Status of TRT Simulation

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Inner Detector Software and Performance Meeting

Talk Outline:

1. SW Responsibilities
2. GEANT3 Status
3. GEANT4 Status
4. Plans for DC0 and beyond

Responsibilities

- Who is doing what:
  - Test Beam: E. Arik, E. Barberio, S. Cetin, C. Driouichi, E. Lytken, S. Morozov, A. Romaniouk, S. Smirnov, V. Tikhomirov
  - TR Work: E. Barberio, P. Nevski, V. Mitsou, A. Romaniouk
  - Readout Studies and Coding: M. Dam
  - ToT and Digit Unpacking: P. Gagnon
  - GEANT3: E Barberio, FL, P. Nevski
  - GEANT4 : E. Lytken, C. Rembser, A. Zalite, Y.Zalite.
- The institutes involved: Bogazici (Istanbul), BNL, CERN, Indiana, Lebedev Institute, Lund, MePhI (Moscow Physical Engineering Institute), Niels Bohr Institute, PNPI (Petersburg Nuclear Physics Institute).

GEANT3 Code Changes

- Two serious bugs have been found in the GEANT3 Transition Radiation (TR) generation routines.
  - Elisabetta Barberio found the first bug that caused TR model parameters for a random part of the TRT to be used during TR generation.
    - Cause: an improperly initialized variable.
    - Result: decreased TR production in the barrel and type A & C wheels and increased TR production in the type B wheels.
  - I found the second bug that caused the TR absorption routine to treat the straw walls as a denser material than Kapton and reduced the number of TR photons reaching the TRT sensitive gas volume.
    - Cause: changing the name of straw material from Kapton to straw.
    - Result: a substantial over-absorption of the generated TR X-Rays before they reached the sensitive gas.

