Search for Heavy, Long-Lived Particles that Decay to Photons at the Fermilab Tevatron

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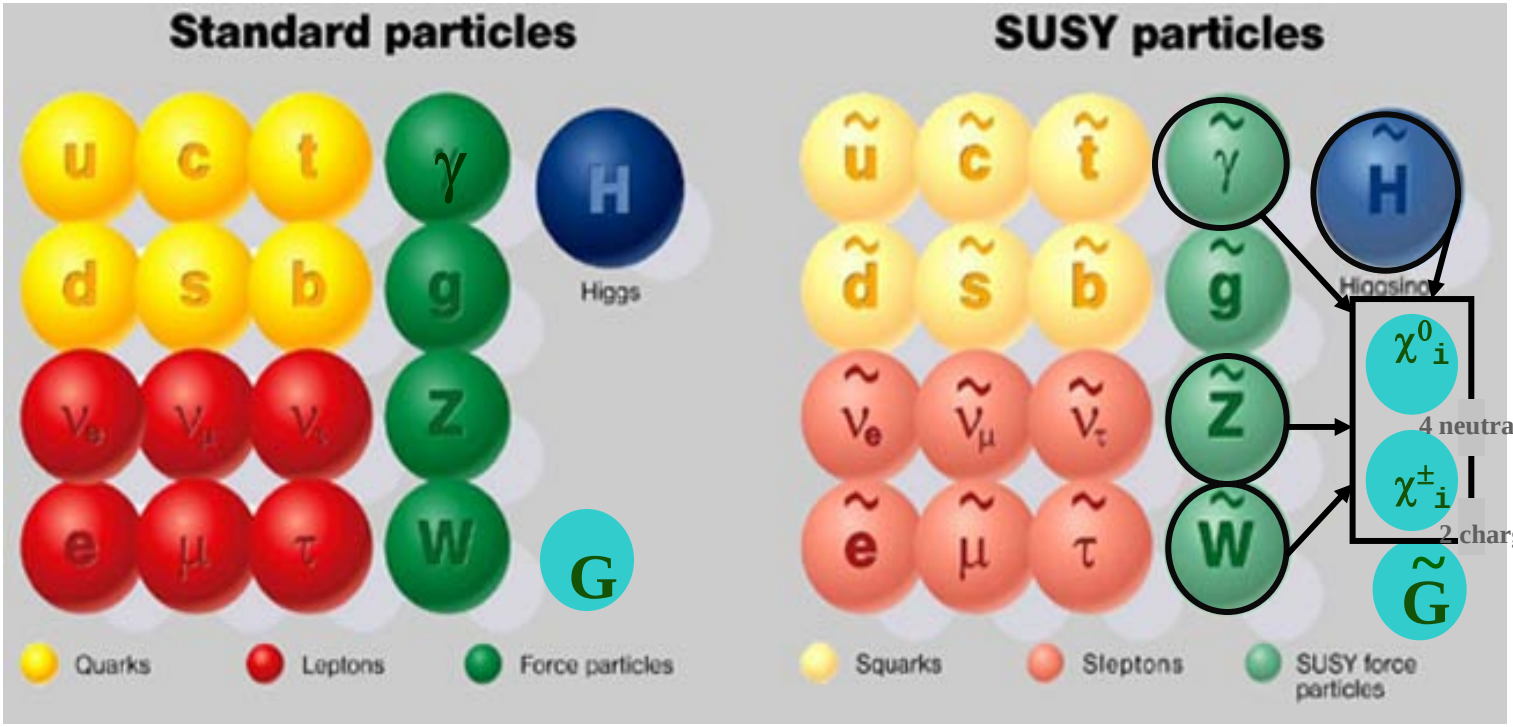
Outline

- Supersymmetry
- Heavy, long-lived particles that decay to photons : Neutralinos
- How to look for Neutralinos :

