Dark Matter Candidate from Lorentz Invariance in 6 Dimensions

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G.Cacciapaglia, A.Deandrea & J.L.P, arXiv: 0907.4993

OUTLINE

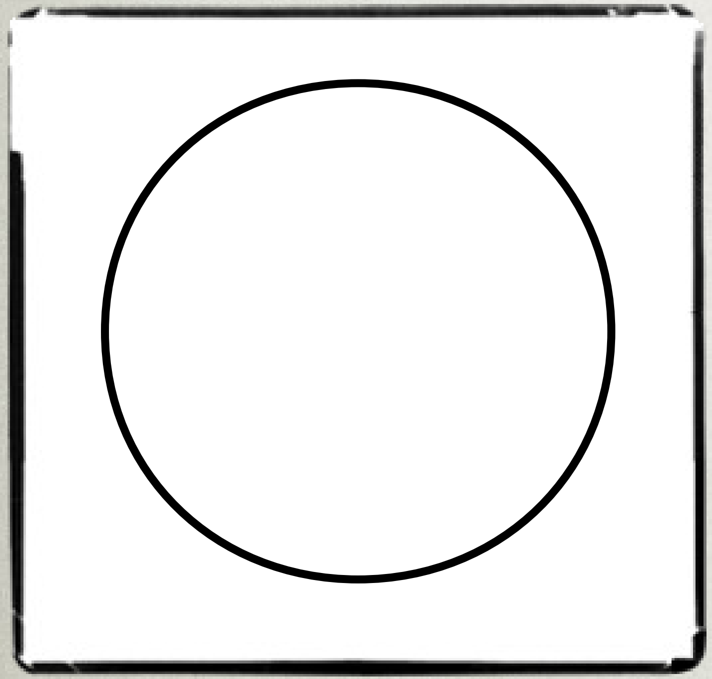
Is it possible to obtain an extra dimensional model with a "natural" dark matter candidate?

↓

- 6D Universal Extra Dimension on a real projective plane.
- Dark matter "constraints" for the extra dimensional radii
- Preliminary results and discussions for phenomenology at LHC

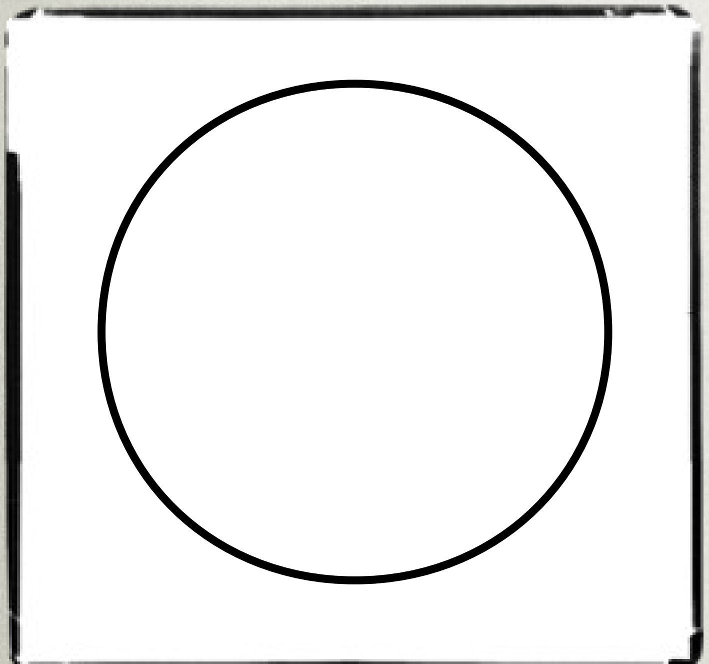
5D Model and KK-Parity

Extra dimension: S_1



5D Model and KK-Parity

Extra dimension: S_1



☢ ☢ ☢

No KK-Parity

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No Chiral Fermions

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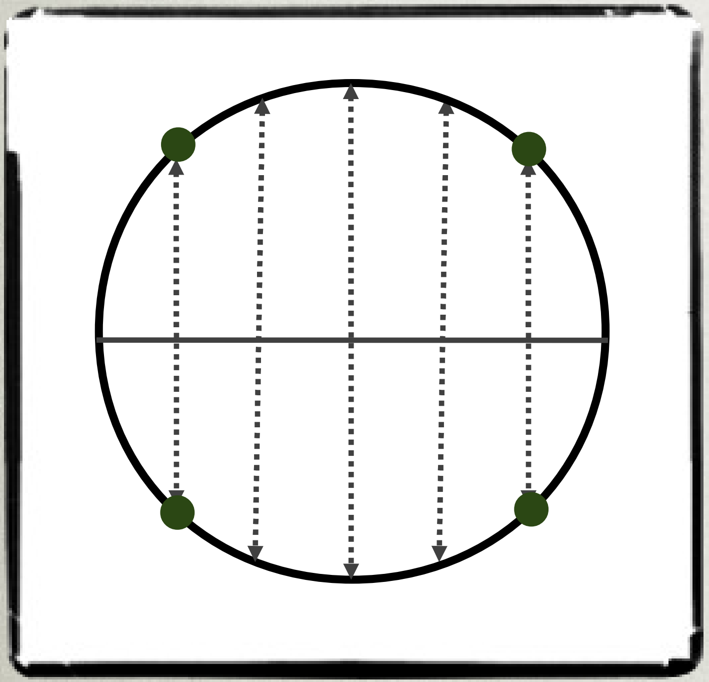
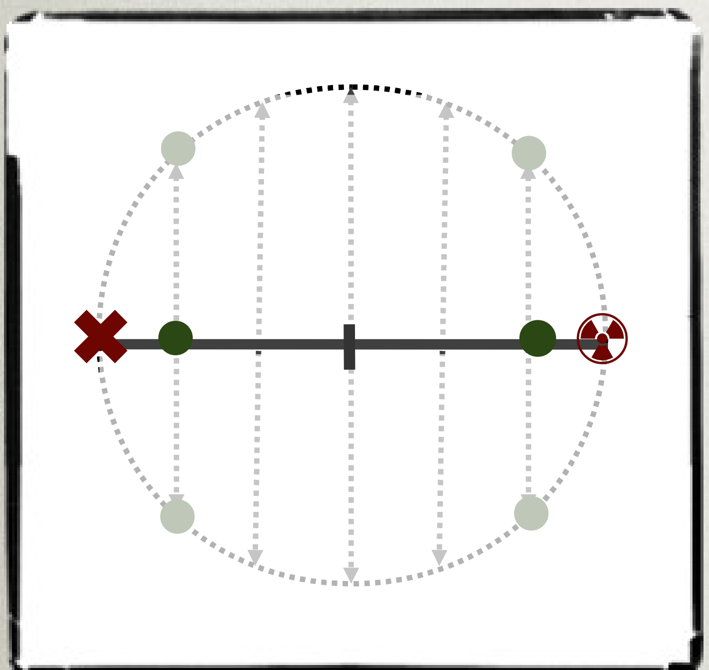
5D Model and KK-Parity

Extra dimension: S_1/Z_2



5D Model and KK-Parity

Extra dimension: S_1/Z_2



KK-Parity only in the bulk

Chiral Fermions

Localized interactions on fixed points
→ Extra symmetry to identify them

Orbifold Without Fixed Points: 6D Model

- In 6D, 17 possible ways to orbifold the extra $\boldsymbol{R}^2$
- Only 3 without fixed points

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No Chiral Fermions

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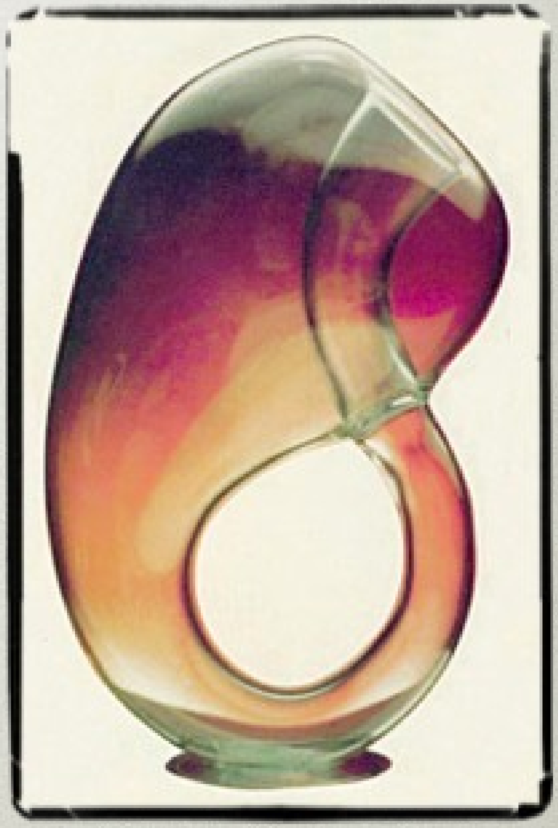


1-Torus

2-Klein Bottle

Last Possibility: The Real Projective Plane

- Definition: $\boldsymbol{R}^2/\mathbf{pgg}$ where $\mathbf{pgg} = \{r, g \,|\, r^2 = (g^2 r)^2 = \mathbf{1}\}$

$$r \quad : \quad \begin{cases} x_5 \sim -x_5 \\ x_6 \sim -x_6 \end{cases},$$

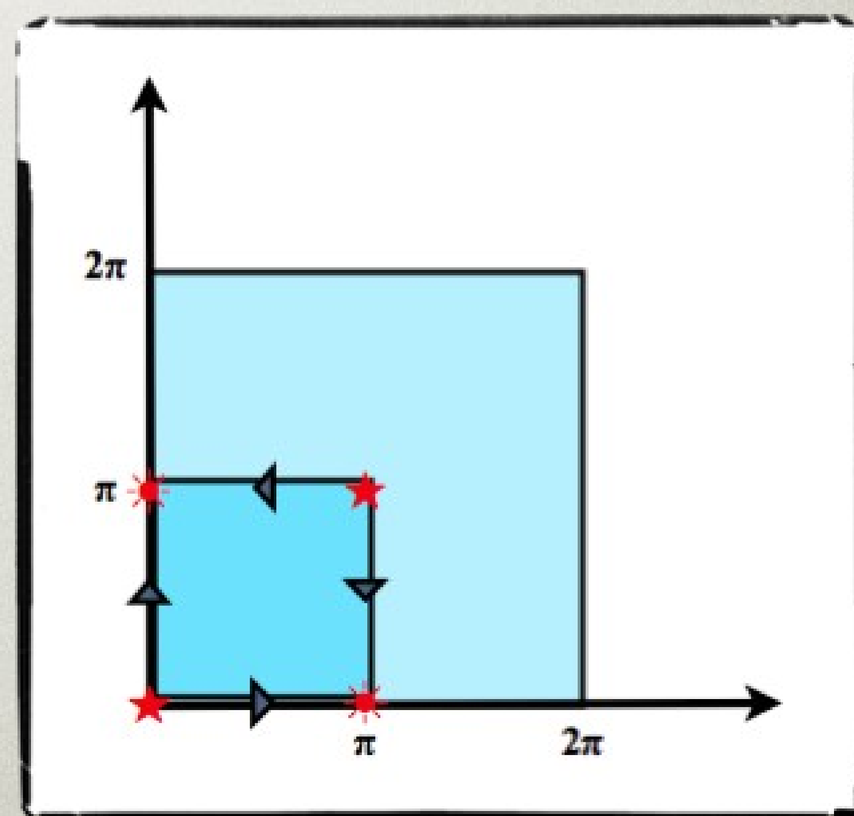
$$g \quad : \quad \begin{cases} x_5 \sim x_5 + \pi R_5 \\ x_6 \sim -x_6 + \pi R_6 \end{cases}.$$

$$\Updownarrow$$

$$g \quad : \quad \begin{cases} x_5 \sim x_5 + \pi R_5 \\ x_6 \sim -x_6 + \pi R_6 \end{cases},$$

$$g' = gr \quad : \quad \begin{cases} x_5 \sim -x_5 + \pi R_5 \\ x_6 \sim x_6 + \pi R_6 \end{cases}.$$

