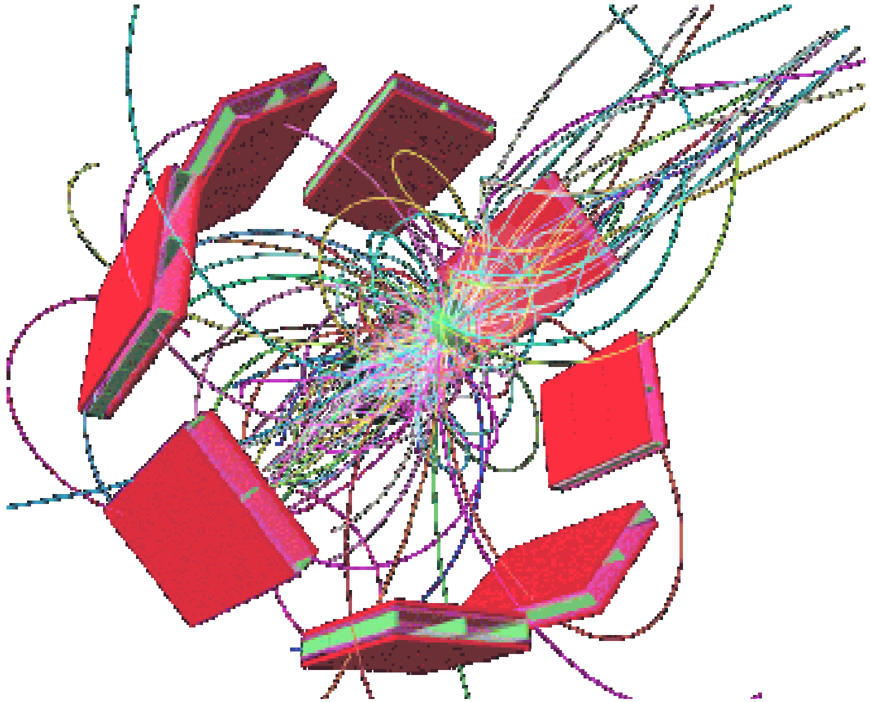
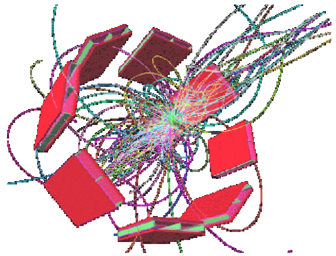
Development of the ATLAS Software and Simulation of the b–quark Physics on ATLAS

(J.Hrivnac, 24 September 2001, Prague)

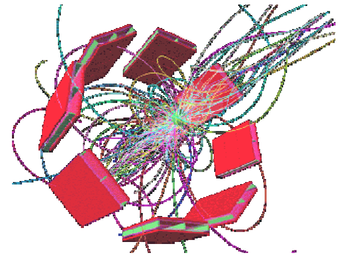
1. Introduction
2. LHC
3. ATLAS
4. Software
5. ATLAS Software
6. Physics
7. Conclusion





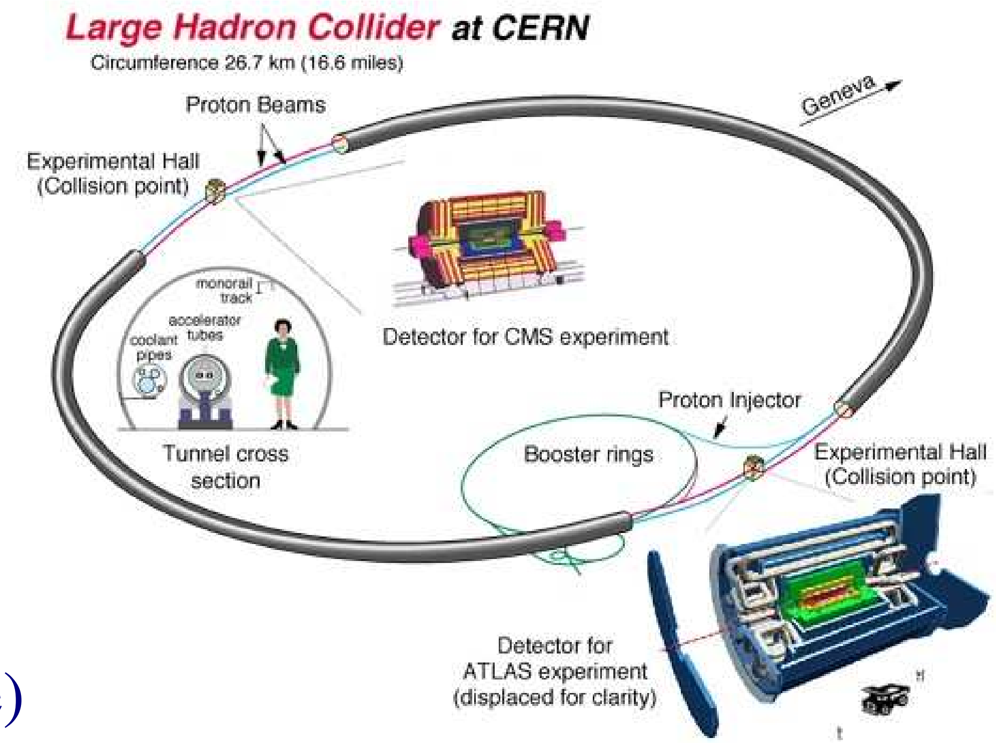
1. Introduction

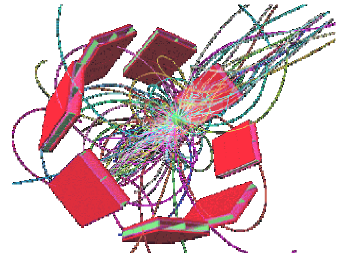
- Except introductions, this theses cover two fields of the preparation of ATLAS experiment:
  - <u>Software Methodology and Design</u> (80%):
    - Software Process
    - Graphics Framework
  - <u>Physics of the B–quark</u> (20%):
    - CP Asymmetry Dilution Factor due to Tagging
    - Beauty Baryon Polarization
- This presentation will cover the original contributions(except where questions have been raised concerning the general parts).



