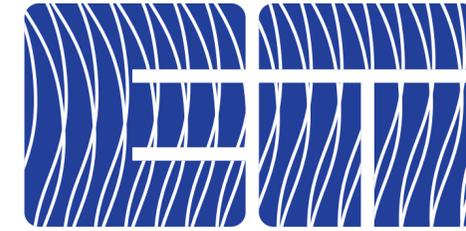


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UNIVERSITÀ DEGLI STUDI DI NAPOLI  
**FEDERICO II**



**EINSTEIN  
TELESCOPE**

# Detection prospects for Core-Collapse Supernovae with the Einstein Telescope

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**Ines Francesca Giudice**

In collaboration with:

M.T. Botticella, L. Izzo, L.A. De Santis, E. Cappellaro, M. Branchesi, L. Girardi and G.Pastorelli

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# KEY OBJECTIVE OF OUR PROJECT

CCSNe are expected sources of broadband complex GWs peaking at kHz frequencies. Their detection is currently limited by detector sensitivity, motivating third-generation observatories for systematic CCSN studies.

**How many CCSNe  
we expect  
within the Milky Way?**

CCSN rate from different probes (counts of massive stars, supernova remnants, chemical abundances...)

CCSN rate estimate from a massive star simulation

**Can the Einstein  
Telescope detect these  
CCSNe?**

Horizon and SNR estimate

Comparison between GW and optical detection capabilities

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# CCSNR AND FRAMEWORK

## Framework:

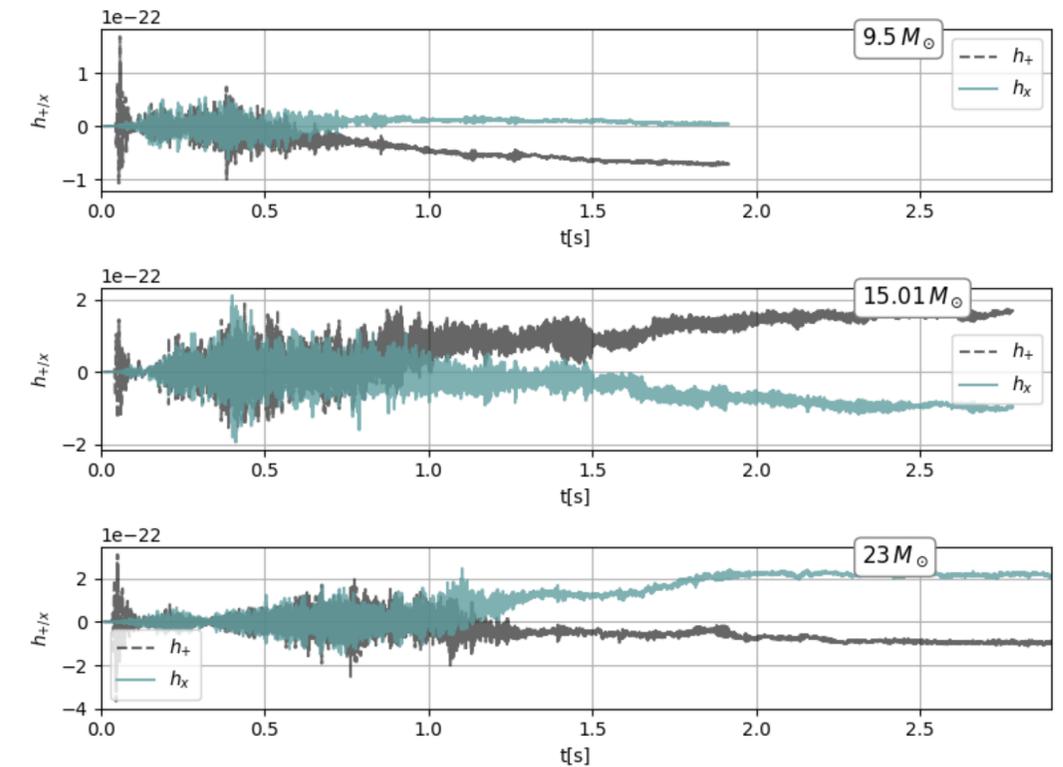
- ▶ **TRILEGAL** spatial distribution of massive stars
- ▶ 3D multi-physics hydrodynamic simulations of CCSN waveforms from D. Radice et al. (2019) and D. Vartanyan et al. (2023) for non rotating progenitors
- ▶ GWFISH adapted for the injection of CCSN waveforms

