Beam Physics Note
TRI-BN-24-35
November 22, 2024

CLS visit fall 2024

A Report

Stephanie Diana Rädel

TRIUMF

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1 Genreal note

This is partially from notes I have taken. The new linac at CLS was designed and build by Research Instrument. The aimed final energy is 250 MeV. I arrived on a Monday where I was greeted by Xavier Stragier. Within that first day he told me: "I still don't know why you are here."

2 Daily notes

2.1 2024-11-11

Power divider: power goes in (one channel) but goes out in two ways, and can be split and you can influence the ratio between power out of both channels.
↪ They give the phase to a cavity. BUT, if you change the phase of one cavity, you influence the phase of the other cavities, because of the power divider.

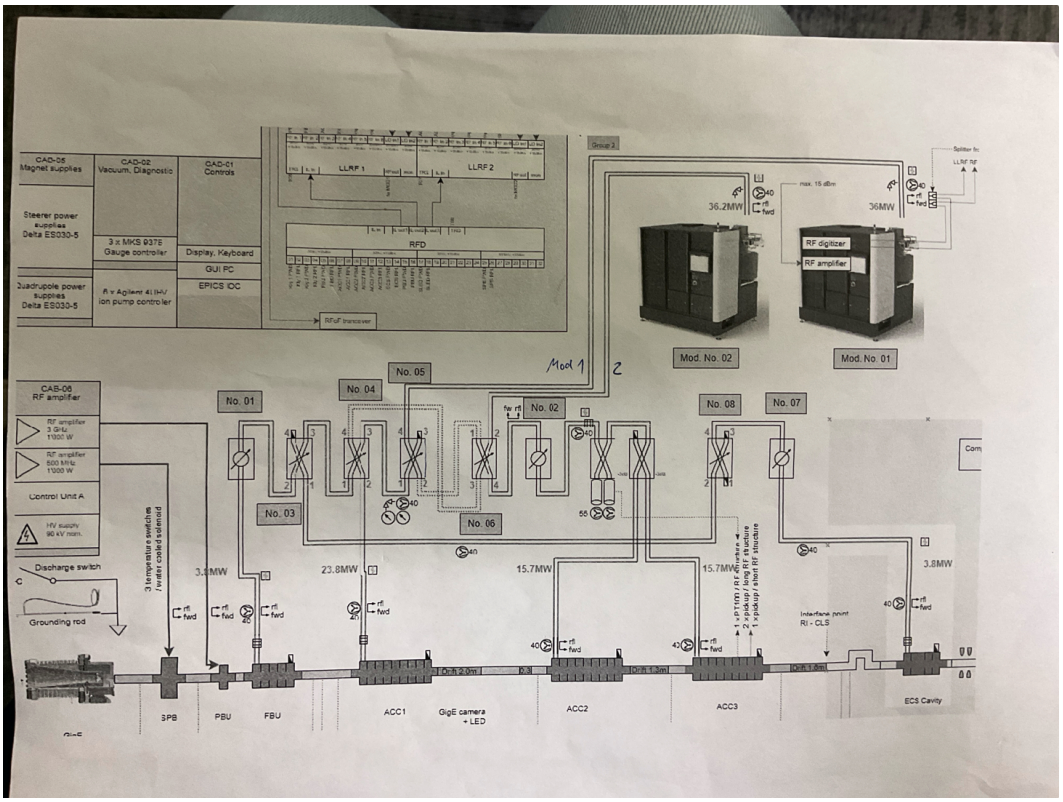


Figure 1: Schematic layout of the CLS/RI linac from the electron gun to first bend.

The problem with this: there are so many combinations. On another note, CLS uses phosphor screens in order to visualize the beam. Those screens have both axes, x and y, on the screen.

