# ATLAS Sub-detector Software

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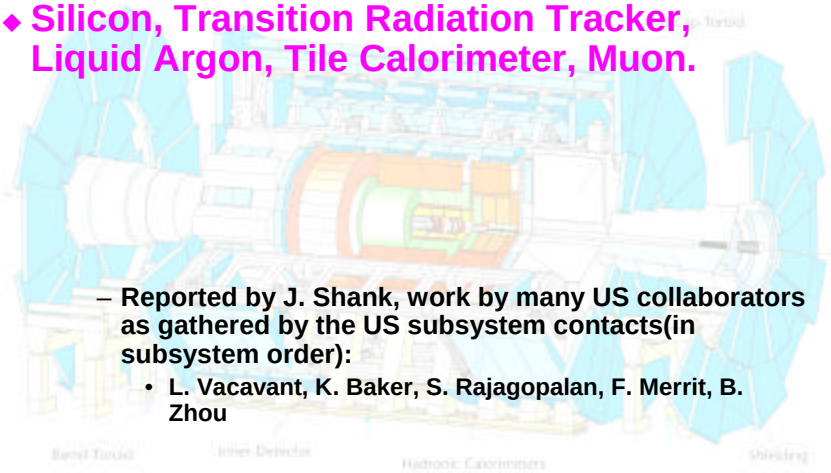
BOSTON UNIVERSITY

DOE/NSF Review of LHC
Software + Computing Projects

18 –20 January 2000, DOE Germantown

# ATLAS Sub-detector Software

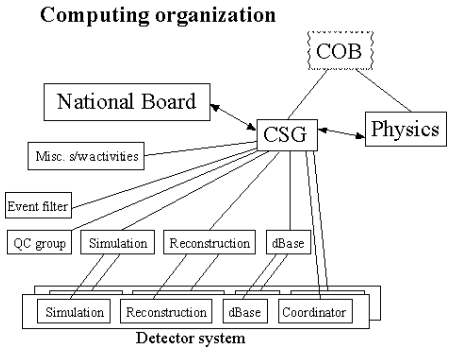
- US active in all detector subsystems:
  - Silicon, Transition Radiation Tracker, Liquid Argon, Tile Calorimeter, Muon.



  - Reported by J. Shank, work by many US collaborators as gathered by the US subsystem contacts(in subsystem order):
    - L. Vacavant, K. Baker, S. Rajagopalan, F. Merrit, B. Zhou

# ATLAS Computing Org. Chart

- **Proposed (N. McCubbin):**




- **…still under discussion.**
  - **But clearly a strong emphasis on detector systems**



# ATLAS Computing organization

| | Offline Coordinator | Reconstruction | Simulation | Database |
|---|---|---|---|---|
| **Chair** | N. McCubbin | D. Rousseau | A. Dell'Acqua | **D.Malon**/ RD Schaffer |
| **Inner Detector** | D. Barberis | D. Rousseau | **F. Luehring** | J. Pater |
| **Liquid Argon** | J. Collot | J. Schwindling | **M. Leltchouk** | S. Simion |
| **Tile calorimeter** | A. Solodkov | **F. Merritt** | A. Solodkov | **T. LeCompte** |
| **Muon** | G. Poulard | J.F. Laporte | A. Rimoldi | **S. Goldfarb** |
| **LVL2 trigger** | | S. Tapprogge | | |
| **Trigger/DAQ** | S. George | | T. Hansl-Kozanecki | H.P. Beck |
| **Event Filter** | V. Vercesi | F. Touchard | | |

# The Common Elements

- The “legacy software” results for the Physics Technical Design Report
- Detector Description
  - DB Û XML Û Generic Model
- GEANT4 Simulation
- Reconstruction
- Test-beam



# Si Tracker Software

Current activities in the US:

- Pixel Test-Beam Simulation with Geant4 [LBNL, L.Vacavant]
  - redesign of the software (OO)
  - validation of G4
- Visualization for the reconstruction [UC Santa Cruz, A.Litke]
  - involved in the development of ATLANTIS (based on ALEPH’s DALI)
  - main goal is to check the pattern recognition in the tracker
- Activities with old legacy software [LBNL, L.Vacavant]
  - No real development activity, some specific studies
  - geometrical acceptance of the pixel endcap layout
  - impact of misalignment of the pixel disks

