MULLARD SPACE SCIENCE LABORATORY
DEPARTMENT OF SPACE AND CLIMATE PHYSICS

Tracking the gas distribution in the Galactic Centre using neutrinos

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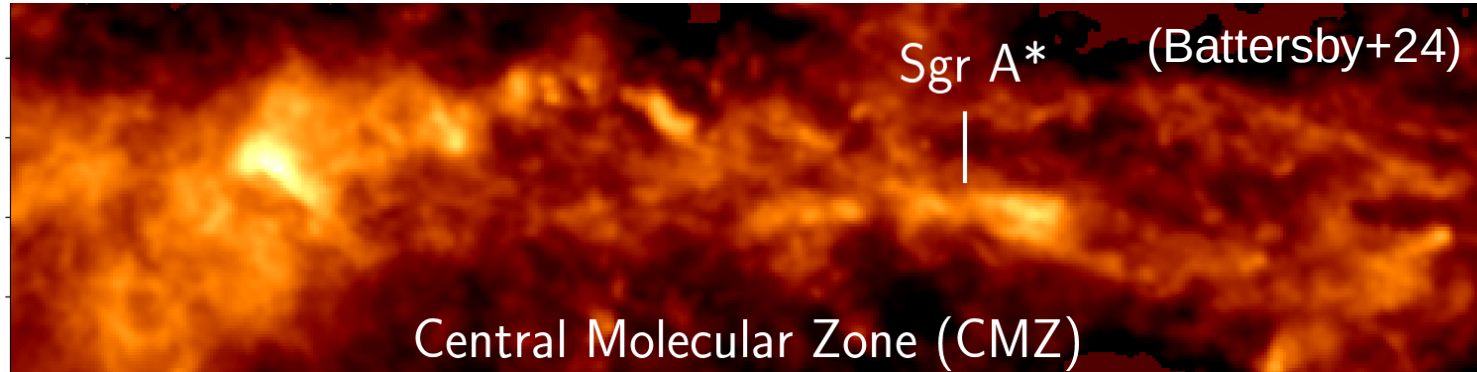
