
MY CUBICLE IS SURROUNDED BY LOUD IDIOTS WHO MAKE IT IMPOSSIBLE FOR ME TO CONCENTRATE ON MY WORK.
Dilbert.com DilbertCartoonist@gmail.com
DID YOU CREATE A PRESENTATION ON WHY YOU COULDN'T DO THE PRESENTATION YOU'RE SUPPOSED TO BE DOING?
YES
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WOULDN'T IT HAVE BEEN JUST AS EASY TO CREATE THE ACTUAL PRESENTA-TION?
I'M HOPING TO USE THIS ONE MORE THAN ONCE.

No CHAMPs at DØ

Flip Tanedo

Presenting: 0809.4472

7 December 2009

Physics 7661, Fall 2009

Collider Physics

Cornell University

WTF is a CHAMP

Kobe Bryant

- 4x NBA CHAMPion
- 2009 NBA Finals MVP
- 2008 NBA MVP
- 11x NBA All-Star
- 2x scoring CHAMPion
- 1997 Slam Dunk CHAMPion

Game-winning buzzer-beating 3-point shot last Friday against the Miami Heat. LAL 108, MIA 107.

WTF is a CHAMP

Experimentalist definition

- Long-Lived Charged Massive Particle
- Massive Metastable Charged Particle
- Heavy Stable Charged Particle
- Charged Massive Stable Particles

Summary: charged shit that makes it out of the collider before decaying

WTF is a CHAMP

Standard Model examples

- Approximately conserved quantum number
  e.g. electron, proton
- Suppressed effective coupling
  e.g. muon (e.g. $\mu \to e\gamma$... man, I hate that process)
- Suppressed phase space
  e.g. neutron (I know: not charged, STFU)

WTF is a CHAMP

Theorist's definition

- GMSB: gravitino LSP, so NLSP may be charged
  e.g. third-generation sfermion (stau)
- AMSB: with $M_2 \ll M_1 \ll M_3$,
  small splitting between χ^+ and χ^0
- Focus point CMSSM: $M_{1,2} \gg \mu$, degenerate
  Higgsino LSP and Higgsino-lke NLSP
- Split-SUSY: very large squark mass
  metastable gluino

WTF is a CHAMP

Collider definition

Let's make some simplifying assumptions

- Only consider electric charge
- Colored charges are a different story (R-hadron)
- Also assume CHAMPs are pair produced
  i.e. ignore cascade decays (for simplicity)

Pair production: LEP gives a model-independent-ish
$M > 100$ GeV bound from $Z \to (\text{CHAMP})^2$

WTF is a CHAMP
Collider definition

Signature looks just like a heavy muon

- Muon chamber hit with associated ECAL tracks

1. Large invariant mass (& high p_T)
2. Slow velocity (time of flight measurement)

Time of flight? We can measure that?

