University of Minho
Department of Informatics

LABORATÓRIO DE INSTRUMENTAÇÃO E
FÍSICA EXPERIMENTAL DE PARTICULAS
LIP

EFFICIENT PROCESSING OF ATLAS EVENTS ANALYSIS IN HOMOGENEOUS AND HETEROGENEOUS PLATFORMS WITH ACCELERATOR DEVICES

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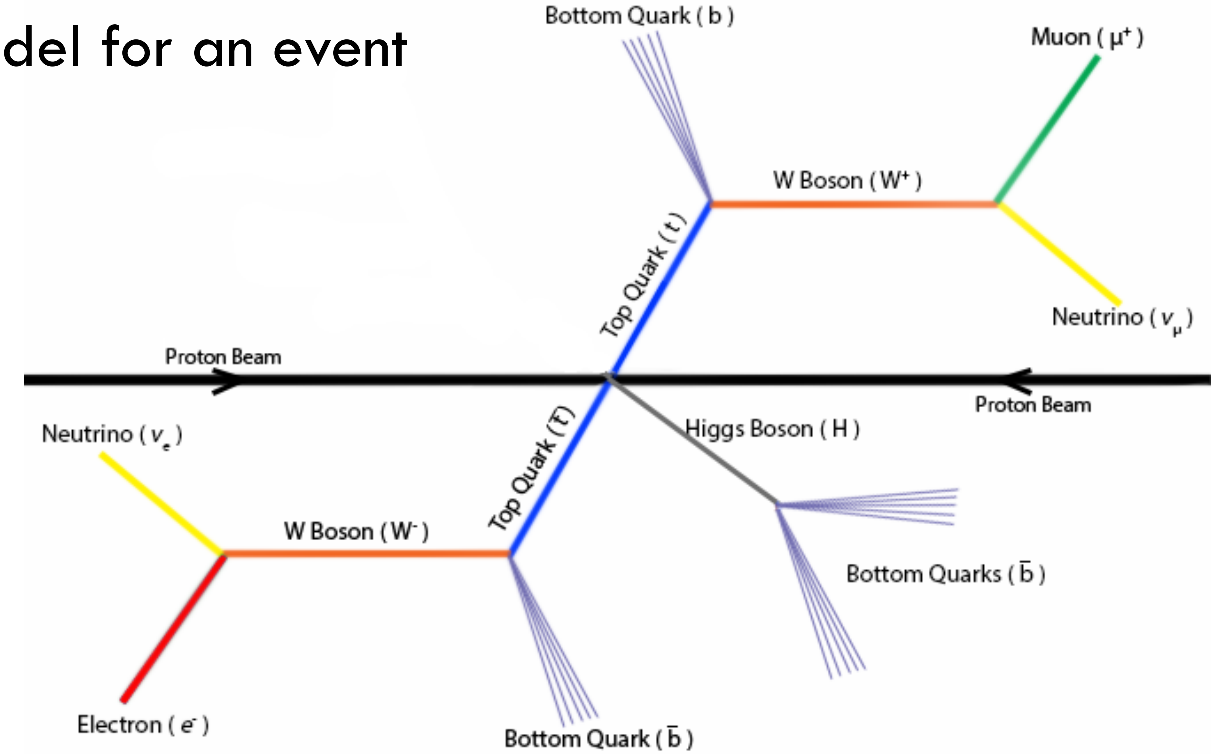
Overview

- Motivation
- Structure of `ttH_dilep`
  - Analysis of critical regions
- Improving efficiency through parallelism
  - On shared memory homogeneous systems
  - On heterogeneous systems with a GPU accelerator
  - Efficient data & workload scheduling