Fundamental domain



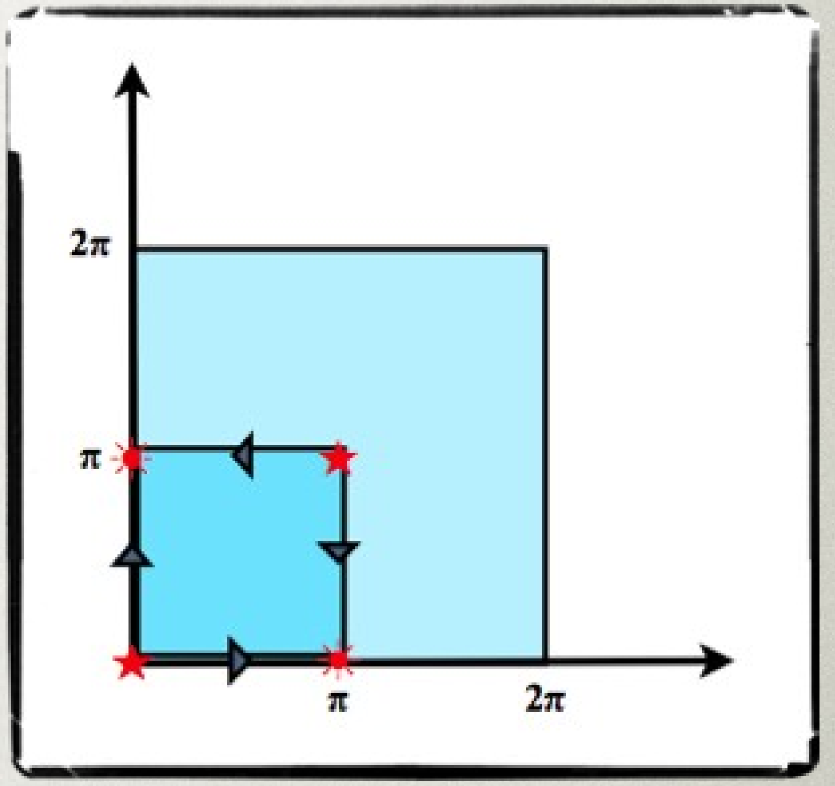
Unbroken KK-Parity: "Natural" DM Candidate

- In the bulk, two discrete parities.
- No fixed point but conical singularities
  (0, π) ~ (π, 0) & (π,π) ~ (0,0)
  ⟶ Localized interactions
- But **here one discrete parity** remains **unbroken** even by localized terms

$$P_{KK} \quad : \quad \begin{cases} x_5 \sim x_5 + \pi R_5 \\ x_6 \sim x_6 + \pi R_6 \end{cases}$$

⟶ **Relic of 6D Lorentz invariance**

- Phase for generic KK modes with momenta (k,l) ⟶ $(-1)^{k+l}$



✪ ✪ ✪
Chiral Fermions
&
KK-Parity
✪ ✪ ✪

Gauge Boson in this Framework

$$S_{\text{gauge}} = \int_0^{2\pi} dx_5\, dx_6 \left\{ -\frac{1}{4} F_{\alpha\beta}F^{\alpha\beta} - \frac{1}{2\xi}\left(\partial_\mu A^\mu - \xi(\underbrace{\partial_5 A_5 + \partial_6 A_6}_{=0 \text{ if } \xi\to\infty})\right)^2 \right\},$$

$$\begin{cases} A_5 = \sum \phi_5(x_5, x_6) A_{(k,l)} \\ A_6 = \sum \phi_6(x_5, x_6) A_{(k,l)} \end{cases} \quad \text{with} \quad \partial_5\phi_5 + \partial_6\phi_6 = 0$$

- Eq. of motion: $(p^2 + \partial_5^2 + \partial_6^2)\phi_{5/6} = 0 \quad \text{and} \quad m_{KK} = \sqrt{\frac{k^2}{R_5^2} + \frac{l^2}{R_6^2}}$
- After we impose parity under **r** and **g:** (p_r, p_g)

Levels (k, l)	P_{KK}	$A_\mu^{(+,+)}$	$A_5^{(-,+)}$	$A_6^{(-,-)}$
(0, 0)	+	$\frac{1}{2\pi}$		
(0, 2l)	+	$\frac{1}{\sqrt{2}\pi}\cos 2lx_6$		
(0, 2l-1)	-		$\frac{1}{\sqrt{2}\pi}\sin(2l-1)x_6$	
(2k, 0)	+	$\frac{1}{\sqrt{2}\pi}\cos 2kx_5$		
(2k-1, 0)	-			$\frac{1}{\sqrt{2}\pi}\sin(2k-1)x_5$
$(k, l)_{k+l \text{ even}}$	+	$\frac{1}{\pi}\cos kx_5 \cos lx_6$	$\frac{l}{\pi\sqrt{k^2+l^2}}\sin kx_5 \cos lx_6$	$\frac{-k}{\pi\sqrt{k^2+l^2}}\cos kx_5 \sin lx_6$
$(k, l)_{k+l \text{ odd}}$	-	$\frac{1}{\pi}\sin kx_5 \sin lx_6$	$\frac{l}{\pi\sqrt{k^2+l^2}}\cos kx_5 \sin lx_6$	$\frac{-k}{\pi\sqrt{k^2+l^2}}\sin kx_5 \cos lx_6$

Tree Level Spectrum
Standard Model

Levels	Mass	$P_{KK}=(-1)^{k+1}$	Gauge Vectors (A^μ, Z^μ, W^μ, G^μ)	Gauge Scalars (A^5, A^6,...)	Fermions	Higgs
(0,0)	0	+	YES	**NO**	YES (Chiral)	YES
(1,0) &(0,1)	1/R	-	**NO**	YES	YES (Dirac)	**NO**
(1,1)	$\sqrt{2}/R$	+	YES	YES	YES (Dirac) x 2	YES
(2,0) &(0,2)	2/R	+	YES	**NO**	YES (Dirac)	YES
(2,1) &(1,2)	$\sqrt{5}/R$	-	YES	YES	YES (Dirac) x 2	YES

Choice of degenerate case: $R_5=R_6=R$

Tree Level Spectrum: LLP Level

Levels	Mass	$P_{KK}=(-1)^{k+1}$	Gauge Vectors (A^μ, Z^μ, W^μ, G^μ)	Gauge Scalars (A^5, A^6,...)	Fermions	Higgs
(0,0)	0	+	YES	**NO**	YES (Chiral)	YES
(1,0) &(0,1)	1/R	**-**	**NO**	YES	YES (Dirac)	**NO**
(1,1)	$\sqrt{2}/R$	+	YES	YES	YES (Dirac) x 2	YES
(2,0) &(0,2)	2/R	+	YES	**NO**	YES (Dirac)	YES
(2,1) &(1,2)	$\sqrt{5}/R$	-	YES	YES	YES (Dirac) x 2	YES

$\boxed{\text{Choice of degenerate case: } R_5=R_6=R}$

Splitting : Radiative And Higgs Corrections

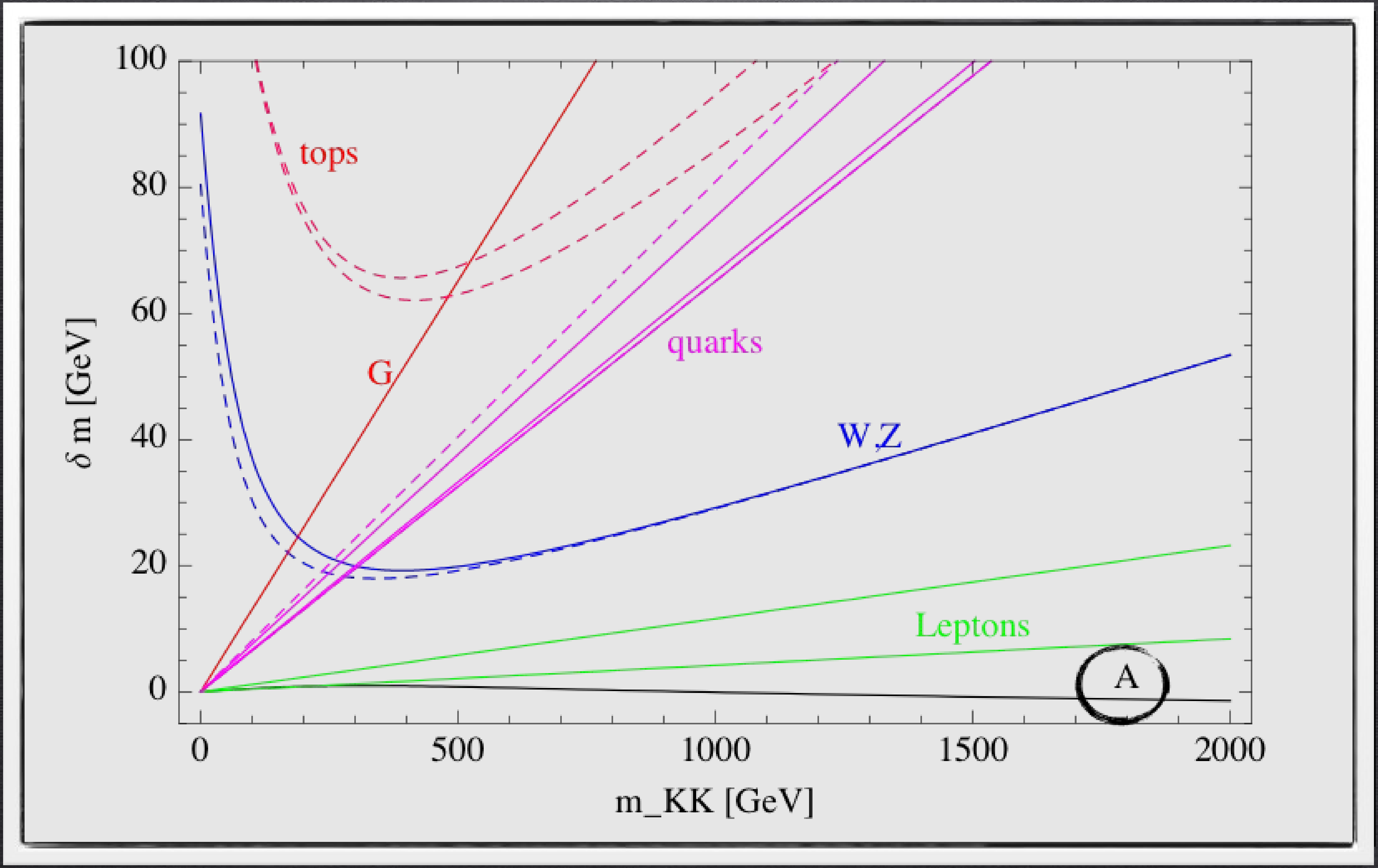
- Calculation for LLP level
- 6D loop calculations: Mixed propagator method

