Current Status and Projected Sensitivity of COSINE-100

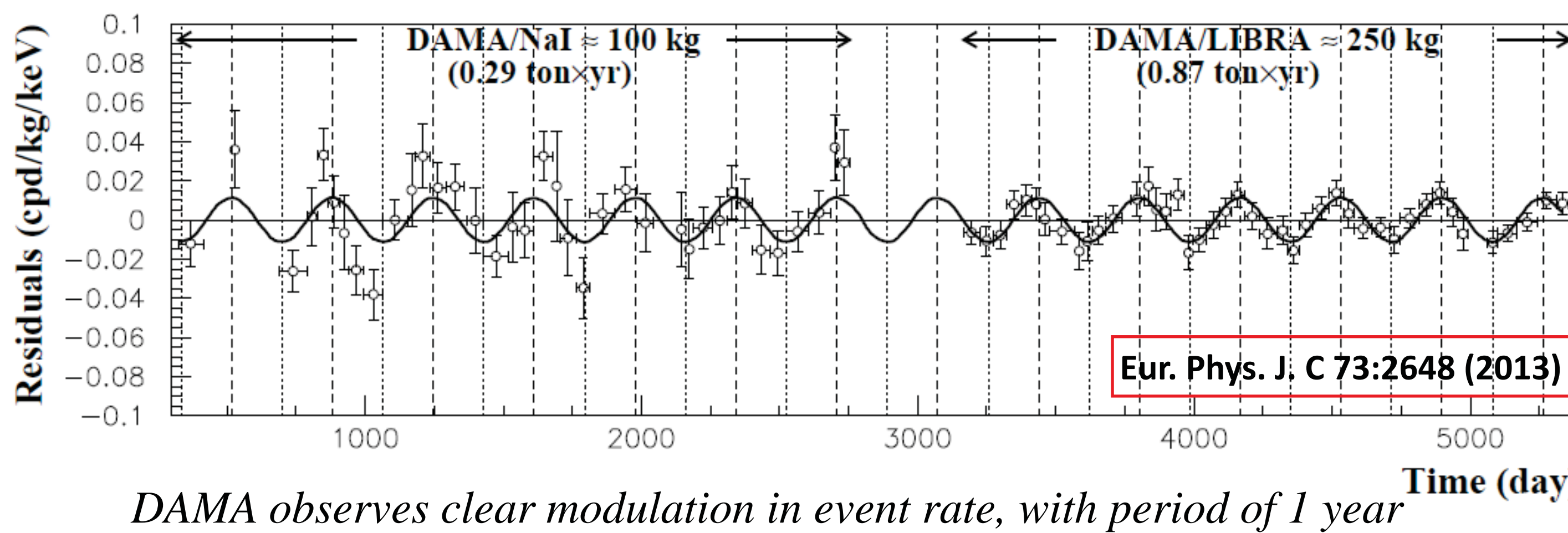