Search for Long-Lived Neutral Particles with the D∅ Detector
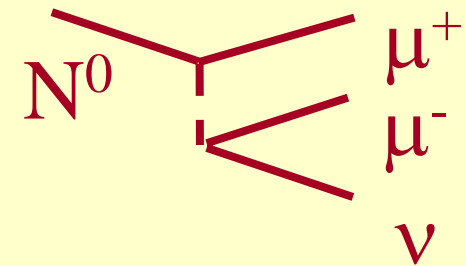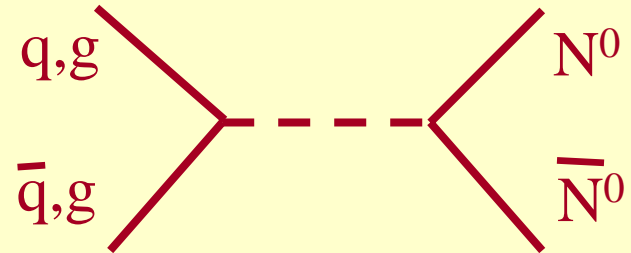
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Introduction

- Goal: search for relatively long-lived neutral particles with hadron collider experiment

- Constraints:
  - small decay region
  - no coupling to Z boson

- Motivations:
  - NuTeV dimuon excess in decay search
  - Unexplored theoretical phase space
    - e.g. uMSSM

q,g

$\bar{q},g$

N^0

$\overline{N^0}$
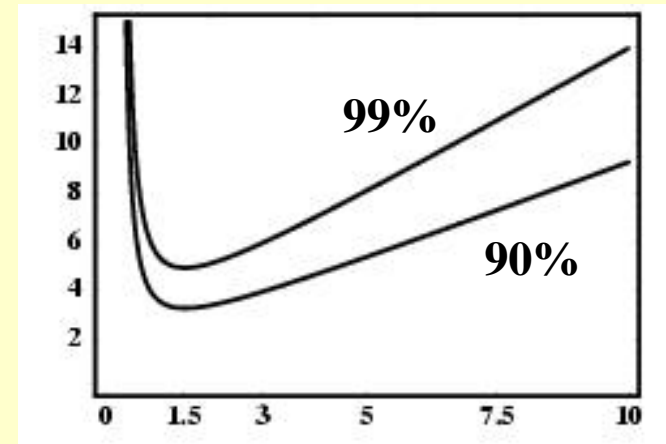
N^0

μ^+

μ^-

ν

NuTeV Neutral Particle Search

- Search for long-lived neutral particle

- Production at primary <u>proton</u> target
  - $p + p \rightarrow N^0 + N^0 + X$

- Decays in region in front of neutrino detector $N^0 \rightarrow \mu\mu\nu$

- Characteristics
  - Mass region 2.2-15 GeV
  - Long lifetime (1.6 km)
  - Weakly interacting

