# Design of a Treatment Control System for a Proton Therapy System

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TUOAFI02

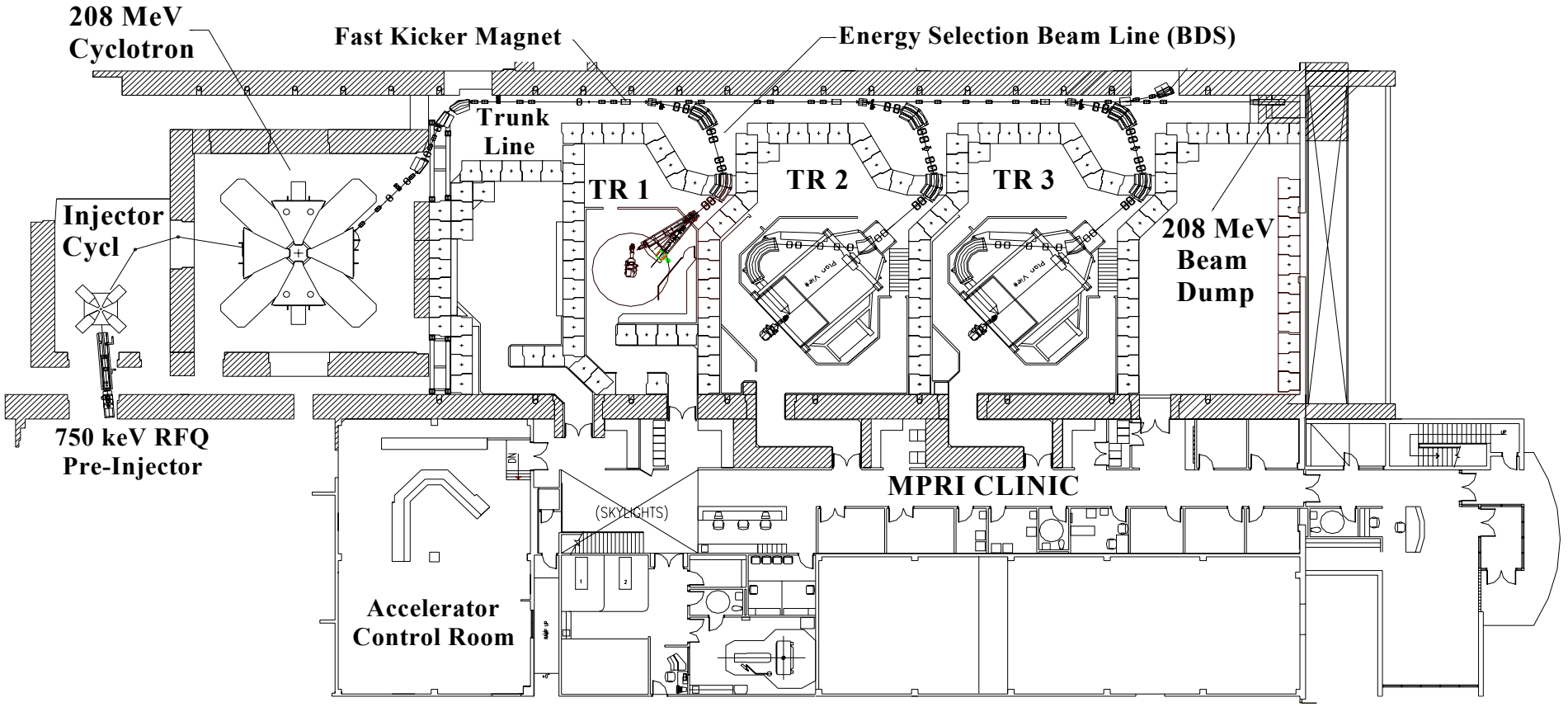
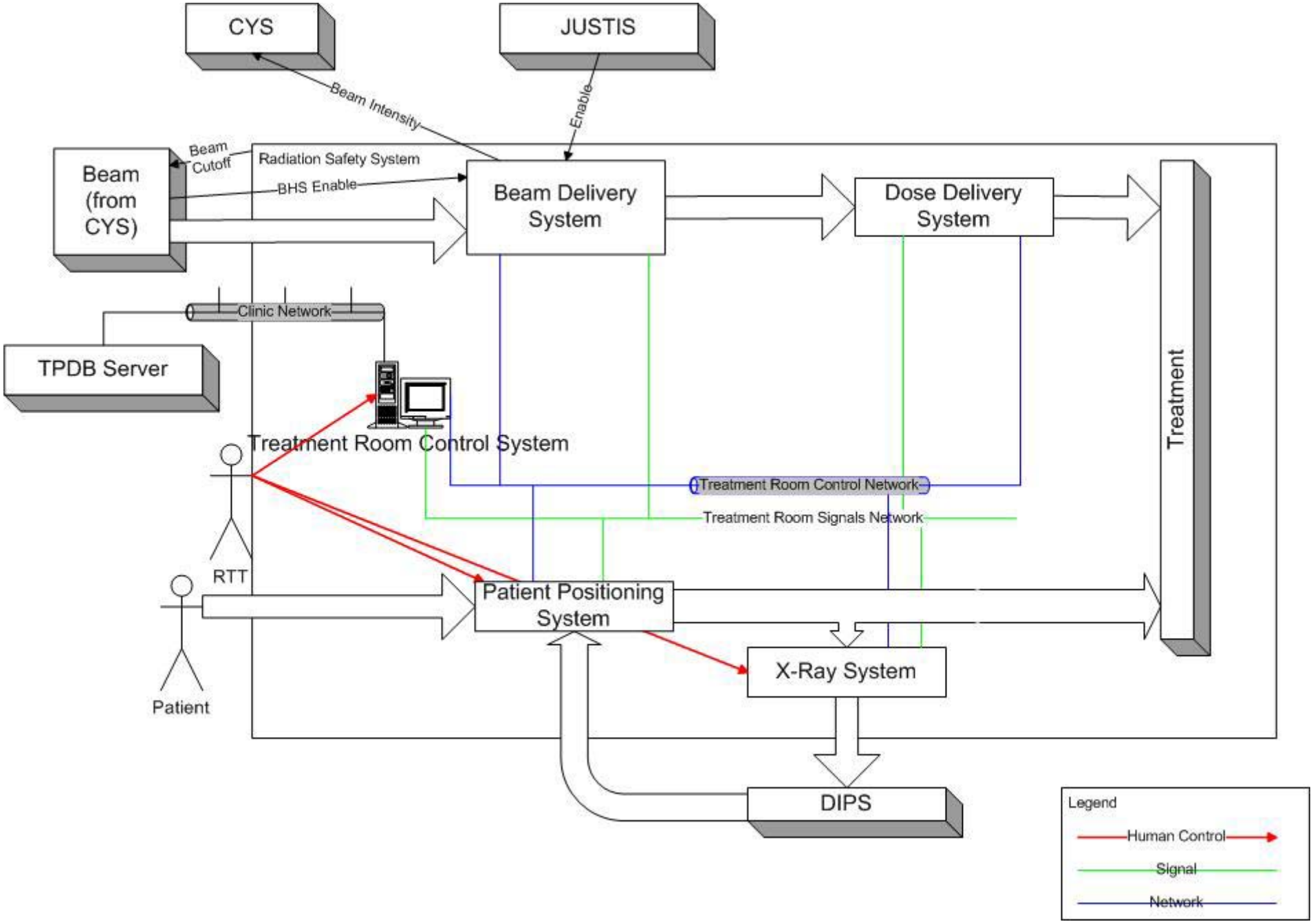



