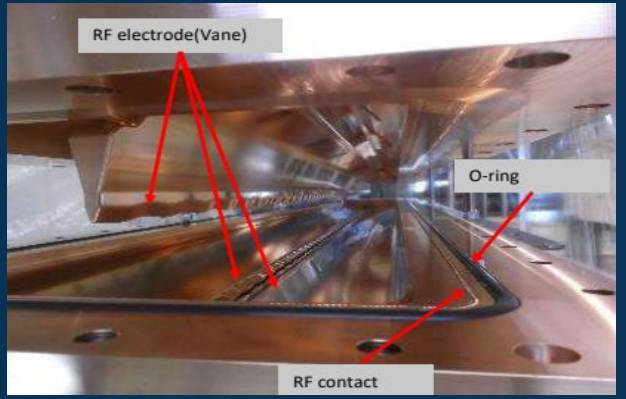
# BNCT Demonstrator

- The Hungarian Academy of Sciences  Center for Energy Research is funding a 10 M€ Boron-Neutron Capture Therapy (BNCT) technology demonstrator near Budapest
- In the fall of 2021, we were asked  to implement Blinky-Lite for the global control system interfacing and interconnecting the:
  - Ion source
  - Radio Frequency Quadrupole (RFQ) particle accelerator
  - Radio Frequency (RF) Power amplifier
  - Lithium Target Station

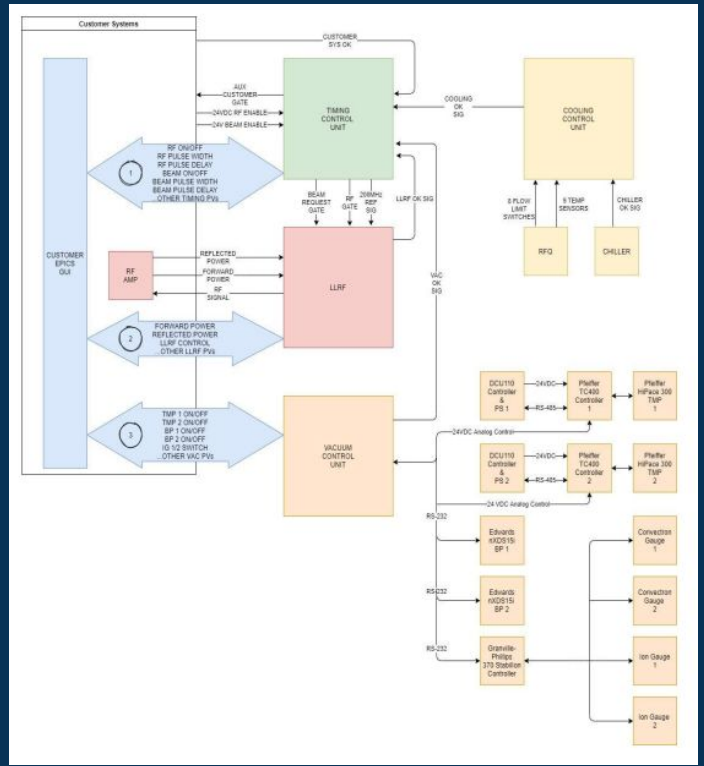
# RFQ Particle Accelerator

- **The RFQ is the main component of the BNCT technology demonstrator.**
  - The RFQ accelerates protons to an energy of 2,500,000 Volts
  - where the protons then hit a Lithium target to produce thermal neutrons for therapy
- **The RFQ was manufactured by Time-Merit Co. Ltd from Hiroshima, Japan**
  - Length: 3 meters
  - Weight: 4000 kg.
  - Copper purity > 99.99%,
  - machining precision: 30 um.

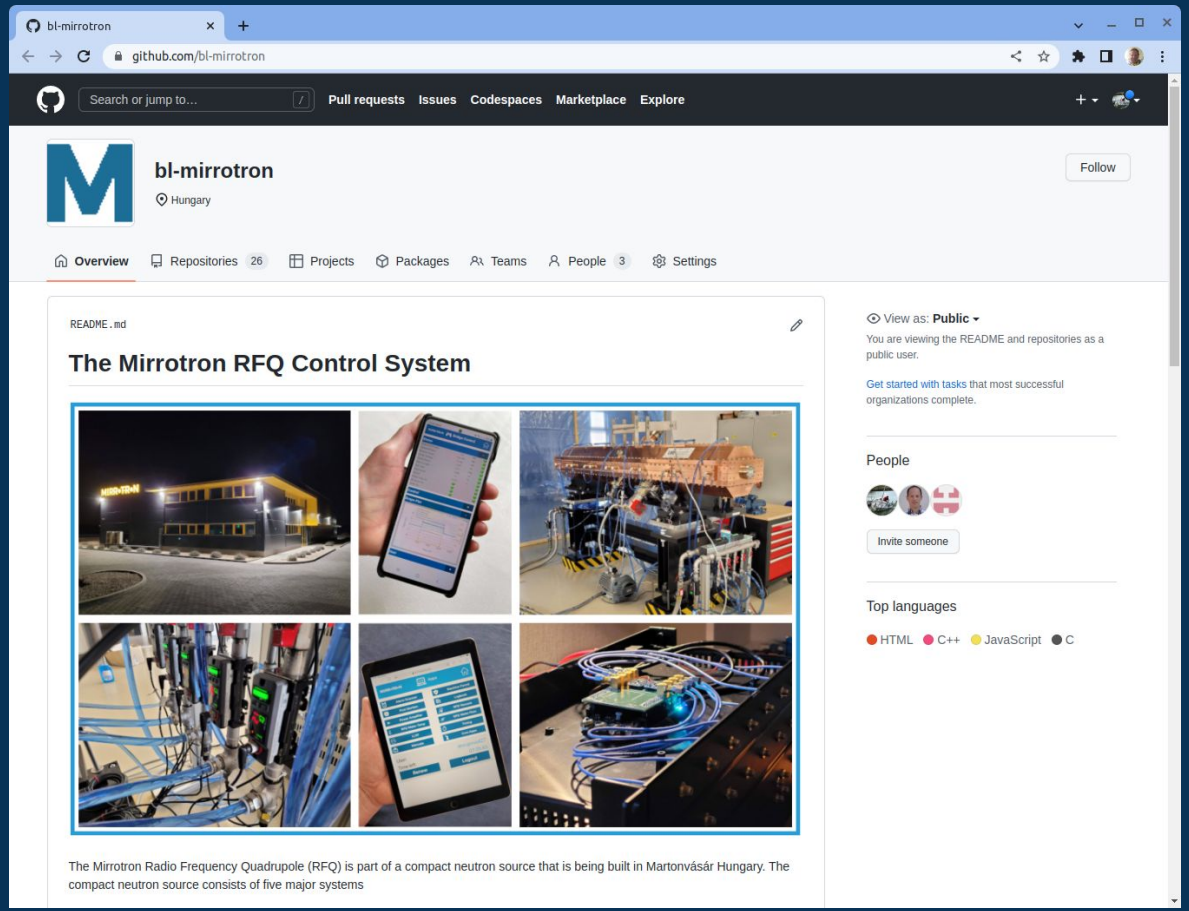


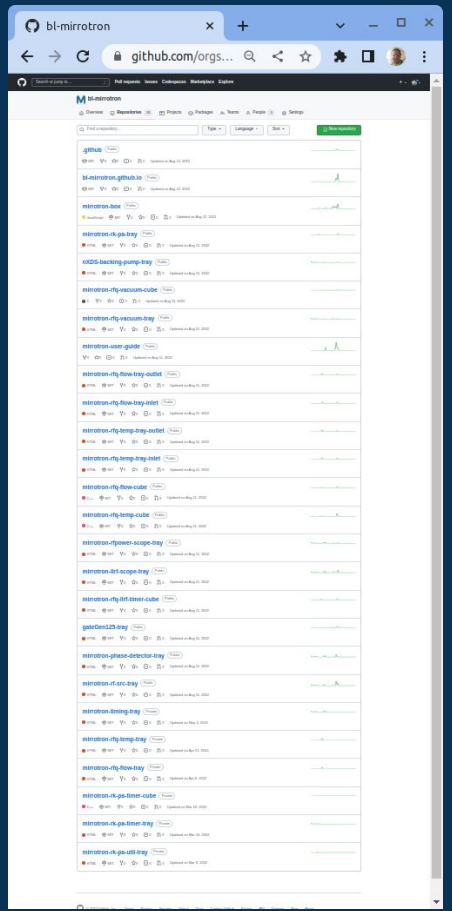

# RFQ Timeline

- The RFQ was to be installed in November 2021 but postponed to March 2022 due to Covid-19.
- In January 2022, the lead engineer for the Time-Merit RFQ left the company abruptly due to Covid-19
  - leaving no documentation for the the electronic controls (RF regulation, cooling, vacuum)
- Time-Merit was unable to find a suitable replacement.
- On March 1, 2022, we promised to redesign, build, install and test the complete RFQ control system
  - by 1 June 2022
  - We completed this task by 15-May-2022