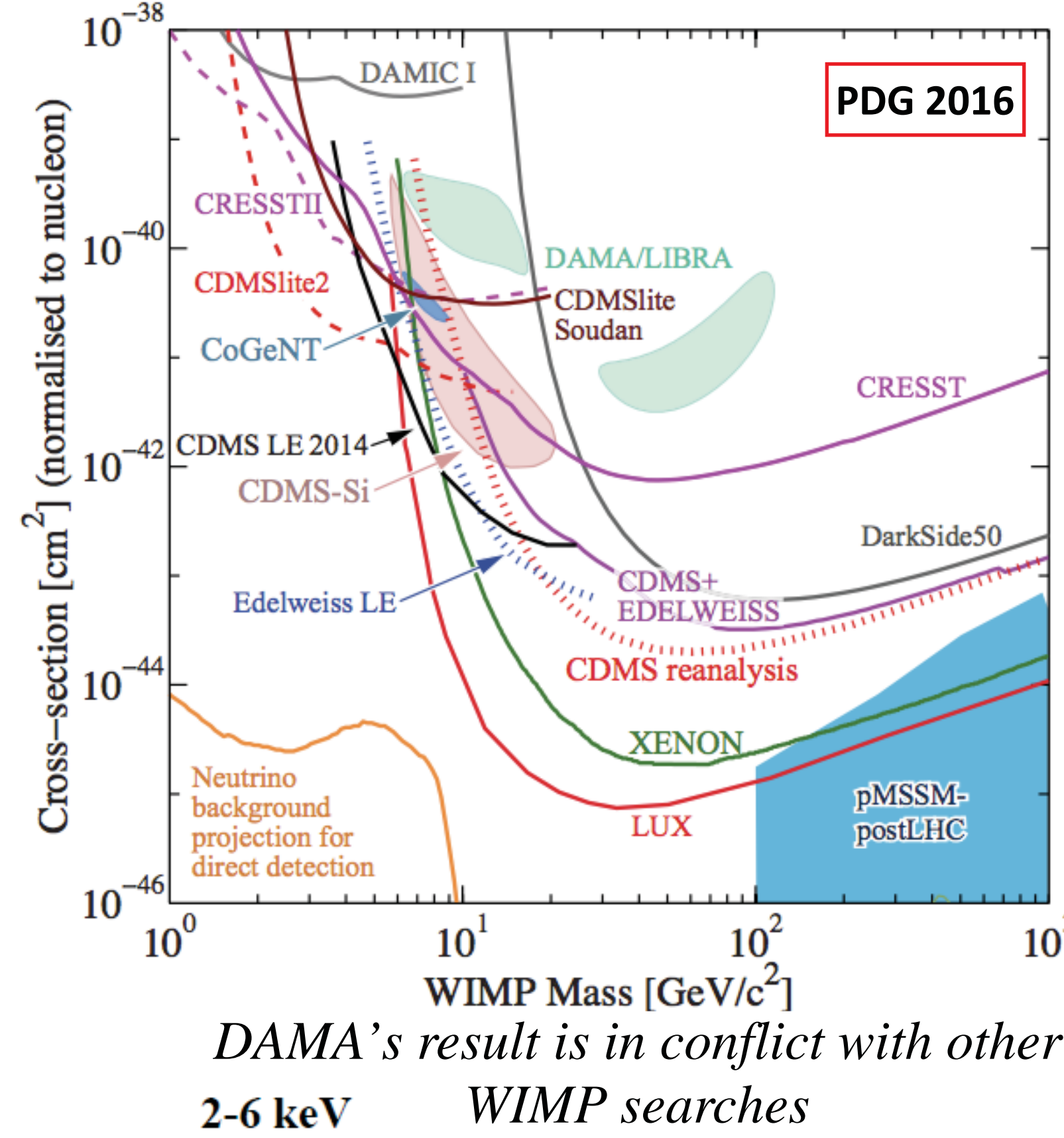## William Thompson, on behalf of the COSINE-100 collaboration

