

Dark Matter Searches with sub-keV Germanium Detector

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- Overview (Collaboration; Laboratory; Program)
- Highlights: Physics & Detector & Results
- New Underground Laboratory at Sichuan
- Status & Plans

7th Patras Workshop on Axions, WIMPs and WISPs

Mykonos (GR)

26 June - 1 July 2011

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)

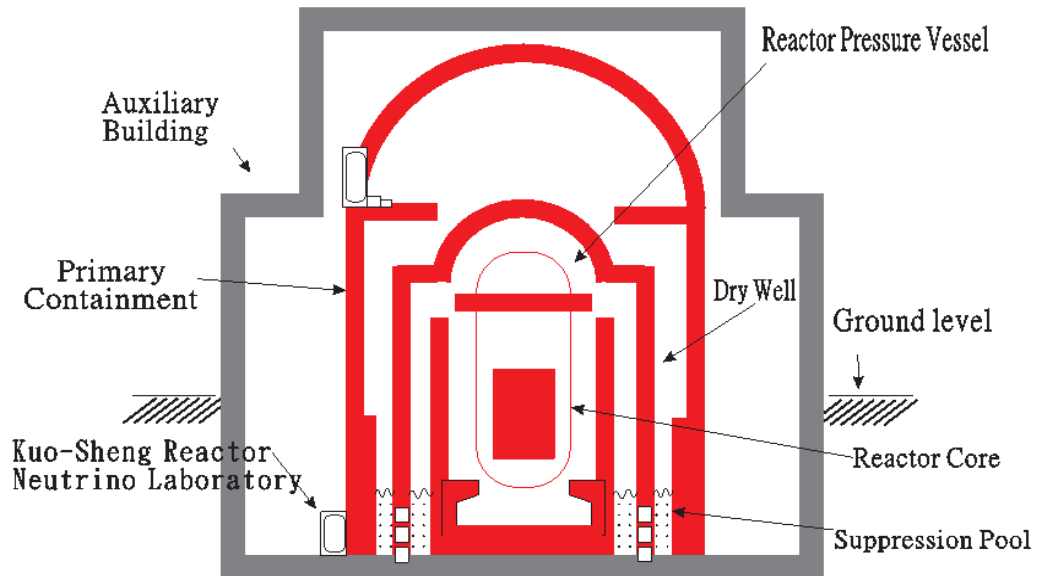
- China (THU, CIAE, NKU, SCU, EHDC)



Kuo Sheng Reactor Neutrino Laboratory



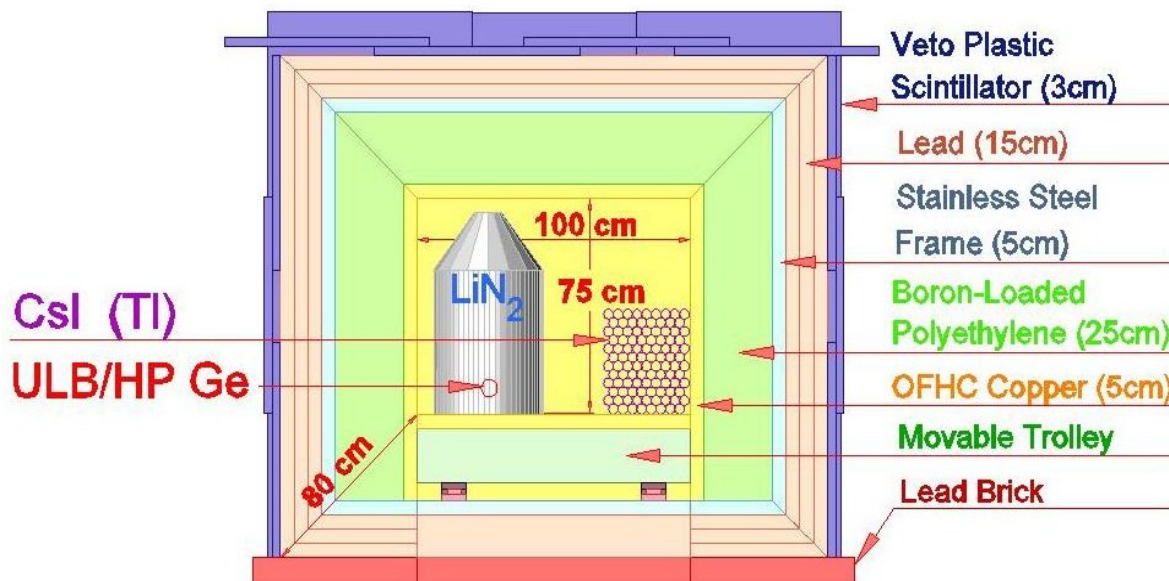
Kuo-Sheng Nuclear Power Station : Reactor Building



Powerful collaboration. Scientists from Taiwan and mainland China are studying neutrino emissions from this nuclear power plant outside Taipei.

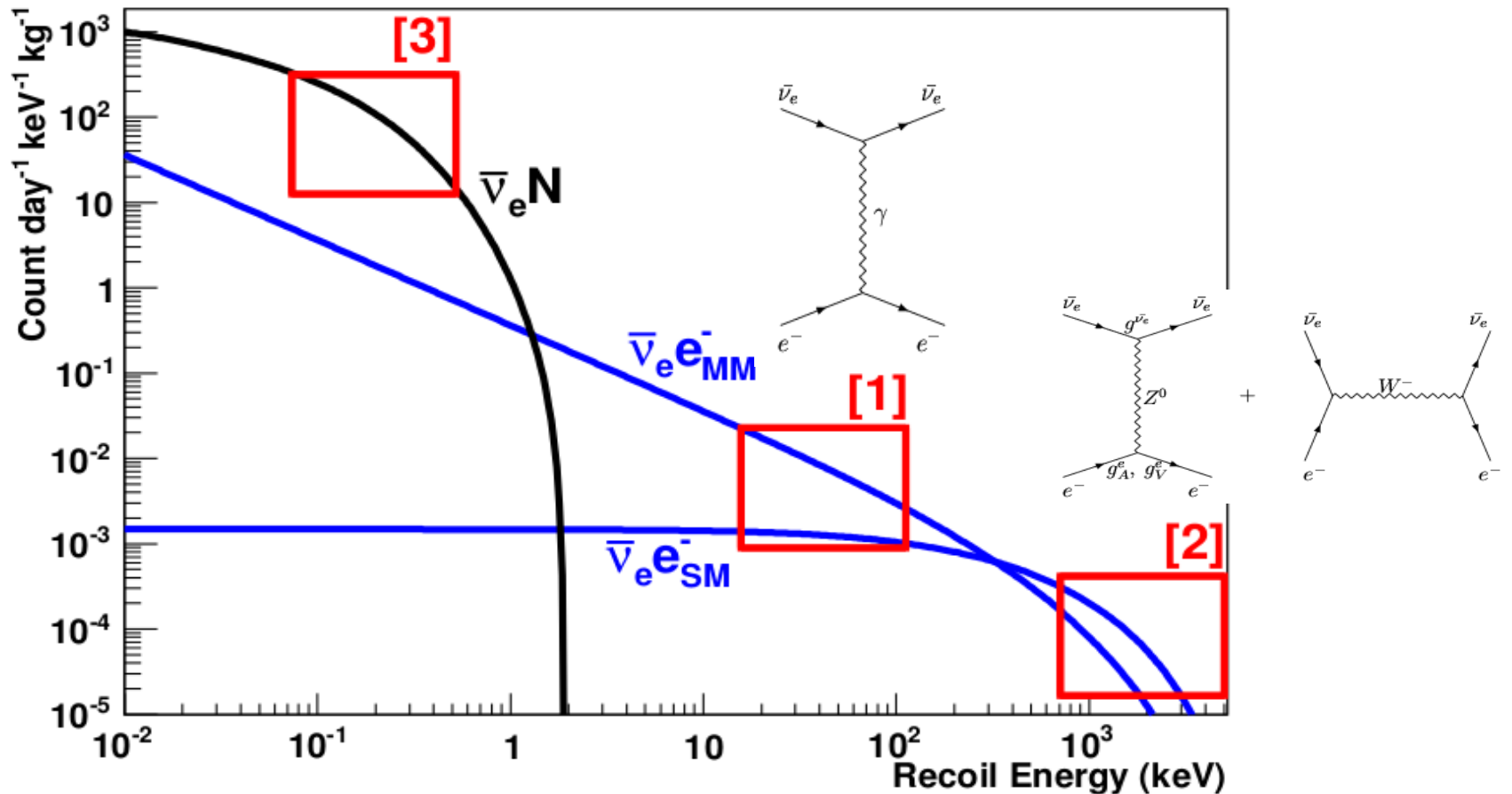
- 2.9 GW each core
- 28m from nearest core
- concrete : ~30mwe overburden
- ~10 m below ground level

