

Operation of the discharge plasma source

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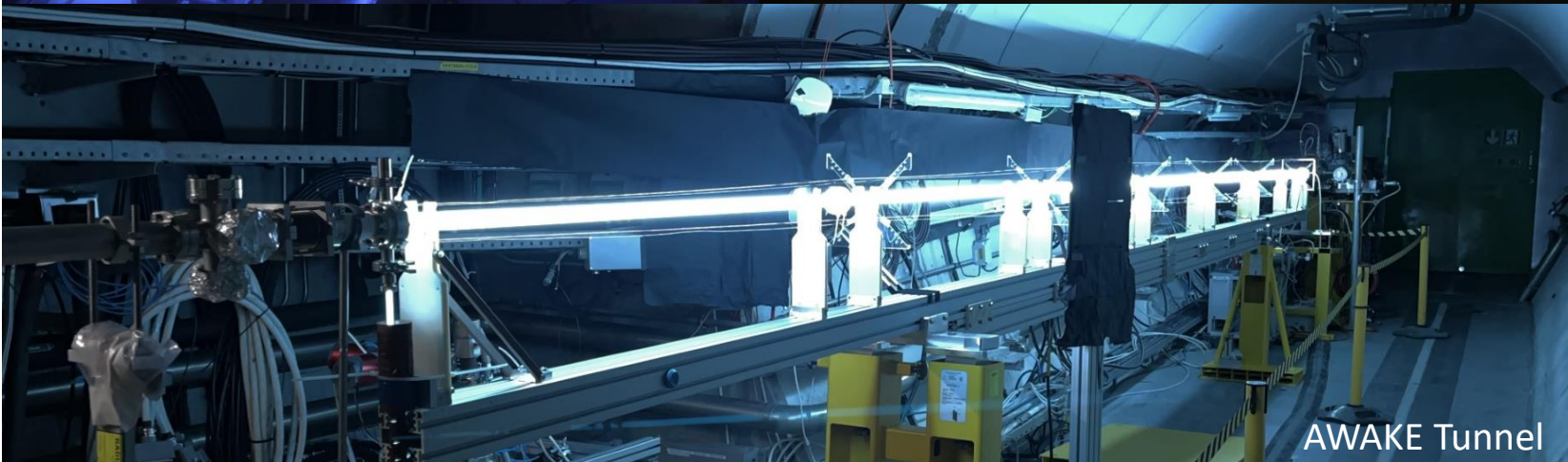
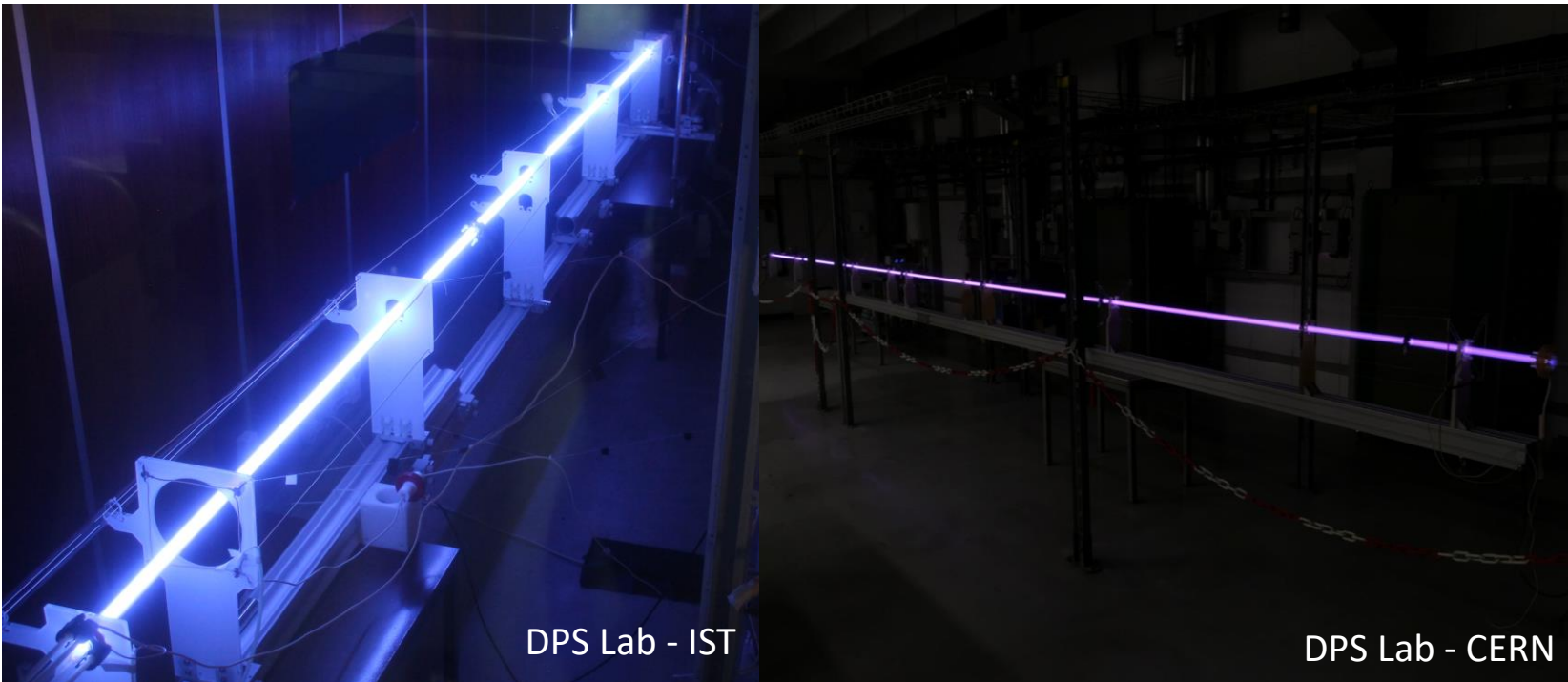
AWAKE

Nuno Torrado¹, N. Lopes¹, F. Silva², C. Amoedo³, A. Sublet³

1. GoLP/IPFN, IST, Lisbon, Portugal

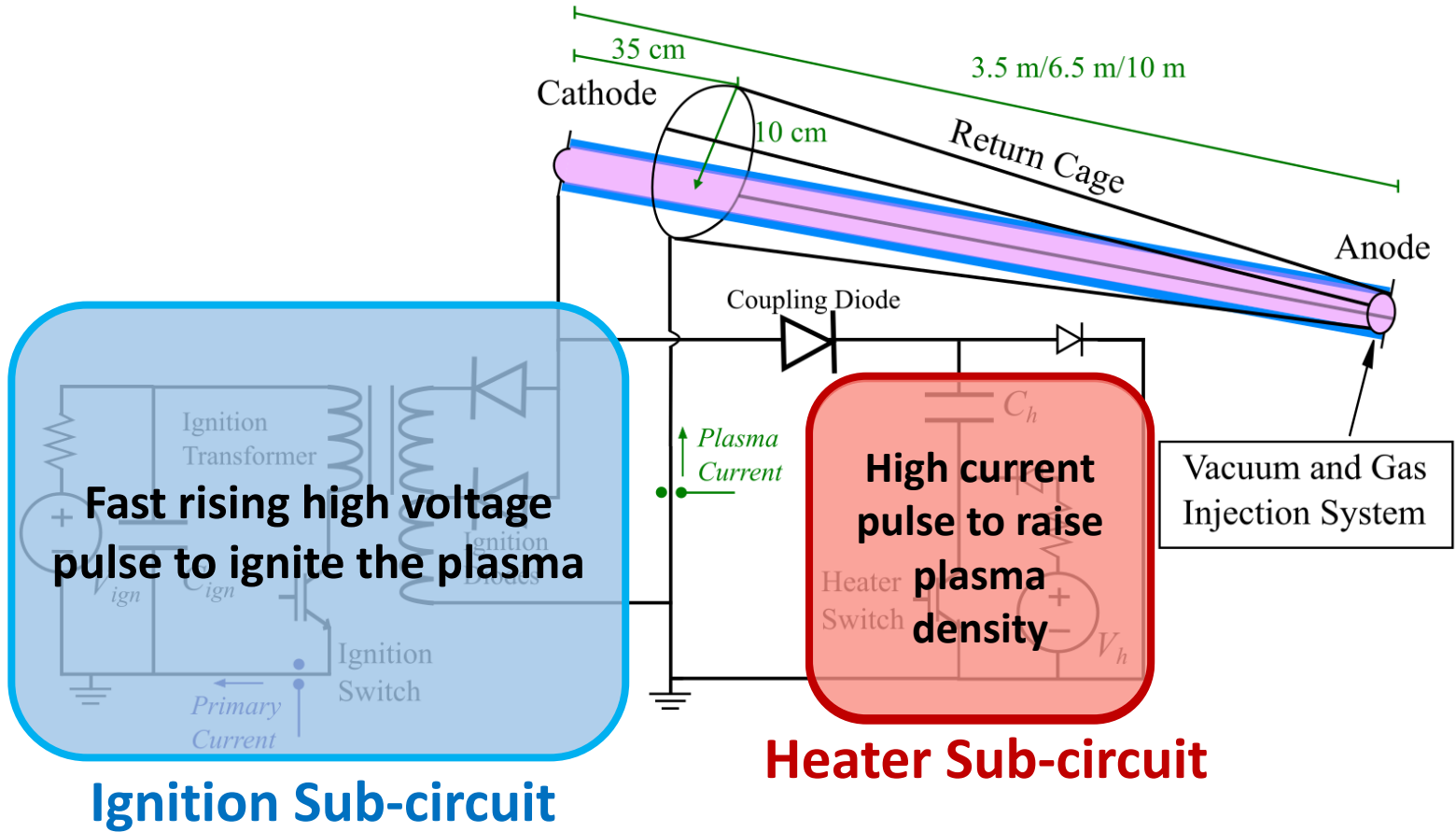
2. INESC-ID, IST, Lisbon, Portugal

3. CERN, Geneva, Switzerland

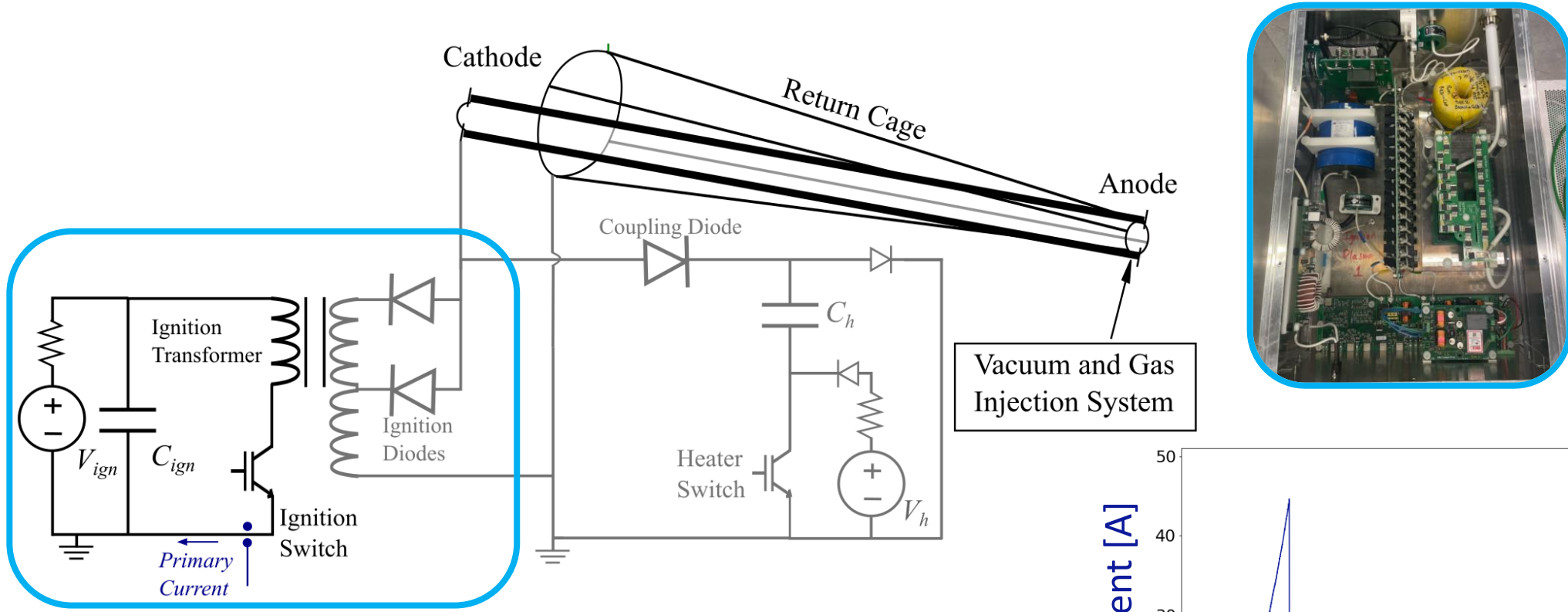


1. Double pulse generator operation
2. Plasma current reproducibility
3. Discharge plasma source operation range
4. Conclusions

