More about the Geant4 Toolkit

Third African School of Physics
Aug 2014

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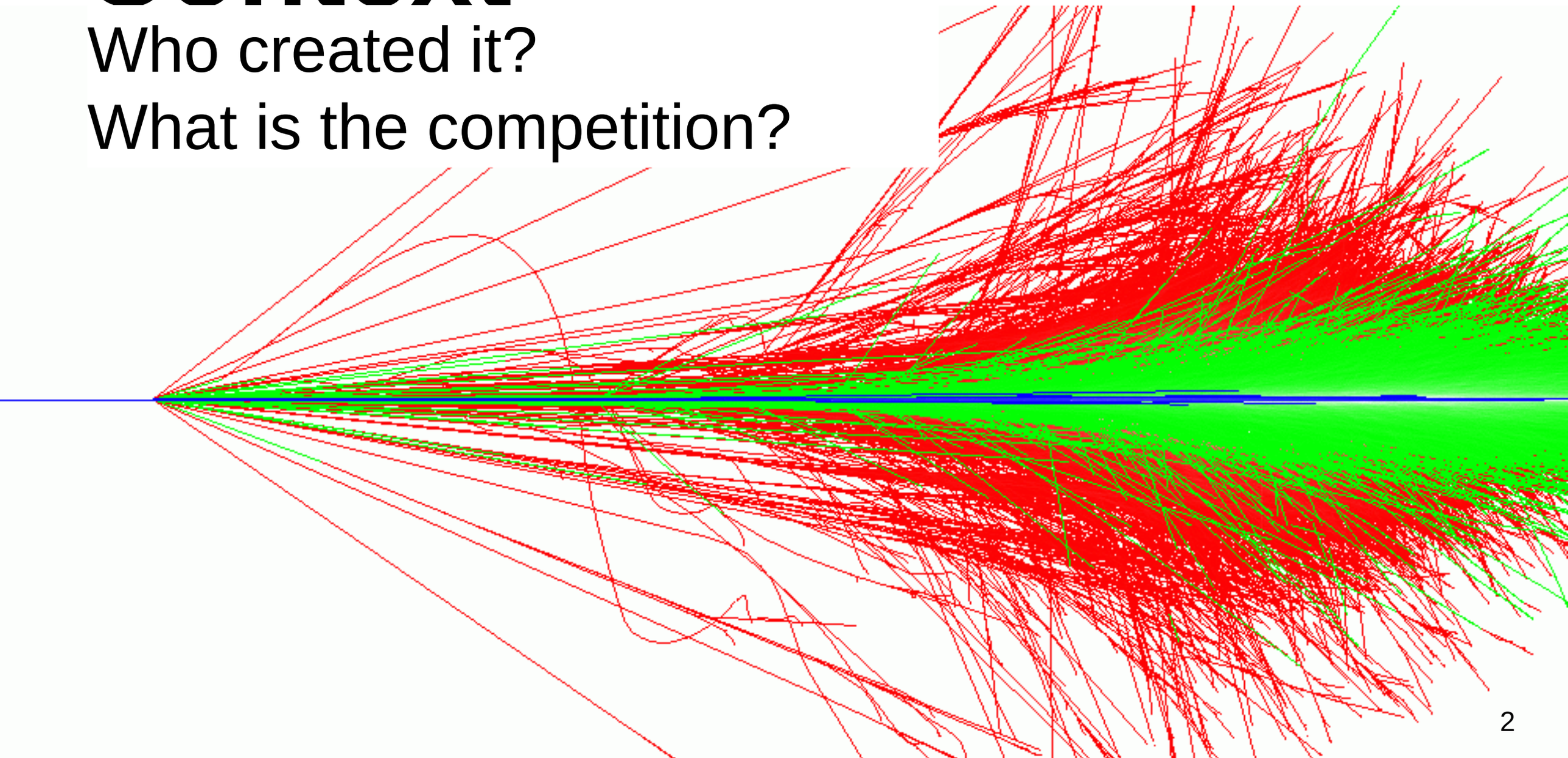
Some material **adapted** from talk by **Andrea Dotti** (now SLAC- before CERN or Geant4 Associates Intl) at the Second African School of Physics, August 2012

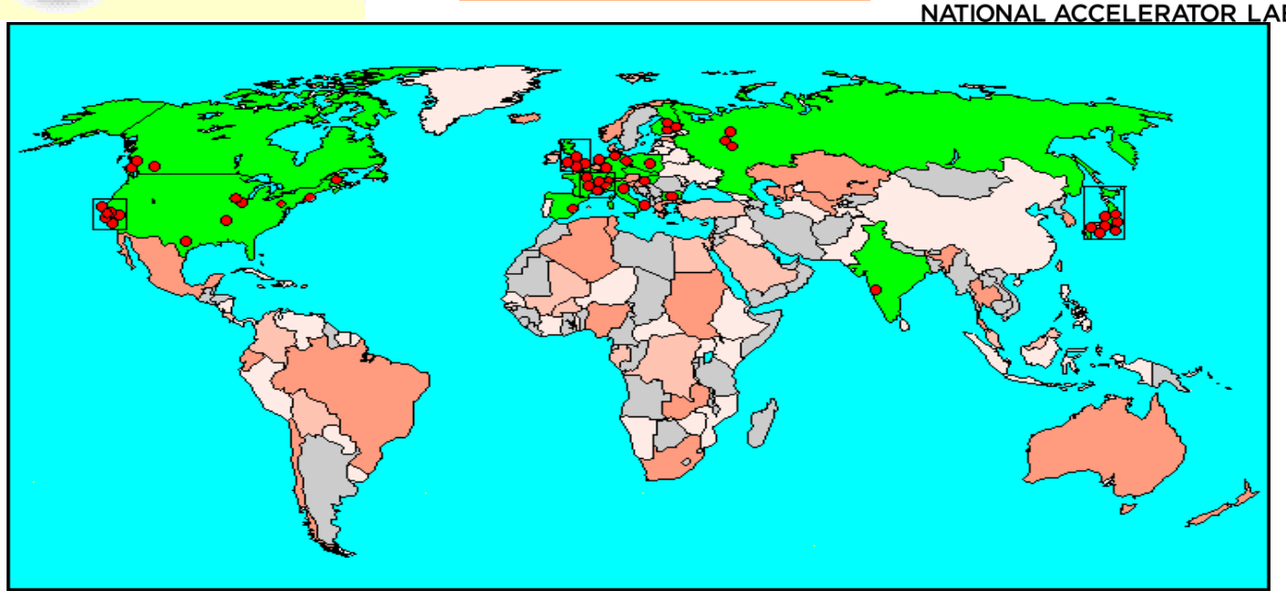
Context

Who created it?

What is the competition?



Worldwide collaboration

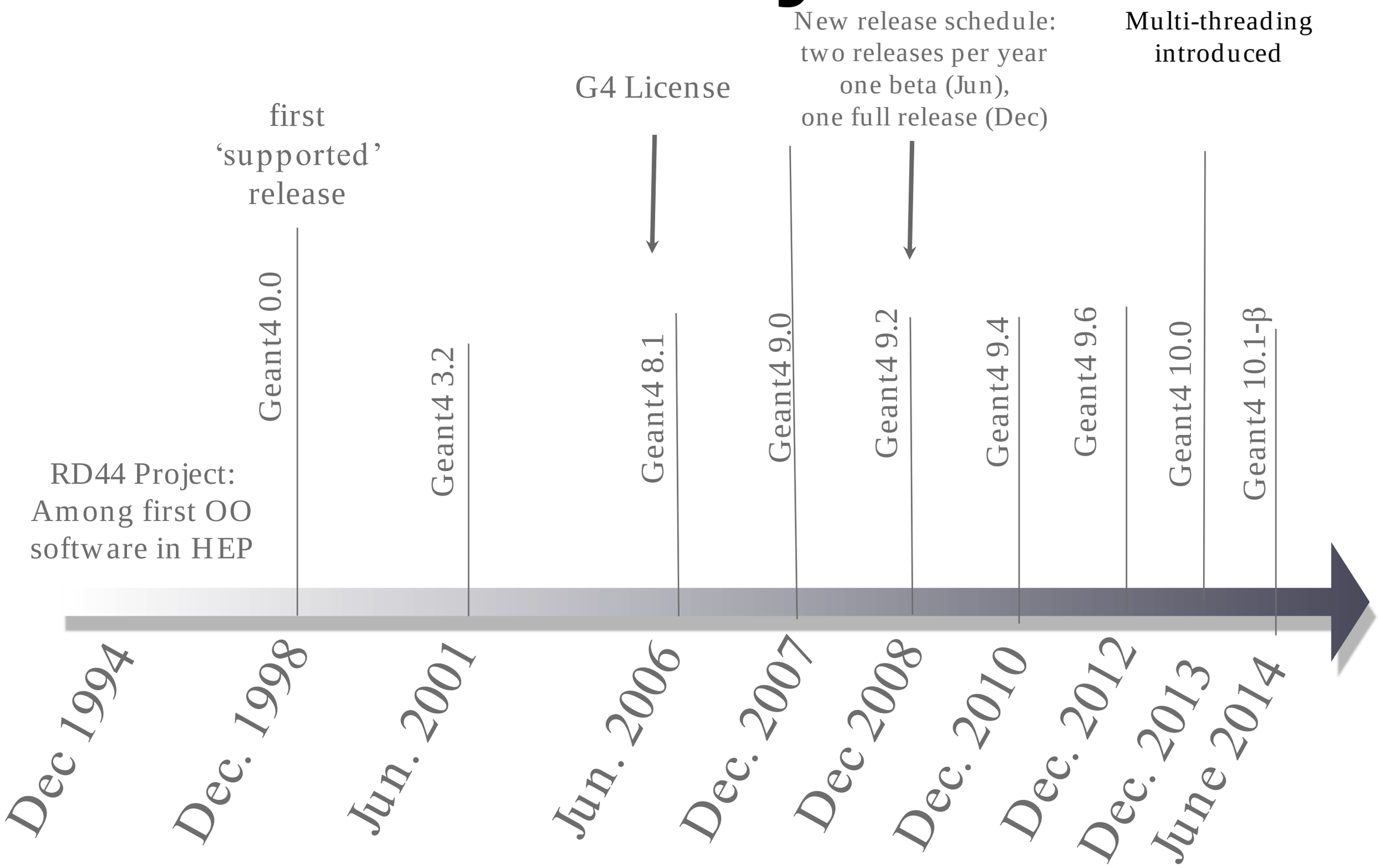


TRIUMF

Lebedev

Collaborators also from non-member institutions, including
IHEP
MEPHI Moscow
Jefferson Laboratory

A bit of history...



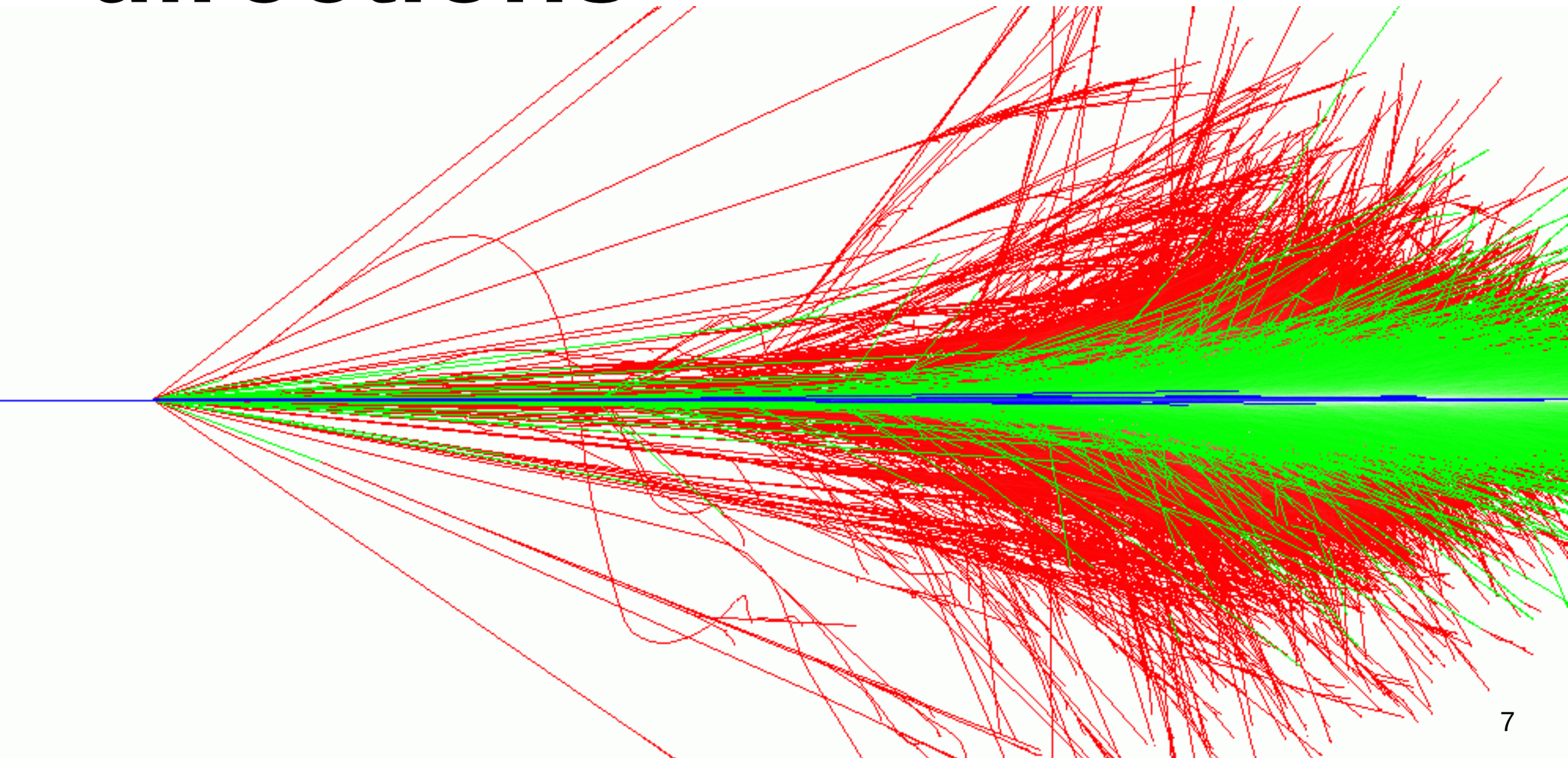
The competition

- A few other ‘all-particle’ transport tools
  - MCNP (and previously MCNPX) - neutrons/gammas, protons, ..
  - FLUKA (INFN/CERN) - used for shielding, accelerator studies
- Many specialized tools
  - e-/e+/γ simulation (typically at lower energies)
    - Penelope: strong low-energy models
    - EGS4nrc: established precision for medical applications
  - Hadronic shower: MARS, SHIELD
  - Ion simulation: HETC
  - Reactor simulation tools

Comparison

- Each tool has its strengths and weaknesses
  - I will give a personal perspective on those of Geant4
- Geant4 has many advantages
  - the most capable geometry engine
  - ability to check the source code (open source)
  - many tools built on top of it
  - very wide user base in many different application domains
- And some challenges:
  - choosing physics engine (‘list’) and ensuring its validation
  - choosing how to build an application
  - the wide user base means the support effort/load is high.

