Searches for Supersymmetry at CMS

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 Universität Heidelberg Seminar, 20th January 2011.

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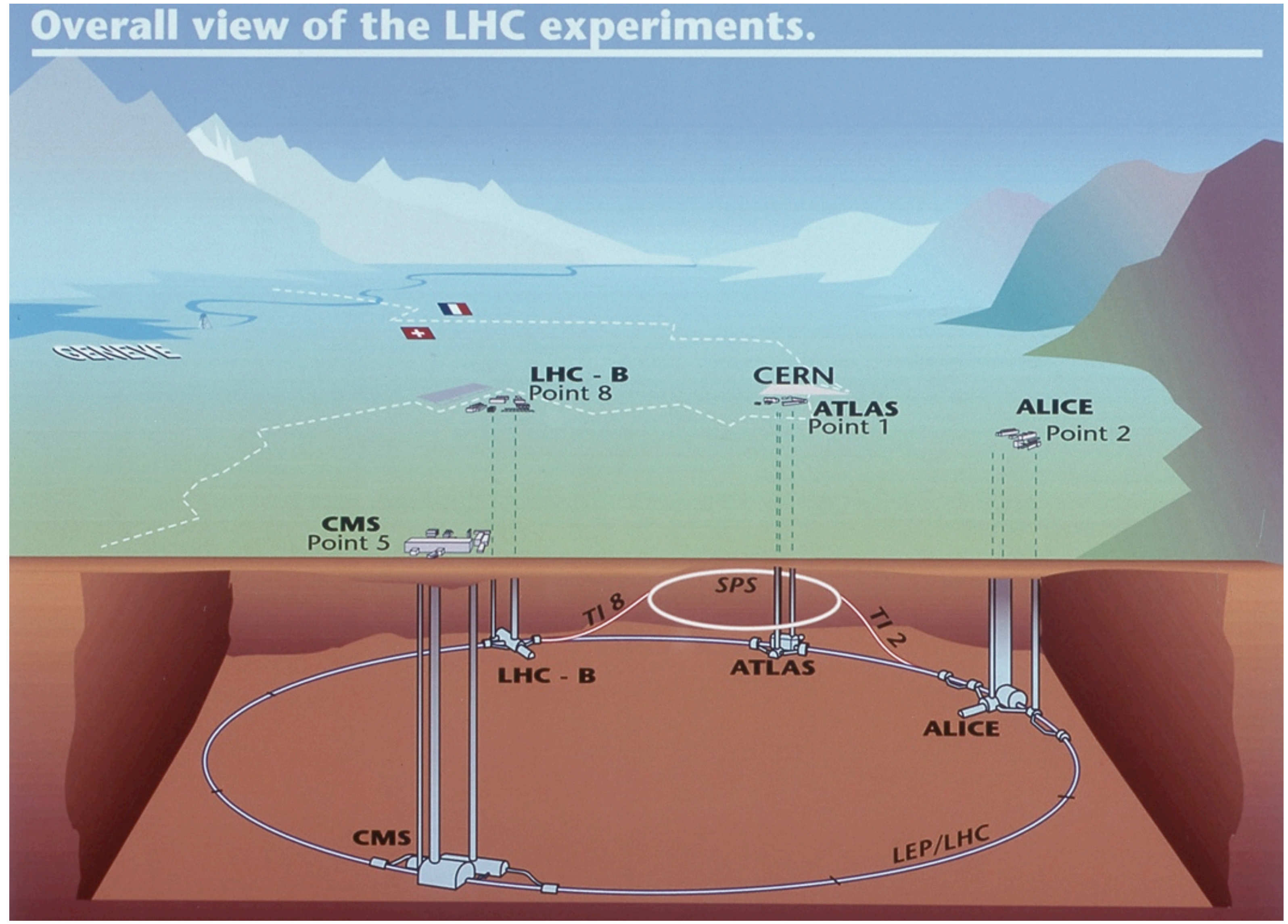
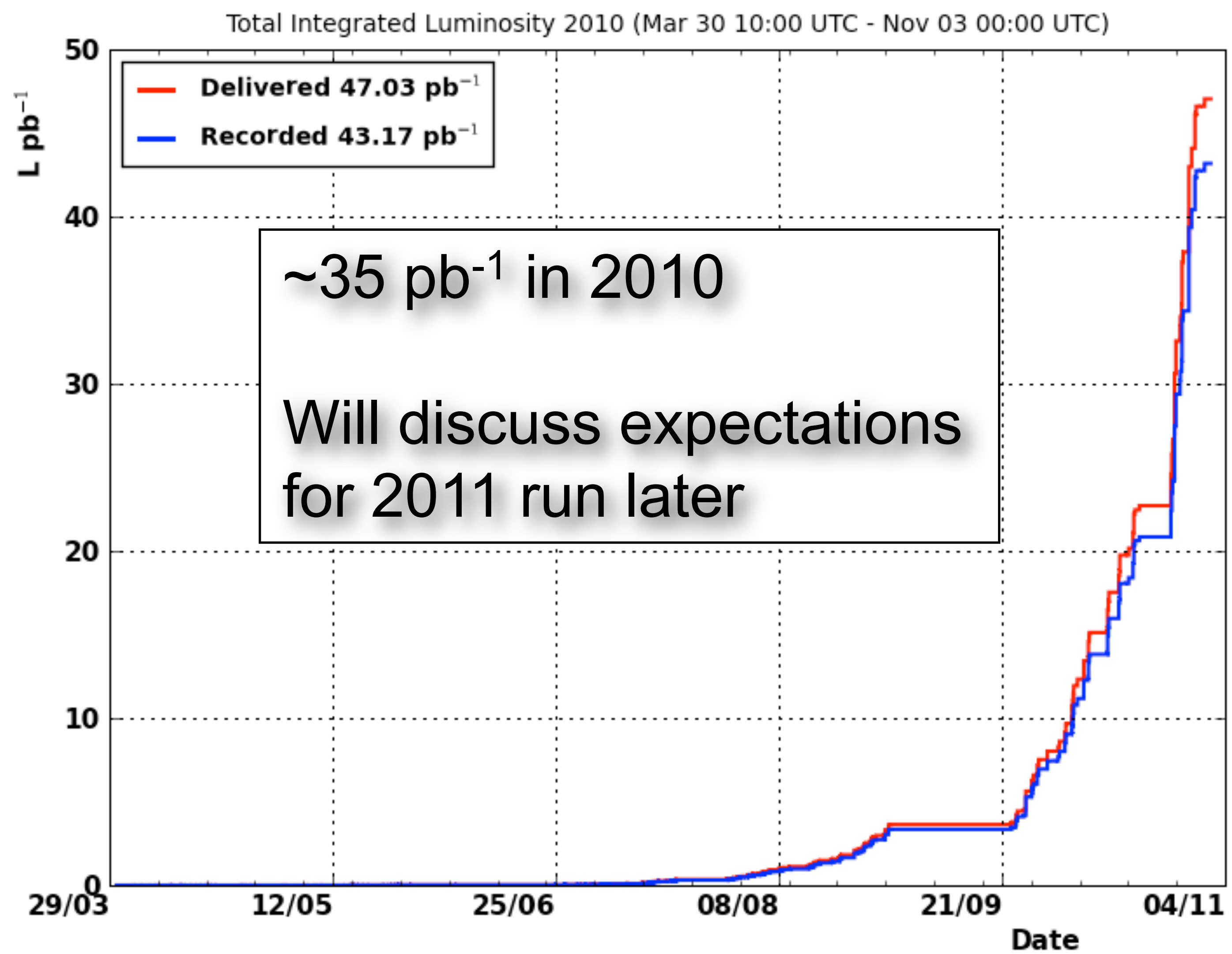
Outline

- Introduction to the LHC and CMS
  - Why you should believe our measurements
- Search strategy
  - What to look for and how to look for it
- Detailed examples
  - Jets + MET
  - Di-photons + MET
  - Long lived stopped particles
- Plans and expectations for 2011
- Interpretation/communication of results
  - How do we tell you what we've found or not

The Large Hadron Collider



The Large Hadron Collider

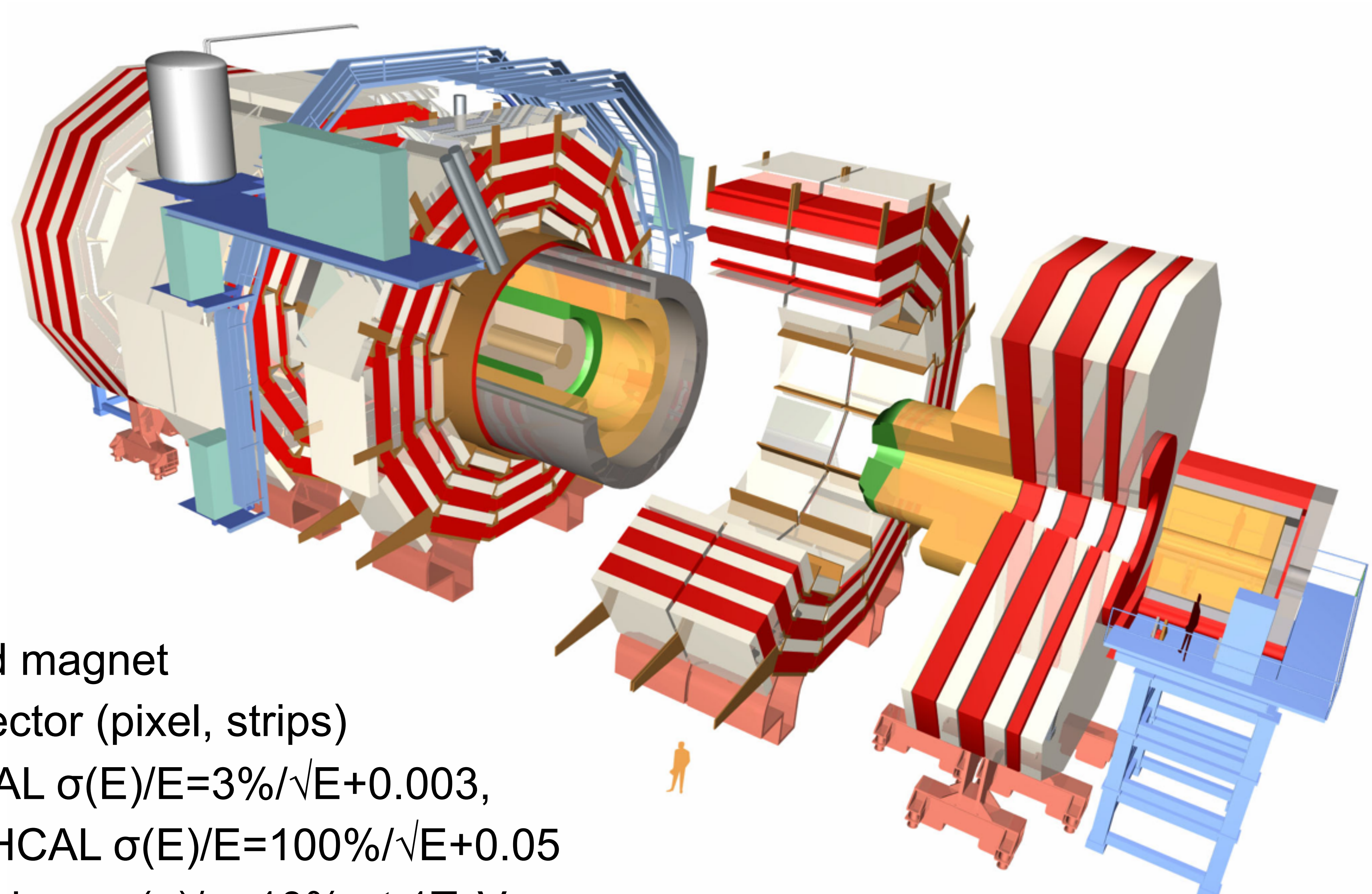


~35 pb^{-1} in 2010

Will discuss expectations for 2011 run later

The CMS detector

JINST3:S08004 (2008)

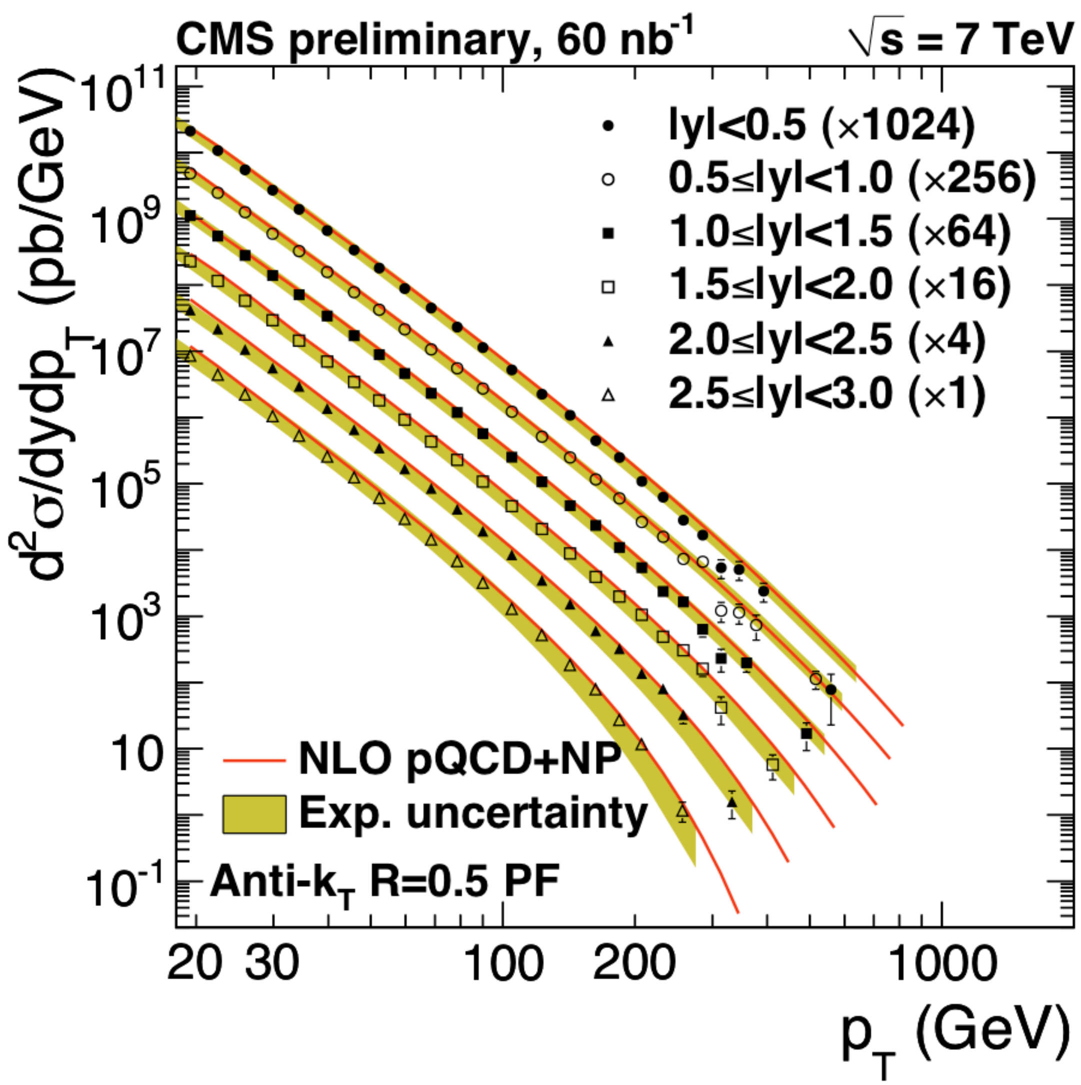


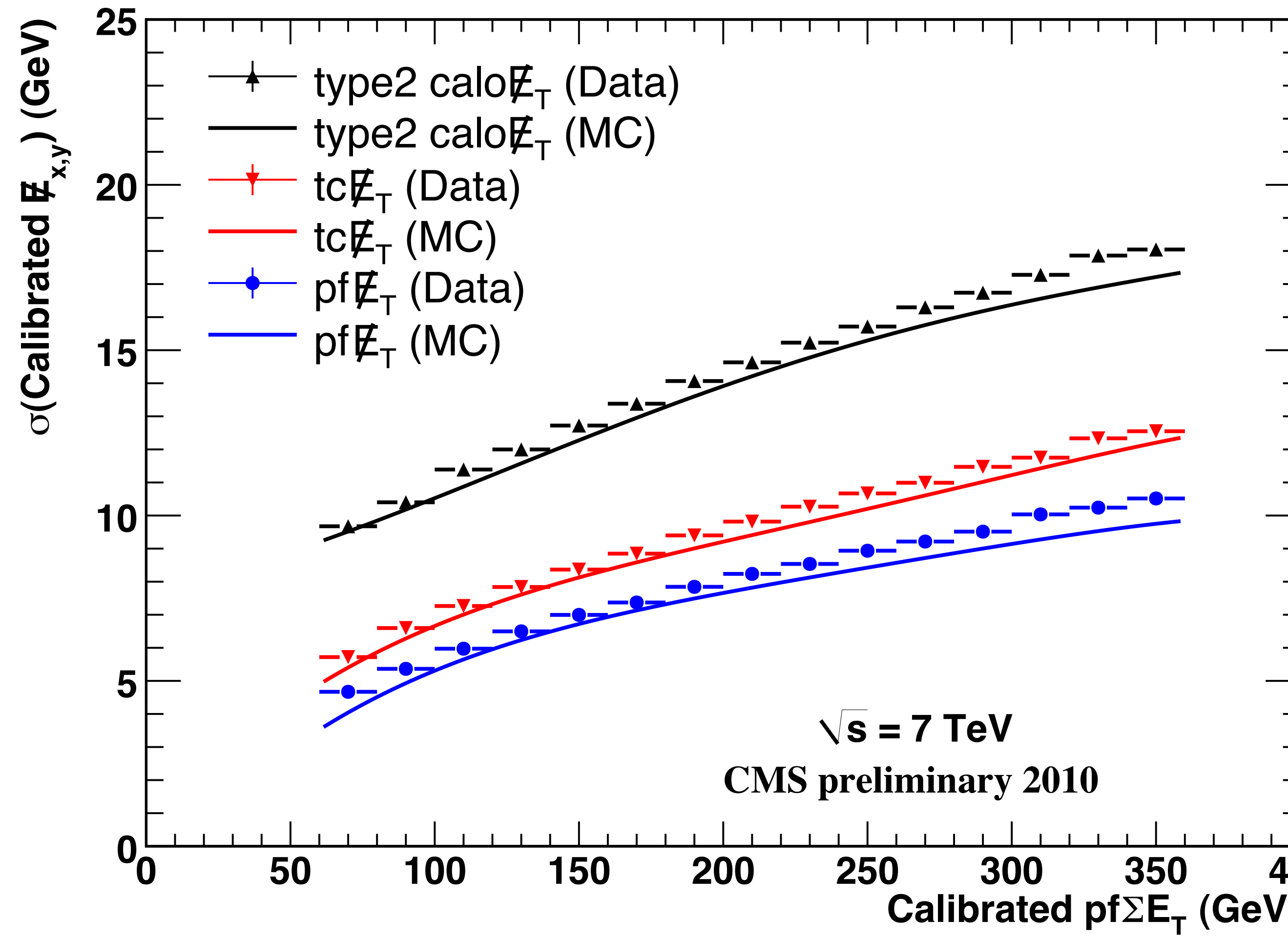
- 4T solenoid magnet
- Silicon detector (pixel, strips)
- Crystal ECAL $\sigma(E)/E=3\%/\sqrt{E}+0.003$,
- Brass/sci. HCAL $\sigma(E)/E=100\%/\sqrt{E}+0.05$
- Muon chambers $\sigma(p)/p<10\%$ at 1TeV

