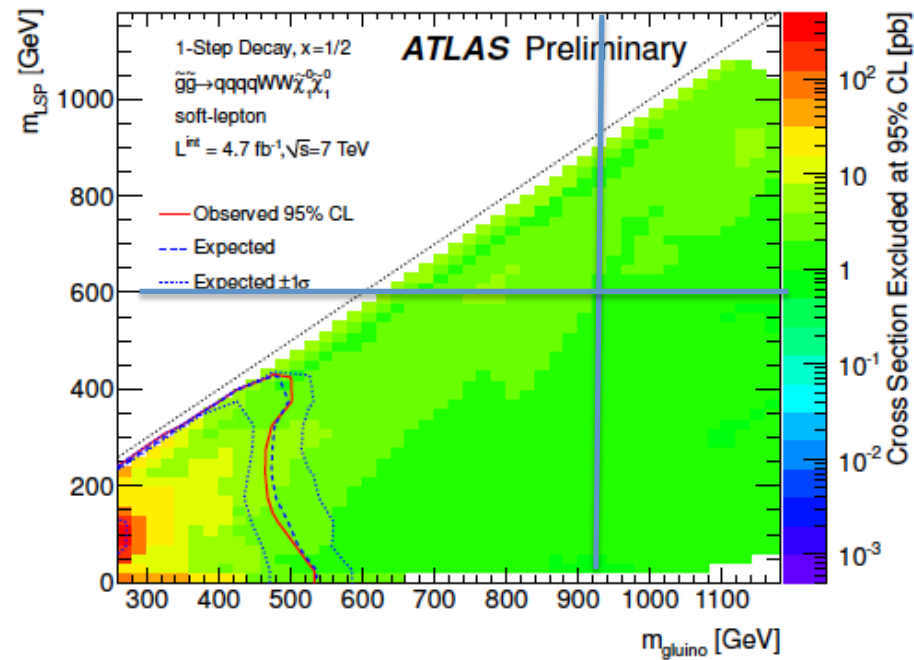
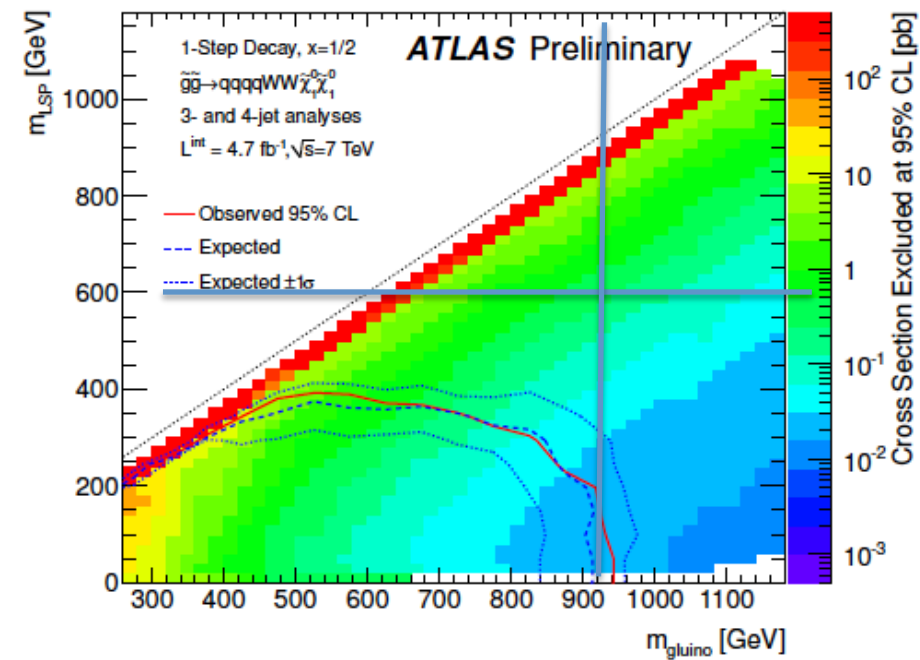


LHC実験最新成果 後半

1. LHC加速器の現状と今後の予定
2. 検出器のレビュー SM過程の check
3. ヒッグス粒子
- 4A. 超対称性 mETもの
- 4B. 超対称性 長生きもの
5. 余剰次元
6. TC, W', Z' 4th

浅井



もう少しアイデアいるかな？

4B SUSY with Exotic signature

Motivation

- (1) AMSB Wino LSP chargino life $\tau = 1-10$ cm
- (2) GMSB stau NLSP stable in detector or decay in ID Gravitino DM
- (3) SPLIT SUSY ($m_0 > 1000$ TeV) gluino \rightarrow R-hadron
- (4) R-parity violation If coupling is small displaced vertex

Signatures

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

(A1) dE/dx energy loss in the semiconductor, $\tau \gg$ detector size

(A2) TOF information in Cal. or muon system ($\beta < 1$)

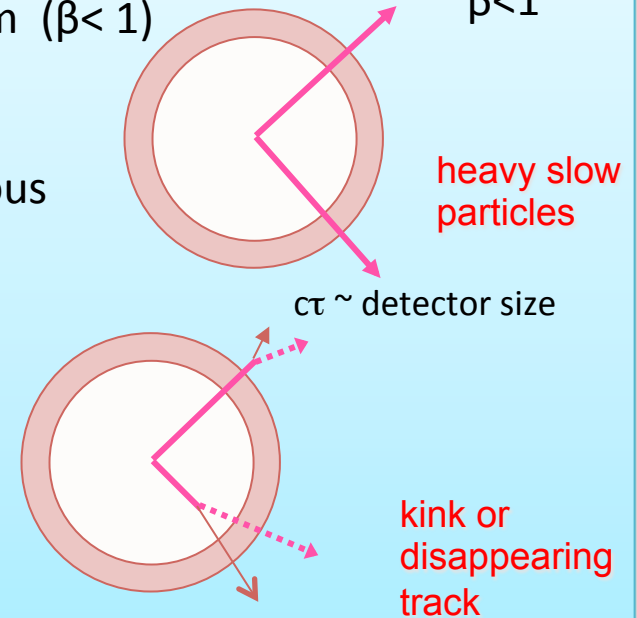
$\beta < 1$

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

(B1) Kink/Disappearing track in the continuous tracking system (ATLAS)

(B2) neutralino decay with long-life displaced vertex is found

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

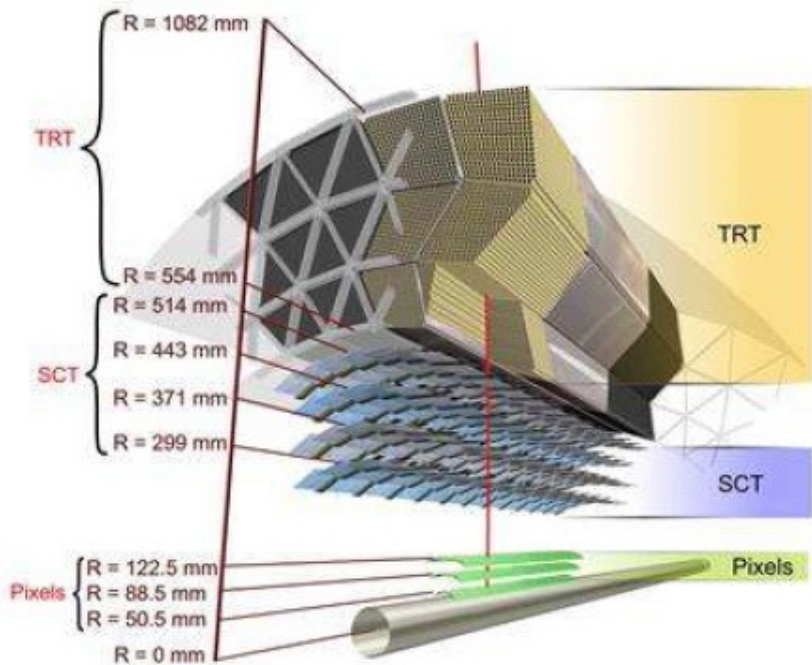


methods as function of lifetime

ctγ 0.1mm 10mm 100mm 1000mm ∞

→

	Displaced Vertex	dE/dx in Pixel	Kink / Disappearing	dE/dx in TRT	Time of Flight In Calorimeter	Time Of Flight In Muon Spectrometer	Stop in Calorimeter
RPV	✓		✓				
AMSB		✓ ?	✓ ★				
Stau LL		✓ ★	✓		✓	✓ ★	✓
Stau SL	✓ ?						
R-had		✓			✓	✓	✓

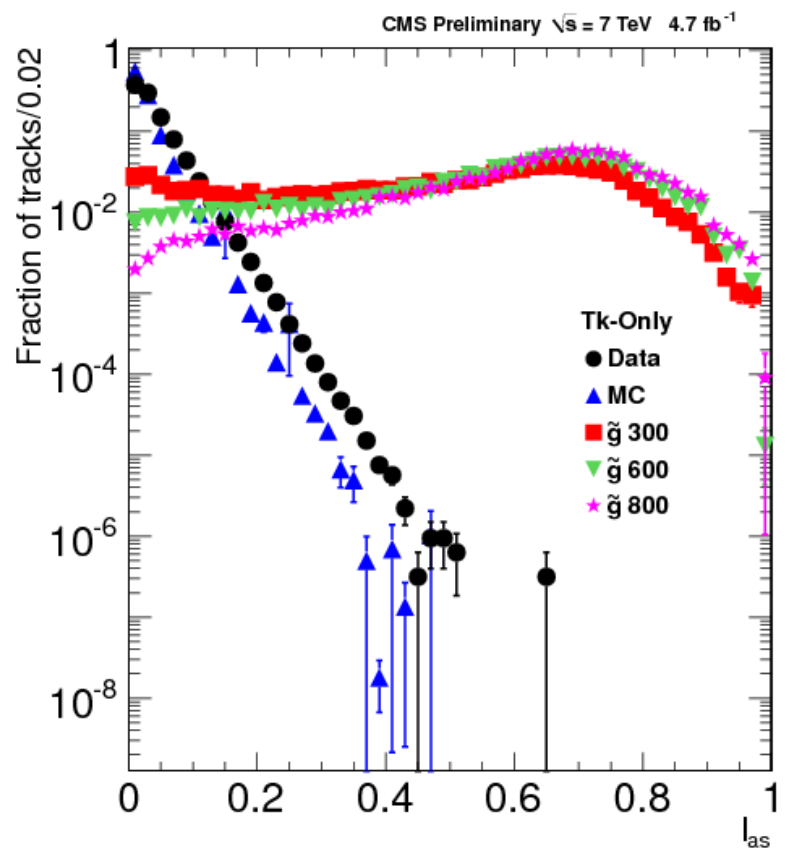
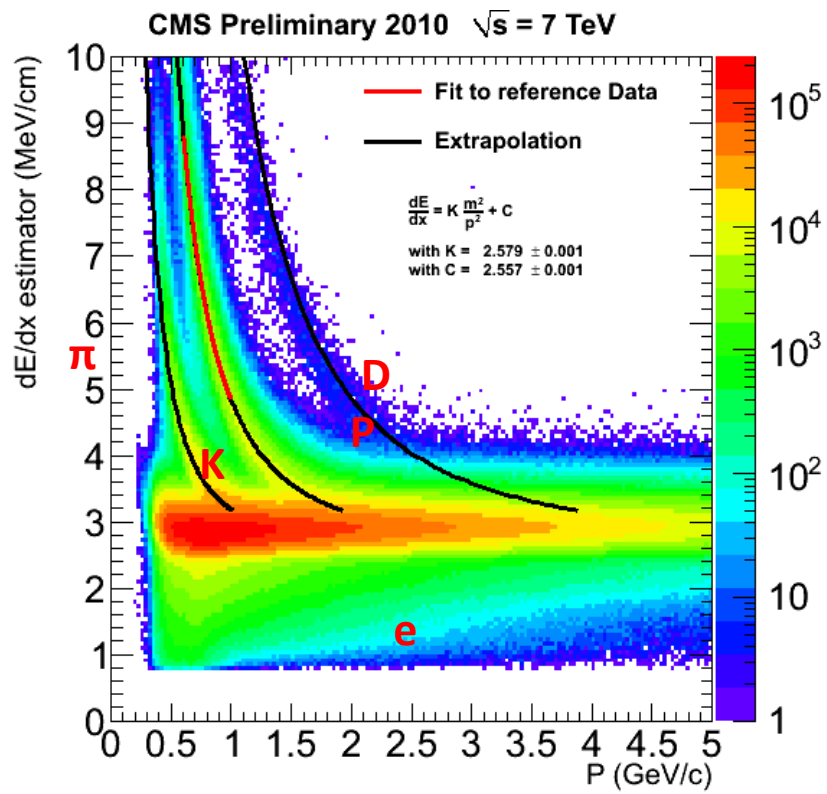


Radius of each detector

	ATLAS	CMS
Vertex	0.1mm	0.1mm
Pixel(dE/dx)	5-10cm	5-100cm
TRT	50-100cm	No
Hcal	2-4m (Δ t ~ 1nsec)	1.5-2.5m
μ	5-10m (Δ t ~ 1nsec)	4-6m

Hadronic calorimeter Fe or cu
Depth 1m time resolution ~ 1nsec

(A1) dE/dx in Si tracker



$$l_{as} = \frac{3}{N} \times \left(\frac{1}{12N} + \sum_{i=1}^N \left[P_i \times \left(P_i - \frac{2i-1}{2N} \right)^2 \right] \right),$$

Ionization energy loss
 $dE/dX \sim 1/(\beta\gamma)^2$

P_i is the probability for a minimum-ionizing particle (MIP) to produce a charge smaller or equal to the i -th charge measurement for the observed path length in the detector

(A2) TOF information using muon/Calo

drift time = TDC output time
 - T_0 (flight time from IP)

drift circle = function(drift time)

Then the position is determined.

But $\beta=1$ is assumed for this calculation.

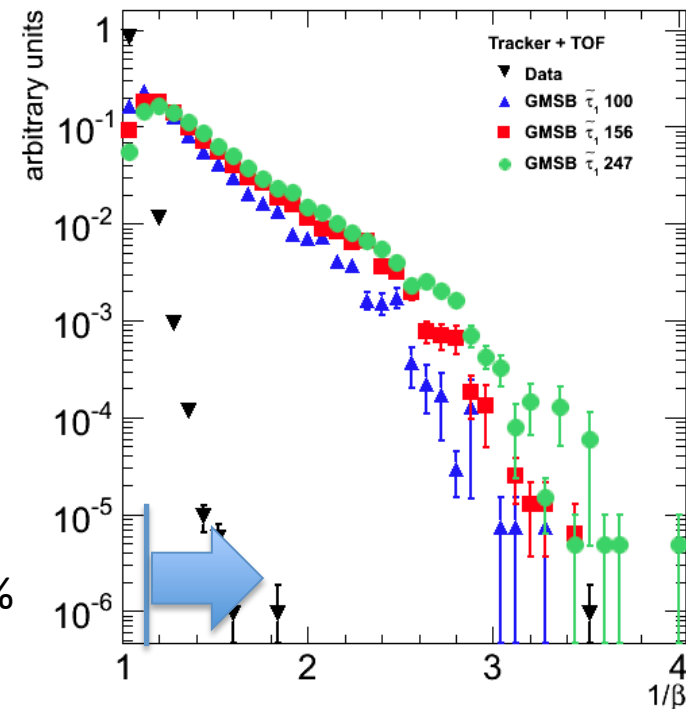
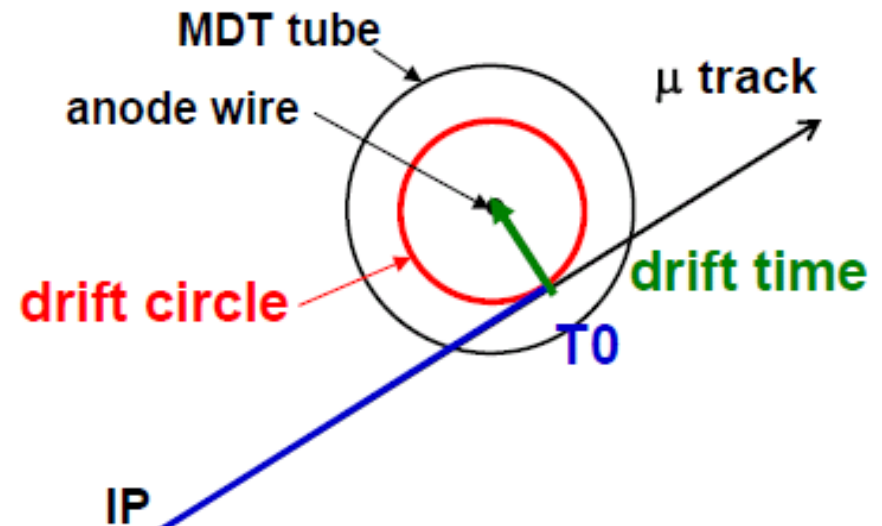
For the particle with $\beta < 1$,
 drift circle become wrong.

Then the χ^2 becomes worse, since the
 calculated drift is worse.

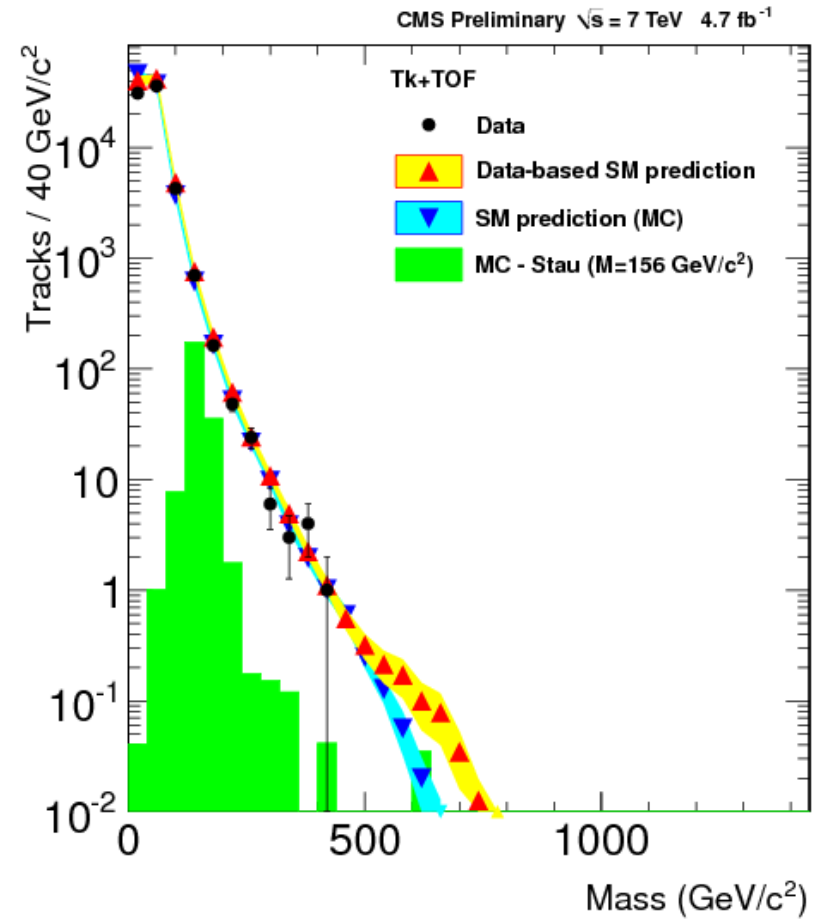
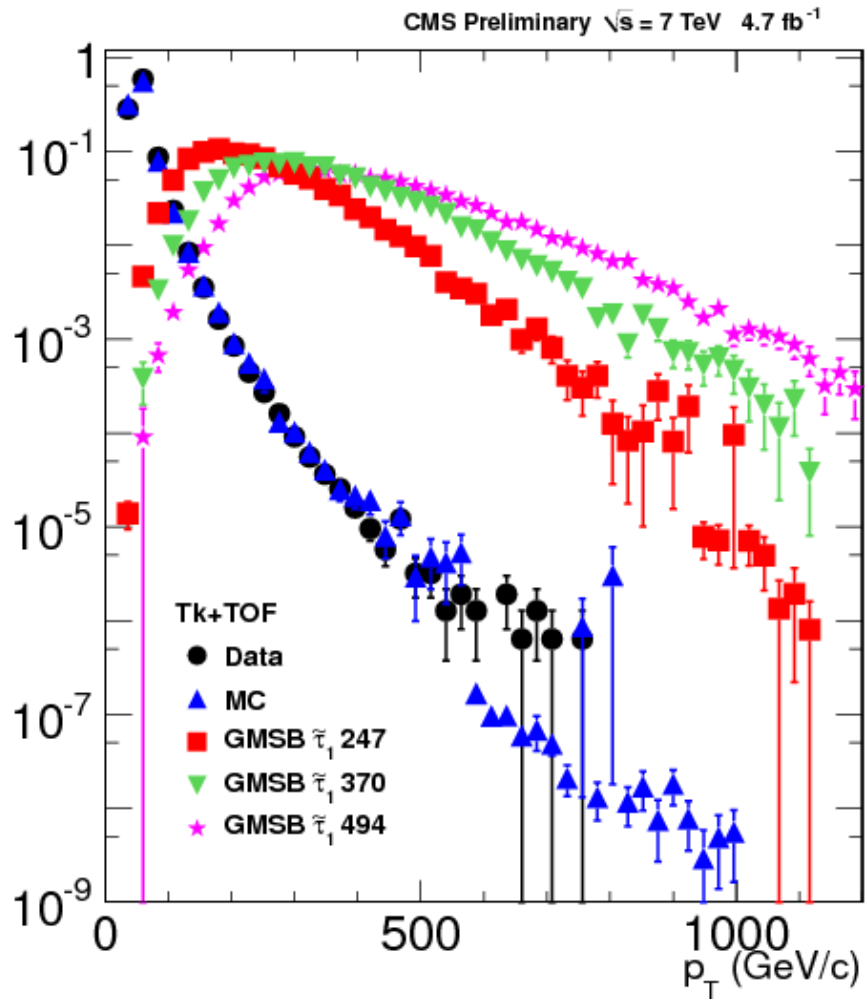
T_0 is fitted to obtain best χ^2

$$\beta = 0.3 - 0.95$$

β resolution $\sim 7\%$

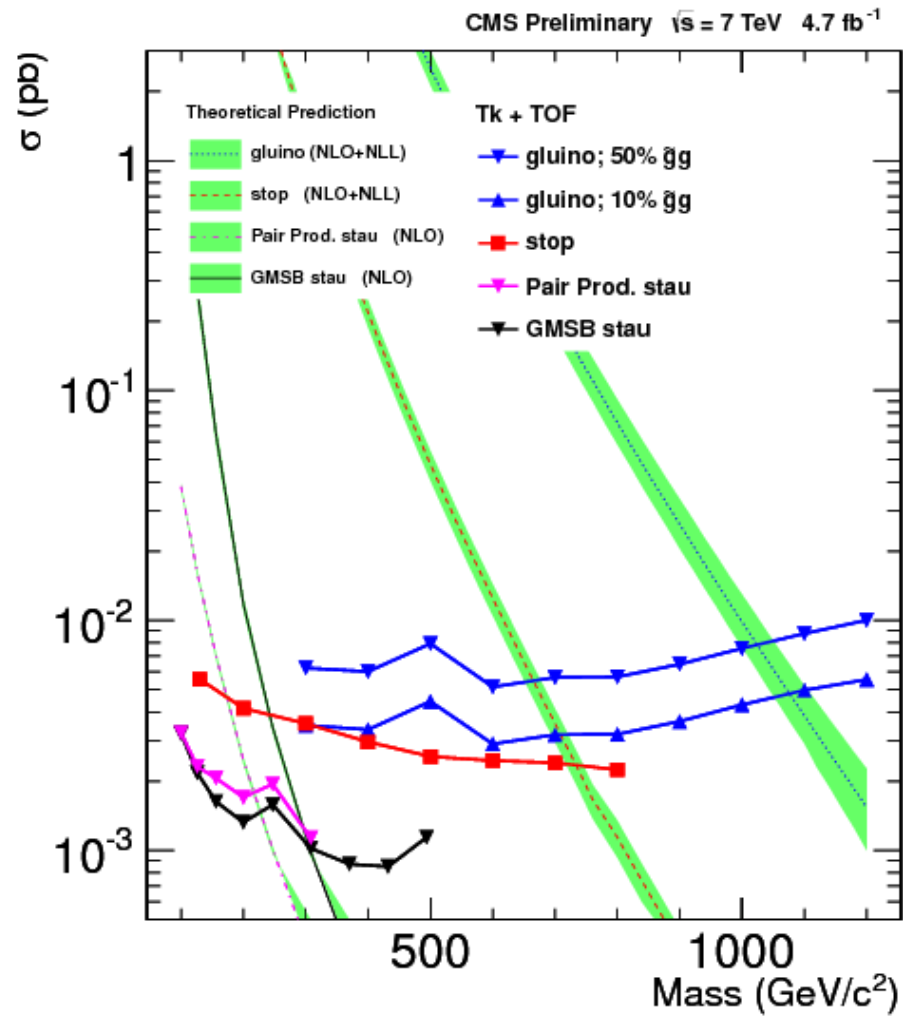


(A1) dE/dx in ID + (A2) muon TOF (I)



$$m = p \frac{\sqrt{1 - \beta^2}}{\beta}$$

(A1) dE/dx in ID + (A2) muon TOF (II)

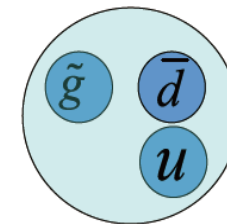


Obtained limits

232 GeV is excluded (95%CL)
for stable stau.
direct production

1091 GeV for stable gluino

R-hadron: R^\pm



Stable R-hadron

(B) 消えたり折れたりするトラック

AMSB Chargino is Long-Lived

since $c\tau \sim 0(10\text{cm})$, reasonable number of Chargino decays in TRT (R=50-100cm)

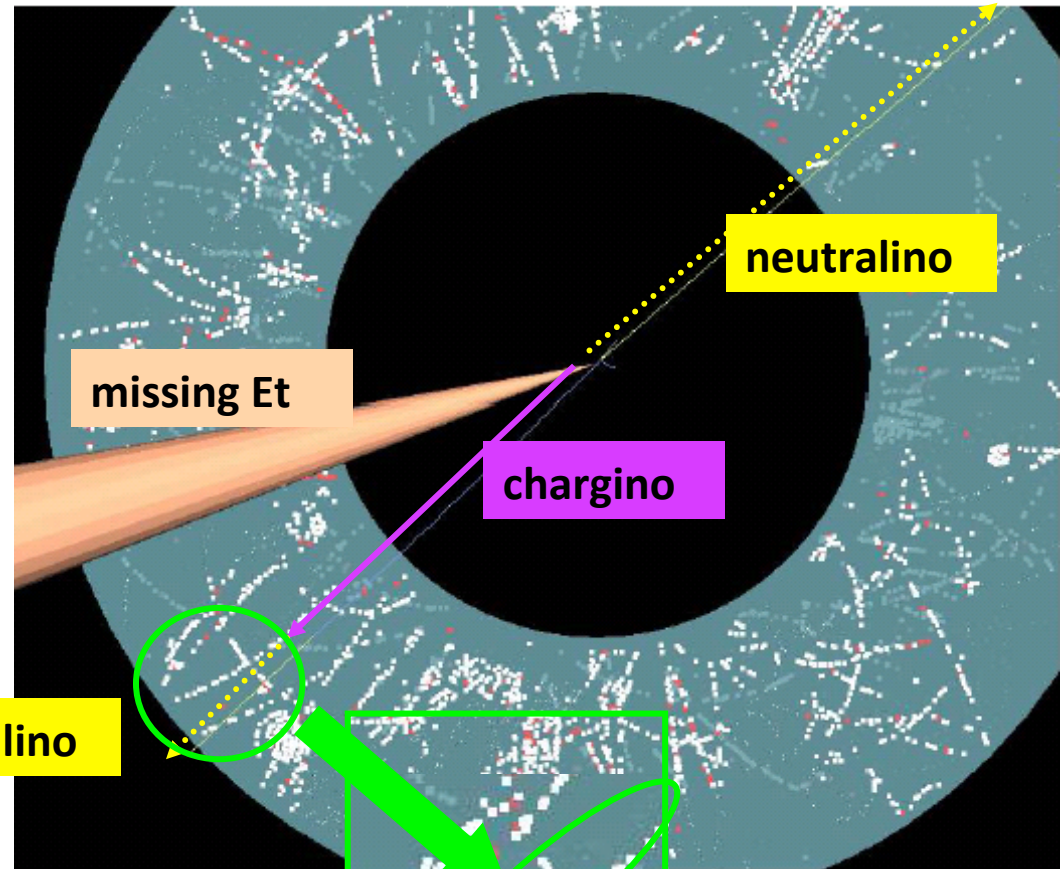
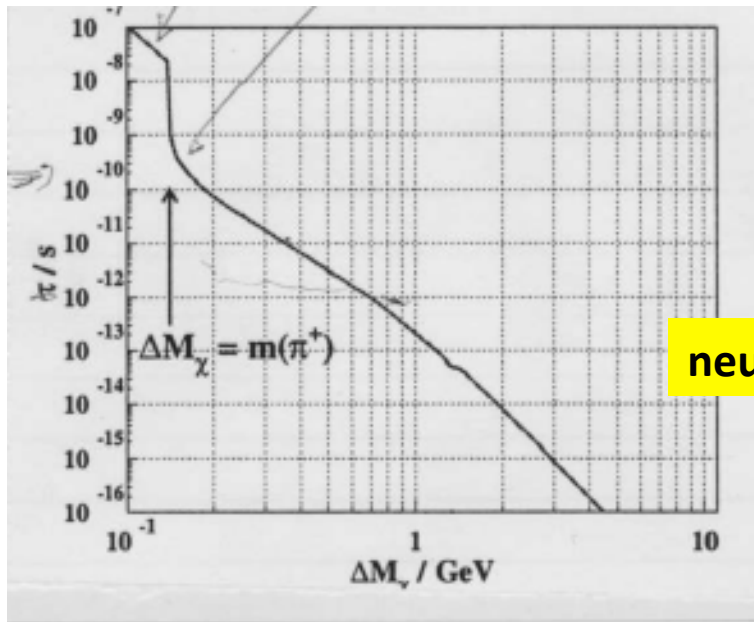
This is the Simulated Events

Wino is LSP/NLSP

$\Delta m(\text{wino}^+ - \text{wino}^0) \sim 150-170\text{MeV}$

Predictable and lifetime $c\tau \sim O(3\text{ cm})$

Charged Wino decays in ID:



BG free (clean)

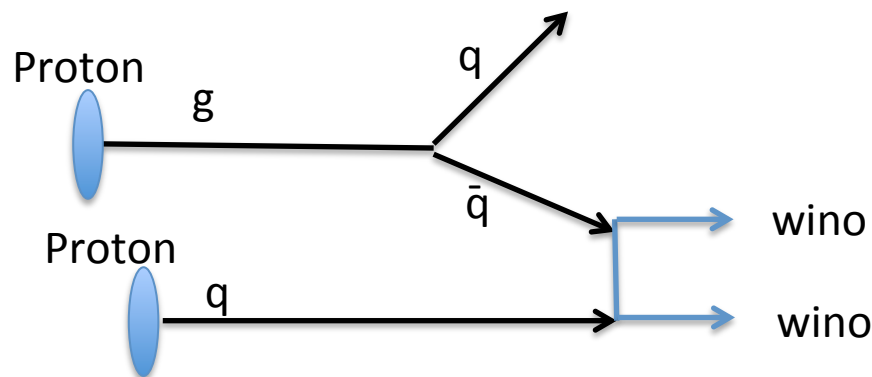
Kink track is observable

Anomaly Mediated SUSY Breaking (Hierarchy case)