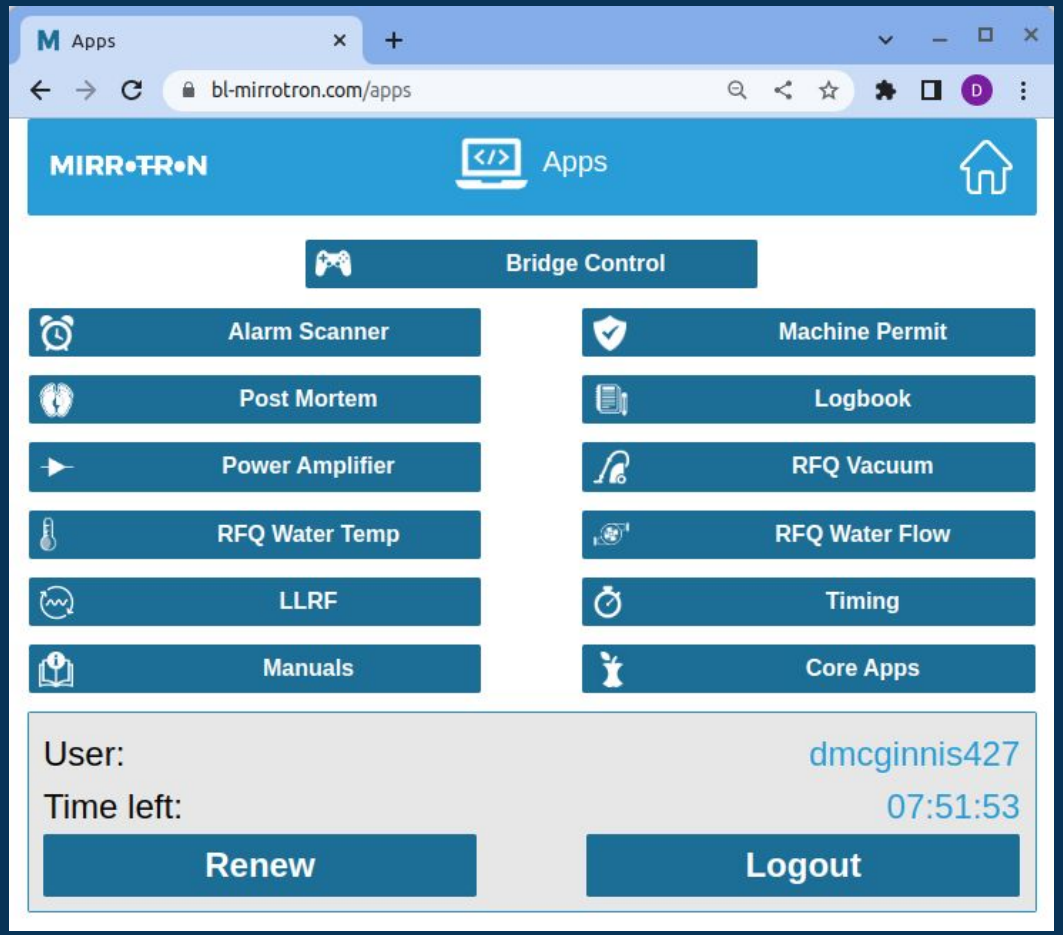


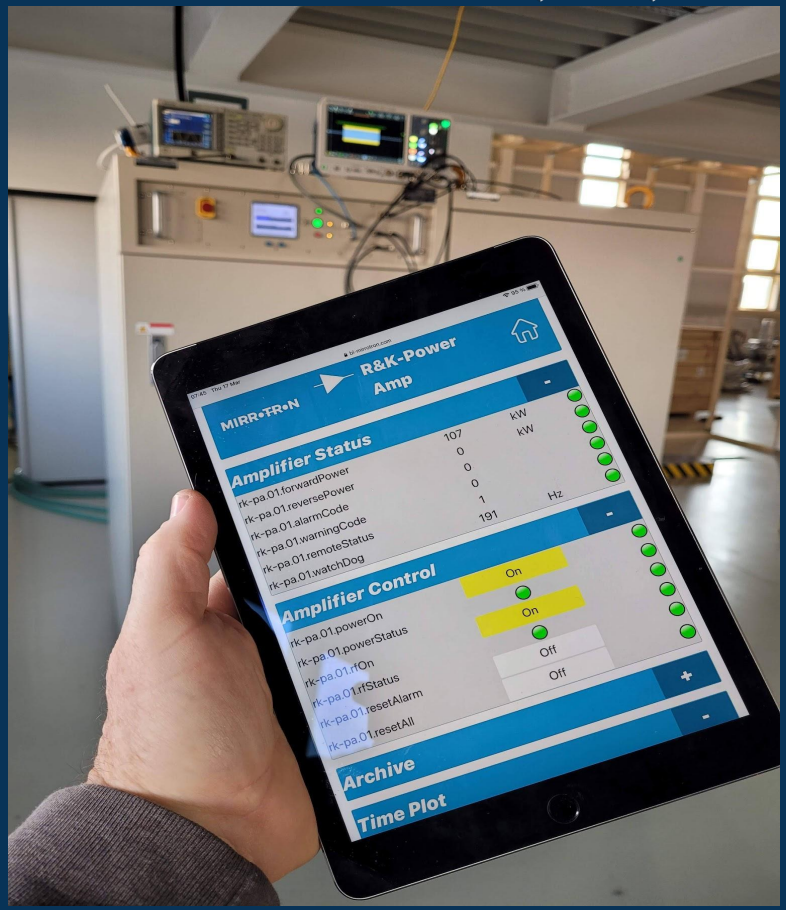
# All open source



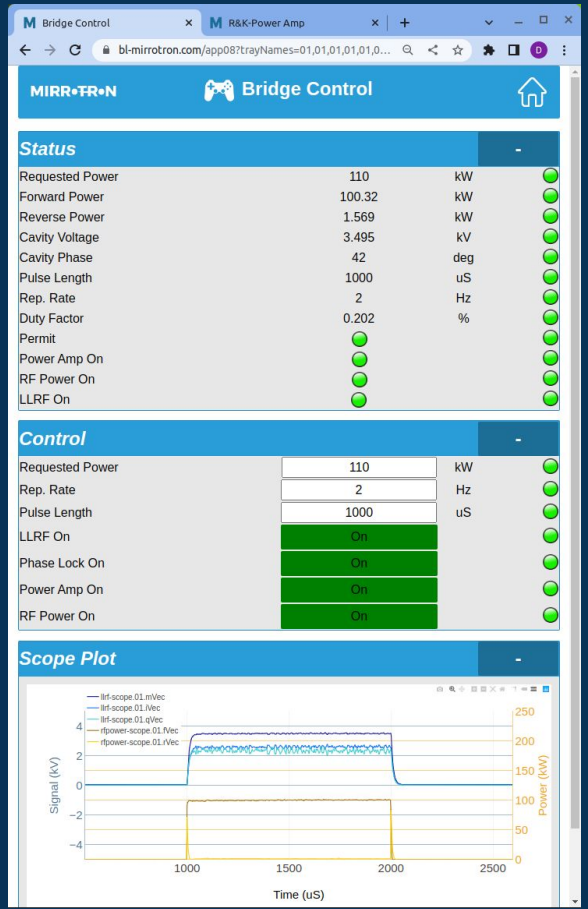



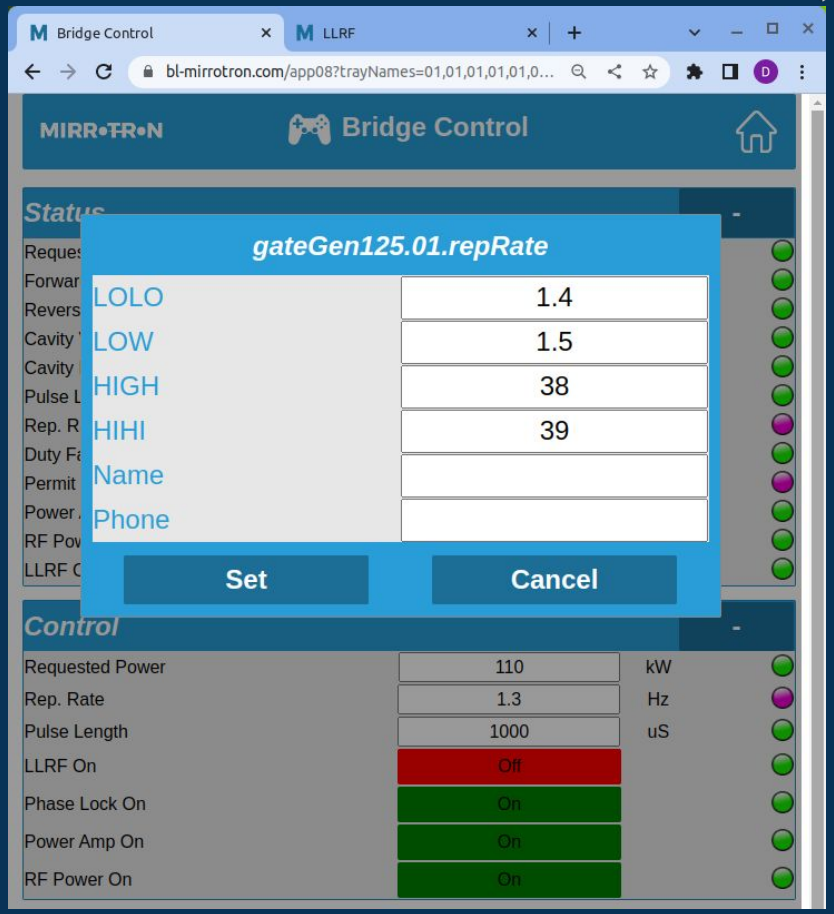
# Mirrotron Applications



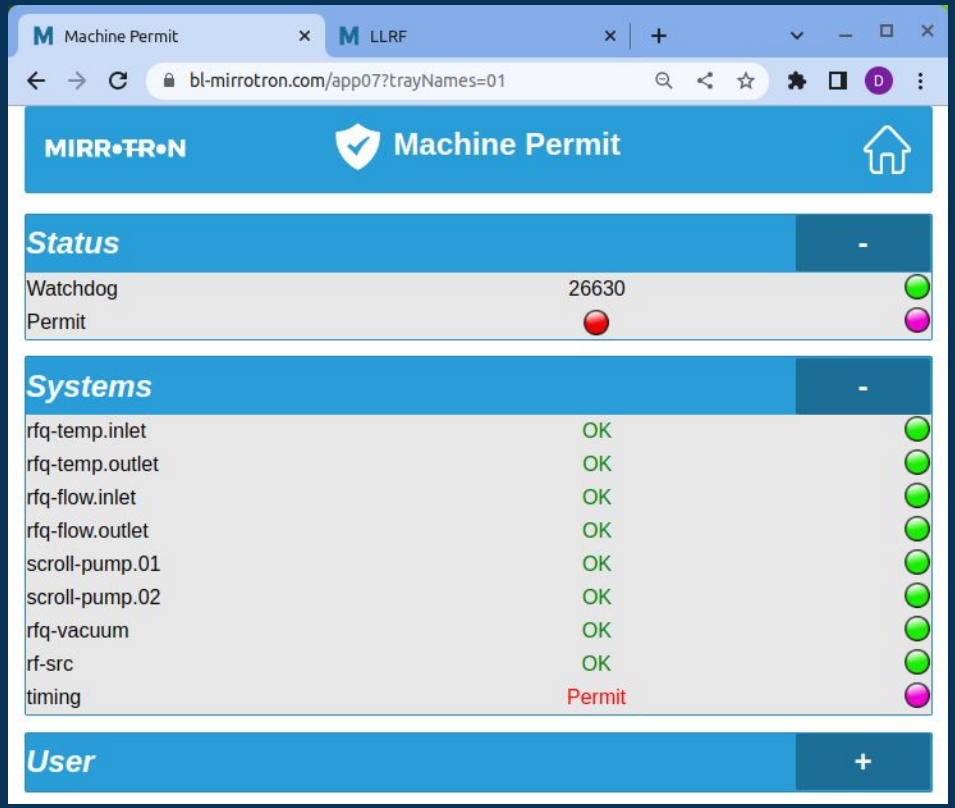



