Test on 2,000 Photomultipliers for the CDF Endplug Calorimeter Upgrade

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for

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Talk Outline

- ❏ **Physics Requirements**
- ❏ **Phototube Specifications**
- ❏ **Test Procedure**
- ❏ **Test Setup**
- ❏ **Measurements and Results**
- ❏ **Conclusions**

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Physics Requirements

- E_{cm} = 2 TeV
- $\mathcal{L} = 2 \text{ x}10^{32} \text{ s}^{-1}\text{cm}^{-2}$
- Integrated ($\mathcal{L}$) = $2\ fb^{-1}$

1. Maximum Energy deposited into a single tower:

	Max Energy per tower (GeV)	Peak Current (mA)	Nom. Gain
EM	770	55	25K
HAD	600	35	250K

2. Maximum Energy flow per tower (~DC background): ~1μA

3. Maximum Total integrated energy deposit per tower: 10 C

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Phototube Specifications

- Good Quantum Efficiency at 480nm (**>12%**) (Y11)
- Photocathode Uniformity > 80%
- Gain range : 10^4 to 10^6
- **spread of Voltages (G =1 0^6) < 20%**
- **Linear Response up to 70 mA Peak Current at G = 500K**
- **low Dark Current (< 5 nA at G = 500K)**
- **Drift of response with time < 6% in 48 hr**
- **Shift of response with ΔI_{BG}= 1μA less than 5%**
- low Temperature dependence
- low Spontaneous Pulse Rate
- Small size

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Data from HAMAMATSU

- Voltage for a G = 500K
- Dark Current at G = 500K
- Cathode Blue (Lum.) Sensitivity

Test Procedure :

"Initial Test"

(at FNAL)

2085

- "Conditioning" (2μA for 48hr at G=500K)
- Gain - Voltage curve
- Dark Current

"Full Test"

(FNAL or Bologna)

1279 806

- Gain - Voltage curve
- Dark Current
- Linearity (at 4 Gains)
- Stability in Time
- Stability with BackGround Current
- Relative **Q. E.** (10% of tubes)

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Conclusions

- We have made extensive measurements on 2085 (Hamamatsu R4125) phototubes for the CDF Endplug Calorimeter: 960 (EM), 846 (HAD)
- We have measured the following properties:
  - Gain vs Voltage
  - Dark Current
  - Linearity
  - Stability vs Time
  - Stability vs background Current
- Some of the properties were measured twice for each phototube
- Measurements taken at three test sites (Hamamatsu, Bologna, Fermilab) are well correlated
- The phototubes show little variation in major properties with manufacturing date
- The Dark Current tends to decrease over time
- 7.5 % (156) of the phototubes failed at least one of our selection criteria
- The phototubes that pass all tests have properties that tipically are well within our specified limits

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