INSTITUTE FOR THE PHYSICS AND MATHEMATICS OF THE UNIVERSE

Split UED

Park, JS, arXiv:0901.0720, Phys. Rev. D 79, 091702 (R)

Chen, Nojiri, Park, JS, Takeuchi, arXiv:0903.1971

Chen, Nojiri, Park, JS, work in progress

Jing Shu

IPMU

Outline

- Motivation.
- Model, mass spectrum and modified couplings.
- Cosmic rays in LKP annihilation.
- Resonance searches from the dijets channel at LHC.
- Missing energy + muti-jets at LHC
- Summary.

Motivation

Recent results in the high energy cosmic rays (PAMELA, ATIC/PPB-BETS) tell us that there are excesses in e+, e-, but not anti-p.

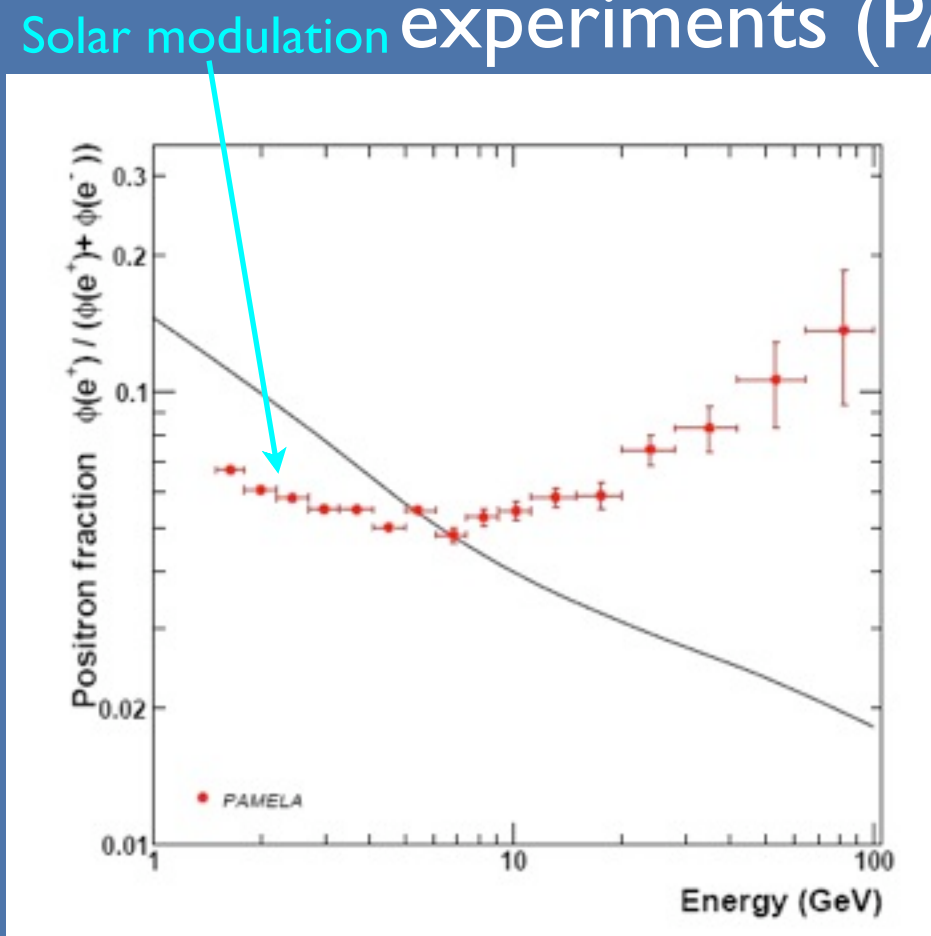
More recently FERMI

↓

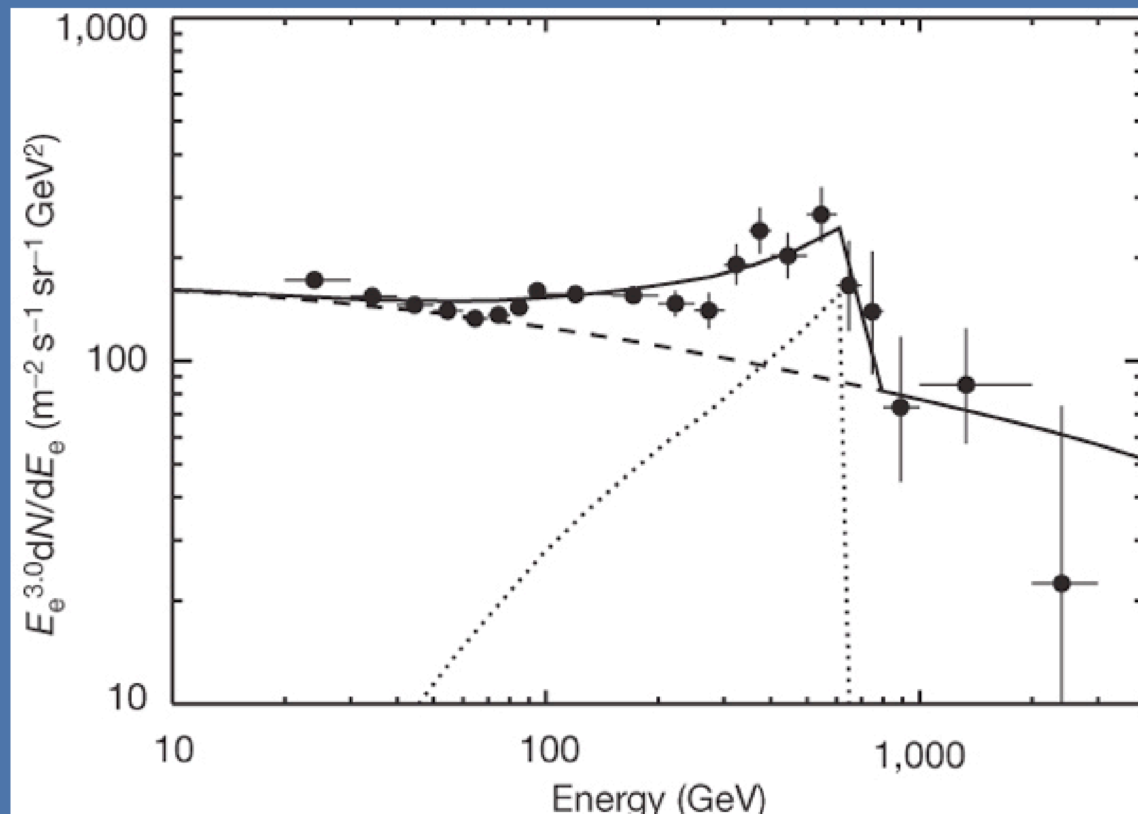
The new challenge begins........

Motivation

We see e- and e+ excesses in different experiments (PAMELA and ATIC)........



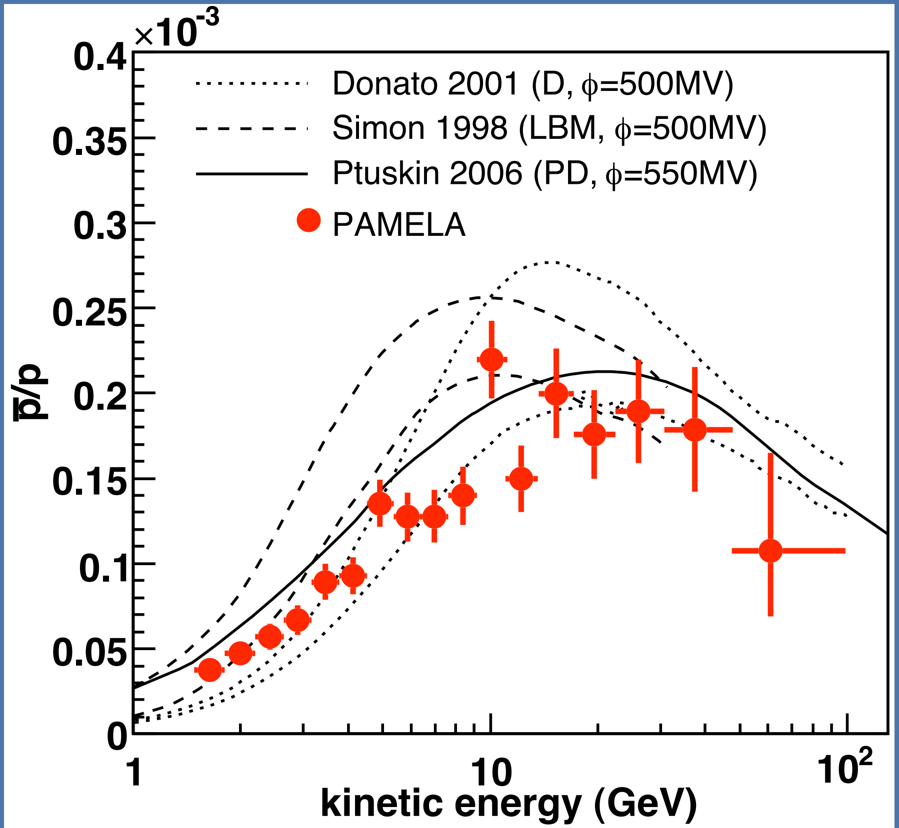
O. Adriani et al., Nature 458: 607 (2009).

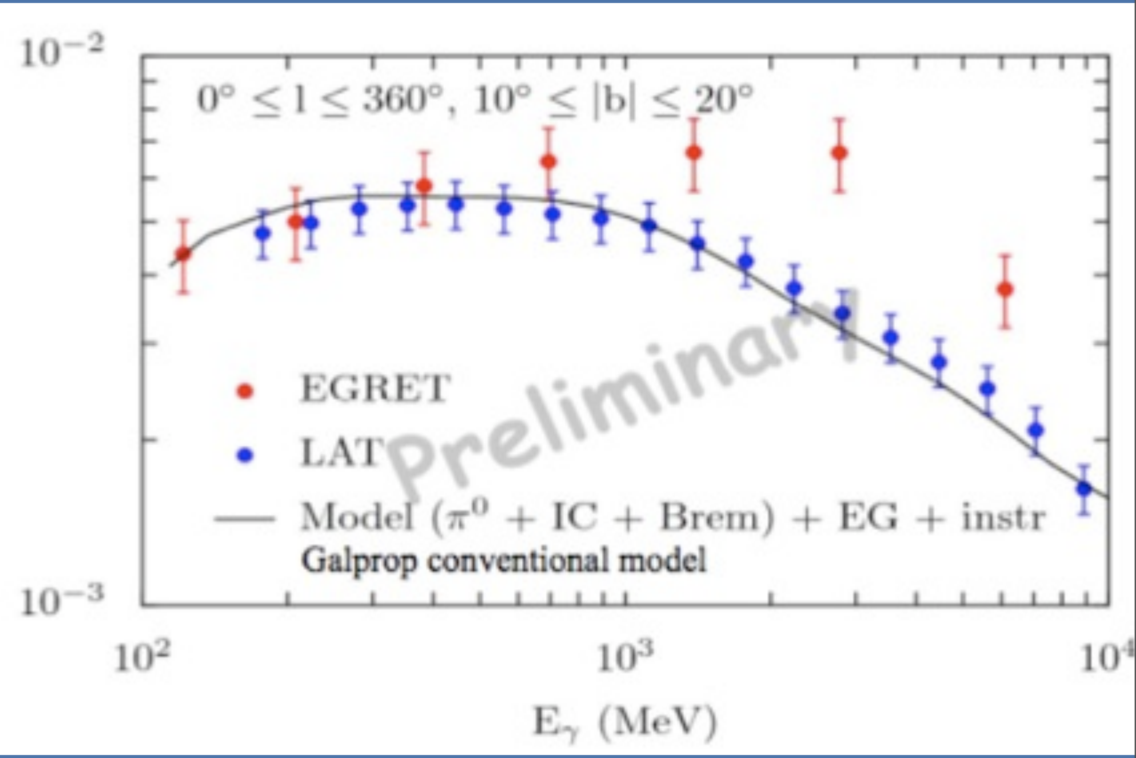


J. Chang et al., Nature 456 (2008) 362.

Motivation

However, cosmic rays from quarks (anti-proton and gamma rays) are quite suppressed!





O. Adriani et al., Phys. Rev. Lett. 102: 051101, (2009).

FERMI preliminary

Motivation

If the cosmic ray excess is interpreted by the DM annilation scenario, the DM will mainly annihilate into leptons.

N.Arkan-Hamed, D. Finkbeiner, T. Slatyer, N. Weiner Phys. Rev. D 79: 015014 (2009)

Conventional wisidom: DM is in the leptonic sector.

↓

"Lepton Jets"

N.Arkan-Hamed, N. Weiner JHEP 0812: 104 (2008)

M. Baumgart, C. Cheung, J. Ruderman, L-T. Wang, I. Yavin arXiv: 0901.0283

Y. Bai, Z-Y. Han JHEP arXiv: 0902.0006

Motivation

What if we modify the DM matter model in the quark sector instead???

We conider to suppress the hadronic BR in mUED to explain the cosmic rays signals from DM annihilation.

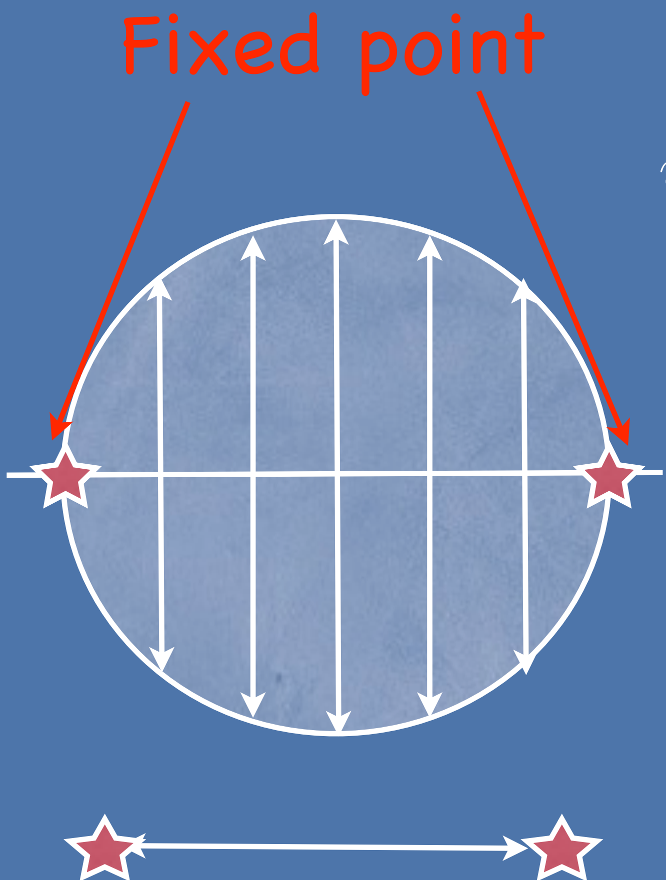
↓

Explain all the cosmic anomalies above.

Novel Jet signals at the LHC......

MUED

We consider a well motivated DM scenario: mUED



S^1/Z_2 Oribifolds:

$$\psi(x,y) = \psi(x, 2L+y) \qquad \phi(x,y) = \phi(x, 2L+y)$$

5D Dirac fermion

$$\psi(x,-y) = \gamma_5 \psi(x,y)$$

The two weyl components have opposite oribifold condition

$$\psi(x, L+y) = \gamma_5 \psi(x, L-y)$$

"+","-" stands for the oribifold even or odd fields

$$\phi(x,-y) = \pm\phi(x,y)$$

$$\phi(x, L+y) = \pm\phi(x, L-y)$$

MUED

KK decomposition:

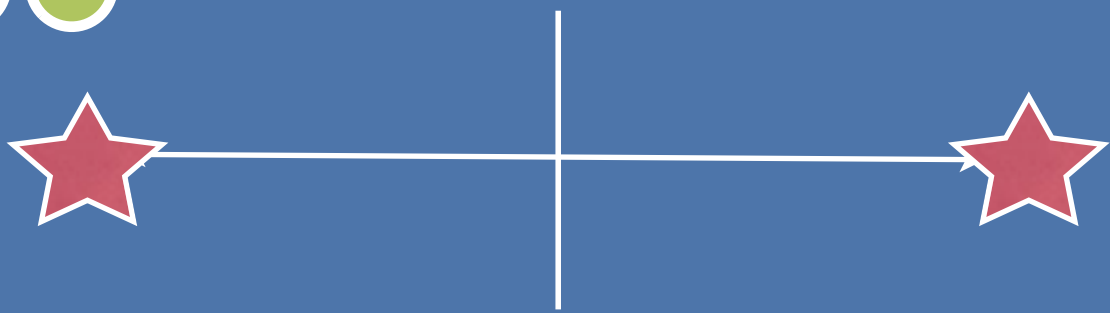
$$\Phi_+(x, x_5) = \frac{1}{\sqrt{\pi R}} \phi_+^{(0)}(x) + \sqrt{\frac{2}{\pi R}} \sum_{n=1}^{\infty} \cos \frac{n x_5}{R} \phi_+^{(n)}(x),$$

$$\Phi_-(x, x_5) = \sqrt{\frac{2}{\pi R}} \sum_{n=1}^{\infty} \sin \frac{n x_5}{R} \phi_-^{(n)}(x).$$

The flat zero mode.

- All SM fields are zero modes with FLAT profiles propagating in the bulk.
- Higher KK modes are sine (oribifold odd) and cosine (oribifold odd) functions .
- The wave fuctions and couplings are "universal".

