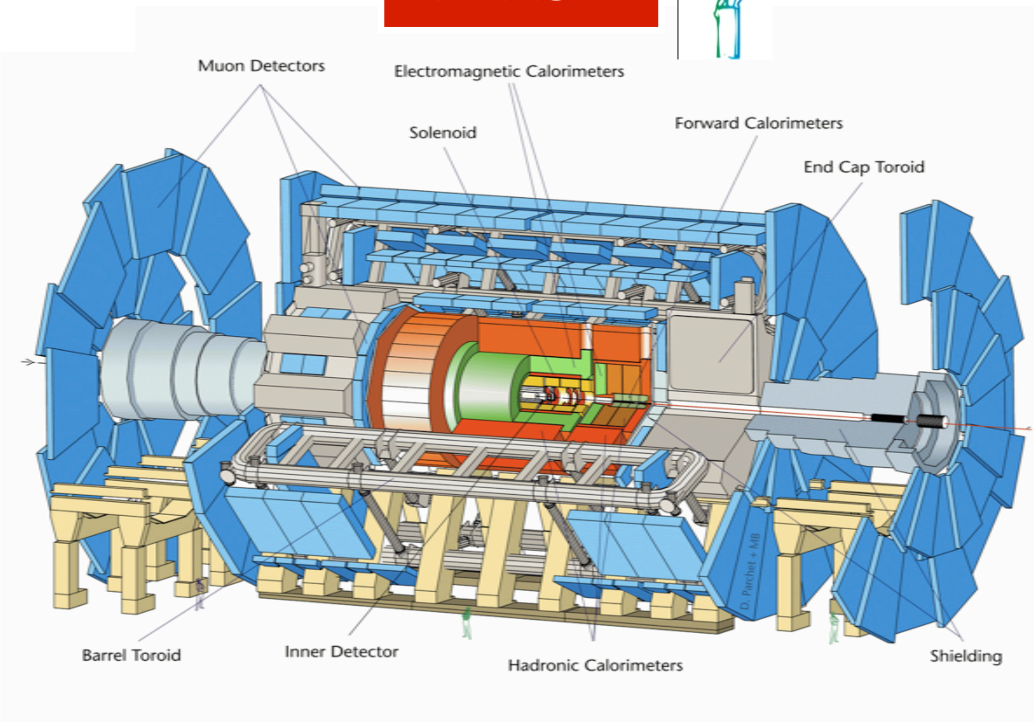
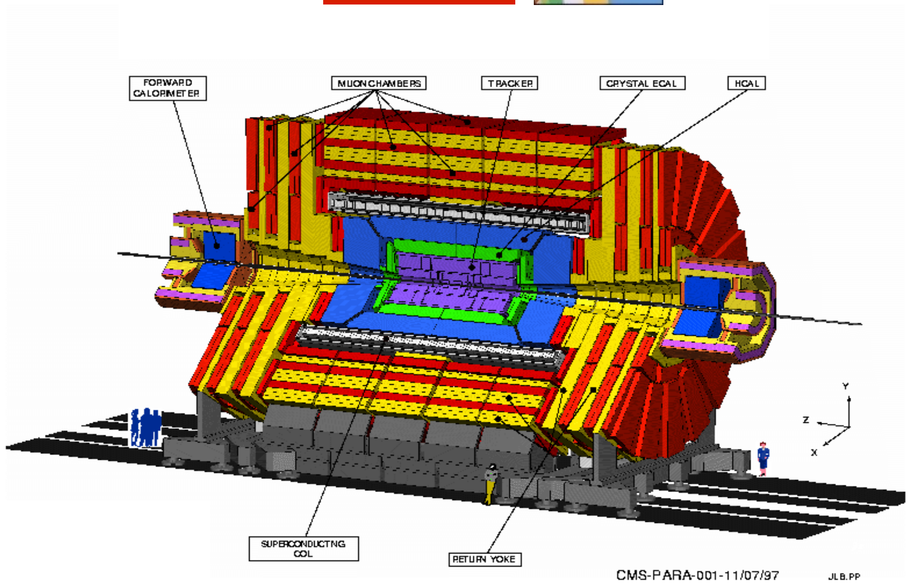
COSMO/CosPA 2010

The Latest Status and Results of LHC Focusing on the Physics@

ATLAS



CMS



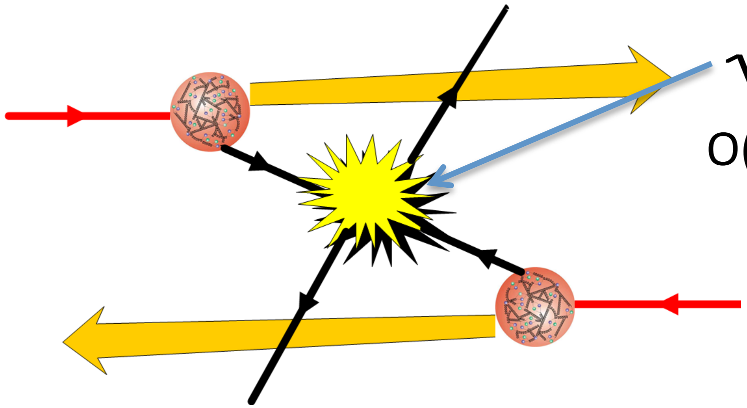
S.Asai (U.Tokyo)

Plan of my talk

1. LHC status and plan
2. The latest results of QCD+EW Physics
   (exercise for detector-understanding)
3. SUSY hunting (Now and future)
4. Higgs perspective
5. Extra dimension (If I have time)
6. Summary and Conclusion

1. LHC status and plan

Luminosity is essential for Hadron collider

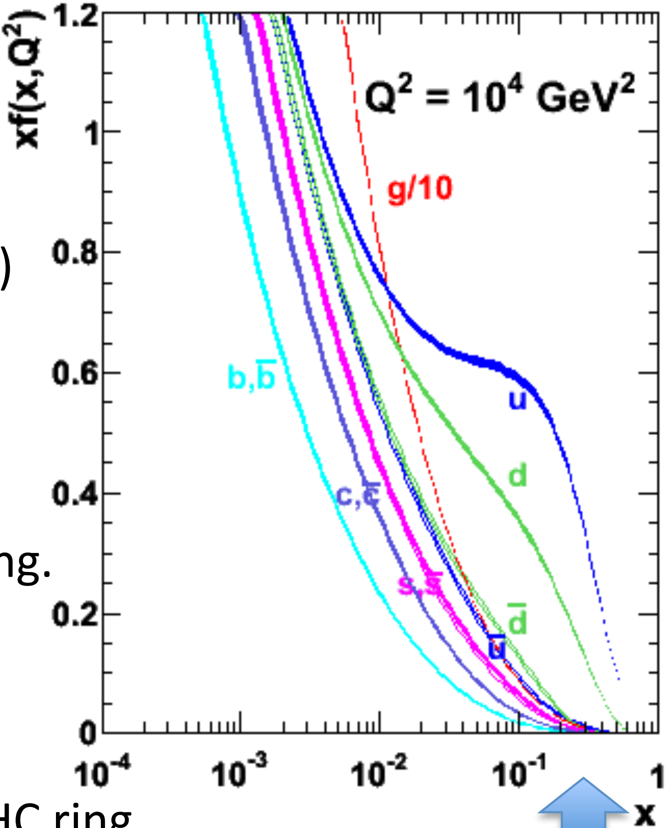


$$\sqrt{\hat{s}} = \sqrt{x_1 x_2}\sqrt{s_{pp}}$$

O(TeV)

(7-- 14TeV)

PDF is steep

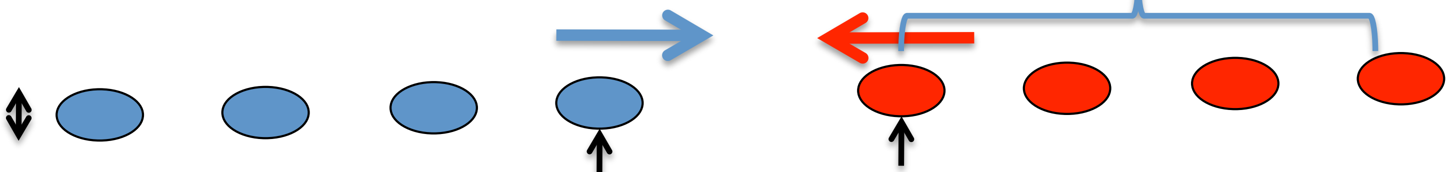


TeV Physics

$$L = \frac{n_1 n_2}{4\pi\sigma_x\sigma_y} f$$

Proton is "Bunch"- structured in Ring.
"n" proton is accumulated in each "bunch".
Frequency f is proportion to N_{bunch}

N_{bunch} in LHC ring



beam size σ_x σ_y

n_1 proton

n_2 proton

"bunch"

Design values of LHC

$n=1.15*10^{11}$, f=40MHz (N_{bunch}=2808)
σ=17μm (σ=√εβ* β*=0.5m)

Peak $L=10^{34}cm^{-2}s^{-1}$
∫Ldt ~ 100 fb^{-1}/year

First target
$L=10^{32}cm^{-2}s^{-1}$

Milestones of First 2010

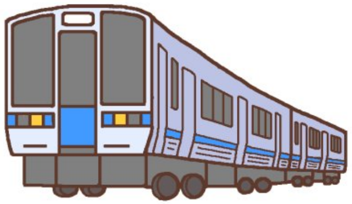
with 3 important parameters and Peak Luminosity.

Date	Achieved	
Mar 30	First collisions at 7 TeV centre of mass. β	Luminosity ~ $2\ 10^{27}\ cm^{-2}\ s^{-1}$
April 24	First stable beams at 7 TeV, 3 on 3, squeeze to 2m.	Luminosity ~ $2\ 10^{28} cm^{-2}\ s^{-1}$
May	Increase bunch intensity to $2\ 10^{10}$, Increase k_b. n	Regular physics runs
May 24	13 on 13, 8 colliding pairs per experiment.	Luminosity ~ $3\ 10^{29} cm^{-2}\ s^{-1}$
June	Increase bunch intensity to nominal, squeeze to 3.5m.	No physics
June 25	First stable beams at 7 TeV, 3 on 3 nominal bunch.	Luminosity ~ $5\ 10^{29} cm^{-2}\ s^{-1}$
July 15	13 on 13, 8 colliding pairs per experiment, $9\ 10^{10}$ / bunch	Luminosity ~ $1.5\ 10^{30} cm^{-2}\ s^{-1}$
July 30	25 on 25, 16 colliding pairs per experiment, $9\ 10^{10}$ / bunch	Luminosity ~ $3\ 10^{30} cm^{-2}\ s^{-1}$
Aug 19	48 on 48, 36 colliding pairs 1 5 and 8 (< in 2), $9\ 10^{10}$ / bunch	Luminosity ~ $6\ 10^{30} cm^{-2}\ s^{-1}$
Aug	Stable running period to consolidate operation and MP n	~2 MJ per beam !
Aug 26	50 on 50, 35 colliding pairs 1 5 and 8 (< in 2), $1.1\ 10^{11}$ / bunch	Luminosity ~ $1\ 10^{31} cm^{-2}\ s^{-1}$

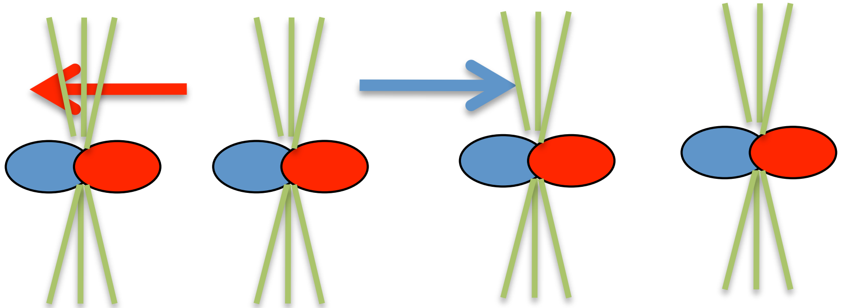
n_{bunch} increased by 10^4
for 4 months

1/10 of first target has been achieved.

Bunch Train

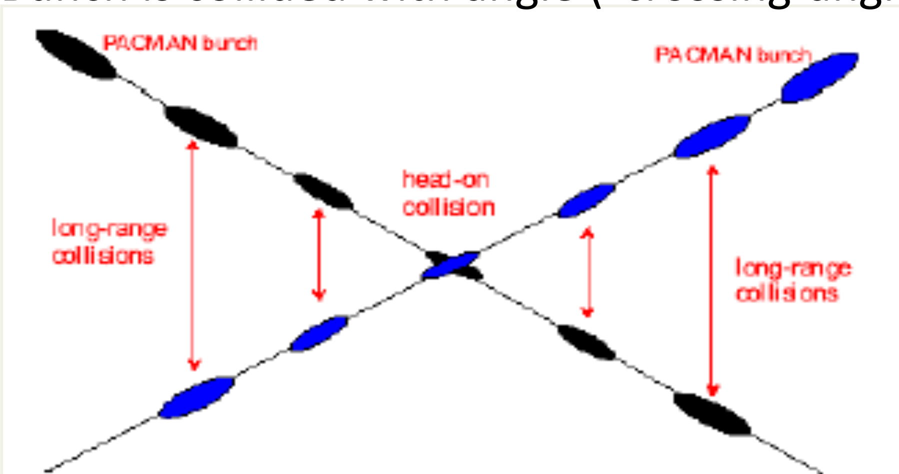


When N_{bunch} increases ("Bunch train")



collision takes place everywhere
-> beam loss becomes serious.

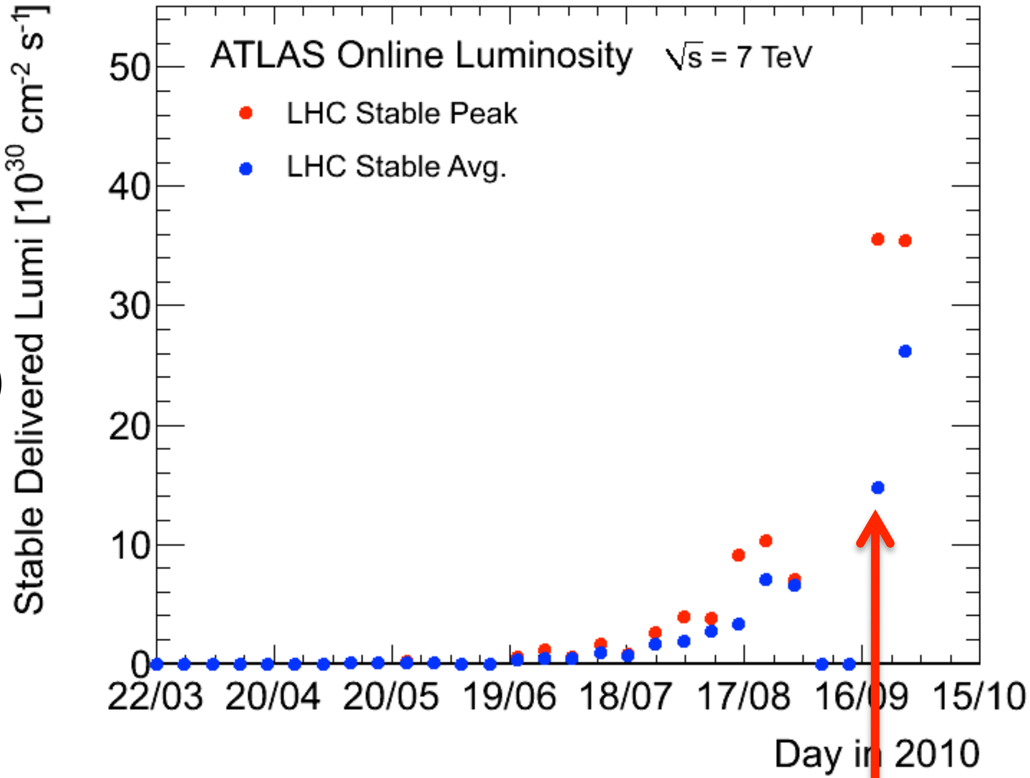
To avoid multi collision
Bunch is collided with angle ("crossing-angle")



θ=285μrad

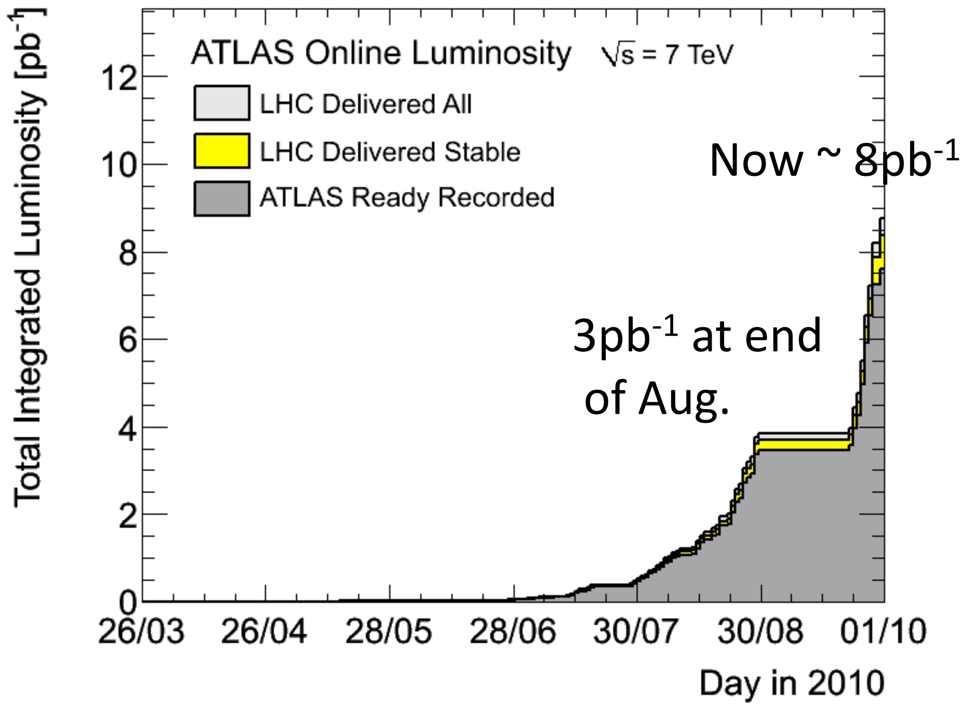
This crossing collision is "crucial" millstone for the next step:

3 weeks Technical stop in September
the crossing collision has been installed.

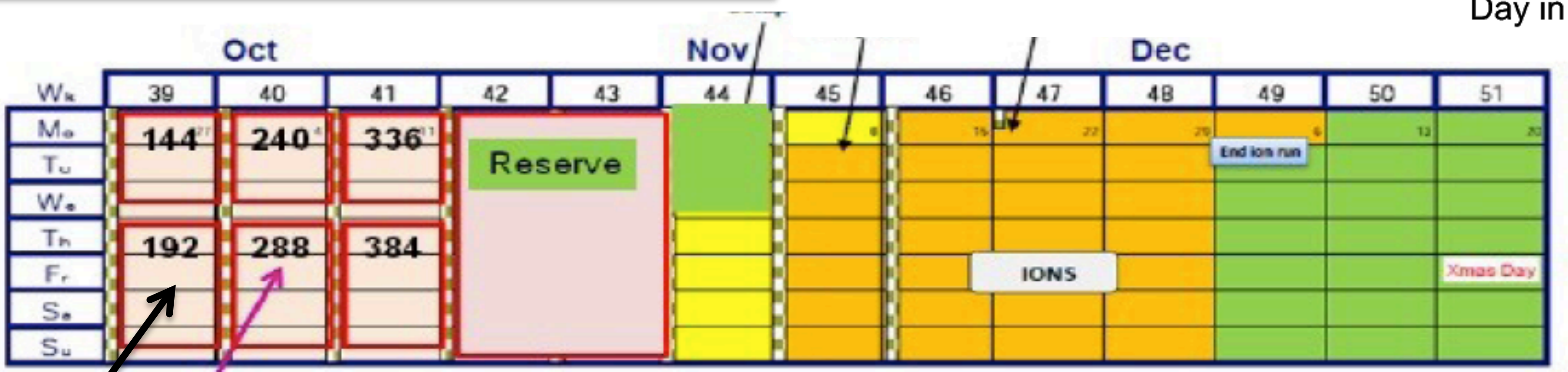


22nd September (Last week)
Successfully collided with angle!!!
Luminosity increase significantly
Clear millstone !!!

Yesterday (30th September)
152+152 bunch train collide successfully,
and Peak Luminosity of $5*10^{31}$ cm^{-2} s^{-1}
is recorded.
>$1pb^{-1}$/ day is delivered.
More than $4pb^{-1}$ data is recorded
in a week.



Time schedule of this year is as follows.

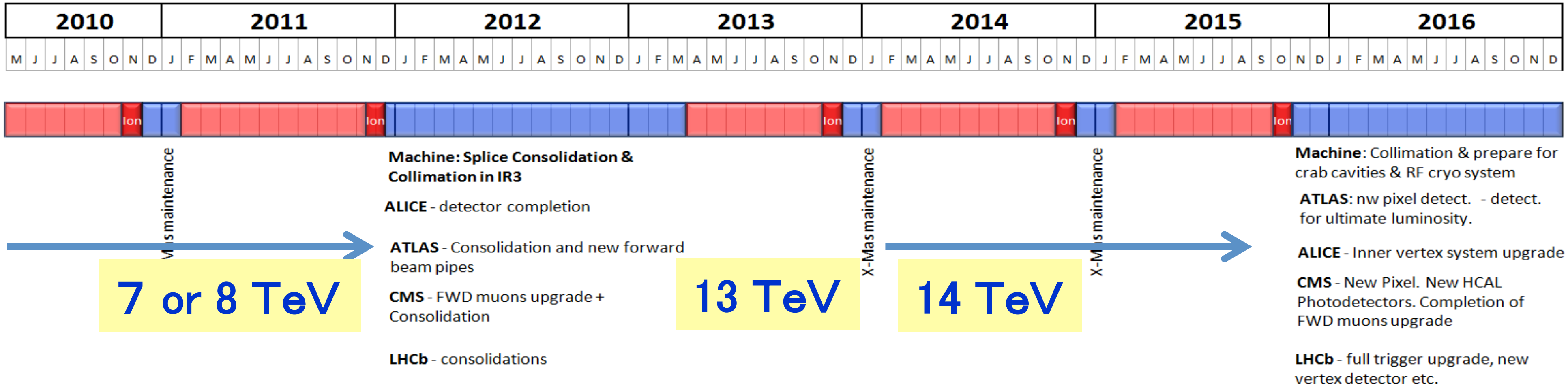


Today

number of Bunch increases step by step

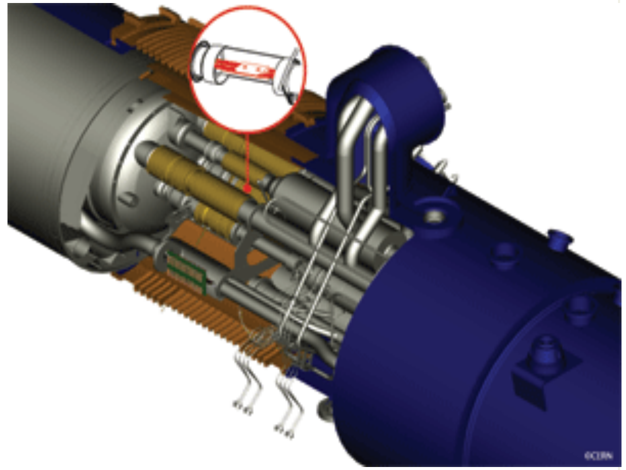
384+384 bunch collide : $L= 10^{32}$ will be achieved with in 2weeks **(First target clear)**
L=30—70 pb^{-1} will be recorded before end of October
It means that L=**$1fb^{-1}$ in the next year** is almost(?) guaranteed. (Realistic)
Unfortunately Heavy Ion run (Pb+Pb) is planned in Nov.

Plan of the next few years



2011 **7-8 TeV L=1fb^{-1}** (L=10^{32}cm^{-2} s^{-1}) Rich discoveries are expected as I will show.

2012 Technical stop(15months) to repair bad connections between superconducting magnets.
This bad connection makes 9.19 incident in 2008.

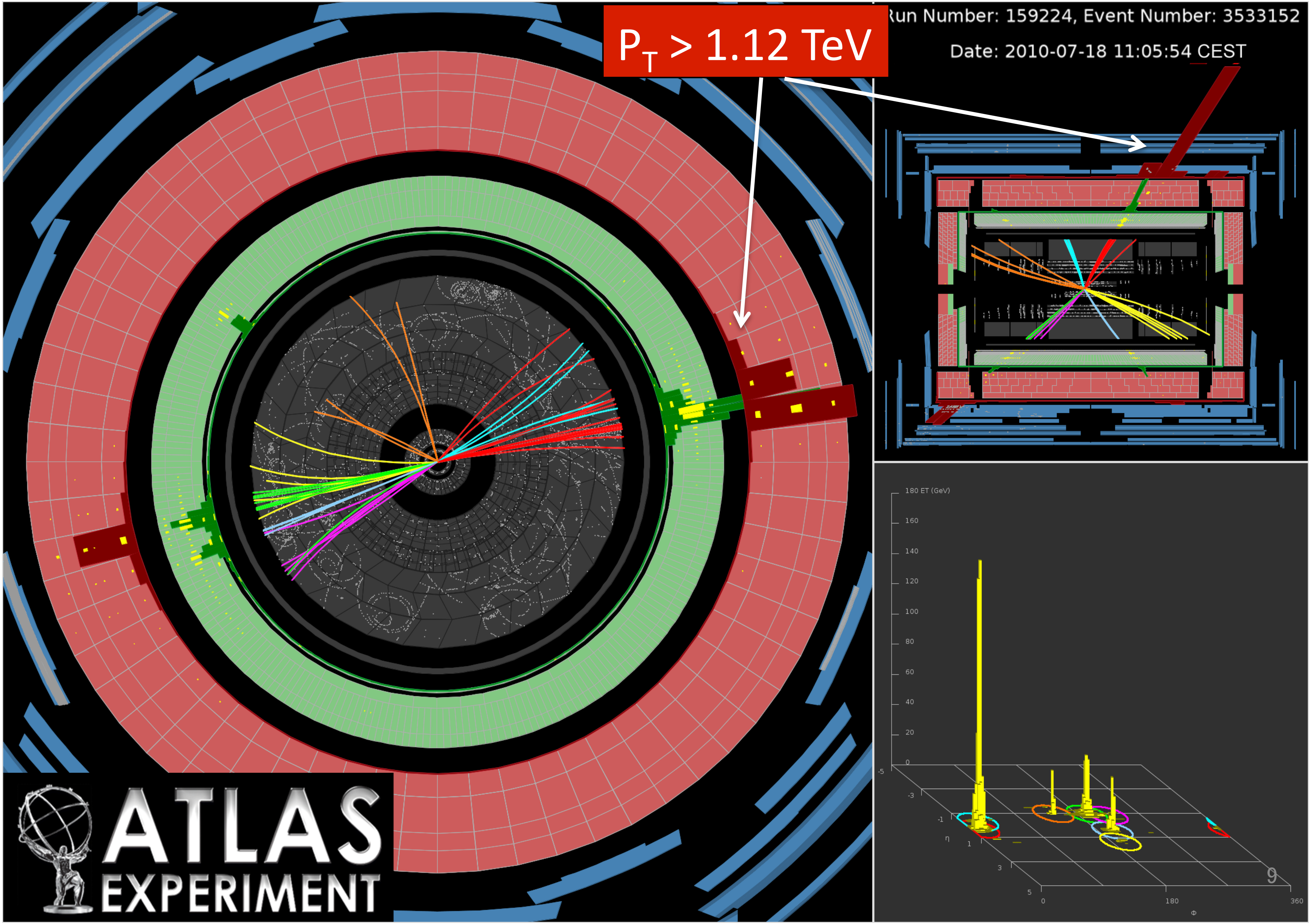


LHC
First Phase
Discovery
Higgs/SUSY

There is some discussion to keep physics collision at 7-8TeV even in 2012 to defeat Tevatron (see Higgs section)

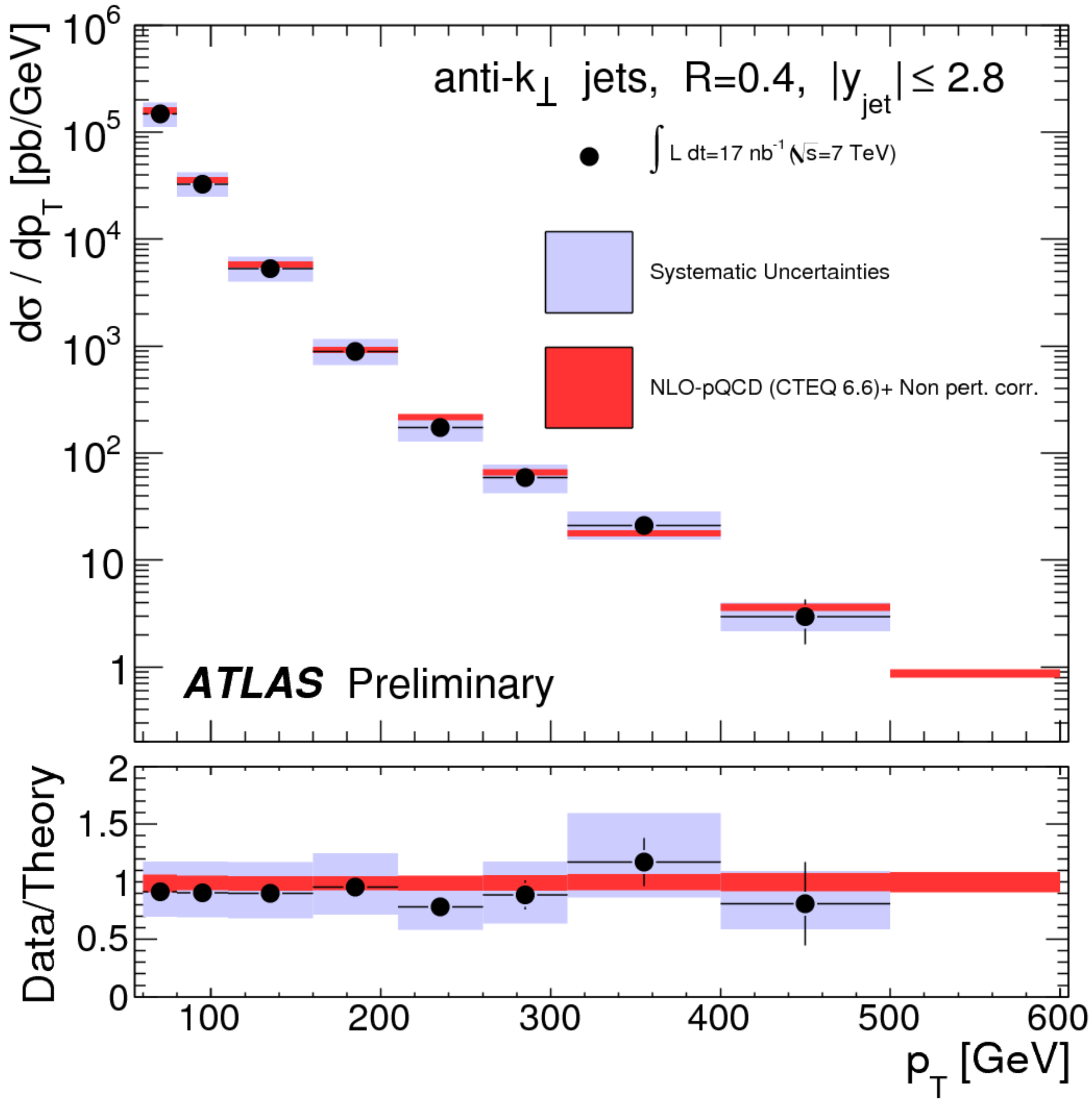
2013 E=13-14TeV L=1fb^{-1}
2014 E=14 TeV L=10fb^{-1}
2015 E=14 TeV L=30fb^{-1} → Move to upgrade of Injection system and Detectors

2. The latest results of QCD+EW



QCD Jet is most popular process in LHC

good exercise of Hadronic response of the detector



Production cross-section are measured as a function of PT:

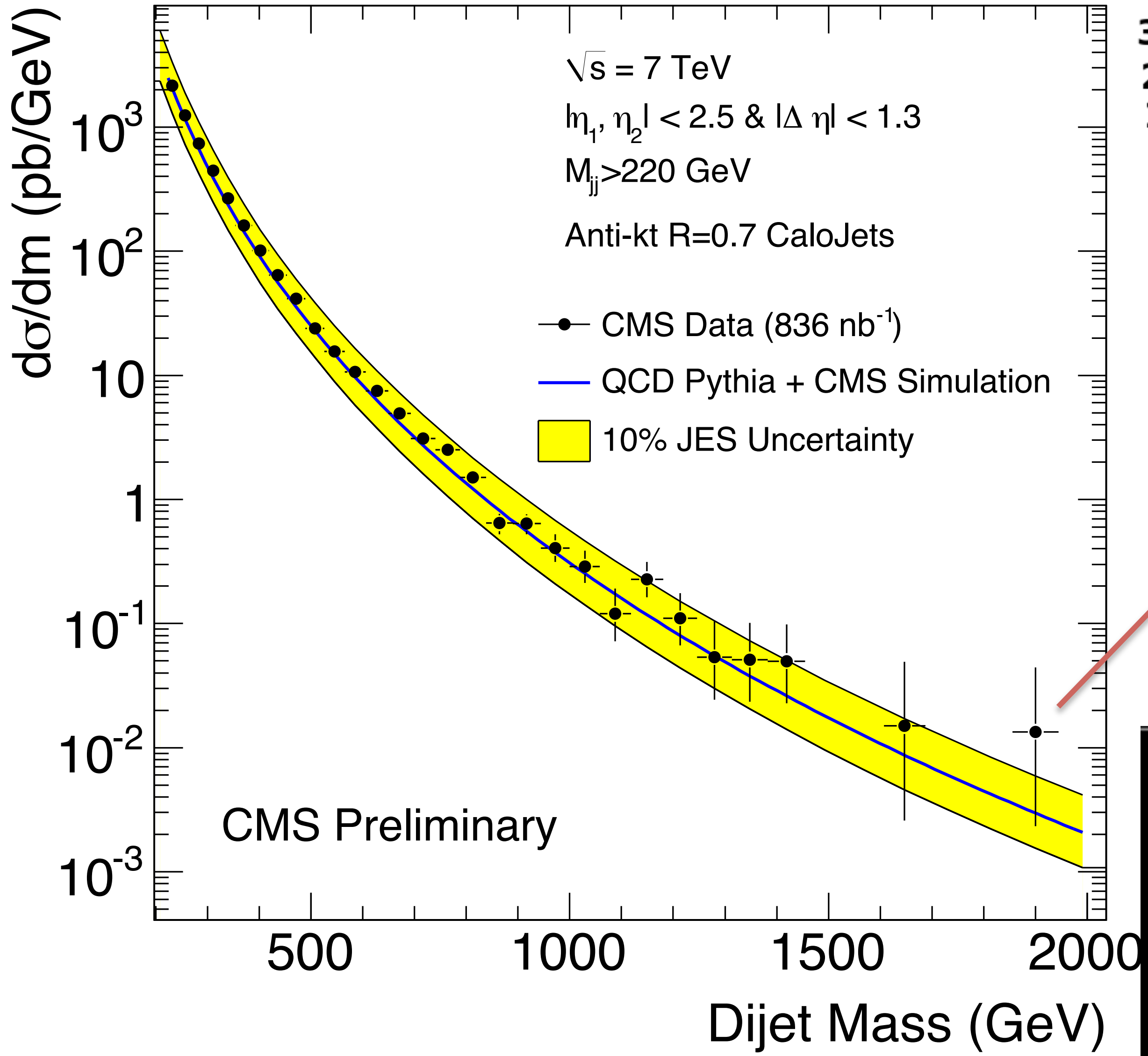
Lower shows the ratio of data/NLO Pred.

