# A few thoughts on two photon production of sleptons with forward protons

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Workshop on High Energy Photon Collisions
at the LHC

# Slepton decay signals

- Right handed sleptons prefer to decay

$$\tilde{\ell} \longrightarrow \ell \tilde{N}_1$$
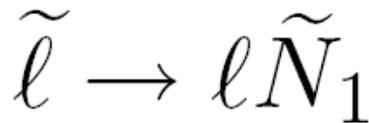
- Left handed sleptons

$$\tilde{\ell} \longrightarrow \ell \tilde{N}_1$$

or

$$\tilde{\ell} \longrightarrow \ell \tilde{N}_2$$
$$\tilde{N}_2 \longrightarrow \ell^+ \ell^- \tilde{N}_1$$
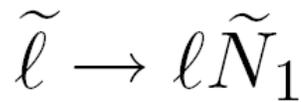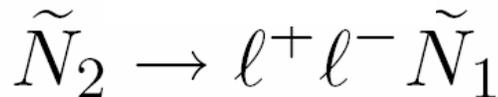
if kinematically allowed
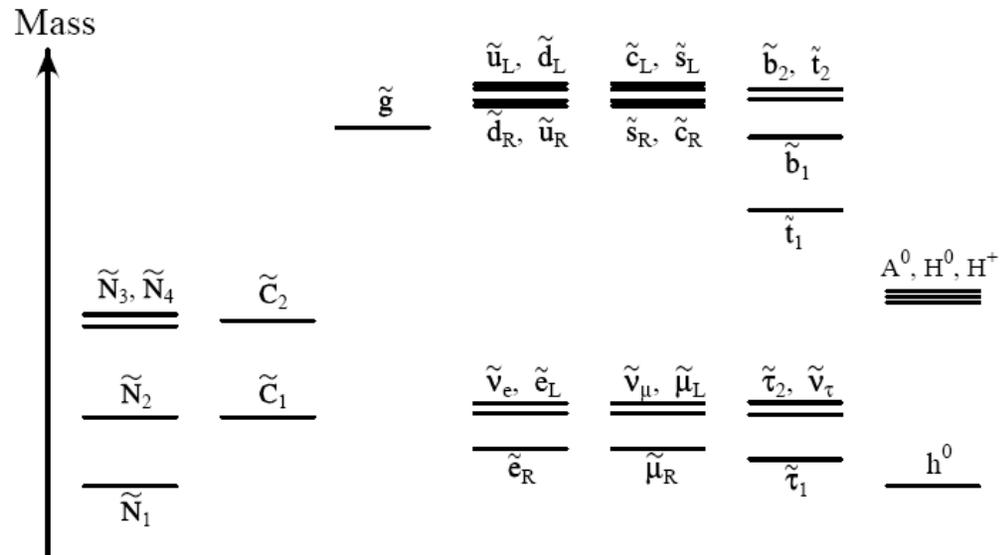
# Two photon production and decay of sleptons

μ      μ

p      N$_1$      N$_1$      p
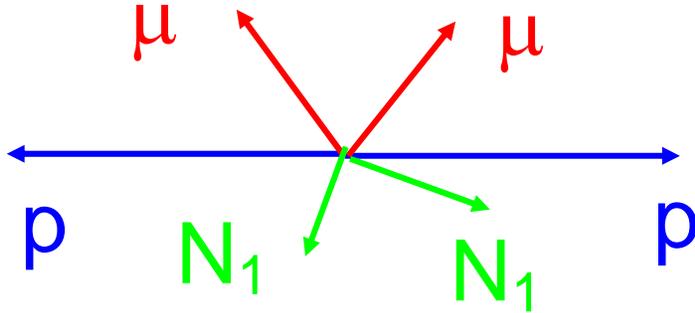
- ## Signal topology:
  - **2μ + 2fp + nothing**

