

Geantino test on Atlas geometry

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Quantitative geantino test

- Special private version(s) of Geant4 has been used to run the geantino test using a GDML dump of almost full ATLAS geometry – current ATLAS geometry without EMEC.
- The test collected information on the number of calls to various functions of G4Solid objects. Such quantitative information is useful for better understanding on how the execution time is consumed, and for better estimation of the effect of changes in the Geant4 geometry code.
- The table on the next slide contains the results of two slightly different tests . The column “Inside” is subdivided in two parts – the first part contains the number of calls to the original `Inside()` functions, the second part contains the number of calls to the `Inside()` functions after the following early return has been introduced in `G4UnionSolid::Inside()` and `G4DisplacedSolid::Inside()`:

```
// Check if point is outside of bounding box  
if (std::abs(p.z() - fBoxCenter.z()) > fBoxSize.z()) return kOutside;
```

Distribution of calls by Solids and Methods (1)

MacBook Pro, Intel Core i5, **2.7 GHz**

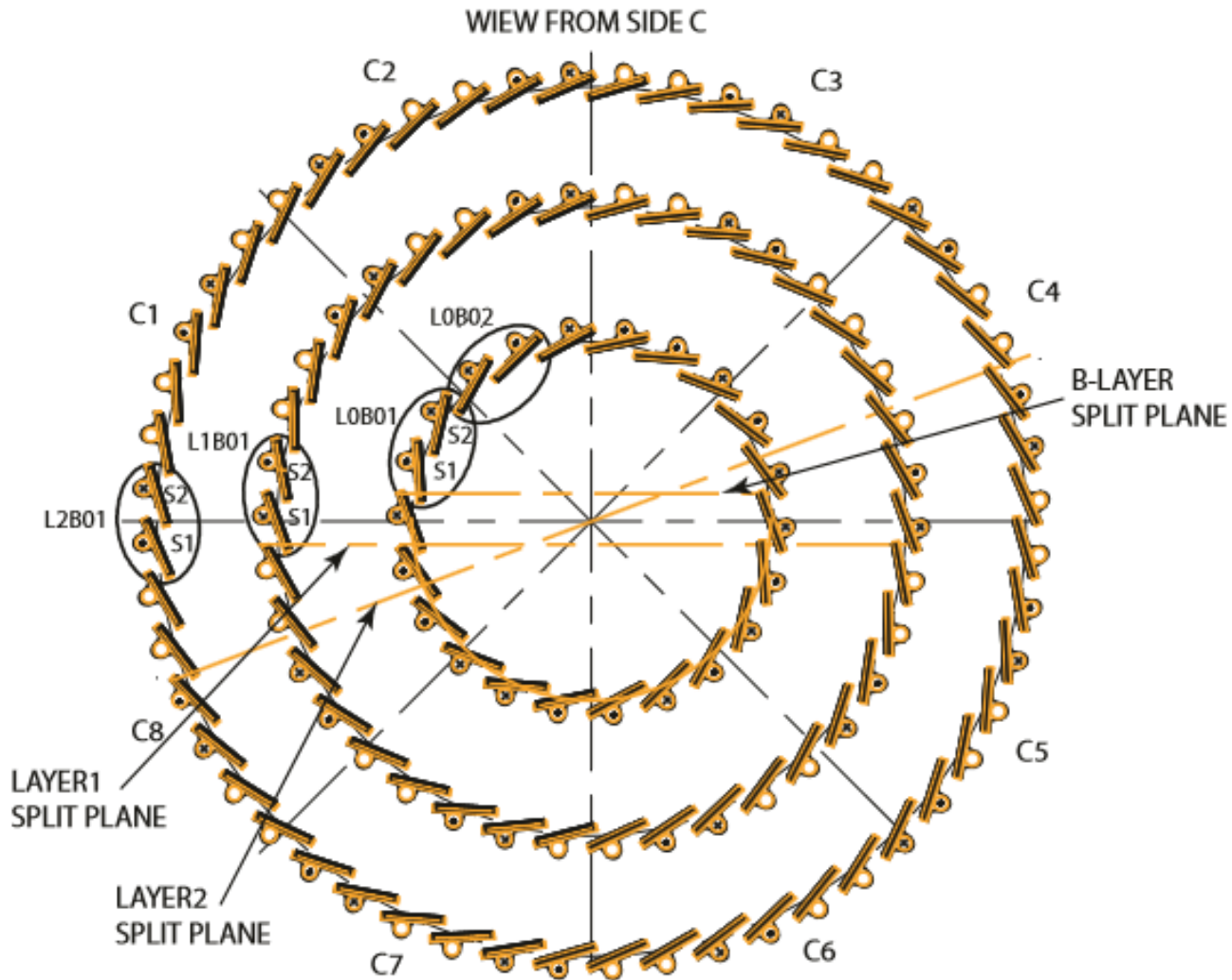
GDML dump of full ATLAS except EMEC

100k events, no. of steps: 160.441.712 – **1604 steps/event**

Execution time: original code – **383 s**, with early return in G4UnionSolid and G4DisplacedSolid – **290 s**

