Forward Preshower Software and Studies

Dennis Shpakov

DØPAM General Meeting

September 30, 1999
Outline:

1. Introduction: Physics Motivation for the Forward Preshower
2. Hierarchy of the FPS Offline Software
3. FPS Geometry Description
4. Event Reconstruction in the Forward Preshower
5. Monte Carlo Studies
6. Detector and Event Display
7. Conclusion: Current Status and Future Plans
Physics Motivation

Trigger efficiency and rejection:

- High $p_T$ electron.
- High $p_T$ photon.
- Low $p_T$ electron.

Offline:

- EM energy resolution.
- EM cluster position reconstruction.
- EM cluster shape reconstruction.
- Identification of electrons inside jets.
1. **High $p_T$ Electron:**
   - $W \rightarrow e\nu$ and $Z \rightarrow e^+e^-$ events,
   - $t\bar{t} \rightarrow e + \text{jets},$
   - SUSY electrons — $W_1Z_2 \rightarrow eee,$
   - multi–boson production.

2. **High $p_T$ Photon:**
   - $W + \gamma$ events,
   - jet + $\gamma$ events.

3. **Low $p_T$ Electron:**
   - $J/\psi$ production physics:
     - $B$-physics (CP violation from $B^0 \rightarrow J/\psi K^0_s,$ $B$ meson lifetime, $B_c$ spectroscopy),
     - energy calibration of the EM calorimeter with $J\psi \rightarrow e^+e^-.$
   - soft electron tagging (semileptonic $B$ decays).
50 GeV $p_T$ Electron in the FPS
50 GeV $p_T \pi^0$ in the FPS:
General Hierarchy of the FPS Software Packages

Low Level Packages:

**fps_address**
Contains utility classes identifying detector modules, individual channels, and collections of channels (clusters).

**fps_event**
Organizes persistent FPS data into container classes.

**fps_unpdata**
Handles the FPS part of the unpacked data chunk
Higher Level Packages:

**fps\_geometry**
Provides alignment interface, strip position information for \((u, v) \rightarrow (x, y, z)\) conversion, and material information for the multiple scattering

**fps\_reco**
Channel and position cluster reconstruction package

**fps\_analyze**
FPS analysis and Monte Carlo vs. reco comparison package

**fps\_display**
FPS portion of the DØRun II event display
**FPS Geometry**

Standard DØ Run II tree structure of reference points:

- Each wedge holds a $u$ and $v$ sublayer of strips.
- Positions of strips are calculated once per run and are updated automatically should the base geometry change.
Event Reconstruction Procedure

1. In each sublayer of each wedge contiguous strips with energies over a threshold are combined into channel clusters.

2. For each crossing of a channel cluster in sublayer $u$ with energy over a threshold with one in sublayer $v$ a reconstructed cluster candidate is created:

   - Weighted average over strips:

     $$ \mathbf{r}^{1, 2} = \frac{1}{N-1} \sum_{i=0}^{N-1} \frac{E_i \mathbf{r}_i^{1, 2}}{\sum_{i=0}^{N-1} E_i}.$$
• Intersection point:

\[
R^\text{hit} = (r_u^1 \times r_u^2) \times (r_v^1 \times r_v^2),
\]

\[
r^\text{hit} = \frac{r_{\text{inner}} + r_{\text{outer}} R^\text{hit}}{2|R^\text{hit}|}.
\]

\[u \text{ strip}\]

\[v \text{ strip}\]

3. Candidates are inversely ordered by the \(u-v\) energy correlation parameter:

\[
C_{uv} = 1 - \frac{|E_u - E_v|}{E_u + E_v}
\]

and top \(N\) (depending on the algorithm) are kept.

4. Reconstructed clusters on each side of the detector within a \((\theta, \phi)\) window are combined into 3-D clusters.
Single Muon Cluster Shapes

MIP layers:

Shower layers:
Single Electron Cluster Shapes

MIP layers:

Shower layers:
Reconstructed vs. MC $\theta$ Position for Single Muons

MIP Layers: $\sigma = 2.1 \text{ mrad}$

Shower Layers: $\sigma = 1.8 \text{ mrad}$
Reconstructed vs. MC $\phi$ Position for Single Muons

MIP Layers: $\sigma = 24\text{mrad}$

Shower Layers: $\sigma = 24\text{mrad}$
Reconstructed vs. MC $\theta$ Position for Single Electrons

MIP Layers: $\sigma = 5.0\text{mrad}$

Shower Layers: $\sigma = 3.3\text{mrad}$
Reconstructed vs. MC φ Position for Single Electrons

MIP Layers: $\sigma = 38\text{mrad}$

Shower Layers: $\sigma = 31\text{mrad}$
Occupancy for QCD Events

Entries: 24047
Mean: 52.21
RMS: 36.26
Energy In Reconstructed Clusters vs. Energy in Strips for 50 GeV Muons

**MIP Layers:**

**Shower Layers:**
Energy In Reconstructed Clusters vs. Energy in Strips for 50 GeV Electrons

MIP Layers:

Shower Layers:
FPS Detector Display

Large Module:

One Side of the Detector:
FPS Event Display

A 50 GeV Electron in the FPS:
Conclusion: Current Activities and Future Plans

1. Ghost removal algorithms are under study (use of $u - v$ energy correlation, “backward” reconstruction starting from EC clusters, etc.).

2. Offline FPS calibration system development started.

3. FPS event display is being integrated into the global DØ Run II event display, “details” mechanism, porting to Linux.

4. Fixes to geometry (“special” module implementation, proper shape of upper module edge).

5. Reco code optimization and cleanup (LinkIndex mechanism, etc.).

6. Physics to hardware address mapping.