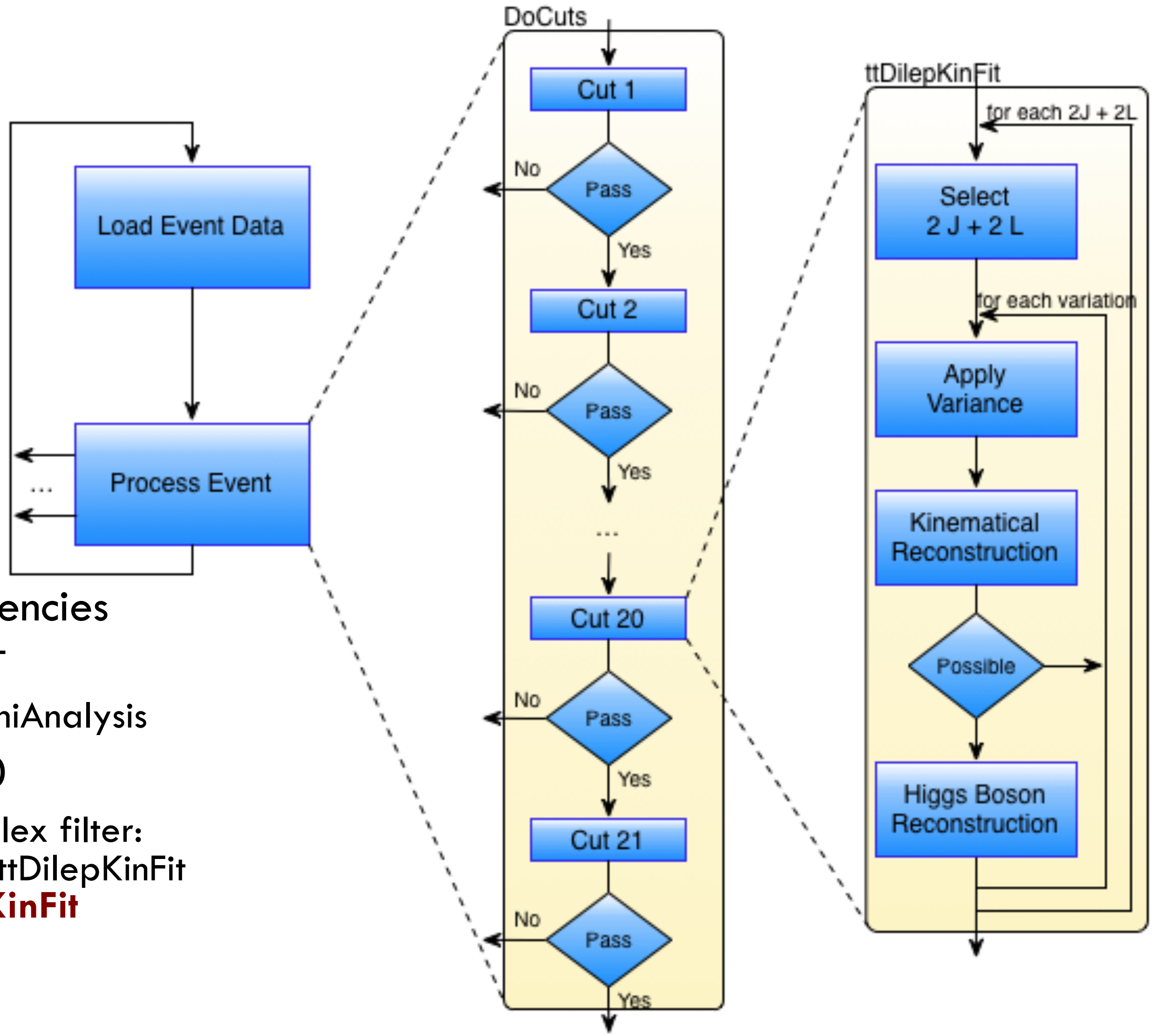
Motivation

- The target model for an event



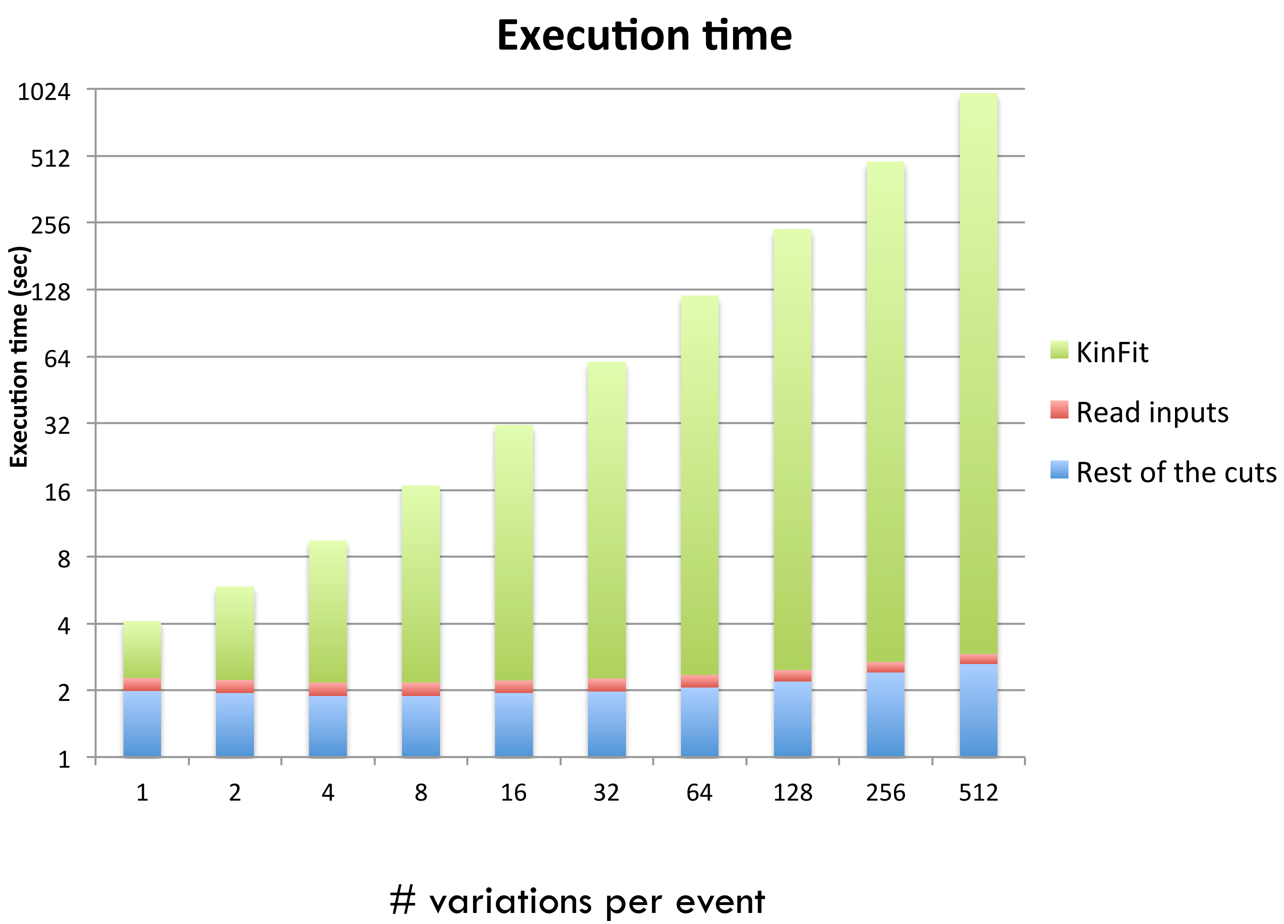
- Reconstruction of the Top Quarks (t&$\bar{t}$) system with Higgs boson
  - the analysis and reconstruction code => ttH_dilep
- Goal: to improve the efficiency of ttH_dilep

