

Abstract

The superconducting driver linac for the Facility for Rare Isotope Beams (FRIB) will accelerate heavy ions to 200 MeV per nucleon. The linac includes 46 SRF cryomodules, with a total of 69 solenoid packages for beam focusing and steering. For efficient beam commissioning and future operation, all of the solenoids must be turned on and reach a stable operating condition in a short time. Additionally, when a warm-up of the cryomodules is needed, degaussing of the solenoid packages is needed to minimize the residual magnetic field in the SRF cavities. An automatic turn-on and degaussing program had been implemented for FRIB cryomodules to meet these requirements. This paper will describe the design, development, and implementation of the automated solenoid control program.

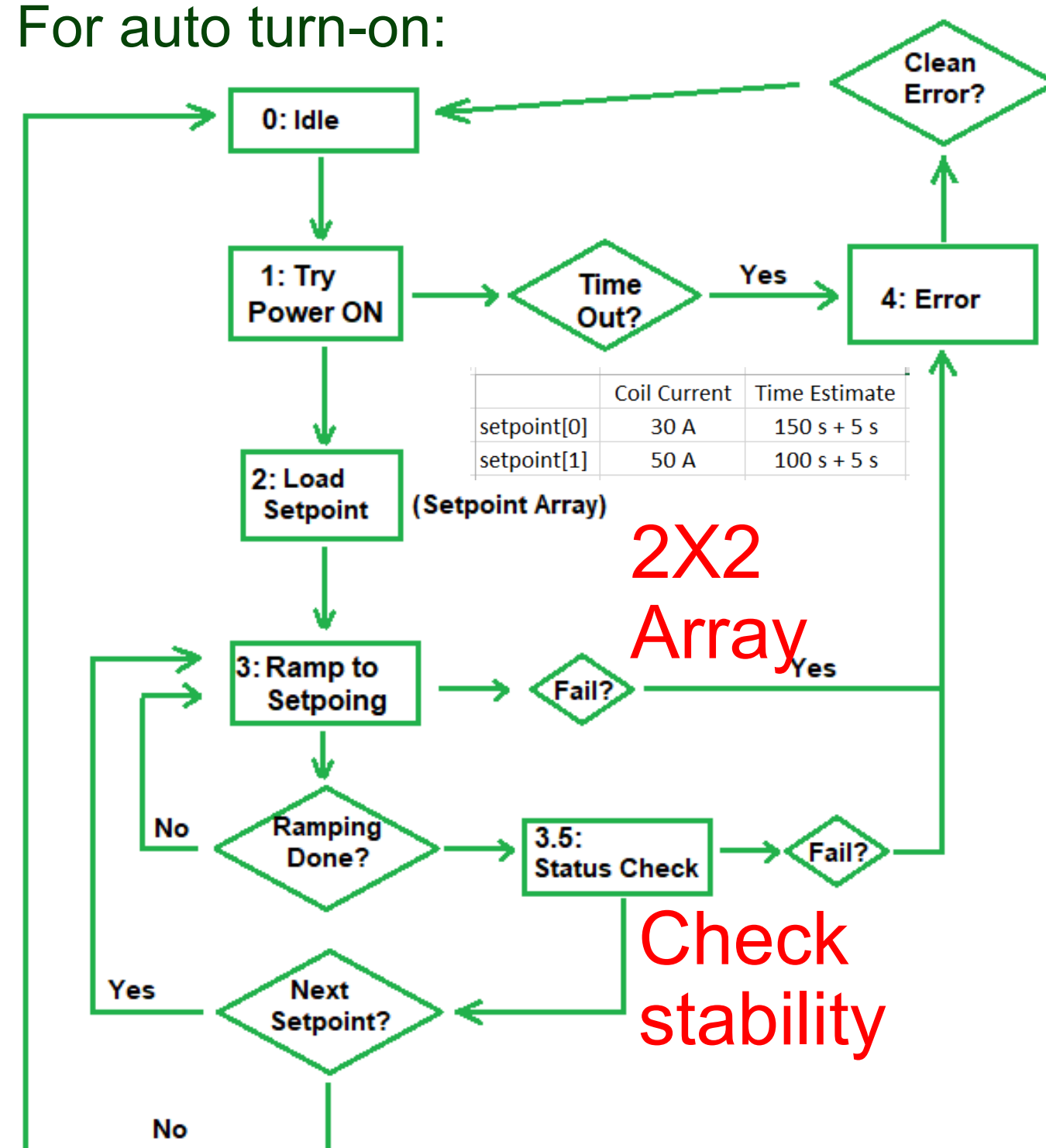
FRIB Cryomodule Solenoid Package Parameters

