Dark Matter Searches with sub-keV Germanium Detector

Li Hau-Bin (on behalf of TEXONO-CDEX collaboration)

Academia Sinica, Taipei, Taiwan.

- Overview (Collaboration, Programs)
- Laboratories : KSNL & CJPL
- Detector R&D
- Status & Plans

ICHEP2012
Melbourne

36th International Conference on High Energy Physics

4 – 11 July 2012
Melbourne Convention and Exhibition Centre

TEXONO-CDEX Collaboration

TEXONO Taiwan EXperiment On NeutrinO (since 1997)

Neutrino Physics at Kuo-Sheng Reactor Neutrino Laboratory (KSNL)

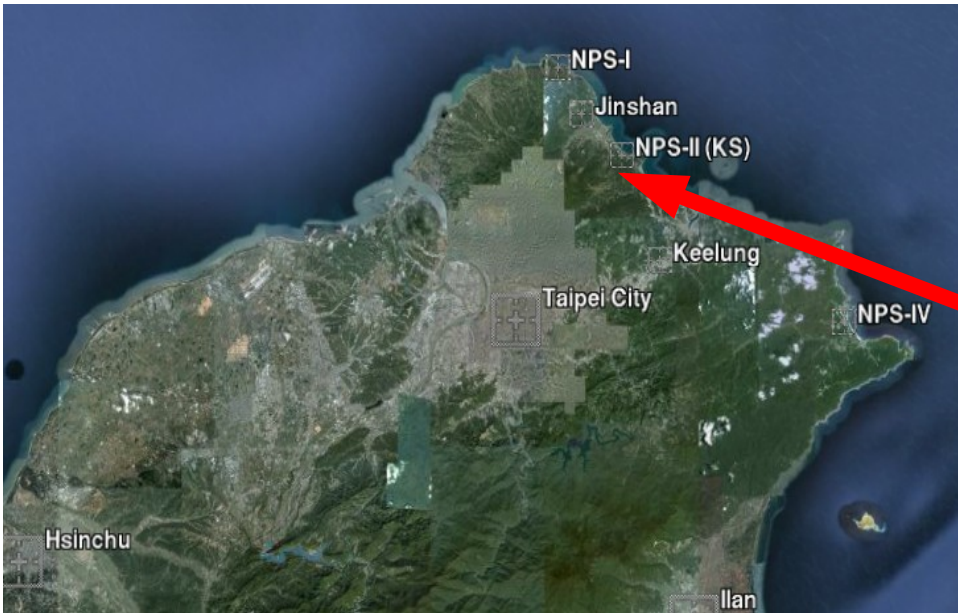- **Taiwan (AS, NTHU, INER, KSNPS)**

- **Turkey (METU)**

- **India (BHU)**

CDEX China Dark Matter Experiment (birth 2009)

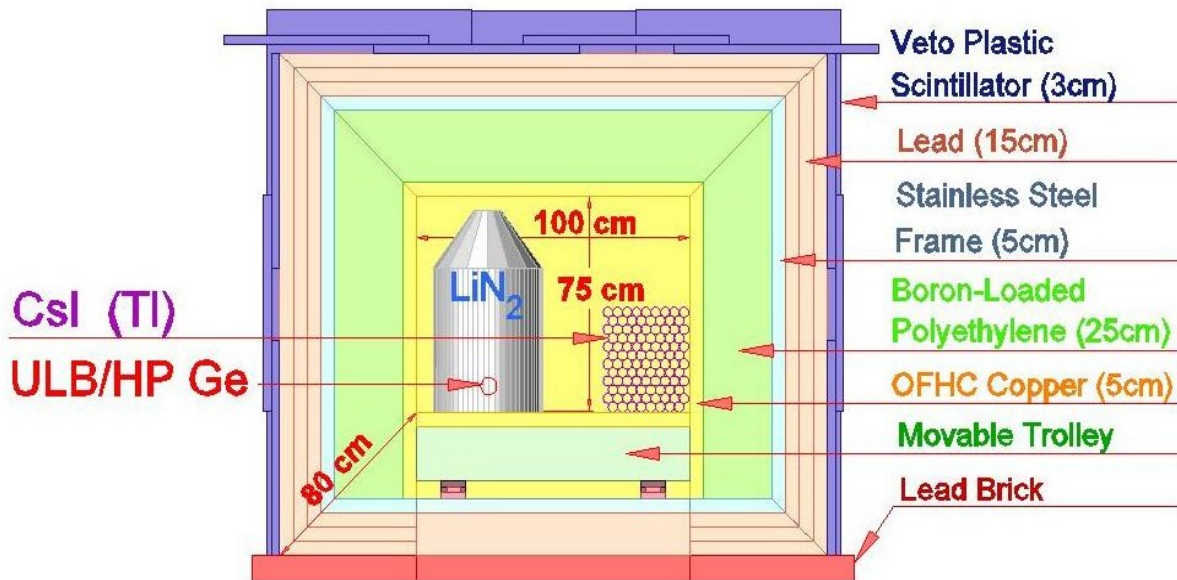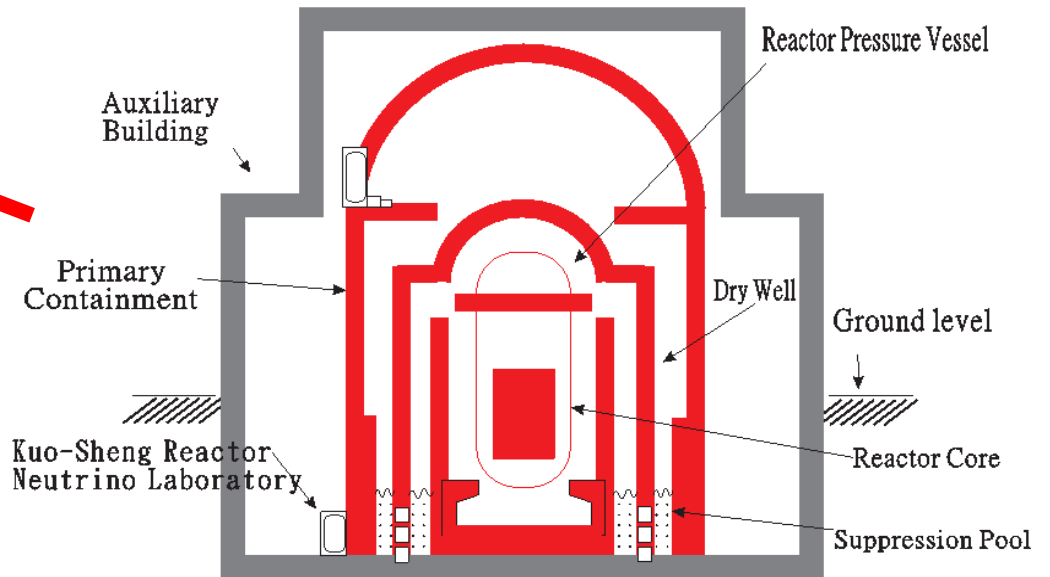Dark Matter Searches at China Jin-Ping Underground Laboratory (CJPL)

