



Experimental Particle Astrophysics in the NSF/Physics Division

**HEPAP Meeting
Newport Beach, CA
December 9-11, 2015**

Jean Cottam & Jim Whitmore
Program Directors for Particle Astrophysics

Reorganization of Experimental Particle Astrophysics (PA)



Particle Astrophysics – Cosmic Phenomena:

This area supports university research that uses astrophysical sources and particle physics techniques to study fundamental physics. This includes the study of ultra-high energy particles reaching Earth from beyond our atmosphere (cosmic-rays, gamma-rays, and neutrinos with the exception of IceCube); searches for supernova neutrinos; and studies of the Cosmic Microwave Background (CMB) and Dark Energy.

Particle Astrophysics – Underground Physics:

This area supports university research that generally locates experiments in low background environments. Currently supported activities include: studies of solar, underground and reactor neutrinos; neutrino mass measurements; and searches for the direct detection of Dark Matter.

Particle Astrophysics – IceCube Research Support:

This area supports university research that utilizes the facilities of IceCube at the South Pole. Currently supported activities include: searches for ultra-high energy neutrinos and studies of the properties of neutrinos.

Neutrinoless Double Beta Decay: This has been moved to Nuclear Physics.



PA Program Scope & Currently Supported Projects

- Direct Dark Matter Detection – WIMP and non-WIMP experiments
SuperCDMS at SNOLAB, XENON100/1T, LUX, DArkSide, PICO, DRIFT, DM-Ice, SABRE, DAMIC, ADMX-HF, ALPS2 and DM-GPS
- Indirect Dark Matter Detection
VERITAS, HAWC, IceCube
- Cosmic Ray, Gamma Ray, and UHE Neutrino Observatories
IceCube, VERITAS, HAWC, Auger, Telescope Array, ARA, ARIANNA
- Cosmic Microwave Background
SPT, ACT-Pol (w/ Gravity)
- Neutrino Properties
Double Chooz, Daya Bay, Project 8, IceCube, IsoDAR
- Solar, Geo- and SuperNova Neutrinos
Borexino, SNEWS
- Planck Scale Physics
Holometer
- Detector R&D
NaI/CsI, LiSc/QD

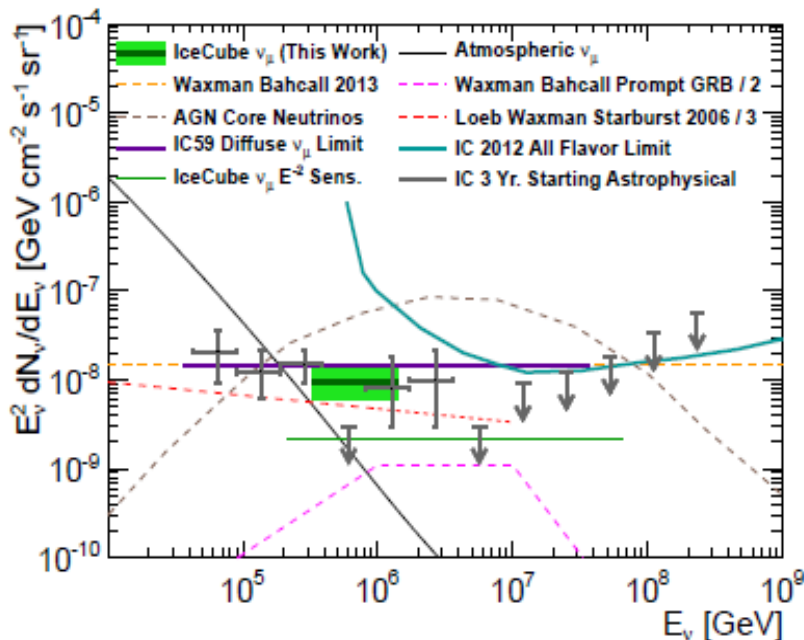
AST

Polar Programs

Highlight: IceCube: HE astrophysical neutrinos



IceCube observed neutrinos coming from the N. Hemisphere, confirming the presence of extragalactic neutrinos and the intensity of the neutrino rate. The first evidence for astrophysical neutrinos was announced in November 2013. The new results are the first independent confirmation of this discovery. This search looks at the universe through the Earth, using our planet to filter the large background of atmospheric muons. More than 35,000 neutrinos were found in data recorded between May 2010 and May 2012.