**Figure 1. The MPRI facility showing the IUCF Cyclotrons, Trunk and ES lines, Treatment Rooms and Clinic.**

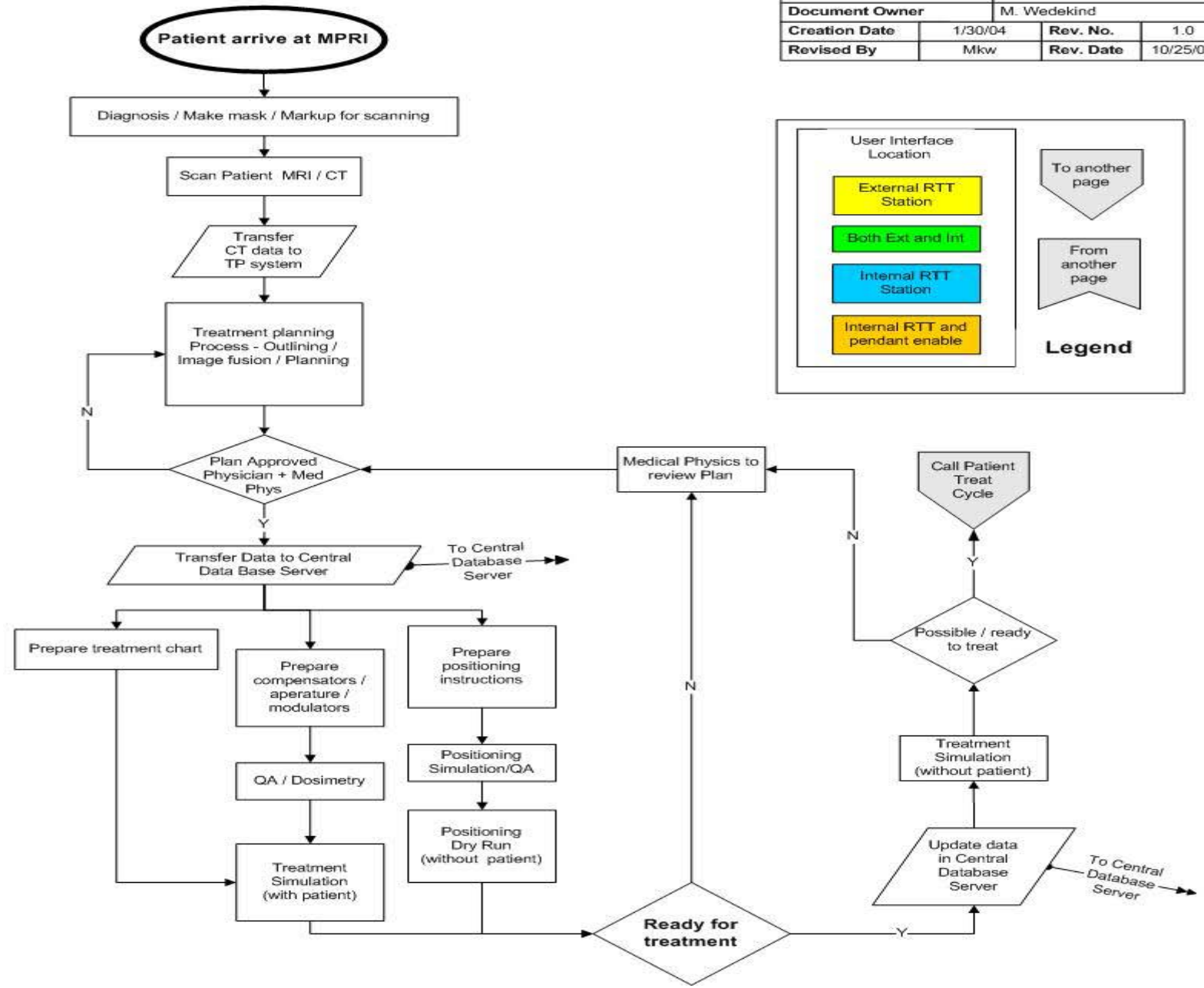
# Partition System Functions

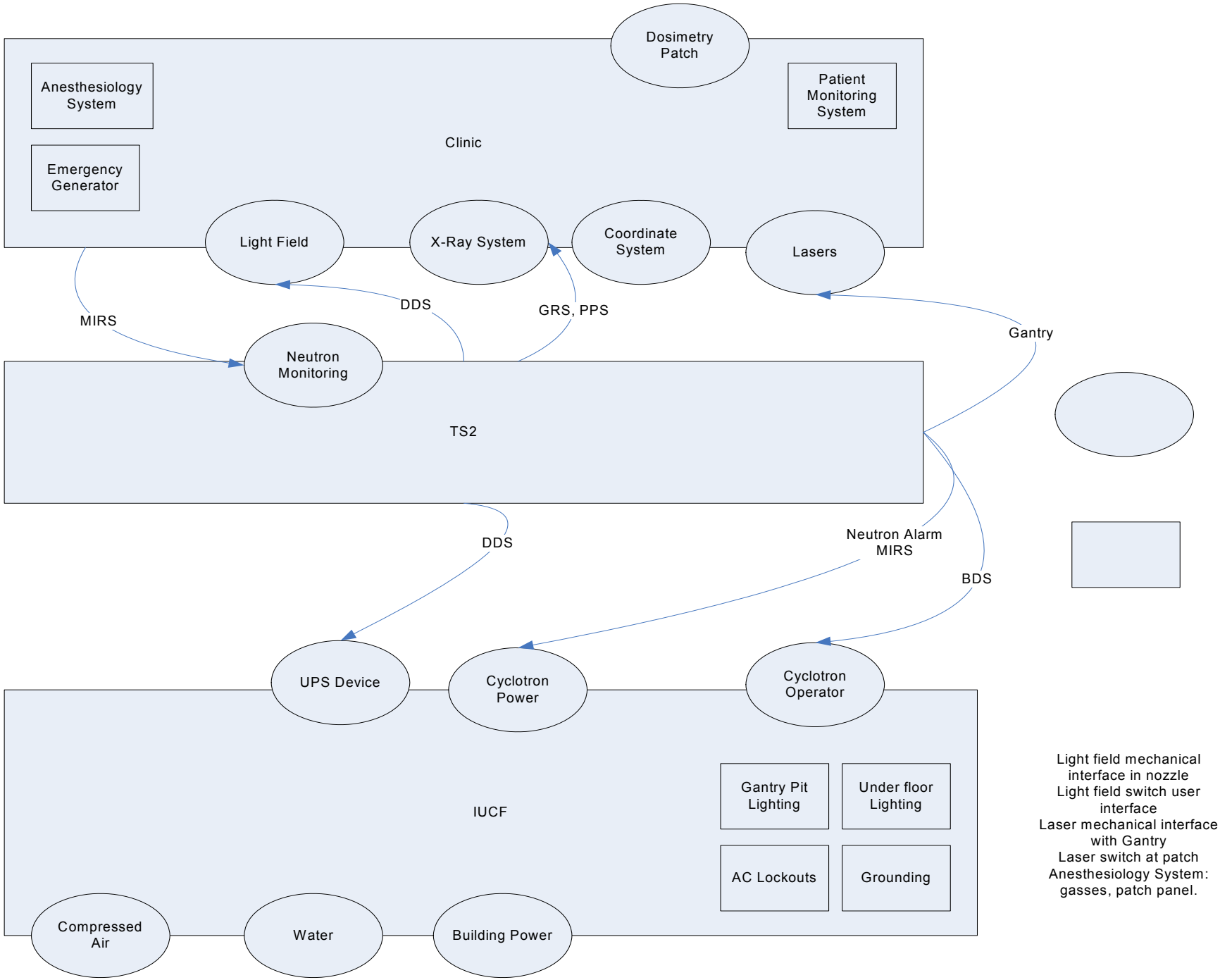
- Beam line control
  - Mimic cyclotron controls
- Dose measurement
  - Realtime measurements and response
- Patient positioning
  - X-Ray adjustment
- User interface
  - Medical data access, interpretation, distribution


CYS
JUSTIS
Beam Intensity
Enable
Beam (from CYS)
Beam Cutoff
Radiation Safety System
BHS Enable
Beam Delivery System
Dose Delivery System
Treatment
Clinic Network
TPDB Server
Treatment Room Control System
Treatment Room Control Network