2. Double pulse generator operation

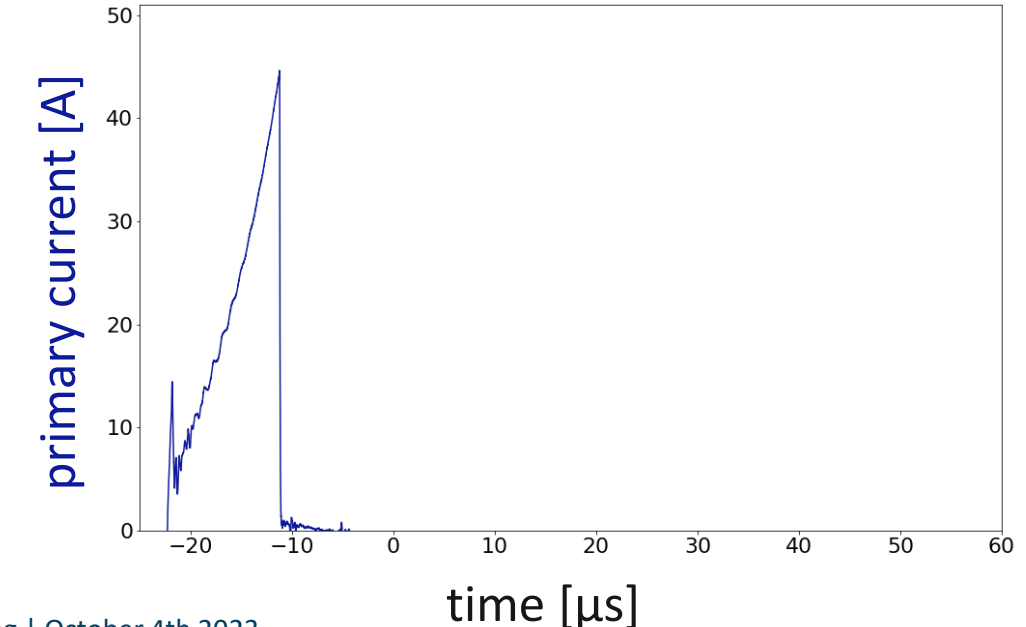


2. Double pulse generator operation – Ignition pulse

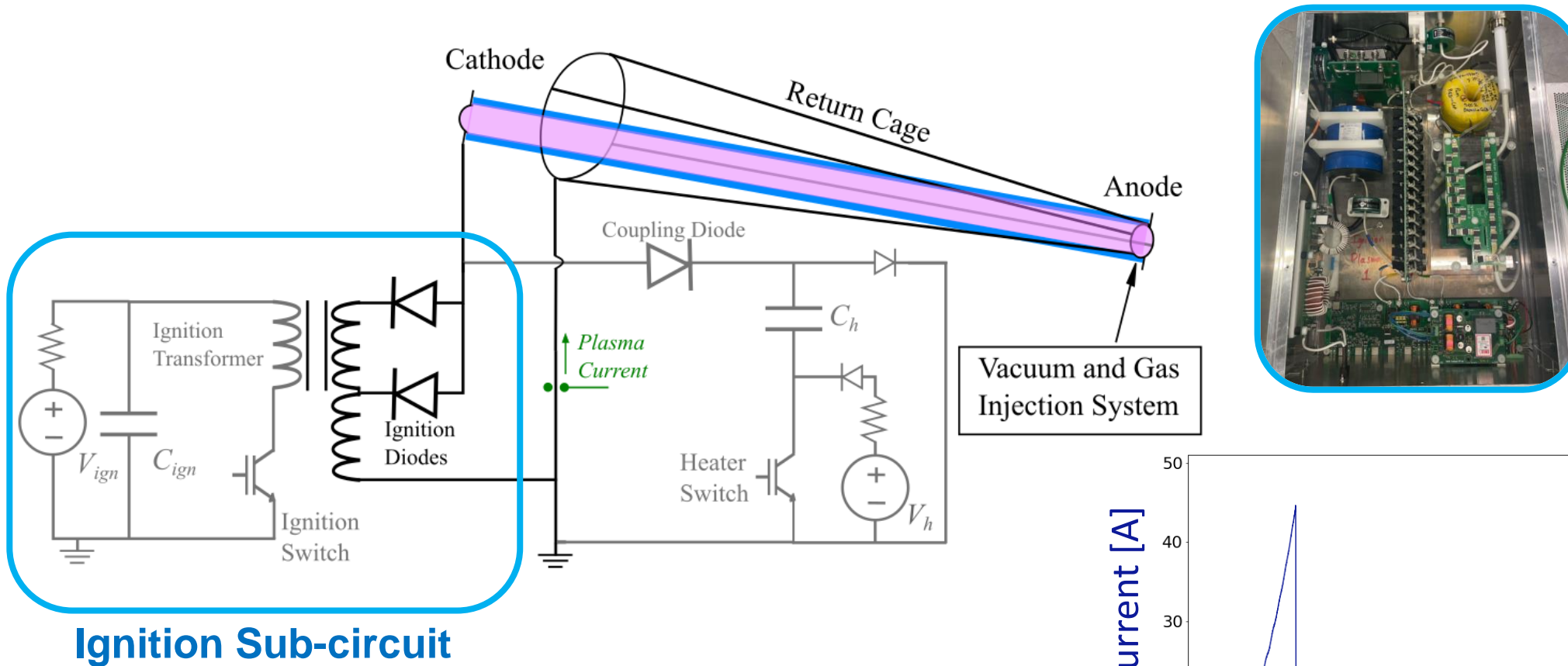


Ignition Sub-circuit

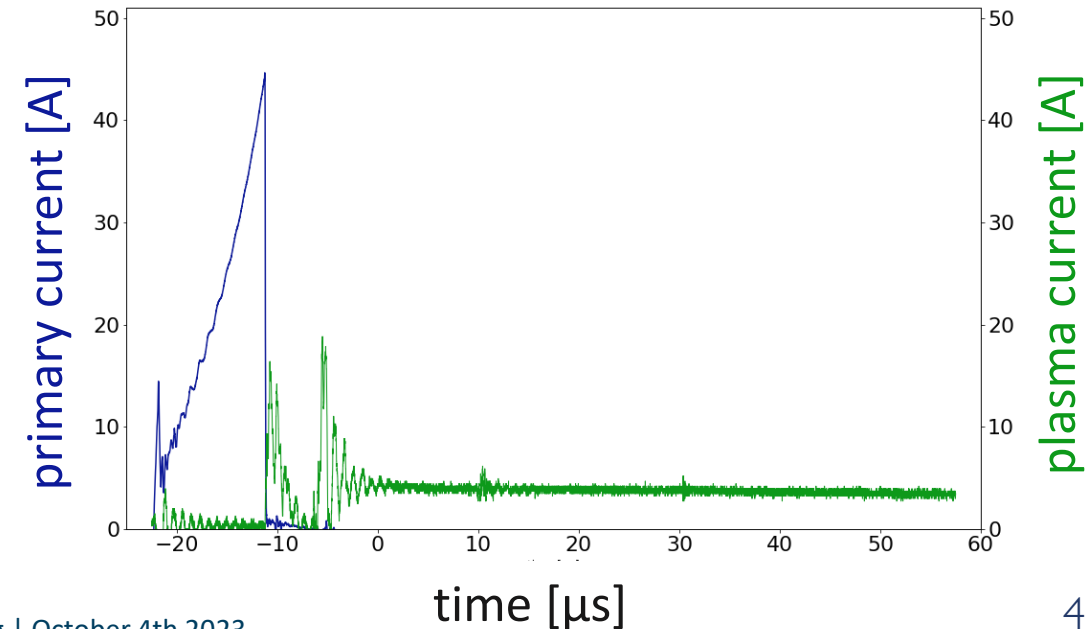
The ignition transformer's magnetizing inductance charges during switch ON (primary current)



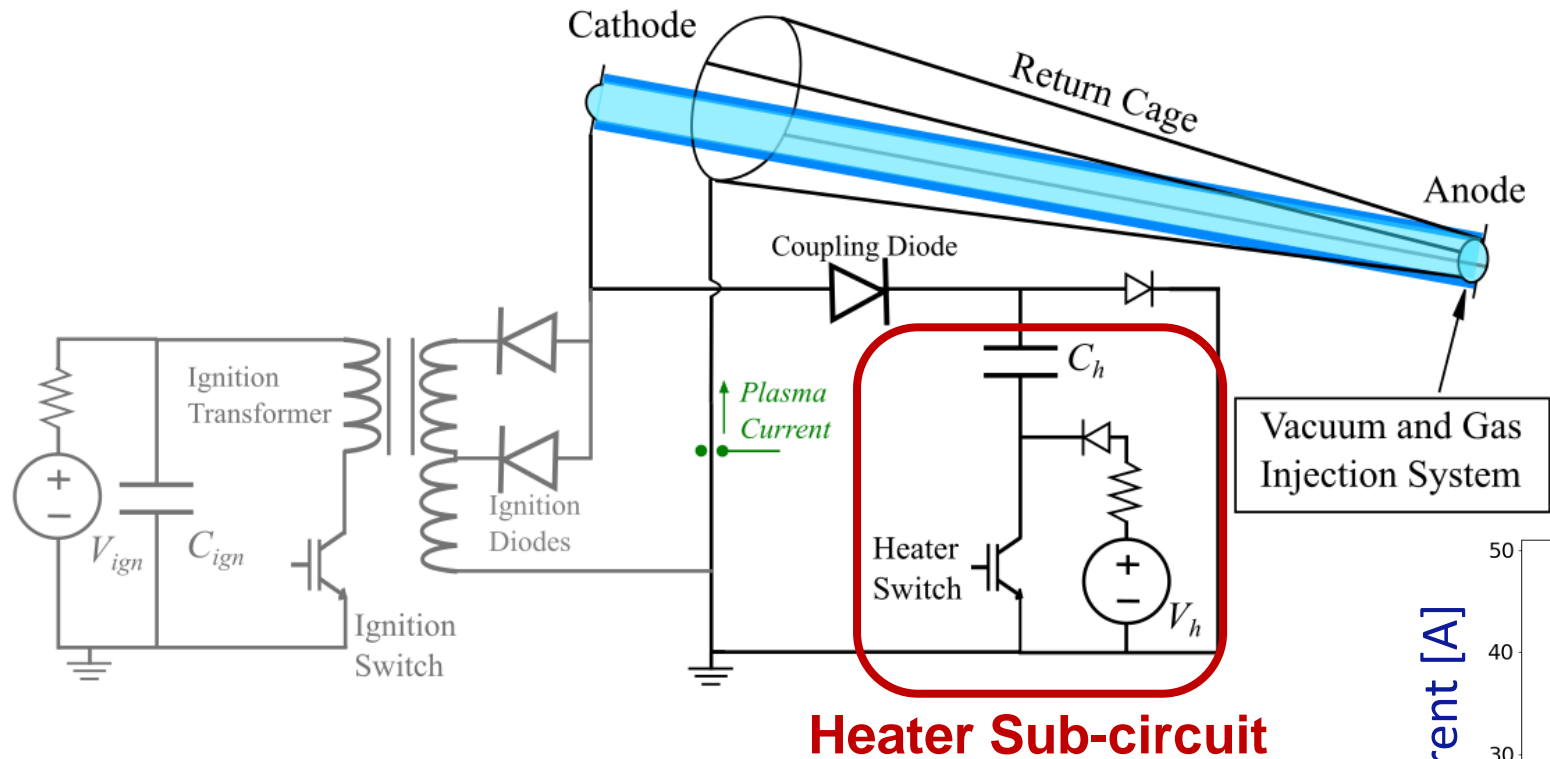
2. Double pulse generator operation – Ignition pulse



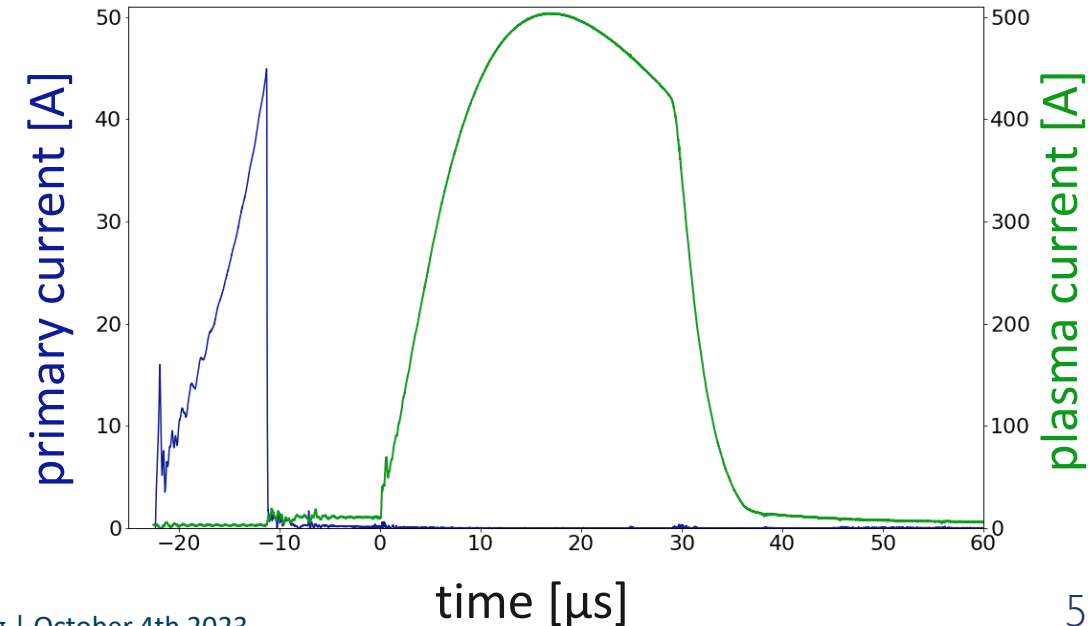
Turning OFF the switch generates a high-voltage pulse (40 kV) on the electrodes
The high-voltage ignition pulse establishes a **low-current (~10 A) arc**.