KK parity



- The reflection symmetry about the mid point + a oribifold Z_2 transformation.
- momentum conservation along 5th direction=translational invariance which is broken by fixed points

KK photo is LKP

Masses quite degnerate at the tree level!

$$(m_n)^2 = \left(\frac{\pi}{L}\right)^2 + (m_0)^2$$

$$\delta(m^2_{B^{(n)}}) = \frac{g'^2}{16\pi^2 R^2}\left(\frac{-39}{2}\frac{\zeta(3)}{\pi^2} - \frac{n^2}{3}\ln \Lambda R\right)$$

$$\delta(m^2_{W^{(n)}}) = \frac{g^2}{16\pi^2 R^2}\left(\frac{-5}{2}\frac{\zeta(3)}{\pi^2} + 15n^2\ln \Lambda R\right)$$

$$\delta(m^2_{g^{(n)}}) = \frac{g_3^2}{16\pi^2 R^2}\left(\frac{-3}{2}\frac{\zeta(3)}{\pi^2} + 23n^2\ln \Lambda R\right)$$

$$\delta(m_{Q^{(n)}}) = \frac{n}{16\pi^2 R}\left(6g_3^2 + \frac{27}{8}g^2 + \frac{1}{8}g'^2\right)\ln \Lambda R$$

$$\delta(m_{u^{(n)}}) = \frac{n}{16\pi^2 R}\left(6g_3^2 + 2g'^2\right)\ln \Lambda R$$

$$\delta(m_{d^{(n)}}) = \frac{n}{16\pi^2 R}\left(6g_3^2 + \frac{1}{2}g'^2\right)\ln \Lambda R$$

$$\delta(m_{L^{(n)}}) = \frac{n}{16\pi^2 R}\left(\frac{27}{8}g^2 + \frac{9}{8}g'^2\right)\ln \Lambda R$$

$$\delta(m_{e^{(n)}}) = \frac{n}{16\pi^2 R}\frac{9}{2}g'^2\ln \Lambda R\,.$$

RG-running

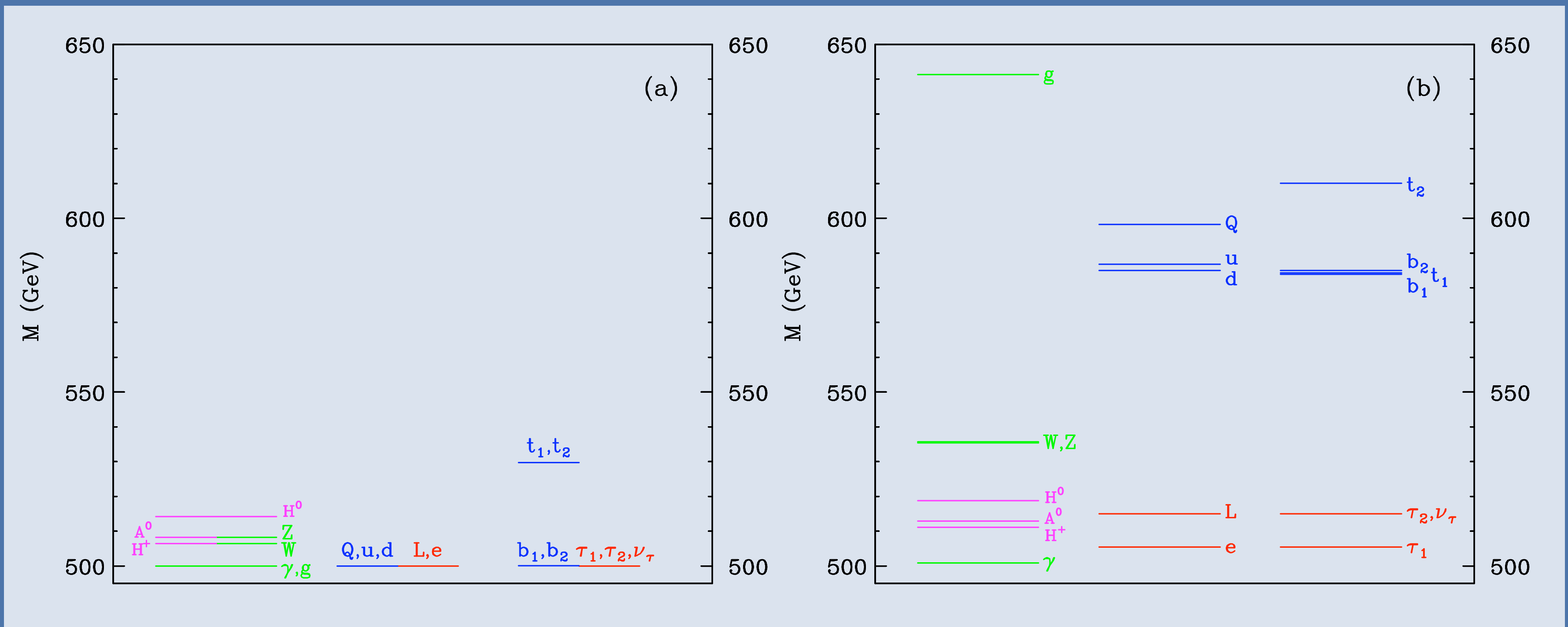
1. KK photon -0.2%
2. KK gluon +30%
3. KK quarks +14%
4. KK leptons +1%

MUED-Spectra

Free parameter: $(1/R, \Lambda)$

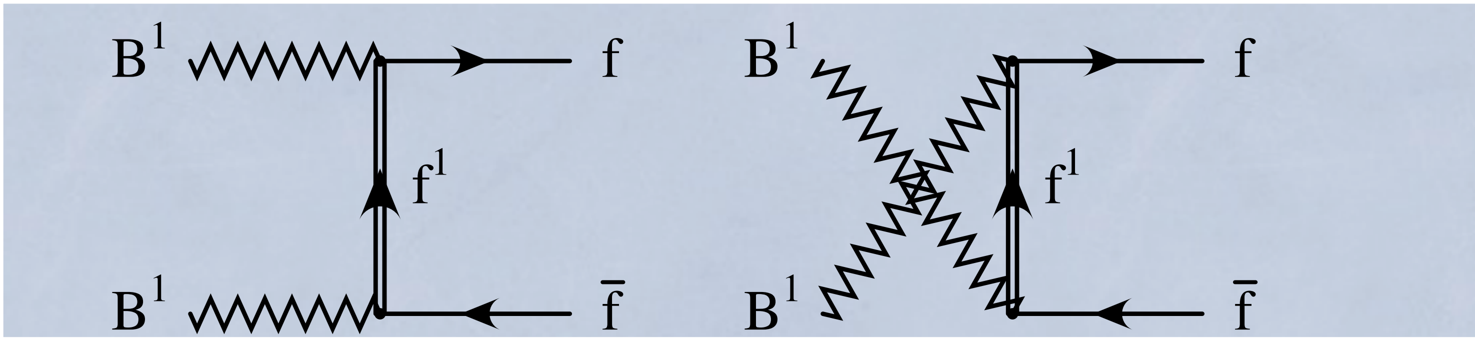
Tree level mass spectra, very degenerate

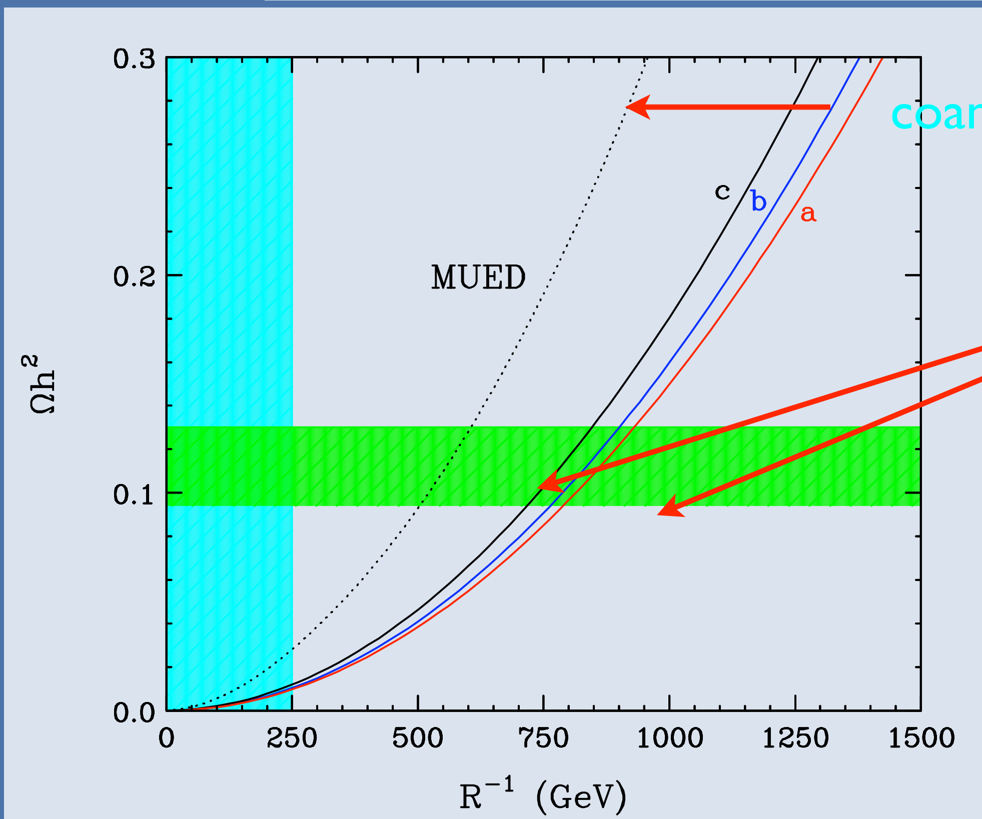
WIth radiative corrections, quasi-degenerate



H-C. Cheng, K. Matchev, M. Schmaltz, Phys. Rev. D 66, 036005 (2002)

DM in MUED





It natually predicts the LKP mass around 600 ~ 800 GeV

Coincident with the ATIC peak!

K. Kong, K. Matchev, JHEP 0601:038, (2006)

DM in MUED

$$\langle \sigma v \rangle_{B_1 B_1 \to f \bar{f}} \simeq \frac{2 g_1^4 C_f}{9 \pi m_{B_1}^2} \frac{1}{(1 + r_f^2)^2}$$

$$C_f = N_c Y_f^4 \qquad r_f = \frac{m_f}{m_{B_1}}$$

$$l_R : q_R = 1^4 : 3 \times (2/3)^4 = 1 : 16/27$$

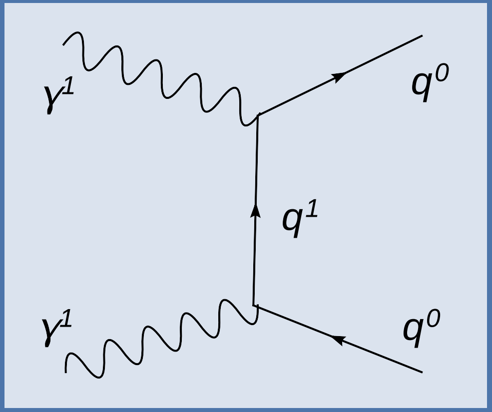
- Slightly hadrophobic (~40%)
- but still hadronic BF is sizable

We need to suppress it!

Solution.......

A obivious solution...............

Increase the mass of q^1 ⟹ suppress



In the NR limit,

$$\langle \sigma v \rangle_{q\bar{q}} \propto m_{\gamma^1}^2 / (m_{\gamma^1}^2 + m_{q^1}^2)^2$$

We need a self-consistent way to increase the KK quark masses while preserve the KK parity!

Model

One way to increase the KK fermion mass is to introduce the 5D bulk fermion mass μ.

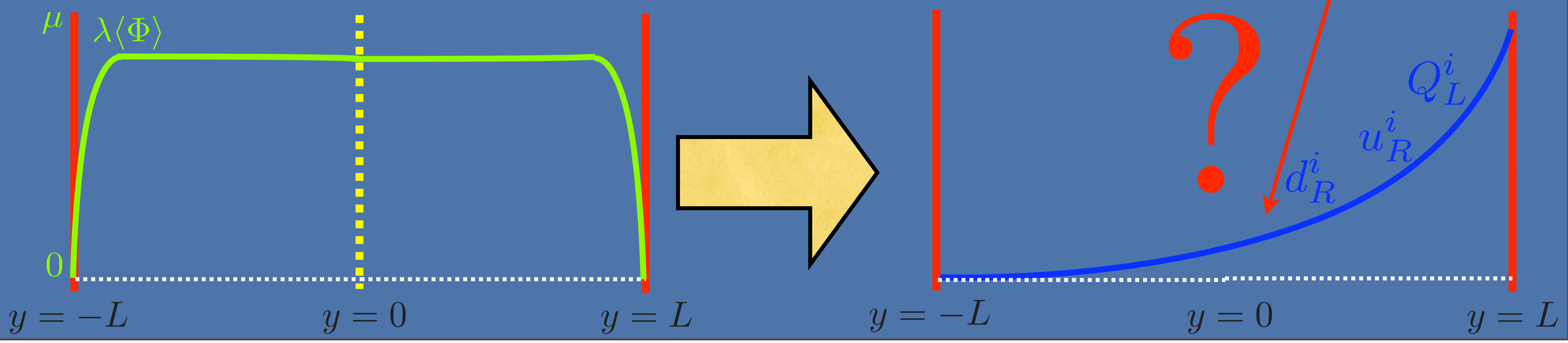
In flat space, $m_n = \sqrt{\mu^2 + k_n^2}$

However, a conventional 5D bulk mass will violate the KK parity

No inversion symmetry

5D bulk mass

SM zero mode



KK parity in ED

I start with -L not 0 here.

For a general 5D Langragian in the oribifolds $y \subset [-L, L]$

$$\Phi(x,y) \to \pm\Phi(x,-y)$$

only "+" if there is a cubic term

$$\Psi(x,-y) \to \pm\gamma_5\Psi(x,y)$$

depends on how one emded the zero mode fermion

$$\Psi_+(y) \to \pm\Psi_+(-y)$$
$$\Psi_-(y) \to \mp\Psi_-(-y)$$

For the interaction with fermions

$$S = \int d^5x \left(\frac{i}{2}(\bar{\Psi}\Gamma^M\partial_M\Psi - \partial_M\bar{\Psi}\Gamma^M\Psi) - \lambda\Phi(y)\bar{\Psi}\Psi \right)$$

$$\Phi(y)(\bar{\Psi}_+\Psi_- + \bar{\Psi}_-\Psi_+) \quad \Rightarrow \quad \Phi(y) = -\Phi(-y)$$

KK decomposition

K. Agashe, A. Falkowski, I. Low, G. Servant, JHEP 0804:027, (2008)

Consider SM quark is embeded in the "+" component:

$$\Psi_+(x,y) = \sum_n g_n(y)\chi_n(x)$$ 5D KK "+" parity

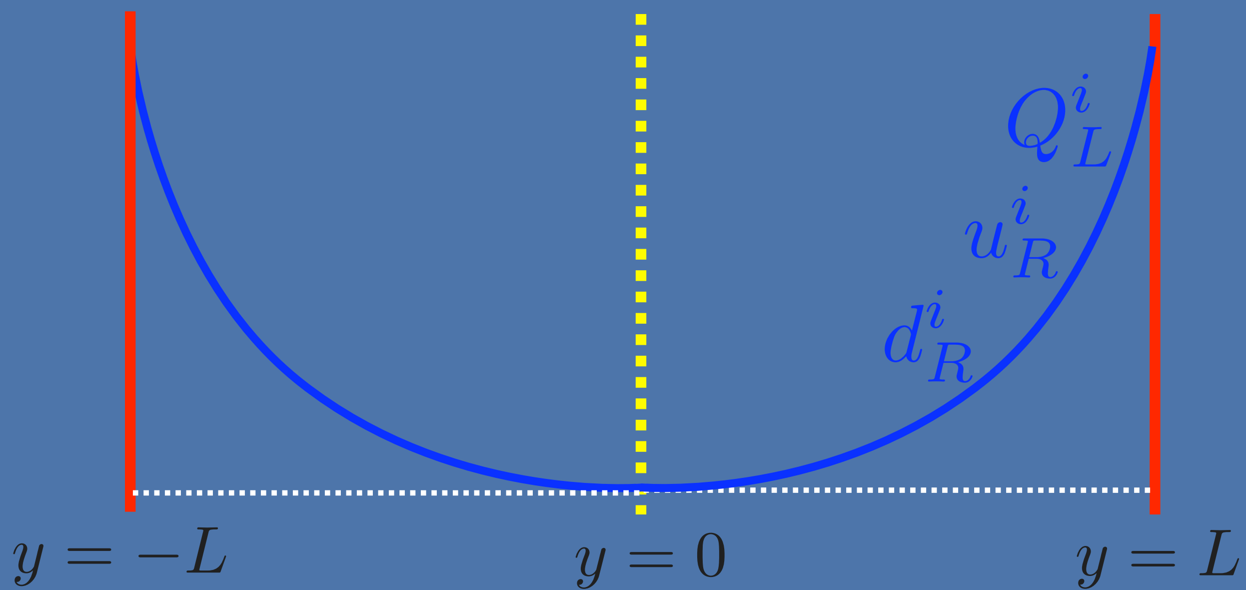
$$\Psi_-(x,y) = \sum_n f_n(y)\psi_n(x)$$ 5D KK "-" parity

For the 4D KK even/odd field $\chi_n(x)$, $g_n(y)$must be symmetric/asymmetric around y=0, which satisfy the +/- boundary condition.

The 5D profile with even/odd KK parity in the interval -L to L is the same as the one with +/- boundary condition at y=0.

The set-up

Theoretical considerations suggest that SM quarks are localized at the boundary, not the center.

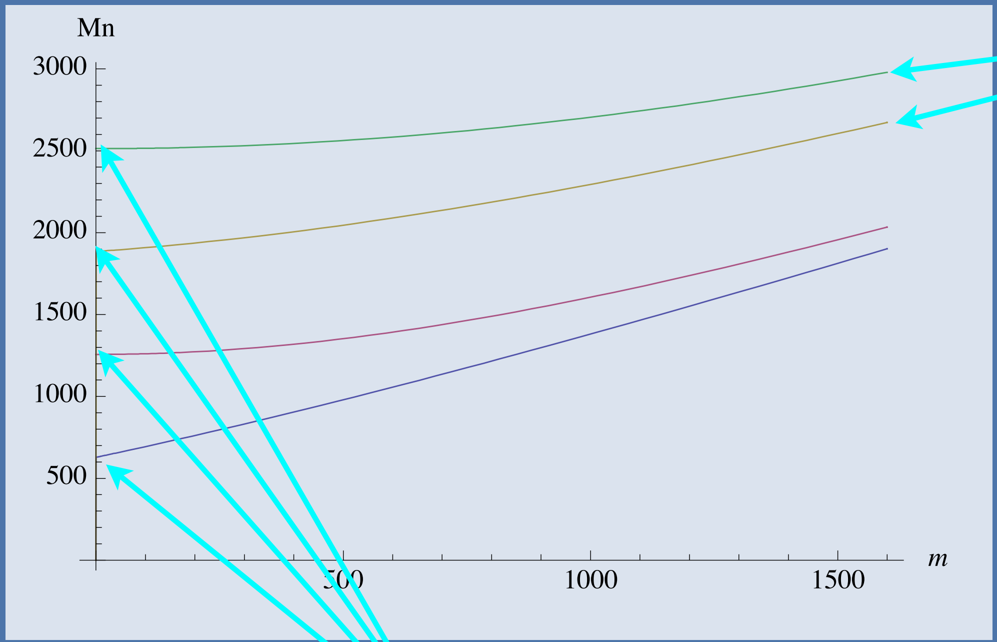


No light mode!

5D anomaly free!

