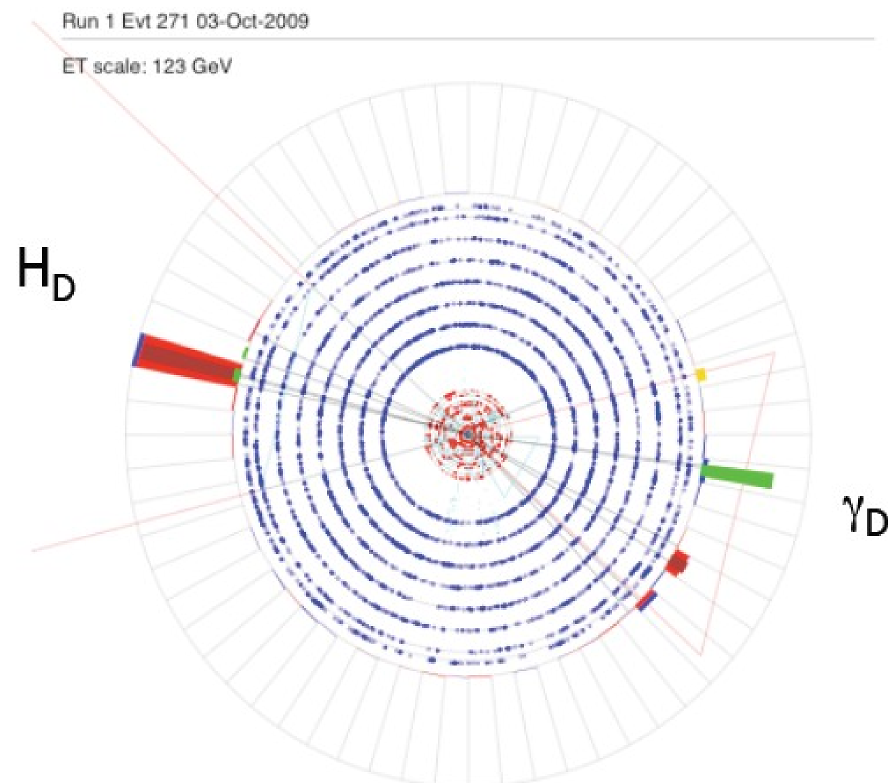
Searches for Leptonic Jets at D0

Andy Haas
Columbia University / SLAC



BOOST 2010 Workshop
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Oxford, UK

**New __preliminary__ results for this workshop... note available shortly!*

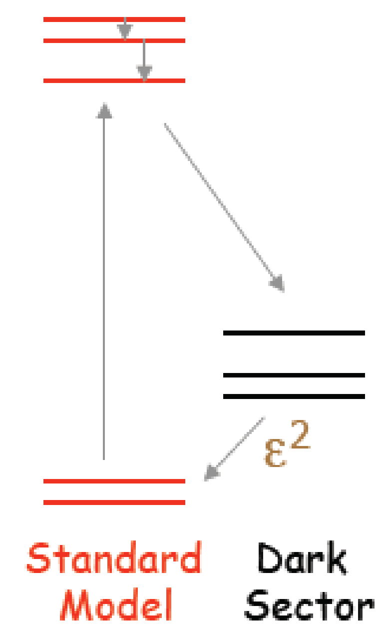
SLAC NATIONAL ACCELERATOR LABORATORY

COLUMBIA UNIVERSITY IN THE CITY OF NEW YORK

Where to find l-jets

- Direct dark-photon production
  - "Guaranteed", if dark sector exists
  - Low cross-section, depends on "ε", soft l-jets
- Decays of Z/h → 2 l-jet i.e. $Z \to \gamma_D H_D$
  - Rate depends on ε, and we know it's small
  - But could hope to reconstruct Z,h peak
- SUSY SMLSP → l-jet
  - Rate could be large! No ε!
  - At least 2 l-jets per event
  - Also get large MET
  - But need low-mass SUSY to be real

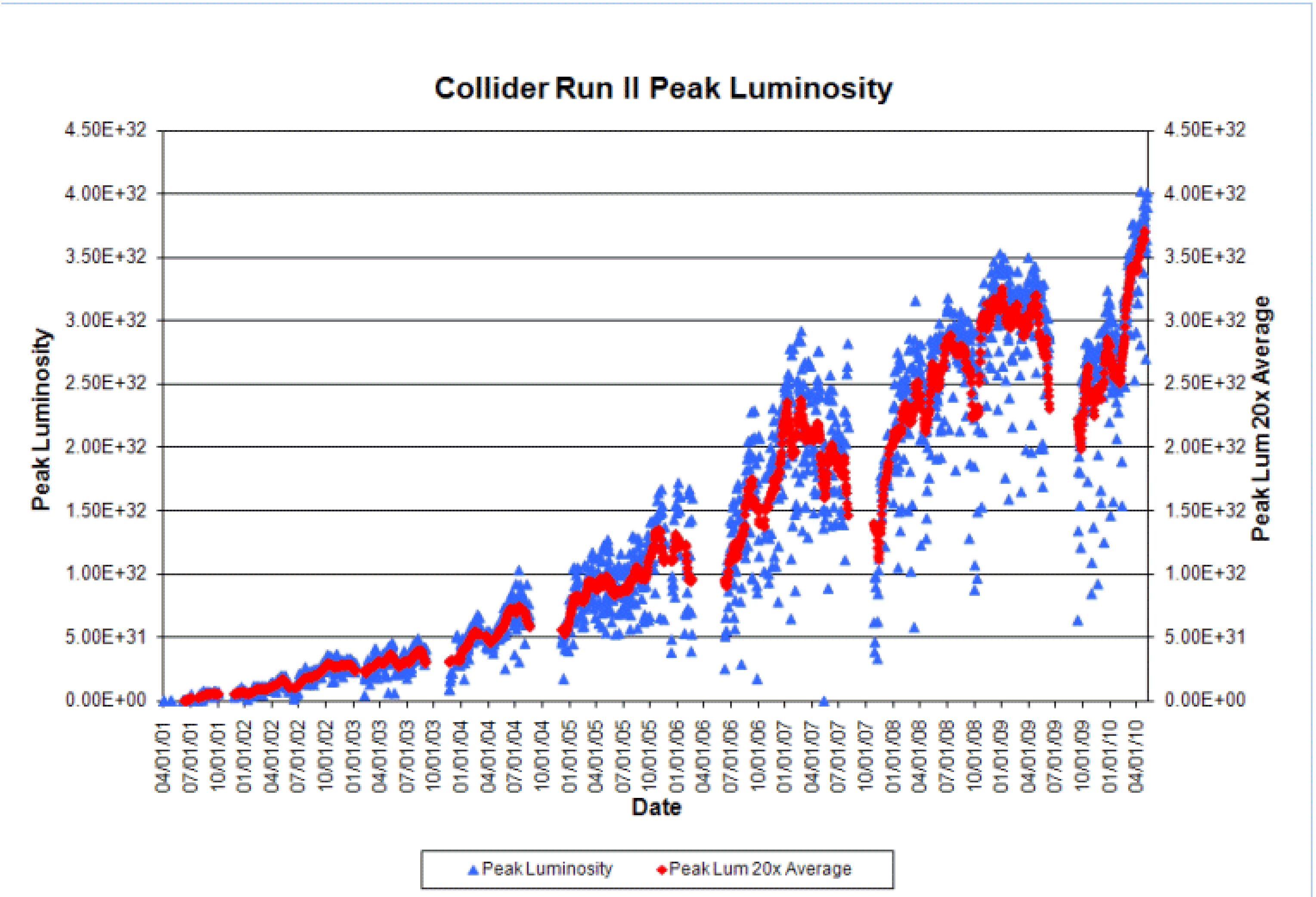
Thanks to BOOST '09 !



