The ISIS Penning Ion Source and the Volume Ion Sources from Frankfurt and DESY for the Production of H^- Ions

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ESS Specifications

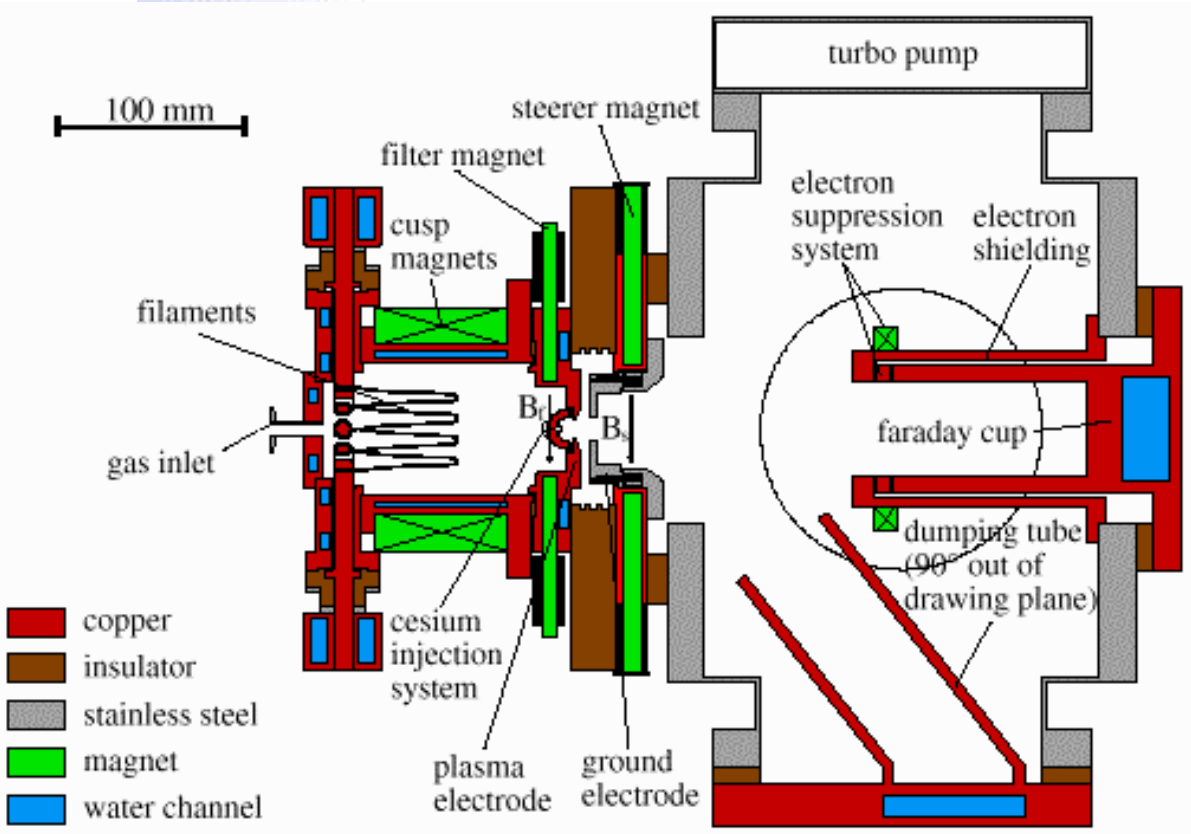
65 mA

1.2 ms, 50 Hz (short pulse)
2.5 ms, 50/3 Hz (long pulse)

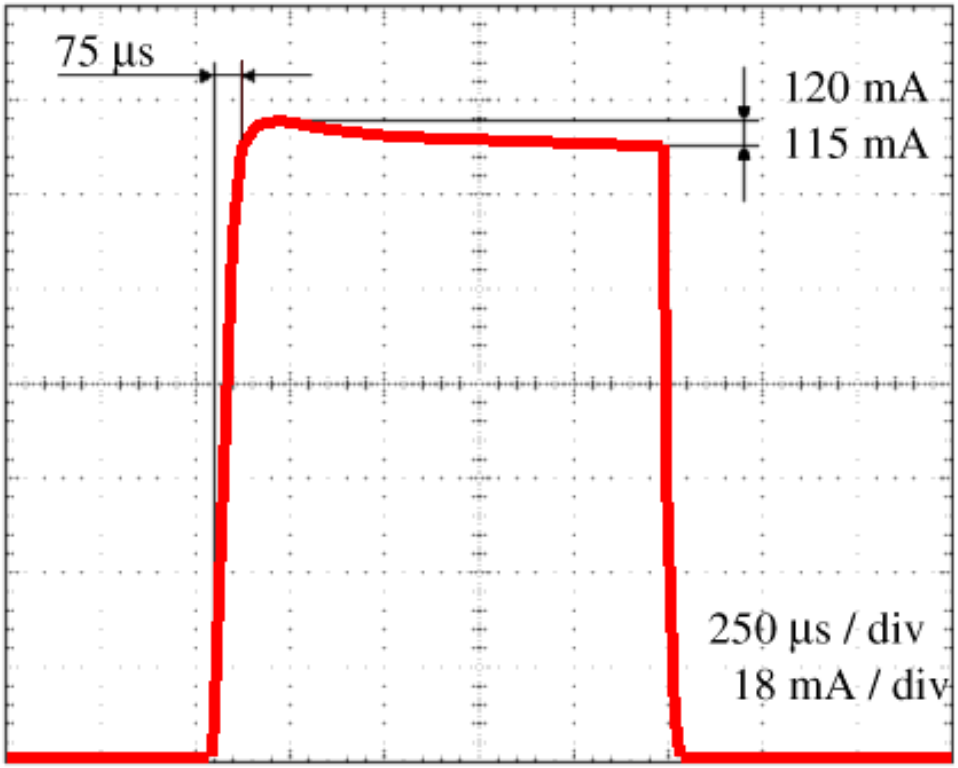
< 0.3 π mm mrad
(normalized rms)
at RFQ matching point