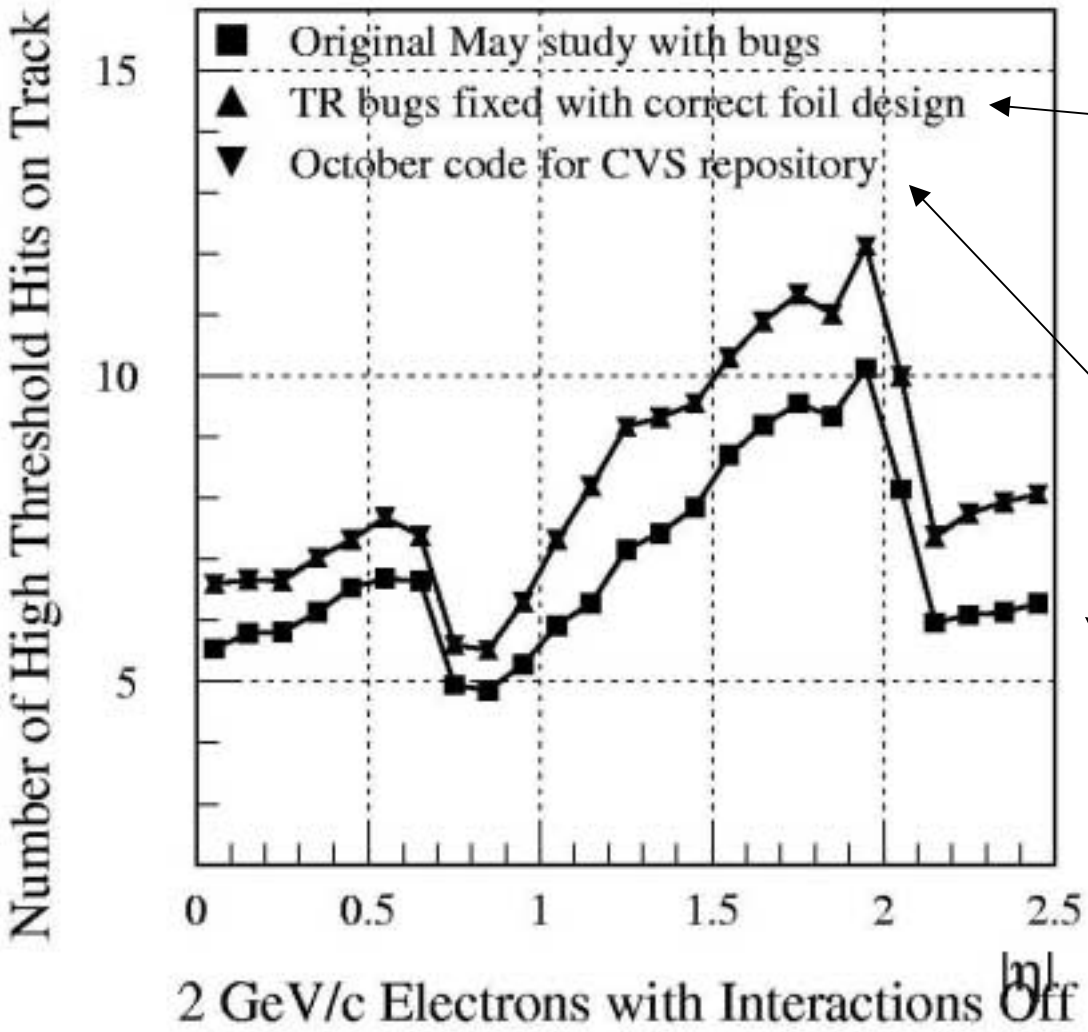
TR Bugs

- The effect of the TR bugs:
  - These bugs caused the results in the TR section of the Physics TDR to be overly pessimistic.
  - Neither bug affected the test beam simulation and the previous comparisons showing good agreement between GEANT3, GEANT4, and data are correct.
- Cause of the bugs:
  - These bugs were put into the simulation when the geometry was changed to have a realistic representation of the end-cap wheel radiator stacks in 1997. Previously the simulation did not have individual foil stacks and the radiator filled the whole wheel volume except that filled by the straws.
- The effect of correcting the bugs is to considerably improve the electron id performance predicted by the the GEANT3 simulation for the full TRT detector.

Other Recent Changes to GEANT3

- Elisabetta Barberio has put two improvements beyond the bug fixes into the TR model:
  - In the end-cap foils the dimensions now match the physical dimensions of the end-cap stacks. This change increases the total length of the radiator that a simulated track sees.
  - The gaps and foil thickness have been tuned to produce results that match recent data.
- In tuning the TR model, the density of end-cap foil stacks was reduced below their physical values so the amount of material in the end-cap wheel is low.
- Z positions and dimensions of the end-cap wheels and the service gaps supplied by Geoff and Andrea C. in May were put into the simulation.

Corrected Code Increases the Number of High Threshold Hits for Electrons



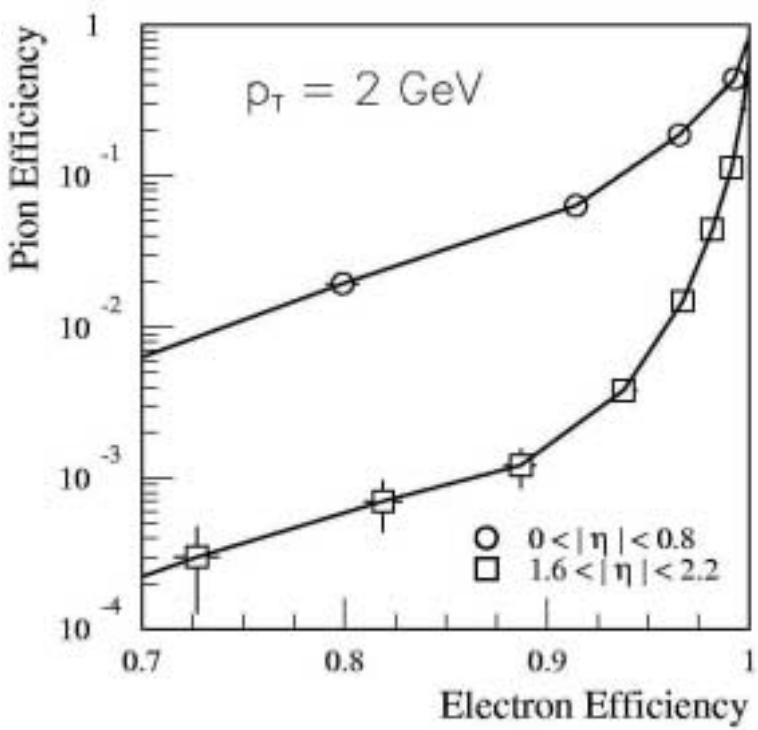
Elisabetta's Barberio's tuned TR generation code is the line labeled "TR bugs fixed"

Code being submitted to CVS repository.

