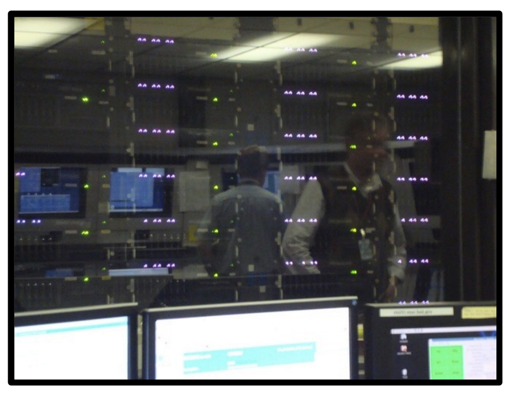
Migration from a Legacy Geometry Code to an Abstract Geometry Modeling Language in STAR

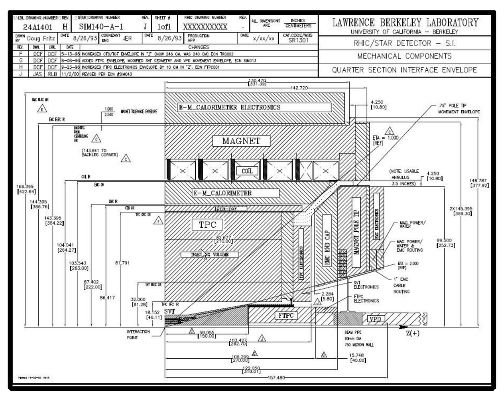
J. Webb, V. Perevoztchikov, J. Lauret

(Planning for Evolution in a Production Environment)

