JÜLICH
FORSCHUNGSZENTRUM

Status of the H^- / p source for ELENA

Cosy‘s „IBA source I“ for negative and positive ions

19. 11. 2012 | Ralf Gebel

Outline

- Source specification
- Status
  - Preparations
  - Documentation
  - Construction
- Safety issues
  - Conventional (H_2, HV)
  - Radiation protection
- Outlook and discussion

IBA‘s ion source specification

Verified for H^- and D^- at COSY

At Cosy in operation from 1996 to 2003: ~ 10000 h

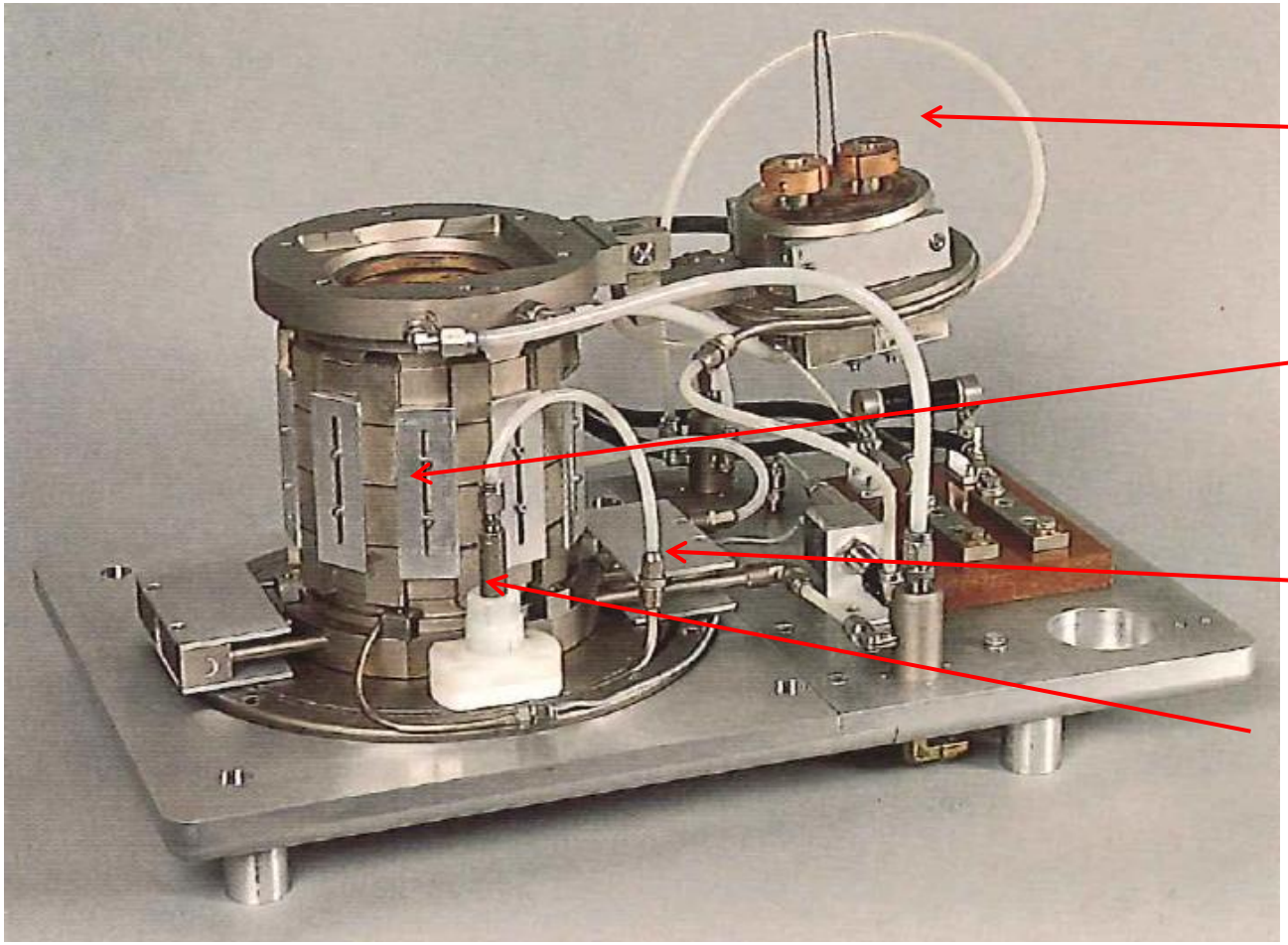
Ion source body

Specifications

	Positive ion version	Negative ion version
Type of ions	H^+, D^+, He^+, He^{2+}, N^+, Ar^+, etc...	H^-, D^-, O^-, etc...
Typical current intensitles (9 dia. mm extraction hole 30 A arc current 30 kV source bias)	$\geqslant$ 5 mA (singly ionized particles) $\geqslant$ 300 μA (doubly charged ions)	$\geqslant$ 2.5 mA (H^- ion)
Normalized emittance	$\leqslant$ 1 π mm mrad	$\leqslant$ 0.65 π mm mrad
Filament power	1.2 kW	
Arc power	6 kW	
Maximum bias voltage	40 kV	
Gas consumption	< 10 std cc/min	
External Dimensions	dia. 155 mm x 230 mm	

