ELENA Ion Source Status

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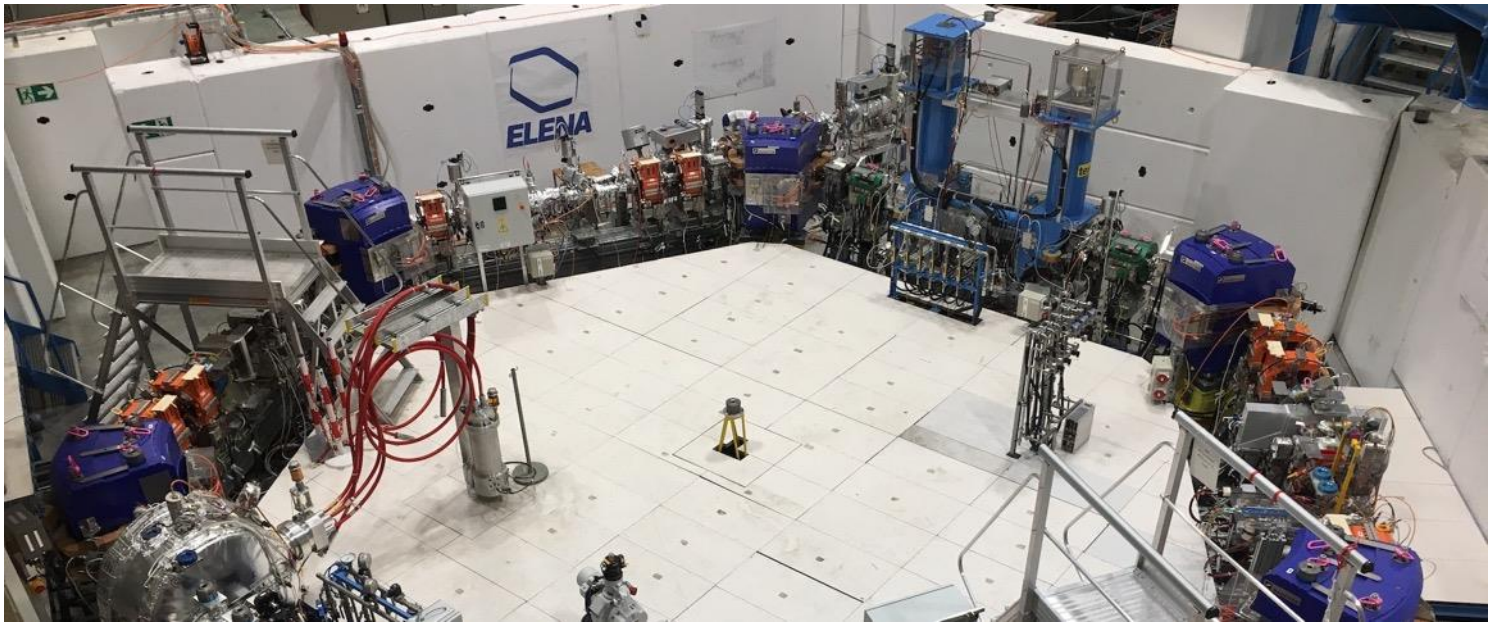
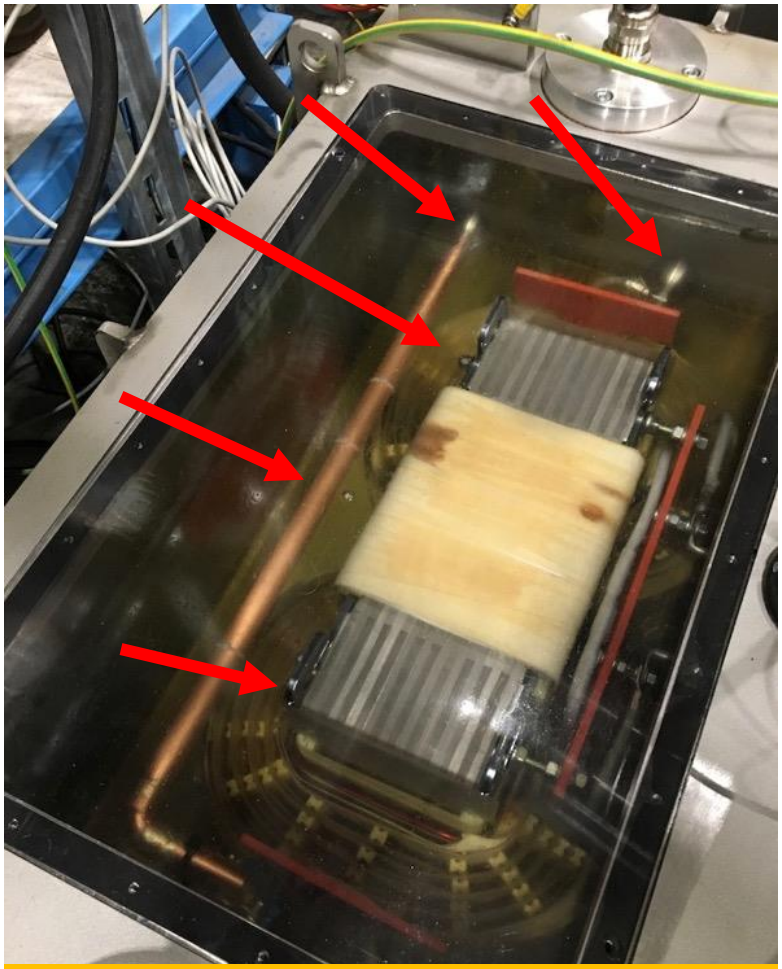
12th Sep. 2019