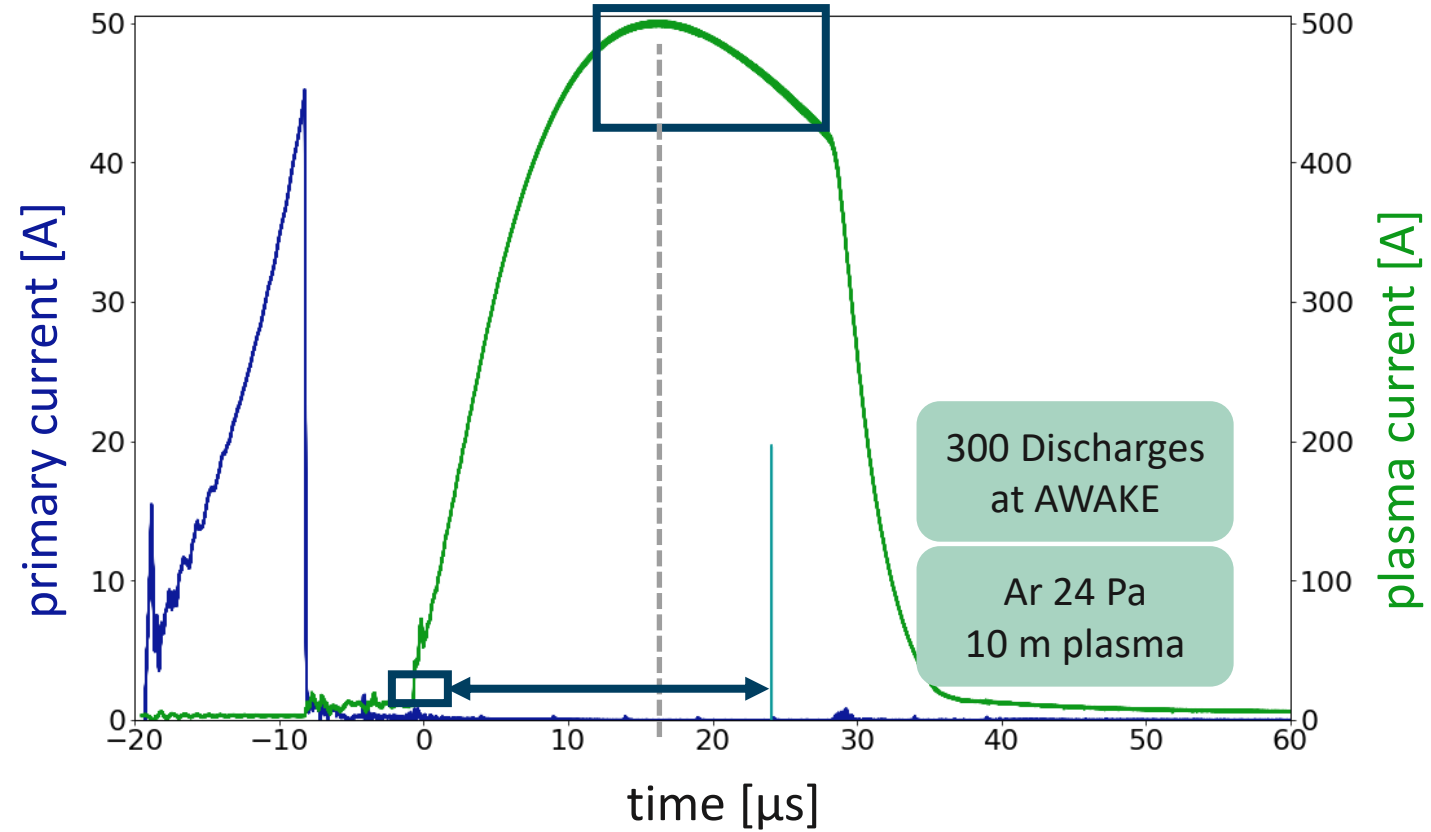
2. Double pulse generator operation – Heater pulse



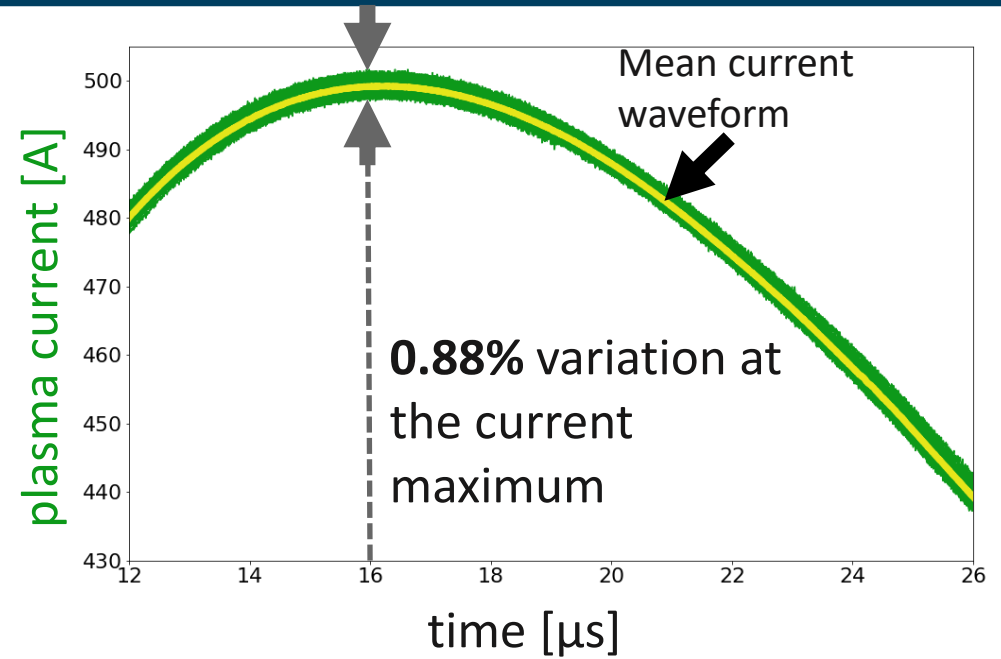
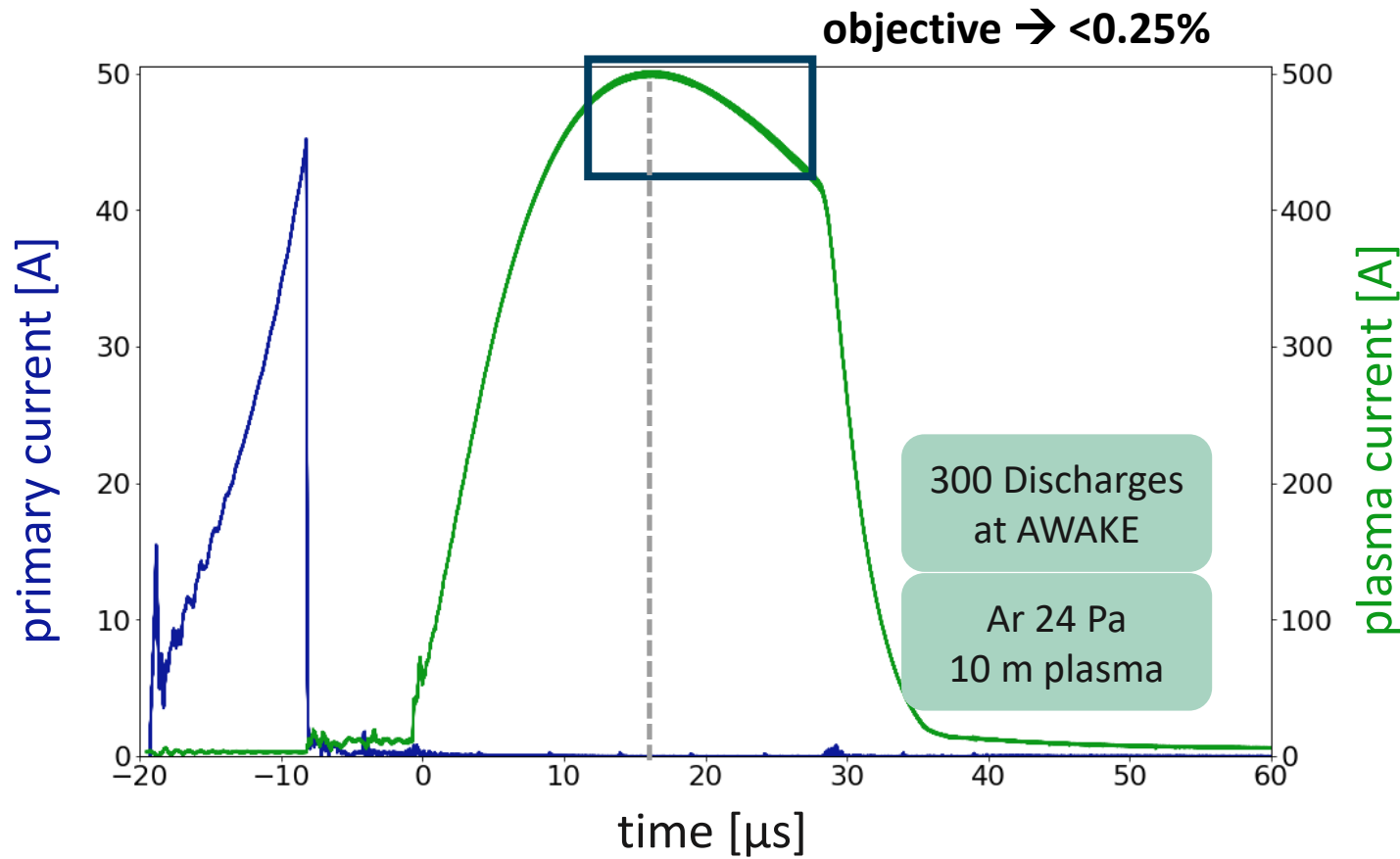
The heater pulse raises the **current (up to 600 A)** and consequently the plasma density.



