Outlook and Gaps for Future Nuclear Physics Program: Gaps in QCD global analysis

Nobuo Sato
ODU/JLab

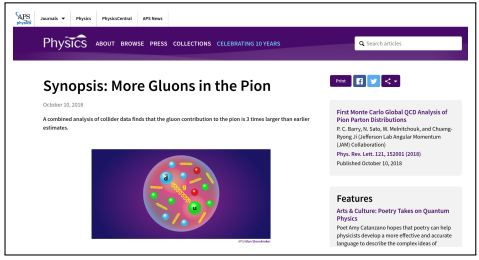
Jefferson Lab 12-GeV Experimental Computing Review
JLab, 2018

JAM highlights

- Barry, NS, Melnitchouk, Ji
  Phys. Rev. Lett. **121**, 1525001 (2018)

- Lin, Melnitchouk, Prokudin, NS, Shows
  Phys. Rev. Lett. **120**, 152502 (2018)

- Ethier, NS and Melnitchouk
  Phys. Rev. Lett. **119**, 132001 (2017)

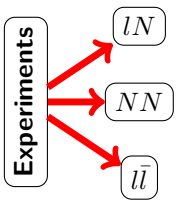


featured in APS

- NS, Ethier, Hirai, Kumano, Melnitchouk, Accardi
  Phys. Rev. D **94**, 114004 (2016)

- NS, Melnitchouk, Kuhn, Ethier, Accardi
  Phys. Rev. D **93**, 074005 (2016)

Global analysis in a nutshell



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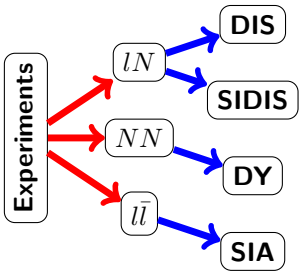

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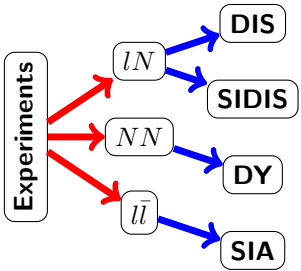

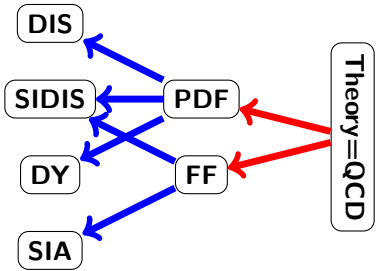

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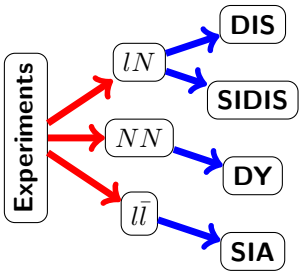

