Control System

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Outline

- Goals
- Scope and strategy
- Progress to date
- Future plans

Goals

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- **Provide Control System infrastructure for NML and associated test stands**
  - **Data acquisition, control, archiving, …**
- **Support efficient testing of cavities and cryomodules and associated instrumentation**
- **Support integration of externally developed instrumentation**
- **Develop new hardware and software control system concepts appropriate for Project X**

Controls Scope

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- Computing and Networking infrastructure
  - Consoles, front-end computers
- Timing system and distribution
- Control System infrastructure and services
  - Software frameworks, archiving, alarms, etc.
- General Purpose front-ends (ADC + digital I/O)
- Vacuum and Motion control subsystems
- RF and instrumentation are different subsystems but use the control system infrastructure

Strategy

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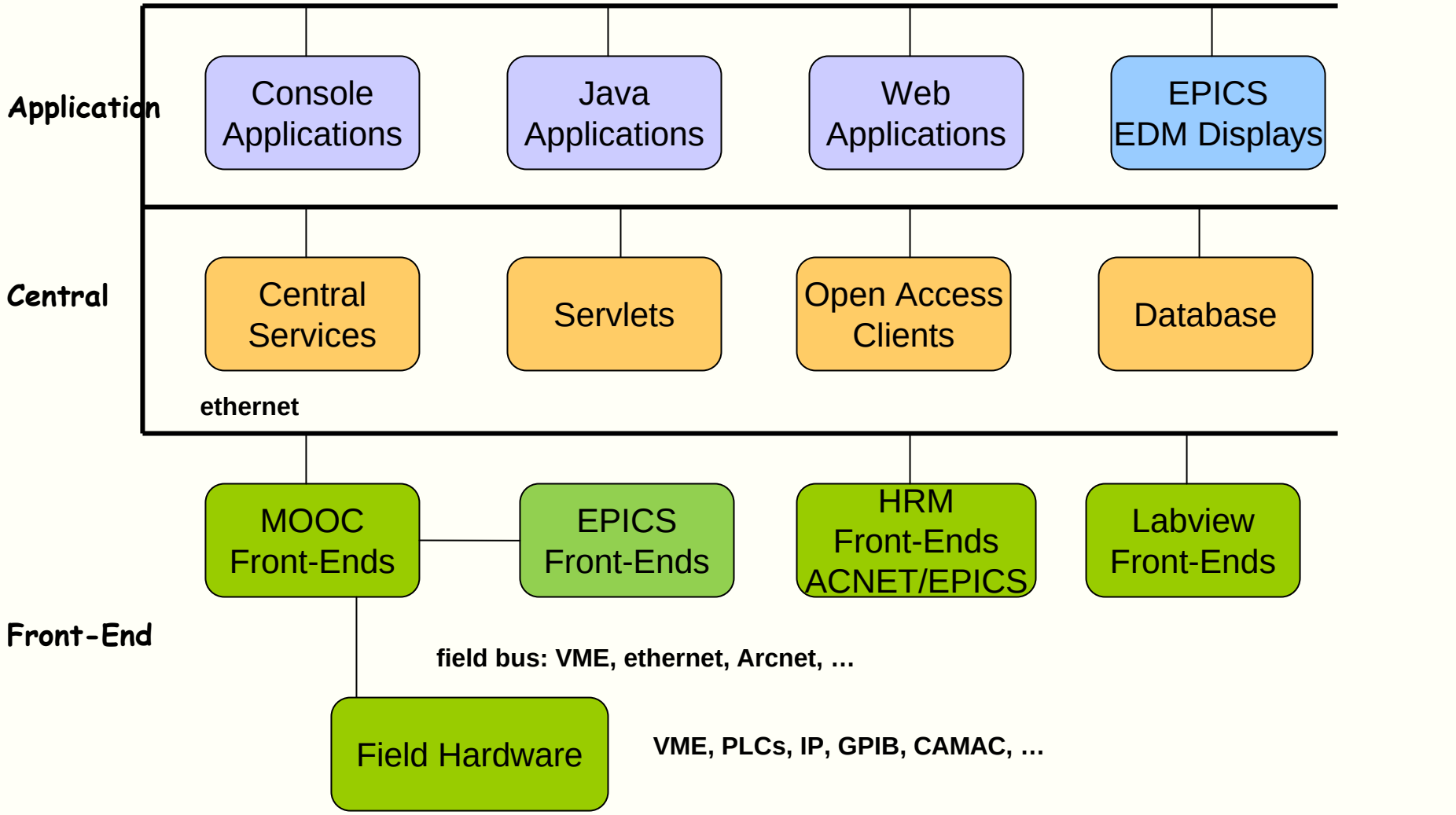
- Current HTS uses mix of EPICS, DOOCS (DESY) and ACNET (Fermilab system)
- Plan for NML uses ACNET as the core system while supporting EPICS "underneath"
  - Leverage substantial infrastructure and experience
  - ACNET core services (archiving, alarms, save/restore)
  - Many subsystems in "native" ACNET
  - EPICS display screens (EDM) can be launched from ACNET consoles and access EPICS & ACNET devices
  - EPICS front-ends (IOCs) can be put under ACNET
    - EPICS devices thus available to applications, alarms, standard archivers, save/restore, etc.
  - Allows externally developed subsystems in EPICS to be integrated