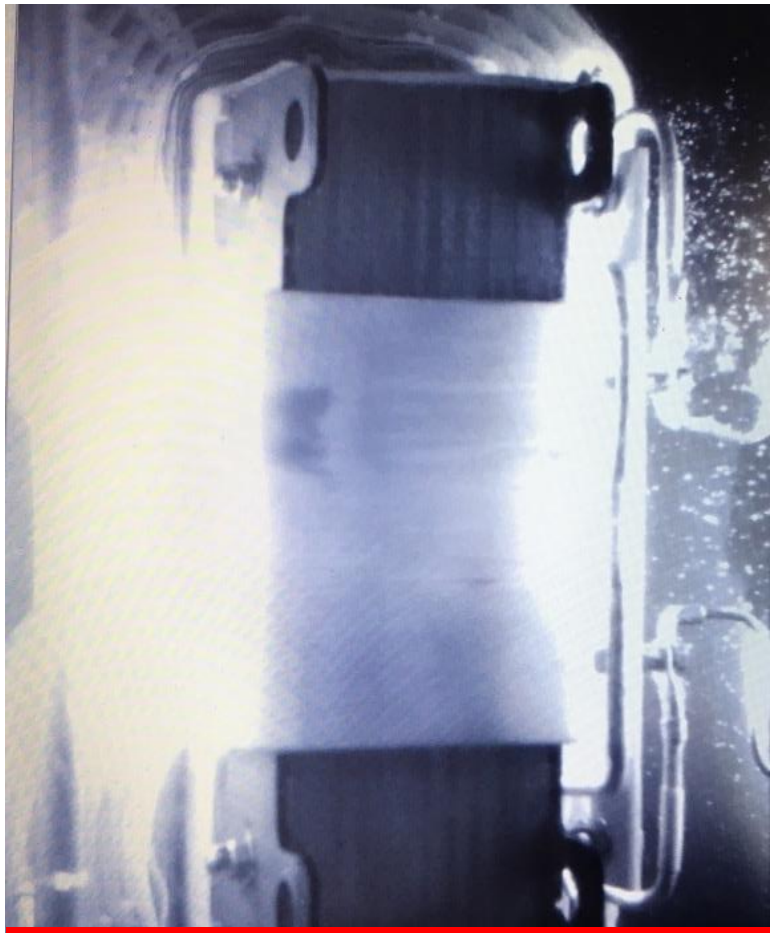
- Insulation Transformer Investigations
- Beam Instability Investigations
- Plans

Insulation Transformer

- Unfortunately, **still problems** with (new) transformer (**arrived and installed in 2019**)
  - (**designed** and **produced** by an **external company** with **constraints** of tank **size** (and its **viewport**))



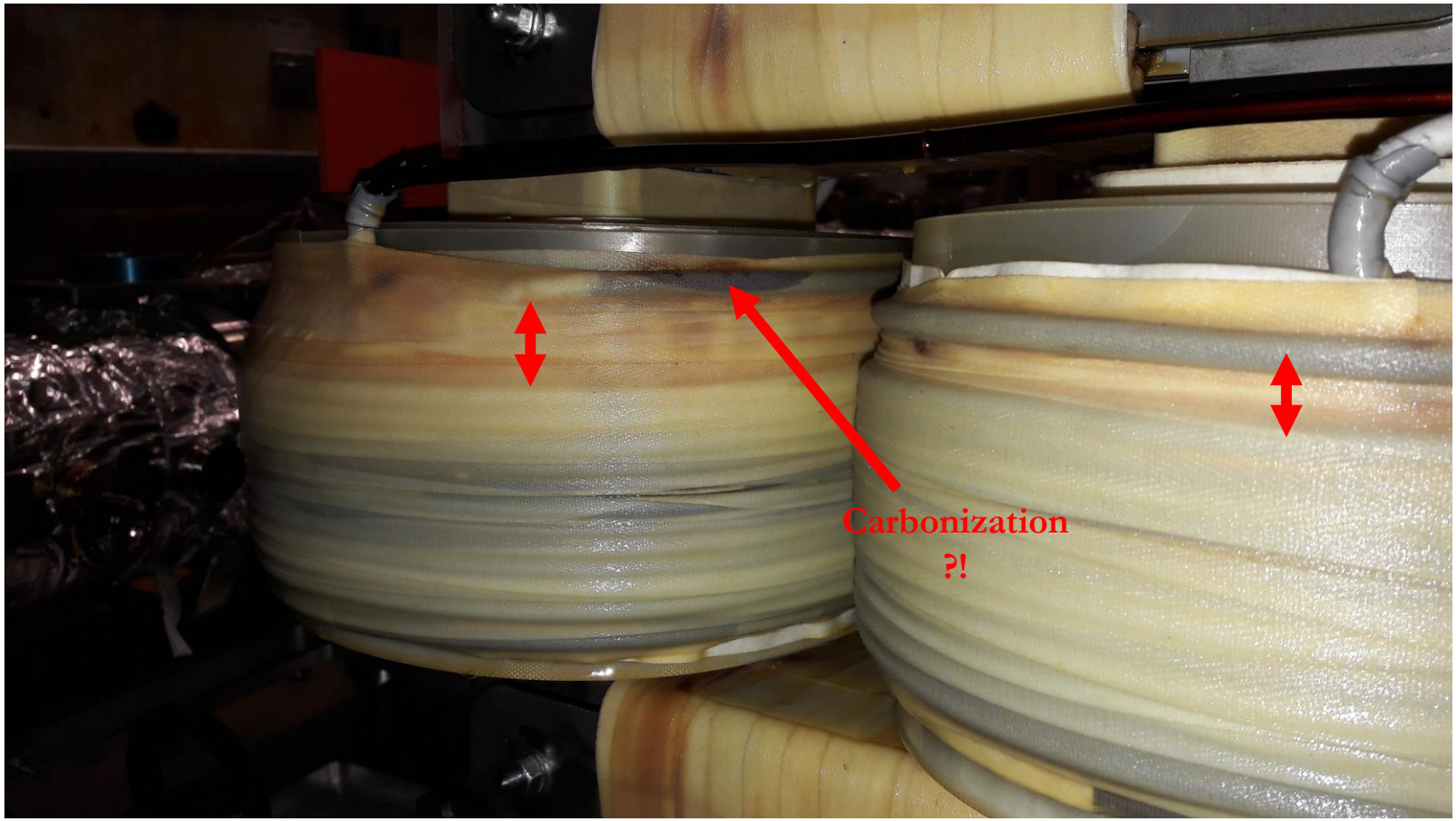
Several improvements by EPC



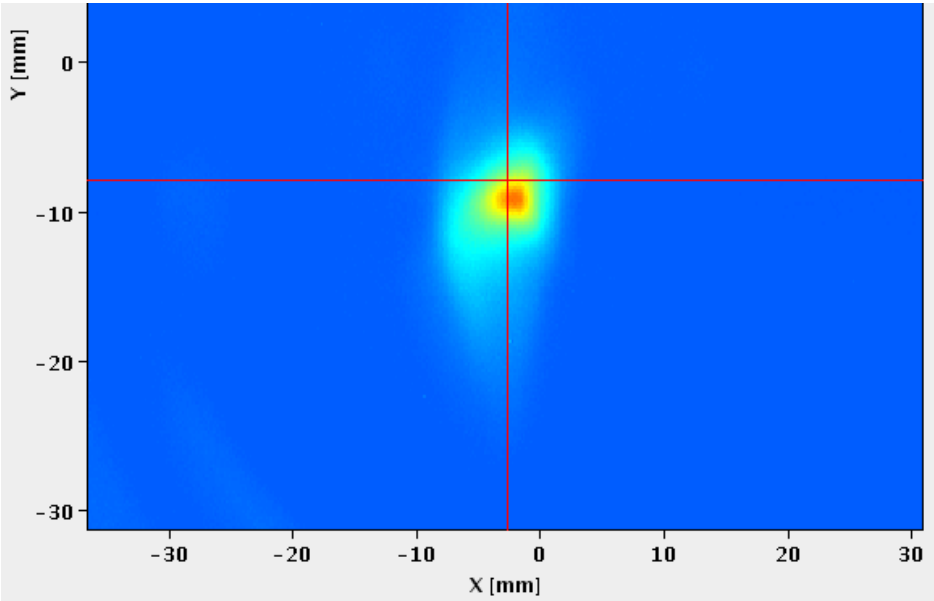
Still sparking + degradation: secondary to magnetic core

Insulation Transformer

- After **investigation by EPC**, it looks like **last turn of secondary winding is to close to magnetic core**: possibly a **construction error** – design maybe good.
- **Present plan** is to **build a new transformer** (for free?) with optimized distances.
  - (Not "possible" to build a 50 Hz + 400 Hz transformer, at least not for free…)



Trying to Cycle the HV @100keV

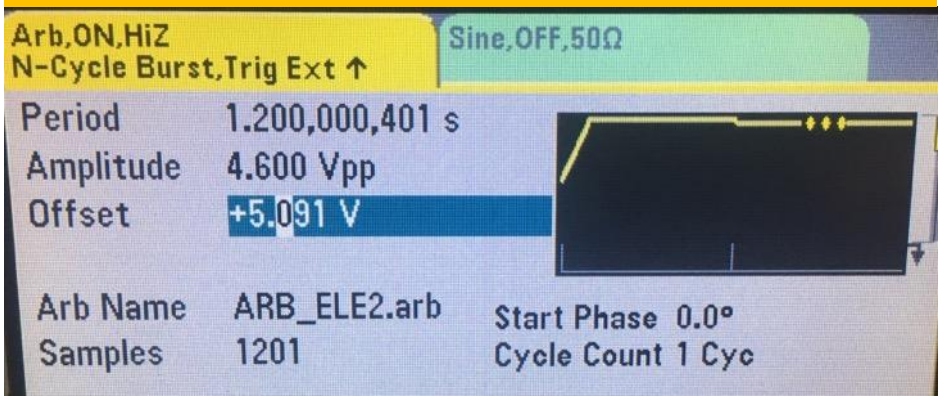


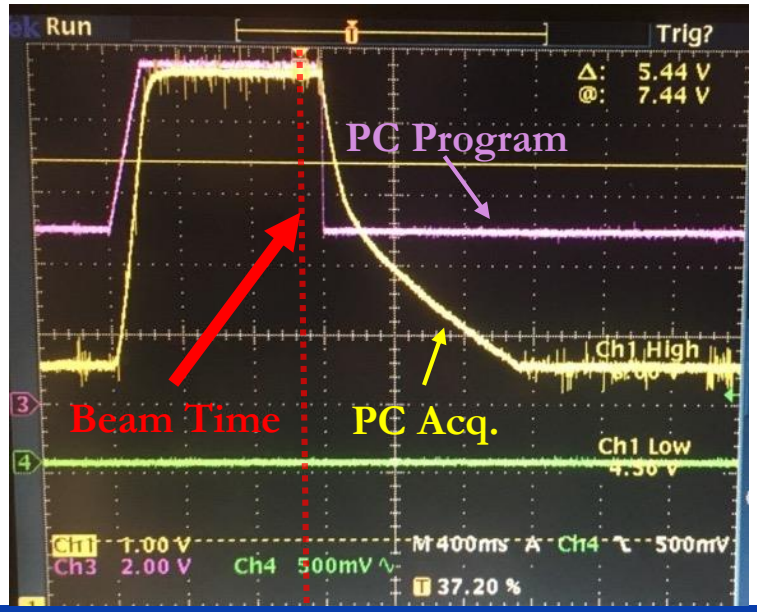
It has been possible to cycle HV and have 100 keV beam in ELENA

However:

- Had to program about **106.6 kV** **at HV PC**
  - **Tested only for a few hours**!
- Only possible to arrive **@95 kV with Positive HV (protons) (sparks in transformer)**
  - **Very little conditioning! To be re-done!**

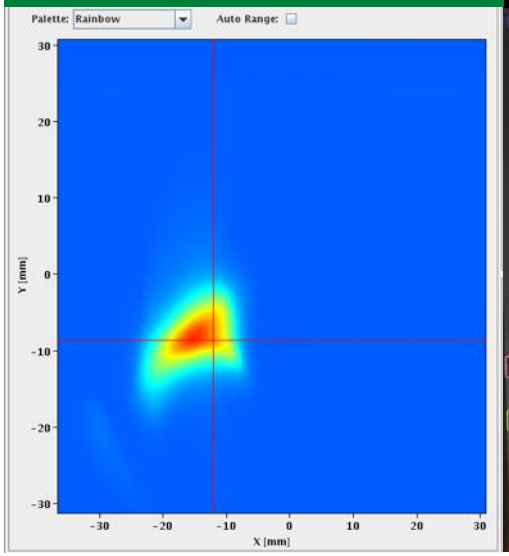
- **200 ms ramp from 56 kV to 106.6 kV**
- **Plateau of about 1 s before making beam**



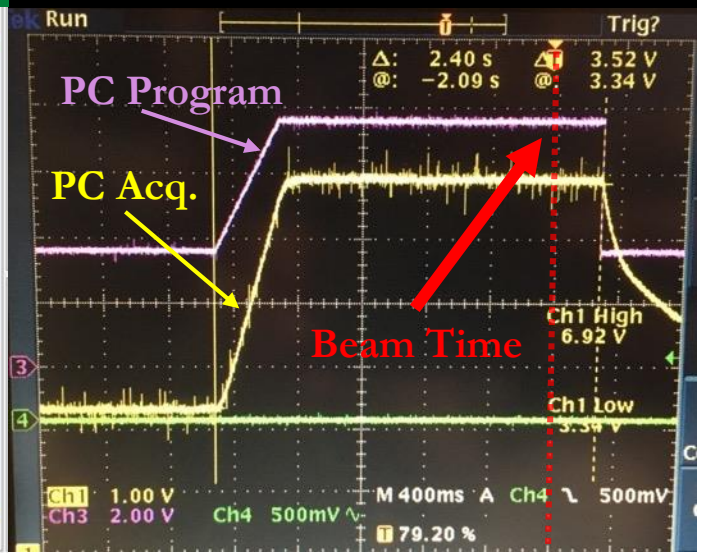


Trying to Cycle the HV:
delay on HV in the source wrt PC – 85 kV example

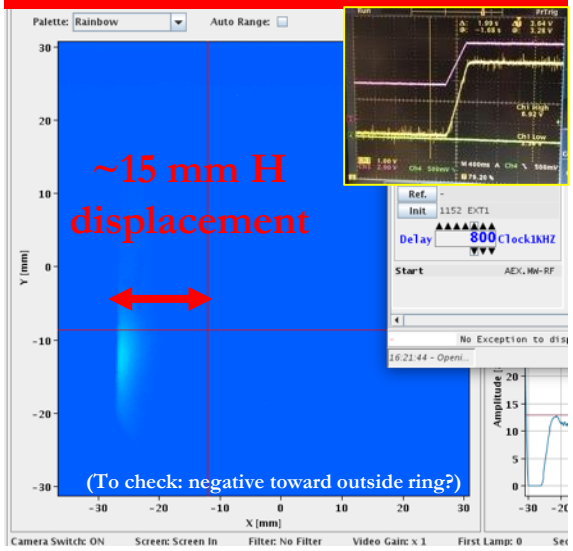
Basic Settings



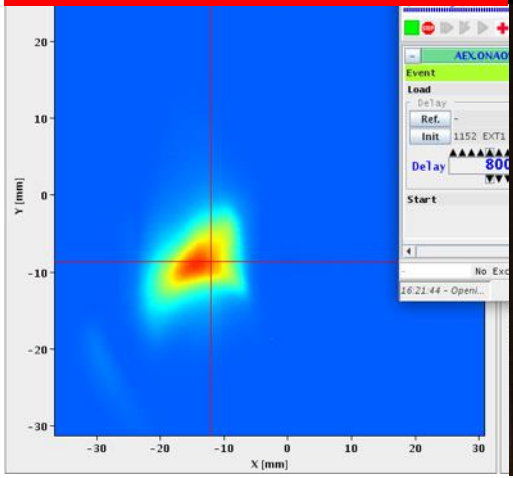
3.728 V offset + 4 V Amp. = 85kV



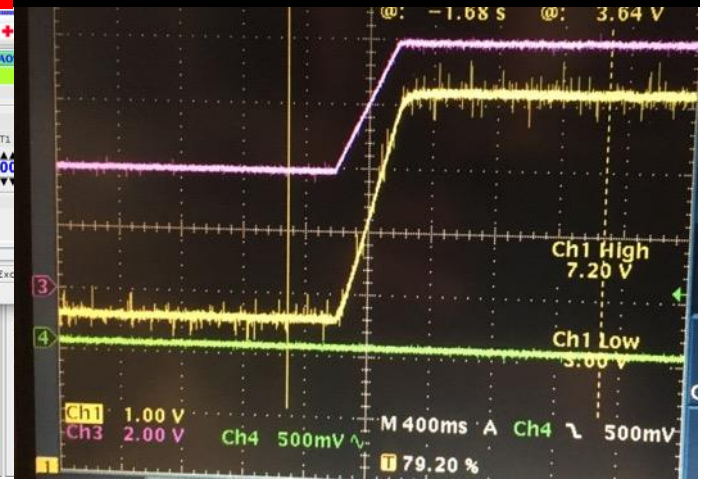
Delay HV by 800 ms



Delay HV by 800 ms



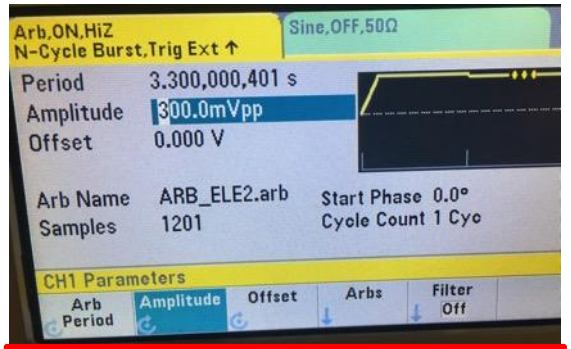
4.028 V offset + 4 V Amp. = 91kV

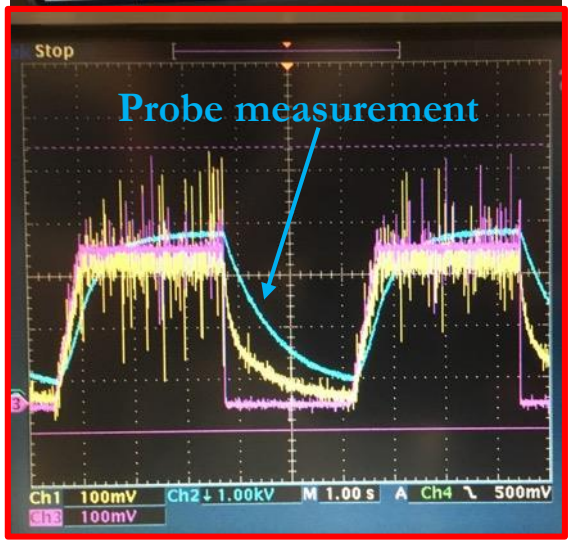


- Prove that despite PC acquisition is already at nominal voltage
- ~6 kV in 800 ms
- Gives **estimate of D_x**:
  - D_x = ~213 [mm/($\Delta E_k/E_{k0}$)]
    = ~418 [mm/($\Delta p/p_0$)]

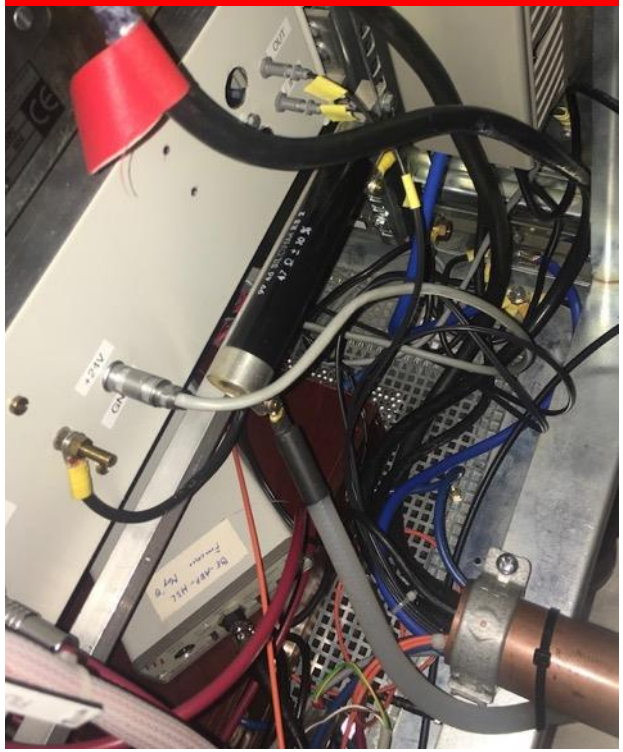
Trying to Cycle the HV:
delay on HV in the source wrt PC: verification

- Quick test with HV probe at 3.3 kV pulses (from 0)



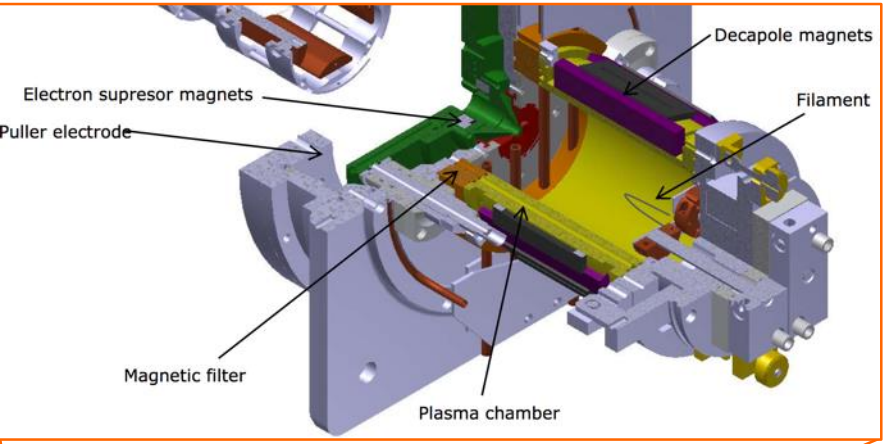


Initially thought could be due to resistor from PC to source



- **EPC investigation:** the **delay** is caused by the **voltage regulation settings** (internal to PC) combined with voltage delay due to **stray capacitances.**
  - **Possible to "solve it" with modification of regulation circuit.**

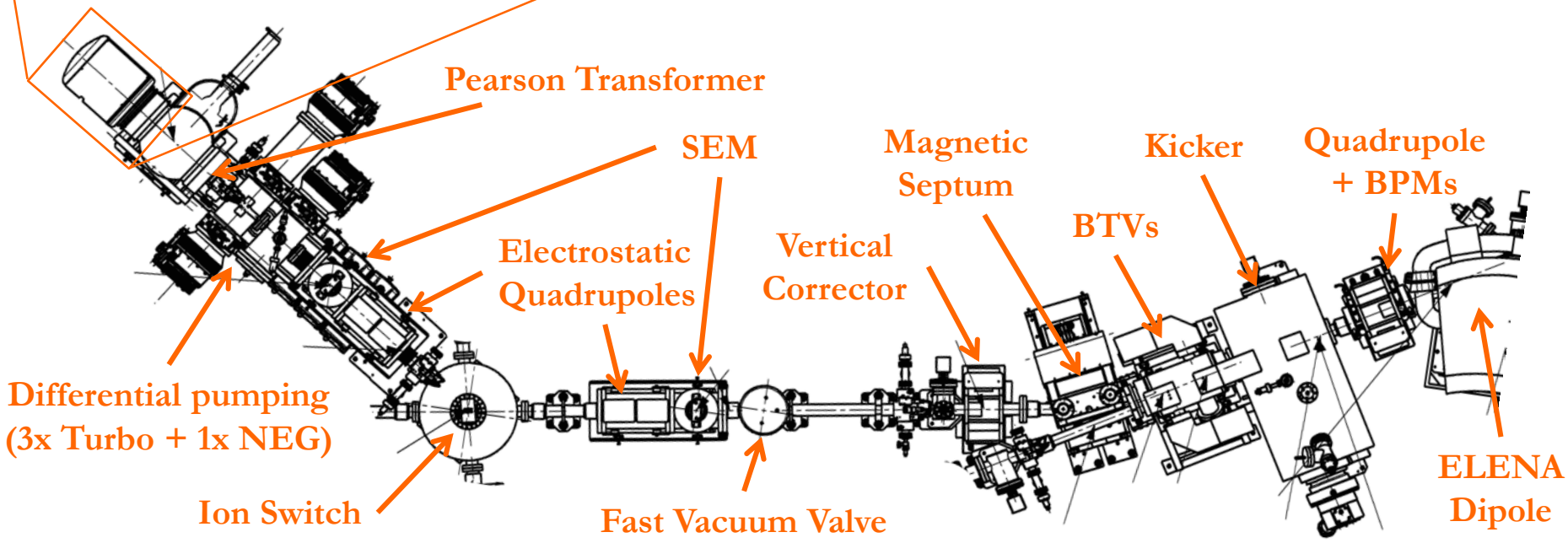
From Source to Ring



Only DC Power Supplies control via PLC in Faraday Cage

Wish list:

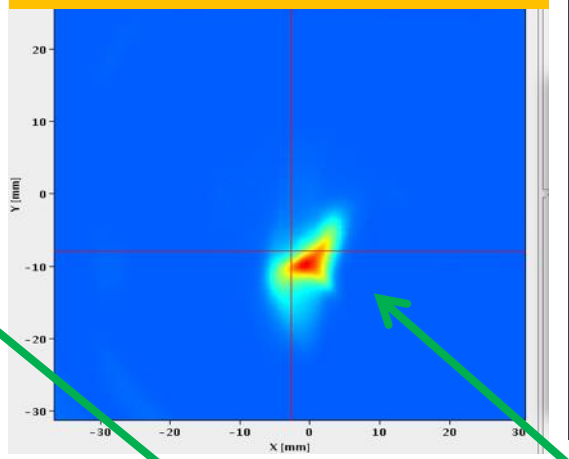
- ~100 uA; ~1 us; ~square pulses
  - Only 650 ns-long pulses injectable by kicker
- Good Stability/Repeatability
  - order ~1% for intensity and beam shape
  - order ~0.1% better for energy
- Transverse optics matched to ring



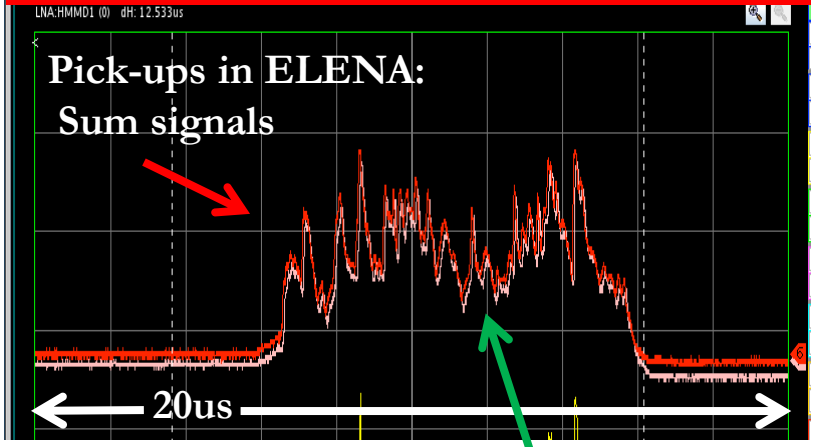
Beam observations

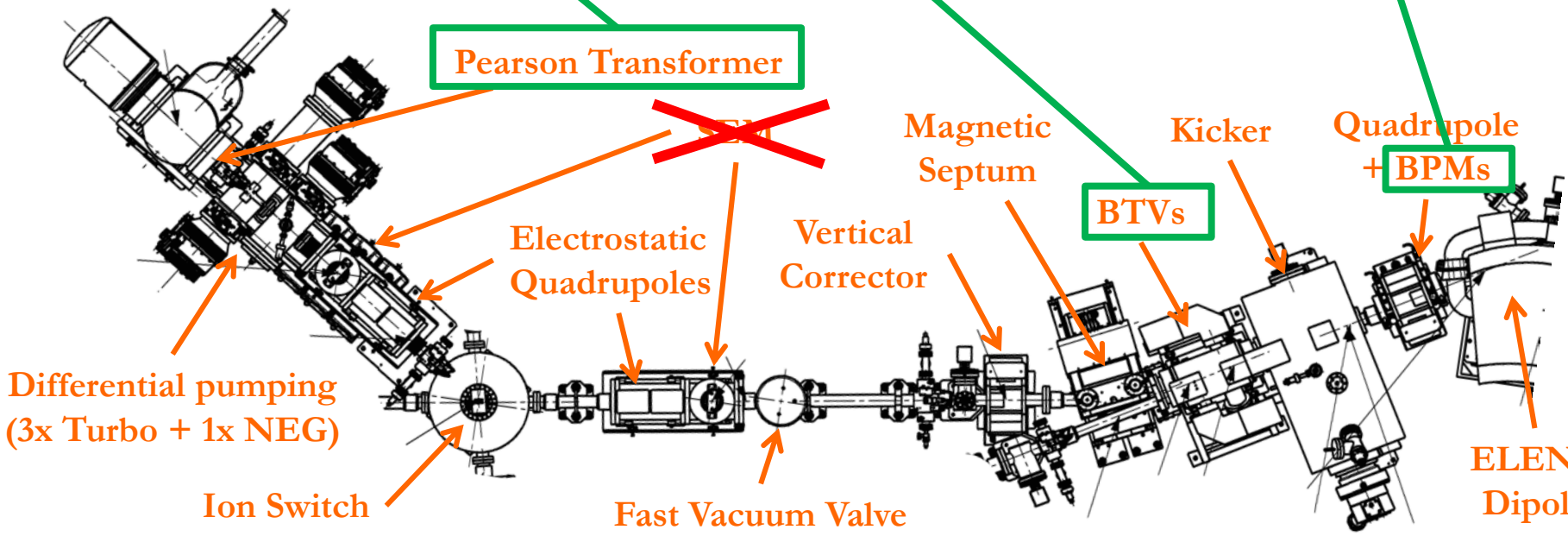
Possible to make ~100 uA beams @source

Poor pointing stability after some time, sometimes

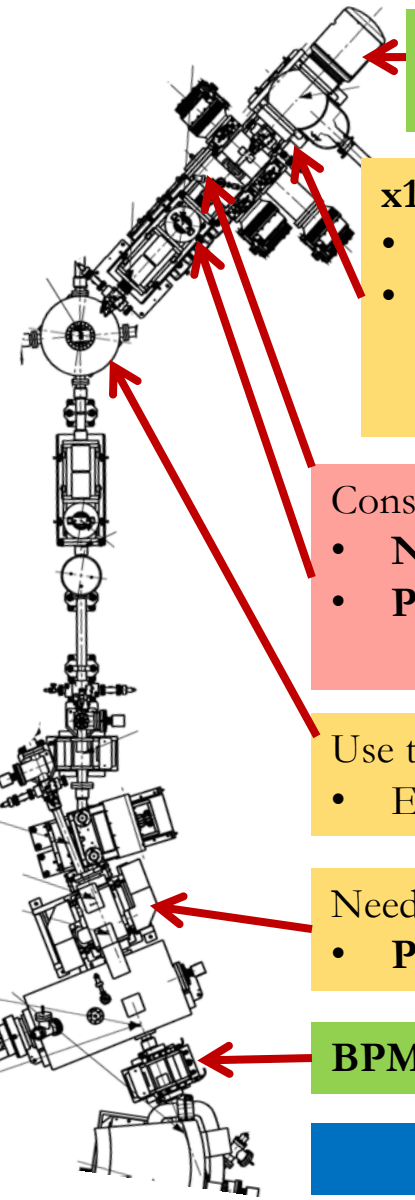


Shot-to-shot, Intra-pulse, Intensity Instability in ELENA





Looking for More Signals



Measurement of **Arc Current** with **Pearson** 150 installed **in Faraday cage**:

- **No major issues observed**, but fast oscillation quickly dumped (<3 us): EM noise?

x10.000 amplifier by Marek Gasior installed on present **Pearson** 110A signal:

- Now **possible** to see **shot-to-shot <u>mean</u> beam intensity**
- **Noise** (of the amplifier) **too high to discriminate intra-pulse oscillations**
  - **x100** more sensitive **Pearson 5753 ordered** – expected to arrive soon
  - **Possible** to install **proper FCT** (but **15kCHF + integration study** needed)

Considered possibility to **install movable Faraday Cup** – **presently postponed!**

- **Not possible** in **differential pumping** section (all viewports occupied)
- **Possible instead of a SEM**, but too tight with timing and too little manpower
  - Use of **SEM as Faraday Cup** also considered, but **too risky** and **too little signal**

Use the **un-used plates** of ion switch **as Faraday Cup** (steering the beam on them)

- Equipment available, **just need (beam+people) time to do some test**

Need to investigate if **intensity oscillation on BTV**

- **Probably an artefact**, maybe possible to correlate BPM and BTV117 (one turn)

BPM amplifiers modified to see high intensity beams (**x20** on **BPM.H25** ; **x5** on **BPM.V25**)

-- More ideas/thoughts (mainly by ABP-HSL) on our wiki page --

Plans (proposal) for the rest of 2019

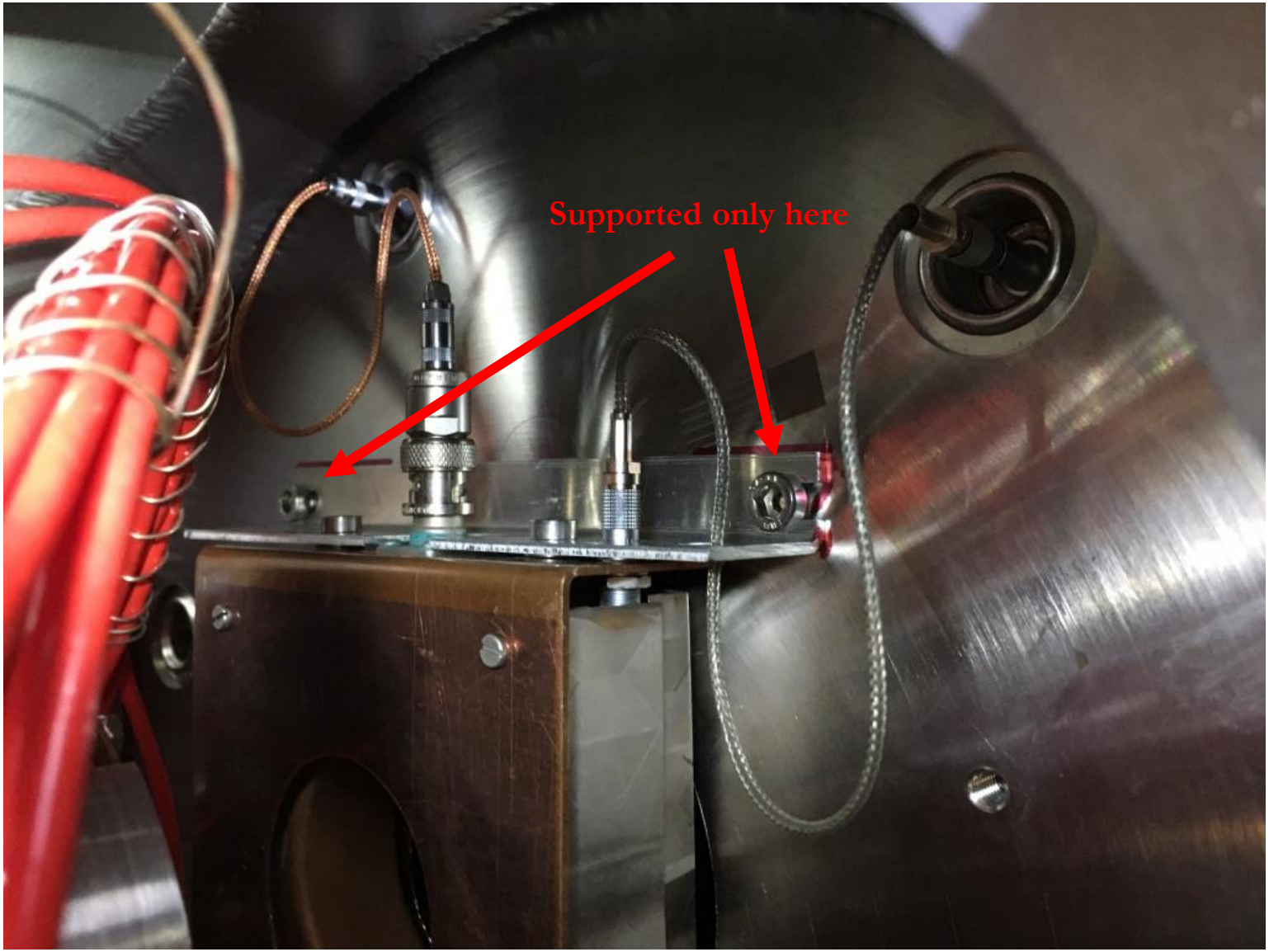
- **Insulation Transformer:**
  - **EPC to produce new 400 Hz transformer** by the **end Oct. 2019**
    - **They need input from us**! Can we cycle **@100 keV +** and **-** for **~days**? **[Sep.]**
  - **For the time being we can use the present one in cycle mode [Sep. - Dec.]**
    - at least **for negative voltages**, for **a few hours**
- **Faraday Cage:**
  - Add **HV measurement** via voltage divider **[Sep. - Oct.]**
  - Optimise for **fast HV cycling** (need to modify HV PC? Cabling?) **[Sep. - Oct.]**
  - Move to **Fug PC both pullers** (not priority, but will make some room in FC rack)
- **Beam Transport:**
  - Install **new Pearson** in front of the source **[Sep. - Oct.]**
  - **Measure instability on Pearson + Ion Switch + BPM (+ BTV) [Oct. - Nov.]**
  - **Investigate/optimize source parameters** to find stable working point **[Oct. - Dec.]**
    - So far no other sources of instability identified along the line…
  - **Transverse optics matching/control** (dream) **[Nov. - Dec.]**
- **Circulating Beam:**
  - Given time constraint, and tune kicker repair, **circulating beam possible only by ~Nov.**