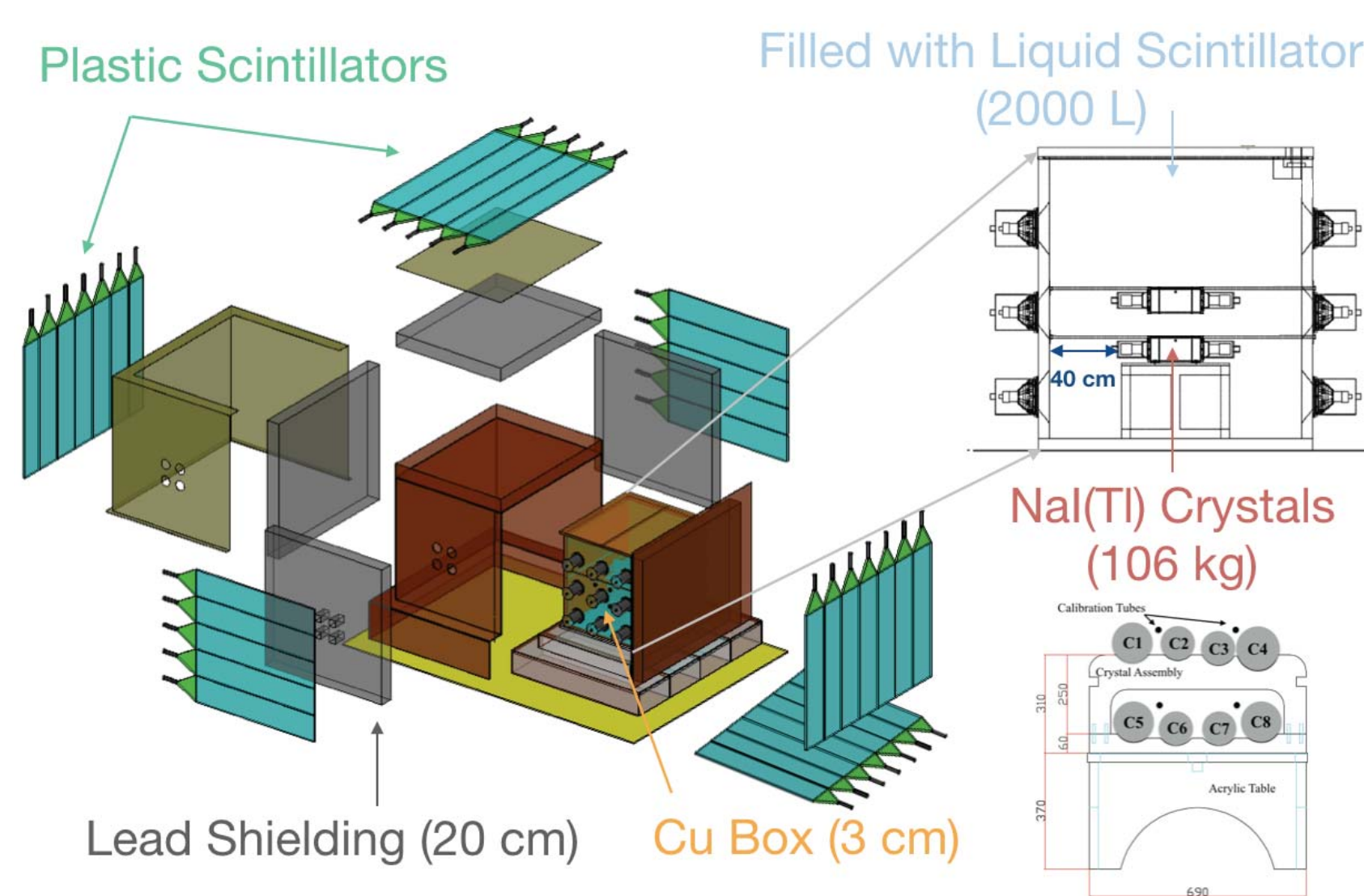*Wright Laboratory, Department of Physics, Yale University, New Haven, CT 06511, USA*