$$
\begin{aligned}
\delta m_B^2 &= \frac{g'^2}{64\pi^4 R^2}\left[-79T_6 + 14\zeta(3) + \pi^2 n^2 L + B_1 - 4B_2\right] , \\
\delta m_W^2 &= \frac{g^2}{64\pi^4 R^2}\left[-39T_6 + 70\zeta(3) + 17\pi^2 n^2 L + 7B_1 - 32B_2 - 2B_3\right] , \\
\delta m_G^2 &= \frac{g_s{}^2}{64\pi^4 R^2}\left[-36T_6 + 84\zeta(3) + 24\pi^2 n^2 L + 9B_1 - 42B_2 - 3B_3\right] .
\end{aligned}
$$

- EWSB: Higgs VEV

$$
\begin{pmatrix} W_n^3 & B_n \end{pmatrix} \cdot \begin{pmatrix} \delta m_W^2 + m_W^2 & -\tan\theta_W m_W^2 \\ -\tan\theta_W m_W^2 & \delta m_B^2 + \tan^2\theta_W m_W^2 \end{pmatrix} \cdot \begin{pmatrix} W_n^3 \\ B_n \end{pmatrix} .
$$

Dark Matter Candidate: Heavy Scalar Photon



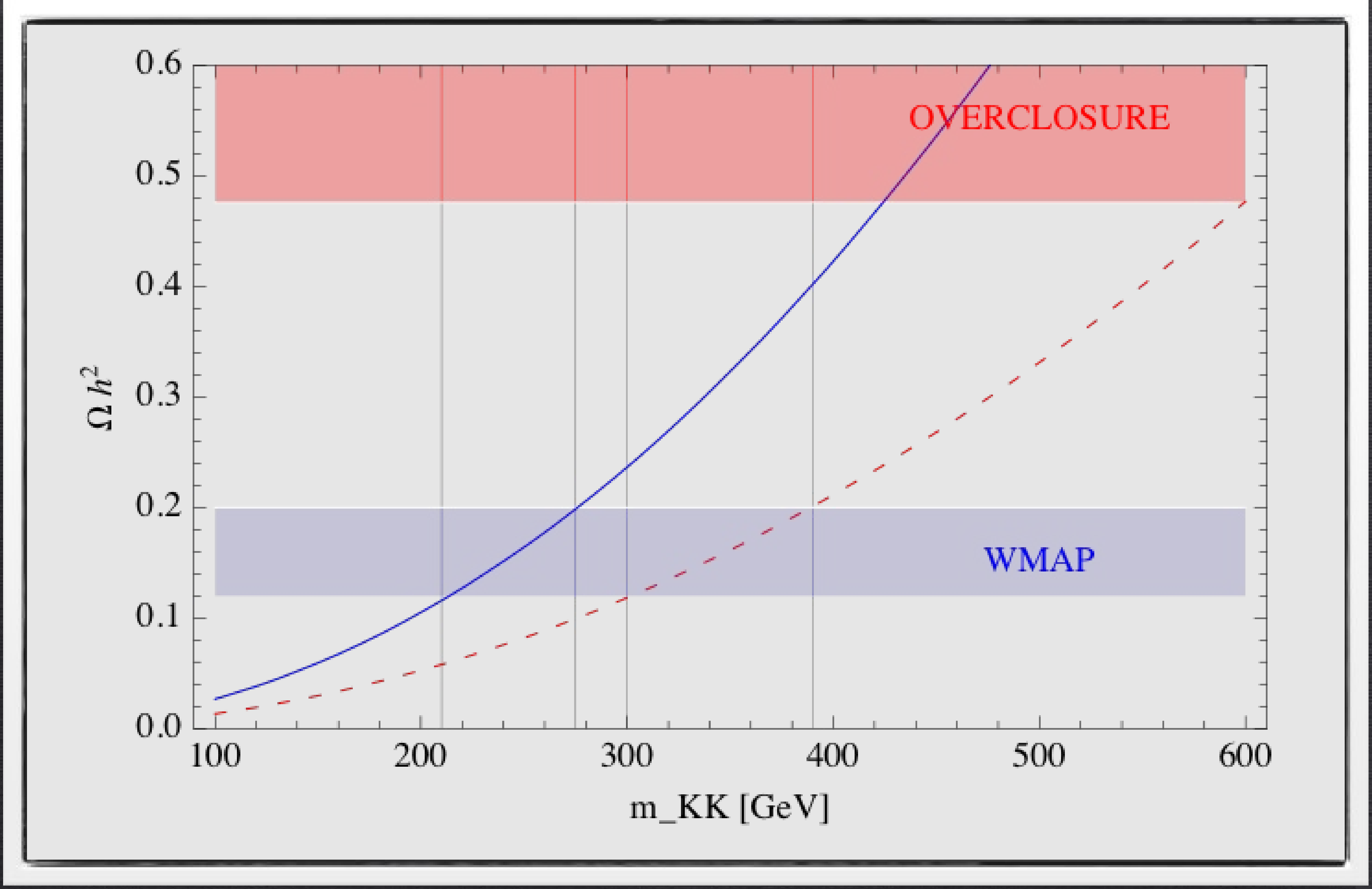
First calculation of relic density

- Included effects:
  - Large co-annihilation (small splitting)
- First approximation:
  - EWSB neglected
  - No resonant annihilation via Higgs or (0,2)-(2,0) tiers
  - Localized kinetic terms neglected

↓

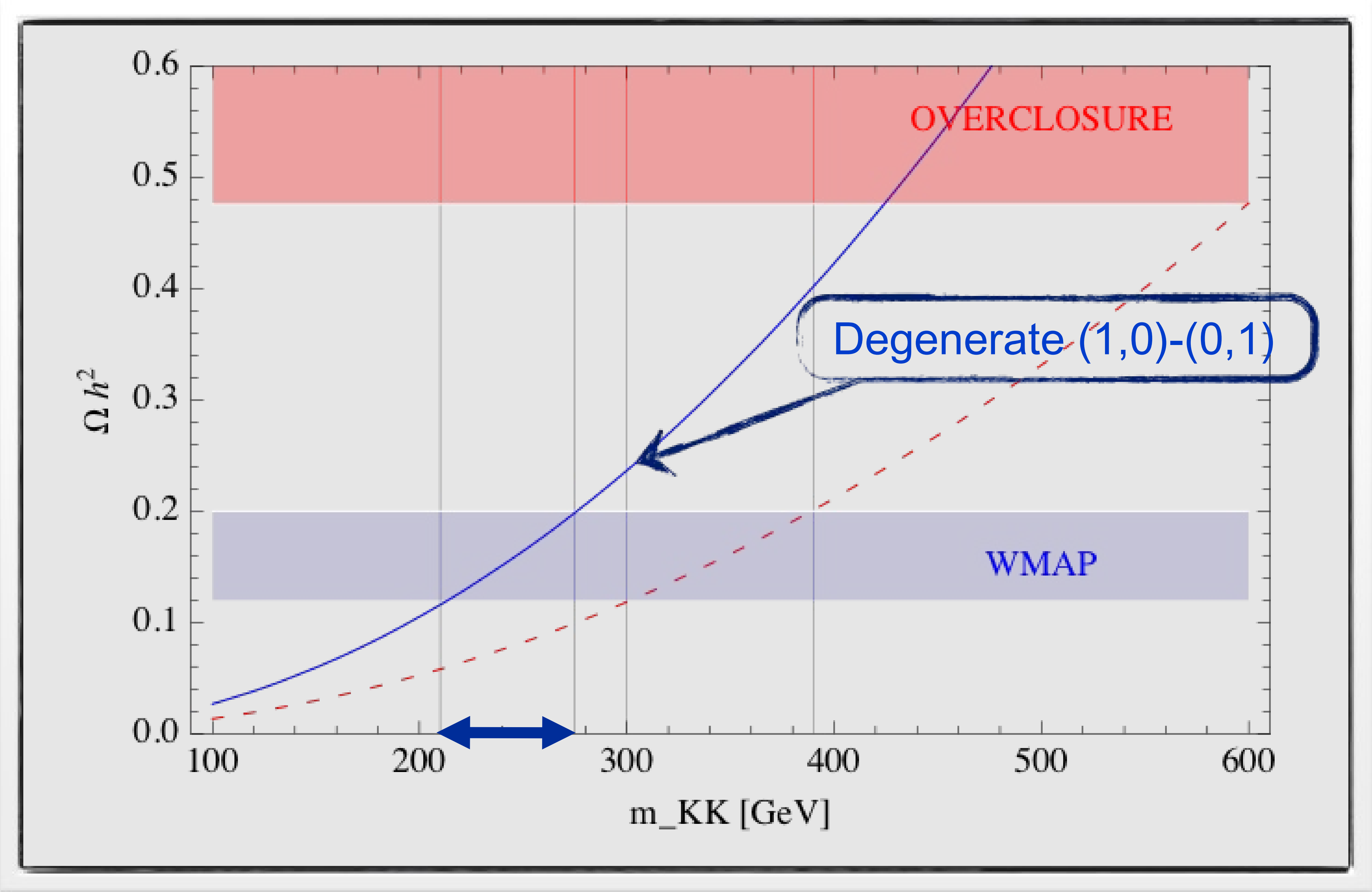
Model soon implemented in FeynRules
& in relic abundance codes

