



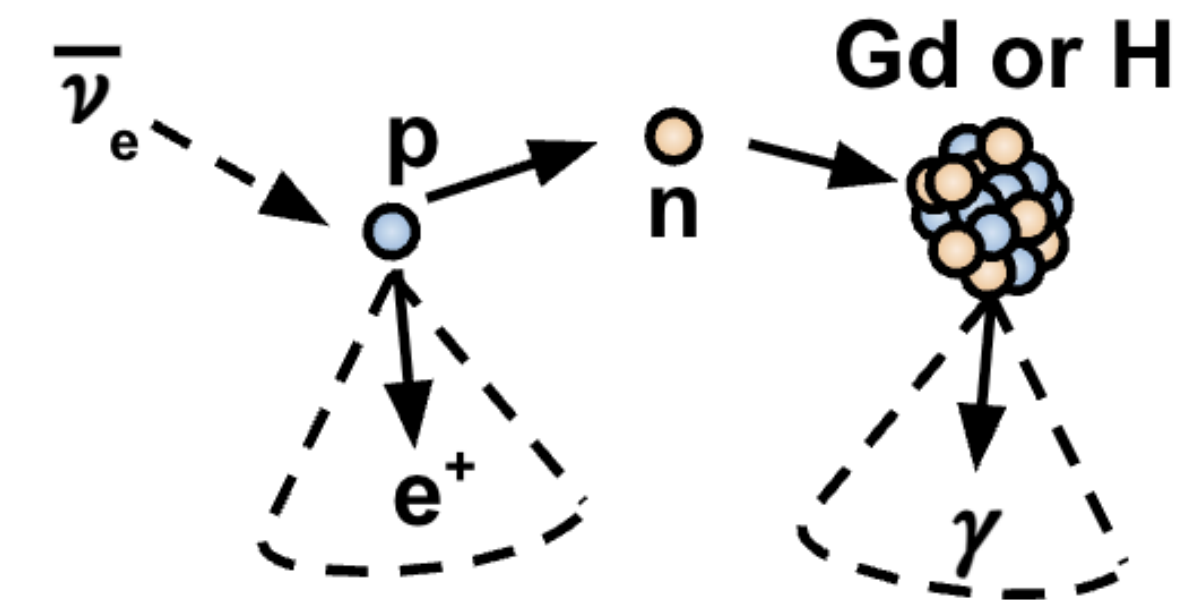
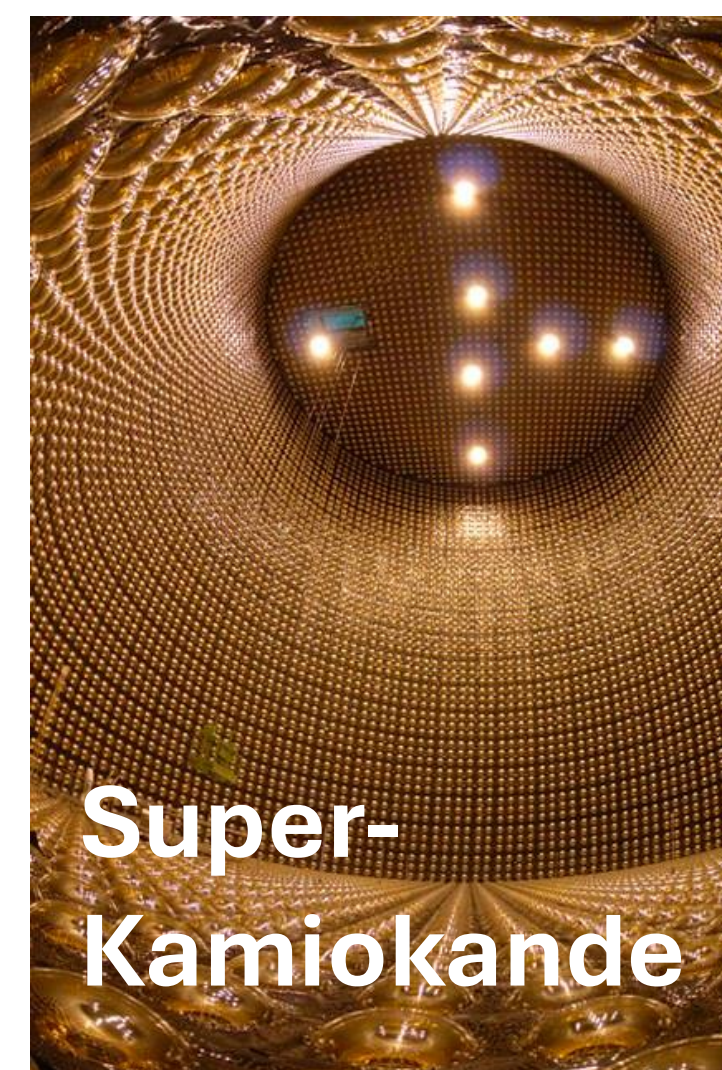
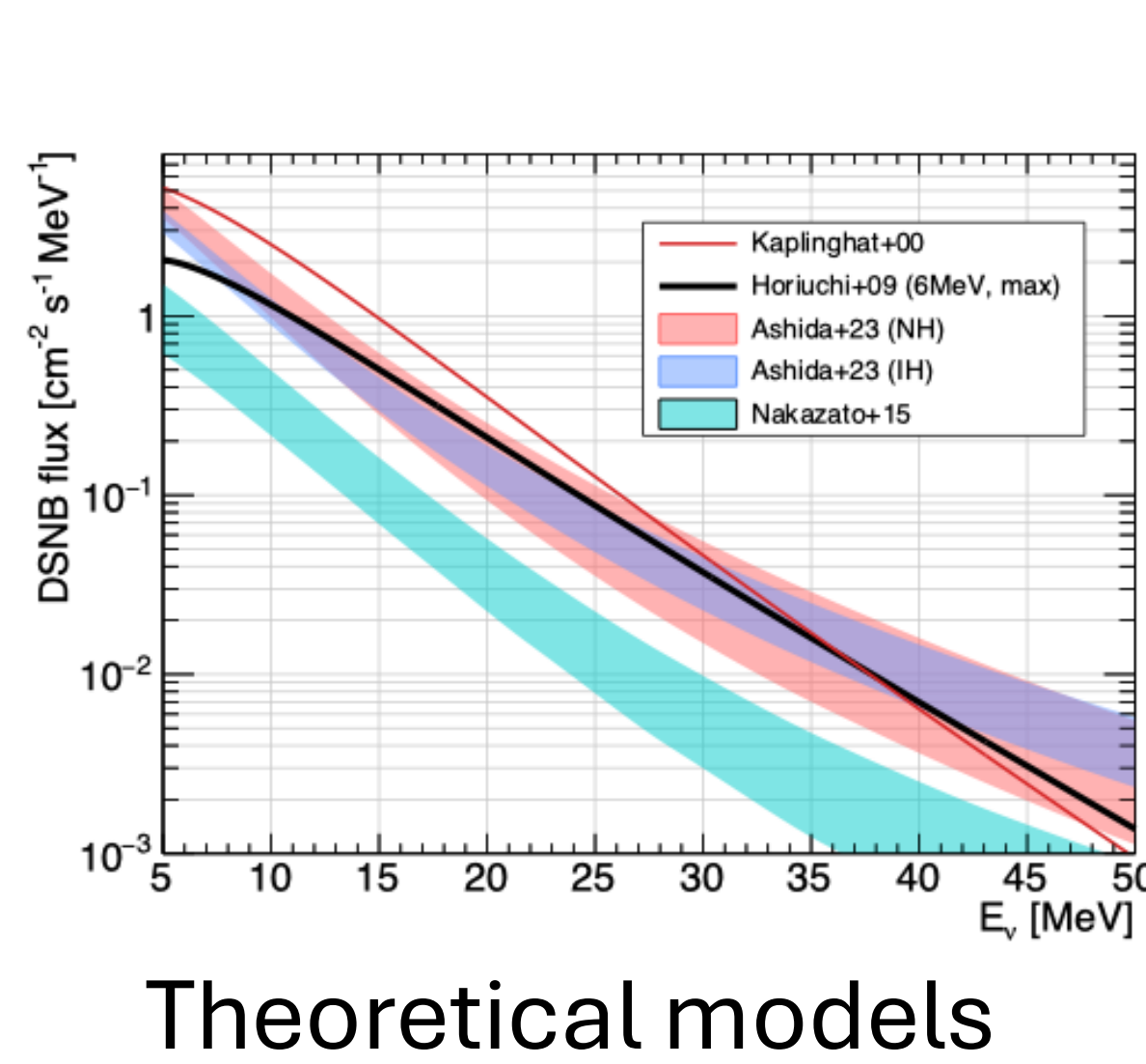
## ~ First $>2.5\sigma$ Indication of the DSNB Signal ~