1. Double pulse generator operation
- 2. Plasma current reproducibility**
3. Discharge plasma source operation range
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3. Current reproducibility – DPS proton run

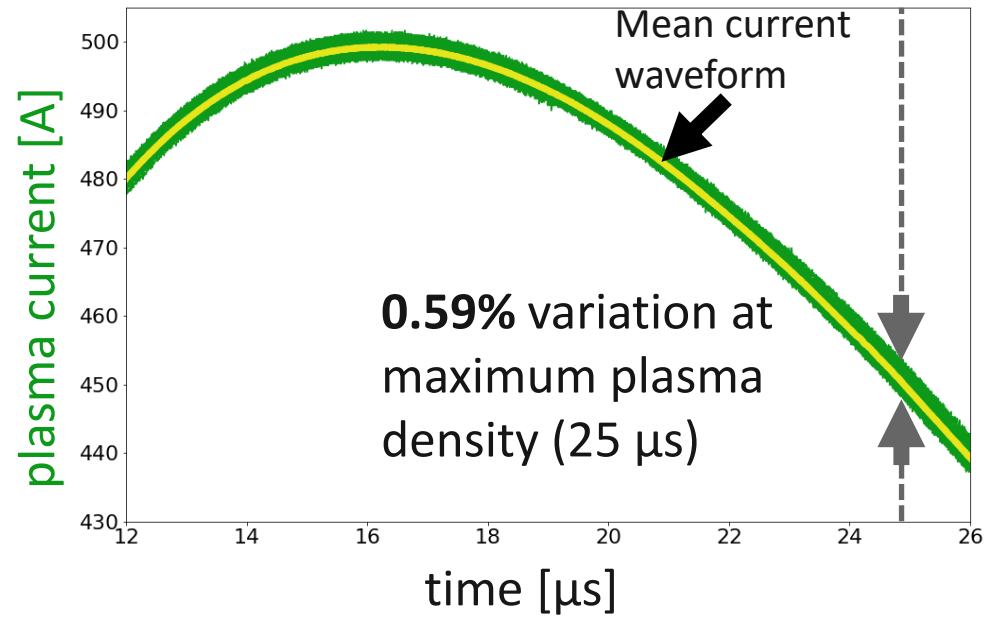
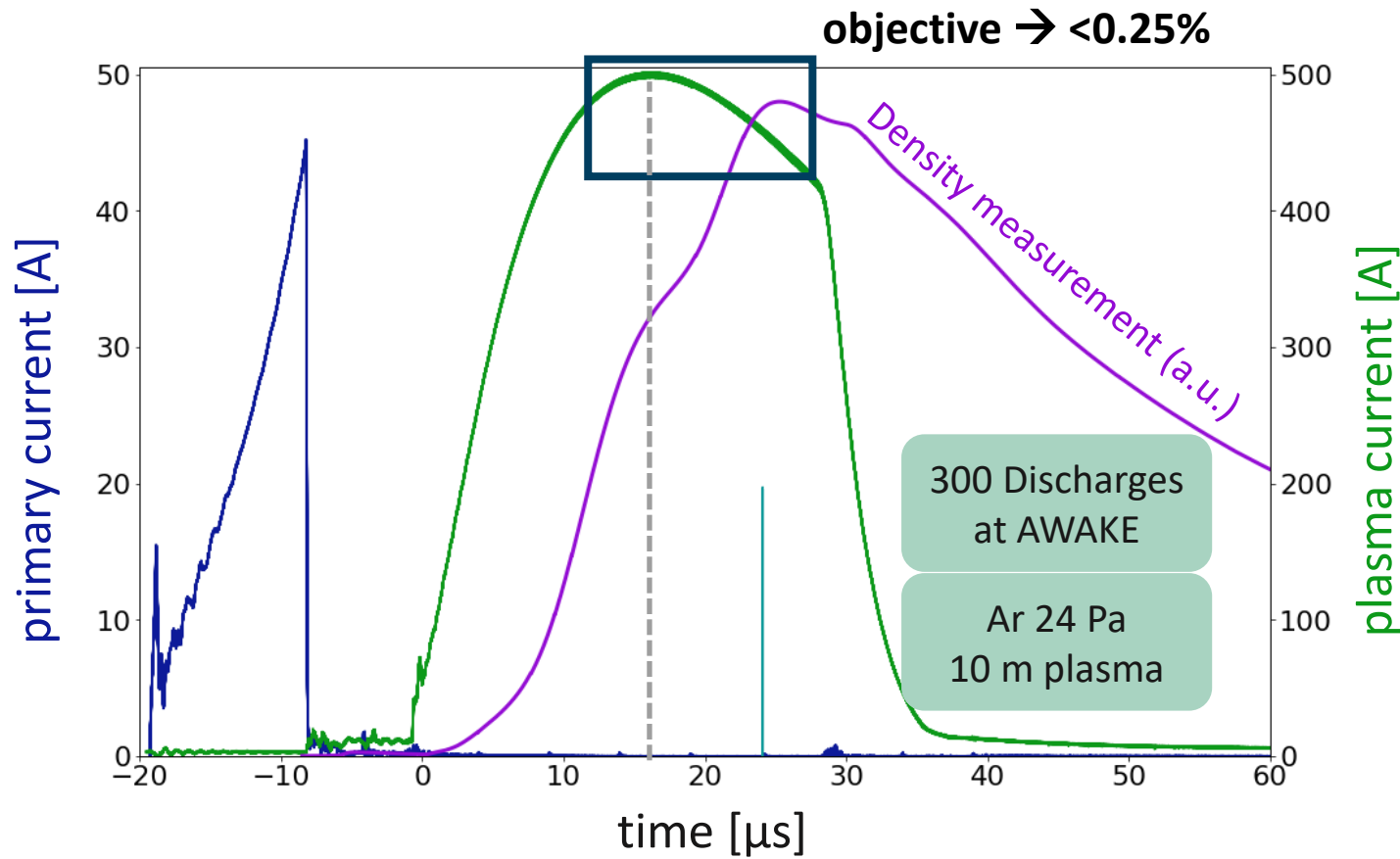


Good electrical reproducibility over 300 discharges
Current maximum variation of 0.88%

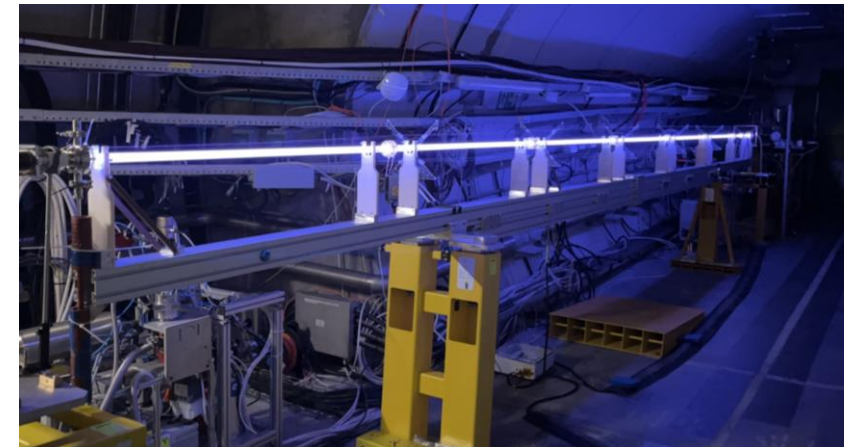


DPS proton run results - May 2023

3. Current reproducibility – DPS proton run

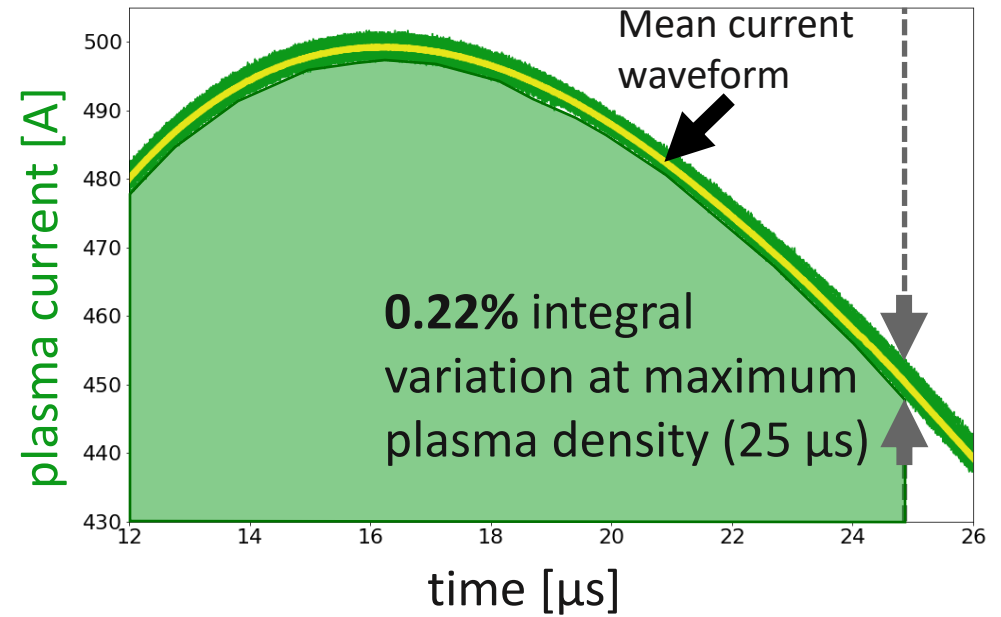
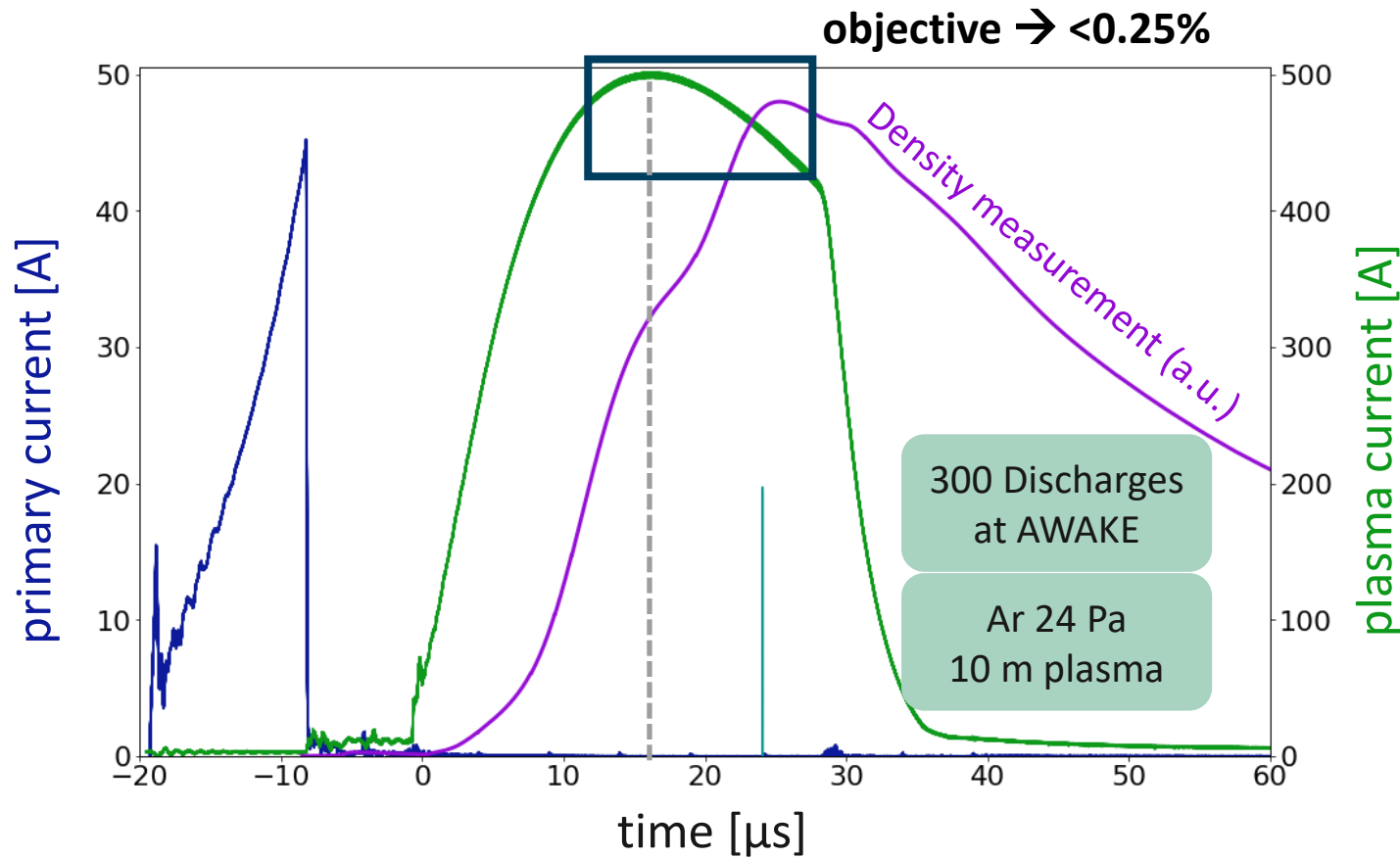


Good electrical reproducibility over 300 discharges
Current maximum variation of 0.88%
Maximum plasma density current variation of 0.59%



