

# CYGNUS 2013

4th International Workshop on Directional Dark Matter Detection



10 - 12 June 2013,  
Oarks Canal Park Hotel,  
Toyama, Japan

## ABSTRACT BOOK

### Scientific Program

Technical progress on direction sensitive detectors  
Data analysis (2D/3D track reconstruction, background rejection,...)  
Sense recognition : analysis strategies & measurements  
Experimental results from directional prototypes  
Theoretical studies  
Dark matter halo dynamics  
Related activities

### International Organizing committee

James Baltus (Brin Muri' College, USA)  
Jeanette Guenardis (CEA Saclay, France)  
Alex Green (U. of Nottingham, UK)  
Ignacio Ferrer (U. de Zaragoza, Spain)  
Dimitri Loubser (University of New Mexico, USA)  
Frederic Marin (LPSC Grenoble, France)  
Kenzo Mitachi (Kobe University, Japan)  
John Murre (Royal Holloway University of London, UK)  
Etsuko Naki (Nagoya University, Japan)  
Daniel Santos (LPSC Grenoble, France)  
Dustin Swarden (U. of Colorado College, USA)  
Neil Spooner (U. of Sheffield, UK)  
Scott Taylor (University of Hawaii, USA)

### Local Organizing committee

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K. Nakamura (Kobe Univ.)  
K. Hirohata (Kobe Univ.)

<http://ppwww.phys.sci.kobe-u.ac.jp/~newage/cygnus2013/>

**June 10 morning session 9:00-**

**【10A1】**

Title: Welcome / CYGNUS: where we are

Author: Kentaro Miuchi

Abstract: Welcome to CYGNUS 2013! The status and aim of the CYGNUS workshop will be discussed

**【10A2】**

Title: DRIFT

Author: Dan Snowden-Ifft

Abstract: I will provide an update on the DRIFT project.

**【10A3】**

Title: Updates on the DMTPC project

Author: James Battat

Abstract: I will present recent updates on the DMTPC project including results from the surface commissioning of the 4shooter detector.

**【10A4】**

Title: MIMAC status and perspectives

Author: Daniel Santos

Abstract:



June 10 afternoon session 14:00-

**【10P1】**

Title: NEWAGE

Author: Kiseki Nakamura

Abstract: Status and latest results of NEWAGE will be presented.

**【10P2】**

Title: Recent Progress on the Directional Dark Matter Detector (D<sup>3</sup>)

Author: Sven Vahsen

Abstract: We present recent progress towards a direction-sensitive WIMP dark matter search based on gas-filled Time Projection Chambers (TPCs) where the drift charge is amplified with Gas Electron Multipliers (GEMs) and detected with pixel electronics. The advantage of this approach is that nuclear recoils can be reconstructed in three dimensions with low energy threshold and low noise, at room temperature. We present performance measurements of small prototypes and a development path towards an affordable, m<sup>3</sup>-scale Directional Dark Matter Detector; D<sup>3</sup>. Such a detector may be particularly suitable for low-mass WIMP searches, and perhaps sufficiently sensitive to clearly determine whether the signals seen by DAMA, CoGeNT, and CRESST-II are due to low-mass WIMPs or background.

**【10P3】**

Title: Status and analysis system of directional dark matter search with nuclear emulsion

Author: Takayoshi Katsuragawa

Abstract: We have been doing research and development for direct dark matter search by nuclear emulsion which is solid state detector. If this experiment is realized, directional detection of dark matter by the large mass target and spin independent is possible. Until now, we constructed base of fully automatic analysis system and nuclear emulsion which can detect submicron tracks. We have demonstrated that it is possible to detect recoil track of 100nm or more by neutron irradiation. This is the track length corresponding to 40keV in C(N,O) target. Additionally, we evaluated the angular resolution of the energy basis by using an ion implant system, and obtained 30 degrees or better resolution. The fully automatic analysis system which can analyze very short tracks lead the experiment to next

phase, small test running. Now we can analyze 1 g detector per ten days. The next, we will do a quantitative study of the background toward test experiment at the Gran Sasso underground.

**【10P4】**

Title: R & D activities of MPGD in JAPAN

Author: Atsuhiko Ochi

Abstract: Micro Pattern Gaseous Detector (MPGD) is one of key technology for fine particle tracking. Recent MPGD activities in Japan will be reviewed in this talk.

**【10P5】**

Title: Measurement of the electron drift velocity in CF<sub>4</sub> and CHF<sub>3</sub> gas mixtures for upcoming directional Dark Matter detectors

Author: Frederic Mayet

Abstract: Measurement of the electron drift velocity in CF<sub>4</sub> and CHF<sub>3</sub> gas mixtures for upcoming directional Dark Matter detectors

Abstract :The knowledge of the electron drift velocity is a key issue for directional detection of galactic Dark Matter as it is used for the 3D track reconstruction. The aim of this paper is to present a dedicated method for the measurement of the electron drift velocity with the MIMAC detector, using a pure CF<sub>4</sub> gas and a CF<sub>4</sub>+CHF<sub>3</sub> gas mixture. This new measurement method uses high energy alpha tracks from a collimated source and includes a profile likelihood method associated to a modeling of the signal induced on the grid. In particular, we show that adding CHF<sub>3</sub> allows us to lower the electron drift velocity while keeping almost the same Fluorine content of the gas mixture. We show that the drift velocity at 50 mbar is reduced by a factor of about 5 when considering 30% of CHF<sub>3</sub>, allowing to improve the three-dimensional track reconstruction.

**【10P6】**

Title: An Update on DRIFT Backgrounds and Recent R&D Results

Author: Dinesh Loomba

Abstract: We provide a brief update on background reduction efforts involving the thin film cathode in DRIFT-IIId. We also show R&D results on an effort to measure electronic and nuclear recoil track properties with the goal of improving the sensitivity of directional dark matter detectors.

**【10P7】**

Title: Radon Detectors

Author: Keishi Hosokawa

Abstract: We show several radon detectors developed for low BG experiments.



**June 11 morning session 9:00-**

**【11A1】**

Title : DRIFT-IIe and DRIFT-III

Author: Neil Spooner

Abstract: DRIFT-IIe and DRIFT-III

**【11A2】**

Title : New idea on direction sensitive DM search

Author: David Nygren

Abstract: New idea on direction sensitive DM search

**【11A3】**

Title :R&D of QPIX

Author: Akira Sugiyama

Abstract: R&D of QPIX

**【11A4】**

Title : Energy partition and distribution of excited species in direction-sensitive detectors for WIMP searches

Author: Akira Hitachi

Abstract: Detectors with directional capability, such as TPC, can observe daily fluctuations of the WIMP window. Information on the charge distribution as a function of the depth of the slow recoil ion is essential for the directional detection of ions recoiled by WIMPs. Detector media for such TPCs are mostly compounds.

The charge distribution is given by the distribution of the electronic energy. However, the evaluation of Lindhard factor, the nuclear quenching factor or the fraction of energy that goes to the electronic energy, becomes extremely difficult for the medium contains more than one element. Also the number of ions produced per unit electronic energy for recoil ions can be considerably different from that for electrons or that for alpha-particles. In this talk, W-values, the quenching factor, the electronic LET (the specific electronic energy deposition along the track of charged particle), the Bragg-like curve (the specific electronic energy deposition as a function of the depth), etc., relating to WIPM searches are discussed

**【11A5】**

Title : Measuring Dark Matter Distribution in Directional Direct Detection

Author: Keiko Nagao

Abstract: In direct detection experiments with directional sensitivity, the dark matter distribution around the Earth can be measured as well as the direction of dark matter. In the talk, I will focus on the experiment with nuclear emulsions, and discuss the possibility to measure the distribution function. Especially, I would like to compare some results of simulations supposing the standard distribution and non-standard ones.

**【11A6】**

Title : Detector developing for directional dark matter search with nuclear emulsion

Author: Takashi Asada

Abstract: "The nuclei recoiled by the WIMPs are expected to fly the order of 100nm in the nuclear emulsion. The key of dark matter search with nuclear emulsion is how detect the direction of such short track.

Nuclear emulsion is mainly composed of gelatin and spherical crystals of AgBr. One crystal is a minimum unit of the detector. To get direction of track, nucleus must penetrate at least two crystals. The average size of crystals in popular nuclear emulsion are 200nm. The size in smallest crystal type emulsion is 40nm, but it's crystals are not stable. These nuclear emulsion were not enough for our purpose. So we have developed emulsions directly on our own. We found a new method to make emulsion. Polyvinyl Alcohol can reduce the growth of the crystals and make them very stable.

Thanks to this method, we can make some type of emulsions. The high sensitivity emulsions, named NIT (Nano Imaging Tracker) has 40nm crystals and it suit to detection of some light nuclei tracks like carbon. The very small crystal emulsion, named UNIT (Ultra-NIT) has 25nm crystals, and it suit to detection of heavy nuclei tracks like bromide. We also report the measurement of these sensitivity with radioisotope and ion implanter."

**June 11 afternoon session 9:00-**

**【11P1】**

Title : PICO-LON dark matter search

Author: Ken-Ichi Fushimi

Abstract: "PICO-LON provides the high sensitivity search for both spin independent and spin independent dark matter. PICO-LON gives the important information on WIMPs parameters. The expected sensitivity and future prospects are presented."

**【11P2】**

Title : Status of XMASS experiment

Author: Hiroyoshi Uchida

Abstract: XMASS is a multi-purpose low-background experiment with liquid xenon. Commissioning data was taken with an 800kg detector at the Kamioka Observatory in Japan between Nov. 2010 and May. 2012, and used to demonstrate detector's performance to search for WIMPs. One of the studies based on this commissioning run data is a light WIMPs search. A high photoelectron yield of our detector (14.7p.e./keV) enabled us to set an upper limit on the WIMP-nucleon cross section for WIMPs with masses below 20GeV and excludes part of the parameter space allowed by other experiments. Another study was conducted to search for solar axions that would be produced by bremsstrahlung and Compton effects in the Sun. With the same data set used for light WIMP search, we set a stringent limit on axion-electron coupling. In this talk we introduce an analysis of WIMP-Xe129 inelastic scattering search. Since an excitation of a low-lying nuclear state of Xe129 (40keV,  $t_{1/2} \sim 1\text{ns}$ ) is expected, subsequent emission of a recoil nuclei and 40keV radiations cause a peak around 40keV in an observed energy spectrum. With appropriate reduction of background, a sensitive search for the interaction can be done and will be reported.

**【11P3】**

Title : DM-ICE

Author: Neil Spooner

Abstract: DM-ICE



#### **【11P4】**

Title : Status of R&D on double phase Argon detector: the ANKOK project

Author: Masashi Tanaka

Abstract: "Liquid argon is known as an excellent target material for WIMP dark matter direct search experiment.

Use of its ionization and scintillation signals, and scintillation pulse shape provides strong discrimination ( $10^8 \sim 10^9$ ) between the electron and nuclear recoil events. Liquid argon is inexpensive, and it is a large advantage for the future large (ton scale) experiments. Relatively small atomic mass ( $A=40$ ) gives higher nuclear recoil energy for WIMP-Ar nuclear scattering, thus it keeps higher sensitivity for low mass WIMP ( $\sim 10$  GeV/c<sup>2</sup>).

On the other hand, the 128 nm VUV scintillation light of argon is relatively hard to detect with nominal photo sensors, and use of wavelength shifter lowers the light detection efficiency ( $\sim 5$  pes/keVee (Ar) compare to 40 pes/keVee (Xe)).

Since PY2012, we are working on a new dark matter search project (ANKOK) at Waseda university using double phase liquid argon detector technique.

As a first stage of the project, we are currently concentrating our effort on further improvement of the scintillation light detection efficiency so that the experiment has better sensitivity for low mass ( $\sim 10$  GeV/c<sup>2</sup>) WIMP. In the next few years, we are targeting to construct a detector with fiducial mass of several tens of kg, and to collect the underground physics data.

In this talk, I will report R&D status and future plan of the ANKOK project."

#### **【11P5】**

Title : KamLAND-Zen Experiment for Neutrino less Double Beta Decay Search

Author: Daisuke Motoki

Abstract: The KamLAND-Zen experiment, which is a part of KamLAND detector, aims at detecting neutrino less double beta decay. Since half-life time of neutrino less double beta decay is expected over  $10^{25}$  years, large scale and low background environment are required to detect such rare event. The KamLAND-Zen immerses a mini balloon filled with <sup>136</sup>Xe loaded liquid scintillator into center of KamLAND detector. 9m radius oil can be used as active shield and veto detector. Total exposure time achieved 85.9 kg yr. As a result we obtained a lower limit for the neutrino less double beta decay half-life of  $>1.9 \cdot 10^{25}$  yr at 90% C.L. Now we are conducting purification of liquid scintillator and Xe in mini balloon for improvement of the sensitivity. In this presentation, I will mention these results and current activities for near future.

**【11P6】**

Title : A review on the discovery reach of directional detection

Author: Frederic Mayet

Abstract: Depending on the unknown WIMP-nucleon cross section, directional detection may be used to : exclude Dark Matter, reject the isotropy hypothesis, discover galactic Dark Matter with a high significance or constrain WIMP and halo properties. I will also show that directional detectors may probe spin dependent dark matter scattering on nucleons that are beyond the reach of other searches (indirect, spin-independent and colliders).

**【11P7】**

Title : Proceedings

Author: Tatsuhiro Naka

Abstract: Instruction on proceedings.

**【11P8】**

Title : Discussion

Author: Mayet / Battat

Abstract: Instruction on proceedings.



**June 12 morning session 9:00-**

**【12P1】**

Title : Kamioka tour instruction / Underground activities

Author: Kentaro Miuchi

Abstract:

**【12P2】**

Title : Discussion 2

Author: Spooner/Miuchi

Abstract:

**【12P3】**

Title : workshop summary

Author: Neil Spooner

Abstract:

