Integrated Predictive Modelling at JET

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Outline

- Why do we need integration?
- Approach, chosen by the Project;
- Project description;
- Progress report;
- Future plans;
- Interaction with JET TF-T and EU ITM-TF

Why do we need integration

- The main motivation comes from the recognition that we are dealing with more and more complex phenomena, which require integrated approach;
- The second motivation is the multiplicity of available codes in JET:
  - 1.5D core transport (ASTRA, CRONOS, JETTO, RITM),
  - MHD stability codes (MISHKA, ELITE, CHEASE, HELENA, IDBALL),
  - 2D SOL codes (B2/EIRENE, EDGE2D/NIMBUS)
  - turbulence simulation codes (KINEZERO, GS2, CUTIE);
  - A number of post-processing tools (UTC, Stat-pack);

Approach, chosen by the Project (1)

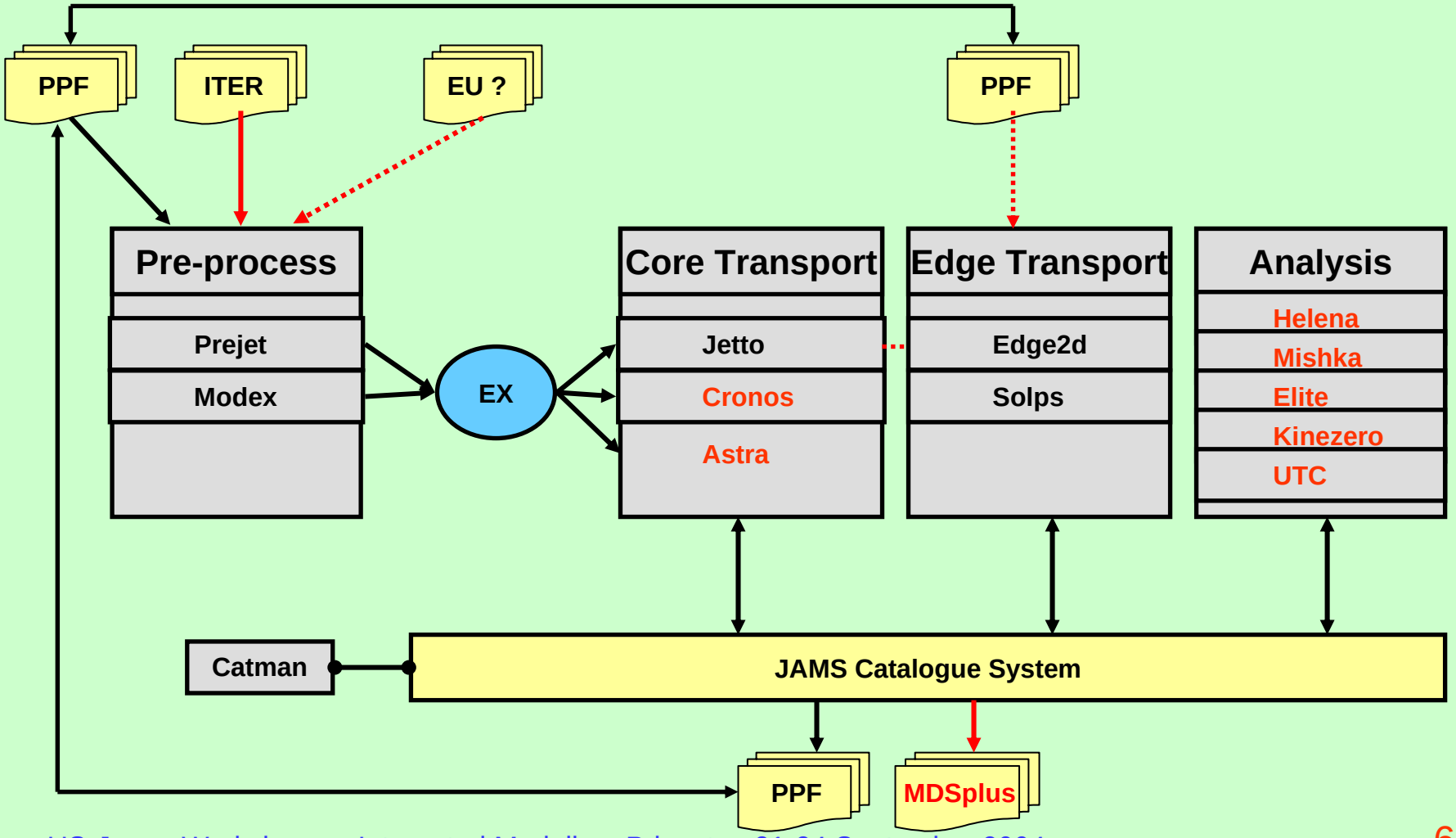
- We decide that the first step towards unification and integration would be to bring all codes under the same shell so that similar codes can share the same input/output files and (in some cases) the same user-friendly environment;
- They will be all linked with JET and ITER Profile databases and will all share the same link with MHD stability codes, turbulence simulation codes and post-processing facilities;
- They will share the same data storage and catalogue system;

Approach, chosen by the Project (2)

- This would allow users to use any code in a similar way and **compare codes** in a very easy way;
- Sharing the same platform and input/output files will allow easier **exchange of specific modules**, which would originally developed for just one specific code;
- If successful, such a joint cluster of codes will act as an attraction point for modellers and code developers and will make easier process of **code integration**;

Approach, chosen by the Project (3)

JAMS Architecture

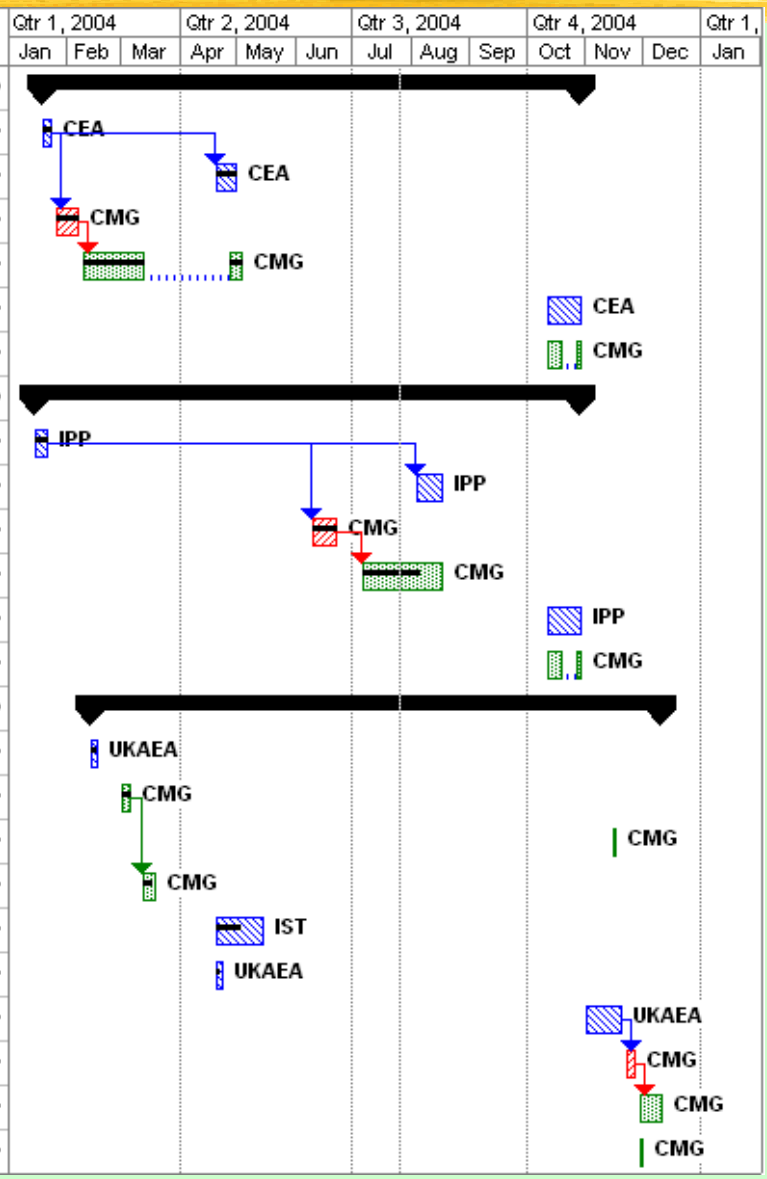


Approach, chosen by the Project (4)

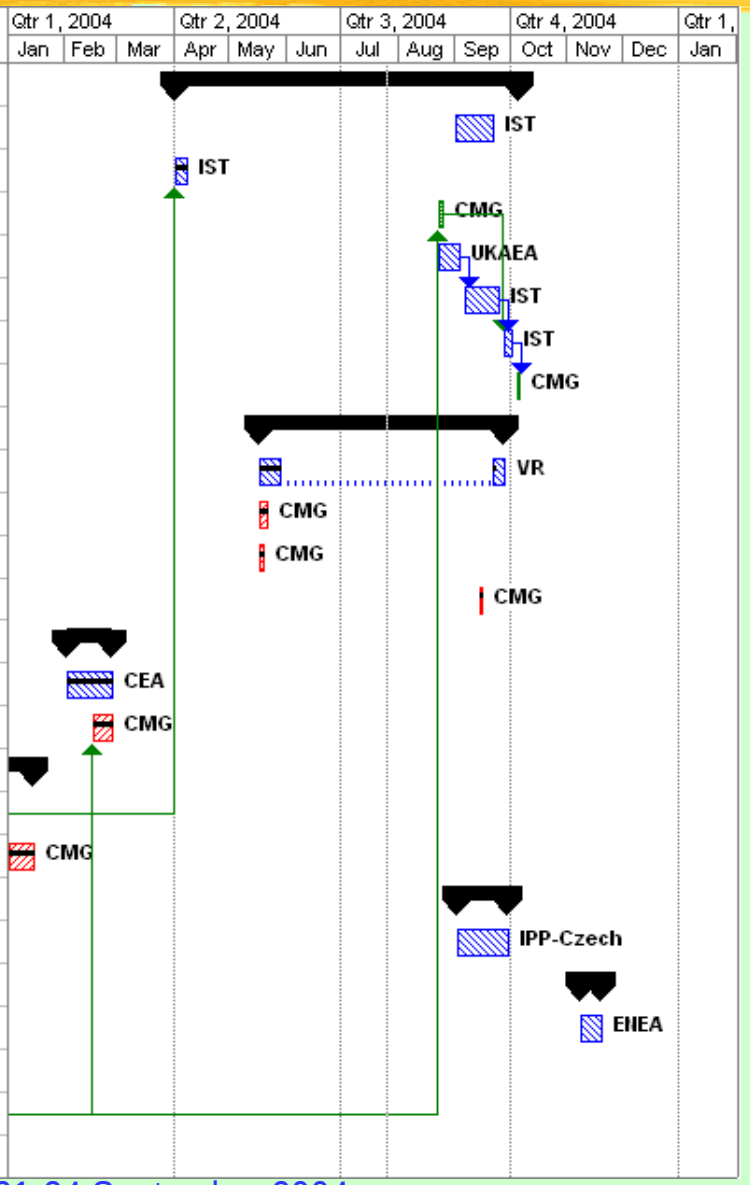
JAMS databases and catalogue system allows:

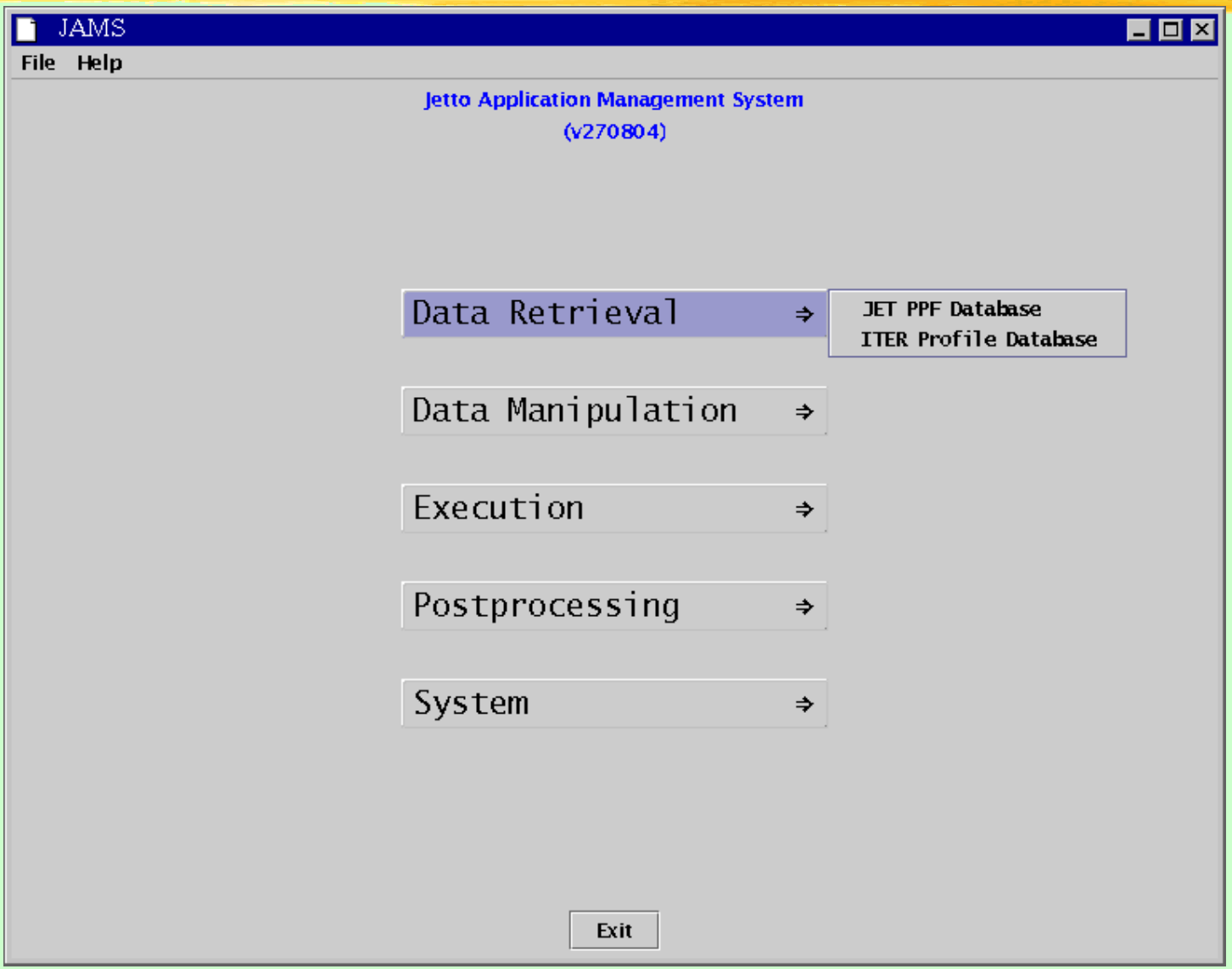
- Sharing data input;
- Sharing results;
- Sharing post-processing tools;
- Browse and manage catalogue file usage;

ID	Task Name	% Comp.
1	**Integration of Cronos**	**69%**
2	Visual design of JAMS interface	100%
3	Cronos input file/JAMS fields definition	100%
4	Coding JAMS interface	100%
5	Coding JAMS interface (JOC)	100%
6	Installation and testing	0%
7	Installation and testing (JOC)	0%
8	**Integration of Astra**	**47%**
9	Visual design of JAMS interface	100%
10	Astra input file/JAMS fields definition	0%
11	Coding JAMS interface	100%
12	Coding JAMS interface (JOC)	75%
13	Installation and testing	0%
14	Installation and testing (JOC)	0%
15	**Integration of MHD stability codes**	**30%**
16	Install Elite at JET	75%
17	Design/implement standard file interface (JOC)	100%
18	Integration into software maintenance system (JOC)	0%
19	Integration of MHD into JAMS interface (JOC)	50%
20	Specification/coding of MHD stability graphical post-processor	50%
21	Specification/coding of MHD stability graphical post-processor	50%
22	Evaluation of equilibrium solvers	0%
23	Standardisation of equilibrium solver code interface	0%
24	JETTO implementation of equilibrium solvers (JOC)	0%
25	Documentation and Web site update	0%



ID	Task Name	% Comp.
26	**Integration of Sanco post-processor**	**9%**
27	Generalisation of Sanco/Jetto link	0%
28	Create JAMS to UTC file converter	100%
29	Integration of UTC into JAMS post-processing options (JOC)	0%
30	Provision of simplified UTC and diagnostic files	0%
31	Installation and testing	0%
32	Documentation and Web site update	0%
33	Documentation and Web site update (JOC)	0%
34	**Integration of GLF-23**	**88%**
35	Installation and testing	80%
36	Installation and testing	100%
37	Implement in JAMS	100%
38	Documentation and Web site update (JOC)	100%
39	**Integration of Kinezero**	**100%**
40	Interface to JAMS data files/Ex-Files	100%
41	Integrate into JAMS post-processor	100%
42	**Integration into MDSPlus**	**100%**
43	Integrate into JAMS catalog	100%
44	Implement ITPA like DB for expt data	100%
45	**LH code**	**0%**
46	Installation and testing	0%
47	**Pellet code**	**0%**
48	Installation and testing	0%
49	**Related tasks**	**100%**
50	Post-processing scheme for JAMS	100%
51	Review JAMS driver methodology	100%




JAMS
File
Help
Jetto Application Management System
(v270804)
Data Retrieval
JET PPF Database
ITER Profile Database
Data Manipulation
Execution
Postprocessing
System
Exit

JAMS – Executing JET PPF Database

File Help

JET PPF DataBase : Shot Number 55763

General | Density & Temperature | Other Data | NBI | RF | LH | Transport | Time Traces

Equilibrium Settings for profile mapping

Source : DDA EFIT Seq. No. 0 PPF Userid JETPPF

Output grid size : 51

Specify times

47.0

And/Or range of times

Number of values in range 0 From 54 To 64

Range for time traces

Trace start time 46 Trace end time 48

Exit Submit

JAMS – Executing JET PPF Database

File Help

JET PPF DataBase : Shot Number 55763

General | Density & Temperature | Other Data | NBI | RF | LH | Transport | Time Traces

Select Signal	DDA	DTYPE	Seq. No.	PPF Userid
☑ Power Density Electrons	NBIP	GE	0	JETPPF
☑ Power Density Ions		GI	0	JETPPF
☑ Particle Source 1		S0	0	JETPPF
☐ Particle Source 2			0	JETPPF
☑ NB Driven Curr.Dens.	NBIP	JBDC	0	jetpp
☐ Fast Ion Density				
☐ Fast Ion Energy Density				
☑ Torque	TRA0	TQJN	0	JETXII

DDA dropdown: NBP2, NBIP, TRA0, JSP, JSPC, ITB, MODEX

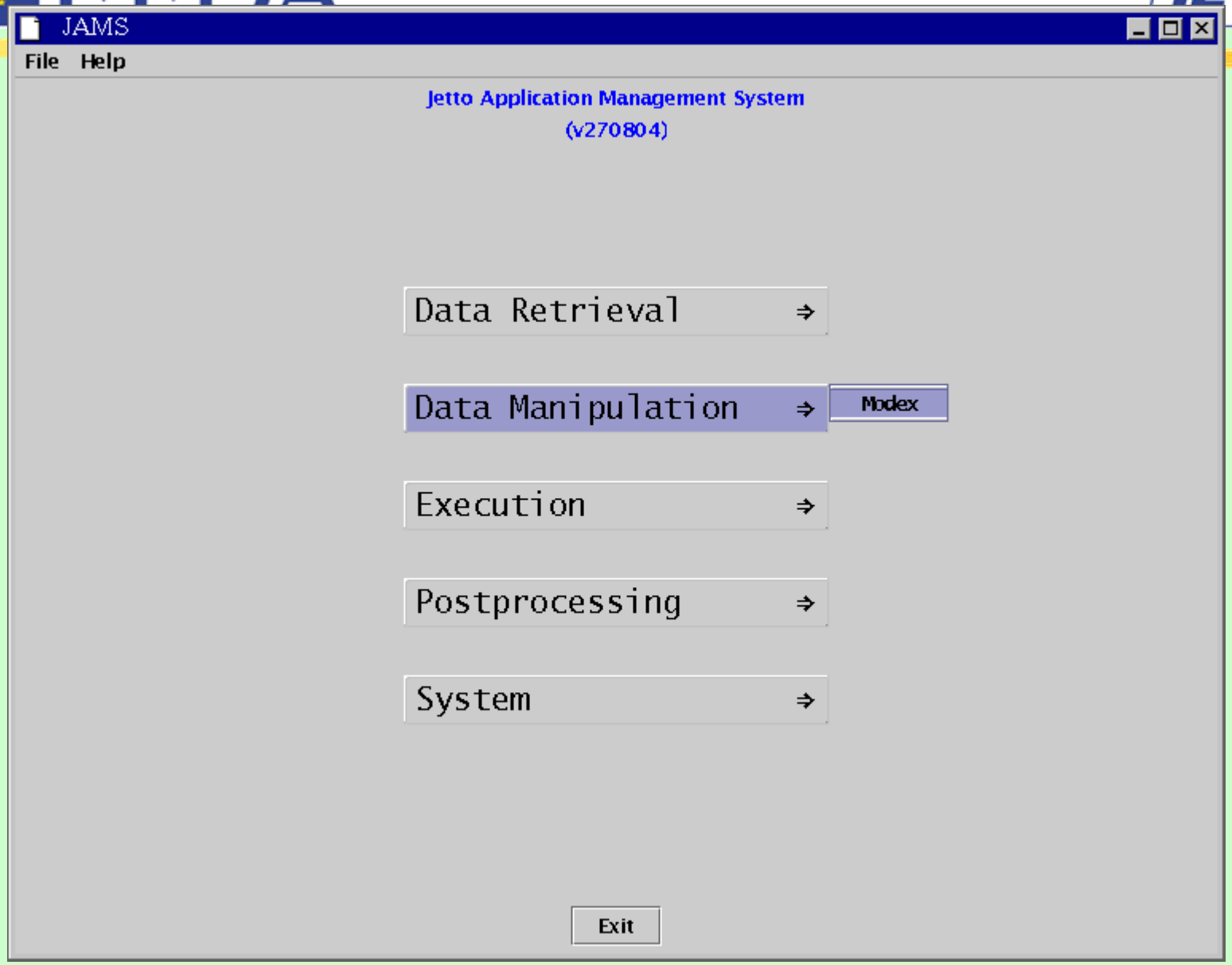
Exit Submit

Prejet Results Summary

Shot Number: 55763

Profile	DDA	DTYPE	Seq.No.	PPF UID	Status
Minor radius, normalised	EFIT		32	JETPPF	Successful
Normalised toroidal flux	EFIT		32	JETPPF	Successful
Normalised poloidal flux	EFIT	x-vec	32	JETPPF	Successful
Sqrt of normalised poloidal flux	EFIT	x-vec	32	JETPPF	Successful
Major radius	EFIT		32	JETPPF	Successful
JETTO rho coordinate	EFIT		32	JETPPF	Successful
Pressure (from equilibrium)	EFIT	P	32	JETPPF	Successful
q (safety factor)	EFIT	Q	32	JETPPF	Successful
Electron Density	LIDR	NE	48	JETPPF	Successful
Electron Temperature	LIDR	TE	48	JETPPF	Successful
Ion Temperature	LIDR	TE	48	JETPPF	Successful
Z-effective	MODEX		0		Successful
Power Density Electrons	NBIP	GE	94	JETPPF	Successful
Power Density Ions	NBIP	GI	94	JETPPF	Successful
Particle Source 1	NBIP	S0	94	JETPPF	Successful
NB Driven Curr.Dens.	*NBIP*	*JBDC*	*0*	*jetpp*	*Failed - PPFG*
Torque	*TRAO*	*TQIN*	*0*	*JETXII*	*Failed - PPFG*
Plasma Current	MAGN	IPLA	4	JETPPF	Successful

