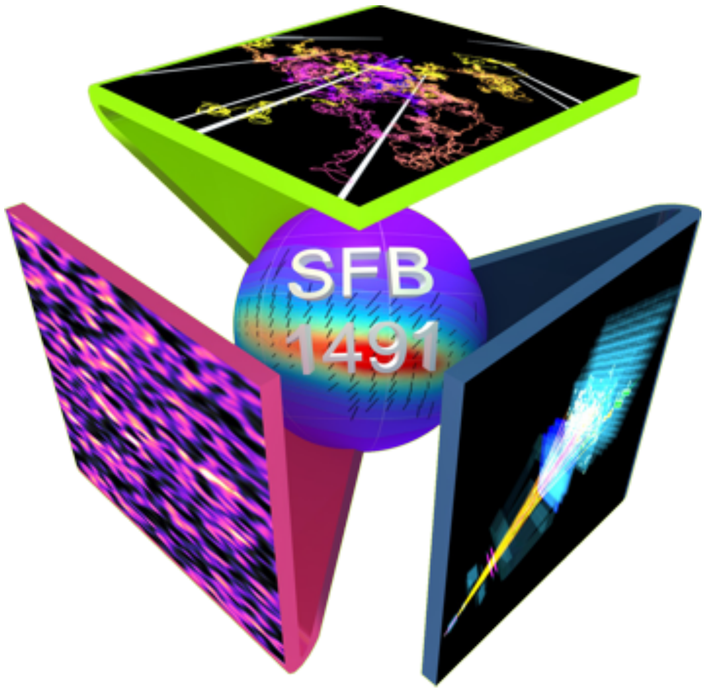


Dark Matter

Highlights

CIM Kickoff Meeting, RUB, 2022-05-31

Hendrik Hildebrandt, Ruhr University Bochum

RUB

erc

European Research Council

Established by the European Commission

GCCL

GERMAN CENTRE FOR COSMOLOGICAL LENSING

Heisenberg-Programm

DFG Deutsche Forschungsgemeinschaft

CIM key question (3)

What are the connections between the cosmic signatures of baryonic and dark matter, moving down to the lowest halo masses and out to large galactocentric distances?

Dark Matter in CIM

Overview

- Lowest mass, least luminous galaxies are ideal candidates for DM searches.
- γ and ν observations need to be interpreted through detailed modelling.
- Gravitational lensing and dust measurements down to the lowest masses.
- Completion of the MW dwarf galaxy census.
- Cross-correlation of DM large-scale structure and wide-field γ surveys.

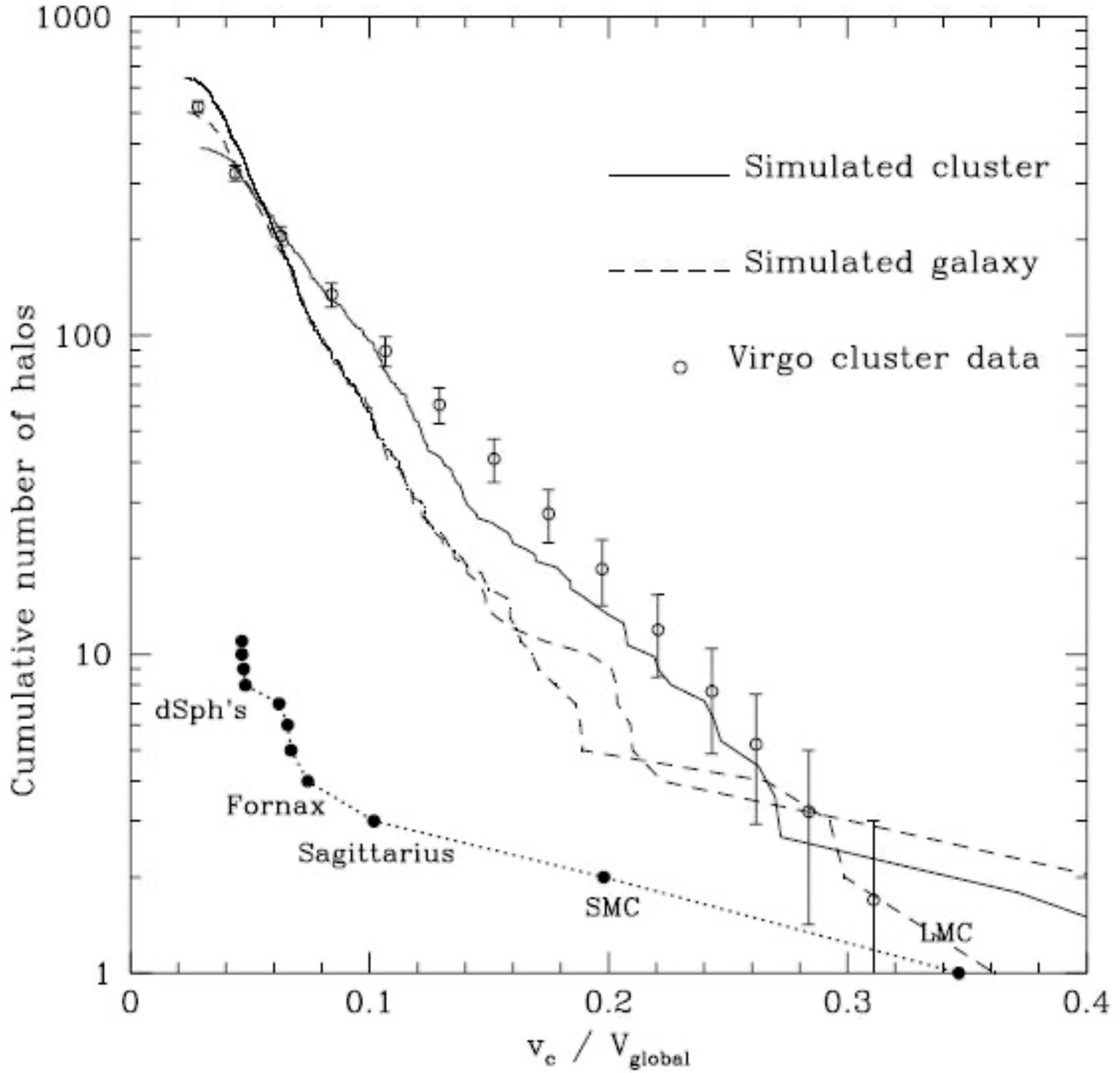
Dark Matter in CIM

Projects

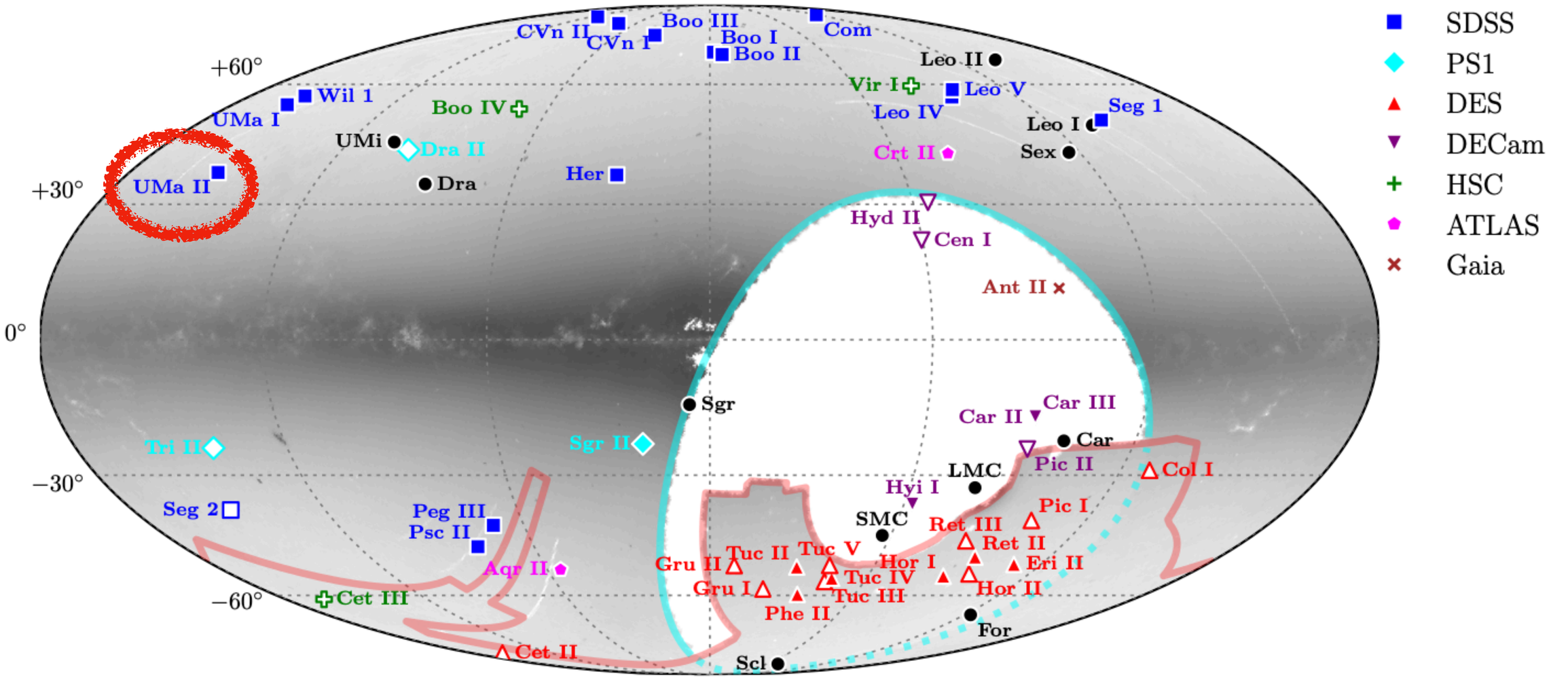
- F5
  - Search for MW satellites

Missing Satellites Problem

20 years ago



Moore et al., 1999



Drlica-Wagner et al. (2020)

