Direct search of dark matter in Asia

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Outline

1. Japan: XMASS
2. Korea: KIMS
3. China
   - CDES
   - PANDAX
   - R&D at IHEP
4. Remarks

1. Japan: XMASS collaborations

Kamioka Observatory, ICRR, Univ. of Tokyo:
Y. Suzuki, M. Nakahata, S. Moriyama, M. Yamashita, Y. K [redacted]
Y. Koshio, A. Takeda, K. Abe, H. Sekiya, H. Ogawa, K. Ko
K. Hiraide, A. Shinozaki, S. Hirano, D. Umemoto, O. Taka

IPMU, University of Tokyo: K. Martens, J.Liu

Kobe University: Y. Takeuchi, K. Otsuka, K. Hosokawa, A. Murata

Tokai University: K. Nishijima, D. Motoki, F. Kusaba

Gifu University: S. Tasaka

Yokohama National University: S. Nakamura, I. Murayama, K. Fujii

Miyagi University of Education: Y. Fukuda

STEL, Nagoya University: Y. Itow, K. Masuda, H. Uchida, Y. Nishitani, H. Takiya

Sejong University: Y.D. Kim

KRISS: Y.H. Kim, M.K. Lee, K. B. Lee, J.S. Lee

41 collaborators,
10 institutes

XMASS experiment

●XMASS

◎ **Xenon MASSive detector for Solar neutrino (pp/^{7}Be)**

◎ **Xenon neutrino MASS detector (double beta decay)**

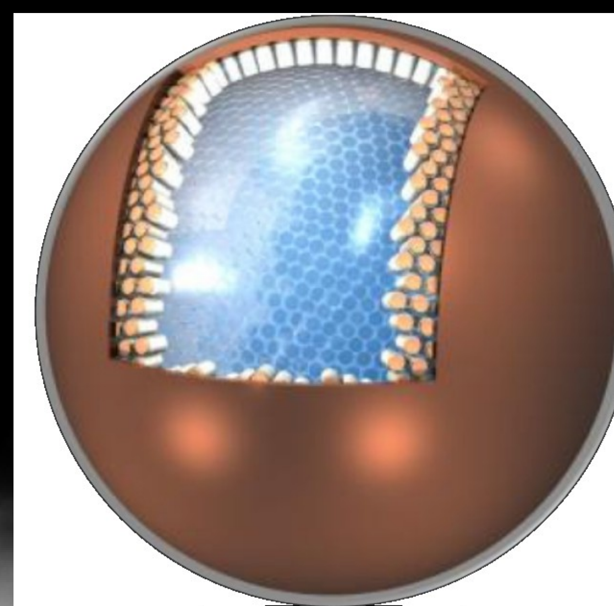
◎ <u>**Xenon detector for Weakly Interacting MASSive Particles**</u>

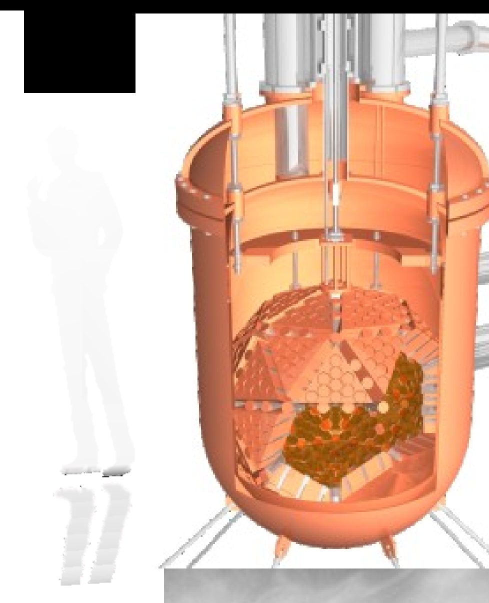
- It was proposed that Liquid xenon was a good candidate to satisfy scalability and low background.

Y. Suzuki, hep-ph/0008296

- As the first phase, an 800kg detector for <u>a dark matter search</u> was constructed.

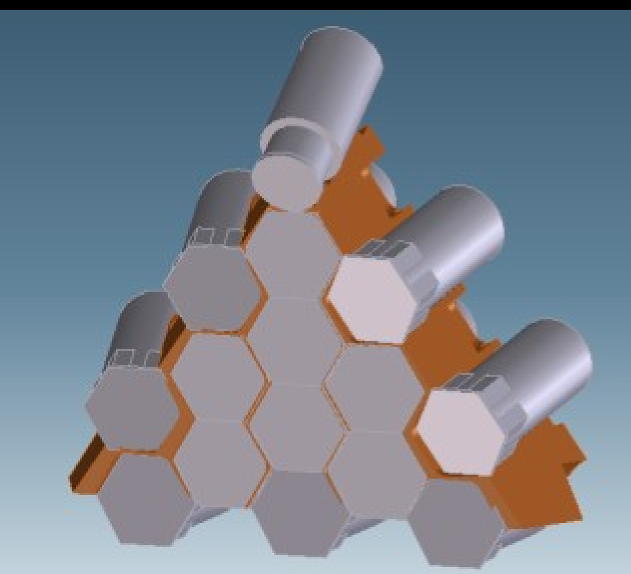
10ton FV (24ton) 2.5m Solar ν, 0νββ, DM in future	100kg FV (800kg) 0.8m, **DM** **First phase**

