

Diagnostics for Linac 4 Ion Source Prototypes

C.Schmitzer on behalf of:

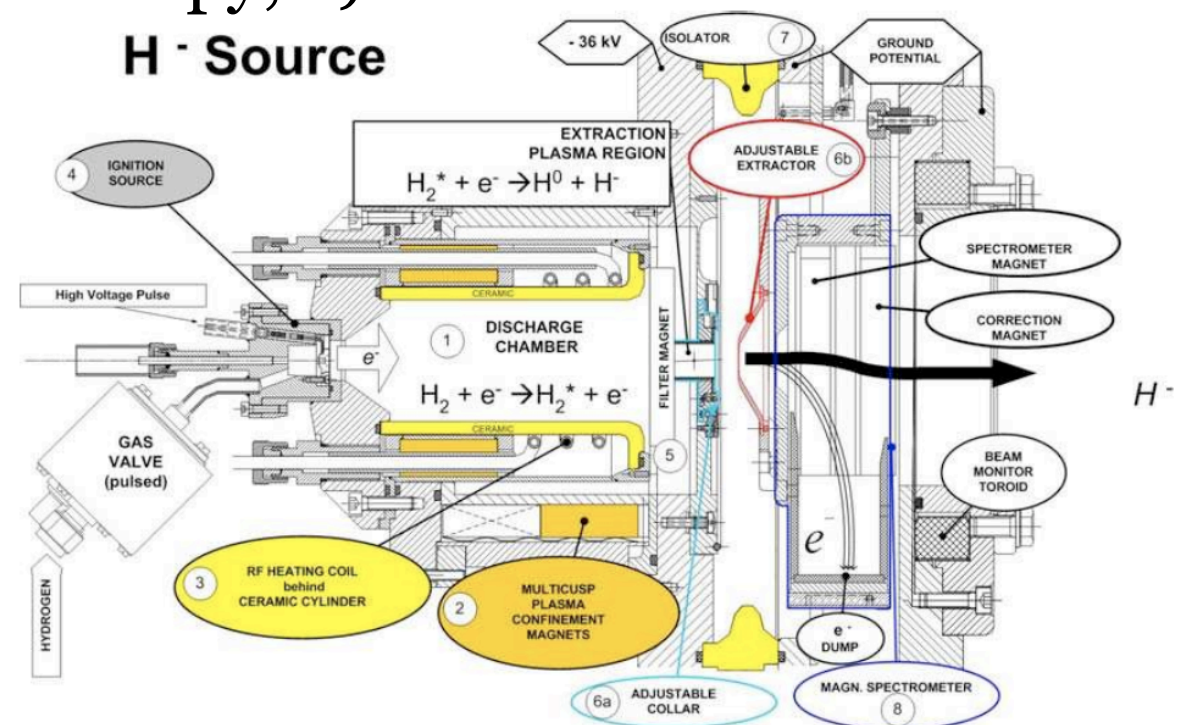
Linac 4 Ion Source Teams - Cern

O.Tarvainen, J.Komppula - University of Jyväskylä

Volume H- Ion Source

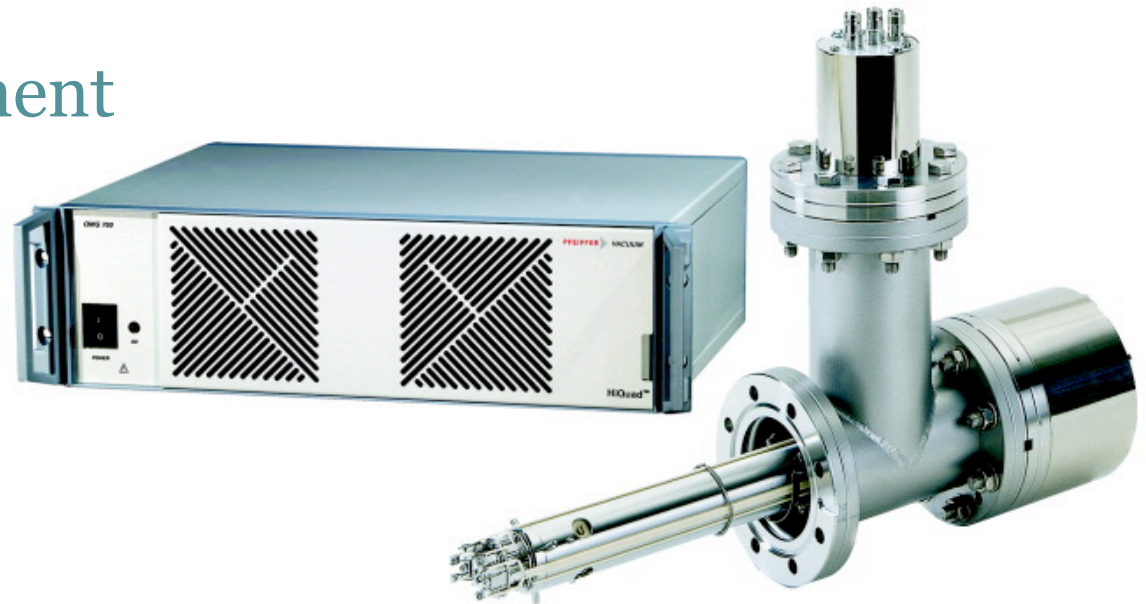
- several fields of physics involved simultaneously (Plasma, Surface, Vacuum, Molecular- Atomic Spectroscopy,..)