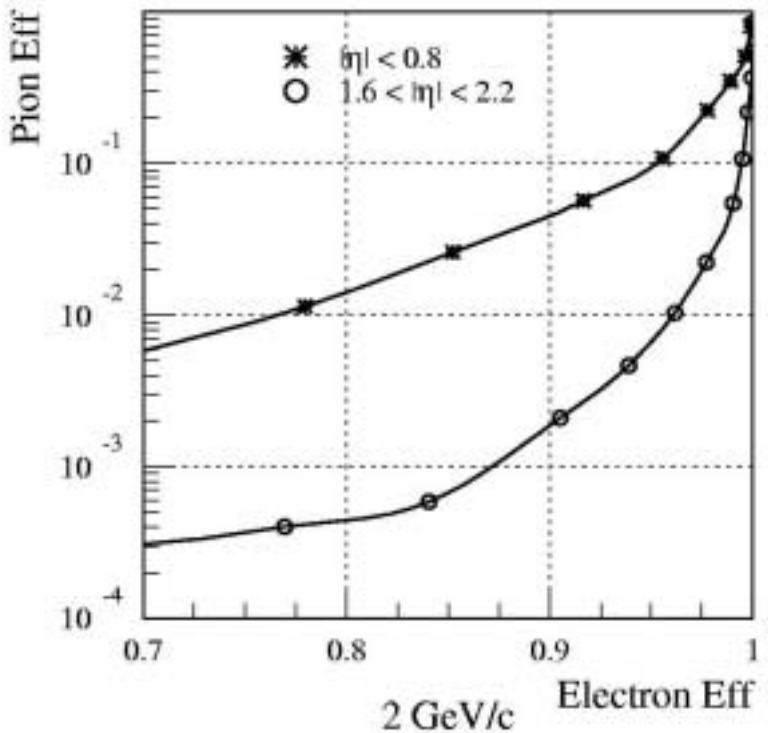
Similar to Physics TDR Code.

Pion Rejection at 2 GeV/c

- The current code produces results very close to the old ID TDR study even though the geometry and TR generation parameters are different.



ID TDR Result 1997
(NOT Physics TDR)