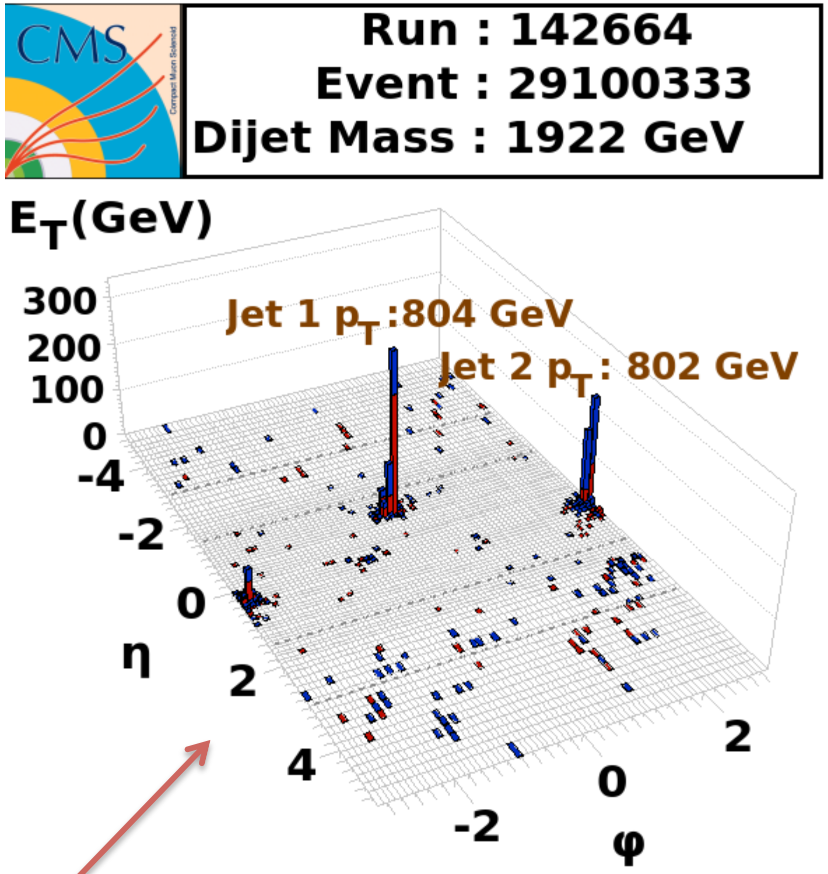
LHC results are consistent with QCD(NLO) prediction for all eta and Pt region.

Main systematic error is jet energy scale ~7% in this summer.

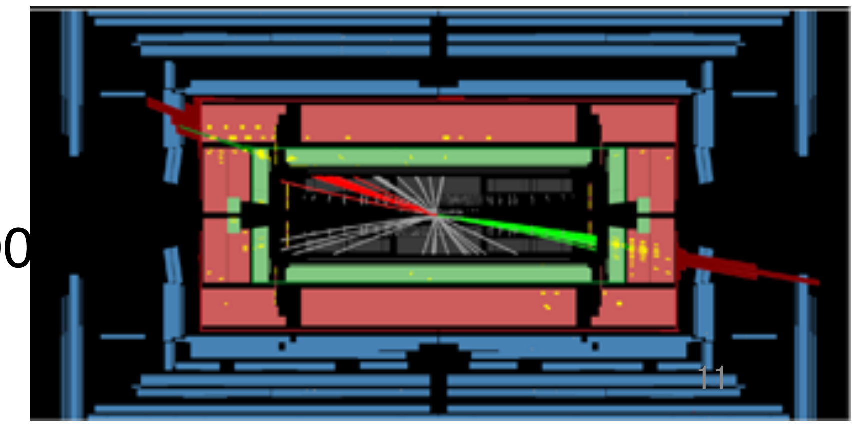
Finally we will control jet energy scale with 1% accuracy.

Invariant mass of 2jet

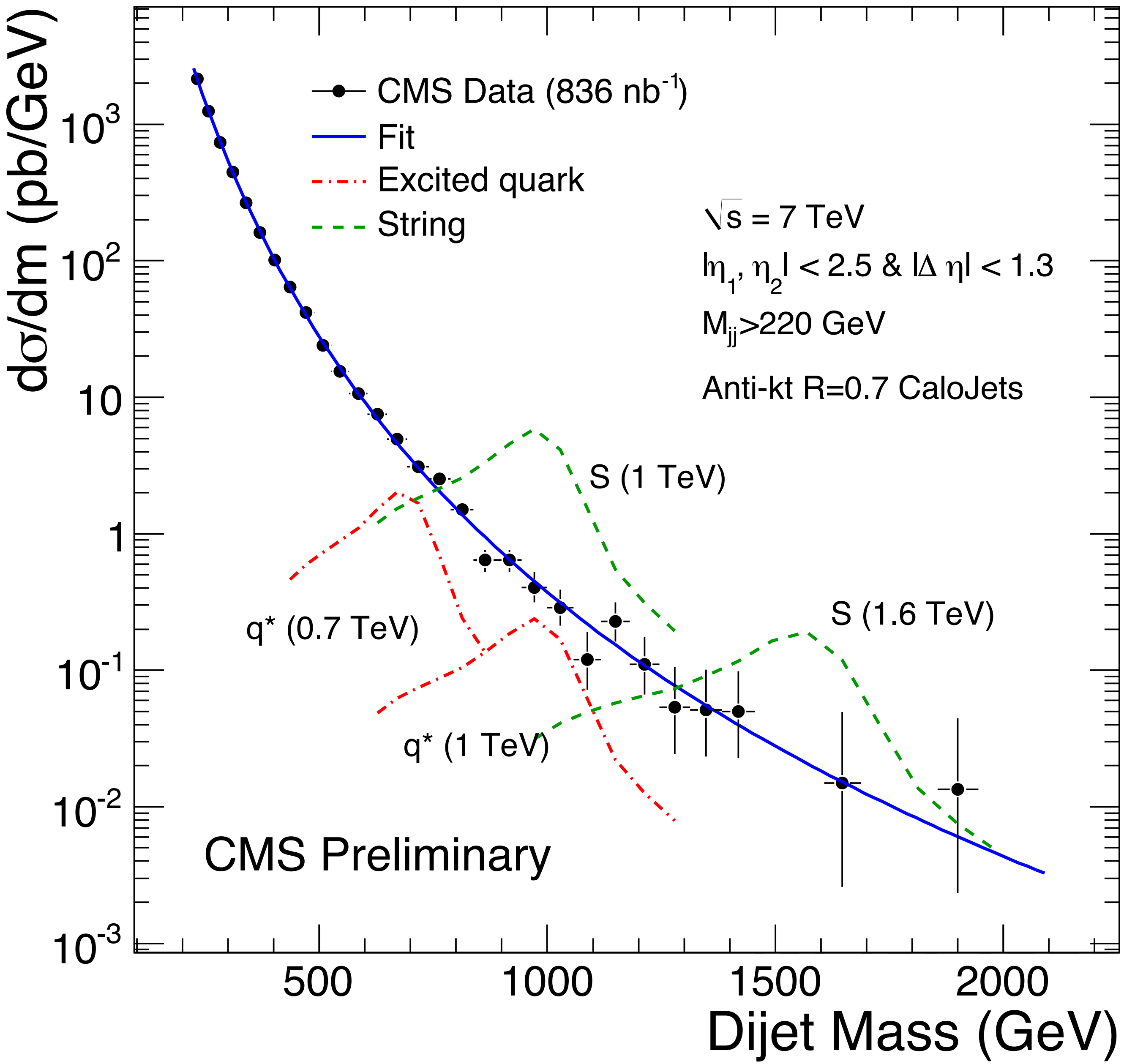




ATLAS Mjj=2.6TeV



Using this result, we can set limits on the new physics decaying into 2jets



Excited quark

q+g -> q*→q + g

TeV Scale ED

gg->String resonance->gg

qq->String resonance->qq

qg->String resonance->qg

95%CL Limit

m(q*)>1.26TeV (ATLAS Pub.)

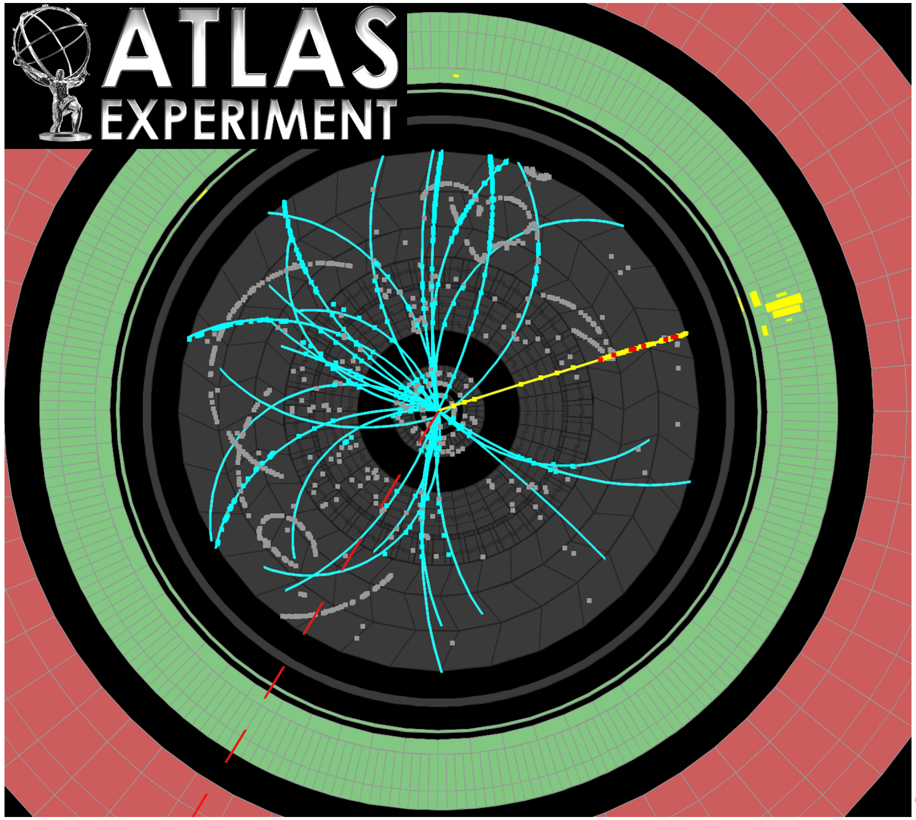
m(String) > 2.1TeV (CMS Prelim.)

These are stringent than the Tevatron results.!!! (m(q*)>840GeV)

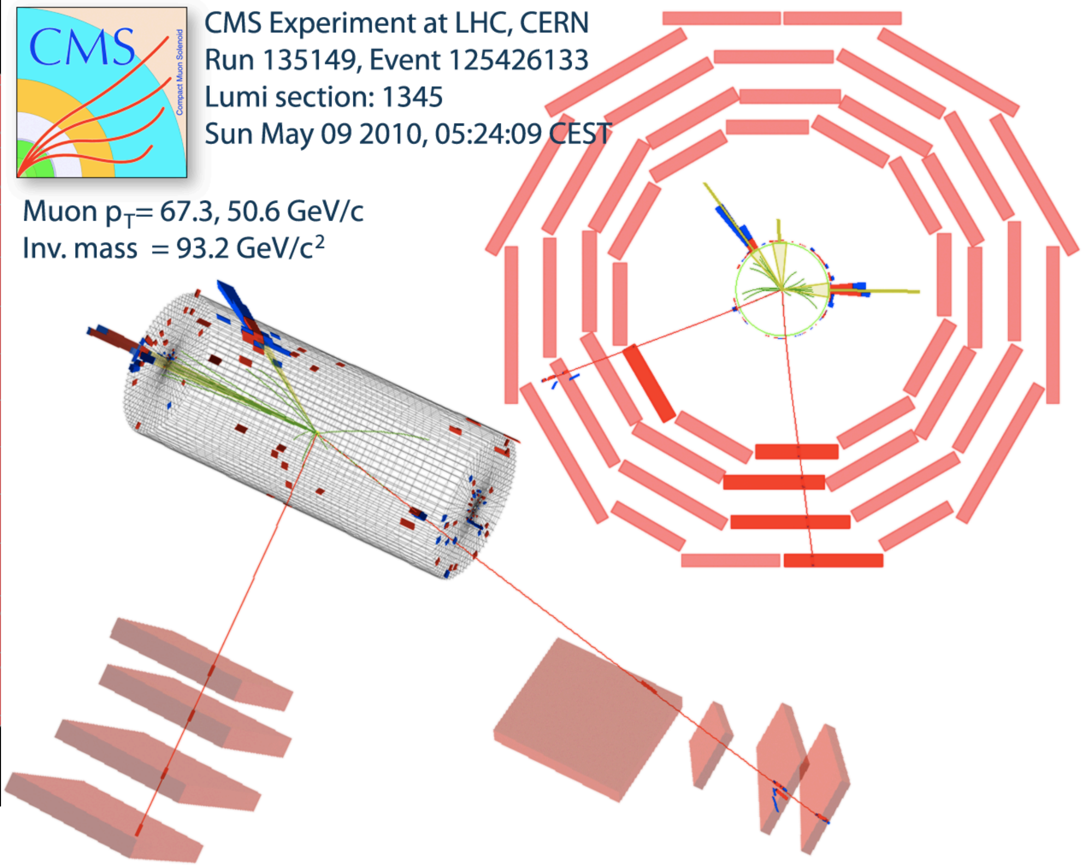
W(→l ν) and Z(→ ll)   Boson

Good exercise for lepton

- $\sigma_{NNLO}(W^+ \to \ell^+ \nu) = 6.16$ nb
- $\sigma_{NNLO}(W^- \to \ell^- \nu) = 4.30$ nb
- $\sigma_{NNLO}(Z/\gamma * \to \ell\ell) = 0.96$ nb



W→eν   PT_W ~ small

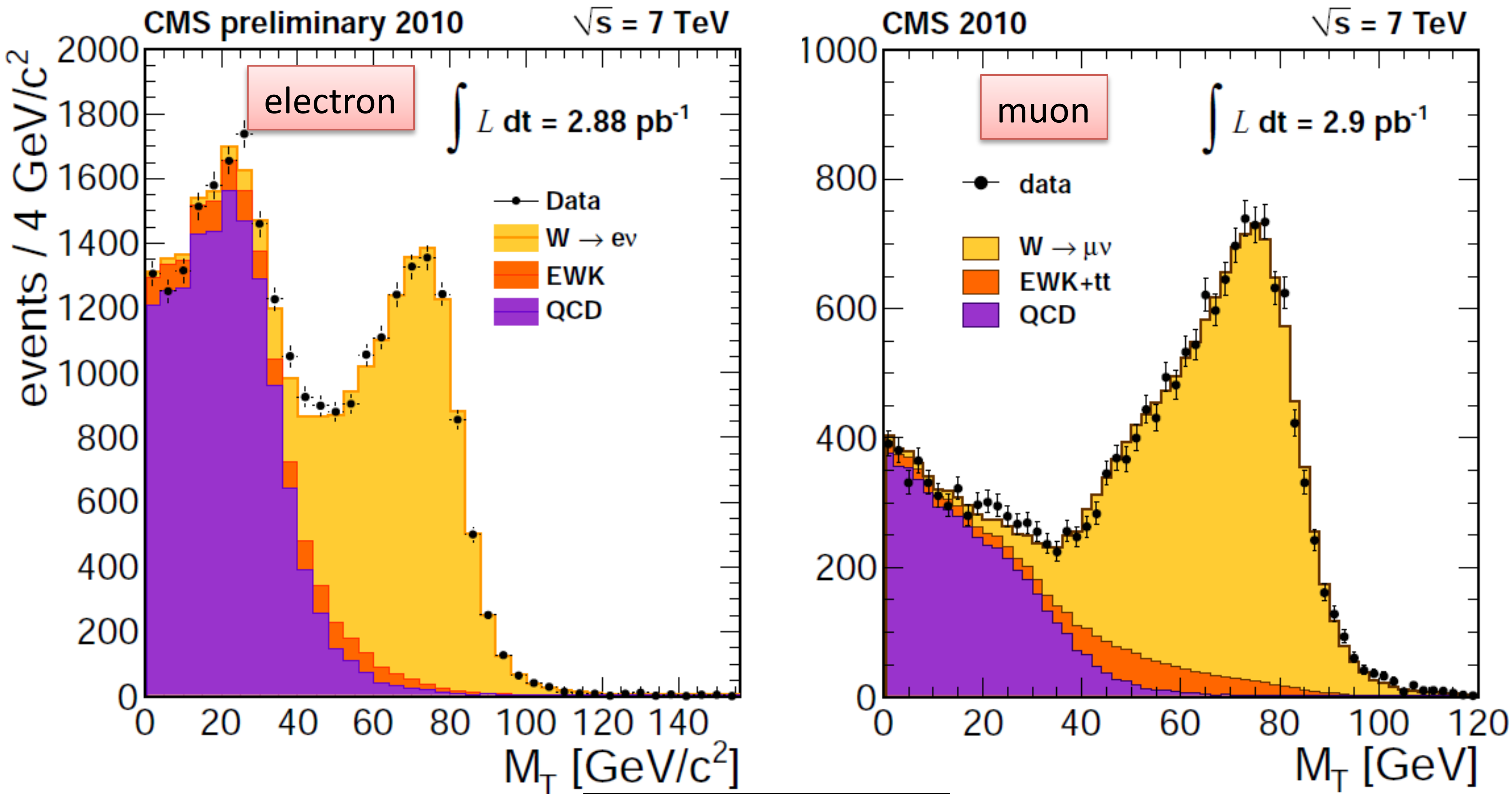


Z(→μμ)+ 2jets

Typical performance
ε(electron)〜80%
ε(muon)〜90%

e/mu give clear trigger
Fake Prob. ~ $10^{-3} – 10^{-4}$ for e and mu
(Jet is misidentified as lepton)

W(→l ν) MT distributions

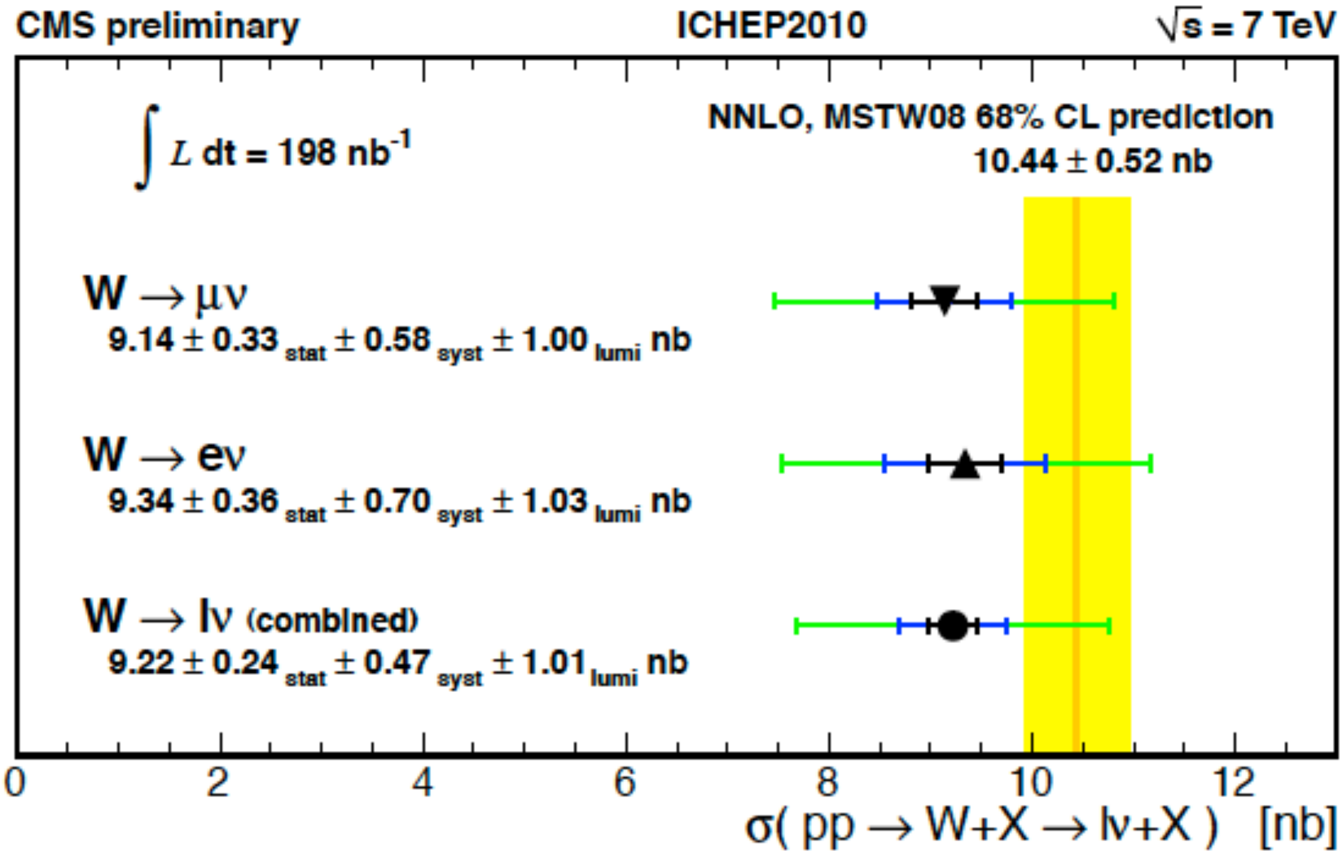


$$M_T = \sqrt{2 P_T^{\ell} \not{E}_T (1 - \cos\varphi)}$$

Well-isolated Lepton (PT>20GeV) & mET is required. Jacobian peak is clearly observed on MT (QCD : fake lepton contributes to small MT region)

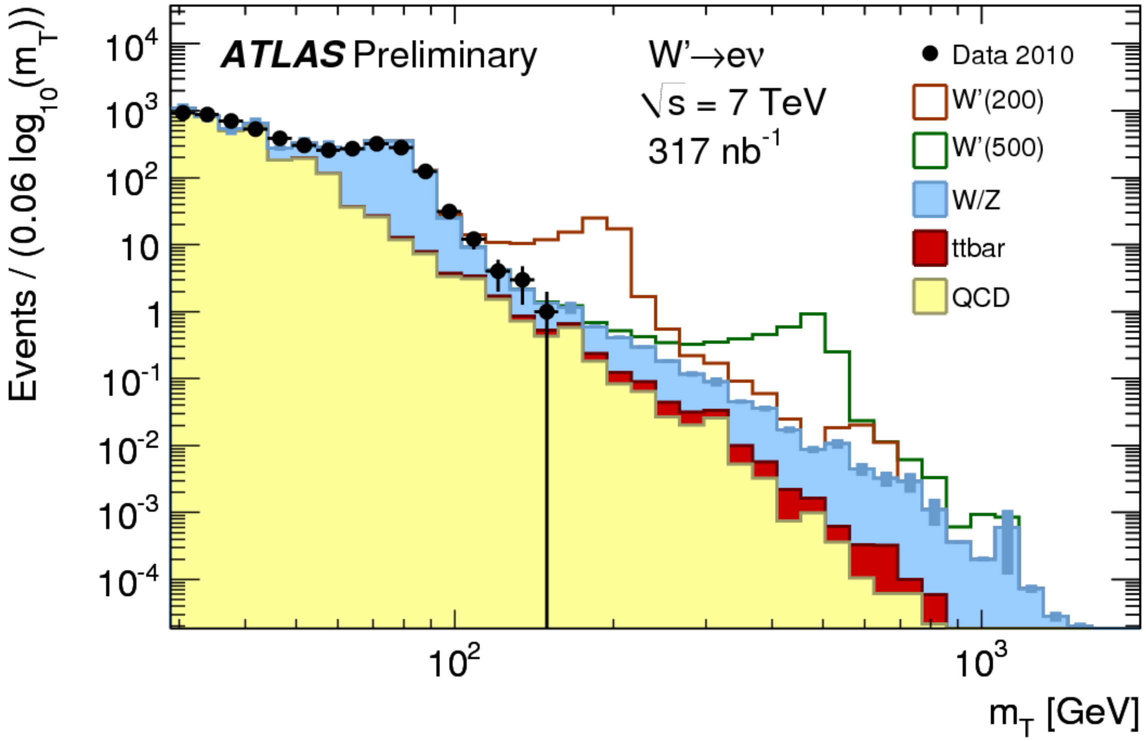
σ×Br

The measured σ×Br are listed here ($L=0.2pb^{-1}$)



error 4% PDF

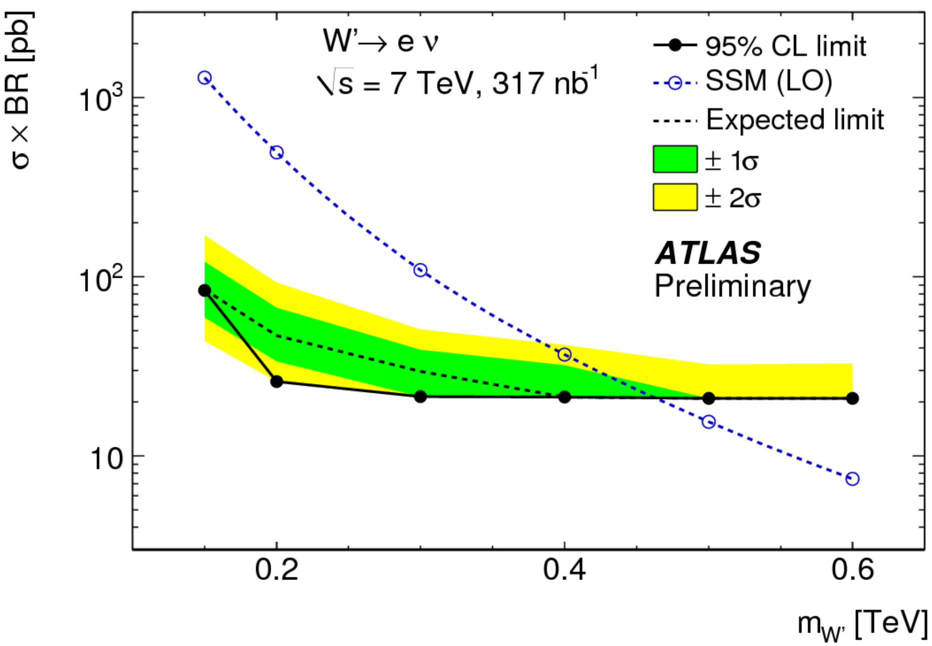
Statistical error is 3% even with this lower luminosity (Now we have 40 times)
Luminosity has large systematic error now (11%) -> finally reduce to 3-4%
Identification efficiency / fake prob. (now we use MC prediction) have also 3-5% systematic error. -> **Now we effort to reduce these systematic errors.**
We will show the differential cross-section (PT,eta,Njet…) with the date of $O(10pb^{-1})$



Using MT distributions ,
we can search for W' (→lν)

We assume W' has the same coupling to SM particles.