- big parameter space
- different diagnostics to characterize the Prototypes



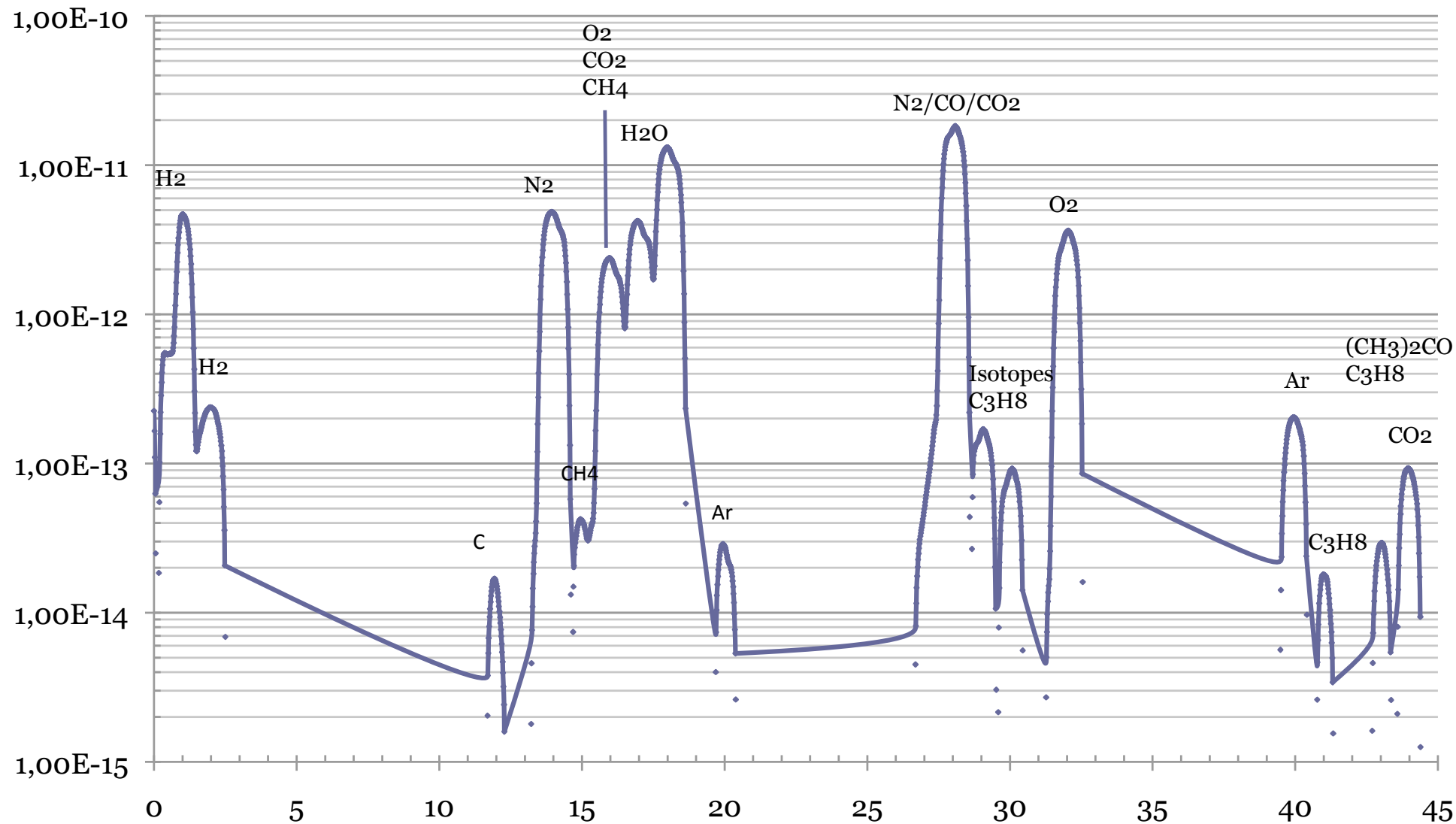
Rest Gas Analyzer

- QMA 125 Faraday and 90° SEM, 0-100 amu
 - Leak testing
 - Outgassing of equipment
 - Purity of injected gas
 - Overheating damage
 - Online capability



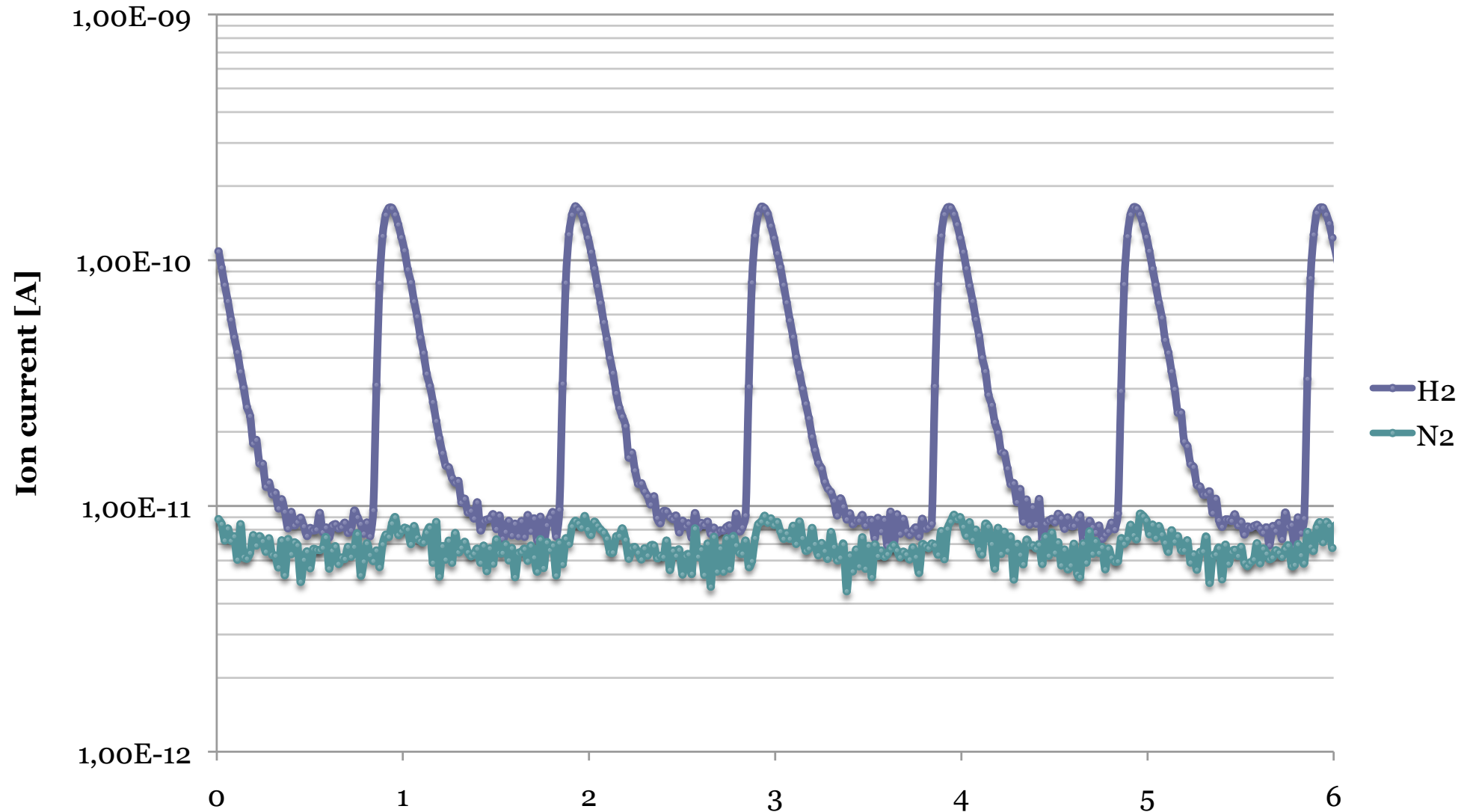
Rest Gas Analyzer - Spectrum

RGA Spectrum - Vacuum Chamber



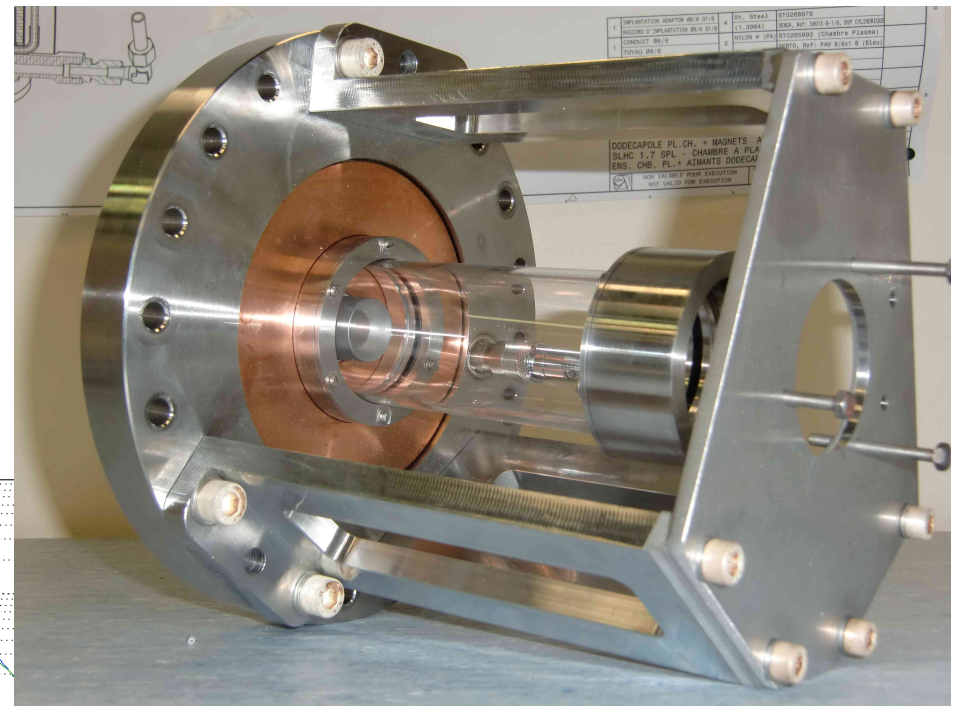
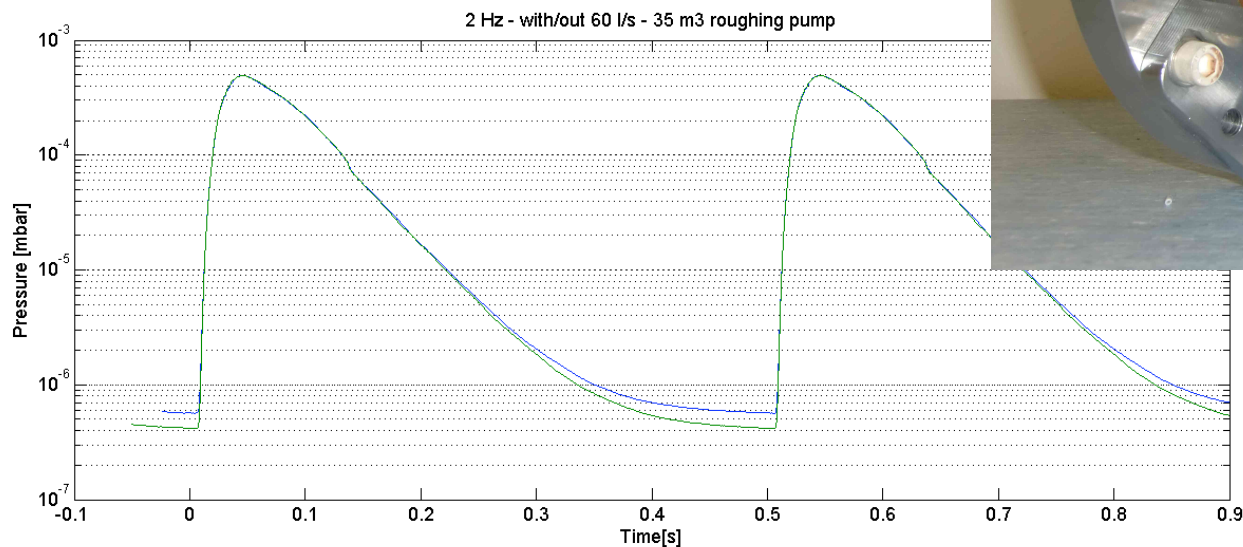
Rest Gas Analyzer - Gas injection

