Predictions for Dark Matter in Galaxy Clusters from Future Radio Surveys

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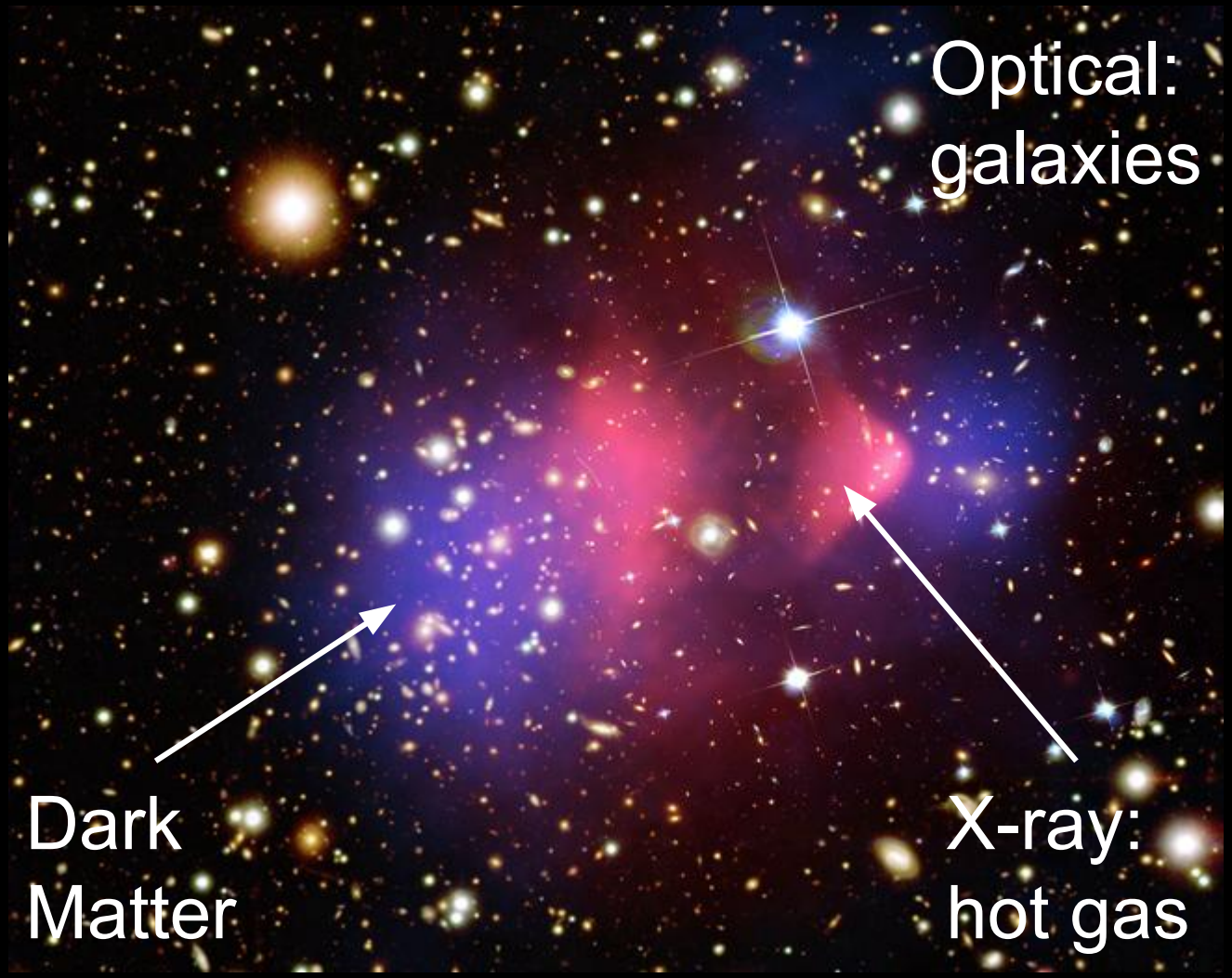
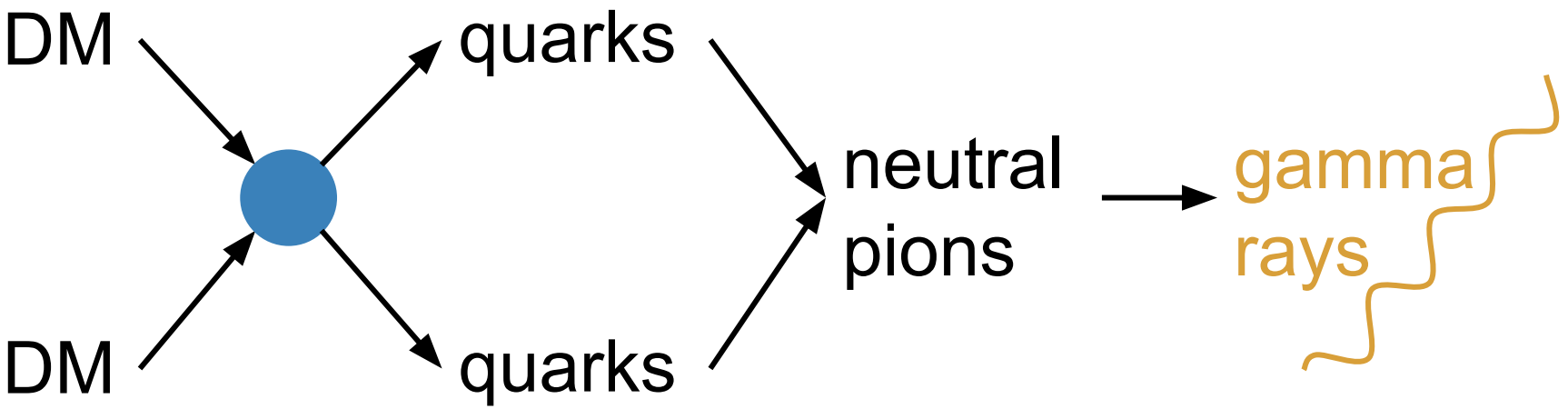
The Many Facets of Extragalactic Radio Surveys

