CERN EP Software R&D

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Architects' Forum, 2018-10-18

CERN EP R&D Exercise

- New R&D programme on new Detector Technologies
  - HL-LHC detector R&D is winding down now
  - What research will be needed for the next generation of detectors?
    - CLIC, FCC-ee, FCC-hh, CEPC, ...
- Define a 5 year programme, running from 2020-2025
- Working Groups:

Silicon Detectors	Gas Based Detectors
Calorimetry and Light Based Detectors	Detector Mechanics and Cooling
Integrated Circuits	High Speed Links
Software	Detector Magnets

Excellent detectors require excellent software

Software R&D Process

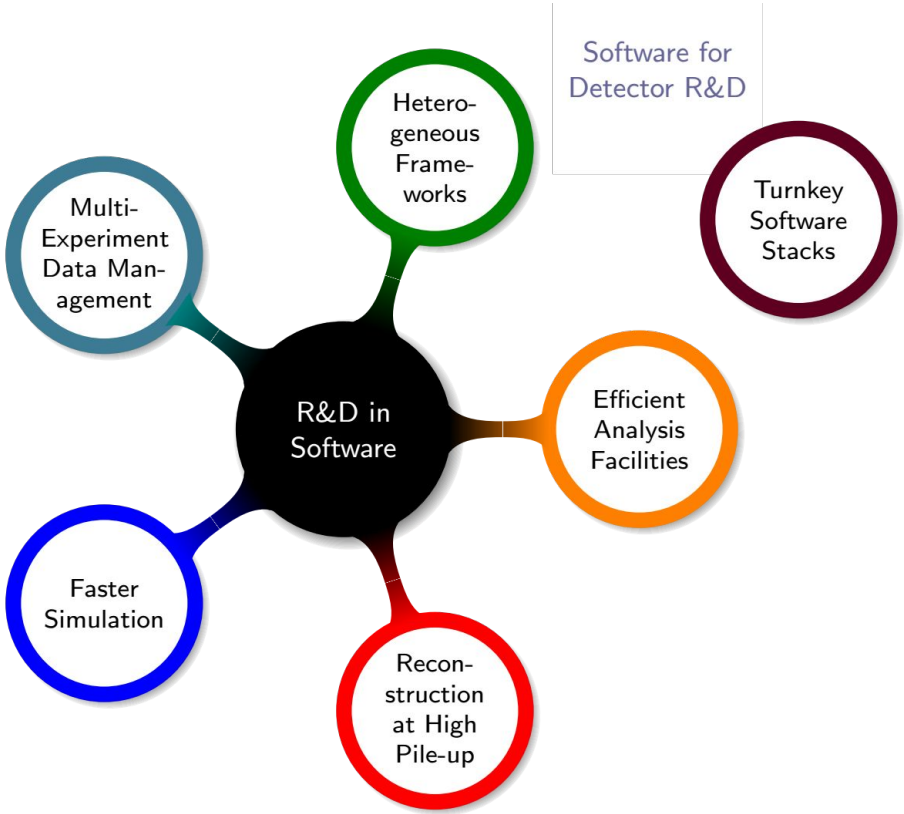
- Wide consultation with the global HEP Software and Computing community
  - Two sets of lightning talks, open to everyone to present their ideas
- Alignment with wider community R&D (e.g. IRIS-HEP) identified in the HSF Community White Paper
- Core group formed, many software experts from all of the EP software groups in different experiments
  - Advice from CERN IT and some outside experts
- Identified the key challenges for the future, presented in 2 workshops
  - Focus on areas where there is a *step-change* required
- These R&D lines form part of the R&D report that is in an advanced state of preparation (see agenda of second R&D workshop)

Software Proposals

- Faster Simulation
- Reconstruction at High Pileup
- Efficient Analysis Facilities
- Heterogeneous Frameworks
- Multi-experiment Data Management

Plus

- Turnkey Software Stacks



See Jakob's last presentation for the group, for motivation and longer summary

In a nutshell...

- Faster Simulation
  - Higher statistics from detectors, so MC errors can become even more significant
  - Rarer processes are targeted, so a better understanding of background is needed
  - All this requires *faster simulation* and with more accuracy in some places
  - Targets: Integrated ML to speed up physics processes; sub-detector fast simulation; end-to-end fast chains, with reconstruction
- Reconstruction at High Pileup
  - New tracking and calorimetry detectors planned for future experiments
  - High pile-up crucial to the physics programmes, but have to control reconstruction times
  - Targets: Mathematical fundamentals of timing detectors; tracking in high-granularity calorimeters; dynamic domain decomposition for regions of high physics interest

In a nutshell...