# G4 Pixel test beam simulation

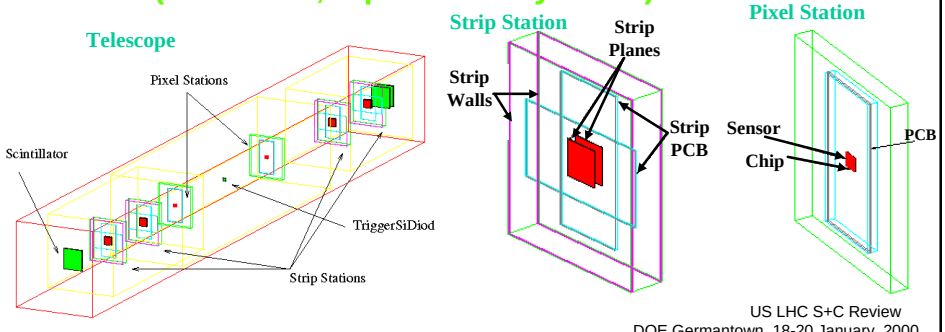
- **Goals:**
  - To gather experience with OO (new paradigm for most of us) and with GEANT4 + validate G4
    - The physics part of G4 is very different from GEANT3. The test-beam simulation project allows us to:
      - **cross-check G4 vs G3**
      - **cross-check G4 vs Data**
  - Test-bed for the ATLAS Pixel System

The following parts are currently being developed within the test-beam simulation project and will be re-used directly for the whole pixel system: pixel module geometry, user-defined material management and physics interactions, user-defined tracking and stepping related classes, digitization, infrastructure (histogramming, visualization, GUI).



# G4 Pixel test beam simulation

- **Status: Current version (0.2) features:**
  - As complete as the G3 simulation
  - Design allows easy reconfiguration
    - STL collection of TelescopeElements (insertable, reposition anywhere)

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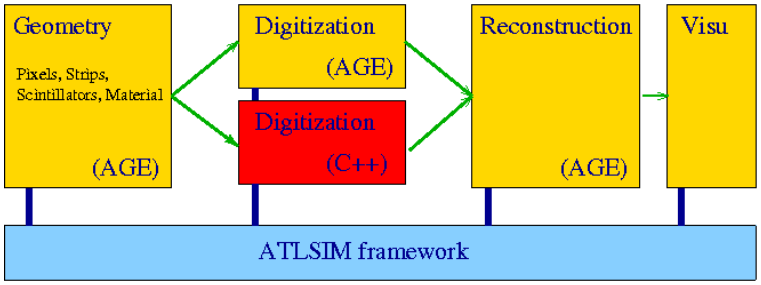
# G4 Pixel test beam simulation

- **Development framework**
  - For testing, the C++ digitization is being developed independently of G4 and can be run in 3 modes:
    - Stand-alone for quick checks. Reads in ASCII file of hits.
    - Within ATLSIM for checks against the "old" digitization
    - Within GEANT4