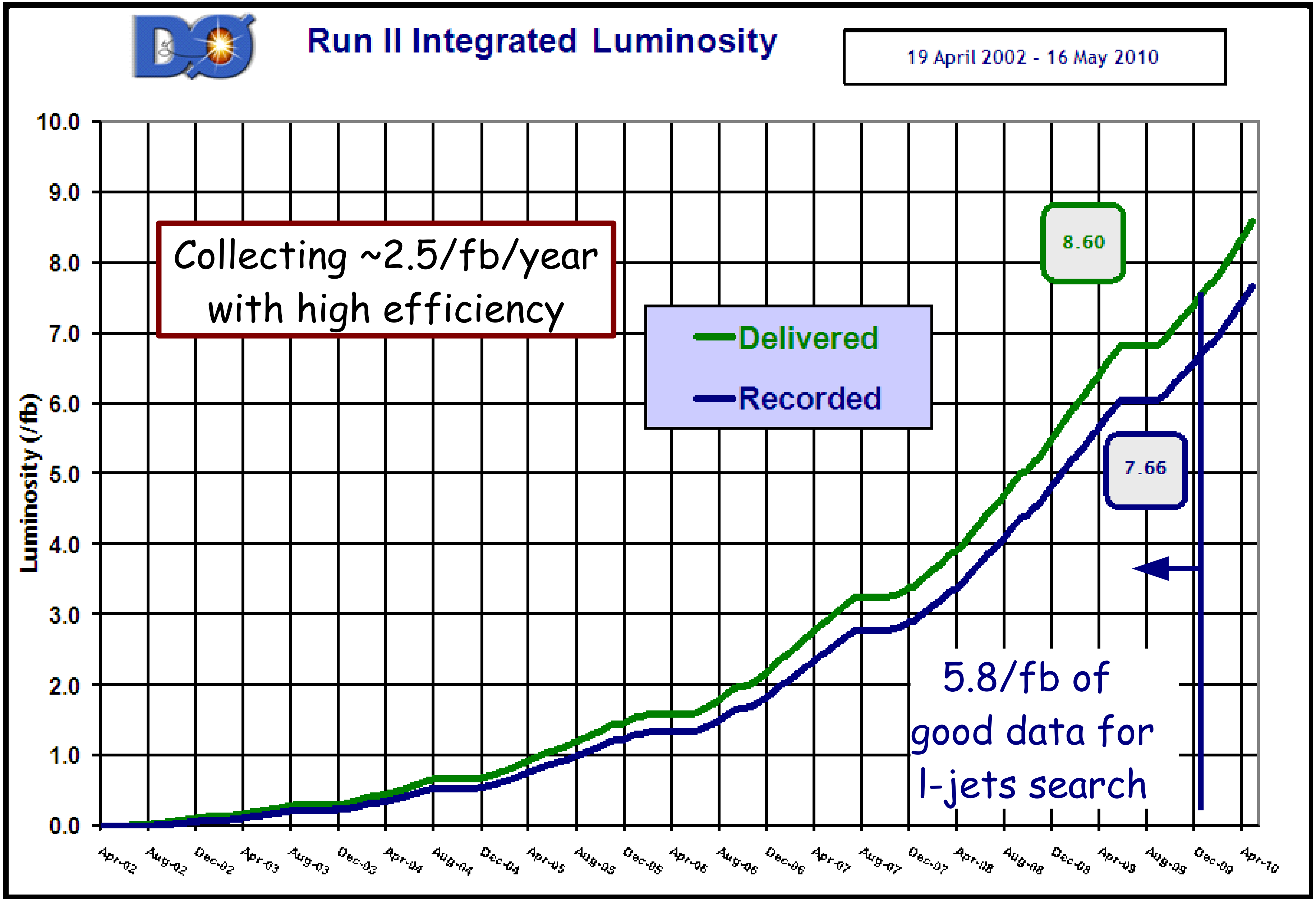
Focus on SUSY case first – uses strengths of Tevatron

Tevatron Performance

- Stores typically start at >350/ub/s
- (LHC record: ~0.2/ub/s … but improving fast, ~1/ub/s soon)

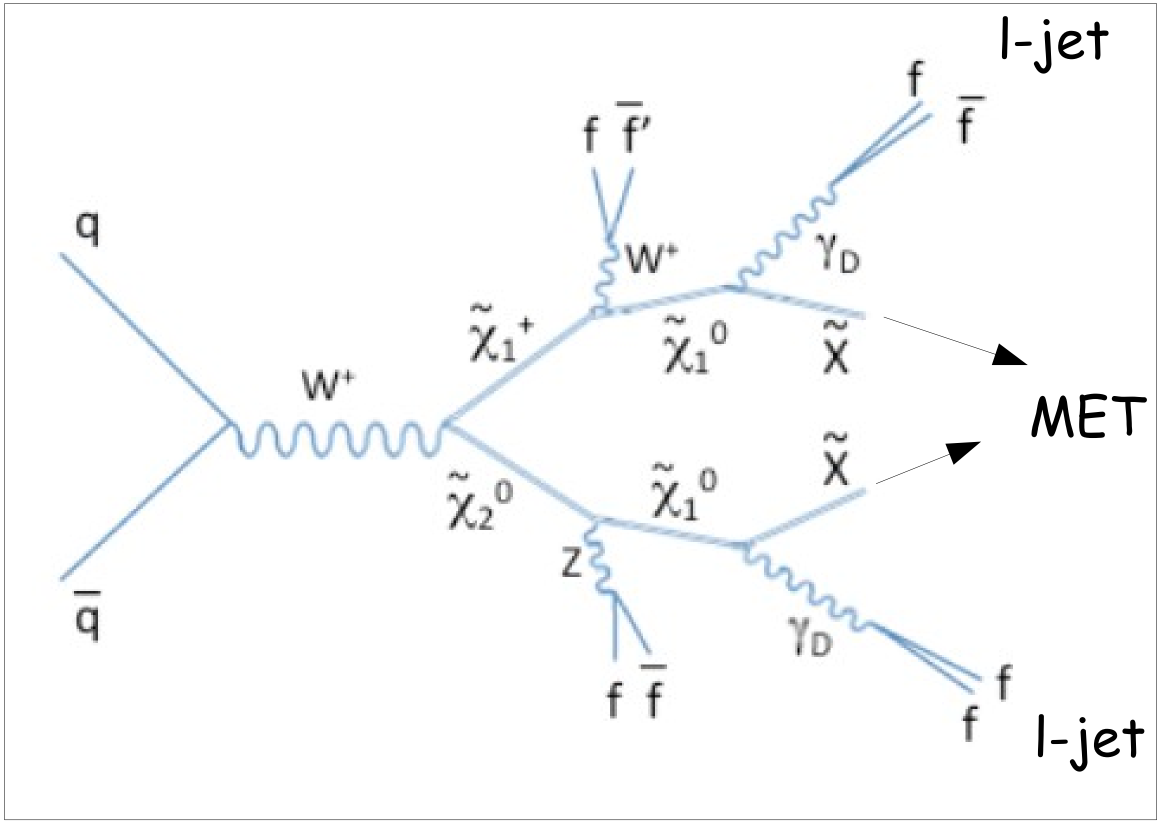


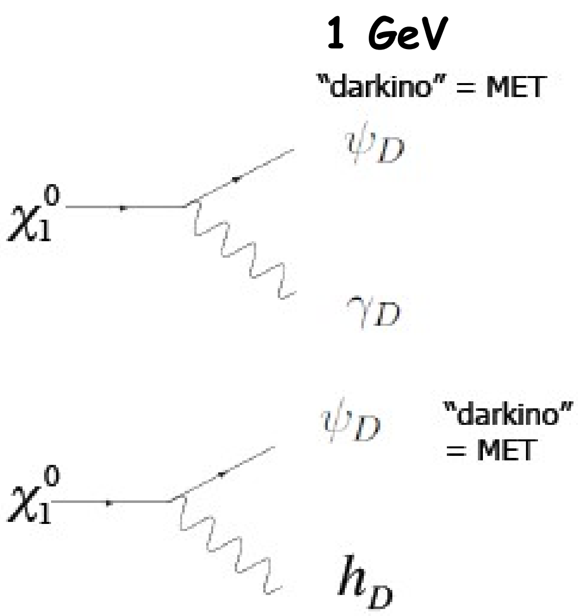
Tevatron Performance



Decays to the dark side

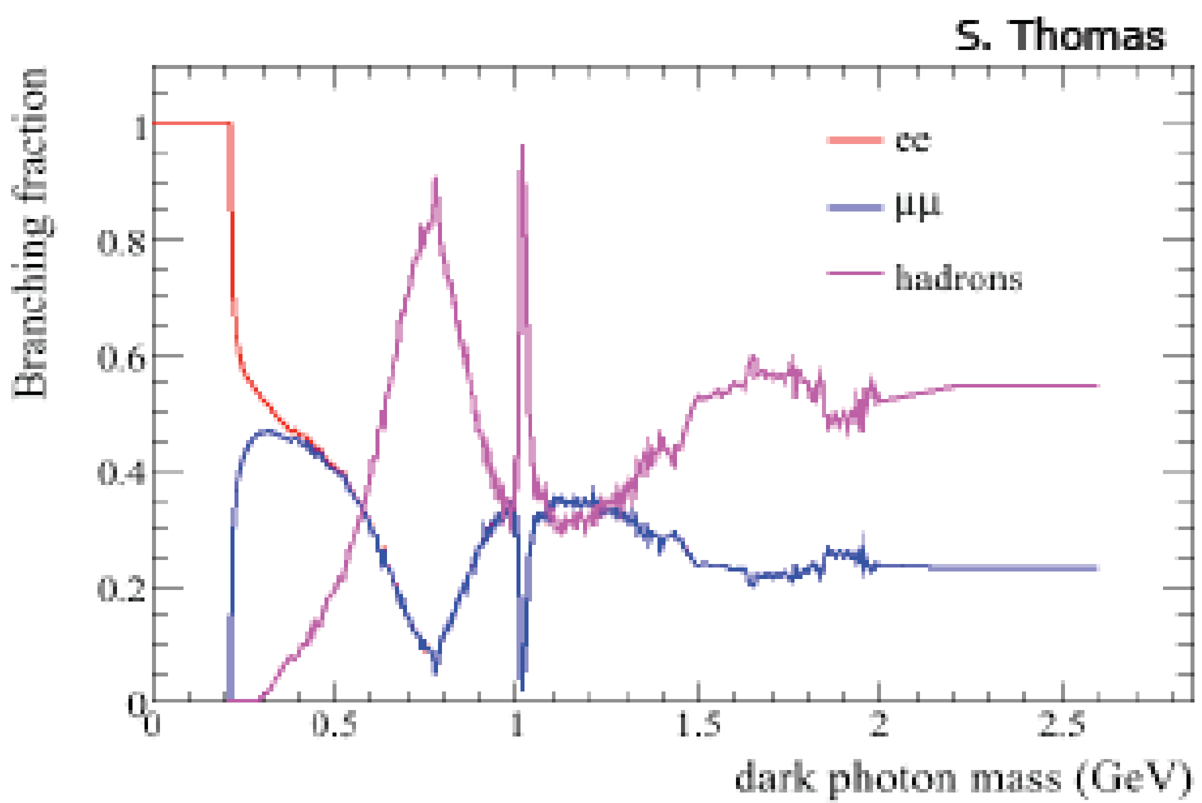
- For a benchmark, use GMSB SPS8 point, σ =20fb
  - Kinematics do not change much for other similar SUSY points
- All SM LSPs decay to l-jet
- Focus on simpler case of dark photon + darkino (MET) first





Dark Photon Decays

- BR(e)=BR(μ), except below $2m_\mu$
- Depends on "R", well-measured at e^+e^- colliders
- BR to pions is large near hadronic resonances
- We study a range of dark photon masses from 0.15 to 2.0 GeV



L-jet Identification

"Electron l-jet"

EM cluster, p_T>15 GeV

Matched to p_T>10 GeV track

"Muon l-jet"

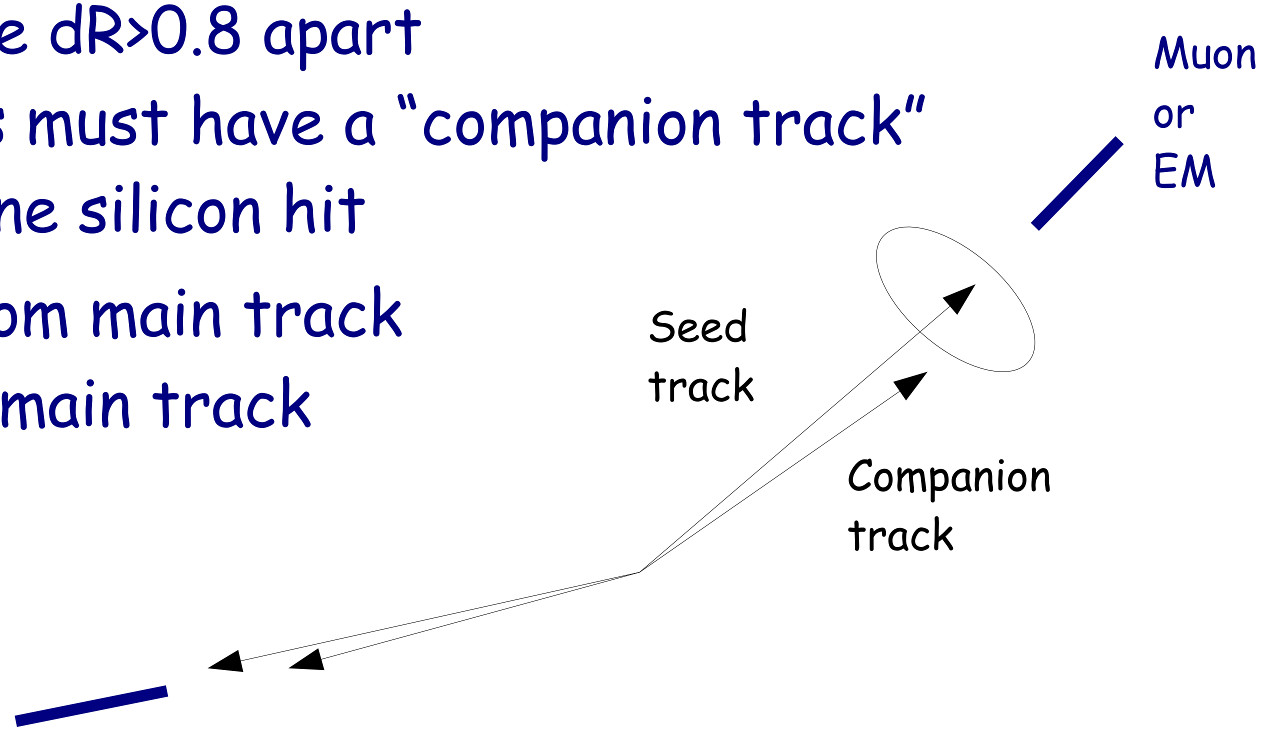
3 hit track in muon system

Matched to p_T>10 GeV track

The two tracks must be dR>0.8 apart

Each of the two tracks must have a "companion track"

- p_T>4 GeV, at least one silicon hit
- dR<0.2, |dz|<1cm from main track
- Opposite sign from main track

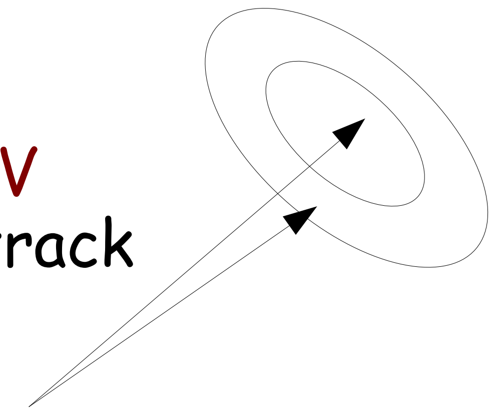


dR=sqrt(dphi²+deta²)

L-jet Isolation

- Need isolation to separate from huge QCD background
- But keep isolation loose enough to not kill possible signals!
  - May have many more tracks, be wider from radiation, etc…

Track isolation < 2 GeV, in 0.2<dR<0.4



Muon isolation in calorimeter < .066*pT+2.35 GeV
dR<0.4 and dR>0.1 of either muon or companion track

Electron isolation in calorimeter < .085*pT-.53
0.2<dR<0.4 in EM layers and dR<0.4 in hadronic layers
(corrected for underlying event and pileup at high luminosity)

Isolation cuts are functions of l-jet pT so not to bias MET measurement

Two L-jet Data Sample

Look at MET distribution
(not μ corrected - calorimeter only)

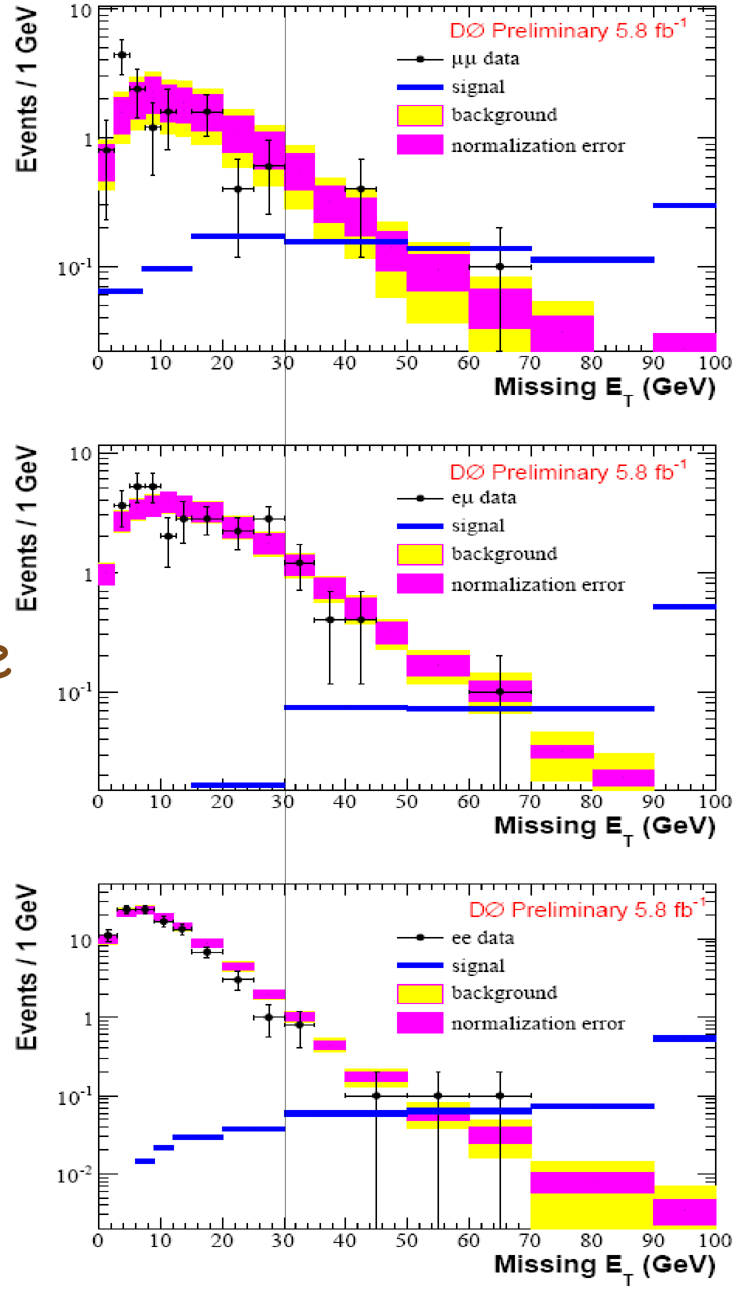
Compare data to non-isolated background scaled to data for MET<15 GeV

- Normalization uncertainty from statistics

Systematics on the background shape are determined from changes in the MET shape when just one or the other l-jet is non-isolated

Signal MC has large MET

Require MET > 30 GeV



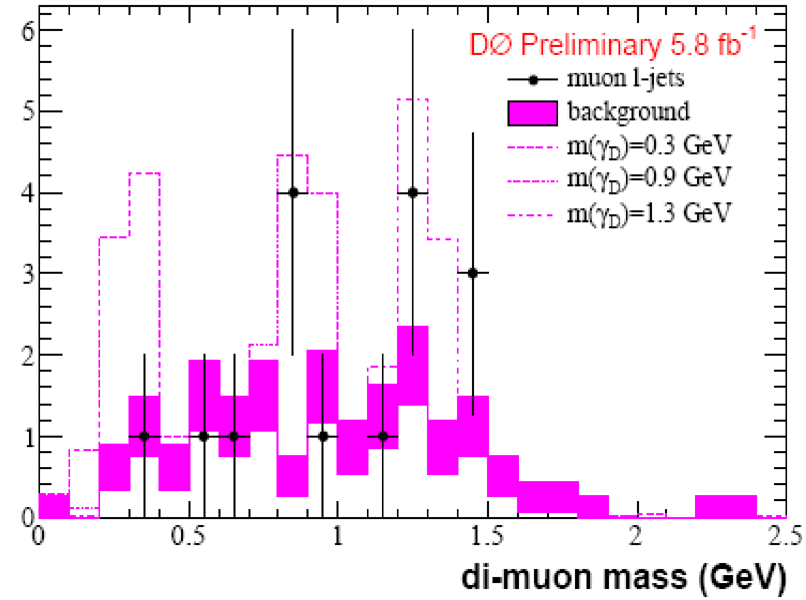
Resonance Search

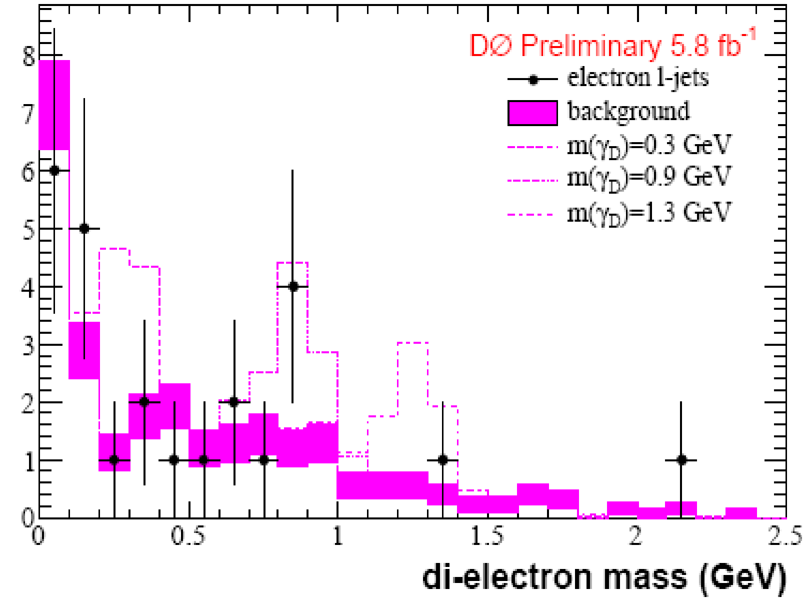
For events with 2 isolated l-jets and MET>30 GeV, look for resonance in track / companion track mass

Background estimated from isolated di-l-jet sample with MET<20 GeV

BR's, mass windows:

$m(\gamma_D)$ (GeV)	BR(ee)($\mu\mu$)	M_{reco}^{low}-M_{reco}^{high} (GeV)	Eff. e	Eff. μ
0.15	1 0	0.0 - 0.3	0.81	-
0.3	0.53 0.47	0.1 - 0.4	0.82	0.88
0.5	0.4 0.4	0.3 - 0.6	0.81	0.89
0.7	0.15 0.15	0.4 - 0.8	0.85	0.89
0.9	0.27 0.27	0.6 - 1.1	0.82	0.91
1.3	0.31 0.31	0.9 - 1.4	0.72	0.79
1.7	0.22 0.22	1.0 - 1.8	0.73	0.76
2.0	0.24 0.24	1.3 - 2.2	0.73	0.83



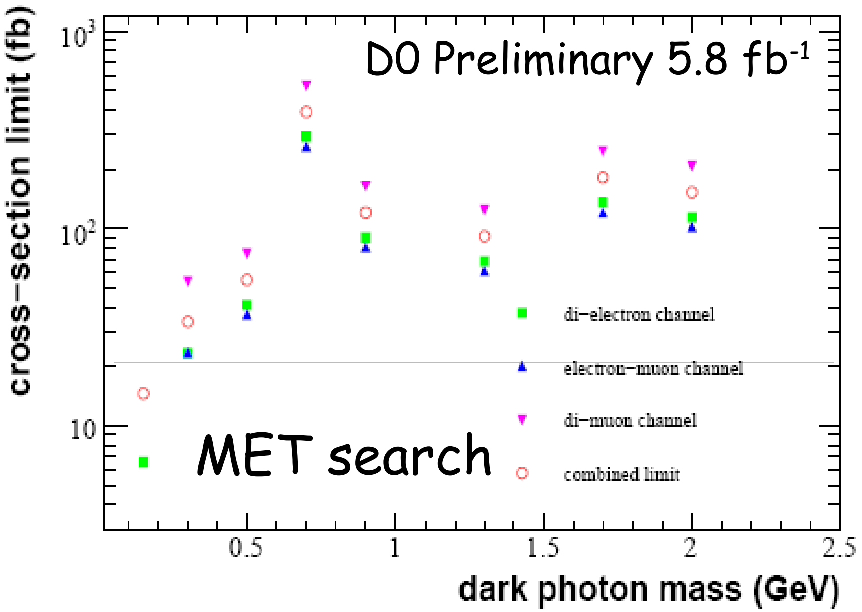


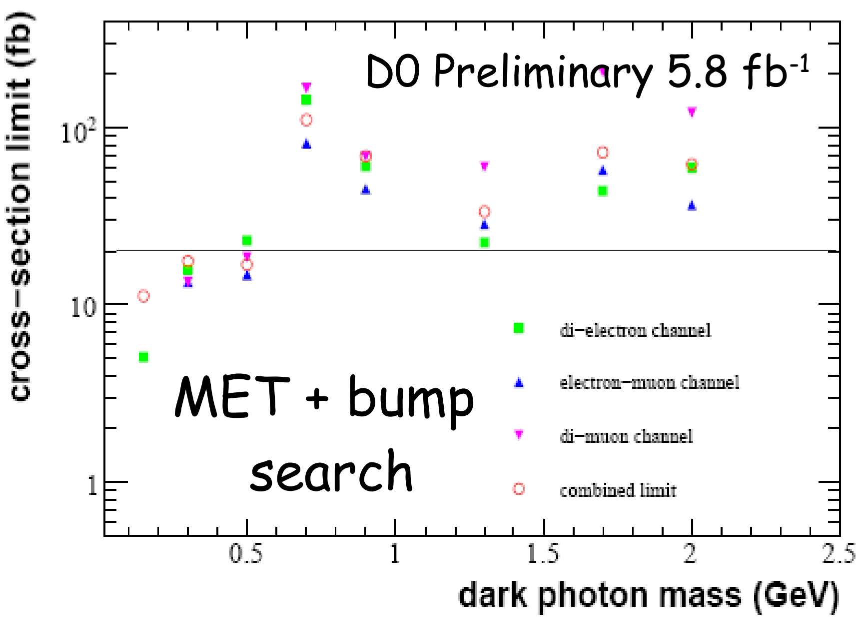
Results

- Calculate limits using Bayesian
- Systematics
  - Signal efficiency, 20%
  - Background normalization, 20-50%
  - Luminosity, 6.1%
- Limit for all channels combined corrects for SPS8 acceptance

Channel	Data	Background	SPS8 Acc.	Reco. eff.	Total eff.
ee	7	10.2 ± 1.7	0.45	0.20	8.9 %
$e\mu$	11	17.5 ± 4.2	0.53	0.15	7.8 %
$\mu\mu$	3	8.6 ± 4.5	0.50	0.12	5.8 %

- Rules out SPS8 for decays to l-jets for some masses
  - Would also rule out other SUSY points with lighter chargino / neutralino or strong production



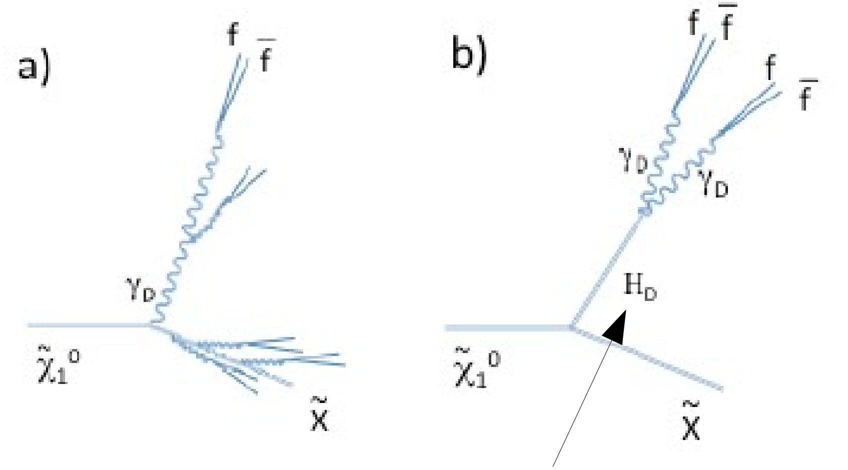


More complicated dark sector

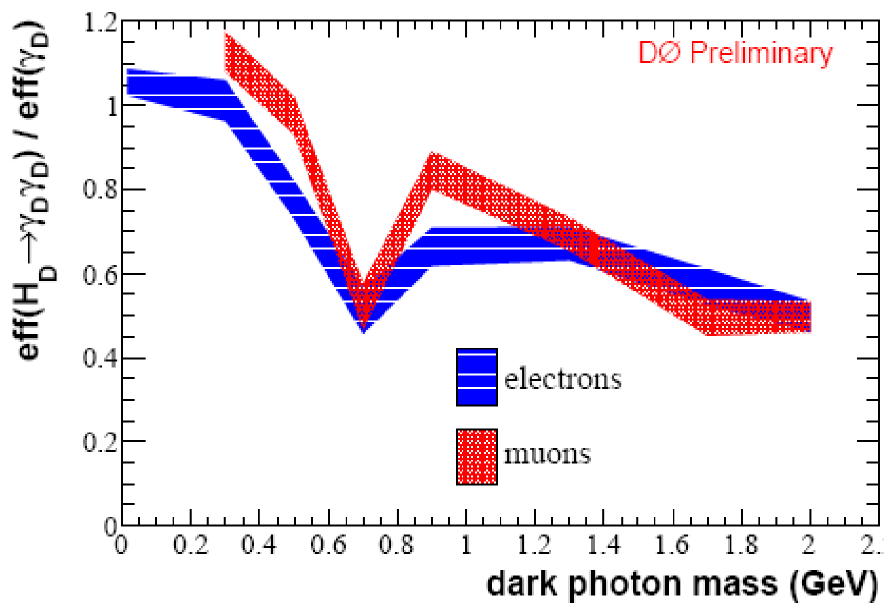
Studied using MC simulation only

a) Additional dark radiation / showers
- Adds additional tracks, hadronic E
- Raising dark coupling from 0 → 0.3 decreases efficiency by up to 20%
- Independent of dark photon mass

b) Decays to dark Higgs
- Gives softer leptons
- Up to 50% lower efficiency, for large dark photon mass



$m(\gamma_D)$	0.15	0.3	0.5	0.7	0.9	1.3	1.7	2.0
$m(H_D)$	1.2	1.2	1.2	1.6	2.0	3.0	4.0	4.5



Summary

- First search for two l-jets + MET at a hadron collider
  - Studied both electron and muon l-jets (ee, emu, mumu)

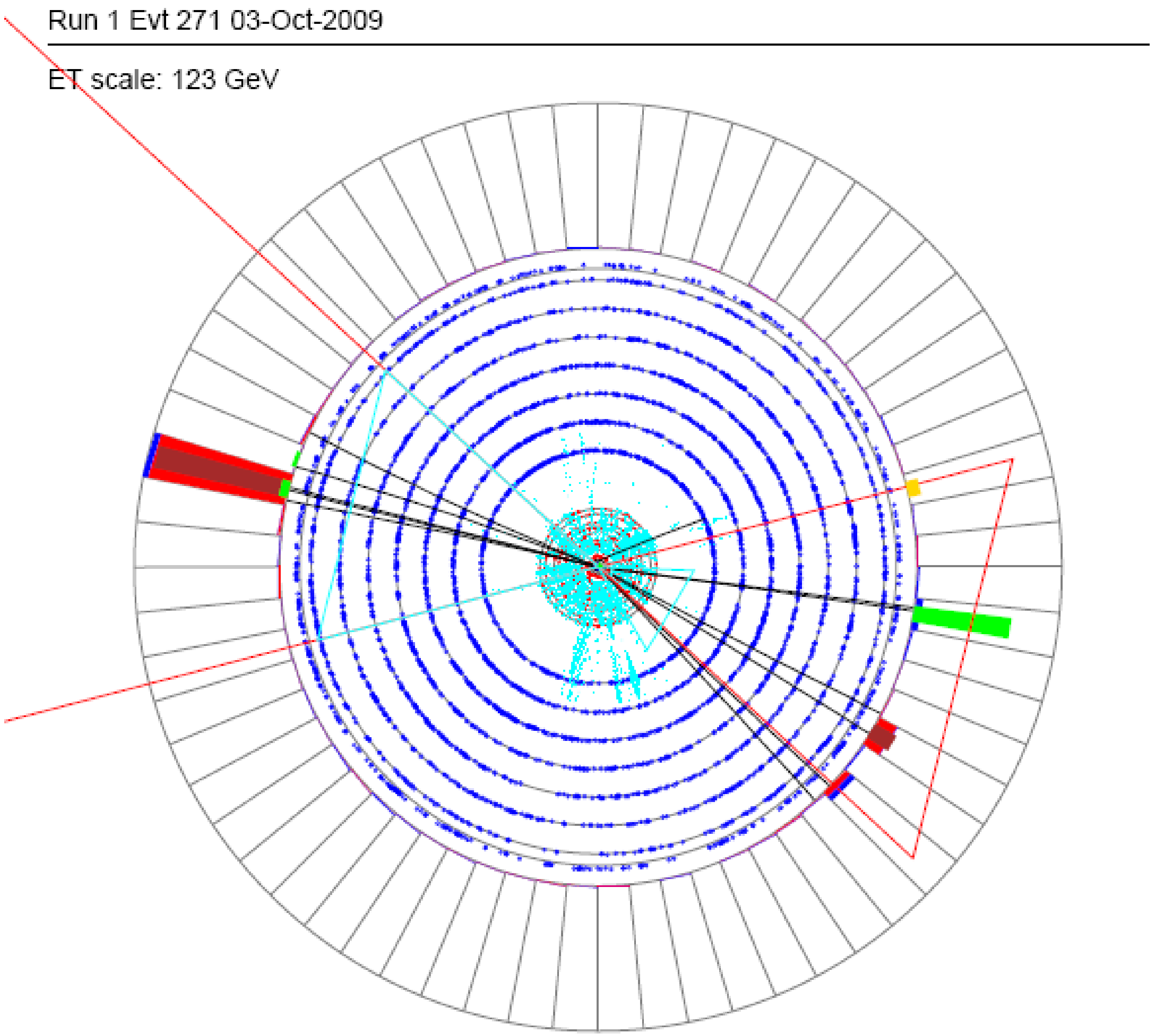
- No excess seen over background at large MET
- No sign of a resonance in the high (or low) MET l-jet mass

- Rules out scenarios with light SUSY particles decaying to l-jets
  - Also sensitive to more complicated dark-sector decays/showers

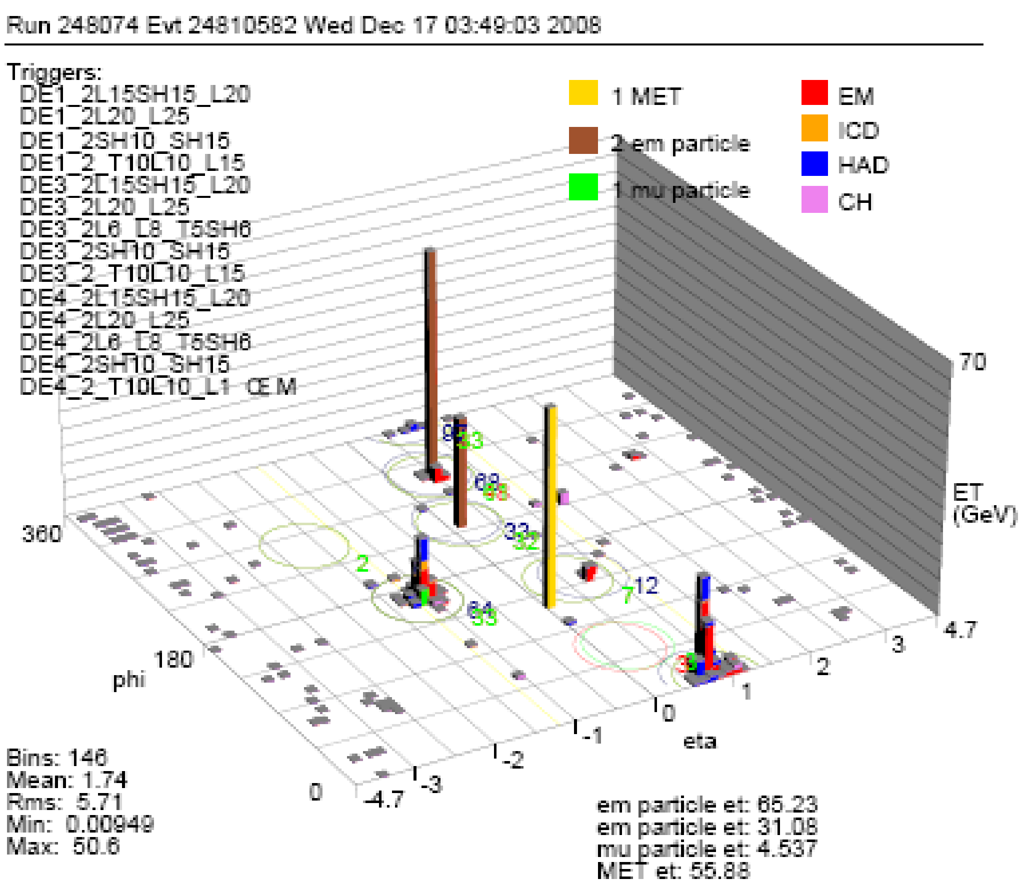
Thanks also to participants of BOOST '09 and A. Falkowski, J. Ruderman, M. Strassler, S. Thomas, I. Yavin, and J. Wacker

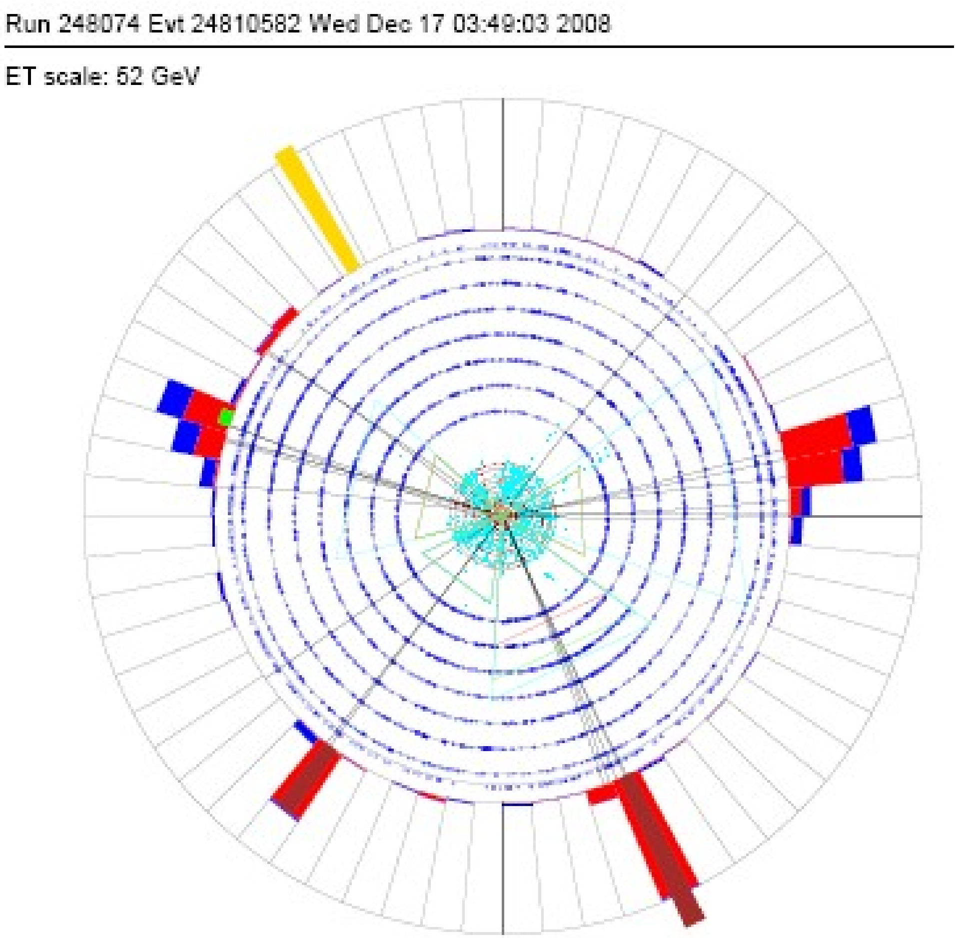
Backup

MC Signal Event



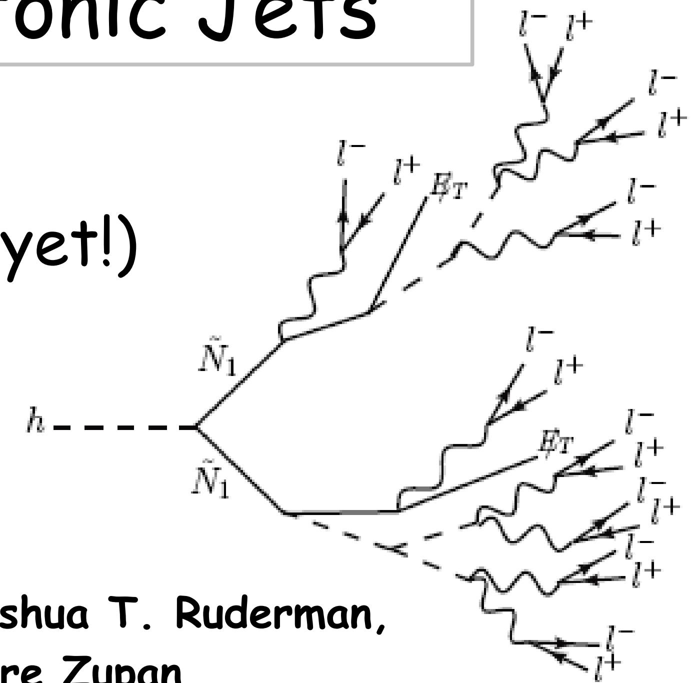
Two electron l-jets with large ME_T





Searches for Higgs → Leptonic Jets

- Leptonic jets could also hide the Higgs
- Not searched for generically at colliders (yet!)



- Narrow jets of leptons (and pions maybe)
- Probably some ME_T
- Probably resonances of l+l- pairs inside jets

Adam Falkowski, Joshua T. Ruderman, Tomer Volansky, Jure Zupan arXiv:1002.2952