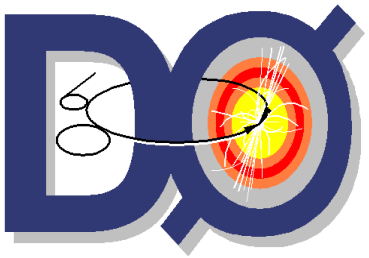
Searches for BSM signatures at the Tevatron

Andy Haas
SLAC National Accelerator Laboratory / Columbia University

for the DØ and CDF Collaborations

DPF 2009 - Wayne State University
July 27, 2009

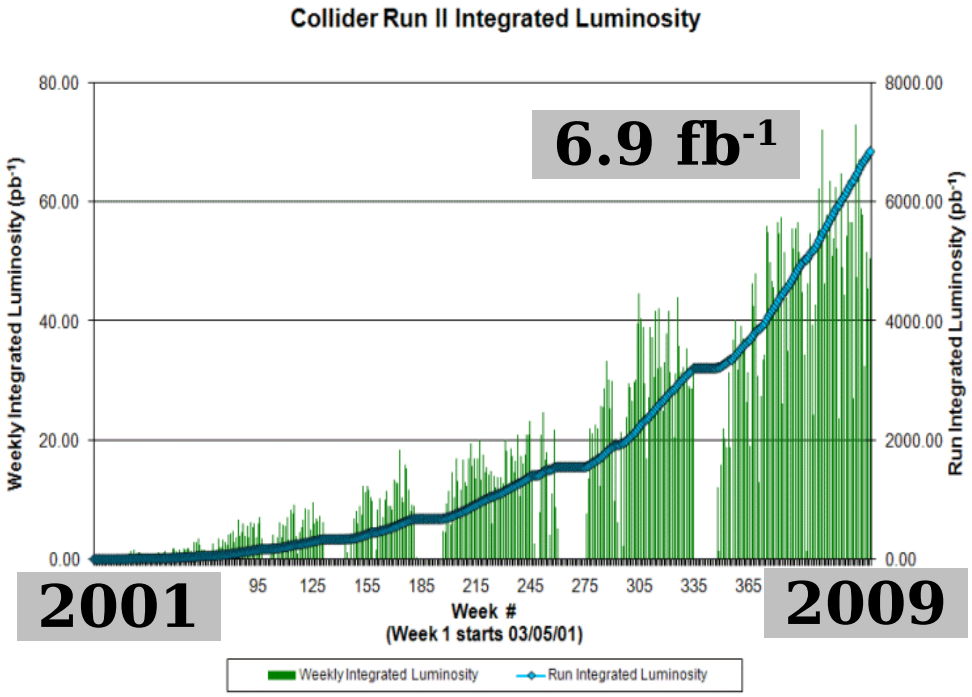


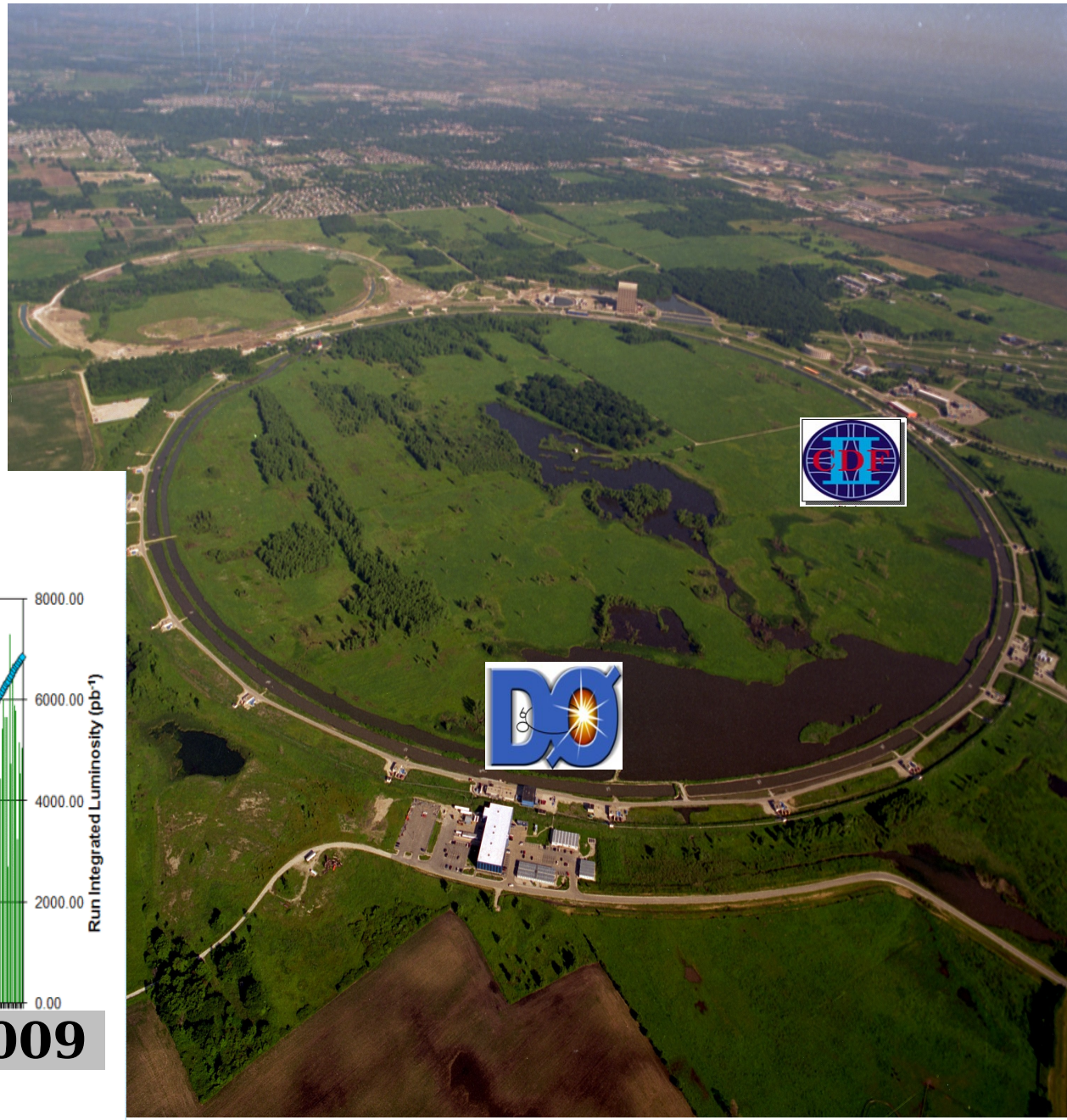
Fermilab Tevatron

$p\bar{p}$ @ 1.96 TeV

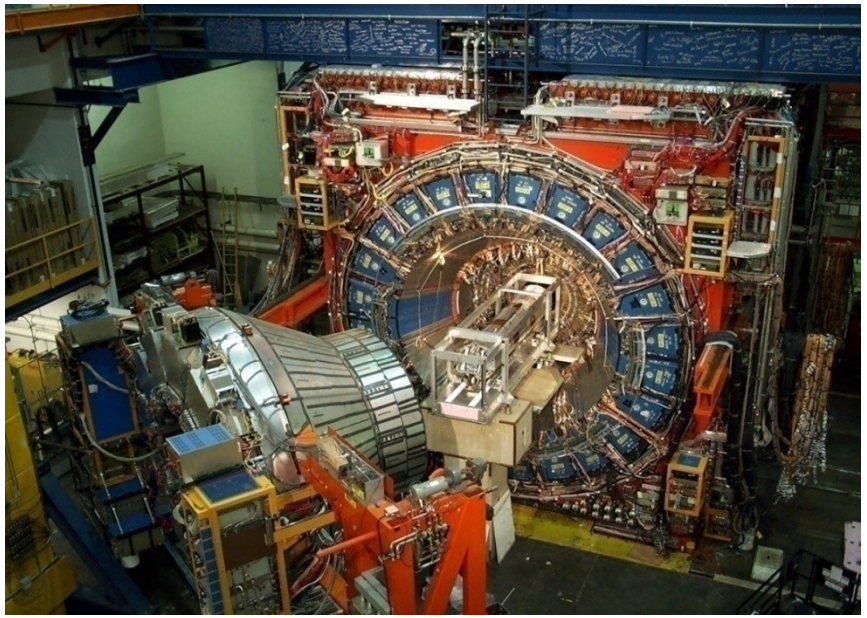
Now >2 fb^{-1}/year

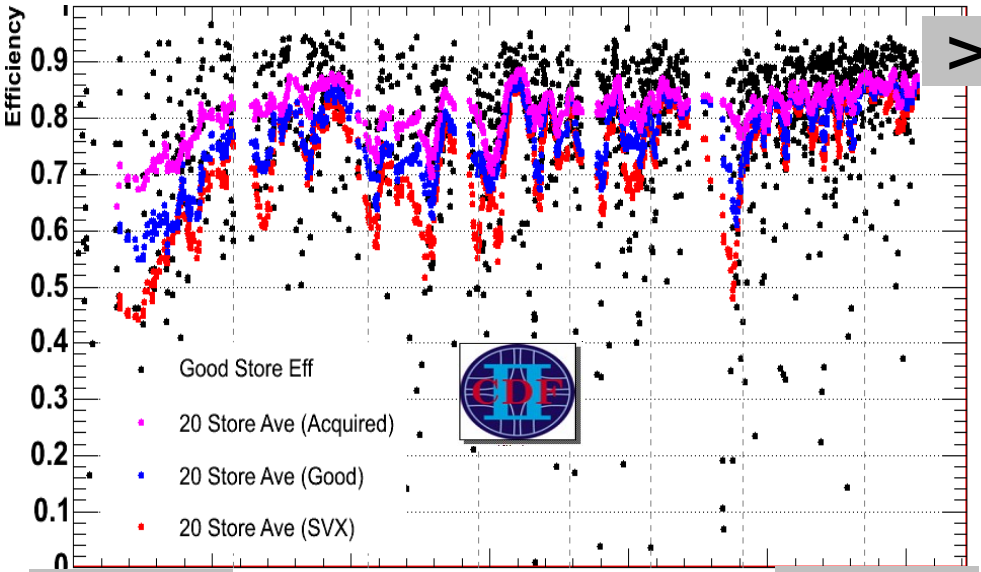
Still the energy frontier!



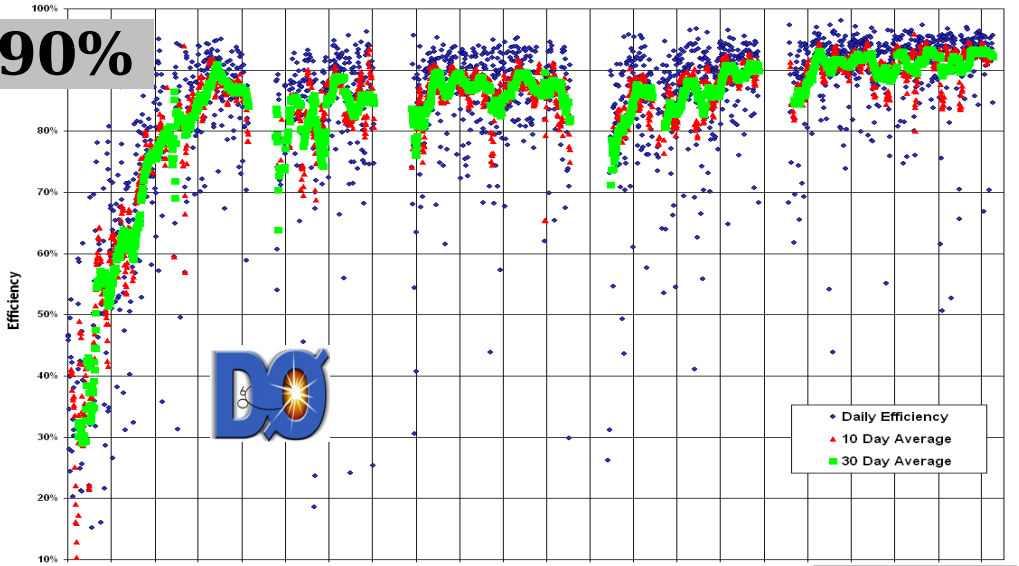


CDF and DØ Detectors





>90%



2001 2009 2001 2009

“Beyond the SM”

Well-motivated extensions of the SM
- *SUSY, Large Extra Dimensions, ...*

Natural extensions of the SM
- *Lepto-Quarks, 4th Gen., W'/Z', H. Valley, ...*

New, weird particles (or un-particles)
- *Long-lived, quirks, lepton-jets, ...*

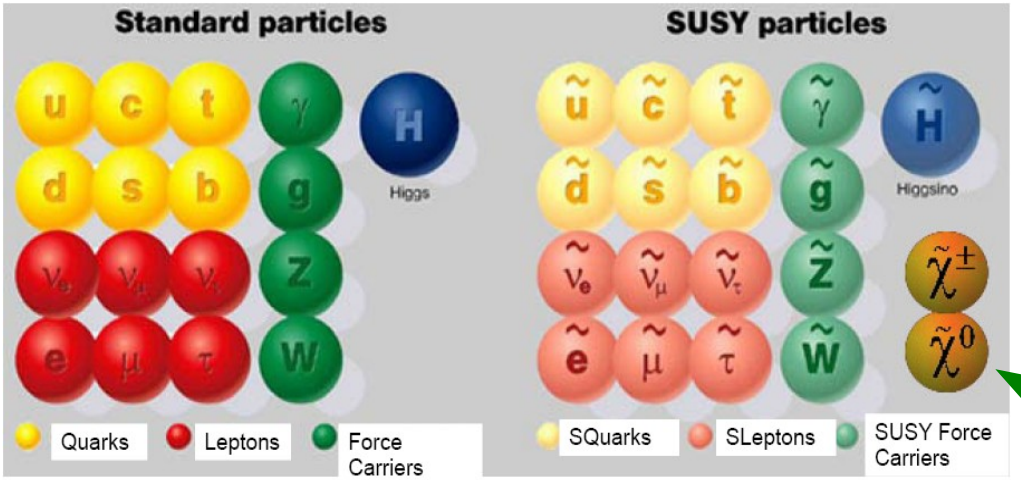
BSM Higgs
- *MSSM, **N**MSSM, fermiophobic, ...*

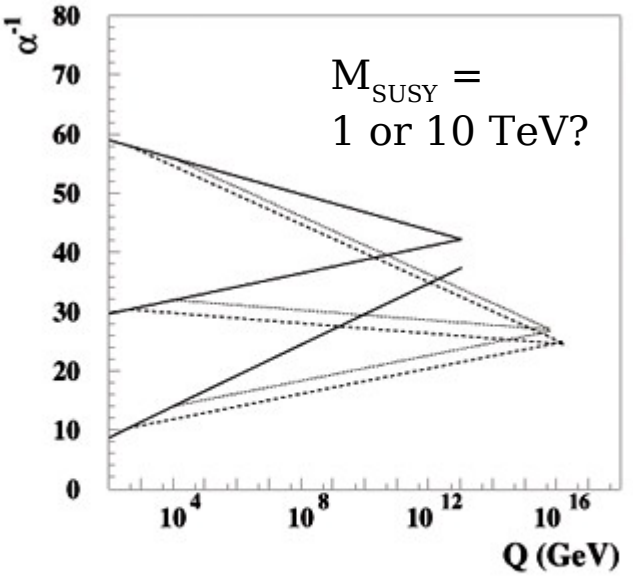
Indirect evidence
- *Rare decays, $B_s \to \mu\mu$, B_s mixing phase, ...*

None of the above : model-independent, ... ?

SUSY

Still the most popular theory
(despite hiding for >30 years!)



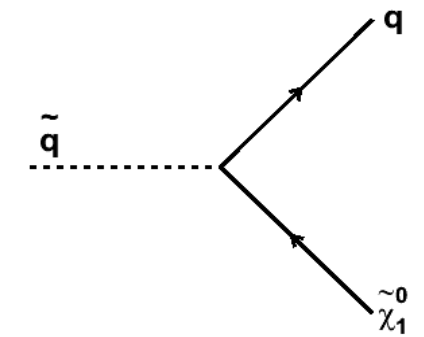


Signatures depend on SUSY *breaking*
Usually there's MET (dark matter!)

Look for excess of MET +
jets, b/c-jets, leptons, photons

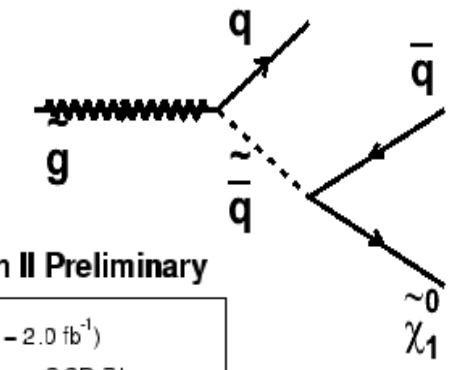
(of course we do RPV too...)

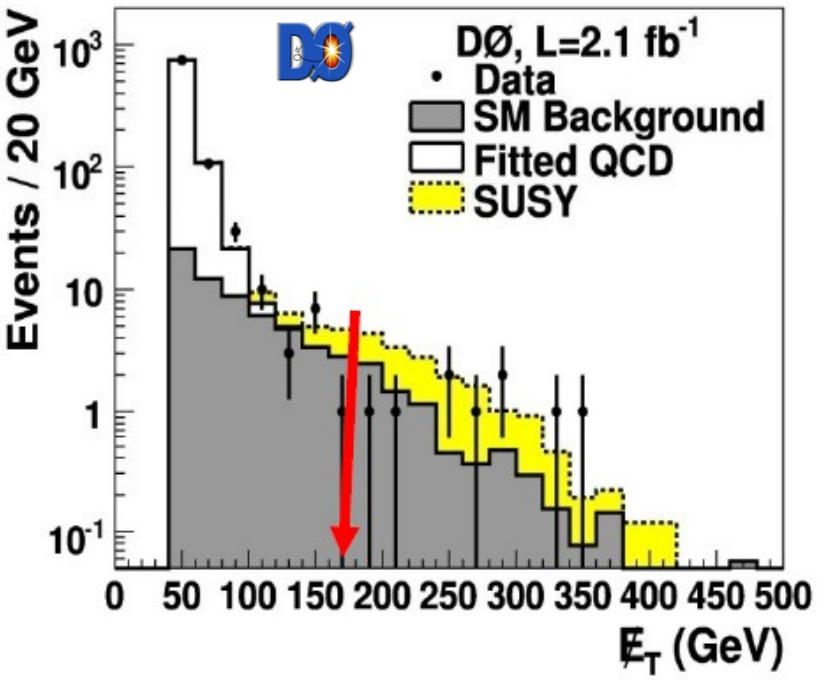
Squarks / Gluinos

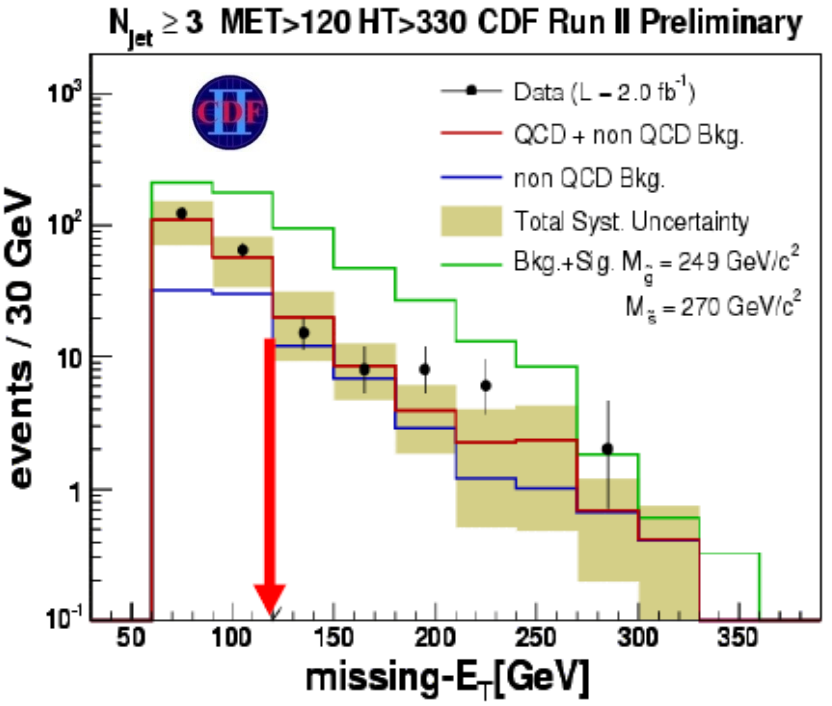


2, 3, or 4 jets + MET

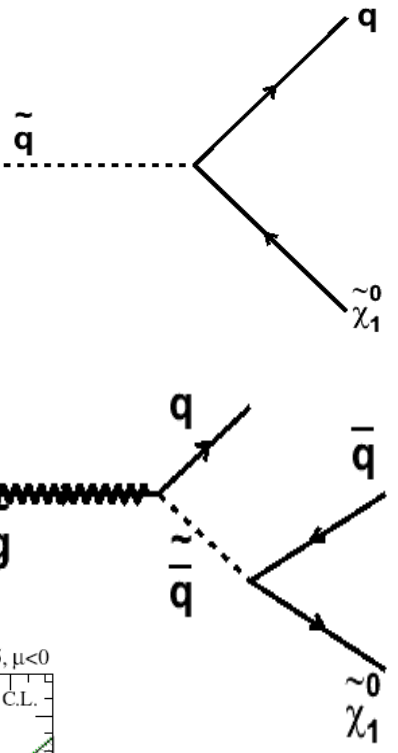
- $qq \rightarrow qq\chi_1^0\chi_1^0$ $(m_q < m_g)$
- $qg \rightarrow qqq\chi_1^0\chi_1^0$ $(m_q \sim m_g)$
- $gg \rightarrow qqqq\chi_1^0\chi_1^0$ $(m_q > m_g)$