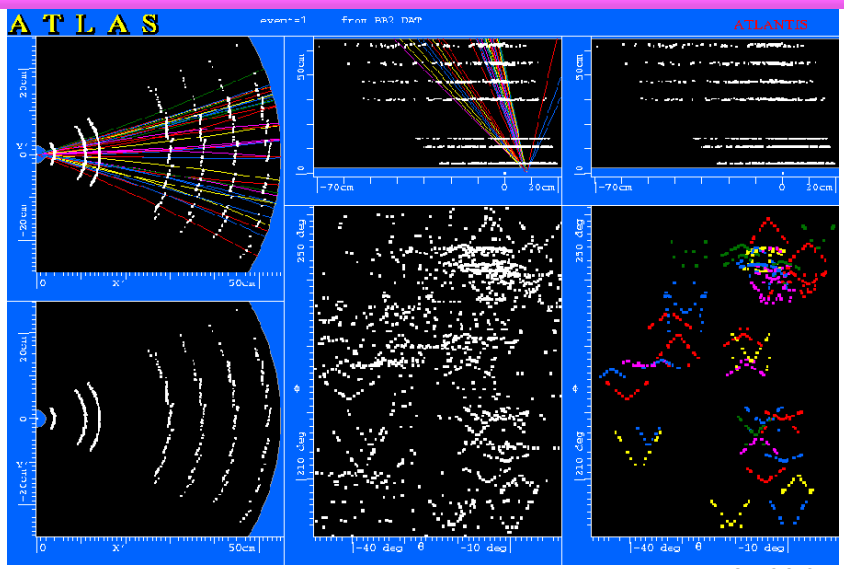





# Si Visualization

- **Status**
  - UCSC joined the effort to develop ATLANTIS
  - Working on ID display to check pattern recognition
- **Short term plan:**
  - Interface to read existing simulated events
  - Use to compare existing tracking packages
  - Work on conversion to OO

# Si Event Display






# Future Activities in Si

- Pixel test-beam simulation
- Refinements of pixel G4 description
  - Emphasizing correct simulation of the pixel modules
- Design evolution Þ whole pixel simulation
  - Integration in the ATLAS framework
  - Database/detector description
- Coordinate with similar efforts for SCT
- Work on visualization with ATLANTIS

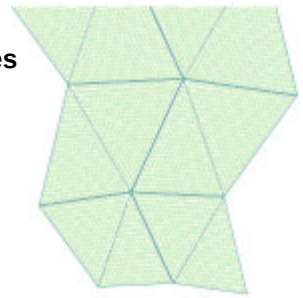
# TRT Software

- Many GEANT3 studies:
  - material budgets
  - Pile-up studies
  - Results in several ATLAS notes and TDRs
- Test-beam software
  - Comparing G3 with data
    - No TR in G3-added by ATLAS
- Physics simulations
  - With ATLAS fast MC, ATLFAST
    - Results in Physics TDR, ATLAS notes.
      - – SUSY Higgs, e.g.



# TRT GEANT3 WORK

**TRT Barrel Modules Fully Simulated**



- TRT SW Liaison Work:
  - Included TRT barrel modules
  - Careful tuning of material
  - Improved straw response and electronics model
  - A fair number of bug fixes
- Fake rate and track finding efficiency studies for the Physics TDR.

# Future TRT effort

- G3 Þ G4 starting with test-beam
- Improve e-p separation with neural nets
- Design of the TRT data event model
- Define transient Û persistent mapping



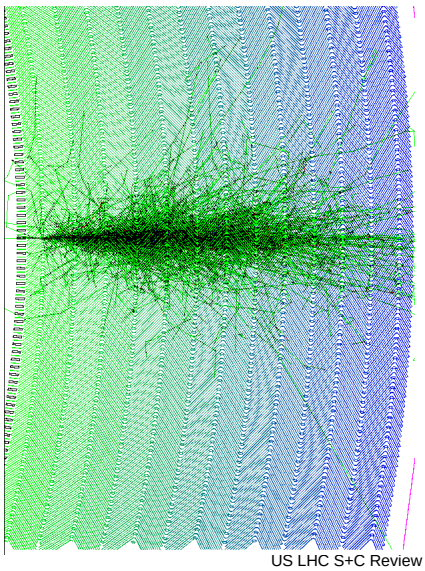
# Liquid Argon Software

- Simulation
  - GEANT3 in the Physics TDR
    - Optimization of strip width based on $p^0$ rejection and pointing studies
    - Optimal depth and granularity of each of 3 samplings for different Pb thickness
    - Simulation of dead material in front of the Cal.
- DB/Detector description
- Test beam
- Calibration
- Detector response and physics studies

# Liquid Argon Simulation in G4

- Struggling with the accordion geometry in G4
  - no appropriate shape
- Large memory usage vs long tracking time