The Muon System

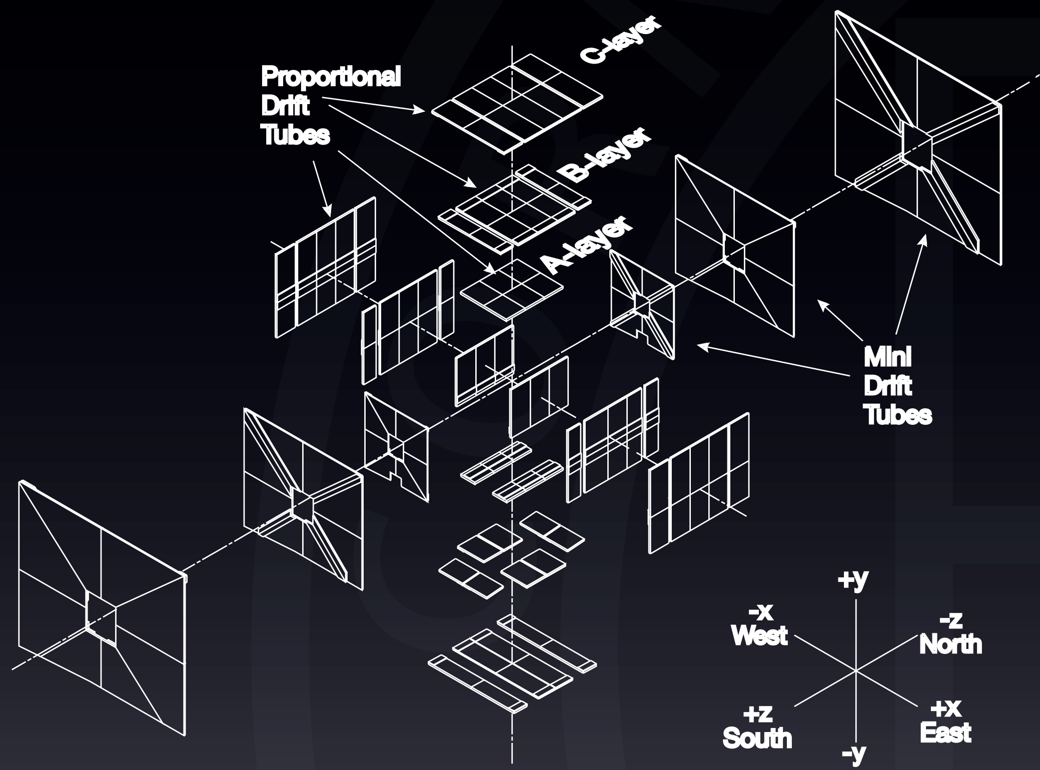
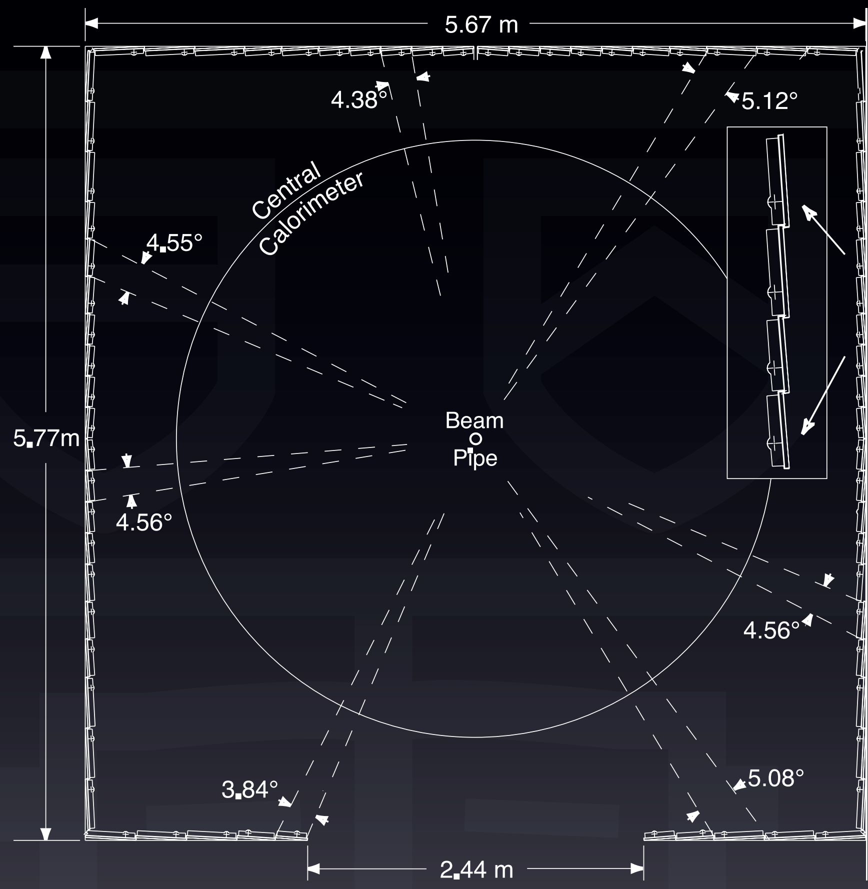


