

Istituto Nazionale di Fisica Nucleare





HTCondor usage for data processing

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FOOT Software Tutorial 11-12/02/2025

Tier1 @ CNAF

CNAF is the computing center of INFN (Italian National Institute for Nuclear Physics)

- Tier1 is the main INFN data center
 - Part of the Worldwide LHC Computing "Grid"
 - Key facility for many HEP, nuclear physics, astrophysics and neutrino experiments



Access to Tier1 can be requested following the instructions reported <u>here>></u>

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Tier1 for FOOT

Two-step login:

- 1) Jump-host server Bastion(ssh <options> user@bastion.cnaf.infn.it)
 Not to be used → only needed to enter the CNAF
 net and connect to our machines
- 2) Dedicated User Interfaces (UI) for FOOT \rightarrow Real work environment!
 - ui01-foot (ssh <options> user@ui01-foot.cr.cnaf.infn.it)
 - wi02-foot (ssh <options> user@ui02-foot.cr.cnaf.infn.it)
- →Almalinux9 machines (8 CPUs, 16GB RAM)
- →ROOT (6.30/02) already available source /opt/exp_software/foot/root_shoe_foot.sh
- →SHOE installation is very straightforward (see <u>here>></u>)





Tier1 for FOOT – useful tips

Two-step login can be performed in one step with:

ssh -XYC -J \${USER}@bastion.cnaf.infn.it \${USER}@ui01-foot.cr.cnaf.infn.it

Copy file to and from Tier1 with "scp" or "rsync":

scp -p -r -oProxyCommand="ssh -W %h:%p \${USER}@bastion.cnaf.infn.it" <paths>

rsync -P -azv -e 'ssh -o "ProxyCommand ssh \${USER}@bastion.cnaf.infn.it -W %h:%p"' <paths>

Where you have to specify your **\${USER}** and the **<paths>** are:

<your-local-path> \${USER}@ui01-foot.cr.cnaf.infn.it:<path-on-Tier1>

→ Copy from Tier1 to local

Copy from local to Tier1

Tier1 storage



DATA

SW

HOME

Each folder on the Tier1 has a specific task

→ Optimized for large files

/storage/gpfs_data/foot : parent directory (~110 TB)
/storage/gpfs_data/foot/shared : Experimental data
/storage/gpfs_data/foot/shared/SimulatedData : MC simulation data
/storage/gpfs_data/foot/\${USER} : User data (create if not present!)

→Optimized for small files

/opt/exp_software/foot : parent directory
/opt/exp_software/foot/\${USER} : User software (create if not present!)

→ Optimized for small files

→ Daily backup but limited and shared by all the collaboration

```
/home/FOOT-T3 : parent directory (~110 GB)
/home/FOOT-T3/${USER} : User $HOME
```

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Tier1 storage



Each folder on the Tier1 has a specific task



Tier1 – Software

The UIs serve only as interfaces

- Not designed for demanding tasks
- Main purpose is I/O
- Limited resources (not more than a laptop) 8 cpu, 16 GB RAM
- Shared by all people working in the experiment

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BE CAREFUL WHAT YOU LAUNCH ON THESE MACHINES!

(maybe just avoid launching stuff here if you can...)



So... How does one work on the Tier1?

Tier1 – HTCondor



The UIs are interfaced to the CNAF computing resources through the **HTCondor** batch system

- Best way to fully exploit the Tier1 resources
- From UI, a user can submit jobs to condor
- Job scheduler → handles resource assignment and execution of the jobs
- What is needed to do that?

1) Executable file

 \rightarrow what the job has to do

2) Submit file

 \rightarrow job parameters for the scheduler



Tier1 – HTCondor example



Executable file

/opt/exp_software/foot/zarrellafoott3/sleep.sh

#!/bin/bash

echo "Test HTC job" sleep 10 echo "Test done!"

Submit file

/opt/exp_software/foot/zarrellafoott3/sleep.sub

executable = /opt/exp_software/foot/zarrellafoott3/sleep.sh

- = /home/F00T-T3/zarrellafoott3/sleep.log
- = /home/F00T-T3/zarrellafoott3/sleep.err
- = /home/F00T-T3/zarrellafoott3/sleep.out

queue

output

log error

Tier1 – HTCondor example





- To submit a job:
- 1) Set the HTCondor environment \rightarrow source /opt/exp_software/foot/set_HTC_env.sh
- 2) Submit the job to the scheduler \rightarrow condor_submit /opt/exp_software/foot/zarrellafoott3/sleep.sub

Tier1 – HTCondor example





- 1) Set the HTCondor environment \rightarrow source /opt/exp_software/foot/set_HTC_env.sh
- 2) Submit the job to the scheduler \rightarrow condor_submit /opt/exp_software/foot/zarrellafoott3/sleep.sub

Scripts already available in SHOE to create aux files and submit jobs!

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Possible to run all steps of the FOOT workflow on Tier1



SHOE on Tier1 – MC simulation

shoe/Simulation/runFOOTSimulation.sh

- Monte Carlo file generation (FLUKA)
- Works for all campaigns and run numbers (full list available <u>here>></u> and in shoe/Reconstruction/FOOT.cam)
- Simulate *n* events in total
 - → n/e jobs of e events each
 - ➔ Jobs run in parallel and merge afterwards
- Least useful of the scripts



Official FOOT simulation files available at /storage/gpfs_data/foot/shared/SimulatedData Example

./runFOOTSimulation.sh -o /storage/gpfs_data/foot/\${USER}/CNA023PS_MC -c CNA023PS_MC -r 200
-n 1000000 -e 1000 -k 1



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Blue args are optional!!!



