



# **EMTiming and Searching for New Physics**

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**for the EMTiming group**

**January 2004**

**CDF Collaboration Meeting**

# Outline

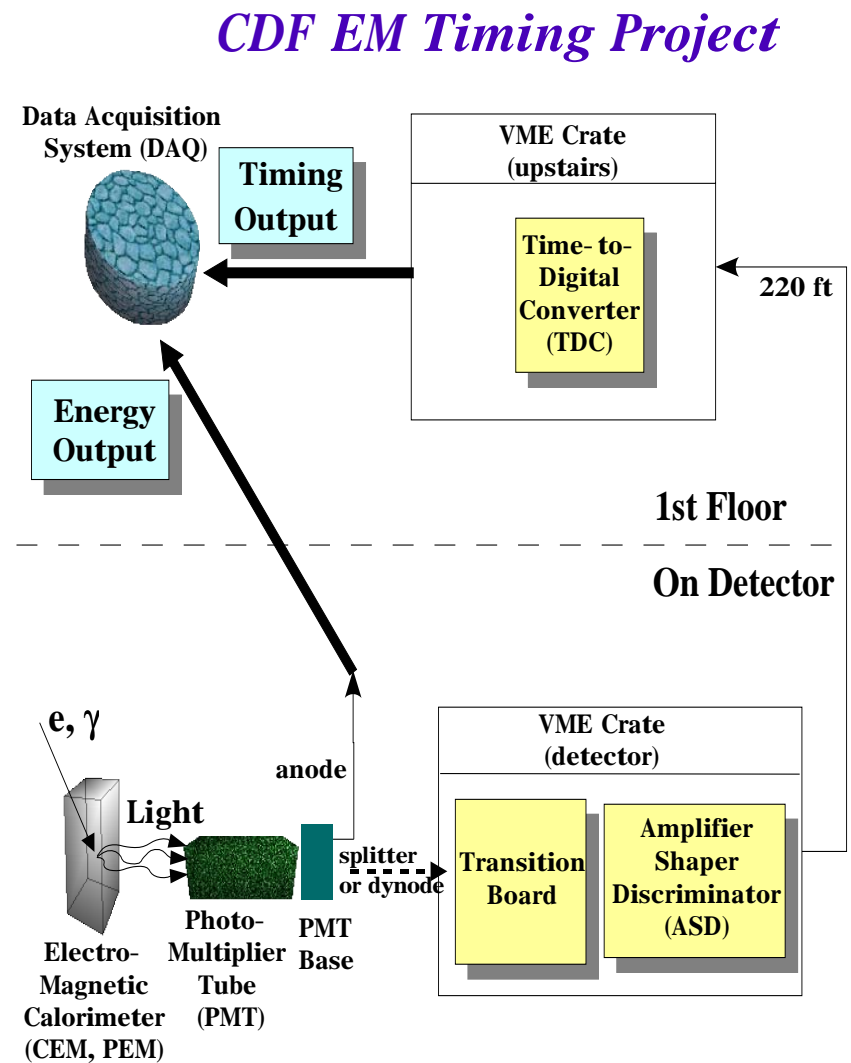
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- **Physics motivation**
  - Analyses EMTiming can help now
- **Overview of the system**
- **Preliminary performance results**
- **A new possibility: Searching for long lived-particles which decay to photons**

*[hepr8.physics.tamu.edu/hep/emtiming/](http://hepr8.physics.tamu.edu/hep/emtiming/)*

# EMTiming Overview

- The EMTiming system gives the time of arrival of energy which is deposited in a tower in the CEM or PEM
- **Hardware virtually identical to existing HADTDC system**
- In the past, the HADTDC system has effectively indicated the presence of non-beam related energy which causes MET e.g. cosmics.



# How does EMTiming help?

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**HADTDC can help if objects in the event are likely to be from the collision. But:**

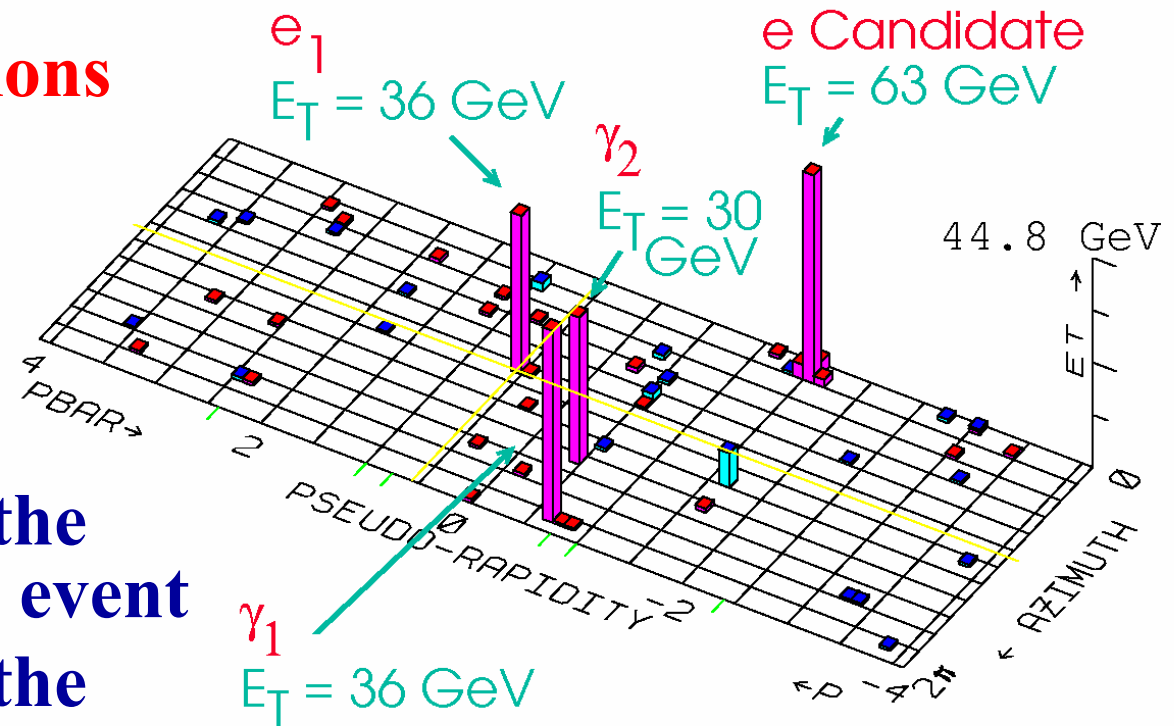
- **What if there is lots of “non-collision energy” deposited in the CEM/PEM and very little/none in the CHA/WHA/PHA?**
- **Timing resolution is much worse around threshold (larger widths, long tails)**
- **Photons leave no HAD energy, or energy around threshold → Poor or no timing handle, fake Met hard to reject**