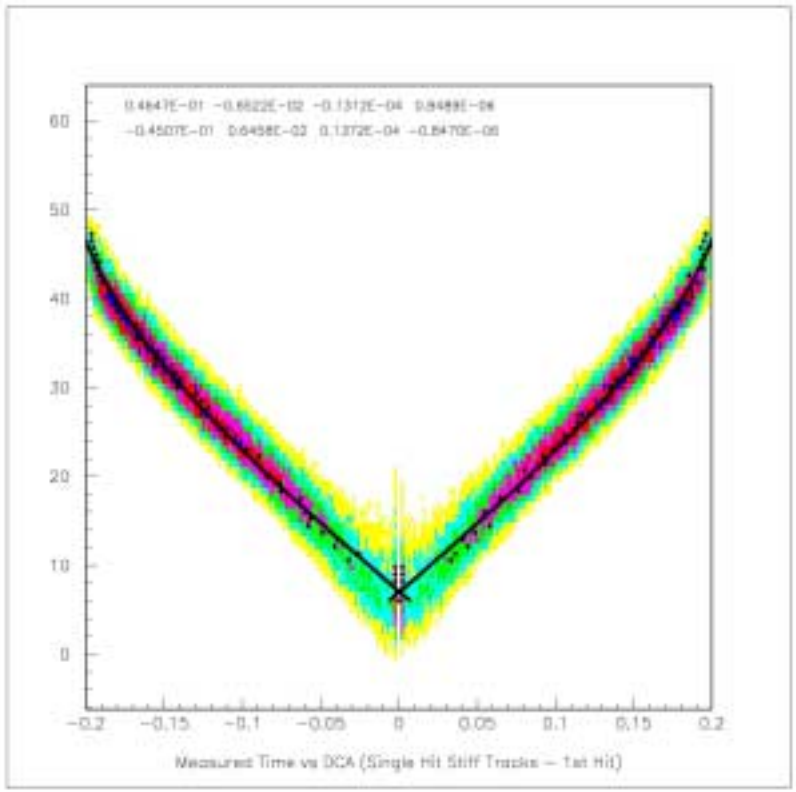


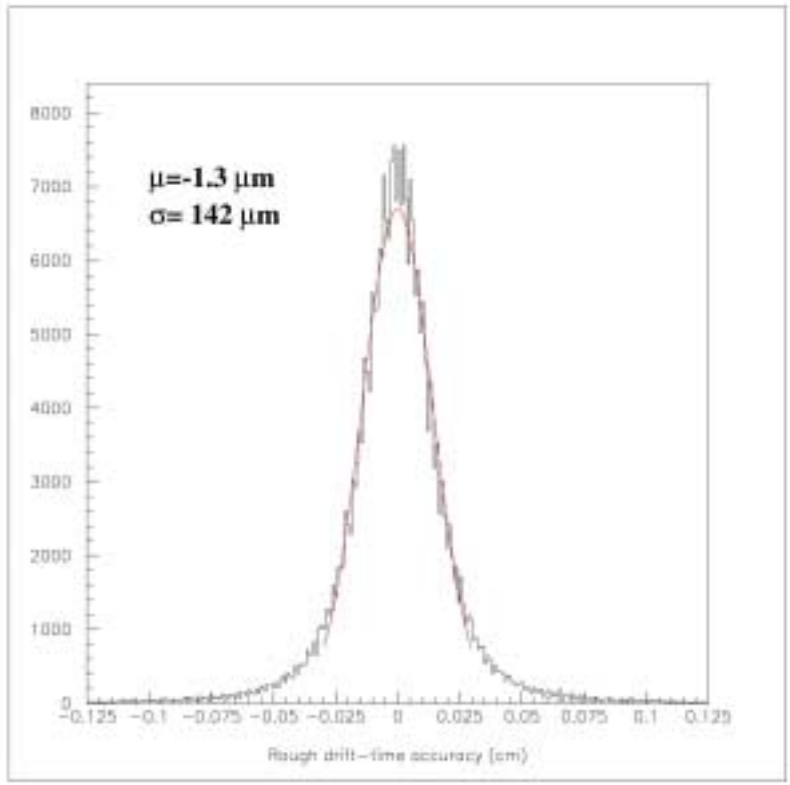
Current Tuned Code

TRT Digitization Unpacking for xKalman

- For xKalman to use the digits generated by the current version of the TRT code, a revised drift time to drift distance (rt) function was needed in the routine that unpacks the TRT digitizations. Pauline Gagnon has modified the unpacking so:
  - The routine checks whether the digits were made using the previous TRT version (ID and Physics TDR) and adjusts the rt relationship accordingly.
  - The routine adjusts automatically for whether time of flight is in use.
  - The routine uses the result of cubic fit method developed by Serge Smirnov instead of a linear rt relationship.

Most Recent V-Plots





Release of Latest GEANT3 TRT Code

- Yesterday I committed and tagged the TRT GEANT3 code as TRT-04-03-00 (superceding TRT-04-02-17).
- The release of the code was slowed because when the foil stack dimensions were changed, the content of a data structure was altered in a non-backwards compatible way. Pavel determined that this did not cause problems so the TRT code could be released.
- Releasing the new xKalman TRT unpacking routine has to be coordinated with the reconstruction release because a common block is extended.

