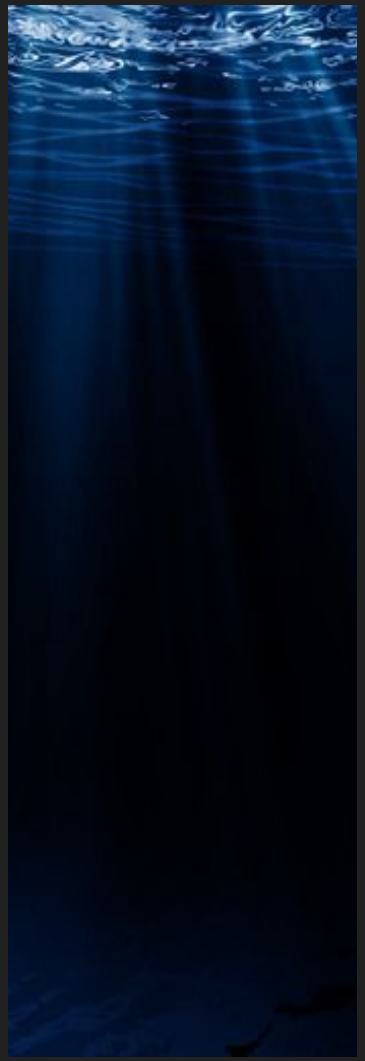




WIMP Dark Matter Searches from the Galactic Centre with KM3NeT

Adriana Bariego Quintana

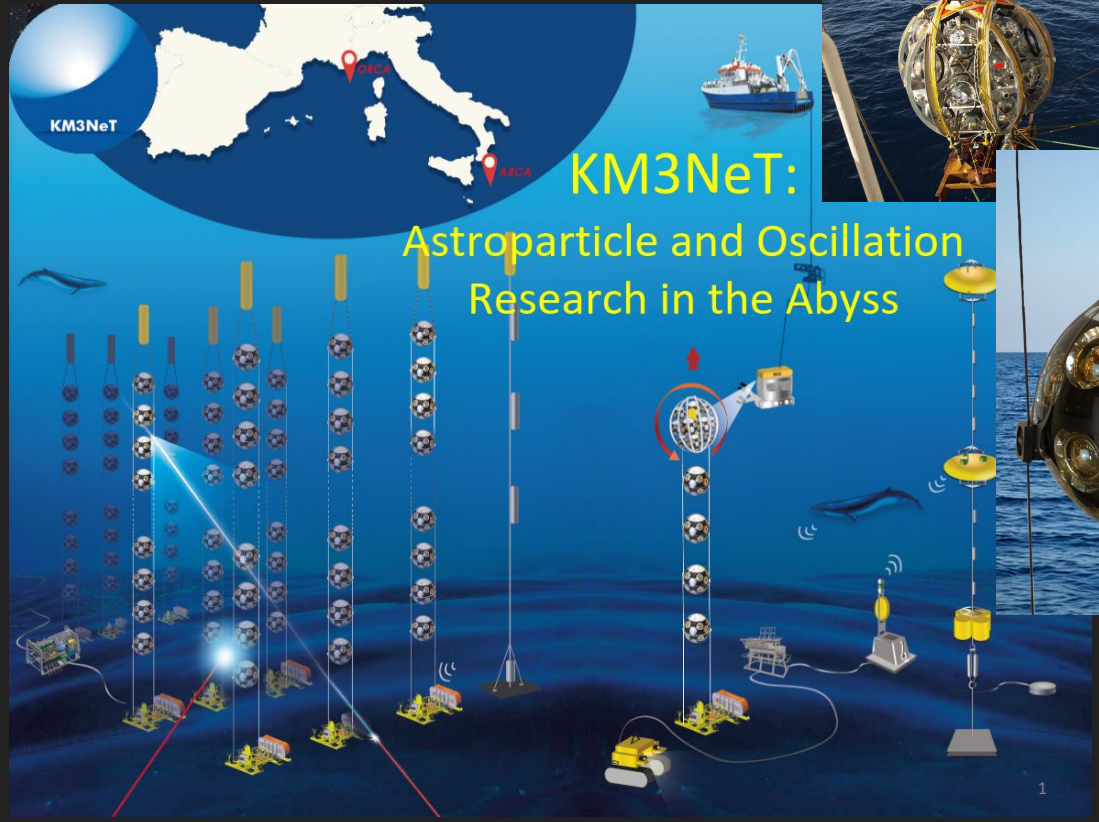
on behalf of the KM3NeT Collaboration

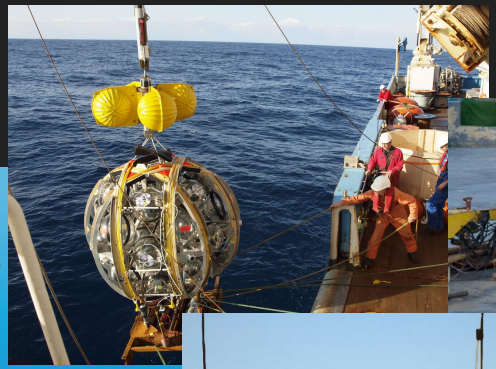
MINISTERIO DE CIENCIA, INNOVACIÓN Y UNIVERSIDADES

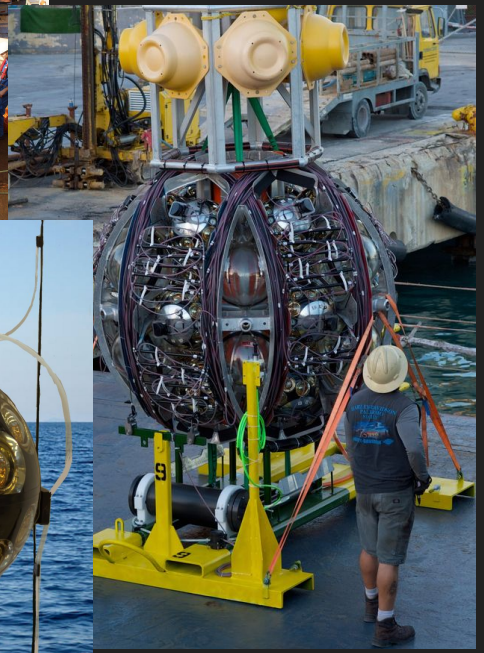
Cofinanciado por la Unión Europea

AGENCIA ESTATAL DE INVESTIGACIÓN

Detector Deployment

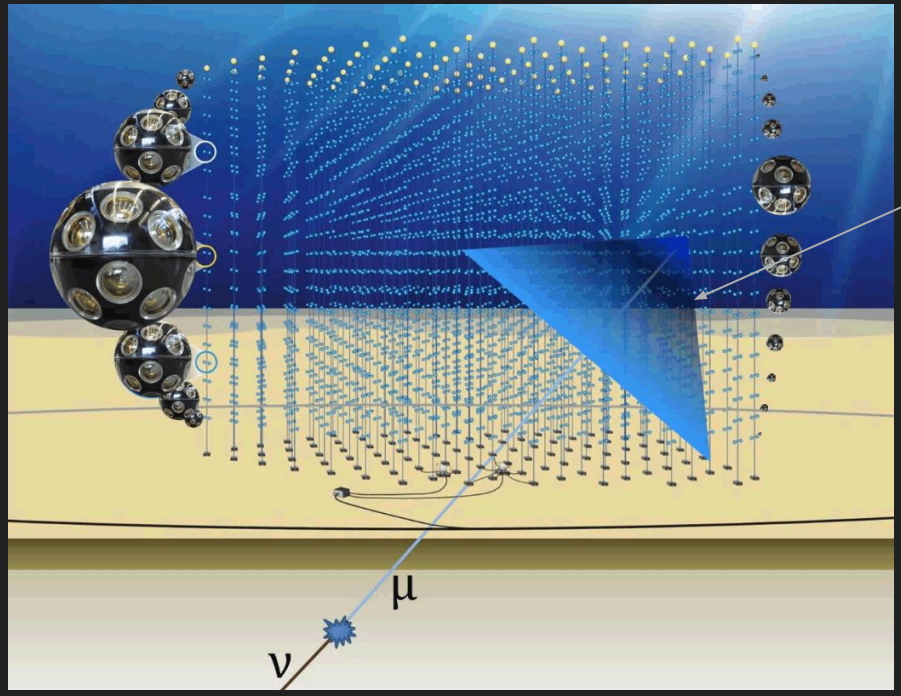




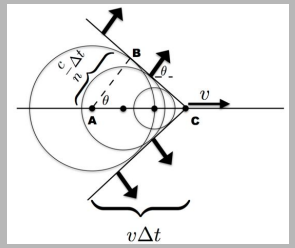




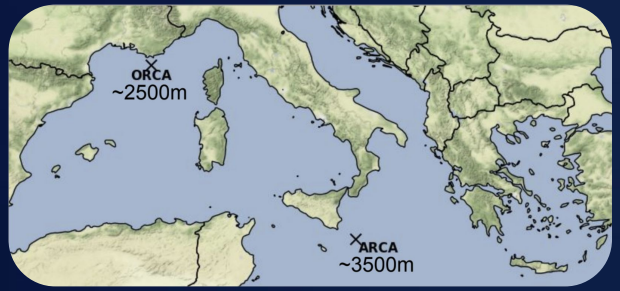
Detection method



Cherenkov Effect



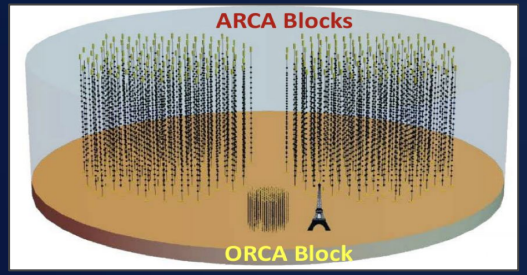
KM3NeT Detectors



ARCA

ORCA

KM3NeT/ARCA Detector



KM3NeT/ARCA:

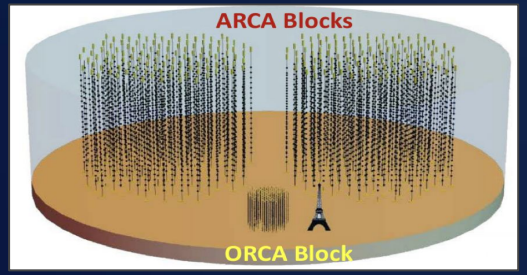
- Energies: 500 GeV to 100 TeV
- Depth: 3500 m
- Astrophysical ν
- Configuration: 51 lines



ARCA

ORCA

KM3NeT/ORCA Detector



KM3NeT/ORCA:

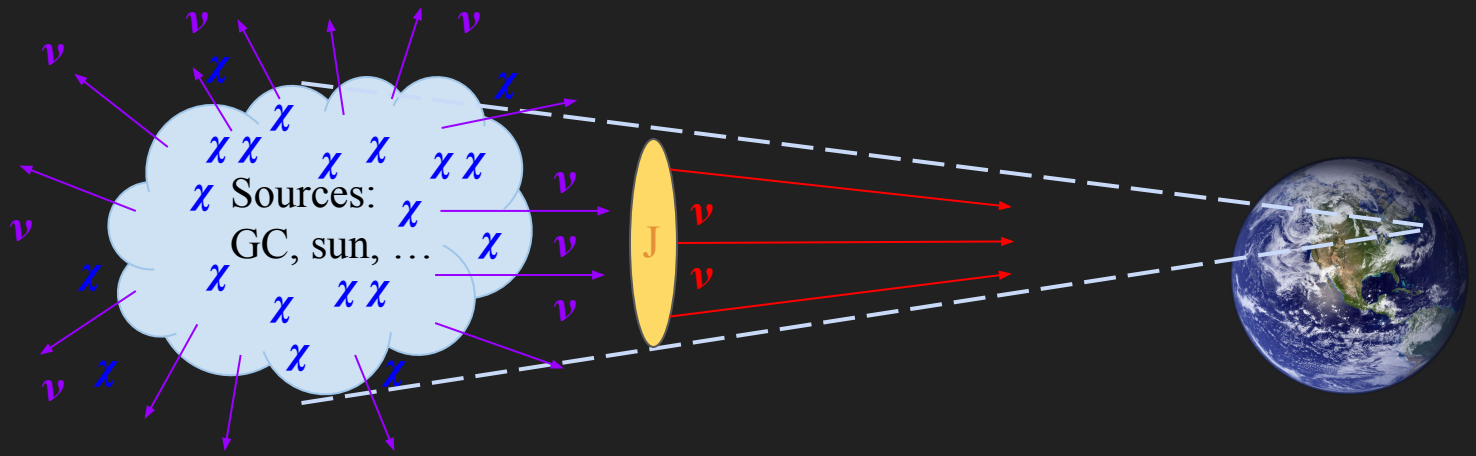
- Energies: 2 GeV-10 TeV
- Depth: 2450 m
- ν properties
- Configuration: 38 lines