# Models with large EM energy

Types of high  $P_T$  physics with photons and/or MET

- SUSY ( $N_2 \rightarrow \gamma N_1$ , light gravitinos)
- Large Extra Dimensions
- Excited leptons
- New dynamics
- $V + \text{Higgs} \rightarrow V + \gamma\gamma$
- $W/Z + \gamma$  production
- Whatever produced the  $e\gamma\gamma + \text{MET}$  candidate event
- Whatever produced the CDF  $\mu\gamma + \text{Met}$  excess

$e\gamma\gamma\cancel{E}_T$  Candidate Event



Standard Model background  
estimate of  $10^{-6}$

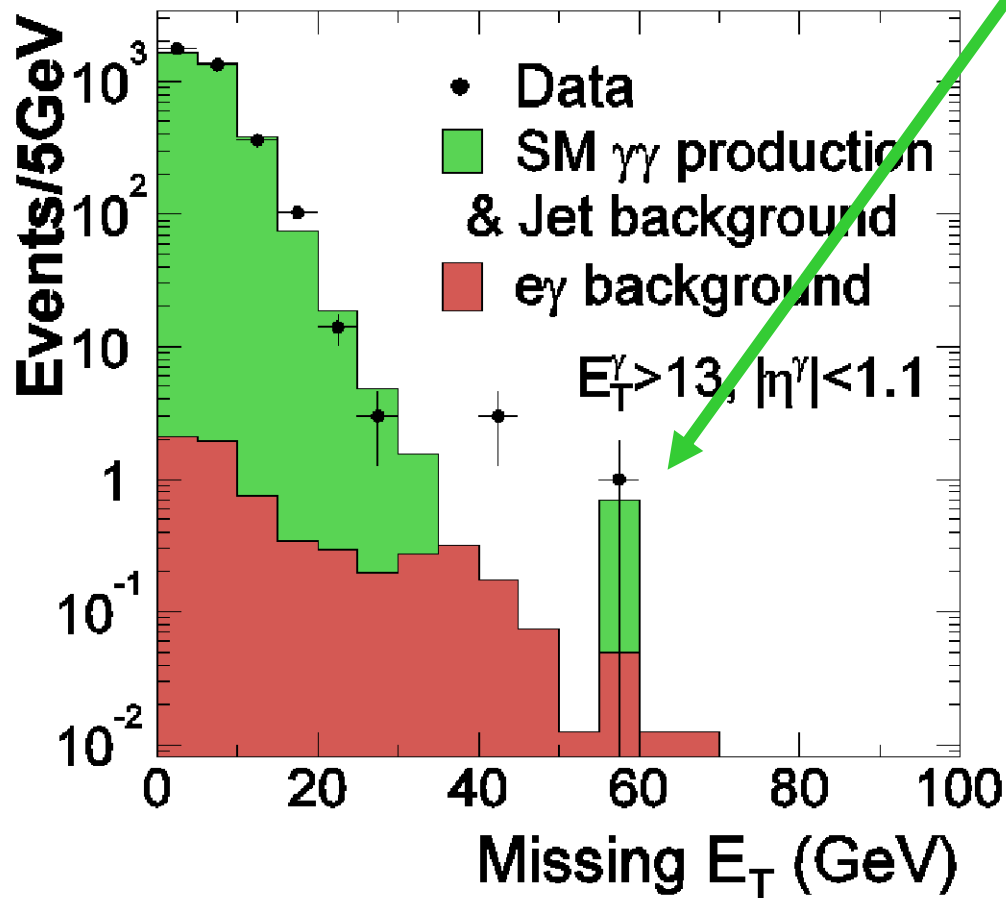
# Run I Example: $e\bar{e}\gamma + \text{Met}$ event

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- **In Run I: Expected  $\sim 1.4$  of the 4 EM objects in the  $e\bar{e}\gamma + \text{Met}$  candidate to have HAD timing. Only 2 did (both were in time)**
- **In Run II without EMTiming: Only  $\sim 5\%$  of  $e\bar{e}\gamma + \text{Met}$  events would have HAD timing for all objects.**

**EMTiming is  $\sim 100\%$  Efficient  
Timing Resolution is Optimized at Large Energy**

# Run II: Diphoton +Met analysis



This event has one tower ( $E=1.5$  GeV) “near the photon” which is 85 ns out of time. No timing info for 75 & 14 GeV photons.

