Marco Drewes, Université catholique de Louvain

Neutrino Minimal Standard Model — a unified theory of microscopic and cosmic scales

02. 10. 2020

Snowmass 2021

Rare Processes and Precision Frontier Townhall Meeting

Letter of Interest:
https://www.snowmass21.org/docs/files/summaries/NF/ SNOWMASS21-NF3_NF1-EF9_EF0-RF4_RF6-CF1_CF3-TF11_TF9-AF5_AF0-195.pdf

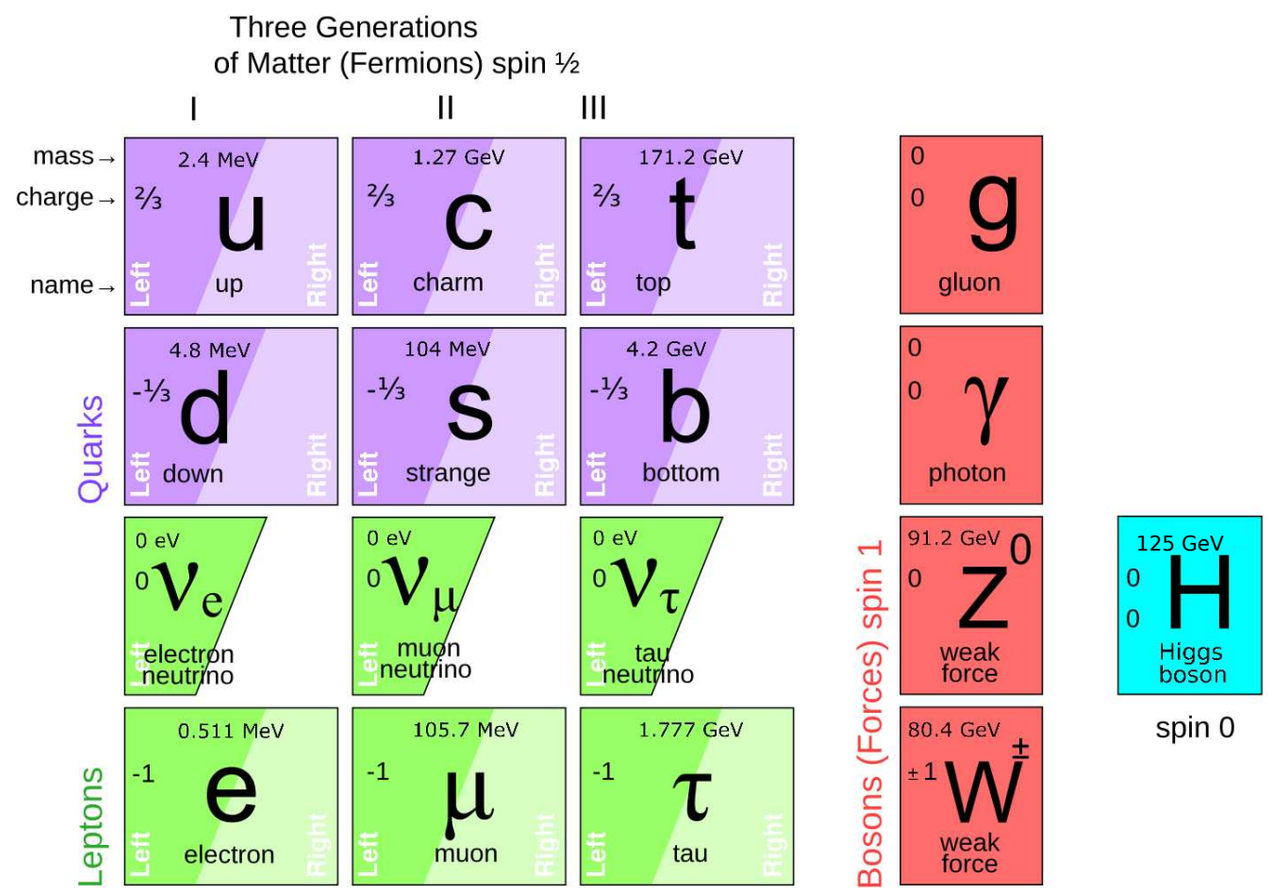
Physics Case

A Minimal Model: The νMSM

Pure Type I seesaw with RH Neutrinos below EW scale

Asaka/Shaposhnikov 0503065, 0505013

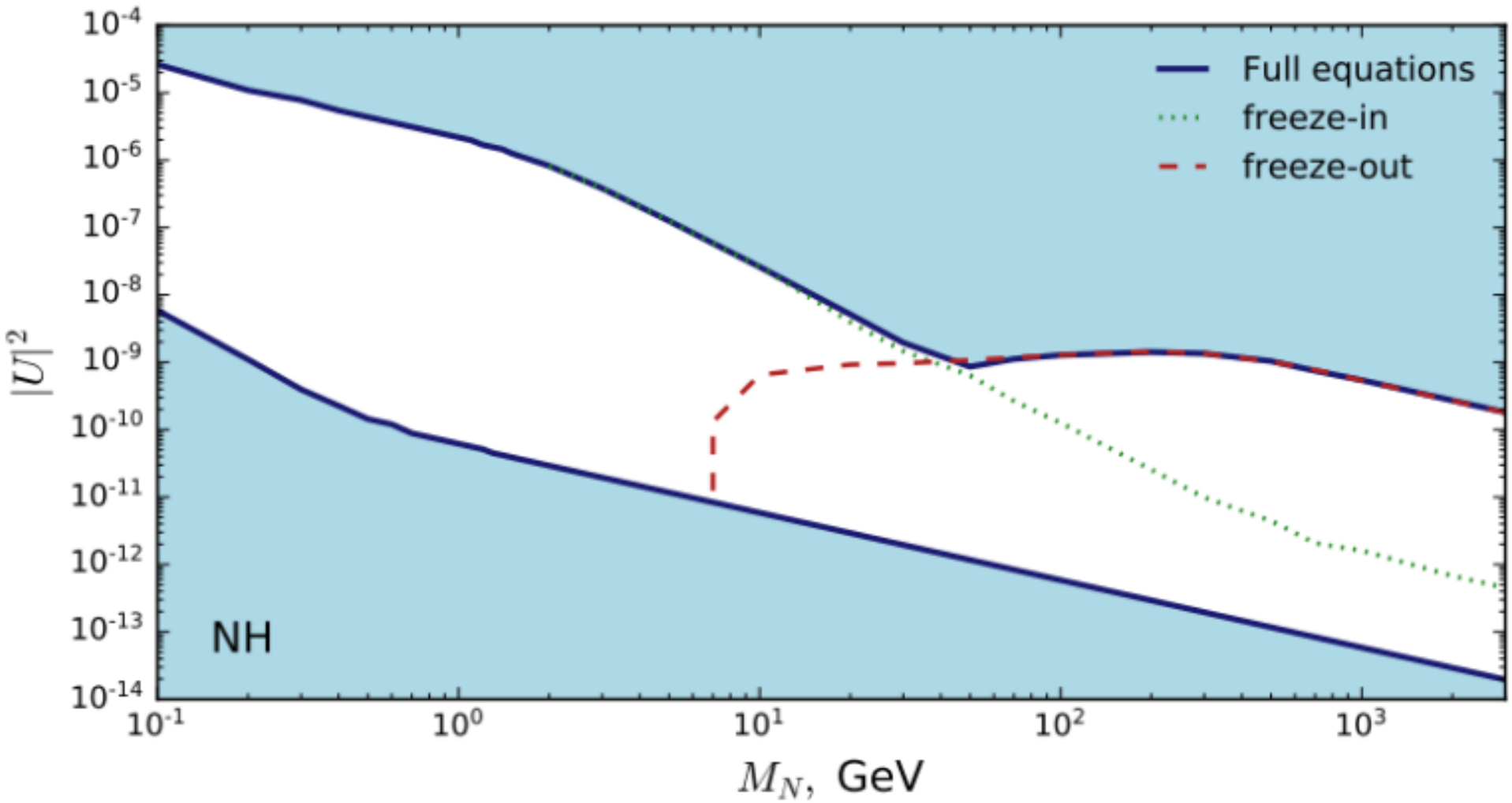
- **two RH Neutrinos have degenerate ~GeV masses**
  seesaw + leptogenesis
- **one has a ~keV mass and feeble couplings**
  Dark Matter candidate



Can be consistent theory up to the Planck scale

Shaposhnikov 0708.3550, Shaposhnikov/Wetterich 0912.0208, Bezrukov et al 1205.2893,

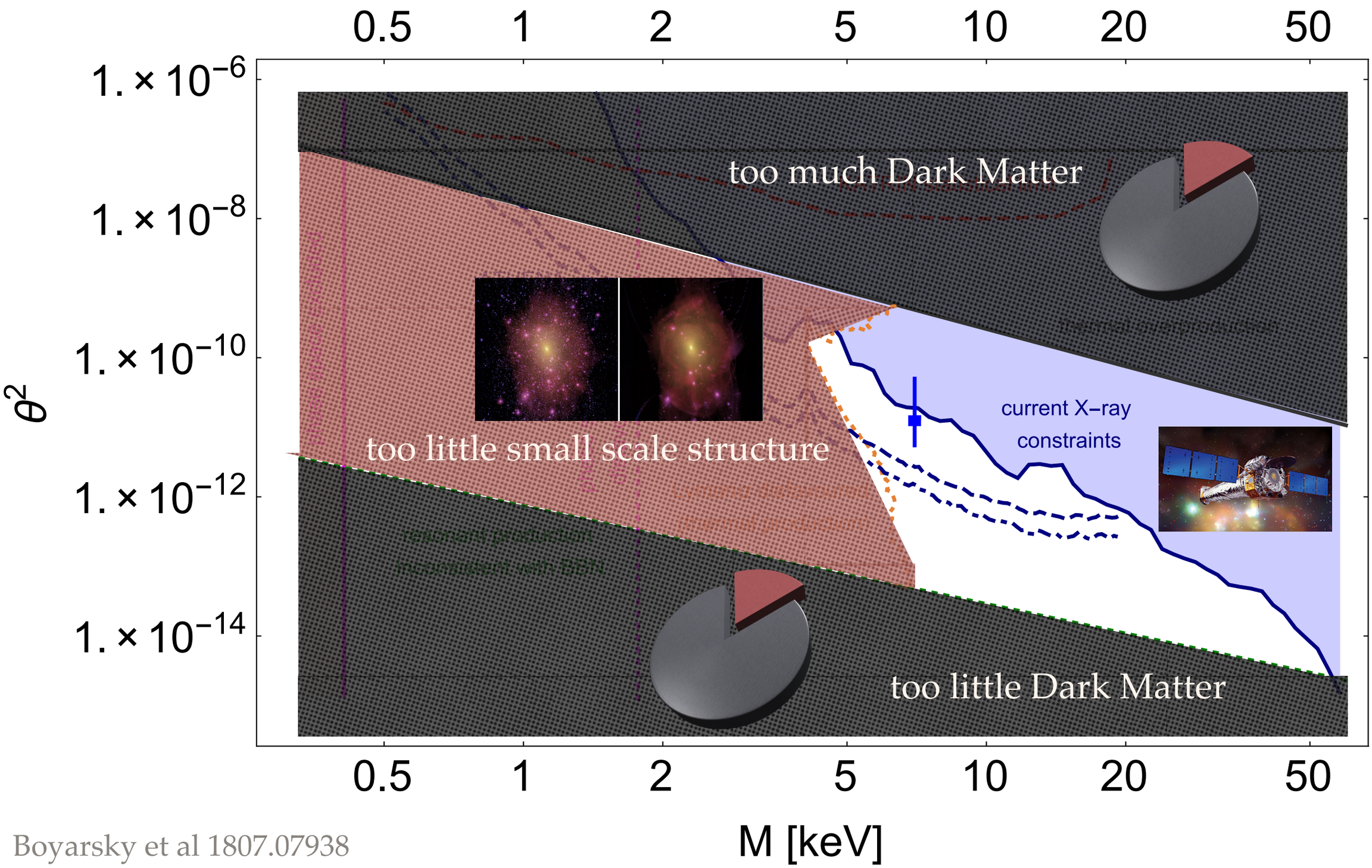
Leptogenesis in the νMSM



2008.13771

- Baryon asymmetry of the universe can be explained in freeze-out scenario ("resonant leptogenesis") and freeze-in scenario ("ARS leptogenesis") Klaric/Shaposhnikov/Timirsyasov 2008.13771
- In less minimal scenarios the leptogenesis parameter space can be much bigger (e.g. if the third heavy neutrino is allowed to participate in leptogenesis Abada et al 1810.12463)

Sterile Neutrino Dark Matter



Boyarsky et al 1807.07938

What will we do?

Complementarity in the νMSM

Indirect probes at accelerators
rare decays, EWPD,
lepton universality)

new detectors
(FASER, Codex-b,
MATHUSLA, Al3X,
ANUBIS

Collider searches for heavy neutrinos

X-ray searches: SRG/eROSITA, SRG/
ART-XC, ATHNEA, XRISM, Lynx…

absolute neutrino mass
searches (KATRIN ect.)

CMB and LSS :
absolute neutrino mass

non-accelerator
searches
(TRISTAN…)

astrophysics:
supernovae etc.

neutrinoless
double β decay

Structure formation:
simulation, observation

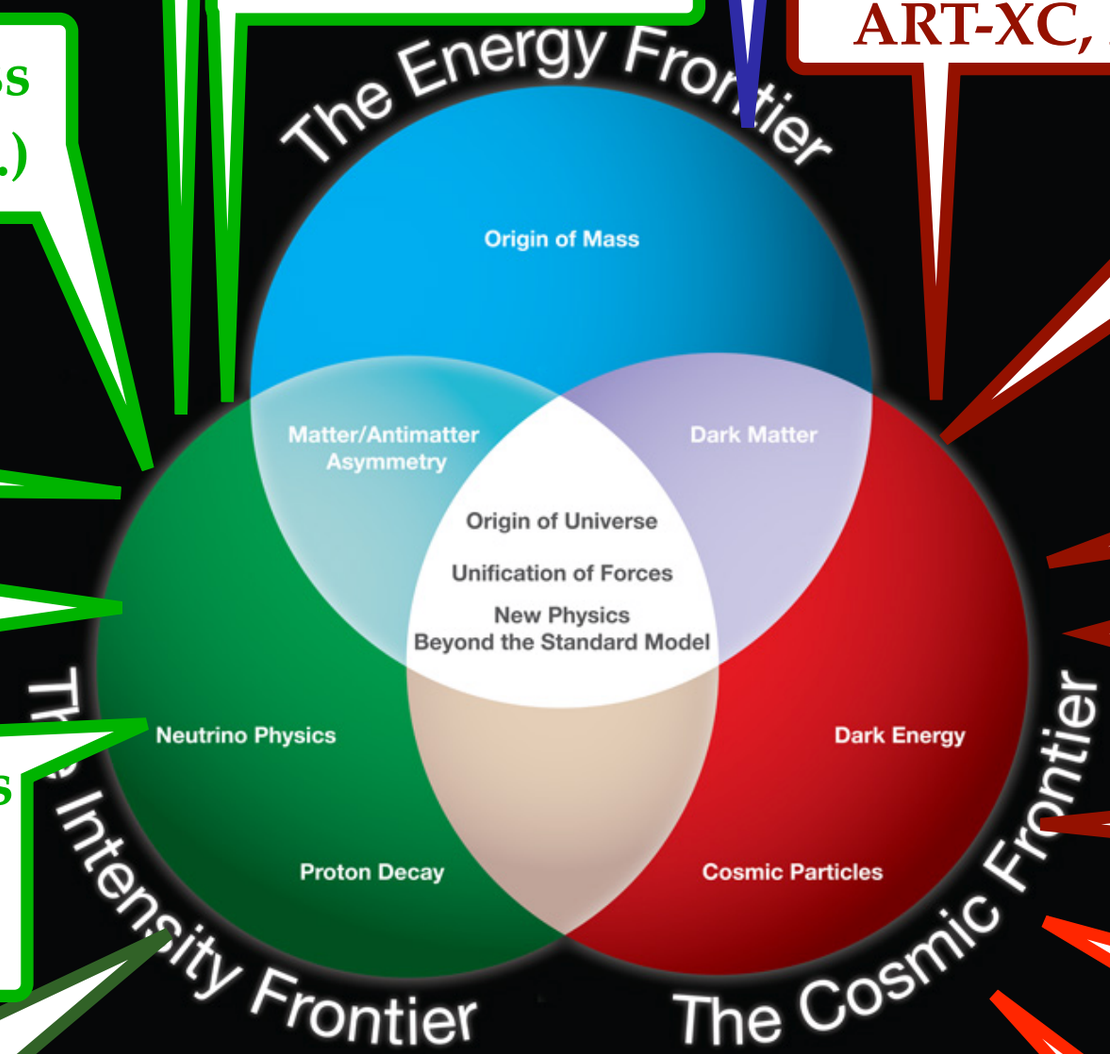
fixed target experiments
(SHiP, NA62, DUNE,
T2K..)

IGM temperature:
WDM vs CDM

neutrino oscillation
experiments
DUNE, Hyper-K

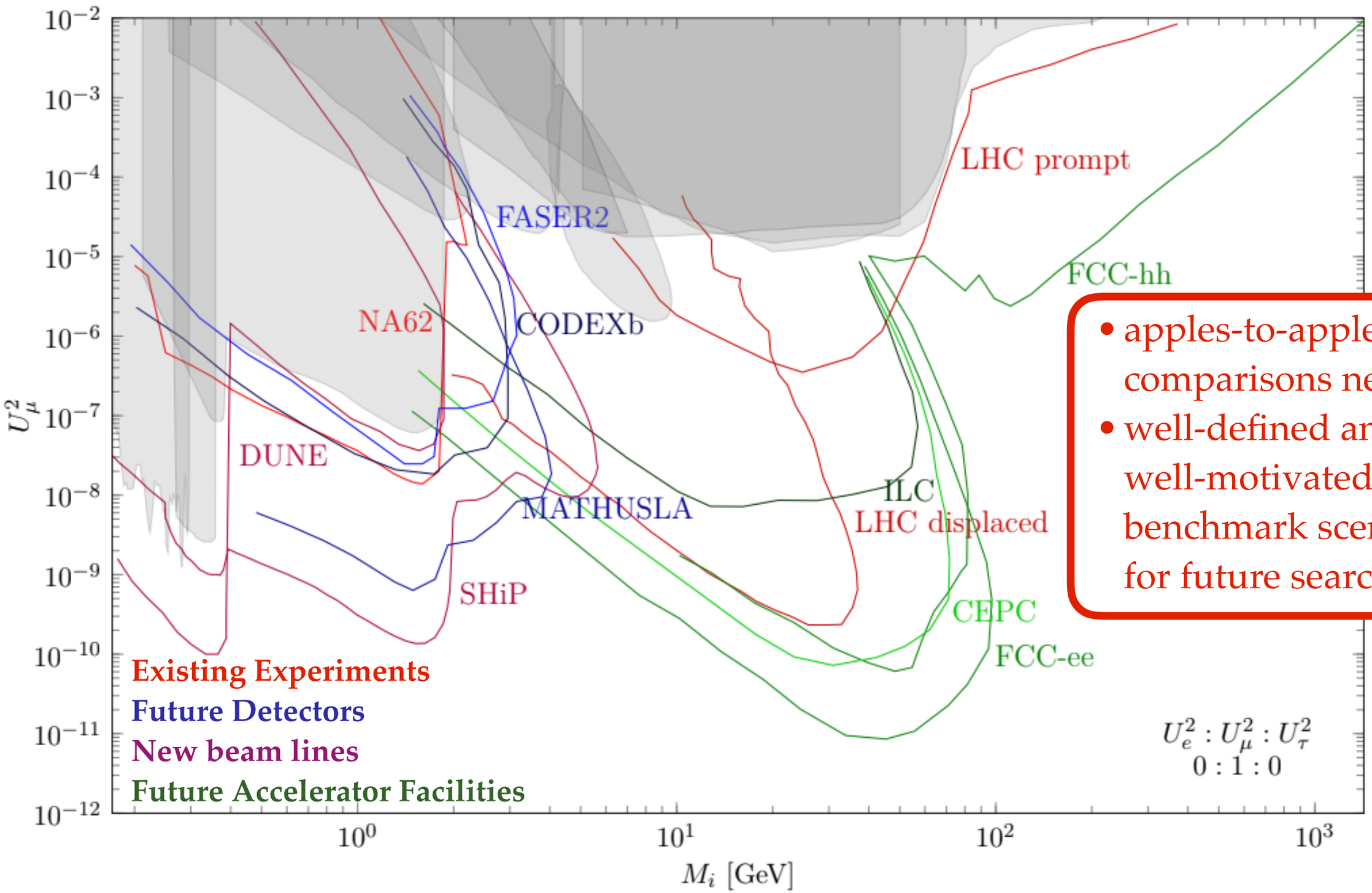
Theory: leptogenesis
parameter region

Theory: Sterile neutrino
DM production



RF, NF, EF, CF, TF

Heavy Neutrino Searches (RF, EF, AF)



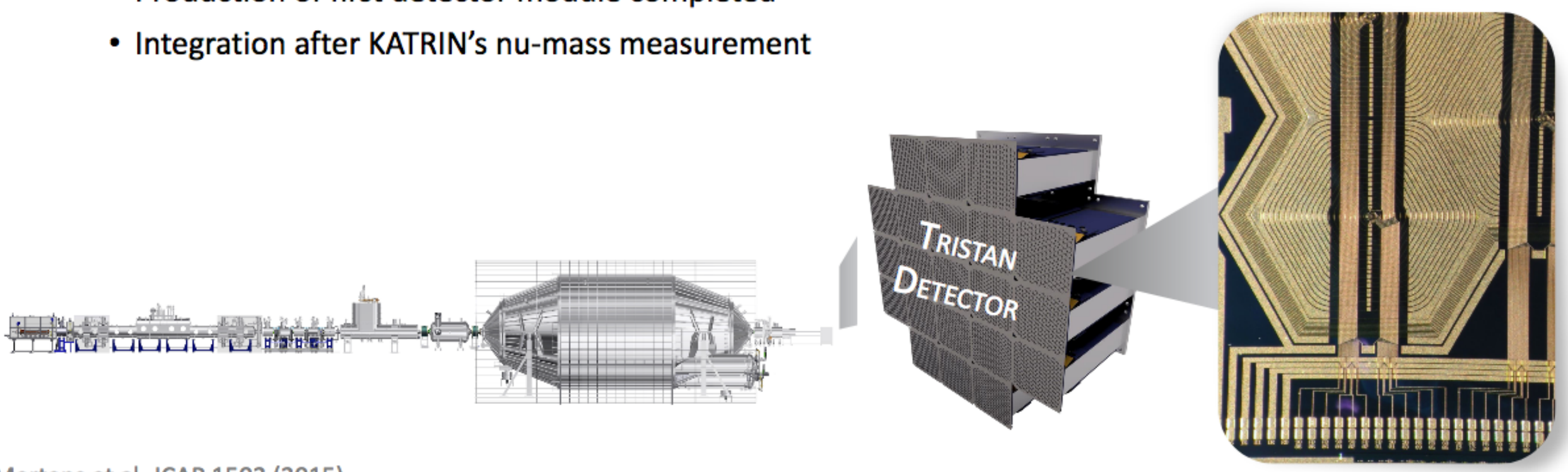
- apples-to-apples comparisons needed
- well-defined and well-motivated benchmark scenario for future searches

Laboratory Dark Matter Search (RF)

Search for sterile neutrinos with a

Novel detector system for KATRIN

- 3500-pixel silicon drift detector (SDD) focal plane array
- Excellent performance (noise, resolution, linearity) of first prototypes demonstrated
- Production of first detector module completed
- Integration after KATRIN's nu-mass measurement

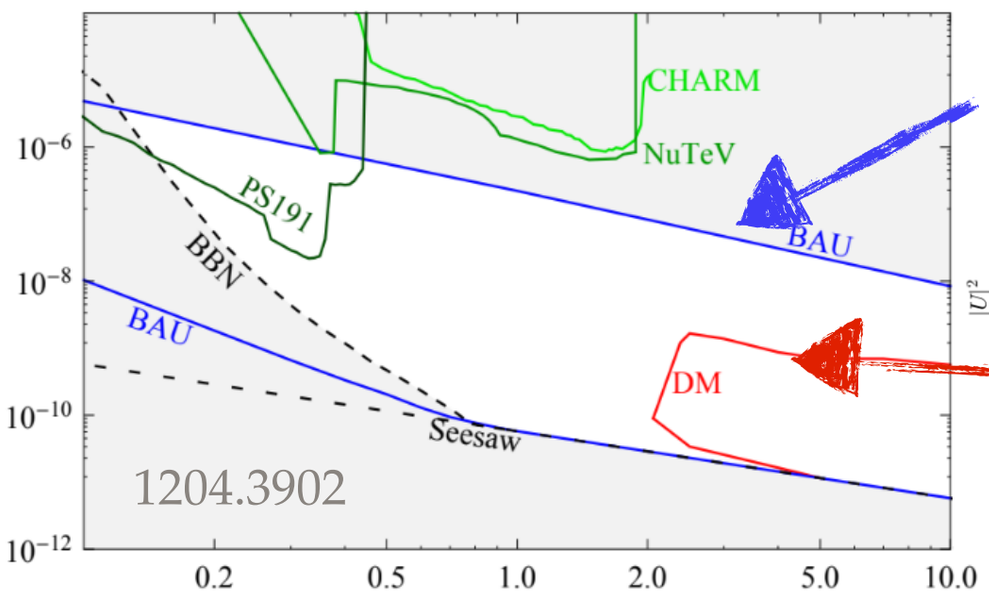


Mertens et al. JCAP 1502 (2015)
Mertens et al. J. Phys. G46 (2019)

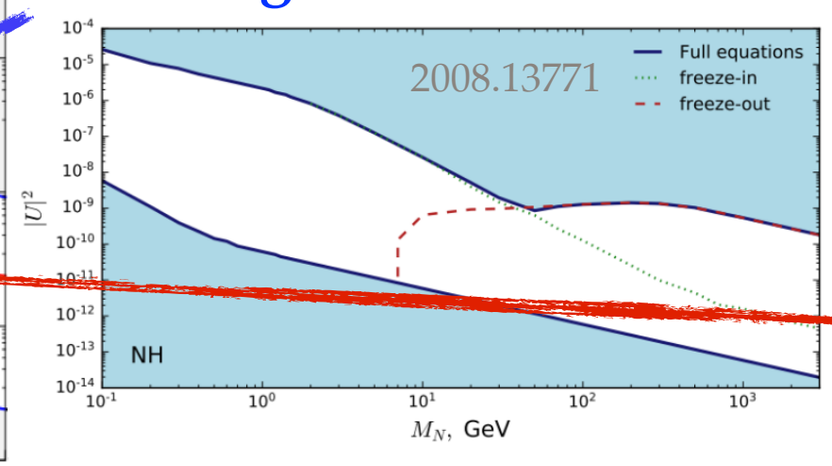
Slide by Susanne Mertens

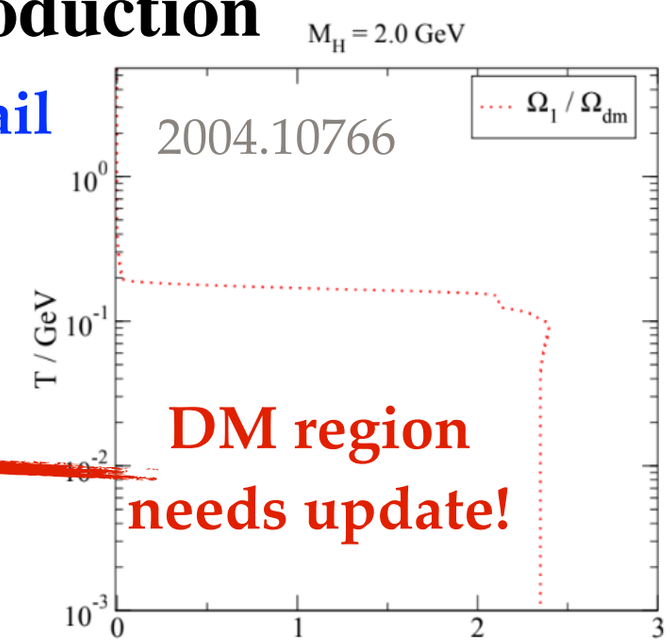
Theory (TF) input for RF

Identification of the parameter region of resonant DM production



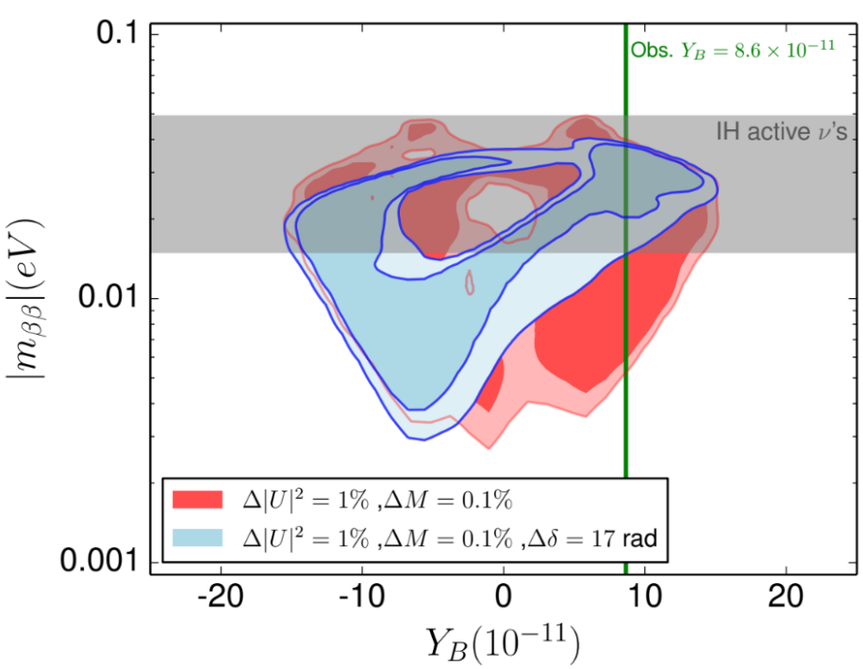
BAU region was studied in detail



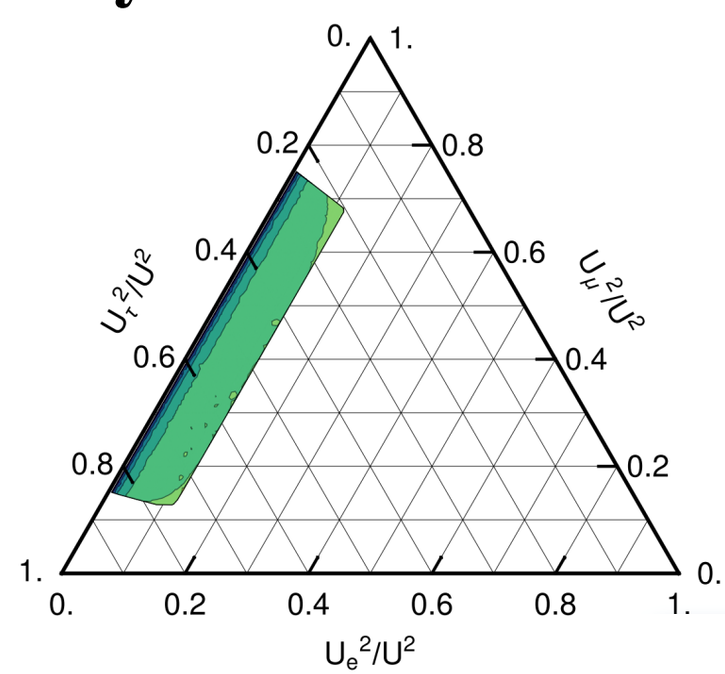


DM region needs update!

Full exploitation of the complementarity of the different "frontiers"



1606.06719



More cross-frontier studies needed!

1710.03744 1609.09069

Schedule for developing a contributed paper?

To be discussed:

νMSM involves many frontiers and aspects, it could appear in many Snowmass papers…

…or do we want a dedicated paper to avoid fragmentation and emphasise a well-defined physics case?

What we would like to come out of Snowmass?

Call for research at all frontiers, exploit complementarity

- **Inspire the community (new searches etc…)**
- **Coordination of work in the US and elsewhere**
- **Attracting interested collaborators**
- **Ensure data/results are published in a re-interpretable way**

Establish the νMSM as a well-defined benchmark model for future detector studies etc

Building a strong case for funding agencies