The masses

In case μ >0



μ

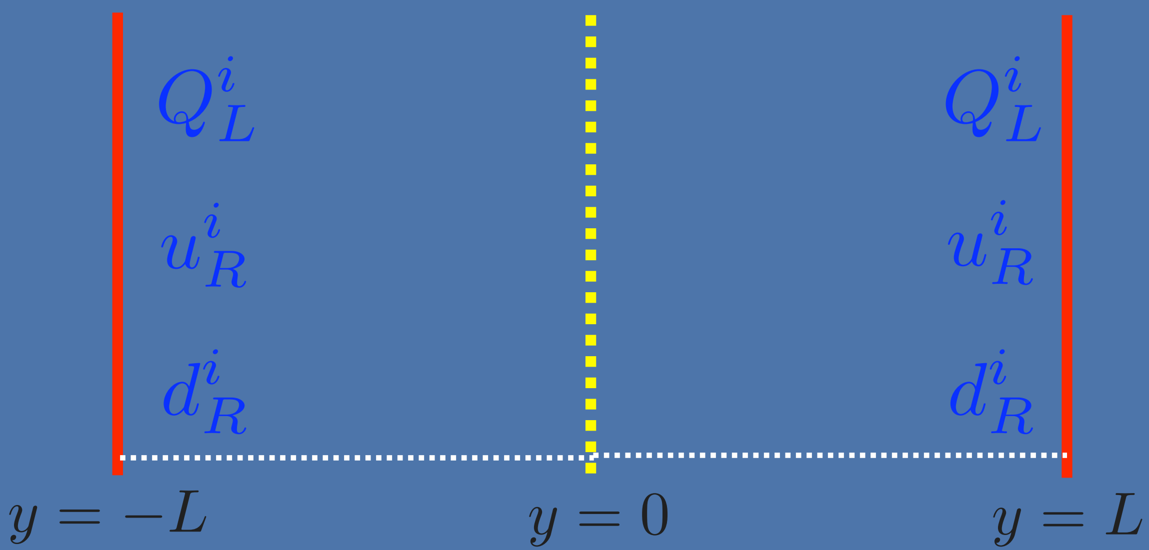
For large negative mass m, the nth KK odd and even quarks tend to be degenerate.

m=0, the same as MUED!

For very large negative mass m, the KK quark mass could be decoupled!

The “well localized” case

$\mu \to +\infty$

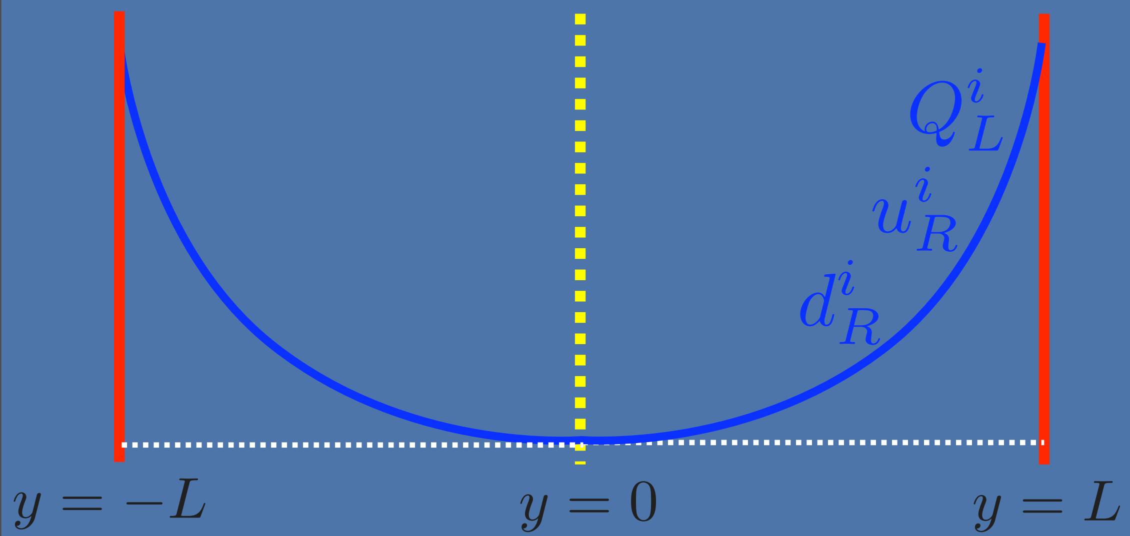


No KK quarks!

$$\frac{g_{200}}{g_0} = \sqrt{2}\mathcal{F}_{2n}(x) = \sqrt{2}\frac{2x}{1-e^{2x}}\int_0^1 ds e^{2xs}\cos(\pi n s) \longrightarrow \sqrt{2}$$

Violation of KK

5D translational invariance is violated by the bulk profile

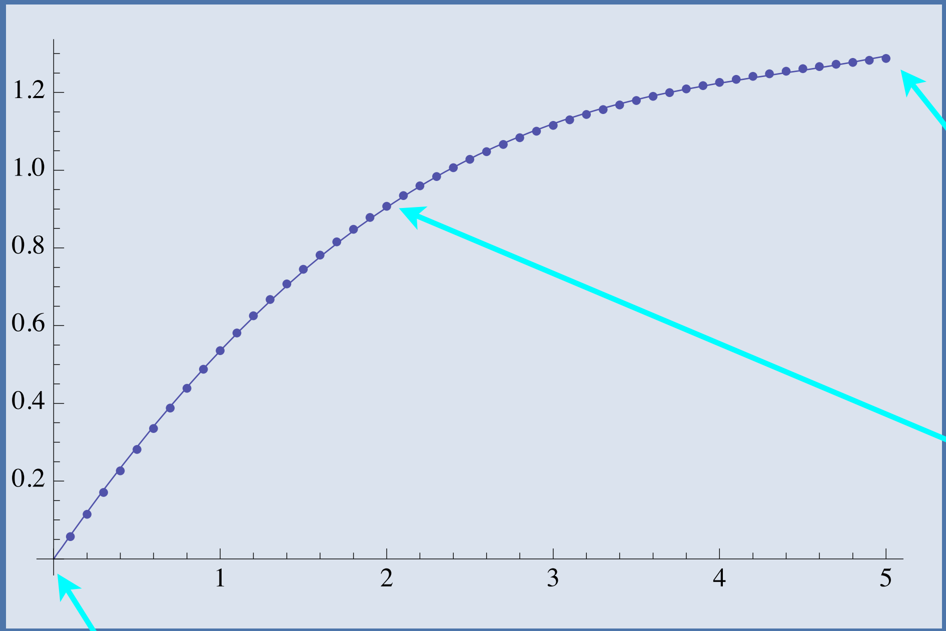


KK # violation at the tree level!

KK even gauge bosons/scalars directly coupled to quarks!

The couplings

g200/g0   Coupling that violate KK number



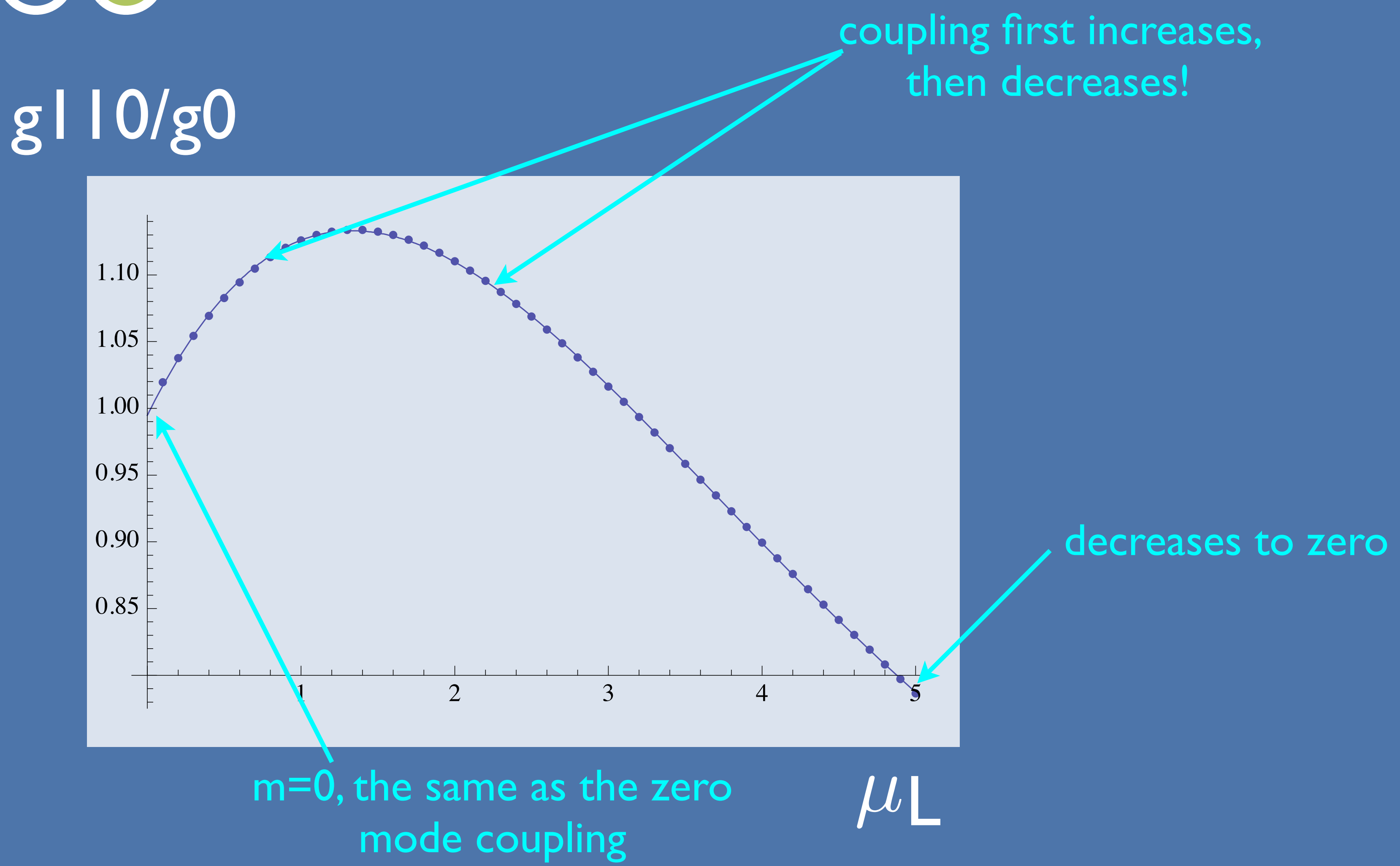
μL

saturated to 1.4142.......

always increases

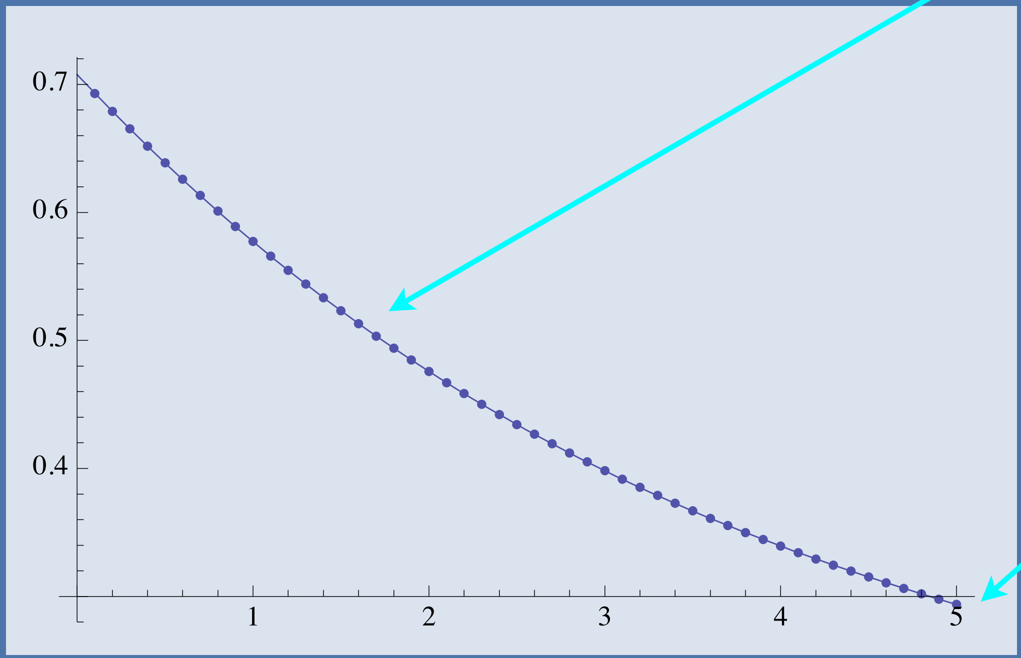
m=0, KK# conservation as in MUED!

The couplings



The couplings

g211/g0



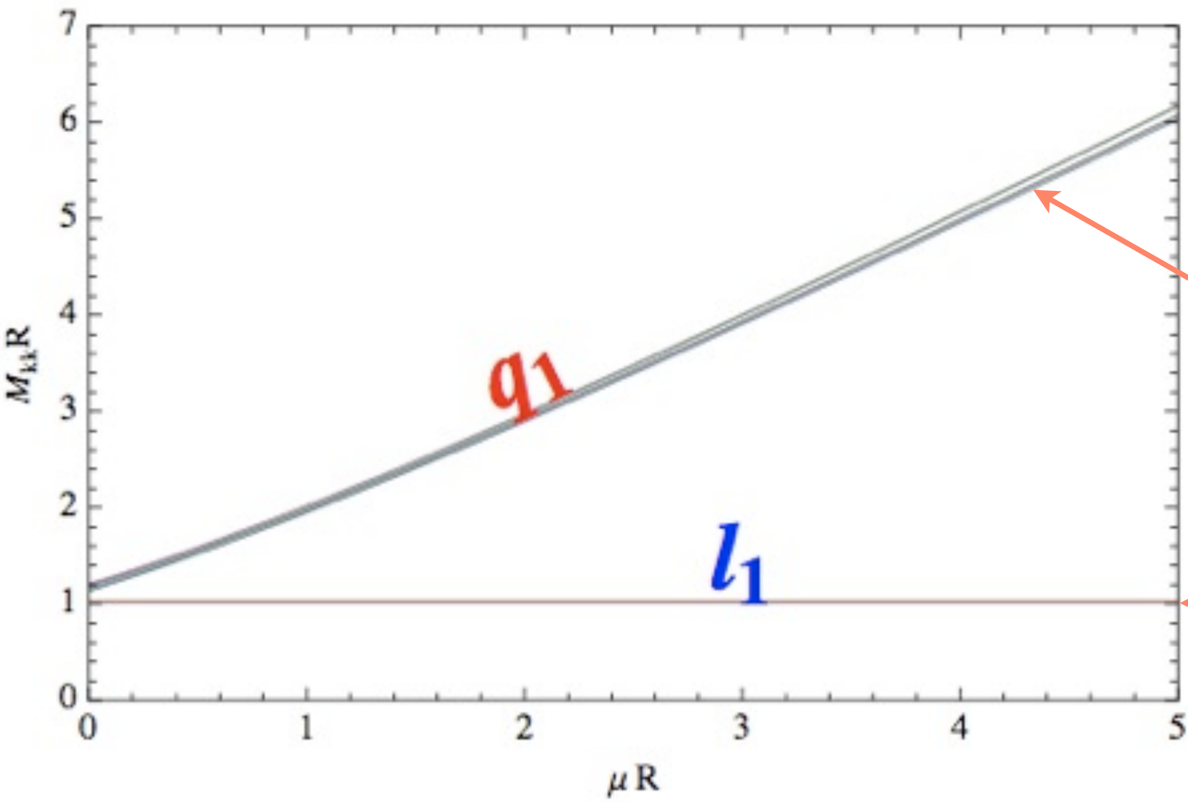
μL

coupling always decreases!

decreases to zero

Split-Mass spectrum

Consider the one-loop radaitive corrections:



$$\lambda_q \langle \Phi(y) \rangle = \mu \epsilon(y)$$

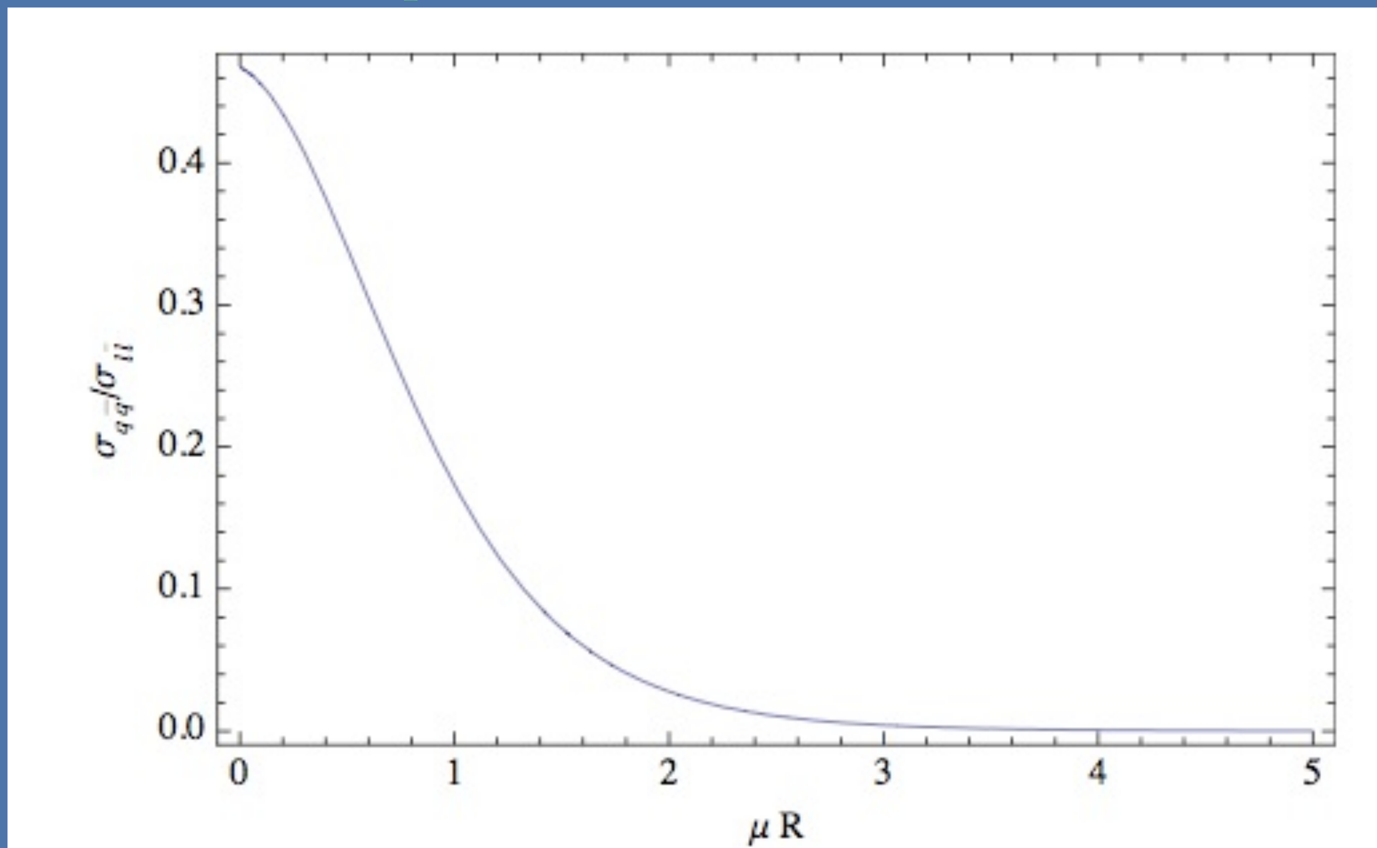
$$m_n^2 = \mu^2 + k_n^2$$

$$m_n^2(lepton) = \frac{n^2}{R^2}$$

Chen, Nojiri, Park, JS, Takeuchi, arXiv:0903.1971

Branching Fraction

$$\frac{\sigma_{qq}}{\sigma_{ll}} = \frac{\sum_q Y_q^4}{\sum_l Y_l^4} \left(\frac{m_{B_1}^2 + m_{l_1}^2}{m_{B_1}^2 + m_{q_1}^2}\right)^2 \simeq 0.42 \times (1 + m_{q_1}^2 / m_{B_1}^2)^{-2}$$



