



Science and
Technology
Facilities Council

First Beam Extraction from the Non-Caesiated External RF-Coil H⁻ Ion Source at ISIS

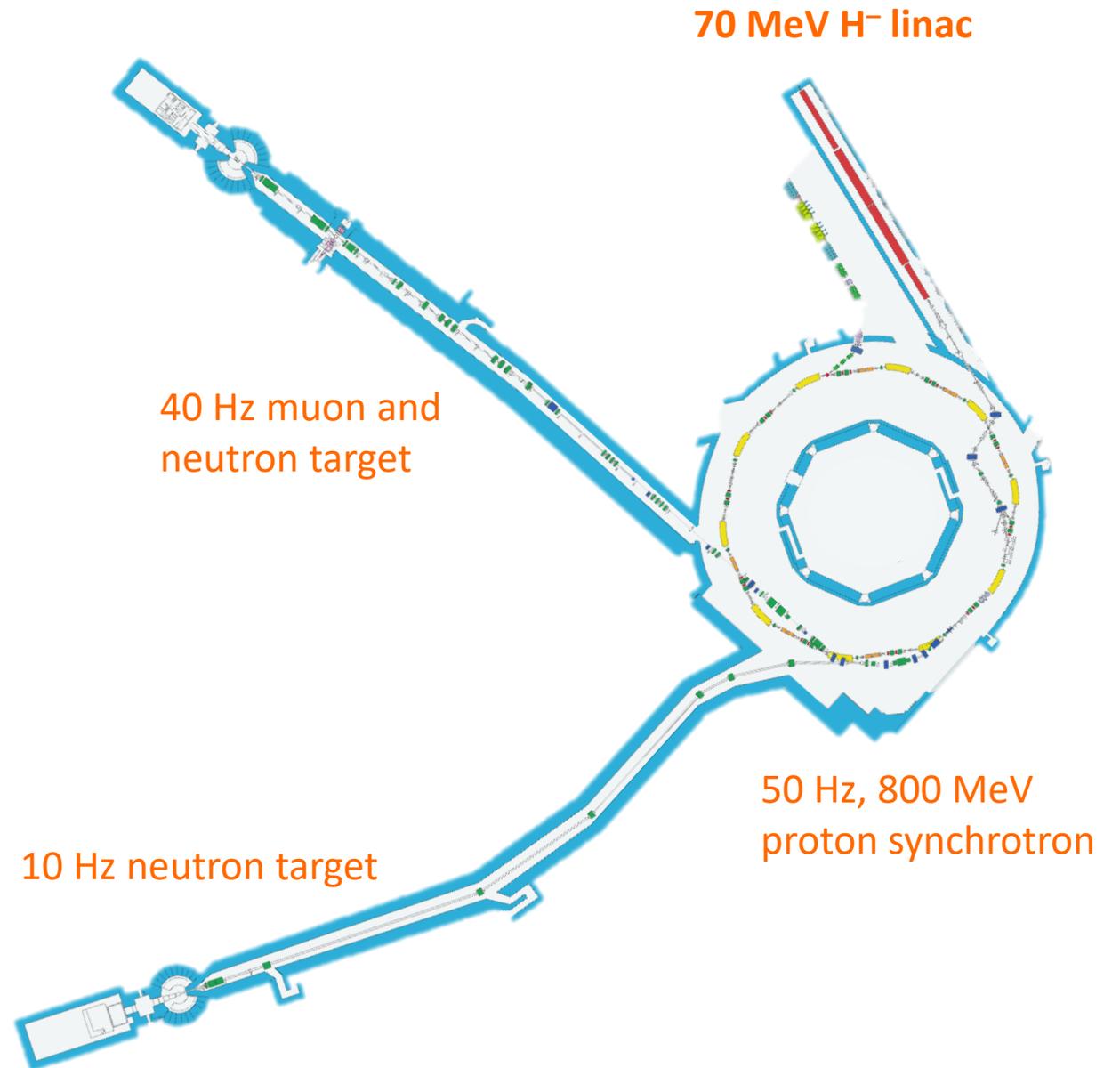
Dr. Scott Lawrie

Ion source section leader

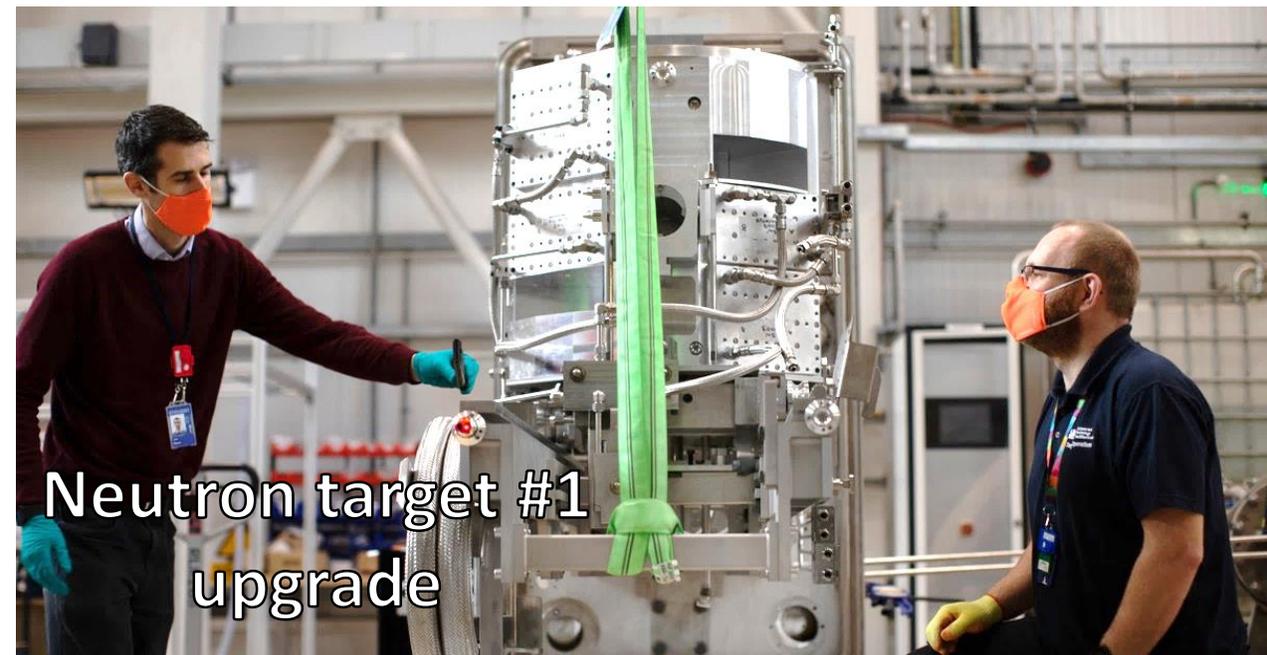
ISIS pulsed spallation neutron & muon facility
Rutherford Appleton Laboratory, UK

Contents

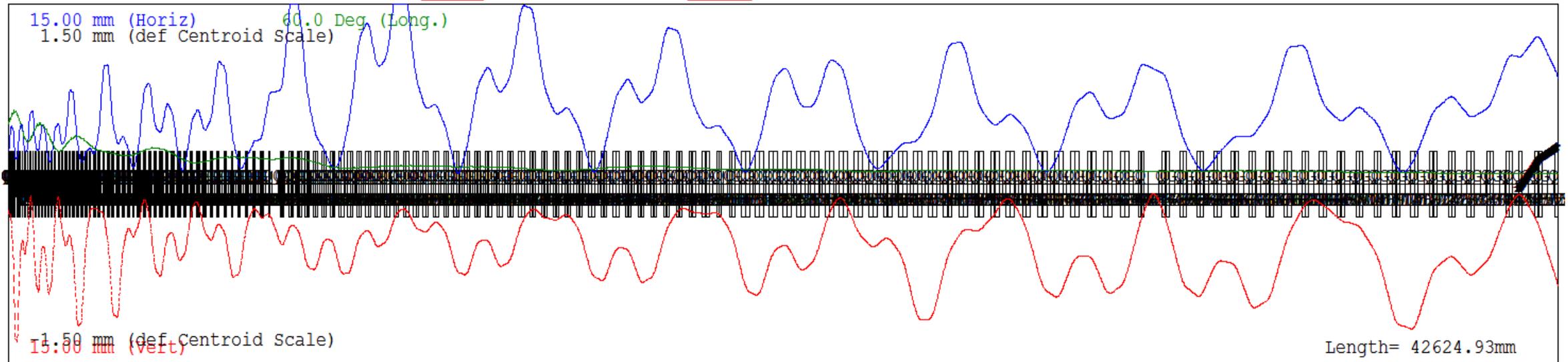
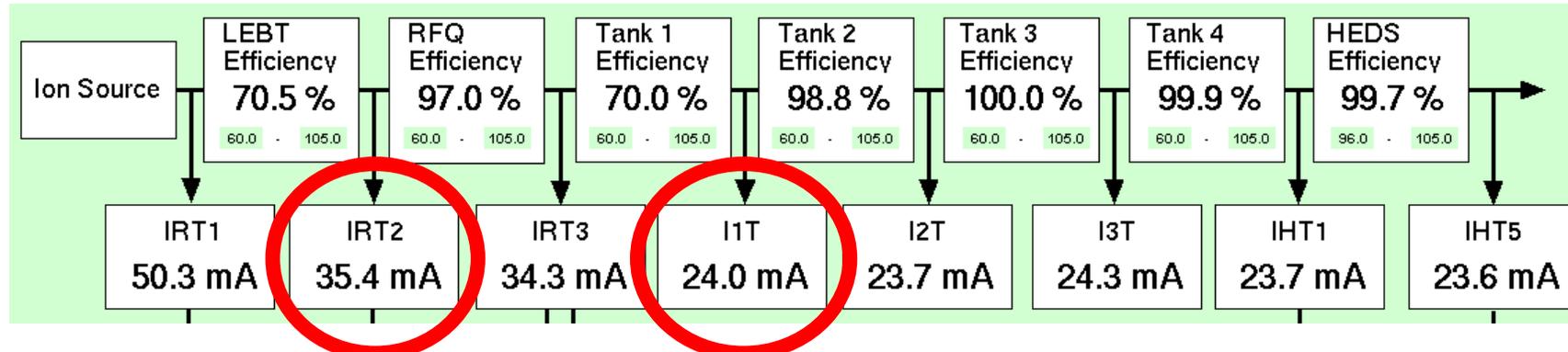
- Recent Developments at ISIS
- New pre-injector, including a MEBT
- New volume-type H^- ion source
- First extracted beam
- RF pickup mitigation
- Electron suppression