Standard Model physics

CMS-PAS-QCD-10-011

CMS-PAS-JME-10-004

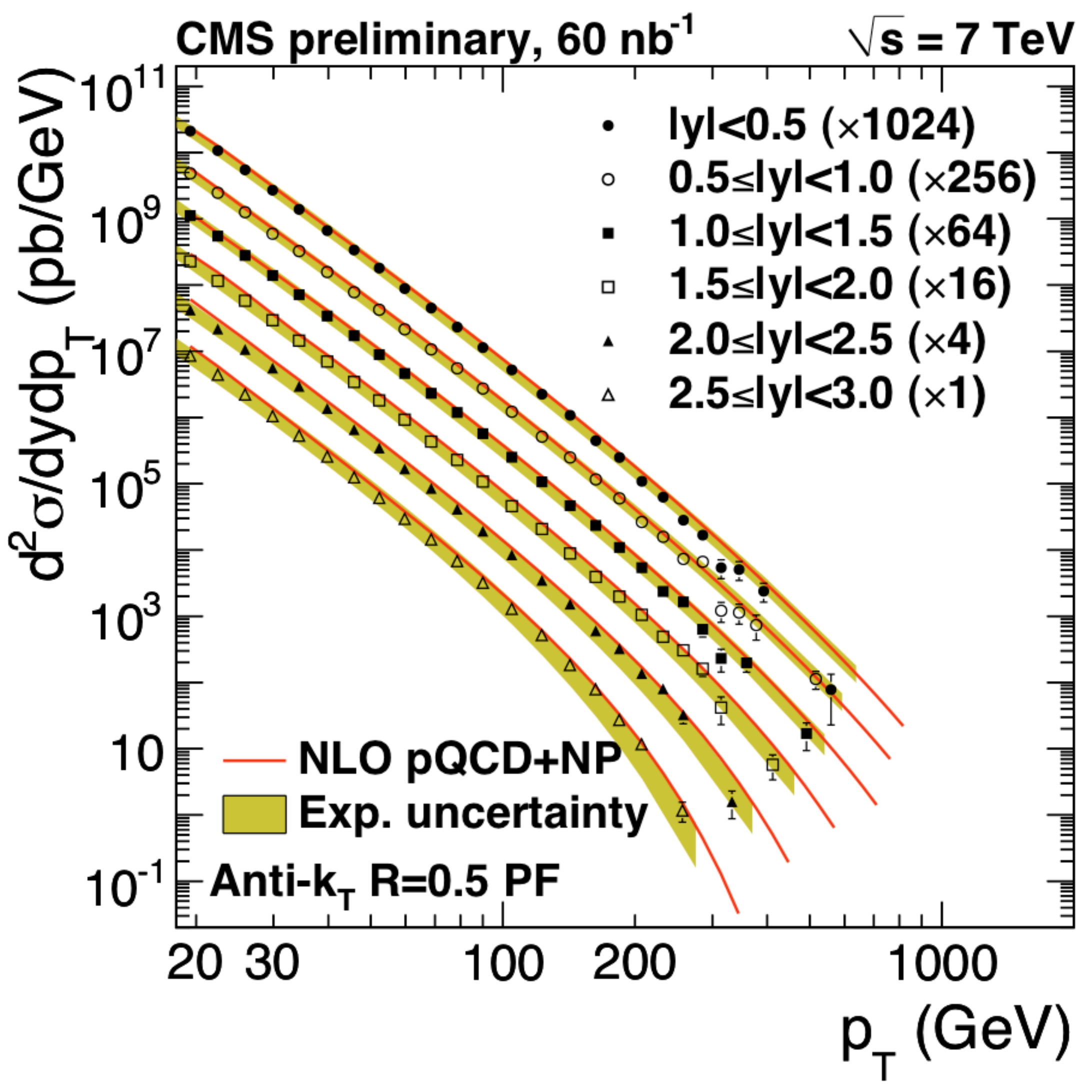




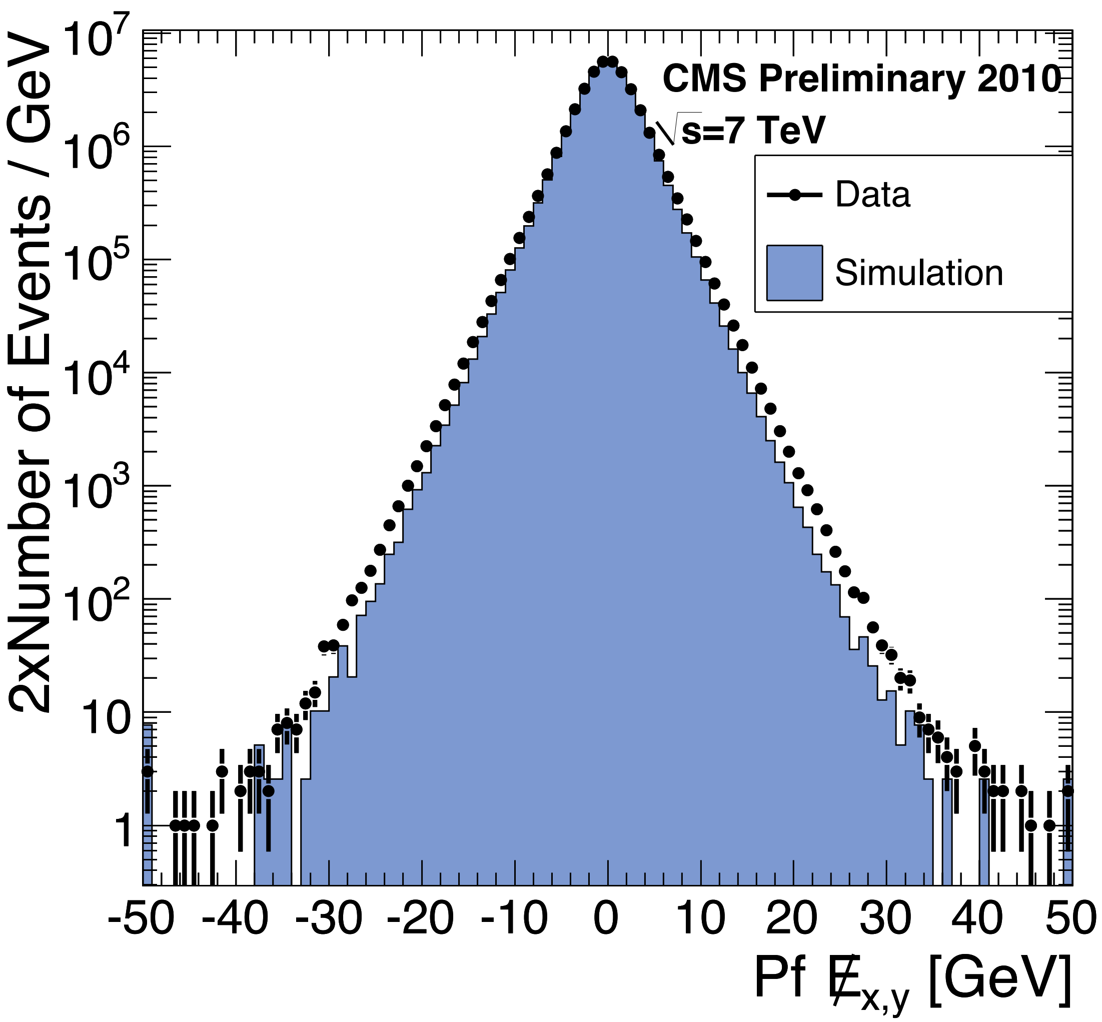
- Measurements of jet cross sections and MET resolution
- Jets and MET in good shape already

Standard Model physics

CMS-PAS-QCD-10-011



CMS-PAS-JME-10-004



- Measurements of jet cross sections and MET resolution
- Jets and MET in good shape already

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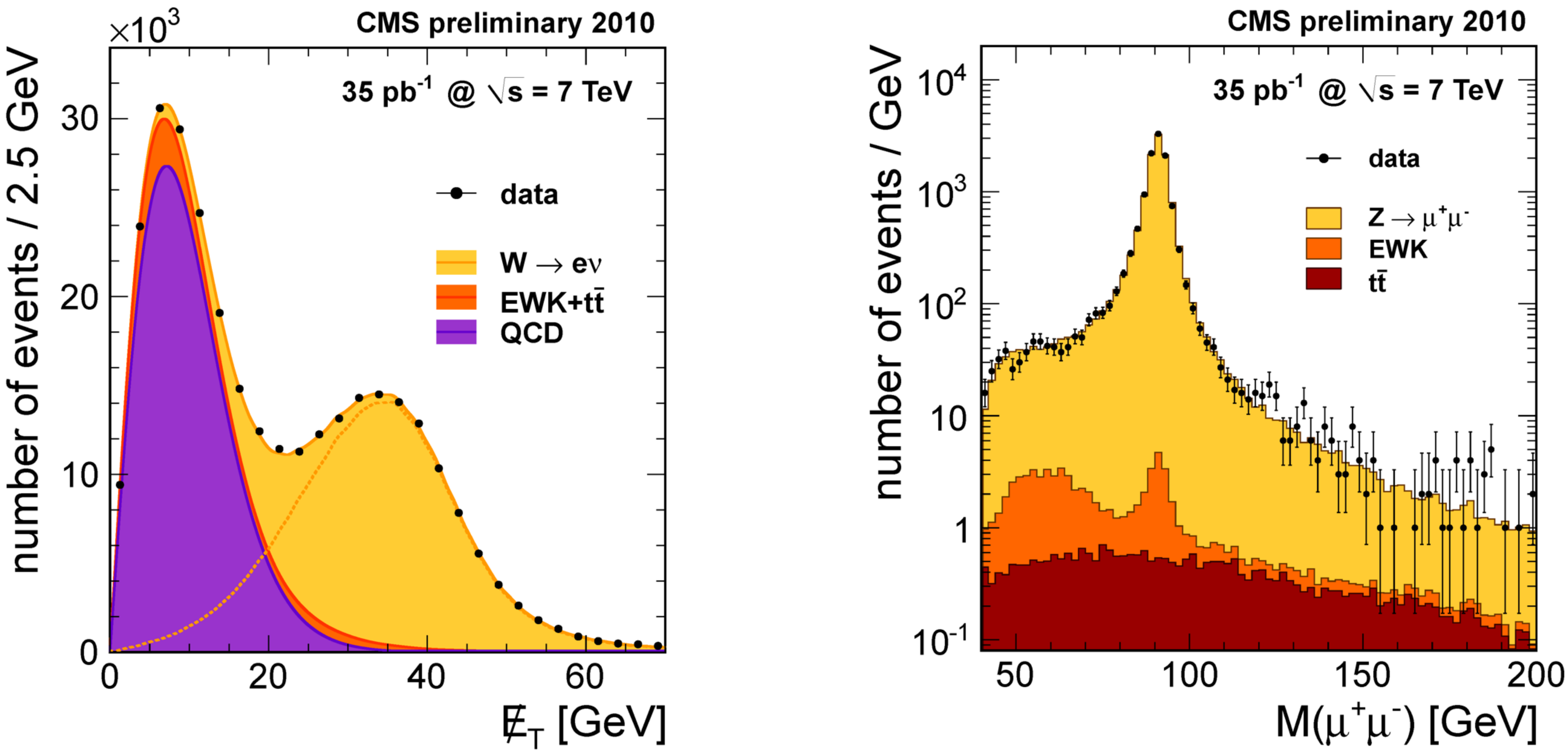
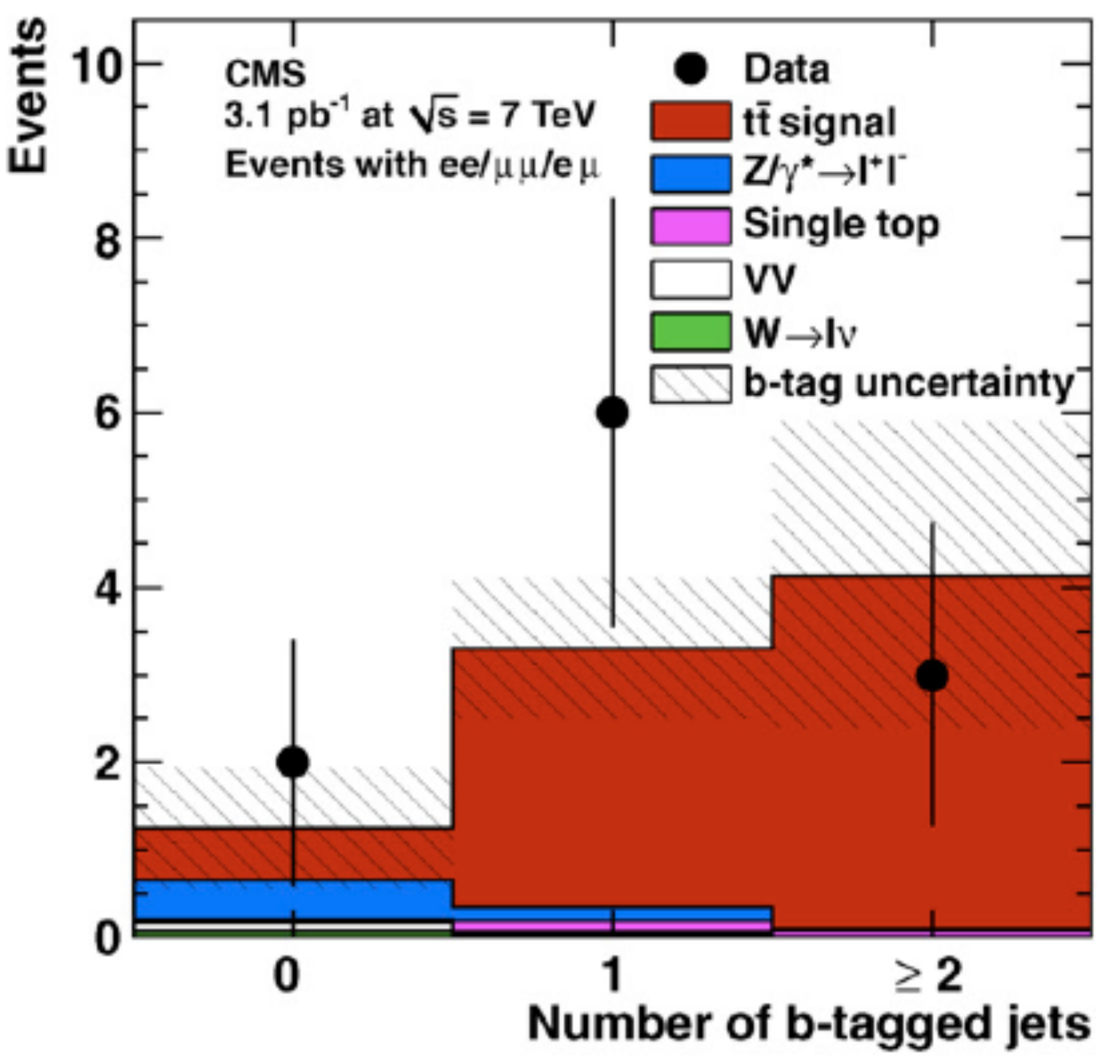
Standard Model physics