>20 days' lifetime

JWGU Frankfurt H⁻ Volume Source

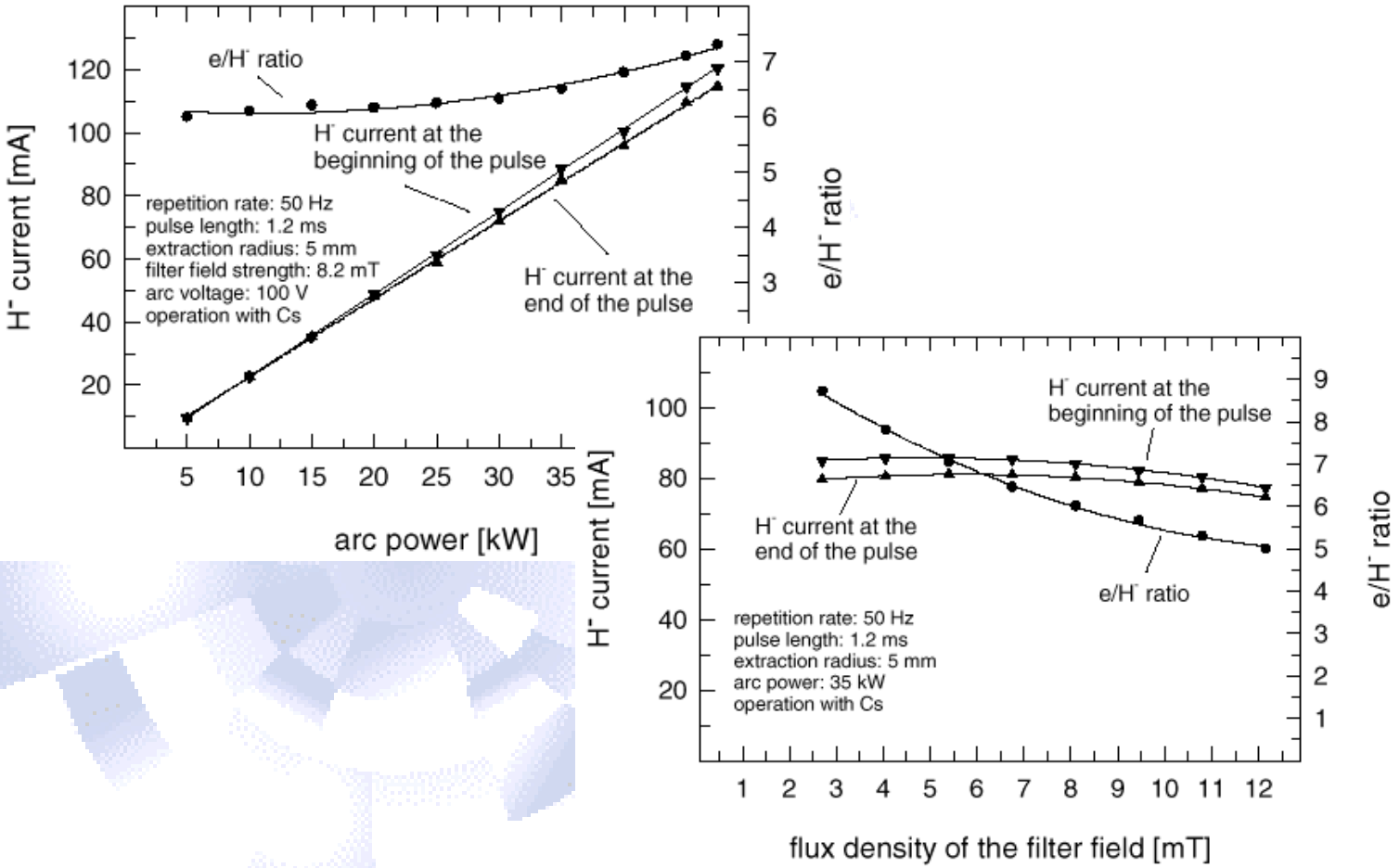


Results



- 120 mA, 1.2 ms, 50 Hz, 33 kV extract, 47.5 kW

Results (2)


e/H⁻ ratio
H⁻ current at the beginning of the pulse
H⁻ current at the end of the pulse
repetition rate: 50 Hz
pulse length: 1.2 ms
extraction radius: 5 mm
filter field strength: 8.2 mT
arc voltage: 100 V
operation with Cs
H⁻ current [mA]
e/H⁻ ratio
arc power [kW]
H⁻ current at the beginning of the pulse
H⁻ current at the end of the pulse
e/H⁻ ratio
repetition rate: 50 Hz
pulse length: 1.2 ms
extraction radius: 5 mm
arc power: 35 kW
operation with Cs
H⁻ current [mA]
e/H⁻ ratio
flux density of the filter field [mT]

