GEANT4 and Secondary Particle Production

Jeff Patterson

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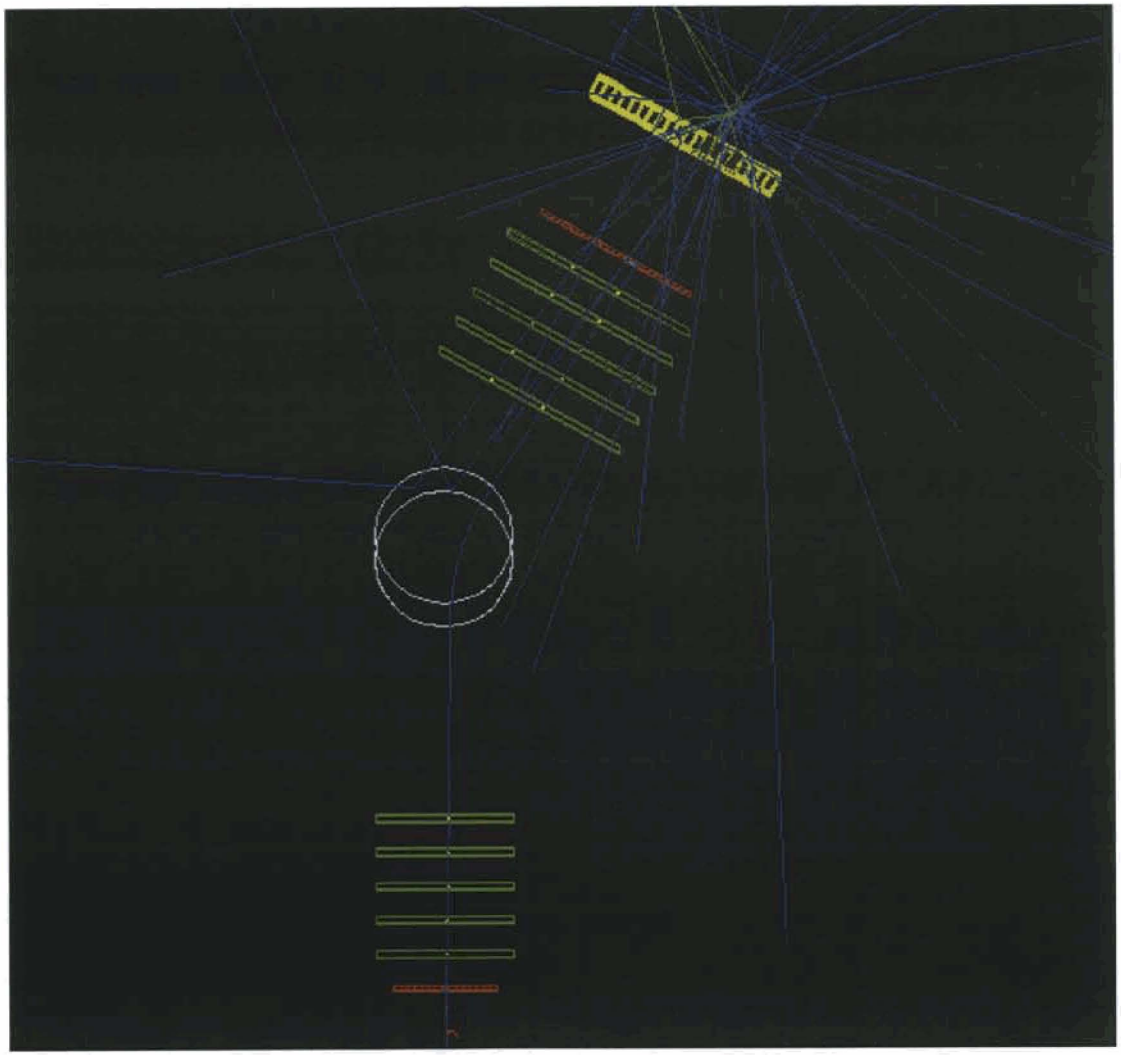
GEANT4 Intro

- GEANT 4 is a Monte Carlo tool set developed by the High Energy Physics Community (CERN, SLAC, etc) to perform simulations of complex particle detectors.
- Written in the frame work of C++ and Object Oriented Design (OOD)
- Tool set includes
  - Robust physics models and data sets to predict particle interactions with materials
  - Programming environment to simulate arbitrarily complex ensembles of geometries and materials
  - Visualization tools for graphical representations of simulated world and particle interactions
  - Complete set of analysis tools and plotting capabilities