Recent Long Shutdown

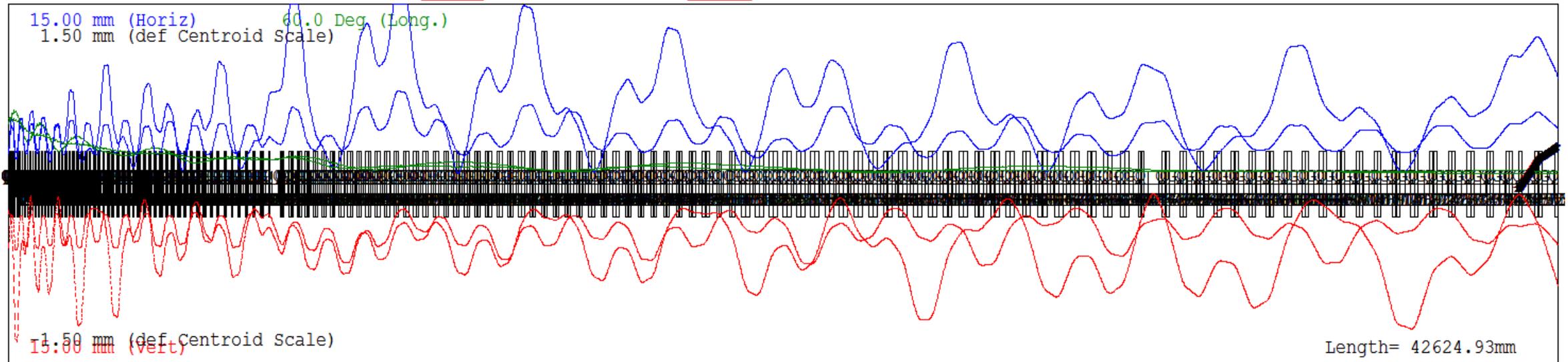
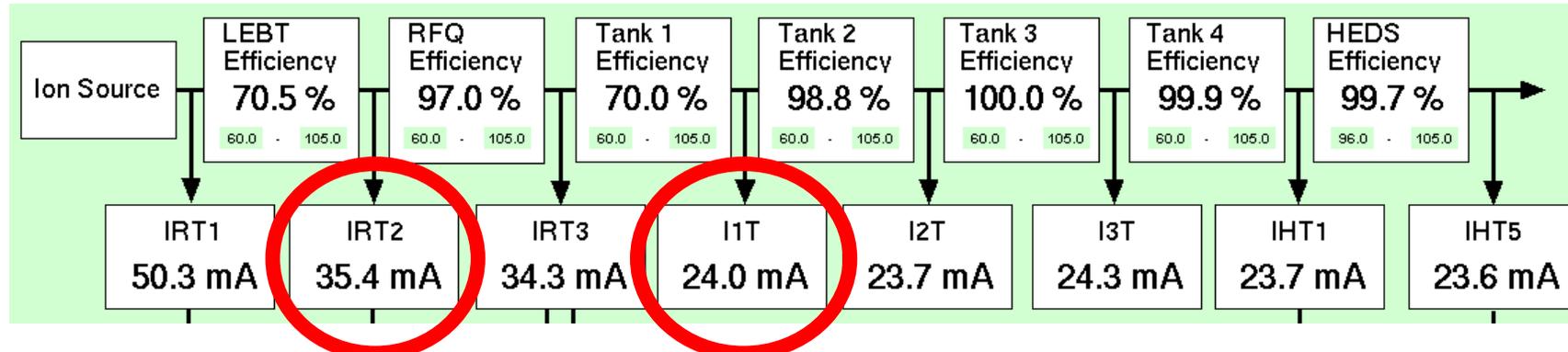


Next Shutdown – Pre-injector Upgrade



- Existing linac has 50% beam loss due to mismatch from RFQ
- Add MEBT between RFQ and Tank1 to improve transmission

Next Shutdown – Pre-injector Upgrade



- Existing linac has 50% beam loss due to mismatch from RFQ
- Add MEBT between RFQ and Tank1 to improve transmission

Pre-injector Test Stand



- Ion source, LEPT, RFQ & MEPT in shielded test stand, offline from ISIS
- Test each component in sequence, aiming for full transport by Summer 2023
- Soak-test for one year to prove reliability, then transfer to ISIS linac in 2025