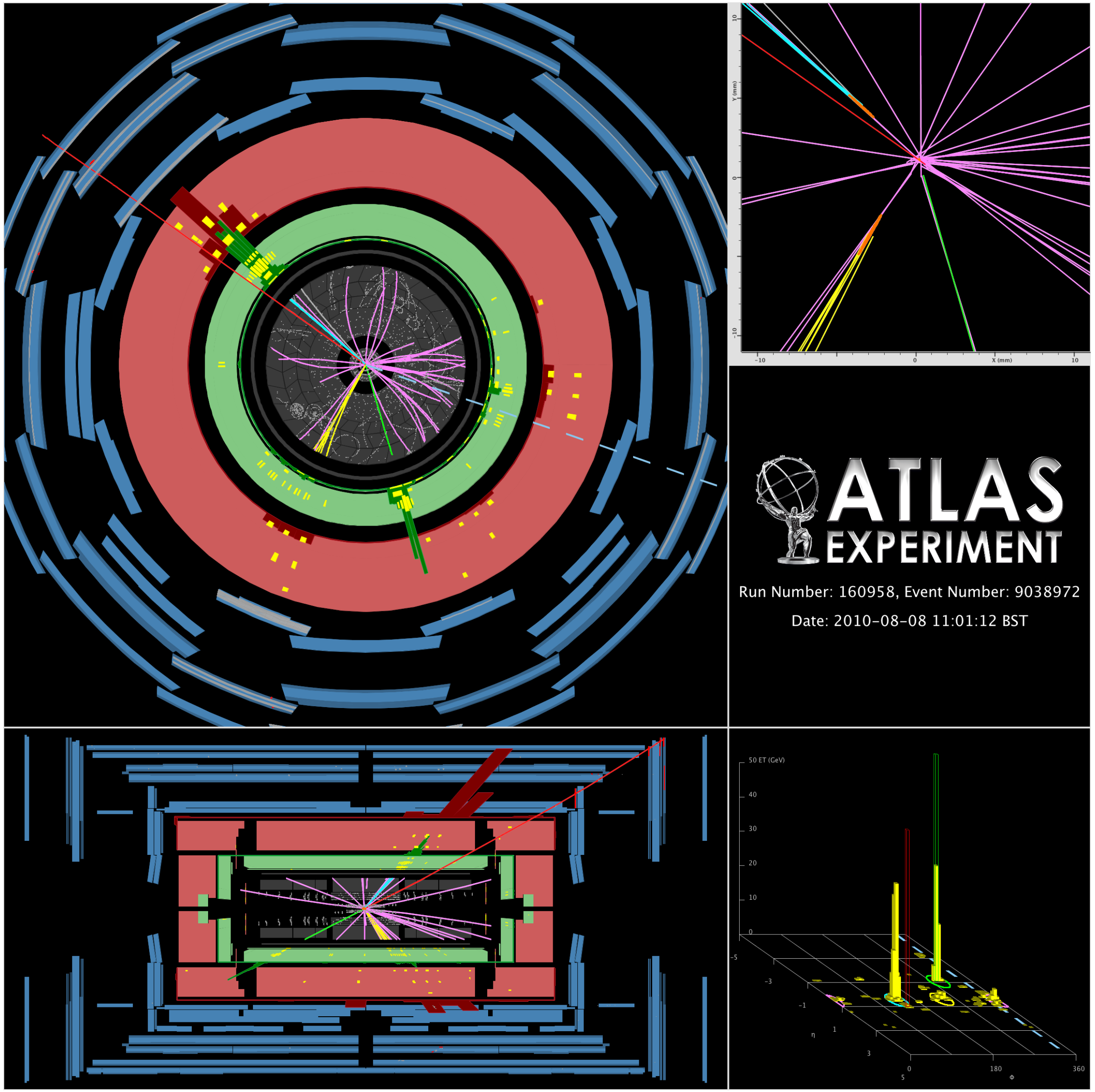
Mass [GeV]	Γ(GeV)	B	σB [pb]
150	3.88	0.1084	1296
200	5.34	0.1054	495
300	9.18	0.0924	109
400	12.98	0.0874	36.8
500	16.68	0.0852	15.5
600	20.34	0.0840	7.6



M(W')>465GeV 95%CL

(Tevatron M(W')>1TeV
Next year will take over)

Top quark



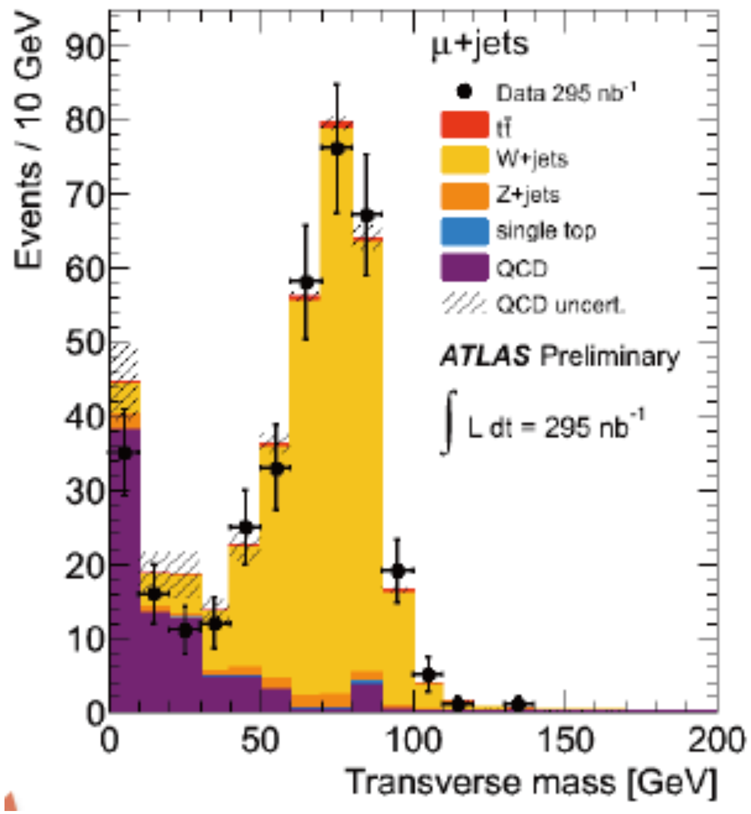
σ(7TeVNLO)=157pb
σ(7TeV W -> lnu) = 30nb

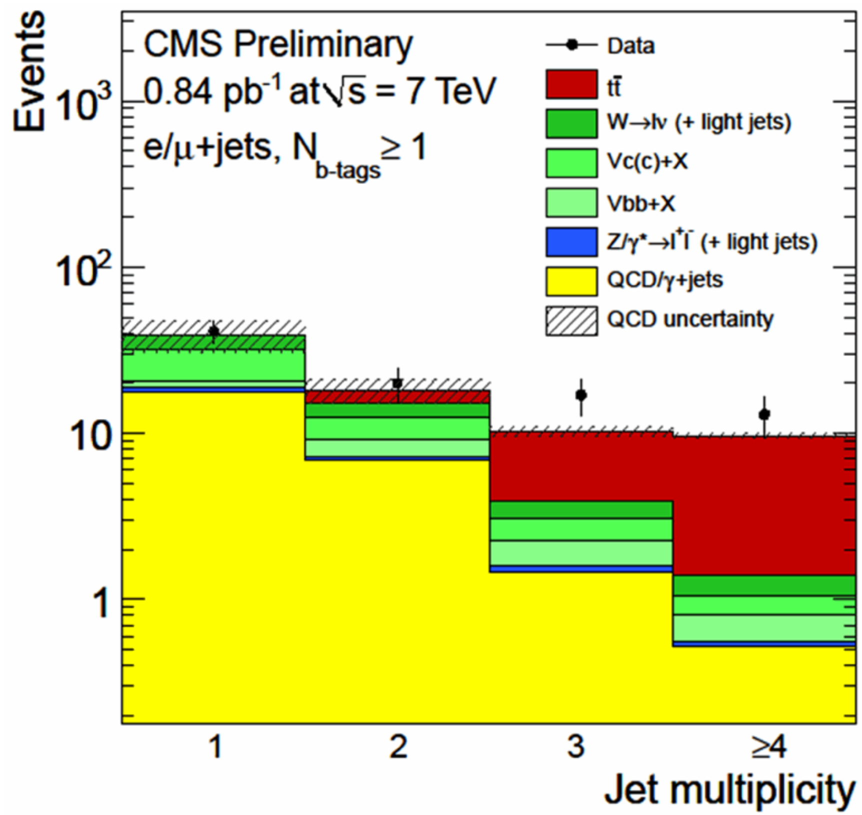
W+jets(including b)
is the serious background.

This candidate is leptonic decay events:
tt->bWbW
(W->enu) (W->munu)
Clear 2 b jets

We have O(10) candidate events with data of $L=0.8pb^{-1}$

Top quark is heavy (~173GeV)
cross-section is suppressed comparing to 14TeV
(σ(14TeV NLO)=830 pb
factor 5 suppressed)


μ+jets
Data 295 nb-1
tt̄
W+jets
Z+jets
single top
QCD
QCD uncert.
ATLAS Preliminary
∫ L dt = 295 nb-1
Events / 10 GeV
Transverse mass [GeV]
0
10
20
30
40
50
60
70
80
90
0
50
100
150
200

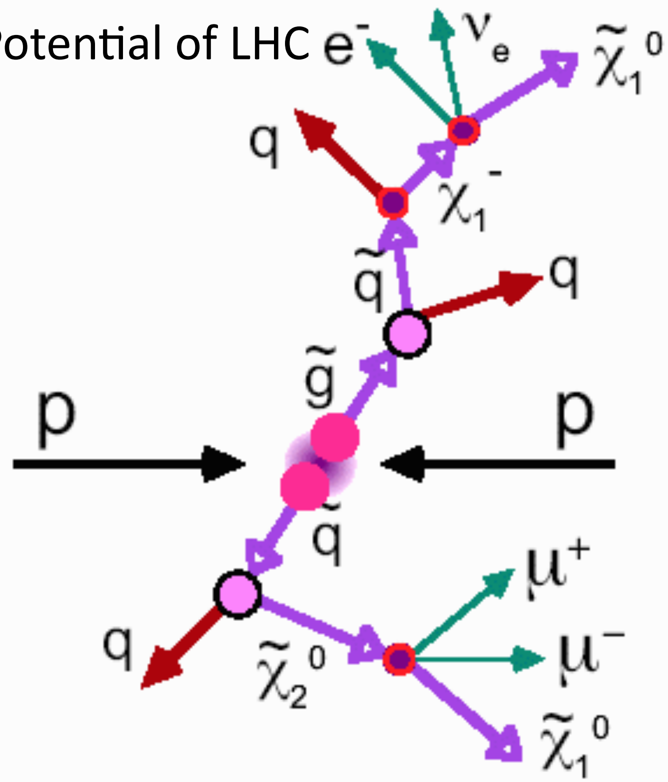

CMS Preliminary
0.84 pb-1 at √s = 7 TeV
e/μ+jets, N b-tags ≥ 1
Data
tt̄
W→lν (+ light jets)
Vc(c)+X
Vbb+X
Z/γ*→l+l- (+ light jets)
QCD/γ+jets
QCD uncertainty
Events
Jet multiplicity
1
10
10^2
10^3
1
2
3
≥4

3. SUSY hunting (Now and Future)

Stimulating presentation between LHC and cosmology has been given on Monday by Prof. Roszowski

I just focus on this site

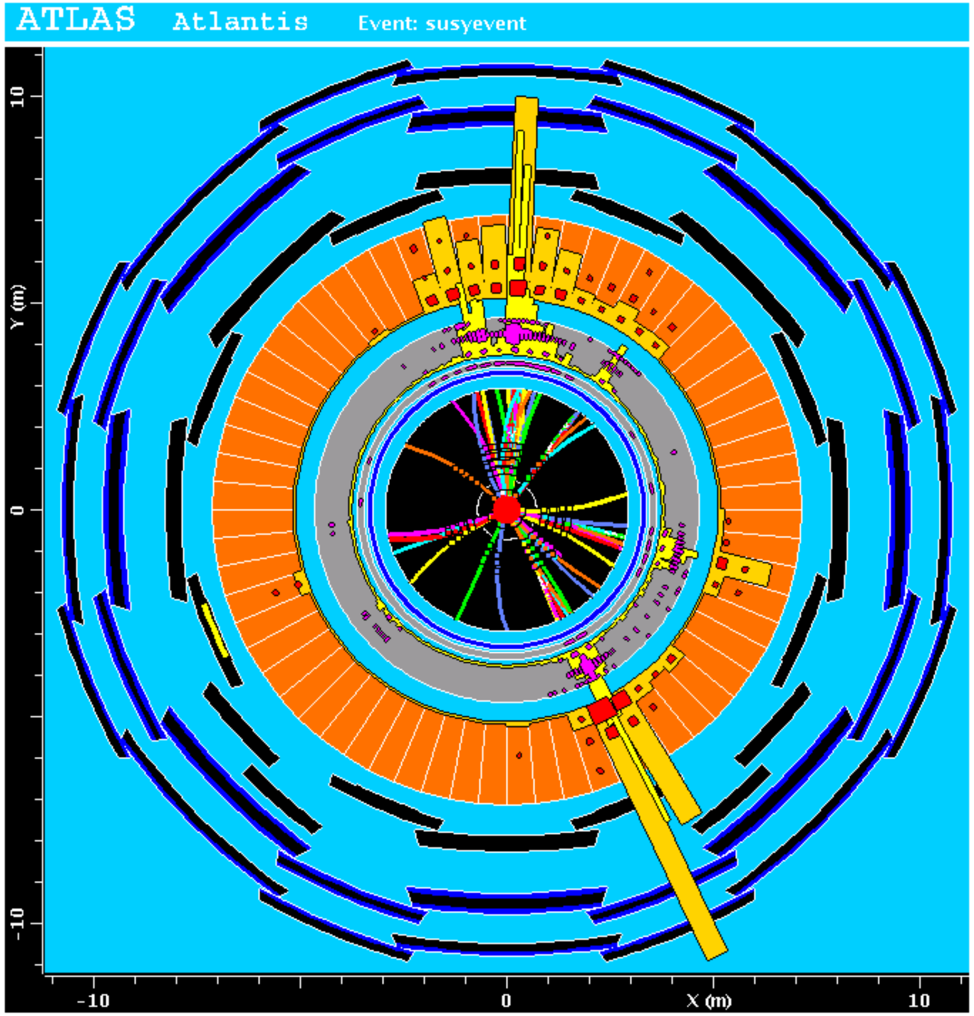
- Research strategy
- Latest results
- Potential of LHC



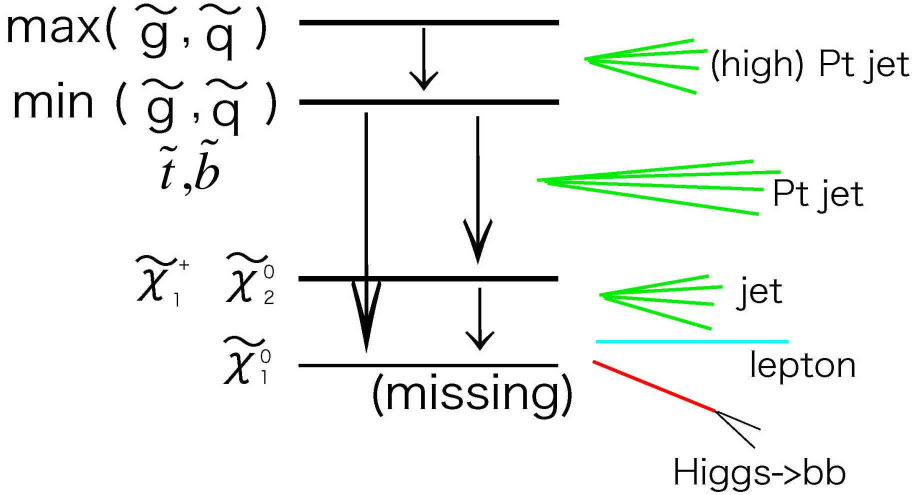
Event Topologies of SUSY Signal @ LHC

SUSY provides various interesting event topologies !!

"Typical" Events topology of SUSY signal is like this



Gluino/squark are produced first, then cascade decay is followed.



LHC is DM-factory

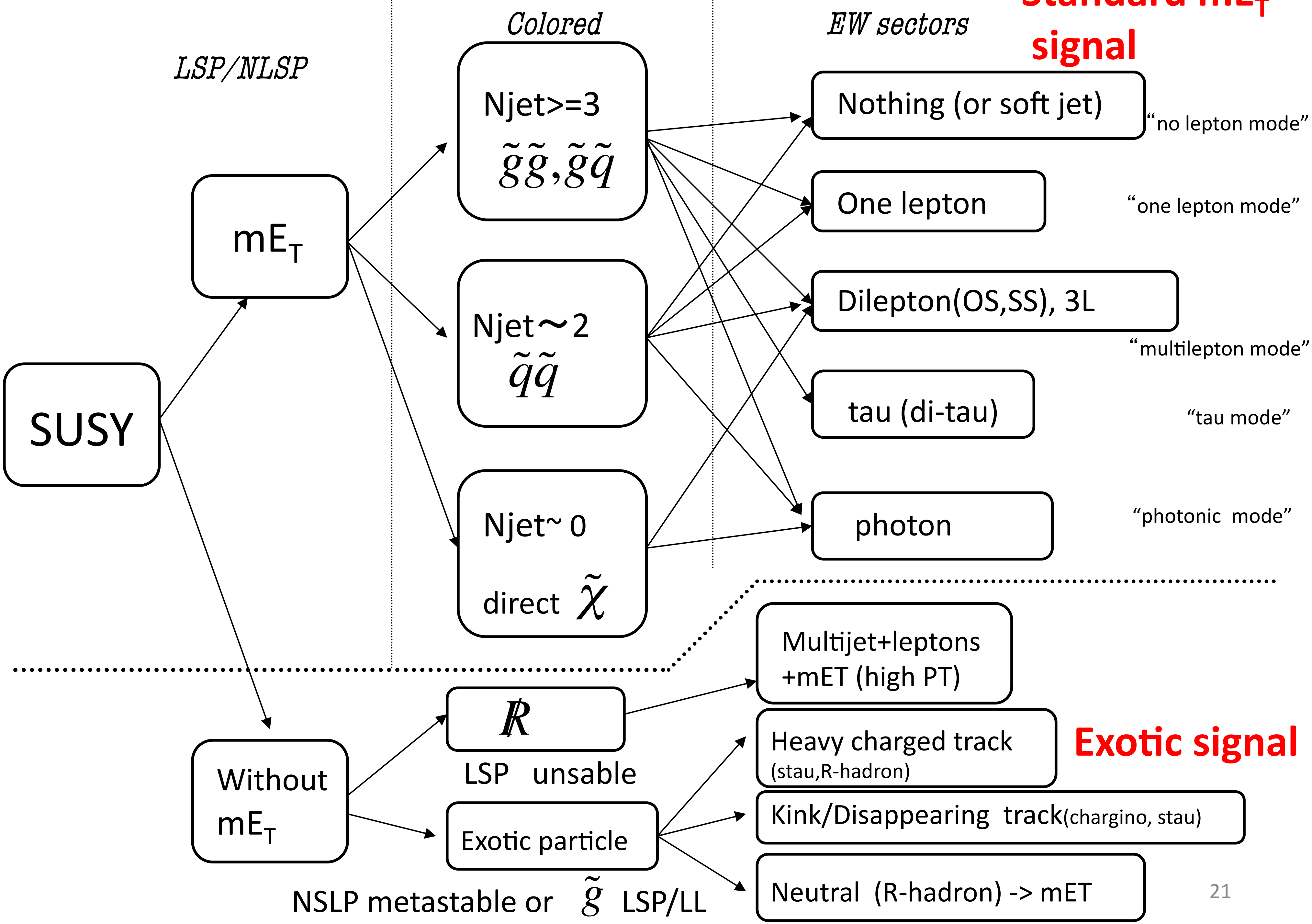
Sorry ! Axion-DM believer

Event topologies of SUSY

	multi leptons
$\not{E}_T$ + High P_T jets +	b-jets
	τ-jets

Differ from Tevatron and LEP

more detail classification are summarized in this figure:



We perform the **"Topology-base"** studies at LHC

Promising **event topologies with mE_T** are listed:

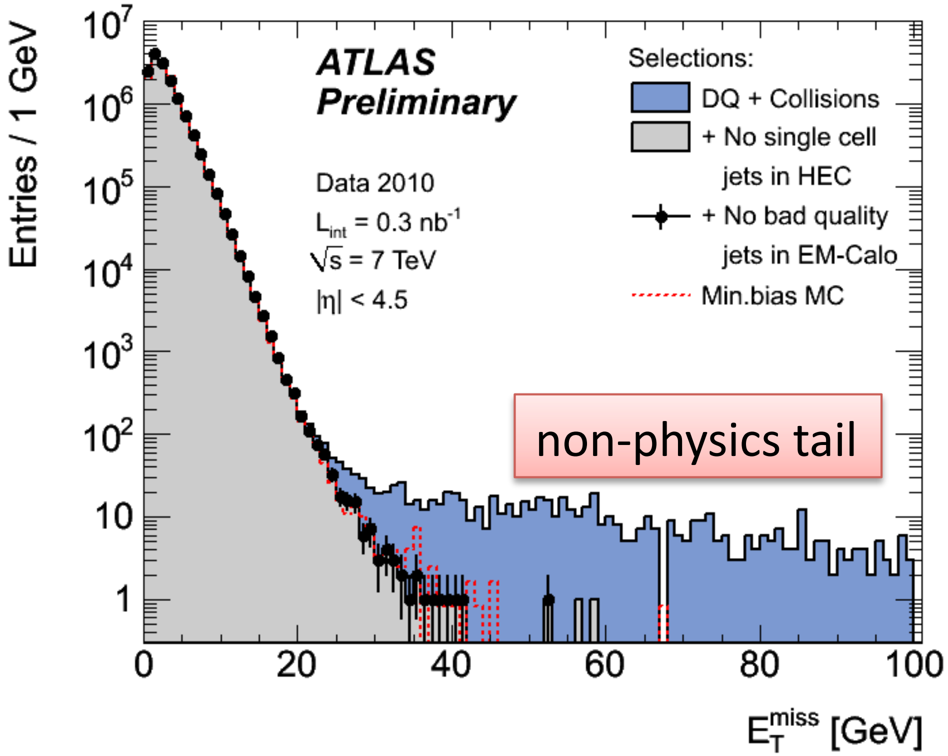
Jet multi (high Pt)	Additional obj.	Favored Model	Dominant SM background processes
High Multiplicity Nj>=3,4	No lepton	SUGRA,AMSB, Large m0	QCD(light & bb/cc) $t\bar{t}(\to b\bar{b}q\bar{q}\tau\nu)$ Z(->nunu) and W(->taunu) + jets ★
	One lepton	SUGRA,AMSB, Large m0	$t\bar{t}(\to b\bar{b}q\bar{q}\ell\nu)$ W(->lnu)+jets ★
	Dilepton,3L	SUGRA,AMSB, GMSB (Nm>1)	OS: $t\bar{t}(\to b\bar{b}\ell\nu\ell\nu)$ SS,3L ZW,ZZ $t\bar{t}(\to b\bar{b}\ell\nu\ell\nu)$
	Tau	Large tanβ, GMSB (Nm>1)	W (->taunu) $t\bar{t}(\to b\bar{b}q\bar{q}\tau\nu)$
	b	SUGRA, etc	$t\bar{t}(\to b\bar{b}q\bar{q}\tau\nu)$ ★
	γ	GMSB (Nm∼1) $\tilde{\chi}_1^0 \to \gamma\tilde{G}$	Almost BG Free $t\bar{t}(\to b\bar{b}e\nu e\nu)$ FSR
Low Multiplicity Nj∼1,2	No lepton	squark production KK Graviton	Z(->nunu) W(->taunu)
	One lepton	squark production	W,Z $t\bar{t}(\to b\bar{b}\ell\nu\ell\nu)$
No jet Nj = 0	One Lepton	W'	W
	Dilepton,3L	Direct $\tilde{\chi}$	WW,WZ,ZZ WZ main for 3L

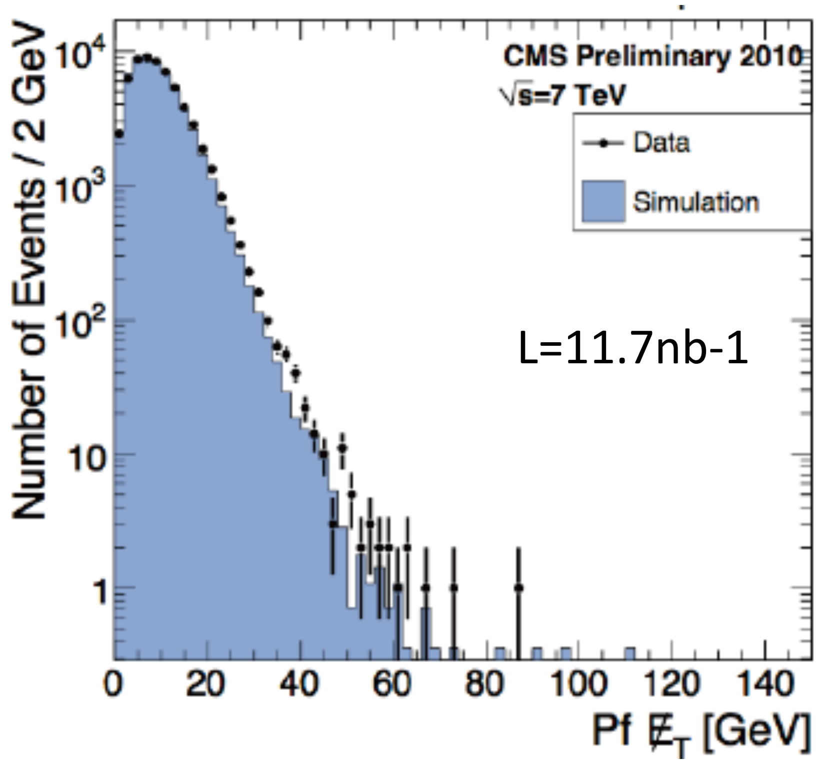
★ Promising Discovery channels, Today I show three results

mE_T is key for SUSY hunting, but mE_T is not so easy variable

Basically $mE_T = - \Sigma \vec{E}_T\text{(Calorimeter)} - \Sigma \vec{P}_T\text{(muon)}$

but real life is difficult





(1) Noise of Calorimeters are crucial.
Remove noise clusters using cluster shape and pulse shape.

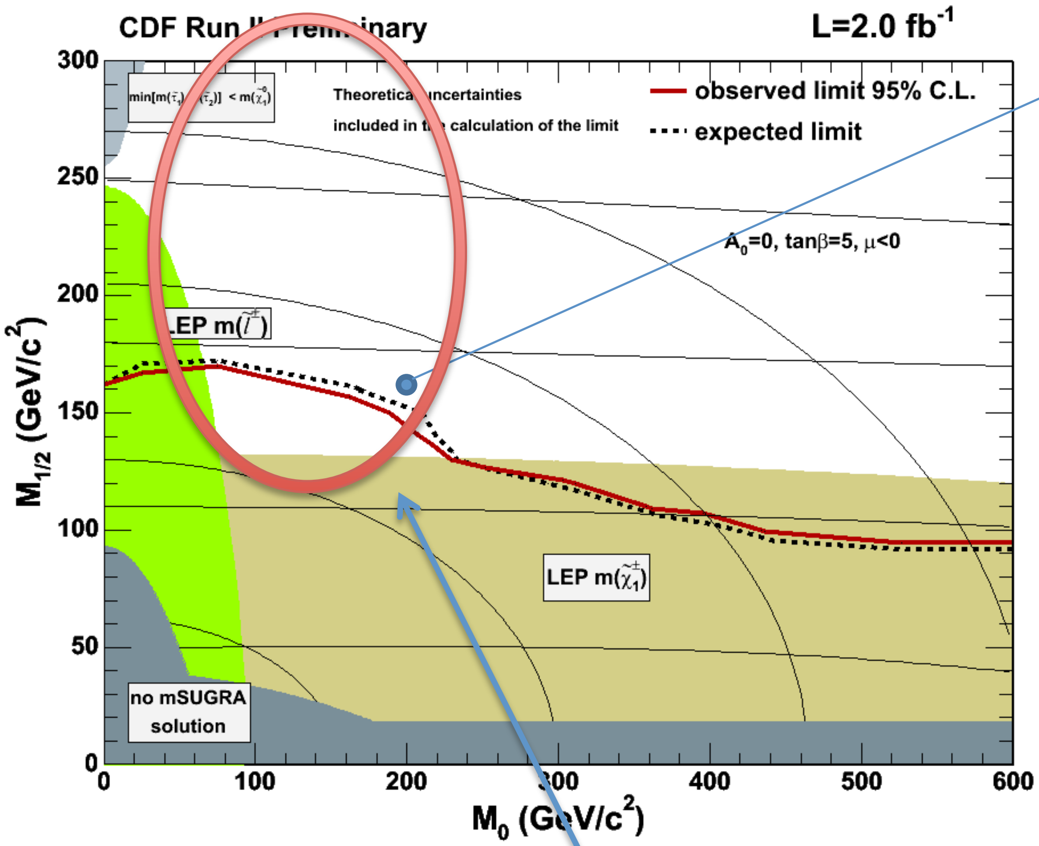
(2) Cosmic ray: Bremsstrahlung from cosmic muon

(3) Beam halo

mE_T distribution for Data and MC
Good agreement for the wide dynamic range.

These non-physics tails are removed at first.

Benchmark Point for very early stage of SUSY analysis



This point is called as "SU4" in my talk.

m_0=200GeV m1/2=160GeV

Just Above of CDF limit

- gluino ~ 410GeV
- squark~410GeV
- slepton~210GeV
- ch1 ~ 113GeV
- nu1(LSP) ~ 61GeV
- σ = 60 pb (7TeV)

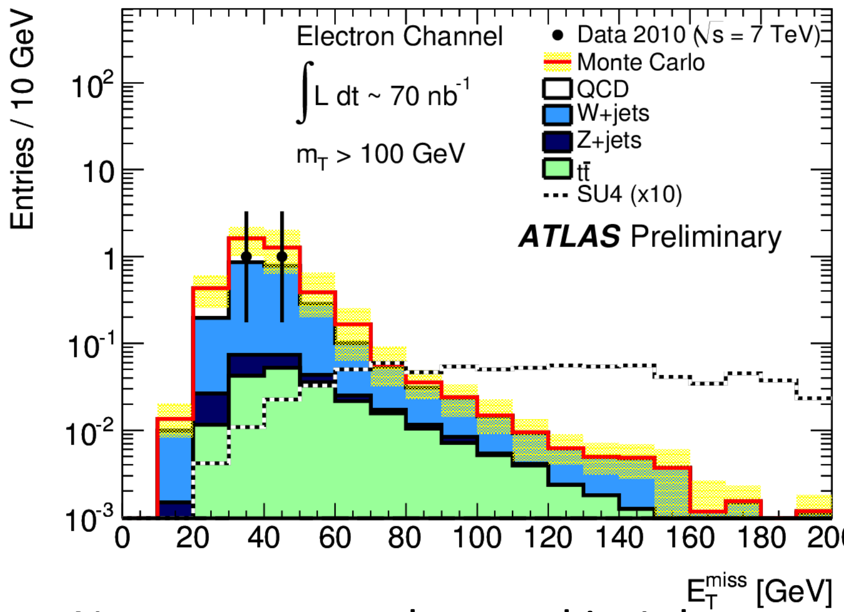
DM –inspired region ($0.09 < \Omega x\ h^2 < 0.13$)

This SU4 is not just toy point. It is also possible point for DM business.