Relic Density And Radii First Estimation



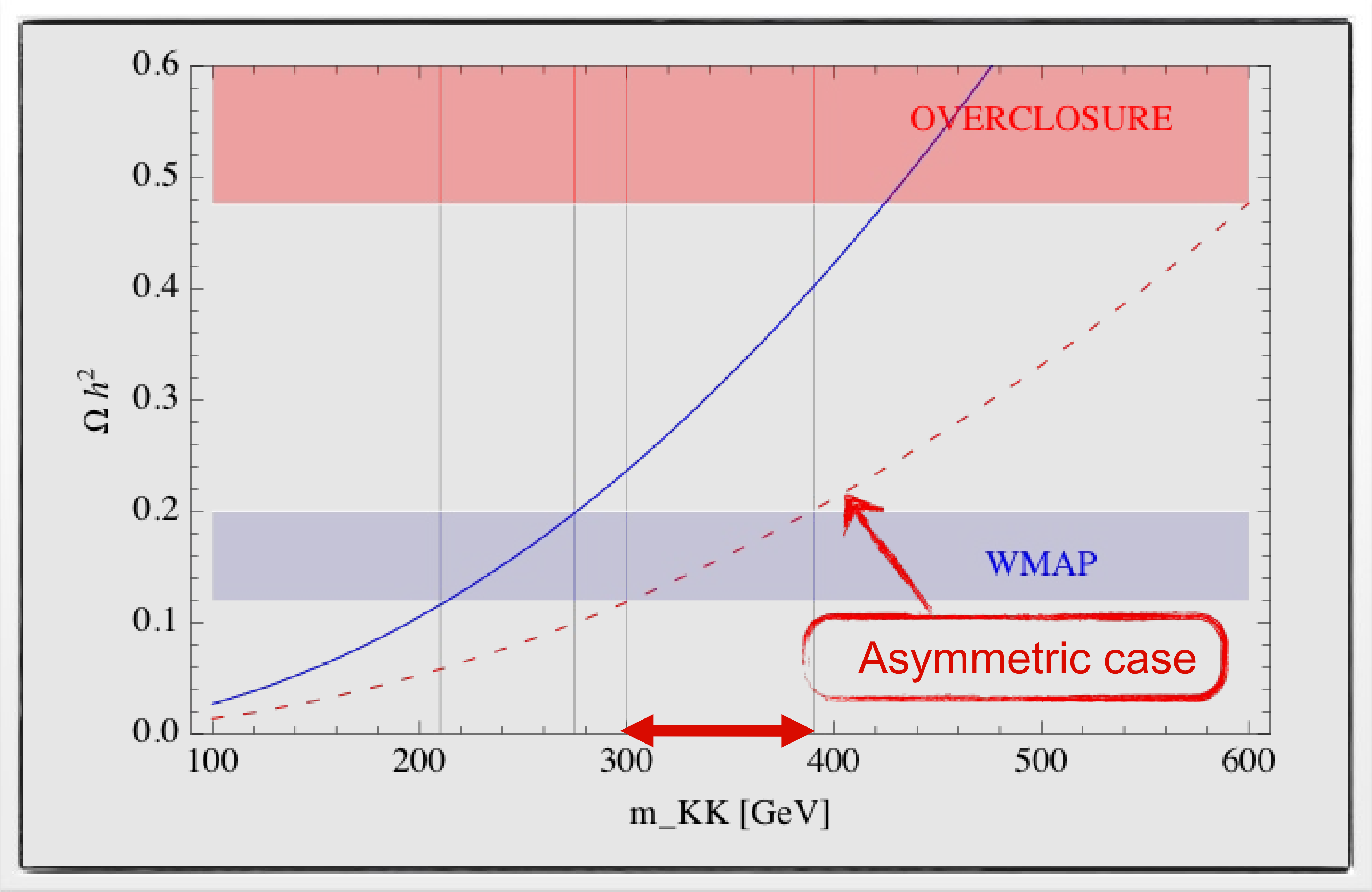
Relic Density And Radii First Estimation

200 GeV<1/R<300 GeV



Relic Density And Radii First Estimation

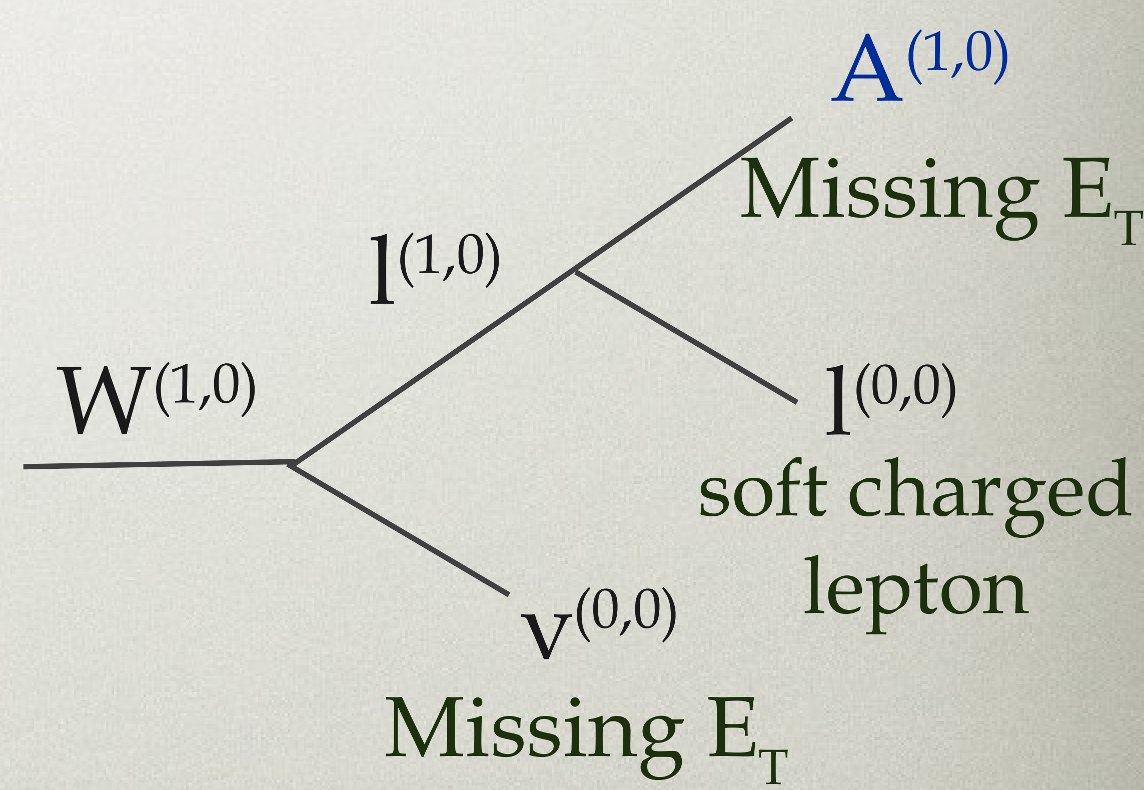
300 GeV<1/R<400 GeV



Phenomenology @ LHC : Decays of lightest tier

- Production cross sections of the lightest tier for $1/R \sim 300 \div 400$ GeV: 10 fb < σ_{prod} < 1 pb (preliminary work of B.Kubik)
- Small splitting $\longrightarrow$ Difficult detection of the lightest tier

	$m_X - m_{LLP}$ in GeV	decay mode	final state + MET
$t^{(1,0)}$	70	$bW^{(1,0)}$	bjj $bl\nu$
$G^{(1,0)}$	40-70	$qq^{(1,0)}$	jj
$q^{(1,0)}$	20-40	$qA^{(1,0)}$	j
$W^{(1,0)}$	20	$l\nu^{(1,0)}$, $\nu l^{(1,0)}$	$l\nu$
$Z^{(1,0)}$	20	$ll^{(1,0)}$	ll
$l^{(1,0)}$	< 5	$lA^{(1,0)}$	l
$A^{(1,0)}$	0	-	



Phenomenology @ LHC : Decays of Heavier tiers

- Tiers (1,1) @ √2/R & Tiers (2,0)-(0,2) @ 2/R

via localized kinetic terms

via loops (& kinetic terms)

