

# Job workflow support via condor DAGs

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NuComp Meeting

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# Outline

- Motivation
- Condor DAGs
- Supporting experiment job workflows
- Example applications
  - ◆ MINERvA MC workflows
  - ◆ SAM data handling jobs
  - ◆ Everything else
- Status

# Motivation

- Job dependencies

- ◆ Many grid processing tasks require multiple steps
  - ▶ For example, MINERvA MC generation requires 4 serial job submissions
    - ▷ Output from one stage feeds into the next
  - ▶ More complex dependencies are on the horizon
    - ▷ Eg., event overlays for “rock muons” could introduce additional jobs with new dependencies
  - ▶ Experiment currently runs stages jobs by hand, or writes scripts to watch condor
- ◆ A generic tool that supports job workflows would be helpful in such cases

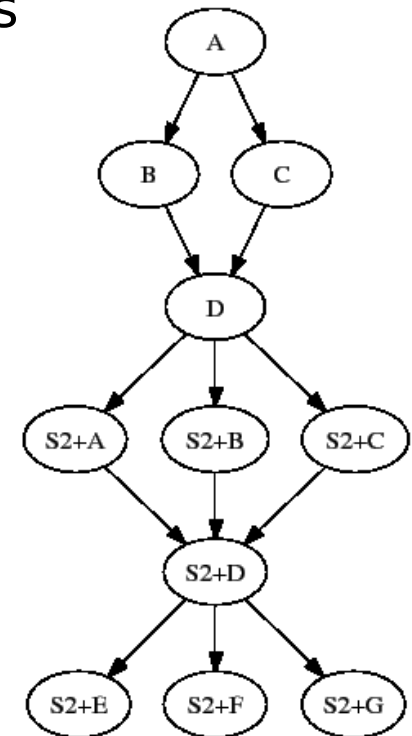
- Job associations

- ◆ Most grid computation submits same application in many parallel jobs
  - ▶ Typically, many submitted at once with a single script
  - ▶ A different input / output file for each
  - ▶ By far the most common and ubiquitous pattern of job submission
- ◆ These jobs are logically related in a way that is invisible to the batch system, and therefore to generic batch system / monitoring tools

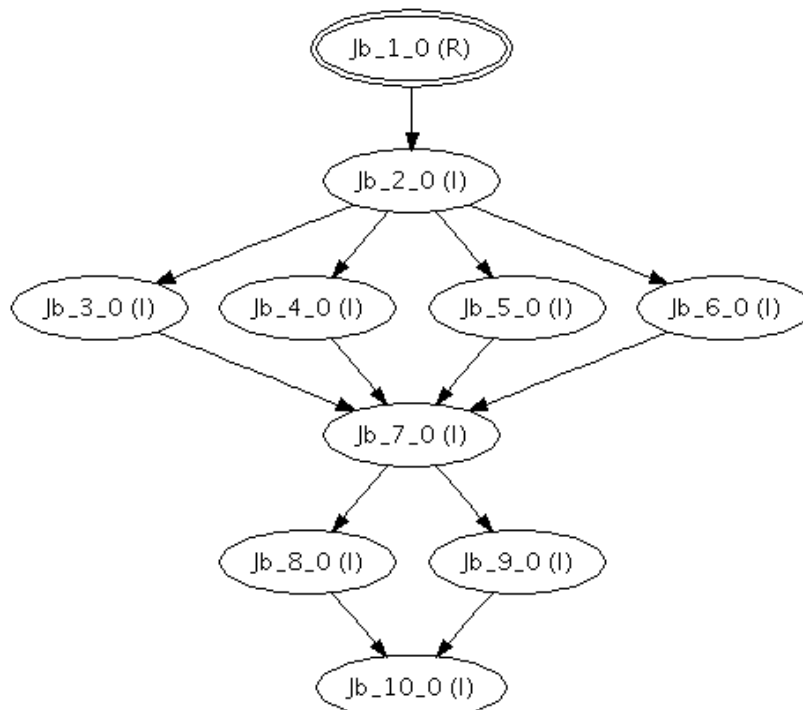
# The Condor DAG

- Condor has features to support job dependencies

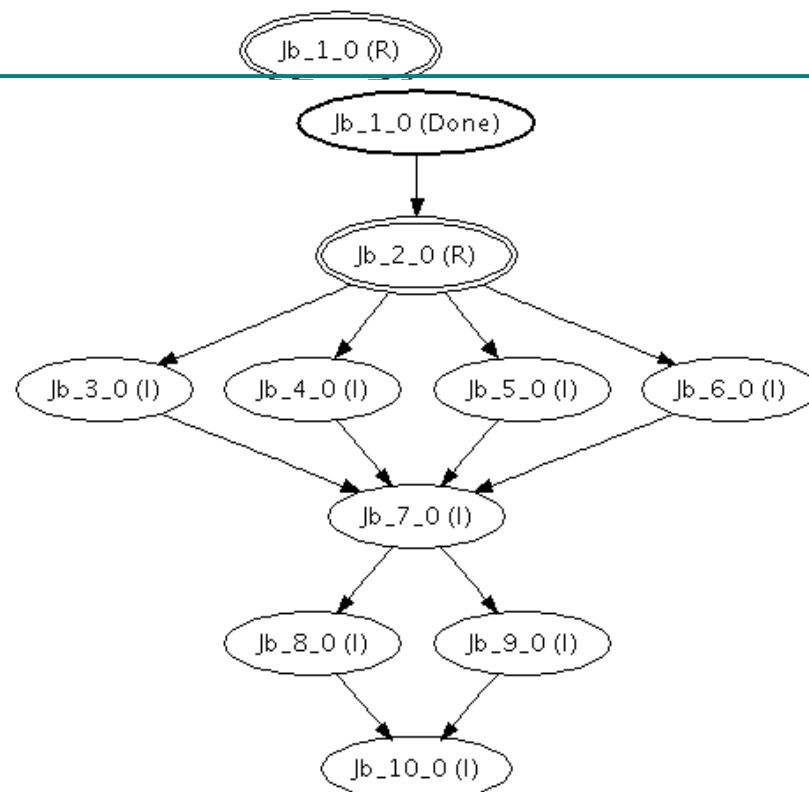
- ◆ Uses directed acyclic graphs (DAG) to represent job dependencies
- ◆ By using DAG to run a set of jobs, condor will:
  - ▶ Enforce an arbitrary, user-specified set of dependencies between jobs
  - ▶ Optionally run a script before or after any individual job
  - ▶ Stop a sequence on an error
    - ▷ Provides a “rescue” DAG in this case that knows what has already completed successfully
  - ▶ Allow additional monitoring options
    - ▷ `condor_q -dag`
    - ▷ Visualization of the execution state of the DAG
  - ▶ Allow a limit on number of jobs in a DAG that are executing at a given time