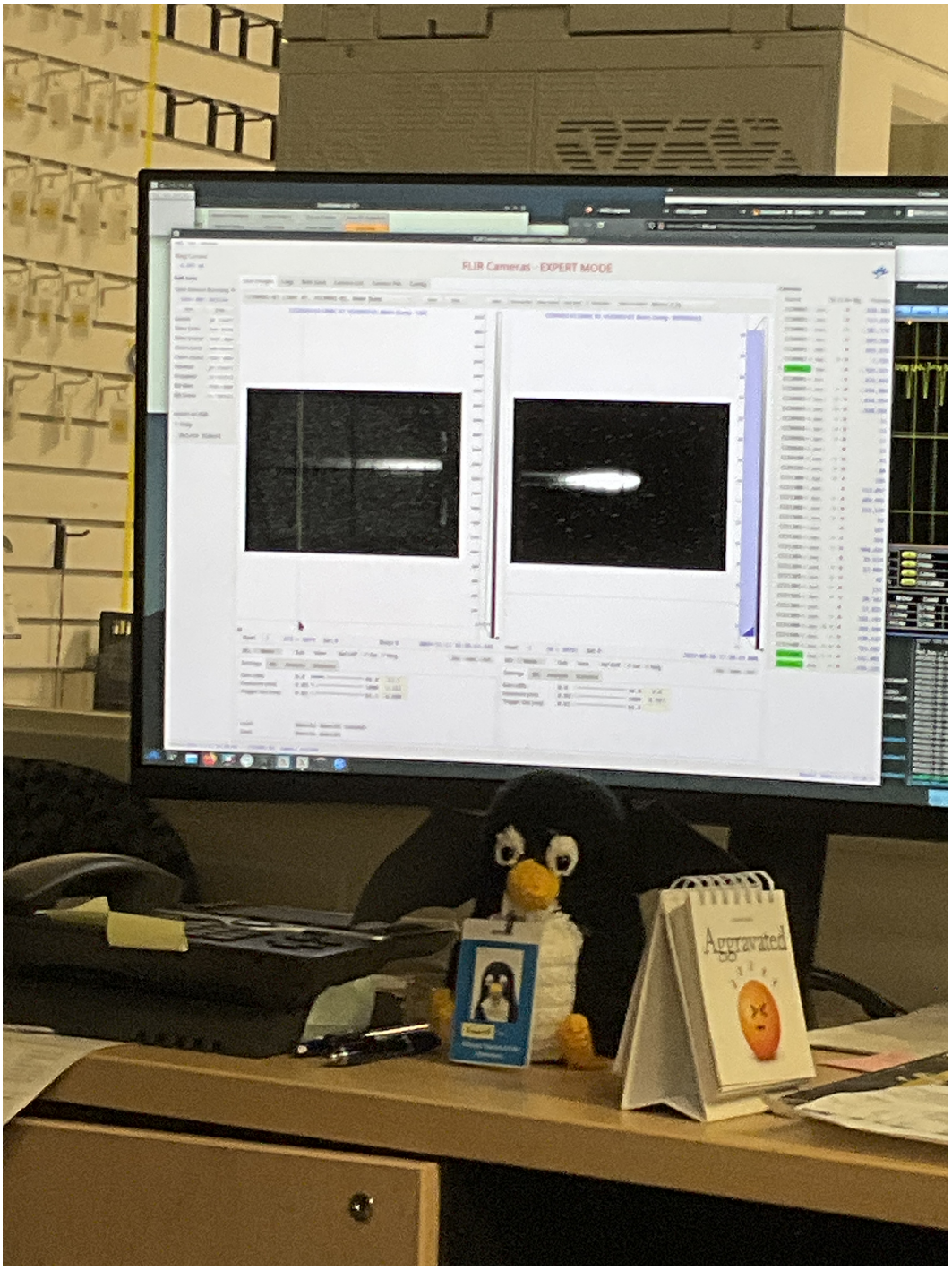


Figure 2: "FLIR Cameras - EXPERT MODE" page title

This way (the axis on screen), they can see if they are in focus or if the camera was moved, e.g. someone bumps into it.

From further away, it is also not here possible to read what is displayed on the screen.

Figure 3: CLS Operator Thomas (left) and Research Instrument physicist Kay Dunkel (right) commissioning at with also the new control system.

With the fact of lines on the screen and RI under time pressure to finish the commissioning the question is: Do I get the chance to "play" with the accelerator pre bunching? And can I take pictures" Does it makes sense to actually take those pictures?

2.2 2024-11-12

CLS cavity ⇒ slat cavity (sketches by Kai Dunkel):

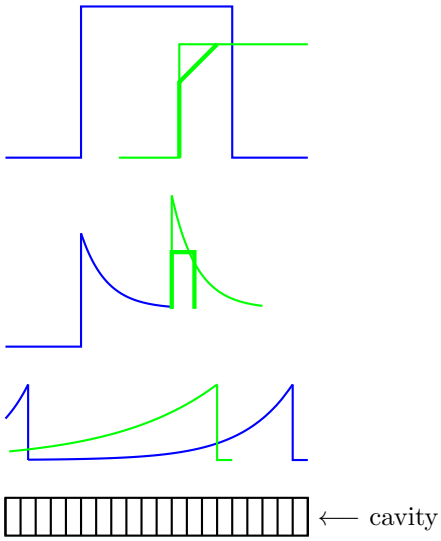


Figure 4: Principle of a slat cavity. Blue line is first signal, second signal is in green. Top, green is soften, which results in a different wave form. The second (green) wave arrives after blue one in the cavity. We try to time the green signal, so the wave does fit best (at the end of the cavity) so maximal energy can be translated into the bunch.

Since Monday was a stat holiday, Tuesday was the first day of the week. I was happy to go to the manned front desk in order to get my access card going. Unfortunately, there was no contract found in order to get my card going. This ment I was a visitor, with which I needed to be accompanied every minute being on site. I turned to Xavier who didn't even understand the problem. Frédérick, who took over as the person handling my visit, checked if my trainings were still up-to-date but nothing further. And he was also in Sweden that week, so he couldn't help. I turned to Grant for help and he started the contract process. On Thursday I got the access card comfortably running again.

2.3 2024-11-13

I had chats with Grant Bilbrough and Kathryn Janzen on the lack of CLS leadership (the CEO was fired, the science director (Gianluigi Botton) went to the Diamond Light Source, Mark Boland was fired, the interims CEO, a former accountent, became CEO this year). On top of that, scientist left CLS within the last year, last one and a hlaf year in bigger numbers than usual.

Grant and Kathryn also showed me the CLS user portal.