**Can't tell if photons are in time, can't tell if Met is reliable**

**We will reject this event, based on the small, poorly measured HAD energy rather than the well measured dominant part of the event**

# Motivation Summary

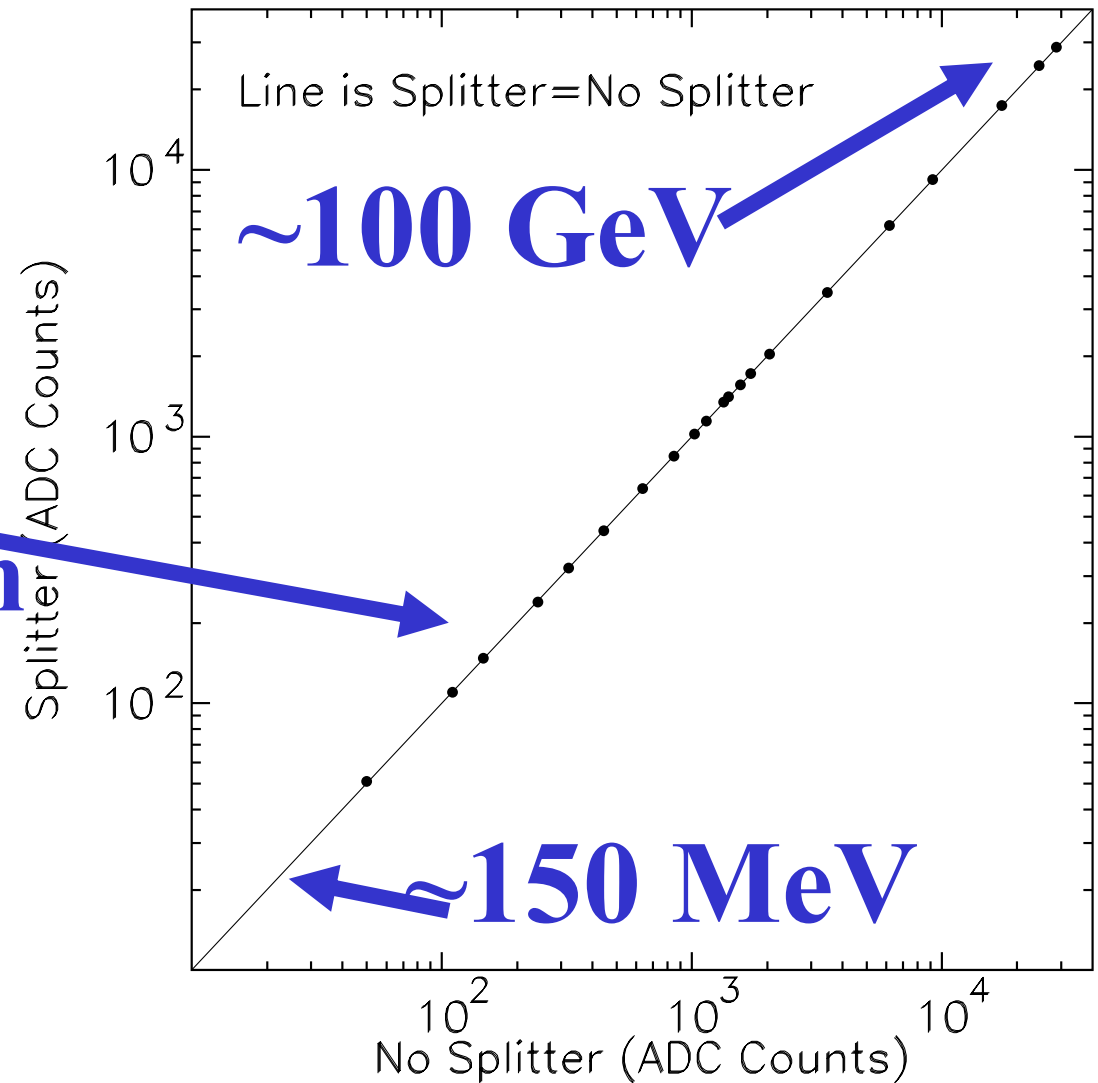
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1. **Photon handle**: Would provide a vitally important handle that could confirm or deny that all the photons in unusual events (e.g.  $e e \gamma + \text{Met}$  candidate event) are from the primary collision.
2. **Met handle**: For events with large EM energy, full calorimeter coverage reduces the cosmic ray and beam halo background sources and improves the sensitivity for high- $P_T$  physics such as SUSY, LED, Anomalous Couplings etc.



# System Design Completed and Tested

- **Lots of testing prior to installation**
- **No measured adverse effect on current system**
- **Production completed in Fall 2003**



# Current EMTiming Coverage

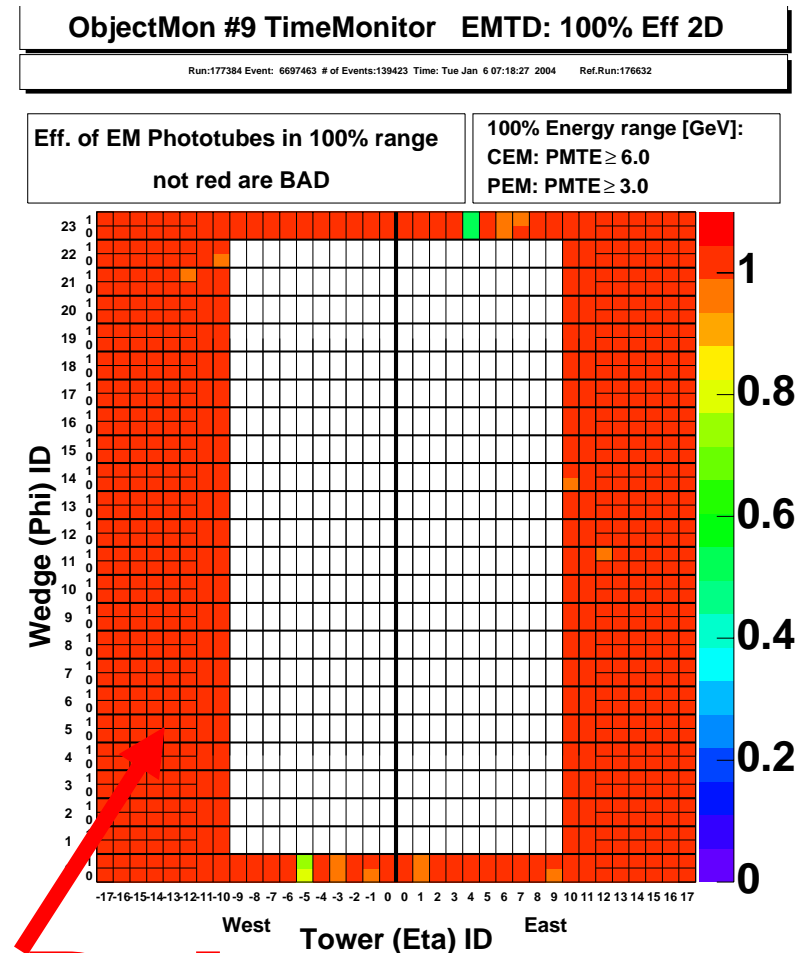
**Partial installation  
completed Fall 2003\***

