Exascale Computing at the LHC : Narrative

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1 Funding Strategy

Exascale computing is an enormously growth-oriented area. Even during lean economic times, the US Federal Government is pledging to support this area of research, for instance in the Department of Energy Exascale Computing Initiative [1]. Indeed, the DOE Office of Science has this to say about the area:

> The Exascale initiative will be significant and transformative for Department of Energy missions.

The current level of funding for the DOE EIC and related activities is $21M. [2].

In addition to governmental programs such as above, private sector funding sources are also available, such as the Google Faculty Research Awards [3], which has an interest in exascale computing projects also.

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2 Project Organization

The principle investigators (PIs) of this proposal have a widely-varied and applicable skill set to accomplish the goals of extending LHC computing to the exascale.

- Salvatore Rappoccio has 15 years of experience programming in a high-energy physics environment, as well as other numerical software design for the private sector. He is an expert in several critical areas of event reconstruction at CMS which can be optimized for multicore usage.
- Lukasz Ziarek . . . .
- Steven Ko . . . .
- Peter Elmer . . . .
- Matthew Jones . . . .

Add your bla bla bla above. .

3 Introduction

With the discovery of a new boson with mass around $m = 125$ GeV [4, 5] (henceforth referred to as the H), a new phase of particle physics has begun. The questions have shifted from the cause of the breaking of the electroweak symmetry, to the nature of that symmetry breaking. Two major questions arise. The first is the exact nature of the particle responsible for the electroweak symmetry breaking. The second is how a particle with a relatively low mass around $m = 125$ GeV can be responsible for electroweak symmetry breaking without extremely large fine tuning in nature, cancelling the large radiative corrections to its mass.

With 25 fb^{-1} of 7 and 8 TeVdata delivered by the LHC in 2011-2012, and instantaneous luminosities reaching $7 \times 10^{33}\mathrm{cm}^{-2}\mathrm{s}^{-1}$, the processing time to reconstruct each event collected by CMS was approximately 20 seconds per event. However, as the instantaneous luminosity is increased, the computational time currently scales quadratically. As the upgraded LHC is expected to deliver $> 12 \times 10^{33}\mathrm{cm}^{-2}\mathrm{s}^{-1}$ in the upcoming run, the processing time per event is expected to reach several minutes per event as shown in Figure 1. Furthermore, in future runs of the LHC in the next 15 years, the luminosity is expected to reach as high as $> 1 \times 10^{34}\mathrm{cm}^{-2}\mathrm{s}^{-1}$, which would correspond (naively) to several hours of computational time per event! Clearly, it is necessary for the computing power to scale in order to compensate for this dramatic increase in CPU time with instantaneous luminosity.

However, with the expected end of the historic scaling of single-core processing capability [6] (**NEED MORE MATERIAL HERE**), it is imperative to utilize a parallel processing strategy in order to maintain the levels of computational speed of LHC data in the immediate future.

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References

[1] US Department of Energy Office of Science, (2010), The Opportunities and Challenges of Exascale Computing.

[2] US Department of Energy Office of Science, (2013), ASCR Budget.

[3] Google, (2013), Faculty Research Awards.

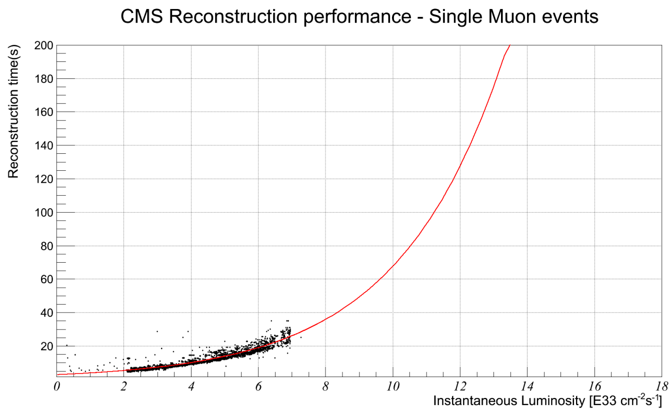

Figure 1: Event processing time versus instantaneous luminosity.

[4] CMS Collaboration, S. Chatrchyan et al., Phys. Lett. B (2012), 1207.7235.

[5] ATLAS Collaboration, G. Aad et al., Phys. Lett. B (2012), 1207.7214.

[6] K. Bergman et al., Defense Advanced Research Projects Agency Information Processing Techniques Office (DARPA IPTO) (2008), Exascale computing study: Technology challenges in achieving exascale systems.