10 GeV shower Þ

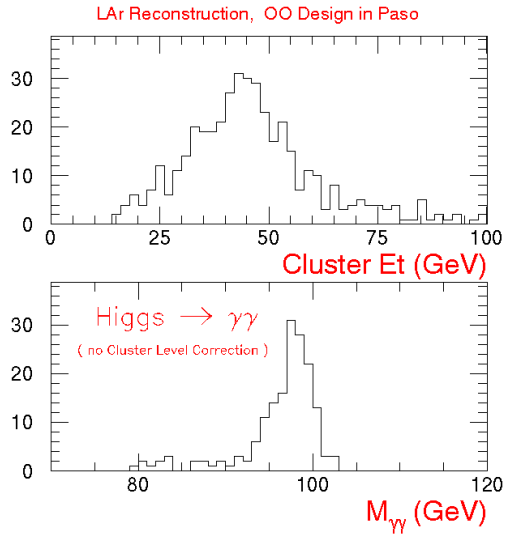




# LAr Reconstruction (OO)

- **USDP:**
  - Use cases have been developed
  - Prototype designed with UML
  - First implementation in PASO (Provisional Analysis Skeleton for Object oriented software)
  - Reads data from the old GEANT3 simulation
  - Implements basic cell and cluster finding algorithms and outputs the following:

# LAr Reconstruction (OO)






# TileCal (Hadron Calorimetry)

- **Tilecal Pilot Project: test-beam analysis system using OO/C++ and Objectivity, developed by U.S. groups.**
- **Present system has full functionality of old Fortran analysis system.**
  - **All initial Pilot Project goals have been met.**
  - **Tutorial was presented at CERN in Nov 99, with examples and online documentation.**
- **Future development**
  - **Optimal filtering; improvements in structure of code, classes, documentation and user interface**
  - **Added functionality and new analysis tools (E.g., LHC$^{++}$)**
  - **Use in other sub detector test-beams**

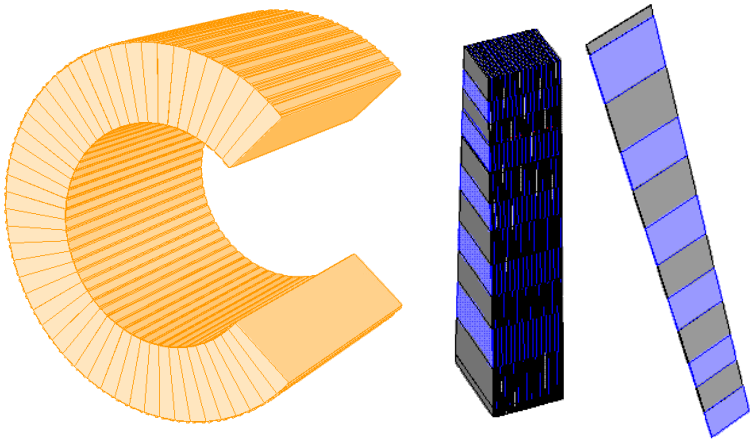
# TileCal (Hadron Calorimetry)

- PASO (Provisional Analysis Skeleton in OO)
  - This is an off-line analysis framework for the development of OO analysis, able to read Geant3 tapes generated for TDR studies.
  - Tilecal work with PASO has begun with development of transient data record for “full ATLAS” Tilecal system.
  - Will be able to read Geant3 tapes by Feb 2000.
  - Development of cluster-finding techniques during spring 2000.



# TileCal detector description

- XML



- Work well underway on development of Tilecal detector description using XML (essential for Geant4).

