MPB Report: MICE C&M

Pierrick Hanlet

30 April 2014

Outline

I Introduction

II Description

III Integrated Hardware Plan

IV Higher Level Operation

V Other Items

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The Task
"the obvious"

Controls and Monitoring (C&M):

- **provide hardware controls**
- **provide user interfaces**
  - **synoptic displays – GUIs**
- **protect equipment**
  - **alarm handling**
  - **data archiving**
- **contribute to protect data quality**
  - **alarm handling**
  - **data archiving**

***Not* responsible for personnel protection**

The Procedure

- **Subsystems controls built/commissioned independently**
  - specified by subsystem owners
  - interlocks built in at component level
  - standalone C&M tested with subsystems
- **New integrated C&M hardware**
  - re-arrange racks to share space/resources
  - install in RR2 – allows access while running
- **Higher level controls interface with subsystems**
  - *Document in progress*
  - *MICE-NOTE-GEN-431*

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- ✔ I Introduction
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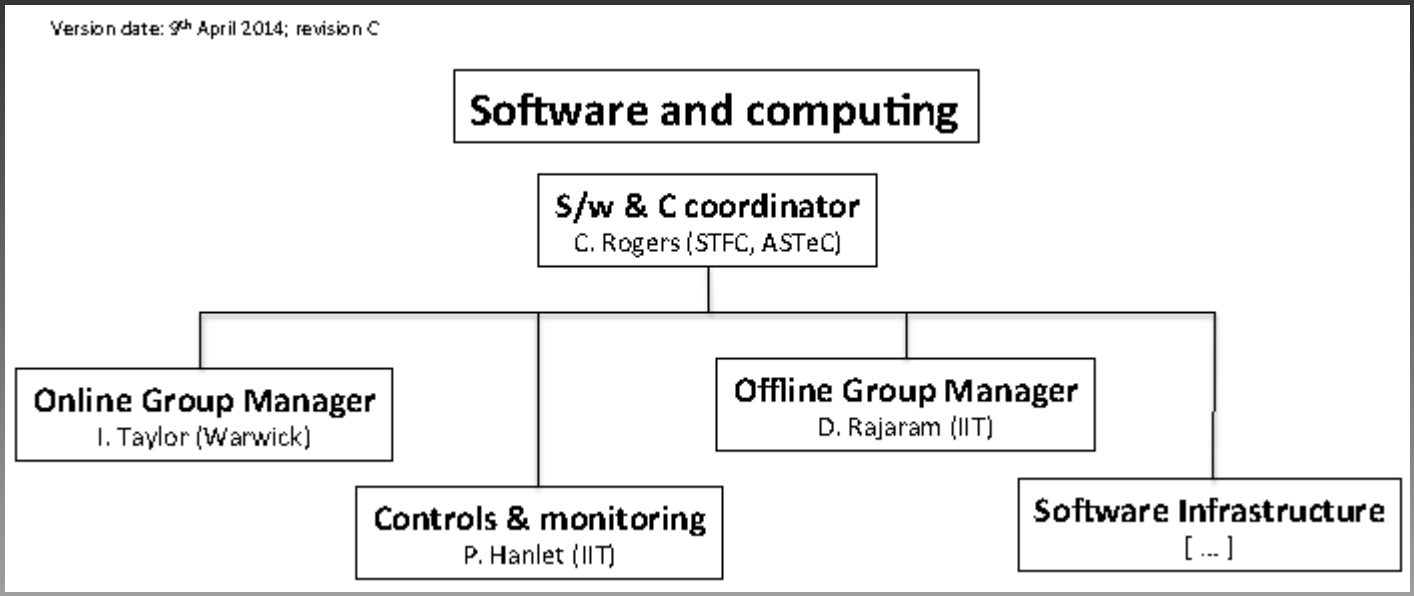
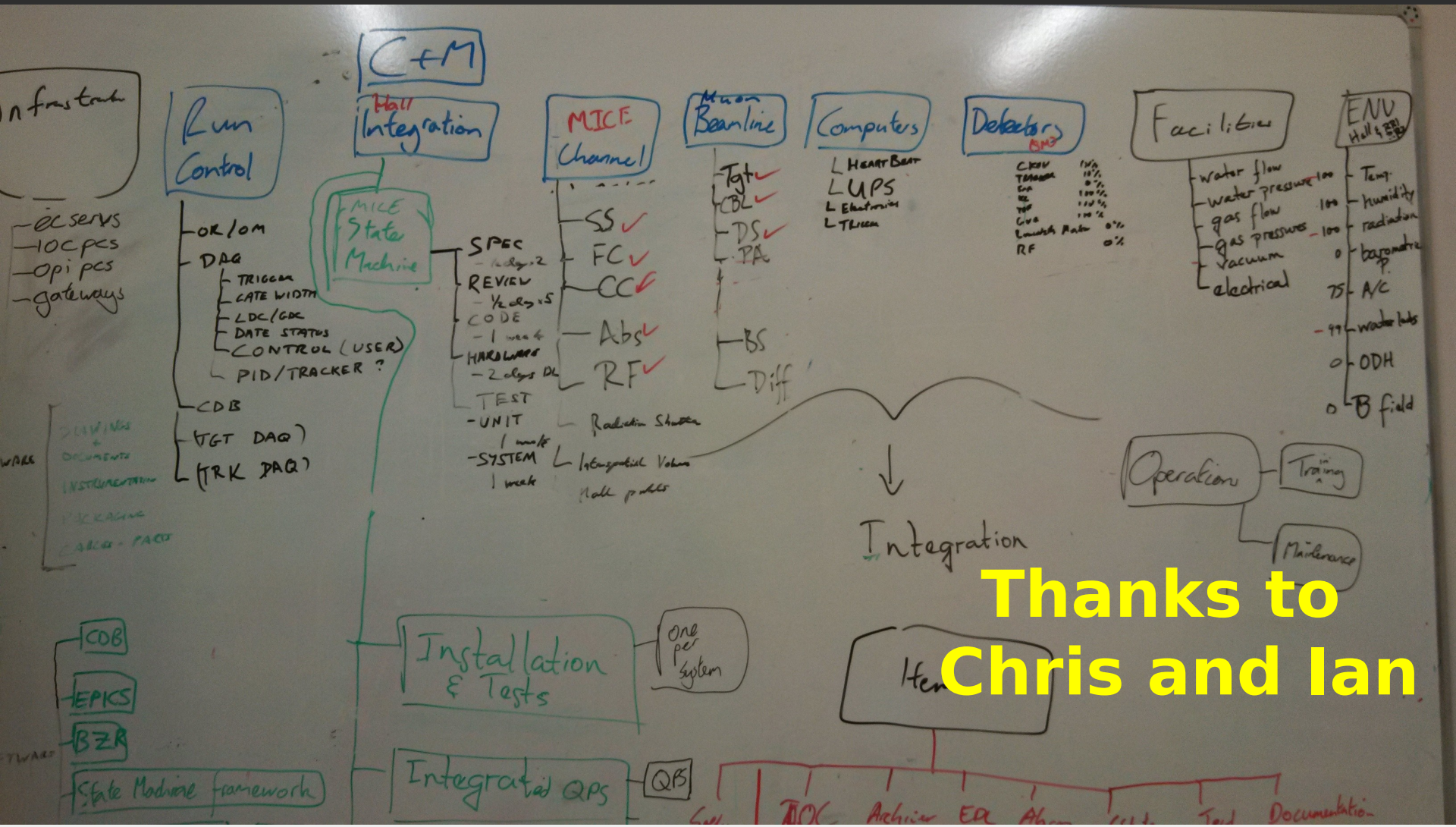
Organization



