Using Sequencing to Improve Operational Efficiency and Reliability

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Talk Outline

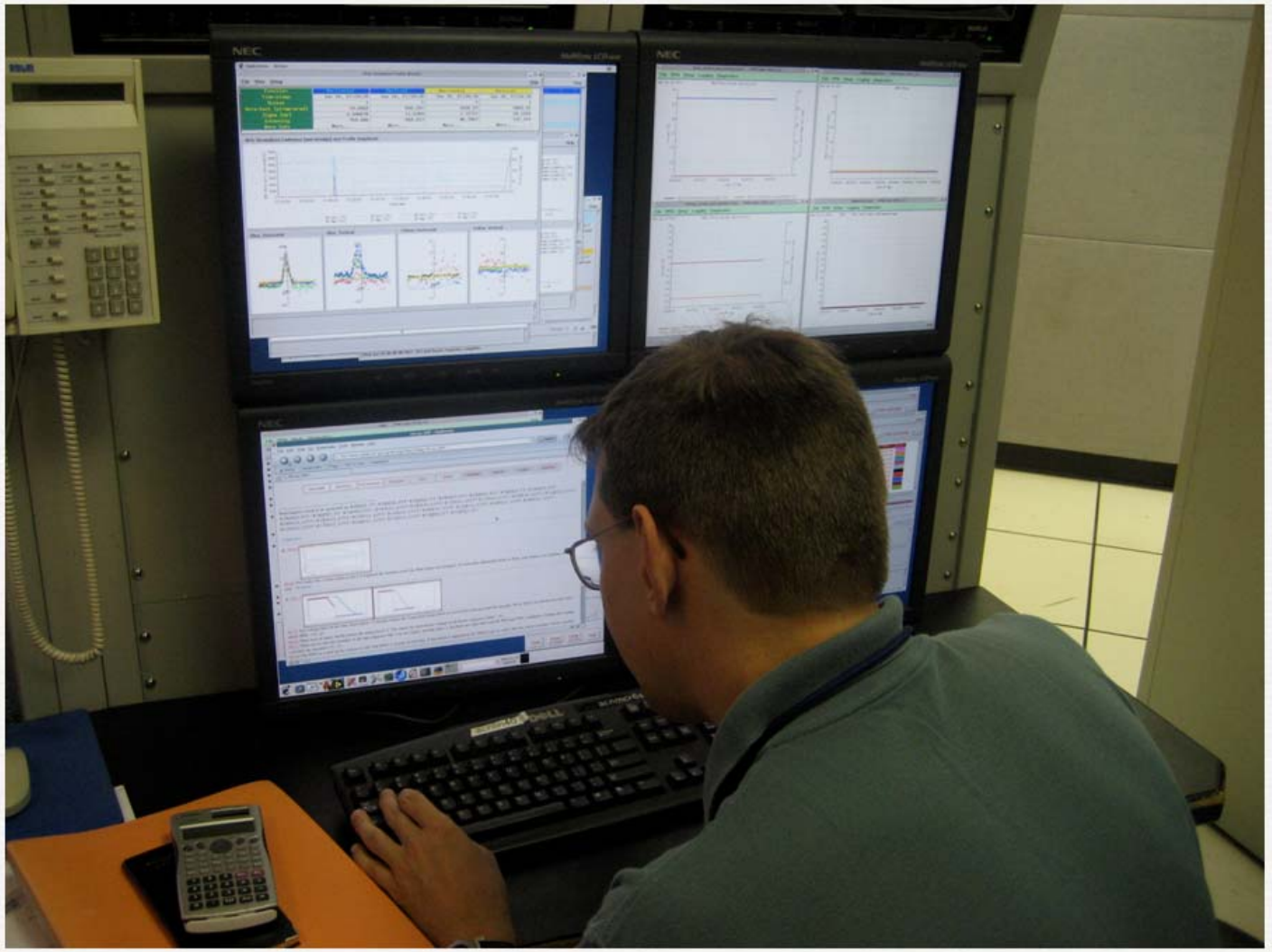
- What is sequencing? Why use it?
  What problems does it solve?
- Description of the BNL sequencing system.
- How is sequencing used at BNL.
- Sequencing Pros and Cons at BNL.


PHOBOS
10:00 o'clock
12:00 o'clock
BRAHMS & PP2PP ($\vec{p}$)
2:00 o'clock
RHIC
4:00 o'clock
PHENIX ($\vec{p}$)
8:00 o'clock
STAR ($\vec{p}$)
6:00 o'clock
NASA - BAF
μ g-2
HEP/NP (p)
LINAC
BOOSTER
AGS
TANDEMS

Common Activities by Operations at BNL

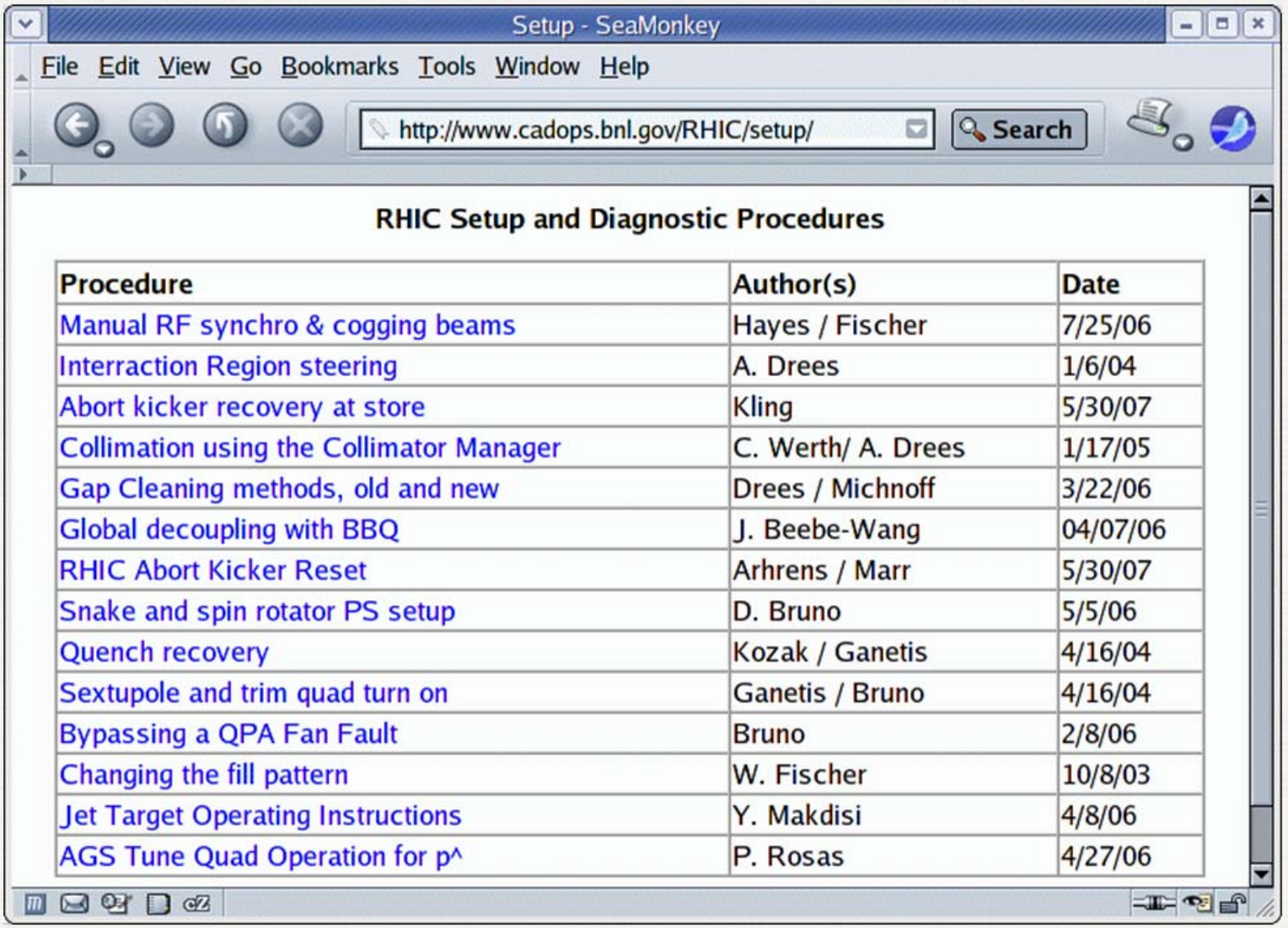
- RHIC Collider
  - New Fill - preparation, injection, acceleration
  - Optimizations - squeeze, steering, collimation
  - End Fill - dump beam, hysteresis
- Other
  - NASA/NSRL - switch species, access, optimize
  - Beam studies/experiments, documentation