The STAR Experiment

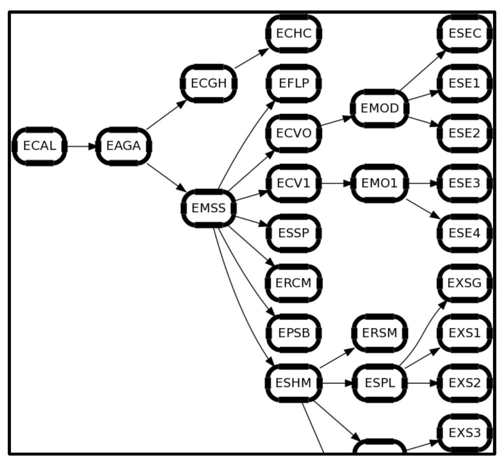


This is what Physicists think we do

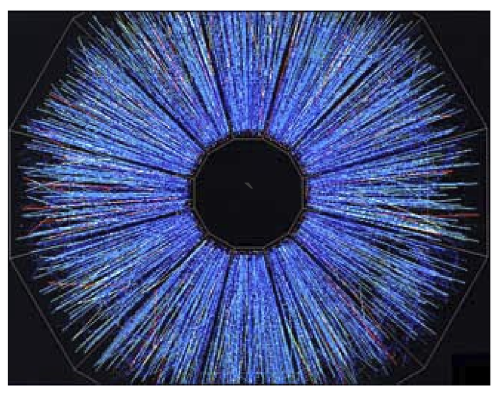


This is what Engineers think we do

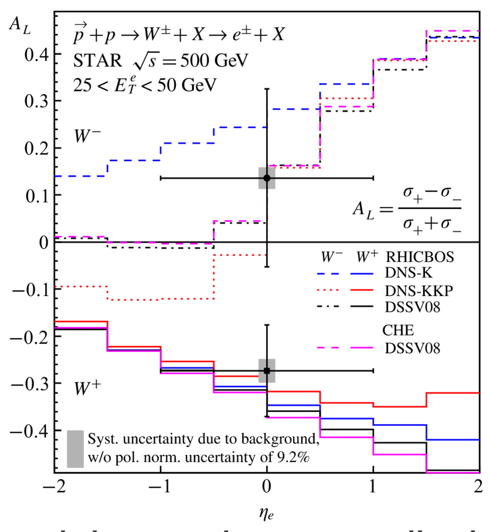
This is what the public thinks we do



This is what the simulation group thinks we do



This is what the TPC group thinks we do



And this is what we really do

Introduction

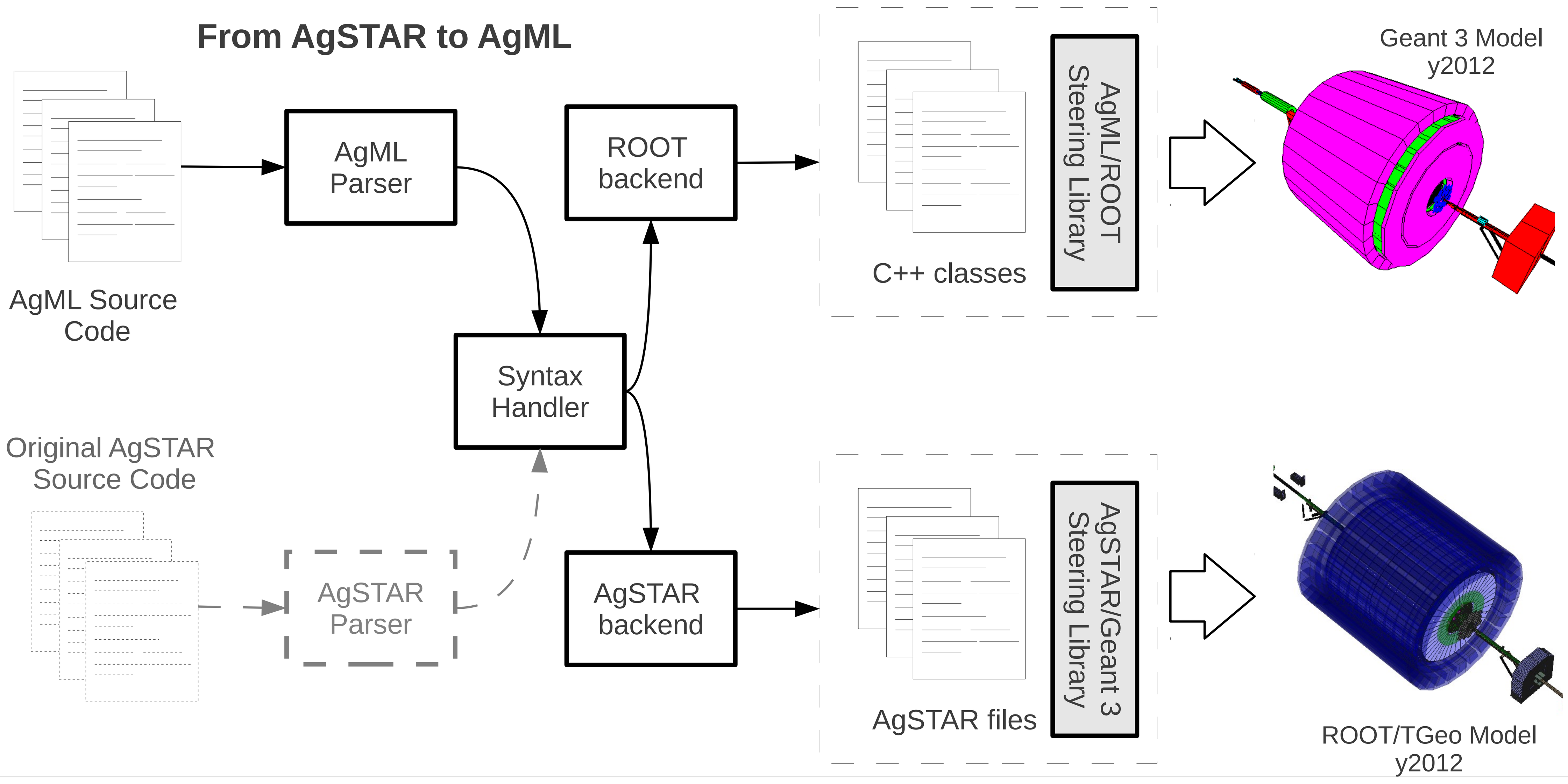
The STAR experiment has migrated its FORtran-era geometry model, developed over more than a decade of operation, to an Abstract Geometry Modeling Language (AgML). By decoupling the description of the model from the underlying software framework, we are able to provide a consistent single-source geometry for both our ROOT-based reconstruction codes and our legacy FORtran simulation package. We have been able to port the geometry model with little impact on ongoing operations. The geometry model implemented in AgML reproduces the material budgets of the original geometry for most of the configurations in which the STAR experiment has run, and we can demonstrate consistency in event reconstruction between the two versions. By adopting this approach, we have been able to preserve the description contained within our original geometry files. This means that the transition from our legacy codes to the new framework was achieved completely by the core software team, without significant demands placed on the time of detector experts who have moved on from software development and are engaged in running the experiment and analyzing data.

