



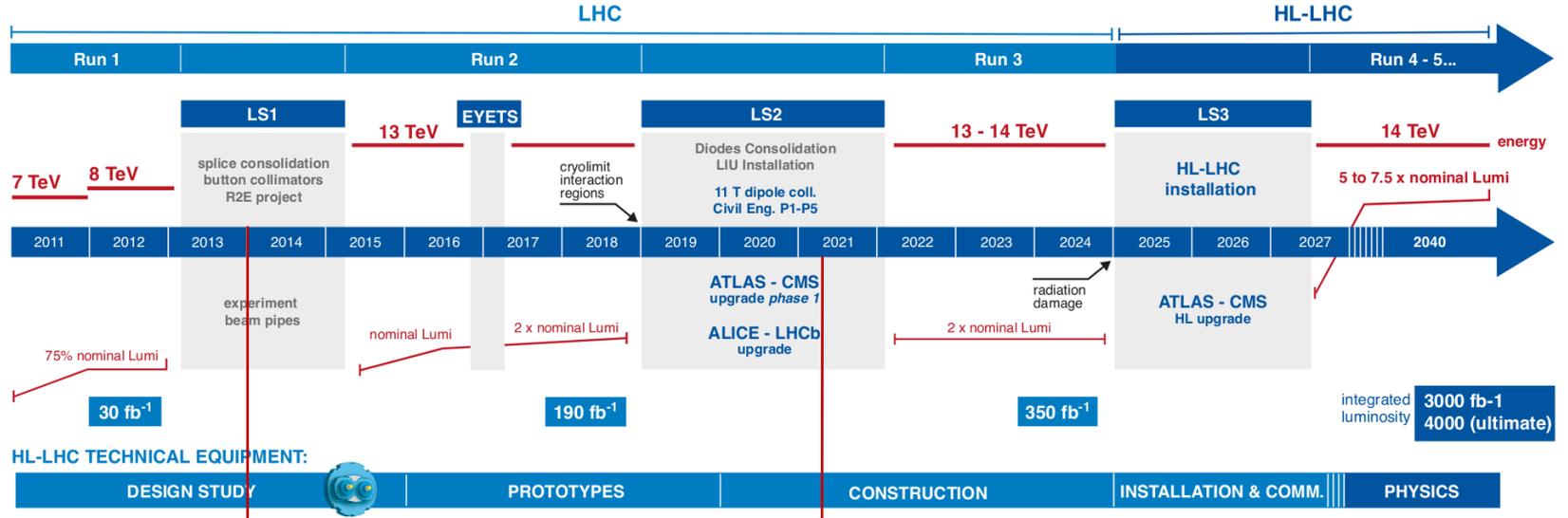
Detector Simulation Mini-Workshop
HL-LHC Computing Review Stage-2: Common Software Projects
29th April 2021
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Review goals

- As expressed in the review charge:
 - https://drive.google.com/file/d/1AxIQYMuoHbPm6lqtUc9kQsfzIRTz2h_w/view
- The main goal of this review is to ensure the experiments, WLCG, and the relevant software projects, have common and realistic expectations of requirements and timescales.
- This review, therefore, is expected to help the experiments plan their strategies and assist the projects in focusing on priorities and identifying any pinch-points.
- The review is intended to establish that there is a credible plan and that all parties are “on the same page”.



LHC / HL-LHC Plan



Simulation R&D

Geant4 MT, merged to production since 2014

Geant-V R&D, stopped end 2019. VecGeom integrated in G4.

