Sensitivities for DM search in the Galactic Center with KM3NeT/ORCA-6

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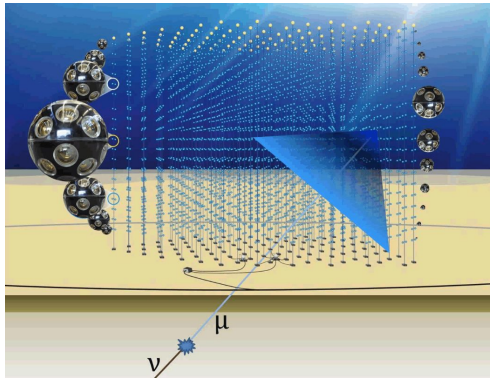
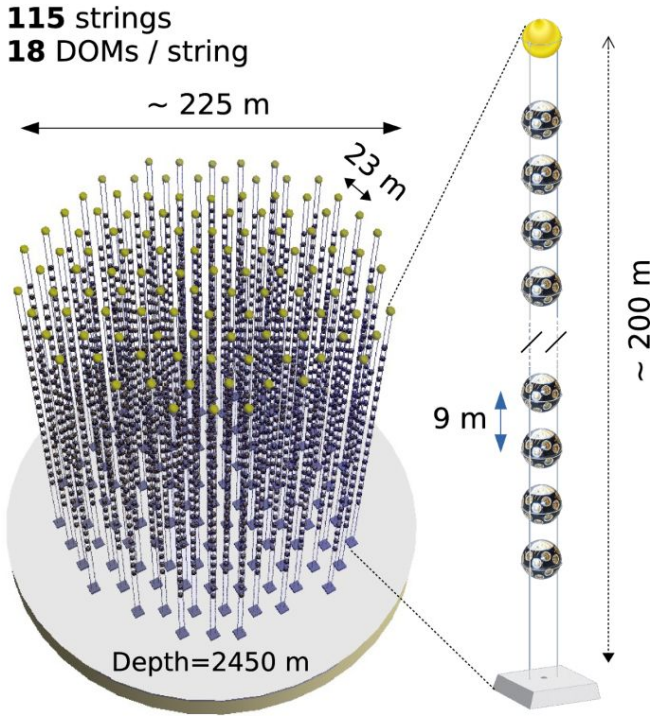
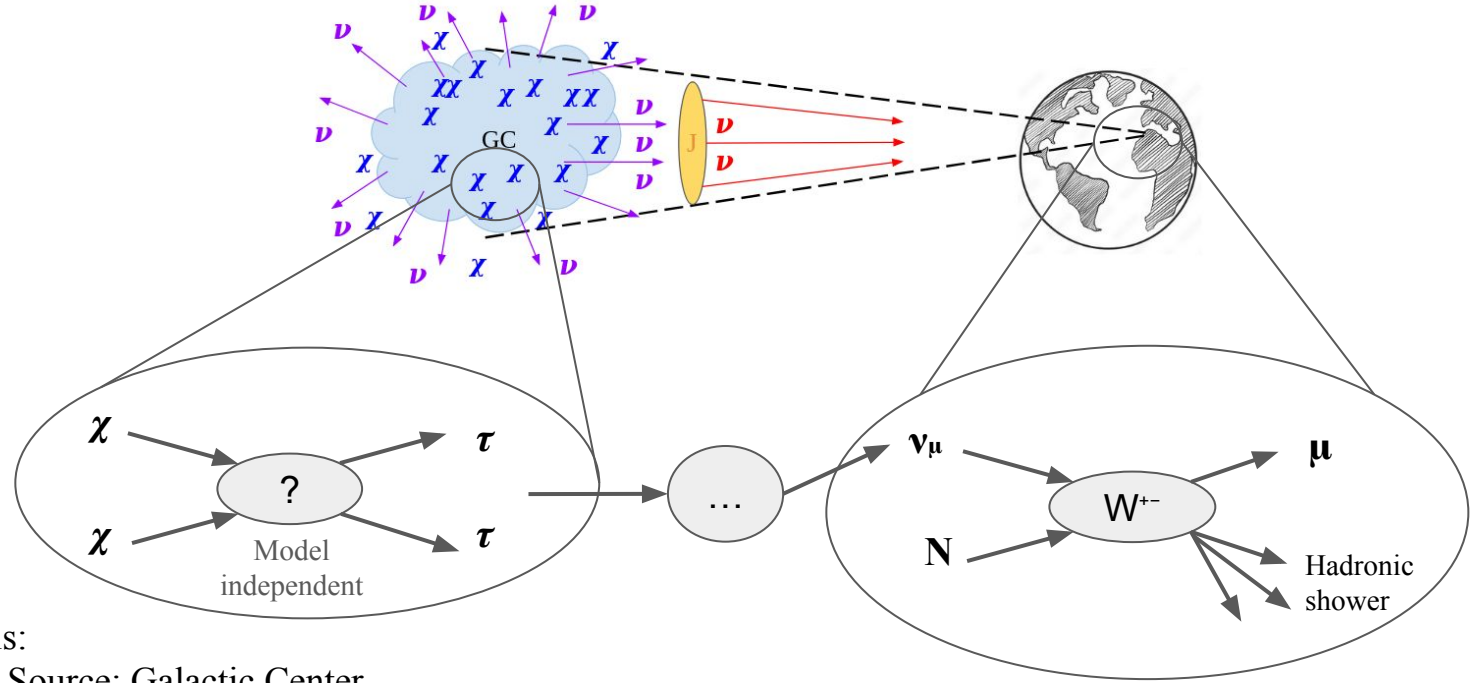
KM3NeT: ARCA and ORCA detectors.