OK Print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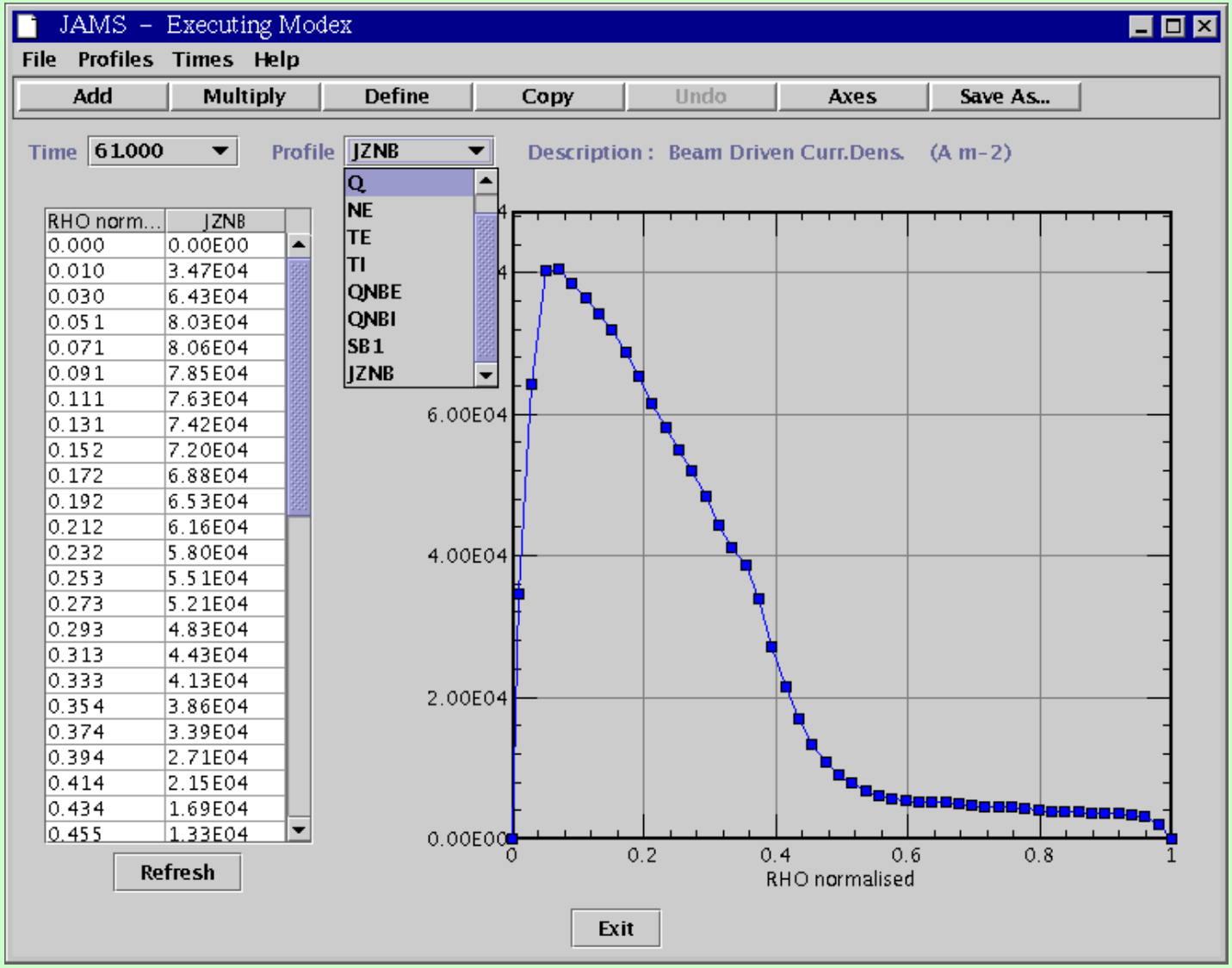
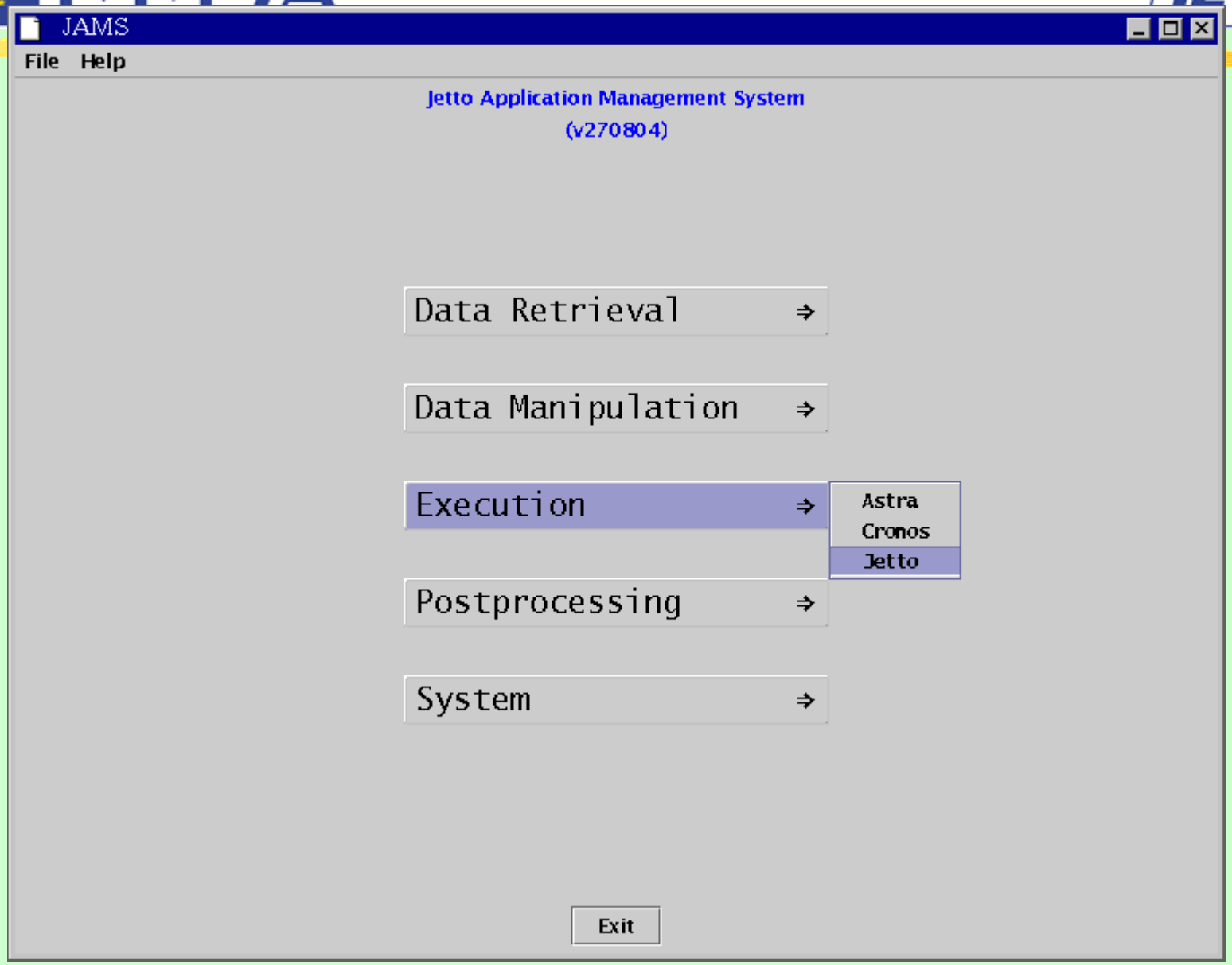
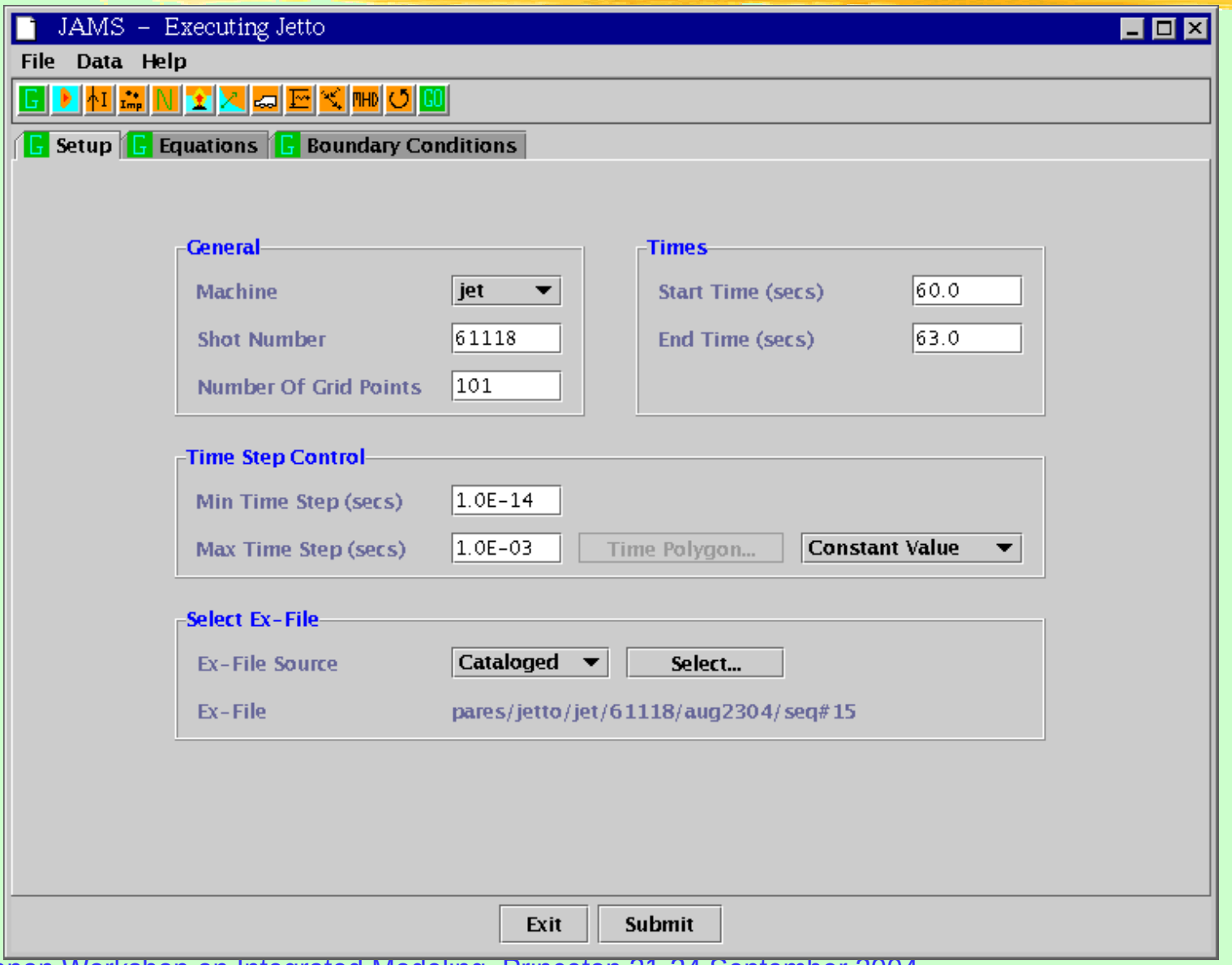
Jetto Application Management System
(v270804)
Data Retrieval
Data Manipulation
Modex
Execution
Postprocessing
System
Exit


JAMS – Executing Modex
File Profiles Times Help
Add Multiply Define Copy Undo Axes Save As...
Time 61.000
Profile JZNB
Description : Beam Driven Curr.Dens. (A m-2)
Q
NE
TE
TI
QNBE
QNBI
SB1
JZNB
RHO norm... JZNB
0.000 0.00E00
0.010 3.47E04
0.030 6.43E04
0.051 8.03E04
0.071 8.06E04
0.091 7.85E04
0.111 7.63E04
0.131 7.42E04
0.152 7.20E04
0.172 6.88E04
0.192 6.53E04
0.212 6.16E04
0.232 5.80E04
0.253 5.51E04
0.273 5.21E04
0.293 4.83E04
0.313 4.43E04
0.333 4.13E04
0.354 3.86E04
0.374 3.39E04
0.394 2.71E04
0.414 2.15E04
0.434 1.69E04
0.455 1.33E04
Refresh
6.00E04
4.00E04
2.00E04
0.00E00
0
0.2
0.4
0.6
0.8
1
RHO normalised
Exit