	Inside x 10 ⁶	Normal x 10 ⁶	SafetyToIn x 10 ⁶	SafetyToOut x 10 ⁶	DistToIn x 10 ⁶	DistToOut x 10 ⁶
G4Box	4201 857	4	45	15	41	26
G4Trap	8793 557	0.2	71	25	65	32
G4Trd	264 219	2	54	62	50	65
G4Tubs	640 148	0.6	84	44	76	41
G4Extruded	17 11	0.6	2	1	2	1
G4Polycone	28 19	0.3	5	13	5	6
G4Union	11954 11072	19	71	31	68	235
G4Subtraction	656 654	6	15	26	13	25
G4Displaced	13594 11973	4	104	8	99	27
Total	40147 25510	37	451	225	419	458
		All – 1590 (G4Tubs – 246, G4Polycone – 29)				

Atlas Pixel detector – 112 staves



No. of staves: B-layer – 22, Layer 1 – 38, Layer 2 – 52

Pixel Stave Profile

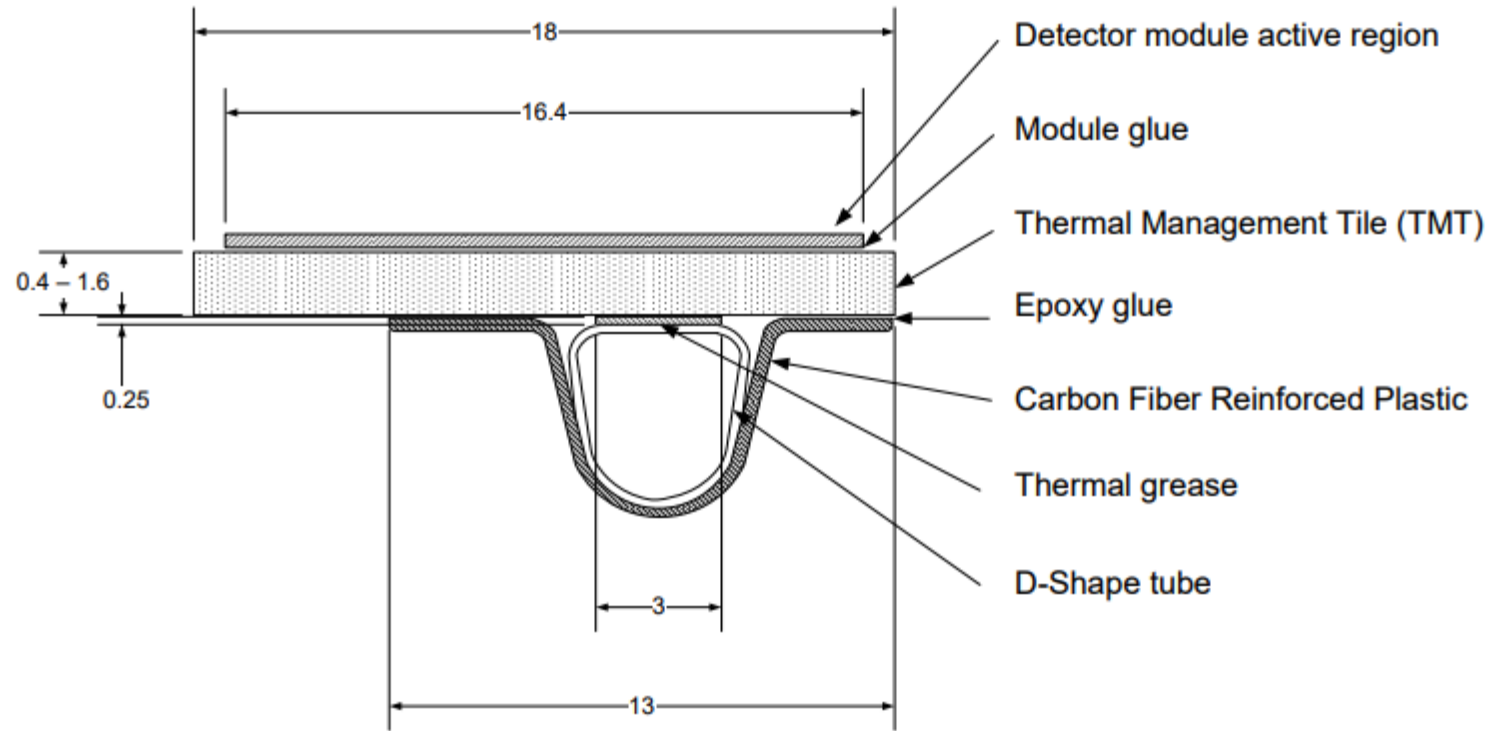


Figure 2.7: Pixel Stave Profile

TMT is defined as a Boolean union of 42 solids – 6 G4Box solids and 36 G4Trap solids