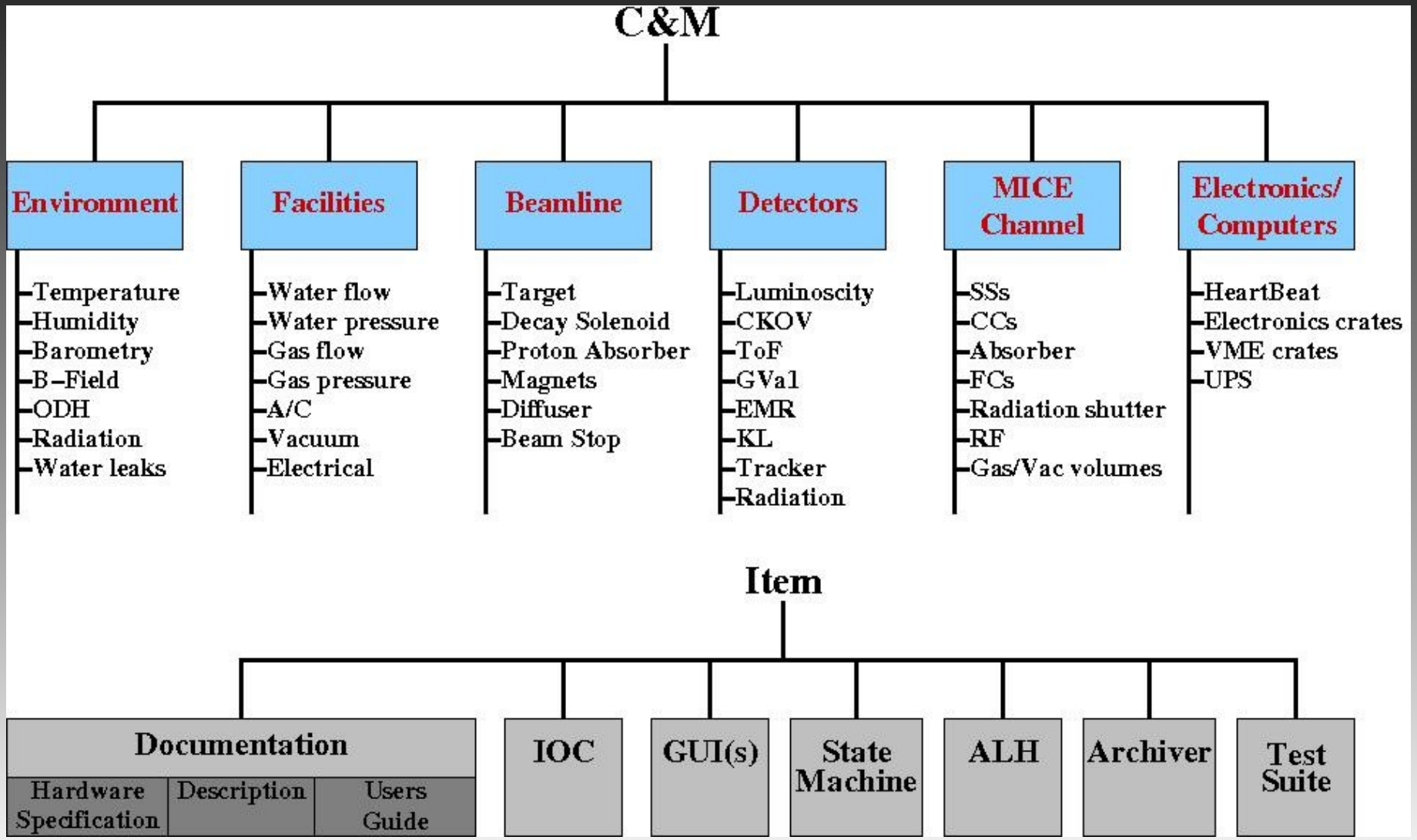
Since last MPB, C&M is its own package.

Computing infrastructure continues to be handled by Online

Organization



Organization



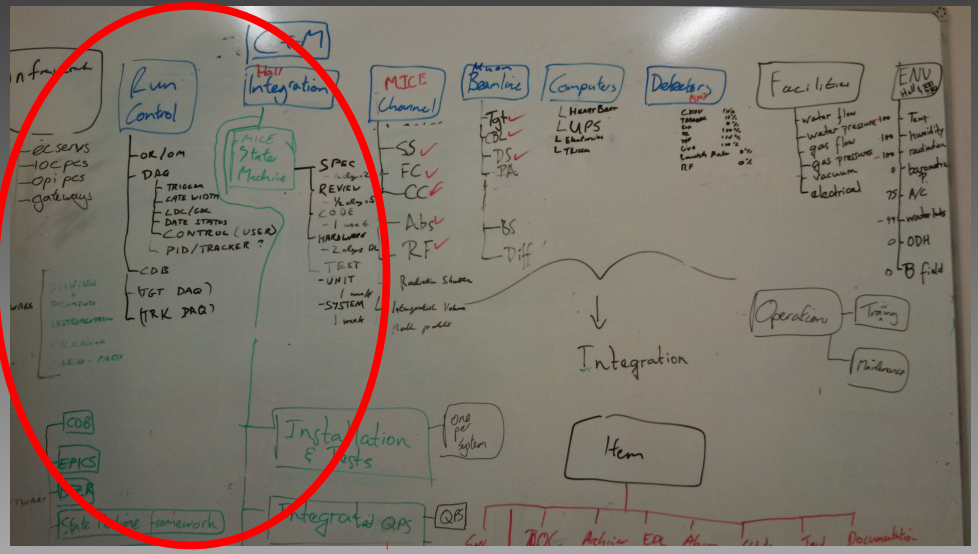
Organization Understanding the Scope

Partial list example

			Owner	Required Time (Hours)	Proportion Done (%)	Person Occupancy	Modifier	Estimated Task Time (Days)	Actual Time Taken
Environment	Temperature Humidity Barometry WaterLeaks	IOC	Hanlet	3	95	60.00%	1	0.03	
		GUI(s)	Hanlet	1	95	60.00%	1	0.01	
		ALH	Heidt	1	80	5.00%	1	0.50	
		Archiver	Heidt	1	80	5.00%	1	0.50	
		StateMachine	NA	0	0	0.00%	1	0.00	
		TestSuite	NA	0	0	0.00%	1	0.00	
		Documentation	Taylor	0	0	50.00%	1	0.00	
	B-Field	IOC	Hanlet	24	0	60.00%	1	5.00	
		GUI(s)	Hanlet	2	0	60.00%	1	0.42	
		ALH	Heidt	1	0	5.00%	1	2.50	
		Archiver	Heidt	1	0	5.00%	1	2.50	
		StateMachine	NA	0	0	0.00%	1	0.00	
		TestSuite	NA	0	0	0.00%	1	0.00	
		Documentation	Uchida	0	0	5.00%	1	0.00	
	ODH	IOC	Hanlet	12	0	60.00%	1	2.50	
		GUI(s)	Hanlet	1	0	60.00%	1	0.21	
		ALH	Heidt	1	0	5.00%	1	2.50	
		Archiver	Heidt	1	0	5.00%	1	2.50	
		StateMachine	NA	0	0	0.00%	1	0.00	
		TestSuite	NA	0	0	0.00%	1	0.00	
		Documentation	Nebrensky	0	0	50.00%	1	0.00	
	Radiation	IOC	Hanlet	24	0	60.00%	1	5.00	
		GUI(s)	Hanlet	1	0	60.00%	1	0.21	
		ALH	Heidt	1	0	5.00%	1	2.50	
		Archiver	Heidt	1	0	5.00%	1	2.50	
		StateMachine	NA	0	0	0.00%	1	0.00	
		TestSuite	NA	0	0	0.00%	1	0.00	
		Documentation	Torun	0	0	1.00%	1	0.00	

Organization
Understanding the Scope

What remains:



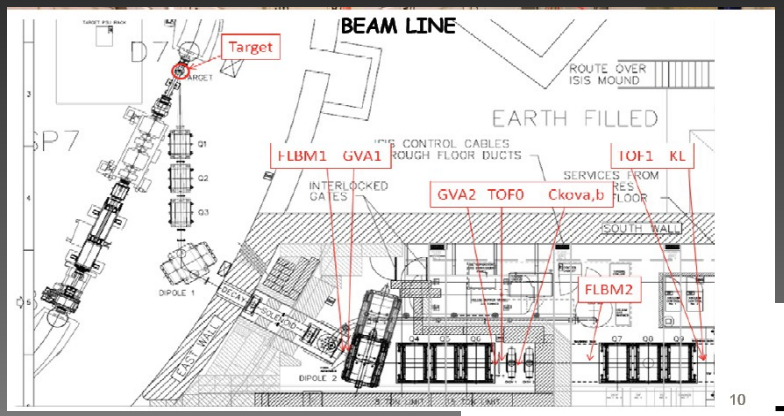
- Integration
  - infrastructure
  - hardware installation
  - State Machines
  - Run Control