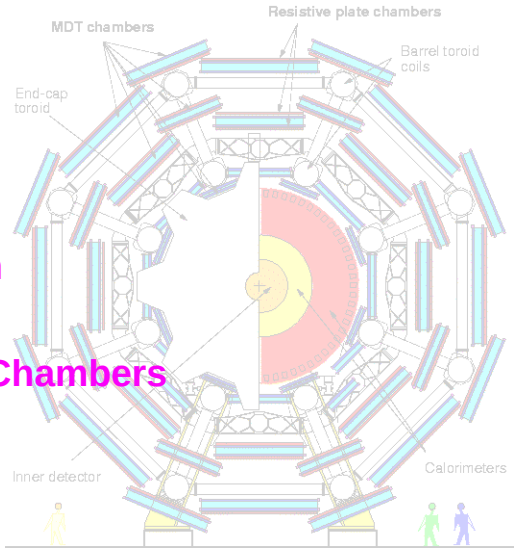
# TileCal (Hadron Calorimetry)

- Discussions underway with LAr group concerning:
  - Common data structures for Tilecal and LAr.
  - Common or parallel code structure for cluster-finding.
  - Combined effort on jet reconstruction and energy resolution.
  - To be discussed: combining LAr and Tilecal energies at the cell/tower level, before cluster-finding is carried out.



# Muon Software

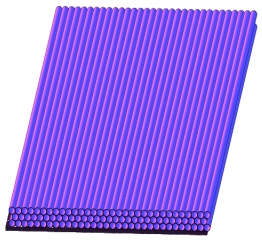
- Areas of US involvement:
  - DB
  - Simulation
  - Reconstruction
  - Trigger
  - Cathode Strip Chambers



# Muon DB/Detector description

- **An MDT1 Multilayer Stack in XML:**

```
<composition name="MU_MDT1_OuterTubes">
   <mposZ volume="MU_MDT1_Tube"
          ncopy="32" Z0="-480." dZ="30.0" rot="0 90 0" index="0 0 0" />
</composition>
<composition name="MU_MDT1_Stack">
   <posXYZ volume="MU_MDT1_OuterTubes" X_Y_Z="0  33.48  0" index="0 2 0" />
   <posXYZ volume="MU_MDT1_InnerTubes" X_Y_Z="0   7.50  0" index="0 1 0" />
   <posXYZ volume="MU_MDT1_OuterTubes" X_Y_Z="0 -18.48  0" index="0 0 0" />
   <posXYZ volume="MU_MDT1_Support"    X_Y_Z="0 -40.98  0" />
</composition>
```