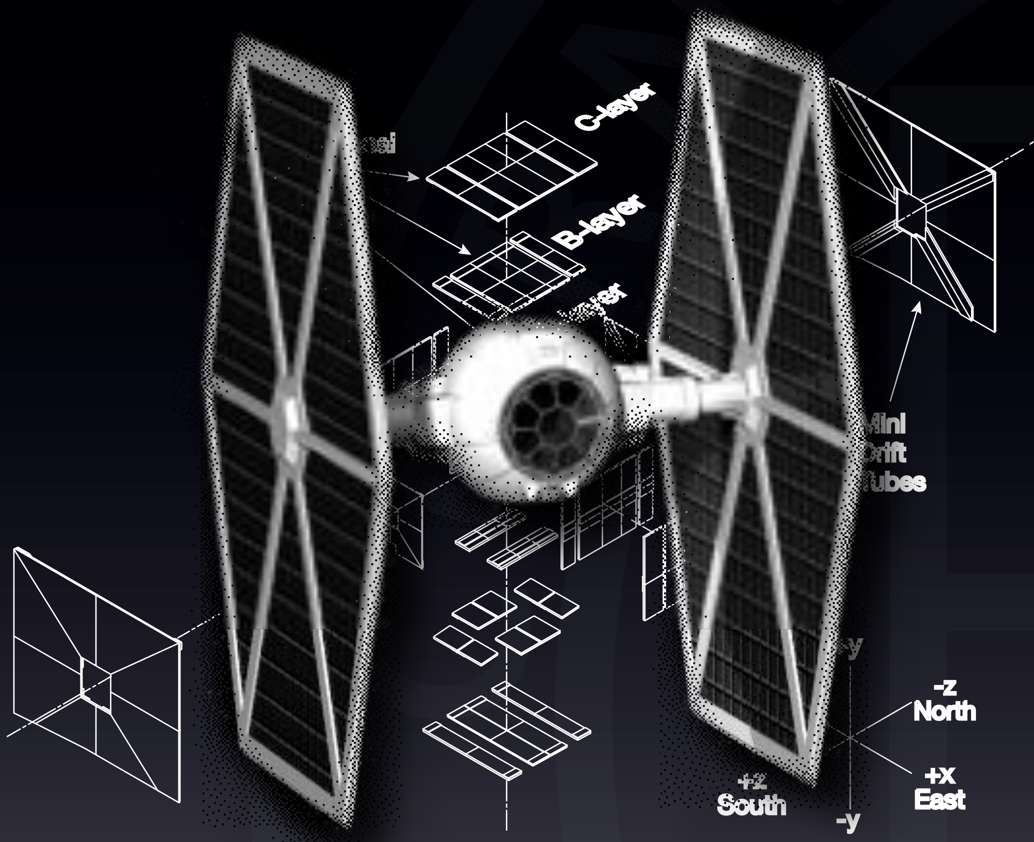
Fig. 44. Exploded view of the muon wire chambers.



