Status Report of Non-homogenous Magnetic Field Study

Jason Abernathy
Christian Hansen
Dean Karlen

Goal of the Study

- To develop:
  - **A new TPC simulation in an existing framework (Geant4 / Mokka / Marlin)**
  - **A Marlin version of the likelihood method of fitting tracks to data which uses LCIO**

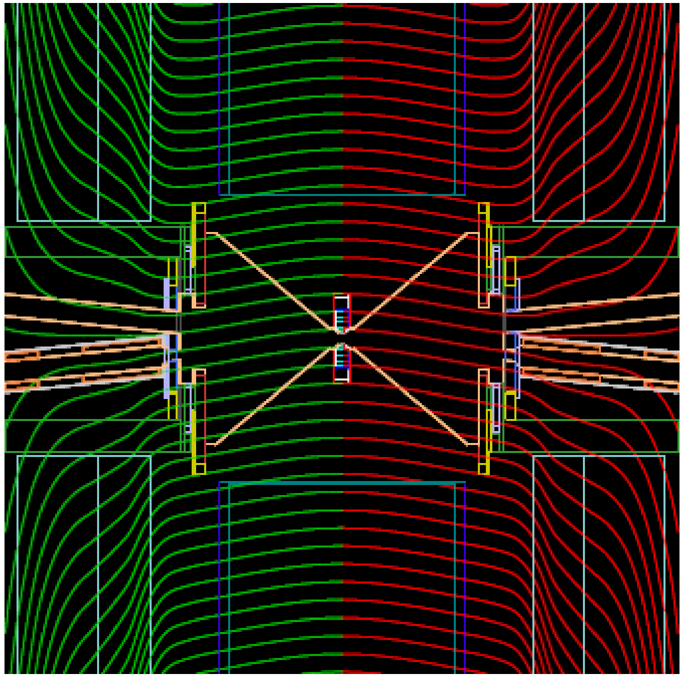
- To determine:
  - **The effects of a non-homogenous (NH) magnetic field on the resolution of the TPC**
  - **Methods of taking this into account**

Sources of a NH Magnetic Field

- Main Solenoid Field Crossing Angle
  - **A crossing angle of 2 – 20 mrad is introduced to reduce unwanted bunch interactions and allow more accurate post-IP diagnostics**
    - Polarization
    - Energy
  - **The crossing angle causes a non-homogenous field**
- Main Solenoid Field Imperfections
  - **How much an affect will this have?**

Sources Continued…

- IR compensation (DID, anti-DID)
  - **Tries to compensate for the main solenoid field in the interaction region using for example a detector integrated dipole**
  - **Can make things nice in the IR but the field will affect the TPC as well**



Consequences of NH Field

- Changed the path of particles
  - **Primary Particles**
  - **Electrons in the TPC drift gap**

- The field will have to be mapped
  - **Hall probe**
  - **Use data to find corrections**
  - **Resolution of $\delta B/B_z < 1 \times 10^{-5}$ is required**

Simulation

- Implemented using Mokka
  - **Allows parameters to be stored in a MySQL database and accessed with drivers**
    - Gas composition
    - Geometry
- Energy deposits created by primary particles are converted into clouds of electrons with
  - **Mean position (x, y, z, t)**
  - **Transverse / Longitudinal deviation**
  - **Number of electrons in cloud (1 per 26 eV)**

Simulation Continued…

- Clouds are transported through “sections” of the TPC
  - **Gas sections**
  - **Amplification devices (currently only GEMs)**
- Uses Langevin theory of electrons in gas

Assuming $\vec{E} = [0, 0, E_z]$ and $\mu = \frac{d_v}{E_z}$ we get

$$v_x = \frac{d_v}{1+(\omega\tau)^2}\left\{-\frac{\omega\tau}{B}B_y + \left(\frac{\omega\tau}{B}\right)^2 B_z B_x\right\}$$

$$v_y = \frac{d_v}{1+(\omega\tau)^2}\left\{\frac{\omega\tau}{B}B_x + \left(\frac{\omega\tau}{B}\right)^2 B_z B_y\right\}$$

$$v_z = \frac{d_v}{1+(\omega\tau)^2}\left\{1 + \left(\frac{\omega\tau}{B}\right)^2 B_z^2\right\}$$