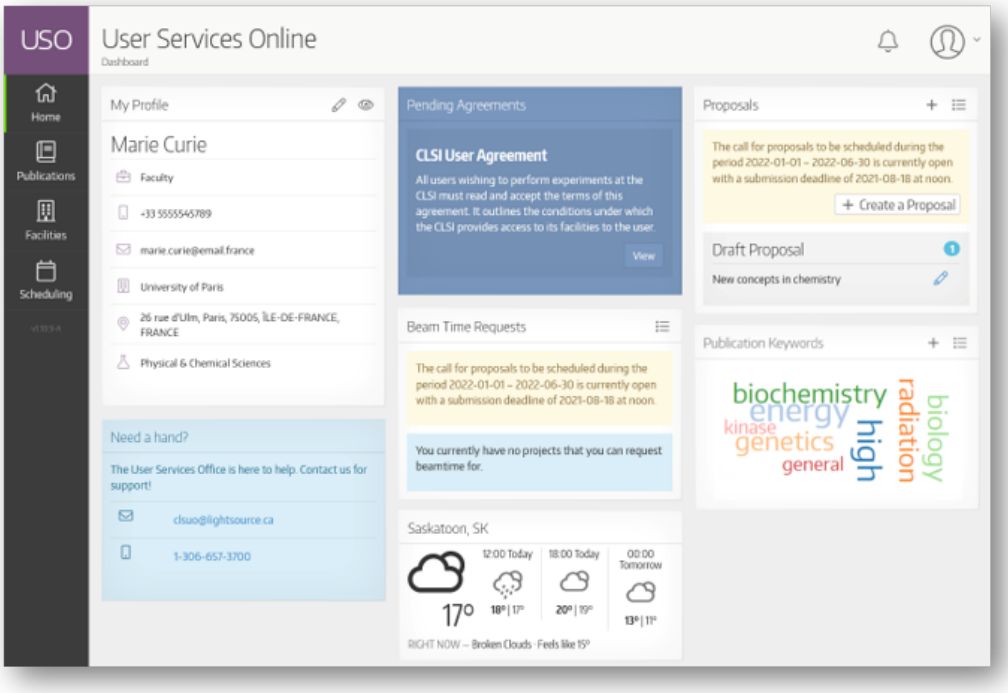


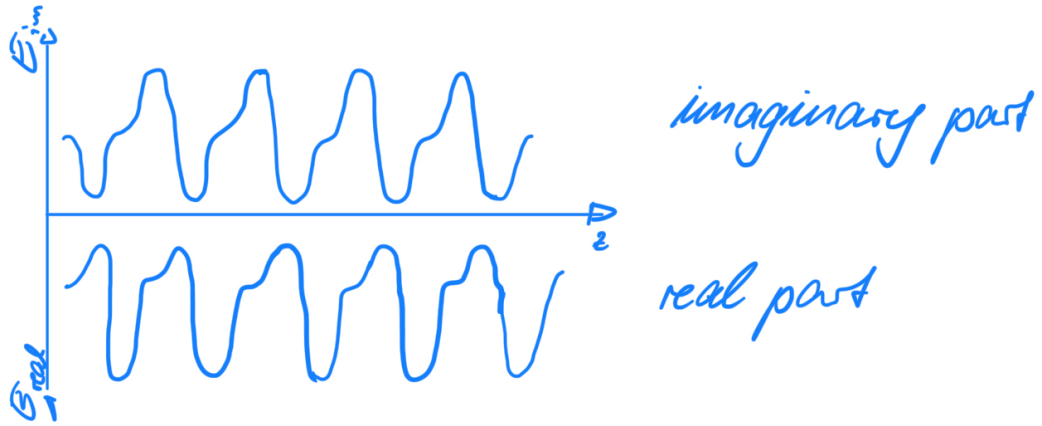
Figure 5: User portal landing page, the Dashboard, is the first page after login with all necessary information, eg. profile, training status and machine status.

Discussion with Xavier on GPT implementation:
The bunch is starting at basically -10 cm.
↪ That is how TSTEP works, with α, β, γ.
-0.0115 in z
at 0 is the cathode

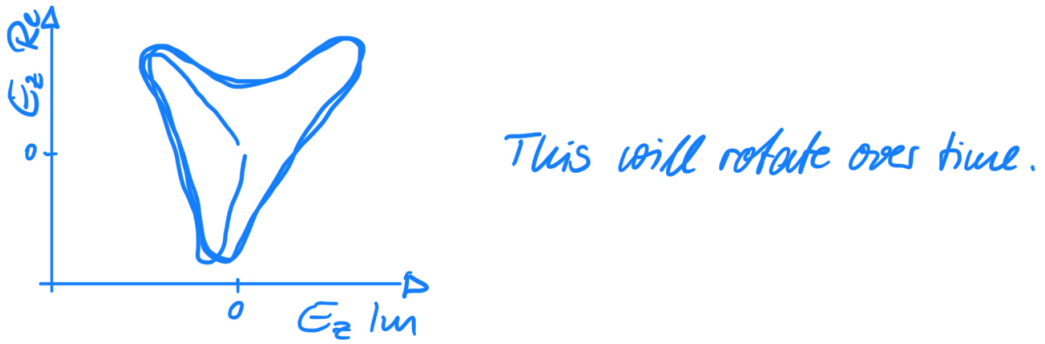
traveling wave:
Xavier splits E_z in real and imaginary part. GPT user manual 'map 1D_TM' ⇒ equation (4.113).