**EMTiming now covers:**

- **Entire PEM**
- **Wedges 0 and 23 in the CEM**

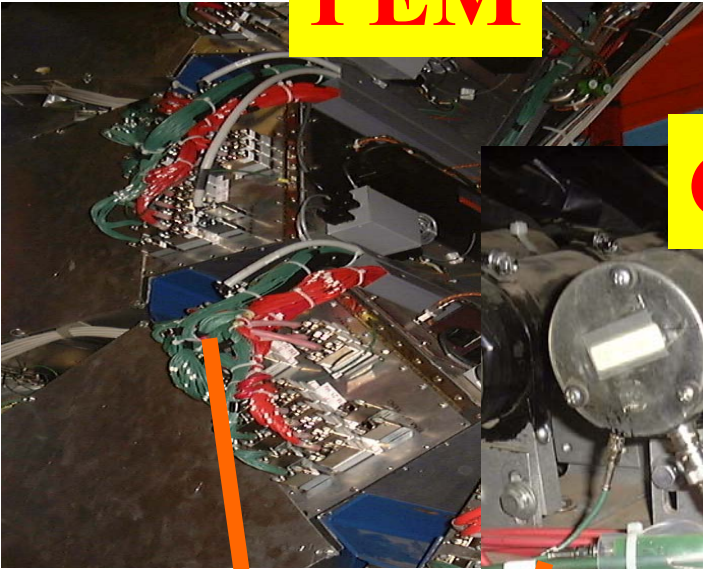
**The rest is ready to be installed in 2004**

\*Max G, Slava, Lew, Jamie, Dervin, Peter W., Vadim and D.T.