Squarks / Gluinos



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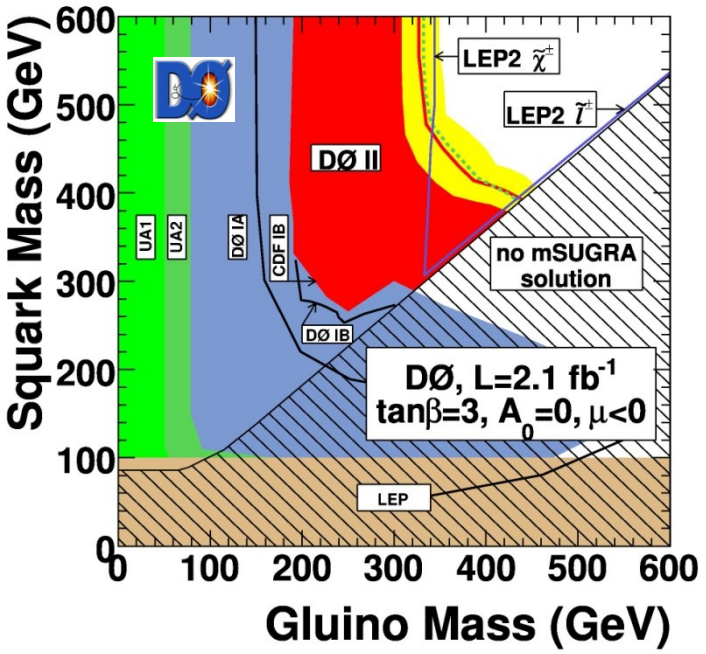
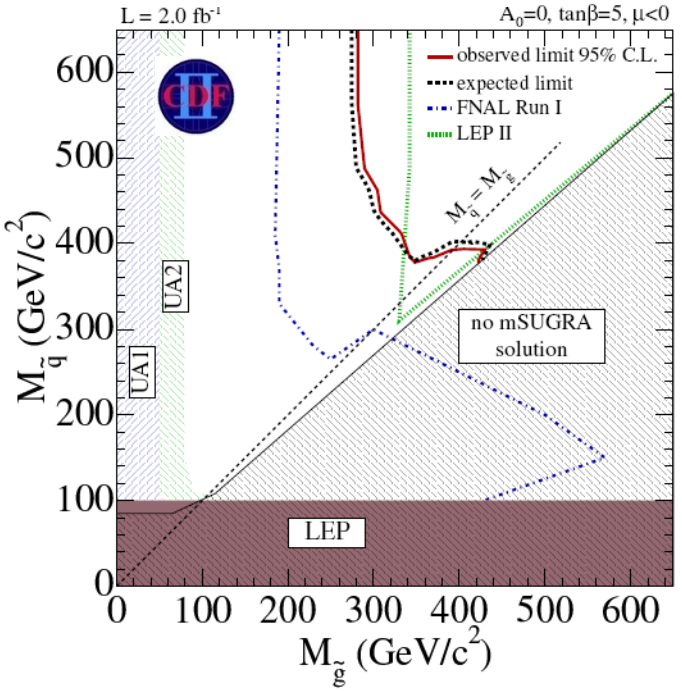
Sergey Uzunyan - Later this session

arXiv:0712.3805



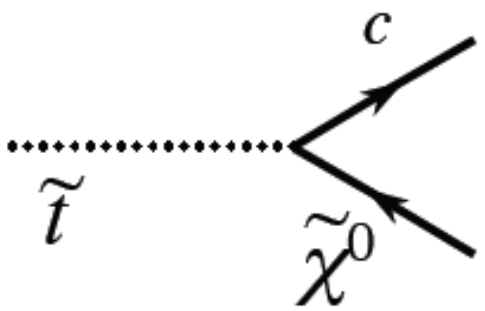
arXiv:0811.2512



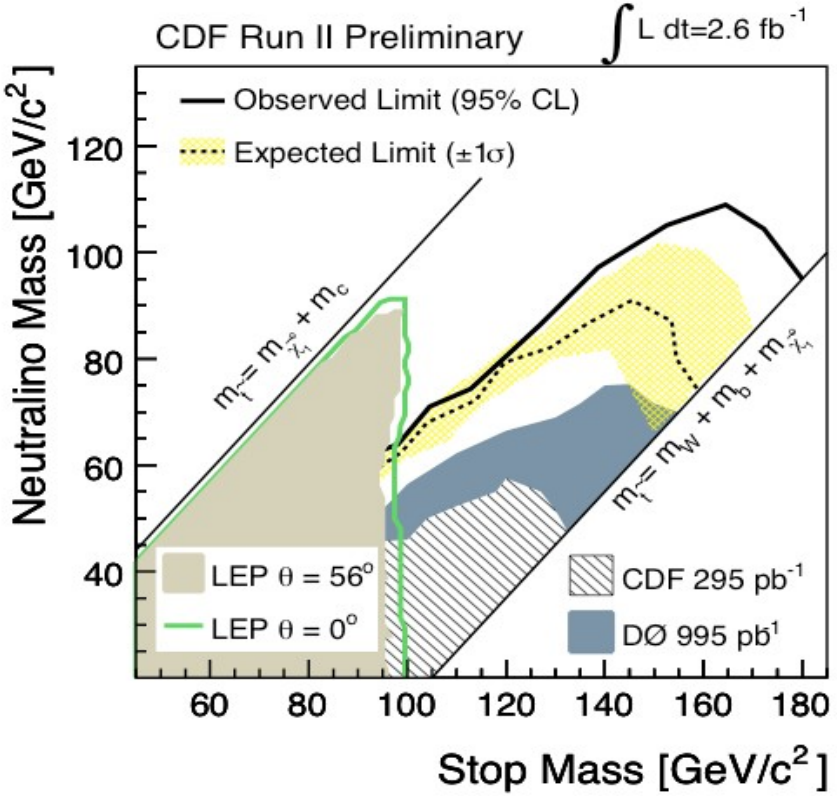
2/fb: squark / gluino masses > ~400 GeV

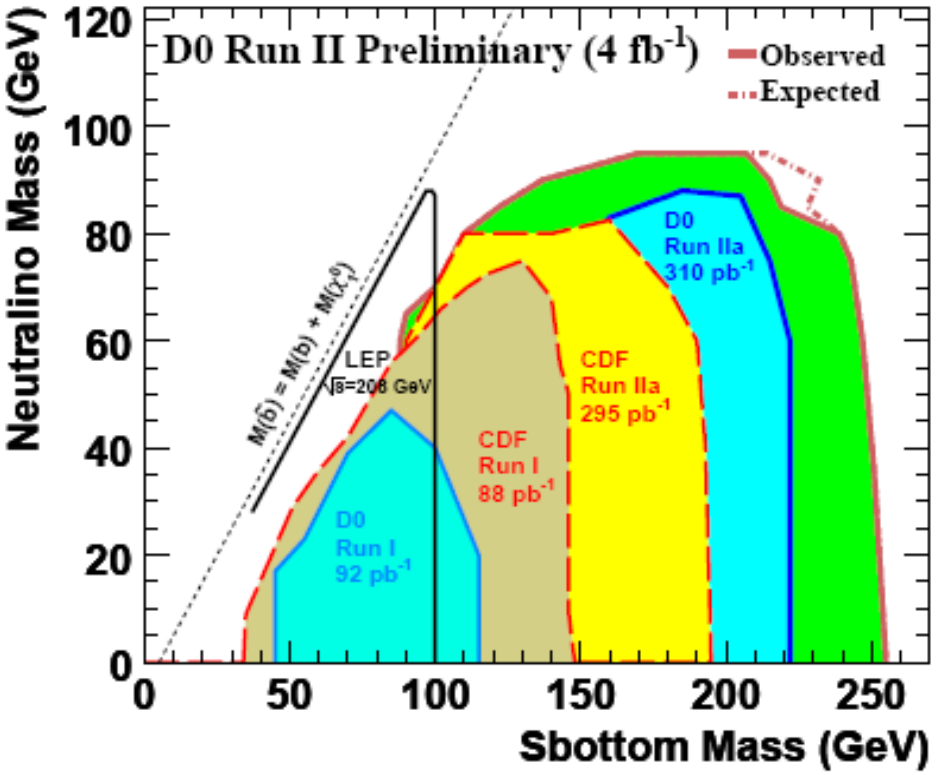
Light Stop / Sbottom

2 c/b-jets + MET



$$p\bar{p} \rightarrow \tilde{b}_1\bar{\tilde{b}}_1 \rightarrow b\tilde{\chi}_1^0\bar{b}\tilde{\chi}_1^0$$

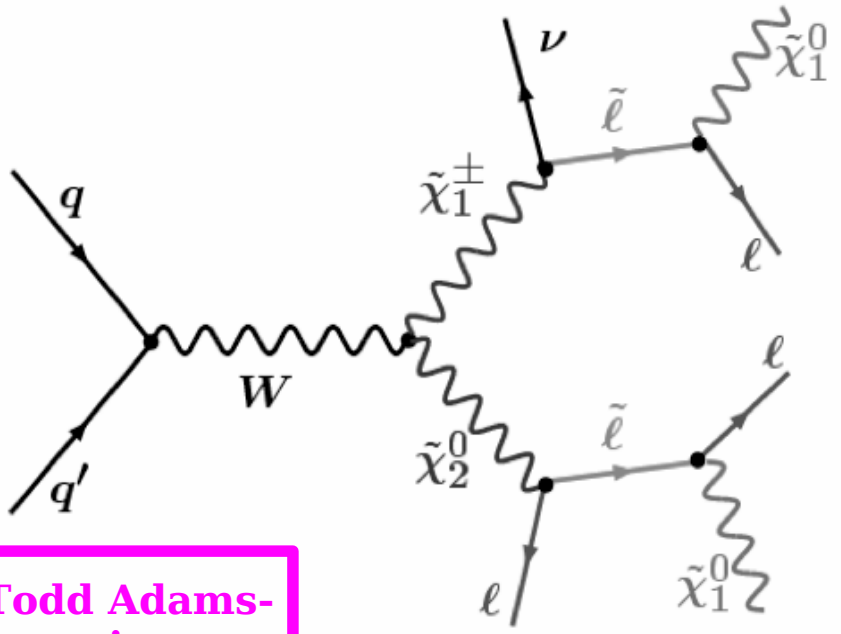




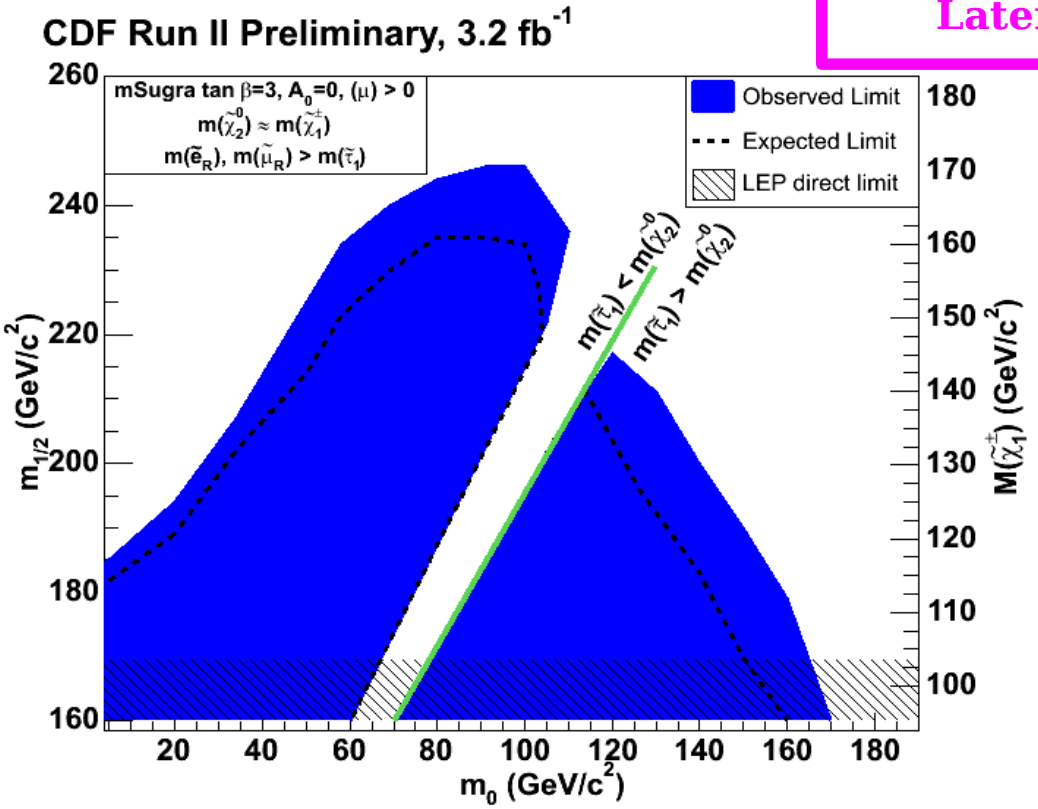
Tri-leptons

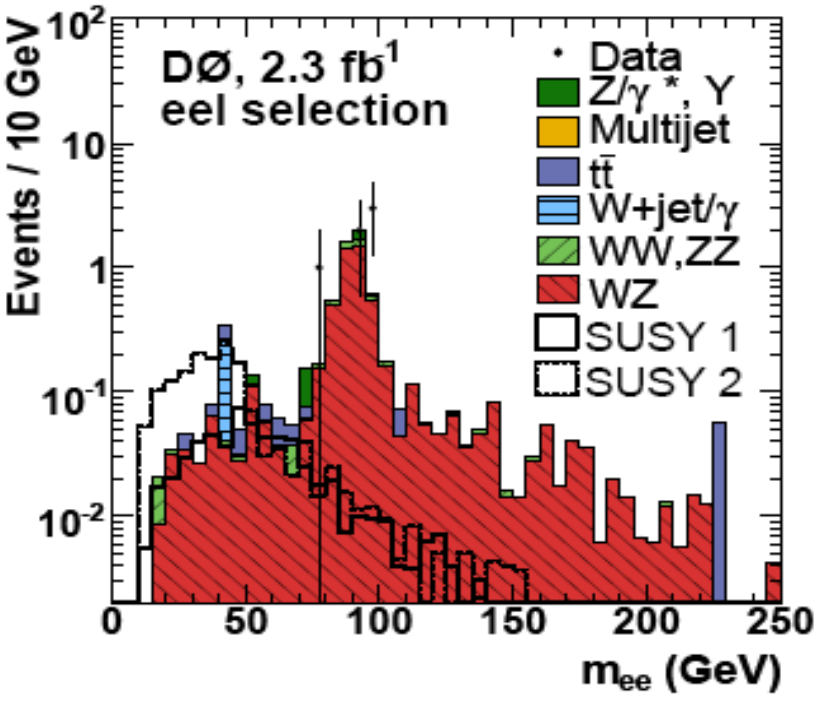
Look for 3 leptons (or 2 l + track)
- Look out for taus!