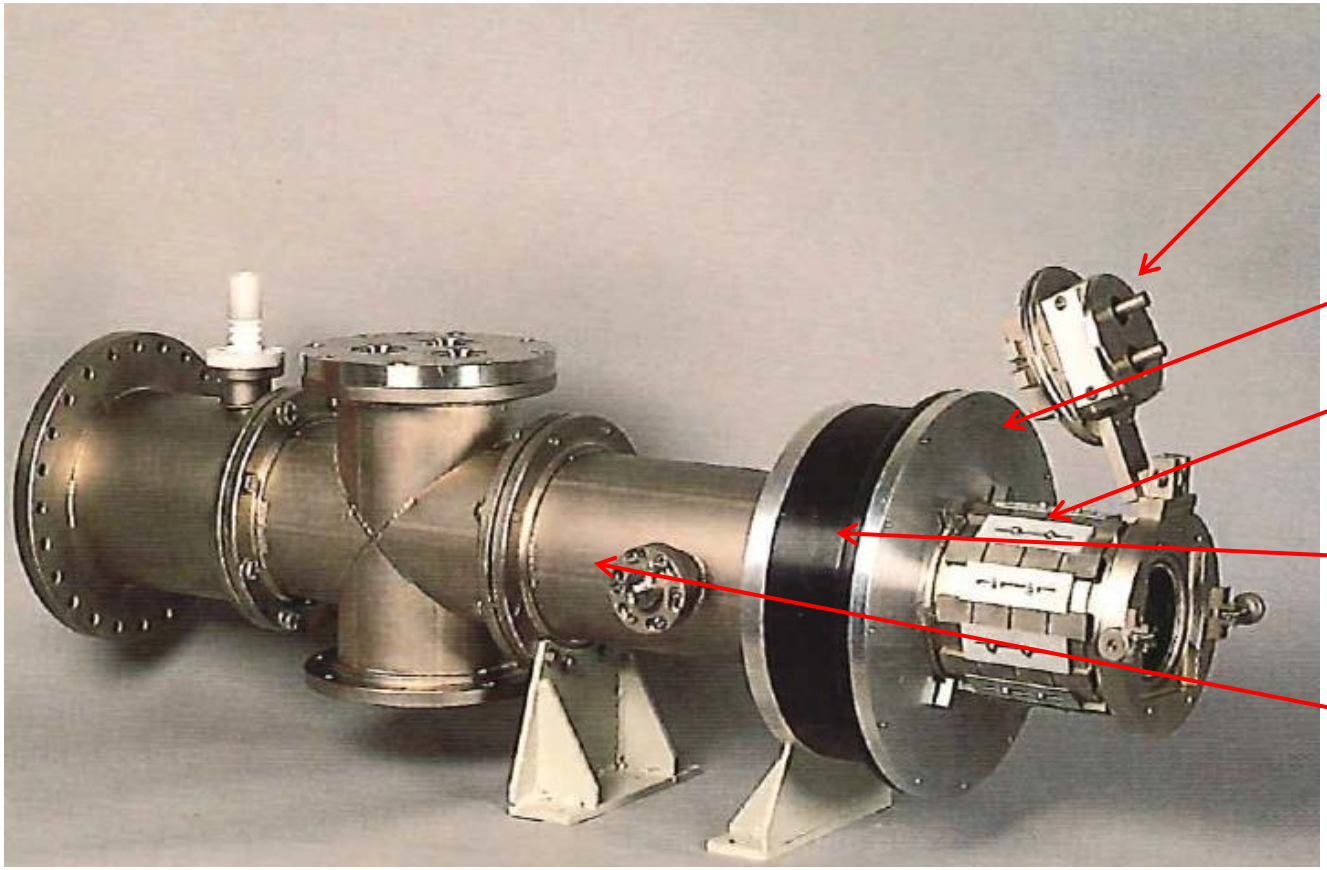
Specs from the IBA brochure

The negative ion source



IBA negative ion source (product information 1991)

The positive ion source



IBA positive ion source (product information 1991)

Maintenance interval: about 2 weeks

TABLE 1. Operational time of the unpolarized COSY ion sources.

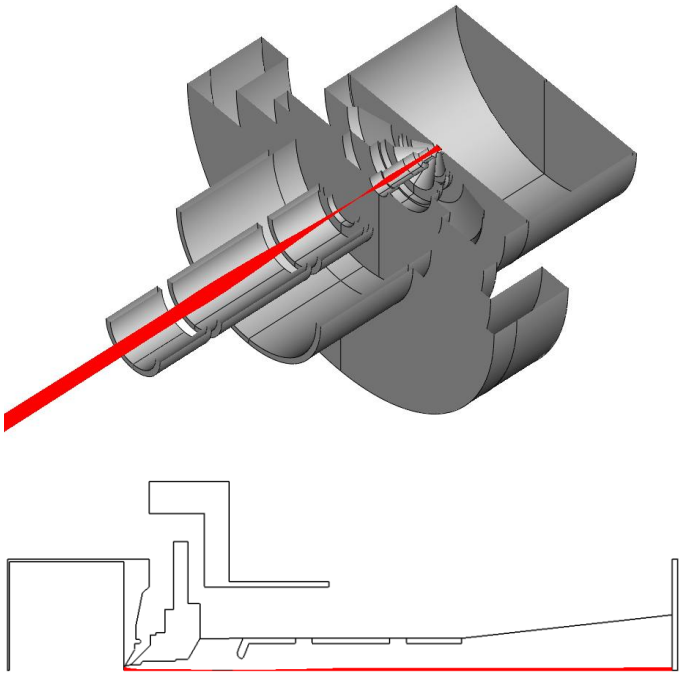
Ion source	operational hours	Filaments #	Max. usage hours	Defects #	MTTF* hours
IBA_1 1997 - 2003	10530	26	816	8	342
AEA 1998 -	66790	128	1324	24	437
IBA_2 2004 -	21353	44	1101	17	436

