

CMS Experience with Geant4

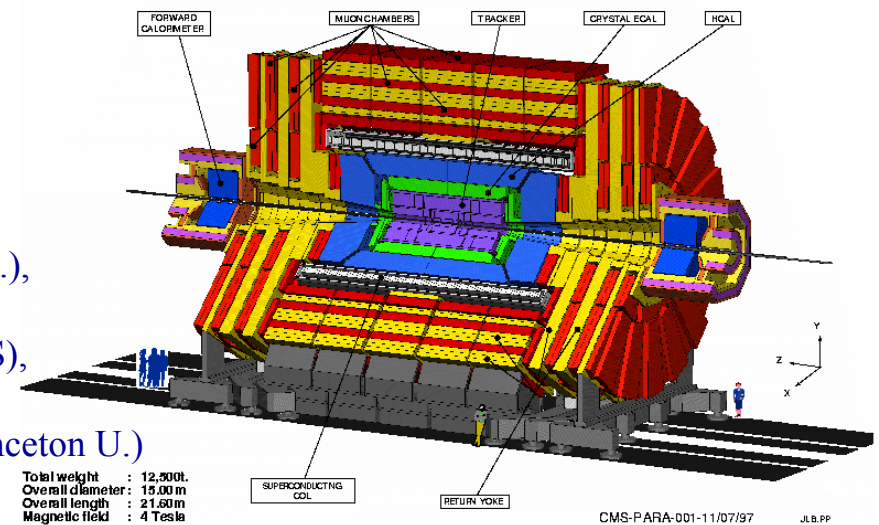
A. De Roeck/CERN

20/10/04

Application Area Meeting

OSCAR Contributors

S. Abdulline (FNAL), N. Amapane (U. Torino), V. Andreev (UCLA),
 P. Arce (CIEMAT), S. Banerjee (TIFR), T. Boccali (SNS, Pisa),
 M. Case (UC Davis), A. De Roeck (CERN), S. Dutta (U. Pisa),
 G. Eulisse (NorthEastern U.), D. Elvira (FNAL), A. Fanfani (U. Bologna),
 F. Ferro (INFN, Genova), M. Liendl (CERN), S. Muzaffar (NorthEastern U.),
 A. Nikitenko (Imperial College), K. Lassila-Perini (HIP),
 I. Osborne (NorthEastern U.), M. Stavrianiakou (FNAL), T. Todorov (IREs),
 L. Tuura (NorthEastern U.), H.P. Wellisch (CERN),
 J. Weng (Karlsruhe U./CERN), T. Wildish (Princeton U.), S. Wynhoff (Princeton U.)
 M. Zanetti (INFN), A. Zhokin (ITEP), P. Zych (Warsaw U.)





