Outline:

● Overview
  ➢ Upgrade objectives and the role of the scintillation counters

● The Run I counters
  ➢ Characteristics, performance and problems

● Filling the holes and extending the coverage: New counters
  ➢ Design and performance

● Refurbishing old counters
  ➢ Method and results
Muon Upgrade objectives

- Trigger on muons at increased luminosity (\(>10^{32}\)) and shorter bunch crossings (396 ns, 132 ns)
- Increase coverage

RUN I

- CMU
  - Coverage: 0\(<\eta\)<0.6
  - Drift time: 800 ns

- CMP/CSP
  - Coverage: 0\(<\eta\)<0.6
  - Drift time: 1.4 \(\mu\)s

RUN II

- CMX/CSX
  - Coverage: 0.6\(<\eta\)<1
  - Drift time: 1.4 \(\mu\)s

- BMU/BSU
  - Coverage: 1\(<\eta\)<1.5
  - Drift time: 800 ns

Aug. 20th, 2000
The muon trigger

scintillation cts. serve to “time stamp” and/or reduce uncorrelated b.g. at level 1
Muon Upgrade subdetectors

Central Muon eXtension (CSX + CMX)

Intermediate Muon BMU + BSU + TSU (new)

Central Muon uPgrade (CSP + CMP) (new) (old)

Central Muon chambers

“miniskirt” (new) lower 90°
Old counter design

PVT - base scintillator (NE114)

CSPs

EMI 9815 PMT

3 m long

2 cm thick

CSX “minskirt counter”

Aug. 20th, 2000

~ 2 m

CSX “arch” counters

~ 2 m
New counter design

Scintillator: UPS-923A from Monokristal, Kharkov, Ukraine. Polystyrene doped with PTP(2%) and POPOP(0.03%)

Wls fiber: double-clad Y11 fiber from Kuraray fiber “mirrored at far end.

Hamamatsu H5783 photomultiplier + Cockroft - Walton base

<table>
<thead>
<tr>
<th>Ctr. type</th>
<th>number</th>
<th>dimensions</th>
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<tbody>
<tr>
<td>CSP</td>
<td>150</td>
<td>320 cm x 30.5 cm x 2 cm</td>
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<tr>
<td>BSU</td>
<td>432</td>
<td>164 cm x 17 cm x 1.5 cm</td>
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Figure 1. The counter design.
Counter readout

Aug. 20th, 2000
New counter assembly
Counter output calibration

Each counter output is calibrated in absolute terms (number of photoelectrons/ADC channel) by exposing it to low-level pulsed light (~1 p.e./pulse) and locating the centroid single p.e. distribution.

Aug. 20th, 2000
Counter response (in photoelectrons) to cosmic muons is measured in steps of ~20 cm and the results are fitted to extract counter characteristics.

Measurements are automated (4 ctrs at a time).

$$n_{pe}(x) = n_0(\exp(-x/l) + r \cdot \exp(-(2L-x)/l))$$

From the fit, one extracts:

- $n_0$ (zero extrapolation)
- $r$ (reflection coefficient of fiber mirrors)

keeping known fiber attenuation constant at 3 m.
Counter parameters
and test results using cosmic muons

<table>
<thead>
<tr>
<th>L3 counter</th>
<th>$n_{pe}$ at 315 cm</th>
<th>PMT s/n</th>
<th>gain at 800 v E-05</th>
<th>gain at 950 v E+05</th>
<th>Attenuation measurement</th>
<th>LED AMPL at PLATEAU</th>
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<tr>
<td></td>
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<td>$n_0$</td>
<td>$n_{end}$</td>
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<td>85</td>
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<td>6.20</td>
<td>4.65</td>
<td>3.40</td>
<td>35.1</td>
</tr>
</tbody>
</table>

Fermi VS Dubna NPE

CSP Test Results

Aug. 20th, 2000
Problems with “Old” counters: efficiencies were lower than expected

CSP efficiencies

- We used muons ($E_T > 8$ GeV) from $Z \rightarrow \mu\mu$ data sample
- The overall efficiency of the system in Run1 is $88.2 \pm 3\%$.
- If we remove the non-working counters: $91.8\%$
- Removing the gaps space between the counters increase by $1.8\%$ the total efficiency.
- The occupancies for the north wall is $0.77 \pm 0.01\%$ events per channel, south wall is $0.85 \pm 0.01\%$ events per channel.

CSX efficiencies

time dependence evident

Aug. 20th, 2000
Attenuation - length for good and bad counters

Response to cosmic muons confirms degradation in attenuation-length and reveals a corresponding degradation in light yield.
We unwrap some counters

Most of the counters display pronounced aging effects

Good NE114

Bad NE114
Old Counter refurbishment:
wls fiber ribbon added to one side and routed to existing pmt
CSP Repair: Work at Lab 5
Distributions of fixed counter outputs

Average npe = 16 p.e.  
Average npe = 58 p.e.
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