Yale

Wright Laboratory

Motivation

- Dark matter signal modulates due to Earth's motion in galactic rest frame, with period of one year
- DAMA collaboration observes annual modulation at 9.3σ, in conflict with other experiments
- Goal: Model independent test of DAMA using same target material (NaI(Tl)), with similar mass and background

PDG 2016

DAMA's result is in conflict with other WIMP searches

DAMA observes clear modulation in event rate, with period of 1 year

Eur. Phys. J. C 73:2648 (2013)

Detector

Schematic of COSINE-100 detector and shielding

- Plastic Scintillators
- Filled with Liquid Scintillator (2000 L)
- NaI(Tl) Crystals (106 kg)
- Lead Shielding (20 cm)
- Cu Box (3 cm)

- 8 NaI(Tl) crystals for total mass of 106 kg
- Located at Yangyang Underground Laboratory in Yangyang, South Korea
- Detector positioned at depth of 700 m (~1600 m.w.e.)

- Physics run began September 2016
- Initial run will last for 2 years
- Next phase of experiment: COSINE-200
  - Twice as massive, higher radiopurity
  - Aim: 1 dru background rate

Yangyang Underground Laboratory

Detection Technique

- Standard halo model: Roughly uniform distribution of dark matter in our neighborhood of Milky Way
- Orbit around Sun induces modulation in terrestrial dark matter flux
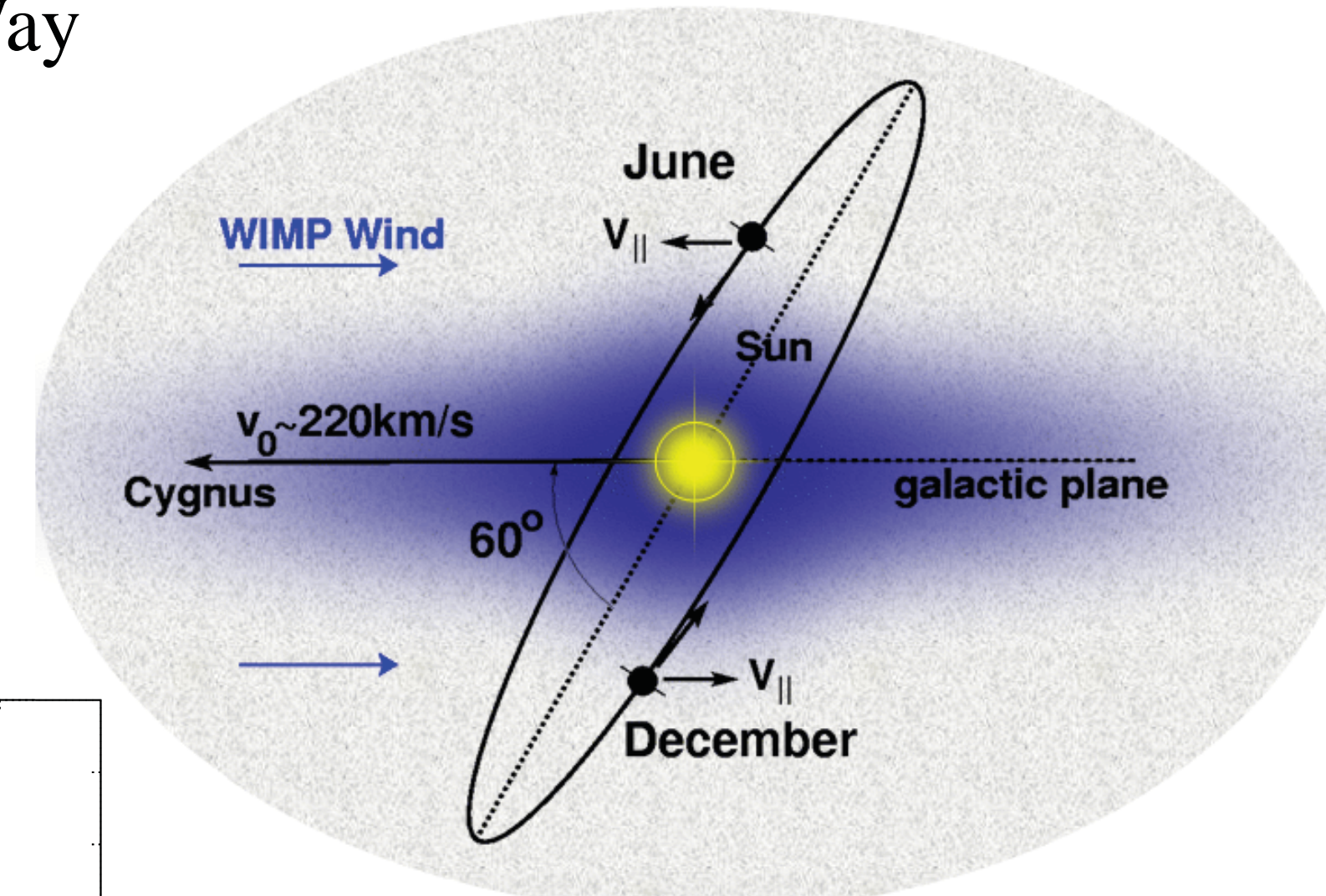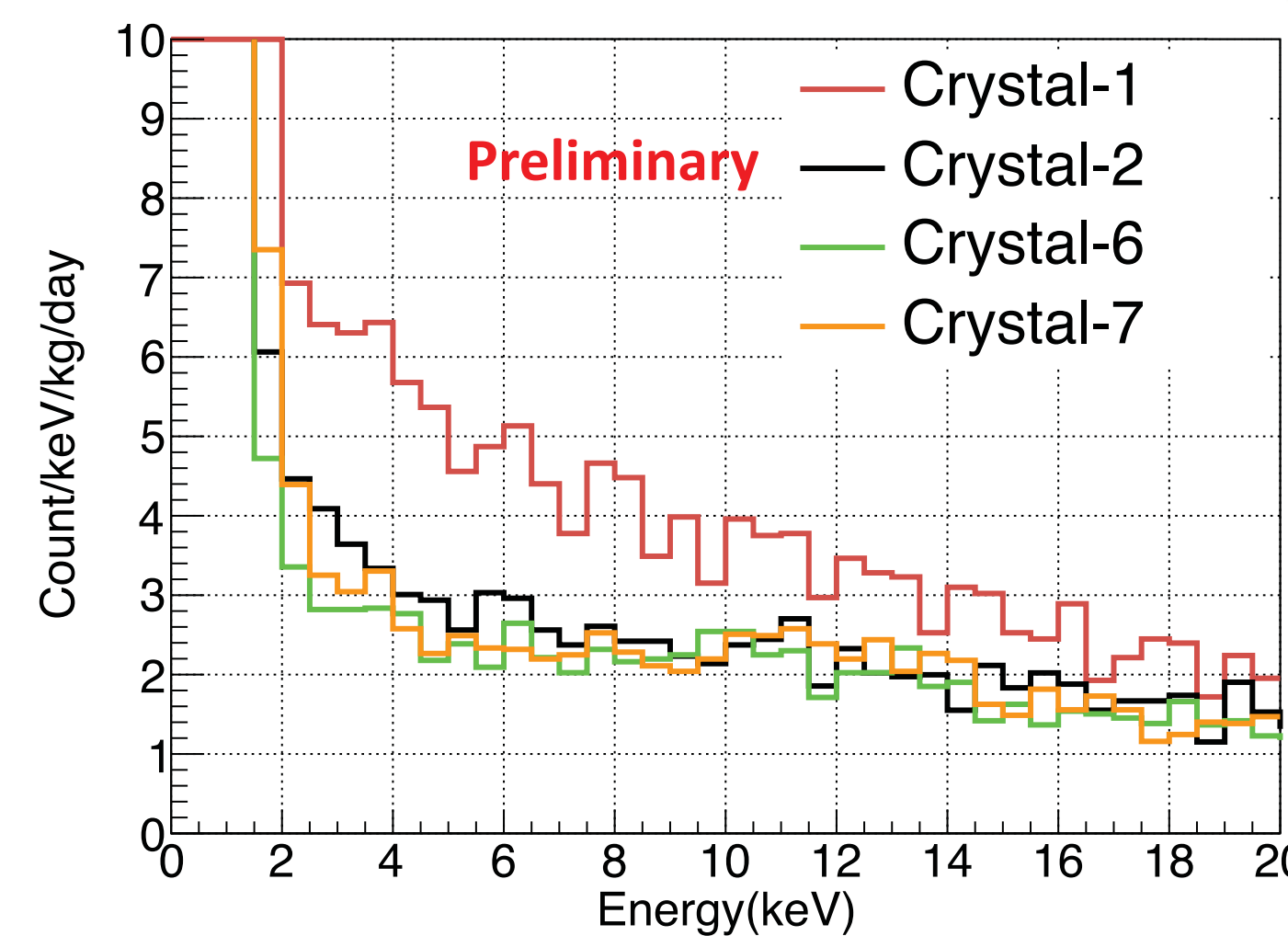- Modulation provides method of background reduction

