Detector System Requirements for TDAQ session

IDEA drift chamber

F. Grancagnolo
INFN – Lecce

Data Transfer issues:
IDEA DCH at Z-pole - Example

Running conditions

- **91 GeV** c.m. energy
- **200 KHz** trigger rate
  - **100 KHz** Z decays
  - **30 KHz** $\gamma\gamma \rightarrow$ hadrons
  - **50 KHz** Bhabha
  - **20 KHz** beam backgrounds

DCH operating conditions

- drift cells: **56,000** , layers: **112**
- max drift time (≈1 cm): **400 ns**
- cluster density: **20/cm**
- gas gain: **6×10^5**
- single e^- p.h.: **6 mV**
- r.m.s. electronics noise: **1 mV**
- e^- threshold: **2 mV**; rise time **1 ns**
- signal digitization:
  12 bits at 2×10^9 bytes/s

"full signal spectrum" data transfer

- **Z decays:**
  10^5 events/s × 20 tracks/event × 130 cells/track × 4×10^{-7} s × 2×10^9 Bytes/cell/s ≅ **200 GB/s**
- **γγ → hadrons:**
  3×10^4 events/s × 10 tracks/event × 130 cells/track × 4×10^{-7} s × 2×10^9 Bytes/cell/s ≅ **30 GB/s**
- **Bhabha:**
  5×10^4 events/s × 2 tracks/event × 0 cells/track × 4×10^{-7} s × 2×10^9 Bytes/cell/s ≅ **0 GB/s**
- **Beam noise** (assume 2.5% occupancy):
  2×10^4 events/s × 1.5×10^3 cells/event × 4×10^{-7} s × 2×10^9 Bytes/cell/s ≅ **25 GB/s**
- **Isolated peaks** (assume 2.5% occupancy):
  2×10^5 events/s × 1.5×10^3 cells/event × 4×10^{-7} s × 2×10^9 Bytes/cell/s ≅ **250 GB/s**

Transferring all digitized data (reading both ends of wires):

≥ 1 TB/s

A proposed solution for data reduction

The solution consists in transferring, for each hit drift cell only the minimal information relevant to the application of the cluster timing/ counting techniques, i.e. **the amplitude** and **the arrival time of** each peak associated with **each individual ionisation electron**, instead of the **full spectrum of the signal**.

This is accomplished with a fast readout algorithm (**CluTim**) - which identifies in the digitized drift chamber signals the individual ionization peaks and records their time and amplitude - implemented on a **FPGA** for the real time parallel pre-processing of the data generated by the drift chamber and successively digitized by a 12-bit monolithic **pipeline sampling ADC** at conversion rates of up to **2.0 GSPS**.

CluTim data transfer

- **Z decays:**
  10^5 events/s × 20 tracks/event × 130 cells/track × 50 peaks/cell × 2 Bytes/peak ≅ **25 GB/s**
- **γγ → hadrons:**
  3×10^4 events/s × 10 tracks/event × 130 cells/track × 50 peaks/cell × 2 Bytes/peak ≅ **4 GB/s**
- **Bhabha:**
  5×10^4 events/s × 2 tracks/event × 0 cells/track × 50 peaks/cell × 2 Bytes/peak ≅ **0 GB/s**
- **Beam noise** (assume 2.5% occupancy):
  2×10^4 events/s × 1.5×10^3 cells/event × a few peaks/cell × 2 Bytes/peak ≅ **0 GB/s**
- **Isolated peaks** (assume 2.5% occupancy):
  2×10^5 events/s × 1.5×10^3 cells/event × a few peaks/cell × 2 Bytes/peak ≅ **0 GB/s**

Transferring only time and amplitude of each electron peak (reading both ends of wires):

≈ 60 GB/s