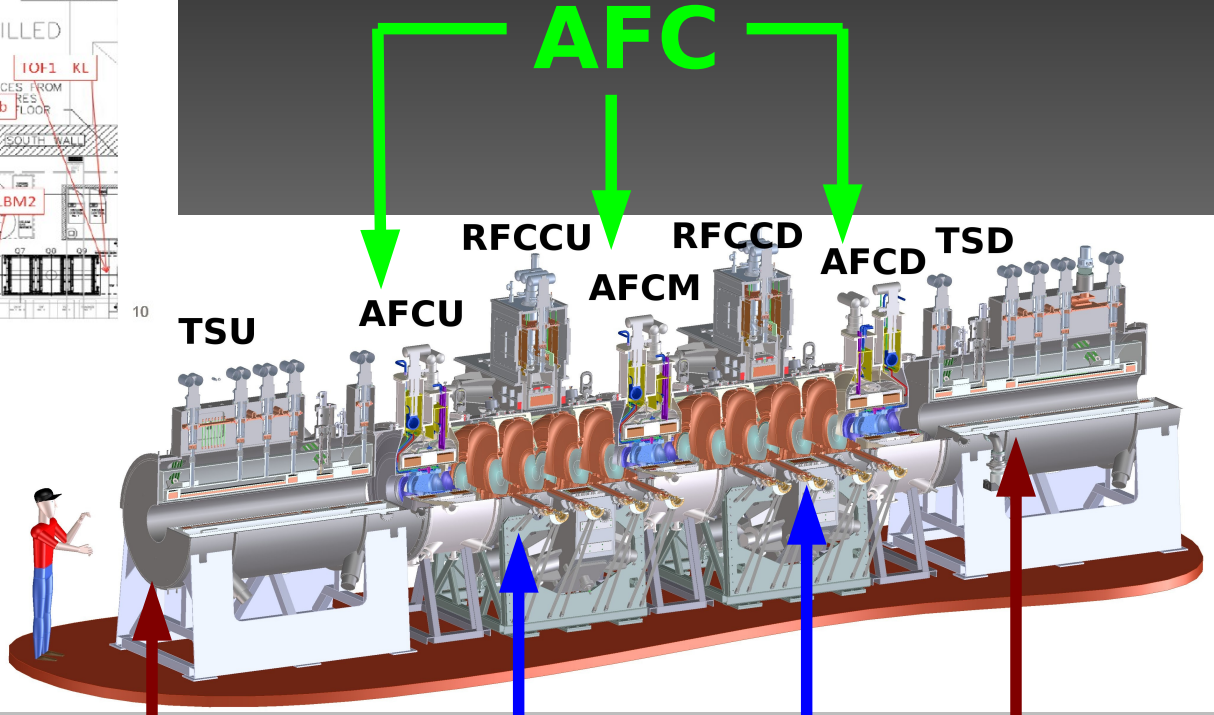
- STATUS: in progress – more later

Organization

- **Large systems provided by controls team from Daresbury Lab (DL):**
  - SS/FC/DS/conventional magnets
  - LH_2 system
  - Integrated cooling channel controls
  - FC/DS quench protection
  - Target/Tracker infrastructure
  - Vacuum
- **Target/Tracker: Leaver/Robinson/Adey**
- **Coordination/integration: Hanlet**
- **Smaller systems: Hanlet/Taylor/Heidt**

MICE Channel





Controls & Monitoring

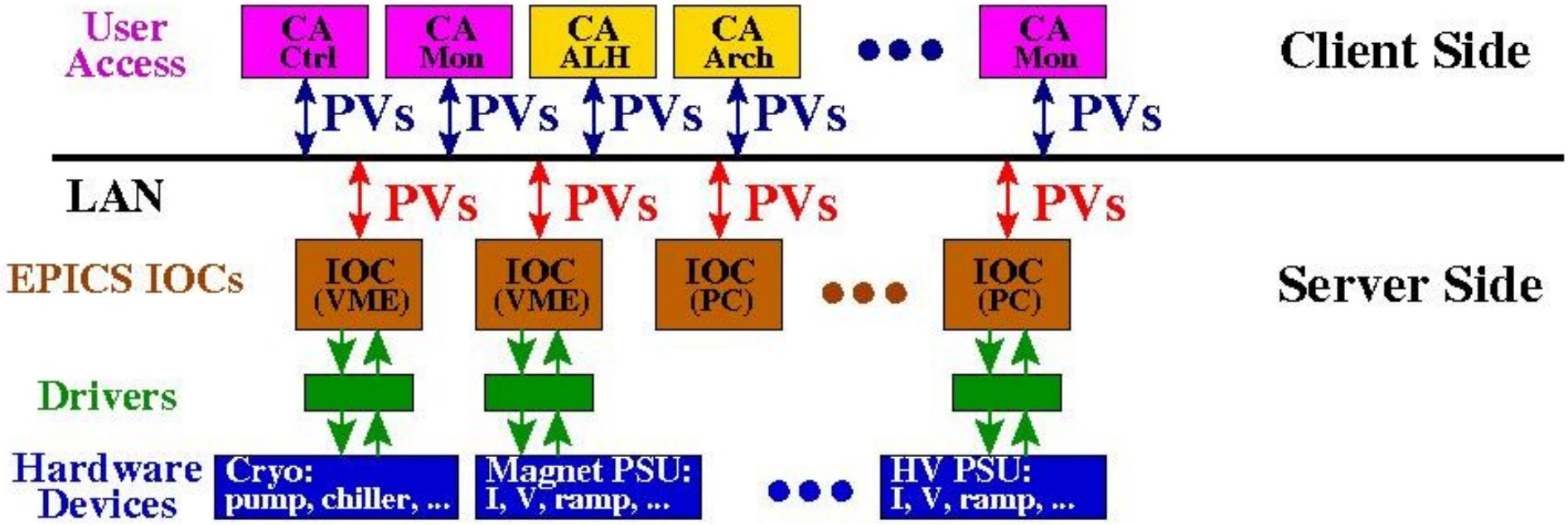
- **Beamline**
  - conventional magnets
  - proton absorber
  - beam stop
  - diffuser
- **Particle ID (PID)**
  - GVa1
  - ToF 1/2/3
  - CKOV A/B
  - KL
  - EMR
- **Environment**
  - temp./humidity..
- **Facilities/Computing**
- **Target**
- **SC Solenoids**
  - spectrometer solenoids
  - focus coil(s)
  - coupling coils (Step V or VI)
  - decay solenoid
- **Trackers**
- **Absorbers**
  - LH_2
  - solid absorbers
- **RF** (Steps V&VI)

These systems require:
- vacuum
- cryogenics
- power supplies

Framework: EPICS

Experimental Physics & Industrial Control Systems

- **HW+Drivers connect to IOCs** (Input/Output Controllers)
- **IOCs create PVs** (process variables) **to represent params**
- **PVs are further described with native fields**
- **PVs available on LAN to other IOCs or clients**



Hardware Description

DL Platform

- IOCs are VME based system with Hytek processors running VxWorks.
- Sensor controllers interfaced via RS232.
- CANbus employed for interlocks/digital controls
- Analog devices monitored/controlled with VME based ADCs and DACs.
- LH_2 system controlled by Omron PLCs
  - EPICS used solely for remote monitoring