Recent and Future directions



Fixes and Improvement

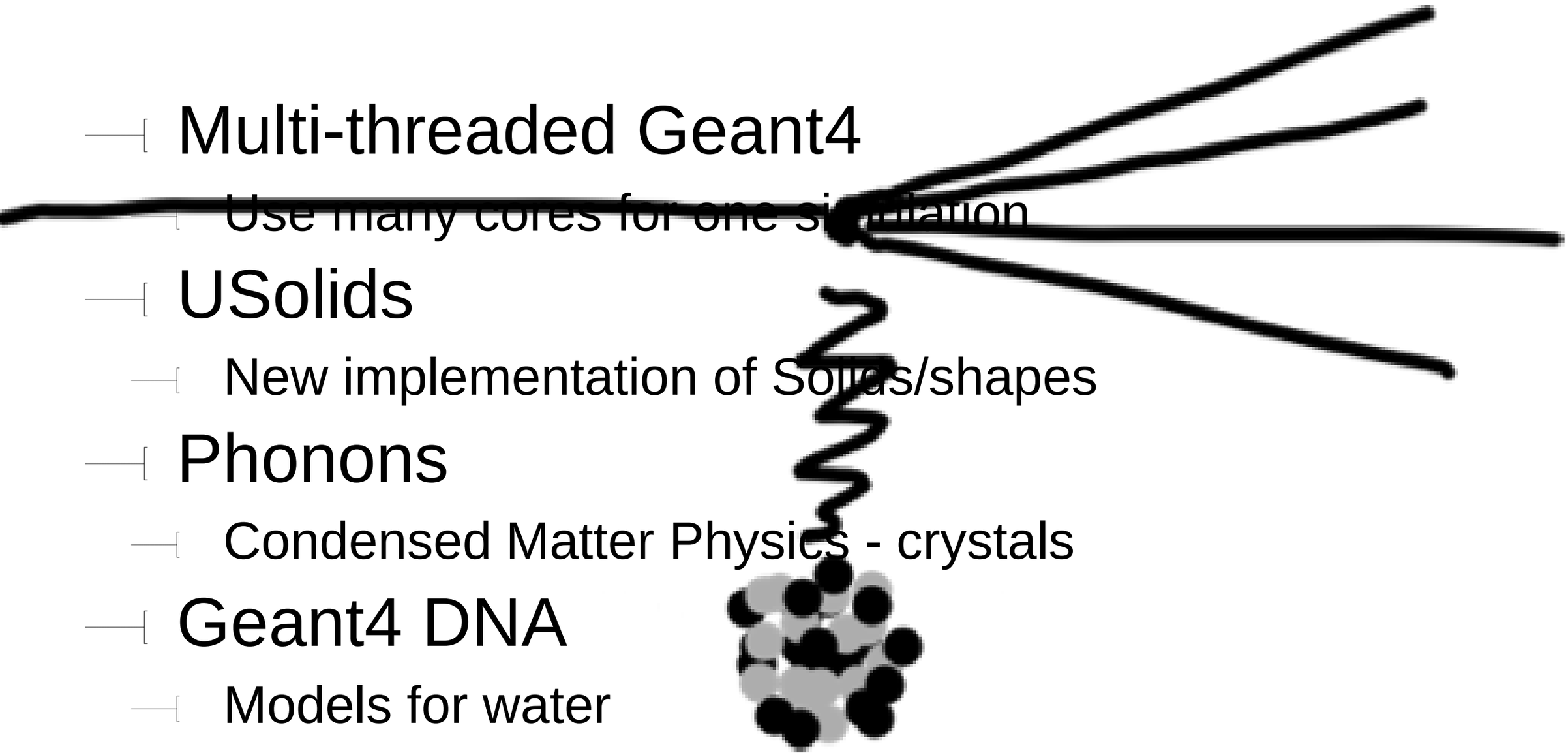
- G4 Collaboration solicits input on its proposed workplan each year at meetings of the ‘Geant4 Technical Forum’
- One production release per year (Nov/Dec)
- One beta development release per year (June)

- Fixes are provided in patches
  - Created ‘as needed’ when issues/fixes are found
  - Example:10.0 patch 2 on 13th June 2014