MEBT Components

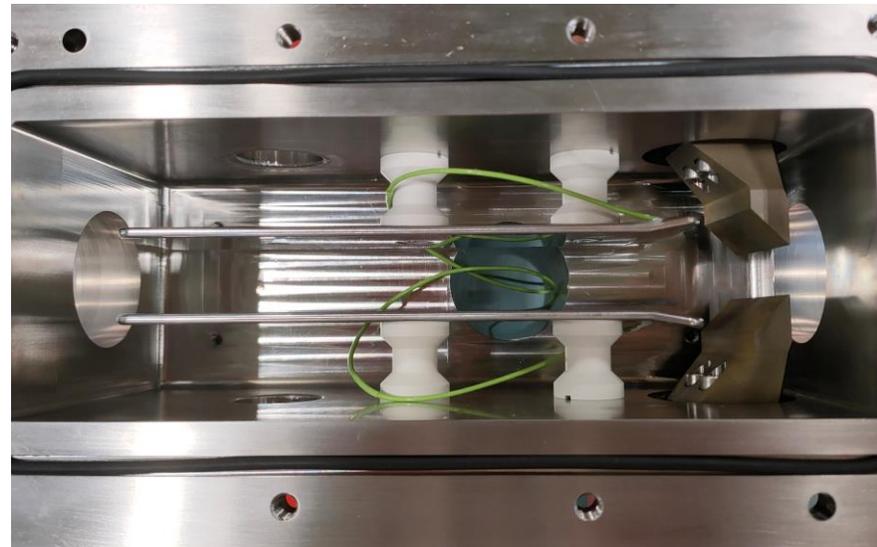
4 x Re-bunching Cavities



8 x Quadrupole Magnets & Steerers



Chopper and 2 x Dumps

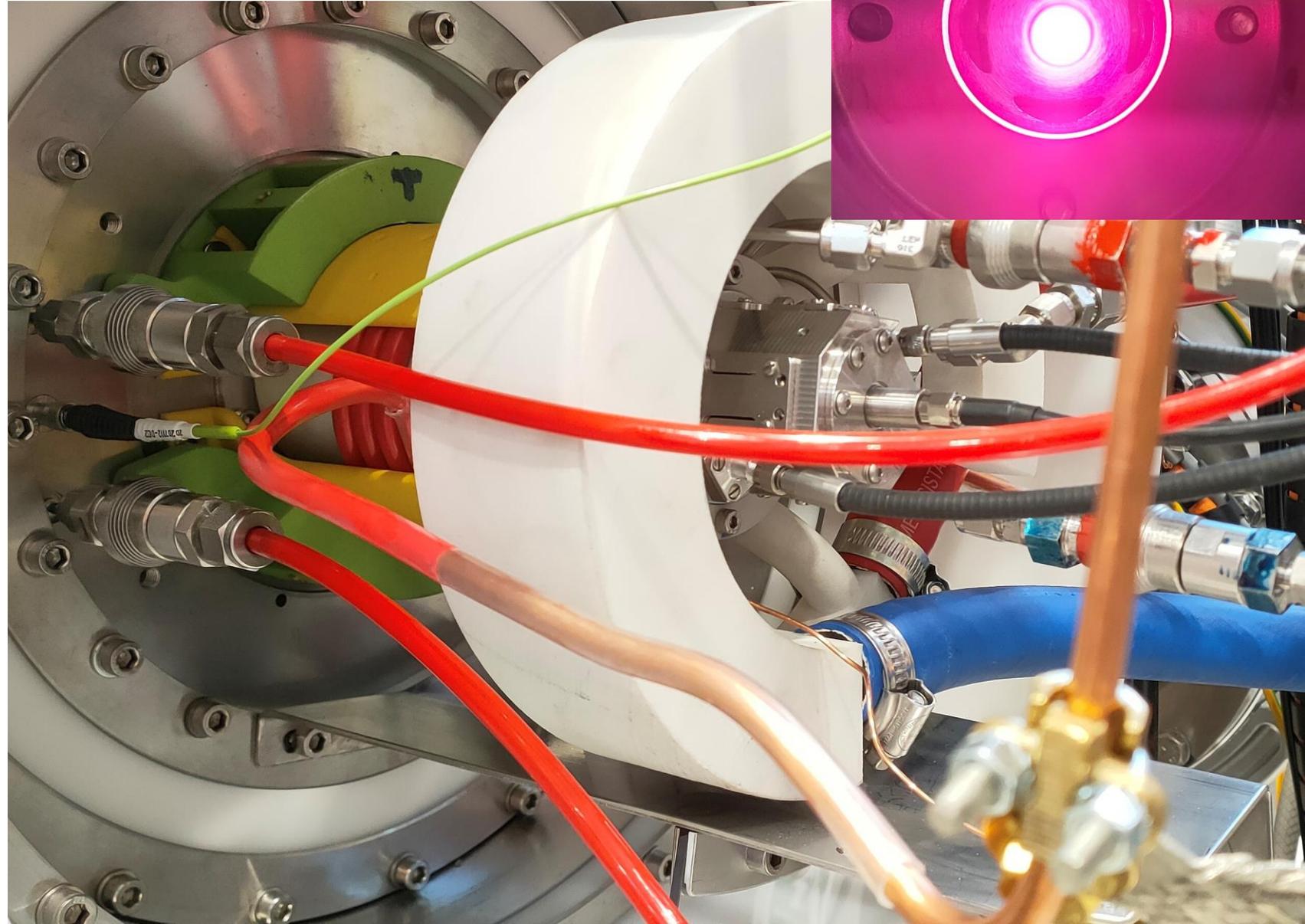


4 x Beam Position Monitors



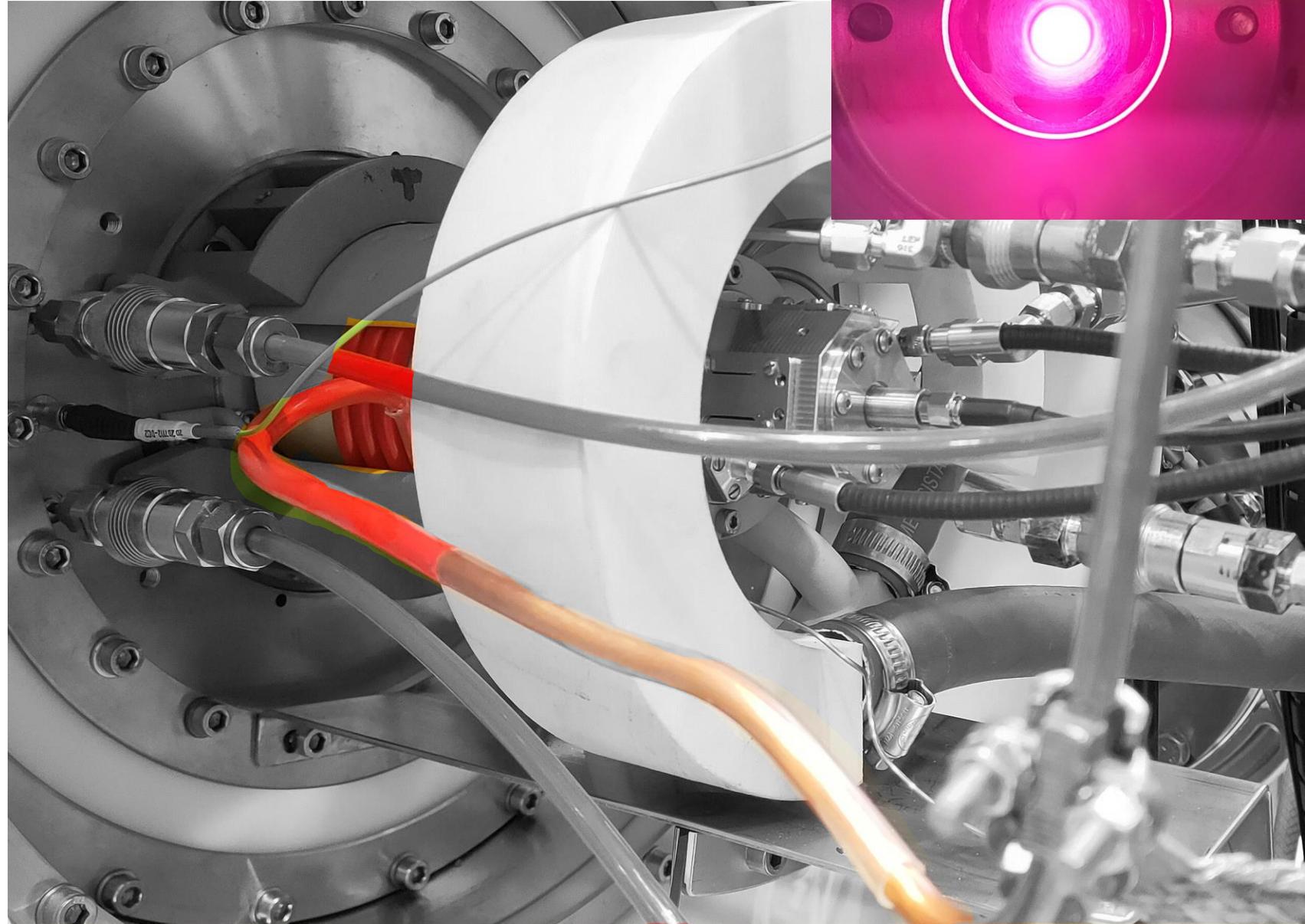
RF Volume H⁻ Source

- 2-4 MHz, 100 kW RF
- 50 Hz, 1 ms pulses
- 5% duty factor
- ECR electron ignitor
- Adjustable filter field
- Many 3D-printed parts
- 35 mA H⁻ beam
- $\epsilon_{4.RMS} < 1.2 \pi$ mm mrad
- No caesium
- Easy operation
- Should last forever!

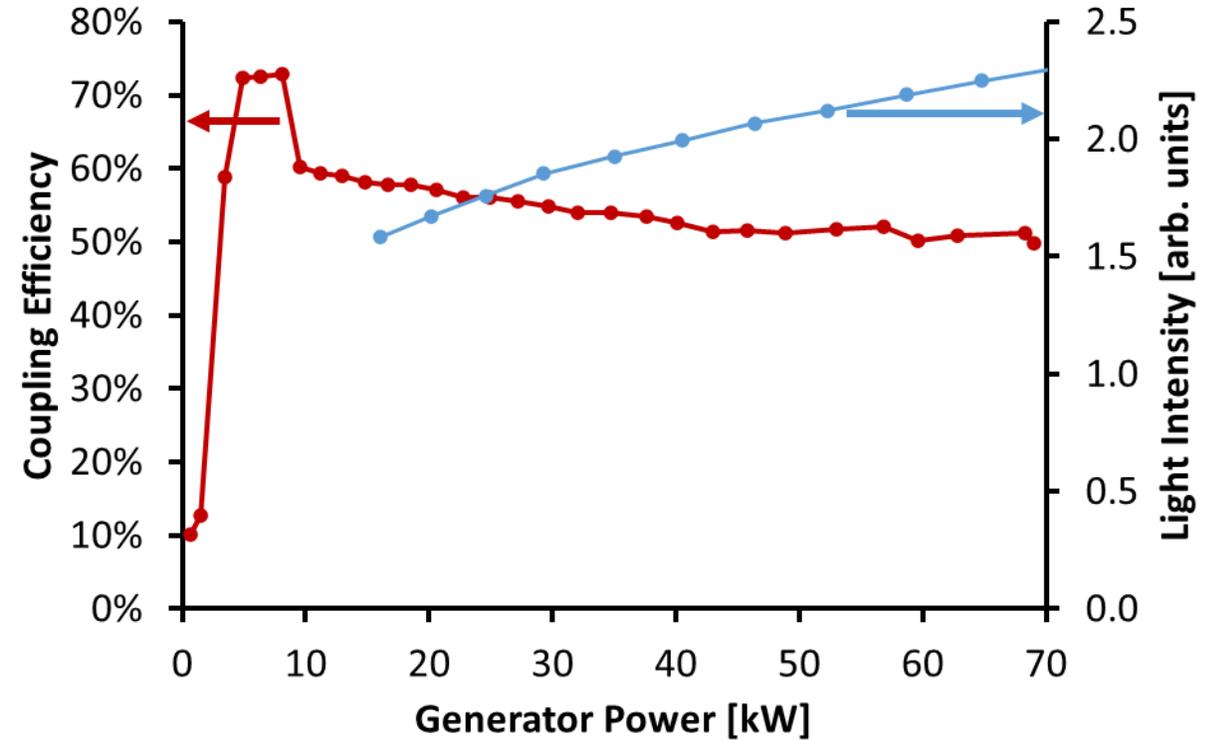
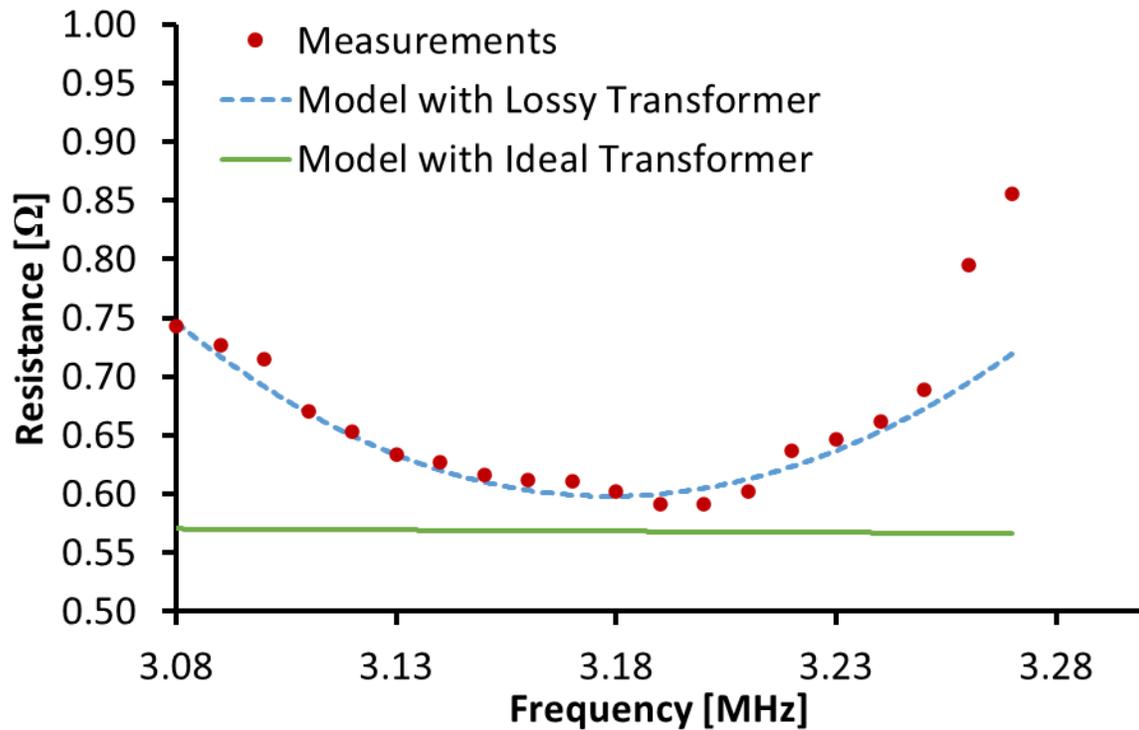


RF Volume H⁻ Source

- 2-4 MHz, 100 kW RF
- 50 Hz, 1 ms pulses
- 5% duty factor
- ECR electron ignitor
- Adjustable filter field
- Many 3D-printed parts
- 35 mA H⁻ beam
- $\epsilon_{4,\text{RMS}} < 1.2 \pi \text{ mm mrad}$
- No caesium
- Easy operation
- Should last forever!