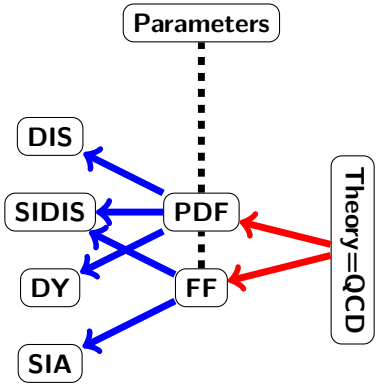

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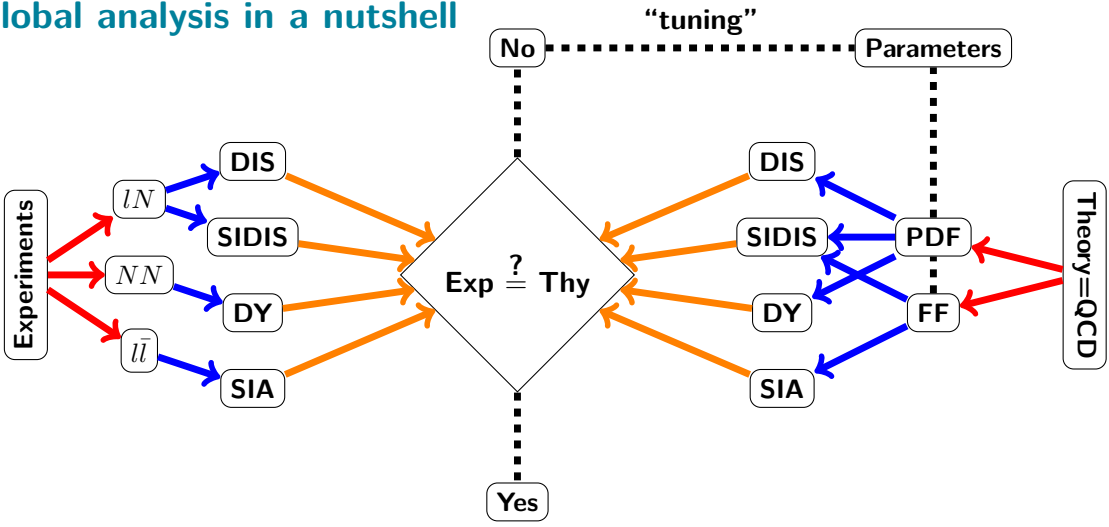

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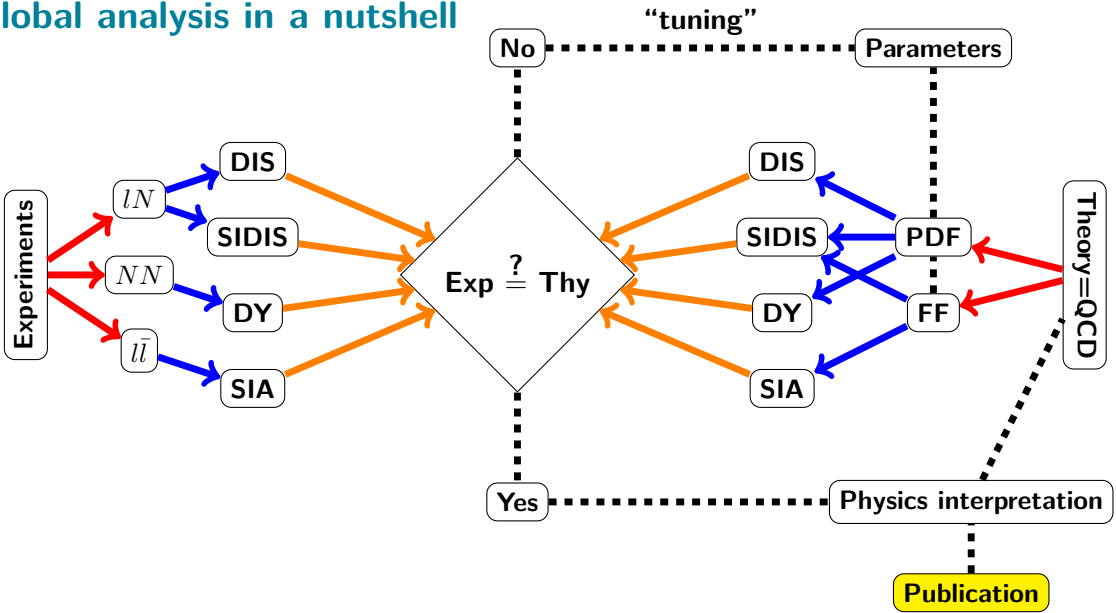