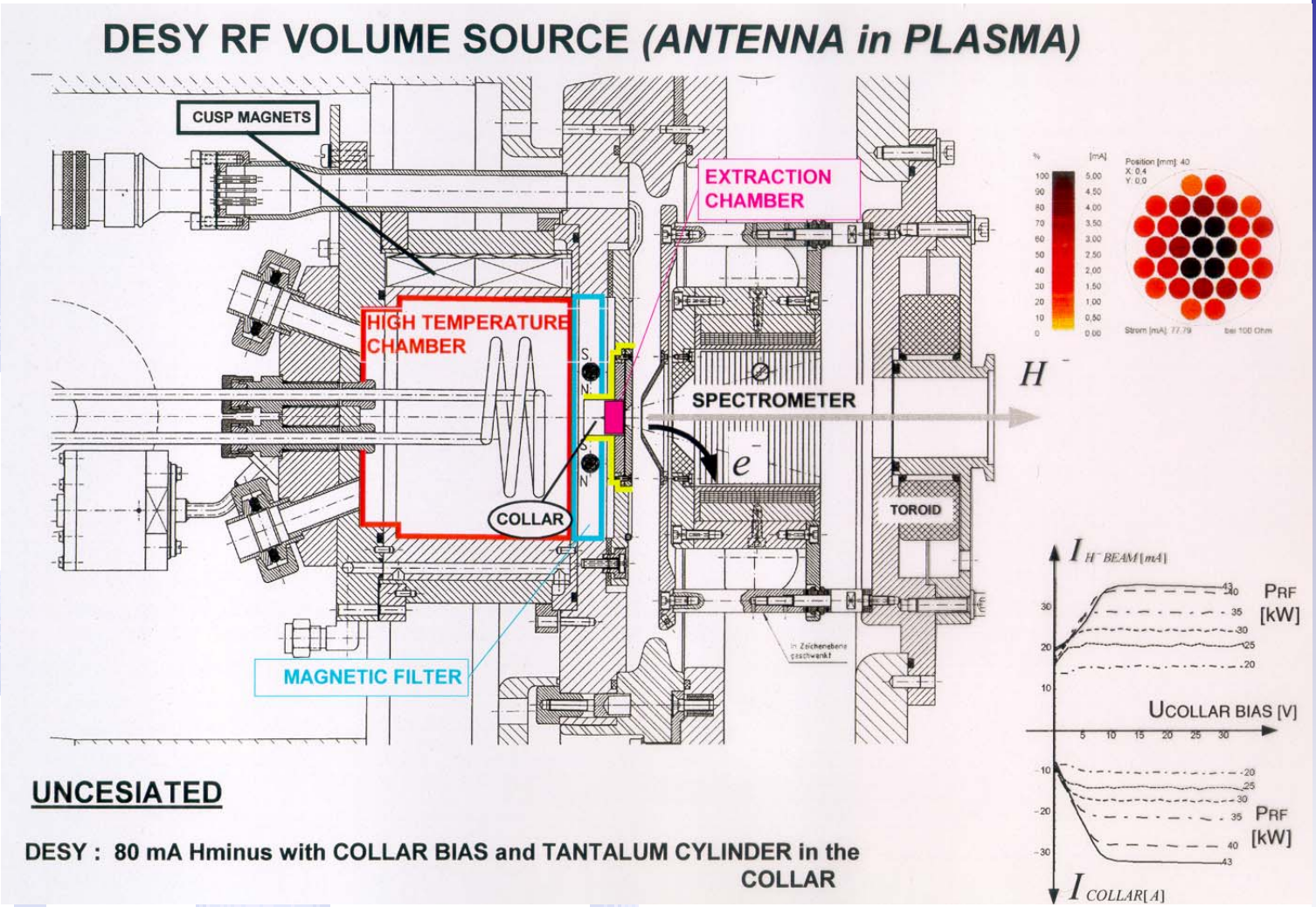
Future Work

- Demonstrate source reliability and stability over operational lifetimes
- Confirm expected lifetime (15 - 20 days) with 4 filament set up, try thicker filaments and larger power supply for longer lifetimes
- Investigate Cs injection at higher arc powers (at the moment arc power must be dropped for 15 mins every 10 - 18 hrs to facilitate this process)
- Measure emittance with slit-grid device
- Investigate long pulse option

'The Frankfurt H^- source for the European Spallation Source', K. Volk et al., LINAC 1998, TH4057.

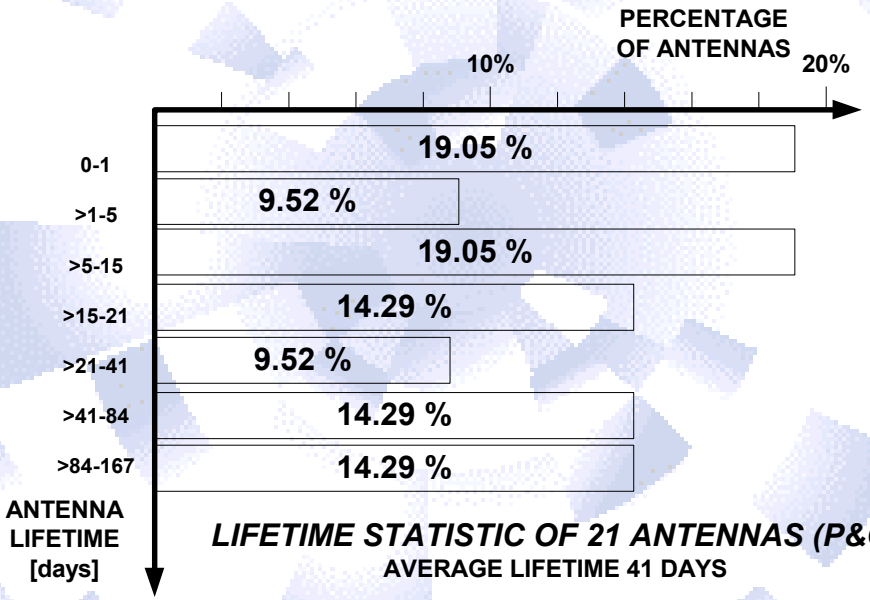
- Investigate external RF coupling in collaboration with DESY