GEANT4 Simulation Status

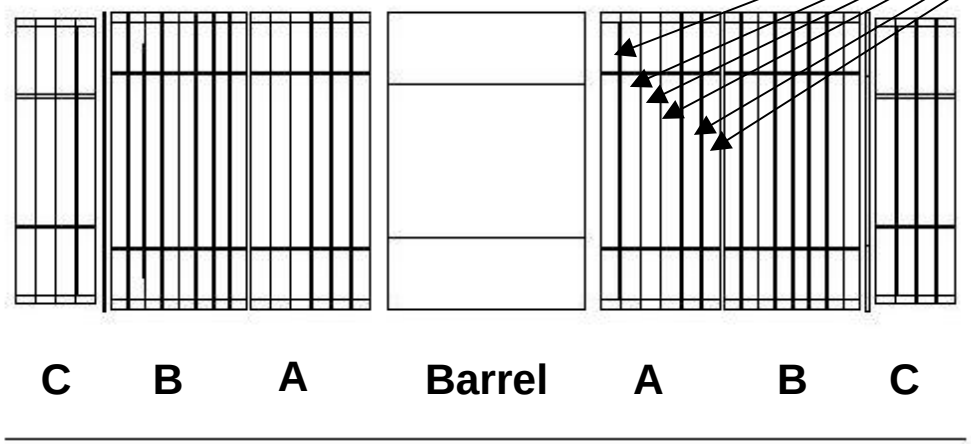
- The TRT full detector simulation has been put into GEANT4 by Andrei and Yura Zalite:
  - Both the barrel and end-cap geometry and materials have been tested in GEANT4. A few very minor parts of the geometry still need to be added.
  - The rewriting of the TRT digitization into C++ is nearly complete and tested within GEANT4. This digitization routine was developed initially for use with the testbeam simulation and has been shown to reproduce the testbeam results.

Simulation in FADS

- With the help of Andrea Dell'Acqua, Andrei and Yura are also putting this code into FADS:
  - The geometry has been read from compact XML into FADS.
  - The C++ digitization will soon be usable in FADS.
- Note: FADS stands for "Framework for ATLAS Detector Simulation" and is being used in the short term to integrate the ATLAS full detector GEANT4 simulation.

End-Cap Geometry in FADS

The TRT geometry is read from compact XML into FADS to create the geometry.

