Upgrading the SHINE Local TPC Data Acquisition System

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Figure: Left: Phase diagram of strongly interacting matter. Right: Coverage of past (and future) data taking runs.
Motivation for open charm measurements:

1. What is the mechanism of open charm production?
2. How does the onset of deconfinement impact open charm production?
3. How does the formation of quark-gluon plasma impact $J/\Psi$ production?
Feasibility of Open Charm Measurements

SHINE has already confirmed its ability to measure $D^0$ mesons (31% of open charm production) after installation of prototype vertex detector.

After 2020 upgrades, SHINE expects to be able to measure all popular $c$ and $\bar{c}$ carriers.

Figure: $D^0$ peak measured by SHINE

$\sigma_{D^0}=14.6 \pm 3.2$ MeV
yield = 62 ± 19

NA61/SHINE performance
NA61/SHINE 2020 Upgrade

Construction of Vertex Detector (VD) for $D^0$, $\bar{D}^0$ decay reconstruction

Replacement of the TPC read-out electronics to increase data rate to 1 kHz

New trigger and data acquisition system

New Time-of-Flight detectors

Upgrade of Projectile Spectator Detector

Figure: NA61/SHINE experiment schematic
Simulating the TPC DAQ

My project: to prepare a simulated data flow to the online event reconstruction system

- Set up a miniature TPC
- Take data with new readout electronics
- Develop software to feed this data to online reconstruction system
A Simulated TPC Using Cosmic Rays

- Trigger system: two layers of scintillators and photomultiplier tubes
- Detector: Low Momentum Particle Detector (miniature TPC) filled with gas mixture
- Readout electronics: 4 cards of 32 channels each
Online Event Display (particle tracks!)

Figure: Left: Pads vs. channels histogram. Right: Waveform plot of time vs. channel.
Simulated Data Flow

- **Reader**
  - Read header and total file size
  - Load everything else into buffer
  - Raw Event Object
    - Buffer of data
    - Event ID
    - Length of event

- **Queue of Raw Event Objects**

- **Decoder**
  - Read subheaders, separate data into channels, get ADC & timestamp values

- **Queue of Decoded Event Objects**
  - Data can be sent to event reconstruction software!

- **Data files (binary)**
Simulating Trigger Signals

• Need a way of simulating the pseudo-random timing of receiving events
• Distribution of randomly generated time delays given an average rate fits to an exponential decay function
• Pull time delays from this probability distribution to simulate real data taking
• Combine this software with pulses from an Arduino to create hardware trigger
Summary

• NA61 is shifting to a focus on measuring charm production at SPS energies
• This requires an increased data rate, which means new readout electronics
• In order to test event reconstruction software, I created a simulated flow of data from TPC readout electronics to the event reconstruction software
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Pictures!
Backup
Models of charm production

Predictions for $\langle c\bar{c} \rangle$ in central Pb+Pb collisions at beam momentum of 158A GeV/c differ by about two orders of magnitude.

HSD: Linnyk, Bratkovskaya, Cassing, IJMP E17 1367.
HRG, Quark Coalesc. Stat.: Gorenstein, Kostyuk, Stoecker, Greiner, PL B 509, 277.
SMES: Gazdzicki, Gorenstein, APP B30, 2705.
Charm yield as the signal of deconfinement

Phase Transition: $T_c \approx 150$ MeV

- confined matter $\rightarrow$ quark-gluon plasma
- $D\bar{D}$ mesons $\rightarrow$ (anti-)charm quarks
- $2M \approx 3.7$ GeV $\rightarrow$ $2m \approx 2.6$ GeV

Statistical Model of Early Stage

- $m_Q^c = 1.3$ GeV
- $g_{w}^c = 10$

QCD-inspired calculations
$J/\psi$ suppression as the signal of deconfinement

Medium reduces probability of $J/\psi$ production.