# CDF $\tau$ triggers, analysis, and susy prospects

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## OUTLINE

- Motivation
- CDF Run II Detector/Trigger System
- $\tau$ Triggers
- $\tau$ physics analysis
- $\tau$'s in SUSY Trilepton search

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**Philadelphia**
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# Motivation for $\tau$ Triggers

◊ **Standard Model:**

B physics: $\Upsilon$, $(B^{\pm}, B^0, B_s)$, $(D^{\pm}, D^0, D_s)$

Electoweak: Drell-Yan $(\gamma, Z^0) \rightarrow \tau^+\tau^-$

Top: $t\bar{t}$ channel with $W \rightarrow \tau\nu_\tau$

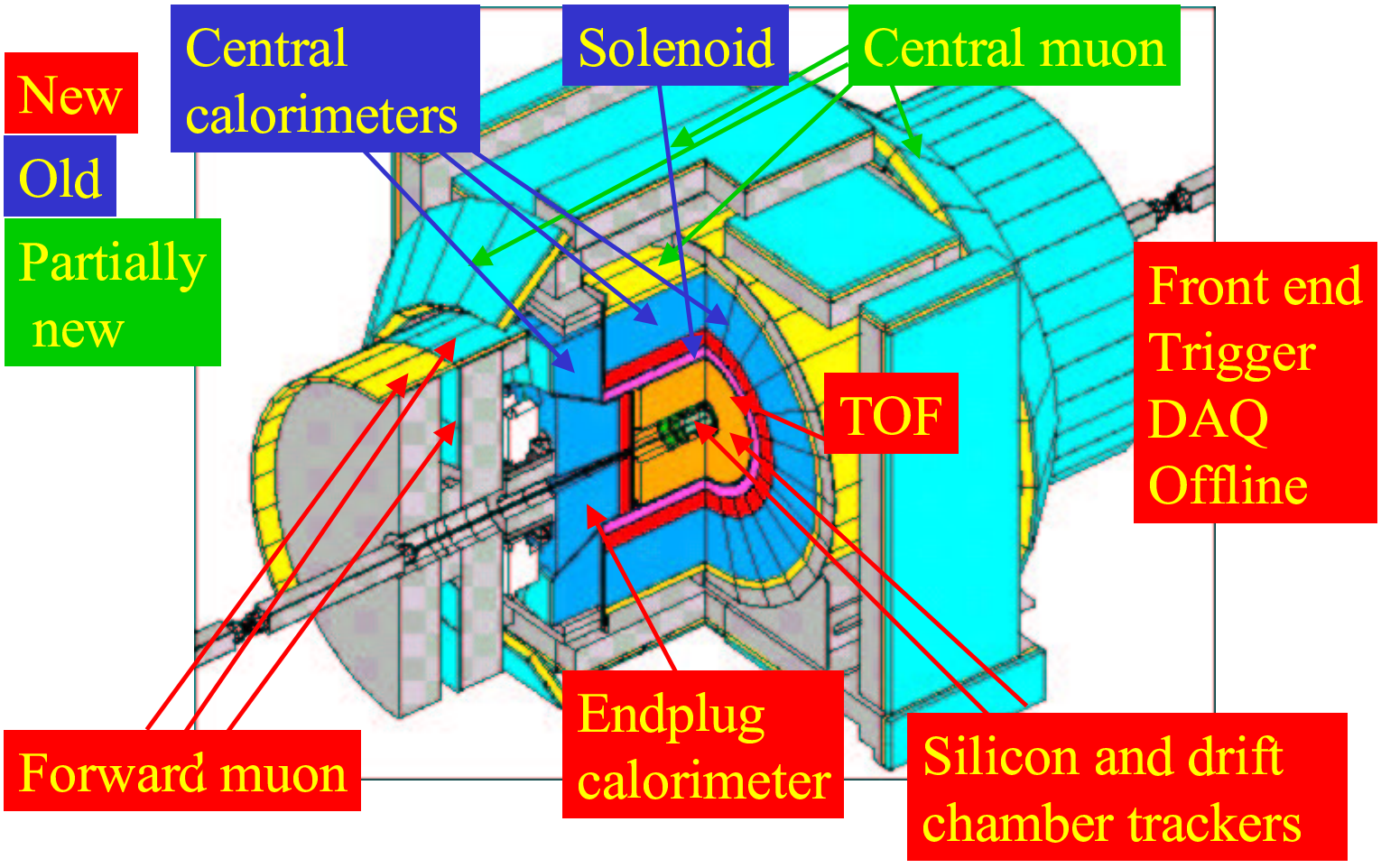
Higgs: $WH^0$ or $ZH^0$ production
with $W/Z \rightarrow \tau$ or jet, $H^0 \rightarrow b\bar{b}/\tau^+\tau^-$