Saki Fujita (IPMU), Masayuki Harada, Yosuke Ashida, and Andrew Santos for the SK Collaboration

#360

### 1. Diffuse Supernova Neutrino Background (DSNB)

The DSNB is the as-yet undetected flux of neutrinos and antineutrinos emitted by all core-collapse supernovae throughout cosmic history [1].



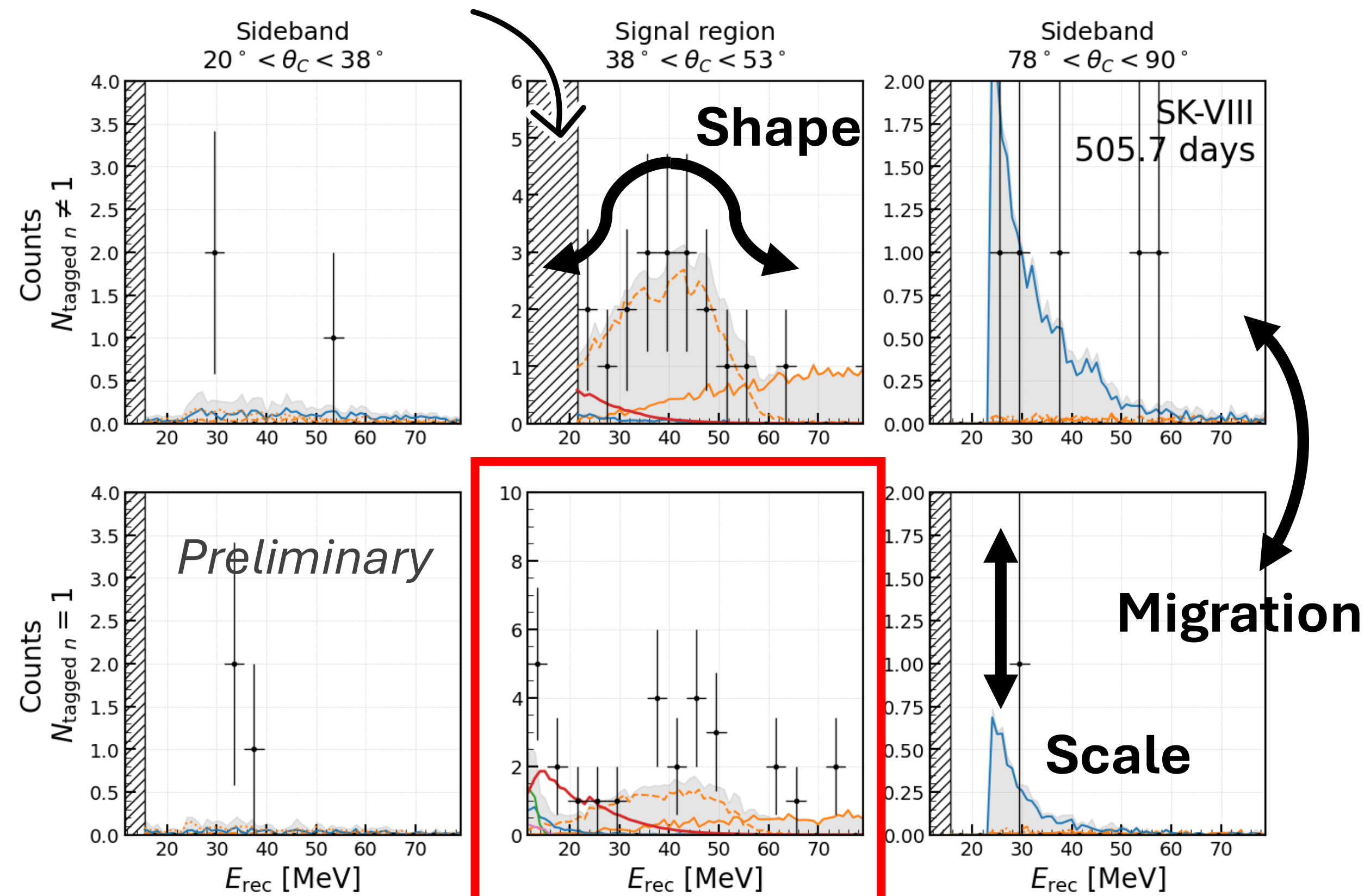
→ Search via **inverse beta decay** channel  
→ Gd greatly enhances neutron-tagging [2]

