



A tale of two programs



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T5 - Software development: S2

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A performance wall

Need to leverage micro //

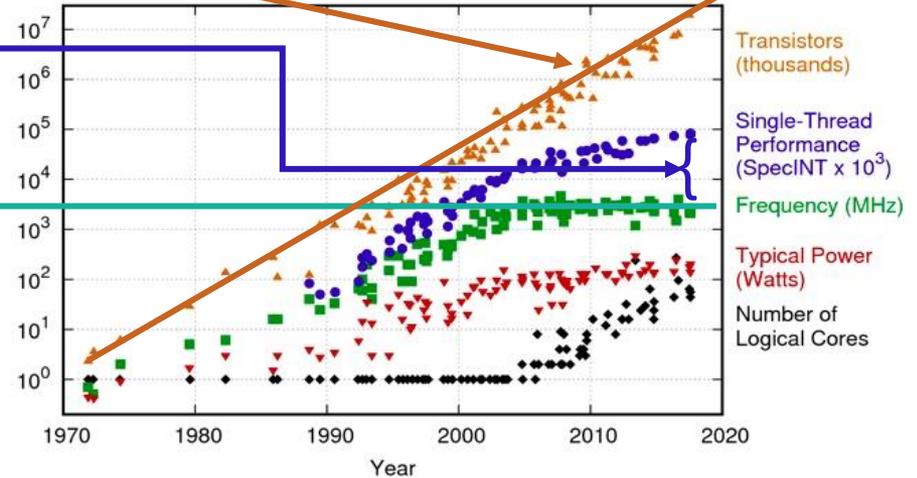
Some HEP code is here

Typical HEP code @ 0.8 CPI

200 Computing Centers in 20 countries: >600k cores

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

42 Years of Microprocessor Trend Data

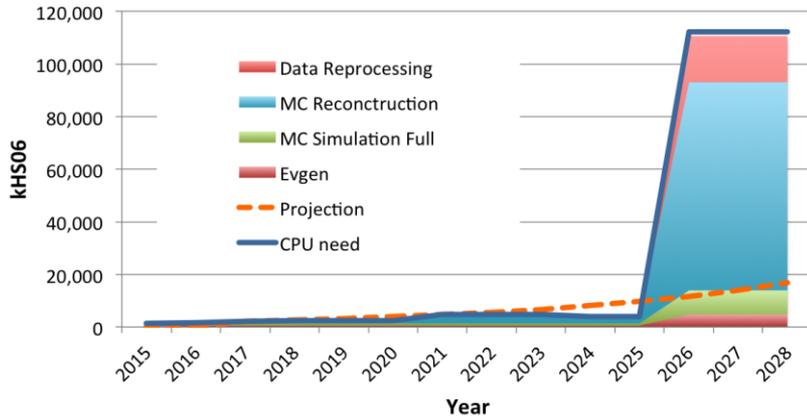


Original data up to the year 2010 collected and plotted by M. Horowitz, F. Labonte, O. Shacham, K. Olukotun, L. Hammond, and C. Batten
 New plot and data collected for 2010-2017 by K. Rupp
<https://www.karlrupp.net/2018/02/42-years-of-microprocessor-trend-data/>

Large increase in demand

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

CPU needs (kHS06)



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

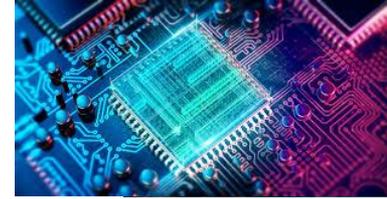


Looking for performance in

- SIMD
- new techniques (DL GN)

