NUCLÉAIRE & PARTICULES

Laboratoire Leprince-Ringuet

ÉCOLE POLYTECHNIQUE

IP PARIS

Status of the Spectral Analysis

for the DSNB search

Rudolph Rogly - *December 18th, 2024*

Neutrino Group Meeting

Reminder about the spectral analysis pipeline

Backgrounds prediction

Atmospherics prediction from Atmospherics MC

Spallation prediction from smart reweighting of the IBD MC

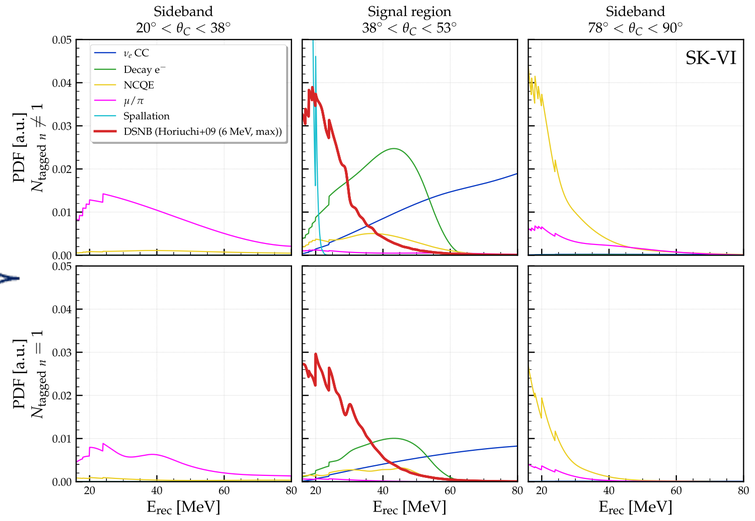
Signal prediction

IBD MC encoded in the derivation of a response matrix

+

DSNB predicted fluxes

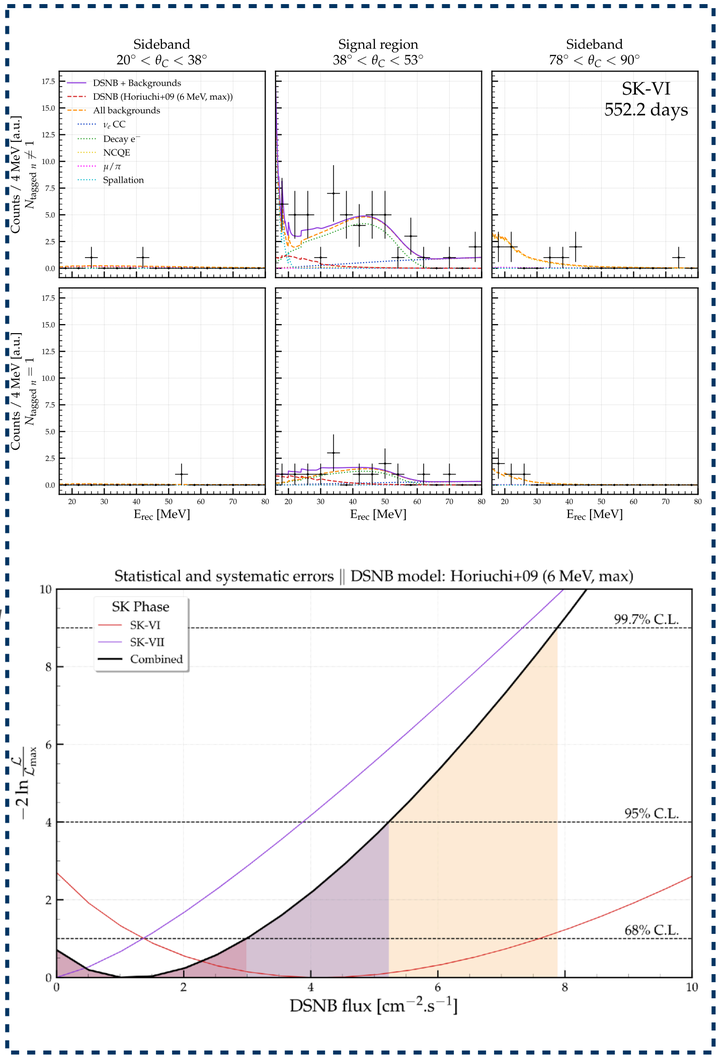
DSNB model-dependent & shape-only driven analysis