◊ **Beyond the Standard Model:**

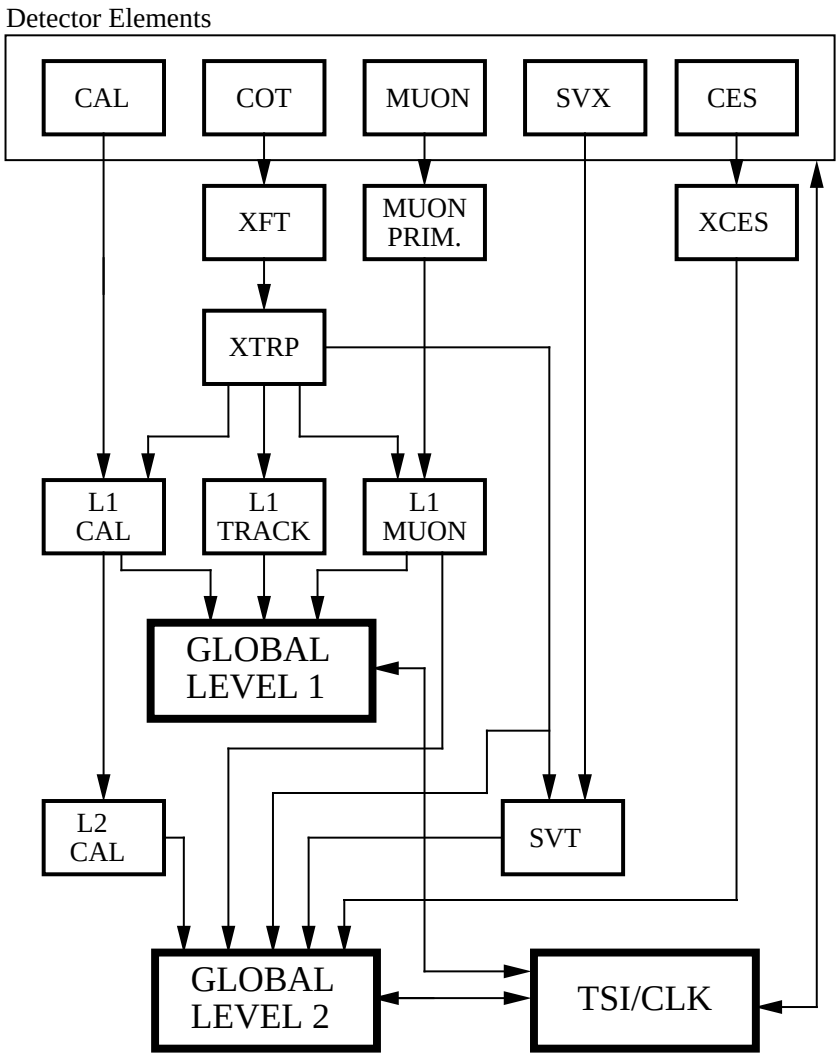
SUSY searches: $p\bar{p} \rightarrow \tilde{\chi}_1^{\pm}\tilde{\chi}_2^0$,

$\not{R}_p$ SUSY, MSSM Higgs, ...