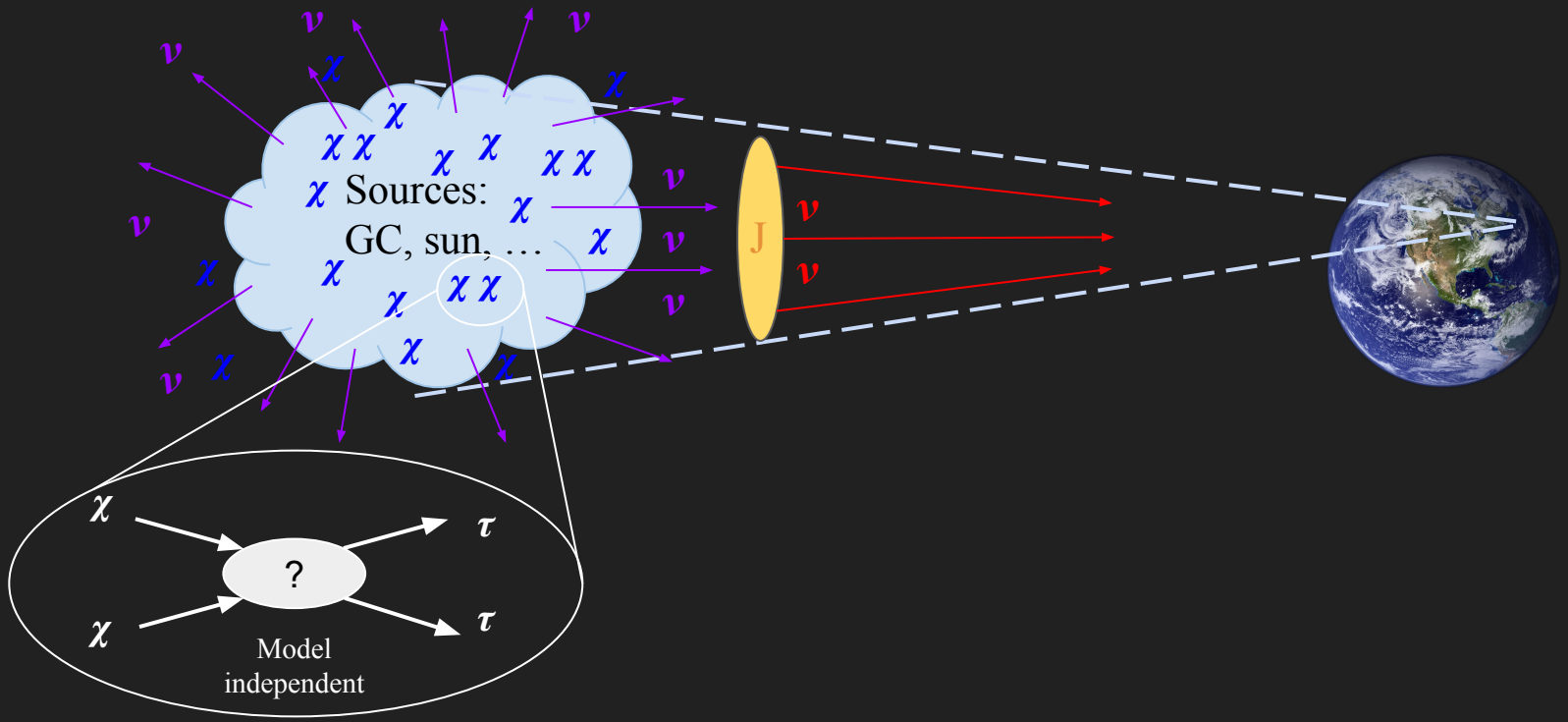
ARCA

ORCA

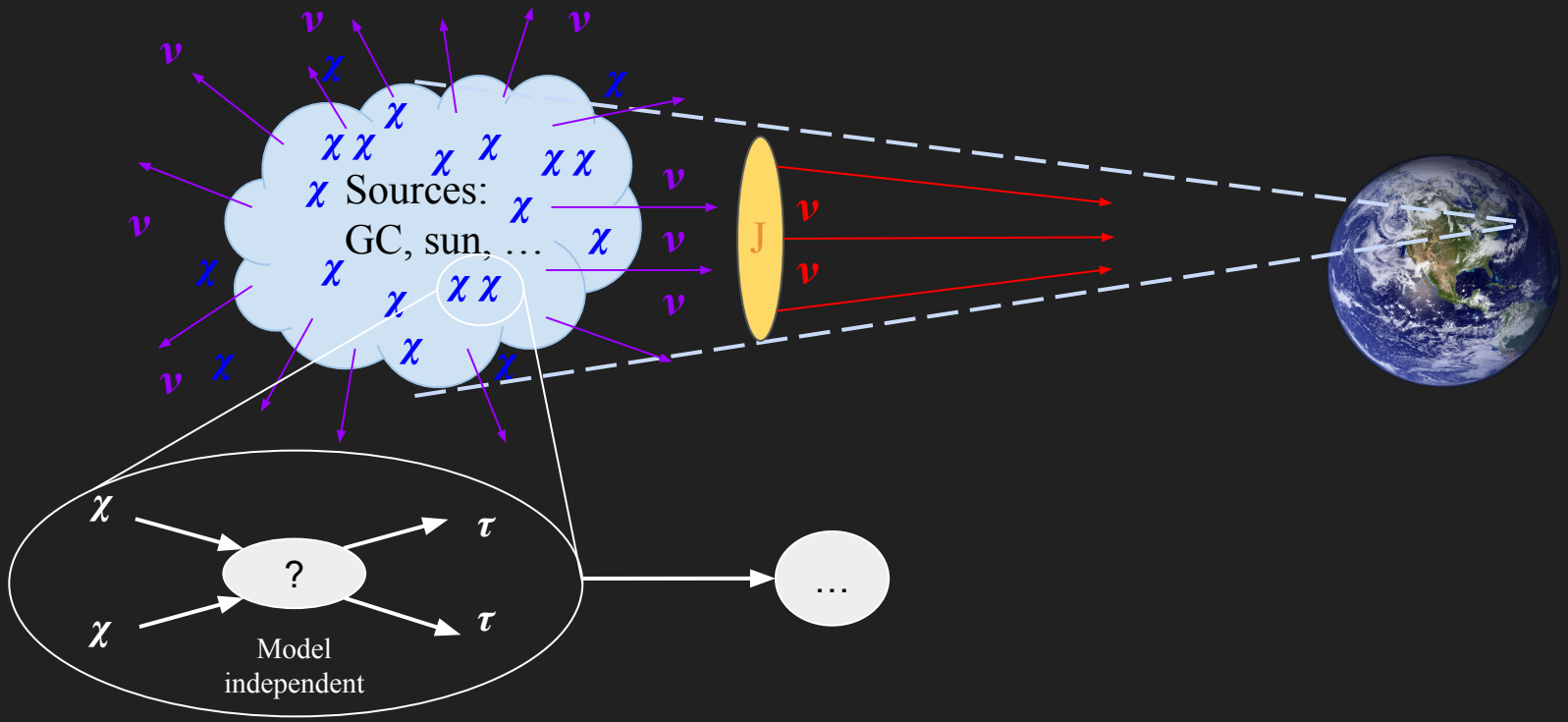
WIMP Dark Matter Searches



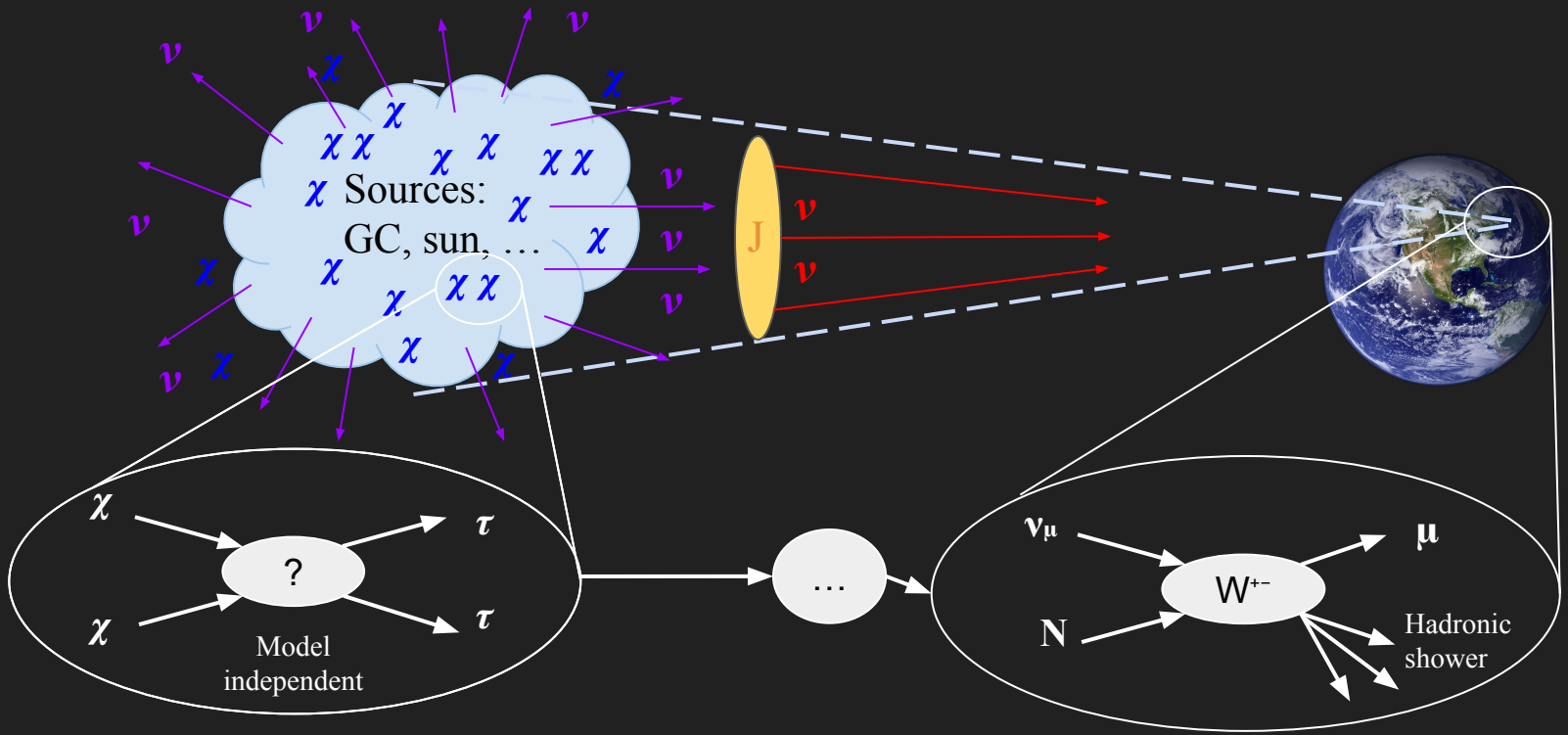
WIMP Dark Matter Searches



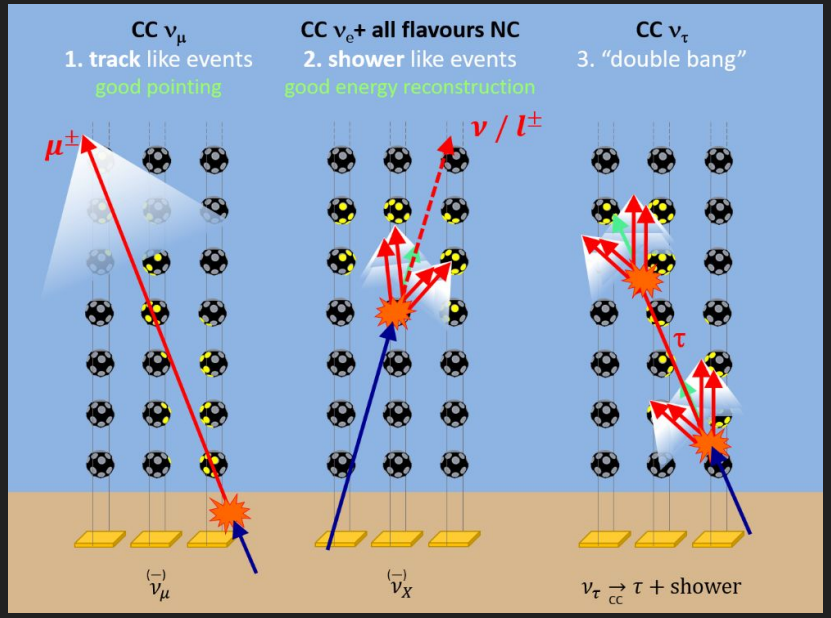
WIMP Dark Matter Searches

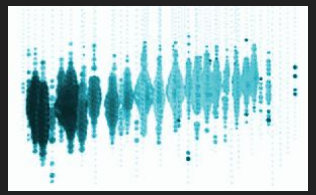


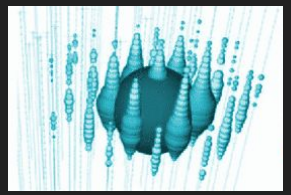
WIMP Dark Matter Searches

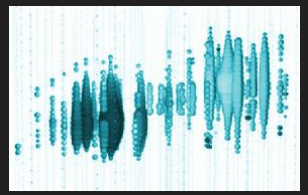


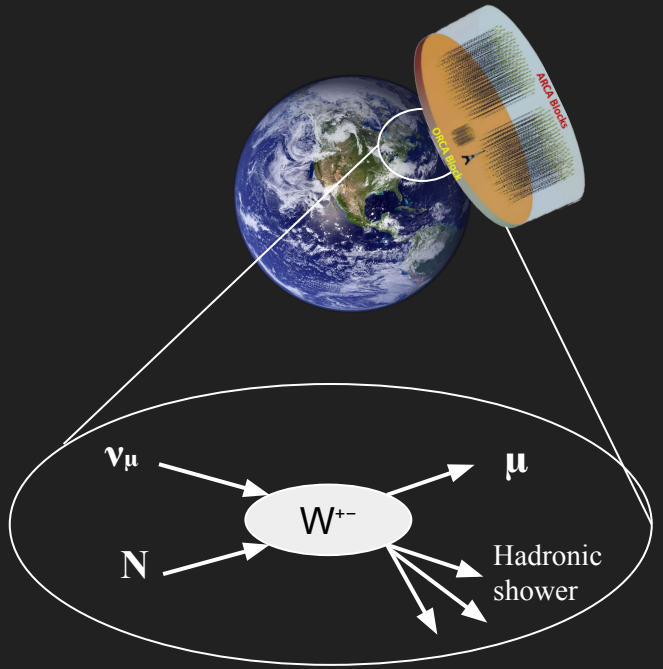