- Expected background: 0.07 ± 0.01

- Observed 3 $\mu\mu$ events
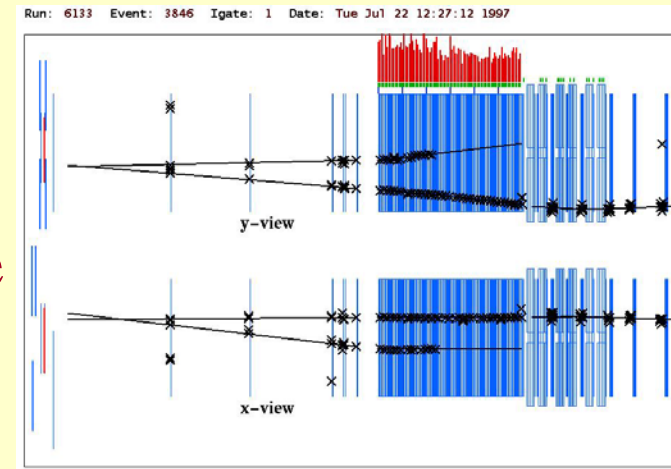
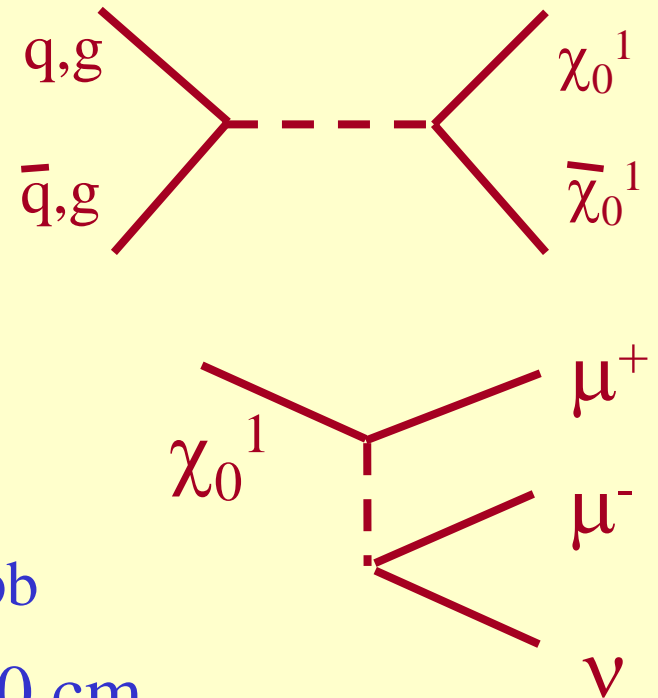Lifetime (km)

Theoretical Example

- Could be RPV unconstrained MSSM

  - $\tan\beta = 10$
  - $M_1 = 50$
  - $M_2 = 200$
  - $M_3 = 400$
  - $\lambda_{122} = 0.01$

  - $RS = 0.1$
  - $\mu = -5000$
  - $m_A = 500.0$
  - $M(\text{squark}) = 300.0$
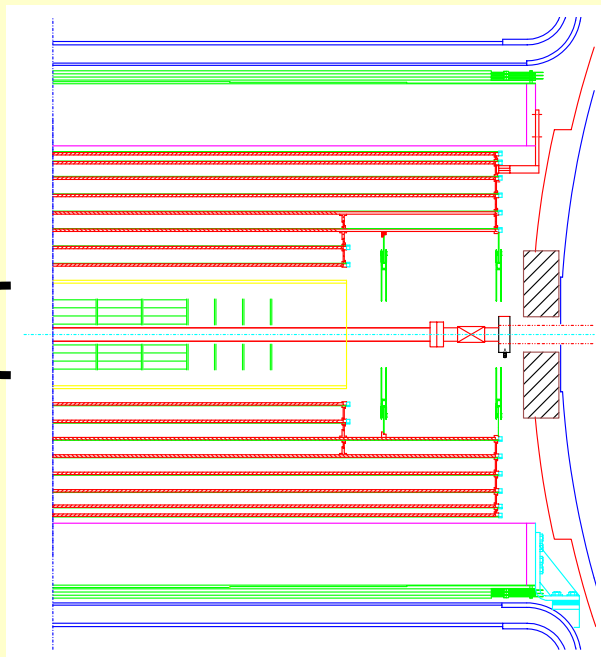 - $M(\text{other}) = 1500.0$