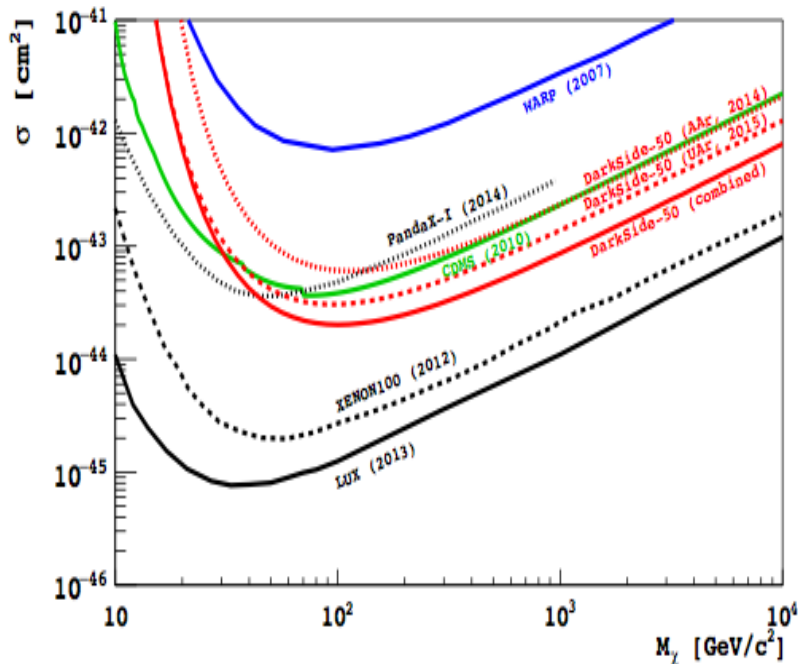


Above 100 TeV, the measured rate cannot be explained by neutrinos produced in the Earth's atmosphere, indicating the astrophysical nature of high-energy neutrinos. The analysis suggests that more than half of the 21 neutrinos above 100 TeV are of cosmic origin. This independent observation, with a significance of 3.7 sigma and in good agreement with previous results by the Collaboration, also confirms the high rate of astrophysical neutrinos.

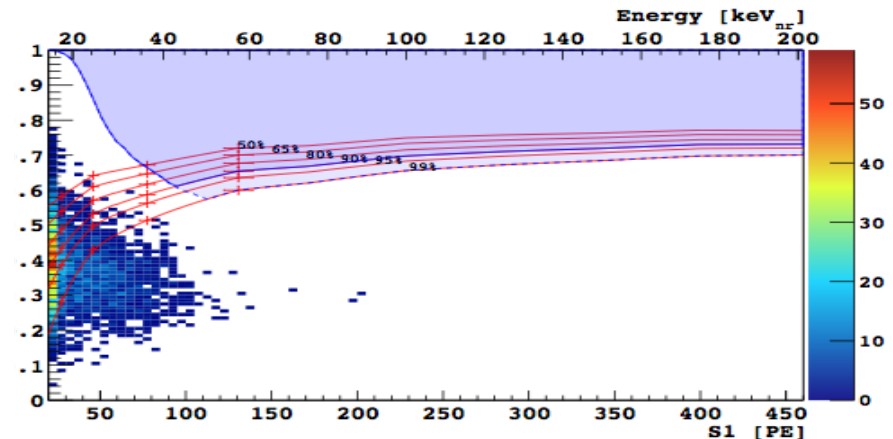
Highlight: DArkSide-50: Dark Matter search



The DA-50 dark matter search reports the first results obtained using a target of low-radioactivity argon extracted from underground sources. The experiment is located at the LNGS and uses a two-phase time projection chamber as a detector. A total of 155 kg of low radioactivity argon has been obtained, and they have determined that underground argon is depleted in ^{39}Ar by a factor $(1.4 \pm 0.2) \times 10^3$ relative to atmospheric argon. They find no evidence for dark matter in the form of WIMPs in 70:9 live-days of data with a fiducial mass of (36.9 ± 0.6) kg.



The observed suppression is sufficient to allow multi-tonne-year exposures with this argon to be free of ^{39}Ar background.

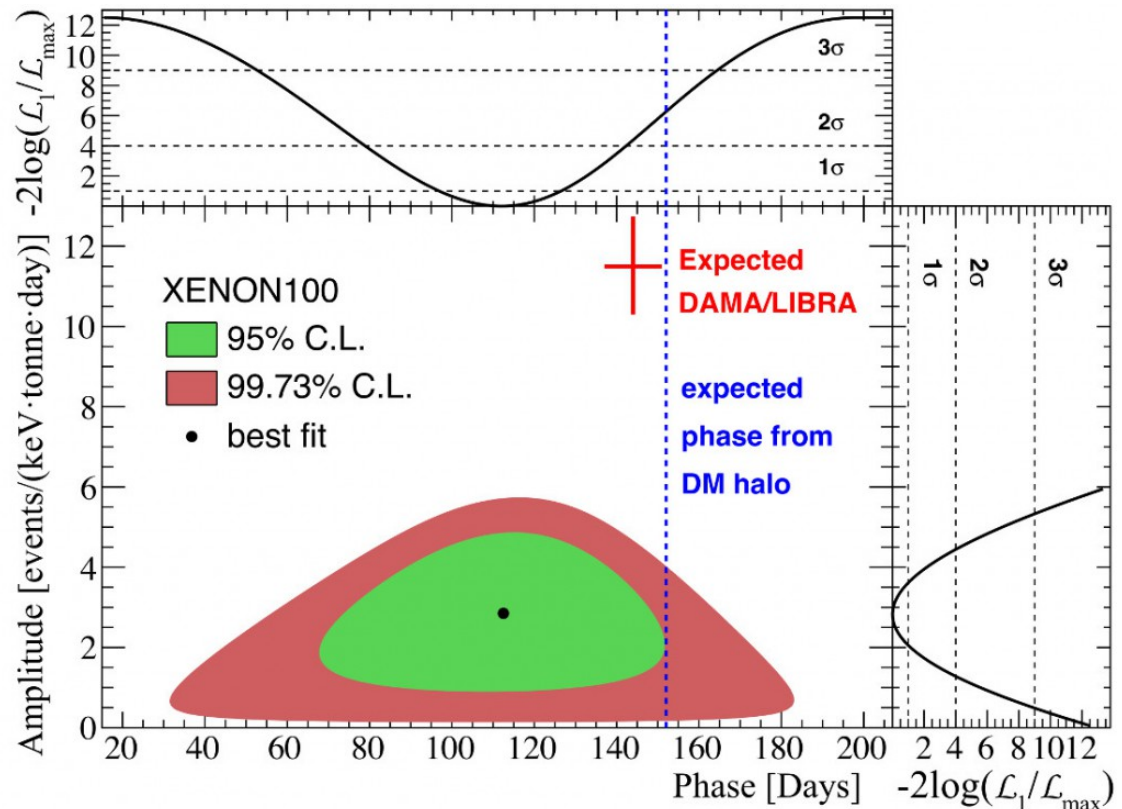


Highlight: XENON100: DM Modulation Search



From 224.6 live days, they find a global significance of less than 1σ for all periods suggesting no statistically significant modulation in the data. The DAMA/LIBRA annual modulation interpreted as a dark matter signature with axial-vector coupling of WIMPs to electrons is excluded at 4.8σ .

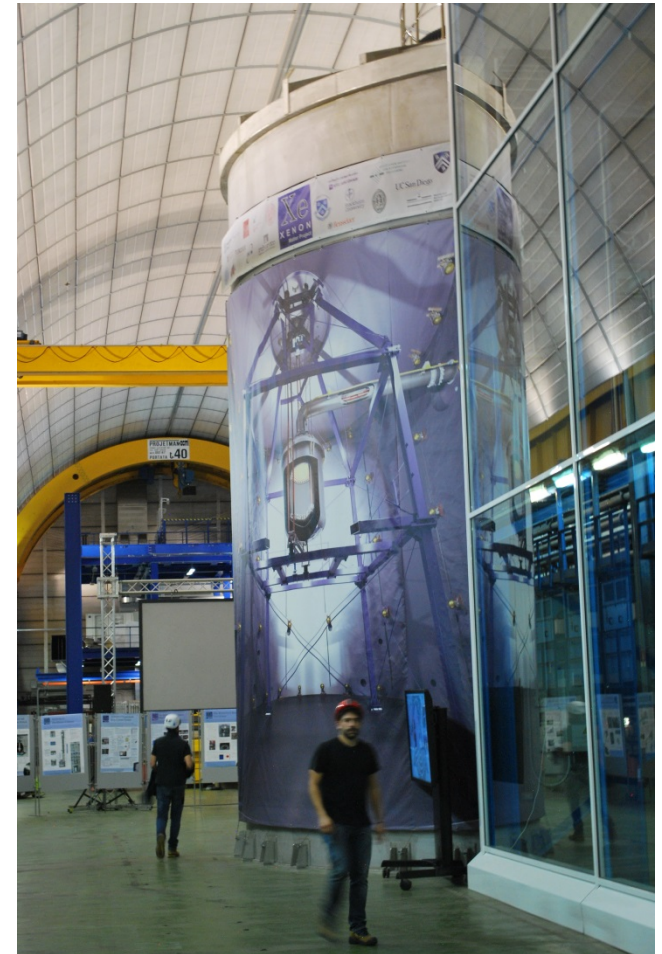
Best-fit amplitude and phase of annual modulation signal in XENON100 from a profile likelihood study. Expected signal from DAMA/LIBRA and expected phase from the standard Dark Matter halo overlaid for comparison.



Highlight: XENON1T: Inauguration at LNGS on Nov 11, 2015



The inauguration at Gran Sasso was attended by the XENON scientists along with guests from funding agencies as well as journalists and colleagues. About 80 visitors were able to join the ceremony directly at the experimental site in Hall B. Even more guests followed the introductory presentations in the LNGS auditorium, where Elena Aprile, Professor at Columbia University and founder of the XENON project, illustrated the evolution of the XENON program from the early beginnings with a 3kg detector 15 years ago to the present-day instrument XENON1T with a total mass of 3500kg.



Status update: SuperCDMS at SNOLAB



- Jointly selected by NSF and DOE in the G2 Dark Matter down-select process
- Detector is being designed to “cover” the low-mass WIMPs region (below ~ 10 GeV)
- Being managed as a “single project” with a single Project Director
- Each agency is mainly responsible for different WBS elements
- Sharing management costs
- NSF funding started in FY2015

Status update: Cosmic Microwave Background Activities

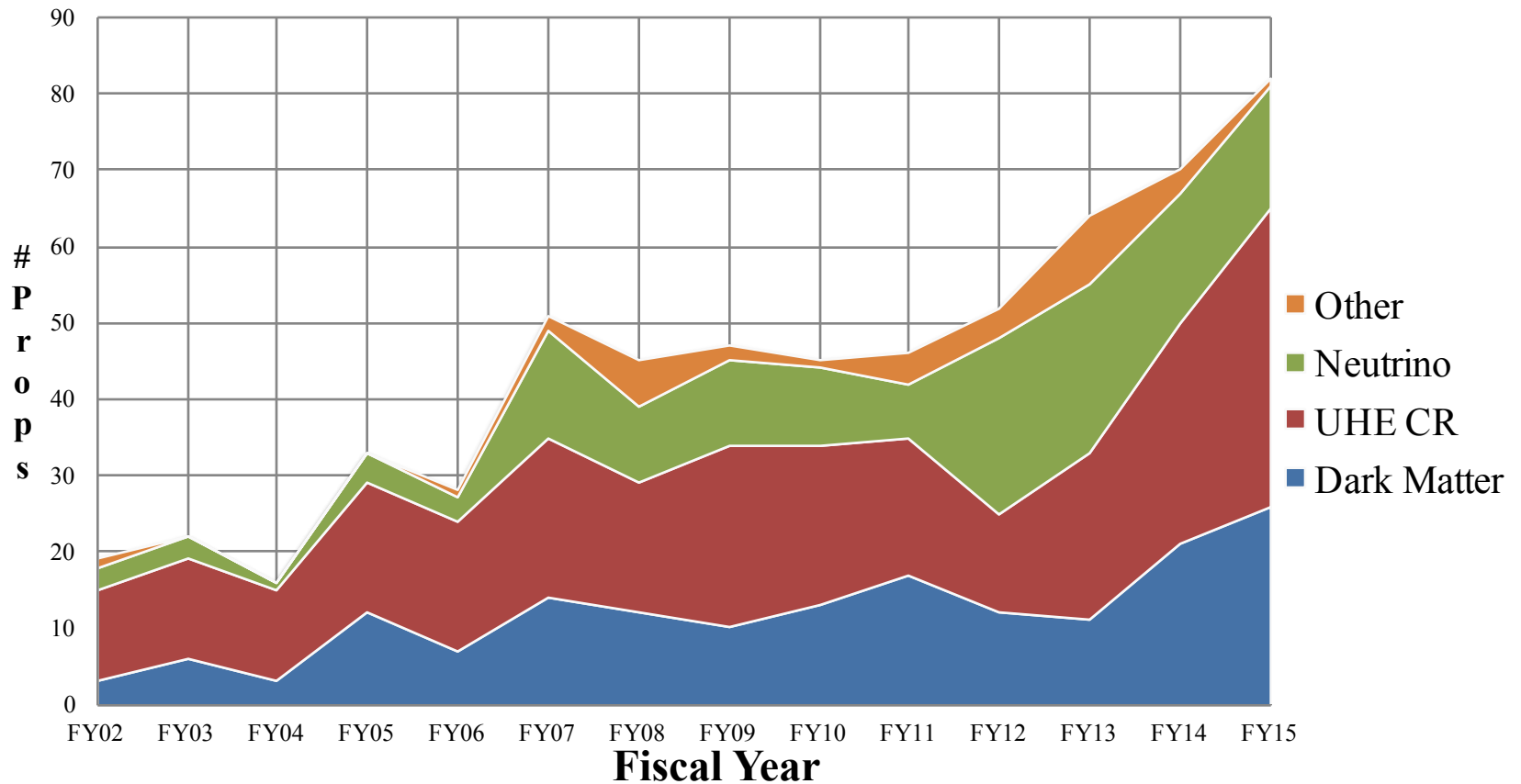


- CMB experiments are supported by multiple agencies and offices. Each plays an important role:
 - NSF – MPS/AST, MPS/PHY, GEO/PLR
 - DOE - HEP
 - NASA - Astrophysics
- The agencies are discussing how best to coordinate current and future CMB support.
- Support for CMB Stage IV will involve a coordinated, multi-agency process and will depend upon the results of the NWNH mid-decadal review.