Knowledge-Based Worker
(uses expertise and experience)



Rule-Based Worker
(uses written procedures)

Rule-Based Worker
(uses written procedures)



RHIC Setup and Diagnostic Procedures

Procedure	Author(s)	Date
Manual RF synchro & cogging beams	Hayes / Fischer	7/25/06
Interraction Region steering	A. Drees	1/6/04
Abort kicker recovery at store	Kling	5/30/07
Collimation using the Collimator Manager	C. Werth/ A. Drees	1/17/05
Gap Cleaning methods, old and new	Drees / Michnoff	3/22/06
Global decoupling with BBQ	J. Beebe-Wang	04/07/06
RHIC Abort Kicker Reset	Arhrens / Marr	5/30/07
Snake and spin rotator PS setup	D. Bruno	5/5/06
Quench recovery	Kozak / Ganetis	4/16/04
Sextupole and trim quad turn on	Ganetis / Bruno	4/16/04
Bypassing a QPA Fan Fault	Bruno	2/8/06
Changing the fill pattern	W. Fischer	10/8/03
Jet Target Operating Instructions	Y. Makdisi	4/8/06
AGS Tune Quad Operation for p^	P. Rosas	4/27/06

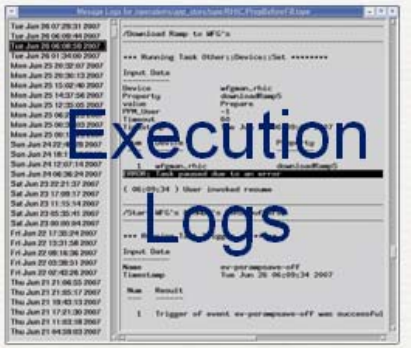
Problems with Written Procedures

- The Writer and the User
  - Often written by an expert, executed by others.
  - Underlying assumptions about user knowledge.
  - Different users execute procedures in different ways.
- Procedure Maintenance
  - Very hard to maintain procedures that are at the right level of detail and are of the right length.
  - Procedures are often not kept up to date.

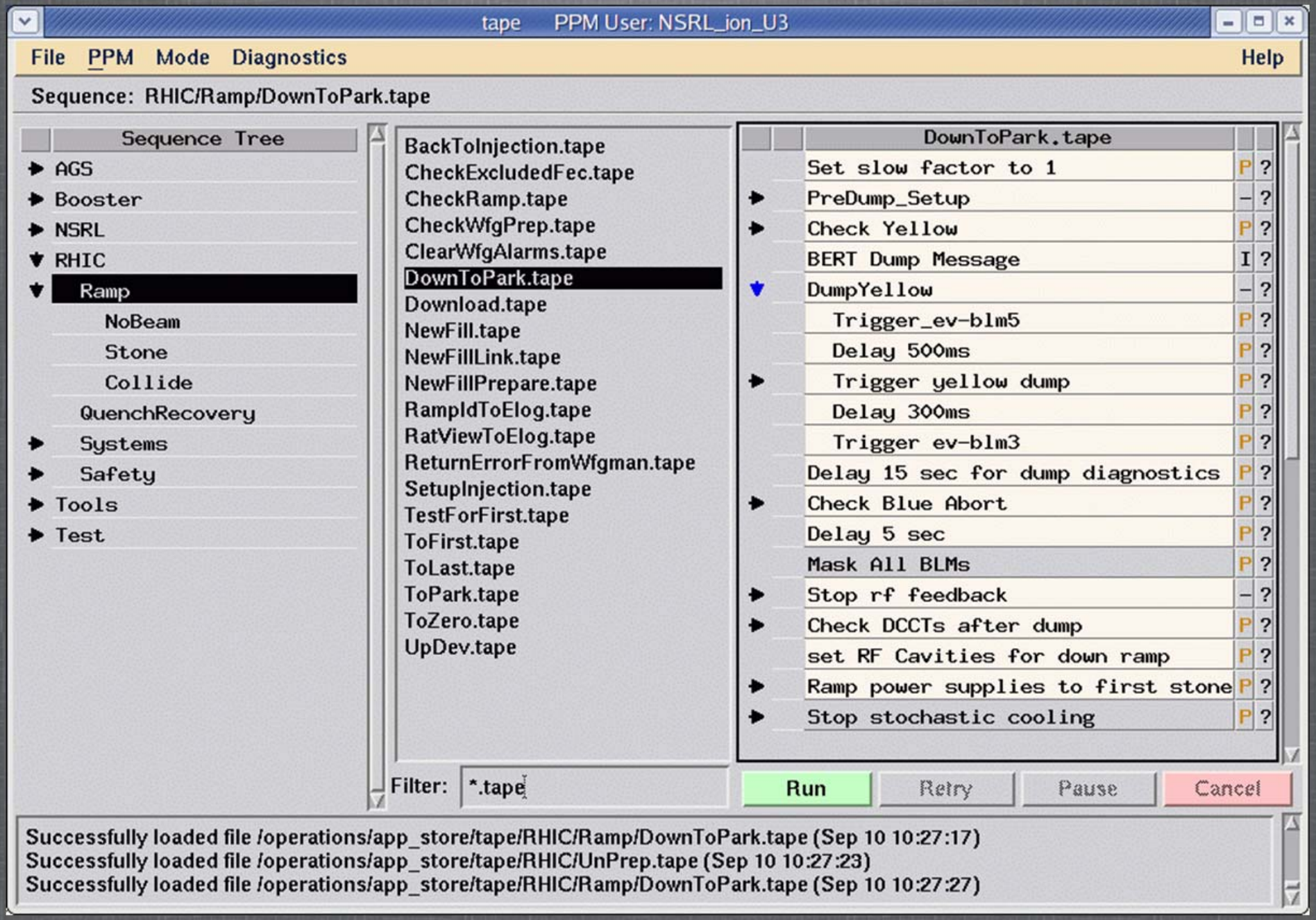
Benefits of Automating Procedure Execution Using Sequencing