# The Upgraded CDF Detector



# RUN II TRIGGER SYSTEM



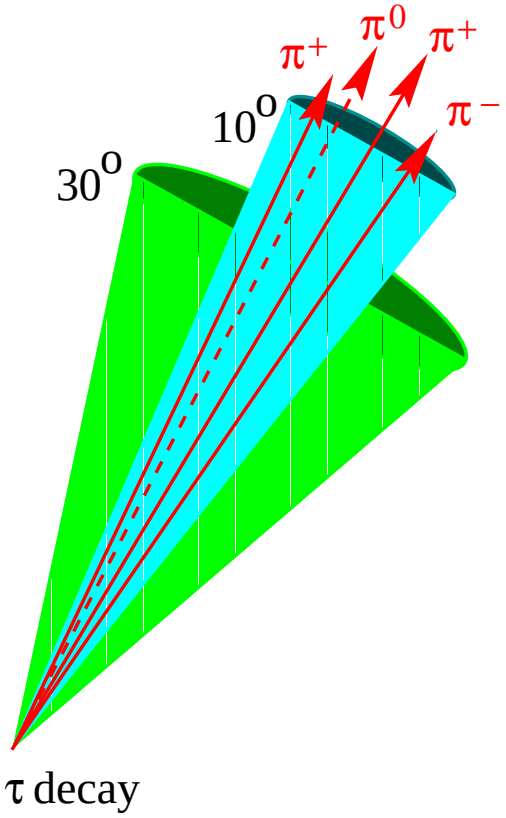

- **Three-stage trigger system keeps up w/event rate**

  **L1 and L2 Custom Designed VME**

  **L3 Processor Farms with event reconstruction**

# Tau Triggers

- Di-Tau
- Muon plus track
- Electron plus track
- Tau plus $\not\!\!E_T$



## ◊ Electron + track trigger

- **Level 1: EM Shower with XFT track**

  $E_T(e) > 8$ GeV, $Had/Em < 1/8$

  Associated XFT $p_T \geq 8$ GeV/c

- **Level 2:**

  **EM Shower Cluster**

  $E_T(e) > 8$ GeV, XCES $> 2$ GeV

  $Had/Em < 1/8$

  **2nd XFT track**

  $p_T > 5$ GeV/c

  $|\Delta\phi(e, \text{track})| > 10°$

- **Level 3:**

  **electron matched to EM Shower**

  $|\Delta z_{\text{CES}}| < 8$ cm, $\chi^2_{\text{CES}} < 20$

  $E_T > 8$ GeV, $p_T > 8$ GeV/c

  **$\tau$-cone track requirements**

  $p_T \geq 5$ GeV/c, $|\eta| \leq 1.5$

  $N_{track}^{10°-30°} = 0$

  ($p_T > 1.0$ GeV/c and $|\Delta z| < 15$ cm)