TODAY

Remaining time for evolution

Three main lines

- Adiabatic improvements of detailed simulation
 - Technical improvements
 - Code revision, modern standards, more use of acceleration techniques, etc.
 - Together with physics precision improvements
 - If speed-up by factor f , need to improve physics precision by typically factor \sqrt{f} !
 - Improvements in the models can be more computational demanding.
 - It is not excluded (but not promised !) that a factor $f \sim 2$ is not out of reach
 - Please do not take this factor 2 as a target !
- Improve fast simulation
 - Classical parametric approaches (ie, like GFlash for EM showers)
 - But also modern techniques based on Machine Learning
 - Might be an approach for hadronic showers and advanced models
 - Important development as fast simulation could play the role of a security net of that era
 - And also, explore wider use of biasing techniques
- R&D accelerators and new architectures
 - Large spread of GPUs :
 - how much could they be a solution to the simulation needs ?
 - Benchmarking of new architectures
 - Very much interested in benchmarking on A64FX (ongoing)
 - But also future NVIDIA material, like GRACE

Some news

▪ **Tasking:**

- Geant4 will move to a tasking scheme this year (G4 11.0)
 - Deployment as default mode (instead of MT) is the main development goal of this year
- Tasking is expected to bring further functionalities by easing
 - Sub-event parallelism, by splitting big events onto several cores
 - Hybrid computing, by sub-tasking to accelerators part of the CPU load
 - These will not be delivered this year !

▪ **EM showers on GPU:**

- First and **very preliminary** results on EM showers on GPU
 - Results obtained by Jonas Hahnfeld, using G4HepEm, in the context of the AdePT project
 - Aiming for a proof of concept
- Process 10k 10 GeV e-, no mag-field, in sampling calorimeter
 - System : AMD Ryzen 9 3900 (12C/24T), GeForce RTX 2070 SUPER
 - **43 s on CPU** (24 threads) versus **33.7 s on GPU** card
- Be aware that some important features are not yet included !
 - no safety calculation (perf. ↘), improved VecGeom navigation (perf. ↗), ...
 - Connection with CPU for sending back possible hadronic part is not present, etc.
- But we see this transport works, and this gives the order of magnitude of performances !
- Further estimations are expected this year

Issues proposed to discussion (1/2)

- Two types of improvements:
 - Increase of event throughput
 - At same or better physics quality when doable
 - At reduced physics quality when acceptable
 - Increase of physics quality
 - To have systematic effects scaling down as $1/\sqrt{N}$
 - To serve new use-cases : eg high granularity calorimetry
 - Evolutions which may not be doable by adiabatic refinement of existing models
 - Keeping high level of physics expertise is vital !
 - **Input from experiments is essential**
- Computing resources exploitation:
 - Tasking should help to handle computing resources in a more flexible way
 - On the CPU side, but for hybrid too
 - Accelerators are considered at first place as a way to increase event throughput
 - But they may also provide additional computing resources to improve physics modeling
 - For physics models that require or will require compute intensive calculations
 - Along the same vein, broader use of vector registers should be considered as well
 - For the physics and for the geometry
 - Changes in the way to exploit resources will impact experiments simulation processing flow
 - **Geant4 – experiments interactions is essential**

Issues proposed to discussion (2/2)

- Data from simulation:
 - Full simulation provides the most precise and detailed data
 - With highest physics quality
 - Not obvious if processing on accelerators would deliver the same level of details
 - But a priori with same physics quality, for those provided
 - Already known that shower parameterization provides reduced information
 - With reduced physics quality too
 - **Iterations with experiments needed to understand above relative needs**
- Time scales & risks
 - Adiabatic evolutions are the simplest to integrate by the experiments
 - As non-disruptive, they are not subject to strong time constraints
 - Time scales related R&D:
 - Time scale for R&D itself to demonstrate its feasibility
 - Time scale for evolving the R&D code into a production one
 - Needed adaptation of the code itself, but also series of validations
 - Time scale for experiments to integrate such new features in their computing model
 - And to develop and conduct their own validations
 - The experience of the MT showed that the two last stages take time too !
 - **How to fit with the HL-LHC plans ?**
 - **How to cope with risks related to R&D ?**
 - **Again, iterations are needed !**

And last not least

- Beyond the
 - BIG technical/computing challenge,
 - and the BIG physics challenge,
- We have also one BIG human challenge !
 - We are reaching a generation turning point in Geant4
 - We must pass the current long experience to a younger generation
 - **We need to prepare the next generation of Geant4 developers who will serve the HL-LHC experiments for the next decades !**

Thank you !