H₂, N₂ time resolved RGA



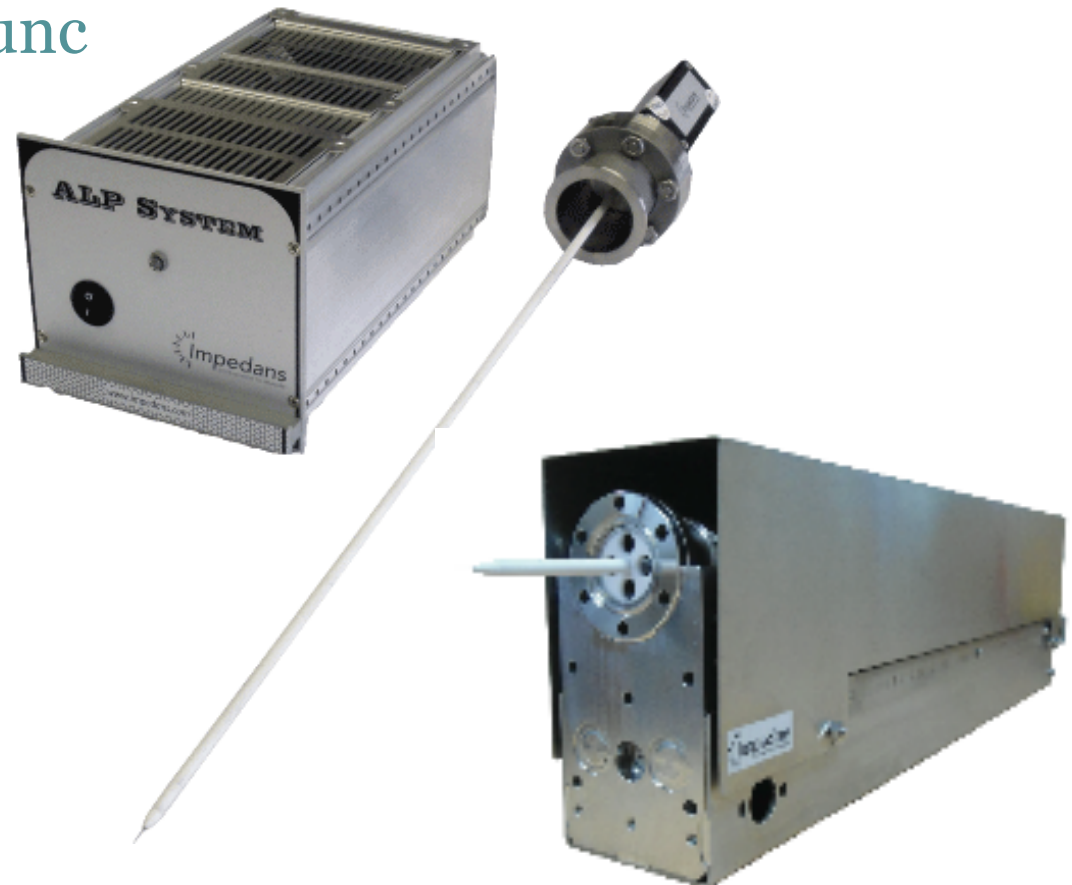
Gas Dynamics

- Dedicated Mock-Up measurements
 - In all gas regimes
 - P dependent Conductivity
 - Pressure monitoring
 - Dynamic pressure
 - plasma chamber



Plasma Diagnostics - Langmuir

- 2 MHz compensated Langmuir Gauge
 - Electron energy density func
 - Plasma potential
 - Electron temperature
 - Ion Current Density
 - 80 megasamples per sec.
 - Plasma simulations
 - Inserted through collar dedicated measurements