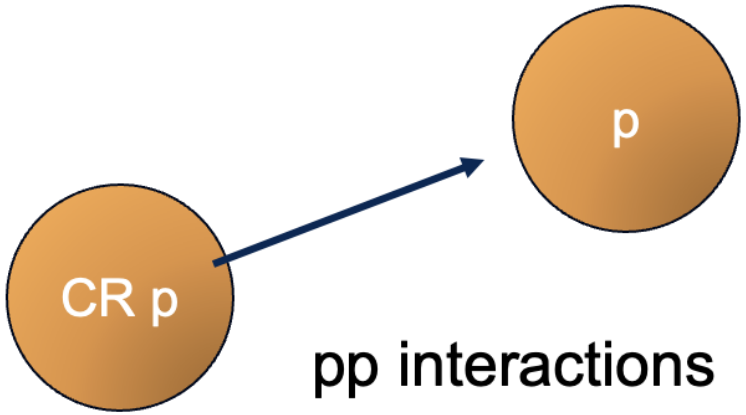
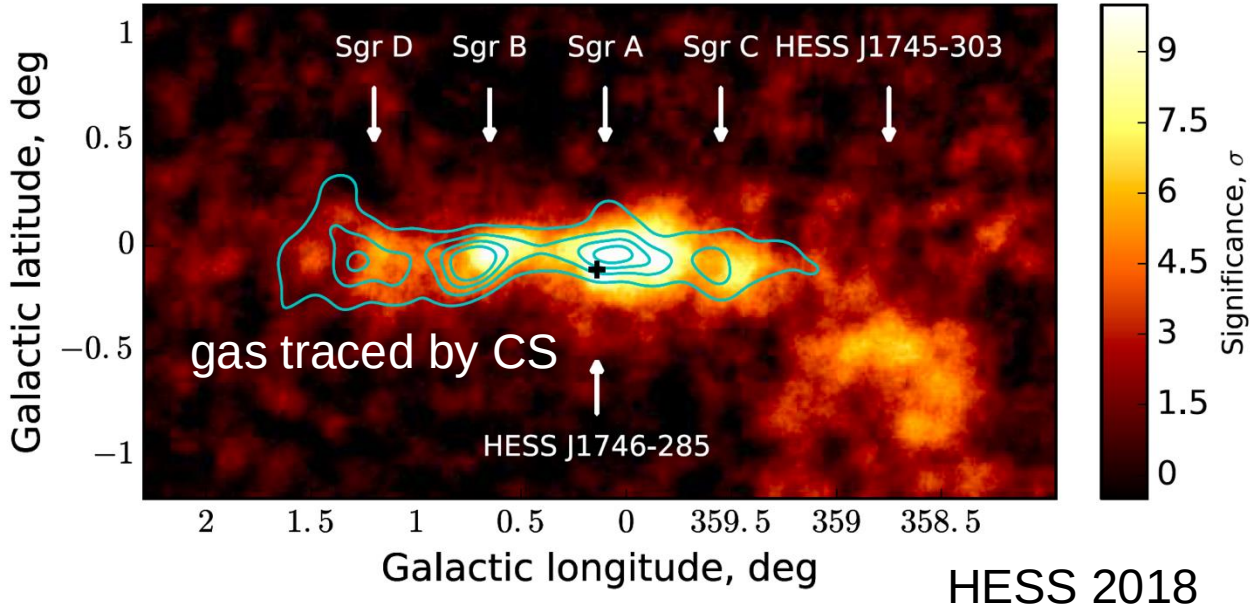
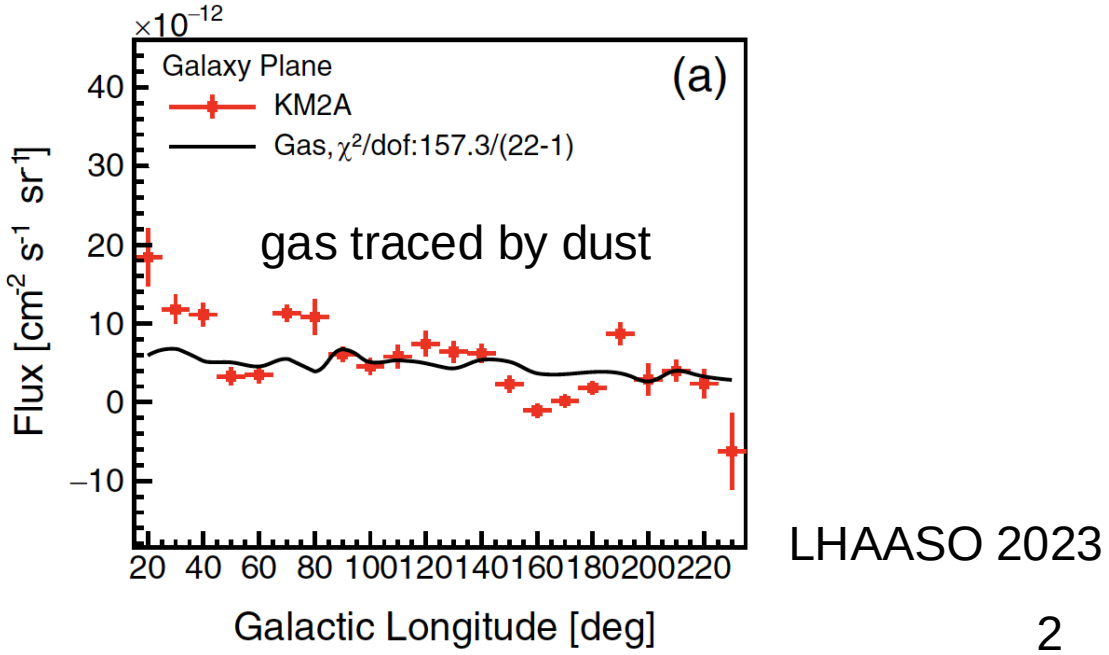
Cosmic rays and neutrinos in the multi-messenger era
9-13 Dec, Paris