- ## SM backgrounds
  - **pγγp → pWWp → pμνμνp**
  - **pγγp → pμμp**
  - **pγγp → pττp → pμμ(4ν)p**
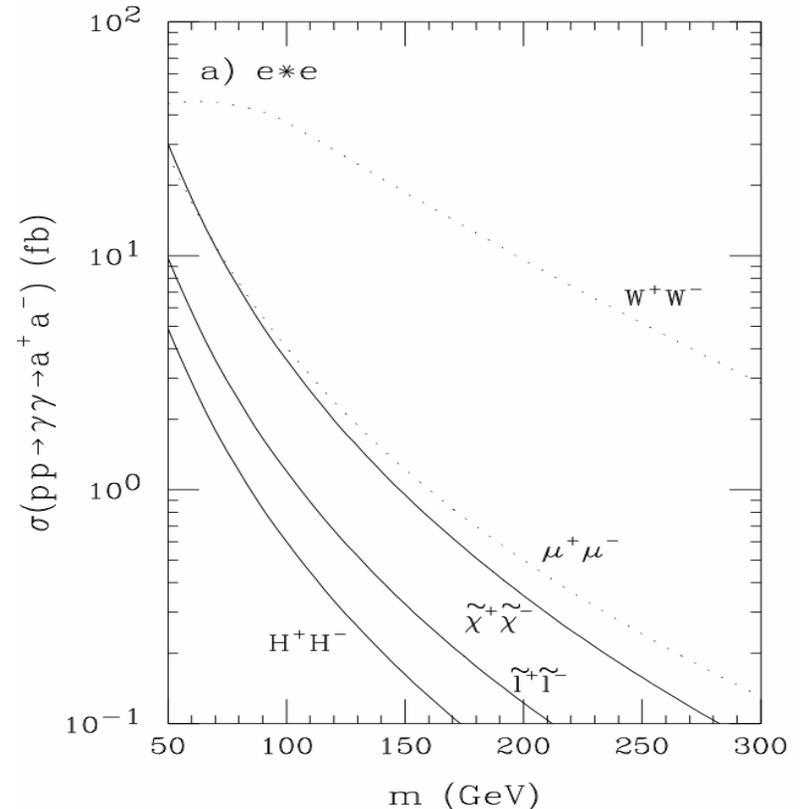
# Efficiency for proton double tag is good

- With both sets of detectors we see 60% efficiency from HECTOR (UCL)
  - **FP420 +TOTEM is needed for best efficiency**
- We get a healthy number of events in 100 fb-1



- Can't afford to lose too many signal events when we make cuts to reject background
- How much information do we get "for free" from measurement of forward protons plus muons?
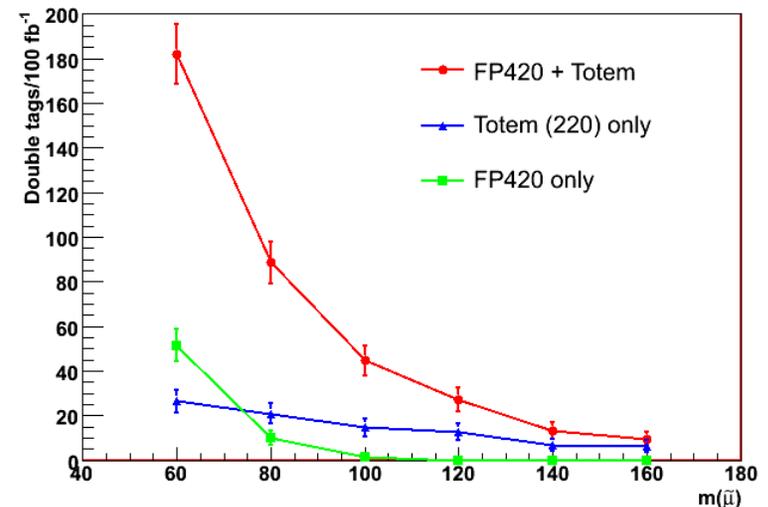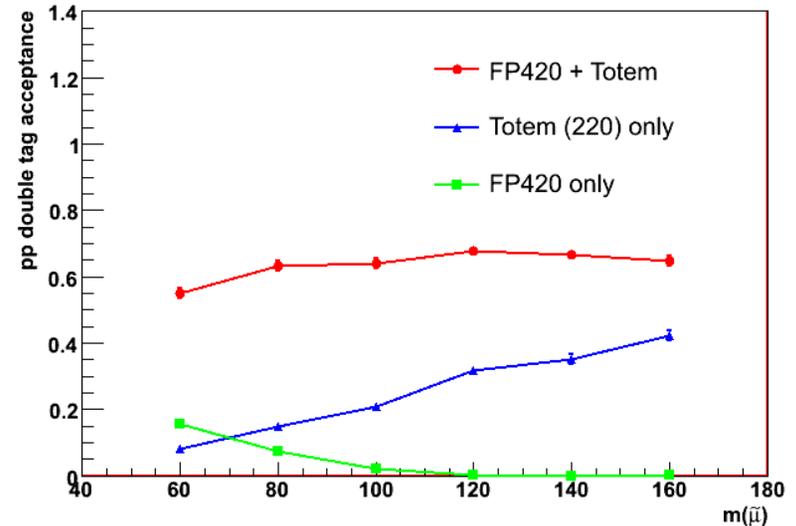
# Information is not sufficient to reconstruct the full kinematics