Illustration of Earth's path through dark matter halo

Crystal energy spectrum in COSINE-100

- WIMPs interact via coherent elastic scattering with a sodium or iodine nucleus
- Nuclear recoil emits scintillation light

WIMP Simulation

- Scattering energy spectrum calculated within standard halo model
- Rate R of dark matter interactions with energy from E_1 to E_2 and cross section σ given by:

$$R(t, E_1, E_2) = \int_0^\infty dE\ \epsilon(QE)\Phi(QE, E_1, E_2)\frac{\rho}{2m\mu^2}\sigma\ \eta(E, t)$$

$$\eta(E, t) = \int_{u>v_{min}} \frac{f(\boldsymbol{u}, t)}{u} d^3u$$

- Annual modulation, function of time t, encoded in mean inverse speed η.
- Dark matter velocity $\boldsymbol{u}$ follows Maxwellian distribution $f(\boldsymbol{u},t)$
- Detector efficiency ϵ, energy resolution Φ, and quenching factor Q also accounted for.
- WIMP mass m, reduced mass μ, and dark matter density $\rho = 0.3$ GeV/cm^3 also affect rate
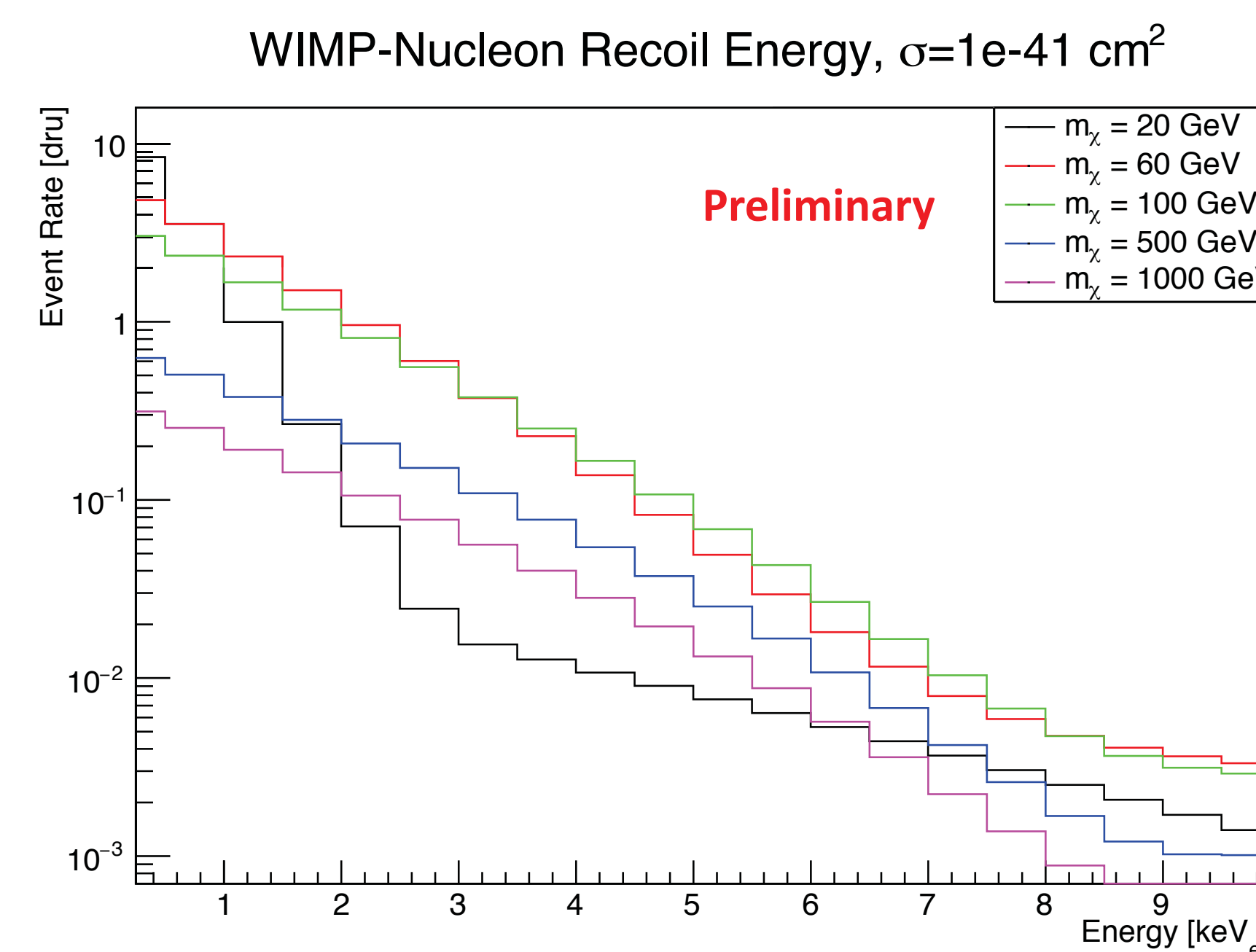
Calculated recoil energy spectra for various WIMP masses. Note linearity of event rate in cross section for spin-independent interactions

Sensitivity

- WIMP simulation used with Monte Carlo simulations to establish projected sensitivity in no-signal case
- No-signal spectrum simulated as Poisson fluctuations on flat 4.3 dru background
- Likelihood analysis between simulated and theoretical spectra used to establish exclusion limits at desired C.L.
- Similar analysis performed to generate DAMA-preferred contours
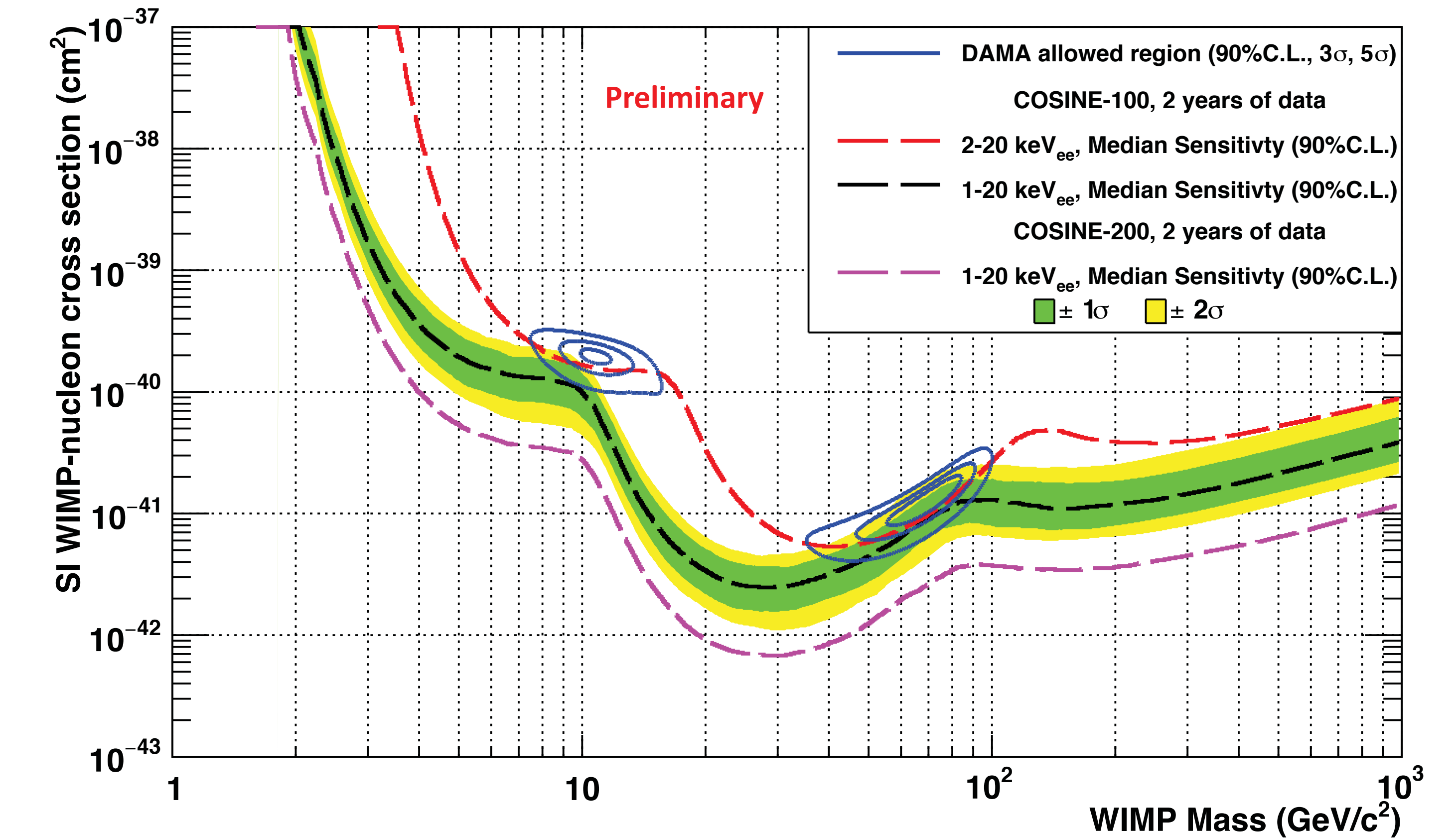
Projected sensitivity of COSINE-100 with 1 keV$_{ee}$ (2 keV$_{ee}$) threshold in black (red) with 2 years of data and COSINE-200 in magenta with 3 years of data. DAMA-preferred contours displayed using data from Eur. Phys. J. C 73:2648 (2013)

Conclusions & Prospects

- Model-independent test of DAMA's claim of dark matter discovery
- With 1 keV$_{ee}$ threshold, COSINE-100 will cover majority of DAMA-allowed parameter space in 2 years
- Please visit us at http://cosine.yale.edu

Crystal detectors after installation