Different times of flight for particles at different polar angles are compensated for by varying cable lengths since the front-end electronics do not allow such timing adjustments.

Source: D0 Run II TDR, Nucl.Instrum.Meth.A565:463-537,2006; arXiv:physics/0507191

The Muon System



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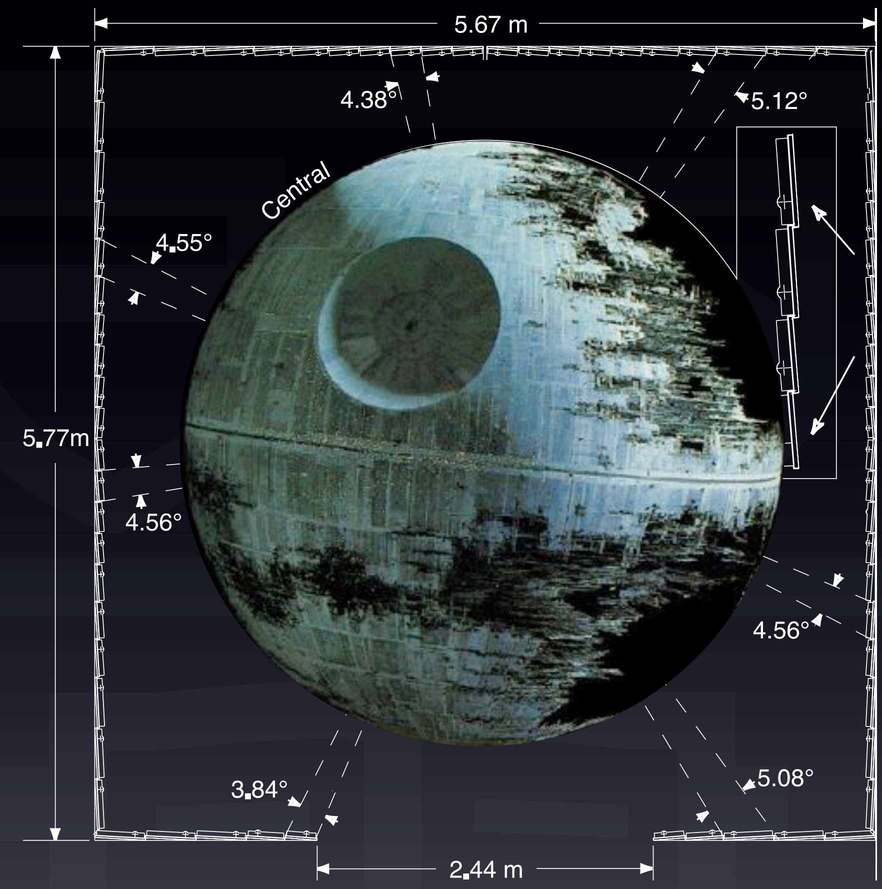

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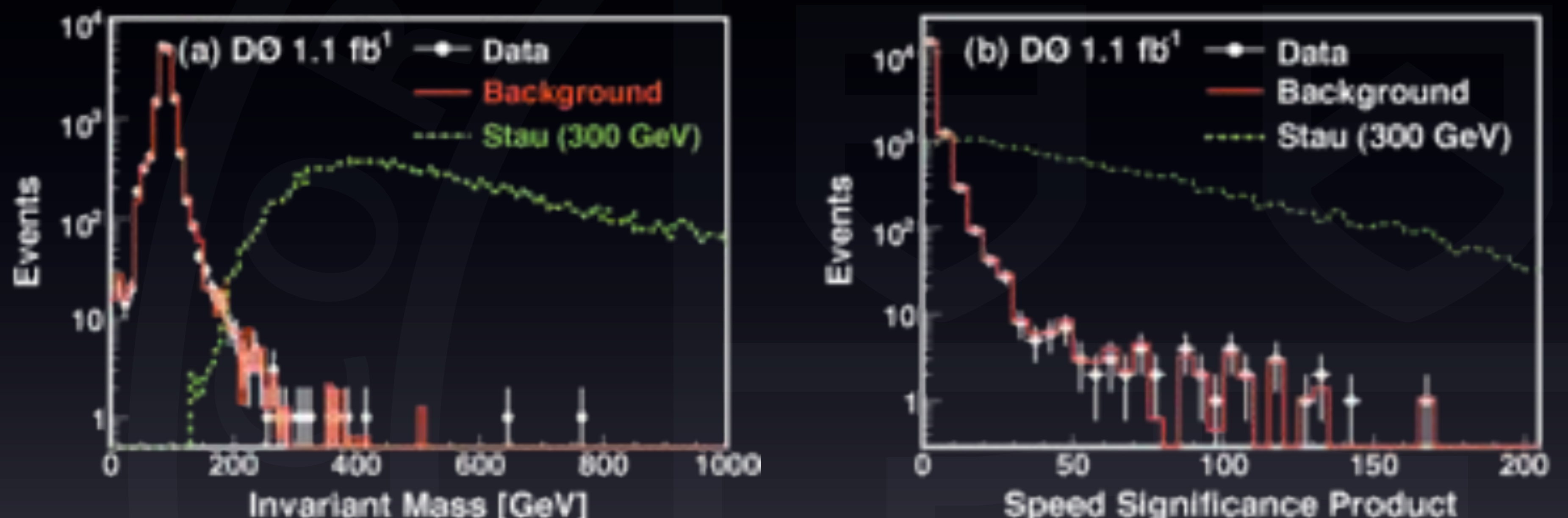
Cuts and BG