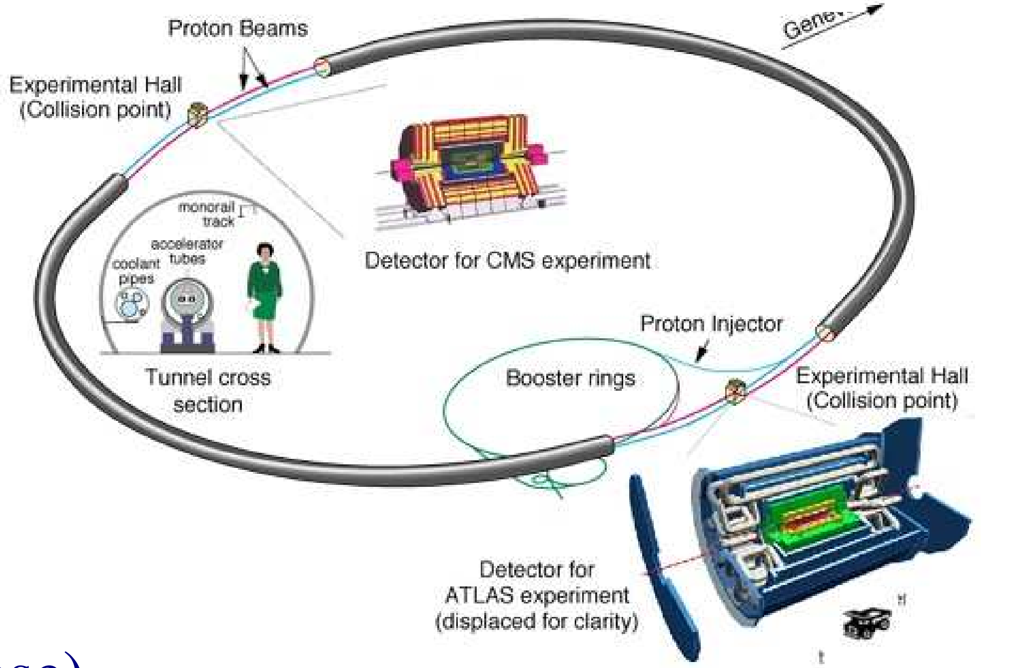
2. LHC

- 2 x 7 TeV p (later Pb)
- $L = 1.7\ 10^{34}\ cm^{-2}s^{-1}$
- Bunch crossing per 25ns
- Pileup = 23
- Experiments:
  - ATLAS, CMS (general purpose)
  - ALICE (heavy ions)
  - LHCb (b–quark physics)
- Start: 2005–7





2. LHC



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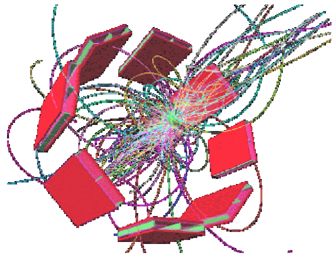
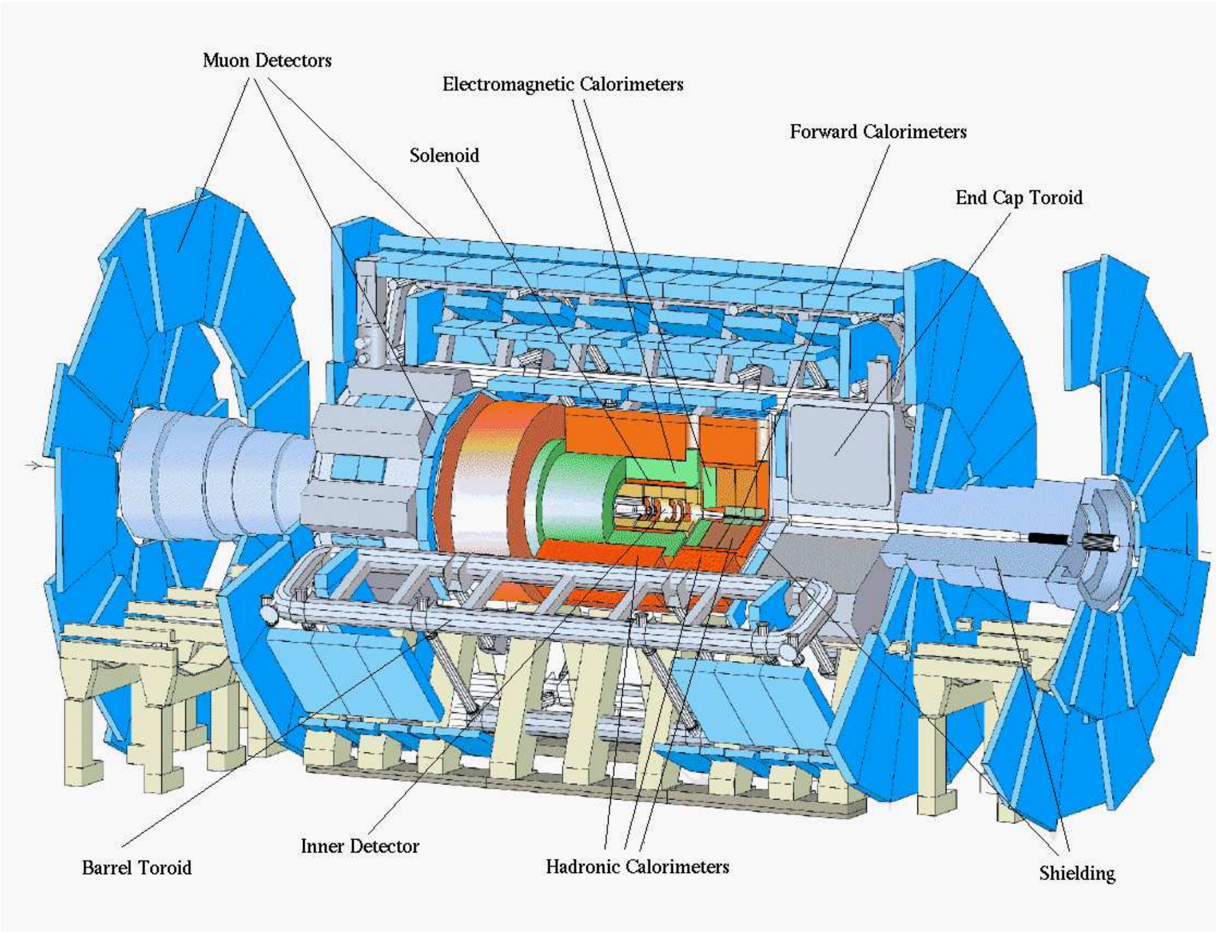
  - LHCb (b–quark physics)
- Start: 2005–7

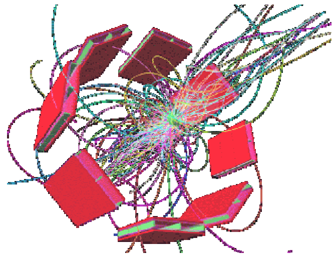
R.L.: Hadron compositeness is an advantage.
It is an advantage as it allows us to study struction functions, hard processes and hadronisation..
It is a disadvantage with respect to the energy of the constituent' interaction