Treatment Room Signals Network
RTT
Patient
Patient Positioning System
X-Ray System
DIPS
Legend
Human Control
Signal
Network

# Main Patient Therapy Flow Chart

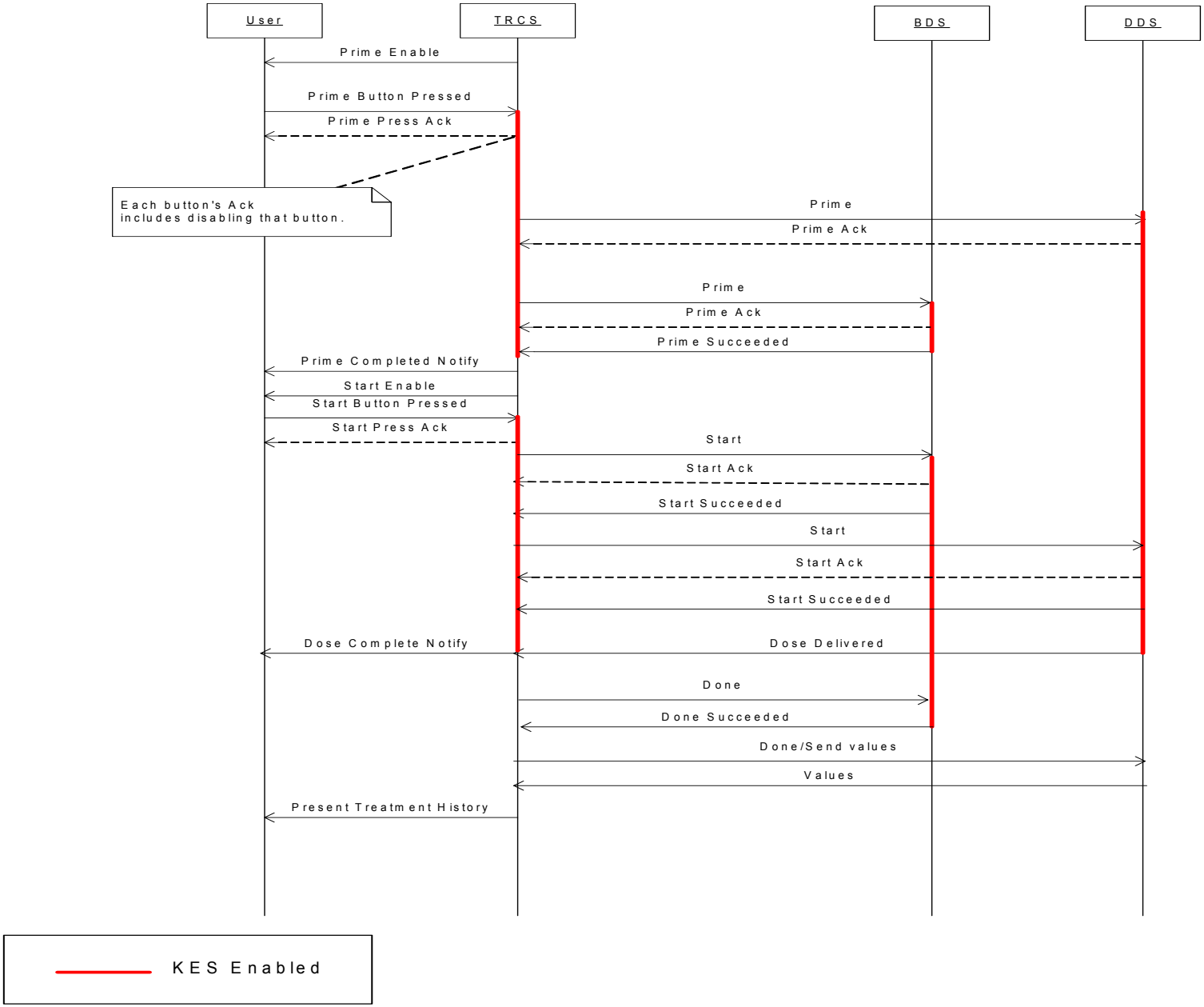
| Indiana University Cyclotron Facility | | | |
|---|---|---|---|
| Document Title | TS2 Treatment Process Flow | | |
| Document Number | 100421 | | |
| System/Subsys Manager | D. Friesel | | |
| Document Owner | M. Wedekind | | |
| Creation Date | 1/30/04 | Rev. No. | 1.0 |
| Revised By | Mkw | Rev. Date | 10/25/04 |






Light field mechanical interface in nozzle
Light field switch user interface
Laser mechanical interface with Gantry
Laser switch at patch
Anesthesiology System: gasses, patch panel.