|  | Unknowns: |  |  | Constraints: |
|---|---|---|---|---|
| C.M. | 4 | | C.M. | 4 |
| 2 slepton | 8 | | 2 muons | 8 |
| 2 neutralinos | 8 | | C.M. decay vertex | 4 |
| 2 muons | 8 | | Slepton decay vertex | 8 |
| Total: | 28 | | | 24 |

- On an event-by-event basis cannot determine:
  - **M(slepton)**
  - **M(neutralino)**
  - **Cone ambiguity in slepton direction**

# Forward protons determine the C.M. Energy
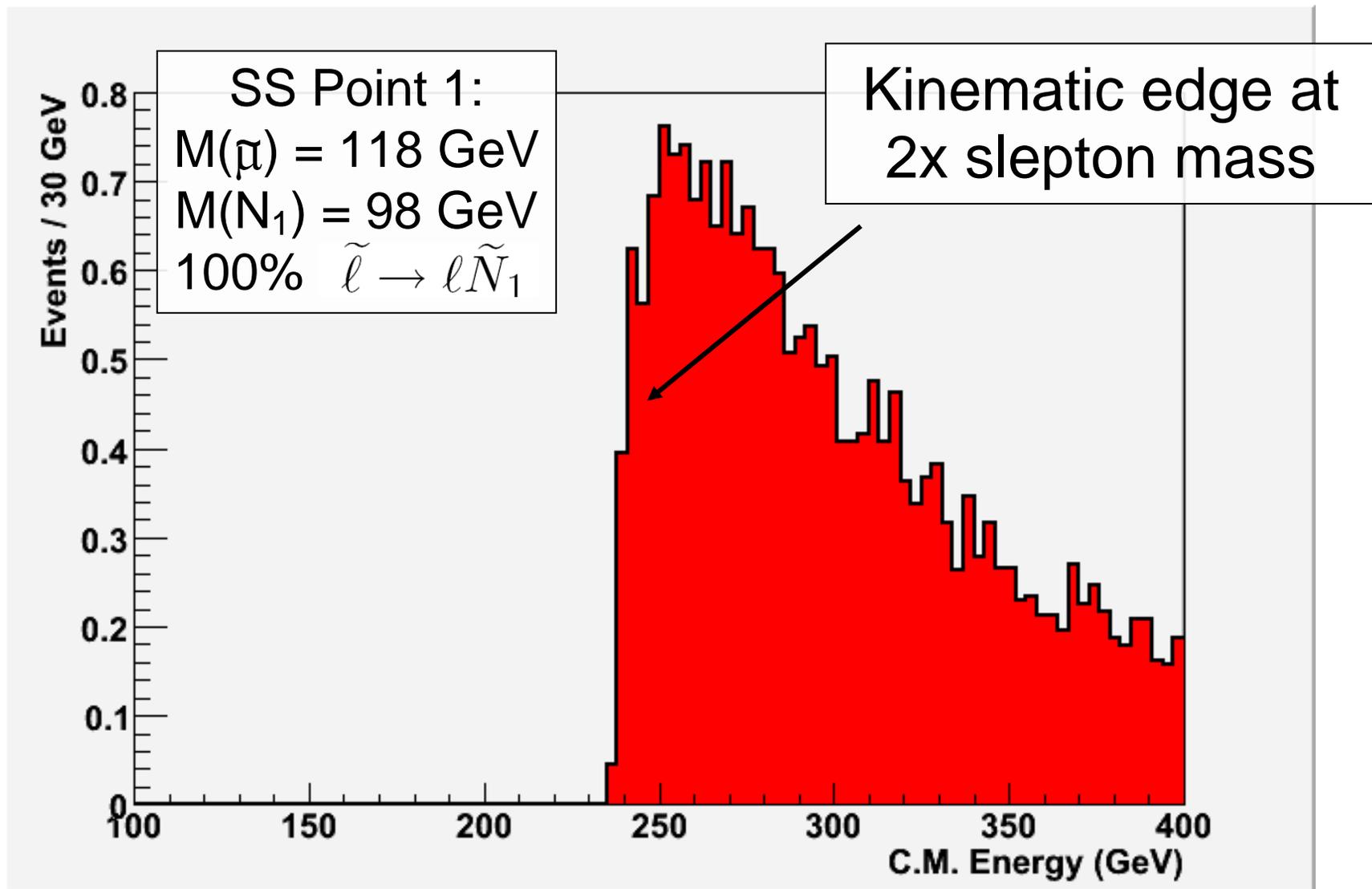
SS Point 1:
$M(\tilde{\mu})$ = 118 GeV
$M(N_1)$ = 98 GeV
100% $\quad \tilde{\ell} \rightarrow \ell \tilde{N}_1$