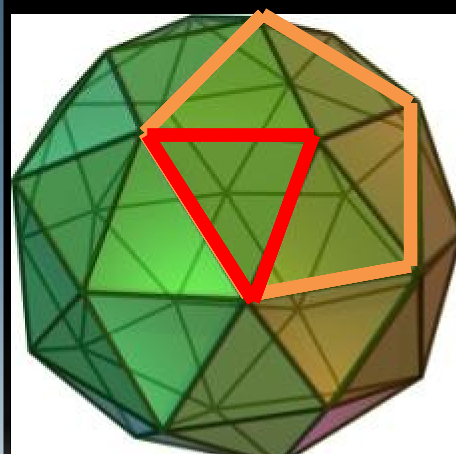


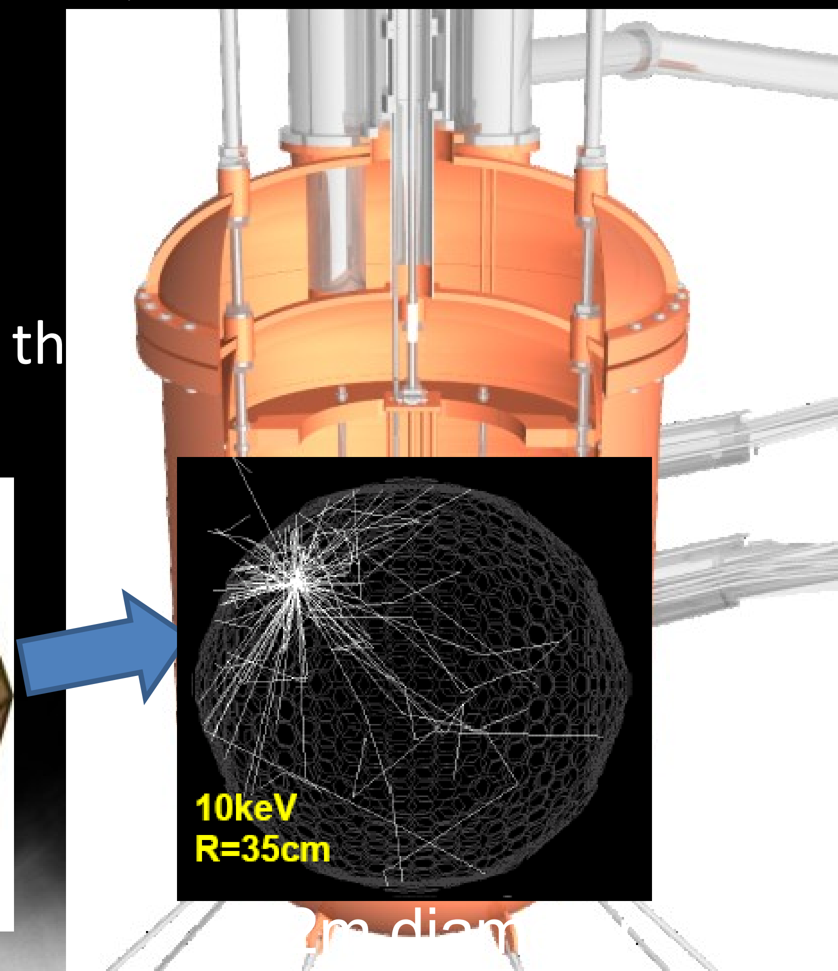


Structure of the 800kg detector

- Single phase liquid Xenon (-100^{o}C, ~0.065MPa) scintillator
  - 835kg of liquid xenon, 100kg in the fiducial volume
  - 630 hex +12 round PMTs with 28-39% Q.E. are in LXe.
  - photocathode > 62% inner surface
  - Pentakis dodecahedron
  - Interaction position reconstruction
  - 5keV$_{\text{electron equiv.}}$ (~25keV$_{\text{nuclear recoil}}$) th

