# Performance benchmarks & Tools
# Geometry


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# Outline

- Evolution of performance from 5.2.p02 to 8.2.p01
  - Pure tracking geometrical tests
  - Benchmarks with field
- Considerations following questions from reviewers

- Geometry tools and usability
  - Tools for building and setup geometry models
  - Tools for debugging geometries
  - Interfaces to CAD and external applications

# ‘Pure tracking’ benchmark

- Honeycomb calorimeter
  - Basic benchmark application used since early days
    - Calorimeter setup from CERN School of Computing 1995
    - Consisting of two modules, a matrix of 26 by 50 tubes each
  - Tracking ‘geantinos’ along predefined directions

| Geant4 version | User time (s) | System time (s) | Ratio | |
|---|---|---|---|---|
| 5.2.p02 | 2.570 | 0.000 | 0.84 | |
| 6.2.p02 | 3.050 | 0.100 | 1.00 | (1) |
| 7.0.p01 | 3.000 | 0.000 | 0.98 | |
| 7.1.p01 | 3.060 | 0.010 | 1.00 | |
| 8.0.p01 | 3.070 | 0.020 | 1.00 | |
| 8.1.p02 | 3.020 | 0.020 | 0.99 | |
| 8.2.p01 | 3.140 | 0.010 | 1.03 | (2) |

# ‘Pure tracking’ benchmark - 2

(1) - G4Navigator becomes a base class in 6.0

- Good portion of key methods become virtual
  - To accommodate Tgeo/VMC interface

(2) - LocateGlobalPointAndSetup() method in G4Navigator becomes virtual

  - To accommodate Tgeo/VMC interface

- Total CPU penalty from 5.2.p02 to 8.2.p01 for pure tracking sums up to ~ 20%

# Benchmarks with field

- BaBar tracker
  - Geant4 *NTST* benchmark
  - Consists of simulating the BaBar silicon tracker and 40 layers drift chamber, in a 1.5 T constant magnetic field
  - Only transportation, no physics. 100 B-Bbar events simulated

| **Release** | **sec/event** | Ratios | |
|---|---|---|---|
| **7.1.p01a** | 2.23 | 1.00 | |
| **8.0.p01** | 2.23 | 1.00 | |
| **8.1.p02** | 2.33 | 1.04 | <--- ***G4FieldTrack::LoadFromArray()*** not inline |
| **8.2** | 2.49 | 1.12 | <--- ***LocateGlobalPointAndSetup()*** becomes virtual |
| **8.2.p01** | 2.49 | 1.12 | |
| **8.2.ref02** | 2.50 | 1.12 | |

The number of steps and calls to fields are almost the same in all cases

# Benchmarks with field - 2

- BaBar tracker using QGSP_EMV physics list
  - Same benchmark test as in the previous slide, but this time with the QGSP_EMV Physics List. 100 B-Bbar events simulated

| Release | sec/event | Ratios | |
|---|---|---|---|
| **7.1.p01a** | 3.40 | 1.00 | (QGSP_GN) |
| **8.0.p01** | 4.29 | 1.26 | |
| **8.1.p02** | 4.32 | 1.27 | |
| **8.2** | 4.00 | 1.18 | |
| **8.2.p01** | 4.33 | 1.28 | |
| **8.2.ref02** | 4.17 | 1.23 | |

➢ *Variations mainly due to tuning and adding safety checks to Urban Multiple Scattering model*

# Considerations

1. The Geant4 geometry modeler provides since long time constructs and tools for tuning optimal navigation tracking and transportation in field within Geant4
   - Volume assemblies, replicas, parameterised volumes, regions
   - Geometry optimisation options
   - Parameters for field tuning and different stepper algorithms
   - ➢ *Automatically generated/converted geometries/setups will inevitably introduce a penalty, depending on the complexity*
2. By default Geant4 runs in "verbose" mode
   - To allow for proper debugging and information
   - 5-15% CPU improvement (depending on application) can be achieved in transportation/navigation in "no-verbose" mode

# Considerations - 2

- Recent CPU comparisons made in ALICE with Tgeo/VMC reveal
  - Comparable results for pure-tracking benchmarks on different geometry setups and with or without physics
    - without considering points (1) and (2)
  - A penalty in performance induced when L3 field is activated on TPC (5K Hijing particles at 0.5-999 GeV)
    - Particular setup, where low-energy particles are forced to perform small steps
    - First investigations indicating a “conservative” estimation of the geometrical ‘safety’ in Geant4 when field activated
    - Will review the estimation of isotropic ‘safety’
    - May require proper tuning of the field for such use case
    - Further aspects under investigation

