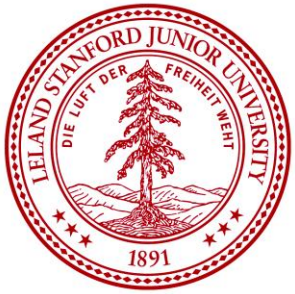
SLAC
NATIONAL ACCELERATOR LABORATORY



Introduction

Amber Boehnlein (SLAC)

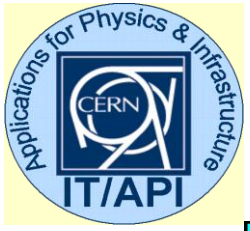
Transforming Geant4 for the future

What is Geant4?

Geant4 is a tool kit that tracks particles through matter, breaking the particle motion into small segments, applying appropriate physical processes and probabilities at each segment.

- These processes can destroy old particles, modify state or create new ones
- Processes include atomic processes like ionization and excitation, decay processes, photonic transitions, secondary emission, etc..
- The wide coverage of physical processes comes from mixture of theory-driven, parameterization, and empirical formulae.
- Successor to Geant 3, Geant 4 Project began in 1994 with the first public release in 1998
- See Makoto Asai's talk for more details

Geant4 Collaboration



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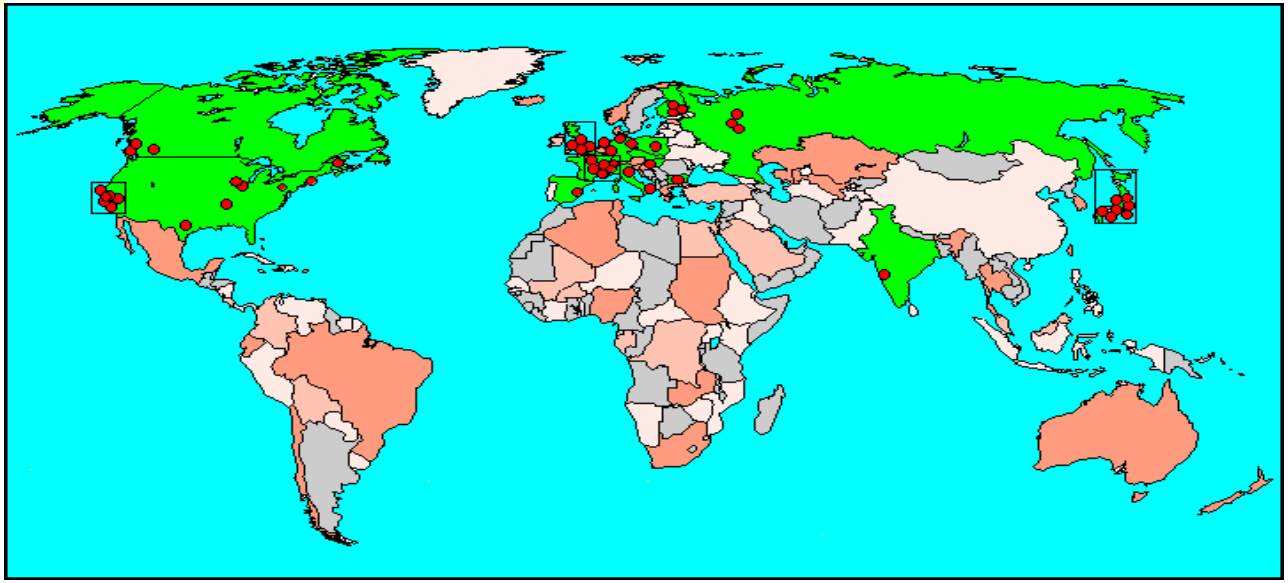
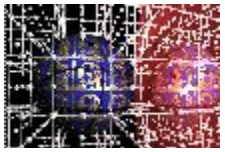