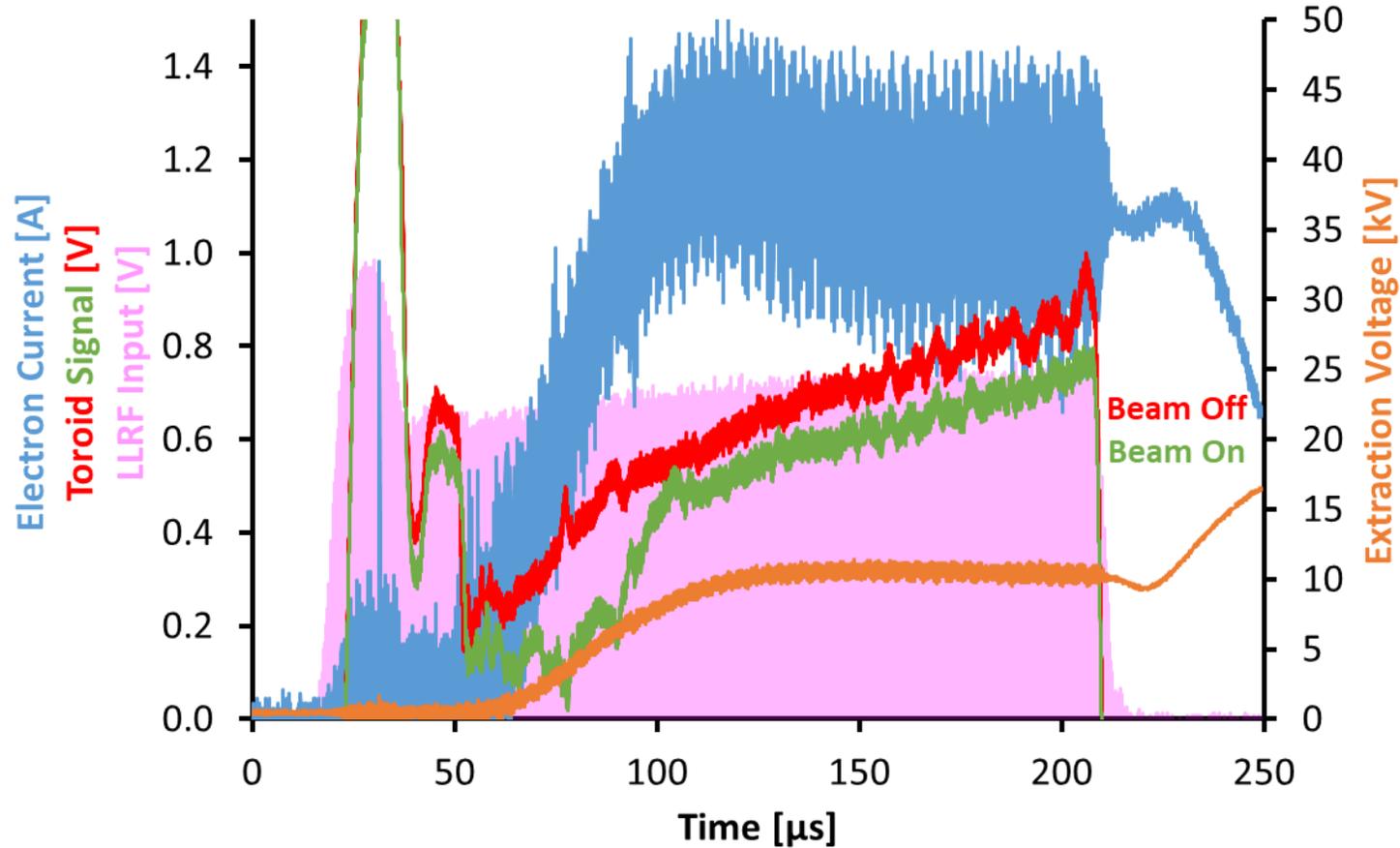
RF Coupling Measurements



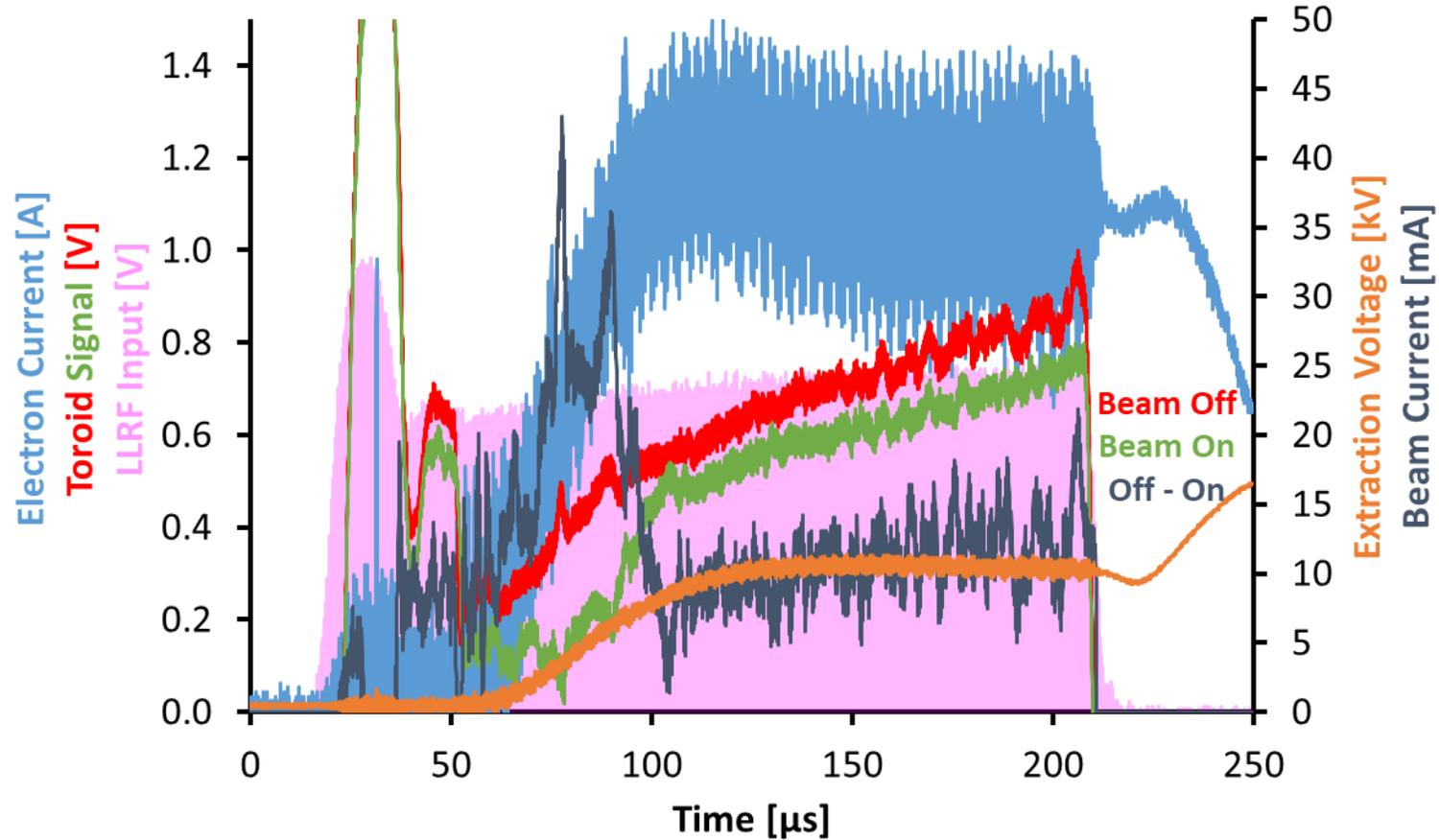
- How much delivered power actually couples into plasma?
- Power efficiency improves for smaller RF-coils
- Efficiency largely independent of power; total light increases
- Collaboration with IPP Garching and SNS – publishing soon



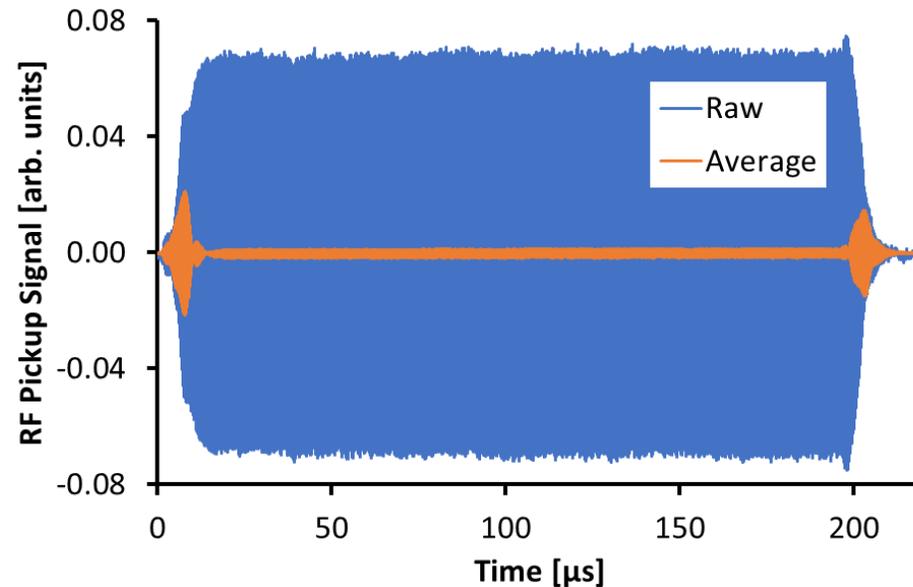
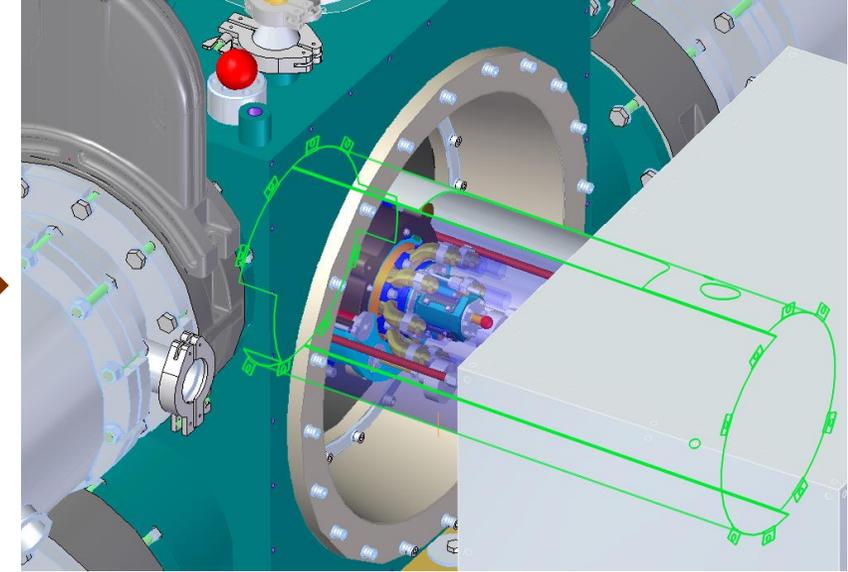
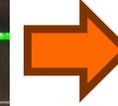
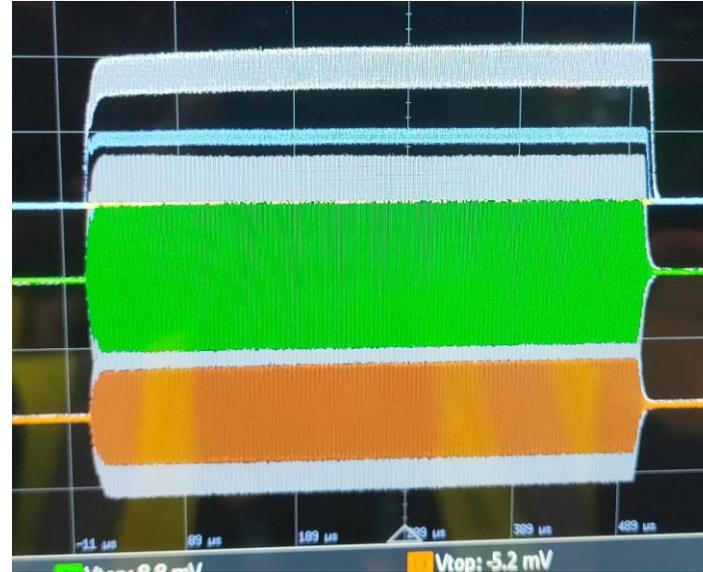
First Extracted Beam