	Aperture	Solenoid integrated square strength	Length	Maximum magnetic field	Steering magnetic field	Steering integrated field strength	Solenoid Current	Steering Current
0.041 Cryomodule	40 mm	13.6 T ² m	250 mm	8 T	0.12 T	> 0.03 Tm	90 A	19 A
0.085, 0.29 and 0.53 Cryomodule	40 mm	28.2 T ² m	500 mm	8 T	0.12 T	> 0.06 Tm	90 A	19 A

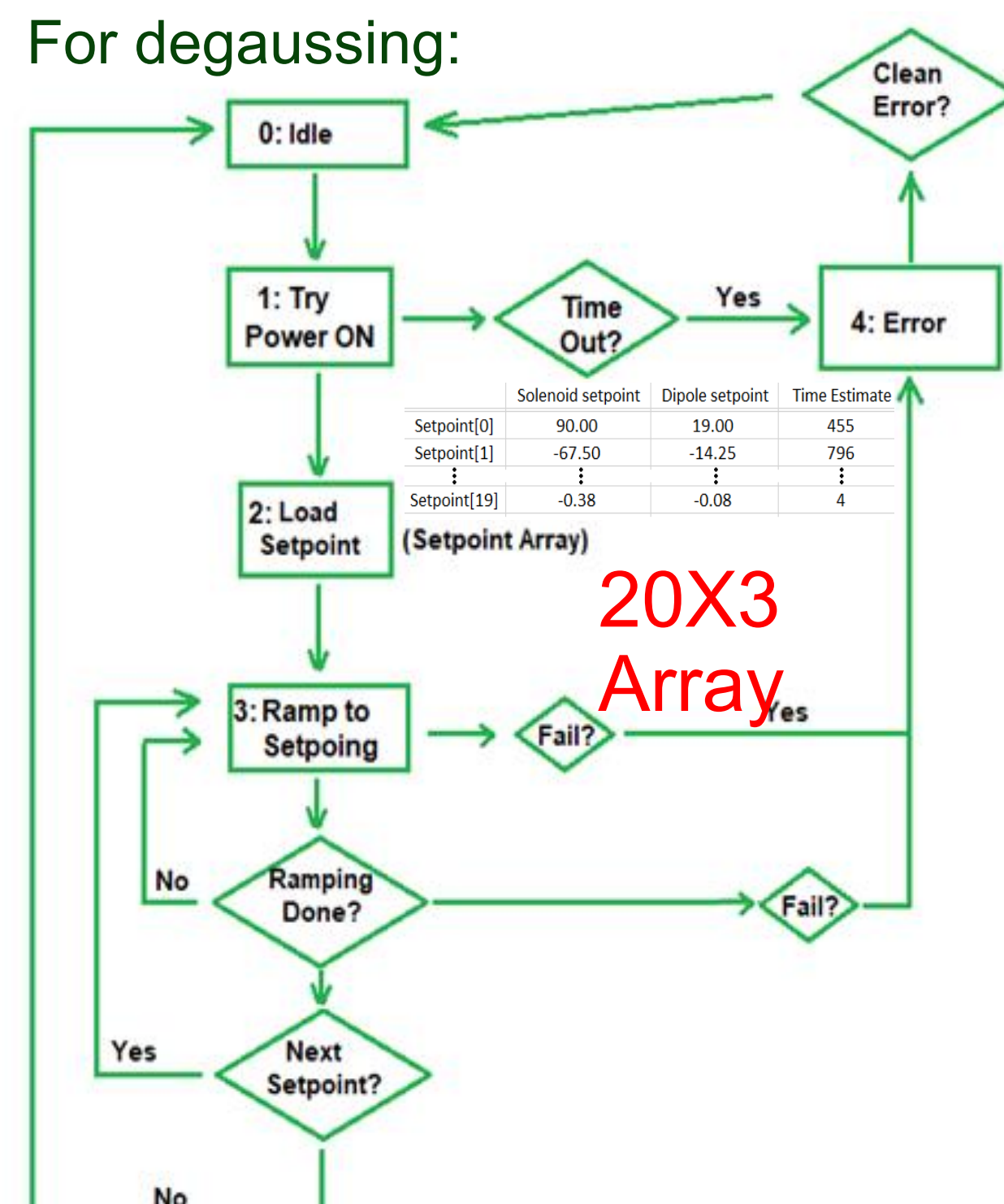
Parameters for FRIB cryomodule solenoid packages