Neutrino signature



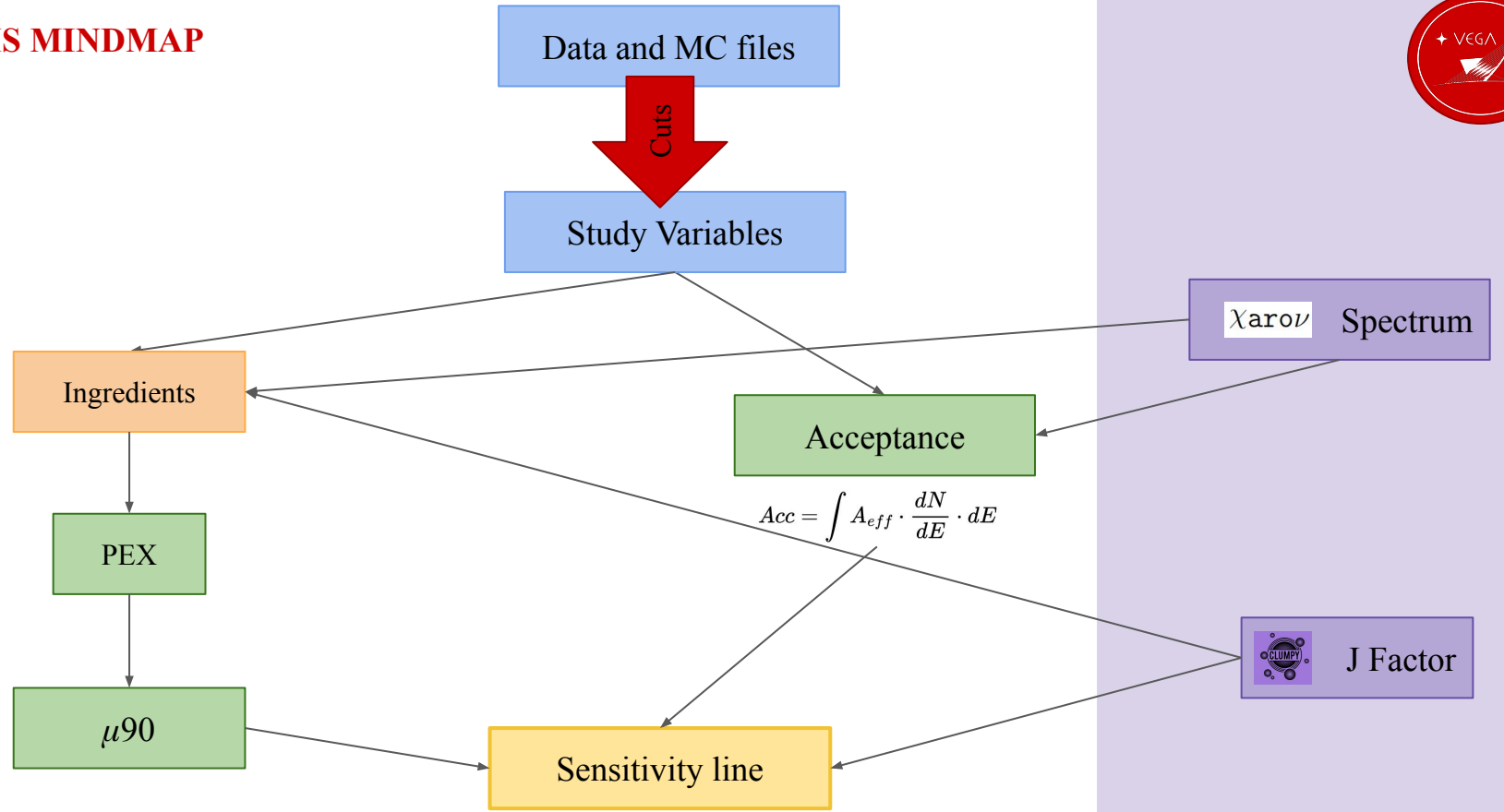




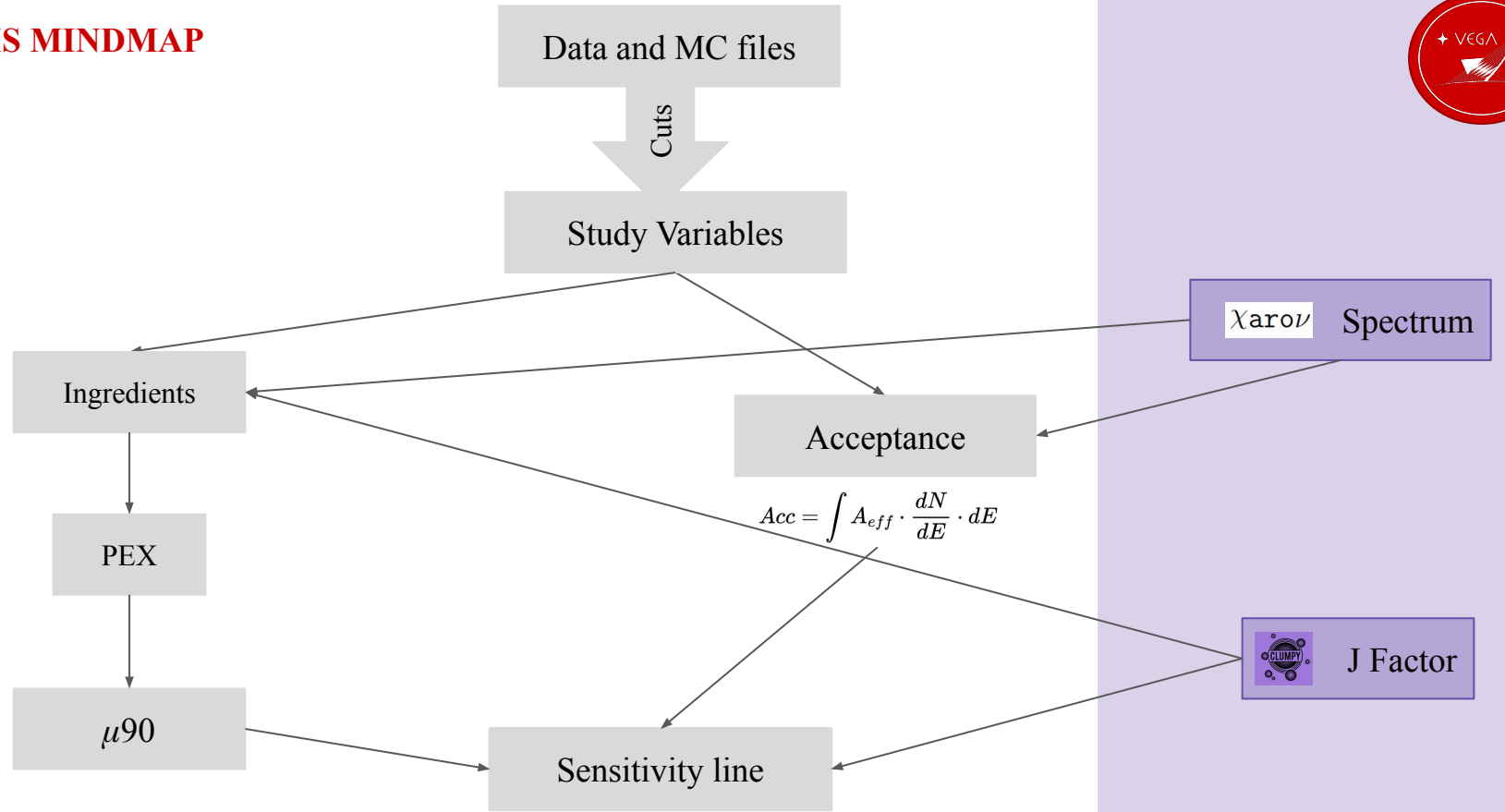




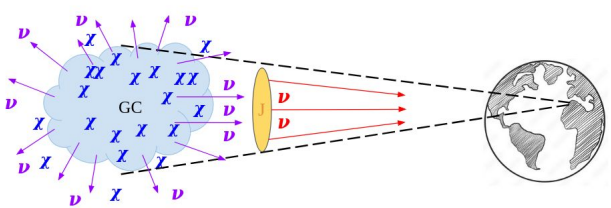
ANALYSIS MINDMAP



ANALYSIS MINDMAP

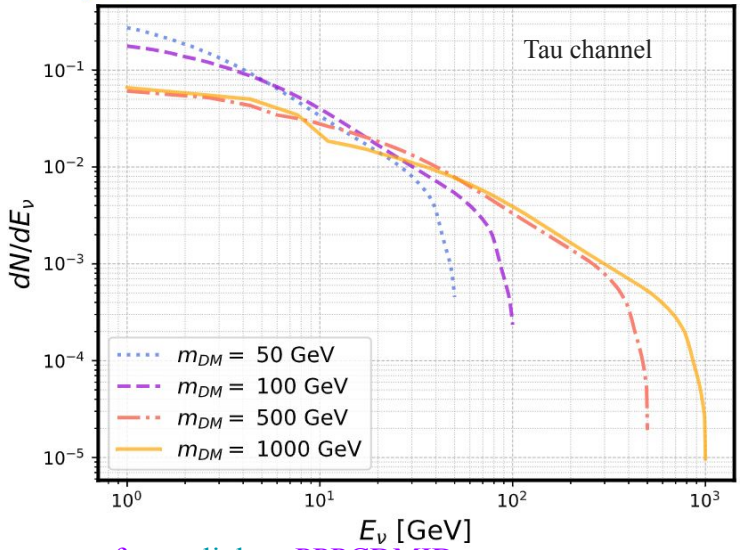


External ingredients: Energy Spectrum & JFactor



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

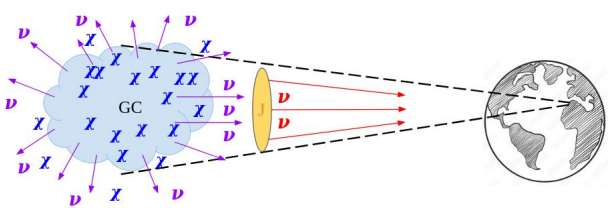
Flux at Earth — Energy Spectrum — J-factor