[1] Beacom, Annu. Rev. Nucl. Part. Sci. 60, 439 (2010)  
[2] Beacom and Vagins, Phys. Rev. Lett. 93, 171101 (2004)

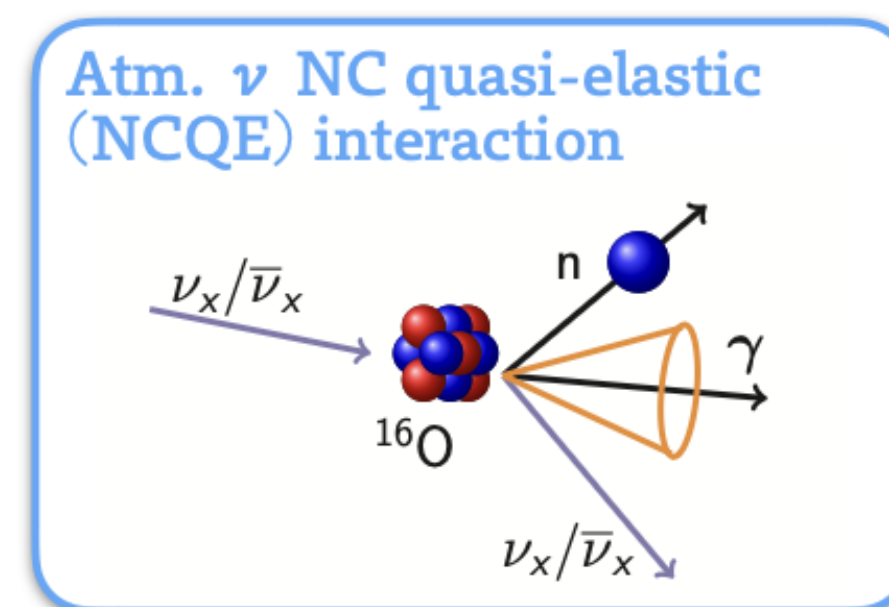
### 2. Key Improvements Over Previous Searches

