A tale of two programs

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T5 - Software development: S2
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A performance wall

Need to leverage micro //

Some HEP code is here

Typical HEP code @ 0.8 CPI

200 Computing Centers in 20 countries: >600k cores

@CERN (20% WLCG): 65k cores; 30PB disk + >35PB tape storage

Large increase in demand

50% of resources used by a single application (GEANT4)
GEANT4

First release in 1998
~1MLOC of C++
~200 authors
One release per year
Complex governance structure
Relatively slow and conservative decision taking process
Experiments demand stability and improvements, typical oxymoron

Looking for performance in
• SIMD
• new techniques (DL GN)

Typical HEP-SIMD performance (0.8 CPI)
MT version: gain in memory footprint (it took 10 years to materialize)
The initial ideas sounded easy

Scheduler

Basket of tracks

Dispatching

Basket of tracks

MIMD

SIMD

Dispatcher

x-sections

Reactions

Geometry navigator

Geometry algorithms

Physics
(R)evolution?

One year of R&D in collaboration with FNAL

Very difficult to implement new transport model adiabatically – must literally “rip apart” the heart of GEANT4

A new start is needed

But GEANT4 is 20+ years x 200FTEs, how is it possible even to hope to do better?

Where to find the manpower

Is it even thinkable to “compete”?
Clayton Christensen, Harvard Business School circa 1995 introduced *disruptive innovation*

incumbents almost always lose†

A theoretical model

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**Performance trajectory of present technology driven by sustaining technological improvements**

**Pace of technological progress**

**Performance which the marketplace demands or can absorb**

**New performance trajectory**

† BIG FOOTNOTE

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No sir, you do not want a ¼” drill

you want a ¼” hole!
Classical Disruptive Innovation

“A disruptive innovation is not a breakthrough innovation that makes good products a lot better.” Clayton Christensen

Every product has users that range from basic to average to sophisticated

Over time, customers can utilize more features and performance

Incumbent companies often add features, cost and functionality faster than their customers can utilize

Recognizing an opportunity, a startup creates a new offering that appeals to most users because it is simpler, easier to use and costs less

Basic and average users switch to the new offering and it gains market share

Do you dare to be a “crappy innovator”?
Though **RCA** pioneered **LCD**, it was one of the dominant players in the dominant **CRT technology**.
More examples

<table>
<thead>
<tr>
<th>Disruptor</th>
<th>Disruptee</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal computers</td>
<td>Mainframe and mini computers</td>
</tr>
<tr>
<td>Mini mills</td>
<td>Integrated steel mills</td>
</tr>
<tr>
<td>Cellular phones</td>
<td>Fixed line telephony</td>
</tr>
<tr>
<td>Community colleges</td>
<td>Four-year colleges</td>
</tr>
<tr>
<td>Discount retailers</td>
<td>Full-service department stores</td>
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<tr>
<td>Retail medical clinics</td>
<td>Traditional doctor’s offices</td>
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<tr>
<td>Uber</td>
<td>Taxi companies</td>
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Does it applies?

In GEANT<X> case there is no incumbent and competitor and market and…
We are the same people!
Same users, same developers (sometimes overlapping), same market

"If you don't cannibalize yourself, someone else will."
- Steve Jobs
Adopted Strategy

GEANT4 toolkit

Geometry
Math
Hadronic
MagF Tran
Electromag
Neutrons
Comp i
Comp j

VGeometry
VMath
VHadronic
VmagF Tran
VElectromag
VNeutrons

GEANTV core

Every new idea has a spectrum of acceptance

leave no (wo)man behind

P. Canal, F. Carminati CHEP 2018
Disruptive (r)evolution?

An entirely new technology (Vectorized transporter)
A continuous flow of new and high quality elements into the existing product
A thorough test for the new elements – substantial reduction of the technological risk
A continuous improvement of performance and quality with the current framework
New code IS better code
No (wo)man left behind (users and developers)
It is today possible to run Geant4 simulations with VecGeom shapes replacing Geant4 shapes (seamless to user)

Geant4 10.1. ships USolids internally optionally one may also compile against external USolids installation

Geant4 release 10.2. will remove internal module in favour of external USolids/VecGeom library

USolids source code repository:

gitlab.cern.ch/VecGeom/VecGeom

Ugeom/VecGeom is developed by the AIDA project. PI Sandro Wenzell
Physics example

- The new algorithm is being now vectorised for GeantV
- It is in an experimental physics list for Geant4
  - Candidate to become the default
- Evolution or revolution?

Source: M. Novak EP/SFT
Benefits to current experiments

CMS has adopted the new geometry with a 10%-15% speedup
The new physics is now becoming standard in GEANT4
The innovation pace has seen an acceleration since the inception of the GEANTV project (2013 onward)
  • New geometry package
  • New multiple scattering
  • New/improved EM processes
  • New neutron package
  • New web site for GEANT4
  • Fast simulation with DL
  • Validation database

Could it have happened without GEANTV?
   (in theory…) YES (...of course)

Would it have happened without GEANTV?
   depends whom you ask

... but if you ask me…
Conclusions

Bringing innovation into HEP code has often been traumatic and divisive

The concept of disruptive innovation is an interesting blueprint but not directly applicable to our community

The GEANTV model (2013-…) has tried to blend our reality with the basic principles of DI

The results have been positive for the HEP community