DESY RF Volume Source



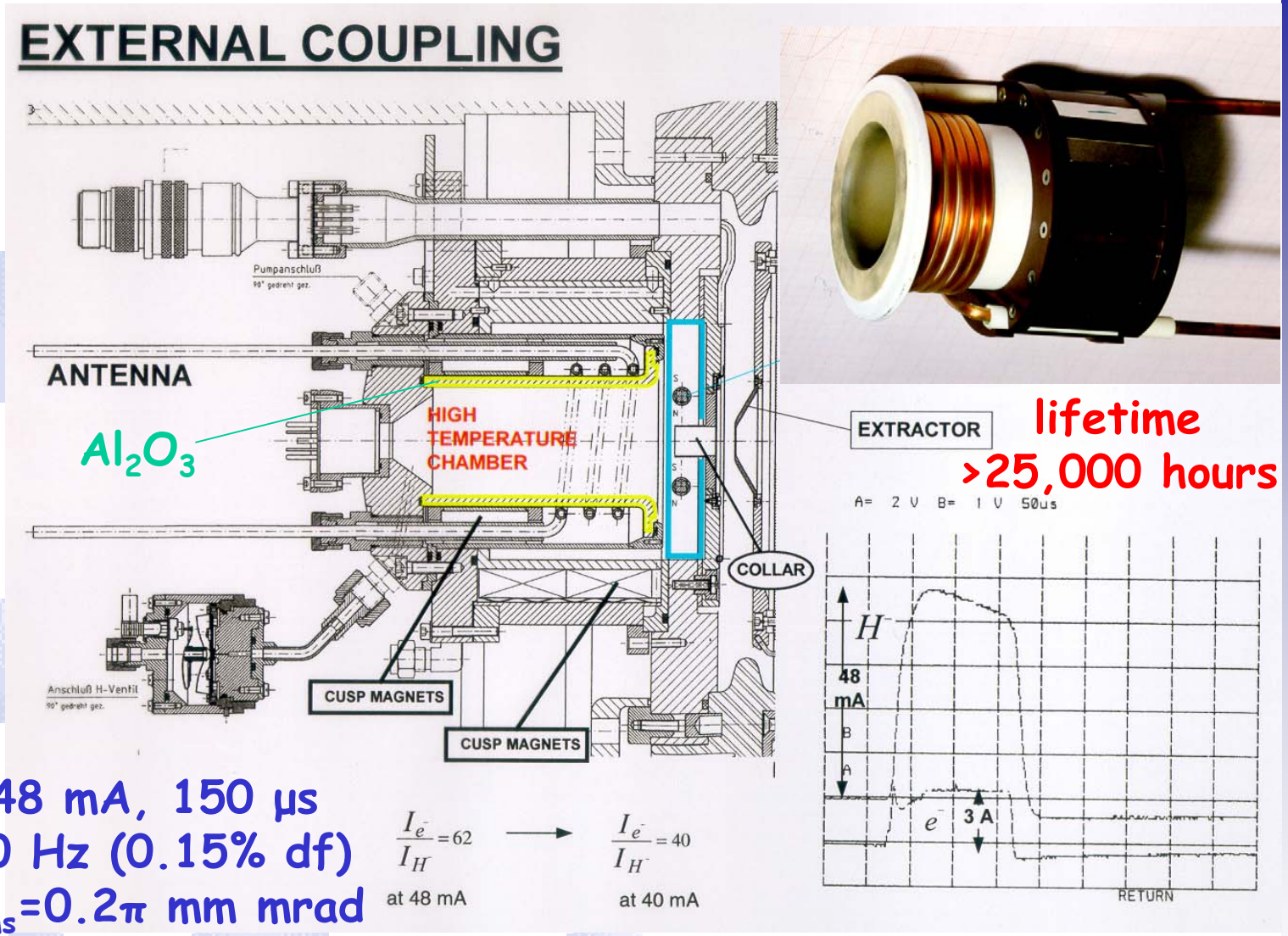
Measured Antenna Data

Is there something better?