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<TRT_A
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  OuterRadius="1076.5"
  Length="863.5"
  NWheels="6">
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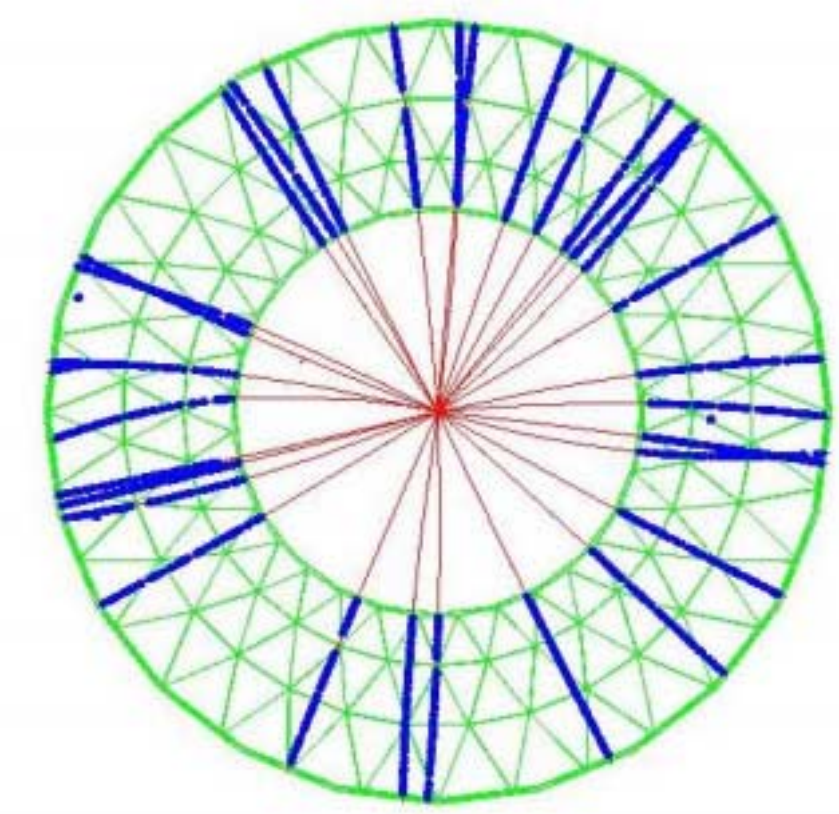
     name="Wheel_A"
     InnerRadius="620."
     OuterRadius="1076.5"
     Length="136."
     DeltaZ="145.5"
     InnerSupportThickness="23.7"
     OuterSupportThickness="72.5"/ >
</TRT_A>
```

Andrei & Yura Zalite

GEANT4 Simulation Status (continued)

- Once the event model is defined, the C++ digitization will be completely integrated into Athena.
- Andrei/Yura have tested that using Athena they can:
  - Read the TRT hits from TDR tapes into the C++ digitization using the RD event model.
  - Create TRT hit objects within Athena.
  - Store the hit objects in the Transient Event Store (TDS).
  - Retrieve the stored hit objects from the TDS.
- We have created hits and digitization definitions for use with the C++ digitization:
  - The new hit definitions differ from the GEANT3 hit definitions which has implications for using the C++ digitization with the old data tapes generated for the physics TDR.

Hits in GEANT4



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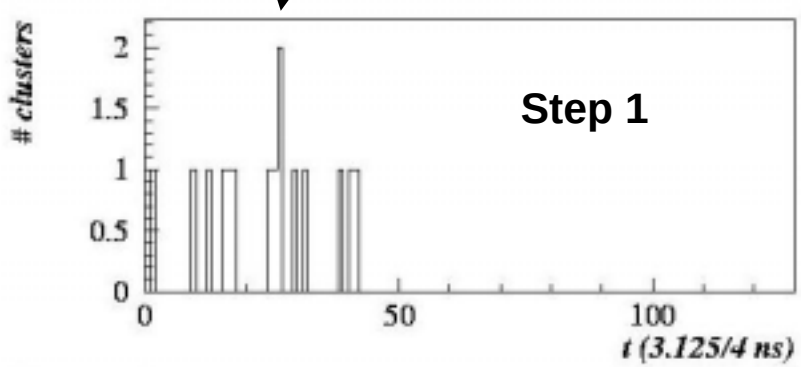
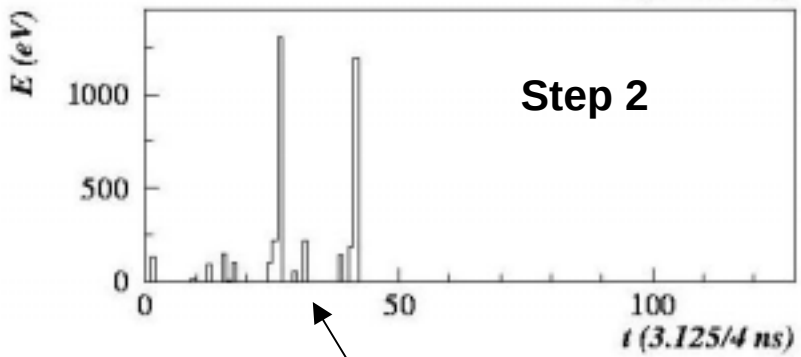
TRT Digitization in C++

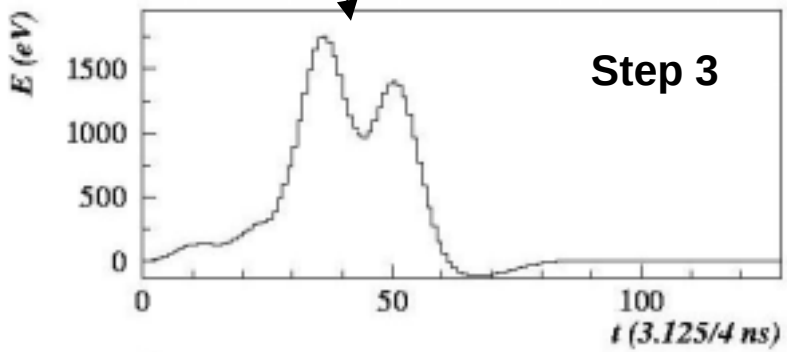
Number of clusters deposited in straw as a function of time.

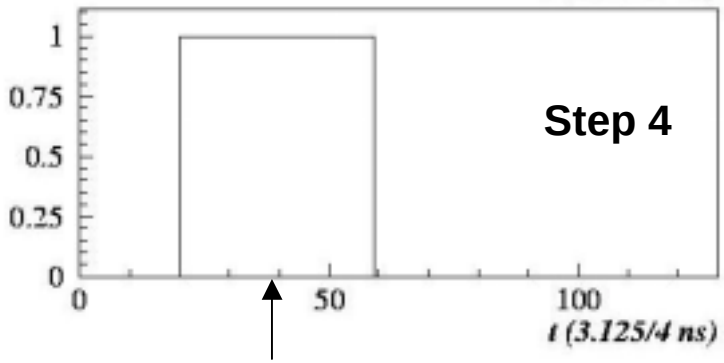




Energy reaching electronics inputs including energy resolution.

Output of shaping electronics shaping.





Discriminator output.

Andrei & Yura Zalite

TRT Code Repository

- Else Lytken has entered the TRT testbeam GEANT4 code into the official ATLAS repository:
  - The code is in: offline/InnerDetector/TRT/TRTTestBeamSim
  - This code was originally developed by Dario Barberis and Ketevi Assamagan and is the basis for a major part of the TRT C++ digitization.
  - Else made a final round of improvements to the code including making it run with GEANT 4.3.0.
- We need to create a similar repository for the full detector simulation and also someone has to update the digitization in the testbeam code to include the additional functionality that Andrei and Yura added to the C++ digitization routine in the full detector.