$$
\begin{aligned}
\hookrightarrow \quad & E_z(z) = E_{z,r}(z) + E_{z,i}(z) \\
\text{to get it in time:} \quad & E_z(z) = [E_{z,r}(z) + E_{z,i}(z)] \times e^{iwt} \\
\text{with:} \quad & e^{iwt} = \cos(wt) - i\sin(wt) : \\
& E_z(z) = E_r \cos(wt) - E_i \sin(wt)
\end{aligned}
$$

Get the real and the imaginary part of the electric field on axis and lay both over each other, but shifted by $\pi/2$. $\rightarrow$ That is, what Xavier is doing. Afterwars, he uses CST to generate the image and real part:



The particle will bounce between aparature (e.g. -0.21) and between aperatur and axi (e.g. -0.1), but never reaches 0 again or even the positive part. (This description is from another picture which I could not sketch.)



$E_z < 0 \Rightarrow$ acceleration
$E_z > 0 \Rightarrow$ deceleration

On a not, I realize, that only the first solenoid (basically the "egun solenoid") is a solenoid on its own. All other solenoids are wrapped around the rf cavities:

today's commissioning:

Figure 6: First 3 m from gun (right), with stand alone solenoid (within green plates), pre-pre buncher (SPB), and the solenoids wrapped around other RF structures (PBU, FBU, ACC1).

- smoothen pulse
- sled pulse shaping

2.4 2024-11-14

today's plan:

- single bunch
- multi bunch
  - increasing "bunch train" (from 10 bunches to 20)

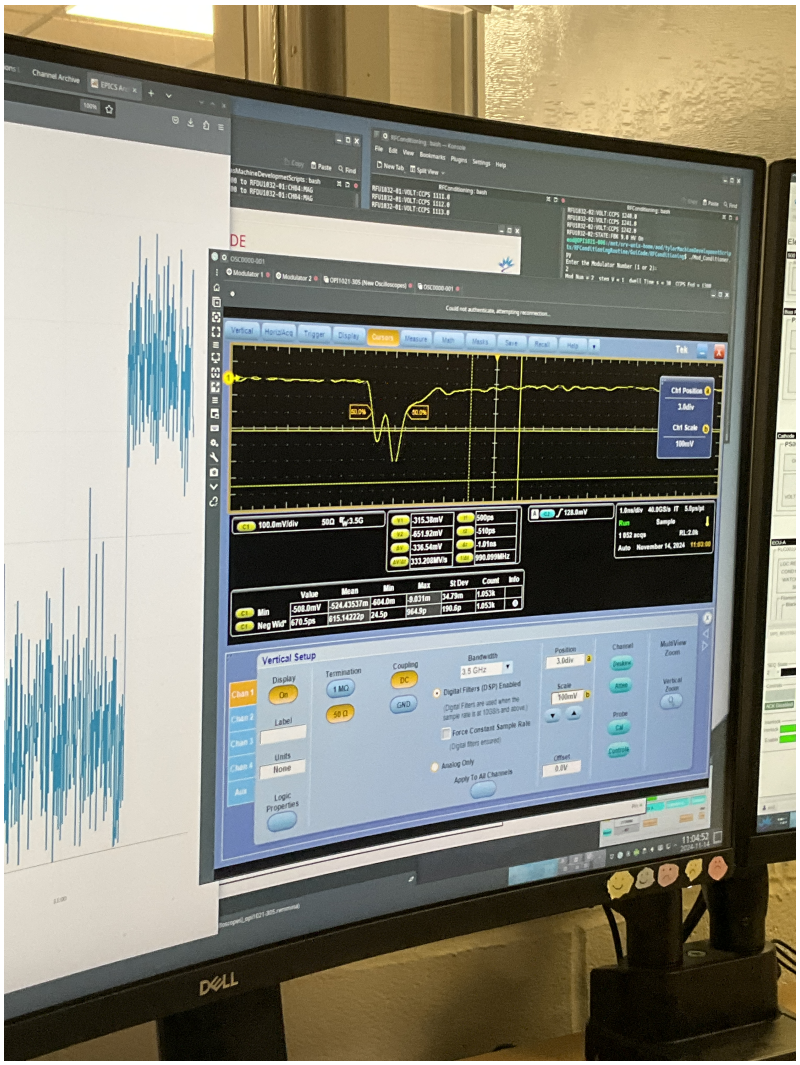


Figure 7: Single bunch on oscilloscope, but smeared into two buckets.

The single bunch was established at 12:07pm, with an energy of 138.19 MeV and a charge of 1.3-1.4 nC. To measure the beam current in a faraday cup, RI/operators need to focuss the beam into the opening of the cup.