Very clean, but low cross-section



Rob Forrest / Todd Adams- Later this session

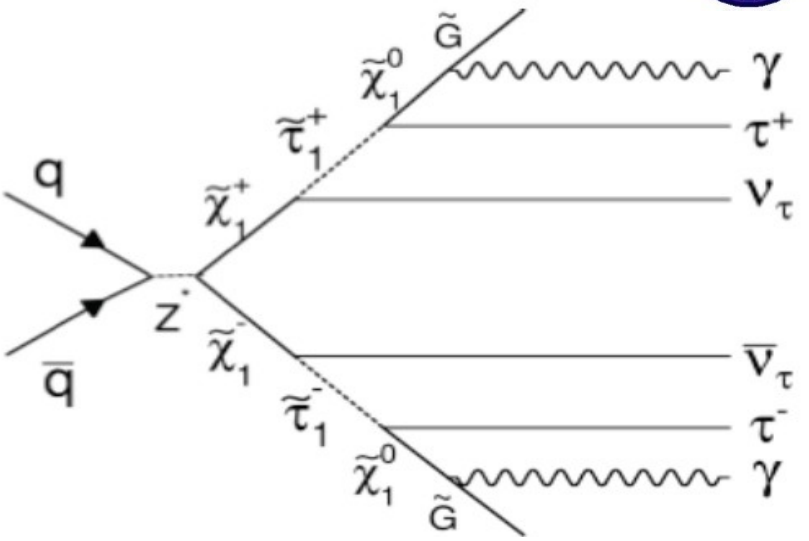


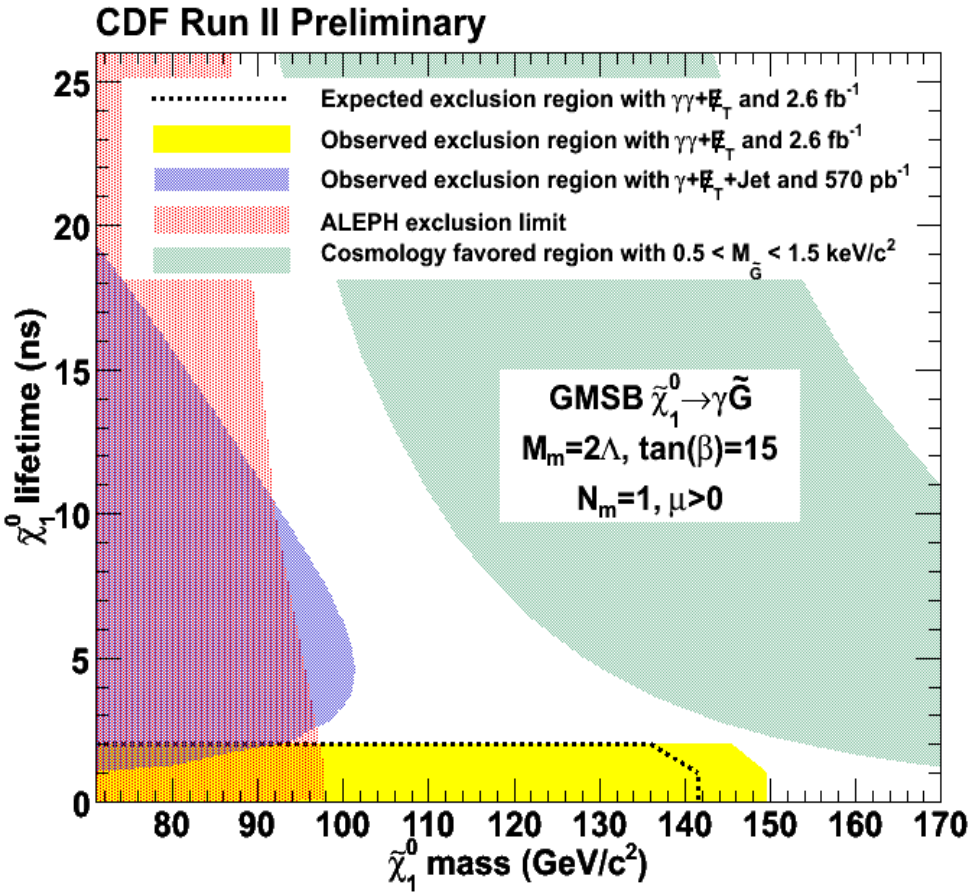


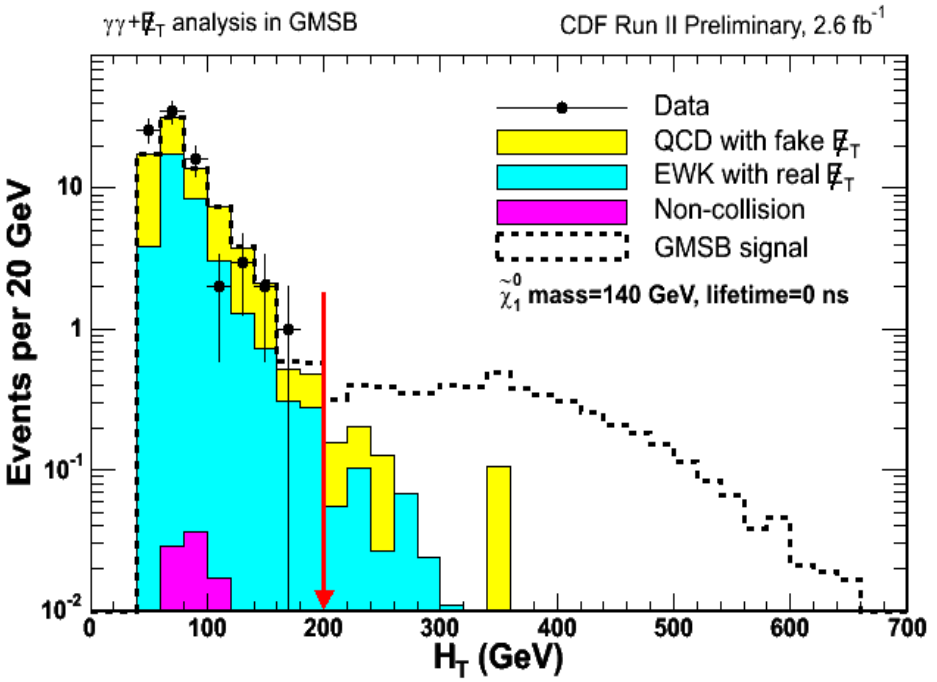
GMSB

2 photons + MET

Eunsin Lee - Later this session



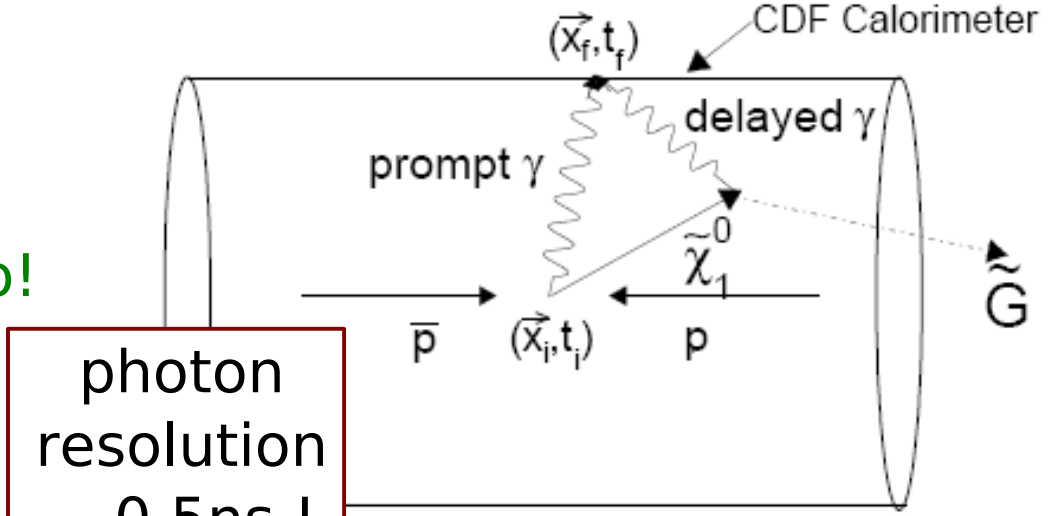




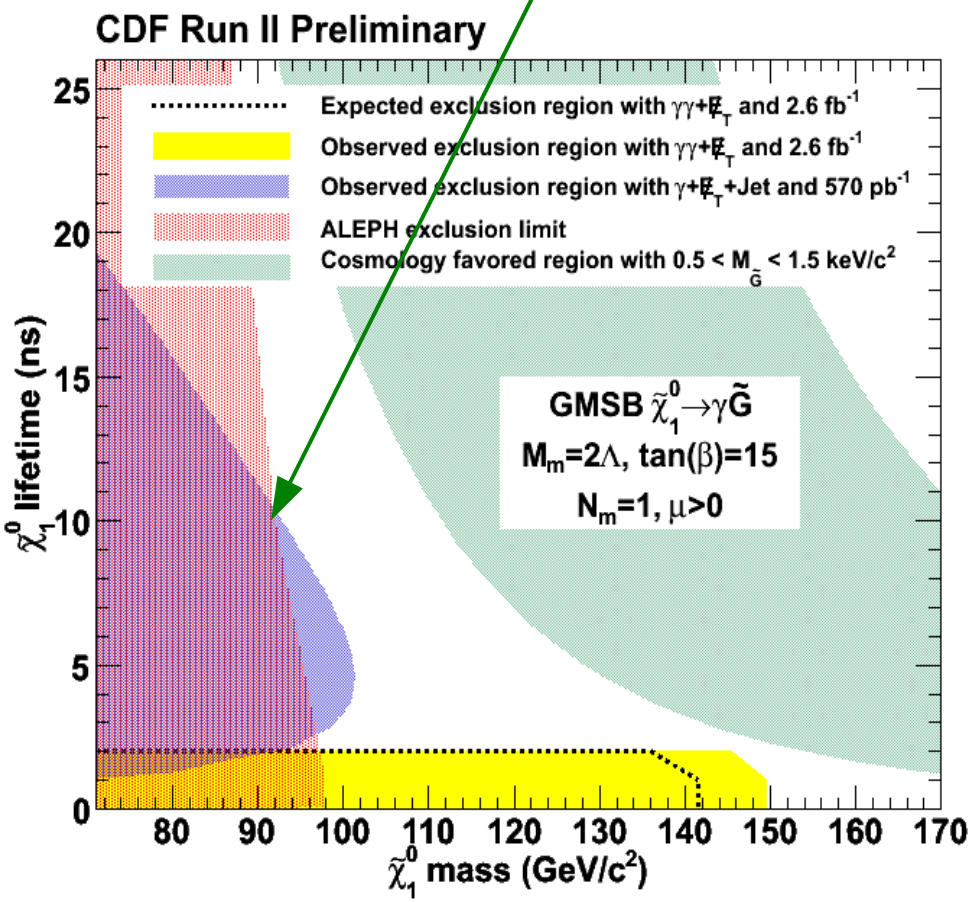
GMSB

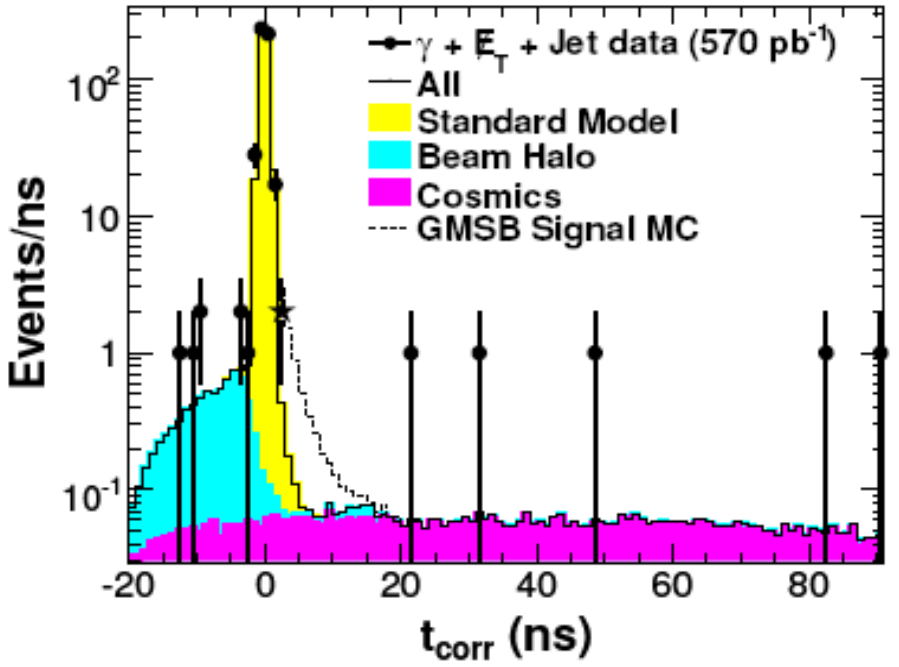
2 photons + MET

Look out for long-lived neutralino!



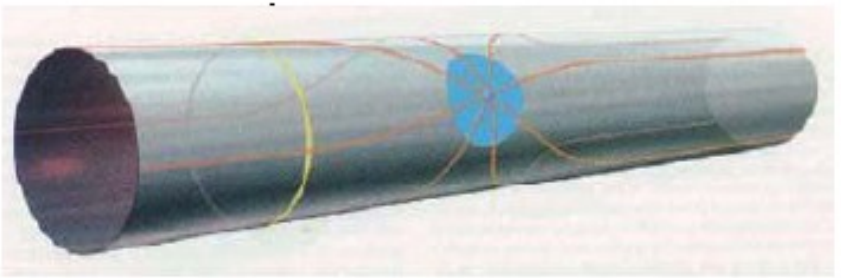
photon resolution ~ 0.5ns !

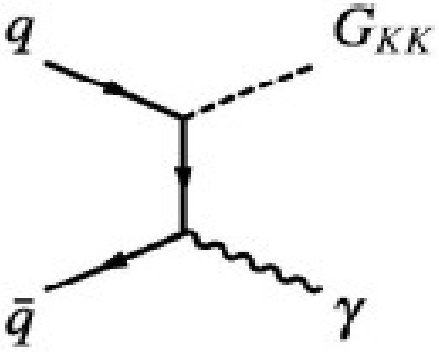




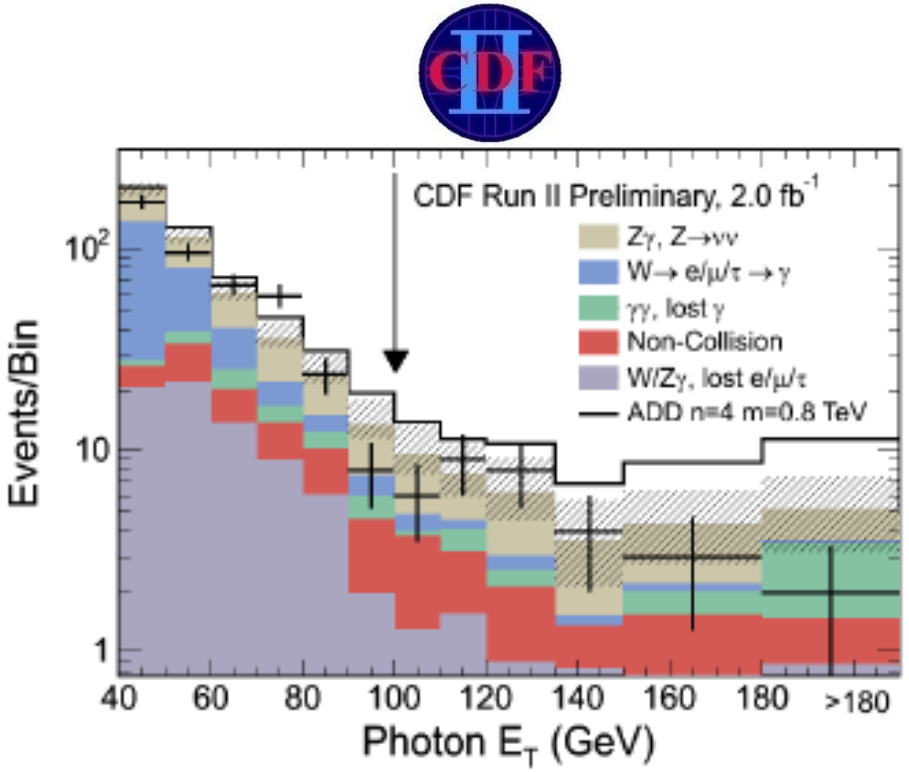
Large Extra Dimensions

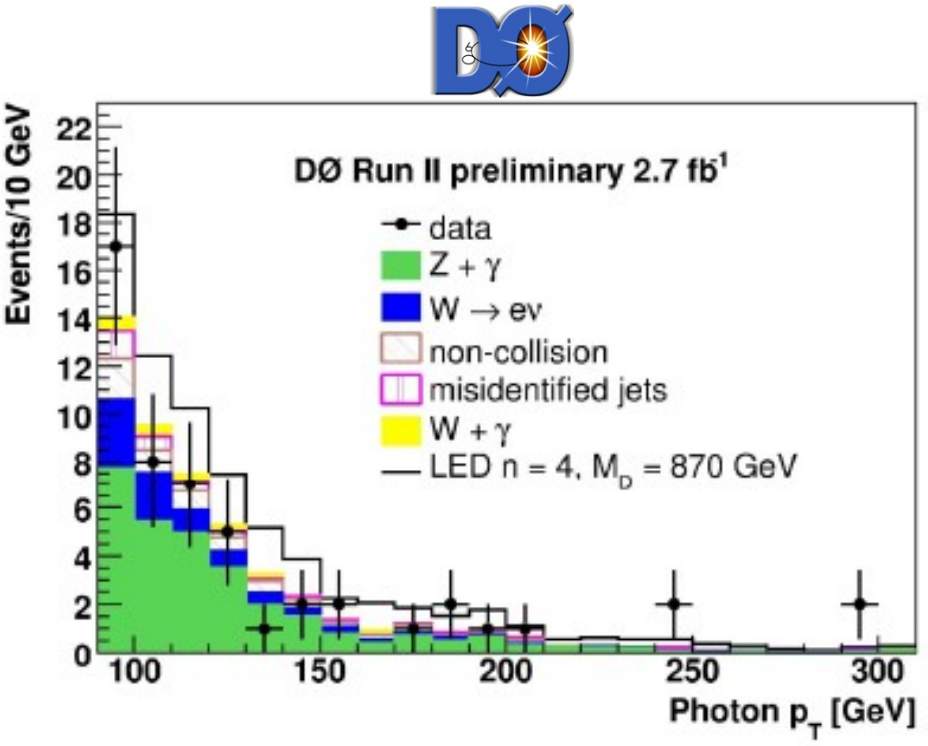
1 photon + MET





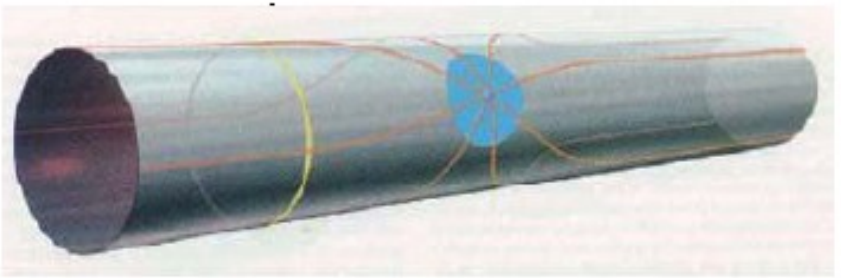
γ+Z($\rightarrow\nu\nu$) is irreducible background

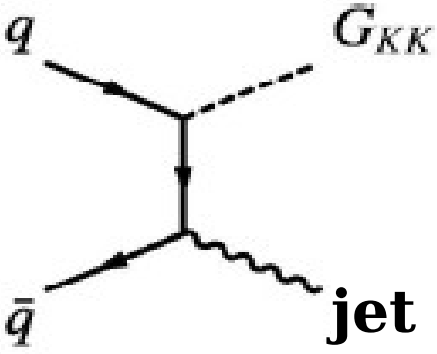




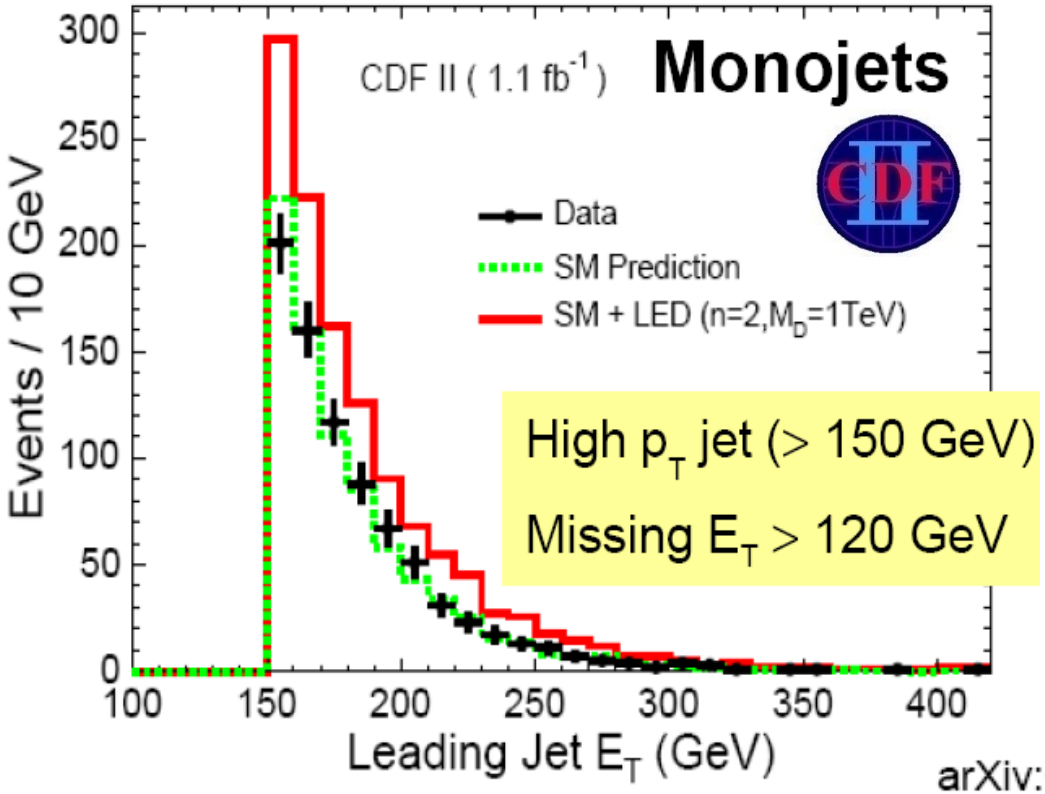
Large Extra Dimensions

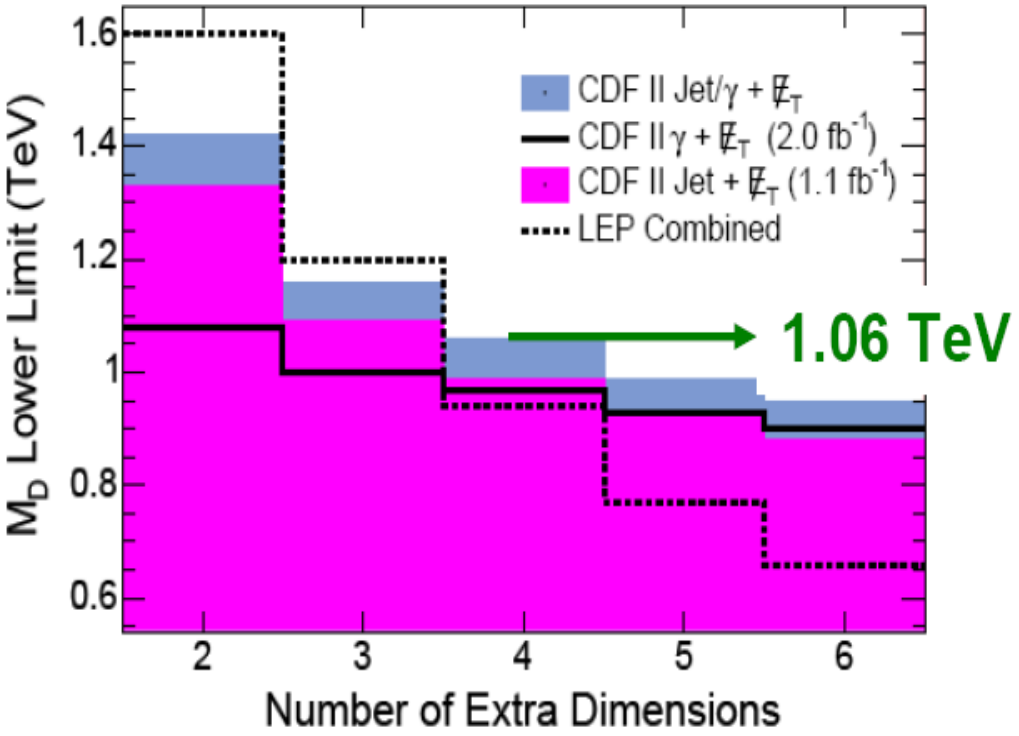
1 jet + MET





jet+Z($\rightarrow\nu\nu$) is irreducible background

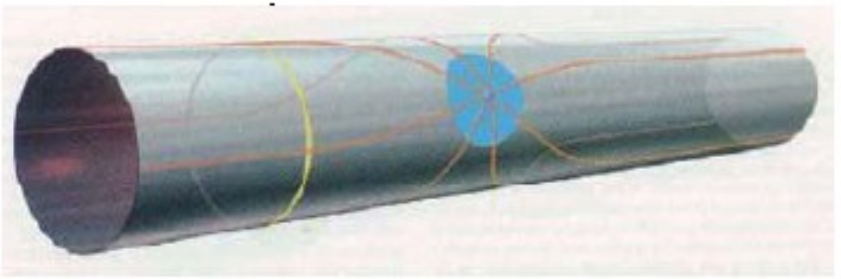


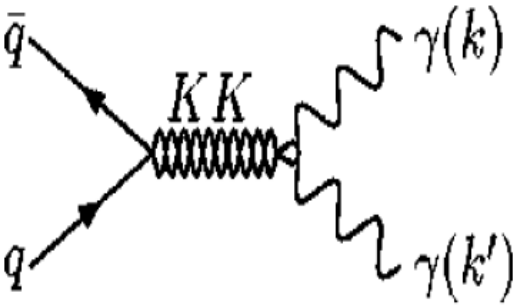


arXiv:0807.3132

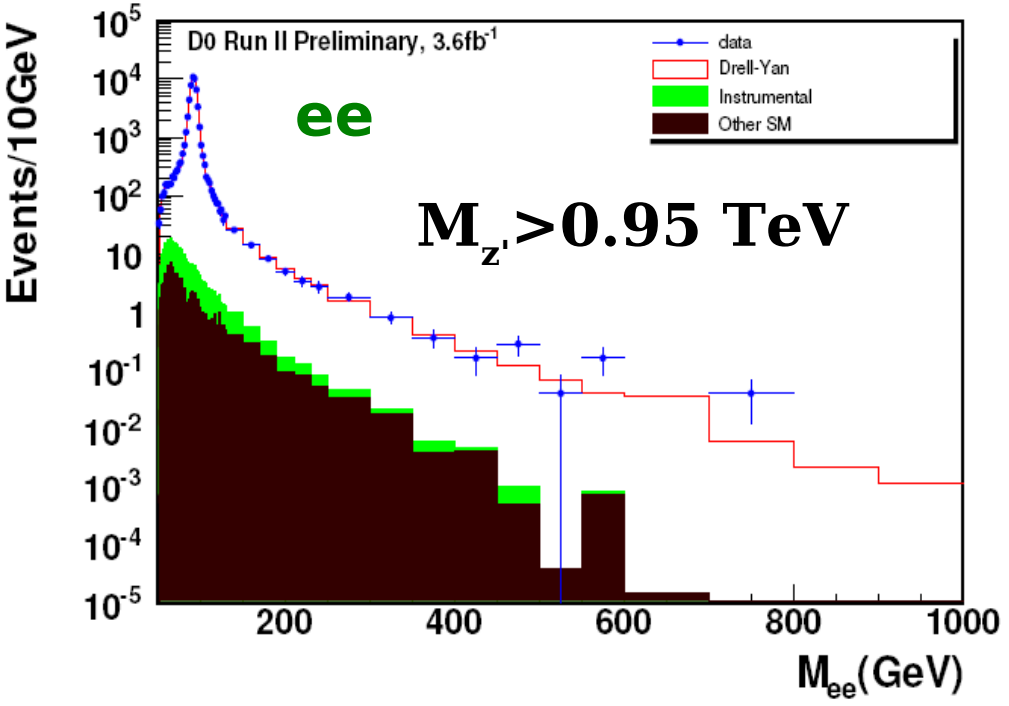
Large Extra Dimensions / Z'