DPS proton run results - May 2023

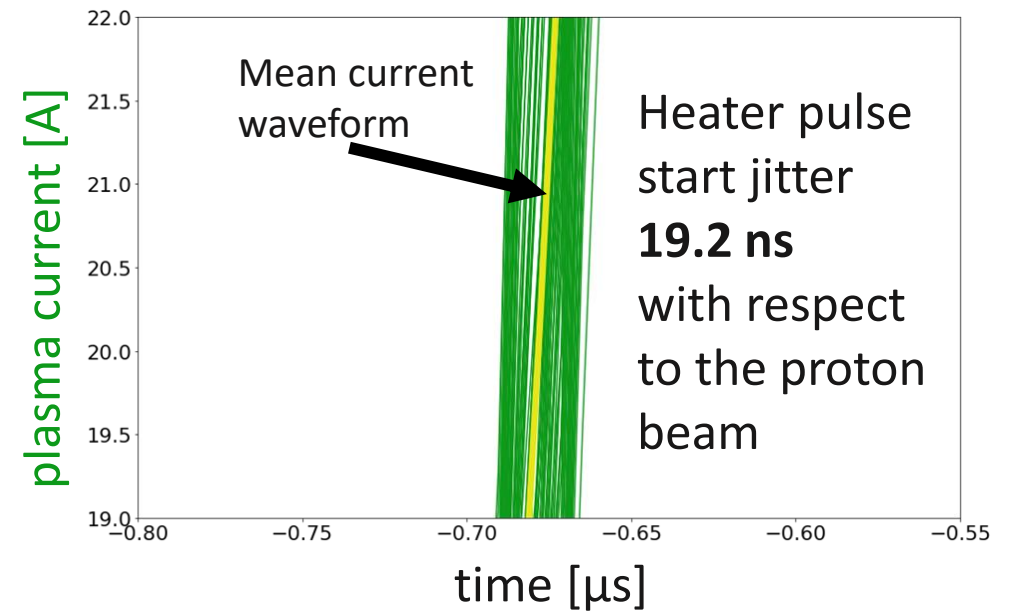
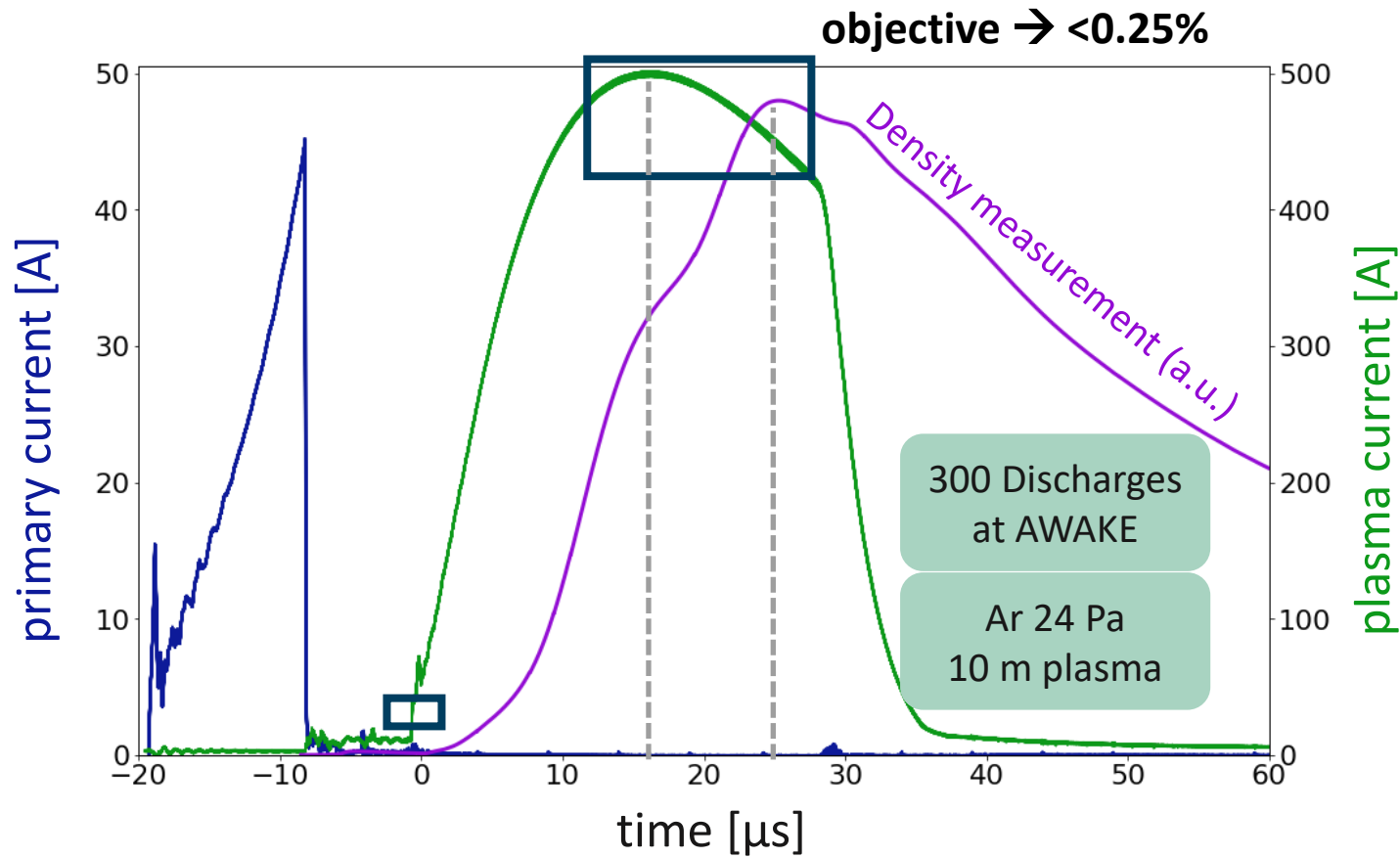
3. Current reproducibility – DPS proton run



DPS proton run results - May 2023

- Good electrical reproducibility over 300 discharges
- Current maximum variation of 0.88%
- Maximum plasma density current variation of 0.59%
- Plasma current integral variation of 0.22%

3. Current reproducibility – DPS proton run

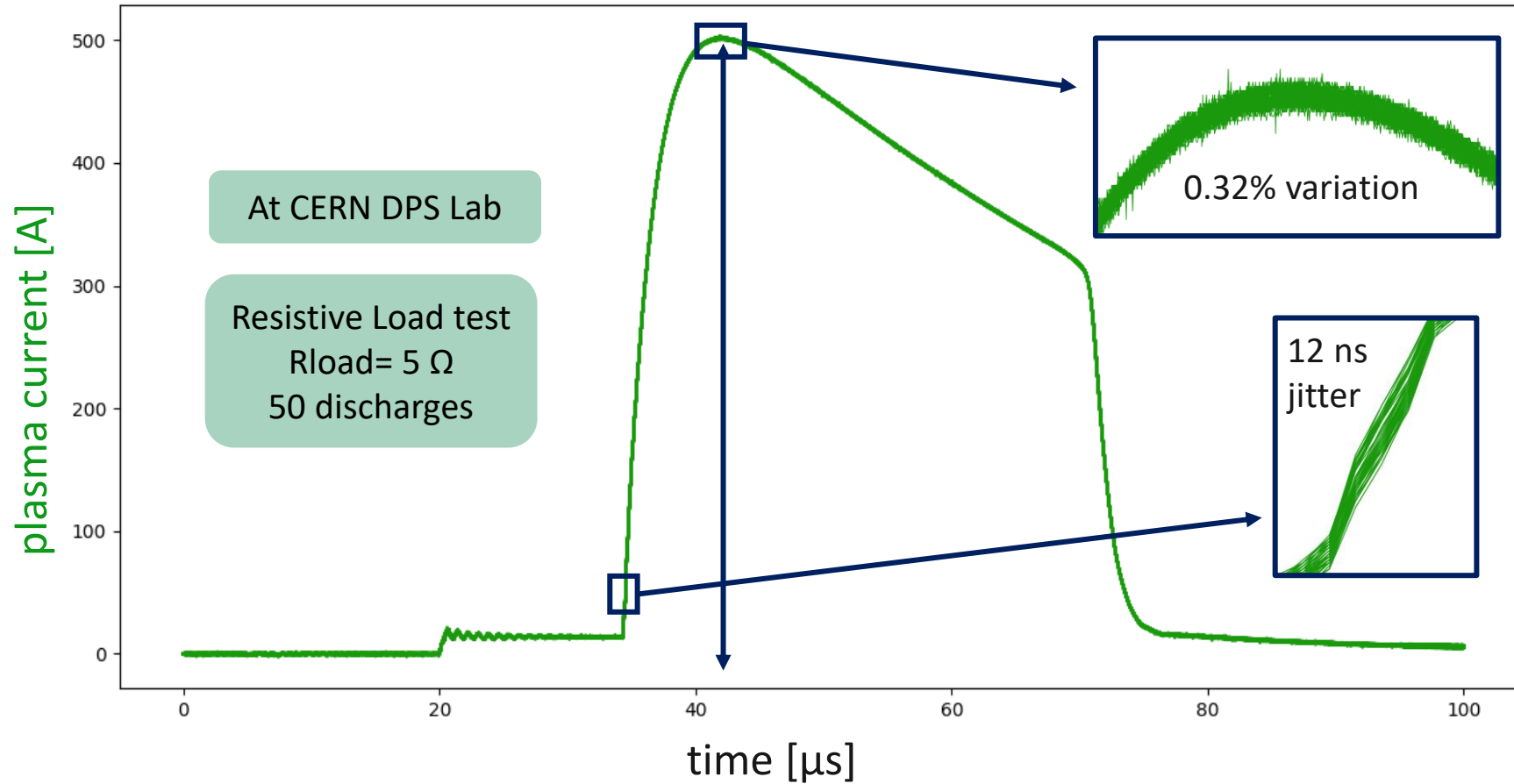


Good electrical reproducibility over 300 discharges
Current variation of $<1\%$
Current pulse jitter of 19.2 ns



DPS proton run results - May 2023

3. Current reproducibility – DPS Lab

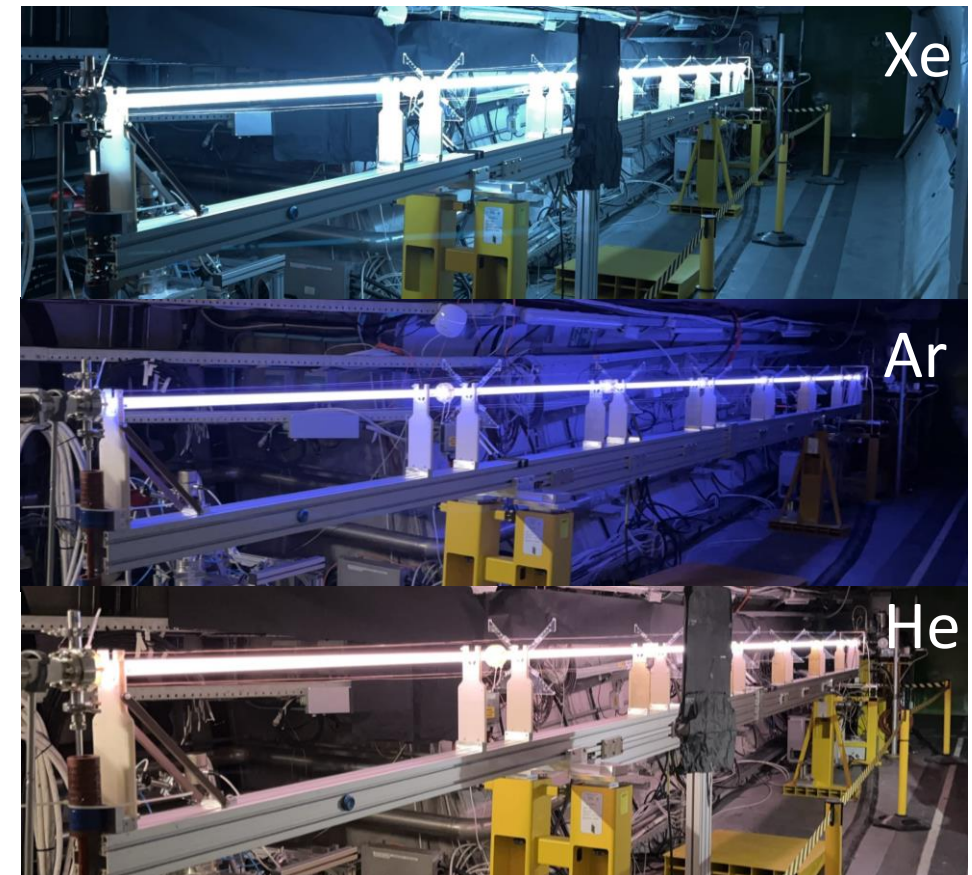


Next steps:

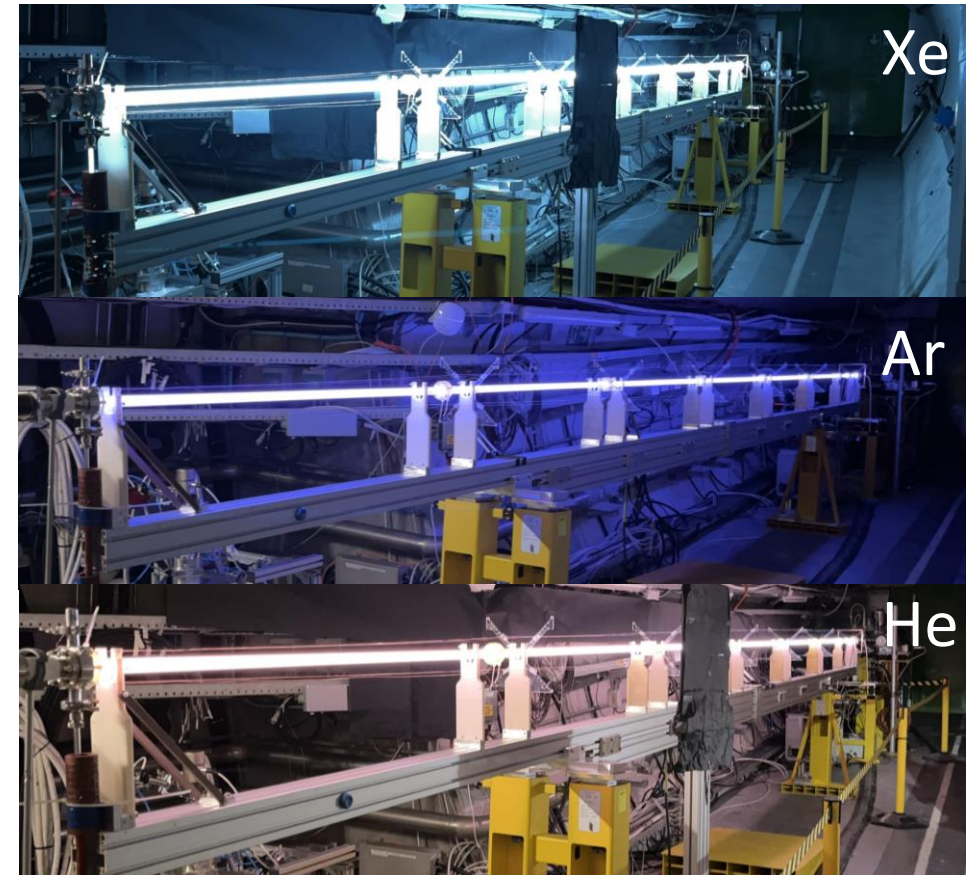
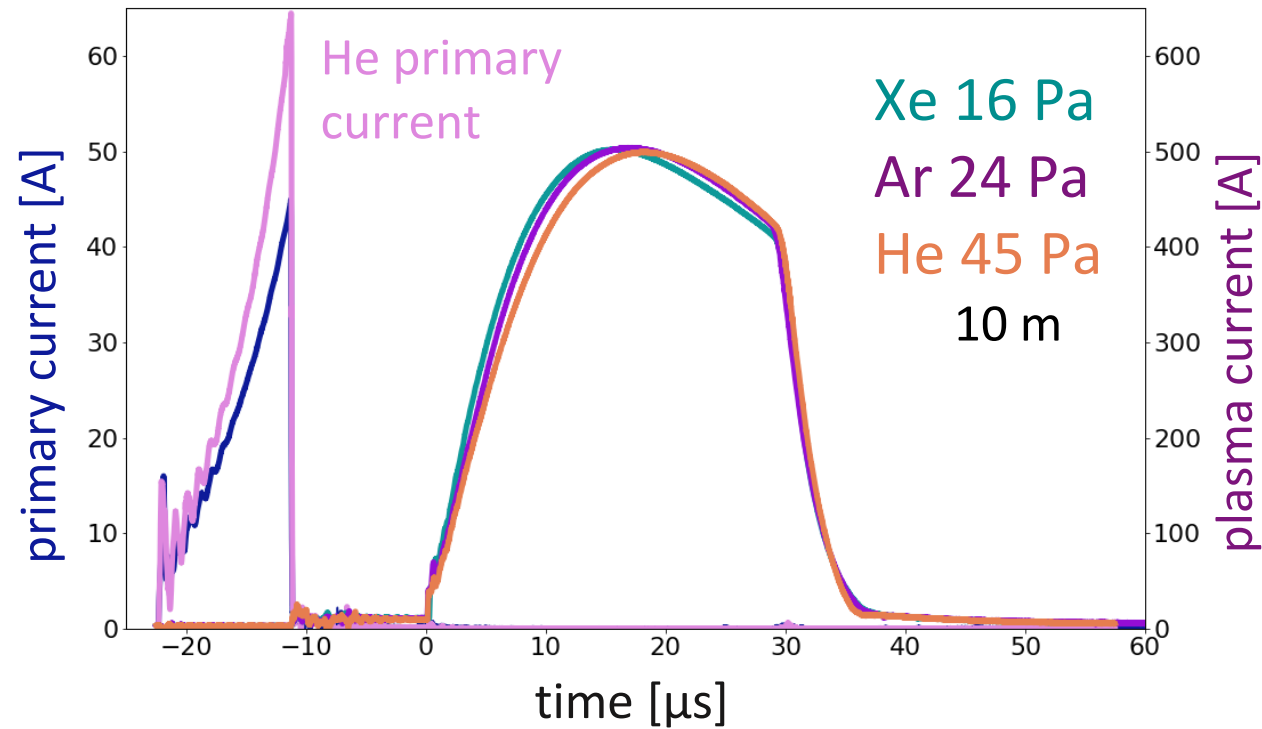
Resistive load replacing the plasma, to determine the sources of the existing current variation

In progress...

1. Double pulse generator operation
2. Plasma current reproducibility
3. **Discharge plasma source operation range**
4. Conclusions

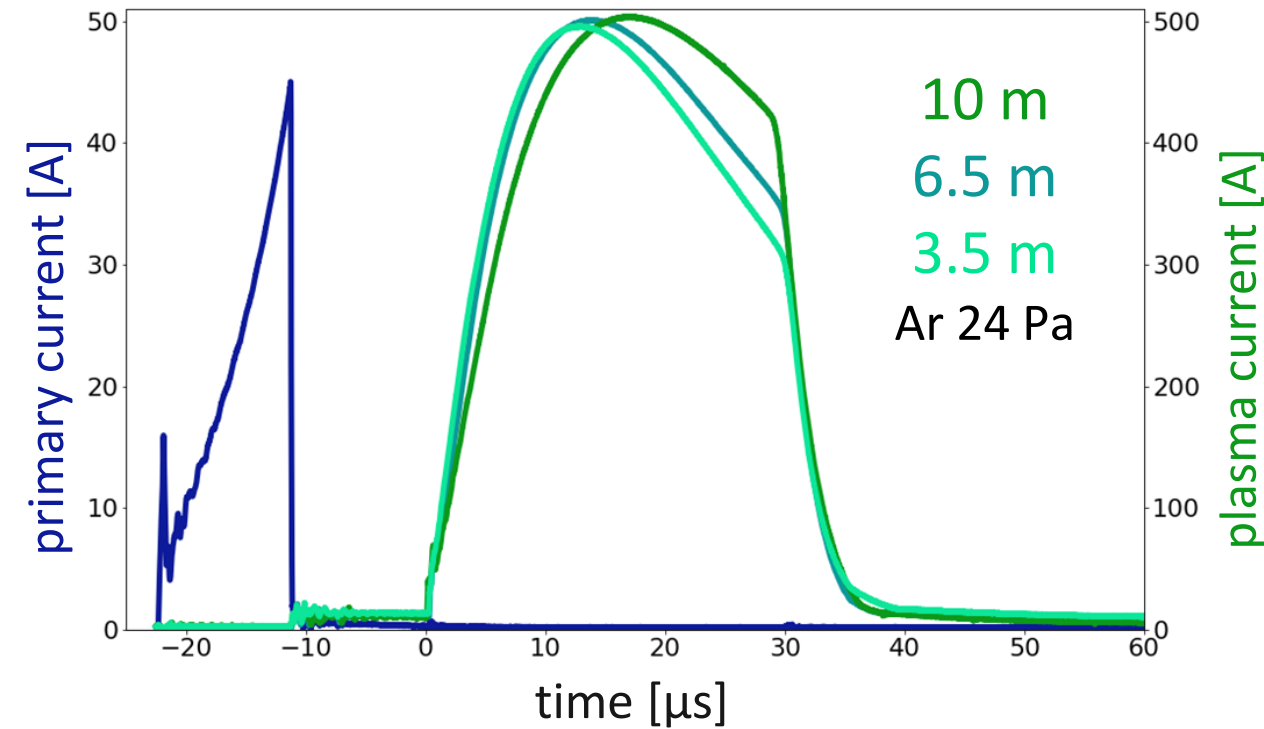


4. Discharge plasma source operation range – Gases

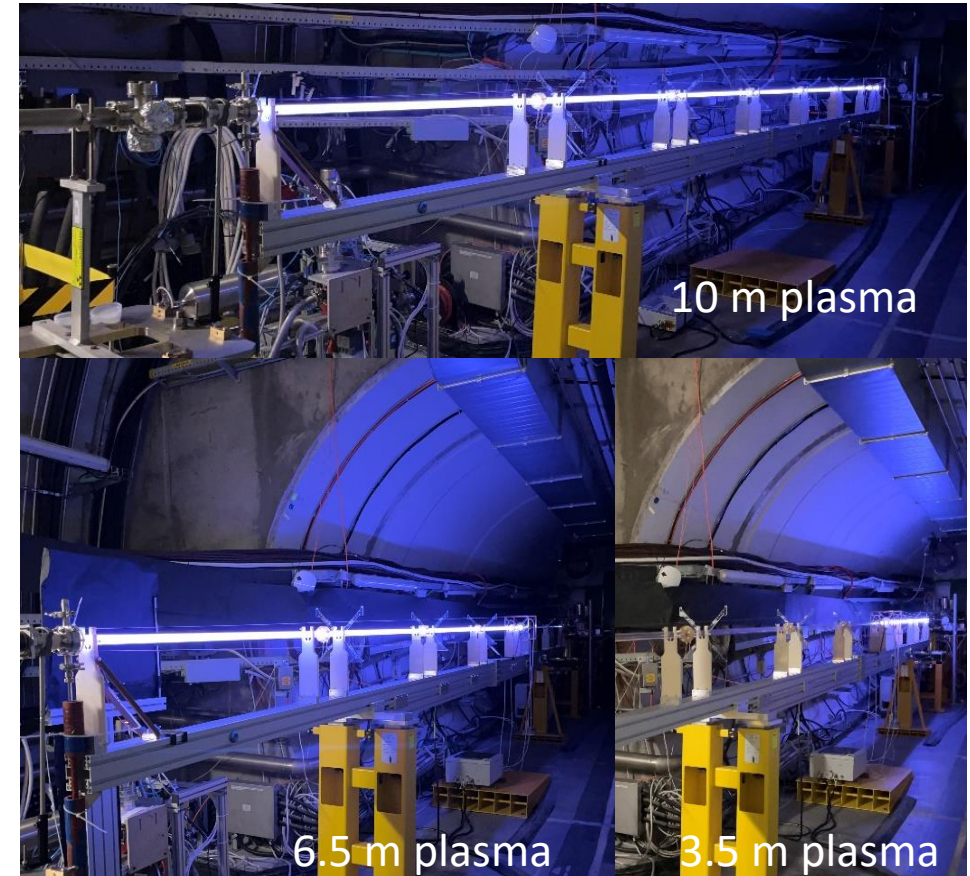


The DPS reaches the target currents in all three lengths and gases.
Gas affects mostly the ignition voltage required, leading to a higher primary current for He.