JAMS
File
Help
Jetto Application Management System
(v270804)
Data Retrieval
Data Manipulation
Execution
Astra
Cronos
Jetto
Postprocessing
System
Exit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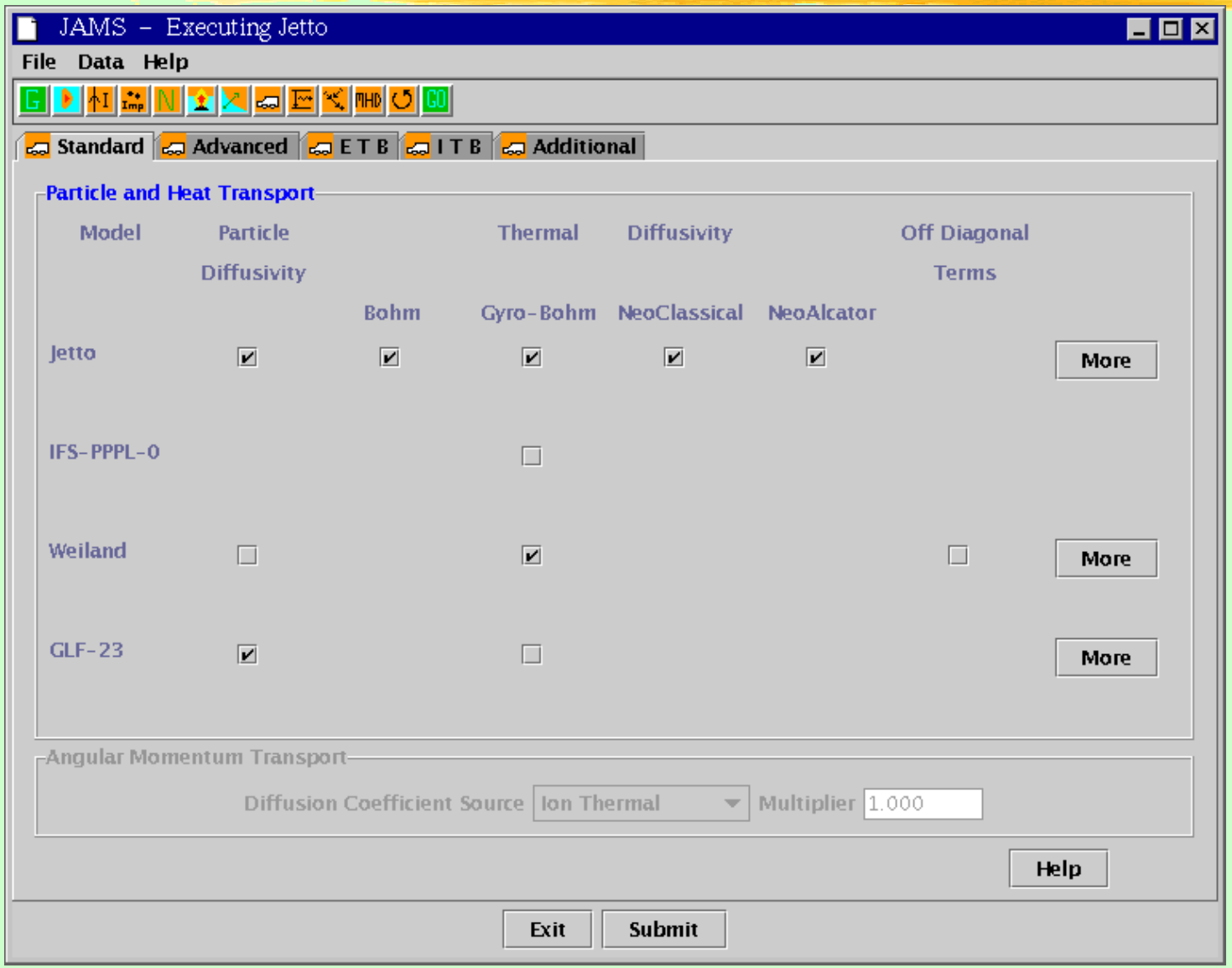
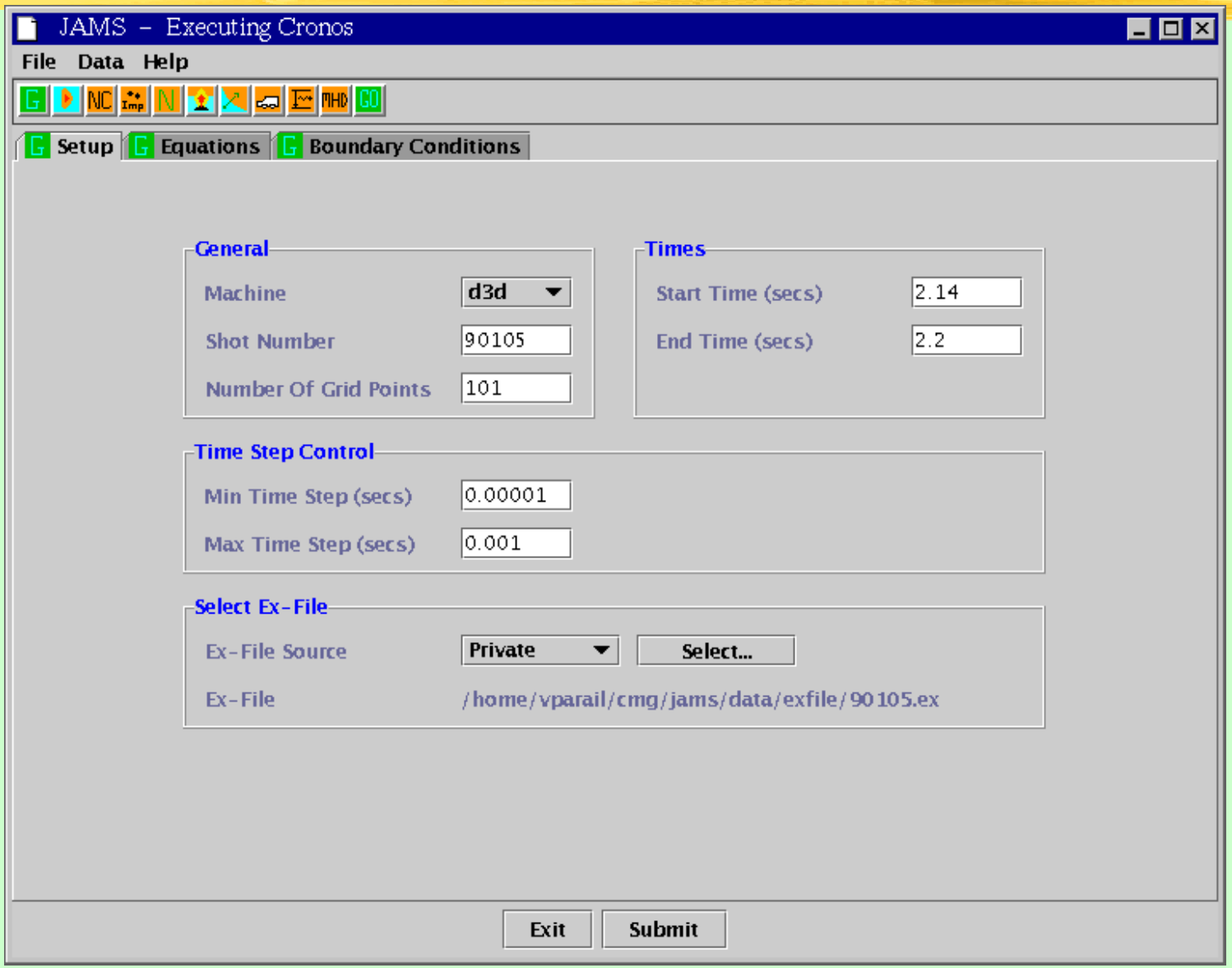
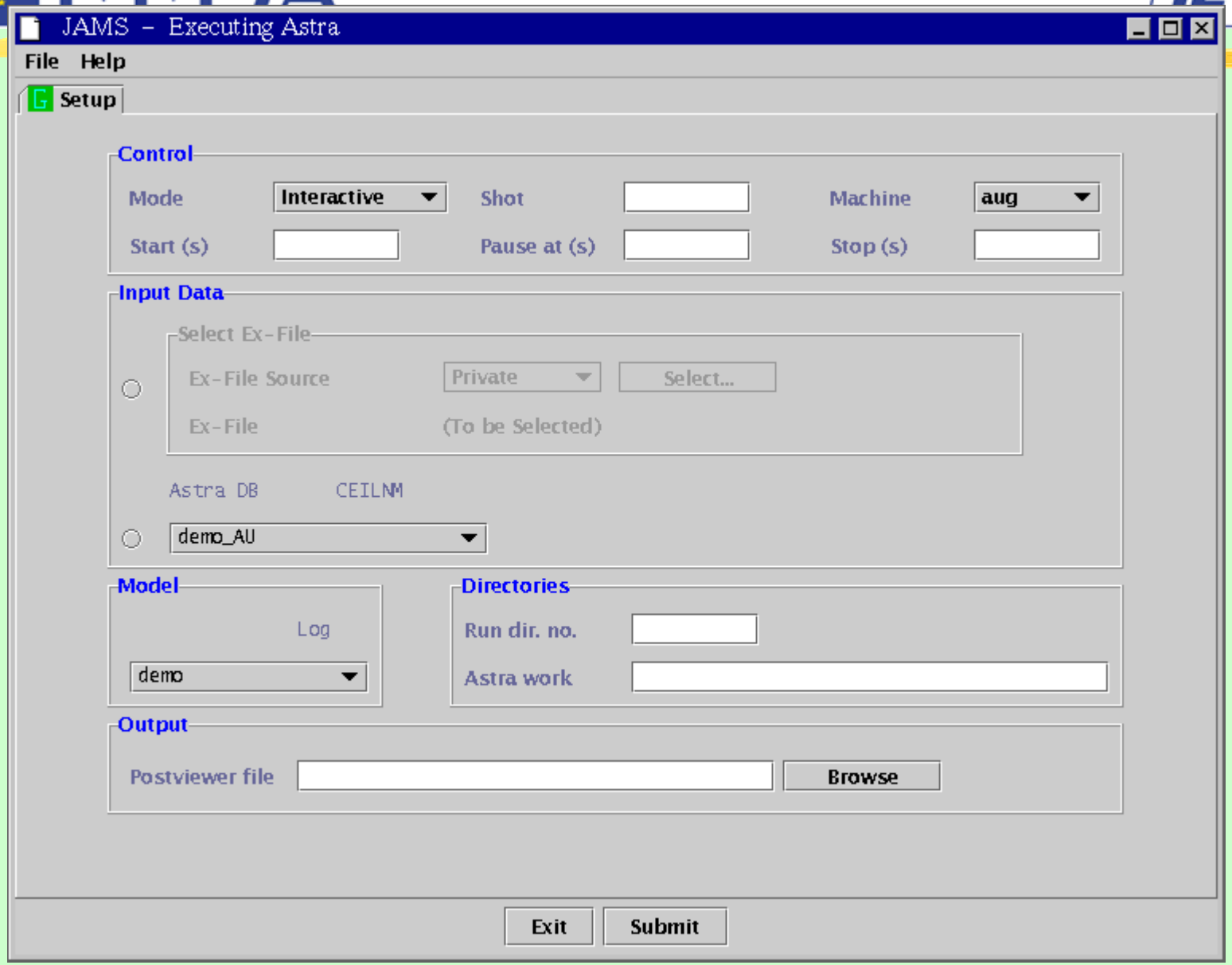
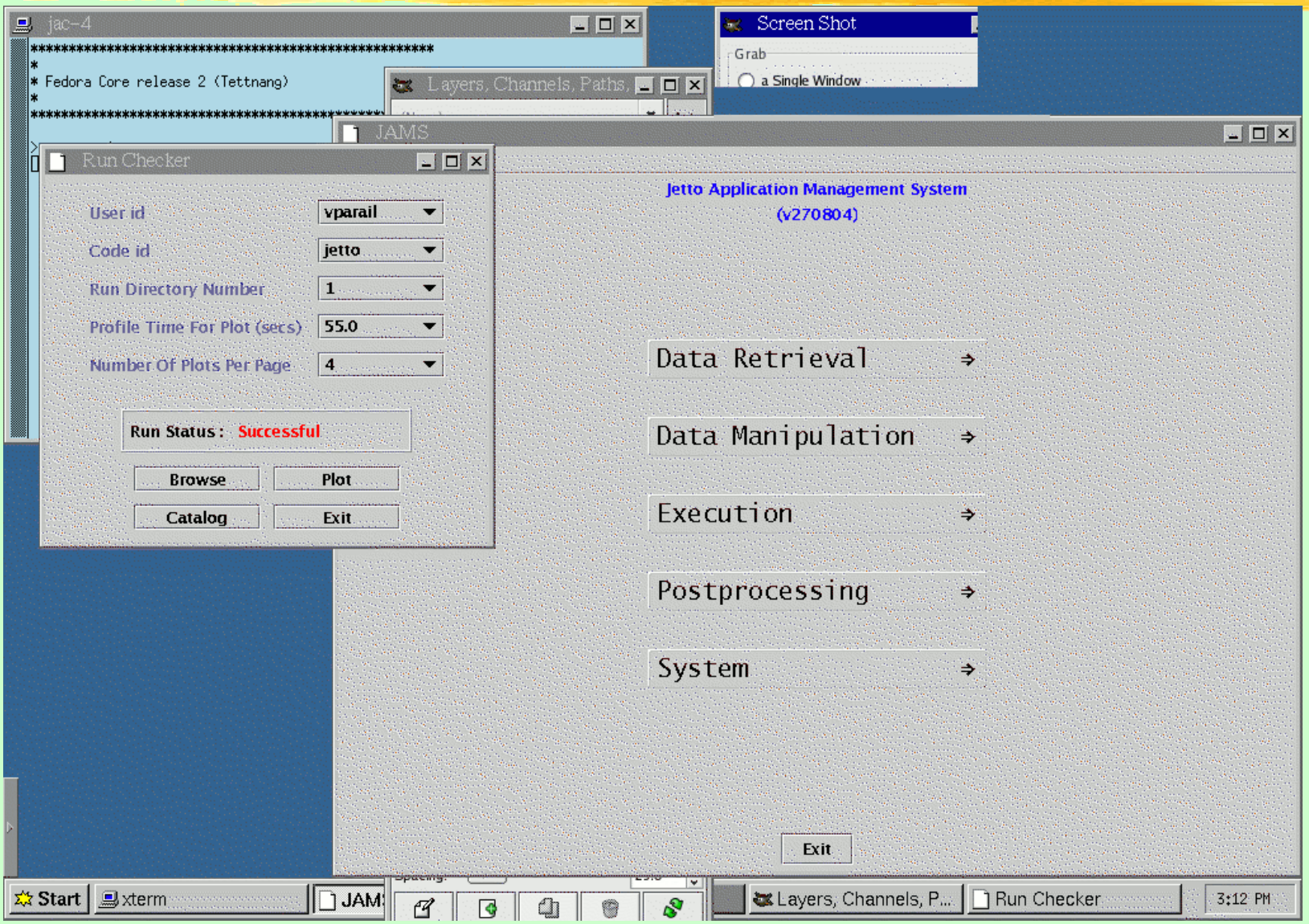
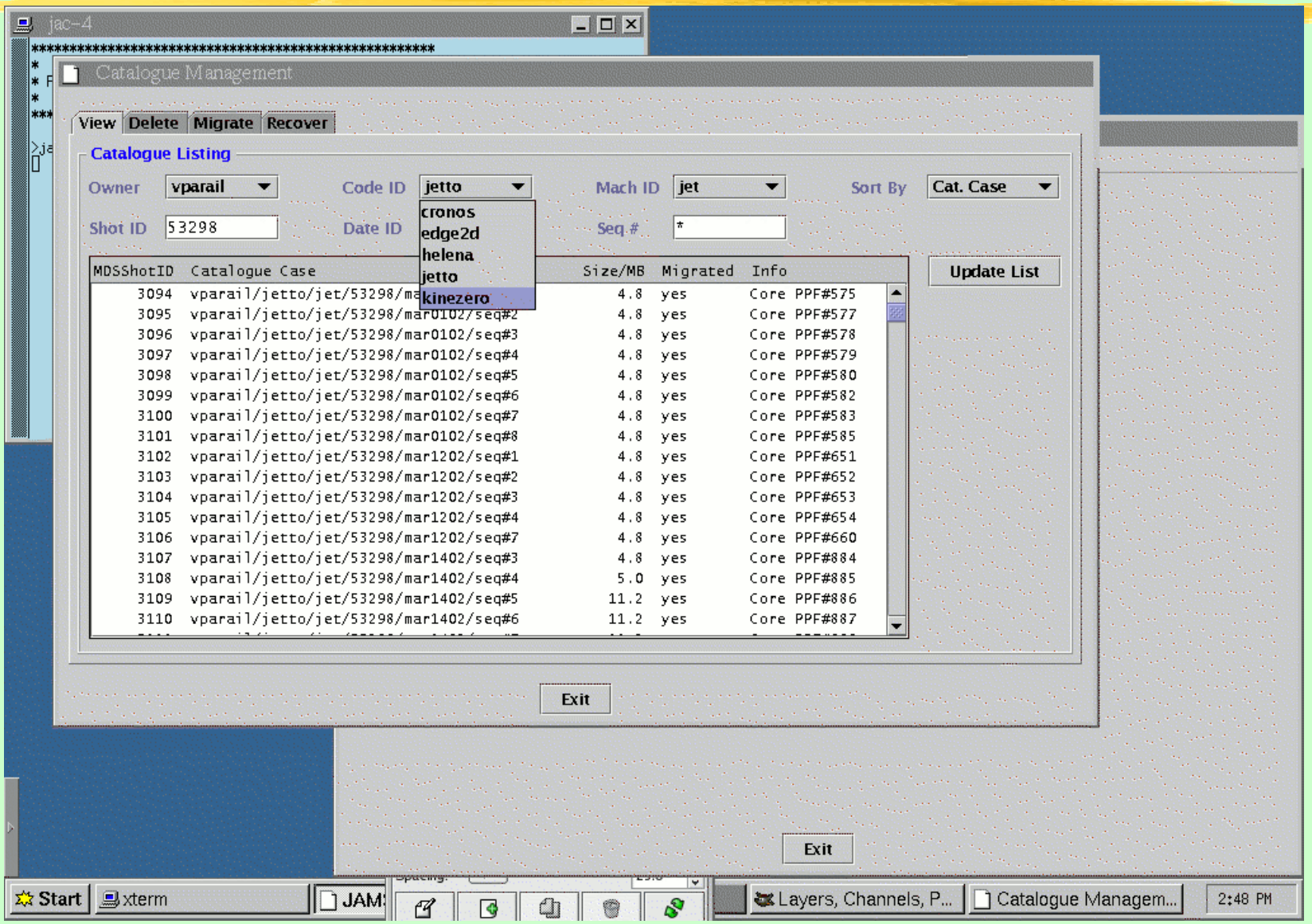
File Data Help
Setup
Equations
Boundary Conditions
General
Machine
jet
Shot Number
61118
Number Of Grid Points
101
Times
Start Time (secs)
60.0
End Time (secs)
63.0
Time Step Control
Min Time Step (secs)
1.0E-14
Max Time Step (secs)
1.0E-03
Time Polygon...
Constant Value
Select Ex-File
Ex-File Source
Cataloged
Select...
Ex-File
pares/jetto/jet/61118/aug2304/seq#15
Exit
Submit