Table shows gluino/chargino masses and cross-section of glunino and direct wino production @7TeV

Mass Gluino	Mass chargino	Gluino σ	Wino σ
842GeV	99GeV	35fb	12pb
984GeV	120GeV	11fb	5.7pb
1124GeV	140GeV	4fb	3.0pb
1251GeV	160GeV	1.6fb	1.8pb
1386GeV	180GeV	0.6fb	1.1pb

Gluino is heavy and cross-section is small.
On the other hand, Chargino is still light



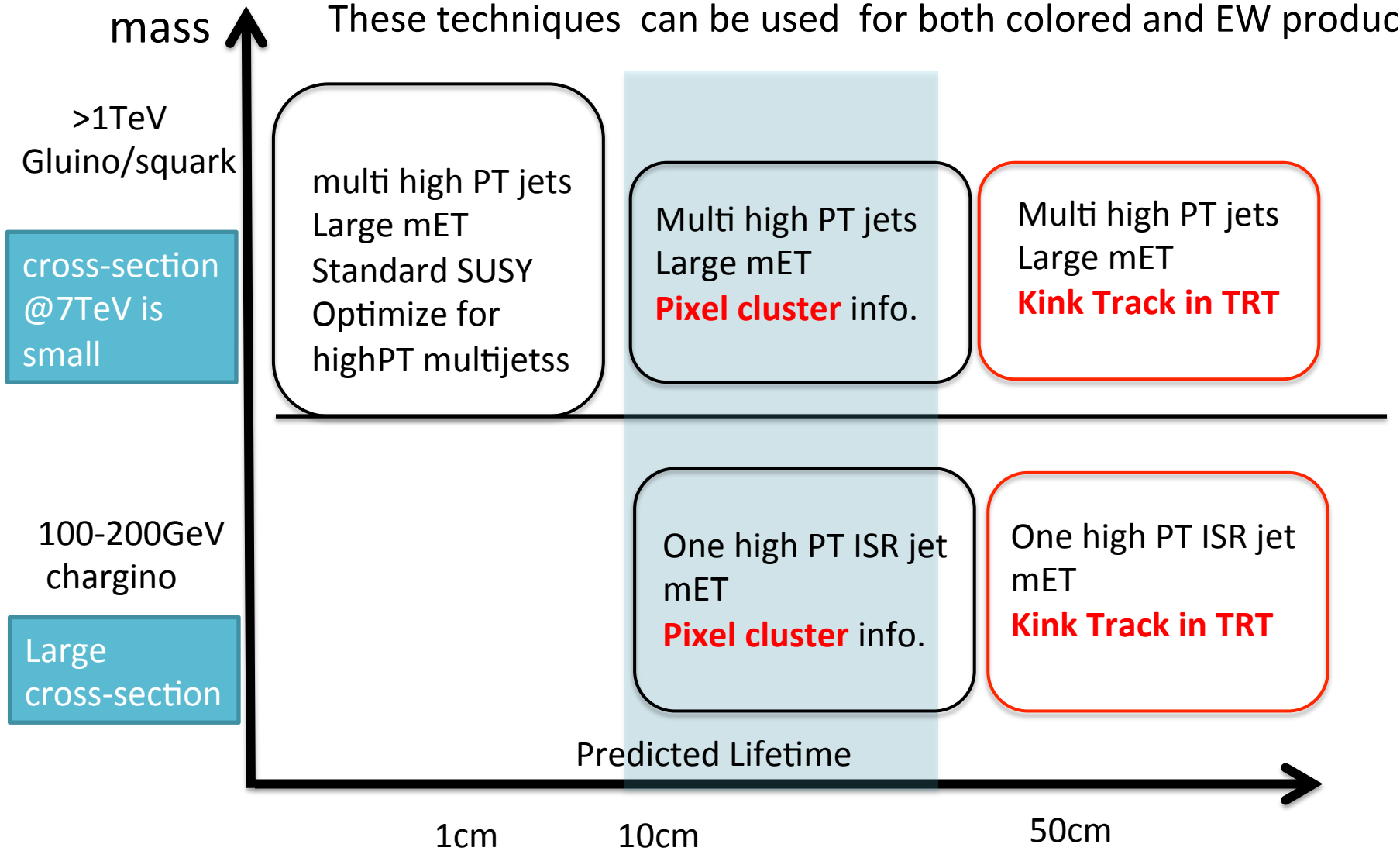
Wino Pair (+-, +0) productions have large cross-section (factor 1000) and also high PT jet (ISR) is expected since LHC is gluon quark collider.

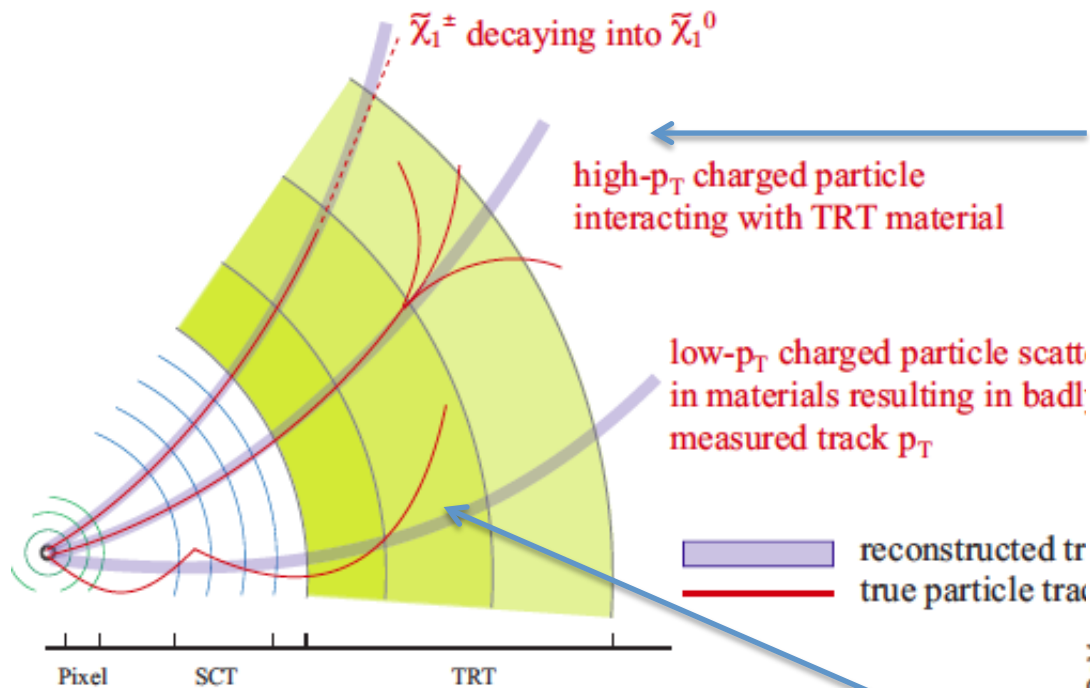
Monojet topology + Wino signal is signature

BUT the similar SM process $gg \rightarrow qZ \rightarrow q \nu \nu$ (monojet) has large cross-section: We need additional signatures of AMSB to reduce this BG process.

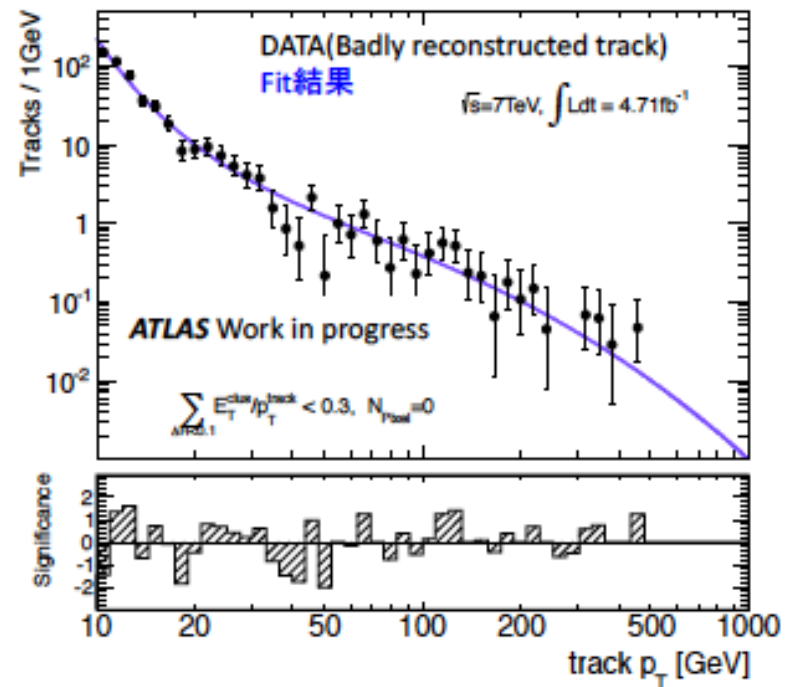
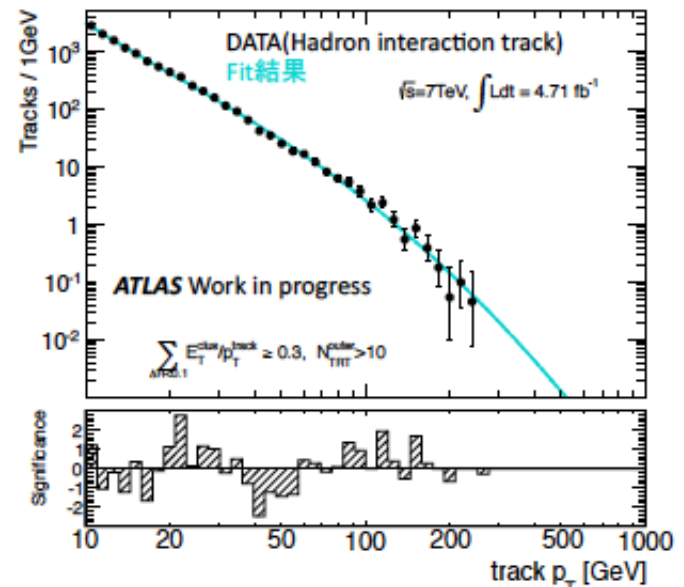
AMSB 5つのトポロジー

These techniques can be used for both colored and EW productions

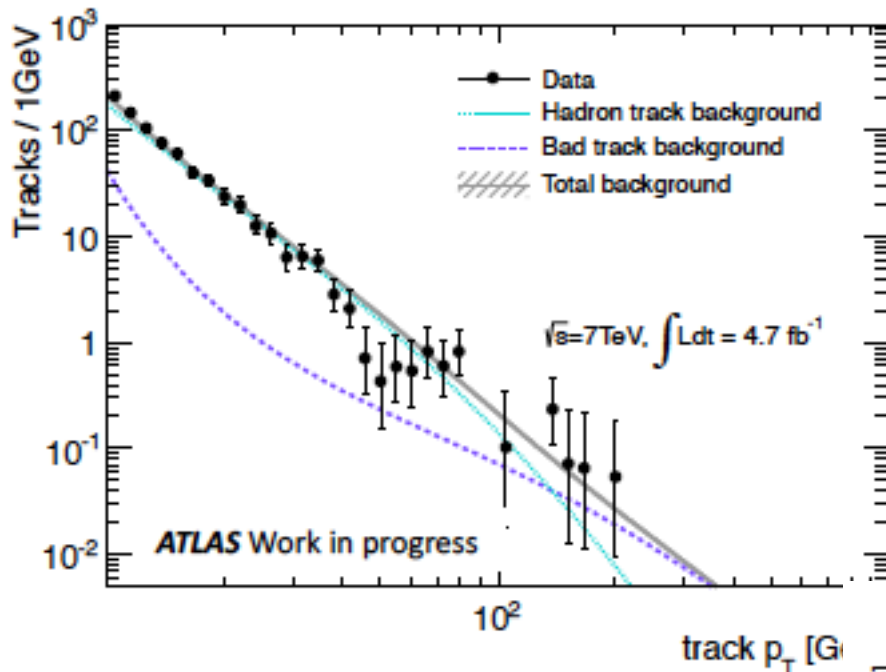




High PT ではこっちが main



Fit result (Background only)



たぶん、EW gauginoが
うまく行った最初の例

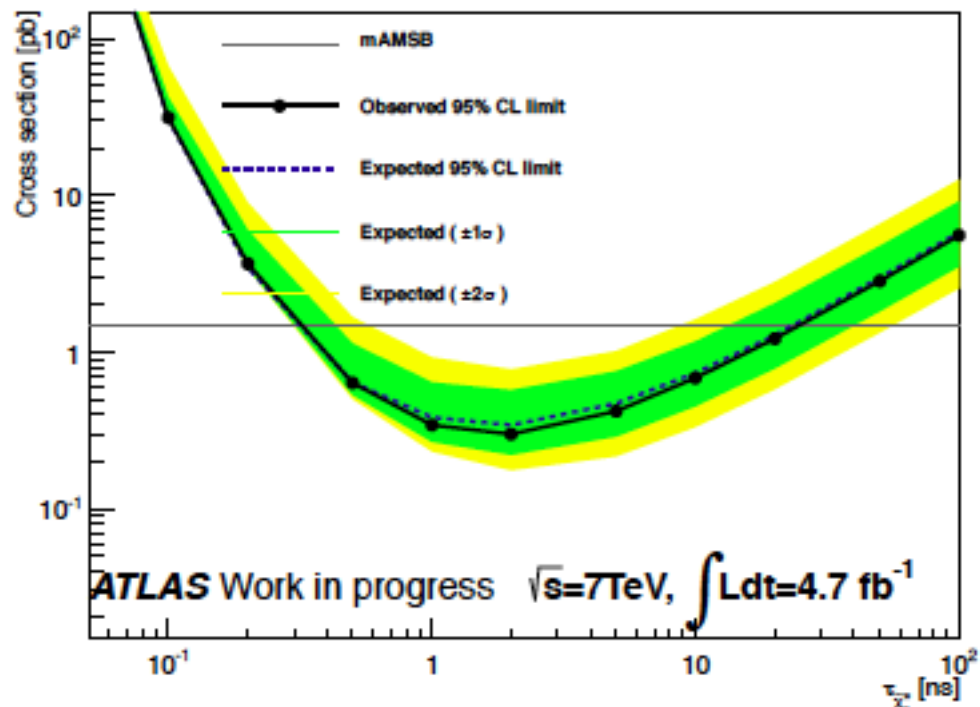
LHCはPPなので、EW directは
そんなにお得でない。
BG suppress する何かメカニズム

PT distribution for disappearing track
in TRT

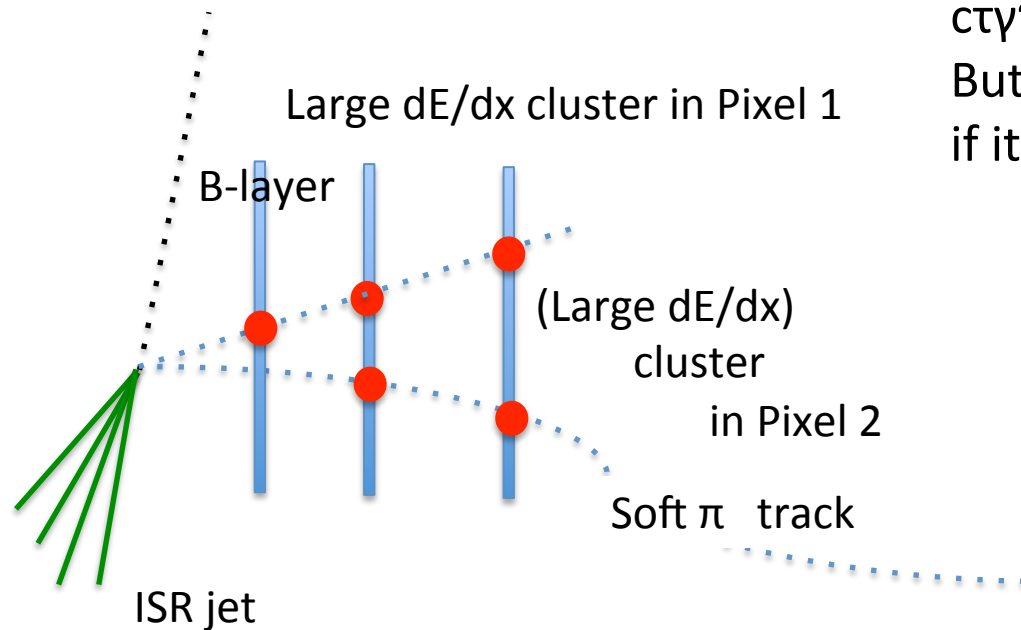
Wino > 181GeV for $\tau=0.3-30$ nsec
Wino > 99GeV for $\tau=0.1-60$ nsec

mAMSB 1:3:5
gluino * 5 Large $m_0 > 900$ GeV?

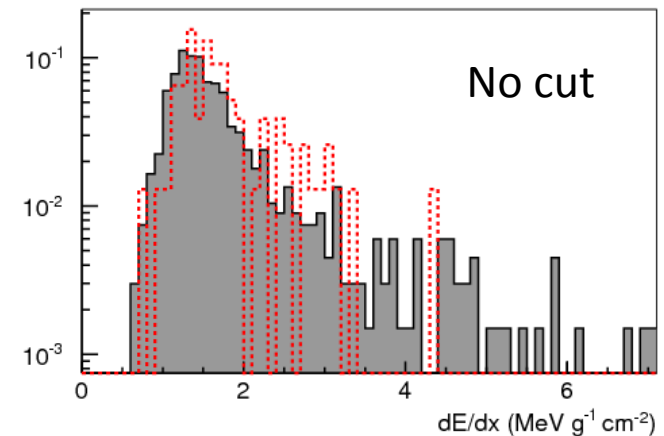
Chargino mass=181GeV



より短寿命をめざして(dE/dx information in Pixel)



$\tau_{\pi} \sim 10\text{cm}$ (No lifetime suppression)
 But Track is not reconstructed
 if it decays before 2nd Layer of SCT.



Extrapolate tracklet from Primary vertex to clusters in Pixel layers assuming $P_T > 100(?)$ GeV
 large dE/dx clusters in Pixel detectors are used. $dE/dx \sim 1/\beta^2$

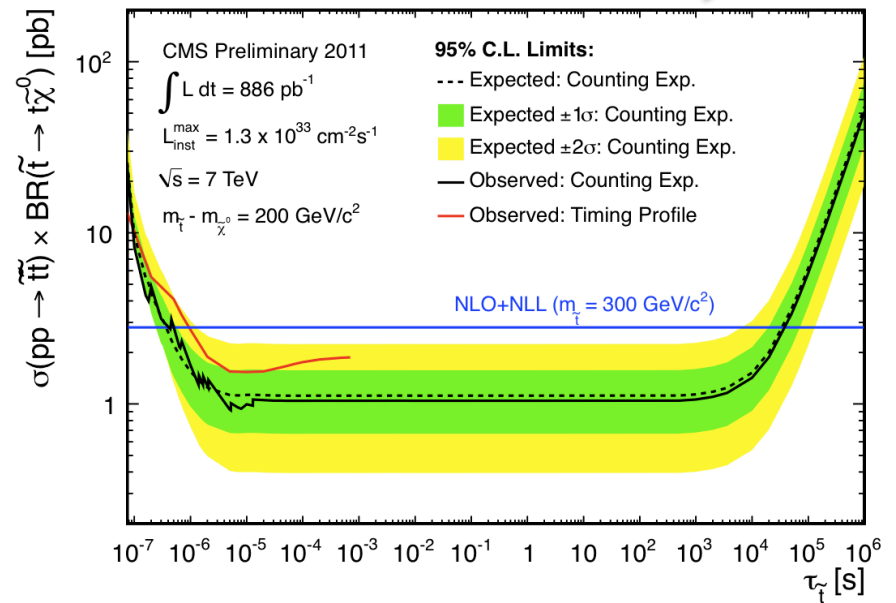
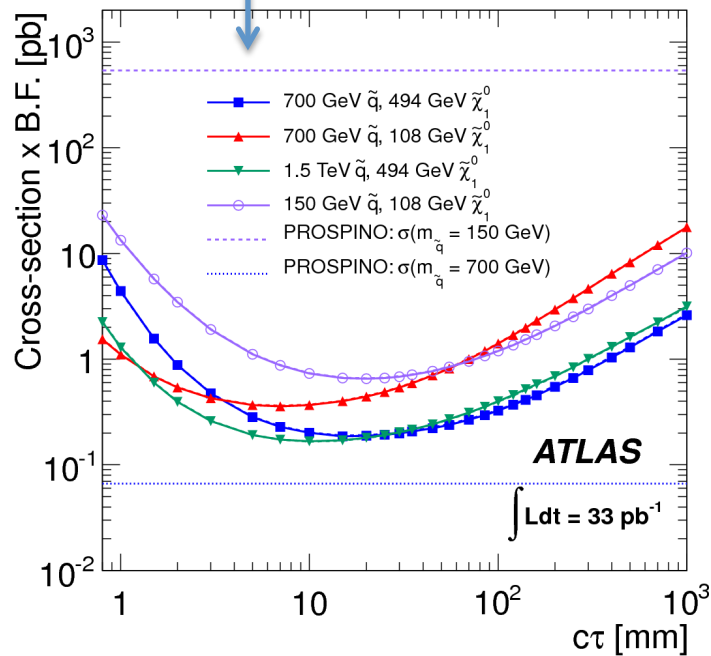
BG? Soft $\pi^{+-} \rightarrow$ reduction are possible since P is low. Combinatorial BG is serious.
 (Shimpei Yamamoto is checking)

Monojet $P_T(>120\text{GeV})$ + Large $m_{\text{ET}}(>100\text{GeV})$ is basic topology ;
 JET+MET trigger is crucial

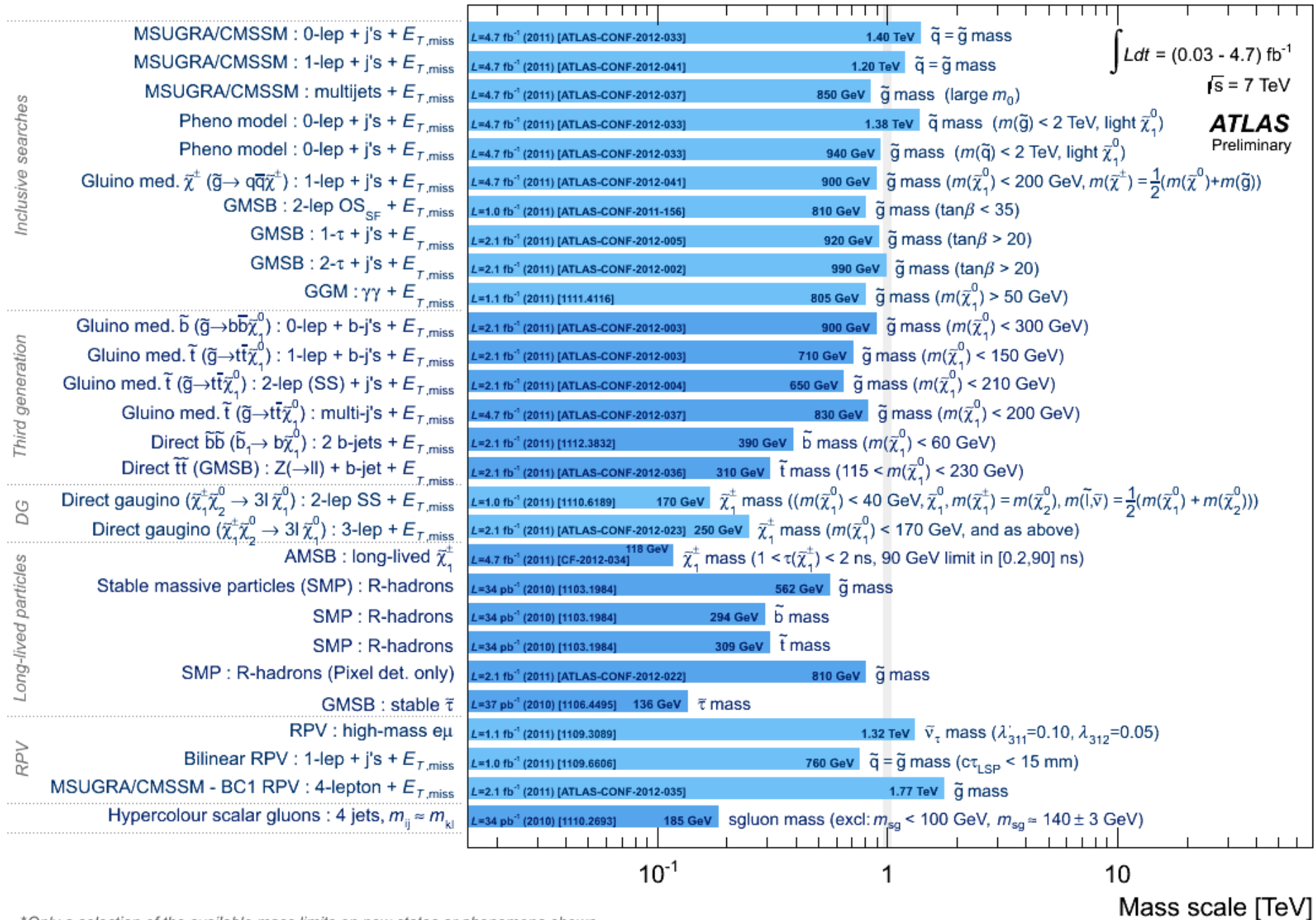
methods as function of lifetime

$c\tau$ 0.1mm 10mm 100mm 1000mm ∞

	Displaced Vertex	dE/dx in Pixel	Kink / Disappearing	dE/dx in TRT	Time of Flight In Calorimeter	Time Of Flight In Muon Spectrometer	Stop in Calorimeter
RPV	✓						
AMSB			✓ wino 180GeV				
Stau LL		✓	stau 232GeV			✓	
Stau SL							
R-had		✓	R-had 1.09TeV Stop 735GeV			✓	



ATLAS SUSY Searches* - 95% CL Lower Limits (Status: March 2012)



*Only a selection of the available mass limits on new states or phenomena shown

まとめ

- (1) mET SUSY squark/gluino $\sim 1.5\text{TeV}$
gluino $\sim 850\text{GeV}$ (large m_0)
- (2) Direct Stop 300-400 GeV
- (3) small Δm ($< 300\text{GeV}$) ISR+ soft
- (4) EW direct
- (5) Long Lived stau $> 230\text{GeV}$
- (6) kink, disappearing AMSB wino $> 180\text{GeV}$ ($\tau > 0.3\text{nsec}$)

おまけ

General comments on BG processes

BG estimation is crucial for SUSY hunting, since no peak is expected.

Main BG is W/Z +jets,

top pair production and QCD multijet processes.

(diboson also contributes to EW gaugino direct production)

Control regions are defined to enhance these SM BG processes and check the various distributions.

BG1: Control regions (QCD)

QCD multi-jets processes contribute to BG for many SUSY searches, when ν emits in a heavy flavor jet or when jet energy is miss-measured (Fake mET) .

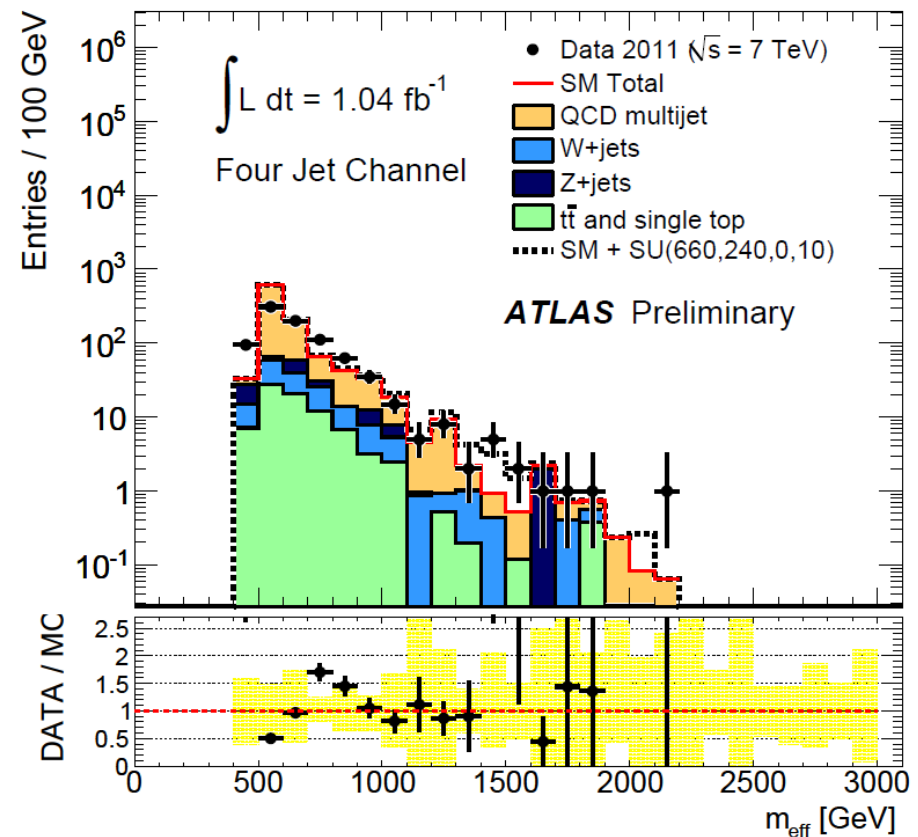
Large mET is useful variable for SUSY. Also Scalar sum of Jet activity(HT) is useful. Sum of them, $M_{\text{eff}} = m_{\text{ET}} + \sum \text{PT}(\text{jet})$ is used in ATLAS.

Data is harder than PYTHIA prediction.

PYTHIA is parton shower scheme, To produce high PT jet, Q^2 of shower evolution is set high, still not enough, On the other hand, Q^2 is high then too many jets are produced in PYTHIA and there is discrepancy.