LIFETIME STATISTIC OF 21 ANTENNAS (P&G)
AVERAGE LIFETIME 41 DAYS

DESY Externally Coupled RF Volume Source



Future Work

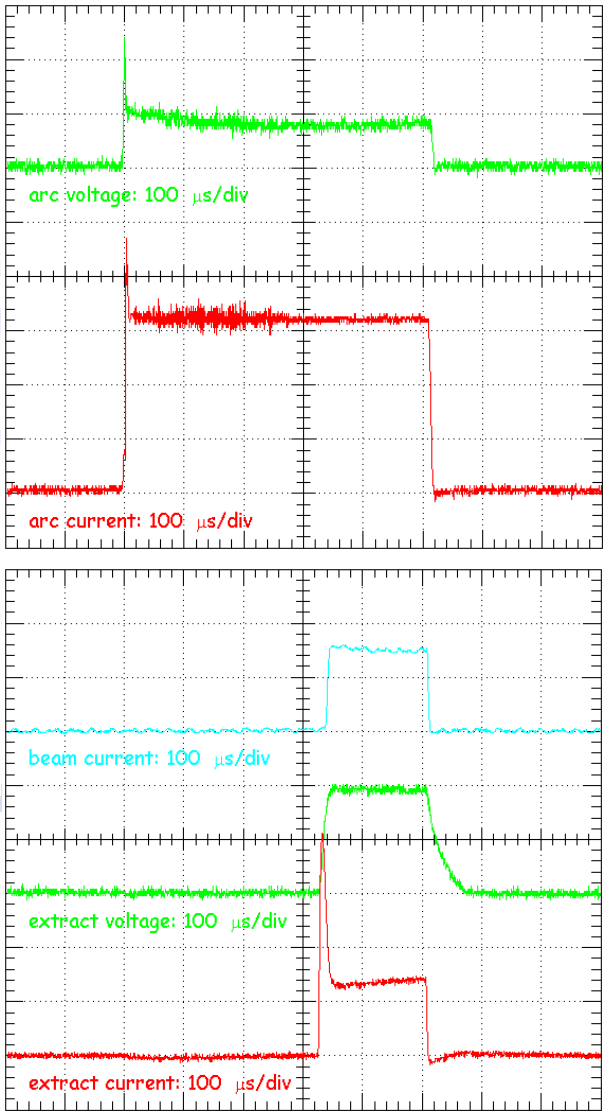
- Improvement of the matching to the RFQ
- New extraction system
- New collar system

'The status of the DESY H^- sources',
J. Peters, RSI 69 (2) 1998.

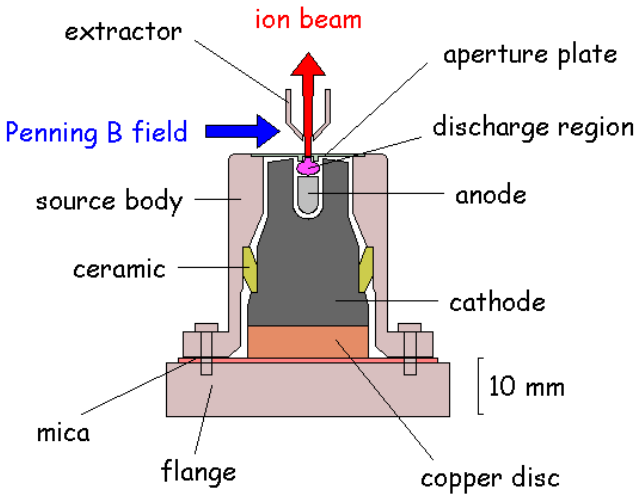
- Investigate external RF coupling
in collaboration with IAP Frankfurt/SNS

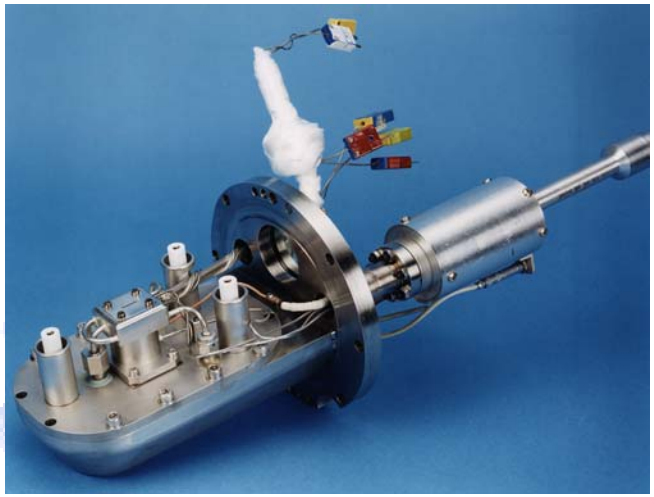
The ISIS Ion Source

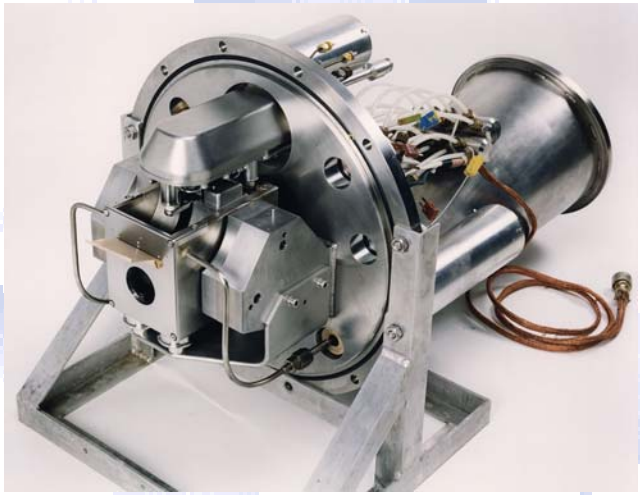
- The ion source used to produce H^- ions on the ISIS spallation neutron source is a Penning surface plasma (SPS) source
- 35 mA through 0.6×10 mm ≈ 600 mA/cm²
- 200-250 μs, 50 Hz (≈ 1% duty factor)
- 26 days average continuous running
- ≈ 20 ml/min H_2, ≈ 3 g/month Cs
- normalised emittance ≈ 2π mm mrad (665 keV, 35 mA, 95%)