Under Development

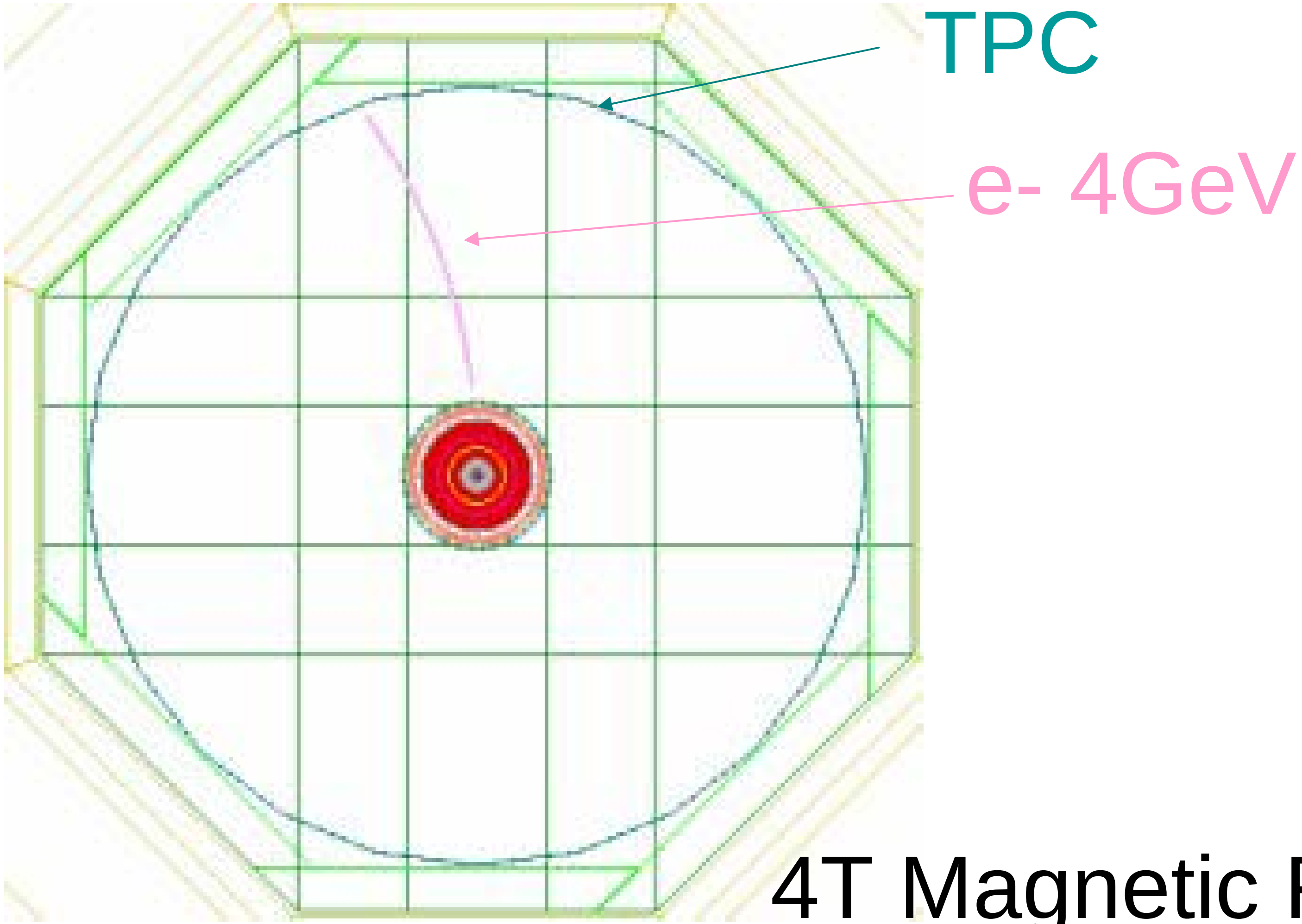
Simulation Continued…

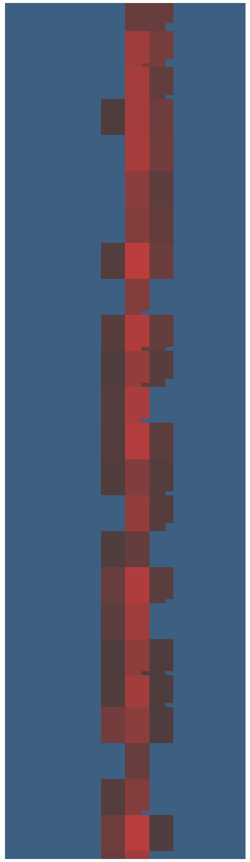
- Electron transport is done with an Euler's technique (using small steps)
- Magnetic field is created from a driver using parameters in a database
  - **FieldX00 driver can handle**
    - Ideal solenoids
    - Ideal solenoid with DID (including a kink)
    - Solenoid from a field map
    - DID from a field map
    - Ideal quadrupole field

Under Development

  - **Values for B_x, B_y, B_z are queried from Geant4**
- Final output is an LCIO file of signals on pads