Mainly resonant decays into SM particles & no Missing E_T

Phenomenology @ LHC : Decays of Heavier tiers

- Tiers (1,1) @ $\sqrt{2}/R$ & Tiers (2,0)-(0,2) @ $2/R$

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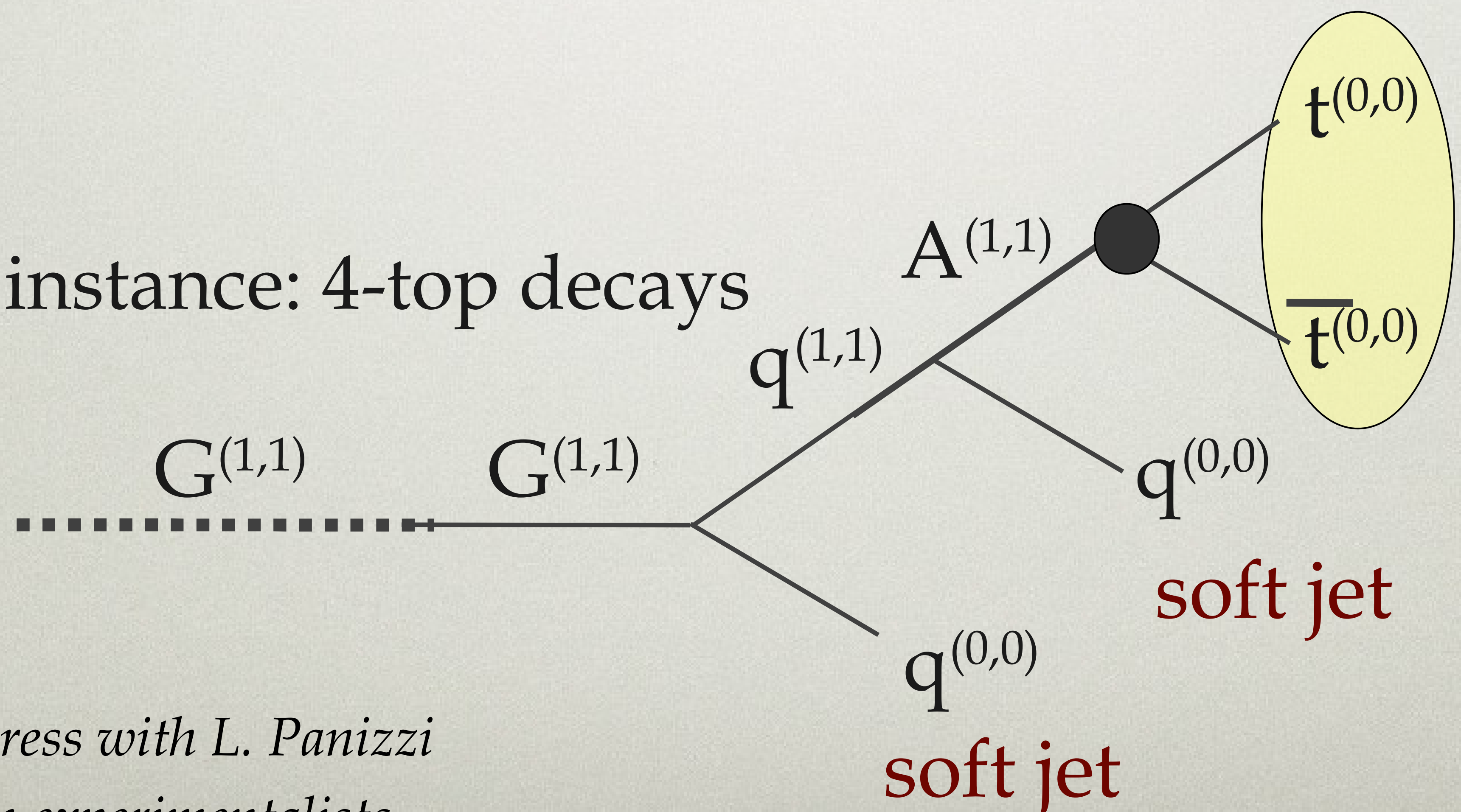
via loops (& kinetic terms)

Mainly resonant decays into SM particles & no Missing E_T

- For instance: 4-top decays



Work in progress with L. Panizzi & CMS Lyon experimentalists.

Phenomenology @ LHC : Decays of Heavier tiers

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via localized kinetic terms

via loops (& kinetic terms)

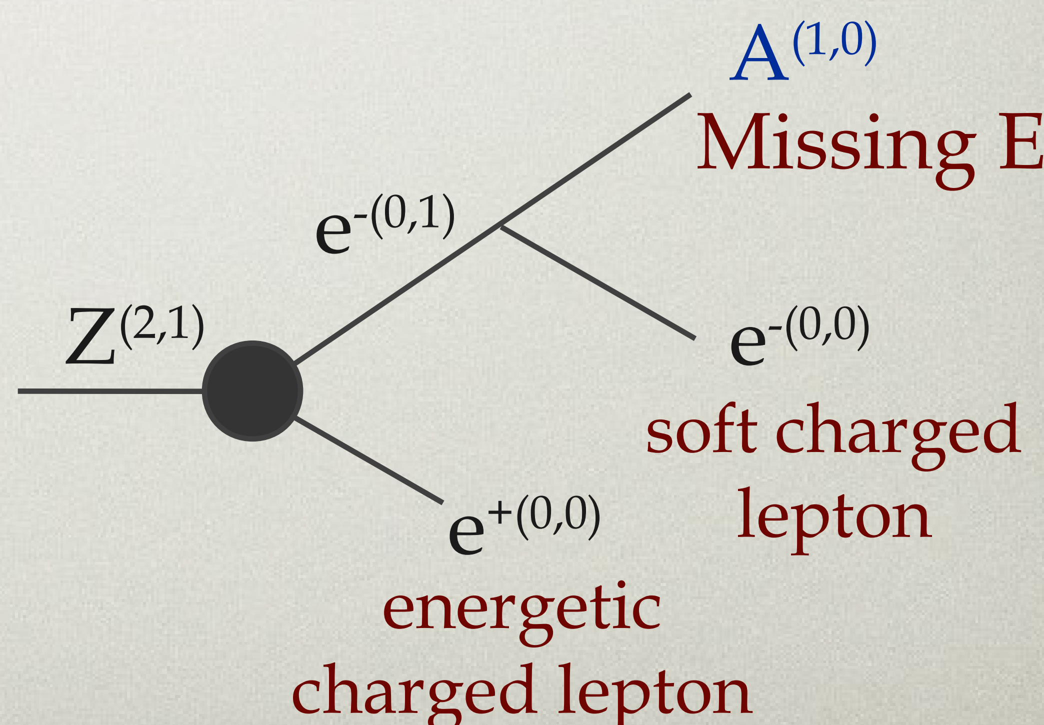
Mainly resonant decays into SM particles & no Missing E_T

- Tiers (2,1) @ √5/R

via loops (& kinetic terms)

→ Can decay into SM particles & Missing E_T

→ Rare but clear signature



Conclusion

- ✓ **KK-Parity is build-in in this 6D space:**
  - **from topology and Lorentz invariance**
  - **without imposing new extra-parity**
- ✓ Good predictability : not so many localized interactions
- ✓ Low mass range for KK-states *(Preliminary study)*
- ✓ Possible extensions: Gauge-Higgs Unification, warped space,...
- ❖ EWPT have to be checked
- ❖ Relic density including EWSB effects, resonant effects,... *(In collaboration with A. Arbey)*
- ❖ Implementation in FeynRules for using generator of events → LHC predictions *(Started in Calchep by Bogna Kubik)*

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✓ Possible extensions: Gauge-Higgs Unification, warped space,...

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THE END

5D Limit Of This Model

$R_6 \longrightarrow 0$

Levels	Mass	$P_{KK}=(-1)^{k+1}$	Gauge Vectors (A^μ, Z^μ, W^μ, G^μ)	Gauge Scalars (A^5, A^6,...)	Fermions	Higgs
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(1,0) & ~~(0,1)~~	1/R	-	**NO**	YES	YES (Dirac)	**NO**
~~(1,1)~~	~~√2/R~~	~~+~~	~~YES~~	~~YES~~	~~YES (Dirac) x 2~~	~~YES~~
(2,0) & ~~(0,2)~~	2/R	+	YES	**NO**	YES (Dirac)	YES
~~(2,1) &(1,2)~~	~~√5/R~~	~~-~~	~~YES~~	~~YES~~	~~YES (Dirac) x 2~~	~~YES~~

5D Limit Of This Model

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Levels	Mass	$P_{KK}=(-1)^{k+1}$	Gauge Vectors (A^μ, Z^μ, W^μ, G^μ)	Gauge Scalars (A^5, A^6,...)	Fermions	Higgs
(0,0)	0	+	YES	**NO**	YES (Chiral)	YES
(1,0)	1/R	-	**NO**	**YES (Only A^6, Z^6,...)**	YES (Dirac)	**NO**
(2,0)	2/R	+	YES	**NO**	YES (Dirac)	YES

Not a usual 5D UED Model limit

$\longrightarrow$ Topological Consequences

Last Possibility: The Real Projective Plane

- Definition: $R^2/\mathbf{pgg}$ where **pgg** $=\{r,g \mid r^2=(g^2r)^2=\mathbf{1}\}$

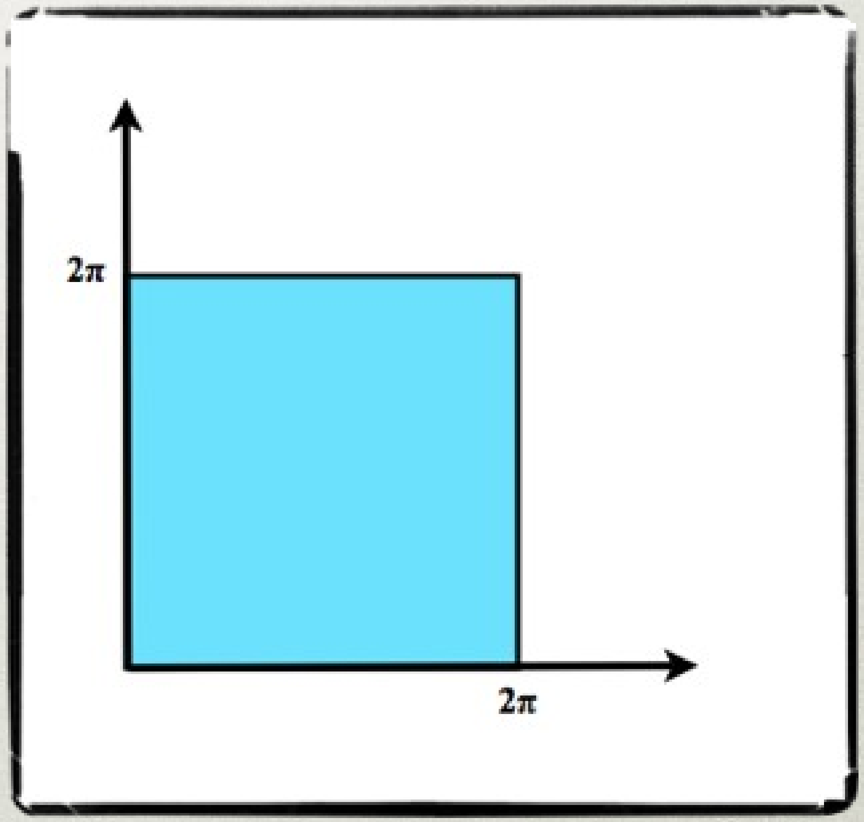
$$r \quad : \quad \begin{cases} x_5 \sim -x_5 \\ x_6 \sim -x_6 \end{cases},$$

$$g \quad : \quad \begin{cases} x_5 \sim x_5 + \pi R_5 \\ x_6 \sim -x_6 + \pi R_6 \end{cases}.$$

$$\Downarrow$$

$$t_5 = g^2 \quad : \quad \begin{cases} x_5 \sim x_5 + 2\pi R_5 \\ x_6 \sim x_6 \end{cases},$$

$$t_6 = (rg)^2 \quad : \quad \begin{cases} x_5 \sim x_5 \\ x_6 \sim -x_6 + 2\pi R_6 \end{cases}.$$



Fondamental domain
Step 1: The torus

Last Possibility: The Real Projective Plane

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$$\Updownarrow$$

$$g \quad : \quad \begin{cases} x_5 \sim x_5 + \pi R_5 \\ x_6 \sim -x_6 + \pi R_6 \end{cases} ,$$

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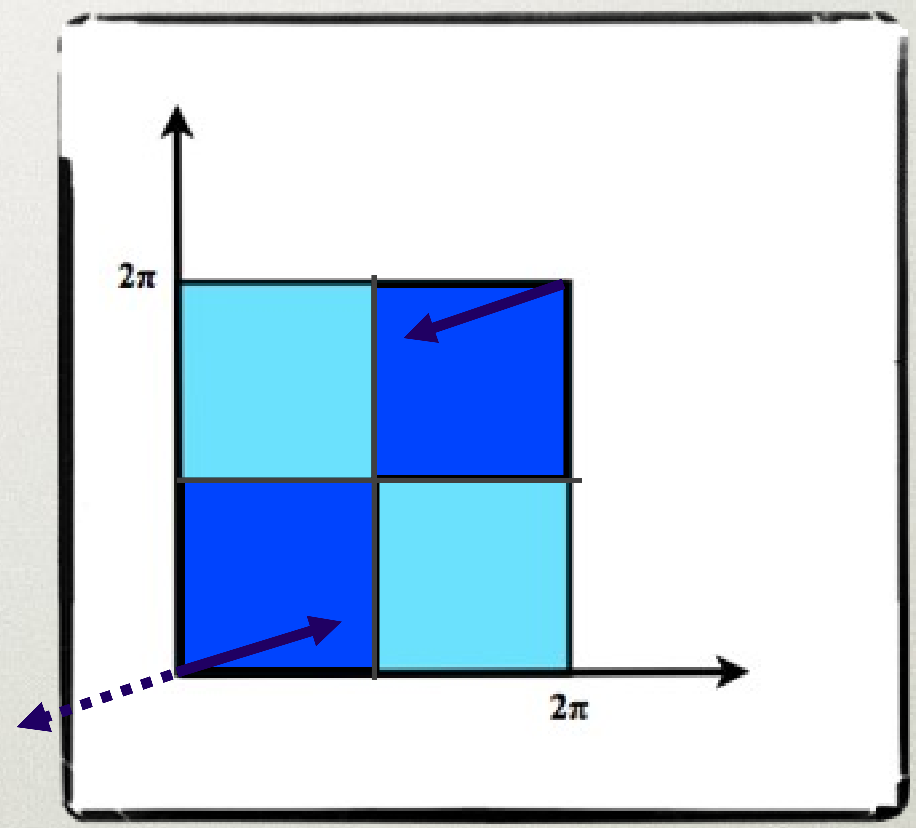


Fundamental domain
Step 2: The rotation

Last Possibility: The Real Projective Plane

- Definition: $\boldsymbol{R^2/\mathrm{pgg}}$ where **pgg** =$\{r,g\,|\,r^2=(g^2r)^2=\mathbf{1}\}$

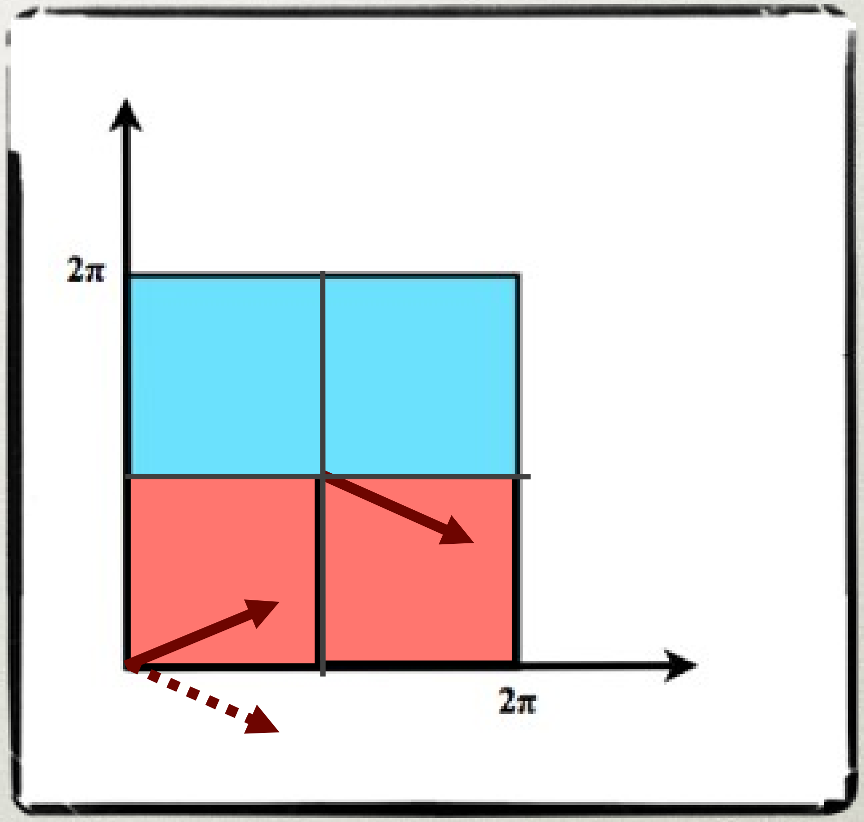
$$r \quad : \quad \begin{cases} x_5 \sim -x_5 \\ x_6 \sim -x_6 \end{cases},$$

$$\boxed{g \quad : \quad \begin{cases} x_5 \sim x_5 + \pi R_5 \\ x_6 \sim -x_6 + \pi R_6 \end{cases}}\,.$$

$$\Updownarrow$$

$$g \quad : \quad \begin{cases} x_5 \sim x_5 + \pi R_5 \\ x_6 \sim -x_6 + \pi R_6 \end{cases},$$

$$g' = gr \quad : \quad \begin{cases} x_5 \sim -x_5 + \pi R_5 \\ x_6 \sim x_6 + \pi R_6 \end{cases}.$$



Fundamental domain
Step 3: The glide

One 6D-Loop Corrections : mixte propagator

- 6D mixed propagator on a torus

$$G_S^{6D}(k, \overrightarrow{y} - \overrightarrow{y}') = \sum_{l=-\infty}^{\infty} G_S^{5D}(\chi_l, x_5 - x'_5)\ f_l^*(x_6) f_l(x'_6)$$

$$f_l(x_6) = \frac{1}{\sqrt{2\pi}} e^{ix_6 l} \quad \text{and} \quad G_S^{5D}(\chi_m, y - y') = \frac{i \cos \chi_m (\pi - |y - y'|)}{2\ \chi_m\ \sin \chi_m \pi} \quad \text{where} \quad \chi_m = \sqrt{k^2 - m^2}$$

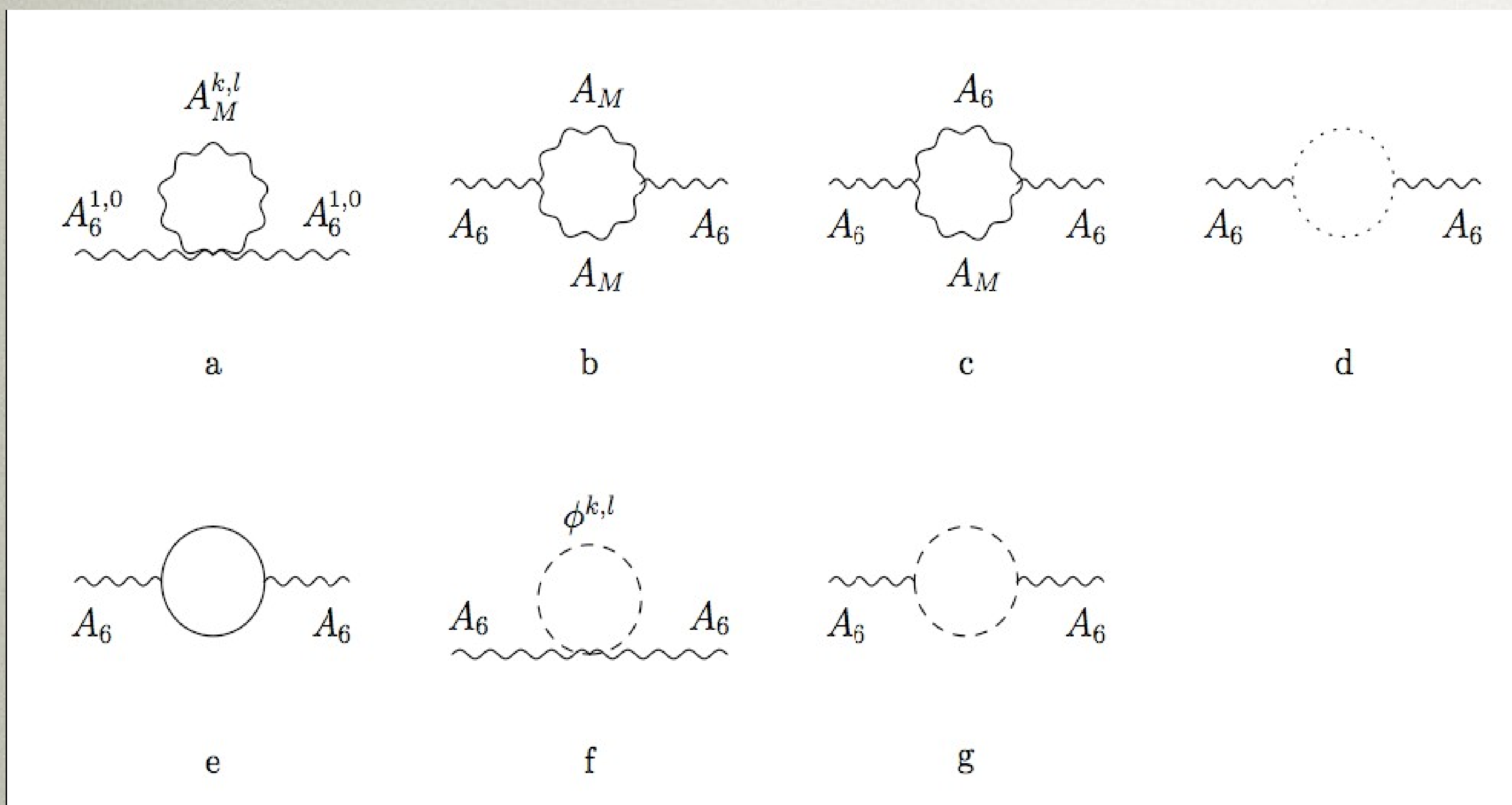
- Propagator in the orbifold

$$G_S^{orb}(p, \overrightarrow{y}, \overrightarrow{y}') = \frac{1}{4} \Big[G_S^{6D}(p, \overrightarrow{y} - \overrightarrow{y}' + \overrightarrow{\Omega}) + p_g\, G_S^{6D}(p, \overrightarrow{y} - g(\overrightarrow{y}') + \overrightarrow{\Omega})$$
$$+ p_r\, G_S^{6D}(p, \overrightarrow{y} - r(\overrightarrow{y}') + \overrightarrow{\Omega}) + p_r\ p_g G_S^{6D}(p, \overrightarrow{y} - r * g(\overrightarrow{y}') + \overrightarrow{\Omega}) \Big]$$