Dark Matter in CIM

Projects

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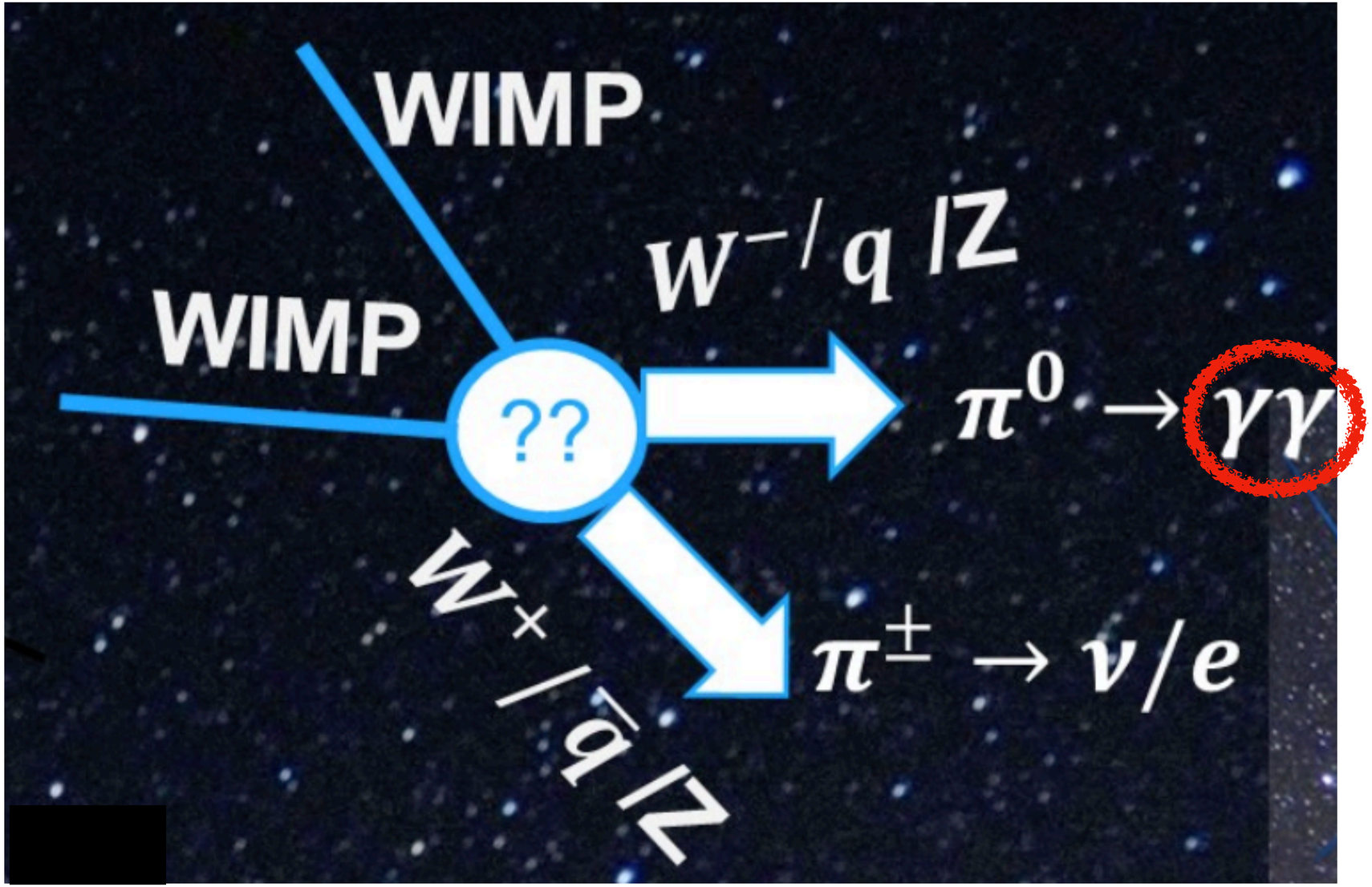
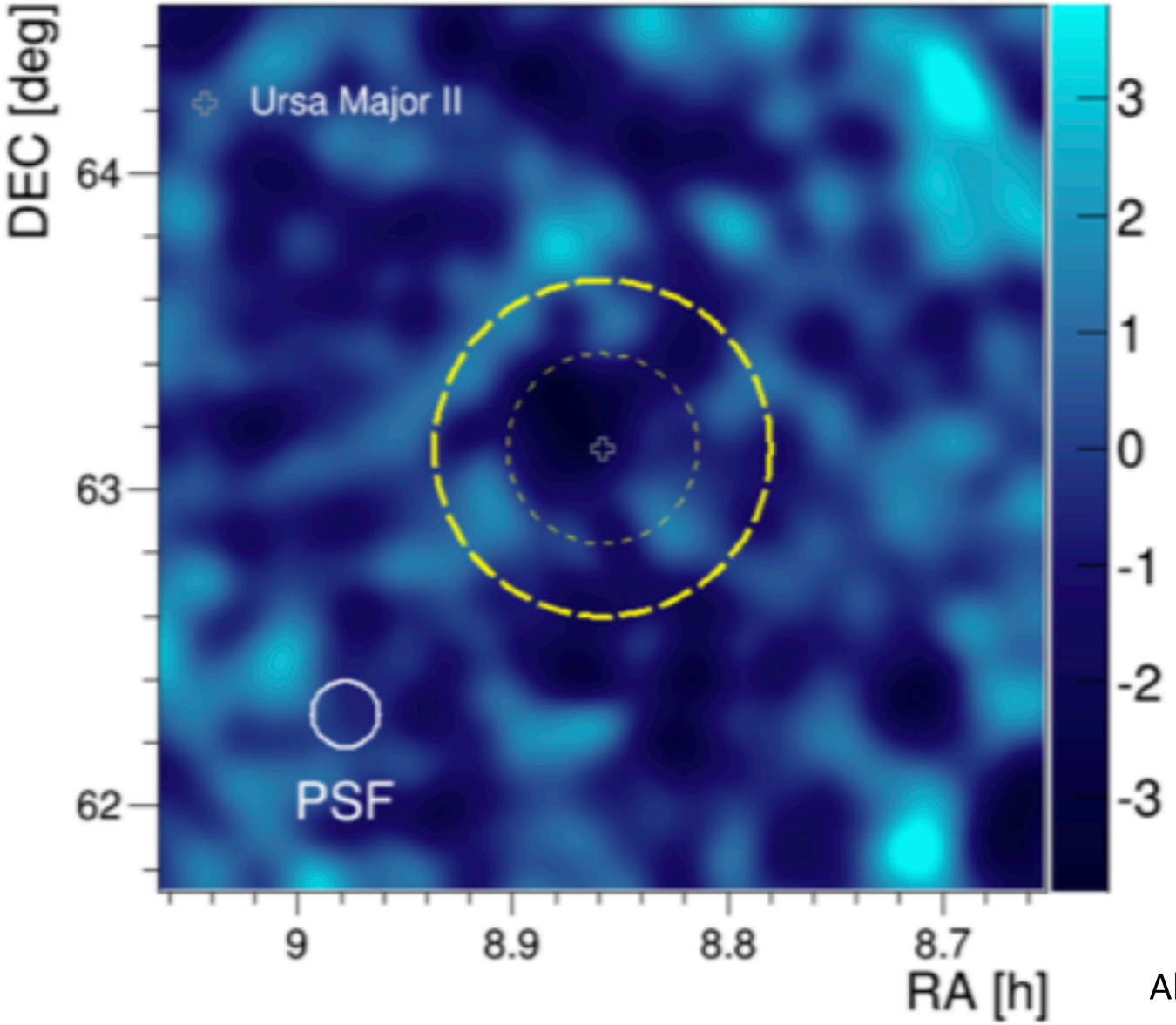
  - Search for MW satellites
  - Gamma observations of the best targets to constrain DM

Indirect detection of DM annihilation



Ursa Major II

MAGIC data



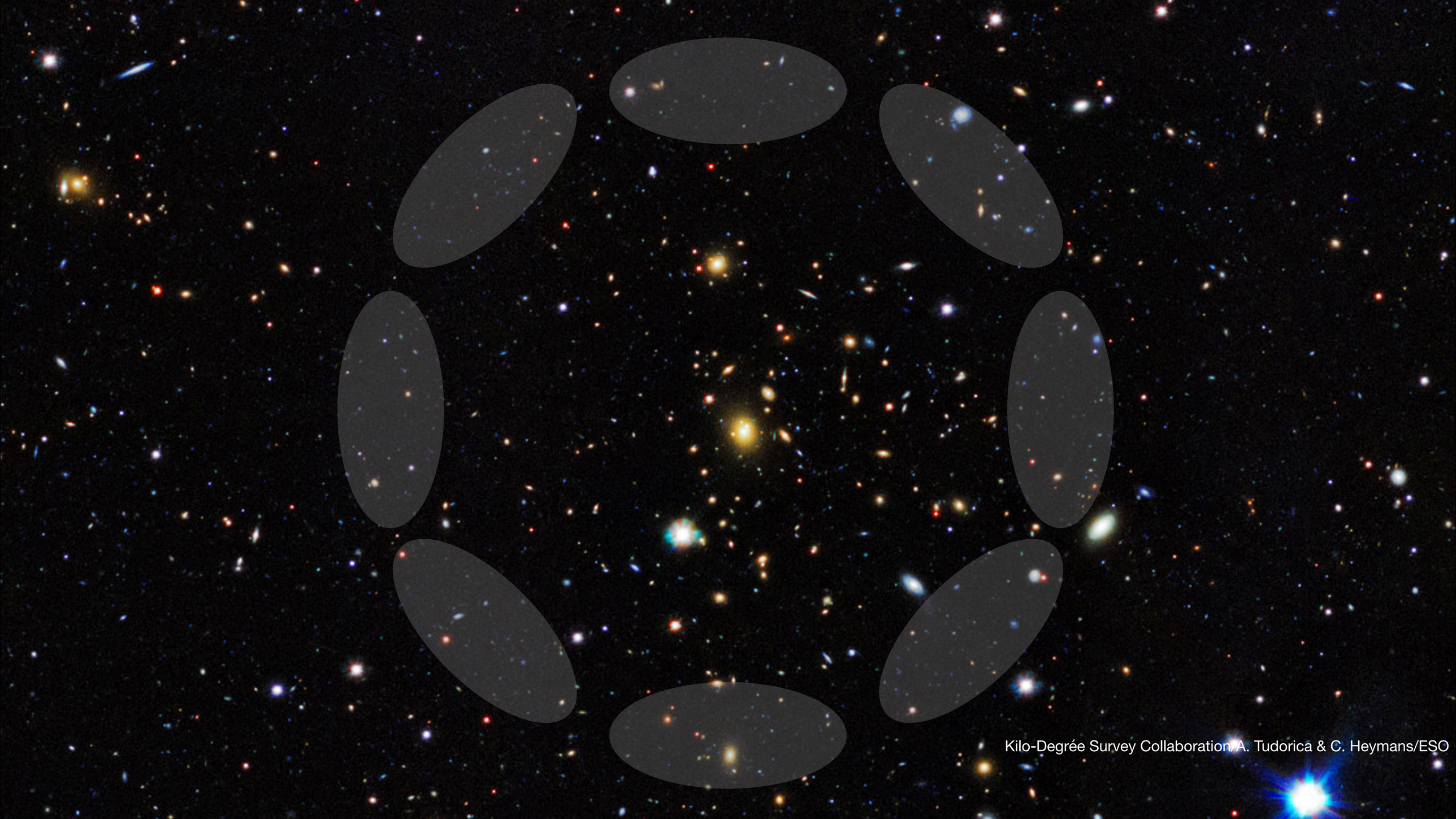
Ahnen et al. (2018)