# Prime/Start/Done Communication Sequence



- Decide on distributed system
  - Allows use of different operating systems, platforms.
  - Allows separate development rates.
  - Requires well defined set of interfaces.

## Major Systems (Software)

BDS – Set and monitor all beam line devices

Vsystem, C, OpenVMS

DDS – Monitor dose delivery

C, QNX

PPS – Set patient position

Robot DLL, C#(.Net), Windows

TRCS – Coordinate treatment process

C++, (Why not) Linux (?)

## Minor Systems (No Software)

MIRS - Radiation Safety

KES – Kicker Enable

ESS – Emergency Stop

# Network Communication

- TCP/IP + Ethernet
- XML-based message protocol
  - System independent
  - Schema checking
  - Existing software packages
- Receiver required to check ranges of all input parameters.

# Messaging Details

- No message echo.
- Messages are entirely ASCII text.
- Expect immediate reply within a timeout (empirically determined).
- Define (delayed) replies to commands that initiate “long” processes.
- Allow asynchronous (error) messages.

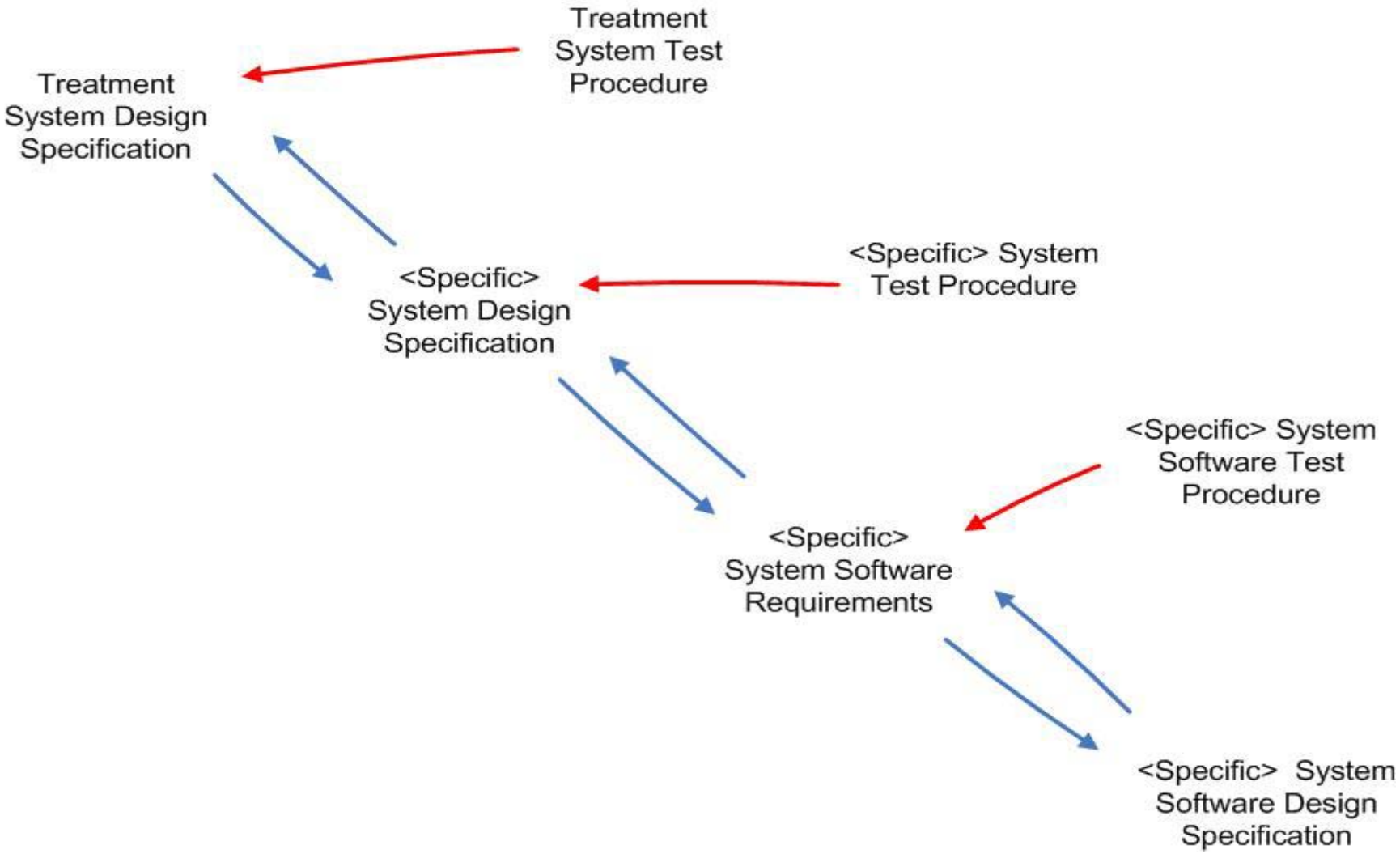
# Testing

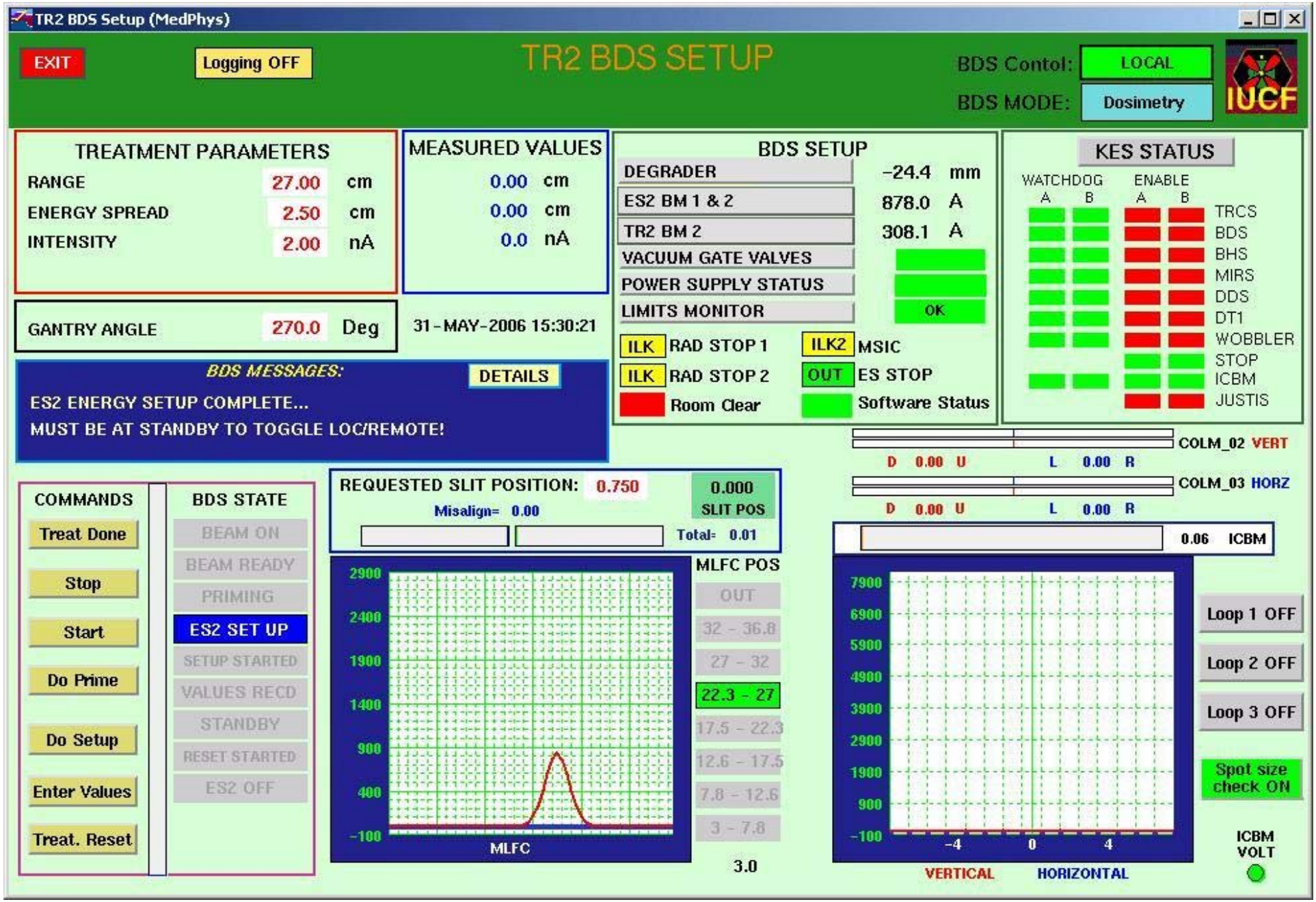
- Code review
- Unit testing
- Integration testing
- Formal Software Test
- Formal System Test