Scalar Tadpole $\longrightarrow$

$$\Pi^{66} = \Pi_T + p_g\ \Pi_G + p_r\ \Pi_R + p_g p_r\ \Pi_{G'}$$

Splittings : One 6D-Loop And EWSB Corrections



$$T_6 = \frac{1}{\pi} \sum_{(k,l) \neq (0,0)} \frac{1}{(k^2+l^2)^2} \sim 1.92$$

$$L = \log\left(\frac{\Lambda^2+n^2}{n^2}\right)$$

$$\frac{1}{4}\frac{g^2 C(r)}{16\pi^4 R^2} \times$$

δm^2 gauge scalars		$\times p_g$	$\times p_g p_r$	$\times p_r$
a	$5T_6$	$5 \cdot 7\zeta(3)$	$3 \cdot (7\zeta(3) + B_1(n))$	$3n^2\pi^2 L$
b	0	0	$-12B_2(n)$	0
c	$-T_6$	$-3 \cdot 7\zeta(3)$	$-(7\zeta(3) + B_3(n))$	$5n^2\pi^2 L$
d	0	0	$-2B_2(n)$	0
e	$-8T_6$	0	0	0
f	T_6	$7\zeta(3)$	$(7\zeta(3) + B_1(n))$	$n^2\pi^2 L$
g	0	0	$-4B_2(n)$	0

Fermions in this Framework

$$
\begin{aligned}
S_\pm &= \int dx_5 \int dx_6\, \frac{i}{2}\Big\{\bar{\Psi}_\pm \Gamma^\alpha \partial_\alpha \Psi_\pm - \left(\partial_\alpha \bar{\Psi}_\pm\right)\Gamma^\alpha \Psi_\pm\Big\} = \\
&= \int dx_5 \int dx_6 \,\Big\{ \; i\bar{\psi}_{L\pm}\gamma^\mu \partial_\mu \psi_{L\pm} + i\bar{\psi}_{R\pm}\gamma^\mu \partial_\mu \psi_{R\pm} + \\
&\qquad + \frac{1}{2}\left[\bar{\psi}_{L\pm}\gamma_5(\partial_5 \mp i\partial_6)\psi_{R\pm} + \bar{\psi}_{R\pm}\gamma_5(\partial_5 \pm i\partial_6)\psi_{L\pm} + h.c.\right]\Big\} \; ;
\end{aligned}
$$

For a left-handed fermion, case $(+\pm)$, the KK modes are given by:

(k,l)	χ_+	χ_-	$\bar{\eta}_+$	$\bar{\eta}_-$
$(0,0)$	$\frac{1}{2\sqrt{2}\pi}$	$\pm\frac{1}{2\sqrt{2}\pi}$	0	0
$(0,l)$	$\frac{1}{2\pi}\cos lx_6$	$\pm(-1)^l\frac{1}{2\pi}\cos lx_6$	$-\frac{i}{2\pi}\sin lx_6$	$\pm(-1)^l\frac{i}{2\pi}\sin lx_6$
$(k,0)$	$\frac{1}{2\pi}\cos kx_5$	$\pm(-1)^k\frac{1}{2\pi}\cos kx_5$	$-\frac{1}{2\pi}\sin kx_5$	$\mp(-1)^k\frac{1}{2\pi}\sin kx_5$

while for both $k, l \neq 0$, there are 2 degenerate solutions for each level which can be parameterized as

$$
\Psi^{(+\pm)} = \begin{pmatrix} (a\cos kx_5\, \cos lx_6 + b\sin kx_5\, \sin lx_6)\, f_l \\ \pm(-1)^{k+l}\,(c\sin kx_5\, \cos lx_6 - d\cos kx_5\, \sin lx_6)\, \bar{f}_r \\ \pm(-1)^{k+l}\,(a\cos kx_5\, \cos lx_6 - b\sin kx_5\, \sin lx_6)\, f_l \\ (c\sin kx_5\, \cos lx_6 + d\cos kx_5\, \sin lx_6)\, \bar{f}_r \end{pmatrix}, \tag{3.16}
$$

where we can use the EOMs and normalization condition to fix the coefficients

$$
\begin{array}{ll} a = \frac{\cos\alpha}{\sqrt{2}\pi} & c = -\frac{k\cos\alpha - il\sin\alpha}{\sqrt{2}\pi\sqrt{k^2+l^2}} \\ b = \frac{\sin\alpha}{\sqrt{2}\pi} & d = \frac{k\sin\alpha - il\cos\alpha}{\sqrt{2}\pi\sqrt{k^2+l^2}} \end{array} \tag{3.17}
$$

Splittings : One 6D-Loop And EWSB Corrections

- Calculation for LLP level
- 6D loop calculations: Mixed propagator method

$$\begin{aligned}
\delta m_B^2 &= \frac{g'^2}{64\pi^4 R^2}\left[-79T_6 + 14\zeta(3) + \pi^2 n^2 L + B_1 - 4B_2\right] , \\
\delta m_W^2 &= \frac{g^2}{64\pi^4 R^2}\left[-39T_6 + 70\zeta(3) + 17\pi^2 n^2 L + 7B_1 - 32B_2 - 2B_3\right] , \\
\delta m_G^2 &= \frac{g_s{}^2}{64\pi^4 R^2}\left[-36T_6 + 84\zeta(3) + 24\pi^2 n^2 L + 9B_1 - 42B_2 - 3B_3\right] .
\end{aligned}$$

- EWSB: Higgs VEV

$$\begin{pmatrix} W_n^3 & B_n \end{pmatrix} \cdot \begin{pmatrix} \delta m_W^2 + m_W^2 & -\tan\theta_W m_W^2 \\ -\tan\theta_W m_W^2 & \delta m_B^2 + \tan^2\theta_W m_W^2 \end{pmatrix} \cdot \begin{pmatrix} W_n^3 \\ B_n \end{pmatrix} .$$

$$\longrightarrow \boxed{\begin{aligned}
m_{A_n,Z_n}^2 &= \frac{n^2}{R^2} + \frac{1}{2}\Big(m_Z^2 + \delta m_B^2 + \delta m_W^2 \\
&\mp \sqrt{(m_Z^2 + \delta m_B^2 - \delta m_W^2)^2 - 4m_W^2(\delta m_B^2 - \delta m_W^2)}\Big) \\
m_{W^+}^2 &= \frac{n^2}{R^2} + \delta m_W^2 + m_W^2 ;
\end{aligned}}$$

Splittings : Heavy Top mass Corrections

- 6D loop calculations: Mixed propagator method

$$\begin{aligned} S_{\text{Yukawa}} &= -\int dx_5 dx_6\, Y_6\, \bar{\Psi}_Q H \Psi_U + h.c. = \\ &= -\int dx_5 dx_6\, Y_6 \left[\eta_{Q+} H \chi_{U-} + \eta_{Q-} H \chi_{U+} + \bar{\chi}_{Q+} H \bar{\eta}_{U-} + \bar{\chi}_{Q-} H \bar{\eta}_{U+}\right] + h.c. \end{aligned}$$

$$\mathcal{L}_{\text{Yukawa(k,l)}} = -(-1)^{k+l} m_{\text{top}} \left(\bar{q}_l^{(k,l)} u_r^{(k,l)} - \bar{q}_r^{(k,l)} u_l^{(k,l)} \right) + h.c.\,.$$

- EWSB: Higgs VEV

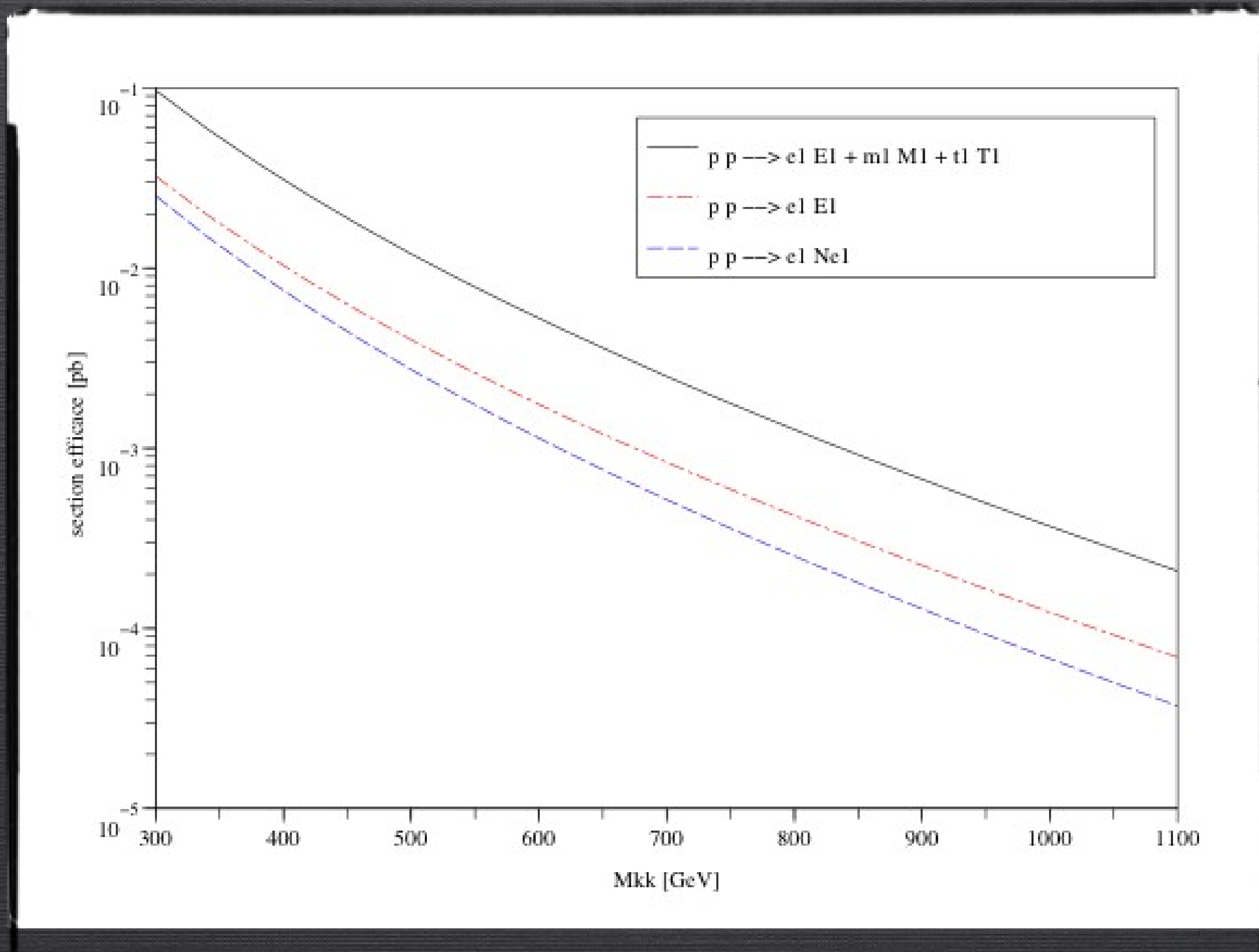
$$\mathcal{L}_{\text{mass}} = -\begin{pmatrix} \bar{q}_l & \bar{u}_l \end{pmatrix} \cdot \begin{pmatrix} \frac{1}{R} + \delta m_Q & -m_{\text{top}} \\ m_{\text{top}} & \frac{1}{R} + \delta m_U \end{pmatrix} \cdot \begin{pmatrix} q_r \\ u_r \end{pmatrix} + h.c.\,.$$