First Extracted Beam

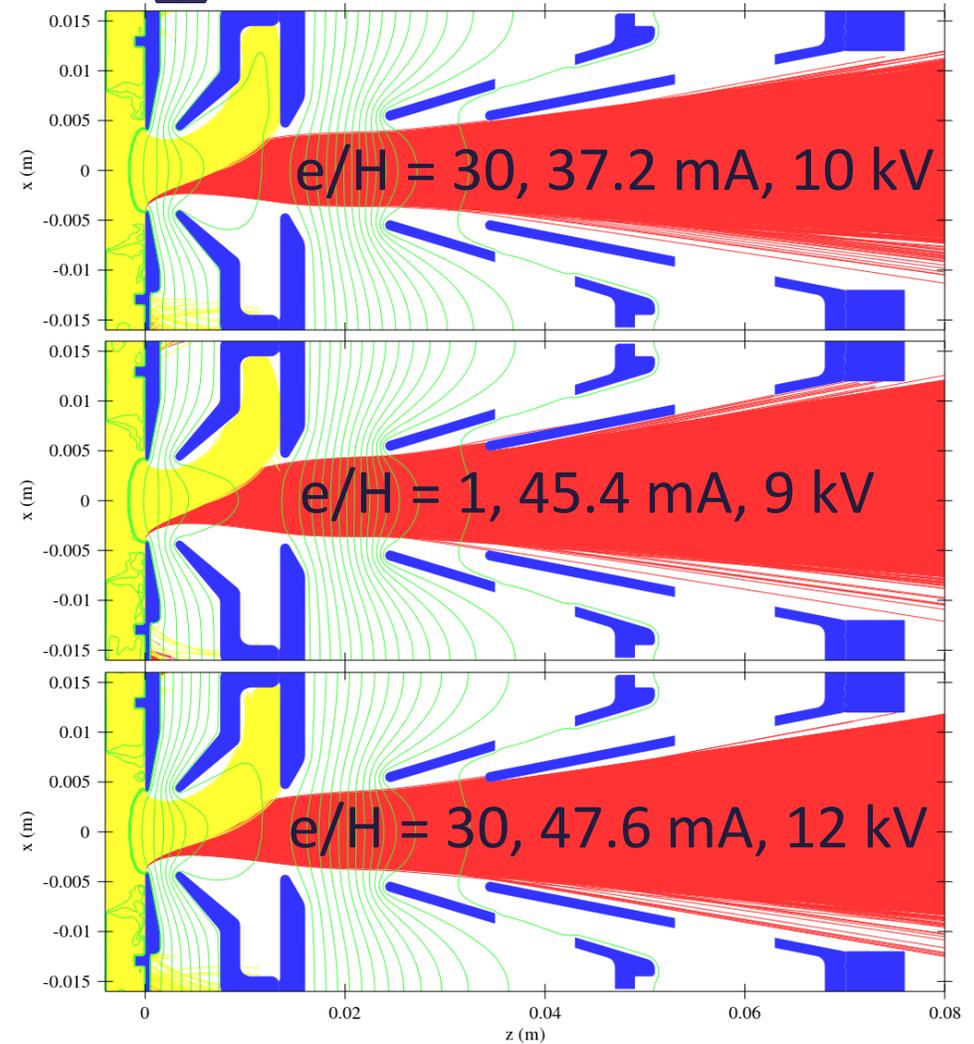
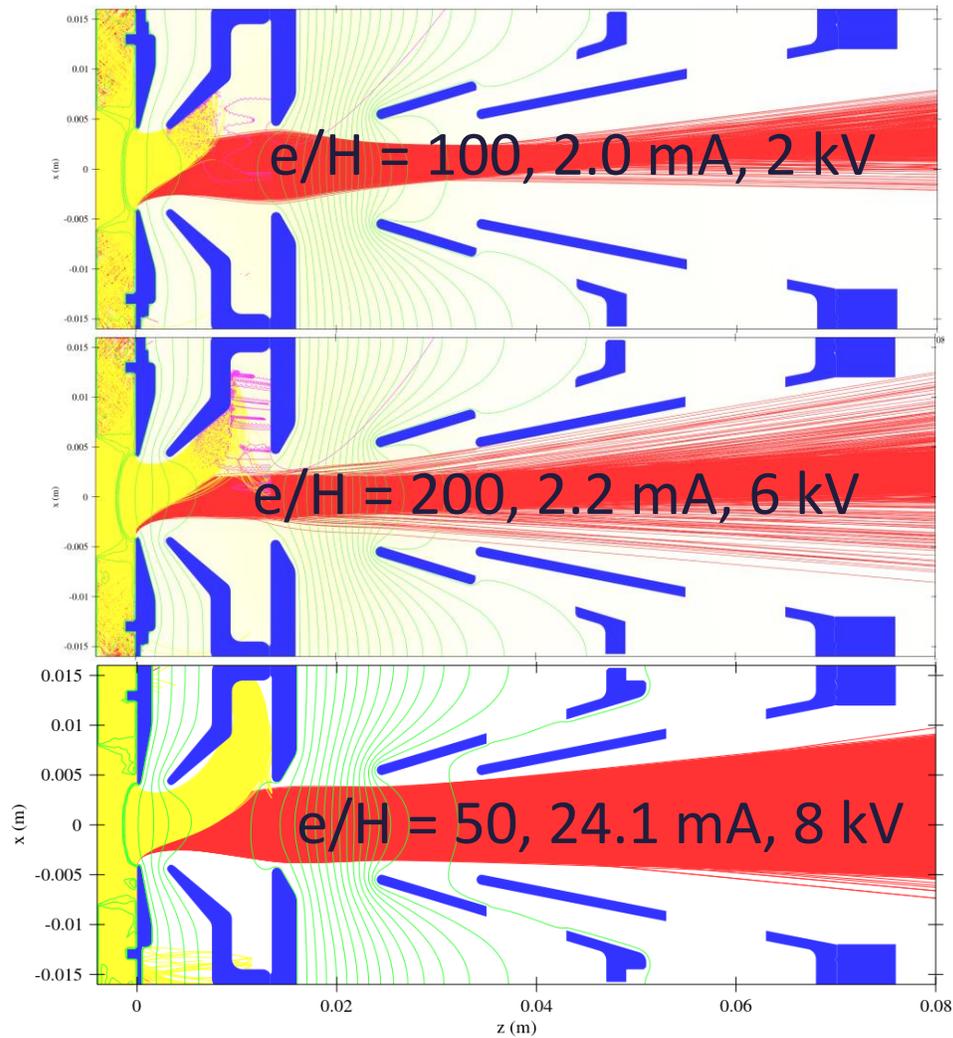


RF Pickup Mitigation



- RF shield around source
- Phase shift allows averaging
- Move cables from power coax
- Add more ferrites and filtering
- Dedicated RF earth
- Move RF amplifier

Flexible Extraction Design



Beam Extraction Investigations

- Pulsed extract PSU can cope with 0.7A
- Voltage gain is tuned with no plasma
- When RF plasma is ignited...