Control System Overview



Accomplishments

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- Computing infrastructure
- Network infrastructure
- Timing Infrastructure
- Control Room
- Ready for CC2 at NML
  - Timing system
  - RF Interlocks
  - Motion Control
  - Cryo data into ACNET for display and logging
  - Vacuum

NML Timing Crate

CC2 Motion Control System

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NML Control Room

CC2 Base Display (EDM)

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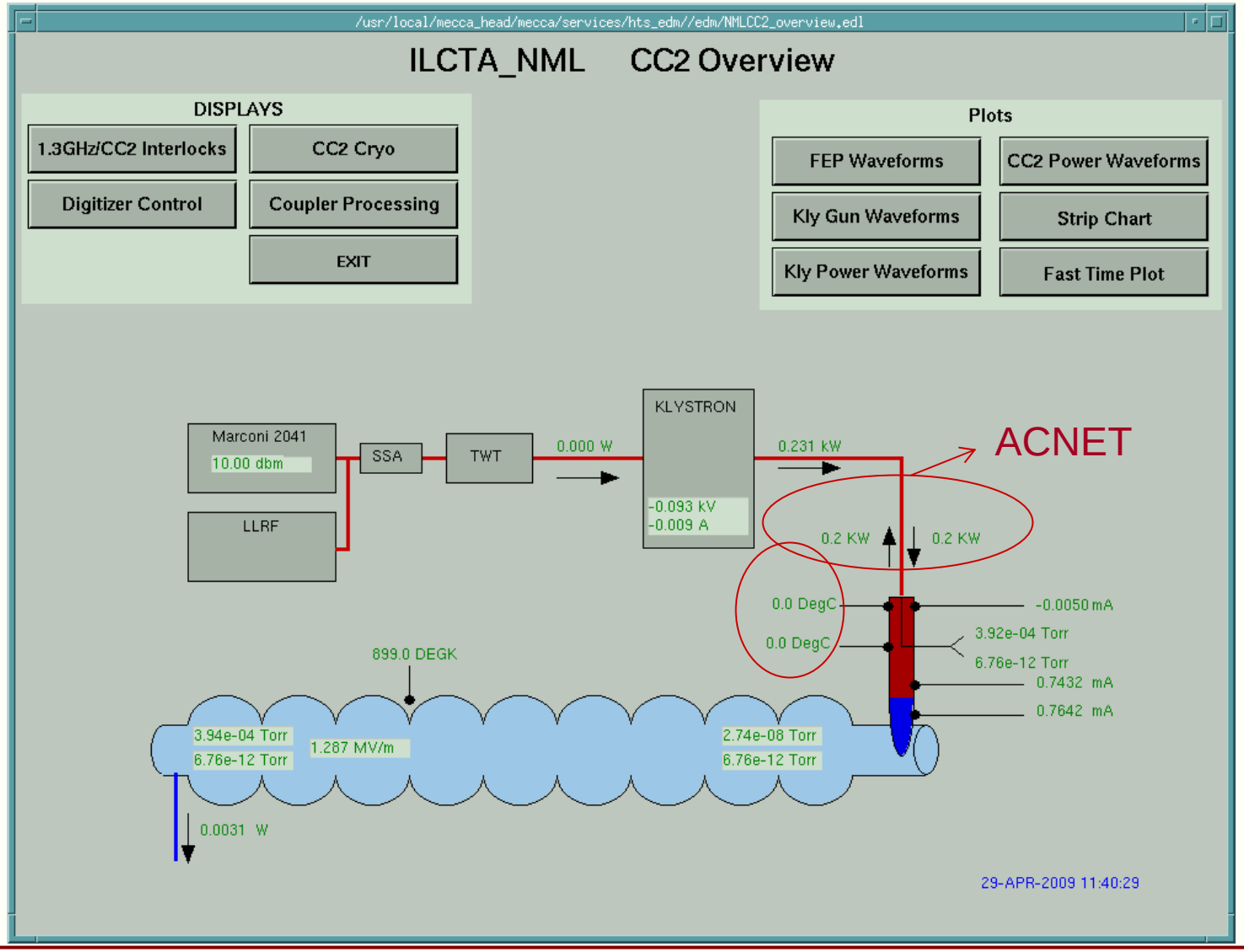

CC2 Klystron Interlocks (EPICS)