Galaxy Clusters



Gamma Rays from DM Annihilation



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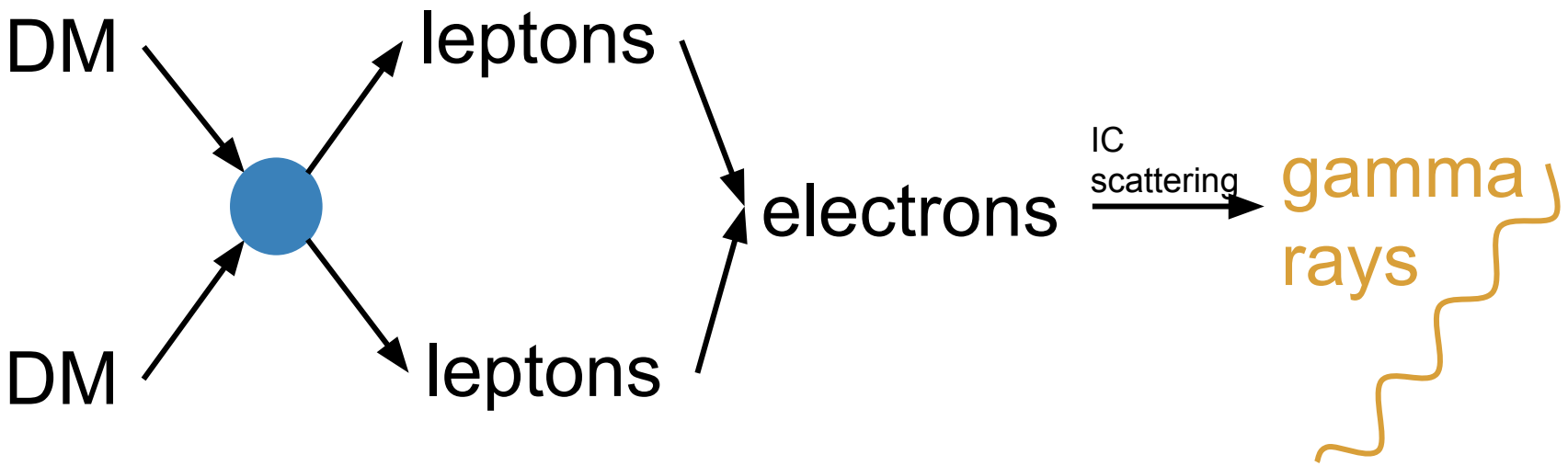

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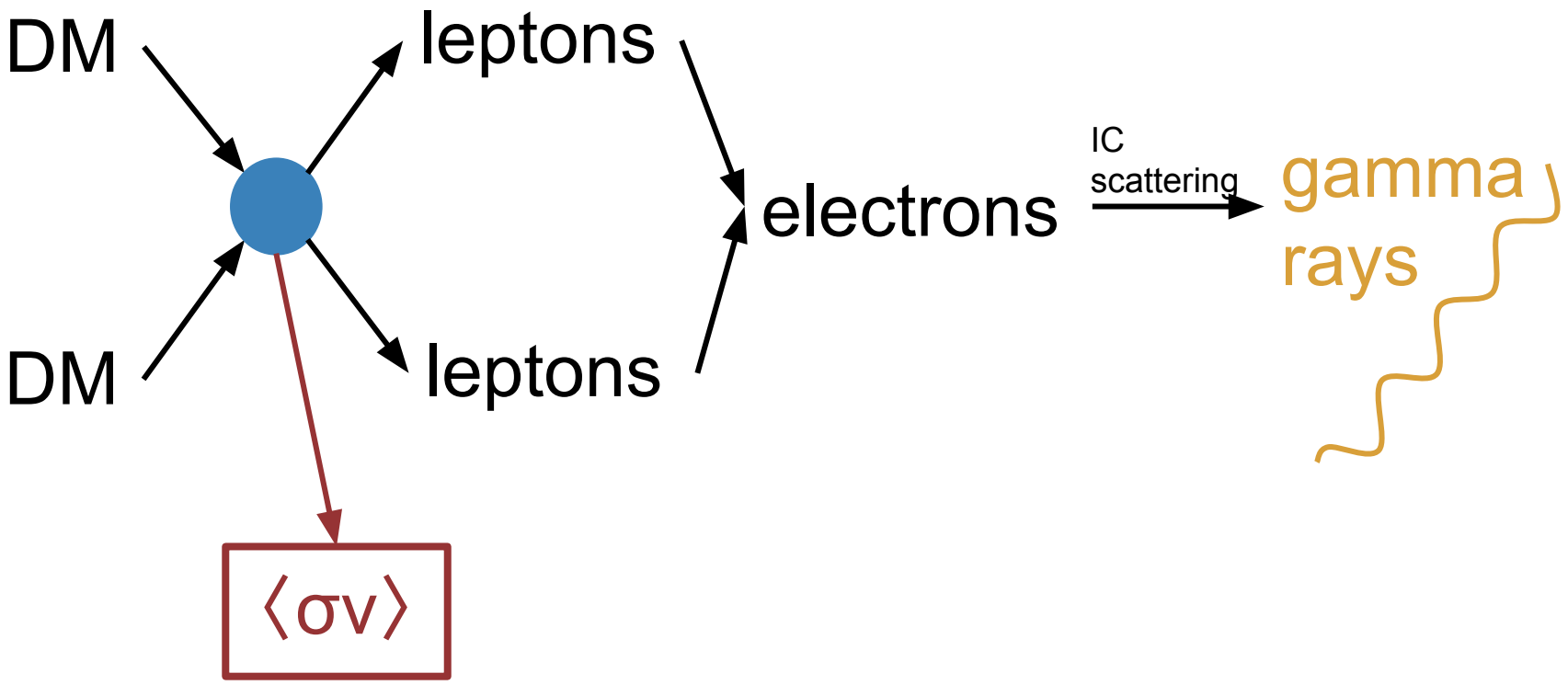
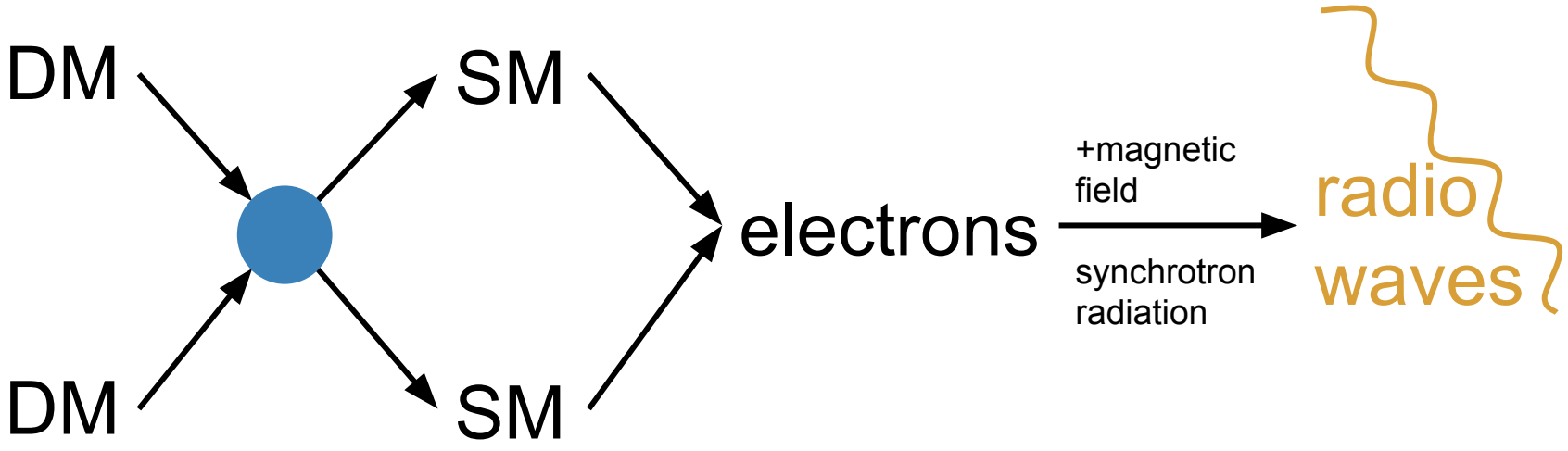
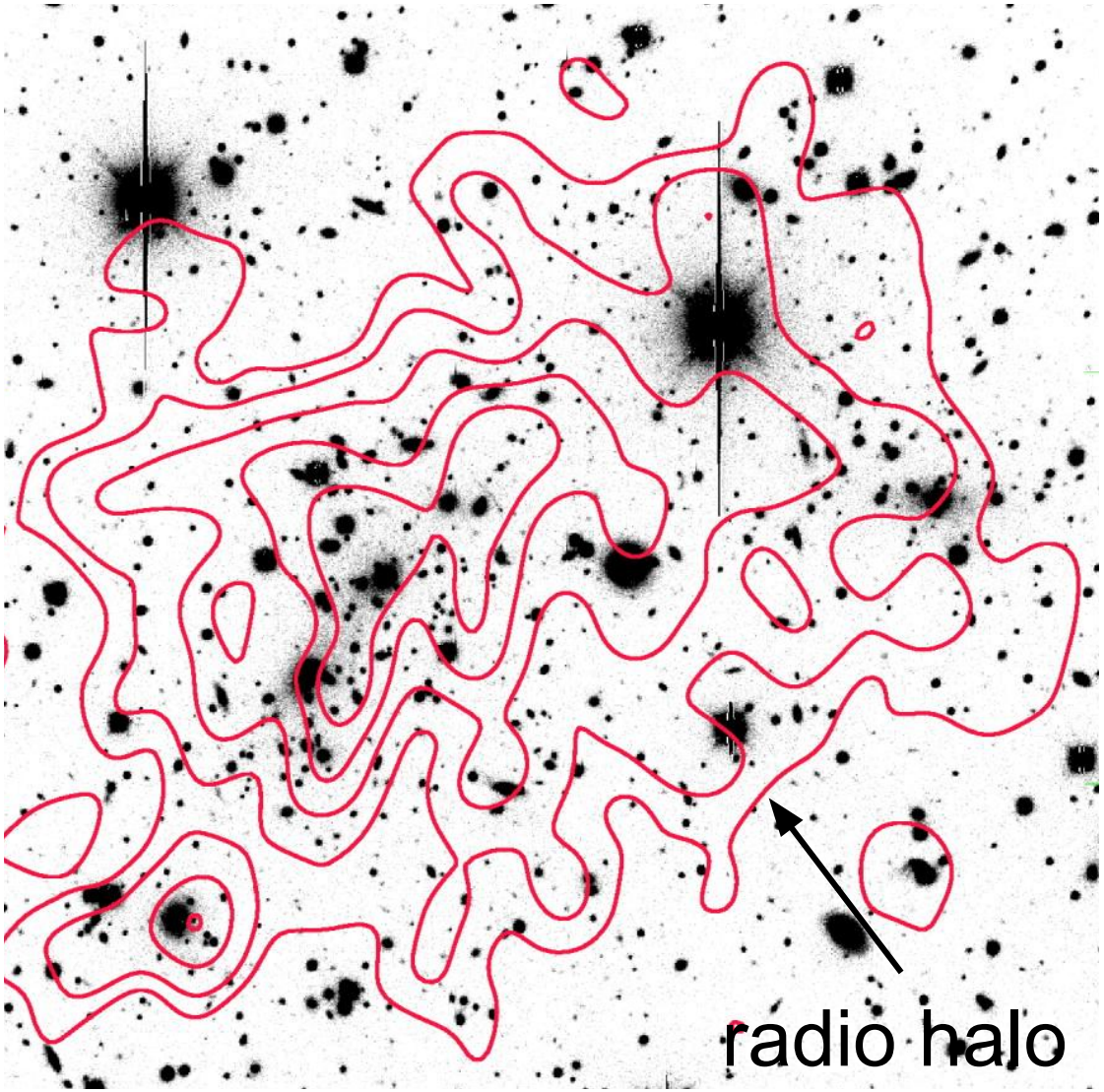