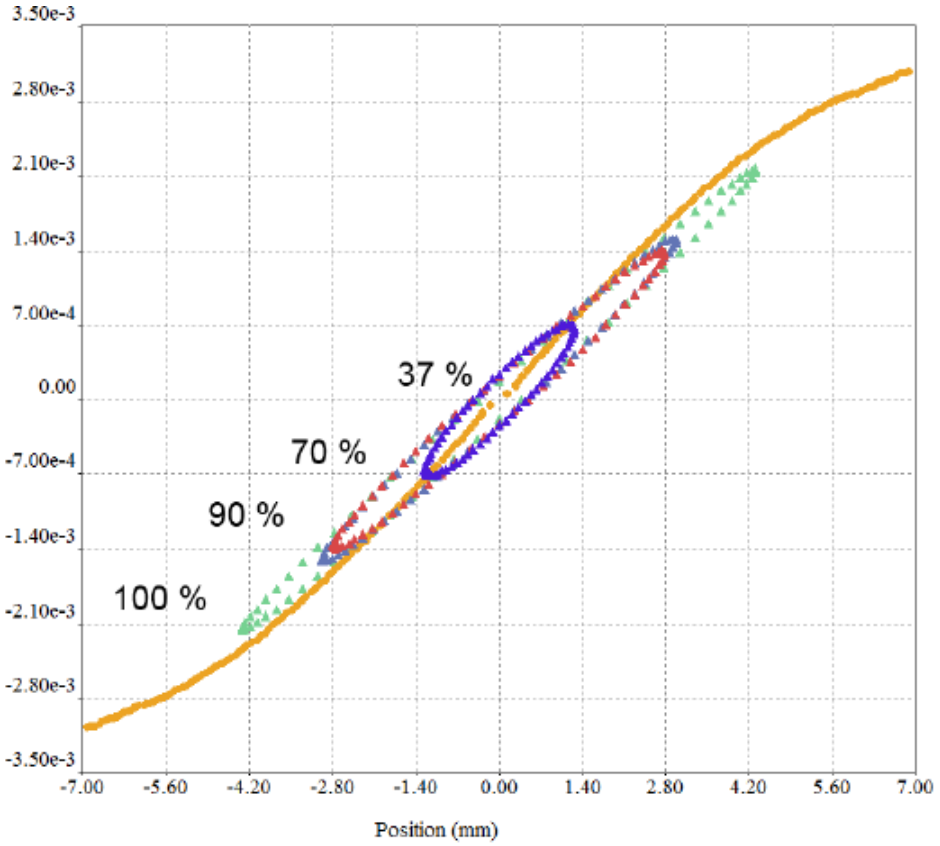
* Mean Time To filament Failure

LORENTZ-EM
Three-dimensional
Particle Trajectory Solver (Hybrid)
Version 9.1 x64
Release Date: August 10, 2012

JÜLICH
FORSCHUNGSZENTRUM

Simulations





3D and 2D-RS extraction and beam transport studies

Emittance plot for 250 µA H^- (100 keV)
4 mm aperture; 400 mm downstream

3D and 2D-RS simulation results

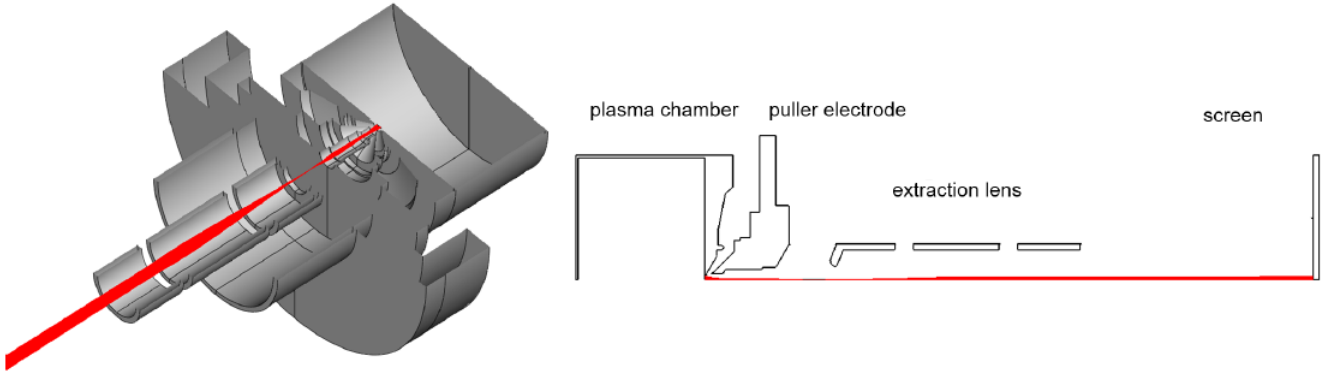


TABLE 2. IBA emittance data from commissioning used for calculating semi-axis-products. First preliminary results from simulation with Lorentz.

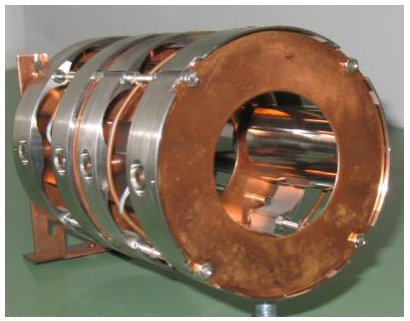
Parameter	unit	25 keV	90%	70%	I_0	90%	70%	37%
		IBA			3EM*			
current	mA	1.35	1.2	0.9	0.25	0.22	0.18	0.09
Emittance								
ε_{RMS}	μm rad				0.81	0.66	0.66	0.32
$\varepsilon_{RMS,norm}$	μm rad	<0.65	0.33	0.12	0.11	0.09	0.09	0.05
TWISS parameter								
α					-11.46	-6.77	-5.86	-2.63
β	m/rad				22.98	13.46	11.91	4.93
γ	m/rad				5.76	3.48	2.97	1.61

* As in Figure 5.

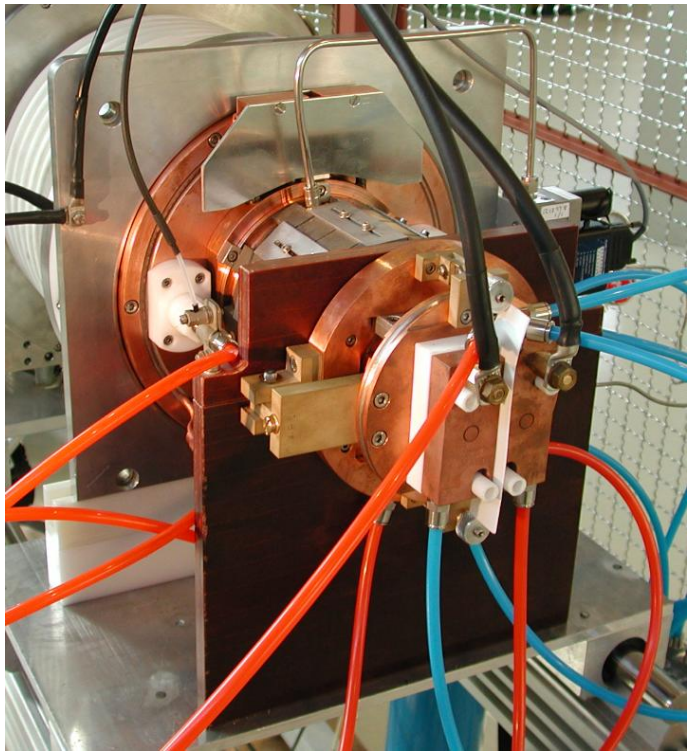
Preparing hardware

Start point is COSY's 1st H^- source:

- Refurbishment of source parts
- Preparation of power supplies, diagnostics and beam line elements

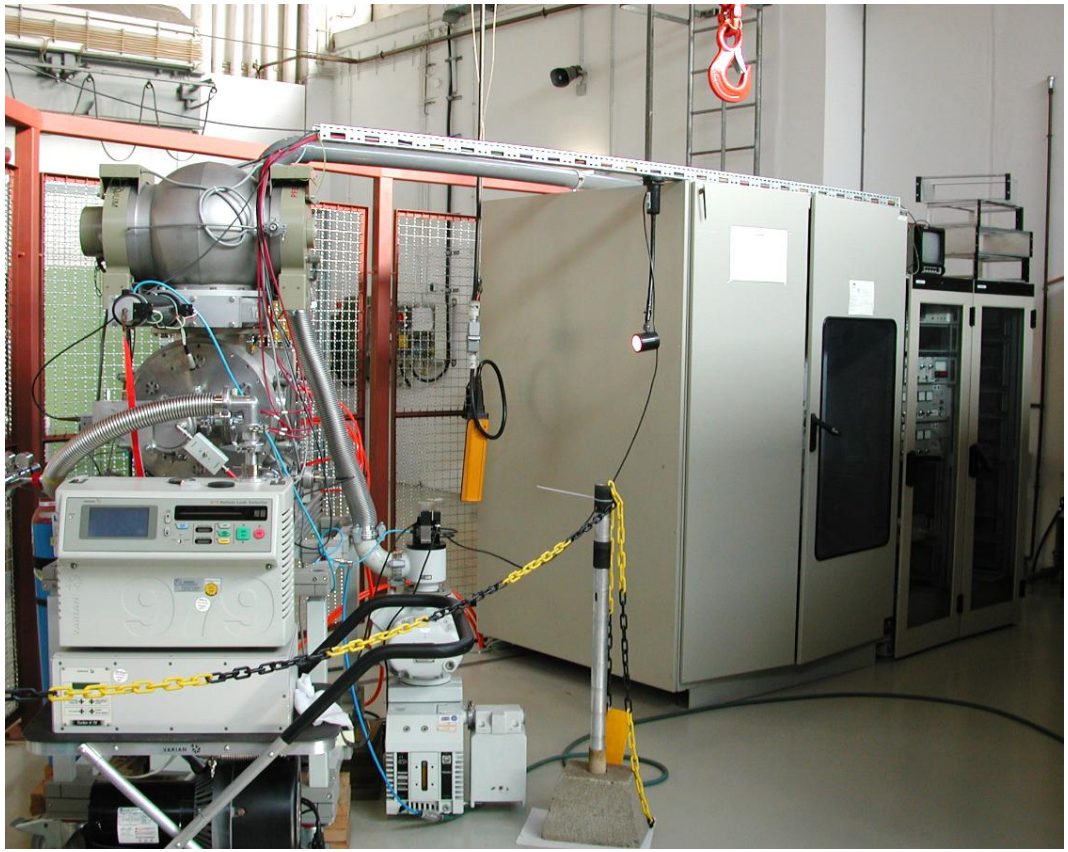


Refurbishment: finished

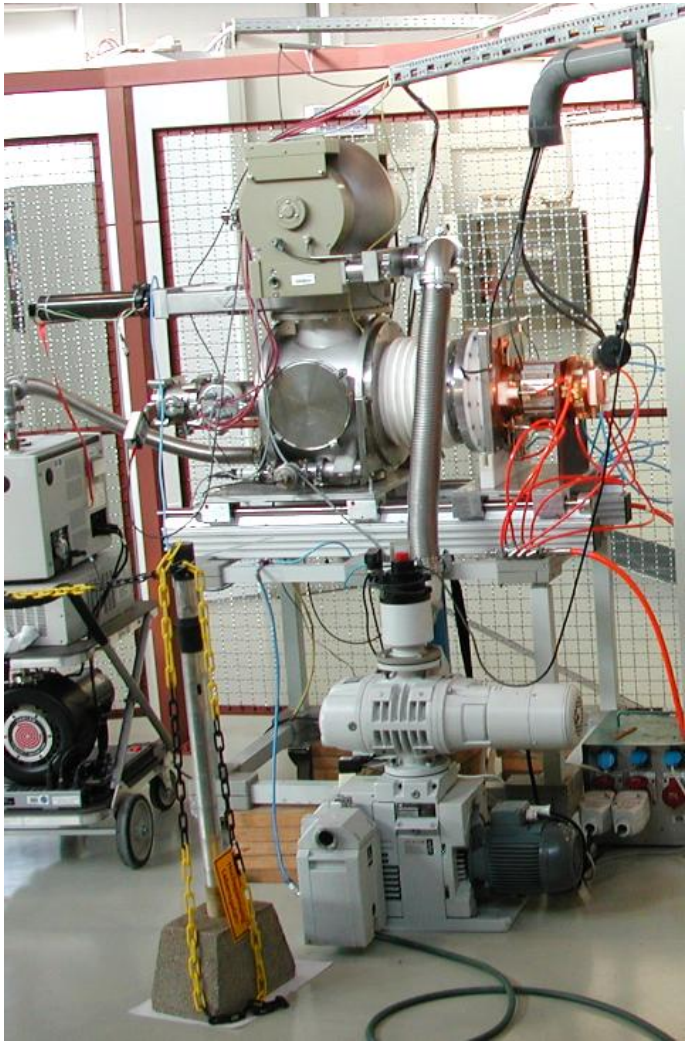


- Cleaning
- Water connectors replaced
- Brass parts replaced (Cu, st. Steel)
- Vacuum leak check: $< 10^{-7}$ mbar l/s
- Magnet alignment check