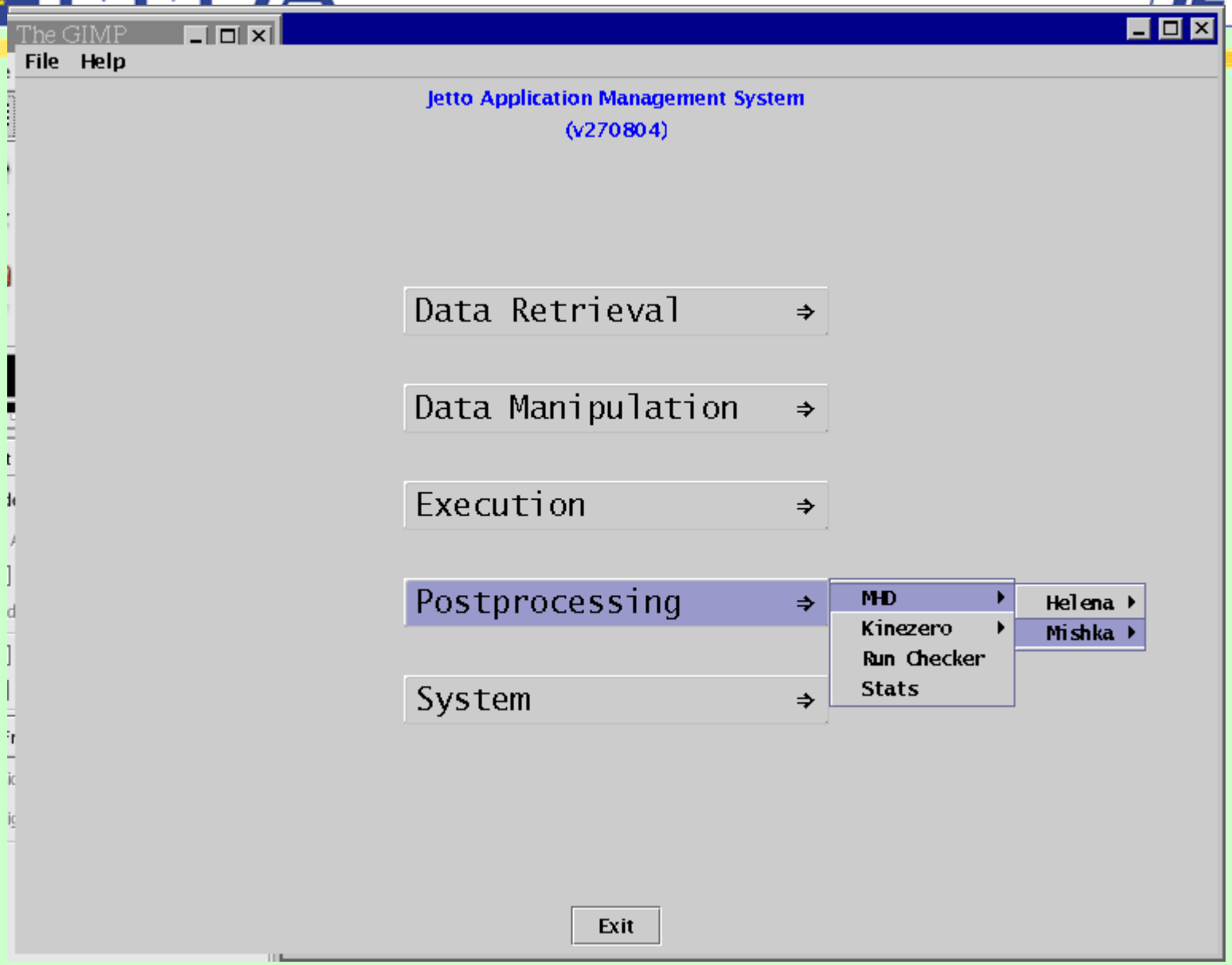

JAMS – Executing Jetto
File Data Help
Standard
Advanced
E T B
I T B
Additional
Particle and Heat Transport
Model
Particle Diffusivity
Thermal Diffusivity
Off Diagonal Terms
Bohm
Gyro-Bohm
NeoClassical
NeoAlcator
Jetto
More
IFS-PPPL-0
Weiland
More
GLF-23
More
Angular Momentum Transport
Diffusion Coefficient Source
Ion Thermal
Multiplier
1.000
Help
Exit
Submit

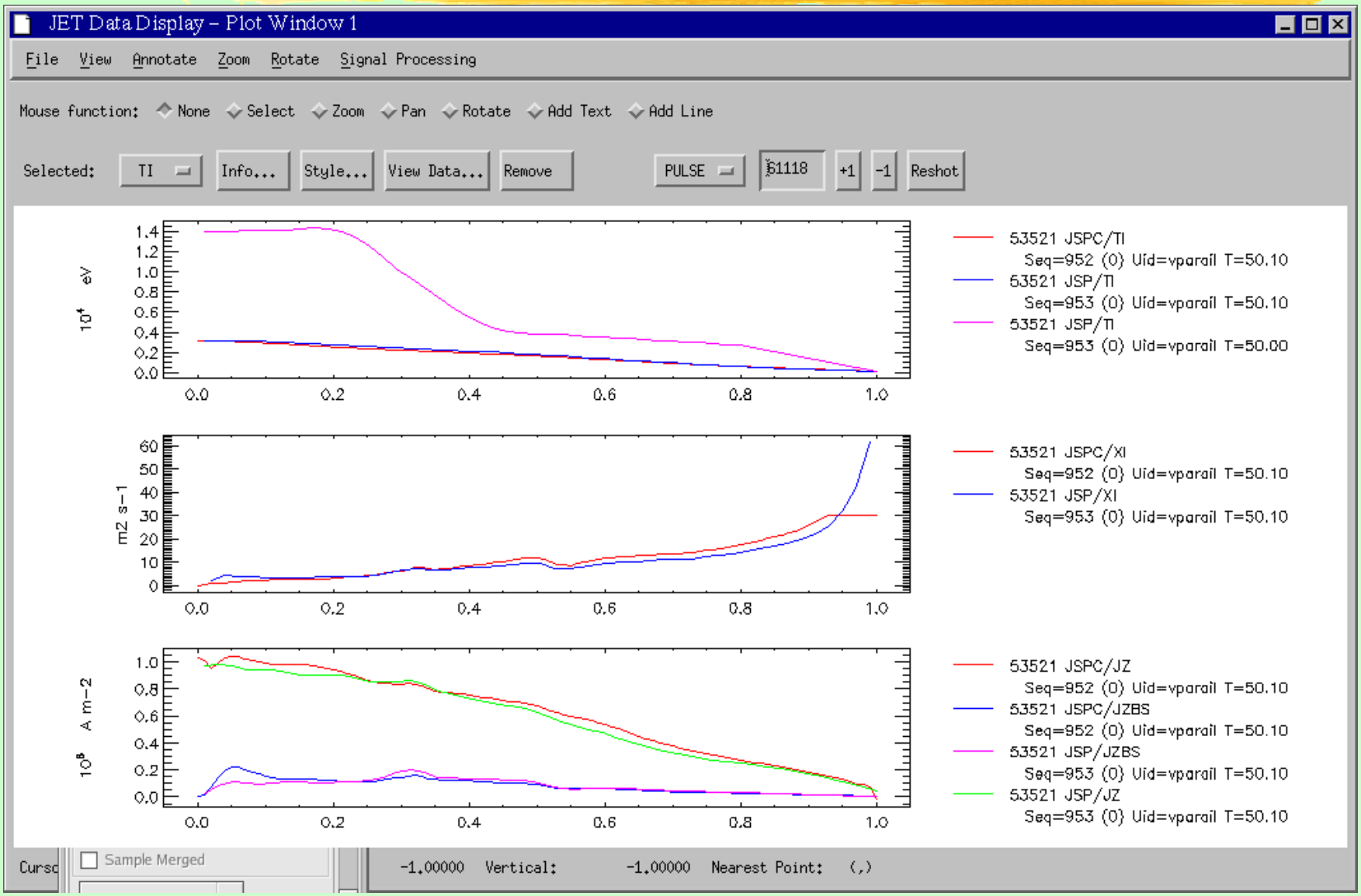

JAMS – Executing Cronos
File Data Help
Setup
Equations
Boundary Conditions
General
Machine
d3d
Shot Number
90105
Number Of Grid Points
101
Times
Start Time (secs)
2.14
End Time (secs)
2.2
Time Step Control
Min Time Step (secs)
0.00001
Max Time Step (secs)
0.001
Select Ex-File
Ex-File Source
Private
Select...
Ex-File
/home/vparail/cmg/jams/data/exfile/90105.ex
Exit
Submit