GEANT4 Methodology



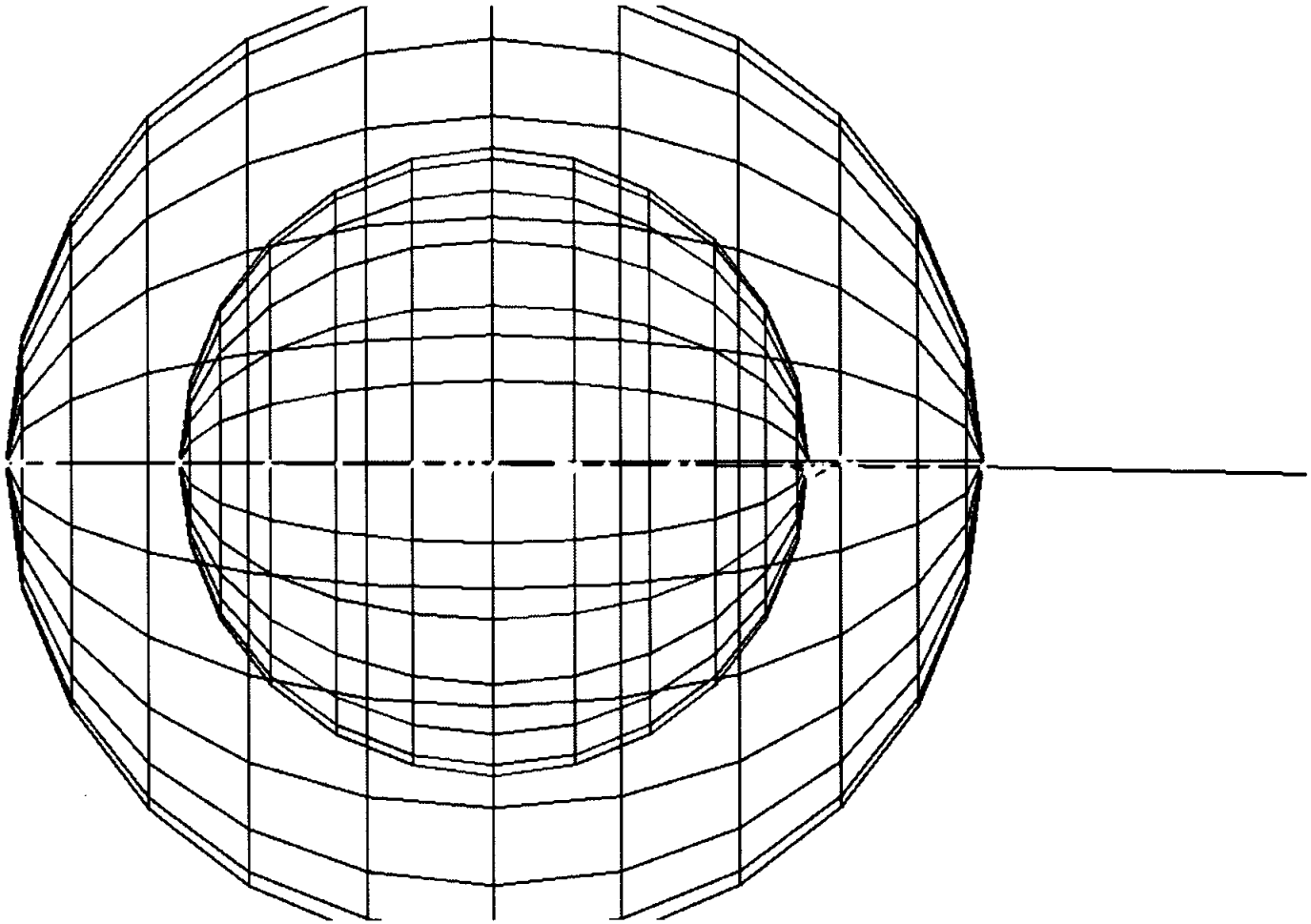
GEANT4 Concepts

- Implemented physics include
  - Electromagnetic, hadronic, and optical processes
  - Valid energy range: 250 eV – TeV
  - Properties of long lived particle, elements, and materials
- User must define which physics process, models, and data set to include in simulation
- User must also define world, and sensitive detectors that are to be simulated
- User must also define environment of energetic particles
- User provides this information in the context of object oriented design

GEANT4 and Space Applications

- Due to the:
- Robust physics implementation
- Extended energy range of validity (about 12 decades)
- Ability to construct complex geometries composed of any arbitrary material,
- One application of GEANT4 is the transport of space radiation environments thru spacecraft to the sensitive microelectronics.
- One can very accurately model the exact geometry of spacecraft and shields
- Allows for systematic study of
- Effectiveness of differently shielding configurations
- Production of secondary particles, which could lead to the enhancement of the SEE, TID, and DD environments