- 2 "muons" with $p_T > 20$ GeV
- At least one track is 'collimated' (E_T, p_T)
  Reducible BG: mesons
- Acolinear, outward moving muons
  Reducible BG: cosmic rays (very bad!)
- Sufficiently close to the beamline
  Reducible BG: Bs, beam halo, cosmic rays
- Irreducible BG: mismeasurements

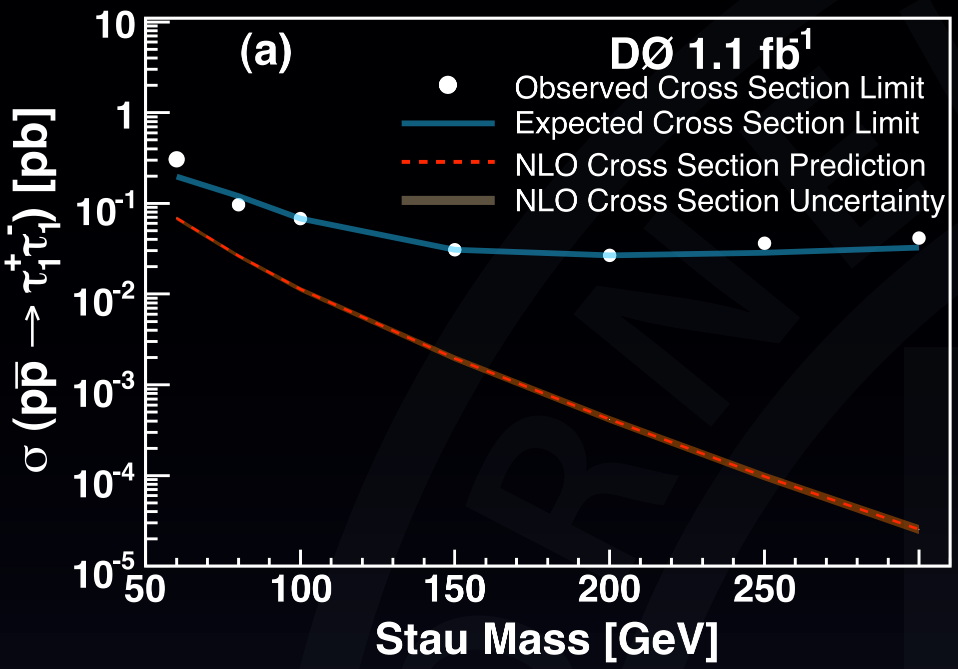
Background Simulation

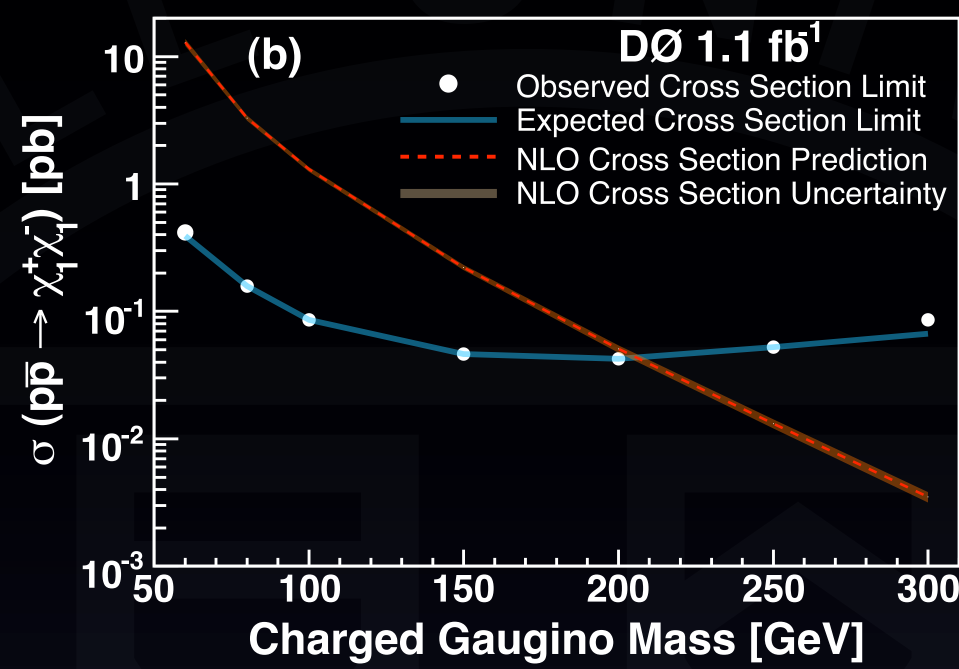
- Randomly combine separate distributions of invariant mass and velocity
  Central tracker is *independent* of muon chamber
- Velocity BG: ‘events’ invariant mass in Z peak: 70 - 110 GeV, passes other cuts
  This is why the pair production assumption is useful
- Invariant mass BG: negative velocity events
- Subtle: modeling BG from the data itself.
  Chosing randomly from separate data sets gives us decorrelated background simulation.