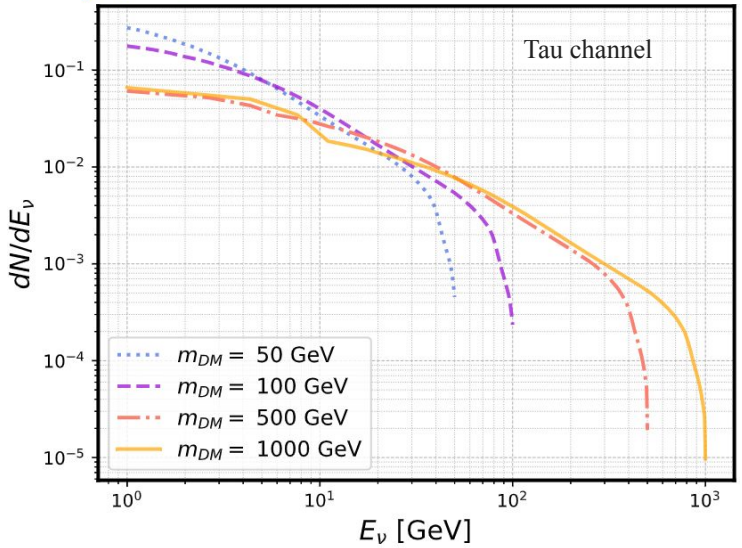
χarον software link or PPPCDMID

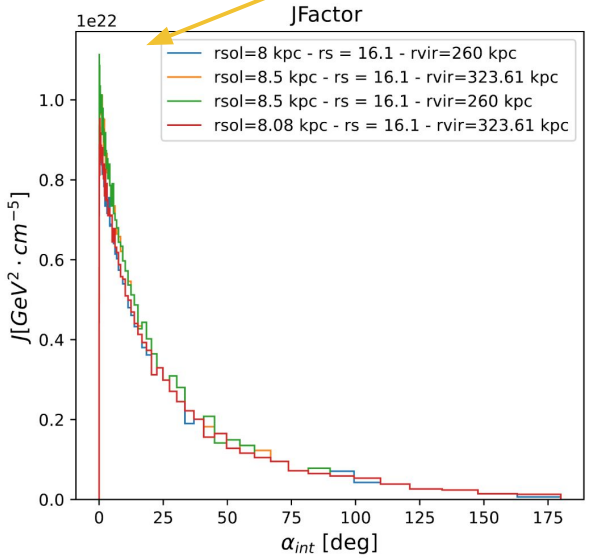
External ingredients: Energy Spectrum & JFactor