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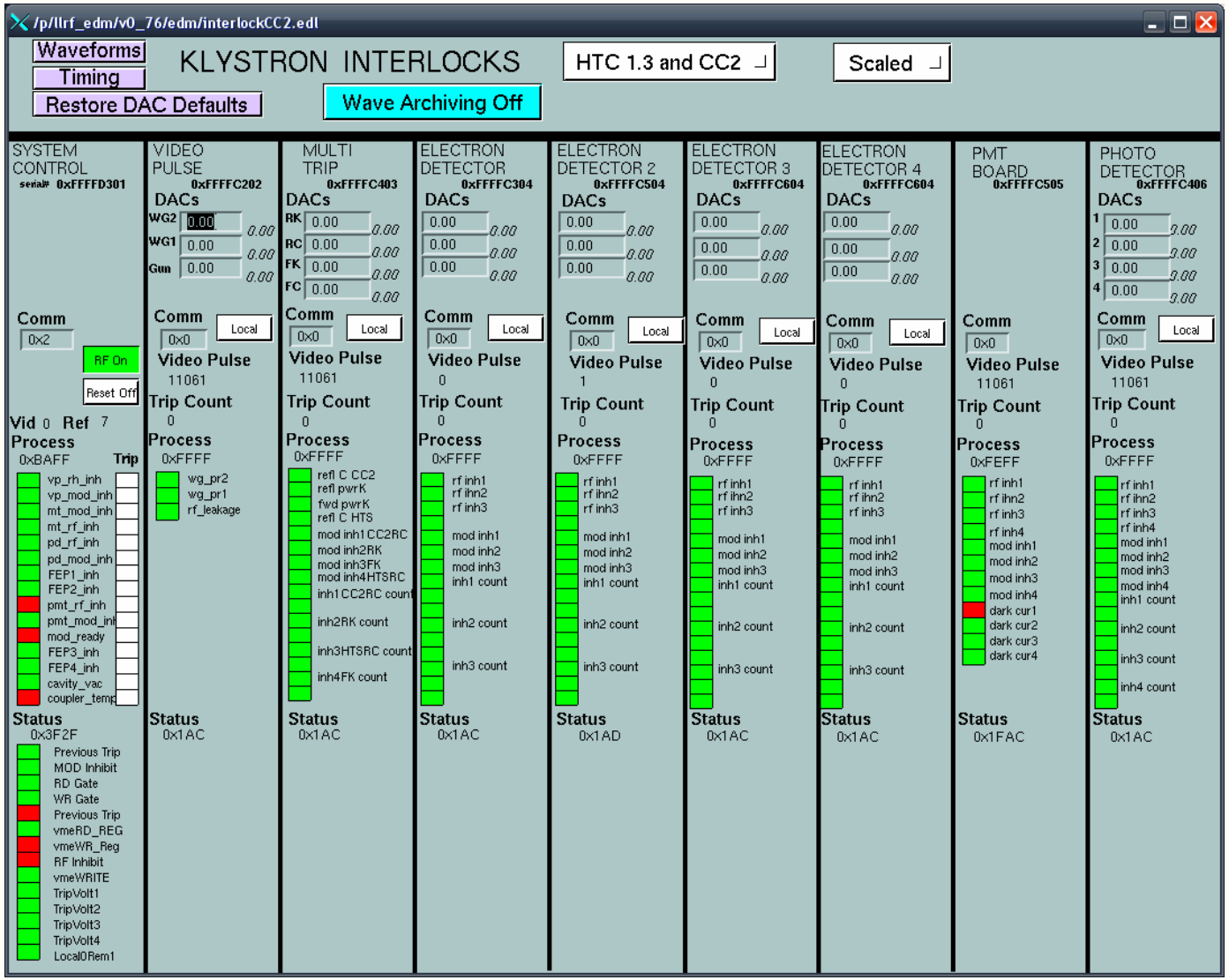

HINS Timing (EPICS)

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/export/home1/schumann/edm/from_cdcvs/llrf_edm//edm/timer.edl

PD_KLY1 Timer Card 1 Definition

	DELAYS	WIDTHS	EVENT	
0	700	10	A7	Modulator Trig
1	3495	3500	A7	Fwd Pwr Interlk Gate
2	3425	3425	A7	Rev Pwr Interlk Gate
3	3400	10	A7	RF Interlk Digitizer Trig
4	3400	3500	A7	RF Gate
5	4100	701	A7	LLRF Gate
6	1000	10	A7	Spectrum Analyzer Trig
7	4000	10	A7	Scope Trigger

RF to Refl Start Delta: 1 / 10 — RF <= 100, RF >

End Delta: 1

All times in microseconds

Restore Defaults | Save Defaults

/export/home1/schumann/edm/from_cdcvs/llrf_edm//edm/timer.edl

PD_KLY1 Timer Card 2 Definition

	DELAYS	WIDTHS	EVENT	
0	700	10	A9	A8 - Ion Src Event Trigger
1	700	10	AC	A7 - RF Event Trigger
2	700	10	A7	A6 - Beam Event Trig
3	3700	10	A7	RF Detector Sample Trig
4	3495	3000	A7	S/H Trigger 1
5	500	10	AC	Spare
6	0	800	AC	LLRF Prepulse
7	3425	10	A7	Spare

RF to Refl Start Delta: 1 / 10 — RF <= 100, RF >

End Delta: 1

All times in microseconds

Restore Defaults | Save Defaults

HINS Timing (ACNET)