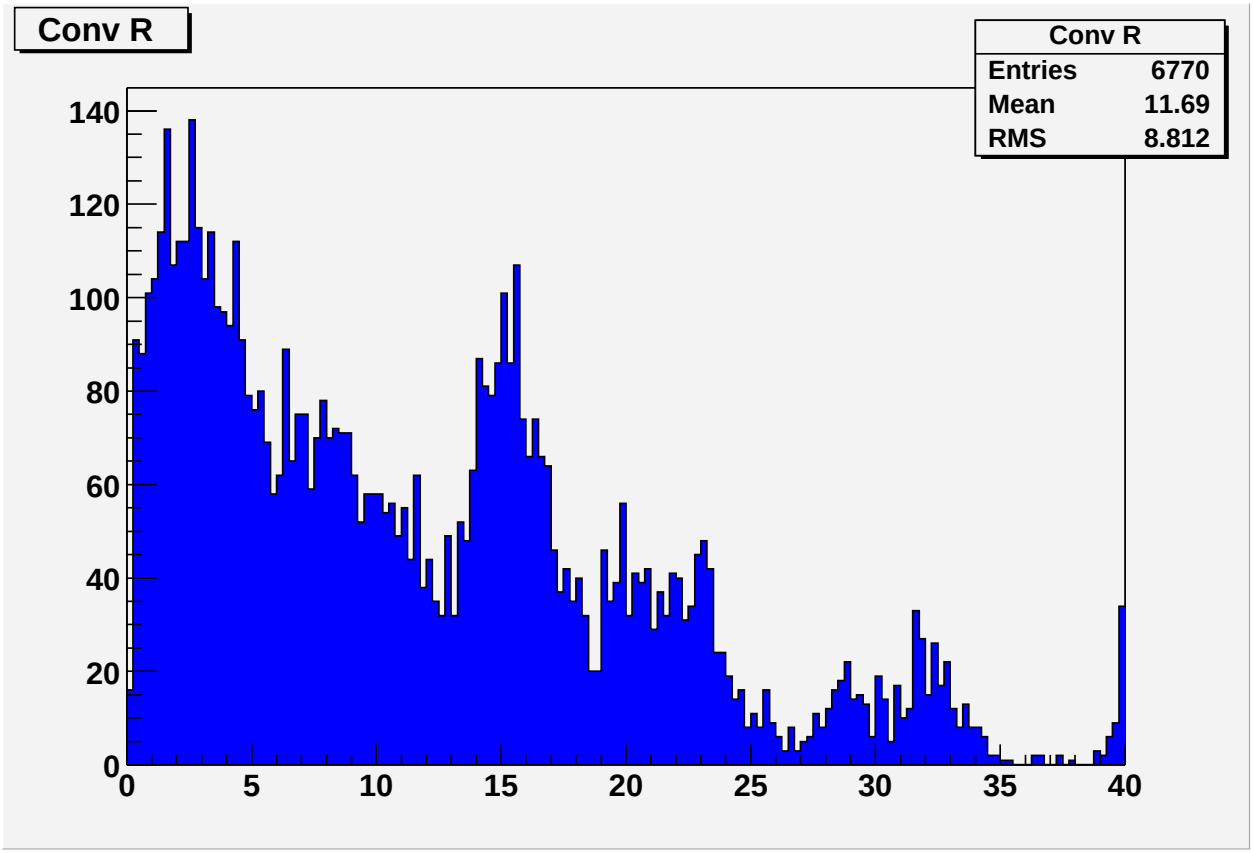
  **electron + $\tau$-cone track object**