- The KM3NeT infrastructure, located in abyssal sites of the Mediterranean Sea, is composed of two undersea Cherenkov neutrino telescopes: ORCA, a dense detector optimised for the measurement of low energy neutrinos, and ARCA, a cubic kilometer detector, intended for low fluxes of astrophysical neutrinos.
- It is composed of Digital Optical Modules with a segmented photo-sensitive area provided by 31 photomultiplier tubes (PMTs), arranged in vertical strings called Detection Units.
- The Cherenkov light is induced by ultra-relativistic charged particles that are produced in neutrino interactions near the detector, this light is measured in the PMTs.
- 23 DUs have been already deployed at the ORCA site and 28 at ARCA .





Theoretical framework.



Details:

→ Source: Galactic Center

→ Density Profile: Navarro-Frenk-White (cuspy)

→ Halo shape: spherical

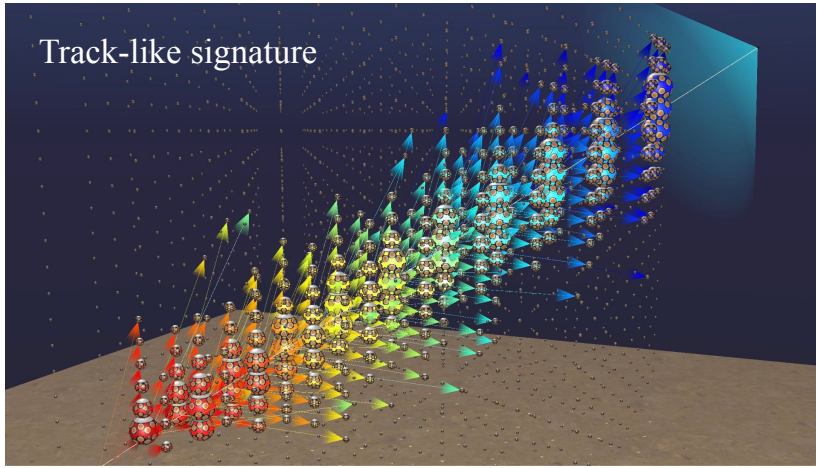
→ Model independent approach

→ DM mass from 50 to 10 000 GeV/c²

→ Annihilation channels $\mu^+\mu^-, \tau^+\tau^-, b\bar{b}, W^+W^-, HH, \nu\bar{\nu}$

Data Set.