Normalized PDFs, after application of 1st/2nd/3rd reductions + n-tag

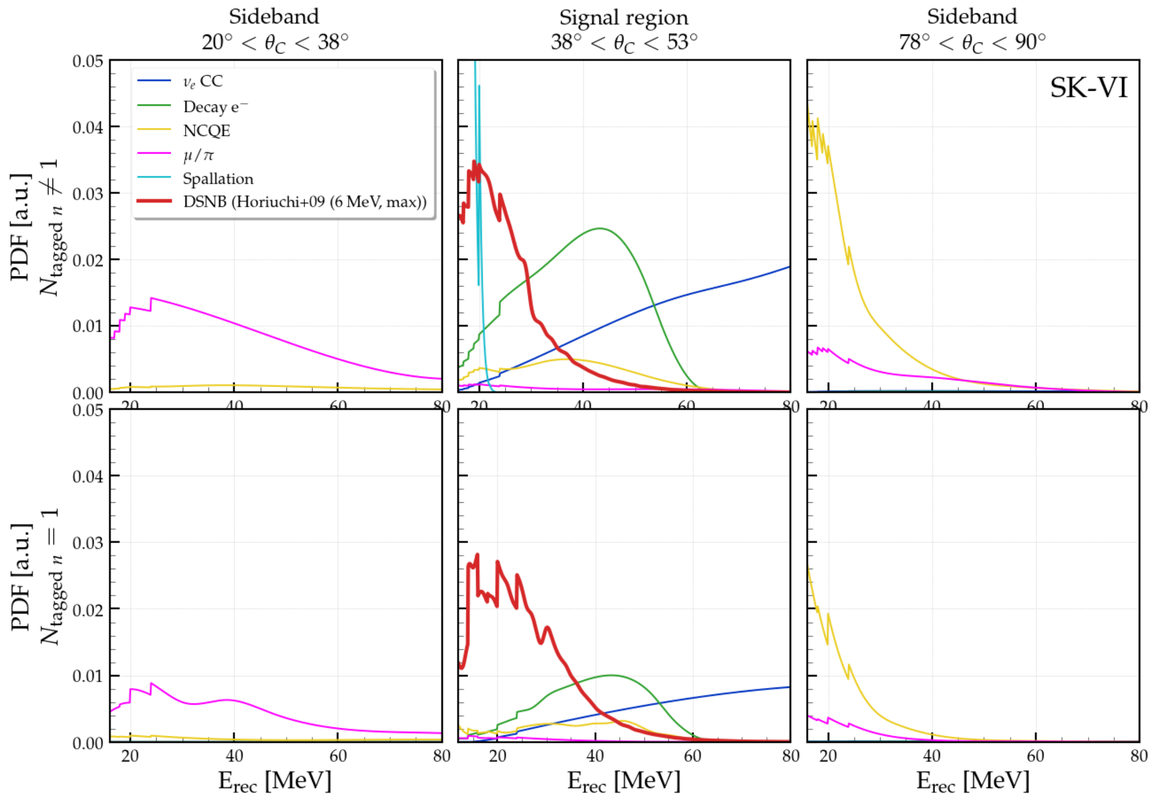
Data

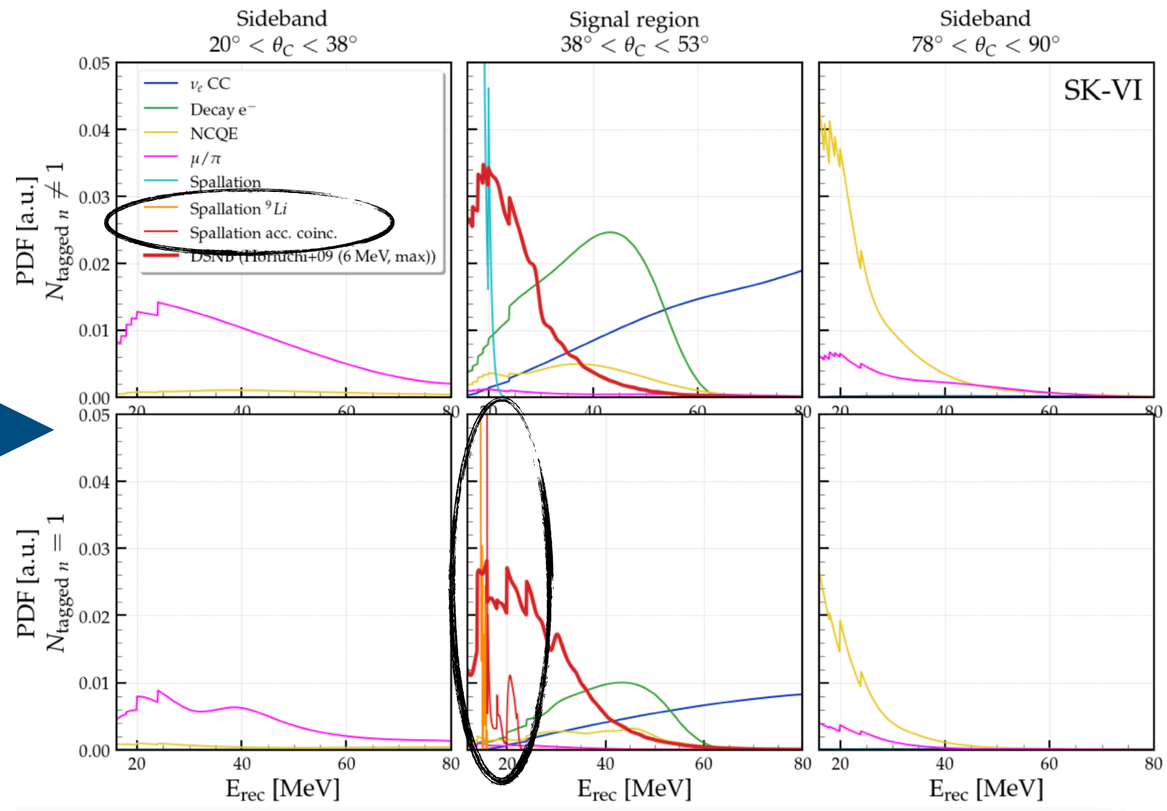
\+ *Extended Likelihood Maximization*



Results

Spallation additional PDFs





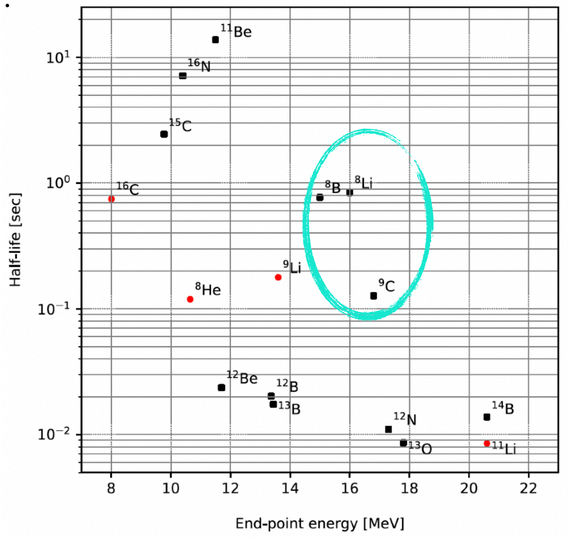
Limitations of the current approach

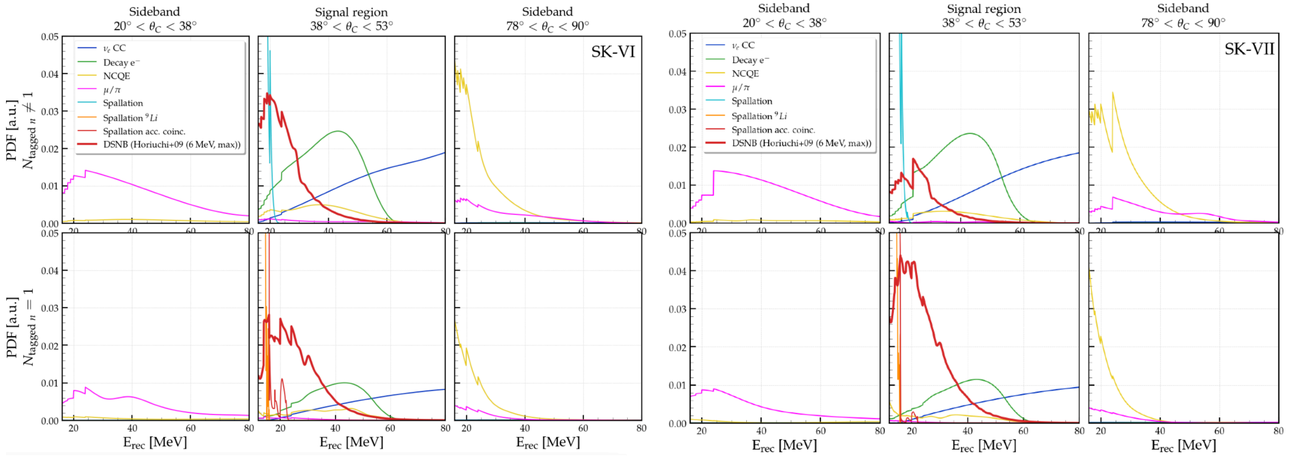
- The modification of the PDF content of the fitting model involves at least 2 additional fitting parameters: $N_{^9Li}$ and $N_{acc.\ coinc.}$.