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

(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

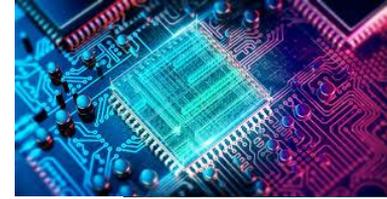
A new start is needed

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

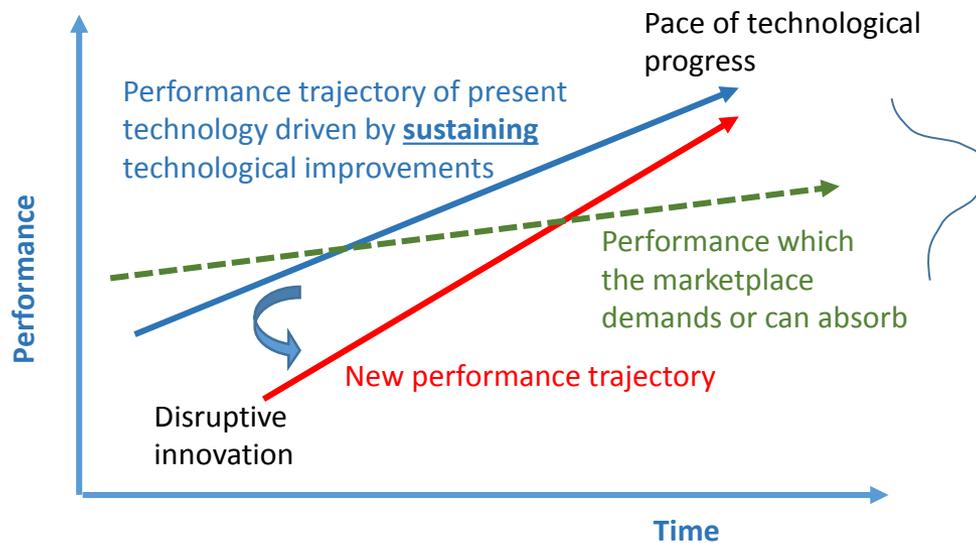
Where to find the manpower

Is it even thinkable to “compete”?

A theoretical model



Clayton Christensen, Harvard Business School
circa 1995 introduced **disruptive innovation**
incumbents almost always lose[†]



No sir,
you do not want a ¼" drill



you want a ¼" hole!



† BIG FOOTNOTE

Classical Disruptive Innovation

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

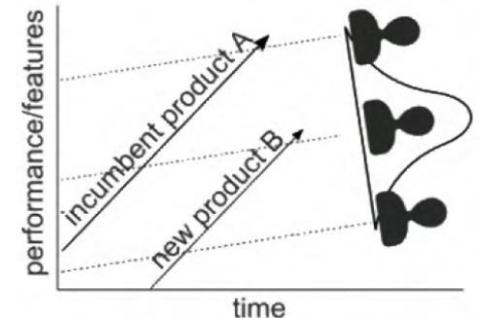
Every product has users that range from basic to average to sophisticated

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”?