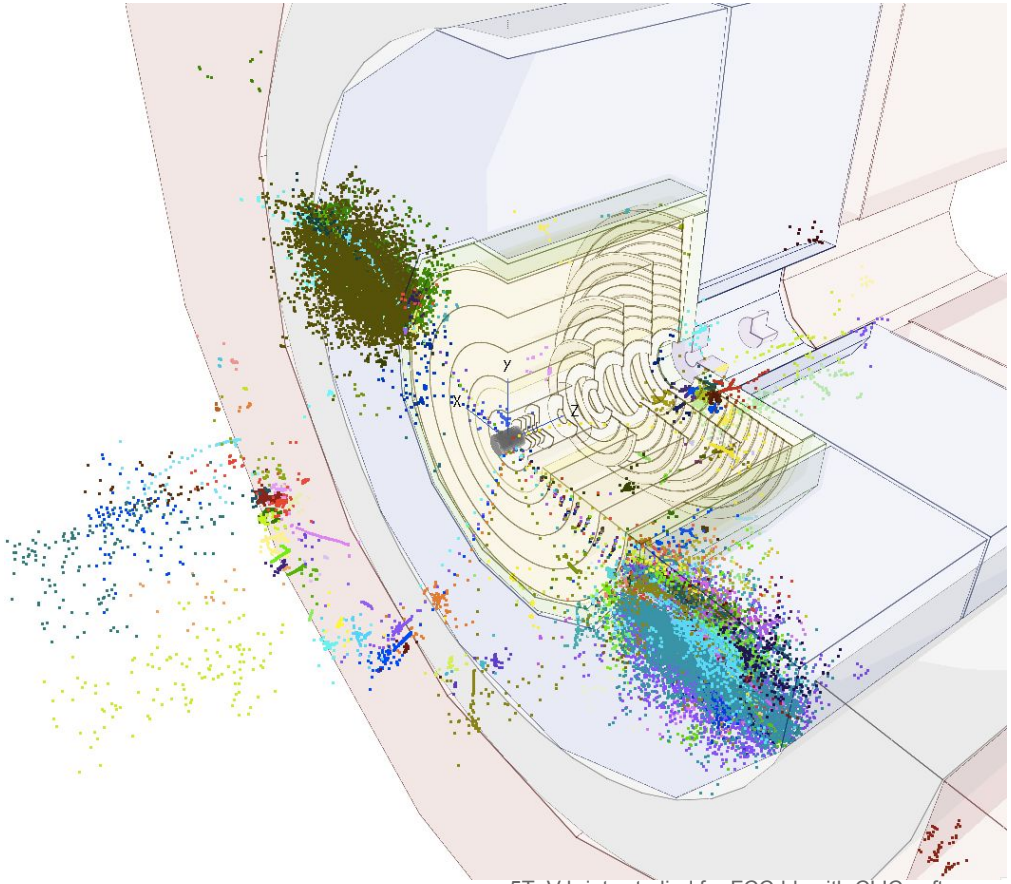
- Efficient Analysis Facilities
  - Greatly increased event rates threatens analyst productivity
  - Modern hardware a real challenge, even for experts
  - Wasted resources today from skimming cycles and unnecessary data transfers
  - Targets: Expressive functional analysis description; dedicated analysis facilities with specialist I/O interfaces; sharing of intermediate results
- Heterogeneous Frameworks
  - Hardware evolution moves further and further from any gains on traditional CPUs
  - Market is driving growth in GPUs and in FPGAs
  - A harder programming model and will need to be integrated into software workflow
  - Targets: plugin library for accelerated resources; flexible scheduling for maximum throughput; message passing model for component exchange; robustness and error recovery

In a nutshell...

- Multi-experiment Data Management
  - Future will have many experiments (HEP, Nuclear, Astro) sharing much scientific computing infrastructure
  - Network and storage resources are currently fixed and relatively inflexible and will need to evolve to be more dynamic
  - Targets: Mechanism for distinct data management instances to cooperate; Dataflow planning across experiments, negotiating data lifetime, QoS, network
- Turnkey Software Stacks
  - Detector concept studies require an end-to-end working stack of software
  - Low level detector design choices ultimately affect physics performance
    - Detector design choices impact greatly on software complexity and costs
  - Complex chain of software that has to be built and validated coherently
  - Targets: Common software stack, initially for FCC and CLIC; Detector description toolkit; Common EDM, to allow algorithm sharing

Next Steps

- Refine and improve EP R&D report
  - Working with EP management on this
  - Costs included!
- Anticipate a presentation to CERN Council
  - Arguing for as much support as we can in these critical areas
- Hopefully to have funding start to flow in 2020



5TeV b-jets studied for FCC-hh with CLIC software