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PB N4<NoSets>

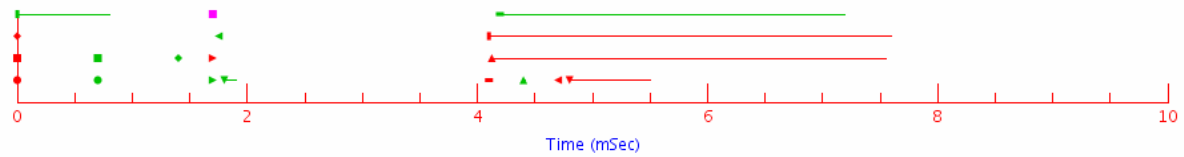
```
N4    HINS TRIGGER PARAMETERS        SET      D/A    A/D   Com-U ◆PTools◆
-<FTP>+ *SA◆ X-A/D   X=TIME      Y=D:TRROT ,          ,          ,
COMMAND ---- Eng-U   I= 0        I= 0      , 0        , 1.0E-10, 1.0E-10
-< 1>+  One+ AUTO    F= 300      F= 360    , 1.0E-06, 1.0E-06, 1.0E-06
  rf     TIMING  vacuum   llrf    cryo   water   diagnos   misc
-E:MTRIGD      MOD FIRE TRIGGER DELAY          .7     *  .7      MS
-E:FPWRGD      Intrlk F Power Gate del       3.495   * 3.495    MS
-E:RPWRGD      Intrlk R Power Gate del       3.425   * 3.425    MS
-E:DIGTRD      Intrlk Digitizr Trig del      3.4     * 3.4      MS
-E:GATED       RF Gate Delay                 3.4     * 3.4      MS
-E:LLRFGD      LLRF Gate Delay               4.1     * 4.1      MS
-E:SPECTD      Spectrum Analyzer Tr del      1       * 1       MS
-E:SCOPED      Scope Trigger Delay           4       * 4        MS
-E:EVA8TD      A8, Ion Src Event Delay        .7     *  .7     MS
-E:EVA7TD      A7, RF Event Tr
-E:RFDETT      RF Detector Sam
-E:SHTRD       Sample & Hold T
-E:LLRFPD      LLRF Prepulse G
```

HINS Timing Plot

File Edit Tasks Tools Help

HINS Timing Plot

Mon Apr 27 07:59:39 CDT 2009



Cursor Position

Event A8 (Beam Acc A6 Ref)	0	Event AA (1Hz)	0	Event A9 (0.1Hz)	0	Intrlk R Power Gate del	4.125
Intrlk Digitizr Trig del	4.1	RF Gate Delay	4.1	LLRF Gate Delay	4.8	Spectrum Analyzer Tr del	1.7
Scope Trigger Delay	4.7	A8, Ion Src Event Delay	0.7	A7, RF Event Trig Delay	0.7	A6, Beam Event Trig del	1.4
Sample & Hold Trig delay	4.4	RF Detector Sample Trig	4.195	LLRF Prepulse Gate delay	0.001	IS MOD TRIG DELAY	1.8
LV SAMP &HOLD TRIG	1.7	HINS Utility Scope Trig	1.75	HINS INST TRIG DEL	1.7		

Plot Widths Start Time (ms) 0 Stop Time (ms) 10 Zoom Center 5 Scale Factor 0.75 Original

NML Cryo Parameters (ACNET)

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PA N4<NoSets> - ACNET Java Console

File View Help

PA PB PC SA SB SC Util GxPA1 GxPA2

```
N4                                    SET     D/A   A/D  Com-U ♦PTools♦
-<FTP>+ *SA♦ X-A/D  X=TIME      Y=D:TRROT ,          ,        ,
COMMAND ---- Eng-U  I= 0        I= 0      , 0 [redacted]  , 0      , 0
-< 1>+  One+ 15_Hz  F= 90       F= 360    , 100    , 10     , 200000
  rf    timing  vacuum   llrf    CRYO   water   diagnos   misc
 N:C2PVH2     2-PHASE RETURN ISOLATION              0      %OPN
 N:C2PVNS     SCRF N2 THERMAL SHIELD                0      %OPN
 N:C2PVJT     SCRF VESSEL FILL VALVE                0      %OPN
 N:C2PVHS     SCRF 5K THERMAL SHIELD                0      %OPN
 N:C2PVCD     SCRF VESSEL COOLDWN VLVE              0      %OPN
 N:C2PV5K     SRF HE SUCT RETURN VALVE                          F
 N:C2PVSC     5K SHIELD COOLDOWN VALVE              0      %OPN
 N:C2PVHV     CCII VAC ISOLATION VALVE              0      %OPN
 N:C2PV2K     CCII VAC THROTTLE VALVE               0      %OPN

 N:C2PTH1     SCRF 1 PHASE INLET PRESS             .02     PSIG
 N:C2PTH3     SCRF VESSEL RETURN PRESS           * 115.9   TORR
 N:C2PTH4     SCRF HEX SHELL OUT PRESS             116     TORR
 N:C2PTH5     5K SHIELD OUTLET PRESS               .23     PSIG
 N:C2PTH6     SCRF PRESS 1000 TORR MAX             748.2   TORR
 N:C2PTH7     SCRF VESSEL PRESS 100                116     TORR
 N:C2PTH8     SCRF PRESS 0 TO 25 PSIG              .08     PSIG
 N:C2PTN7     N2 SHIELD INLET  PRESS               .16     PSIG
 N:C2PTN8     N2 SHIELD OUTLET PRESS               .12     PSIG
 N:C2PTV1     SCRF VESSEL INSUL VACUUM             9.7     MCRN

 N:C2DPH2     SCRF HEX SUPPLY DP                   .04     IN W
 N:C2DPH4     SCRF HEX RETURN DP                  -.01     IN W

 N:NMLUPT     NMLOPC Uptime                      852       Min
```

Connected to clxsrv.fnal.gov:1920

NML Logged Cryo Data (ACNET)

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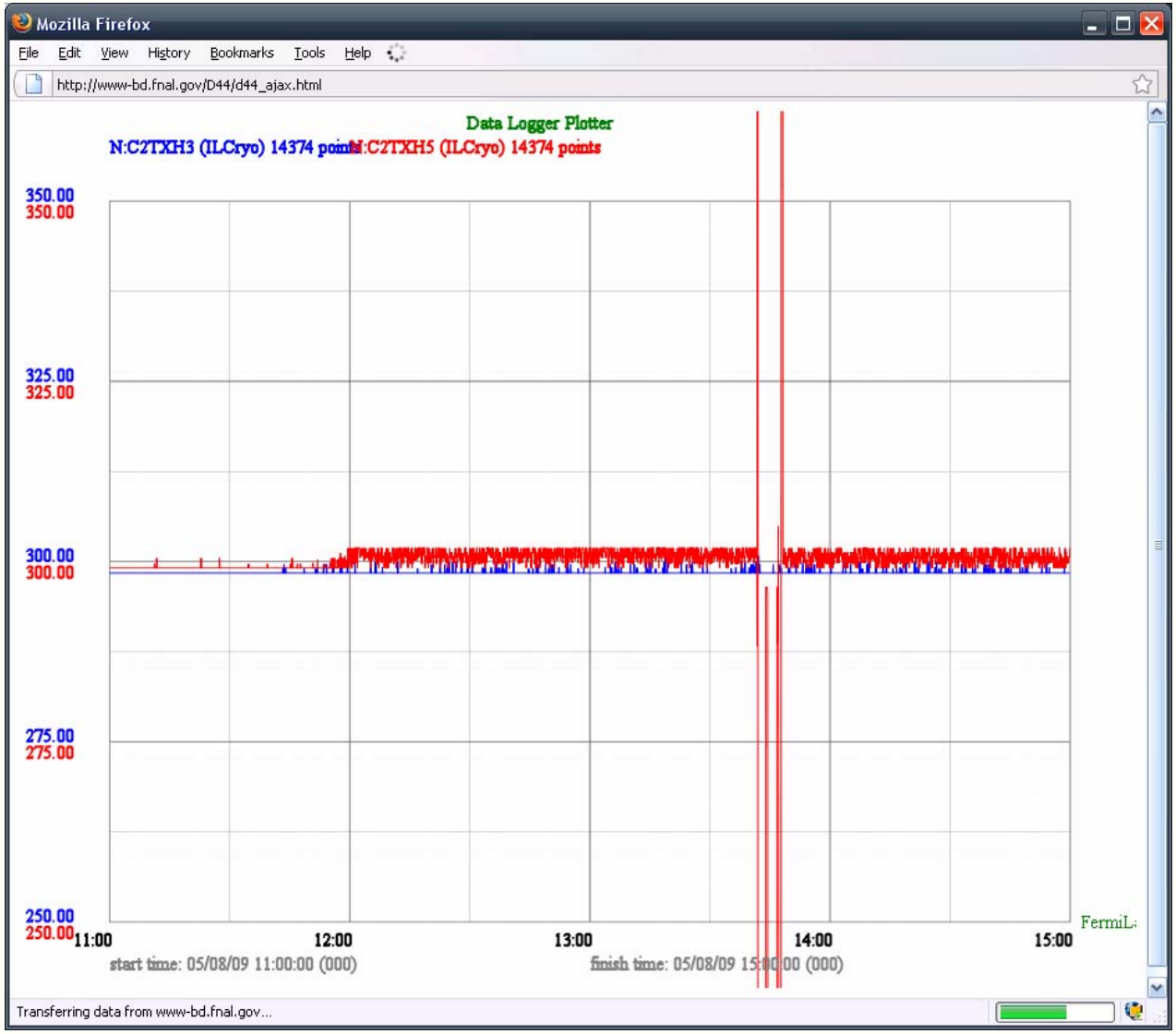

CC2 Cryo Display (ACNET)