Dark Matter in CIM

Projects

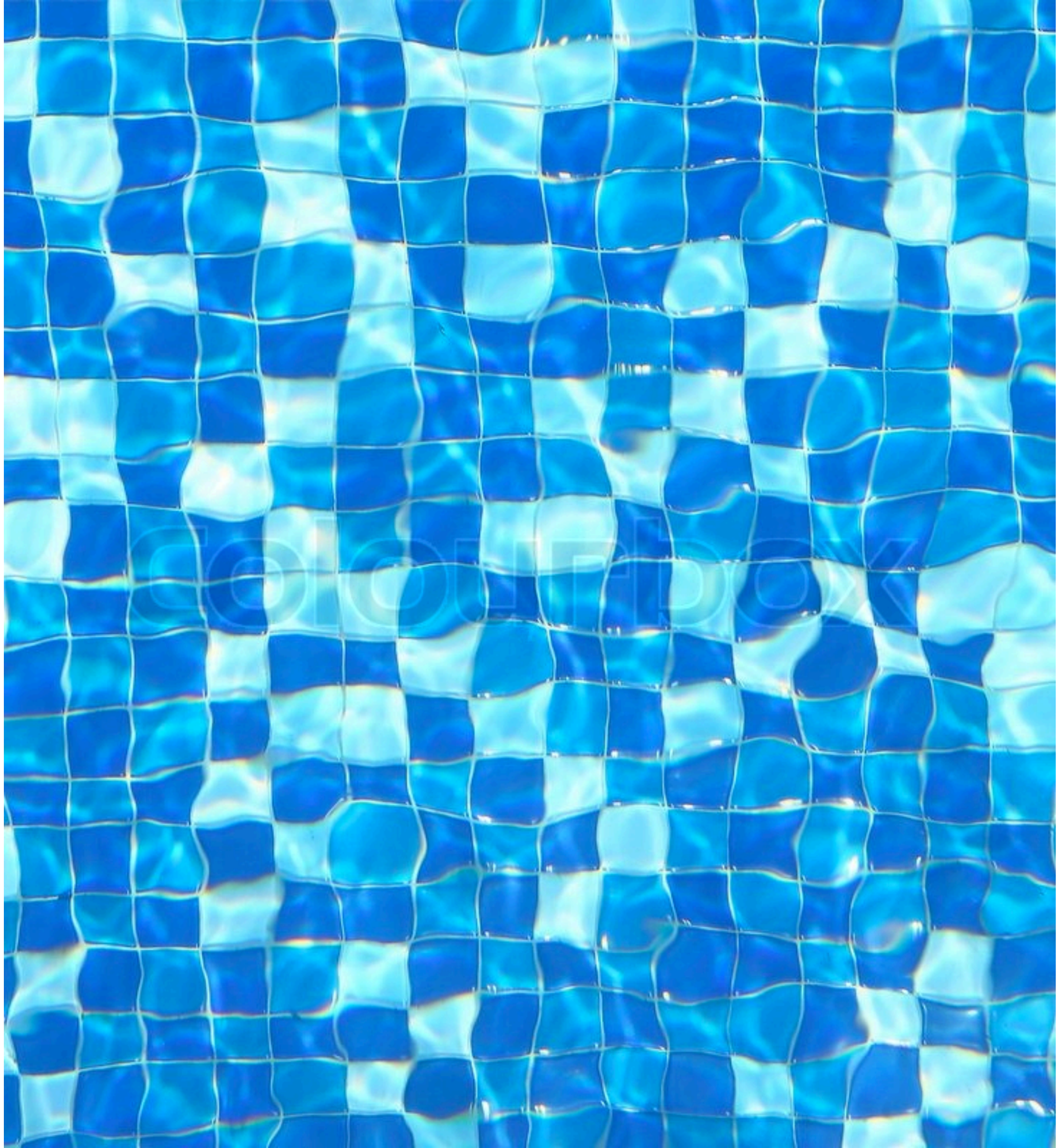
- F5
  - Search for MW satellites
  - Gamma observations of the best targets to constrain DM
  - Wide-field cross-correlation of DM maps and gamma data

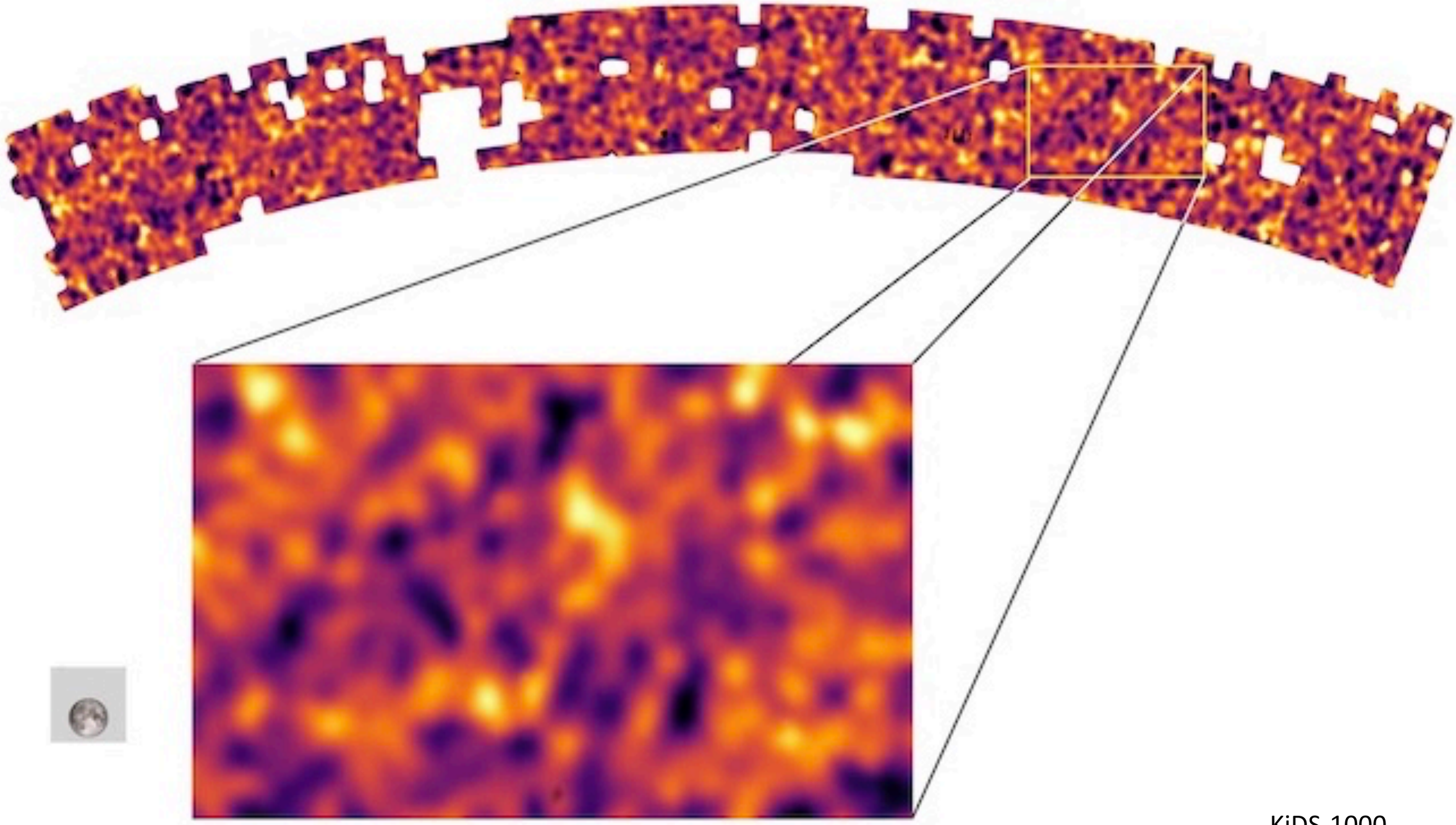

Credit: R. Schirdewahn



Kilo-Degrée Survey Collaboration, A. Tudorica & C. Heymans/ESO

Kilo-Degrée Survey Collaboration, A. Tudorica & C. Heymans/ESO



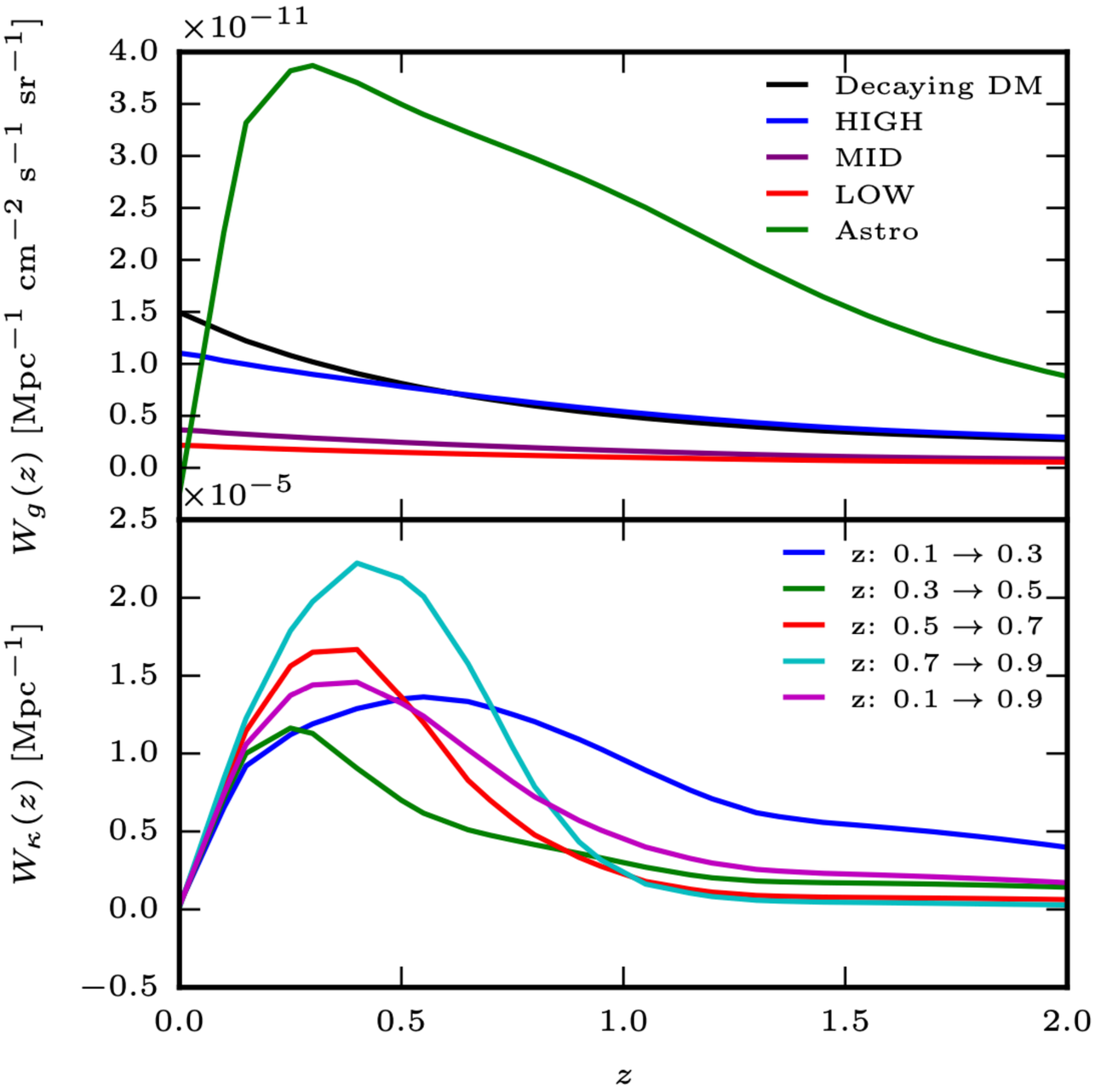


KiDS-1000

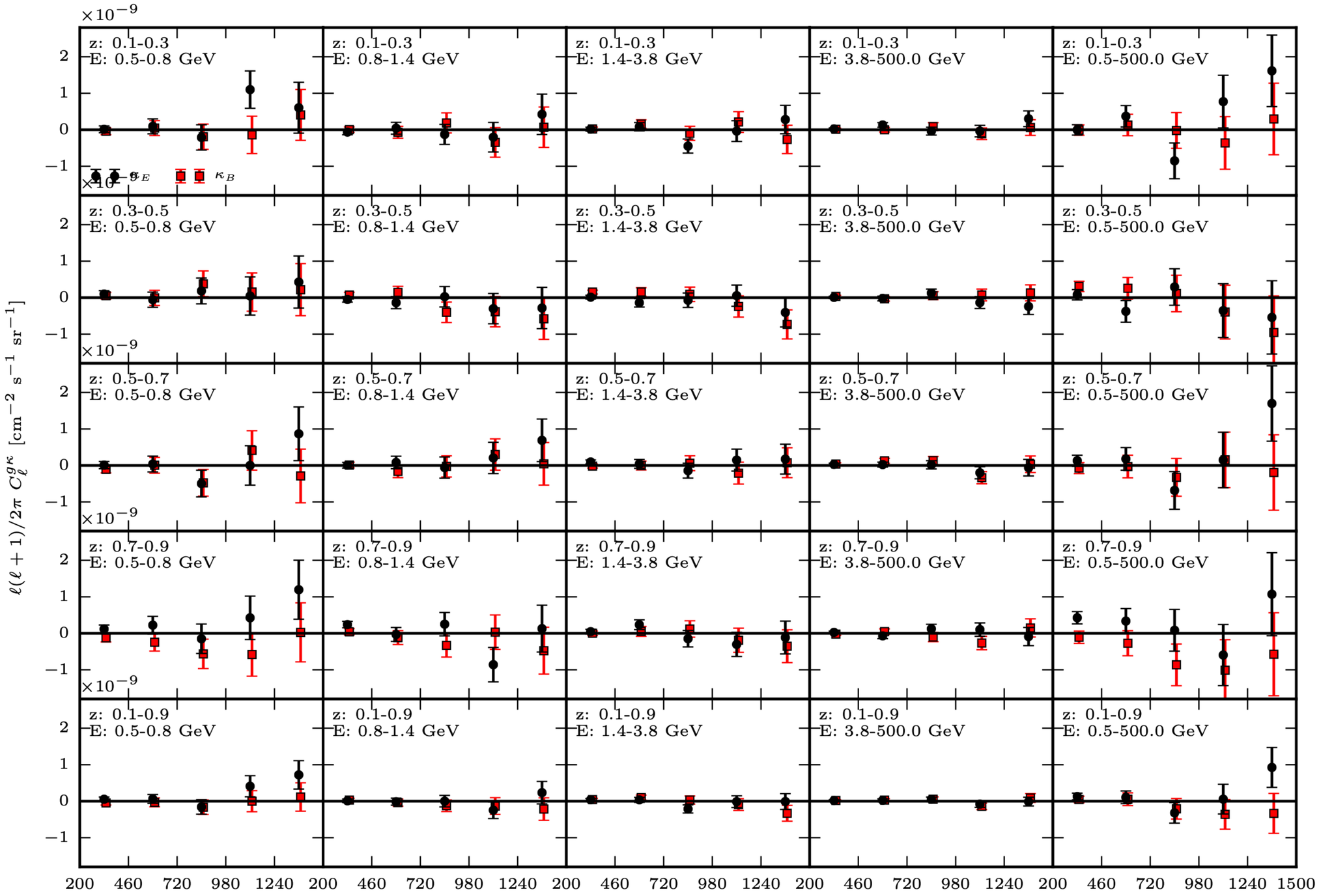
Redshift kernels

m_{DM} = 100 GeV

$\sigma_{ann}v = 3 \times 10^{-26}$ cm^{3}s^{-1}



Tröster et al. (2017)

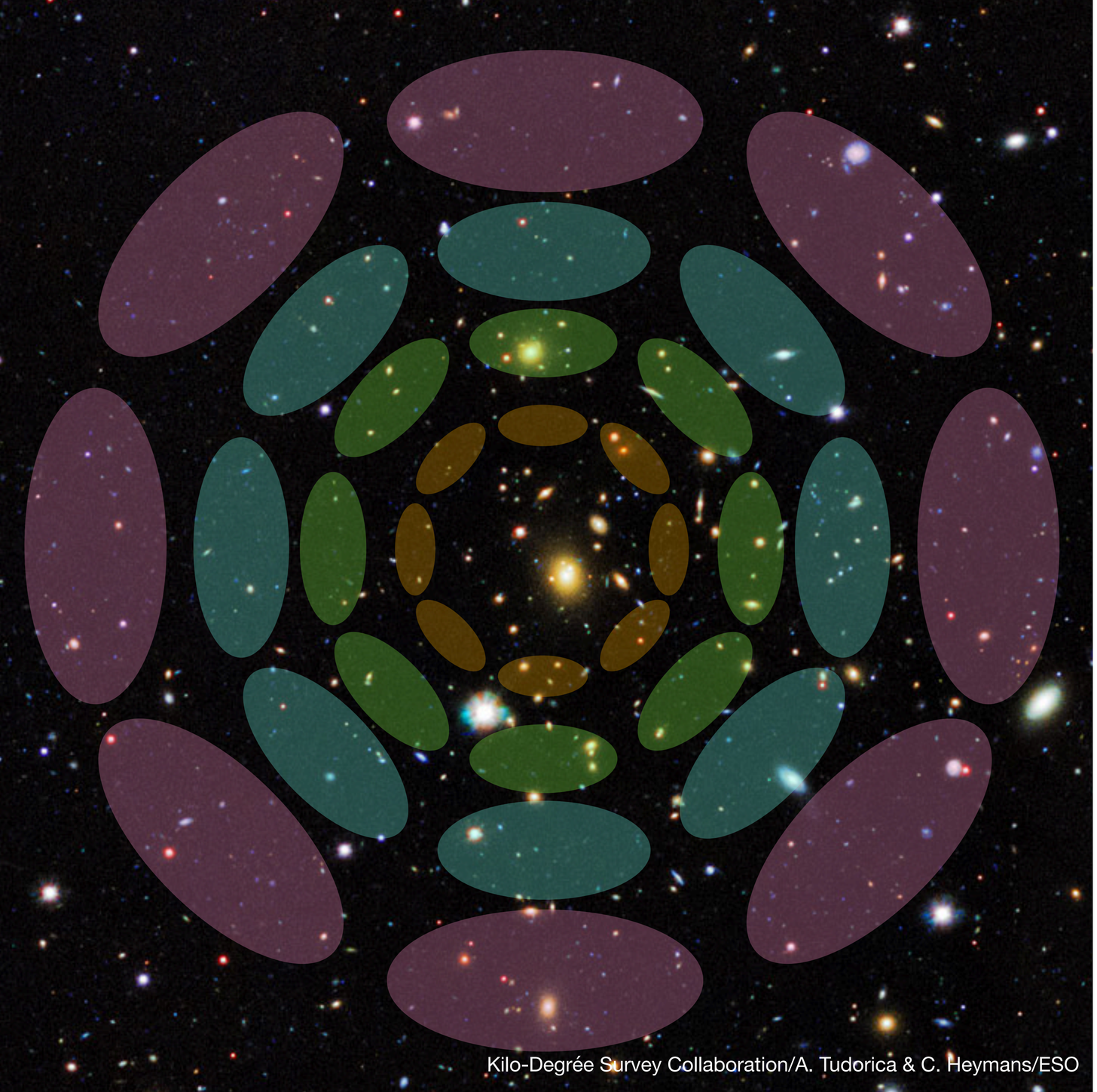


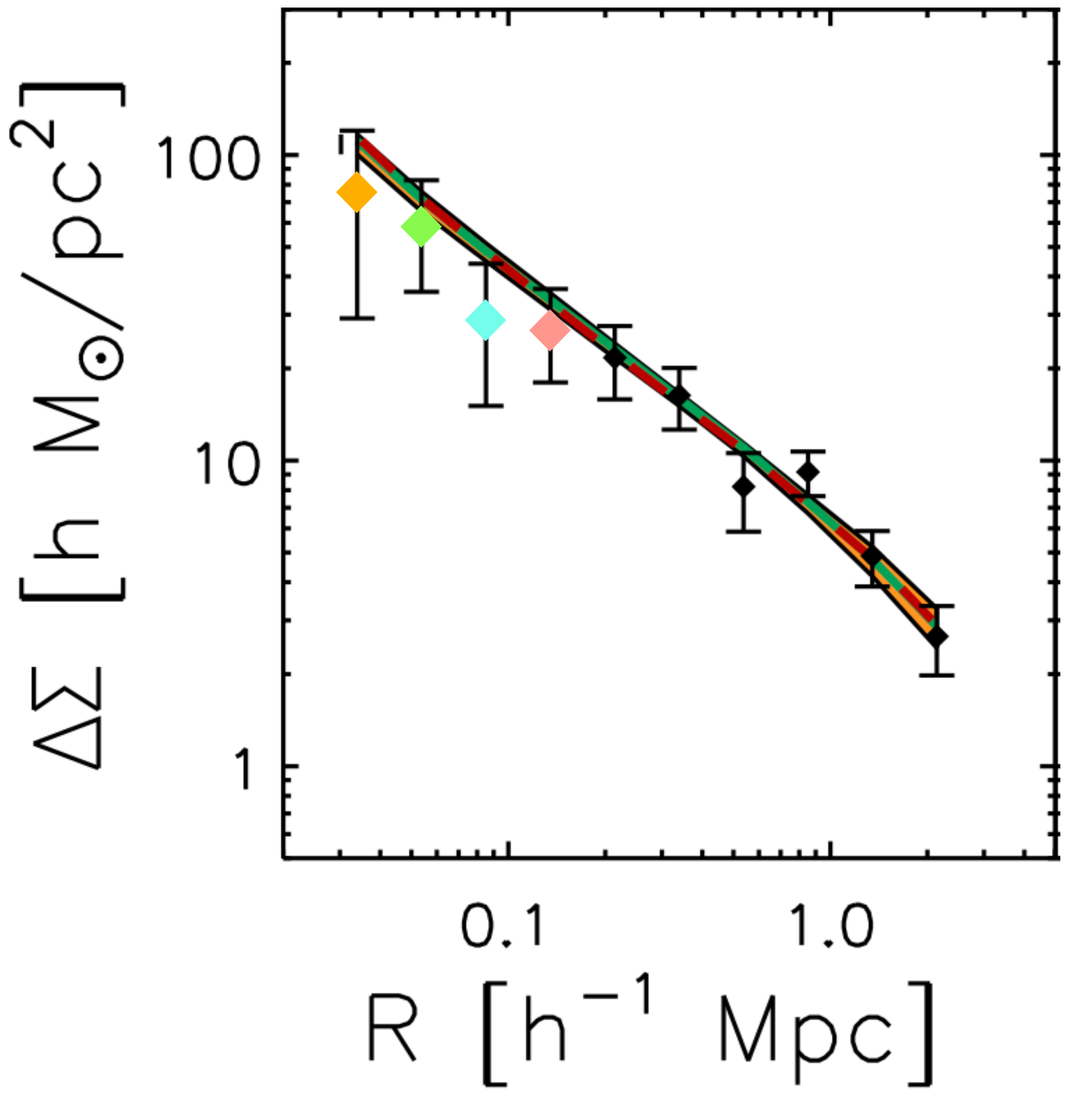
Tröster et al. (2017)

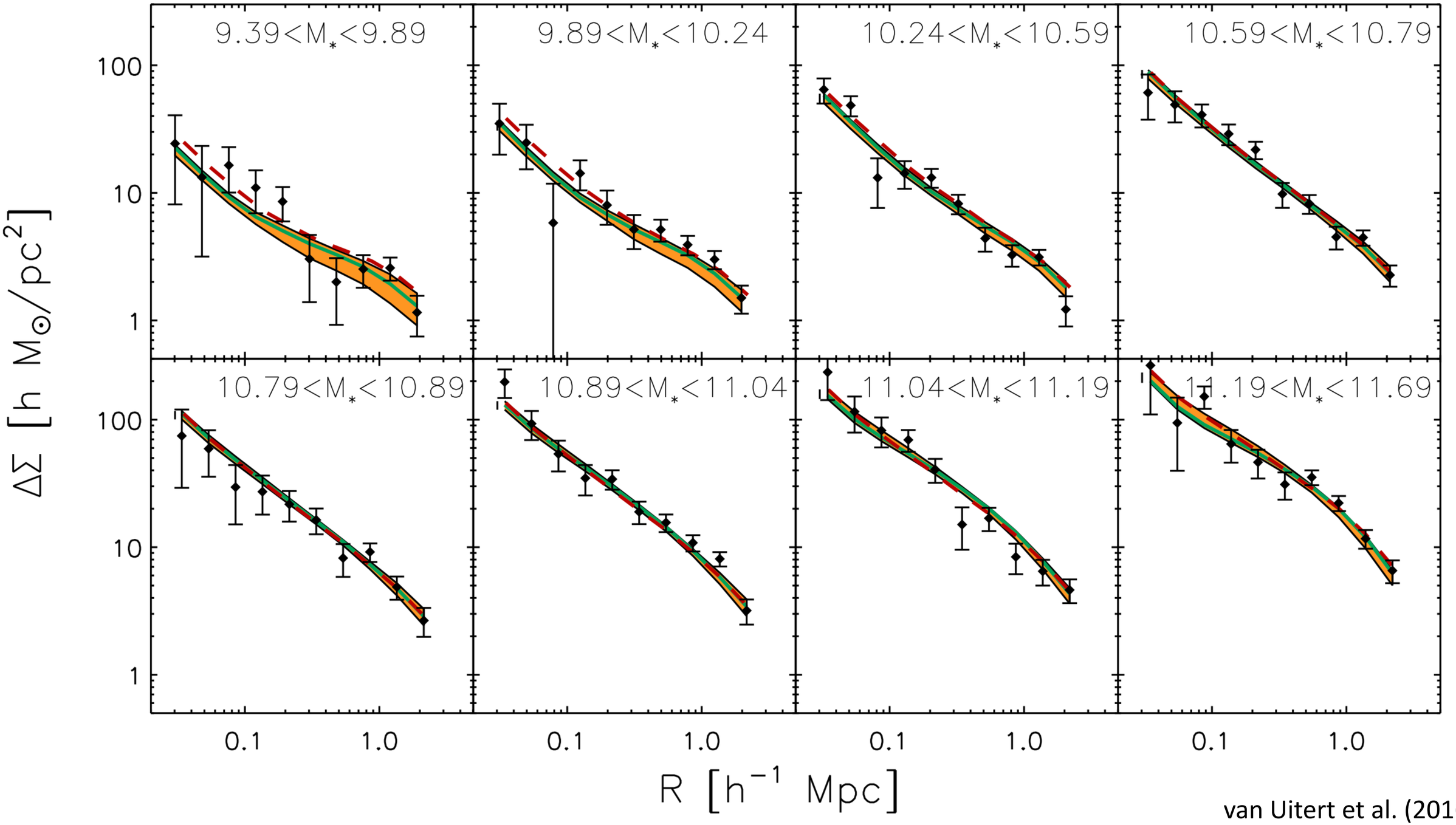
Dark Matter in CIM

Projects

- F5
  - Search for MW satellites
  - Gamma observations of the best targets to constrain DM
  - Wide-field cross-correlation of DM maps and gamma data
- F6
  - Constrain DM profiles of low-mass galaxies with galaxy-galaxy lensing


Kilo-Degrée Survey Collaboration/A. Tudorica & C. Heymans/ESO


ΔΣ [h M⊙/pc²]
100
10
1
0.1
1.0
R [h⁻¹ Mpc]



van Uitert et al. (2016)

Dark Matter in CIM

Projects

- F5
  - Search for MW satellites
  - Gamma observations of the best targets to constrain DM
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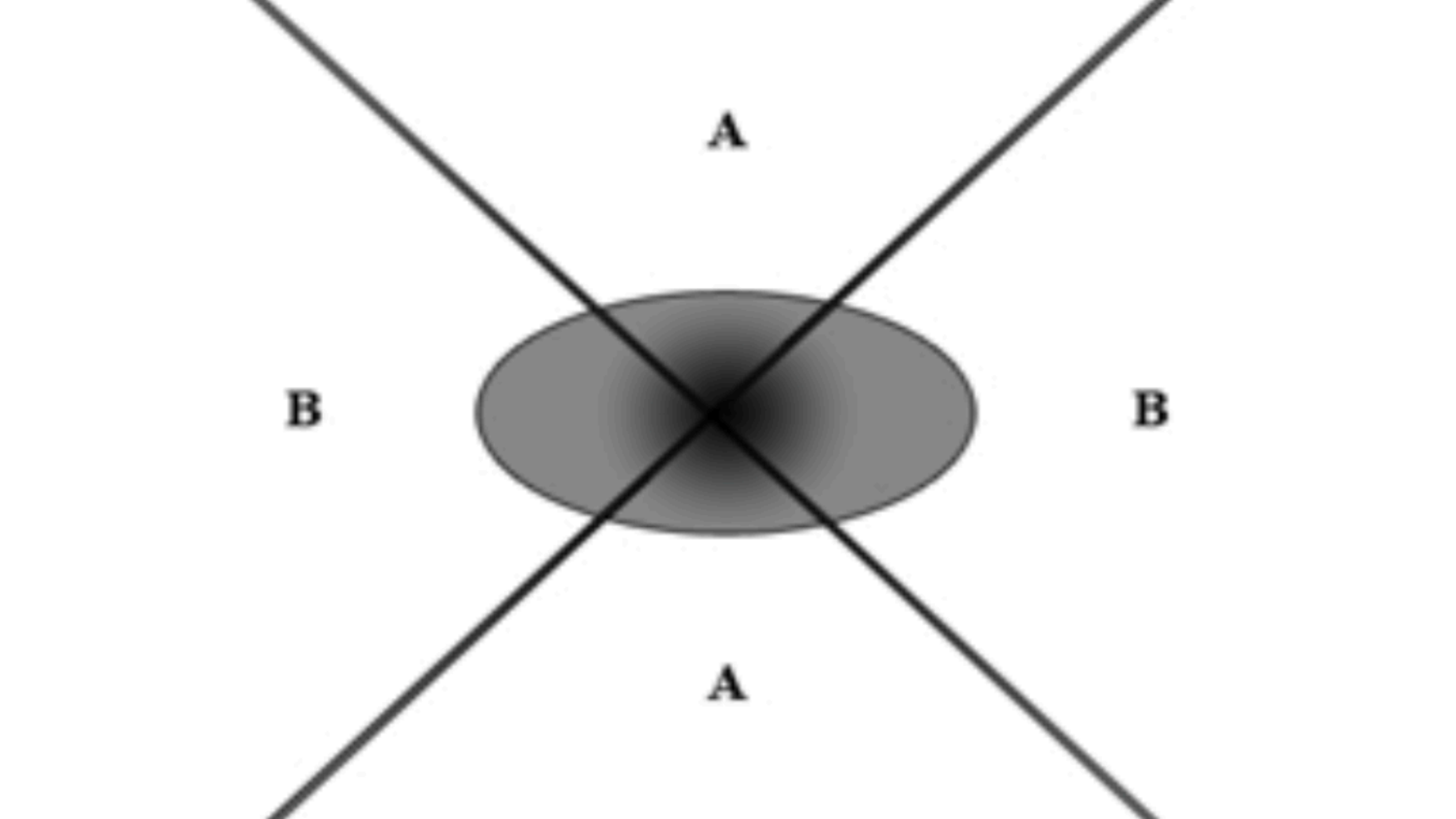
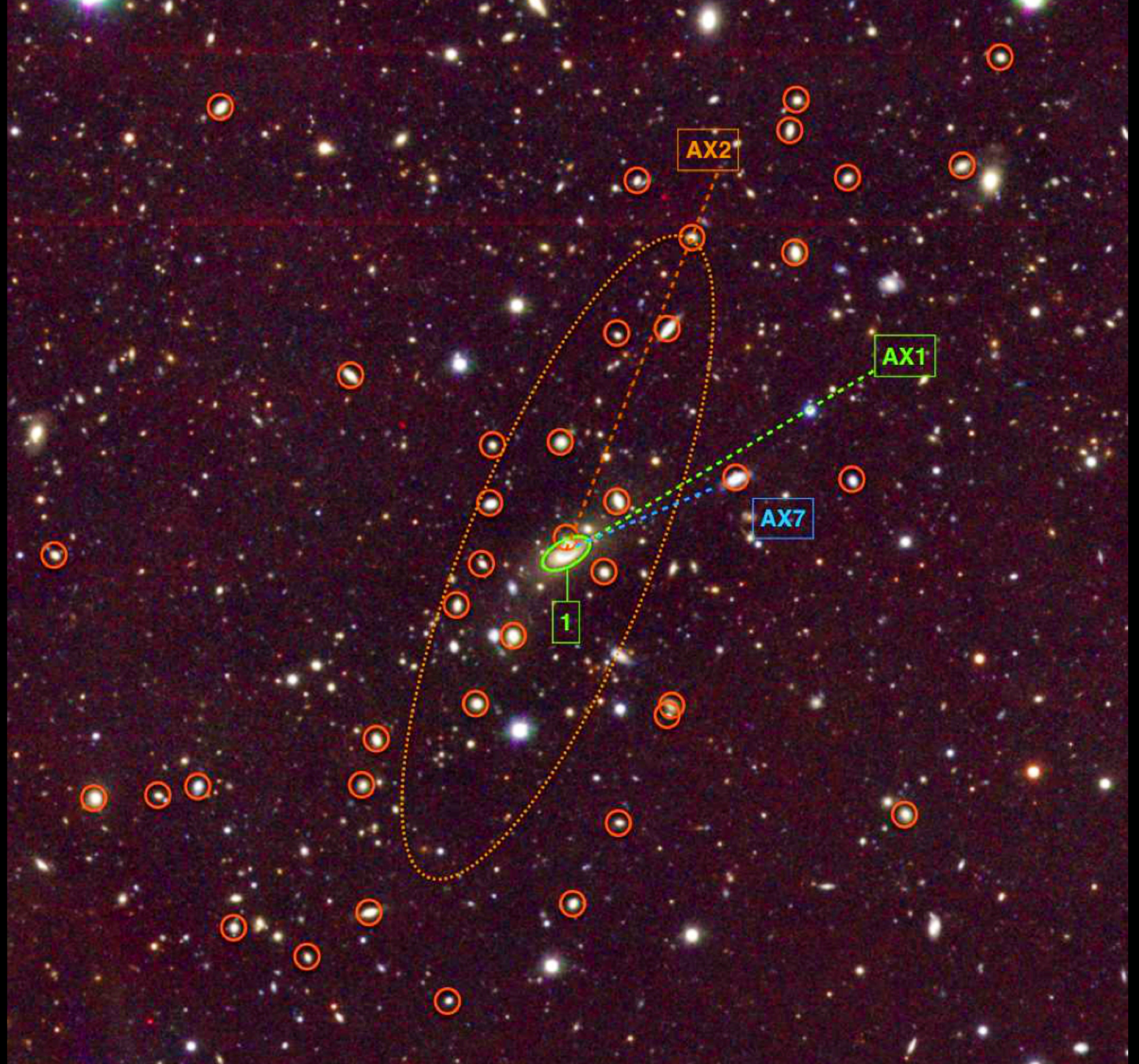
  - Constrain DM profiles of low-mass galaxies with galaxy-galaxy lensing
  - Alignment of stellar light and DM halos, ellipticity/triaxiality of halos