**1** Total ~5000 livedays of data, fully analyzed (~1600 days with Gd)

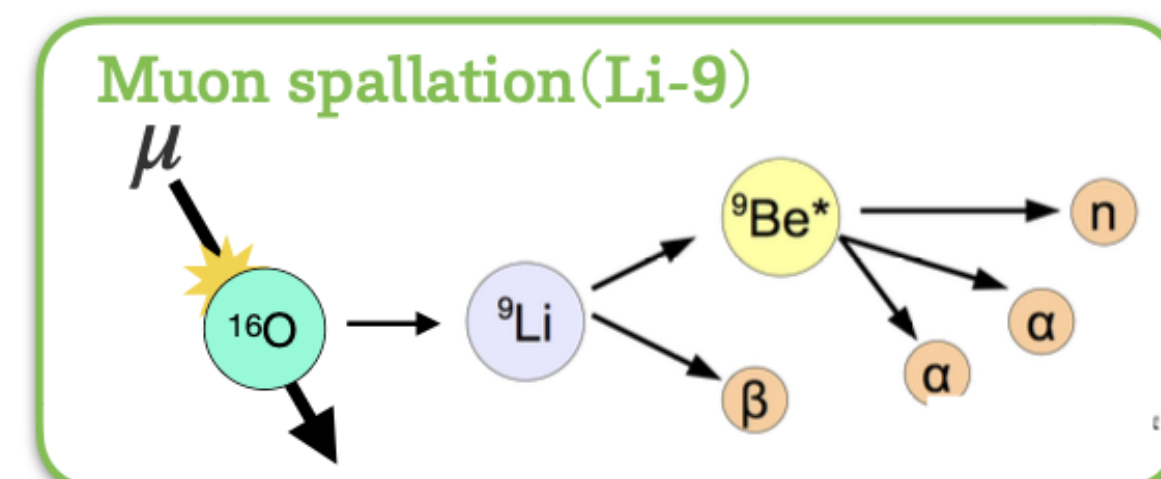
Spallation dominant region ( $E_\nu < 23.3$  MeV)



**2** Reduced atmospheric NCQE backgrounds using ML techniques (see #502)



**3** Reduced systematic uncertainties using inputs from T2K NCQE studies, SK neutron studies, and spallation MC development (see #342)