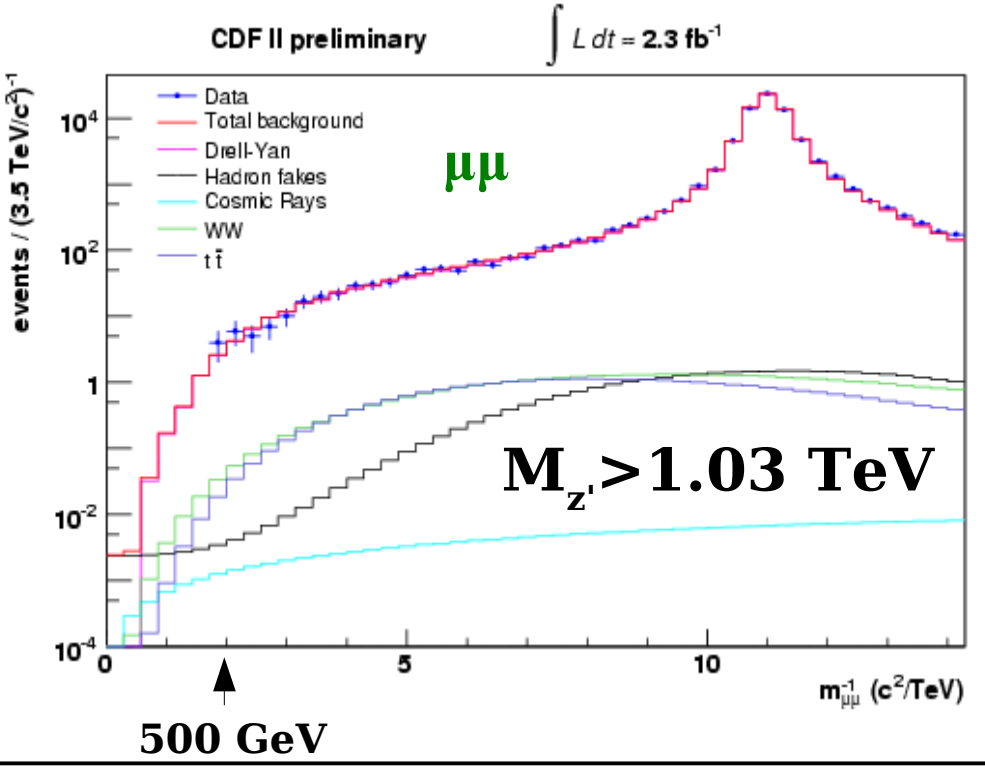
Ioannis Katsanos - Tomorrow's session





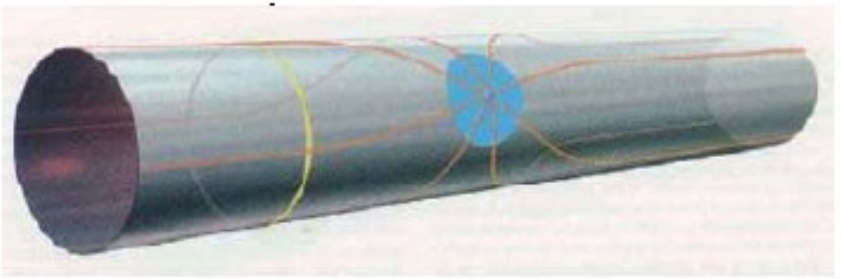
Also ee, μμ, WW/WZ/ZZ, tt, jj *resonances...*

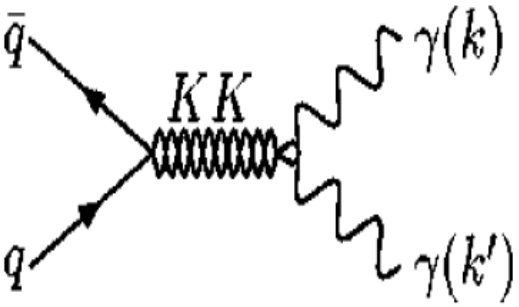




Large Extra Dimensions / Z'

Include jet channels!





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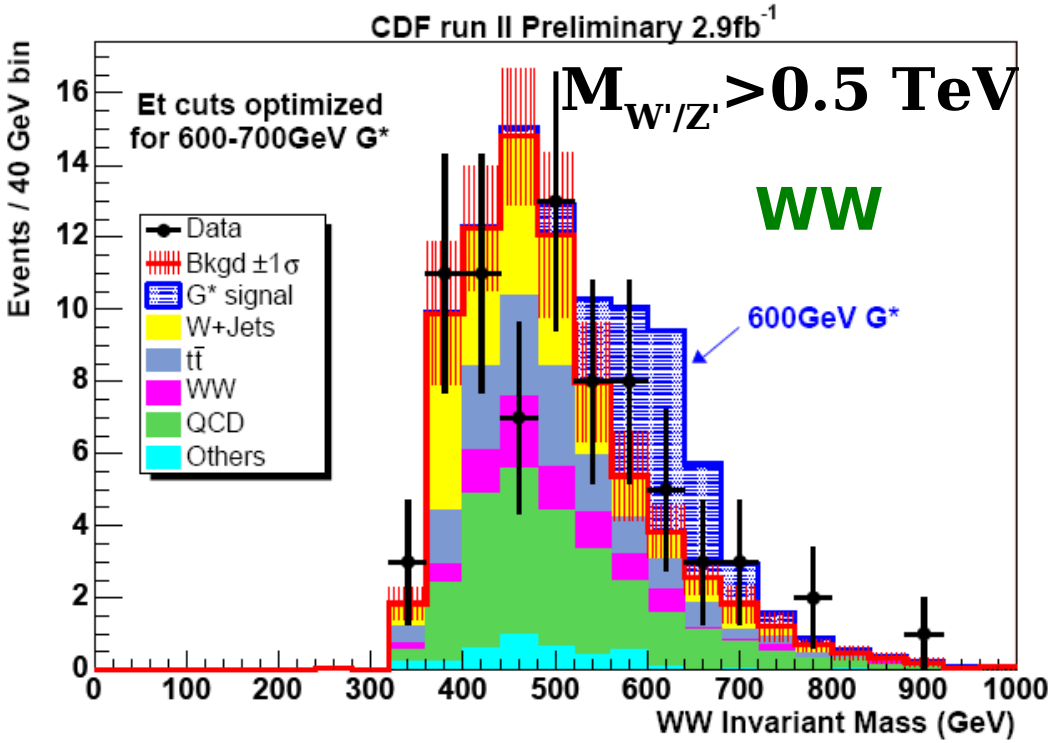

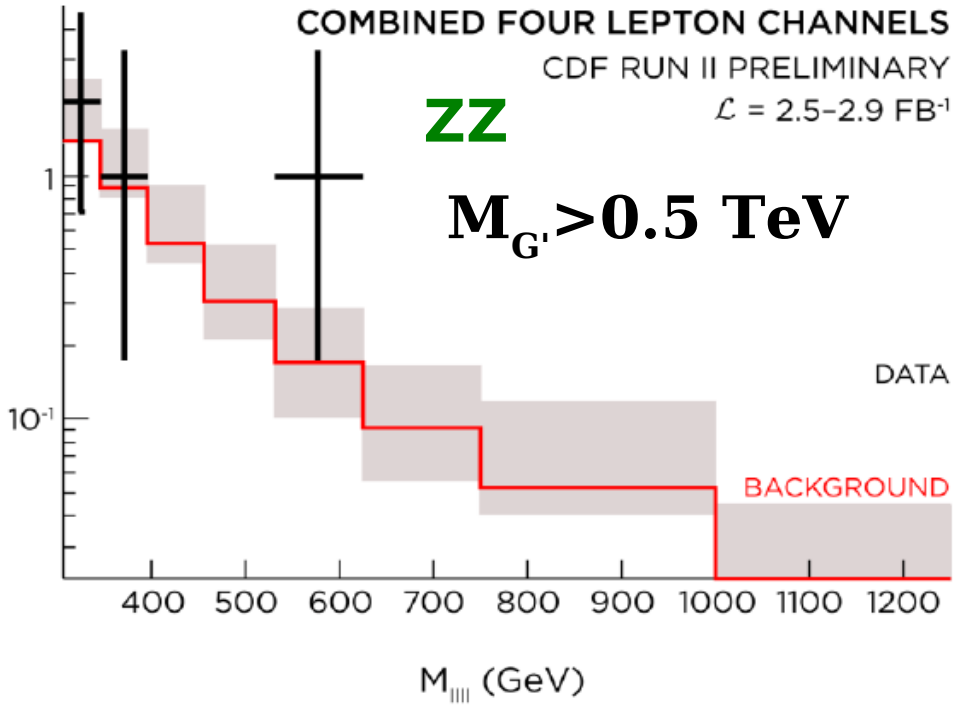

Large Extra Dimensions / Z'

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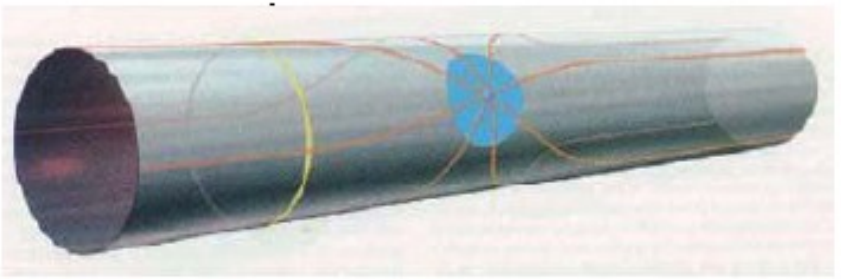

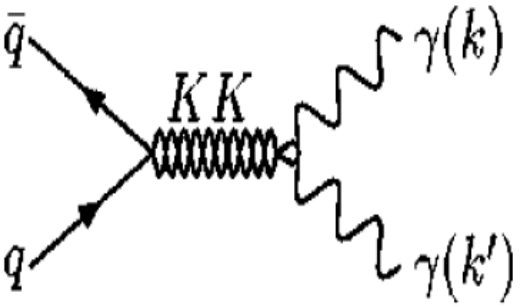

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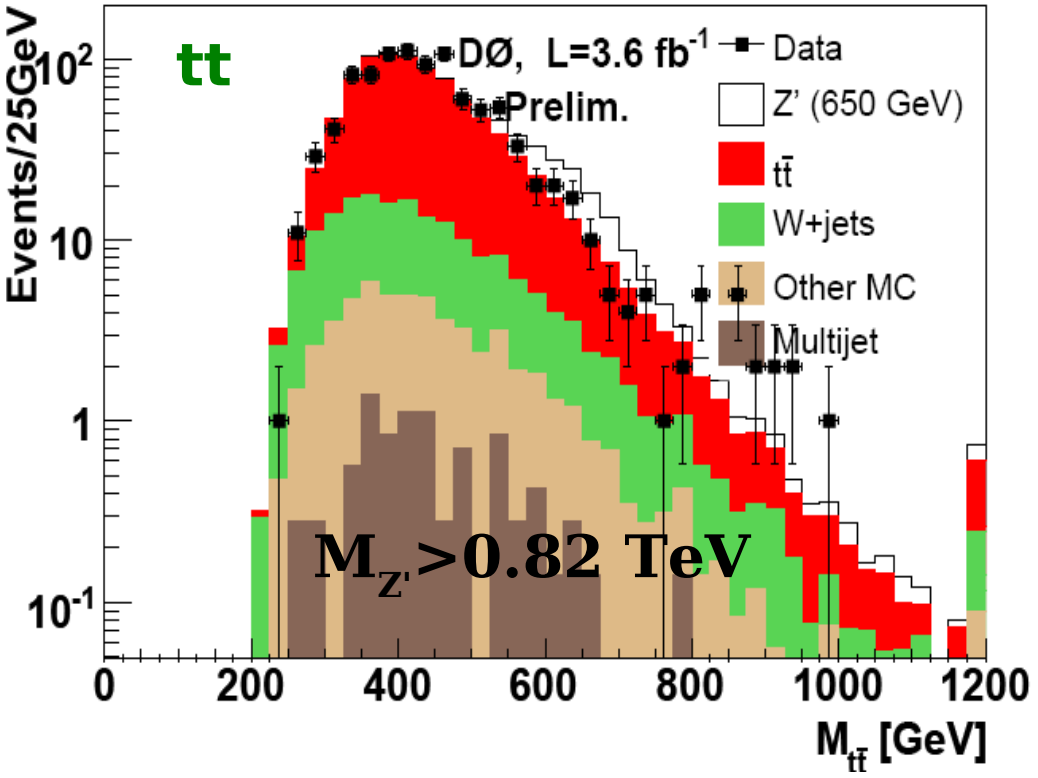
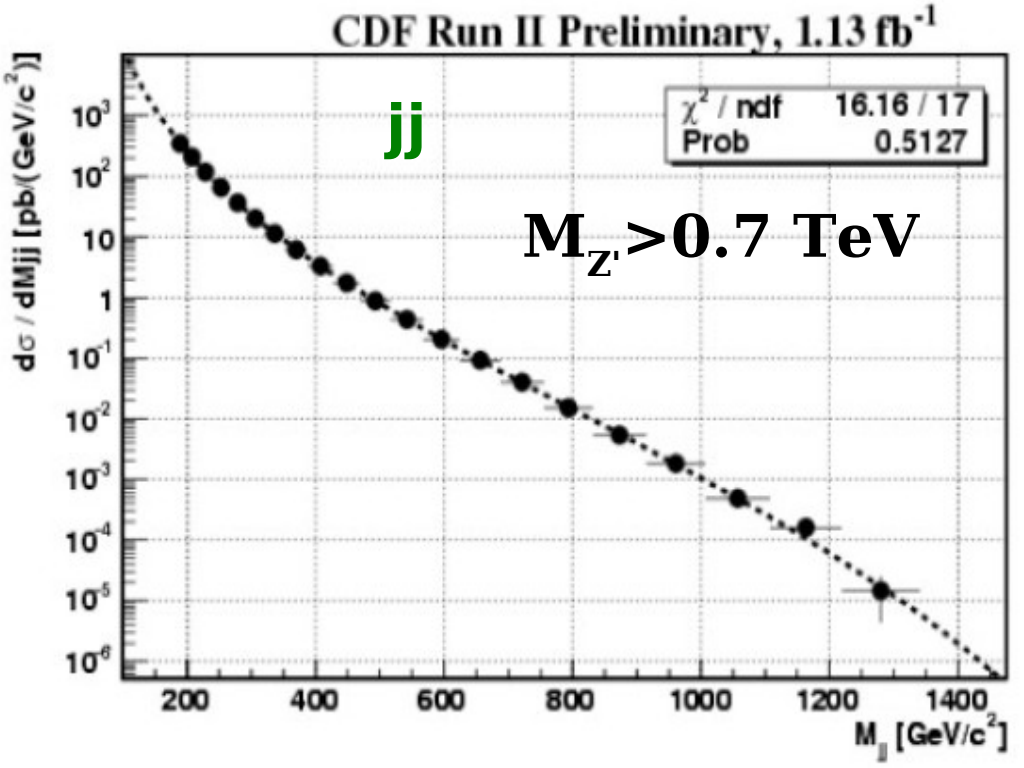


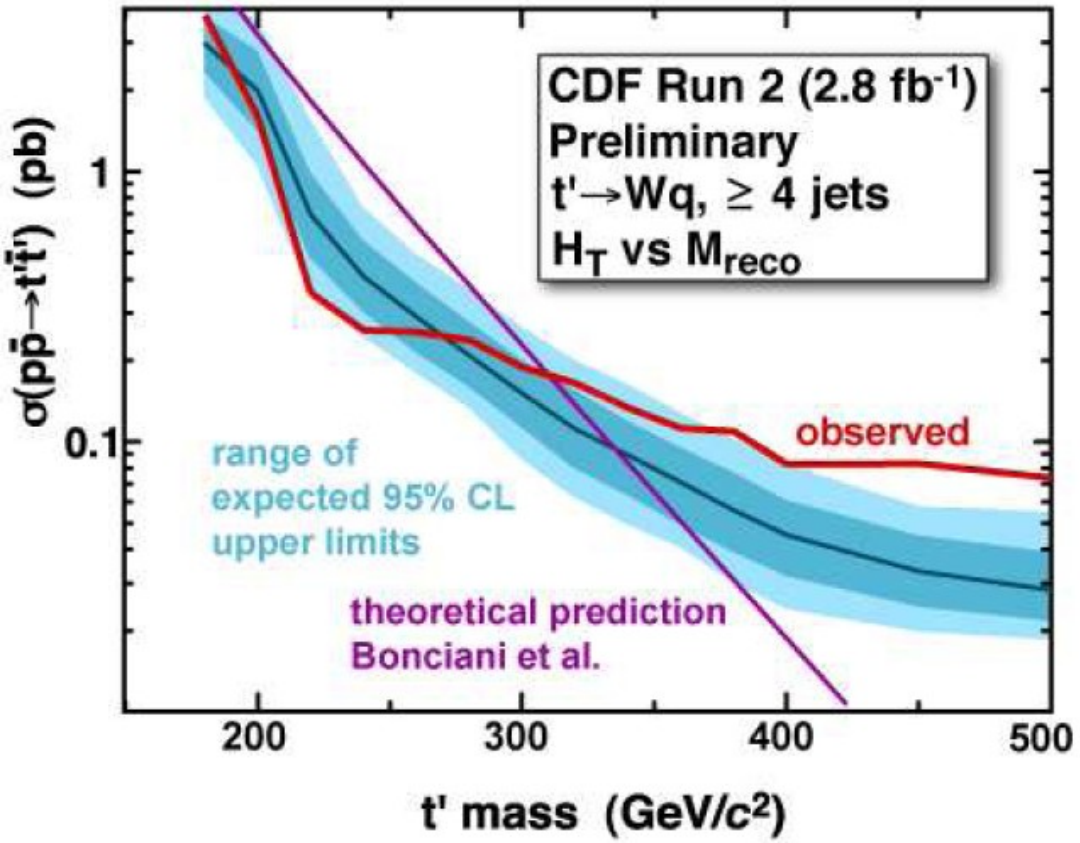


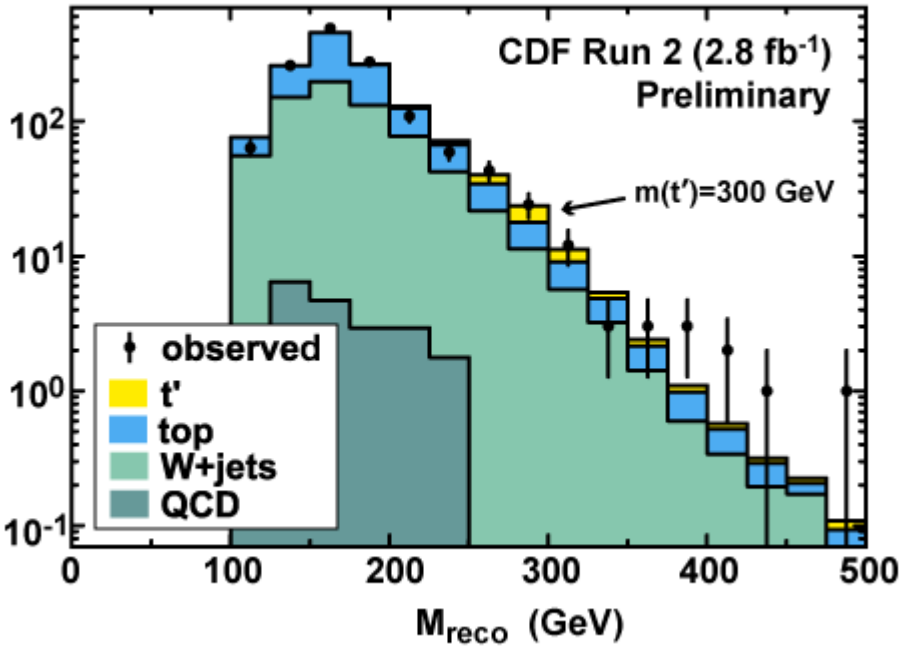
4th Generation : t'

Assume $t'\bar{t}'$ production, with $t' \rightarrow Wq$

Reconstruct $M_{t'}$

Excess at large $M_{t'}$ ...



