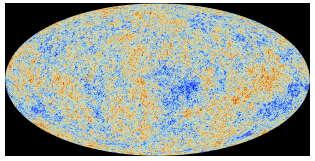
Mathias Garny (CERN)

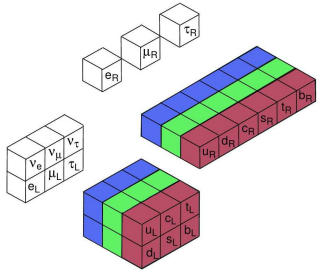
Les Houches, 07.11.14

Particle Physics and Cosmology

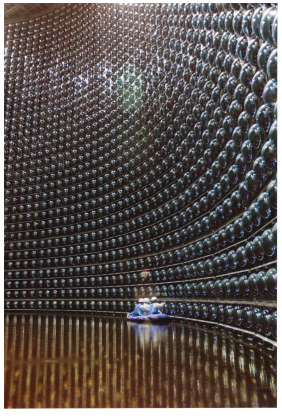
Collider exp.

Baryon asymmetry





$+ \; ?$



Neutrino exp.

Dark Matter

My main interests

- BSM vs Dark Matter
  - Indirect detection: Fermi/HESS/CTA; PAMELA/AMS
  - Interplay with direct detection, collider

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  - Add RH neutrinos, seesaw $m_\nu \sim v_{EW}^2 / M_{\nu_R}$
  - RH neutrinos can be produced in Early Universe, and their decay can produce cosmological matter/antimatter asymmetry (leptogenesis) *Fukugita, Yanagida 86*
  - Systematic approach via CTP to check/refine classical treatment and access regimes where it breaks down: flavor effects, resonant enhancement, RIS-subtraction, ...

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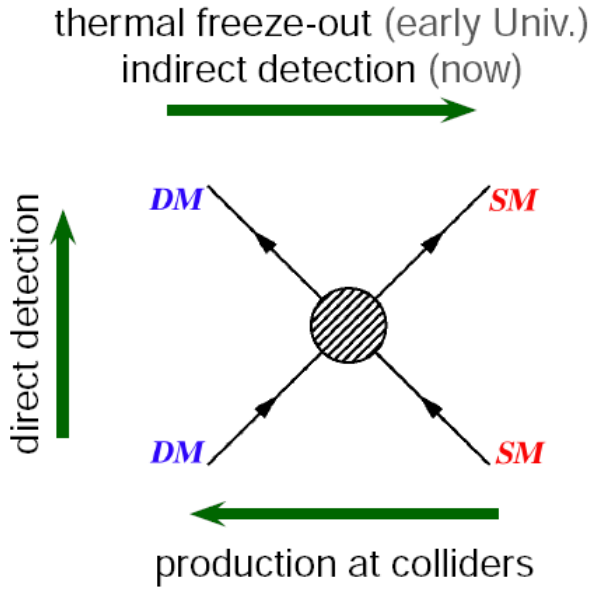
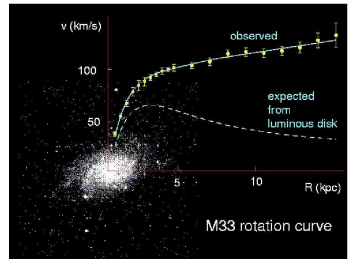
- Massive neutrinos vs Late Universe
  - Impact of CνB on structure formation/CMB
  - Determine mass scale $\sum m_\nu$ (e.g. with Euclid @ $2-5\sigma$)

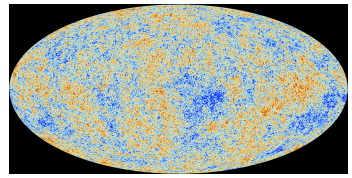
'The decade of the WIMP'

$$\Omega_\chi h^2 = 0.1199 \pm 0.0027 \simeq 0.1\,\text{pb} \cdot c\,/\langle\sigma v\rangle$$

Planck XVI 1303.5076







NB: other well-motivated possibilities: axions, ...

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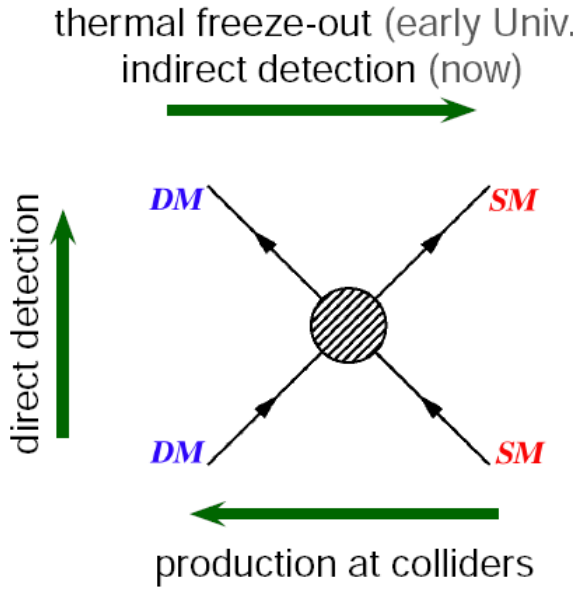
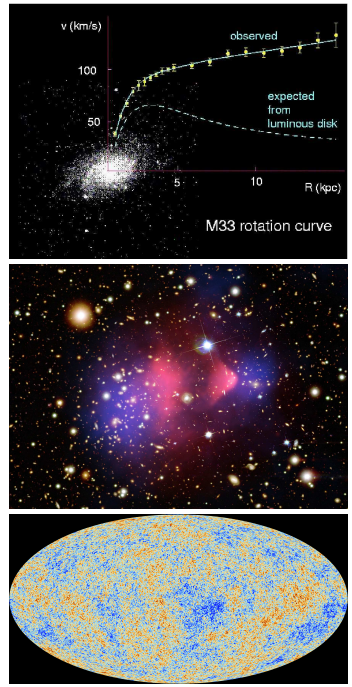
Fermi, H.E.S.S., AMS02, . . . , CTA, GAMMA-400