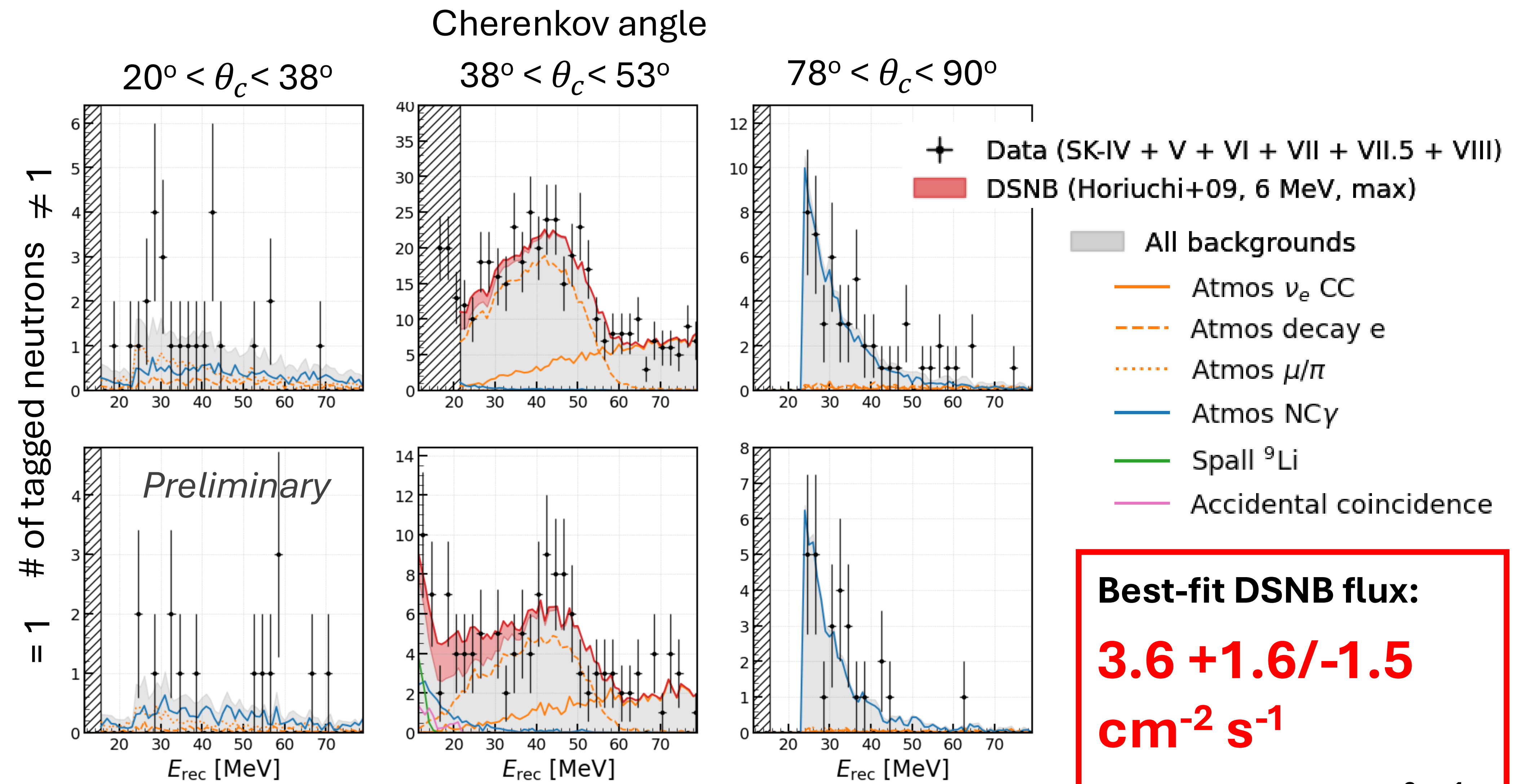


**4** Lowering of the energy threshold in the most DSNB-sensitive region  
**5** Improved spectral fit method with background normalization pull terms and a joint fit of all phases

