
High Performance Computing for HEP Theory

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HEP Theory and Computing

Topical areas with high computing requirements

- Fixed-order (N)NLO calculations
 - Test new theoretical concepts in high-multiplicity processes
 - Generate parton-level event samples for theory and experiment
- QCD resummation
 - Validate algorithms for high fixed-order & logarithmic accuracy
 - Compute predictions / uncertainty estimates for many observables
- MC event generators
 - Validate algorithms to simulate high-multiplicity events at NLO
 - Tuning, release preparation, tests of applicability
- Interpretation of experimental data in terms of new physics models
 - Generate large event samples for many hypotheses and analyze
 - Archive data and/or plots for usage by experiment & theory

Snowmass Study on HPC for HEP Theory

Fast Track:

- Draft white paper
“The computing needs of theoretical HEP at the Energy Frontier”
[Boughezal,Dixon,Hewett,Hoeche,Petriello,Reina,Rizzo]
- Circulated on 03/16 for comments and signatures
- Includes three case studies (next slides)

Slow Track:

- Planning for Energy Frontier meeting at BNL
 - Tutorial using both “Hello World” and real-life examples of MPI / OpenMP parallelization and its usage at NERSC
 - Stir up interest & sign up people for more case studies
 - To be announced later this week
- First follow-up planned in mid May (LoopFest)

Case Study #1: Perturbative QCD at NLO

Current Status:

- No conceptual problems in breaking down NLO calculations into standard modular steps, automate them, and make them public
- Dedicated effort started in the context of Snowmass 2013 to obtain realistic estimate of necessary computing resources
- First exploratory studies at NERSC show enormous potential to utilize codes which are readily available

Expected Benefits of HPC:

- Various existing calculations/software can be made public within a common well-tested framework
- Allows experimental studies involving extensive multiple runs without depending on the computer- and manpower available to theorist locally
- New cutting-edge calculations can fully exploit parallel architectures and availability of large resources for production stage

Case Study #2: Perturbative QCD at NNLO

Current Status:

- Increased precision at LHC imposes ever increasing demands upon theoretical predictions, often necessitating NNLO corrections
- Calculations neither modular nor automated, but still pleasingly parallel due to MC methods
- Prime example: Sector decomposition breaks down singularity structure of double-real radiation correction into many independent sectors

Expected Benefits of HPC:

- NNLO calculations often much more time-consuming than NLO ones
HPC resources in HTC mode will increase throughput significantly
- Allows experimental studies involving extensive multiple runs without depending on the computer- and manpower available to theorist

Case Study #3: BSM Phenomenology

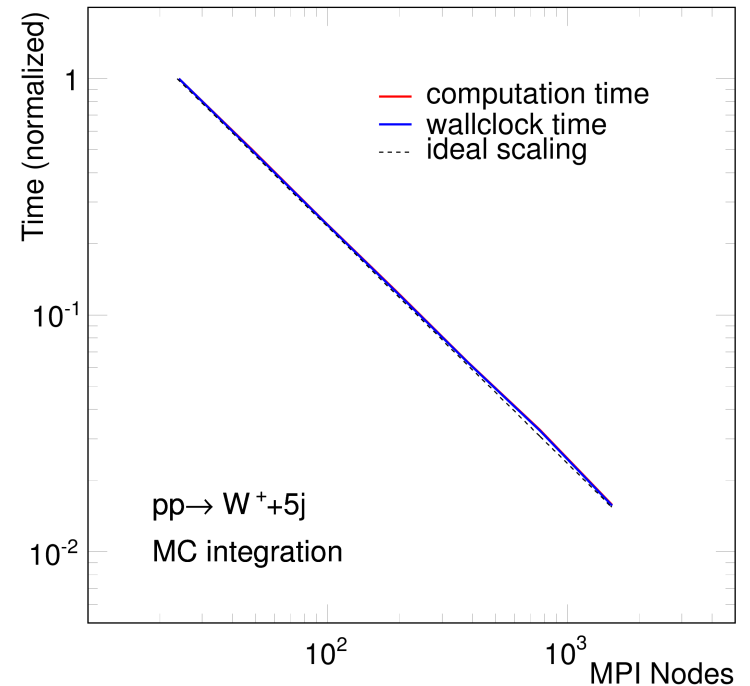
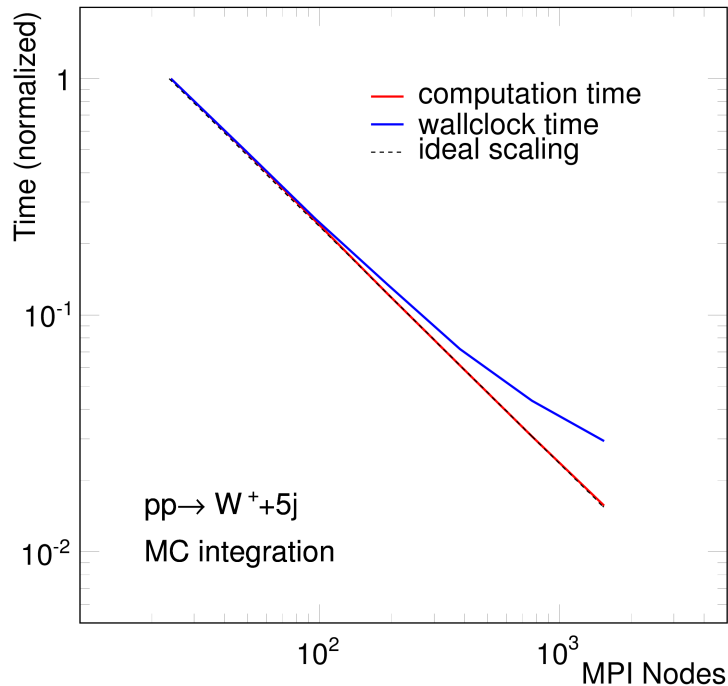
Current Status:

- Development of tools to explore parameter spaces of physics beyond the Standard Model in as much generality as possible
- Availability and efficiency will become more and more crucial during extensive data analysis at down times of LHC and after upgrade

Expected Benefits of HPC:

- Availability of large resources with short I/O times
→ greatly increased throughput
- HPC data centers facilitate easy exchange of results between theory and experiment

HPC Experience at NERSC



- Initially large MPI overhead in pQCD MC when run on many nodes
- Discussions with S. Habib → removed bottlenecks (yesterday!)
- **Much to gain from HPC experience in Cosmology / Lattice QCD**

Summary

- Draft white paper on HPC/HTC for HEP circulated collecting responses from community
- HPC at NERSC tested for cutting edge pQCD / MC
~ scaling shown, ready for production
- Small-scale MPI runs also tested on OSG
Thanks to G. Garzoglio, T. Levshina, M. Slyz!

Ongoing Activities:

- HPC tutorial at East Coast meeting of the Energy Frontier
- Signing up people with interest in HPC for Snowmass study
- Build knowledge base “HPC for THEP”