e.g. 1305.5597 1310.0828, 1410.2242; 1301.1173

XENON100 *1207.5988*
LUX *1310.8214*
. . .
XENON1T
LZ





LHC7+8, LHC13

e.g. CMS 1402.4770, ATLAS 1405.7875

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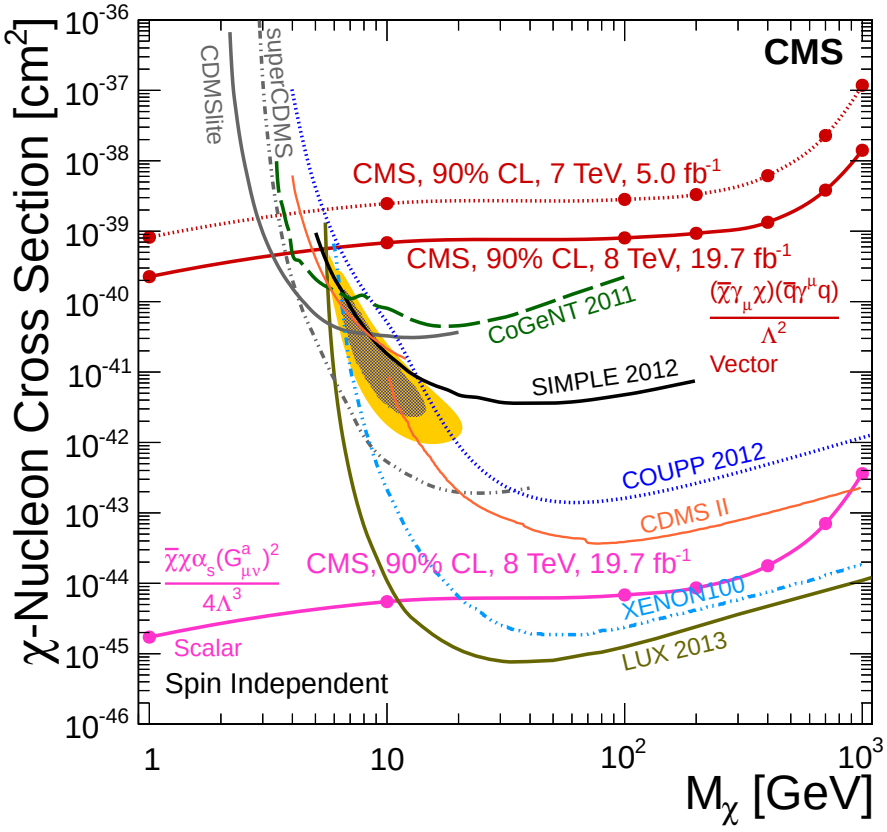
Contact interaction



$$\mathcal{L}_V = \frac{\bar{\chi}\gamma_\mu\chi\,\bar{q}\gamma^\mu q}{\Lambda^2}$$

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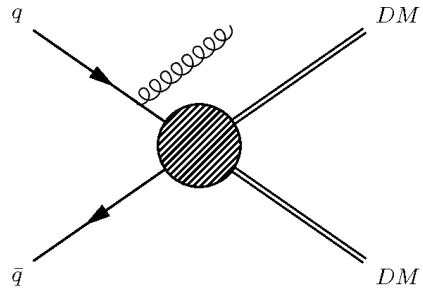

CMS 1408.3583

cf. also Goodman, Ibe, Rajamaran, Sheperd, Tait, Yu 10; Bai, Fox, Harnik 10

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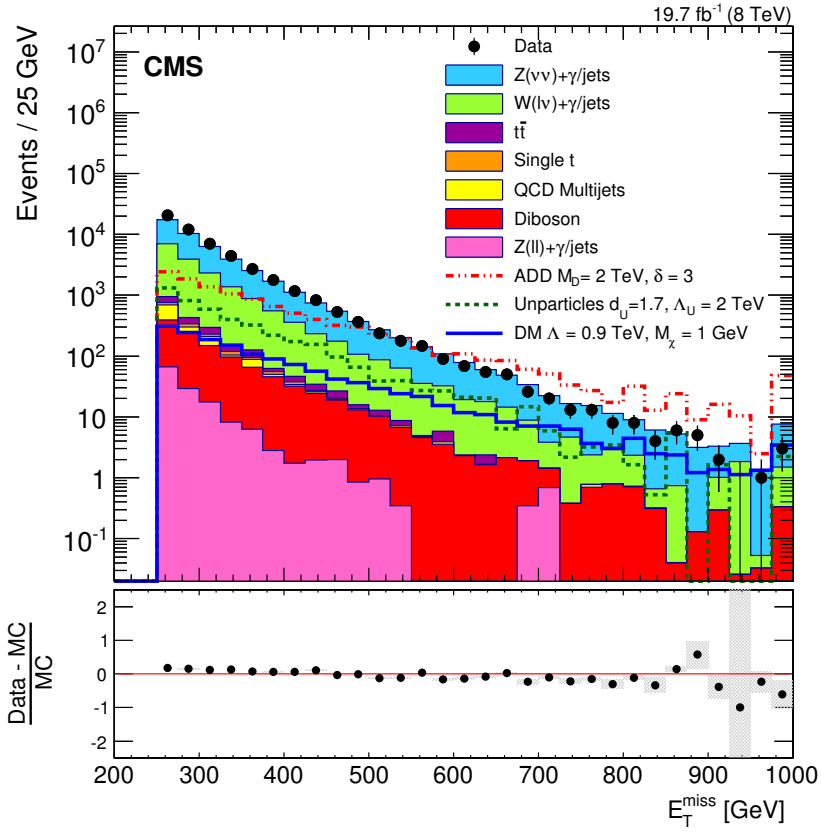

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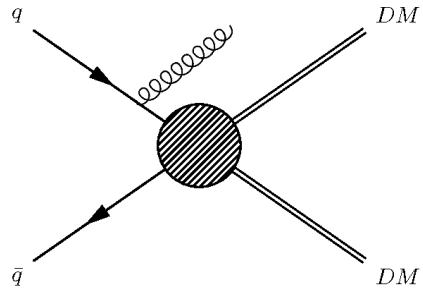

CMS 1408.3583

Validity of contact int. limit?