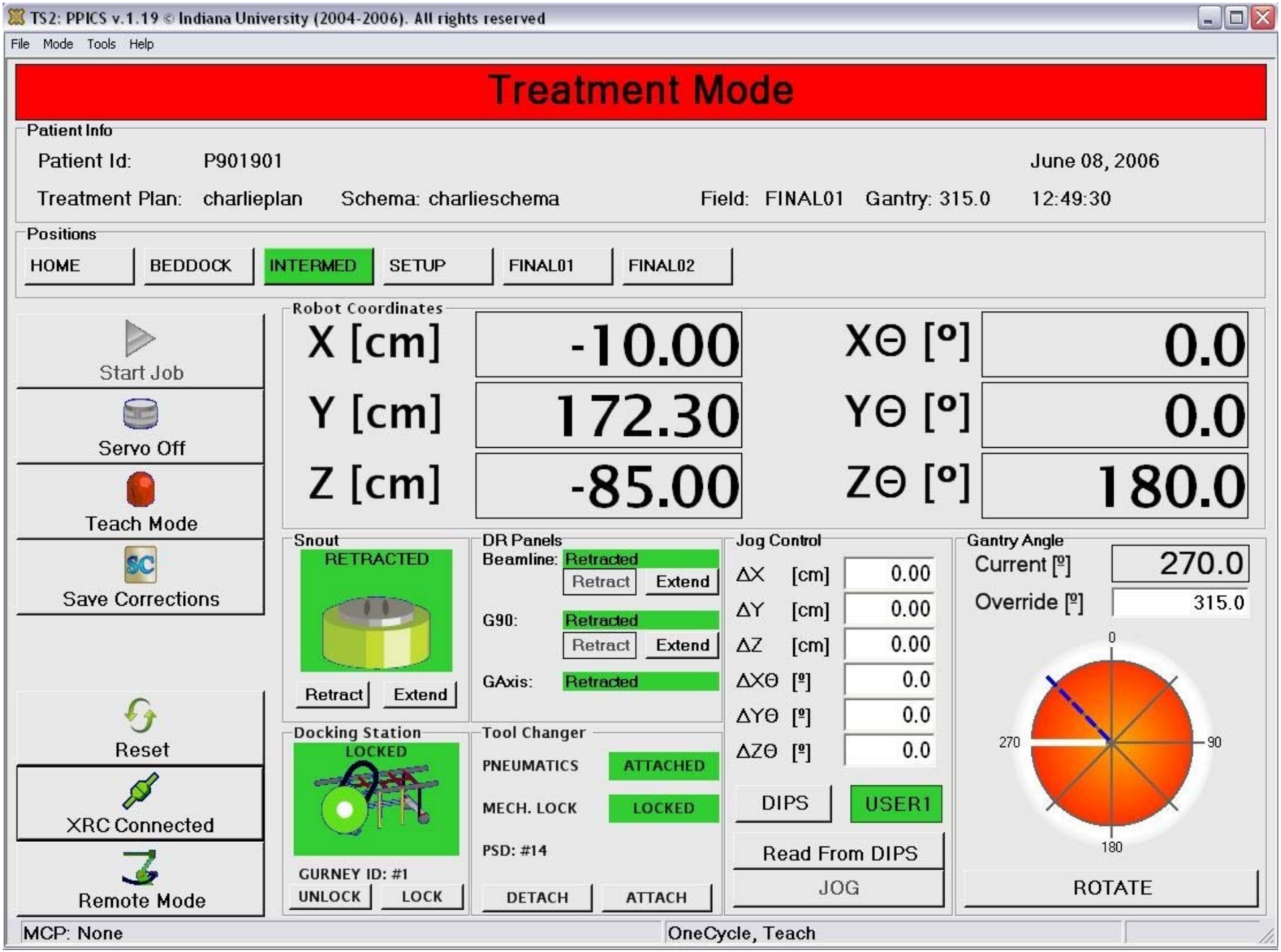
In all cases

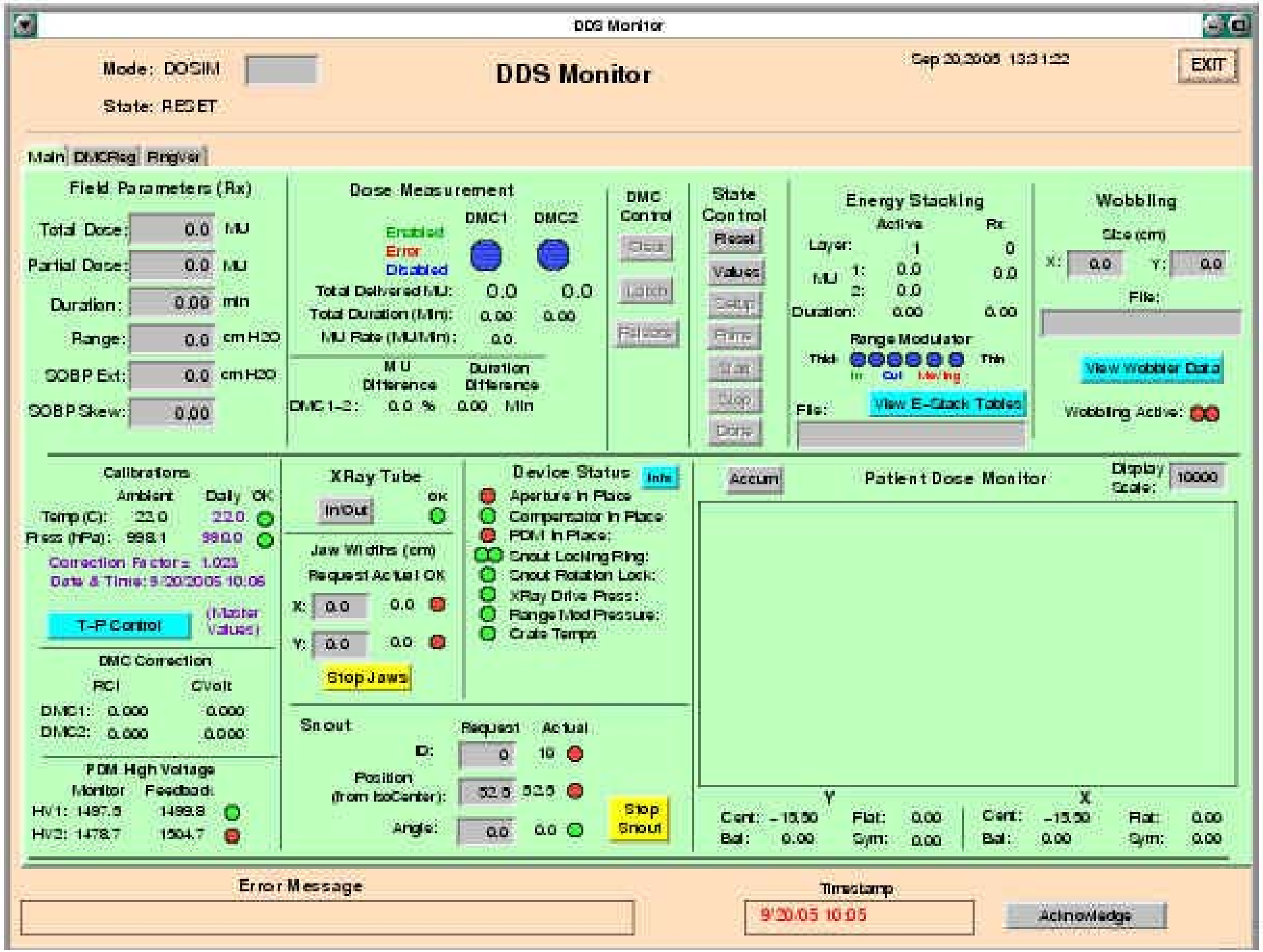
  - Happy path, Sad path
  - Isolation = emulation, NePTUNE
  - Time is ALWAYS underestimated