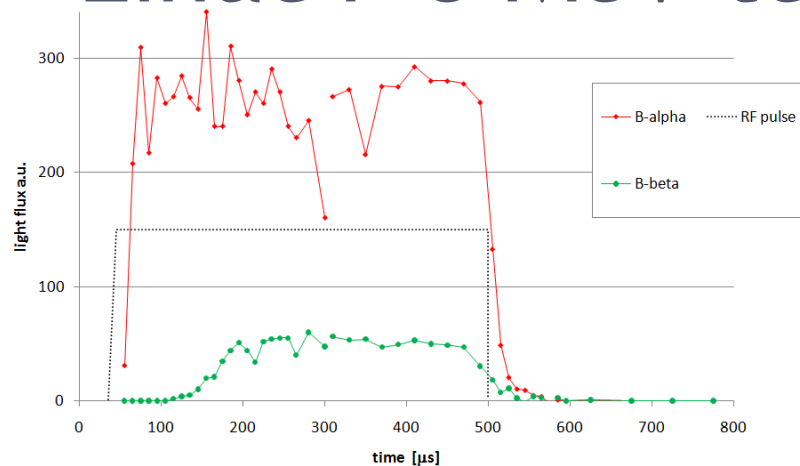


VIS Light Spectrometry

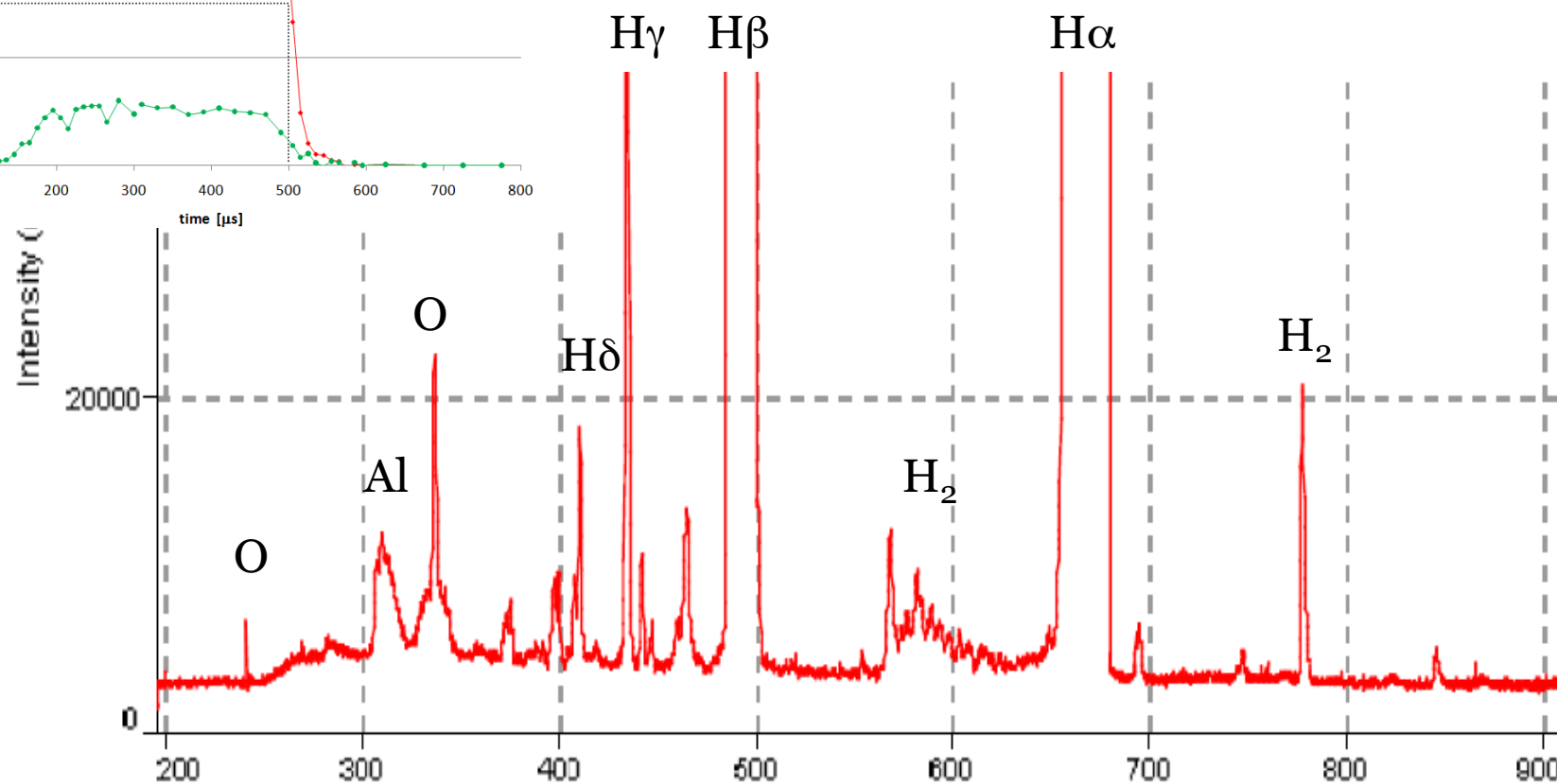
- Visible light spectrometry
 - 200 – 1100 nm, 3.8 ms
 - H Balmer series, impurities
 - Heating Process
 - Online monitoring (H_{α} , H_{β} , H_{γ}) of Plasma (to be correlated with Langmuir)