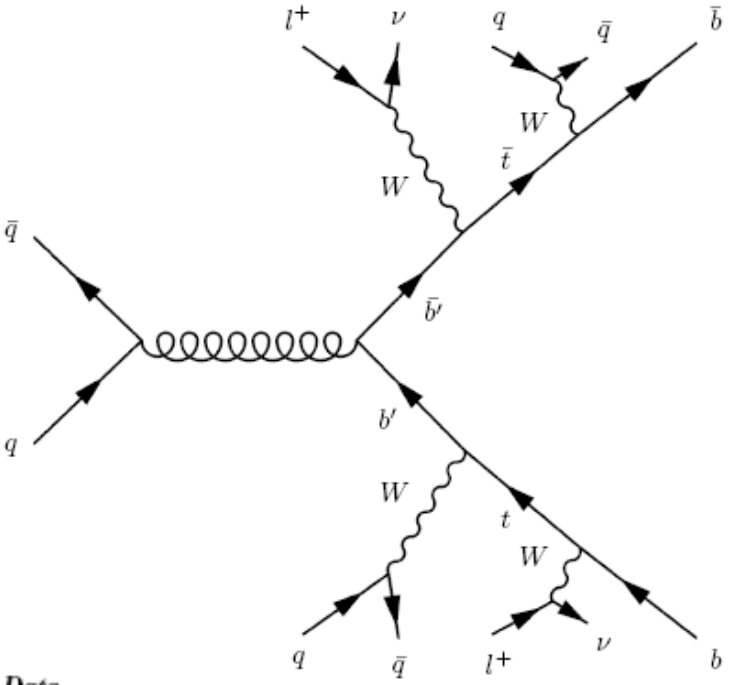


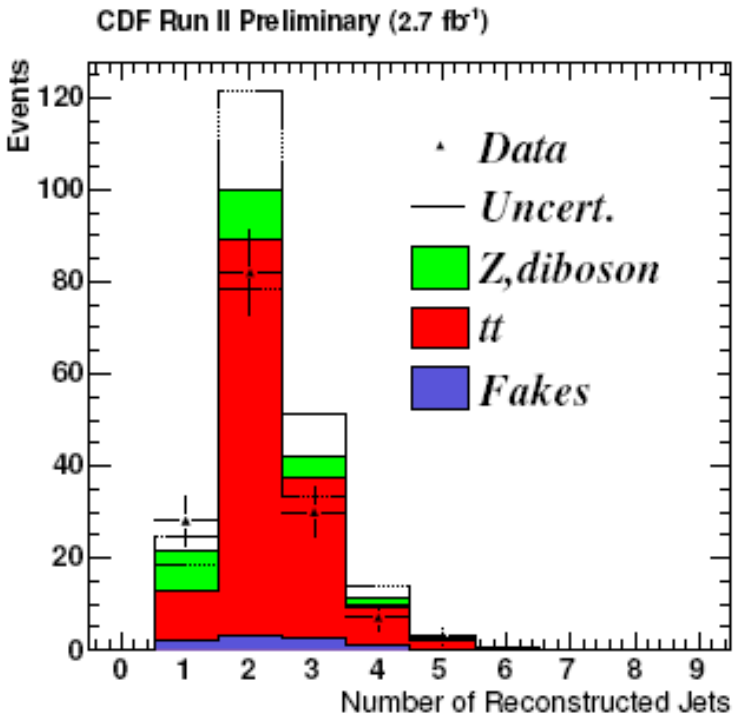
$M_{t'} > 311$ GeV

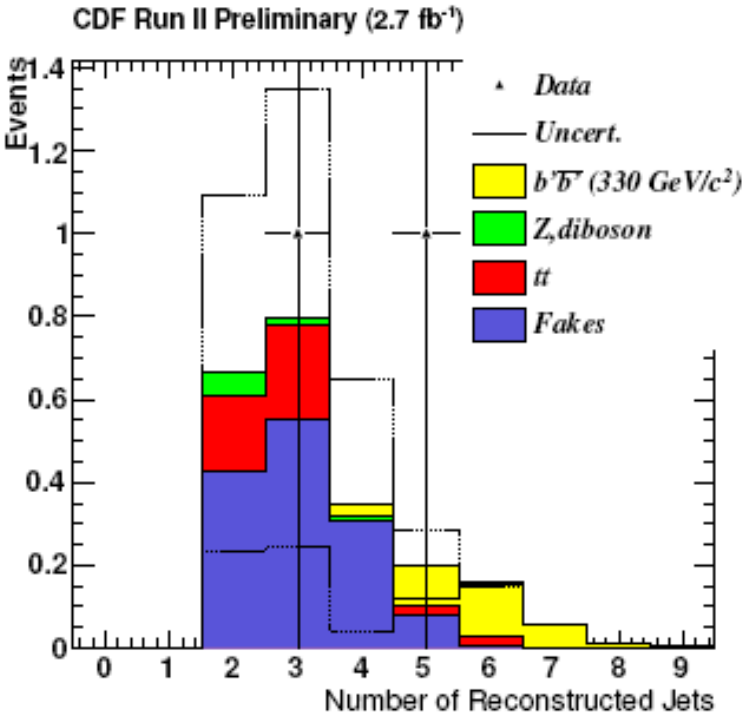
4th Generation: b'

Assume b'$\overline{b}$' production, with b'$\rightarrow$Wt

Same-sign leptons + b-jet(s)



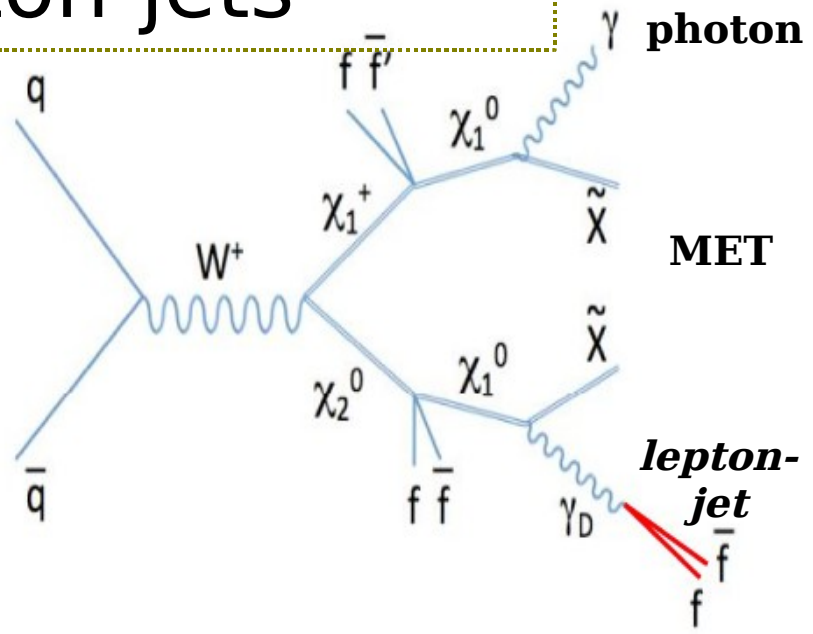




Hidden Valley: lepton-jets

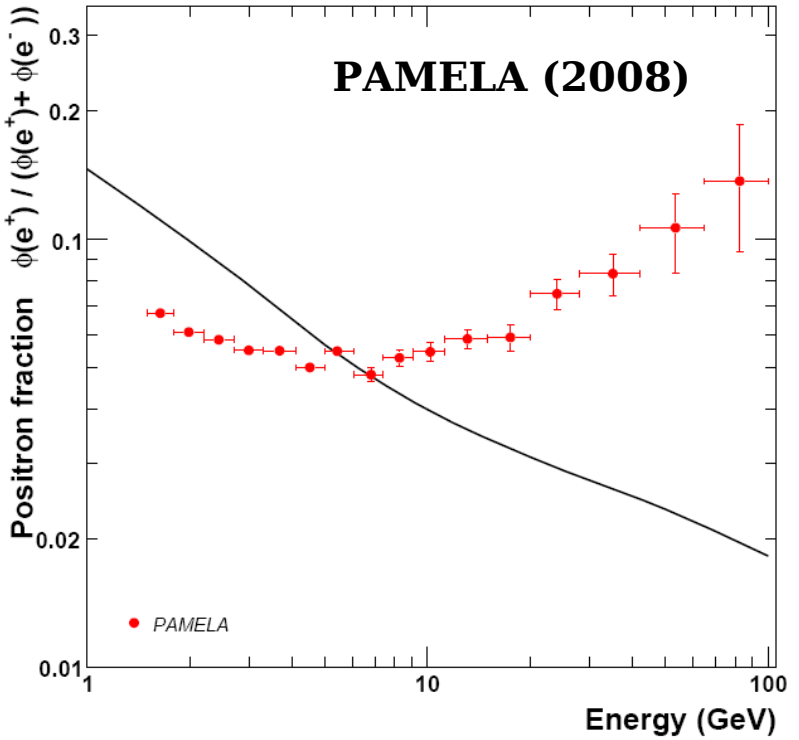
GMSB production, but...

Neutralino → ***dark photon*** (γ_D) + darkino



Todd Adams - Later this session

photon + MET + *lepton-jet*



"Lepton-jet"

- pair (or more) of collinear e's or μ's
- kinematics force leptonic decays!

Hidden Valley: lepton-jets

GMSB production, but...

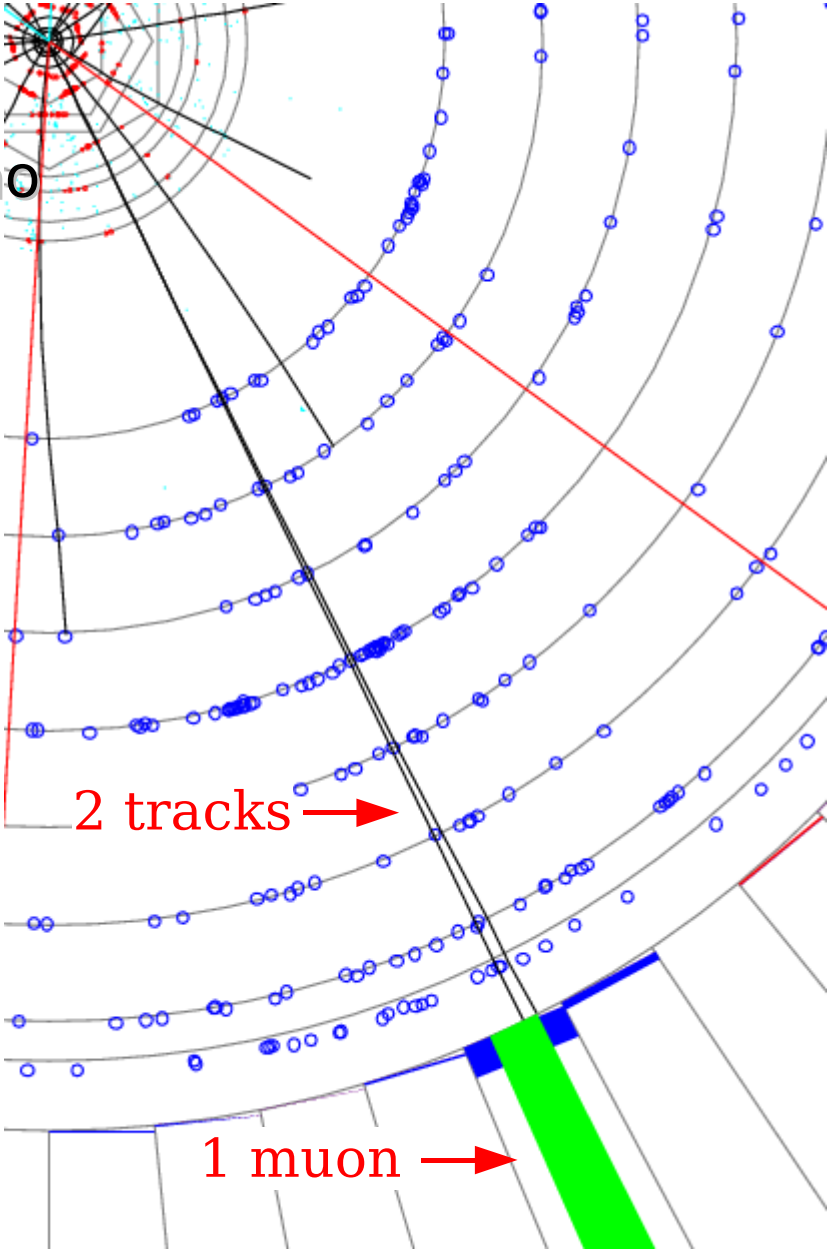
Neutralino → ***dark photon*** (γ_D) + darkino

Todd Adams - Later this session

photon + MET + *lepton-jet*

"Lepton-jet"

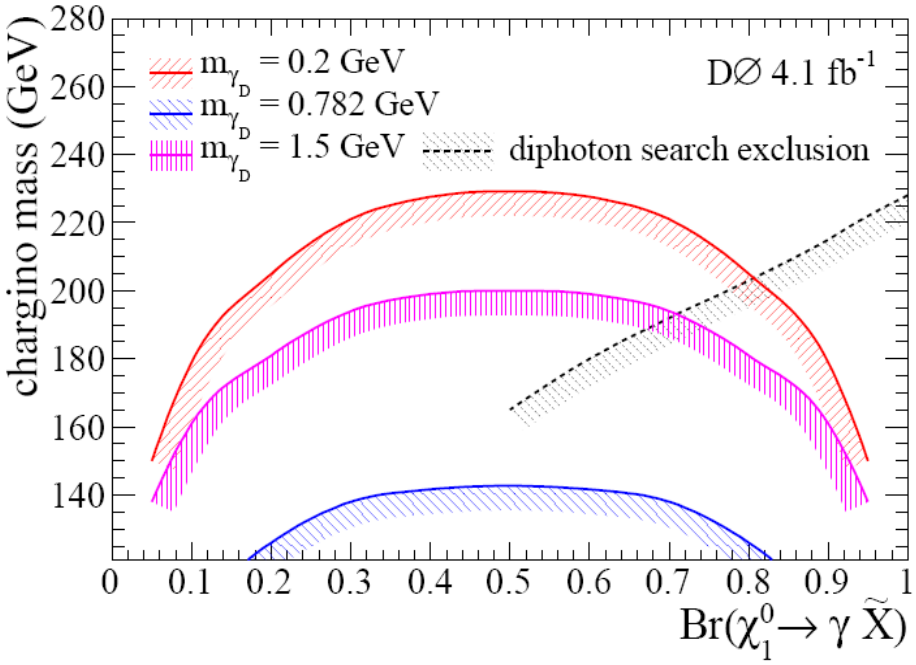
- pair (or more) of collinear e's or μ's
- kinematics force leptonic decays!



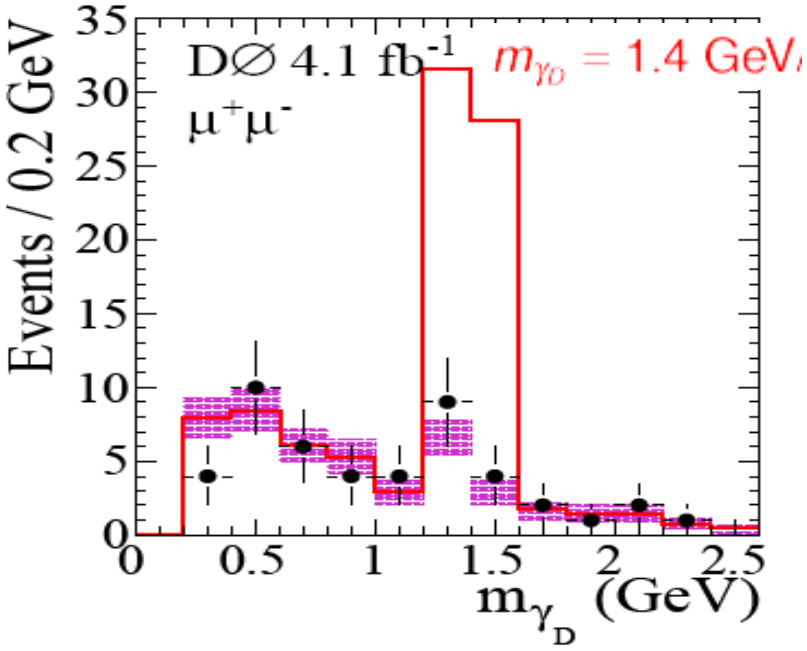
Hidden Valley: lepton-jets

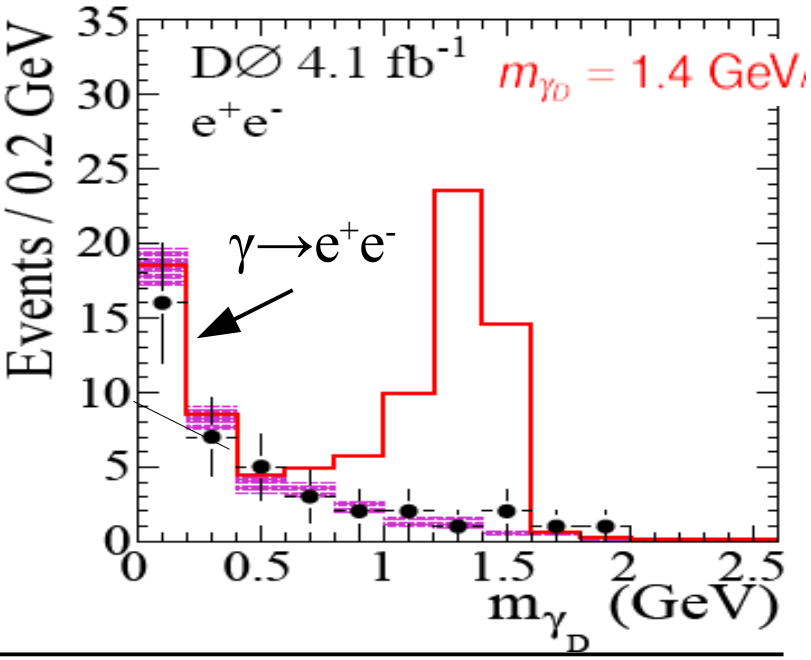
Exclude chargino's up to 230 GeV

Large BR(→γ) gives γγ+MET (GMSB)
Large BR(→γ_D) gives *lepton-jet* pairs



arXiv:0905.1478
Submitted to PRL





Hidden Valley: long-lived $b\bar{b}$-jets

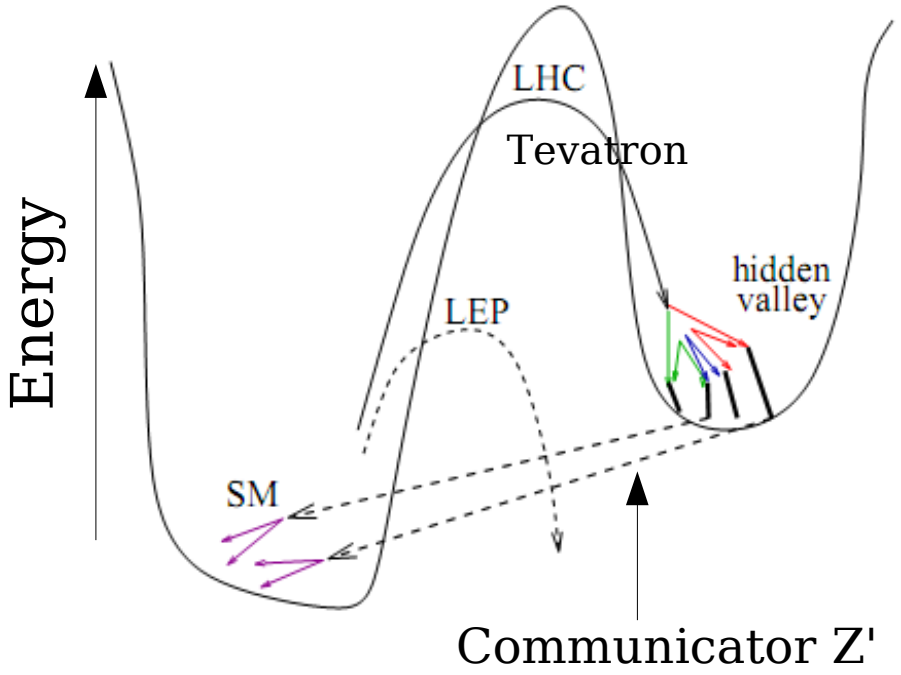
Hidden sector (weakly interacting with the SM)

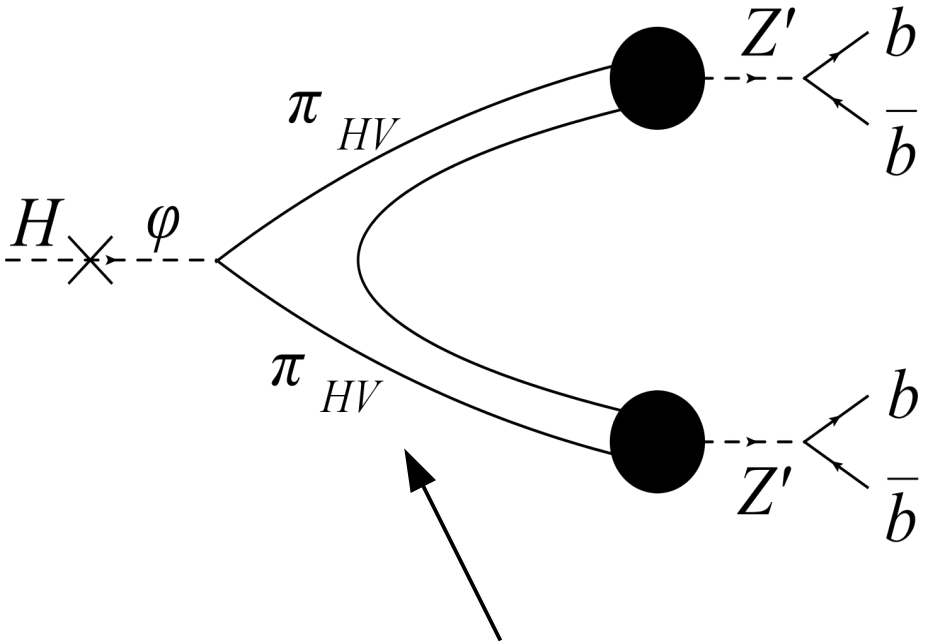
Strongly coupled: v-hadrons, v-pions, etc.