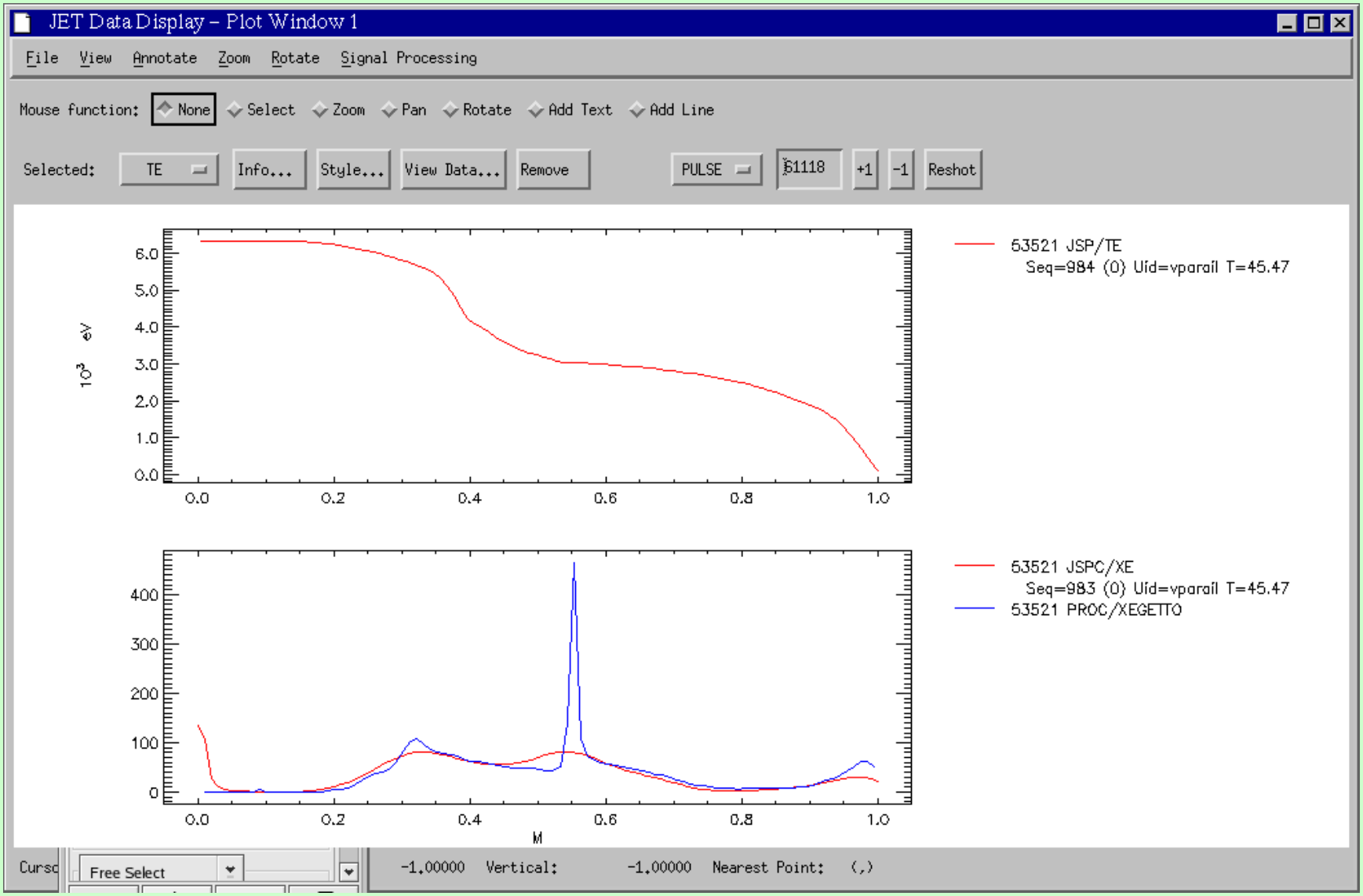

JAMS - Executing Astra
File
Help
Setup
Control
Mode
Interactive
Shot
Machine
aug
Start (s)
Pause at (s)
Stop (s)
Input Data
Select Ex-File
Ex-File Source
Private
Select...
Ex-File
(To be Selected)
Astra DB
CEILNM
demo_AU
Model
Log
demo
Directories
Run dir. no.
Astra work
Output
Postviewer file
Browse
Exit
Submit

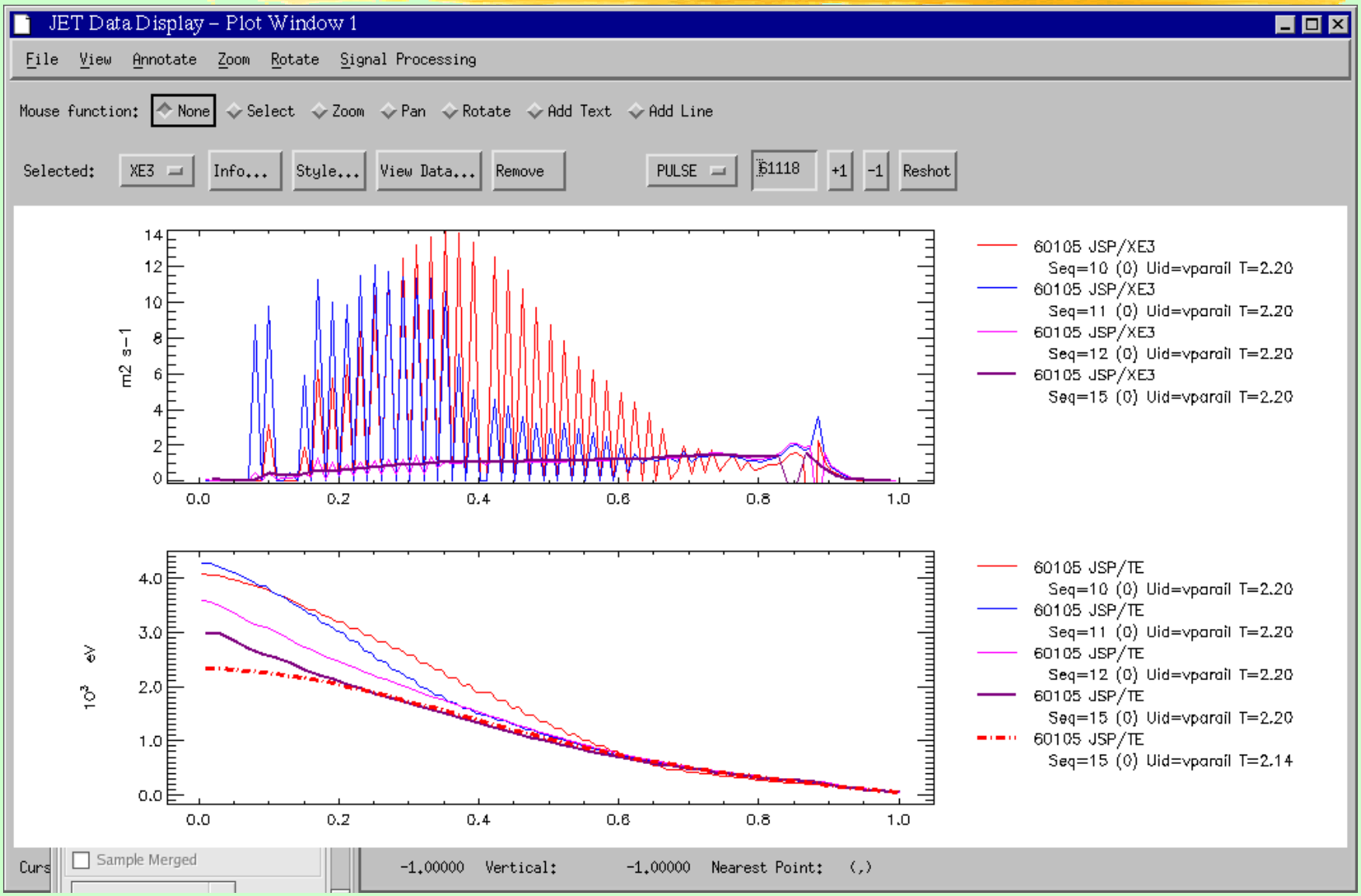

jac-4
* Fedora Core release 2 (Tettnang)
Screen Shot
Grab
a Single Window
Layers, Channels, Paths,
JAMS
Run Checker
User id
vparail
Code id
jetto
Run Directory Number
1
Profile Time For Plot (secs)
55.0
Number Of Plots Per Page
4
Run Status : Successful
Browse
Plot
Catalog
Exit
Jetto Application Management System
(v270804)
Data Retrieval
Data Manipulation
Execution
Postprocessing
System
Exit
Start
xterm
JAMS
Layers, Channels, P...
Run Checker
3:12 PM