Recent History: Geant4 in CMS

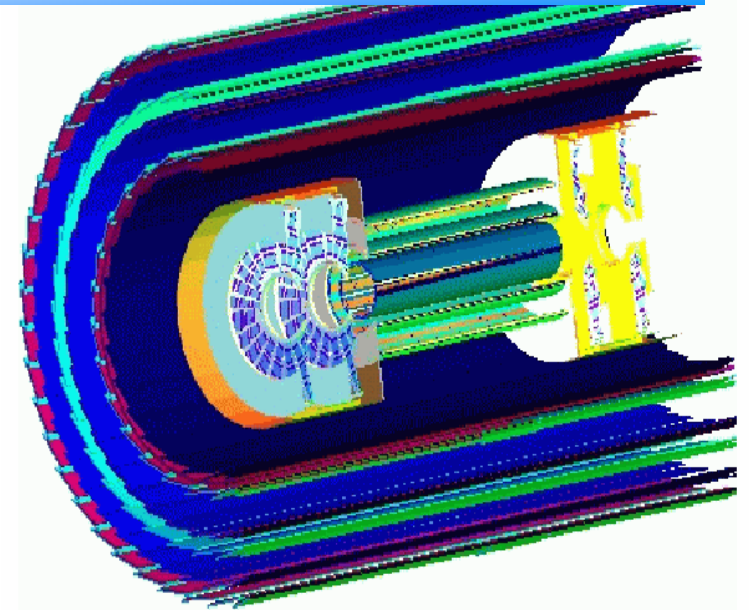
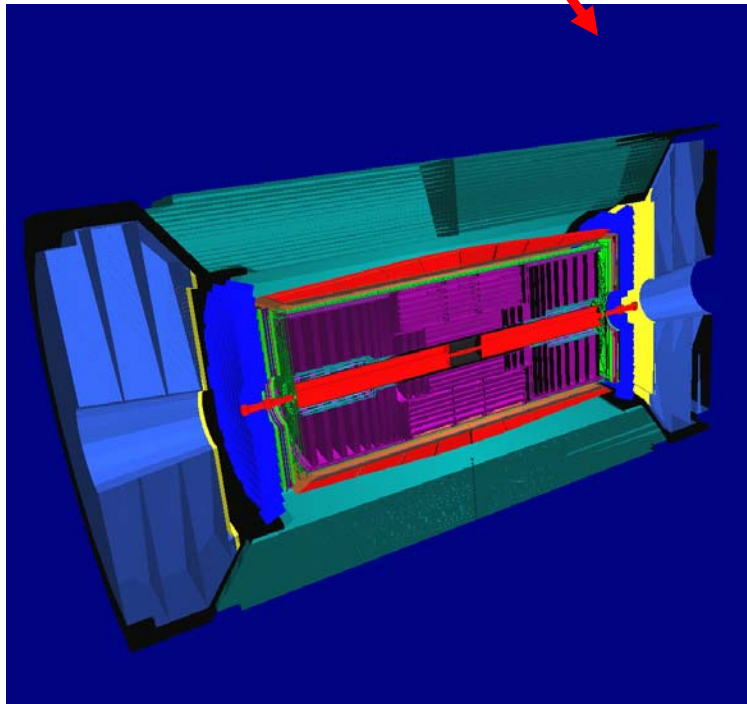
- **June 03**
 - Complete version of the program OSCAR/G4
 - Starting small scale production ($O(10000)$ events)
 - Fix problems
- **August 03**
 - Start large scale production and validation (~ 0.5 M single tracks)
 - Produced first 1 M physics events by end of September 03
- **End of November 03**
 - OSCAR 2.4.5 based on G4 5.2 p2 officially deployed for production
- **December 03**
 - G3 simulation declared dead (~ 50 M GEANT3 events were produced in 03)
 - G4 OSCAR declared the tool for simulation in CMS for the physics TDR, due end of 2005

Excellent collaboration with G4 to track/solve problems during validation

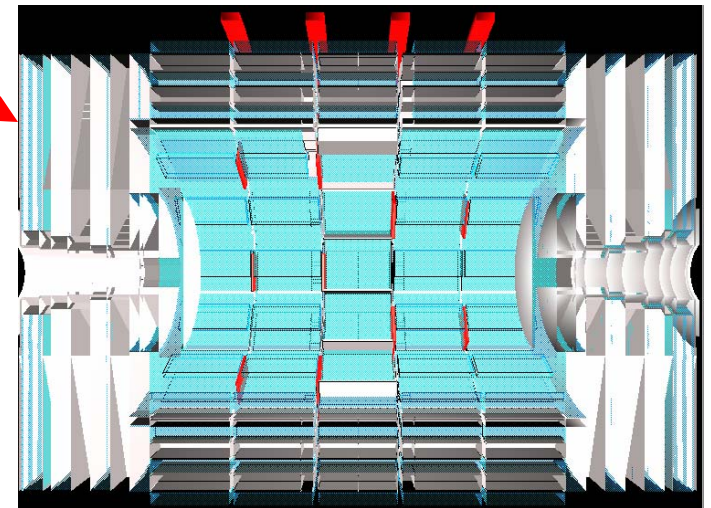
OSCAR

Sliced view of CMS barrel detectors

View of the CMS detector



muon detectors



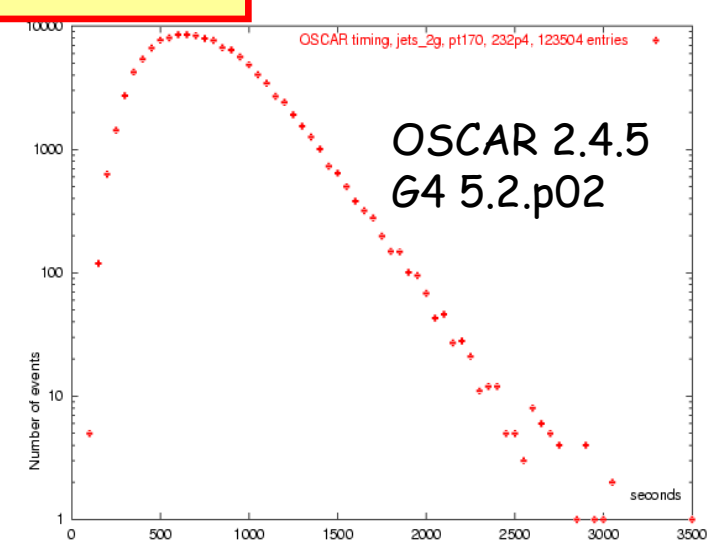
Complete CMS detector geometry included
More than 1M geometrical volumes



Production

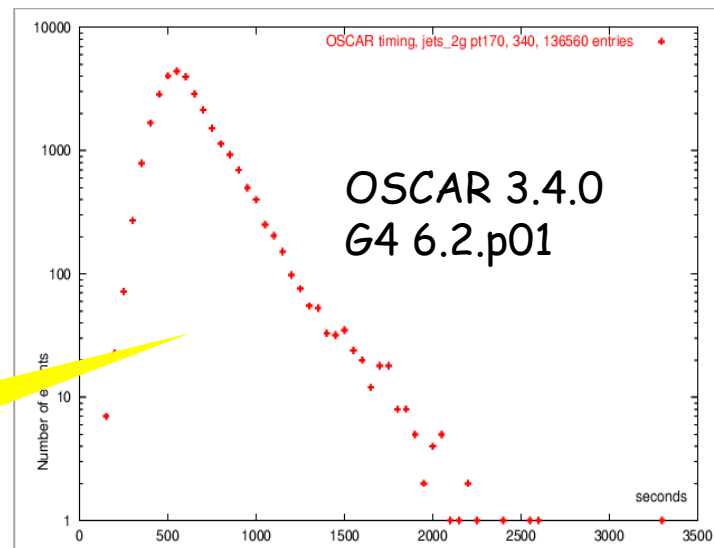
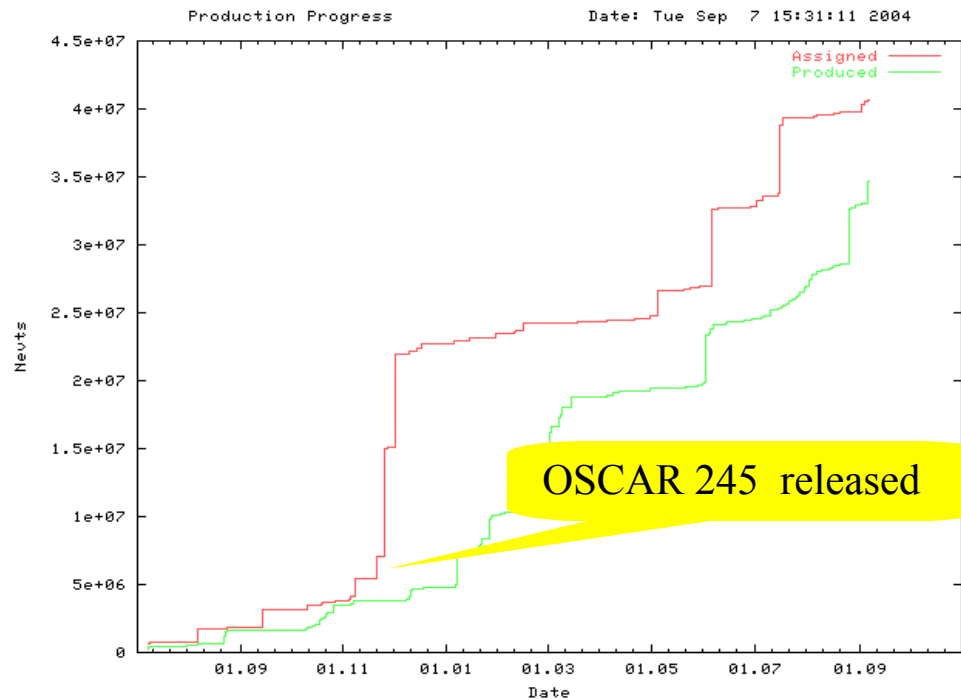
OSCAR 2.4.5 in use for 10 months; longest-used version of any s/w in production; accounts for 35M of 85M events

QCD Dijet events



wall-clock time normalized to 1 GHz CPU

Peak not moved, but tail significantly narrower. Nicer for production, easier to spot stuck jobs





OSCAR/G4: Performance

- CPU time of 2.4.5 is 2xGEANT3 time, but
 - much more sophisticated cut/region scheme
 - more conservative cuts than for CMSIM
 - more detailed physics in G4
 - improvements implemented by G4 team, and by CMS through more optimized access to/use of the (new) magnetic field.
 - we have now a 20-30% better performance of OSCAR compared to the version 2.4.5 (so we are at 1.5 x GEANT3; effort is continuing)
- Memory usage in 2.4.5: 220 MB OSCAR vs 100 MB GEANT3 simulation.
 - further optimization led to ~110 Mb/event for pp (>500 Mb/event for HI)
- Crashes occurred with 2.4.5: about 1/10000 for pp events. Mostly hadronic physics (baryon decays, γ -nuclear int.)
 - latest stress test (800K single particles, 300K full QCD events) showed. No single crash.

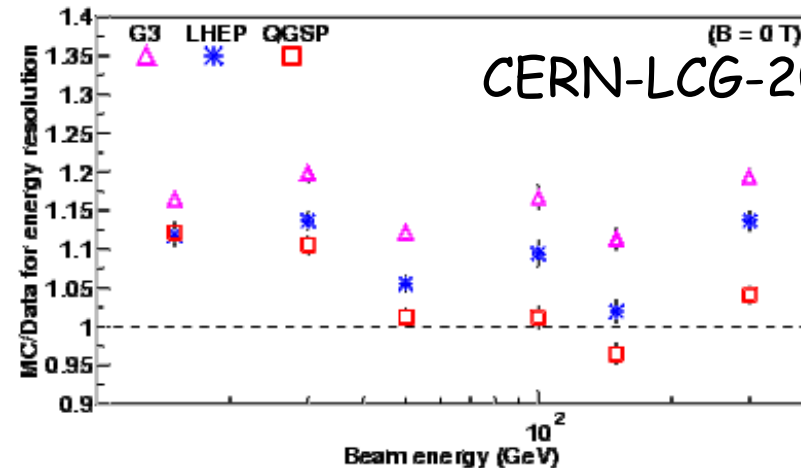
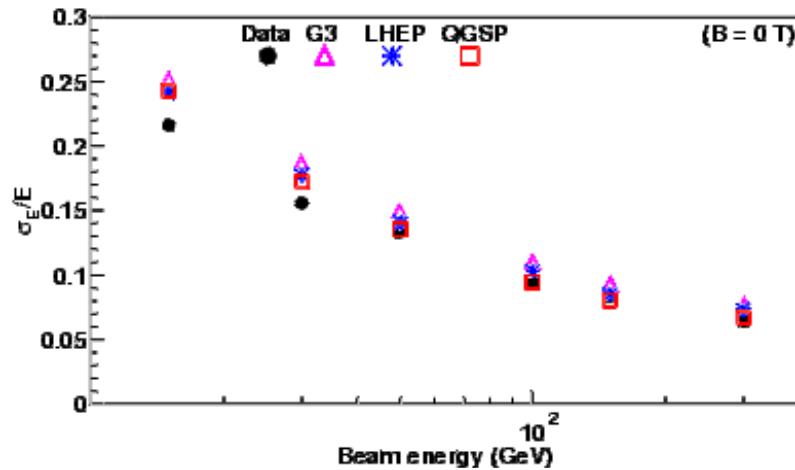
Many thanks to G4 for help!

AIDERT DE KOECK (LEKIN)

Validation of the Physics in OSCAR

Validation of G4 physics in the context of the LCG study group

So far: Comparisons of hadronic test beam data with models in G4
 Also: Comparison of EM physics with test beam data



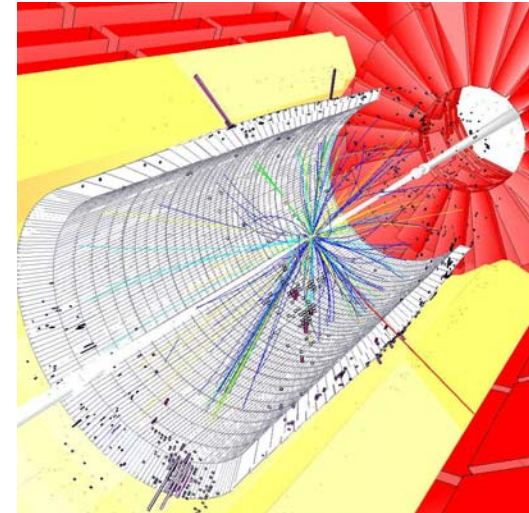
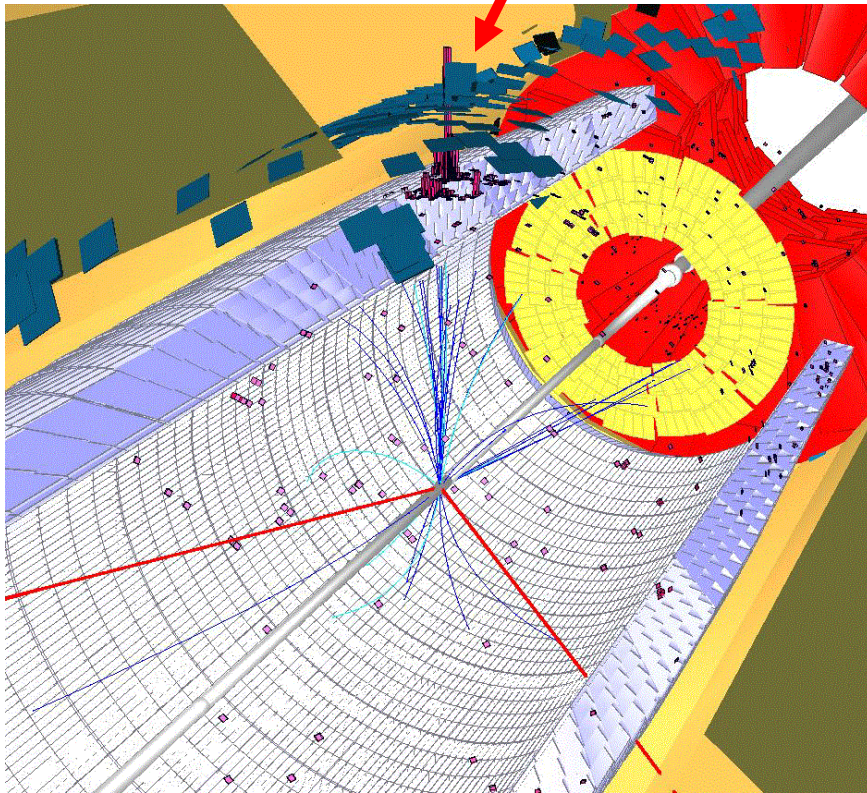
| | Data | LHEP 3.6 | QGSP 2.7 | GHEISHA |
|--|----------------|----------------|----------------|------------------|
| Sampling term a [% $\sqrt{\text{GeV}}$] | 71.6 ± 1.0 | 71.5 ± 1.0 | 74.1 ± 0.9 | $82.9.7 \pm 1.2$ |
| Constant term b [% $\sqrt{\text{GeV}}$] | 1.6 ± 0.1 | 2.5 ± 0.1 | 1.7 ± 0.1 | 2.4 ± 0.1 |

Generally
 QGSP model
 adequate

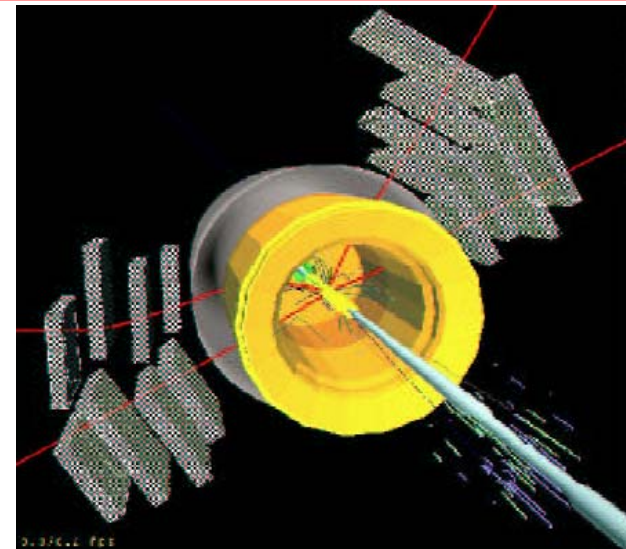
Studies of energy resolutions, e/π ratios, and shower profiles

Physics Events with OSCAR

SUSY events (LM4 point: leptons,
missing E_T)



View of 180 Higgs $\rightarrow ZZ \rightarrow \mu\mu\mu\mu$ event
simulated in CMS Tracker detector



Samples of "standard sets" of events now
automatically produced for each new release

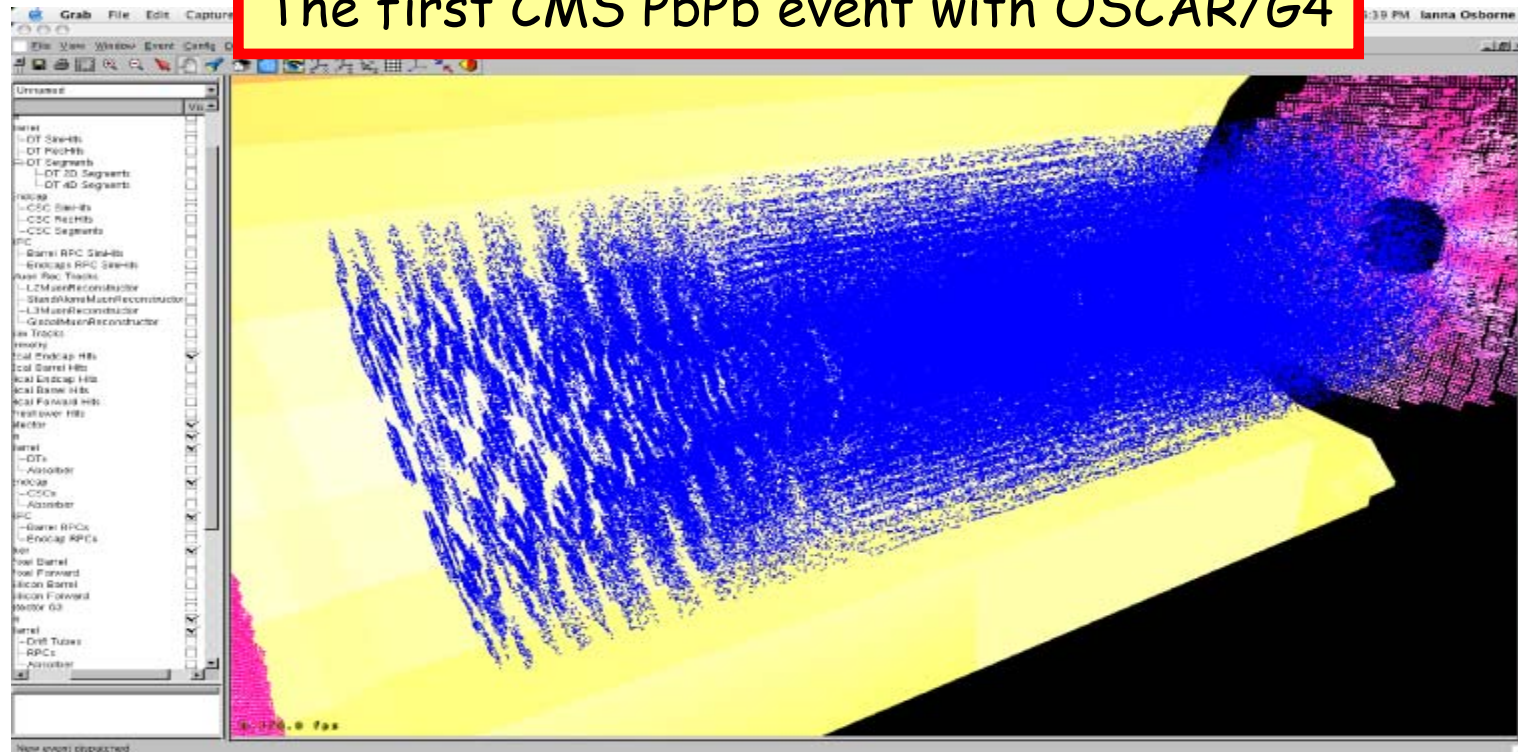
Ultimate test: Heavy-Ion Collisions

- **CMSIM**: chop event in slices of 100 tracks, run them separately
 - Needed due to limitations in CMSIM
- **OSCAR/Geant4** can run full events.
 - Timing is good/Memory > 500 Mbyte (2GB memory machines used)
 - Have now run 100 events without problems

~ Timing for the first event with 55K generator tracks

| Program | CPU (2.8GHz) (min) |
|----------------|--------------------------|
| CMSIM | 230 |
| OSCAR 2_4_5 | 320 |
| OSCAR 3_4_0 | 180 |

The first CMS PbPb event with OSCAR/G4





Summary

- In CMS, OSCAR, the OO simulation program based on the Geant4 toolkit, has successfully replaced its Fortran/Geant3 predecessor. It has been validated and adopted by all CMS detector and physics groups. It has proven robust and performant, easily extensible and configurable.
 - 35M pp interaction events produced
 - First 100 PbPb heavy ion events
- CMS has now entered sustained-mode production:
 - 10M physics events/month through the full chain (simulation, digitization, ..., DSTs)
- OSCAR 3.6.0 released now with G4.6.2 p1
 - new validation phase (new field map, new forward detectors, new G4 version, many improvements...) → Deploy for mass production next month
- Continuing validation of G4 physics (EM+HAD) and performance optimization important. CMS participates in this common effort

Many thanks to G4 collaboration for excellent support