Momentum transfer $\sim$ TeV, limit on suppression scale $\Lambda \sim$ *TeV*

e.g. Busoni, De Simone, Morgante, Riotto 1402.1275; . . .

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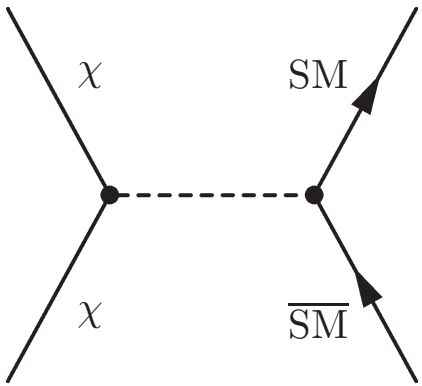
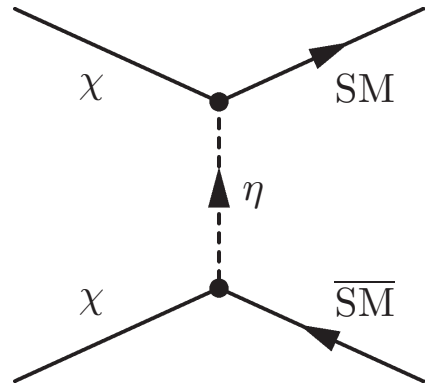
Interplay of ID, DD, LHC

- Bottom-up approach: DM + mediator

s-channel



t-channel



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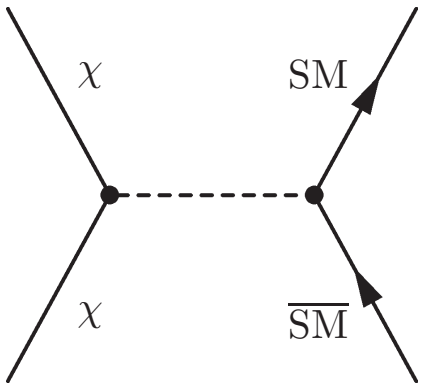

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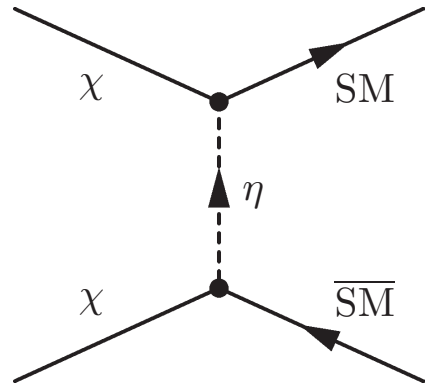
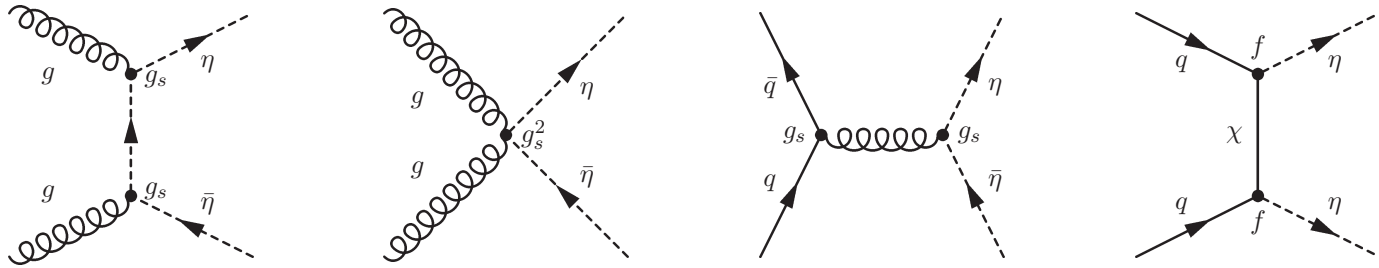


here

When is the mediator important?

- Collider searches (direct production of mediator for $m_\eta \lesssim 2-3$ TeV)



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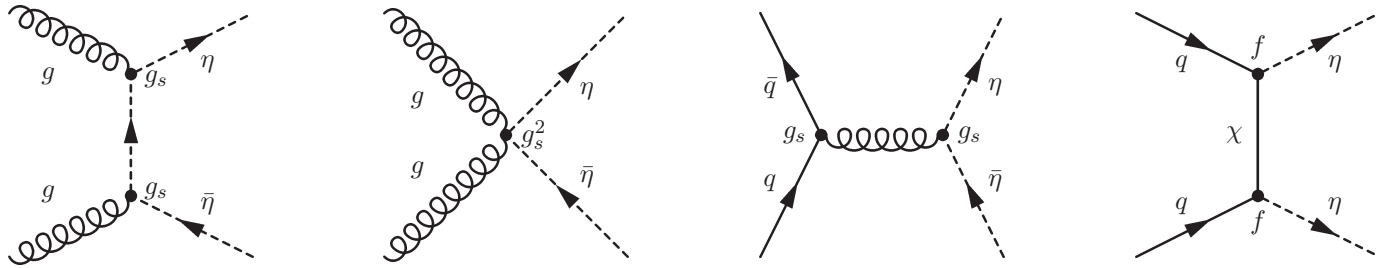