The choice of gas tracer

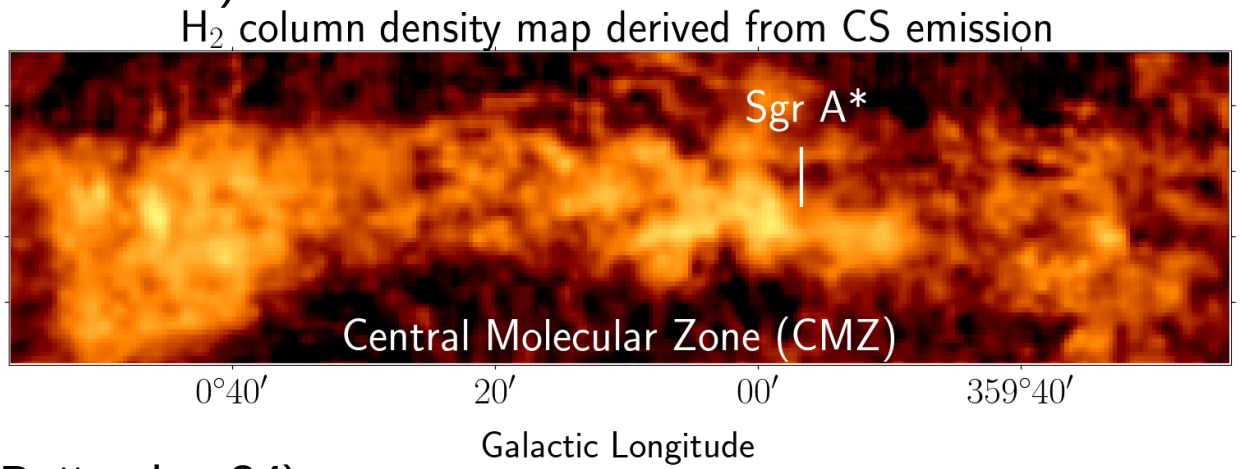




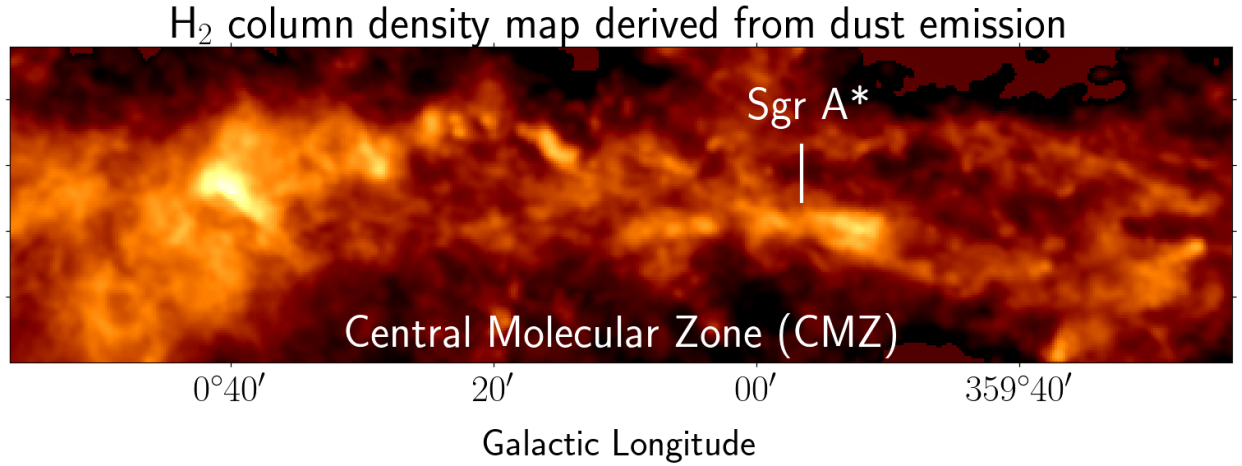


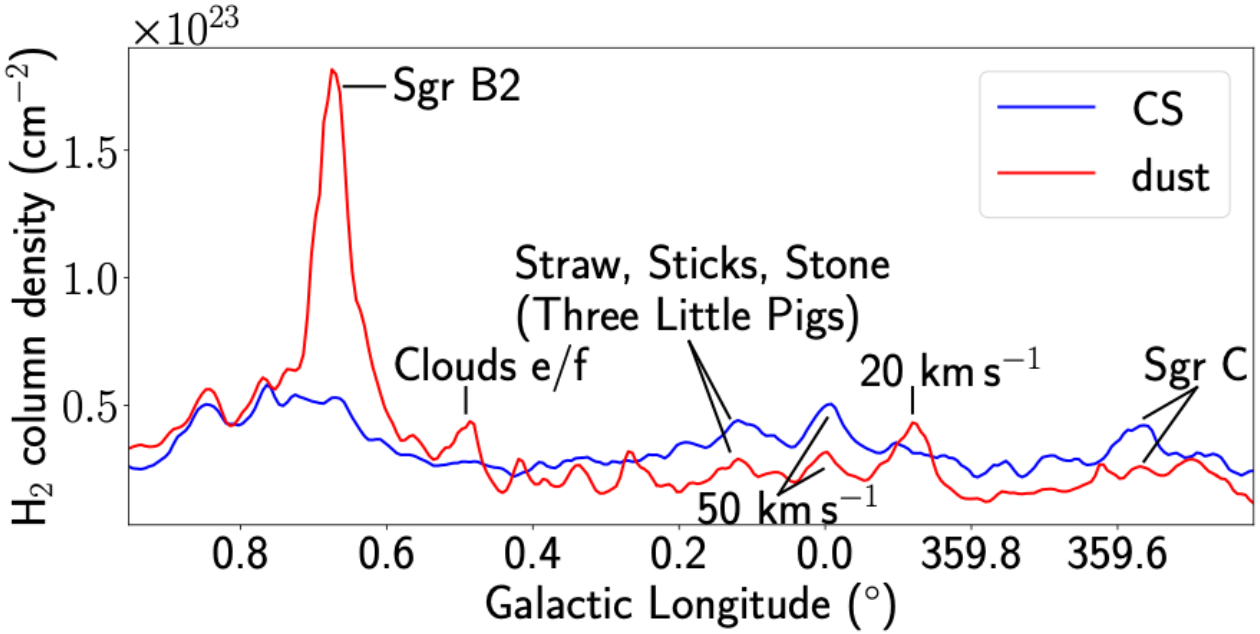
Molecular Clouds in the Galactic Centre

(Tsuboi+99)