QCD BG is estimated with real data using this CR

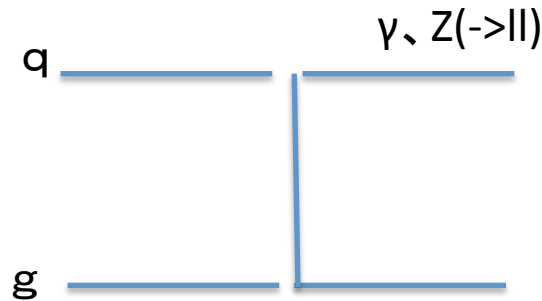
$\Delta\Phi(\text{jet vs } m_{\text{ET}}) < 0.4$ is required to obtain QCD sample



$M_{\text{eff}} = m_{\text{ET}} + \sum \text{PT}(\text{jet})$

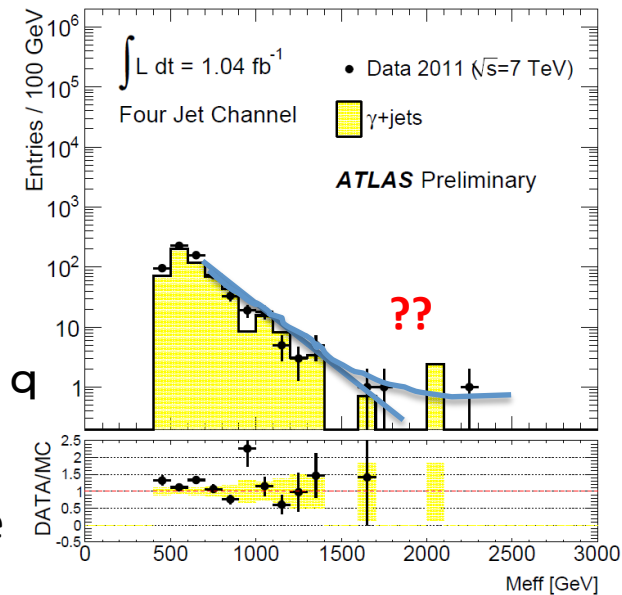
BG2: Control regions (Z)

BG (Z \rightarrow vv)+Jets
can be estimated
with

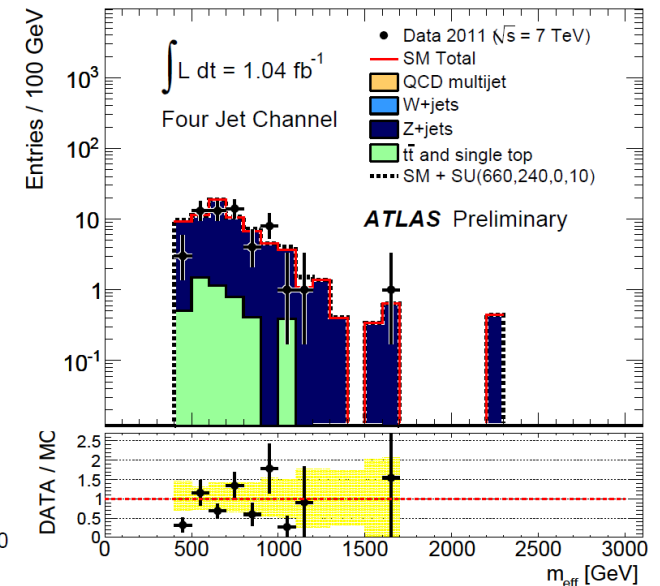


Events with high PT jet are
expected.

Gamma + jets



Z(ll) + jets



Yellow and blues show the simulated distribution of γ +jets and Z(ll)+jets

Currently MC produced by ALPGEN are used and

Normalization has been performed using data. There are two serious problems:

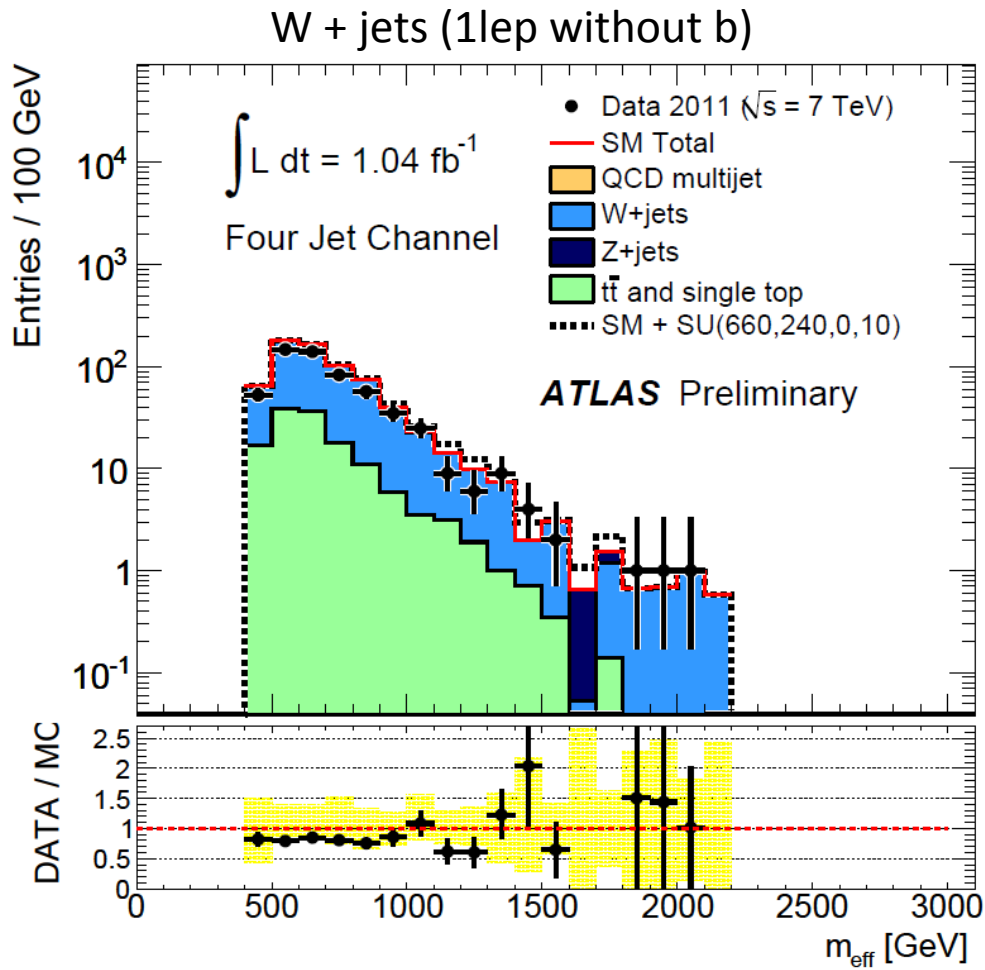
(1) Statistic of both Data & MC are limited in the interesting regions.

No body believes MC for such a high end of the kinematics.

Linear extrapolation or asymptotic?

(2) If use use MC information, JES uncertainties ($\sim 10\%$) will contribute. still high.

BG3: Control regions (W)



$M_T < M_W$ & no bjets are selected to obtain W+jets sample.
 Blue shows the simulated W+jets BG.
 MC is produced with ALPGEN.

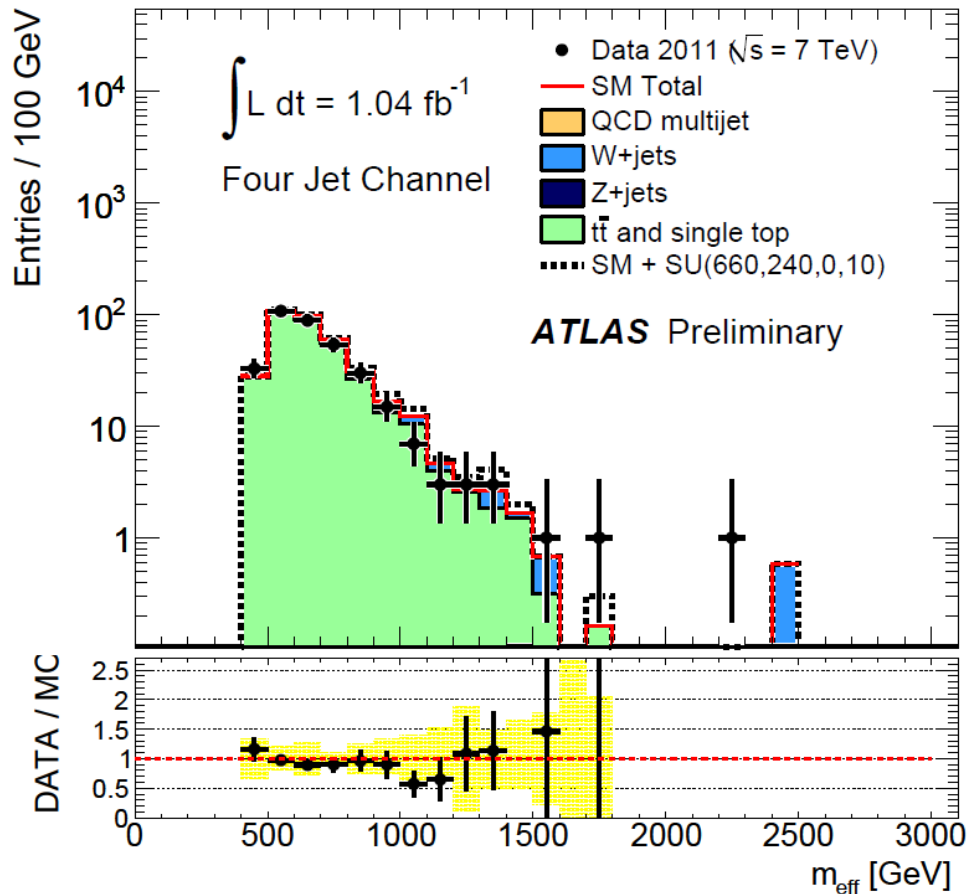
Statistic is high comparing to Z+jets
 Slop is slightly different?
 Data is harder ?

Currently
 Normalization is determined by data
 & shape predicted by ALPGEN is used.

Linear extrapolation ?
 some structure asymptotically ?
 This becomes key I will show later.

Prediction (W+jets BG in high Meff region) is most urgent & important,
 otherwise we can not conclude even if we have an excess, (the same as H->WW)

BG4: Control regions (tt)



$M_T < M_W$ & bjets are selected to obtain $t\bar{t}$ sample and the pure $t\bar{t}$ sample can be selected.

$t\bar{t}$ is not dominant BG except for $m_{\text{ET}} + \text{bjets}$ analysis, since σ at 7TeV is 170pb.

It becomes serious at ECM=14TeV (830pb)

Now basically we use MC even with normalization.

But $t\bar{t} + N_{\text{jets}}$, high m_{eff} regions still need more data and study. Different kinematic regions are used in top WG and SUSY WG

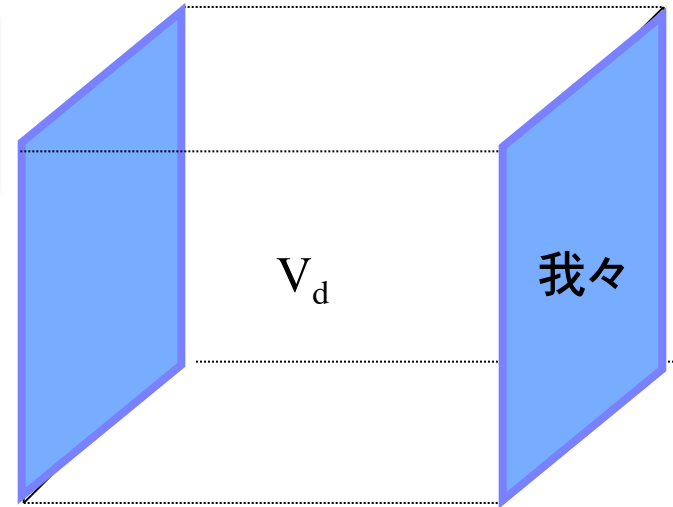
(1) 体積で稼ぐ場合: Large Extra Dimension flat space

$$(M_{pl} / \sqrt{8\pi})^2 = V_d M_D^{2+d} \quad (\text{ADD})$$

$M_D = 1 \text{ TeV}$ とすると

$d=2$ $R \sim 10^{12} \text{ fm} \sim 1 \text{ mm}$

$d=6$ $R \sim 100 \text{ fm}$



軽い KK Graviton ($d=2$ $1/R = 10^{-4} \text{ eV}$ $d=6$ $1/R = 7 \text{ MeV}$)

$1/R \ll \text{TeV}$ G: たくさんのKKモード (それを足し合わせると、Gは強い結合)
貢献するKK modeの数がdが大きくなると急激に減る (感度が悪くなる)

LHCでの信号	Graviton 放出	(monojet, γ +missing)
	Graviton 交換	(high mass lepton pair, high mass jet pair)
		BH, Stringball, 2jet

(2) 曲げて稼ぐか? (RS-I)

曲がった時空(k)

$$\Lambda = \overline{M_{pl}} \exp(-\pi k R)$$

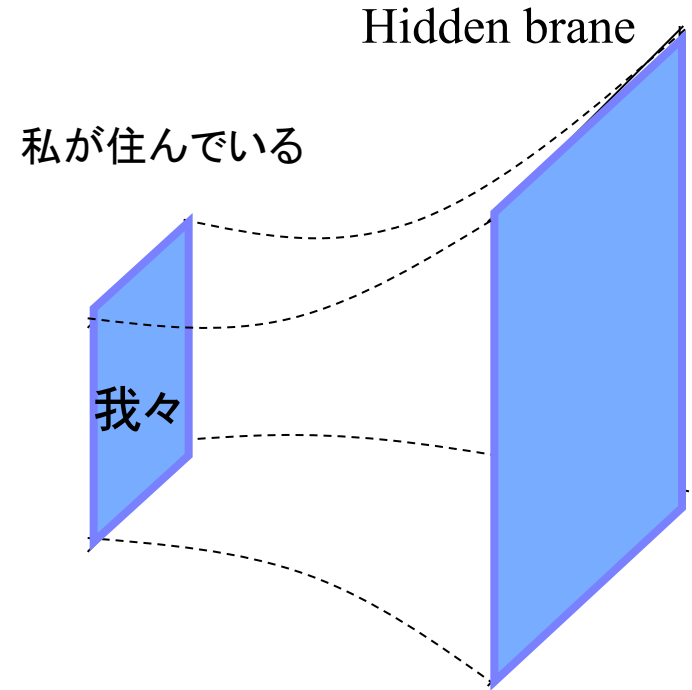
$R \sim 12/k$ とすると $\pi k R \sim 40$

$\Lambda \sim 1 \text{ TeV}$

KK Graviton

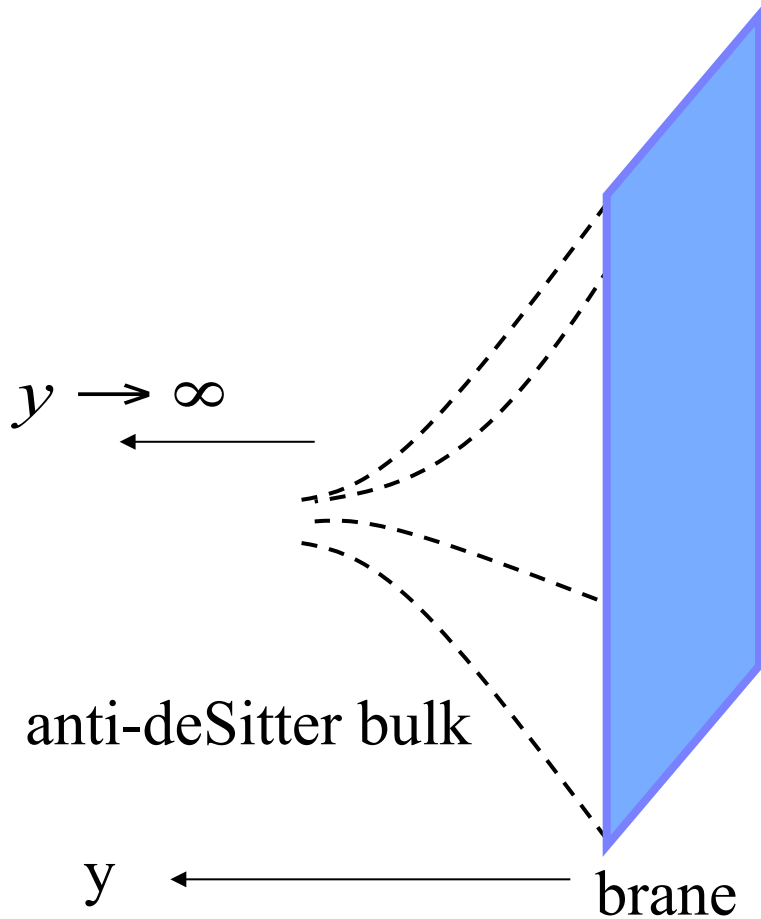
Coupling parameter $c = \sqrt{(8\pi)k/M_{pl}} = 0.01 - 0.1$

$M_n = k x_n \exp(-kr\pi)$ ($x_n = 3.83, 7.02 \dots$ for $n=1, 2, \dots$)



LHCでの信号	KK-Graviton 交換	high mass lepton resonance, high mass $\gamma\gamma$ resonance
	KK gluon 交換	high mass top pair resonance

RS-II



ブレインは一枚

バルクは無限に伸びている

バルクの曲率のため、有効的に
コンパクト化

余剰次元の安定化が不要

このとき どんな現象?

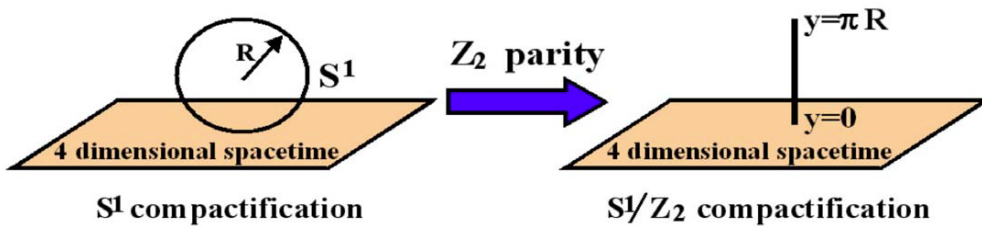
(3) Universal Extra dimension

余剰次元

全てのSM 粒子もちゃんとバルクを伝搬
ゲージボソンだけバルクを伝搬など

SM 粒子にもKK粒子がいる

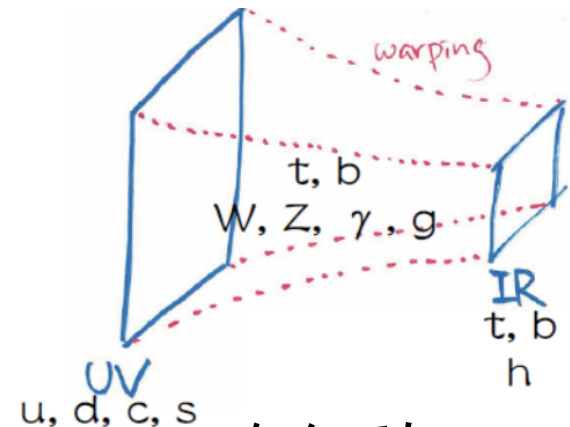
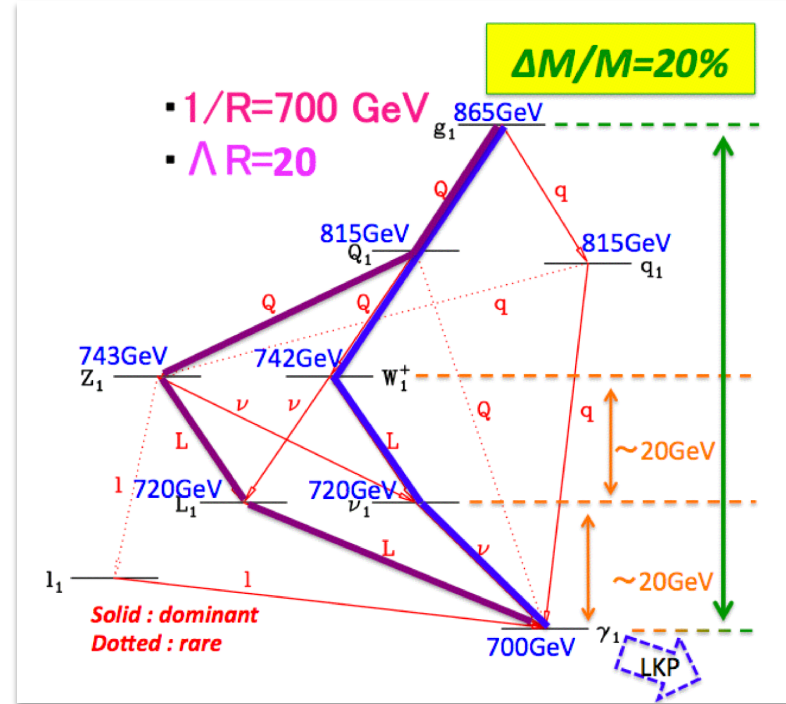
KK Parity SM KK even 1st KK odd



折り返し同視化

LHCでの信号

- 1) KK photon が安定 (DM 0.7-1.5TeV)
SUSY もどき (全体が $1/R$ なので縮退)
- 2) gluon(1) → tt (Gauge Boson だけ
fermionは特殊な面の上)



なんでもあり?

Modelと観測されるtopologyの整理

topology



複雑

	ADD			RS		UED	コメント
	G放出	s	t(含BH)	G	g		
monojet	○						綺麗だけど
γ +missing	○						
$e^+e^- \mu^+\mu^-$ non-reso resonance		○					DY BG
$\gamma\gamma$ non-reso resonance		○		○			Z', W'
$\mu\mu$ (SS)			○				BG free
2jets		○	○	△	△		万能だが
boosted top					○		subjet
multi-object w/o lep with lepton			○				QCD BG
mET+Lepton+jets with Photon			△			○	SUSYもどき
			△			○	GMSUSY

○ good △ 多分 excessするだろうが Leading modeでない

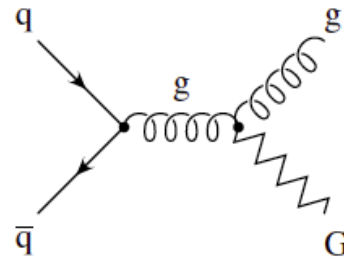
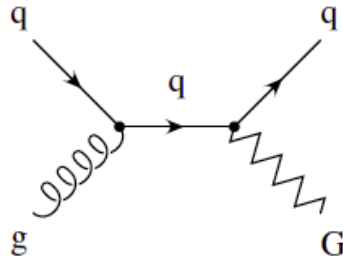
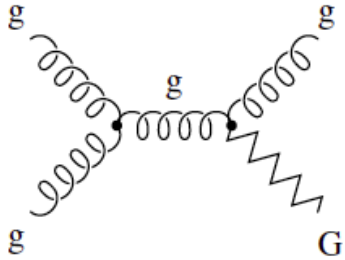
Modelと観測されるtopologyの整理

4つの結果をまとめます

	ADD			RS		UED	コメント
	G放出	s	t(含BH)	G	g		
[A]	monojet	○					綺麗だけど
	γ +missing	○					
[B]	$e^+e^- \mu^+\mu^-$ non-reso resonance		○				DY BG
				○			Z',W'
	$\gamma\gamma$ non-reso resonance		○		○		
	$\mu\mu$ (SS)			○			BG free
[C]	2jets	○	○	△	△		万能だが
	boosted top				○		subjet
[D]	multi-objcet w/o lep with lepton			○			QCD BG
				○			温度?
	mET+Lepton+jets with Photon			△		○	SUSYもどき
			△		○	GMSUSY	

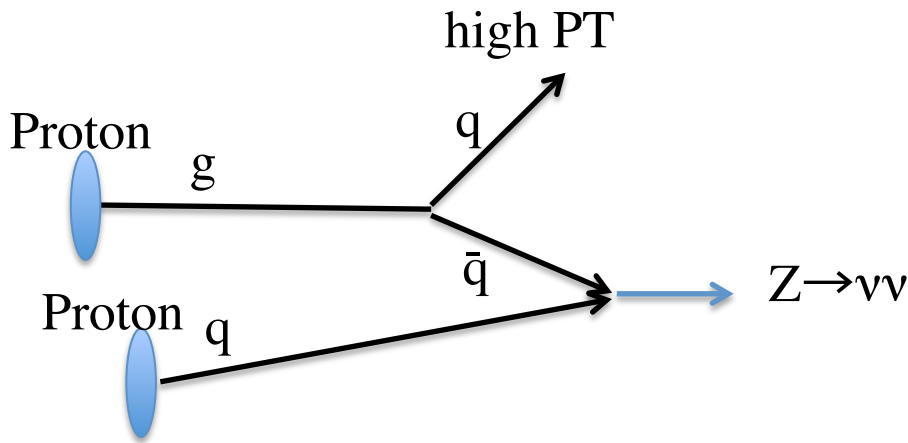
○ good △ 多分 excessするだろうが Leading modeでない

[A] Monojet

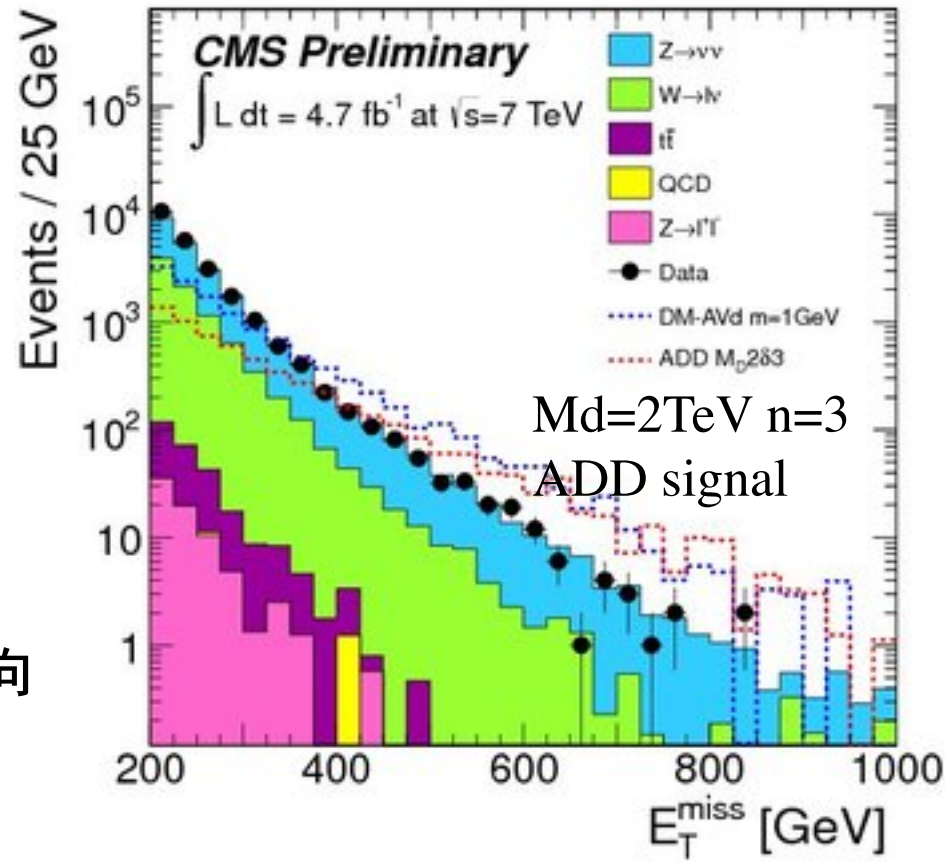


ADD
KK Gravitonが
直接放射
結合 $\sim E$

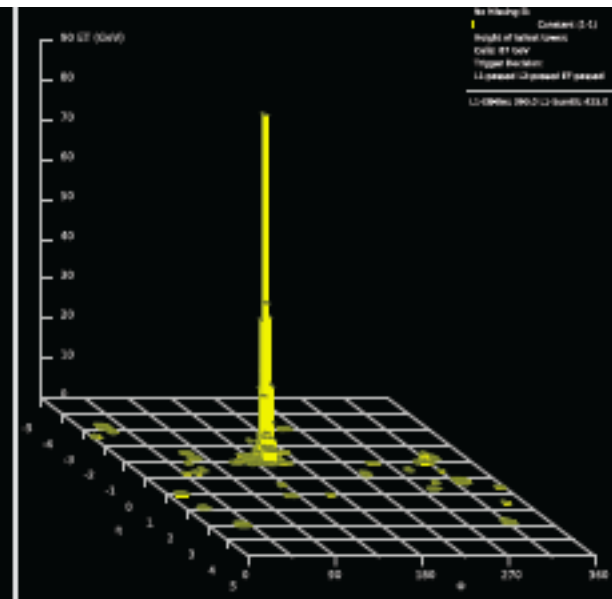
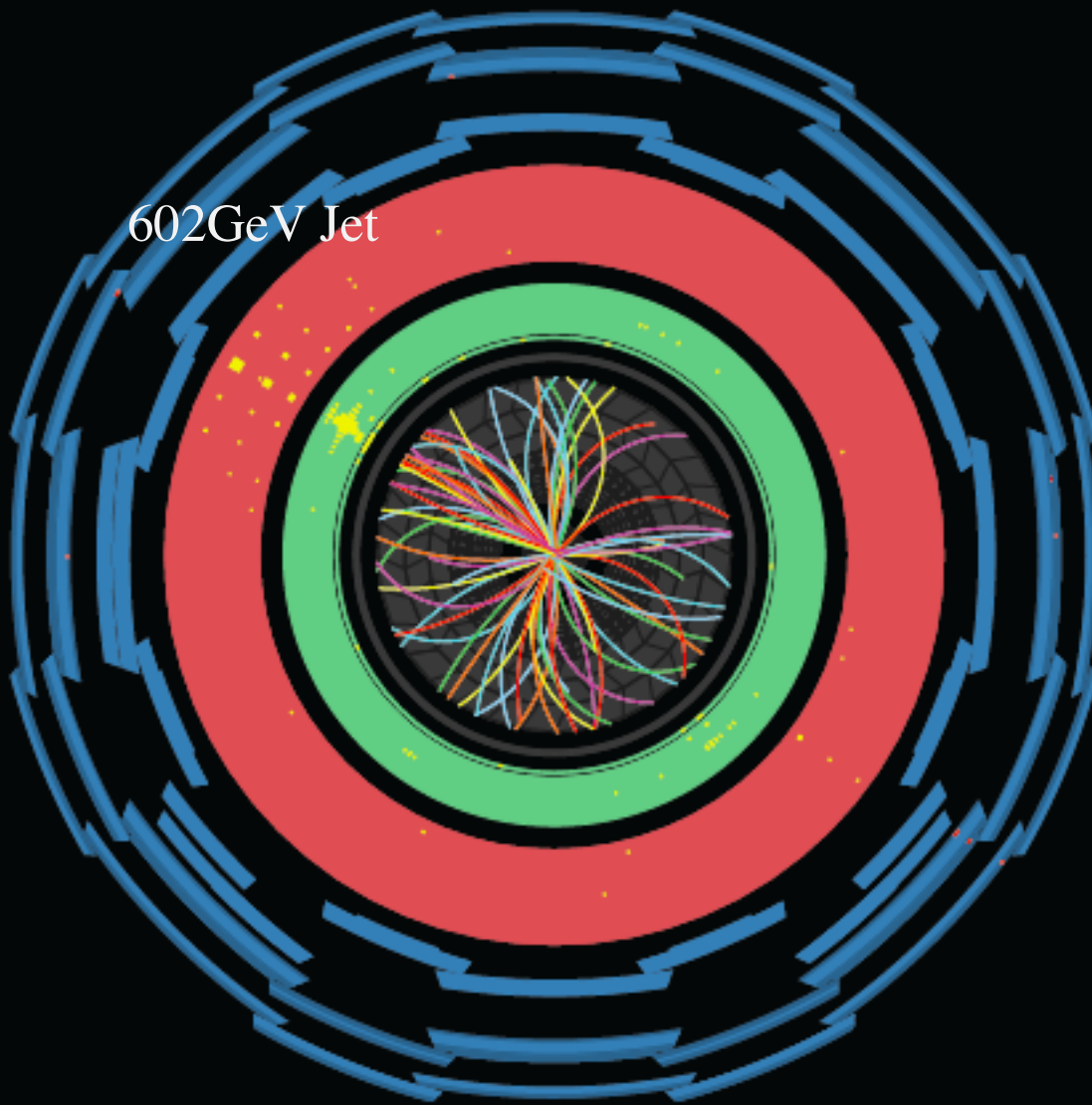
LHCはppなので実はこのBGかなり多い