Solenoid Auto Turn-on and Degaussing State-chart

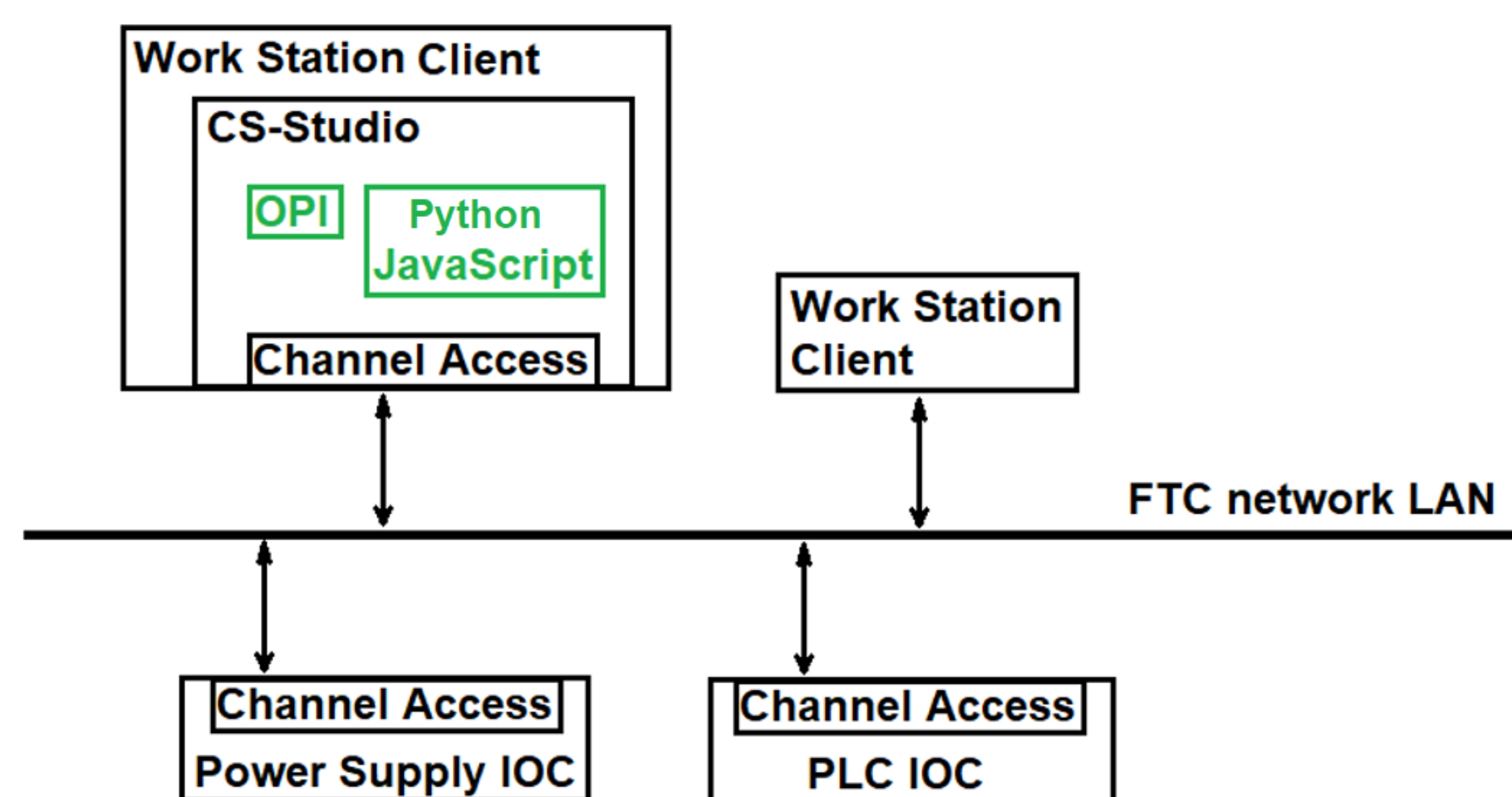
For auto turn-on:



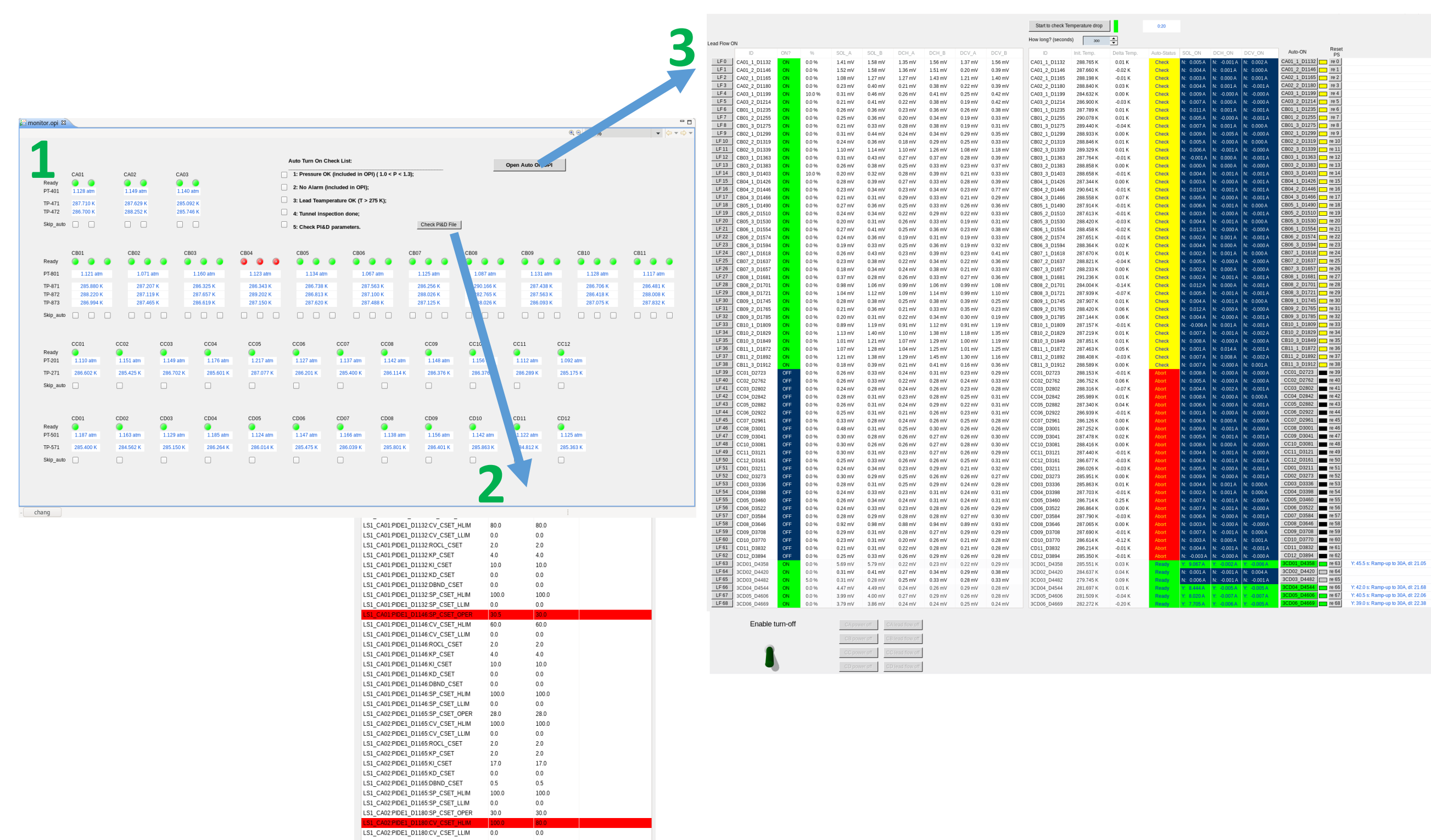
For degaussing:



Left state-chart is auto turn-on procedure state machine. After power supply turned on, the solenoid will be ramp to set-point. For auto turn-on, there are two current set-points. First ramp-up to 30 A and check the stability, then ramp-up to 50 A. Right state-chart is degaussing procedure state machine, it is similar with “auto turn-on”. Difference is the degaussing procedure have 20 set-points for solenoid and another 20 set-points for steering dipoles, and there is no stability check needed for the solenoid package degaussing.

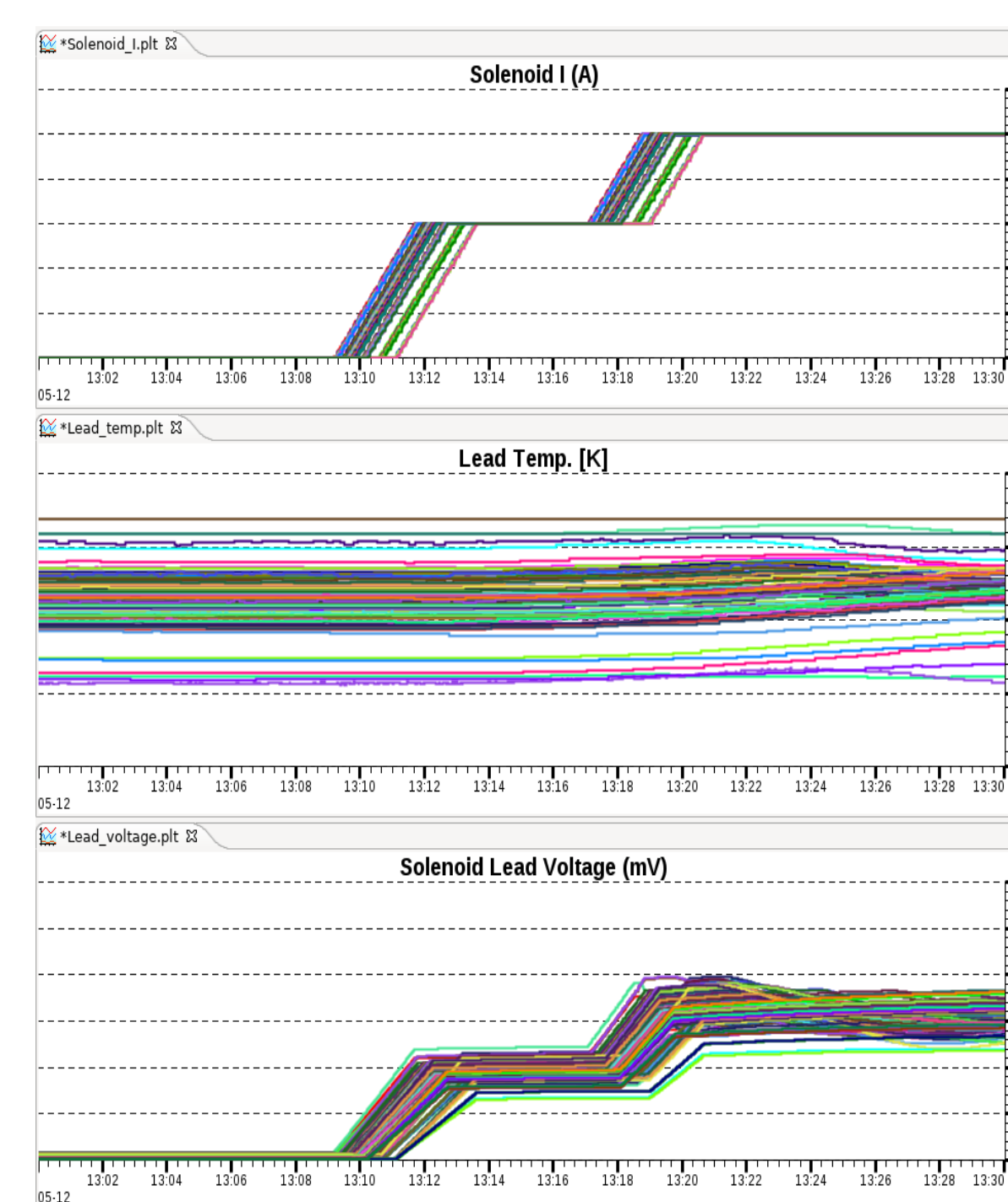


To implement the automated procedure, a client level program had been developed. The program is based on the CS-Studio OPI that embedded Python and JavaScript code for the automated logic. It is run at a client machine which usually is a work station. The work station can control solenoid package's power supply through the “FTC network”. The “FTC network” is a control network based on EPICS and it is for FRIB control only.

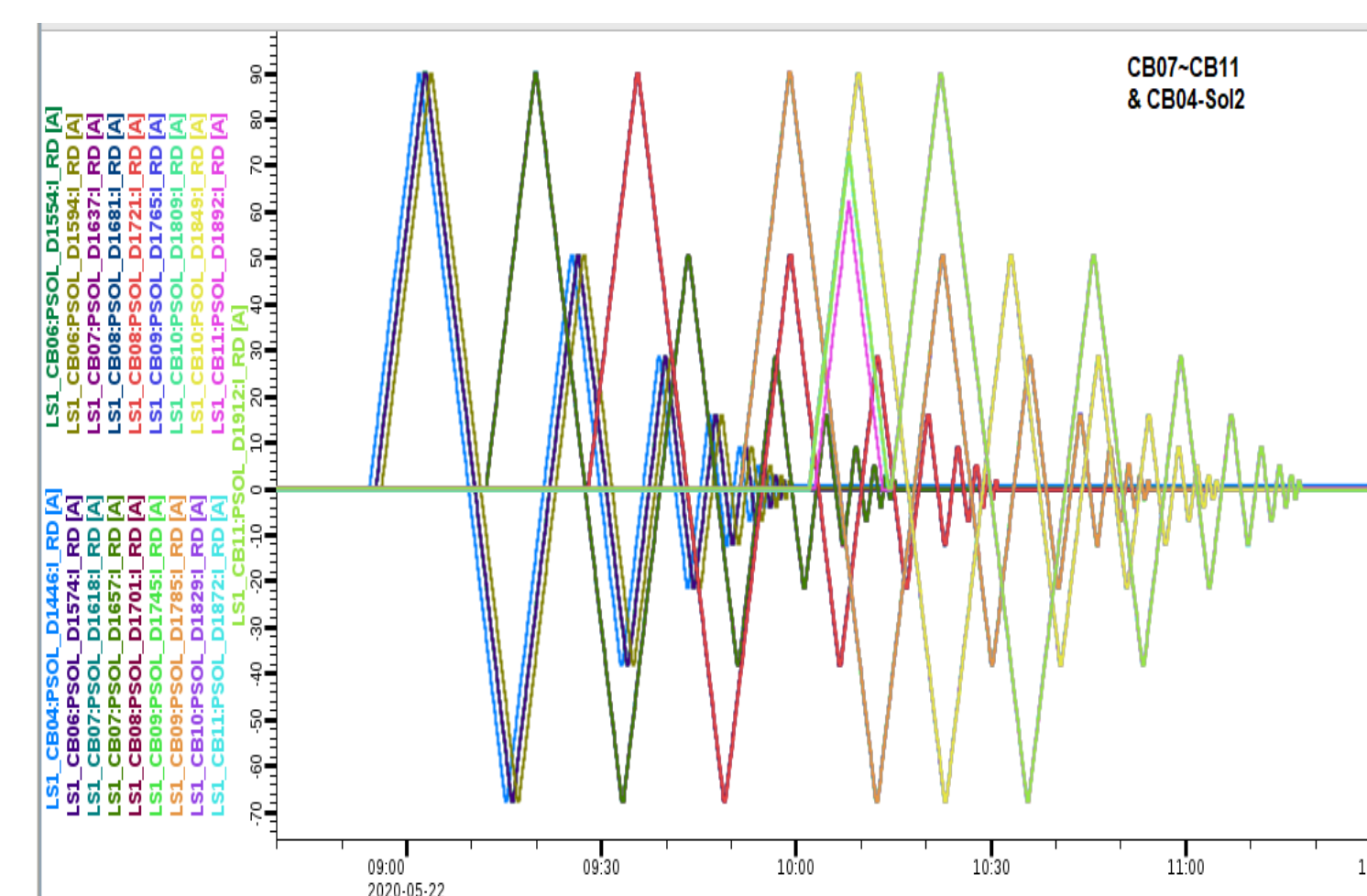


The CS-Studio OPI for the automated solenoid control is comprised of the following three pages: 1) interlock status check, 2) solenoid lead flow valve PID control parameters check, and 3) auto turn-on/degaussing page.