The 'EPICS Archiver Applience Viewer' is CLS's way to not only to use it as a strip tool, it pulls every PV directly from their archiver. The pre given time intervalls are: 30s, 1m, 5m, 15m, 30m, 1h, 4h, 8h, 1d, 2d, 1w, 2w, 1M, 2M, YTD, 1Y, Live. This is basically

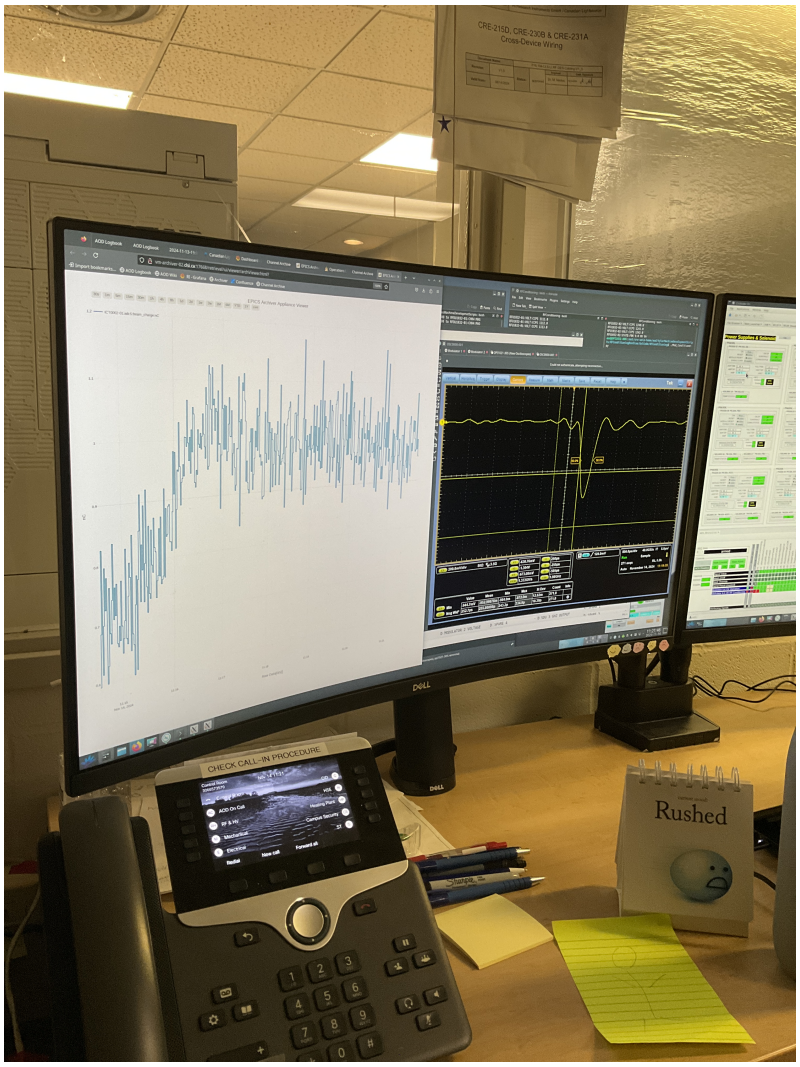


Figure 8: Right: Single bunch on oscilloscope in one bucket, left: 'EPICS Archiver Application Viewer'.

their HLA, using python, HTML, JavaScript, git. I'll contact Grant Bilbrough to get some more screenshots and we could go from here to have a similar app.

The CLS view screen page has already the calculation of the beam size implemented:

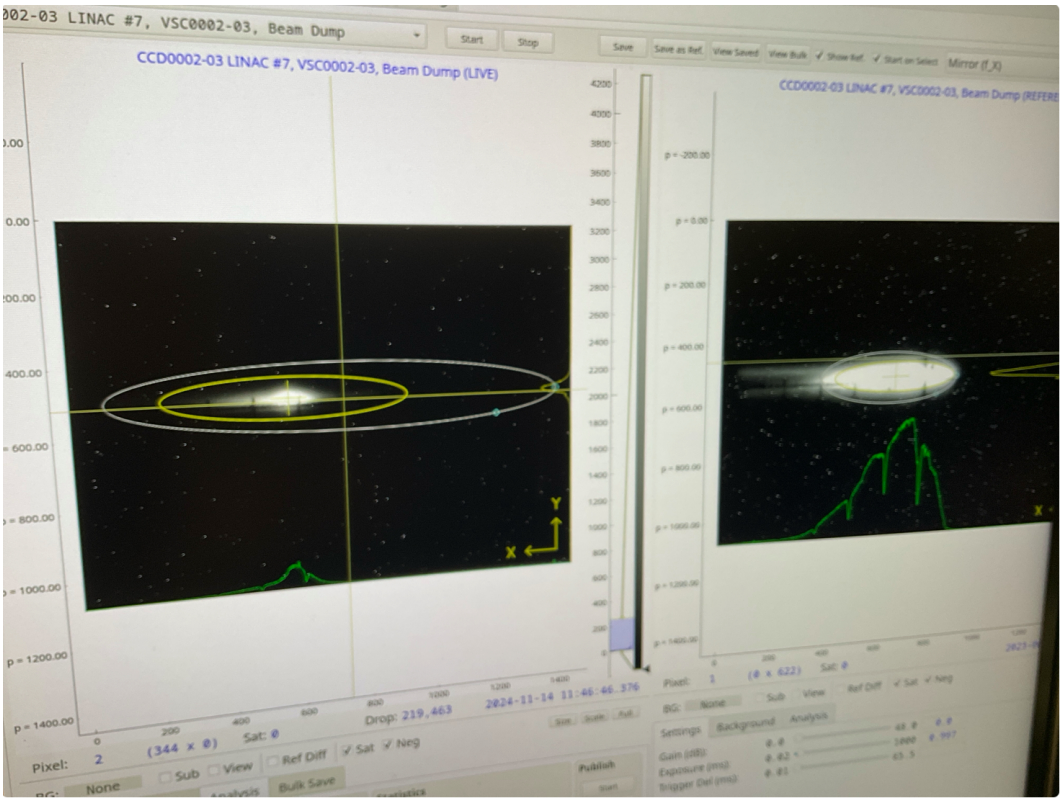


Figure 9: View screen window with the possibility of comparing two different pictures, left: live, right: beam in 2023.