Chen, Nojiri, Park, JS, Takeuchi, arXiv:0903.1971

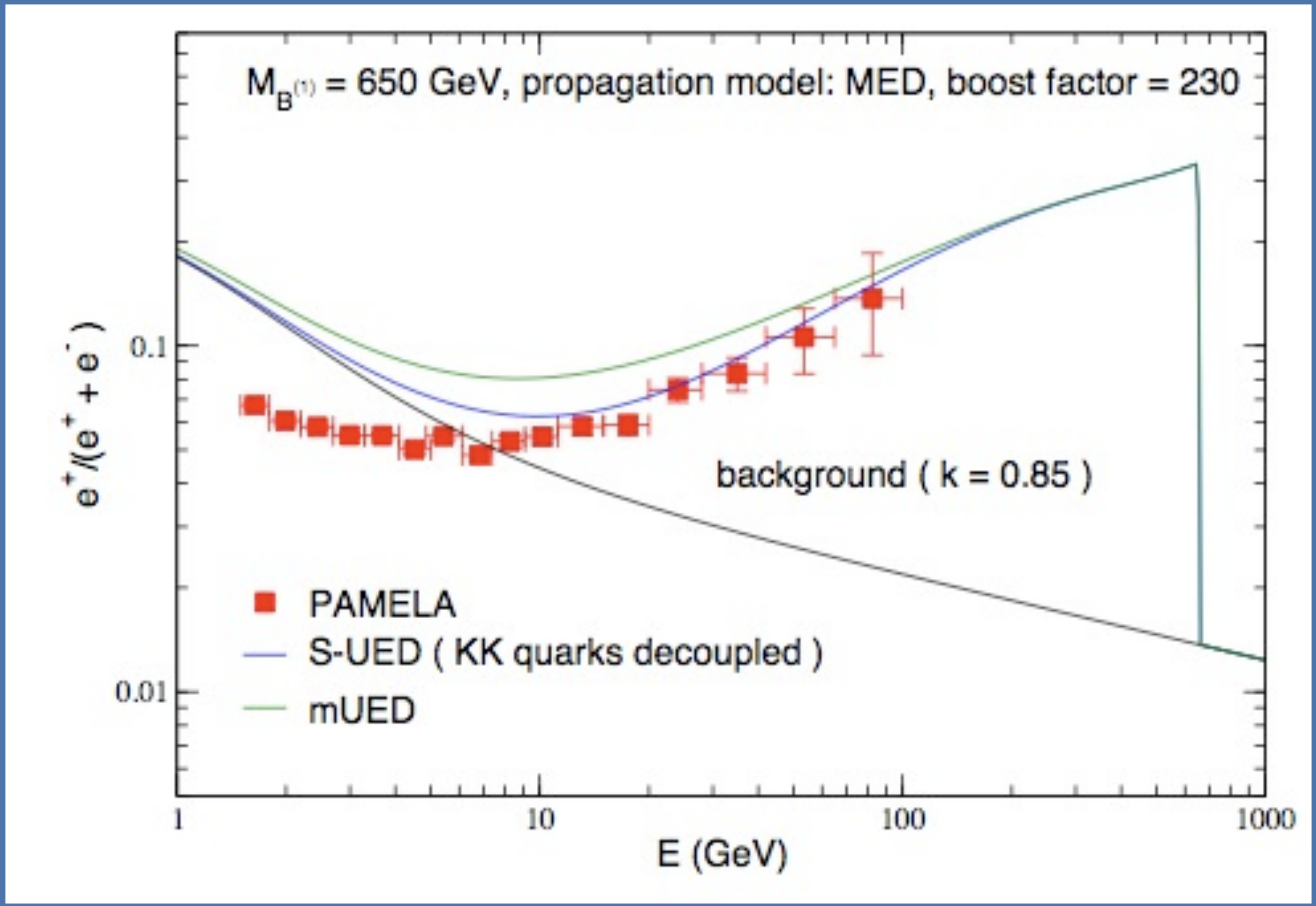
Branching Fraction

All possible branching fractions:

μ (GeV)	0	200	400	600	800	1000
M_{q_1} (GeV)	713	863	1026	1198	1378	1566
$\mathrm{BR}(B_1 B_1 \to q\bar{q})$	29.4%	26.4%	20.6%	14.3%	8.9%	5.2%
$\mathrm{BR}(B_1 B_1 \to l\bar{l})$	64.3%	67.1%	72.3%	78.2%	83.0%	86.5%
$\mathrm{BR}(B_1 B_1 \to \nu\bar{\nu})$	3.8%	3.9%	4.3%	4.6 %	4.9%	5.1%
$\mathrm{BR}(B_1 B_1 \to \phi\phi^*)$	2.3%	2.4%	2.6%	2.8%	3.0%	3.1%

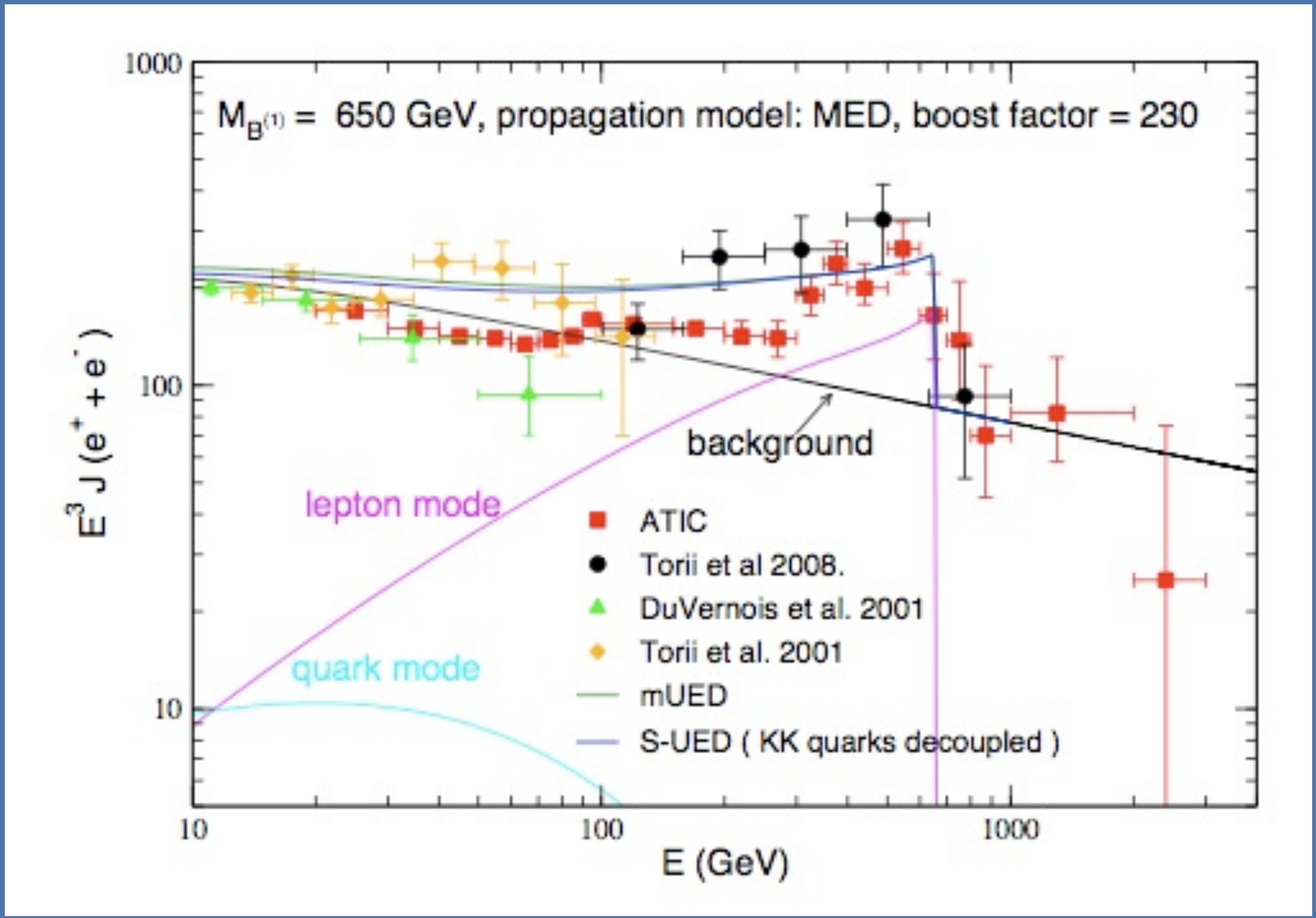
Chen, Nojiri, Park, JS, Takeuchi, arXiv:0903.1971

Fitting PAMELA Positron



Chen, Nojiri, Park, JS, Takeuchi, arXiv:0903.1971

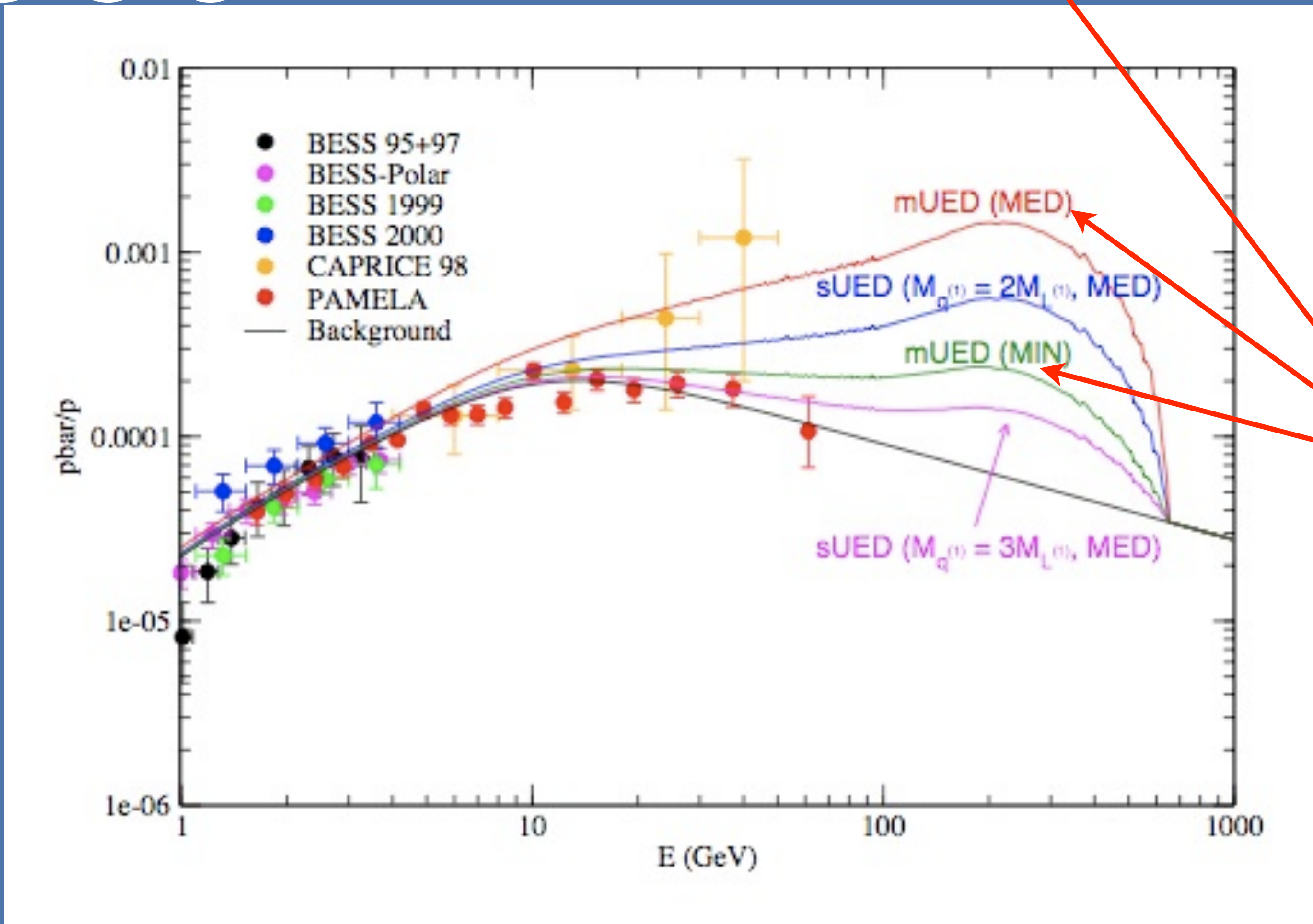
Fitting ATIC/PPB-BETS



Chen, Nojiri, Park, JS, Takeuchi, arXiv:0903.1971

No Anti-Protons

mUED (MAX)

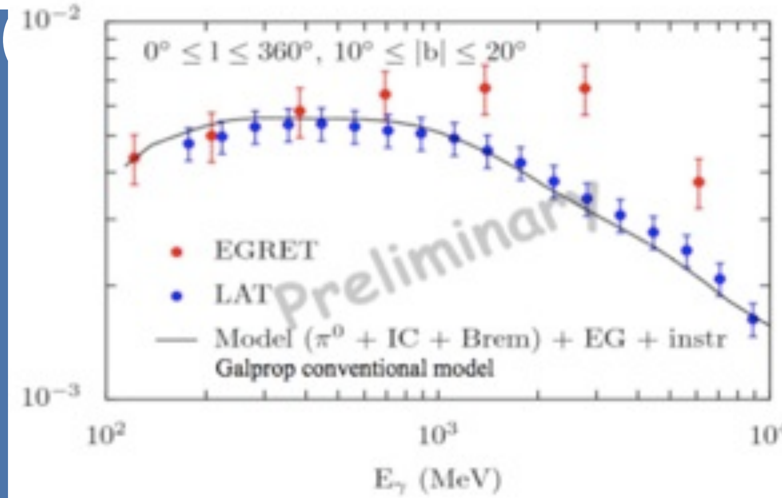


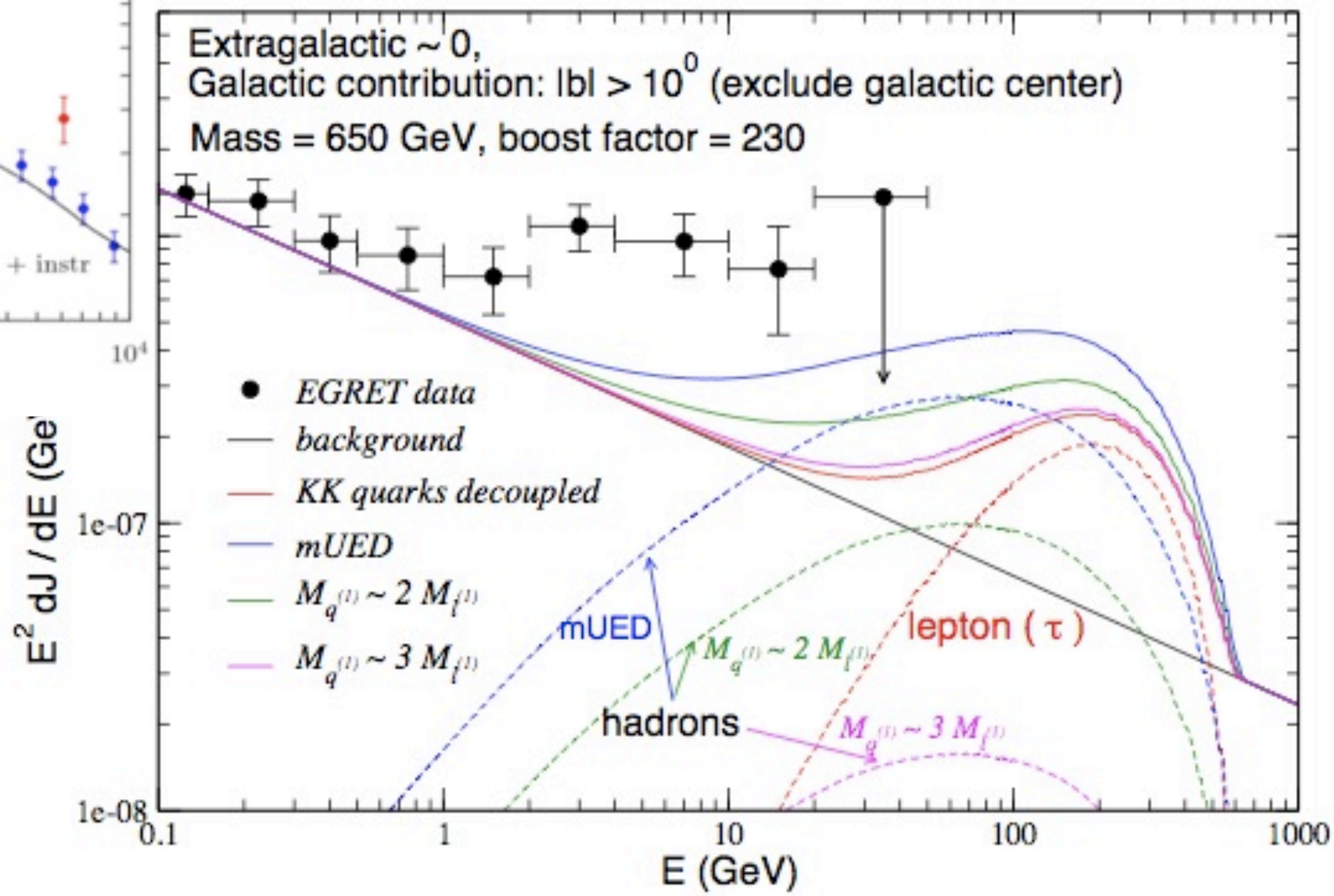
The results, however is very sensitive to the propagation model.

Change progation model from MAX to MIN will increase the anti proton flux by 2 orders of magnitude!