  Photon timing at CDF
- The analysis
- Results
- Conclusions and the future

Supersymmetry

- Modern particle theories beyond the Standard Model (SM) suggest a symmetry between fermions and bosons, called **supersymmetry**, at very high energies
- An important theory, "Gauge Mediated Supersymmetry Breaking" (GMSB), predicts heavy, long-lived particles with masses that can be produced and studied now at Fermilab (Tevatron)

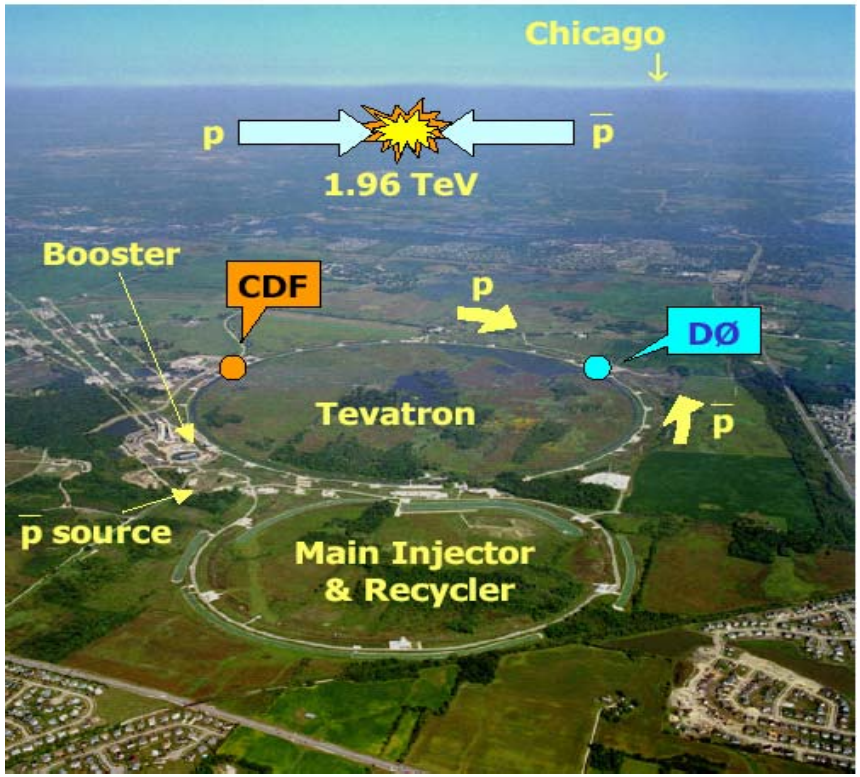


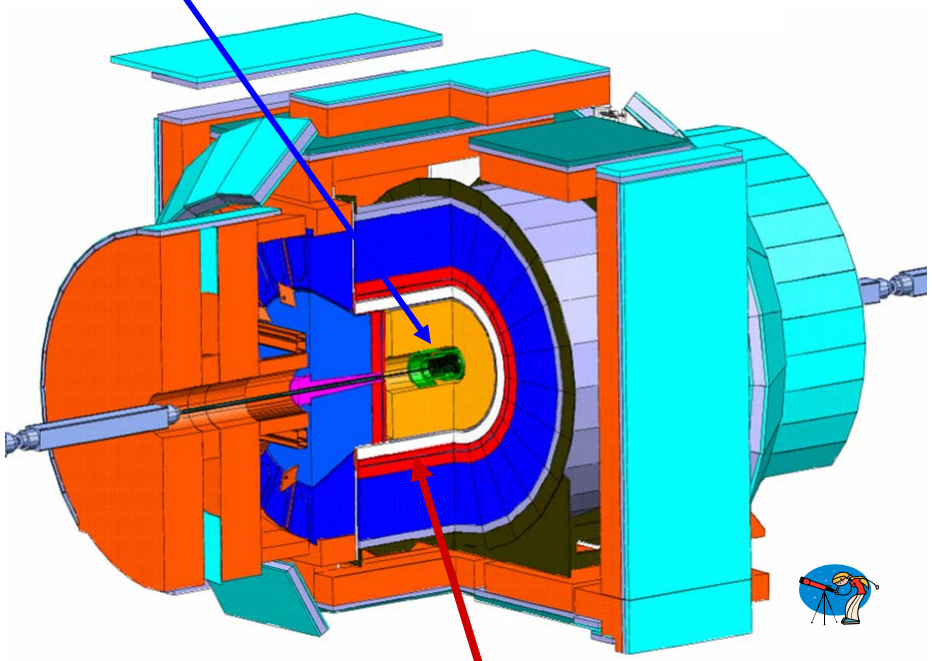
Tevatron at Fermilab :
Collider Detector at Fermilab **(CDF)**