3. ATLAS

1. Magnets
2. Inner Detector
3. Calorimeters
4. Muon Spectrometer
5. Trigger



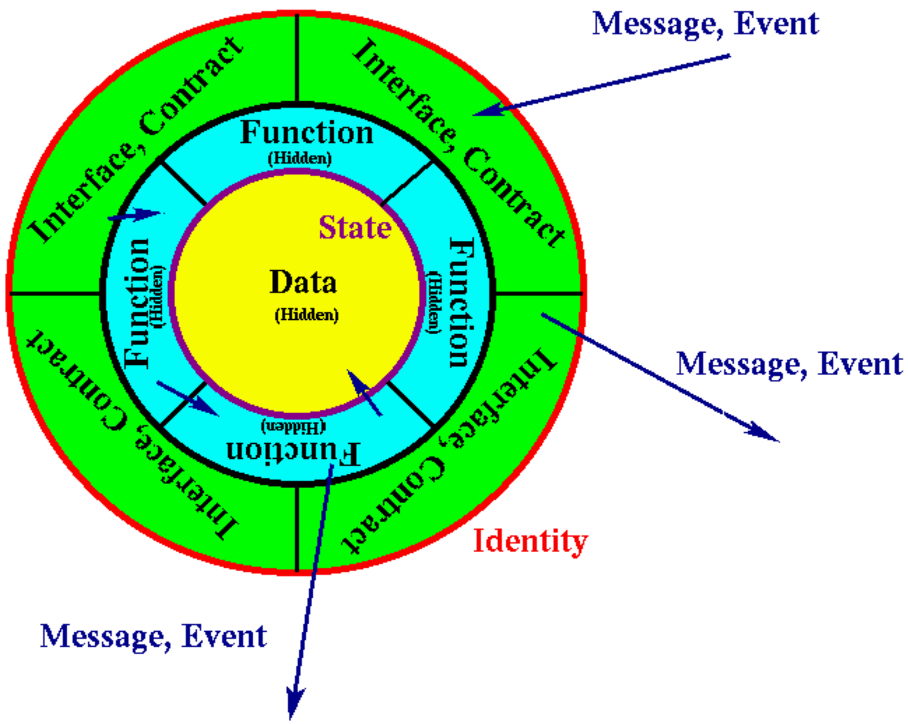


4. Software

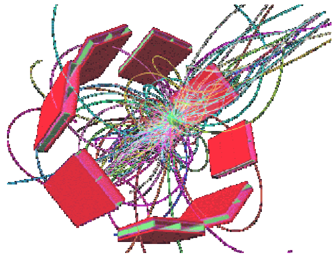
1. Programming Methodology ...
2. Software Process ...
3. CASE Tools
4. Languages ...

4.1. Programming Methodology

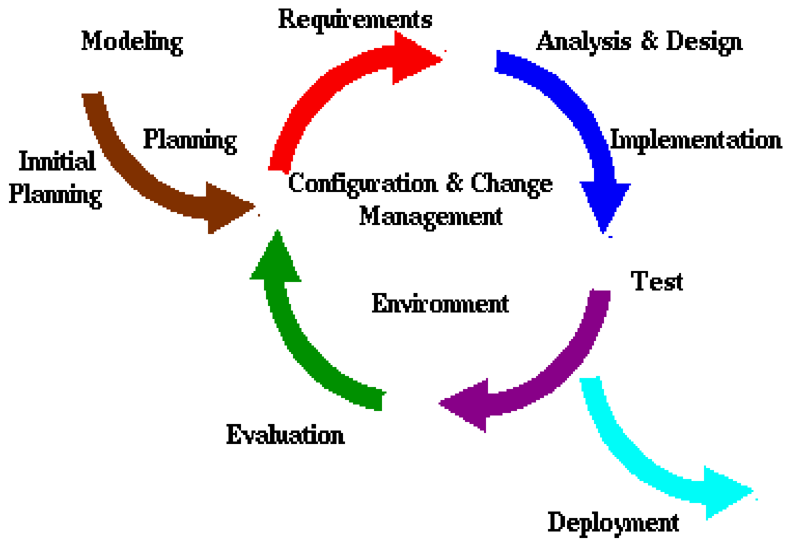
- Basic principles of the Object Oriented Programming (OO) have been shown.
- A set of general Software Design Rules for the Object Oriented Software Development has been formulated.
- A possible evolution of the OO programming has been sketched.

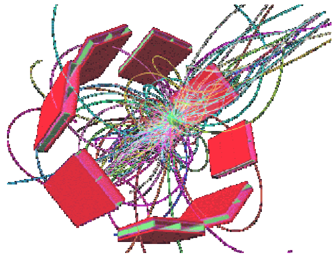


4.2. Software Process



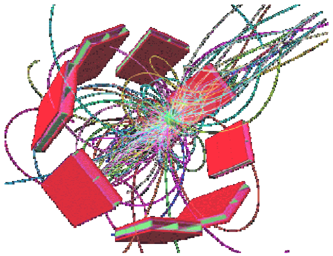
- Traditional processes, previously tried in several HEP experiments, have been found too heavy.
- Lightweight methodologies (like Extreme Programming – XP) has been suggested as suitable for High Energy Physics Environment.
- Basic XP rules have been formulated.





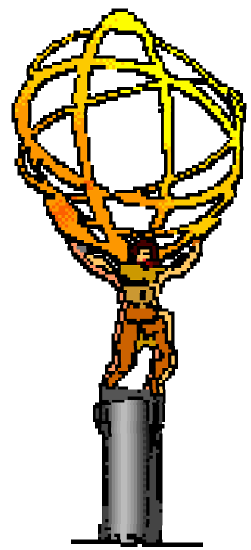
4.4. Languages

- The situation of the current programming languages have been analyzed.
- After a deep evaluation, Java has been recommended as the main implementation language for the ATLAS experiment.

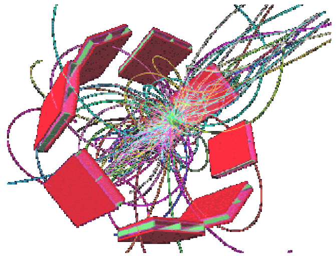


5. ATLAS Software

1. Traditional System
2. Object Oriented System
3. Software Process ...
4. Graphics ...
5. OPATREC



5. ATLAS Software



1. Traditional System
2. Object Oriented System
3. Software Process ...
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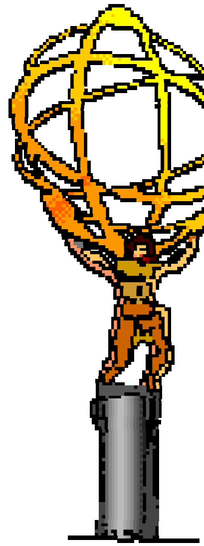
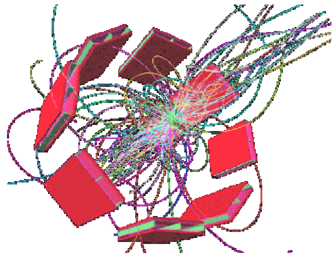


<u>*D.B.: Out of context.*</u>
It's true. However, it is another author's original contribution to the ATLAS software development.

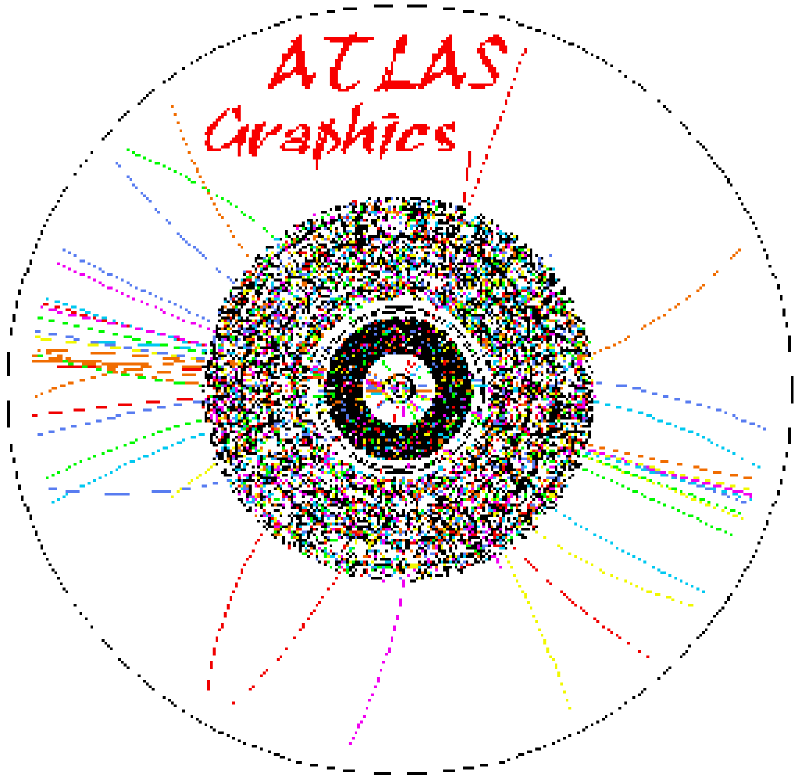
5.3. Software Process

- Situation with the Software Process in ATLAS has been described.
- Procedures for the External Software Handling in ATLAS have been formulated (and accepted by ATLAS).

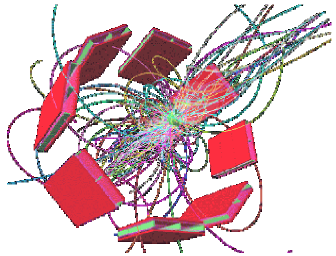


5.4. Graphics

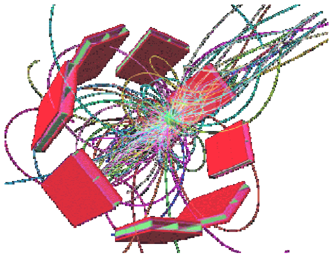
1. User Requirements ...
2. Architecture ...
3. Control Framework ...
4. Scenes ...
5. FreeHEP and HEP Studio
6. Java–C++ Interoperation



5.4.1. User Requirements



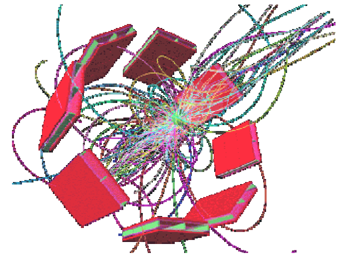
- User Requirements for the Graphics application have been collected and classified.
- Those User Requirements have been subsequently used in other experiments as well (CDF, CMS).



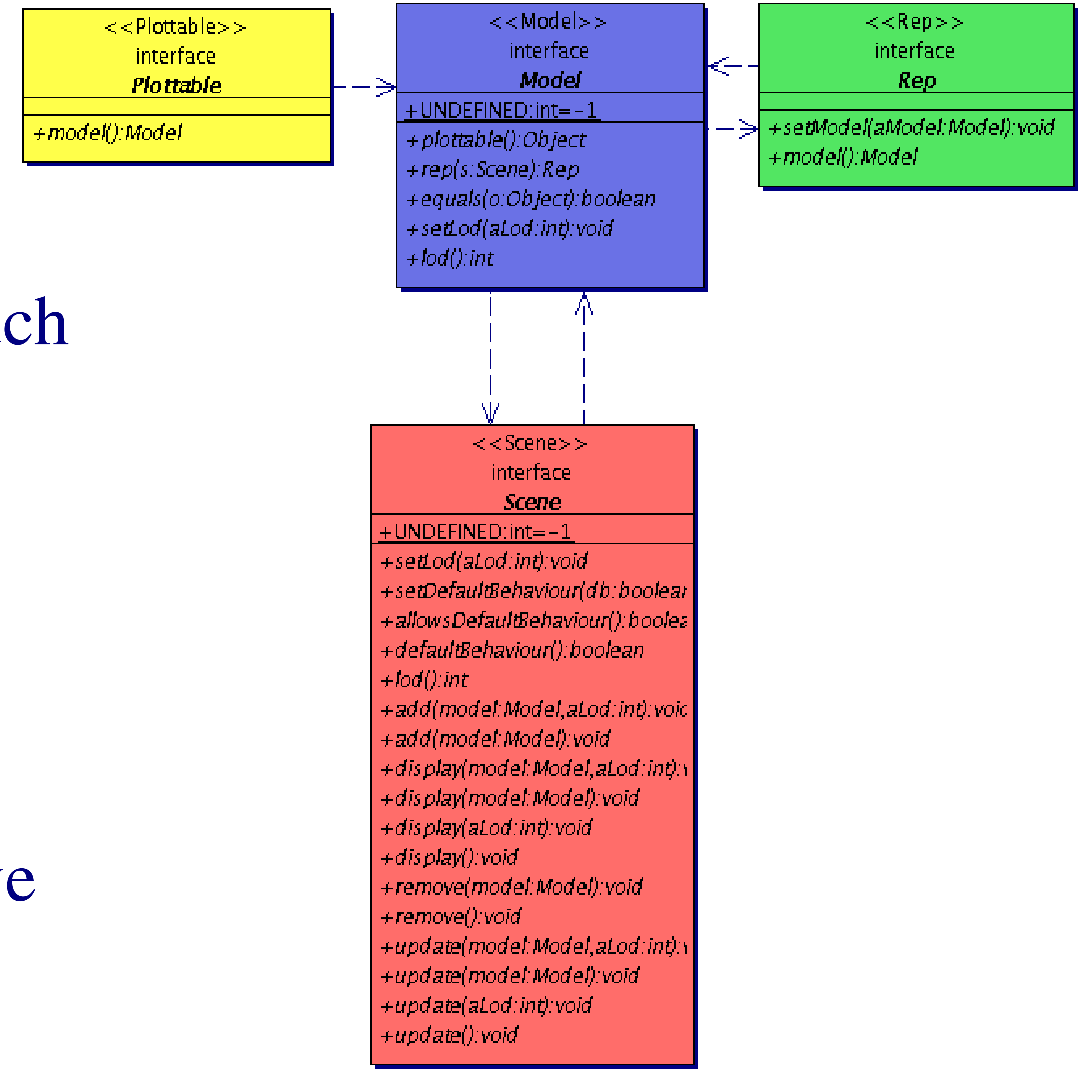
5.4.2. Architecture

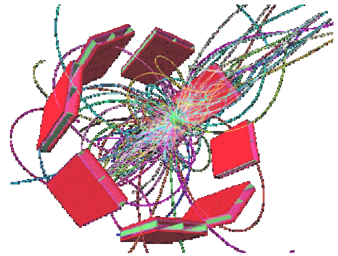
- Starting from the User Requirements, two major Architectural Principles have been formulated:
  - *The fact, that any object is visualized should not influence the design of that object.*
  - *The Architecture of the graphics Framework should not depend on any particular visualization software.*
- Those principles have been then used also in other experiments (CMS).