Source installation

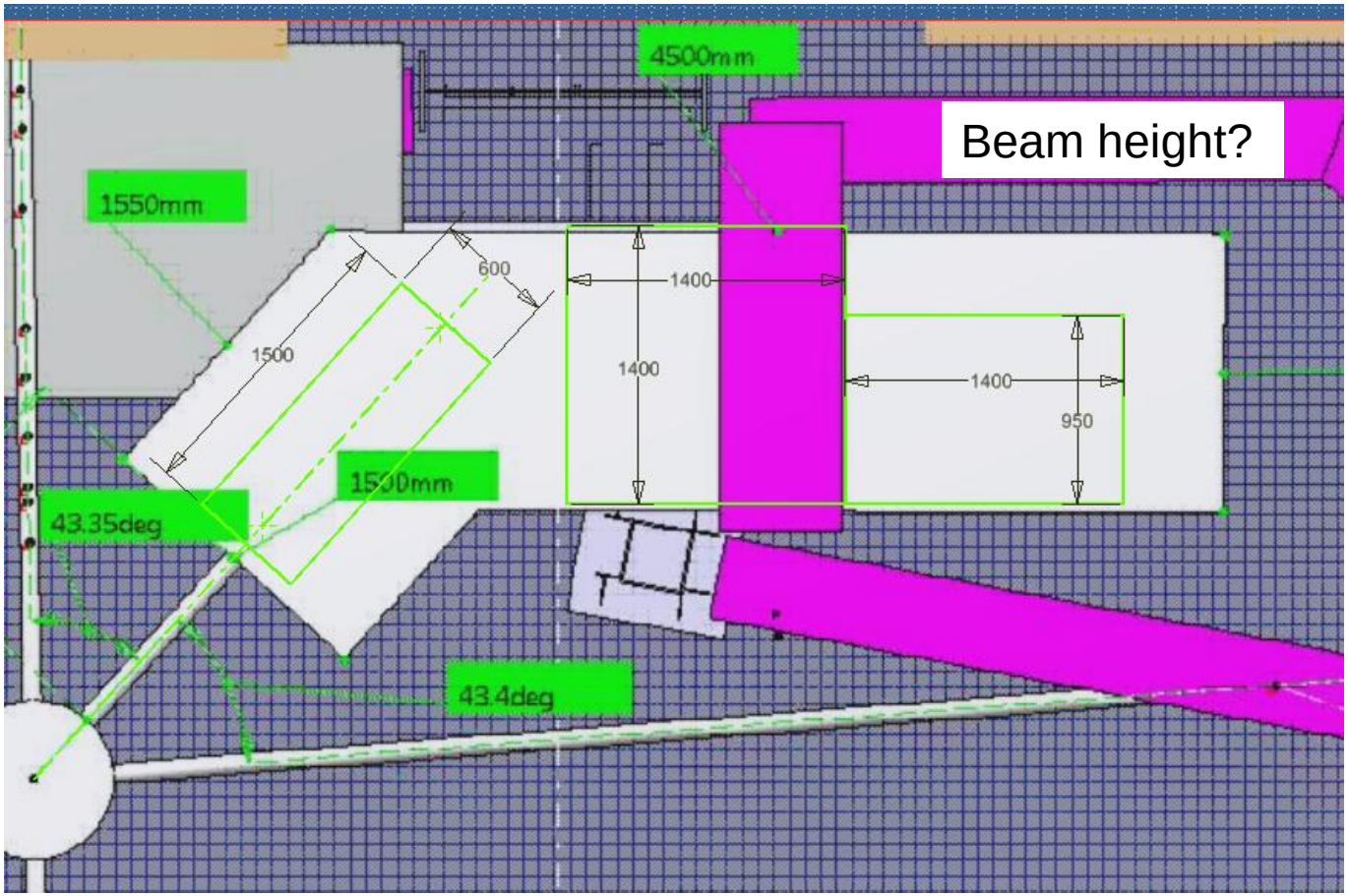


Ion source with HV rack and 2 19” racks



Ion source with short beam line and cup

Proposed installation near ELENA



From paper copies to CAD files

IKP construction started with new CATIA V5 data

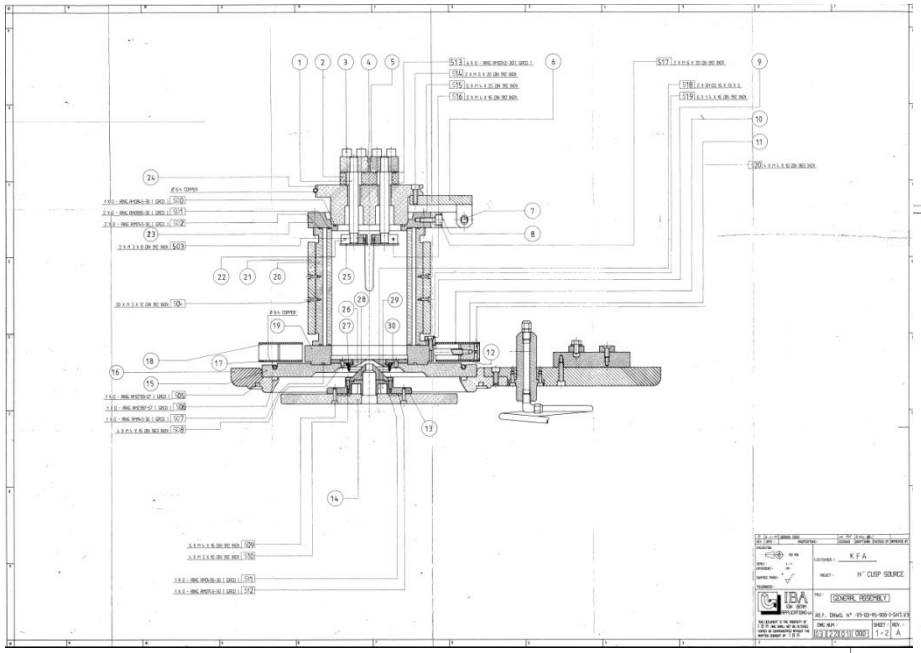
- Support structure
- Faraday cage and HT protection
- Replacement parts

