Status of ELENA H-/p source

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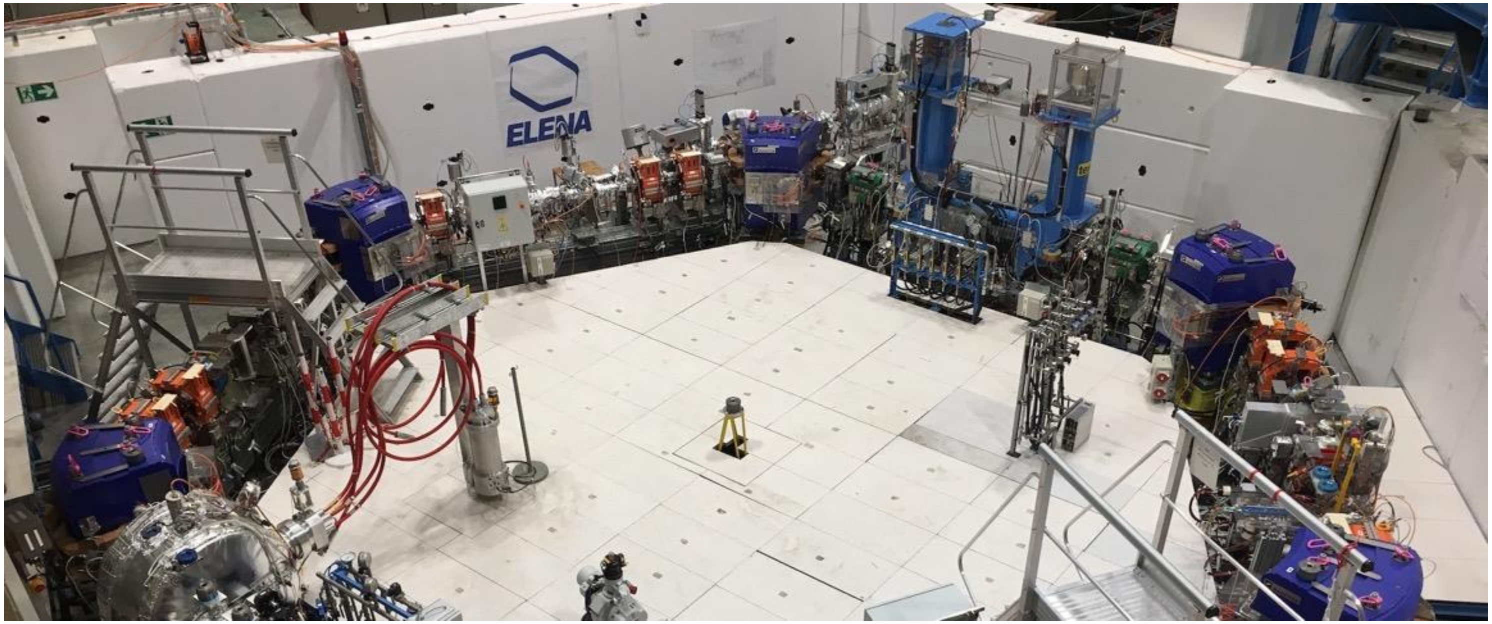
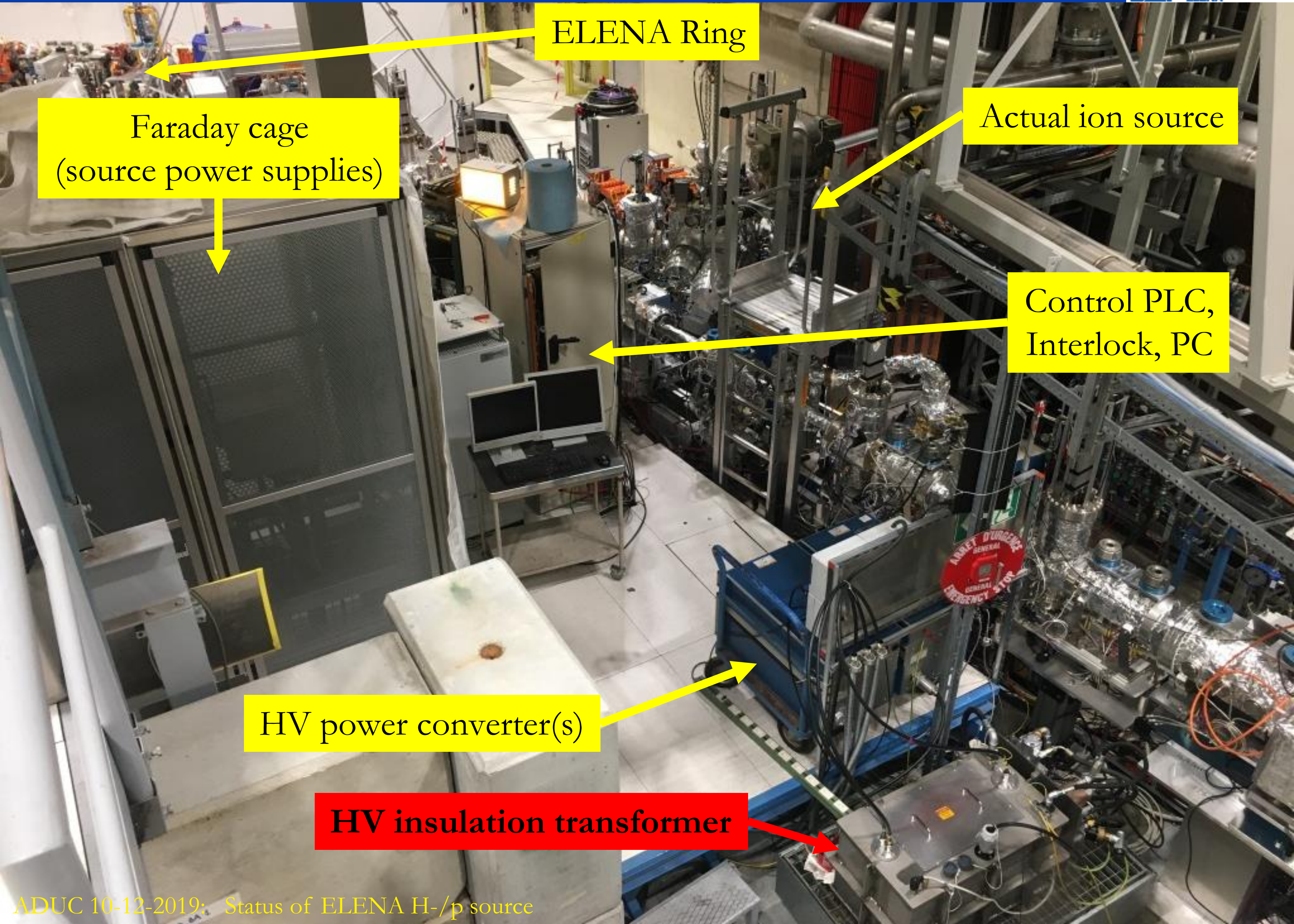
10/12/2019



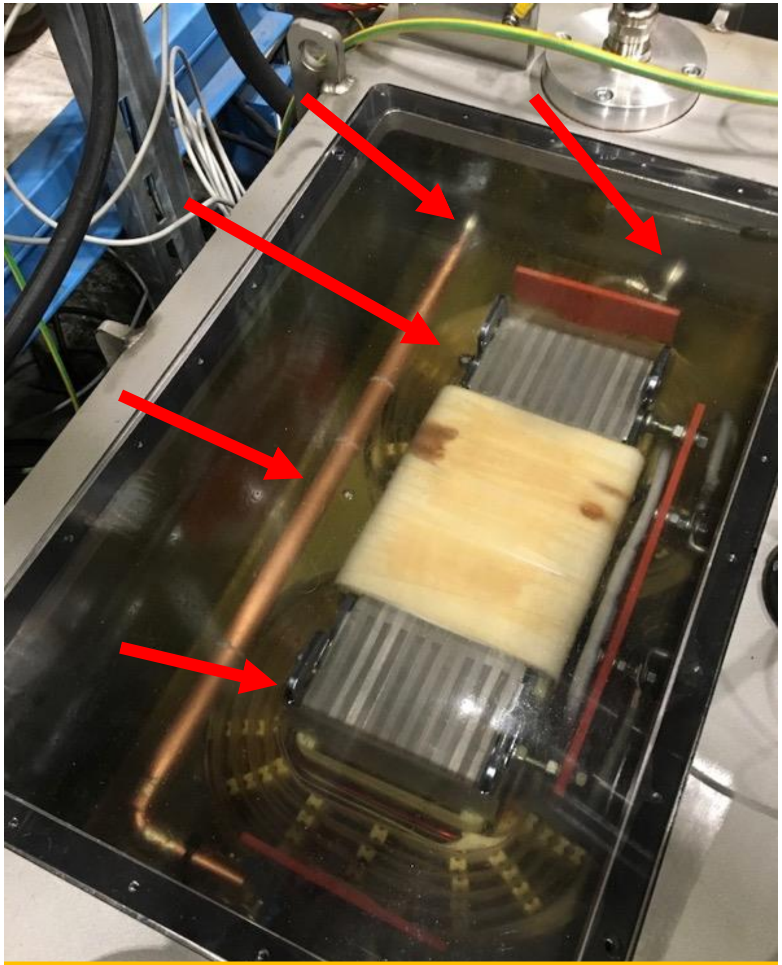
- Ion source overview
- Insulation transformer issues: observations and present solution
- Beam instability observations and possible cure
- Plans and conclusions

Overview of ELENA Source Installation

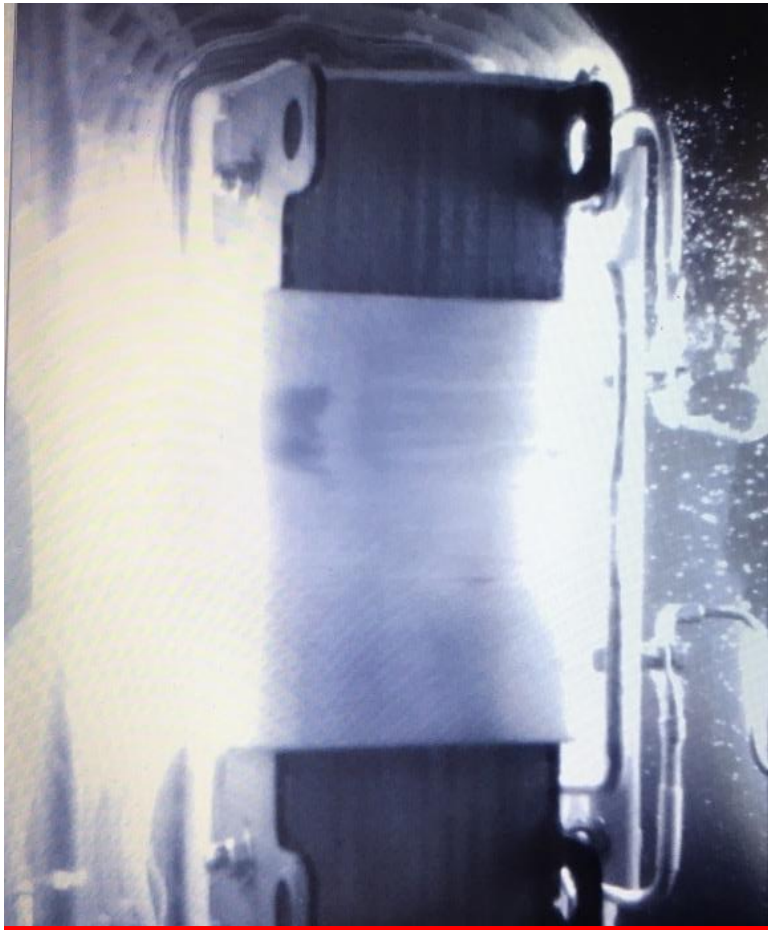


Insulation Transformer (2019v1)

- Built by a (new) **external company** and installed in spring 2019
  - After a few days of tests it started have spark when run @100 keV DC (nominal settings)



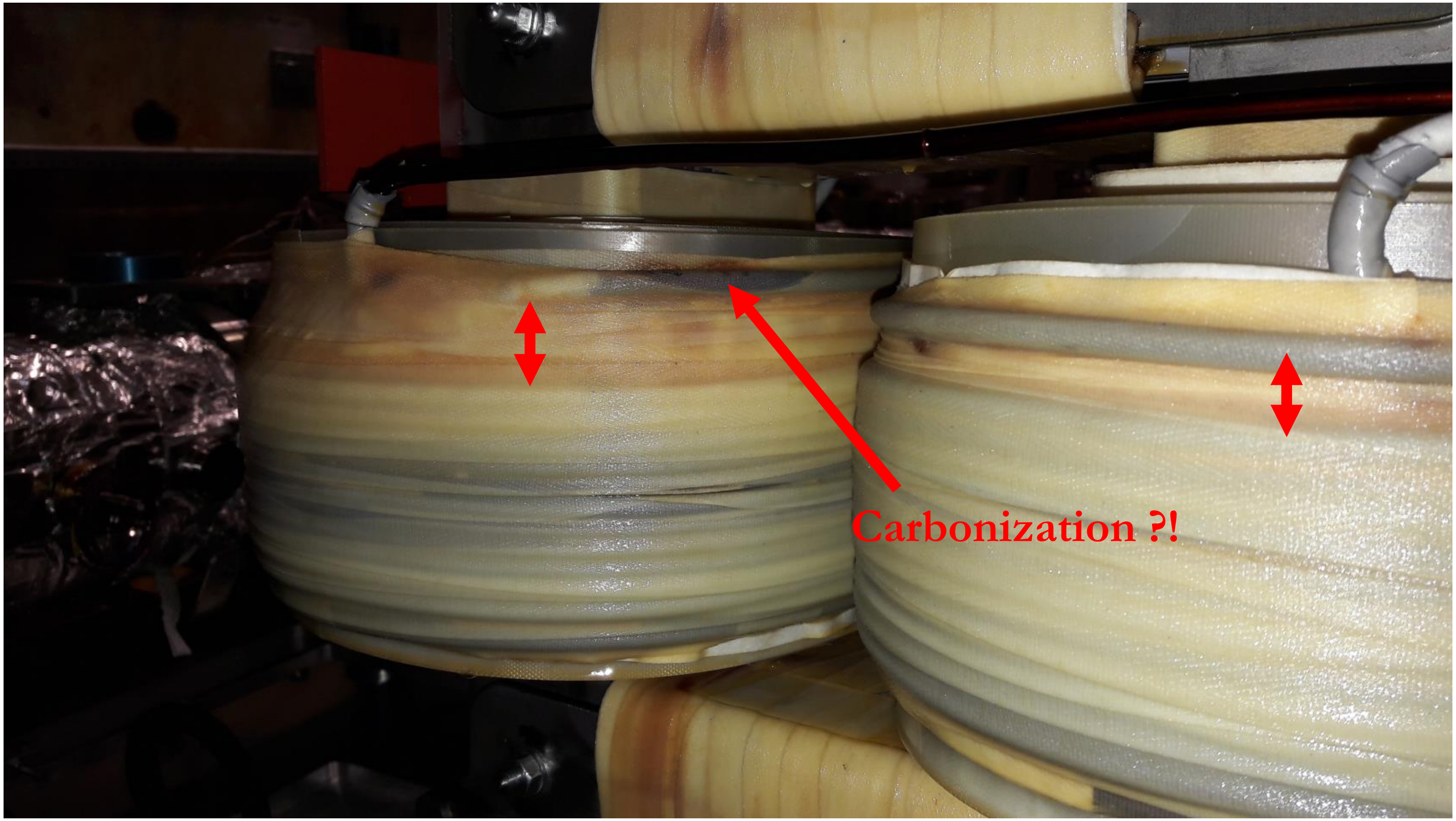
Several attempt improvements by EPC



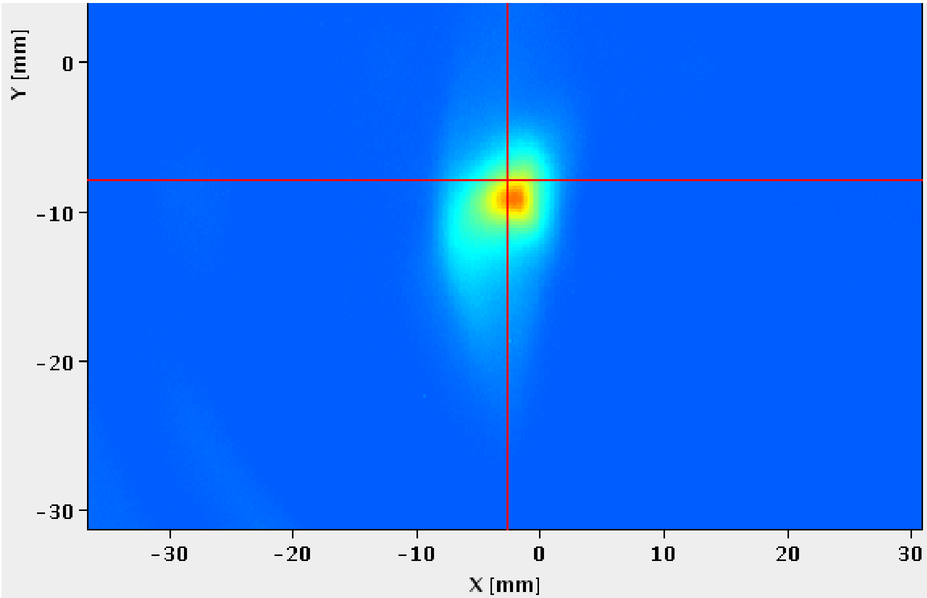
Still sparking + degradation: secondary to magnetic core sparks

Insulation Transformer (2019v1)

- After **investigation by EPC**, it turned out that **last turn of secondary winding was to close to magnetic core**: possibly a **construction error** – design maybe good.
  - **Company agreed to build a new transformer**, with more space between ground and HV, and being more careful in the construction.



Cycling the HV @100keV (2019v1)

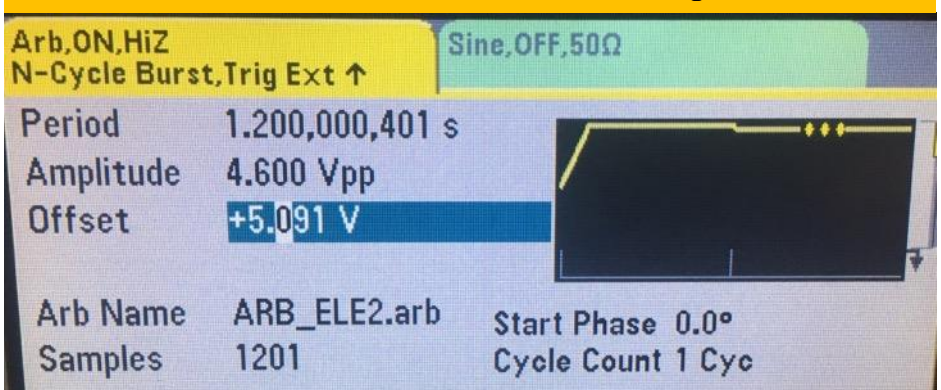


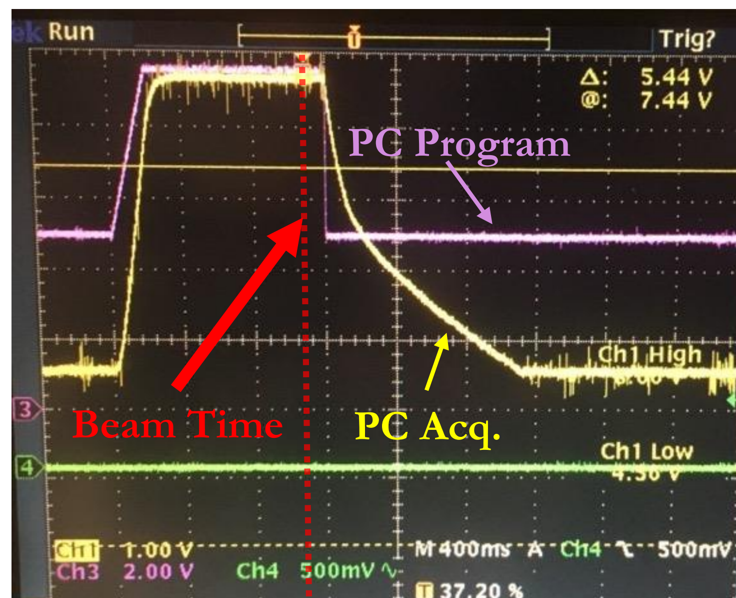
Still, it has been possible to cycle HV and have 100 keV beams in ELENA

However:

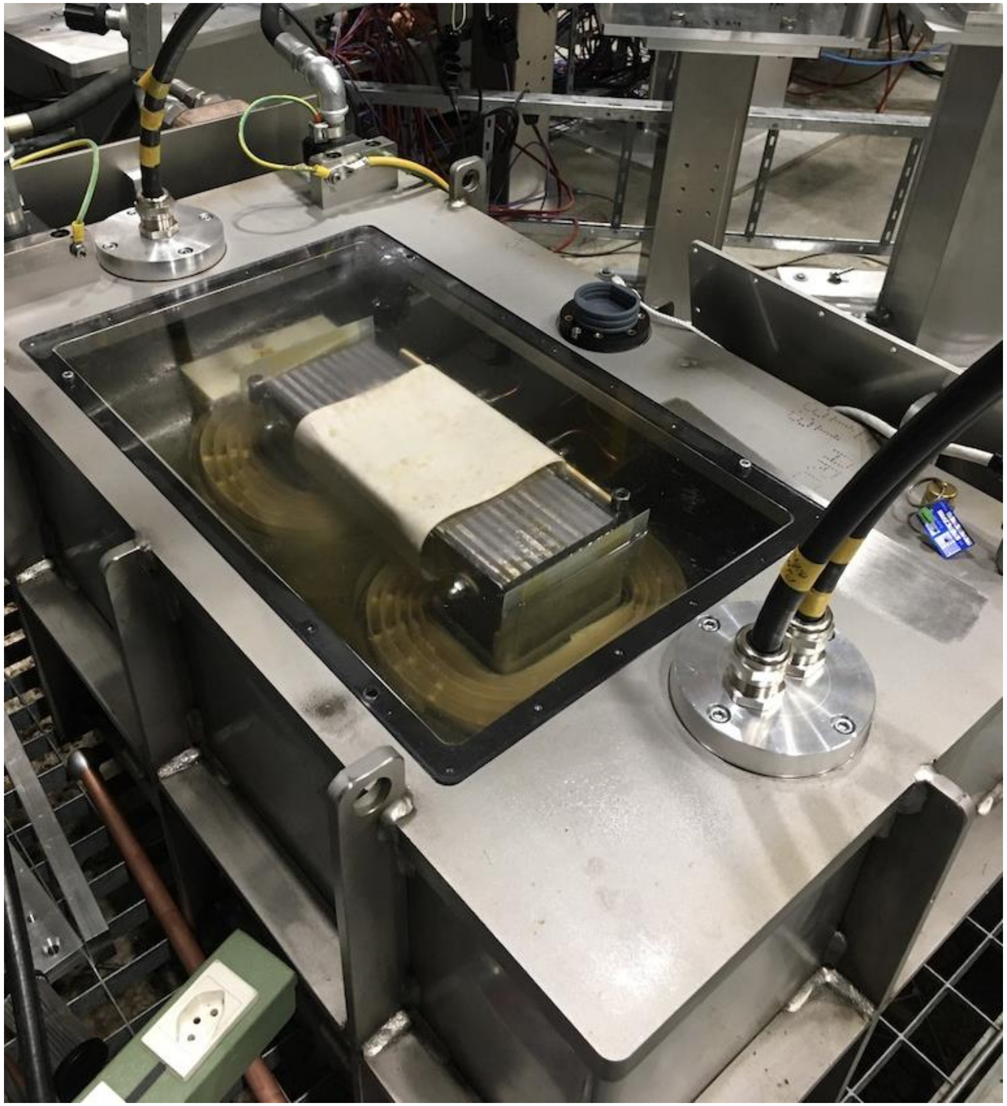
- Had to program about **107 kV on HV PC**
  - **Slow ramp up of HV in the source**
  - **Tested for several hours without problems**
- Only possible to arrive **@95 kV with positive HV, i.e. for possible proton operation**
  - **sparks in transformer**

- **200 ms ramp from 56 kV to 106.6 kV**
- **Plateau of about 1 s before making beam**





New^n transformer (2019v2)

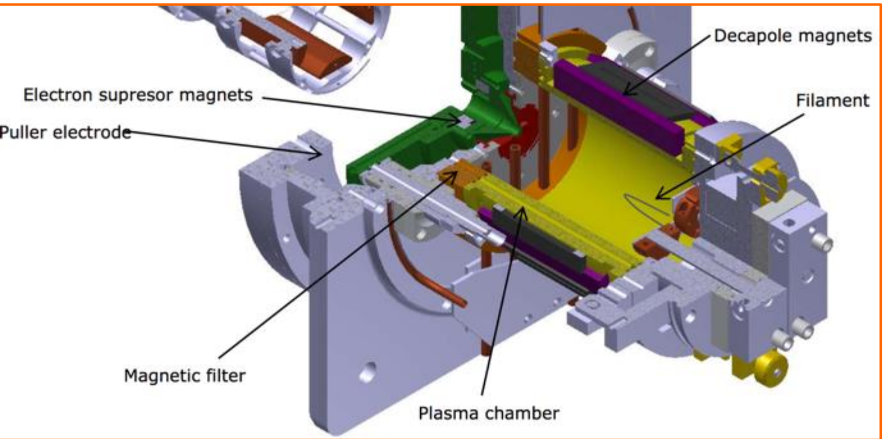


- **Installed** on Thursday 5/12/19
- **Tested** up to **105 keV DC** for a few hours on Friday 6/12/19
- **Used** with beam at **100 keV DC** for about 6 hours on Monday 8/12/19
- **TODO**:
  - **Continue testing** for several hours, eventually for **a few days**. (partial discharges still audible in the transformer)
  - Test with **positive HV** (i.e. proton beam production)

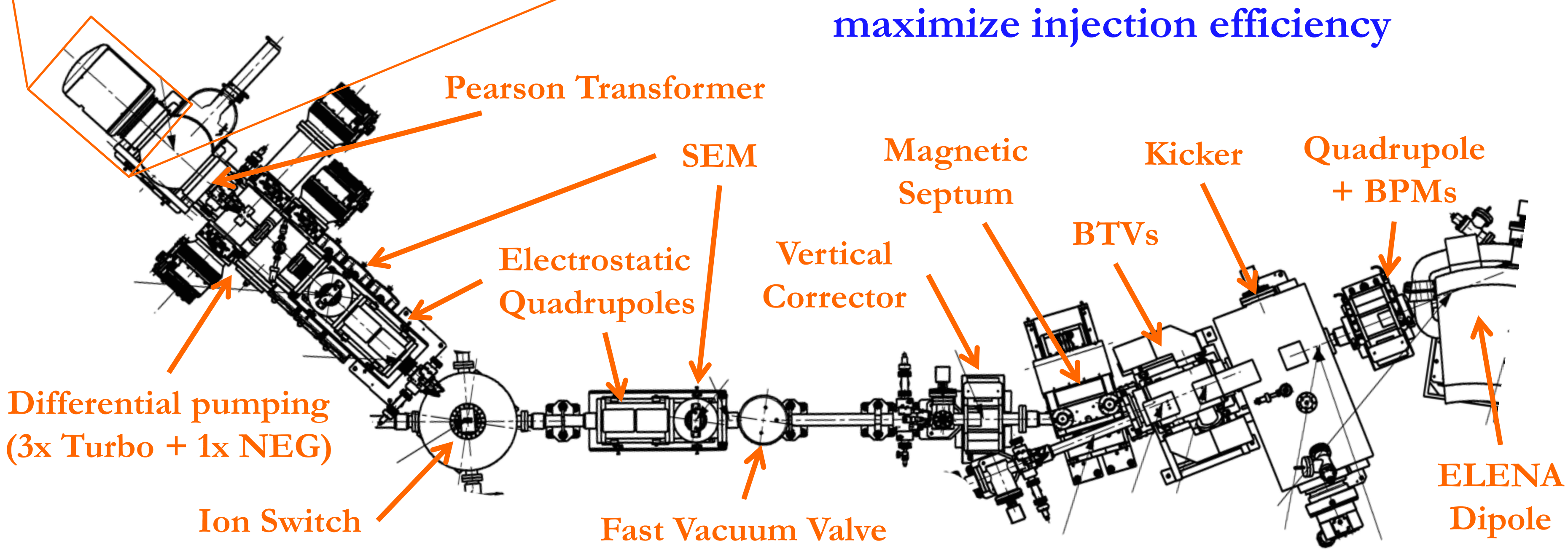
Beam: from source to ring

Wish list:

- ~100 uA; ~1 us; ~square pulses
  - Only 650 ns-long pulses injectable by kicker
  - 500 ns @ 100 uA ≈ 3.1×10^8 particles
- Good Stability/Repeatability
  - Order a few % intensity and beam shape
  - Better than <0.1% energy stability
- Transverse optics matched to ring to maximize injection efficiency

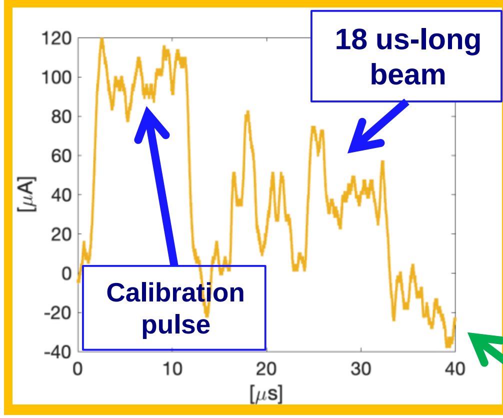


Only DC Power Supplies control via PLC in Faraday Cage

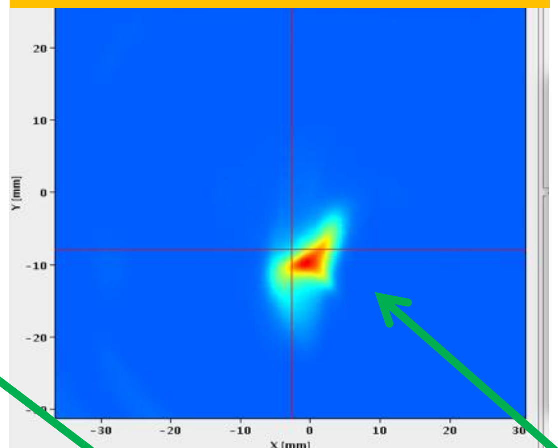


Initial beam observations

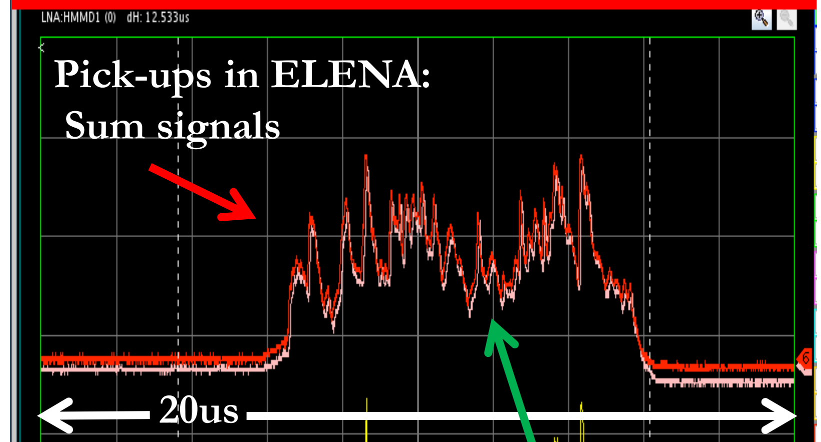
Poor instrumentation available

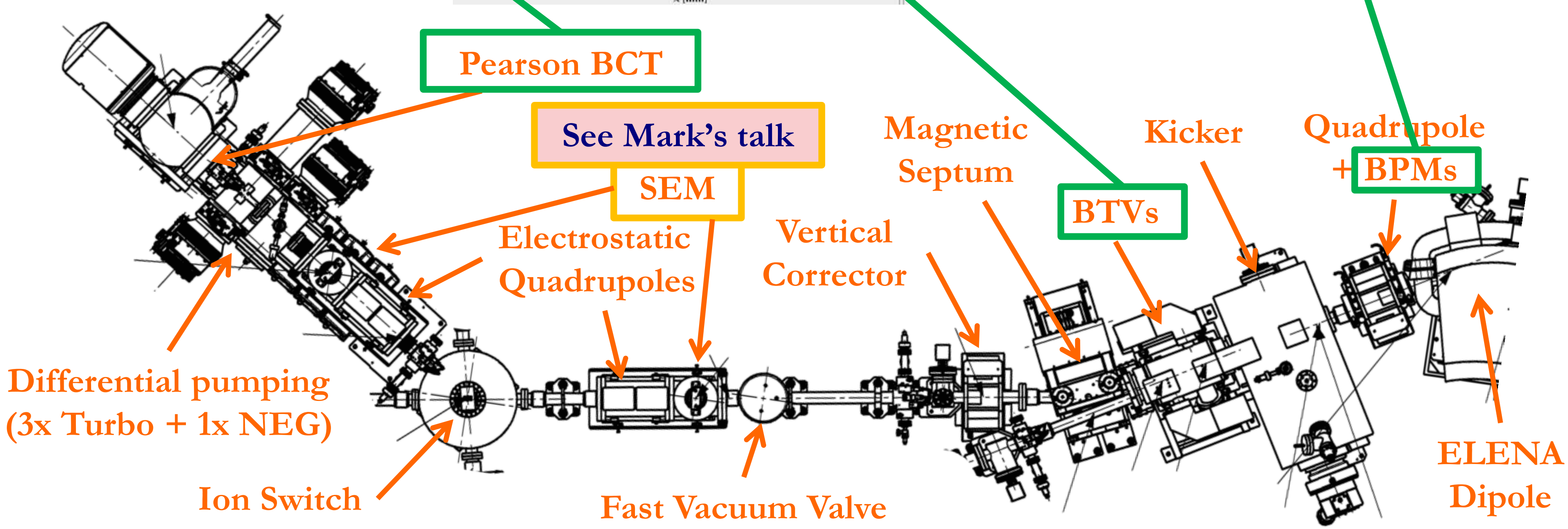


Poor position stability after some time, sometimes

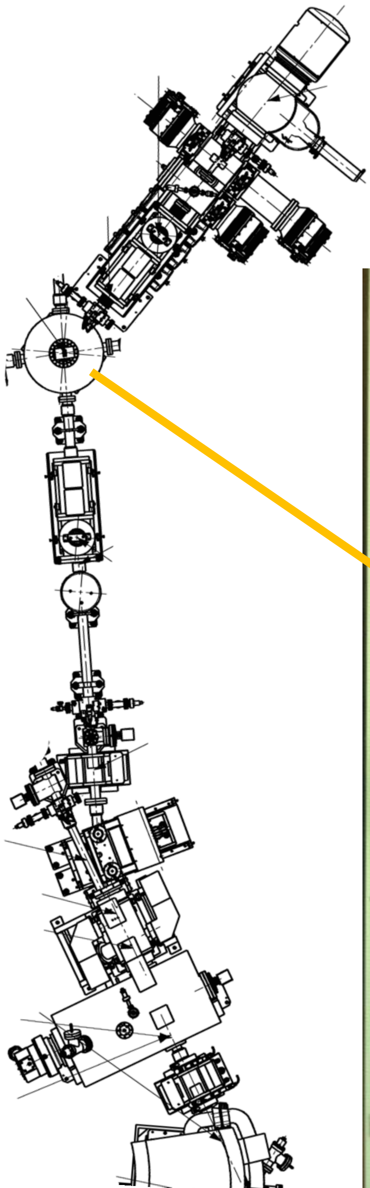


Shot-to-shot, Intra-pulse, Intensity Instability in ELENA



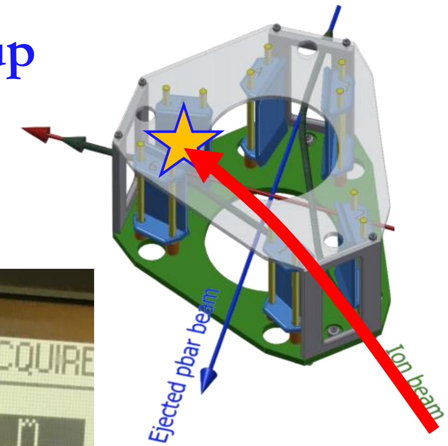


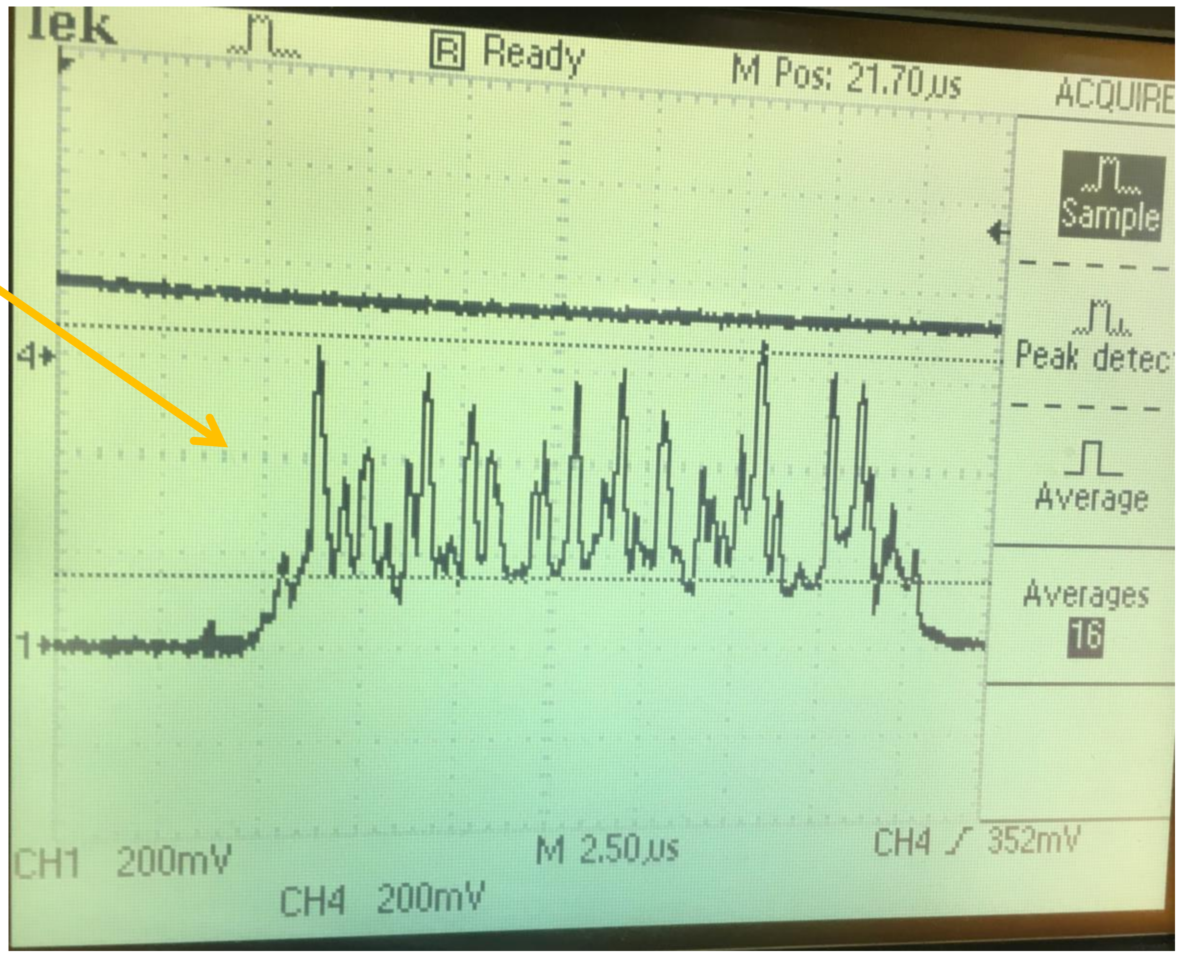
Looking for other possible signals



Using one plate of Ion Switch as a Faraday Cup

- Deposited charge evacuated by a resistance to ground

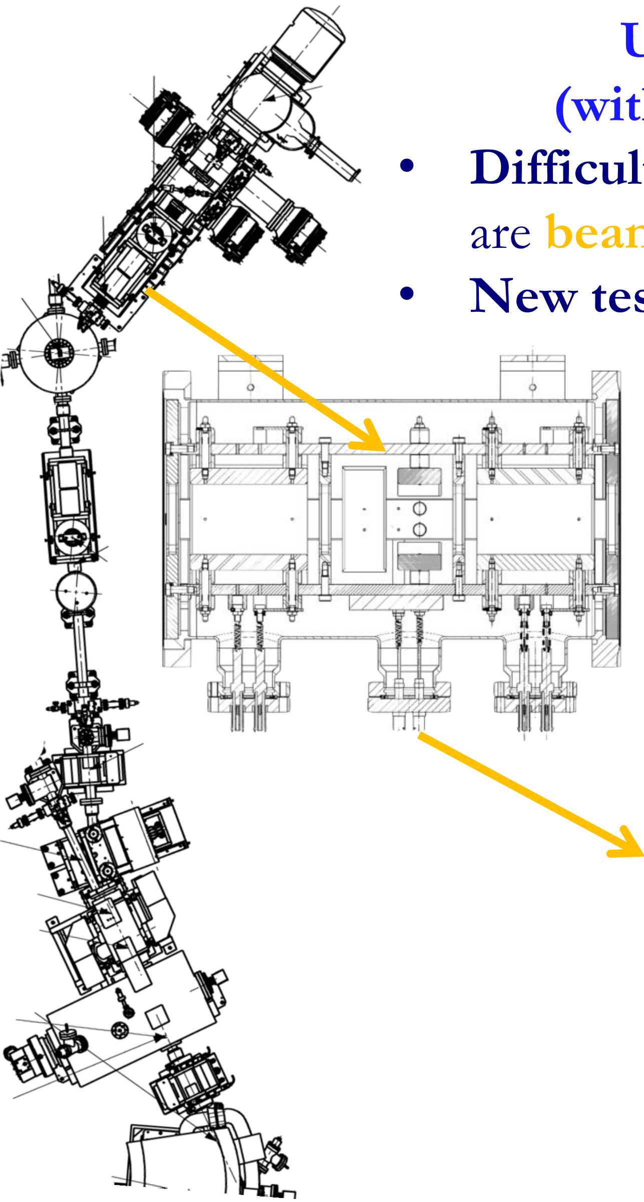


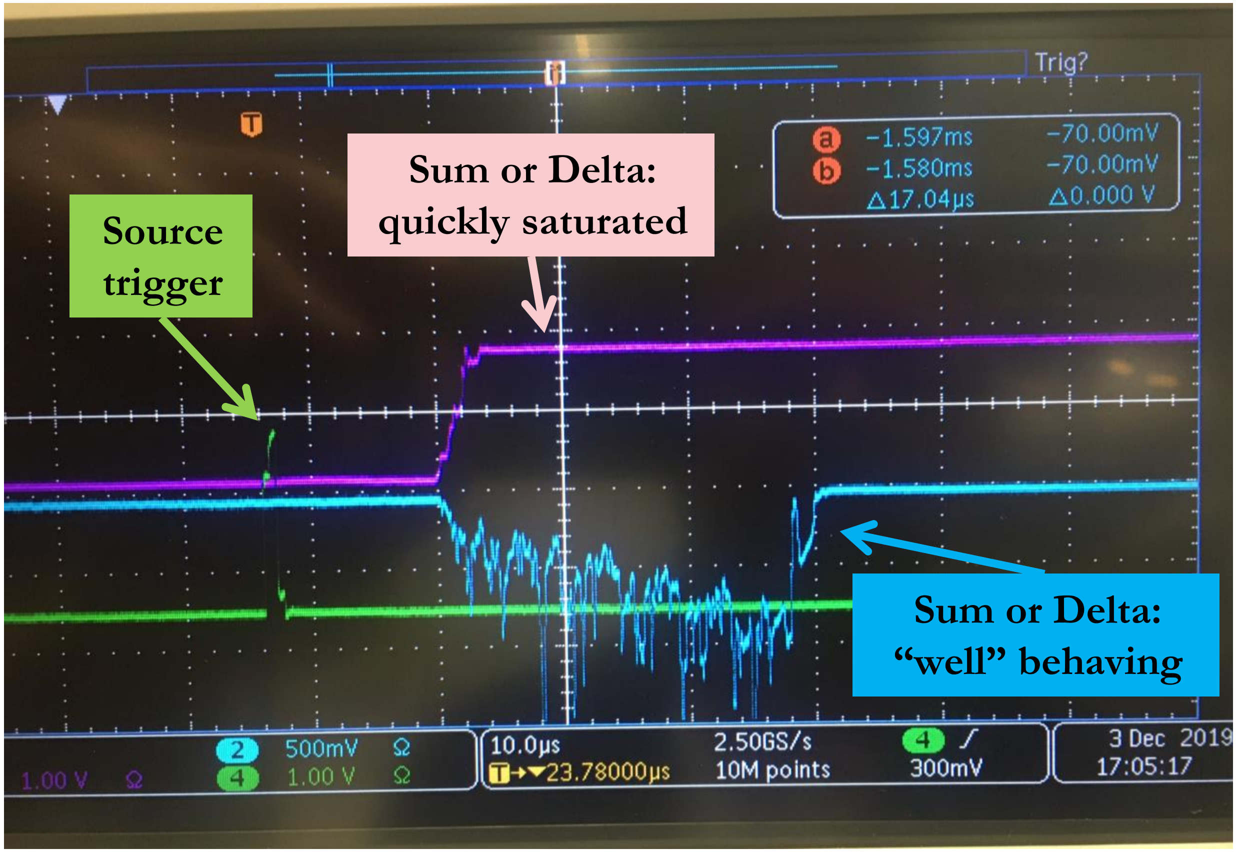


Looking for other possible signals

Using the orbit corrector in LNS line as BPM (with charge amplifier used in ELENA ring BPMs)

- **Difficult measurement**, as amplifiers saturate quickly **if** there are beam losses on the electrodes.
- **New tests** in **LNE50** foreseen for the end of this week

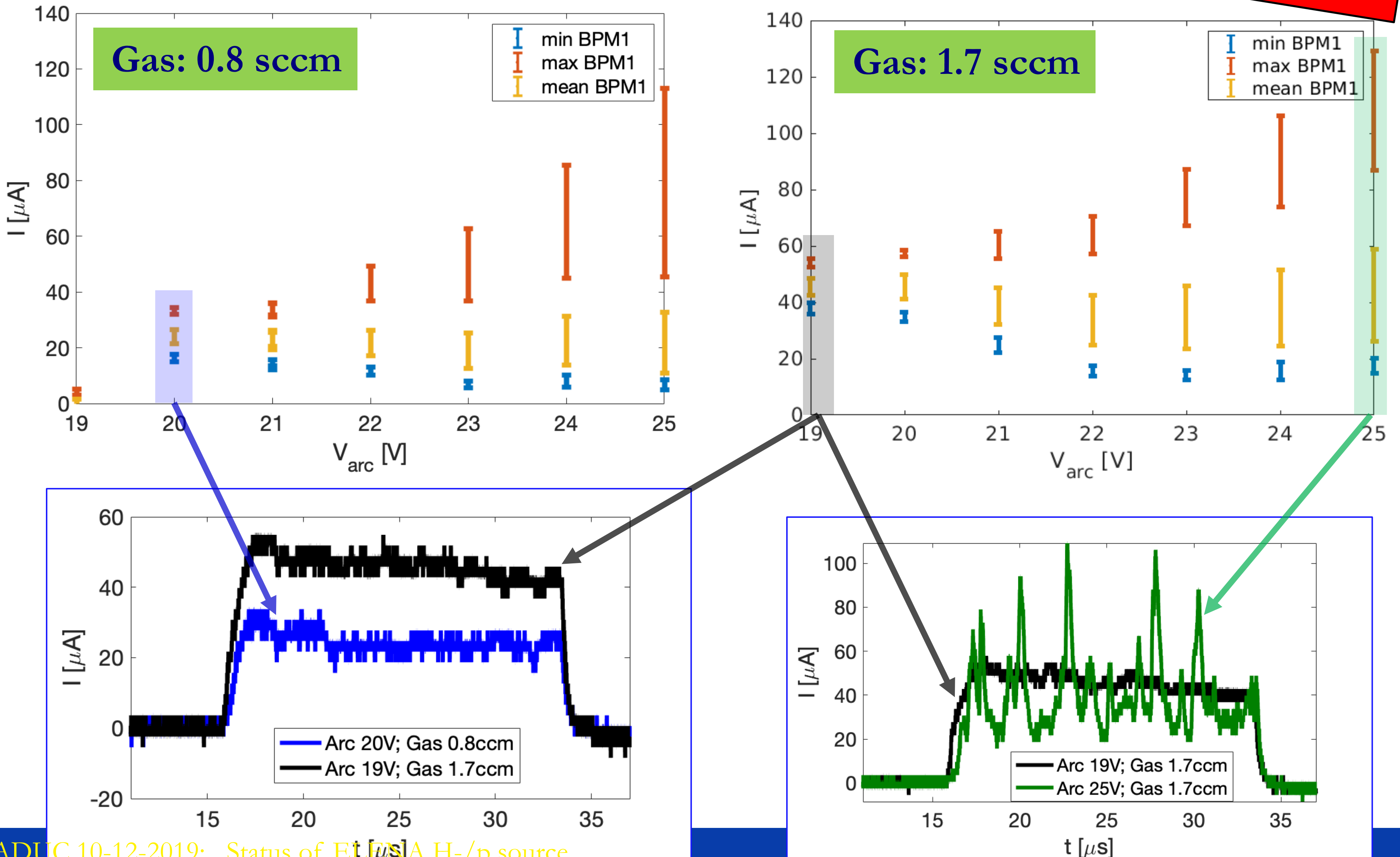




Back to BPM in the ring as main observable
scan over arc voltage

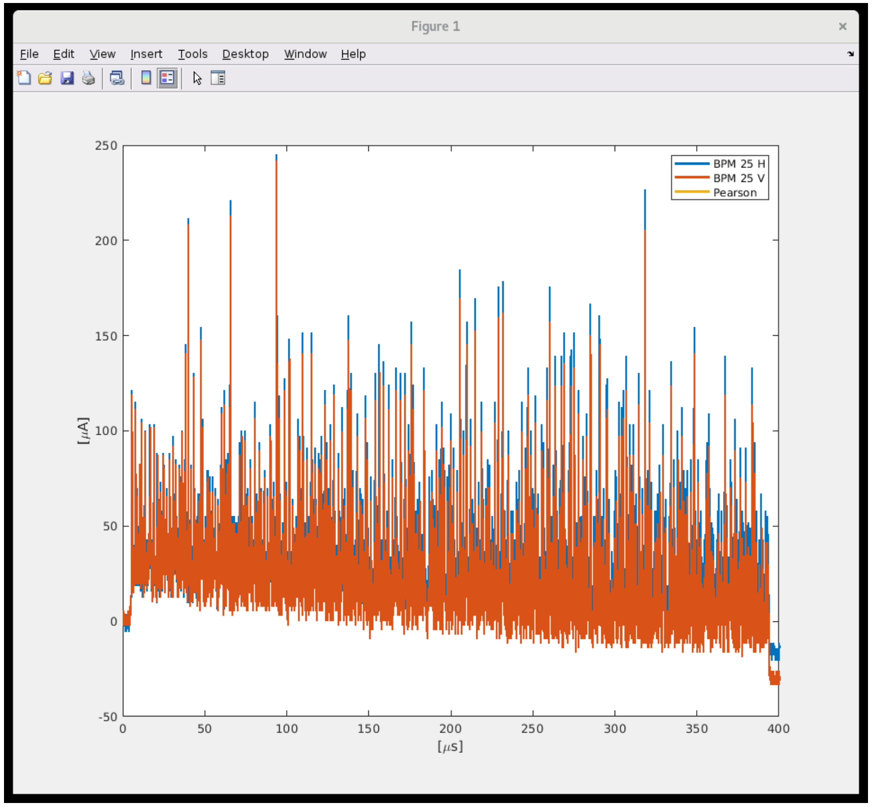
Warning: ~x2.5 over-estimated current

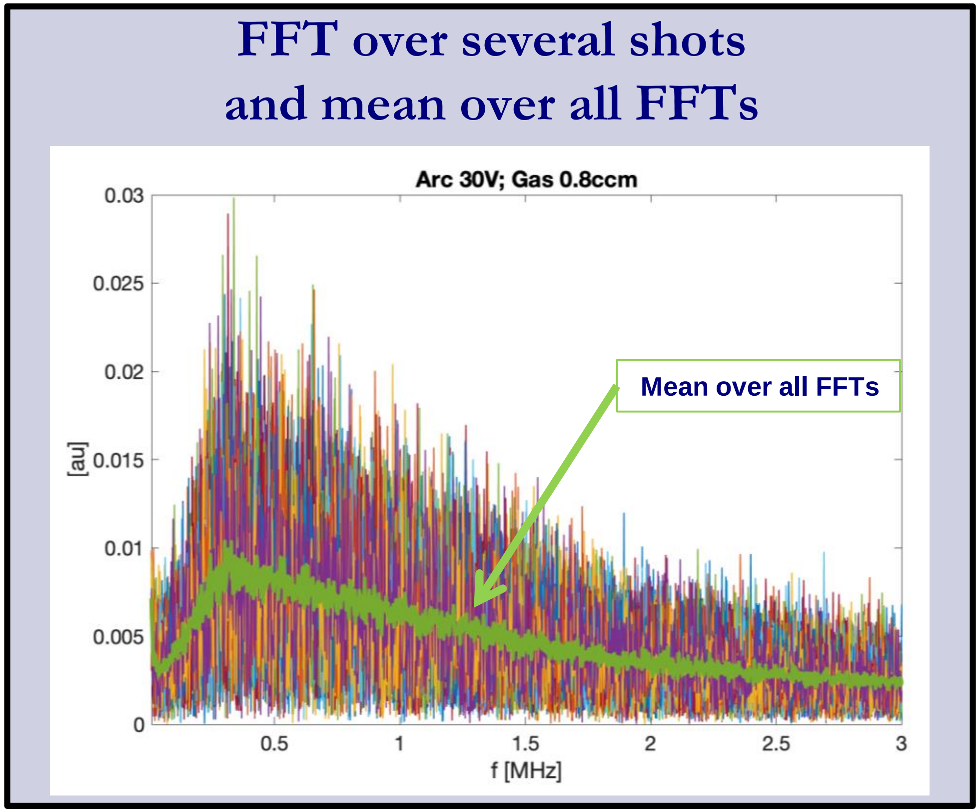
- Basic parameters: 2650 V_{puller}; 6% filament;



Looking at ~long pulses (390 us)

- **Does the oscillation dump with time? (doesn't seems so)**
- Is there a **specific** (plasma?) **frequency**?
  - For **1 MHz oscillation** one would expect **~10^{10} m^{-3} plasma density**
    - **Possible!? To be investigated.**

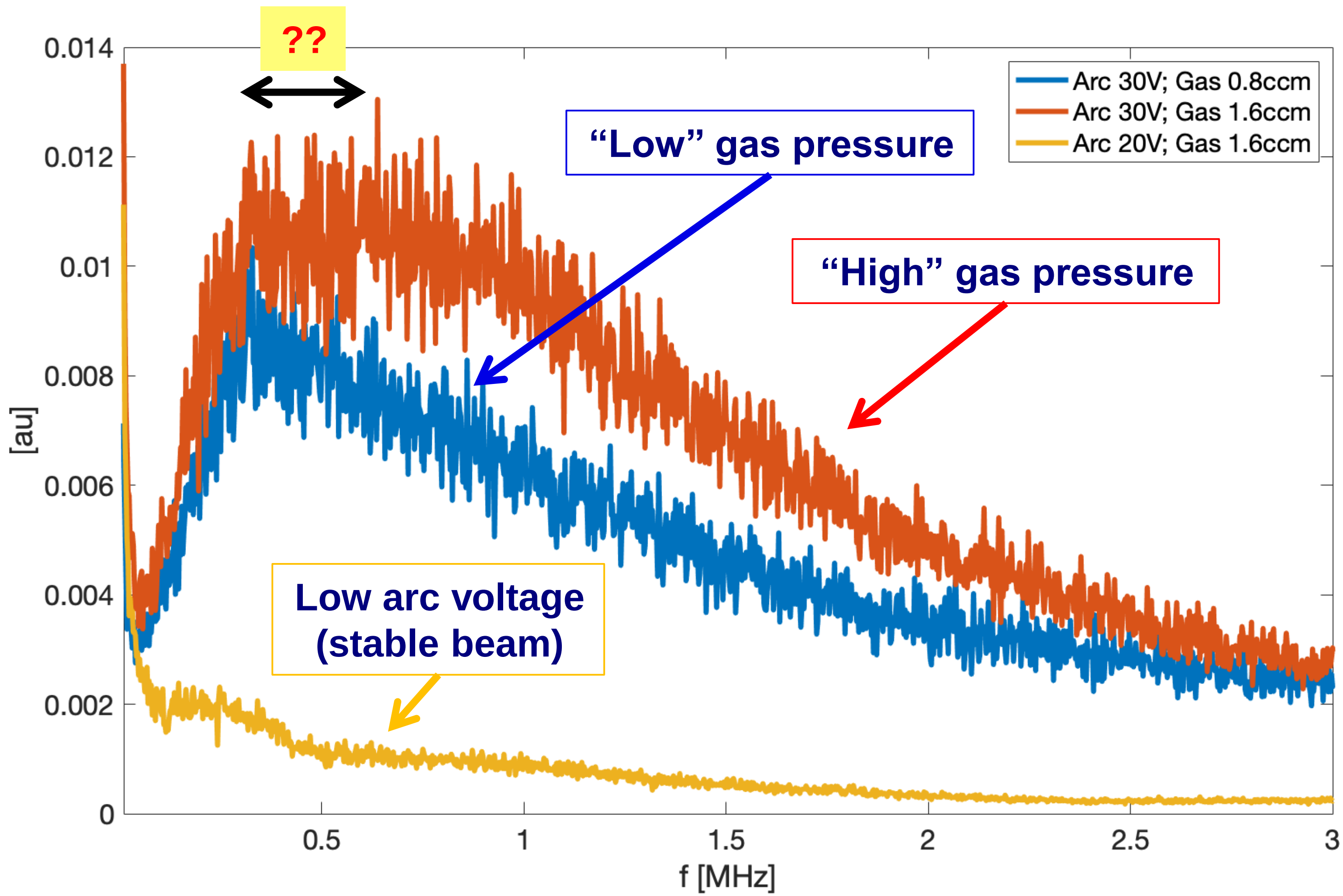




(2650 V_{puller}; 6% filament (7V_{fil}, 45.8 A_{fil}); 30 V_{arc} (1.5 A_{arc}); 0.8 sccm)

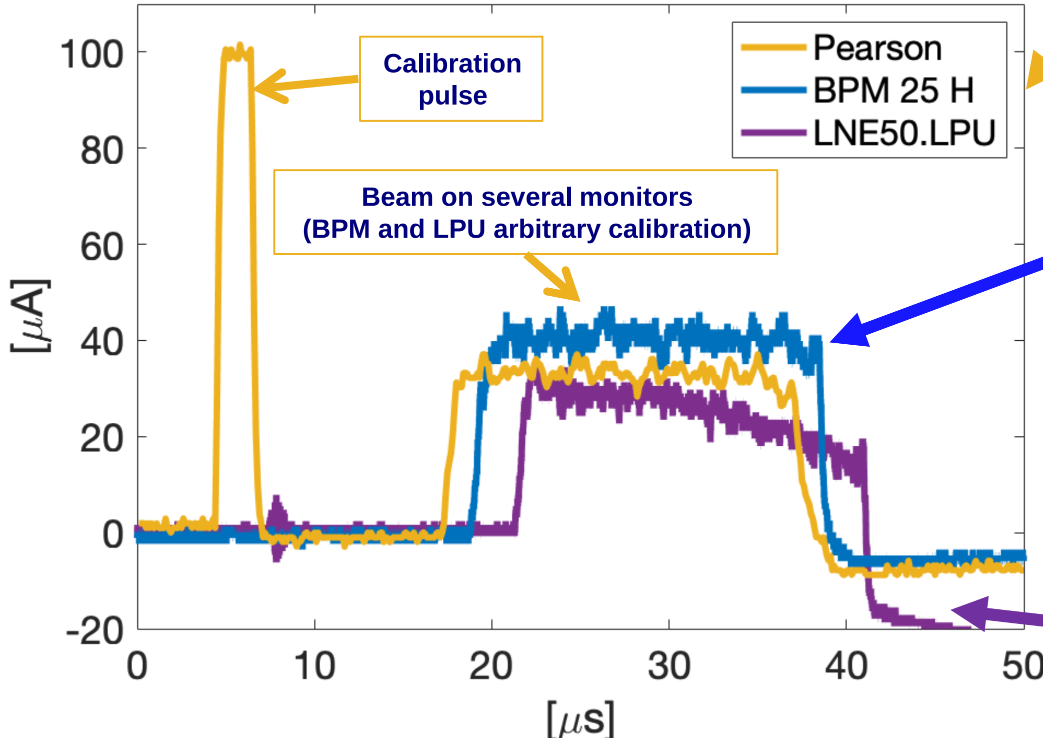
Doubling injected gas

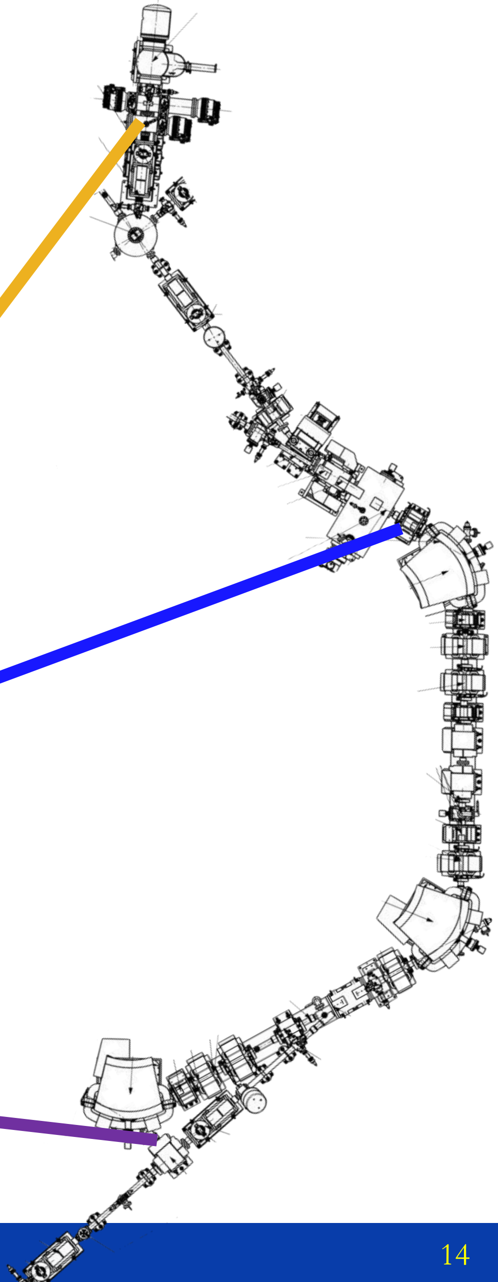
- If plasma oscillation, the "dominant" frequency should move of sqrt(2)
  - Maybe compatible with preliminary observation, but more needed…



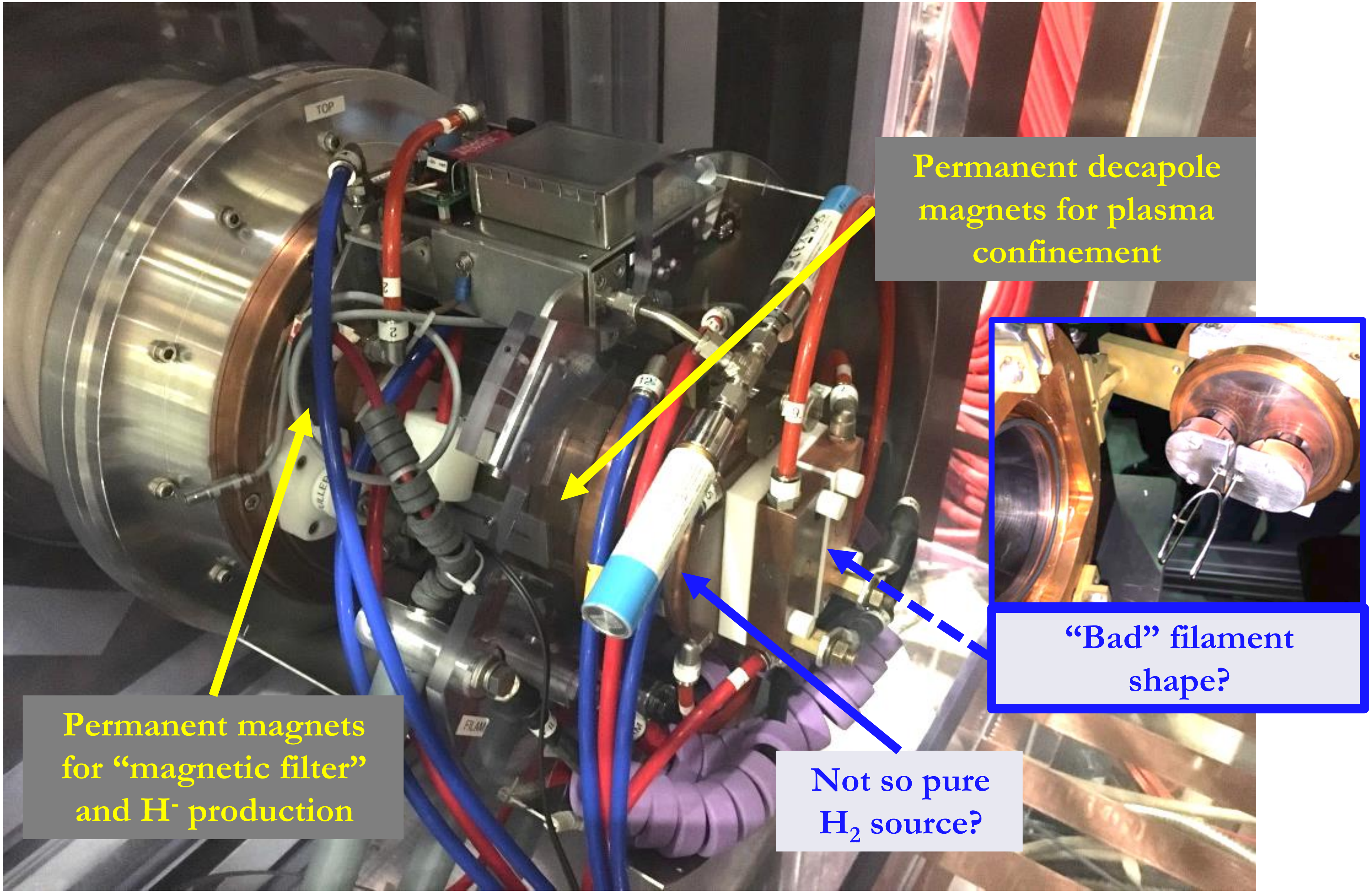
Still, a possible solution identified

- Installed a more **sensitive BCT** in the source
  - **Allows for "standalone" investigations**
- Running with "**low**" **arc voltage**
  - **Great stability**, but lower beam current production

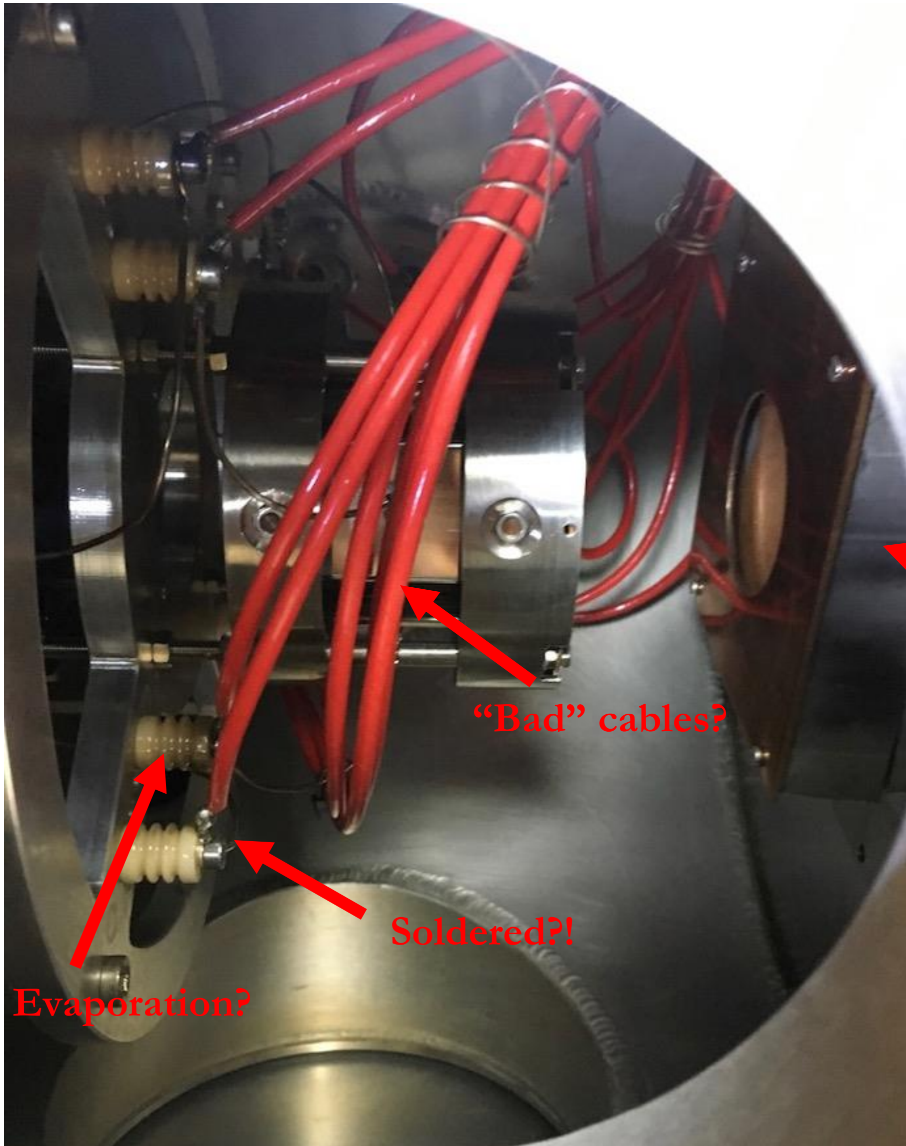


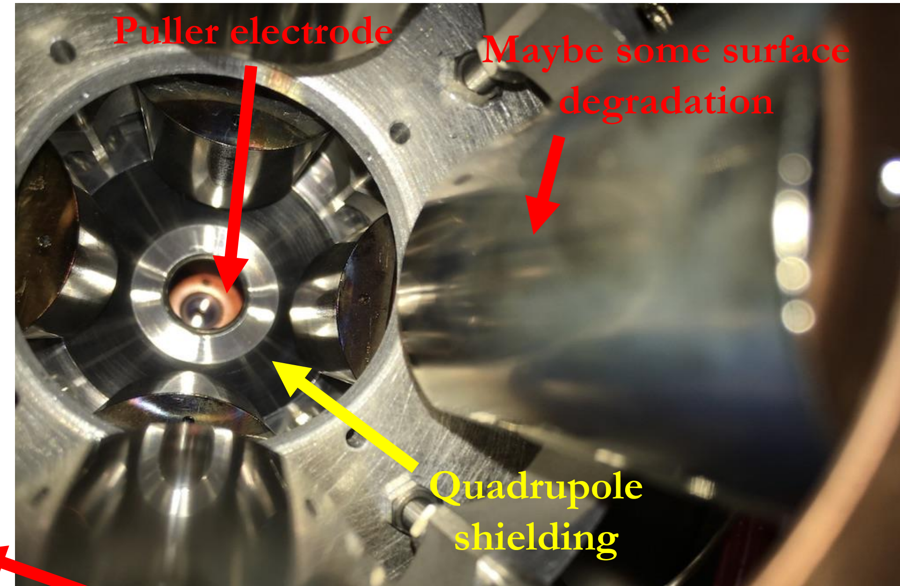


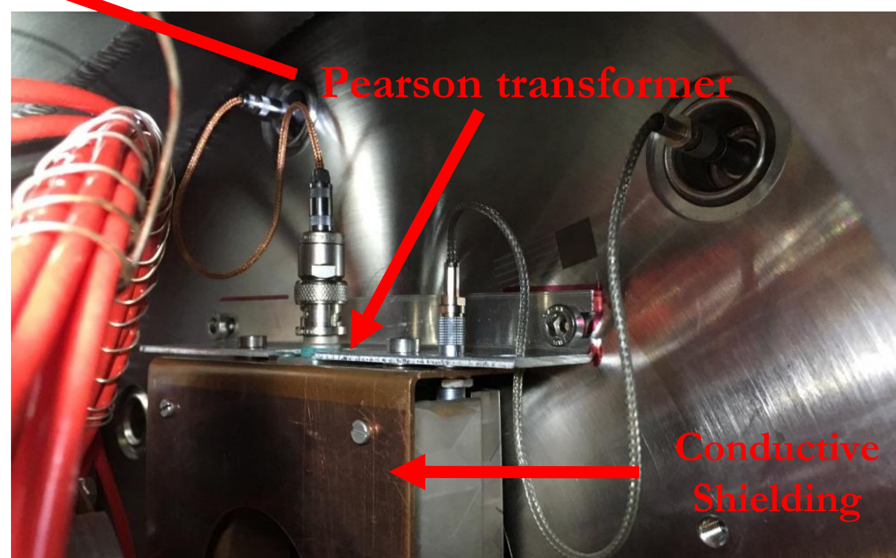
Future investigations:
intra-pulse instability: some wrong configuration?



Future investigations:
position instability: something charging in front of source?







Conclusions

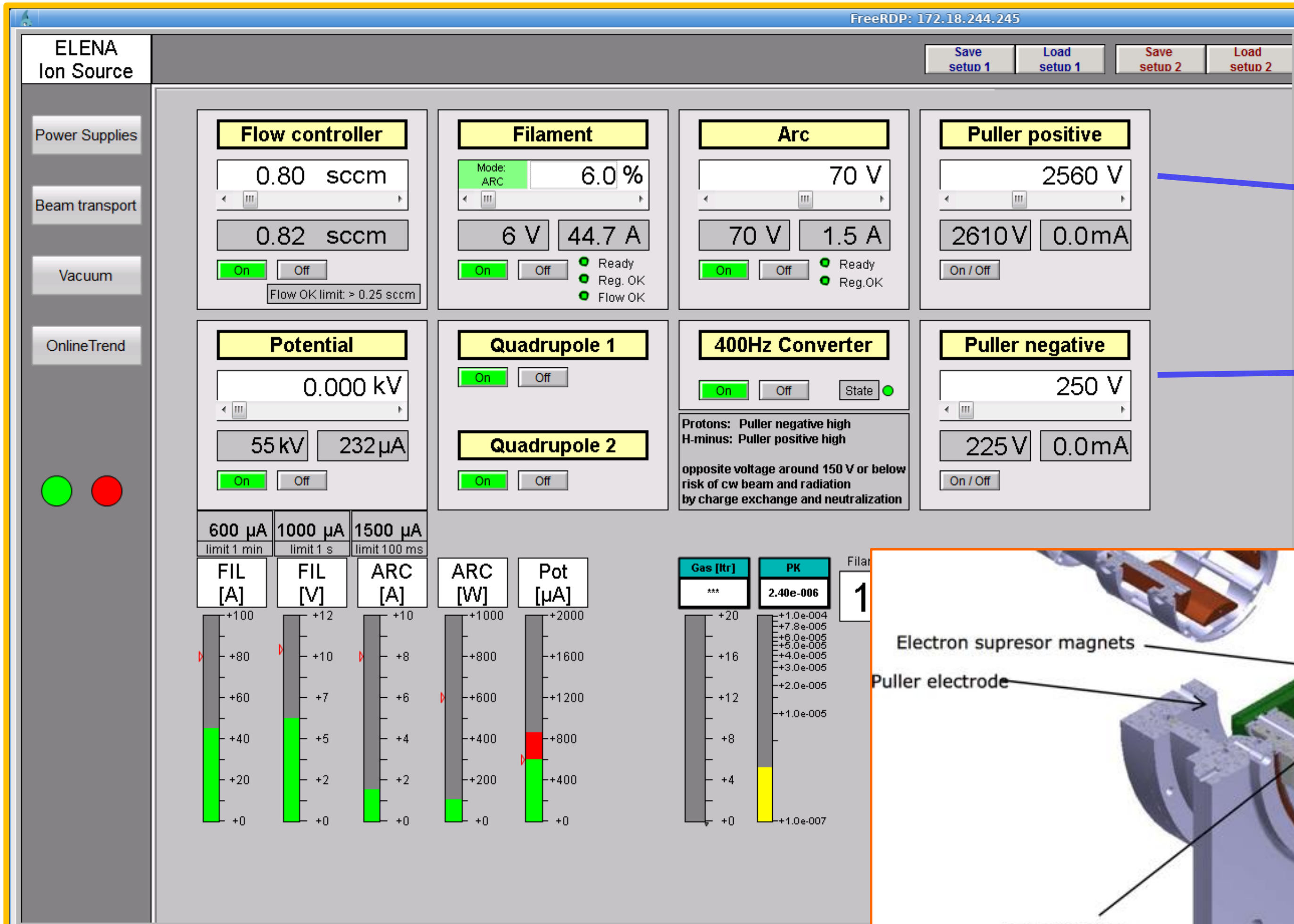
- **HV insulation transformer**
  - **2019v1** version can run **@100 keV in pulsed mode**
    - **Only** possible to run with **H⁻**, **no protons** @100 keV (but lower maybe possible)
  - **2019v2** version looks promising
    - So far tested only for **negative voltage** (H^-): **to be tested for protons**
- Beam **intra-pulse stability**
  - Still **investigating** the **mechanism** that generates the instability
  - **Backup solution: run at low arc voltage**
    - ~about **40 uA stable beam** can be produced and transported to the ring
- Beam **position stability**
  - Probably due to charging up of some components
    - plans to improve shielding and components quality/grounding
  - "**Sporadic**" effect – **not a major threaten** for transfer line commissioning
- **Beam instrumentation improved** for **standalone investigations**

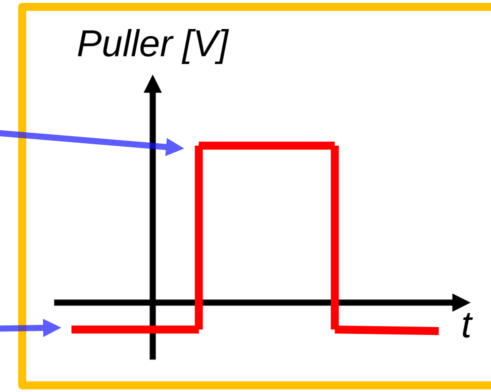
Thank you!

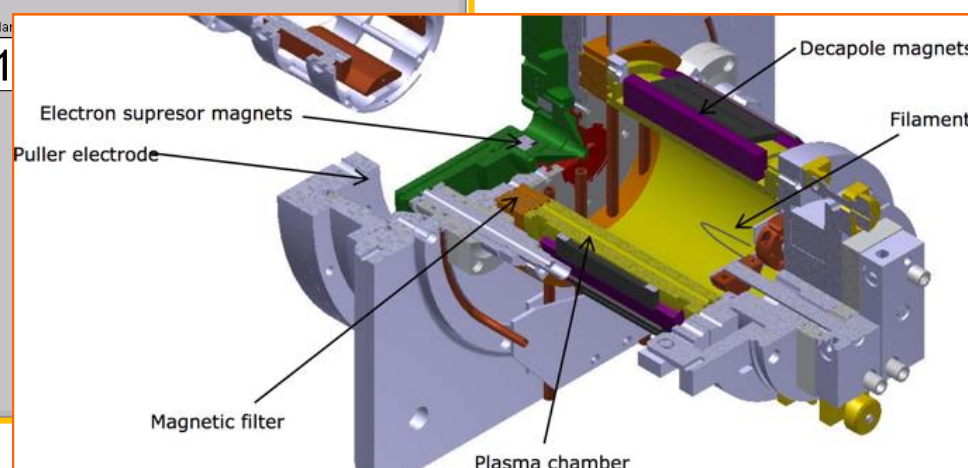
Backup

Source control

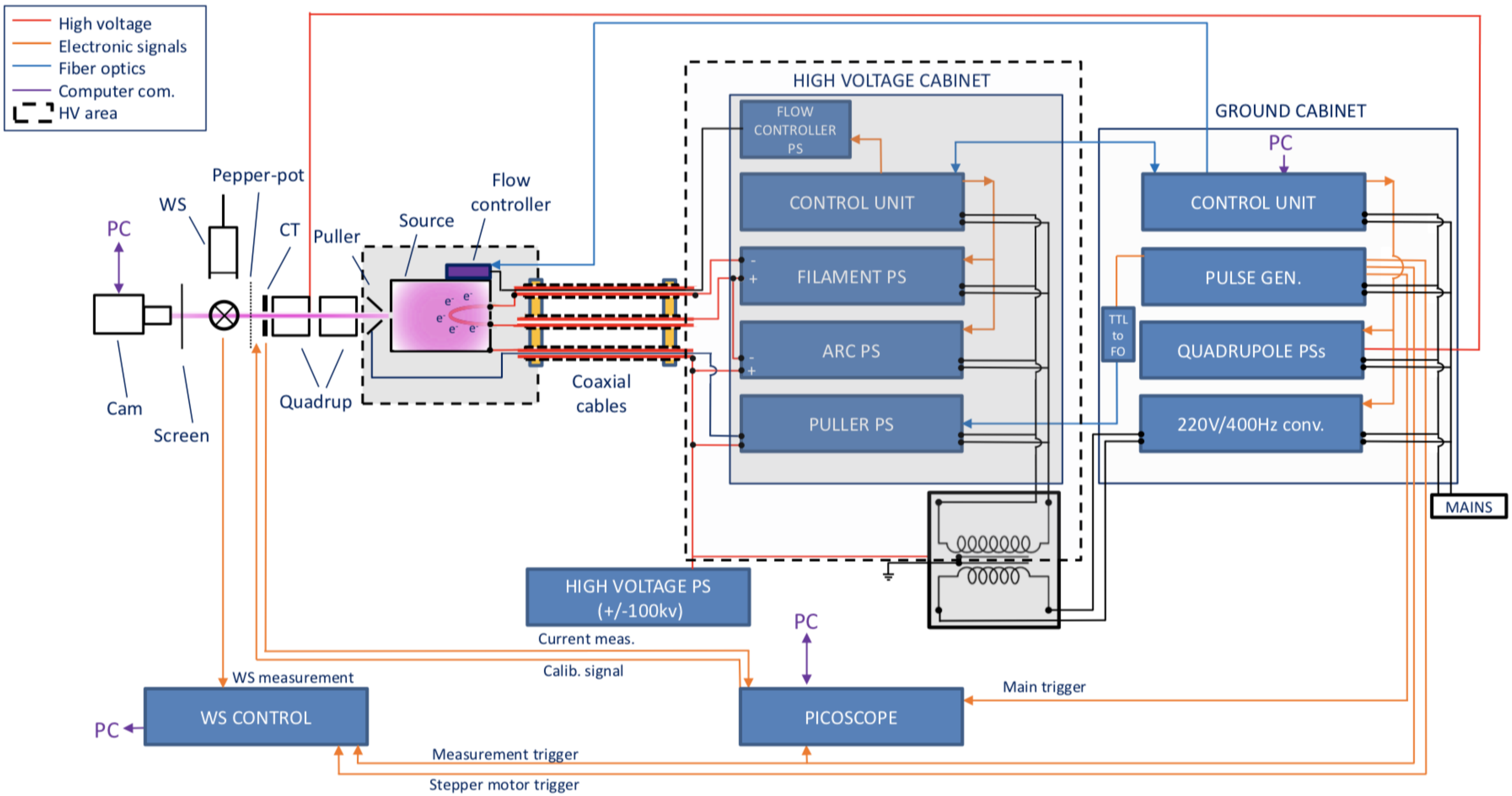
- Control via PLC of main DC voltages
- Filament automatically regulated to keep Arc current stable (?)







Source cabling



from Ana Megía-Macías - link

In which regime are we?

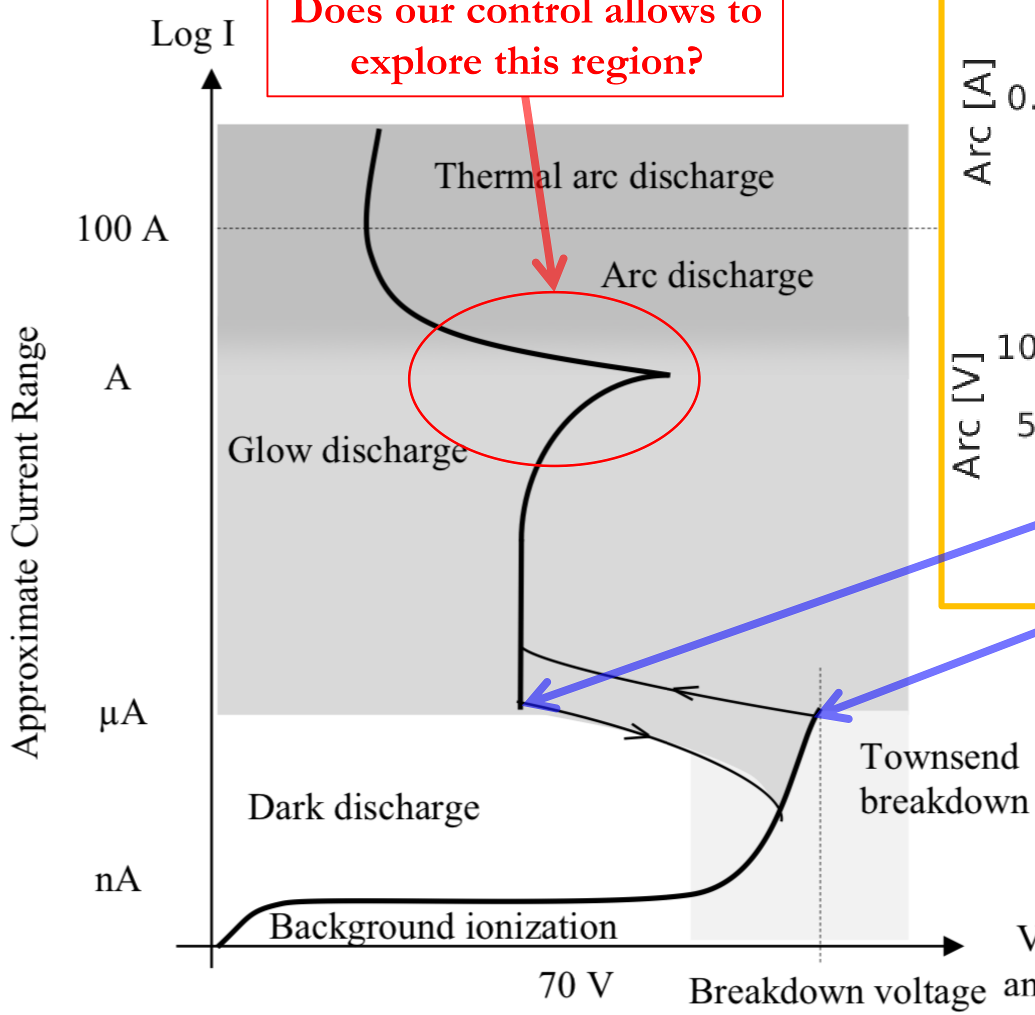
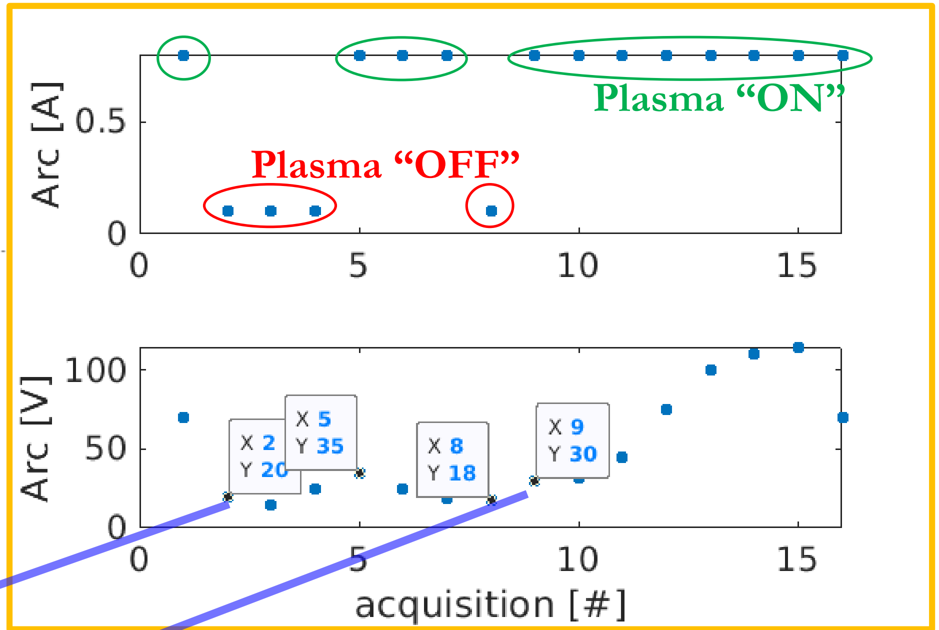


Fig. 3: The current voltage characteristics of a typical electrical discharge



We need ~30 V to "start" the plasma, then down to ~20 V to stop it

From ***Ion sources for high-power hadron accelerators*** by *D. C. Faircloth* - link

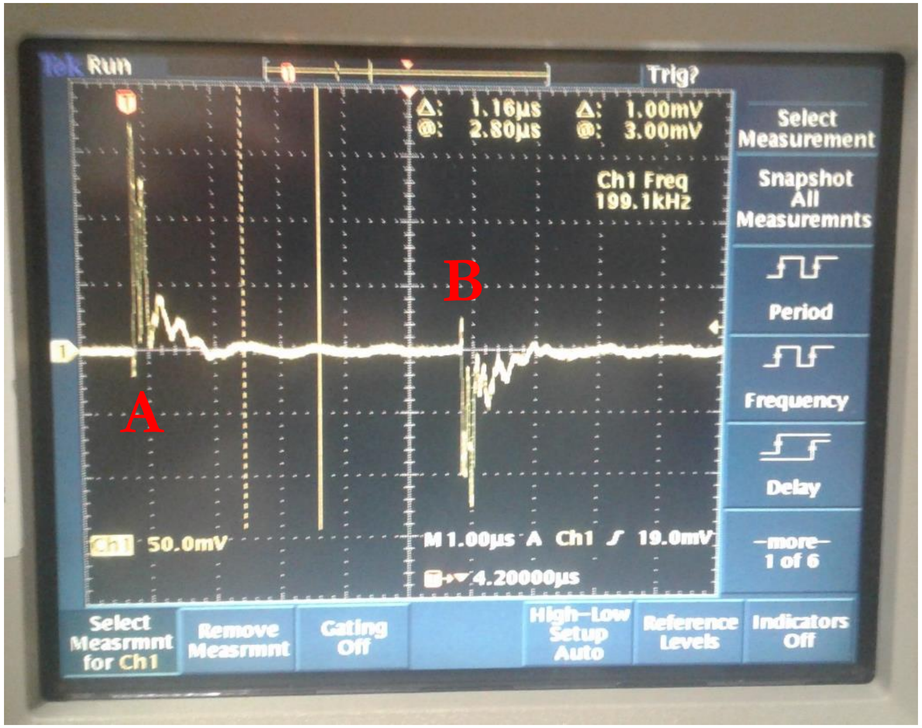
Measure instabilities of arc current

1 us / div
5 mA / div

A & B – switching of puller voltage

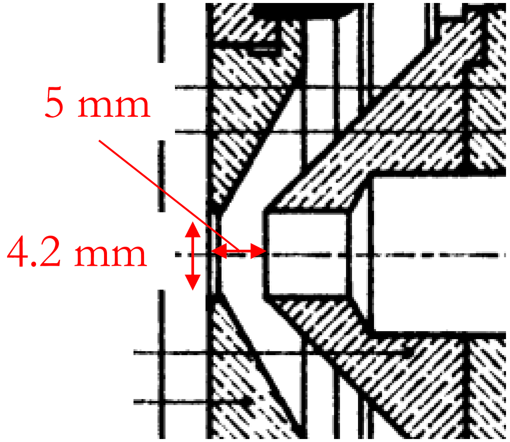
Pearson 110 current transformer placed around arc return cable 10 cm from the exit of the plasma chamber. The source was operated with 38 A filament current and 1 A arc current.

The first peaks in the damped oscillation corresponds to 170 mV*0.1 A/V= 17 mA, which is still significantly lower than the average 1 A arc current. The noise is related to the switching of the puller electrode in time.



! No erratic noise corresponding to the signal seen on the extracted current !

Source perveance

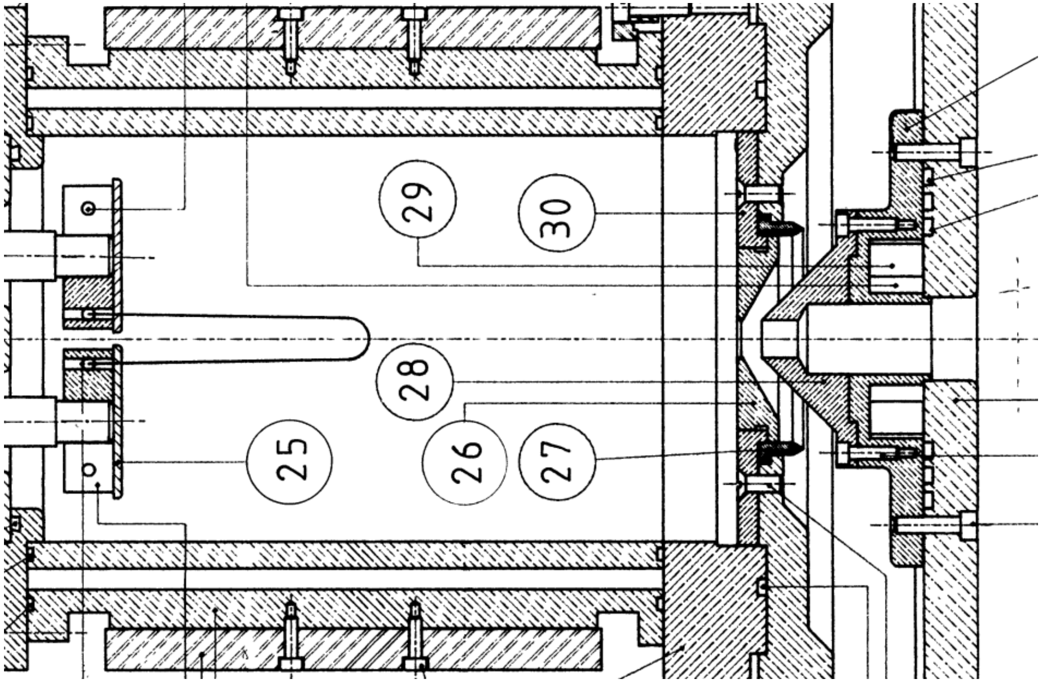


4 mA extractable H- current

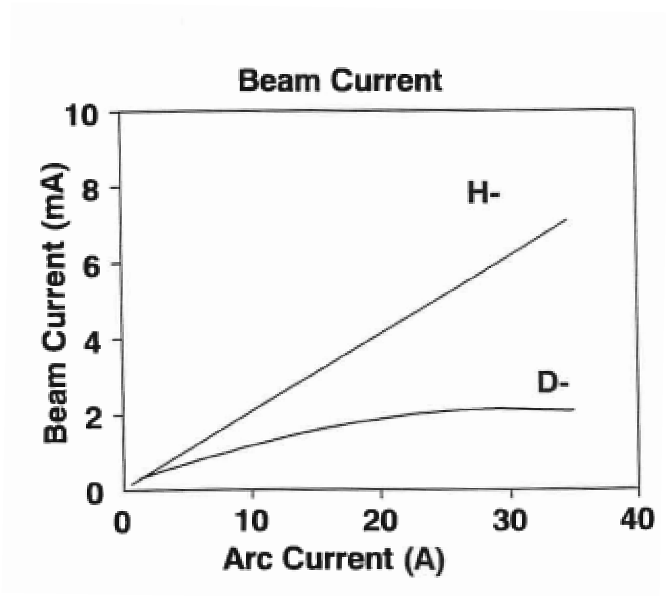
* analytic formula for a planar diode
* plasma electrode diameter 4.2 mm, distance plasma electrode to puller 5 mm, extraction voltage 3000 V, ignoring electrons)

significantly higher than 100 uA being extracted

Ralf Gebel from Julich writes '9 mm and 6 mm plasma electrode versions should be available too, if you need more beam current. 6 mm is fine for 300 uA. 9 mm if you need a milliamp



Source operation point



ELENA source
Iarc=1-2 A
Uarc=70 V
Q=0.006-0.018 Torr*l/s