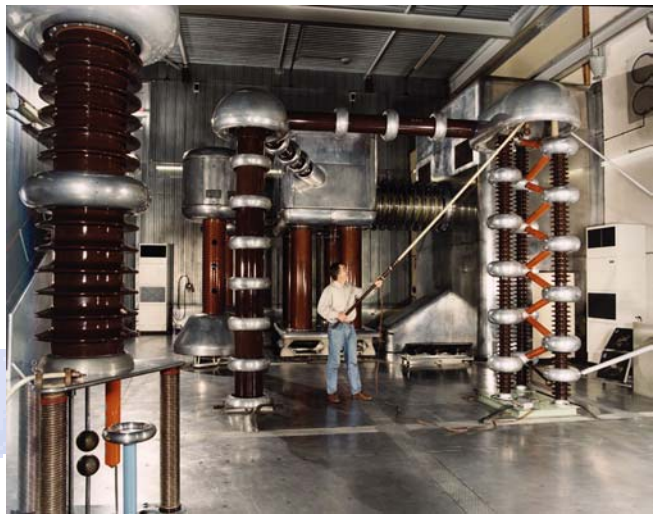


The ISIS Ion Source (2)









The Ion Source Development Rig

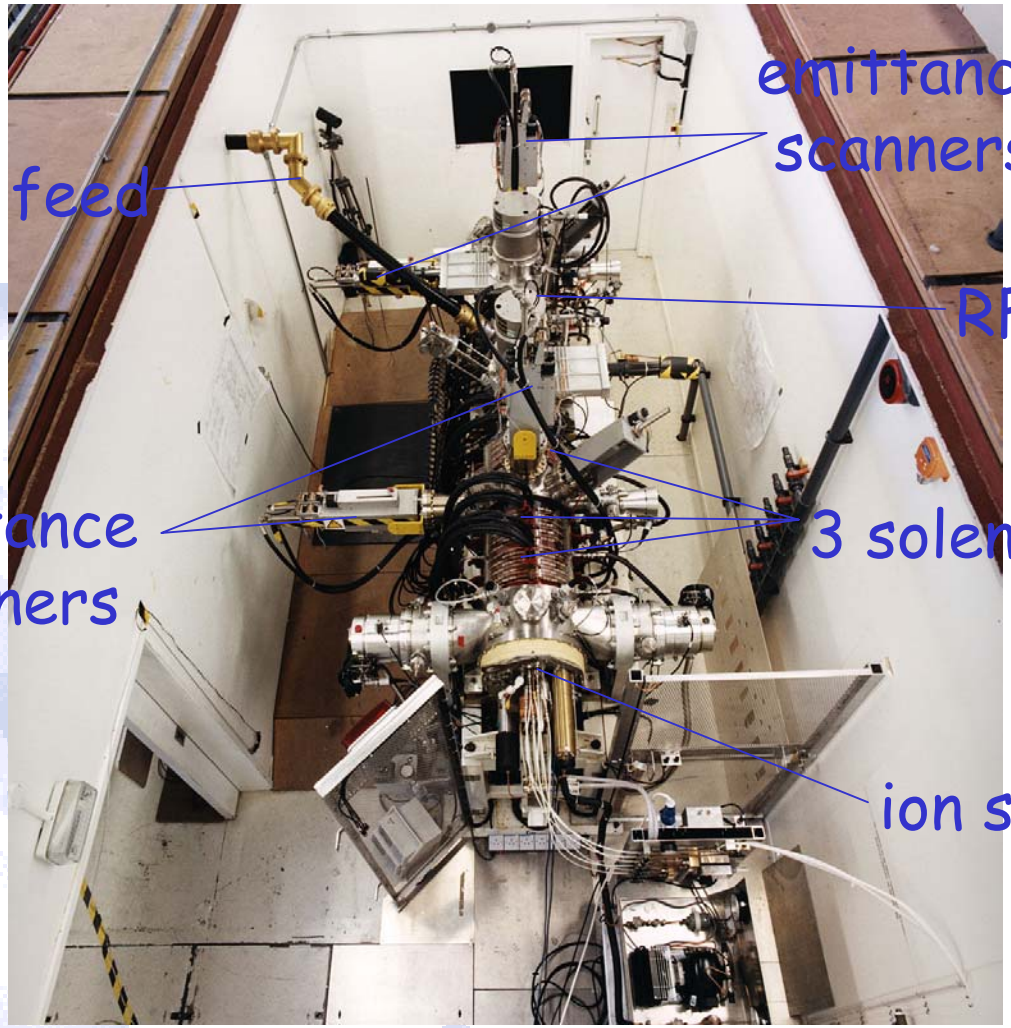
- Ion source mounted on HV platform, 35 kV bias (may be up to 80 kV for ESS)
- Variable output geometry
- Current measurement
  - Beam toroid
  - Faraday cup
- Emittance measurement
  - scanners
  - scintillator+CCD camera
  - photographic paper
- Remote control via f/o ethernet STEbus system