- Use the latest patch for the release you are using

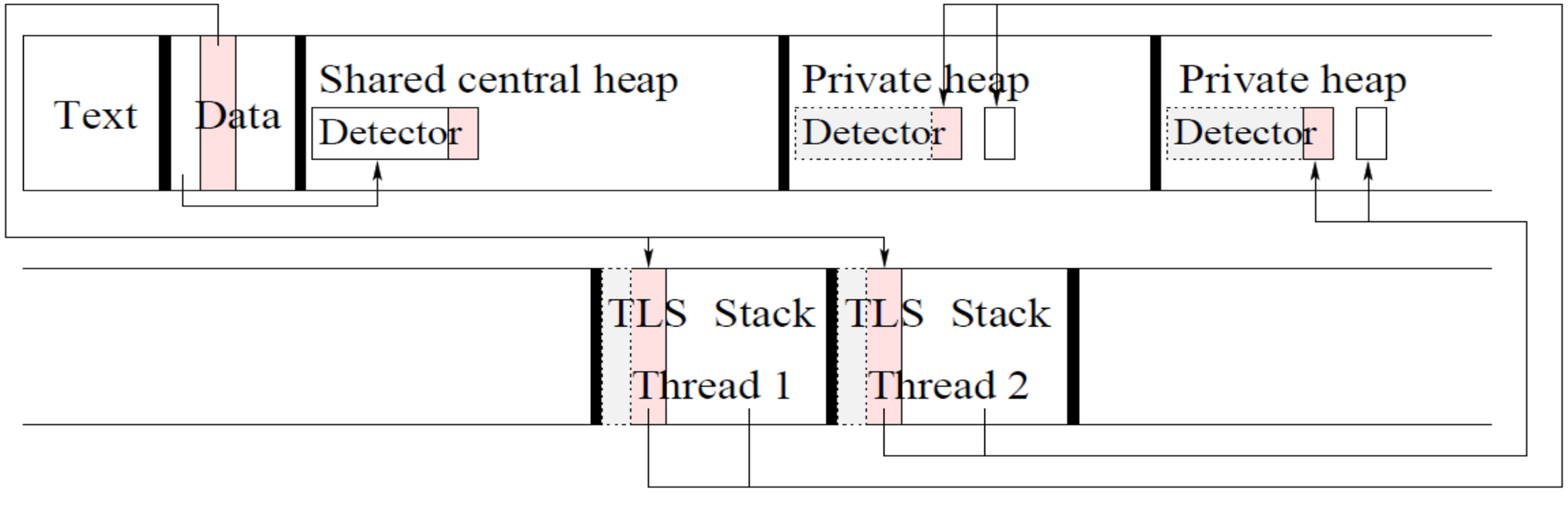
Recent Developments

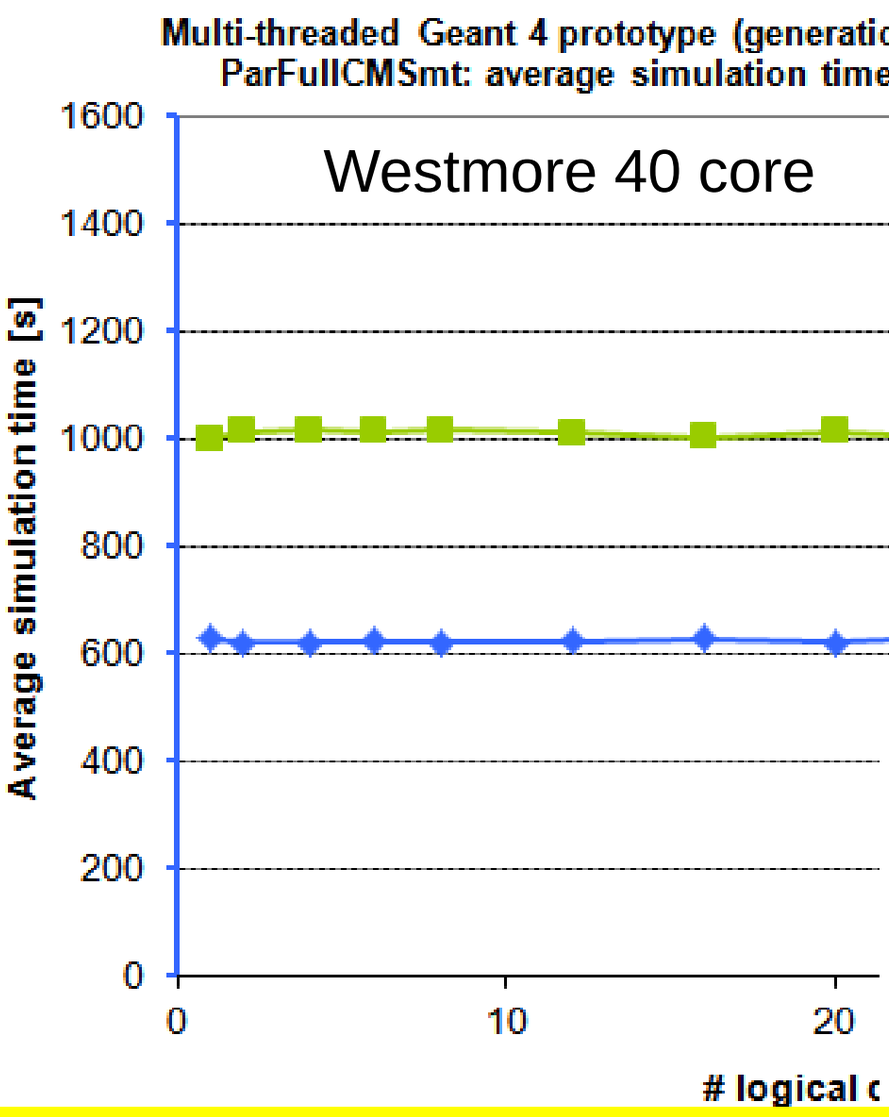
- Multi-threaded Geant4
  - Use many cores for one simulation
- USolids
  - New implementation of Solids/shapes
- Phonons
  - Condensed Matter Physics - crystals
- Geant4 DNA
  - Models for water
  - Effect on large molecules: radiation ‘chemistry’



Multi-threaded Geant4

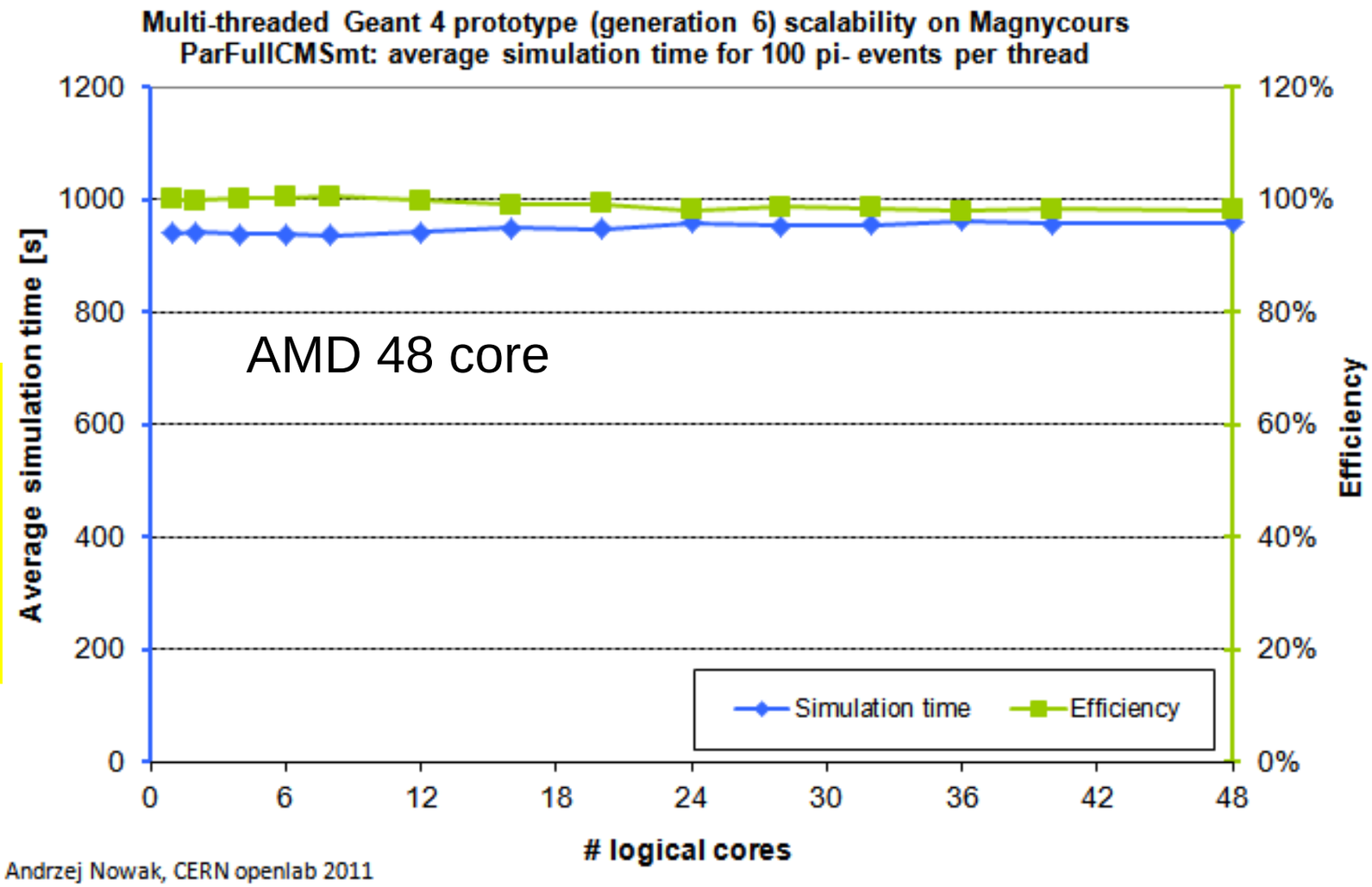
- Offers event-level parallelism within one job with many threads.
  - Uses the many-core machine in a memory-efficient scalable manner.
- Shares data among threads - reduces the memory footprint (compared to having a separate copy if using separate jobs)
  - "Almost read-only" data : data written at initialization phase but kept unchanged after this, i.e. during the 'event loop' of the simulation
- Allocates thread-local heap for transient objects.
  - Full-CMS benchmark shows ~30MB of extra memory per additional thread.





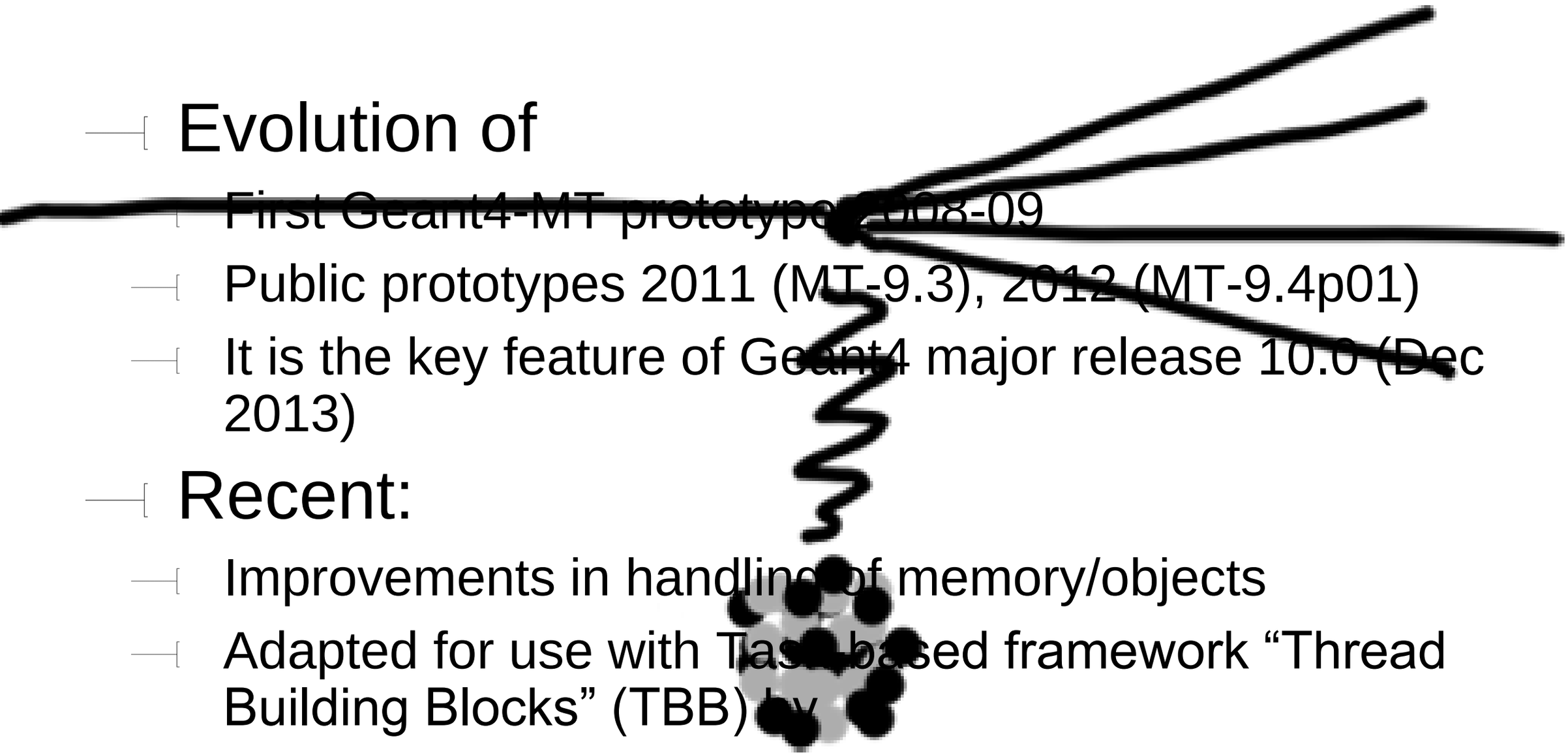
Note: scaling was still perfect with using 80 threads on Westmore (2 threads per core).
G4MT showed excellent scalability for Intel Xeon Phi (MIC) prototype.

Courtesy of Andrzej Nowak (OpenLab)



Multi-threaded Geant4 (cont.)

- Evolution of
  - First Geant4-MT prototype 2006-09
  - Public prototypes 2011 (MT-9.3), 2012 (MT-9.4p01)
  - It is the key feature of Geant4 major release 10.0 (Dec 2013)
- Recent:
  - Improvements in handling of memory/objects
  - Adapted for use with Task-based framework “Thread Building Blocks” (TBB) by
- Ongoing:



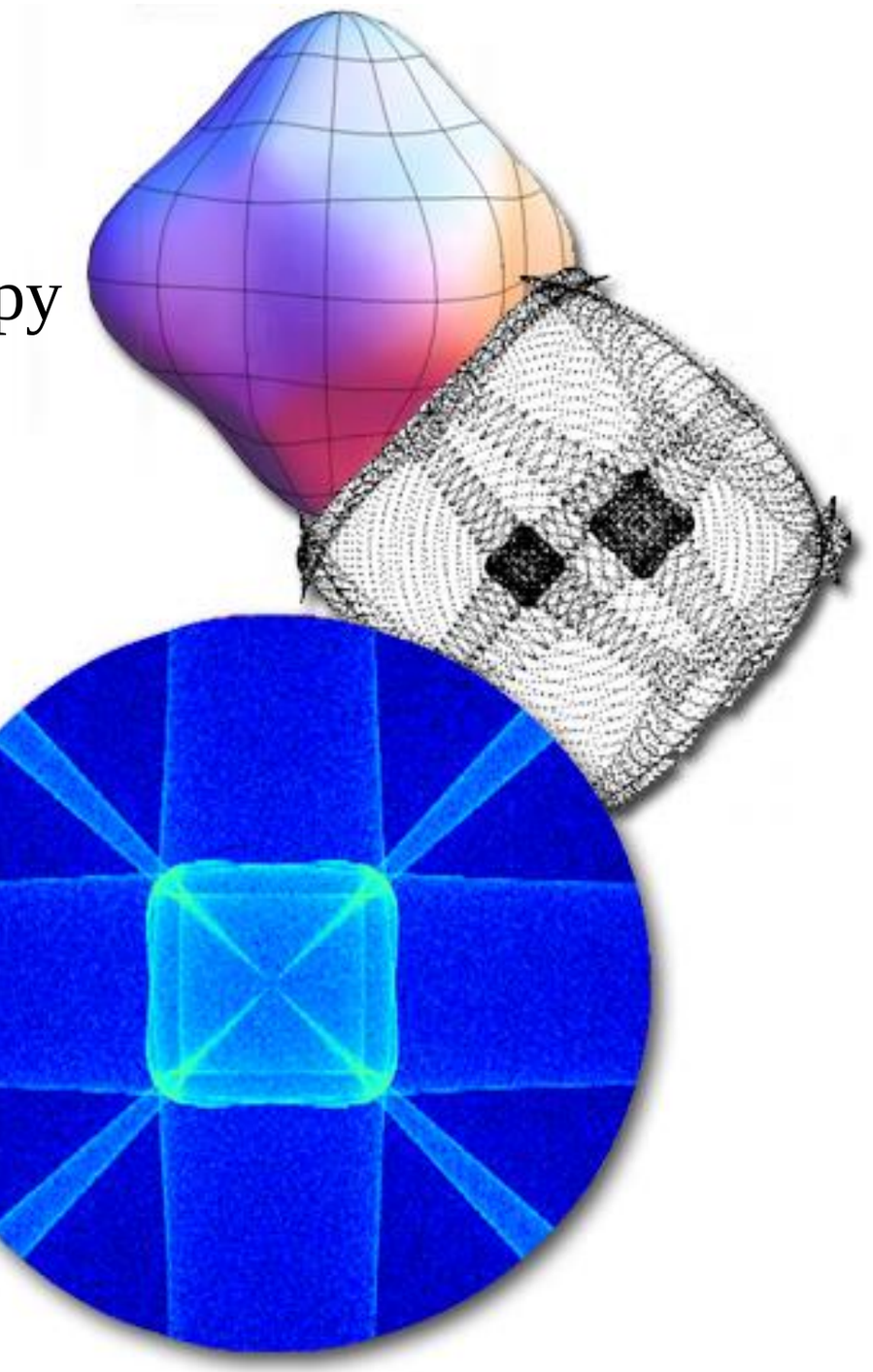
USolids library

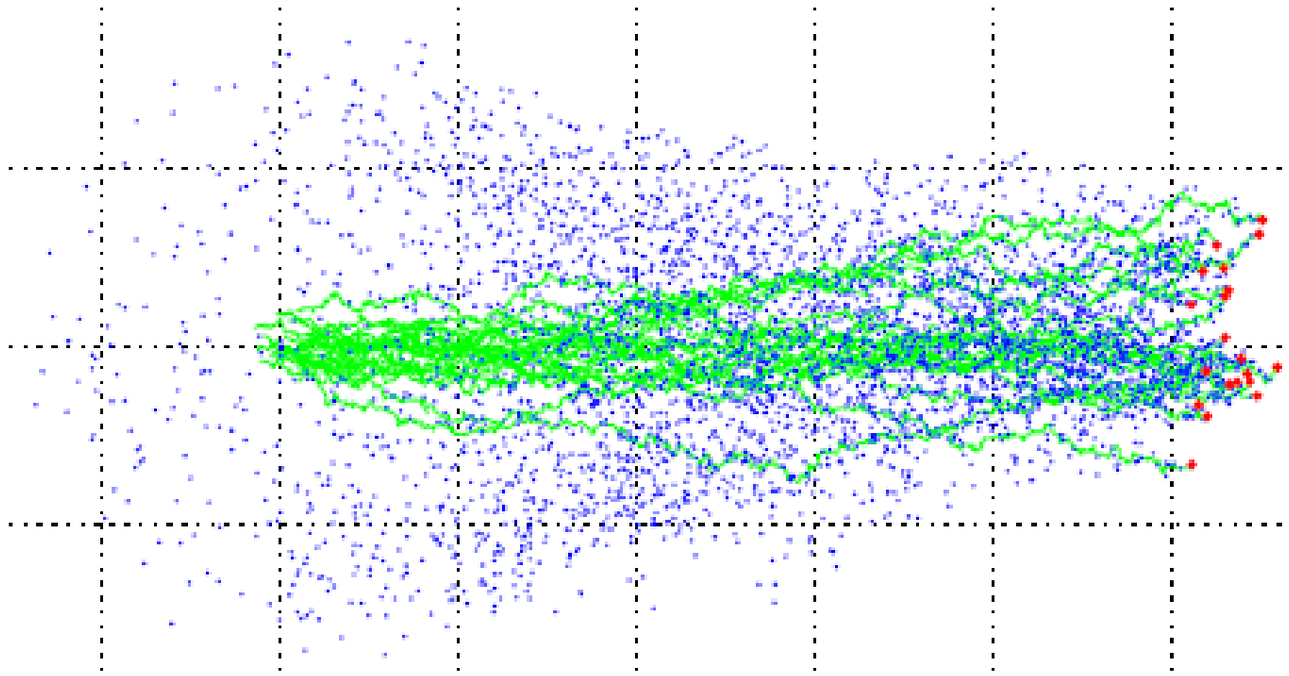
- Common library of shapes for Geant4 & Root
  - Goal: the fastest accurate implementations
  - Effort led by CERN SFT team, with contributions from others
- First version released as build option in Geant4 10.0 (Dec 2013)
  - User can mix USolids with G4Solids, or use USolids ‘first’
  - Additional solids provided in Geant4 10.1-beta (June 2014)
- Extended goals:
  - Vector implementation for one track of ‘complicated’ solids (G4/V)
  - Vectorized implementation of solids for multiple tracks (Geant V)
  - Common code base for scalar, vector and GPU implementations

Condensed Matter Physics in Geant4

•Phonon propagation, including focusing based on elasticity tensor (right)

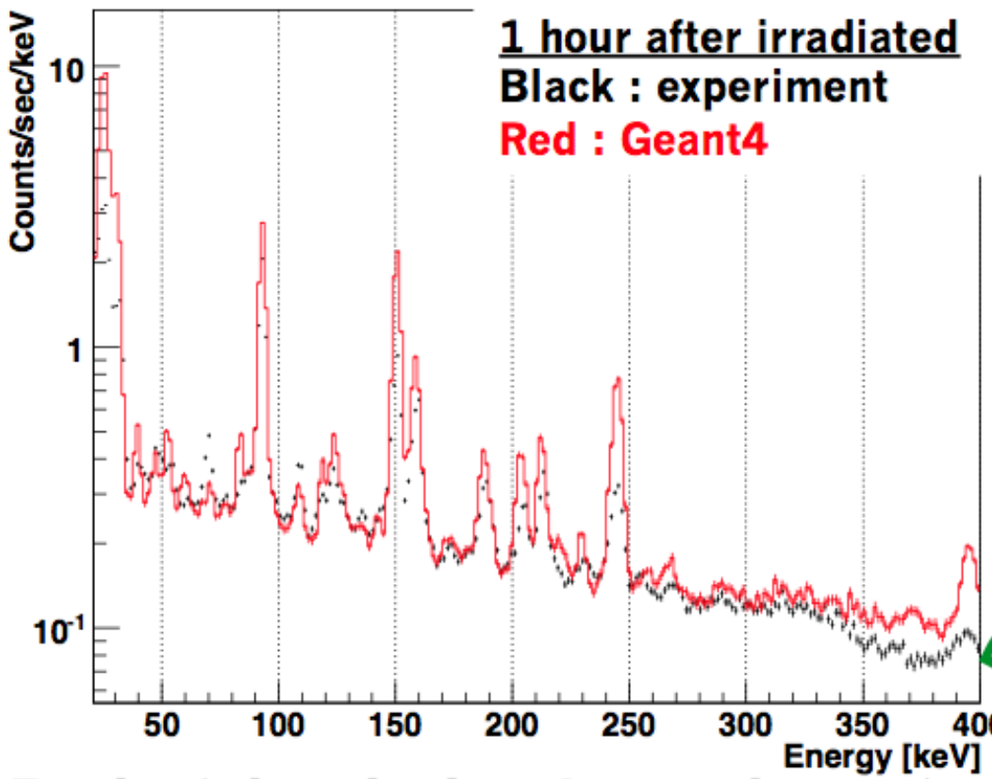
•e-/h+ transport, including conduction band anisotropy and Luke-Neganov emission, under development (below)



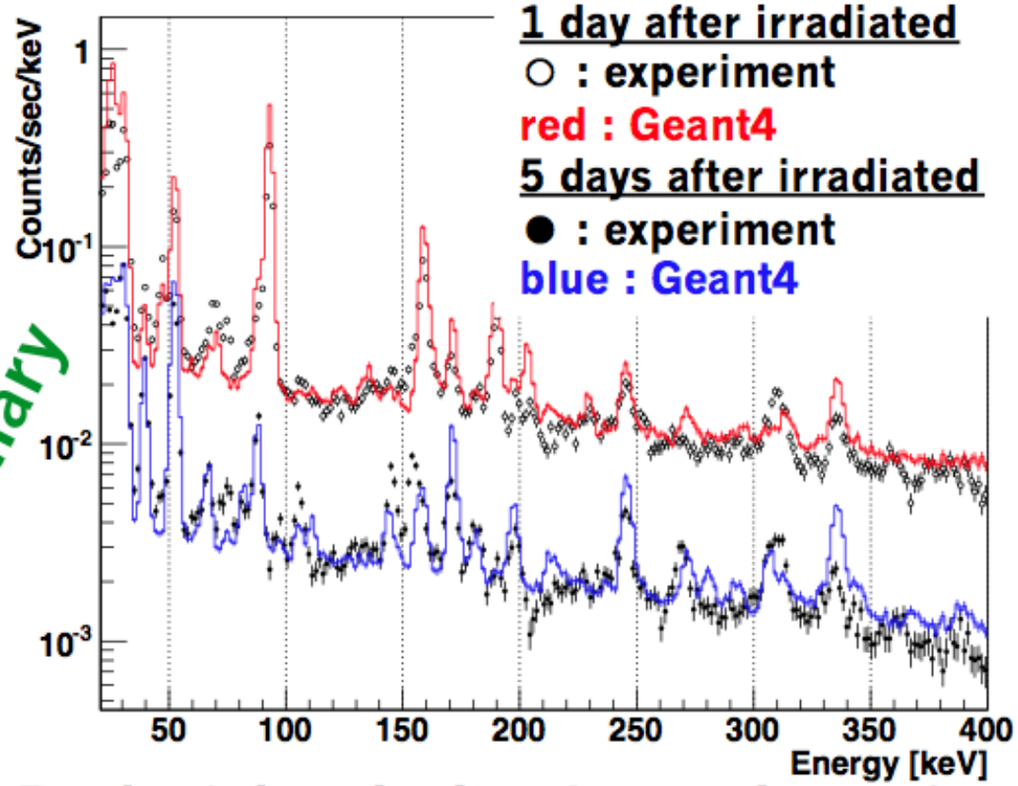


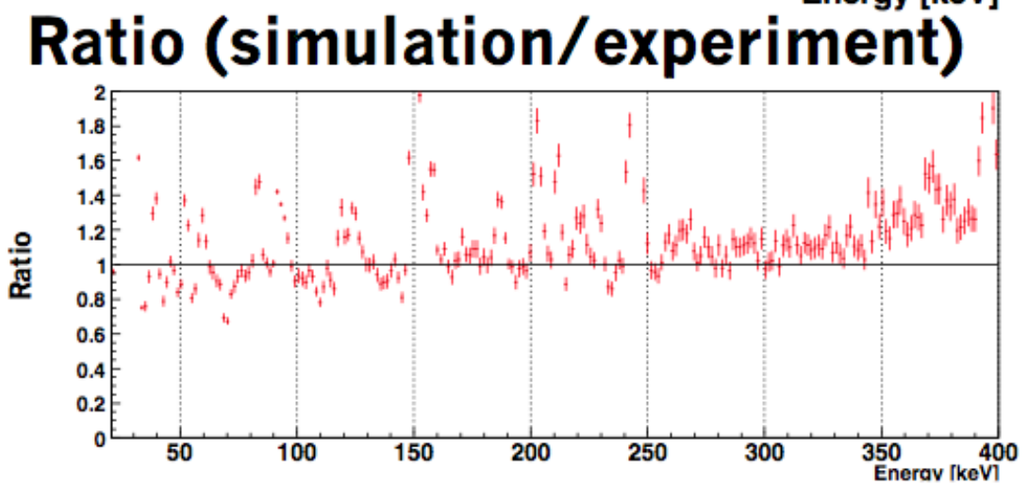
Time evolution of the activation background