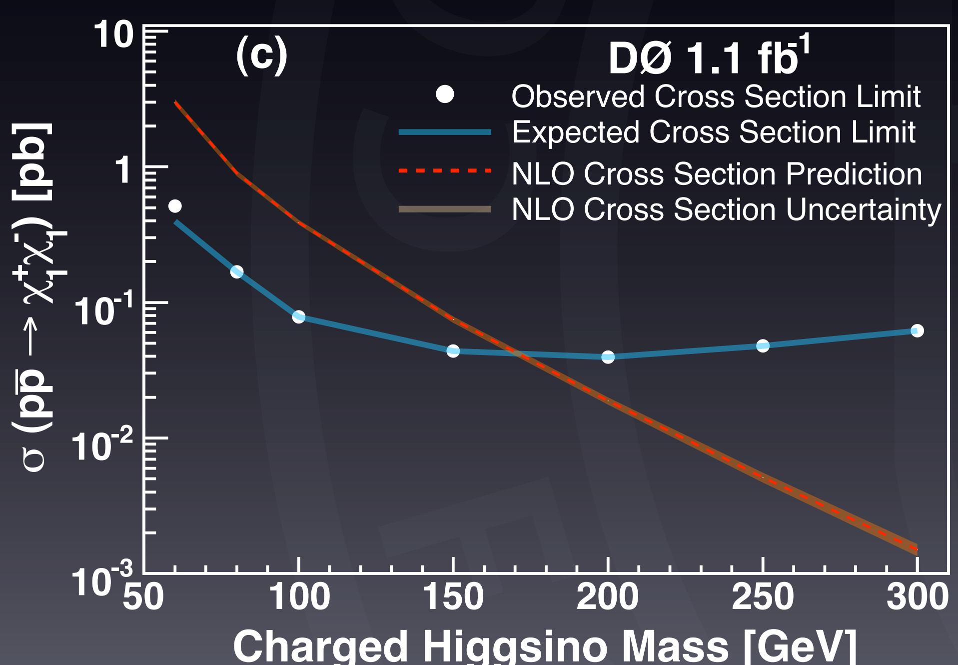
Data vs. Monte Carlo



$$(1-\overline{v})/\sigma_{\overline{v}}$$

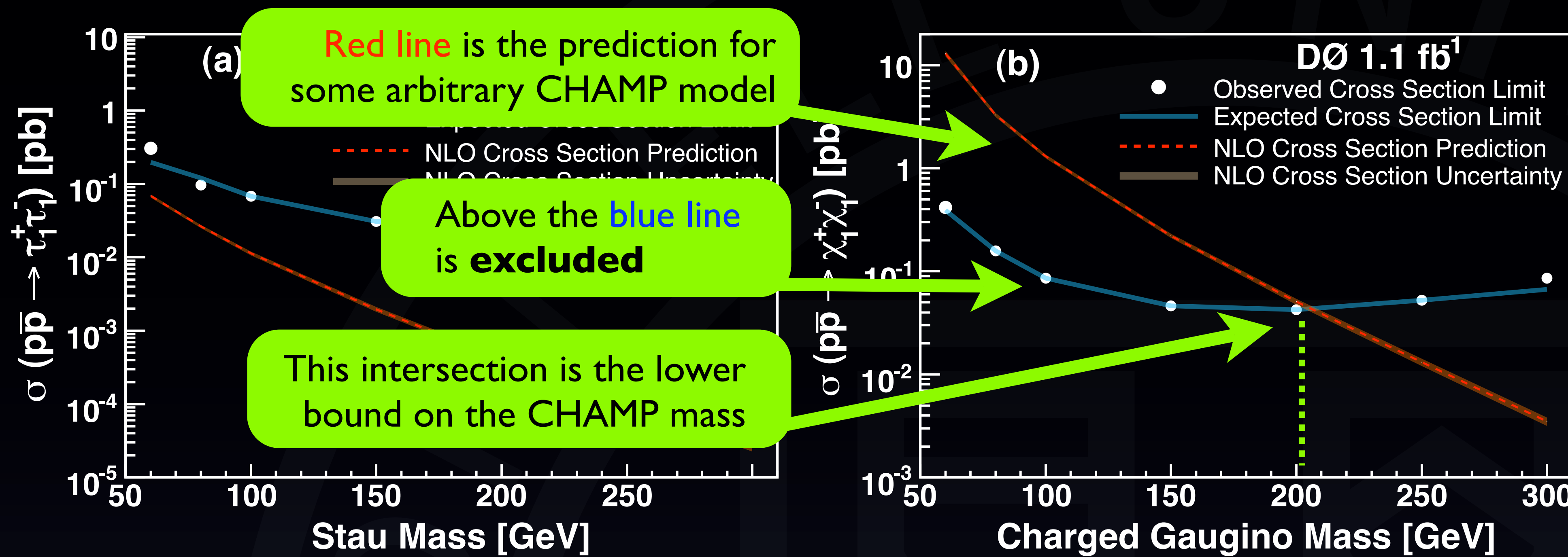


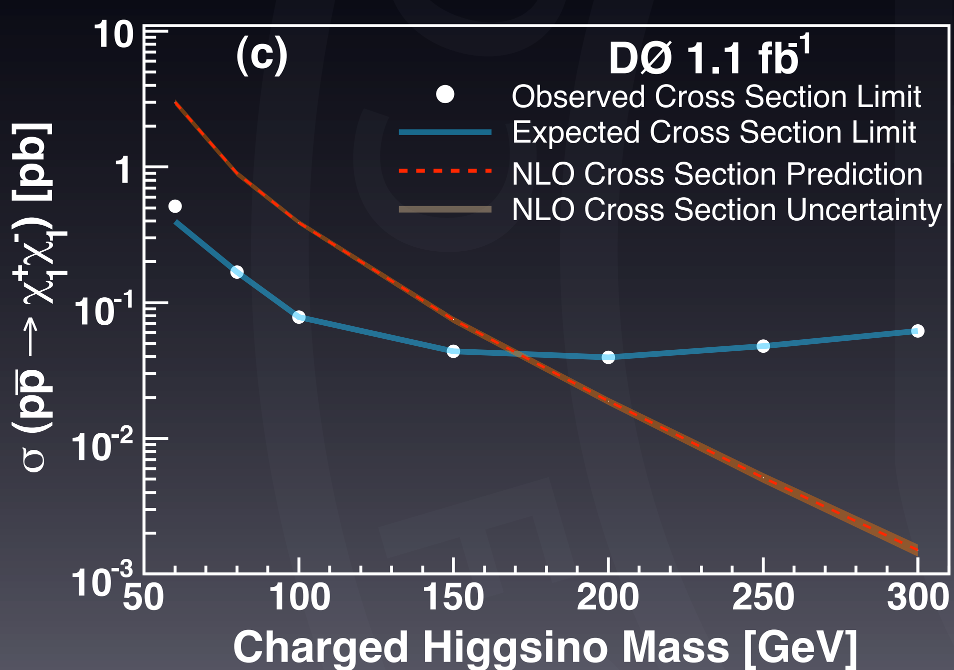




e.g. Stau CHAMP

M(GeV)	Signal	BG	Obs
60	4.7	30.9 ± 3.9	38
100	0.7	1.6 ± 0.8	1
200	0.1	1.7 ± 1.0	1
300	0.004	1.9 ± 0.7	3