VIS Light Spectrometry - Linac4 3 MeV teststand 30 kW, no HT

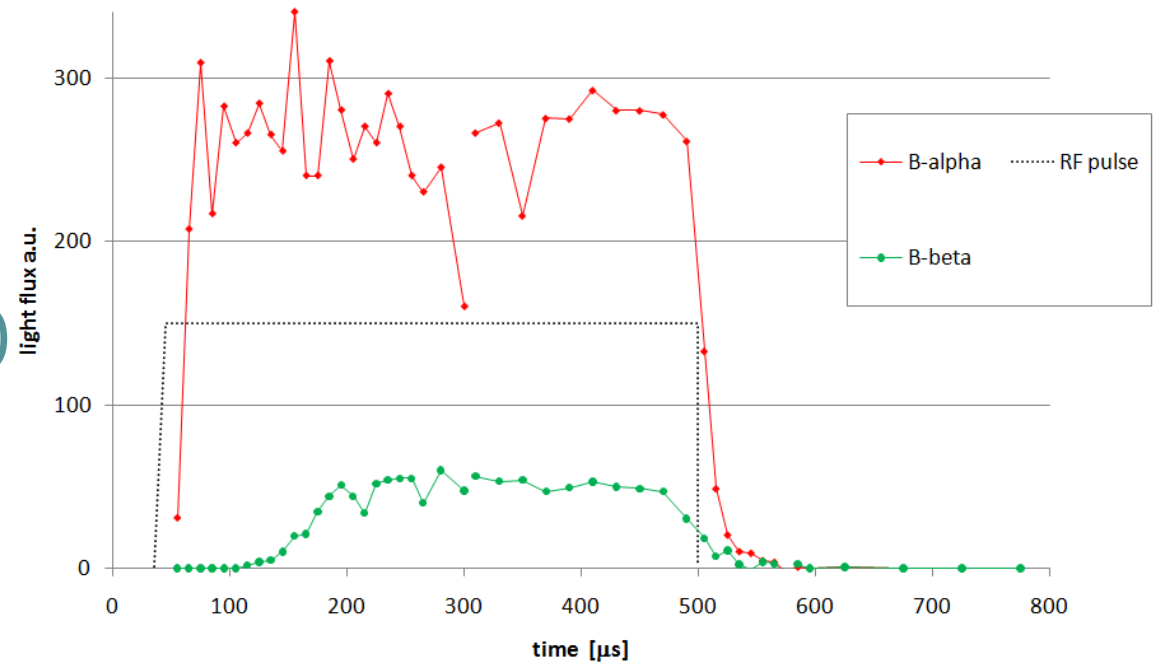


40 kW RF 100 μs



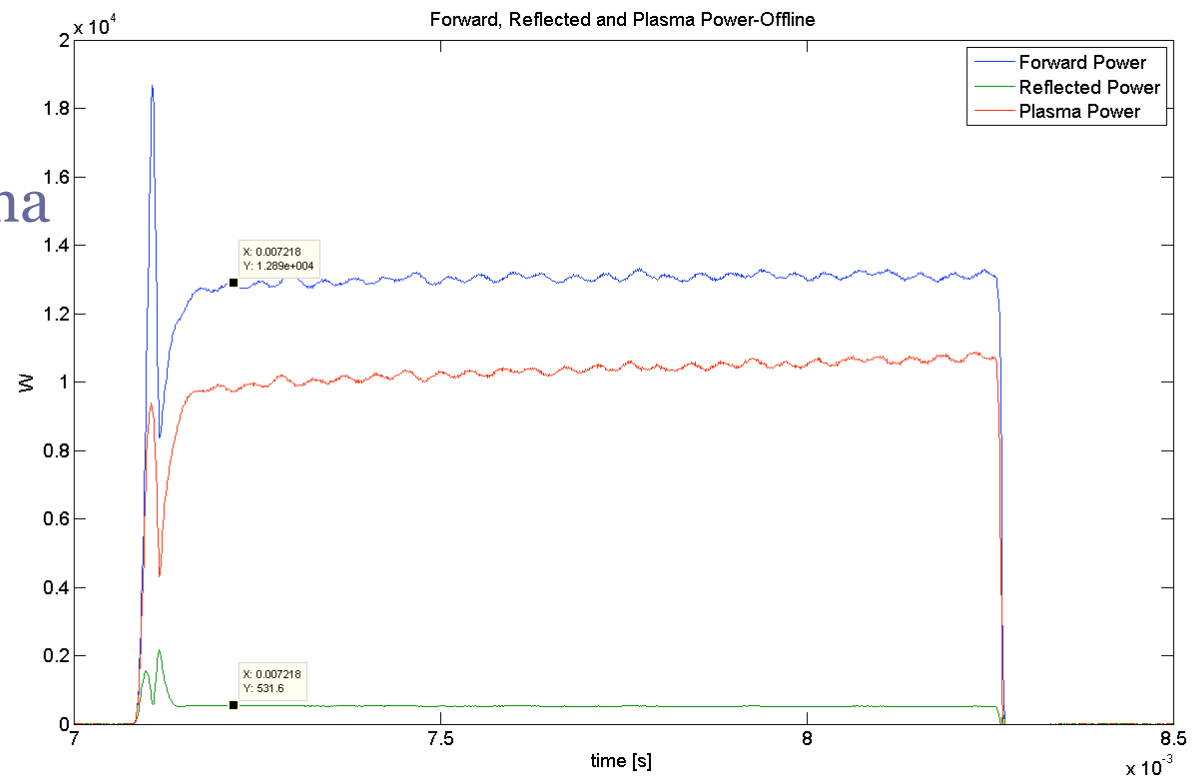
VIS Light Spectrometry

- Visible light spectrometry
 - 200 – 1100 nm, 3.8 ms
 - $H_{\alpha}, H_{\beta}, H_{\gamma}, (H_{\delta}, H^*)$
 - Heating Process
 - Online monitoring of Plasma (Langmuir)



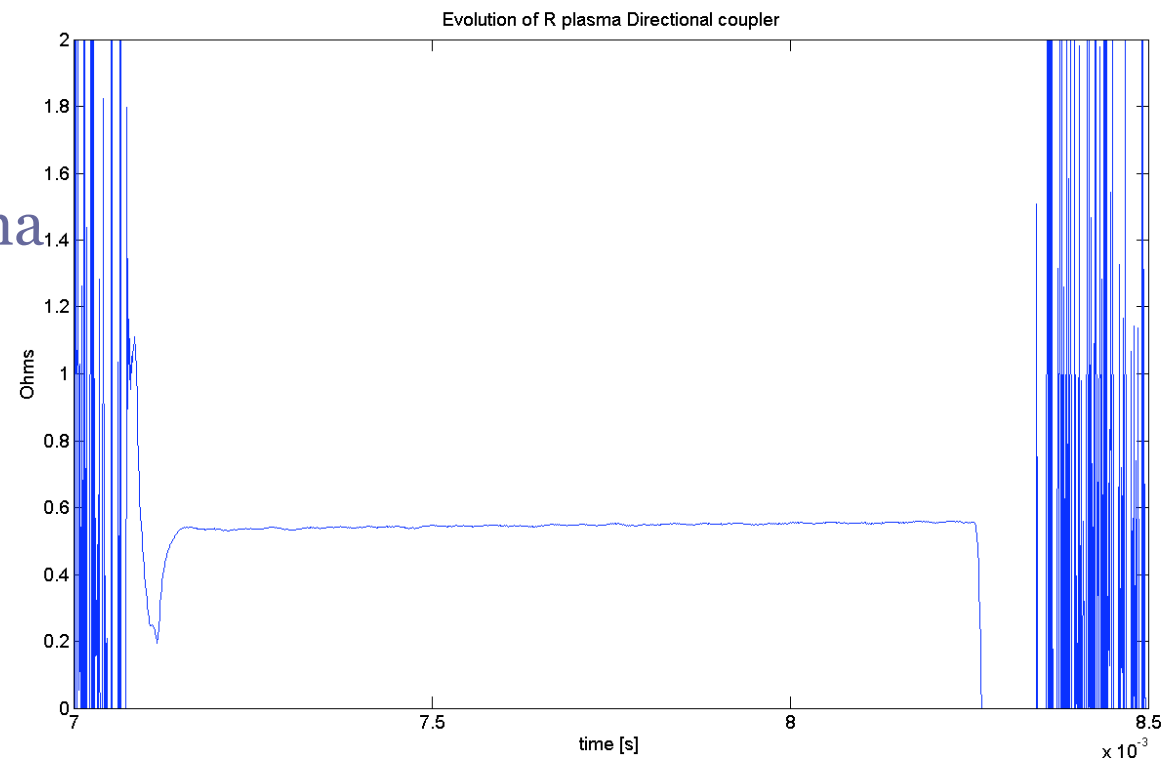
Diagnostics - RF coupling

- Online measurement of V_{Fwd} , V_{Ref} , I_{antenna}
 - Monitoring of Power levels
 - Forward Power
 - Reflected Power
 - Power losses
 - Transmitted to Plasma
 - Plasma Resistance
 - 70% to Plasma
 - 5-10% reflected
 - Characterize mode
 - Capacitive
 - Inductive