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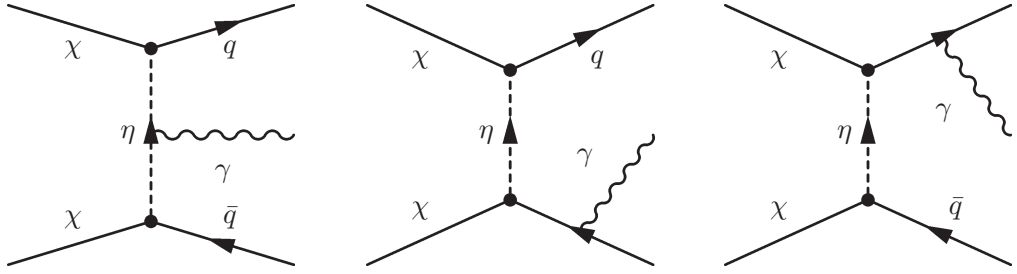

Bergstrom 89; Bergstrom, Bringmann, Edsjo 0710.3169

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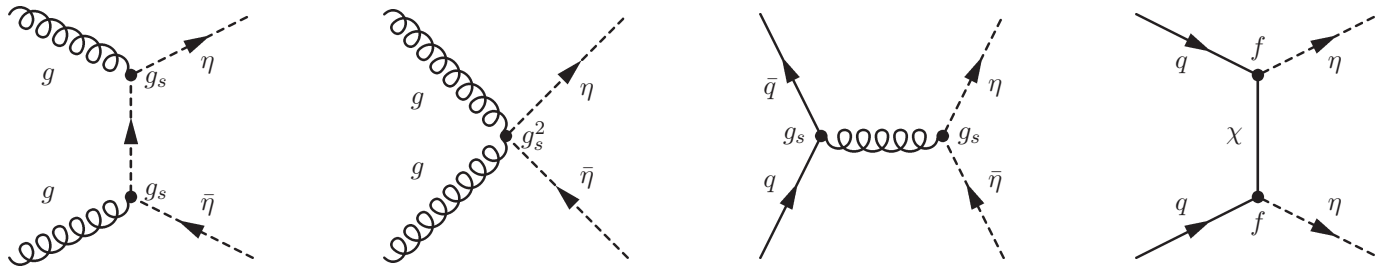

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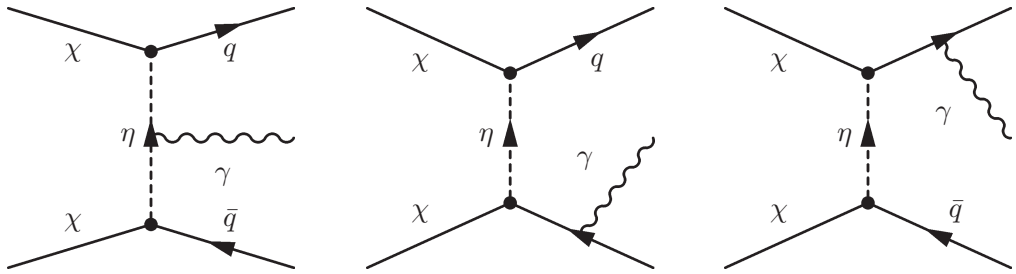

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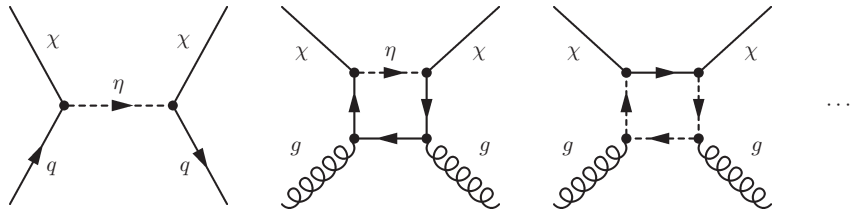
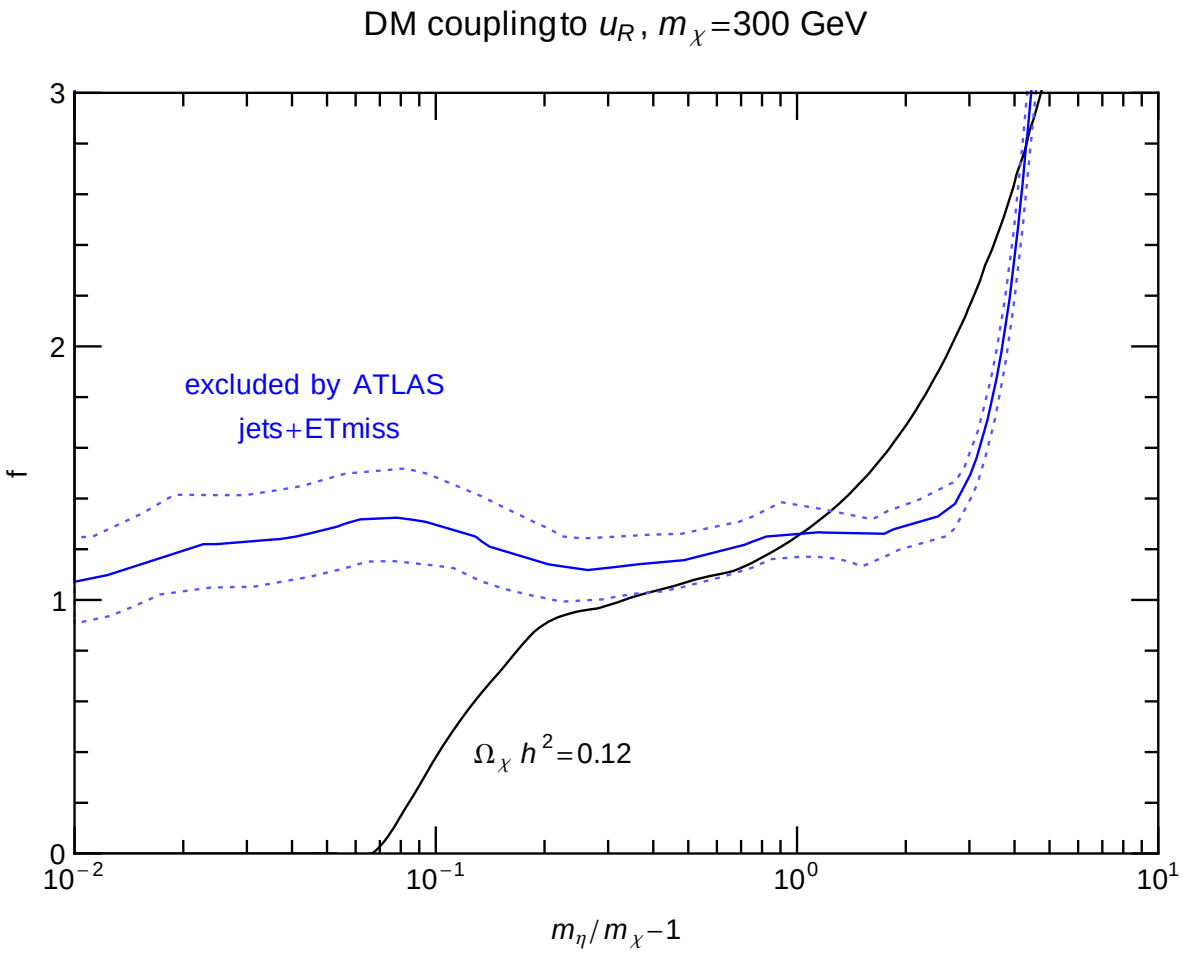
- Direct detection (EFT OK, except resonance for $m_\eta \simeq m_\chi$)