Since there were problems with the cavities that required more and more conditioning of the RF, this was the end of this day.

2.5 2024-11-15

I had a chat with Grant on the view screen matter. He agreed to get the measurement done for me, but it won't be before April next year (new view screens are required and their own schedule for commissioning and beam delivery for users is very tight). I shall write down a 'how to' in order to give this instruction to operations and me getting what I want.

Since the solenoid caused aberrations, we entered the vault and fixed the position:

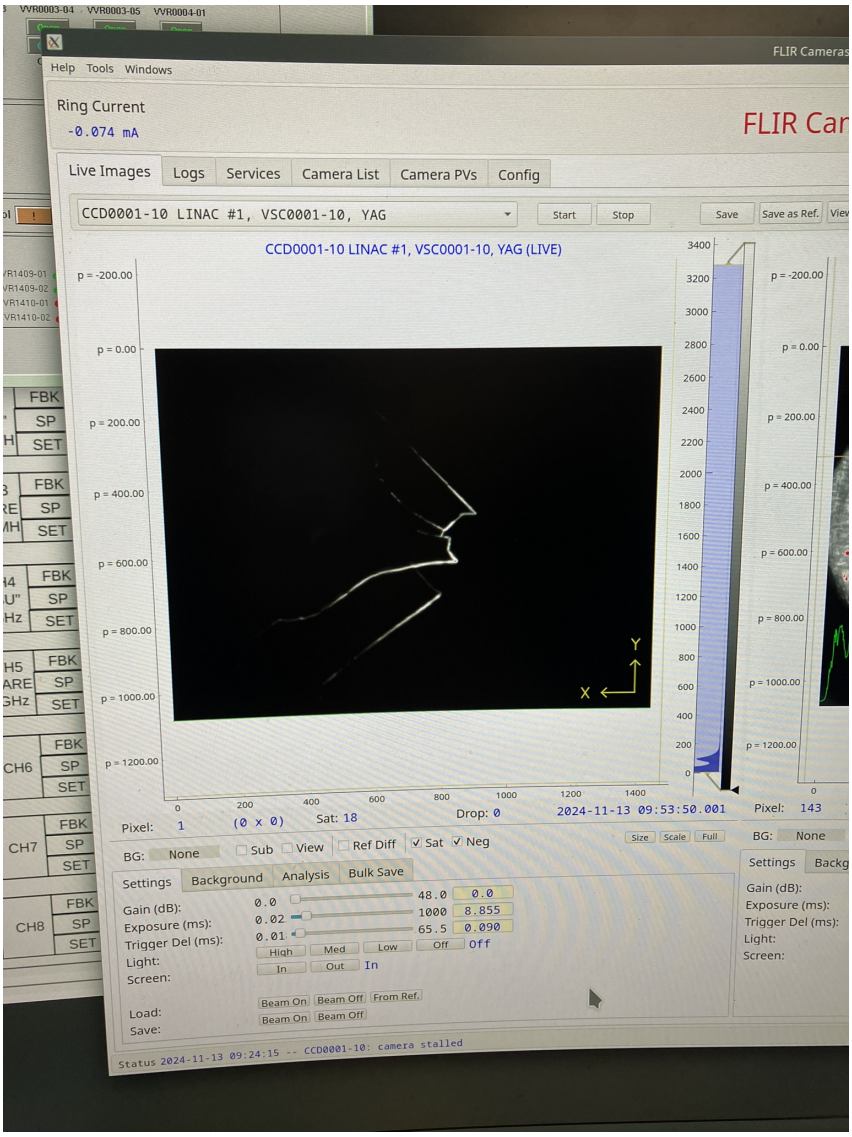


Figure 10: First view screen, which broke first time beam was turned on.

Unfortunately, there were more problems with the coupler and the klystron and their signals. Those parts needed more trouble shooting and then i had to leave for my flight back to Vancouver in the evening.