e.g. Stau CHAMP

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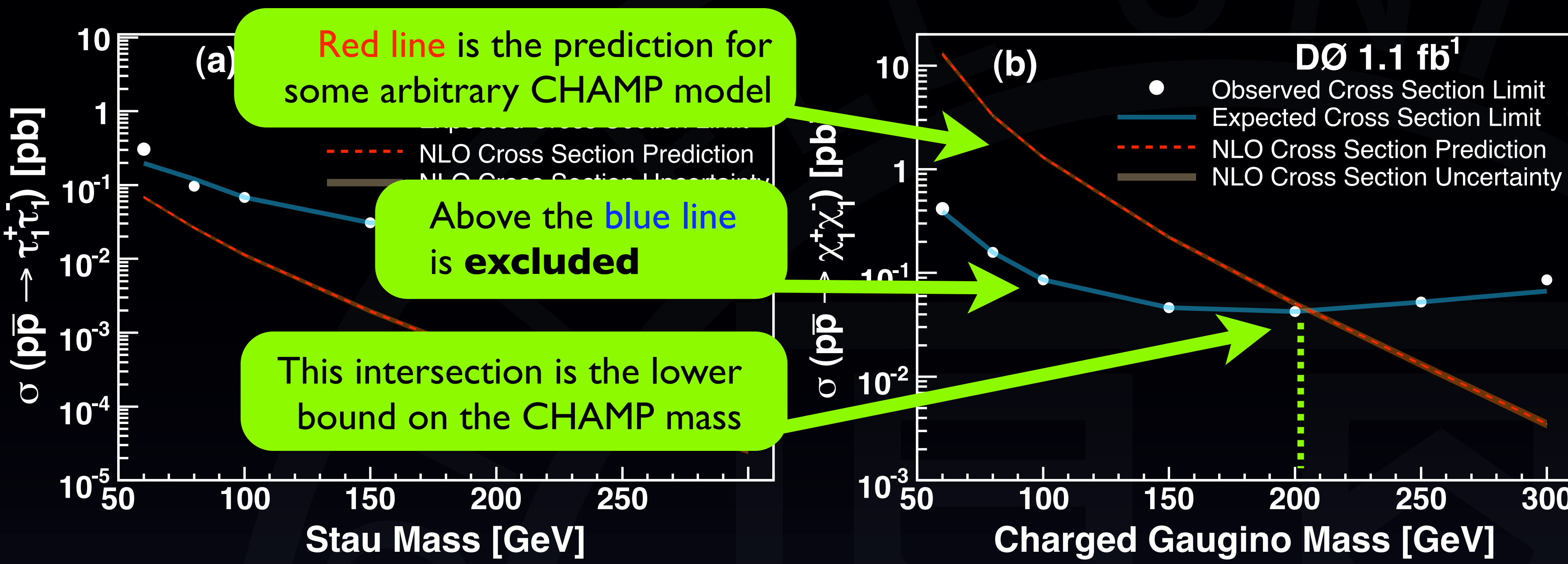
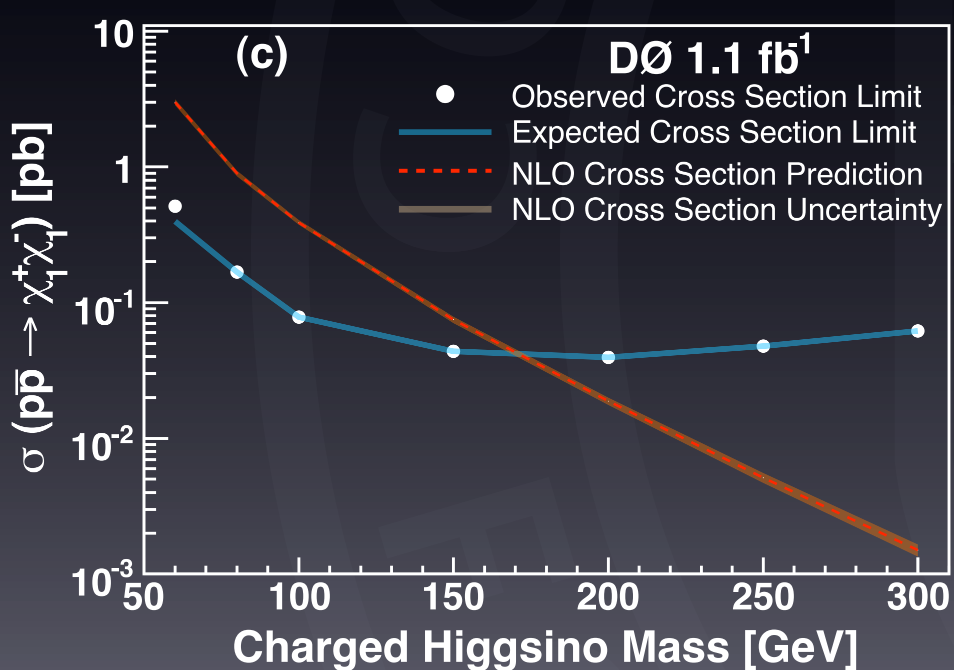