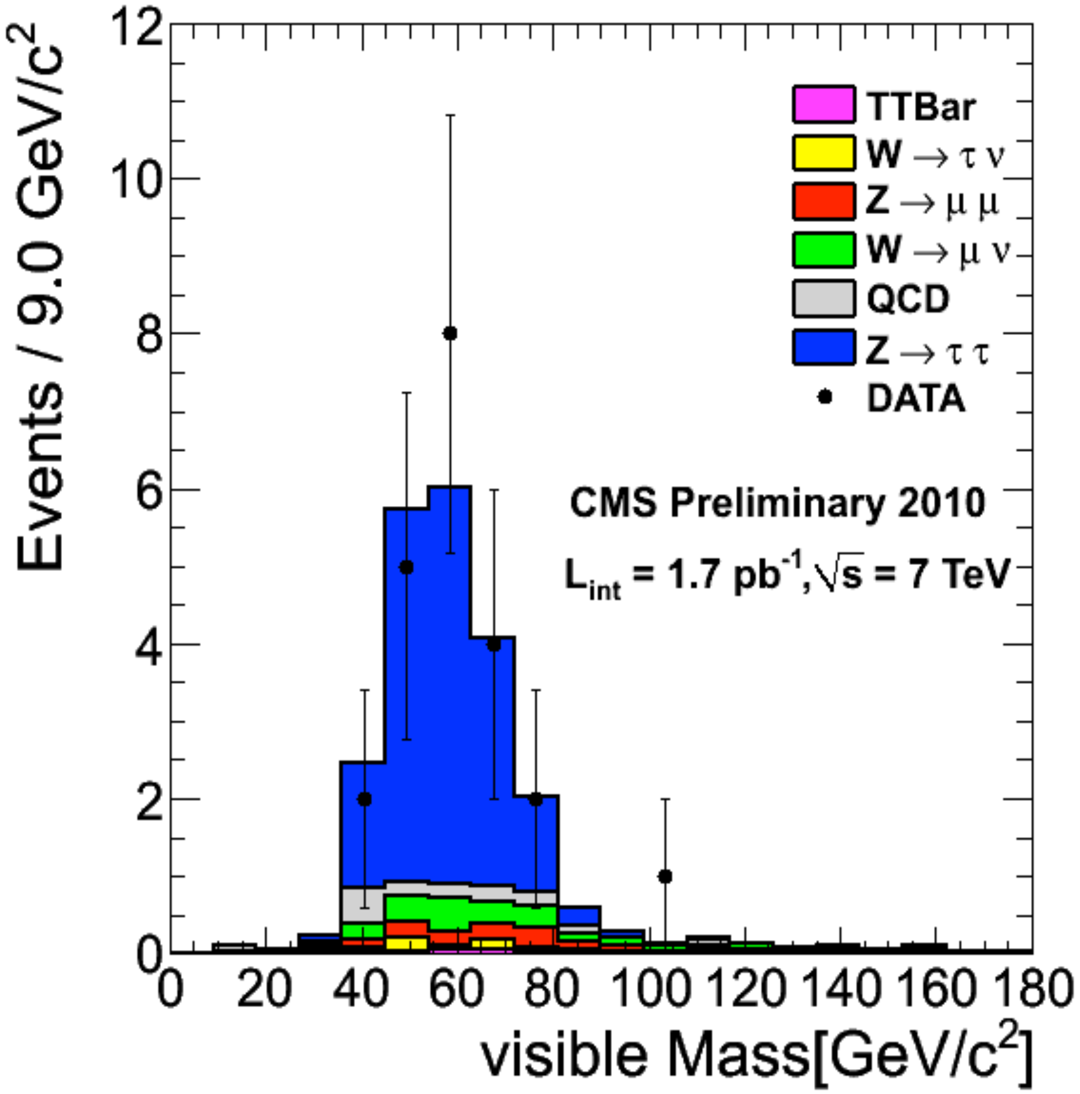


- Beautiful reconstruction of W and Z bosons
- Leptons and MET reconstruction performing well

Standard Model physics

Phys. Lett. B695, 424(2011)





- Top-quark pair-production and Z➔ $\tau^+\tau^-$
- b-tagging and τ-tagging performing well already

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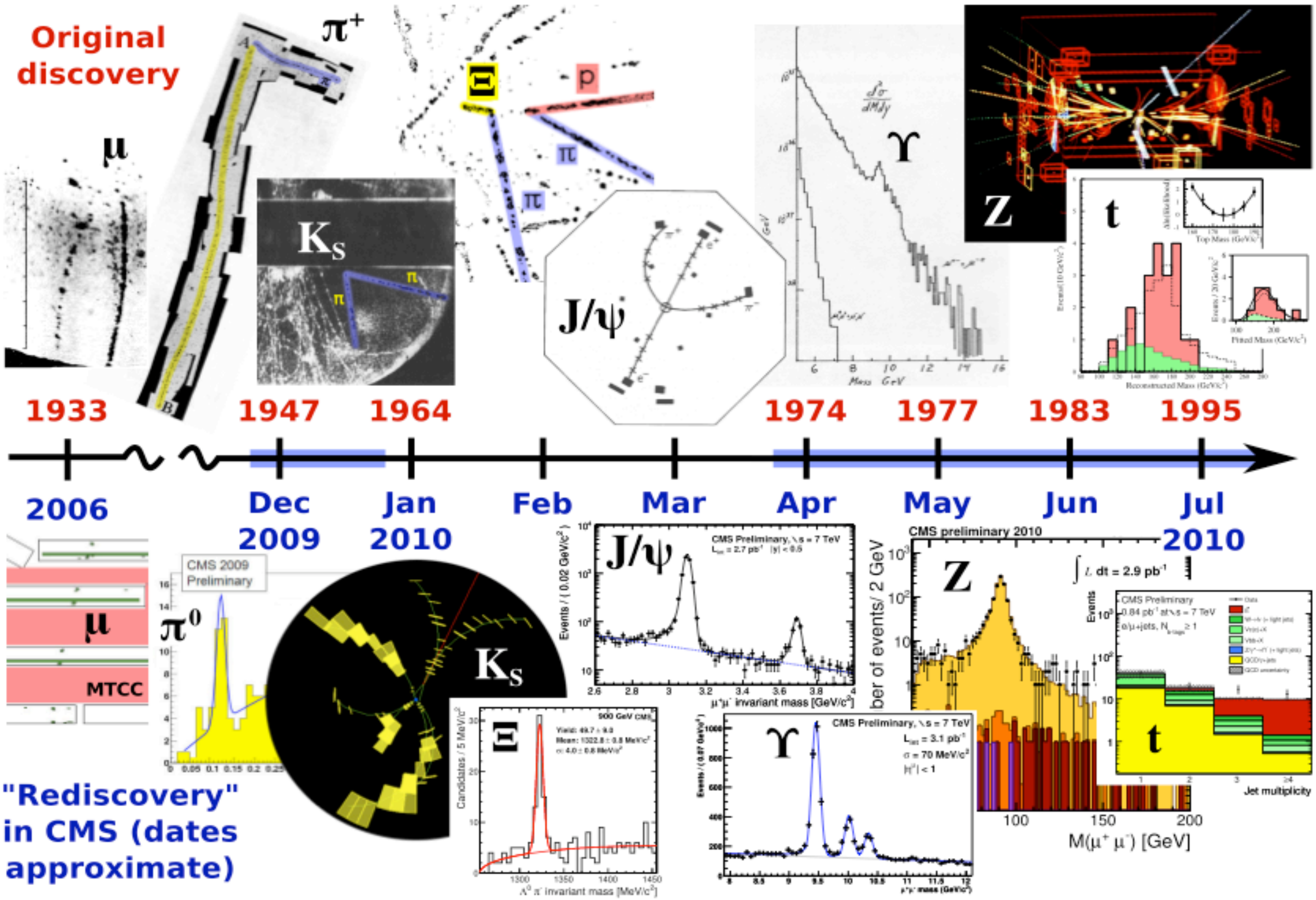
Re-discovery of the Standard Model



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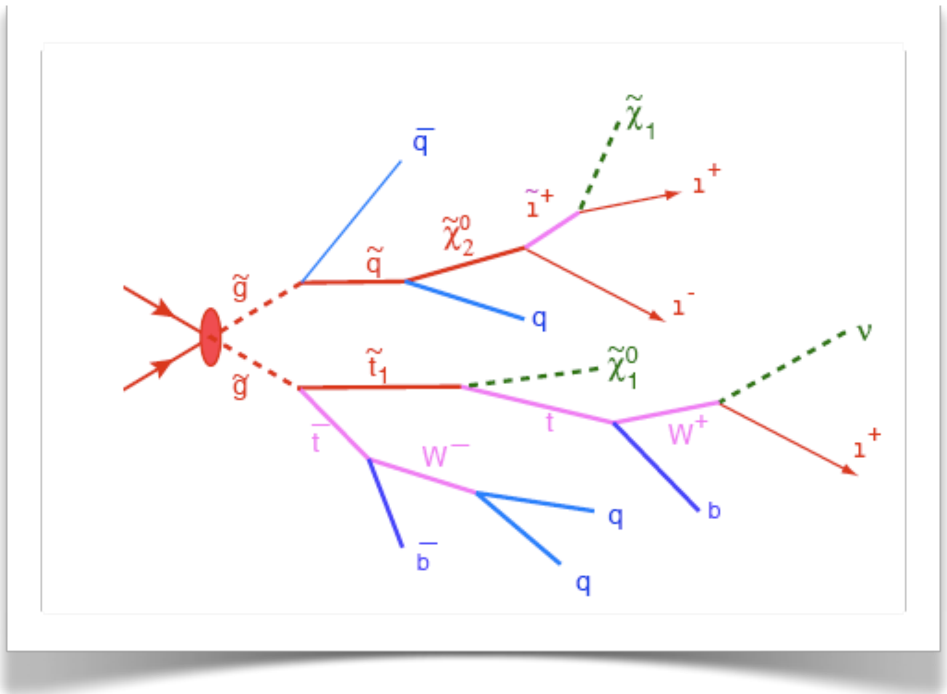
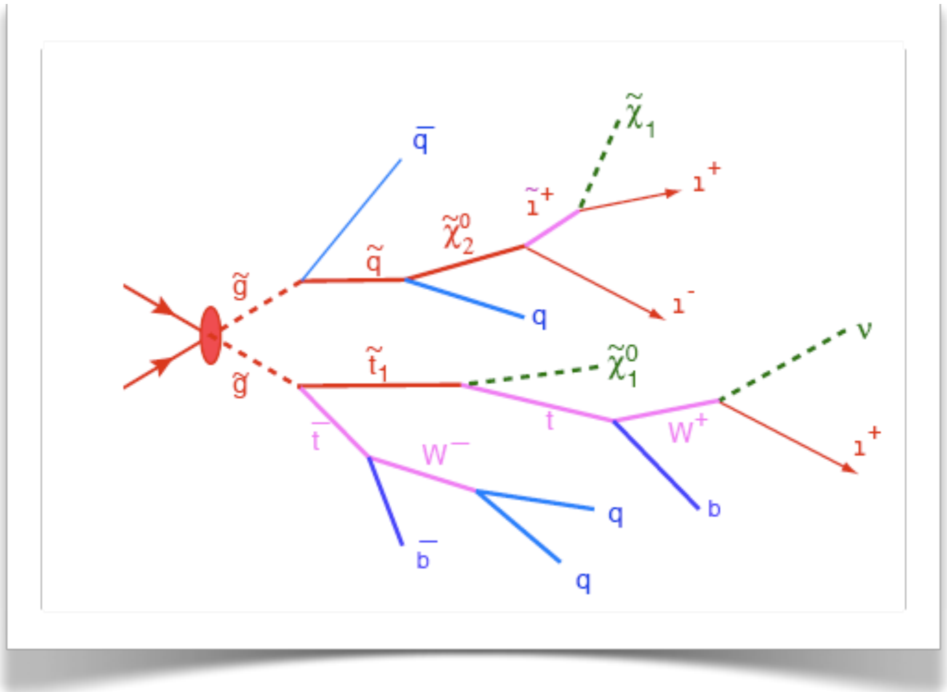
Search strategy (what and how?)



- Production
  - Squark and gluino expected to dominate
  - Strong production so high cross section
  - Cross section depends only on masses
  - Approx. independent of SUSY model

Search strategy (what and how?)



- Production
  - Squark and gluino expected to dominate
  - Strong production so high cross section
  - Cross section depends only on masses
  - Approx. independent of SUSY model
- Decay
  - Details of decay chain depend on SUSY model (mass spectra, branching ratios, etc.)
  - Assume R_P conserved ➔ decay to lightest SUSY particle (LSP)
  - Assume squarks and gluinos are heavy ➔ long decay chains
- Signatures
  - **MET** from LSPs, **high-E_T jets** and **leptons** from long decay chain
- Focus on robust and simple signatures
  - Common to wide variety of models
  - Let Standard Model background and detector performance define searches not models

Backgrounds

- Physics
  - Standard Model processes that give the same signatures as SUSY
  - Cannot rely on Monte Carlo predictions ➔ measure in data
- Detector effects
  - Detector noise, mis-measurements etc. that generate MET or extra jets
  - Commissioning and calibration ➔ good performance shown earlier
- Beam related
  - Beam-halo muons (and cosmic-ray muons), beam-gas events
  - Data and simulation already ➔ measure in situ too

Search strategy (what and how?)

0-leptons	2-photons	1-lepton	SSDL	OSDL	≥3 leptons
Jets + MET	Di-photon + jet + MET	Single lepton + Jets + MET	Same-sign di-lepton + jets + MET	Opposite-sign di-lepton + jets + MET	Multi-lepton

- Generic searches based on MET
- Categorised by numbers of leptons and photons
- Most include jet requirement ➔ strong production

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Search strategy (what and how?)

0-leptons	2-photons	1-lepton	SSDL	OSDL	≥3 leptons
Jets + MET	Di-photon + jet + MET	Single lepton + Jets + MET	Same-sign di-lepton + jets + MET	Opposite-sign di-lepton + jets + MET	Multi-lepton

- Very challenging due to large amount and wide range of backgrounds
- However most sensitive search for strongly produced SUSY
- CMS pursues several complementary strategies
- In principle ATLAS should be better suited to this than CMS
- Extend this in the future to b-tagged final states (2010 dataset)
- Extension to τ and top-tagged final states (2011 dataset)
- **Will show you first result from this search**

Search strategy (what and how?)

0-leptons	2-photons	1-lepton	SSDL	OSDL	≥3 leptons
Jets + MET	Di-photon + jet + MET	Single lepton + Jets + MET	Same-sign di-lepton + jets + MET	Opposite-sign di-lepton + jets + MET	Multi-lepton

- Many gauge mediated models predict photons in final state
- Extend to single photon in future and single photon + lepton
- **Will show you first result from this search**

Search strategy (what and how?)

0-leptons	2-photons	1-lepton	SSDL	OSDL	≥3 leptons
Jets + MET	Di-photon + jet + MET	Single lepton + Jets + MET	Same-sign di-lepton + jets + MET	Opposite-sign di-lepton + jets + MET	Multi-lepton

- Lepton (electron or muon) requirement reduces background considerably
- Basically only ttbar left ➔ topological handles

Search strategy (what and how?)

0-leptons	2-photons	1-lepton	SSDL	OSDL	≥3 leptons
Jets + MET	Di-photon + jet + MET	Single lepton + Jets + MET	Same-sign di-lepton + jets + MET	Opposite-sign di-lepton + jets + MET	Multi-lepton

- Very small Standard Model backgrounds
- Include all three generations of leptons and all cross channels

Search strategy (what and how?)

0-leptons	2-photons	1-lepton	SSDL	OSDL	≥3 leptons
Jets + MET	Di-photon + jet + MET	Single lepton + Jets + MET	Same-sign di-lepton + jets + MET	Opposite-sign di-lepton + jets + MET	Multi-lepton

- Two analyses here: inclusive and Z peak search
- Not including τ final states in 2010
- Several techniques including opposite-sign opposite flavour subtraction
- Shape information and mass edges

Search strategy (what and how?)

0-leptons	2-photons	1-lepton	SSDL	OSDL	≥3 leptons
Jets + MET	Di-photon + jet + MET	Single lepton + Jets + MET	Same-sign di-lepton + jets + MET	Opposite-sign di-lepton + jets + MET	Multi-lepton

- Very clean events with very low Standard Model background
- Include all three generations of leptons and all combinations
- Search inclusively, Z peak, with and without MET
- Some striking Standard Model events observed already

Search strategy (what and how?)

0-leptons	2-photons	1-lepton	SSDL	OSDL	≥3 leptons
Jets + MET	Di-photon + jet + MET	Single lepton + Jets + MET	Same-sign di-lepton + jets + MET	Opposite-sign di-lepton + jets + MET	Multi-lepton

RPV	"Exotic"
R-Parity violating searches	Long-lived particles etc.