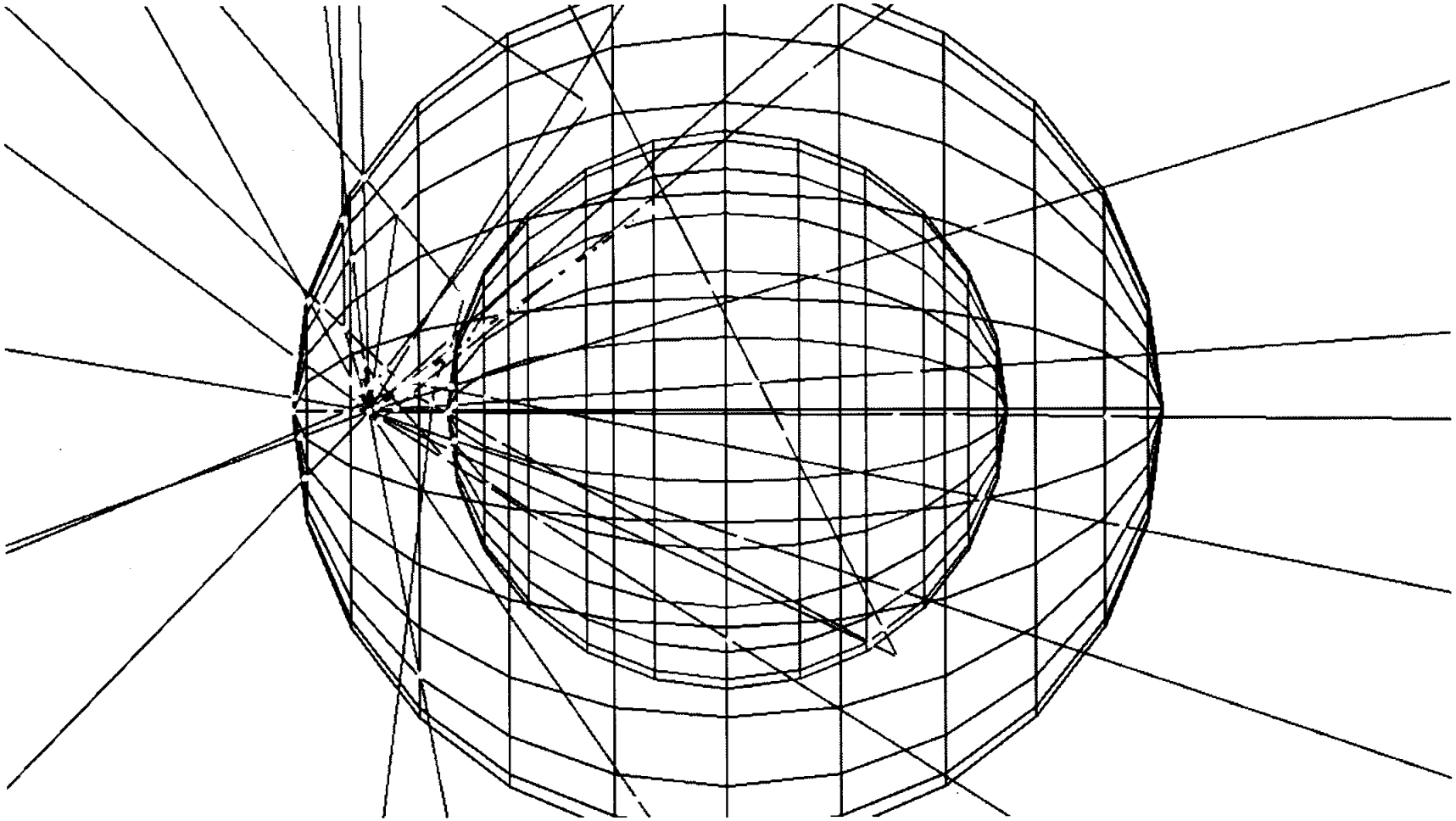
GEANT4 and Particle Transportation



Secondary Production

- GEANT4 simulations show that energetic environments lead to production of secondary products that modern day microelectronics are sensitive too.
- Environments consisting of protons, electrons, and gammas, lead to many types of secondary products
- Protons, neutrons, deuterons, tritons, alphas, pions, etc.
- All these particles could lead to enhancment in SEE rates if not quantified.

Secondary Productions



Summary and Future Work

- GEANT4 is the ideal tool to study radiation transport
- Should be applied to space environments and the complex geometries of modern day space craft.
- Only way to study production of secondaries is to perform Monte Carlo simulations in the forward direction, i.e. Adjoint methodology will not work
- In energetic environment (i.e. Jovian system), the secondary production could lead to a significant enhancement in the SEE environment.
- This will further be quantified in future work and papers.

Future Work

- The trapped proton and electrons belts of the Jovian systems will be studied extensively.
- Electrons fields need special consideration.
  - Electrons are usually not considered to contribute to SEE environment, however they can produce gammas, which can then lead to proton or neutron production.
  - Due to the extremely enhanced electron fields around Jupiter, this requires special attention.
- GEANT4 is the only available tool to study this phenomena.