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

Flux at Earth — Energy Spectrum — J-factor

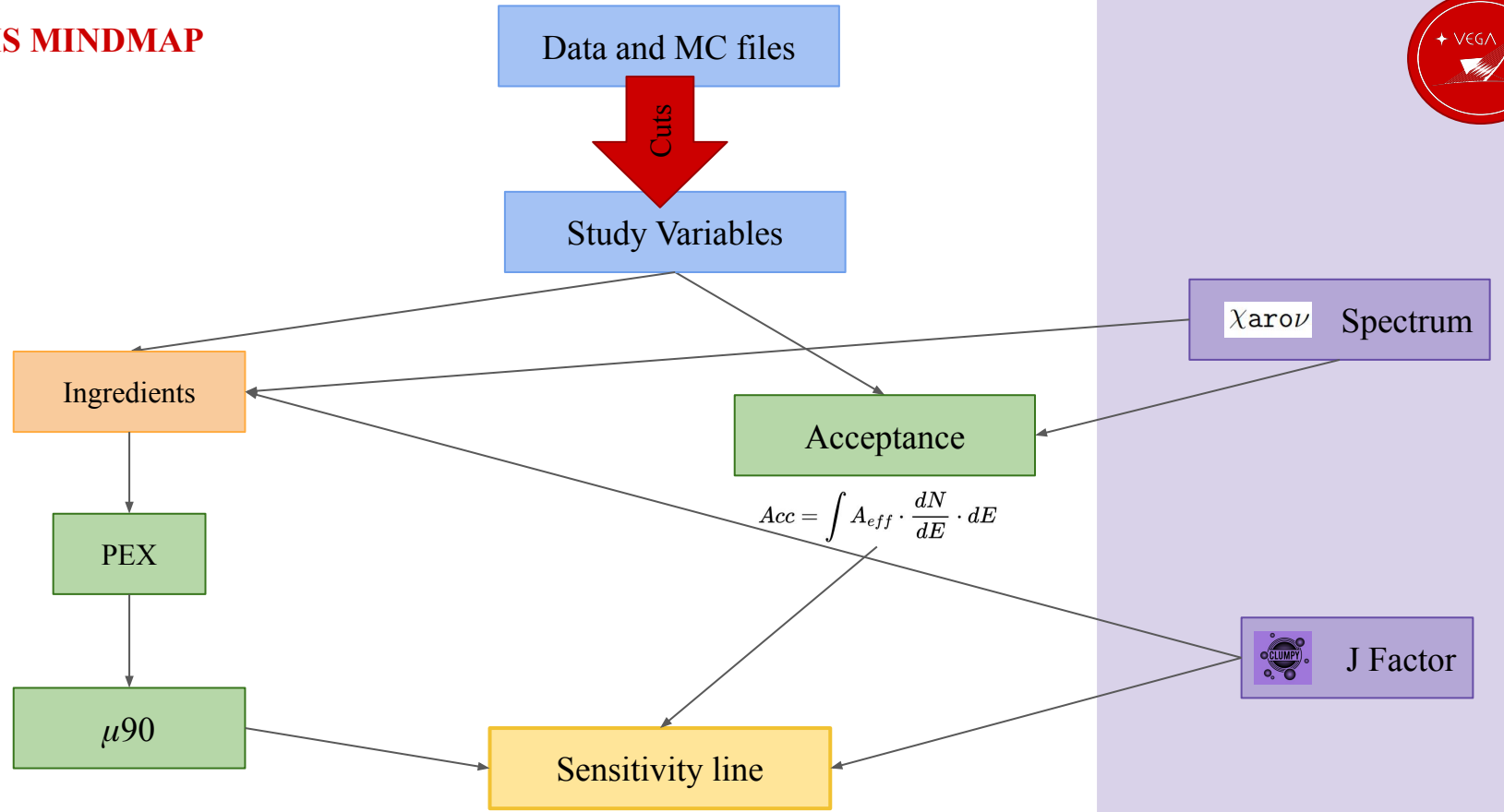




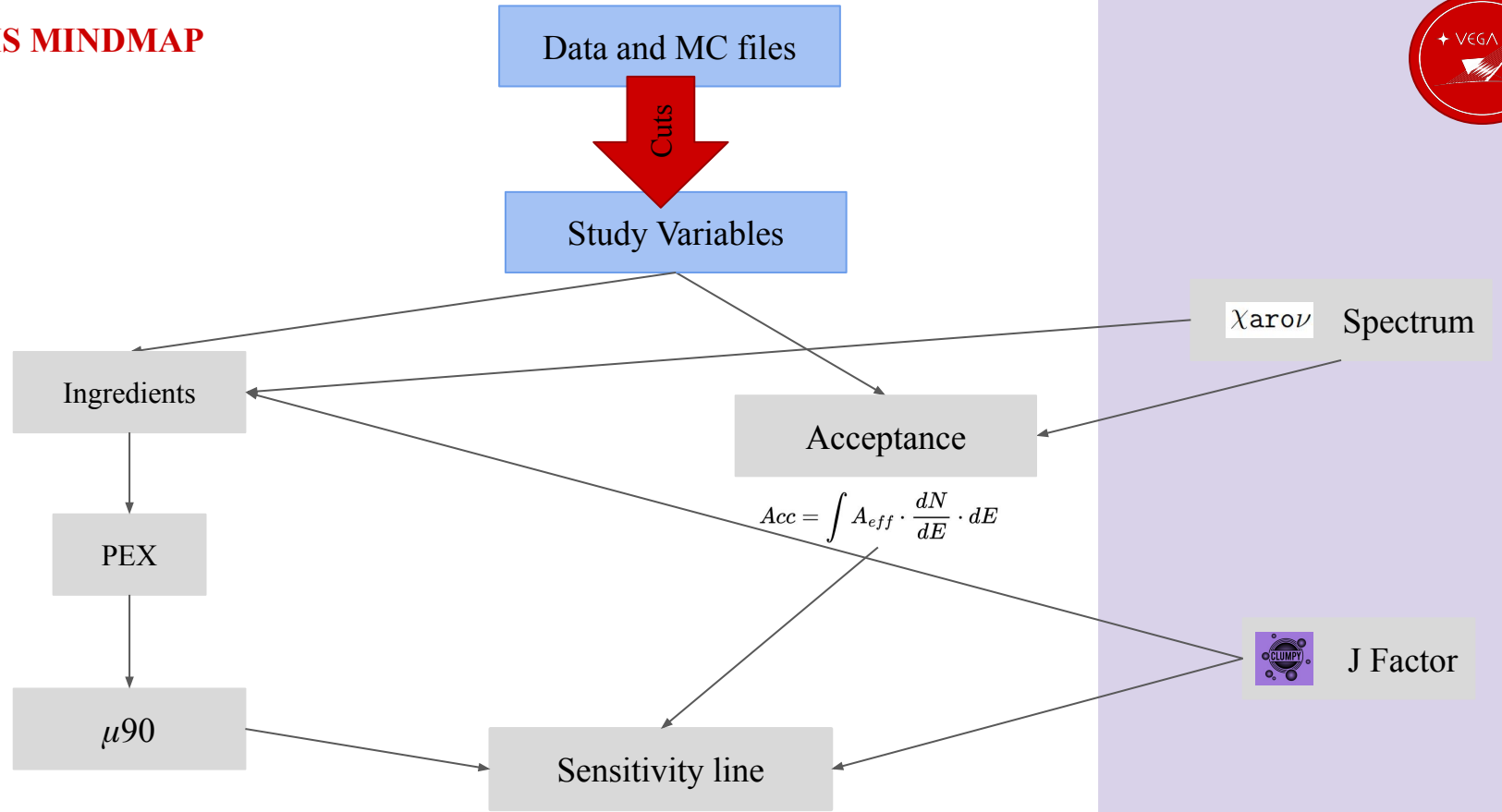
χarονν software link or PPPCDMID

CLUMPY software link

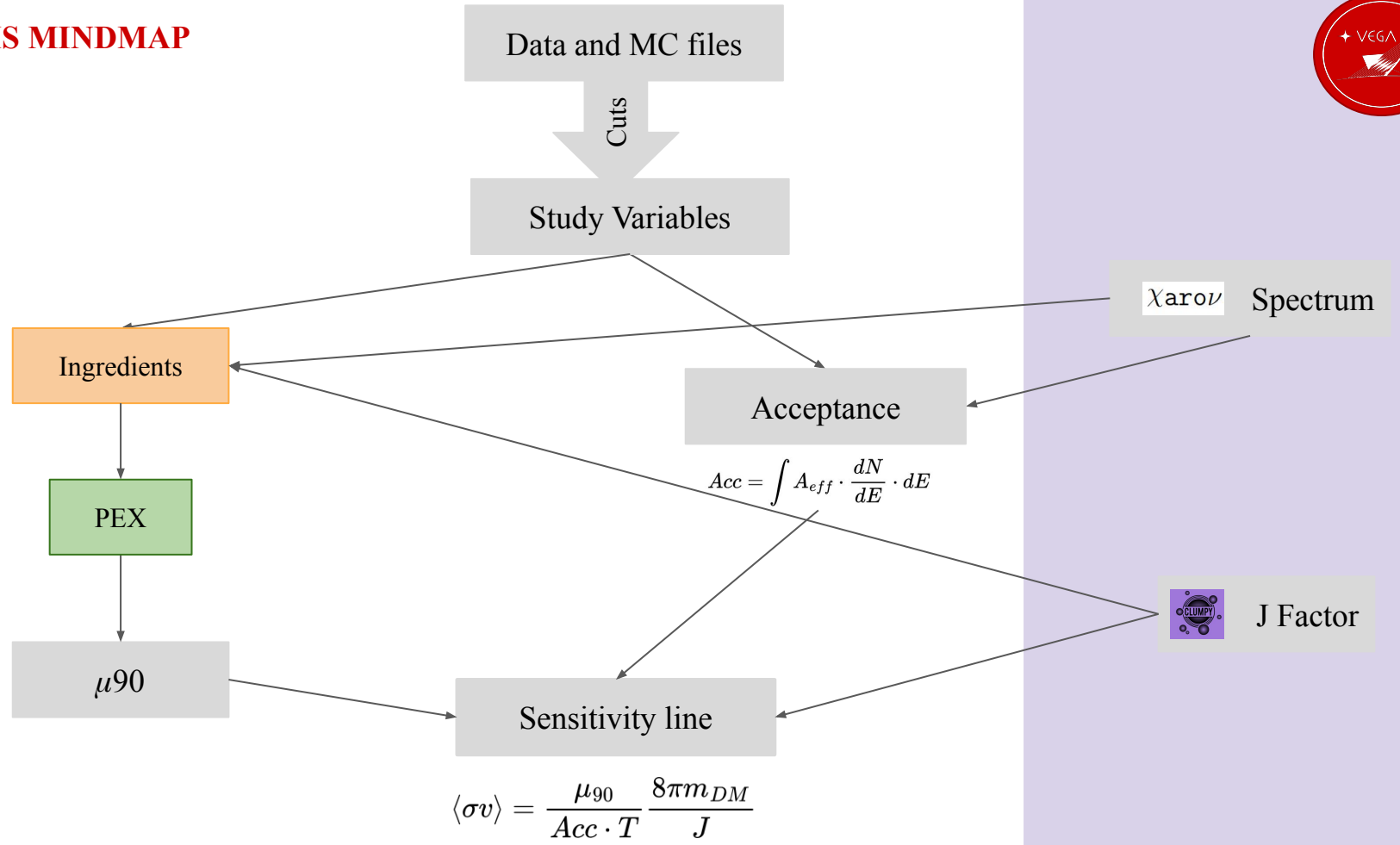
ANALYSIS MINDMAP



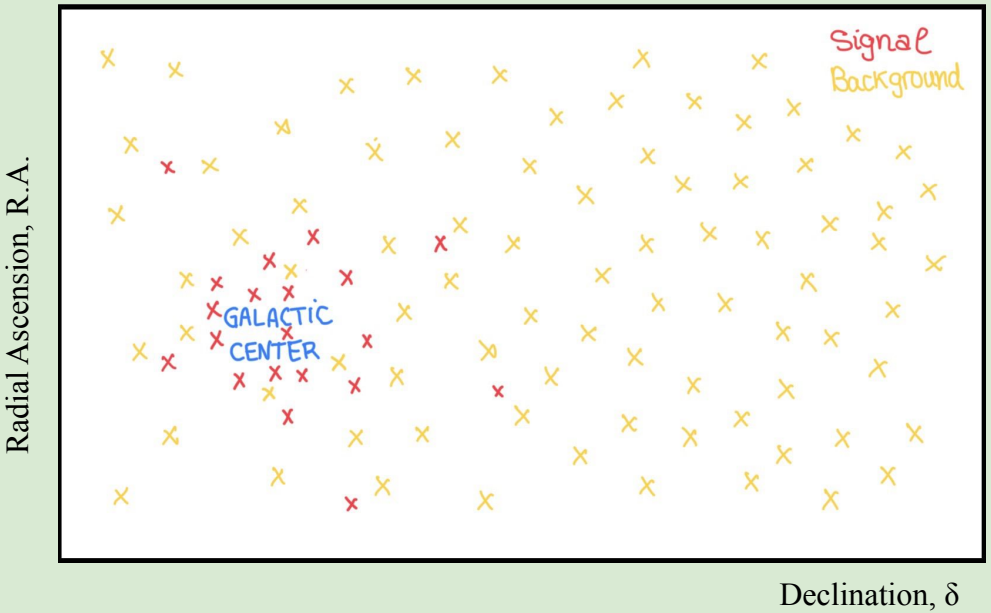
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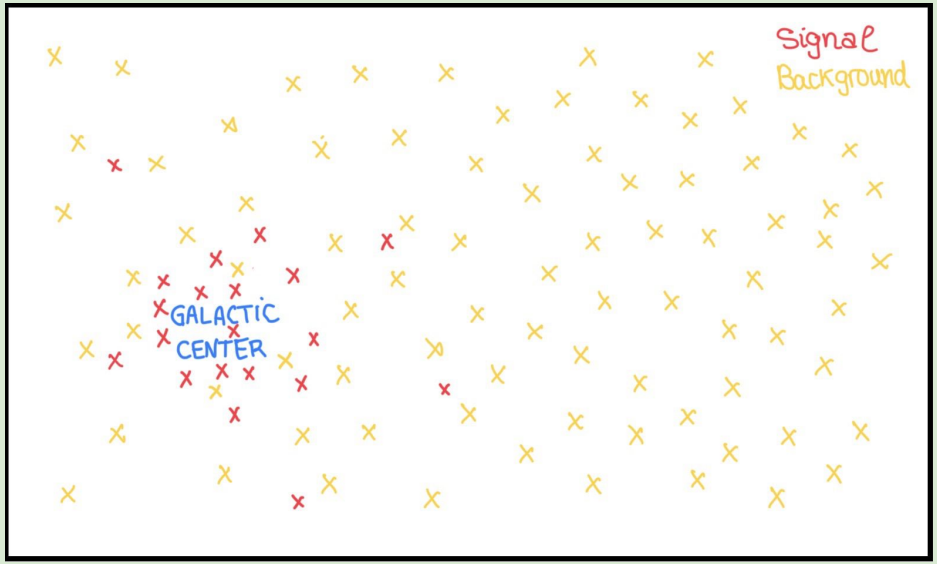
ANALYSIS MINDMAP



Pseudo-experiment creation

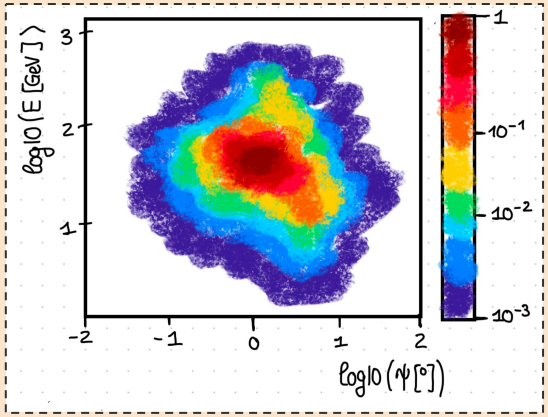


Pseudo-experiment creation



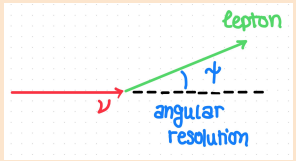
Ingredients

Signal distribution:

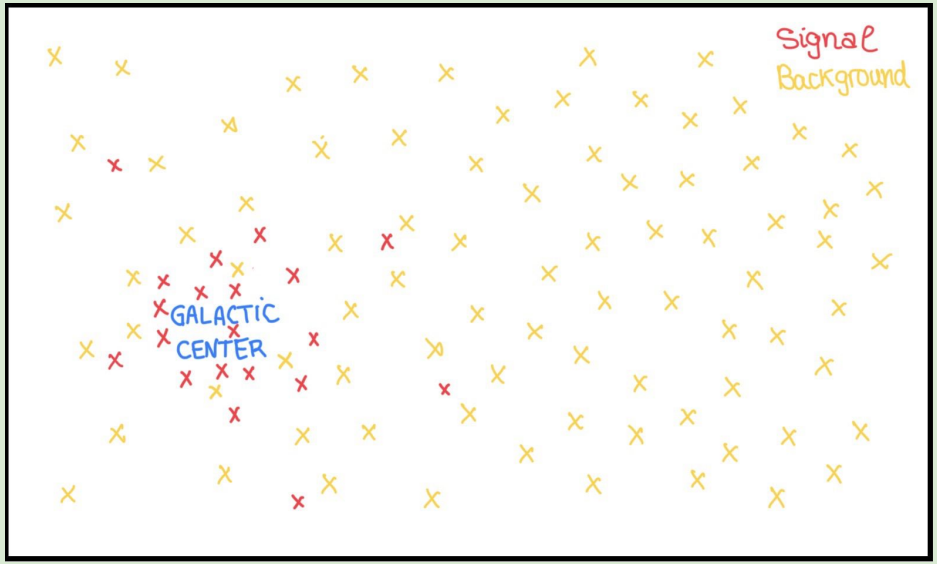


- distribution of angular resolution with reconstructed energy
- DM weights
- smeared with JFactor

⇒ Probability of finding an event at an angular distance ψ from the center of the source ($dP/d\psi$)

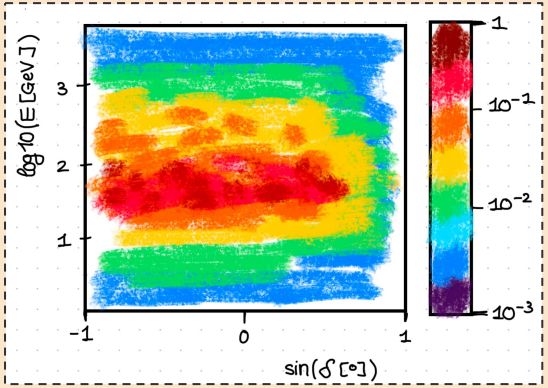


Pseudo-experiment creation



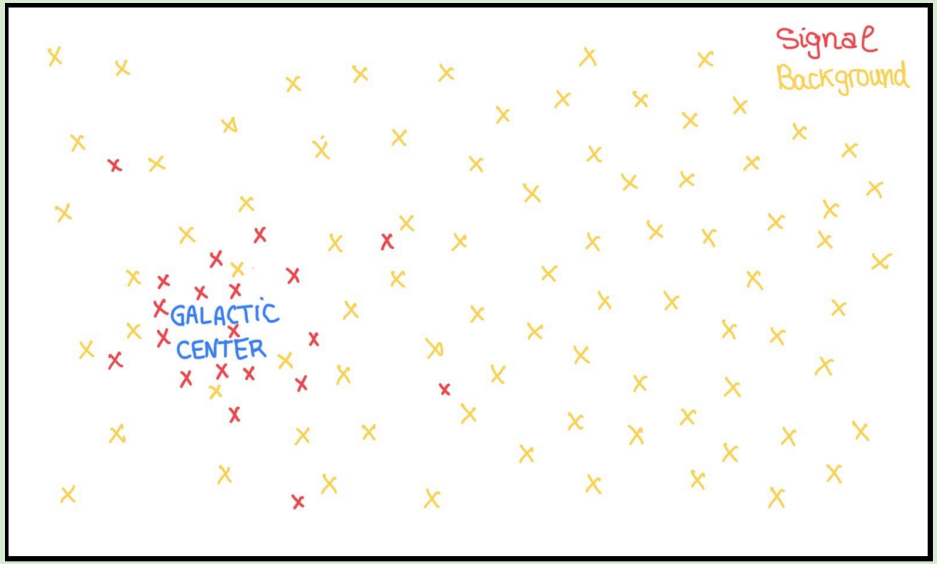
Ingredients

Background distribution:



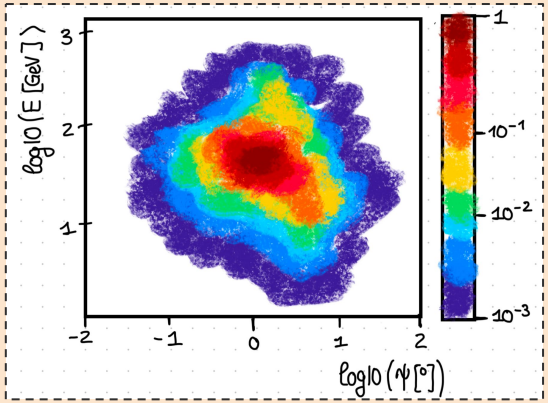
- distribution of declination with reconstructed energy
- atmospheric weights

Pseudo-experiment creation

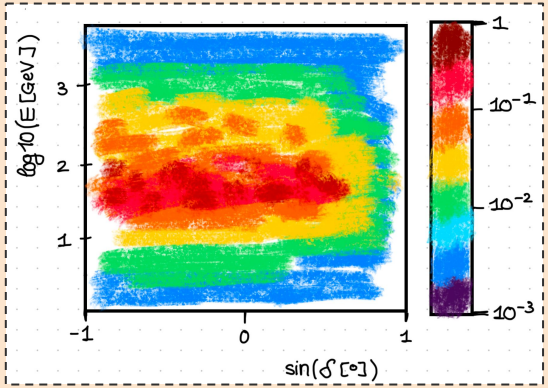


Ingredients

Signal distribution:



Background distribution:



Likelihood evaluation

We minimise the likelihood and fit the number of signal events.