**Red towers are  
fully functional**

**PEM**



# Pictures

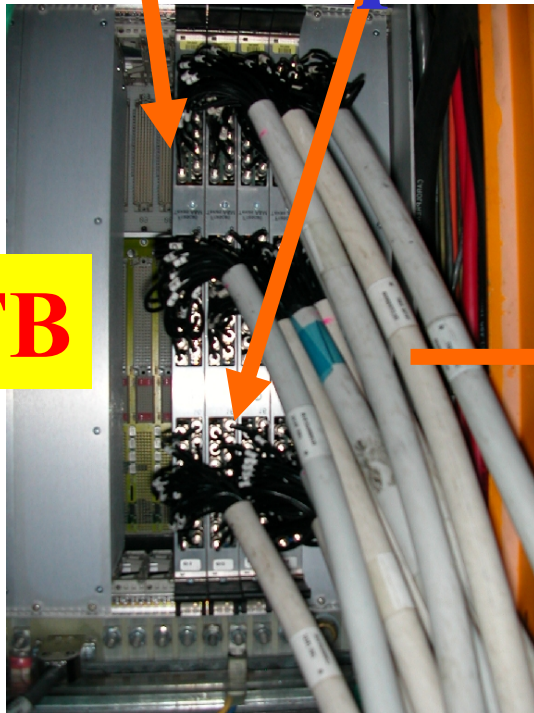
**CEM**



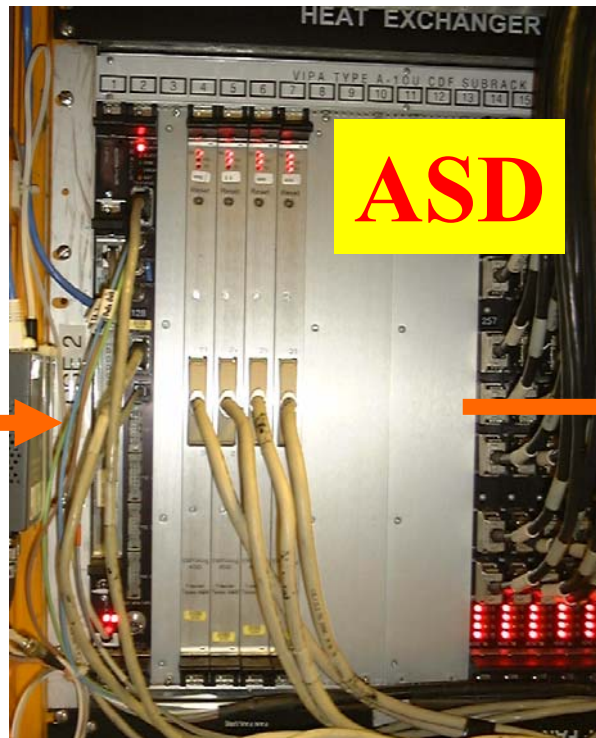
**Teststand**

**Readout path**

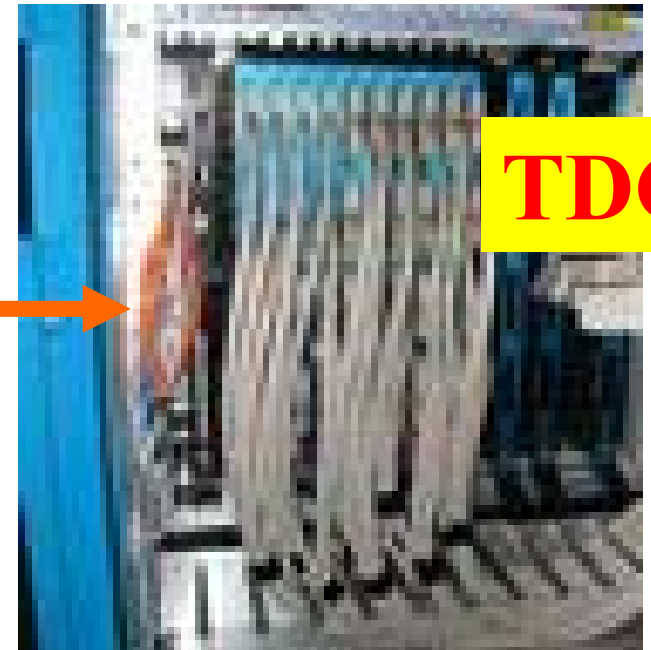
**TB**



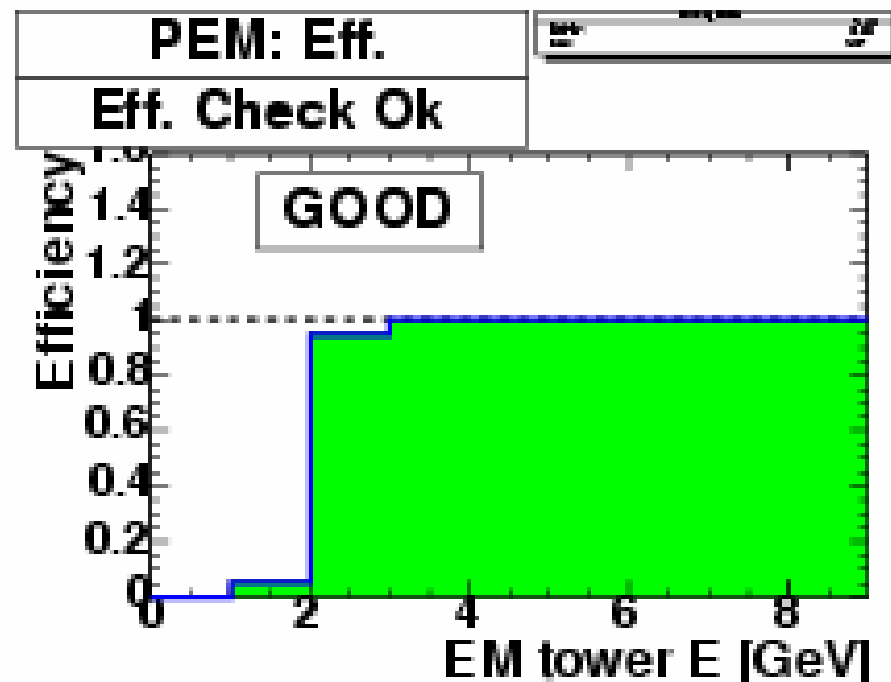
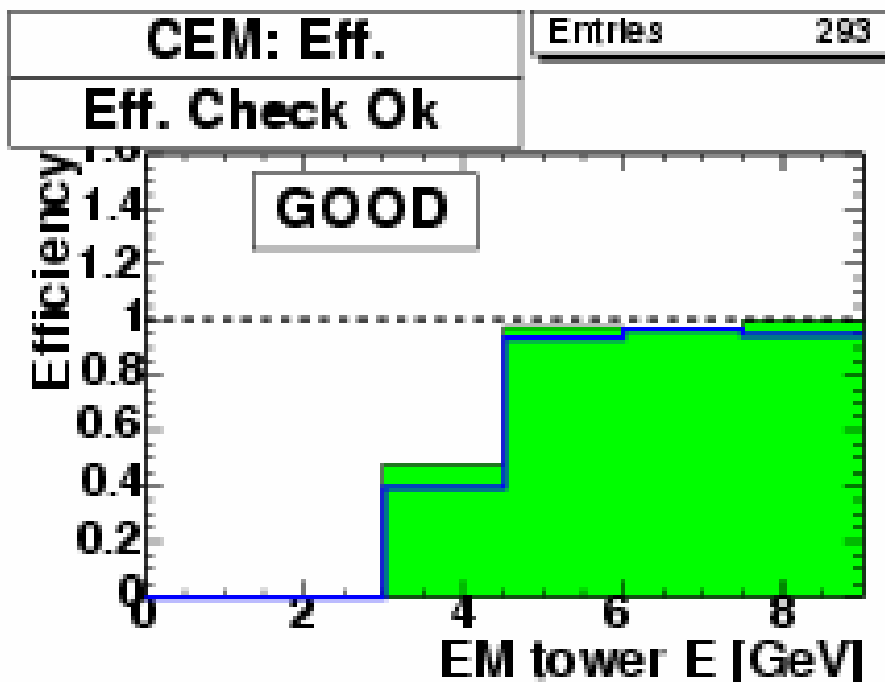
**ASD**