- → Data set: ICRC 2023 ORCA-6 data set
- → Detector configuration: 6 detection units of ORCA
- → Lifetime: 510 days of data taking
- → Background: atmospheric muons
- → Event selection:
  - Track events are considered $\nu_\mu + X \xrightarrow[\text{CC}]{} \mu + Y$
  - Selection cuts to reject atmospheric muons
    - Anti-noise cuts: upgoing events, likelihood of the reconstruction, number of hits of events.
    - Particle identity cuts for tracks: probability of event being muon
  - 4445 events in the data sample survive the cuts.



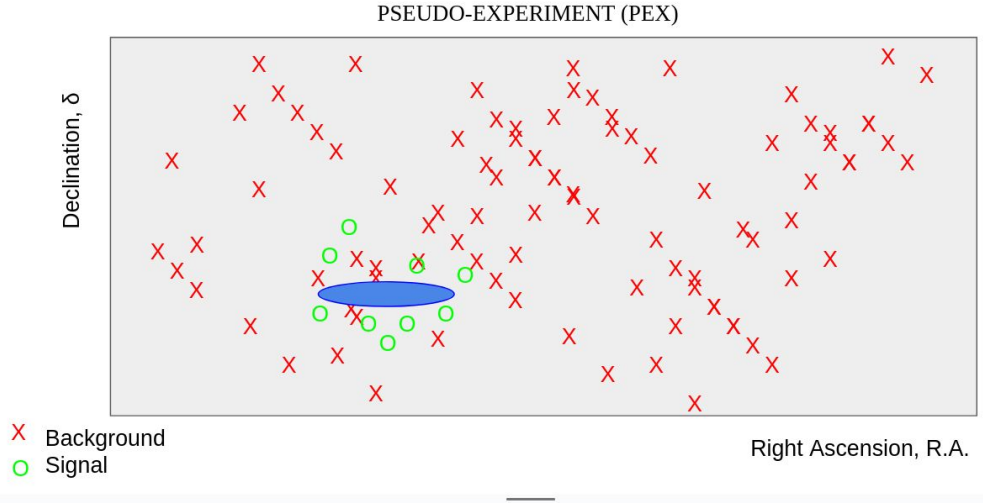
Analysis Method.

$$-\log \mathcal{L} = -\prod_{i=1}^{N_{events}} log\left[n_{sg}P_{sg}(\psi_i, E_i) + (N_{events} - n_{sg})P_{bg}(\delta_i, E_i)\right]$$

Probability of an event to be signal — events characterised by angular distance and energy

Probability of an event to be background — events characterised by declination and energy

We create signal and background event coordinates and energies in pseudo-experiments. Signal and background probability functions are used to determine the amount of signal in each pseudo-experiment. We maximise the likelihood to fit the number of signal events that we are sensitive to