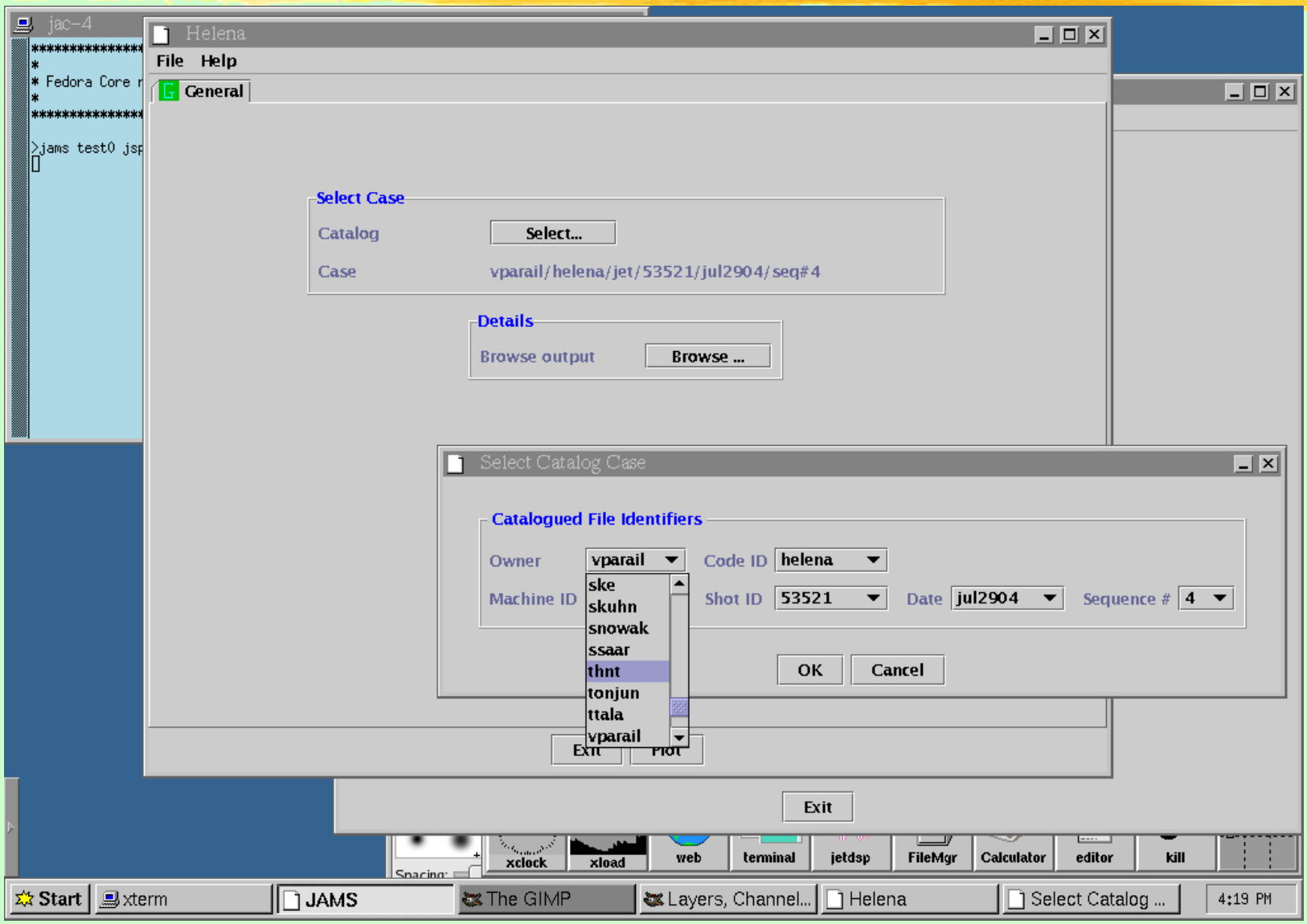

jac-4
Catalogue Management
View
Delete
Migrate
Recover
Catalogue Listing
Owner
vparail
Code ID
jetto
cronos
edge2d
helena
jetto
kinezero
Mach ID
jet
Sort By
Cat. Case
Shot ID
53298
Date ID
Seq.#
*
Update List
MDSShotID Catalogue Case Size/MB Migrated Info
3094 vparail/jetto/jet/53298/ma 4.8 yes Core PPF#575
3095 vparail/jetto/jet/53298/mar0102/seq#2 4.8 yes Core PPF#577
3096 vparail/jetto/jet/53298/mar0102/seq#3 4.8 yes Core PPF#578
3097 vparail/jetto/jet/53298/mar0102/seq#4 4.8 yes Core PPF#579
3098 vparail/jetto/jet/53298/mar0102/seq#5 4.8 yes Core PPF#580
3099 vparail/jetto/jet/53298/mar0102/seq#6 4.8 yes Core PPF#582
3100 vparail/jetto/jet/53298/mar0102/seq#7 4.8 yes Core PPF#583
3101 vparail/jetto/jet/53298/mar0102/seq#8 4.8 yes Core PPF#585
3102 vparail/jetto/jet/53298/mar1202/seq#1 4.8 yes Core PPF#651
3103 vparail/jetto/jet/53298/mar1202/seq#2 4.8 yes Core PPF#652
3104 vparail/jetto/jet/53298/mar1202/seq#3 4.8 yes Core PPF#653
3105 vparail/jetto/jet/53298/mar1202/seq#4 4.8 yes Core PPF#654
3106 vparail/jetto/jet/53298/mar1202/seq#7 4.8 yes Core PPF#660
3107 vparail/jetto/jet/53298/mar1402/seq#3 4.8 yes Core PPF#884
3108 vparail/jetto/jet/53298/mar1402/seq#4 5.0 yes Core PPF#885
3109 vparail/jetto/jet/53298/mar1402/seq#5 11.2 yes Core PPF#886
3110 vparail/jetto/jet/53298/mar1402/seq#6 11.2 yes Core PPF#887
Exit
Exit
Start
xterm
JAM
Layers, Channels, P...
Catalogue Managem...
2:48 PM

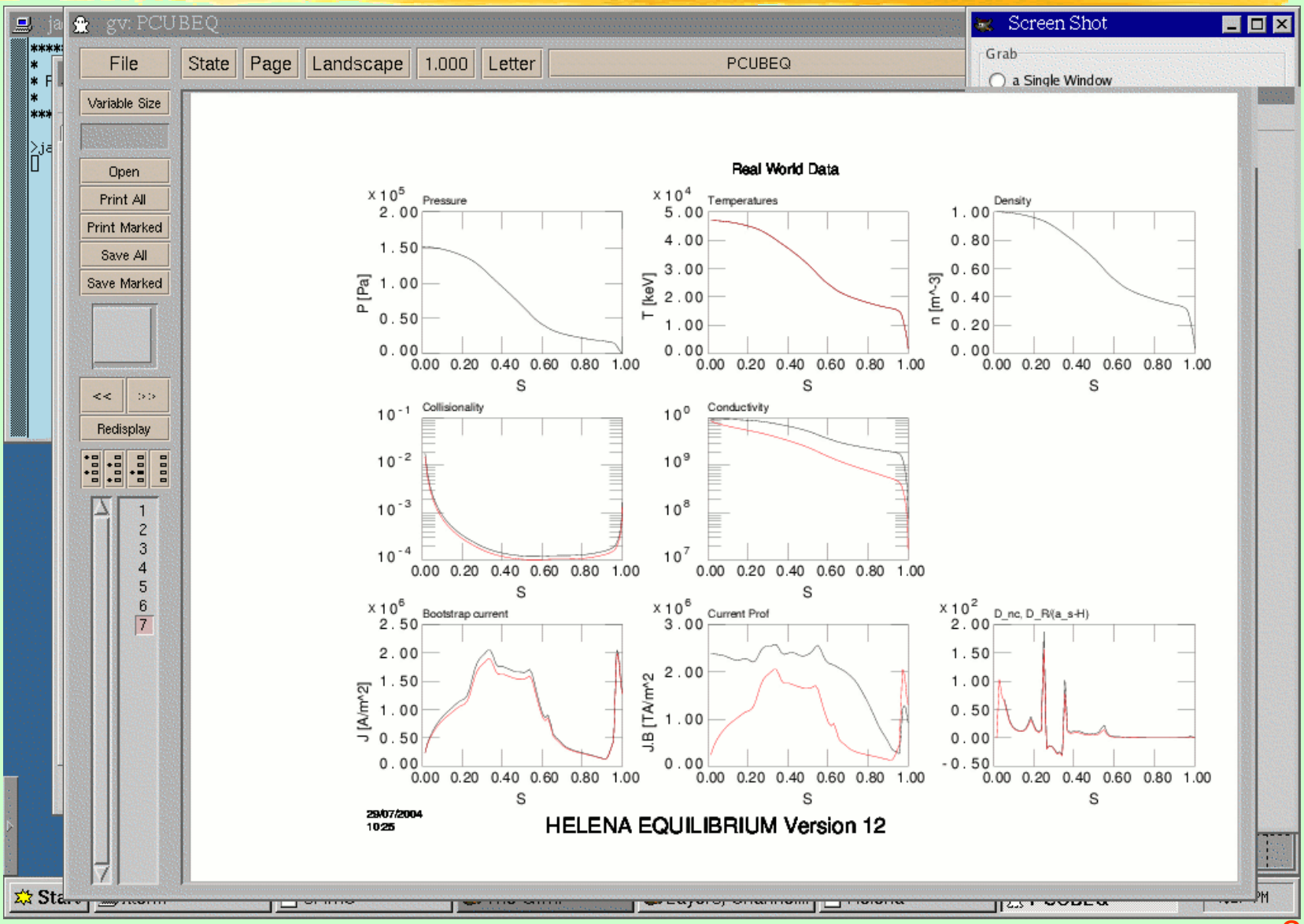

The GIMP
File Help
Jetto Application Management System
(v270804)
Data Retrieval
Data Manipulation
Execution
Postprocessing
System
MHD
Kinezero
Run Checker
Stats
Helena
Mishka
Exit


JET Data Display – Plot Window 1
File View Annotate Zoom Rotate Signal Processing
Mouse function: None Select Zoom Pan Rotate Add Text Add Line
Selected: TI Info... Style... View Data... Remove PULSE 61118 +1 -1 Reshot
10⁴ eV
53521 JSPC/TI
Seq=952 (0) Uid=vparail T=50.10
53521 JSP/TI
Seq=953 (0) Uid=vparail T=50.10
53521 JSP/TI
Seq=953 (0) Uid=vparail T=50.00
m2 s-1
53521 JSPC/XI
Seq=952 (0) Uid=vparail T=50.10
53521 JSP/XI
Seq=953 (0) Uid=vparail T=50.10
10⁸ A m-2
53521 JSPC/JZ
Seq=952 (0) Uid=vparail T=50.10
53521 JSPC/JZBS
Seq=952 (0) Uid=vparail T=50.10
53521 JSP/JZBS
Seq=953 (0) Uid=vparail T=50.10
53521 JSP/JZ
Seq=953 (0) Uid=vparail T=50.10
Sample Merged
-1.00000 Vertical: -1.00000 Nearest Point: (,)


JET Data Display – Plot Window 1
File View Annotate Zoom Rotate Signal Processing
Mouse function: None Select Zoom Pan Rotate Add Text Add Line
Selected: TE Info... Style... View Data... Remove PULSE 61118 +1 -1 Reshot
6.0
5.0
4.0
3.0
2.0
1.0
0.0
10^3 eV
0.0 0.2 0.4 0.6 0.8 1.0
53521 JSP/TE
Seq=984 (0) Uid=vparail T=45.47
400
300
200
100
0
M
53521 JSPC/XE
Seq=983 (0) Uid=vparail T=45.47
53521 PROC/XEGETTO
Free Select
-1.00000 Vertical: -1.00000 Nearest Point: (,)


JET Data Display – Plot Window 1
File View Annotate Zoom Rotate Signal Processing
Mouse function: None Select Zoom Pan Rotate Add Text Add Line
Selected: XE3 Info... Style... View Data... Remove PULSE 61118 +1 -1 Reshot
m2 s-1
60105 JSP/XE3 Seq=10 (0) Uid=vparail T=2.20
60105 JSP/XE3 Seq=11 (0) Uid=vparail T=2.20
60105 JSP/XE3 Seq=12 (0) Uid=vparail T=2.20
60105 JSP/XE3 Seq=15 (0) Uid=vparail T=2.20
10³ eV
60105 JSP/TE Seq=10 (0) Uid=vparail T=2.20
60105 JSP/TE Seq=11 (0) Uid=vparail T=2.20
60105 JSP/TE Seq=12 (0) Uid=vparail T=2.20
60105 JSP/TE Seq=15 (0) Uid=vparail T=2.20
60105 JSP/TE Seq=15 (0) Uid=vparail T=2.14
Curs Sample Merged -1.00000 Vertical: -1.00000 Nearest Point: (,)


jac-4
Helena
File Help
General
Select Case
Catalog
Select...
Case
vparail/helena/jet/53521/jul2904/seq#4
Details
Browse output
Browse ...
Select Catalog Case
Catalogued File Identifiers
Owner
vparail
Code ID
helena
Machine ID
Shot ID
53521
Date
jul2904
Sequence #
4
ske
skuhn
snowak
ssaar
thnt
tonjun
ttala
vparail
OK
Cancel
Exit
Plot
Exit
xclock
xload
web
terminal
jetdsp
FileMgr
Calculator
editor
kill
Start
xterm
JAMS
The GIMP
Layers, Channel...
Helena
Select Catalog ...
4:19 PM


gv: PCUBEQ
File
State
Page
Landscape
1.000
Letter
PCUBEQ
Screen Shot
Grab
a Single Window
Variable Size
Open
Print All
Print Marked
Save All
Save Marked
Redisplay
Real World Data
Pressure
P [Pa]
Temperatures
T [keV]
Density
n [m^-3]
Collisionality
Conductivity
Bootstrap current
J [A/m^2]
Current Prof
J.B [TA/m^2
D_nc, D_R(a_s-H)
S
29/07/2004
10:25
HELENA EQUILIBRIUM Version 12