Radio from DM Annihilation



Radio Emission in Galaxy Clusters



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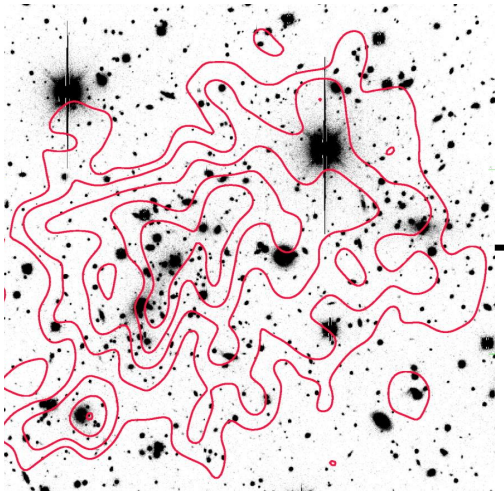
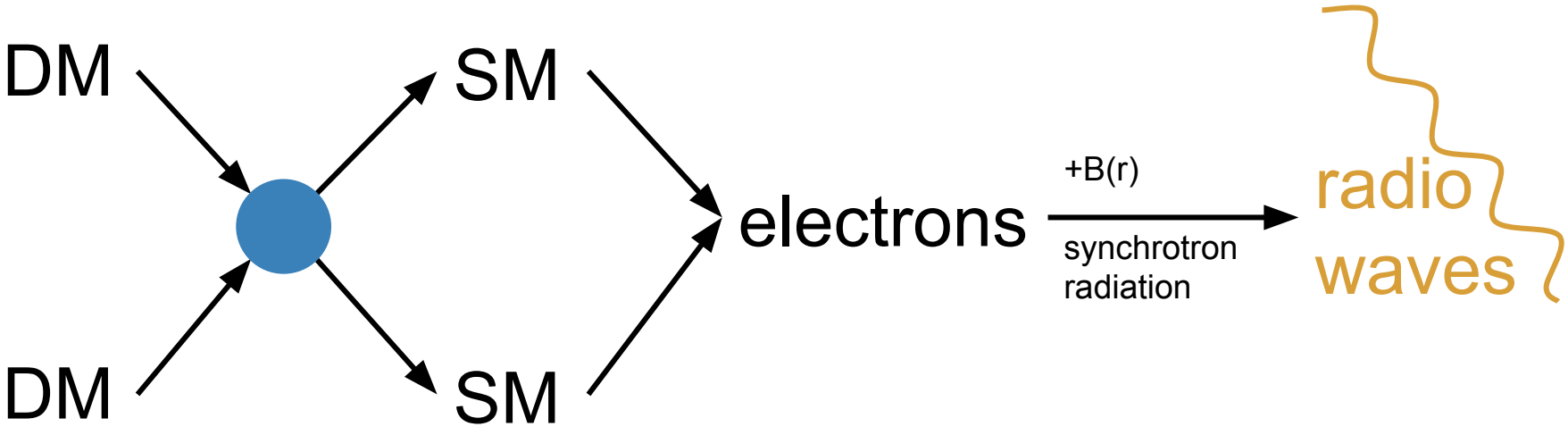


NT electrons and magnetic fields

However: no observable diffuse radio emission from the majority of clusters!

→ Use nondetections to constrain NT component in clusters

Constraining Dark Matter with Radio



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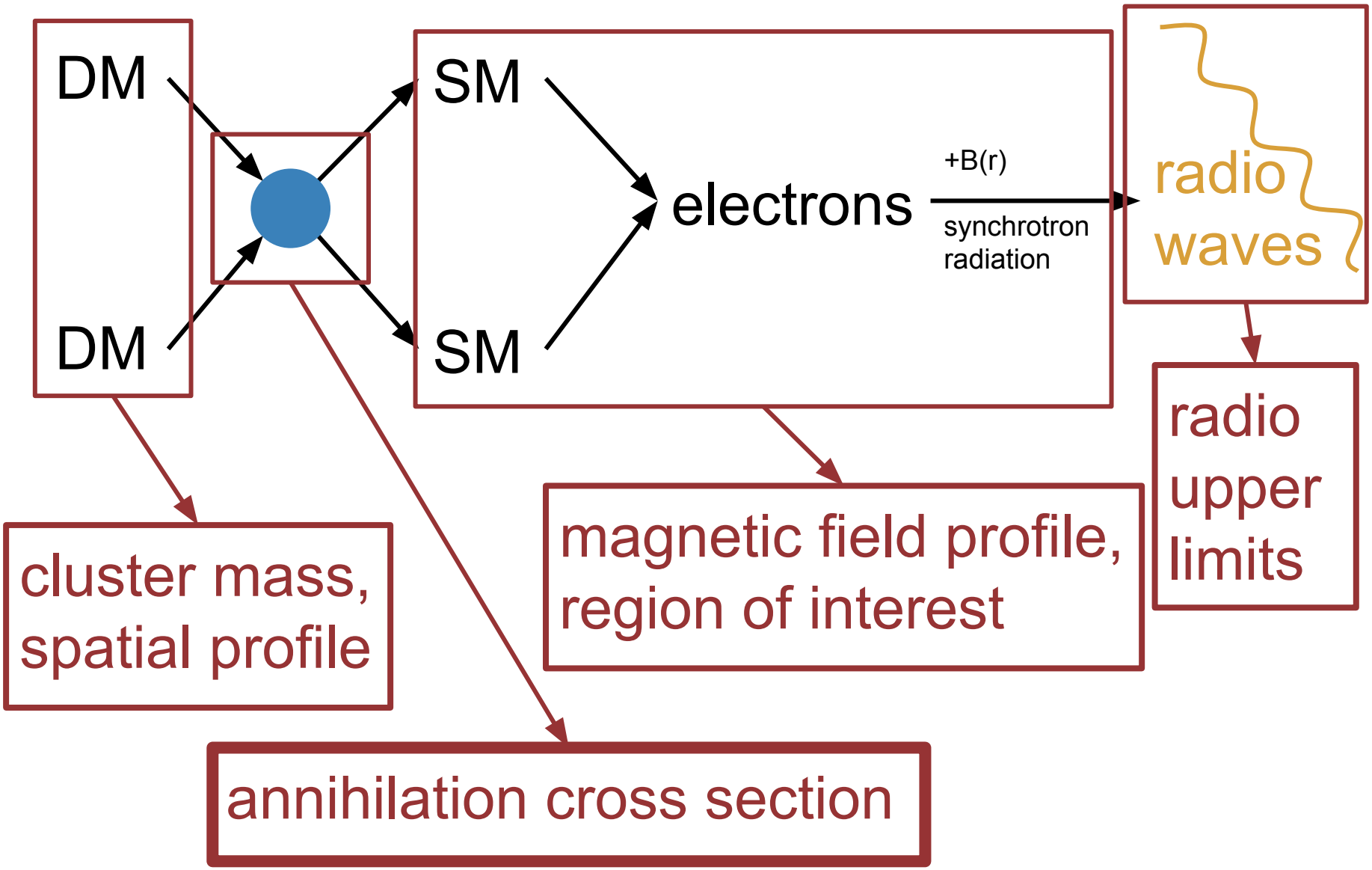

Constraining Dark Matter with Radio

$$S_\nu(r,z) = \frac{\langle \sigma v \rangle}{8\pi m_\chi^2} \int_{\Delta\Omega} \mathrm{d}\Omega \int_{los} \mathrm{d}l \rho_\chi^2(l) \Phi(\nu, B, r, z)$$

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radio upper limits

annihilation cross section: what we constrain

cluster mass, DM profile

synchrotron signal per annihilation

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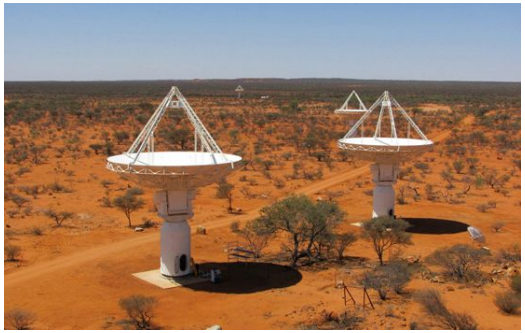
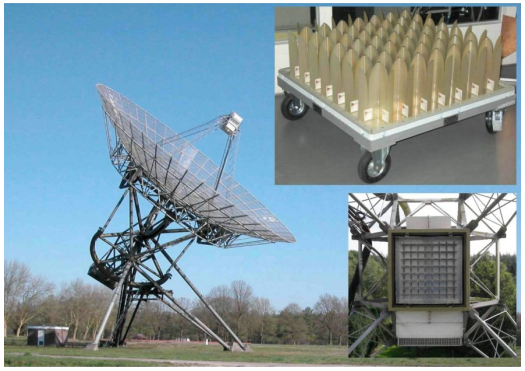
optimal redshift range?
optimal region size?
optimal frequency?