- Yields

  - $LSP = \chi_0^1$ $\sigma \sim 0.024$ pb
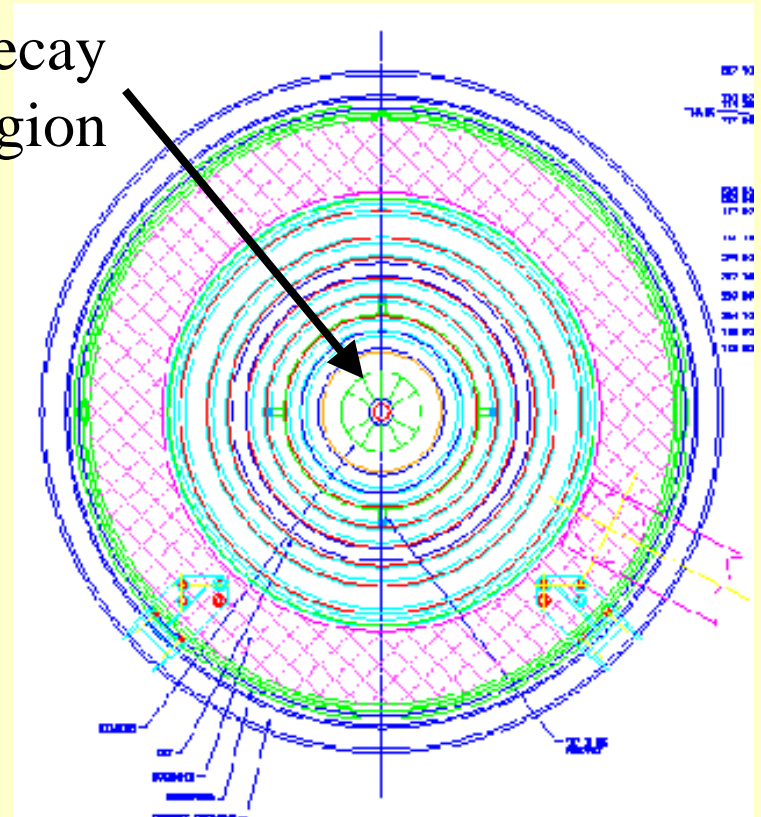 - $M(\chi_0^1) = 5.1$ GeV; $\gamma ct = 24{,}800$ cm

  use SUSYGEN for generation

DØ Experiment

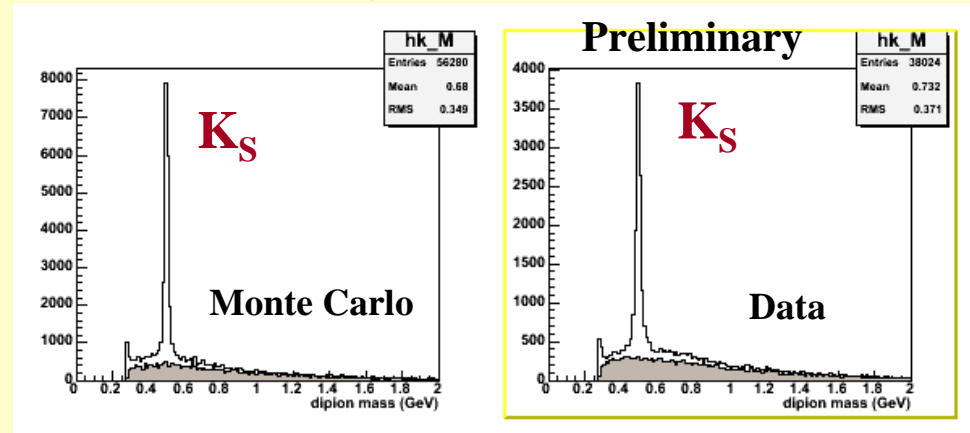- Use the volume *inside* the fiber tracker as a decay region (radius < 20 cm)

