Complementarity in LLP Searches

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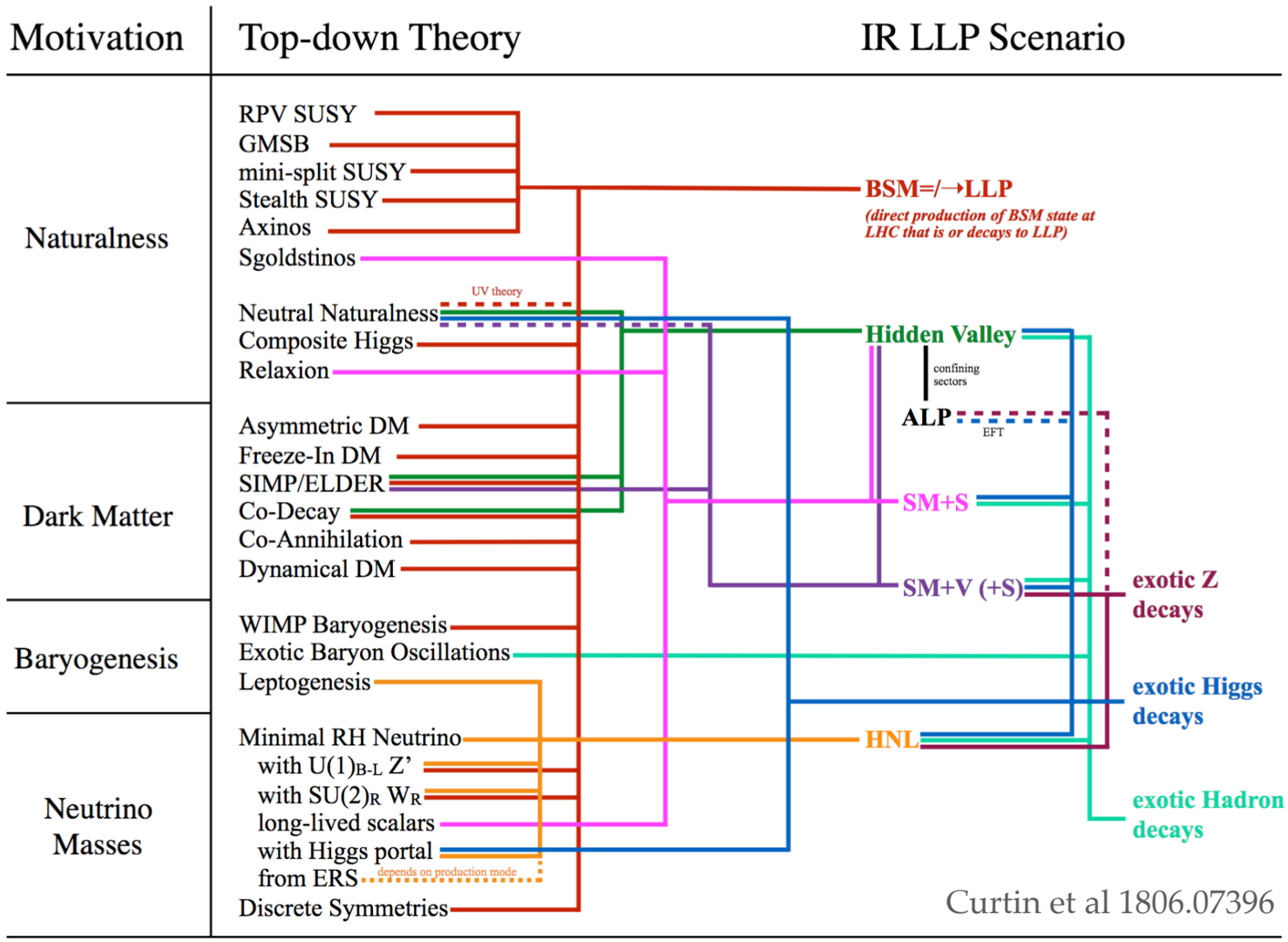
Overview