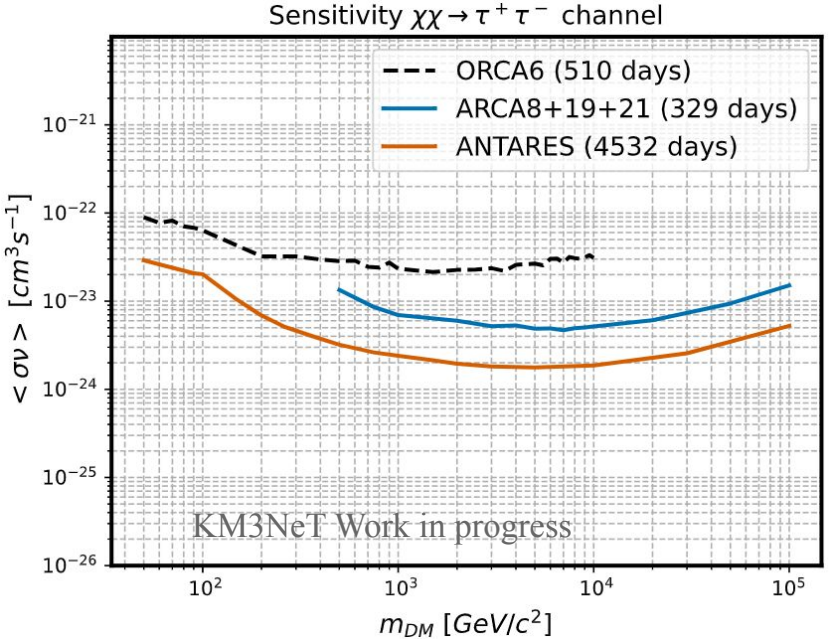


Sensitivity.

For the first time the ORCA-6 data set has been used to search for DM annihilating in the GC. We have obtained the sensitivity of this detector configuration considering WIMP masses in the range 50 GeV/c² to 10 000 GeV/c²

$$\langle \sigma v \rangle = \frac{n_{90}}{Acc \cdot T} \cdot \frac{8\pi m_{DM}^2}{J}$$

In addition, the combination of ARCA-8+19+21 has been used to obtain the 90% upper limit of the thermal cross section for the DM annihilating at the GC. This result is compatible with background.