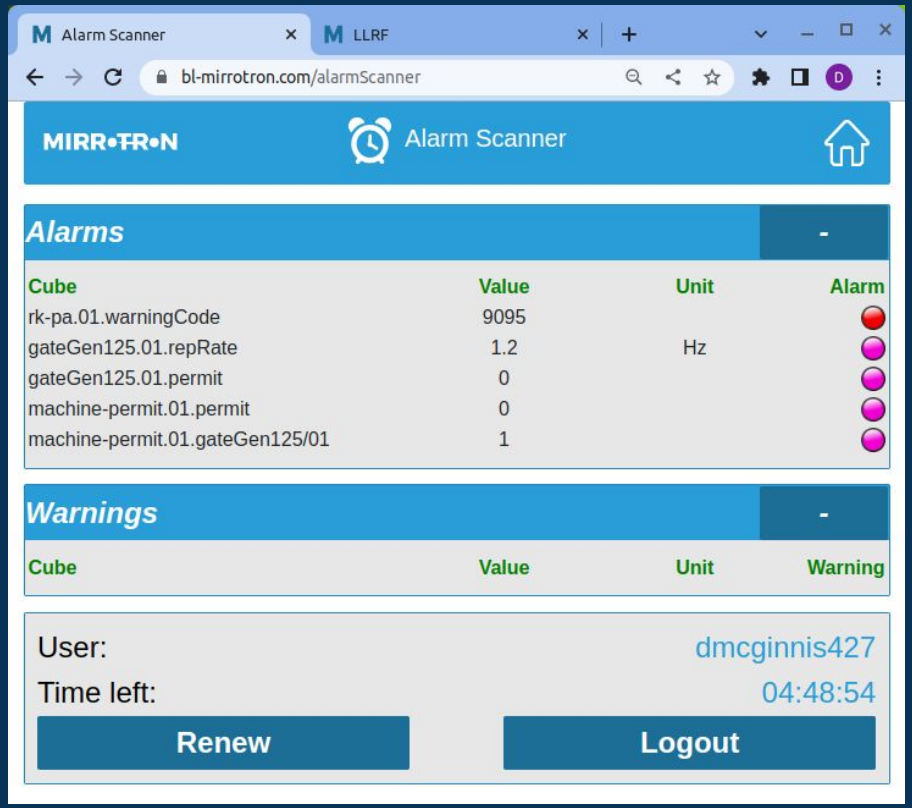
# Dashboard Application



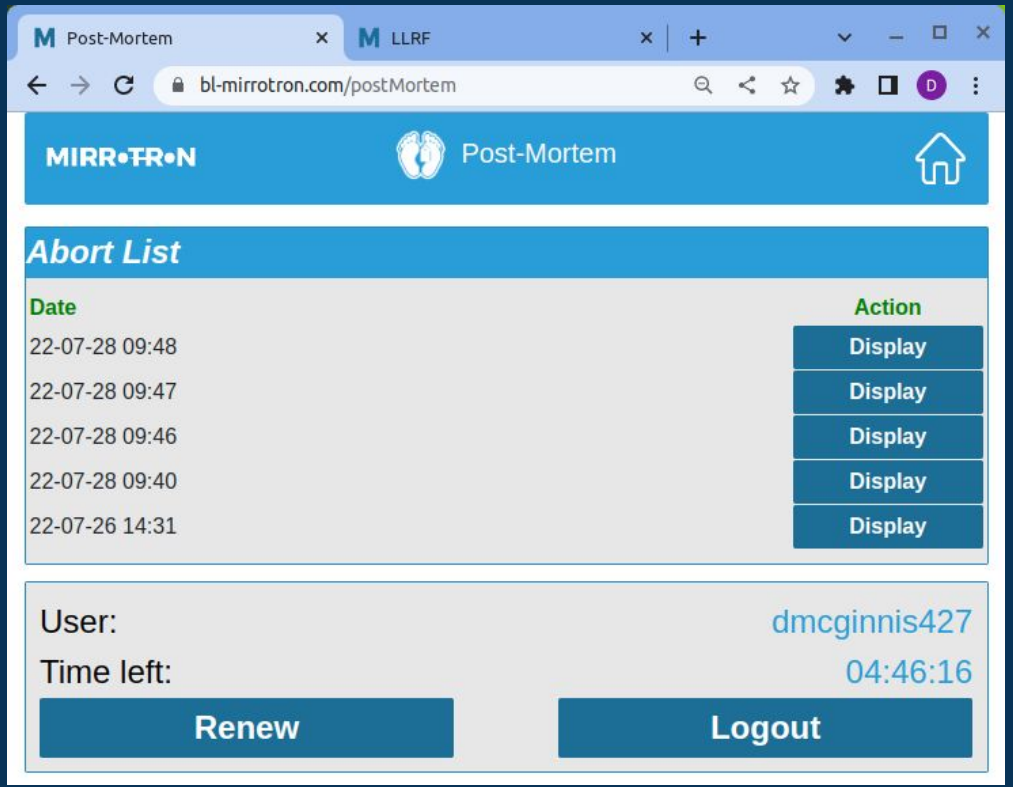



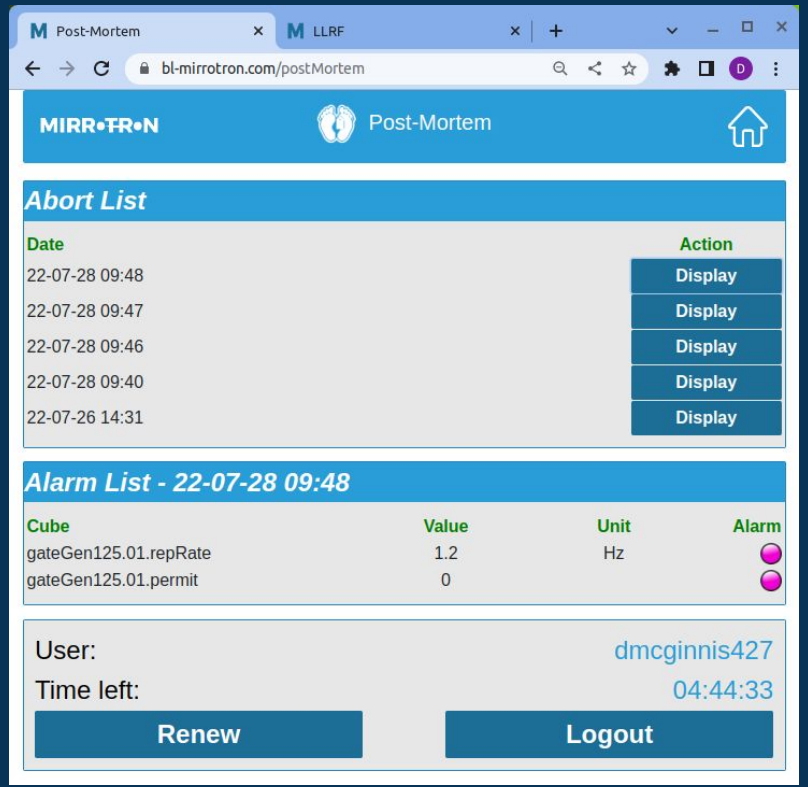
# Machine Permit and Alarm Scanner



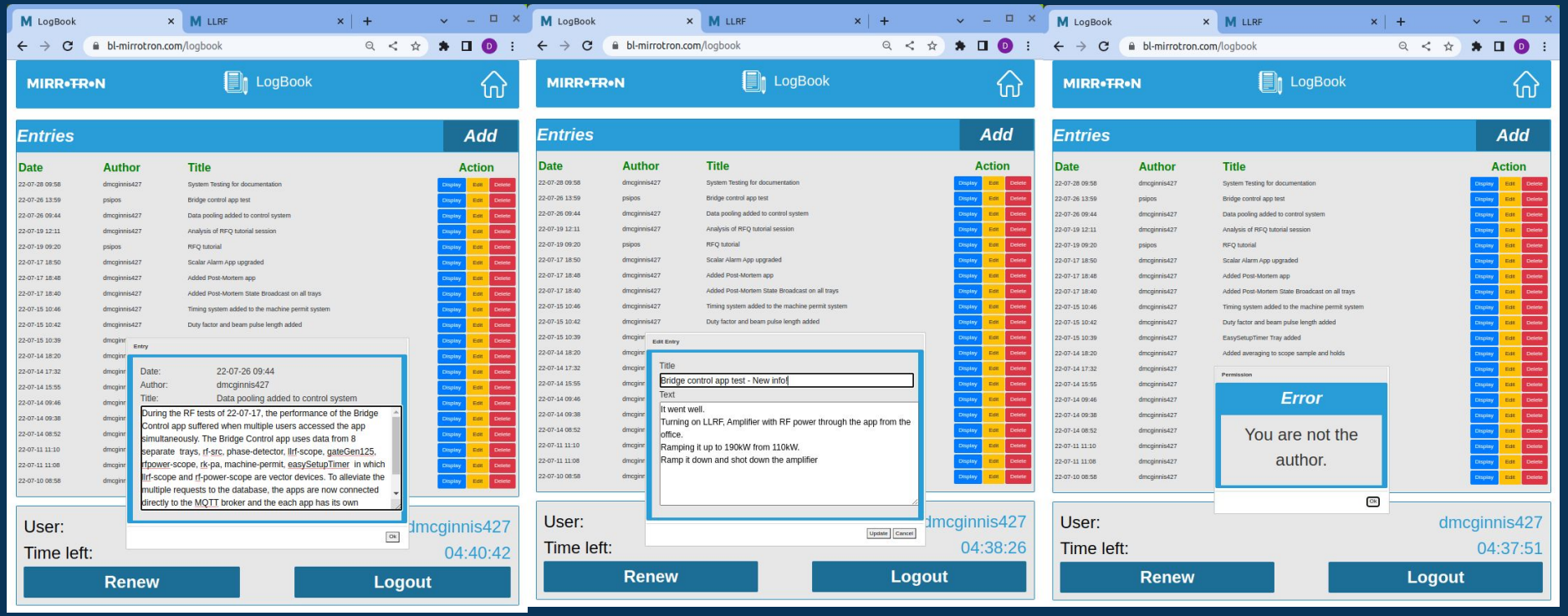