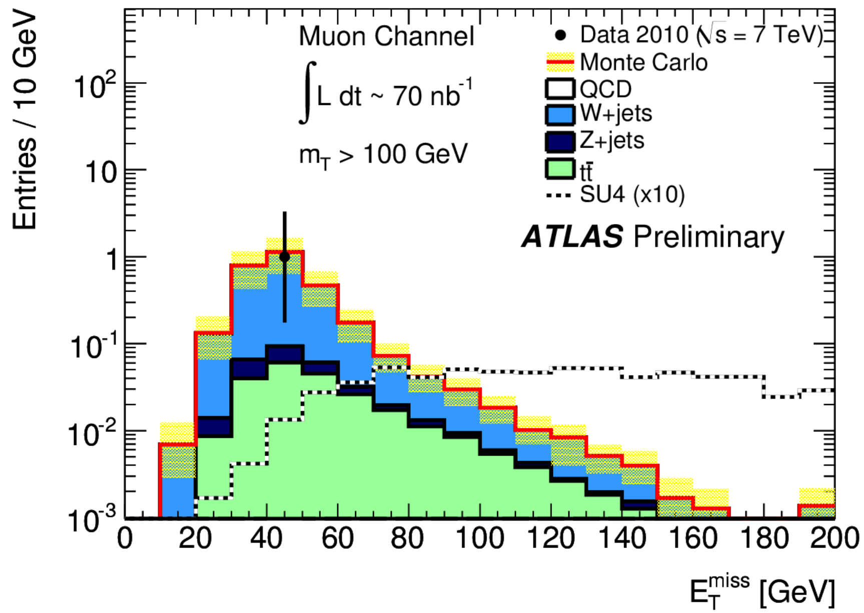
[1] One lepton + multijets +mE_T topology

• Pt lepton > 20 GeV		In Future	
• 2 or more jet with Pt>30 GeV |eta|<2.5	→	100GeV (Leading)	50GeV
• MT >100 GeV			
• mEt > 30 GeV	→	100GeV	

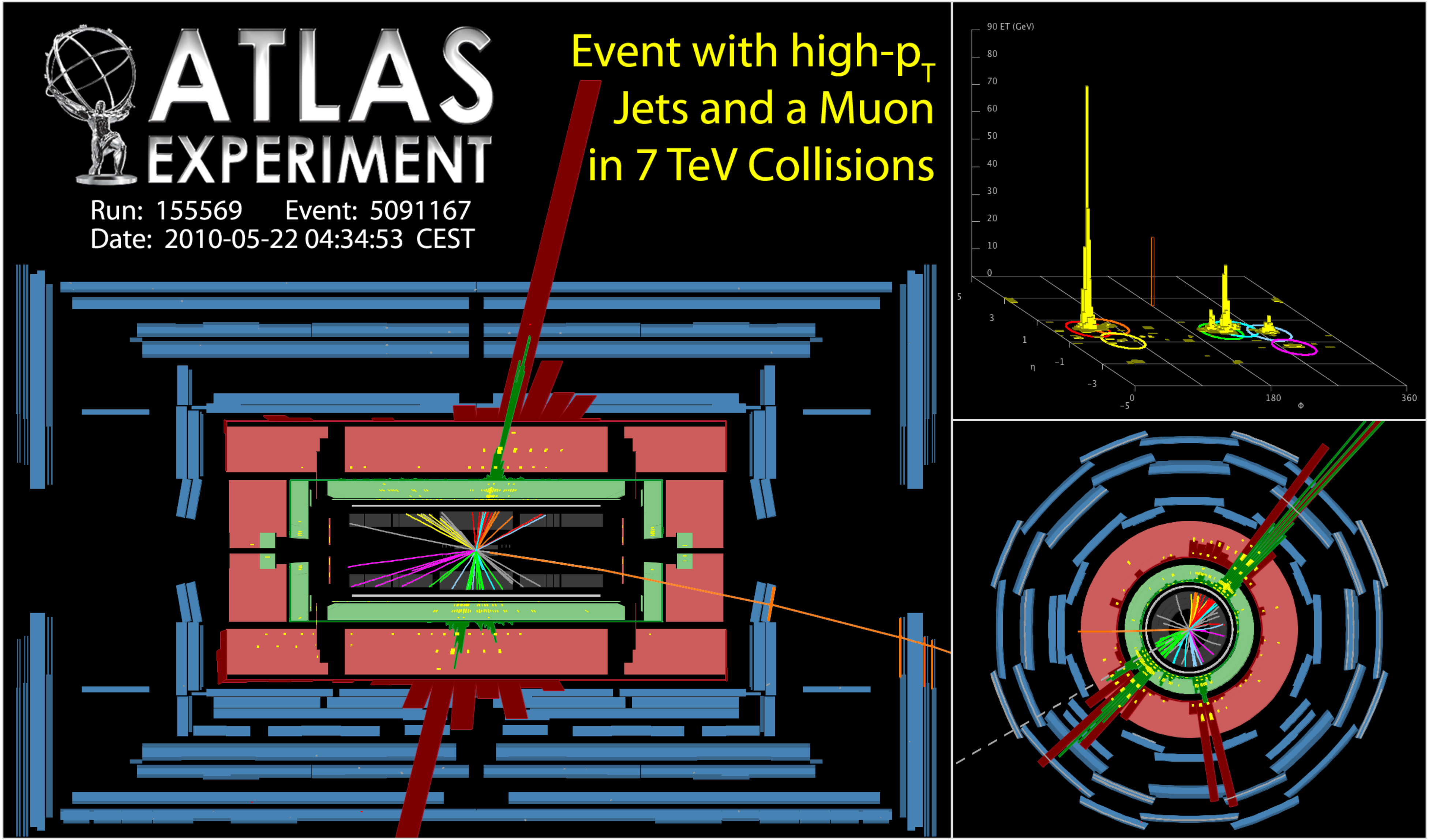
Electron mode



Muon mode



No excess was observed in July.
At that time Luminosity is too small to search for SU4.
We have data with $L=3pb^{-1}$ at end of August. Let's Image the scale is multiplied by factor 40. We have already have sensitivity for SU4.

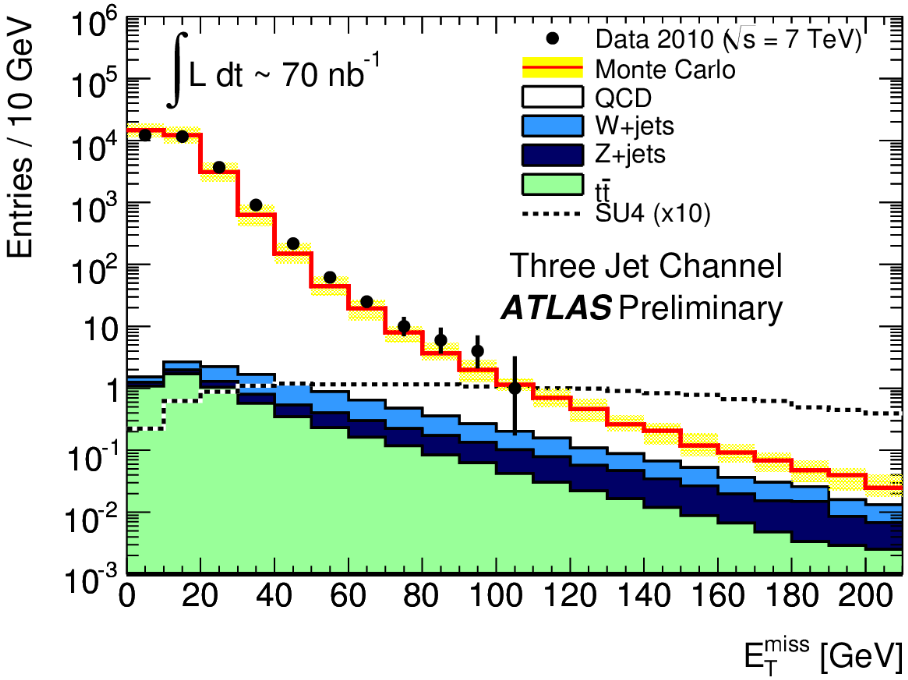


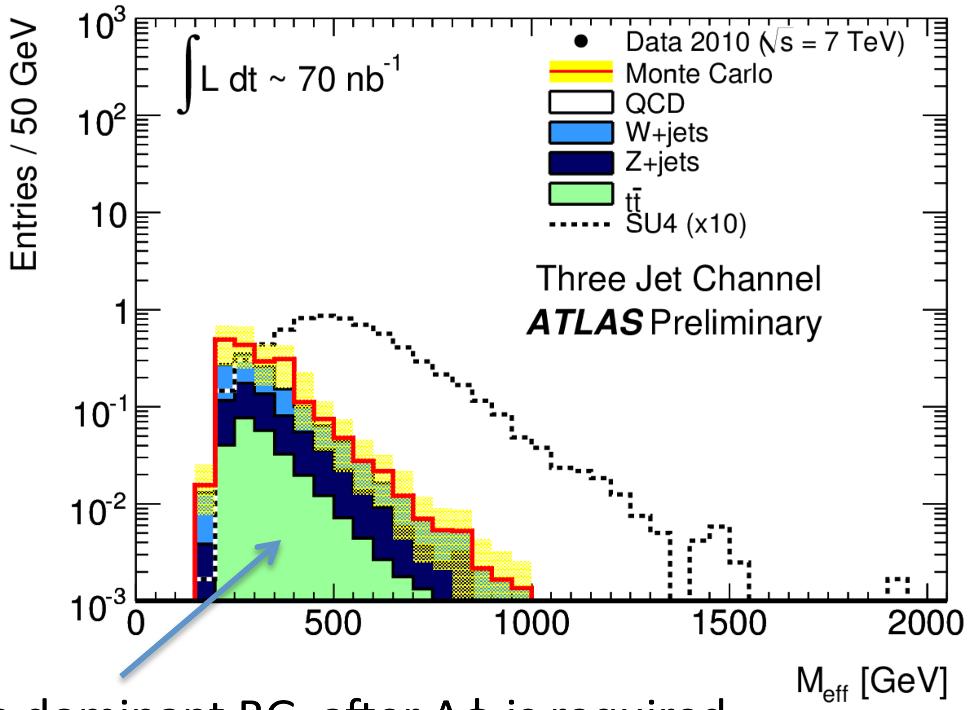
- μ^+ Pt = 25 GeV eta=2.33
- mEt = 118GeV
- Meff (all 3 jets + μ + mET) =1156 GeV
- BUT MT=33GeV

My interpretation is W+multijets

multijets +mET topology (No lepton mode)

- P_{T}_leading jet > 70GeV → 100GeV (In Future)
- At least 3 jet with Pt>30 GeV |eta|<2.5 → 50 GeV
- mE_T > 40 GeV → 100GeV
- $\Delta\phi$(jet, mET) > 0.2
- mET/(Σ PT+mET) > 0.25

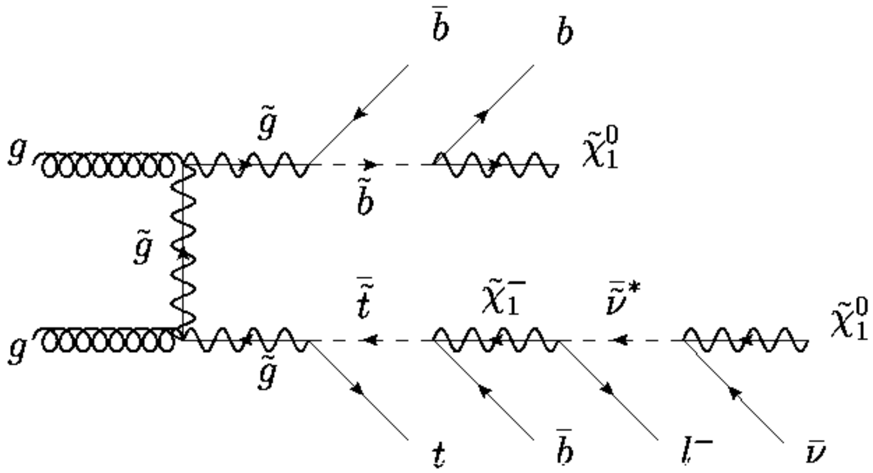




tt and W+jets, in which W decays into tau, are dominant BG after Δϕ is required.

No excess (No event) was observed. This channel is most important when statics of data is limited.

multijets +b-jets + mET topology (b-jet mode)

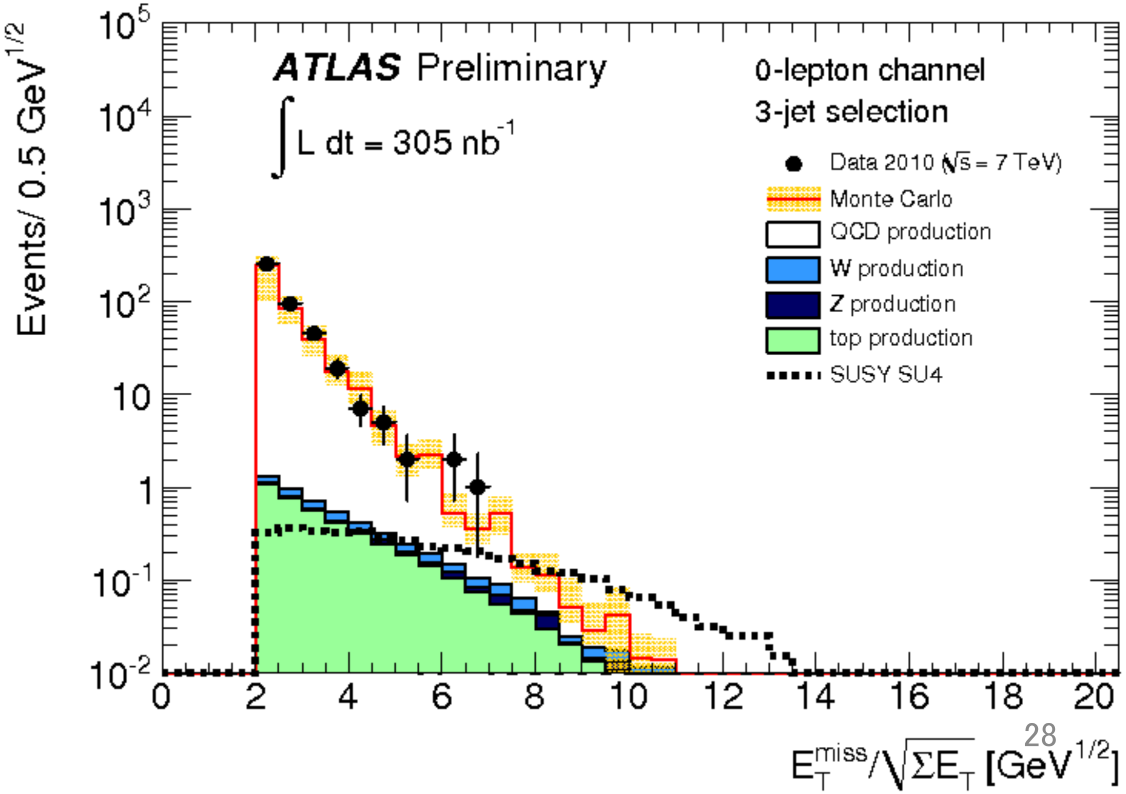


- P_T_leading jet > 70GeV
- At least 3 jet with Pt>30 GeV |eta|<2.5
- At least one good b–jet in the jets
- mEt > $2\sqrt{\Sigma ET}$
- $\Delta\phi$(jet, mET) > 0.2

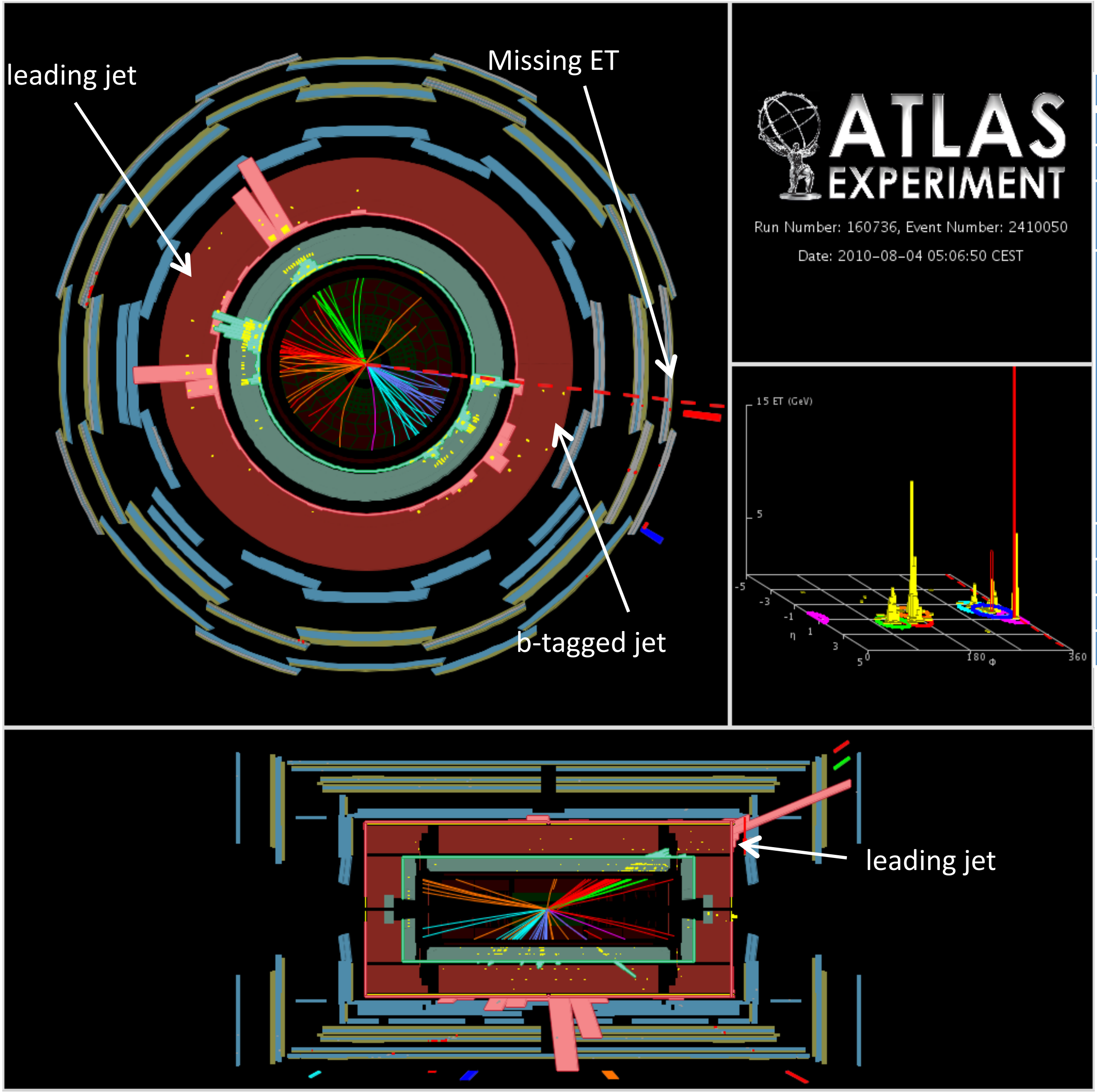
Branching fraction including b-quark is expected to be higher.
Also BG can be suppressed using b-tag,

All distributions are consistent with SM prediction, and no excess was observed.

Now we have data of L>3pb^{-1}, (10 times higher than this plot)



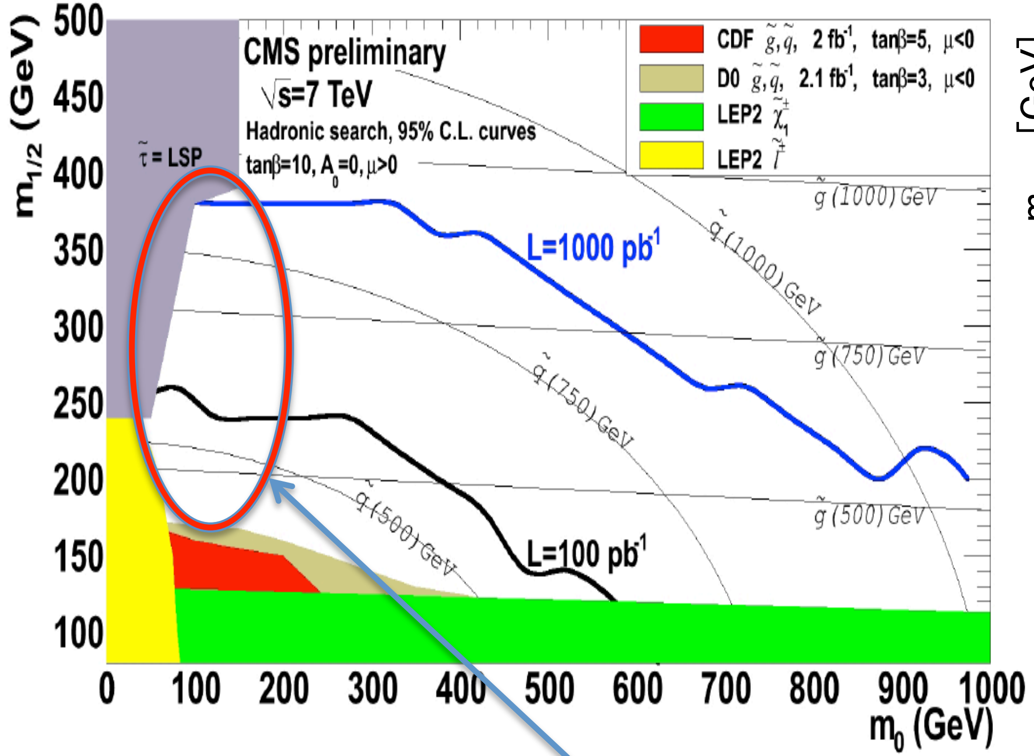
Candidate event of   multijet+b+mET

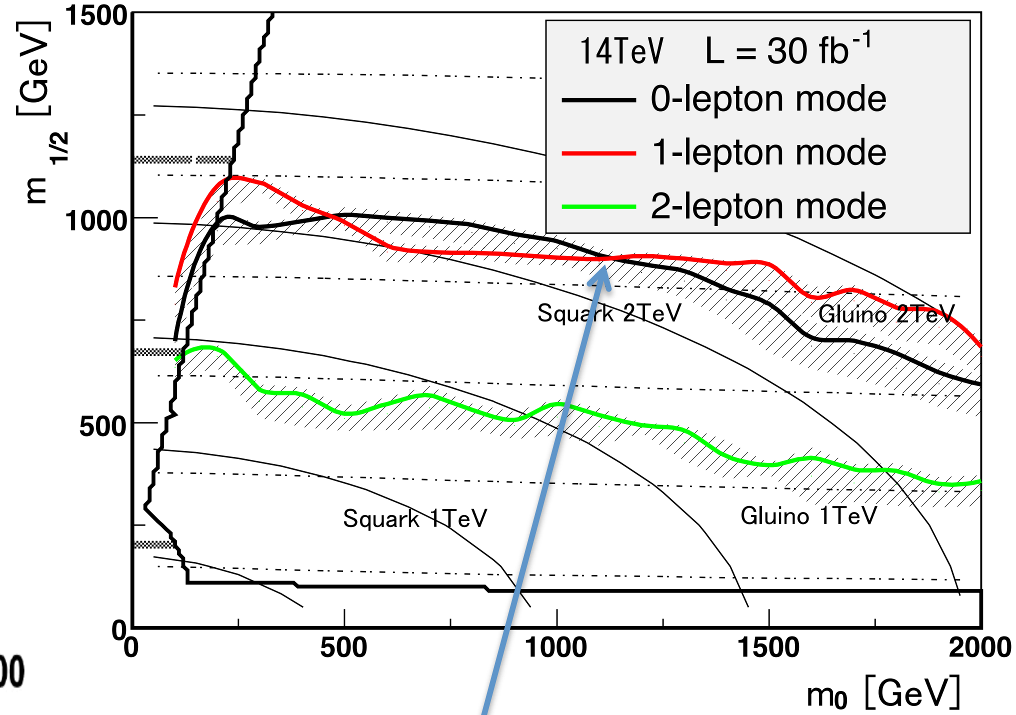


Run no.	160736
Event no.	2410050
Lumi Block	216
MET (Et[GeV], Phi [rad], SumEt[GeV])	MET_Topo (109.0, -0.0888, 452.0)
Jet (Pt[GeV], Eta, Phi[rad], E[GeV], SV0, Dphi[rad])	1st (131.4, 1.086, 2.909, 217.5, 0, 2.998), 2nd (105.5, 1.316, 2.153, 211.3, 0, 2.241), **3rd (56.4, -0.126, -0.538, 57.4, 15.1, 0.450)**, 4th (50.6, 0.096, -3.071, 51.1, 0, 0.6, --) 5th (49.1, 0.699, -0.157, 61.8, 0, --), 6th (43.2, -0.648, -0.882, 53.1, 3.73, --)
minDphi [rad]	0.450
ST	0.255
Meff [GeV]	453
MetSig [√GeV]	5.13

mET is pointed
to 6th PT jet (tagged
as b-jet muon segment
is found in this jet)
My interpretation is
bb+Njets, b->μνX

Prospect at end of 2011 and after





Bulk region of DM will be covered in the next year. m(nu1)~150GeV

And almost upto 2TeV gluino/squrak in 2015 (14TeV L=30fb^{-1}) m(nu1)~400GeV

If not discovery (A) SUSY is too heavy (M(suqark , gluino) >2~3TeV)

(B) SUSY is degenerated. If ΔM(=colored-LSP) < 300GeV
sensitivity becomes worse and need luminosity.
Dedicated analysis helps degenerated case.

(C) SUSY is untruth.

SUSY

Long-lived signatures

Motivation -> Next Talk (Hamaguchi-san)

Without mE_T

- $\not{R}$ — LSP unsable
  - Multijet+leptons +mET (high PT)
- Exotic particle — NSLP metastable or $\tilde{g}$ LSP
  - Heavy charged track (stau,chargino,R-hadron)
  - Kink/Disappearing track(stau,chargino)
  - Neutral (R-hadron) -> mET

Strategy of searching for Long-lived particles

(1) Heavy charged particles (GMSB stau, R-hadron)

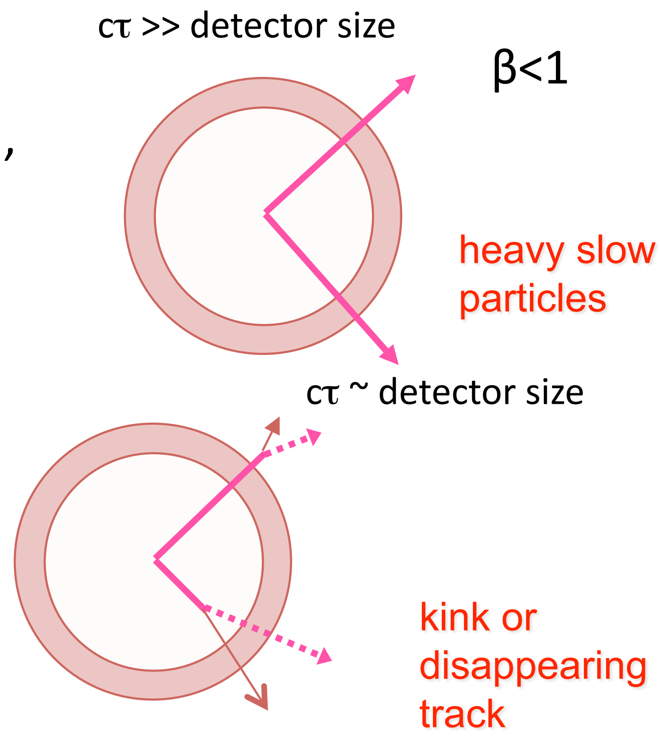
(1A) dE/dx energy loss in the semiconductor ,

(1B) TOF information in muon system (β< 1)

(2) Decay in flight (AMSB wino, GMSB stau)

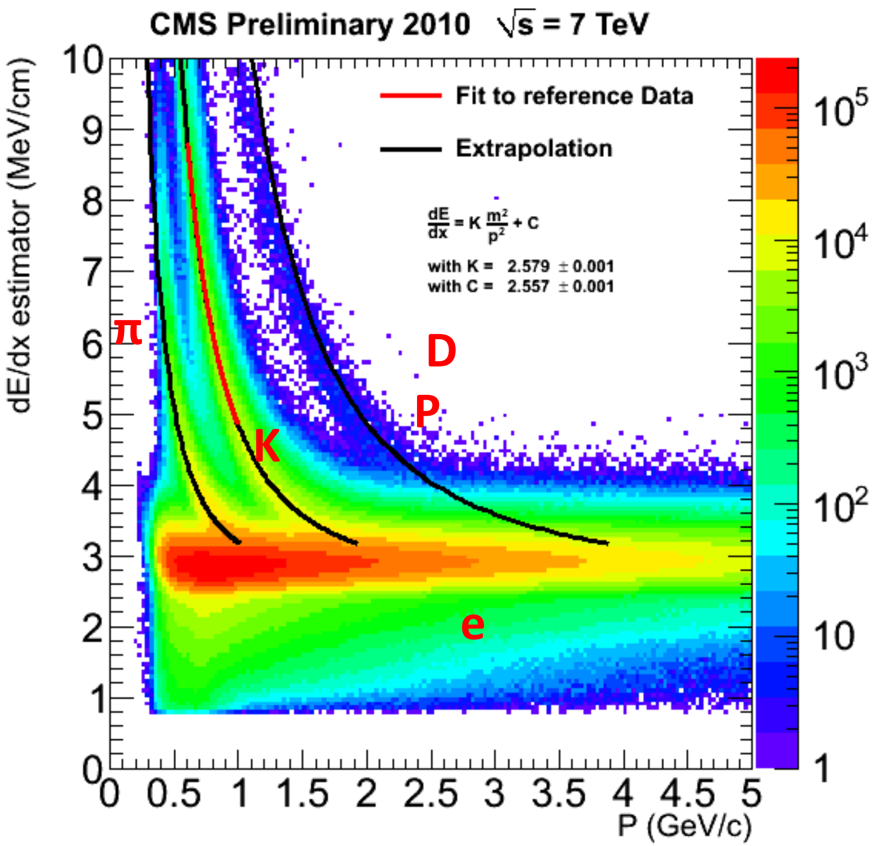
Kink/Disappearing track in the continuous tracking system (ATLAS)

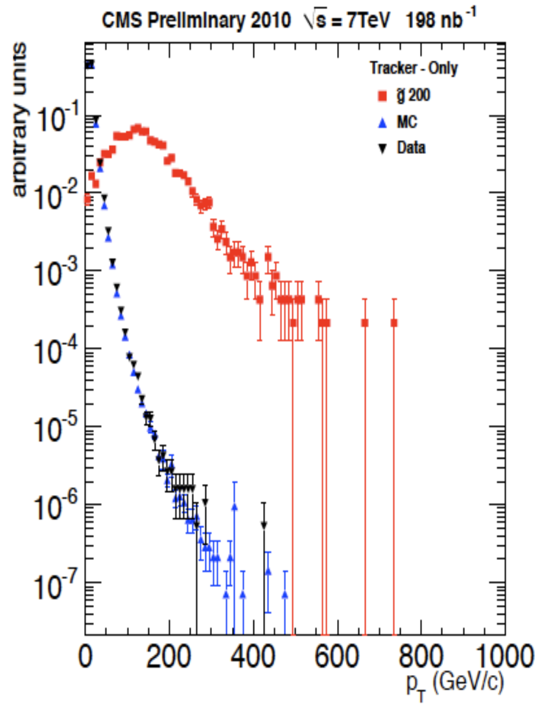
(3) stau and R-hadron(both neutral and charged) stop in the dense material (Hadron calorimeter) dedicated trigger is necessary to catch decay.