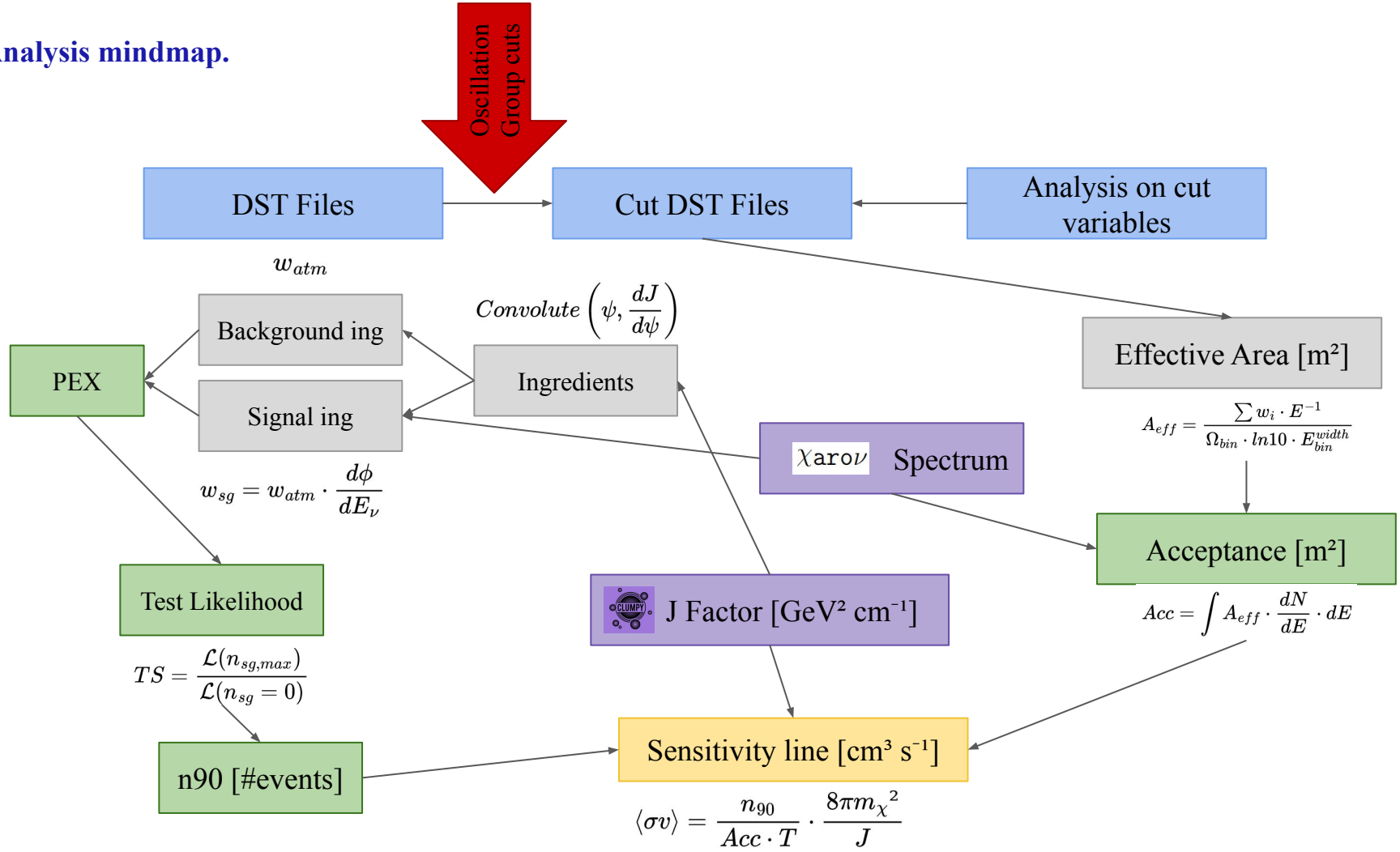


Thank you for your time.

-Adriana-

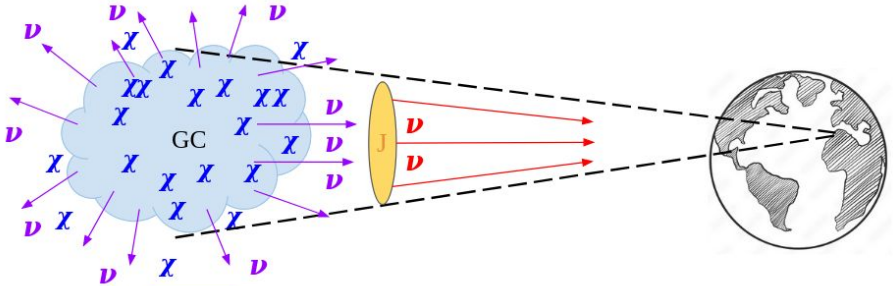
BACKUP SLIDES

Analysis mindmap.



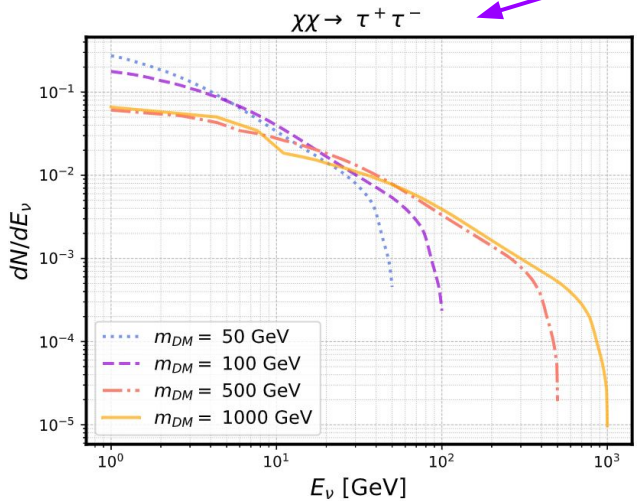
Theoretical framework.