こいつの横方向
運動量分布



602 GeV Jet



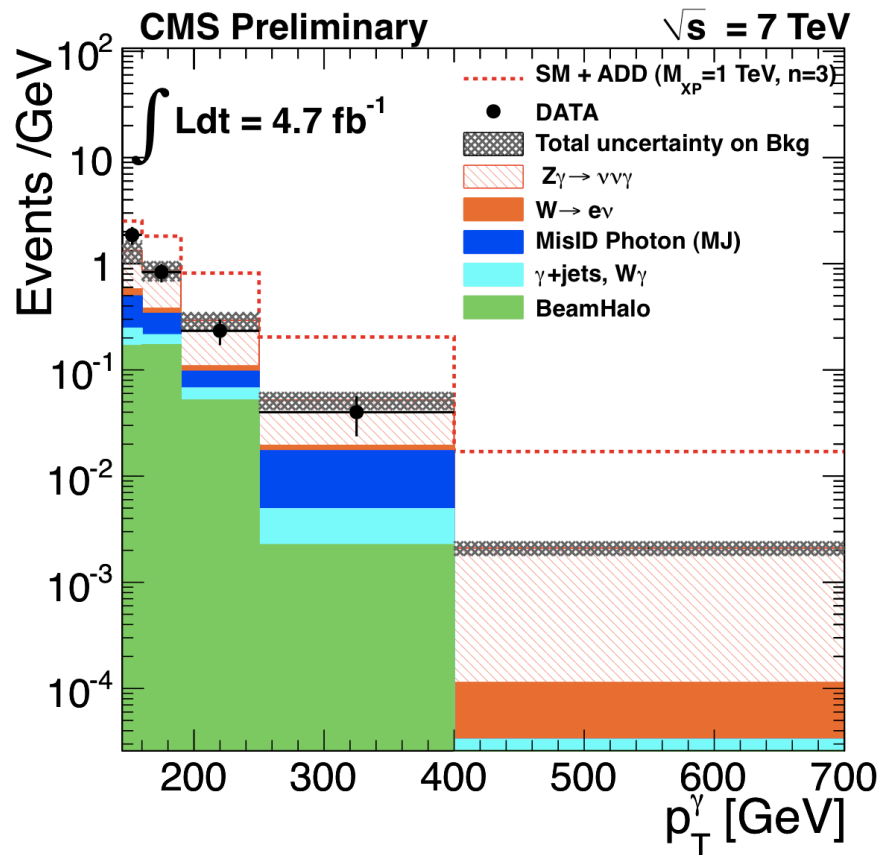
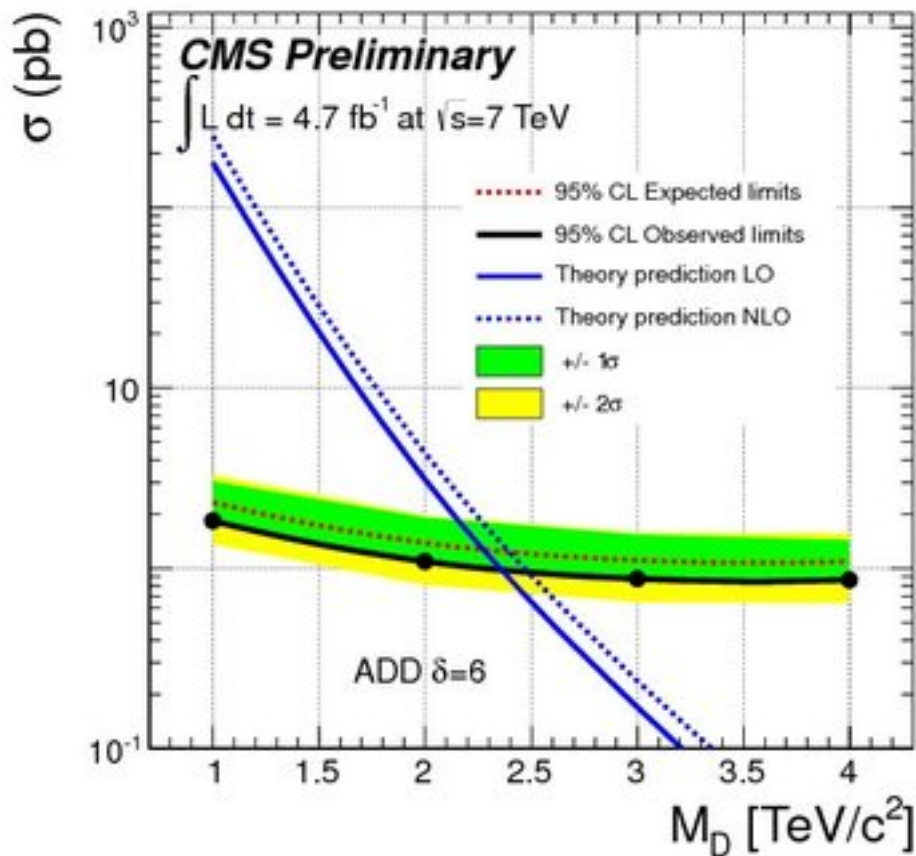
 **ATLAS**
EXPERIMENT

Run Number: 180309, Event Number: 36060682

Date: 2011-04-27 02:33:15 CEST

綺麗な candidate

曲がってる奴は気にしない

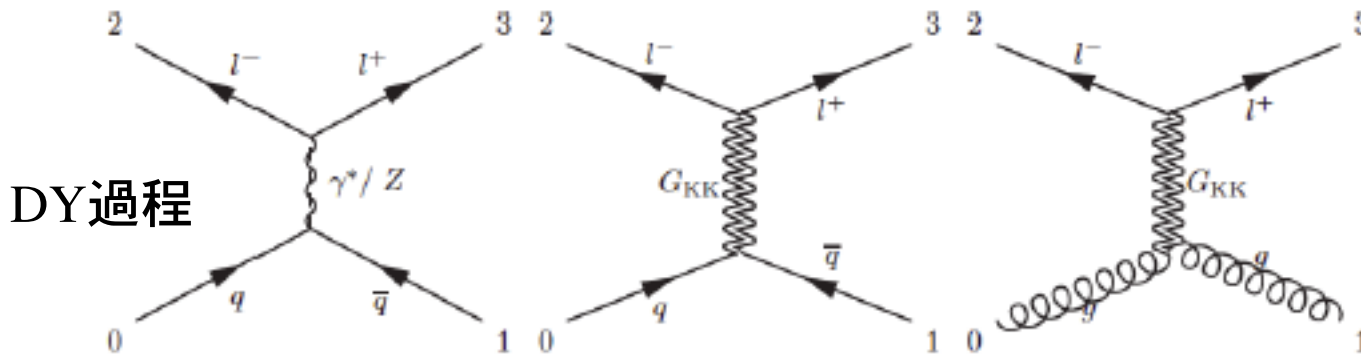


ATLAS, CMSも同じ様な結果

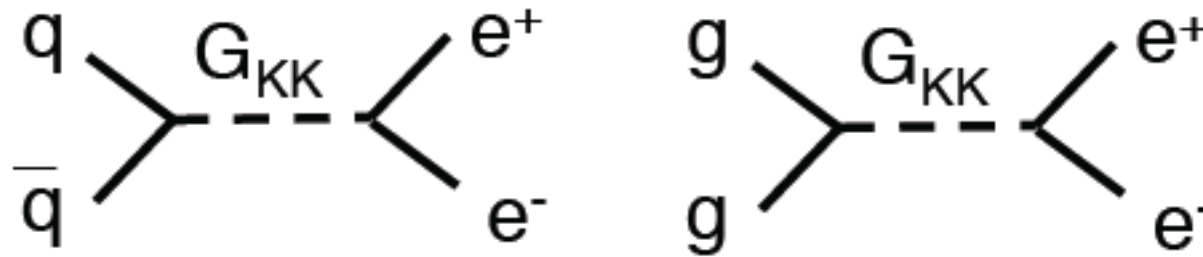
	n=2	n=4	n=6
7TeV 5 fb ⁻¹	4.1TeV	2.8TeV	2.4TeV
8TeV 15fb ⁻¹		3.5TeVぐらい	3.2TeVぐらい
Photon+mET		1.59TeV	1.6TeV

Monojetの方が
 Mono γ より
 感度がいい

[B] $e^+e^- \mu^+\mu^-$ pair (non-reso, reso)



S channel
ADD 連続
連続分布



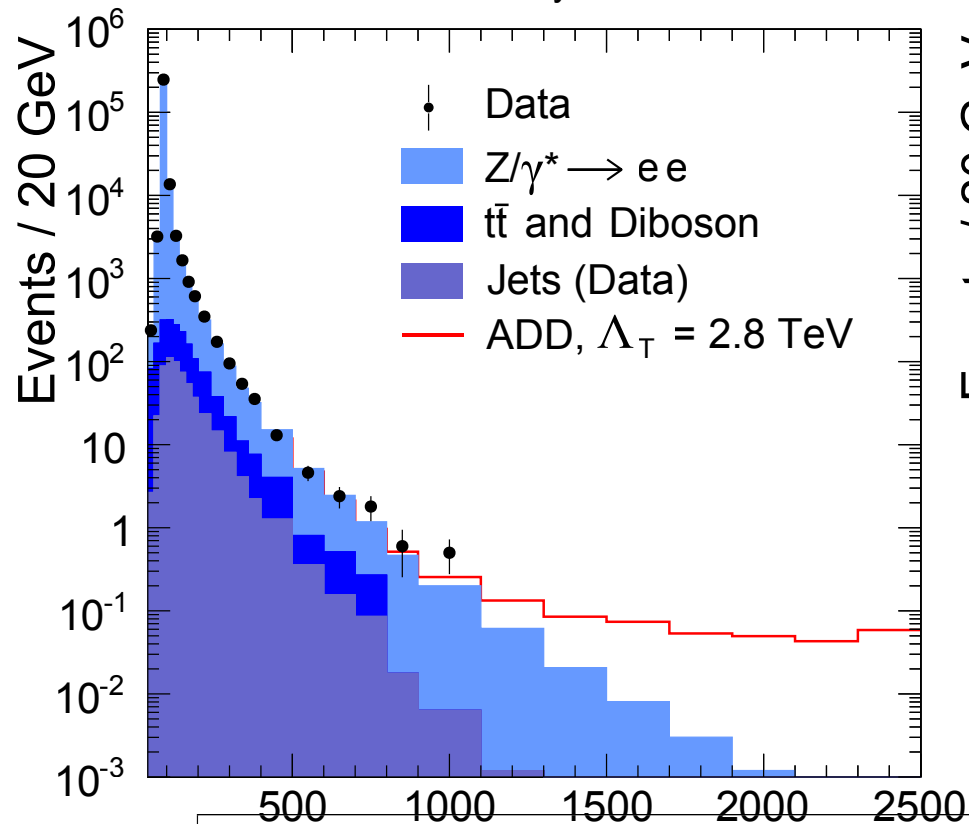
RS resonance
KK Graviton
mass

実験ではレプトン universalityは破れている。

e: jetが間違える確率 10^{-4} 分解能は $\Delta E/E \sim 1/\sqrt{E}$ 良くなっていく

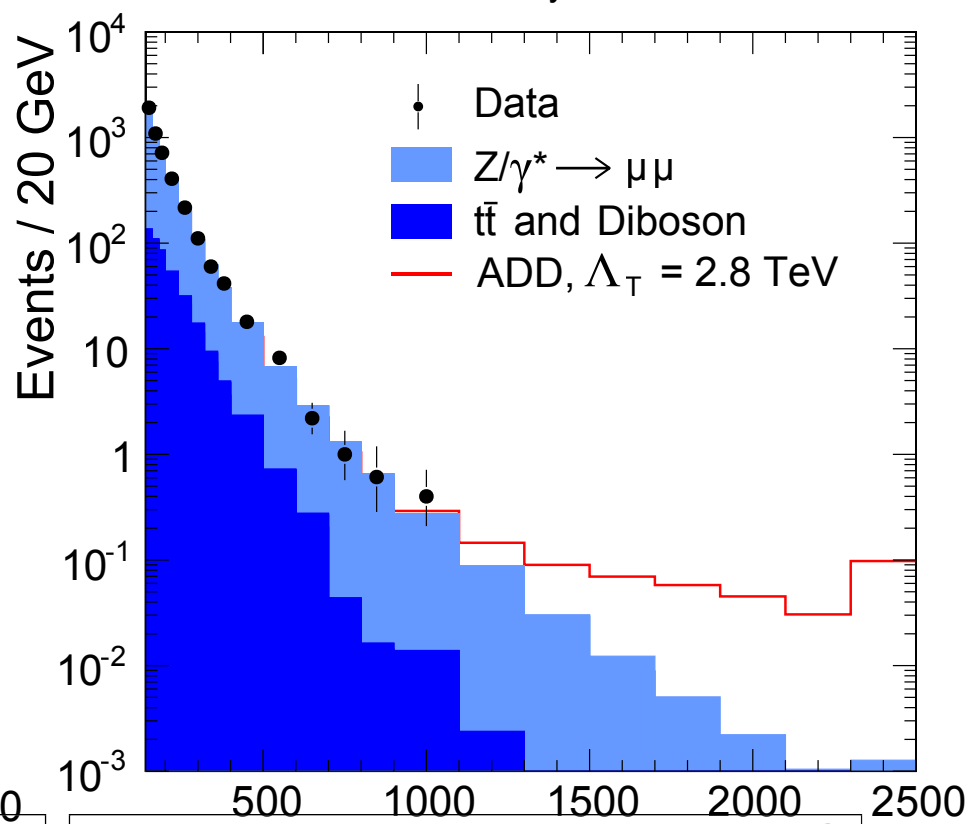
μ : jetが間違える確率 10^{-5} 分解能は $\Delta P/P \sim P$ で悪くなっていく

CMS Preliminary $\sqrt{s} = 7$ TeV, $\mathcal{L} = 2.1 \text{ fb}^{-1}$



$\mu\mu, \mathcal{L} = 2.3 \text{ fb}^{-1}$			
Mass region [TeV]	N_{obs}	Background expectation	Signal exp. $\Lambda_T = 2.8 \text{ TeV}$
Control regions			
0.14–0.20	3723	3690 ± 300	-
0.20–0.40	1674	1605 ± 160	-
0.40–0.60	131	122 ± 13	-
0.60–0.80	16	21 ± 3	-
0.80–1.10	8	5 ± 1	0.8
Signal region			
> 1.10	0	1.0 ± 0.2	3.2

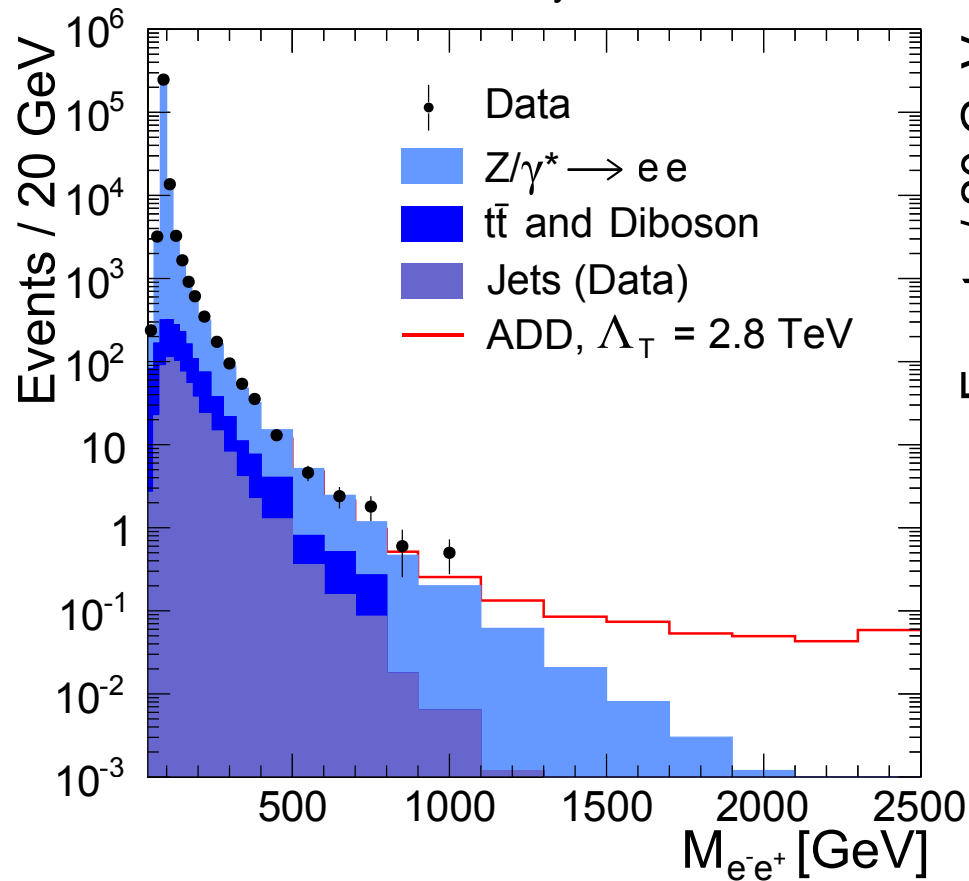
CMS Preliminary $\sqrt{s} = 7$ TeV, $\mathcal{L} = 2.3 \text{ fb}^{-1}$



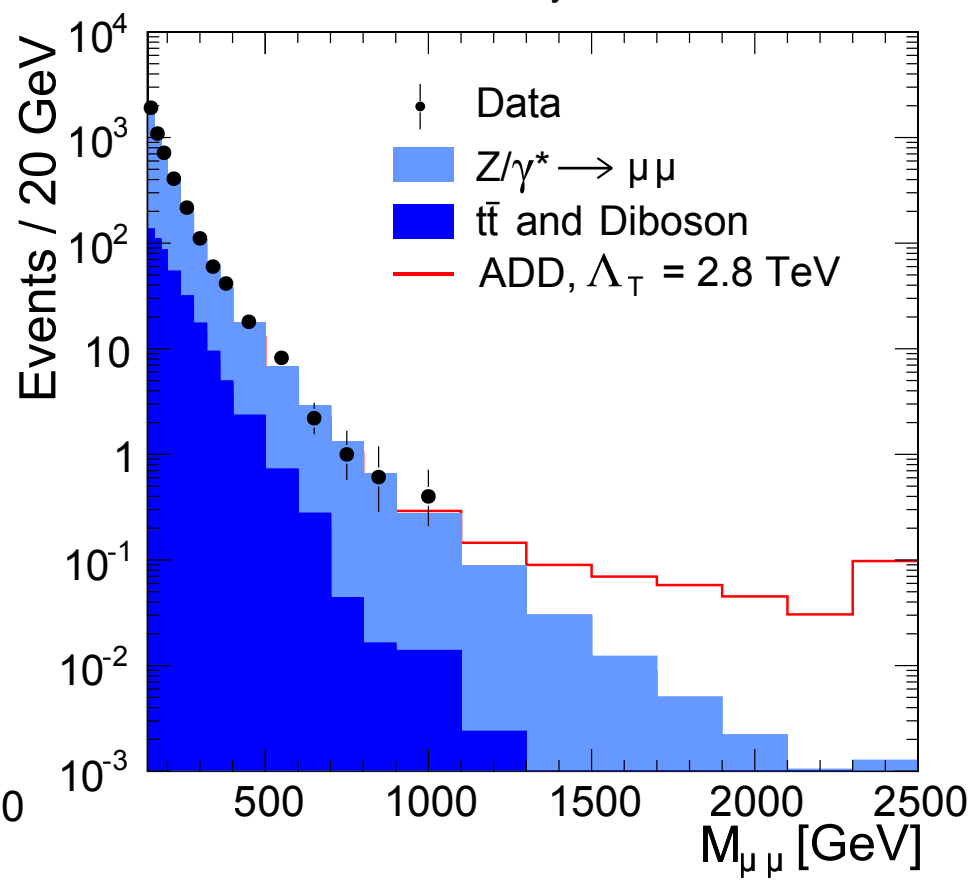
$ee, \mathcal{L} = 2.1 \text{ fb}^{-1}$			
Mass region [TeV]	N_{obs}	Background expectation	Signal exp. $\Lambda_T = 2.8 \text{ TeV}$
Control regions			
0.12–0.20	6592	6598 ± 530	-
0.20–0.40	1413	1301 ± 120	-
0.40–0.60	88	103 ± 11	-
0.60–0.80	21	18 ± 3	-
0.80–1.10	7	6 ± 1	0.6
Signal region			
> 1.10	0	1.3 ± 0.2	2.7

数も
consistent

CMS Preliminary $\sqrt{s} = 7$ TeV, $\mathcal{L} = 2.1$ fb $^{-1}$



CMS Preliminary $\sqrt{s} = 7$ TeV, $\mathcal{L} = 2.3$ fb $^{-1}$



$ee+\mu\mu$

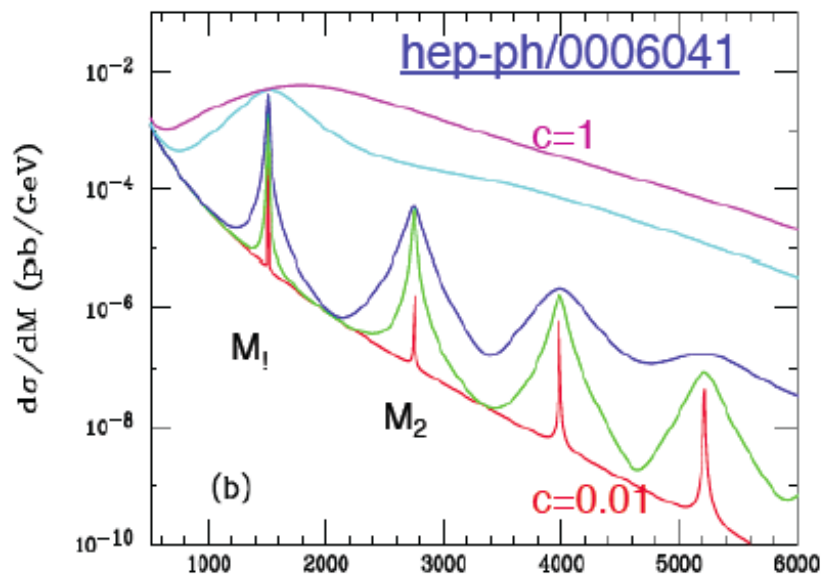
	n=2	n=4	n=6
L=2 fb $^{-1}$	3.8 TeV	3.2 TeV	2.7 TeV

BGがないので monojetより感度がいい。(monojet L=5fb $^{-1}$ と同じ程度)

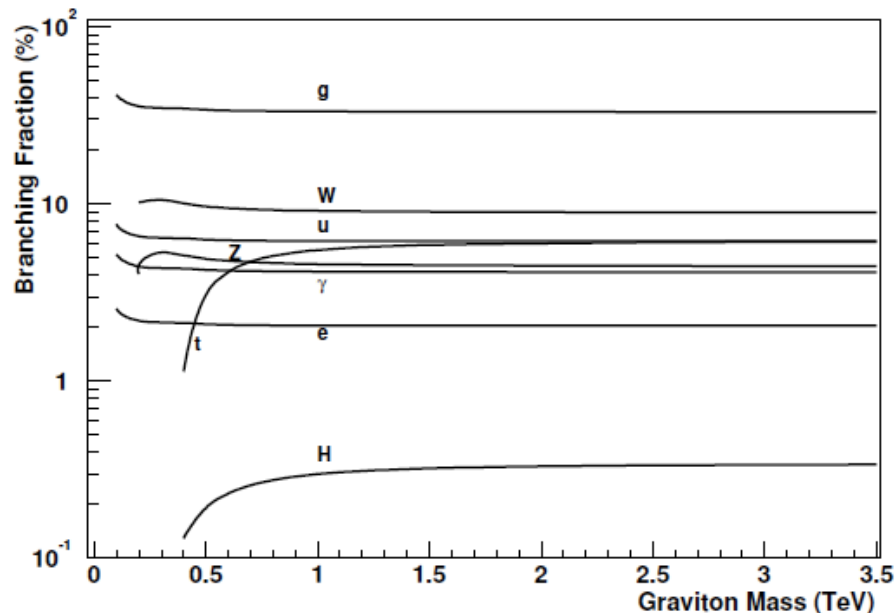
コンタクト qqll interaction で 10.2TeV (95% CL)

KK Graviton resonance (RS)

14TeVの断面積



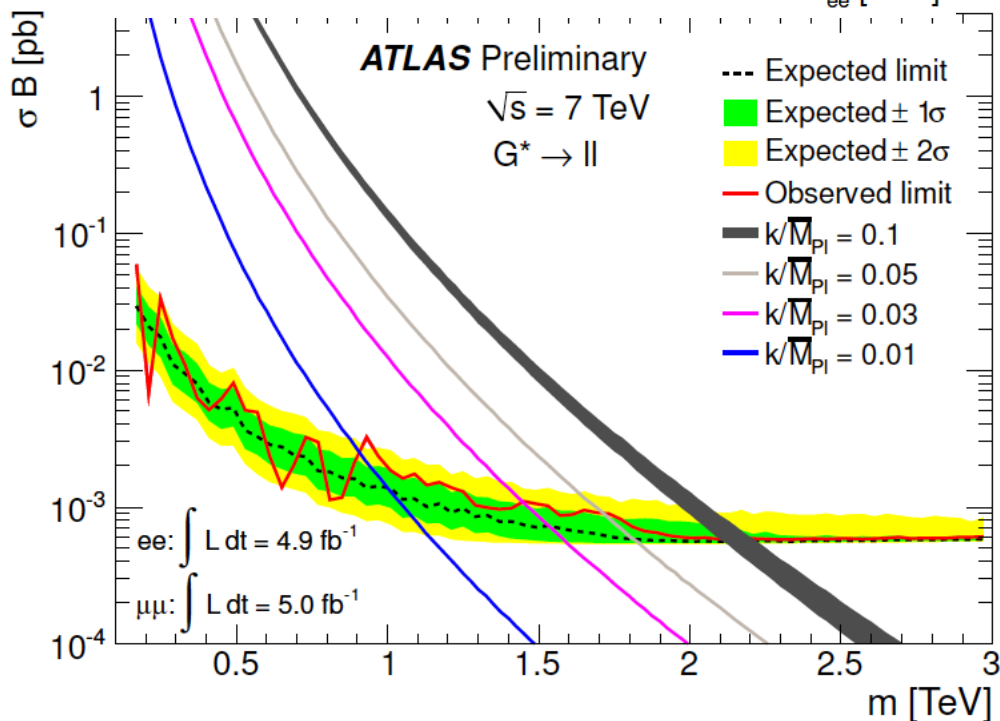
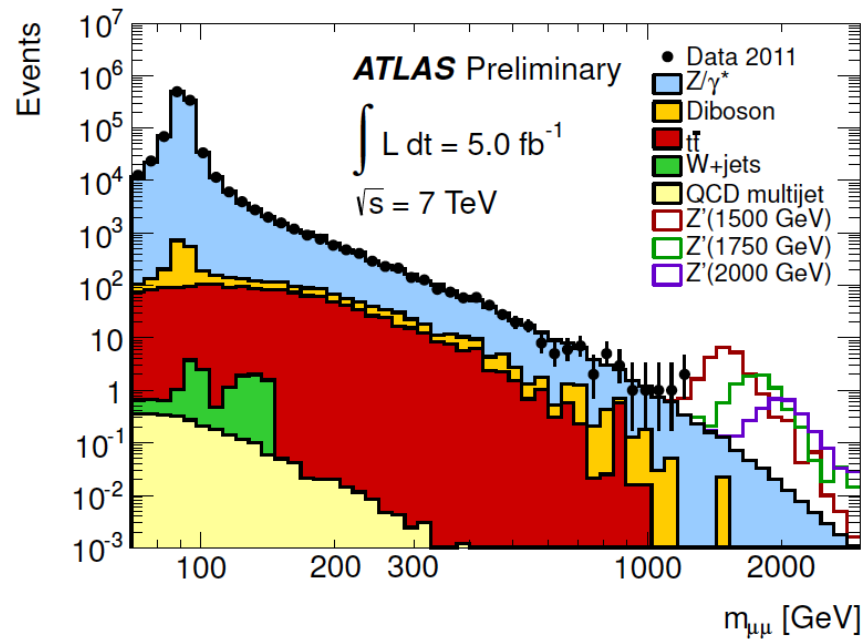
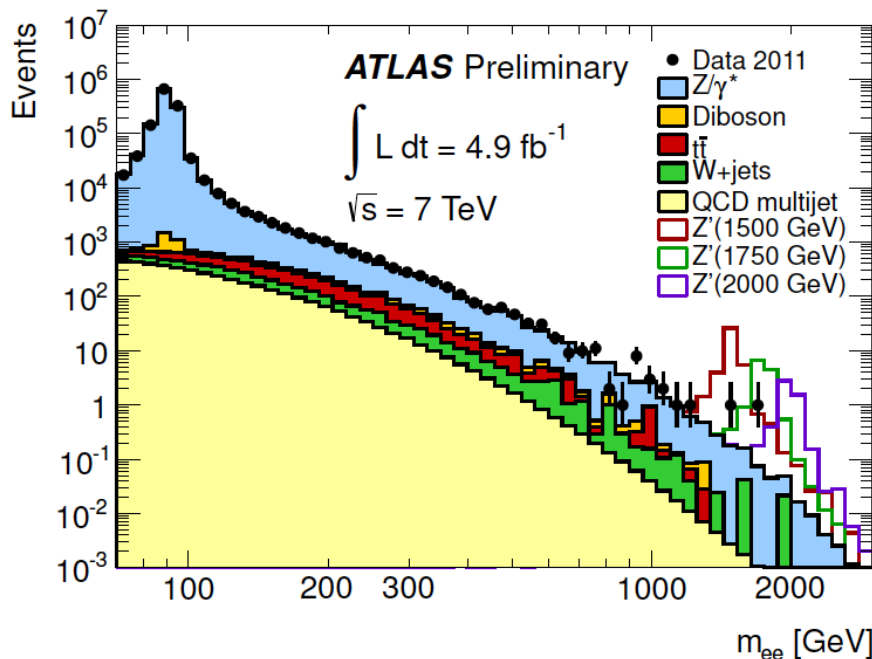
RS Graviton, $M_1=1.5\text{TeV}$, $c=1,0.5,0.1,0.05,0.01$



k/M_{pl} が大きいと(結合大きく)
 信号増える
 幅広がるのでBG増える

分岐比は”民主的” すべてに等しく
 後は自由度 (spin, flavor, color)

e, μ はBr 2%程度で小さいがBGがすくない。
 M11のresolutionがいいことが鍵
 WWもやってみたけど、 diboson BG が結構ある
 CMS が ZZ qq vv



