



# Evaluating IBM POWER Architecture for Deep Learning in High-Energy Physics

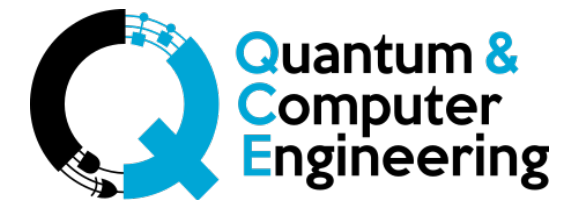
*CERN openlab Workshop 2019*

Ahmad Hesam

23/01/2019

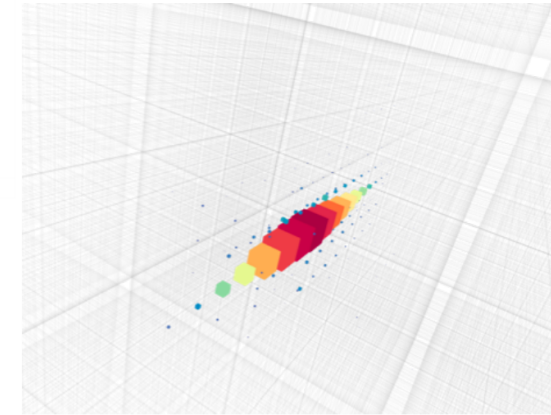
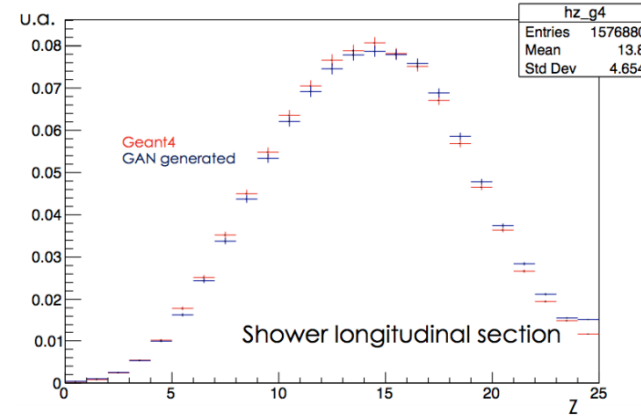
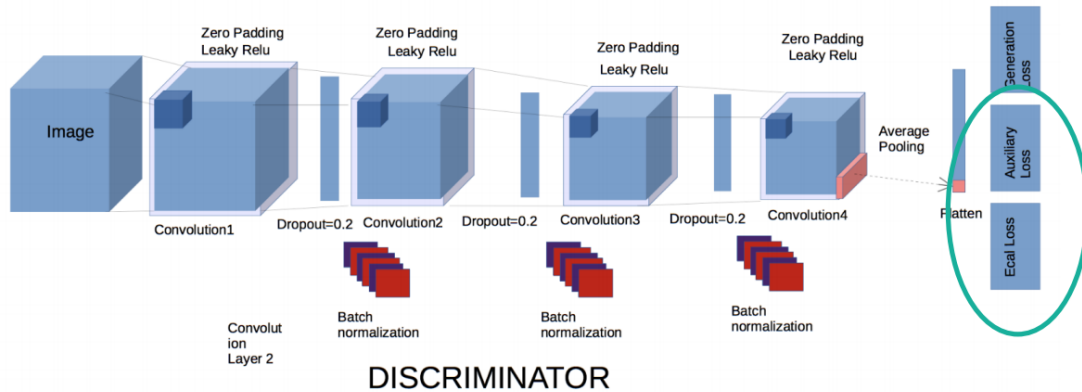
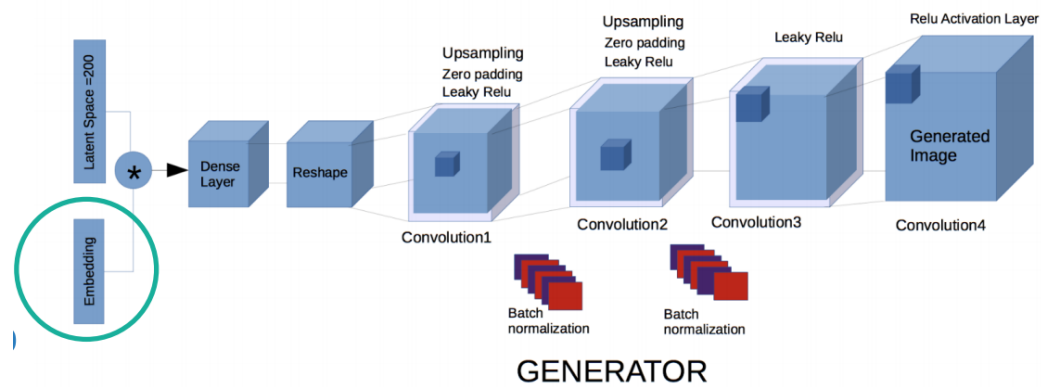
# About Me

- PhD Student from Delft University of Technology
- Quantum and Computer Engineering department
- Research on DL in HEP at CERN openlab in collaboration with IBM



# 3D GAN Architecture

~ 25h training on single P100!