$$m_{t1/2}^2 = \frac{1}{R^2} + m_{\text{top}}^2 + \delta m_Q \left(\frac{1}{R} + \frac{1}{2}\delta m_Q \pm B \right) + \delta m_U \left(\frac{1}{R} + \frac{1}{2}\delta m_U \mp B \right),$$

with

$$B = \sqrt{\left(\frac{1}{R} + \frac{\delta m_Q + \delta m_U}{2} \right)^2 + m_{\text{top}}^2}\,.$$

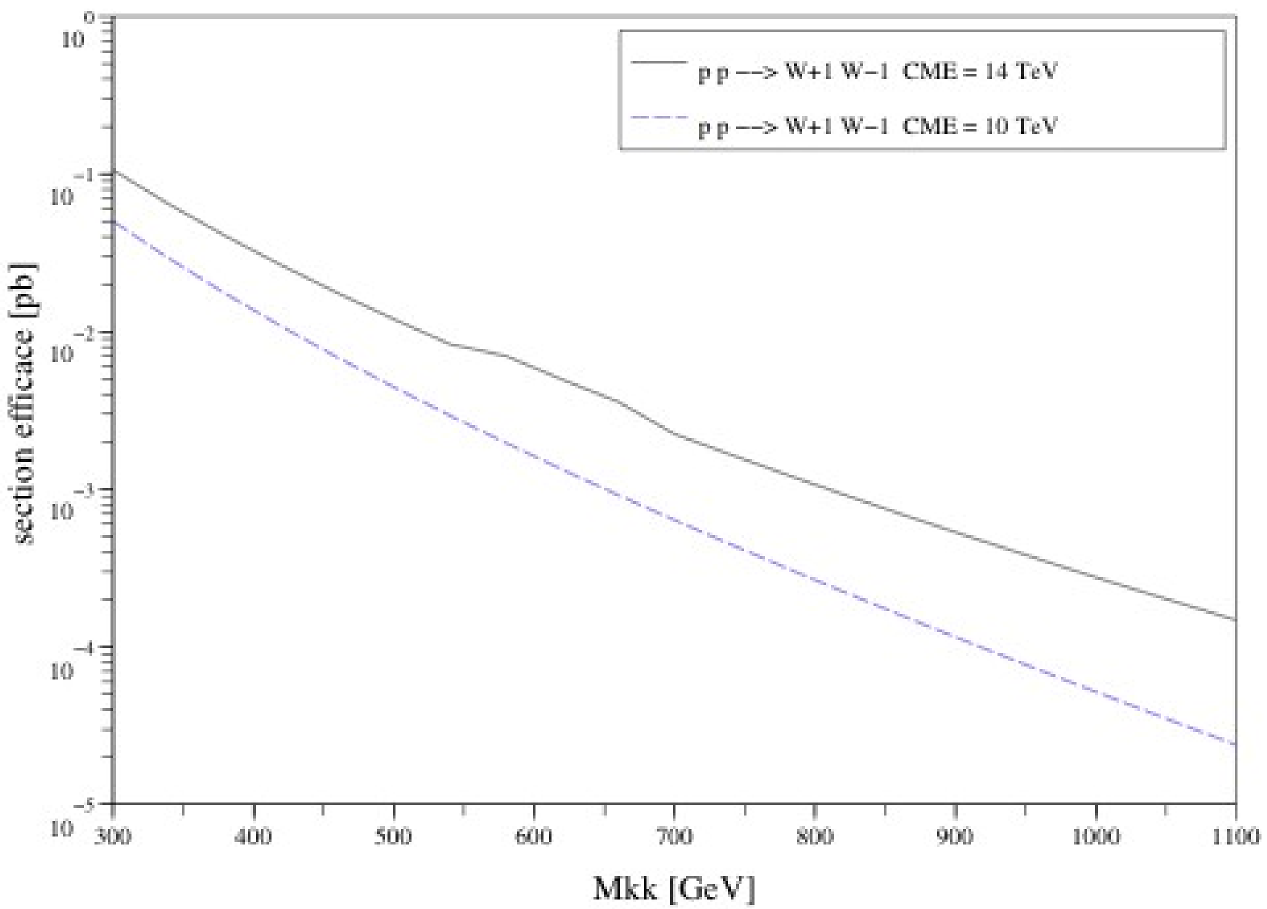
Phenomenology @ LHC : Production

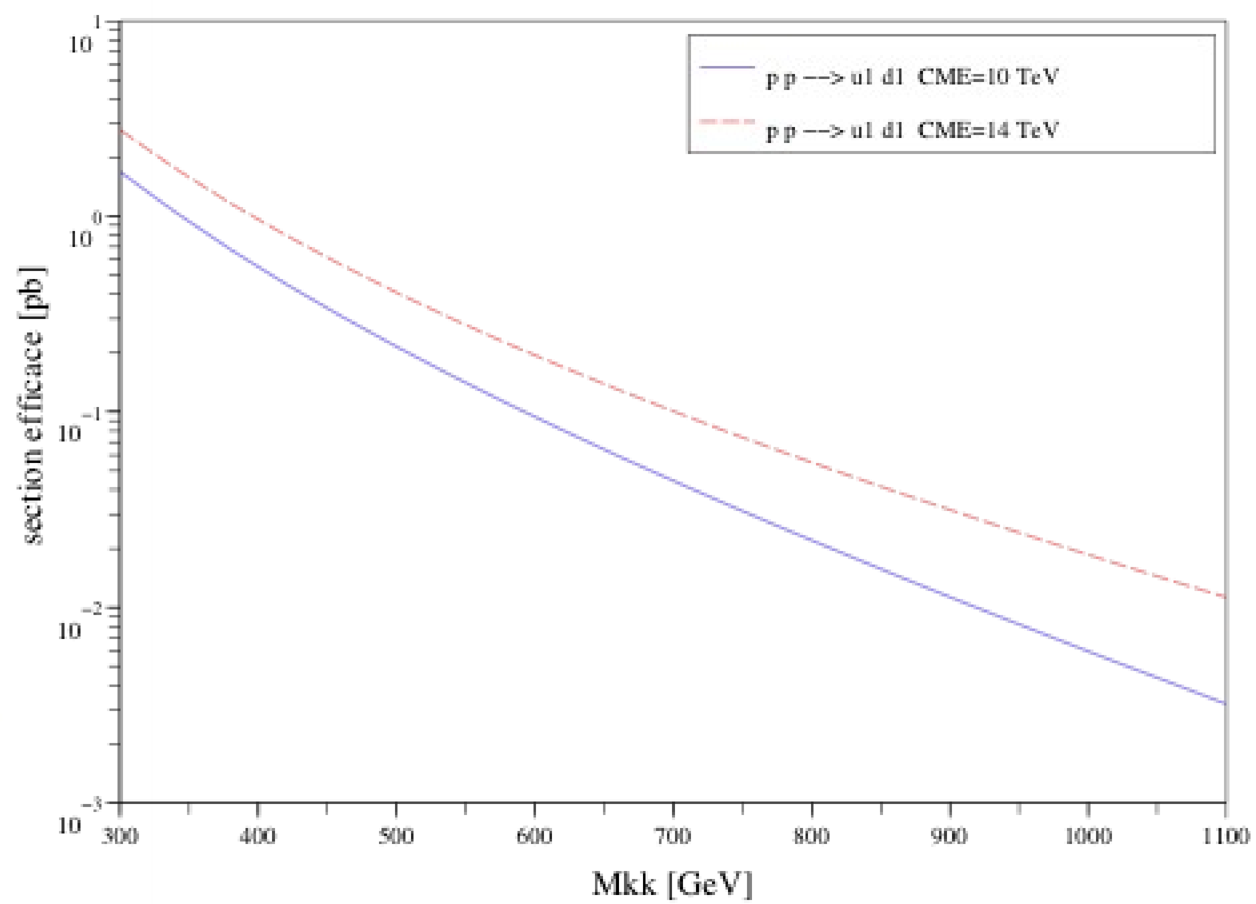


Preliminary
thanks to Bogna Kubik

Phenomenology @ LHC : Production

- Production cross sections of the lightest tier for $1/R \sim 300 \div 400$ GeV: $10\ \text{fb} < \sigma_{prod} < 1\ \text{pb}$





Preliminary plots

Thanks to Bogna Kubik

Phenomenology @ LHC : Decays of lightest tier

- Small splittings ⟶ Detection of the lightest tier will not be easy

	$m_X - m_{LLP}$ in GeV	decay mode	final state + MET
$t^{(1,0)}$	70	$bW^{(1,0)}$	bjj $bl\nu$
$G^{(1,0)}$	40-70	$qq^{(1,0)}$	jj
$q^{(1,0)}$	20-40	$qA^{(1,0)}$	j
$W^{(1,0)}$	20	$l\nu^{(1,0)}$, $\nu l^{(1,0)}$	$l\nu$
$Z^{(1,0)}$	20	$ll^{(1,0)}$	ll
$l^{(1,0)}$	< 5	$lA^{(1,0)}$	l
$A^{(1,0)}$	0	-