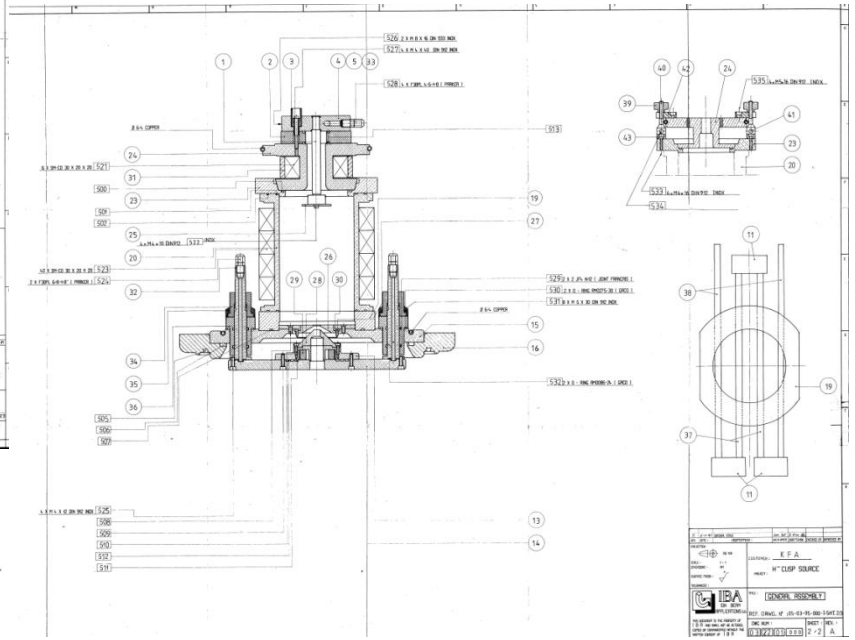
What we need:

- Information about alignment targets for adjustment
- White and black lists for materials
- Safety documentation and requirements

JÜLICH
FORSCHUNGSZENTRUM

Digital copies of drawings are available





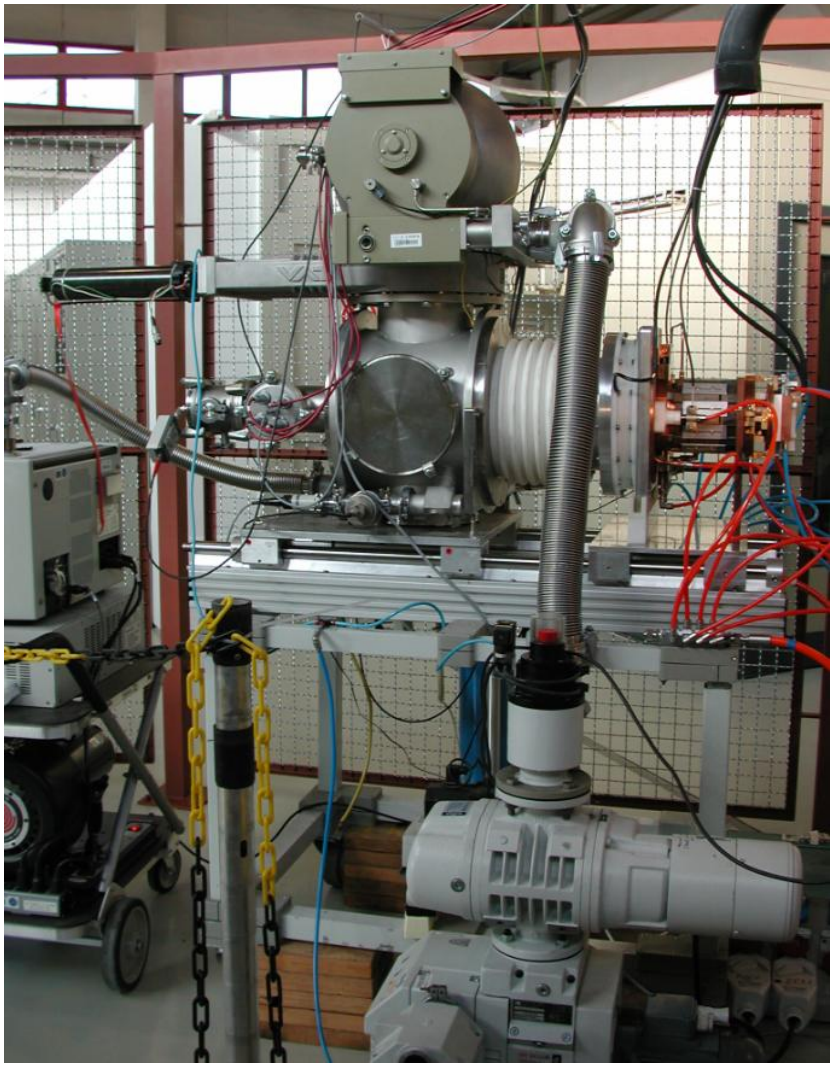
First tests

- Vacuum (5 $\cdot 10^{-7}$ mbar) with:

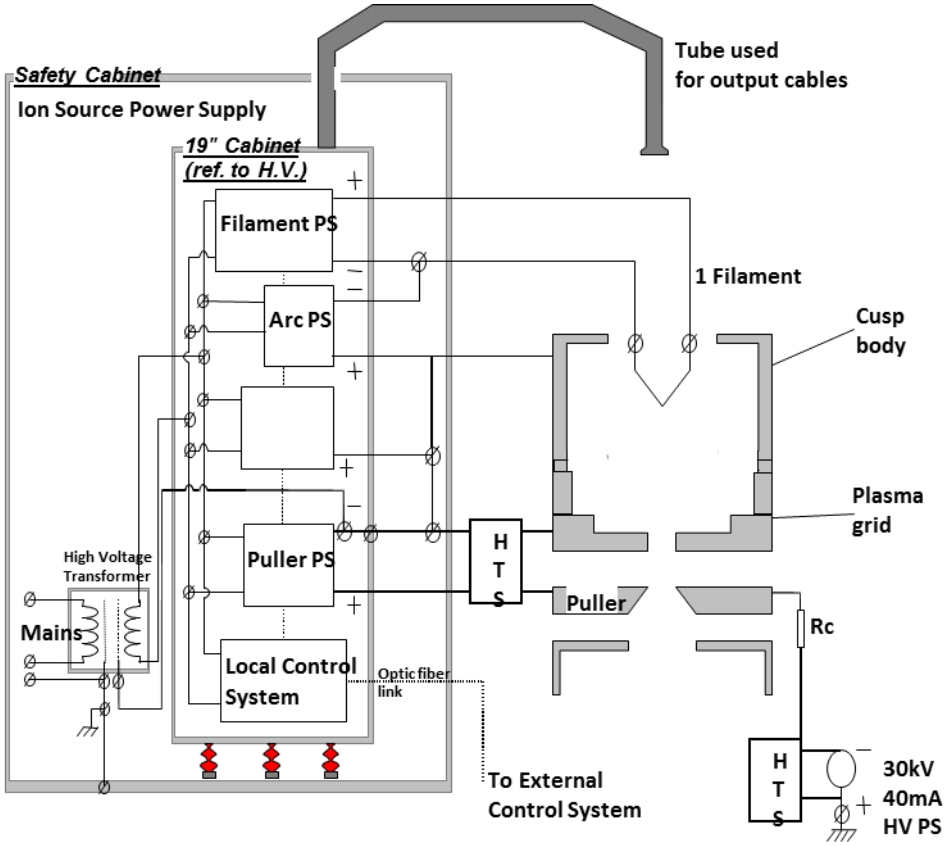
  Pfeiffer TPH 2200
  Leybold WKU250 + D40