New and Future Radio Surveys

ASKAP:
1.4 GHz,
EMU



APERTIF:
1.4 GHz,
WODAN



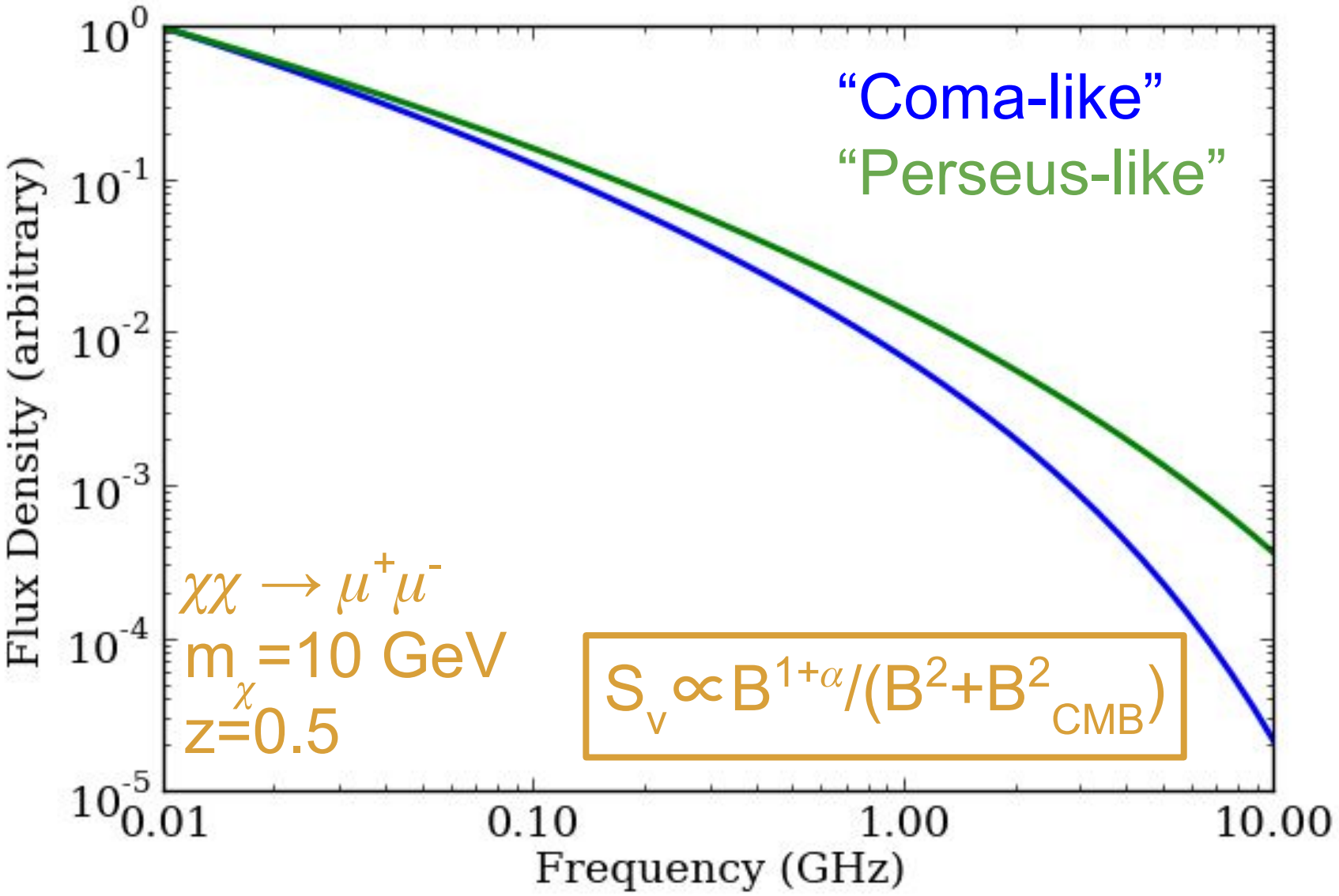
LOFAR:
120 MHz,
MSSS, Tier 1&2

Constraining Dark Matter with Radio

Assumptions:

- DM profile: NFW
- Cluster Mass: Coma (~10^{15} M_{sun})
- Magnetic field: $B(r) \sim n_{th}(r)^{0.5}$
  - "Coma-like": B_{center}~5uG
  - "Perseus-like": B_{center} ~25uG
- No diffusion
- Region of interest: 300 kpc radius