- **Portal Effective Theory**
- **Constraints on LLPs from Cosmology**
- **Global Constraints**
- **LLPs in Heavy Ion Collisions**

Portal Effective Theory



- many scenarios predict comparably light "Hidden Sectors" that give rise to Long Lived Particles (LLPs)
- Hidden Sector couples to SM via "portals"
- A single "portal" operator at high energies can give rise to different interactions at low energies

Desirable: A general EFT framework that maps fundamental parameters at high energies onto low energy observables

Portal Effective Theory

Electroweak Scale PETs ($d \leq 5$)

- Suppressed by small parameter ϵ_{UV}
- $d \leq 5$ captures axion-like particles (ALPs), heavy neutral leptons (HNLs), dark photons, etc.

$\Downarrow$

General GeV Scale PETs ($d \leq 7$ + NDA)

- $d = 6, 7$ Operators capture $1/M_W^2$ suppressed $\Delta F \neq 0$ interactions
- Naive Dimensional Analysis (NDA) counts (4π) loop suppression factors (keep only leading order)

$\Downarrow$

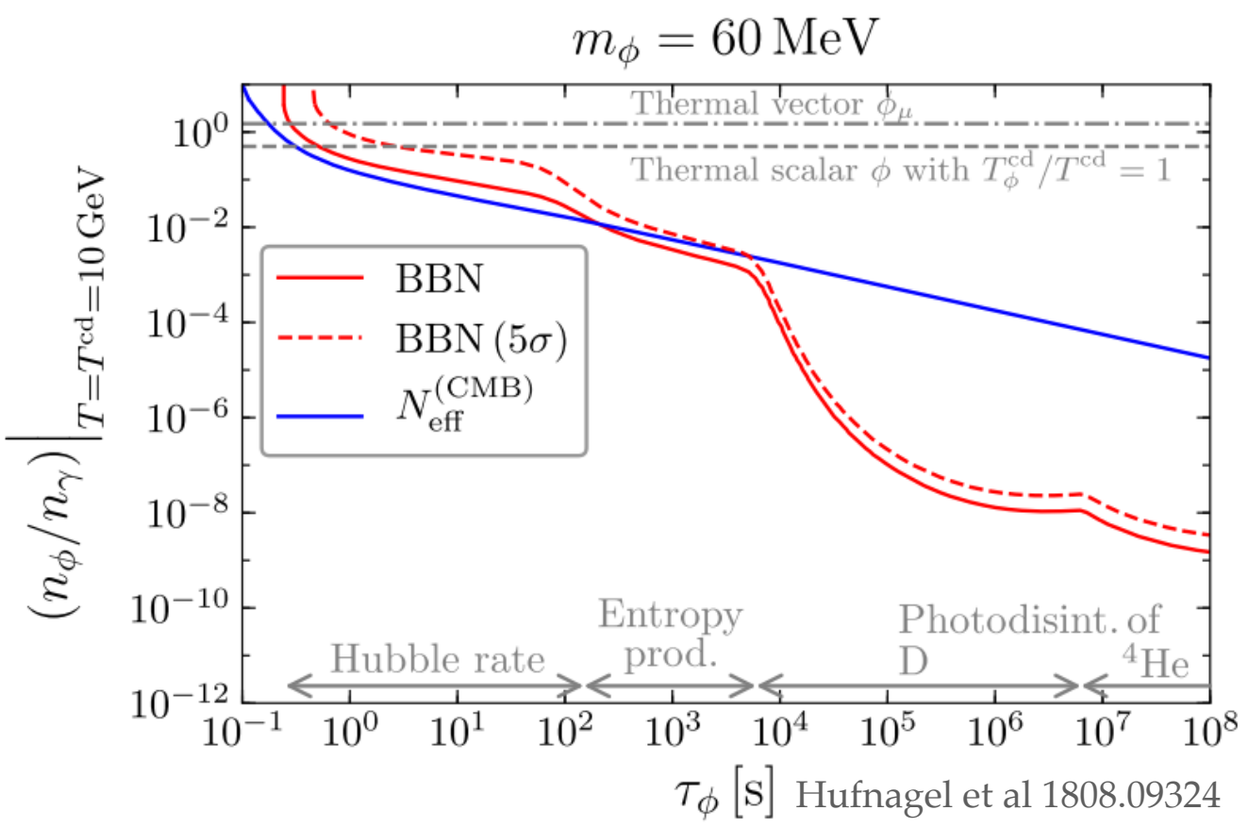
Specific PETs (χPT, HQET, etc.)