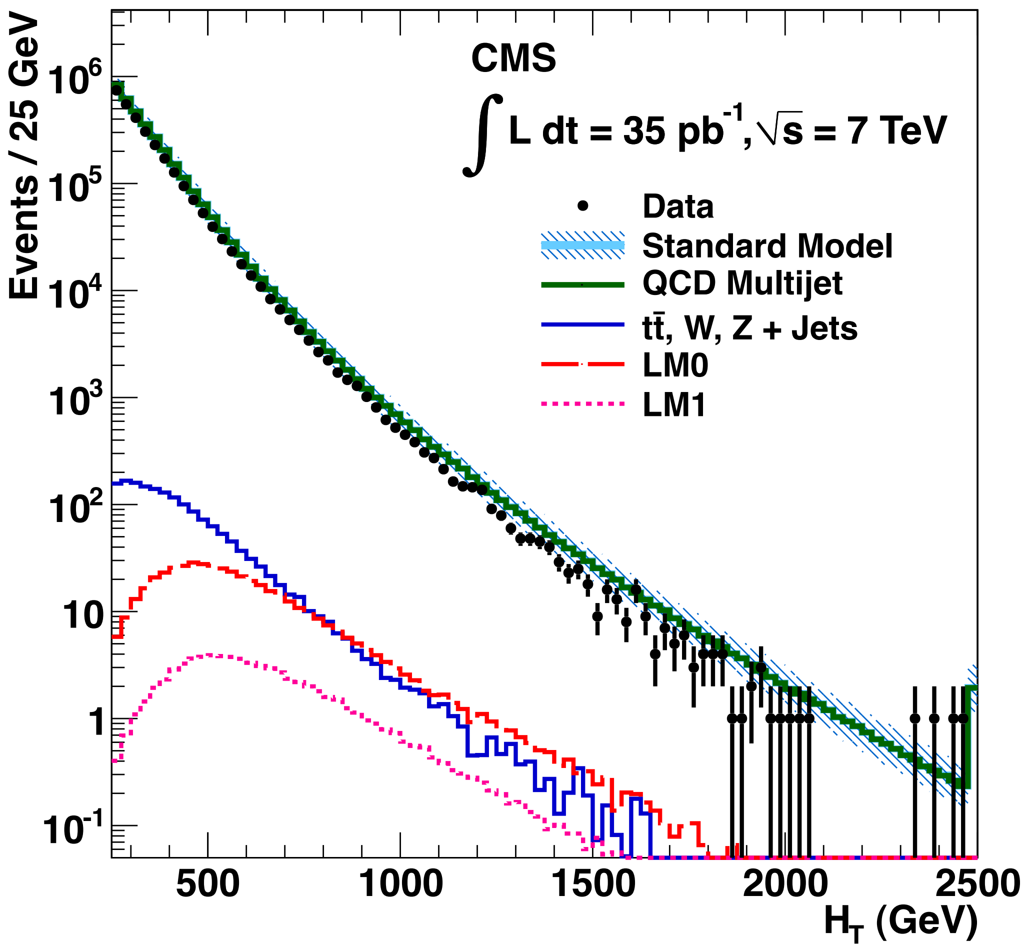
- Non- MET based searches
- R-parity conserving and "exotic" SUSY
- Examples are long lived particles
- **Will show you first result from stopped gluino search**

All hadronic search pre-selection

- Loose sample of hadronic events

hep-ex/0176391

  - Trigger H_T (ΣE_{Tjets}) > 150 GeV (RAW)
  - H_T > 250 GeV
  - Vertex consistent with pp collision
  - At least 2 jets with E_T>50 GeV & |η|<3 anti-k_T (0.5)
  - Leading jet |η|<2.5
  - E_{Tj2}>100 GeV
  - Event veto for isolated electrons and muons with P_T>10 GeV
  - Event veto for isolated photons P_T>25 GeV



- Dominated by multi-jet QCD

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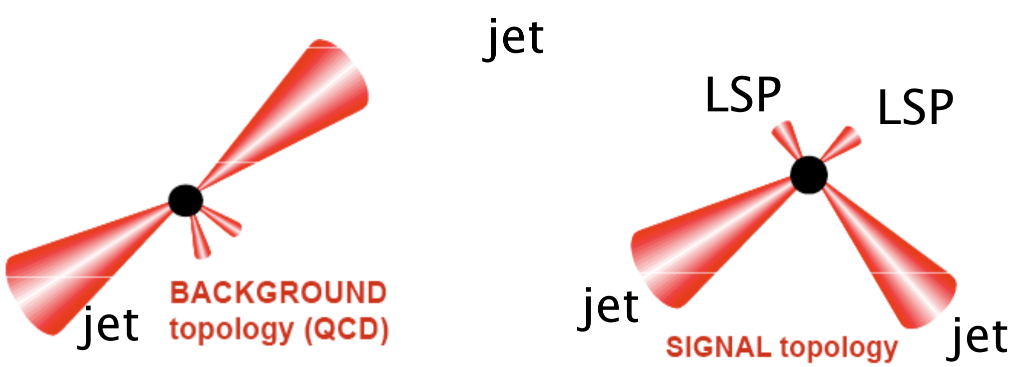
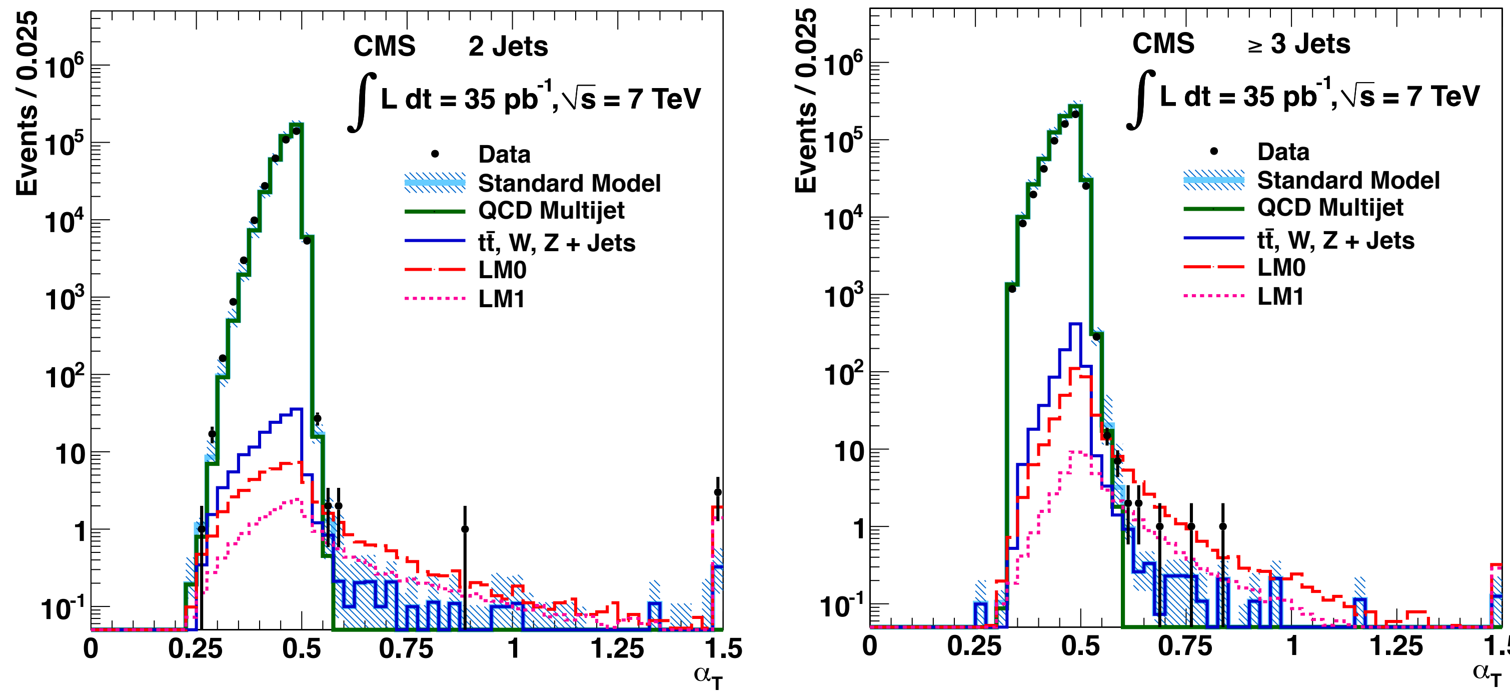
Final selection



$$\alpha_T = \frac{E_{T\ j2}}{M_{T\ j1j2}} = \frac{\sqrt{E_{T\ j2}/E_{T\ j1}}}{\sqrt{2(1-\cos\Delta\varphi)}}$$

PRL101:221803 (2008) & CMS-PAS-SUS-09-001



- No dependence on MET ➔ robust for early LHC running
- Originally proposed for di-jet events ➔ generalised up to 6 jets
- $\alpha_T > 0.55$
- $R_{miss} = H_{Tmiss}/MET < 1.25$ (effect of soft jets)
- For $\Delta\phi^* < 0.5$ the $\Delta R_{ECAL} > 0.3$ (jets pointing to dead CALO cells)
- $H_T > 350$ GeV (beyond previous searches)

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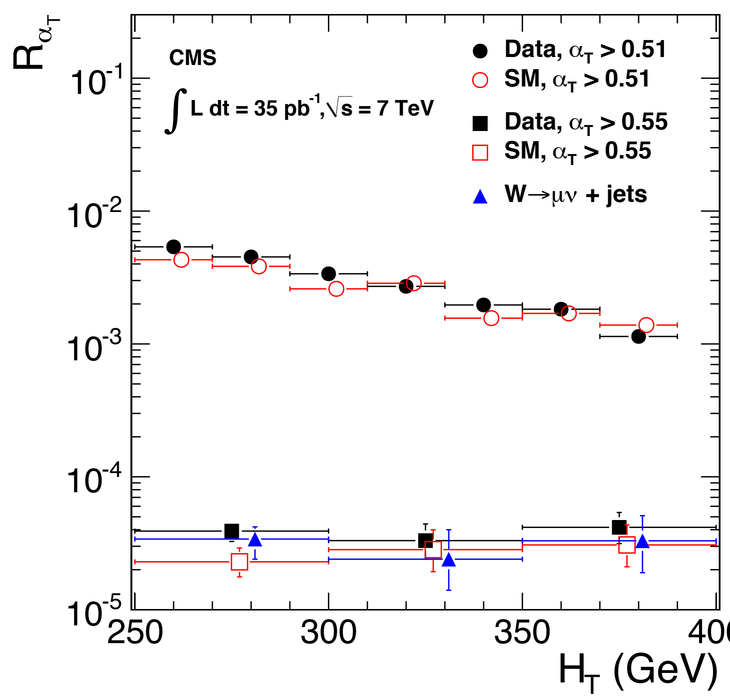
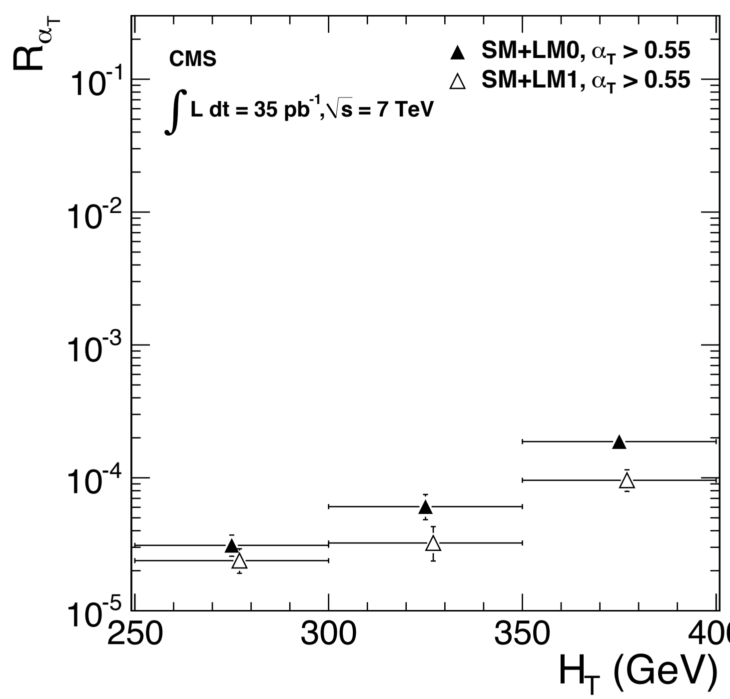
Data and Monte Carlo yields

Selection	Data	SM	QCD multijet	$Z \to \nu\bar{\nu}$	$W + \text{jets}$	$t\bar{t}$
$H_T > 250\,\text{GeV}$	4.68M	5.81M	5.81M	290	2.0k	2.5k
$E_T^{j_2} > 100\,\text{GeV}$	2.89M	3.40M	3.40M	160	610	830
$H_T > 350\,\text{GeV}$	908k	1.11M	1.11M	80	280	650
$\alpha_T > 0.55$	37	30.5±4.7	19.5±4.6	4.2±0.6	3.9±0.7	2.8±0.1
$\Delta R_{ECAL} > 0.3 \vee \Delta\phi^* > 0.5$	32	24.5±4.2	14.3±4.1	4.2±0.6	3.6±0.6	2.4±0.1
$R_{miss} < 1.25$	13	9.3±0.9	0.03±0.02	4.1±0.6	3.3±0.6	1.8±0.1

- Data and Monte Carlo expectation in good agreement (errors are stat.)
- QCD is PYTHIA, EWK backgrounds from MADGRAPH
- For N_{jets}=2 main backgrounds Z➔ νν and W➔τν
- For N_{jets}>2 ttbar also contributes - Z/W/ttbar approx. equal

Inclusive background estimate

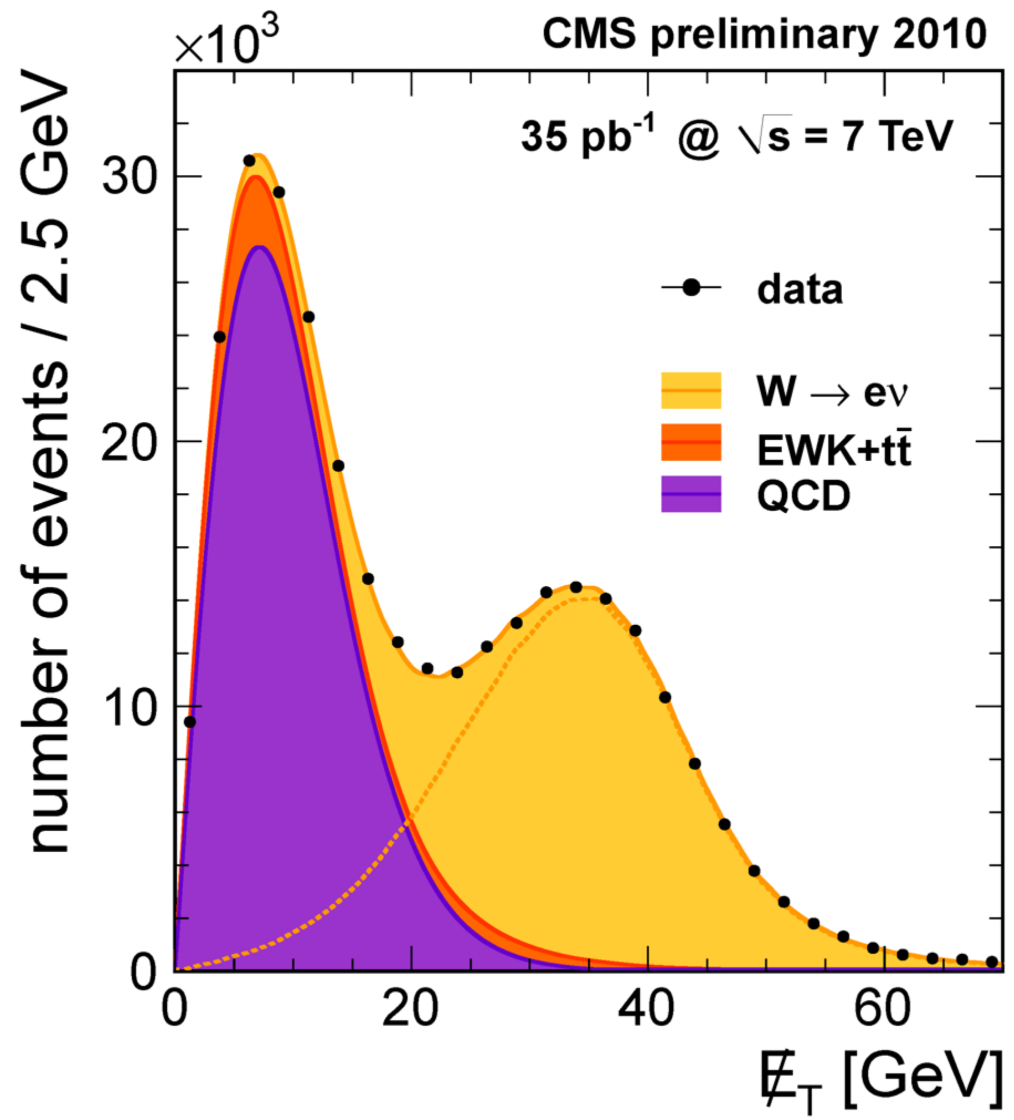




- Use kinematics and control regions to estimate all backgrounds
  - Use lower H_T bins 250-300 GeV and 300-350 GeV to extrapolate into signal region 350 GeV
  - Adjust cuts in control regions to preserve kinematics
  - Define $R\alpha_T = N(\alpha_T>x)/N(\alpha_T<x)$
  - For QCD (mismeasurement) expect this to fall as resolution improves with increasing H_T
  - For EWK (real MET) expect flat behaviour. Check with W/ttbar control sample
  - Indicates final selection is QCD free
  - Extrapolate for low to high H_T
  - Result is $9.4^{+4.8}_{-4.0}$ (stat.) ±1.0 (syst.)