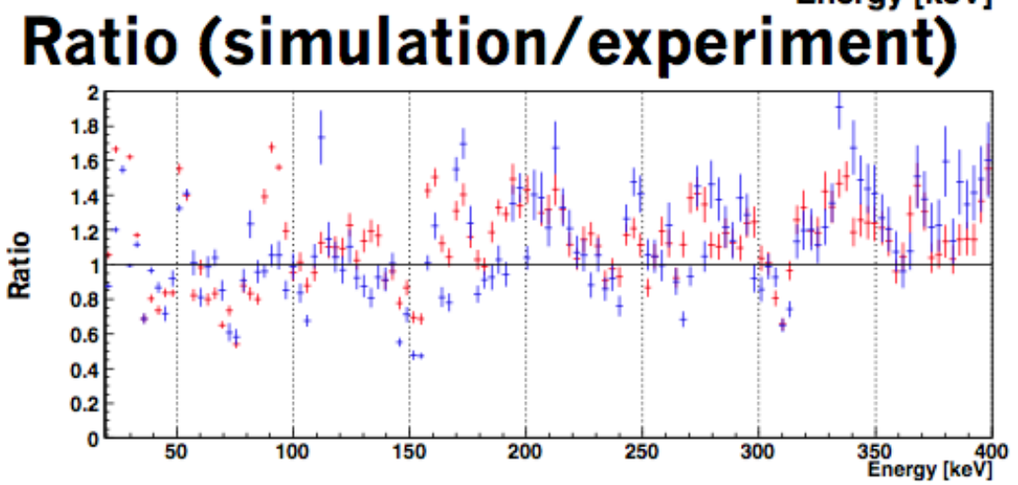
Comparison with Geant4



Preliminary



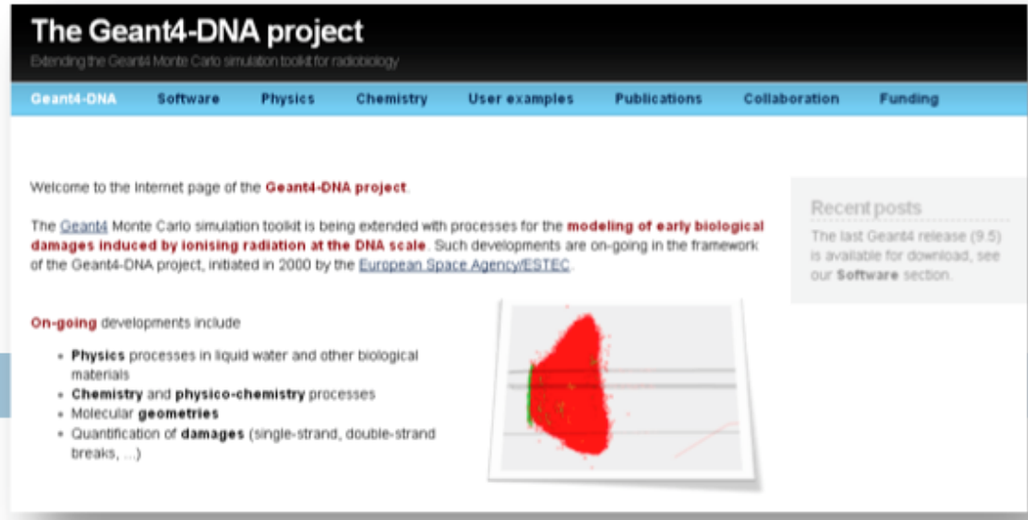




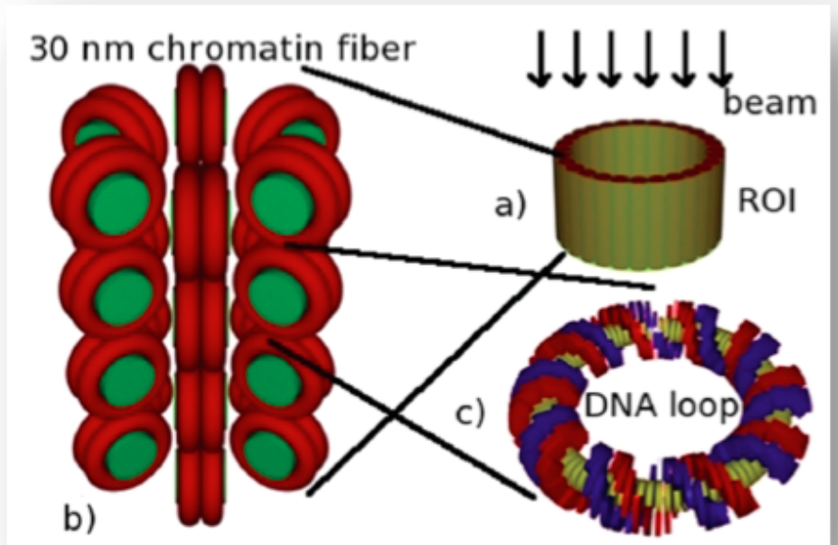
❖ Simulation results agrees with experimental data within a factor of two in terms of the line intensities

The Geant4-DNA project

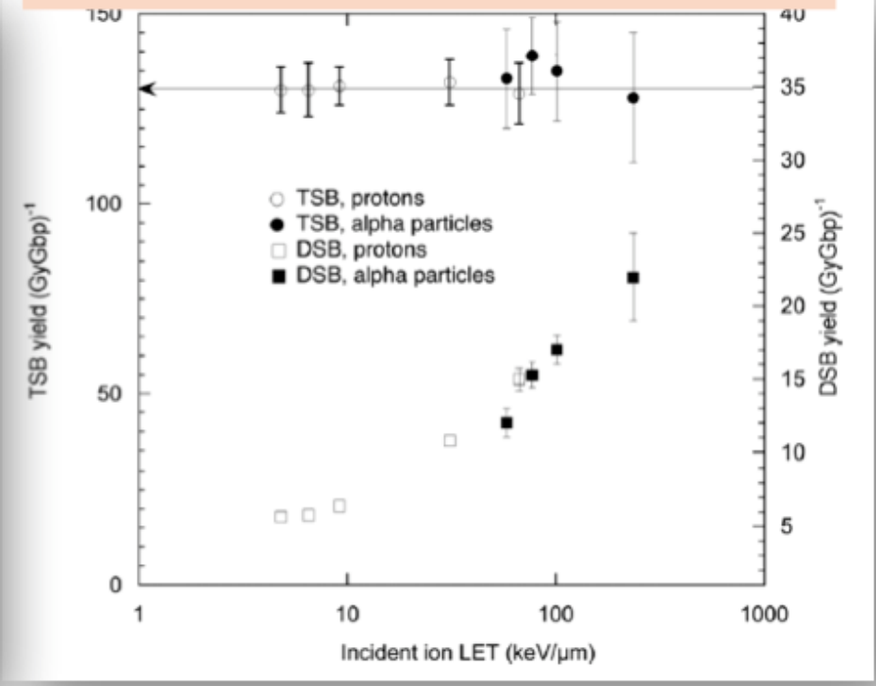
http://geant4-dna.org



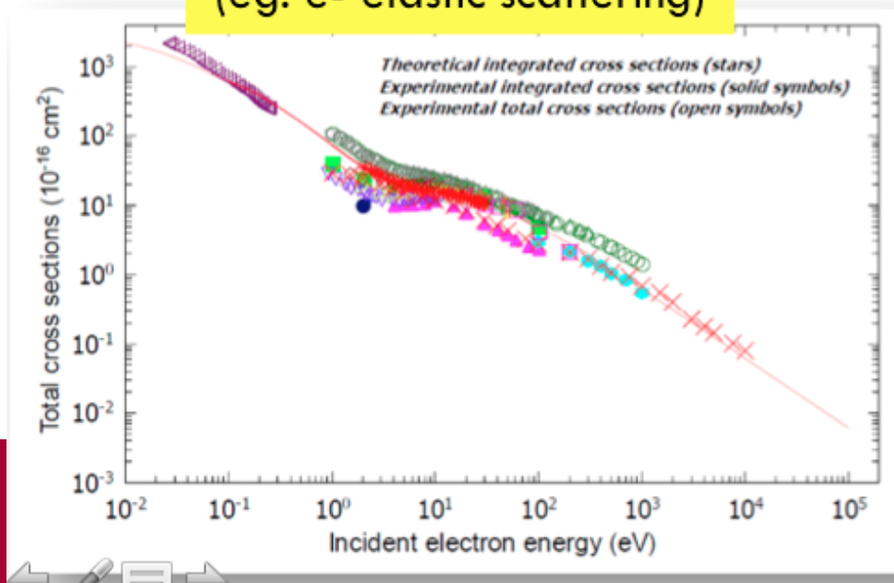
- Initiated in 2001 by the European Space Agency
- Purpose
  - extend Geant4 capabilities for the modelling of early DNA damages from ionising radiation in biological cells
  - including physical and physico-chemistry processes
    - water radiolysis
  - down to the eV and nanometer scales
- Status
  - A full component of the Geant4 toolkit



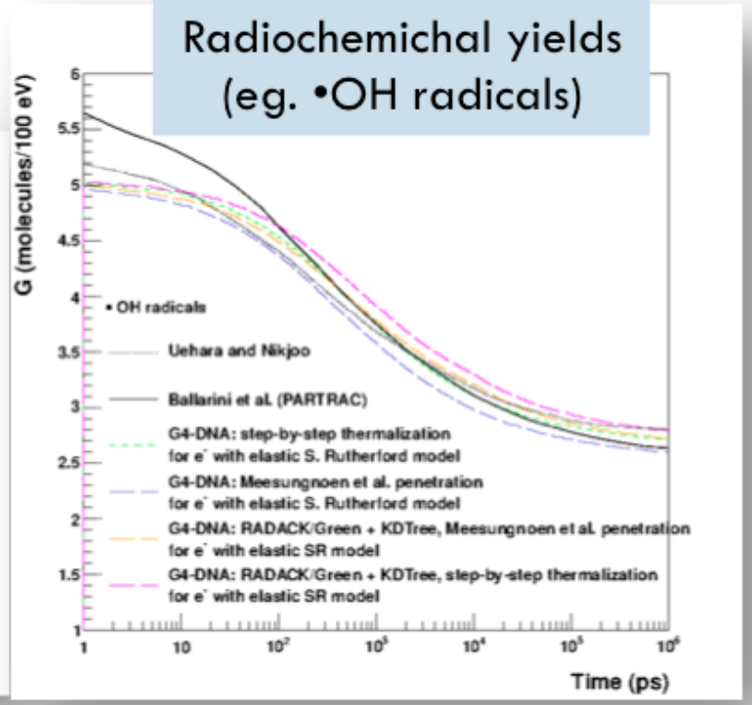
DNA direct damage invariance vs LET



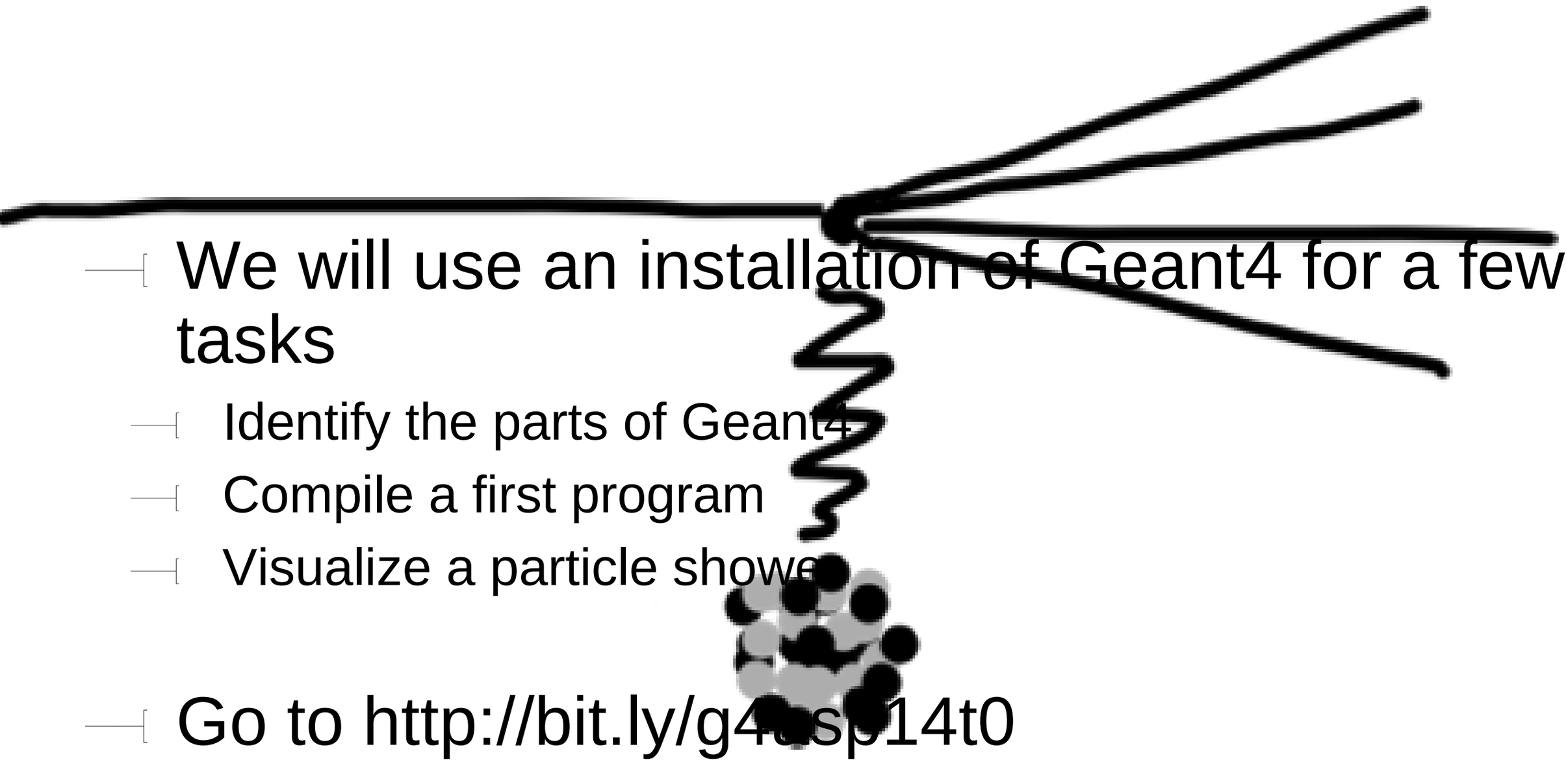
Accurate physics models (eg. e- elastic scattering)



Radiochemichal yields (eg. •OH radicals)



Practical exercises



- We will use an installation of Geant4 for a few tasks
  - Identify the parts of Geant4
  - Compile a first program
  - Visualize a particle shower
- Go to http://bit.ly/g4tsp14t0