Lebedev

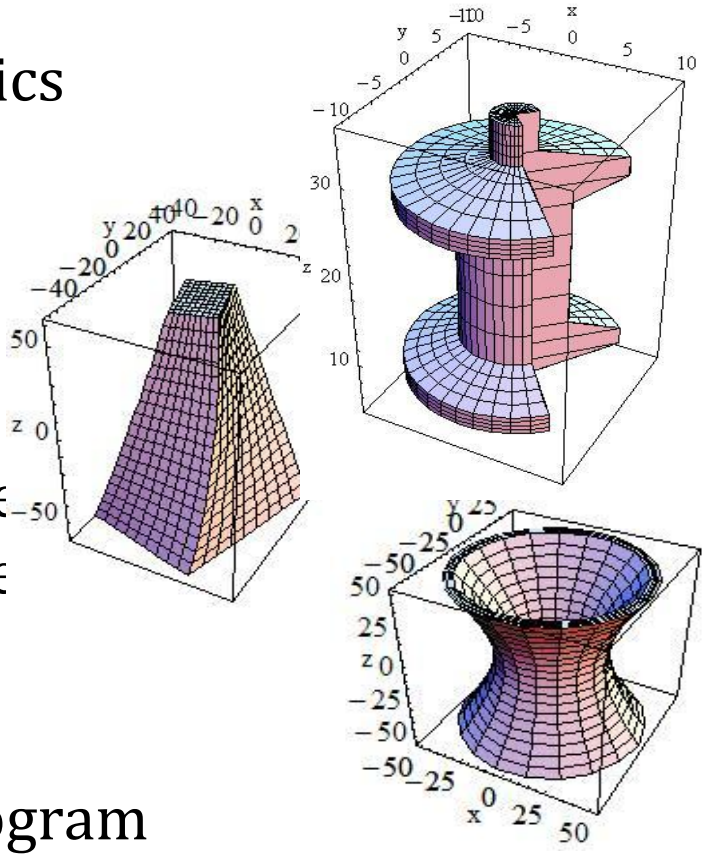


J.W.Goethe Universität

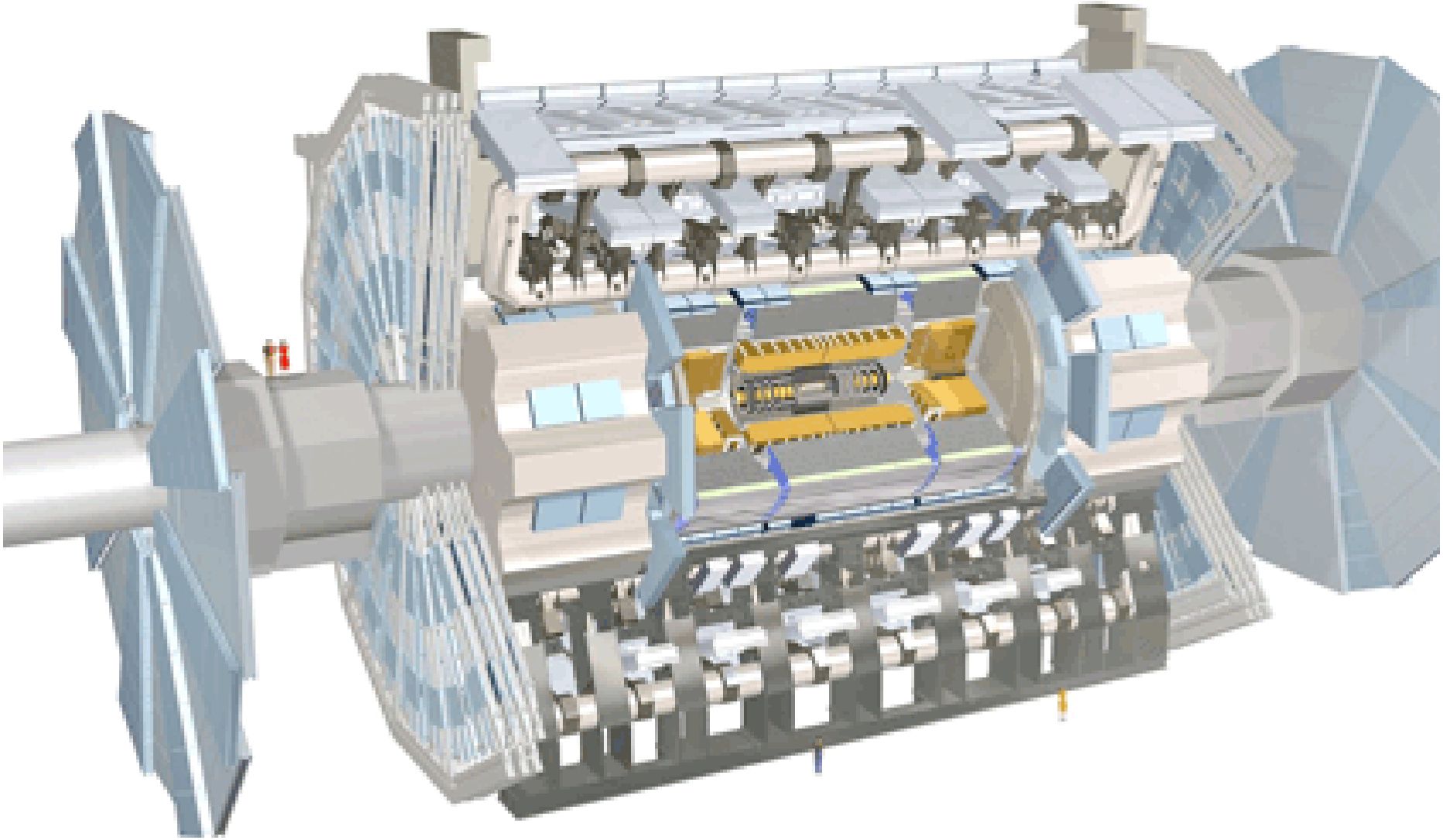
Collaborators also from non-member institutions, including
Budker Inst. of Physics
IHEP Protvino
MEPHI Moscow
Pittsburg University

What Makes Geant 4 Unique?