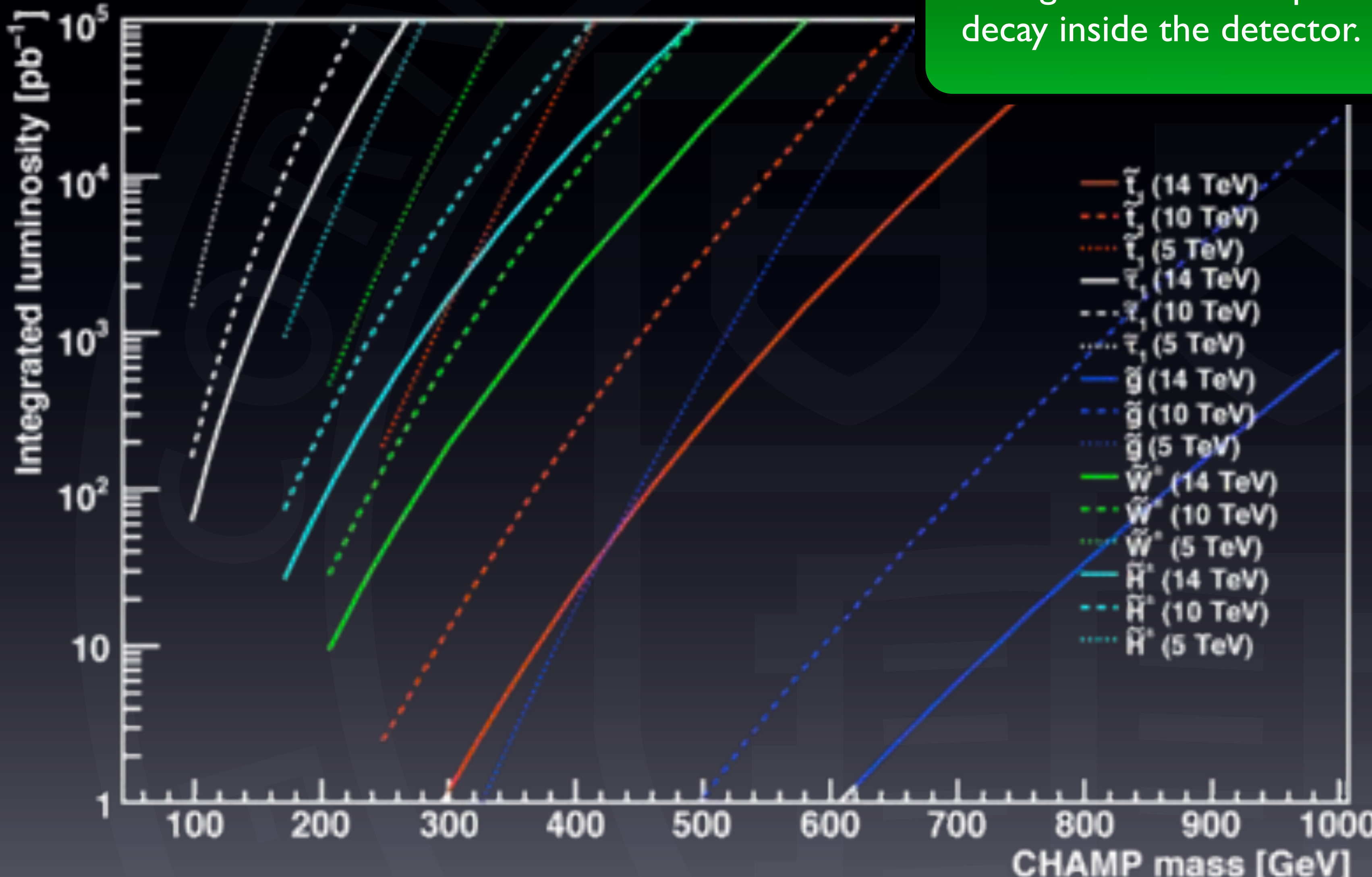
e.g. Gaugino CHAMP

M(GeV)	Signal	BG	Obs
60	445	23.6 ± 3.3	24
100	65	1.6 ± 0.8	1
200	5	1.9 ± 0.5	1
300	0.2	1.7 ± 0.6	2

EXTRA SLIDE

LHC?

In some regions, LHCb might be able to do better due to particle ID. E.g. medium-lived particles that decay inside the detector.



Raklev, 0908.0315

EXTRA SLIDE

Bethe-Bloch

Signatures depend on interaction with detector

CHAMP charge

Max possible KE transfer

depends on β

$$\langle -\frac{dE}{dx}\rangle = \frac{Kz^2Z}{A\beta^2}\left(\frac{1}{2}\ln\frac{2m_ec^2\beta^2\gamma^2T_{\max}}{I^2} - \beta^2 - \frac{\delta}{2}\right)$$

CHAMP velocity

- Energy loss is almost independent of CHAMP mass
- So we can use the tracking system and treat CHAMP as μ
- p measurement in central tracker +
  β measurement from μ system = m measurement
- But: software assumes β=1, track fit is poor for β<0.75
  Can treat β as an additional fit parameter, good to β>0.5

Raklev, 0908.0315

EXTRA SLIDE

Other CHAMPs

- UED with KK-parity
- RS with GUT-parity
- DSB (quantum numbers)
- Leptoquarks
- Additional generations
- Magnetic Monopoles

EXTRA SLIDE

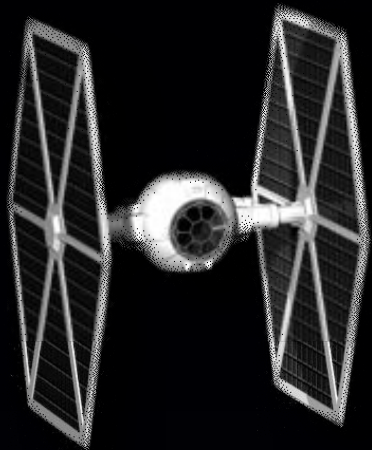
CHAMP Cosmology

- Hard to get a viable dark matter CHAMP
- Strong constraints from, e.g, BBN, CMB, ...
  CHAMP decay injects energetic particles into the plasma, abundance of light elements
- A CHAMP @ LHC would require model building to dilute its early universe density

EXTRA SLIDE

Other Ideas

- Slepton trapping in water tanks
  Feng hep-ph/0405278 (colliders)
  Byrne hep-ph/020252 (cosmic rays)
- R-hadrons: CHAMPs + quarks
  Interactions with nuclei mainly due to quark. Can swap quarks, change electric charge.



Happy Winter Break!

References

- DØ, 0809.4472
- CDF note 8701
- Fairbairn et al, hep-ph/0611040
- Raklev, 0908.0315
- Feng & Smith, hep-ph/0409278