  $|\Delta Z_0| < 15$ cm, $|\Delta R| > 0.175$

# Trigger Commisioning and Characterization

◊ Trigger Efficiency Study

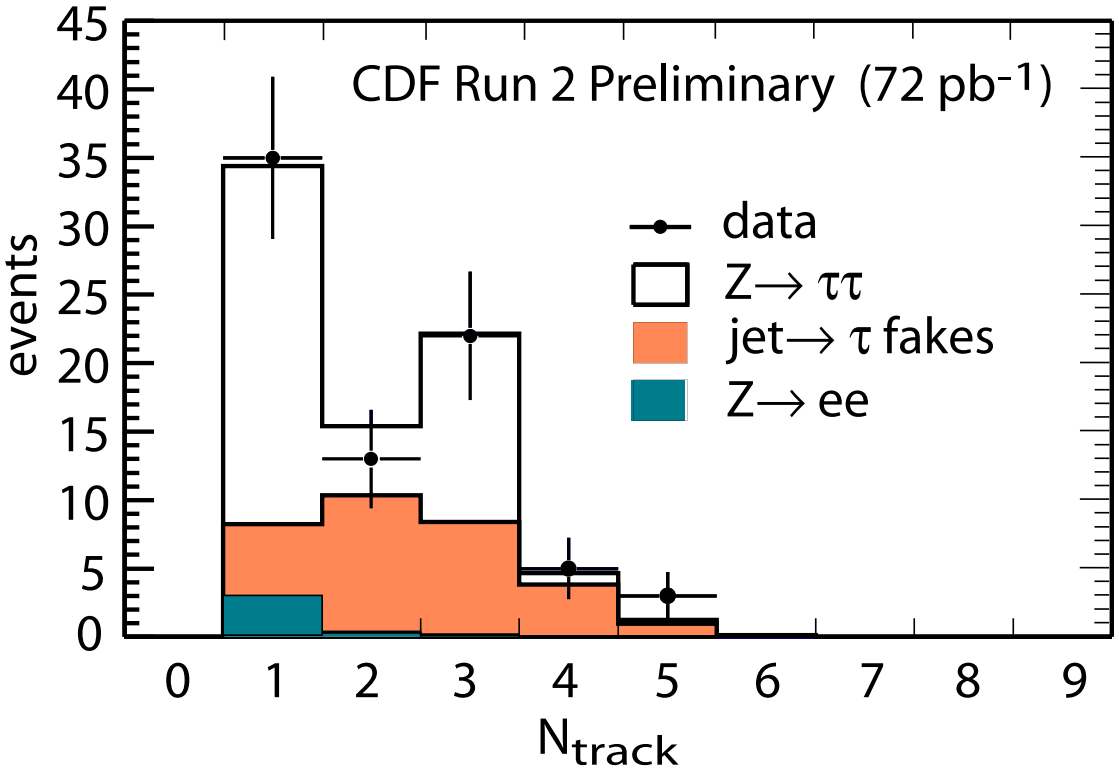
- Used a clean sample of electrons from photon conversions
- Efficiency for Electron +Track trigger path has been calculated
- These results will be used in our $Z \rightarrow \tau_e \tau_h$ cross-section measurement