- For now, no additional systematics on the shape of the accidental coincidence PDF that might come from: e.g. uncertainties in the (IBD) mistag rates values applied to derive the PDF.

- Main limitation of the approach so far: the normalization parameters of the accidental coincidence PDF and ^{9}Li PDF of the n-tag=1 region are completely unconstrained by the normalization parameter of the spallation PDF of the n-tag≠1 region.

  → ***Reminder***: the spallation PDF of the n-tag≠1 region is built from a parametric description of the **contribution of 3 isotopes** in the spectra, that is **valid only above 16 MeV**.





- *NB*: In the 12-16 MeV region in ntag=1/med. θ_c

  → Only 2 data points for SK-VI & 1 data point for SK-VII.

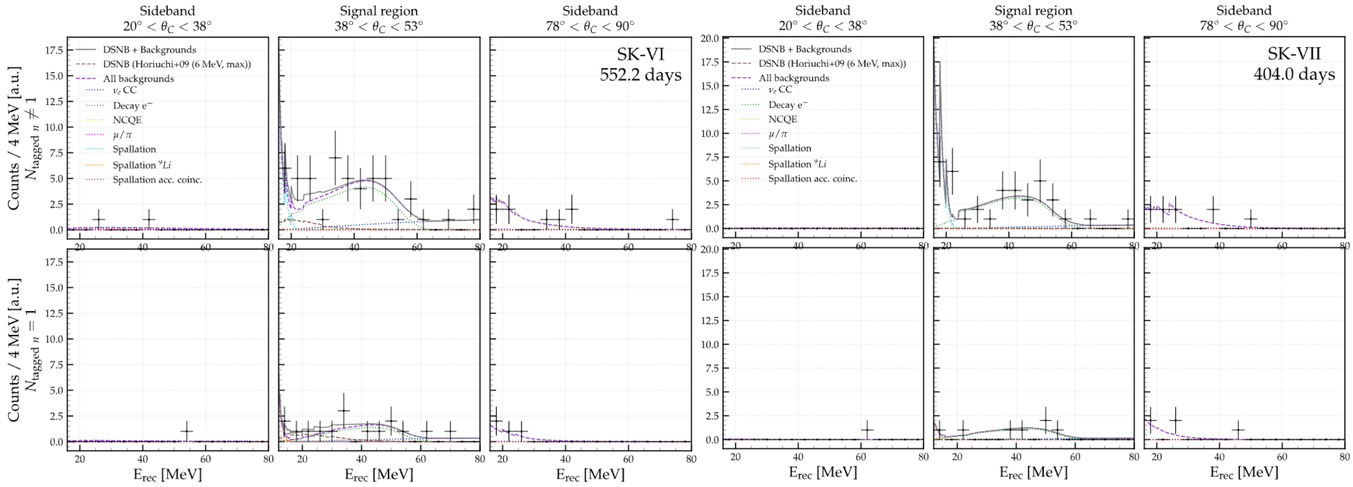
Limitations of the current approach

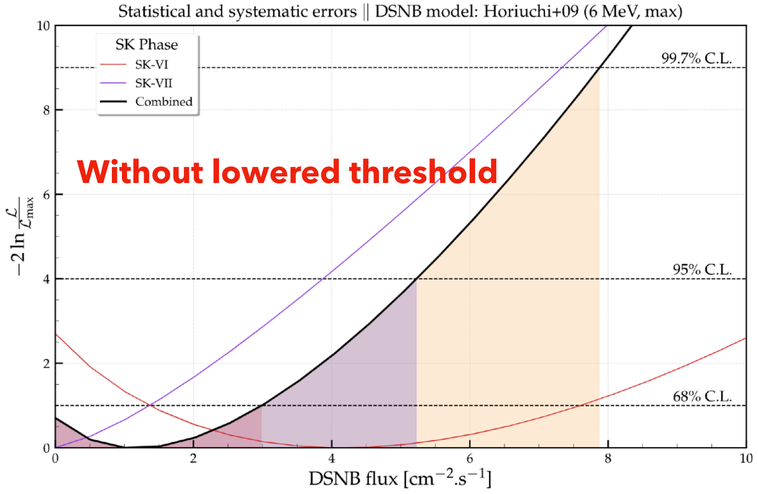
- The modification of the PDF content of the fitting model involves at least 2 additional fitting parameters: $N_{^9Li}$ and $N_{acc.\ coinc.}$.

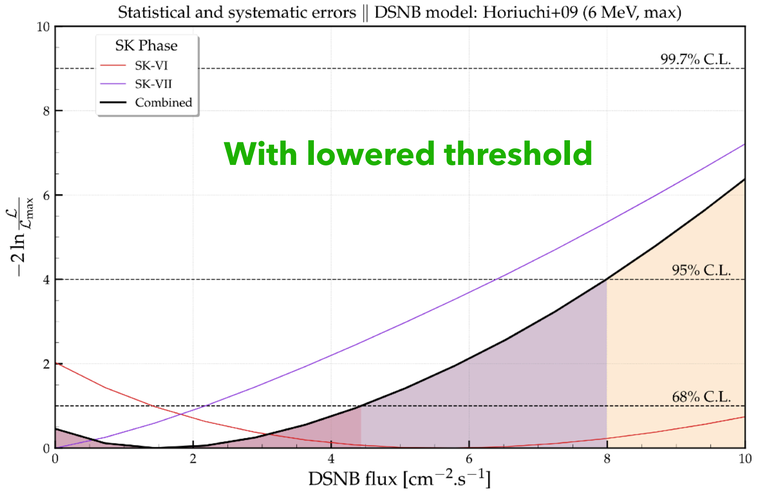
- For now, no additional systematics on the shape of the accidental coincidence PDF that might come from: e.g. uncertainties in the (IBD) mistag rates values applied to derive the PDF.

