Simulation and Event Reconstruction
inside the PandaRoot Framework

Stefano Spataro

for the collaboration
Overview

- Introduction on Panda
- Structure of the framework
- Event generation
- Detector implementation
- Reconstruction
The Panda experiment

Multi purpose detector at FAIR

AntiProton Annihilations at Darmstadt

Physics program

- Charmonium (\(\bar{c}c\)) spectroscopy
- Open charm spectroscopy
- Search for gluonic excitations (hybrids - glueballs)
- Charmed hadrons in nuclei
- Single and double Hypernuclei
- Other options (Parton Distrib., EM Form Factor...)

\(\bar{p}p, \bar{p}A\) collisions

1.5 \(\rightarrow\) 15 GeV/c (\(\bar{p}\) momentum)
Software development in Panda

In September 2006

Panda collaboration board

Developing the code inside FairRoot project

PandaRoot

- Framework for simulation and analysis
- Based on ROOT (5.14)
- Virtual Monte-Carlo (VMC 2.0, G4 8.2)
- Working on many Linux distributions
  and with many compilers

...compiled and running on more than 10 Linux platforms

Debian 3.1
Gentoo
SUSE (9, 10.X)
Fedora (2, 4, 5)
Ubuntu
SL (3, 4)

Gcc 3.3.5
Gcc 3.4.2
Gcc 4.0.2
Gcc 4.0.3
Gcc 4.1.4
Gcc 4.1.2

see D.Bertini talk h. 16:50 here
Cross-check between different distributions

### PandaRoot Dashboard

**10. August 2007 09:59:50 CEST**

#### Nightly - 09.08.07 10:00 to 10.08.07 10:00

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<th>Test</th>
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#### Experimental - 09.08.07 10:00 to 10.08.07 10:00

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Simulation and Event Reconstruction inside the PandaRoot Framework

PandaRoot framework

- High versatility

Event Generation
- UrQmd, EvtGen, DPM...

Transport Model
- Geant3, Geant4, (Fluka)

Digitization Analysis
- Reconstruction

Detector geometries, Magnetic field,...
Event generation

Create physical events for realistic simulation

- Flat generators ➔ Uniform distributions ➔ Acceptance, Efficiency, ...
- EvtGen generator ➔ Handling of complex decay chains ➔ Resonances
- DPM generator ➔ Dual Parton Model (string fragmentation) ➔ background studies
- UrQmd interface ➔ Microscopic model for nuclear reactions ➔ \( \bar{p}A \) collisions
Detector implementation: proposed geometry
Simulation and Event Reconstruction inside the PandaRoot Framework

Stefano Spataro

Beam pipe

Shashlyk EMC

Forward drift chambers

EMC (Fwd endcup)

Muon Detector

Target pipe

TPC/STT

DIRC (Cherenkov)

Micro Vertex

view from geometry manager

COILS (dipole)

Barrel drift chambers

COILS (solenoid)

EMC (barrel/Bkw endcup)
Detector implementation: magnetic field map
Tracking: target spectrometer

DPM @ 3.6 GeV/c (10 evt)

Conformal mapping

Hough Transformation

μ⁻ @ 1 GeV/c
σₚ ~ 1.4%
Tracking: forward spectrometer ($\theta < 10^\circ$)

- Six drift chamber planes
  - Two before the magnetic field
  - Two inside the magnetic field
  - Two after the magnetic field

At the moment:

Pattern recognition:
- Principal Component Analysis

Momentum reconstruction:
- Kick parametrization (4 chambers)

Very fast algorithm (no fit)
Good prefit value for RK/Kalman

$\sigma(p) \sim 2\%$ resolution
Global Tracking

- How to have a high resolution tracking?
- How to merge different detectors?
- How to deal with field inhomogeneity?

Global tracking ⟷ Kalman Filter ⟷ genfit

Already working for TPC

Track Follower ⟷ GEANE

Use of the same geometry for simulation and track following!
Simulation and Event Reconstruction inside the PandaRoot Framework

Stefano Spataro

EMC reconstruction

Barrel (PWO)  
Forward (Shashlyk)

Full digitization and cluster recognition (common code)

Example: neutral channel in barrel

$$\bar{p}p \rightarrow h_c \rightarrow \eta_c + \gamma$$

$$\eta_c \rightarrow \pi^0 + \pi^0 + \eta$$

EvtGen (phase space)

$$\pi^0 \rightarrow \gamma + \gamma$$

$$\eta \rightarrow \gamma + \gamma$$

$$M(h_c) = 3526\text{ MeV/c}^2$$

$$P_z(\bar{p}) = 5609\text{ MeV/c}$$

7 photons in the final state
Simulation and Event Reconstruction inside the PandaRoot Framework

EMC Reconstruction

\[ \bar{p}p \rightarrow h_c \rightarrow \eta_c + \gamma \]

\[ \eta_c \rightarrow \pi^0 + \pi^0 + \eta \]

\[ \pi^0 \rightarrow \gamma + \gamma \]

\[ \eta \rightarrow \gamma + \gamma \]

\[ M(\eta_c) \] 2.98 GeV/c²

\[ M(h_c) \] 3.53 GeV/c²

\[ M(\pi^0, \eta) \] Invariant Mass

\[ M(\eta, \gamma) \] Invariant Mass

\[ 2\gamma \text{ Invariant Mass} \]
Transport Models Comparison

\[ \text{VirtualMC} \rightarrow \text{With exactly the same code Changing only one flag} \]

\[ \mu^- \text{ @ 1 GeV/c} \]

\[ \gamma \text{ @ 1 GeV/c} \]
Simulation and Event Reconstruction inside the PandaRoot Framework

Comparison: $\gamma$ @ 1GeV in EMC

G4 9.0 - EmStandard+EmExtra

Fired crystals multiplicity

lists/cuts tuning

comparison with bench tests

Deposited energy (MC)

Reconstructed energy (clusters)

3MeV threshold per pad
Next goal: PID

Match tracks with PID detectors
Summary

PandaRoot is now the framework for the Panda full simulation

Features:
- Supported and maintained for many Linux/compiler versions
- Several event generators for different physics studies
- Virtual MonteCarlo -> comparison Geant3, Geant4 (Fluka)

Implementations (after one year):
- Spectrometer geometry almost complete
- Full reconstruction for many detectors (EMC, STT, TPC, MVD)
- Global tracking: ongoing (Kalman + GEANE)

To-do list:
- Complete global tracking
- Construct the Particle Identification information