- QCD nonperturbative $\Rightarrow$ Specific PETs
- PET χPT captures meson interactions at NA62 in Kaon mode

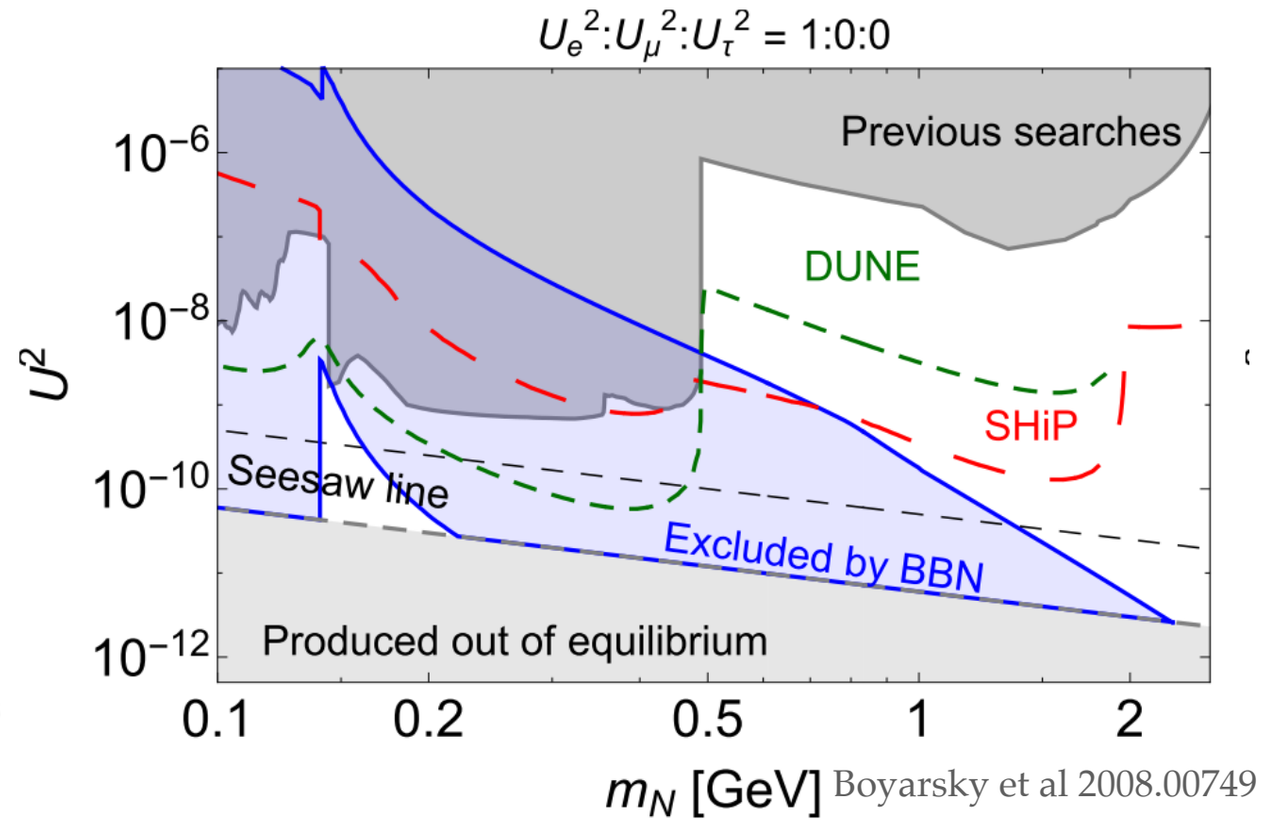
…in development with Chiara Arina, Jan Hajer, Philipp Klose