Chen, Nojiri, Park, JS, Takeuchi, arXiv:0903.1971

Gamma Rays





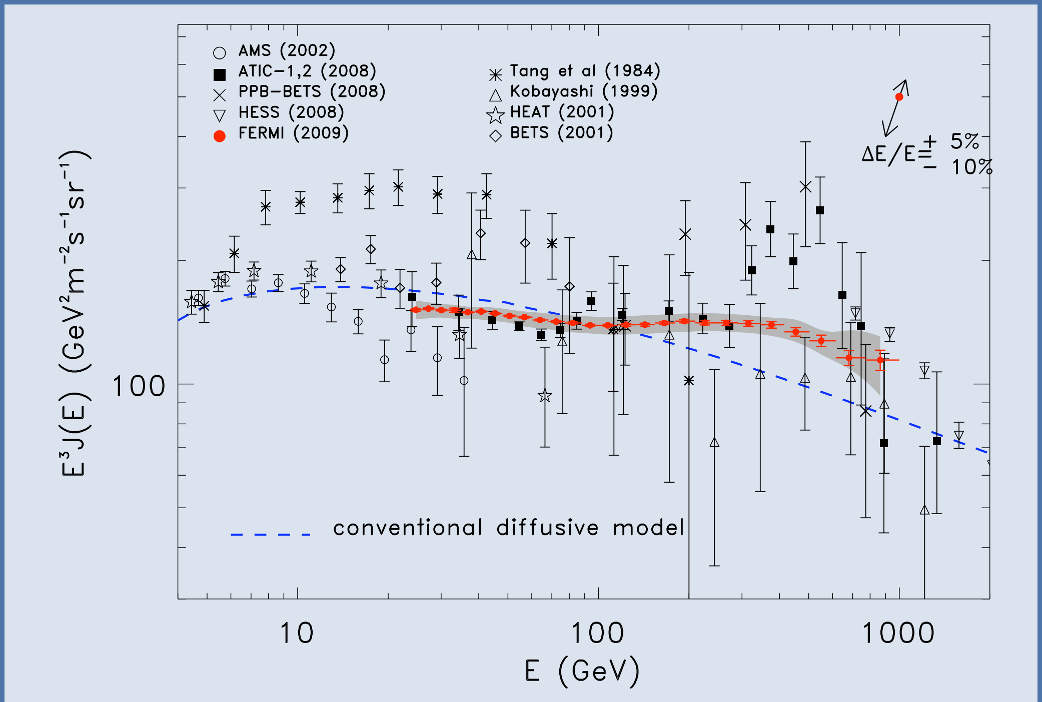
The gamma rays, however, is indepedent of the propagation model.

Chen, Nojiri, Park, JS, Takeuchi, arXiv:0903.1971

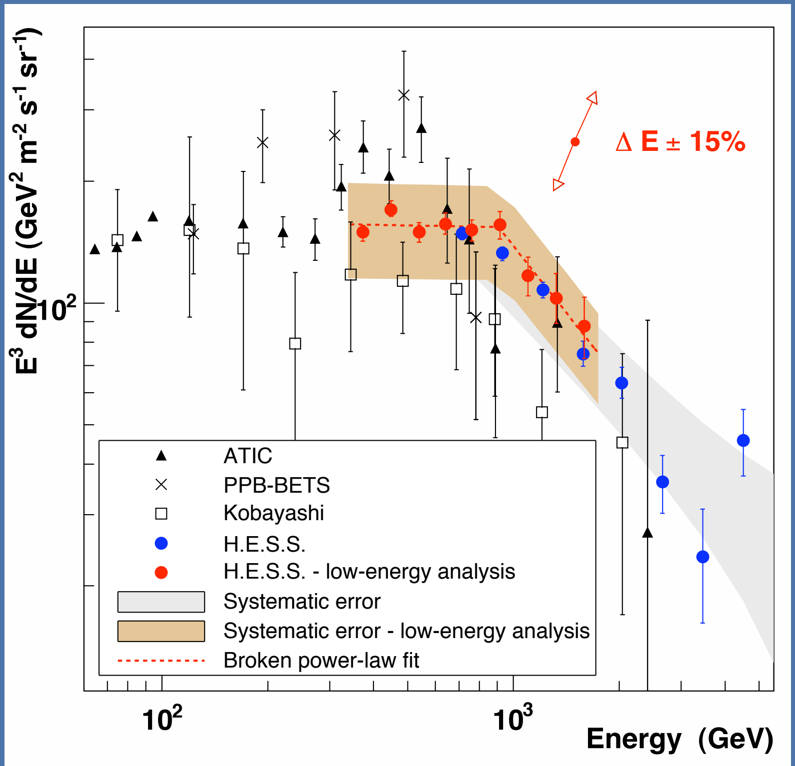
isothermal profile

KK DM after FERMI

We may have to explain it and
Split-UED can explain it!



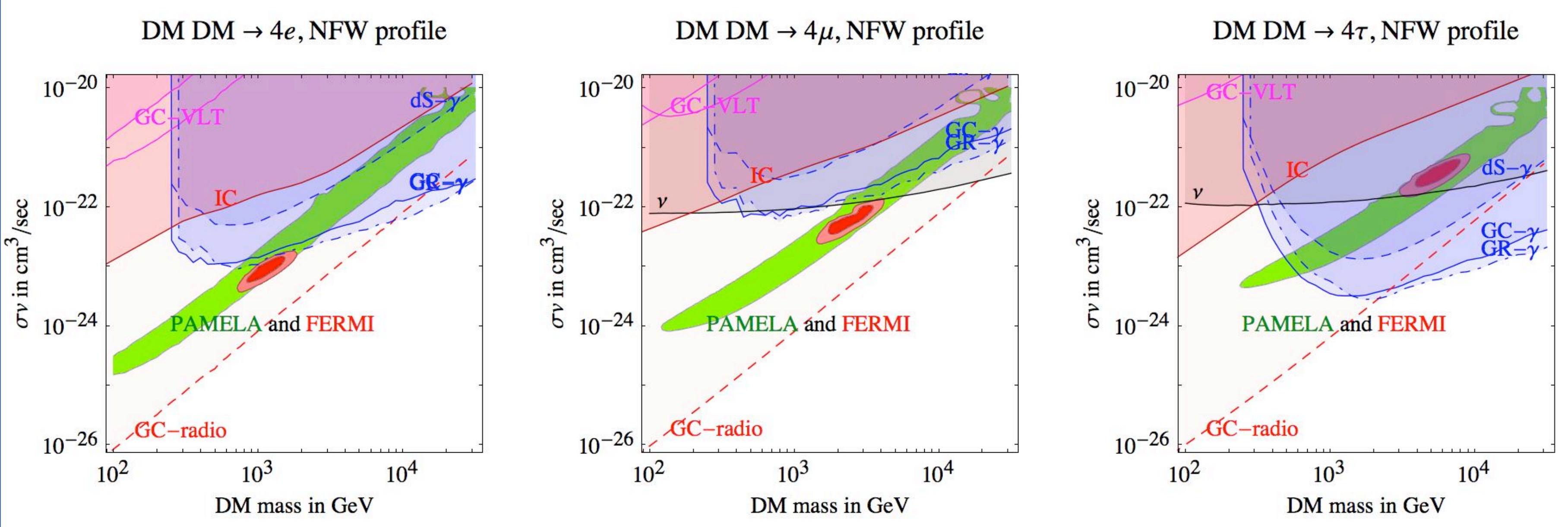
FERMI LAT, arXiv:0905.0025



HESS, arXiv:0905.0105

KK DM after FERMI

NFW profile



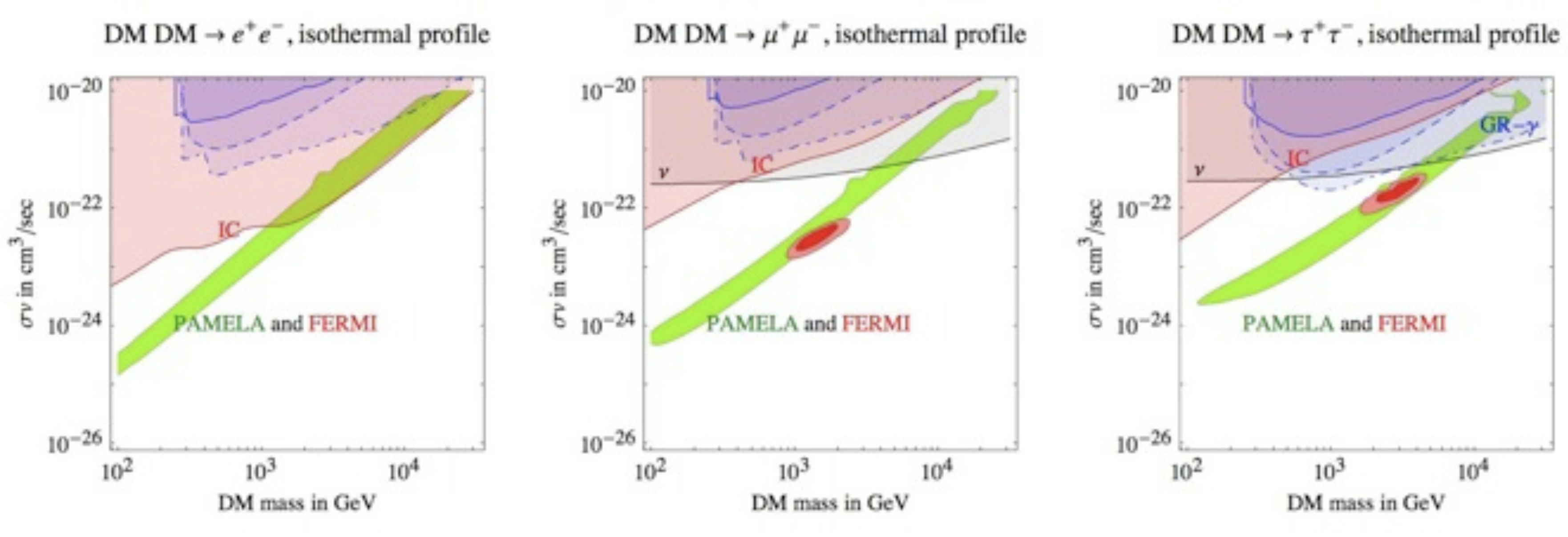
P. Meade, M. Papucci, A. Strumia, T. Volansky, arXiv:0905.0480

Pure annilation into e-/e+ is ruled out.

In direct leptonic annilation scenario, the gamma ray flux at the GC is highly constrain

KK DM after FERMI

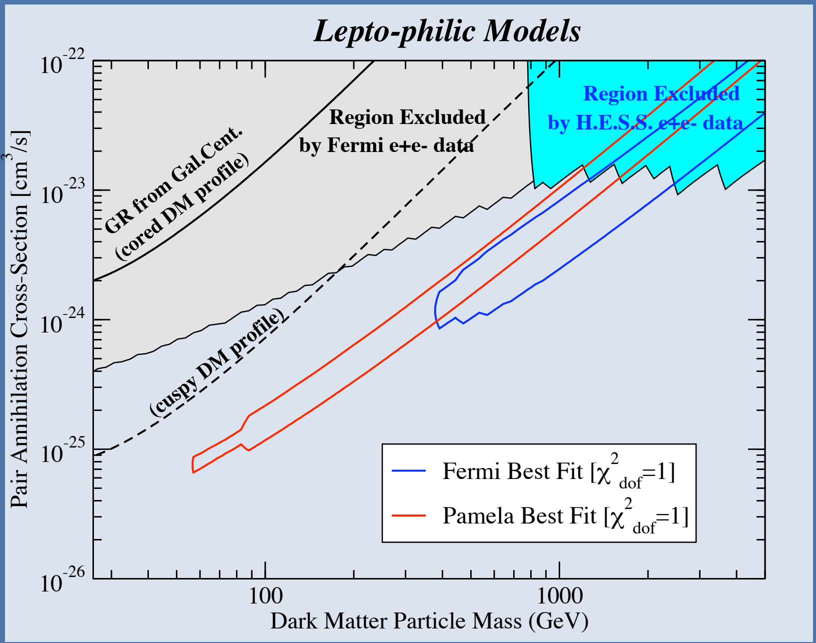
Isothermal profile



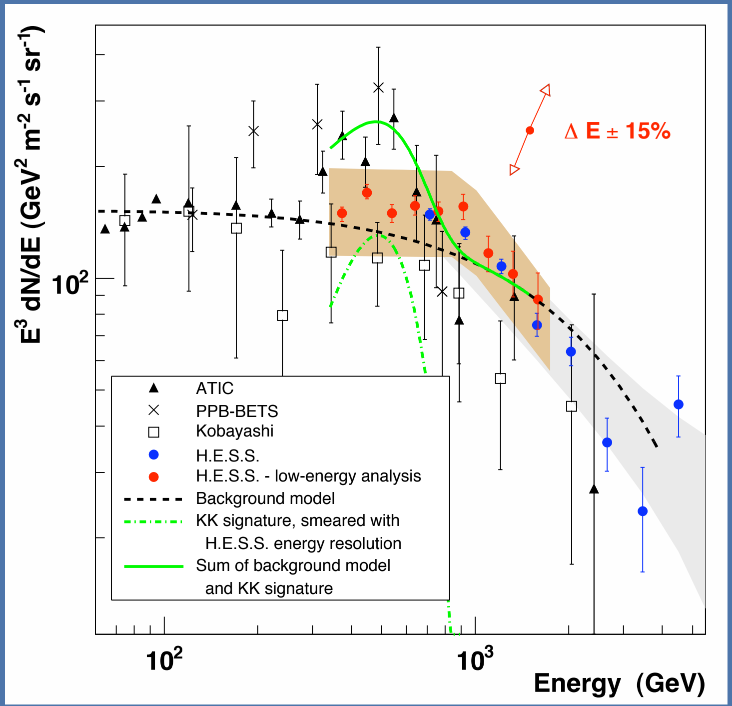
P. Meade, M. Papucci, A. Strumia, T. Volansky, arXiv:0905.0480

It can only work in the DM profiles which is rather flat at GC.

KK DM after FERMI



FERMI LAT, arXiv:0905.0636



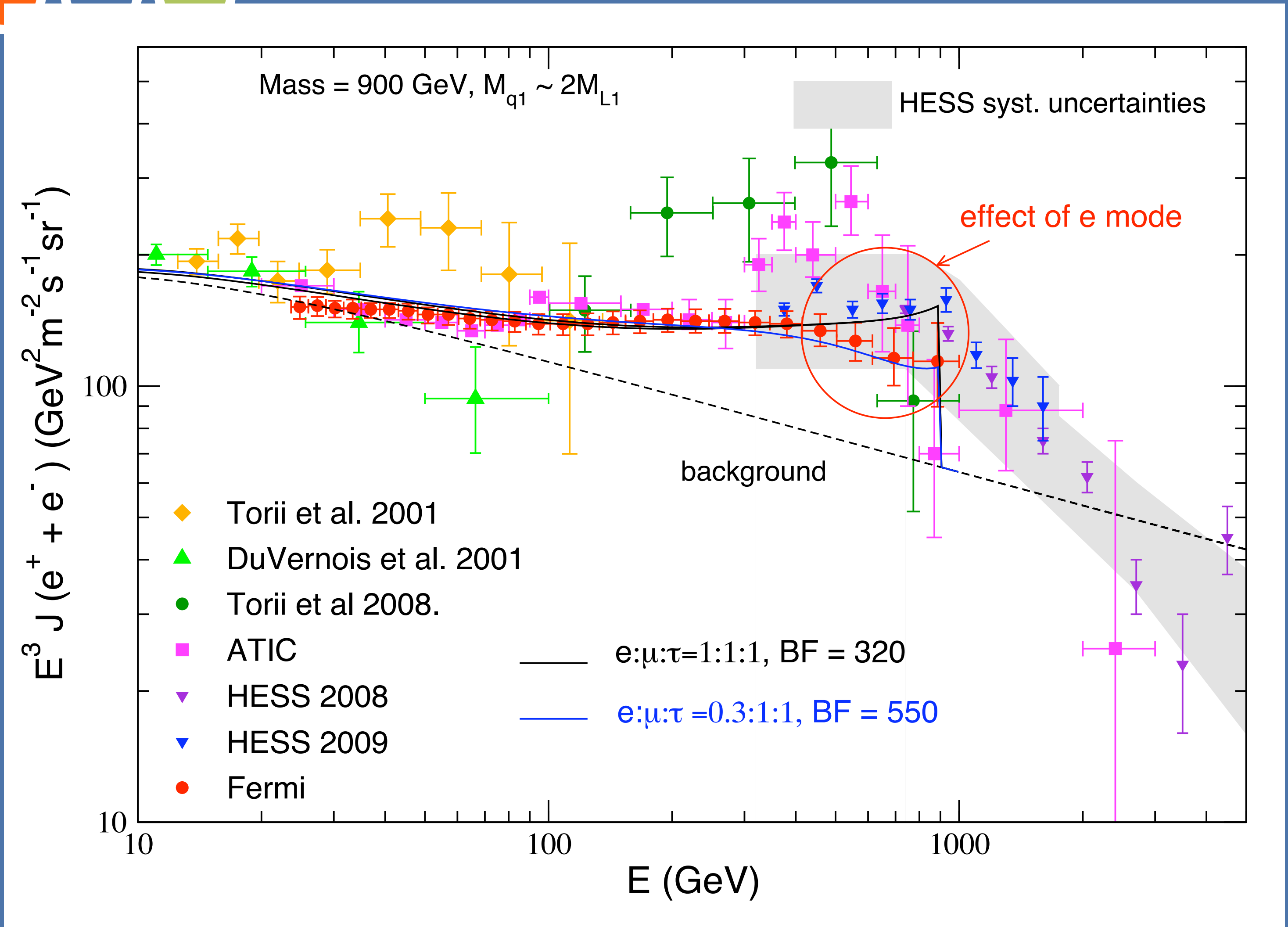
HESS, arXiv:0905.0105

KK DM with 620GeV ruled out?

Annihilation into charged lepton famalies 1:1:1 can explain FERMI

So misleading, what they claimed ruled out 99% is the KK model uased to explain ATIC.