Future Work

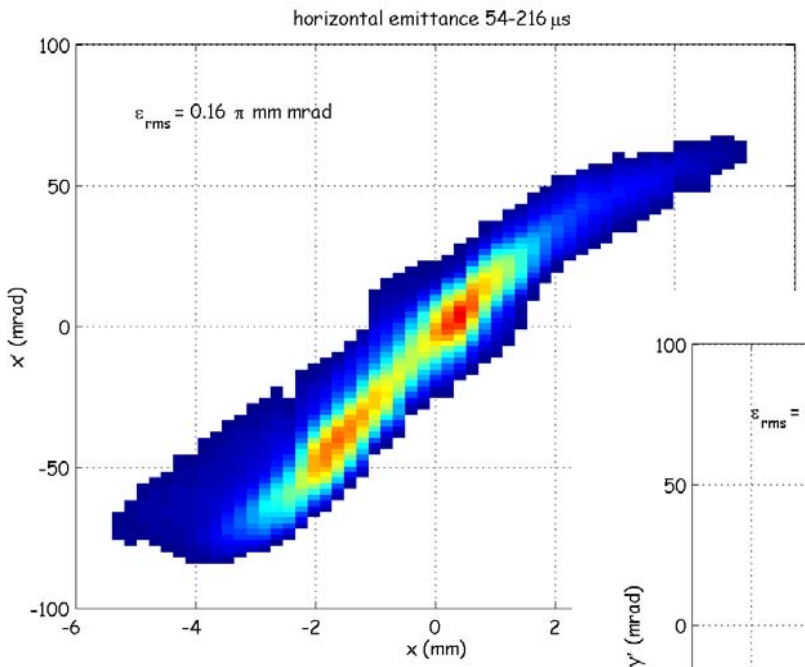
- The ISIS source has already produced 65 mA, but not routinely and with large departures from optimum conditions for source lifetime
- Improved physics and MAFIA modelling
- Component geometry changes
- Extraction at higher potential
- More controlled Penning discharge
- Improved cooling for 1.2 and 2.5 ms pulses to offset heating and demand for Cs
- Thermal modelling with ANSYS
- Higher duty factor extract and arc PSUs
- Include LANL 4X option

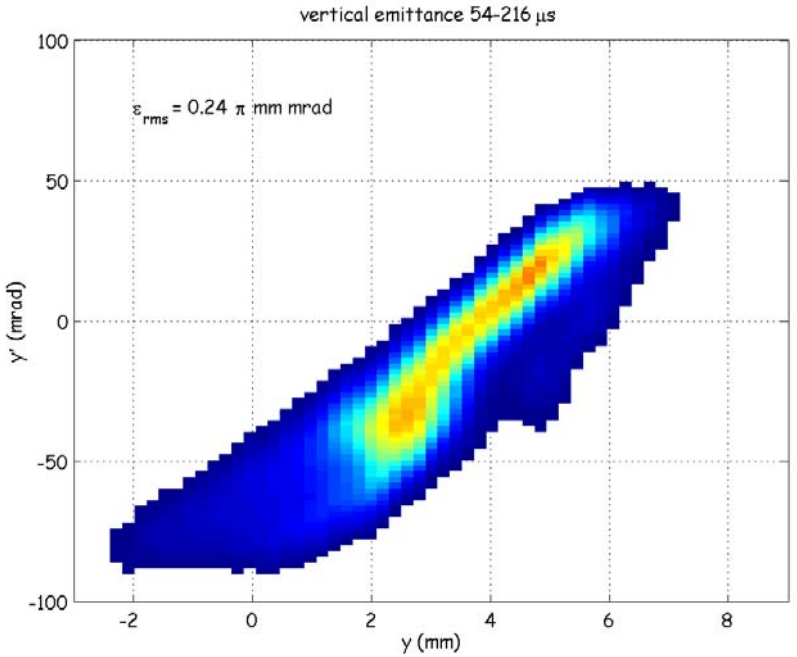
'H^- ion source test and development capabilities at ISIS', J. W. G. Thomason et al., ICIS 2001, RSI 73(2) 2002.

The ISIS RFQ


emittance scanners
RF feed
RFQ
emittance scanners
3 solenoid LEBT
ion source

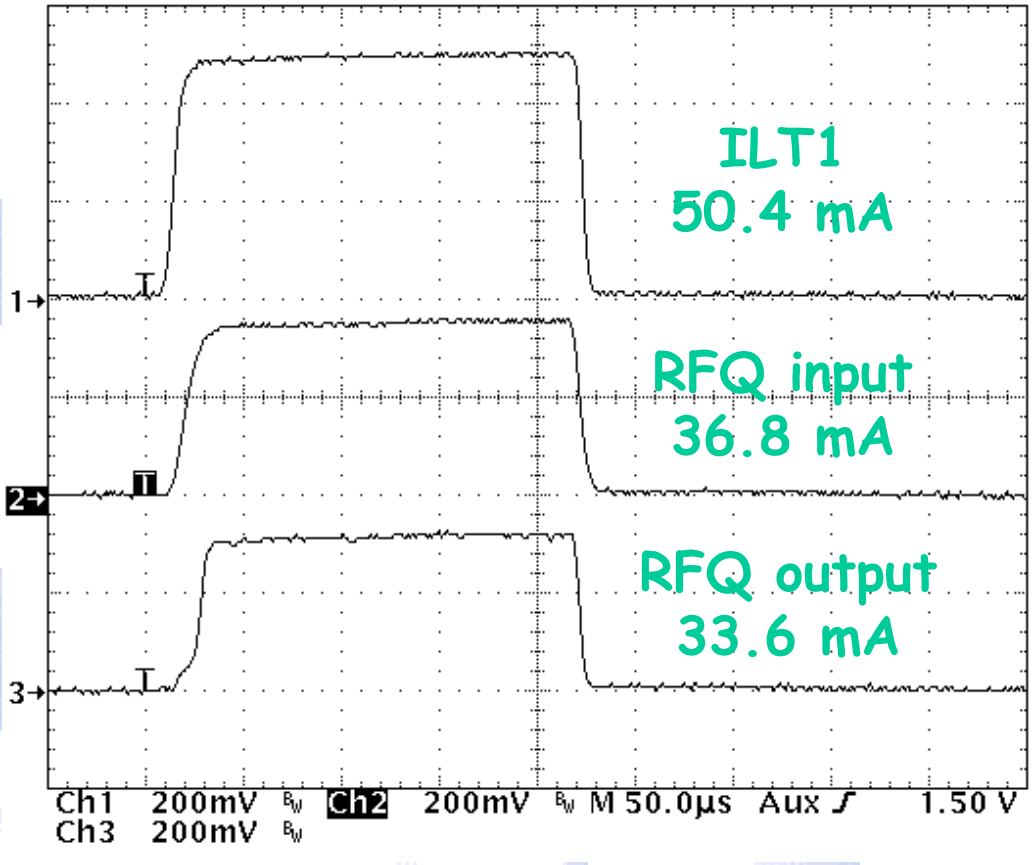
ISIS RFQ LEBT Emittance (1)