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Steel Quality

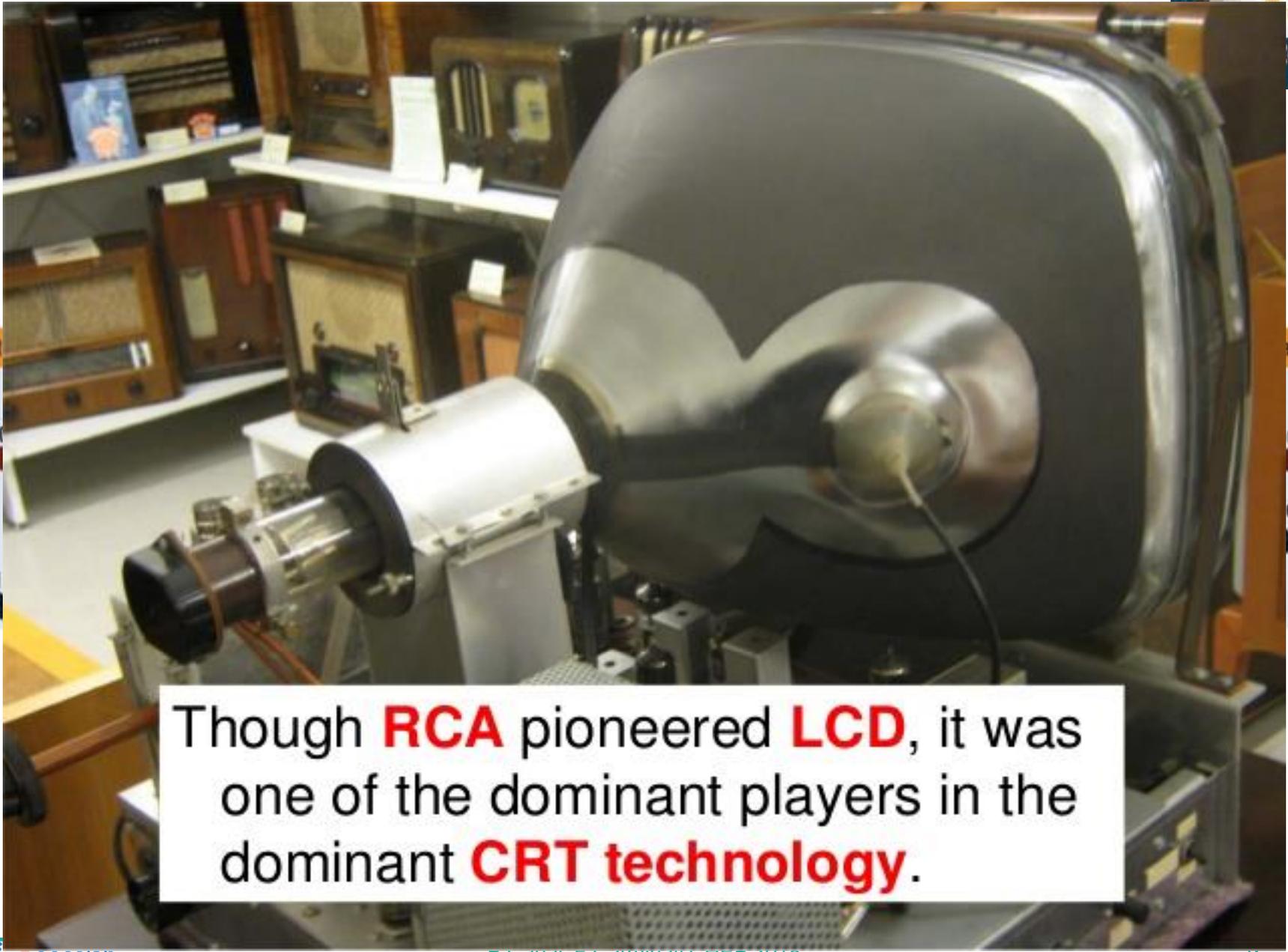
Iron

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Though **RCA** pioneered **LCD**, it was one of the dominant players in the dominant **CRT technology**.



More examples

Disruptor	Disruptee
Personal computers	Mainframe and mini computers
Mini mills	Integrated steel mills
Cellular phones	Fixed line telephony
Community colleges	Four-year colleges
Discount retailers	Full-service department stores
Retail medical clinics	Traditional doctor's offices
Uber	Taxi companies

Does it applies?

In GEANT<X> case there is no incumbent and competitor and market and...

We are the same people!