Co-extracted electron current > 1 A



Extraction voltage pulled down

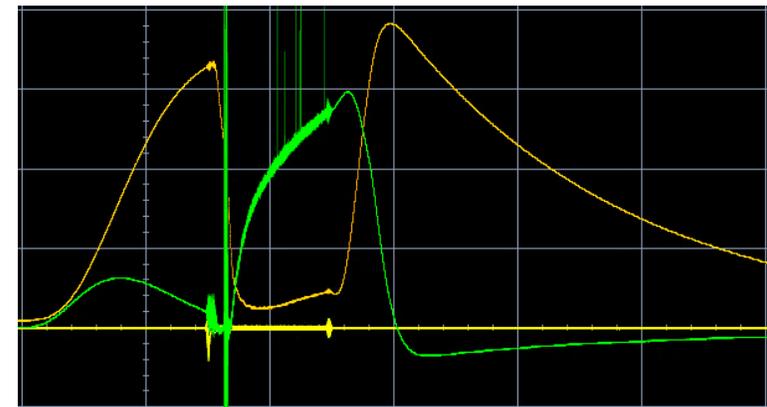
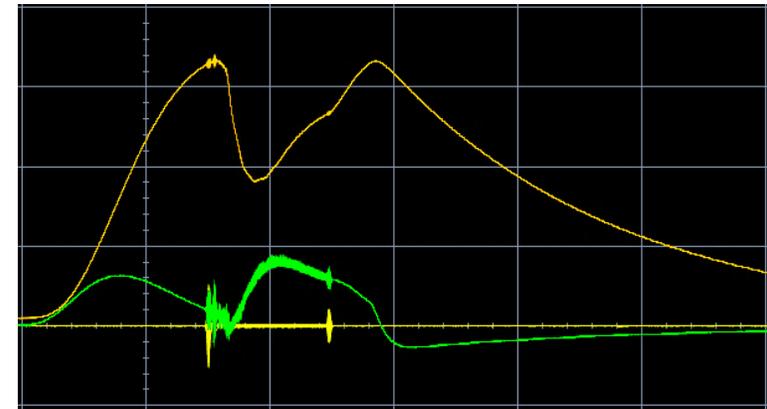
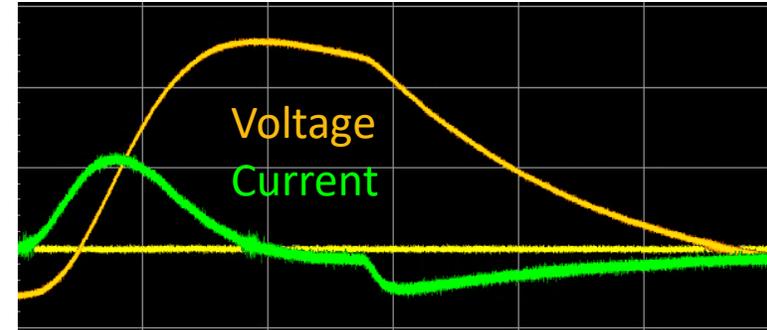


Significant sparking

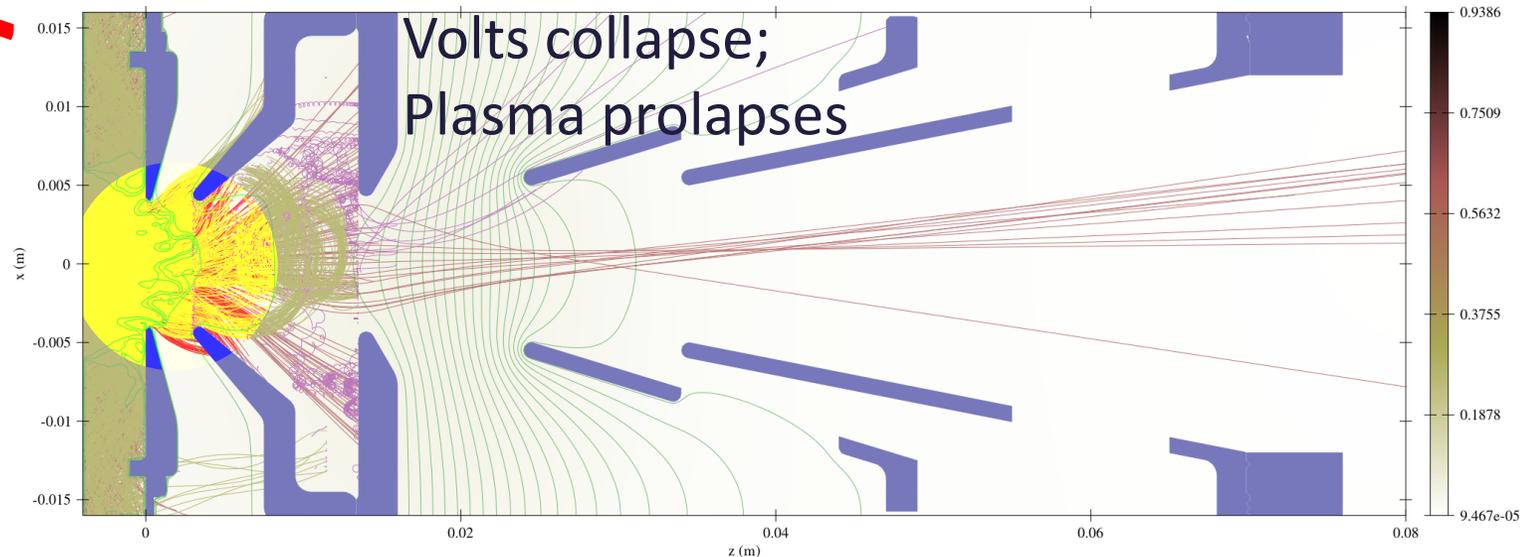
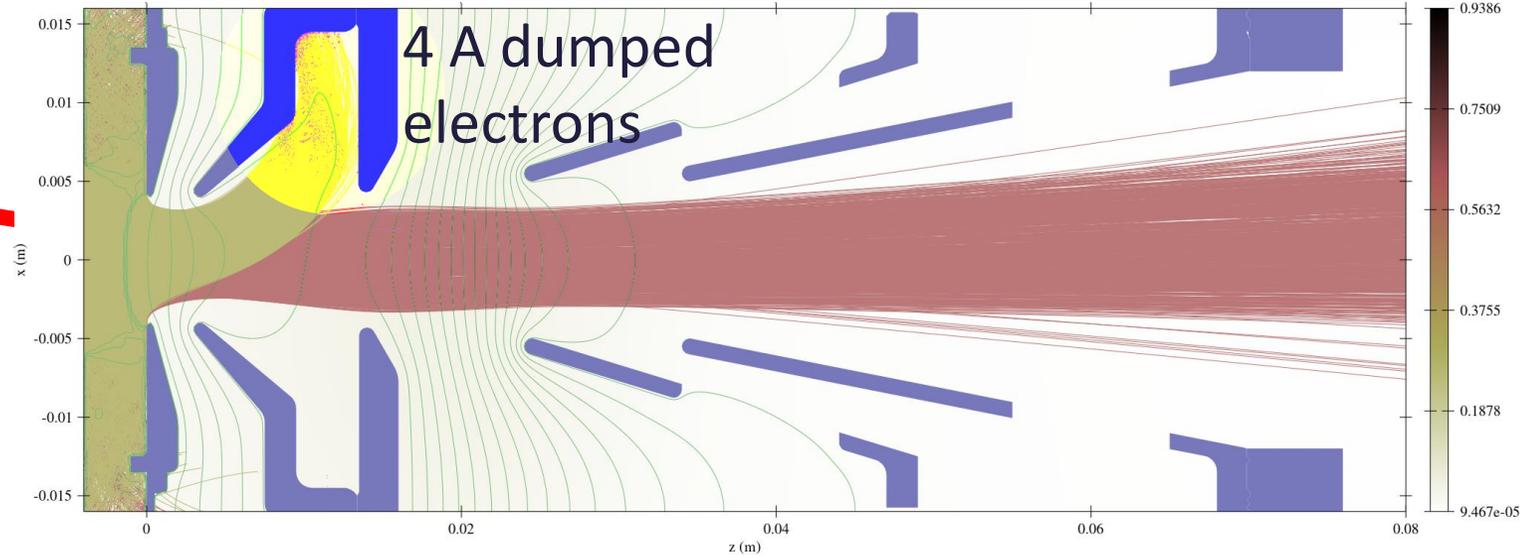
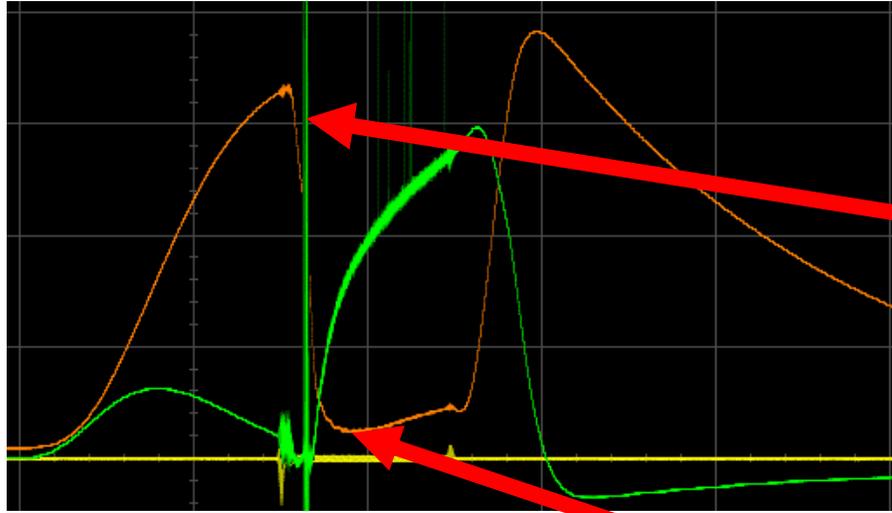