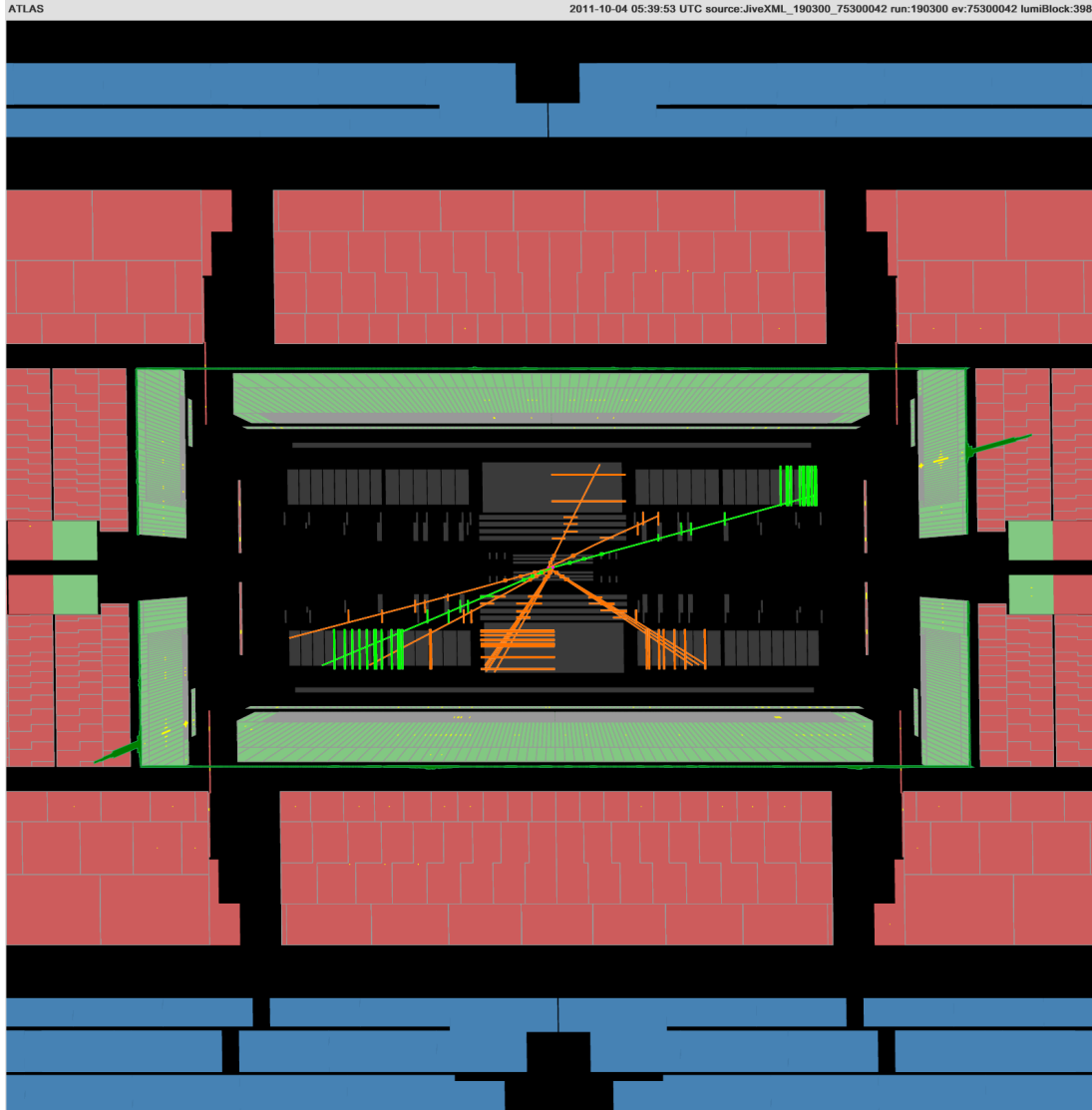
$k/M=$	0.01	0.03	0.1
$L=5$ fb^{-1}	0.91 TeV	1.45 TeV	2.16 TeV

<- 結合弱い強い->

Model/Coupling	$E_6 Z'$ models					
	Z'_ψ	Z'_N	Z'_η	Z'_I	Z'_S	Z'_χ
Mass limit [TeV]	1.76	1.78	1.84	1.84	1.90	1.96

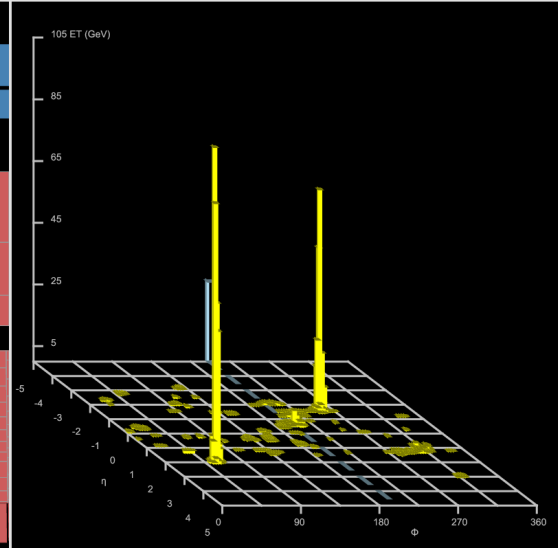
$m_{ee} = 1.66 \text{ TeV}$

Candidate



2011-10-04 05:39:53 UTC source:JiveXML_190300_75300042 run:190300 ev:75300042 lumiBlock:398

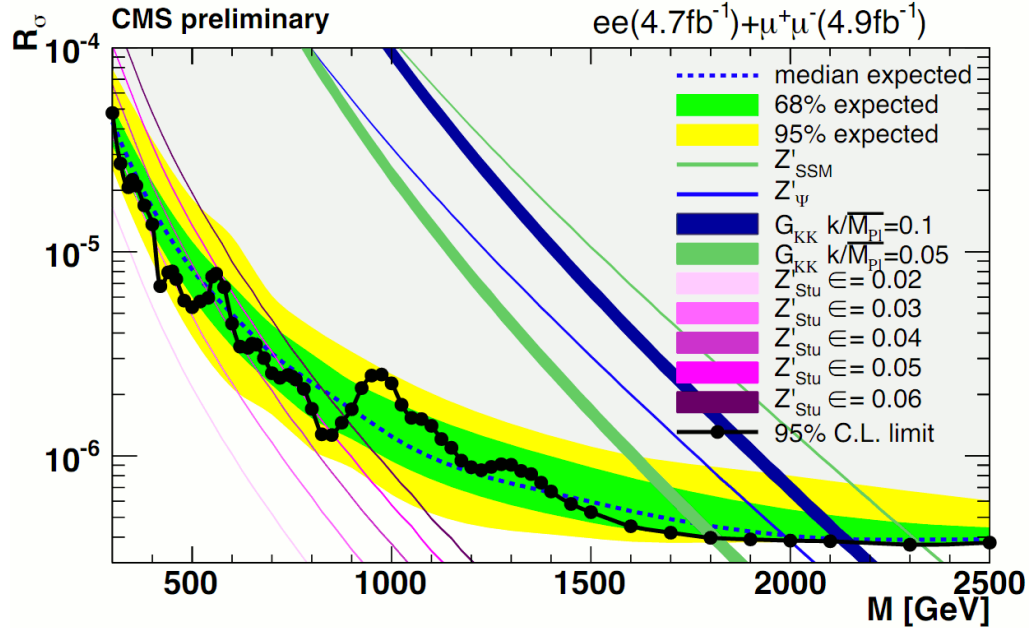
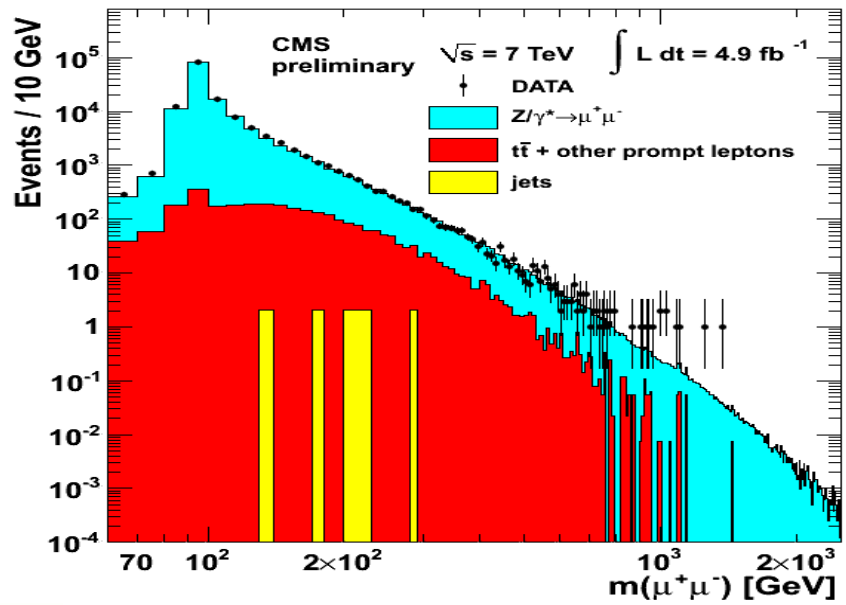
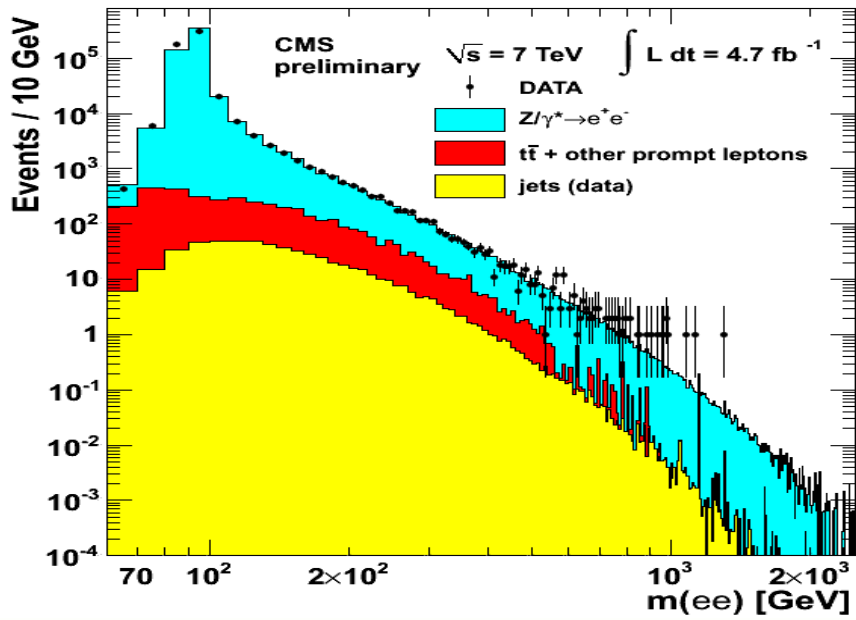
Atlantis



Run Number: 190300, Event Number: 75300042

Date: 2011-10-04 05:39:53 UTC

CMSもexcessはなし



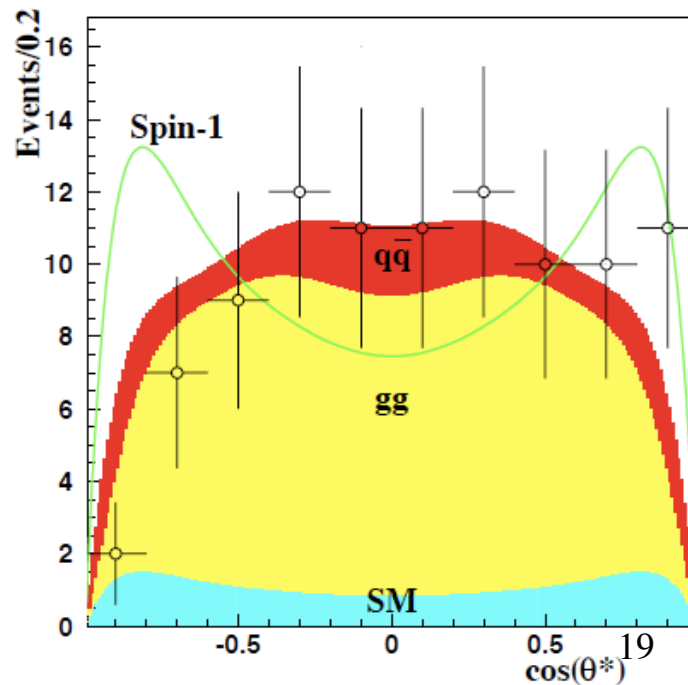
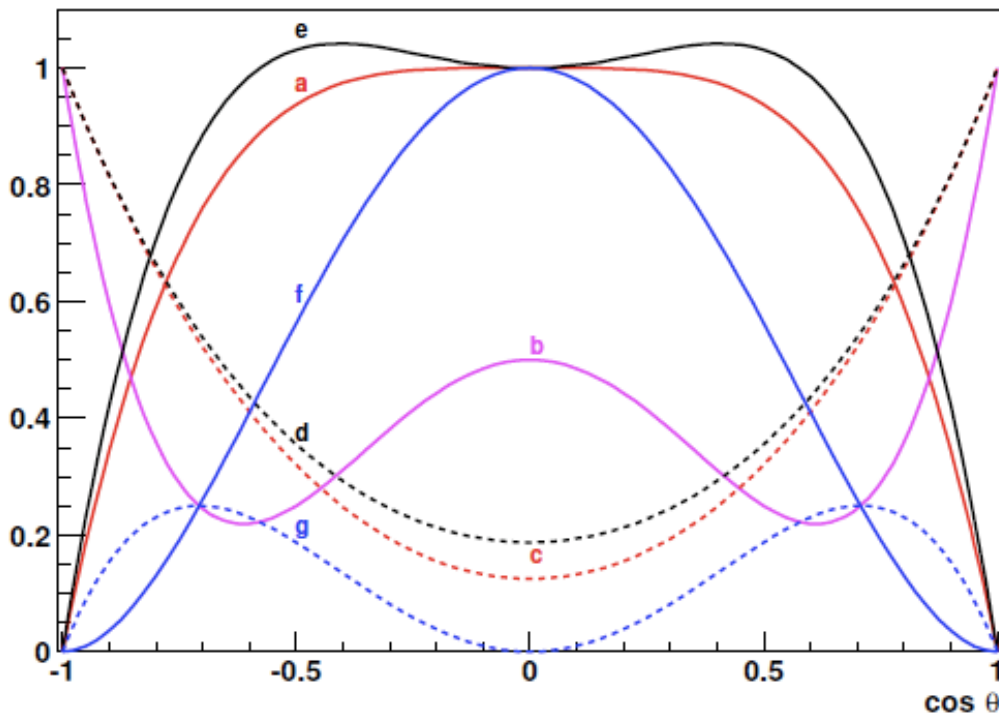
	KK 0.1	SSM	前川さん
L=5 fb ⁻¹	2.1 TeV	2.3 TeV	2 TeV

pp → G_{KK} → e+e- が一番いいチャンネル:

Trackの分解能 $\Delta p/p \sim p$ で高い領域では悪くなる(μ駄目)

カロリメータ分解能 $\Delta E/E \sim 1/\text{SQRT}(E)$ (統計) で良くなる

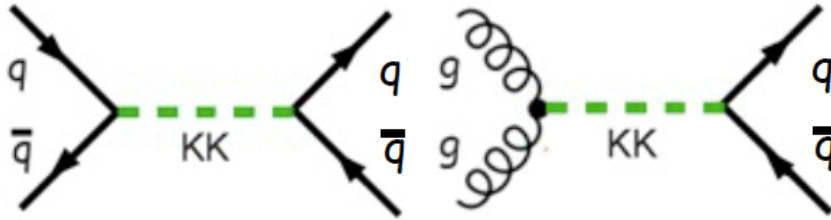
gg → G* → γγ の角度分布がBGに近くなる



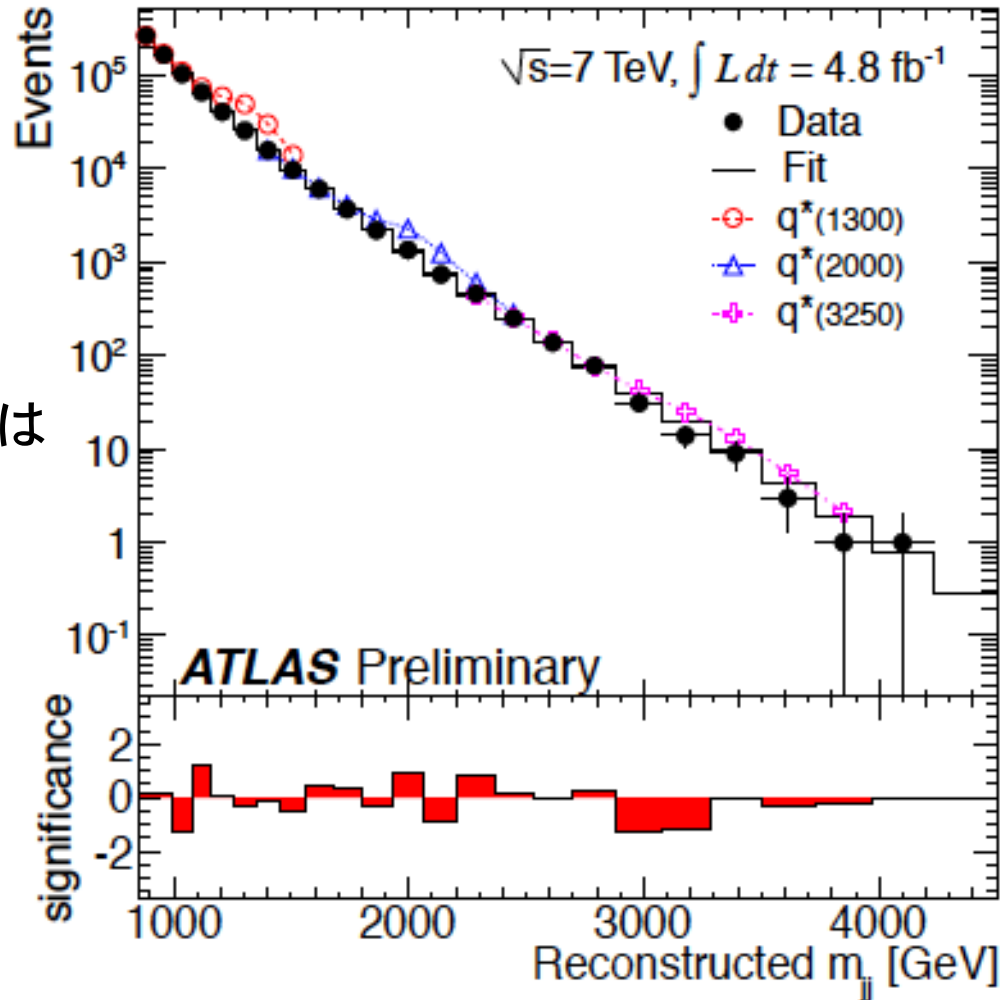
[C] high mass 2jet

$gg \rightarrow gg$

$qq \rightarrow qq$ ADD KK Graviton S-channel ばかりでなく、t-channelも

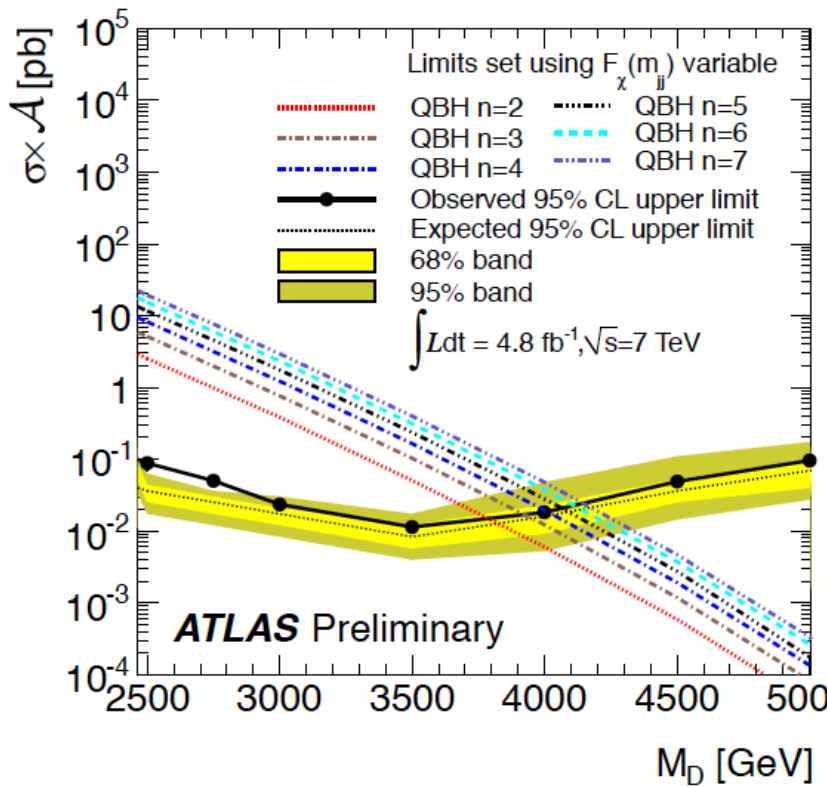
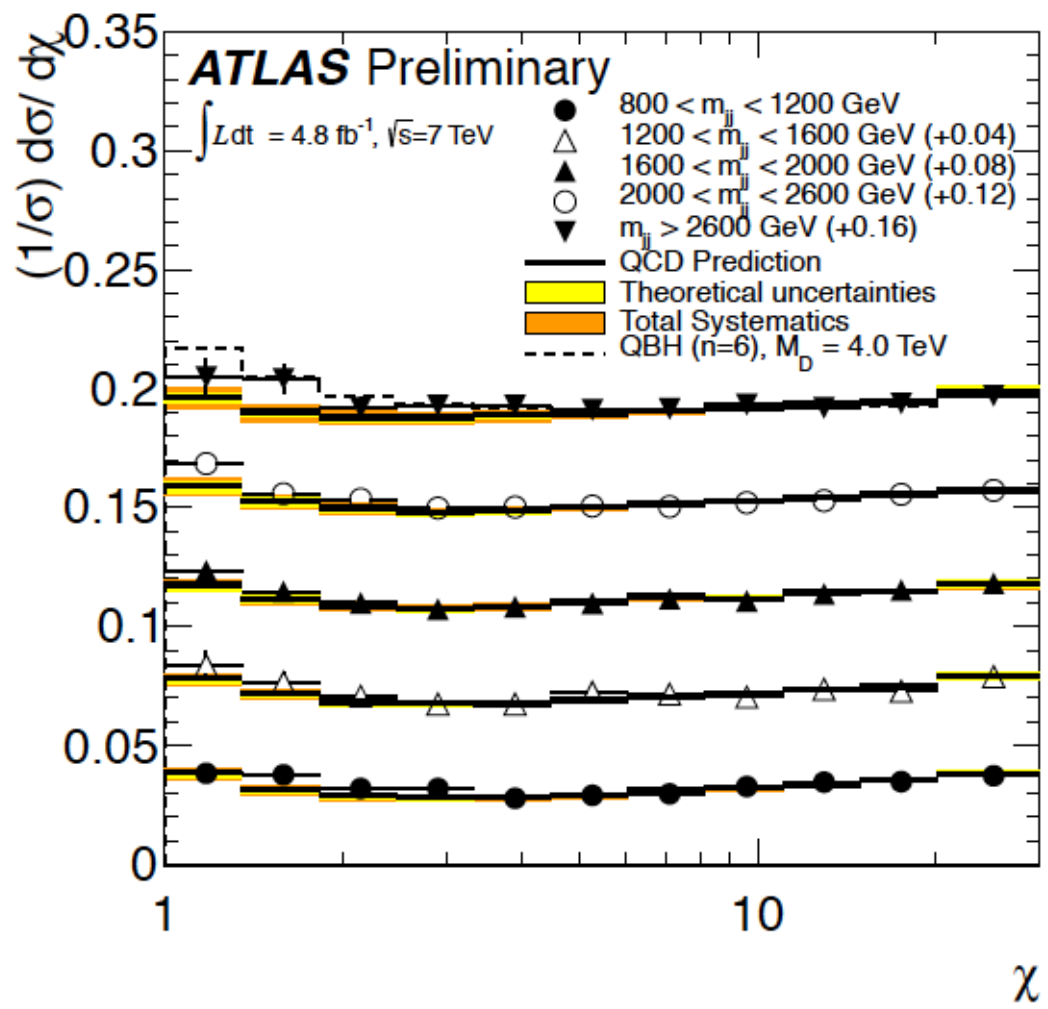


BHが出来ても、十分熱化出来ないときは
2jetに行く Randall-Meade



Invariant mass/角度分布 of 2jet

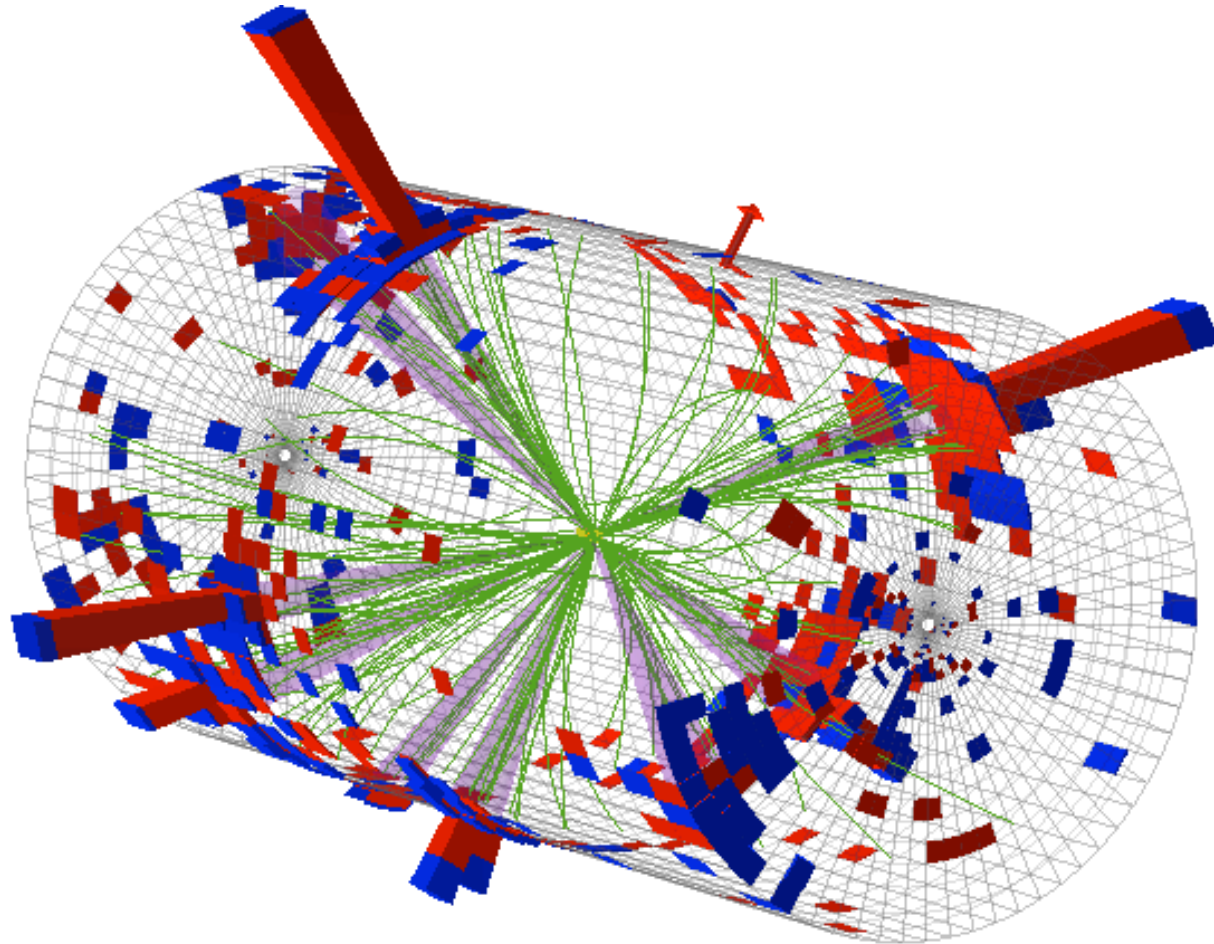
Contact interaction
 $\Lambda > 7.8 \text{ TeV} 95\% \text{CL}$



$\chi = \exp(\ln|1-\eta_1| - \ln|1-\eta_2|)$
 Rapidity Gap small χ 真ん中 large χ 外側
 large χ で normalization として new physics は small χ

$M_D = 3.96 \text{ TeV} (n=6)$

[D] high mass multiobject (BH,SB)



9Jets
 $\Sigma Pt=2.6\text{TeV}$

CMS Experiment at LHC, CERN
Data recorded: Mon May 23 21:46:26 2011 EDT
Run/Event: 165567 / 347495624
Lumi section: 280
Orbit/Crossing: 73255853 / 3161

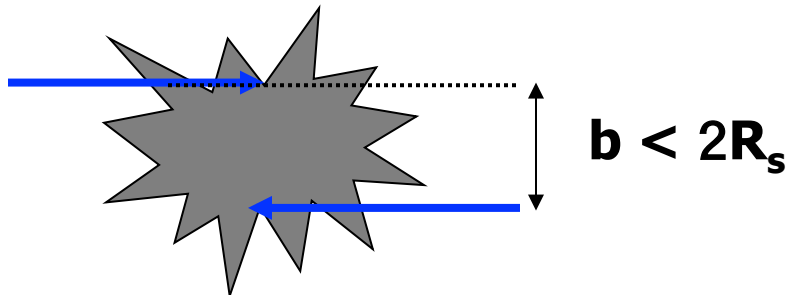
(1)生成過程

余剰次元nまで含めた重力定数 G_D
DLでの定義:

$M_P = 1/G_D$ (Fundamental Planck scale
~ TeV)

このとき シュバルツシルド半径

$$R_S = \frac{1}{\sqrt{\pi} M_P} \left[\frac{M_{BH}}{M_P} \left(\frac{8\Gamma(\frac{n+3}{2})}{n+2} \right) \right]^{\frac{1}{1+n}}$$



$2R_s$ より小さい距離(インパクトパラメーター**b**)
で2つのpartonが衝突すると
ミニブラックホールができる。

衝突するpartonの重心系

$E/2$ のエネルギーのparton:

このpartonのドブロイ波長($2\pi/(E/2)$)

これが $2R_s$ の半径の中に入ると、

“点としてのparton”がぶつかるという

古典的な近似が駄目になる。

ブラックホールの質量 $M_{BH} \sim E$ として、
(全部のenergyが中に入った)

$$4\pi/M_{BH} < 2R_s$$

$$M_{BH} > (4-5.5) M_P \quad (n=2-6)$$

この最低値は、LHCではfix

不連続な閾値:

free parameterとして研究している。

古典的な近似:

$$\sigma = \pi R_S^2 \sim M_P^{-2} (M_{BH}/M_P)^{2/(n+1)}$$

古典断面積からのずれはどのくらい？

Yoshino-Nambu-Rychkov (2つの重力場がぶつかる Aichelburg近似) :
BHが出来る。古典からのズレ: Formation factor

D	4	5	6	7	8	9	10	11
$\sigma_{\text{production}}/(\pi r_H^2)$	0.71	1.54	2.15	2.52	2.77	2.95	3.09	3.20

高次元ほど: 出来やすくなる。2次元surfaceでなく $2+n$ 次元surfaceにtrapされる。

でも $O(1)$

そんなに悪くはない近似

新しい charybdis 2 にはもう取り込まれている。(look at table 形式)

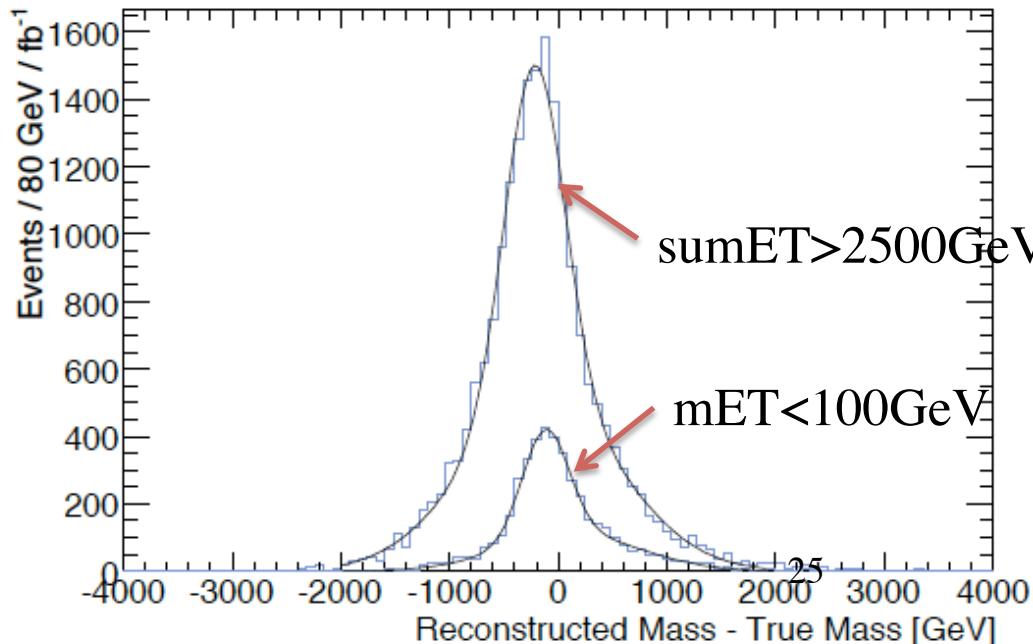
BHのmassの決定: 崩壊で出てきた全粒子のエネルギー・運動量 不変質量
事象ごとにちがうが、PDFの効果で閾値付近がおおくなる。

高い方の分布からPDFの効果を除くと 断面積 $\sigma \sim \text{Mass}$ で増えていくことをcheck

-> BHの有力な傍証?