Backup

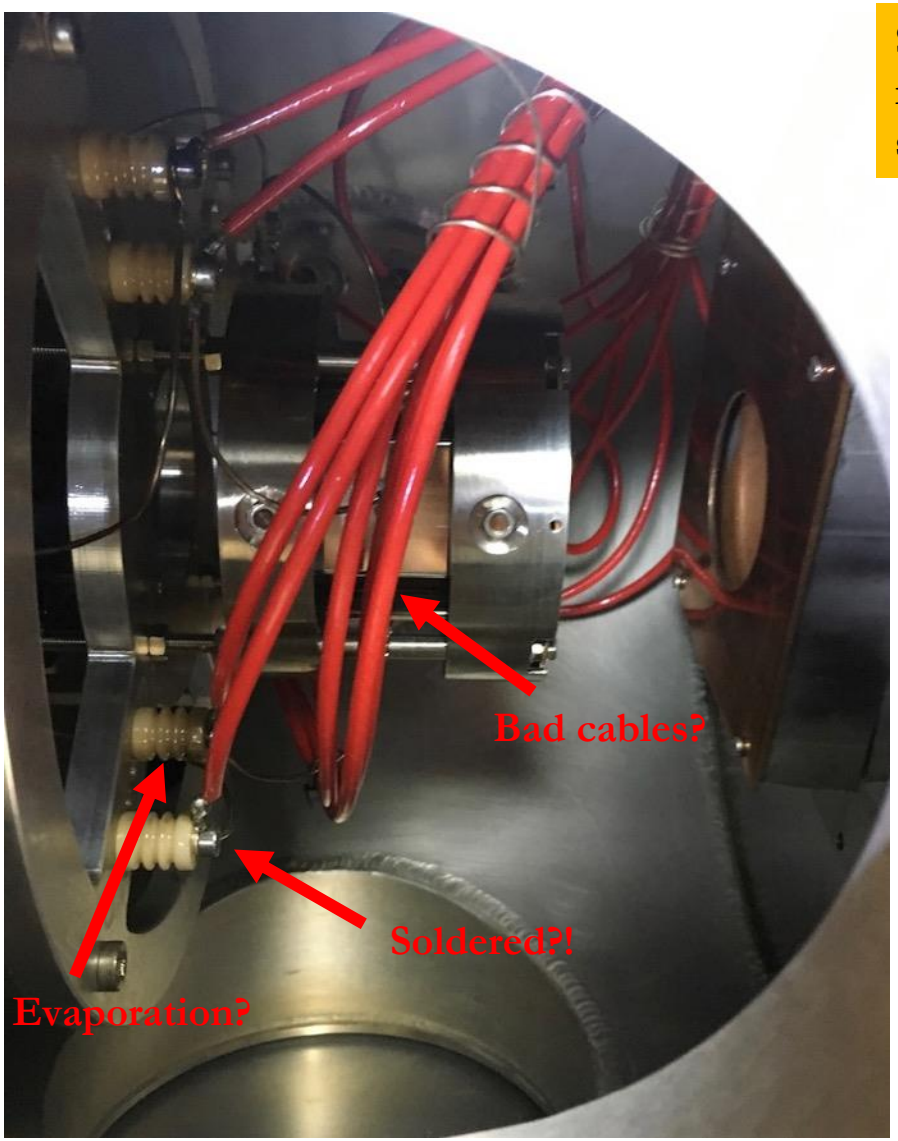
Voltage Divider

Maybe possible to add 0.3 MOhm resistor below last of those 100 MOhm resistors, next to ground.
(will give us ~100 V for 100 kV?)

Change Pearson – probably easy



Vacuum quality in the source



Some concerns about vacuum quality and HV insulation due to possible evaporation of soldering material/bad cables

Some logbook

——— 30/07/2019

- 11:59: Spark @ -90 kV DC after a few minutes of operation - see logbook
- 13:31: Spark @ -85 kV DC after a few minutes of operation - see logbook
- Managed to transport beam @-50kV DC to ELENA, but orbit fluctuations...

Some more info available on logbook

——— 31/07/2019

- Tested with triangular waveform, up to about 100 kV (6.7 V offset + 5 V amplitude, 4s waveform period, i.e. 46.2 - 101.2 kV, ramp up in about 3.6 seconds, ramp down in about 0.4 seconds. No spark observed.

Some pictures available on logbook

——— 01/08/2019:

- Set up with **positive high voltage**. Insulation transformer without 400 Hz, but warm oil.
  - 10:30: spark @ +80 kV DC, after 2 minutes (from +70 kV)
  - 11:09: spark @ AC (+95.7 -- +51.7 kV) after about one minute after ramping up slowly in steps of (2.2 kV)/(one minute), i.e. 200 mV on Offset set to waveform generator.
- Inverted **back to negative HV polarity**. same condition.
  - 11:51 - 12:05: -80 kV DC. no spark.
  - 12:24 - 12:42: AC (-95.7 -- -51.7 kV). no spark
  - 12:46 - 13:33: AC (-100 -- -56 kV). no spark

For first AC test, waveform generator set with **period of 9.8s**. Ramp of 4 V amplitude (from a variable offset, e.g. 5.091 V for 100 kV; 4.7 V for 95.7 kV). ramp up in about 3 seconds, ramp down in about 1 second.

Some pictures available on logbook

- 13:34: going to **period of 4.8 s**, with same waveform. Rump up in about 1.5 s, ramp down in less than 1 s. No spark observed for 10 minutes.

Some pictures available on logbook

- 14:46: **600 ms pulse** (200 ms ramp up, 200 ms flattop, 200 ms ramp down) in a **4.8 s cycle**.
- ramping up slowly to about (-95 -- -50 kV) with no spark observed for a few seconds.