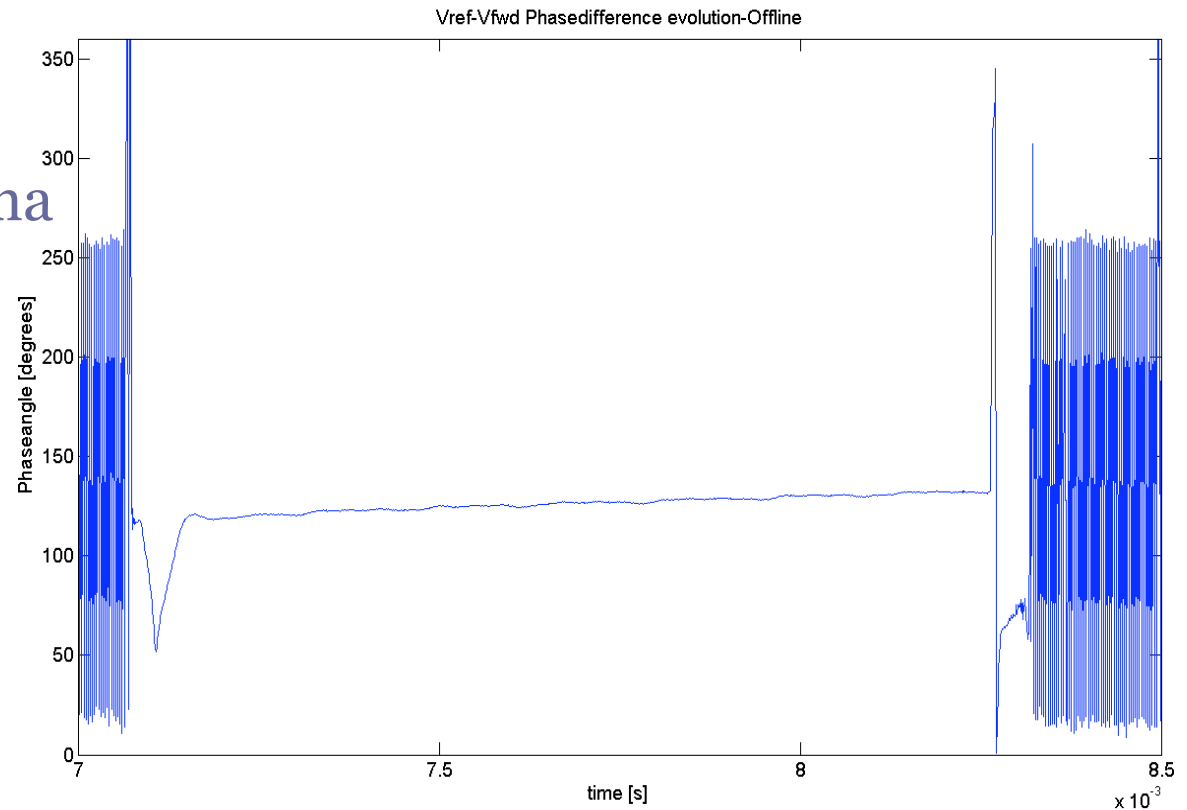
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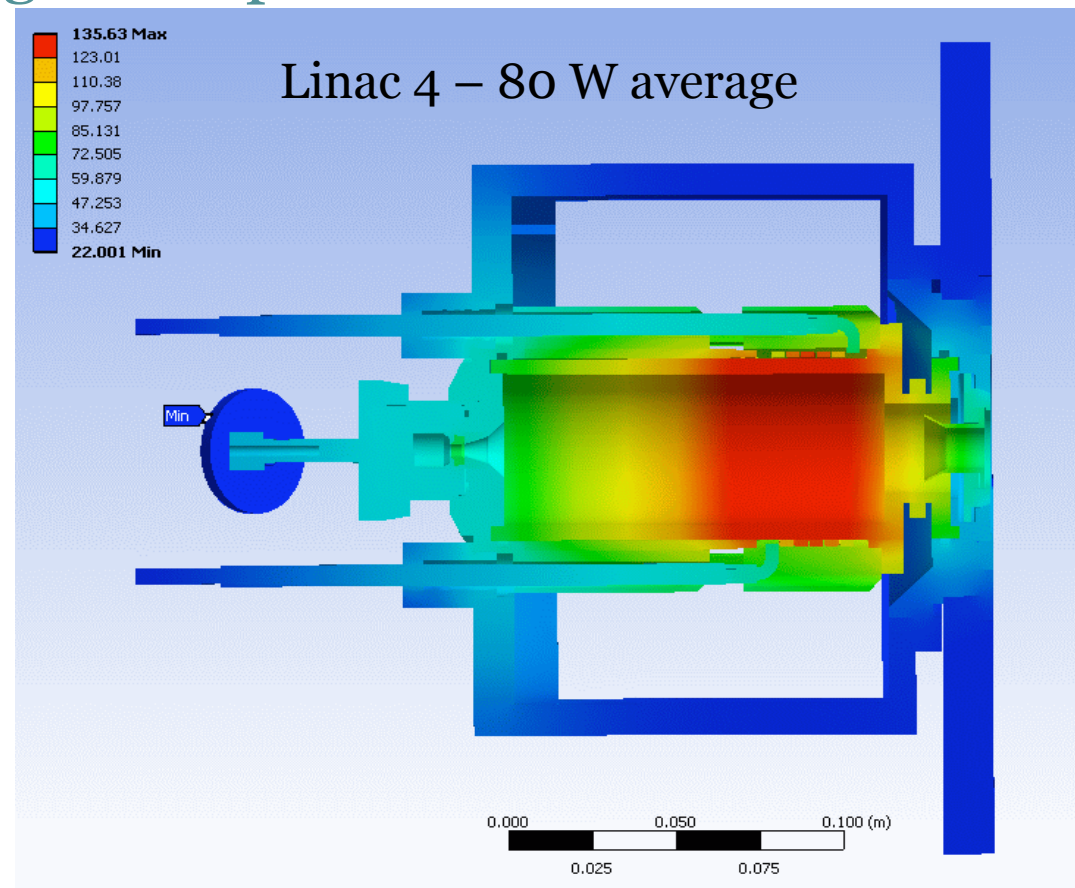
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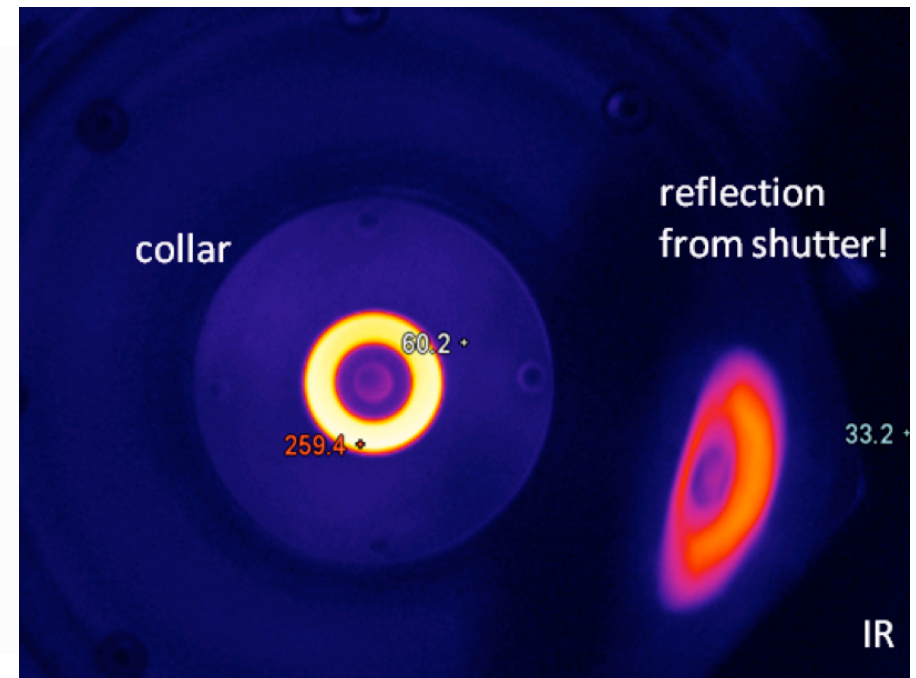
Temperature Measurement

- Heating due to RF-eddy currents and plasma
 - Cooling circuits monitoring – dissipated Power
 - IR Camera to monitor
 - Ferrites
 - Cusp Magnets
 - Ignition element
 - Collar (Ge window)
 - RF heating studies
 - Cu – Shielding



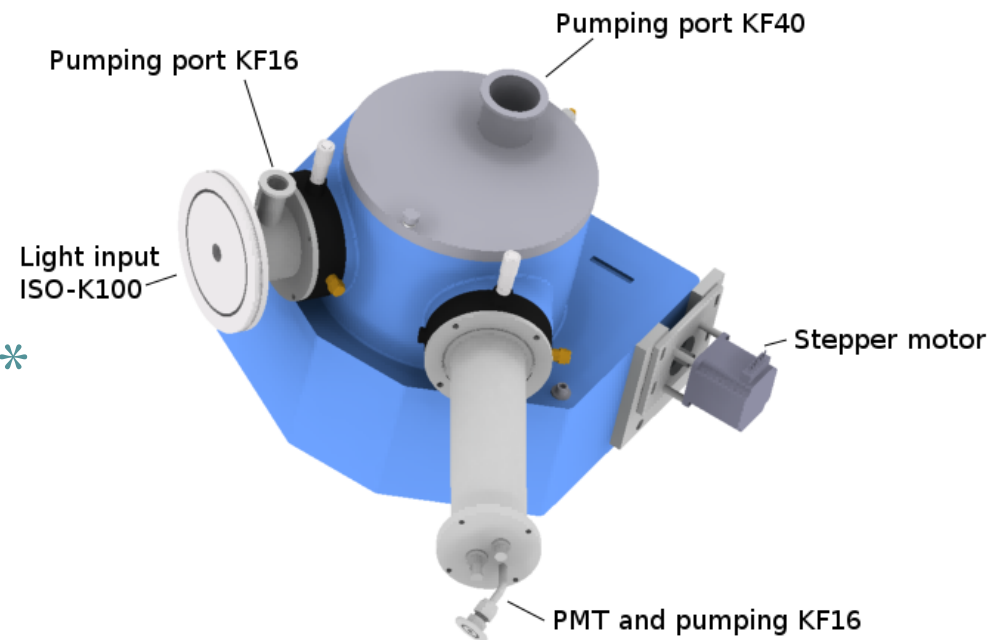
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UV Light Spectroscopy

- UV grating spectrometer
 - 100-250 nm, 1 μ s
 - 600 grooves / mm
 - 200 mm focal length
 - MgF₂ window
 - Lyman- Werner Band, H₂*
 - Heating Process