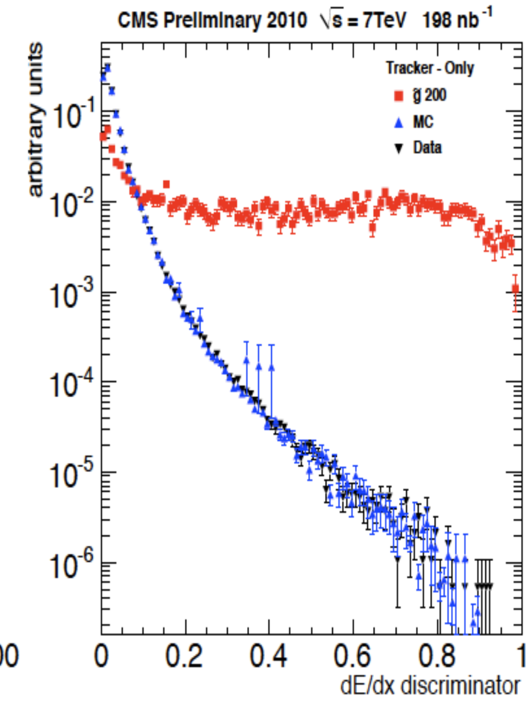
(1A) dE/dx in Si tracker

High PT (>50GeV)
mET > 45 GeV
Large dE/dX





p_t distribution



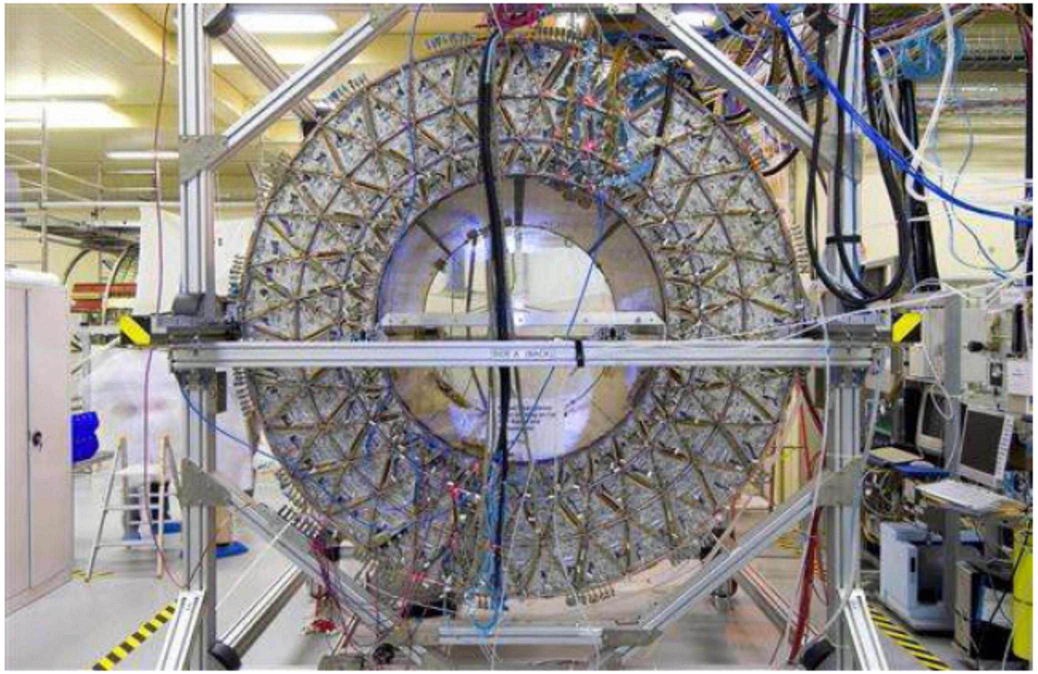
dE/dx discriminator

Ionization energy loss dE/dX ~$1/\beta^2$
We can use this information to search for heavy stable particles.

No event was observed in L=198nb^{-1} and
M(gluino) > 284GeV (95%CL)

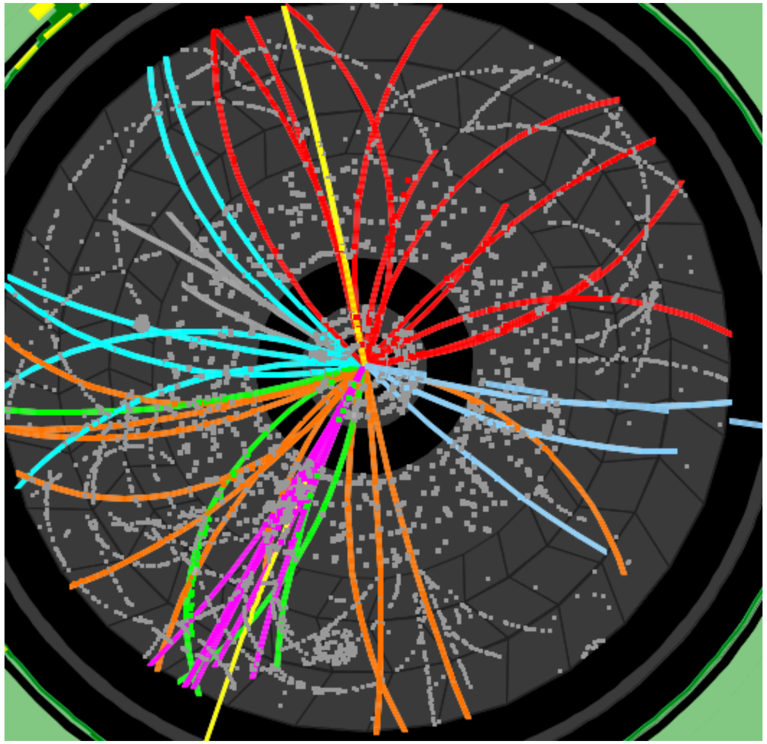
(2) Continuous Tracking System in ATLAS

TRT (Transition Radiation Tracker)



Drift Tube chambers are installed at R=0.5—1m from beam pipe

Real Data



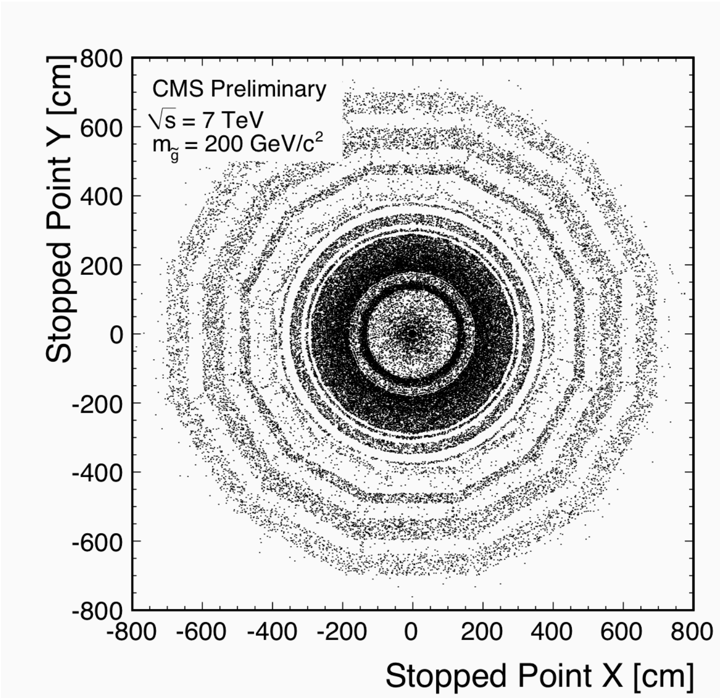
Track can be reconstructed continuously.

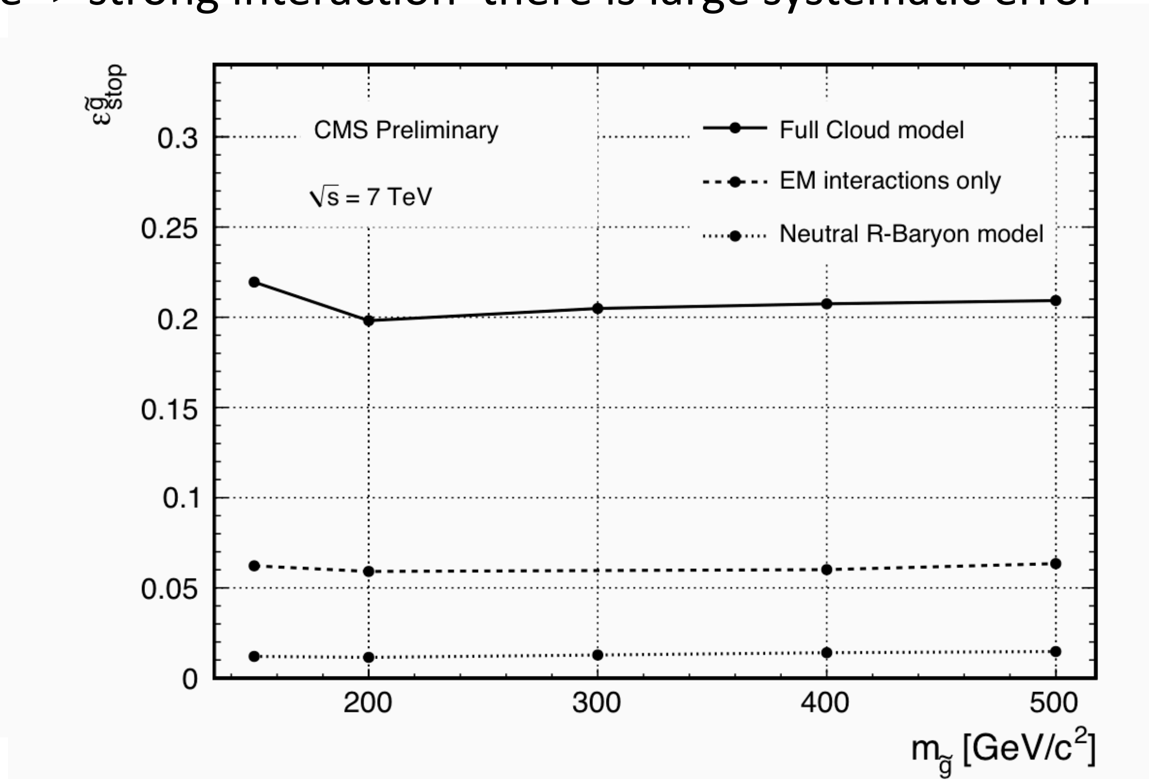
See S.Asai, T.Moroi,Yanagida…
PLB 672(P.339), 664(P.185) 653(P81)

(3) Stop in Calorimeter

(1) charged heavy particles (stau, R^{+-} ….) loss kinetic energy $dE/dx \sim 1/\beta^2$
Emitted particles with small β stop in dense material (Hcal)
-> about 5% will stop (stau case -> See PRL 103:141803(2009) Asai,Hamaguchi,)

(2) Neutral Hadron (R-hadon) case -> strong interaction there is large systematic error

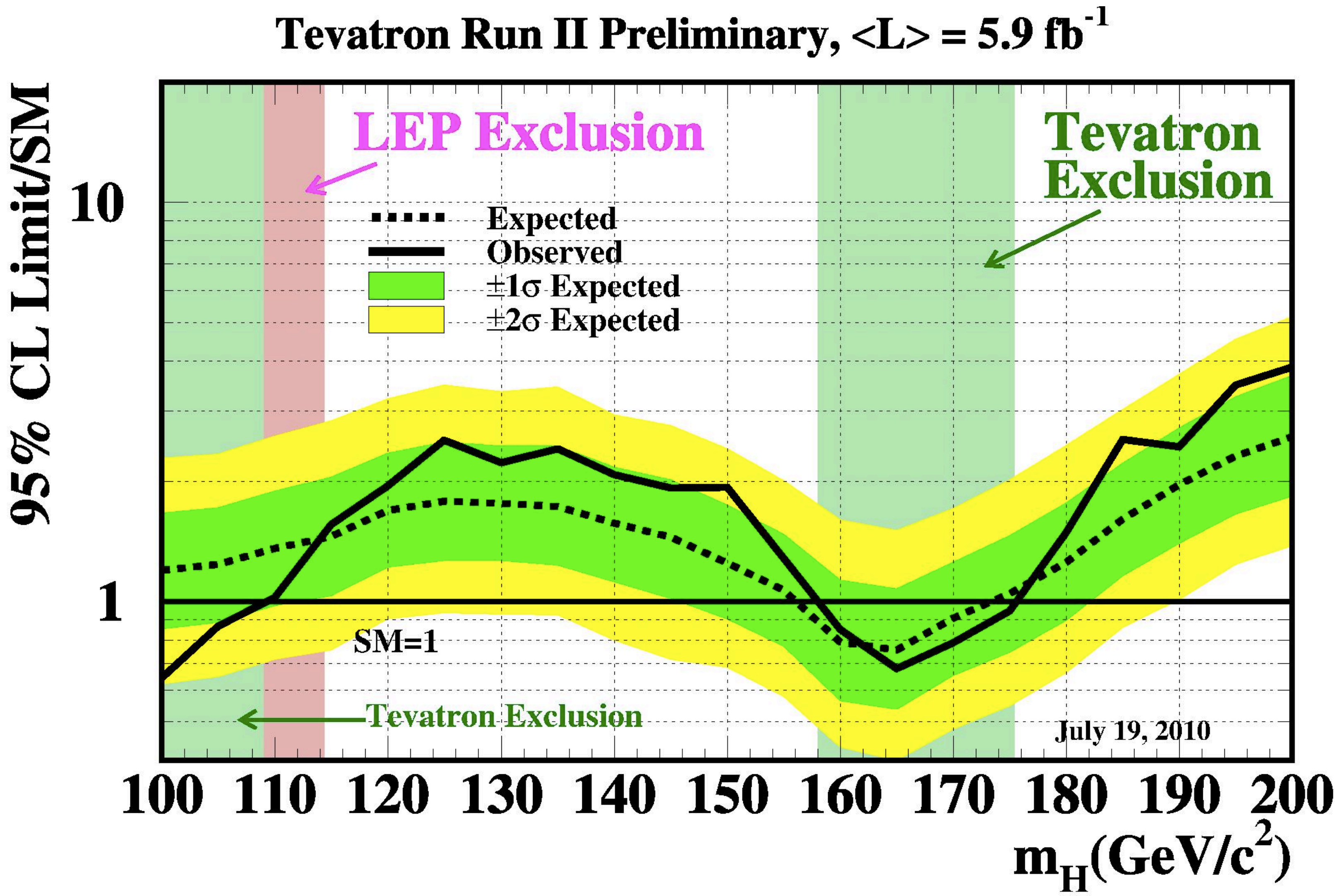


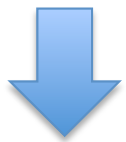


Stop particle decay with $\tau = 10^{-7} - 10^{10}$ sec , single cluster will be observed in Hcal.
Dedicated trigger has been introduced in CMS (empty bunch is used: good for high rate case)
In PRL, beam dump is proposed (good for low rate case).

4. Higgs in Future

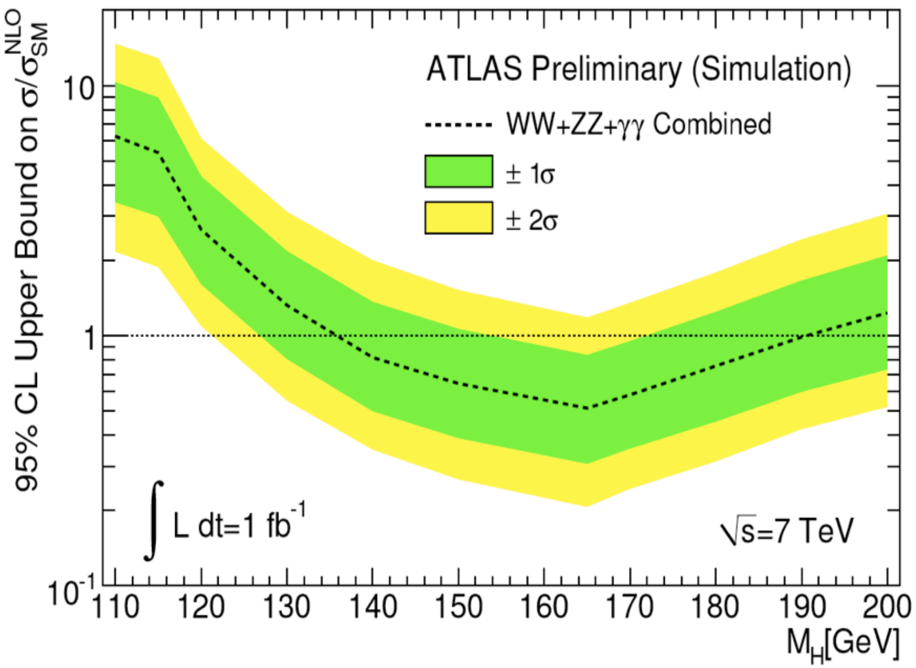
Cold war between LHC and Tevatron is on-going

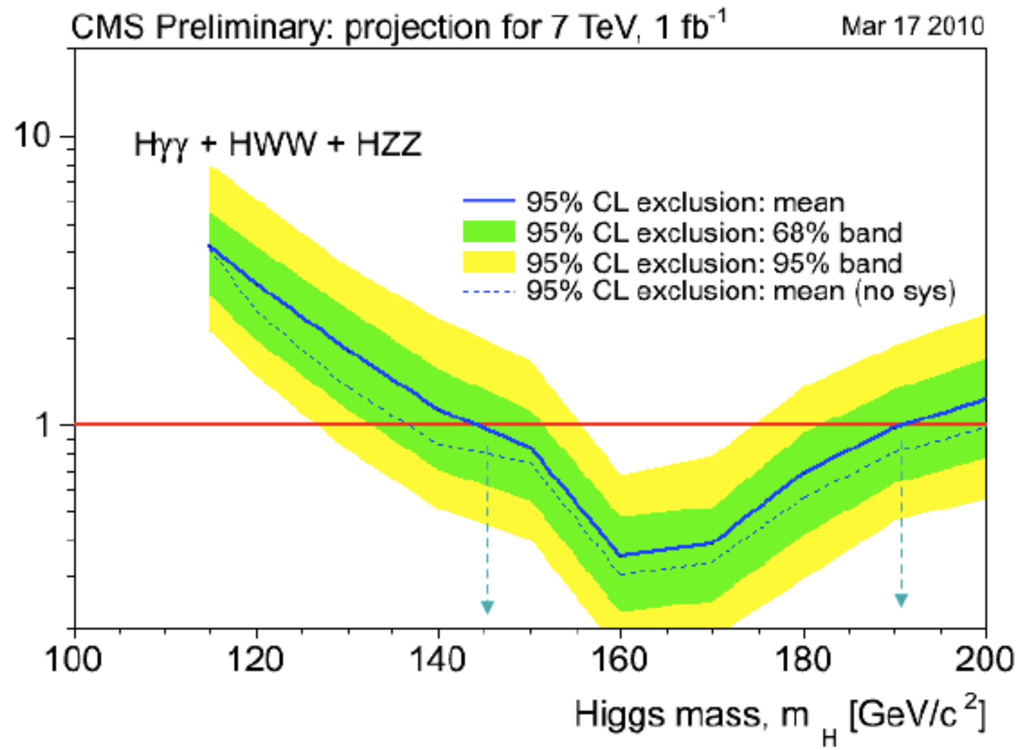



Excluded

Next year it becomes hot war.

The same plots (but just simulated) for ATLAS and CSM with 1fb^{-1} at 7TeV





ATLAS has sensitivity >135GeV   and CMS > 145GeV Region
In the SUSY models, Higgs < 130GeV is promising.

More harder work is necessary for us

Just roughly estimation

（1） Add VBF H->tautau, WH->bb(boosted) gain ~5GeV
（2） Combine ATLAS with CMS gain ~5GeV
(if CMS has the same sensitivity)
（3） LHC is operated at 8TeV gain ~5GeV

We have a potential to examine H > ~120 GeV

(8TeV $L=1fb^{-1}$ A+C)

Do not forget to check “Higgs news” even in the next year.

With $L=10fb^{-1}$ at 14TeV(2014)
Both ATLAS and CMS have the 5σ discovery potential
for all mass range of the SM Higgs

5. Extradimension search based on Event-Topology

There are various models and predictions about ED
We categorize the following event topologies.

(1) High mass lepton pair (ll and lν) (KK Graviton Z',W')

(2) Large mET +single jet (Monojet) (ADD Graviton)

(3) High Pt jet, High mass jets (KK Graviton, contact interaction)
-> both resonance or non-resonance (See QCD section for resoance)

(4) small mET +jets (SUSY-like signal but small mET) (UED)

(5) High Pt, High mass diboson / high mass top pair
(KK Graviton and KK gluon)

(6) High mass & High PT multi-object (mini-blackhole, String ball)

more complicated

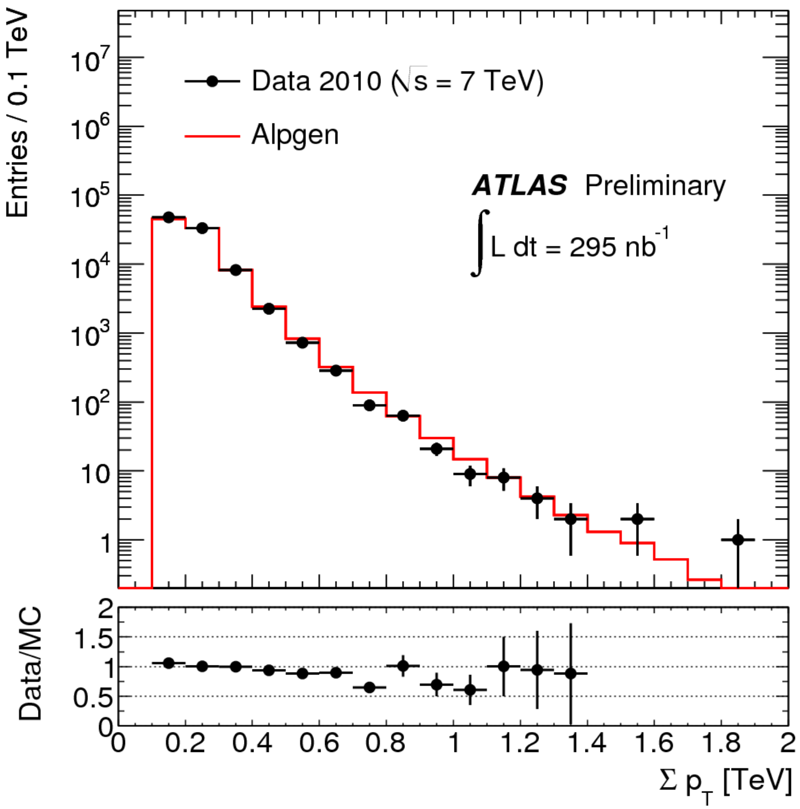
High P_T & High mass multi-object

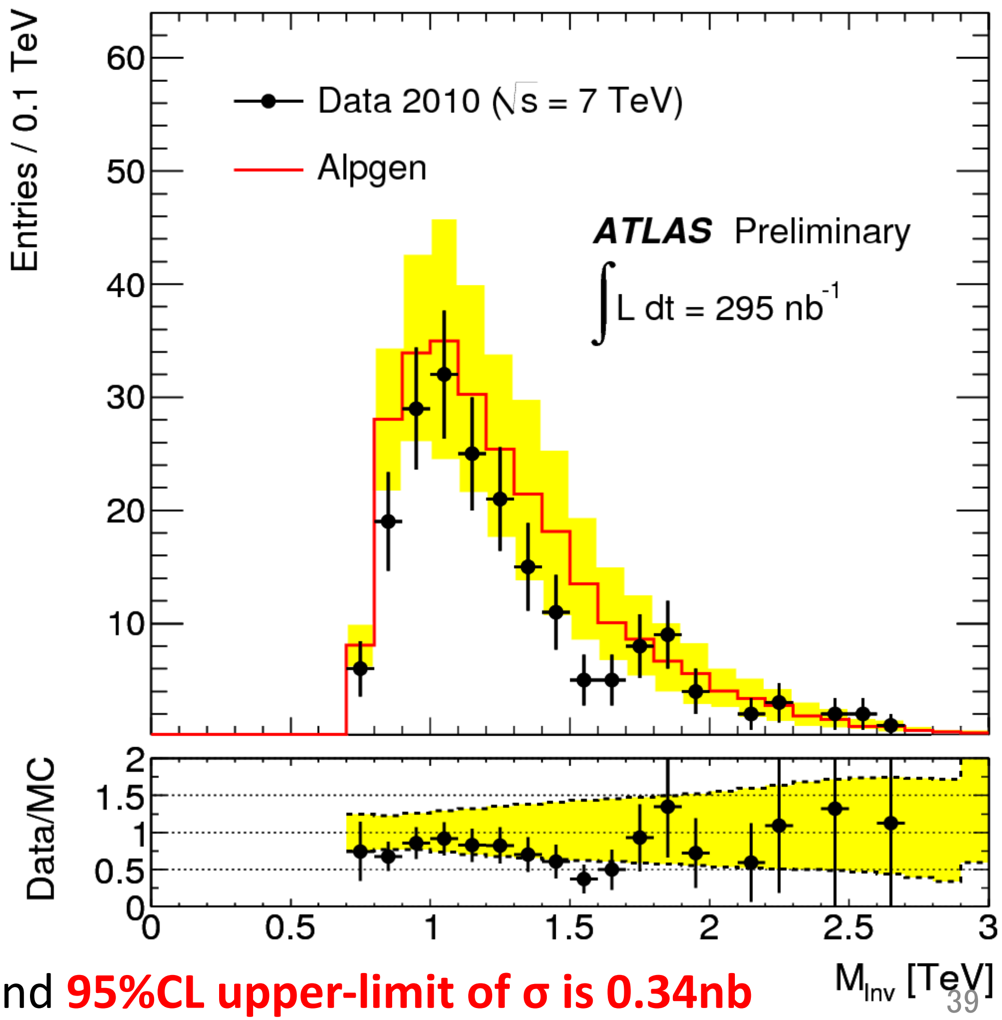
Hawking Radiation of mini-BH or Multibody decay of String Ball.

N_{obj}>=3 (Jet P_T>40GeV, e,mu,gamma P_T>20GeV)

$\Sigma\ P_T >$ 700GeV

$M_{inv} >$ 800GeV





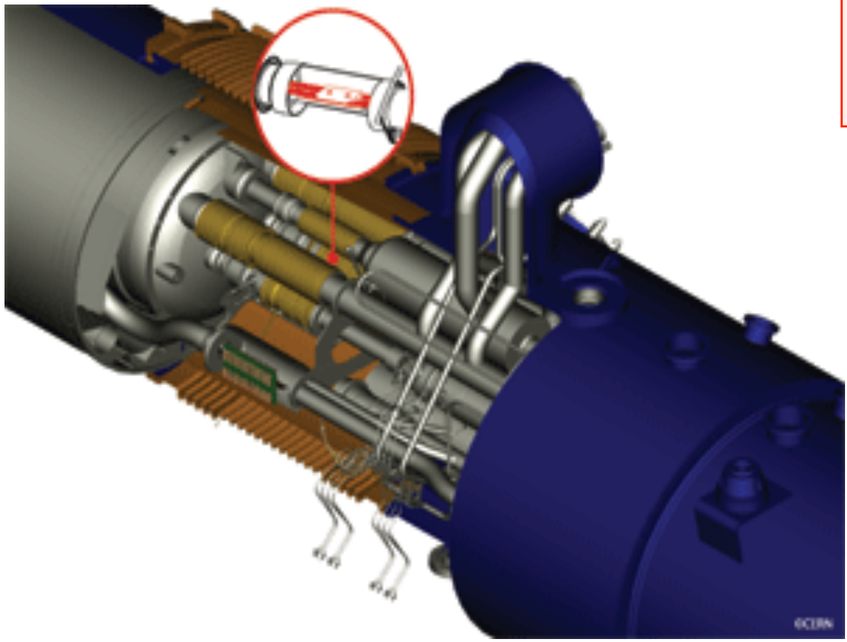
Data is consistent with SM prediction and **95%CL upper-limit of σ is 0.34nb**

Summary and Conclusion

1. LHC is in good operation and will achieve “the first target” soon ($L=10^{32}cm^{-2}s^{-1}$)
2. We expect the data of 30-70pb^{-1} in this year and 1 fb^{-1} in the next year.
3. Detectors work well and have good performance.
4. Our studies are based on the Event-topologies. Exotic topologies are also covered for SUSY.
5. SUSY searches with the mE_T (also dijet resonance search) exceeds already to Tevatron/LEP.
   LHC starts to explore the unknown TeV-world.
6. DM-inspired SUSY will be covered in 2011(bulk) or at least before 2014. -> Not specific models.
7. Higgs also at least before 2014. Keep watch even in the next year.
8. Now no excess is observed except for “Ridge” observed at CMS

Backup slides

（おまけ）



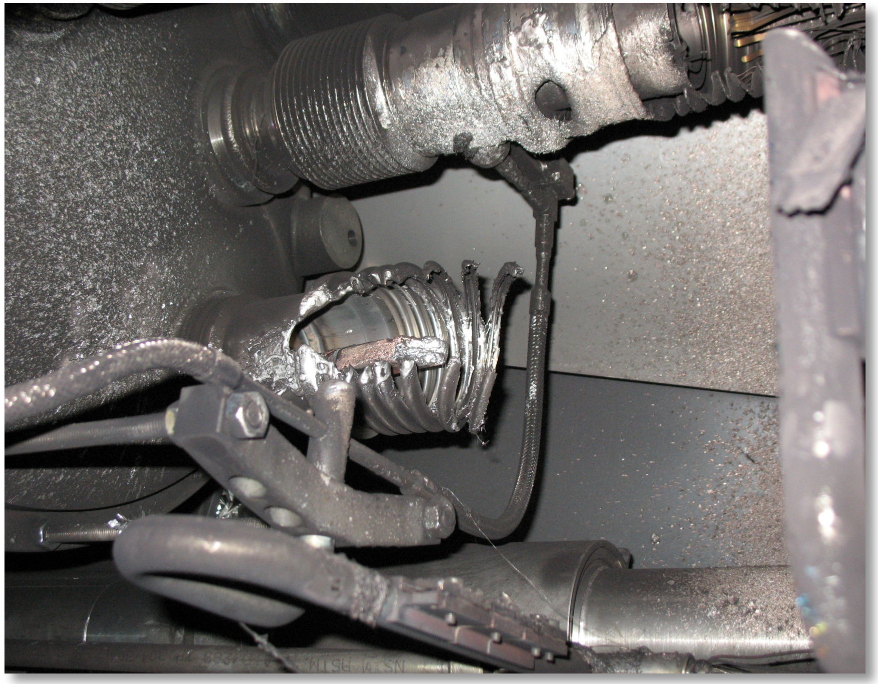
9.19 Accident (2008)

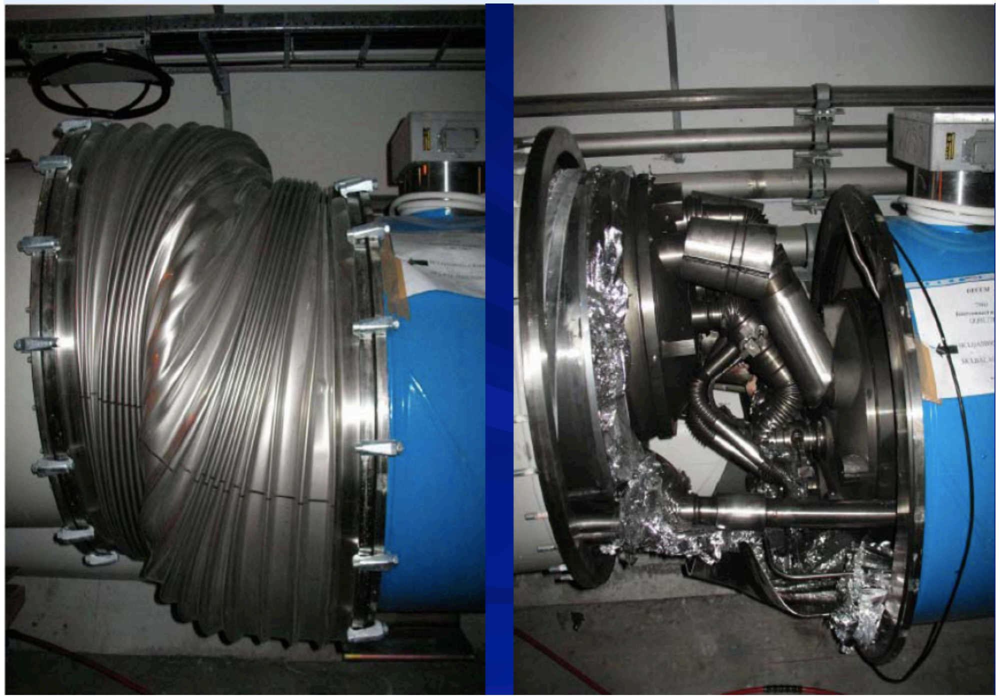
1. There are "Bad connections"
   in the Cupper bar between Magnet-units.
   (I will mention detail later)

2. When the superconducting magnet is quenched, current passes though this cupper bar.
   But temperature goes up quickly due to the bad connection, then L.He boils up.

3. Totally 53 Magnets have been destroyed.

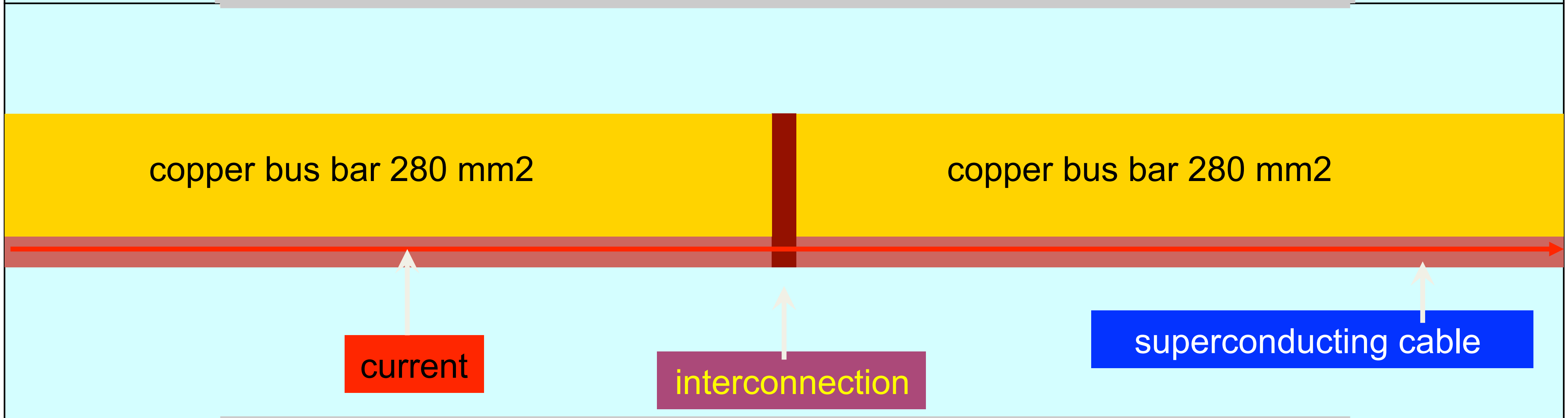
.





Problem（bad connection of splicing ）

When superconducting is quenched, current (～10000A) is dumped using the copper bus bar. But there is bad connection (～50 μ Ω) in splicing between Magnet units. This is the reason of 9.19 accident.

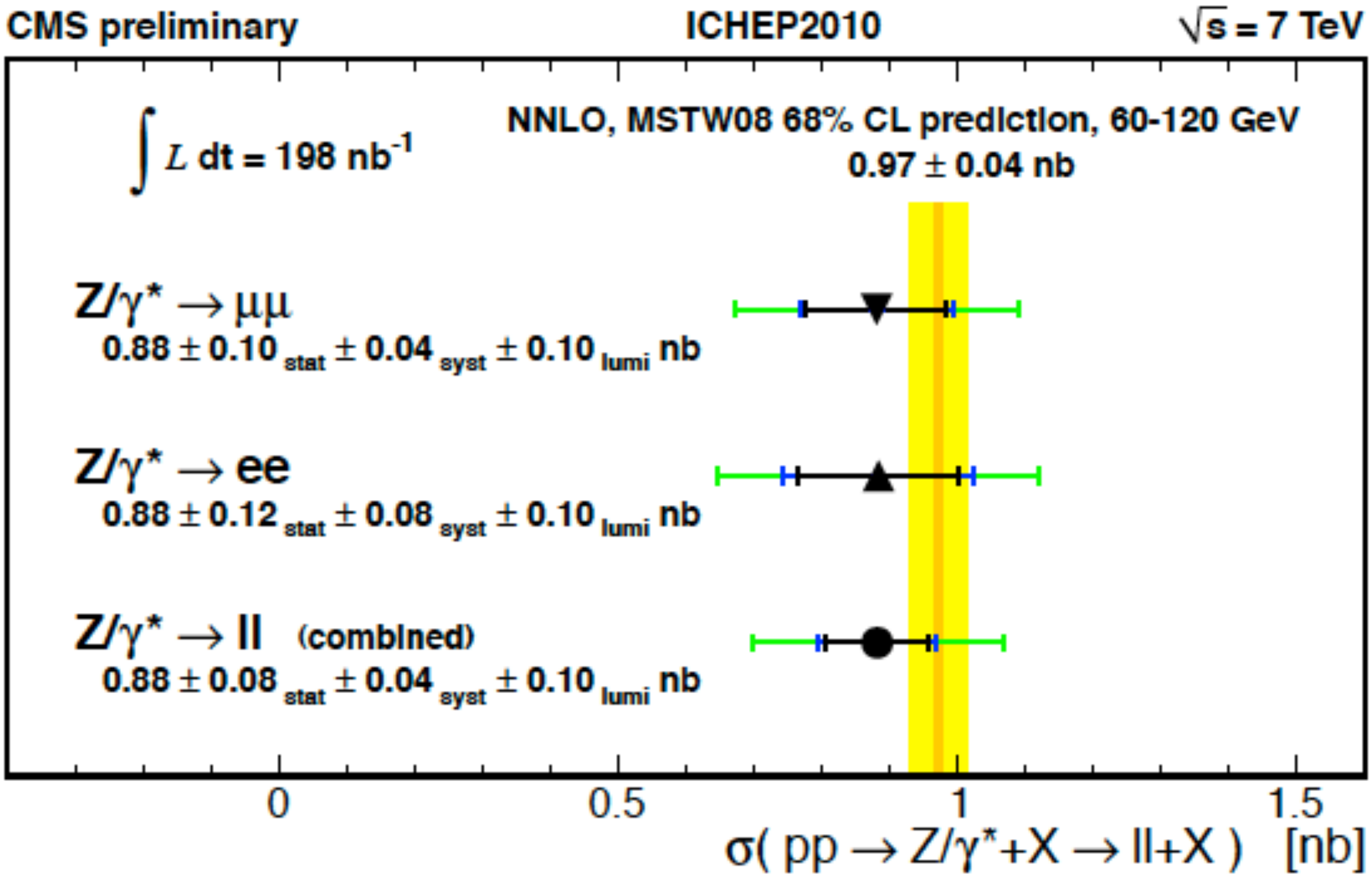


Current is limited for safety and beam energy is limited upto 3.5–4.5 TeV.

We need > several months to reconnect all (bad connected) bars.

(Long shutdown for about 15 months in 2012)

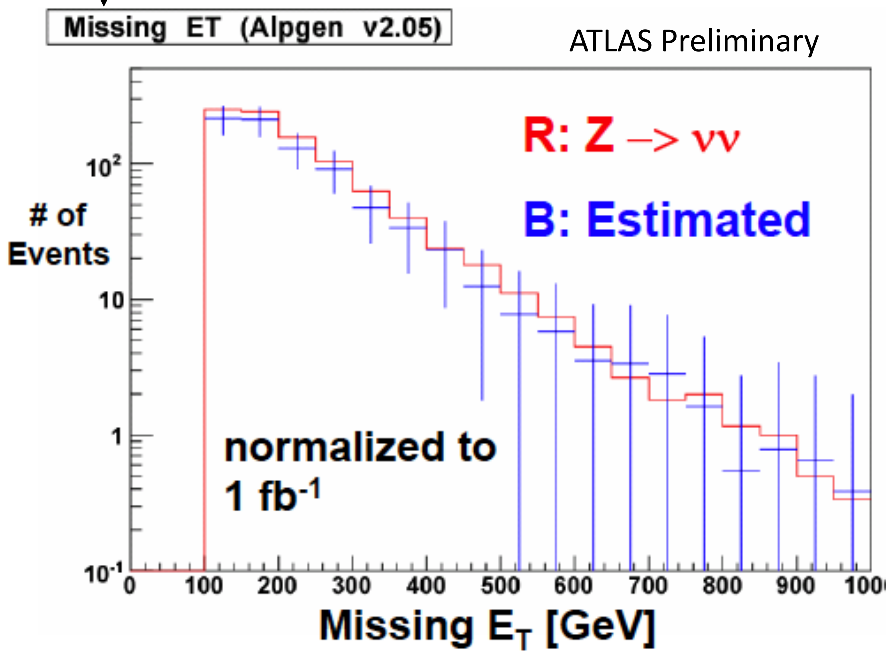
σ ∗ Br   for Z boson



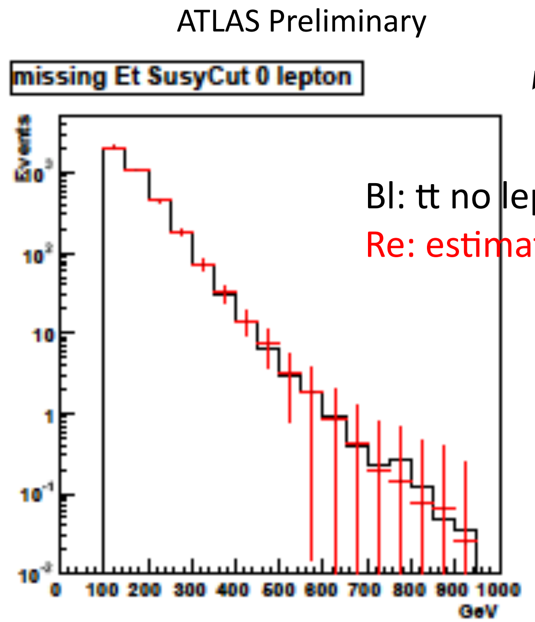
Summary of background estimation with Real data ("No-lepton mode")

Estimated BG processe	Control samples	status
$Z \rightarrow \nu\nu$ + Njets	$Z \rightarrow ee, \mu\mu$ + Njets	OK but stat. limited
Z/W+ Njets	$Z \rightarrow ee, \mu\mu$ + Njets	OK but using MC shape
W+Njets (no lepton)	W->lnu(MT<100GeV)	OK: reweight for W->taunu
tt+Njets (no lepton)	tt+Njets (MT<100GeV)	OK: separate W from CS

Next



L=1fb^{-1}

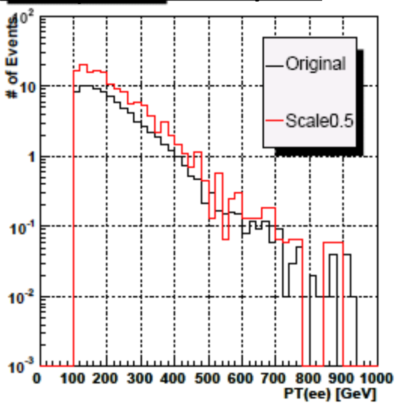


Z(nn)+njets : 157+/-13
Estimated : 142+/-39
(MET>300GeV)

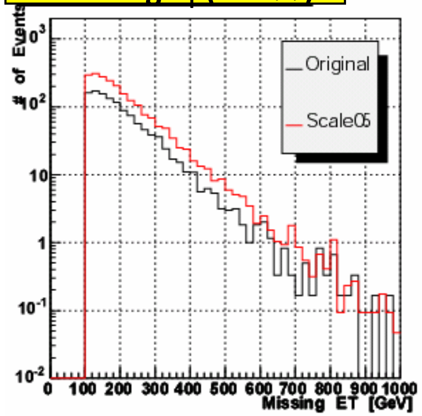
tt(nolepton)127 +/− 11
Estimated 132 +/− 21
(MET>300GeV)

The background distributions are very stable against input parameters, also stable for various generators(ALPGEN/MC@LO/Sherpa), just normalization is different.

p_T(ee) (Z->ee)



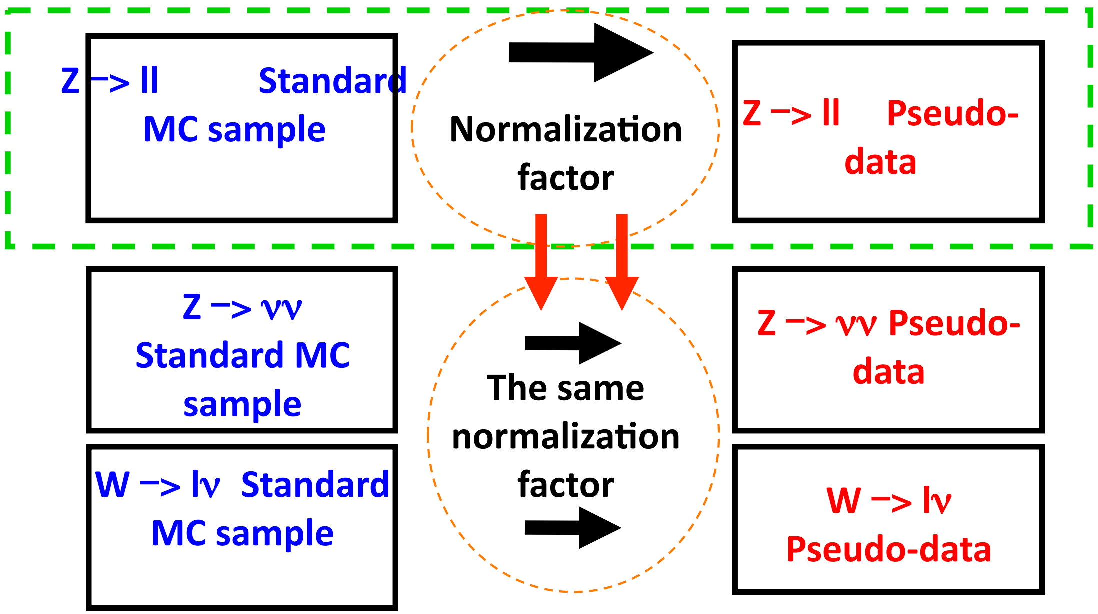
Missing E_T (Z->νν)



Shape of the distributions are insensitive to the input parameters of the Generator (Alpgen+Jimmy).

Renormalization scale, factorization scale, minimum p_T at partons level, minimum distance dR_{ij} between partons, jet definition of MLM matching (minimum E_T, cone size R), and PDF

The normalization of the distributions is affected by these uncertainties.



We use the shape of the MC distributions,

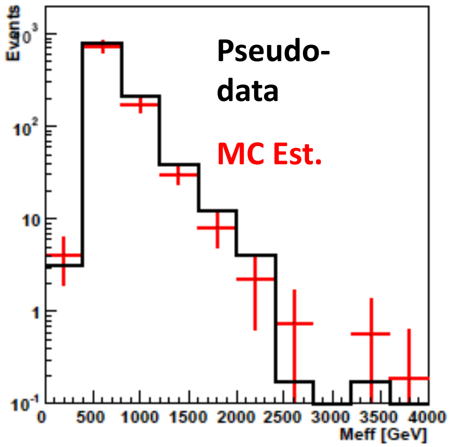
but determine the normalization factor from the real data by comparing p_T(ll) distributions of Z->ll

They have the same diagram -> this normalization factor is common to W/Z

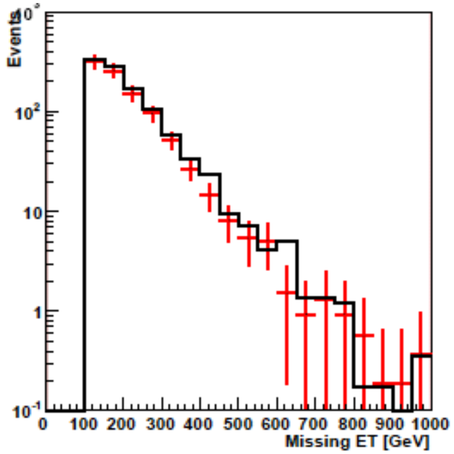
Z –> νν

ATLAS Preliminary

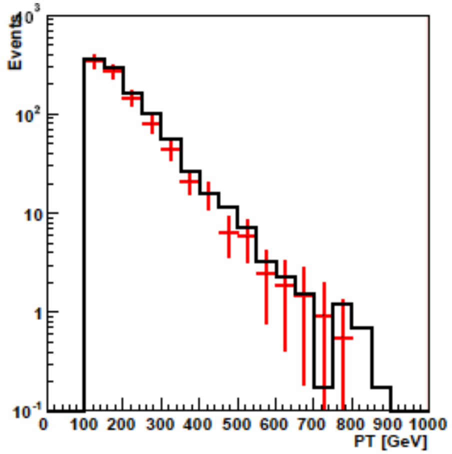
Effective Mass



Missing E_T



Leading Jet P_T

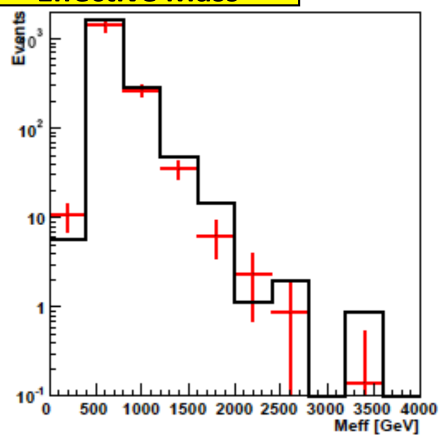


# of Events (MET > 300 GeV)

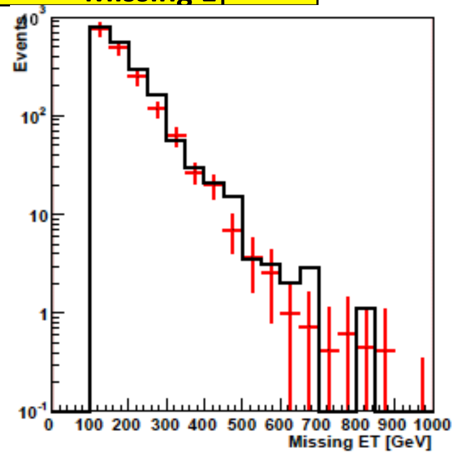
147 +/- 12 (pseudo-data) **118 +/- 20** (estimation)

W –> lν

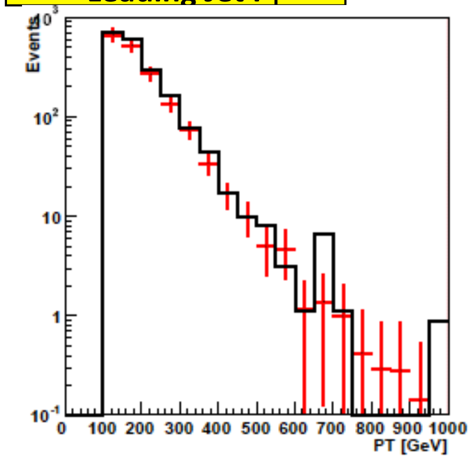
Effective Mass



Missing E_T



Leading Jet P_T



# of Events (MET > 300 GeV)

134 +/- 11 (pseudo-data) **126 +/- 21** (estimation)

statistical errors & errors of normalization factor considered

normalized to 1 fb^{-1}

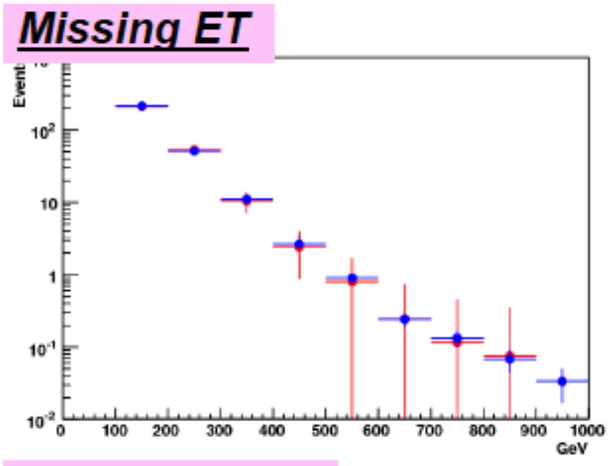
One-lepton mode / OS-dilepton mode

Top -pair is dominant background process for these modes:

We have good control sample of top-pair itself (one lepton& MT<100GeV)

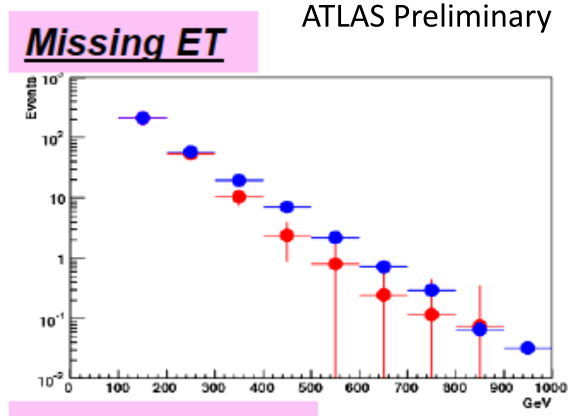
BG(MT>100GeV)
can be estimated
with CS(MT<100GeV)
If no SUSY <5%

IF SUSY exists (1TeV)
accuracy is about 50%
SUSY signal contributes to CS



Without SUSY signal

ATLAS Preliminary

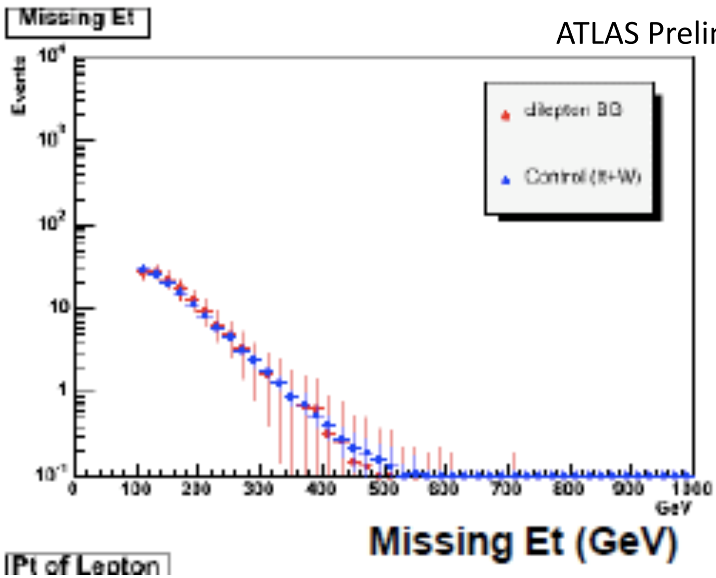


With **1TeV SUSY signal**

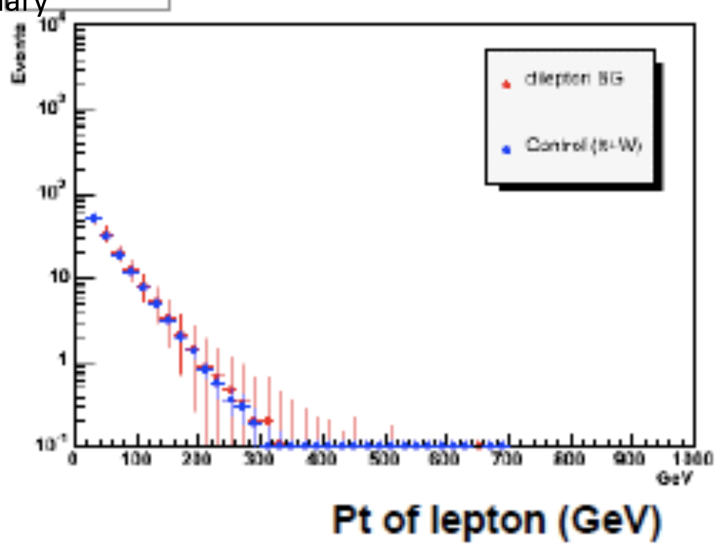
Dilepton BG
can be estimated
with the same CS
If no SUSY <10%

IF SUSY exists (1TeV)
Estimation becomes
Overestimated
about 100%

ATLAS Preliminary



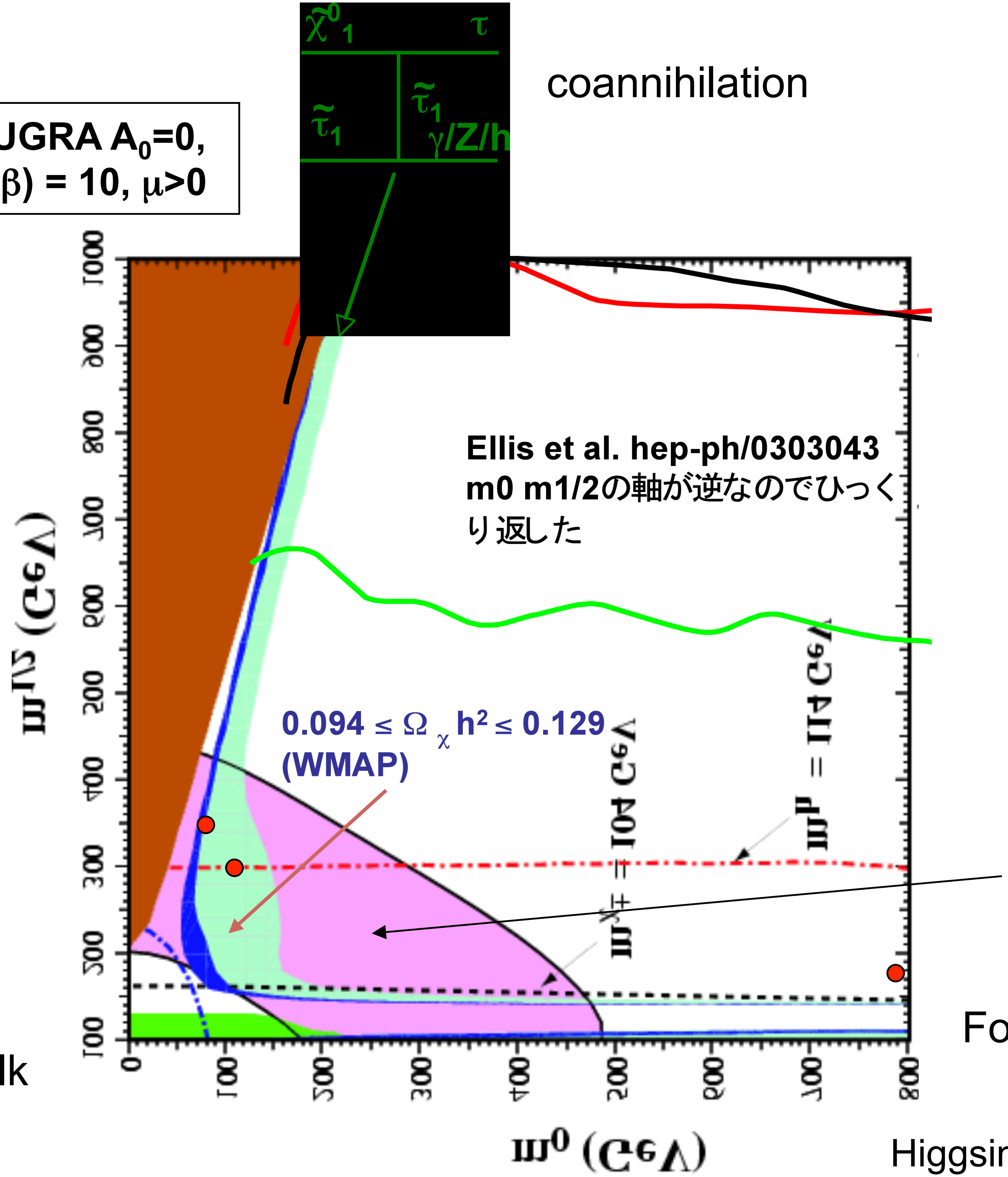
ATLAS Preliminary



No SUSY signal

mSUGRA A_0=0, tan(β) = 10, μ>0

coannihilation

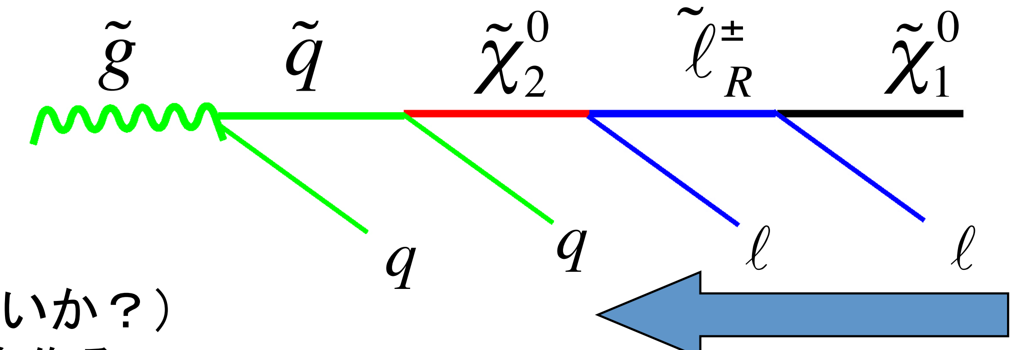


Bulk

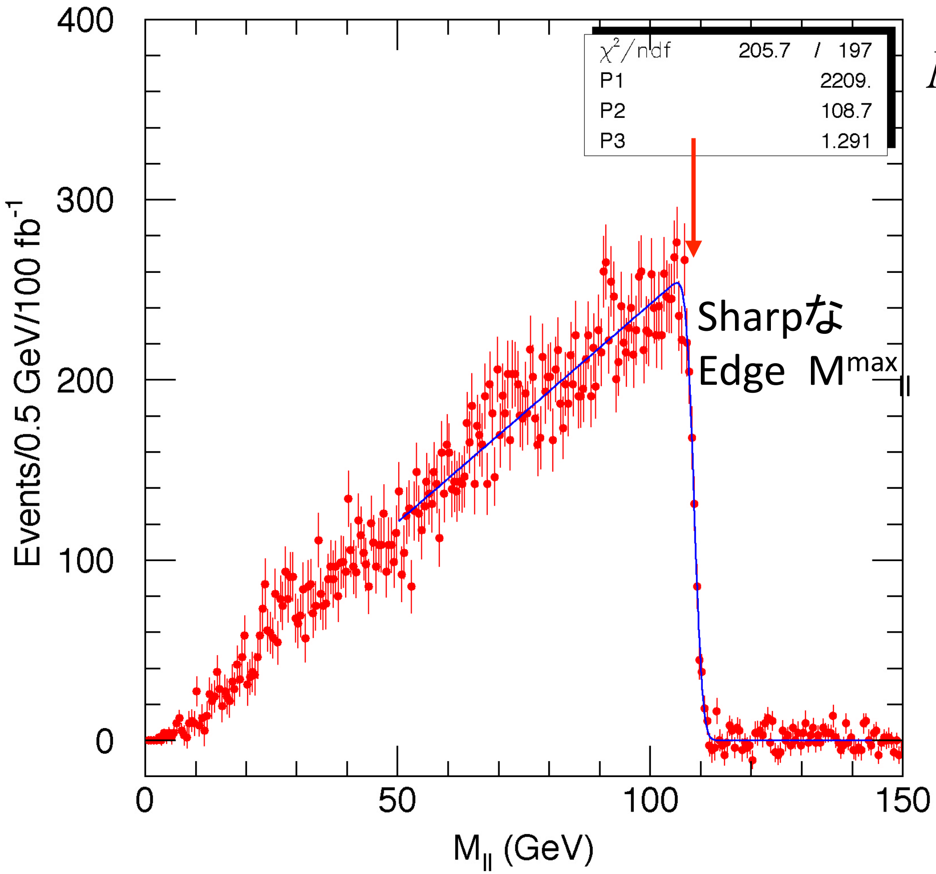
Focus Point

Higgsino成分大きい
Nu1+nu1->WW (Higgsの結合）

質量の再構成に関して



1. 適当なdecay chainを選ぶ **(key point!)**
   （奇麗か？　他のSUSY Decay chain? 長いか？）
2. mass やP_Tなどのkinematic distributionを作る
3. Edgeやendpointからmassの関係に束縛を与える

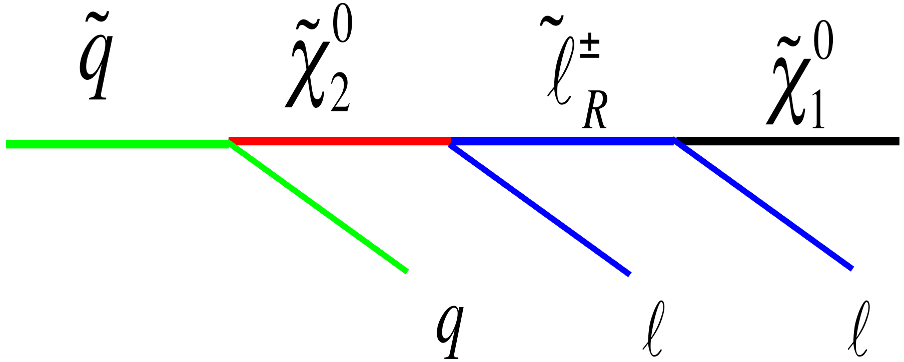


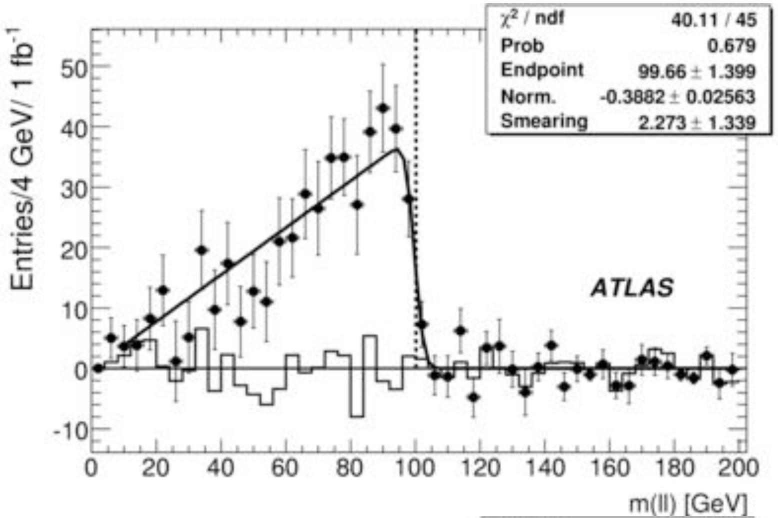
$$M_{\ell\ell}^{\max} = m(\tilde{\chi}_2^0)\sqrt{1-\left(\frac{m(\tilde{\ell}_R^{\pm})}{m(\tilde{\chi}_2^0)}\right)^2}\sqrt{1-\left(\frac{m(\tilde{\chi}_1^0)}{m(\tilde{\ell}_R^{\pm})}\right)^2}$$

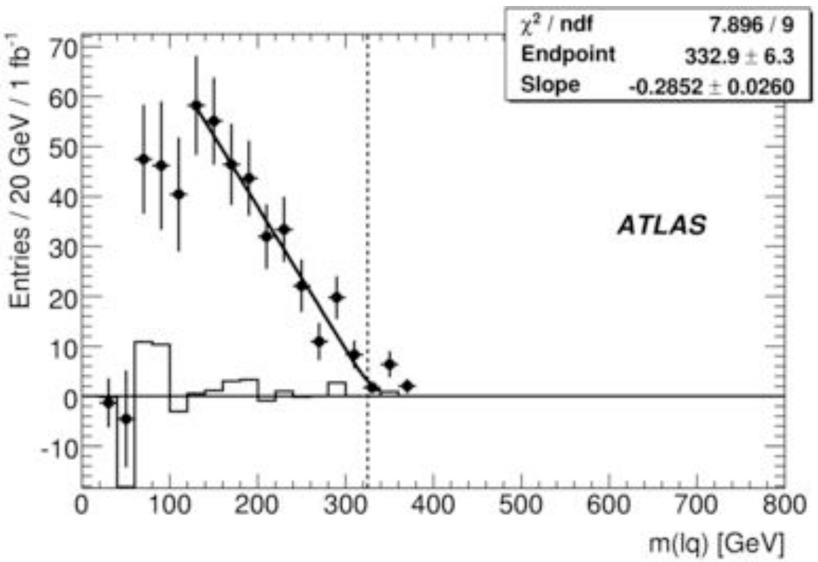
- 一般に関係式の方が未知数（質量）より少ない。Modelの助けを借りてMassの絶対値を決める。
- 2body decay chainが最低3連発した場合は model independentに決めることが出来る。(次のページ)
- tanβが大きいと段数が増えたり、τ、bが多くなる。
- 発見と違って、model依存性が強い。
- Br測定は難しい

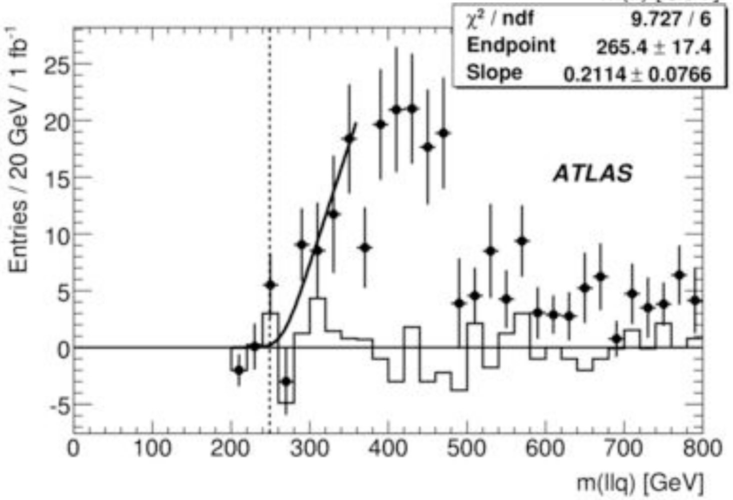
登場人物4人

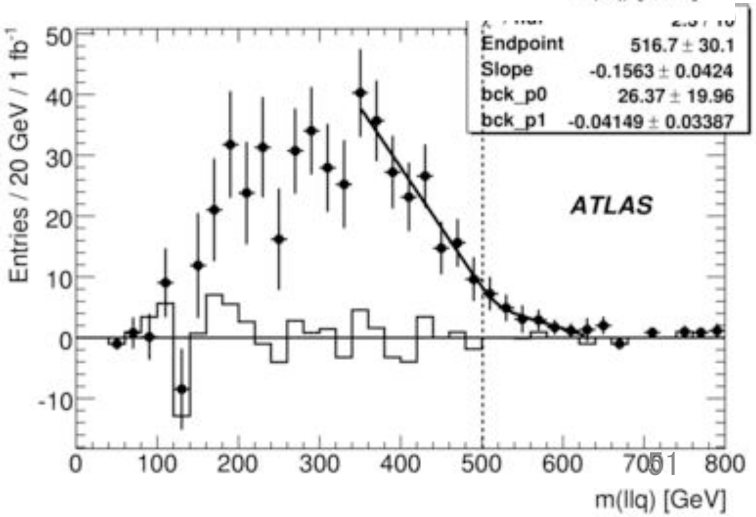
SU3 L=1fb^{-1}







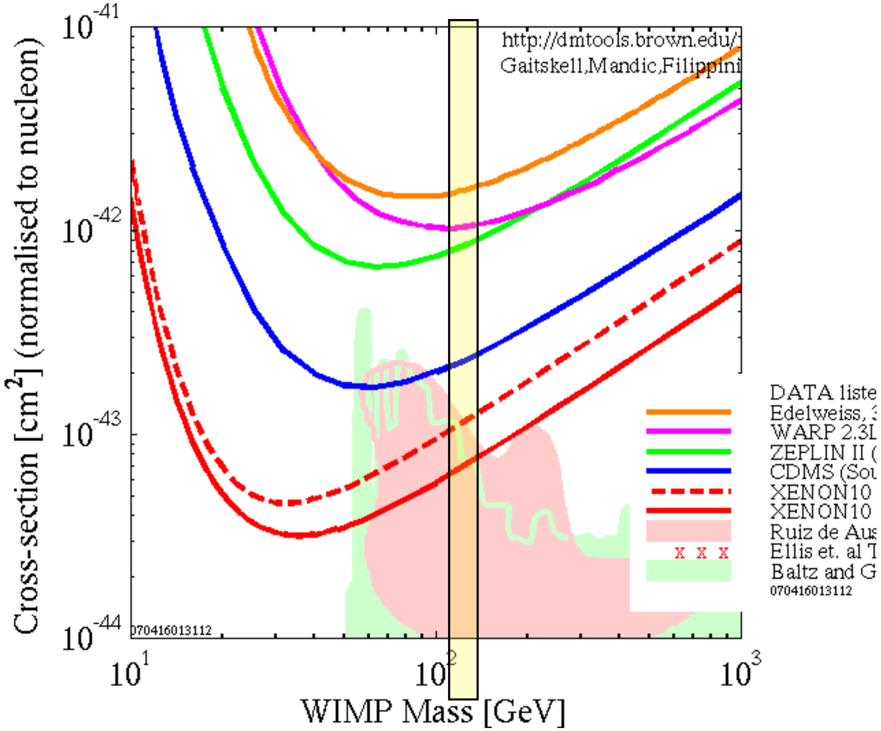




4未知数 vs 4条件 → model independentにmassが決まる。(3-12%程度 L>100fb^{-1} for 700-800 GeV squark, gluino）

DMを決める

Variable	Value (GeV)	Errors Stat. (GeV)	Scale (GeV)	Total
$m_{\ell\ell}^{max}$	77.07	0.03	0.08	0.08
$m_{\ell\ell q}^{max}$	428.5	1.4	4.3	4.5
$m_{\ell q}^{low}$	300.3	0.9	3.0	3.1
$m_{\ell q}^{high}$	378.0	1.0	3.8	3.9
$m_{\ell\ell q}^{min}$	201.9	1.6	2.0	2.6
$m_{\ell\ell b}^{min}$	183.1	3.6	1.8	4.1
$m(\ell_L) - m(\tilde{\chi}_1^0)$	106.1	1.6	0.1	1.6
$m_{\ell\ell}^{max}(\tilde{\chi}_4^0)$	280.9	2.3	0.3	2.3
$m_{\tau\tau}^{max}$	80.6	5.0	0.8	5.1
$m(\tilde{g}) - 0.99 \times m(\tilde{\chi}_1^0)$	500.0	2.3	6.0	6.4
$m(\tilde{q}_R) - m(\tilde{\chi}_1^0)$	424.2	10.0	4.2	10.9
$m(\tilde{g}) - m(\tilde{b}_1)$	103.3	1.5	1.0	1.8
$m(\tilde{g}) - m(\tilde{b}_2)$	70.6	2.5	0.7	2.6



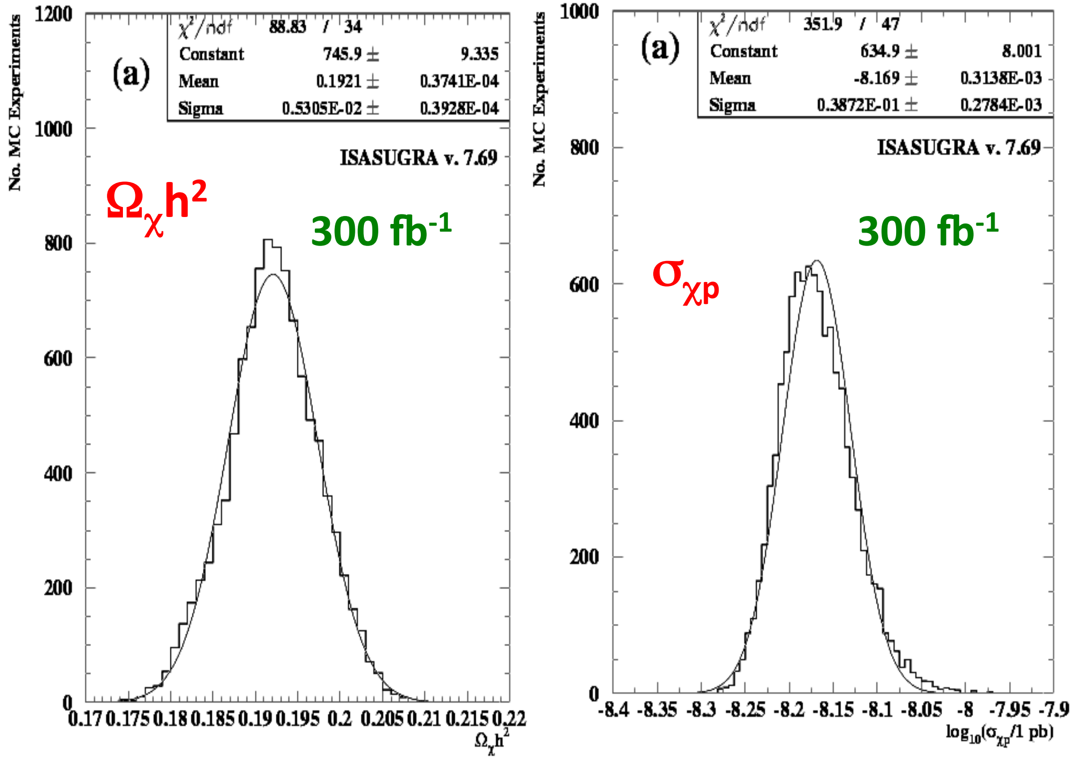
DM particle mass m_χ (GeV)

Modelを仮定

分布のedge→ parameter →

$\Omega_\chi h^2 = 0.1921 \pm 0.0053$

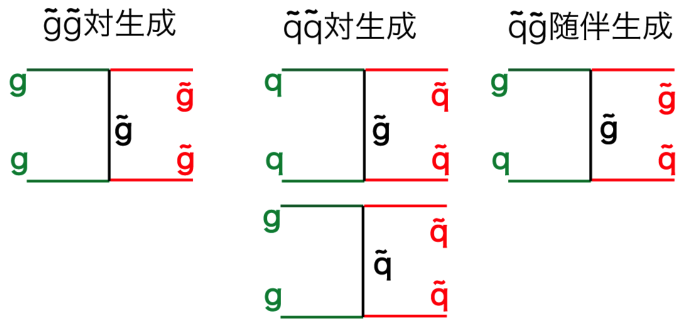
$\log_{10}(\sigma_{\chi p}/pb) = -8.17 \pm 0.04$



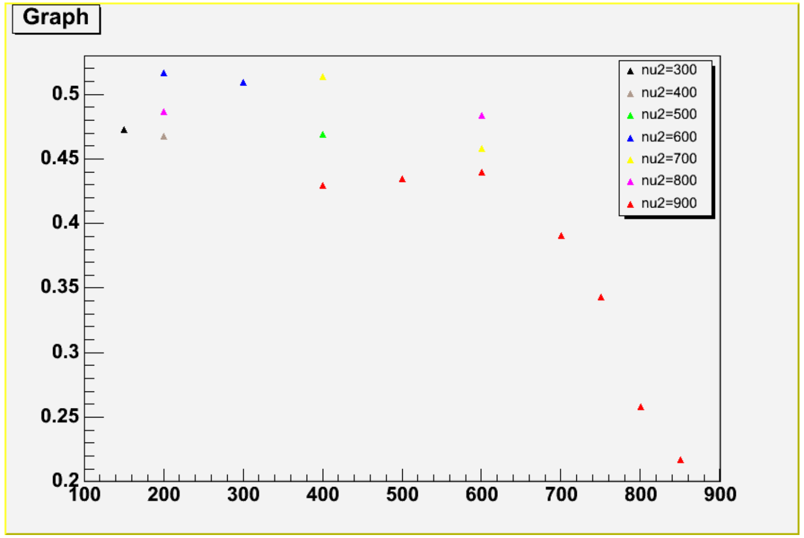
Recoil 実験と直接比較が可能になる

赤　最新Xenon10(Xe2相）

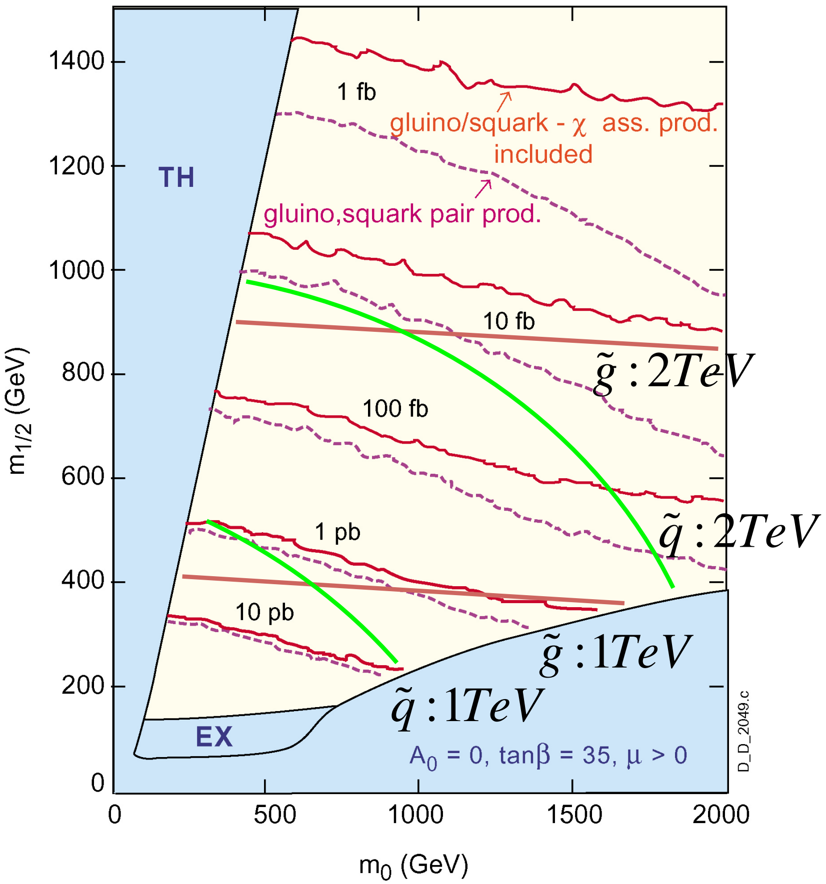
LHCの能力がモデルに著しく依存したSUSYしかカバーできないか？



生成過程は
ただのstrong interaction.
Gluino,squark の
massだけでほとんど
決まる。Cross-section
はmass countur



LSP mass (GeV) for Gluino mass 1TeV



一方崩壊の違いによる
Efficiencyの違いは小さい。
効くのは、LSPとのmass differenceが主:
ΔM(coloured vs LSP)=400GeVくらいまでは
安定
300GeVくらいから急激に小さくなる。
mET分布がきつくなる。

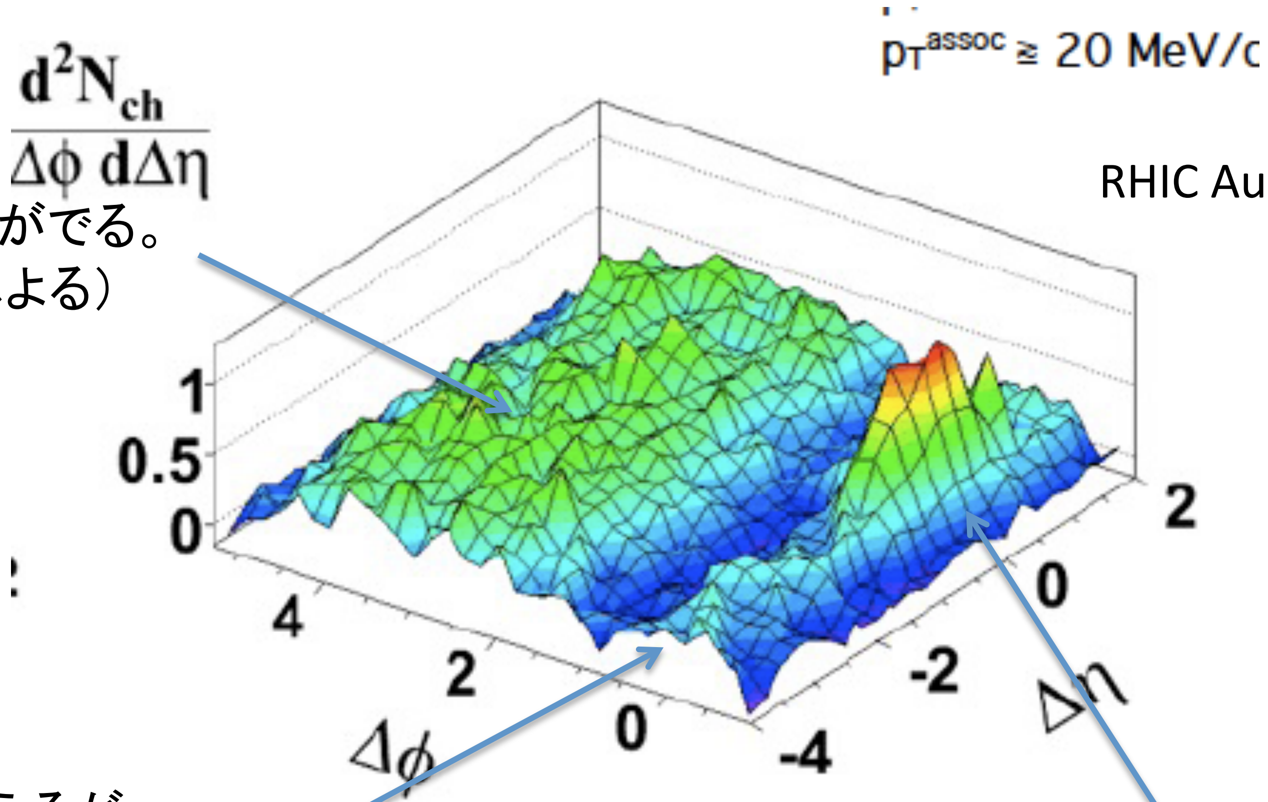
ΔMが極端に小さく(300GeV)なるようなことが
起きなければ、LHCでしくじらない。
Gluino,squarkのmassだけで決まる。

CMSの話

http://indico.cern.ch/conferenceDisplay.py?confId=107440

をみてね

Au+Auをぶつけると　イメージとして熱い液体になって中でいろいろな
振動がぶつかり方で出来る。その”ジオメトリー“効果で　粒子の出る方向が
phase spaceからずれる



RHIC Au+Au

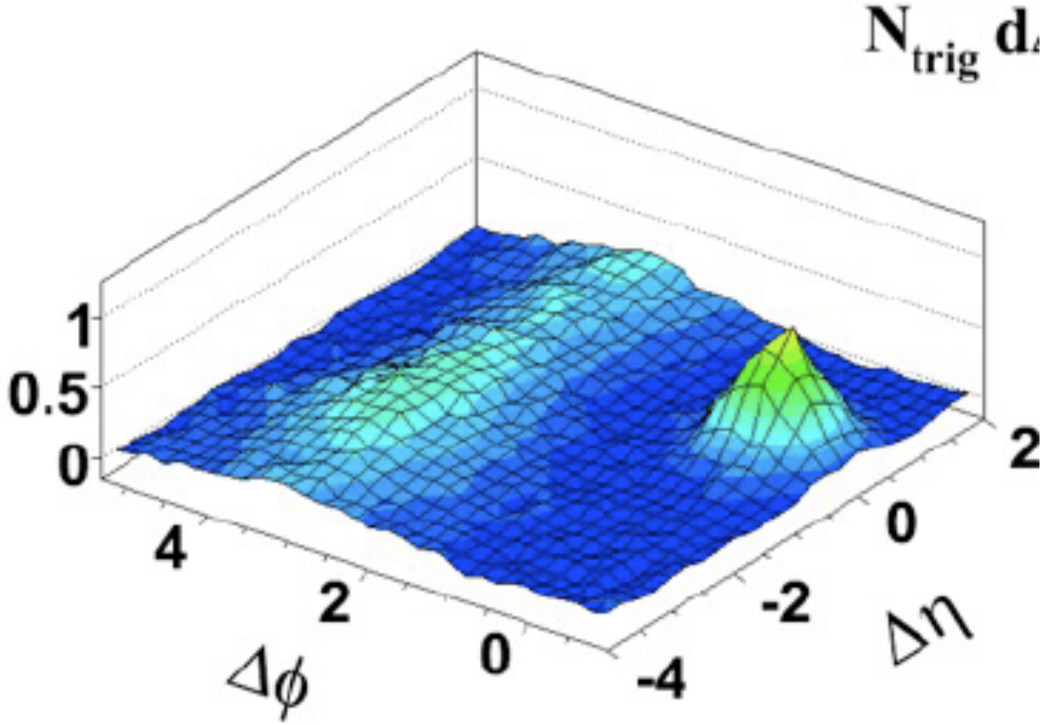
反対側(far side) に粒子がでる。
ほぼηによらない。（少しよる）

同じ側(near side)は
QGPのようなときにみえるが
P+Pではみえていない
（つぎのページ）

ridge　と言うらしい　初めて聞いた

QCD起源　粒子は
そばに出る

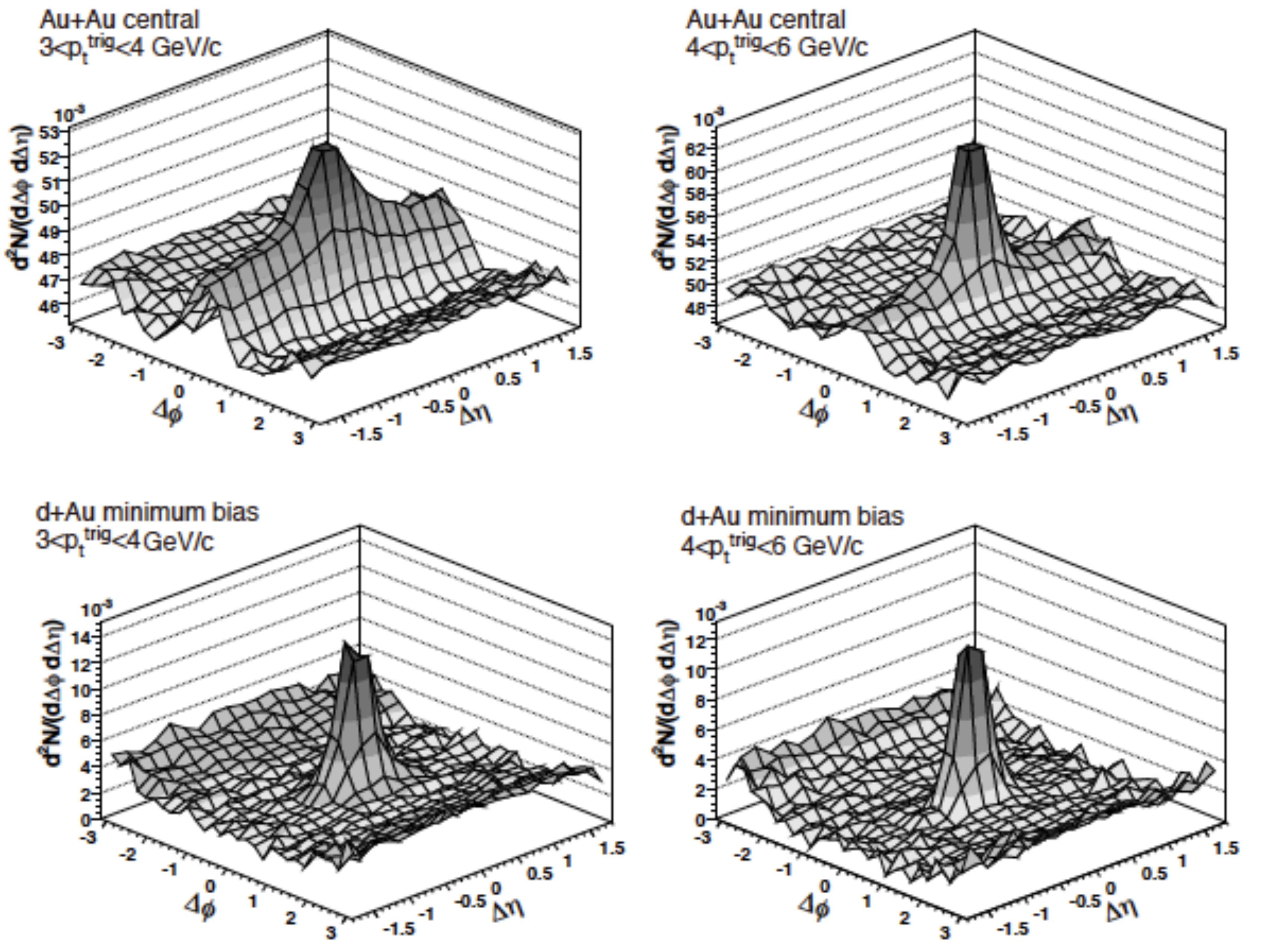
RHIC　で　PPぶつけてもみえていない



PYTHIA p+p 200 GeV

RHICではd＋Auでも見えない

Phys.Rev.C80:064912,200



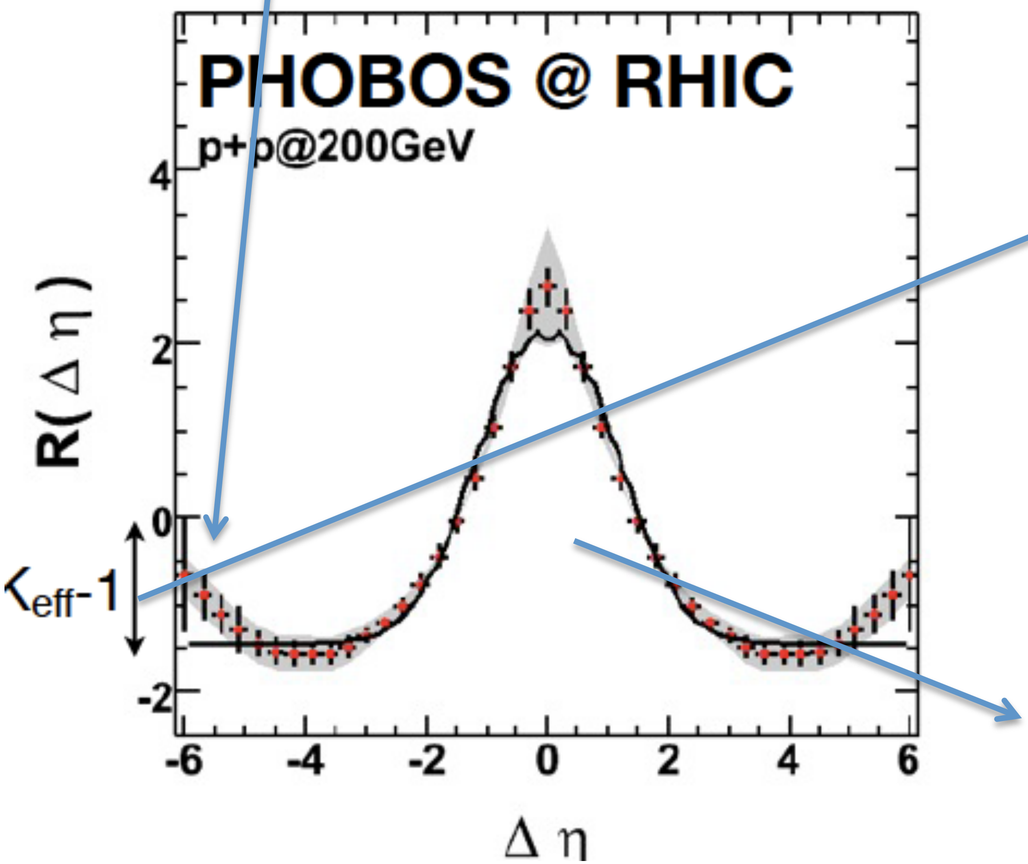
この原因は不明であるが、QGP関係の何かで諸説紛々

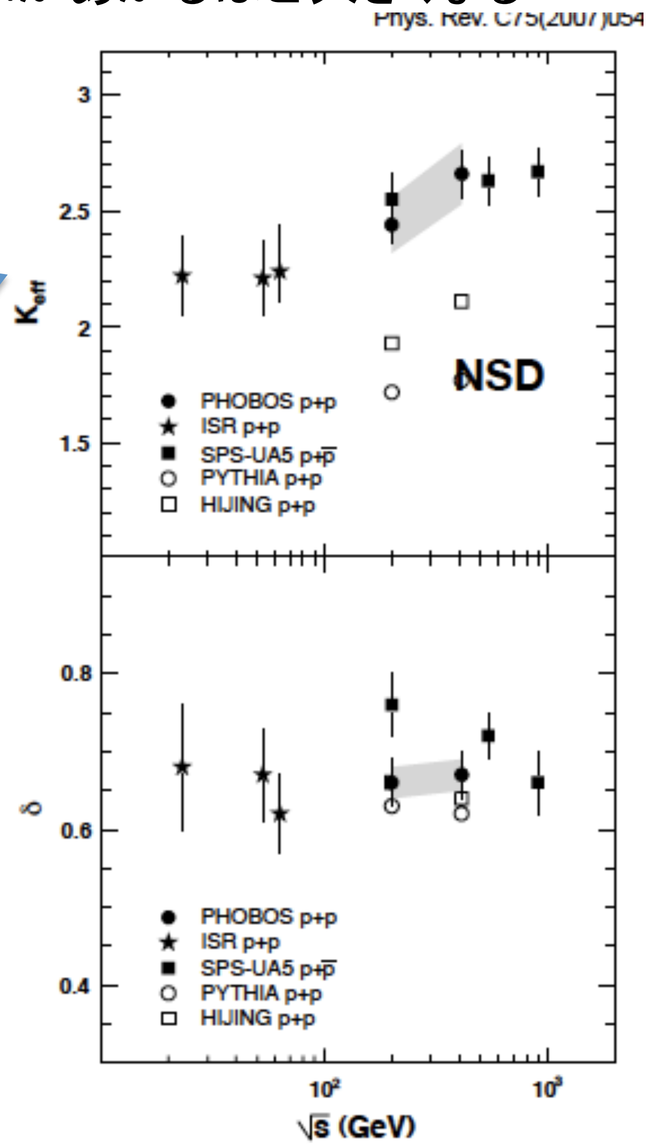
- **Coupling of induced radiation to longitudinal flow**
  Armesto et al., PRL 93, 242301
- **Recombination of shower + thermal partons**
  Hwa, arXiv:nucl-th/0609017v1
- **Anisotropic plasma**
  Romatschke, PRC 75, 014901
- **Turbulent color fields**
  Shuryak, arXiv:0706.3531v1
- **Bremsstrahlung + transverse flow + jet-quenching**
  Majumder, Muller, Bass, arXiv:hep-ph/0611135v2
- **Splashback from away-side shock**
  Pantuev, arXiv:0710.1882v1
- **Momentum kick imparted on medium partons**
  Wong, arXiv:0707.2385v2
- **Glasma Flux Tubes**
  Dumitru, Gelis, McLerran, Venugopalan, arXiv:0804.3858; Gavin, McLerran, Moscelli, arXiv:0806.4718

Currently most compelling explanation is
geometrical fluctuations, not dynamical ones

ちなみに　反対側(far side)のη依存性はPPもあって
これは昔からしられている。
直感的に、パートンのイメージがでてくると増える気がする

ECMがあがるほど大きくなる





Track　efficiency 80-90(eta<1.5) % PT>1GeV

Trigger は　High mul trigger　(L1はハード　sum ET > 60GeV
L2はソフト 3以上のhit あるとラック＞　85 or 70
85はunscaled)

2粒子相関R

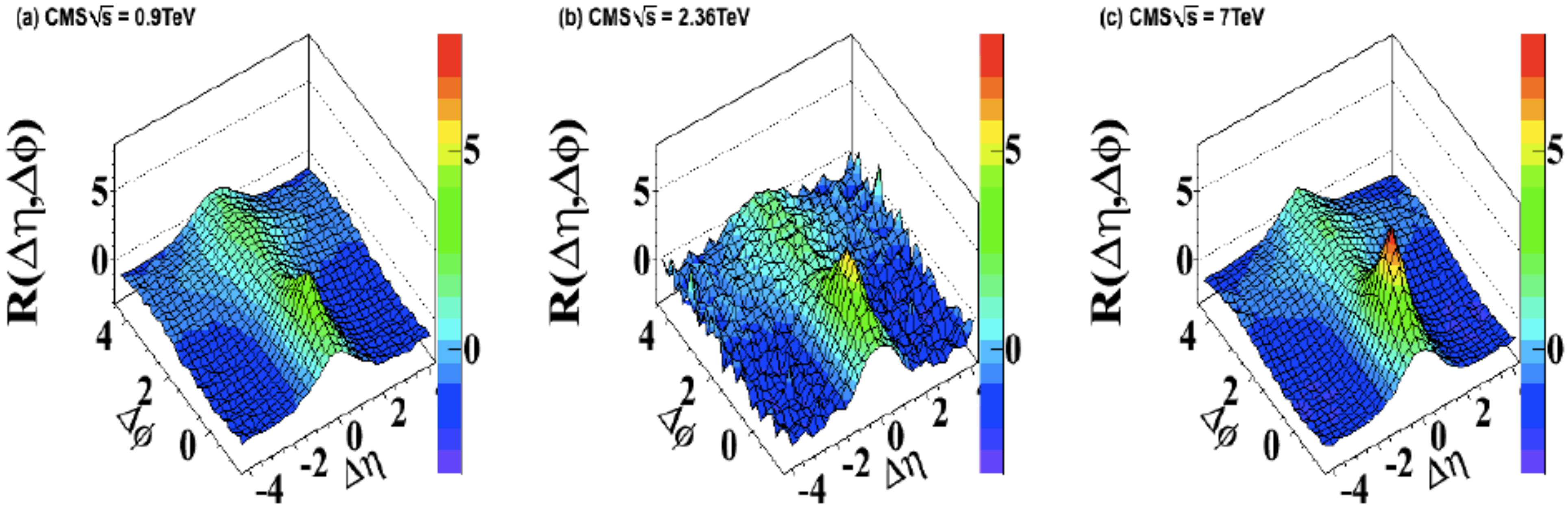
$$R(\Delta\eta,\Delta\varphi)=\left\langle (N-1)\left(\frac{S_N(\Delta\eta,\Delta\varphi)}{B_N(\Delta\eta,\Delta\varphi)}-1\right)\right\rangle_N$$

$$\Delta\eta=\eta_1-\eta_2$$

$$\Delta\varphi=\varphi_1-\varphi_2$$

5E10コリジョンで 354K事象選んだ <-> ATLASで1000倍違う
data量はL=940nb ^-1

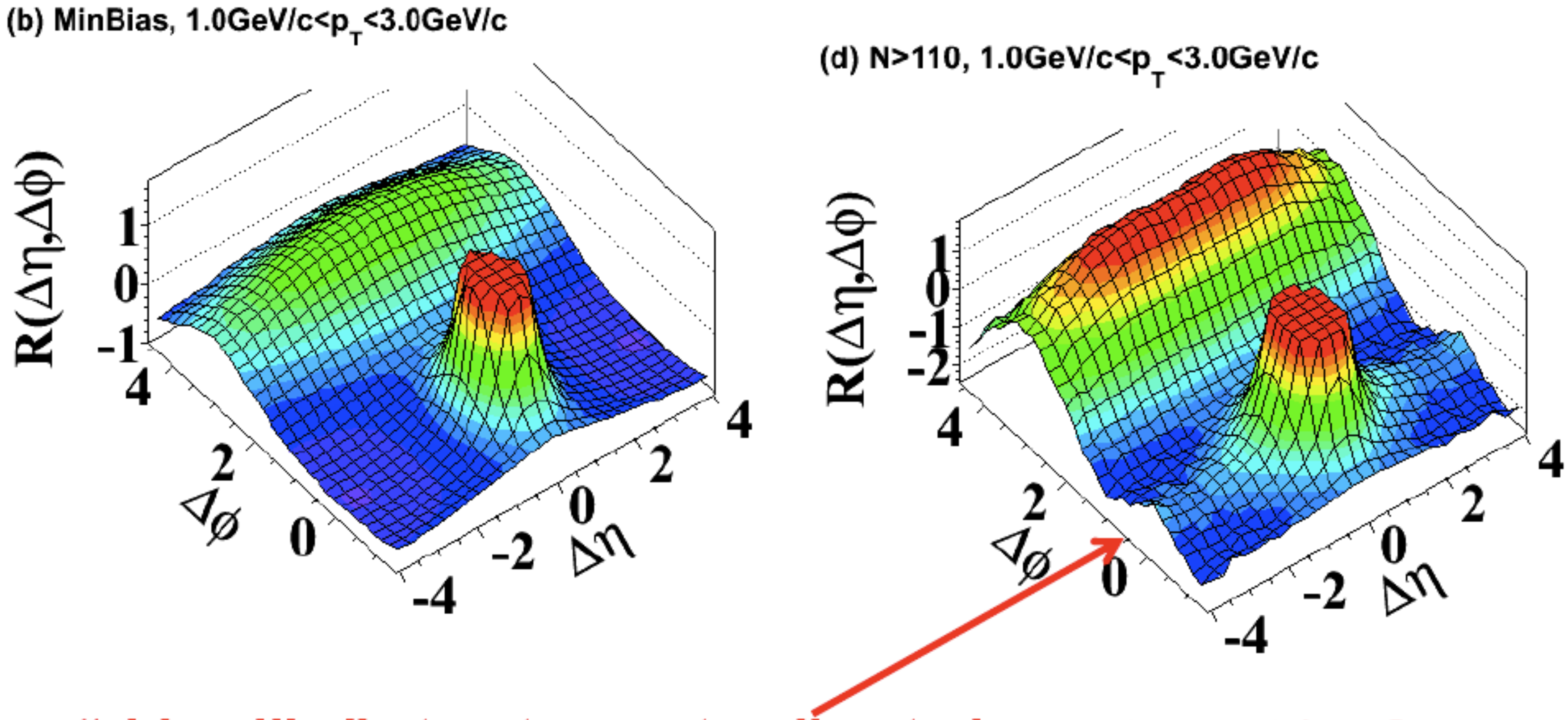
N>110 を要求すると、back-to-back構造がみえる。
QCDの事象が　enhance している



p_T-inclusive two-particle angular correlations in Minimum Bias collisions

ここまでは、MBやQCDの話

N>110(3>PT>1GeV) にすると　Ridgeがみえる。
P+Pなのに！！

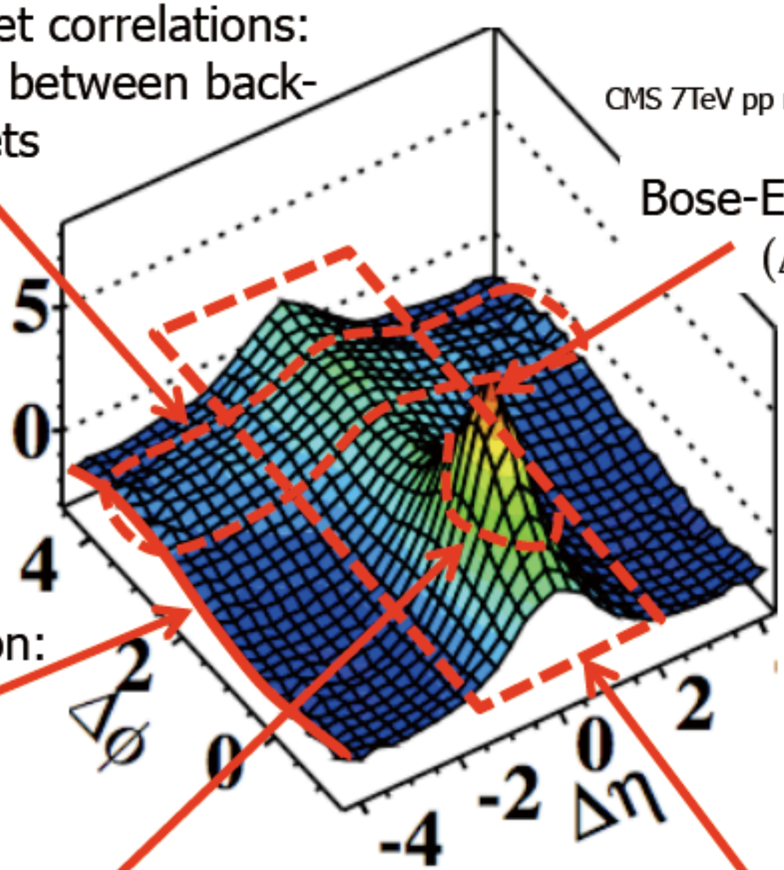


New “ridge-like” structure extending to large Δη at Δφ ~ 0

勉強になります

Angular Correlation Functions

"Away-side" ($\Delta\phi \sim \pi$) jet correlations: Correlation of particles between back-to-back jets



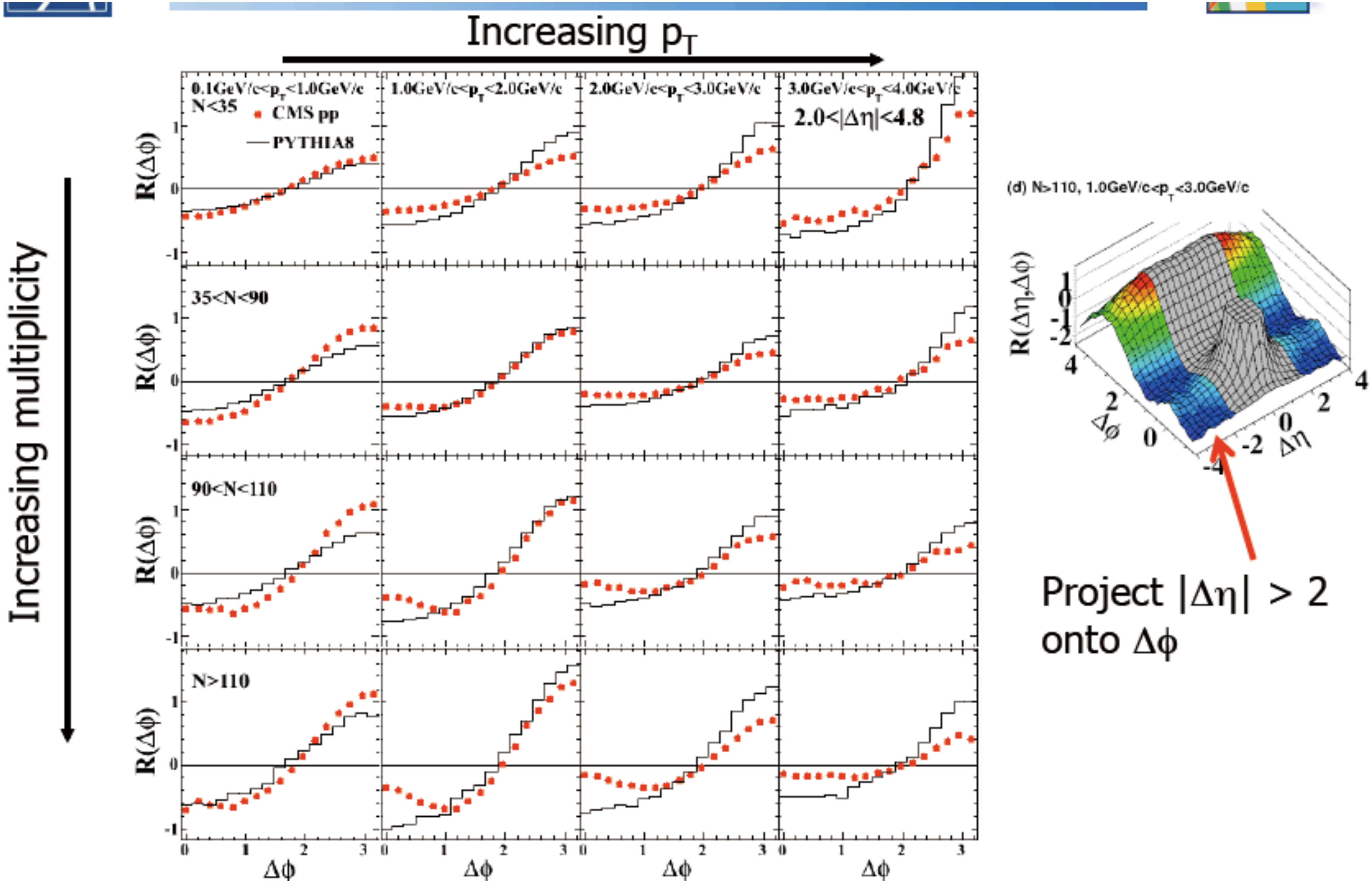
Bose-Einstein correlations: $(\Delta\phi, \Delta\eta) \sim (0,0)$

Momentum conservation: $\sim -\cos(\Delta\phi)$

"Near-side" ($\Delta\phi \sim 0$) jet peak: Correlation of particles within a single jet

Short-range correlations ($\Delta\eta < 2$): Resonances, string fragmentation, "clusters"

PT＞3GeV以上いれると弱くなる。 N>110が一番つよく見える

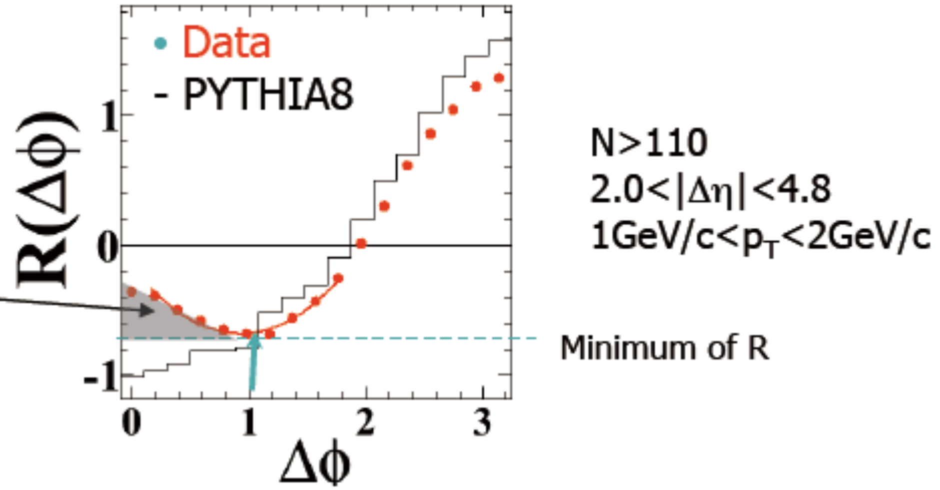


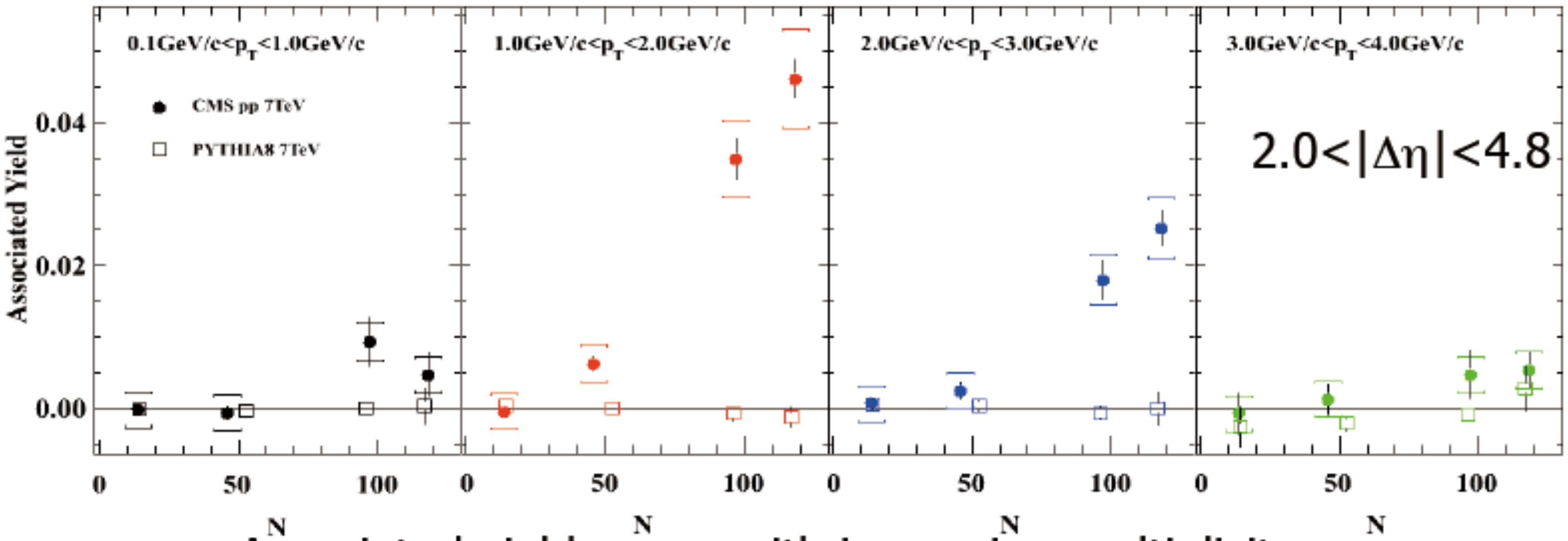
"Ridge" maximal for highest multiplicity and 1 < p_T < 3 GeV/c

PT=1-2GeV ＞2-3GeV でよく見える。 3GeV以上や1GeV以下は見えない

Zero Yield At Minimum (ZYAM)

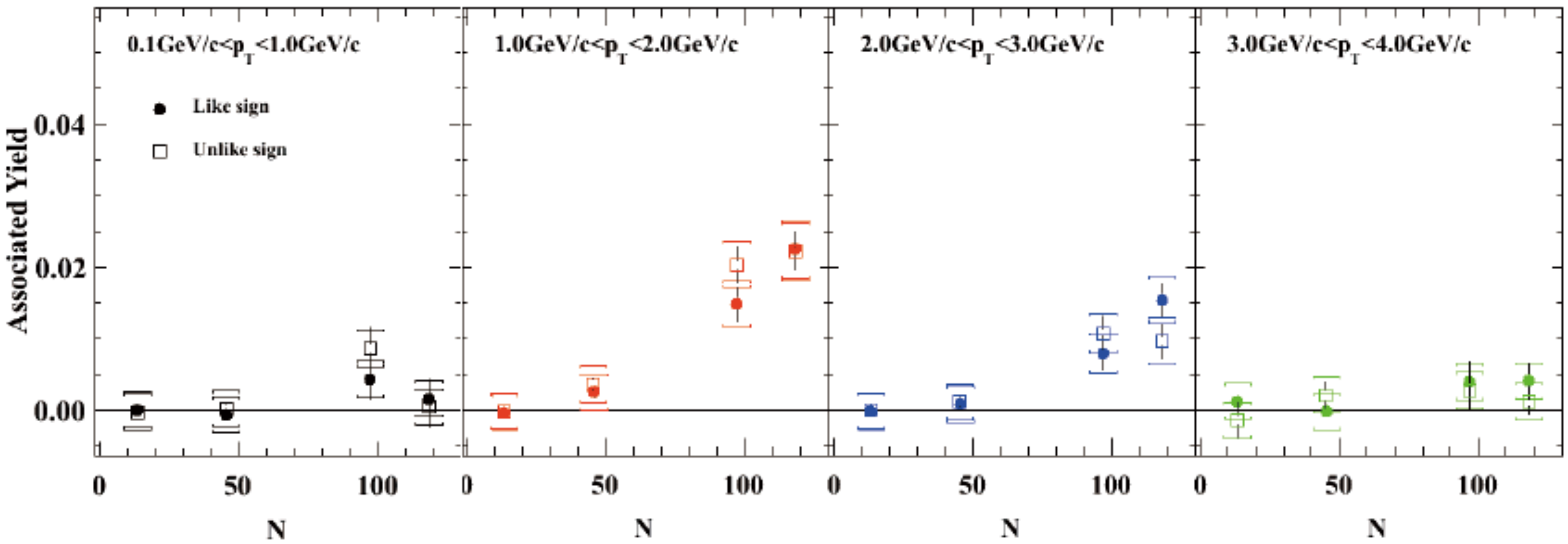
Associated yield:
correlated multiplicity per particle





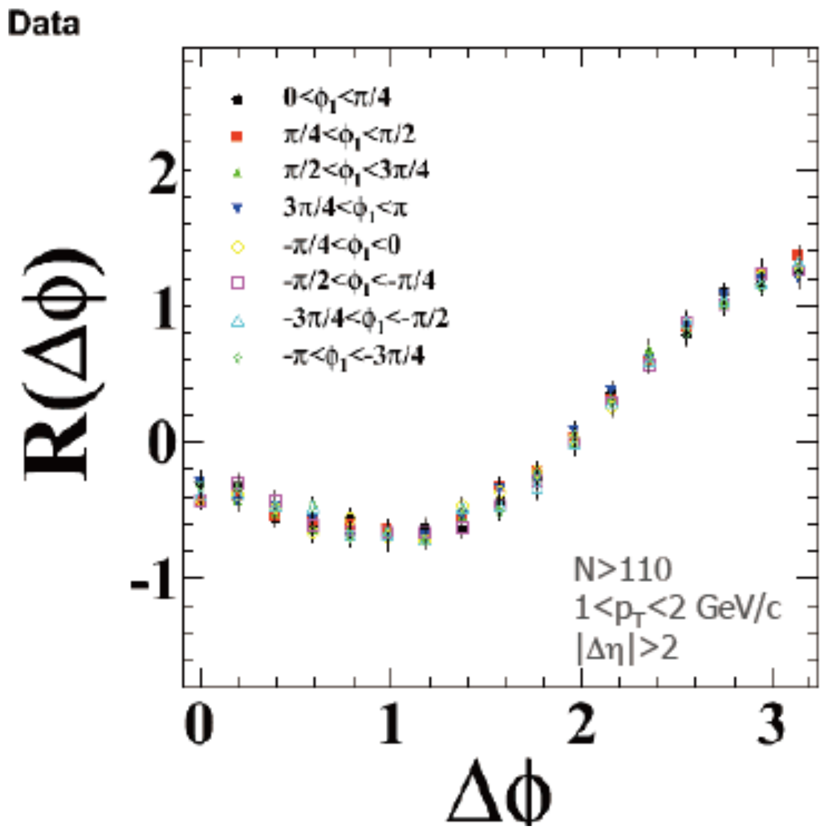
Associated yield grows with increasing multiplicity

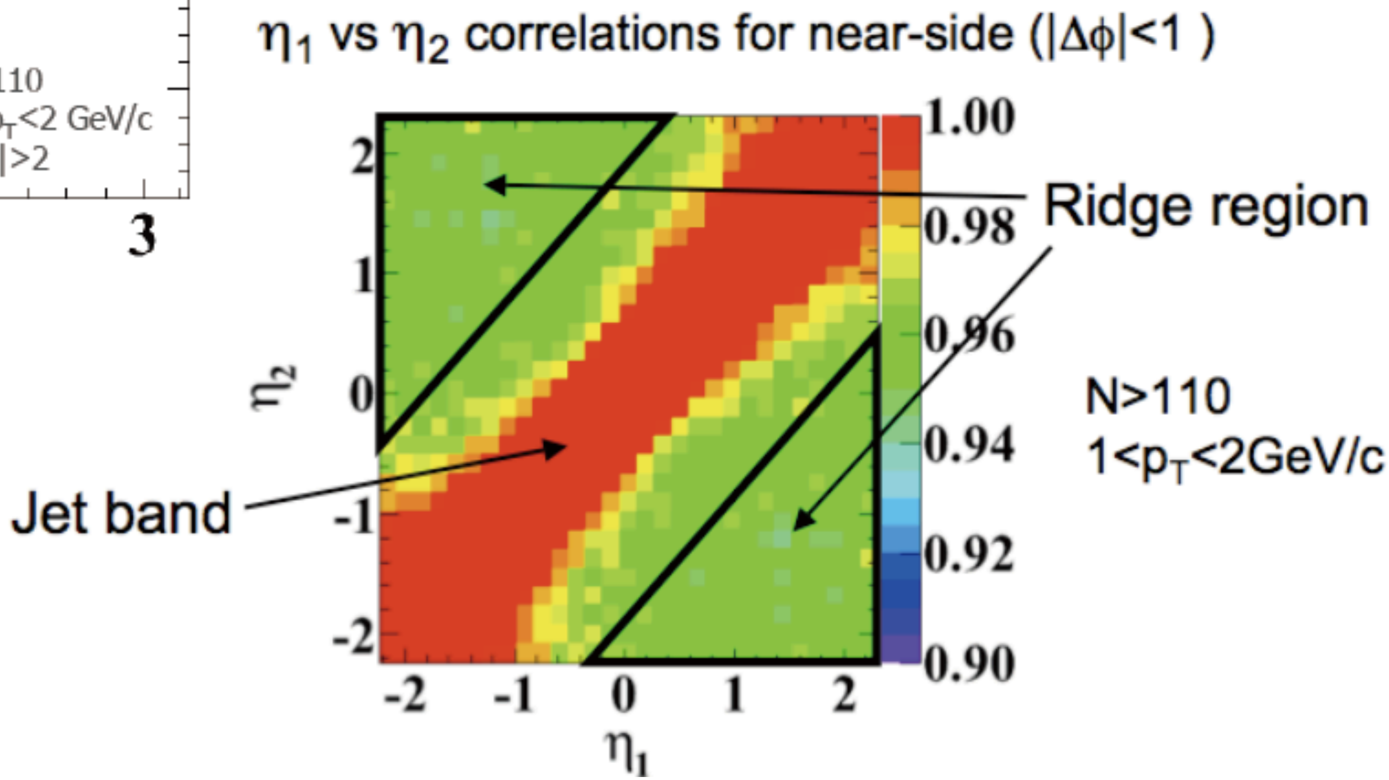
電荷は関係ない。same sign も　opposite signも同じ



No dependence on relative charge sign

検出器効果でない　（ϕ対称、 ridgeの事象は特別なetaにいない）





なんなんでしょう？

ほんとうに trigger バイアスないのかな？

Rigdeは　QGPでなく　soft QCDの話ってことになるよね。