- Main limitation of the approach so far: the normalization parameters of the accidental coincidence PDF and ^{9}Li PDF of the n-tag=1 region are completely unconstrained by the normalization parameter of the spallation PDF of the n-tag≠1 region.

  → ***Reminder***: the spallation PDF of the n-tag≠1 region is built from a parametric description of the **contribution of 3 isotopes** in the spectra, that is **valid only above 16 MeV**.







Significant increase in the statistical uncertainty due to the lack of constraints in the current version of the fit.

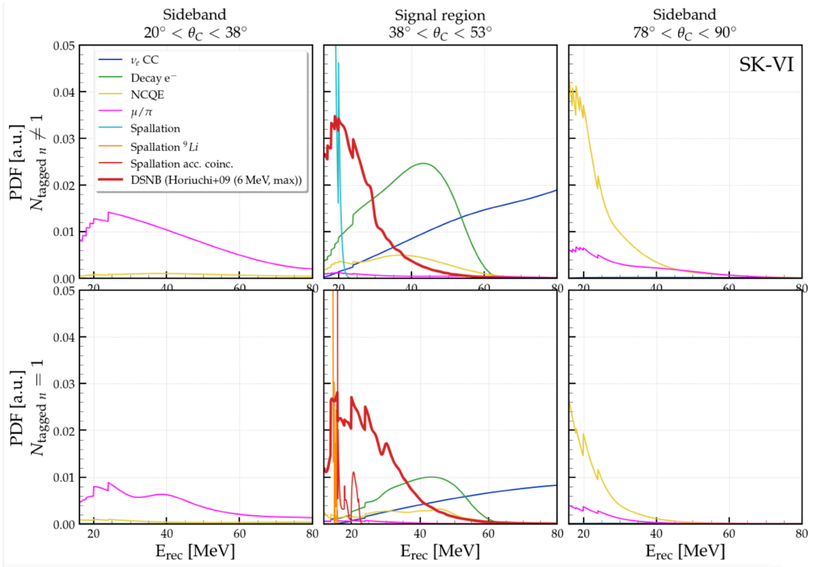
Still working on this.

Unbinned vs. Binned Fit — Rationale

1. Assess the impact of the PDFs sharpness in the final results:

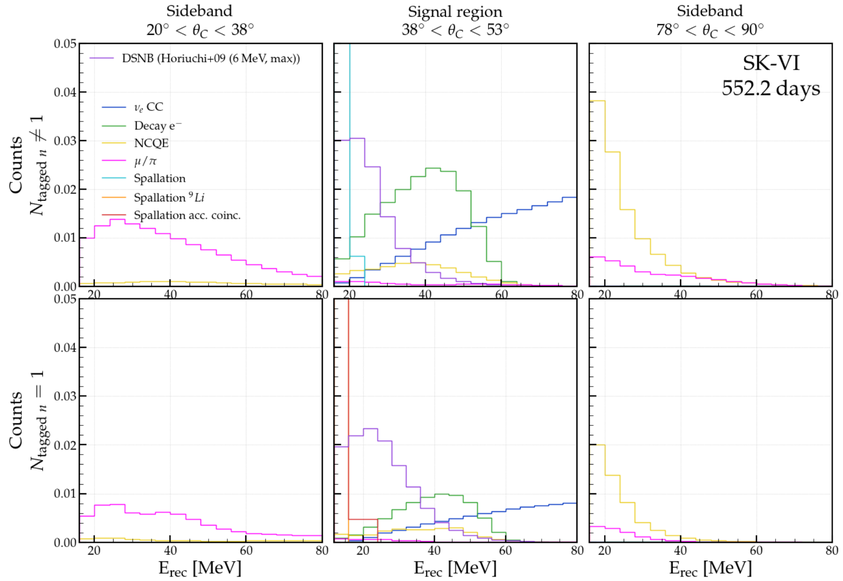
➡ For the *unbinned fit*, some sharp variations in the PDFs due to the application of the binned spallation (and solar) cut efficiencies, that are not smoothly-varying.

➡ For the *binned fit*, these sharp variations are washed out by the integration over the energy bin (see below).



From unbinned

to binned



2. **Derive a goodness-of-fit**:

➡ For the *unbinned fit,* no such natural statistics.

➡ For the *binned fit,* we can use the ~~standard χ^2~~ ***deviance*** *aka* ***G***-statistics:

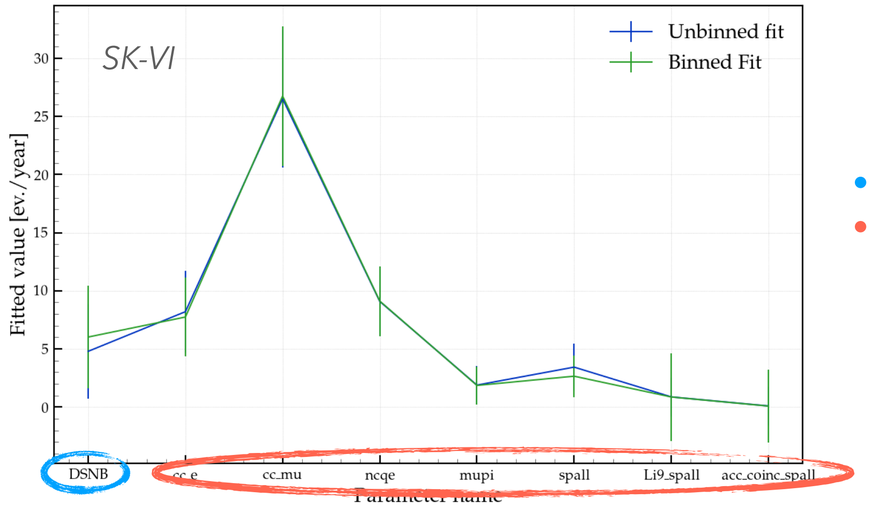
$$G(Data, Model) = \sum_{bin\ n°i} Data[i] \cdot \ln\left(\frac{Data[i]}{Model[i]}\right)$$