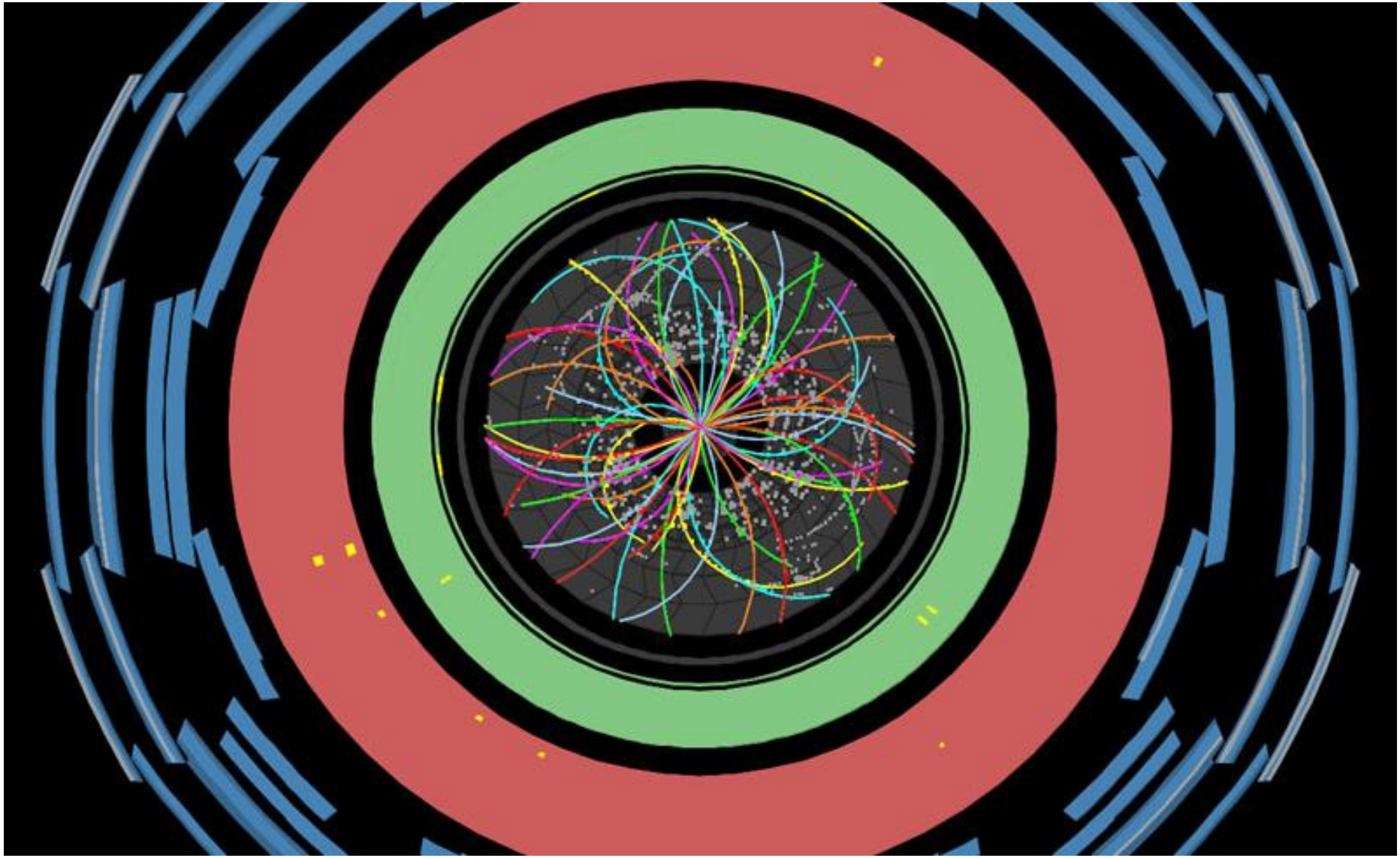
- Geant 4 is distinguished from other Monte Carlo Particle Transport codes by
  - The comprehensive suite of physics processes and particle types
  - The complexity of geometrical descriptions leads to realistic representations.
  - A collaborative open source mode leveraging international expertise
- Enables the user to select physics processes/models and choice of GUI/visualization/persistency/histogram ming technologies