Structure of ttH_dilep (3)



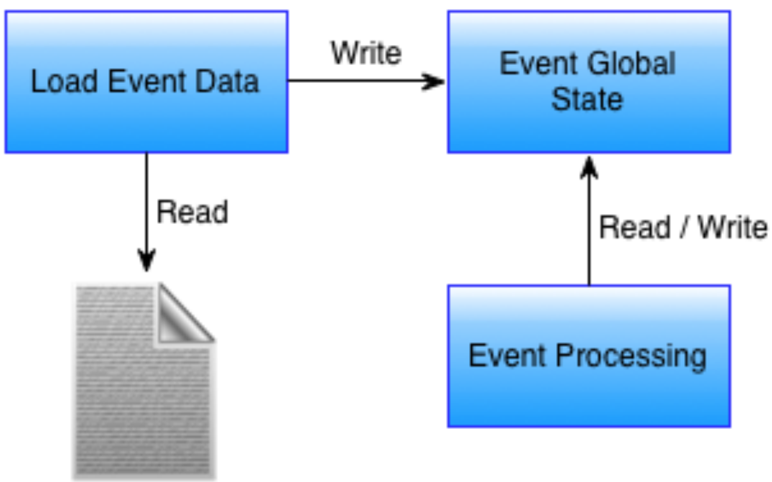
- Dependencies
  - ROOT
  - LipMiniAnalysis
- Cut #20
  - Complex filter:
    ttDilepKinFit
    aka **KinFit**

Critical regions

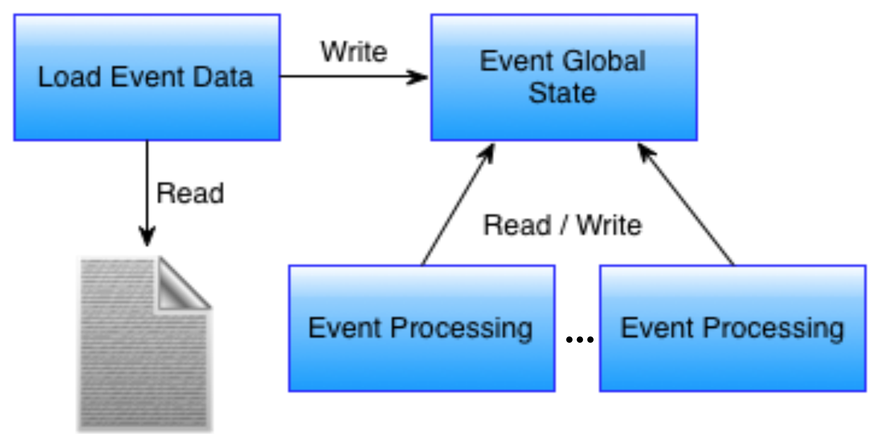


Improving efficiency with parallelism…

Sequential

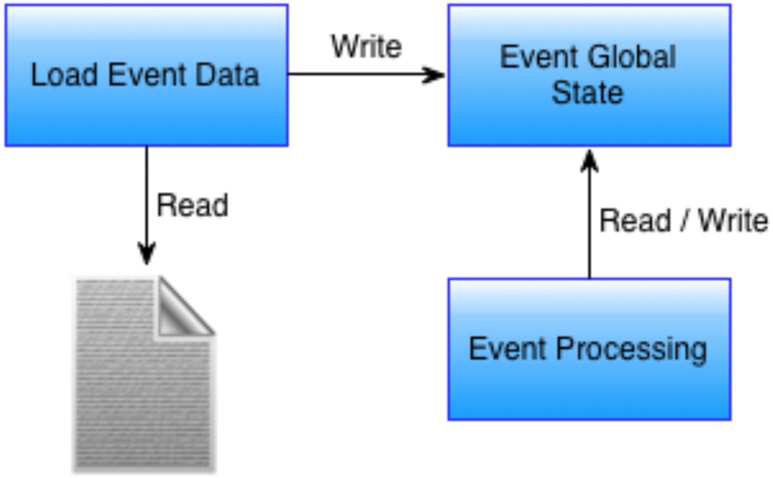


Parallel

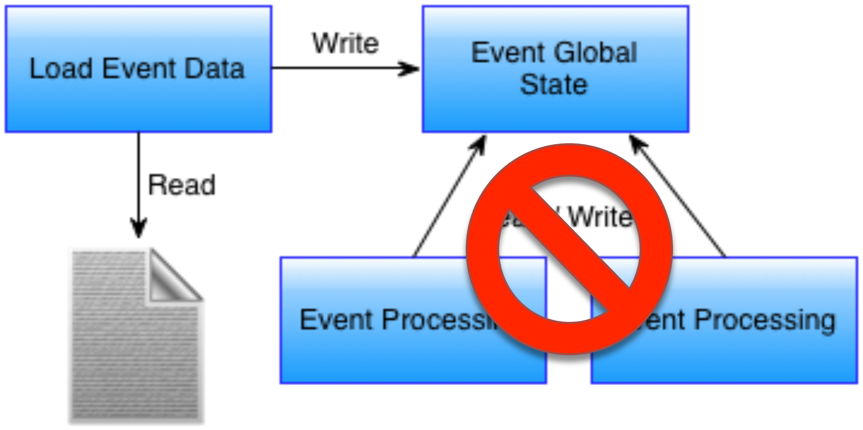


… no way with single global state!

Sequential

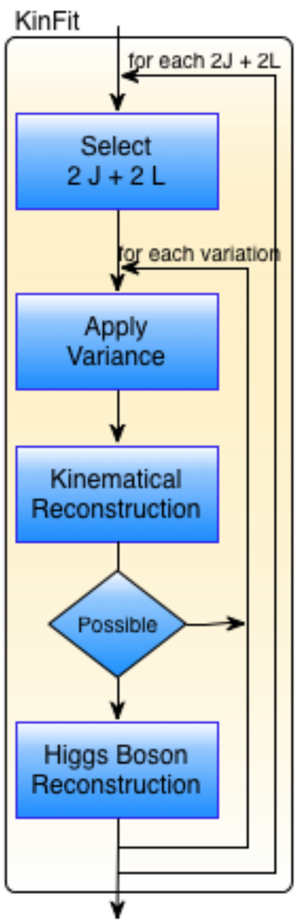


Parallel

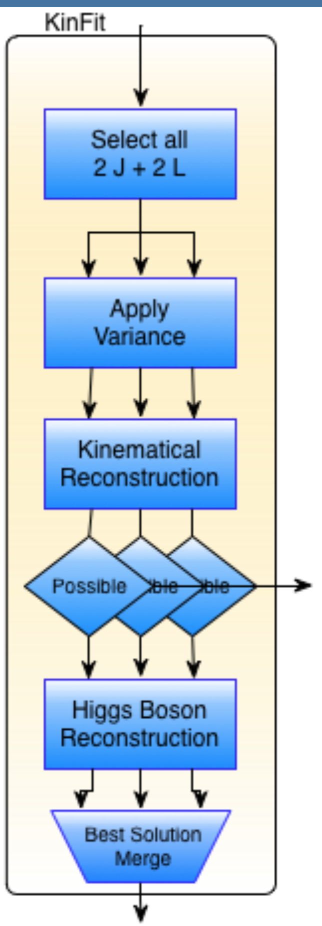


Approach 1: parallelize KinFit, shared memory, no h/w accelerators

Sequential



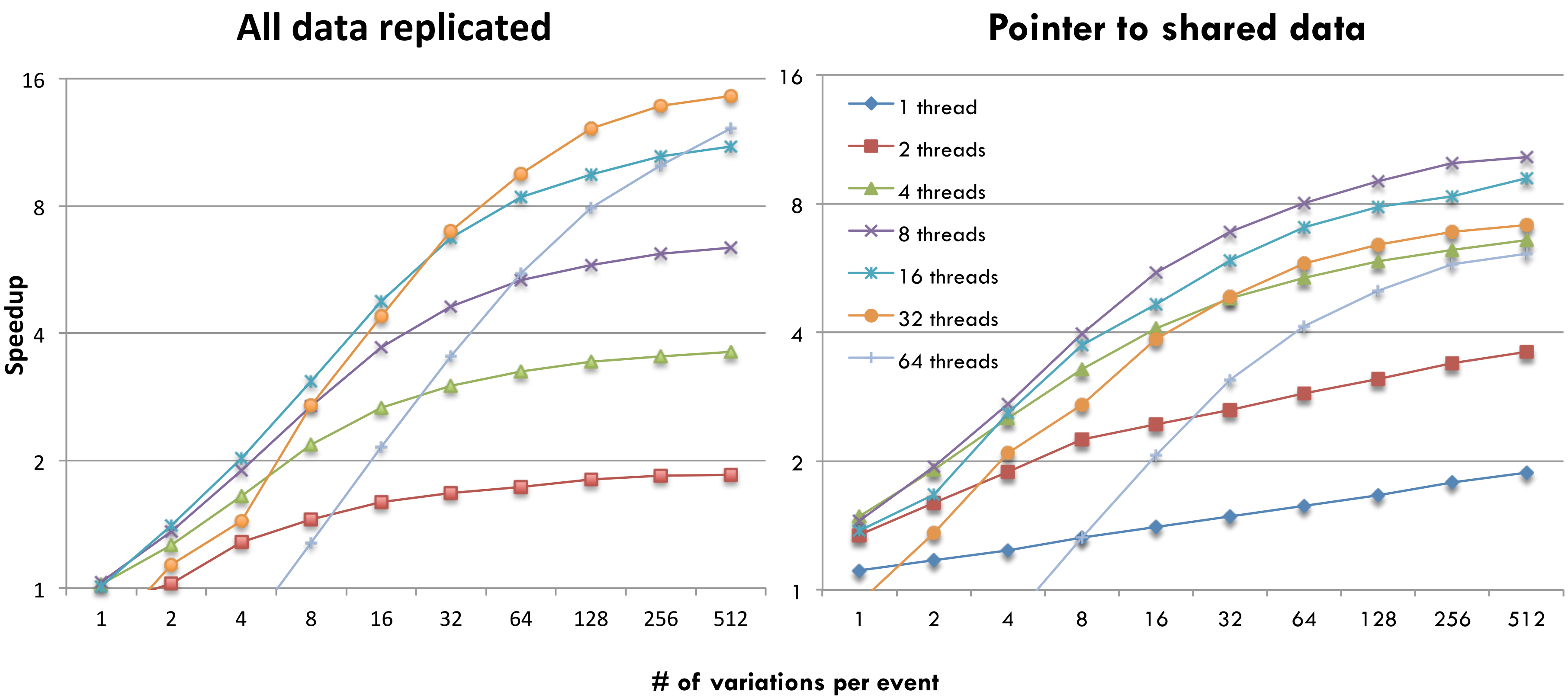
Parallel



- Selects all sets of <u>2 jets & 2 leptons</u>, and builds a new data structure for each set
- In parallel:
  - applies a tolerance (variation) to each measure
  - performs a kinematical and Higgs boson reconstructions
  - selects the best solution (reduction)
- The new data structure:
  - all data are replicated; or
  - common data share a pointer

Performance analysis (1)

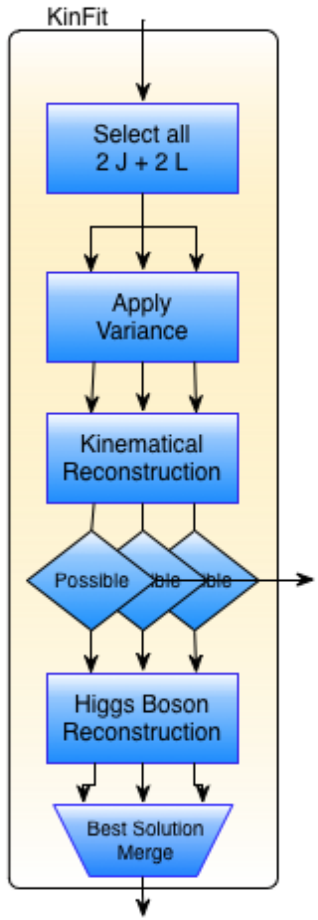
System: 2 x Intel E5-2670 (total 16 cores, 32 threads)



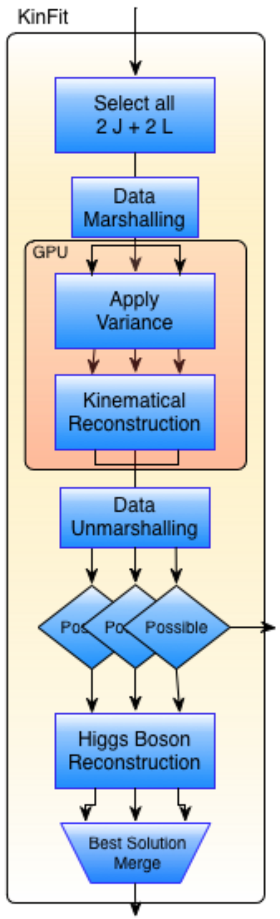
Plots: speedup *versus* the original sequential version

Approach 2: parallelize KinFit, with GPU accelerator (distributed memory)

Parallel, no accelerator



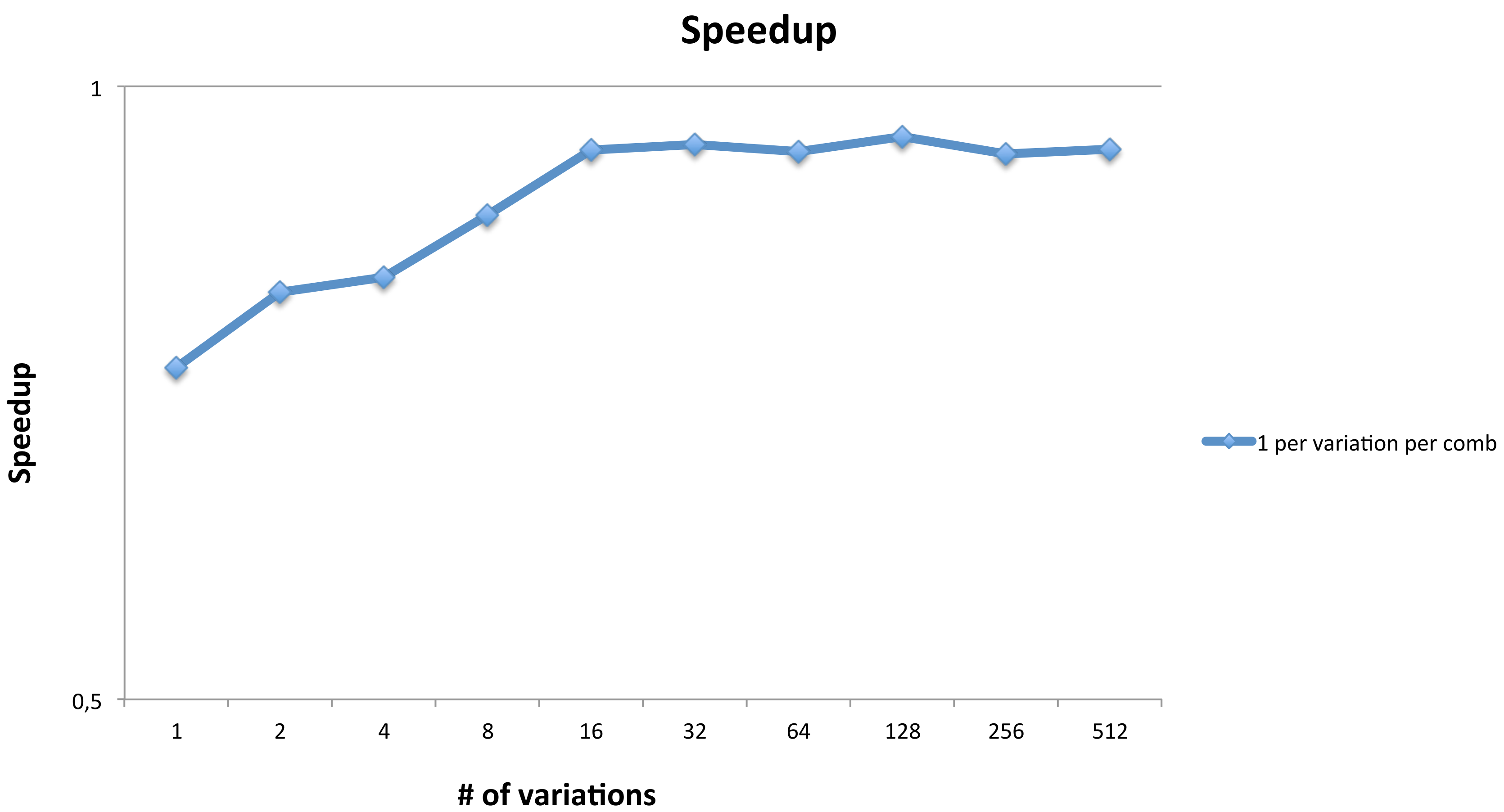
Parallel: multicore + GPU



- Data (un)marshalling:
  - Transform ROOT (and application classes) in arrays to transfer to and from the GPU
- In the GPU:
  - Apply the variance on the inputs
  - Perform the kinematical reconstruction
- Parallel reconstruction of the Higgs boson on CPU

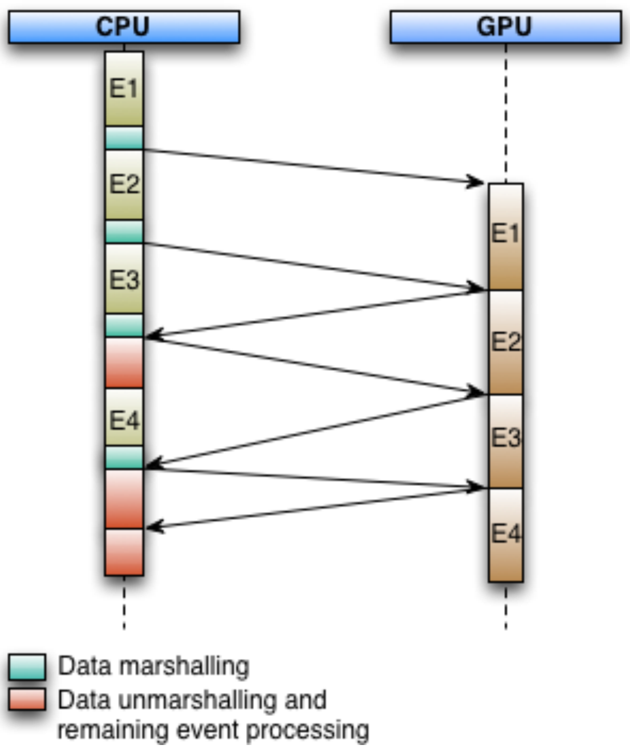
Performance analysis (1)

System: 2 x AMD Opteron 6174 (total 24 cores) and NVidia Tesla Fermi C2050 GPU

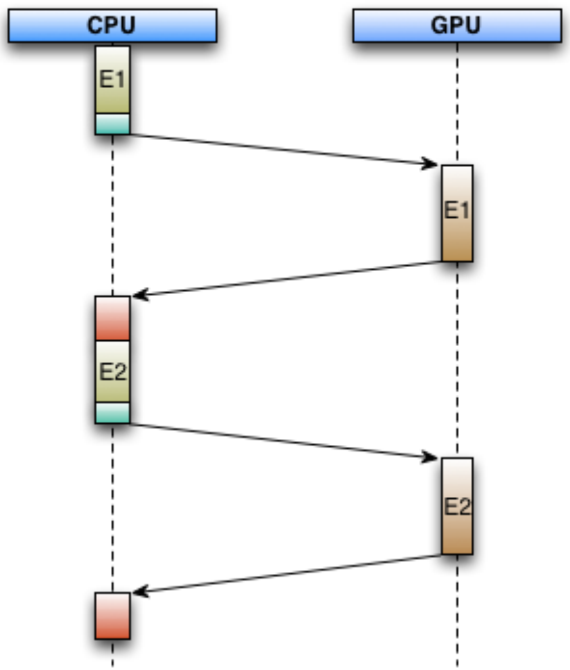


Performance analysis (2)

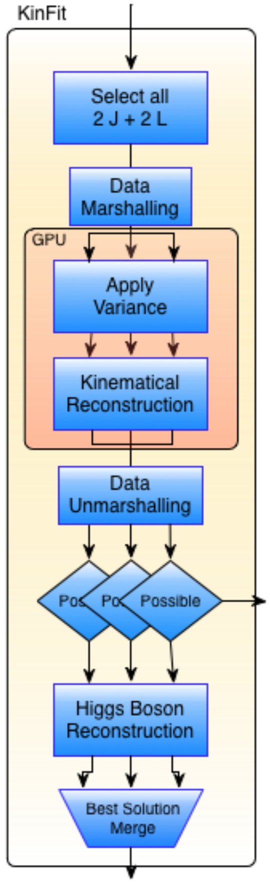
Ideal execution



Current execution



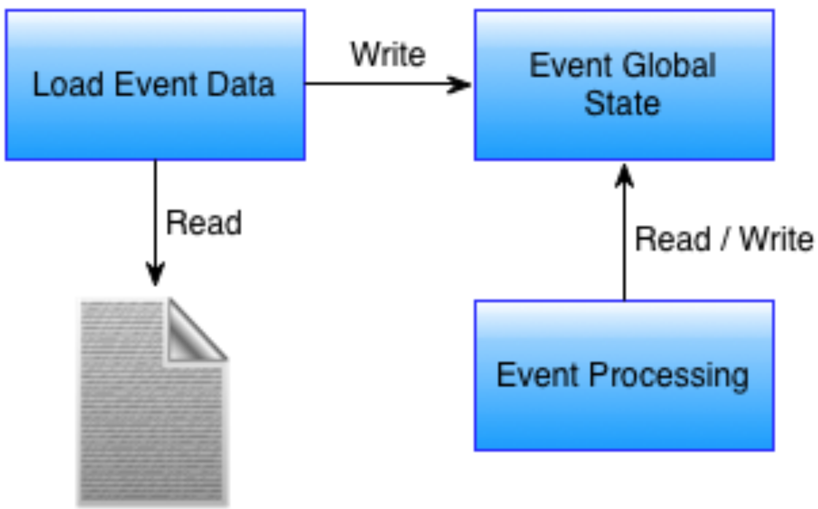
For 256 variations the CPU is idle 31% of the time…



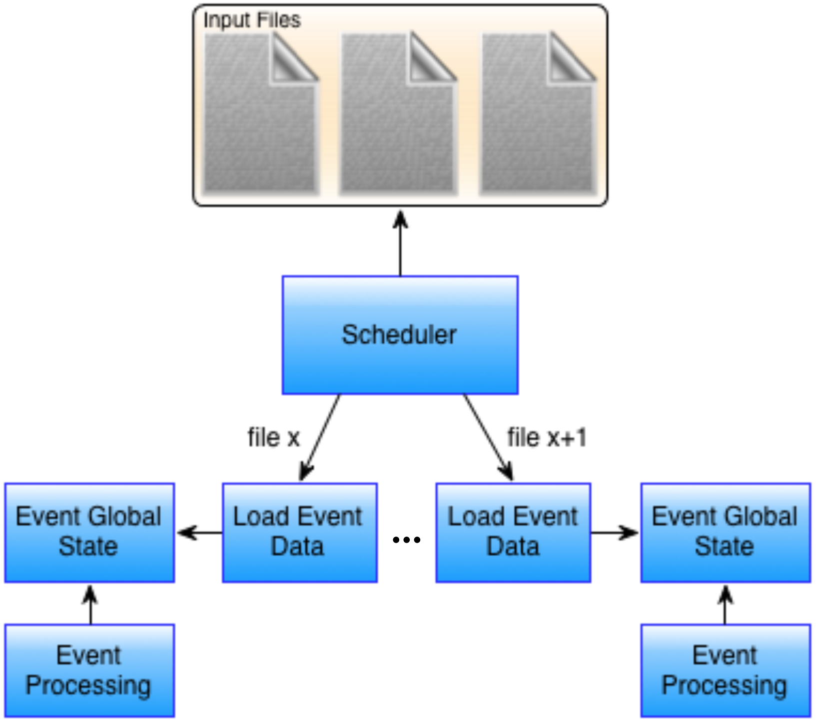
A single global state **prevents** simultaneous CPU & GPU processing

Approach 3: events from different files

Sequential

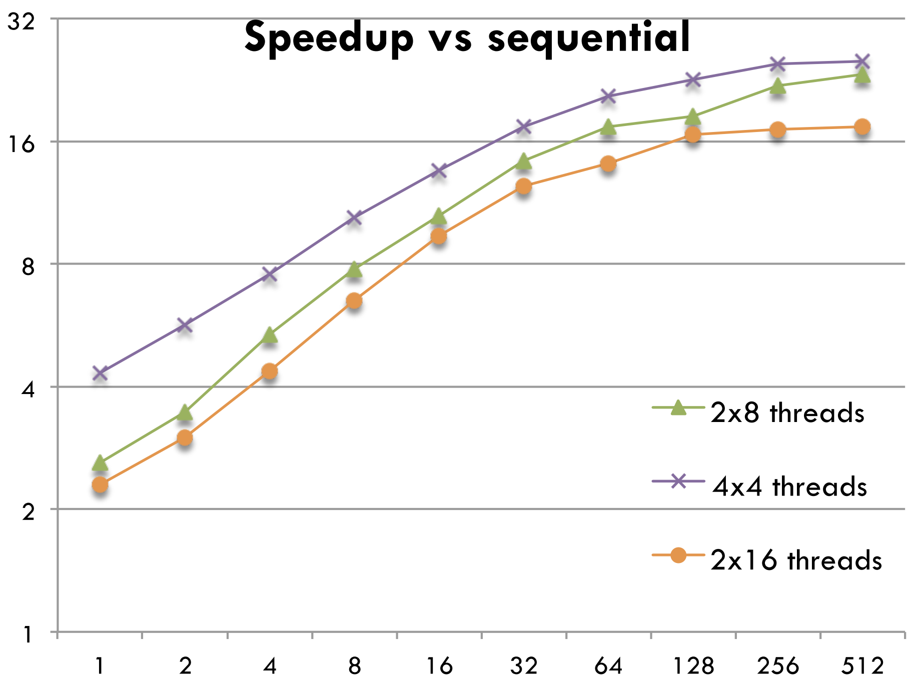


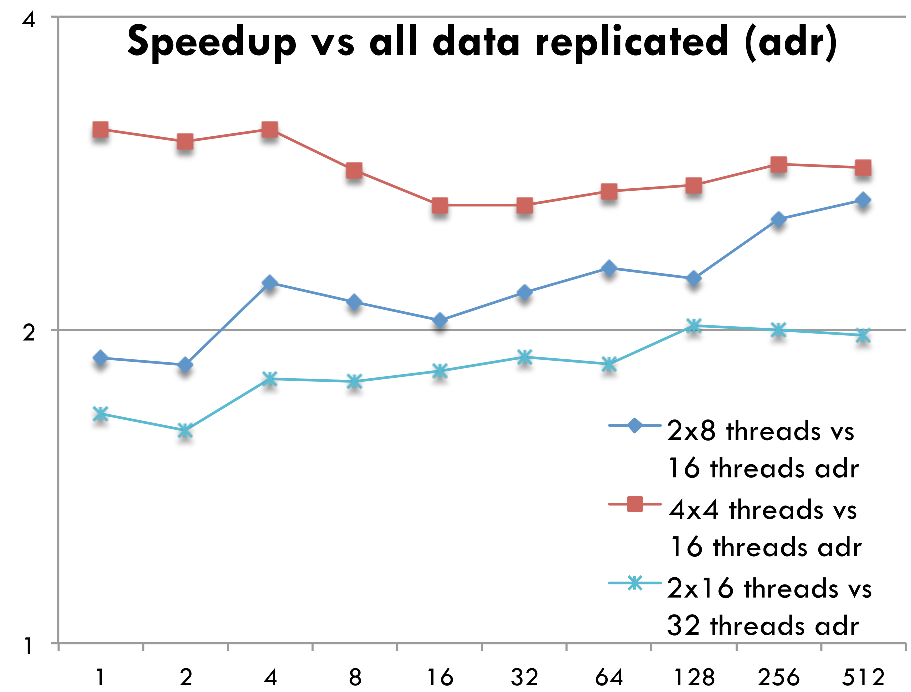
Parallel



Performance analysis (1)

System: 2x Intel E5-2670 (total 16 cores, 32 threads)





# of variations

Conclusions

- Homogeneous systems
  - All data replicated provides the best performance (multiple CPUs)
  - Pointer to shared data provides the best efficiency (single CPU)
- Heterogeneous systems
  - Unefficient GPU usage due to the lack of a global data structure
  - Xeon Phi preliminary implementation limited by the drivers
- Scheduler provides the best efficiency for multi-CPU systems
  - Allied to a parallelization of LipMiniAnalysis a tool can be developed that automatically extracts parallelism

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