Strassler and Zurek, Phys. Rev. Lett. B651:374 (2007).

v-particles could be long-lived

- but < 1 second, (big-bang nucleosynthesis)



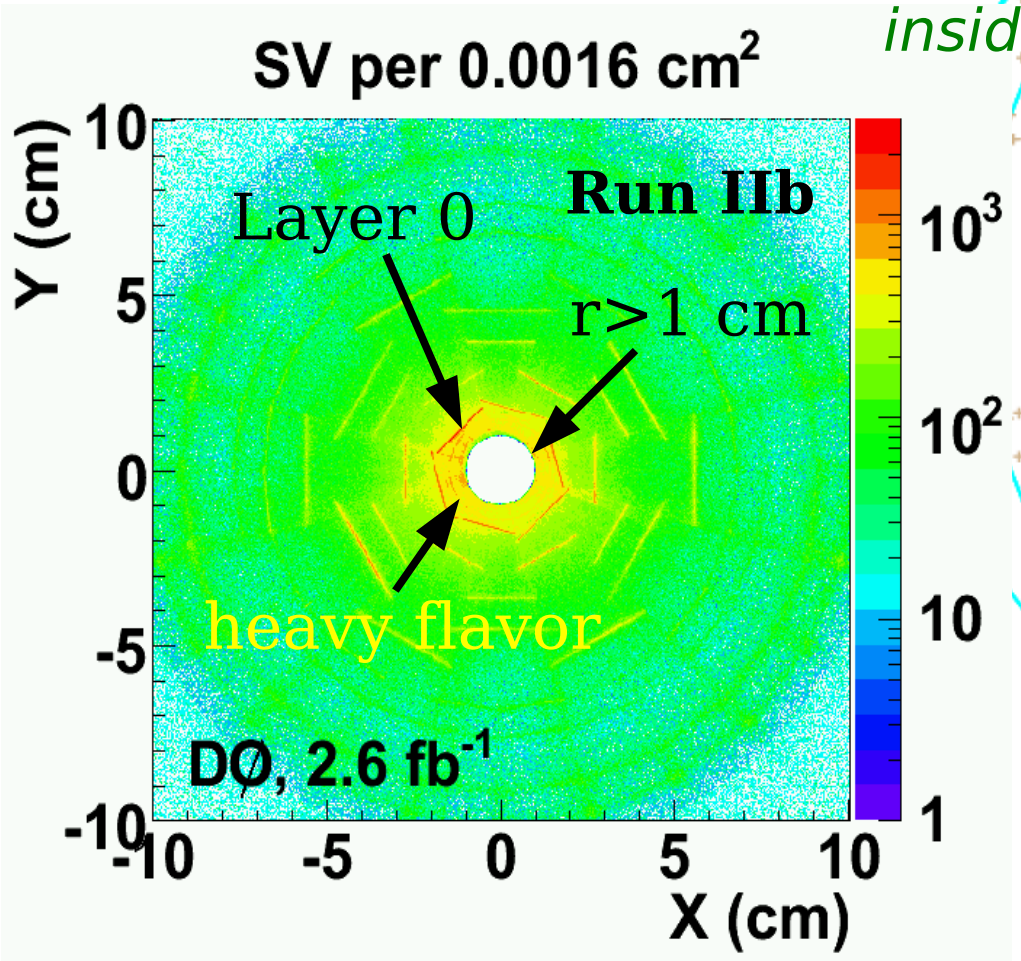


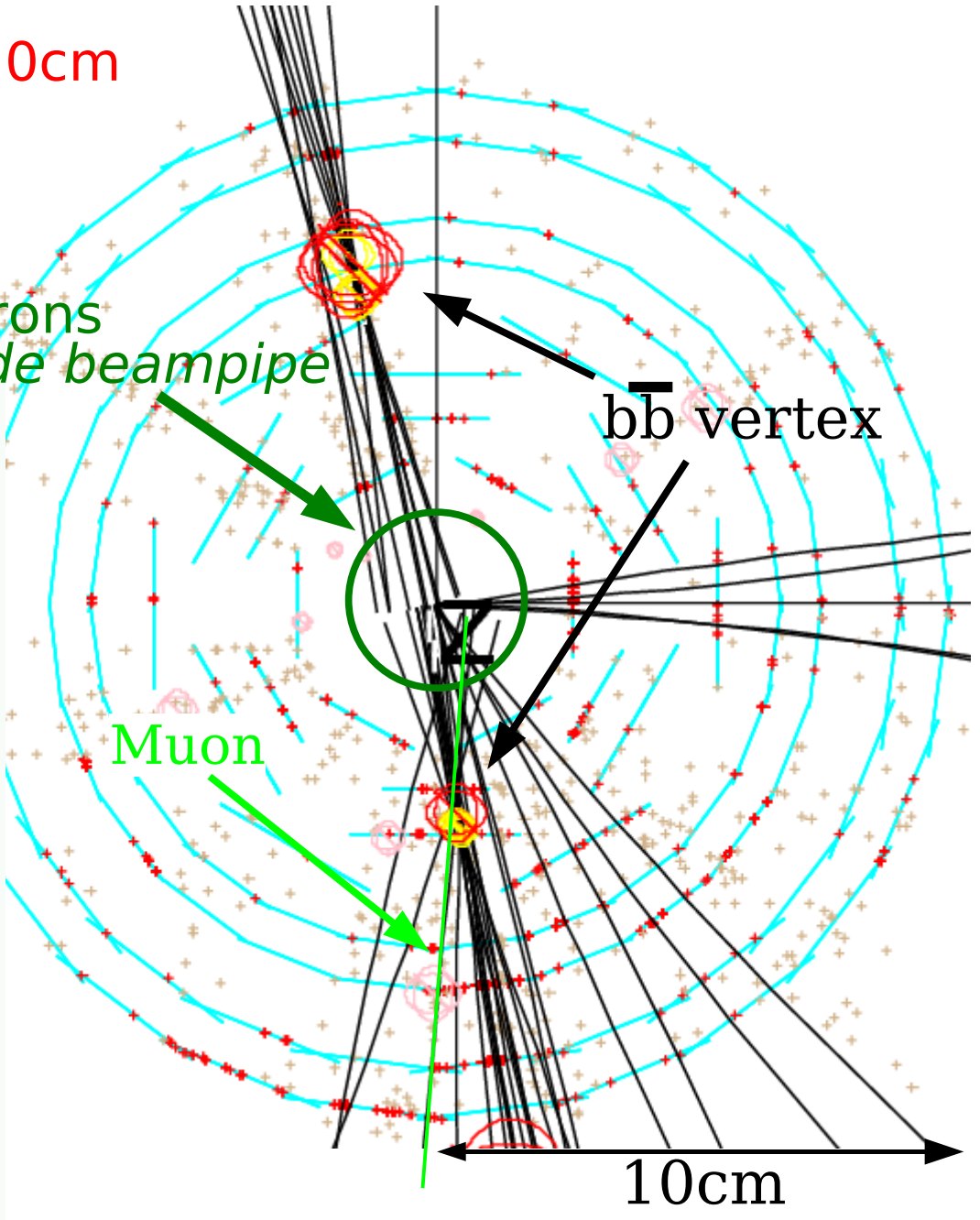
Long-lived (cm's)

Hidden Valley: long-lived $b\bar{b}$-jets

Pairs of vertices with 1.6cm<r<20cm

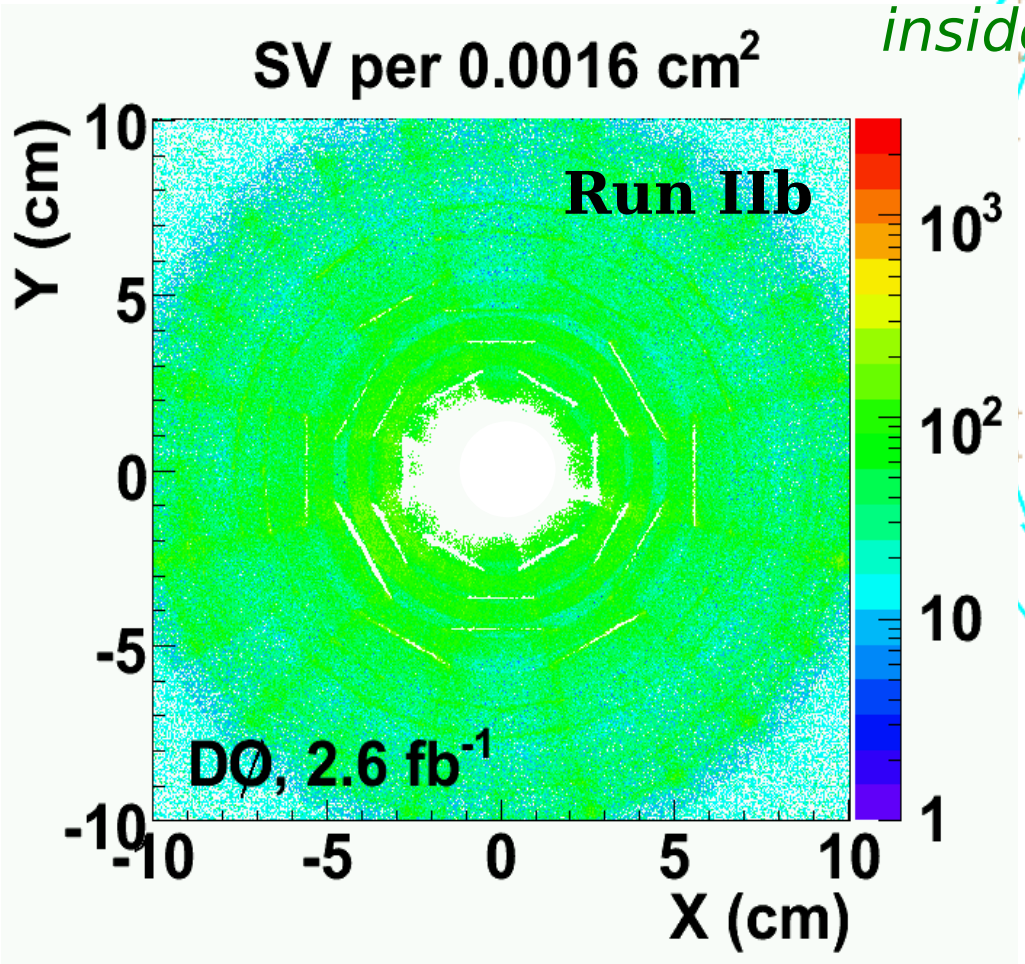
Remaining background is mainly
material interactions...

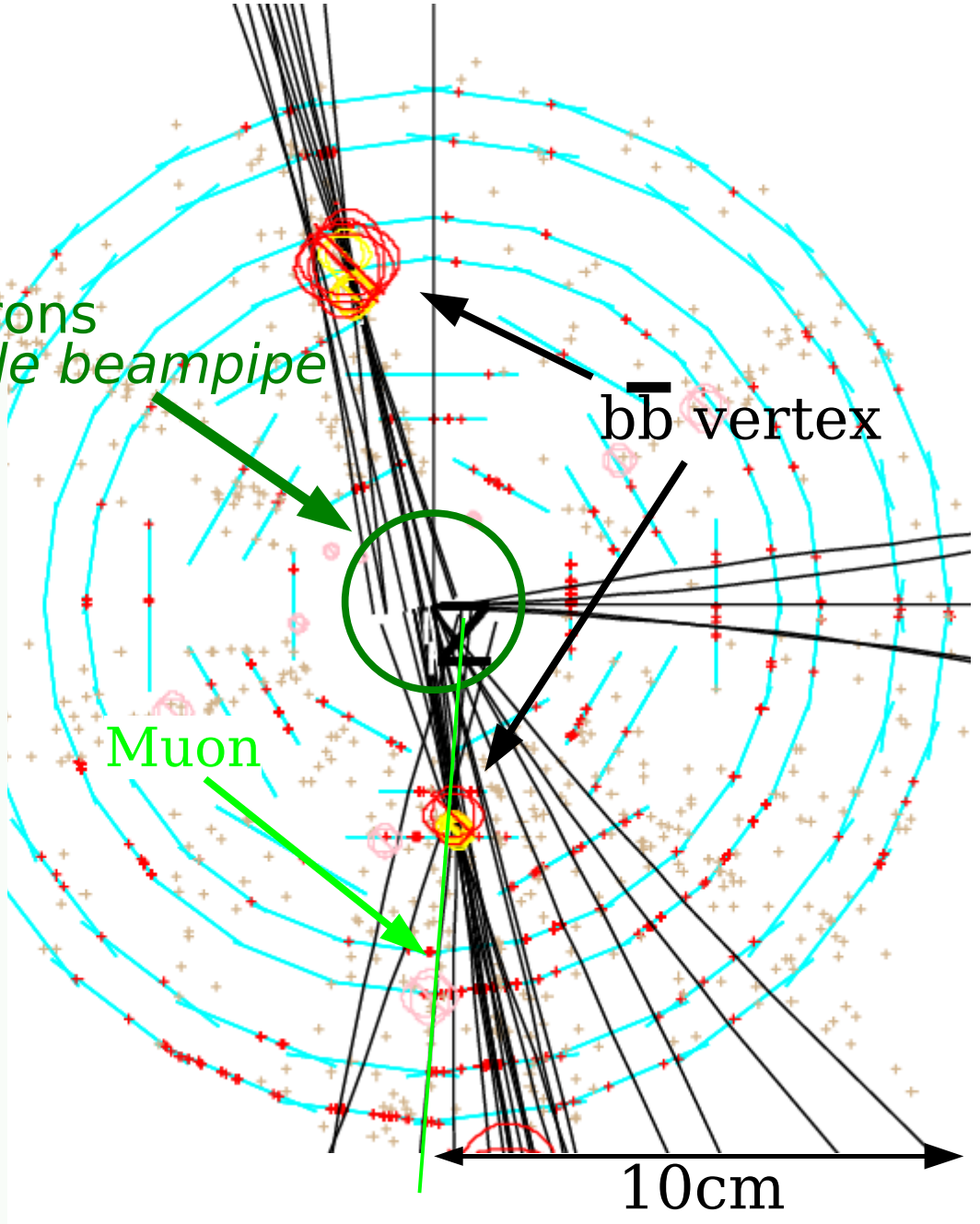




Hidden Valley: long-lived $b\bar{b}$-jets

Reject vertices in high-density regions!





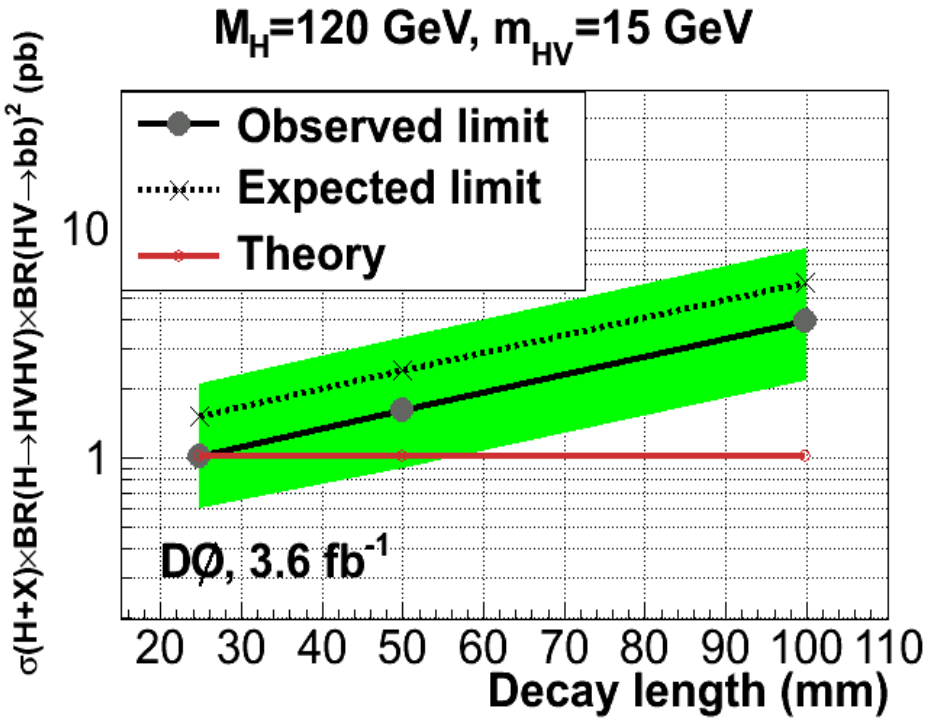
Hidden Valley: long-lived $b\bar{b}$-jets

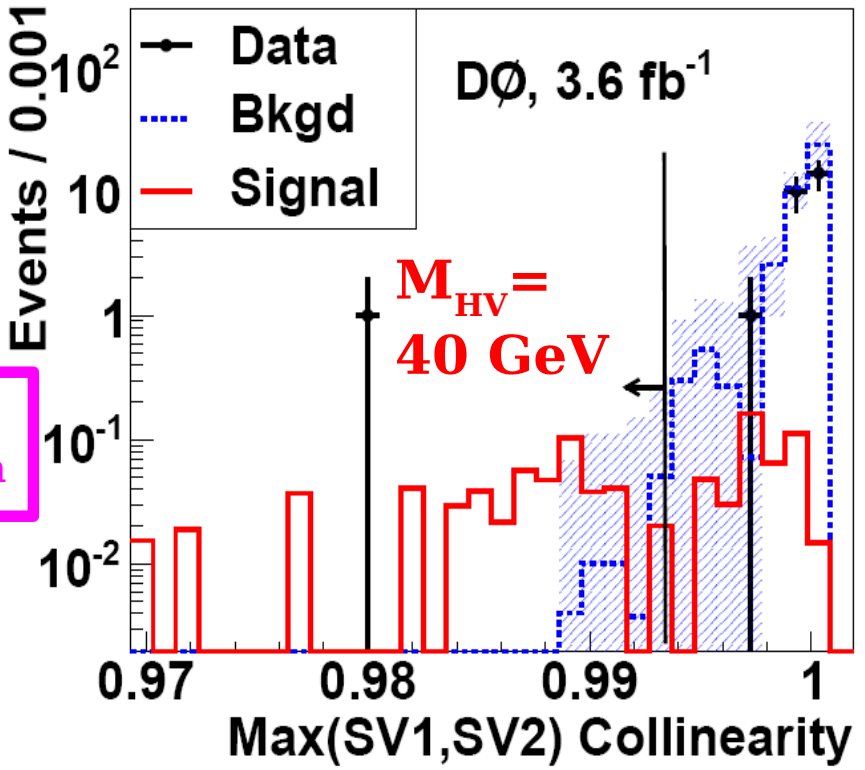
Cut on vertex "collinearity" (or mass)