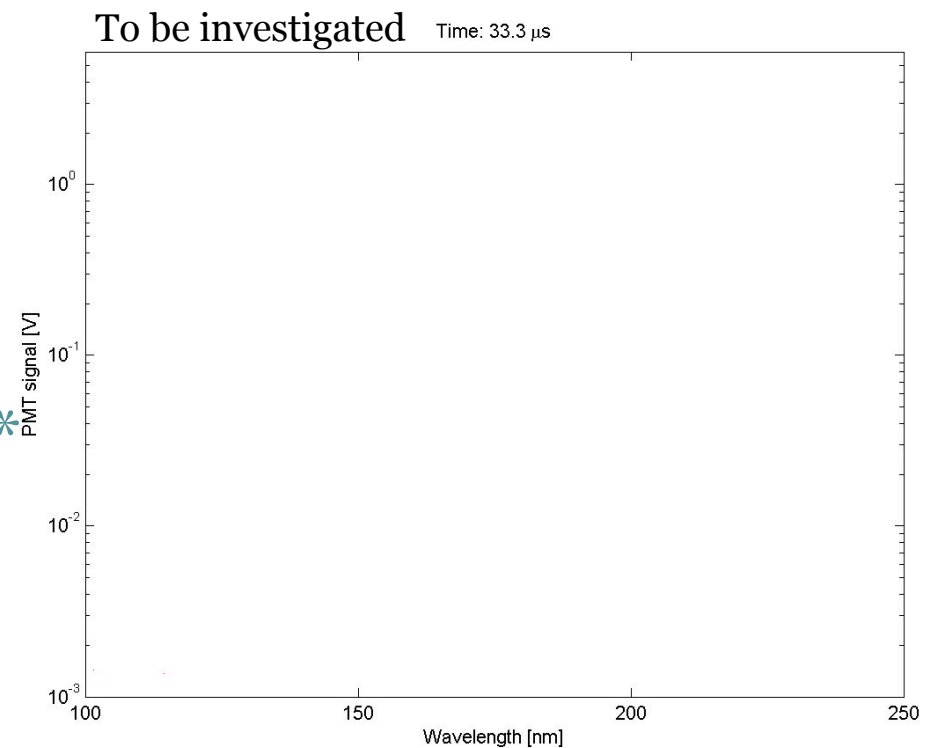


Courtesy of O.Tarvainen, J.Komppula

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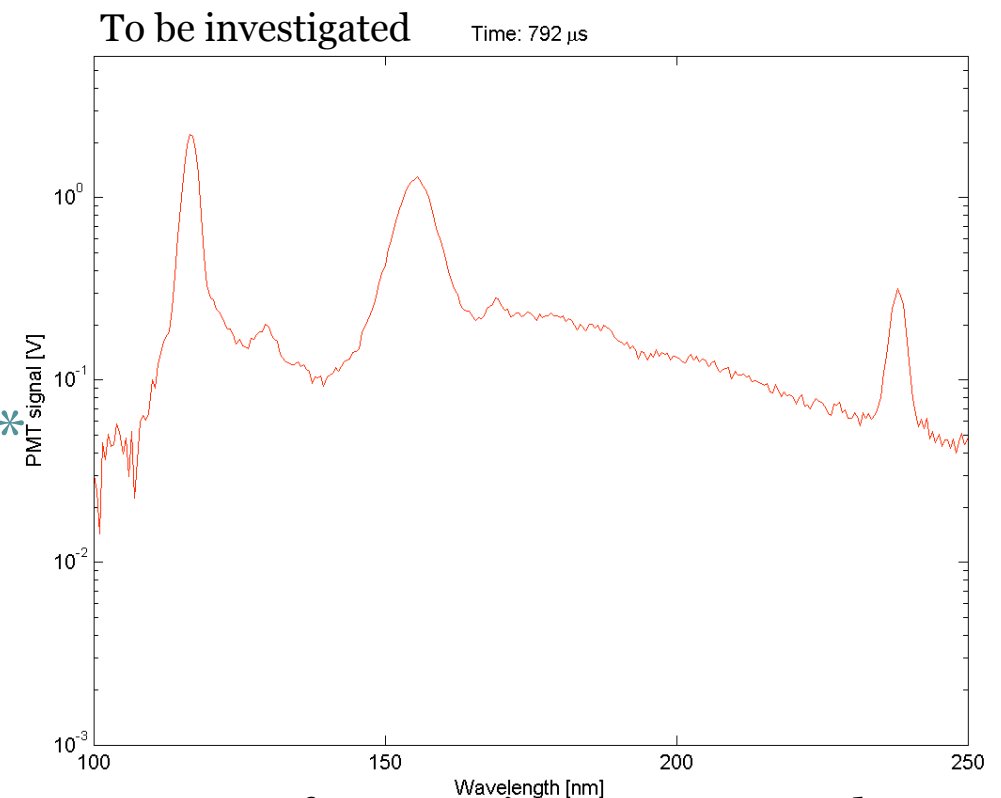


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UV Light Spectroscopy

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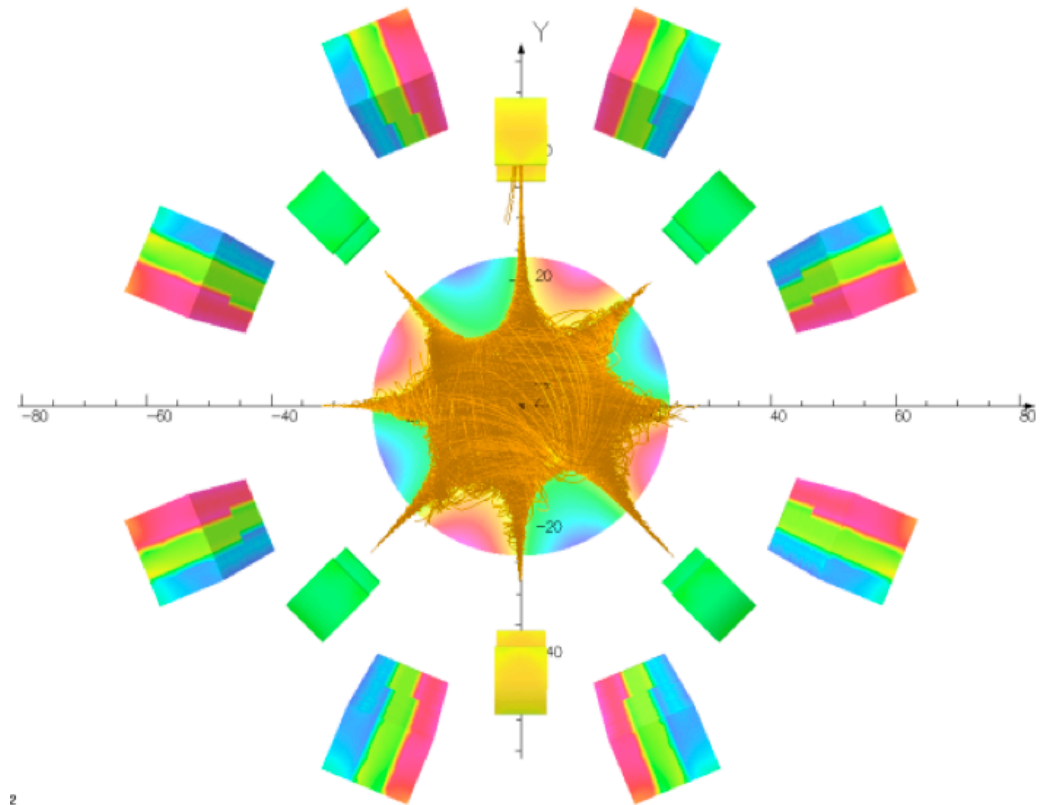
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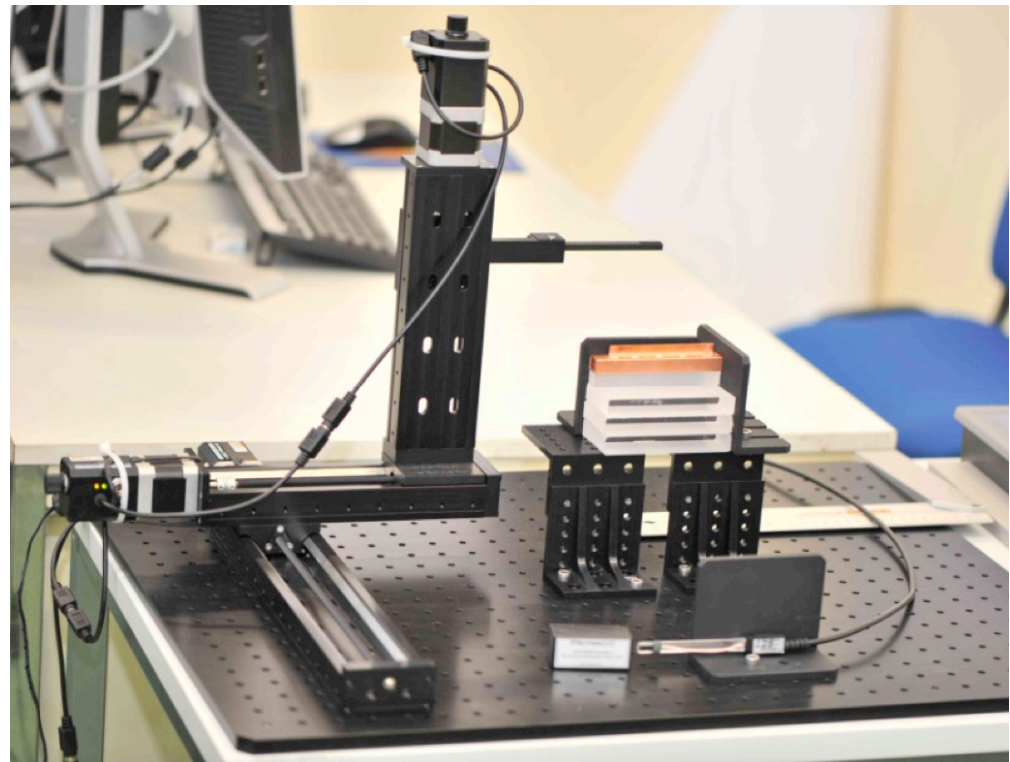
Magnetic Field Measurements