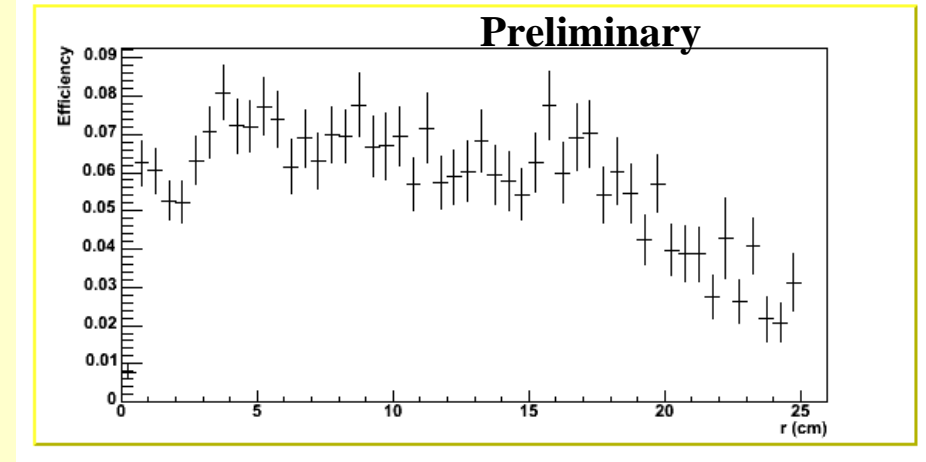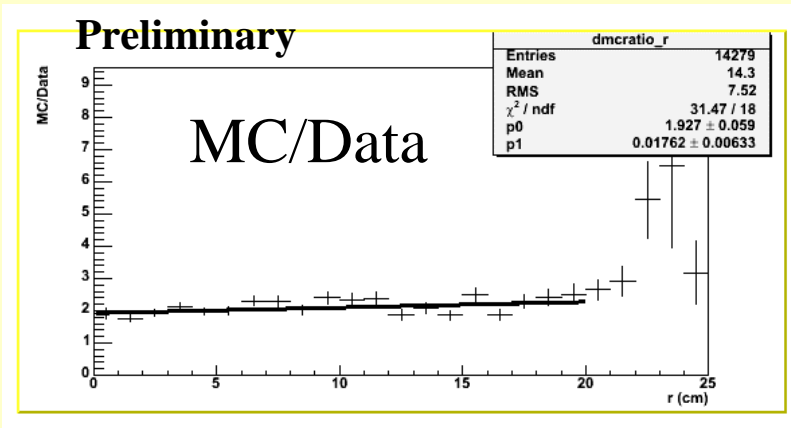Decay region

Decay region

side view

end view

K_S Signal

Invariant Mass

- Use K_S to demonstrate ability to vertex at large radius
  - fit pairs of central tracks

K_S — Monte Carlo

Preliminary K_S — Data

Efficiency vs. radius

Preliminary

MC/Data

radius (cm)

Preliminary

radius (cm)

We can reconstruct vertices out to 20 cm

Dimuon Data Sample

- Data set: August 2002 – August 2004
- Require dimuon trigger
- At least 2 muons with
  - central track match (at least 14 CFT hits)
  - $\chi_{track}^2 < 4$
  - calorimeter isolation $E_{0.1<R<0.5} < 2.5$ GeV
  - $p_T(\mu) > 4$ GeV
  - reject cosmic rays (timing cut)
- Perform vertex fit for all muon pairs in each event
- Require vertex $\chi^2 < 4$