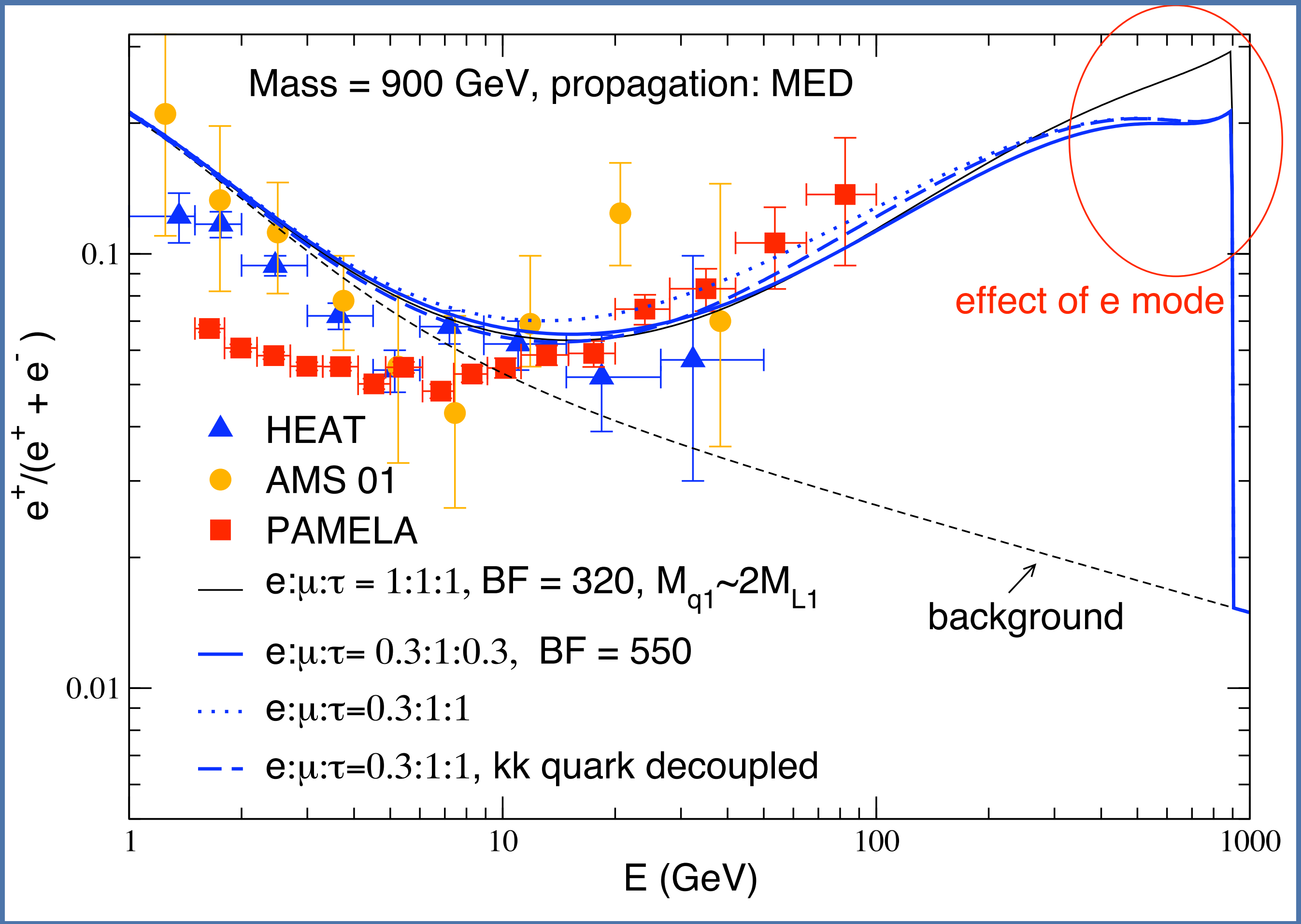
KK DM after FERMI



Can not split too much for e- boz of LEP bounds

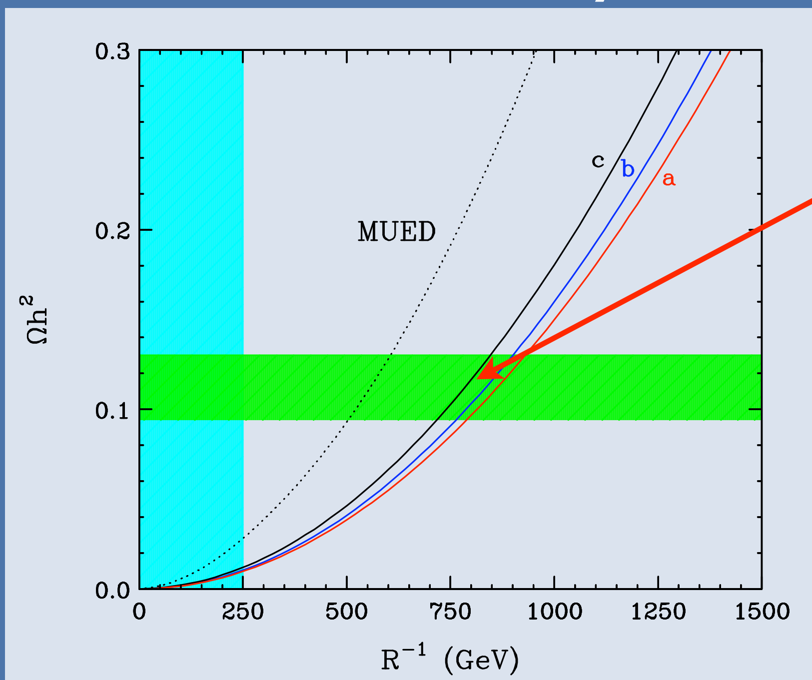
But enough to fit the data very well.

KK DM after FERMI



KK DM after FERMI

The relics density can work



K. Kong, K. Matchev, JHEP 0601:038, (2006)

no coannihilation

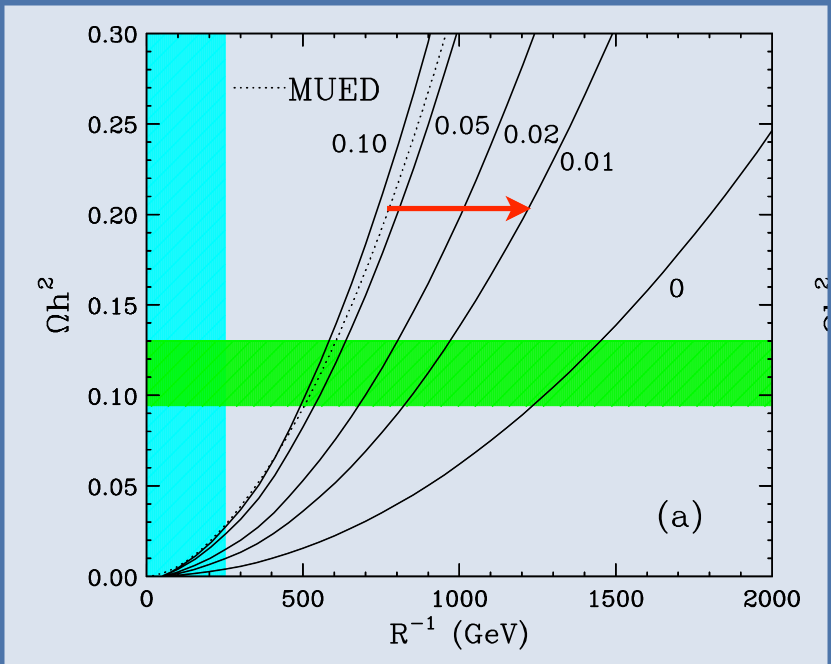
Mass around 800~900GeV

GOOD for FERMI

A small bulk mass for leptons will remove the coannilation from the charged leptons

KK DM after FERMI

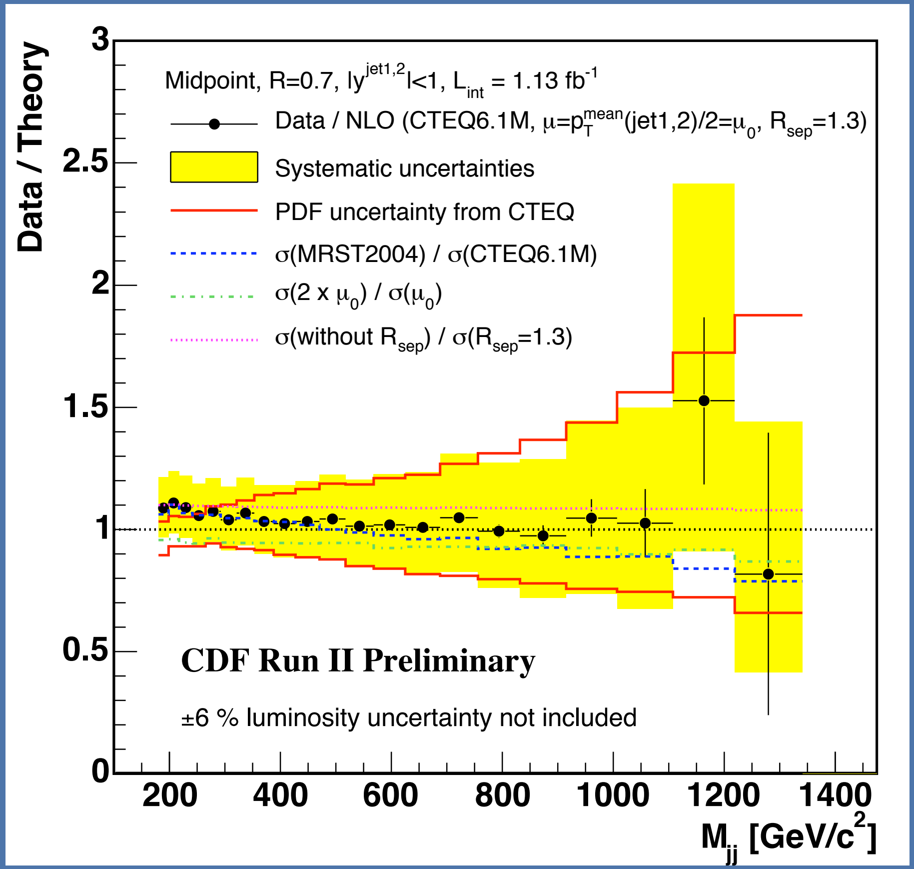
If one wants even more massive DM, coanihilation from EW gauge bosons can make it work



K. Kong, K. Matchev, JHEP 0601:038, (2006)

Quite degnerate B1, Z1, W1, novel signal at the LHC

Bounds from Tevatron

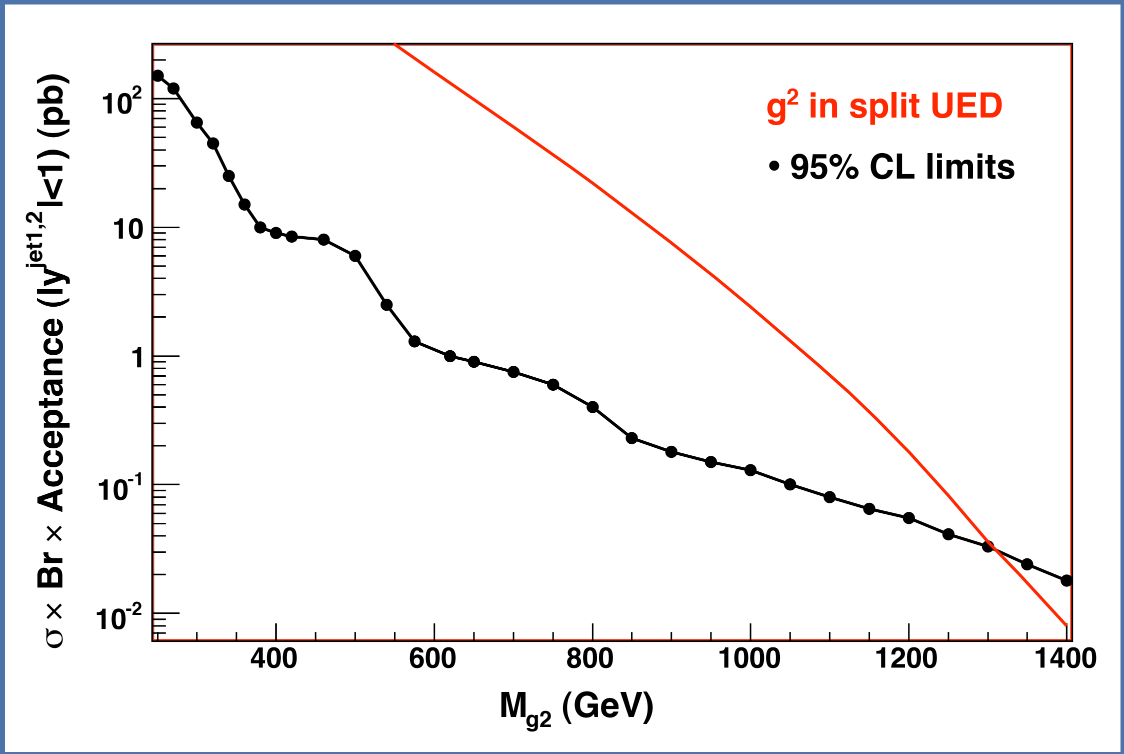


CDF notes 9246

The most stringent bound is from four quark interactions.

The bound is loose due to the large uncertainties in high invariant mass

Bounds from Tevatron



$M_{g^2} > 1.3\ \mathrm{TeV}$

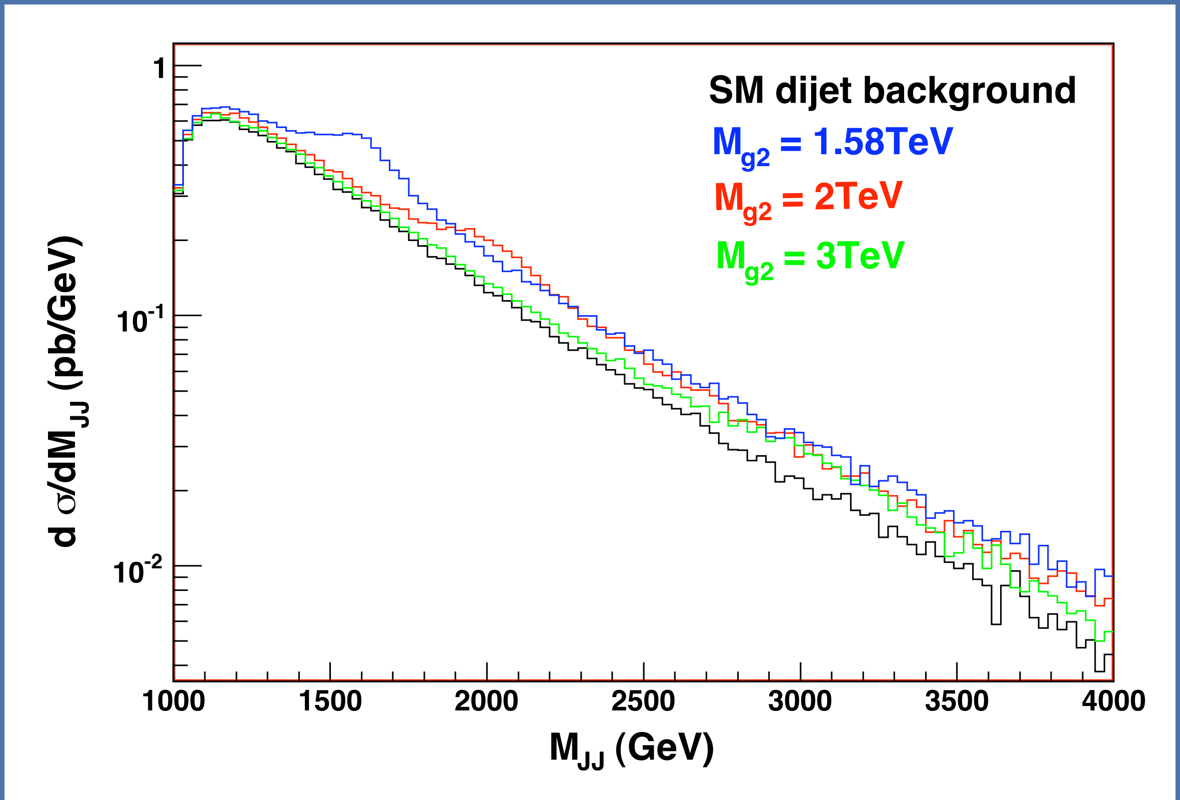
$$\frac{1}{R} > 510\ \mathrm{GeV}$$

OK for ATIC and FERMI

CDF notes 9246

LHC resonances

At LHC, the even KK gauge bosons (gluons) are copiously produced.



Cuts: $|\eta| < 2.5$

$p_T > 500$ GeV

pQCD is reliable

Discovery

Broad resonances

At the early stage, up to 4 TeV

Full LHC running time, more than 6 TeV

M_{g2} (TeV)	1.58	2	3	4	5	6
Γ_{g2} (GeV)	270	334	482	627	769	909
$S/\sqrt{B}$ (100 pb^{-1})	66.5	38.2	11.9	4.3	–	–
$S/\sqrt{B}$ (100 fb^{-1})	2103	1208	376	137	86	22

MET search.......

In MUED, the MET + jets is hopeless because the jets are so soft.

Standard search with well studied background

SUED		SUSY	
q_{L1}	1347 GeV	$\tilde{u}_L$,$\tilde{d}_L$	1355, 1358
u_{R1}	1322	$\tilde{u}_R$	1304
d_{R1}	1318	$\tilde{d}_R$	1263
g_1	794	$\tilde{g}$	799
A_1	621	$\tilde{\chi}_1^0$	622

In sUED, the jets from KK quark decay are very hard.

Mass reconstruction in MET + jets is possible.

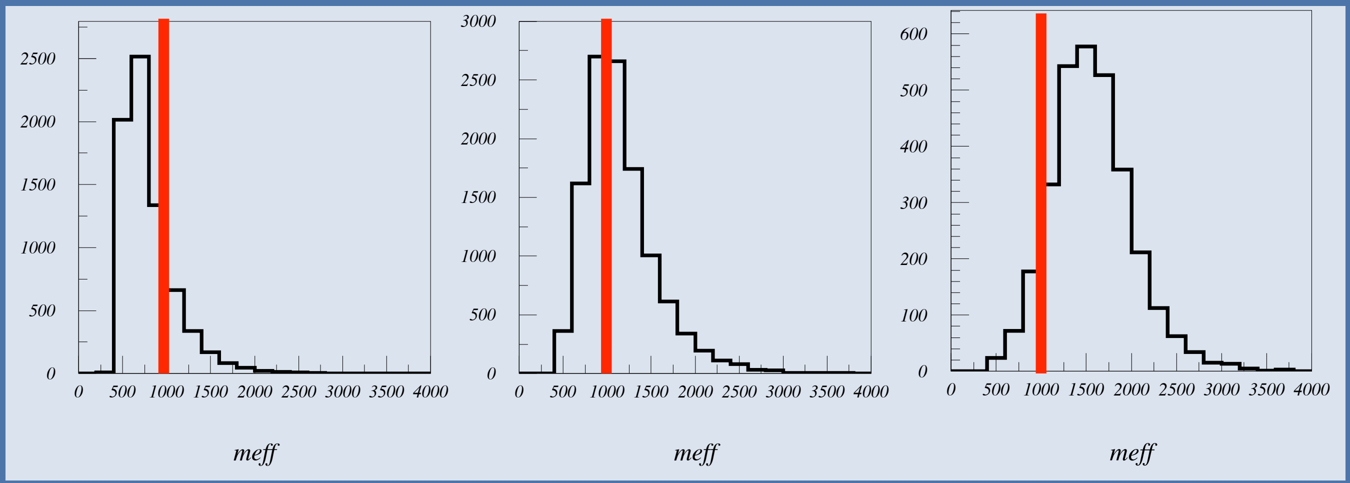
Kinametic here is independent of spin, we rescale the SUSY events with the same spectra.

Big Cross section for fermion pair production.

MET search.......

We consider the KK quark pair production...........