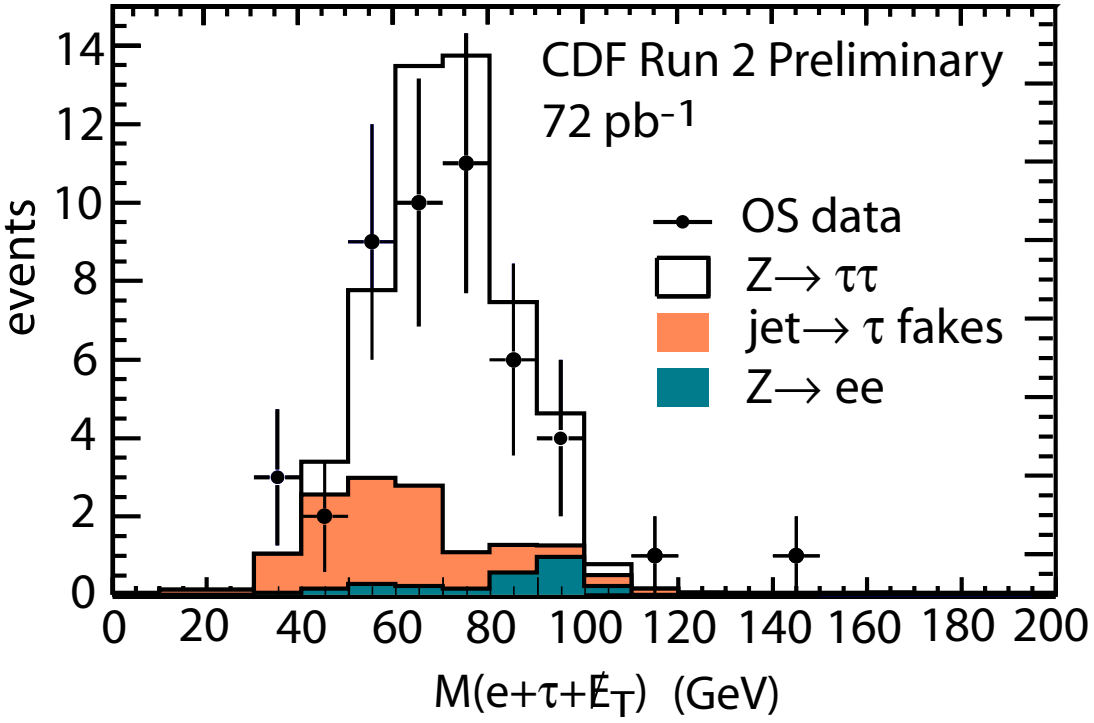



Radius of conversion for the conversion dataset used in efficiency studies

# Finding Taus: $Z \to \tau_e \tau_h$ first result

- "Electron + Track"+$\not\!\!E_T$ topology
- One central hadronic $\tau$ candidate
  - $P_T(trk) + E_T(\pi_0) > 20$ GeV/c
  - Seed Tower $E_T > 6$ GeV
  - Seed Track $P_T > 6$ GeV/c
  - Standard CDF $\tau$ id cuts
- One central electron candidate
  - $E_T > 10$ GeV
  - $P_T > 8$ GeV/c
  - Conversion Removal
  - Standard CDF electron id cuts
  - $Z \to ee$ Removal
- Event Level Cuts (to supress W+jets, QCD)
  - $M_T(ele + \not\!\!E_T) < 25$ GeV/$c^2$
  - $\vec{\Sigma}(P_T(ele) + \not\!\!E_T) > 25$ GeV


CDF Run 2 Preliminary (72 pb-1)
data
Z→ ττ
jet→ τ fakes
Z→ ee
events
Ntrack


CDF Run 2 Preliminary
72 pb-1
OS data
Z→ ττ
jet→ τ fakes
Z→ ee
events
M(e+τ+ET) (GeV)