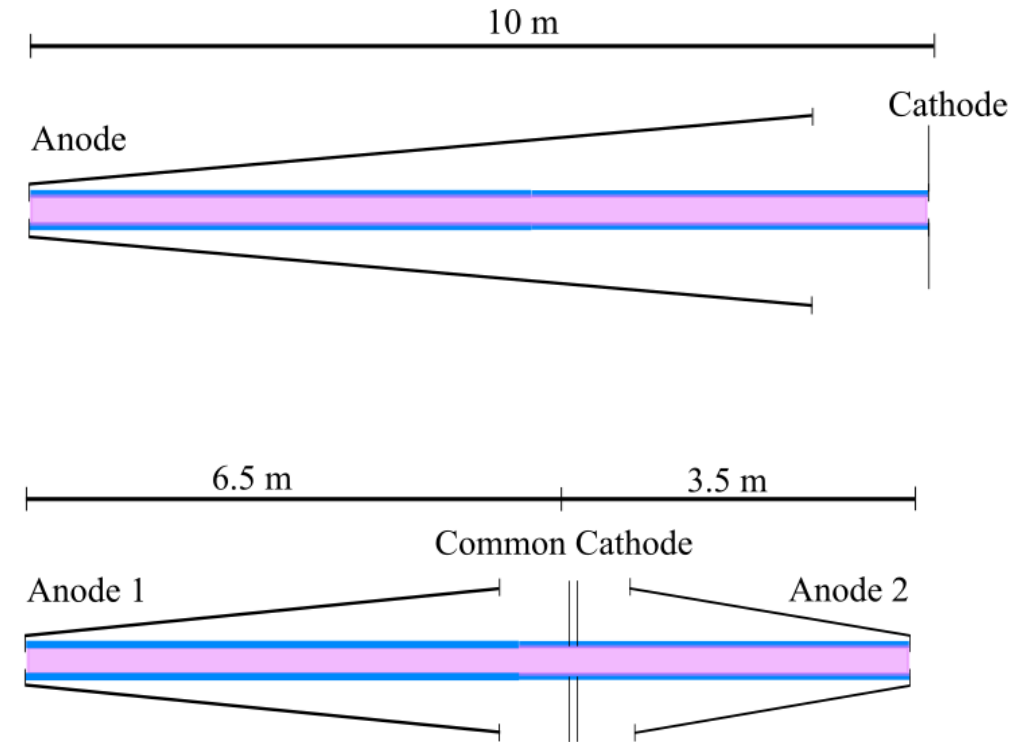
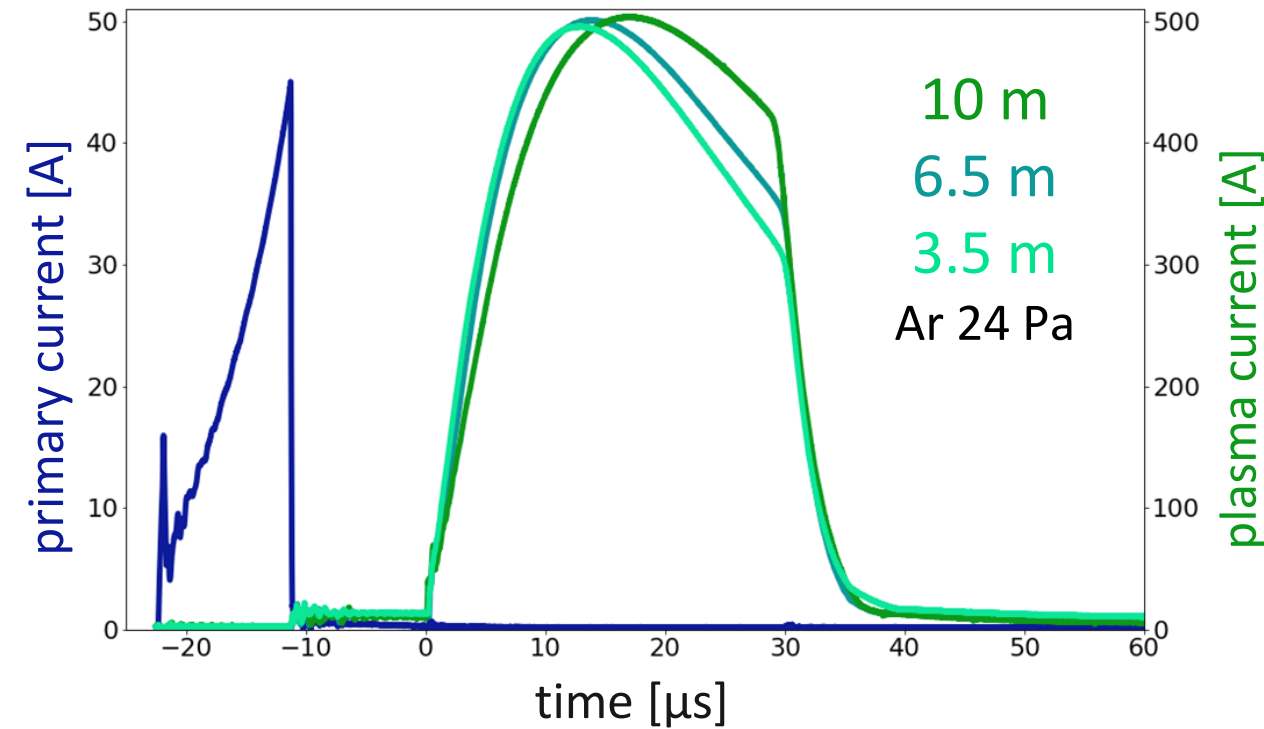
4. Discharge plasma source operation range – Length



The DPS reaches the target currents in all three lengths and gases.
Gas affects mostly the ignition voltage required, leading to a higher primary current for He.
Plasma length affects the load impedance, thus causing differences in the pulse shape



4. Discharge plasma source operation range – Length

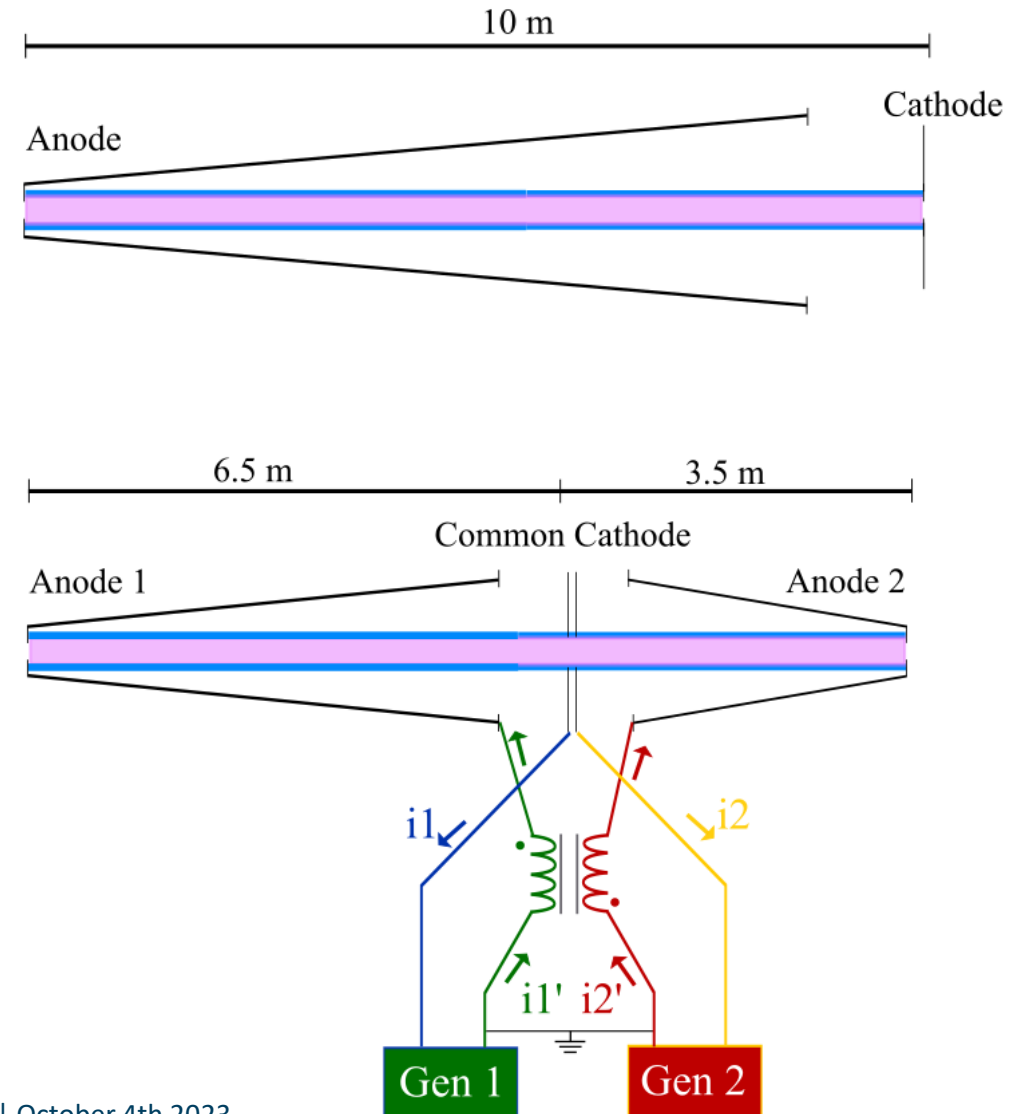
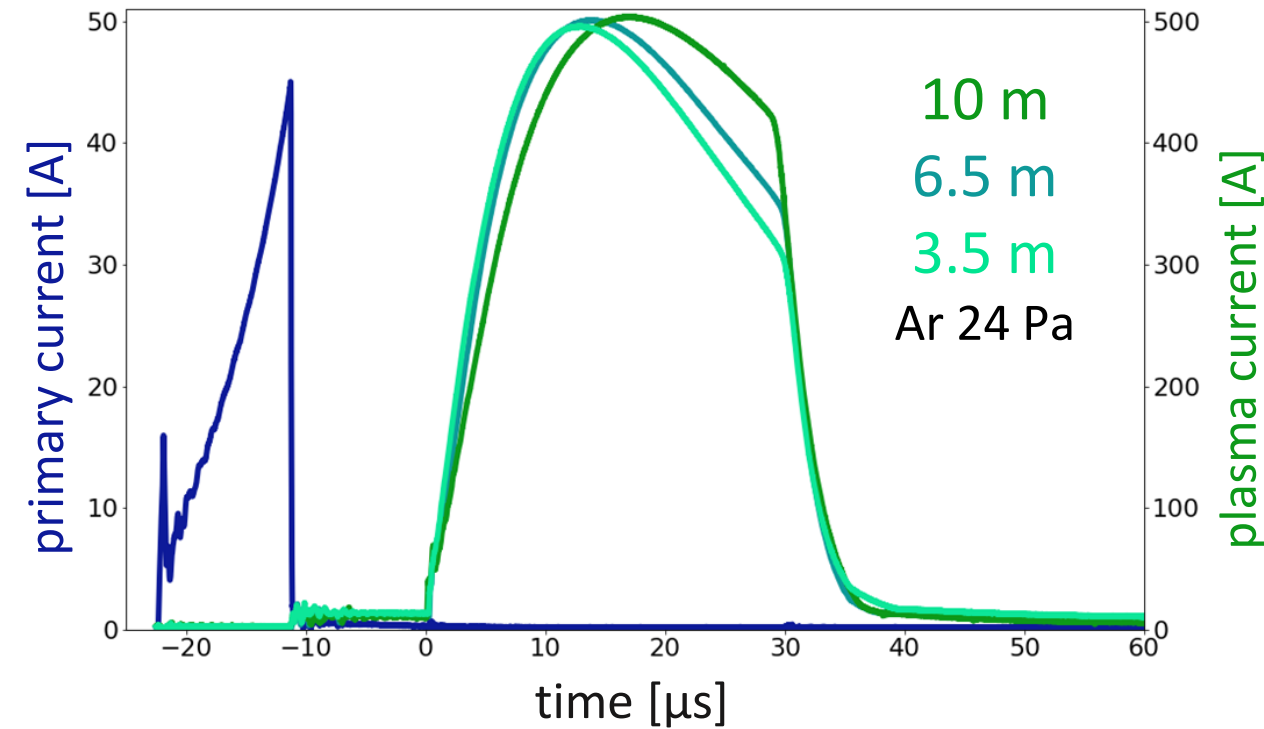


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4. Discharge plasma source operation range – Double plasma

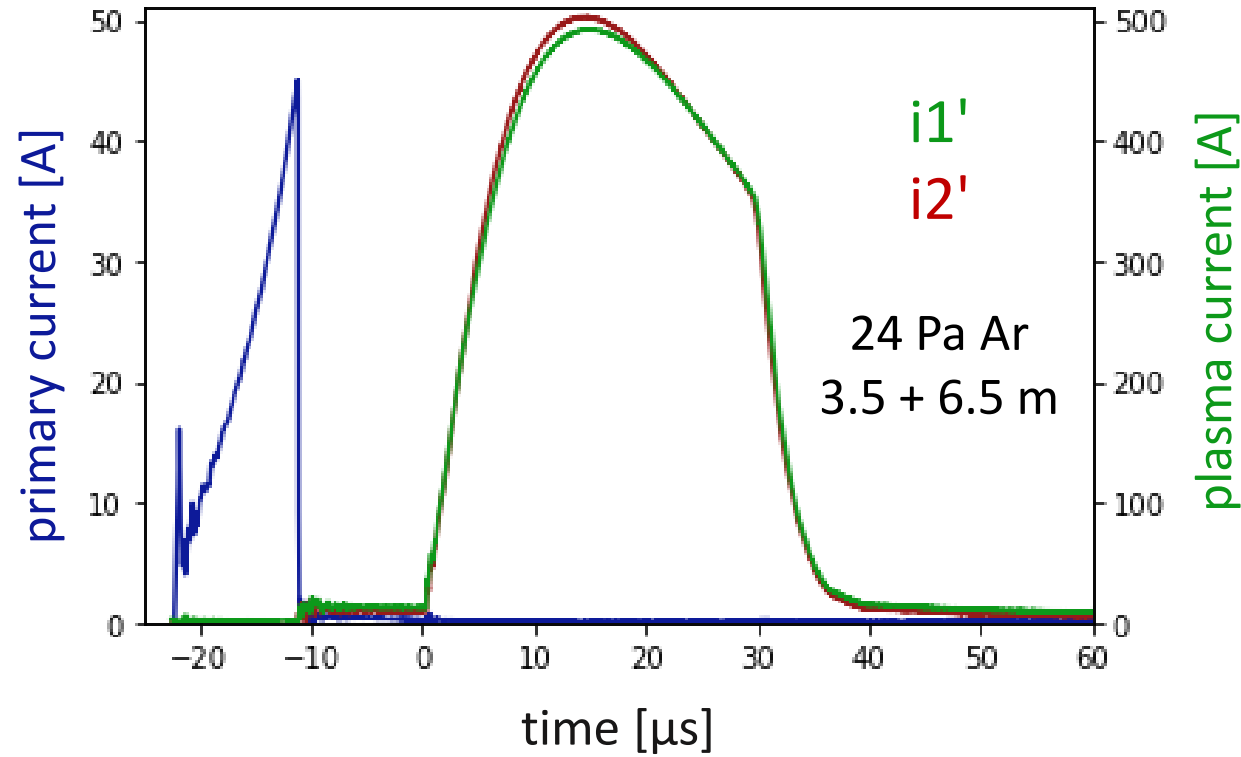


The DPS reaches the target currents in all three lengths and gases.