No beam measurable

- Will try DC extraction

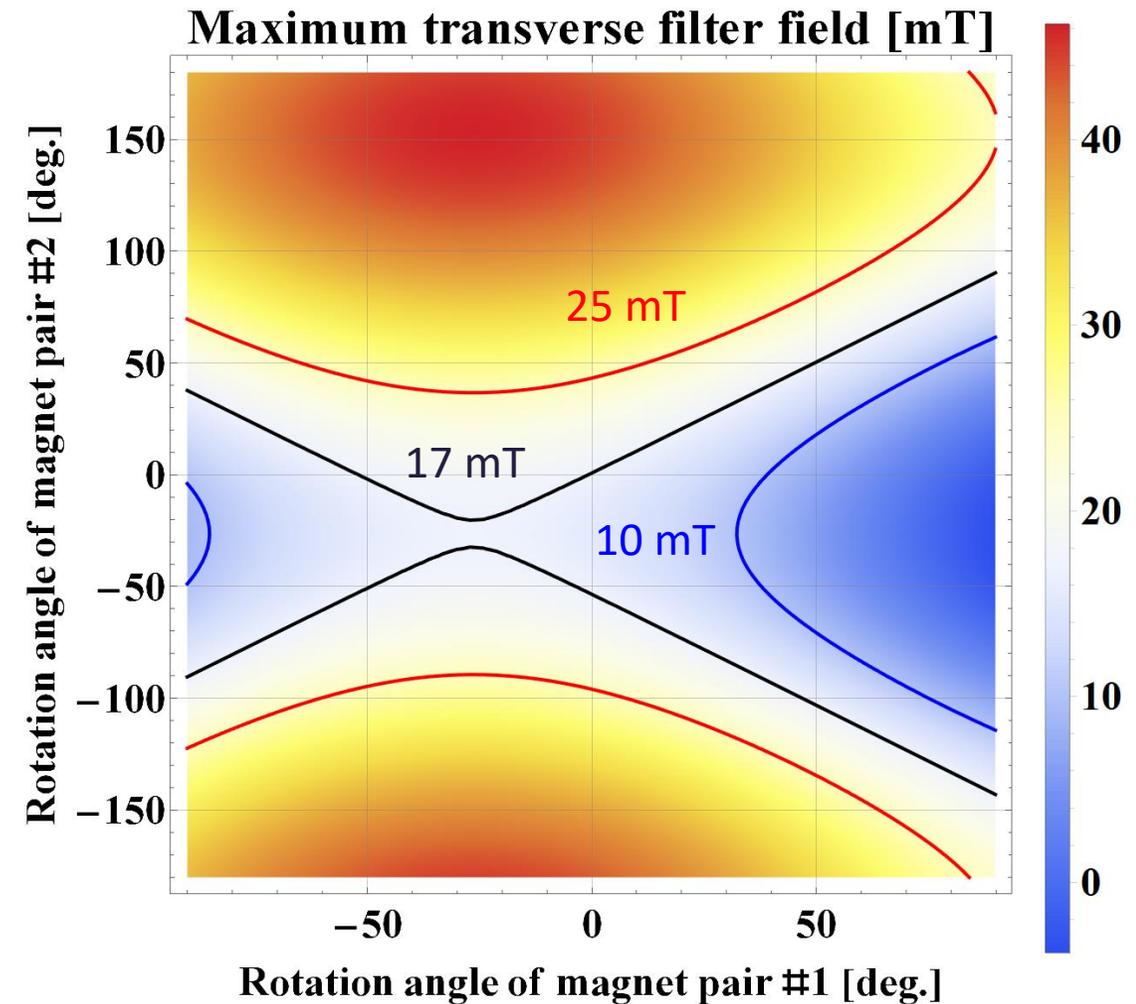
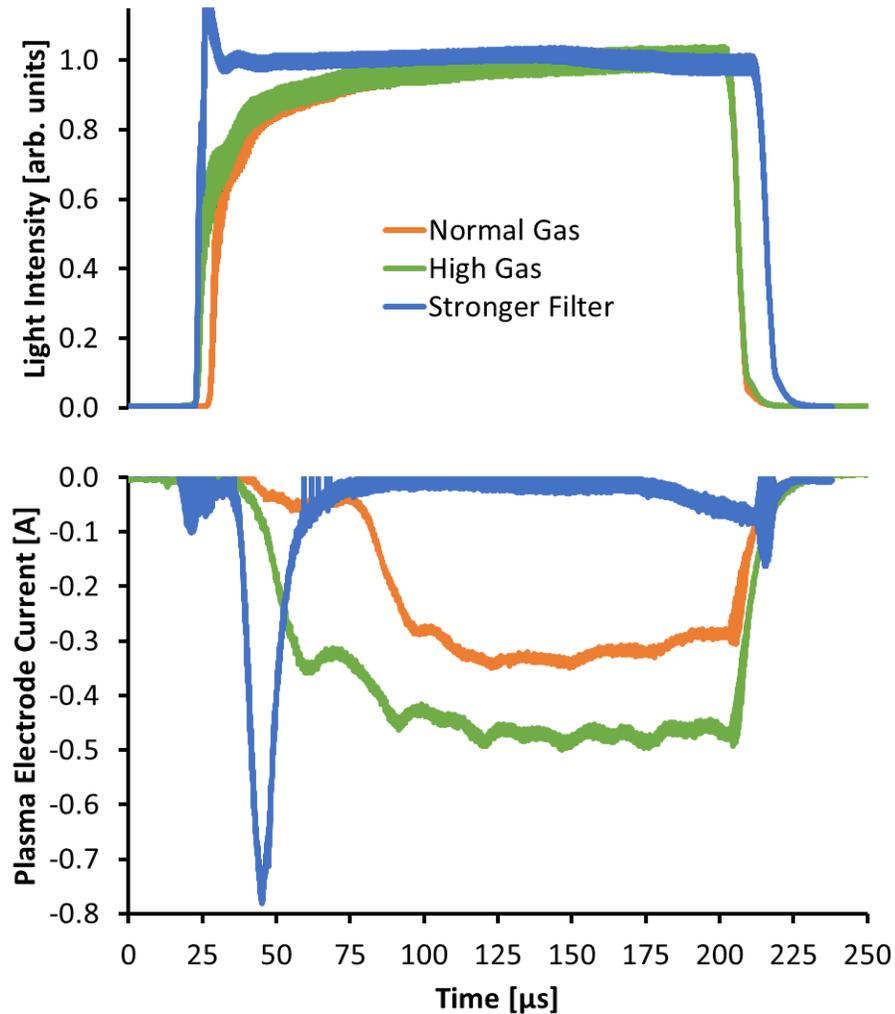


Off-nominal Extraction Settings



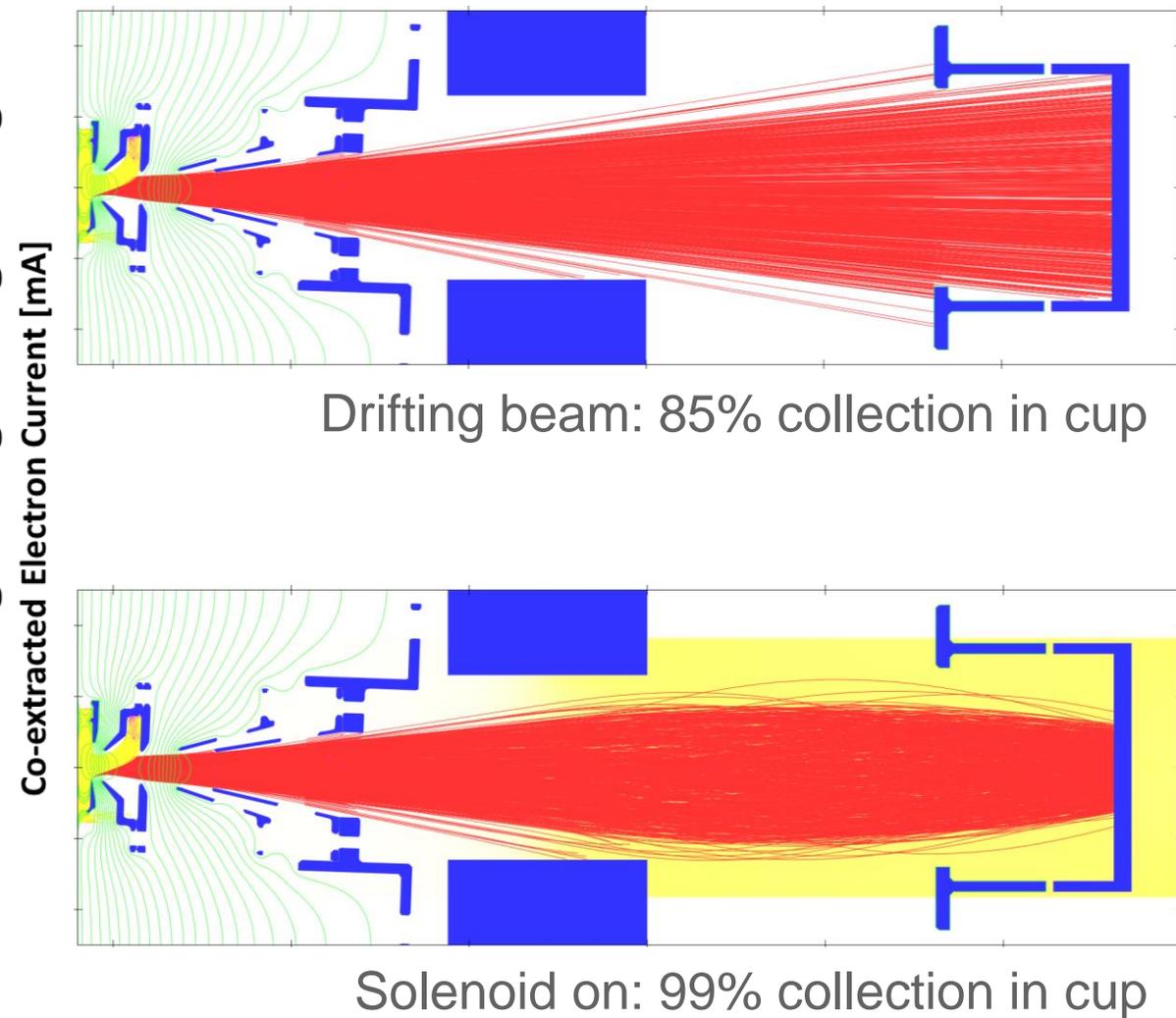
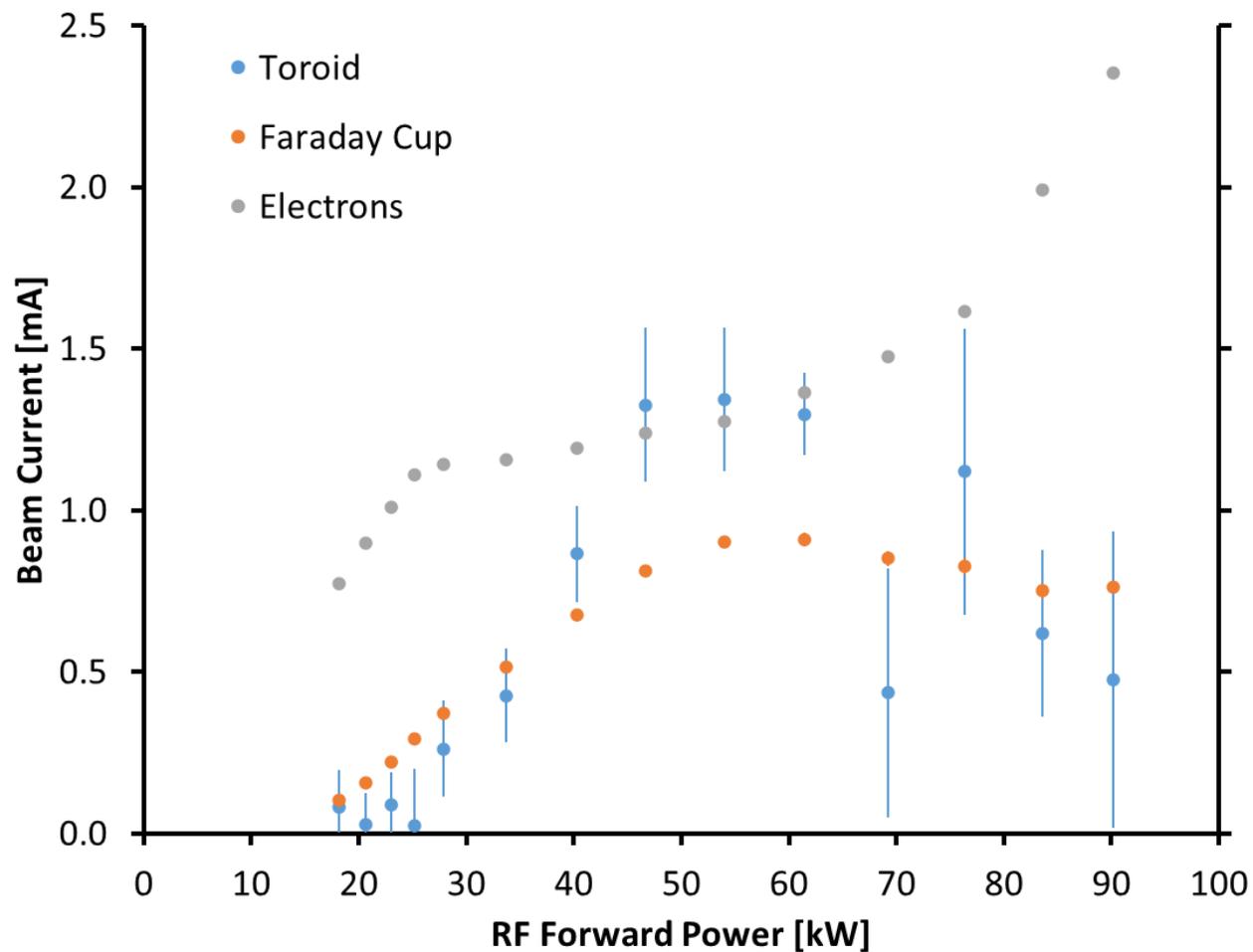
- High current pulls volts down
- Plasma meniscus prolapses
- Plasma shorts to extractor!