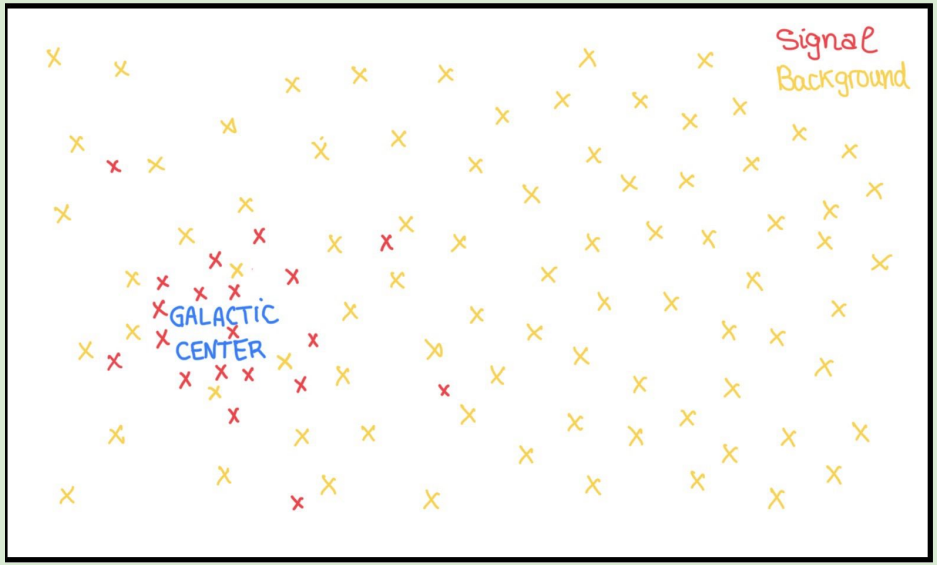
Probability of an event to be signal

Probability of an event to be background

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

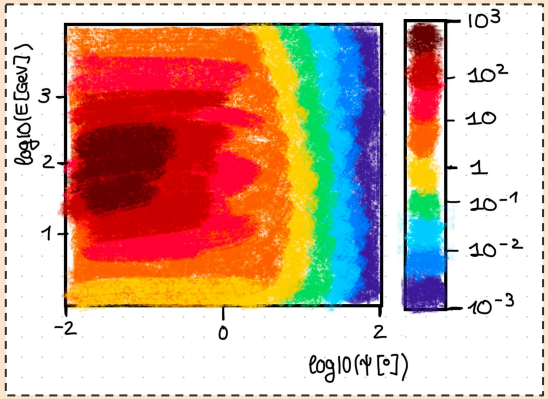
events characterised by angular distance and energy

events characterised by declination and energy

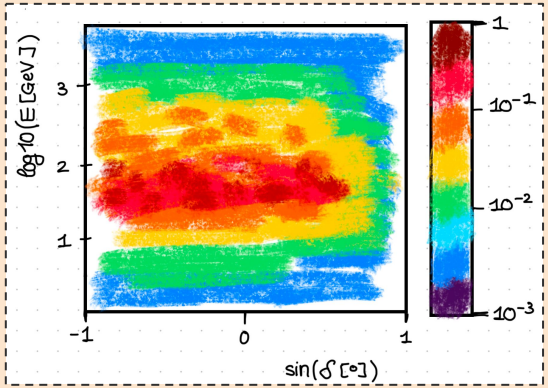


Ingredients

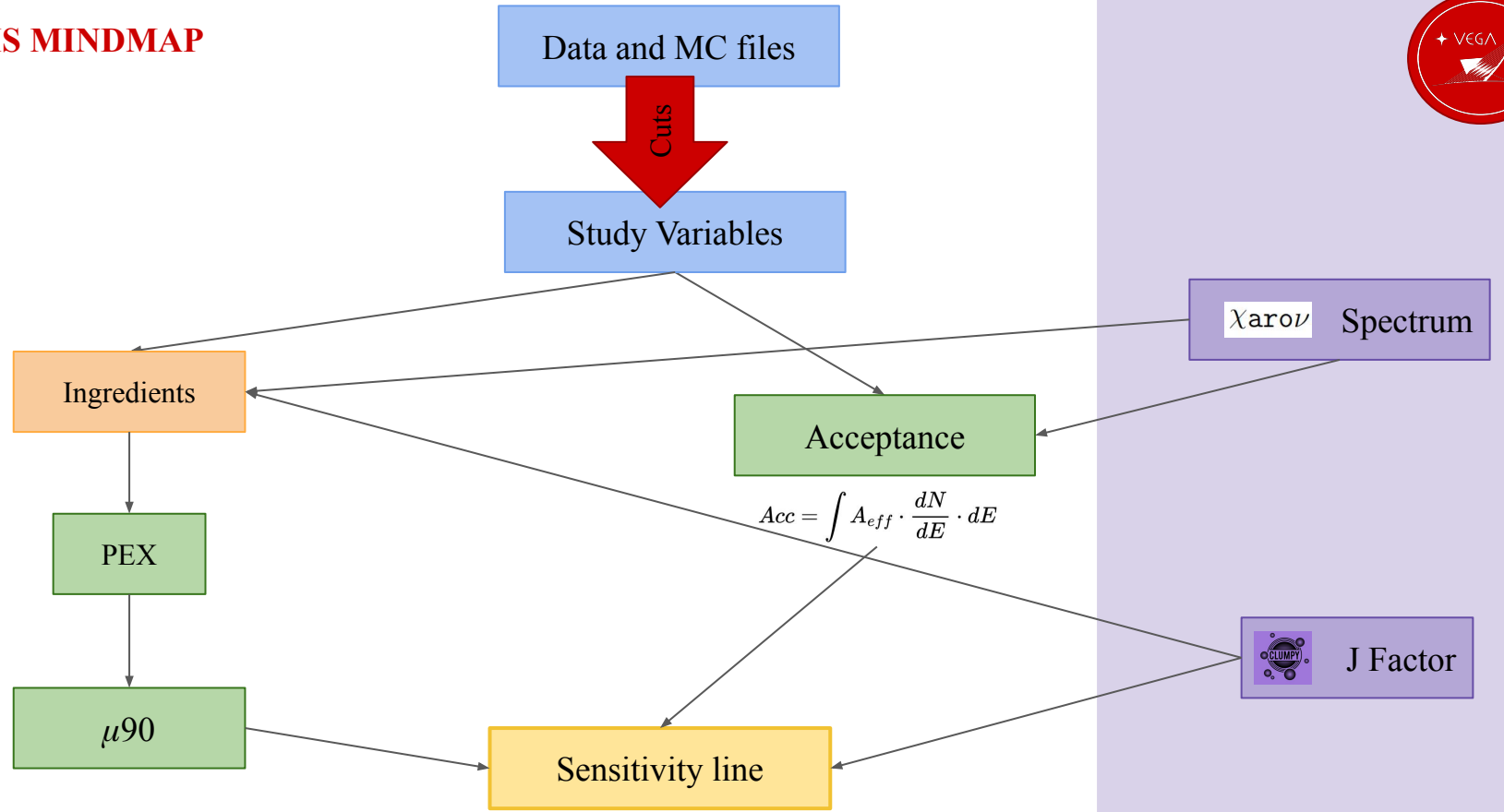
Signal probability:



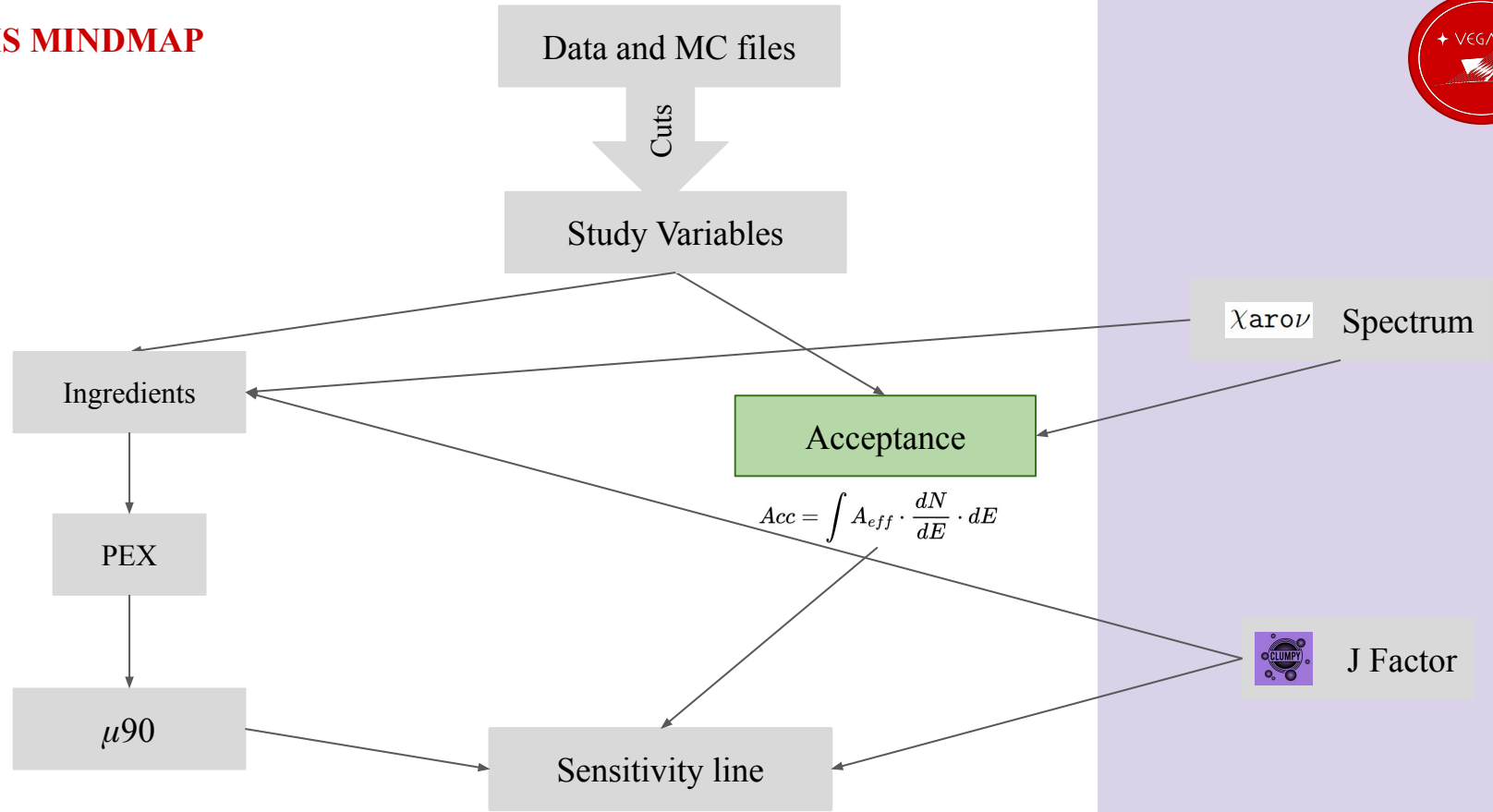
Background probability:



ANALYSIS MINDMAP

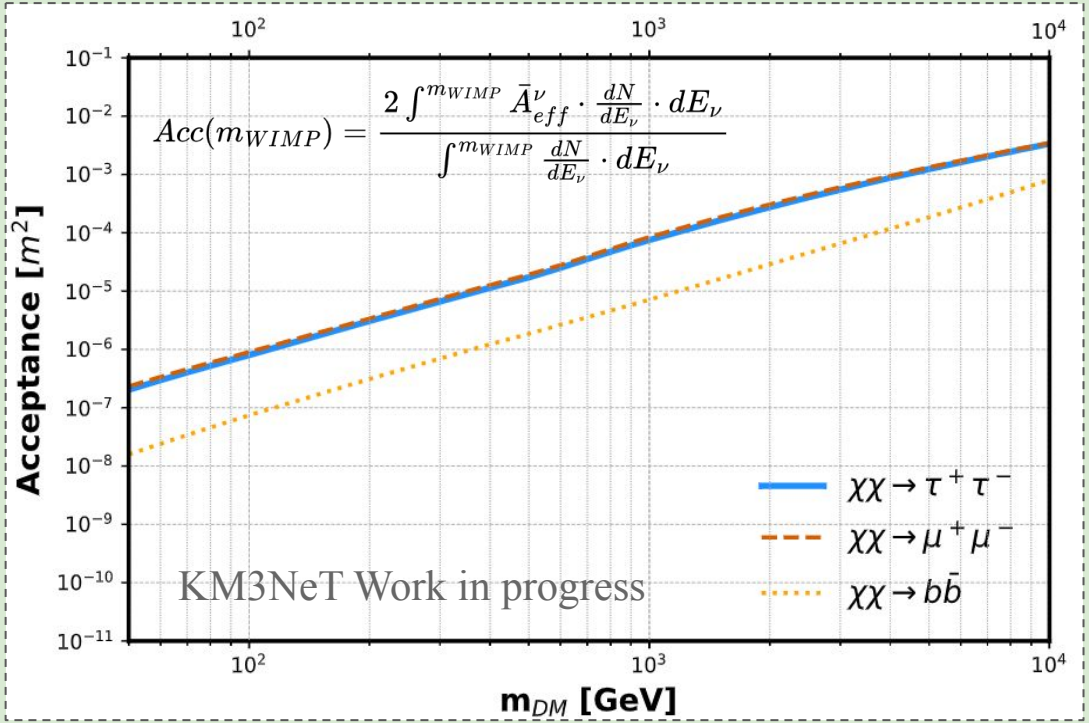


ANALYSIS MINDMAP

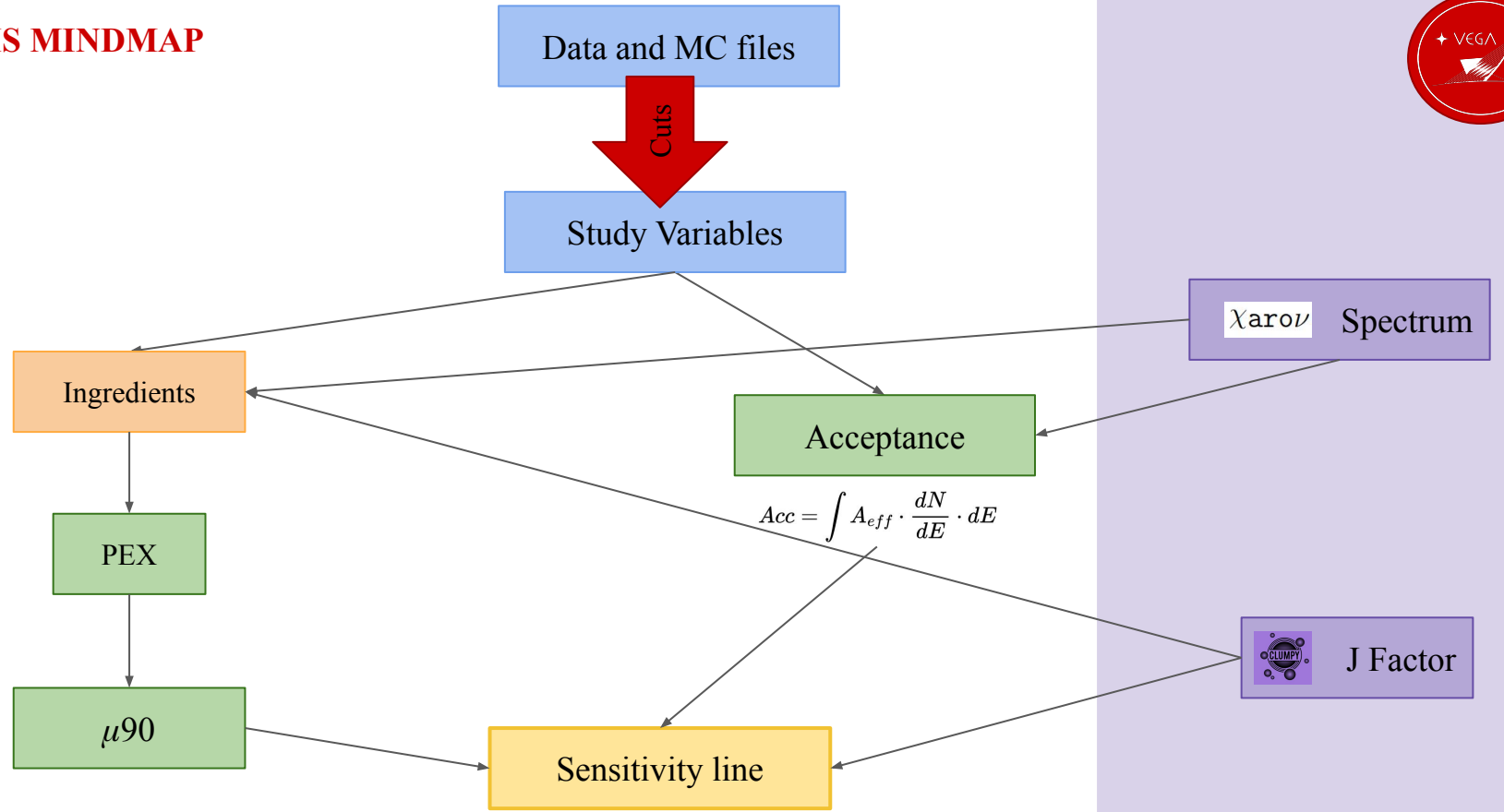


Acceptance

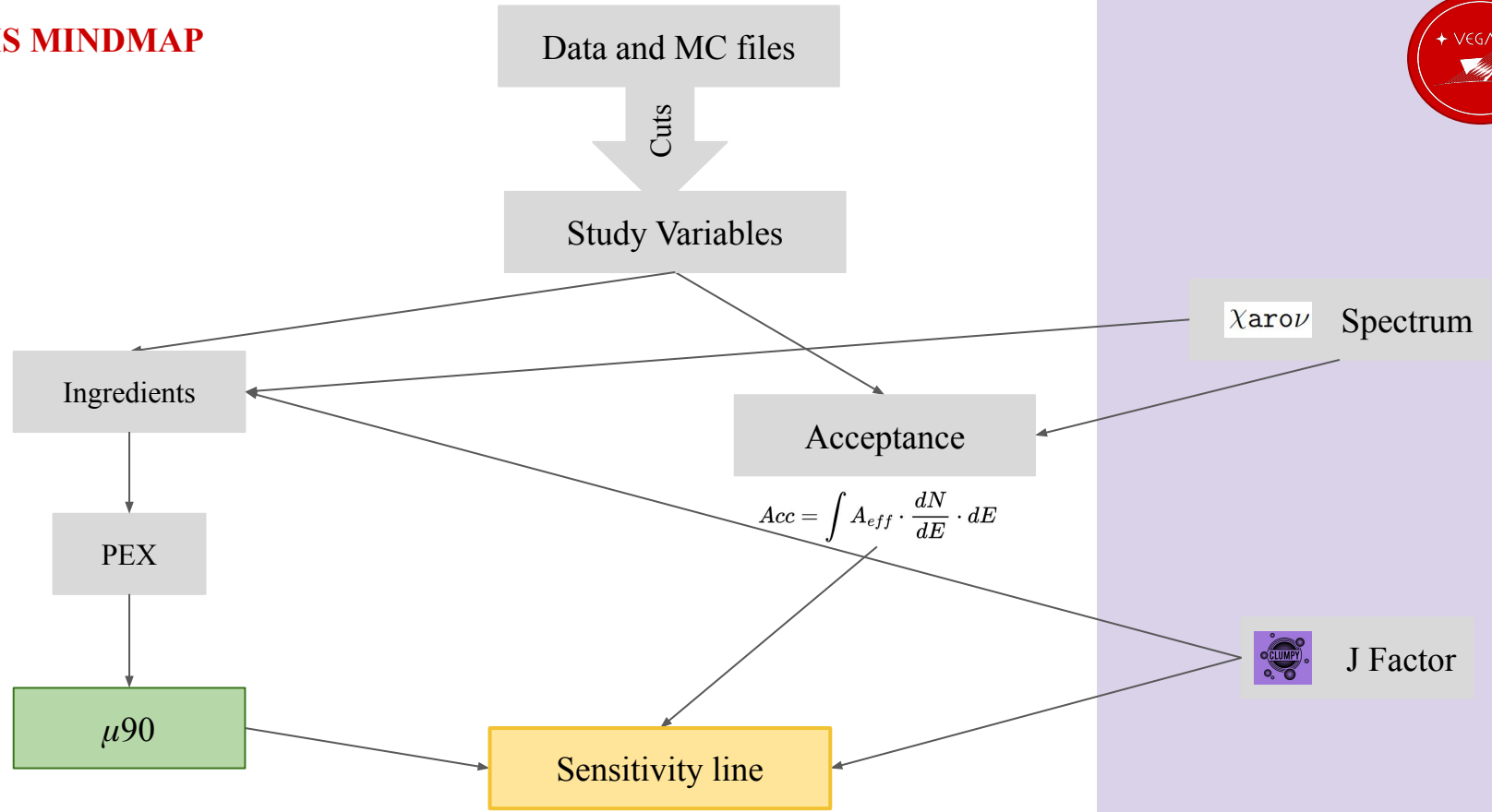
The acceptance is the modulation of effective area through the energy spectrum of the source.
It describes the ability of the detector to measure signal events.



ANALYSIS MINDMAP



ANALYSIS MINDMAP

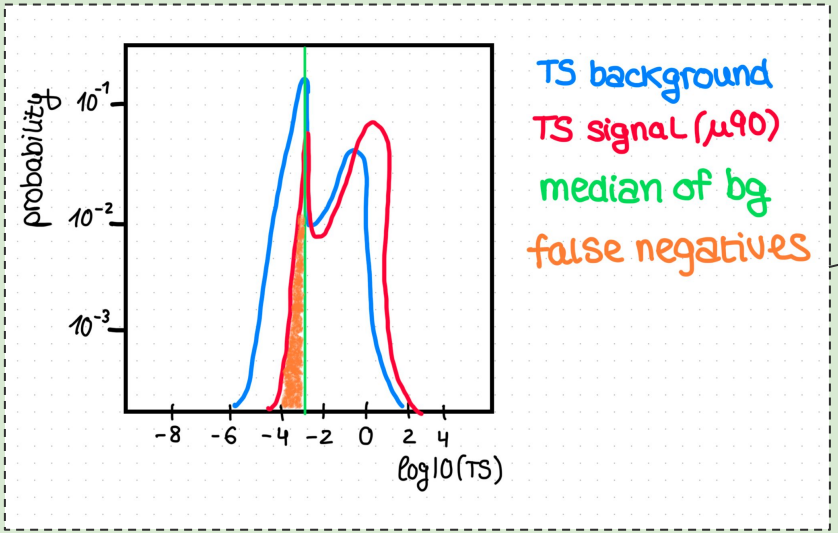


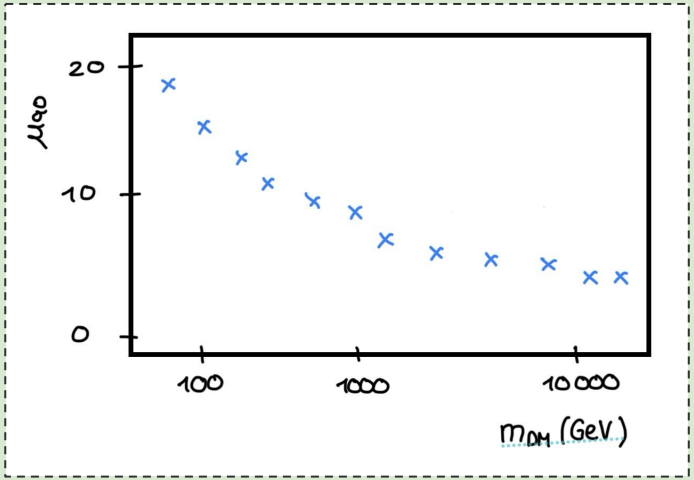
Test-Statistic and $\mu 90$ creation

The sensitivity is the upper limit on detectable signal events, assuming the data behaves like the average background. It is calculated at a given confidence level (C.L.) of 90%, meaning that for a signal at this sensitivity, we would fail to detect it 10% of the time (mistaking it for background).

We obtain the sensitivity by comparing test statistic (TS) distributions from signal-injected data to the median TS of pure background data.

$$TS = \frac{\mathcal{L}(n_{sg,max})}{\mathcal{L}(n_{sg} = 0)}$$





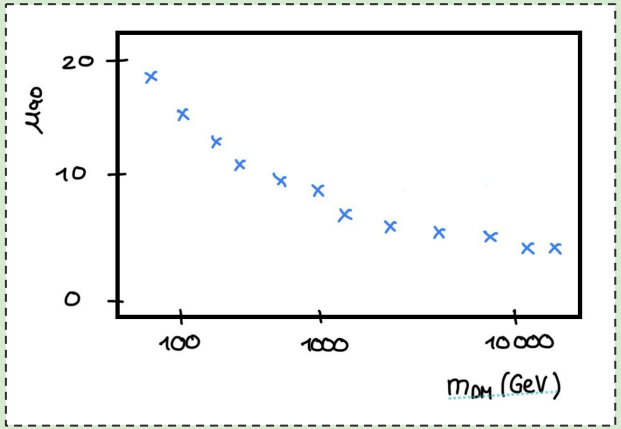
Sensitivity

Confidence intervals are derived from the test statistic (TS) distributions to exclude regions of the signal parameter space at a given confidence level.