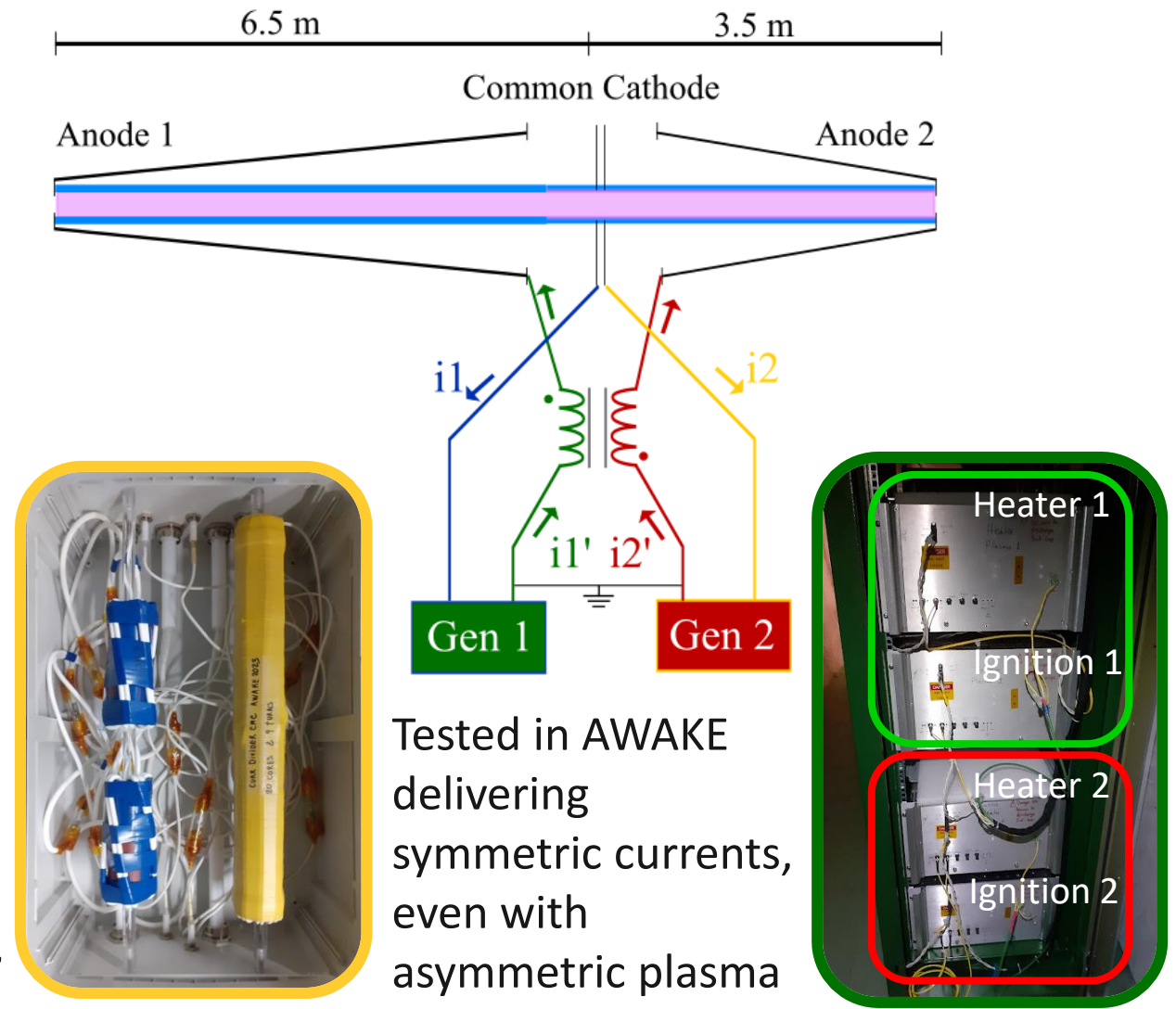
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4. Discharge plasma source operation range – Double plasma

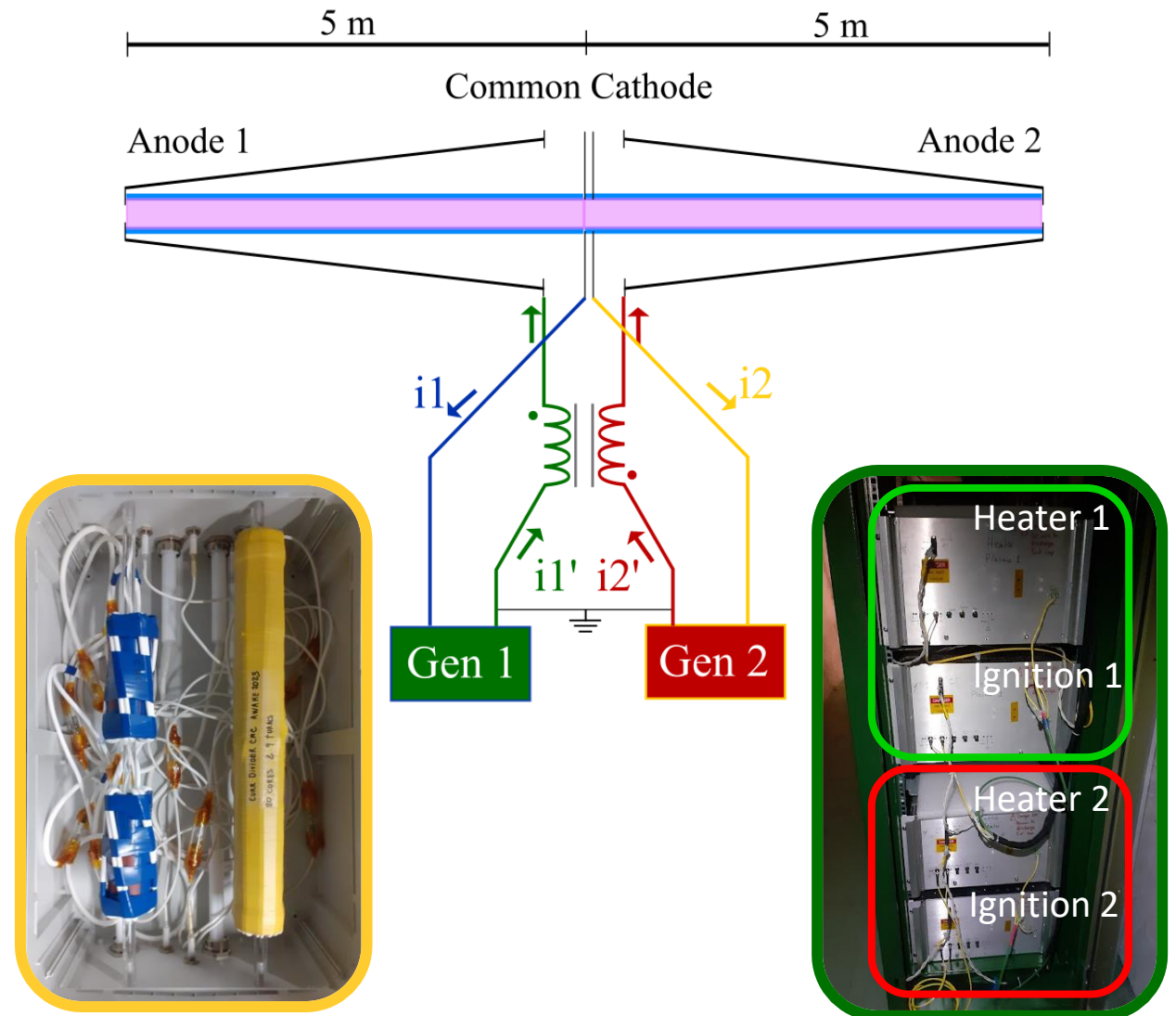
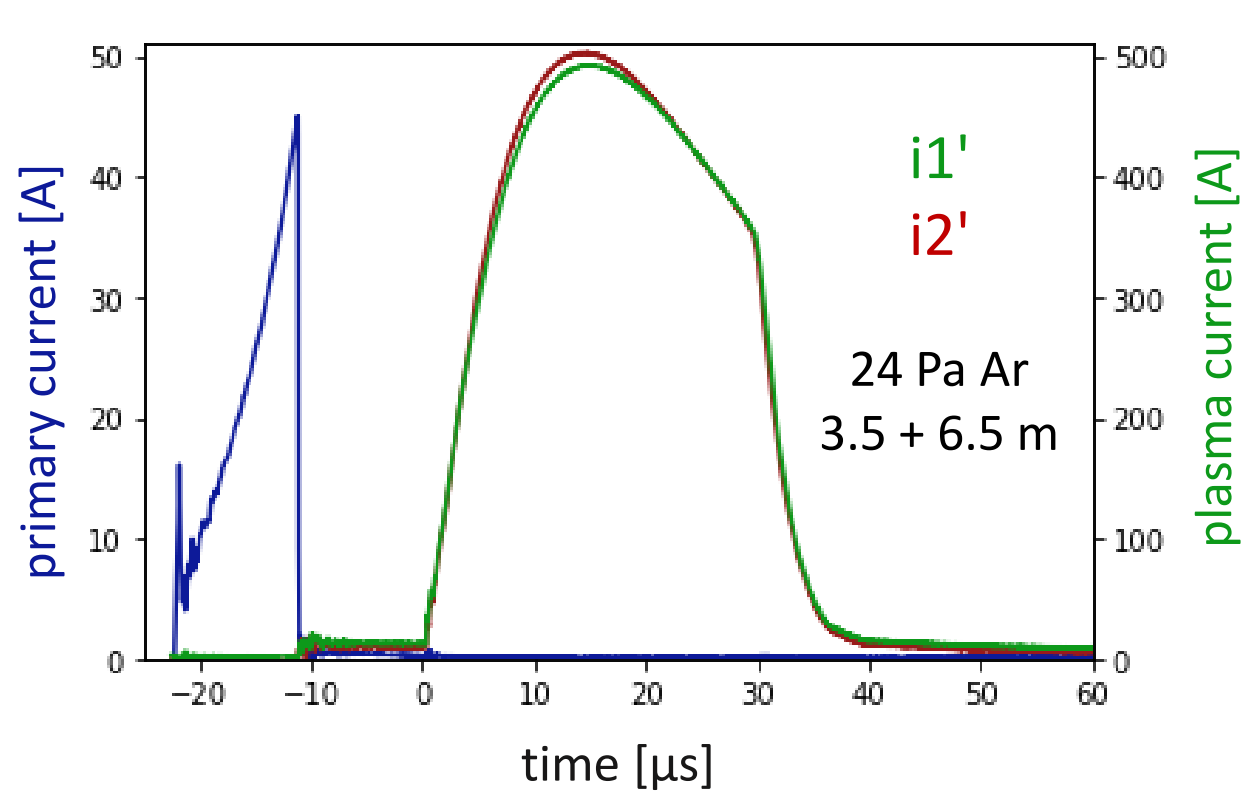


The double plasma current is equalized by a current balancing module: a high-current and small leakage inductance magnetic choke. The high-frequency impedance of each winding adjusts, forcing current symmetry between both plasmas.



Tested in AWAKE delivering symmetric currents, even with asymmetric plasma lengths.

4. Discharge plasma source operation range – Double plasma



Next steps:

Symmetric double plasma (5 m + 5 m)

The double pulse generator uses an ignition and a heater pulse to produce long (3.5, 6.5 or 10 m) and reproducible plasma.

The current reproducibility measured is below 1%, and the heater pulse jitter is around 20 ns

The double pulse generator can accommodate a large spectrum of operation - three different gases and four different configurations (3.5 m, 6.5 m, 10 m single, 3.5 + 6.5 m)

Promising double plasma tests indicate that scalability is potentially achievable by introducing current balancing modules

The next steps involve: further testing of the pulse generator's reproducibility and the introduction of symmetric double plasmas