$$387 \text{ pb}^{-1} \text{ integrated luminosity}$$

Dimuon Invariant Mass
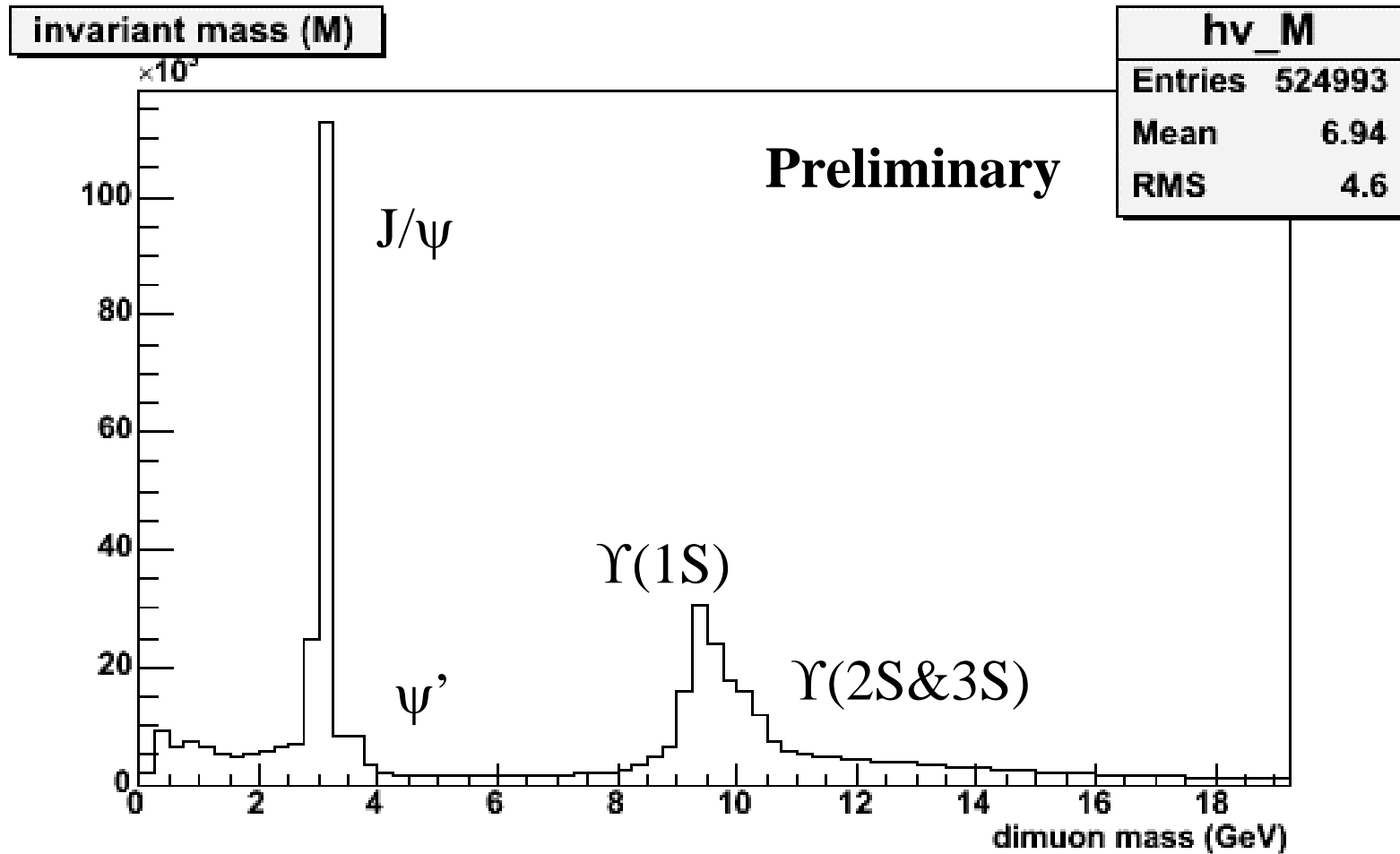
Signal Selection

- Additional criteria:
  - opening angle < 0.5 radians