Kinematic edge at
2x slepton mass

**Boost muons to C.M. frame**

The muon momentum is determined by slepton-neutralino mass difference, slepton boost and $\cos(\theta^*)$

$N_1$

$\cos(\theta^*)$

$\mu$

$\tilde{\mu}$

$\tilde{\mu}$

$Q$ in $\tilde{\mu} \rightarrow \mu N_1$

Muon 1 momentum (GeV)

C.M. Energy (GeV)
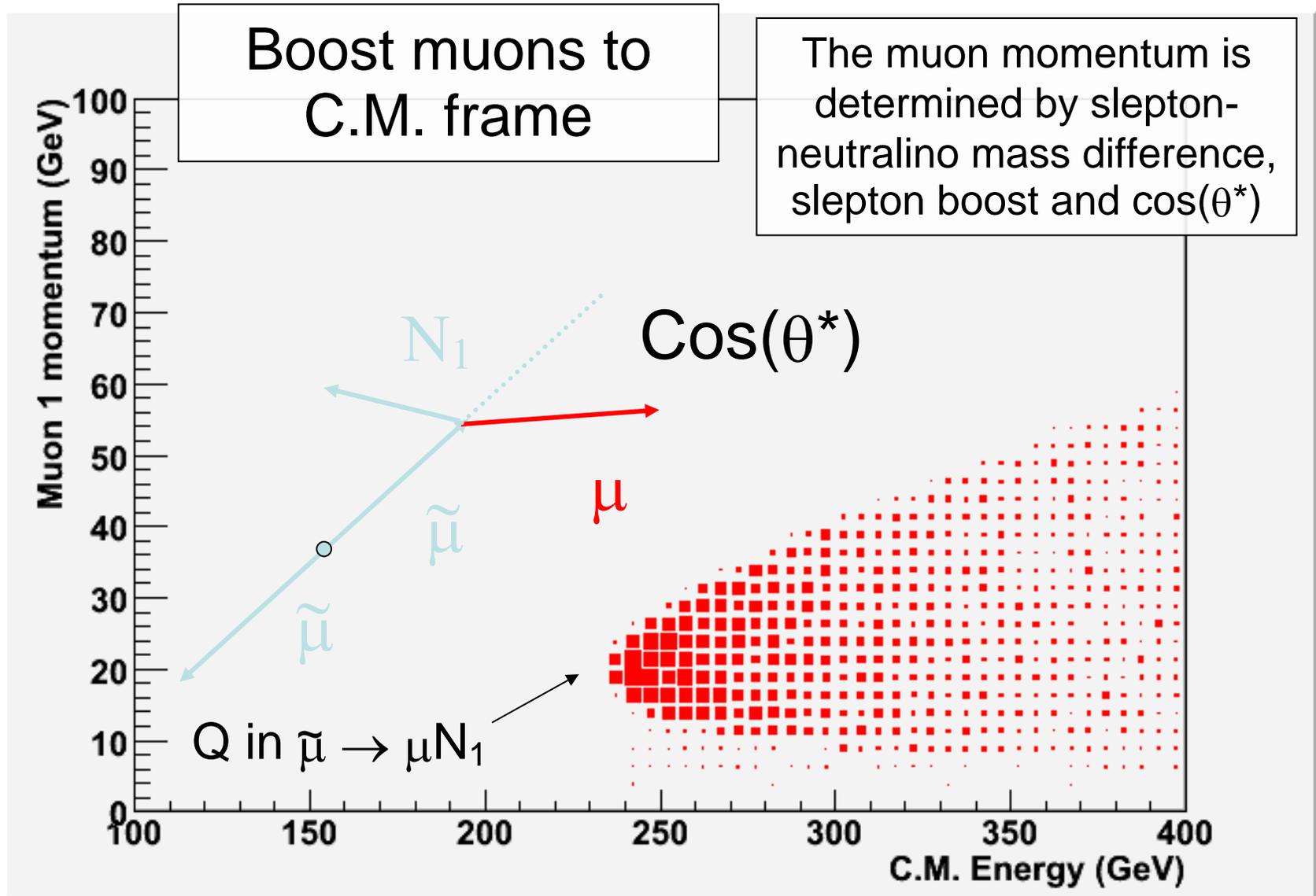
Maximum signal significance is at the kinematic endpoint
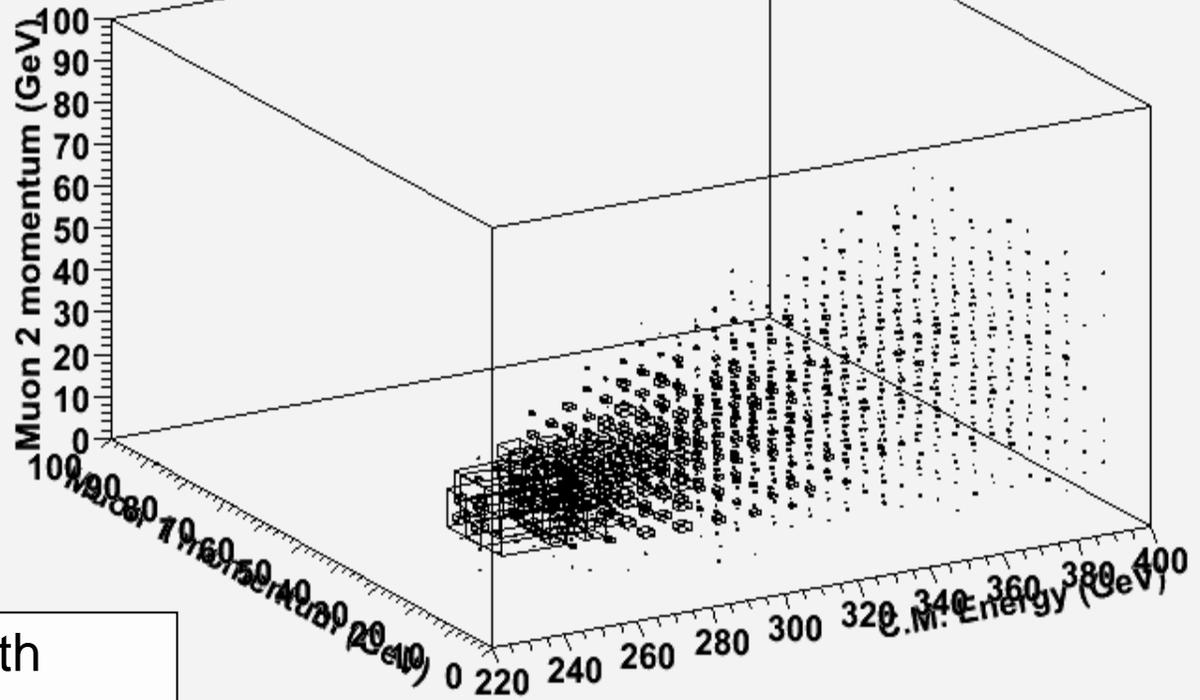