It takes a lot of stuff to detect particles…



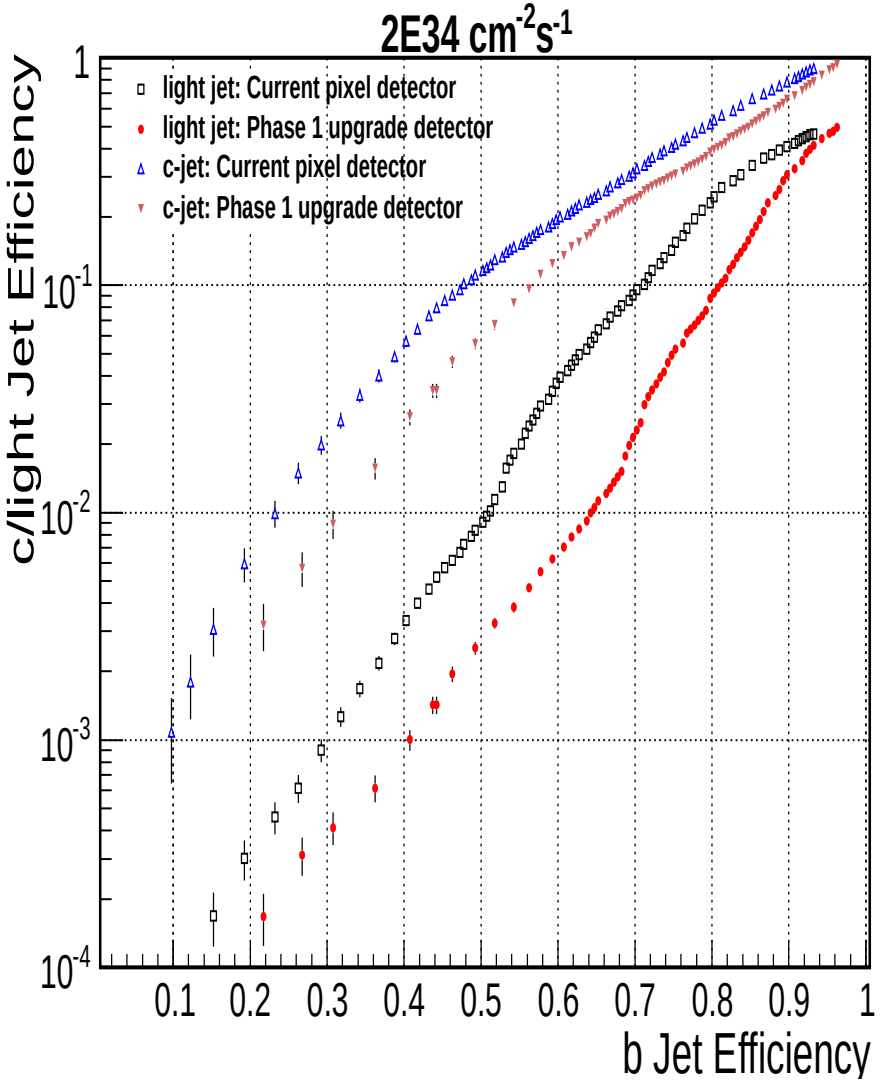
The process



Full Experiment Life Cycle

- Geant4 is used to support the full lifecycle of HEP experiments