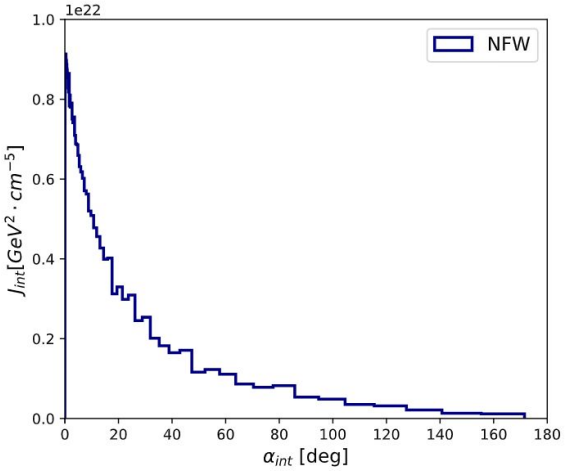
χarov software link
CLUMPY software link



$$\frac{d\Phi_\nu}{dE_\nu} = \frac{1}{4\pi}\frac{\langle\sigma v\rangle}{2m_\chi{}^2}\frac{dN_\nu}{dE_\nu}\int_{\Delta\Omega}\int_{l.o.s.}\rho^2 dl d\Omega$$

Flux at Earth — Energy Spectrum — J-factor



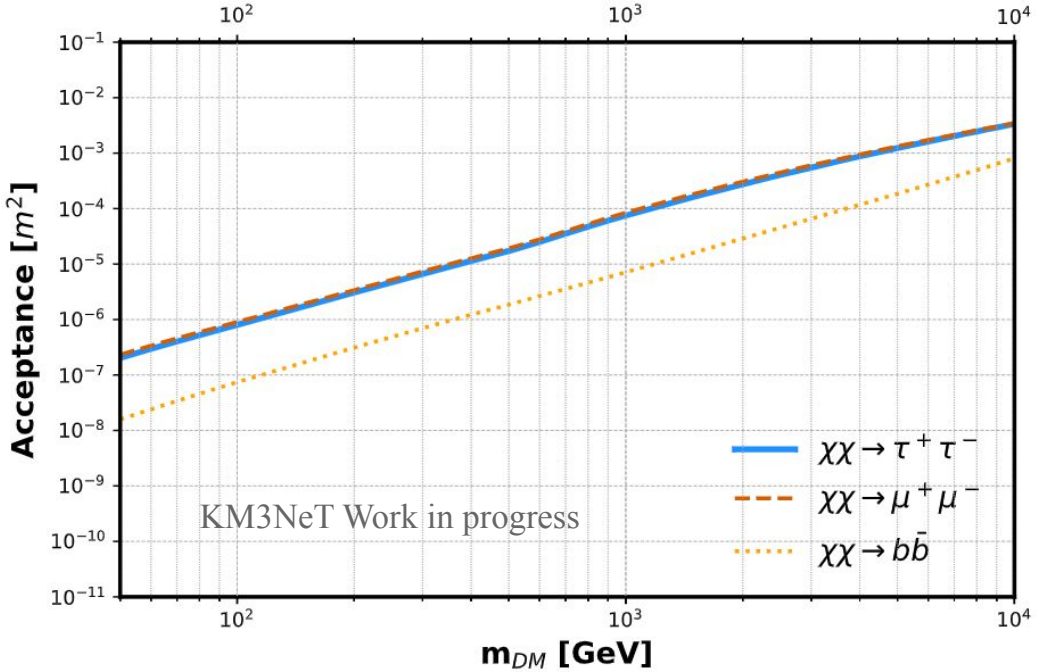


Effective areas and acceptances.

The effective area and the acceptances of the detector are obtained to study the ability of the detector to detect signal events.

$$Acc(m_{WIMP}) = \frac{2\int^{m_{WIMP}} \bar{A}^{\nu}_{eff} \cdot \frac{dN}{dE_\nu} \cdot dE_\nu}{\int^{m_{WIMP}} \frac{dN}{dE_\nu} \cdot dE_\nu}$$

We calculate the average effective areas for tracks using CC muon neutrino files (future implementation of other flavours)



Analysis Method.

The test statistic distributions $TS = \frac{\mathcal{L}(n_{s,max})}{\mathcal{L}(n_s = 0)}$ are used to determine the mean number of signal events which can be identified as background with a 90% confidence level, **n90**.

Number of signal events compatible with background fluctuations on 90% confidence level.