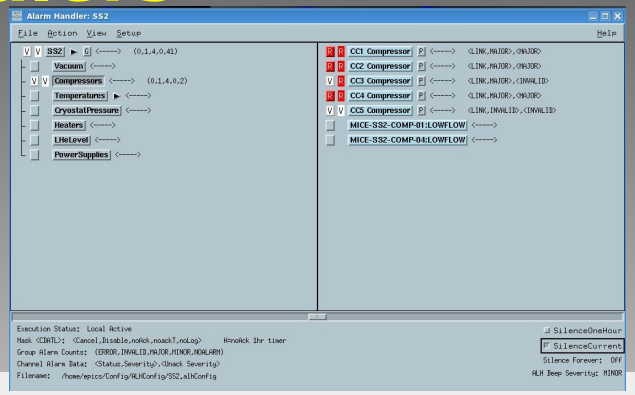
Hardware Description

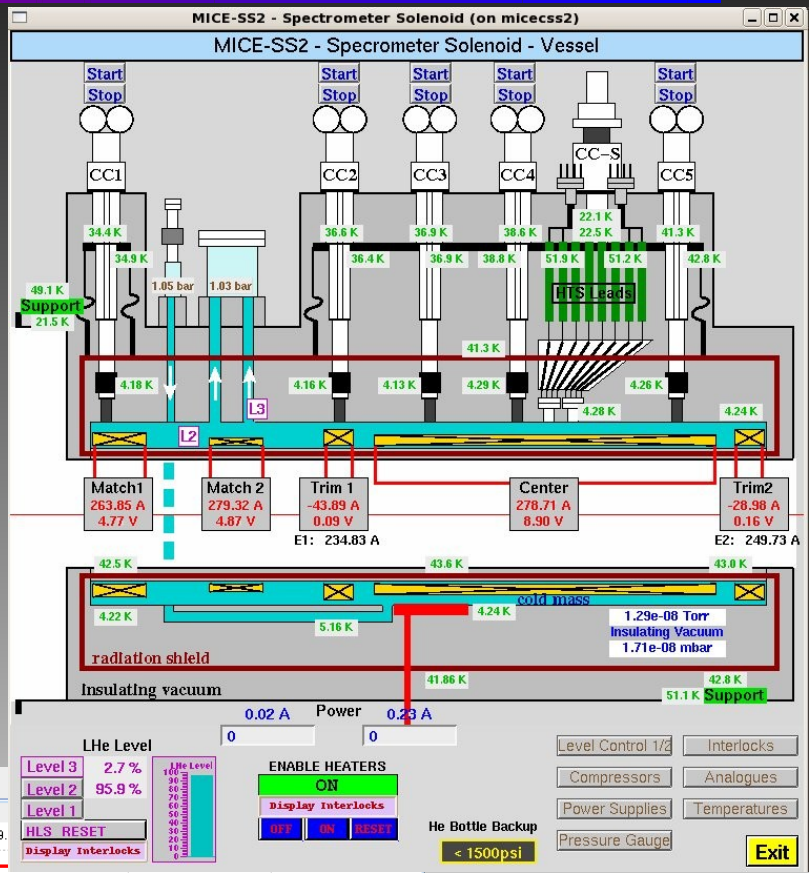
- Other IOCs implemented on Linux PCs
  - Ckov, radiation monitoring, high voltage for the PID detectors, proton absorber, beamstop, RF tuners, environment monitoring, air conditioning, LH_2 monitoring, and computer/electronics ``heart beat'' monitoring
- Employ a variety of interfaces
  - serial RS232 and RS485, SNMP, and TCP/IP.

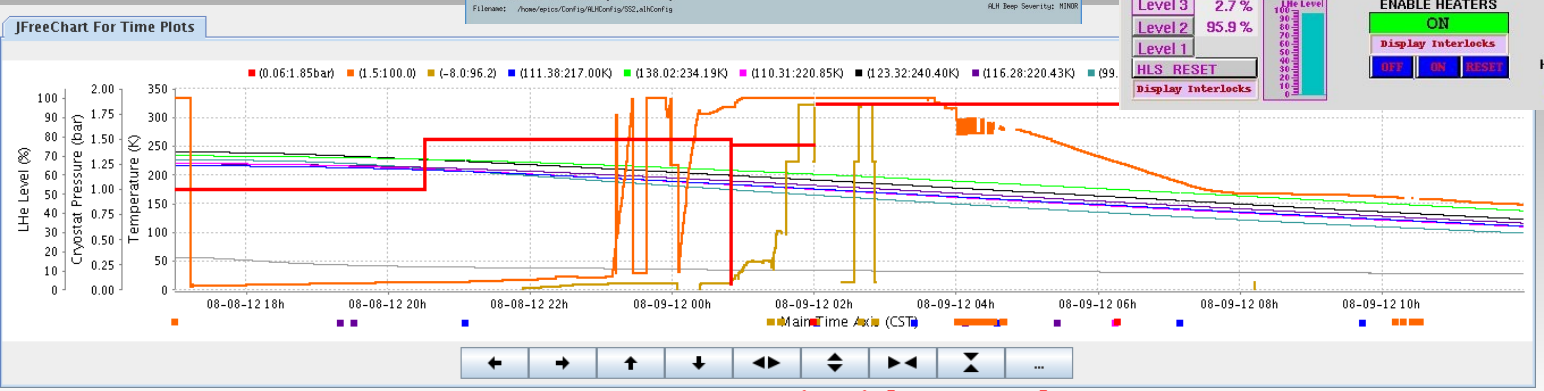
Framework: EPICS

PVs are used for:

- controlling the hardware
- interacting with other IOCs
- graphical displays – GUIs
- alarm handlers
- archiving