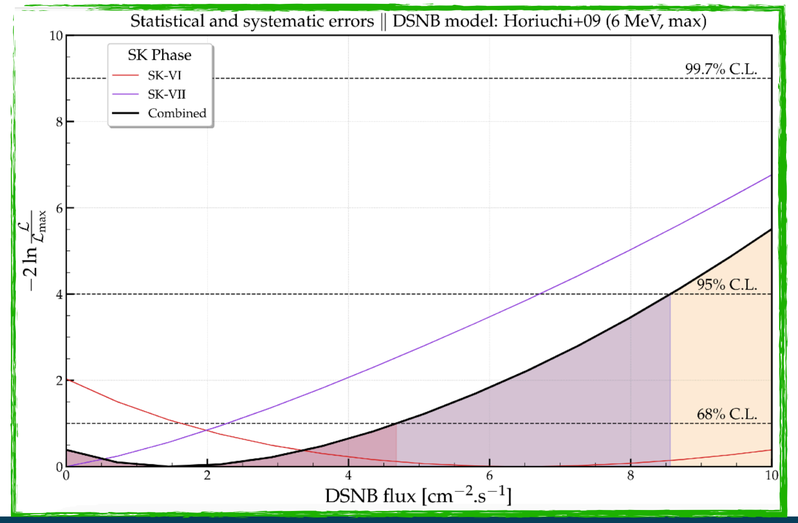
Unbinned vs. Binned Fit - Results / Comparison

1. Assess the impact of the PDFs sharpness in the final results:

➡ For the *unbinned fit*, some sharp variations in the PDFs due to the application of the binned spallation (and solar) cut efficiencies, that are not smoothly-varying.

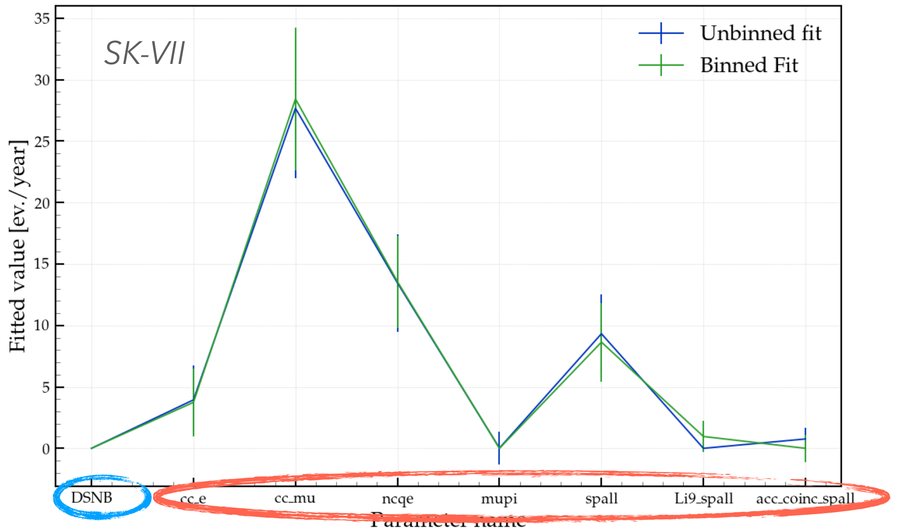
➡ For the *binned fit*, these sharp variations are washed out by the integration over the energy bin.