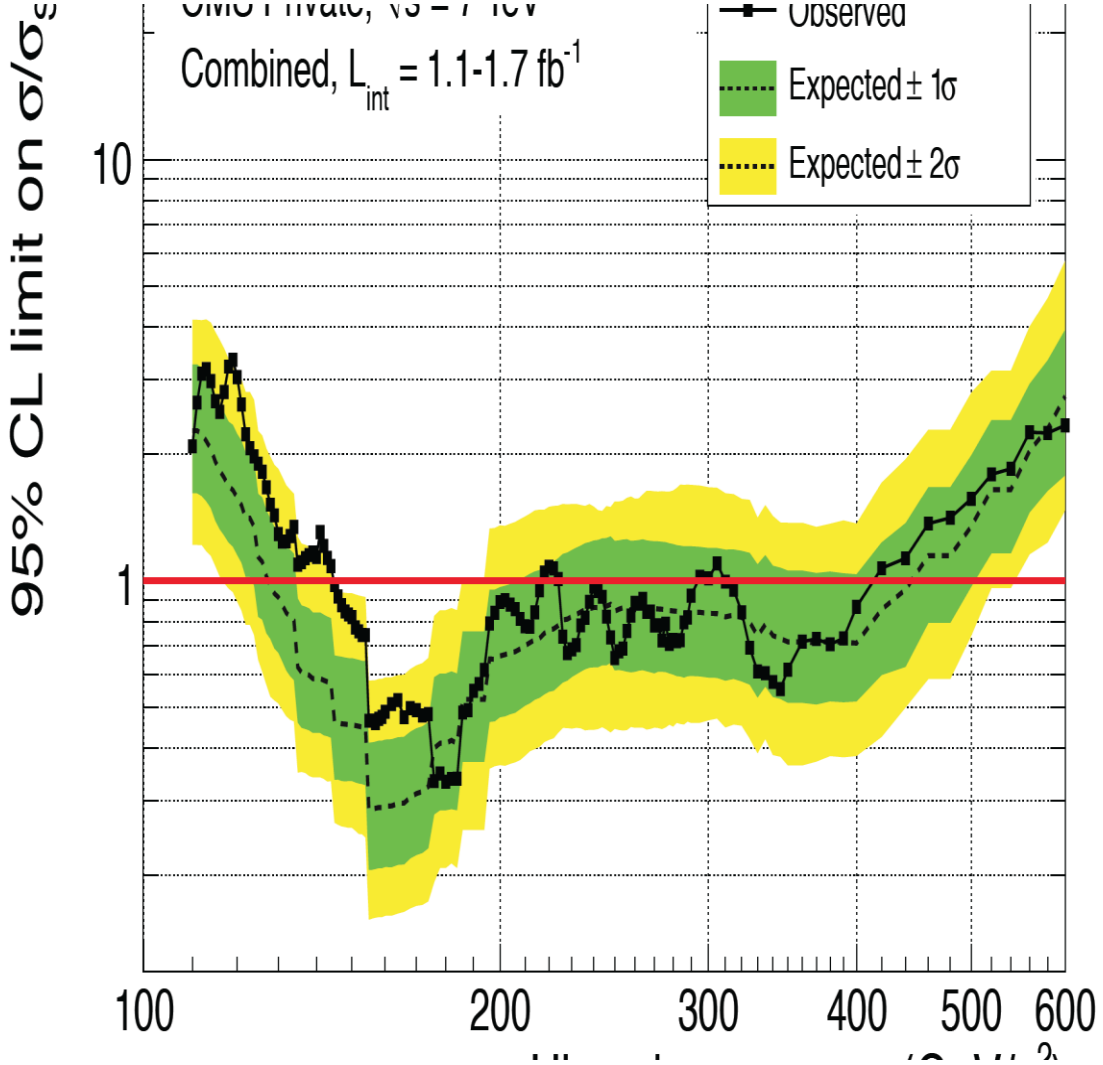
- Detector design
- Commissioning&calibration
- Software development



Life Cycle continued: Role in Analysis:

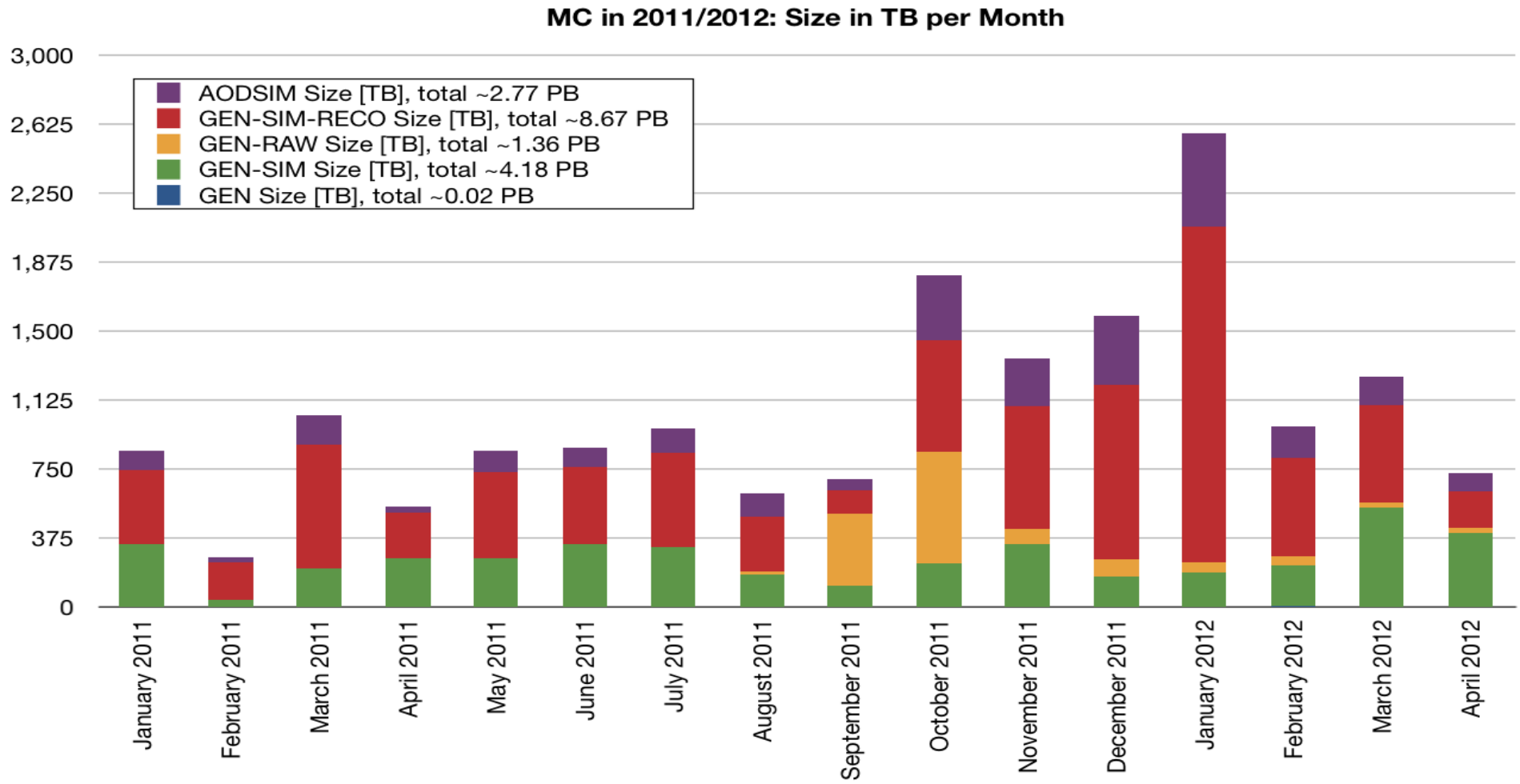
- Since Analysis rely on MC; Any useful data curation must also curate the experiment's Geant4 program
- (Plot show for illustrative purpose—not up to date)

- More details in Tom Lecompte's talk



The economics: CMS

G4 produces BIG Data! (See Rob Ross's talk for details)

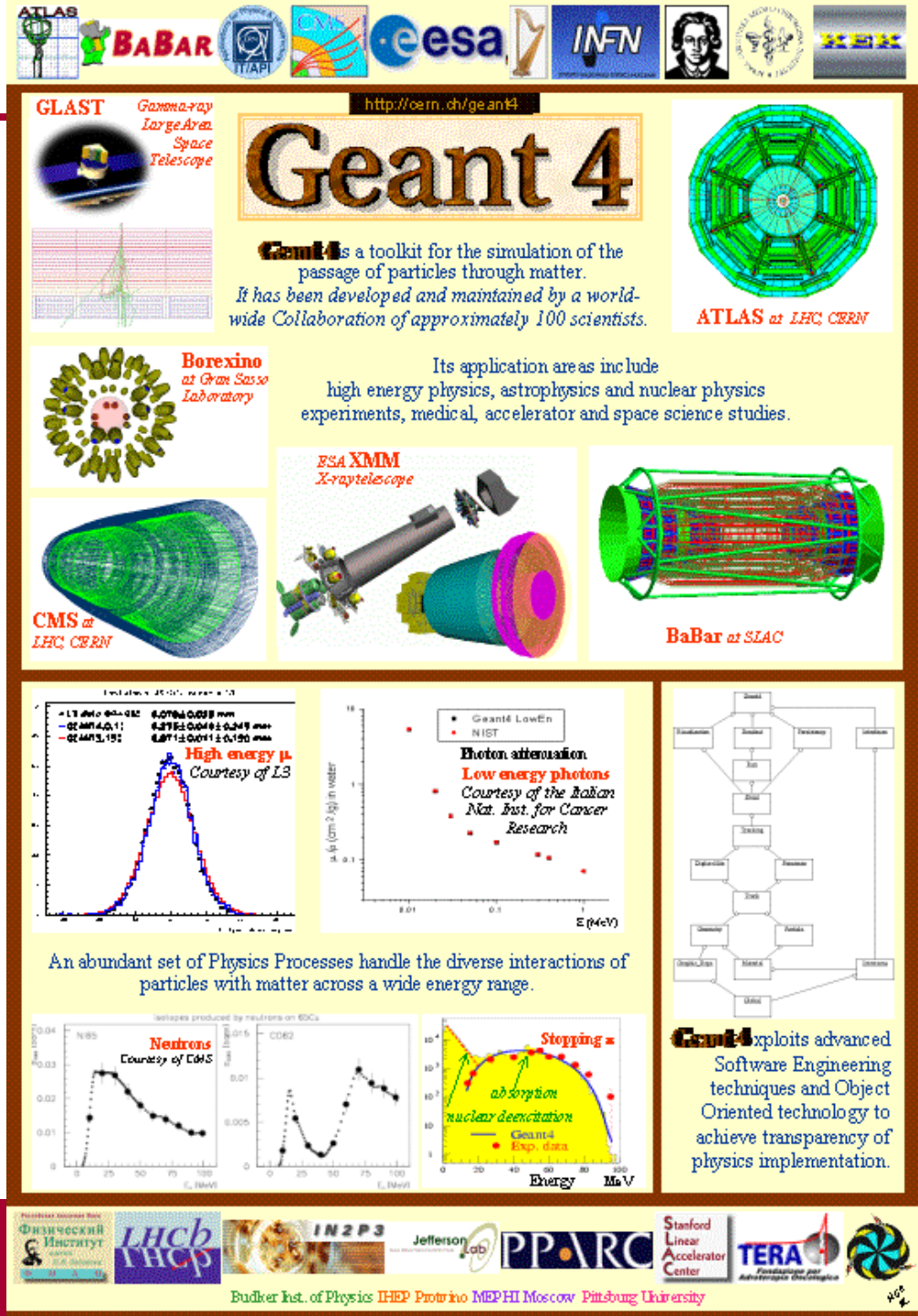


Economics: continued: ATLAS resource report

- **Simulation (full and fast):** The time per event for full simulation was improved significant- ly. In July 2011, this time was ~5000 HS06 sec. Now the average over all production is 2700 HS06 sec. This improvement was achieved by introducing “Frozen Shower” parameterization in the forward calorimeters, by detector geometry optimizations, and by switching to 64-bit running.
- The ATLAS physics programme has greatly benefitted from the ability to simulate substan- tially more events than planned. This ability was enabled primarily by a combination of the improved CPU performance of the full simulation and of more CPU resources available than estimated for this purpose, in large part because of opportunistic use of additional resources and because of availability of more CPU resources than requested or pledged. Increased sim- ulation has also required improvements in the sizes of simulated events and changes to data distribution policies for simulated samples.

See Rob Fowler and Jim Kowolkowski’s talks for more details

- These unique features of Geant 4 has lead to extended use beyond Particle and Nuclear Physics and beyond into condensed matter, radiation production, astrophysics, space science and medical applications.



Tool for Particle Simulation

- Joseph Perl - SLAC National Accelerator Laboratory
- Harald Paganetti, Jan Schümann - Massachusetts General Hospital
- Bruce Faddegon, Jungwook Shin - University of California San Francisco

UCSF University of California San Francisco

SLAC NATIONAL ACCELERATOR LABORATORY

MGH 1811

Work supported by the U.S National Institutes of Health under contract number 1R01CA140735-01

American Association of Physicists in Medicine

- "

2012 AAPM GRANT AND FELLOWSHIP RECIPIENTS

Seed Grant Recipients

Huanjun Ding, Ph.D. *University of California, Irvine*

"Quantification of breast density using photoncounting spectral mammography"

Magdalena Bazalova, Ph.D. *Stanford University*

"Towards radiation therapy with very high-energy electron beams"

Summer Undergraduate Fellowship

Jaebum Chung

(Sponsored by the AAPM Southern California Chapter)

Mentor: Dimitre Histrov Hristov, Ph.D. Stanford University

Paul Leo

Mentor: Anil Sethi, Ph.D. Loyola University Medical Center Chicago

Hannah Ponek

Mentor: Mahadevappa Mahesh, Ph.D. Johns Hopkins University

Lauren Rigsby

Mentor: George X. Ding, Ph.D. Vanderbilt University

Sean Rose

Mentor: Rob B. Mooij, Ph.D. University of Pennsylvania

Stephanie Sodergren

Mentor: Jean Pouliot, Ph.D. University of California, San Francisco

Minority Undergraduate Summer Experience (Muse)

Desmond Fernandez

Mentor: Chris Beltran, Ph.D. Mayo Clinic

Omar Orbe-Toledo

Mentor: Eduardo G. Moros, Ph.D. H. Lee Moffitt Cancer Center

Coming Soon!
The following programs are still in review.
The Fellowship for the training of a doctoral candidate in the field of Medical Physics
The AAPM Support for Clinical Residency in Imaging Medical Physics