Hisano, Ishiwata, Nagata 1110.3719; Gondolo, Scopel 1307.4481; Drees, Nojiri; ...

Direct production of the mediator $gg, qq \to \eta\eta,\ \eta \to \chi q$

DM-SM-med. coupling strength

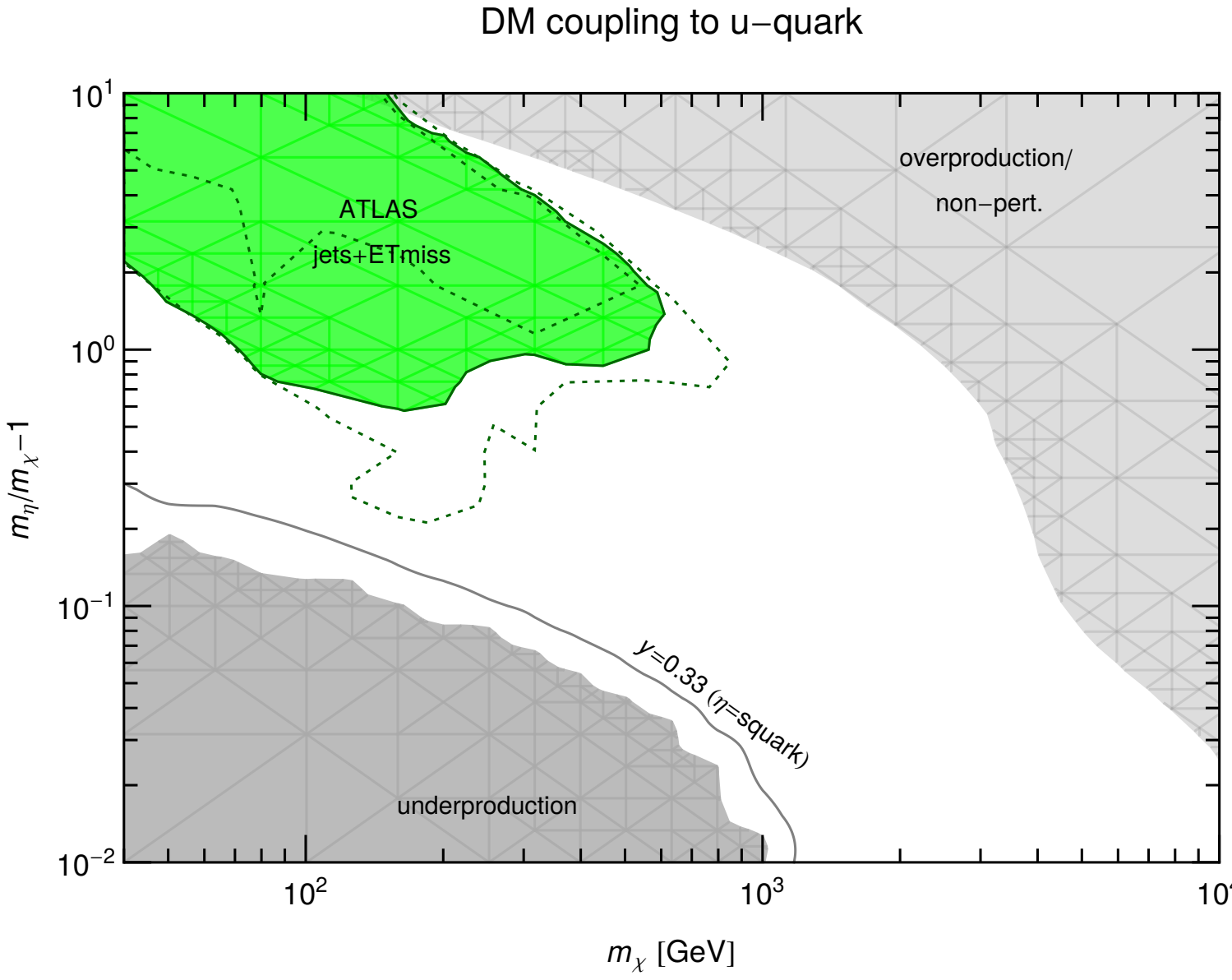


MG, Ibarra, Rydbeck, Vogl 1403.4634; cf. also Papucci, Vichi, Zurek 1402.2285 for Dirac DM