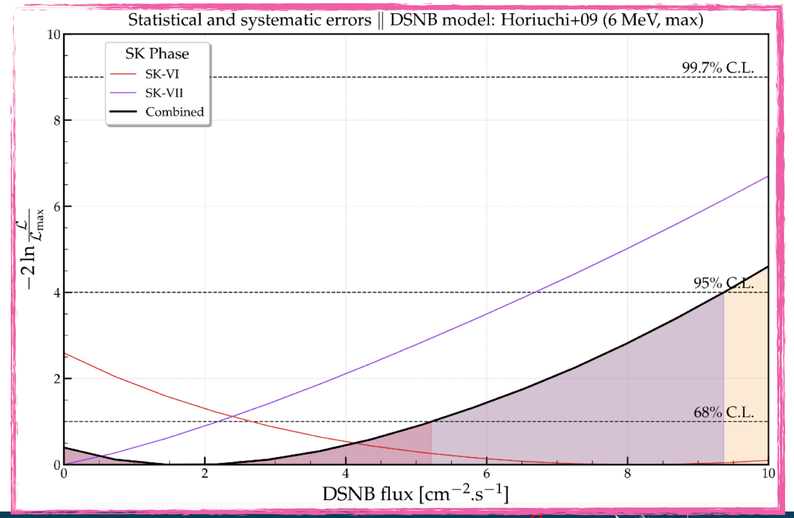




- Signal parameter
- Background categories parameters

- Unbinned Fit
- Binned Fit



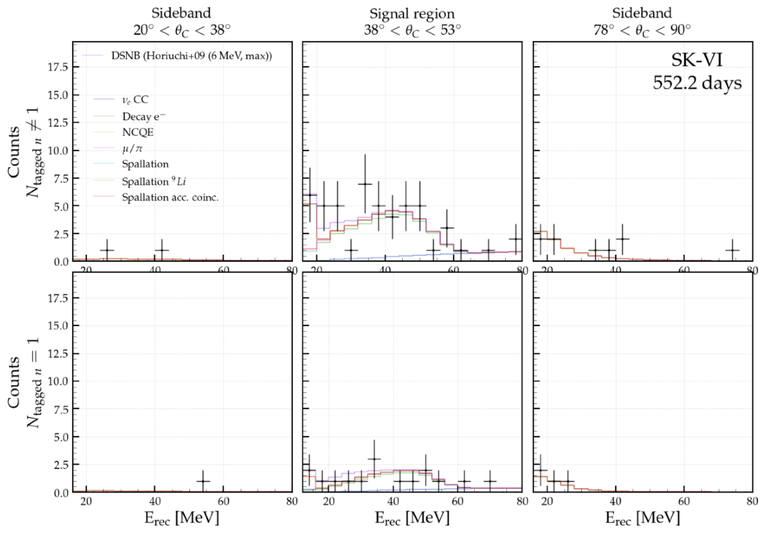


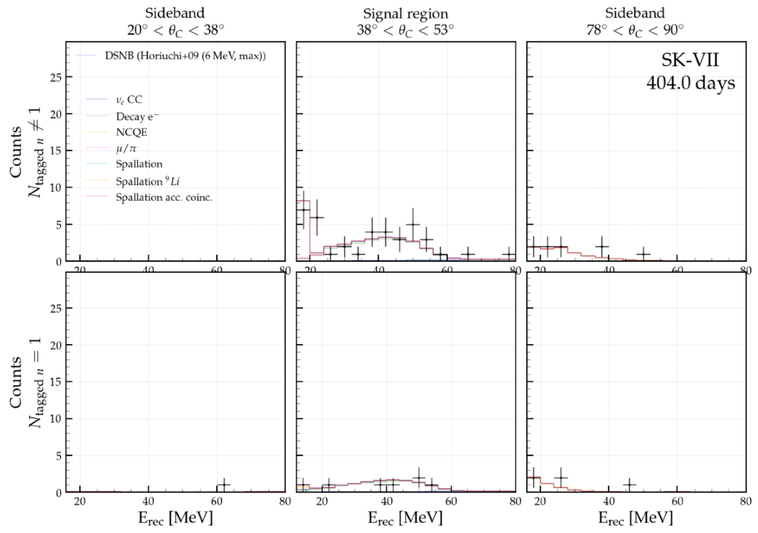
Binned Fit - Goodness-of-fit

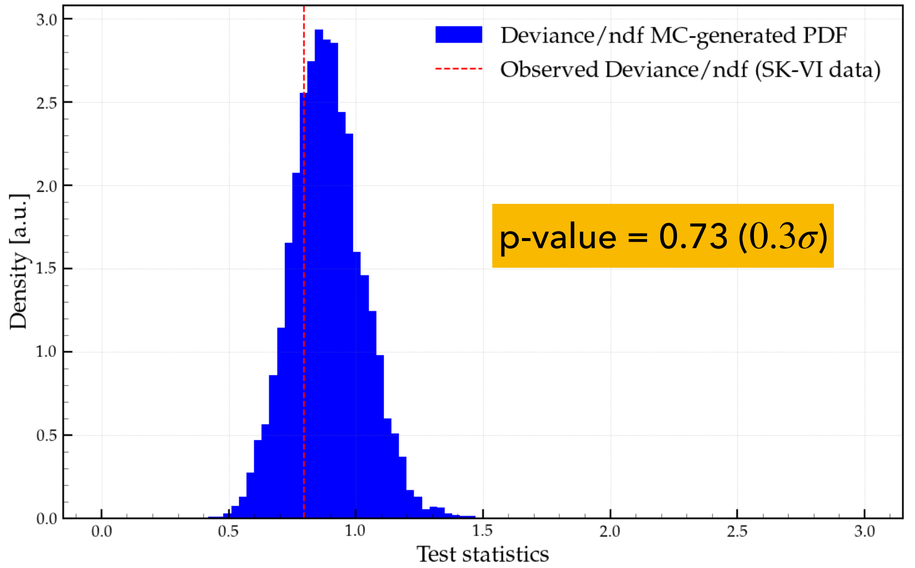
2. **Derive a goodness-of-fit**:
   - ➡ For the *unbinned fit,* no such natural statistics.
   - ➡ For the *binned fit,* we can use the ***deviance*** *aka* ***G***-statistics:

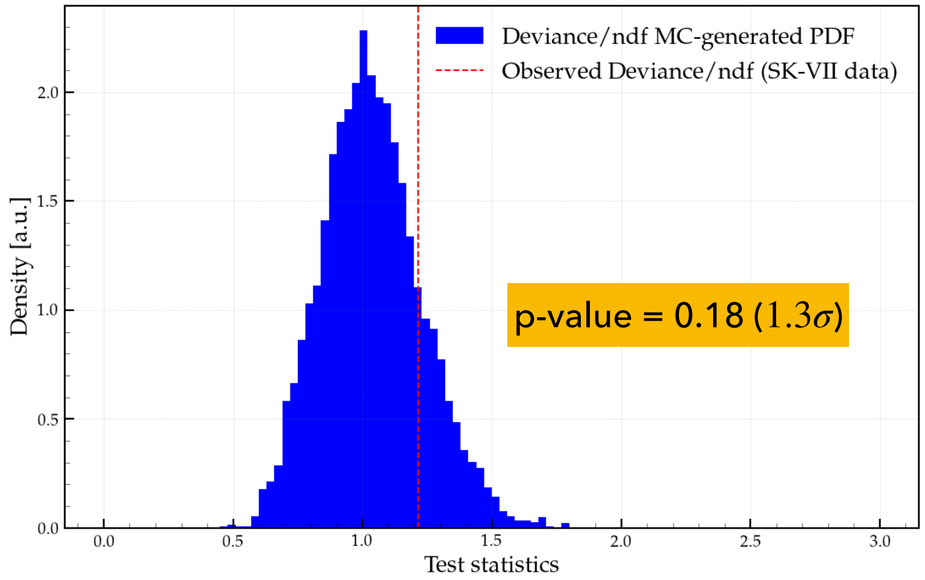
$$G(Data, Model) = \sum_{bin\ n°i} Data[i] \cdot \ln\left(\frac{Data[i]}{Model[i]}\right)$$

→ Very good agreement for SK-VI fit / Good agreement for SK-VII fit.