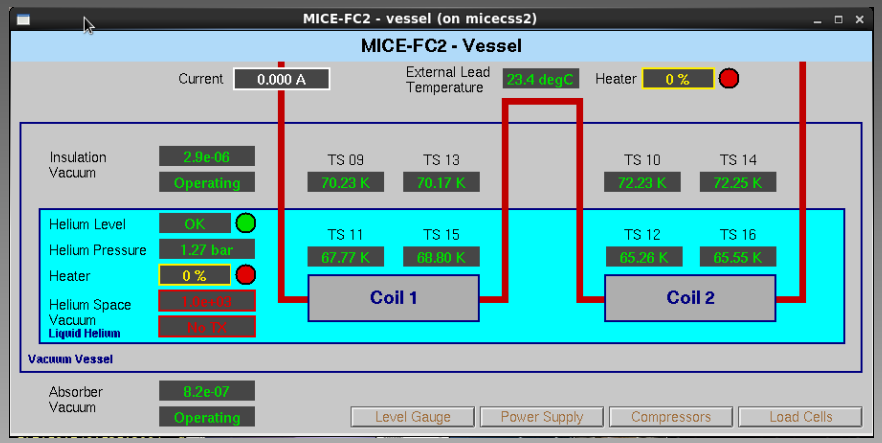


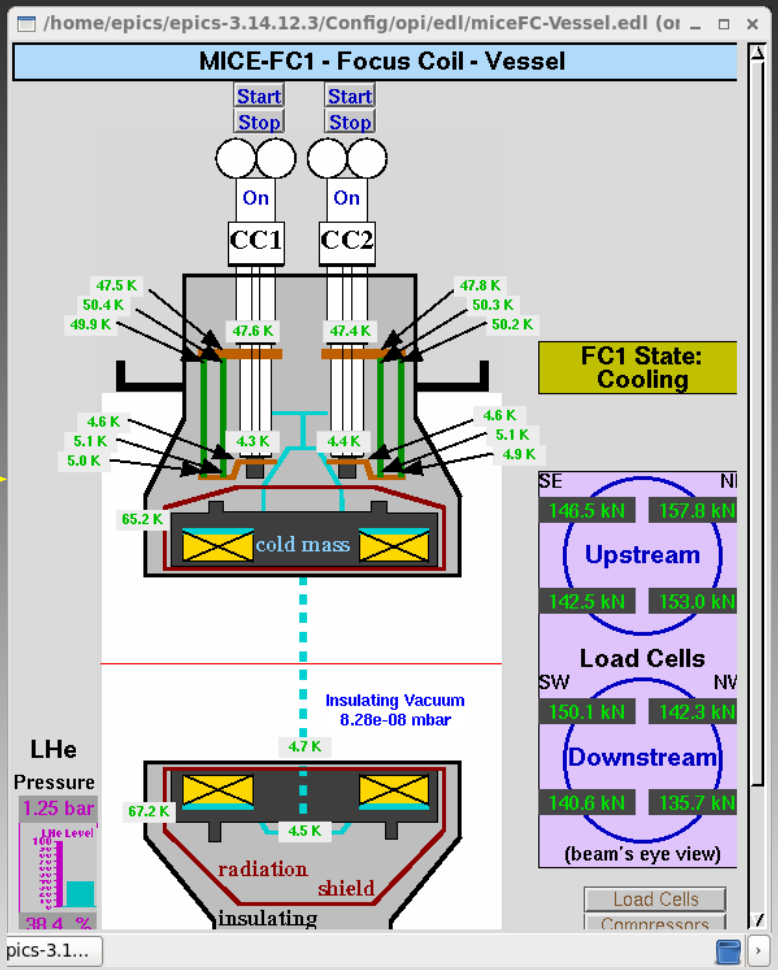




User Interfaces

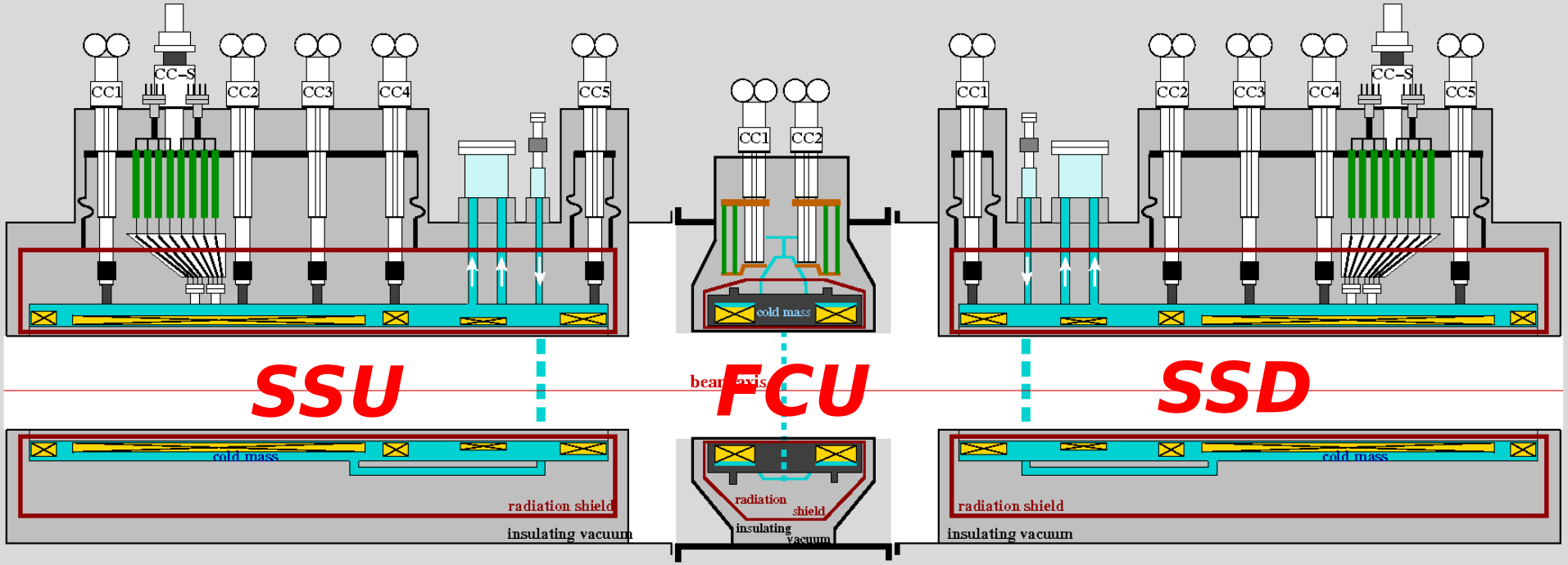
Progress on FC interface





Working toward uniform interfaces

Step IV Interface



- Vacuum
- Compressors
- Cryogenics
- Pressure
- Power Supply

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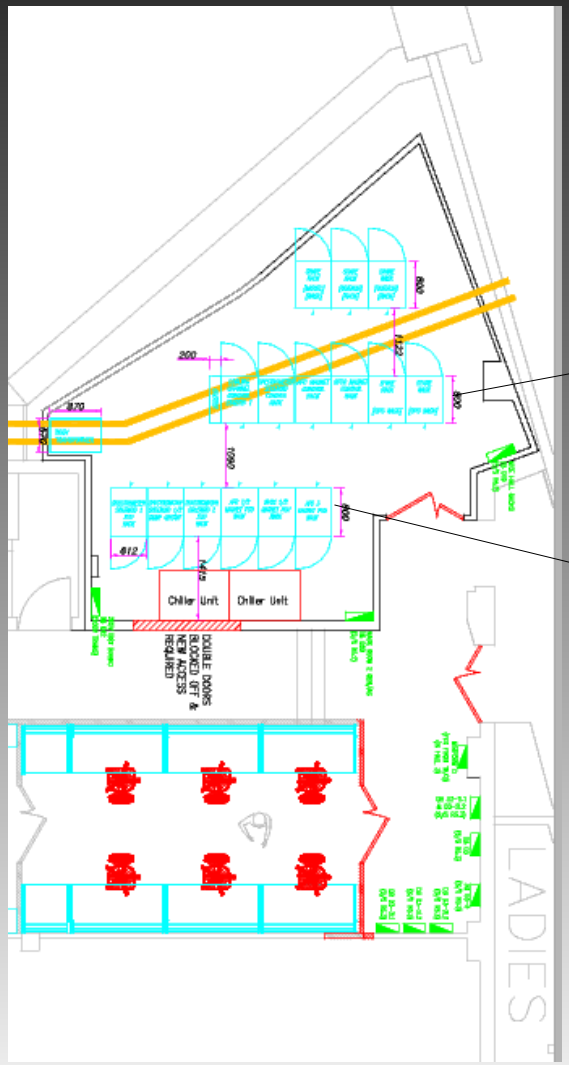
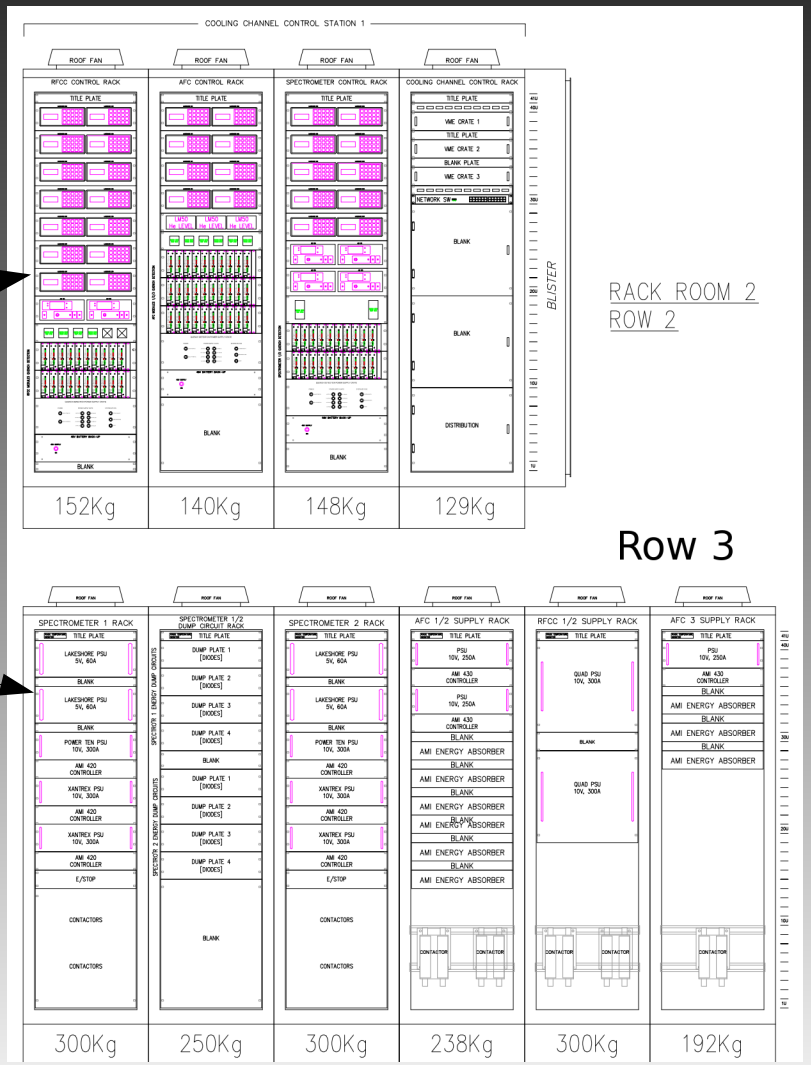
Hardware Plan

Step IV Rack Layout





Hardware Progress

DL C&M racks for Rack Room 2

Awaiting controllers to populate racks

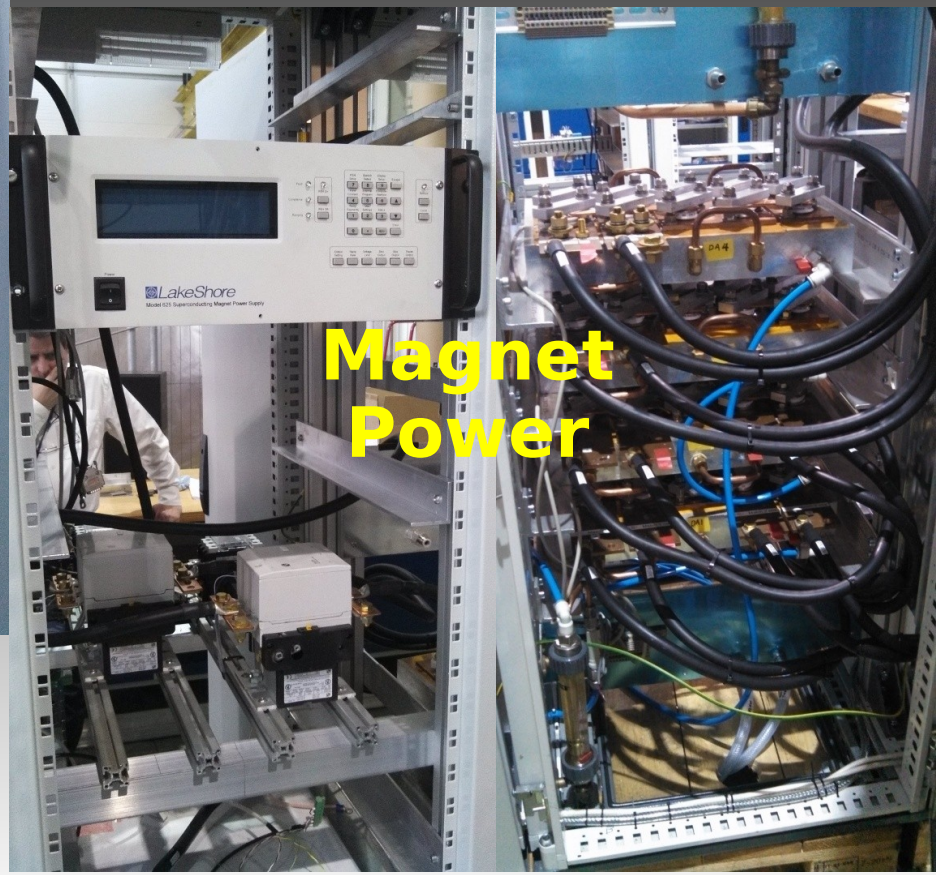
Hardware Progress

Canbus/
Controllers

Inputs

Analog
Sensors

Energy
Absorber



Magnet
Power

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Higher Level Operation

With installation/commissioning of the new controls HW (DL), the subsystems must be able to operate together, share resources, and not adversely affect each other. These are handled by:

- **State Machines for each major subsystem**
- **Mother State Machine**
- **Run Control**

Documented in MICE Note 431

High Level Procedure

- Each major subsystem has a state machine
- For each state, PVs of interest identified:
  - alarm limits are determined
  - archiving parameters are determined
  - critical PVs enabled/disabled
- Interlocks determined (HW & SW)
- Consultant/Experts identified for each state
  - "What if ...?" questions are identified
  - meetings with experts & owners by state
- Documentation
  - subsystem descriptions
  - subsystem operation manuals
  - integrated system manual

State Machines

EPICS state notation language employed:

- define equipment operational states
- for each state:
  - define transitions out of state
  - set alarm limits
  - set archiving features
  - define critical variables
- check for software interlocks; e.g. quench
- check for errors
- check for transition

All parameters come from configuration database (CDB) – ensures correct settings

State Machine Requirements

Subsystem Owners must enumerate the states and provide for each state:

1)Description of state
2)Transition into state
3)PVs of interest
4)Alarm limits for PVs
5)Archiving features for PVs
6)AutoSMS (auto dialer) flag
7)Hardware interlocks*
8)Software “interlocks” (enables)

- Required for each state
- Stored in the CDB

State Machine: SS Example

Spectrometer Solenoid Magnets:

1)Offline
2)Pumping: establish insulating vacuum
3)Pumped_Warm: insulating vacuum established
4)Pre_Cooling: N_2 pre-cooling (T>100K)
5)Cooling: cryo-coolers lower shield/cold mass T
6)LHe_Filling: add liquid He
7)Cold_Ready: cold and stable
8)Ramping: applying current
9)Powered: stable operation
10)Quenched: quench detected
11)Error: error requires operator intervention
12)Testing: interlocks disabled for manual testing