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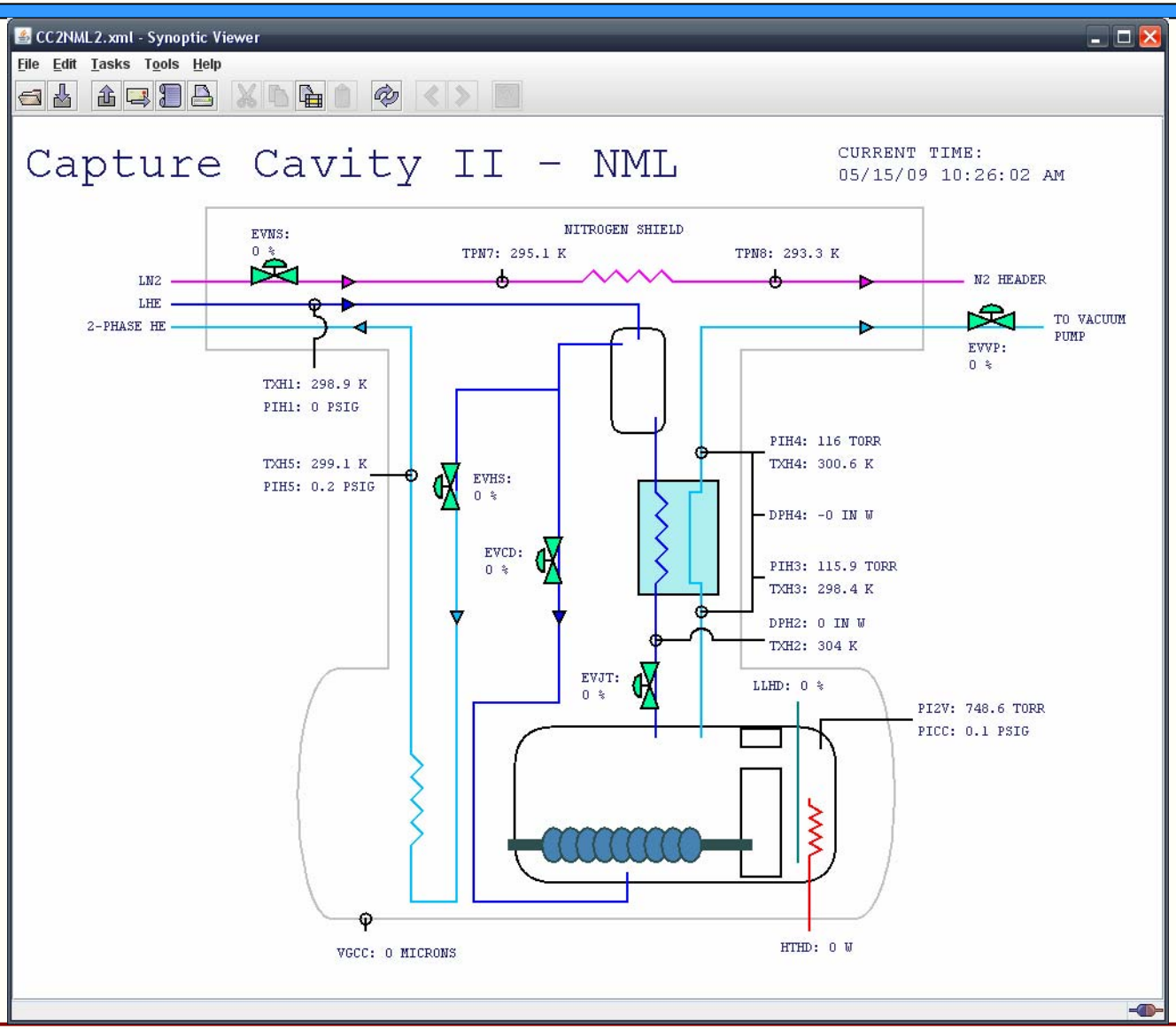