Simulation Continued…





4T Magnetic Field

Reconstruction

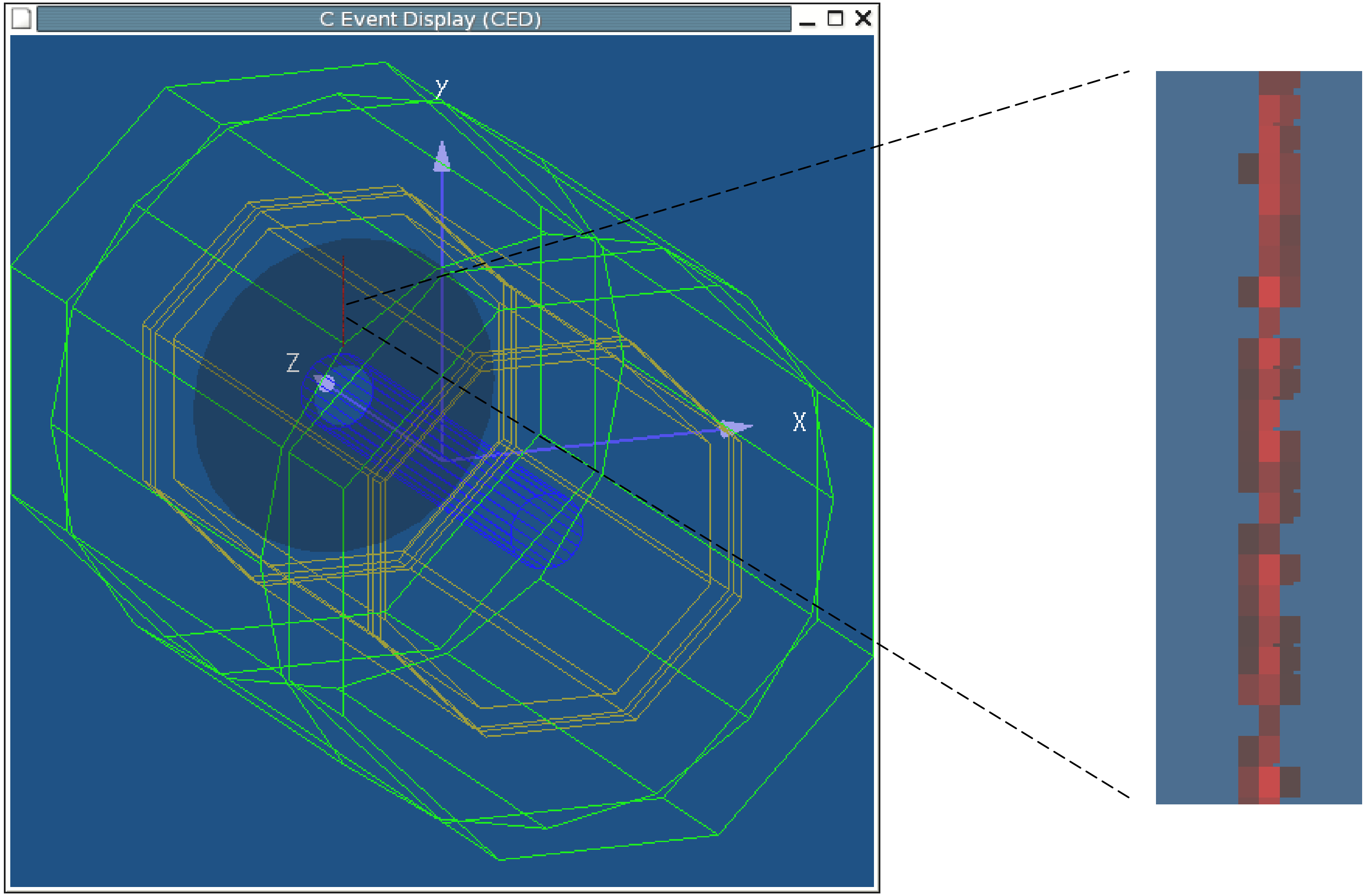
- Uses the Marlin framework
  - **Based on "processors" which acts upon and creates new sets of data**
- Modular pieces are being developed in parallel
  - **Signal calibration**
  - **Pattern recognition / Seed Track**
  - **TrackFitterLikelihood (UVic)**
- More info on TPC Marlin reconstruction framework was given in C.Hansen's talk yesterday

Reconstruction Continued…

- TrackFitterLikelihood
  - **Developed by D.Karlen**
  - **Uses parameters**
    - σ_0: base diffusion of TPC components
    - D: diffusion constant of TPC gas
    - P_{noise}: modifies how spurious signals affect likelihood
    - LCIO Track Parameters
      - Φ, Ω, $\tan(\lambda)$, d_0, z_0
  - **Assumes a line-gaussian distribution**
  - **Calculates the likelihood of observing the data given a hypothetical track**
  - **Minuit minimizes the –log likelihood**

Under Development

Reconstruction Continued…



Future Work / Goals

- Momentum Resolution study
  - **Determine a good estimate of the TPC resolution under user-defined magnetic field conditions**
- Develop methods to map the inhomogenities with data from the TPC and other sub-detectors

References / More Information

- References
  - "The drift of electrons and ions in gases or, how to design a good TPC"
    - http://www.google.com/url?sa=U&start=1&q=http://www.pd.infn.it/gruppi/g1/2002Vavra_student_lecture.pdf&e=9797
  - Adrian Vogel's Homepage
    - http://www.desy.de/~vogel/
  - 2005 Snowmass (Ron Settles)
- More Information
  - http://particle.phys.uvic.ca/~mcgeac00
    - Jabrnthy@uvic.ca
  - http://particle.phys.uvic.ca/~hansen
  - http://linearcollider.ca/Members/Karlen