# Post Mortem Application



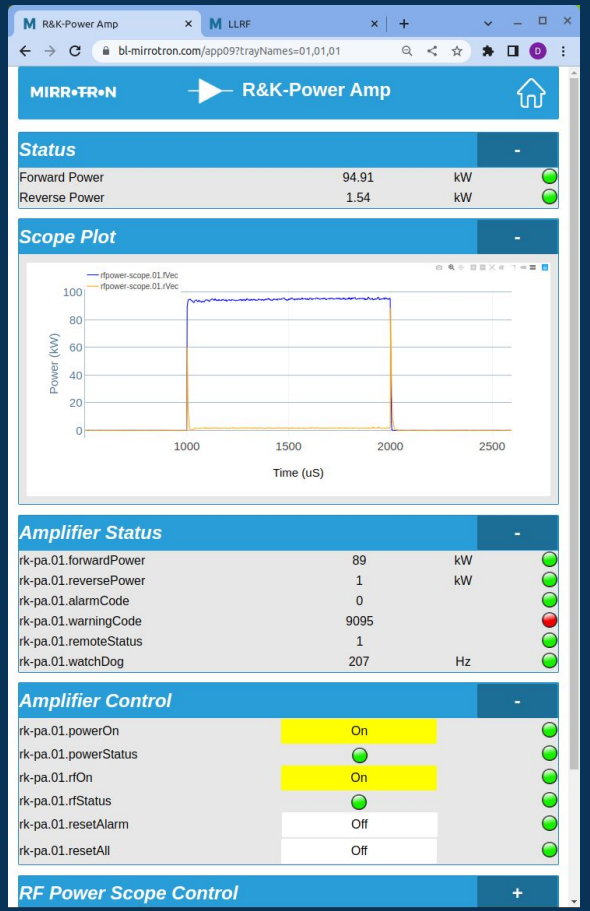
# Logbook Application



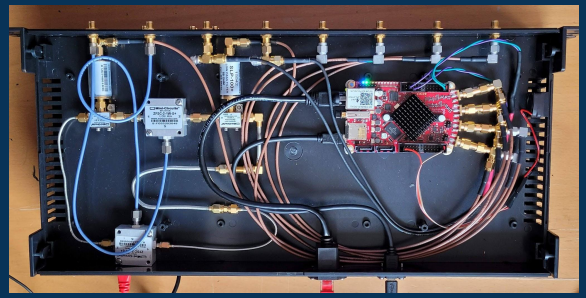
# RF Power Amplifier

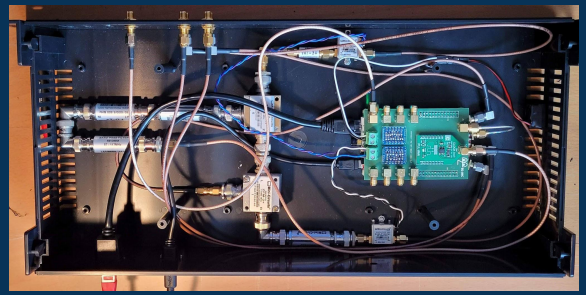
**1.3 M€, solid state RF power amplifier (SSA) to Blinky-Lite .**

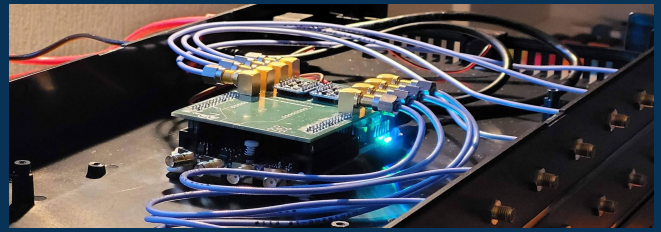
- The amplifier consists of 84 power transistors with 12 independent parameters for a total of 1008 devices
- The amplifier provides 300kW @200MHz
- Modbus TCP interface