AgML provides a rich syntax geared towards the rapid development of detector geometries, and is supported by a C++ library which steers the creation of the concrete geometry model. The interface to the steering code is specified by an abstract base class, enabling new geometry implementations to be created easily. Thus, AgML will allow us to seamlessly migrate to new technologies in the coming decade as the STAR program draws to a close and evolves into eSTAR.

From AgSTAR to AgML

The AgML framework is based on XML. The language specification includes markup elements for geometry definition, flow control, looping, variable declaration and data structures. The AgML (XML) parser is essentially a sophisticated pre-processor, transforming recognized markup elements into the target code specified by user-defined backends. Expressions in AgML are exported directly to the target language.

The STAR geometry was originally implemented using the Advanced Geant Interface [1] (AgSTAR) framework. AgSTAR used the MORtran preprocessor to extend the FORtran programming language with geometry keywords, providing a high-level interface with the GEANT 3 [2] library, and C-like syntax for flow control.



AgML modules were automatically created from the original AgSTAR sources using an AgML backend and the common syntax handler

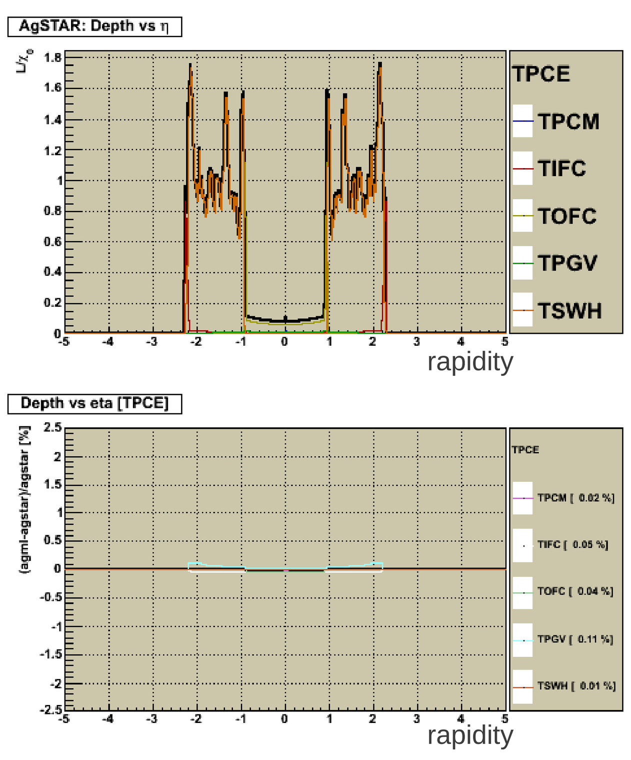
The AgML compiler framework is implemented in python, using the xml.sax module for parsing XML and using the pyparsing module for parsing the AgSTAR language.

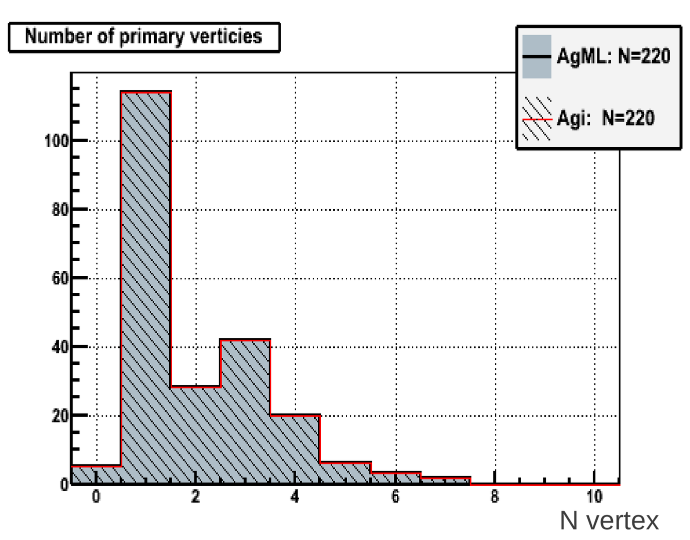
Multiple concrete geometry models can be supported from the single-source AgML files by implementing a new backend and a new support library.

Validation

Reproducibility of existing data was an important design requirement. The goal of AgML was to reproduce the material budgets of existing versions of STAR to better than 1%. A dedicated Monte Carlo application StarBASE[4] was used to compare the material budgets for every volume in the STAR detector. The plot at the right shows the material in the AgSTAR model of the STAR TPC volume and its daughters in the top plot. The bottom plot shows the percent difference between AgML and AgSTAR.

We were able to demonstrate agreement between the two models to much better than our stated design goal of 1% for most of the 36 geometry releases since 2005.





Track reconstruction studies were performed to ensure that the AgML geometry would integrate with the STAR reconstruction software and provide results equivalent to the original AgSTAR model. Data from the RHIC 2010 AuAu run at $\sqrt{s}$=200 GeV were processed by the same reconstruction chain, using both AgML and AgSTAR geometries as reference.

The plot at the left compares the vertex multiplicity in minimum bias events for one run at STAR. The distributions are identical, and in fact understate the level of agreement as out of 123,000 tracks analyzed the new model differed by only three tracks at low p_T.

Outlook and Path Forward

- STAR has evolved dramatically over more than a decade of operation, but so has the technology employed in the field
  - FORtran has become obsolete, MORtran essentially dead
  - GEANT 3 is no longer being developed, and Geant 4 has reached production-quality maturity
  - ROOT/TGeo provides a path to migrate to Geant 4
- The geometry models in simulation and reconstruction had diverged, with reconstruction using a custom model
  - Updates were not always consistently applied to both
  - Overly simplistic reconstruction geometry not sufficiently accurate, and incapable of supporting new detectors
  - Demonstrated a clear need to reach a common framework

The Abstract Geometry Modeling Language was developed to provide a path forward, automating the process of translation and providing a level of abstraction which will streamline the process of integrating future technologies as they emerge.

- A new tracker is being developed for STAR: Stv
  - Nearing completion it will utilize the ROOT/TGeo geometry model provided by AgML
- New detectors are being developed to support the future eSTAR program
  - Geometries developed in AgML
  - Immediate access to simulation and reconstruction geometries allows rapid integration into the STAR analysis chain, simplifying R&D efforts

AgML provides physicists the capability to rapidly integrate new tracking detectors into the STAR software stack and to quickly begin studying detector performance in a realistic, consistent and flexible simulation and reconstruction environment.

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[1] A. Artamonov et al, "DICE-95", internal note ATLAS-SOFT/95-14, CERN, 1995.
[2] GEANT - Detector Description and Simulation Tool, CERN, Geneva 1993.
[3] R. Brun et al, "The ROOT Geometry Package", Nucl. Instrum. Meth. A502:676-680,2003.
[4] StarBASE, J. Phys. Conf. Ser. 331 032033 (2011)