Kuo Sheng Reactor Neutrino Laboratory



Flexible design allowed for different **detectors** and different **physics**

Physics program



[1] Neutrino Magnetic Moment [PRL03, PRD07](#)

[2] Standard Model neutrino-electron scattering [PRD10](#)

[3] νN coherent scattering

→ Dark Matter Search [PRD-RC09](#)

Physics goals for sub-keV Ge Detectors

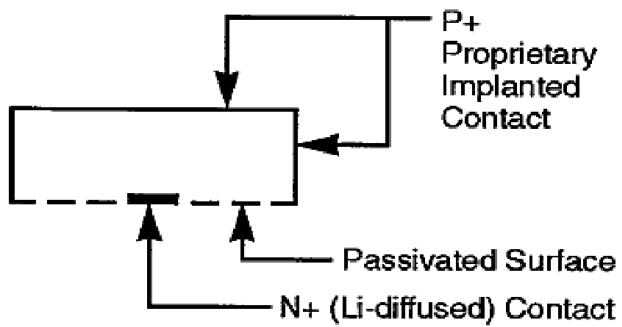
mass $\sim 1\text{kg}$: threshold $\sim 100\text{eV}$: bkg $\sim 1\text{cpkkd}$

[count day⁻¹ keV⁻¹ kg⁻¹]

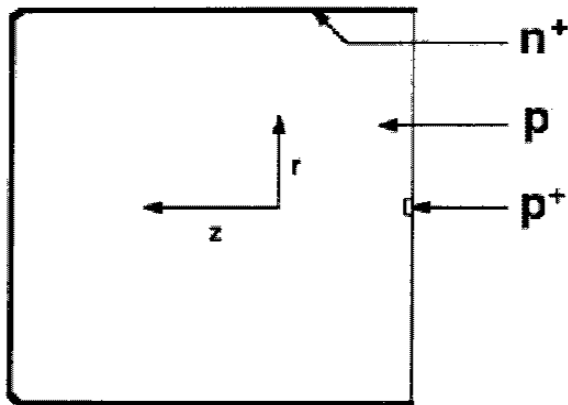
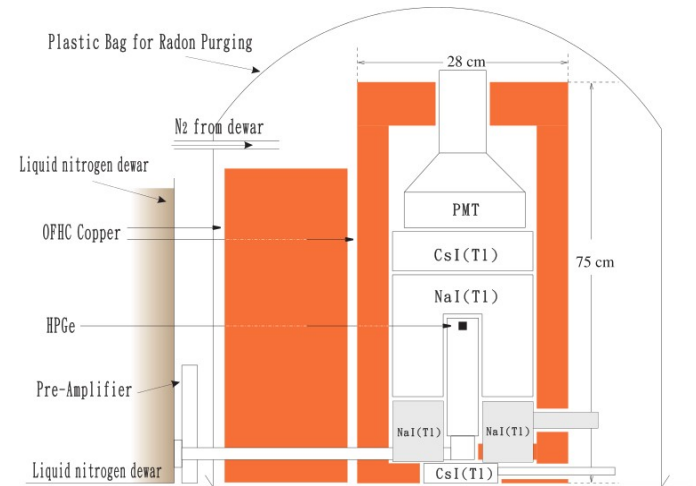
- νN coherent scattering.
- Low-mass WIMP searches.
- Improve sensitivities on neutrino magnetic moments.
- Implications on reactor operation monitoring.
- Open new detector window & detection channel.

Ge detectors

- various kinds of Ge detectors had been studied.

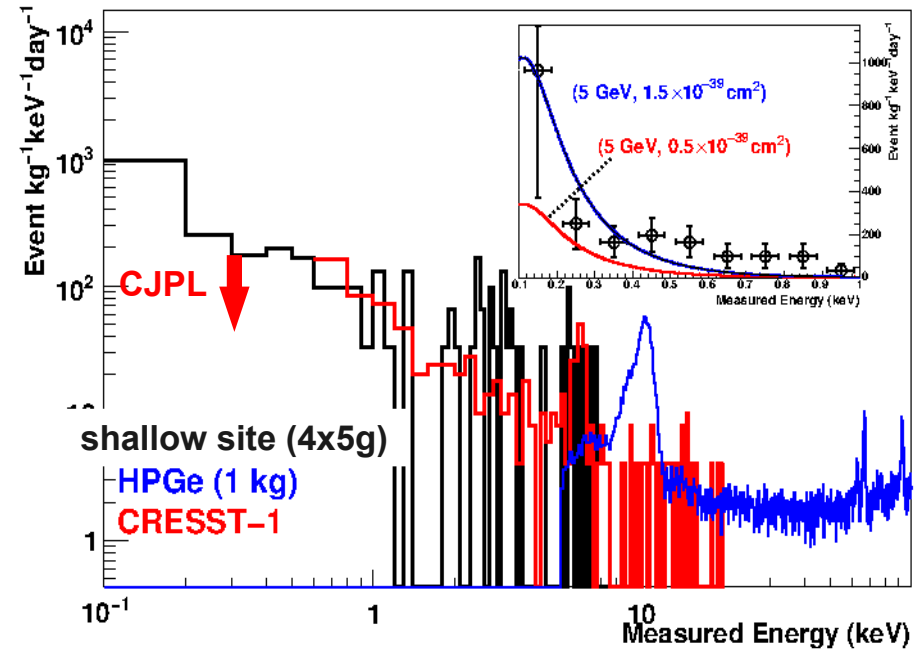
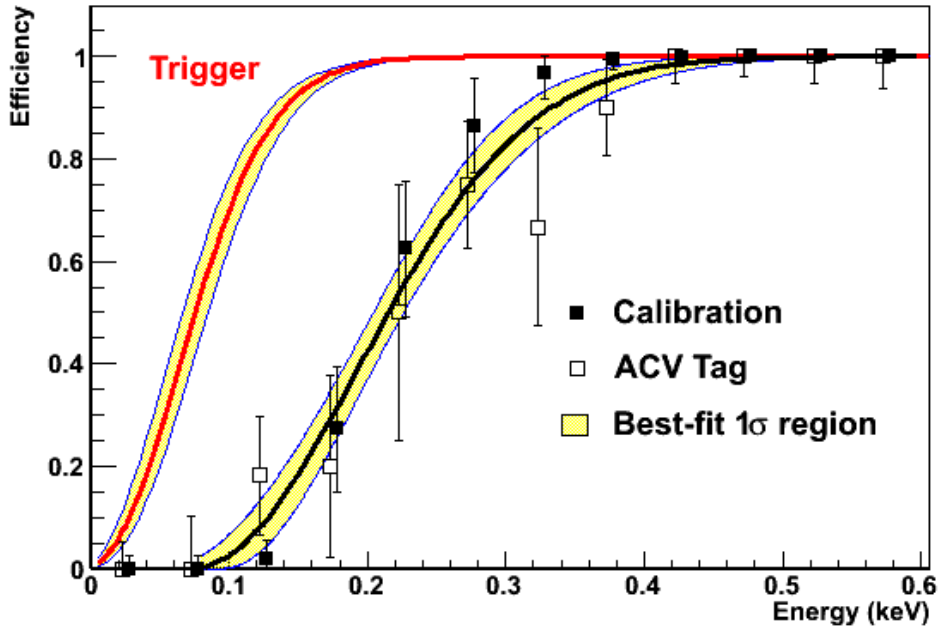