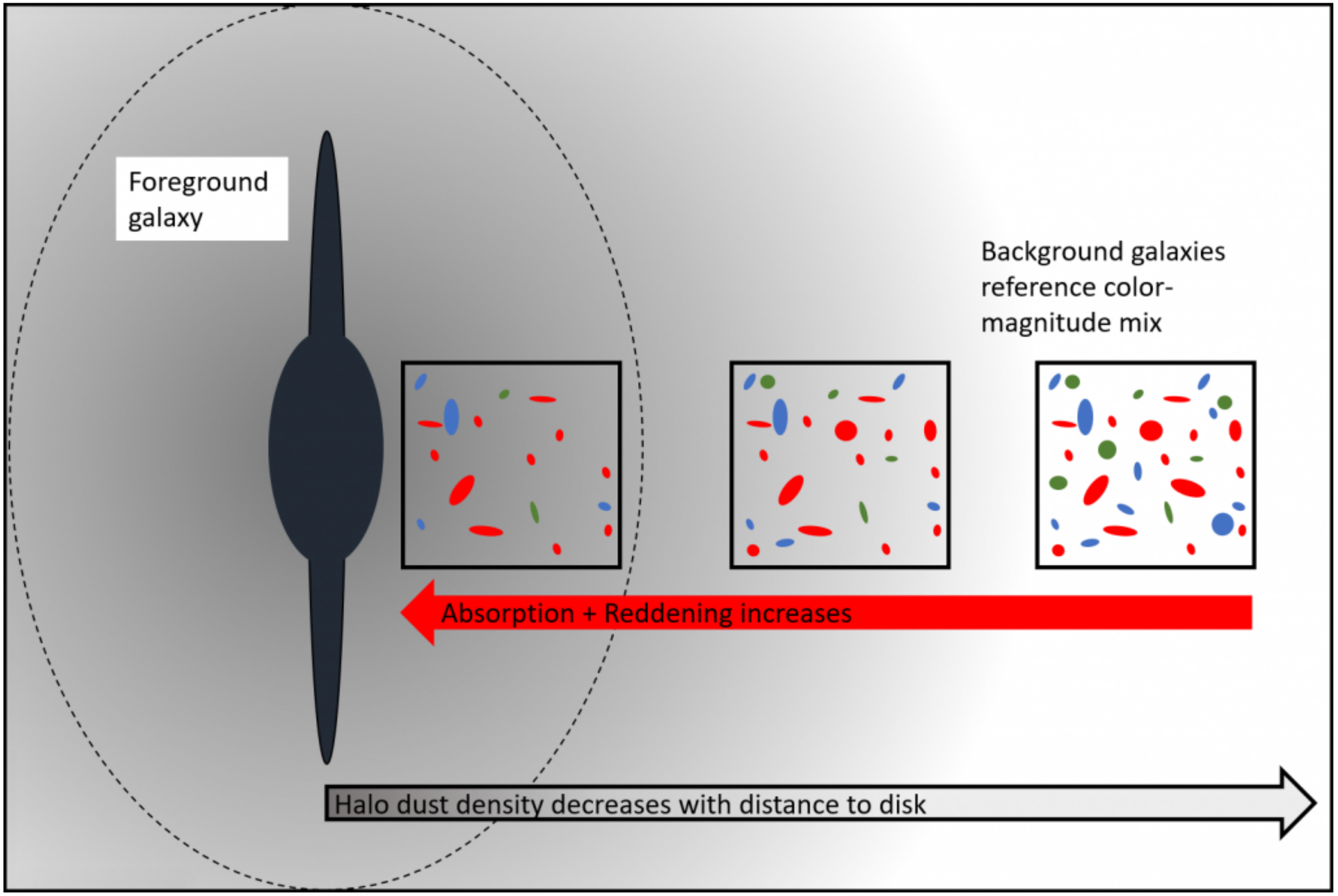

A
B
B
A

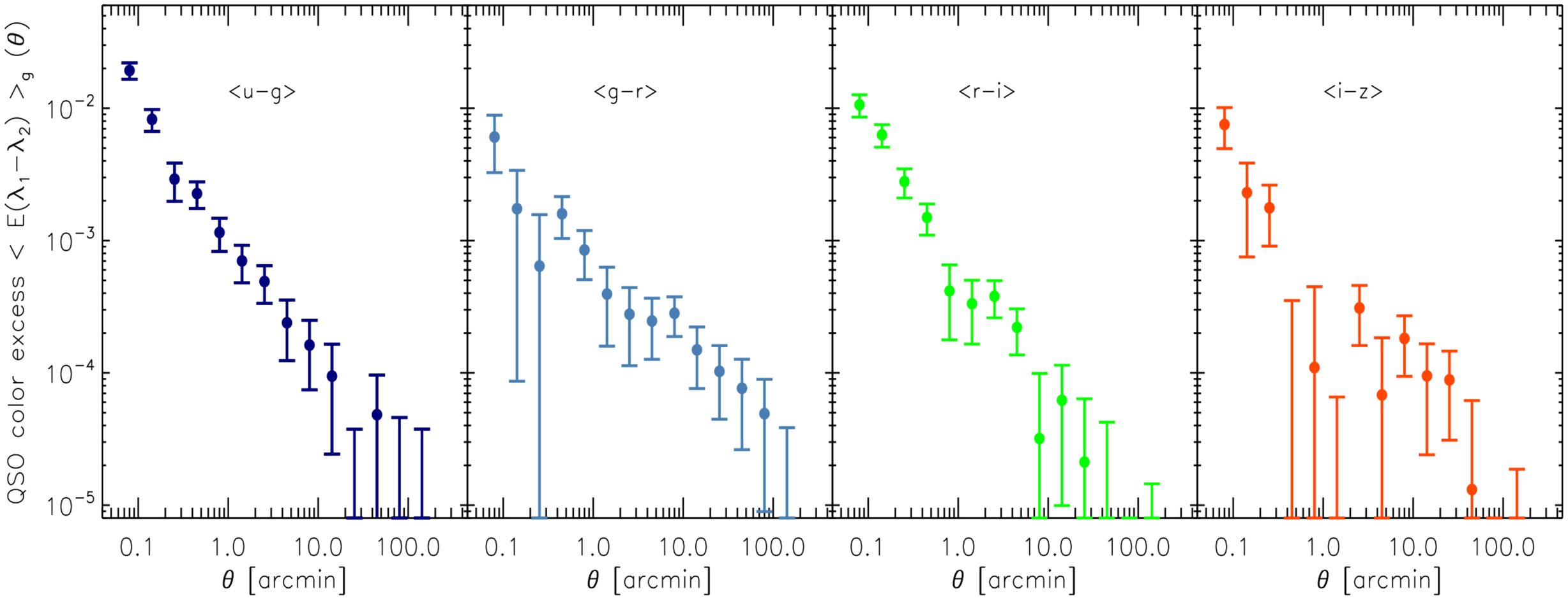

AX2
AX1
AX7
1

Dark Matter in CIM

Projects

- F5
  - Search for MW satellites
  - Gamma observations of the best targets to constrain DM
  - Wide-field cross-correlation of DM maps and gamma data
- F6
  - Constrain DM profiles of low-mass galaxies with galaxy-galaxy lensing
  - Alignment of stellar light and DM halos, ellipticity/triaxiality of halos
  - Dust measurements around same samples and 100 largest edge-on galaxies


Foreground galaxy
Background galaxies reference color-magnitude mix
Absorption + Reddening increases
Halo dust density decreases with distance to disk