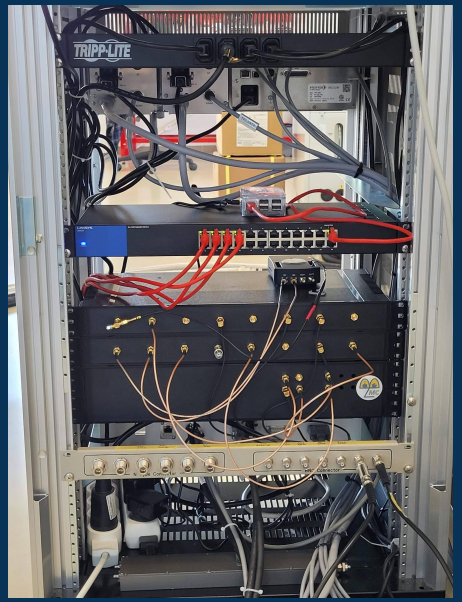


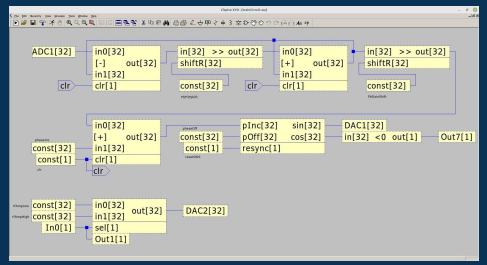
# RFQ RF Regulation

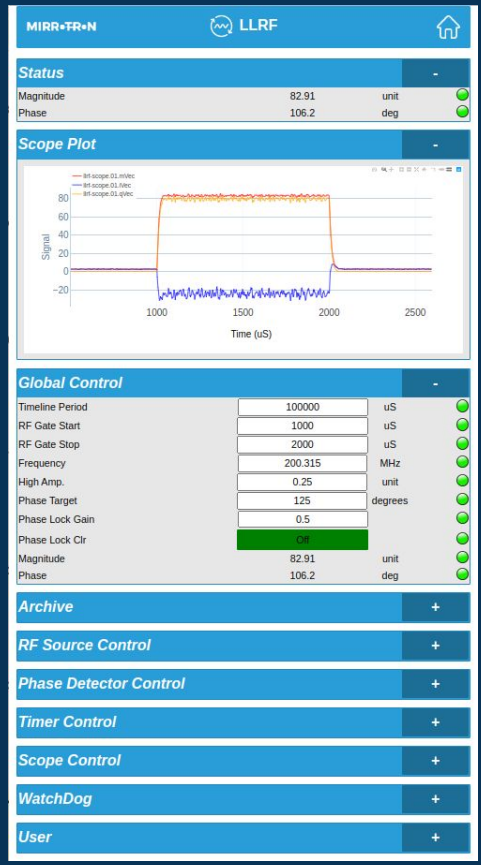






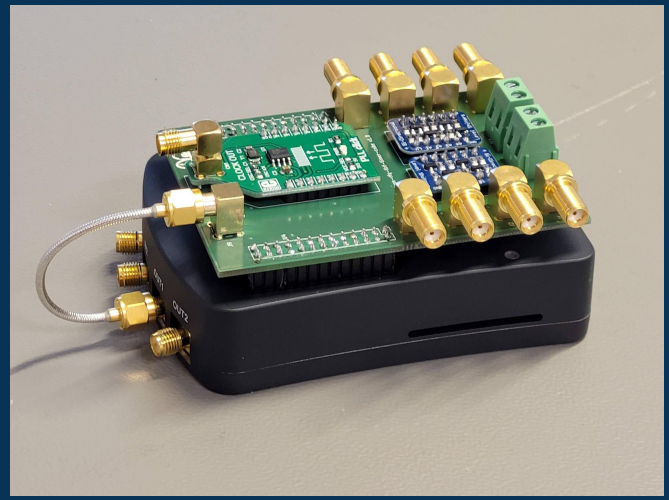


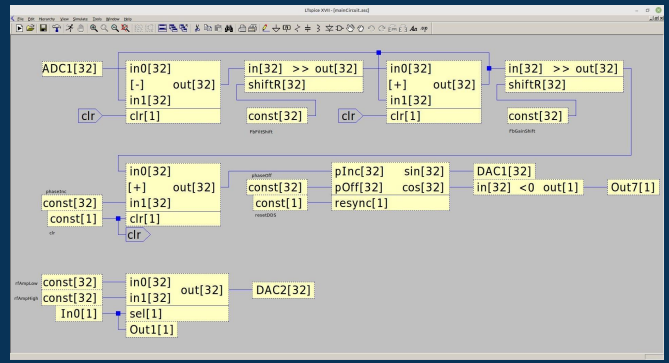



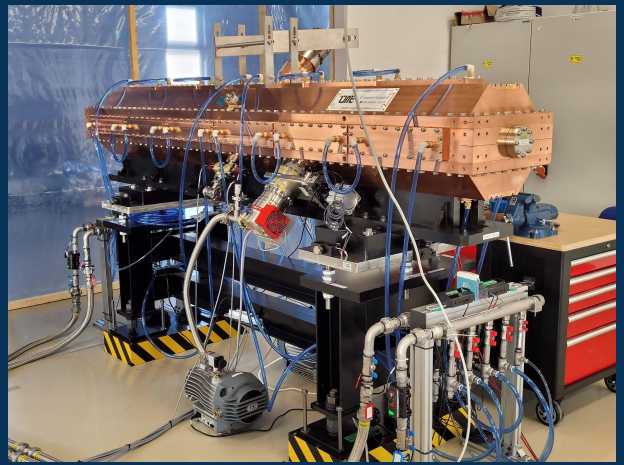
# Blinky-Lite DSP Technology

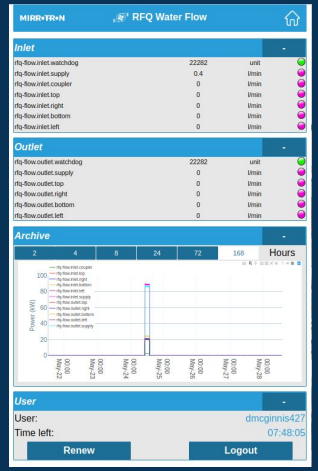
- **The fractional bandwidth of the RFQ is 0.0001**
  - so the RF frequency to the RFQ must be controlled to 1 part in 1 million
  - as the cavity warms up and down though 300kW of power cycles.
- **To control with this precision, we implemented a direct digital synthesizer**
  - on a Xilinx Zync 7010 SOC FPGA on the Red Pitaya Stemlab 125-14
  - and then directly mounted a Blinky-Lite tray to the SOC memory giving real time control of the RF system through Blinky-Lite
- **This presents a whole new world of possibilities for digital signal processing with secure web control!**

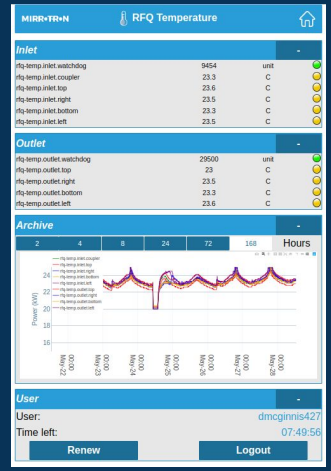




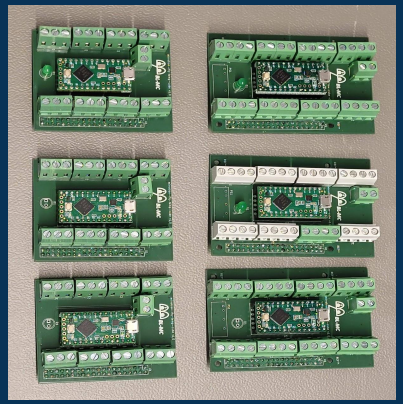
# RFQ Cooling

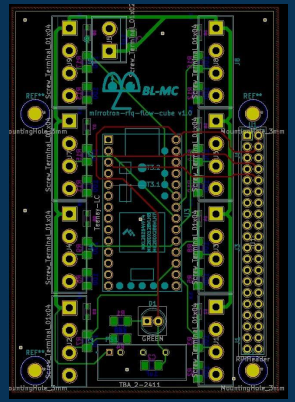


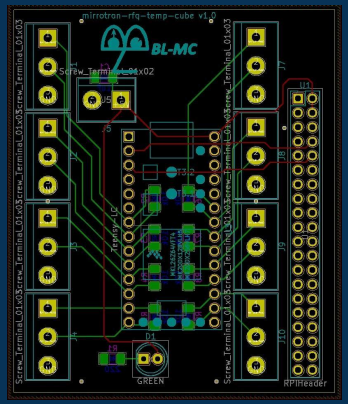

MIRROTRON
RFQ Water Flow
Inlet
rfq-flow.inlet.watchdog 22282 unit
rfq-flow.inlet.supply 0.4 l/min
rfq-flow.inlet.coupler 0 l/min
rfq-flow.inlet.top 0 l/min
rfq-flow.inlet.right 0 l/min
rfq-flow.inlet.bottom 0 l/min
rfq-flow.inlet.left 0 l/min
Outlet
rfq-flow.outlet.watchdog 22282 unit
rfq-flow.outlet.supply 0 l/min
rfq-flow.outlet.top 0 l/min
rfq-flow.outlet.right 0 l/min
rfq-flow.outlet.bottom 0 l/min
rfq-flow.outlet.left 0 l/min
Archive
2 4 8 24 72 168 Hours
User
User: dmcginnis427
Time left: 07:48:05
Renew
Logout


MIRROTRON
RFQ Temperature
Inlet
rfq-temp.inlet.watchdog 9454 unit
rfq-temp.inlet.coupler 23.3 C
rfq-temp.inlet.top 23.6 C
rfq-temp.inlet.right 23.5 C
rfq-temp.inlet.bottom 23.3 C
rfq-temp.inlet.left 23.5 C
Outlet
rfq-temp.outlet.watchdog 29500 unit
rfq-temp.outlet.top 23 C
rfq-temp.outlet.right 23.5 C
rfq-temp.outlet.bottom 23.3 C
rfq-temp.outlet.left 23.6 C
Archive
2 4 8 24 72 168 Hours
User
User: dmcginnis427
Time left: 07:49:56
Renew
Logout