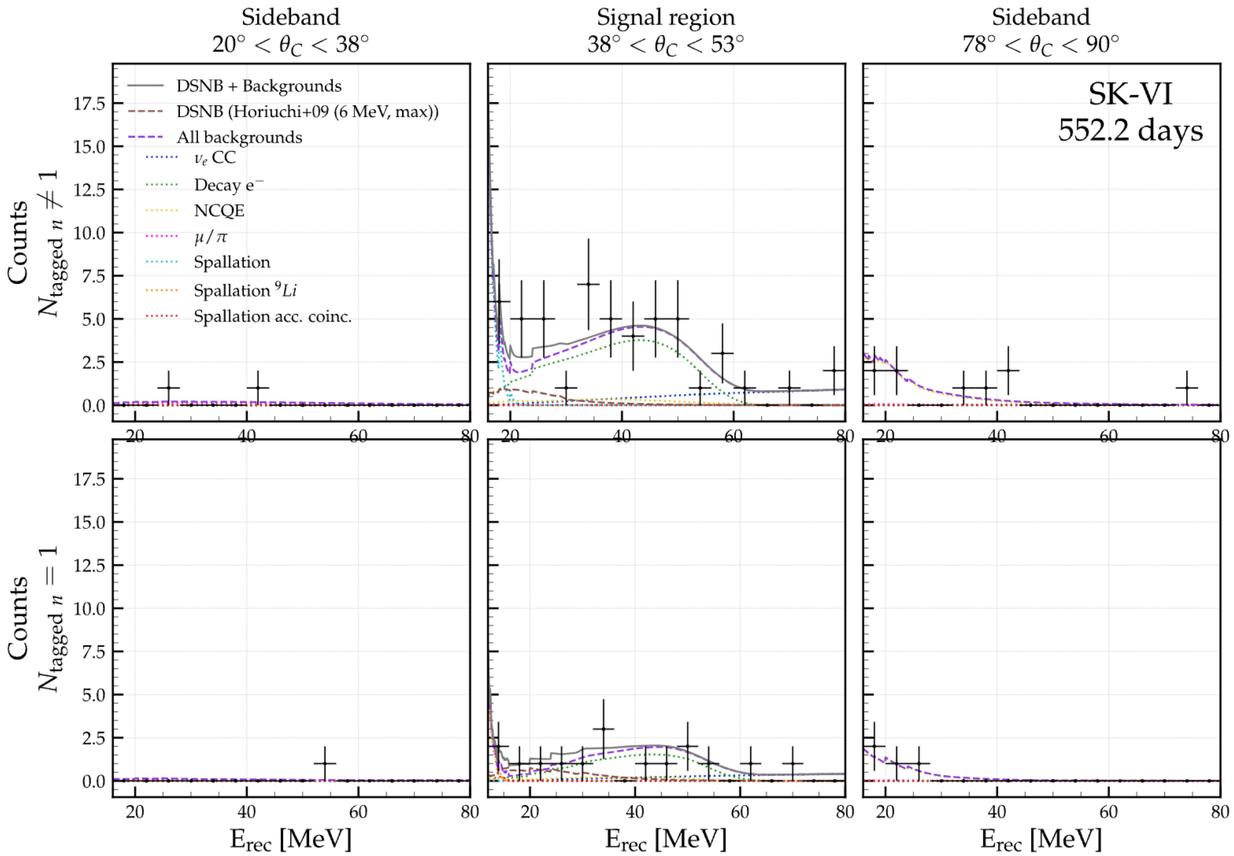




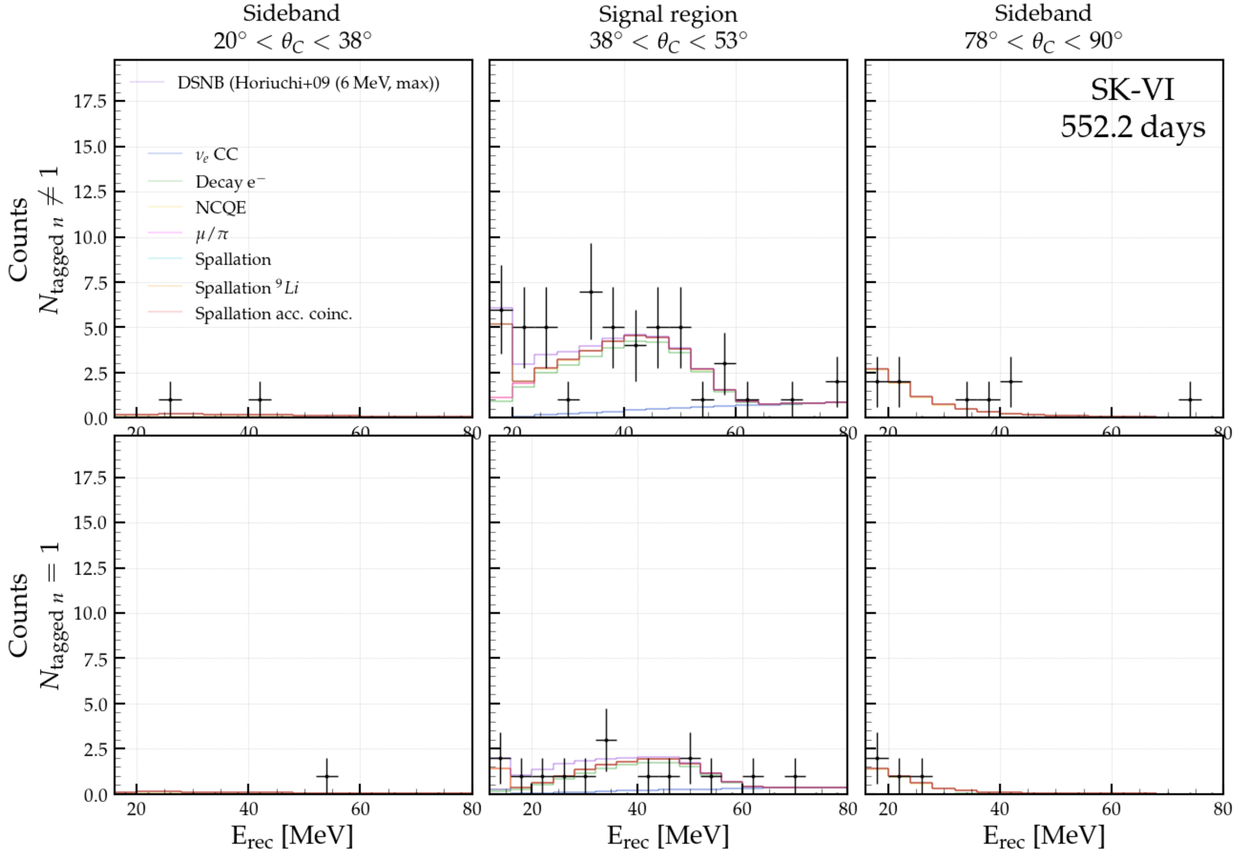


Back-up

Binned vs. Unbinned Fit - Result Plots (SK-VI)