5.4.3. Control Framework



- Based on the defined Architectural Principles, the graphics Control Framework has been Designed.
- The Framework has been then implemented both in C++ and Java, the Java version being much more functional.
- The Framework is part of the ATLAS Offline Framework (Athena).
- Graphics User Requirements, Design and implementation have been successfully reviewed by ATLAS and outside reviewers.

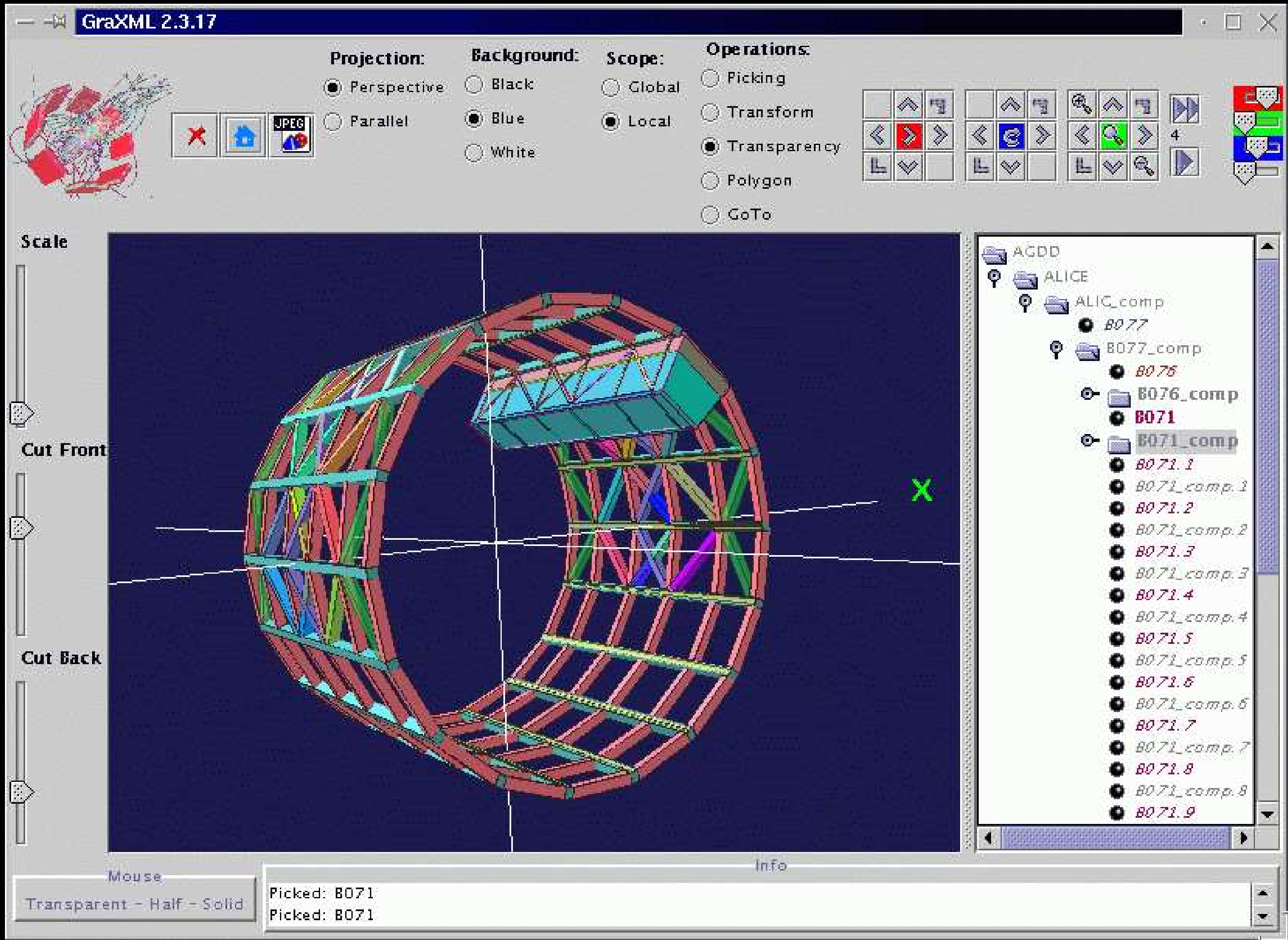




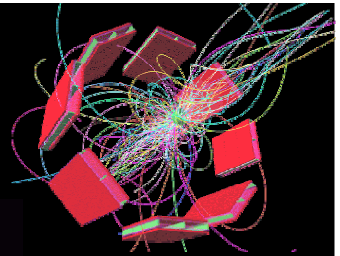
5.4.4. GraXML

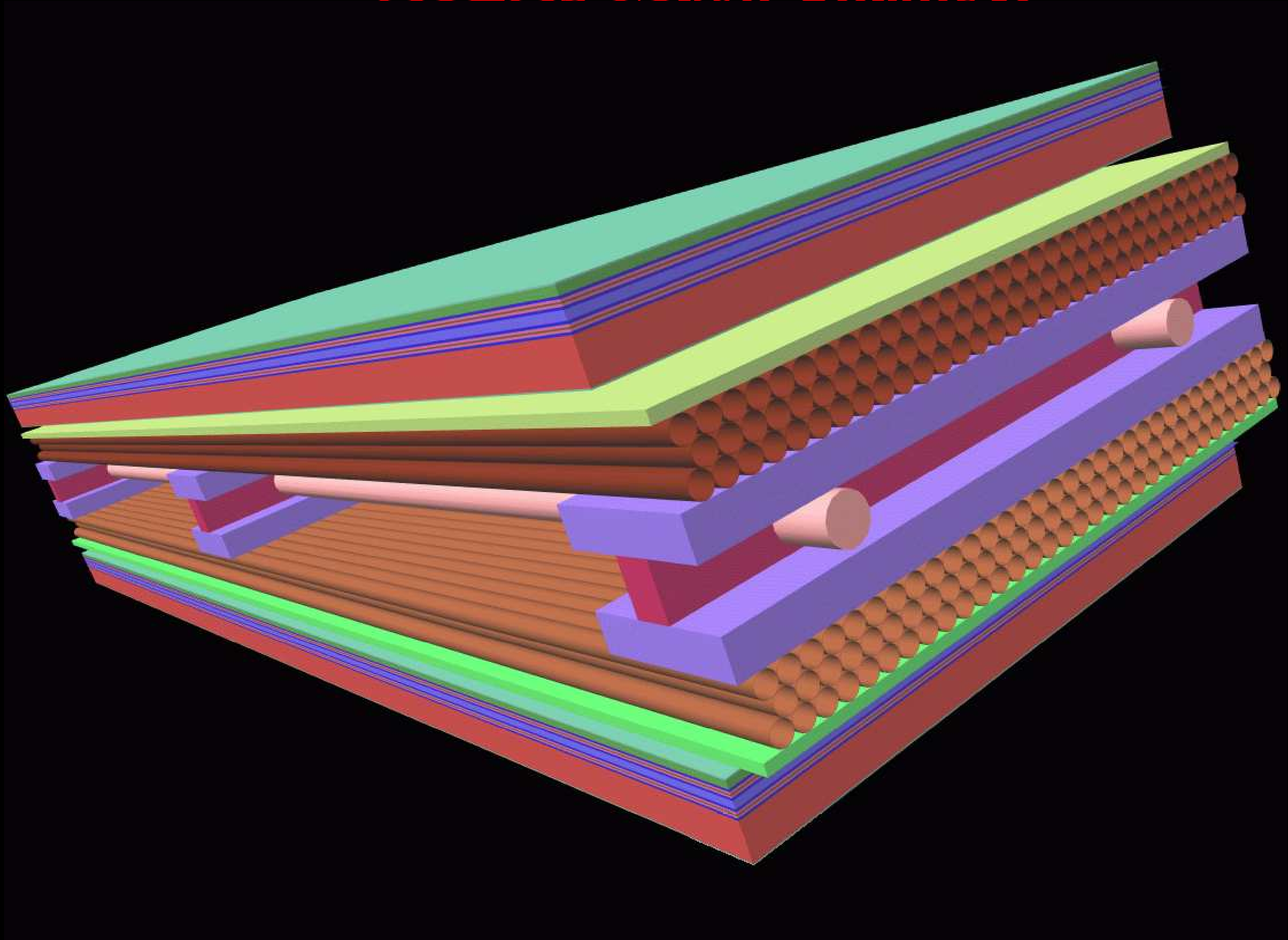
- 3D Event & Detector Display GraXML has been developed.
- It runs both standalone and as a part of the ATLAS Graphics Framework.
- Components of the GraXML have been contributed into the FreeHEP project.