Synchrotron Signal from Dark Matter



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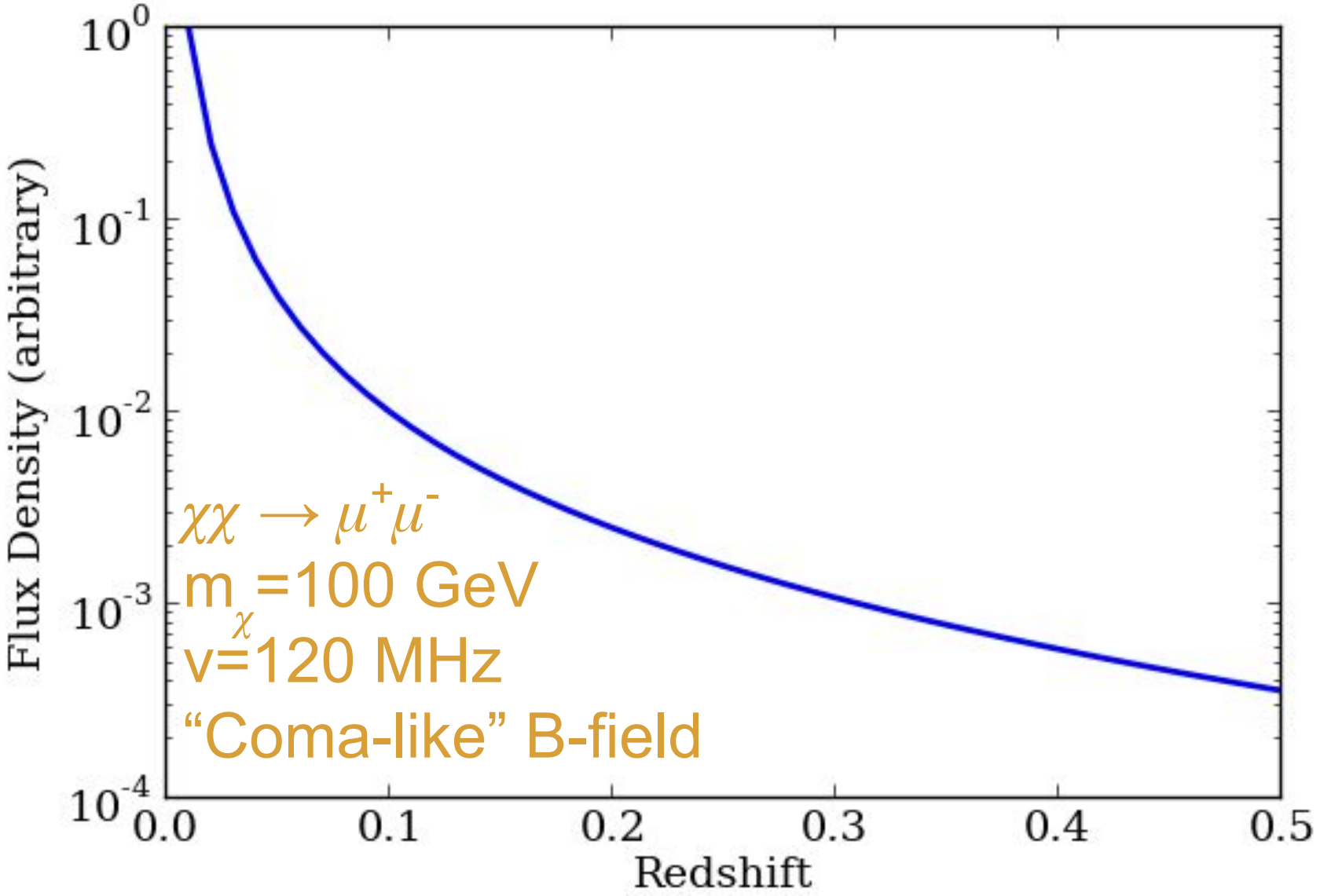
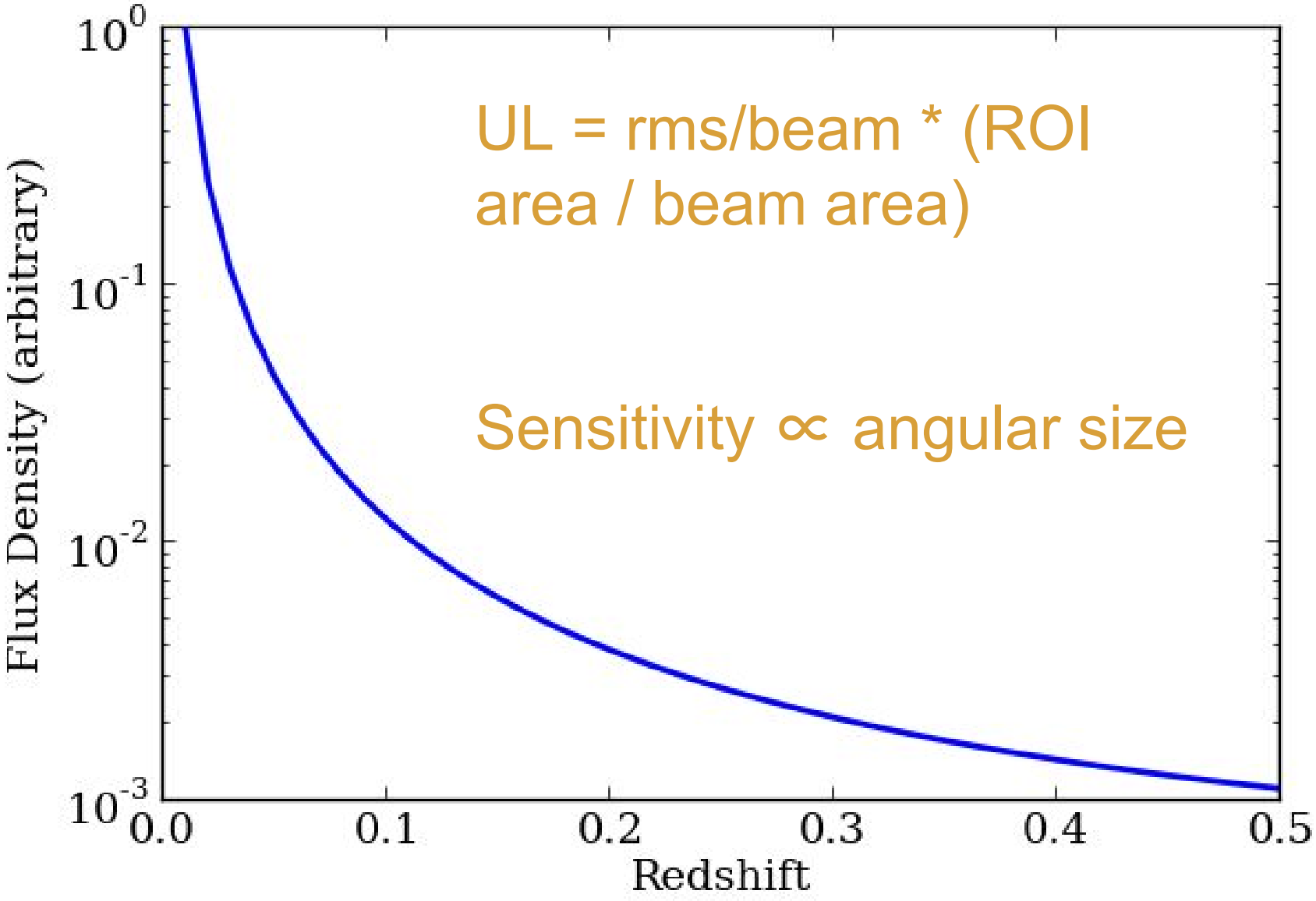


Radio Survey Sensitivity

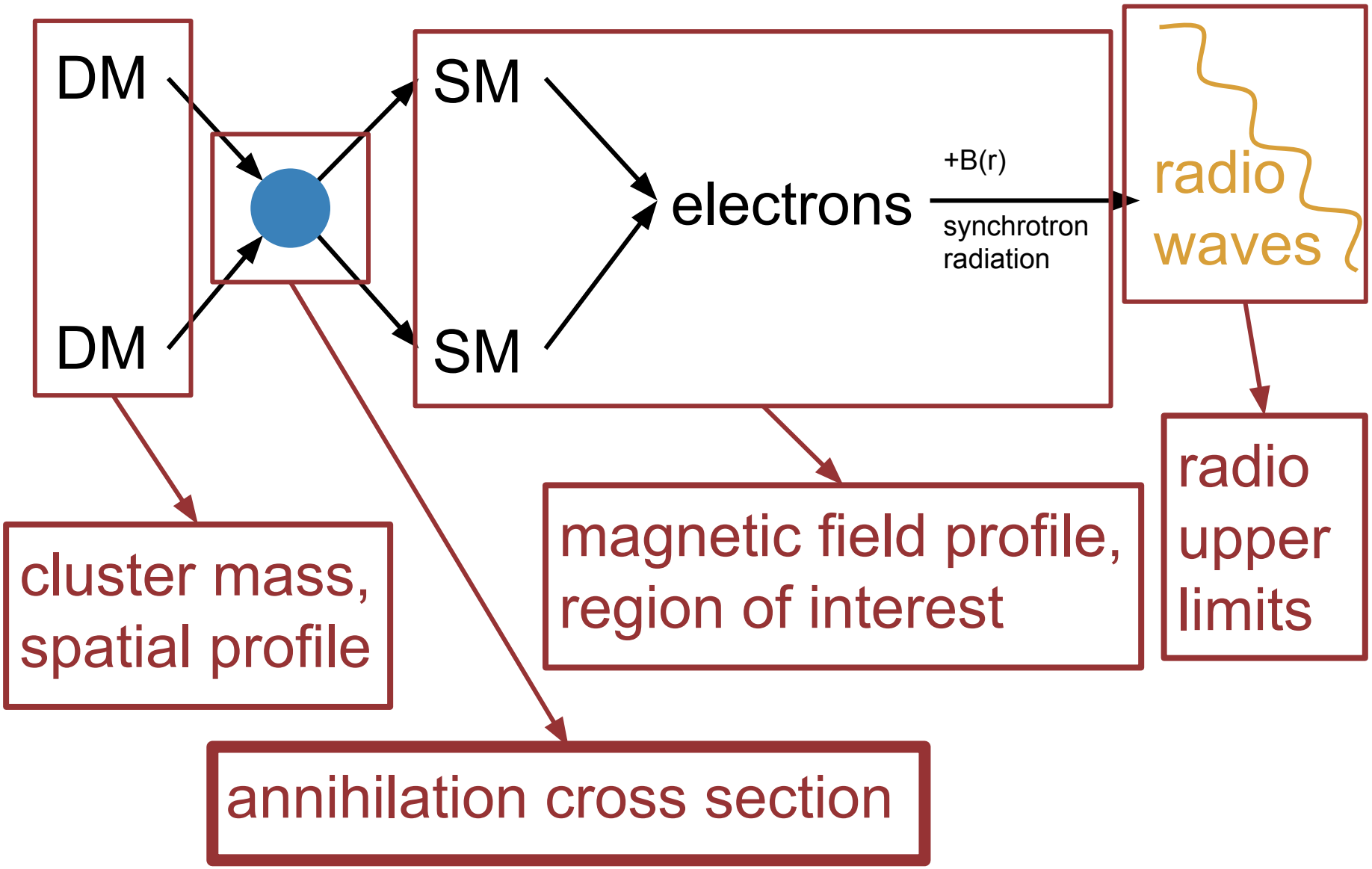
Assumptions:

- 25’’ beam size
- LOFAR (120 MHz):
  - Tier 1: 100 μJy/beam
  - Tier 2: 15 μJy/beam
- APERTIF and ASKAP (1.4 GHz)
  - WODAN and EMU: 10 μJy/beam

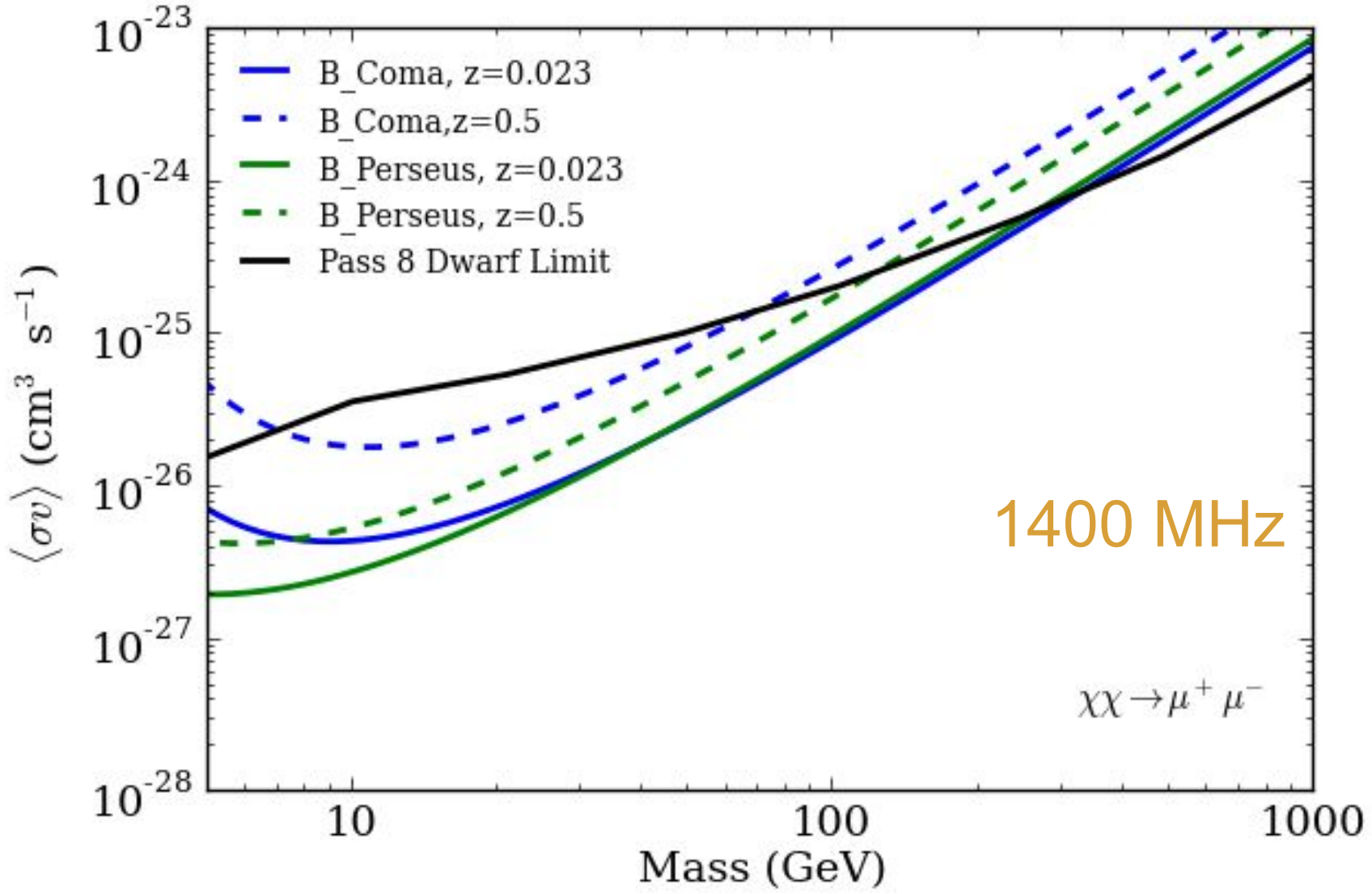
Radio Survey Sensitivity



Constraining Dark Matter with Radio



DM Annihilation Limits from Radio



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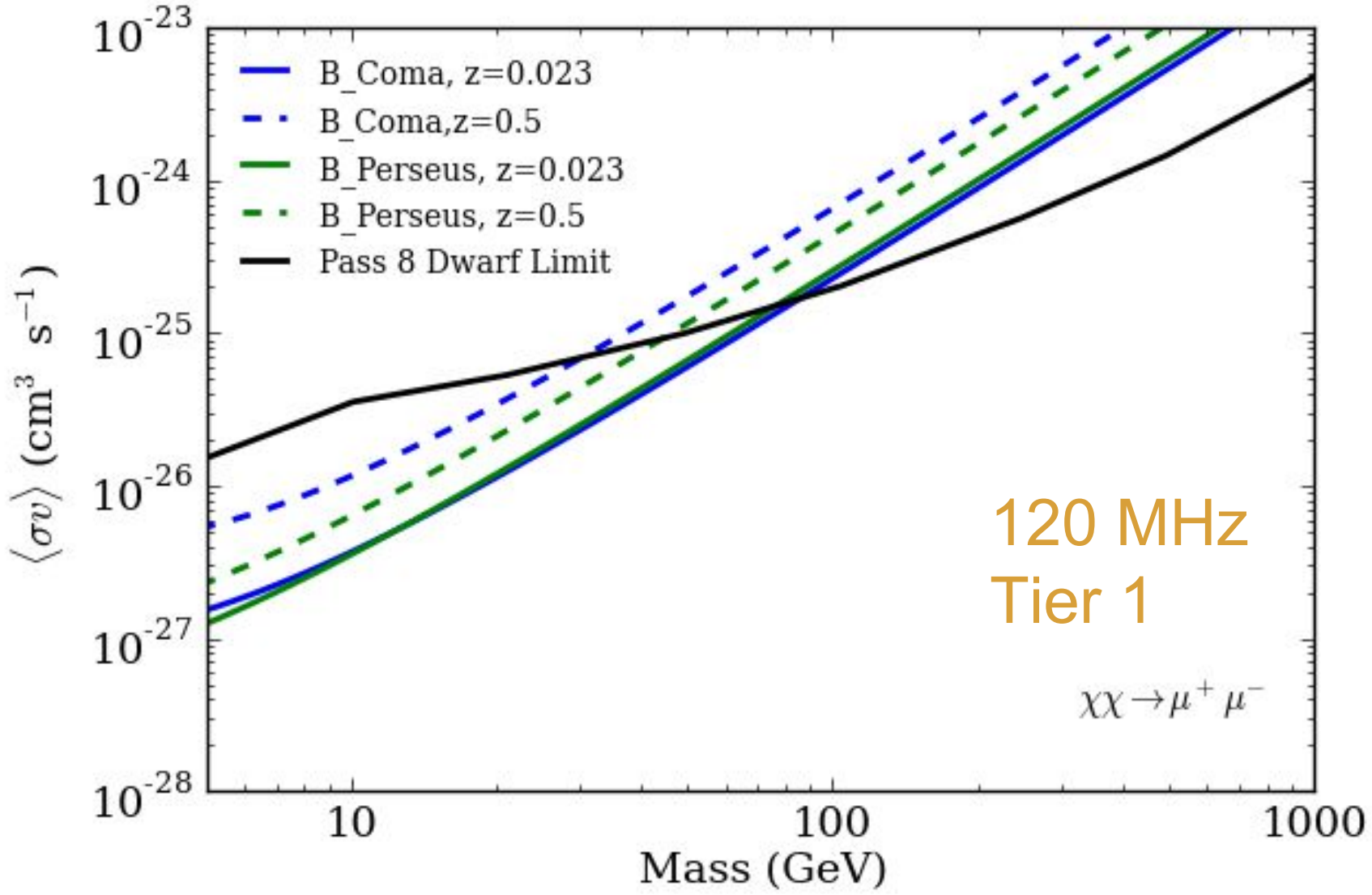