HERWIG + ACERJET



$\tilde{g}\tilde{g}$ $\tilde{g}\tilde{q}$ $\tilde{q}\tilde{q}$

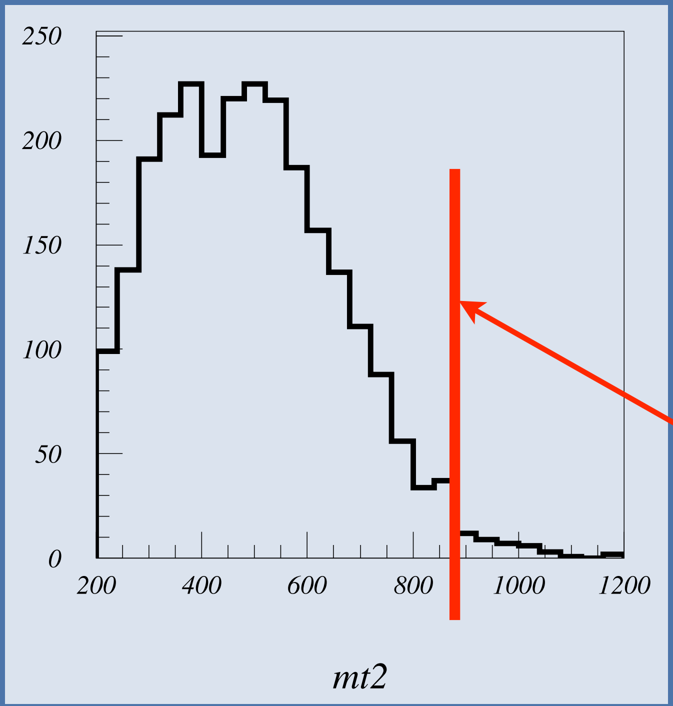
meff cuts (>1TeV) easily select the KK quark events

scalar sum of the leading jets and $p_{T miss}$

MT2

For 2 leading jets + MET

$$M_{T2} = \min_{p_{Tmiss}=p_1^T+p_2^T} [\max(M_T(p_1, p_{j_1}) M_T(p_2, p_{j_2}))]$$



p1, p2 are the test invisible particle momenta that make up p_{Tmiss} .

For $A \rightarrow Xq$

$$M_{T2}^{\text{end}} = m_A - \frac{m_X^2}{m_A}$$

For $q_1 \rightarrow g_1 q$

$$M_{T2}^{\text{end}} \approx 882\text{GeV}$$

Confirm the theoretical g1 masses.

More physics has to be done in this direction!

Summary

- We build the double kink mass background to localize the SM fermions while preserve the KK parity.
- It explains all the cosmic ray excesses.
- The model violate the KK # at the tree level in the quark sector, one can discover 2nd KK gauge bosons at LHC.
- Mass reconstruction is possible through MET + mutijets.

Some clarification!

The model here is NOT nothing but a model lies in the parameter space of origin UED with BLK.

- The BLK will only decrase the KK masses, so one can never decouple the KK modes (KK quarks) in the theory.
- BLK will never affect the zero mode, so one can never localize the SM fermions.
- One can expain the flavor hierarchy in flat space with KK parity.

Reproduce some kind of RS behavior if higgs at the enter

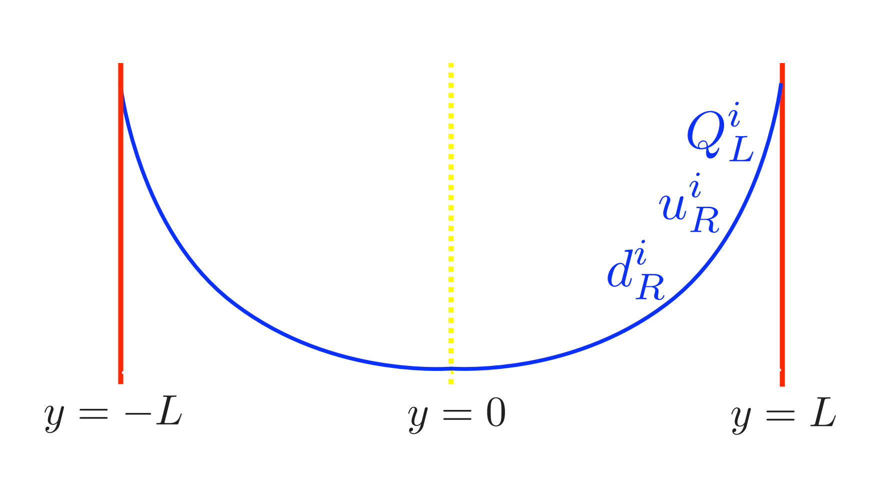
Csaki, Heinonen, Park, JS, work in progress

Backup slices

Split-UED

SCP, Jing Shu[arXiv:0901.0720] PRL submitted

- Double Kink-mass for quarks introduced (1 new parameter)
- Quarks are quasi-localized on boundaries (split-wave function)



- KK parity respected :-)
- KK quarks are heavier by 5D mass term (split-spectrum)

$$m_n^2 = \mu^2 + k_n^2$$

MET search.......

The jets from KK quark is hard, and measuable.

	cross section(pb)	generated	standard cut	$M_{\rm eff} > 1$ TeV	$M_{\rm eff} > 1.5$ TeV
$\tilde{q}\tilde{q}$	0.13	7595	3069	2799	1629
$\tilde{g}\tilde{q}$	0.62	37584	11448	6829	1851
$\tilde{g}\tilde{g}$	0.61	37381	6609	1356	257

KK decomposition

Consider SM quark is embeded in the "+" component:

$$\Psi_+(x,y) = \sum_n g_n(y)\chi_n(x) \qquad \text{5D KK "+" parity}$$

$$\Psi_-(x,y) = \sum_n f_n(y)\psi_n(x) \qquad \text{5D KK "-" parity}$$

For the 4D KK even/odd field $\chi_n(x)$, $g_n(y)$must be symmetric/asymmetric around y=0, which satisfy the +/- boundary condition.

The 5D profile with even/odd KK parity in the interval -L to L is the same as the one with +/- boundary condition at y=0.

KK decomposition

$$\Psi_+(x,y) = \sum_{n^+,n^-} g_{n^+}(|y|)\chi_{n^+}(x) + \epsilon(y) g_{n^-}(|y|)\chi_{n^-}(x)$$

$$\Psi_-(x,y) = \sum_{n^+,n^-} \epsilon(y) f_{n^+}(|y|)\psi_{n^+}(x) + f_{n^-}(|y|)\psi_{n^-}(x)$$

E. O. M. :

$$\partial_y g_n + \mu g_n - m_n f_n = 0$$
$$\partial_y f_n - \mu f_n + m_n g_n = 0$$

BCs:

g_{n^+} $(+,+)$ g_{n^-} $(-,+)$

f_{n^+} $(-,-)$ f_{n^-} $(+,-)$

KK decomposition

The 5D profiles for the even modes:

$$
\begin{aligned}
g_{0^+} &= A_0 e^{-my} \\
g_{n^+} &= A_{n^+}\left(\cos(k_{n^+}y) - \frac{m}{k_{n^+}}\sin(k_{n^+}y)\right) \\
f_{n^+} &= -A_{n^+}\frac{m_{n^+}}{k_{n^+}}\sin(k_{n^+}y)
\end{aligned}
$$

$$m \sim -\mu$$

The Masses:

$$m_{n^+} = \sqrt{m^2 + k_{n^+}^2}$$

$$k_{n^+} = n\pi/L$$

KK decomposition

The solution for the odd modes (m<0):

$$g_{n-} = -A_{n-}\frac{m_{n-}}{k_{n-}}\sin(k_{n-}y)$$

$$f_{n-} = A_{n-}\left(\cos(k_{n-}y) - \frac{m}{k_{n-}}\sin(k_{n-}y)\right)$$

Masses:

$$m_n = \sqrt{m^2 + k_n^2}$$

$$k_{n-} = m\tan(k_{n-}L)$$

When m increases from $-\infty$ to 0

kn- decreases from $n\pi/L$ to $(n-1/2)\pi/L$

KK decomposition

In case m>0

When m increases from 0 to $+\infty$

kn- increases from $(n-1)\pi/L$ to $(n-1/2)\pi/L$

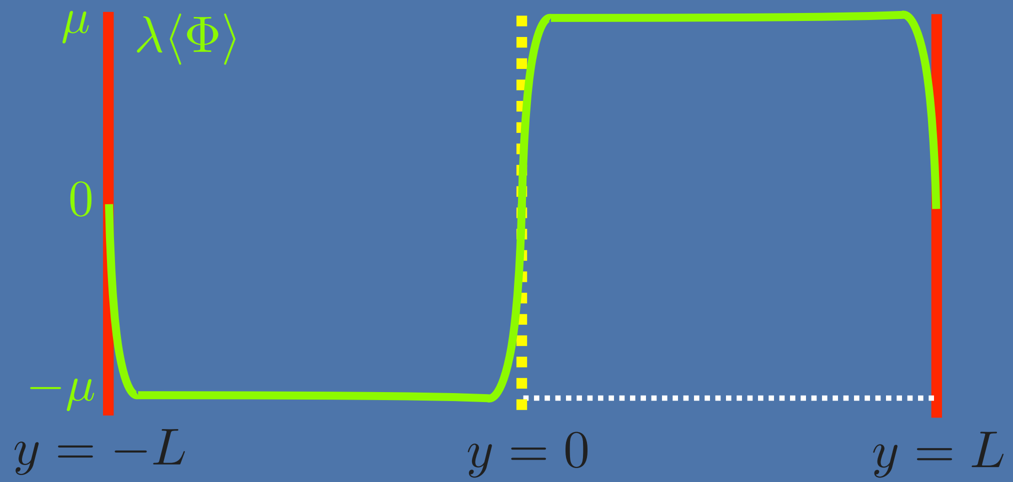
There is a special solution (light mode) when n=1

$$g_{1-} = -A_{1-}\frac{m_{1-}}{k_{1-}}\sinh(k_{1-}y)$$

$$f_{1-} = A_{1-}\left(\cosh(k_{1-}y) - \frac{m}{k_{1-}}\sinh(k_{1-}y)\right)$$

$$m_{1-} = \sqrt{m^2 - k_{1-}^2} \qquad m \to +\infty \quad m_{1-} \to 0$$

Zero mode

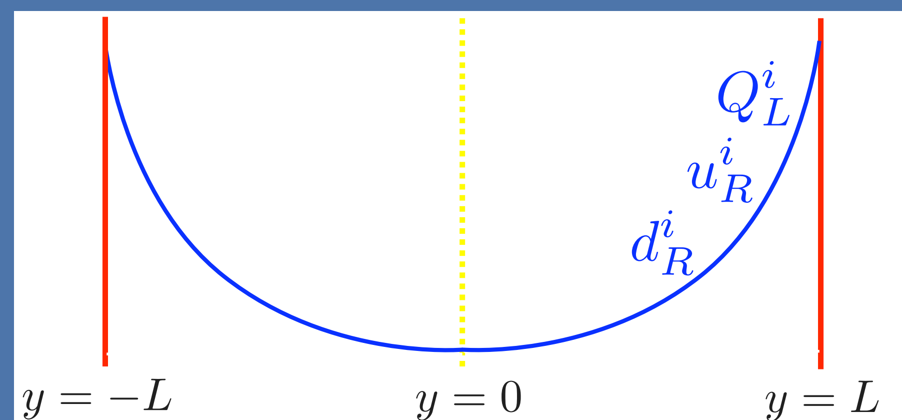


"kink" like profile

simplest: "step" fuction

$$\lambda\Phi(y) = m(y) = \mu\epsilon(y)$$

$$g_{0+}(y) = N_+ \exp(-\int_0^y \Phi(s)ds)$$



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KK decomposition

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$$\Psi_-(x,y) = \sum_{n^+,n^-} \epsilon(y) f_{n^+}(|y|)\psi_{n^+}(x) + f_{n^-}(|y|)\psi_{n^-}(x)$$

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BCs:

$$g_{n^+} \quad (+,+) \quad g_{n^-} \quad (-,+)$$

$$f_{n^+} \quad (-,-) \quad f_{n^-} \quad (+,-)$$

KK decomposition

The 5D profiles for the even modes:

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KK decomposition

In case m>0

When m increases from 0 to $+\infty$

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There is a special solution (light mode) when n=1

$$g_{1-} \;=\; -A_{1-}\frac{m_{1-}}{k_{1-}}\sinh(k_{1-}y)$$

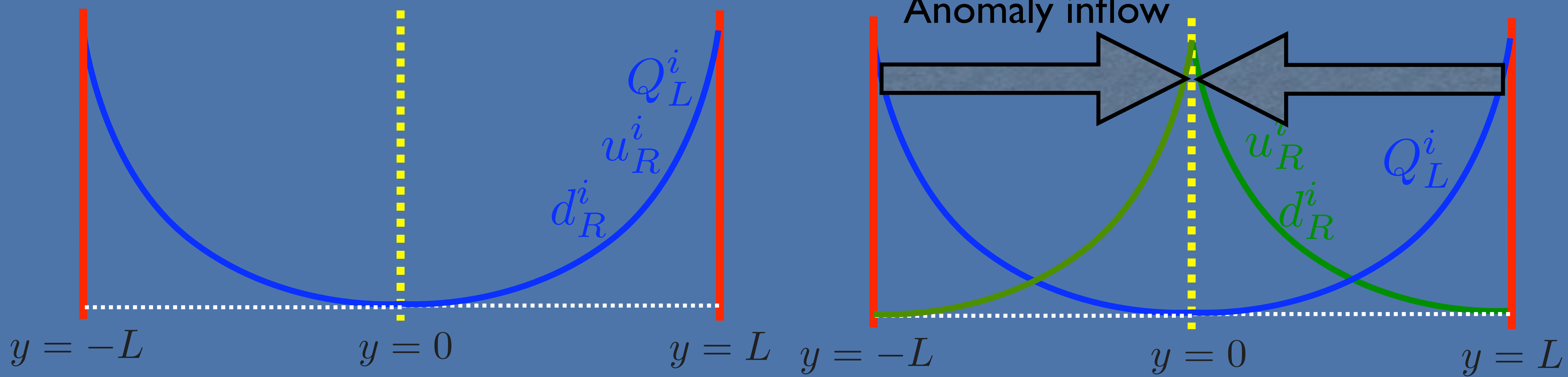
$$f_{1-} \;=\; A_{1-}\left(\cosh(k_{1-}y)-\frac{m}{k_{1-}}\sinh(k_{1-}y)\right)$$

Troublesome in phenomenology, we have to forbid it.

$$m_{1-}=\sqrt{m^2-k_{1-}^2} \qquad m\rightarrow+\infty \quad m_{1-}\rightarrow 0$$

KK decomposition

Indeed, such a sign (μ<0) controls the zero mode localized at the center.



No light mode

has light mode

The anomaly cancellation

In a 5D theory, one has to worry about the localized anomaly even when the zero mode is anomaly free.

$U(1)_Y^3$

$SU(2)_L^2 - U(1)_Y$

$U(1)_Y - \text{gravitational}$

Can not be cancelled in the quark/lepton sector alone!

The 5D anomalies from the lepton sector is localized at the boundary y=-L, L.

The anomaly cancellation

For for a 5D quark field whose left/right-handed has the (α_0, α_1) boundary condition at y=0, L

$$\partial_C J^C = \frac{\mathcal{Q}}{2}\left[\alpha_0 \delta(y) + \alpha_1 \delta(y-L)\right]$$

$\mathcal{Q}$ is the corresponding consistent anomaly of a left/right-handed spinor

Notice the anomalies induced by the KK even state ("+" at y=0) will cancel those by the KK odd state ("-" at y=0) at y=0.

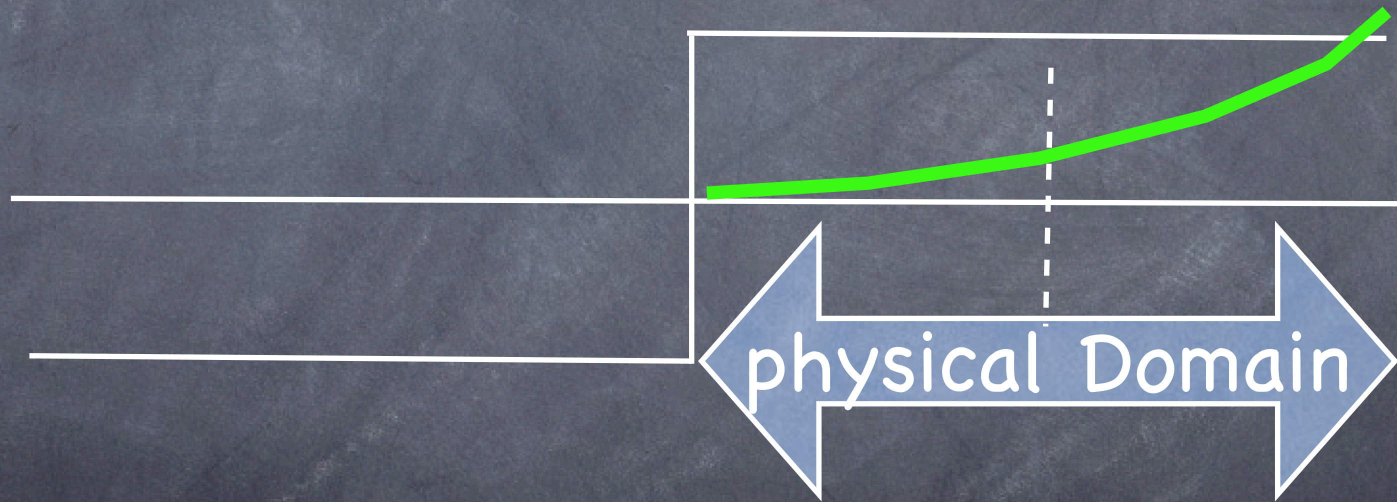
The 5D anomalies from the quark sector is also localized at the boundary y=-L, L.

The two will cancel each other!

Kink-Mass

$$S = \int d^5 \bar{\Psi} i \Gamma_M D^M \Psi - \lambda \Phi(y) \bar{\Psi}\Psi$$

$$m_n^2 = \mu^2 + k_n^2$$



Zero mode
wave function

$$f(y) \sim e^{\mu y}$$

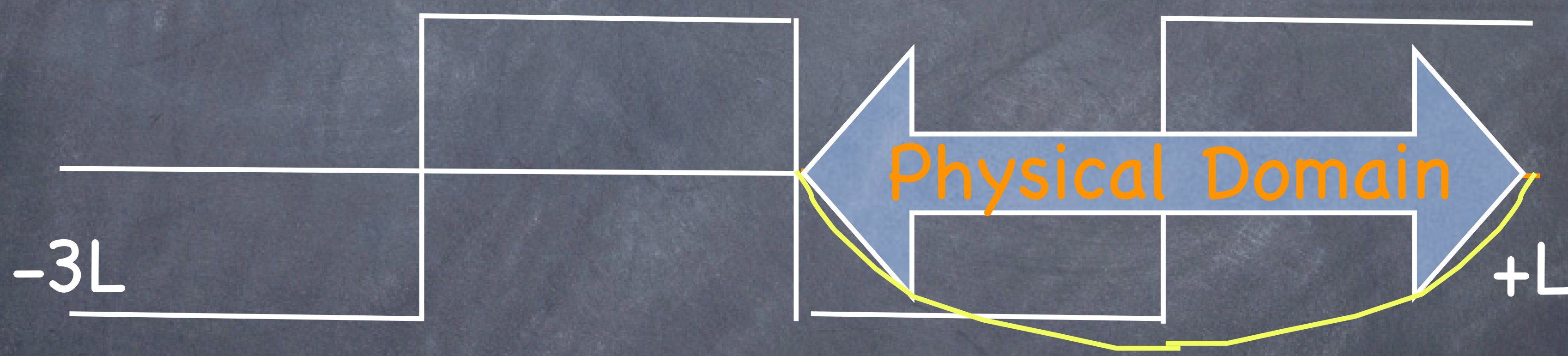
KK-parity is not respected.