Reinterpretation of ATLAS search for jets + missing energy
$\mathcal{L} = 20.3$ fb^{-1} (signal regions with 2-4jets; matching for two ad. jets)

ATLAS 1405.7875; ATLAS-CONF-2013-047

Complementarity (for thermal production)



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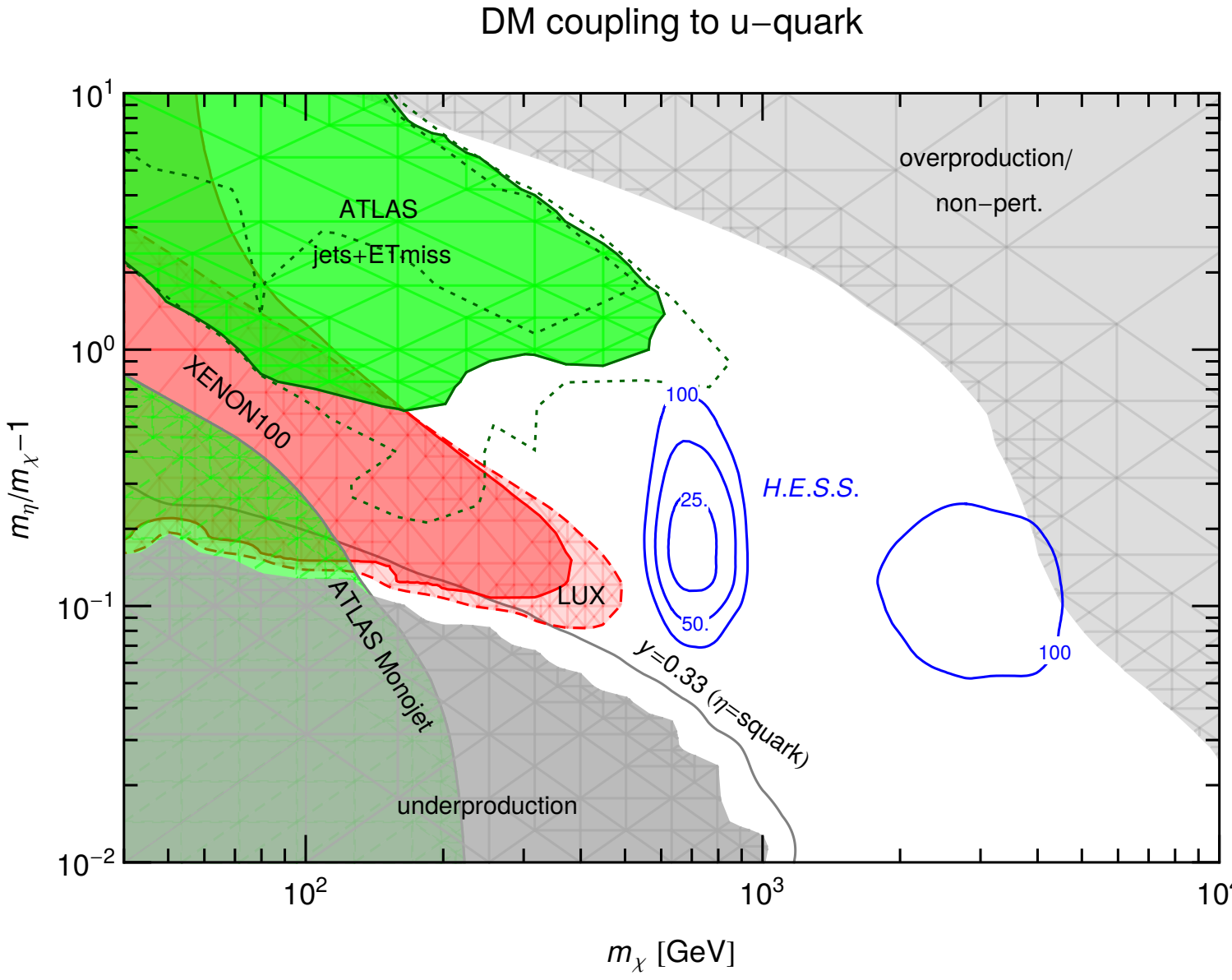