**TDC**



# EMTiming Efficiency from Data



**CEM:  $E^* > \sim 5$  GeV**

**PEM:  $E^* > \sim 2$  GeV**

**For fully instrumented towers we become fully efficient for all useful photon energies**

**\*Energy not  $E_T$  Negligible fake rates**

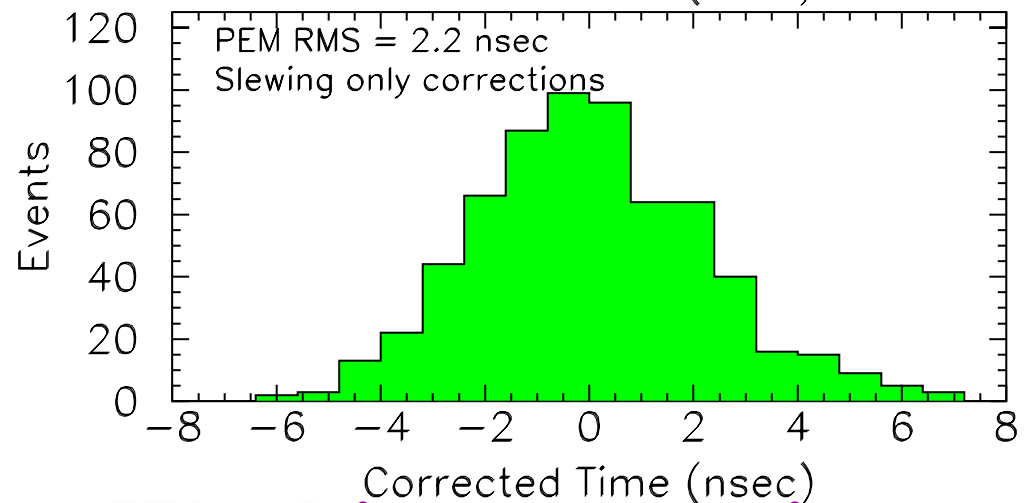
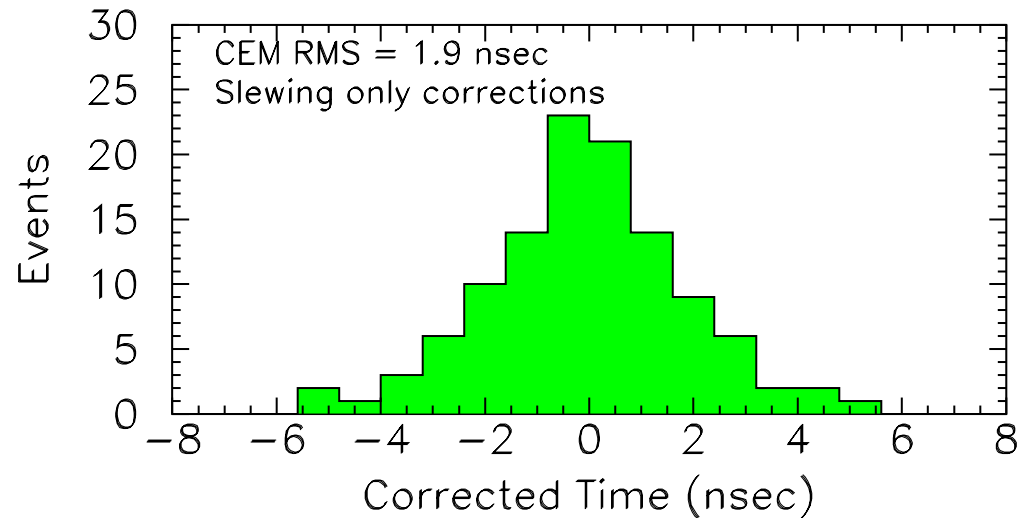
# Preliminary Timing Resolution Results

- **Have only done Energy Slewing corrections so far**
- **Working on  $t_0$  and  $Z_0$  correction**

Summing over all energies:

$$\sigma_{\text{CEM}} = 1.9 \text{ nsec}$$

$$\sigma_{\text{PEM}} = 2.2 \text{ nsec}$$

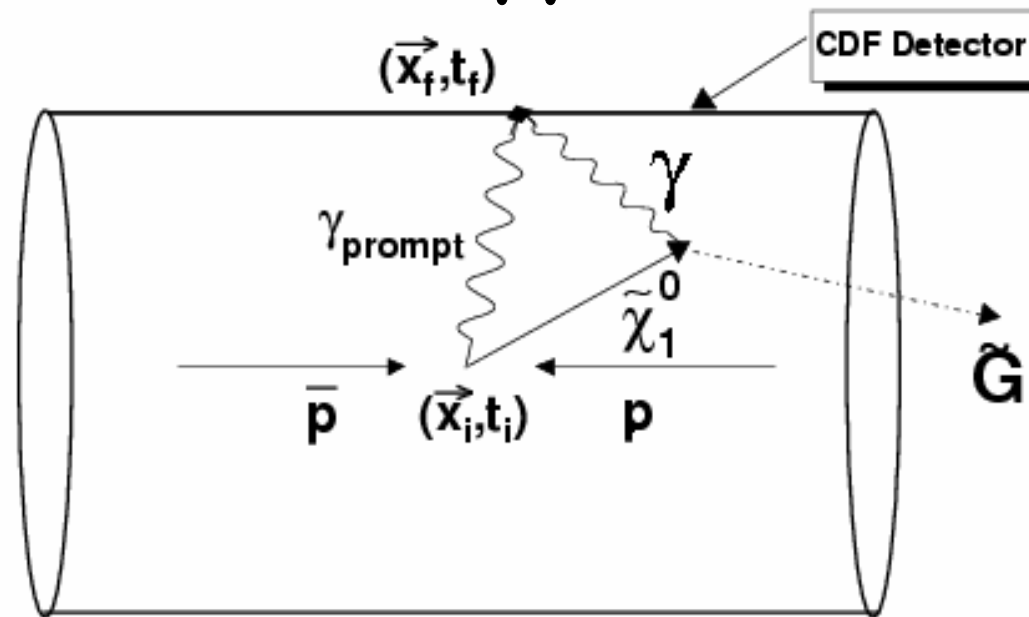


Working on getting calibrations into database



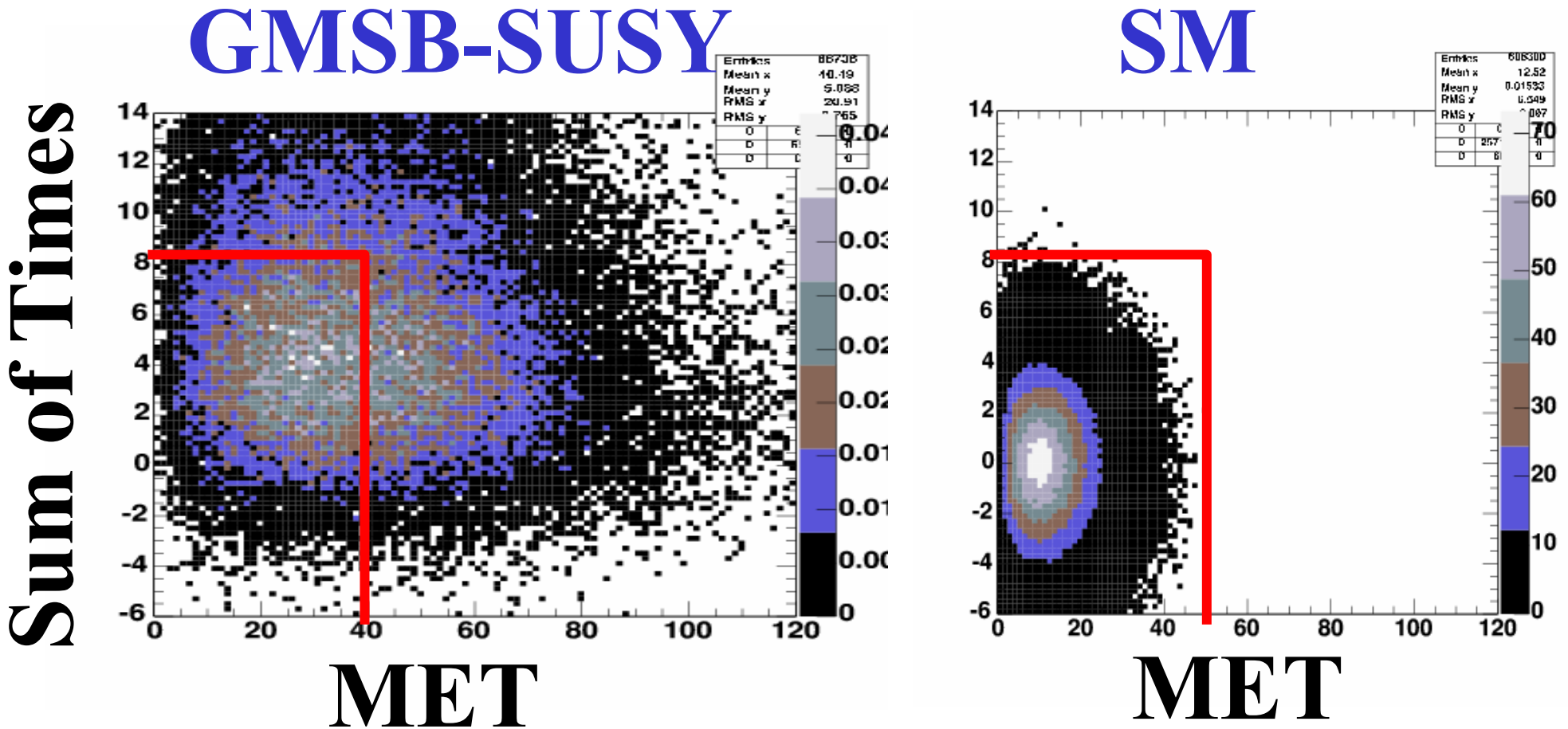
# Search for Long-Lived Particles?

- **GMSB-SUSY predicts  $N_1 \rightarrow \gamma G$  with nsec lifetimes**
- **Most sensitive in  $\gamma\gamma + \text{Met}$  channel\***



\*Peter Wagner & D.T.