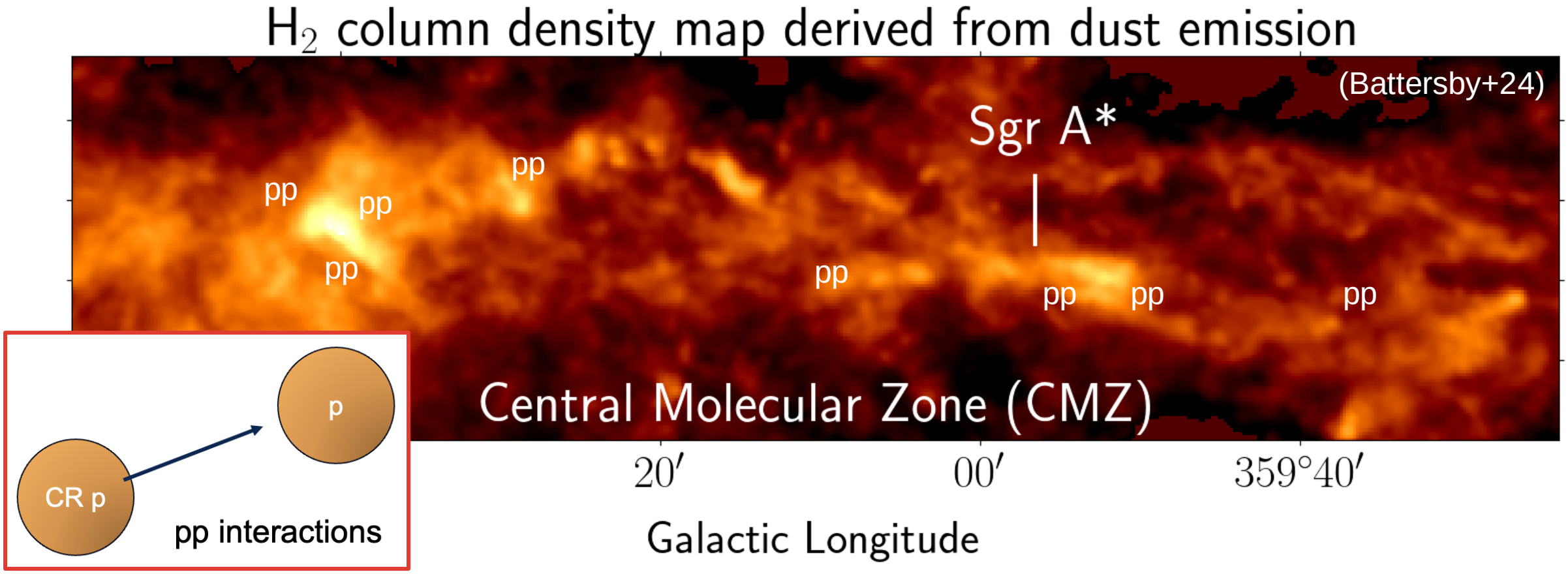


(Battersby+24)





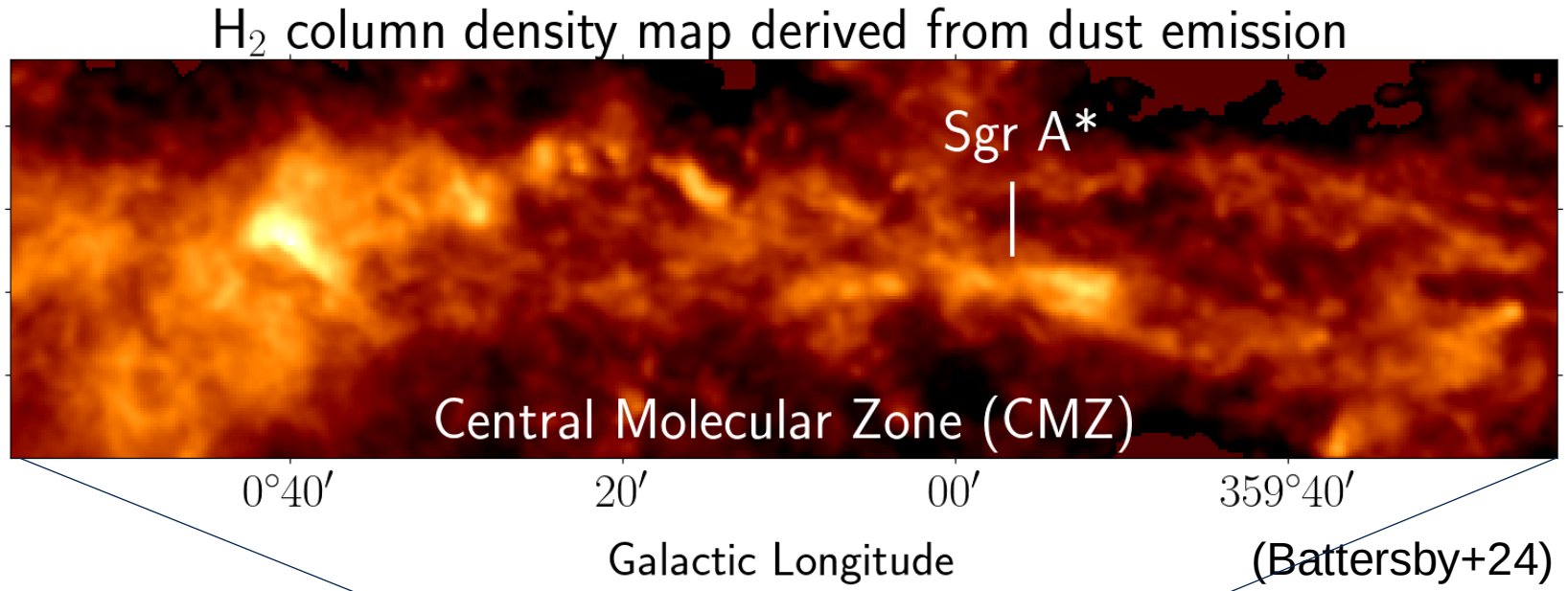
Probing the gas distribution with neutrinos



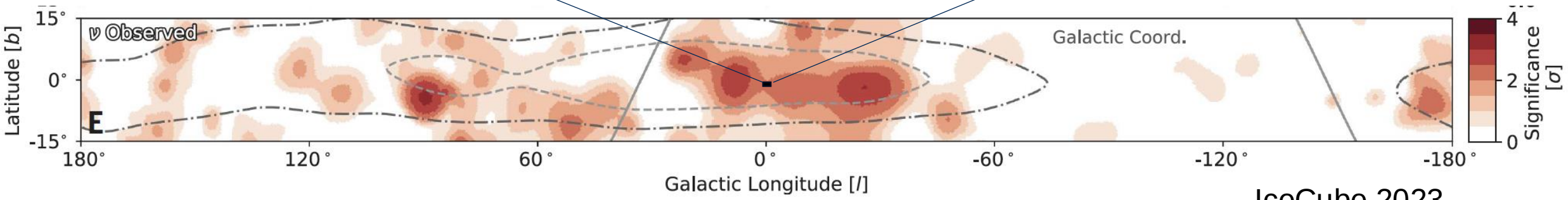
$$p + p \rightarrow \pi^+ + \pi^- + \pi^0 + \cdots$$

$$\pi^+ \rightarrow \mu^+ + \nu_\mu \rightarrow e^+ + \nu_e + \bar{\nu}_\mu + \nu_\mu$$
$$\pi^- \rightarrow \mu^- + \bar{\nu}_\mu \rightarrow e^- + \bar{\nu}_e + \bar{\nu}_\mu + \nu_\mu$$
$$\pi^0 \rightarrow 2\gamma$$

Neutrino Observation of the Galactic Centre

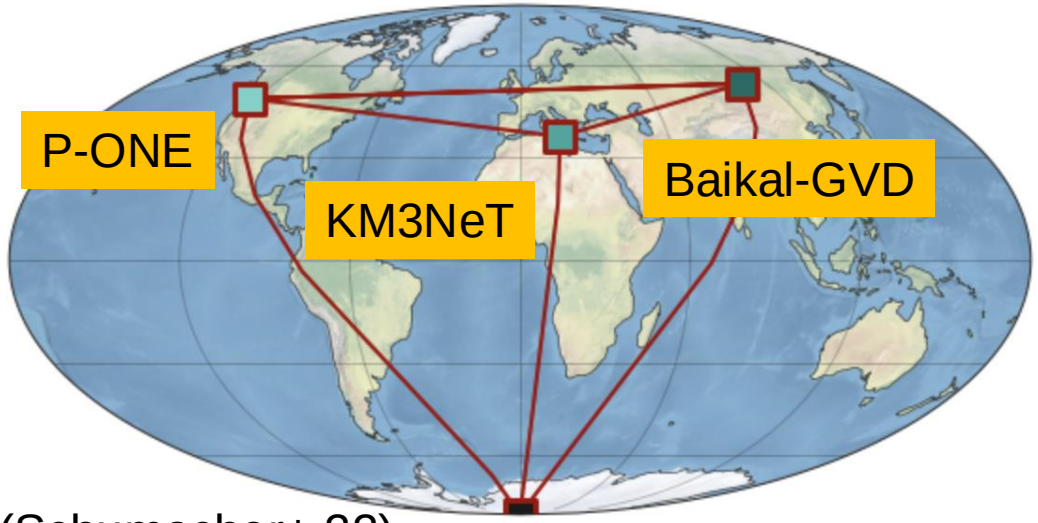


(Battersby+24)