Summary

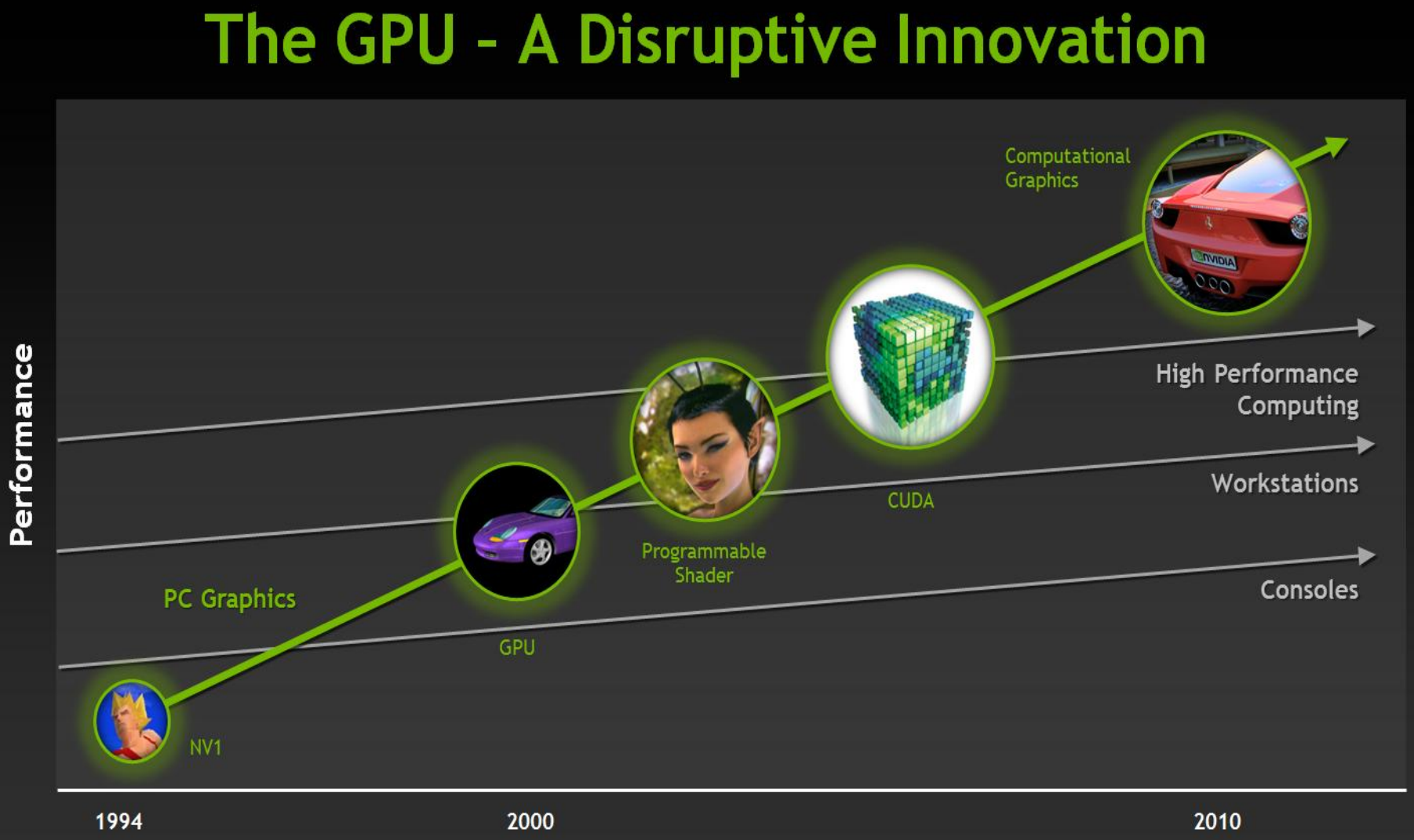
- Geant 4 is an incredibly powerful tool kit that fills a unique niche in the world of Monte Carlo Transport Codes
- It is indispensable within particle physics
  - It's a bit slow but the experiments usually find a way to cope sometimes by making physics trade-offs
- It is in wide use in aerospace, radiation protection and medical physics and beyond
  - National Prizes are good!
  - It requires a lot of knowledge to use it which is a by-product of its complexity
- It has been supported by small and dedicated international community for 18 years

So why are we here?

Because of

The plethora of issues represented by 30 or more years of collective scientific wisdom encapsulated in a legacy code base

To Change Gears



Moving Forward:

- There is incredible potential in the collaboration of Computer Scientists and domain scientists
  - Bring the best minds together
  - Enable computational physics on new architectures
  - Shorten development cycles?
    - Career issues
  - G4 is 'big data' in several ways—cross section tables and other internal data as well as out put data
- Adoption and support beyond original community
  - Work within an international collaboration
  - Public/Private Partnerships

- The science in Geant 4 has the potential to be a disruptive technology

- A development collaboration for re-architecting Geant 4 has the potential to disrupt scientific code development paradigm and manipulation of Big Data

Let's Transform Geant4!