W+jets and ttbar backgrounds

- Select a high P_T muon sample (same as ttbar cross section)
  - Same cuts as signal region excluding muon in calculations (H_{Tmiss}>140 GeV)
  - M_T>30 GeV to ensure pure W/ttbar sample - no QCD
  - Use MC efficiencies and acceptances with this muon samples
    - Estimate number of semi-leptonic decays that are not vetoed due to low P_T leptons or leptons out of acceptance
    - Estimate number of hadronic τ decays which end up in the signal sample
  - Result is $6.1^{+2.8}_{-1.9}$ (stat.) ± 1.8 (syst.)
  - Systematic (~30%) is conservative



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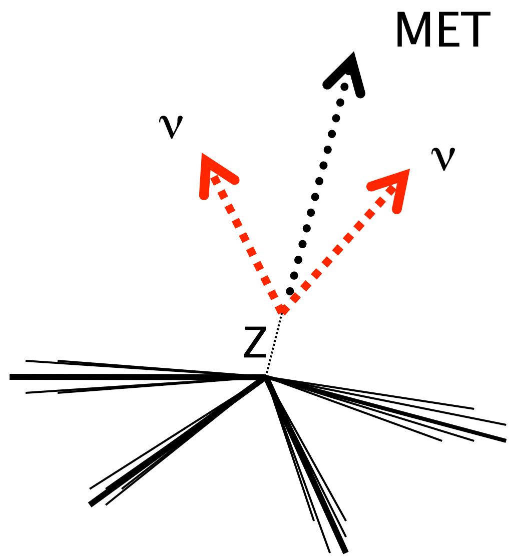
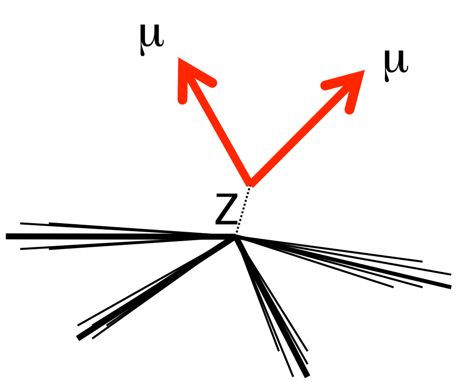
Z → νν background

- Data-driven background estimates
- Z → νν + jets ➔ irreducible background
  - **Replacement technique**

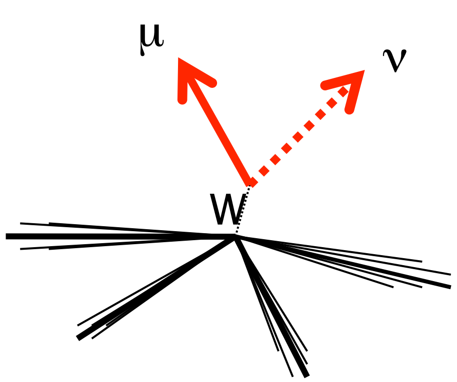




Z → ll + jets

Strength: very clean

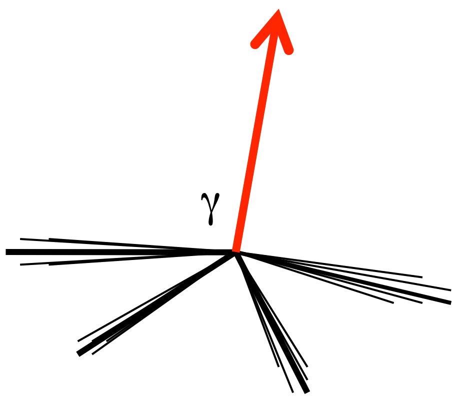
Weakness: low statistics



W → lν + jets

Strength: larger statistics

Weakness: background from SM and SUSY



γ + jets

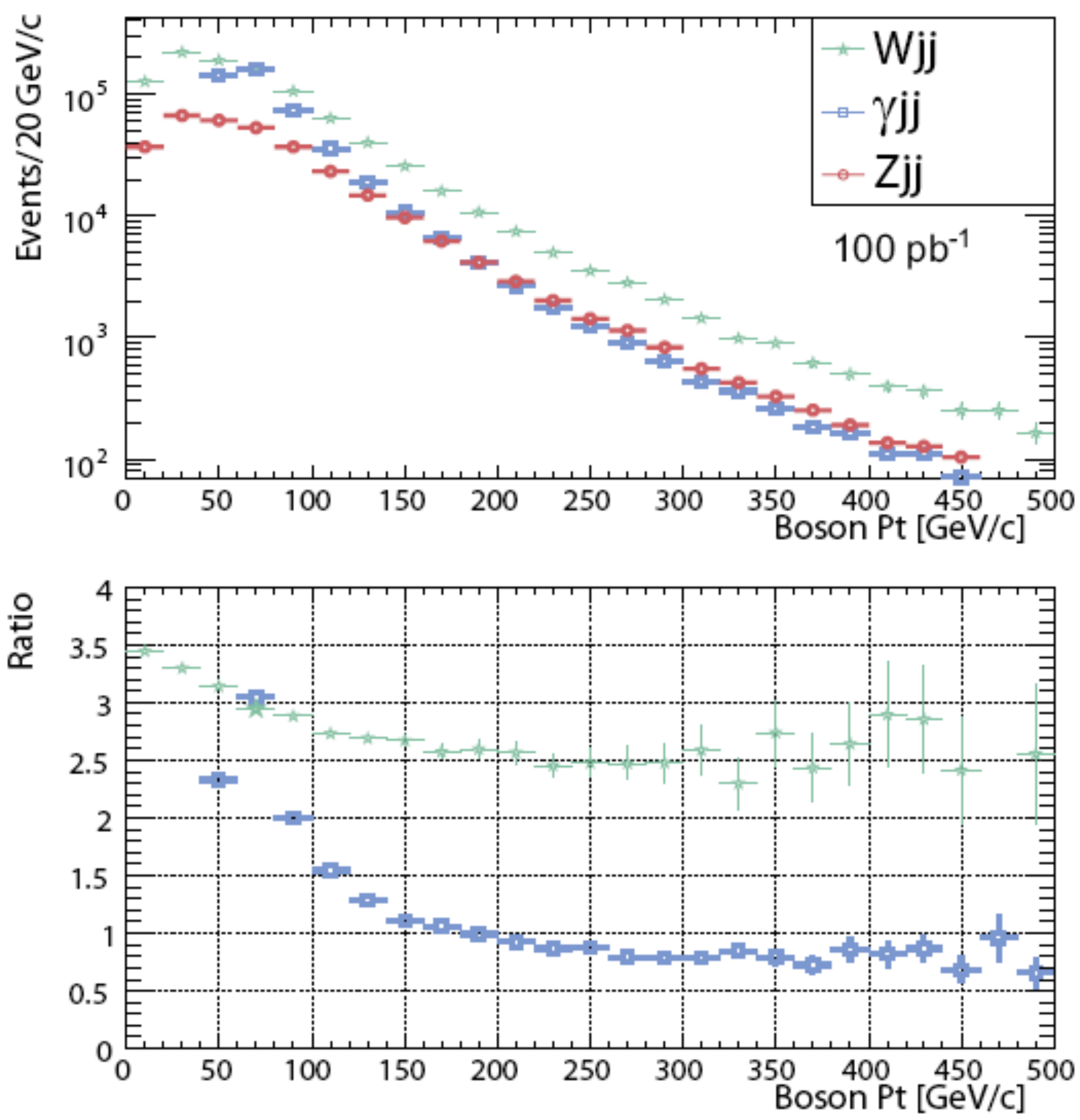
Strength: large statistics and clean at high E_T

Weakness: background at low E_T, theoretical errors

$Z \rightarrow \nu\nu$ background

- Using γ + jets events
  - Select very clean γ + jets sample
  - $P_{T\gamma} > 100$ GeV
  - $|\eta_\gamma| < 1.45$
  - $\Delta R(\gamma,jet) > 1.0$
  - $H_{Tmiss} > 140$ GeV
  - Yields 7 events in data
  - Use MC to scale $\gamma \rightarrow Z$
  - Result is $4.4^{+2.3}_{-1.6}$ (stat.) ± 1.8 (syst.)
  - Largest systematic from $\gamma \rightarrow Z$ theory
- Cross check with W sample
  - Result is $4.9^{+2.6}_{-1.8}$ (stat.) ± 1.5 (syst.)
  - ttbar contamination in muon sample

CMS-PAS-SUS-08-002



100 pb-1 @ 14 TeV COM

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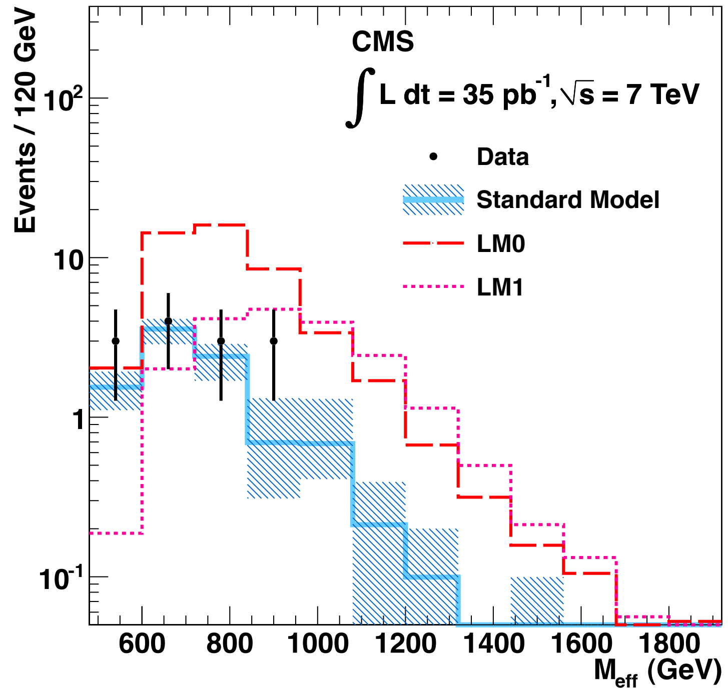
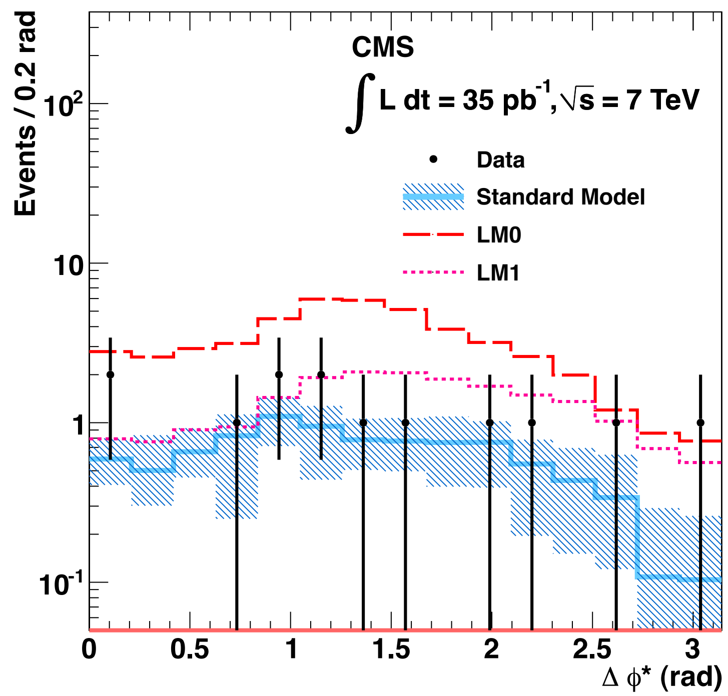
Observed data events

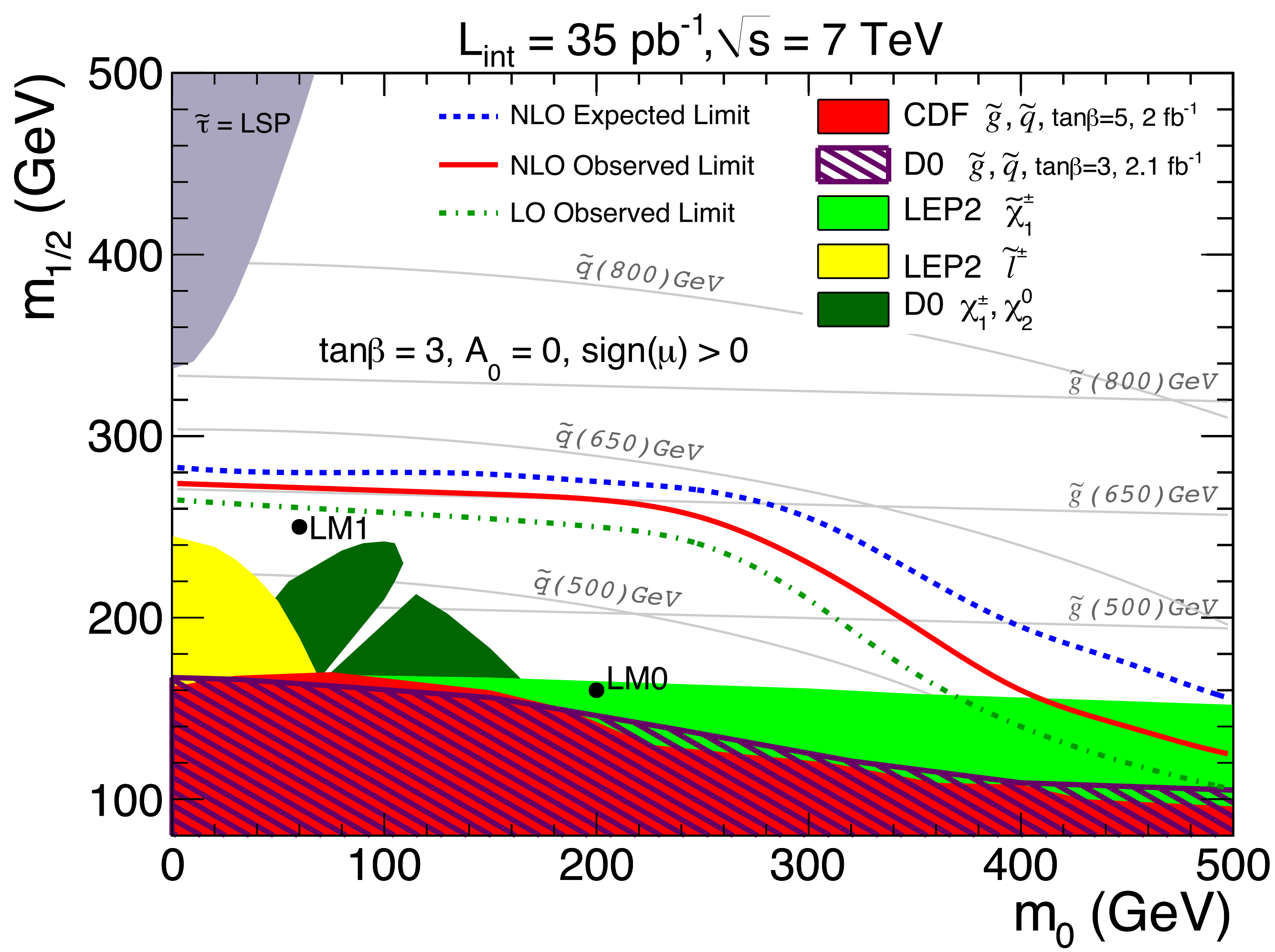




- Background summary
  - Inclusive $9.4^{+4.8}_{-4.0}$ (stat.) ±1.0 (syst.)
  - EWK $10.5^{+3.6}_{-2.5}$
- Examine events selected in data
  - $M_{eff} = H_T + H_{Tmiss}$ scale of event
  - $\Delta\phi^*$ distribution not peaked
- Events consistent with EWK background

Interpretation in CMSSM

- Signal acceptance uncertainty dominated by luminosity error (11%)
- Use Feldman-Cousins method to set 95% CL, using Profile-Likelihood to deal with nuisance parameters
- Upper limit on signal events is 13.4
- p value for SM only = 0.3
- Very weak dependence on tanβ
- Significant extension of excluded region over Tevatron experiments



Production mechanism	Yields for 35 pb^{-1}	ϵ_{total}(%)	$\epsilon_{signature}$(%)
$\tilde{q}\,\tilde{q}$	9.7±0.1	16.0±0.1	22.2±0.4
$\tilde{q}\,\tilde{g}$	8.8±0.1	14.4±0.1	23.0±0.5
$\tilde{g}\,\tilde{g}$	0.71±0.02	12.0±0.4	22.5±2.0

Search with di-photon events

CMS-PAS-SUS-10-002

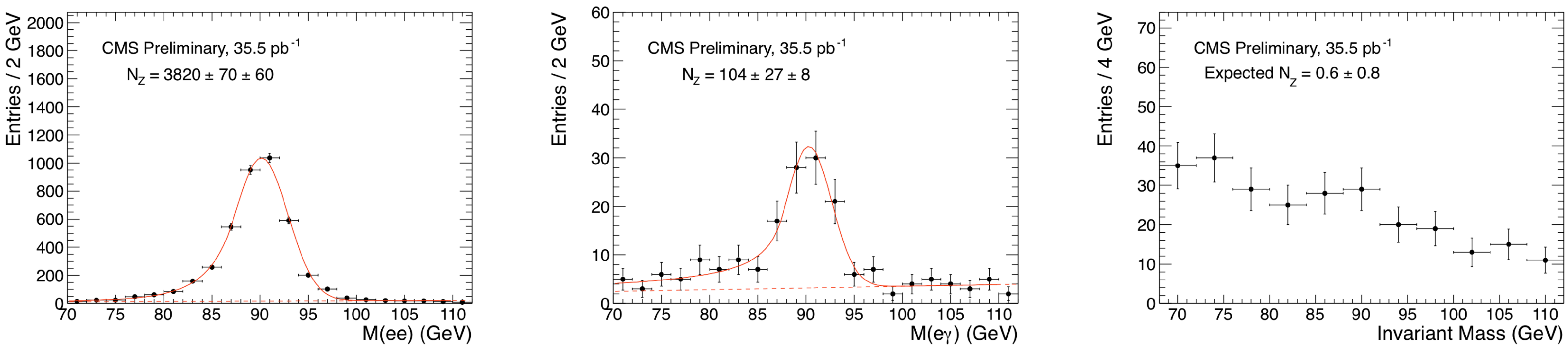
- Pre-selection
  - Trigger: single photon $P_{T\gamma}$ > 30 GeV
  - Require two photons with $P_{T\gamma}$ > 30 GeV and $|\eta\gamma| < 1.4$
  - Shower shape ID cuts
  - Veto if H/E>5%
  - $Isolation_{TRK} < 0.001xE_T + 2$ GeV
  - $Isolation_{ECAL} < 0.006xE_T + 4.2$ GeV
  - $Isolation_{HCAL} < 0.0025xE_T + 2.2$ GeV

  - Distinguish electrons and photons by track in pixel detector
  - At least one jet E_T>30 GeV (cleans up beam and cosmic backgrounds)
- Define two control samples for later
  - fake-fake (ff) - fail track isolation or shower shape
  - Z (ee) - two electrons and Z mass window cut (90 ± 20 GeV)

Electroweak backgrounds

- Irreducible SM backgrounds Zγγ and Wγγ negligible

- Main electroweak background
  - W ➔ eν where e is mis-ID as a γ and also a real or fake γ in the event
  - Measure mis-ID rate $f_{e\rightarrow\gamma}$ from the number of Z➔ ee events in the ee and eγ samples
  - Result is 1.4 ± 0.4%
  - Apply this to eγ sample to get prediction



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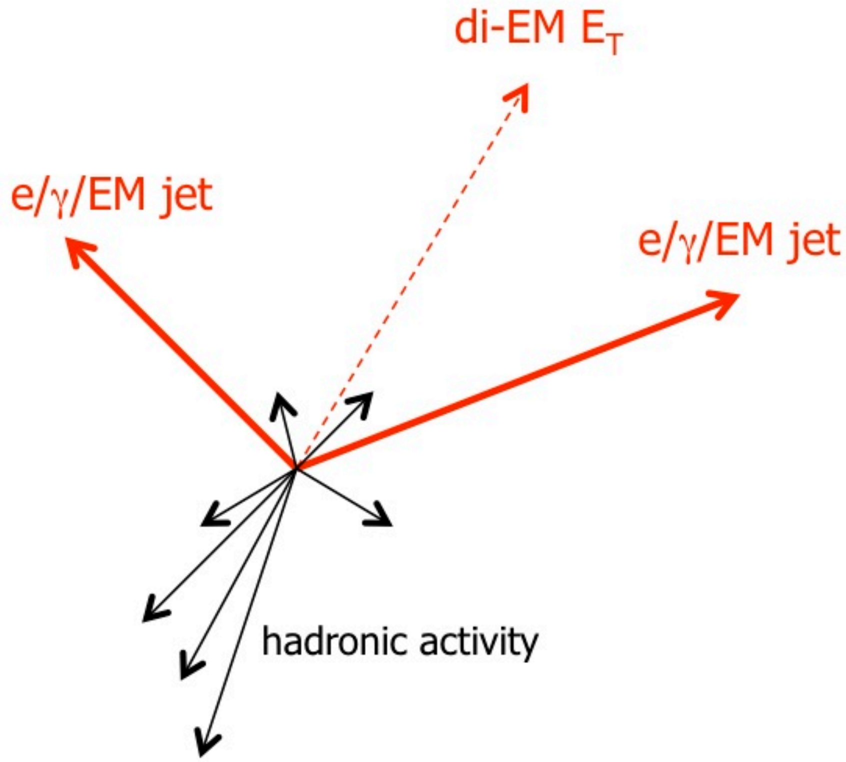
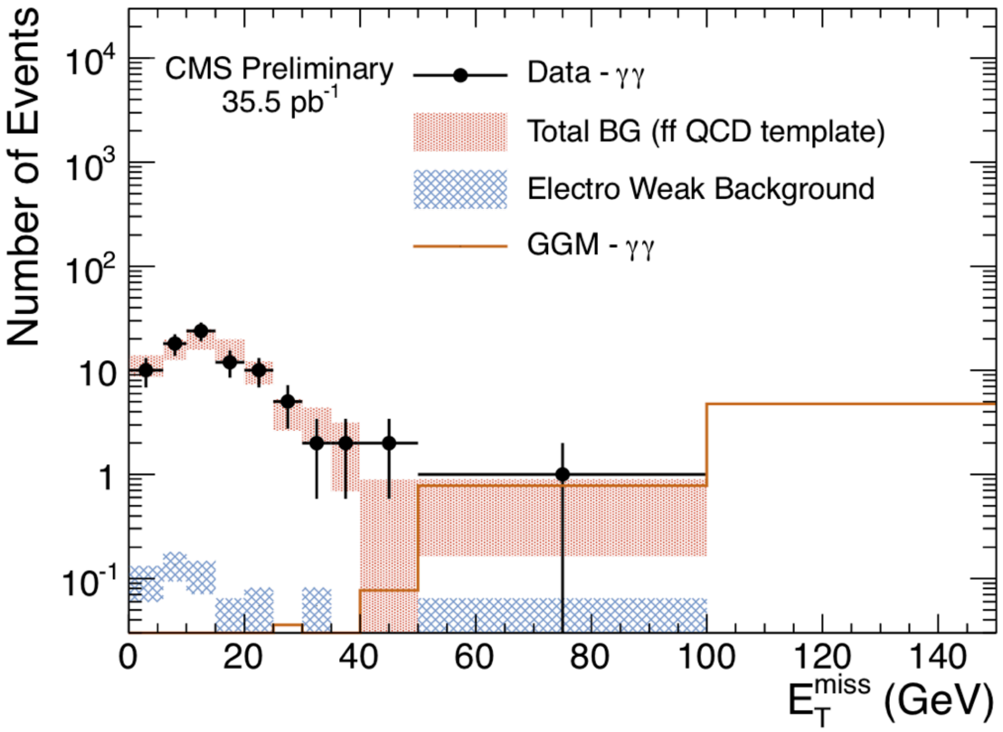
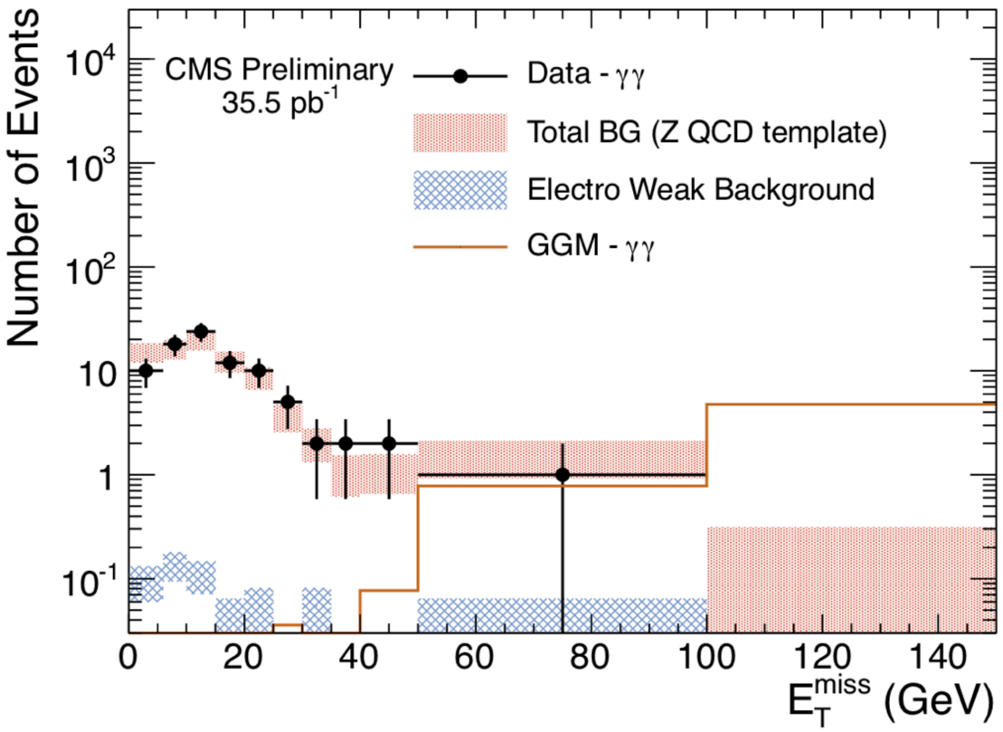
QCD backgrounds

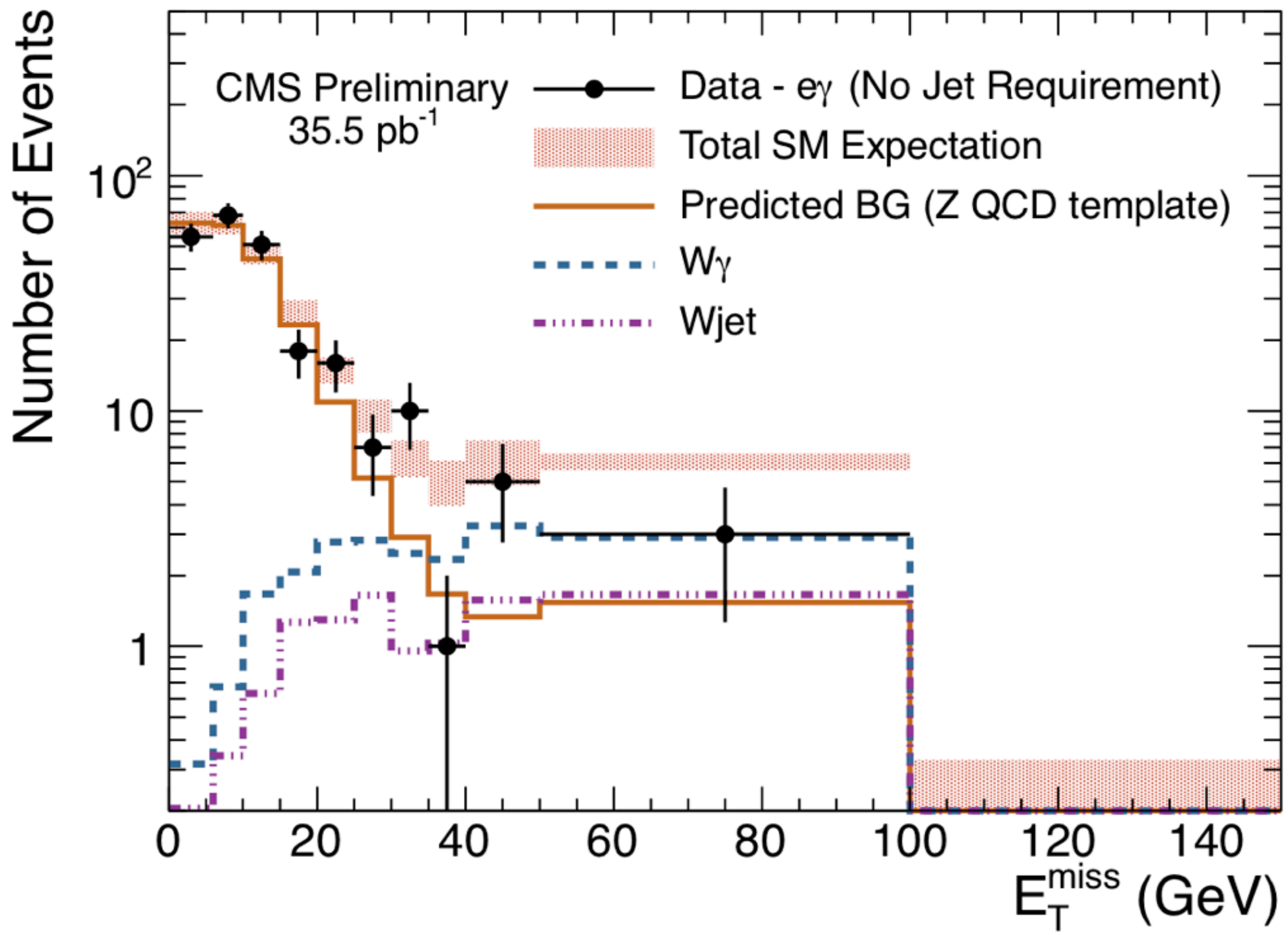






- ECAL resolution much better than HCAL
- MET resolution dominated by HCAL
- Reweight ff and ee control samples to signal γγ E_T spectrum
- Normalise at low MET (<20 GeV)

Wγ cross check



- Proof that if a signal is was there we would have seen it
- "Discover" Standard Model Wγ events by switching to eγ sample

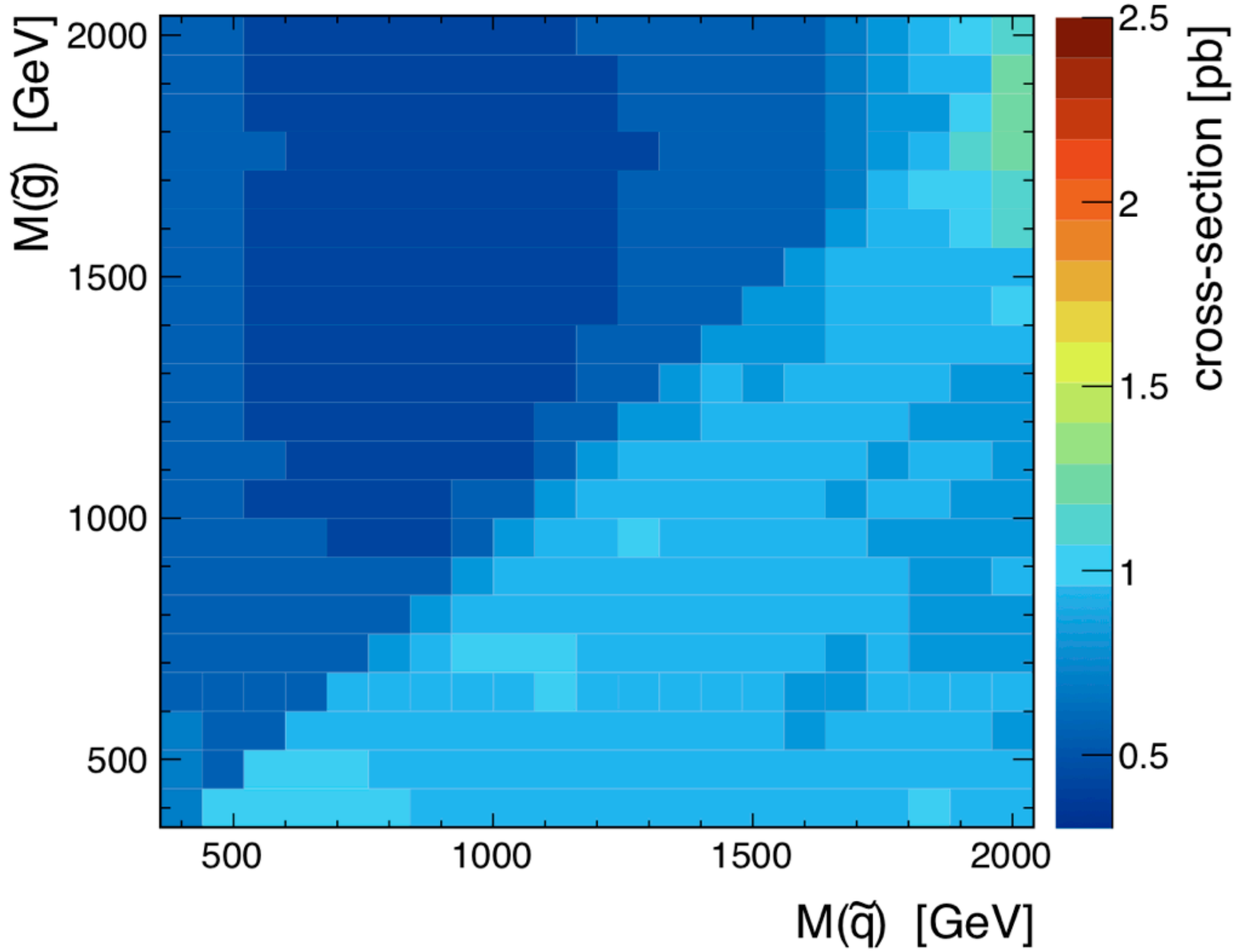
Interpretation in a GGM model

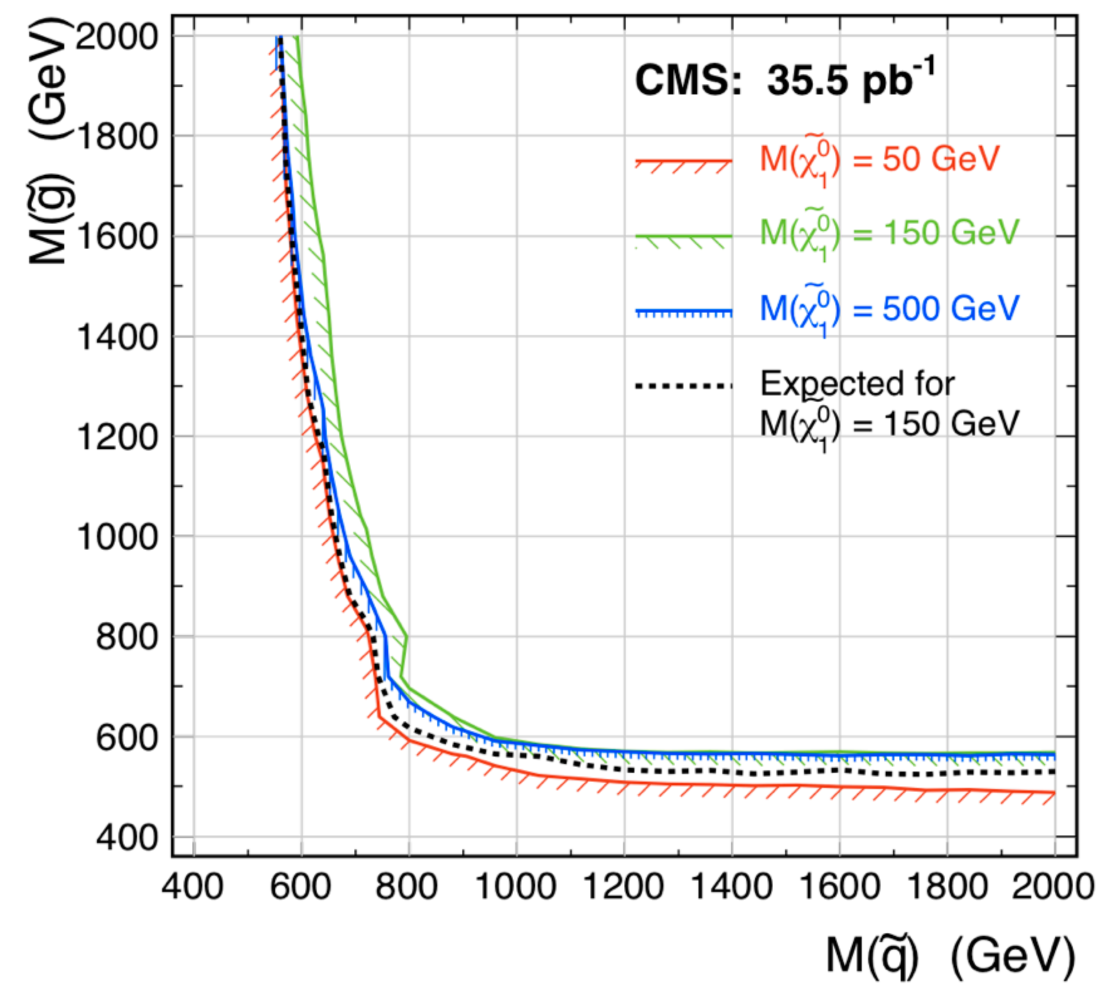
- Observe 1 event MET >50 GeV consistent with 1.2 ± 0.8 background

Type	Number of Events	stat error	reweight error	normalization error
$\gamma\gamma$ events	1.0			
fake-fake QCD background est.	0.49 ± 0.40	± 0.36	± 0.06	± 0.07
$Z \rightarrow ee$ QCD background est.	1.67 ± 0.64	± 0.46	± 0.38	± 0.23
background from $e\gamma$	0.04 ± 0.15	± 0.15	± 0.0	± 0.01
Total Background ≥ 50 GeV (using ff)	0.53 ± 0.40			
Total Background ≥ 50 GeV (using ee)	1.71 ± 0.68			

- Only three "light" particles: neutralino, gluino, and squark
- Gluino decays: Two jets and gaugino. Can be 3-body or cascade depending on m(squark)-m(gluino)
- Squark decays: If heavier then gluinos: quark + gluino gives three jets + gaugino. If lighter then gluino: quark and gaugino gives one jet + gaugino
- Each event has: Two gauginos ➔ in our simple model neutralinos ➔ two Photons + MET and between two and six jets from SUSY cascades

Interpretation in a GGM model





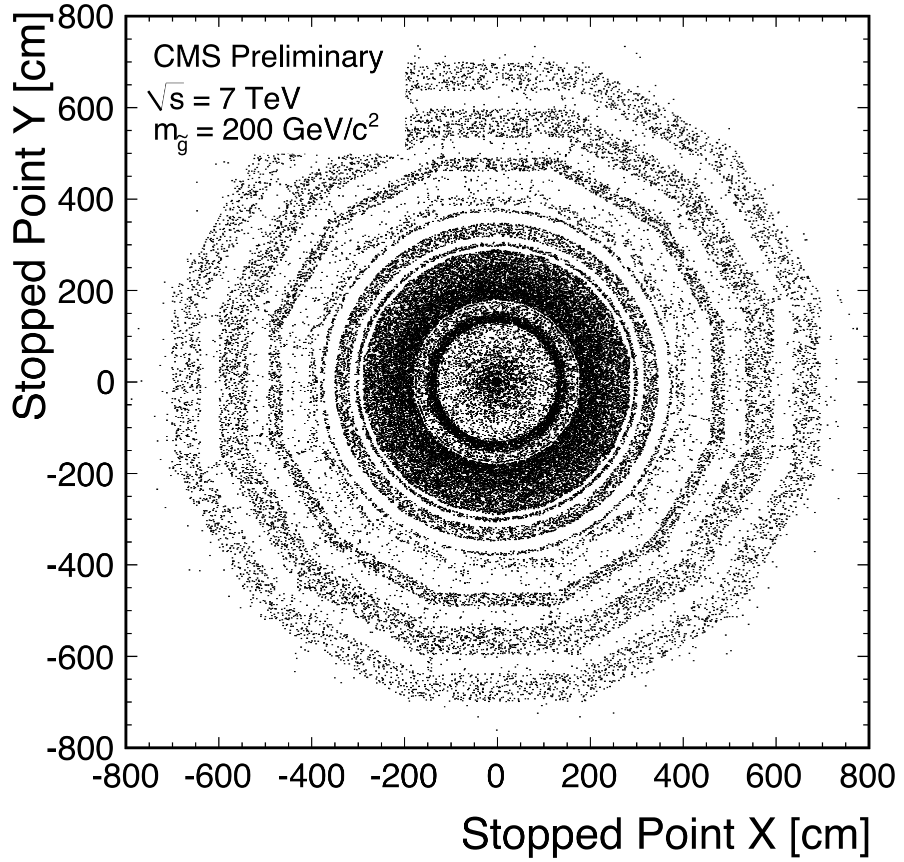
- 95% CL upper limit for simple model for neutralino mass = 150 GeV
- Upper limits between 0.3 and 1.1 pb depending on masses
- Factor of ~10 better than Tevatron could do with 6 fb^{-1}

Long-lived particle searches

- Long-lived particles possible in many theories
  - For example many SUSY models with stau NLSP with Gravitino LSP
- Long-lived charged particles with lifetimes of O(100-1000)s could explain the discrepancy between Li abundance and BBN
- Two complementary approaches:
  - High momentum tracks with large dE/dx E loss (high $\beta > 0.4$)
  - **Stopped particles** may decay any time ➔ signal out-of-time with LHC beam

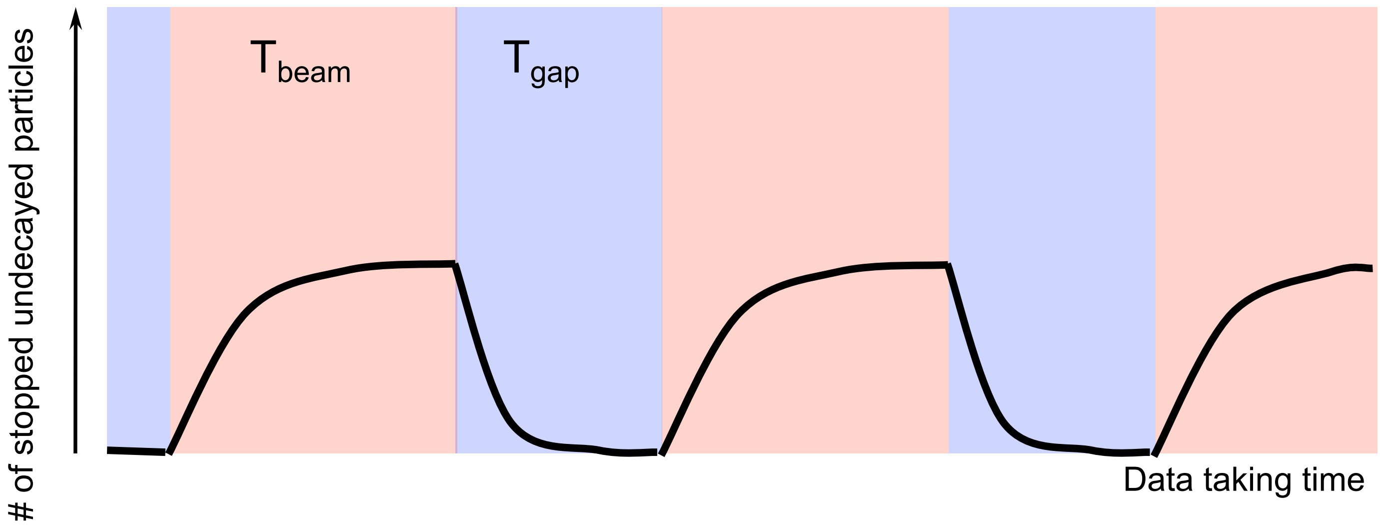
Stopped particle searches

PRL 106, 011801 (2011)



- Long-lived particles produced in pp collisions
- Particles stop in detector in brass absorber in barrel hadronic calorimeter
- Search for decays during non-collision times (between bunches, orbits and fills)

- Trigger is simple jet trigger in HCAL with $E_T > 20$ GeV
- Fight against HCAL noise and cosmic muons



Stopped particle searches

- Background determination
  - Noise rate is measured from 95 hours taken at 2-7x10^{27} $cm^{-2}s^{-1}$
  - Data was taken with 62 hours at higher intensities with 312 proton bunches per beam.

  - Reject real collisions
  - Reject if either beam monitor fired (beam monitor 175m either side)
  - Reject if in beam crossing within -2 to 1 of collision BX
  - Reject if has reconstructed vertex
  - Beam halo filter
  - Cosmic filter

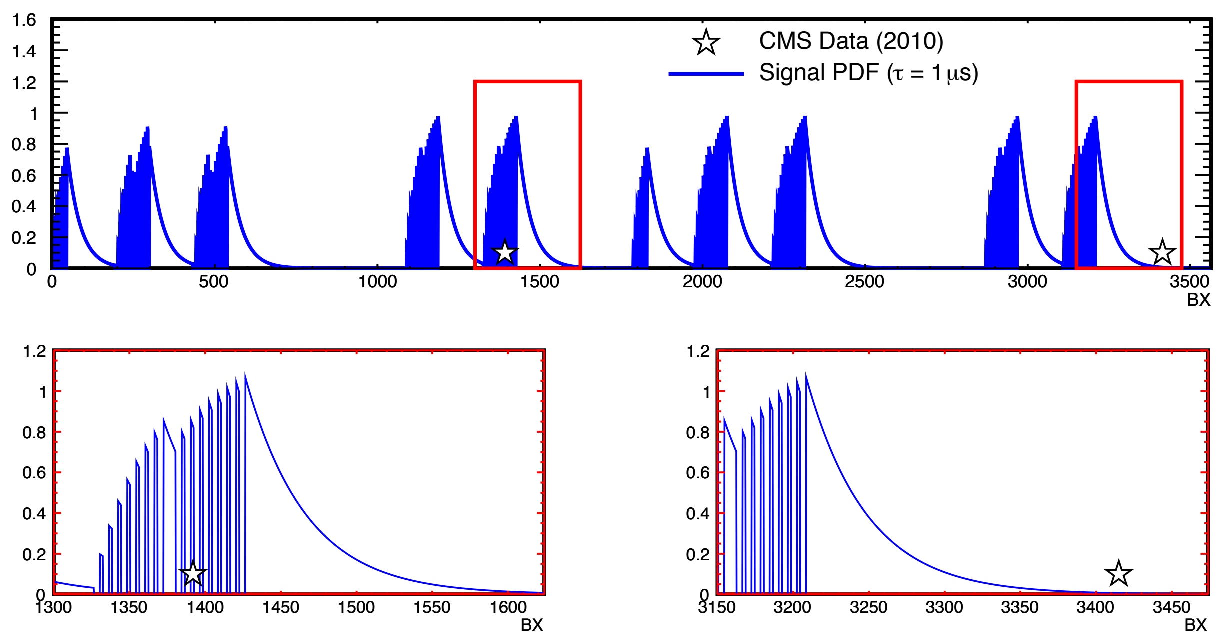
  - Monitor stability of N_{-1} filters to set uncertainty

Two ways to search

- Counting experiment - need to measure and normalise background absolutely (big systematic on normalisation) ➔

Lifetime [s]	Expected Background (± stat. ± syst.)	Observed
1×10^{-7}	$0.8 \pm 0.2 \pm 0.2$	2
1×10^{-6}	$1.9 \pm 0.4 \pm 0.5$	3
1×10^{-5}	$4.9 \pm 1.0 \pm 1.3$	5
1×10^{6}	$4.9 \pm 1.0 \pm 1.3$	5

- Time-profile analysis - build a PDF for gluino decay for a given mass and lifetime - compare shapes with CMS data (no need to normalise) ➔



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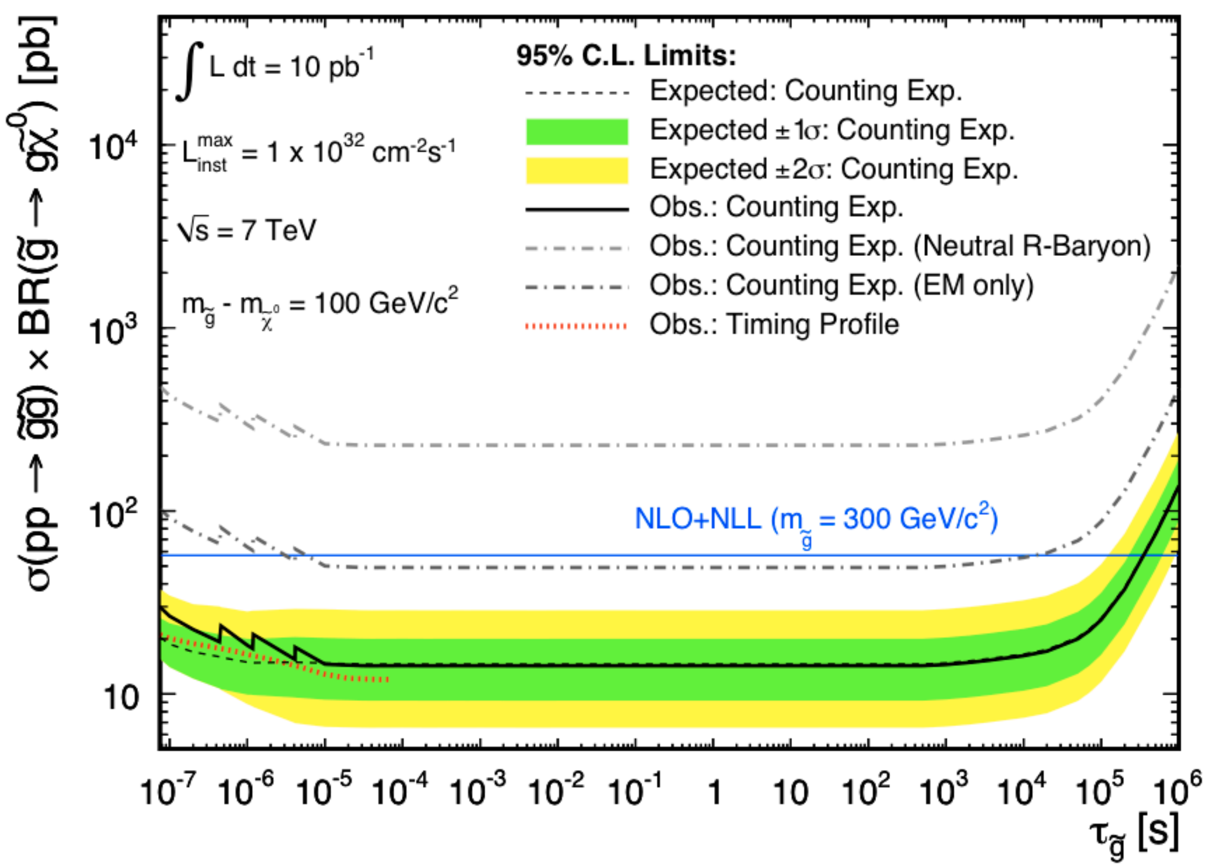
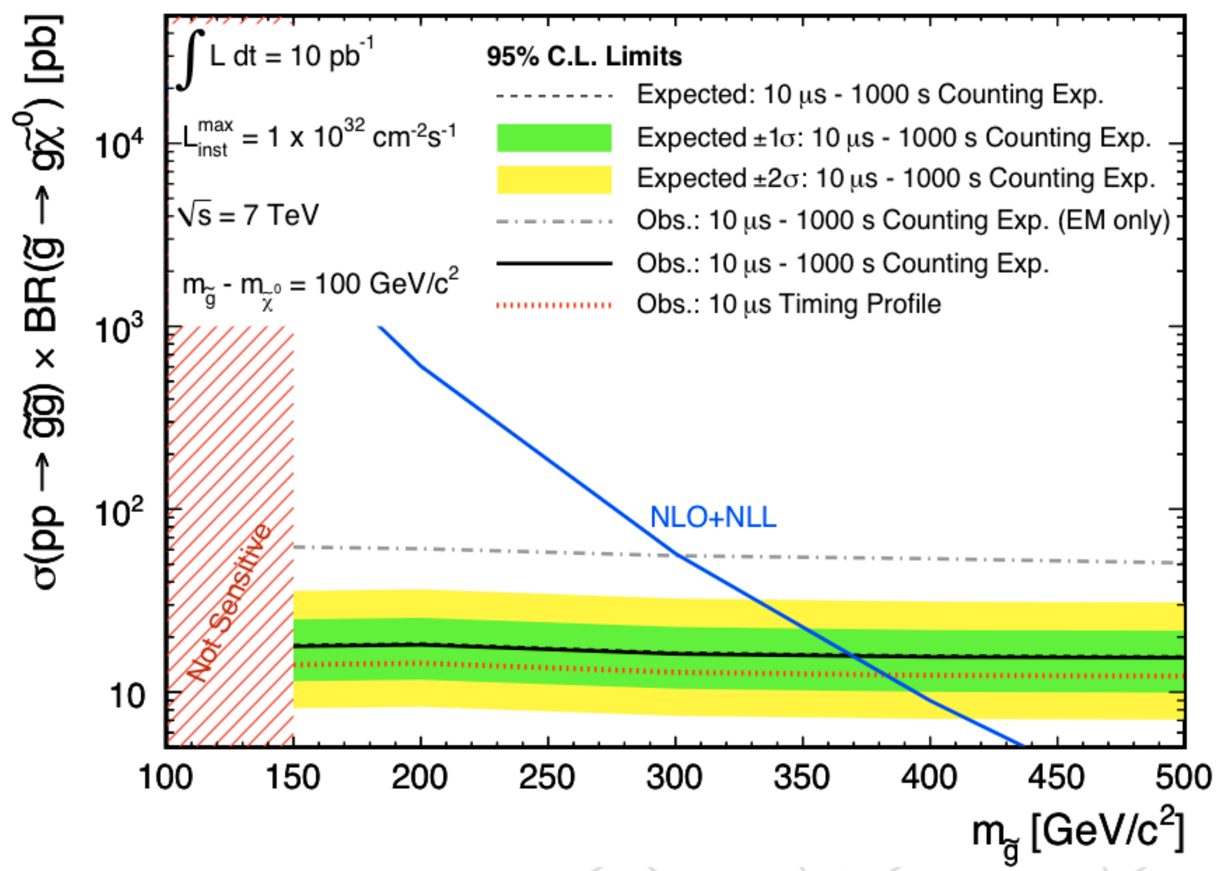
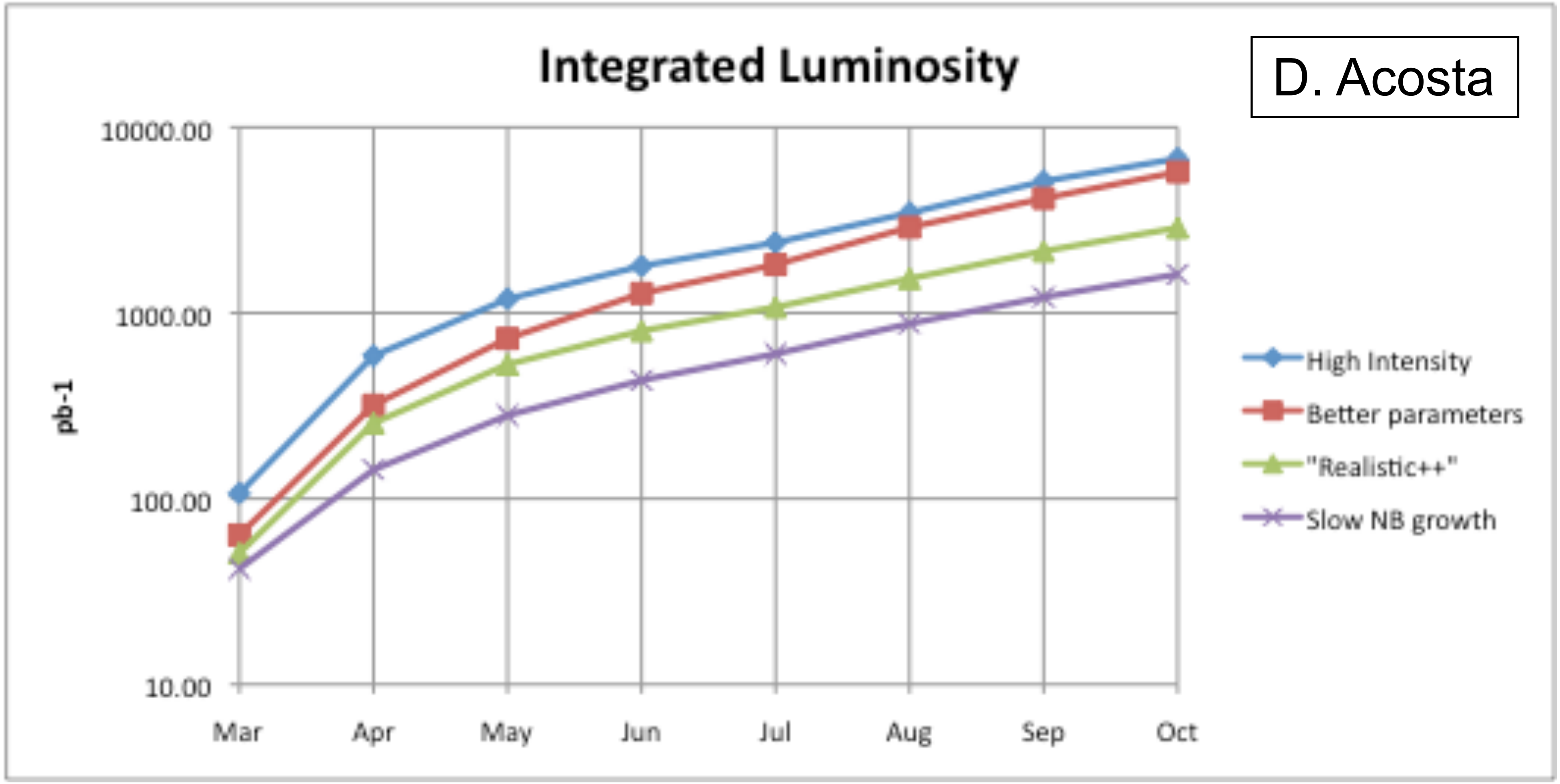
Stopped particle searches





- Under some assumptions lifetimes from 10μs to 1000s excluded
- So far limits on stopped gluinos ➔ technique could be used to set limits on stopped staus with more data

Expectations for 2011



- Will know much more after the LHC Chamonix workshop
- Could be 8 TeV centre-of-mass energy and running in 2012?

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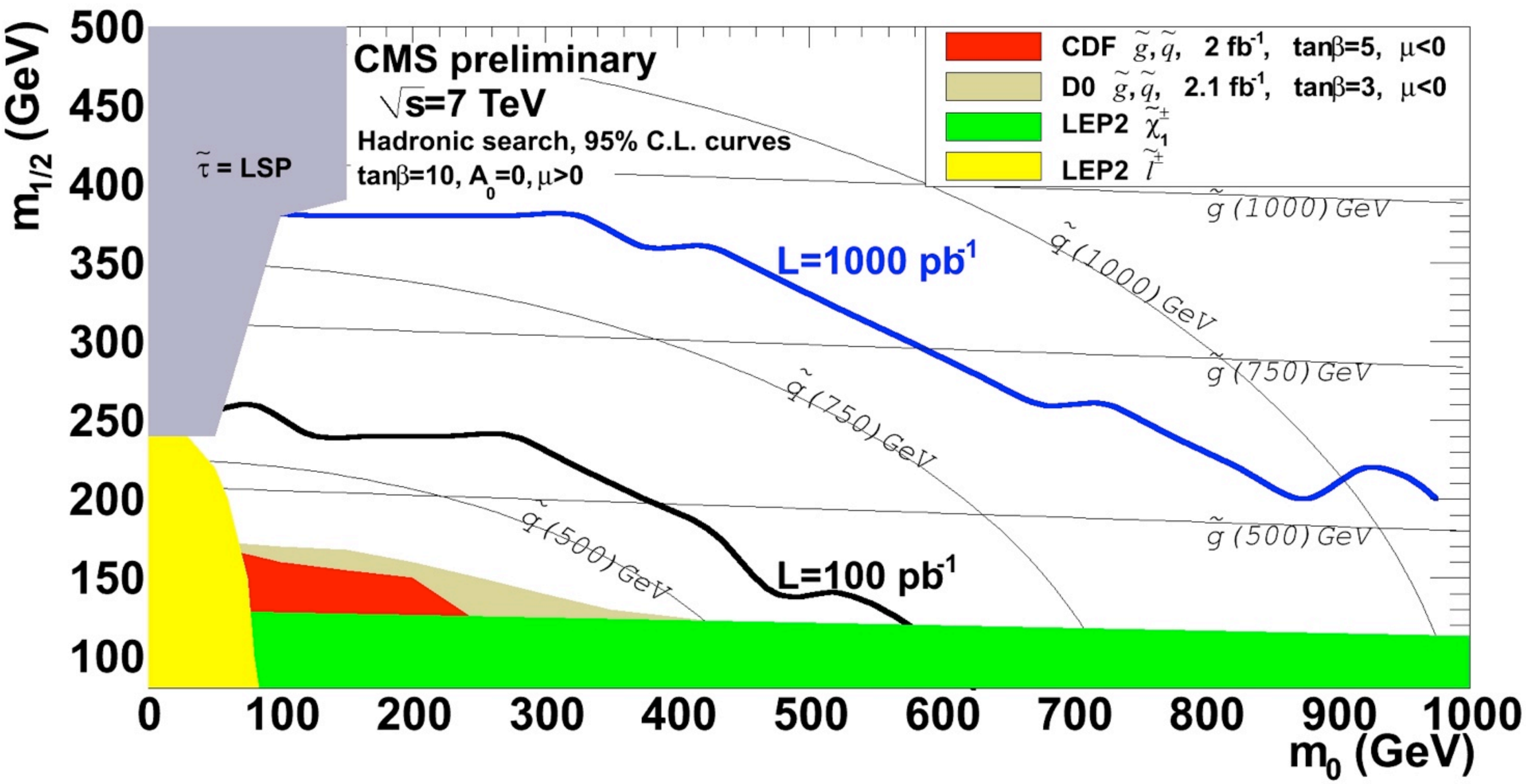
Plans for 2011

- Analyses are designed for discovery not limits
  - Data-driven background estimates
  - Multiple methods and cross-checks built in
  - Analyses categorised by topology, not by model
  - Analyses designed for maximum coverage, not necessarily best model sensitivity
- We will continue to develop our programme in 2011
  - Run current searches until they are no longer appropriate
  - In parallel develop and evolve techniques for higher luminosity
  - More use of shapes with more data, in 2010 just counting experiments
  - Weak production can come into the game (so far only strong)
  - Challenges with triggers, pile-up…..

Reach in 2011

CMS-NOTE-2010-008



- Expect us to do better than this!
- Expect our results expressed in less constrained models ➔

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Interpretation/communication

- A moving (evolving) target ➔ we need feedback
- First papers
  - mSUGRA/CMSSM to connect to previous generations of experiments
  - Cross sections x BR and information on efficiencies
- Under discussion now between ATLAS/CMS/Theory
  - Common simple/less constrained models
  - A few slides on this coming up ➔
- Bit further down the line
  - Full likelihoods in some computer format (RooStats?)
  - Some more elaborate solution?

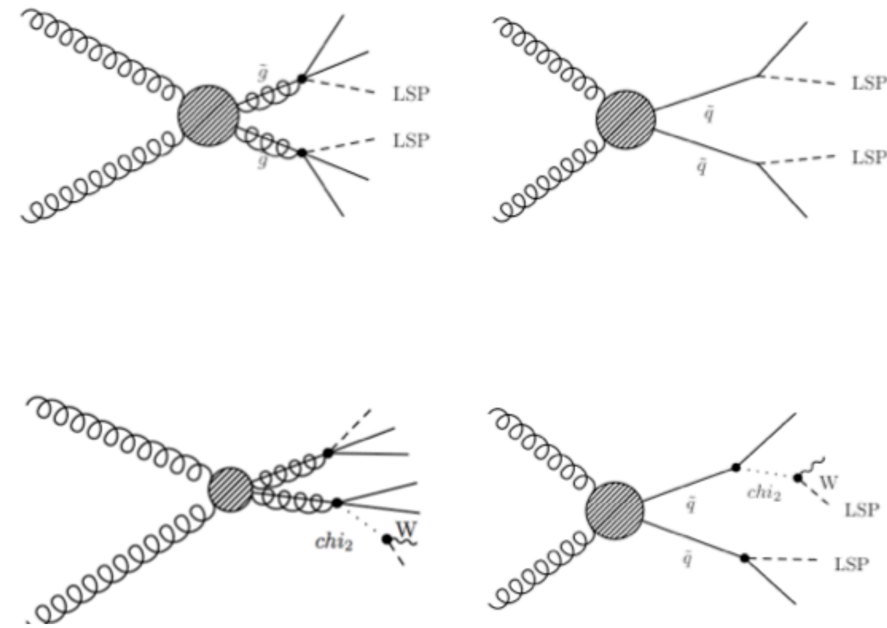
Simplified Models

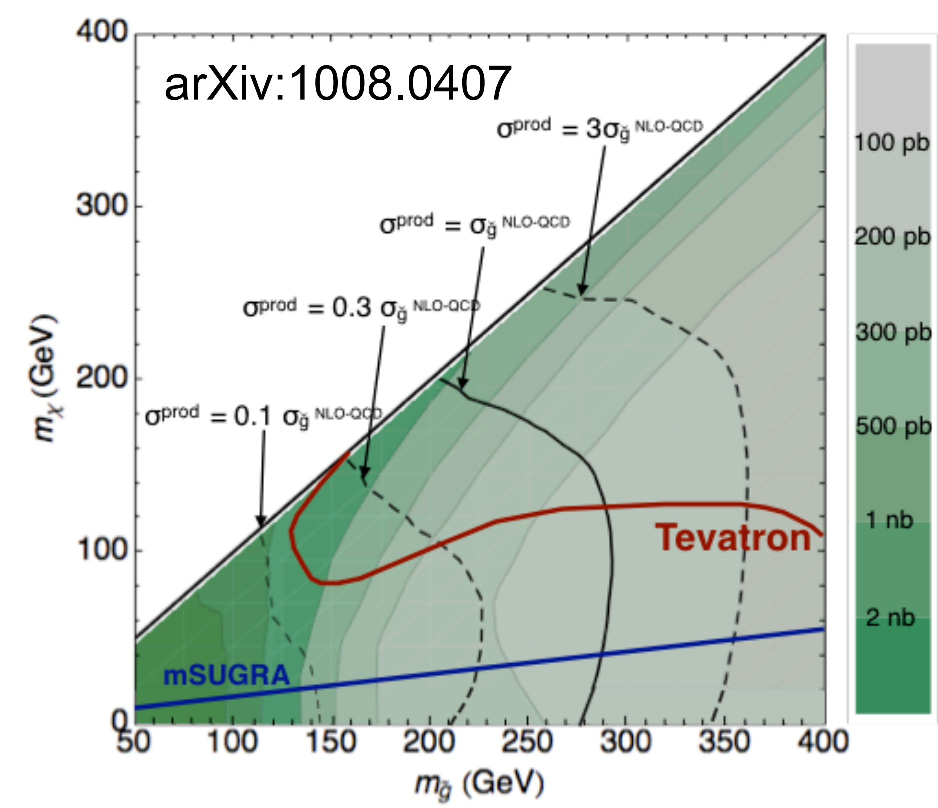
- Workshops at CERN and SLAC
  - Models proposed at: http://www.lhcnewphysics.org
  - Agreed on reference topologies for early searches
  - Cover what one might see in the first ~50 pb^{-1}
  - All initiated by strong production
  - Inspired by SUSY and SUSY-like New Physics (all involve MET)

- Increasing order of complexity
  - Hadronic decays
  - Decays with one or two leptons
  - Decays with heavy flavours
  - Photon and multi-leptons (based on GGM models as di-photon search)

Simplified Models

- Proposal for all-hadronic search
  - Squark anti-squark pair production with decay sqark → q + χ
  - Gluino pair production with decay gluino → qqbar + χ
  - χ can be the LSP or an intermediate state, decaying to W + LSP
  - Kinematics specified by masses
  - Direct case $m_{gluino}(m_{squark})$ vs m_{LSP} 2D plot
  - For cascade decays (arbitrary) slices of intermediate particle
  - Given "reference" cross section set limits





- Currently under discussion at CMS

Conclusions

- First SUSY limits from CMS in 2010 are being published
- Preparing programme for 2011/12 run
- Wide range of searches underway
- Need to work closely together to have efficient exchange of information
- Thanks for the invitation to speak today!

Backup: Links

- ATLAS latest results
  - https://twiki.cern.ch/twiki/bin/view/Atlas/AtlasResults
- ATLAS Physics TDR
  - http://cdsweb.cern.ch/record/1125884?ln=en
- CMS latest results
  - https://twiki.cern.ch/twiki/bin/view/CMS/PhysicsResults
- CMS Physics TDR
  - http://cmsdoc.cern.ch/cms/cpt/tdr/

Backup: Benchmark points

Low mass (LM) mSUGRA benchmarks

Benchmark	m0	m1/2	A0	tanb	sgn(mu)	Notes
LM0	200	160	–400	10	1	
LM1	60	250	0	10	+	
LM2	185	350	0	35	+	
LM2mhf360	185	360	0	35	+	
LM3	330	240	0	20	+	
LM4	210	285	0	10	+	
LM5	230	360	0	10	+	
LM6	85	400	0	10	+	
LM7	3000	230	0	10	+	
LM8	500	300	–300	10	+	
LM9	1450	175	0	50	+	
LM9p	1450	230	0	10	+	
LM9t175	1450	175	0	50	+	mtop = 175
LM10	3000	500	0	10	+	
LM11	250	325	0	35	+	
LM12						TBD
LM13						focus point, TBD

High mass (HM) mSUGRA benchmarks

Benchmark	m0	m1/2	A0	tanb	sgn(mu)	Notes
HM1	180	850	0	10	+	
HM2	350	800	0	35	+	
HM3	700	800	0	10	+	
HM4	1350	600	0	10	+	

GMSB (GM) benchmarks

Benchmark	Lambda	M_mess	N5	C_Grav	tanb	sgn(mu)	Notes
GM1b	80	160	1	1	15	+	
GM1c	100	200	1	1	15	+	
GM1d	120	240	1	1	15	+	
GM1e	140	280	1	1	15	+	
GM1f	160	320	1	1	15	+	
GM1g	180	360	1	1	15	+	

Particle	SU1	SU2	SU3	SU4	SU6	SU8.1	SU9
$\tilde{d}_L$	764.90	3564.13	636.27	419.84	870.79	801.16	956.07
$\tilde{u}_L$	760.42	3563.24	631.51	412.25	866.84	797.09	952.47
$\tilde{b}_1$	697.90	2924.80	575.23	358.49	716.83	690.31	868.06
$\tilde{t}_1$	572.96	2131.11	424.12	206.04	641.61	603.65	725.03
$\tilde{d}_R$	733.53	3576.13	610.69	406.22	840.21	771.91	920.83
$\tilde{u}_R$	735.41	3574.18	611.81	404.92	842.16	773.69	923.49
$\tilde{b}_2$	722.87	3500.55	610.73	399.18	779.42	743.09	910.76
$\tilde{t}_2$	749.46	2935.36	650.50	445.00	797.99	766.21	911.20
$\tilde{e}_L$	255.13	3547.50	230.45	231.94	411.89	325.44	417.21
$\tilde{\nu}_e$	238.31	3546.32	216.96	217.92	401.89	315.29	407.91
$\tilde{\tau}_1$	146.50	3519.62	149.99	200.50	181.31	151.90	320.22
$\tilde{\nu}_\tau$	237.56	3532.27	216.29	215.53	358.26	296.98	401.08
$\tilde{e}_R$	154.06	3547.46	155.45	212.88	351.10	253.35	340.86
$\tilde{\tau}_2$	256.98	3533.69	232.17	236.04	392.58	331.34	416.43
$\tilde{g}$	832.33	856.59	717.46	413.37	894.70	856.45	999.30
$\tilde{\chi}_1^0$	136.98	103.35	117.91	59.84	149.57	142.45	173.31
$\tilde{\chi}_2^0$	263.64	160.37	218.60	113.48	287.97	273.95	325.39
$\tilde{\chi}_3^0$	466.44	179.76	463.99	308.94	477.23	463.55	520.62
$\tilde{\chi}_4^0$	483.30	294.90	480.59	327.76	492.23	479.01	536.89
$\tilde{\chi}_1^+$	262.06	149.42	218.33	113.22	288.29	274.30	326.00
$\tilde{\chi}_2^+$	483.62	286.81	480.16	326.59	492.42	479.22	536.81
h^0	115.81	119.01	114.83	113.98	116.85	116.69	114.45
H^0	515.99	3529.74	512.86	370.47	388.92	430.49	632.77
A^0	512.39	3506.62	511.53	368.18	386.47	427.74	628.60
H^+	521.90	3530.61	518.15	378.90	401.15	440.23	638.88
t	175.00	175.00	175.00	175.00	175.00	175.00	175.00