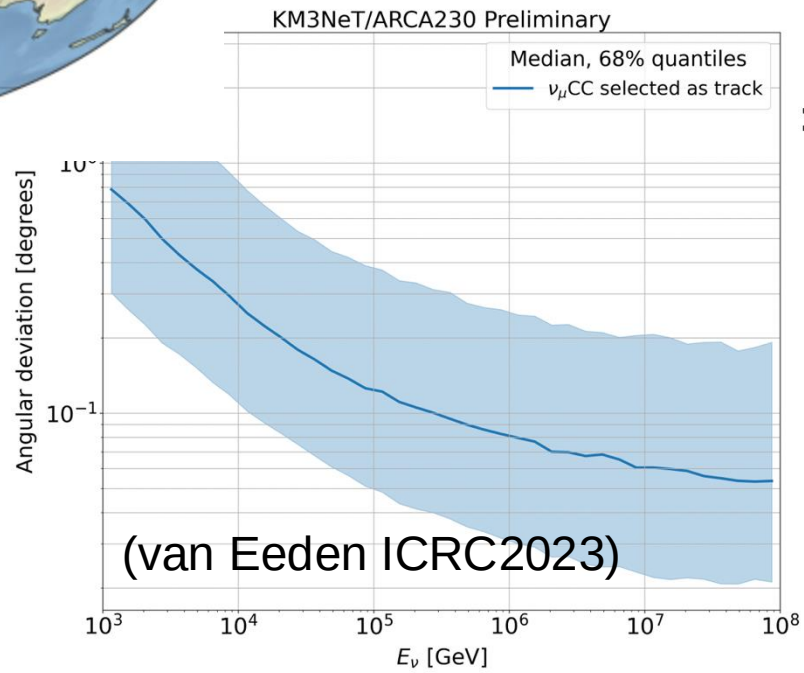


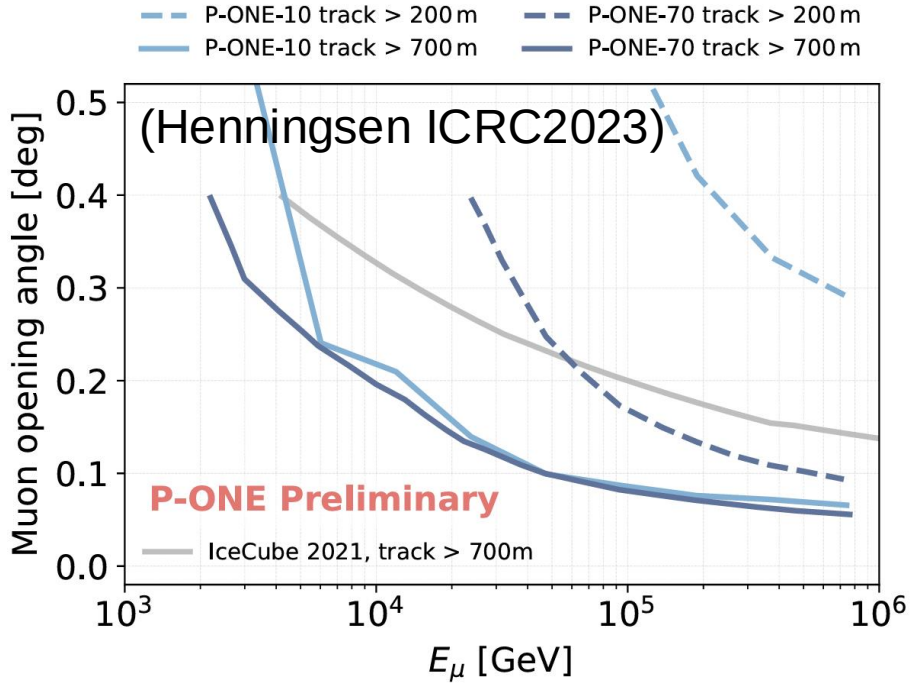
IceCube 2023

Neutrino Observation of the Galactic Centre



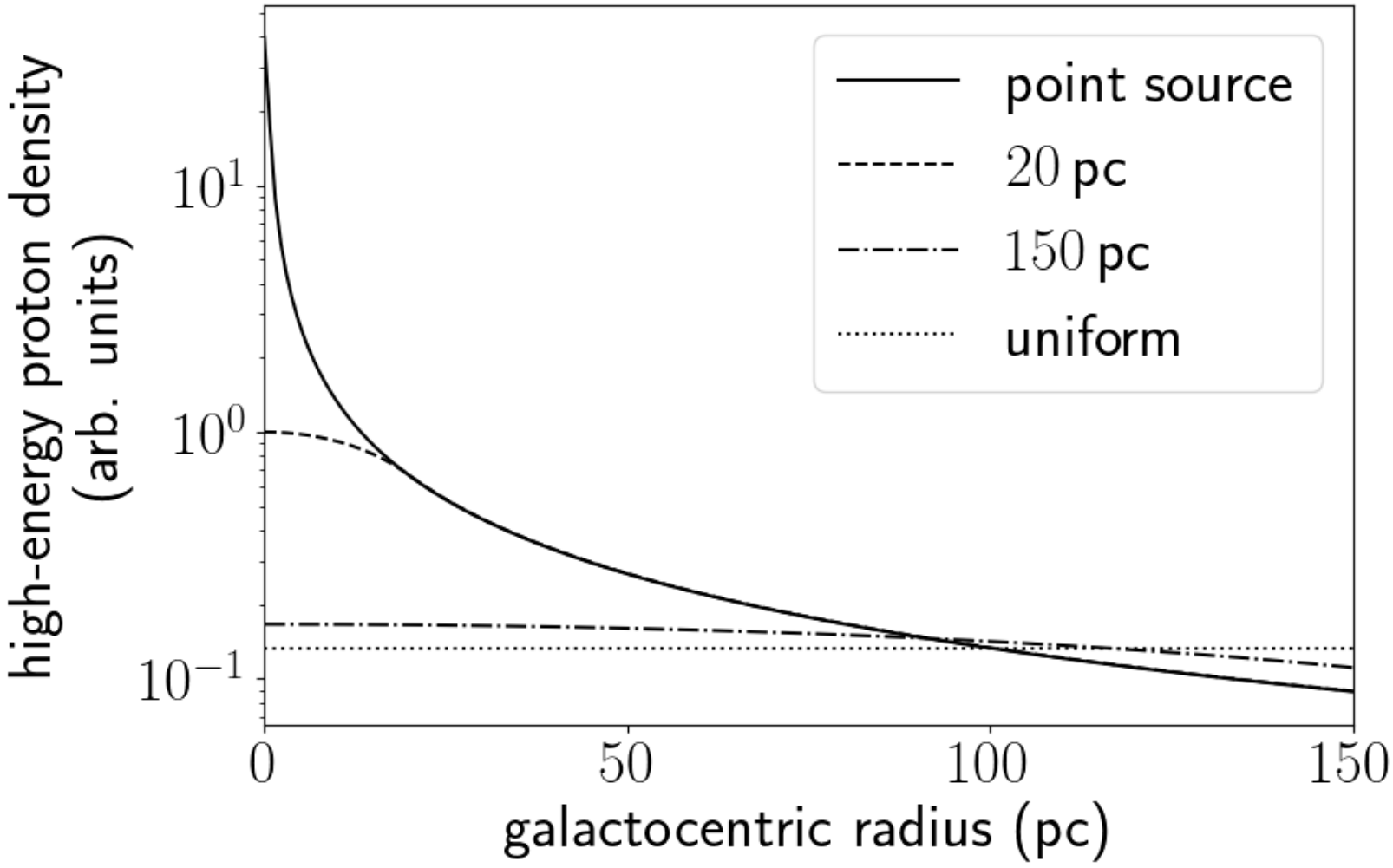
(Schumacher+ 22)