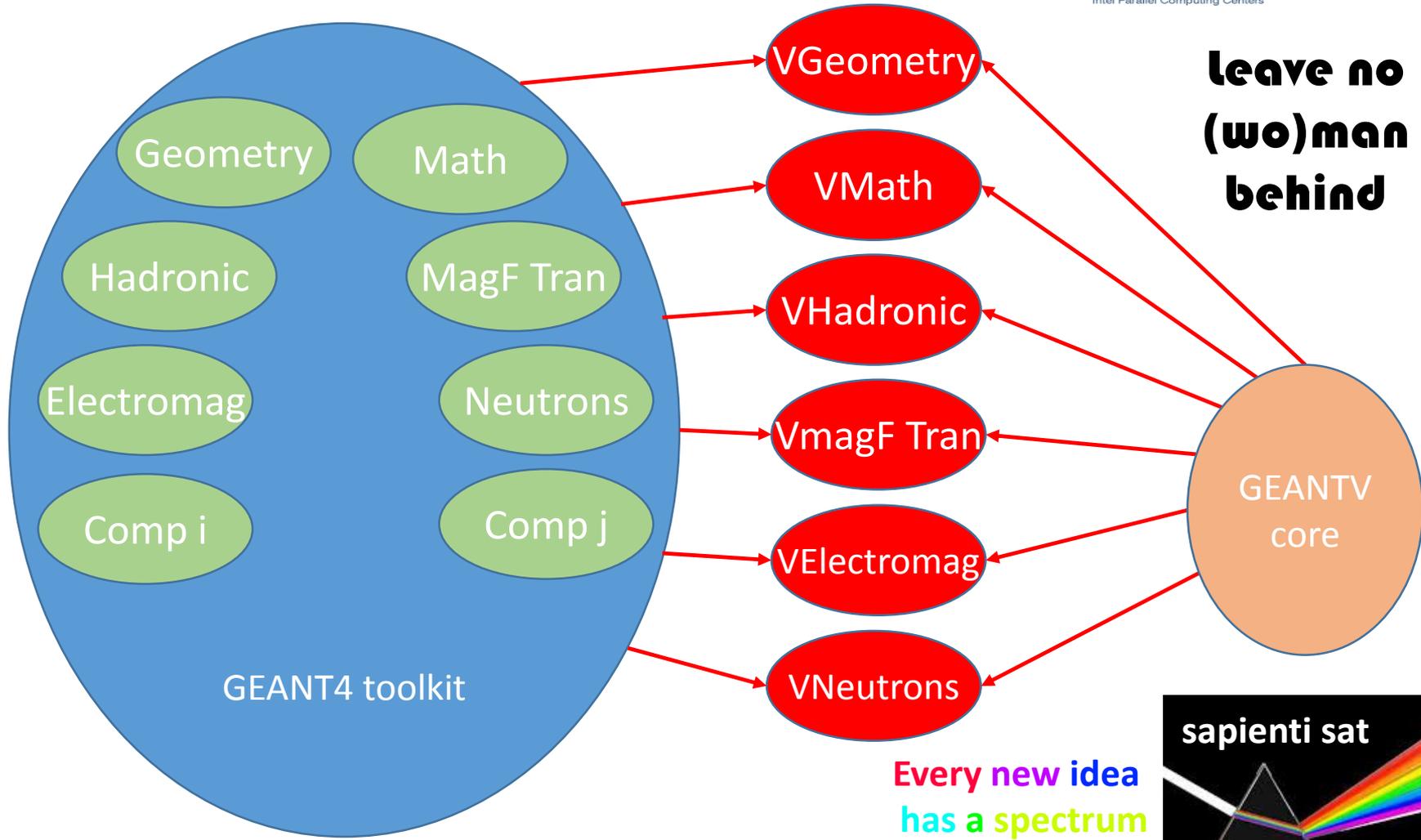
Same users, same developers (sometimes overlapping), same market

"If you don't **cannibalize yourself**,
someone else will."

- Steve Jobs



Adopted Strategy



**leave no
(wo)man
behind**

**Every new idea
has a spectrum
of acceptance**





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

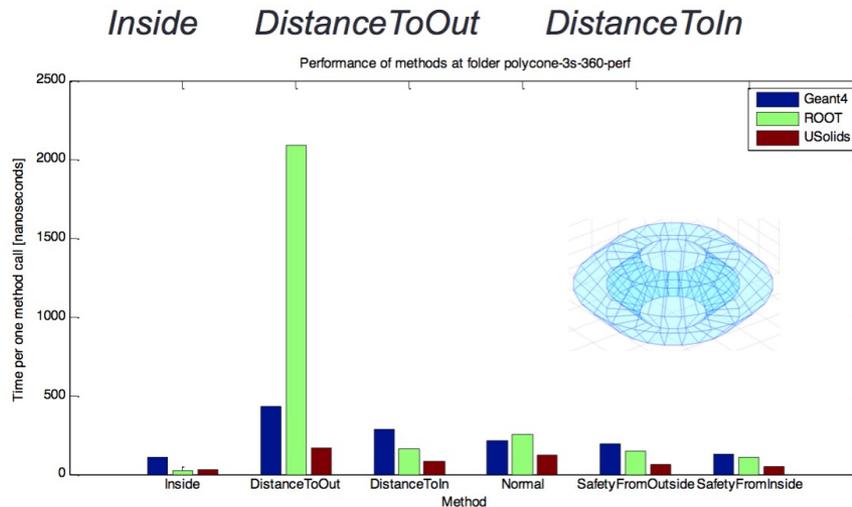
A continuous improvement of performance and quality with the current framework

New code IS better code

No (wo)man left behind (users and developers)