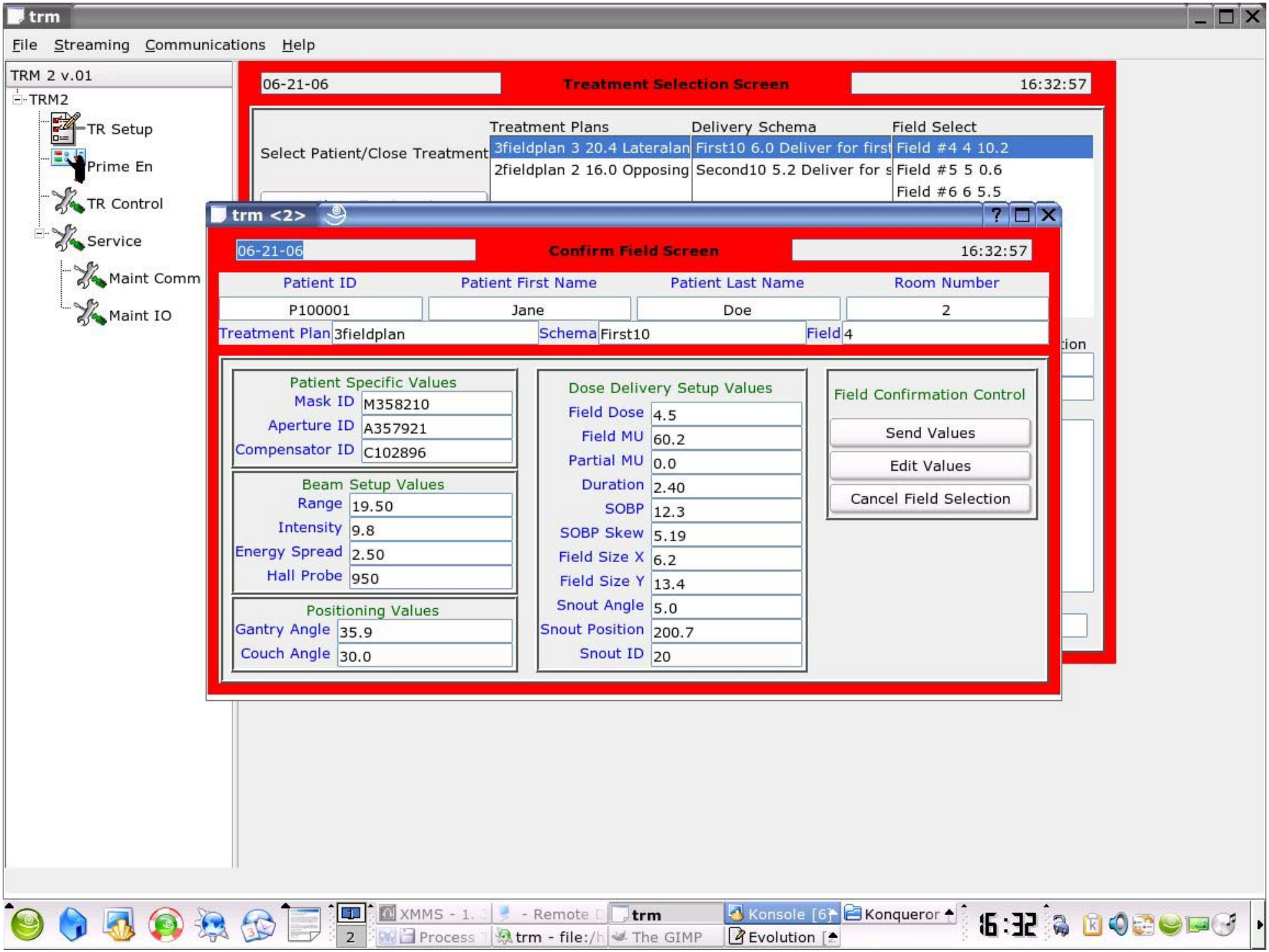
# Testing

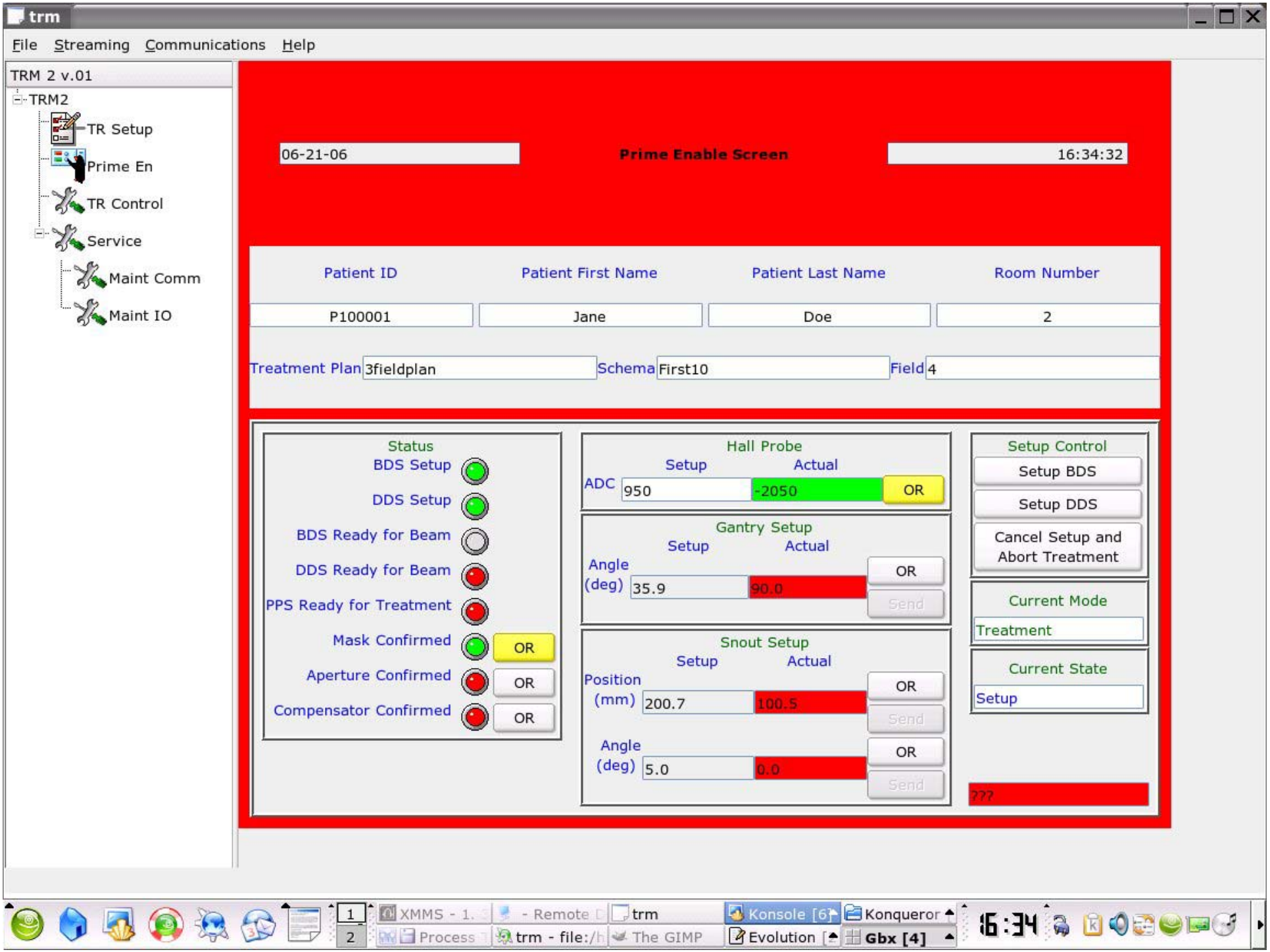

Treatment
System Test
Procedure
Treatment
System Design
Specification
<Specific> System
Test Procedure
<Specific>
System Design
Specification
<Specific> System
Software Test
Procedure
<Specific>
System Software
Requirements
<Specific> System
Software Design
Specification


TR2 BDS Setup (MedPhys)
EXIT
Logging OFF
TR2 BDS SETUP
BDS Contol:
LOCAL
BDS MODE:
Dosimetry
IUCF
TREATMENT PARAMETERS
RANGE 27.00 cm
ENERGY SPREAD 2.50 cm
INTENSITY 2.00 nA
MEASURED VALUES
0.00 cm
0.00 cm
0.0 nA
GANTRY ANGLE 270.0 Deg
31-MAY-2006 15:30:21
BDS SETUP
DEGRADER -24.4 mm
ES2 BM 1 & 2 878.0 A
TR2 BM 2 308.1 A
VACUUM GATE VALVES
POWER SUPPLY STATUS
LIMITS MONITOR
OK
ILK RAD STOP 1
ILK RAD STOP 2
Room Clear
ILK2 MSIC