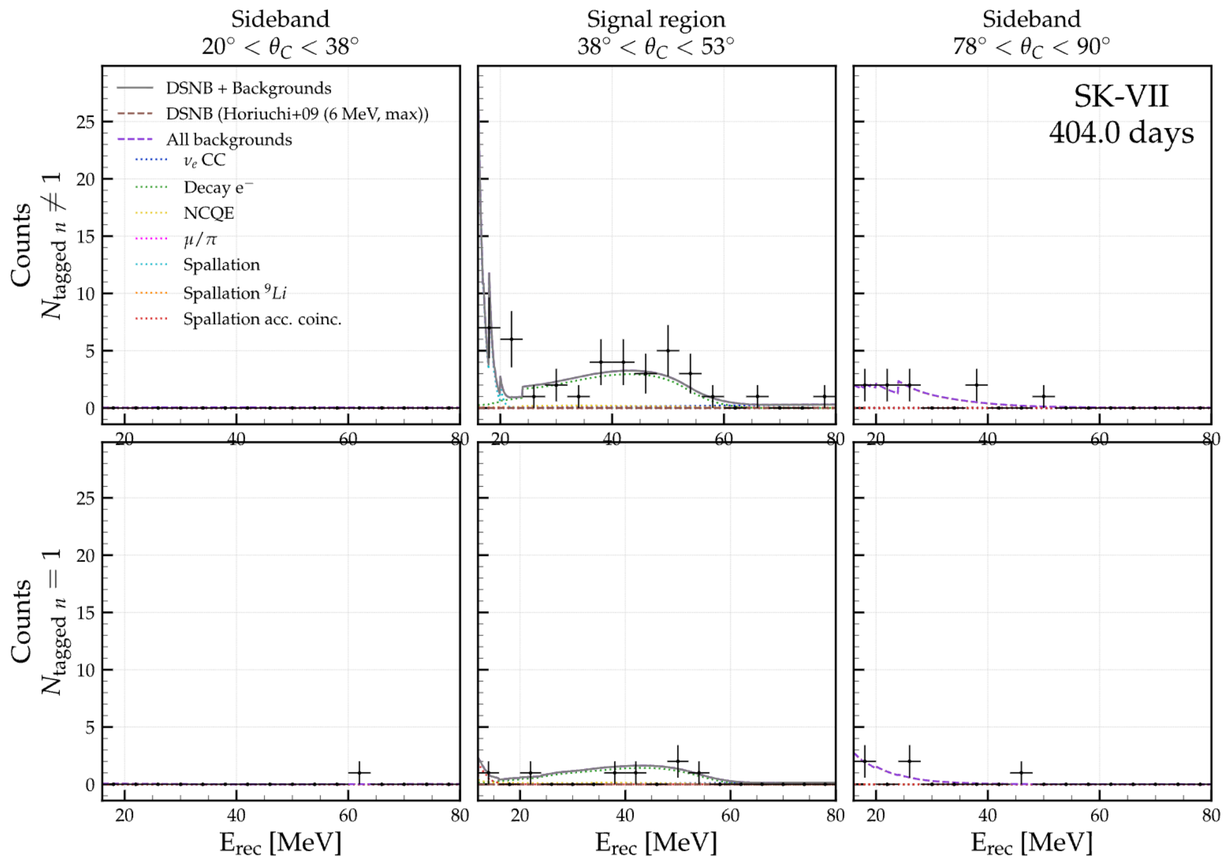
Unbinned fit



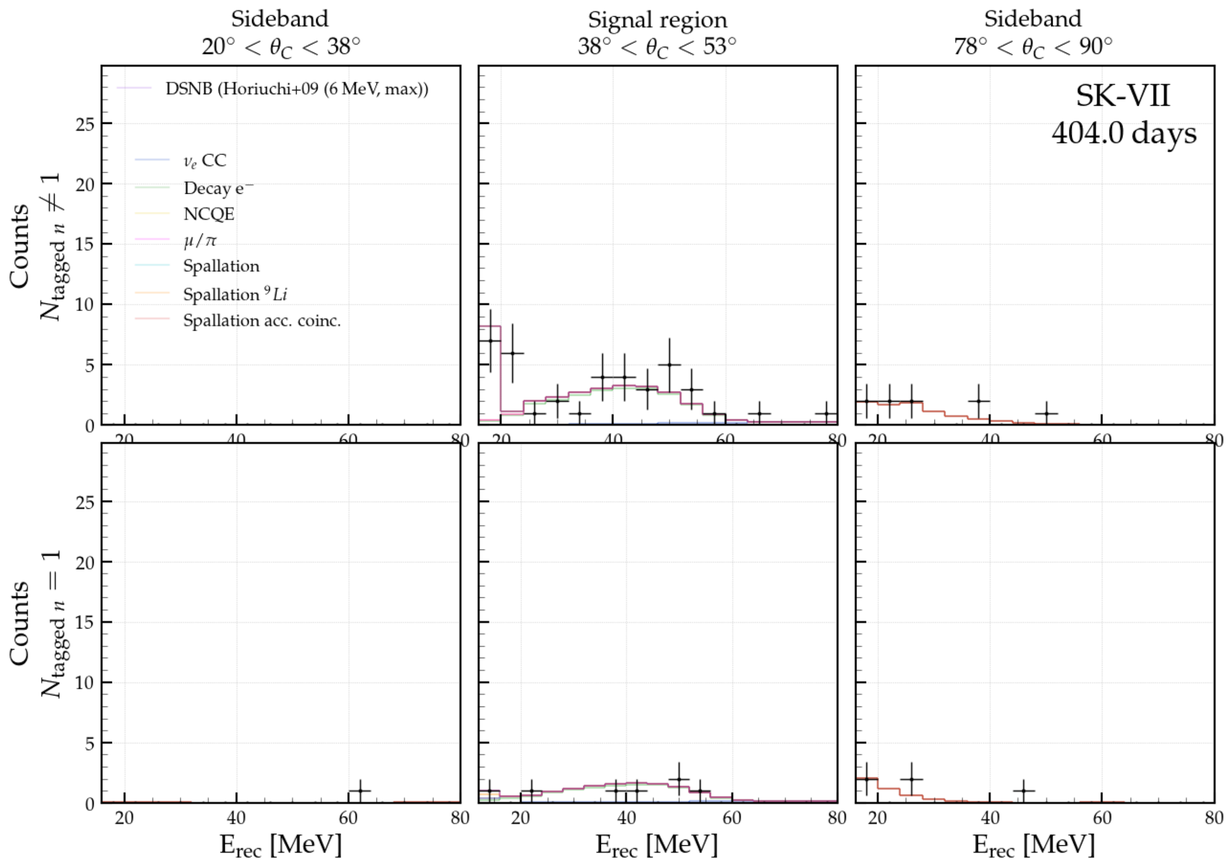
Binned fit

PS: Histograms are stacked on this plot, contrary to the unbinned plot.

Binned vs. Unbinned Fit - Result Plots (SK-VII)



Unbinned fit



Binned fit

PS: Histograms are stacked on this plot, contrary to the unbinned plot.

Binned Fit - Bin-by-Bin Data-to-Fit disagreement