- Preparation of

  PLC
  Interlock
  Diagnostics
  …



Preparing parts: HV cabinet



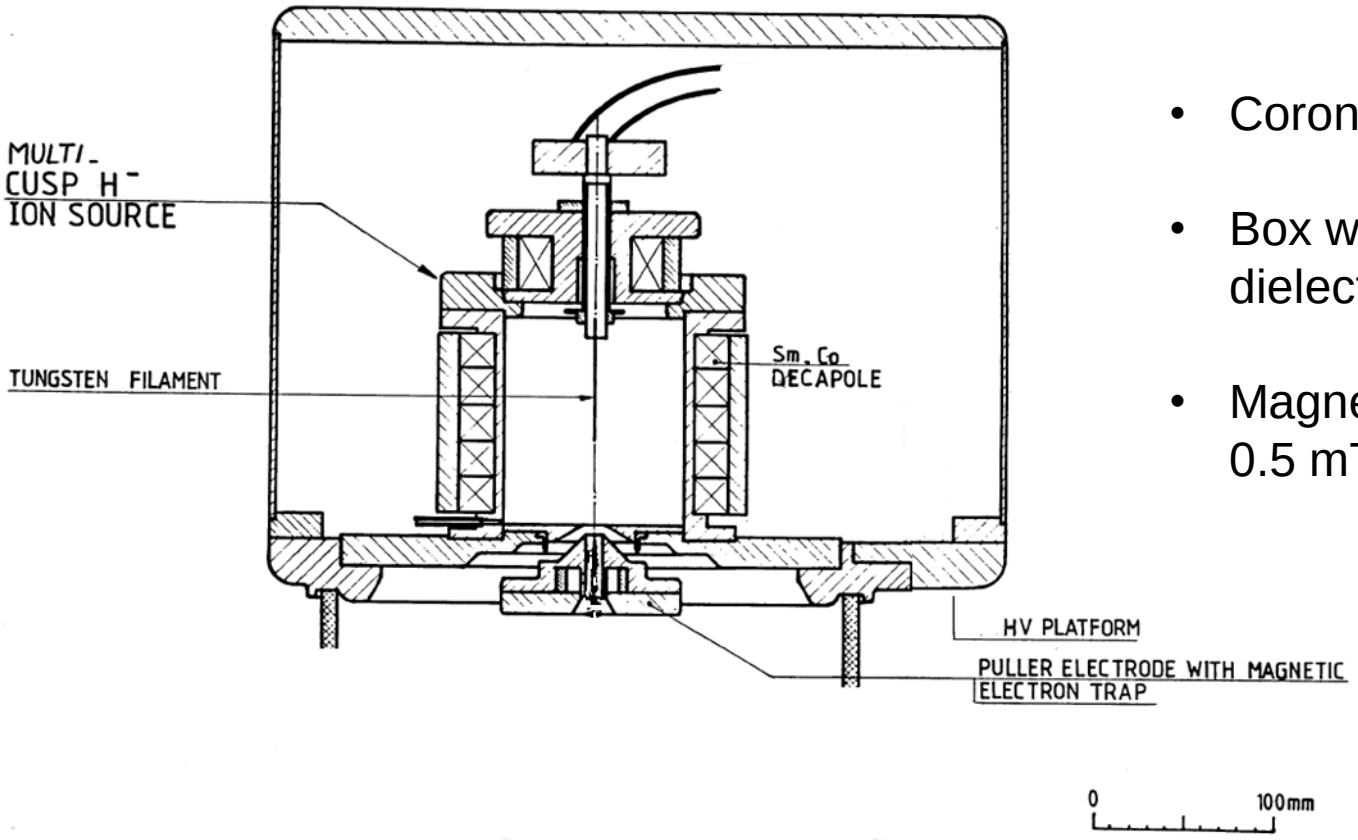
Arrangement of power converters

Arc Current	10 – 15 A
Arc Voltage	80 – 120 V
Gas Flow	< 0.1 mbar ℓs^{-1}
Filament Current	60 - 90 A
Beam Current H-	~ 0.2 mA
Beam Energy	30 (100) keV H^-
Electron trap current	25 – 30 mA
Divergence (1/e half angle)	15 mrad
Emittance (normalized ,rms)	<0.1πmmmrad

Modifications in preparation:

- **High Voltage Transistor Switches for Puller (extraction electrode)**
- **Reversed polarity for p operation**
- **120 kV transformer (400 Hz)**

Safety issue 1: high voltage



- Corona screen
- Box with high dielectric strength
- Magnetic shielding? 0.5 mT on box