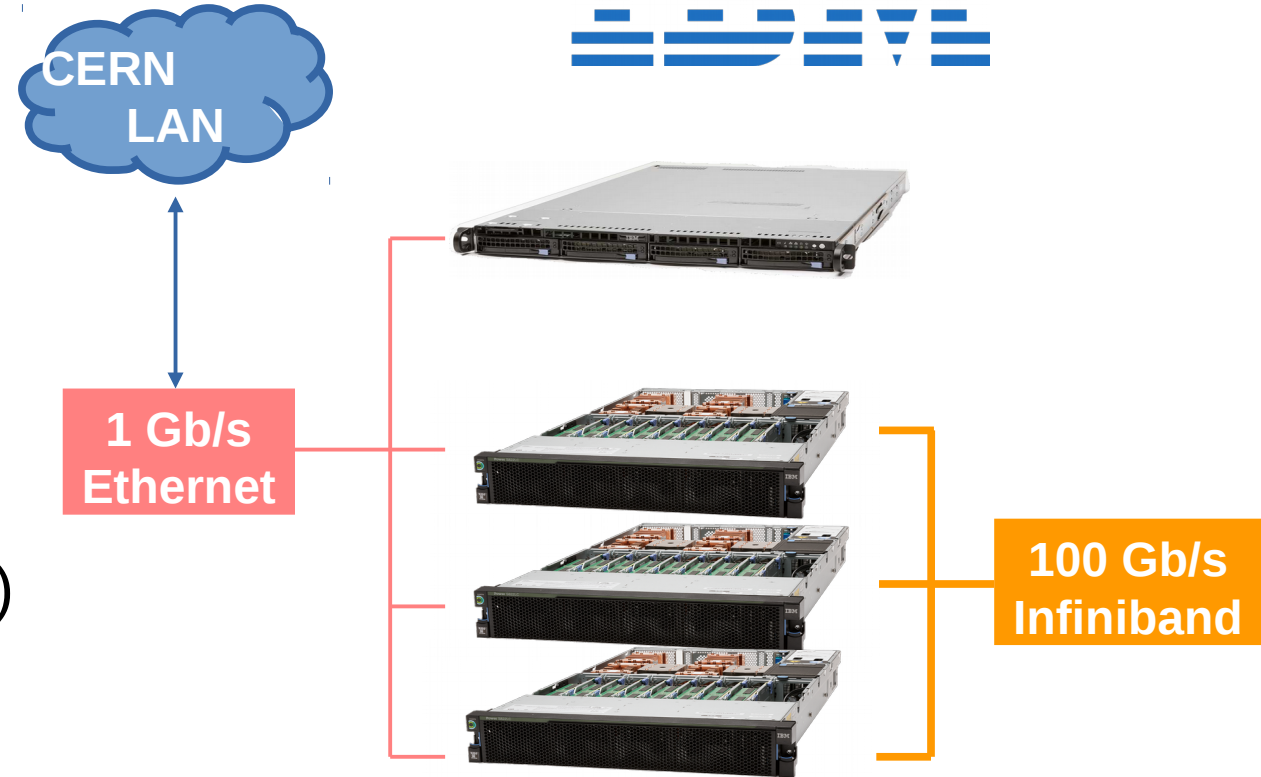
# IBM Minsky

## 1x IBM SC821LC (login node)

- 1x POWER8 socket (=8 cores)
- 64 GB DDR4

## 3x IBM SC822LC (worker nodes)

- 2x POWER8 sockets (=16 cores)
- 4x NVIDIA P100
- CPU ↔ GPU NVLink
- 256GB DDR4



# IBM Minsky

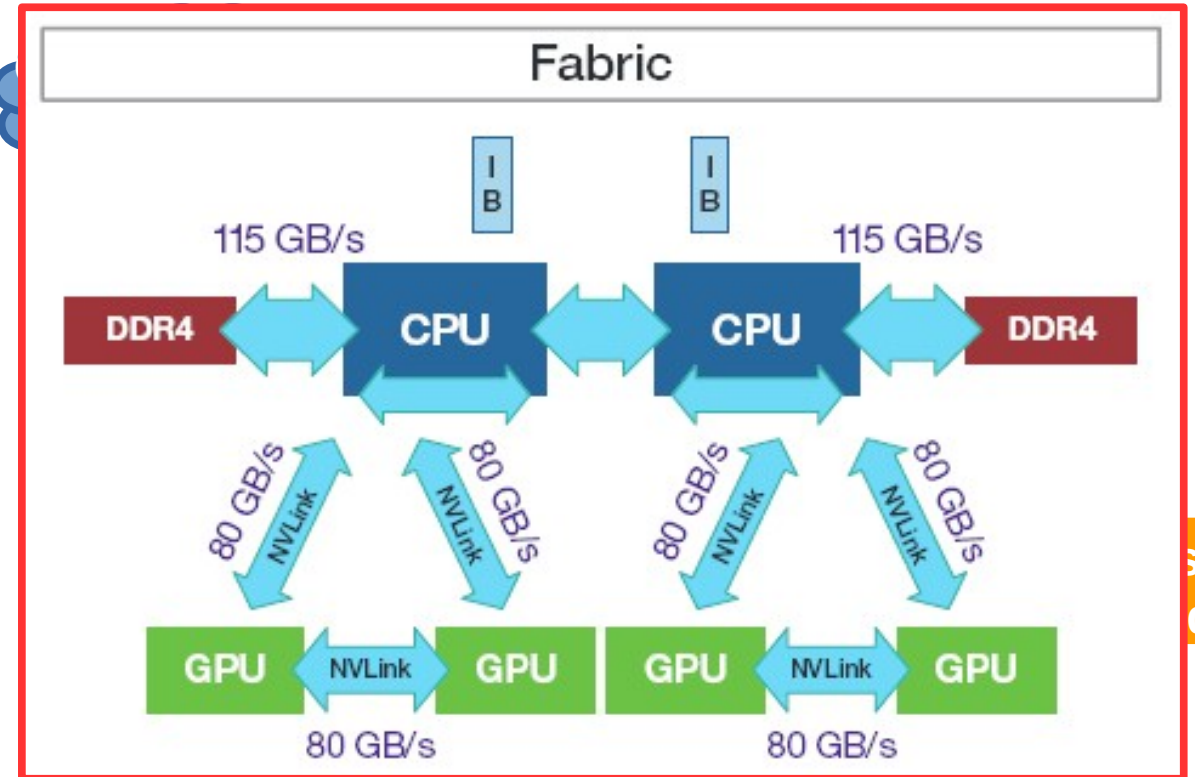
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TDM



<http://developercongress2017.openpowerfoundation.org/wp-content/uploads/2017/05/Porting-Applications-to-OpenMP4.5.pdf>

# IBM Deep Learning Stack

## PowerAI Software Distribution: Optimized for Power

Deep Learning Frameworks & Enhancements

 TensorFlow

 Distributed Deep Learning

 Caffe

 Large Model Support

 IBM Caffe

 AI Vision Tools

 Watson APIs

Supporting Capabilities And Libraries

Distributed Frameworks

 NVIDIA DIGITS

 AI Vision Runtime

OpenBLAS

 IBM Spectrum Conductor

 Bazel

 IBM Data Science Experience

 NVIDIA NCCL

IBM Services And Support

 Entire Stack Support

 Pioneering AI Research

 Education & Certification


 Optimization and testing

## IBM Power Accelerated Servers: Ideal for PowerAI

IBM Services And Support

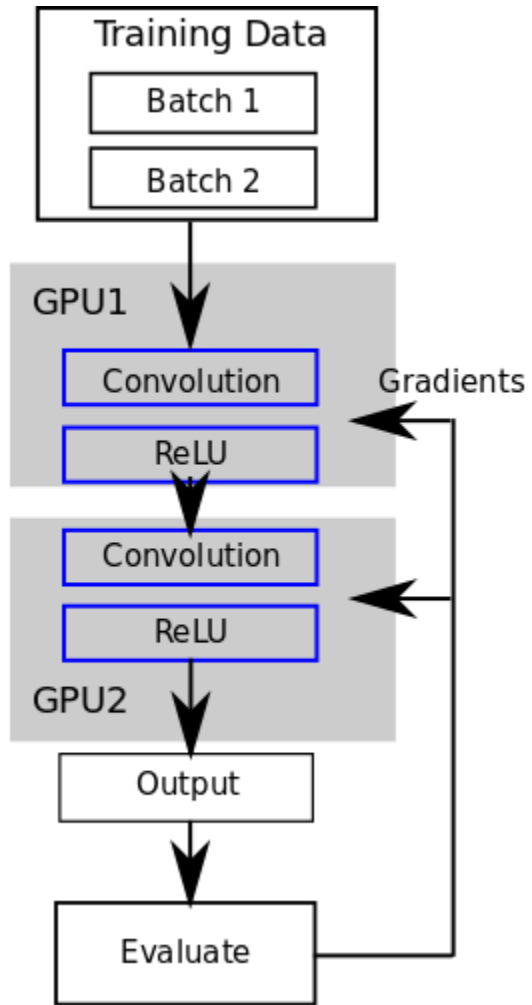
 Acceleration Superhighway

 Designed for The AI era

 Enterprise Grade

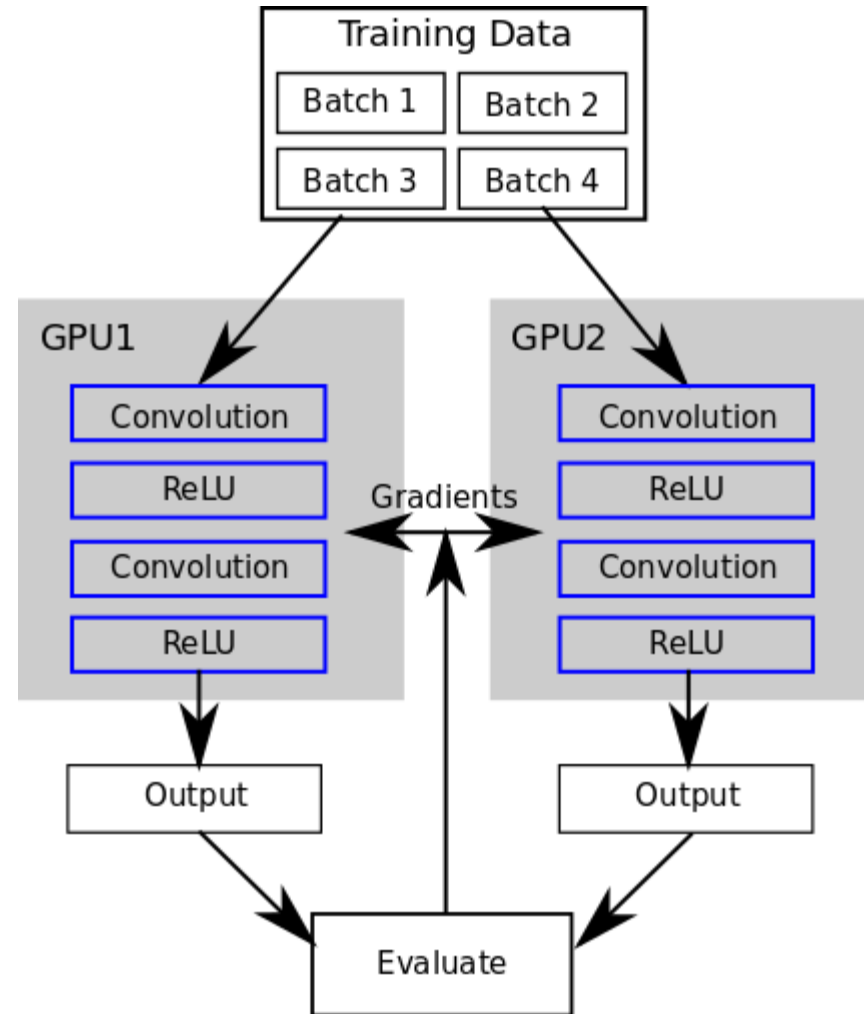
 POWER9 Performance

# Model Parallelism

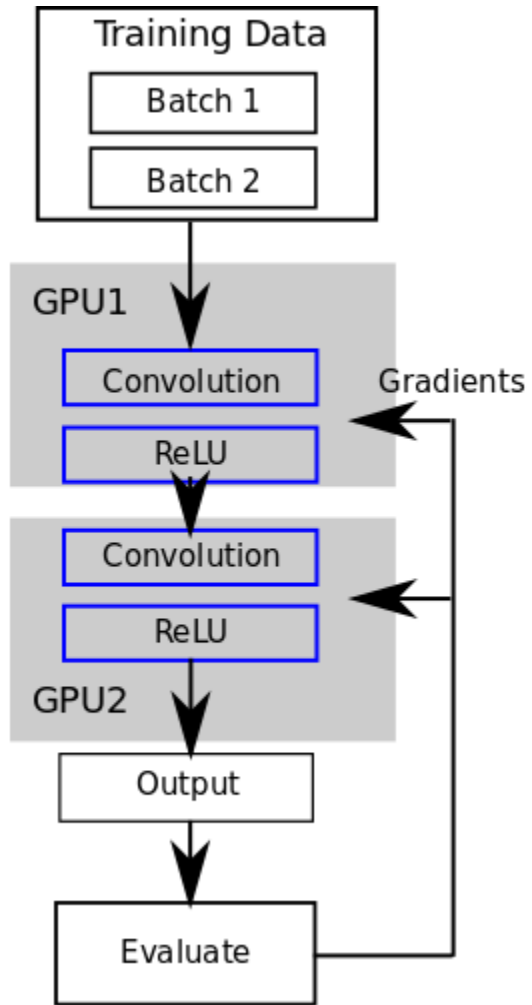


vs.

# Data Parallelism

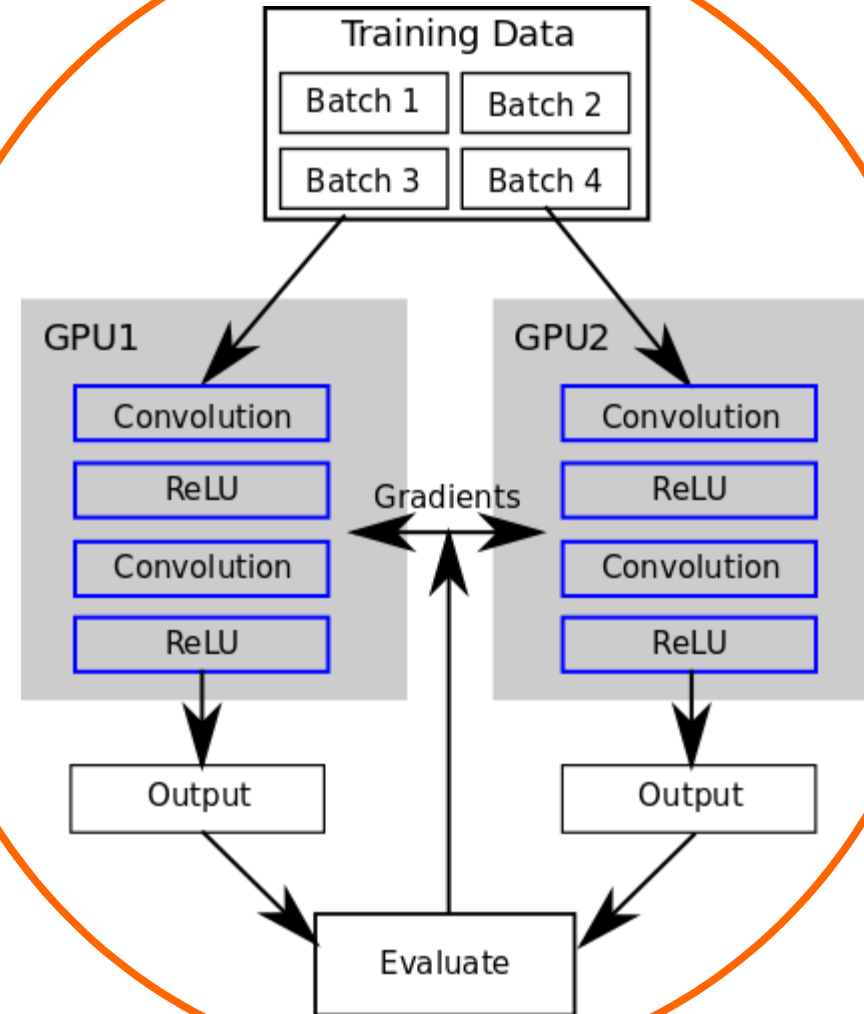


# Model Parallelism



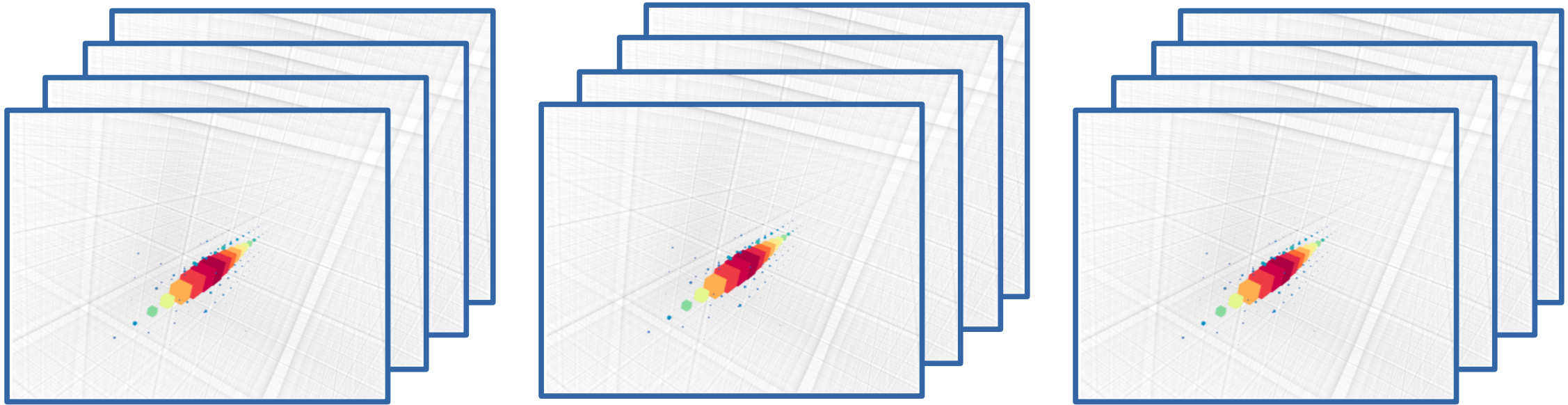
vs.

# Data Parallelism





# Distributed Deep Learning



v2.2.2

+



v1.12.0

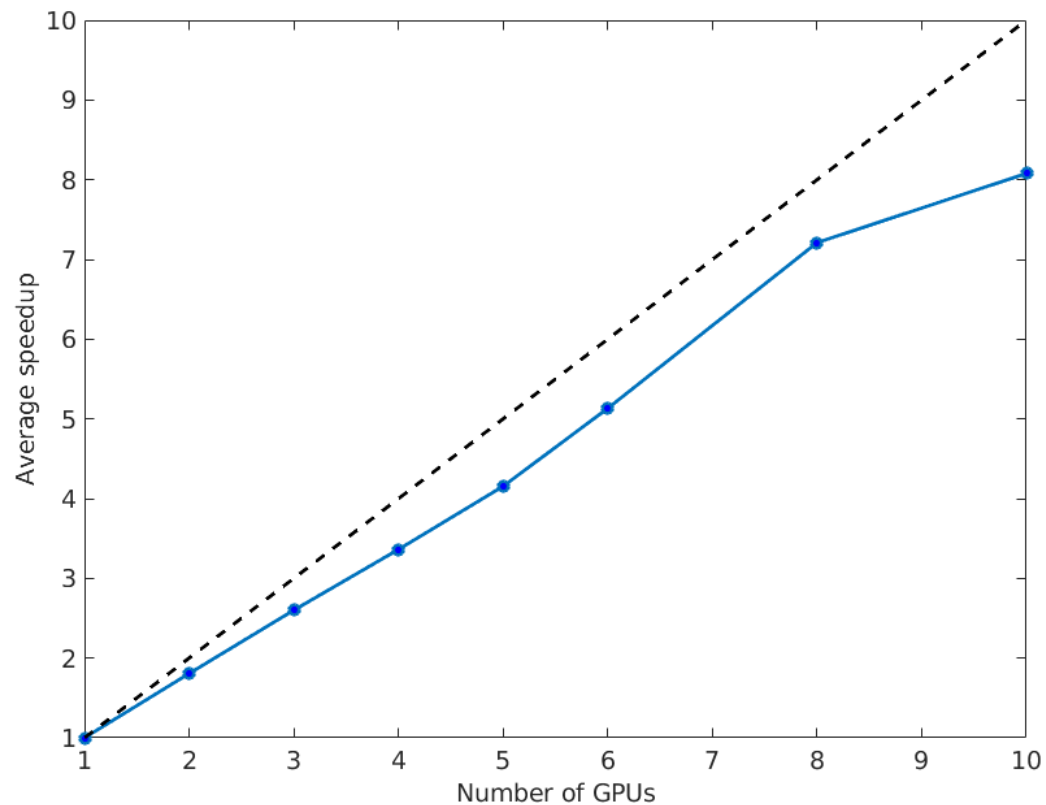
+



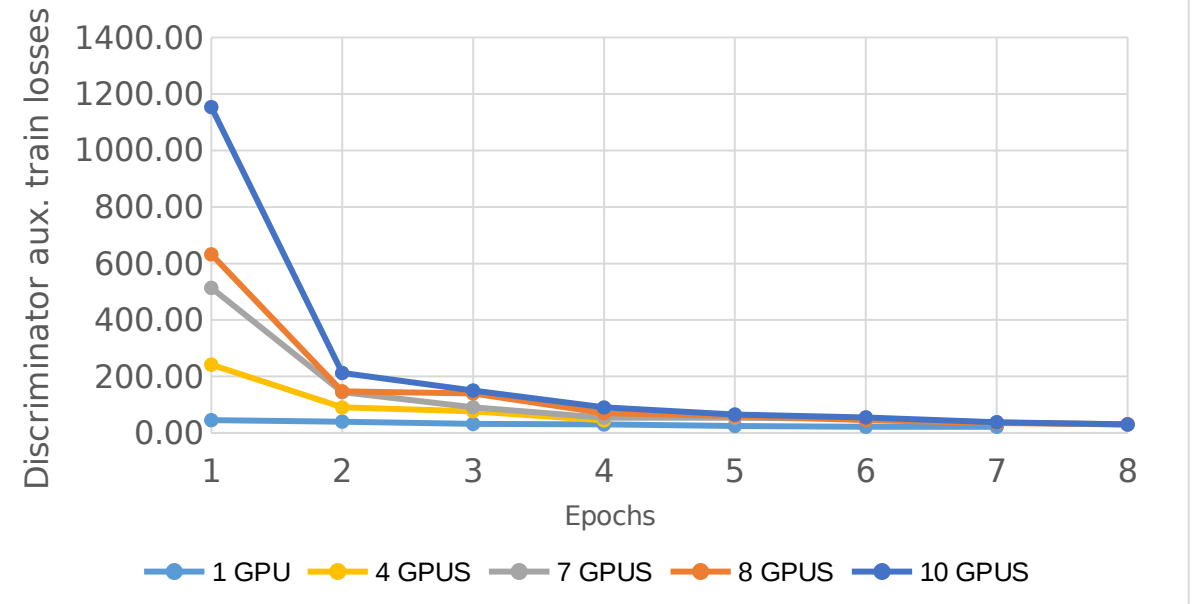
v0.15.1

# Performance Results: Training

Scaling behavior over multiple nodes / GPUs on IBM Minsky

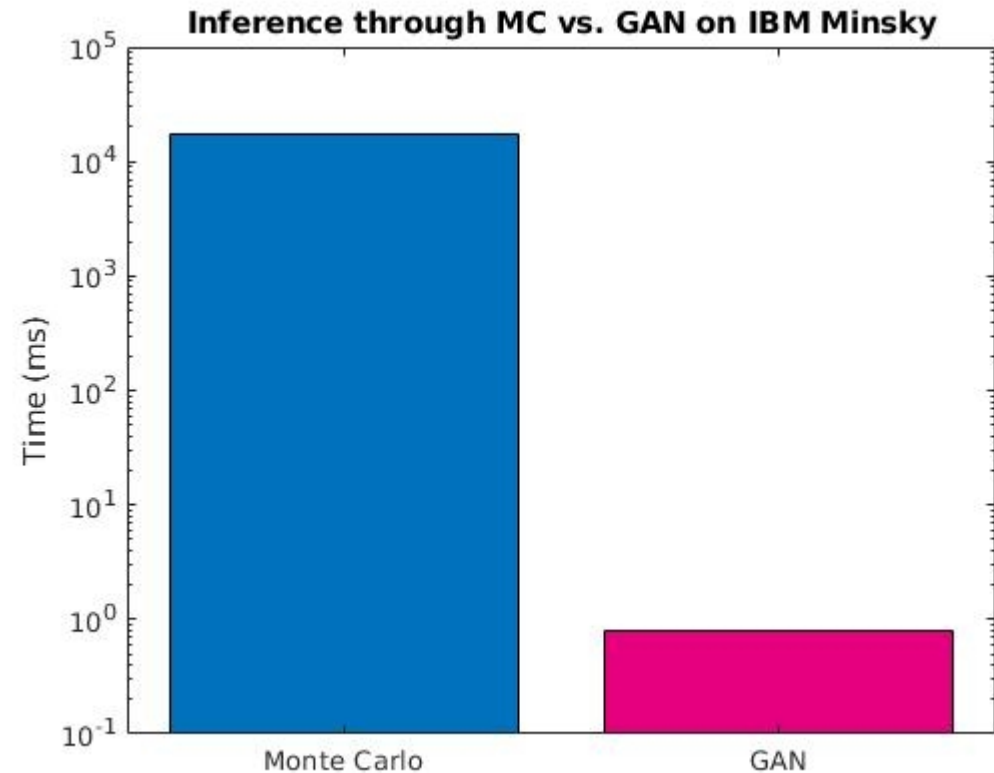


Convergence of losses for distributed learning on IBM Minsky

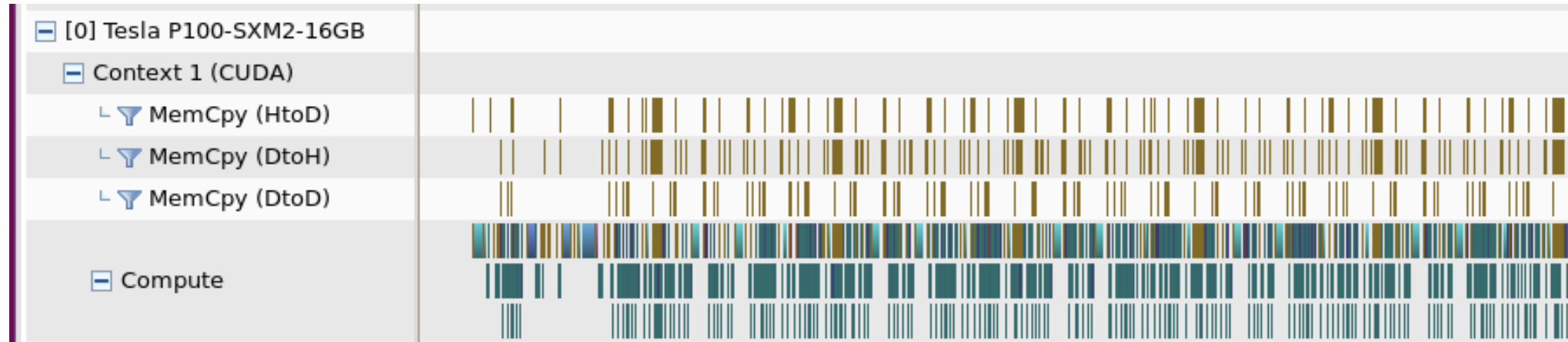


# Performance Results: Inference

- Inference on single P100 GPU
- 17 sec → 0.8 ms
- 4 orders of magnitude improvement



# Performance Results: NVLink



High bandwidth interconnects alleviates stalls for memcpy operations → higher throughput

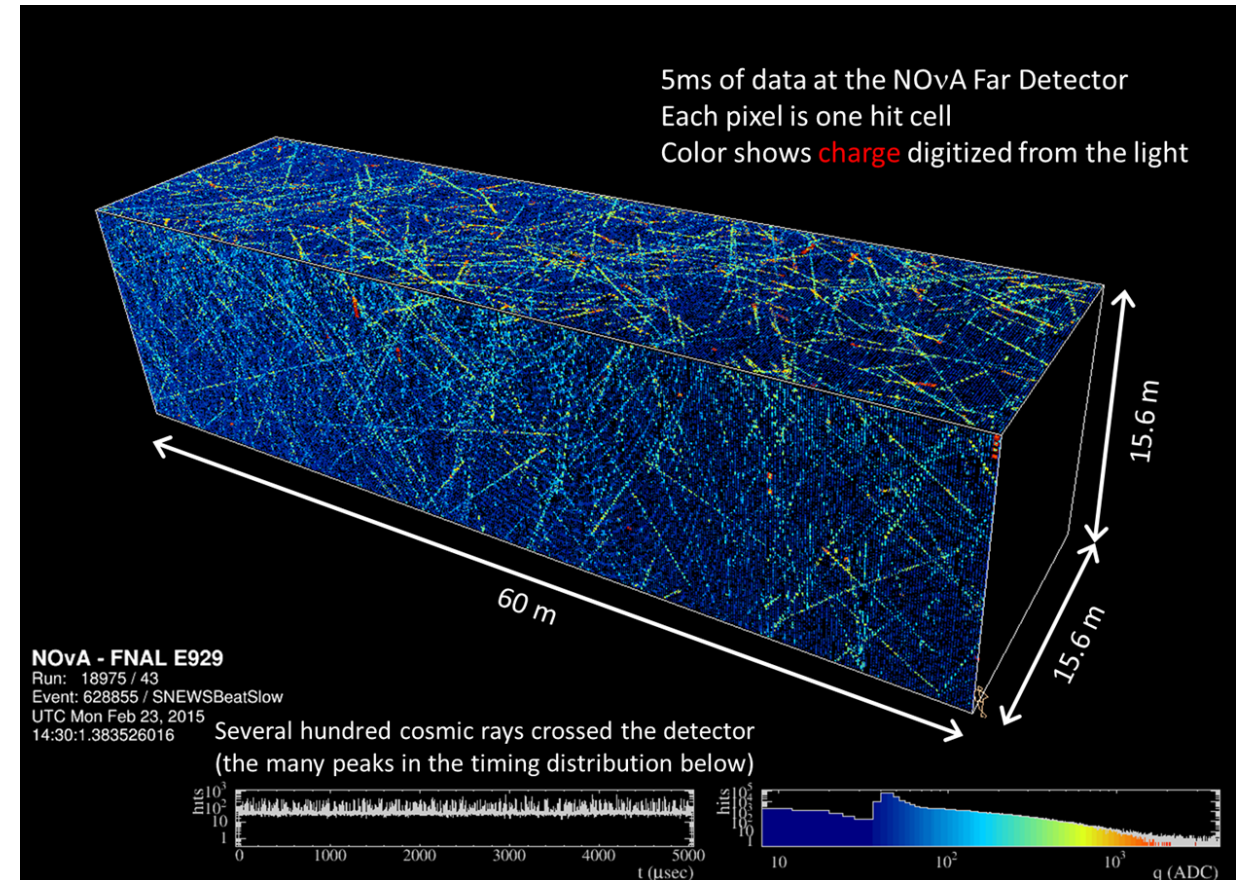
# Conclusion: POWER for DL

- 25 hours of training → 3 hours of training on 10 GPUs over 3 nodes
- Convergence of losses for varying number of GPUs
- NVLink between CPU ↔ GPU enables high throughput

# Upcoming PhD Research



- Deep Learning approach for offline event reconstruction in DUNE neutrino experiments
- Find novel methods of harnessing the cutting-edge in HPC
- Large data sets → strain on memory bandwidth → IBM is adapting its architecture towards this trend



Example of a neutrino event data display (NovA Experiment)



# QUESTIONS?

Ahmad Hesam

[ahmad.hesam@cern.ch](mailto:ahmad.hesam@cern.ch)