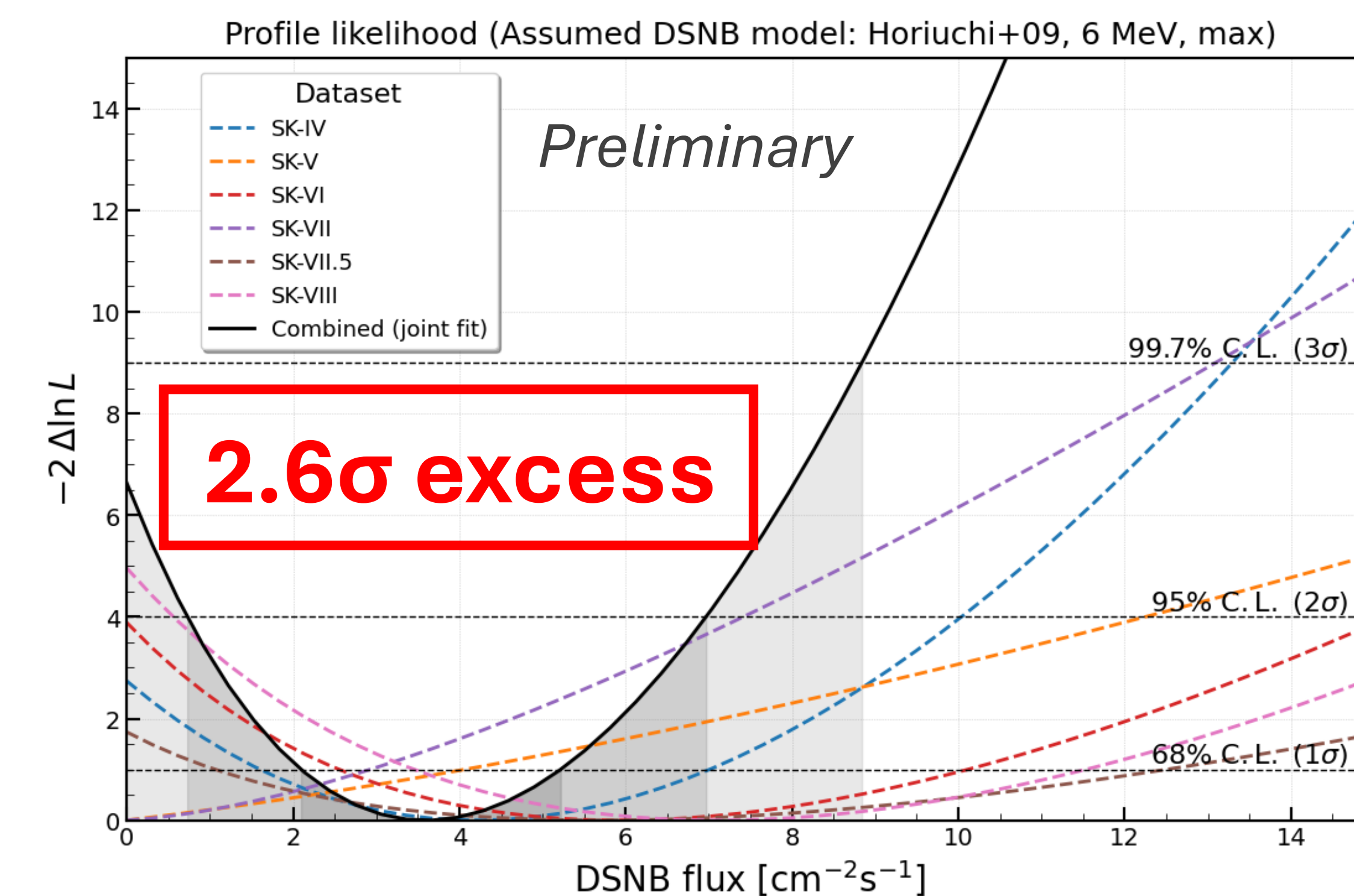
$E_\nu > 13.3$  MeV

### 3. Spectral Fit Analysis: Joint Fit of SK-IV ~ SK-VIII Datasets

Fit 1 signal and 6 bg spectra to the data in an extended unbinned maximum likelihood fit



**Best-fit DSNB flux:**  
 **$3.6^{+1.6/-1.5}$**   
 **$\text{cm}^{-2} \text{s}^{-1}$**   
Pred: 2.1 - 3.9  $\text{cm}^{-2} \text{s}^{-1}$  for Horiuchi+09, 6 MeV



- Control of backgrounds:**
- $^9\text{Li}$  remaining rate (50% → 30%)
  - NC $\gamma$  scale (71% → 45%)
  - Neutron multiplicity (40% → +12-27%/-30%)
  - Free-floating → pull term
  - Likelihood sum → joint fit

### 4. Conclusion

- The SK collaboration reports a **first  $>2.5\sigma$  indication** of the DSNB signal based on a spectral fit analysis of a 22.5 x 5000 kton-day dataset. The best-fit DSNB signal is  **$3.6^{+1.6/-1.5} \text{cm}^{-2} \text{s}^{-1}$**  ( $4.8^{+2.2/-2.0}$  events  $\text{yr}^{-1}$ ) for  $E_\nu > 13.3$  MeV, assuming the Horiuchi+09, 6 MeV, max DSNB model, corresponding to a  **$2.6\sigma$  tension** with the null hypothesis ( $5 \times 10^{-3}$  one-sided p-value).