Distribution of calls by Solids and Methods (2)

MacBook Pro, Intel Core i5, **2.7 GHz**

The GDML dump used in previous test, where **112 physical volume with TMT have been removed**

100k events, no. of steps: 159.739.590 – **1597 steps/event** (-7 steps per event)

Execution time: original code – **186 s**, with early return in G4UnionSolid and G4DisplacedSolid – **183 s**

	Inside x 10 ⁶	Normal x 10 ⁶	SafetyToIn x 10 ⁶	SafetyToOut x 10 ⁶	DistToIn x 10 ⁶	DistToOut x 10 ⁶
G4Box	236 194	4	38	15	34	21
G4Trap	30 30		28	25	25	25
G4Trd	264 219	2	54	62	50	65
G4Tubs	640 148	0.6	84	44	76	41
G4Extruded	17 11	0.6	2	1	2	1
G4Polycone	28 19	0.3	5	13	5	6
G4Union	164 162	7	23	19	21	21
G4Subtraction	656 654	6	15	26	13	25
G4Displaced	865 860	4	54	8	52	15
Total	2900 2297	25	303	213	278	220
		All – 1039 (G4Tubs – 246, G4Polycone – 29)				

Comparison of two geometries

- Introduction of the early return in `G4UnionSolid::Inside()` and `G4DisplacedSolid::Inside()` essentially reduces the total number of calls to `Inside()`, however it can not fully compensate the overhead of the algorithms in `G4BooleanSolid`

A much better effect has been achieved by removing TMT

- The number of steps has reduced by 7 steps per event:
1597 steps/events instead of 1604 steps/events
- The number of calls to `Inside()` has reduced more than 10 times:
2900 x10⁶ instead of 40147 x10⁶
- The number of calls to other (“heavy”) functions has reduced by ~30%
1039 x10⁶ instead of 1590 x10⁶
- Execution time of the geantino test has reduced more than 2 times
186 s instead of 383 s

Distribution of calls by Solids and Methods (3)

aibuild027.cern.ch, SLC6, **1.20 GHz**

Simulation of 10 events in real ATLAS environment

No. of steps: unknown

Execution time: **~250 s / event** (>35% in EMEC)

	Inside x 10 ⁶	Normal x 10 ⁶	SafetyToIn x 10 ⁶	SafetyToOut x 10 ⁶	DistToIn x 10 ⁶	DistToOut x 10 ⁶
G4Box	425 38	1	19	5	9	4
G4Trap	991 101	1	111	42	38	23
G4Trd	34 29		16	14	6	9
G4Tubs	173 146	9	168	124	66	46
G4Extruded	3 2		3			
G4Polycone	335 332	1	21	120	9	41
G4Union	1298 1162	3	23	6	14	22
G4Subtraction	40 35		13	1	2	
G4Displaced	1402 1149	1	34	4	19	5
Total	4701 2994	16	408	316	163	150
		All – 1053 (G4Tubs – 413, G4Polycone – 192)				

Comparison with geantino test #2

- Quantitative characteristics are very similar:
 - Number of calls to Inside(): 2994 vs 2900
 - Number of calls to other functions: 1053 vs 1039
- The execution time of the geantino test #2 can be used as a good estimation of the time consumed by Geant4 Solids and Navigator in real simulation
 - Conversion factor:
 - $2.70 \text{ GHz} / 1.20 \text{ GHz} = 2.25$
 - Estimation of the execution time of the geantino test #2 on aibuil027:
 - $186 * 2.25 \geq 420 \text{ s}$
 - Execution time that would be consumed by Geant4 Solids and Navigator in one event:
 - $420 / 10 \geq 42 \text{ s}$
 - Estimation of the percentage:
 - $42 / 250 \geq 17\%$
 - If to exclude time spent in EMEC (>35%):
 - $42 / (250 * 0.65) \geq 26\%$

Summary

- Percentage of the execution time consumed by Geant4 Solids and Navigator in the ATLAS simulation: ~30%
- Similar percentage for CMS
- Unfortunately it is not easy to estimate the ratio between the time spent by Solids and the time spent by Navigator, however:
 - In average during one step there are 3 calls to Safety and 3 calls to Distance
- It is confirmed that a big number of calls to Inside() in the ATLAS simulation is due to the definition of TMT as a Boolean solid
- Redefinition of TMT (replacement of a Boolean union with an Assembly of volumes) can give 2-3% speed up in the full ATLAS simulation and up to 30% speed up in the simulation of the Pixel detector