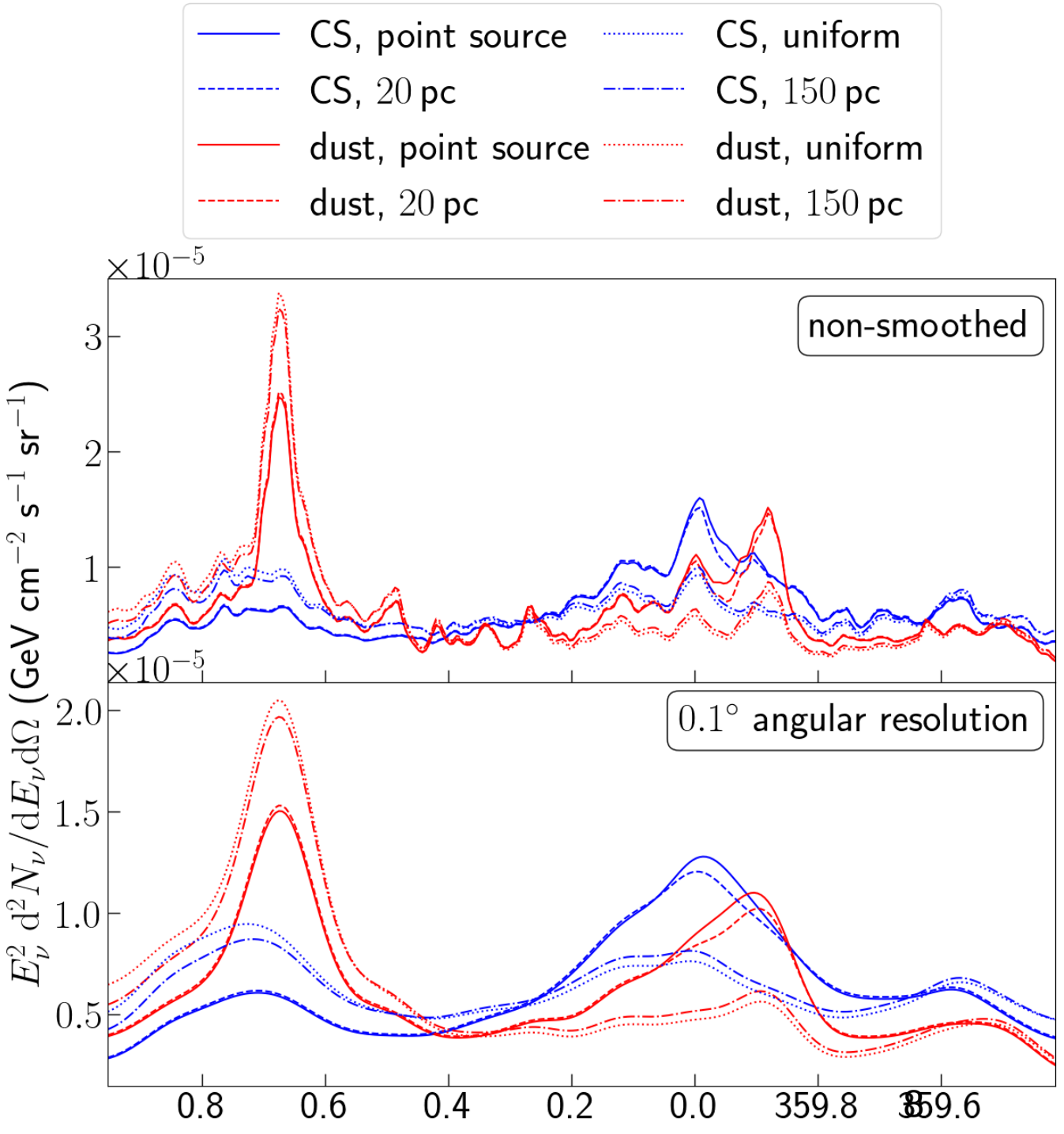
angular resol. ~ 0.1° for tracks

CR distribution around the Galactic Centre



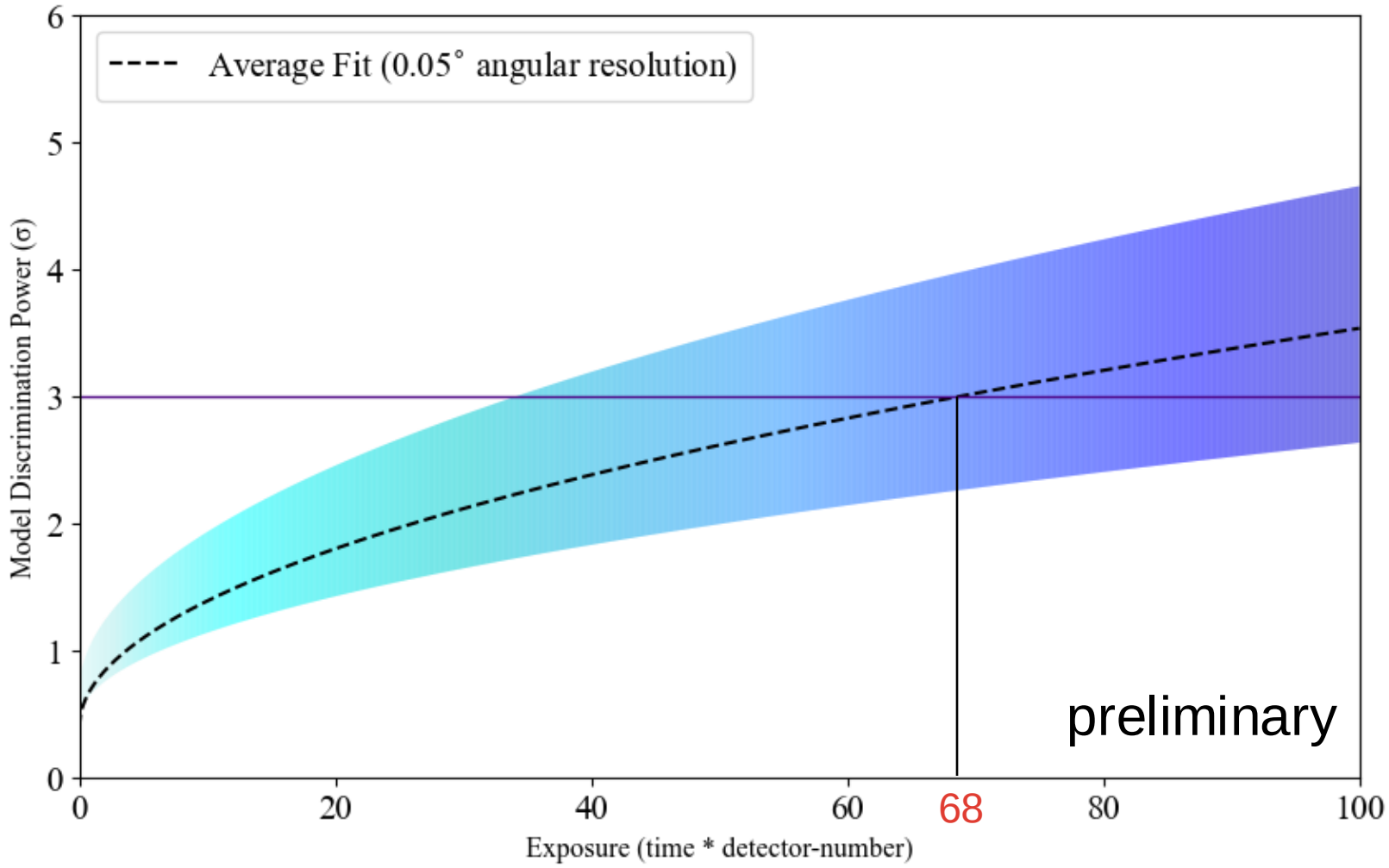
Neutrino brightness distribution

- 2 gas distribution models (CS and dust)
- 4 CR distribution models (point source, 20 pc, 150 pc, and uniform)
- **How long does it take to distinguish between CS and dust?**



Predicted discrimination power

- If we have KM3NeT, Baikal-GVD, and PONE altogether, it will take ~23 years to reach 3 sigma
- But, if we also have TRIDENT, NEON, HUNT…