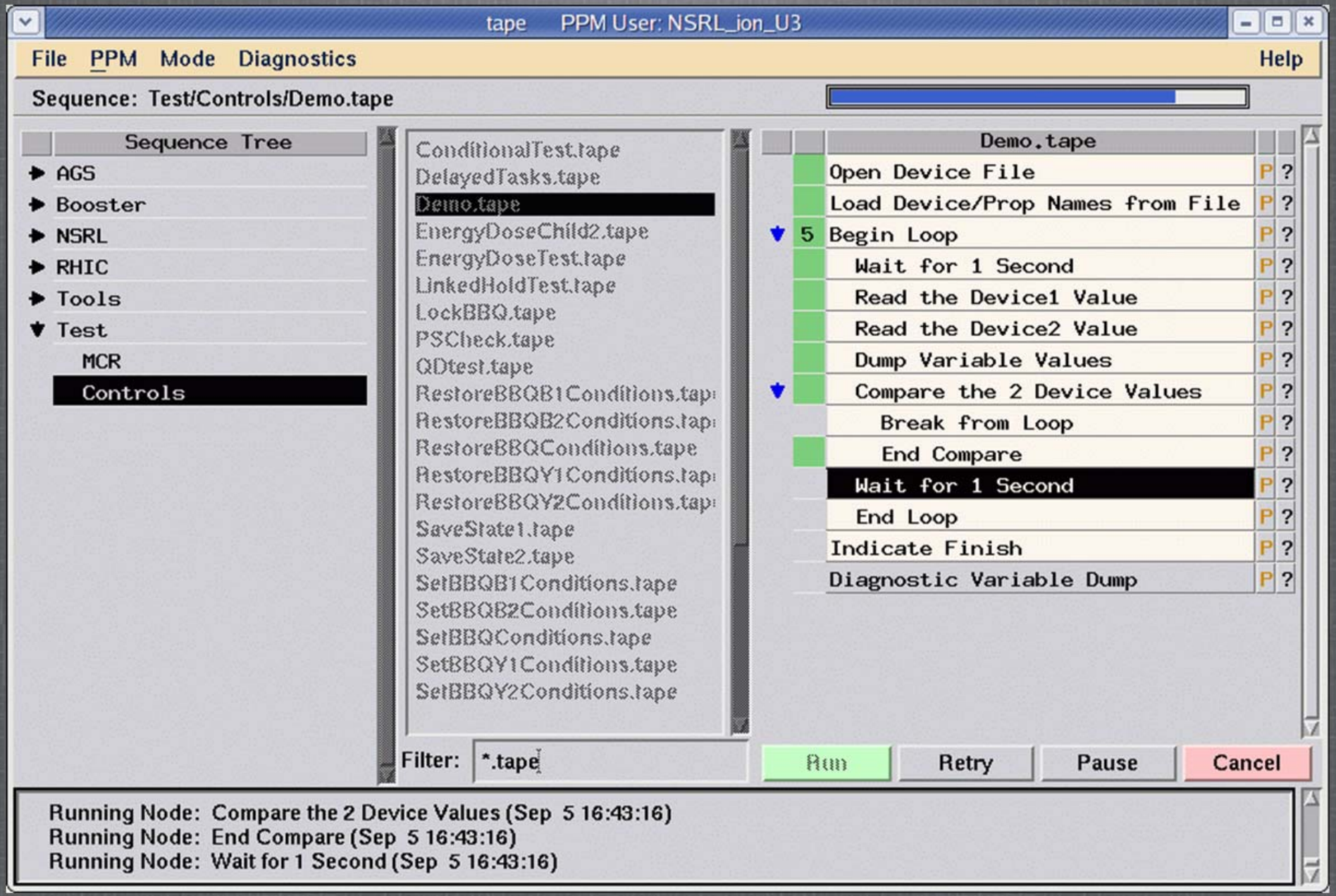
- Major speed improvements can be achieved.
- Sequences are executed the same way by all users.
- Sequence execution and maintainence are tightly coupled.
  To execute the sequence properly, you must fix it.
- Execution is less error prone.
  Steps are not skipped. Workarounds are not needed.
- Relieves operators of monotonous tasks.
  Frees their time for other activities.
- Easy to document what's been done and when.