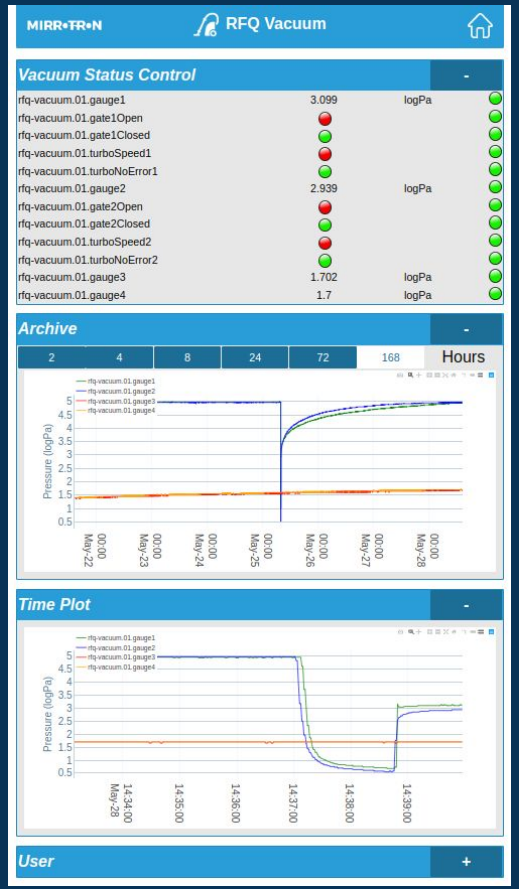

Channel #2

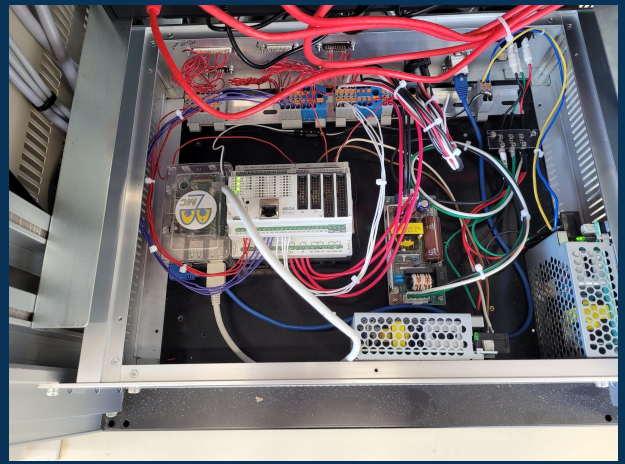


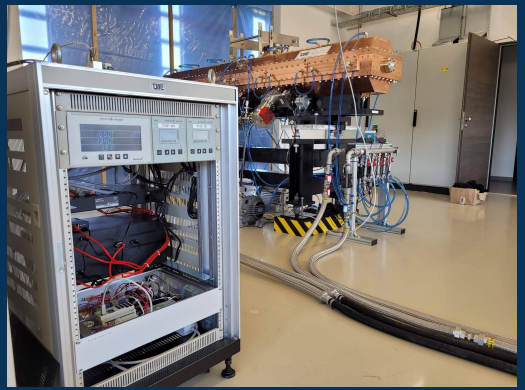

BL-MC
mirrotron-rfq-flow-cube v1.0


mirrotron-rfq-temp-cube v1.0
BL-MC
Screw_Terminal_01x02
GREEN
RPiHeader

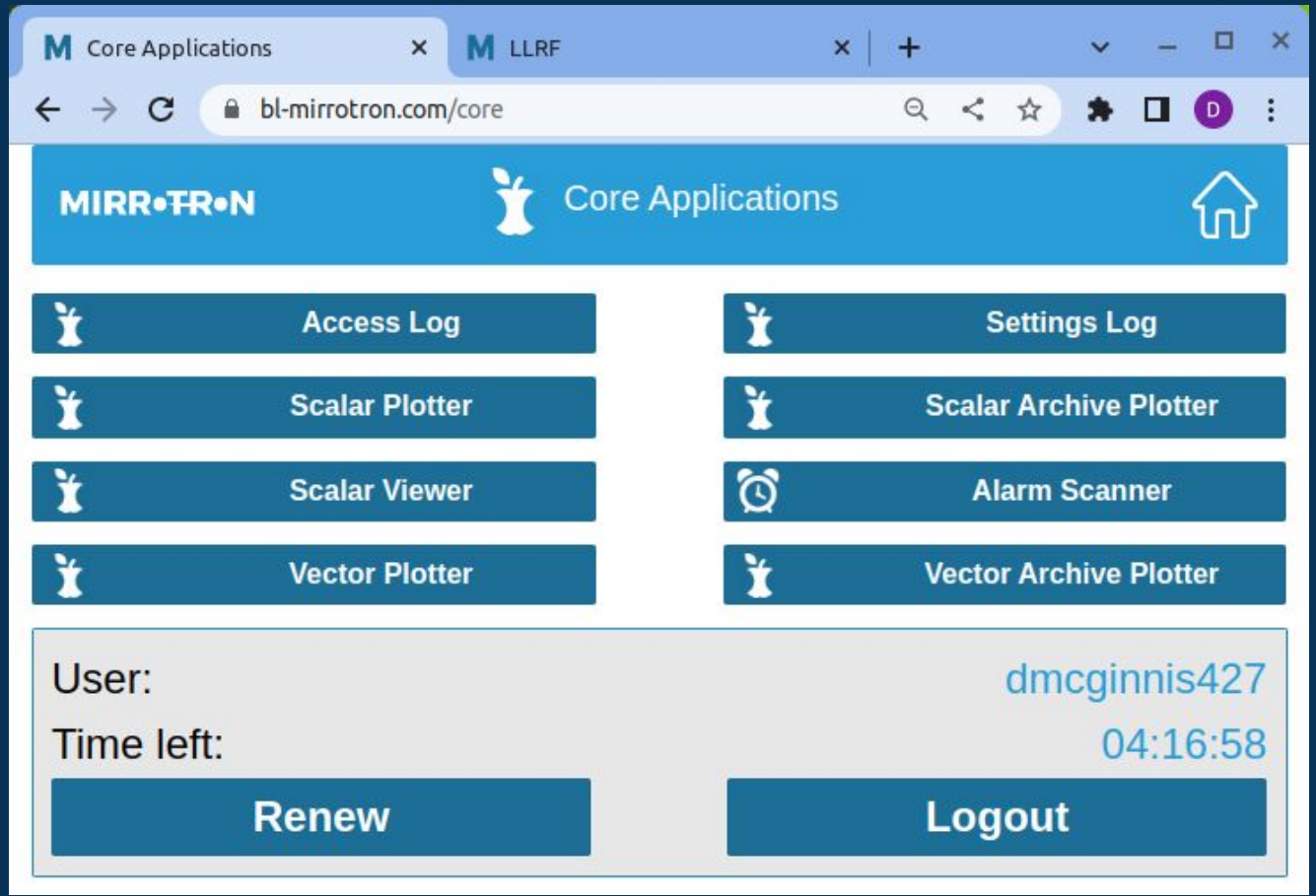
# RFQ Vacuum


MIRRORON
RFQ Vacuum
Vacuum Status Control
-
rfq-vacuum.01.gauge1 3.099 logPa
rfq-vacuum.01.gate1Open
rfq-vacuum.01.gate1Closed
rfq-vacuum.01.turboSpeed1
rfq-vacuum.01.turboNoError1
rfq-vacuum.01.gauge2 2.939 logPa
rfq-vacuum.01.gate2Open
rfq-vacuum.01.gate2Closed
rfq-vacuum.01.turboSpeed2
rfq-vacuum.01.turboNoError2
rfq-vacuum.01.gauge3 1.702 logPa
rfq-vacuum.01.gauge4 1.7 logPa
Archive
-
2
4
8
24
72
168
Hours
Pressure (logPa)
May-22
May-23
May-24
May-25
May-26
May-27
May-28
Time Plot
-
Pressure (logPa)
May-28
14:34:00
14:35:00
14:36:00
14:37:00
14:38:00
14:39:00
User
+