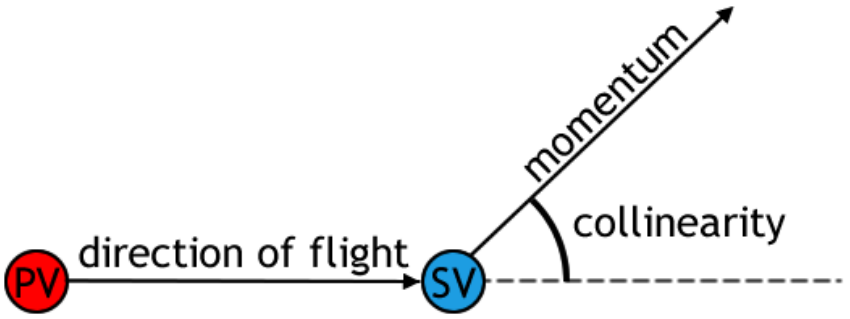
Limits vs. M_H, M_{HV}, HV decay length

arXiv:0906.1787
Submitted to PRL

Andy Haas (ME) - Tomorrow's Higgs session







Long-lived charged particles

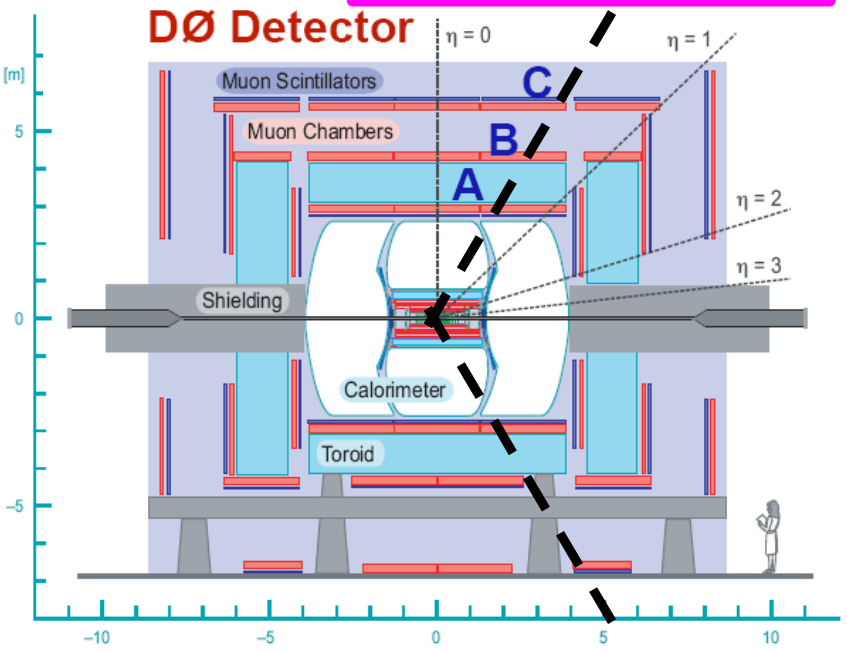
Yunhe Xie - Tomorrow's session

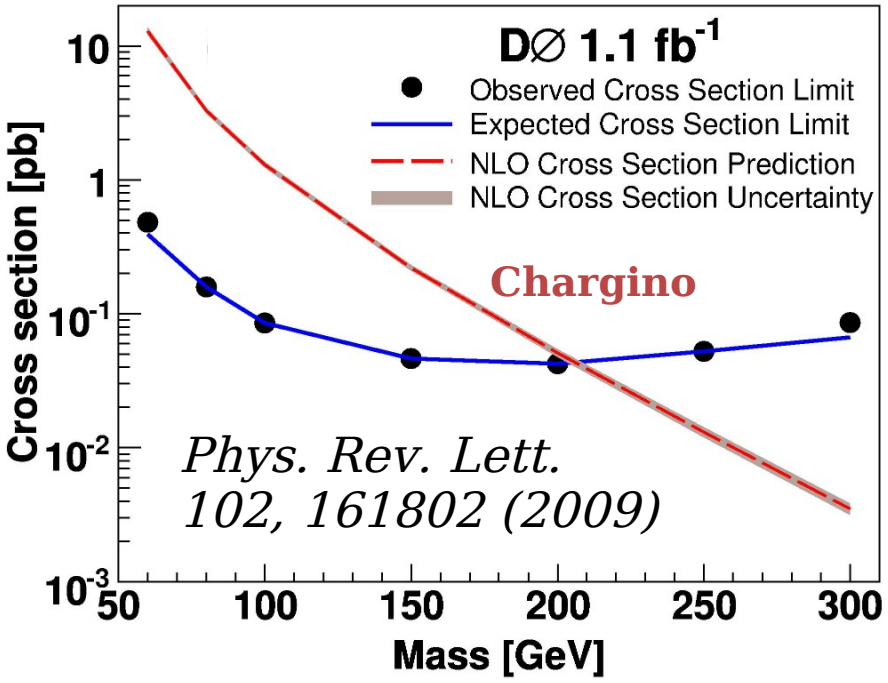
"Slow muons"

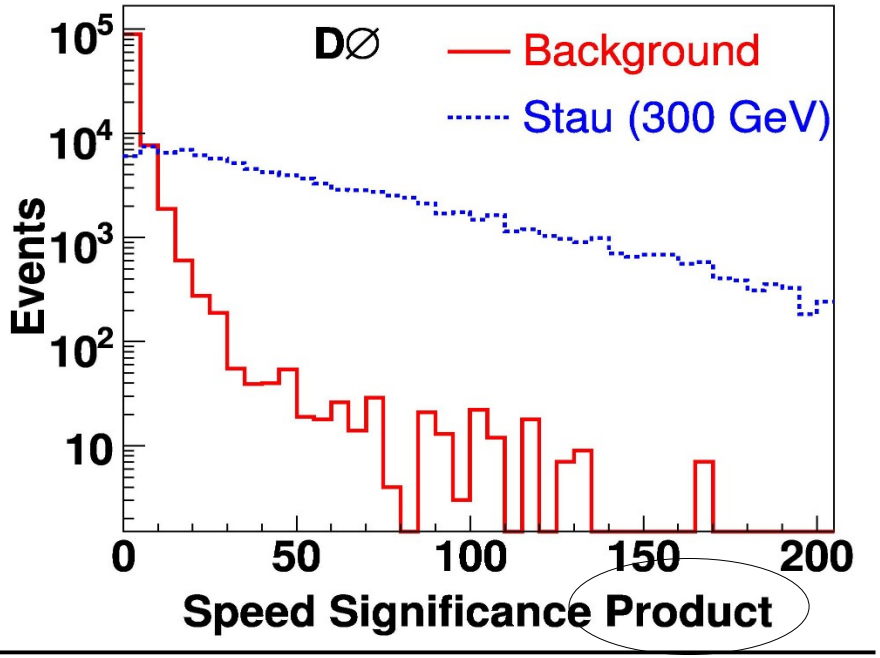
- Long-lived stop, stau, R-hadrons, chargino, ...

Charged track, highly ionizing (dE/dx) and ***late*** **(TOF)**

Exclude ~ 50 fb cross-section







Long-lived charged particles

"Slow muons"

- Long-lived stop, stau, R-hadrons, chargino, ...

TOF detector timing

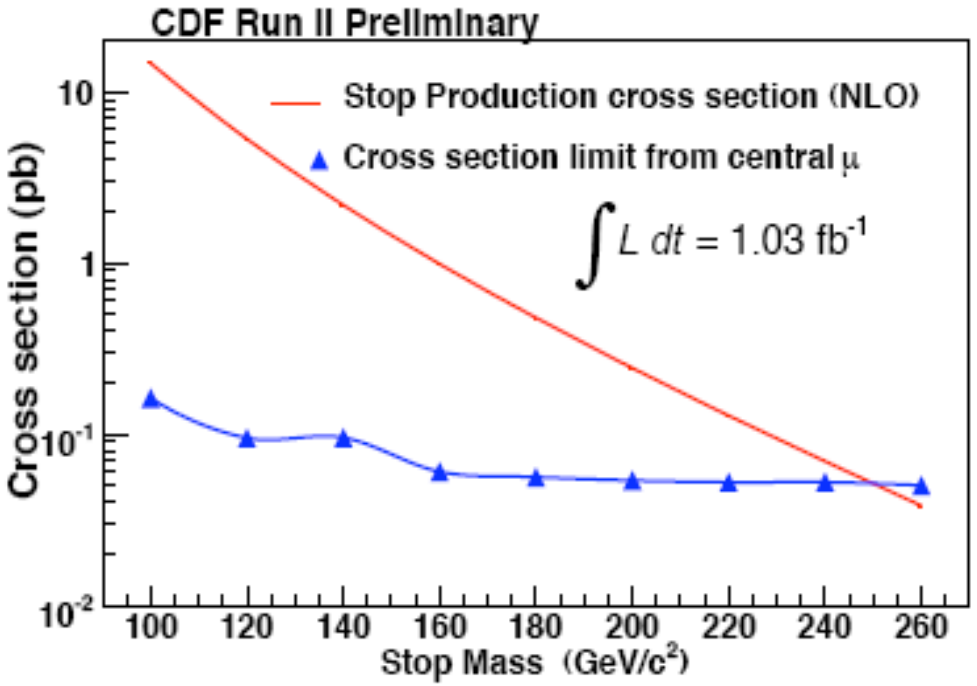
+

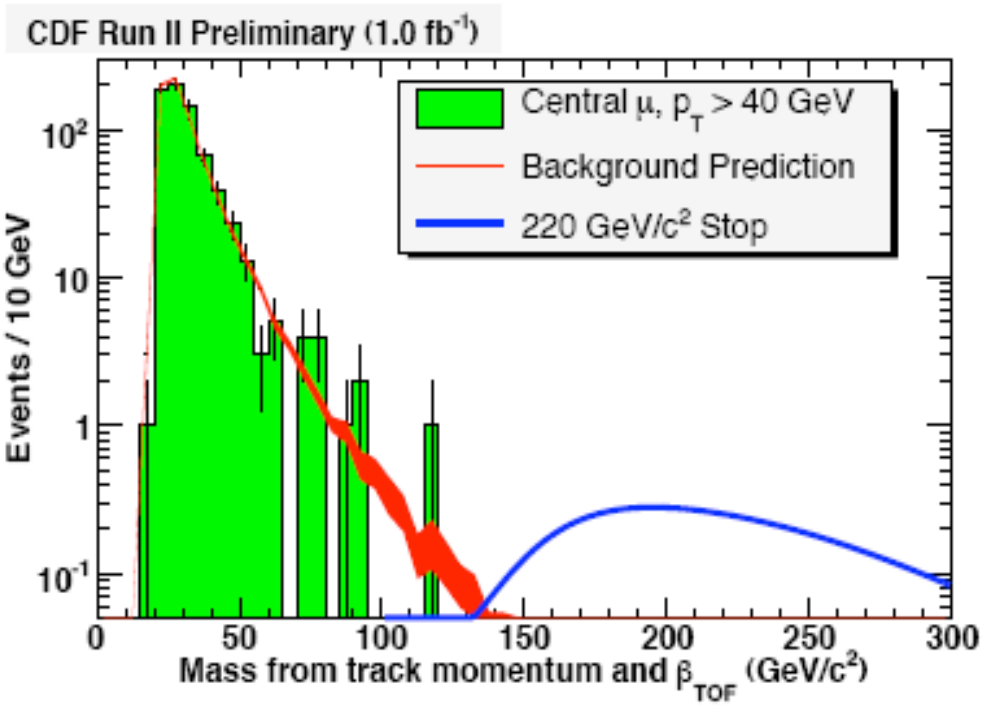
tracking drift-chamber timing

(3x worse resolution)

Charged track,
highly ionizing (dE/dx) and ***late*** **(TOF)**

Exclude ~ 50 fb cross-section



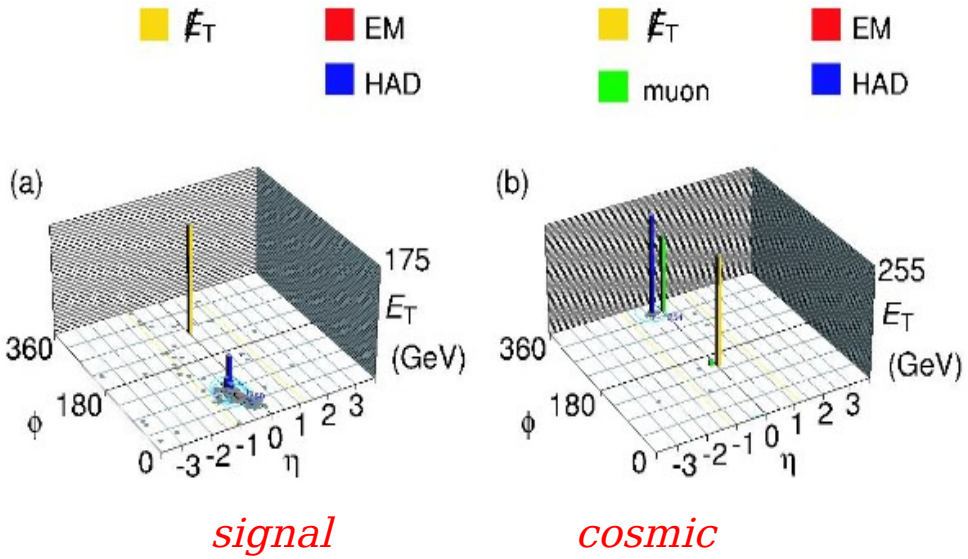


Stopping R-hadrons (gluinos)

Long-lived gluino (R-hadron)

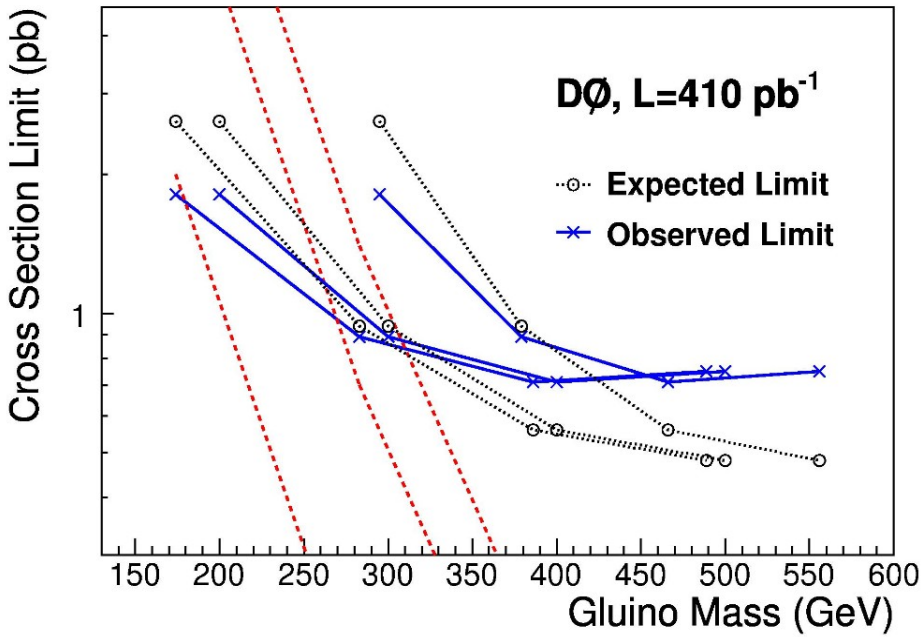
Some will *stop* in the calorimeters!

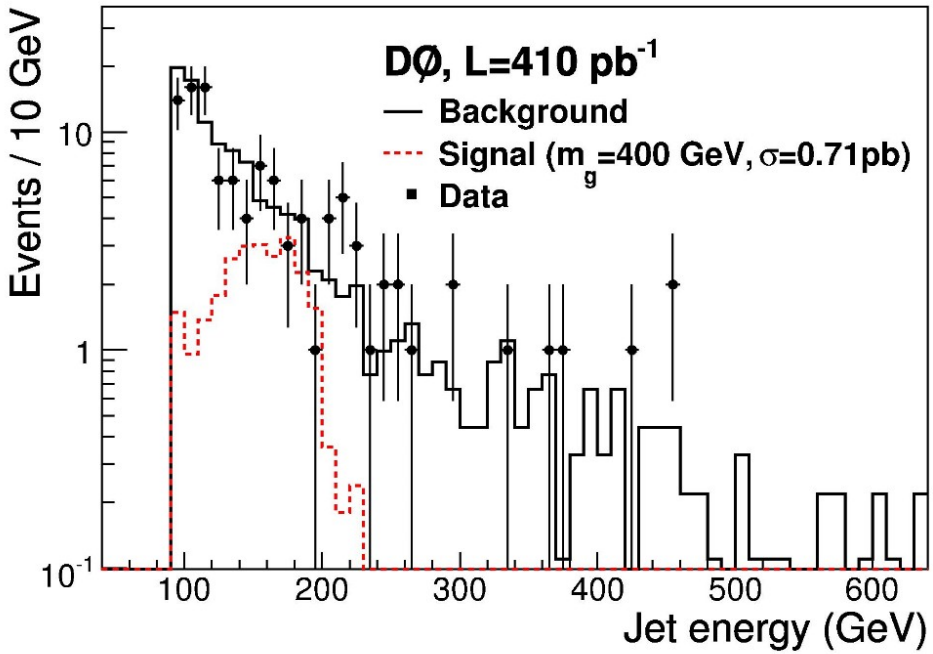
Look for decays to jets
when there's no beam collisions



signal *cosmic*

PRL 99, 131801 (2007)





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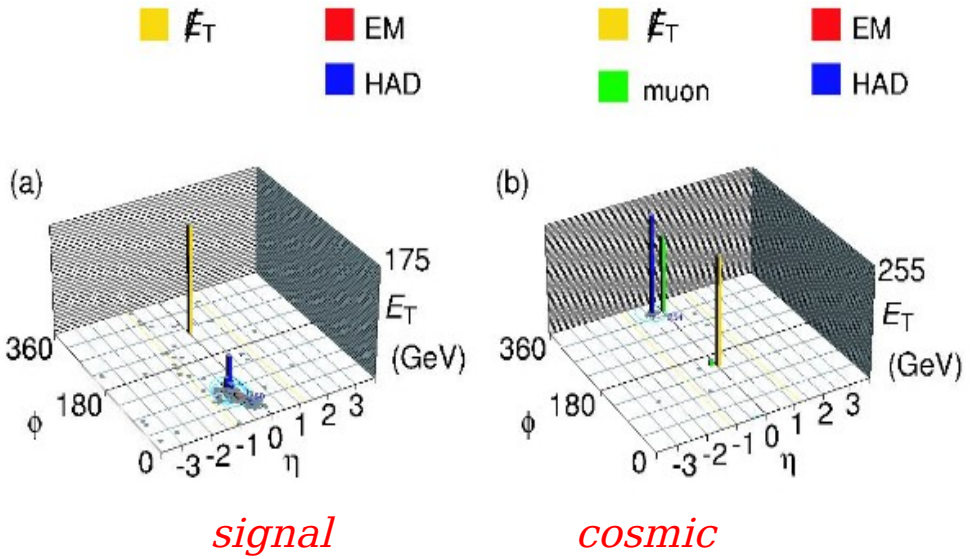