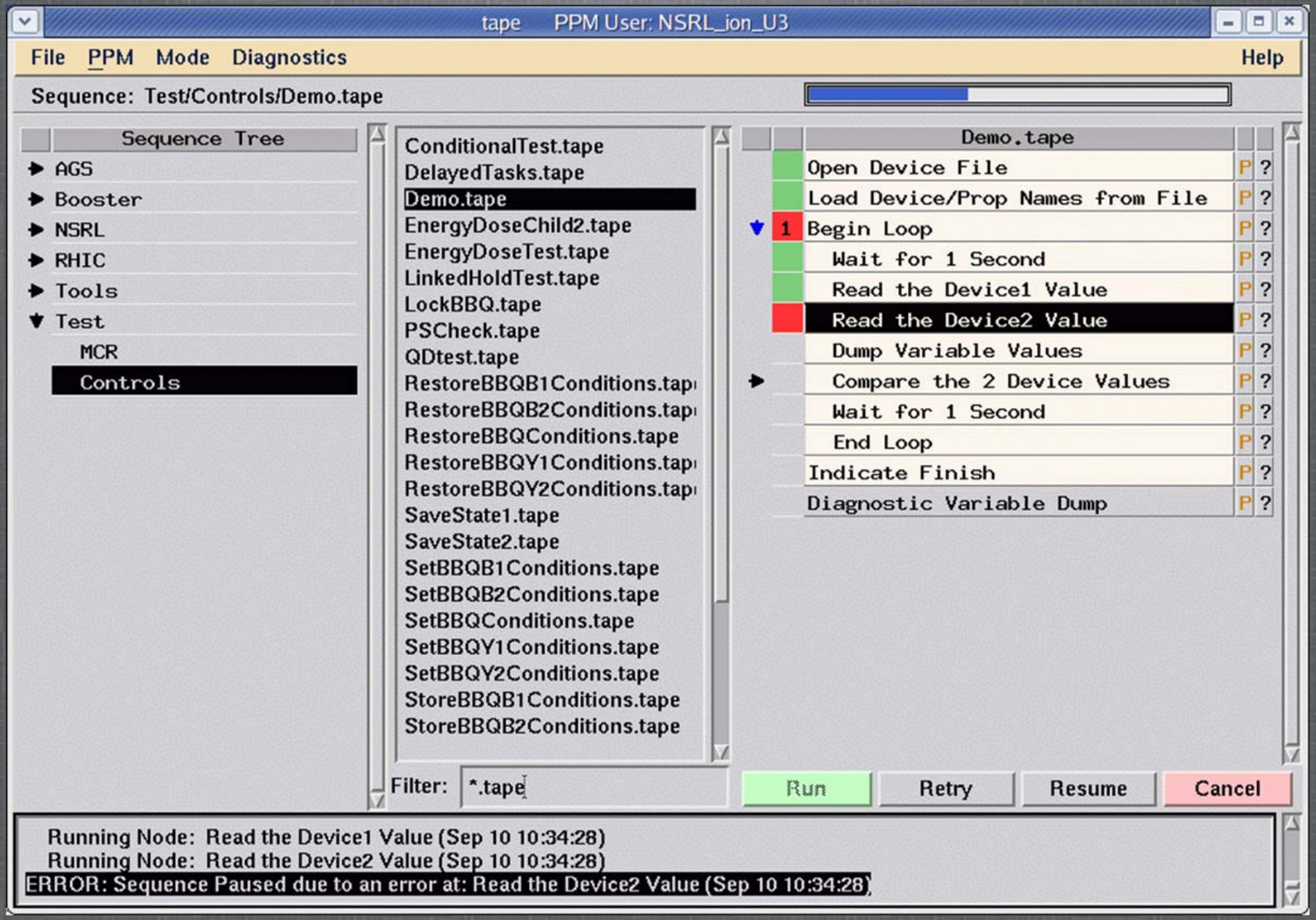
Components of the BNL Sequencer System

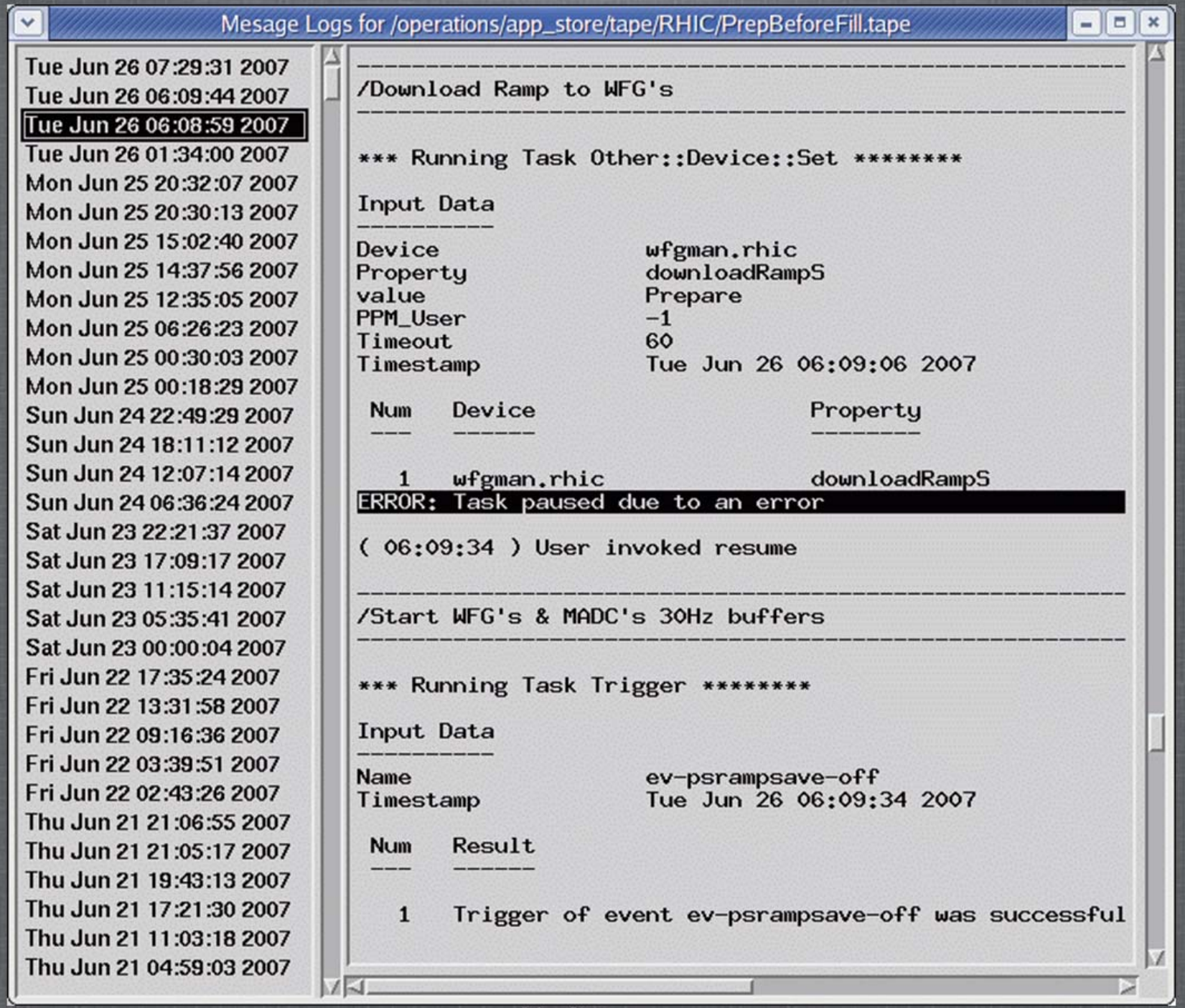


Controls Devices, Servers, Applications, Logbook


tape PPM User: NSRL_ion_U3
File PPM Mode Diagnostics Help
Sequence: RHIC/Ramp/DownToPark.tape
Sequence Tree
AGS
Booster
NSRL
RHIC
Ramp
NoBeam
Stone
Collide
QuenchRecovery
Systems
Safety
Tools
Test
BackToInjection.tape
CheckExcludedFec.tape
CheckRamp.tape
CheckWfgPrep.tape
ClearWfgAlarms.tape
DownToPark.tape
Download.tape
NewFill.tape
NewFillLink.tape
NewFillPrepare.tape
RampIdToElog.tape
RatViewToElog.tape
ReturnErrorFromWfgman.tape
SetupInjection.tape
TestForFirst.tape
ToFirst.tape
ToLast.tape
ToPark.tape
ToZero.tape
UpDev.tape
DownToPark.tape
Set slow factor to 1
PreDump_Setup
Check Yellow
BERT Dump Message
DumpYellow
Trigger_ev-blm5
Delay 500ms
Trigger yellow dump
Delay 300ms
Trigger ev-blm3
Delay 15 sec for dump diagnostics
Check Blue Abort
Delay 5 sec
Mask All BLMs
Stop rf feedback
Check DCCTs after dump
set RF Cavities for down ramp
Ramp power supplies to first stone
Stop stochastic cooling
Filter: *.tape
Run
Retry
Pause
Cancel
Successfully loaded file /operations/app_store/tape/RHIC/Ramp/DownToPark.tape (Sep 10 10:27:17)
Successfully loaded file /operations/app_store/tape/RHIC/UnPrep.tape (Sep 10 10:27:23)
Successfully loaded file /operations/app_store/tape/RHIC/Ramp/DownToPark.tape (Sep 10 10:27:27)


tape PPM User: NSRL_ion_U3
File PPM Mode Diagnostics Help
Sequence: Test/Controls/Demo.tape
Sequence Tree
AGS
Booster
NSRL
RHIC
Tools
Test
MCR
Controls
ConditionalTest.tape
DelayedTasks.tape
Demo.tape
EnergyDoseChild2.tape
EnergyDoseTest.tape
LinkedHoldTest.tape
LockBBQ.tape
PSCheck.tape
QDtest.tape
RestoreBBQB1Conditions.tap
RestoreBBQB2Conditions.tap
RestoreBBQConditions.tape
RestoreBBQY1Conditions.tap
RestoreBBQY2Conditions.tap
SaveState1.tape
SaveState2.tape
SetBBQB1Conditions.tape
SetBBQB2Conditions.tape
SetBBQConditions.tape
SetBBQY1Conditions.tape
SetBBQY2Conditions.tape
Filter: *.tape
Demo.tape
Open Device File P ?
Load Device/Prop Names from File P ?
5 Begin Loop P ?
Wait for 1 Second P ?
Read the Device1 Value P ?
Read the Device2 Value P ?
Dump Variable Values P ?
Compare the 2 Device Values P ?
Break from Loop P ?
End Compare P ?
Wait for 1 Second P ?
End Loop P ?
Indicate Finish P ?
Diagnostic Variable Dump P ?
Run Retry Pause Cancel
Running Node: Compare the 2 Device Values (Sep 5 16:43:16)
Running Node: End Compare (Sep 5 16:43:16)
Running Node: Wait for 1 Second (Sep 5 16:43:16)


tape PPM User: NSRL_ion_U3
File PPM Mode Diagnostics Help
Sequence: Test/Controls/Demo.tape
Sequence Tree
AGS
Booster
NSRL
RHIC
Tools
Test
MCR
Controls
ConditionalTest.tape
DelayedTasks.tape
Demo.tape
EnergyDoseChild2.tape
EnergyDoseTest.tape
LinkedHoldTest.tape
LockBBQ.tape
PSCheck.tape
QDtest.tape
RestoreBBQB1Conditions.tap
RestoreBBQB2Conditions.tap
RestoreBBQConditions.tape
RestoreBBQY1Conditions.tap
RestoreBBQY2Conditions.tap
SaveState1.tape
SaveState2.tape
SetBBQB1Conditions.tape
SetBBQB2Conditions.tape
SetBBQConditions.tape
SetBBQY1Conditions.tape
SetBBQY2Conditions.tape
StoreBBQB1Conditions.tape
StoreBBQB2Conditions.tape
Filter: *.tape
Demo.tape
Open Device File
Load Device/Prop Names from File
1 Begin Loop
Wait for 1 Second
Read the Device1 Value
Read the Device2 Value
Dump Variable Values
Compare the 2 Device Values
Wait for 1 Second
End Loop
Indicate Finish
Diagnostic Variable Dump
Run
Retry
Resume
Cancel
Running Node: Read the Device1 Value (Sep 10 10:34:28)
Running Node: Read the Device2 Value (Sep 10 10:34:28)
ERROR: Sequence Paused due to an error at: Read the Device2 Value (Sep 10 10:34:28)