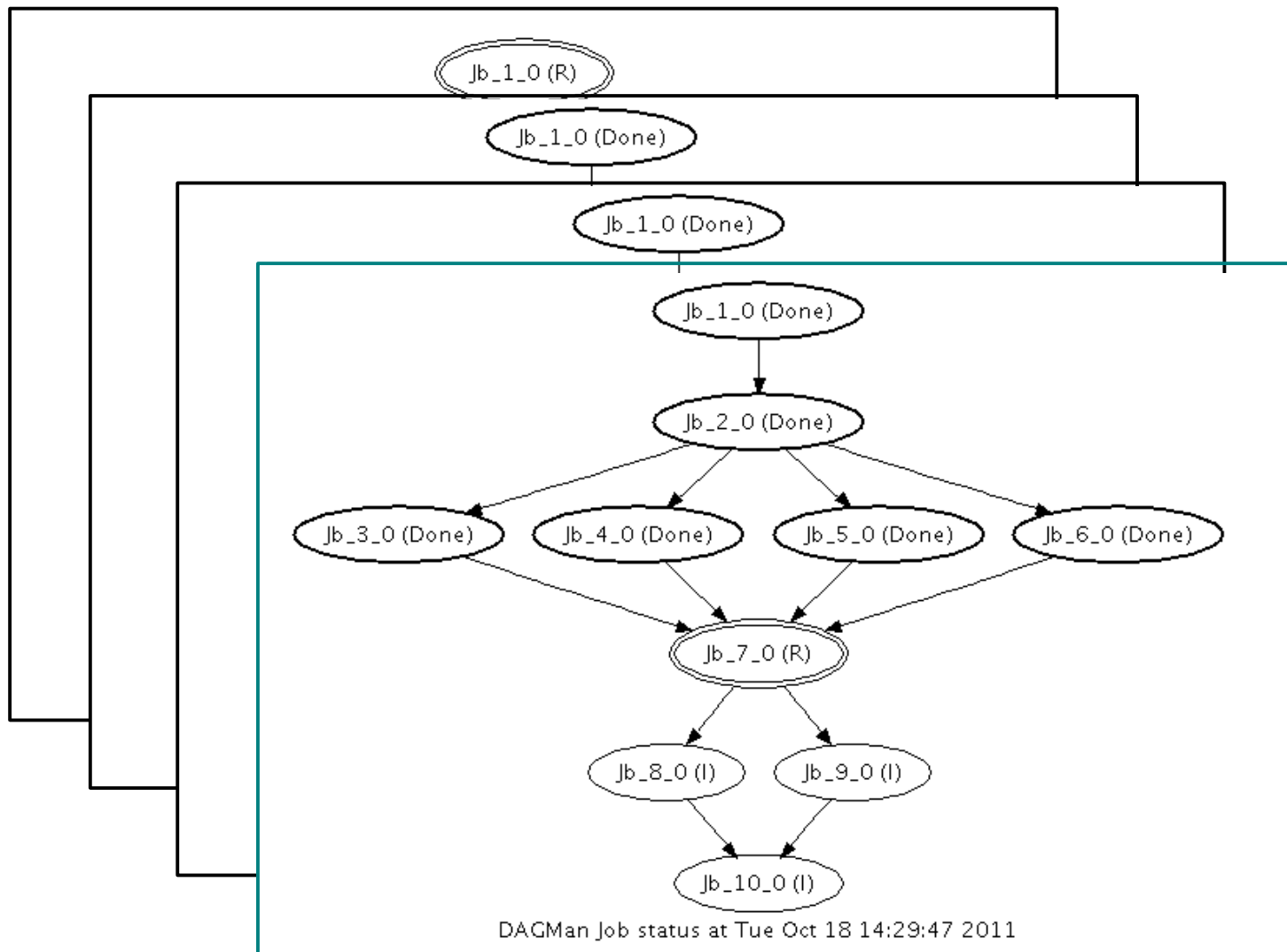
Example condor DAG  
(from condor manual)

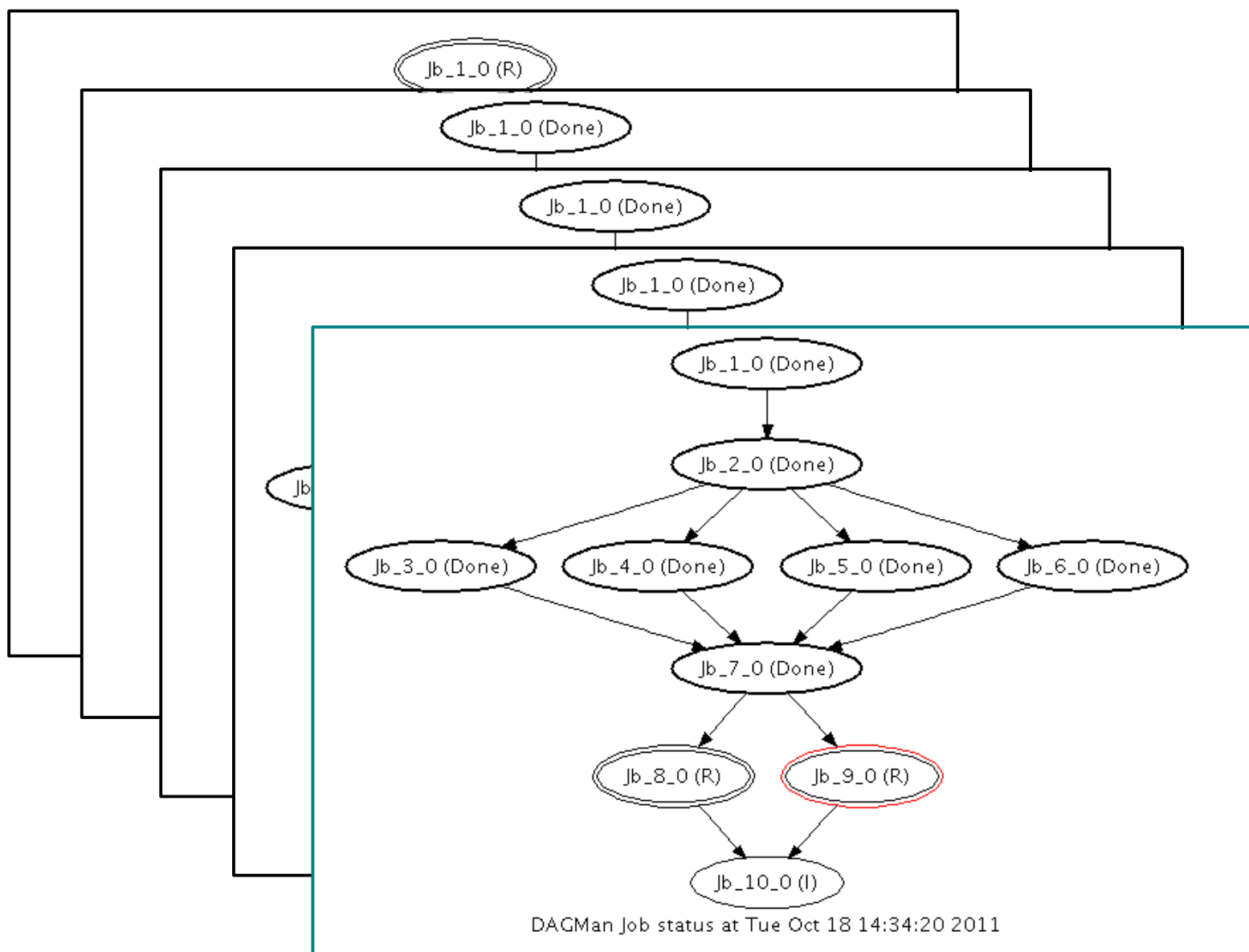


DAGMan Job status at Tue Oct 18 13:54:25 2011



DAGMan Job status at Tue Oct 18 14:12:56 2011

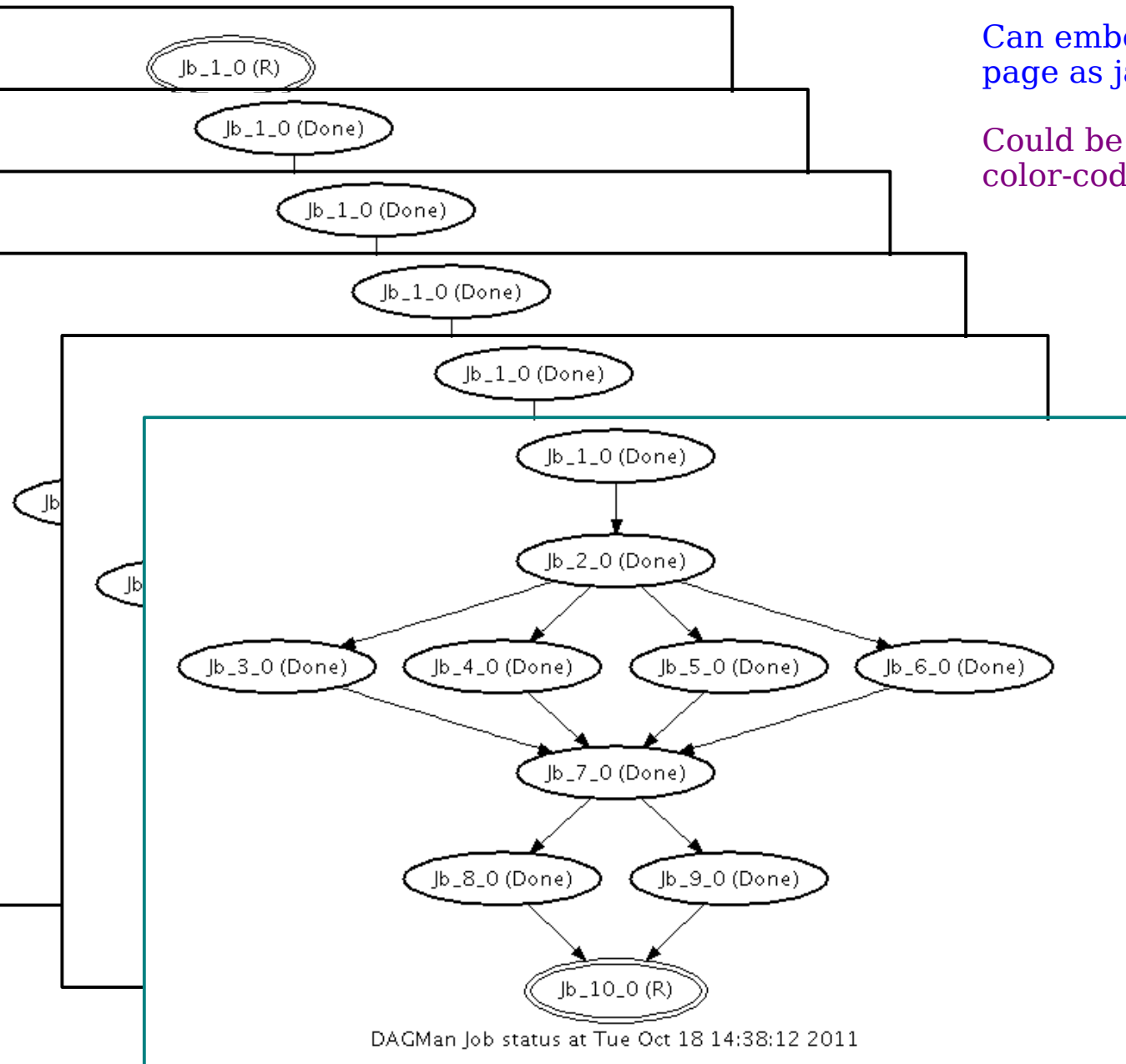






Can embed in web  
page as java applet

Could be useful if  
color-coded



# Supporting job workflows

- Most typical use case: replicate a single pattern run in parallel
  - ◆ Can specify a large job as  $N \times$  (the pattern template)
  - ◆ REX supporting a simple tool to assist in generating DAGs of this type
    - ▶ `/grid/fermiapp/common/tools/dagNabbit.py`
      - ▷ Full documentation available from the script  
`/grid/fermiapp/common/tools/dagNabbit.py -manual | less`
    - ▶ User specifies easy things
      - ▷ Job dependency template (a file with a few XML-style tags)
      - ▷ Scripts for each template node that produce a list of condor command files for that node
        - *IF job submission scripts already do this*
    - ▶ `dagNabbit.py` then generates the full dependency tree and submits the DAG

# Example application (1)

- MINERvA MC workflow

- ◆ Original experiment submission script submits N jobs for one of four stages