LLPs in Cosmology

- LLPs can affect cosmological observables through their presence (expansion rate of the universe) or decays (entropy injection, disturbance of distribution function, dissociation of nuclei…)
- Observables: N_{eff} and light element abundances in intergalactic medium
- This can provide a “floor” for experimental searches
- CMB S4 experiment will set new bounds



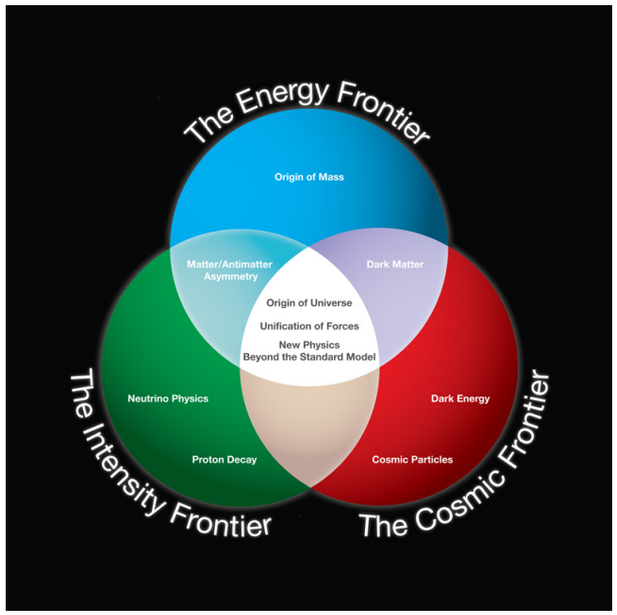
Hufnagel et al 1808.09324



Boyarsky et al 2008.00749

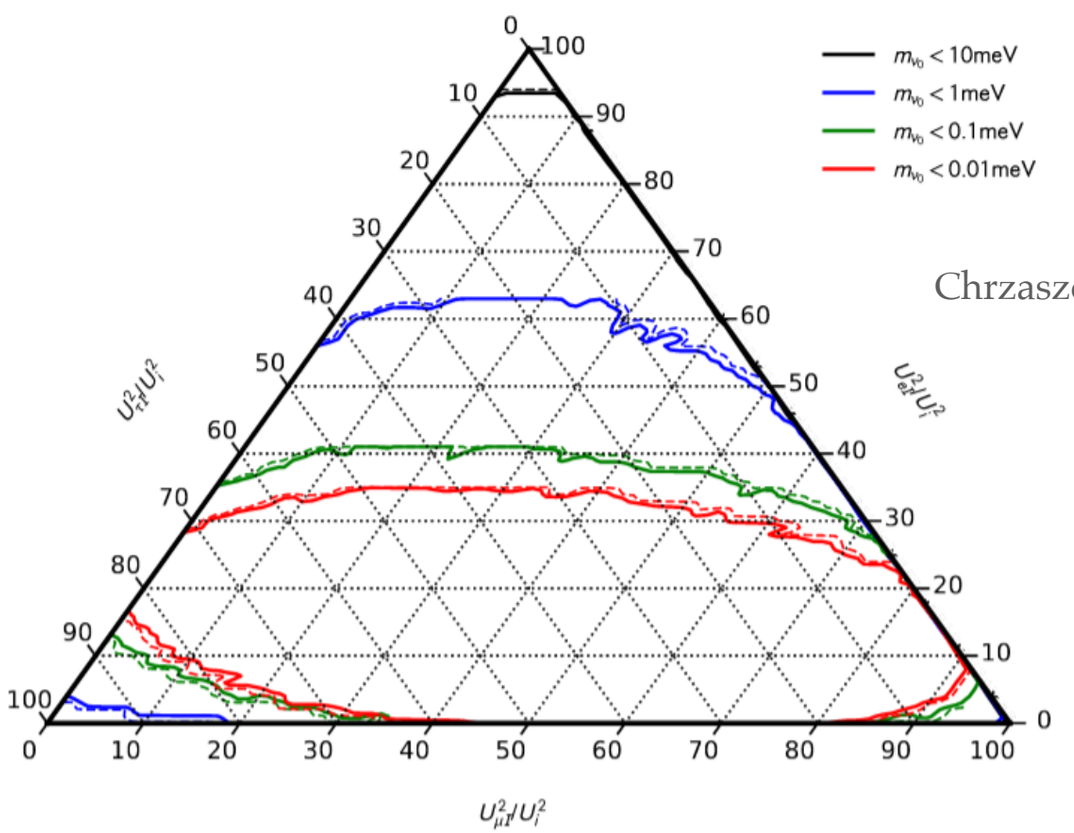
…combined BBN + CMB studies planned with Isabel Oldengott