Surround the collision point with a huge detector

The Tevatron (accelerator) : to produce high energy $p\bar{p}$ collisions

CDF : To study the collisions

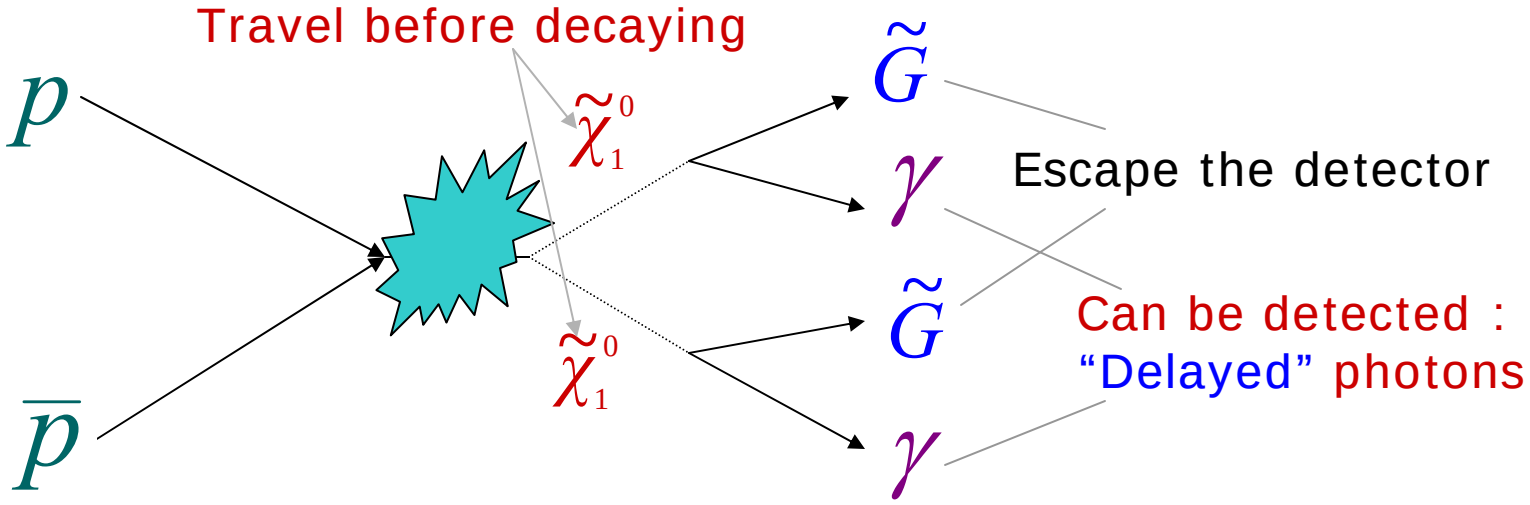




EM Calorimeter: Photon timing + 4-momentum

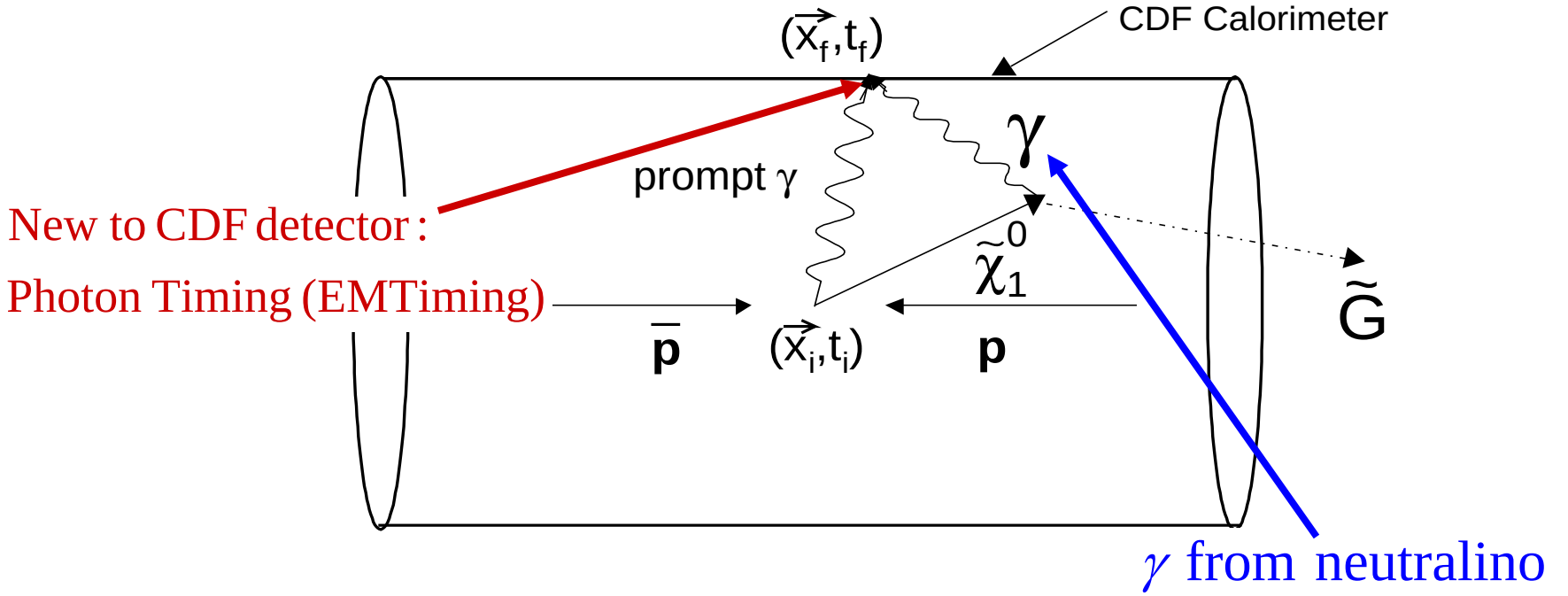
Heavy, Long-lived Particles that decay to photons : Neutralino $\tilde{\chi}^0$

- GMSB predicts the existence of Neutralinos, $\tilde{\chi}_1^0$ and Gravitinos, $\tilde{G}$
- In $p\bar{p}$ collisions at the Tevatron neutralino pairs can be produced. Each decays preferably(~100%) via $\tilde{\chi}_1^0 \rightarrow \gamma \tilde{G}$
- $\tilde{\chi}_1^0$ can travel a macroscopic distance before decaying
- Model well described by mass and lifetime of neutralino



How to look for Photons that come from Neutralinos that travel before decaying

- We measure arrival time of photon (t_i) and collision time (t_f)
- SM photons travel directly from collision point to the detector with speed *c*
- Photons from neutralinos arrive at detector later than "expected" from the collision point