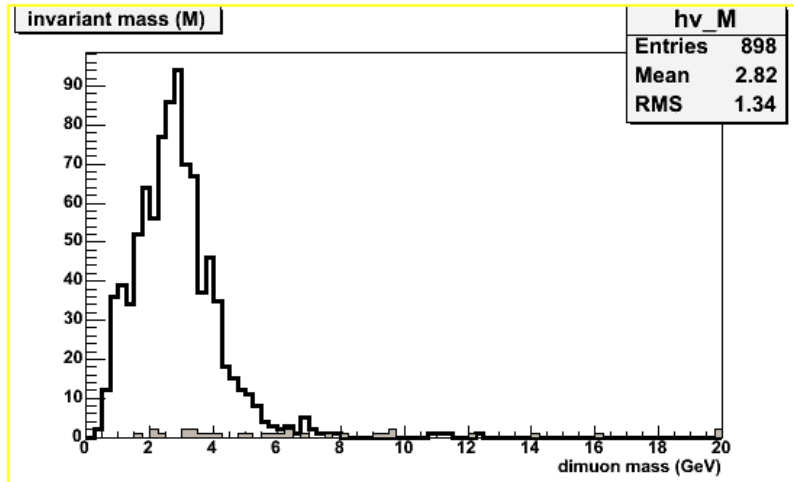 - $r/\sigma_r > 6$ $r = \sqrt{(v_x - v_x(PV))^2 + (v_y - v_y(PV))^2}$
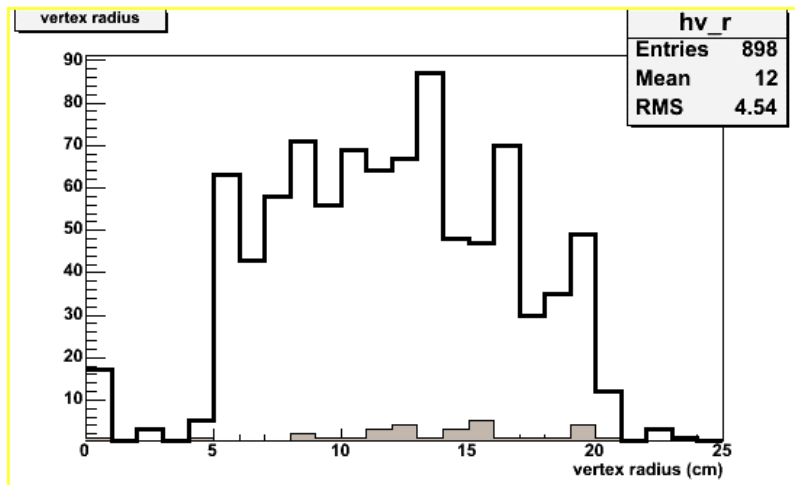 - $5 < r < 20$ cm   PV = primary vertex