Sensitivity to both M($\tilde{\mu}$) and $\Delta M(\tilde{\mu}\text{-}N_1)$

# Irreducible backgrounds occupy this space differently
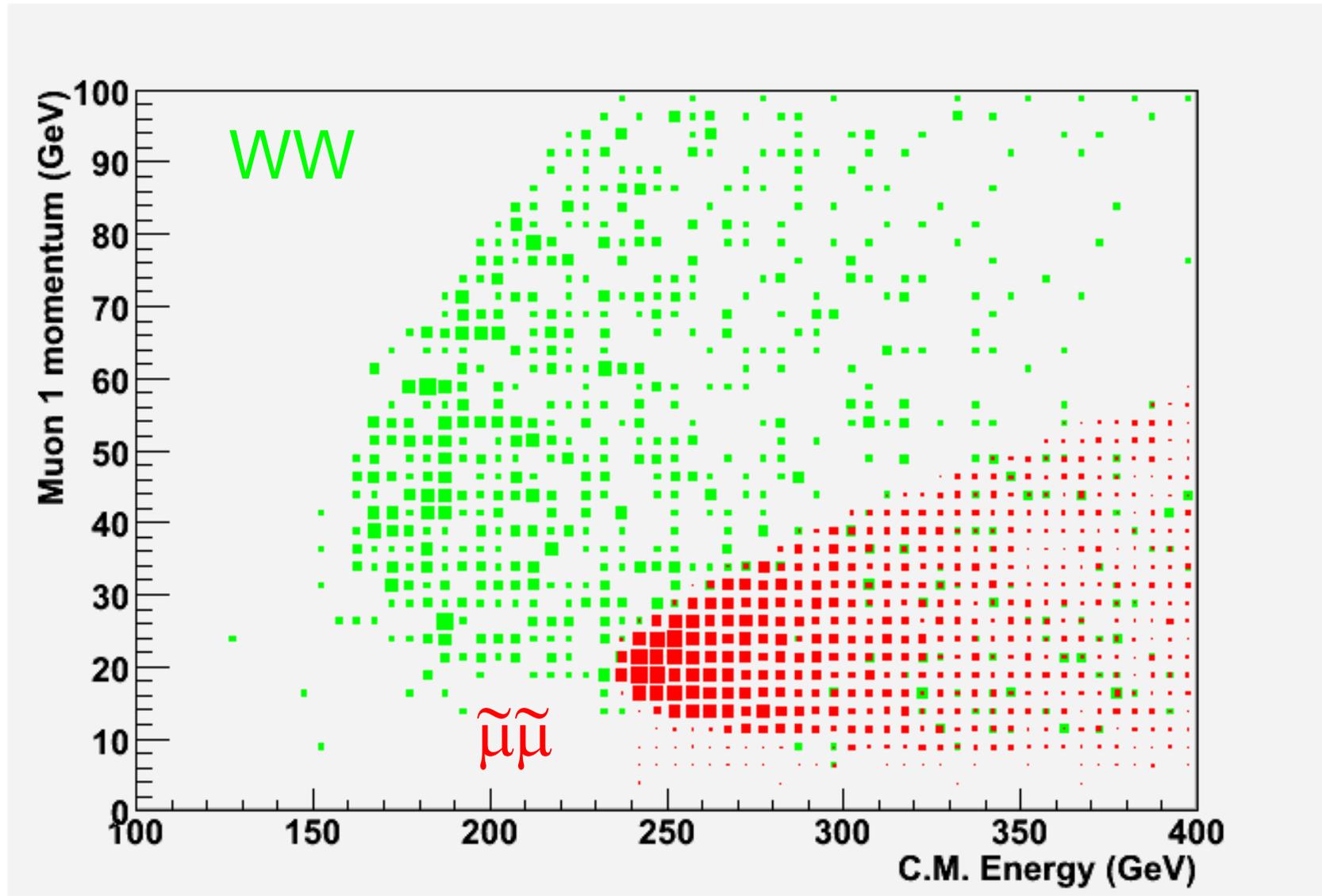
# Suppressing dimuon backgrounds