Geometry example

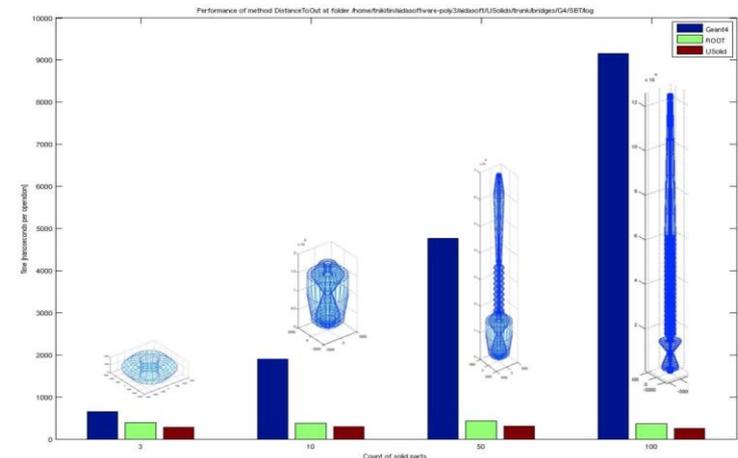
Snapshot from historical slide



- Geant4 release 10.2. will remove internal module in favour of external USolids/VecGeom library
- USolids source code repository: gitlab.cern.ch/VecGeom/VecGeom

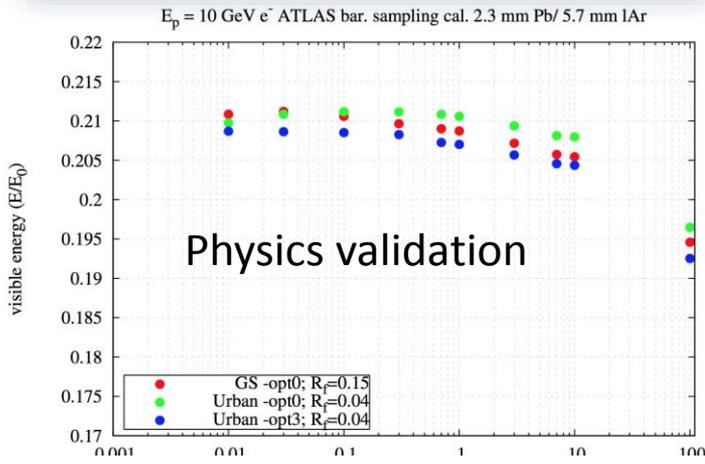
- It is today possible to run Geant4 simulations with VecGeom shapes replacing Geant4 shapes (seamless to user)
- Geant4 10.1. ships USolids internally optionally one may also compile against external USolids installation

Revised UPolycone performance Scalability for DistanceToOut()



Physics example

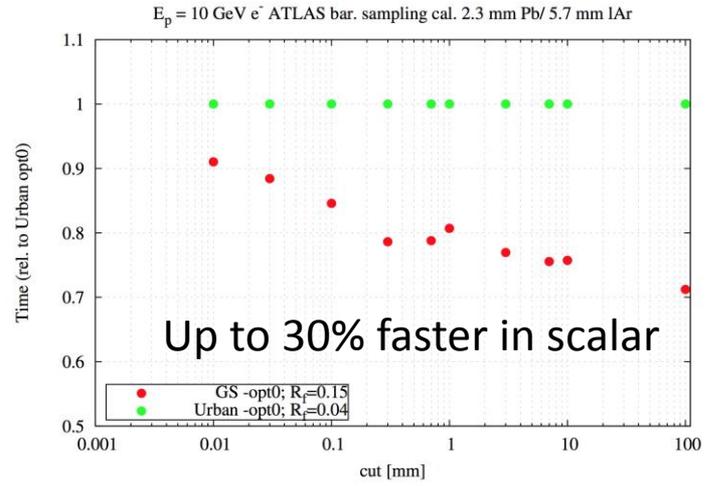
Snapshot from historical slide



Less charged steps (30%-50%)

cut [mm]	Urban-opt0	GS-opt0	Urban-opt3
100	27241	15510	51862
10	35789	21898	64588
7	36505	22457	65431
3	38760	24270	68165
1	41341	26216	71677
0.7	42182	26867	72870
0.3	45024	29348	81452
0.1	50420	34467	87487
0.03	59302	43295	95970
0.01	78181	62549	114558

Table: number of charged steps



- 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?

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