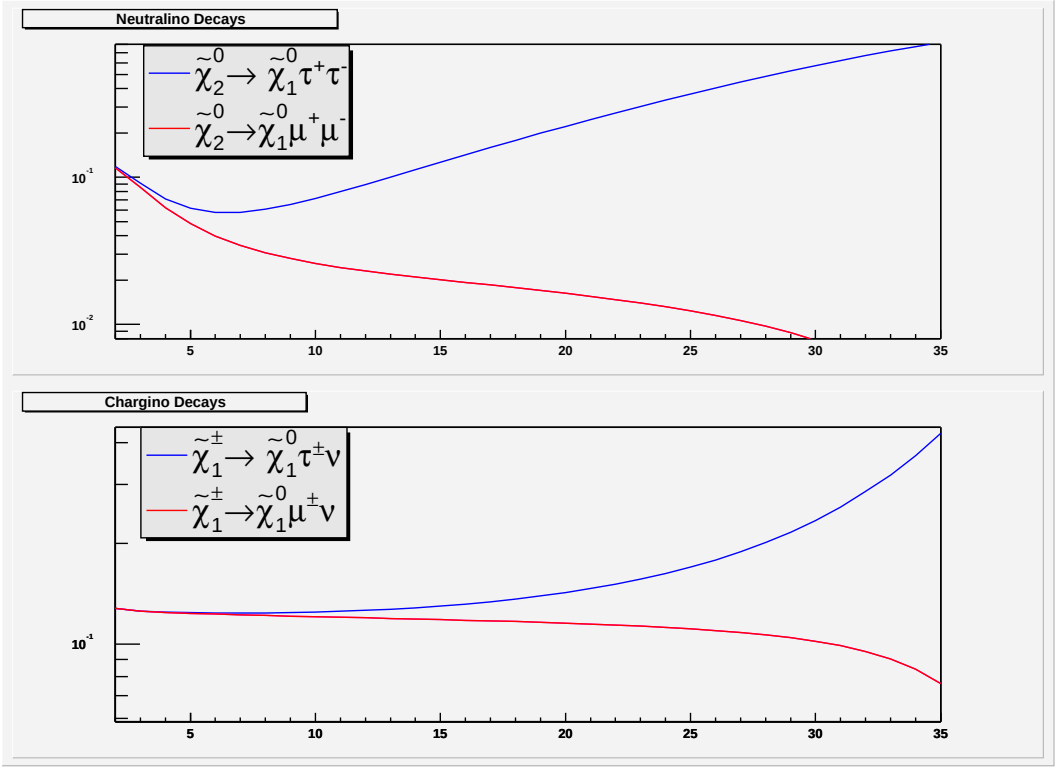
# SUSY Trilepton

◊ Golden Signature For SUSY

◊ Previous searches were based on four tri-lepton channels: $eee, ee\mu, e\mu\mu$, and $\mu\mu\mu$.

◊ This limits the SUSY parameter space at large $\tan\beta$ where branching ratios for $\tau's$ are dominant.

## Plot of Branching Ratios versus $\tan\beta$



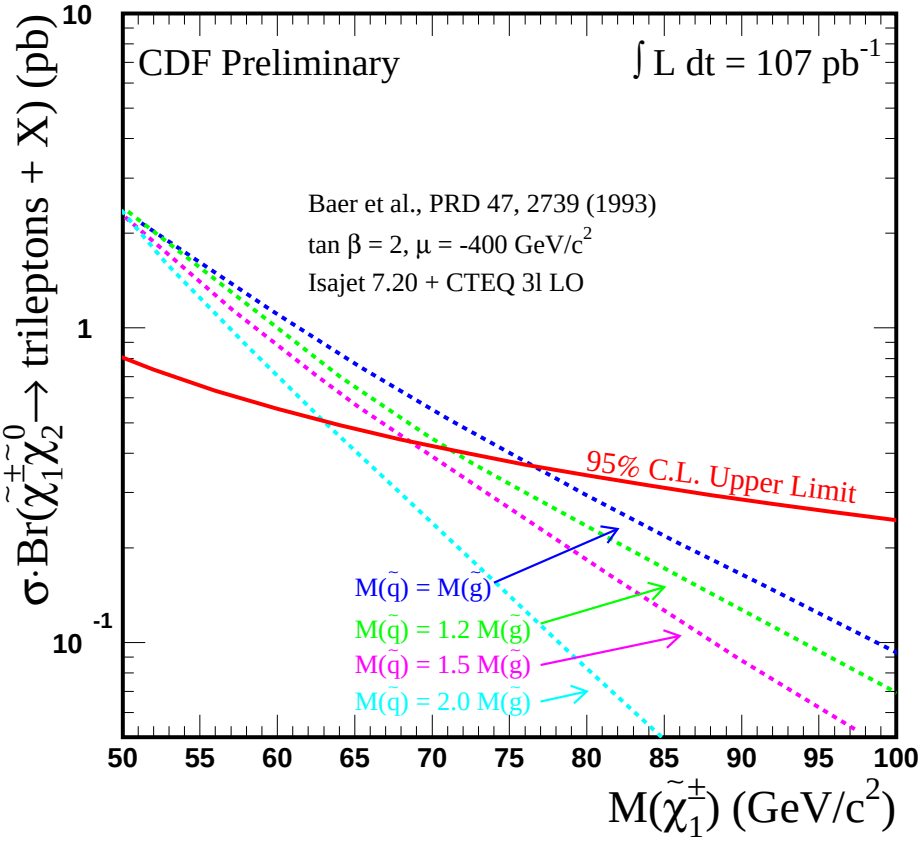

mSUGRA points: $m_0 = 150$, $m_{1/2} = 150$, $A_0 = 0$, sign$(\mu) = +1$

# SUSY Trilepton Run 1 Search

- Searched for three isolated, separated leptons from the same vertex
- Require $|q_1 + q_2 + q_3| < 3$
- Remove cosmics, Z, $\Upsilon$, and J/$\Psi$
- $\not{E}_T > 15$GeV
- Results consistent with Standard Model Background