**Clean topological suppression of backgrounds using associated track cut, demonstrated by CDF in dimuon analysis**
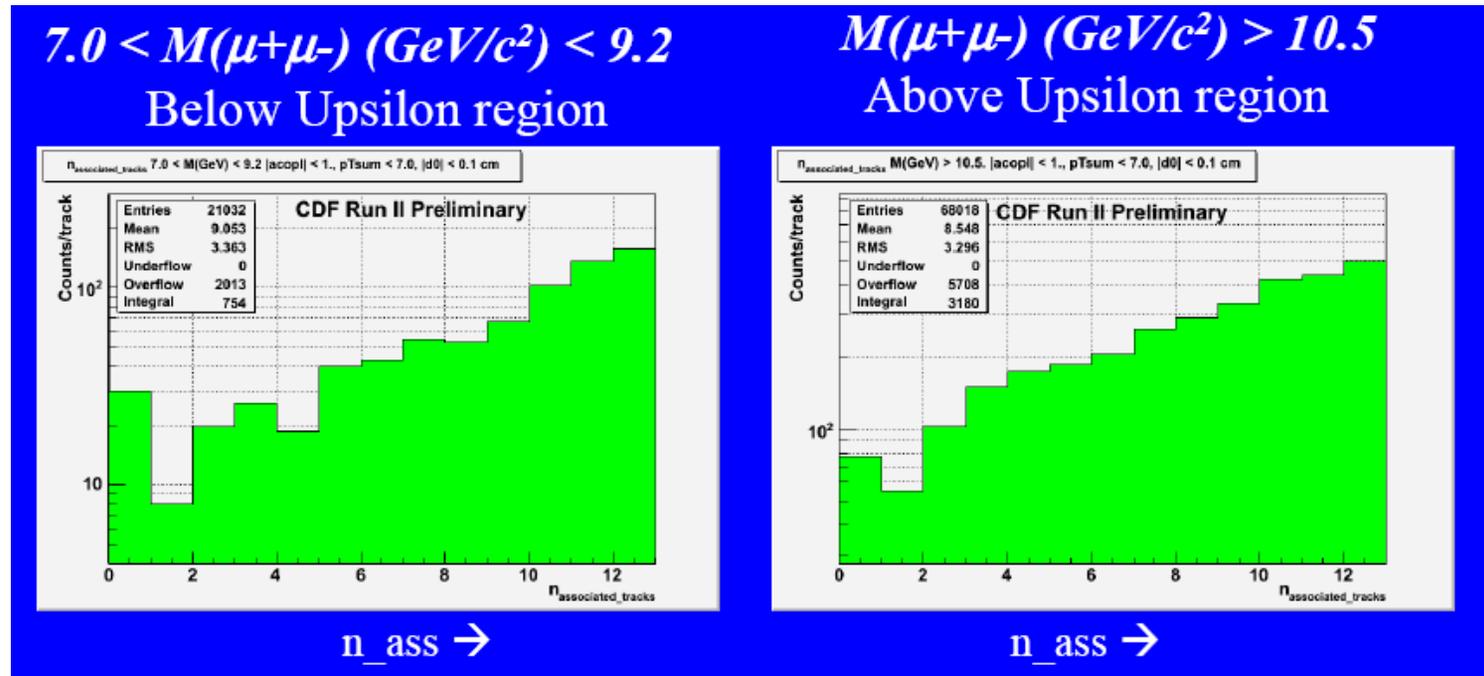


M. Albrow, Low-X August 2007

## Can we validate this technique for the slepton analysis in data?

# Proton Tag Overlaps [p][X][p]

- Single diffractive rate is large at 2e33 cm$^{-2}$ s$^{-1}$
  - **How often is there a random overlap [p][X][p] of central dimuon with two forward protons?**

- Single diffractive proton rate
  - **0.238 / BX**
- Double rate
  - **Poisson statistics for N=2 divided by 2**
  - **0.023 / BX**
- Proton timing of 20ps
  - **Suppression factor of 24 (FP420 proposal)**