## Observed rate:

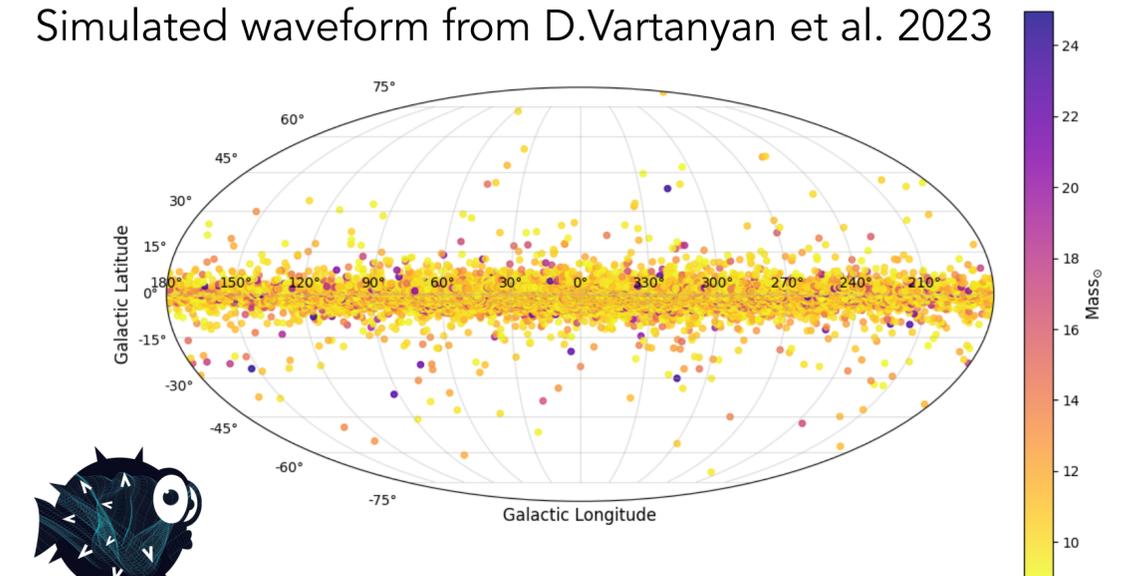
- ▶ **Detection Challenges:** dust absorption in the Galactic disk
- ▶ Rate from the combination of indirect proxies:  $1.63 \pm 0.46$  events per century (Rozwadowska et al. 2021)

## Rate from a massive star distribution:

- ▶ **Progenitor mass range:** from 9 to  $25 M_{\odot}$
- ▶ **Preliminary estimate** of CCSN rate from simulations:  $\sim 1.3$  events per century