OUT ES STOP
Software Status
KES STATUS
WATCHDOG A B
ENABLE A B
TRCS
BDS
BHS
MIRS
DDS
DT1
WOBBLER
STOP
ICBM
JUSTIS
BDS MESSAGES:
DETAILS
ES2 ENERGY SETUP COMPLETE...
MUST BE AT STANDBY TO TOGGLE LOC/REMOTE!
COLM_02 VERT
D 0.00 U
L 0.00 R
COLM_03 HORZ
D 0.00 U
L 0.00 R
0.06 ICBM
COMMANDS
Treat Done
Stop
Start
Do Prime
Do Setup
Enter Values
Treat. Reset
BDS STATE
BEAM ON
BEAM READY
PRIMING
ES2 SET UP
SETUP STARTED
VALUES RECD
STANDBY
RESET STARTED
ES2 OFF
REQUESTED SLIT POSITION: 0.750
0.000
SLIT POS
Misalign= 0.00
Total= 0.01
MLFC POS
OUT
32 - 36.8
27 - 32
22.3 - 27
17.5 - 22.3
12.6 - 17.5
7.8 - 12.6
3 - 7.8
3.0
2900
2400
1900
1400
900
400
-100
MLFC
7900
6900
5900
4900
3900
2900
1900
900
-100
-4
0
4
VERTICAL
HORIZONTAL
Loop 1 OFF
Loop 2 OFF
Loop 3 OFF
Spot size check ON
ICBM VOLT