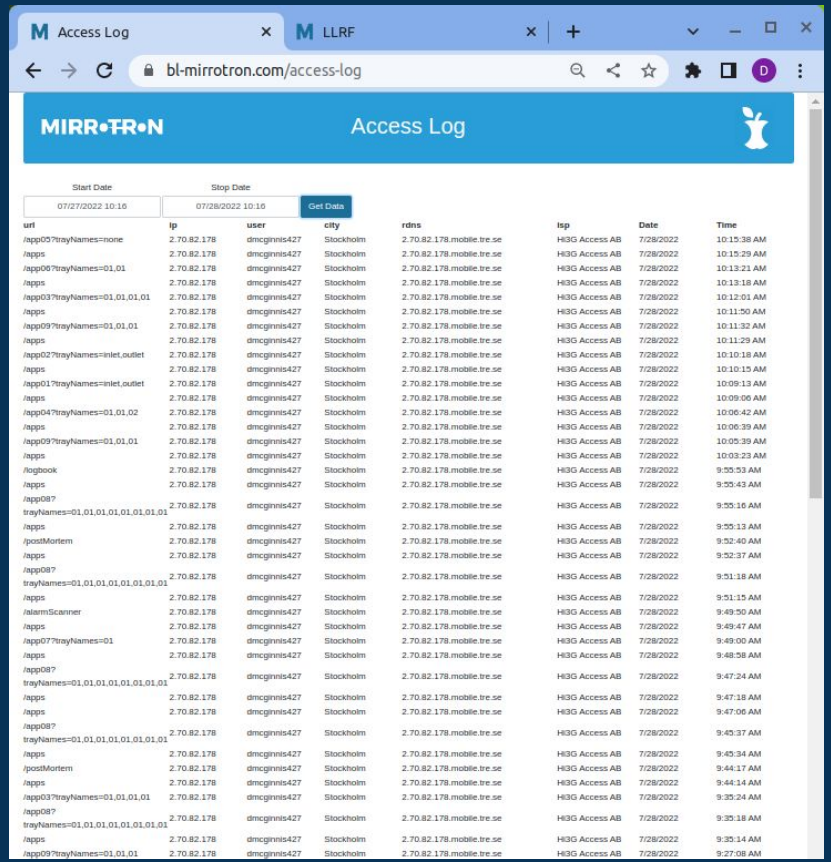


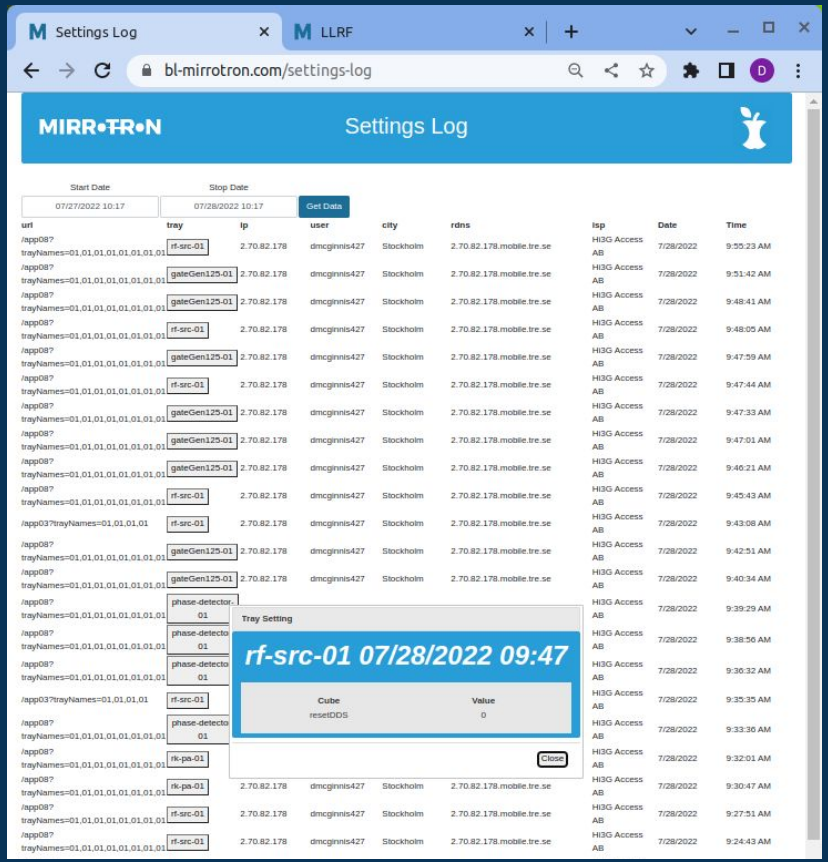


# Core Applications

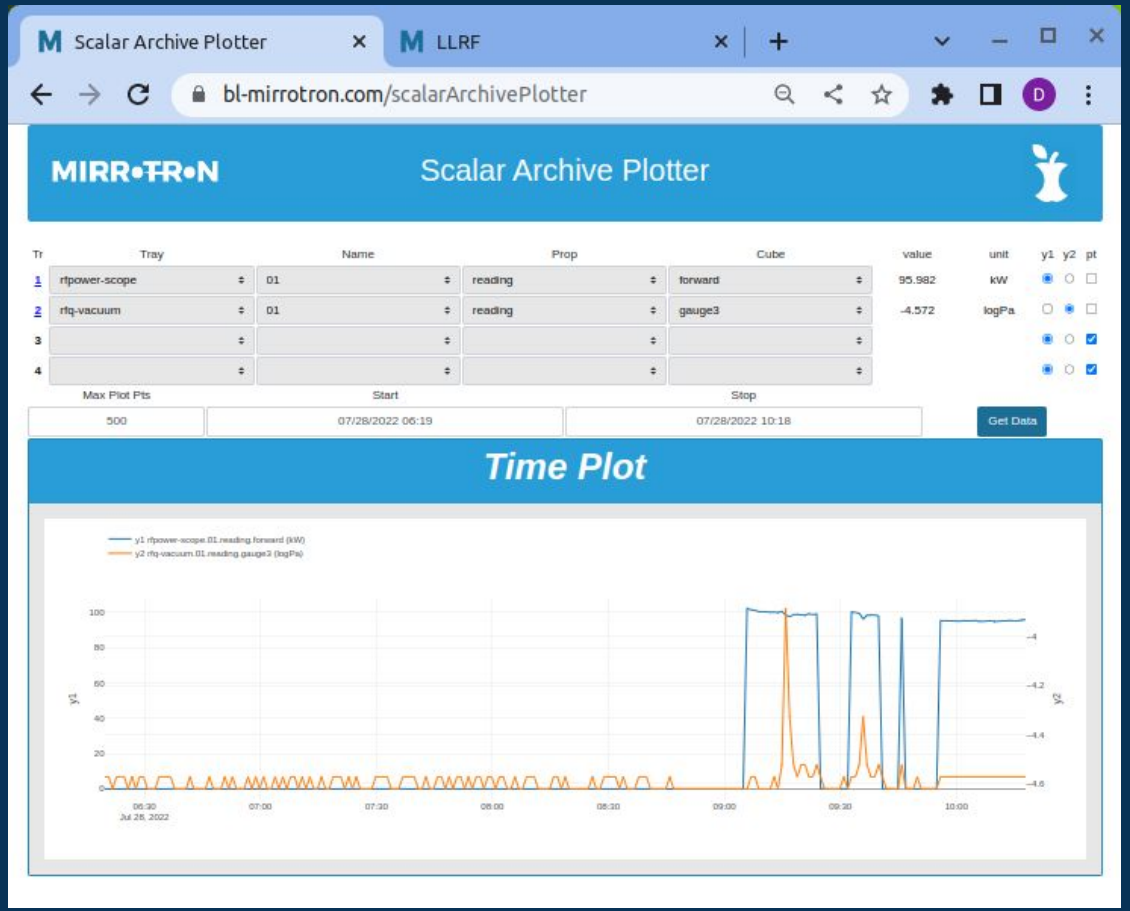


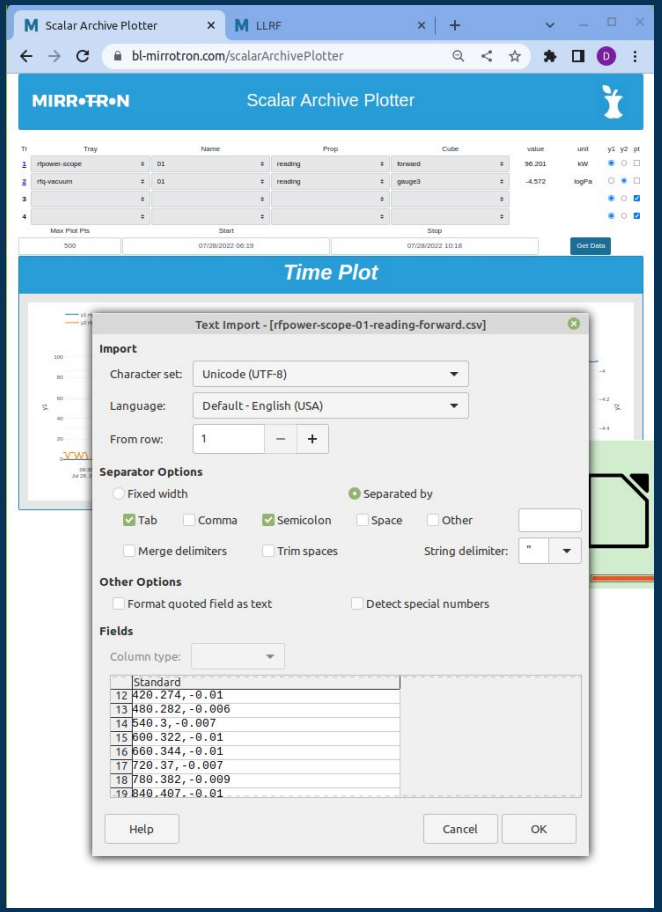
# Access and Settings Log



# Archive Plotters and Export



# RFQ Online Documentation