Successfully used in training/mapping SS magnets

SS1 Example

For each state, owner provides

Load these to CDB

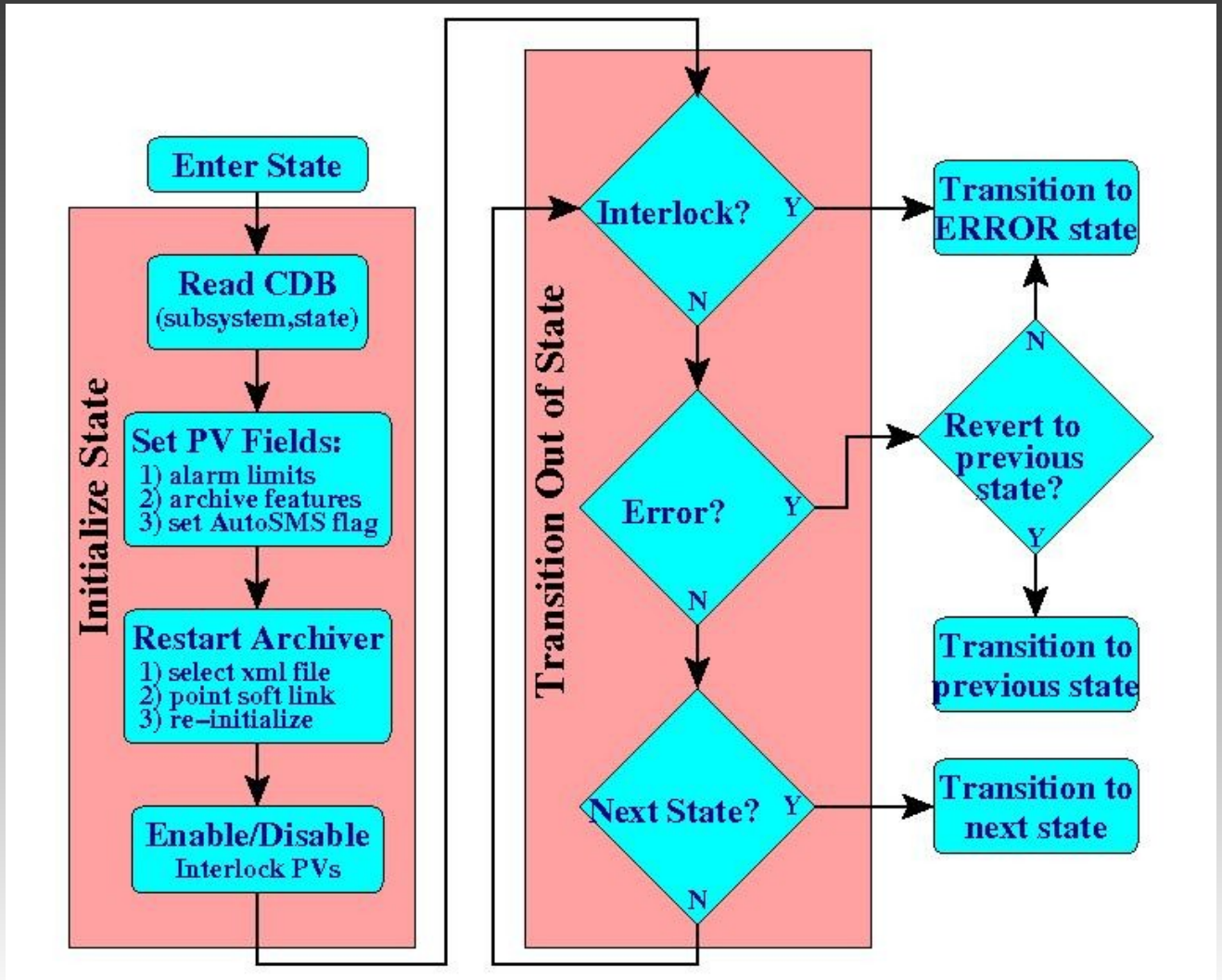
PV Name	Description	Measured Low	Measured High	ALARM Low	ALARM Low	ALARM High	ALARM HiHi	Units	ARCHIVER mode	ARCHIVER frequency (s)	ARCHIVER deadband	AutoSMS	Transition description	Transition value
MICE-SS1-VAC-01:PGAUGE	Roughing Vacuum			1.0e-01	1.0e-01	5.0e-01	2.0e+00	torr	monitor	333	1.0e-01	TRUE	N/A	0.0e+00
MICE-SS1-SD-01:RDGK	Top of HTS lead S1 side			0.0	0.0	170.0	175.0	K	scan	333		FALSE	N/A	0.0
MICE-SS1-SD-02:RDGK	Rad Shield near vertical copper plates			0.0	0.0	212.0	218.0	K	scan	333		FALSE	N/A	0.0
MICE-SS1-SD-03:RDGK	CC1 Cu Plate			0.0	0.0	187.0	192.0	K	scan	333		FALSE	N/A	0.0
MICE-SS1-SD-04:RDGK	Rad Shield near MC end upper support			0.0	0.0	275.0	280.0	K	scan	333		FALSE	N/A	0.0
MICE-SS1-SD-05:RDGK	CC2 Cu Plate			0.0	0.0	217.0	222.0	K	scan	333		FALSE	N/A	0.0
MICE-SS1-SD-06:RDGK	Rad Shield			0.0	0.0	221.0	226.0	K	scan	333		FALSE	N/A	0.0
MICE-SS1-SD-10:RDGK	CC1 Stage 1			0.0	0.0	194.0	199.0	K	scan	333		FALSE	N/A	0.0
MICE-SS1-SD-11:RDGK	CC2 Stage 1			0.0	0.0	200.0	205.0	K	scan	333		FALSE	N/A	0.0
MICE-SS1-SD-12:RDGK	CC3 Stage 1			0.0	0.0	212.0	217.0	K	scan	333		FALSE	N/A	0.0
MICE-SS1-SD-13:RDGK	CC4 Stage 1			0.0	0.0	218.0	223.0	K	scan	333		FALSE	N/A	0.0
MICE-SS1-SD-14:RDGK	Cold Head single stage strap			0.0	0.0	69.0	74.0	K	scan	333		FALSE	N/A	0.0
MICE-SS1-SD-15:RDGK	CC5 Stage 1			0.0	0.0	247.0	252.0	K	scan	333		FALSE	N/A	0.0
MICE-SS1-SD-16:RDGK	CC1 Cu Plate			0.0	0.0	245.0	250.0	K	scan	333		FALSE	N/A	0.0
MICE-SS1-SD-19:RDGK	Rad Shield			0.0	0.0	236.0	241.0	K	scan	333		FALSE	N/A	0.0
MICE-SS1-SD-20:RDGK	CM support EC end lower support			0.0	0.0	236.0	241.0	K	scan	333		FALSE	N/A	0.0
MICE-SS1-SD-21:RDGK	Rad Shield inside bore matching coil end			0.0	0.0	400.0	400.0	K	scan	333		FALSE	N/A	0.0
MICE-SS1-SD-24:RDGK	CM support matching coil end upper support			0.0	0.0	242.0	247.0	K	scan	333		FALSE	N/A	0.0
MICE-SS1-SD-25:RDGK	Centre of of Radiation bore at bottom			0.0	0.0	244.0	249.0	K	scan	333		FALSE	N/A	0.0
MICE-SS1-SD-26:RDGK	Bottom of outer cylinder of Radiation shield			0.0	0.0	225.0	230.0	K	scan	333		FALSE	N/A	0.0
MICE-SS1-SD-27:RDGK	On the single stage cooler lead surface			0.0	0.0	81.0	86.0	K	scan	333		FALSE	N/A	0.0
MICE-SS1-CR-01:RDGK	Cold Mass bottom by M1			0.0	0.0	105.0	110.0	K	scan	333		FALSE	N/A	0.0
MICE-SS1-CR-02:RDGK	Cold Mass top by E2			0.0	0.0	105.0	110.0	K	scan	333		FALSE	N/A	0.0
MICE-SS1-CR-03:RDGK	CC3 Cu Plate			0.0	0.0	218.0	223.0	K	scan	333		FALSE	N/A	0.0
MICE-SS1-CR-04:RDGK	CC4 Cu Plate			0.0	0.0	203.0	208.0	K	scan	333		FALSE	N/A	0.0
MICE-SS1-CR-05:RDGK	CC1 Stage 2			0.0	0.0	179.0	184.0	K	scan	333		FALSE	N/A	0.0
MICE-SS1-CR-06:RDGK	CC2 Stage 2			0.0	0.0	207.0	212.0	K	scan	333		FALSE	N/A	0.0
MICE-SS1-CR-07:RDGK	CC3 Stage 2			0.0	0.0	219.0	224.0	K	scan	333		FALSE	N/A	0.0
MICE-SS1-CR-08:RDGK	CC4 Stage 2			0.0	0.0	227.0	232.0	K	scan	333		FALSE	N/A	0.0
MICE-SS1-CR-09:RDGK	CC5 Stage 2			0.0	0.0	242.0	247.0	K	scan	333		FALSE	N/A	0.0
MICE-SS1-CR-10:RDGK	Cold Mass bottom of LTS leads			0.0	0.0	200.0	205.0	K	scan	333		FALSE	N/A	0.0
MICE-SS1-CR-11:RDGK	Low fill line heater			0.0	0.0	100.0	105.0	K	scan	333		FALSE	N/A	0.0
MICE-SS1-CR-12:RDGK	Cold Mass bottom heater			0.0	0.0	100.0	105.0	K	scan	333		FALSE	N/A	0.0
MICE-SS1-CR-13:RDGK	Top of HTS lead S2 side			0.0	0.0	129.0	134.0	K	scan	333		FALSE	N/A	0.0
MICE-SS1-CC-01:STA	Cryo Compressor 1 status			0.0	0.0	0.0	0.0	-	monitor	60.0	0.0	TRUE	N/A	0.0
MICE-SS1-CC-02:STA	Cryo Compressor 2 status			0.0	0.0	0.0	0.0	-	monitor	60.0	0.0	TRUE	N/A	0.0
MICE-SS1-CC-03:STA	Cryo Compressor 3 status			0.0	0.0	0.0	0.0	-	monitor	60.0	0.0	TRUE	N/A	0.0
MICE-SS1-CC-04:STA	Cryo Compressor 4 status			0.0	0.0	0.0	0.0	-	monitor	60.0	0.0	TRUE	N/A	0.0
MICE-SS1-CC-05:STA	Cryo Compressor 5 status			0.0	0.0	0.0	0.0	-	monitor	60.0	0.0	TRUE	N/A	0.0
MICE-SS1-CC-01:ALM	Cryo Compressor 1 OR of alarm states			0.0	0.0	0.0	0.0	-	monitor	60.0	0.0	TRUE	N/A	0.0
MICE-SS1-CC-02:ALM	Cryo Compressor 2 OR of alarm states			0.0	0.0	0.0	0.0	-	monitor	60.0	0.0	TRUE	N/A	0.0
MICE-SS1-CC-03:ALM	Cryo Compressor 3 OR of alarm states			0.0	0.0	0.0	0.0	-	monitor	60.0	0.0	TRUE	N/A	0.0
MICE-SS1-CC-04:ALM	Cryo Compressor 4 OR of alarm states			0.0	0.0	0.0	0.0	-	monitor	60.0	0.0	TRUE	N/A	0.0
MICE-SS1-CC-05:ALM	Cryo Compressor 5 OR of alarm states			0.0	0.0	0.0	0.0	-	monitor	60.0	0.0	TRUE	N/A	0.0
MICE-SS1-PS-01:RP	Vent line pressure from ADC			1.05	1.10	1.50	2.00	bar	monitor	1.0	0.02	FALSE	N/A	0.0
MICE-SS1-PS-01:ALM	Sum of alarm states			0.0	0.0	0.0	0.0		monitor	1.0	0.00	FALSE	N/A	0.0
MICE-SS1-PS-01:ERR	Communication error codes								monitor	1.0	0.00	FALSE	N/A	0.0
MICE-SS1-PS-02:RP	Fill line pressure from ADC			1.05	1.10	1.50	2.00	bar	monitor	1.0	0.02	FALSE	N/A	0.0
MICE-SS1-PS-02:ALM	Sum of alarm states			0.0	0.0	0.0	0.0		monitor	1.0	0.00	FALSE	N/A	0.0
MICE-SS1-PS-02:ERR	Communication error codes								monitor	1.0	0.00	FALSE	N/A	0.0
MICE-SS1-HET-01:Sts	Cold mass heater			0.0	0.0	0.0	1.0	-	monitor	1.0	0.0	TRUE	N/A	0.0
MICE-SS1-HET-02:Sts	Fill line heater			0.0	0.0	0.0	1.0	-	monitor	1.0	0.0	TRUE	N/A	0.0
MICE-SS1-LEVEL-01:LEV	Low level			0.0	0.0	100.0	100.0	%	scan	3.0	0.0	FALSE	LEVEL=LOW	95.0
MICE-SS1-HLS-01:Sts	Low level switch			-1.0	-1.0	2.0	2.0		monitor	10.0	0.0	FALSE	N/A	0.0
MICE-SS1-LEVEL-03:LEV	Low level overflow			0.0	0.0	10.0	20.0	%	scan	10.0	0.0	FALSE	N/A	0.0