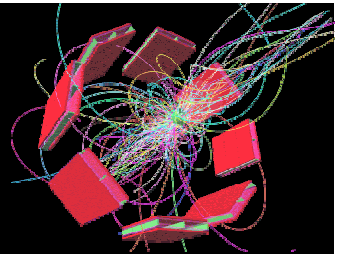
ALICE Detector



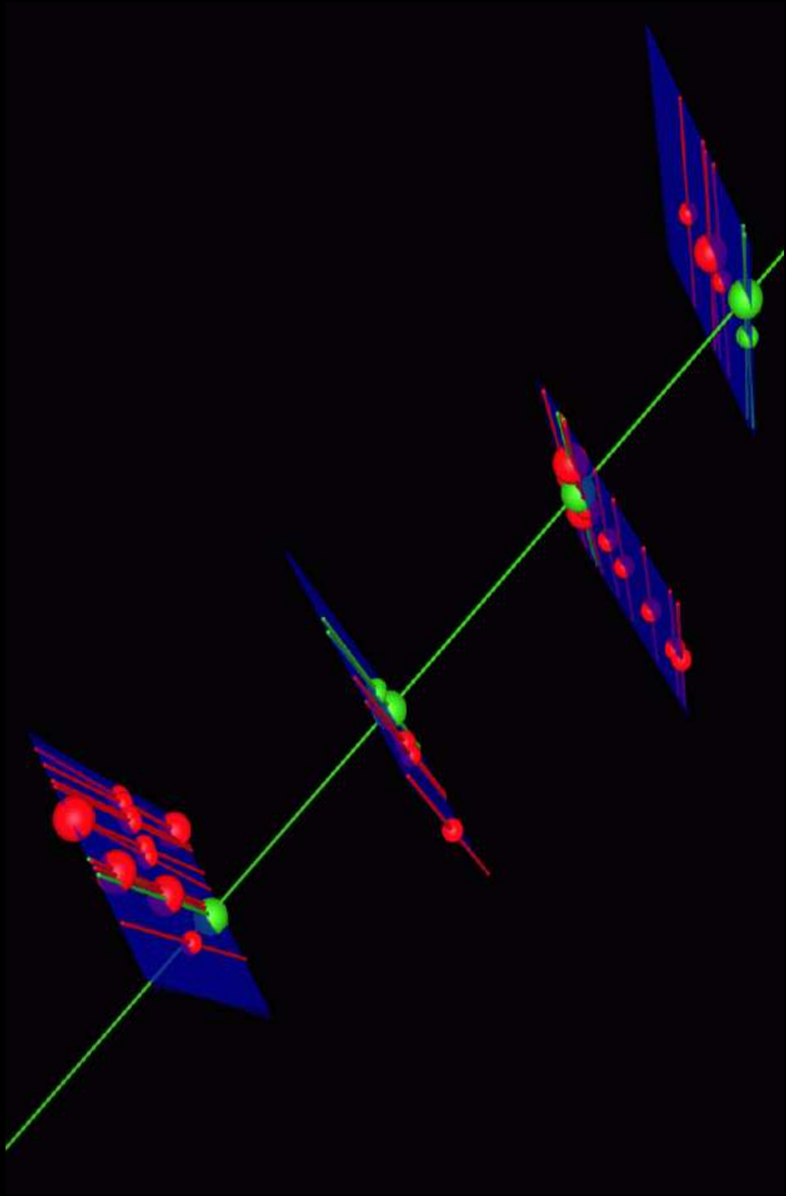
ATLAS Muon Chamber

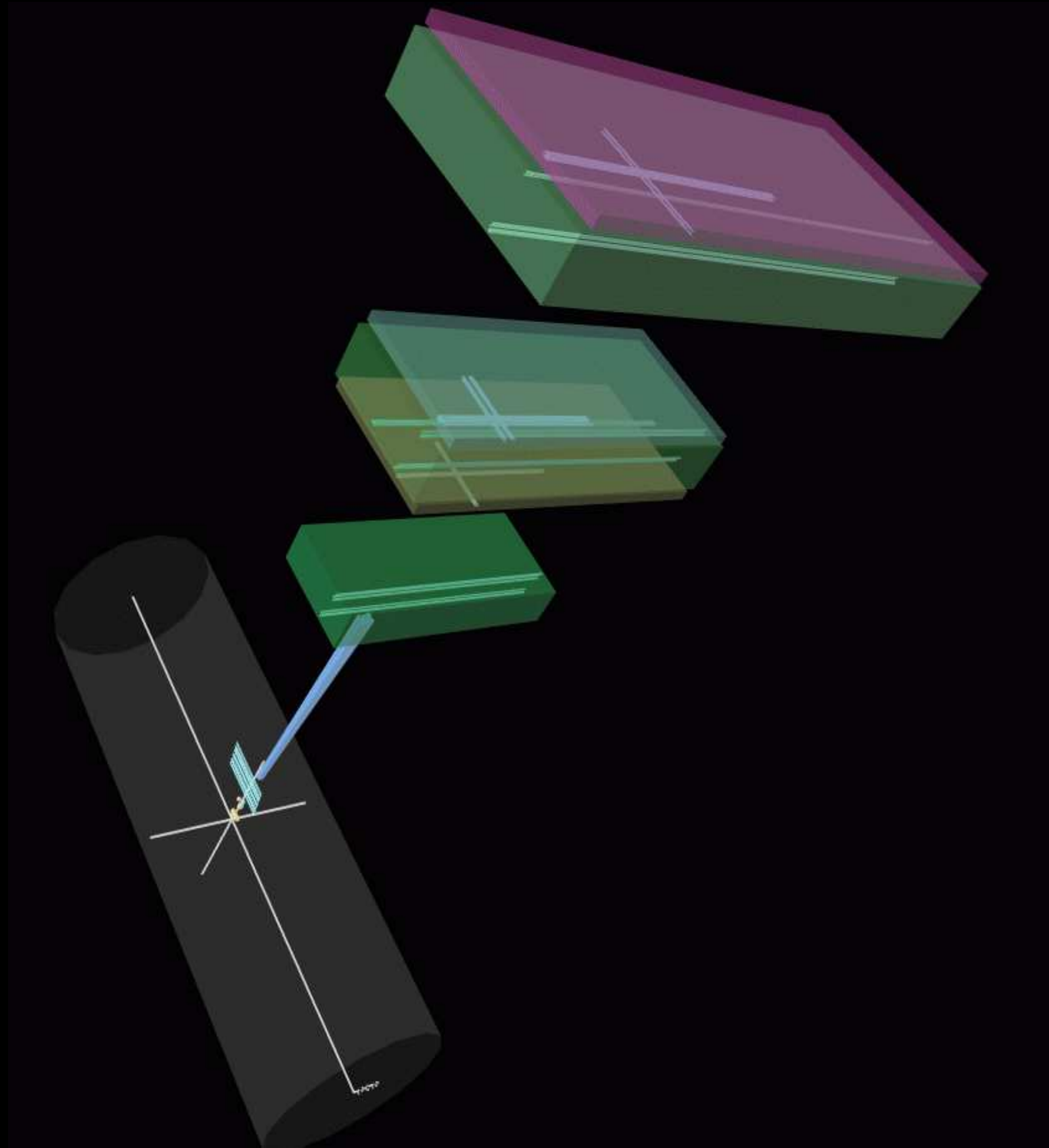




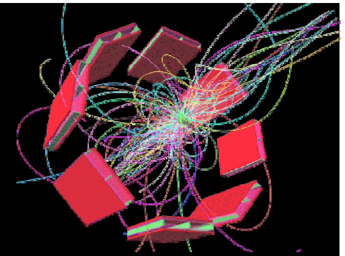


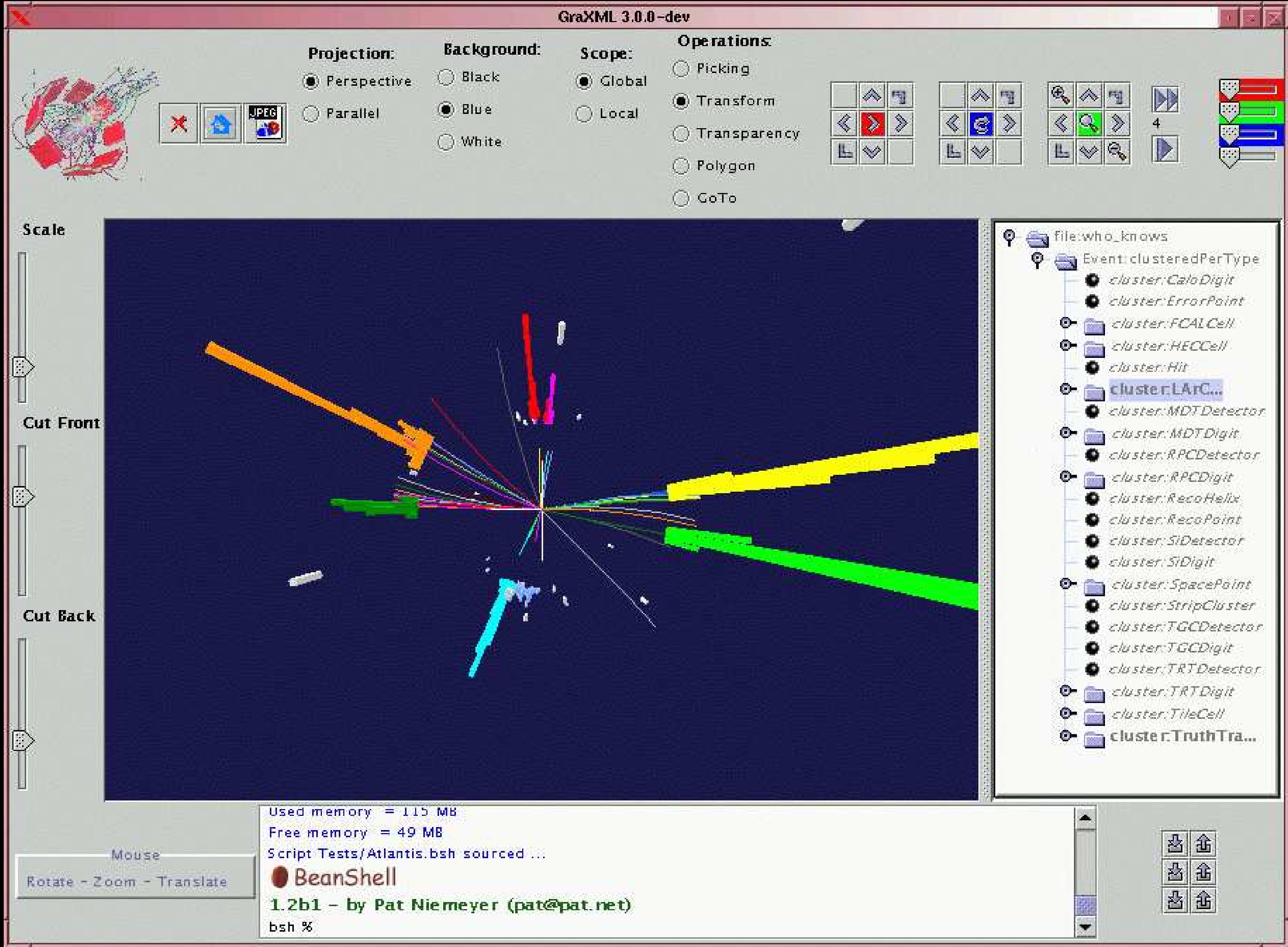
Track in ATLAS



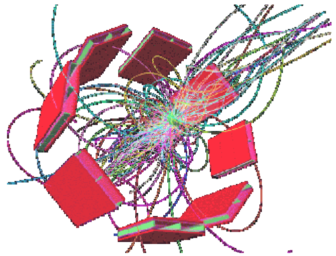


ATLAS Event

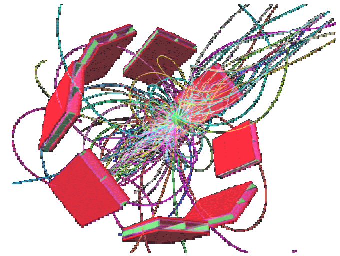



GraXML 3.0.0-dev
Projection:
Perspective
Parallel
Background:
Black
Blue
White
Scope:
Global
Local
Operations:
Picking
Transform
Transparency
Polygon
GoTo
Scale
Cut Front
Cut Back
file:who_knows
Event:clusteredPerType
cluster:CaloDigit
cluster:ErrorPoint
cluster:FCALCell
cluster:HECCell
cluster:Hit
cluster:LArC...
cluster:MDTDetector
cluster:MDTDigit
cluster:RPCDetector
cluster:RPCDigit
cluster:RecoHelix
cluster:RecoPoint
cluster:SiDetector
cluster:SiDigit
cluster:SpacePoint
cluster:StripCluster
cluster:TGCDetector
cluster:TGCDigit
cluster:TRTDetector
cluster:TRTDigit
cluster:TileCell
cluster:TruthTra...
Used memory = 115 MB
Free memory = 49 MB
Script Tests/Atlantis.bsh sourced ...
BeanShell
1.2b1 – by Pat Niemeyer (pat@pat.net)
bsh %
Mouse
Rotate - Zoom - Translate

6. Physics



1. ATLAS Physics
2. B–Physics
3. CP Violation Dilution Factor ...
4. Beauty Baryon Polarization ...



R.L.: What is g in the Higgs–lepton coupling ?
$g = e / \sin(\theta_W)$

R.L.: $M_H < 2M_Z$ should $M_H > 2M_Z$.
Yes, it's a typo.

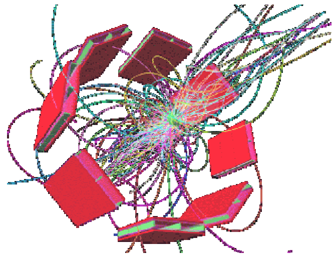
1. ATLAS Physics
2. B–Physics
3. CP Violation Dilution ...