Possible Simulation Improvements

- Features that need to / could be added:
  1. Revising the TRT service material amounts. There now are detailed spread sheets for most parts of the TRT.
  2. Understanding if we need to model ionization produced by tracks with energies below where the PAI model works.
  3. The effect of electronic noise, threshold variation, crosstalk, etc. We now have reasonable data on all of these effects but they still need to be entered into the simulation.
  4. Modeling the variations in the electronics signal shaping with the charge deposited in the straw. Currently a single fixed signal shape is used in the simulation. The simulation results are known to be fairly sensitive to the signal shape.
  5. Implementing a Transition Radiation Model in GEANT4.

Plans Through DC0

- Test generating hits and digits within FADS
  - The new TRT digitization is written in C++ and is (mostly) independent of GEANT4. The GEANT4 PAI model is used to generate ionization clusters “on the fly” during digitization to avoid having to store the clusters as part of the hits.
- Compare of the results of GEANT3 & GEANT4.
- Redo Physics TDR Study on the use of TR for pion rejection with:
  - The TR bugs fixed.
  - The revised end-cap radiator geometry.
  - The current inner detector geometry.
  - The use of pile-up.

Plans through DC0

- DC0 events will be mainly generated in GEANT3 because:
  - This allows the use of Transition Radiation. We don't have a tested working model of TR in GEANT4 and there is not enough time remaining to solve this before DC0 starts.
  - The current TRT geometry (used in both GEANT3 and GEANT4) is not compatible with RD's event model which uses an old TRT geometry.
- We will also try to use events from FADS if this possible.

Plans for work from DC0 to DC1

- Implement the use of the C++ digitization within Athena.
- Continue detailed comparisons of GEANT3 and GEANT4 results for simulation of the full detector.
- Use the new event model as soon as it is ready.
- Begin work on using TR in the GEANT4 simulation.
  - Most of what needs to be done is in the GEANT4 tracking / hits and not in modifying the C++ digitization.
- Add the noise, crosstalk, etc. to the simulation.
- Revise the TRT serviced material amounts now that the TRT mechanical design is nearing completion.