Particle Astrophysics Proposals



Number of PA Proposals

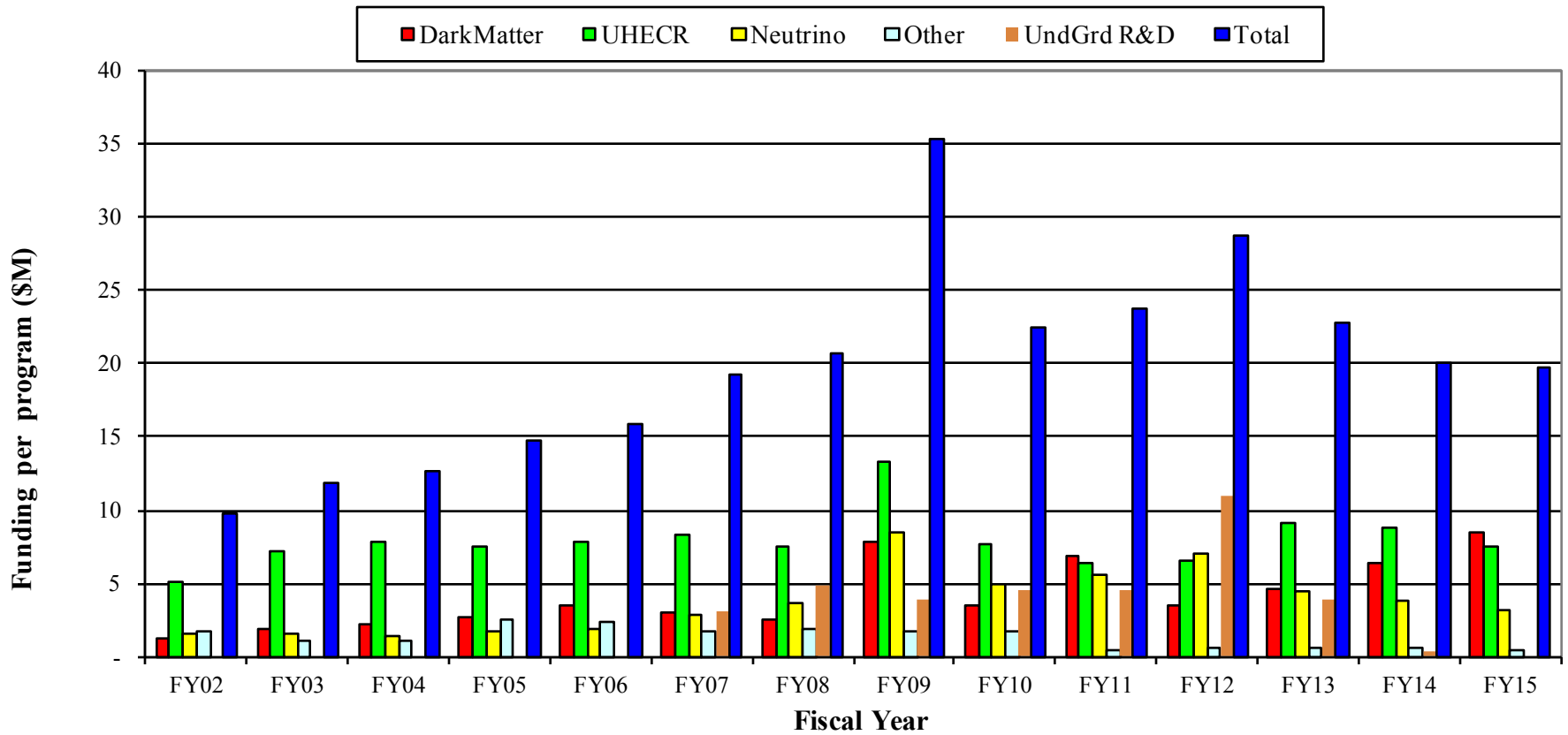


(“Neutrino” includes $0\nu\beta\beta$ for <2015)

PA Program Funding FY2002-2015



Yearly Funding for PA Program (\$K)



PA Program Funding in FY2015



PA funding by topic for FY2015