- ◆ Modified script to:
  - ▶ Allow creation of condor command files without submitting them
  - ▶ Write a template file for multiple steps
    - ▷ For each node, specifies the no-submit script for a single stage
  - ▶ Call dagNabbit.py with template as input
    - ▷ dagNabbit.py assembles and submits the DAG command file

Command line did not change, except that multiple stage flags are now allowed.

# Example application (1)

- MINERvA MC workflow

- ◆ Example template file created by the new script:

```
# This DAG description was created by process_MC_series.pl
```

```
<serial>
```

```
./process_MC_series.pl minerva 130 -genie -no_submit -f 1 -l 5 -n 5 -g -geo Full
```

```
</serial>
```

```
<serial>
```

```
./process_MC_series.pl minerva 130 -cal -no_submit -f 1 -l 5 -n 5 -g -geo Full
```

```
</serial>
```

```
<serial>
```

```
./process_MC_series.pl minerva 130 -minos -no_submit -f 1 -l 5 -n 5 -g -geo Full
```

```
</serial>
```

```
<serial>
```

```
./process_MC_series.pl minerva 130 -reco -no_submit -f 1 -l 5 -n 5 -g -geo Full
```

```
</serial>
```

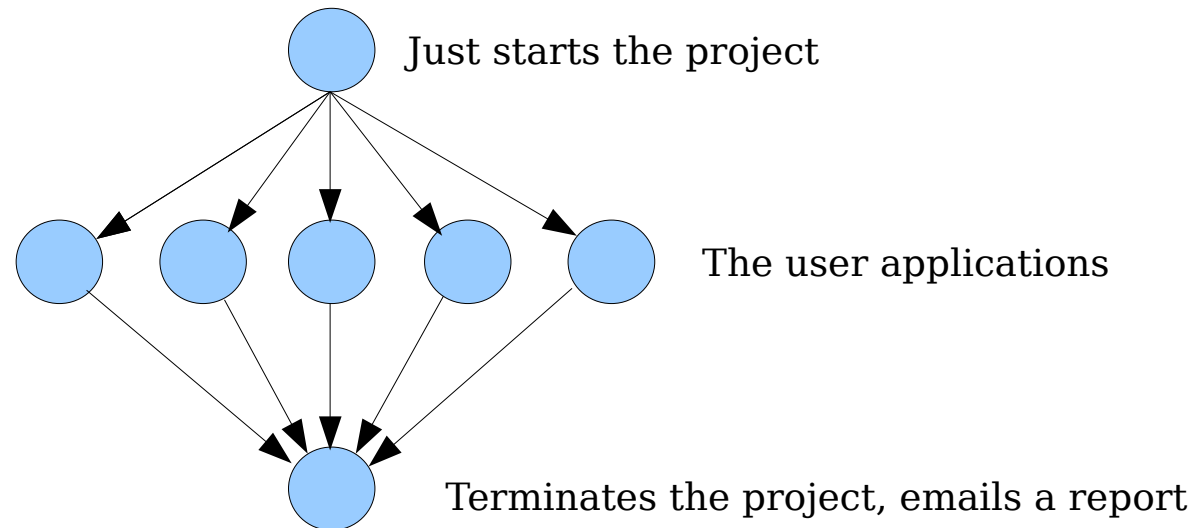
# Example application (1)

- MINERvA MC workflow
  - ◆ Resulting DAG command file (the part we want to avoid writing by hand):

```
JOB Jb_1 /minerva/app/users/condor-tmp/rs/genie_wrapper_SIM_minerva_00000130_0001_v8r3.sh_20110913_235659_1.cmd
JOB Jb_2 /minerva/app/users/condor-tmp/rs/genie_wrapper_SIM_minerva_00000130_0002_v8r3.sh_20110913_235700_1.cmd
JOB Jb_3 /minerva/app/users/condor-tmp/rs/genie_wrapper_SIM_minerva_00000130_0003_v8r3.sh_20110913_235701_1.cmd
JOB Jb_4 /minerva/app/users/condor-tmp/rs/genie_wrapper_SIM_minerva_00000130_0004_v8r3.sh_20110913_235703_1.cmd
JOB Jb_5 /minerva/app/users/condor-tmp/rs/genie_wrapper_SIM_minerva_00000130_0005_v8r3.sh_20110913_235704_1.cmd
JOB Jb_6 /minerva/app/users/condor-tmp/rs/SystemTestsApp.exe_20110913_235705_1.cmd
JOB Jb_7 /minerva/app/users/condor-tmp/rs/SystemTestsApp.exe_20110913_235706_1.cmd
JOB Jb_8 /minerva/app/users/condor-tmp/rs/SystemTestsApp.exe_20110913_235708_1.cmd
JOB Jb_9 /minerva/app/users/condor-tmp/rs/SystemTestsApp.exe_20110913_235709_1.cmd
JOB Jb_10 /minerva/app/users/condor-tmp/rs/SystemTestsApp.exe_20110913_235710_1.cmd
JOB Jb_11 /minerva/app/users/condor-tmp/rs/MinosSim-SIM_minerva_00000130_0001_v8r3.sh_20110913_235711_1.cmd
JOB Jb_12 /minerva/app/users/condor-tmp/rs/MinosSim-SIM_minerva_00000130_0002_v8r3.sh_20110913_235712_1.cmd
JOB Jb_13 /minerva/app/users/condor-tmp/rs/MinosSim-SIM_minerva_00000130_0003_v8r3.sh_20110913_235714_1.cmd
JOB Jb_14 /minerva/app/users/condor-tmp/rs/MinosSim-SIM_minerva_00000130_0004_v8r3.sh_20110913_235715_1.cmd
JOB Jb_15 /minerva/app/users/condor-tmp/rs/MinosSim-SIM_minerva_00000130_0005_v8r3.sh_20110913_235716_1.cmd
JOB Jb_16 /minerva/app/users/condor-tmp/rs/SystemTestsApp.exe_20110913_235717_1.cmd
JOB Jb_17 /minerva/app/users/condor-tmp/rs/SystemTestsApp.exe_20110913_235718_1.cmd
JOB Jb_18 /minerva/app/users/condor-tmp/rs/SystemTestsApp.exe_20110913_235720_1.cmd
JOB Jb_19 /minerva/app/users/condor-tmp/rs/SystemTestsApp.exe_20110913_235721_1.cmd
JOB Jb_20 /minerva/app/users/condor-tmp/rs/SystemTestsApp.exe_20110913_235722_1.cmd
parent Jb_1 child Jb_6
parent Jb_2 child Jb_7
parent Jb_3 child Jb_8
parent Jb_4 child Jb_9
parent Jb_5 child Jb_10
parent Jb_6 child Jb_11
parent Jb_7 child Jb_12
parent Jb_8 child Jb_13
parent Jb_9 child Jb_14
parent Jb_10 child Jb_15
parent Jb_11 child Jb_16
parent Jb_12 child Jb_17
parent Jb_13 child Jb_18
parent Jb_14 child Jb_19
parent Jb_15 child Jb_20
```

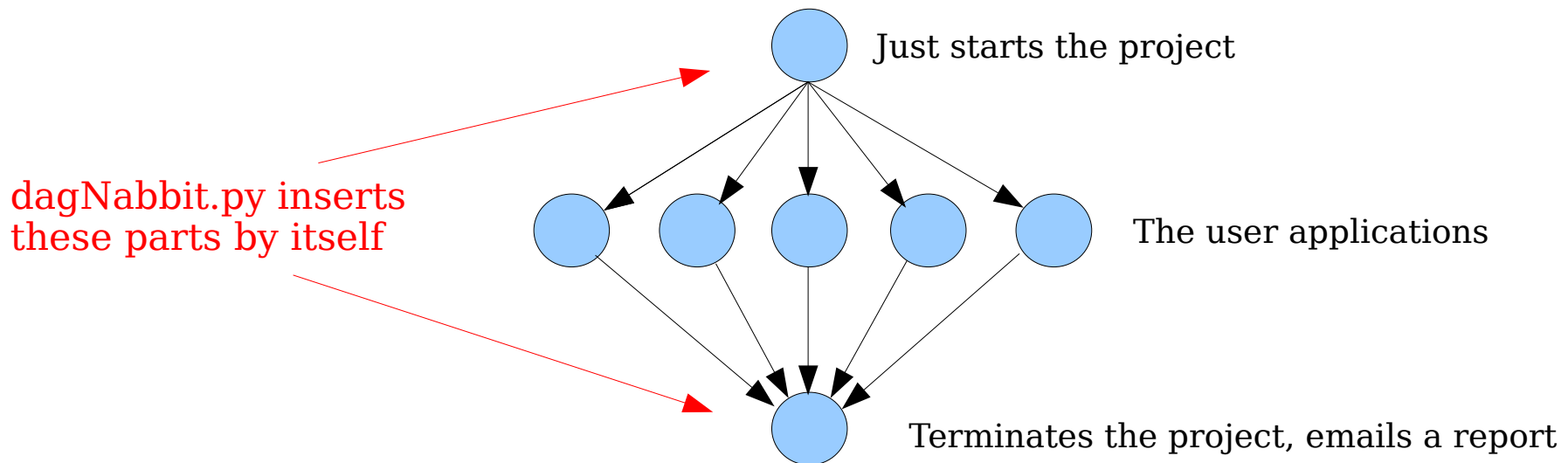
## Example application (2)

- Job that uses a SAM project to deliver files
  - ◆ Run all jobs associated with a given SAM dataset within a single DAG
  - ◆ A pre-script before all application nodes starts the SAM project
  - ◆ A post-script after all application nodes terminates the project



## Example application (2)

- Job that uses a SAM project to deliver files
  - ◆ Run all jobs associated with a given SAM dataset within a single DAG
  - ◆ A pre-script before all application nodes starts the SAM project
  - ◆ A post-script after all application nodes terminates the project



## Example application (3)

- Any job that runs parallel instances of a single application
  - ◆ i.e, everything we run... Really.
- Why?
  - ◆ To manifest the logical connection between jobs that are submitted together
    - ▶ e.g., jobs processing a single run or set of runs, MC for a given configuration, etc.
  - ◆ Allows the monitoring to aggregate jobs that are logically connected
    - ▶ Can simplify the long list of jobs otherwise returned by condor\_q
    - ▶ New monitoring depends upon this ([see figures on next 3 pages](#))
  - ◆ Allows management of associated jobs as a unit
    - ▶ Set a limit on the number of jobs in a DAG executing at a given time
      - ▷ Can be an important handle for managing resource utilization (eg, disk or DB I/O)
    - ▶ Can remove the single DAG process to remove all underlying jobs
    - ▶ Can create a single email summary for the entire DAG
      - ▷ Eliminates the deluge of email from the many individual jobs within a single submission



caf/cdfgrid Web Monitor

http://cdfcaf.fnal.gov/caf/cdfgrid/index.html

Google

Most Visited FNav Code Fermi CD CDI CD Fin Lab Fin Leave Traffic Wthr Nat'l Hrly JIRA Ops rep WthrUG Lists

caf/cdfgrid Web Monitor

CDFGrid CAF Web Monitor

History

Analyze

Overview

Site Overview

System status

Completed jobs

Jobs status

Users prio

By accounting group:

common

group\_MCprod

group\_calib

group\_dbg

group\_highprio

group\_italy

group\_ntp

group\_prd

By user:

aaltonen

amanou

amitl

bcarls

benwu

carron

cdfprd

cdfprd\_cal

cdfprd\_ntp

corbeo

dcox1

elagin

evah

hughes

jsw

limosani

mitra

nig

oksana

onoprien

pilot

seiva

sforza

skwang

takavuki

weiming

wick

By length:

test

CDFGrid CAF overview

History

System Info

	Total VMs	Usable	Claimed	Load=0	Load<30	Assigned	Free	VM Load	Load
Current	11094	5547	5541	3331	74	2	4	1992	1992
Avg.	9465	4730	4573	2106	146	8	148	History	

Total CAFMarks	Claimed CAFMarks	Free CAFMarks	VM Load CAFMarks	Avg. CAFMarks/VM
18185.2k	18173.0k	12.2k	6303.0k	3278.0

/hour	Started sections	Finished sections	Submitted jobs	Terminated jobs
Last 3 mins	895.69	585.65	51.67	51.67
Last 24 mins	660.04	642.41	20.15	20.15

Sections by Accounting Group(ordered by AcctGroup)

Accounting Group	Quota	Running	Assigned	Idle	Wait	Held	Completed	Removed	Low0	Low30	Total	Jobs	History
common	2080*	1383	0	721	12	0	2716	0	367	41	4832	204	History
group_MCprod	519	50	0	0	0	0	0	0	31	17	50	1	History
group_calib	232	1965	0	896	206	0	1545	0	1461	7	4612	53	History
group_dbg	55	0	0	0	2	0	0	0	0	0	2	1	History
group_highprio	887	5	0	0	0	0	0	0	5	0	5	1	History
group_italy	188	145	0	14	0	0	9	0	0	4	168	12	History
group_ntp	499	34	0	0	0	0	486	0	0	0	520	26	History
group_prd	1087	1946	0	0	0	0	1410	0	1448	5	3356	22	History
Total (8)		5528	0	1631	220	0	6166	0	3312	74	13545	320	

\* - Estimated, no real quota

User Sections (ordered by User)

User	Running	Assigned	Idle	Wait	Held	Completed	Removed	Low0	Low30	Total	Jobs
aaltonen	152	0	721	0	0	216	0	14	7	1089	117
amanou	21	0	0	0	0	0	0	0	0	21	21
amitl	394	0	0	0	0	0	0	0	1	394	1
bcarls	1	0	0	0	0	3	0	0	0	4	1
benwu	44	0	0	0	0	10	0	0	3	54	3
carron	2	0	0	0	0	0	0	0	0	2	2
cdfprd	1946	0	0	0	0	1410	0	1448	5	3356	22
cdfprd_cal	1065	0	806	206	0	1545	0	1461	7	4612	53

Find:

Next

Previous

Highlight all

Match case

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# Sample user summary page

caf/cdfgrid Web Monitor

http://cdfcaf.fnal.gov/caf/cdfgrid/index.html

Most Visited ▾ FNav Code Fermi CD CDI CD Fin Lab Fin ▾ Leave Traffic Wthr Nat'l Hrly JIRA Ops rep WthrUG Lists

caf/cdfgrid Web Monitor

## CDFGrid CAF Web Monitor [History|Analyze]

Overview  
Site Overview

Ove System status

Site Completed jobs

Syst Jobs status

Con Users prio

Jobs By accounting group:

Use

By i

- common
- group\_MCprod
- group\_calib
- group\_dbg
- group\_highprio
- group\_italy
- group\_nlp
- group\_prd

By user:

- aaltonen
- amanou
- amit
- bcarls
- benwu
- carron
- cdfprd
- cdfprd\_cal
- cdfprd\_ntp
- corbeo
- dcou1
- elagin
- evah
- hughes
- isw
- limosani
- mitra
- nig
- oksana
- onoprien
- pilot
- seiva
- sforza
- skwang
- takavuki
- weiming
- wick

By length:

- test
- medium
- long

### CDFGrid CAF jobs for user cdfprd\_cal

[Status|Long]

Job	Priority	User	Accounting User	Length	Submit Time	Total	Runn ing	Assi gned	Idle	Wait	Held	Comp leted	Remo ved	Fail ed	Time out	Trou bled	Err. RiC	Back up	Lost	Low0	Low30	Comp rtime	Comp utime	Run load	Run mem	Tarball size	Job	Initial Comm
573454	27746.74/0	cdfprd_cal	group_calib.cdfprd_cal	long	19:22	161	1	0	0	0	0	160	0	0	0	0	0	0	0	1	0	7h 32'	2h 4'	0.00	119M	0.0M	573454	/webLoader.sh http://www-cdf.fnal.gov/Tarballs/CalibExe_6.1.6.m_maxopt.tgz --station=cdf-fnc --dataset=CalibExe_1_bphys --project=cdfprc fncdfrv0_CalibExe_1_bphysr_298782 --exec_script=/cdfopr/farm/do_exe.sh /calib/CalibExe.sh --n_exe_tri FCP_USER=cdfprd_cal -x FCP_HOST= FCP_PATH=/cdf/local/disk01/cdfpr CALIB_PASS_NAME=10A -x CALIB -x prodPass=1 -x FCP_PATH=/cdf/loc /stream -x FCP_USER: FCP_HOST=fcddata401.fnal.g FCP_LOGS=log -x FCP_META=log -x OUTPUTFILELIST=/ /CalibExe_streamb_outp
573455	27746.74/0	cdfprd_cal	group_calib.cdfprd_cal	long	19:23	192	1	0	0	0	0	191	0	0	0	0	0	0	0	1	0	7h 34'	1h 57'	0.00	119M	0.0M	573455	/webLoader.sh http://www-cdf.fnal.gov/Tarballs/CalibExe_6.1.6.m_maxopt.tgz --station=cdf-fnc --dataset=CalibExe_1_bphys --project=cdfprc fncdfrv0_CalibExe_1_bphysr_298796 --exec_script=/cdfopr/farm/do_exe.sh /calib/CalibExe.sh --n_exe_tri FCP_USER=cdfprd_cal -x FCP_HOST= FCP_PATH=/cdf/local/disk01/cdfpr CALIB_PASS_NAME=10A -x CALIB -x prodPass=1 -x FCP_PATH=/cdf/loc /stream -x FCP_USER: FCP_HOST=fcddata401.fnal.g FCP_LOGS=log -x FCP_META=log -x OUTPUTFILELIST=/ /CalibExe_streamb_outp
573490	27746.74/0	cdfprd_cal	group_calib.cdfprd_cal	long	21:37	52	1	0	0	0	0	51	0	0	0	0	0	0	0	0	0	6h 27'	1h 43'	0.91	832M	0.0M	573490	/webLoader.sh http://www-cdf.fnal.gov/Tarballs/CalibExe_6.1.6.m_maxopt.tgz --station=cdf-fnc --dataset=CalibExe_1_gphys --project=cdfprc fncdfrv0_CalibExe_1_gphysr_298754 --exec_script=/cdfopr/farm/do_exe.sh /calib/CalibExe.sh --n_exe_tri FCP_USER=cdfprd_cal -x FCP_HOST= FCP_PATH=/cdf/local/disk01/cdfpr CALIB_PASS_NAME=10A -x CALIB -x prodPass=1 -x FCP_PATH=/cdf/loc /stream -x FCP_USER:

Find:  Next Previous ☐ Highlight all ☐ Match case

Done

- weiming
- wick

By length:

- test

	1	0	0	0	0	3	0	0	0	4	1
bcarls	1	0	0	0	0	3	0	0	0	4	1
benwu	44	0	0	0	0	10	0	0	3	54	3
carron	2	0	0	0	0	0	0	0	0	2	2
cdfprd	1946	0	0	0	0	1410	0	1448	5	3356	22
cdfprd_cal	1065	0	806	206	0	1645	0	1461	7	4612	63

Find:  Next Previous ☐ Highlight all ☐ Match case

Done

Drill-down to job summary...

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18

# Sample job summary page

caf/cdfgrid Web Monitor

http://cdfcaf.fnal.gov/caf/cdfgrid/index.html

Most Visited FNav Code Fermi CD CDI CD Fin Lab Fin Leave Traffic Wthr Nat'l Hrly JIRA Ops rep WthrUG Lists

caf/cdfgrid Web Monitor

## CDFGrid CAF Web Monitor [History|Analyze]

Overview  
Site Overview  
System status  
Completed jobs  
Jobs status  
Users prio  
By accounting group:  
By user:  
By length:  
By leng

**CDFGrid CAF jobs for job 573624** [jid detail](#) [Short](#) [Status](#)

- Waiting, display:  
☐ all  
☐ none  
☐ checked:  
☒ Idle  
☒ Wait  
☒ Held

- Running, display:  
☐ all  
☐ none  
☐ checked:  
☒ Low 0  
☒ Low 30  
☒ Full Speed

- Completed, display:  
☐ all  
☐ none  
☐ checked:  
☒ Successfully Completed  
☒ Data Lost  
☒ Failed  
☒ Data Backups  
☒ Execution Error  
☒ Removed

Submit Query

Job: 573624 Length: long Real time limit: 72h  
User: cdfprd\_cal Accounting User: group\_calib.cdfprd\_cal Priority: 27764.86/0  
Submit time: Dec 03 02:39 Tarball size: 0.0M  
Initial Command: ./webloader.sh http://www-cdf.fnal.gov/prdwww/cdfprd\_cal/Tarballs/CalibExe\_6.1.6.m\_maxopt.tgz /cdfopr/farm/start\_loader --station=cdf-fncdfrsv0 --dataset=CalibExe\_1\_gphysr\_298992\_298992 --project=cdfprd\_cal --fncdfrsv0\_CalibExe\_1\_gphysr\_298992\_298992\_20101203\_023927 --exec\_script=/cdfopr/farm/do\_exe.sh --setup\_script=/Production/calib/CalibExe.sh --n\_exe\_tries=1 --x FCP\_USER=cdfprd\_cal --x FCP\_HOST=fcddata401.fnal.gov --x FCP\_PATH=/cdf/local/disk01/cdfprd\_cal/current/streamg --x CALIB\_PASS\_NAME=10A --x CALIB\_PARM\_SET=Pass10Prod --x prodPass=1 --x FCP\_PATH=/cdf/local/disk01/cdfprd\_cal/current/streamg --x FCP\_USER=cdfprd\_cal --x FCP\_HOST=fcddata401.fnal.gov --x FCP\_HIST --x FCP\_LOGS --x FCP\_META --x FCP\_CRASHED --x OUTPUTFILELIST=/Production/calib/CalibExe\_streamg\_outputs.lst --job=\$

Input Source: USERSAM  
Output File: cdfprd\_cal@fcddata401.fnal.gov:/cdf/local/disk01/cdfprd\_cal/current/streamg/Cafoutdir/CalibExe.cdfprd\_cal-fncdfrsv0\_CalibExe\_1\_gphysr\_298992\_298992\_20101203\_023927.\$t.gz  
Schedd: schedd\_1@fcdhead10.fnal.gov

1	2	3	4
<b>Completed</b> RetCode: 0 (Real: 7h 54', CPU: 2h 40') Ready: Dec 03 02:42 Started: Dec 03 06:08 Ended: Dec 03 14:02 Condor ID: 14179193	<b>Completed</b> RetCode: 0 (Real: 5h 58', CPU: 2h 57') Ready: Dec 03 02:43 Started: Dec 03 06:08 Ended: Dec 03 12:06 Condor ID: 14179196	<b>Completed</b> RetCode: 0 (Real: 8h 19', CPU: 3h 12') Ready: Dec 03 02:43 Started: Dec 03 06:08 Ended: Dec 03 14:28 Condor ID: 14179199	<b>Completed</b> RetCode: 0 (Real: 8h 17', CPU: 3h 5') Ready: Dec 03 02:43 Started: Dec 03 06:08 Ended: Dec 03 14:26 Condor ID: 14179201
5	6	7	8
<b>Completed</b> RetCode: 0 (Real: 7h 51', CPU: 2h 38') Ready: Dec 03 02:43 Started: Dec 03 06:08 Ended: Dec 03 14:00 Condor ID: 14179205	<b>Completed</b> RetCode: 0 (Real: 4h 3', CPU: 2h 40') Ready: Dec 03 02:43 Started: Dec 03 06:08 Ended: Dec 03 10:12 Condor ID: 14179208	<b>Running</b> (8h 39') On: vm35@fcdcaf1040.fnal.gov (v1.6_2a@fcdosg0) Load: 1.00 Load0 %: 56.60 MemUsed: 508Mb Ready: Dec 03 02:43 Started: Dec 03 06:08 Condor ID: 14179211	<b>Completed</b> RetCode: 0 (Real: 8h 26', CPU: 3h 17') Ready: Dec 03 02:43 Started: Dec 03 06:08 Ended: Dec 03 14:35 Condor ID: 14179214
9	10	11	12
<b>Completed</b> RetCode: 0 (Real: 6h 54', CPU: 3h 49') Ready: Dec 03 02:43 Started: Dec 03 06:08 Ended: Dec 03 13:03 Condor ID: 14179217	<b>Completed</b> RetCode: 0 (Real: 4h 46', CPU: 3h 20') Ready: Dec 03 02:43 Started: Dec 03 06:09 Ended: Dec 03 10:55 Condor ID: 14179219	<b>Completed</b> RetCode: 0 (Real: 5h 38', CPU: 2h 36') Ready: Dec 03 02:43 Started: Dec 03 06:09 Ended: Dec 03 11:47 Condor ID: 14179225	<b>Completed</b> RetCode: 0 (Real: 5h 44', CPU: 2h 42') Ready: Dec 03 02:44 Started: Dec 03 06:09 Ended: Dec 03 11:53 Condor ID: 14179227
13	14	15	16
<b>Completed</b> RetCode: 0	<b>Completed</b> RetCode: 0	<b>Completed</b> RetCode: 0	<b>Completed</b> RetCode: 0

Find:  Next Previous Highlight all Match case

Done

By length:

bcrls	1	0	0	0	0	3	0	0	0	4	1
benwu	44	0	0	0	0	10	0	0	3	54	3
carron	2	0	0	0	0	0	0	0	0	2	2
cdfprd	1946	0	0	0	0	1410	0	1448	5	3356	22
cdfprd_cal	1065	0	806	206	0	1545	0	1461	7	4612	53

Find:  Next Previous Highlight all Match case

Done

By length:

bcrls	1	0	0	0	0	3	0	0	0	4	1
benwu	44	0	0	0	0	10	0	0	3	54	3
carron	2	0	0	0	0	0	0	0	0	2	2
cdfprd	1946	0	0	0	0	1410	0	1448	5	3356	22
cdfprd_cal	1065	0	806	206	0	1545	0	1461	7	4612	53

Find:  Next Previous Highlight all Match case

Done

Status of each section within the job

Drill down to section status page...

R. Snider

# Status

- Existing dagNabbit script
  - ◆ Supports basic serial and parallel sub-sequences
    - ▶ Serial steps or branching parallel steps not yet supported, but will be
    - ▶ MINERvA MC submission scripts currently using this
  - ◆ Supports startup and termination scripts for the entire DAG (almost ready)
    - ▶ Needed for SAM jobs and a terminal job mailer
- To be added
  - ◆ Support for pre and post scripts on individual nodes
  - ◆ Integrating SAM project startup, completion
  - ◆ Job summary mailer
- Can already start integrating into experiment submission scripts

The end