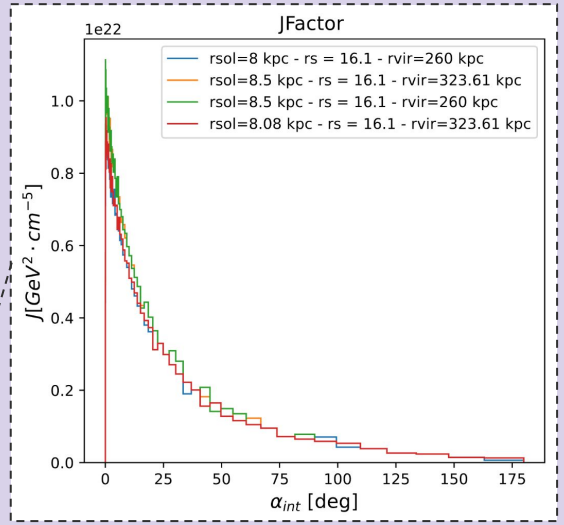
The parameter of interest for us is the thermally-averaged WIMP pair annihilation cross section,

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

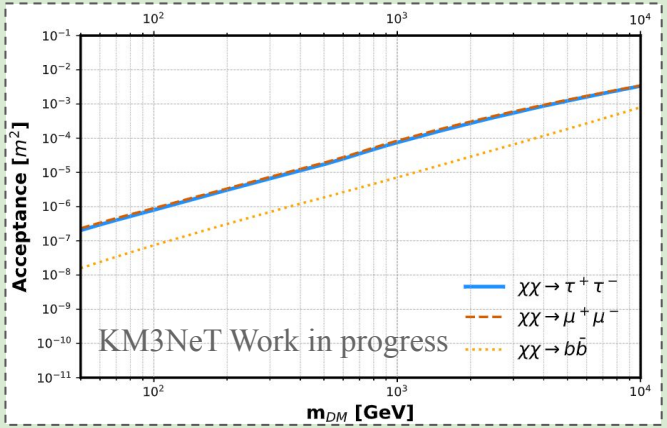
$\mu 90$

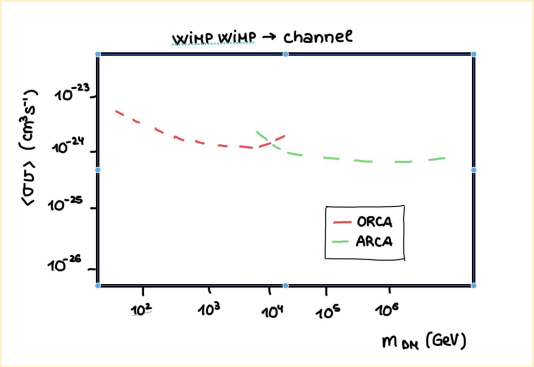


JFactor

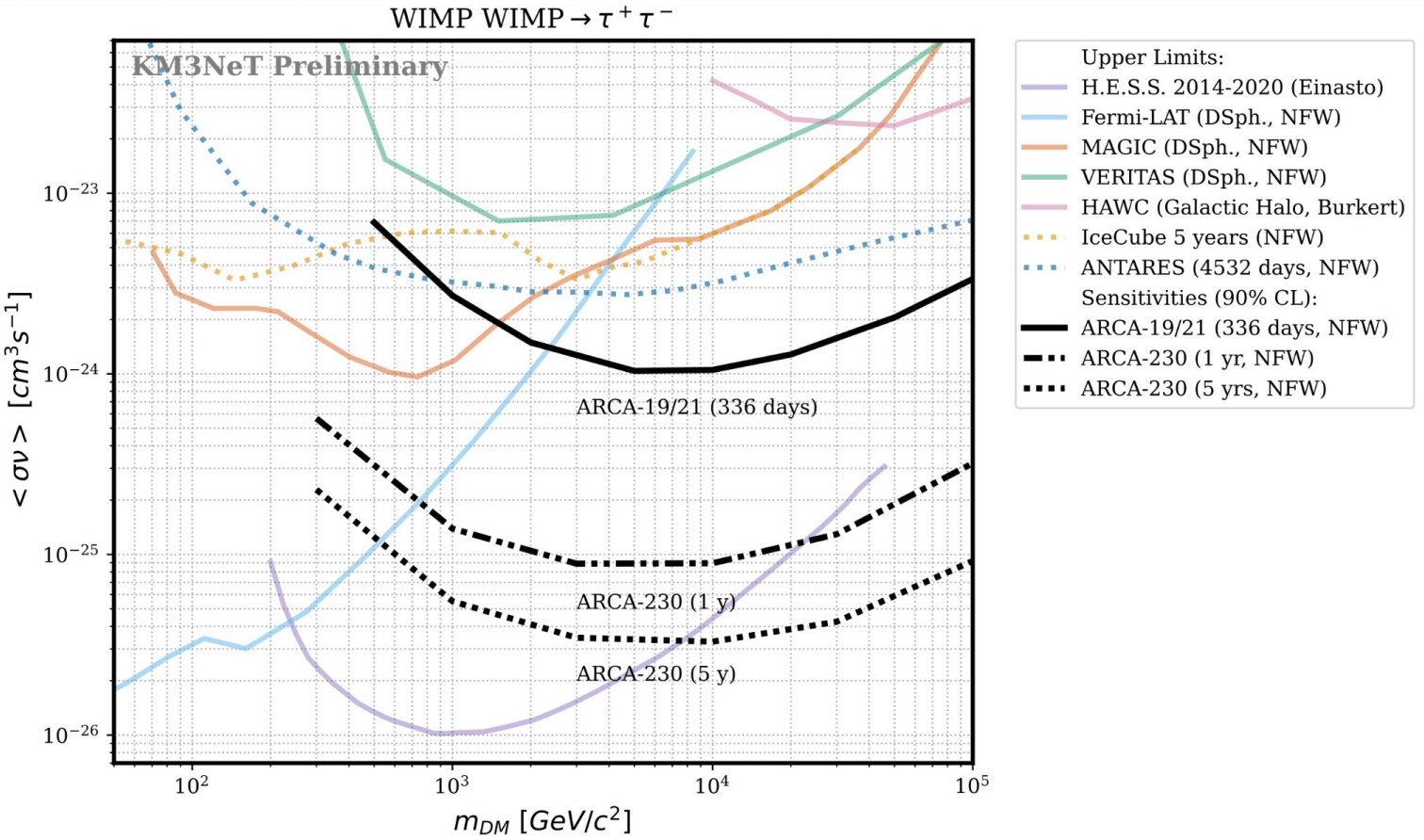


Acceptance





Sensitivities



At IFIC in Valencia, we have a long-standing involvement in dark matter research, contributing to global efforts in understanding dark matter.

- Thanks for your time -



KM3NeT/ANTARES Collaboration Meeting in Louvain (February 2025)



VEGA group in Valencia (2026)

Additional slides

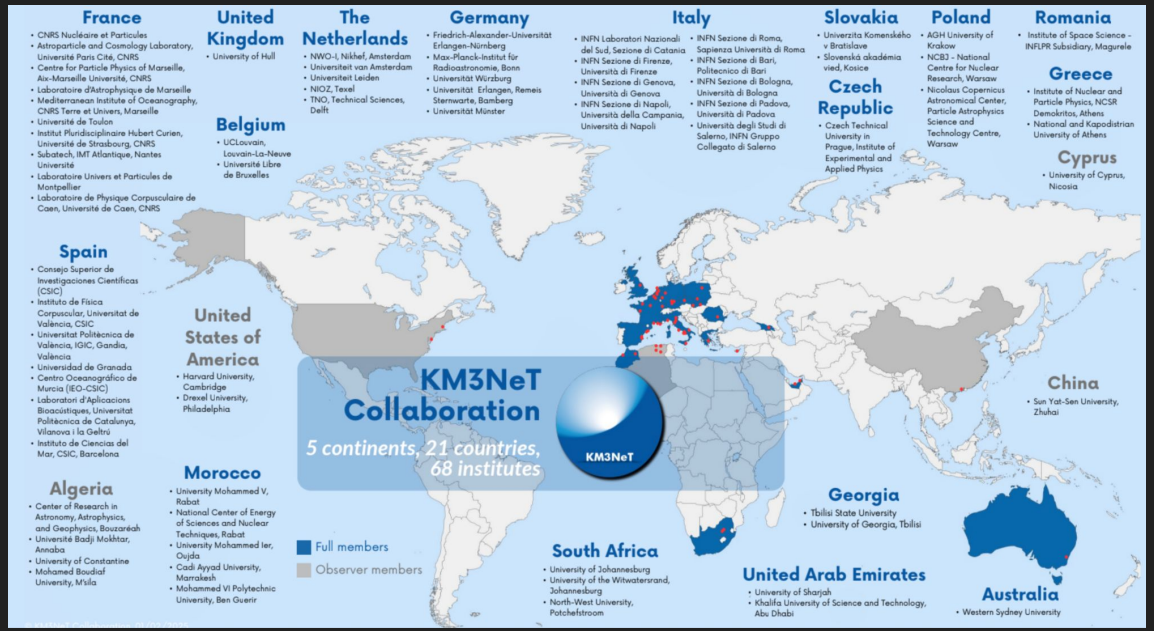






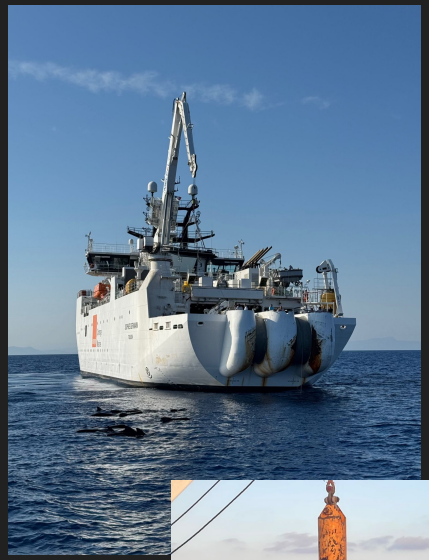
VEGA group 2024.

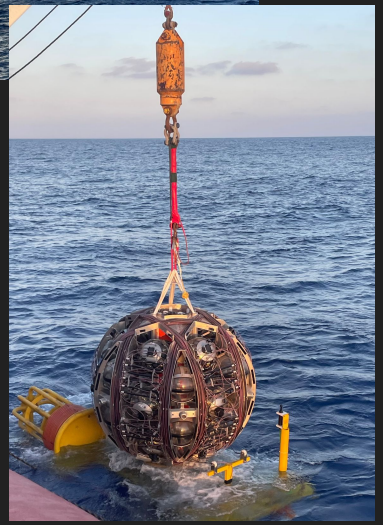




Detector Deployment







Detection method



Likelihood evaluation

We minimise the likelihood and fit the number of signal events.

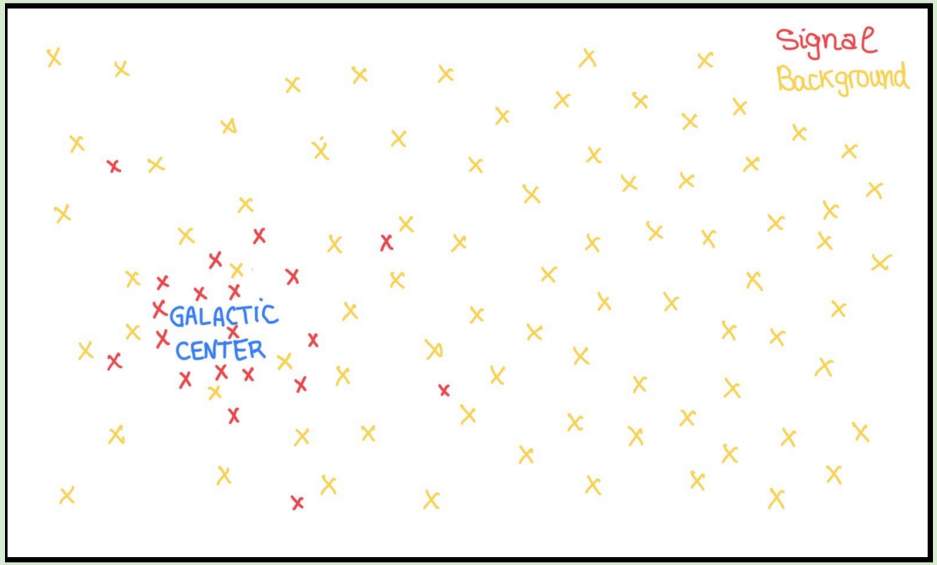
$$-\log \mathcal{L} = -\prod_{i=1}^{N_{events}} log\left[n_{sg}P_{sg}(\psi_i, E_i) + (N_{events} - n_{sg})P_{bg}(\delta_i, E_i)\right]$$

Probability of an event to be signal

Probability of an event to be background

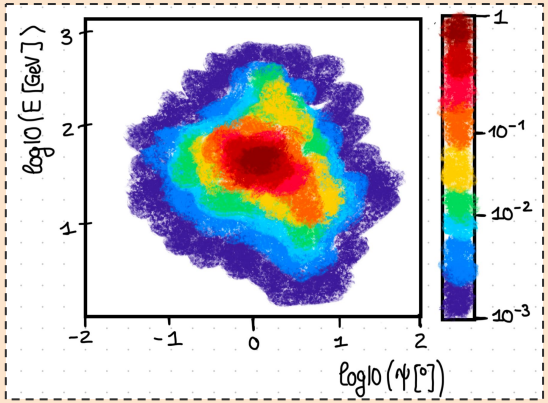
events characterised by angular distance and energy

events characterised by declination and energy



Ingredients

Signal distribution:



Background distribution:

