Run Permit System Architecture at the Facility for Rare Isotope Beams

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Background

The Facility for Rare Isotope Beams (FRIB), currently under initial commissioning, accelerates heavy ions up to a beam power of 400kW. Capable of accelerating a wide variety of ion species at variable beam energies, machine protection risks are of significant concern. In one of several efforts to address these risks, a Run Permit System (RPS) is under development and testing.

The primary roles of the RPS are:

- Determine if accelerator state is appropriate to produce beam
- Distribute state-appropriate configuration to dependent systems
- Indicate to dependent systems that beam production may commence or continue

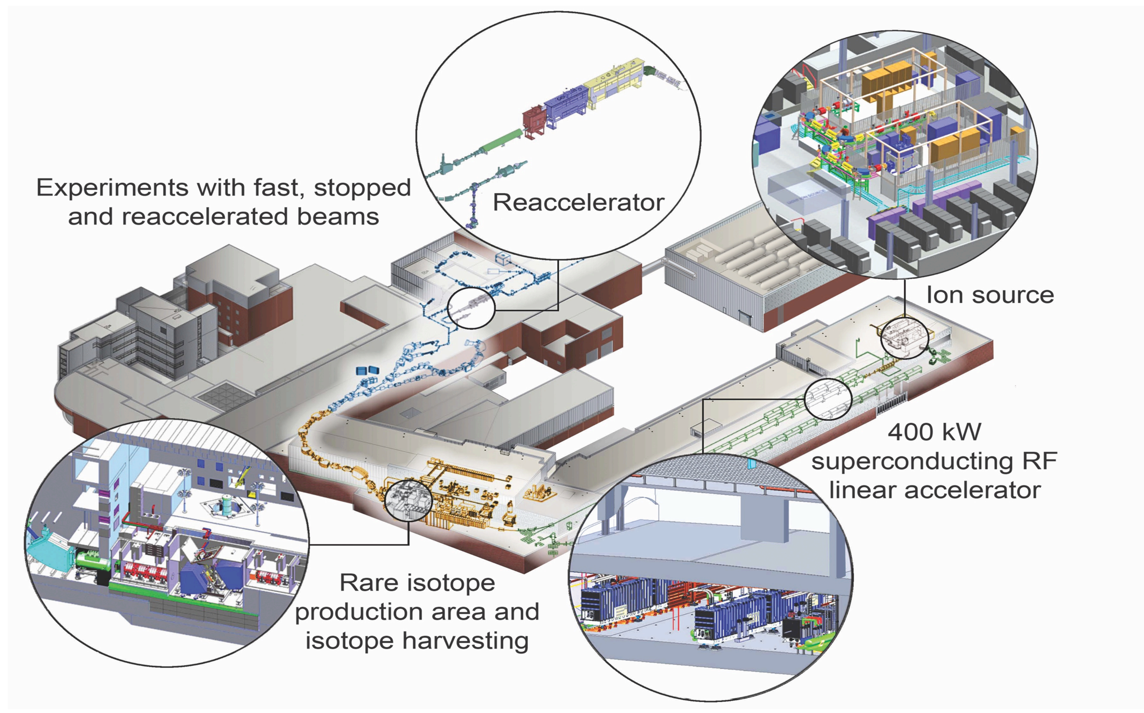

Figure 1: Layout and major components of FRIB

Accelerator State

The scope of the RPS touches upon many systems: Personnel Protection System (PPS), Global Timing System (GTS), Machine Protection System (MPS), Diagnostic instrumentation, and optics power supplies. Given the potential breadth of impact of the RPS, some means of defining and constraining scope was necessary.

The notion of *Machine Modes* and *Beam Modes* are incorporated here, and define the geographic scope of beam propagation as well as the attributes of the produced beam itself (maximum power, timing structure), respectively. The set of accelerator state comprising Machine and Beam Modes, ion species, and charge state are provided by the RPS user interface and form the *keys* to a database query which returns the curated hardware settings for that state-set.

Table 1: Example FRIB Machine Modes

ID	Description	Beam Modes
M0	Maintenance (no beam)	B0
M1	Beam delivery up to linac	B0, B8
M4	Beam delivery to experimental systems	B0, B1, B2, B5

Table 2: Example FRIB Beam Modes

ID	Time Structure/Power	Scope
B0	No Beam	Entire machine
B1	CW/10-400 kW	Entire Machine
B8	Variable/2-650 eμA at Faraday Cup	Front End

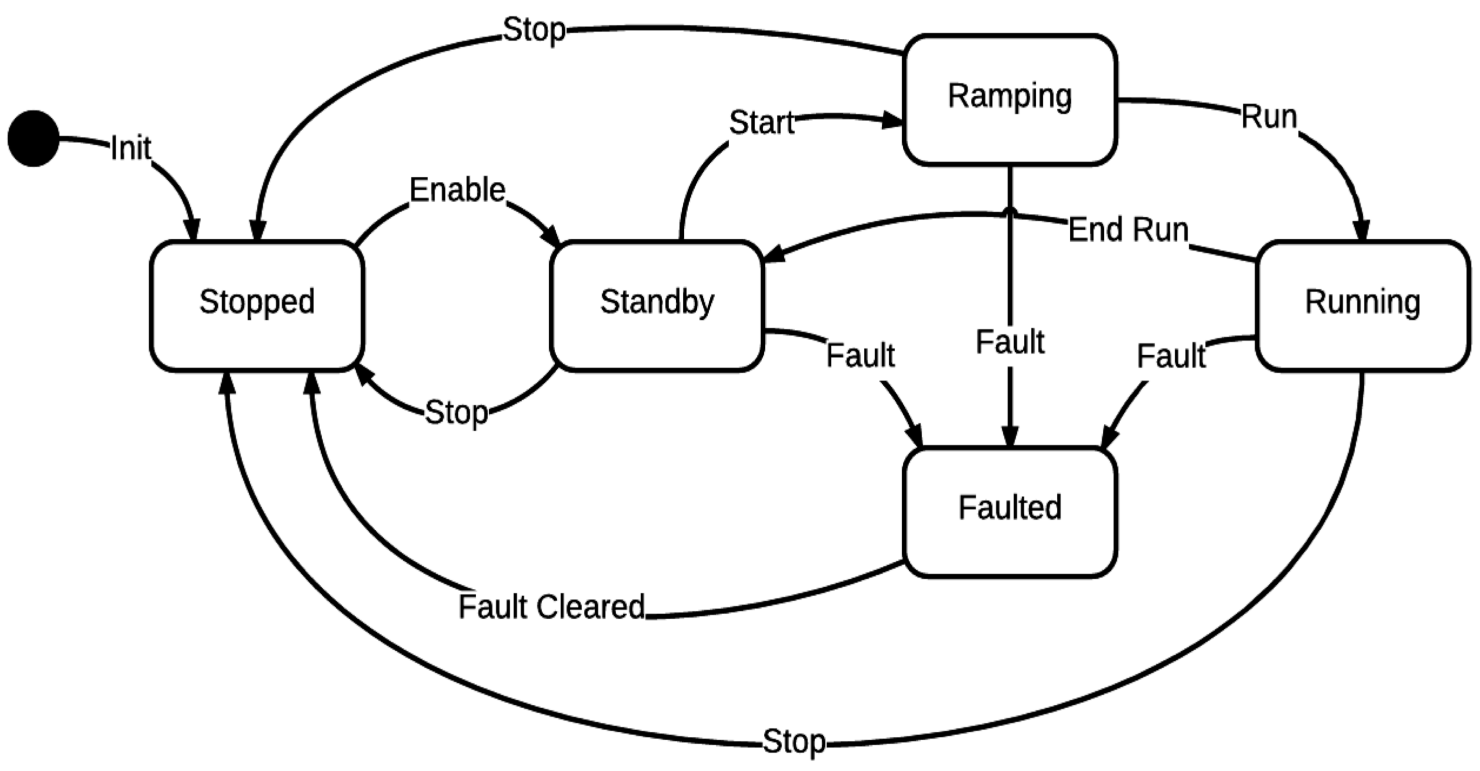

Figure 3: RPS finite state machine model

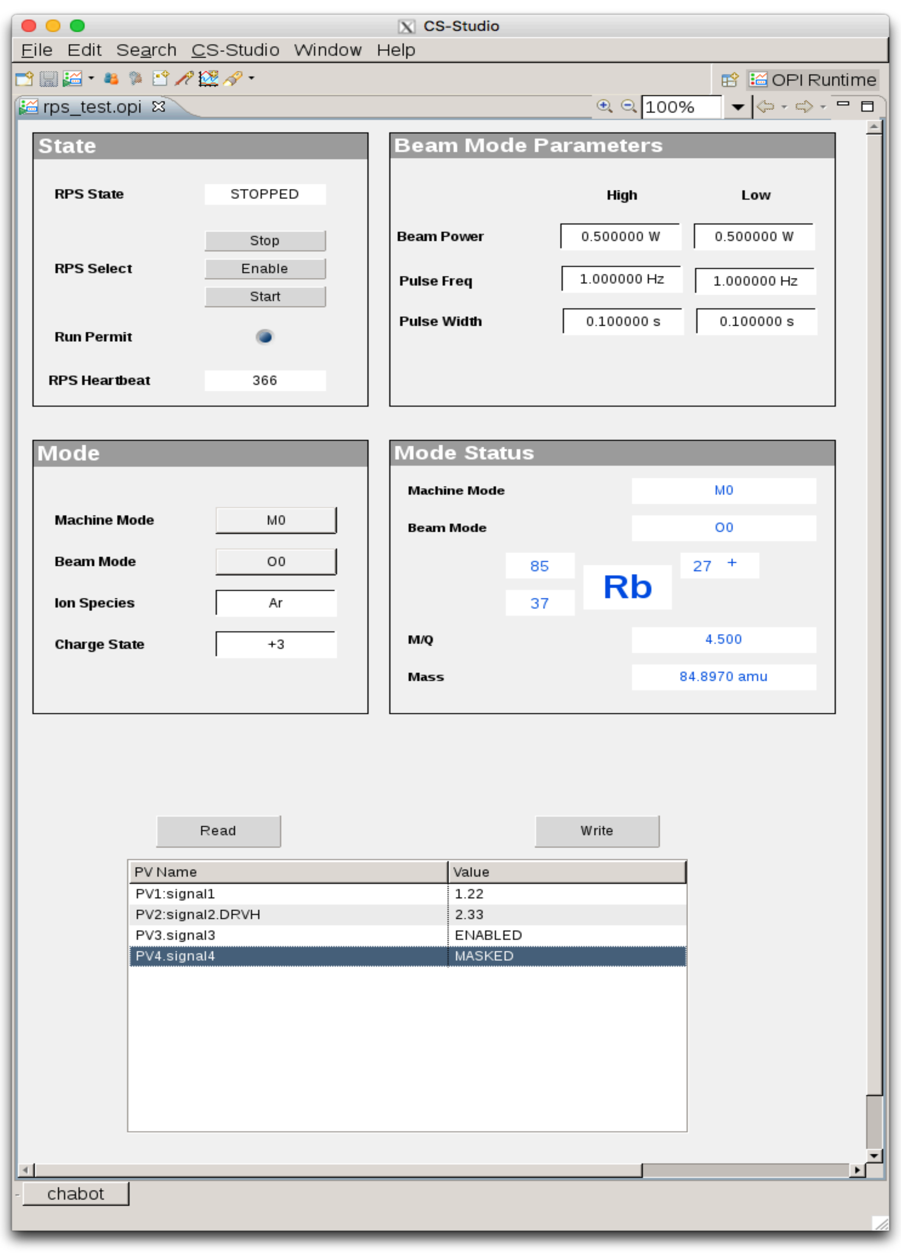

Figure 2: RPS user interface, CS-Studio

RPS Structure and Operation

The user-provided events, *Enable*, *Start*, and *Stop* govern the state transition behavior of RPS software. All other state changes are governed by hardware events observed in the control system.

When an *Enable* transition is requested, the RPS will query a database using the current set of *accelerator state* to obtain suitable parameters for distribution to the hardware. The parameters include power supply range limits, diagnostic device alarm limits or device in-beam/out-of-beam state, and which MPS sensors should be masked off.