ただ組むだけでは、 ν の効果で低くなる。(Gravitonまで考慮すればでもっと低くなる):
 $m_{\text{ET}} < 100\text{GeV}$ で効果を抑えることができる。

立ち上がり、THS付近の研究は、古典的でないBHを探ることができるが、



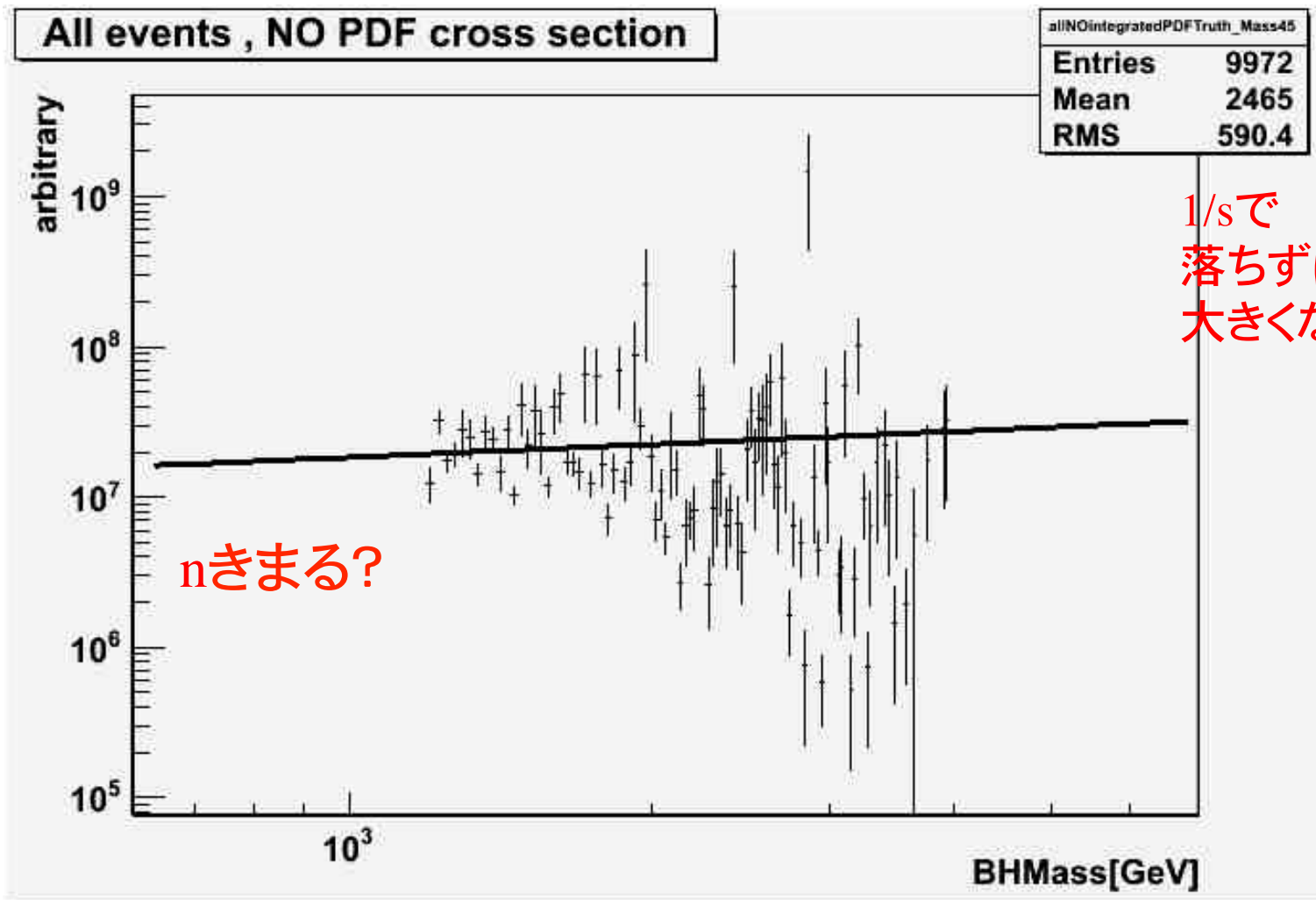
ズレは -100GeV
分解能は 200GeV 程度
事象ごとに
 10% ほどで M_{BH} が決まる。

電荷も観測可能?
jet: jet-charge あとで

古典物理であることの証明できるか？

微分断面積測定をPDFの weight を解く

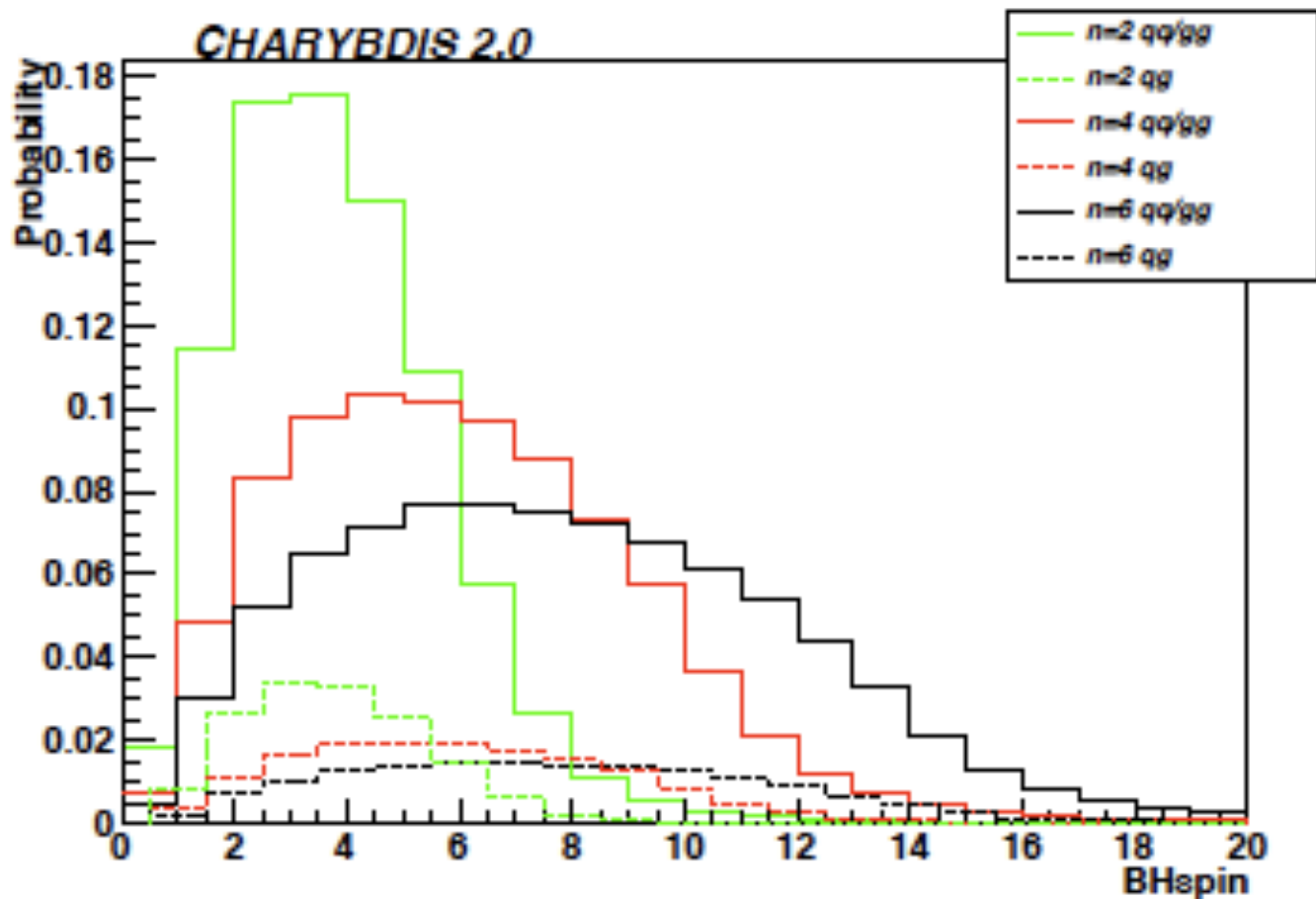
去年の4年生と遊んだ結果



7TeV
L=100fb⁻¹
MD=1TeV
を仮定して

Mth=1TeV
から生成

断面積の多くがhead-on collisionでなく、角運動量
 $J_{\max} = R S M_{\text{BH}}/2 \sim 3\text{-}10$ 程度($n=2\text{-}7$)をもっている。
 $E = M_{\text{BH}}/2$ 最大 R_s のimpact parameter 断面積は R_s の大きい方が効くので
 大部分のBHは、角運動量をもつことになる: 廻るといろいろ面白いことがおきる



(2)崩壊過程

10^{-26} 秒程度の短い寿命



(1) Balding phase

BHには毛が4本(mass, 電荷、角運動量、QCD色)しかない。
多重極、その他の量子数を失う過程（主にGravitonを出す）

(2) Spin-Down phase スピンをうしなっていく（ホーキング放射に従う）
角運動量より beam pipeに垂直な成分にゲージ粒子がたくさん出る。

(3) Schwarzschild phase spin=0 (2)と同時進行だが(2)の方が早い
丸いBlackholeが質量を失う（ホーキング放射）

軽く熱く

なっていく(4) $M_{BH} \sim M_P$ 量子重力の効果が重要 で扱いにこまる

- (1) 古典近似使う $M(\text{BH}) \gg M_{\text{D}}(\text{planck})$
古典近似 πr^2
 r が大きいところ impact parameter が大きい 角運動量が大い

パートン $P=M(\text{BH})/2$ ドブロイ波長 $2\pi/P < R_s$
- (2) 禿げるphase
BHには毛が3本(mass, 電荷, 角運動量)しかない。
多重極、その他の量子数を失い 過程 (Gravitonを出す)
- (3) Spinをうしなっていく、massも ホーキング輻射 (1)よりこのが大事
角運動量より beam pipeに垂直な成分がたくさんでる。
- (4) シュバルツシルド相 $\text{spin}=0$
丸いBlackholeが質量を失う (ホーキング輻射)
- (5) $M(\text{BH}) \sim M_{\text{D}}$ string になる。(量子重力の効果が重要)

スピンドアウン過程でゲージ粒子放出が大事
ゲージ粒子はスピン軸の方にしやすい。

尾田欣さんのスライド

(Casals, Doran, Kanti 06 からの図)

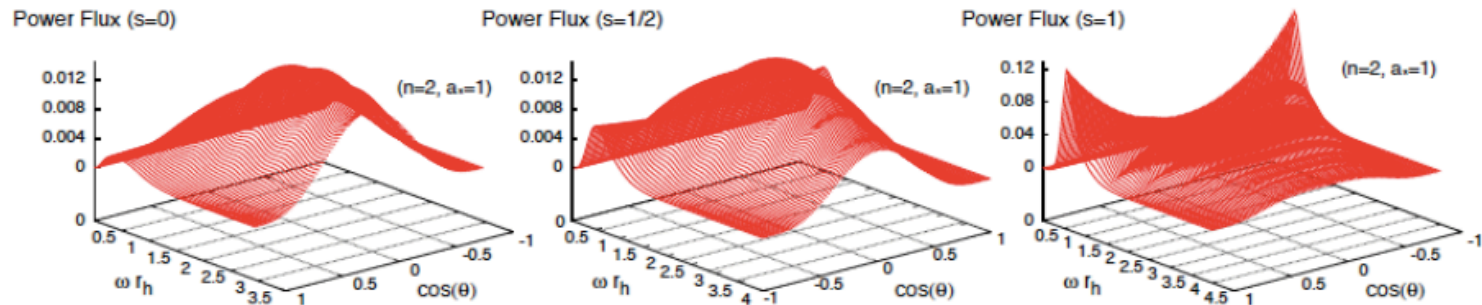
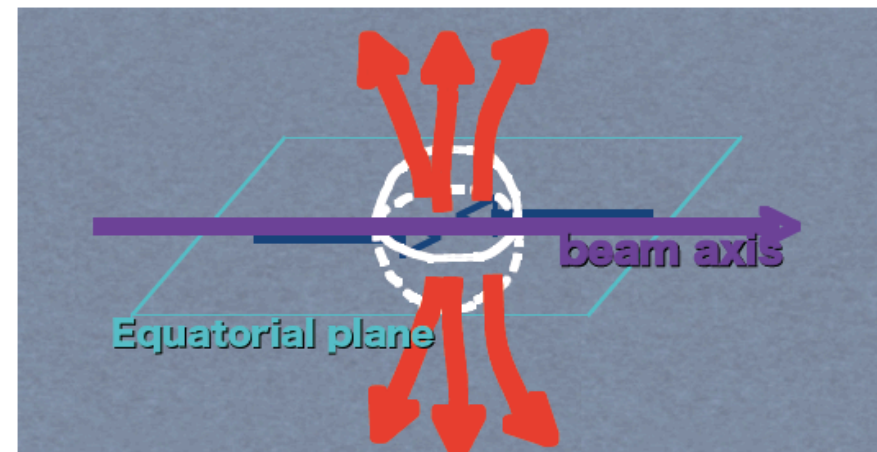


Figure 16: Angular distribution of the power spectra for (a) scalars, (b) fermions, and (c) gauge bosons on the brane from a 6-dimensional black hole with $a_* = 1$.

ゲージ場はビーム軸と垂直な極方向に放射される。

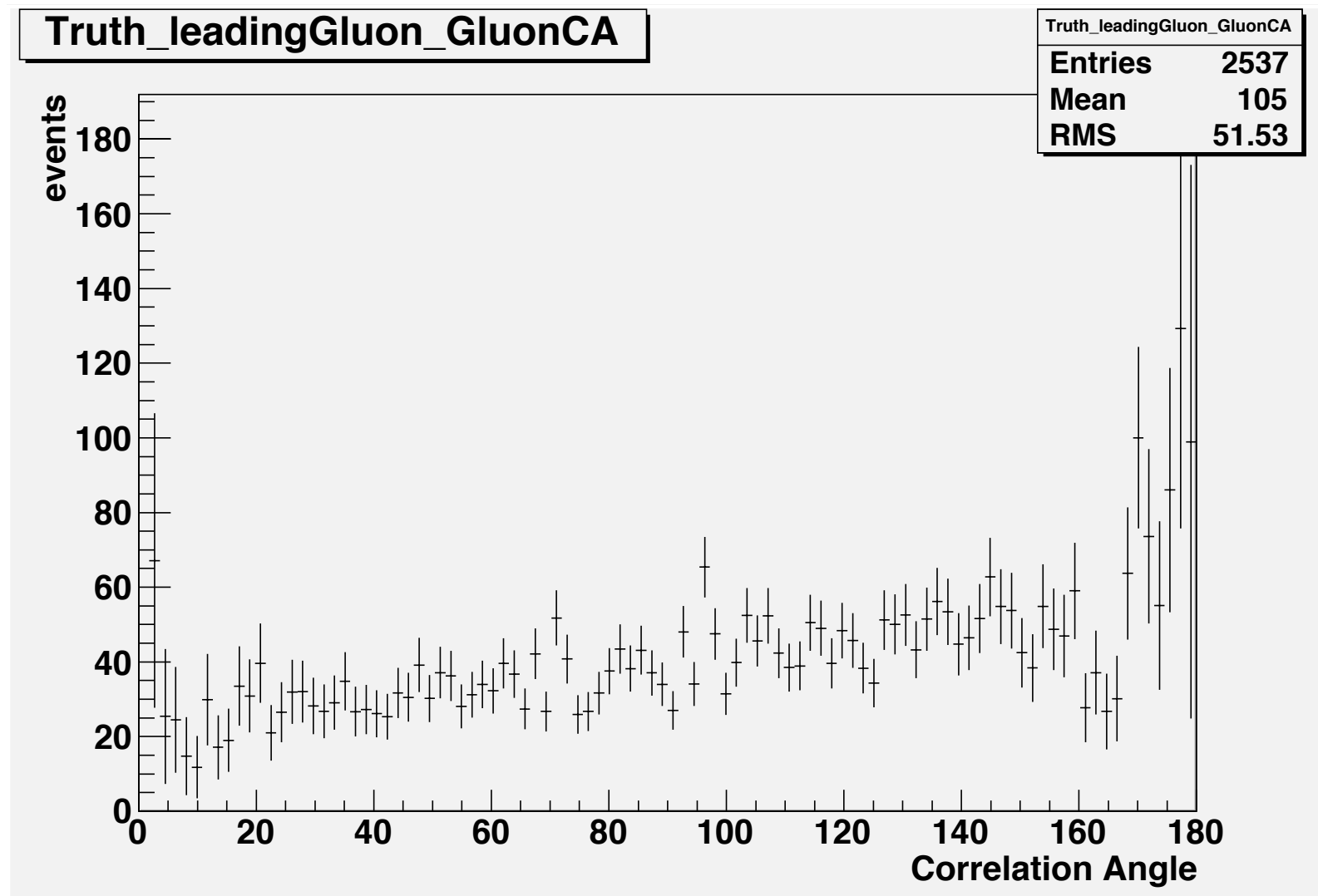
(Ida, KO, Park 02, Casals, Doran, Kanti 06)



PhotonやLeading Gluon と残りが特定の方向をむくか？

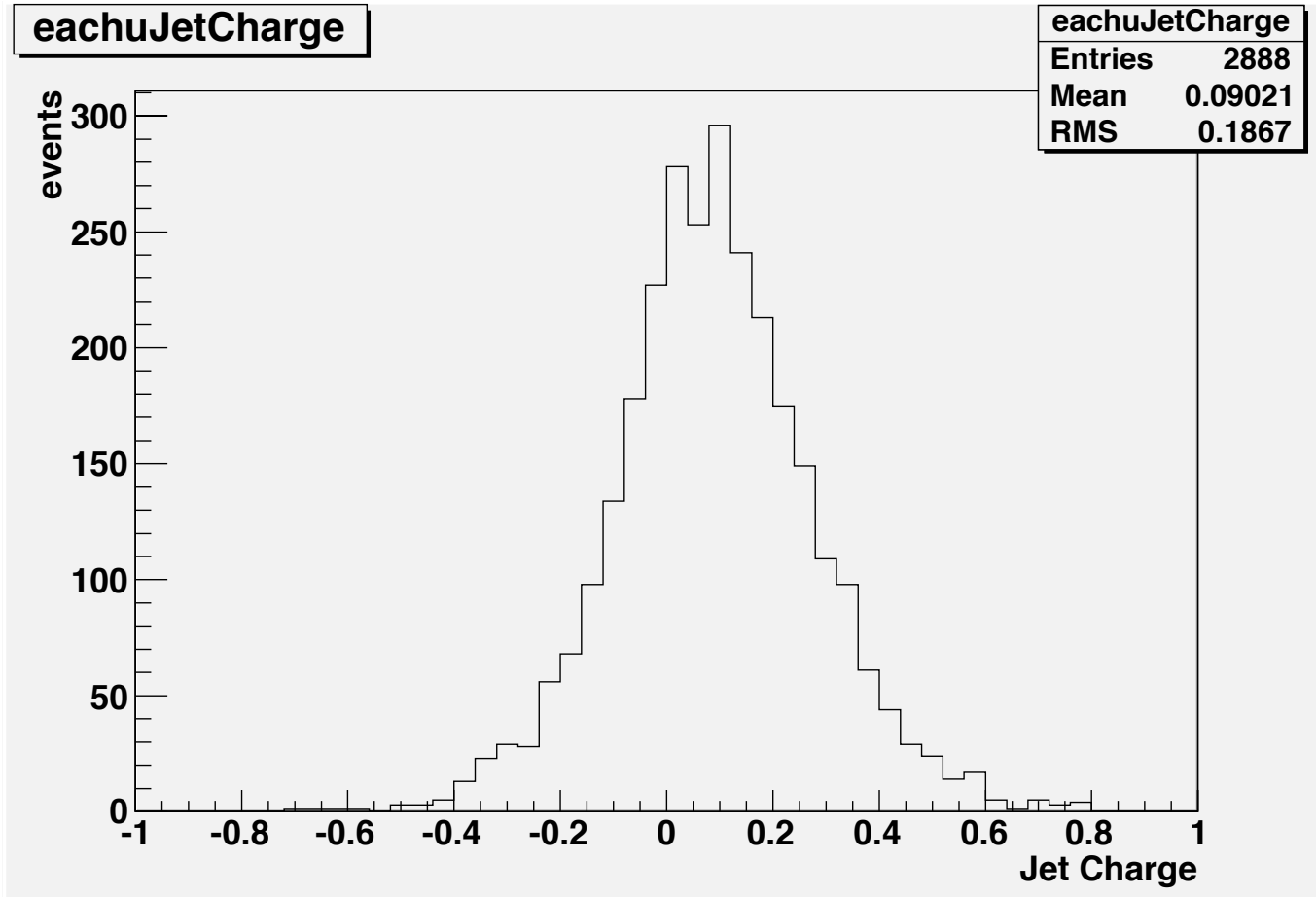
gluon, Photon ゲージ粒子の vector sum

Leadingの相関 揃いやすい傾向は見えない -> せいぜい 10-20個の粒子
kinematics のback-to-backの効果で見えない



あと、charge計れるかな～

jet charge charge of jet $\Sigma qP^{(1/3)}$



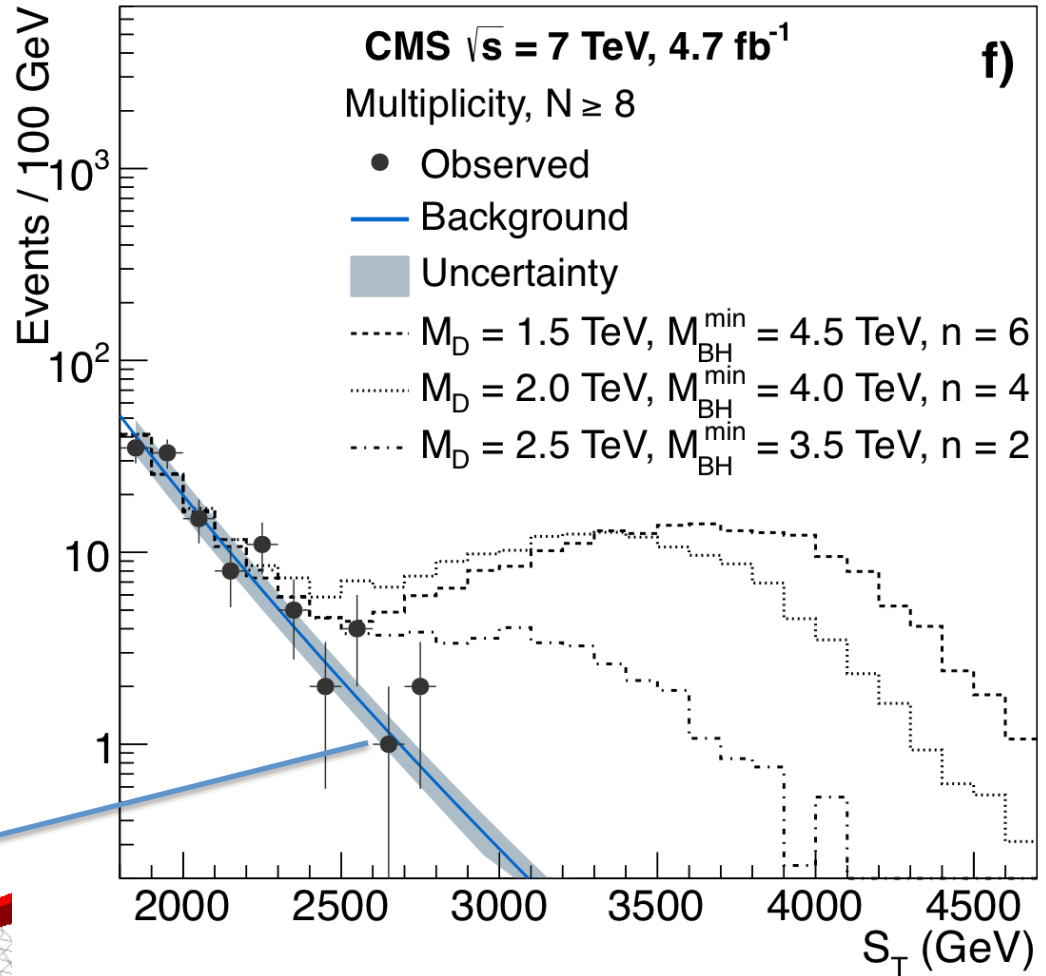
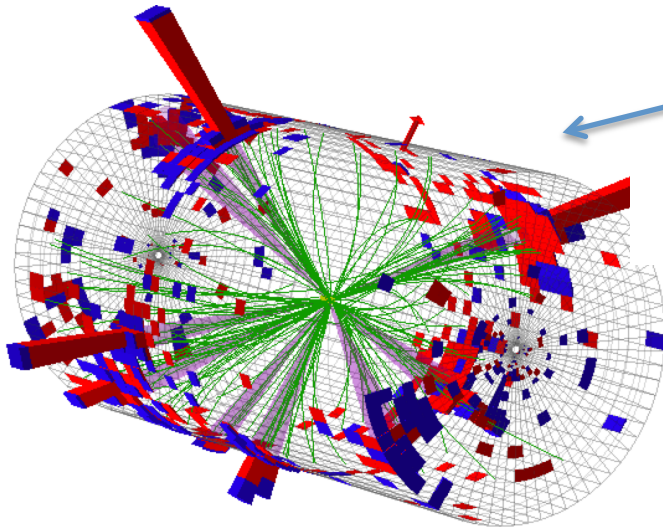
もうちょっと
おまちを

CMS

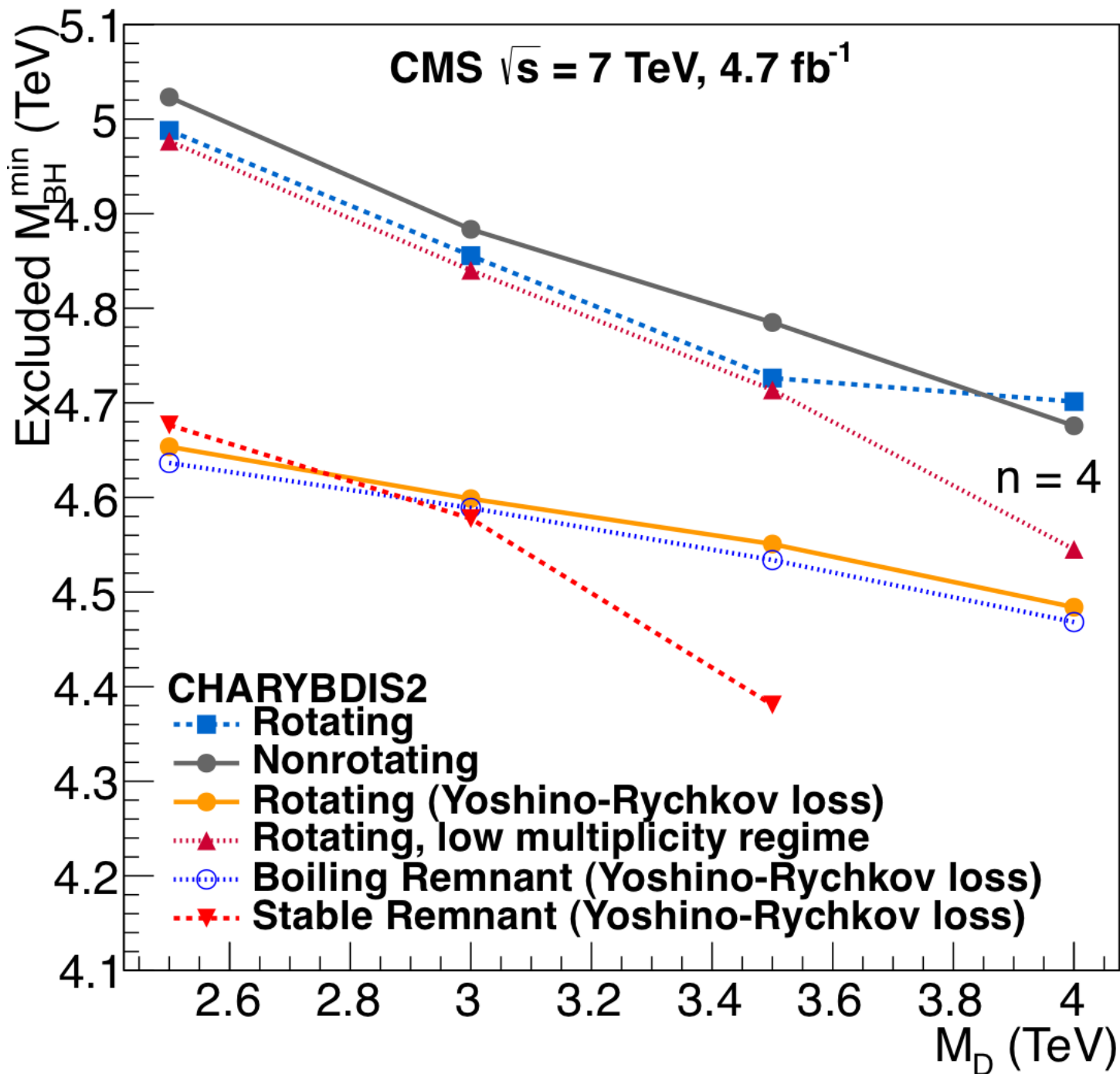
Multijets (N=3-8にわけて)