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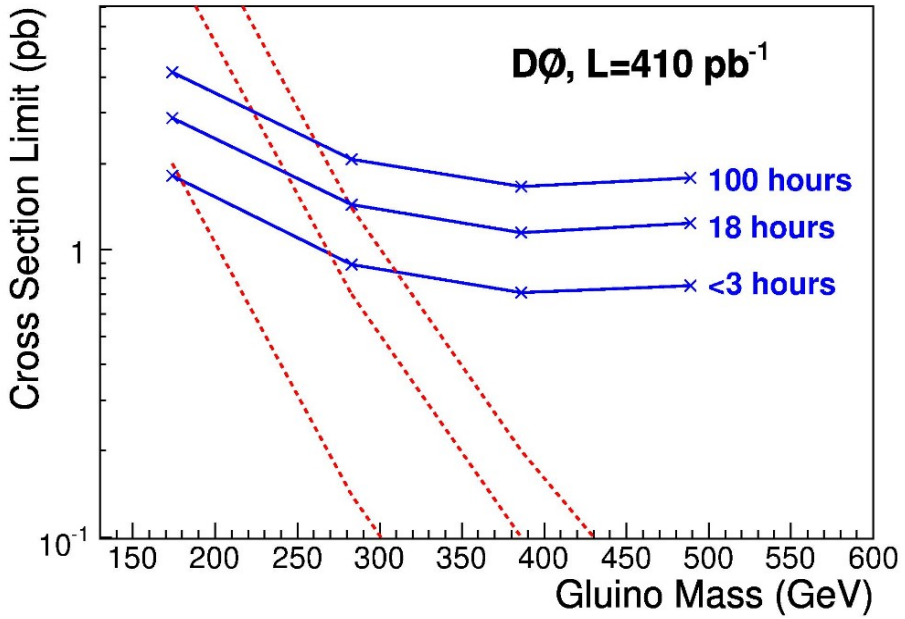
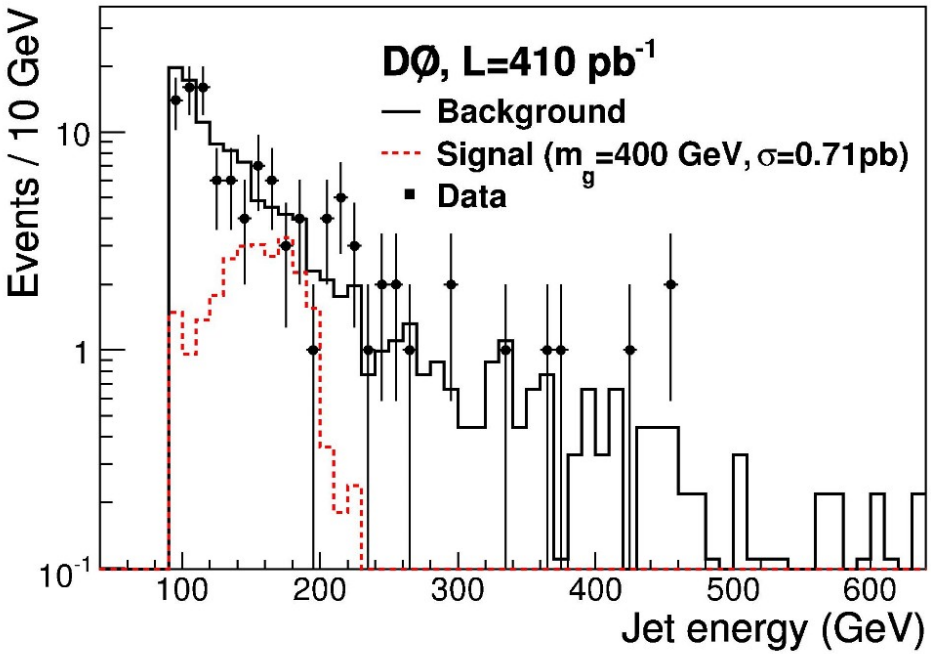
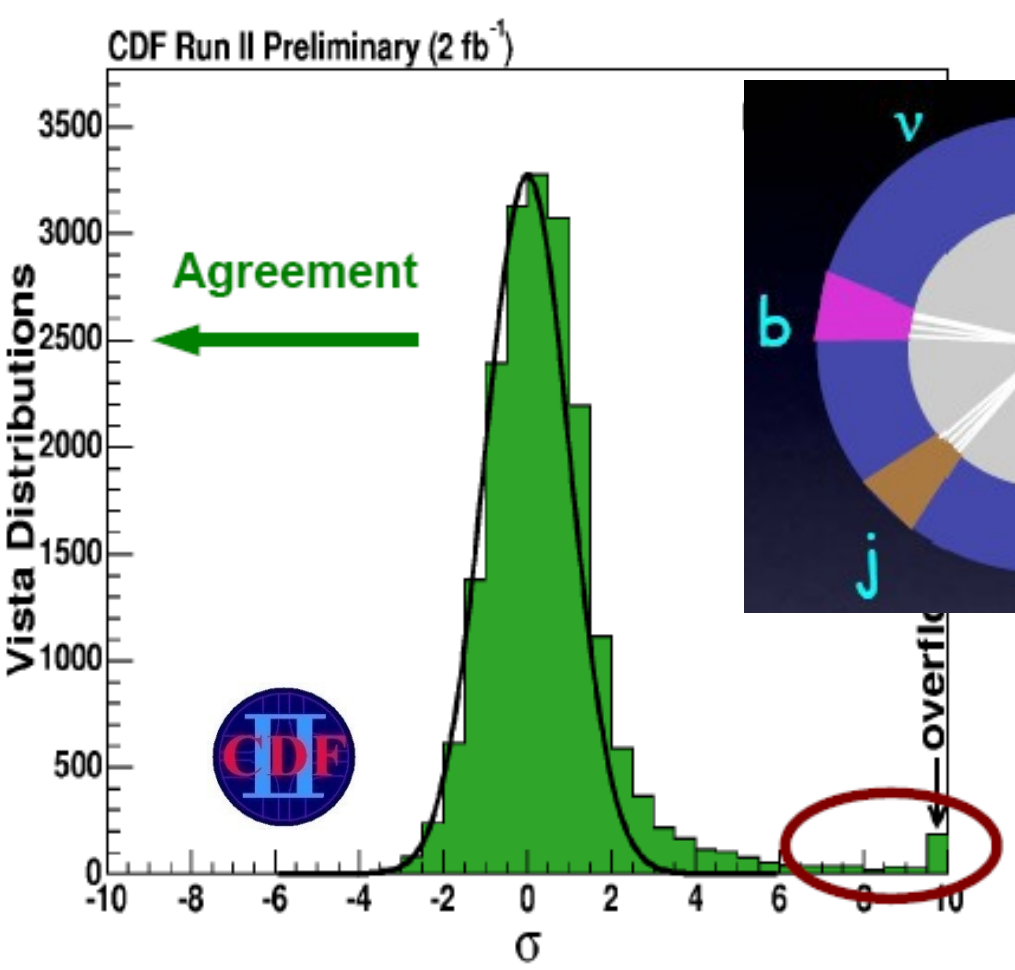


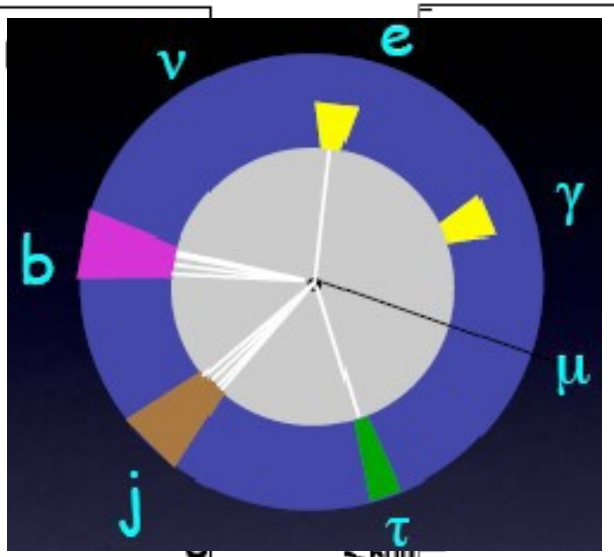


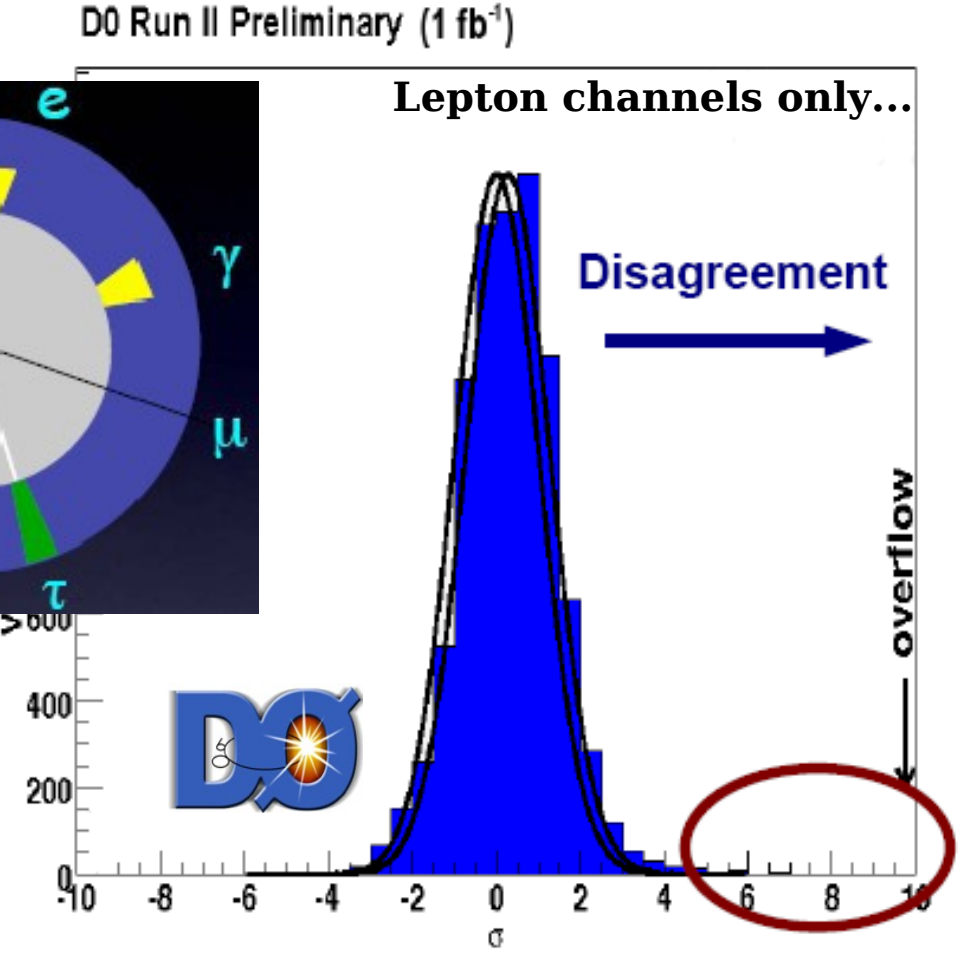
“Model-independent” Searches

Jim Linnemann - Thursday's session

Beware: only uses “isolated”, well-understood physics objects!







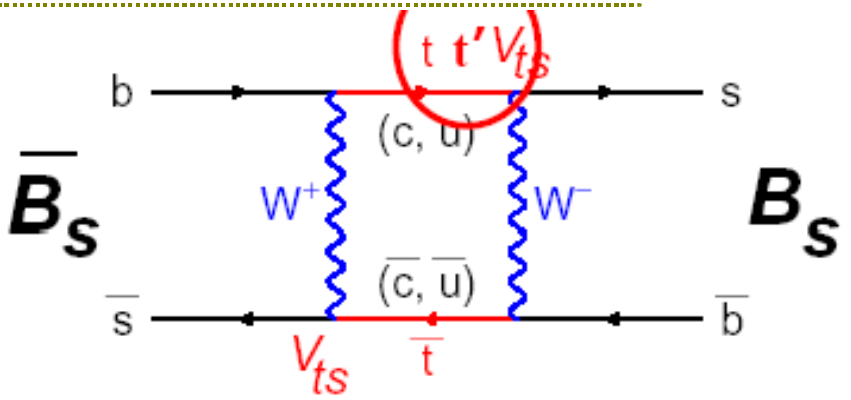
555 discrepancies mostly in multijets dominated states

24 histograms show discrepancies after trials

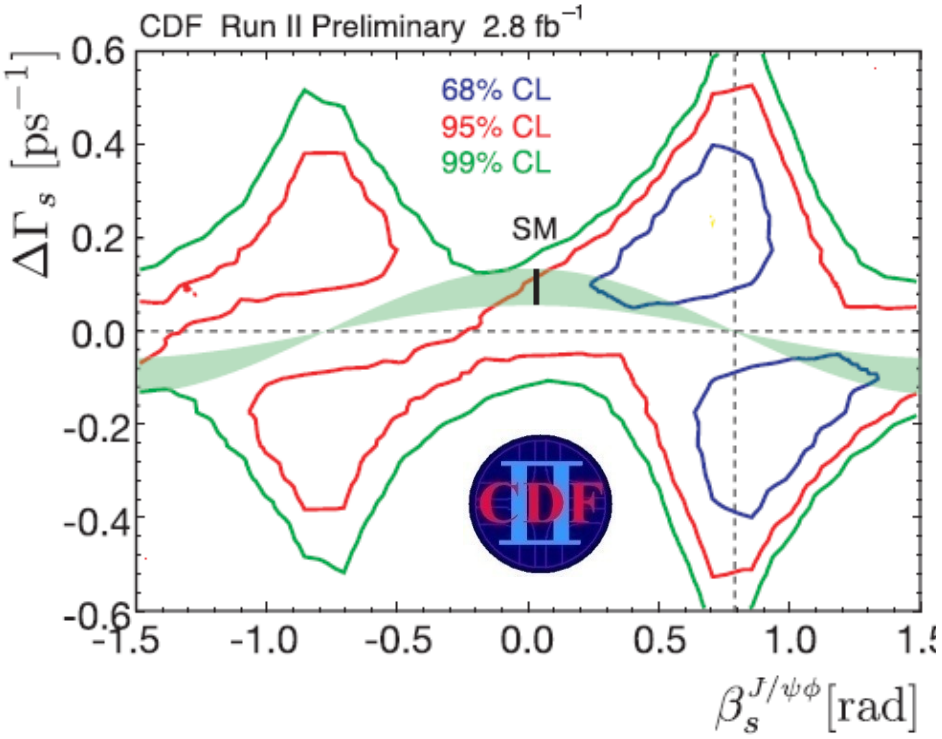
Excitement in B_s mixing?

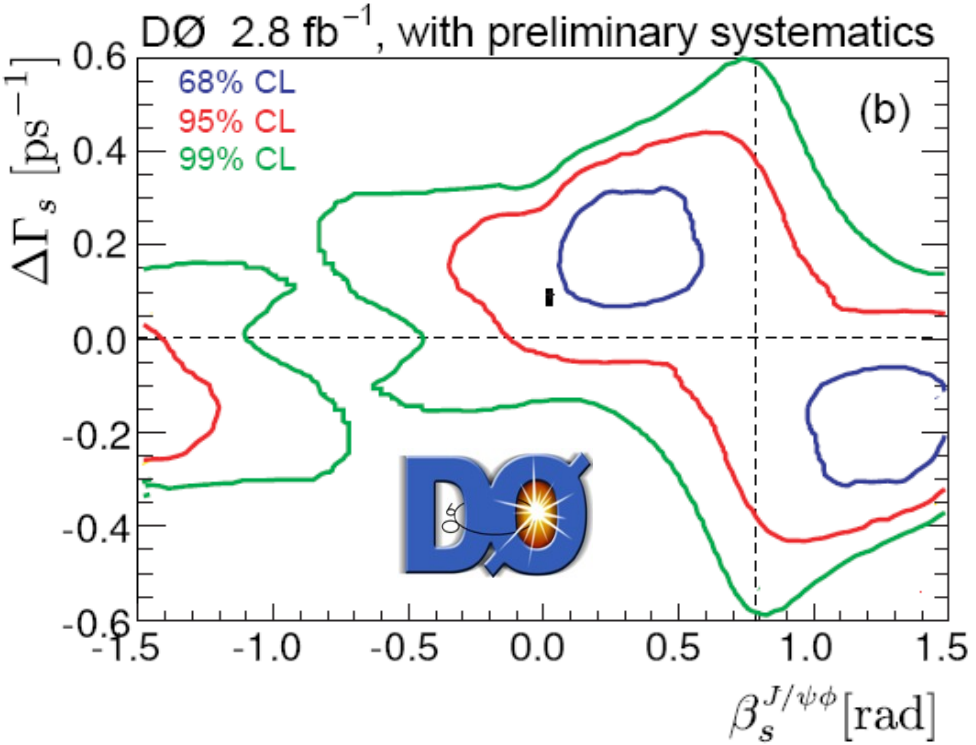
$B_s \rightarrow J/\psi\,\phi$ decays

Find CP even/odd fractions
(via angles of $J/\psi\,\phi$)
vs. proper decay time



$$V_{ts}V_{tb}^*/V_{cs}V_{cb}^*$$





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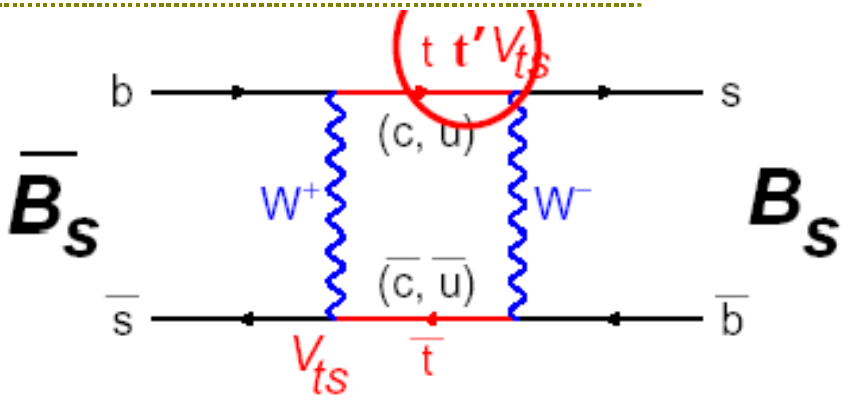

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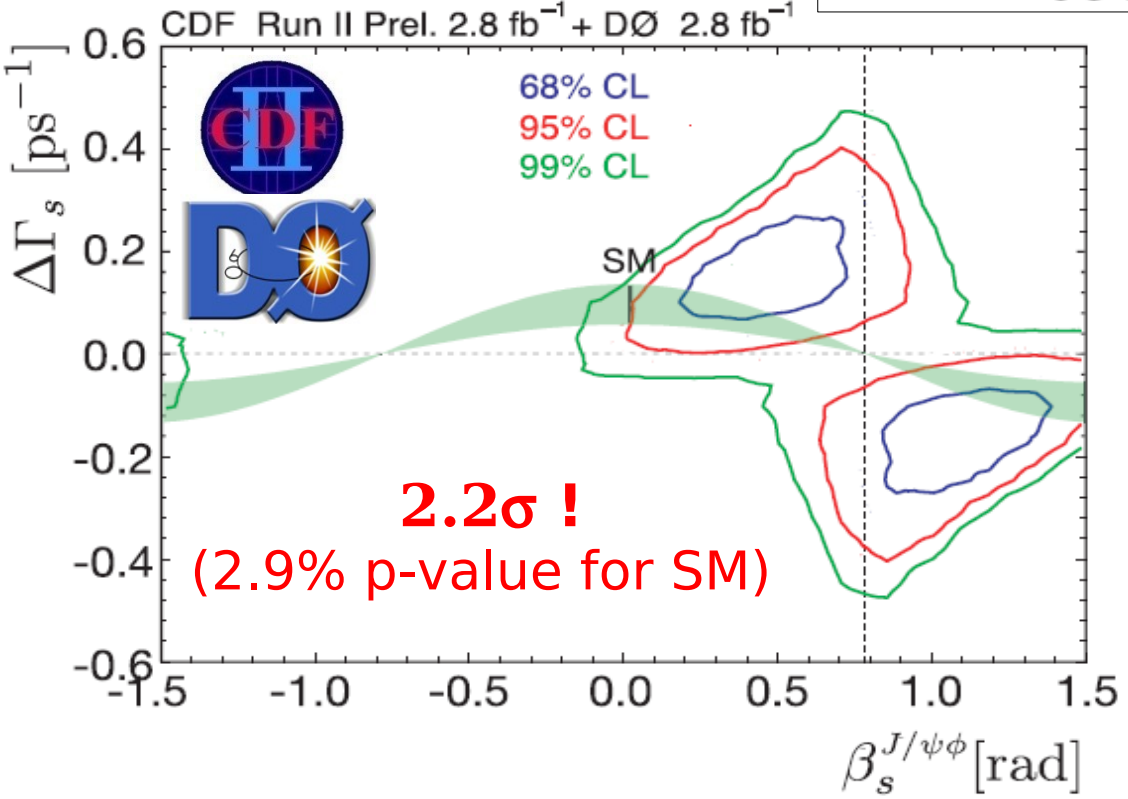


2.2σ !
(2.9% p-value for SM)

Ignacio Redondo - Tomorrow's HF/CPV session

Conclusions

Tevatron has searched in a wide range of *models* ...

... and a wide range of *signatures* ...

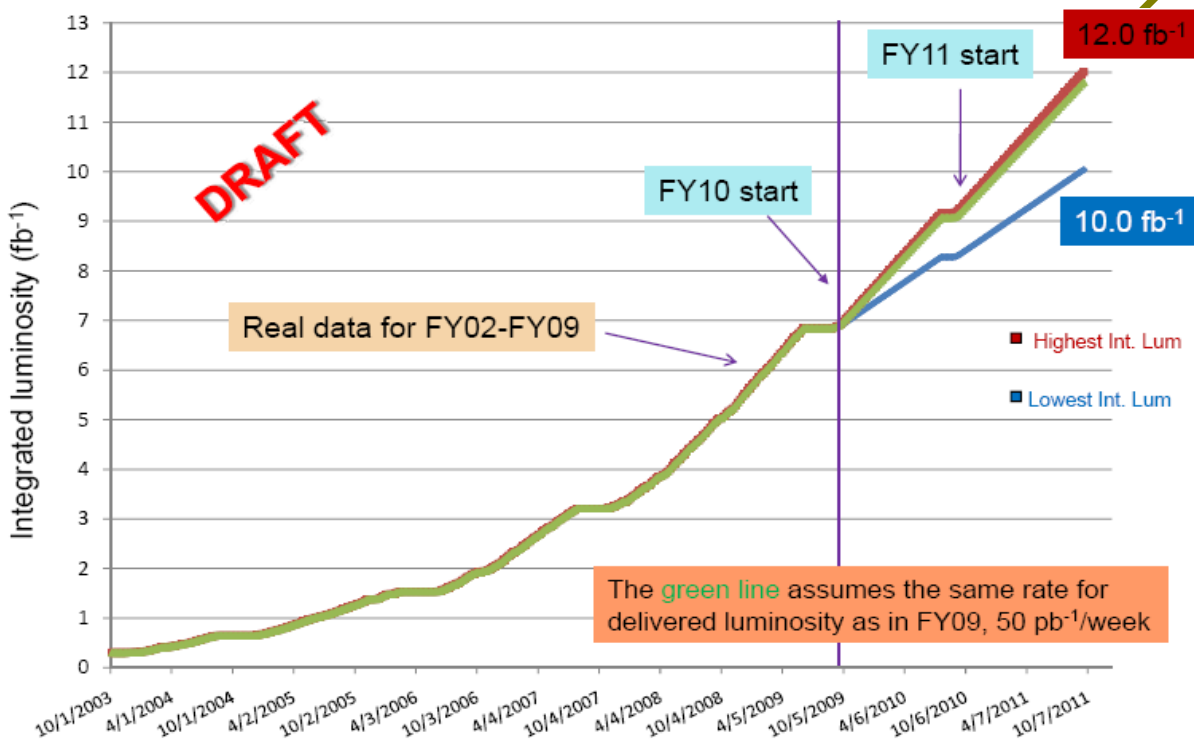
... and even in *"model-independently"*

Unfortunately,
no discoveries so far...

Leo Bellantoni -
Tomorrow's plenary session

Outlook

More data coming!
3x more for analyses



Possible to see hint of new physics in “standard channel” pre-LHC

- Keep updating key analyses

But must continue to look in new places!

- Lepton jets, Long-lived decays, Quirks?, Un-particles??

Discovery may be just one clever analysis away…

Backup