Menard et al. (2010)

Personell

- F5
  - Stefan Fröse (PhD student; TUD)
  - Anna Wittje (PhD student; RUB)
  - Shiyang Zhang (master student in Leiden) starting PhD at RUB Nov 1st.
  - 2 master students (Tristan Gradetzke, Yasha Franz) at TUD.
- F6
  - Adam Enders (PhD student; RUB, Bomans)
  - Hiring round for 2nd position (RUB, Wright)

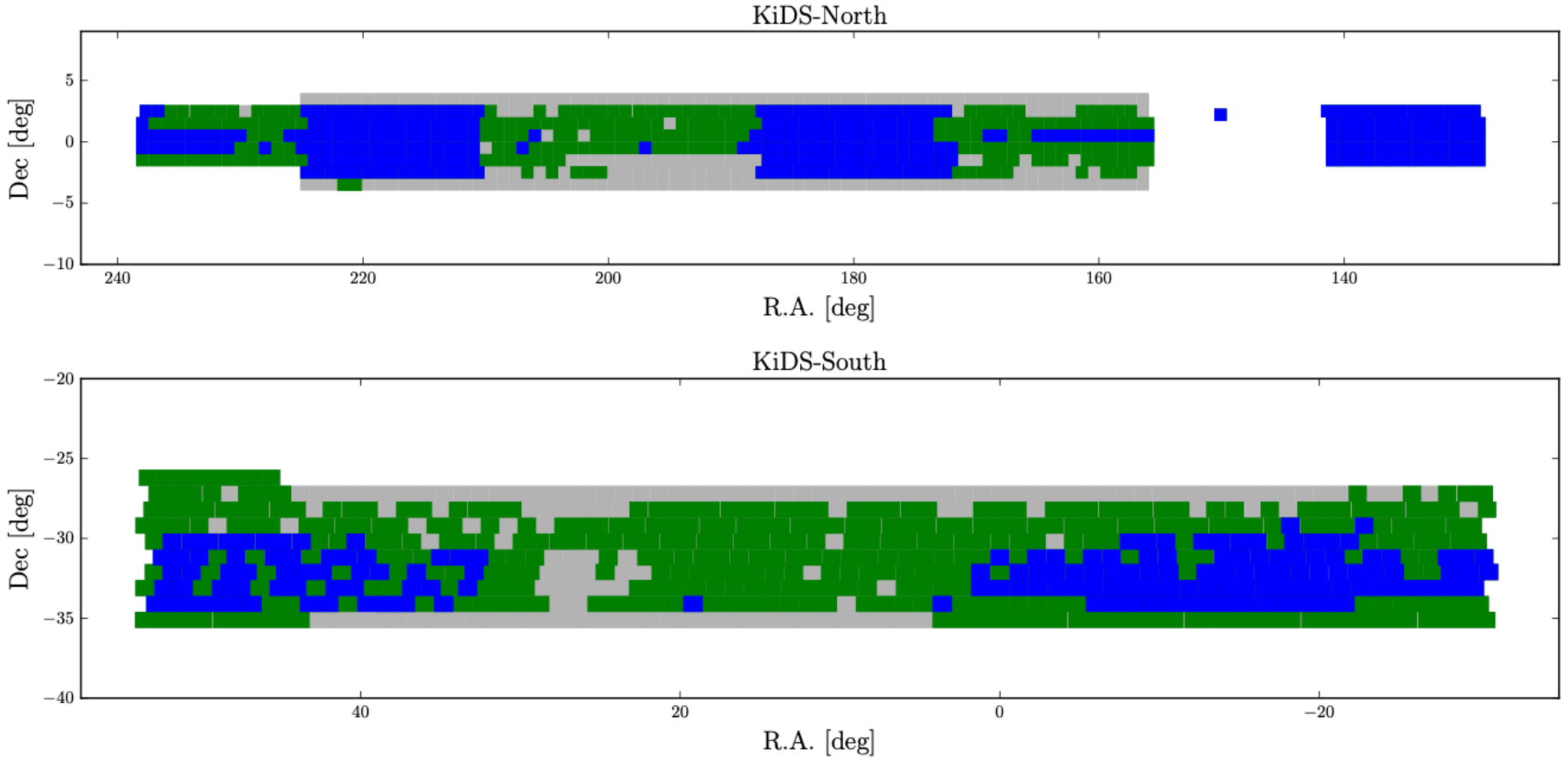
Work update

Data preparation
optical/NIR, RUB

- Final KiDS-DR5 (*ugriZYJHK*$_s$) is approaching the finish line.
- CFIS-3500 (*ur*) has just been released internally.
- UNIONS-800 (*ugriz*) as a testbed for future UNIONS data.
- Significant efforts in the Euclid and LSST@Rubin/DESC consortia.

KiDS-DR5

Coordination: Angus Wright

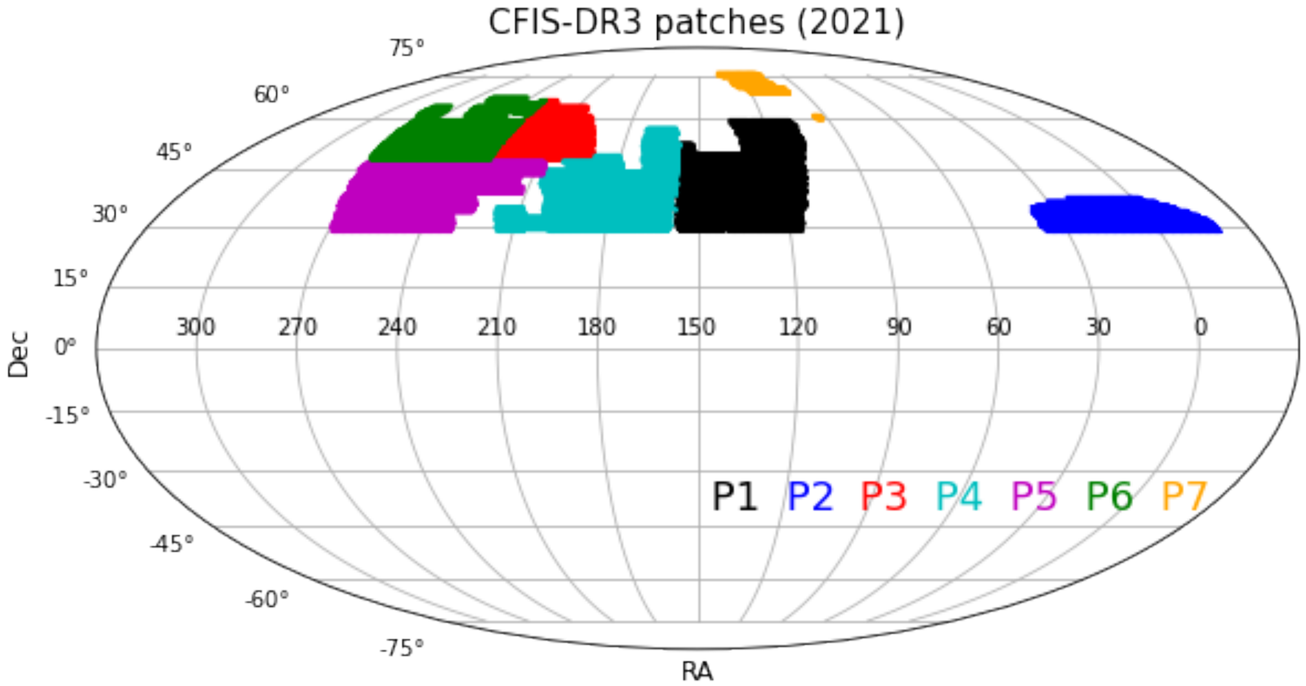


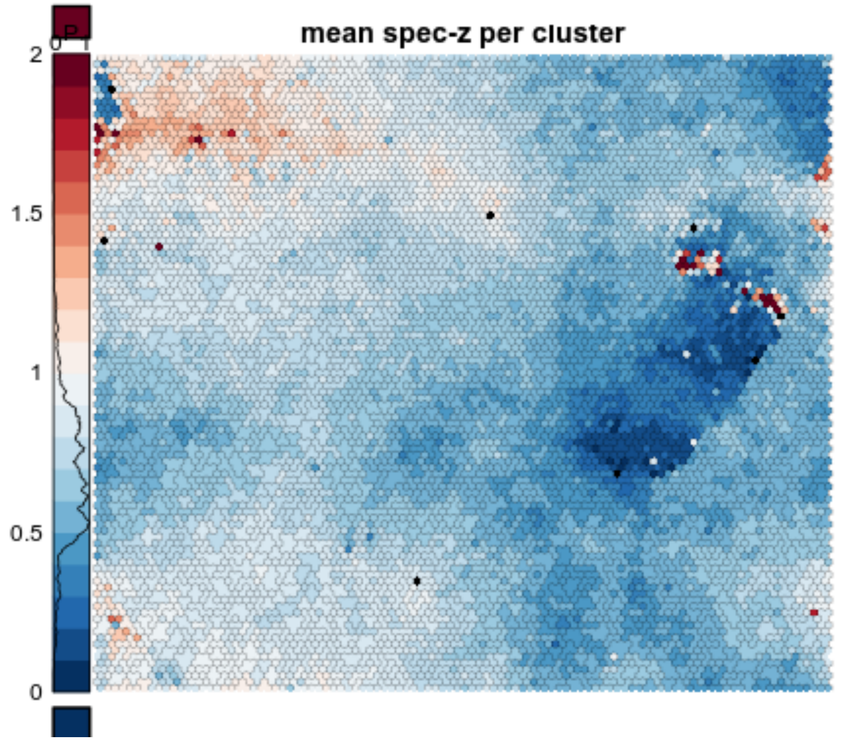
DR3 DR4 DR5

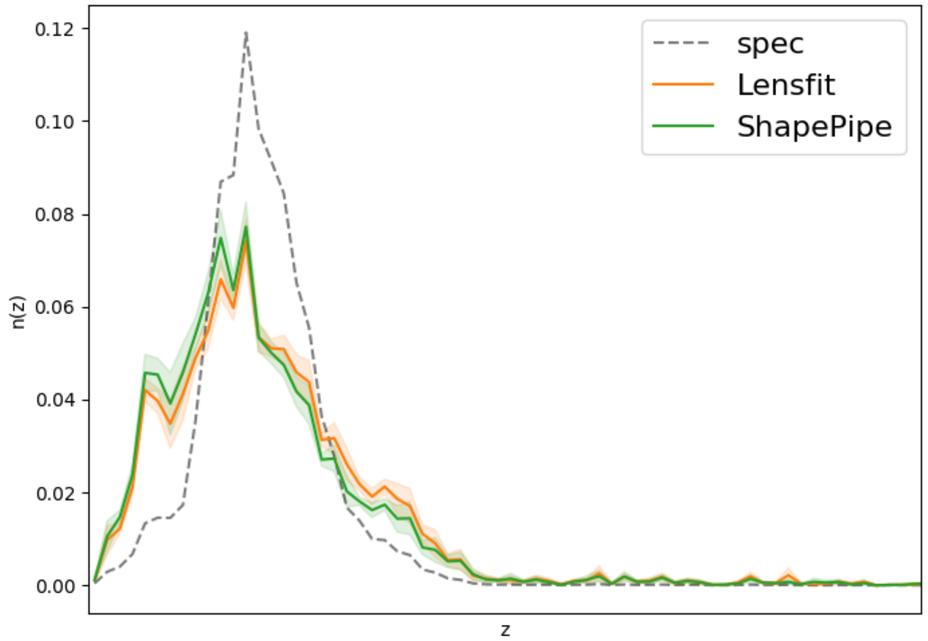
Kuijken et al. (2019)

CFIS-3500

n(z) determination by Anna W.