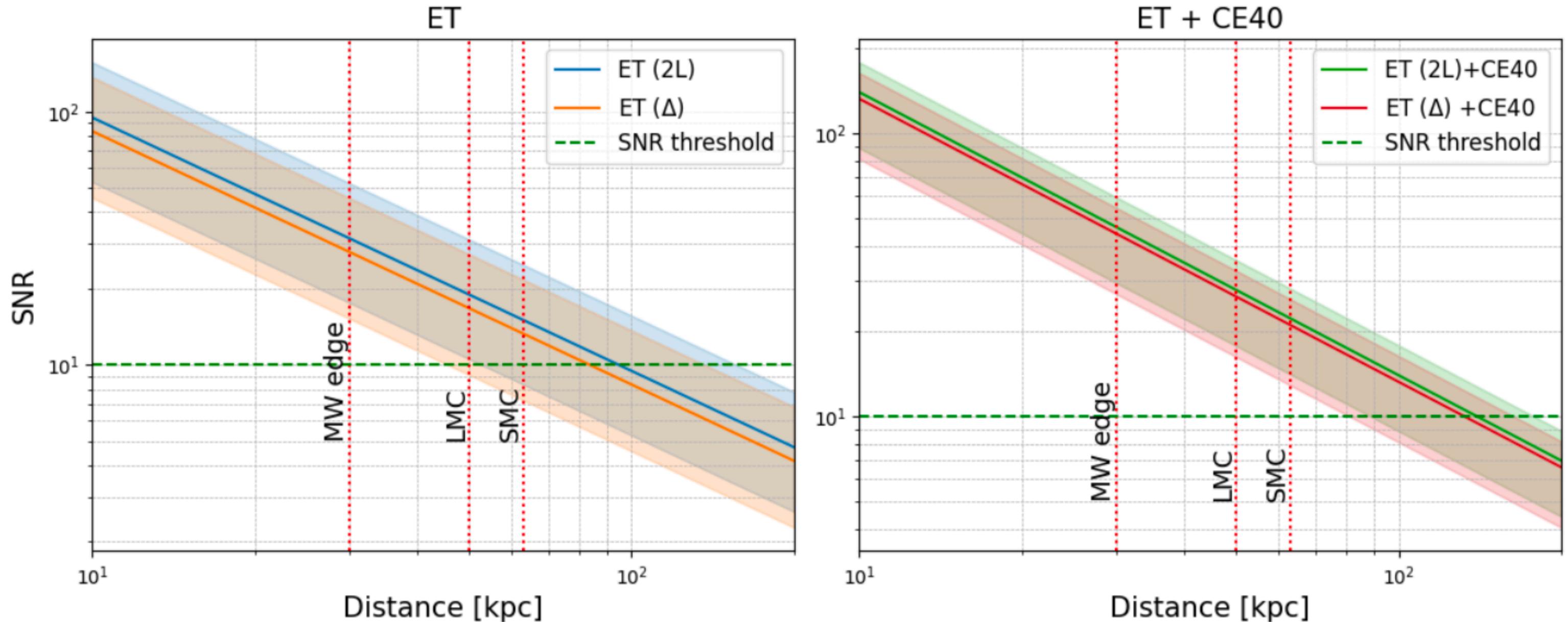


Simulated waveform from D.Vartanyan et al. 2023



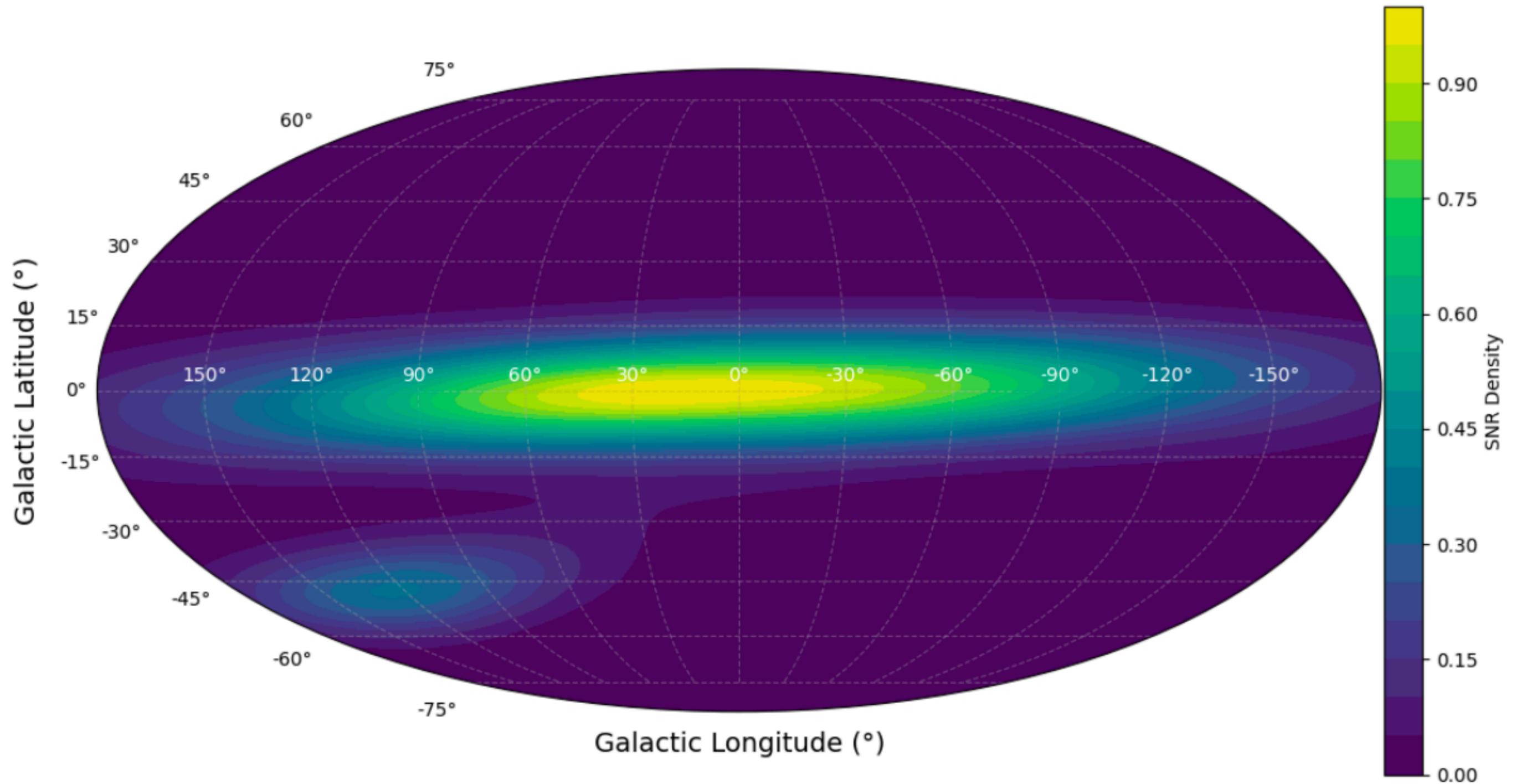
Spatial distribution from TRILEGAL

# HORIZON AND LAYOUT COMPARISON

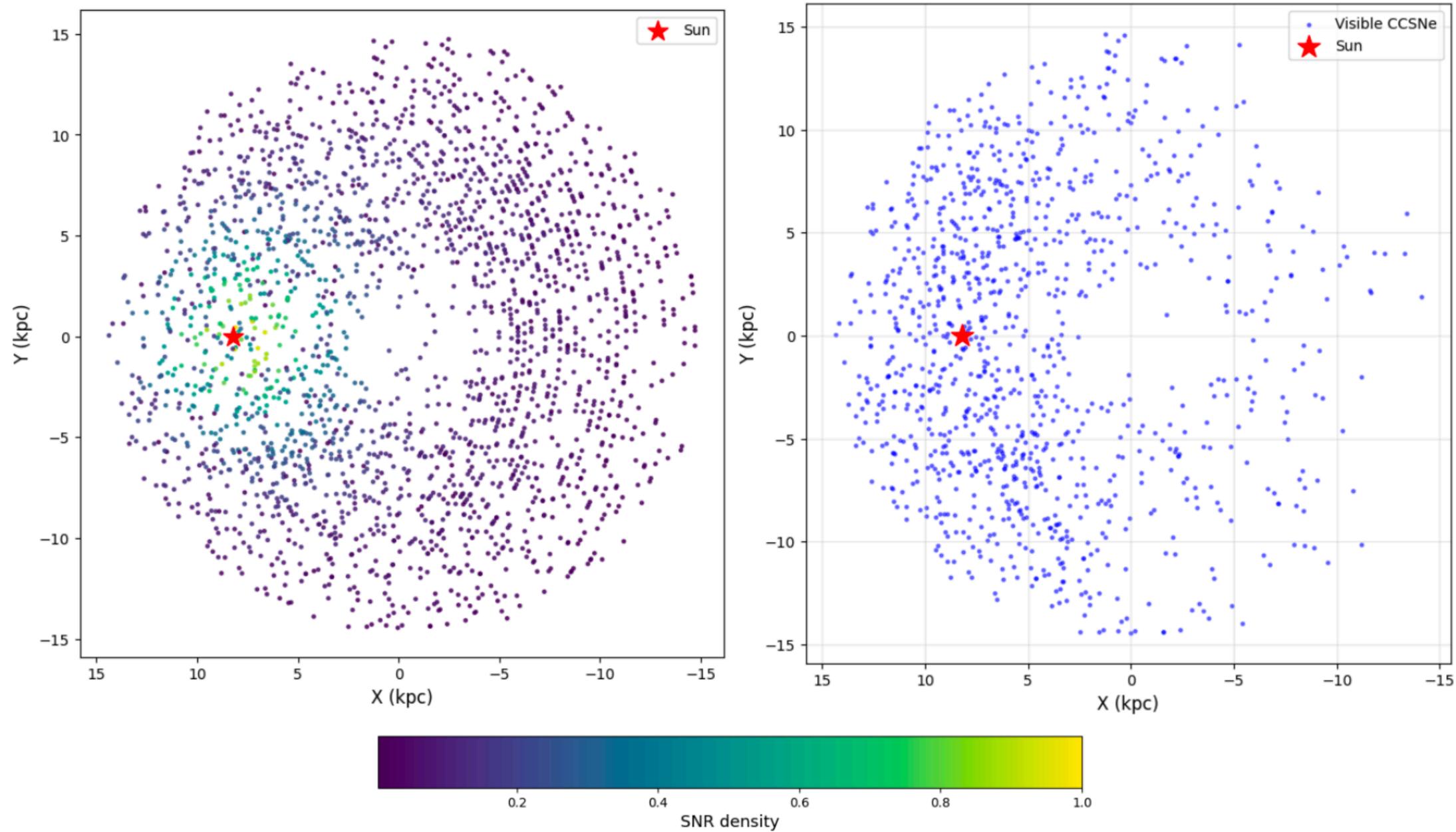


CCSN signals may be detected in **nearby galaxies** with ET+Cosmic Explorer, expanding CCSN multi-messenger astronomy **beyond the Magellanic Clouds**.

# SNR MAP



# GW AND OPTICAL COMPARISON



***50% of the possible Galactic CCSNe are lost in the optical***

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# CONCLUSIONS

CCSNe are promising sources for **multimessenger astrophysics**:

- ▶ To date, no CCSN has been through GWs, and only SN 1987A has been observed through neutrino emission.
- ▶ Even a single multimessenger event could revolutionize our understanding of CCSNe.

The **Einstein Telescope** will open a new era in GW detection from these events:

- ▶ In our work we estimated **expected GW detection rate** and **horizon of ET** for the CCSNe.
- ▶ **Preliminary results** suggest possible detection up to the Magellanic Clouds in synergy with Cosmic Explorer, and that the ET will be able to detect the CCSNe lost by the optical surveys due to faintness, dust extinction etc.
- ▶ **Immediate implementation**: Simulation with waveform models for **rotating progenitor stars** of CCSNe and analysis of the massive star spatial distribution to the **Andromeda Galaxy** ( $\sim 700$  kpc).

**Future perspectives:**

- ▶ Coordination between **neutrino** and **GW detectors** to maximize detection confidence and sky localization;
  - ▶ Optimization of **EM follow-up strategies** to capture SBO and probing explosion geometry and nucleosynthesis.
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