# Tools for building geometries

- Ability to replicate, divide and parameterise volumes to be placed
  - Especially useful for optimising memory consumption on complex geometries
  - Implementation of setups parameterised by material
- Ability to assemble volumes in patterns and replicate them
  - Available since release 3.2 in 2001
  - Especially useful for describing areas of detector which may be subject to misalignments
    - Unique transformation which can be changed at run time
- Ability to reflect volume hierarchies
- Ability to handle geometries which change in time
- Ability to customise production (cuts) by geometrical region
  - CPU performance optimisation
- Ability to customise local fields per volume (parameters and stepper algorithms)
  - CPU performance & precision optimisation

# Tools for building geometries - 2

- GGE (Graphical Geometry Editor)
  - GUI tool for relatively simple geometries
  - Ability to generate source code for geometry description
- Handling of ‘parallel’ geometries (since 8.2)
  - Setup of geometries and navigation tuning for fast parameterisations
  - Possibility to apply geometrical importance biasing for charged and not-charged particles
  - Setup of scoring/tallies in generic positions within the tracking geometry
- Other tools (since 8.0/8.1):
  - Ability to compute geometrical volume of a generic shape
    - Ability to estimate the ‘mass’ of a detector (hierarchy if volumes)
  - Ability to compute the surface area of a generic shape

# Tools for debugging geometries

- Ability to detect overlaps
  - Once geometry constructed
    - Run-time overlap checks, tuneable in resolution and level of deepness in the geometry tree (since release 4.0)
    - Graphical tool (DAVID) for analysing and highlight overlaps based on postscript output of geometrical model (since 1.0)
    - Since 8.1, possibility to verify overlaps for each placed volume in the tree (against daughter and mother volumes)
  - While constructing the geometry (since 8.1/8.2)
    - Checks for each volume being placed or parameterised
      - Being extended to support all available solids and also cases of ‘encapsulation’ of volumes
      - Now automatically activated during navigation in case of “stuck” tracks for the suspected volumes

# Tools for debugging geometries - 2

- Running G4Navigator in ‘check-mode’
  - Introduced in release 6.1
  - Flag which can be activated at run-time (in ‘verbose’ mode, the default)
  - Forces additional checks on correctness and accuracy of solids response
  - Allows for identifying potential problems in the geometry model

# Interface to external applications

- Possibility to import/export geometry models cross applications
  - Through GDML and related tools
    - Allows for import/export of models from/to Root/Tgeo
  - Through direct object persistency with Root/IO
- Possibility to import geometry models from CAD systems
  - Translation of geometrical shapes to - approximated - tessellated shapes through existing tools (e.g. STViewer)
  - Import translated geometries through GDML
    - Tessellated shapes imported as G4TessellatedSolid
  - ❖ Allows to import also complex geometry models and shapes
  - ❖ To be considered for integration of complex shapes otherwise difficult to code

# Planned developments for 2007 in Geometry

- Tunable geometrical tolerance - *(1)*
- Parallel navigation & transportation as default - *(1)*
- Re-factoring and revision of biasing/scoring processes - *(1)*
- New G4ExtrudedSolid specific shape - *(1)*
- Integration of *Geant4e*, error-propagation module - *(1)/(2)*
- Full application tuning & benchmark suite for field - *(1)/(2)*
- Optimised navigation for voxelised phantom geometries - *(2)*
- New G4Paraboloid specific shape - *(2)/(*)*

*(1) - Major release 9.0 end of June 2007*

*(2) - Minor release 9.1 in December 2007*

*(*) - If manpower will be assigned: summer student project*

# Manpower - Geant4 Geometry WG

| | |
|---|---|
| • John Apostolakis, CERN | - 10% |
| • Pedro Arce Dubois, CIEMAT | - 10% |
| • Makoto Asai, SLAC | - 10% |
| • Gabriele Cosmo, CERN | - 25% |
| • Vladimir Grichine, CERN | - 10% |
| • Alex Howard, CERN | - 25% |
| • Ivana Hrivnacova, IPN Orsay | - 5% |
| • Tatiana Nikitina, CERN | - 80% |

- Total (including development and support): 1.75 FTE
  - *Considering the effort and amount of requests, it is a concern !*