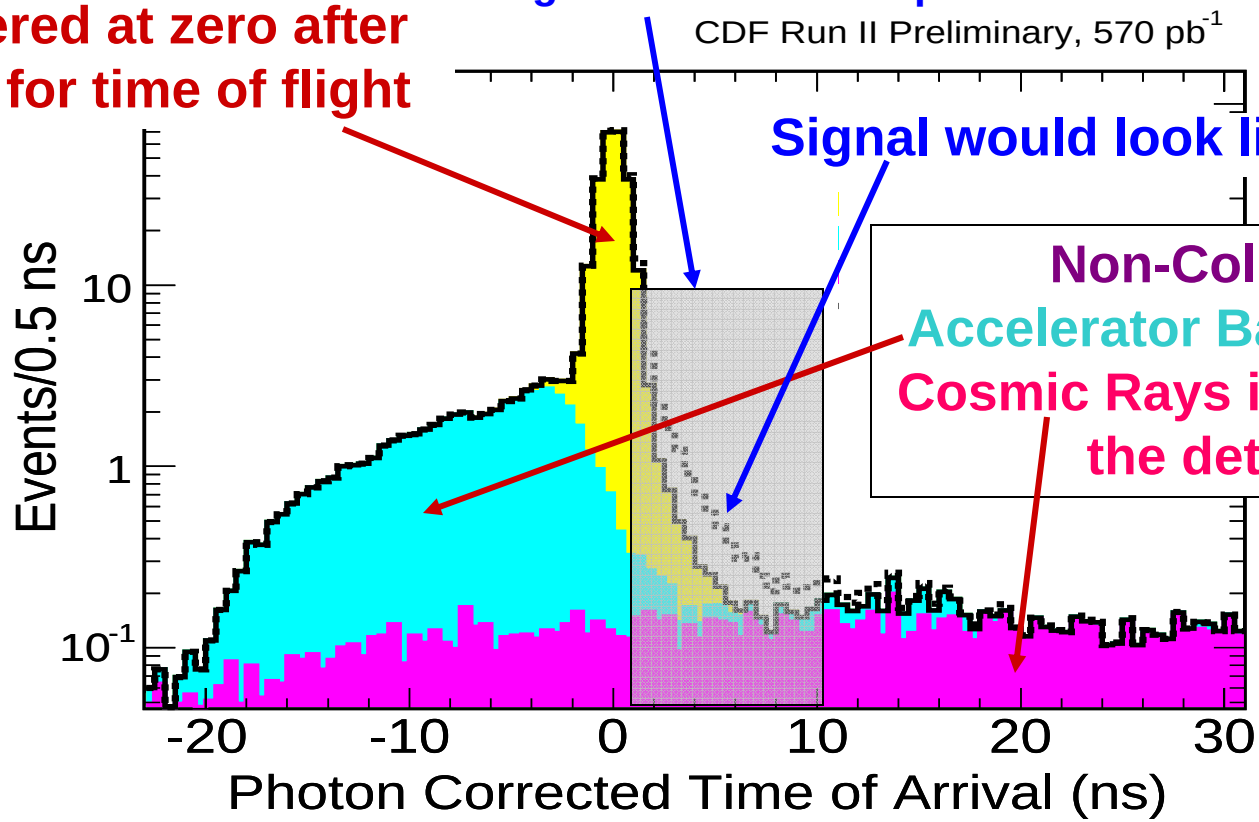
The analysis

- Backgrounds are estimated from data : Non-collision and SM photon candidates
- Supersymmetry (signal) simulated by Monte Carlo (MC)

Blind Window Region : Signal would show up here

SM : Centered at zero after correcting for time of flight

Signal would look like this



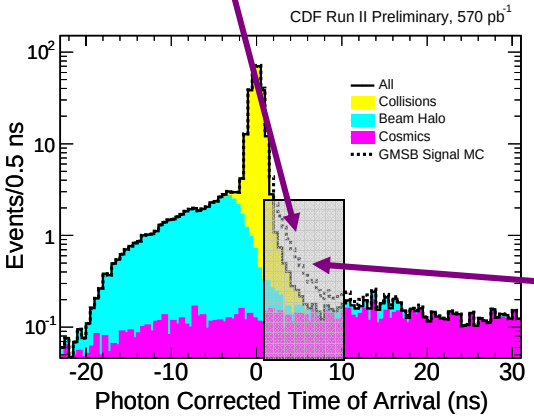
Non-Collision : Accelerator Backgrounds, Cosmic Rays interacting in the detector