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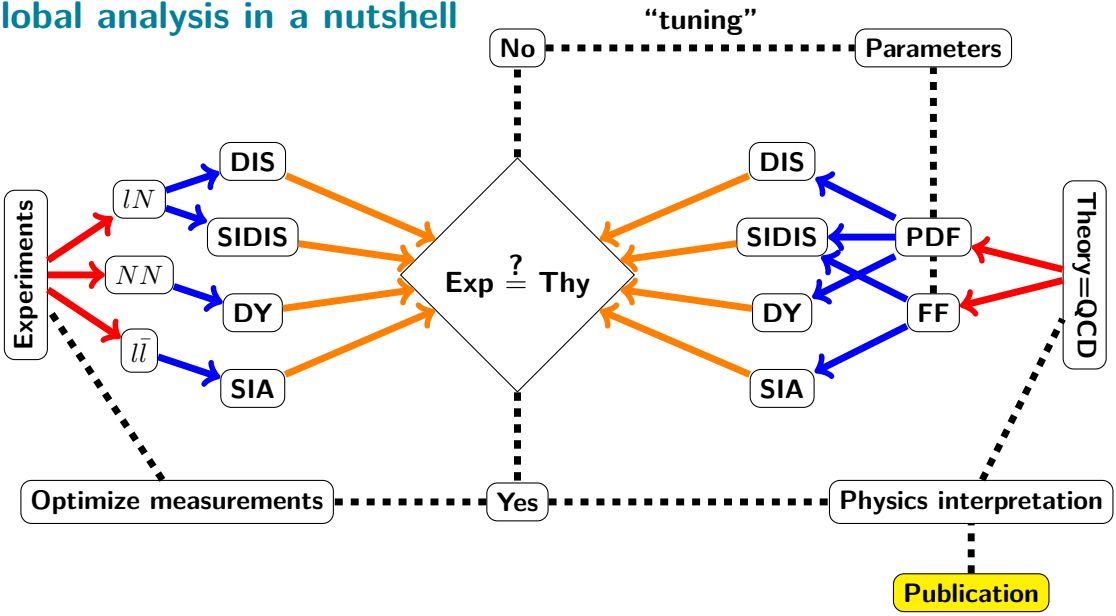
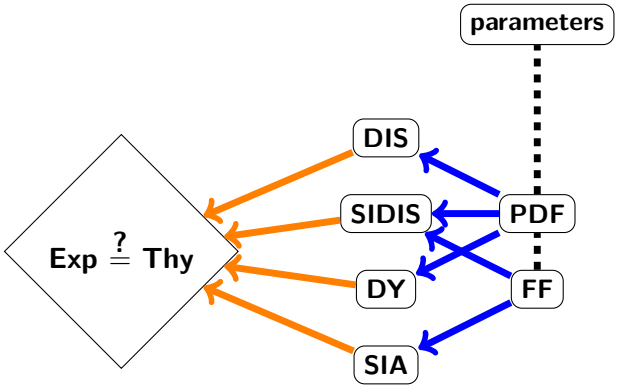
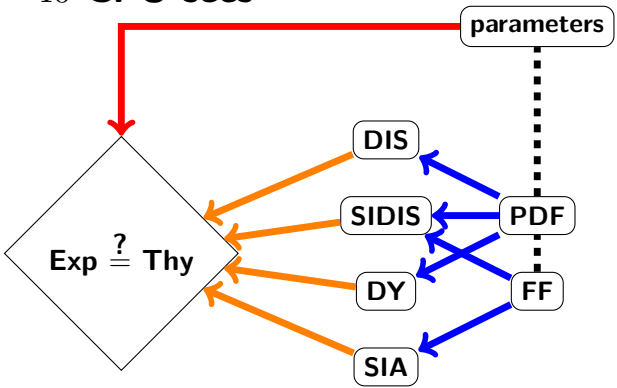


Metrics (Collinear PDFs and FFs)



Metrics (Collinear PDFs and FFs)

