HONORS 135 - Ideas in Honors - Week 7

DAQ and Analysis

Demo: Geiger counter and Bananas

Overview: High data rate, triggers. How to select a trigger. Low probability events. Show diagrams of a DAQ, but keep it simple. Talk about hardware and software triggers and processing. Then data storage and analysis. Monte Carlo, detector acceptance simulation. Show Higgs plot, explain reconstructed mass.

Class plan:

- 10min. Review material about detector methods. Detectors usually produce an electrical signal, examples.
- 20min. Geiger counter and Bananas. Explain Geiger counter detection principle.
- 10min. Discussion:
  - How do you know you detected a particle with the Geiger counter? How does the counter know?
  - If you wanted to do some science, what would you record from the counter?
- 30min Slides to cover DAQ, then Trigger.
  - DAQ - Data Acquisition. General overview: data goes into DAQ -¿ storage, if trigger.
  - Data pathway. Analog signal from detector hardware. Amplify and digitize. Digitizing has drawbacks- faster means lower resolution. Record attributes like pulse width, amplitude, and timestamp.
  - Simple example from Vandelli: thermometer-adc-computer-trigger-storage. Why do you need a trigger?
  - Triggers. Motivation: you have more data than you can record, you need to pick. A trigger selects what to ignore, and what to pass on. There are huge numbers involved: Roughly one Higgs for every 10,000,000,000 pp interactions. Only want to trigger on interesting events.

- Trigger hierarchy - low level to higher level. Low level needs to make a decision quickly, high level can reconstruct to look for important events. Examples in CMS and ATLAS. Some triggers are hardware, complex ones are software. Blurry picture analogy.
- Pileup: On average, you have a 25 nanosec between collisions, so particles from an old collision are STILL in detector when new collision happens. Show picture of event (Dahmes, 318526 31). Ways to determine which particles come from which vertex, requires incredibly precise tracking.
- Busy logic: trigger only acknowledged when electronics not busy. Downtime is important design concern.
- Actual DAQ hardware example: Muon system. Mezzanine, CSM, Readout Buffer, computer.
- Data storage: huge amounts of data, stored in magnetic tape and on hard drives.
- Once data is stored, problem of distributing it around the world. It's a nontrivial task. The WWW, and the Grid. 300 trillion collisions. 25 petabytes per year in 2012. 1PB is 13 years of HD video. ATLAS alone collects about a TBit/sec
- Analysis: now you have access to data, what next? You need to reconstruct the tracks of particles from a series of hits in detector. Mostly see secondary particles, look for vertex and reconstruct mass of original particle. Make histogram of masses, get mass peak around a certain value. See Higgs discovery histogram, the bread and butter of particle discovery. Show J/psi peak.
- Final note on Monte Carlo. Sometimes, useful to predict expectation: detector design, acceptance simulation, predict fraction of missed particles. You take an event generator, and simulate many events trough the detector. Use same reconstruction software and look at results. Monte Carlo is repeated, randomized simulations.

References:

- Bryan Dahmes: http://indico.cern.ch/event/318526/
- Bryan Dahmes: http://indico.cern.ch/event/318528/
- Wainer Vandelli: http://indico.cern.ch/event/318370/material/slides/0.pdf
- Wainer Vandelli: http://indico.cern.ch/event/318373/material/slides/0.pdf