# Muon DB/Detector description

- **A BMS1 Barrel Station in XML:**

```
<composition name="MU_BMS1_Station">
   <posXYZ volume="MU_BMS1_UpperRPC" X_Y_Z="0  251.96  0" index="0 1 0"/>
   <posXYZ volume="MU_BMS1_UpperMDT" X_Y_Z="0  133.48  0" index="0 1 0"/>
   <posXYZ volume="MU_BMS1_Spacer"   X_Y_Z="0    0     0" />
   <posXYZ volume="MU_BMS1_LowerMDT" X_Y_Z="0 -133.48  0" index="0 0 0"/>
   <posXYZ volume="MU_BMS1_LowerRPC" X_Y_Z="0 -251.96  0" index="0 0 0"/>
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```
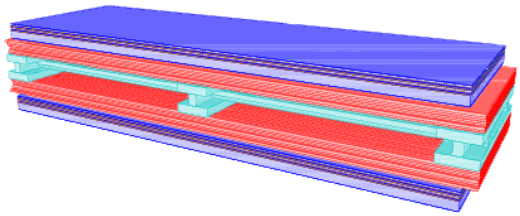
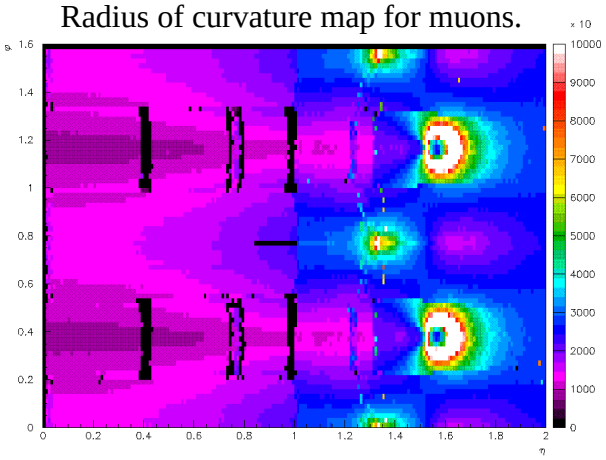



See Goldfarb's web site for full details: http://home.cern.ch/muondoc/software/Database/

# Muon Level 2 Trigger

Radius of curvature map for muons.

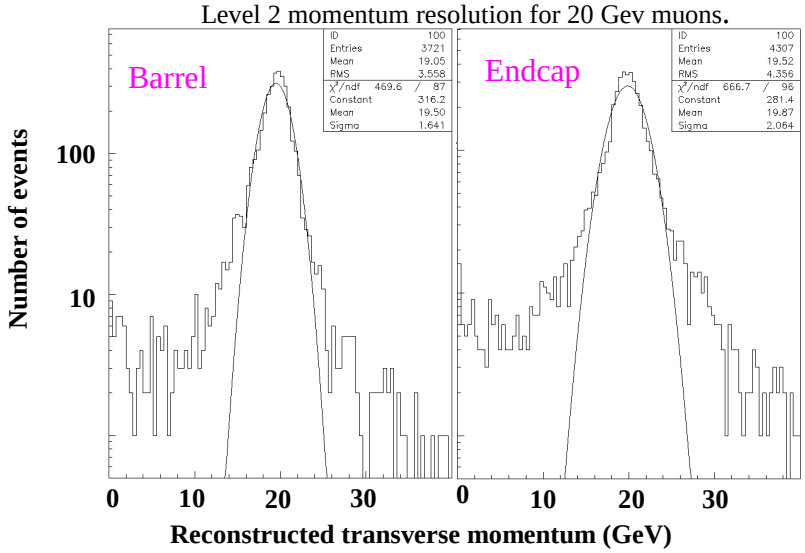






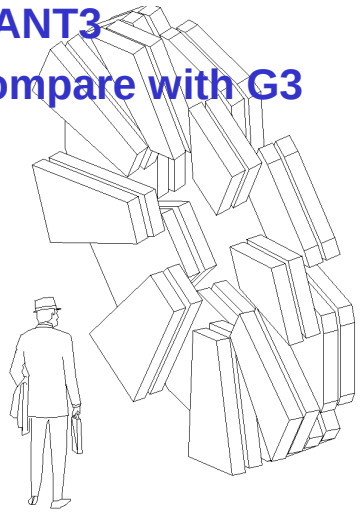

# Muon Level 2 Trigger

Level 2 momentum resolution for 20 Gev muons.



# Cathode Strip Chambers

- Many studies with GEANT3
- Development in G4, compare with G3
- Reconstruction in OO
- Test beam



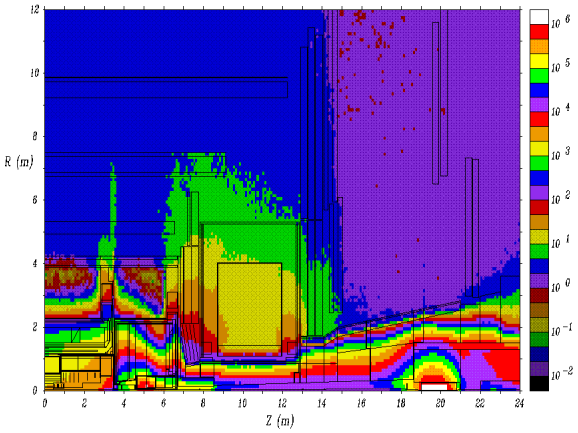


# Cathode Strip Chambers

- Complete GEANT3 geometry
  - Incorporating signal simulation based on photo-absorption ionization model.
    - Gas properties and electrode geometry taken into account
    - Tuned with test-beam data for position accuracy and high background rate performance
  - Adding more details to the geometry now
    - Details of frames, corners and dead areas.

# Neutron Background Studies

Total neutron flux KHz/cm$^2$






# Conclusions

- **Broad range of activities, well integrated in the whole of ATLAS**
- **Working closely with US work in core**
- **Leadership roles in many areas**
- **Well positioned for future software agreements**
  - **(we expect subdetector software MOU's to be later than core software MOU's)**