A query failure, or any failure in device parameter distribution will obstruct any state transitions until the logged failure is addressed by operational staff.

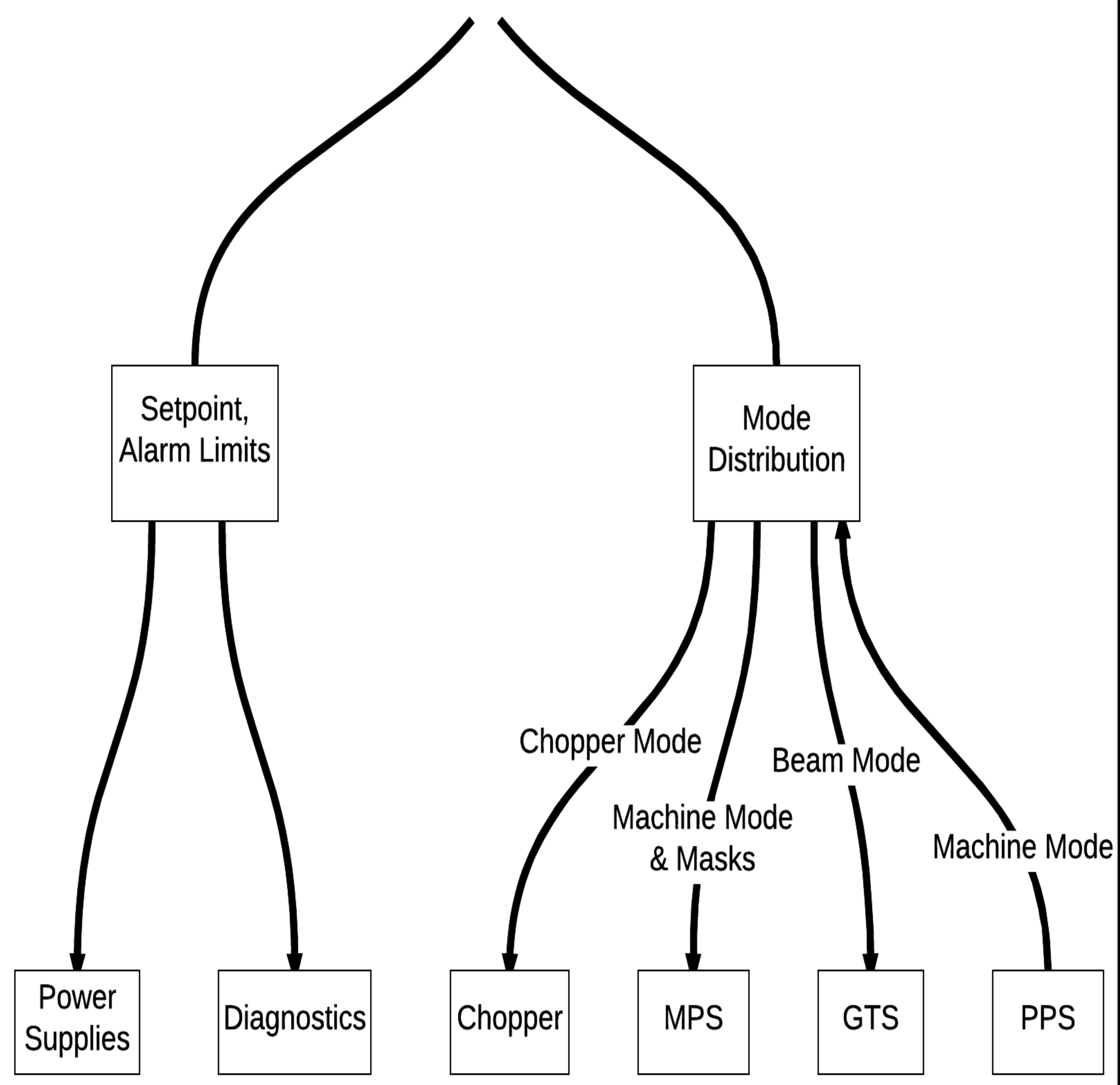

Figure 4: Data flow between RPS and sub-systems

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