4. Beauty Baryon Polarization ...

R.L.: Htt channel is missing for $M_H < 120$GeV.
I haven't mentioned this channel explicitly.
It is important as tt allows efficient trigger and
Htt gives ttH coupling.

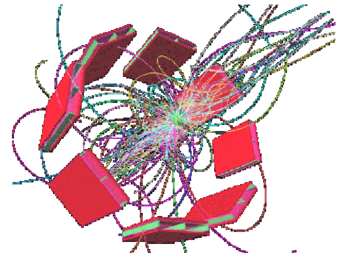
R.L.: How many bb produced in
Tevatron comparing to ATLAS ?
b in fiducial volume:
ATLAS: > 24 kHz
CDF: 700–1400 Hz

R.L.: More detailed comparison between
ATLAS and other experiments.
$\delta\sin(2\beta) = 0.05$ (B–factories),
0.05 (CDF)
0.005 (LHC), 0.017 (ATLAS)
BaBar: 10^8 bb till end 2002
ATLAS: 10^{12} bb per year

6.3. CP Violation Dilution Factor



- The rates dN/dt for $B^0_d \rightarrow J/\psi K^0 \mu X$ were calculated for several options of the detector setup (air–core toroid vs. iron-core toroid, electron vs. muon tracking, full vs. staged detector).
- The CP violation dilution factor D arising from mistagging of muon was shown to be independent on muon p_T and equal to 0.82 ± 0.04 (for trigger $p_T > 6$ GeV).
- From dN/dt and D the p_T–dependence of the error on CP–violation parameter sin(2φ) was obtained. It depends on p_T only through statistics.
- The results have been used in the ATLAS detector design.



6.3. CP Violation Dilution Factor

- The ra... severa... core to... detector).

R.L.: Has been studied the possibility of using large p_T of μ from B to make cleaner selection ?
Better strategy is to trigger on CP after Lvl.2.

- The CP violation dilution factor D arising from mistagging of muon was shown to be independent on muon p_T and equal to 0.82±0.04 (for trigger p_T < 6 GeV).
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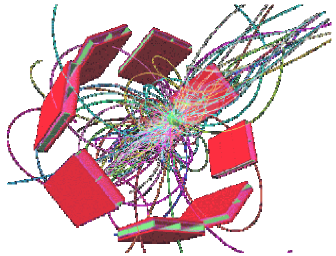
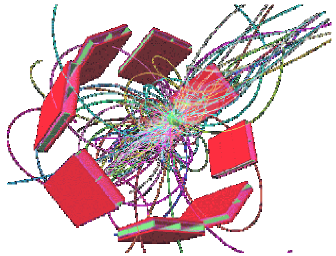


6.4. Beauty Baryon Polarization

- The possibility of beauty baryon polarization measurement by cascade decay angular distribution analysis in the channel $\Lambda^0 J/\psi \rightarrow p\pi^- l^+ l^-$ is demonstrated.
- The polarization of Λ^0_b can be measured with the statistical precision better than 0.016, the polarization of Ξ^0_b with the precision better than 0.28.
- The study has been included in the ATLAS Technical Design Report, the results have been recently updated to take into account new data from Fermilab.



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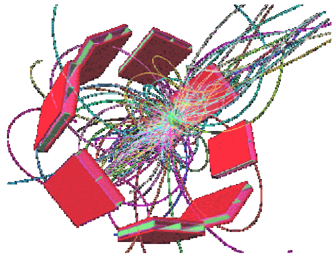
D.B.: It will have to be repeated later.
Yes, but the initial study has to be done already now.

R.L.: Different values in different chapters.
Chapter 6.4.3 has not been updated (omission).



7. Conclusion

- The work presented in the Theses has contributed to the design and construction of the ATLAS detector and to the assessment of its capabilities in several areas:
  - Software Methodology and Design:
    - Software Process
    - Graphics Framework
  - Physics of the B–quark:
    - CP Asymmetry Dilution Factor due to Tagging
    - Beauty Baryon Polarization
  - Many of the described results and products have been published and are used in ATLAS as well as in other experiments.