- **China (THU, CIAE, NKU, SCU,EHDC)**

Kuo Sheng Reactor Neutrino Laboratory


Kuo-Sheng Nuclear Power Station : Reactor Building

- ## Physics Programs

- Neutrino Magnetic Moment
  PRL03, PRD05, PRD07

- neutrino-electron scattering(SM/BSM)
  PRD10x2, PRD12
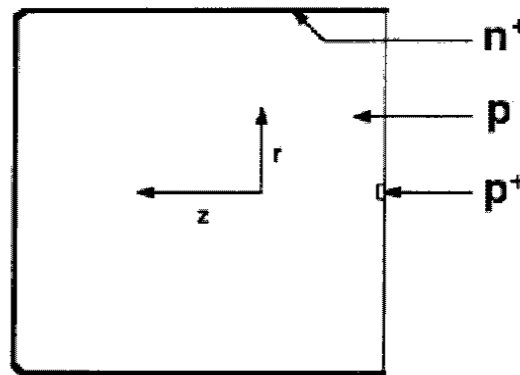
- νN coherent scattering

  →**Dark Matter Search** **PRD-RC09**

Physics goals for sub-keV Ge Detectors

mass ~1kg : threshold ~100 eV : bgk ~1 cpkkd

- **Low-mass WIMP searches.**

  [count day^{-1} keV^{-1} kg^{-1}]

- νN coherent scattering.

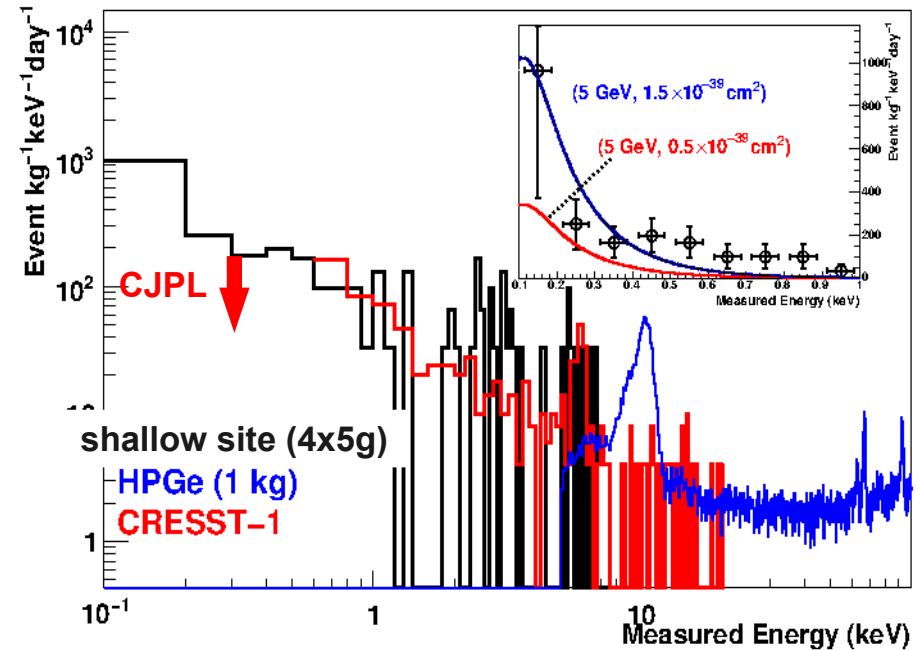- Improve sensitivities on neutrino magnetic moments.
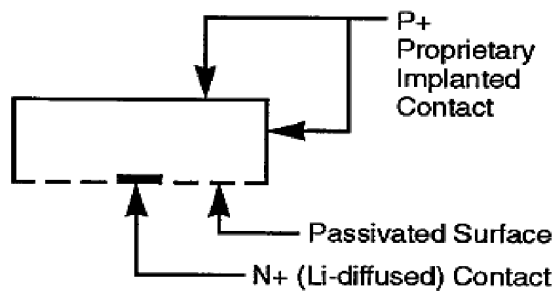
ULEGe : ~g, threshold ~220 eV

PCGe : ~kg, threshold ~300 eV
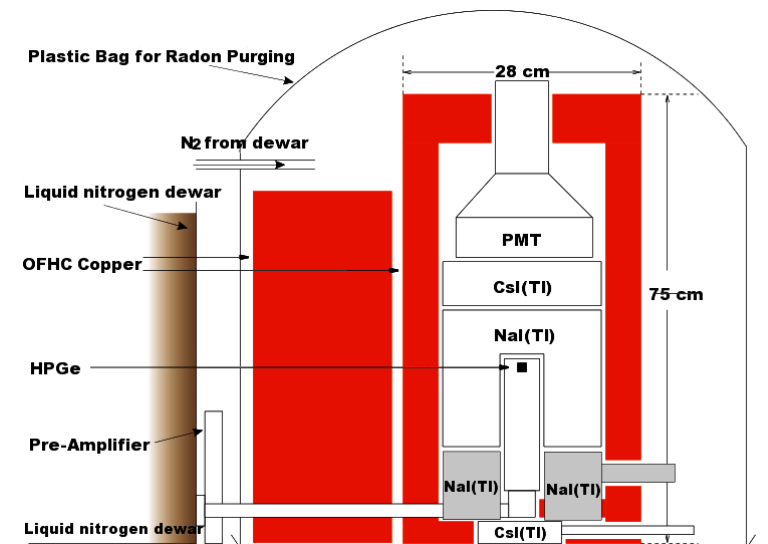
Dark Matter Results from 4x5 g Ge
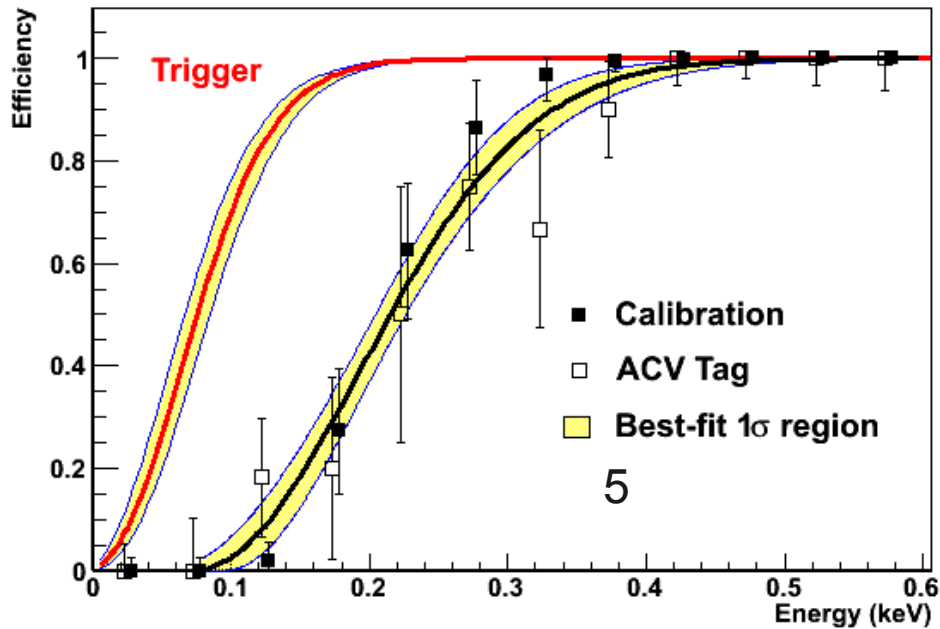
trigger ~100eV : software threshold ~ 220eV

PRD-RC09

sub-keV Background :

- *Not fully explained* with conventional background modeling.

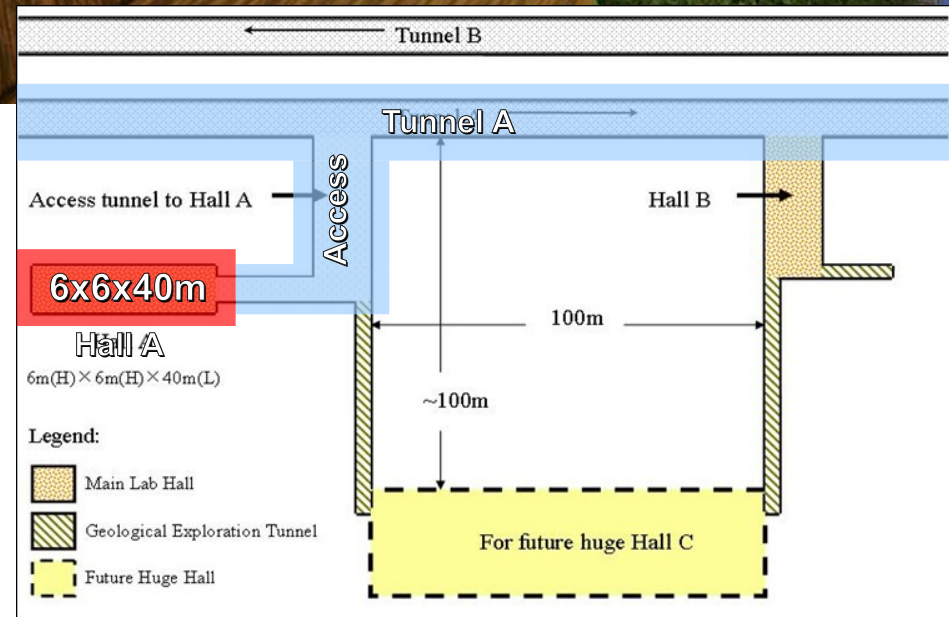- Intense studies on background understanding ongoing (simulation, background measurement, analysis)
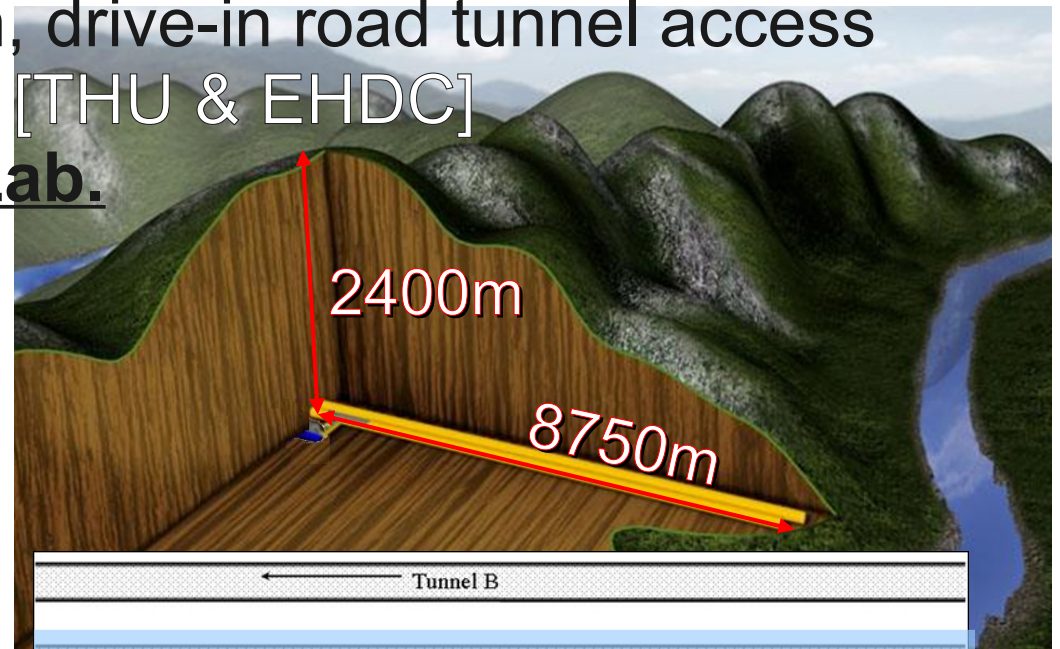
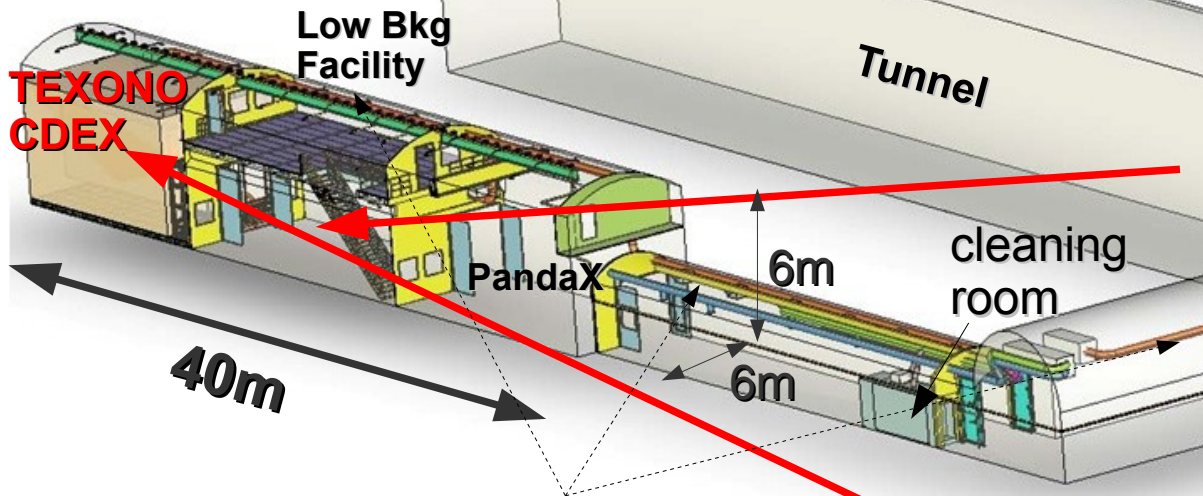# China Jin-Ping Underground Laboratory (CJPL)

CJPL ▲ 中国锦屏地下实验室
China Jinping Underground Laboratory
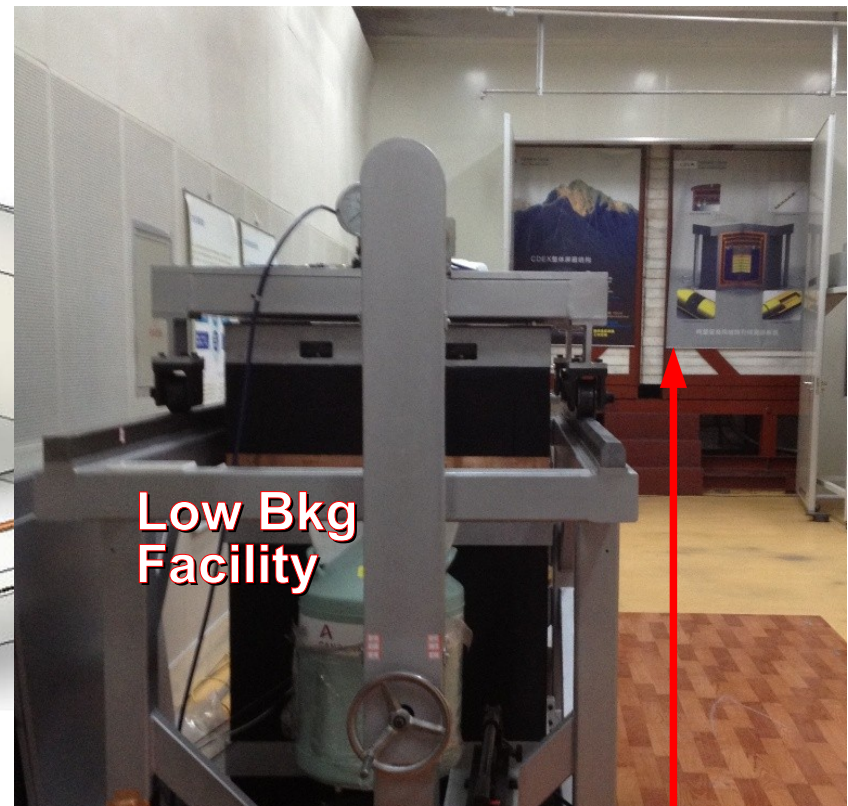
- 2400+ m rock overburden, drive-in road tunnel access
- 6x6x40 m cavern ready   [THU & EHDC]
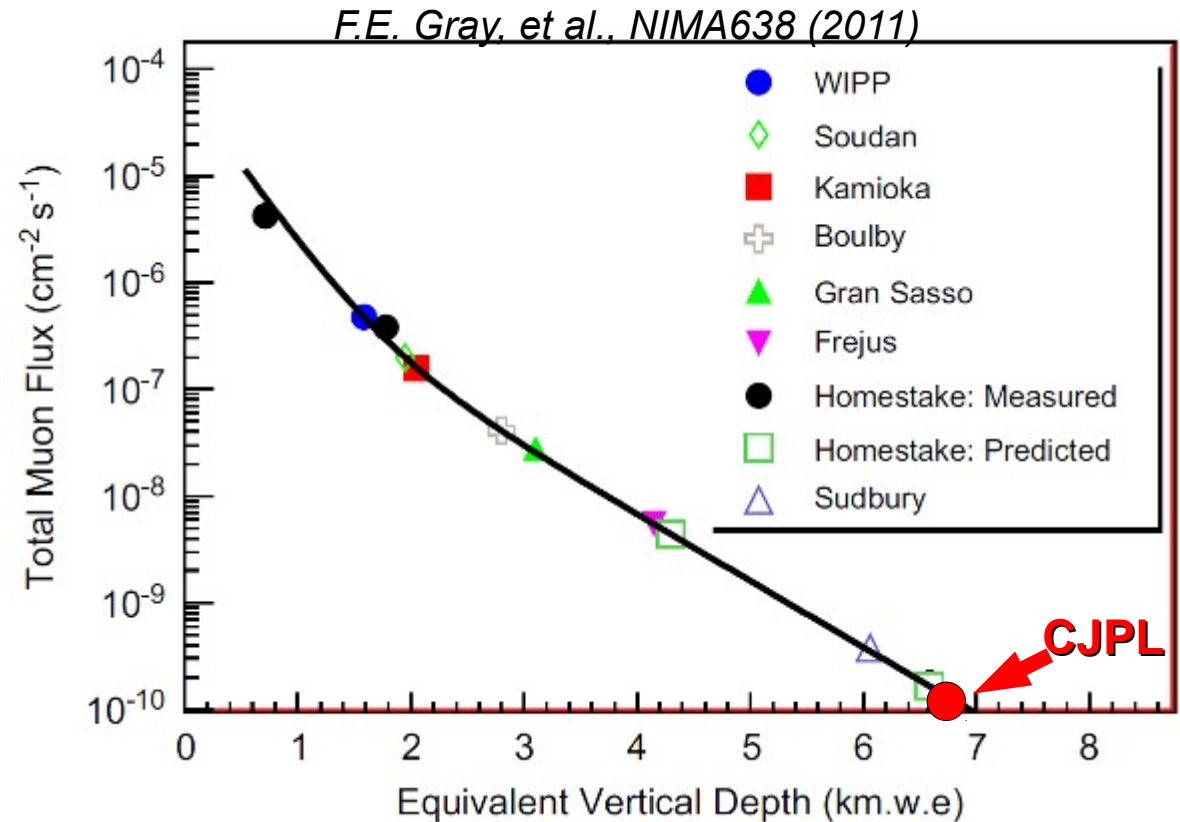- **Deepest Underground Lab.**

2400m
8750m

Tunnel B
Tunnel A
Access tunnel to Hall A → Access   Hall B →
6x6x40m
Hall A
6m(H)×6m(H)×40m(L)
100m
~100m

Legend:
Main Lab Hall
Geological Exploration Tunnel
Future Huge Hall

For future huge Hall C

CJPL Hall A: Basic Infrastructures

TEXONO CDEX

Low Bkg Facility

Tunnel

PandaX

cleaning room

6m

6m

40m

ventilation (complete at 2011)

Low Bkg Facility

4x5 g ULEGe

1 kg PCGe

2011-2012

Cosmic Ray

F.E. Gray, et al., NIMA638 (2011)
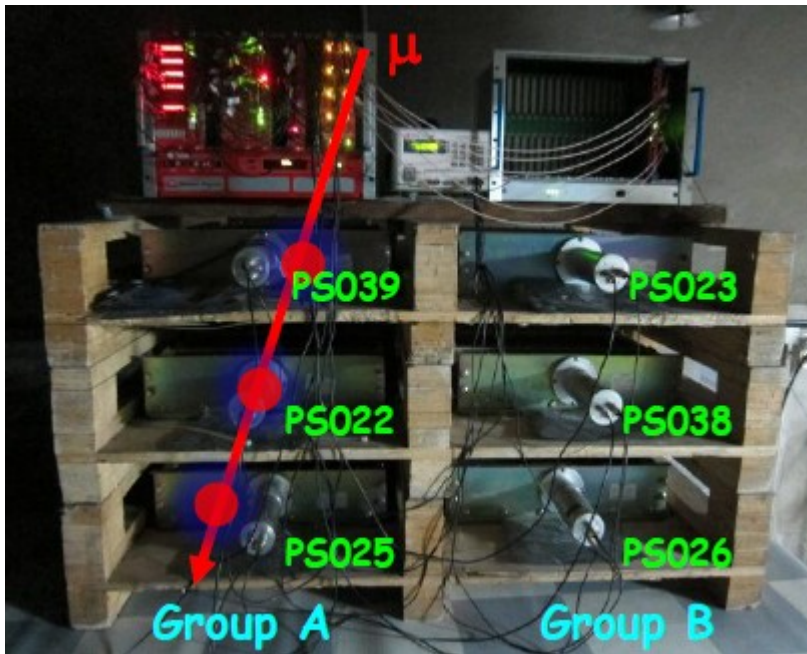
- 28 events in 178 days (1 m^2) [i. e. ~6 muons month^{-1} m^{-2}]

- Consistent with expectation :
  $\approx 2 \times 10^{-10}$cm^{-2}s^{-1} $\approx$ 10^{-8} of ground level

- Measurement of ambient background (gamma, thermal-neutrons, fast-neutron).

sub-keV Ge Detector : R&D and Challenges

- Quenching Factors -- nuclear recoils' Ionization Yields. [adopted TRIM]

- Energy Definition & Calibration.

- Trigger Efficiencies near threshold.

- Physics vs. Noise Pulse-Shape Selection : algorithms & efficiencies.

- Bulk vs. Surface Events Selection : algorithms & efficiencies.

- Background understanding : *NOT fully explained* with conventional background modeling (crucial for νN coherent scattering also).

PCGe : Trigger & PSD Effeciency
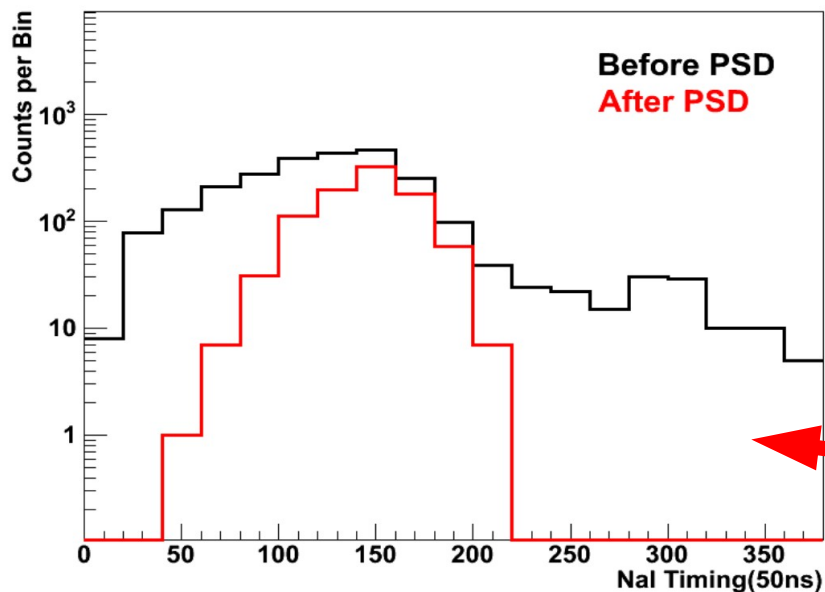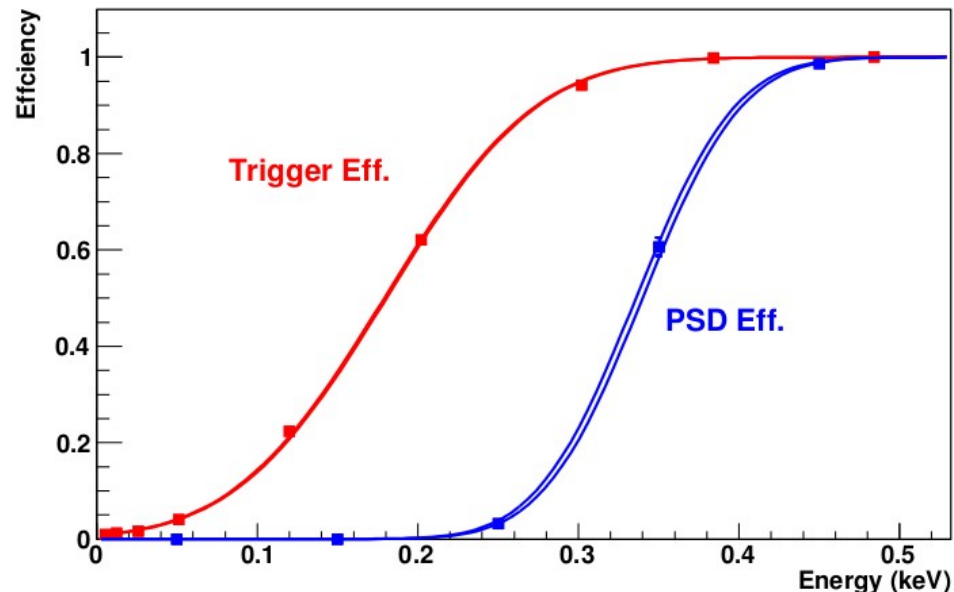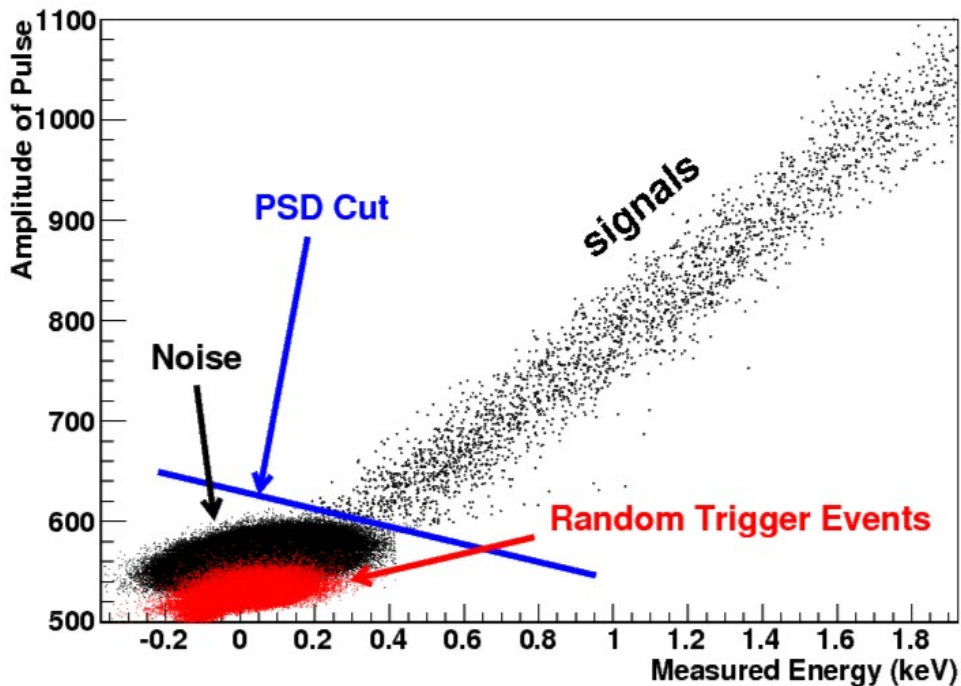
Trigger Eff. from background data & pulser.

- Trigger threshold (Eff. = 50%) ~ 170 eV
- PSD threshold (Eff. = 50%) ~ 320 eV

- A correct PSD cut, not only get rid of noise, but also pick up anti-Compton events with correct timing.

900g PCGe : Bulk and Surface

- n+ inactive layer is not totally dead, deposit partial charge.
- ^{241}Am(60keV γ) → surface rich.
- Cosmic without anti-Compton (neutron rich) → bulk rich.
- Intense efforts on :
  efficiency(probability of bulk event being identified as bulk event)
 **contamination**(probability of surface event being indentified as bulk event)
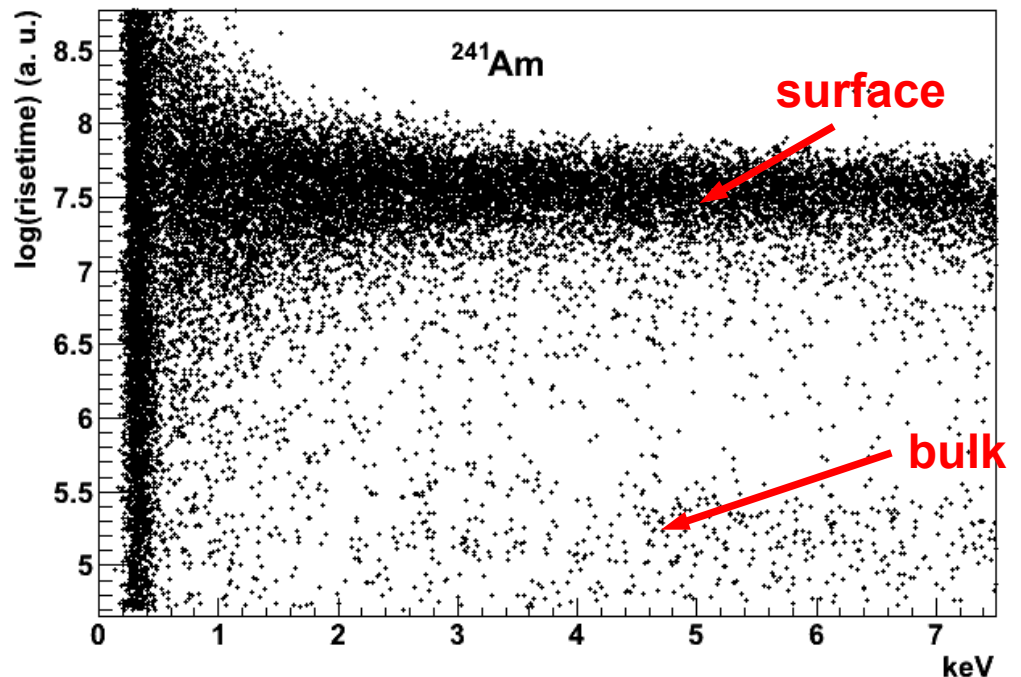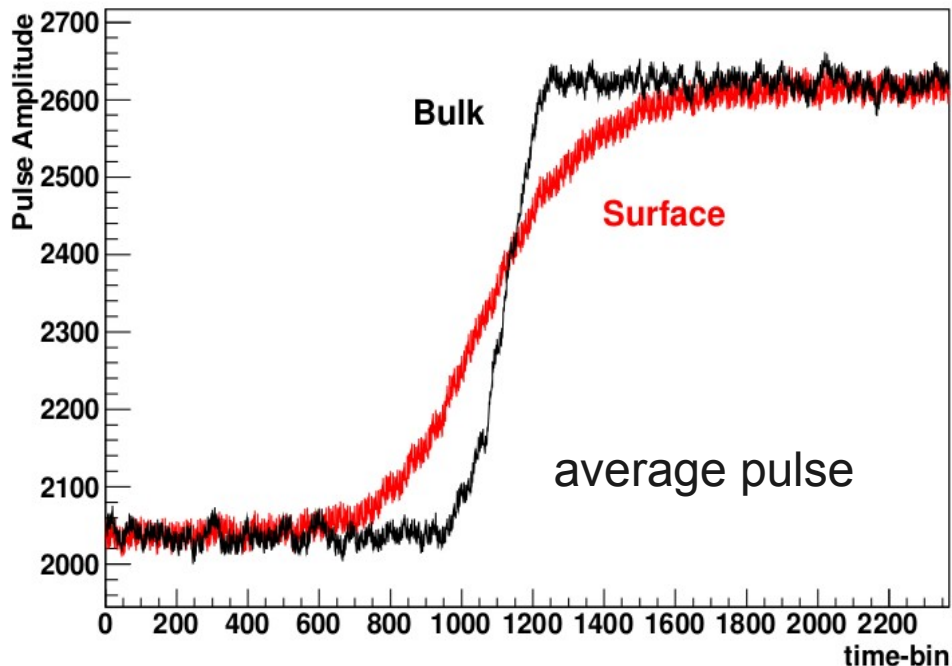
Plans at CJPL

- 2010+: characterize background at CJPL, set up low background material screening Facilities.

- 2011-12: Repeat PRD-09 measurement with 20 g ULEGe and 1 kg PCGe.

- 2012-15: 10 kg range PCGe array, with Liquid Argon Anti-Compton.

- 2015-Beyond: Evaluate 1 ton scale experiment, Explore Double Beta Decay program.
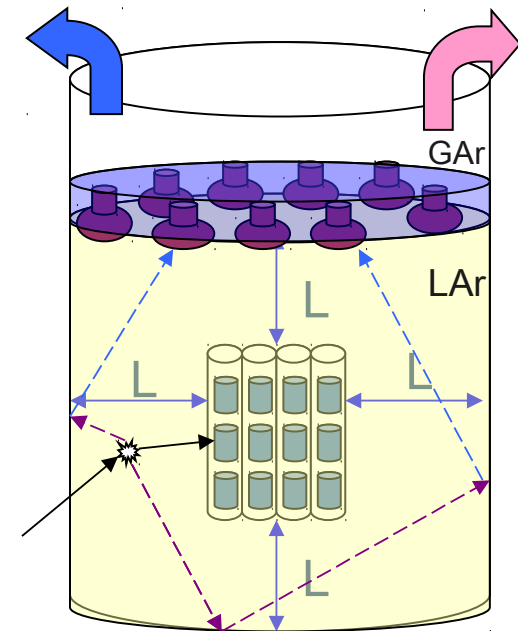
Expected Sensitivities at CJPL
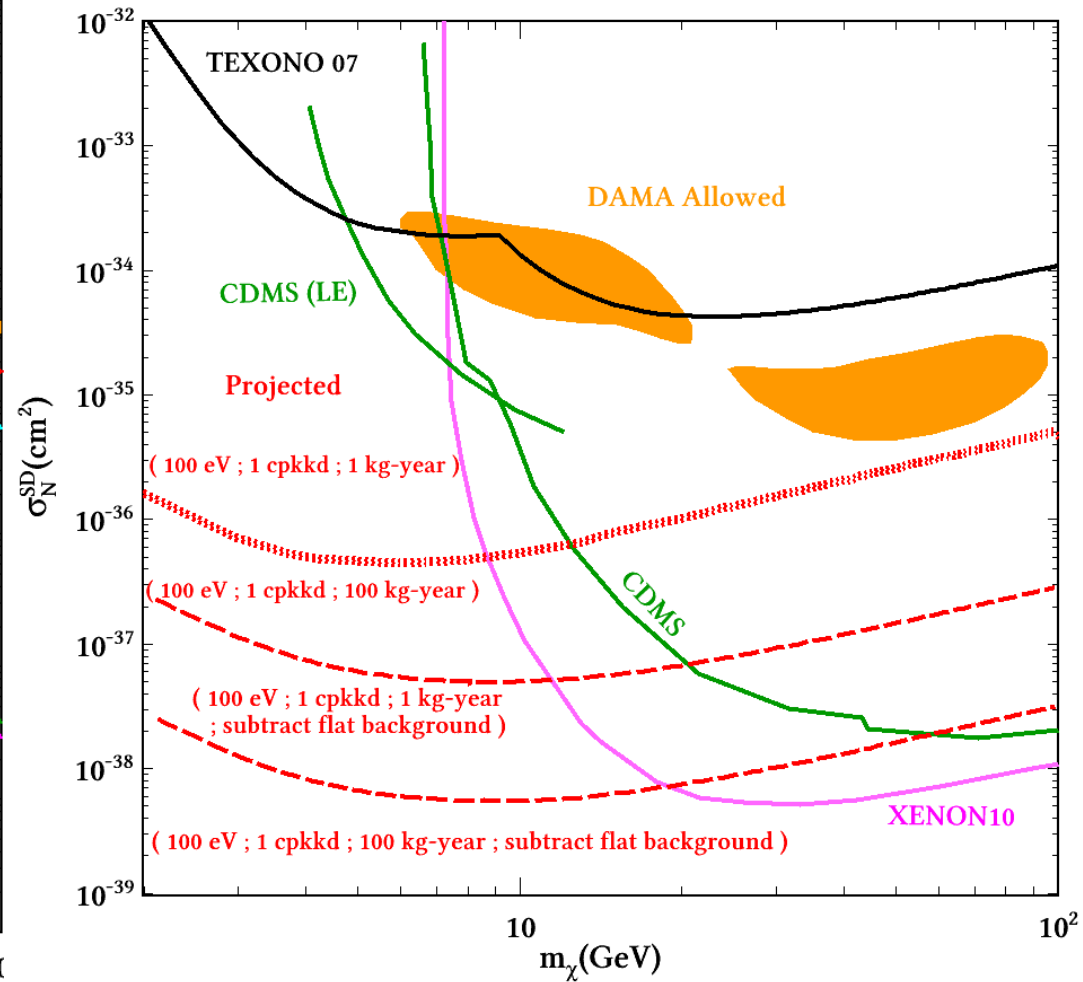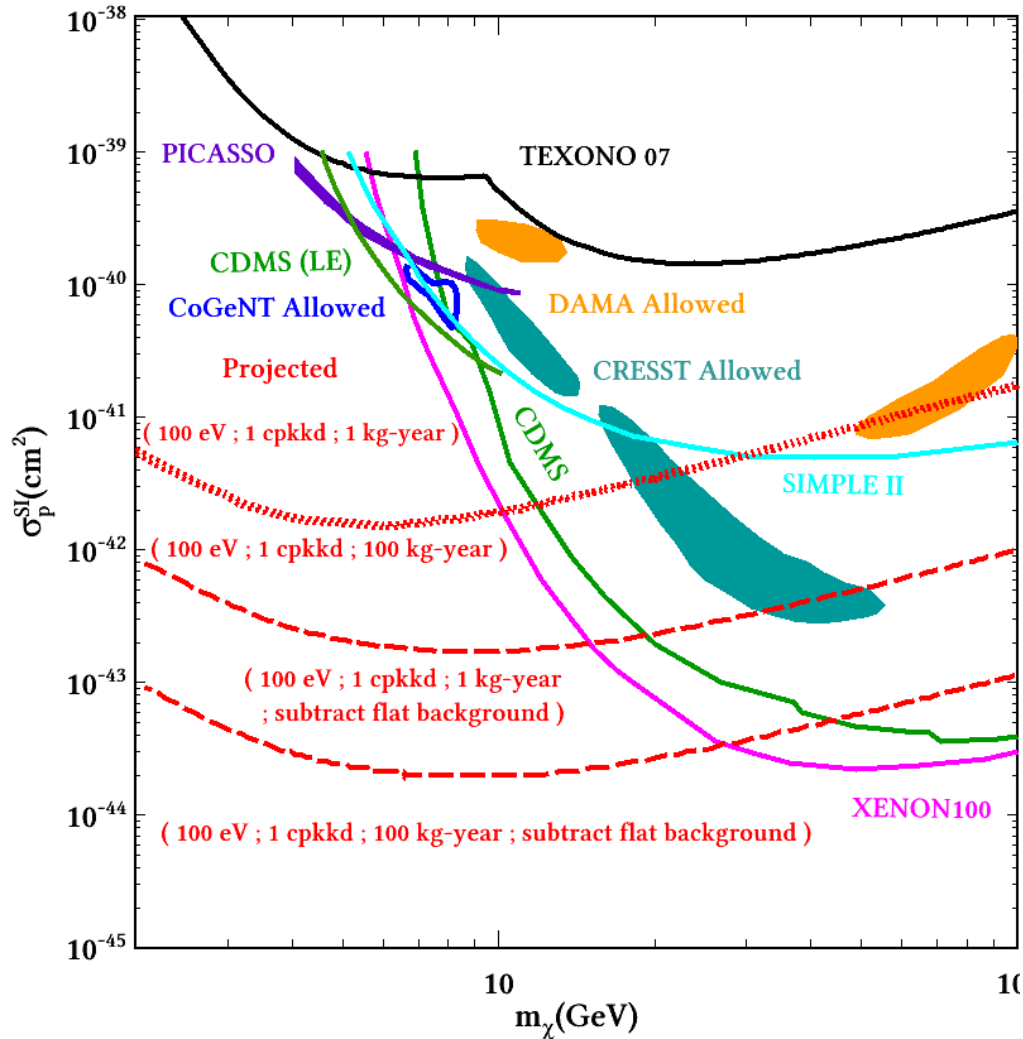
- without background subtraction → background level
- with background subtraction → error of background → statistics
- key-factor → **background understanding and suppresion at sub-keV**

<u>Prospects</u>

- **<u>CJPL</u>** is the deepest operating underground laboratory in the world. Engineering Data 2011; Physics Data 2012.

- CDEX-TEXONO Dark Matter Program at **<u>CJPL</u>** focuses on sub-keV Ge detectors and low-mass WIMP region.

- Focuses at **<u>KSNL</u>**: sub-keV Ge to support dark matter program AND towards νN coherent scattering.

- Intense efforts on Ge & LAr Detector R&D.

- Background Understanding at sub-keV region.

Thank You