SHOE on Tier1 – MC file processing

shoe/Reconstruction/scripts/runShoeBatchT1 MC.sh

- Monte Carlo file processing (DecodeGlb)
- Split processing in 20k events/job
- I/O paths forced in /storage/gpfs data/foot
- Campaign and run retrieved automatically
- Can merge in single ROOTfile (-m argument)
- Can process multiple MC input files (-f argument)

- inside file! Decoded runShoeBatchT1 MC MC ROOTfile ROOTfil Arguments -i **Input file** (in /storage/gpfs_data/foot/) **Output directory** (in /storage/gpfs_data/foot) -0 Merge output files (optional, default "1") -m
- -f **Use full statistics** (optional, default "0")

 Mandatory to pre-set the FootGlobal.par and all configurations/calibrations! Also, it is mandatory to test DecodeG1b before with few events (-nev 1000)!

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optional!!!

Example

Full documentation

SHOE on Tier1 – Data processing

Full documentation



Also, it is mandatory to test DecodeG1b before with few events (-nev 1000)!

Example

./runShoeBatchT1.sh -i /storage/gpfs data/foot/shared/DataGSI2021sync/ -o /storage/gpfs data/foot/\${USER}/results -c GSI2021 -r 4306 -l 4310 -m 1

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SHOE on Tier1 – Data Analysis (beta)

Full documentation

inside file!



shoe/Reconstruction/scripts/runAnalysisBatchT1.sh

- **Data analysis** (DecodeGlbAnalysis)
- Further process of decoded files
- I/O paths forced in /storage/gpfs_data/foot
- Campaign and run found from file
- Can work on both data and MC
- Possible to launch everything in a single job
 -n No b (for specific analysis applications), default 50k events/job



- -o Output file (in /storage/gpfs_data/foot/, optional)
- -m Is MC (optional, default "0")
- -n No batch (optional, default "0")

• This script works but is still in development! \rightarrow you can ignore it for the moment...

Example./runAnalysisBatchT1.sh -i /storage/gpfs_data/foot/\${USER}/Merge_CNA02023_6106.root-o /storage/gpfs_data/foot/\${USER}/MergeAna_CNA02023_6106.root -m 0 -n 0

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HTCondor jobs monitoring and handling





HTCondor jobs monitoring and handling



Once all your jobs are completed, you **need** to remove them from the queue

condor_rm \$USER

condor_rm -all

If for some reason your jobs run for too long (>~1 hour), it is likely that something broke

Usually SHOE's "fault" \rightarrow check if output files are creates + condor_tail

^{*}Other possible issues can be pointed out in the auxiliary files of each job (.out/.err/.log)

Further info and commands in the <u>CNAF-Tierl</u> and the <u>HTCondor</u> documentations

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If you can't find out why it is failing, try harder! And then obviously ask me if you need!

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HTCondor interaction: summary

Set HTCondor environment

source /opt/exp_software/foot/set_HTC_env.sh

Operation	Command	
Check job queue	condor_q condor_q -nobatch condor_q -run	
Check job output	condor_tail jobId condor_tail -f jobId	
Transfer auxiliary files	condor_transfer_data jobId condor_transfer_data -all	
Remove jobs from queue	condor_rm \$USER condor_rm -all condor_rm -constraint "jobStatus=={id}"	1 pending 3 removed 5 held



{id}

2 running 4 completed

6 submission err

HTCondor interaction: summary

Set HTCondor environment

source /opt/exp_software/foot/set_HTC_env.sh

Operation Command Usually not needed when using SHOE scripts! condor q condor q -nobatch Check job queue (please check your queue sometimes or condor q -run probably I will tell you to do it...) condor tail jobId Check job output condor tail -f jobId Transfer condor transfer data jobId condor transfer data -all auxiliary files {id} condor rm \$USER **Remove jobs** condor rm -all 1 pending 2 running from queue 3 removed 4 completed condor rm -constraint "jobStatus=={id}" 6 submission err 5 held

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Auxiliary files handling

All jobs produce some auxiliary files containing output/error/logs

- After long discussion with CNAF, everything is put by default in user \$HOME
- Dedicated folders for different scripts ("HTC_SHOEreco", "HTC_SHOEanalysis", etc.)
 - Automatically created if not present
 - Campaign and run number in name for simplicity
 - Useful to check jobs when a failure happens



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- After long discussion with CNAF, everything is put by default in user \$HOME
- Dedicated folders for different scripts ("HTC_SHOEreco", "HTC_SHOEanalysis", etc.)
 - Automatically created if not present
 - Campaign and run number in name for simplicity
 - Useful to check jobs when a failure happens
- **\$** HOME disk space is shared!!!! Make sure to remove your aux files if your jobs are successful!!

```
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    /home/F00T-T3 : parent directory (~110 GB)
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```

Summary



Large-scale data processing with HTCondor on Tier1

- 2 dedicated FOOT User Interfaces (ui01-foot, ui02-foot)
 - ROOT available (source /opt/exp_software/foot/root_shoe_foot.sh)
 - ✓ Easy SHOE installation

• HTCondor resources for batch processing

- Easy environment setting (source /opt/exp_software/foot/set_HTC_env.sh)
- ✓ Scripts available in SHOE to:
 - Produce Monte Carlo simulations (shoe/Simulation/runF00TSimulation.sh)
 - Process Monte Carlo files (shoe/Reconstruction/scripts/runShoeBatchT1_MC.sh)
 - Process Experimental data (shoe/Reconstruction/scripts/runShoeBatchT1.sh)
 - Analyze Simulated/Experimental data (shoe/Reconstruction/scripts/runAnalysisBatchT1.sh)