Mesage Logs for /operations/app_store/tape/RHIC/PrepBeforeFill.tape
Tue Jun 26 07:29:31 2007
Tue Jun 26 06:09:44 2007
Tue Jun 26 06:08:59 2007
Tue Jun 26 01:34:00 2007
Mon Jun 25 20:32:07 2007
Mon Jun 25 20:30:13 2007
Mon Jun 25 15:02:40 2007
Mon Jun 25 14:37:56 2007
Mon Jun 25 12:35:05 2007
Mon Jun 25 06:26:23 2007
Mon Jun 25 00:30:03 2007
Mon Jun 25 00:18:29 2007
Sun Jun 24 22:49:29 2007
Sun Jun 24 18:11:12 2007
Sun Jun 24 12:07:14 2007
Sun Jun 24 06:36:24 2007
Sat Jun 23 22:21:37 2007
Sat Jun 23 17:09:17 2007
Sat Jun 23 11:15:14 2007
Sat Jun 23 05:35:41 2007
Sat Jun 23 00:00:04 2007
Fri Jun 22 17:35:24 2007
Fri Jun 22 13:31:58 2007
Fri Jun 22 09:16:36 2007
Fri Jun 22 03:39:51 2007
Fri Jun 22 02:43:26 2007
Thu Jun 21 21:06:55 2007
Thu Jun 21 21:05:17 2007
Thu Jun 21 19:43:13 2007
Thu Jun 21 17:21:30 2007
Thu Jun 21 11:03:18 2007
Thu Jun 21 04:59:03 2007
/Download Ramp to WFG's
*** Running Task Other::Device::Set ********
Input Data
Device wfgman.rhic
Property downloadRampS
value Prepare
PPM_User -1
Timeout 60
Timestamp Tue Jun 26 06:09:06 2007
Num Device Property
1 wfgman.rhic downloadRampS
ERROR: Task paused due to an error
(06:09:34) User invoked resume
/Start WFG's & MADC's 30Hz buffers
*** Running Task Trigger ********
Input Data
Name ev-psrampsave-off
Timestamp Tue Jun 26 06:09:34 2007
Num Result
1 Trigger of event ev-psrampsave-off was successful

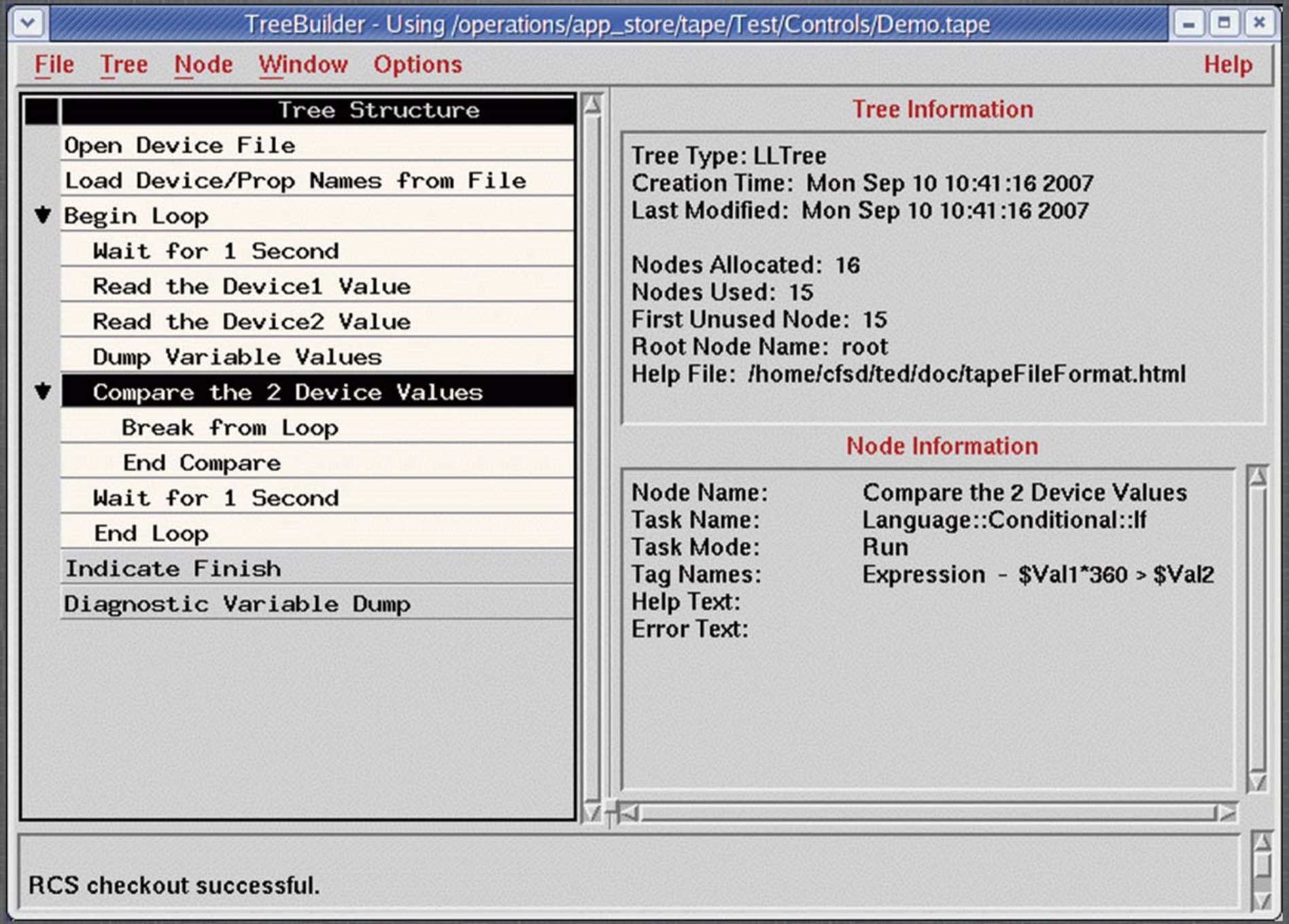
/operations/app_store/tape/Test/Controls/Demo.tape