Global Constraints

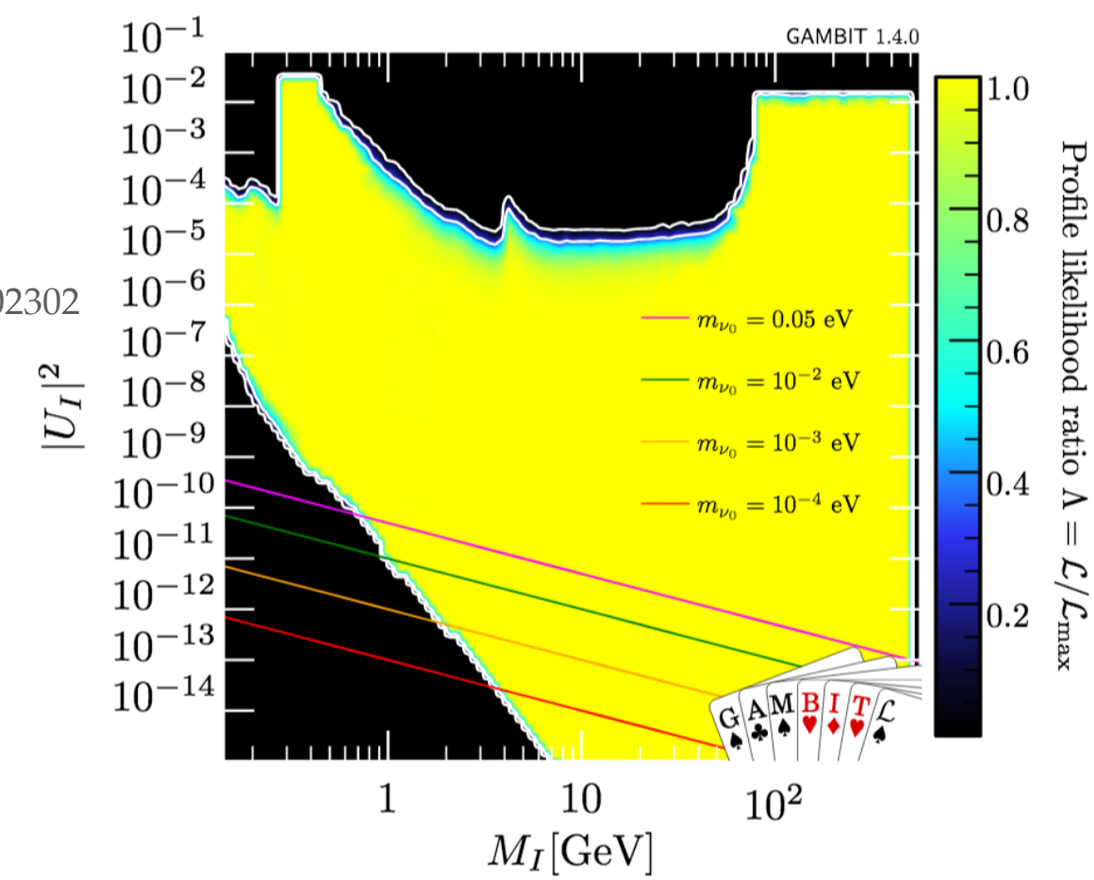


Combined observables from different sources can

- identify full exclusion potential of future experiments by projecting improvement in direct and indirect searches
- In case of a discovery: Can help to pin down underlying model (minimal type-I seesaw is fully testable)
- Example: RH neutrino mass and mixing