Electron Suppression

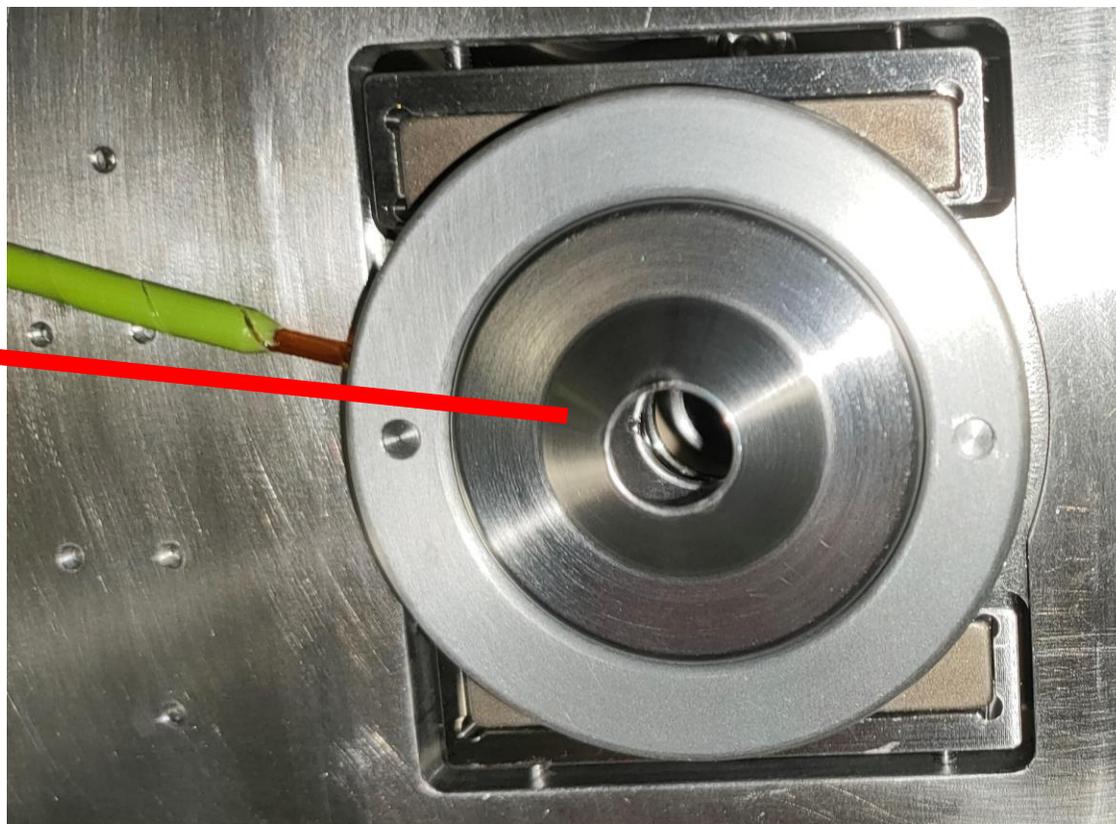


- Find optimum filter field and gas pressure
- Will also try smaller emission apertures (3, 5 & 7 mm, compared to 8 mm diameter now)

RF Power Ramp

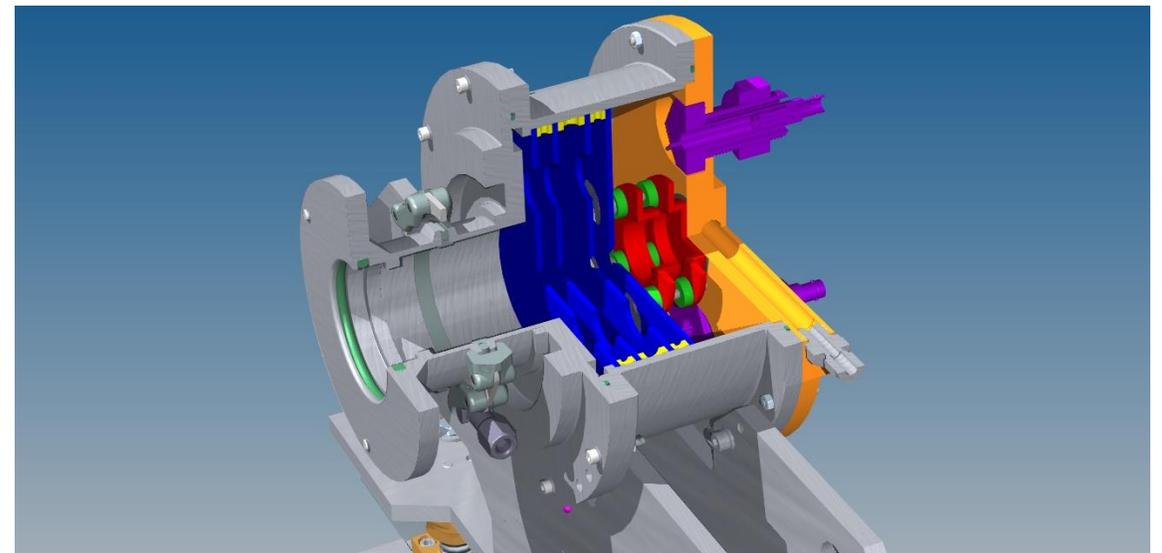
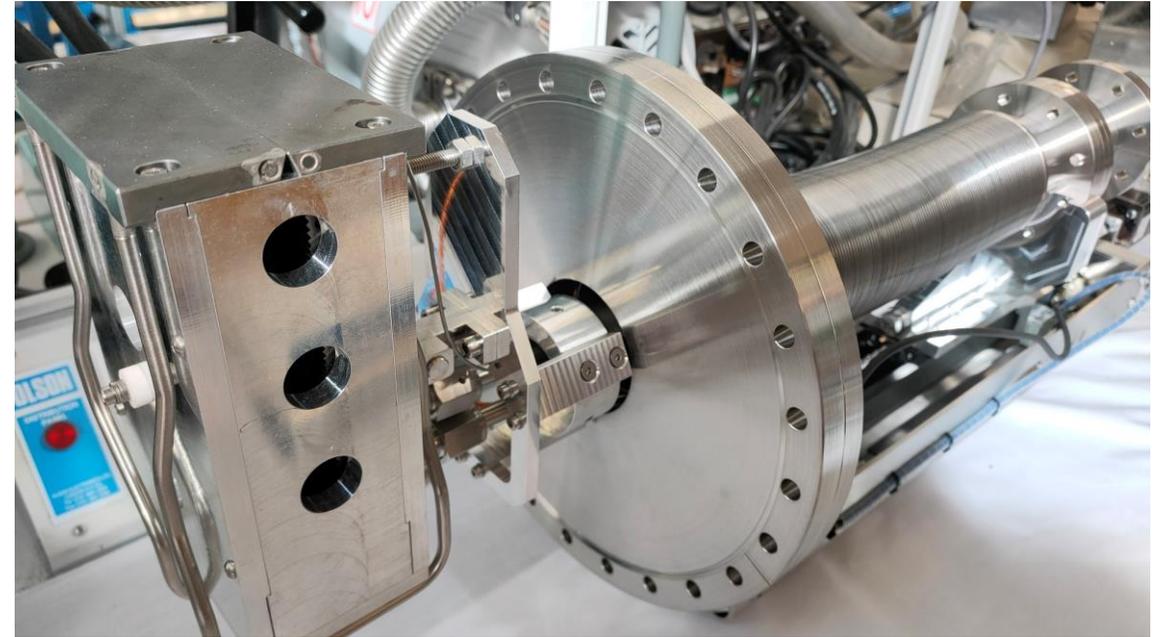


Extraction Electrode Inspection



Conclusion and Next Steps

- Very simple and reliable RF plasma
- 50 Hz, 1 ms, 70 kW as standard
- Extracted beam behaves as expected
- RF pickup mitigation
- Optimise e/H ratio
- Emittance scans
- LEBT beam into RFQ mask
- MEBT beam Summer 2023
- Soak test then transfer to ISIS





Science and
Technology
Facilities Council

Thank you



Science and Technology Facilities Council



@STFC_matters



Science and Technology Facilities Council