Safety issue 2: Hydrogen

Hydrogen consumption: max. 16 l/day

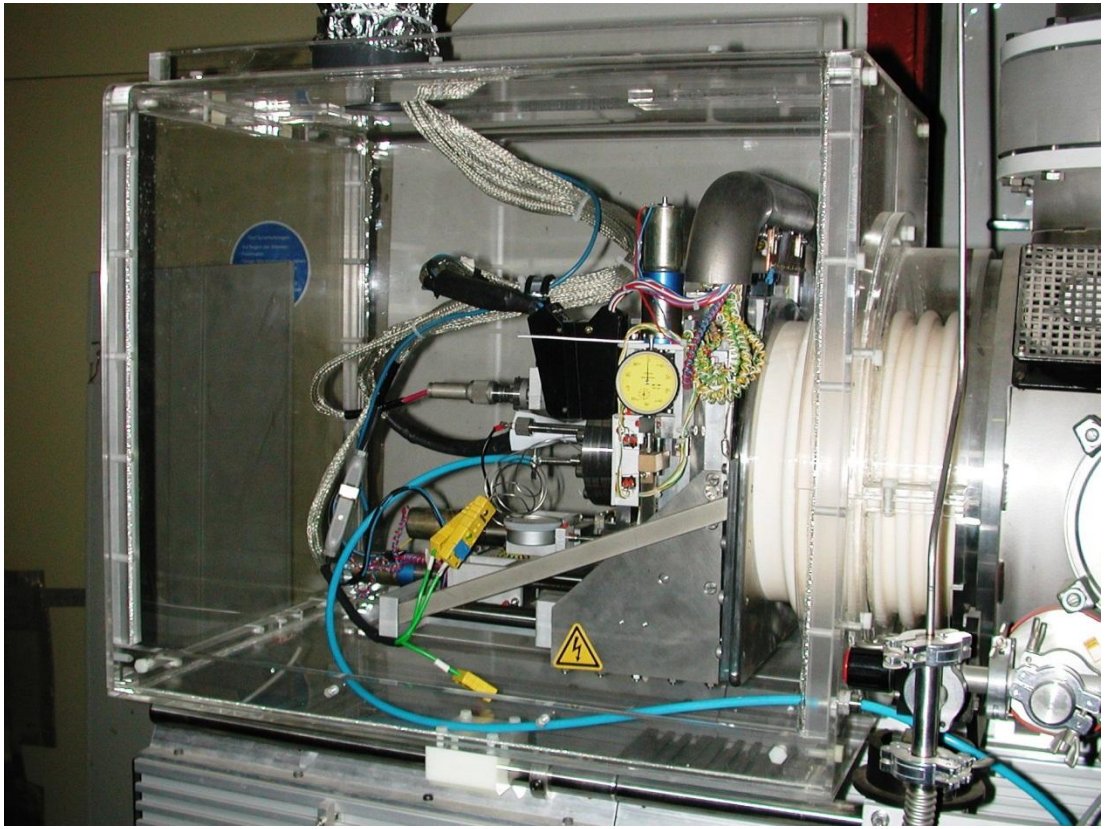
- Check air exchange rate
- Use a H_2 generator instead of bottles

Safety issue 3: radiation protection

The ion source is a stray radiation source

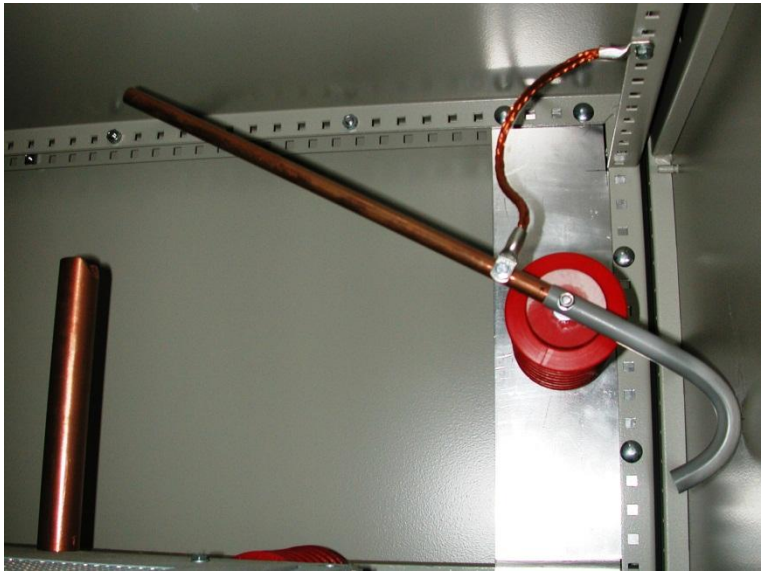
- Notification and approval of German authorities is mandatory
- Jülich will apply for approval in 2013
  - COSY RP officer will estimate (simulate) dose distribution
  - Measurements during test phase for verification
- Expectation (Experience e.g. from „100 kV“ Cs source)
  - sufficiently shielded by chamber design
  - ELENA source operates with low duty factor (10^{-6})

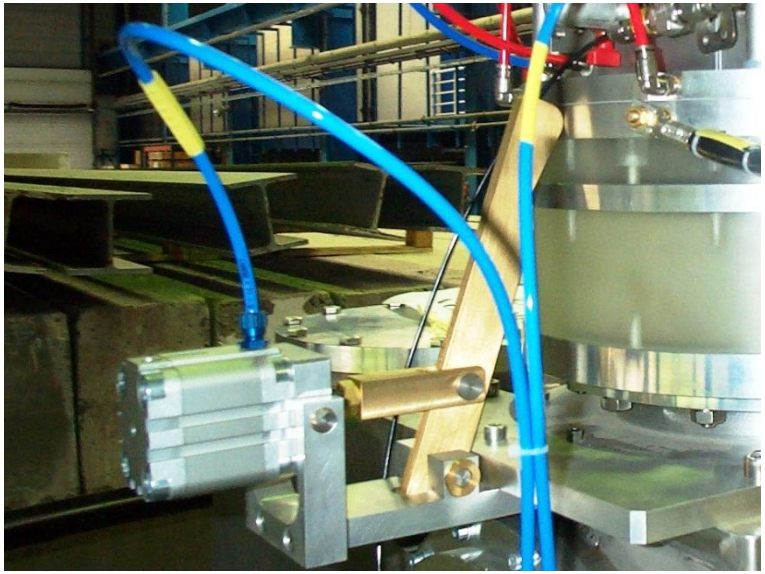
Safety issues at the ion sources



Polycarbonate box for the source

Grounding





- Mechanics at the 19“ rack
- Pneumatics at the source

Outlook

- Continuation of tests below 30 kV
  - Pulse schemes with semiconductor switches
  - Operation as proton source
  - Measure specs

- Enable operation up to 100 kV
  - Installation of 120 kV transformer
  - Tests with available power supplies +/- 65 kV
  - Realize safety
  - …