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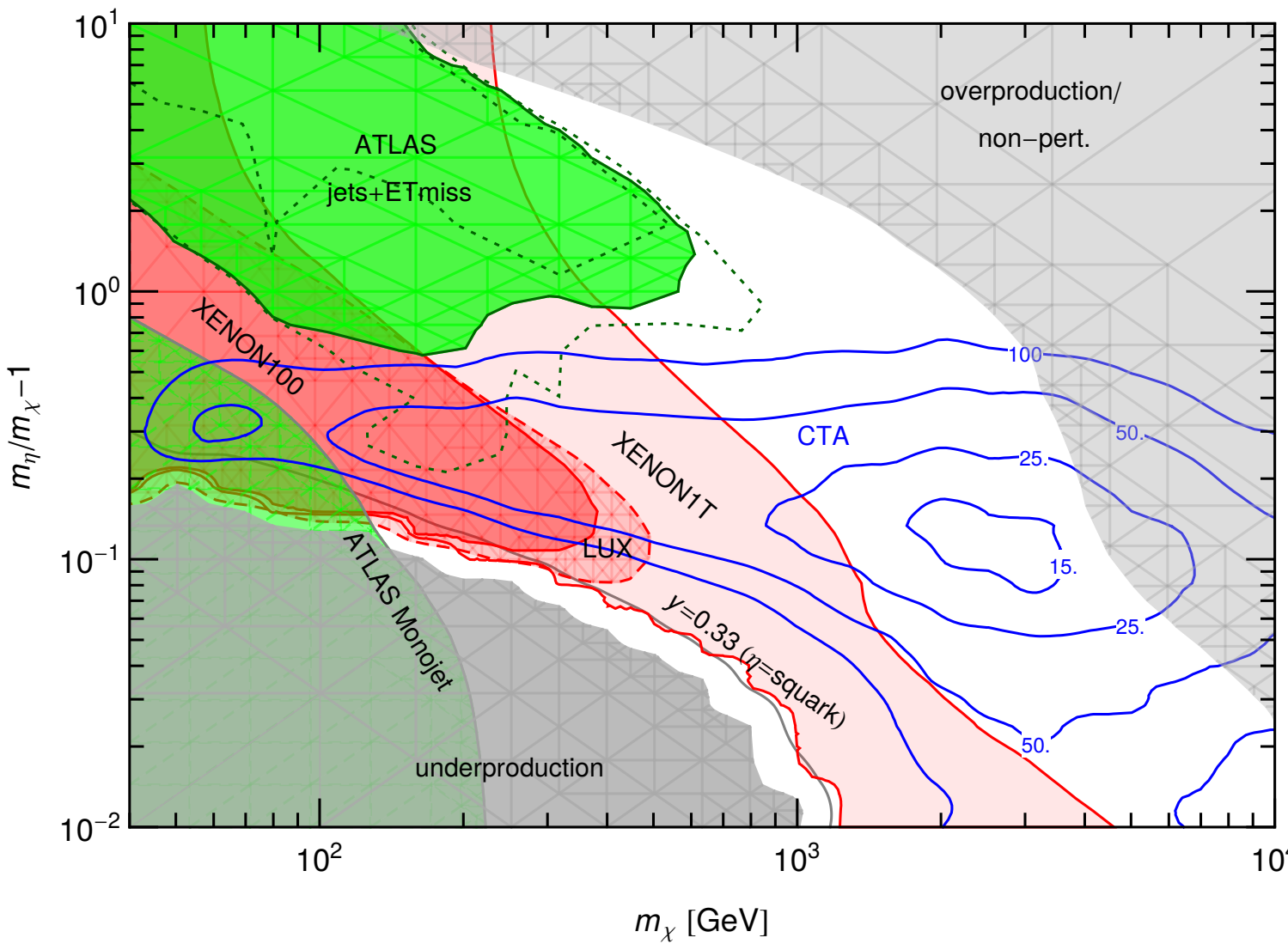
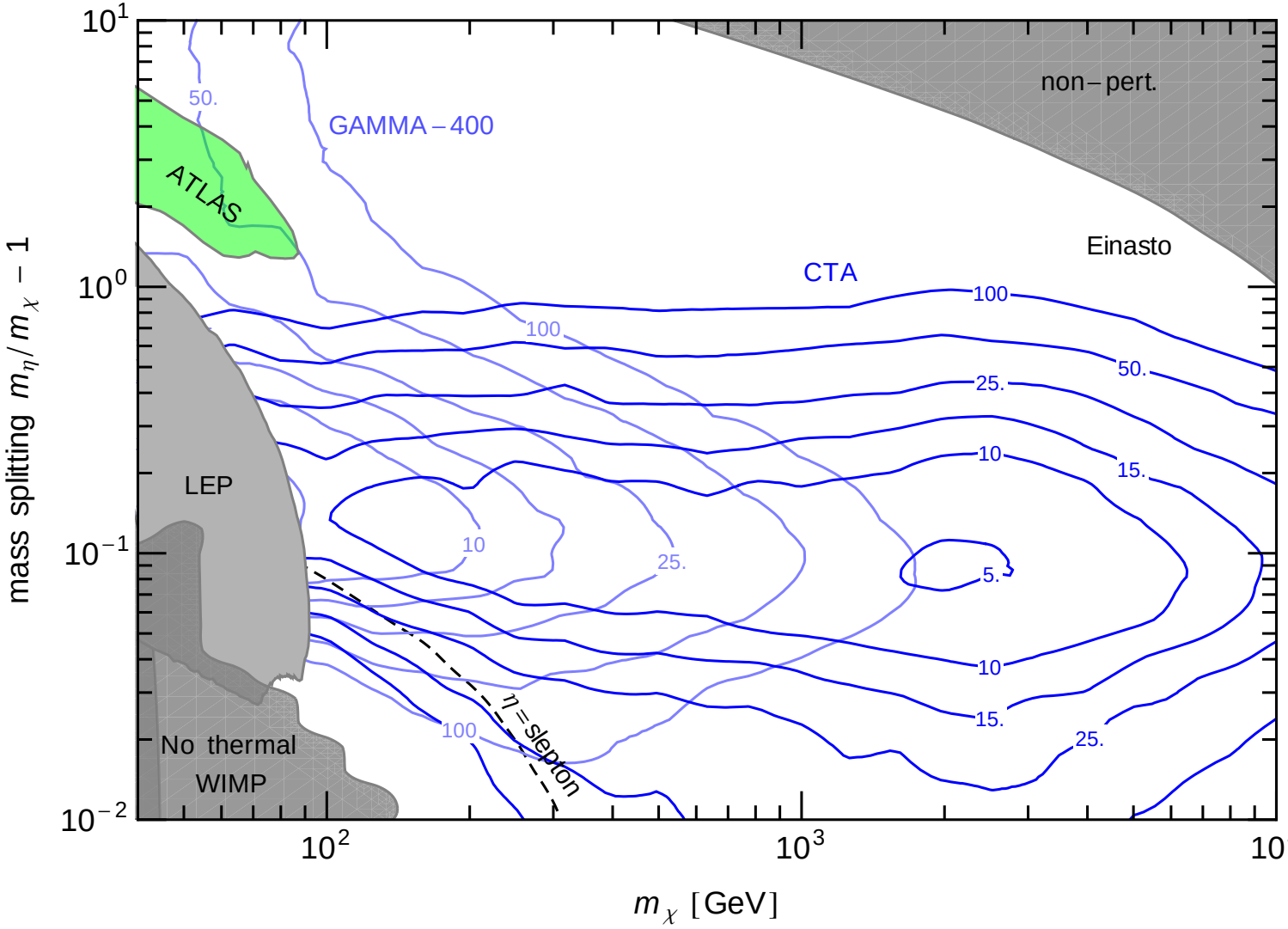


MG, Ibarra, Rydbeck, Vogl 1403.4634

DM coupling to leptons

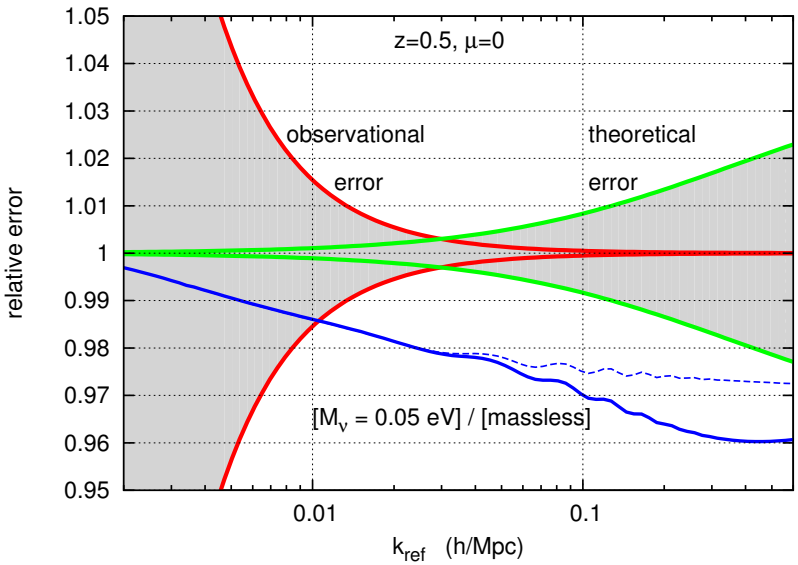


MG, Ibarra, Pato, Vogl 1306.6342

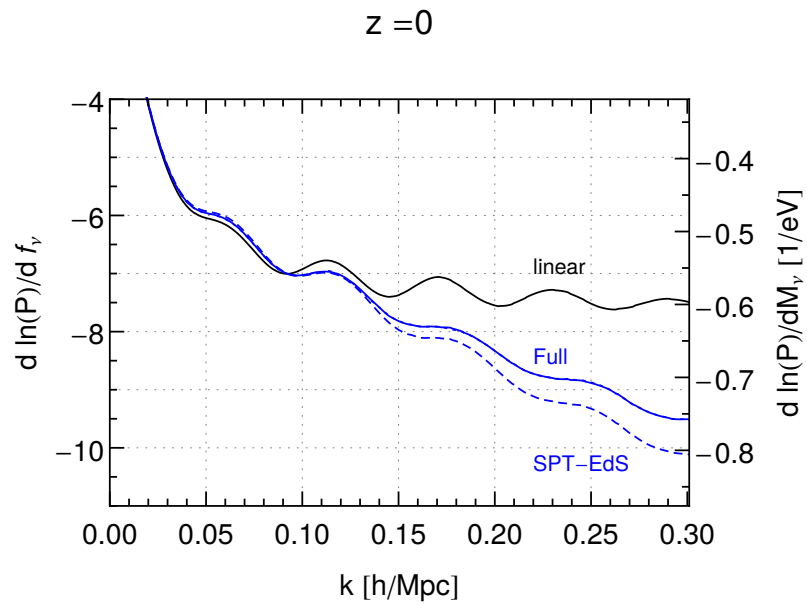
Massive neutrinos vs Late Universe

- Current bound from CMB(+BAO) $\sum m_\nu < 0.23(0.98)\,\mathrm{eV}$
- ν oscillation $\sum m_\nu > 0.05\,\mathrm{eV}$
- Determination with future large-scale structure observations (Euclid) at $2-5\sigma$ depending on control of (mildy) non-linear physics

Power spectrum $P(k)/P_{massless\ \nu}(k)$



Audren, Lesgourgues, Bird et. al. 1210.2194



Blas, MG, Konstandin, Lesgourgues 1408.2995

Sensitivity depends on theory uncertainty at weakly non-linear scales

$$\sigma(M_\nu) \simeq \begin{cases} 25\mathrm{meV} & \text{fiducial (2\%th. err. at } k = 0.4h/Mpc, z = 0.5) \\ 14\mathrm{meV} & \text{th. err. } / = 10, k_{max} = 0.6h/Mpc \end{cases}$$

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  - Interplay indirect, direct detection, collider
  - Implementation of EW int. bremsstrahlung in DarkSUSY
- Massive neutrinos vs Early Universe
  - Systematic approach to leptogenesis via CTP to check classical treatment and access regimes where it breaks down: flavor effects, resonant enhancement, RIS-subtraction, ...
  - Implications for phenomenology (bounds M_{ν_R}, m_ν)
  - Various aspects of nonequilibrium (Q)FT
- Massive neutrinos vs Late Universe
  - Impact of CνB on structure formation/CMB
  - Developments in cosmic PT

find me in 53-1-047