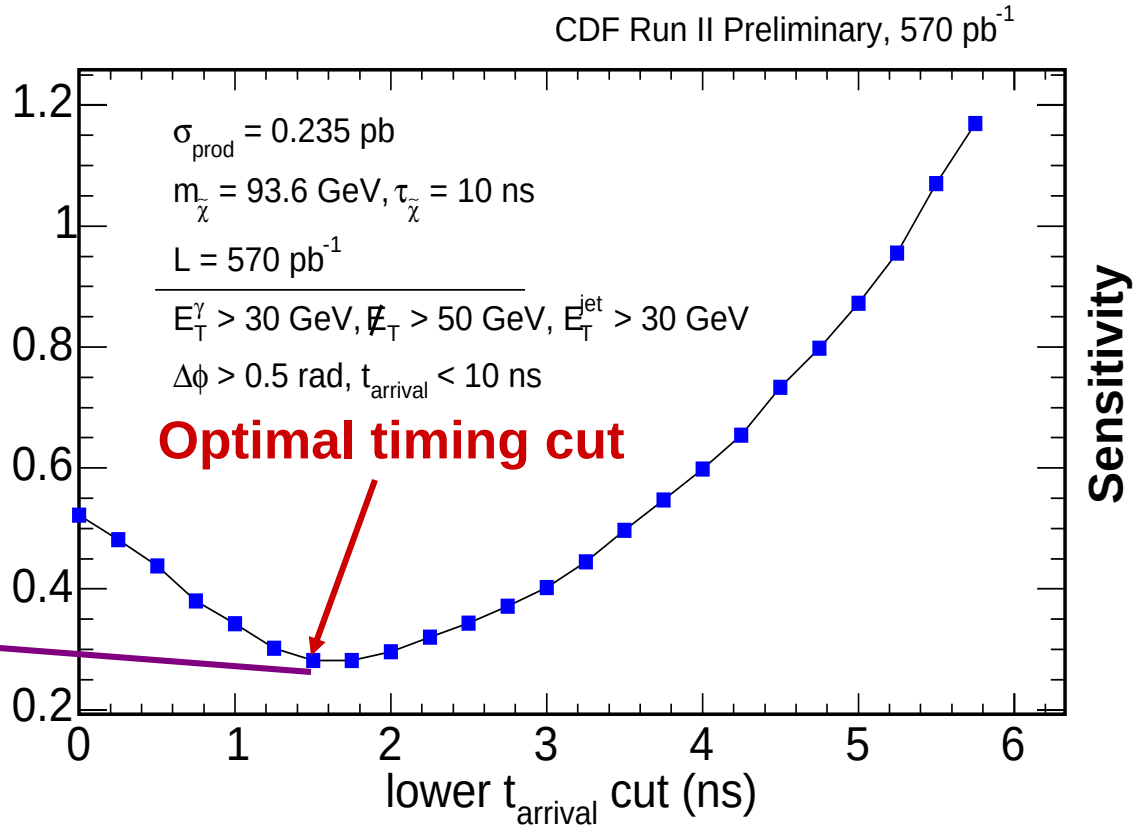
Analysis (Cont.)

- We want to optimize our sensitivity :

  Optimizing time window for the best expected cross section limit (σ_{exp}^{95}) to determine the blind window region