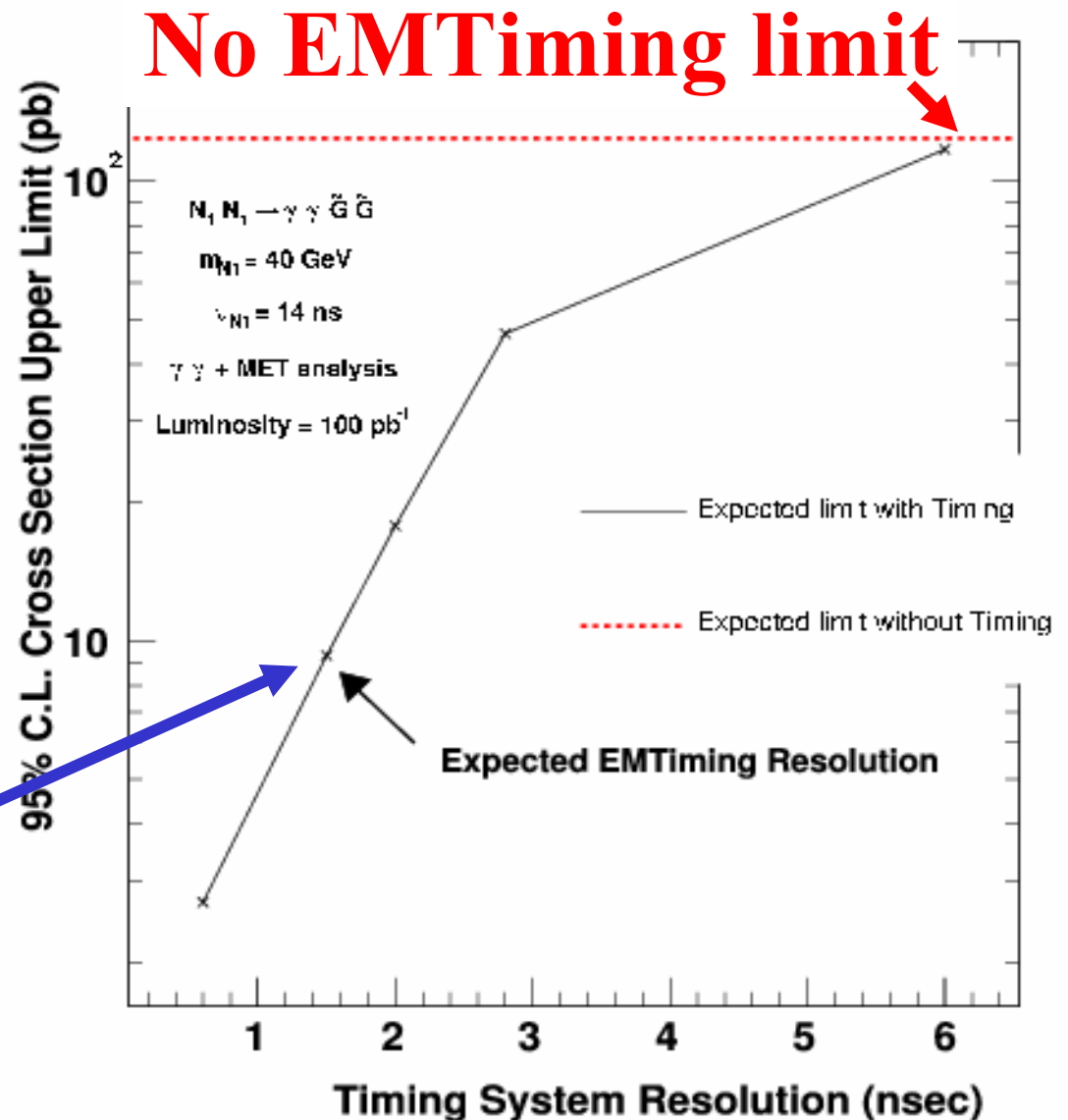
# Compare GMSB vs. SM in $\gamma\gamma$ +Met



**Signal can be well separated from SM**

# Sensitivity vs. Timing Resolution

**Standard**  
 **$\gamma\gamma$ +Met analysis**  
**plus a cut on**  
**time of arrival**  
**of both photons**  
**Excellent**  
**prospects with**  
**our resolution**





# Expected Exclusion Region for $400\text{pb}^{-1}$

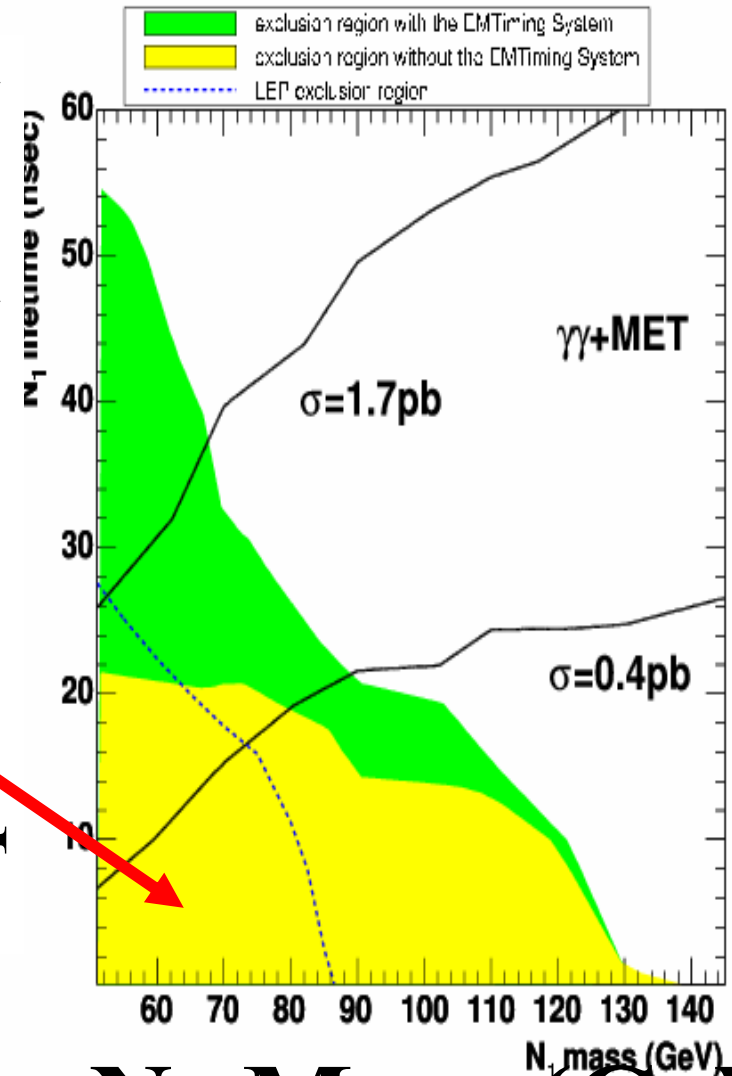
**Without EMTiming:**

**extend LEP-  
LIMITS for mass,  
but not lifetime**

**With EMTiming:**

**Extend all LEP  
limits**

**$N_1$  Lifetime (nsec)**



**$N_1$  Mass (GeV)**

# EMTiming - Summary

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- **Enhances background rejection, especially for searches with photons and/or Met**
- **Helps answer the question “Are all the photons in unusual events from the primary collision?”**
- **Big chunks of the system already installed and working well\* → Finish installation this year**
- **Lots of interesting physics to do be done!**

**\*Thanks Rob & Mike**