HINS RFQ Control - EDM

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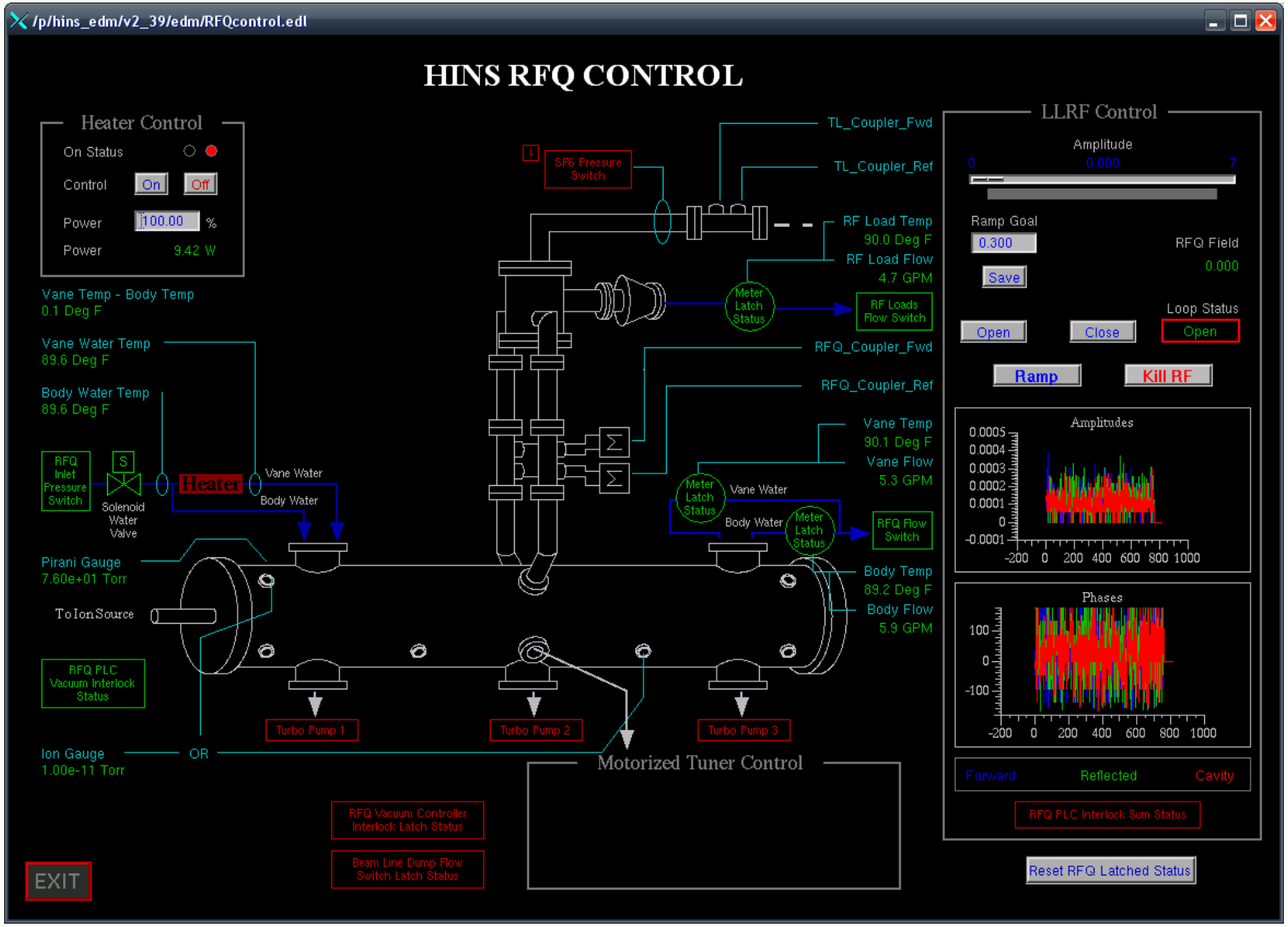
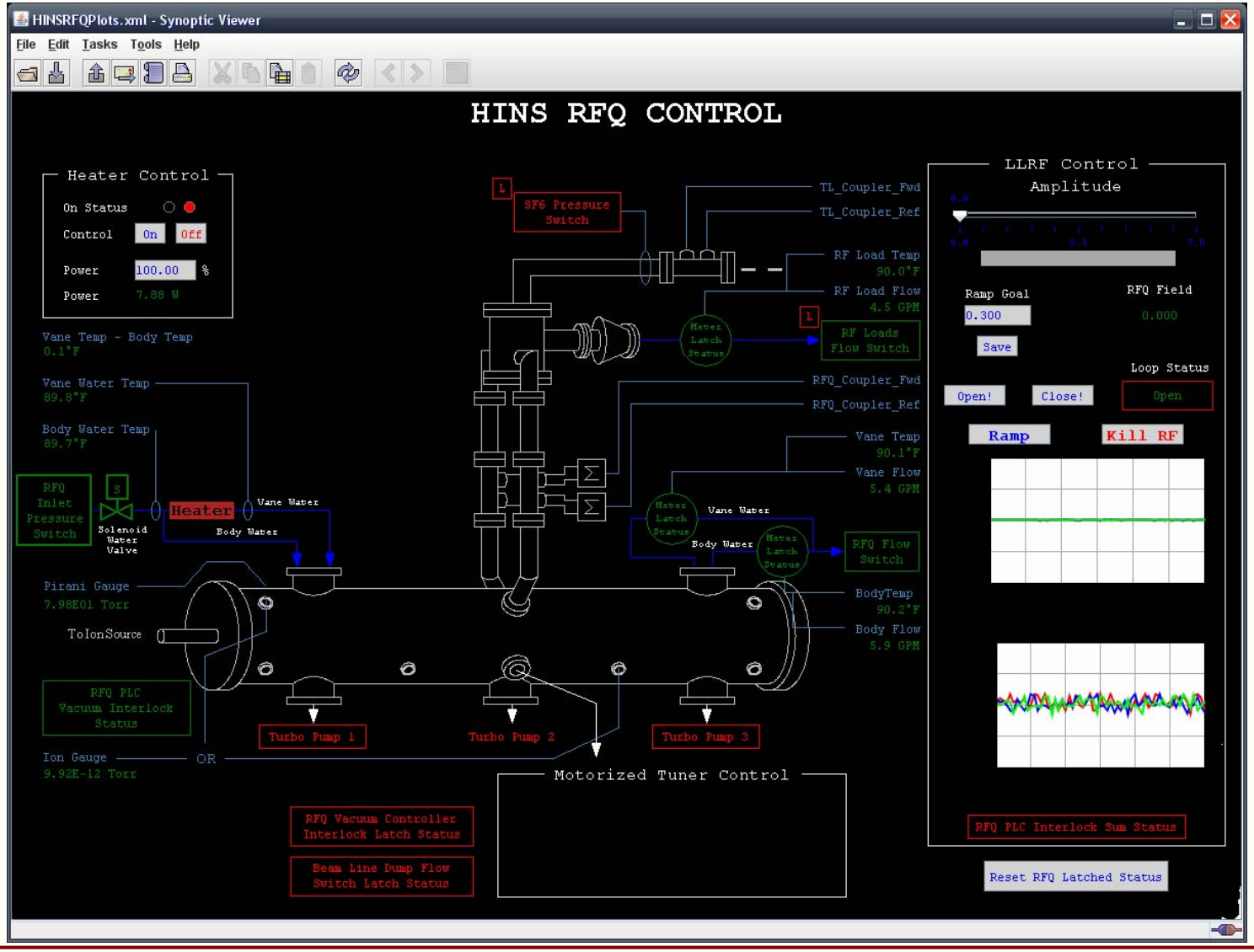


HINS RFQ Control - ACNET

Fermilab



RFQ Control – ACNET - Firefox

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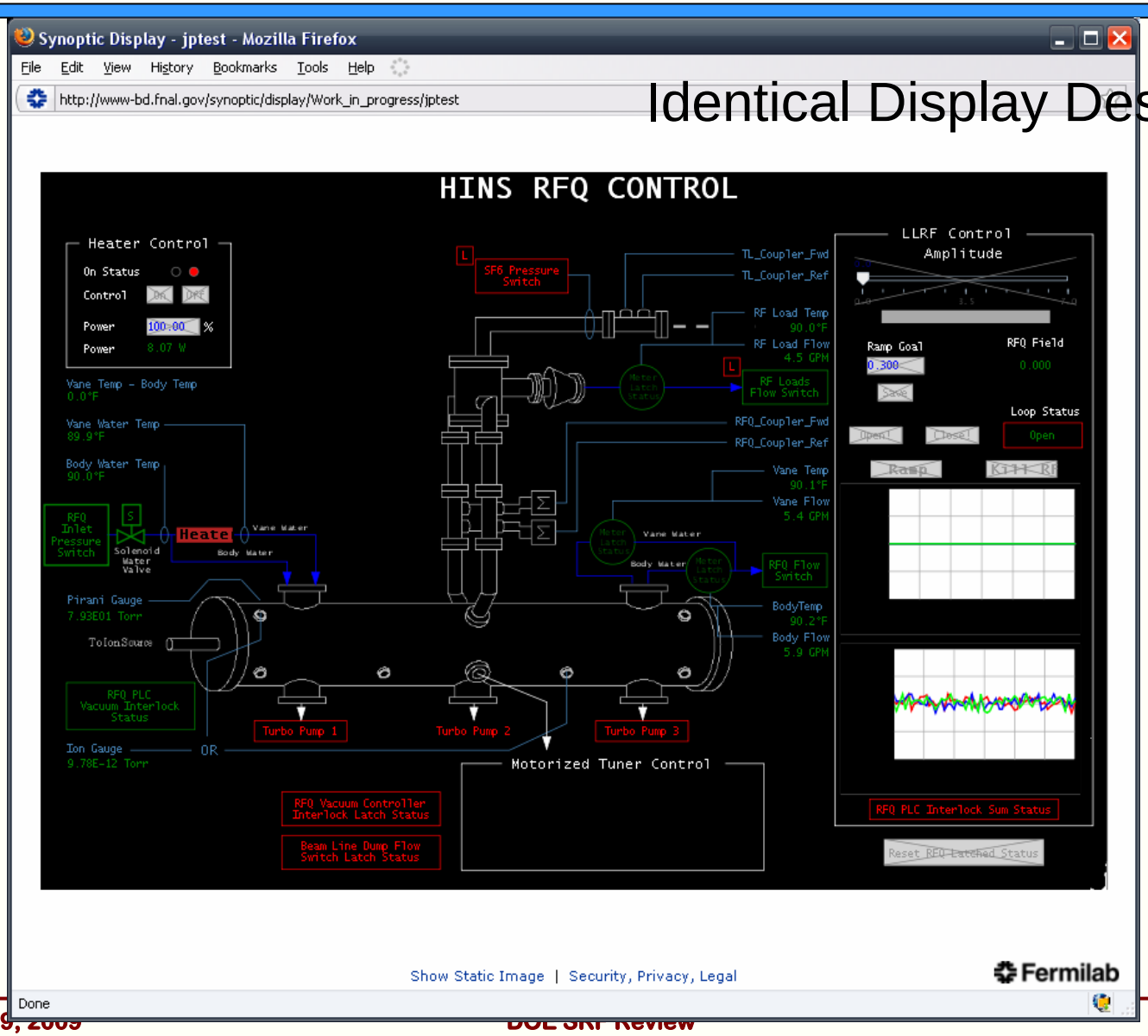
Identical Display Description



Plans

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- **Support hardware systems as they are added**
  - CC2 in progress
  - Cryomodule 1 summer/fall
  - Cryomodule 2 next year
  - …
- **Incorporate injector when it moves from A0**
  - Preliminary plan for required hardware exists
  - Additional work on machine protection and application software will be required for beam operation

Plans

- Prototype new things applicable for Project X
  - New timing protocol
  - Machine protection
  - New hardware platforms
  - New software infrastructures
- Controls currently done by Fermilab personnel
  - ~10 people; ~3 FTEs; shared with HINS
- Instrumentation or other subsystems developed elsewhere in EPICS could be integrated

Plans

Fermilab

- **Equipment needed includes**
  - **Network switches**
  - **Console computers**
  - **Front-end processors**
  - **General purpose ADC/Digital I/O front-ends**
  - **Motion Control hardware**
- **Propose purchasing equipment for injector + 4 cryomodules with ARRA funds**

Conclusions

- NML control system will integrated with the main Fermilab control system
  - Will support EPICS subsystem integration
- Basic ingredients are operational for CC2 at NML
- Straightforward to extend to cryomodules as they become available
- As well as supporting SCRF work, NML provides a good test bed for main control system upgrades for the NOνA era and Project X