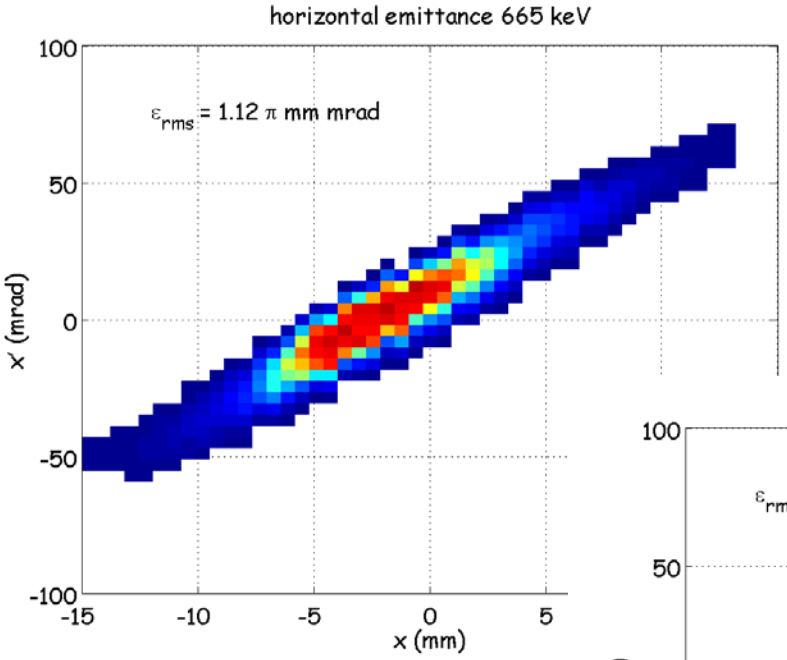
≈ 30 mA, 225μs, 35 keV, 17 kV extraction

RFQ Transmission

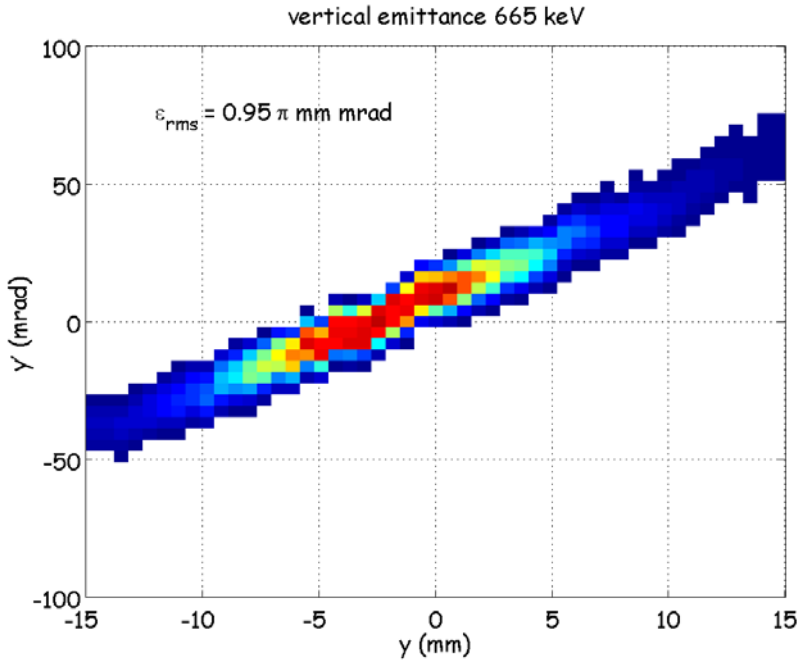


RFQ transmission efficiency 91.3 %

ISIS RFQ 665 keV Emittance



22.5 mA,
225μs, 50 pps
90% transmission



excellent agreement with simulations

Conclusions

- There is a great deal of work still to be done to provide H^- ion sources for ESS, but confidence of success is high

- European union support for H^- source development (through HP-NIS) has been obtained at just the right time, but more effort may be necessary in order to complete the R&D within the ESS timeframe

- International collaboration is of vital importance and is now reaching very encouraging levels - a worldwide workshop on H^- ion sources will be held 30th and 31st May in Saclay, France