High ST = ΣPT_{jet}

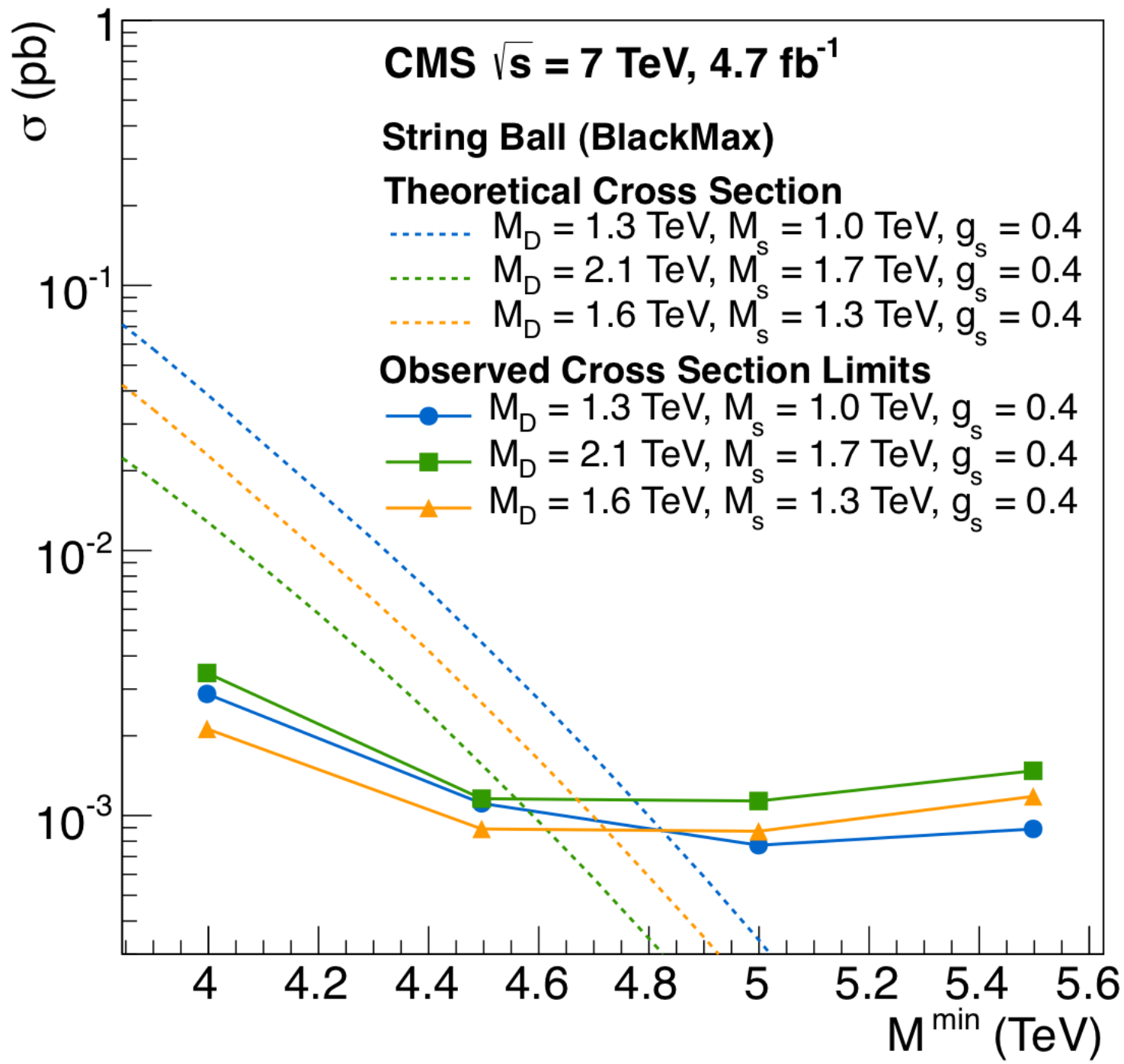
9 jets ST = 2650 GeV



QCD が main
N=2,3 で形を fit できめて
この形で N>3 fit
Small ST で fit する .
(ほんとうに正しい?)

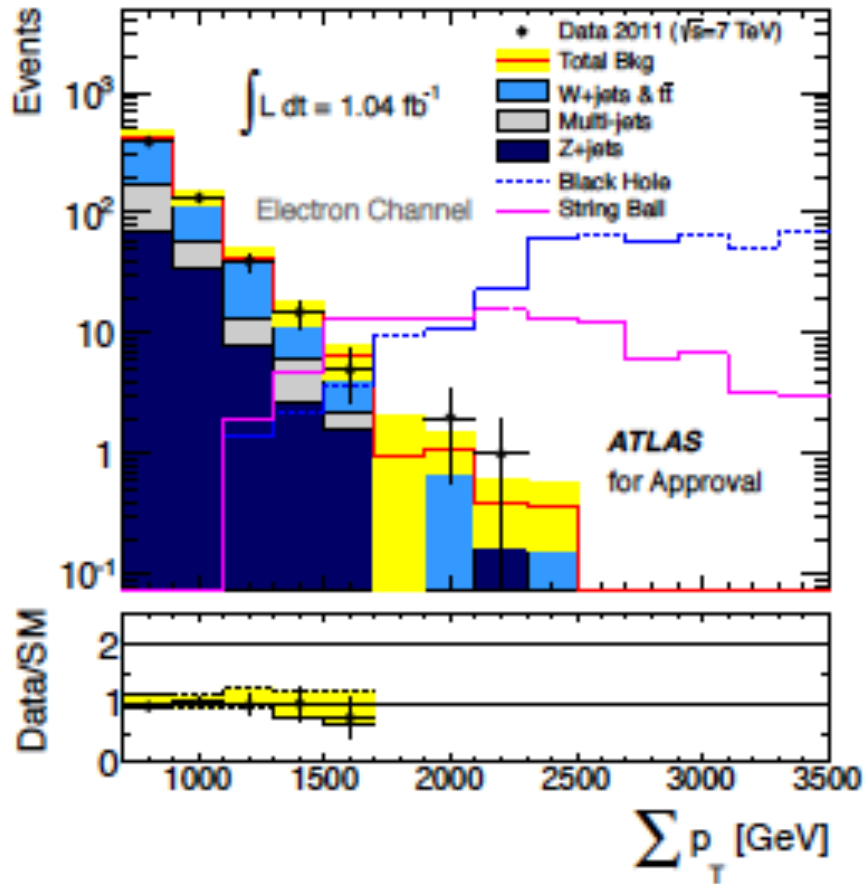


??

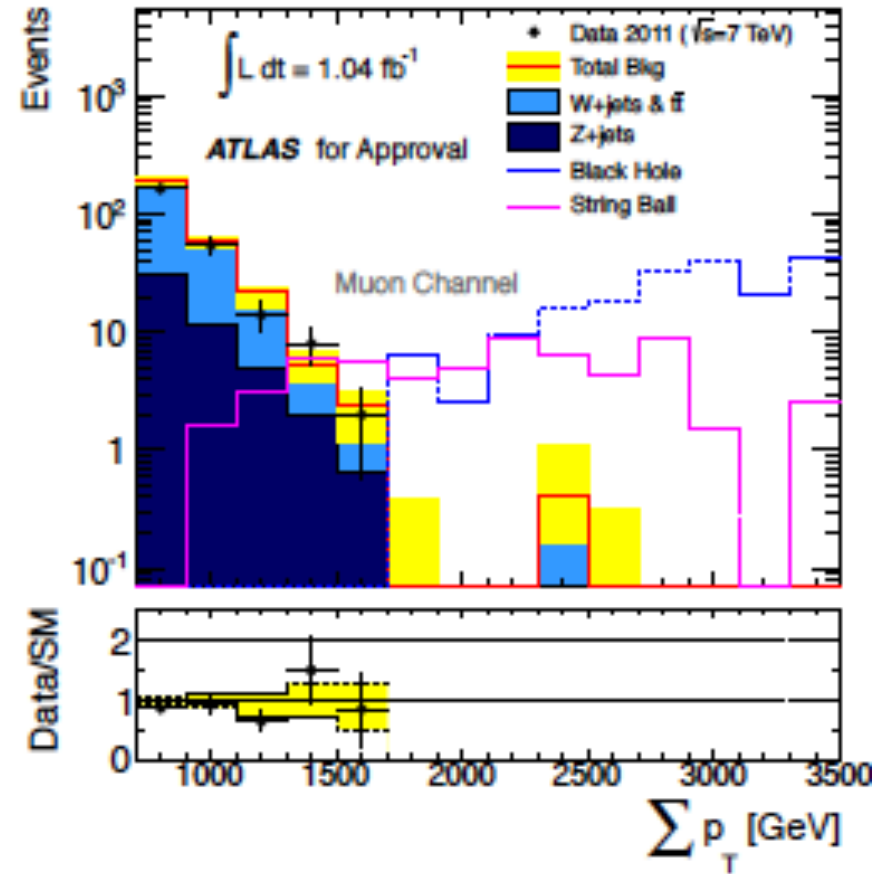


Lepton($P_T > 40 \text{ GeV}$) + MultiJets

W+Jets, $t\bar{t}$ main BG



(a) Electron channel



(b) Muon channel

Data BG consistent

No Excess was found

topology



複雑

	ADD			RS		UED	コメント
	G放出	s	t(含BH)	G	g		
monojet	○						綺麗だけど
γ +missing	○						
$e^+e^- \mu^+\mu^-$ non-reso resonance		○		○			DY BG Z',W'
$\gamma\gamma$ non-reso resonance		○		○			
$\mu\mu$ (SS)			○				BG free
2jets		○	○	△	△		万能だが
boosted top					○		subjet
multi-objcet w/o lep with lepton			○				QCD BG
mET+Lepton+jets with Photon			△			○	SUSYもどき
			△			○	GMSUSY

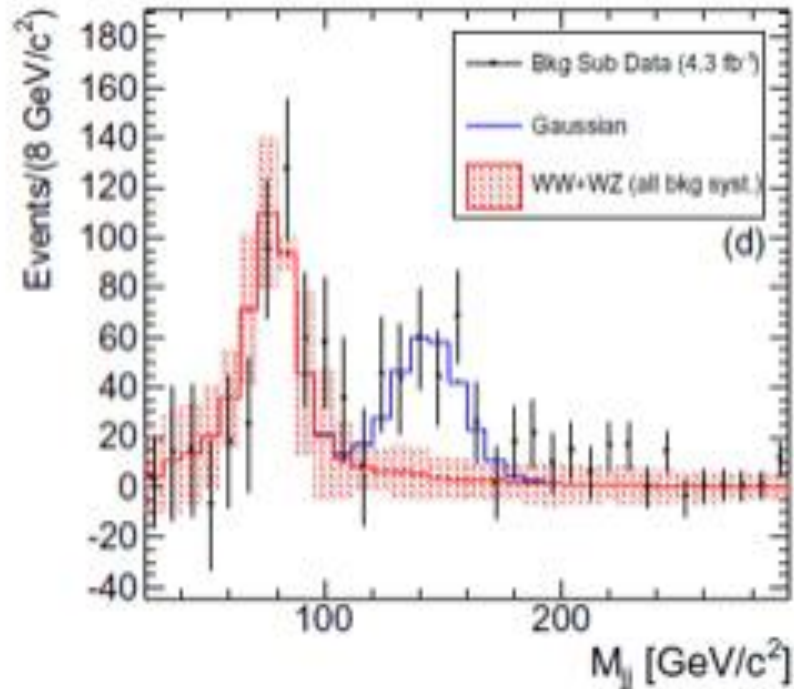
3TeV 2.7TeV ~ 1-2TeV 1.2 TeV

$\Lambda > 10.2\text{TeV}/7.8\text{TeV} (\text{llqq/jjjj})$

1TeV

1.5TeV

technicolor



$$\pi_{\text{TC}} \ 160\text{GeV}$$

$$Q_{\text{TC}} \ 290\text{GeV}$$

Low scale Technicolor model

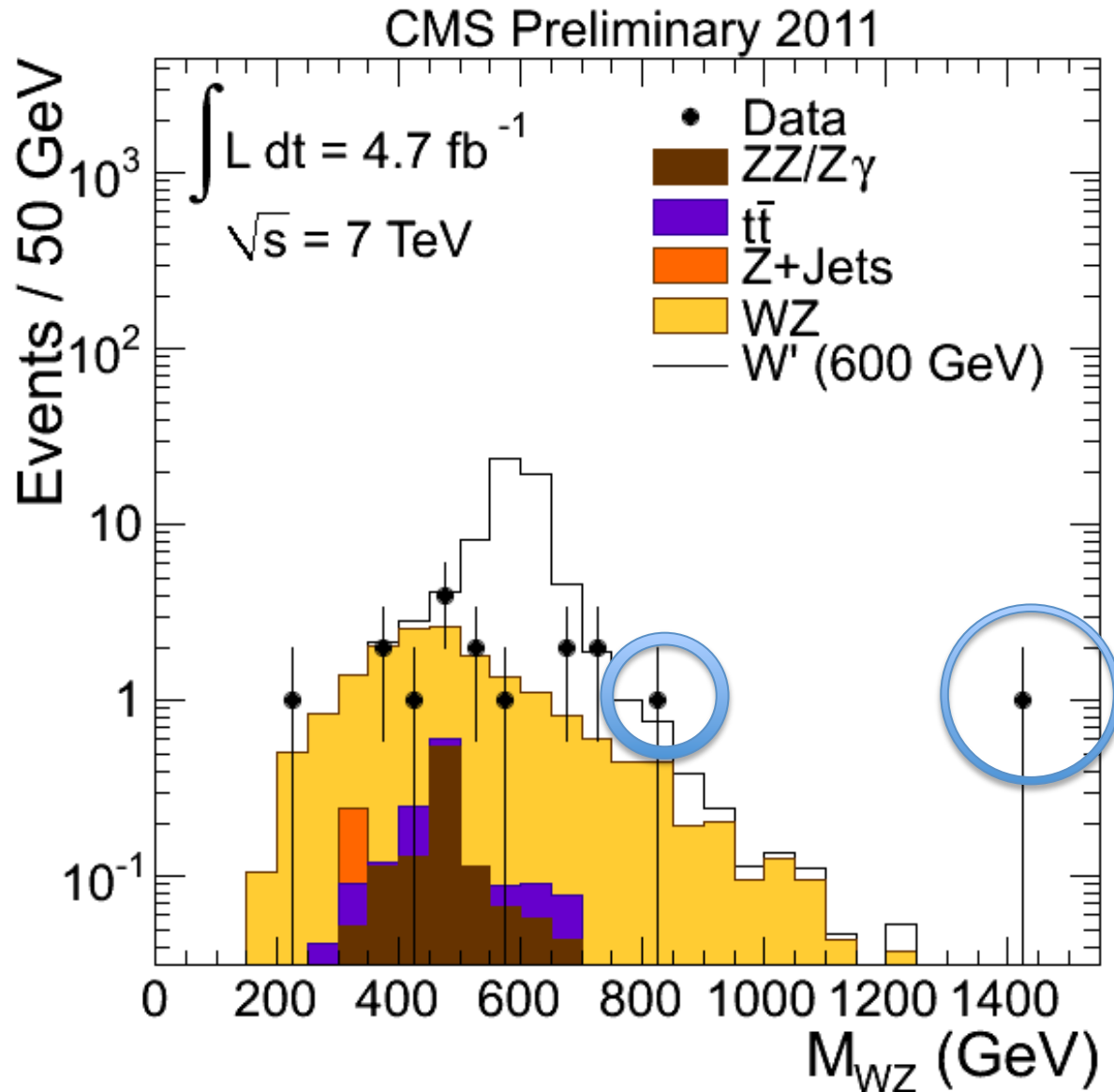
Techni Scalar NGB π_{TC} (W,Zに少し混ざっている)

Techni Vector ρ_{TC} ω_{TC} , massはほぼ縮退を仮定(isospin)

こいつらのmass 400-800GeV くらい

$$\begin{aligned} \rho_{TC}^{+-0} \quad \omega_{TC}^0 &\rightarrow WZ, WW, ZZ \quad (m(\rho_{TC}) < m(W) + m(\pi_{TC})) \rightarrow 4l/11\nu/ \\ &\rightarrow \gamma \pi_{TC}, W\pi_{TC} \text{ or } Z\pi_{TC} \quad \rightarrow l\nu jj \\ &\rightarrow \parallel \\ &\rightarrow 2 \pi_{TC} \rightarrow 4\text{fermion} \quad (\text{Not Yet}) \end{aligned}$$

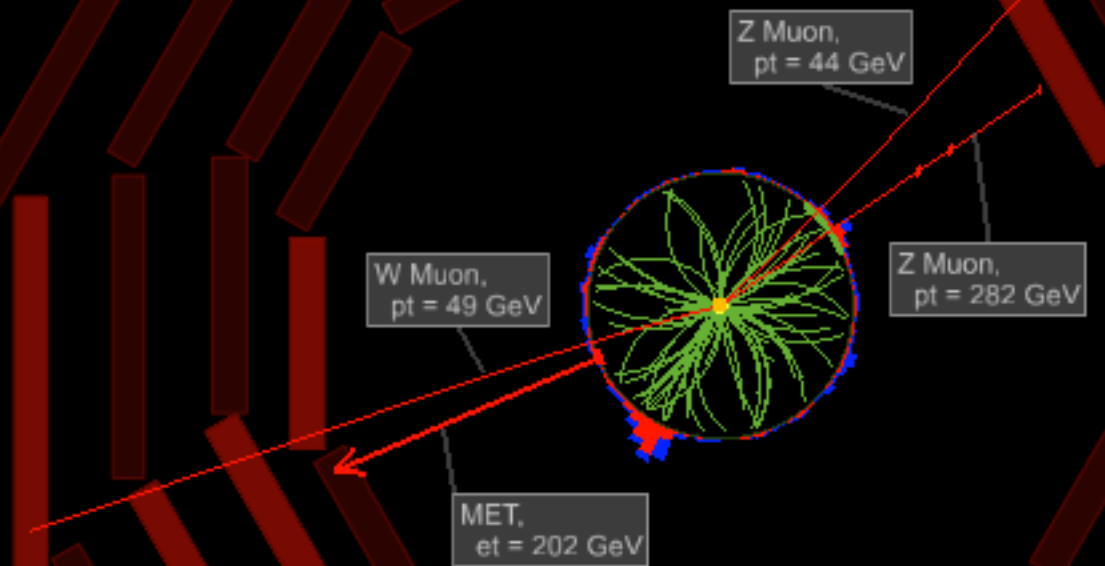
[A] WZ -> 3lepton+mET



どんなのか？

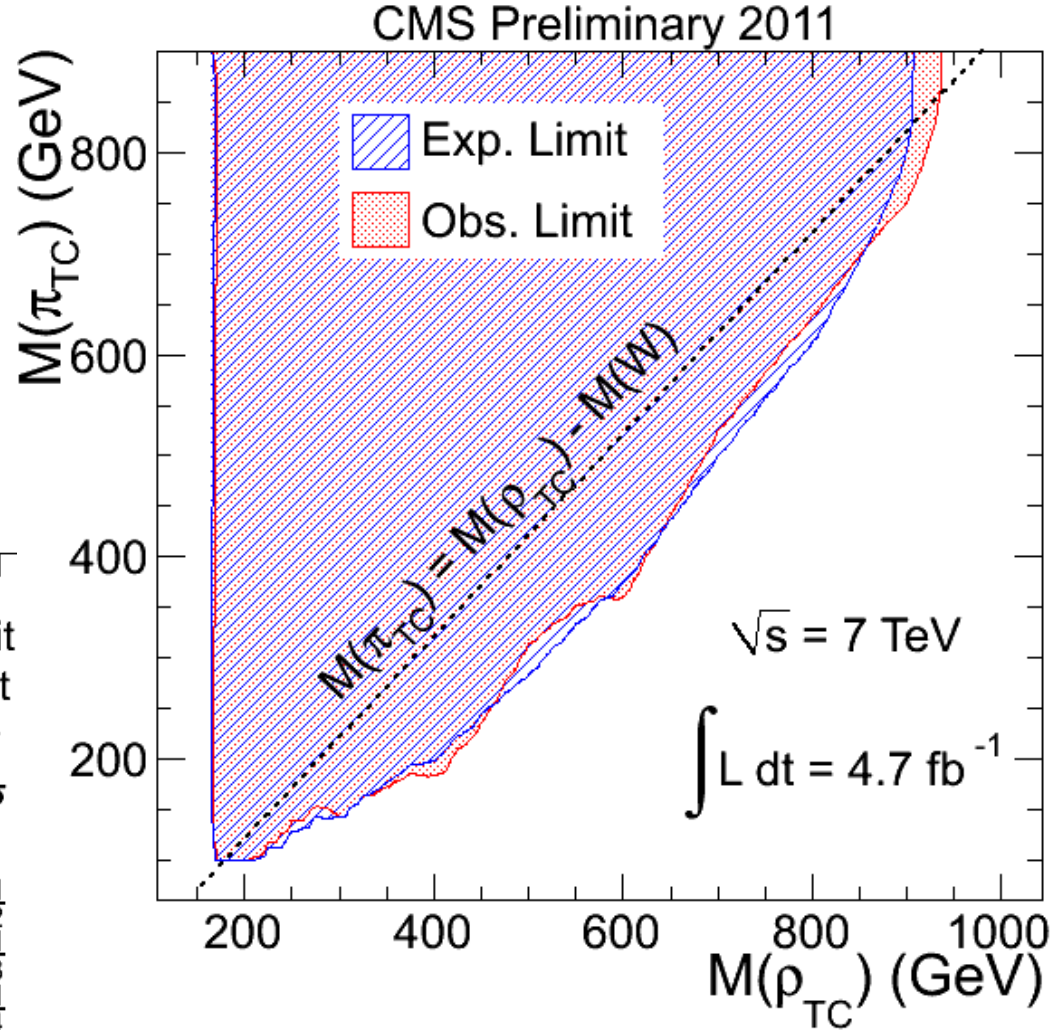
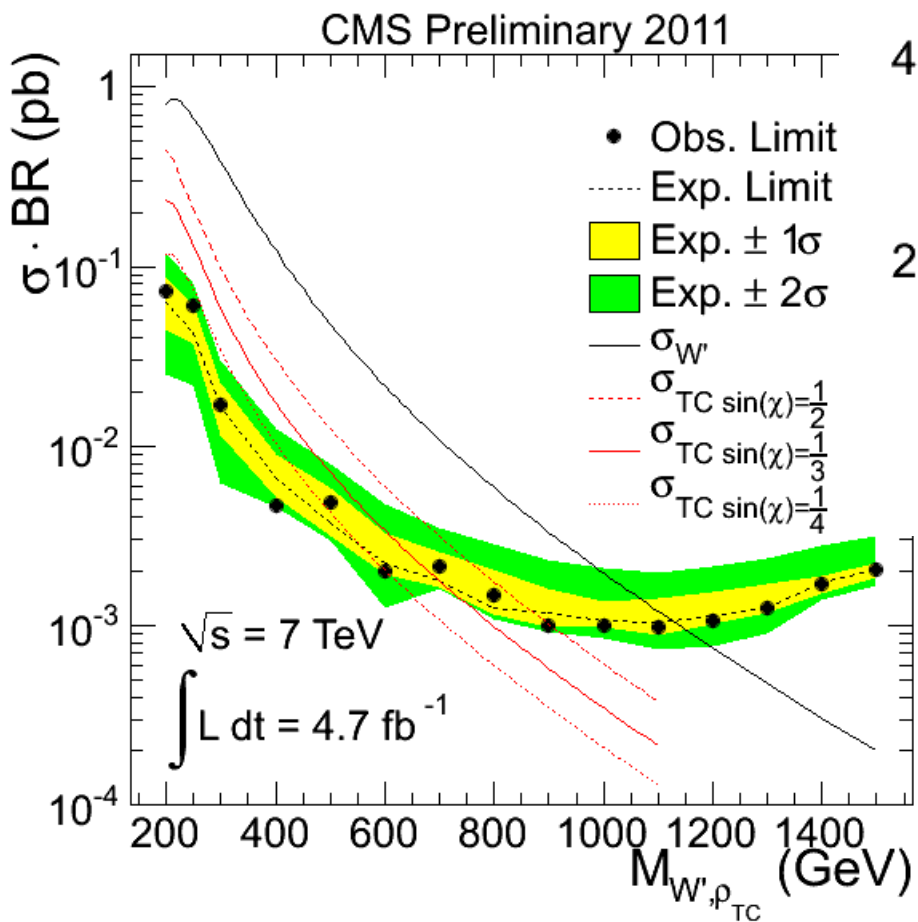


CMS Experiment at LHC, CERN
Data recorded: Fri Jul 29 06:56:28 2011 CEST
Run/Event: 172033 / 579311723
Lumi section: 436



M_WZ: 815 GeV
HT: 376 GeV
M_Z: 88 GeV
pt_Z: 326 GeV
MT_W: 15 GeV
pt_W: 252 GeV

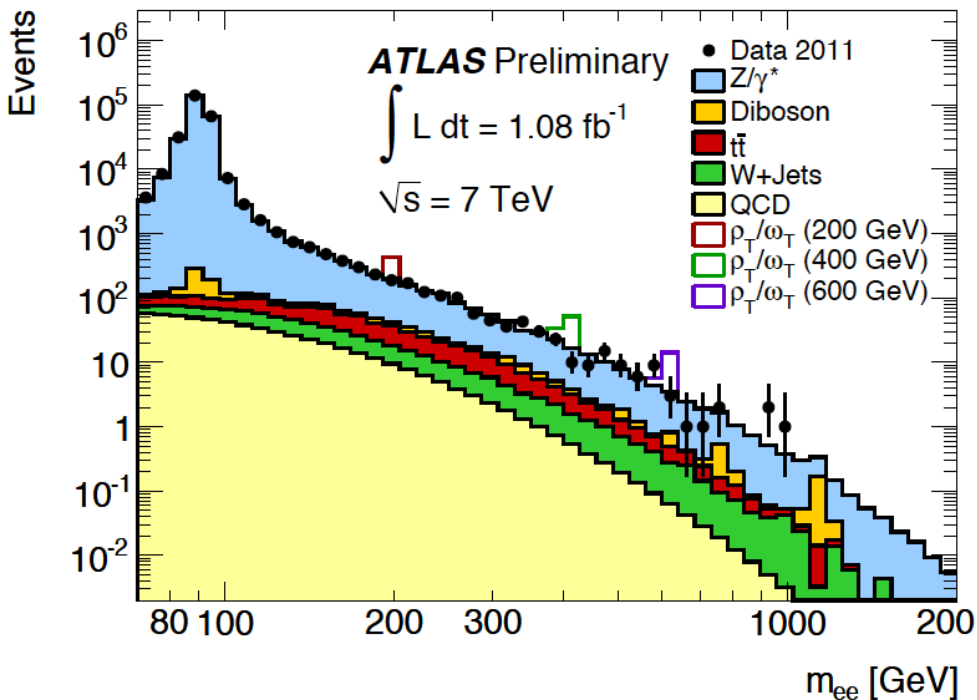
$W' \rightarrow WZ$ (SM) 1141 GeV



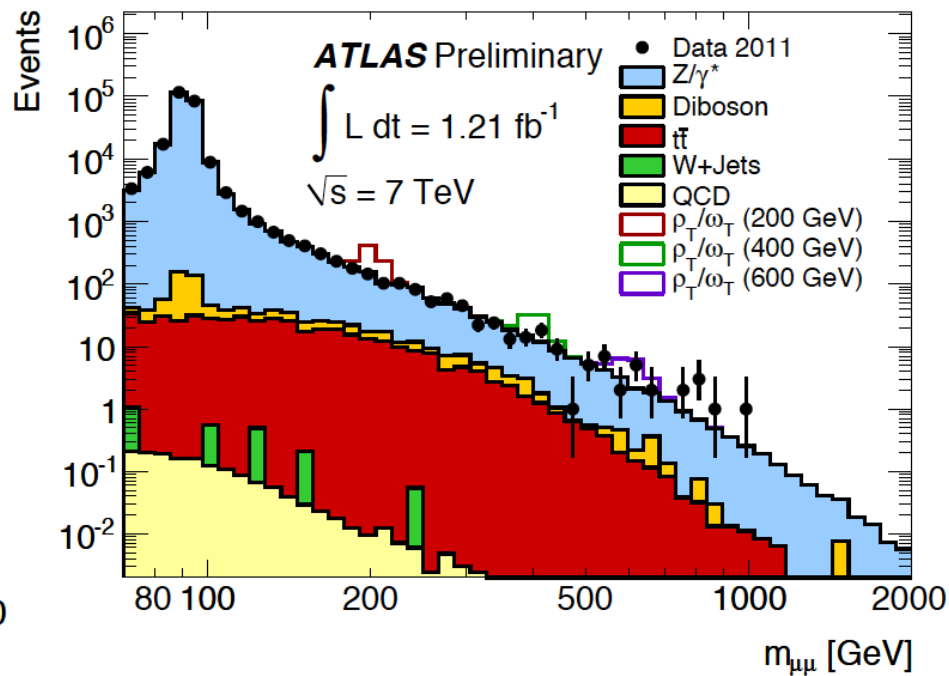
900 GeVくらいまでもうexclude

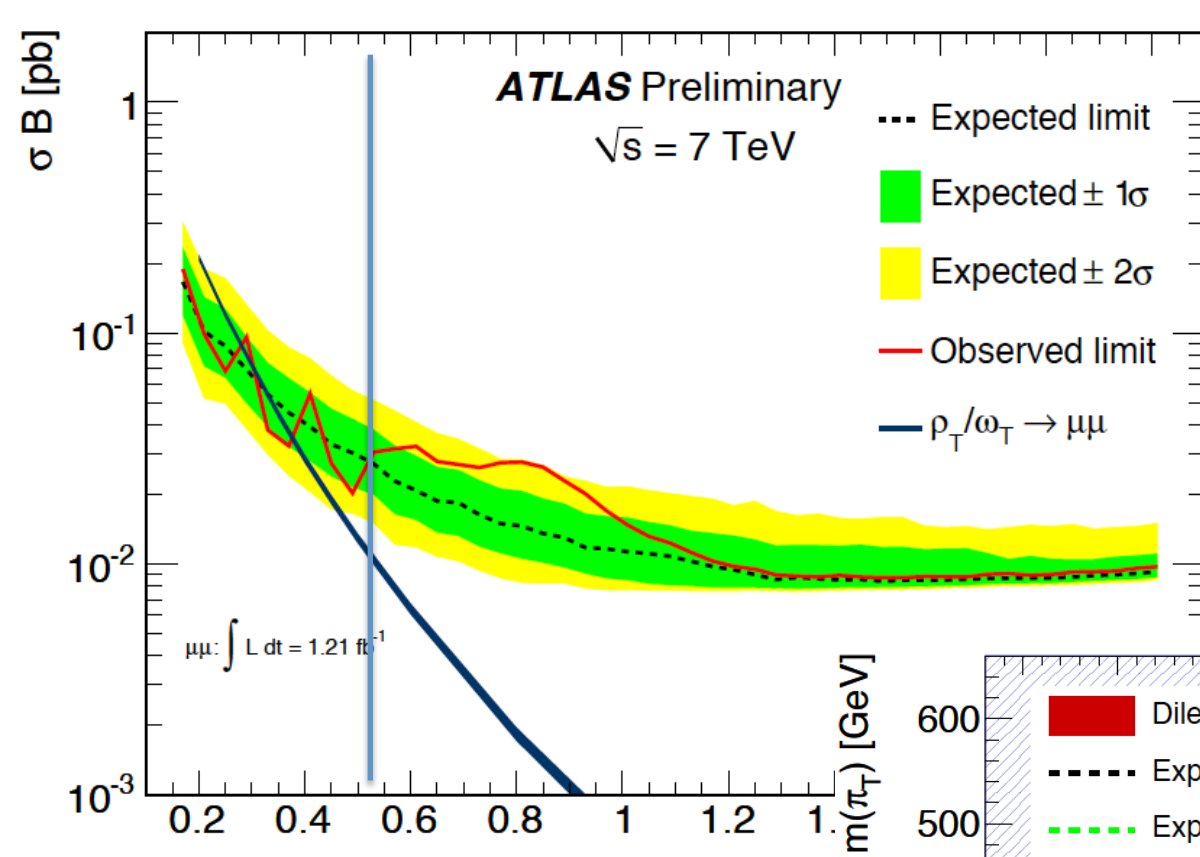
[B] high mass lepton pair

(5fb^{-1} は G_{KK} の所)



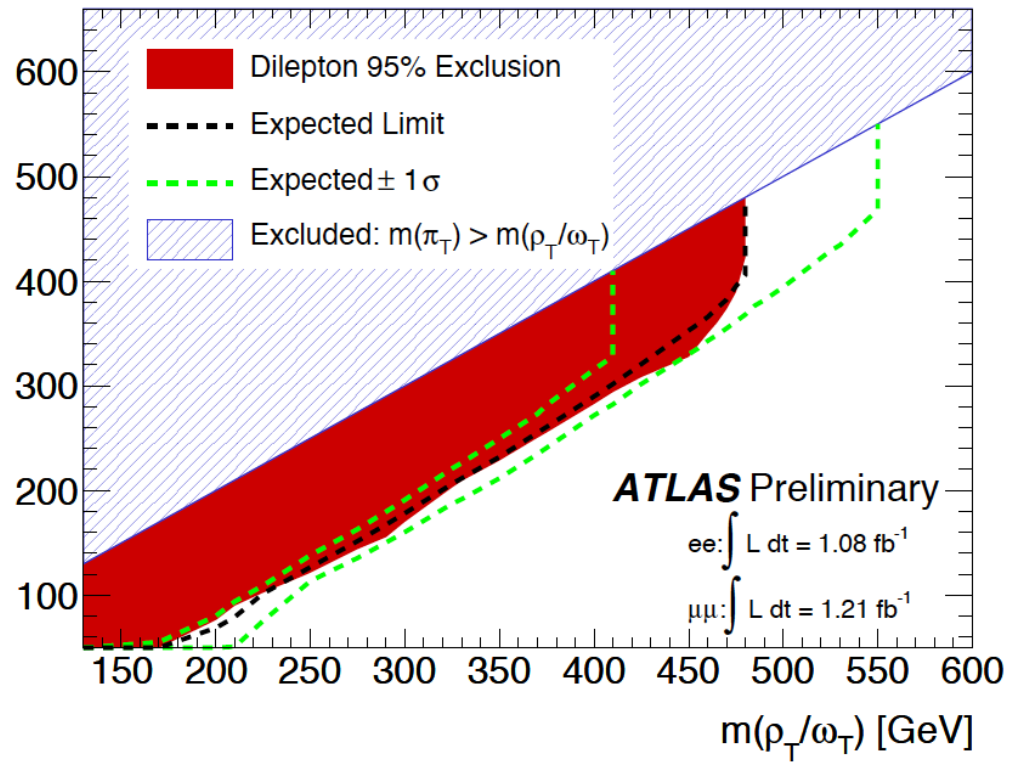
分解能とBG



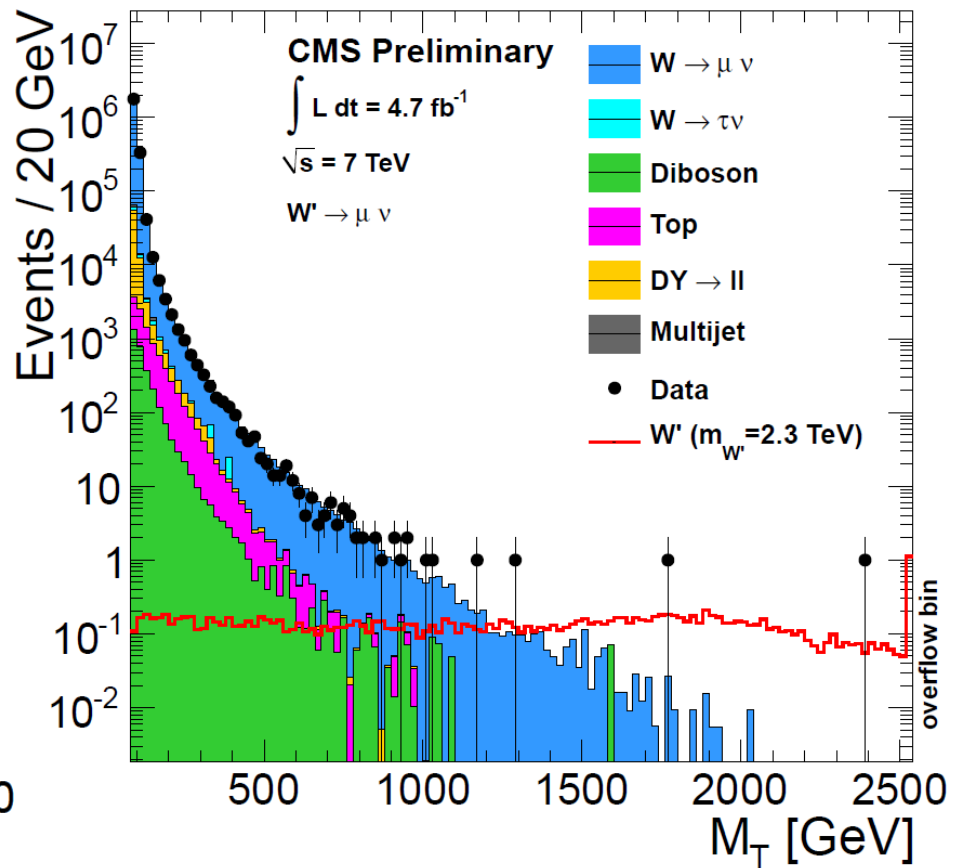
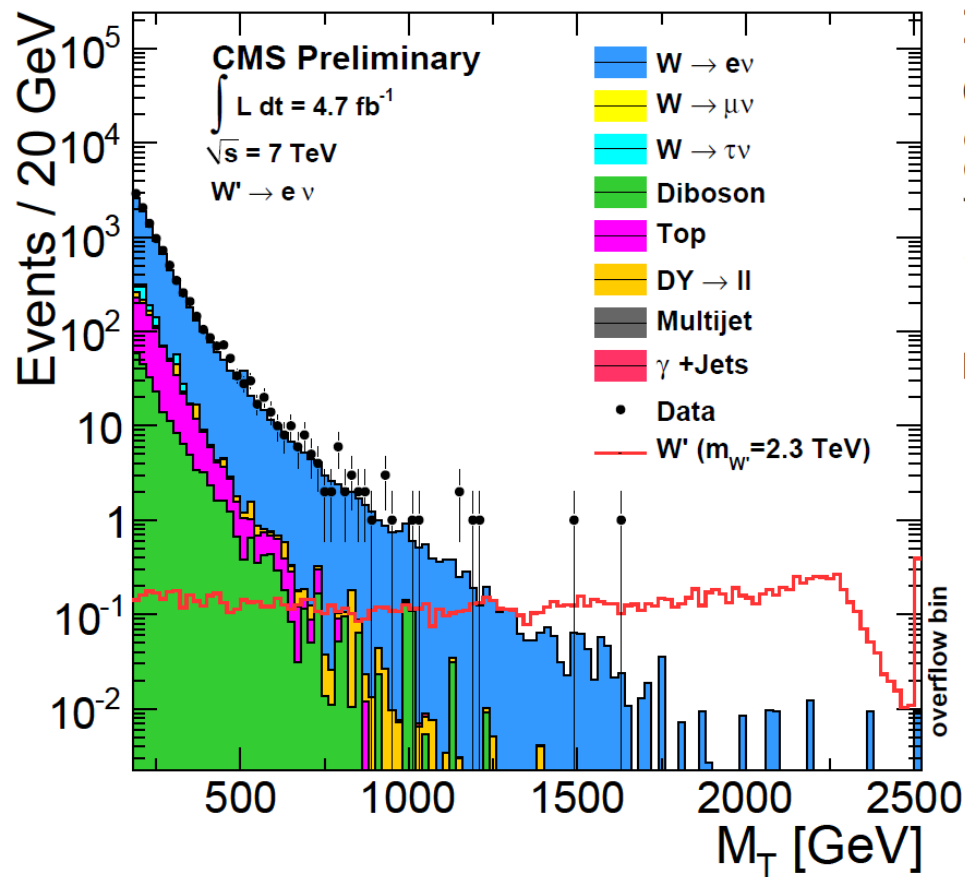


480GeV

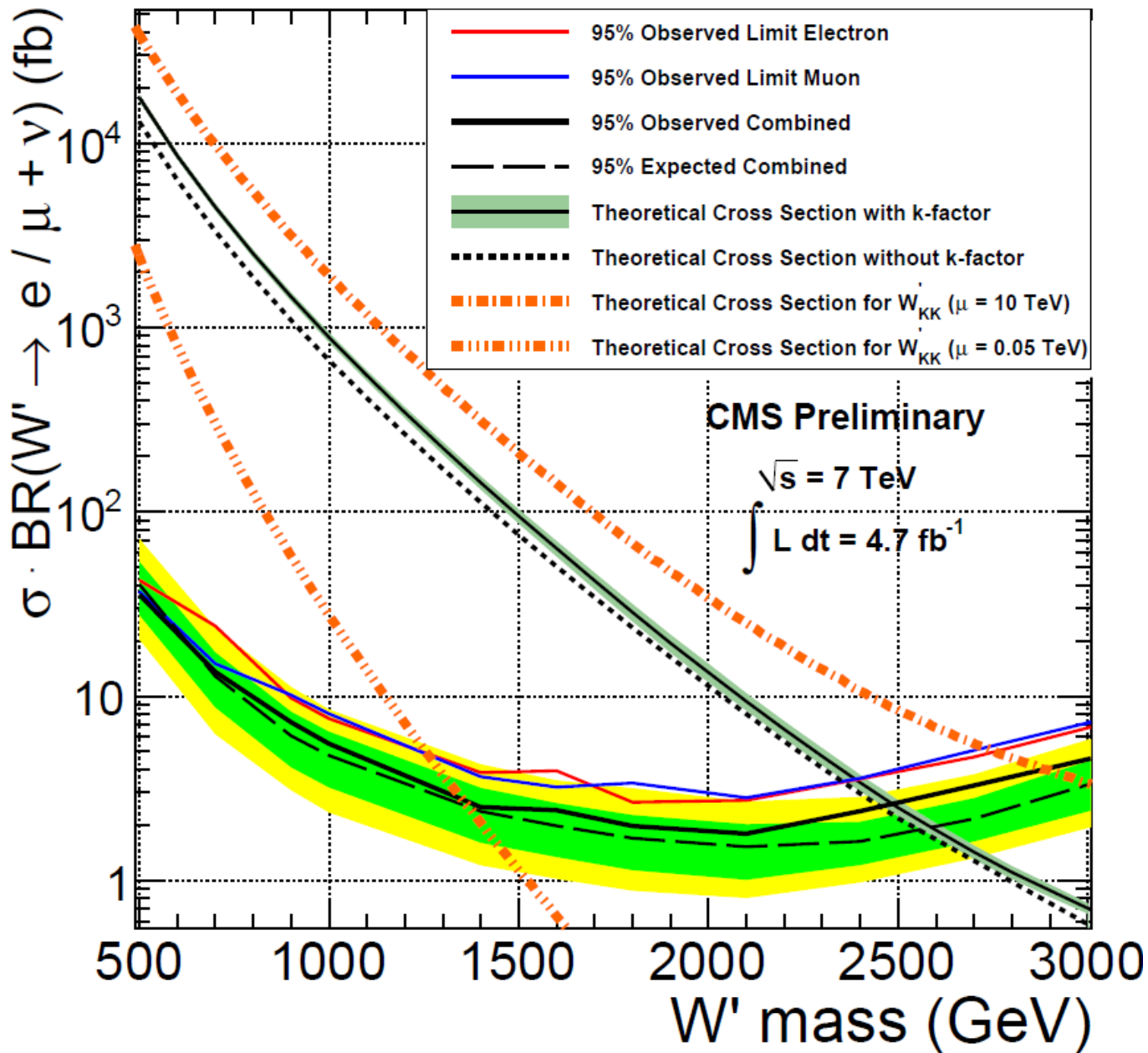
5fb-1にすると650?



DY W($\rightarrow l \nu$) MT distributions



$$M_T = \sqrt{2P_T^\ell E_T (1 - \cos \varphi)}$$



W' 2.45TeV

第4世代

[1] $y_{q4} > 1$ Higgs で exclude $> 700\text{GeV}$

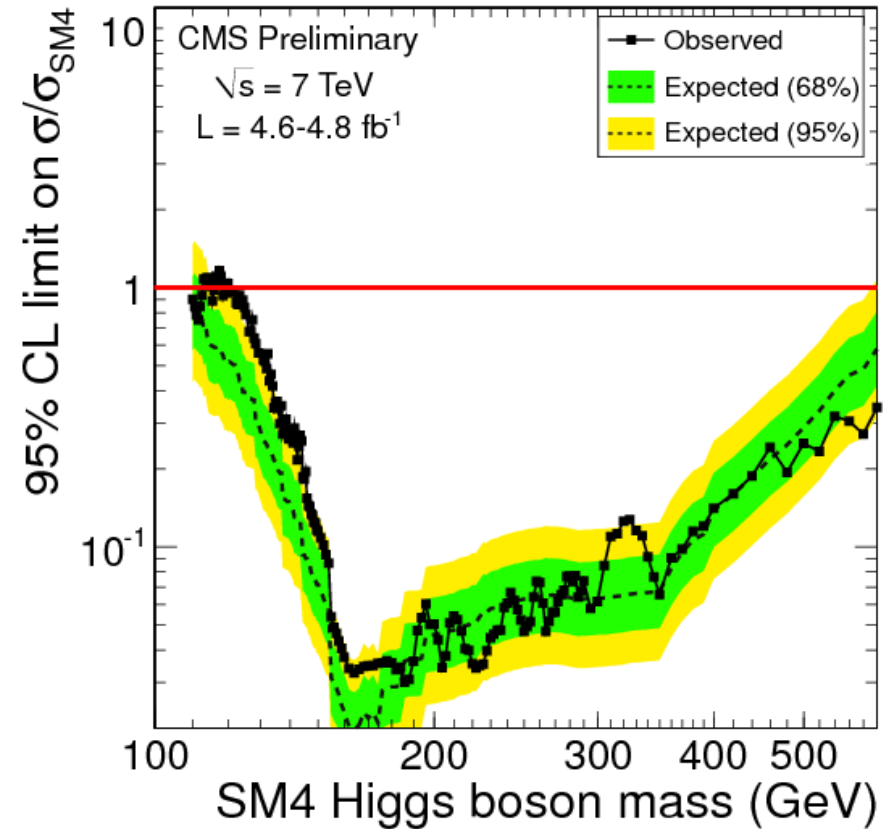
[2] $V_{q4 t,b} = 0$

Heavy stable particle

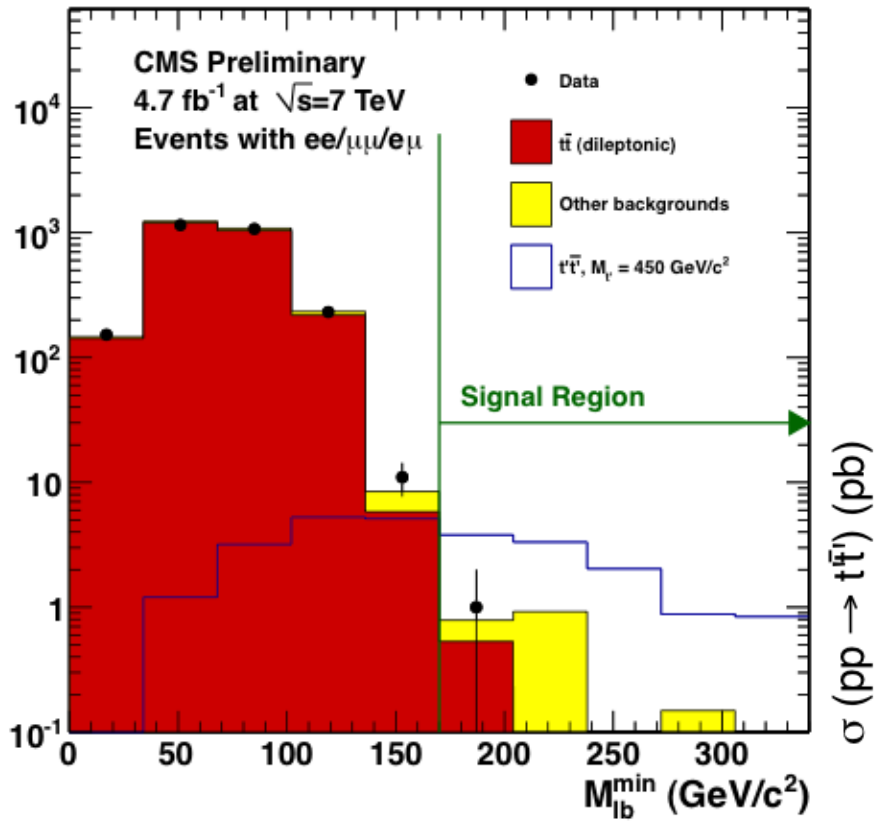
Stable stop $735\text{GeV} + \alpha$ (LR)

[3] $V_{q4 t,b}$ が まあまああって decay

Q4 \rightarrow Wq	(jjWW \rightarrow jj 2l+mET)	350GeV (L=1fb ⁻¹)
U' \rightarrow Wb	(bbWW \rightarrow bbl+ MET)	552GeV
D' \rightarrow Wt	(ttWW \rightarrow at least 1 b + 3L or SS L)	600GeV

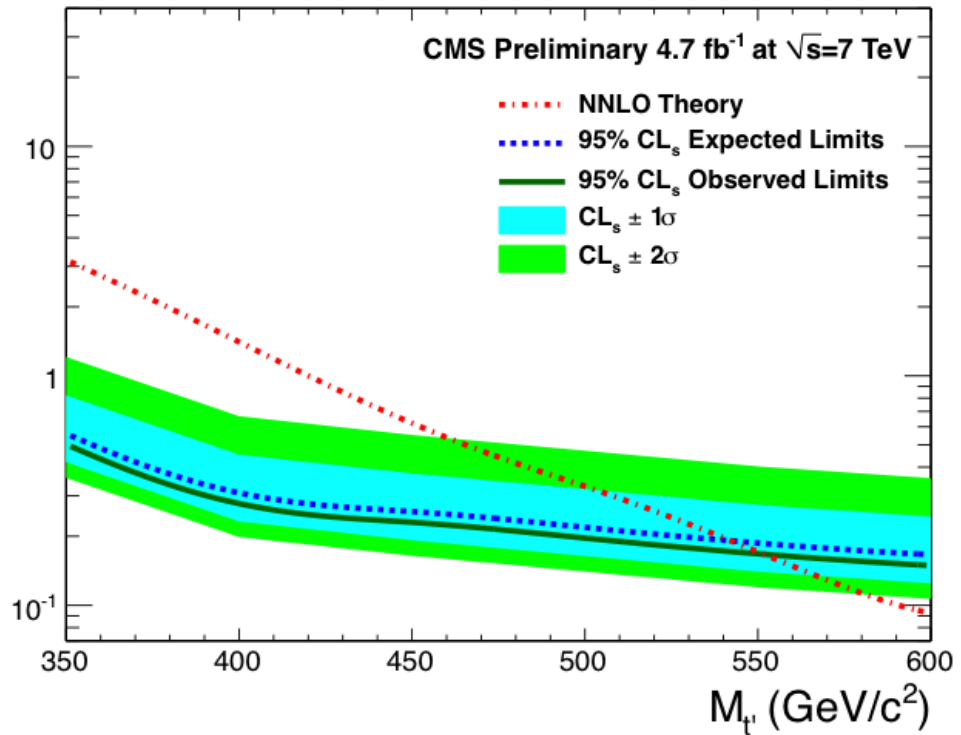


$t_4 t_4 \rightarrow b W \quad b W \rightarrow bb ll + mET$



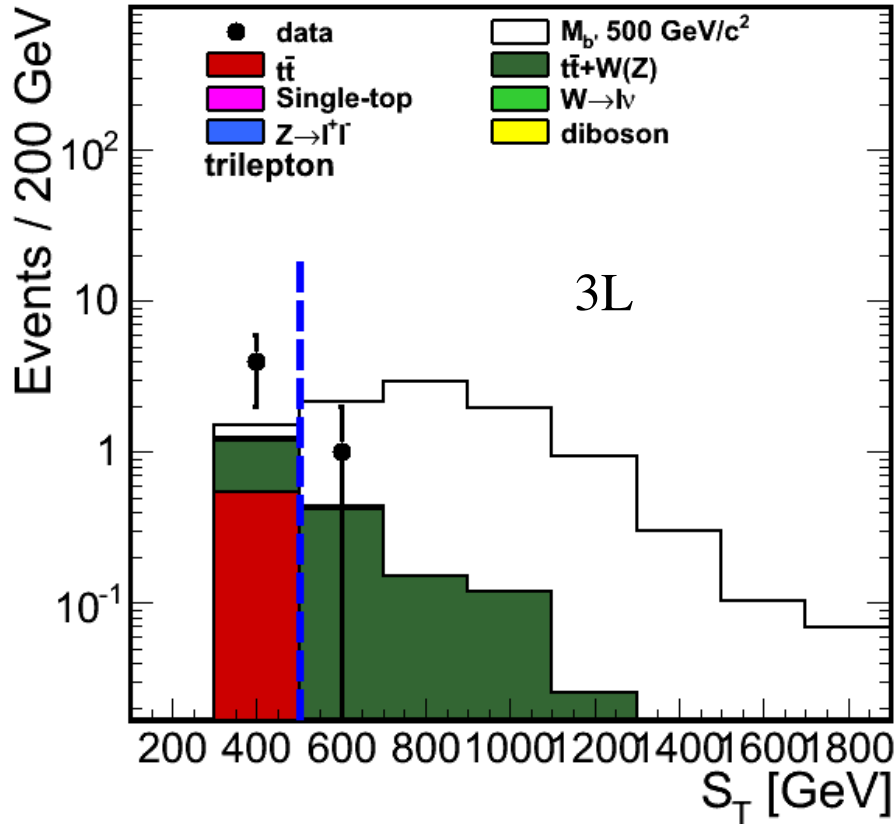
$M(t_4) > 552$ GeV (95%CL)

2lepton + 2 b + mET で4通りのM(bl)
M(bl) でcutをかける

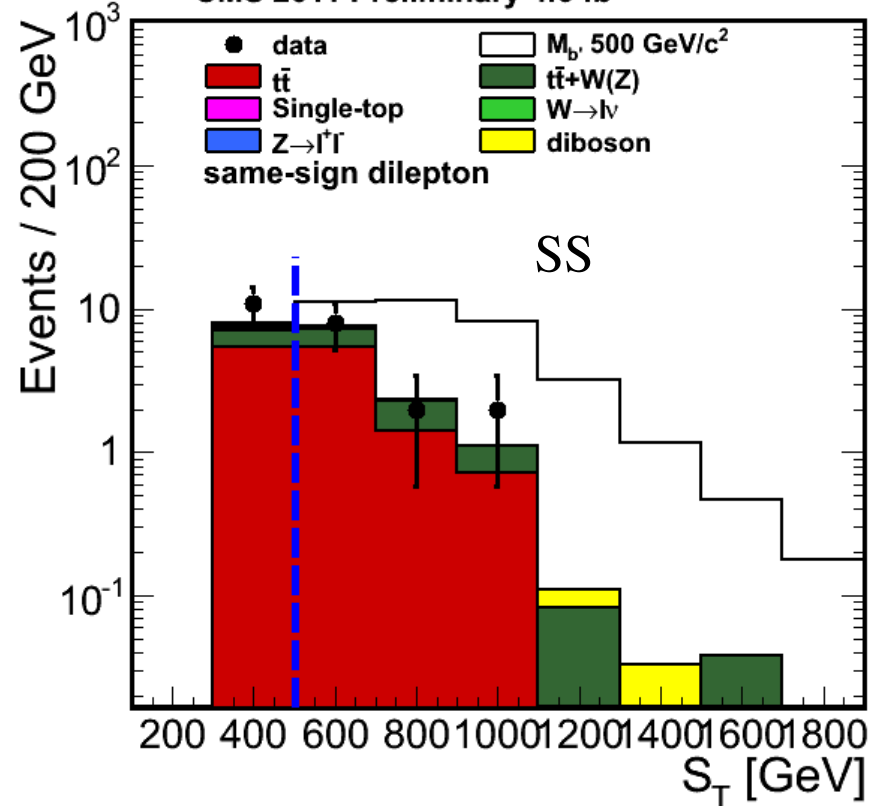


$b_4 b_4 \rightarrow t W \quad t W \rightarrow b b 4 W$

CMS 2011 Preliminary 4.6 fb⁻¹



CMS 2011 Preliminary 4.6 fb⁻¹



at least one b + 3L / SS 2L
ST でcutをかける

$M(b_4) > 600 \text{ GeV} \quad (95\% \text{ CL})$

ATLAS Exotics Searches* - 95% CL Lower Limits (Status: March 2012)

ATLAS
Preliminary

$\int L dt = (0.04 - 5.0) \text{ fb}^{-1}$
 $\sqrt{s} = 7 \text{ TeV}$

Extra dimensions

CI

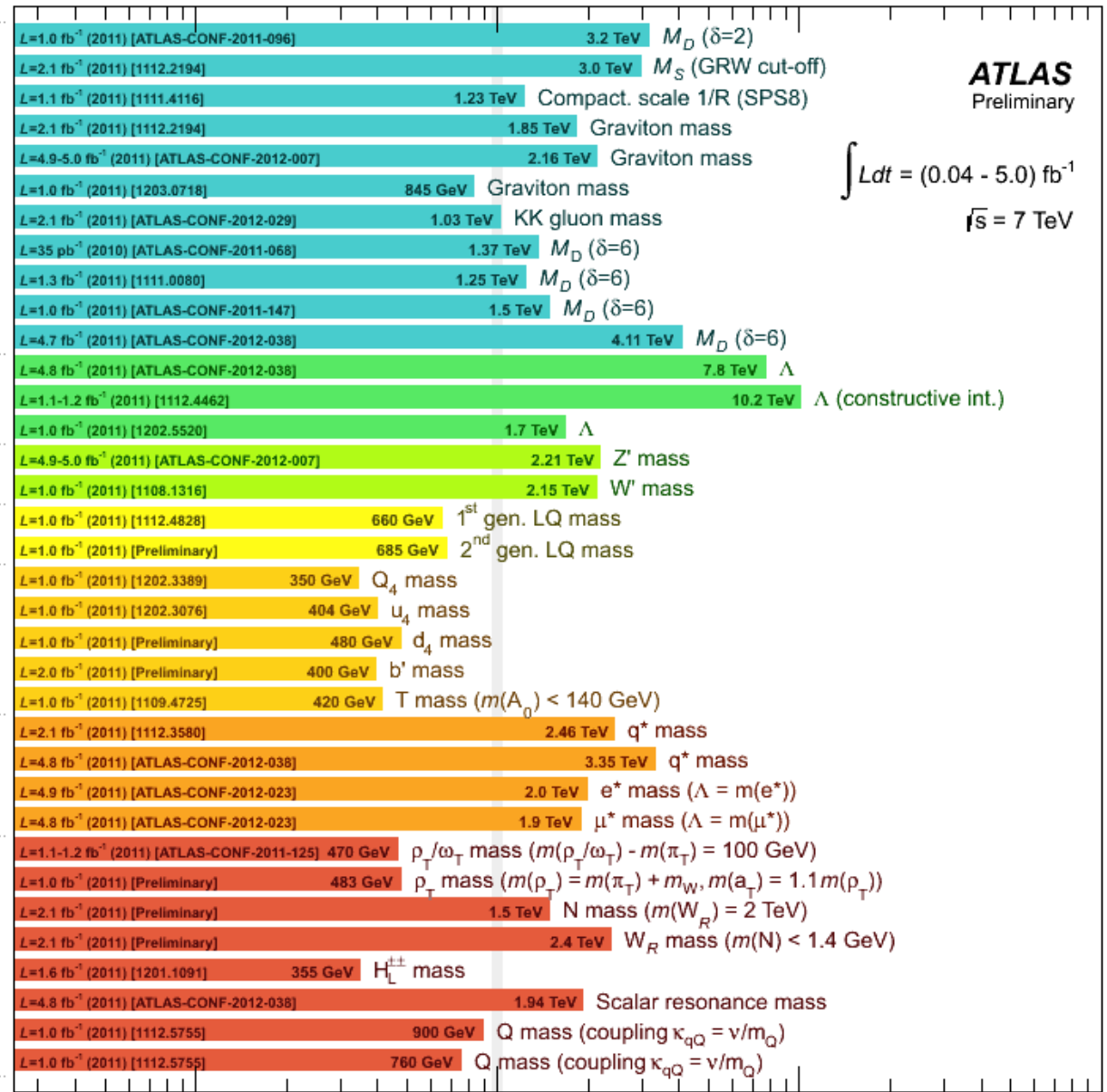
V

LQ

New quarks

Excit. ferm.

Other



*Only a selection of the available mass limits on new states or phenomena shown

Mass scale [TeV]