TS2: PPICS v.1.19 © Indiana University (2004-2006). All rights reserved
File Mode Tools Help
Treatment Mode
Patient Info
Patient Id: P901901
June 08, 2006
Treatment Plan: charlieplan Schema: charlieschema Field: FINAL01 Gantry: 315.0 12:49:30
Positions
HOME BEDDOCK INTERMED SETUP FINAL01 FINAL02
Start Job
Servo Off
Teach Mode
Save Corrections
Reset
XRC Connected
Remote Mode
Robot Coordinates
X [cm] -10.00
Y [cm] 172.30
Z [cm] -85.00
XΘ [º] 0.0
YΘ [º] 0.0
ZΘ [º] 180.0
Snout
RETRACTED
Retract Extend
DR Panels
Beamline: Retracted
Retract Extend
G90: Retracted
Retract Extend
GAxis: Retracted
Jog Control
ΔX [cm] 0.00
ΔY [cm] 0.00
ΔZ [cm] 0.00
ΔXΘ [º] 0.0
ΔYΘ [º] 0.0
ΔZΘ [º] 0.0
DIPS USER1
Read From DIPS
JOG
Gantry Angle
Current [º] 270.0
Override [º] 315.0
0
270
90
180
ROTATE
Docking Station
LOCKED
GURNEY ID: #1
UNLOCK LOCK
Tool Changer
PNEUMATICS ATTACHED
MECH. LOCK LOCKED
PSD: #14
DETACH ATTACH
MCP: None
OneCycle, Teach


DDS Monitor
Mode: DOSIM
State: RESET
DDS Monitor
Sep 20,2005 13:31:22
EXIT
Main
DMCRsg
Ringvsr
Field Parameters (Rx)
Total Dose: 0.0 MU
Partial Dose: 0.0 MU
Duration: 0.00 min
Range: 0.0 cm H2O
SOBP Ext: 0.0 cm H2O
SOBP Skew: 0.00
Dose Measurement
DMC1
DMC2
Enabled
Error
Disabled
Total Delivered MU: 0.0 0.0
Total Duration (Min): 0.00 0.00
MU Rate (MU/Min): 0.0
MU Difference
Duration Difference
DMC 1-2: 0.0 % 0.00 Min
DMC Control
Clear
Latch
Release
State Control
Reset
Values
Setup
Prime
Start
Stop
Done
Energy Stacking
Active
Rx
Layer: 1 0
MU 1: 0.0 0.0
2: 0.0
Duration: 0.00 0.00
Range Modulator
Thick
Thin
In
Out
Moving
File:
View E-Stack Table
Wobbling
Size (cm)
X: 0.0
Y: 0.0
File:
View Wobbler Data
Wobbling Active:
Calibrations
Ambient
Daily
OK
Temp (C): 22.0 22.0
Press (hPa): 998.1 998.0
Correction Factor = 1.023
Date & Time: 9/20/2005 10:05
T-P Control
(Master Values)
DMC Correction
PCI
CVolt
DMC1: 0.000 0.000
DMC2: 0.000 0.000
PDM High Voltage
Monitor
Feedback
HV1: 1497.5 1499.8
HV2: 1478.7 1504.7
XRay Tube
In/Out
OK
Jaw Widths (cm)
Request
Actual
OK
X: 0.0 0.0
Y: 0.0 0.0
Stop Jaws
Device Status
Info
Aperture In Place
Compensator In Place
PDM In Place:
Snout Locking Ring:
Snout Rotation Lock:
XRay Drive Press:
Range Mod Pressure:
Crate Temps
Snout
Request
Actual
ID: 0 19
Position (from IsoCenter): 32.5 32.5
Angle: 0.0 0.0
Stop Snout
Accum
Patient Dose Monitor
Display Scale: 10000
Y
Cent: -15.50
Flat: 0.00
Bal: 0.00
Sym: 0.00
X
Cent: -15.50
Flat: 0.00
Bal: 0.00
Sym: 0.00
Error Message
Timestamp
9/20/05 10:05
Acknowledge


trm
File Streaming Communications Help
TRM 2 v.01
TRM2
TR Setup
Prime En
TR Control
Service
Maint Comm
Maint IO
06-21-06
Treatment Selection Screen
16:32:57
Select Patient/Close Treatment
Treatment Plans
Delivery Schema
Field Select
3fieldplan 3 20.4 Lateralan
First10 6.0 Deliver for first
Field #4 4 10.2
2fieldplan 2 16.0 Opposing
Second10 5.2 Deliver for s
Field #5 5 0.6
Field #6 6 5.5
trm <2>
06-21-06
Confirm Field Screen
16:32:57
Patient ID
Patient First Name
Patient Last Name
Room Number
P100001
Jane
Doe
2
Treatment Plan 3fieldplan
Schema First10
Field 4
Patient Specific Values
Mask ID M358210
Aperture ID A357921
Compensator ID C102896
Beam Setup Values
Range 19.50
Intensity 9.8
Energy Spread 2.50
Hall Probe 950
Positioning Values
Gantry Angle 35.9
Couch Angle 30.0
Dose Delivery Setup Values
Field Dose 4.5
Field MU 60.2
Partial MU 0.0
Duration 2.40
SOBP 12.3
SOBP Skew 5.19
Field Size X 6.2
Field Size Y 13.4
Snout Angle 5.0
Snout Position 200.7
Snout ID 20
Field Confirmation Control
Send Values
Edit Values
Cancel Field Selection
XMMS - 1.
Remote
trm
Konsole [6]
Konqueror
Process
trm - file:/h
The GIMP
Evolution
16:32


trm
File Streaming Communications Help
TRM 2 v.01
TRM2
TR Setup
Prime En
TR Control
Service
Maint Comm
Maint IO
06-21-06
Prime Enable Screen
16:34:32
Patient ID
Patient First Name
Patient Last Name
Room Number
P100001
Jane
Doe
2
Treatment Plan 3fieldplan
Schema First10
Field 4
Status
BDS Setup
DDS Setup
BDS Ready for Beam
DDS Ready for Beam
PPS Ready for Treatment
Mask Confirmed
Aperture Confirmed
Compensator Confirmed
OR
Hall Probe
Setup
Actual
ADC 950 -2050 OR
Gantry Setup
Angle (deg) 35.9 90.0 OR Send
Snout Setup
Position (mm) 200.7 100.5 OR Send
Angle (deg) 5.0 0.0 OR Send
Setup Control
Setup BDS
Setup DDS
Cancel Setup and Abort Treatment
Current Mode
Treatment
Current State
Setup
???