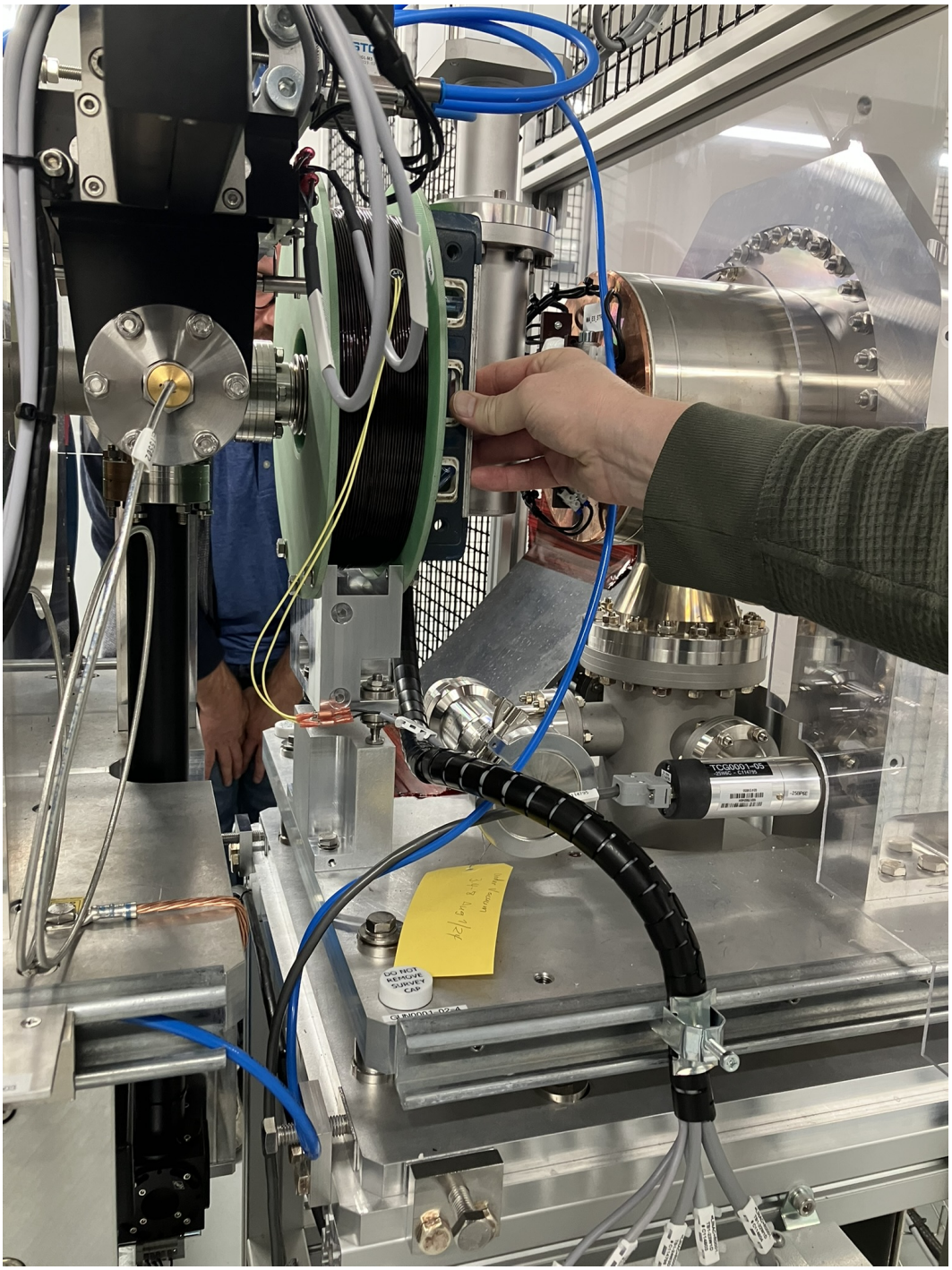


Figure 11: Figuring out the misalignment of the egun solenoid.

Figure 12: Electron gun within its cage.

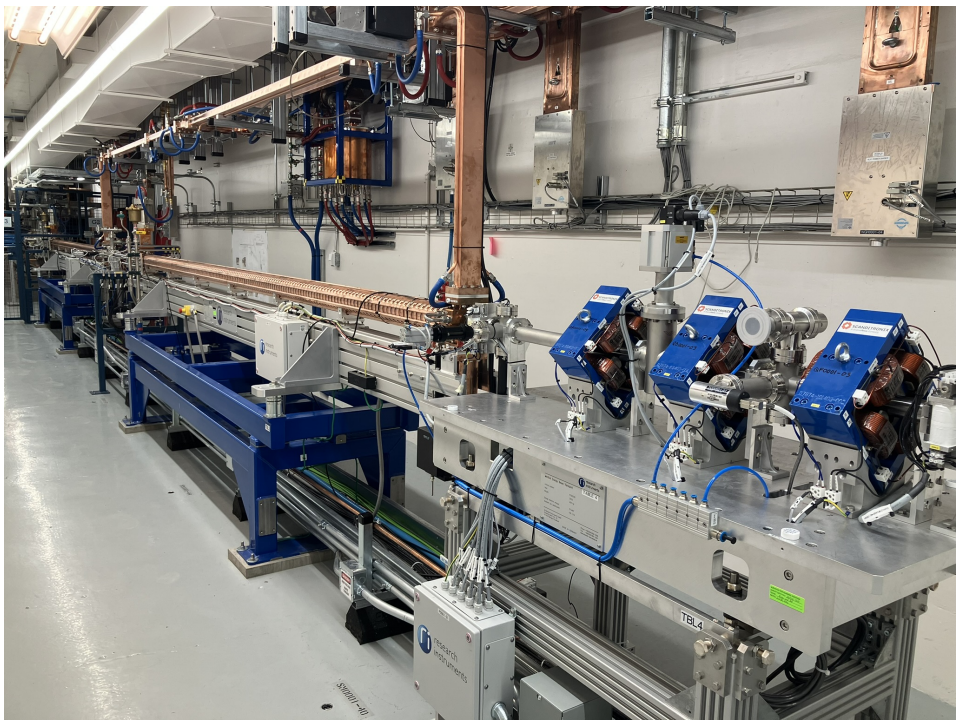


Figure 13: Quadrupoles and ACC2.