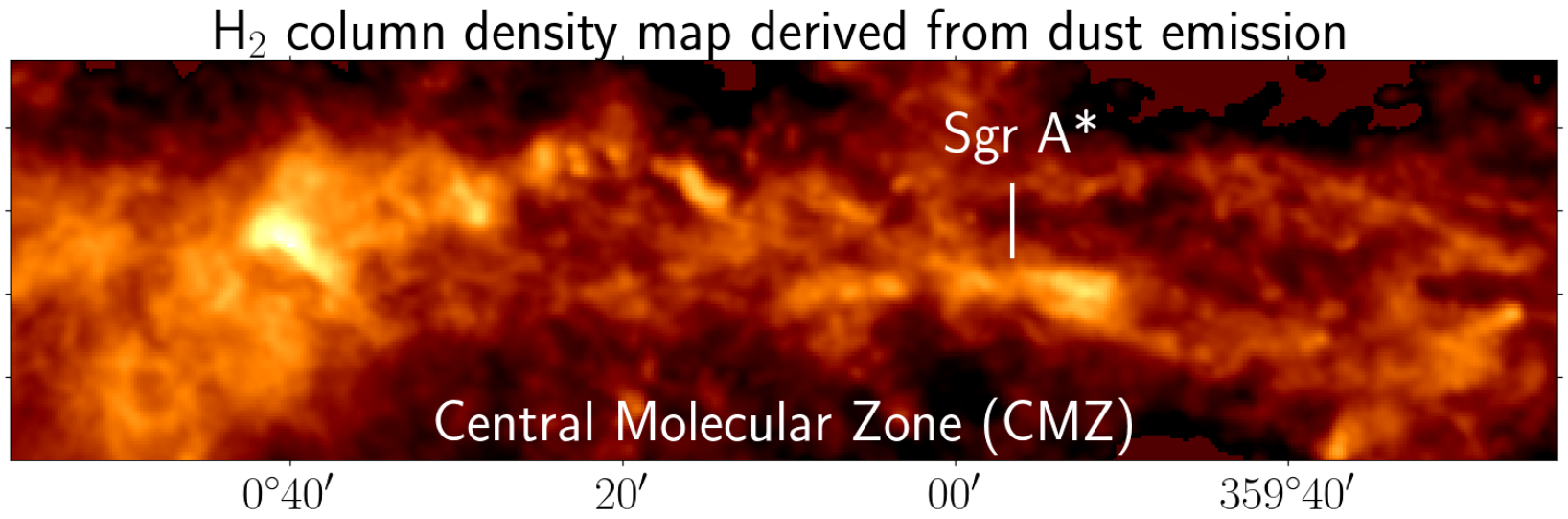
Conclusion

- Gas distribution of the CMZ probed by different tracers has a large discrepancy
- Neutrinos are an unambiguous tracer of gas mass
- Future neutrino observations of the CMZ will help calibrate its mass content

Backup slides

Why the Galactic Centre?

- The Central Molecular Zone is the largest molecular cloud region in the Galaxy
- One of the brightest neutrino sources in the Milky Way
- Astrophysical implications: low star formation rate, Galactic inflow, etc.



(Battersby+24)

Gamma-ray observations