Chrzaszcz et al 1908.02302

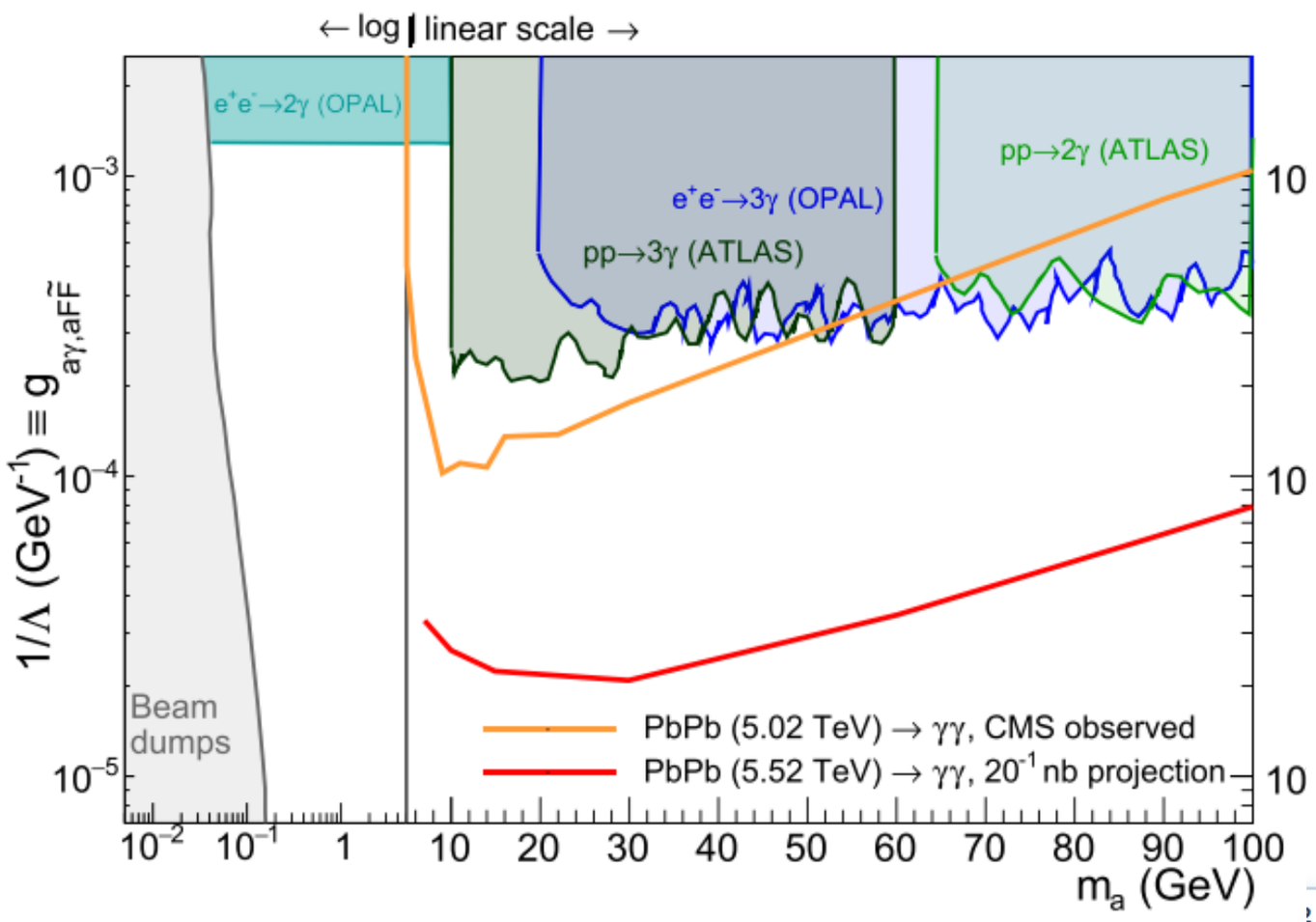


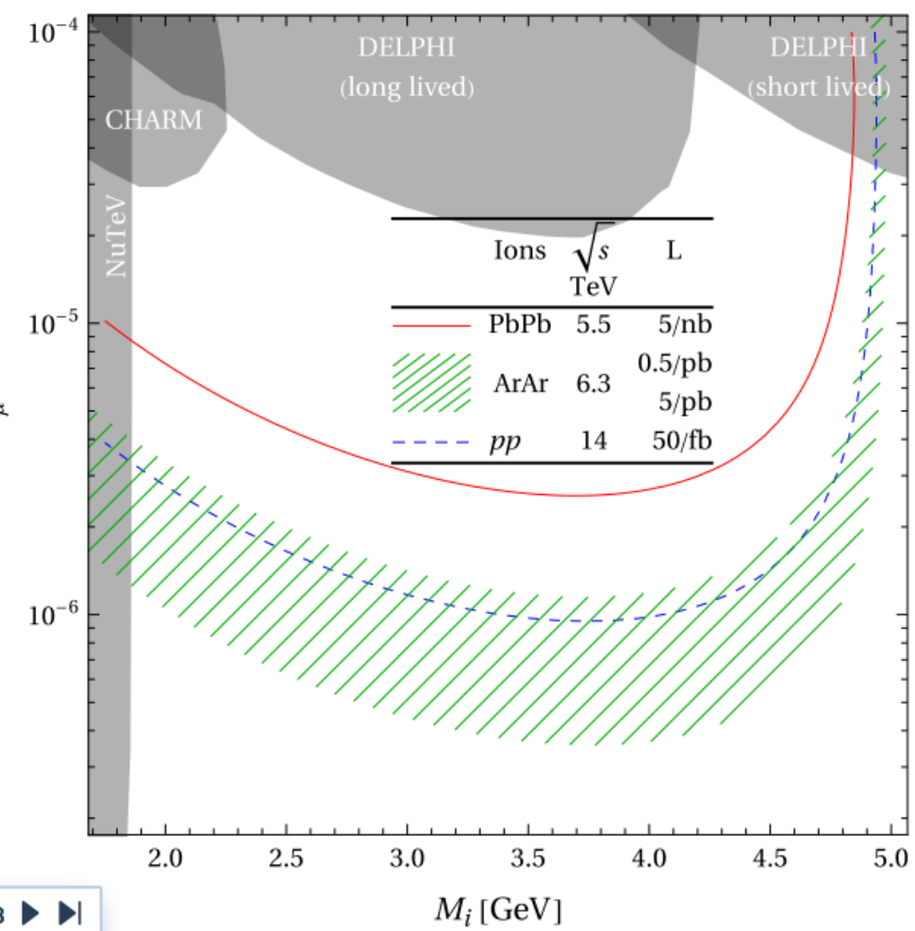
…further studies planned with **M. Chrzaszcz, T. Gonzalo, J. Harz., C. Weniger**

LLPs in Heavy Ion Collisions

Heavy Ion collisions have a number of advantages: Bruce et al 1812.07688

- new production mechanisms (e.g. in strong fields)
- different backgrounds (no pile-up, …)
- very low triggers





…ongoing studies with **Jan Hajer, Andrea Giammanco, Hesham el Faham**

dedicated workshop at ECT* May 17-21, 2021 https://indico.cern.ch/event/831940/