Commissioning Result

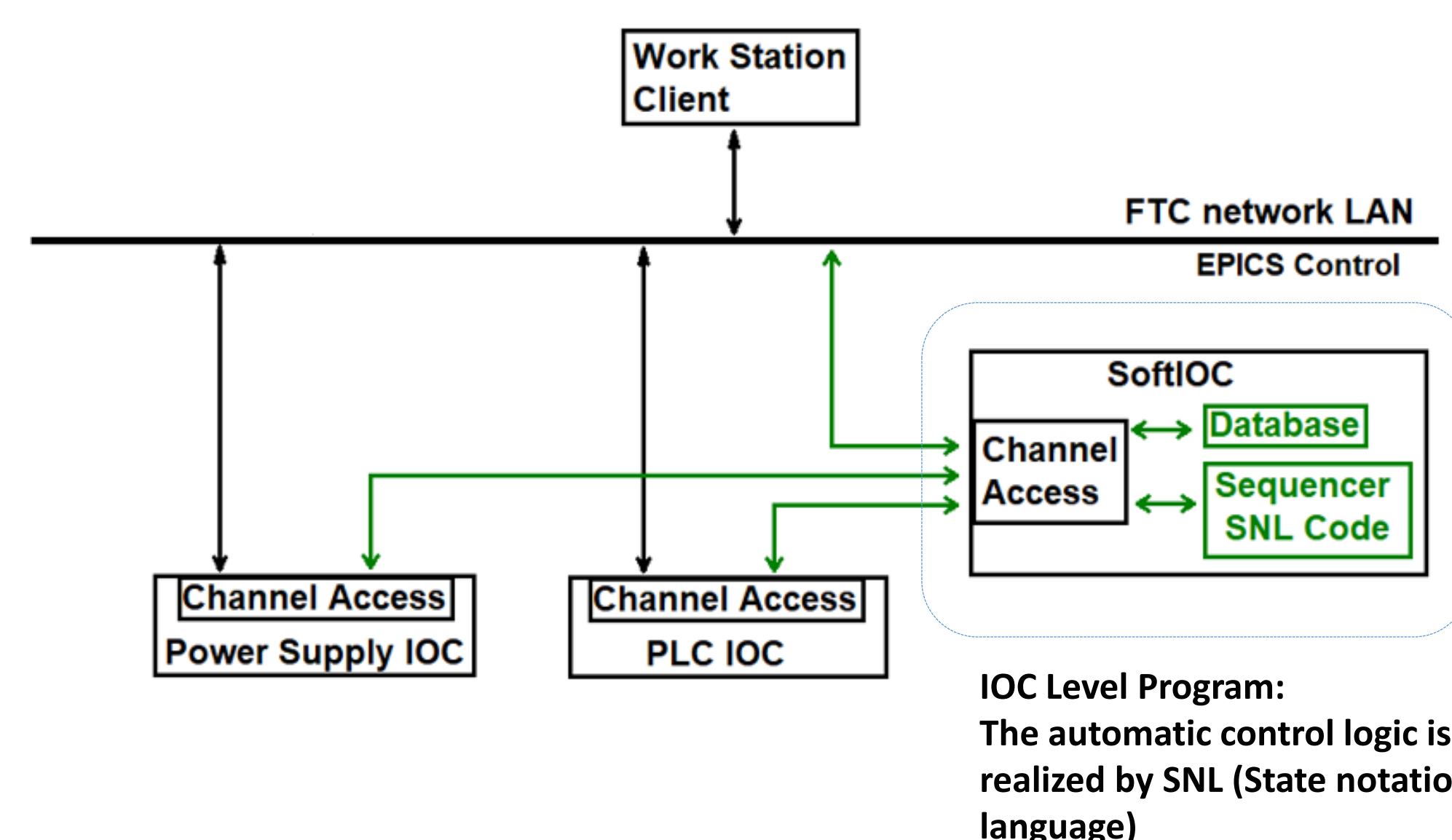


All FRIB solenoids auto turn-on details (before beam commissioning start)



Solenoids automatic degaussing details (before the FRIB linac warm-up)

IOC Level Program Develop and Future Plan



IOC Level Program:
The automatic control logic is realized by SNL (State notation language)

So far, the automatic turn-on and the degaussing logical were tested and verified. The client level program worked fine for the beam commissioning. Now, there is an IOC level program have been developed. In future, the IOC level program will be deployed and be operated for solenoid packages for all FRIB cryomodules.