- Cusp and Filter Fields
 - Design in Opera
 - Offset Halbach Cusp
- B-field teststand
 - 3-axis Hall sensor
 - 150x150x10 μm
 - 30 μT – 20 T
 - Linear drives
 - Rotation table



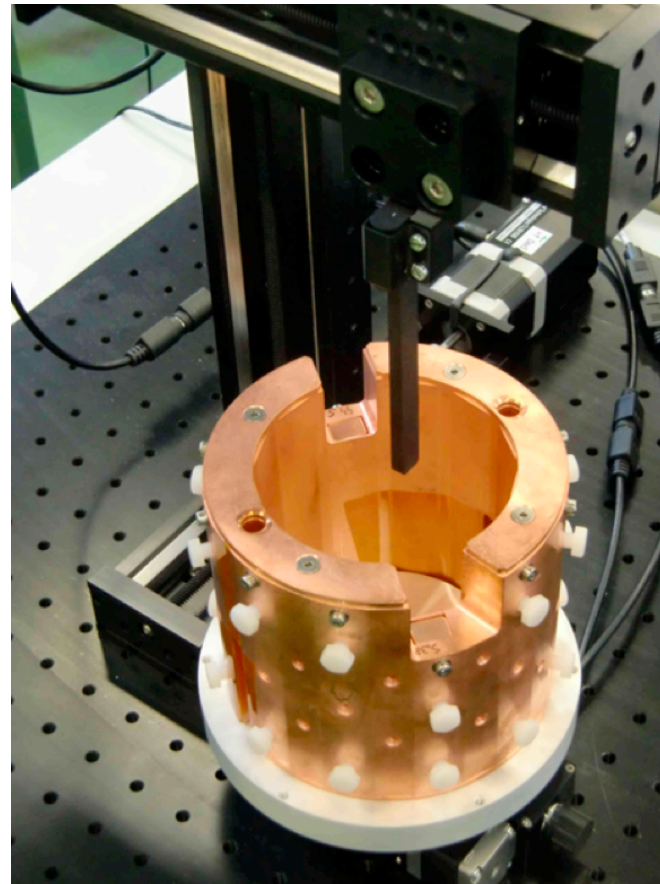
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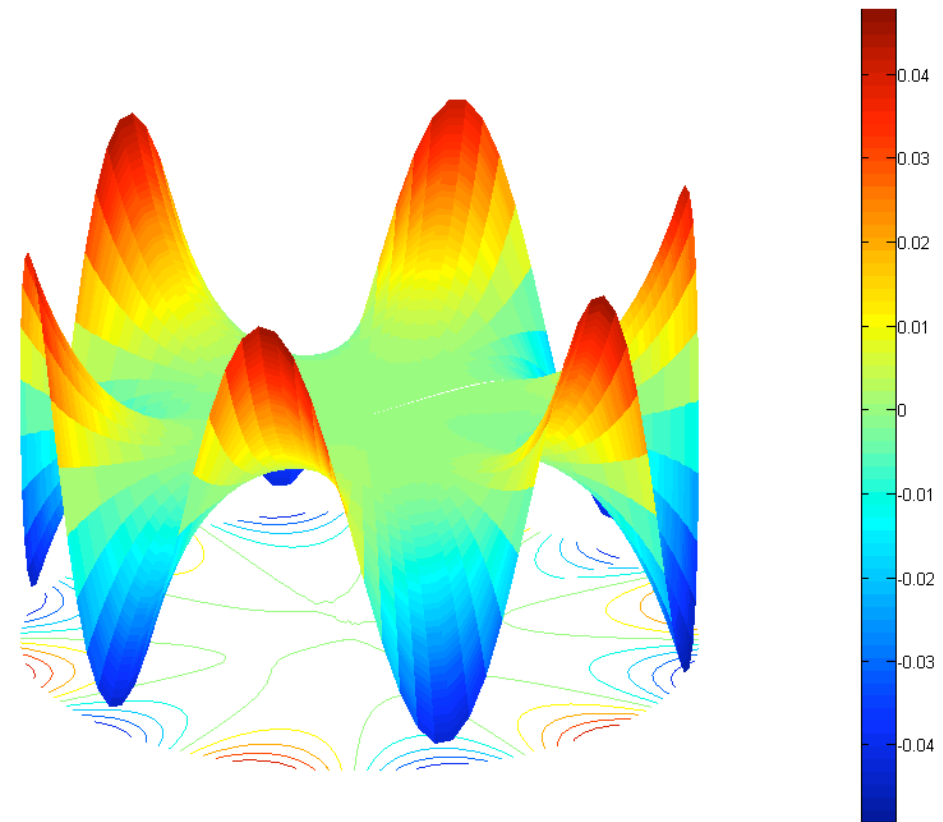
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Diagnostic Methods

Device	Plasma Generator bat. 357	Ion Source bat. 357	L4 3MeV bat. 152
RGA	x	x	x
Langmuir	x	-	-
VIS	x	x	x
RF coupling	x	x	x
Temperature	x	x	x
B-field	dedicated	-	-

Diagnostic Methods

	Measurement time[h]	Online	Production/ Installation	Material [kCHF]
RGA	40	x	0.09	45
Langmuir	80		0.03	40
VIS	80	x	0.22	25
RF coupling	15	x	0.17	5
Temperature	40	(x)	0.06	15
B-field	40		0.17	15
Total	295 h / 2 m		0.74 FTE	145 kCHF

Summary

- En route towards a better understanding of H-ion sources and characterisation methods
- Developing measurement routines and acquiring know-how for optimisation
- Developing online quality assurance methods for operation
- Prototype characterisation ca. 2 months
- Manpower:
- Material costs: 145 kCHF