~ 40 **CPU secs**



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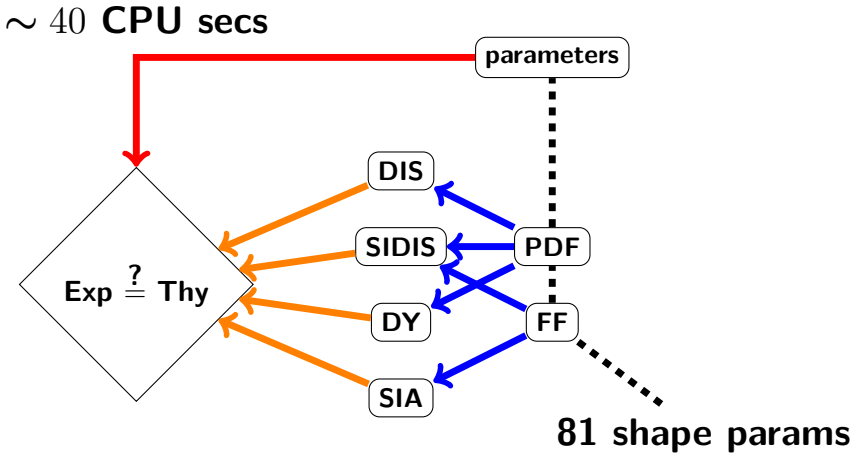

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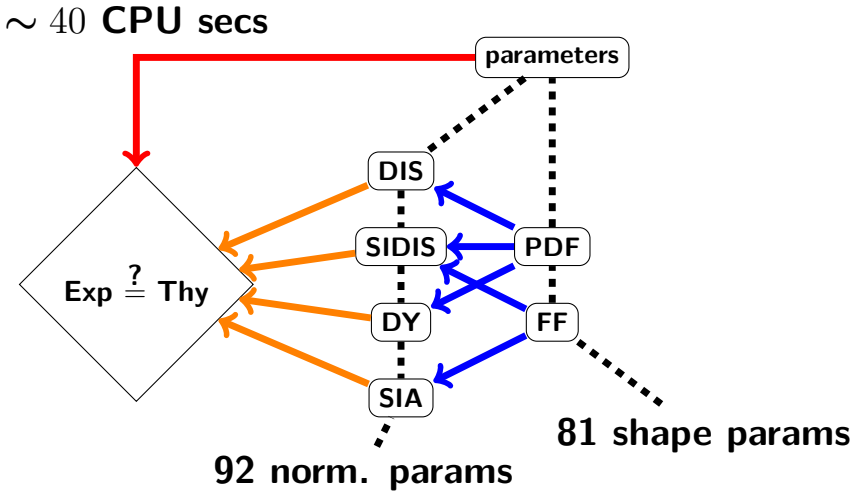

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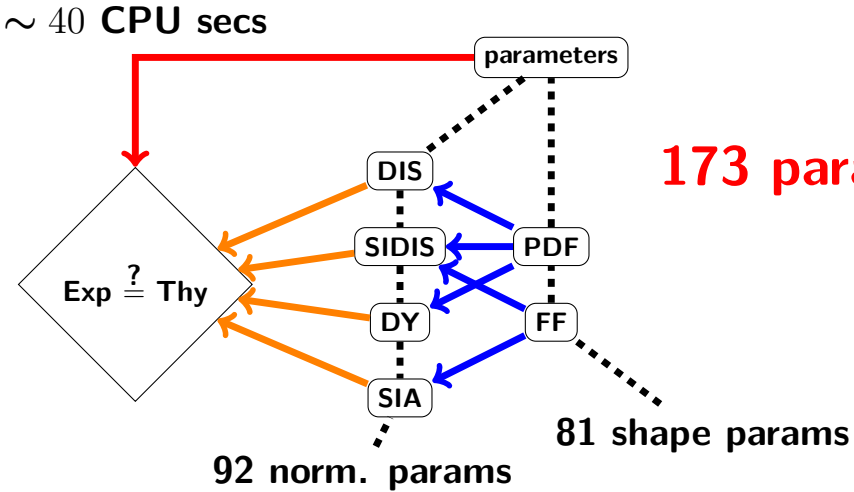
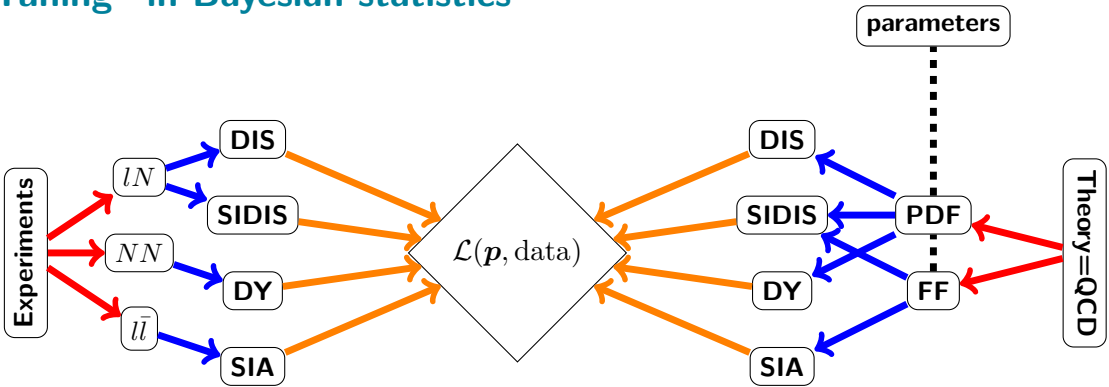


173 parameters

“Tuning” in Bayesian statistics



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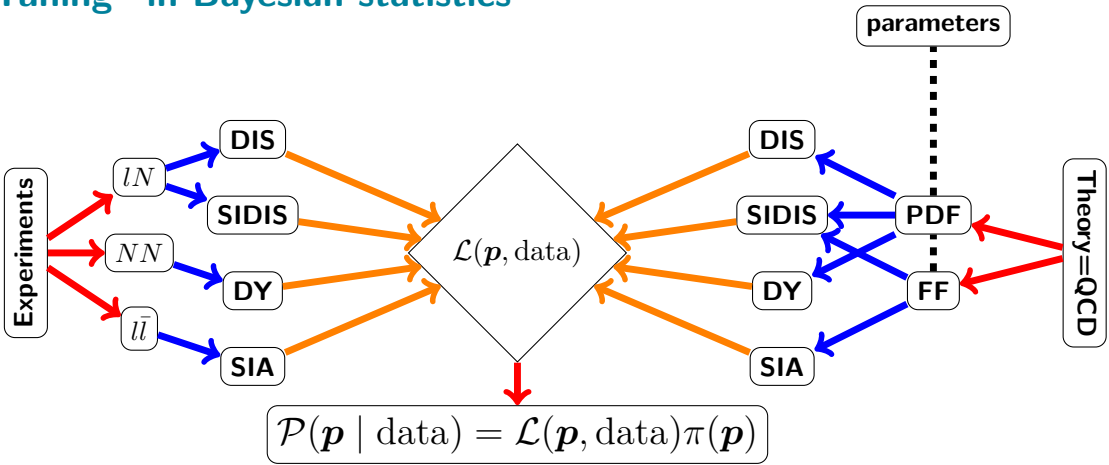

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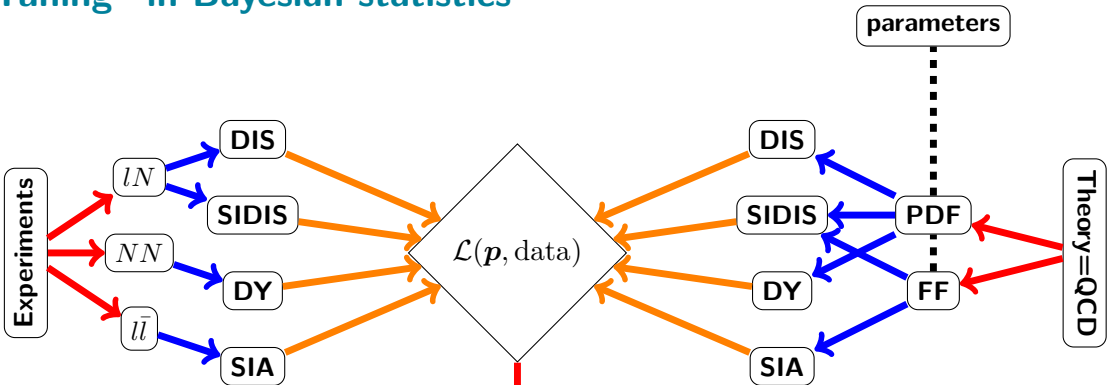
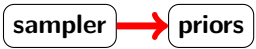


Iterative Monte Carlo approach



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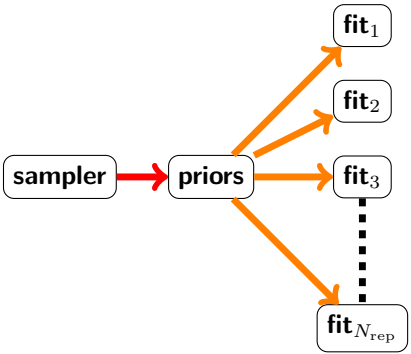

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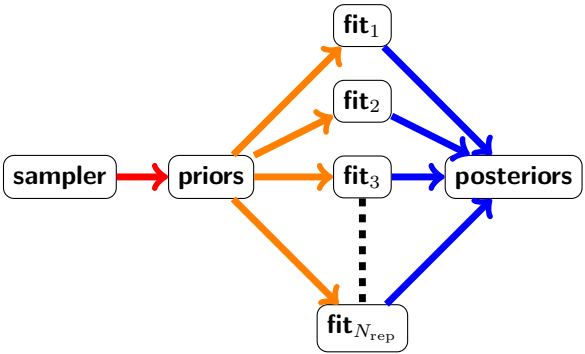
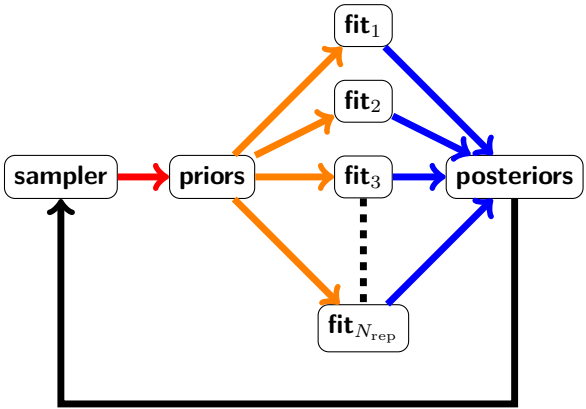
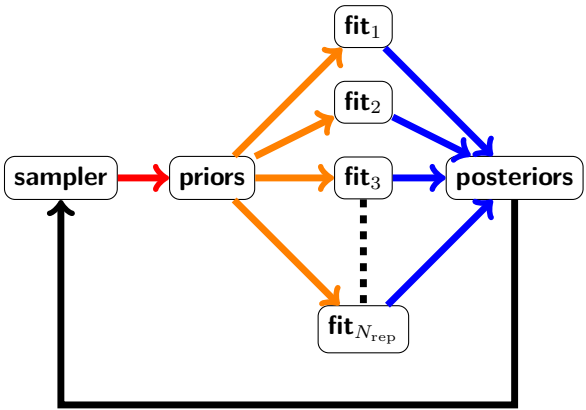


Iterative Monte Carlo approach



repeat $N_{\rm iter}$ until convergence

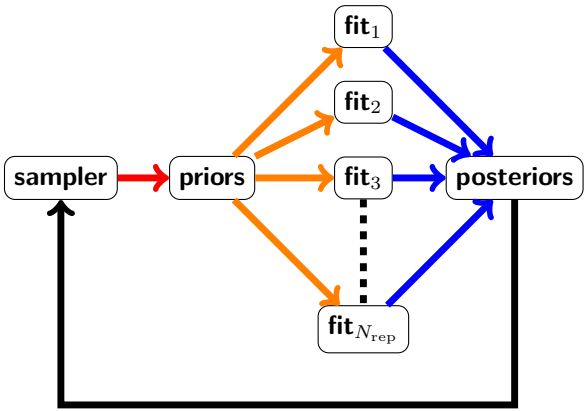
Iterative Monte Carlo approach



Collinear PDF and FFs

- $N_{\rm params} = 173 \rightarrow N_{\rm steps} = 30k$
- $\tau_{\rm cpu/step} \sim 40$ secs
- $N_{\rm samples} = N_{\rm steps} \times N_{\rm rep} \times N_{\rm iter}$
  $= 30k \times 1k \times 20$
- $\tau_{\rm total} \sim 7,000,000$ hours/trial

Iterative Monte Carlo approach



TMD PDF and FFs

- $N_{\text{params}} = 173 \rightarrow N_{\text{steps}} = 30k$
- $\tau_{\text{cpu/step}} \sim 10$ mins
- $N_{\text{samples}} = N_{\text{steps}} \times N_{\text{rep}} \times N_{\text{iter}}$
  $= 30k \times 1k \times 20$
- $\tau_{\text{total}} \sim 100,000,000$ hours/trial

What can help?

- **Hardware for testing and development**
  - + Currently we have laptops and a single 10-core workstation (ODU)
  - + For 3 developers, a set of 3 16-core workstations has been requested
  - + Interactive farm is limited for testing
- **GPU integration**
  - + The tensor contractions are computationally expensive
  - + A summer intern (2019) will be implementing the calculations on GPU
  - + nvidia enabled GPU has been requested

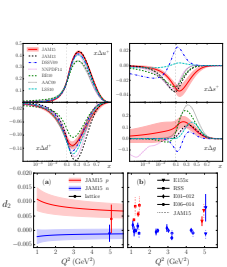
What can help?

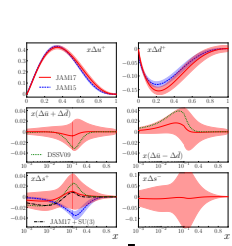
- **Parallelization and cluster computing**
  - In the past IT helped to develop parallelization using ZMQ
  - However, more development is needed
  - Assistance to find optimal strategy to use cluster computing
  - Resource allocation for global analysis (JAM)
    - allow all developers to run on the farm
    - dedicated data storage allocation

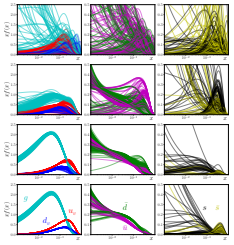
What can help?

- **Computing outside Jlab**
  - **AWS**
    - $4k (JSA postdoctoral award) was utilized to run jobs on AWS
    - pretty expensive → need to have a specialist to diagnose proper usage
  - **NERSC**
    - till end of 2018, Kostas Orgino's his lattice resources at William & Mary
    - maybe is time to plan a request to NERSC → assistance is needed

Summary and outlook







webfitter

JLab 12/RHIC

TMDs

2015

2016

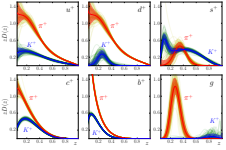
2017

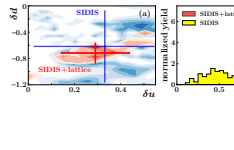
2018

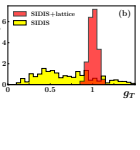
2019

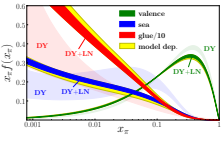
2020

EIC









Jefferson Lab Angular Momentum Collaboration