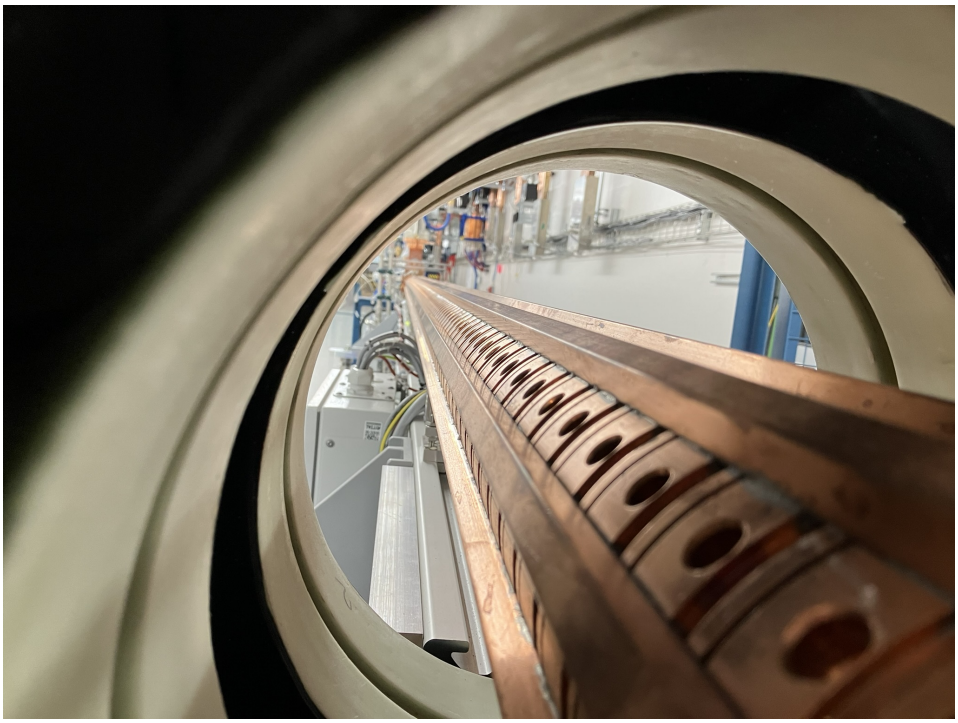


Figure 14: Solenoid around ACC1.

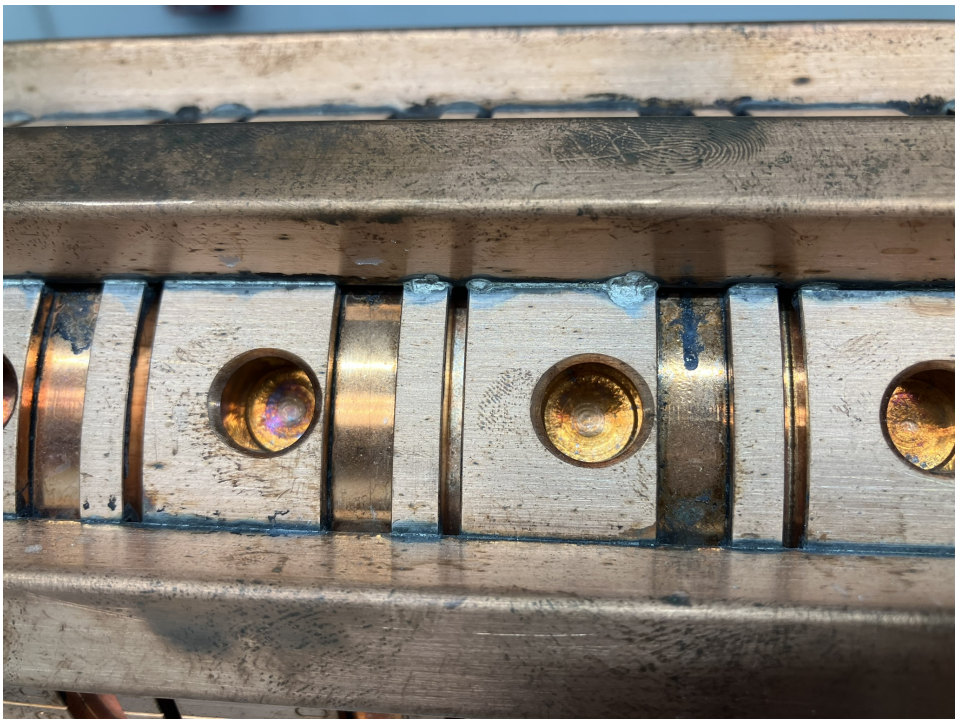


Figure 15: Accelerating cells with hole to manually adjust the field within by force (hammer).