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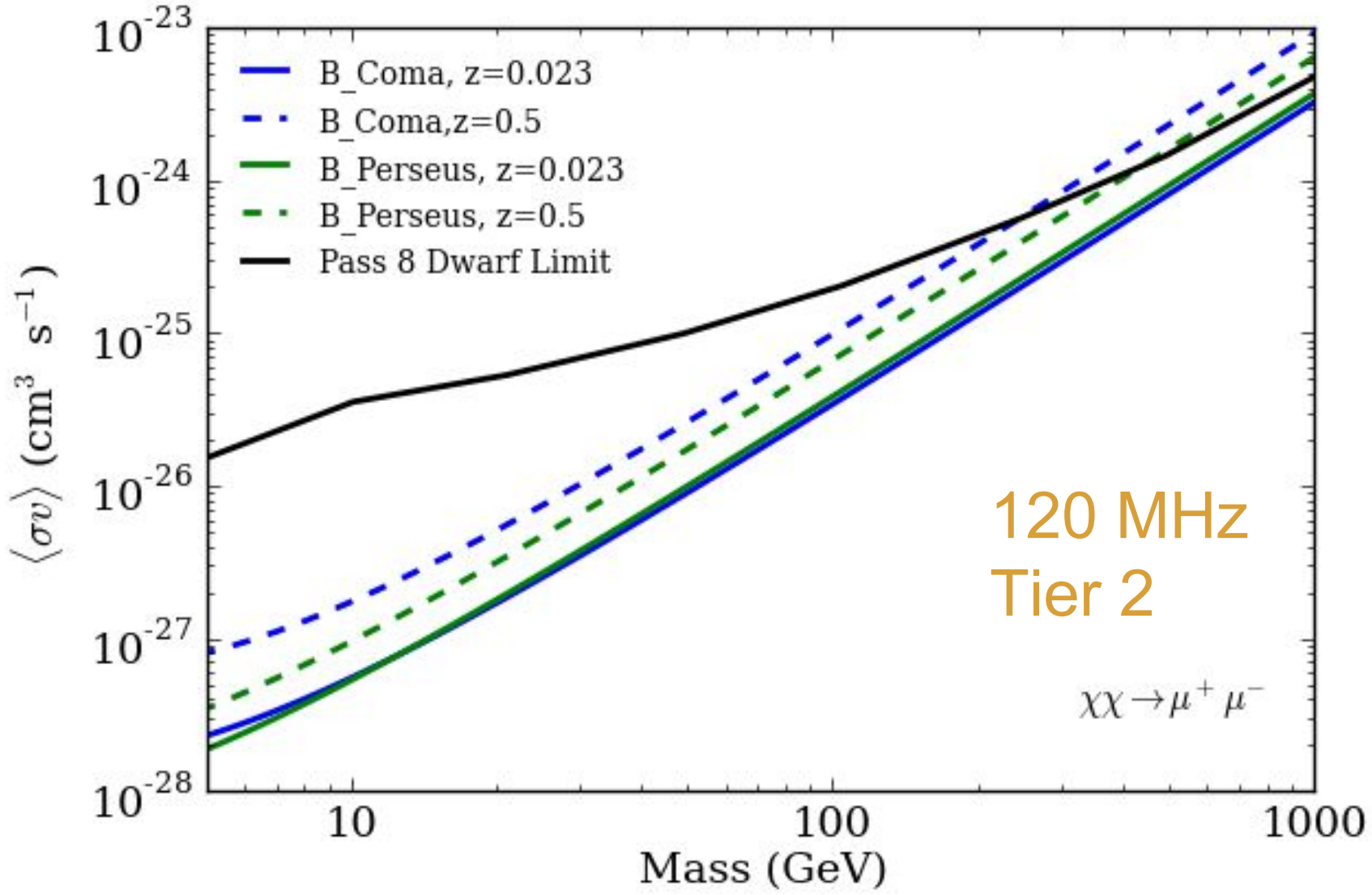

Conclusions

- nondetections from upcoming surveys can strongly constrain dark matter annihilation
- constraints weakly dependent on redshift
  - larger sample of clusters to study
- dedicated pointings/image analysis would yield better constraints
- next up: constraints on DM from upper limits from MSSS