4x5 g : threshold ~220eV



PCGe : ~kg mass, threshold ~300eV

4x5 g Ge : performance

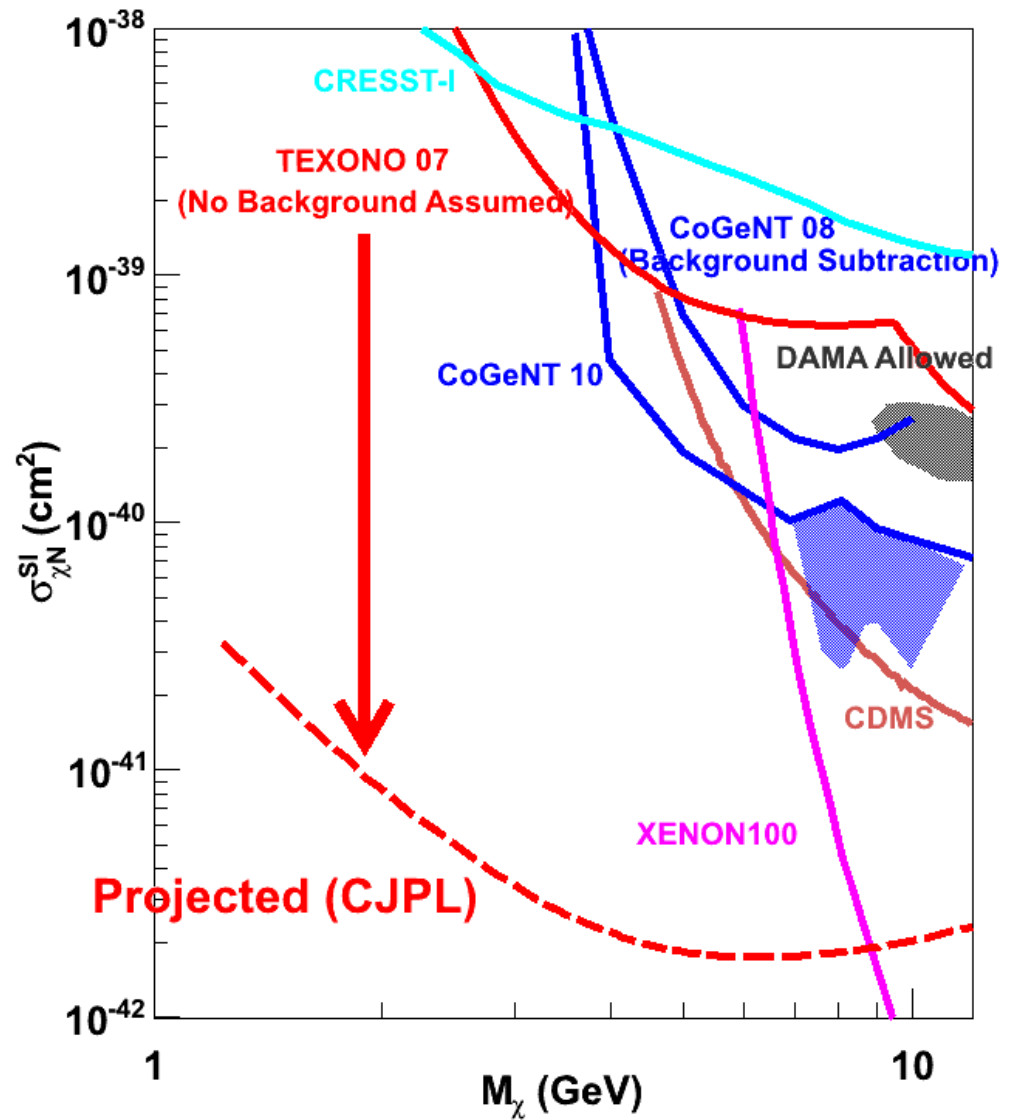
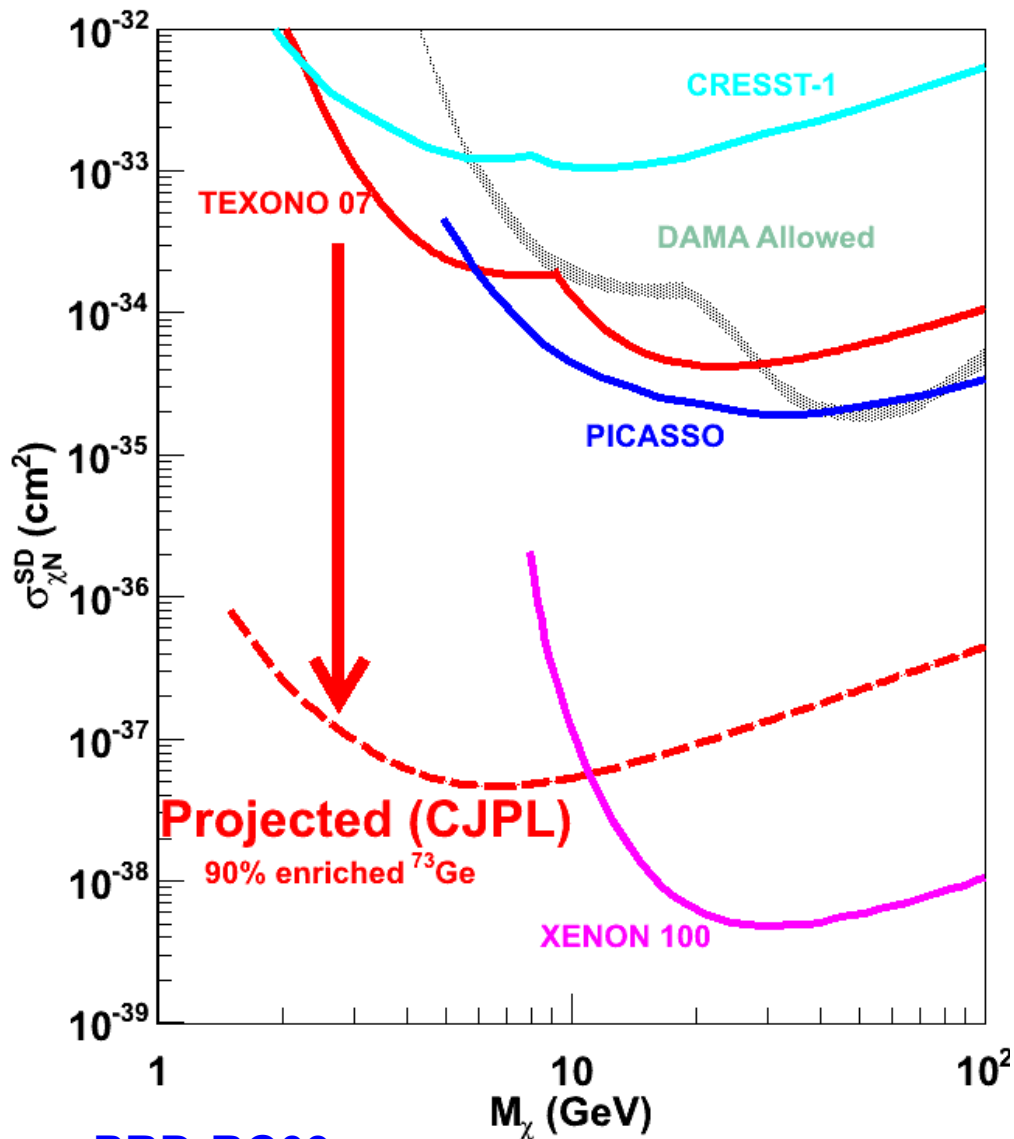


trigger $\sim 100\text{eV}$: software threshold $\sim 220\text{eV}$

sub-keV Background :

- Not fully explained with conventional background modeling
- Intense work on hardware, software and data taking at new underground lab CJPL

Limits & Goals on low mass WIMP



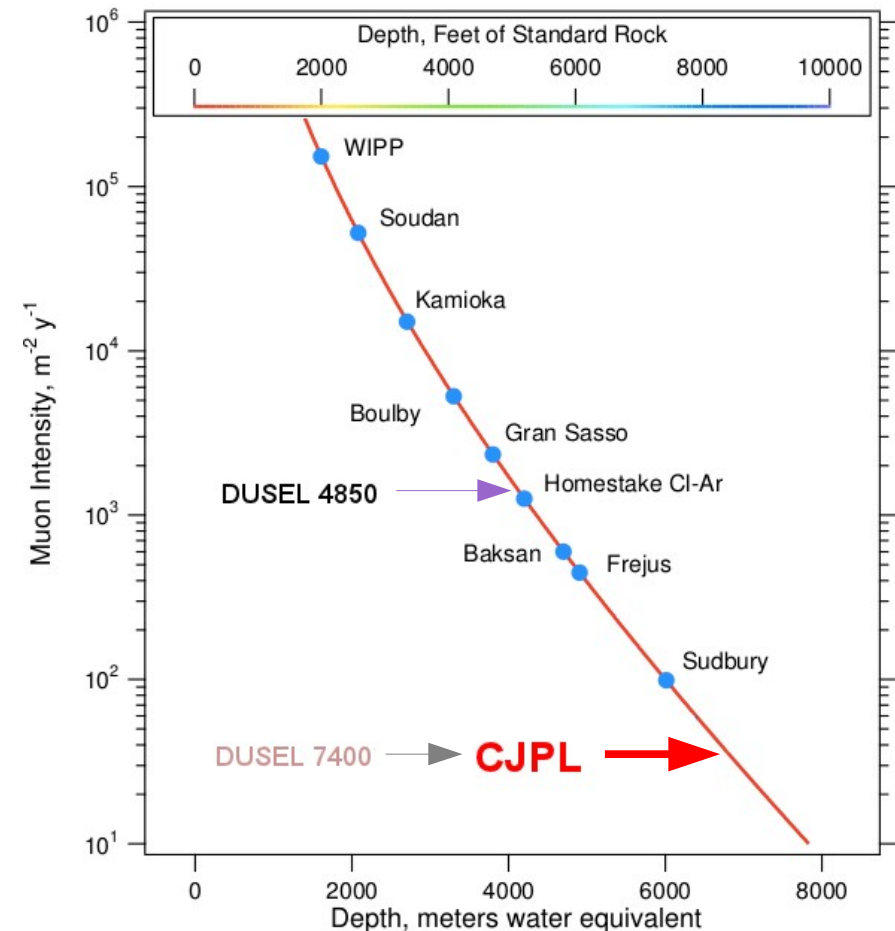
China Jin-Ping Underground

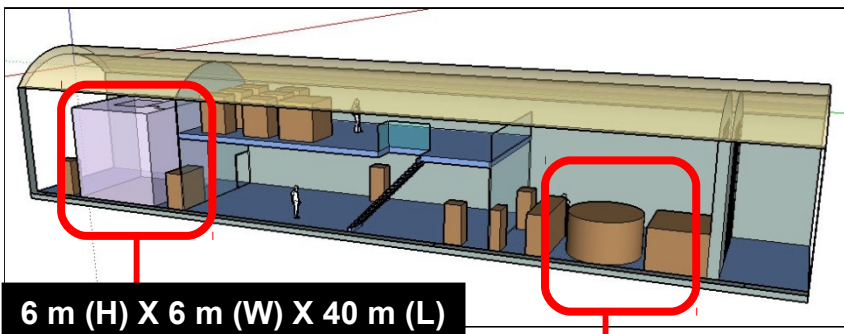
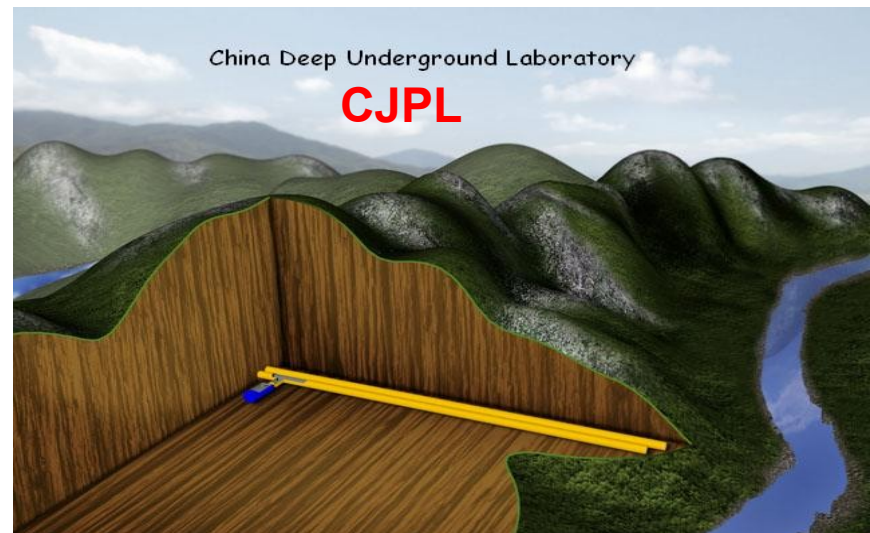
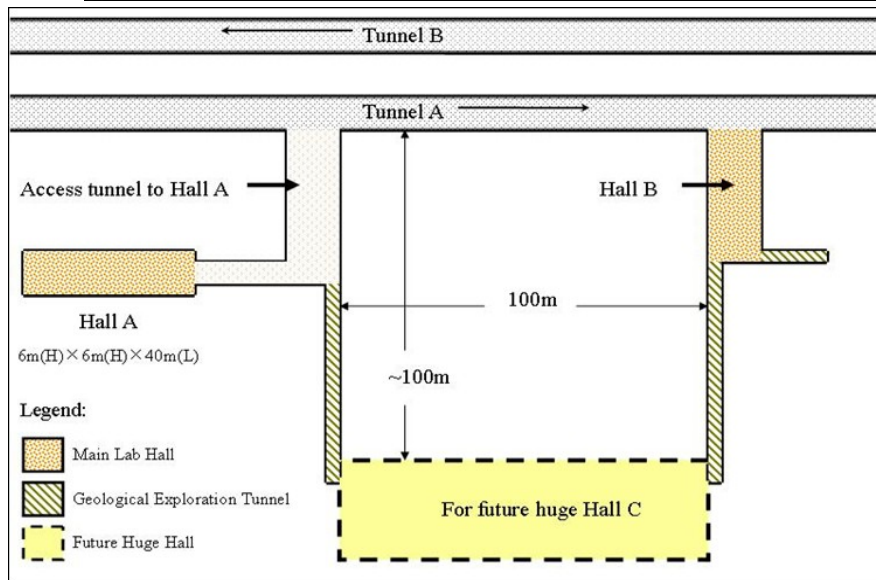
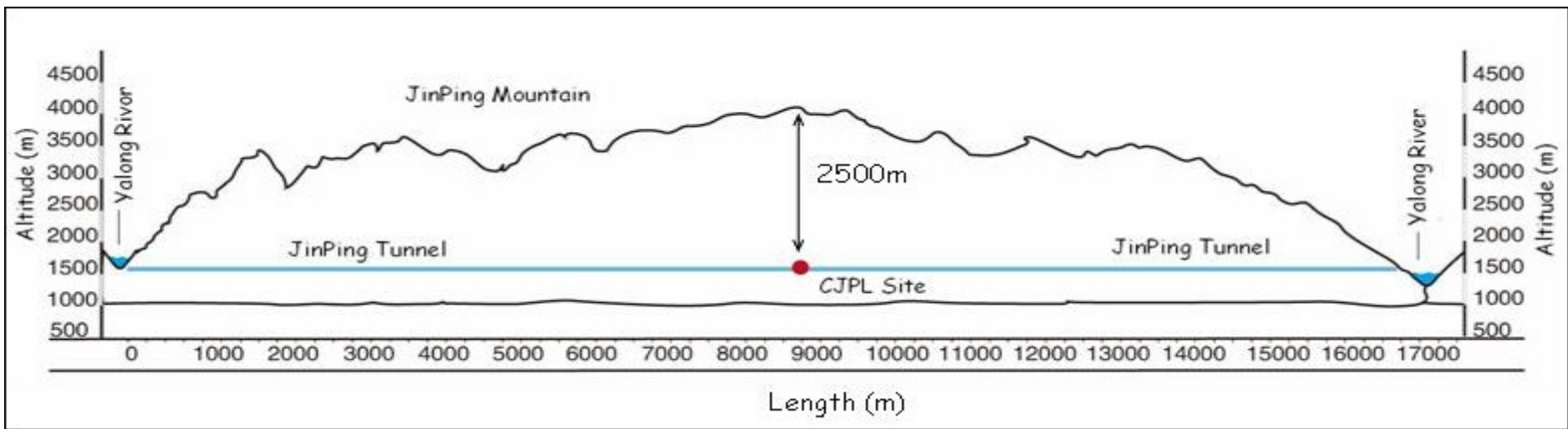
Laboratory (CJPL)

CJPL

中国锦屏地下实验室
China Jinping Underground Laboratory

- 2500+ m rock overburden, drive-in road tunnel access
- 6x6x40 m cavern under construction [THU & EHDC]
- DM-Search: 20 g ULEGe 2010 ; 1000 g PCGe 2011





TEXONO-CDEX

PandaX

China, others dig more and deeper underground labs

From tiny to gargantuan, experiments are in the works to exploit the shielding from cosmic rays that being deep underground offers.

PARTICLE PHYSICS:

Chinese Scientists Hope to Make Deepest, Darkest Dreams Come True

Dennis Normile

Science 5 June 2009:
Vol. 324, no. 5932, pp. 1246 - 1247
DOI: 10.1126/science.324_1246

Good Supporting Infrastructures



二滩水电开发有限责任公司 清华大学

战略合作协议签字仪式

2009年5月



THU-EHDC MoU 2009/5/8

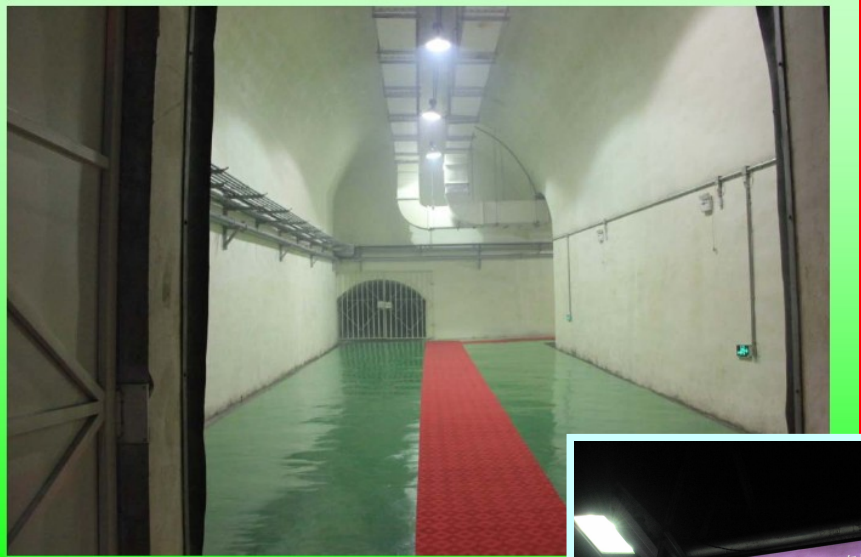


CJPL Excavation 2009/7—2010/4

2010/01/27

2010/04/24

6月20日土建工程建成并通过验收



Inauguration Ceremony 2010/12/11

CJPL Hall A:

Basic Infrastructures Completed & Research Started Sept 27, 2010.

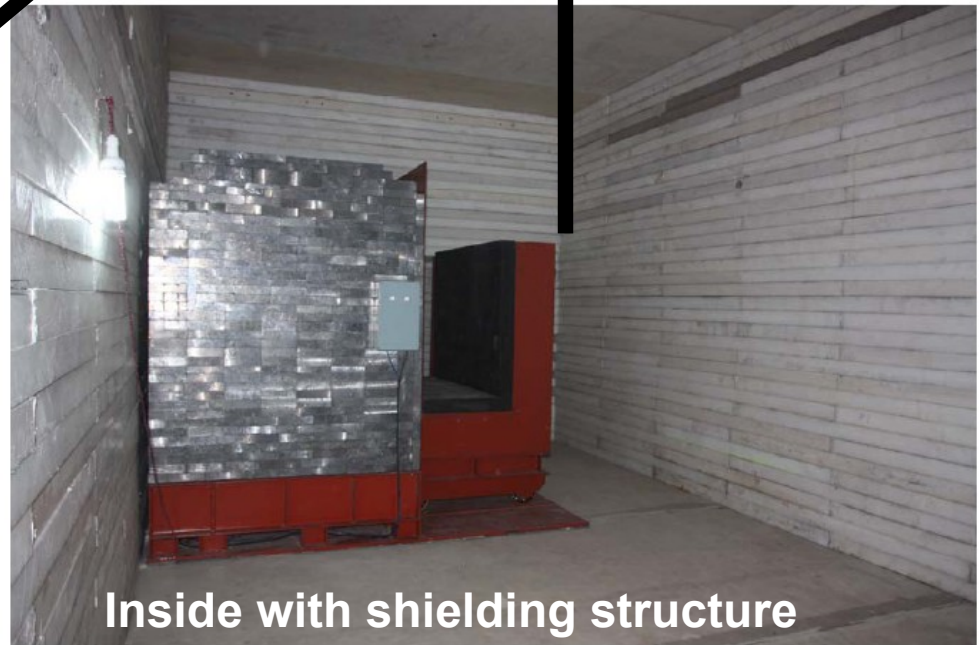
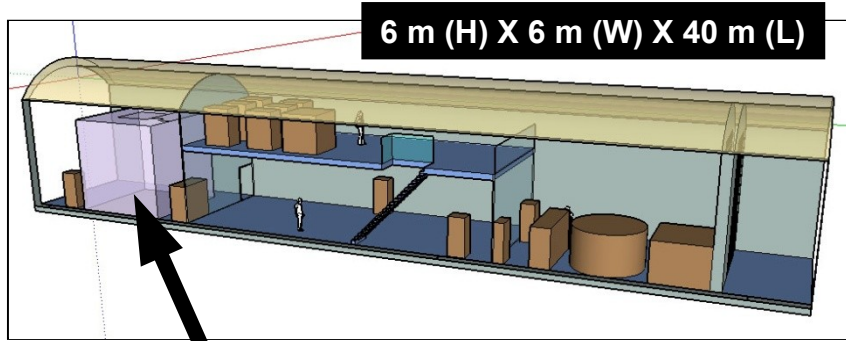
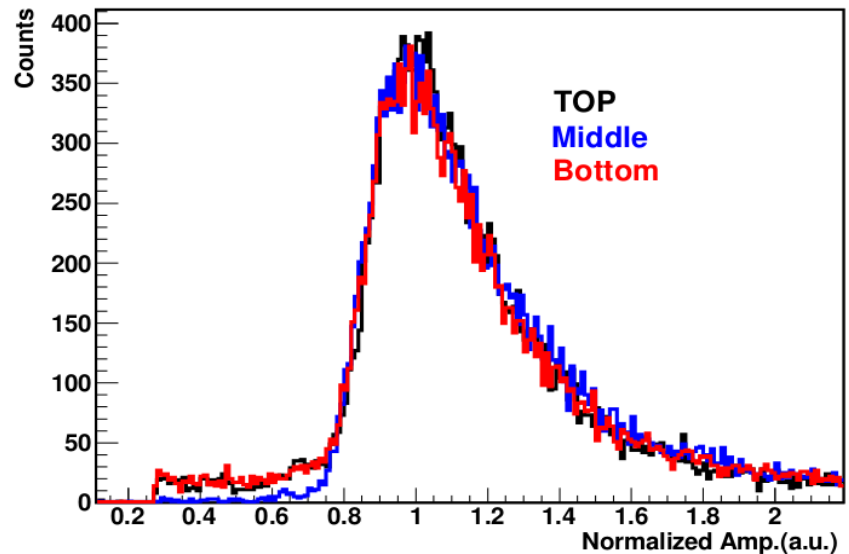
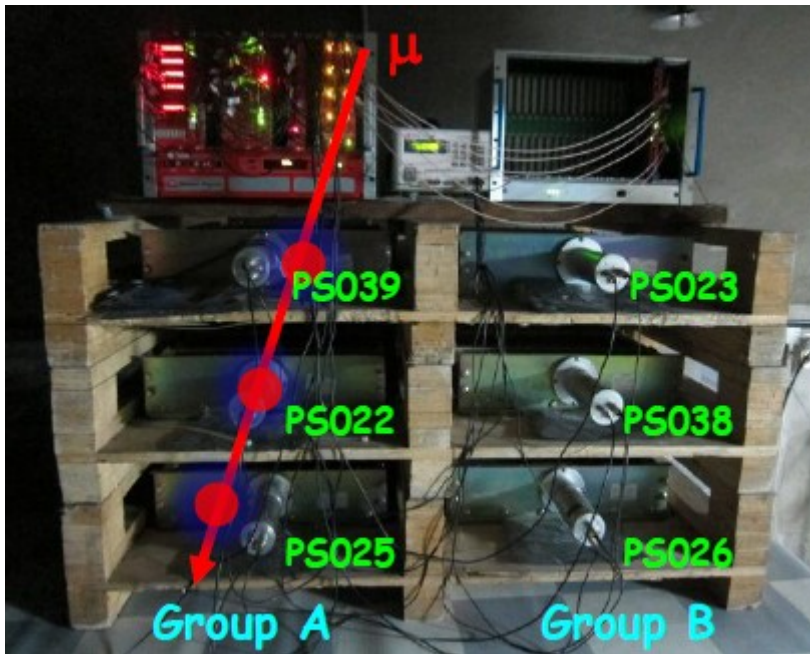


图 2 从里往外看之二

Cosmic Ray

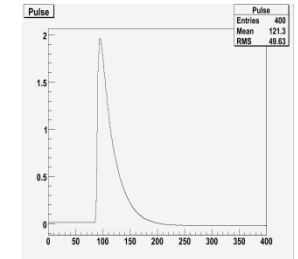
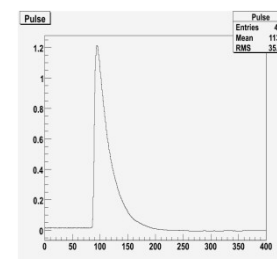
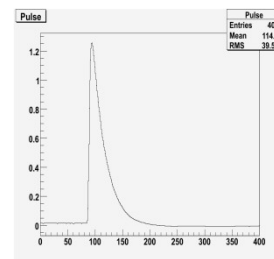


calibrated at sea level

- First observation at underground:

2010/12/10 04:49:19

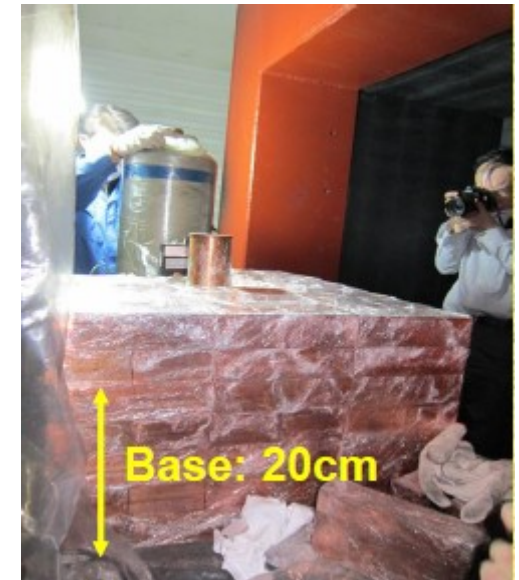
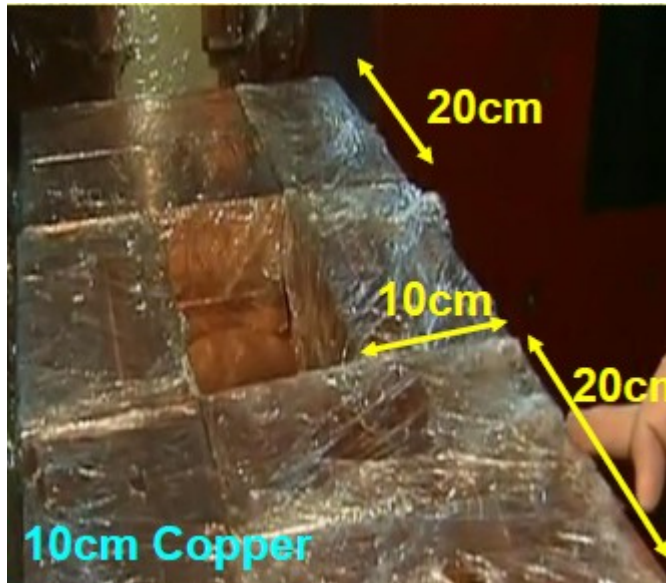
- 6 events in 33 days (1 m²) [\sim 100Hz at sea level]
- Consistent with expectation.
- Measure of ambient radioactivity (gamma, neutrons, radon) underway.



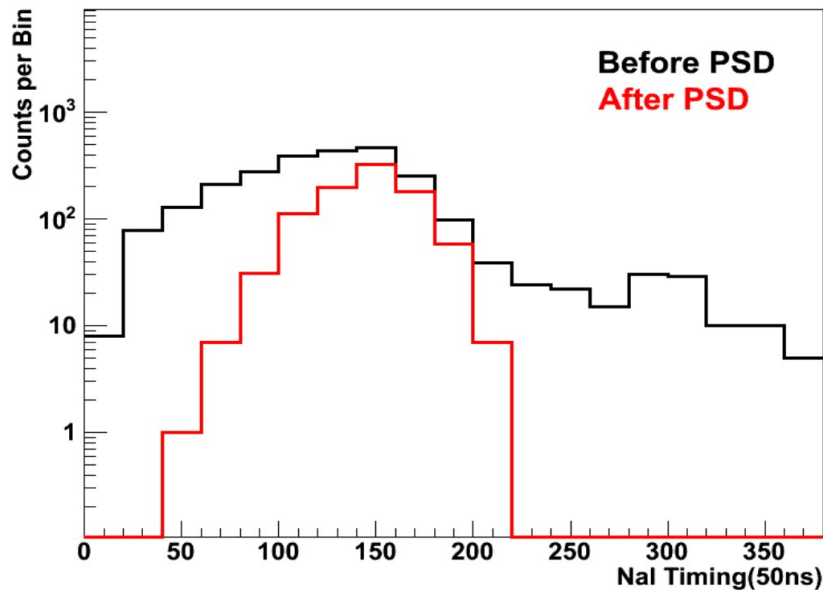
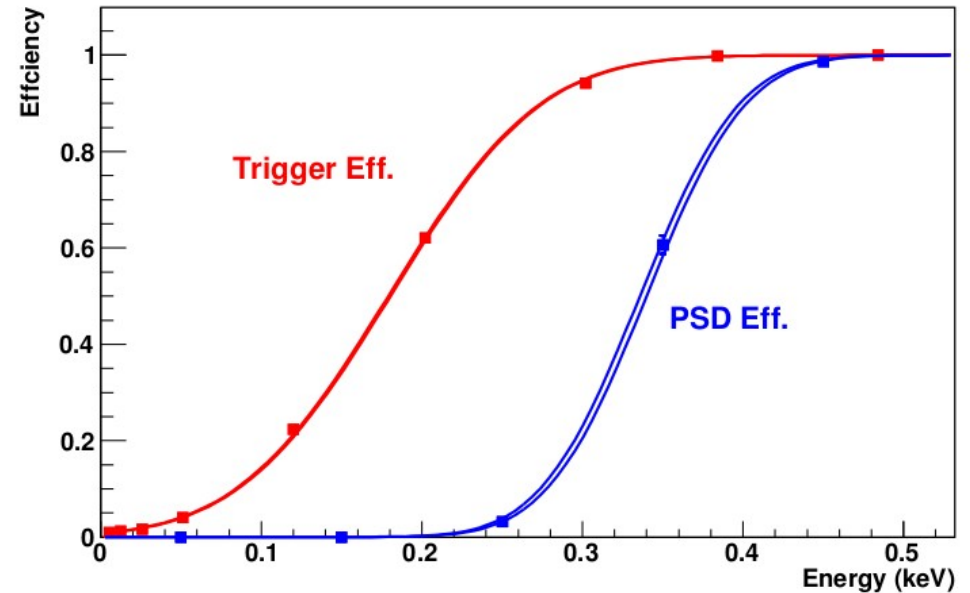
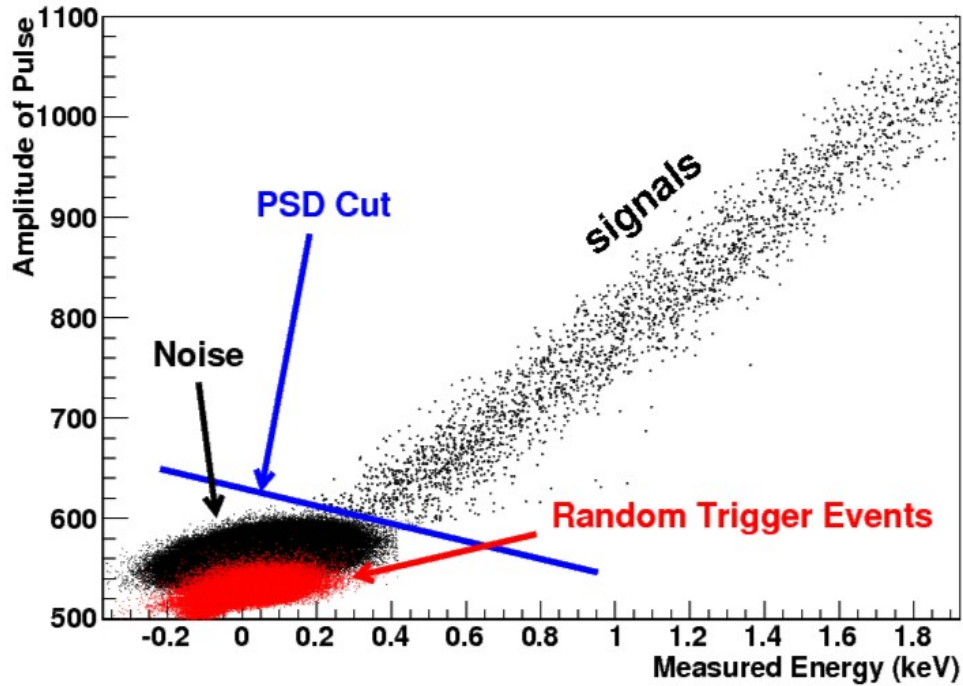
TEXONO-CDEX at CJPL

- **2011**: Repeat PRD-09 measurement with 20-g ULEGe
- **2011-12**: 1-kg PCGe **installed**.
- **2012-14**: 10-kg range PCGe array, with Liquid Argon Anti-Compton.

Data Taking Configurations in CJPL – Feb 2011



PCGe : Trigger & PSD Efficiency

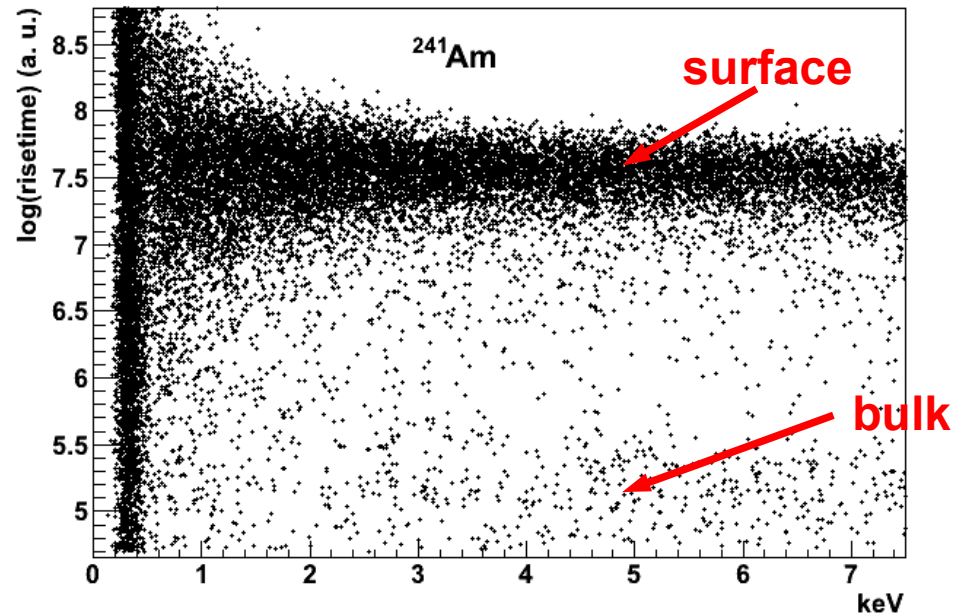
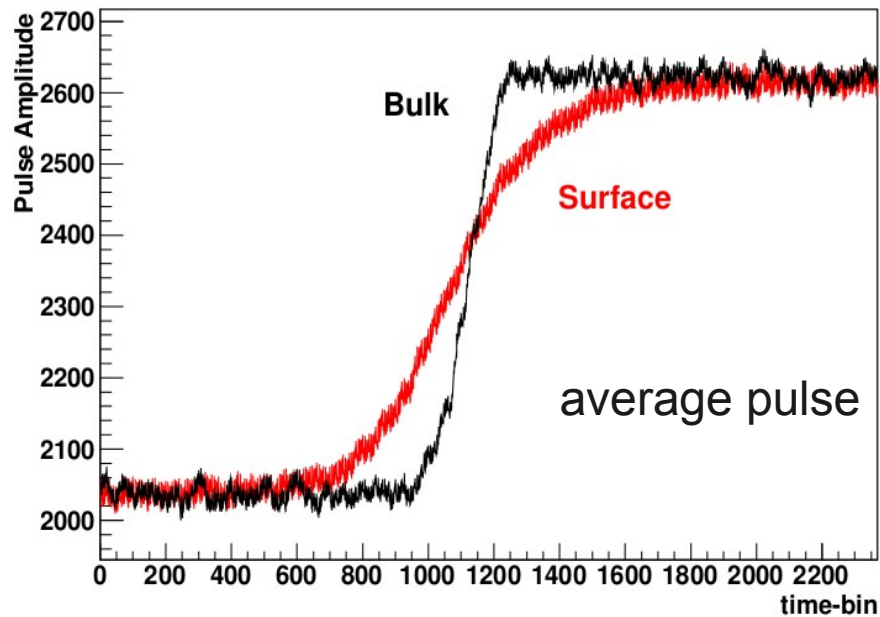
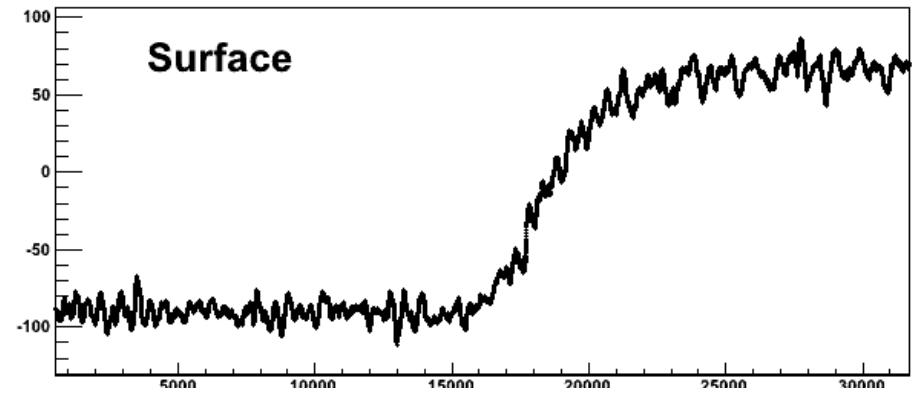
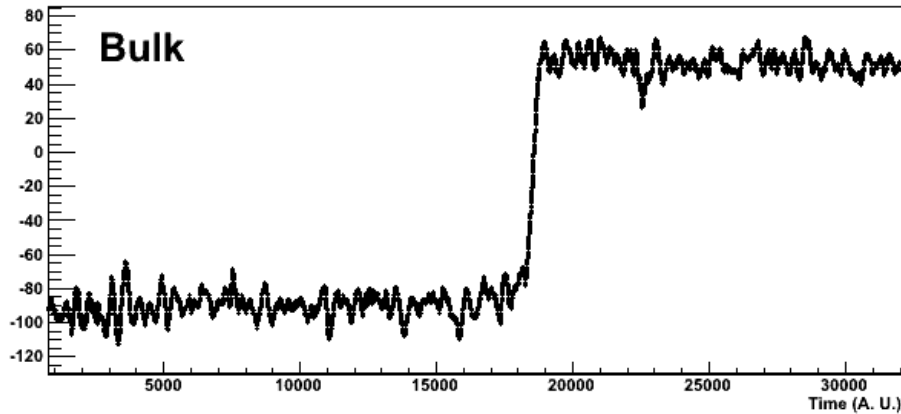


Trigger Eff. from background data & pulser.

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

900g PCGe : Bulk and Surface

- n+ inactive layer is not totally dead, deposit partial charge.
- ^{241}Am (60keV γ) \rightarrow surface rich.
- Cosmic without anti-Compton (neutron rich) \rightarrow less surface events.



Status and Plans

- Competitive limits at **WIMP-mass $<10\text{GeV}$** obtained with **sub-keV** Ge prototype at a shallow depth reactor laboratory KSNL, for both **spin-independent** and **spin-dependent** couplings
- Studies on **background** understanding at sub-keV range
- Data taking as KSNL with **500g/900g Point-Contact Ge**
- Evolving to dedicated dark matter searches at new **deep underground laboratory** at Sichuan CJPL 2010.
- Prepare towards detectors at 10-kg range
- **Goals** : open new detection channel and detector window for neutrino and dark matter physics ; available for surprises