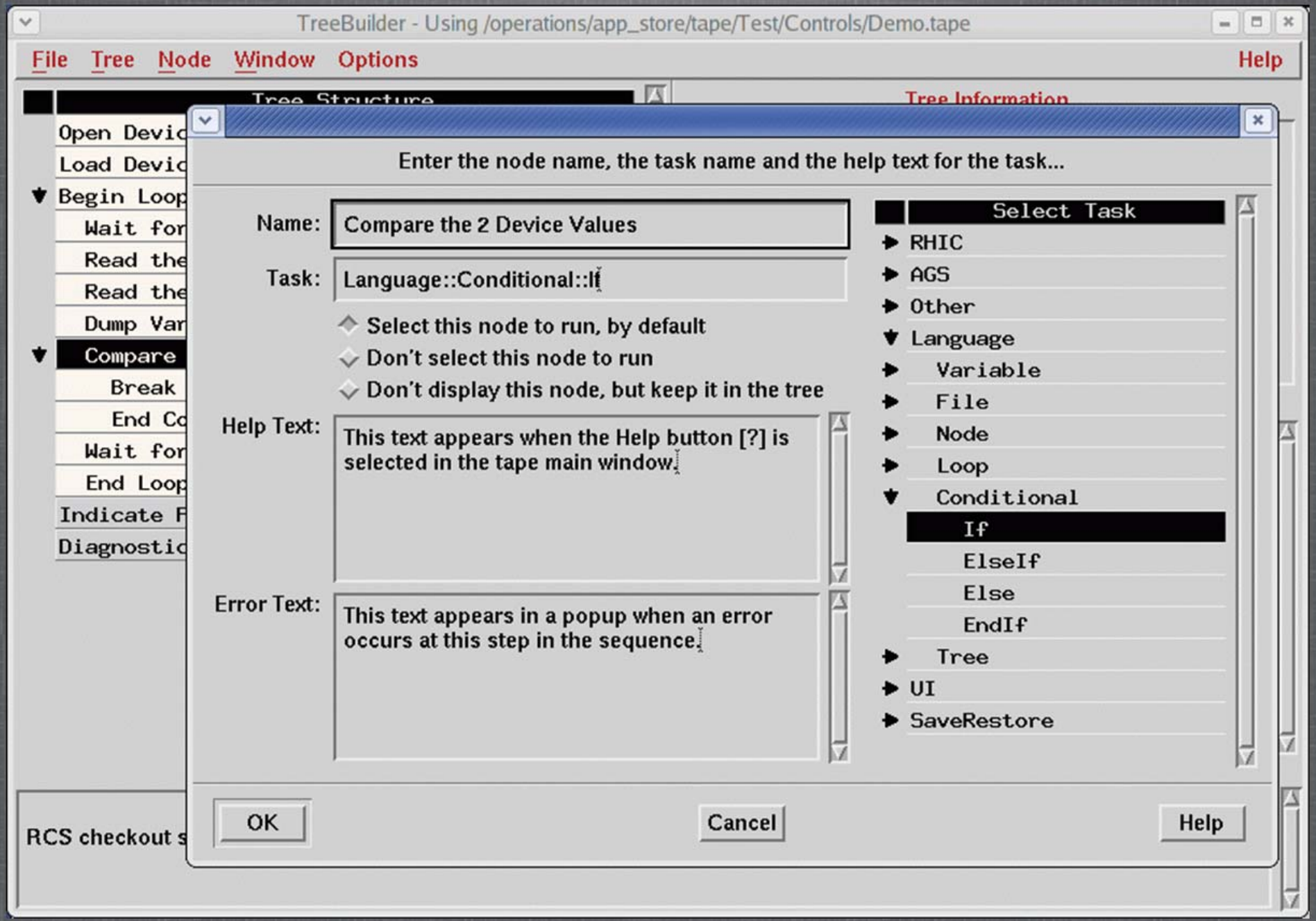
File Edit Search

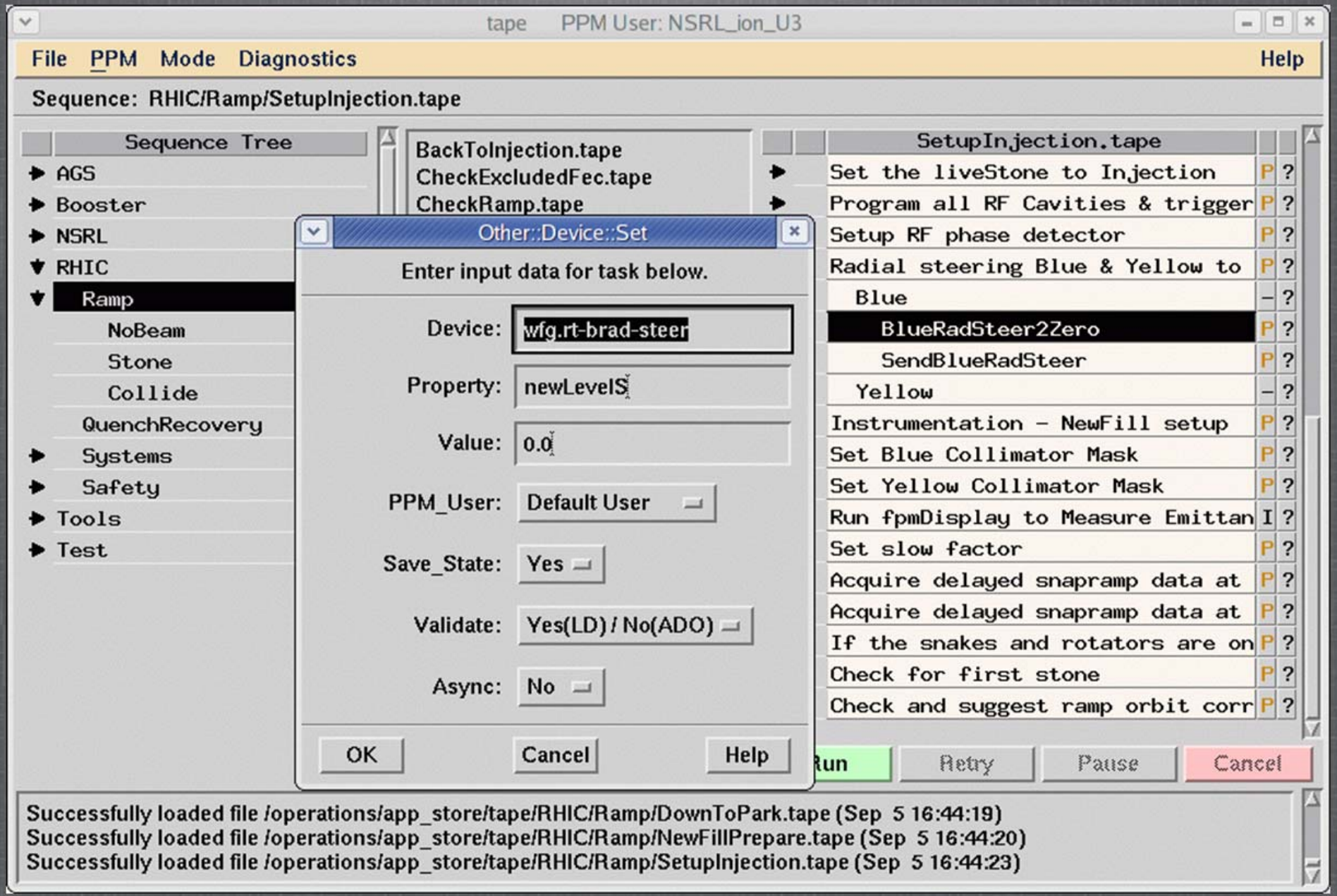
Find: Replace with:

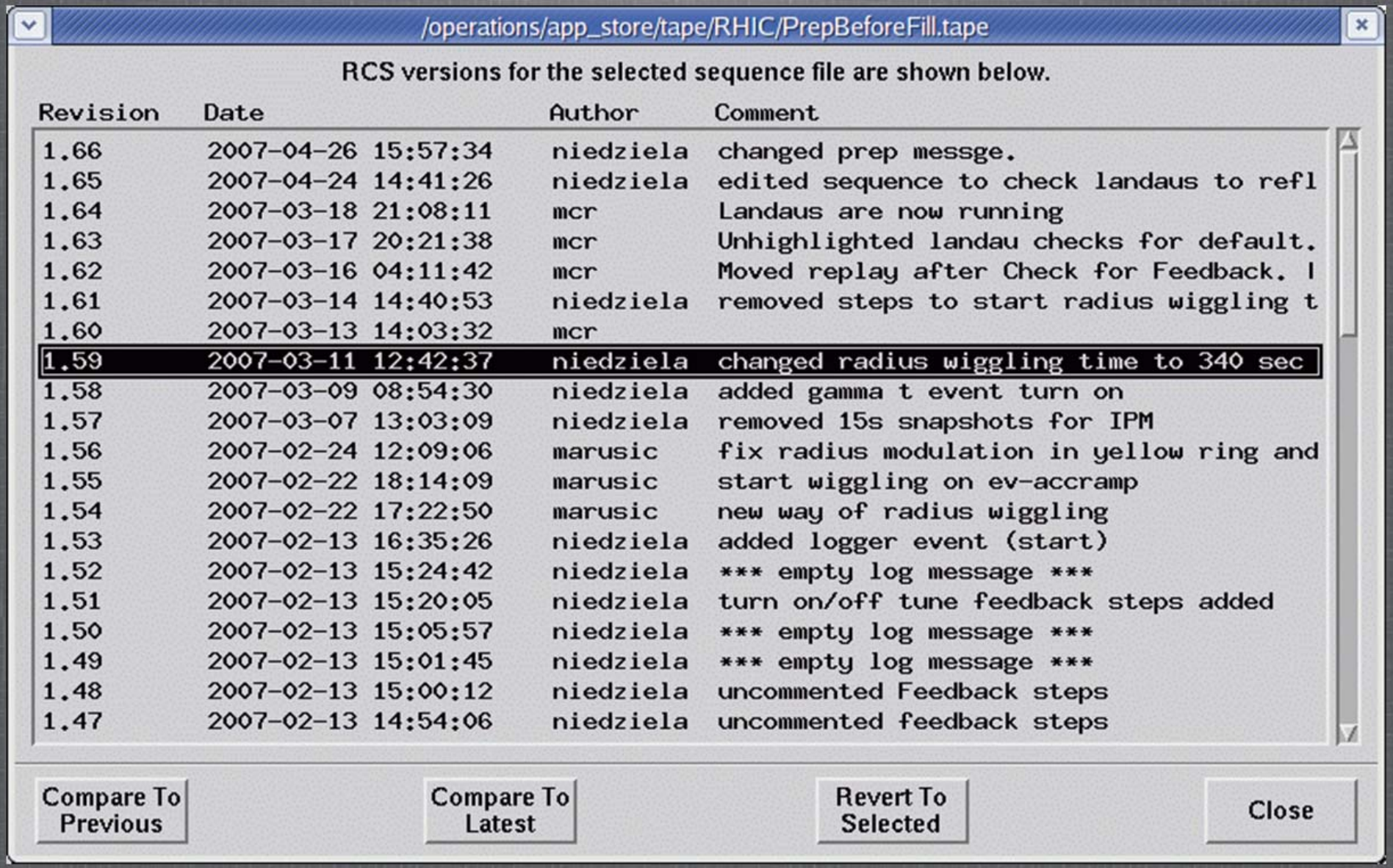
```
TYPE tape -version 5
HELPFILE /home/cfsd/ted/doc/tapeFileFormat.html

NAME  Open Device File
TASK  Language::File::Open
TAGS  -Filename /home/cfsd/ted/demo.txt -Nickname Demo

NAME  Load Device/Prop Names from File
TASK  Language::Variable::SetFromFile
TAGS  -Nickname Demo -Variable_Names $Dev1,$Prop1,$Dev2,$Prop2

NAME  Begin Loop
TASK  Language::Loop::Begin

        NAME  Read the Device1 Value
        TASK  Other::Device::Get
        TAGS  -Device $Dev1 -Property $Prop1 -Output_Variable $Val1

        NAME  Read the Device2 Value
        TASK  Other::Device::Get
        TAGS  -Device $Dev2 -Property $Prop2 -Output_Variable $Val2

        NAME  Compare the 2 Device Values
        TASK  Language::Conditional::If
        TAGS  -Expression $Val1*360 > $Val2

                NAME  Break from Loop
                TASK  Language::Loop::Break

                NAME  End Compare
                TASK  Language::Conditional::EndIf

        NAME  End Loop
        TASK  Language::Loop::End
```

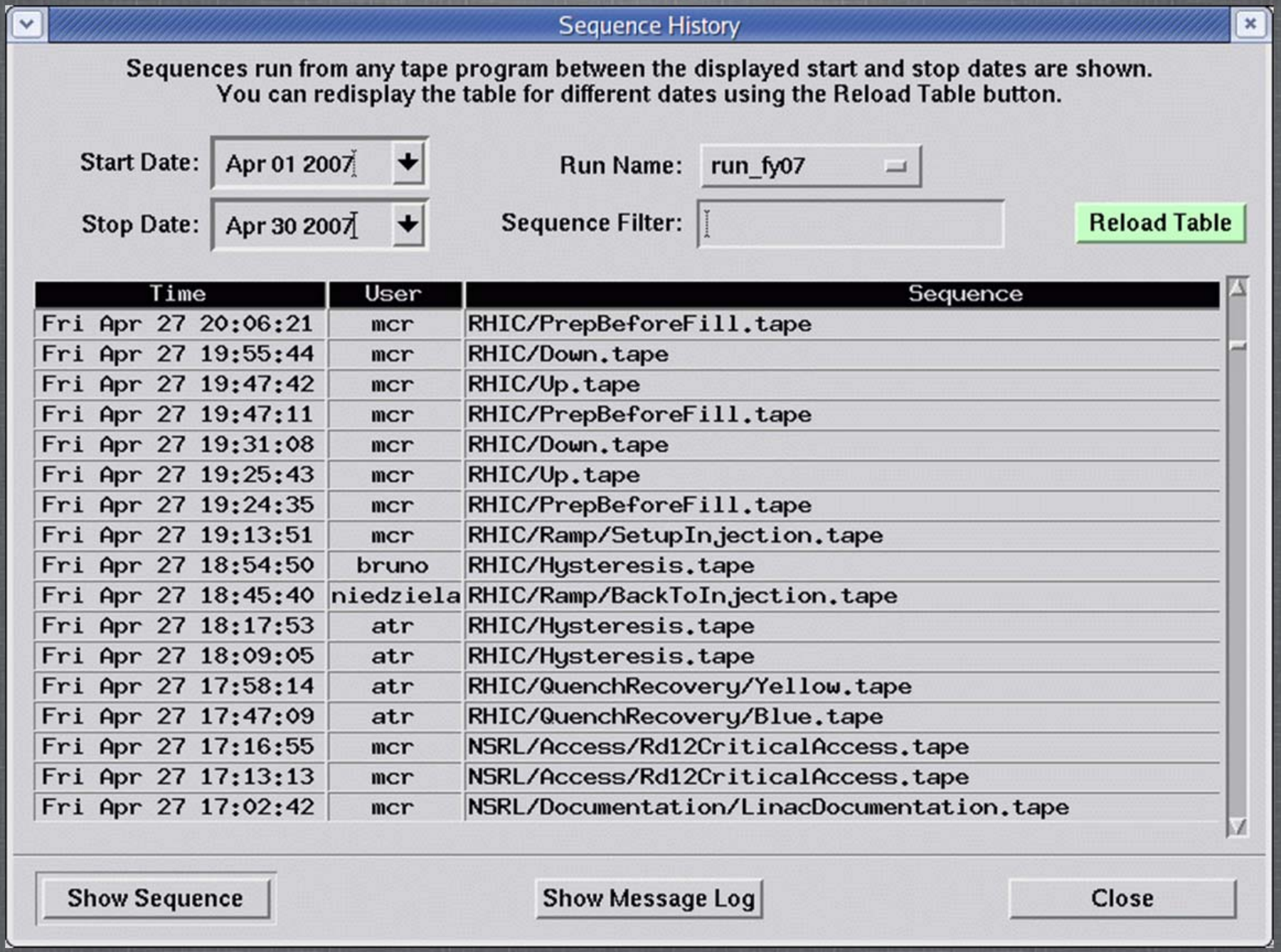
Loaded 1 Kbytes from /operations/app_store/tape/Test/Controls/Demo.tape.


TreeBuilder - Using /operations/app_store/tape/Test/Controls/Demo.tape
File Tree Node Window Options Help
Tree Structure
Open Device File
Load Device/Prop Names from File
Begin Loop
Wait for 1 Second
Read the Device1 Value
Read the Device2 Value
Dump Variable Values
Compare the 2 Device Values
Break from Loop
End Compare
Wait for 1 Second
End Loop
Indicate Finish
Diagnostic Variable Dump
Tree Information
Tree Type: LLTree
Creation Time: Mon Sep 10 10:41:16 2007
Last Modified: Mon Sep 10 10:41:16 2007
Nodes Allocated: 16
Nodes Used: 15
First Unused Node: 15
Root Node Name: root
Help File: /home/cfsd/ted/doc/tapeFileFormat.html
Node Information
Node Name: Compare the 2 Device Values
Task Name: Language::Conditional::If
Task Mode: Run
Tag Names: Expression - $Val1*360 > $Val2
Help Text:
Error Text:
RCS checkout successful.

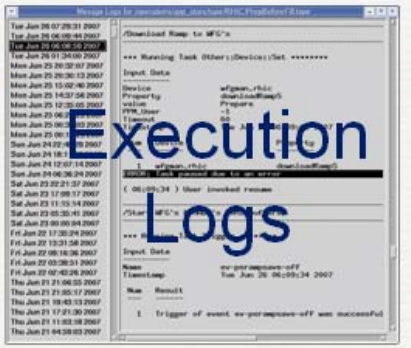

TreeBuilder - Using /operations/app_store/tape/Test/Controls/Demo.tape
File Tree Node Window Options Help
Tree Structure
Tree Information
Open Devic
Load Devic
Begin Loop
Wait for
Read the
Read the
Dump Var
Compare
Break
End Co
Wait for
End Loop
Indicate F
Diagnostic
RCS checkout s
Enter the node name, the task name and the help text for the task...
Name:
Compare the 2 Device Values
Task:
Language::Conditional::If
Select this node to run, by default
Don't select this node to run
Don't display this node, but keep it in the tree
Help Text:
This text appears when the Help button [?] is selected in the tape main window.
Error Text:
This text appears in a popup when an error occurs at this step in the sequence.
Select Task
RHIC
AGS
Other
Language
Variable
File
Node
Loop
Conditional
If
ElseIf
Else
EndIf
Tree
UI
SaveRestore
OK
Cancel
Help


tape PPM User: NSRL_ion_U3
File PPM Mode Diagnostics Help
Sequence: RHIC/Ramp/SetupInjection.tape
Sequence Tree
AGS
Booster
NSRL
RHIC
Ramp
NoBeam
Stone
Collide
QuenchRecovery
Systems
Safety
Tools
Test
BackToInjection.tape
CheckExcludedFec.tape
CheckRamp.tape
Other::Device::Set
Enter input data for task below.
Device: wfg.rt-brad-steer
Property: newLevelS
Value: 0.0
PPM_User: Default User
Save_State: Yes
Validate: Yes(LD) / No(ADO)
Async: No
OK
Cancel
Help
SetupInjection.tape
Set the liveStone to Injection
Program all RF Cavities & trigger
Setup RF phase detector
Radial steering Blue & Yellow to
Blue
BlueRadSteer2Zero
SendBlueRadSteer
Yellow
Instrumentation - NewFill setup
Set Blue Collimator Mask
Set Yellow Collimator Mask
Run fpmDisplay to Measure Emittan
Set slow factor
Acquire delayed snapramp data at
Acquire delayed snapramp data at
If the snakes and rotators are on
Check for first stone
Check and suggest ramp orbit corr
Run
Retry
Pause
Cancel
Successfully loaded file /operations/app_store/tape/RHIC/Ramp/DownToPark.tape (Sep 5 16:44:19)
Successfully loaded file /operations/app_store/tape/RHIC/Ramp/NewFillPrepare.tape (Sep 5 16:44:20)
Successfully loaded file /operations/app_store/tape/RHIC/Ramp/SetupInjection.tape (Sep 5 16:44:23)


/operations/app_store/tape/RHIC/PrepBeforeFill.tape
RCS versions for the selected sequence file are shown below.
Revision Date Author Comment
1.66 2007-04-26 15:57:34 niedziela changed prep messge.
1.65 2007-04-24 14:41:26 niedziela edited sequence to check landaus to refl
1.64 2007-03-18 21:08:11 mcr Landaus are now running
1.63 2007-03-17 20:21:38 mcr Unhighlighted landau checks for default.
1.62 2007-03-16 04:11:42 mcr Moved replay after Check for Feedback. I
1.61 2007-03-14 14:40:53 niedziela removed steps to start radius wiggling t
1.60 2007-03-13 14:03:32 mcr
1.59 2007-03-11 12:42:37 niedziela changed radius wiggling time to 340 sec
1.58 2007-03-09 08:54:30 niedziela added gamma t event turn on
1.57 2007-03-07 13:03:09 niedziela removed 15s snapshots for IPM
1.56 2007-02-24 12:09:06 marusic fix radius modulation in yellow ring and
1.55 2007-02-22 18:14:09 marusic start wiggling on ev-accramp
1.54 2007-02-22 17:22:50 marusic new way of radius wiggling
1.53 2007-02-13 16:35:26 niedziela added logger event (start)
1.52 2007-02-13 15:24:42 niedziela *** empty log message ***
1.51 2007-02-13 15:20:05 niedziela turn on/off tune feedback steps added
1.50 2007-02-13 15:05:57 niedziela *** empty log message ***
1.49 2007-02-13 15:01:45 niedziela *** empty log message ***
1.48 2007-02-13 15:00:12 niedziela uncommented Feedback steps
1.47 2007-02-13 14:54:06 niedziela uncommented feedback steps
Compare To Previous
Compare To Latest
Revert To Selected
Close


Sequence History
Sequences run from any tape program between the displayed start and stop dates are shown.
You can redisplay the table for different dates using the Reload Table button.
Start Date: Apr 01 2007
Stop Date: Apr 30 2007
Run Name: run_fy07
Sequence Filter:
Reload Table
Time | User | Sequence
Fri Apr 27 20:06:21 | mcr | RHIC/PrepBeforeFill.tape
Fri Apr 27 19:55:44 | mcr | RHIC/Down.tape
Fri Apr 27 19:47:42 | mcr | RHIC/Up.tape
Fri Apr 27 19:47:11 | mcr | RHIC/PrepBeforeFill.tape
Fri Apr 27 19:31:08 | mcr | RHIC/Down.tape
Fri Apr 27 19:25:43 | mcr | RHIC/Up.tape
Fri Apr 27 19:24:35 | mcr | RHIC/PrepBeforeFill.tape
Fri Apr 27 19:13:51 | mcr | RHIC/Ramp/SetupInjection.tape
Fri Apr 27 18:54:50 | bruno | RHIC/Hysteresis.tape
Fri Apr 27 18:45:40 | niedziela | RHIC/Ramp/BackToInjection.tape
Fri Apr 27 18:17:53 | atr | RHIC/Hysteresis.tape
Fri Apr 27 18:09:05 | atr | RHIC/Hysteresis.tape
Fri Apr 27 17:58:14 | atr | RHIC/QuenchRecovery/Yellow.tape
Fri Apr 27 17:47:09 | atr | RHIC/QuenchRecovery/Blue.tape
Fri Apr 27 17:16:55 | mcr | NSRL/Access/Rd12CriticalAccess.tape
Fri Apr 27 17:13:13 | mcr | NSRL/Access/Rd12CriticalAccess.tape
Fri Apr 27 17:02:42 | mcr | NSRL/Documentation/LinacDocumentation.tape
Show Sequence
Show Message Log
Close

Components of the BNL Sequencer System



Controls Devices, Servers, Applications, Logbook

Categories of Sequences Created

- Routine Procedures (injection, ramping, hysteresis)
- Failure Recovery (magnet quench)
- Time Sensitive (cogging, rebucketing, steering)
- State Changes (species switching, energy scaling)
- System-Specific (RF, PS, instrumentation, collimators)
- Safety (to controlled or restricted access)
- Beam Studies and Experiments
- Documentation (start of day, end of day)

Use of the BNL Sequencer (Jan 2007 - June 2007)

- 492 different sequences available (69% for RHIC)
- 13,992 sequence executions (45% for RHIC)
- 85% of the sequences were run by Operations
- Most sequences were created by, and almost all are maintained by, the Operations staff

Important Generic Sequence Tasks

- Device - Set, SetFromArchive, Wait, Compare, Ramp
- Save/Restore - SaveArchive, RestoreArchive
- User Interface - ShowMessage, GetText, GetSelection
- Other - SequenceReference, TimerWait, RunCommand
- Variable - Set, SetFromFile, Compare, Clear, Dump
- Loop - Begin, End, Break, ForEach
- Conditional - If, ElseIf, Else, EndIf

Summary - Sequencing Pros

- Procedures are executed reproducibly and reliably. Executions are logged for later viewing.
- Procedure automation leads to time savings.
- Sequences can be built and owned by Operations.
- Sequences can be built from reusable modular pieces.
- Improves the quality of life for Operations personnel.
  - Permits multitasking
  - Monotonous tasks reduced

Summary - Sequencing Cons

- A lockup or crash of the sequencer can lead to confusion about what was executed and how to recover.
- Knowledge of the sequence details can deteriorate quickly. Sequences need to be understandable.
- Easy to run potentially harmful sequences.

Questions?