Signal Simulation

- Run SUSYGEN – RPV unconstrained MSSM
- Require one N^0 to decay within $r = 5$-20 cm
  - Account for decay probability separately
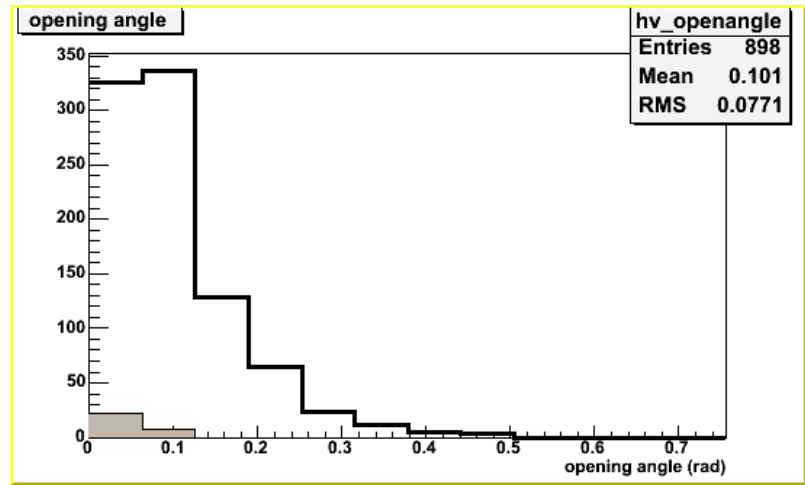- Allow $N^0 \rightarrow \mu\mu\nu$, $\mu e \nu$, $ee\nu$
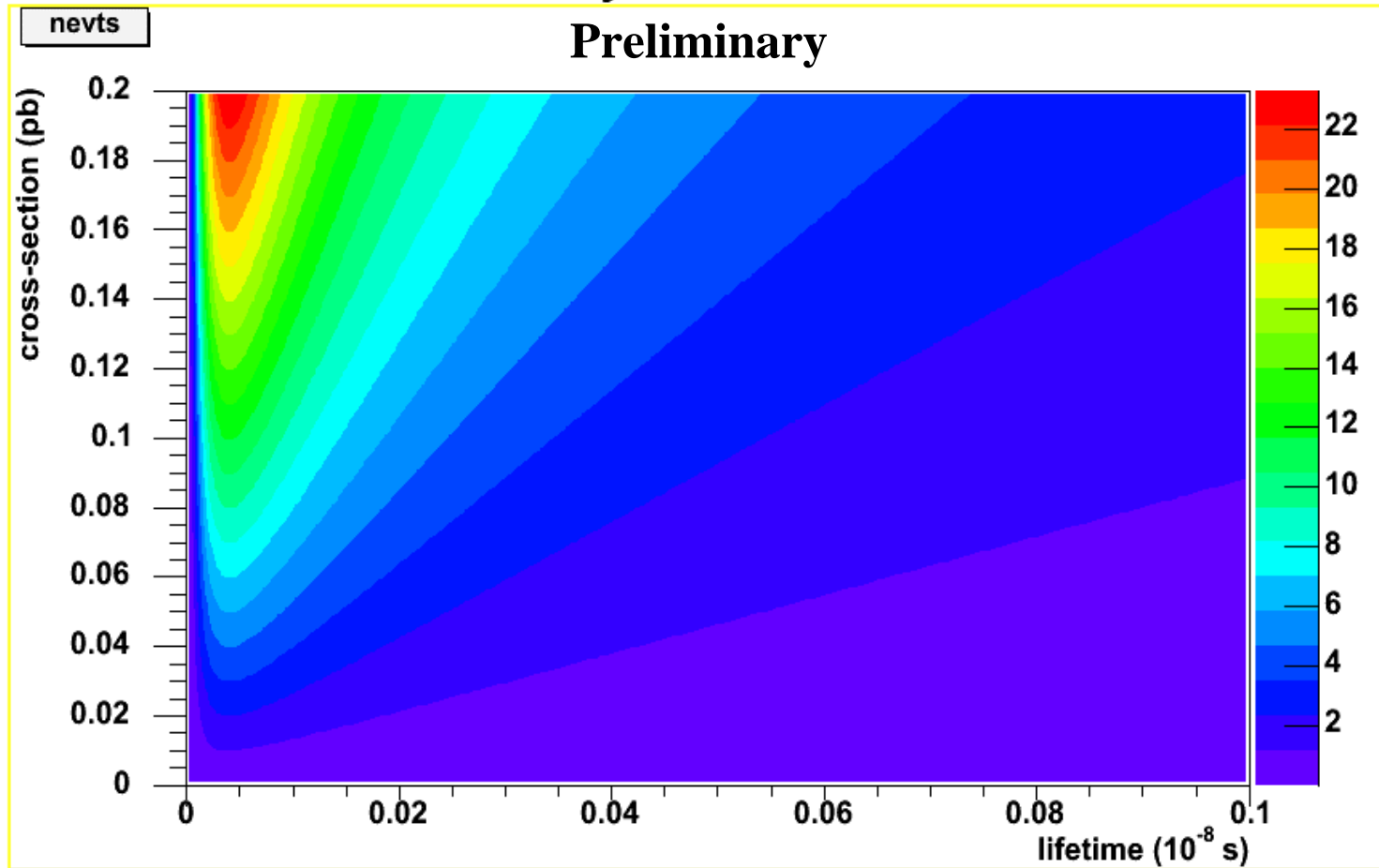
Signal Study

invariant mass (GeV)

radius (cm)

opening angle (radians)

DØ Sensitivity

387 pb^{-1} using acceptance from SUSYGEN MC

Summary

- DØ has the ability to reconstruct vertices at large radial displacement

- Tevatron's high energy and luminosity allow probes of new theoretical phase space

- We have a new analysis technique to search for long-lived neutral particles produced in $p\bar{p}$ collisions

NuTeV's Three Events