- Fake rate
  - **9.28e-4 / BX**

Pythia single diffractive spectrum into the 220 and 420 acceptances
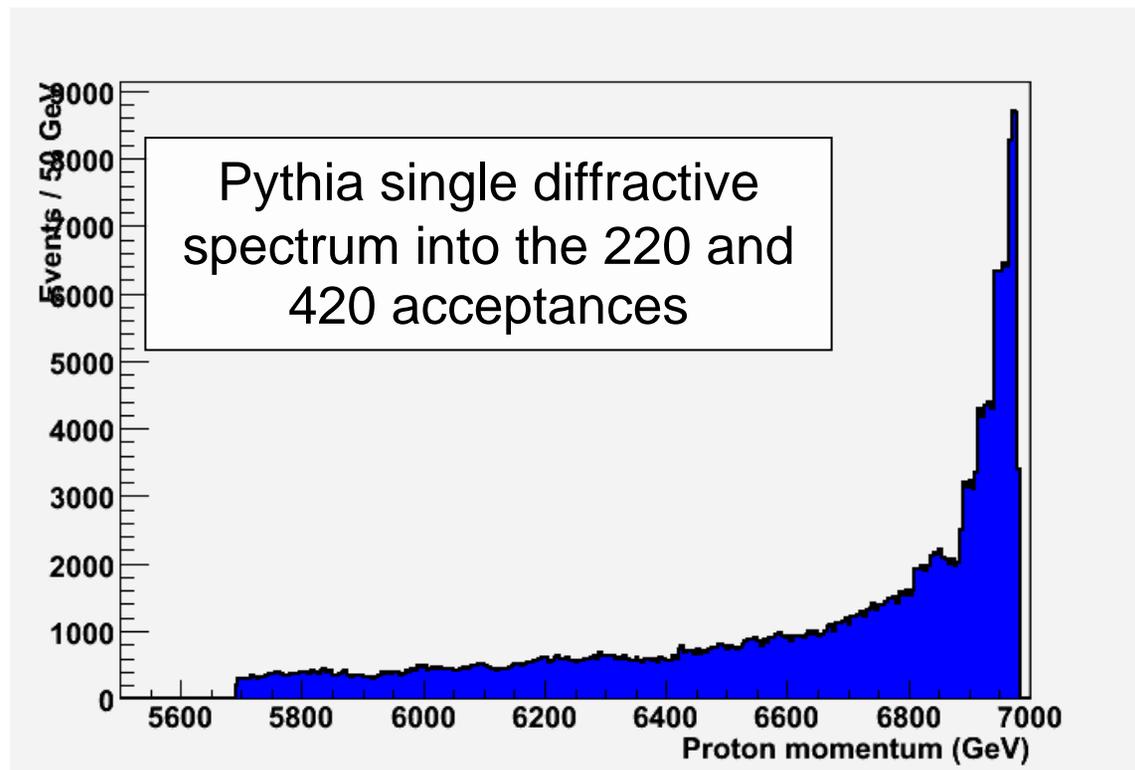
# Studying background suppression in data

- In the 100 fb$^{-1}$ sample there will be
  - **100 fb$^{-1}$ x $\sigma(\mu\mu X)$ x 9.28e-4 (proton fake rate) [p][$\mu\mu X$][p] background events**
  - **0.09 fb$^{-1}$ of $\mu\mu X$ triggers yields an unbiased [$\mu\mu X$] sample with equivalent statistics**
  - **Combine them with MC forward protons [p][$\mu\mu X$][p] to generate background sample**
    - Validate the suppression cuts

- The small sample will have the correct overlap backgrounds and detector effects if taken at the same luminosity as the real data set.
  - **At lower luminosity the $\mu\mu X$ triggers can be combined with an appropriate number of minbias events to create the correct overlap conditions**

- Such a data sample would allow the background level in the real slepton analysis to be predicted

# Conclusion

- Adding proton double tag information provides three useful quantities
    - **C.M. energy, C.M. P($\mu_1$), C.M. P($\mu_2$)**
        - Information on M(slepton)
        - Information on M(slepton)-M(neutralino)
        - Additional background rejection

- Background levels in the full slepton analysis can be determined with a 0.1% $\mu\mu$X sample taken at the same luminosity

# Extra slides

# Drell-Yan + 2 overlap protons

- Take a sample of Drell-Yan dimuons
  - **Add two single diffractive protons randomly chosen from the PYTHIA distribution weighted by 9.28e-4**
  - **No topological cuts**

- In the region:
  - **220 < E(C.M.) < 400 (GeV)**
  - **0 < P($\mu_1$) < 100 (GeV)**
  - **0 < P($\mu_2$) < 100 (GeV)**
  - **N(DY+fake) = 35K**
  - **N(signal) = 20**

- Ratio sets the scale of the needed topological rejection

- We are beginning a FastSim study of background rejection