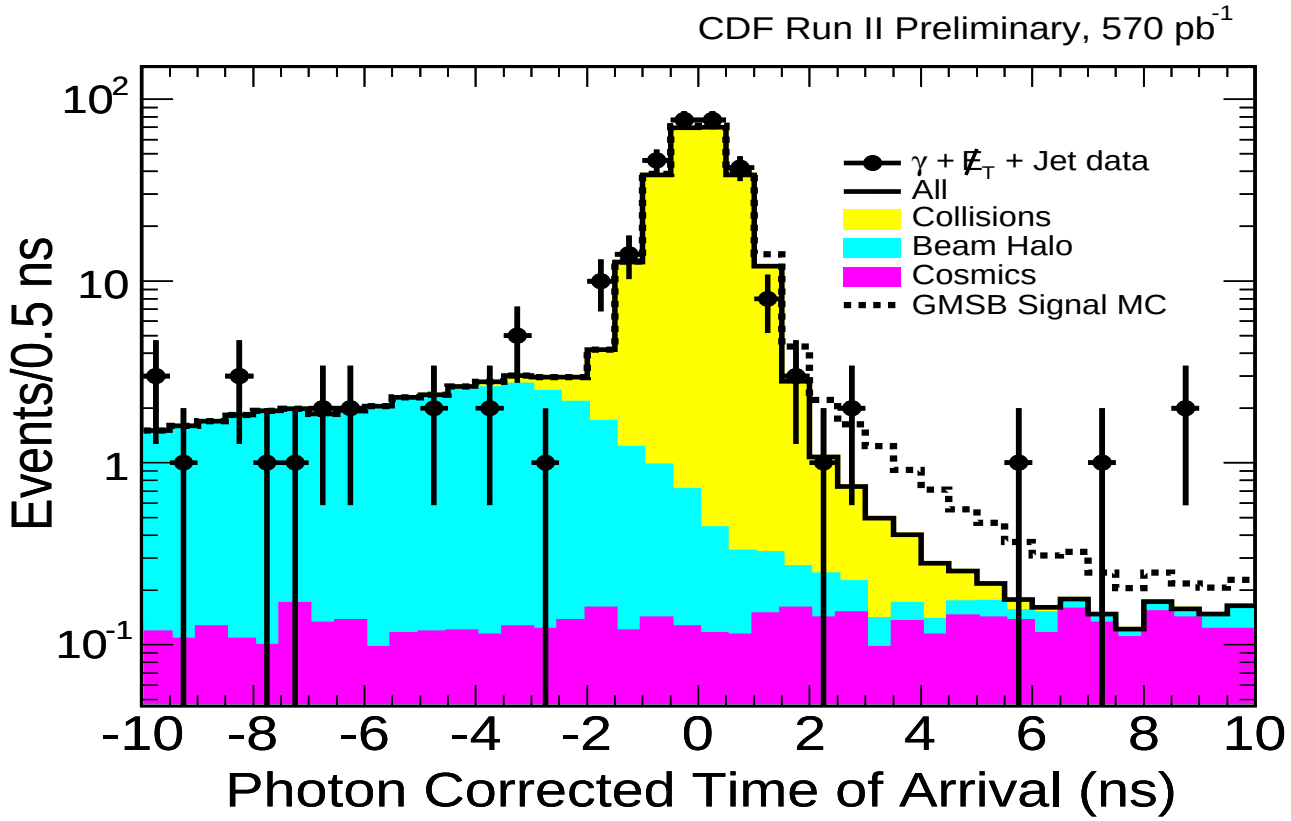
7.6±1.9 :
Bkg events expected
6.8±0.7 :
Signal events expected





