Lombard, Alain Marmillon, Jose Marques Balula, Serge Mathot, Oystein Midttun, Pierre Moyret, David Nisbet, Michael O'Neil, Mauro Paoluzzi, Laurent Prever-Loiri, Uli Raich, Jose Sanchez Arias, Claus Schmitzer, Richard Scrivens Didier Steyaert, Henrik Vestergard, Giovanna Vandoni, Mats Wilhelmsson, Laszlo Abel, Alessandro Bertarelli, Oliver Bruning, Maryse Da Costa, Alain Demougeot, Paolo Chiggiato, Dan Faircloth, Ramon Folch, Philippe Frichot, Roland Garoby, Jonathan Gulley, Alexandre Gerardin, Christophe Jarrige, Erk Jensen, Emmanuel Koutchouk, Detlef Kuchler, Robert Mabillard, Marina Malabaila, Cristiano Mastrostefano, Sophie Meunier, Catherine Montagnier, Jose Monteiro, Mauro Nonis, Julien Parra-Lopez, J. Peters, Stephen Rew, Miguel Riesgo Garcia, Ghislain Roy, Stefano Sgobba, Franck Schmitt, Alain Stalder, Laurent Tardi, Dominique Trolliet, Donatino Vernamonte and Fredrik John Carl Wenander.