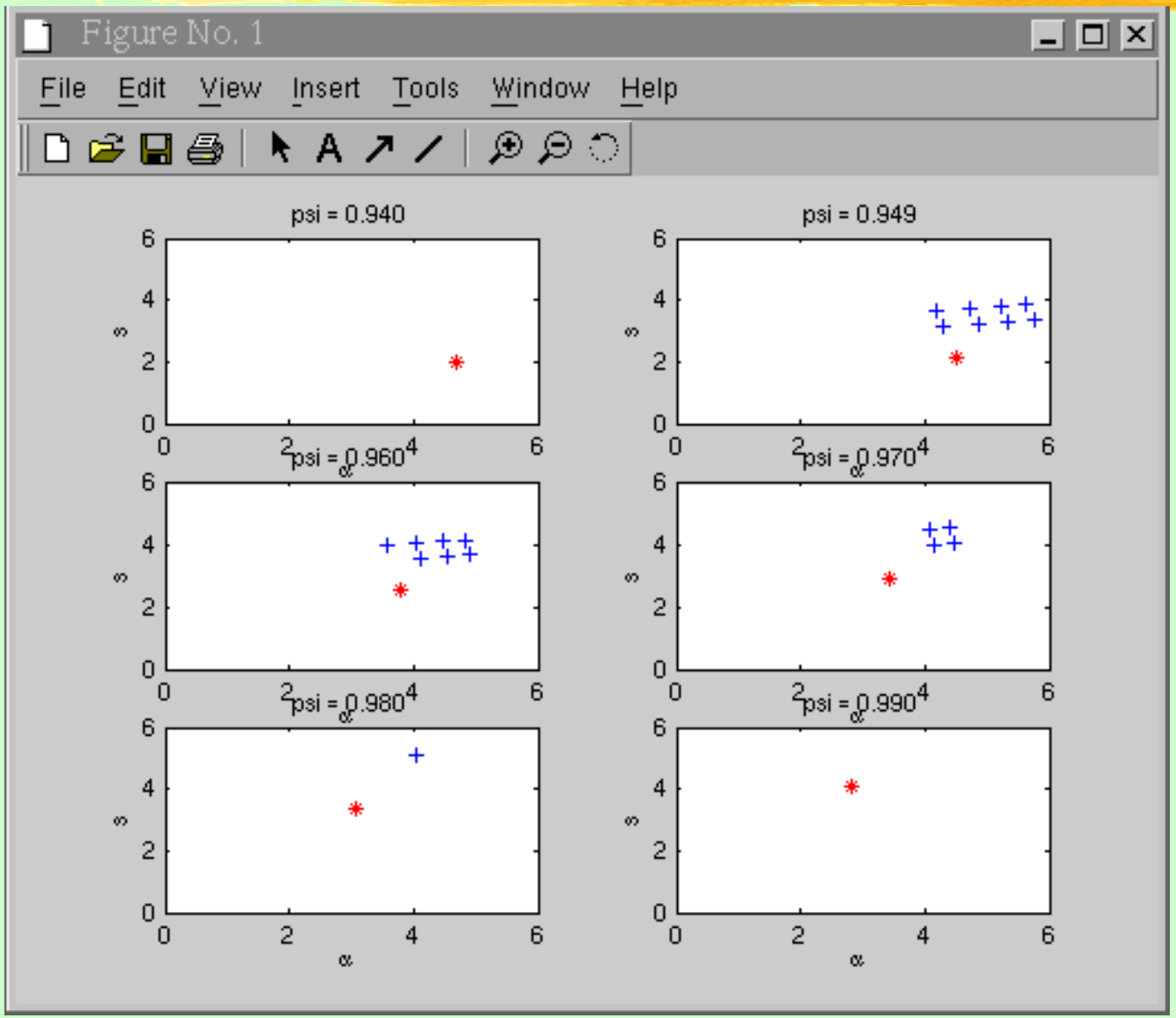
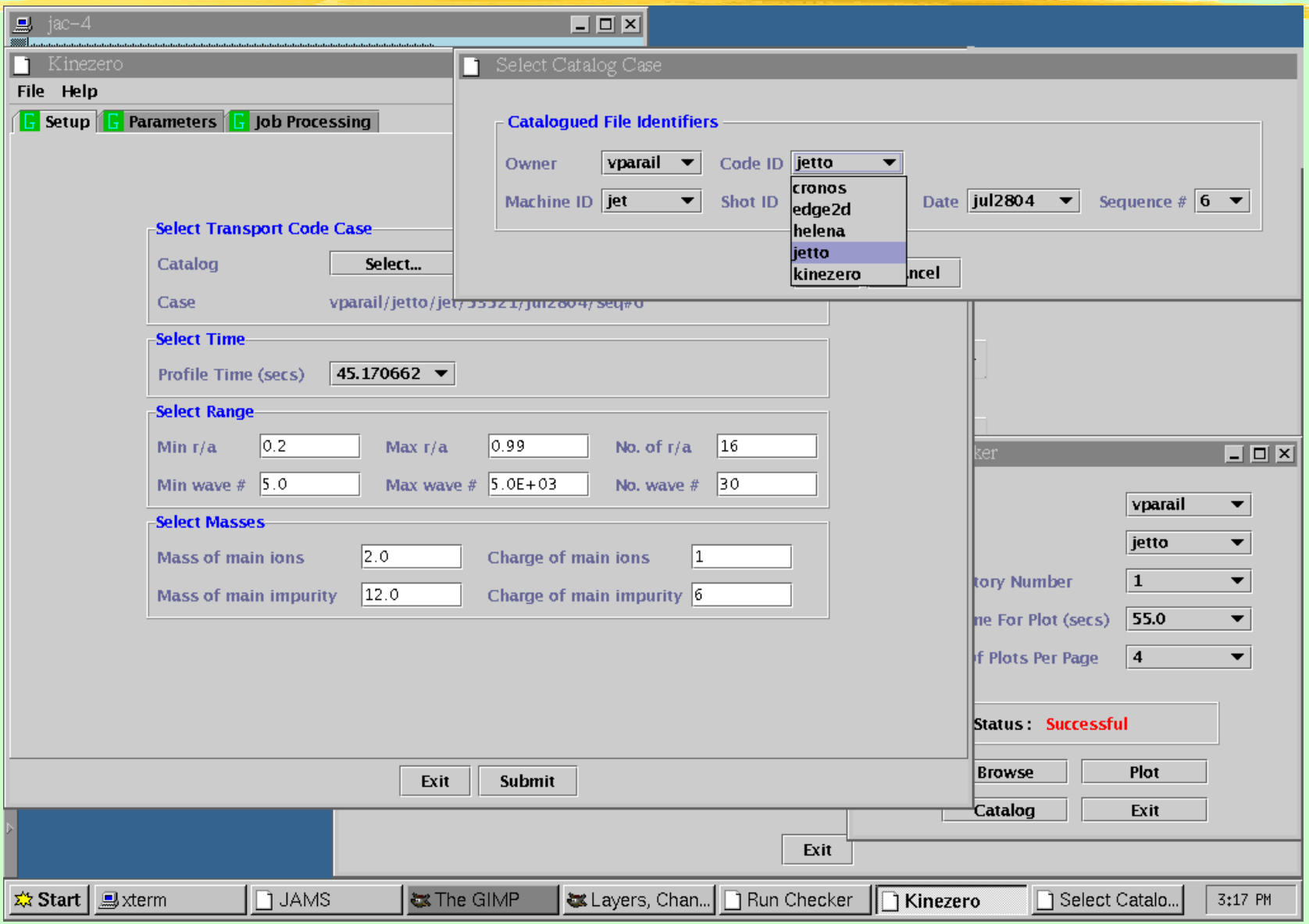


Figure No. 1
File Edit View Insert Tools Window Help
psi = 0.940
psi = 0.949
psi = 0.960
psi = 0.970
psi = 0.980
psi = 0.990
α
α


jac-4
Kinezero
File Help
Setup
Parameters
Job Processing
Select Catalog Case
Catalogued File Identifiers
Owner vparail
Code ID jetto
Machine ID jet
Shot ID
Date jul2804
Sequence # 6
cronos
edge2d
helena
jetto
kinezero
Select Transport Code Case
Catalog
Select...
Case
Select Time
Profile Time (secs) 45.170662
Select Range
Min r/a 0.2
Max r/a 0.99
No. of r/a 16
Min wave # 5.0
Max wave # 5.0E+03
No. wave # 30
Select Masses
Mass of main ions 2.0
Charge of main ions 1
Mass of main impurity 12.0
Charge of main impurity 6
Exit
Submit
vparail
jetto
1
55.0
4
Status : Successful
Browse
Plot
Catalog
Exit
Start
xterm
JAMS
The GIMP
Layers, Chan...
Run Checker
Kinezero
Select Catalo...
3:17 PM

Kinezero

File Help

Setup | Parameters | Job Processing

Select Transport Code Case

Catalog: Select...

Case: vparail/jetto/jet/53521/jul2804/seq#

Select Time

Profile Time (secs): 45.170662

Select Range

Min r/a	0.2	Max r/a	0.99	No. of r/a	16
Min wave #	5.0	Max wave #	5.0E+03	No. wave #	30

Select Masses

Mass of main ions	2.0	Charge of main ions	1
Mass of main impurity	12.0	Charge of main impurity	6

Exit | Submit

Select Catalog Case

Catalogued File Identifiers

Owner: vparail — Code ID: jetto

Machine ID: ske, skuhn, snowak, ssaar, thnt, tonjun, ttala, vparail — Shot ID: 53521 — Date: jul2804 — Sequence #: 6

OK | Cancel

Exit

Start | xterm | JAMS | xclock | xload | web | terminal | jetdsp | FileMgr | Calculator | editor | kill | Desk 1 | Spacing: | s, Channel... | Kinezero | Select Catalog ... | 2:46 PM

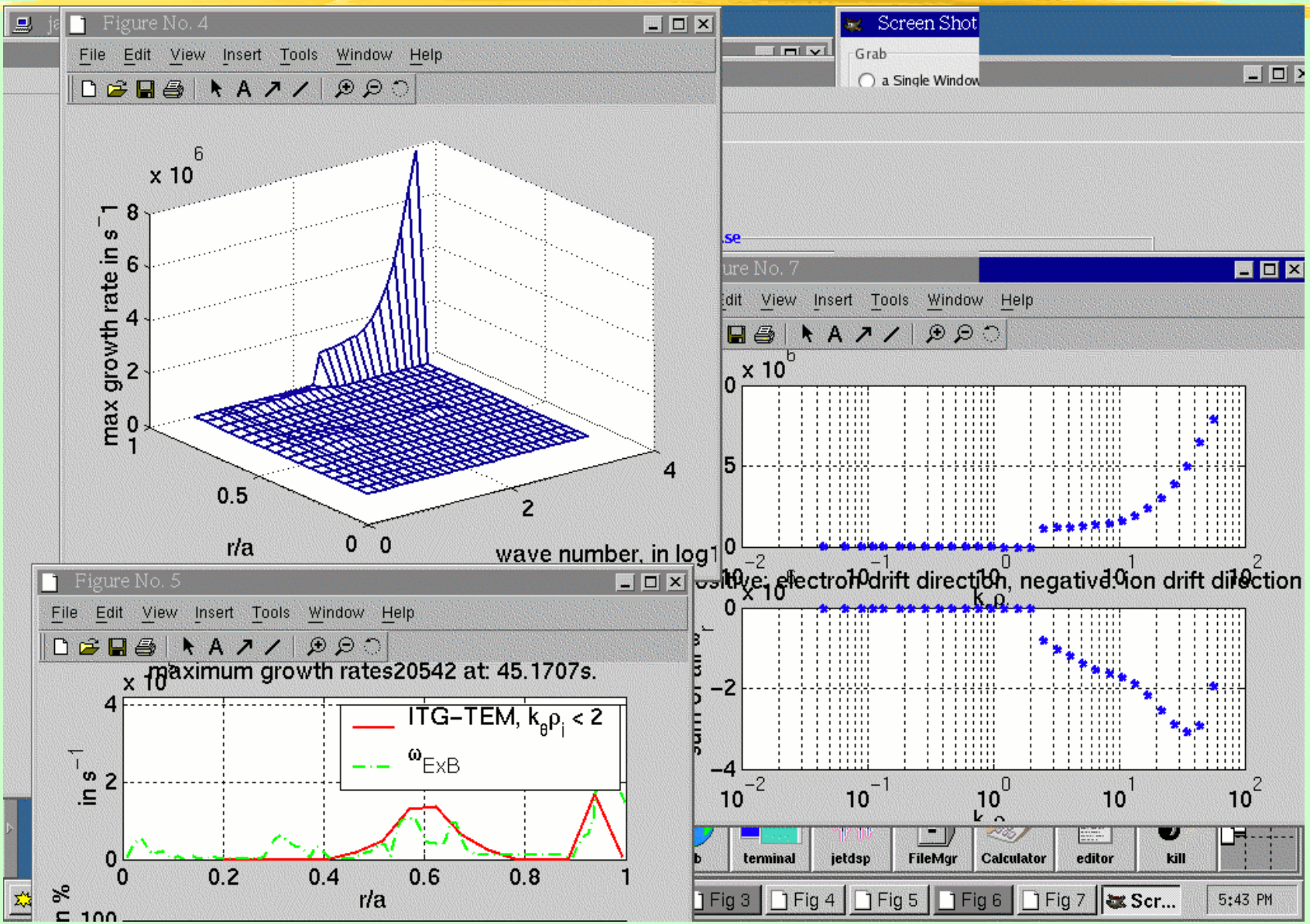


Figure No. 4
File Edit View Insert Tools Window Help
x 10^6
max growth rate in s^-1
r/a
wave number, in log1
Figure No. 5
File Edit View Insert Tools Window Help
maximum growth rates20542 at: 45.1707s.
x 10^4
ITG–TEM, $k_\theta \rho_i < 2$
ω_{ExB}
in s^-1
r/a
Screen Shot
Grab
a Single Window
Figure No. 7
File Edit View Insert Tools Window Help
x 10^6
positive: electron drift direction, negative: ion drift direction
k_θρ
terminal
jetdsp
FileMgr
Calculator
editor
kill
Fig 3
Fig 4
Fig 5
Fig 6
Fig 7
Scr...
5:43 PM

Actions and near-future plans

- In co-operation with TF-T we recently announced a joint training course for the users of our system, which is scheduled for late November;
- This will include training in JETTO/SANCO, CRONOS, (possibly ASTRA), KINEZERO and MISHKA (possibly ELITE) and already attracted 32 attendees;
- We start to do a benchmarking exercise between JETTO and CRONOS, which already brought some interesting results;
- We got a voluntary and extremely generous help from Valentina Huber, CODAS, who is creating a user-friendly interface for 2D SOL transport code EDGE2D;

Future Plans

- Completing the user-friendly suite of transport, MHD and turbulence simulation codes, which are needed for a fully integrated tokamak modelling;
- Start benchmarking existing codes in order to make codes more modular and use existing and anticipated modularity to optimise our system;
- Prepare interfaces between JAMS and other EU tokamak databases so that users can use our tools EU-wise;
- Optimise our co-operation with TF-T, EU ITM TF and international collaborators in code development and integrated predictive modelling;

Conclusions

- The Project progresses in accordance with the plan;
- In my opinion the project, if extended over the next year, will create the best **working** tool for integrated tokamak modelling available for EU users and other JET collaborators both at JET and remotely;
- Effective management of the suite by DAMD requires two extra full-time professional;