Large-scale structure

Master thesis by Tristan Gradetzke (TU Dortmund)

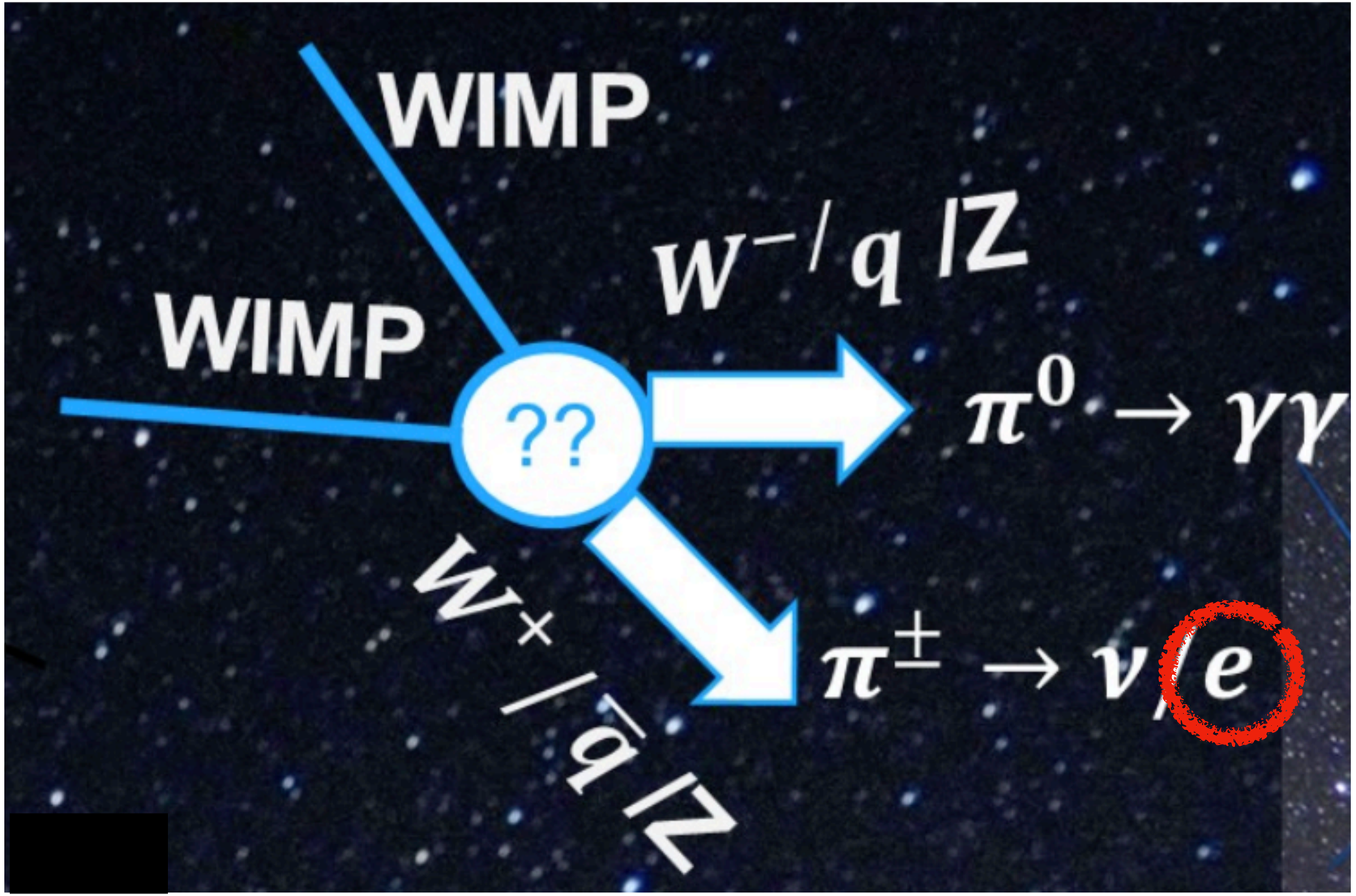
- Meeting of the TUD and RUB groups for coordination.
- MAGIC archive research: Is there any data that can be used for cross-correlation science now? Overlap with optical/NIR surveys.
- Pathfinder for cross-correlations between optical/NIR (KiDS-VIKING, CFIS/UNIONS, LSST, Euclid) and gamma data (Fermi, CTA).
- Bi-directional transfer of expertise and - maybe most importantly - getting used to each other’s language.

Connection with/extension to the radio

TUD & RUB, F5 & F6

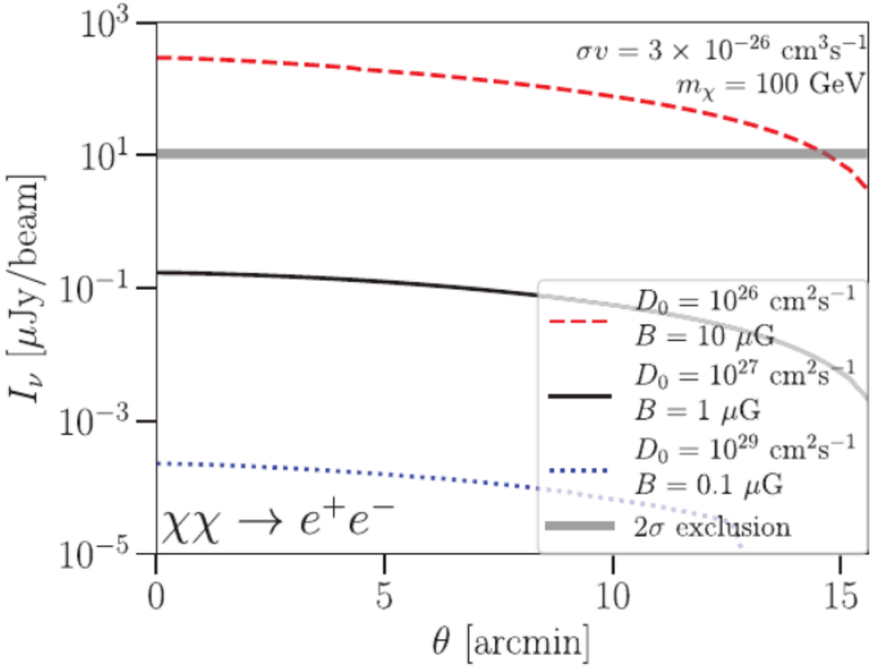
- Getting involved in development of software “clumpy”.
- Include predictions for radio fluxes.
- Letter of intent for LOFAR observations of dwarf galaxies (DM search).

Indirect detection of DM annihilation



DM constraints with LOFAR

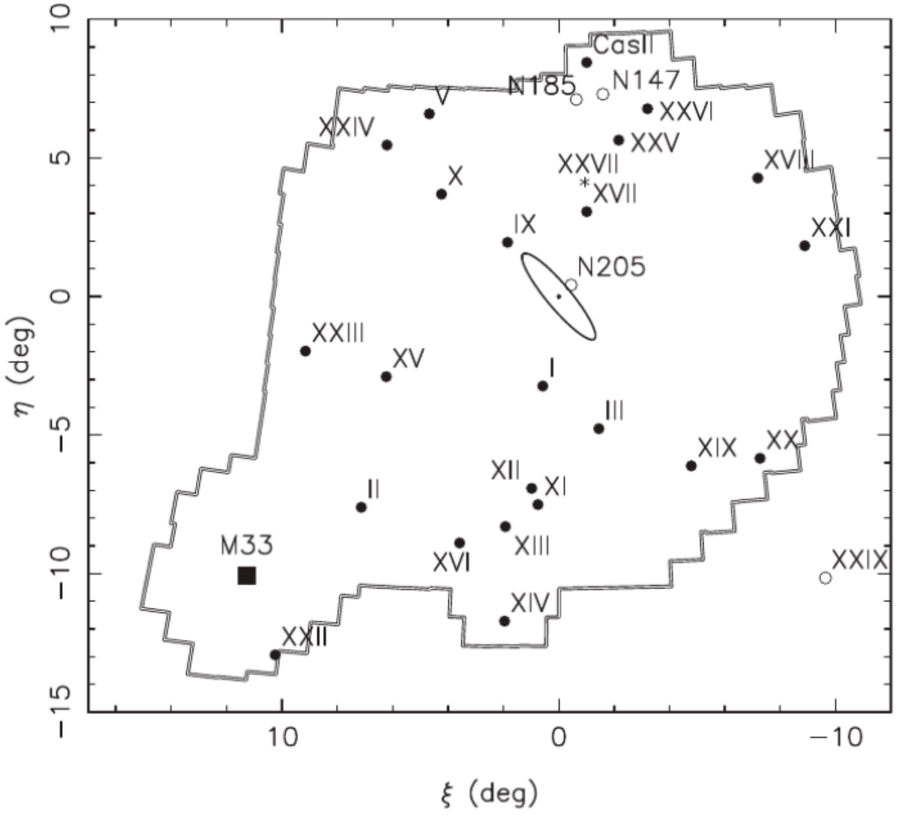
Canes Venatici I (MW halo dSph)



No-detection at 2σ = 11 μJy

Vollmann et al. 2020

Pilot project A2 & F5: M31 halo dSph
(WiHi: J. Teuchert)
Goal: limit for stack of 23 dSph with LOFAR LoTSS 150 MHz data



Distribution of Dsph around M31 from PandAS

Martin et al. 2016

Outlook

- Assemble the full team.
- Try out methods with existing data and simulations.
- Delays of Euclid (Soyuz launcher!) and LSST.
- **Learn from each other!**

Dark Matter

Presentations this week

- Anna Wittje, Wednesday morning: “Wide-field imaging surveys for weak gravitational lensing and galactic halo science”
- Angus Wright, Thursday morning: “Exploring feedback processes via shear-, magnitude-, and colour-position correlation functions”
- Stefan Fröse, Thursday afternoon: “Dark Matter Search: Gamma + Radio”