Double kink-mass

SCP, Jing Shu[arXiv:0901.0720] PRL submitted

$$m_n^2 = \mu^2 + k_n^2$$

$$S = \int d^5 \bar{\Psi} i \Gamma_M D^M \Psi - \lambda \Phi(y) \bar{\Psi} \Psi$$

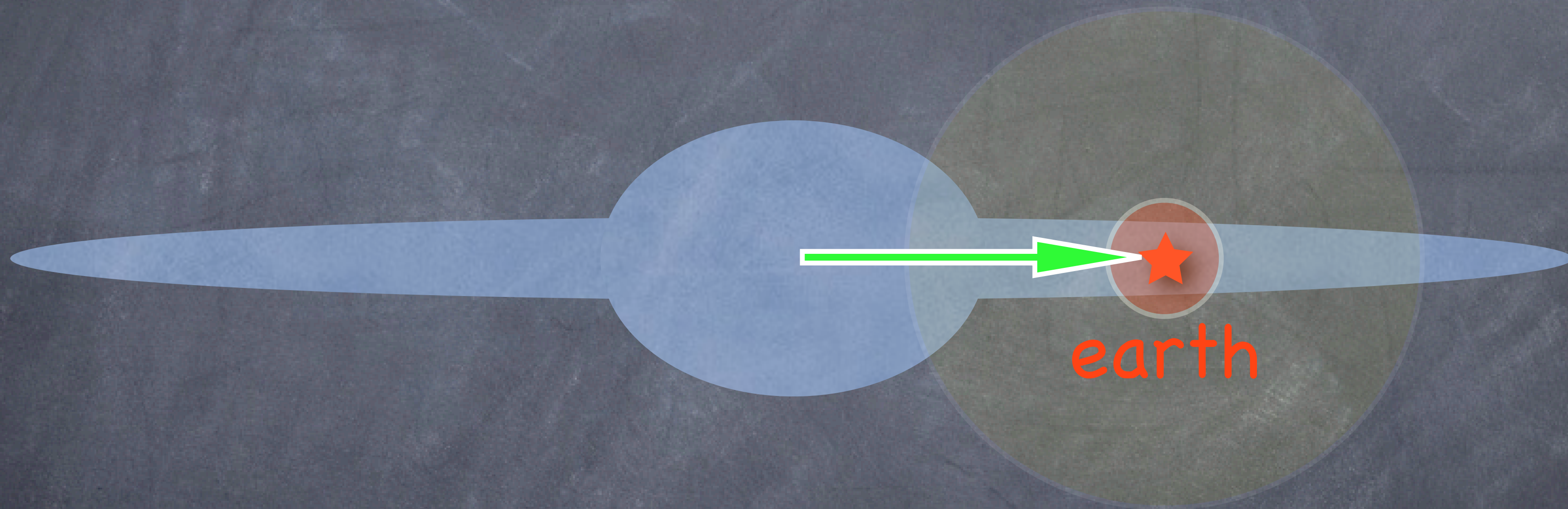


Zero-mode profile

$$\begin{aligned} f(y) &= e^{\int_{-L}^{y} m(y) dy} \\ &= e^{-m(y-L)} (y < 0) \\ &= e^{m(y+L)} (y > 0) \end{aligned}$$

KK-parity respected

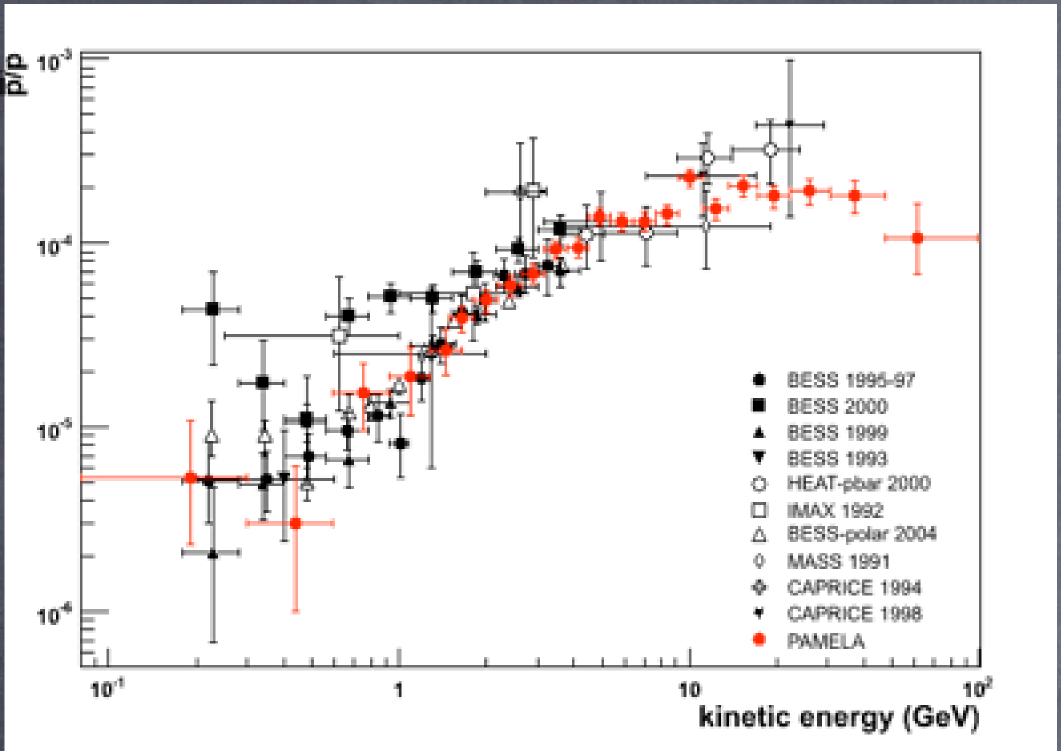
B1+B1->e+,gamma,p-..



- Positron mostly from "local" source
- Photon goes straight (mostly from the center)
- Antiproton diffuses longer

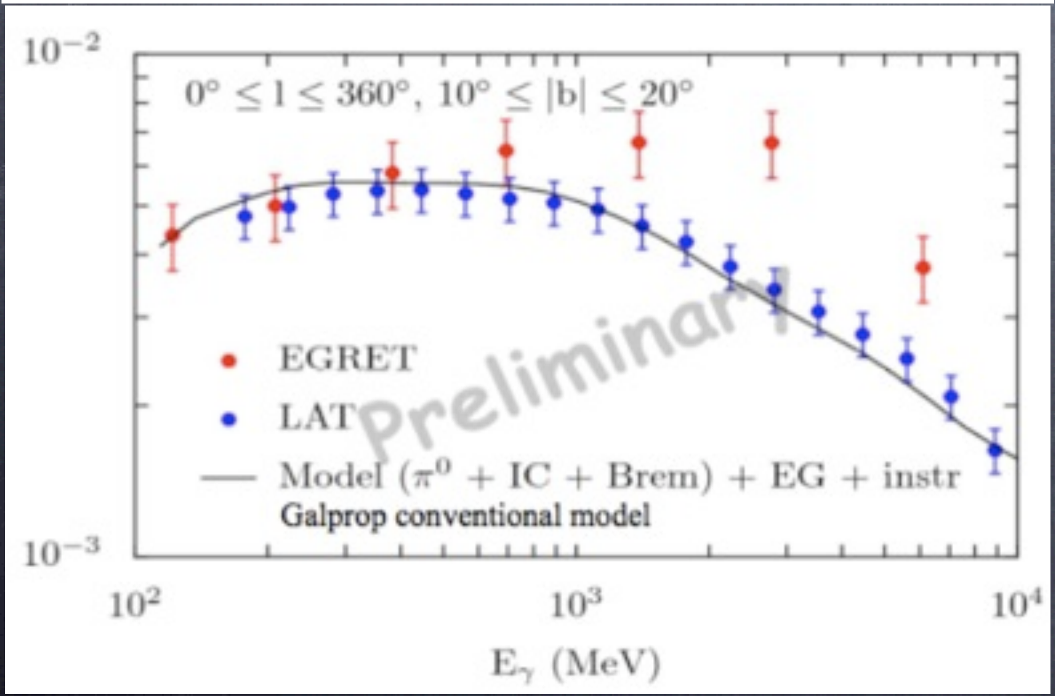
However!

No excess in anti-proton
PAMELA, PRL(2009)



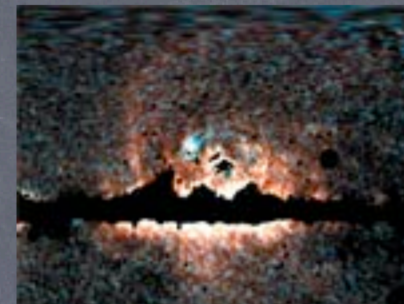
(T_T)

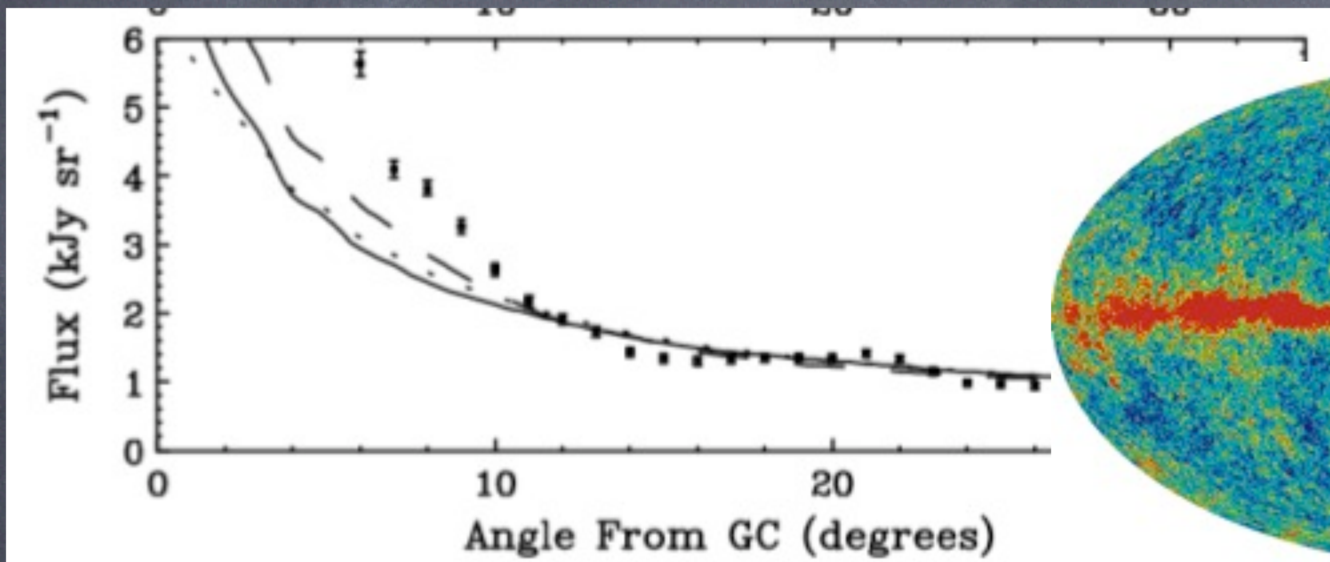
No excess in gamma-ray from Halo
Fermi, preliminary

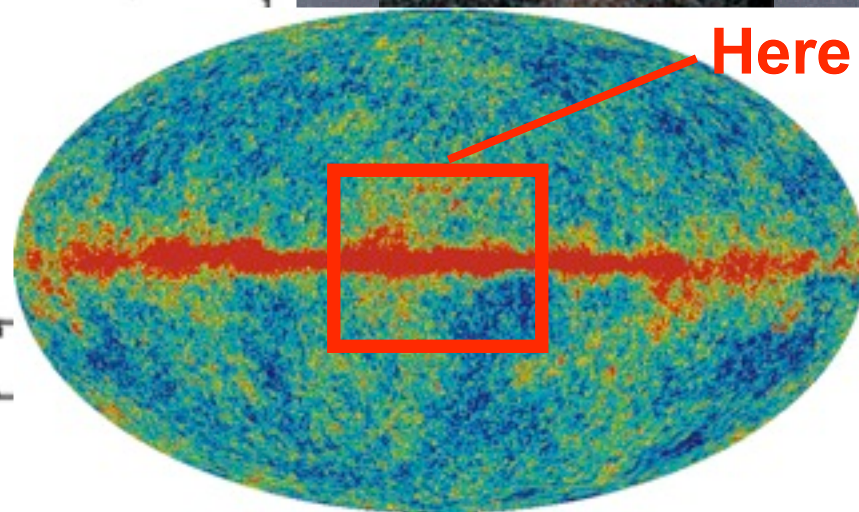


==> need for extension

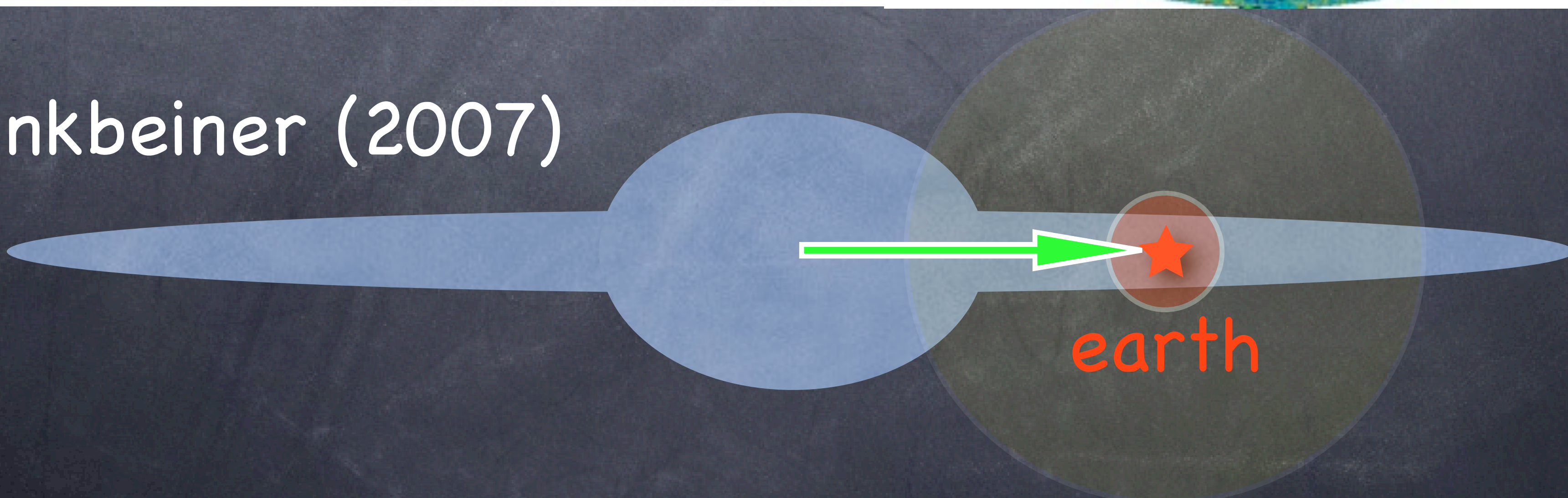
WMAP Haze:
photon from GC





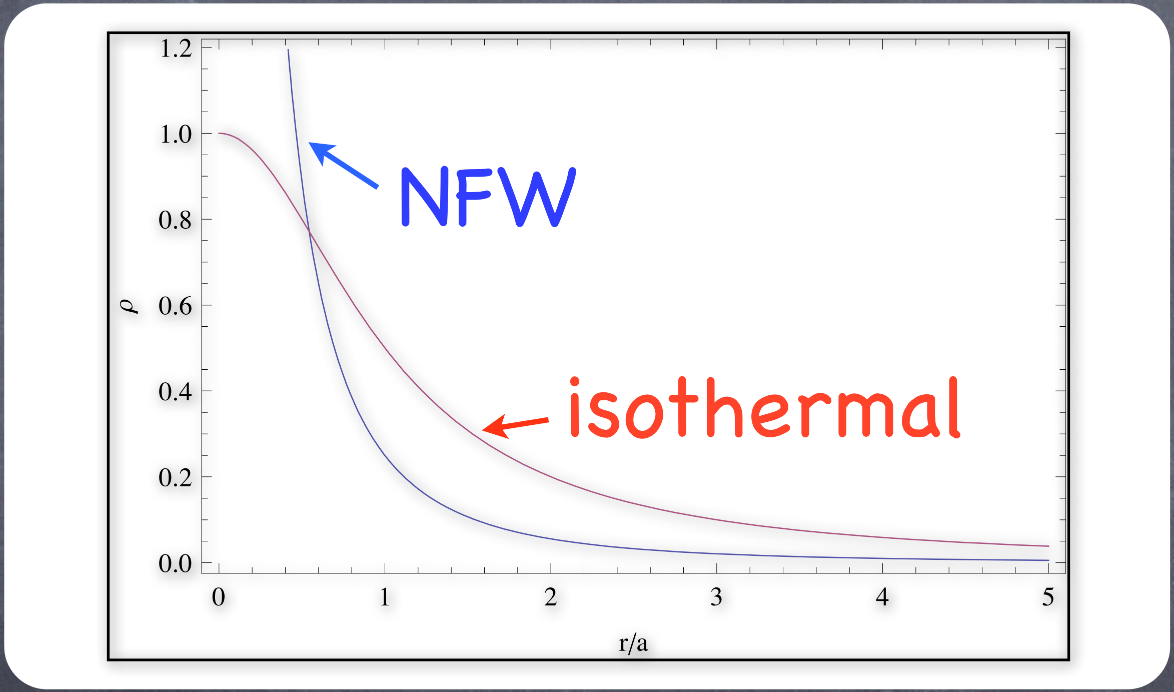


Finkbeiner (2007)



Supple: Halo profile

$$\rho(r) = \frac{\rho_0}{(r/a)^\gamma[1+(r/a)^\alpha]^{(\beta-\gamma)/\alpha}}$$



Profile	alpha	beta	gamma
NFW	1	3	1
Isothermal	2	2	0