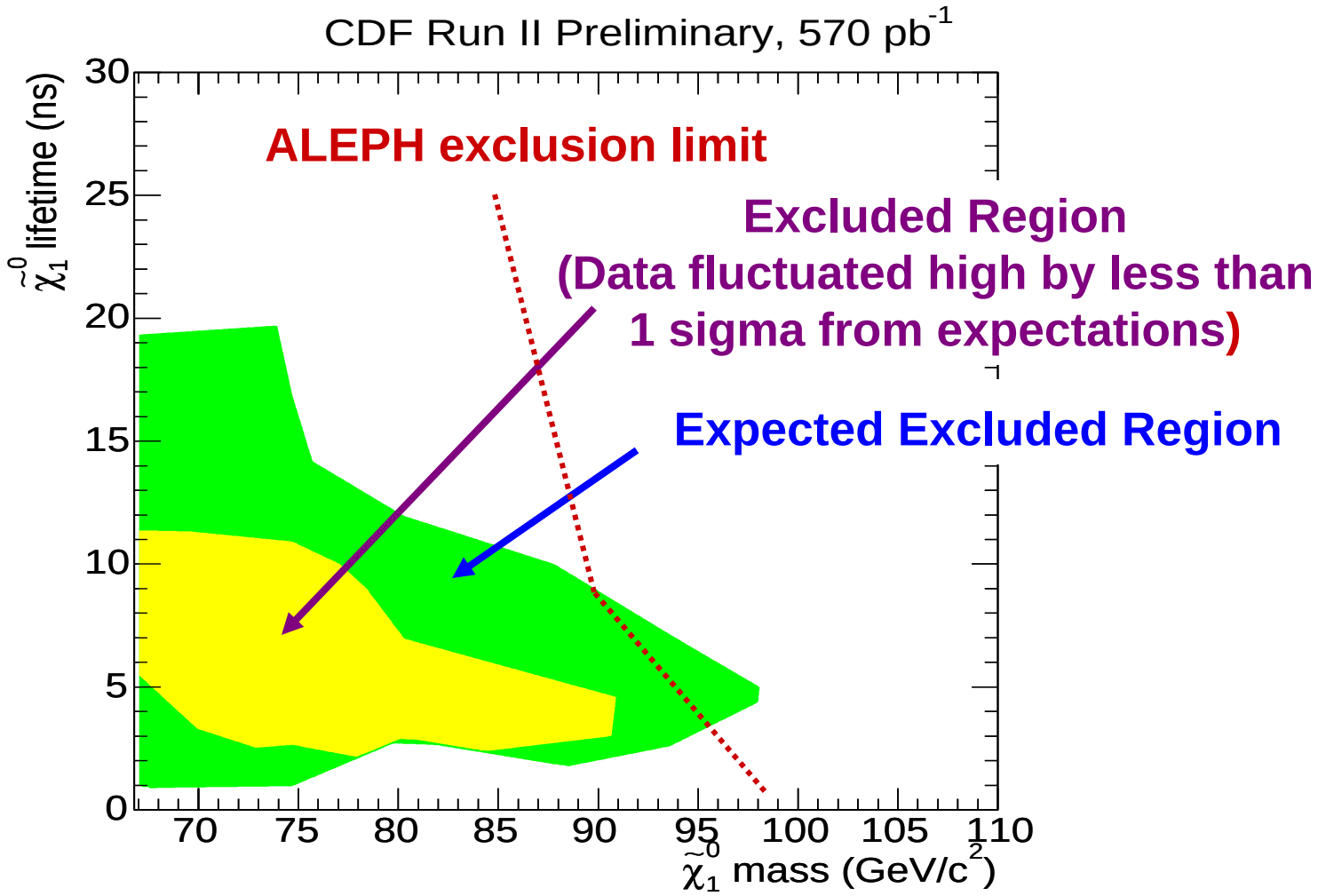
Results for 1st year data taking

- We observe **10** events in the signal region consistent with the background estimate of **7.6±1.9** events
- No evidence for long-lived neutralinos : Set limits on Supersymmetry (GMSB)

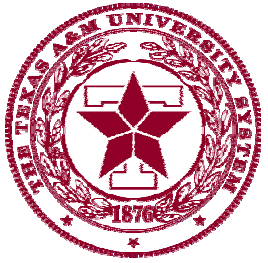


Limits

- We set limits on Supersymmetry (GMSB)



Conclusions and the future



- We have presented the first search for heavy, long-lived particles that decay to photons at the Fermilab Tevatron
- Limits on the neutralino mass and lifetime are among the worlds most sensitive in GMSB models
- Only used first year of data taking
- The next couple of years are exciting as the analysis increases its chance for discovery
- News of delayed photons will be a hallmark of Supersymmetry