State Machine Algorithm

For each subsystem & state, the algorithm:

Transitions:
- manual
- automatic

Note: states can be static or dynamic



State Machine Status

Existing *(at least started)*:

- **Spectrometer Solenoids**
- **Focus Coil**
- **Decay Solenoid**

Required *(not started)*:

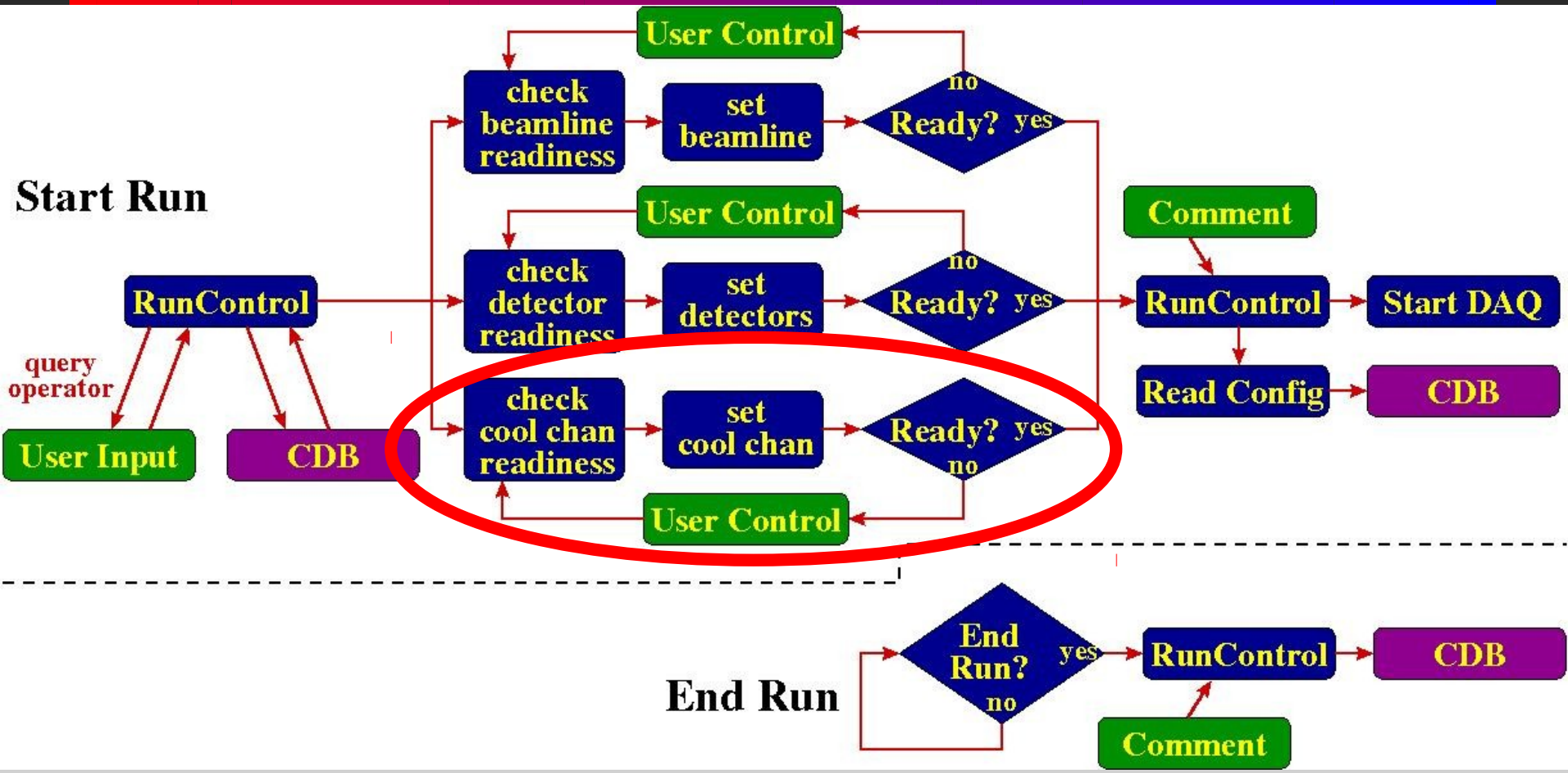
- **Absorber**
- **Conventional magnets**
- **Target**
- **Trackers**

Run Control

Checks readiness of all required subsystems

- **Serves to control**
  - **Beamline magnets**
  - **Particle ID detectors**
  - **Trackers**
  - **Absorber(s)**
  - **Channel magnets power supplies**
  - **RF (Step V or VI)**
- **Integrates:**
  - **Beamline**
  - **DAQ**
  - **target**
  - **tracker**
  - **absorbers**
  - **SC magnets**

State Machine Effect on RunControl



State machines for magnet control greatly reduces complexity of RunControl. RC need only check state of each magnet.

Outline

- ✔ I Introduction
- ✔ II Description
- ✔ III Integrated Hardware Plan
- ✔ IV Higher Level Operation
- V Other Items

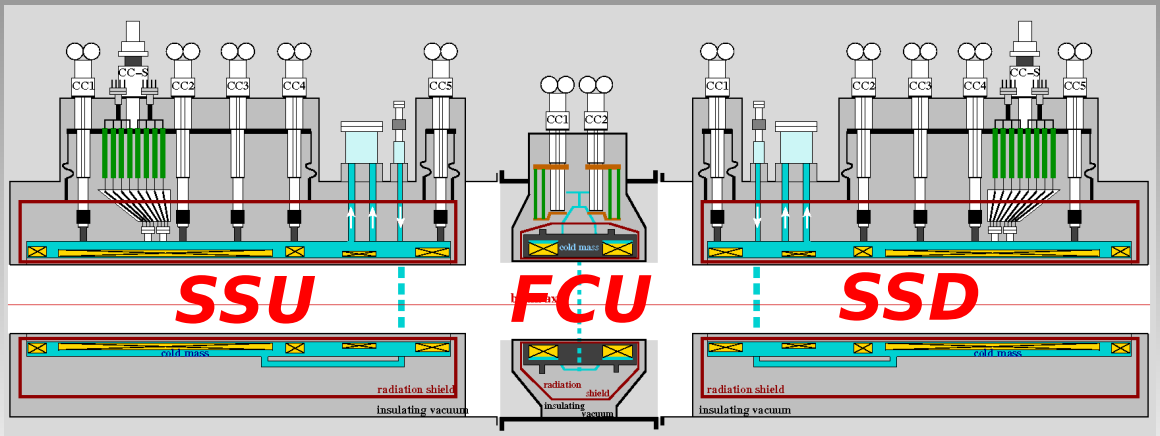
Other Items

- Risks
  - Personnel
  - Expertise
  - Tests
- Infrastructure
  - computing
  - code repository
  - documentation
- Cleaning up
  - production and development versions
  - Alarm Handlers and Archivers
  - testing tools

* Ian Taylor
* Chris Heidt

Conclusions

- Much progress since last MPB
- Resource loaded schedule in progress
- Integrated HW plan in place
- State machines under development
- Will soon have 4 SC solenoids
- Still risks in personnel and expertise



- ***Needs to be finished within 7 months!***