◊ SUSY Model

- MSSM scenario w/MSUGRA inspired mass relations
- Limits for the given scenario and the following parameters:
- For $tan\beta = 1.1, \mu = -400 GeV/c^2, M(\tilde{q}) = M(\tilde{g})$ : $M(\tilde{\chi}_1^{\pm}) > 77 GeV/c^2$




**Mass and $\sigma \cdot Br$ limits from CDF run1**

- **LEP2 has set limits (given parameters) for $M(\tilde{\chi}_1^{\pm}) > 103.5 GeV/c^2$**
- **We're eager to extend these limits/discover SUSY!**

  **Detector Improvements**

  **Higher $\sqrt{s} = 1.96 TeV$**

  **$\tau$ triggers!**

  **More $\int \mathcal{L} dt$**

# Conclusions

**Tau Physics is very important in Run II.**

- **SUSY searches at large $\tan\beta$**
  **$\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0$, MSSM Higgs,...**
- **Precision Electroweak, $t\bar{t}$, Higgs**

**Tau Triggers are installed and commissioned at CDF.**

- **Data is already coming in**
- **First results $Z \to \tau_e\tau_h$**
- **We look forward to new physics searches using data collected by these triggers.**

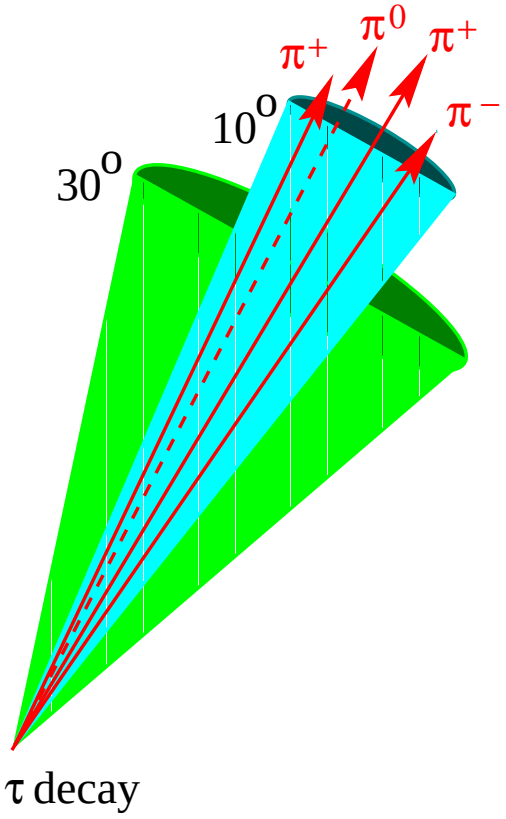



Table 1: Tau Cuts

| Tau Variables | Cuts |
|---|---|
| $\lvert\eta_{det}\rvert$ | $< 1.0$ |
| $E_T^{clu}$ | $> 20$ GeV |
| Seed Tower $E_T$ | $> 6$ GeV |
| Seed Track $p_T$ | $> 6$ GeV/$c$ |
| Mass(tracks+$\pi^0 s$) | $< 1.8$ GeV/$c^2$ |
| Cal Iso ($\Delta R$=0.4) / $E_T^{clu}$ | $< 0.1$ |
| $\lvert z_0(\tau) - z_0(e)\rvert$ | $< 5$ cm |
| $N_{\text{axial SL}}$, $N_{\text{stereo SL}}$ (for seed track) | $\geq 3$ |
| $N_{track}^{\text{iso cone}}$ ($p_T > 1.0$ GeV/$c$) | 0 |
| $N_{\pi^0}^{\text{iso cone}}$ ($E_T > 0.5$ GeV) | 0 |
| Electron Removal | $\xi \equiv E_T^{had}/\Sigma\lvert p_T\rvert > 0.1$ |
| Fiducial Region | $9 < \lvert z_{CES}\rvert < 230$ cm |