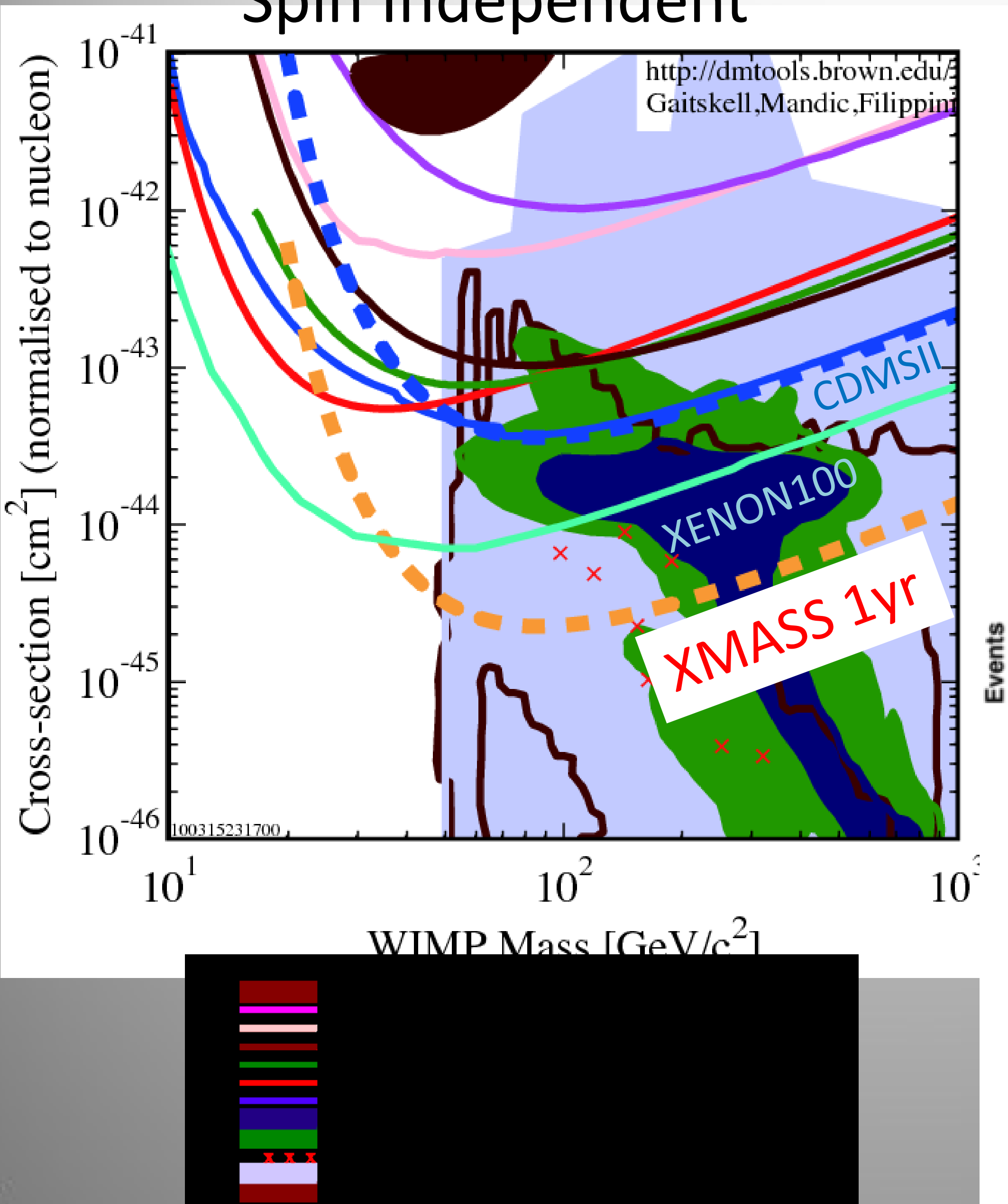






Expected sensitivity

Spin Independent



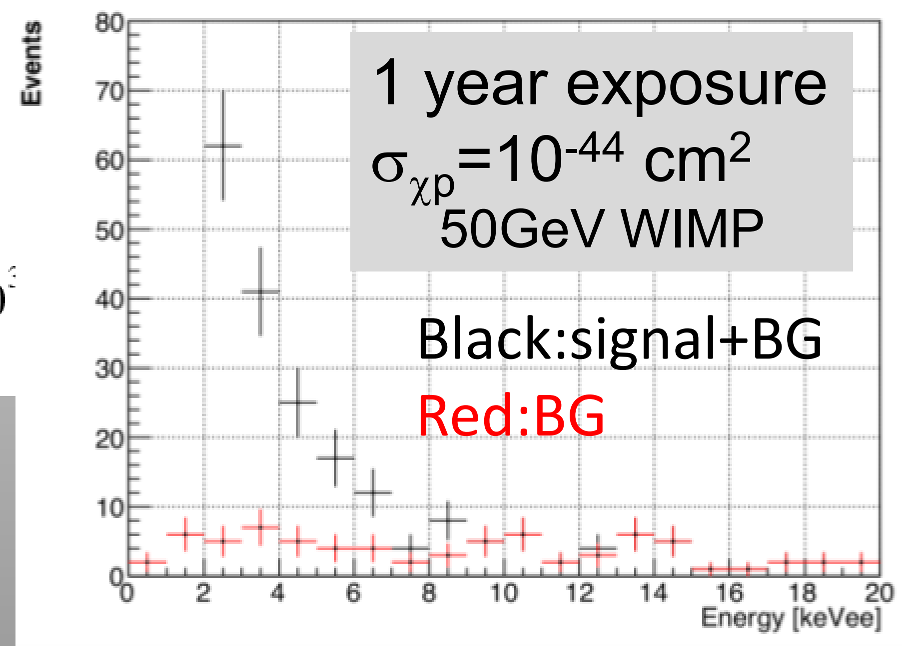
$\sigma_{\chi p}$>2x10^{-45} cm^2 for 50-100GeV WIMP, 90%C.L.

1yr exposure, 100kg FV,

BG: 1x10^{-4} /keV/d/kg

Scintillation efficiency: 0.2

Expected energy spectrum

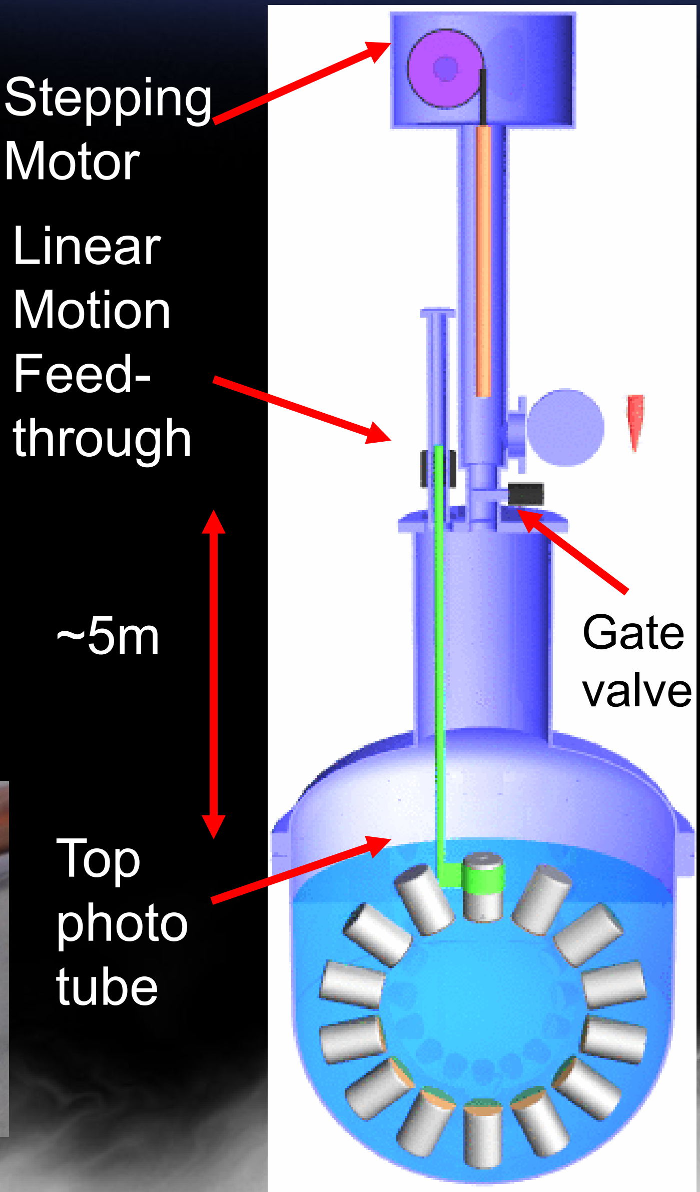



As of Sep. 2010

Demonstration of the detector performance

- Calibration system
  - Introduction of radioactive sources into the detector.
  - <1mm accuracy along the Z axis.
  - Thin wire source for some low energy γ rays to avoid shadowing effect.
  - ^{57}Co, ^{241}Am, ^{109}Cd, ^{55}Fe, ^{137}Cs..

Source rod with a dummy source



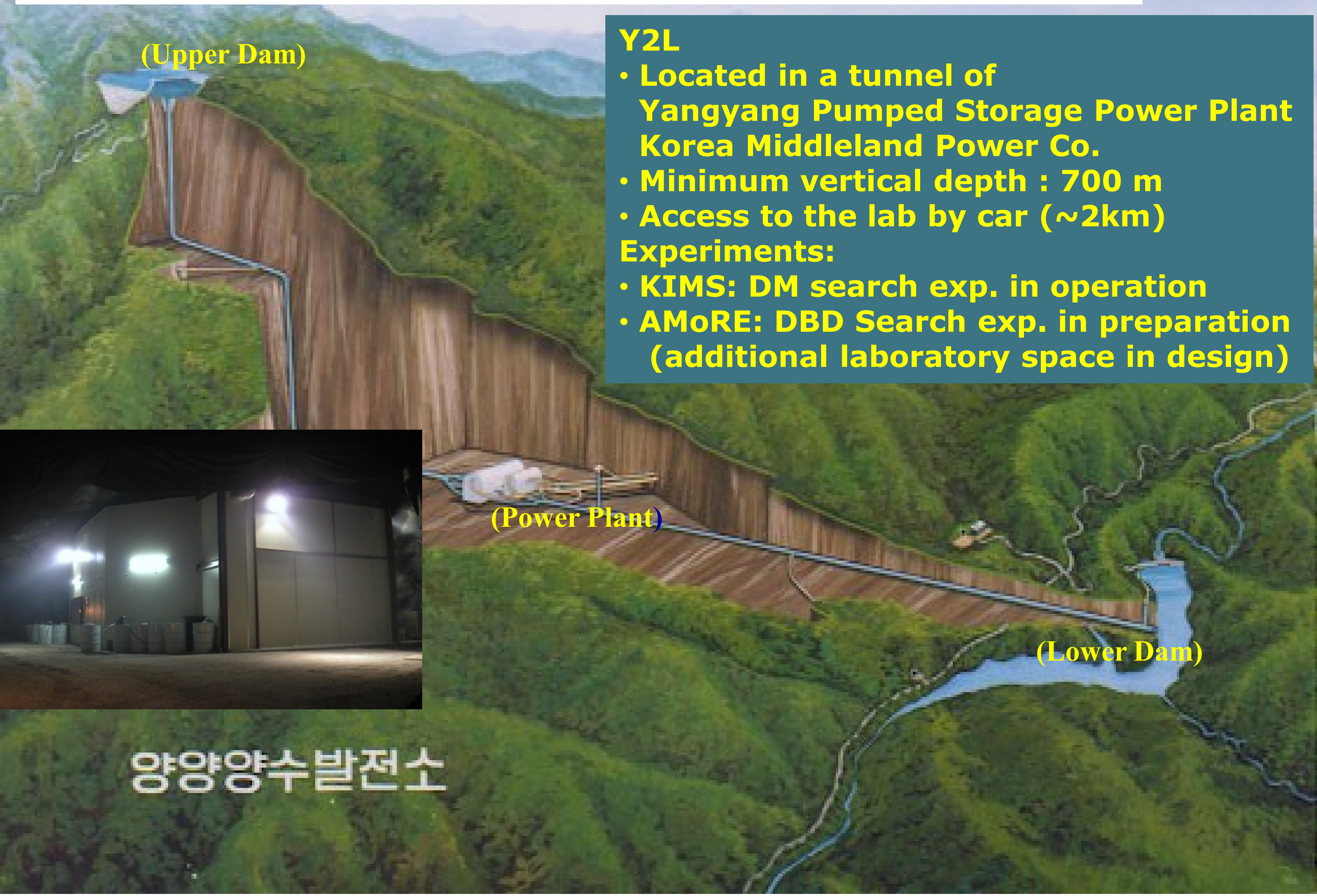
XMASS summary

- The XMASS 800kg detector aims to detect dark matter with the sensitivity $2x10^{-45}cm^2$ (spin independent case).
- It utilizes a single phase of LXe target.
- Construction of the 800kg detector finished last winter.
- Commissioning runs are on going to confirm the detector performance and low background properties.
  - Energy resolution and vertex resolution were as expected. ~1cm position resolution and ~4% energy resolution for 122keV γ.
  - Radon background are close to the target values and Kr contamination will be evaluated soon.

2. Korea: YangYang UGL(Y2L)

Y2L
- Located in a tunnel of Yangyang Pumped Storage Power Plant Korea Middleland Power Co.
- Minimum vertical depth : 700 m
- Access to the lab by car (~2km)

Experiments:
- KIMS: DM search exp. in operation
- AMoRE: DBD Search exp. in preparation (additional laboratory space in design)



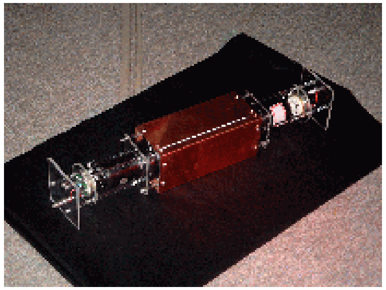
KIMS(Korea Invisible Mass Search)

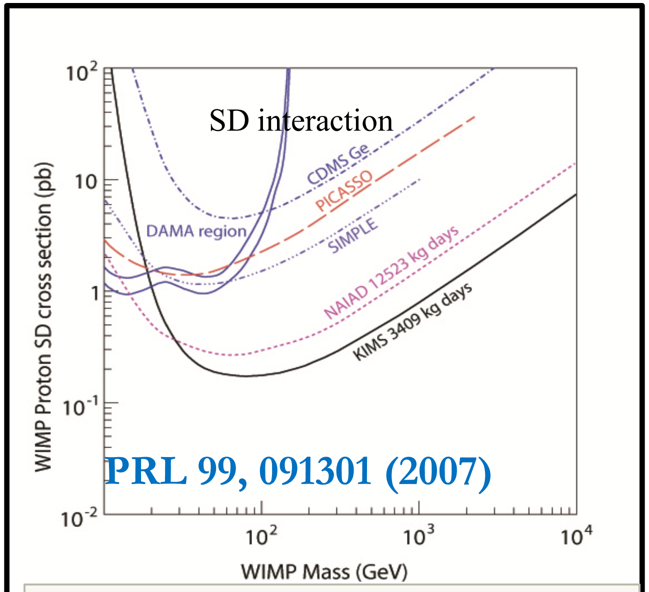
DM search experiment with CsI crystal

CsI(Tl) Crystal 8x8x30 cm^3 (8.7 kg)

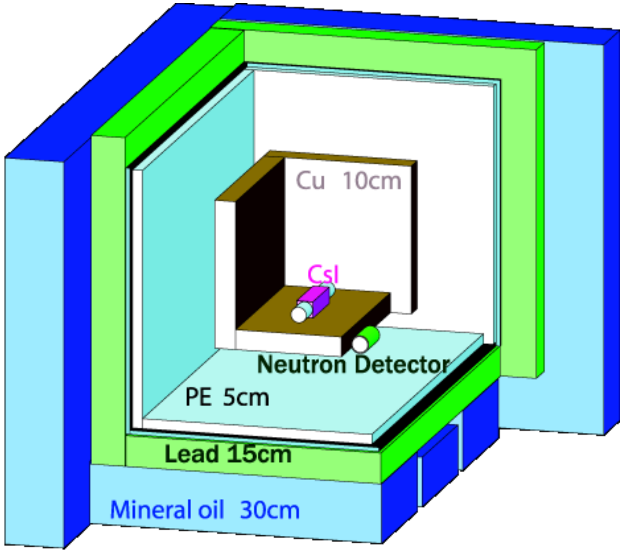
3” PMT (9269QA) : Quartz window, RbCs photo cathode

~5 Photo-electron/keV





Best limit on SD interactions
in case of pure proton coupling

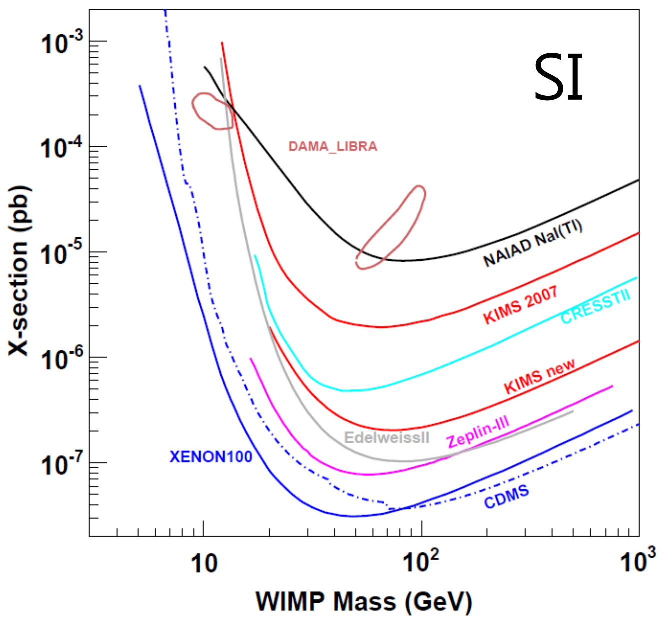


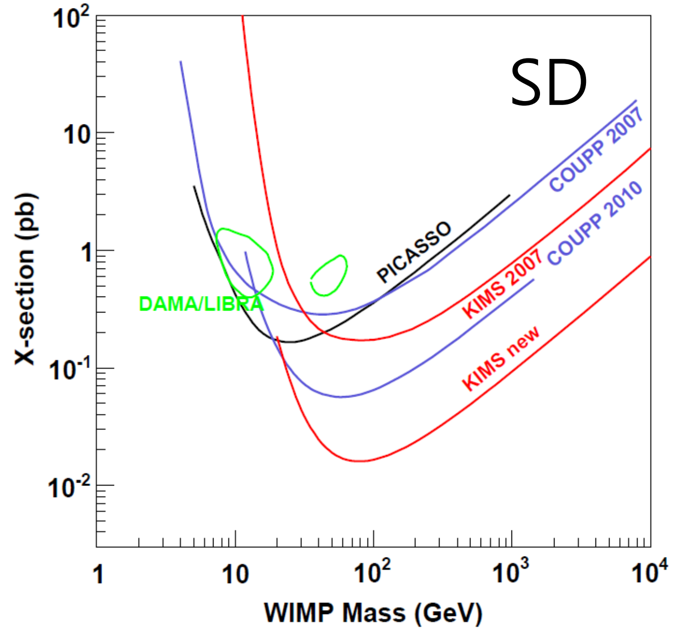
12 crystals(104.4kg) running

- Stable data taking for more than a year
- Unique experiment to test DAMA annual modulation

New result on WIMP search Preliminary

~ 1 year data, Total exposure: 32793 kg days





AM analysis after full 2 year data collection : ~ end of Aug.

KIMS(Korea Invisible Mass Search) coll.

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Yonsei University

I.S.Hahn
Ewha Womans University

Y.H.Kim, K.B.Lee, M. Lee
Korea Research Institute of Standard Sciences

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3. China

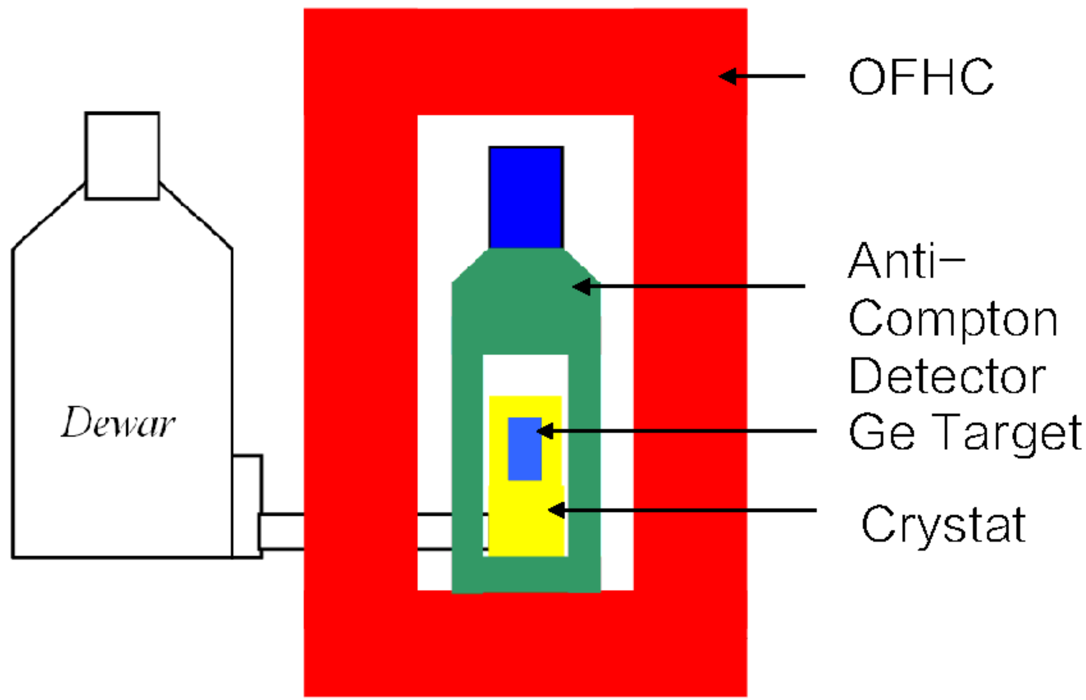
3.1 CDEX: China Darkmatter EXperiment

- Tsinghua University, THU
- Sichuan University, SCU
- Nankai Univeristy,NKU
- China Institute of Atomic Energy, CIAE
- Ertan Hydropower Company, EHDC
- Collaborate with TEXONO and KIMS group.

CJPL

CDEX-1kg @ CJPL

- ✓ Point-contact Ge array detector with ultra-low energy threshold (~300eV or less).
- ✓ Mass of Ge target: 5g, 20g, 1000g.
- ✓ Ultra-pure CsI(Tl) crystal serve as active shielding and anti-compton detector.



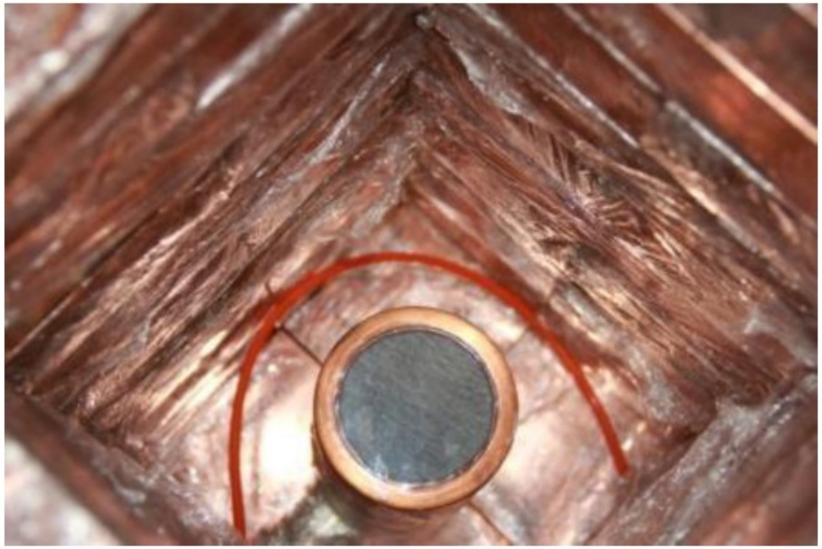
CJPL

CDEX Shielding System

图 5 大门开启

CJPL

CDEX-1kg scale HPGe detector

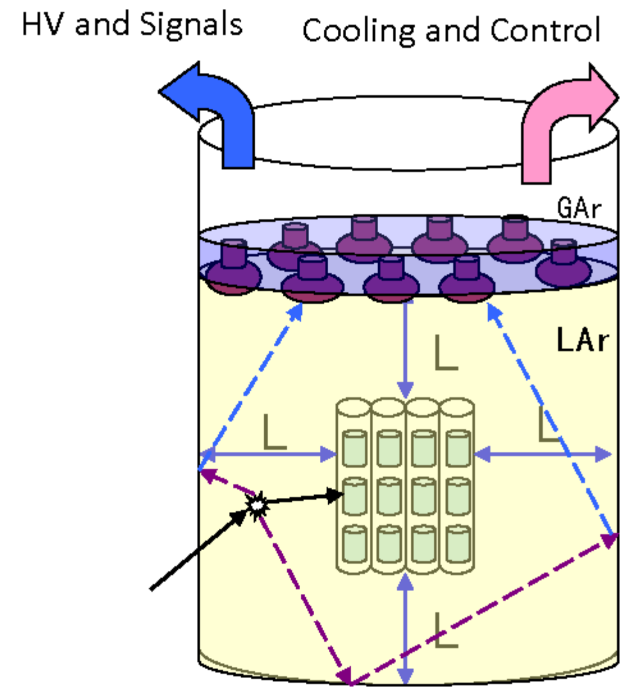


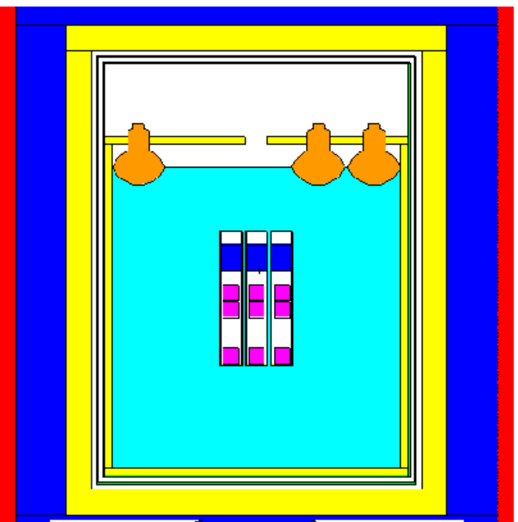
- 20g HPGe running now!
- 1kg PCGe detector testing!

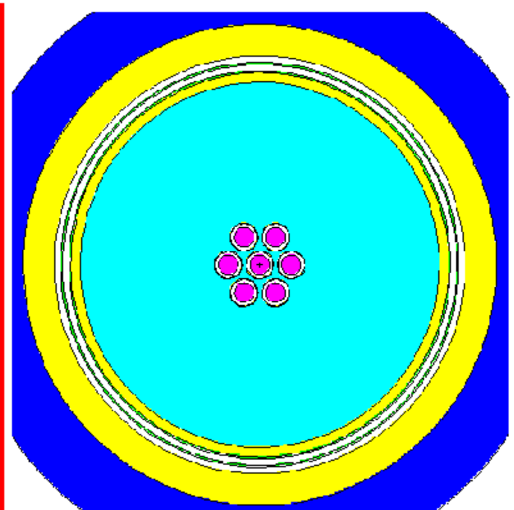
CJPL

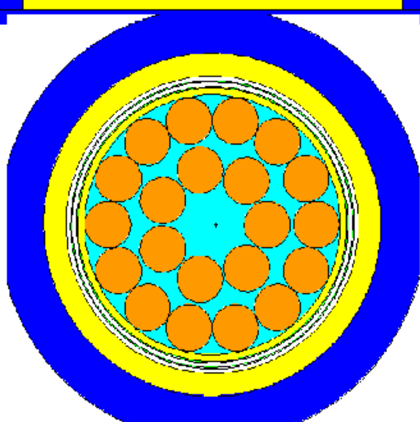
CDEX-10kg

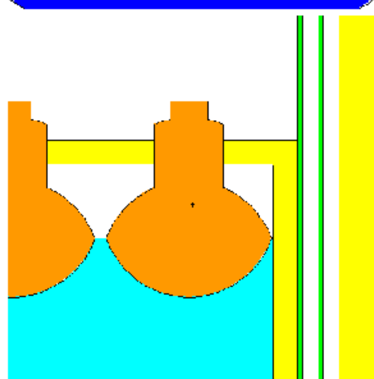
LAr: Passive shielding +Active shielding.
Ge: Encapsuled into Al vacuum tube for cooling.
Ge: Three PCGe in one tube.
WLS: Transfering 128nm light to~420nm light.

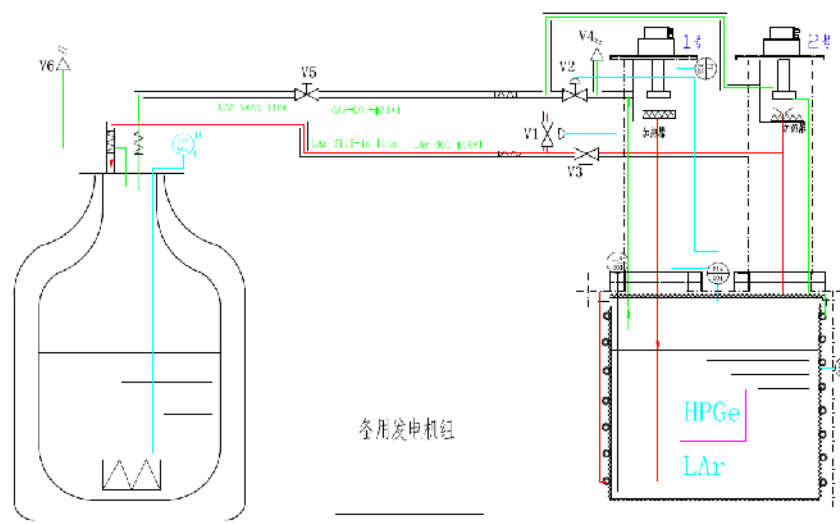






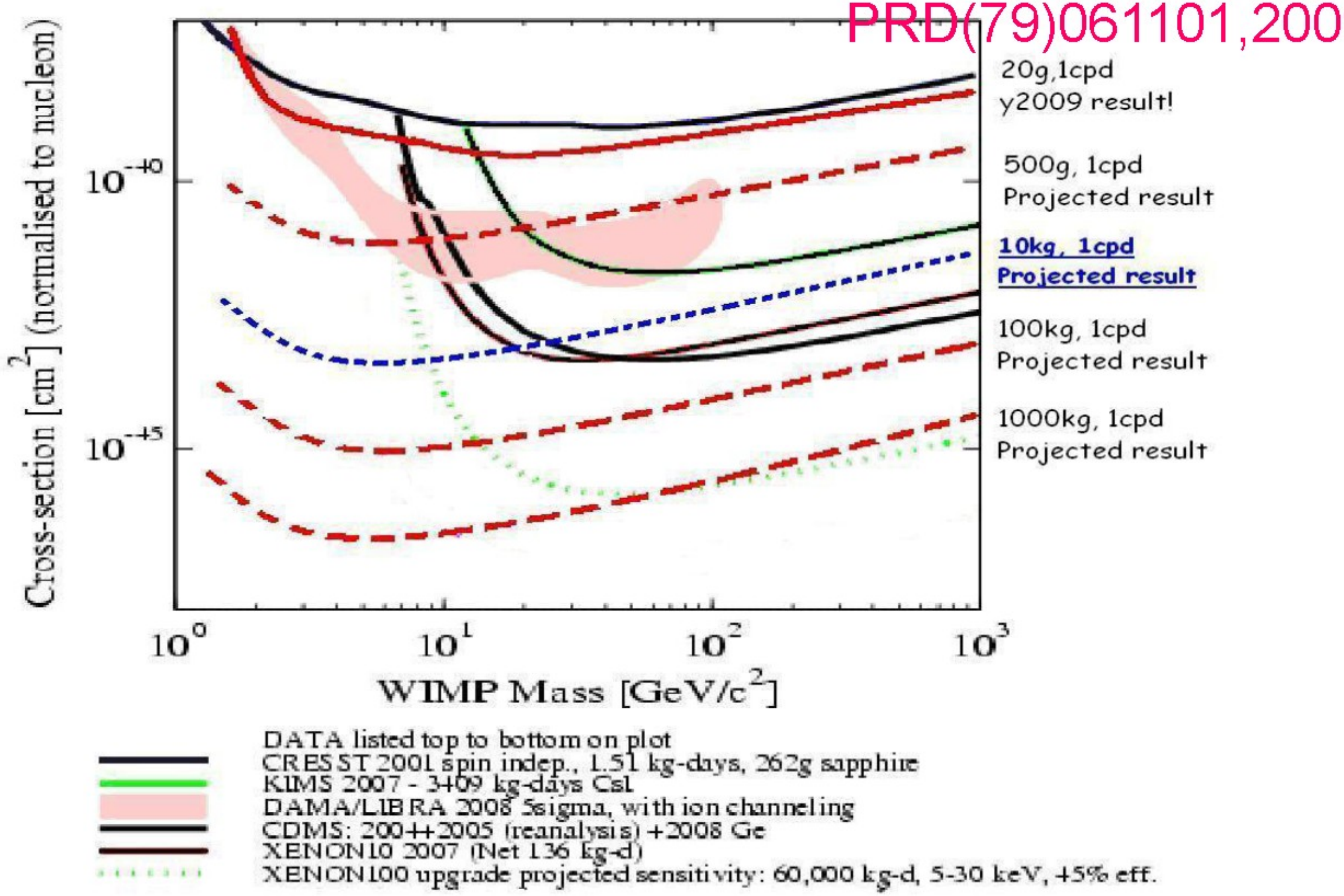






CDEX physics goals

PRD(79)061101,2009



CJPL

CDEX: Summary

- CJPL with deepest rock overburden in the world run now. Muon flux measuring and LBF under construction!
- CDEX Experiment: First DM experiment in CJPL. 20g +1kg ULE-HPGe detector running now; 10kg under engineering design, 1 ton PCGe +LAr AC in the future;
- The development of Ge detector technology is important to lower the detector cost . CDEX will also focus on the new Ge detector development.

CJPL

3.2 PANDA-X Dark Matter Search

Originally PANDA was intended to be a complement of the XENON100 detector. However, before the design started the liaison was cut, and the design in nearly all details is entirely different and originally developed at Jiao Tong.

The Panda team:

PANDA-X Dark Matter Search

Improvements over XENON100:

Less background due to deeper site

Multiple Gamma and Neutron events in larger detector

Better Gamma – Neutron band separation (higher E – Field)

Enhanced light collection

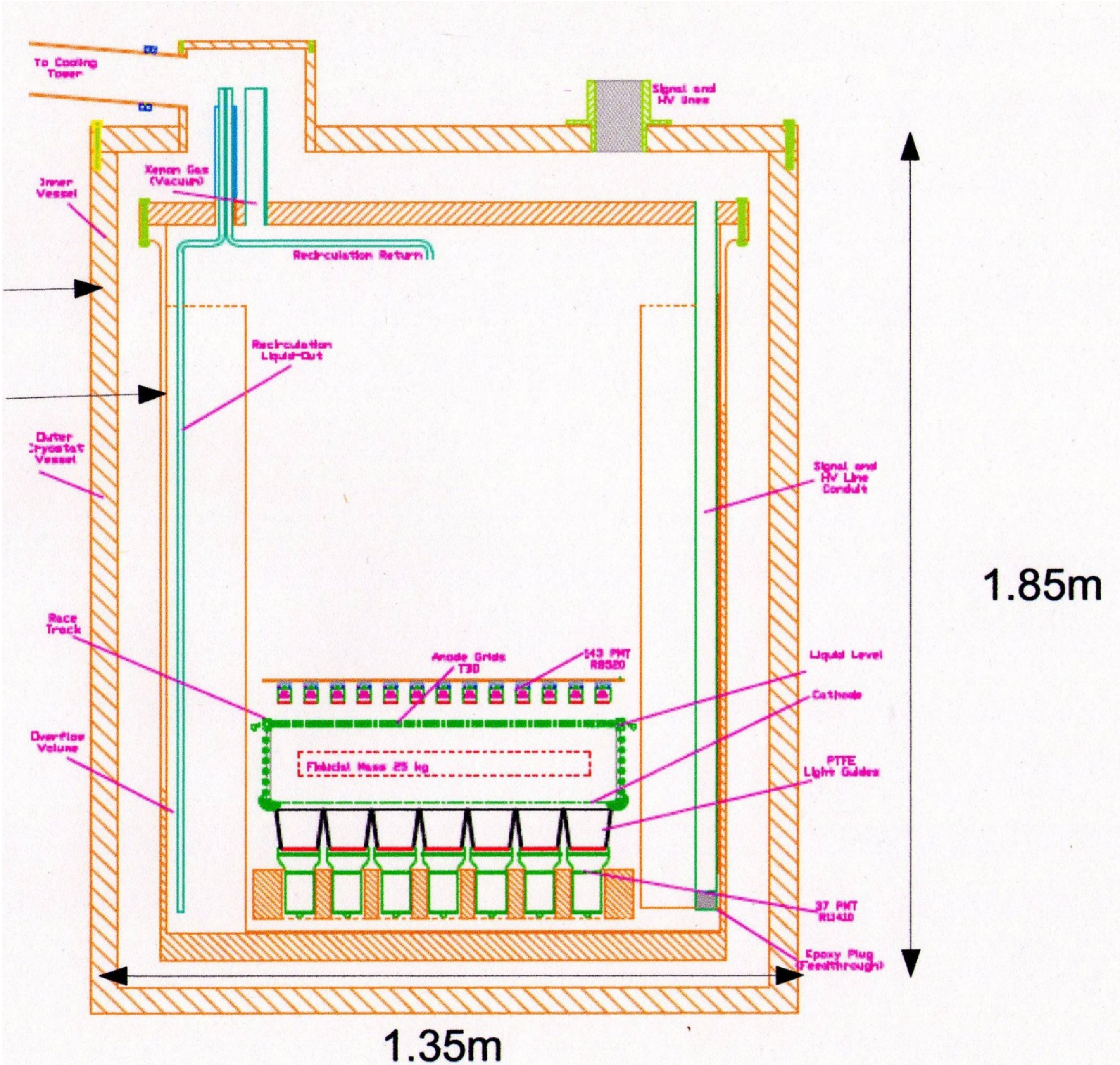
Reduced amount of Teflon

Larger distance of Bottom PMT to Active Volume

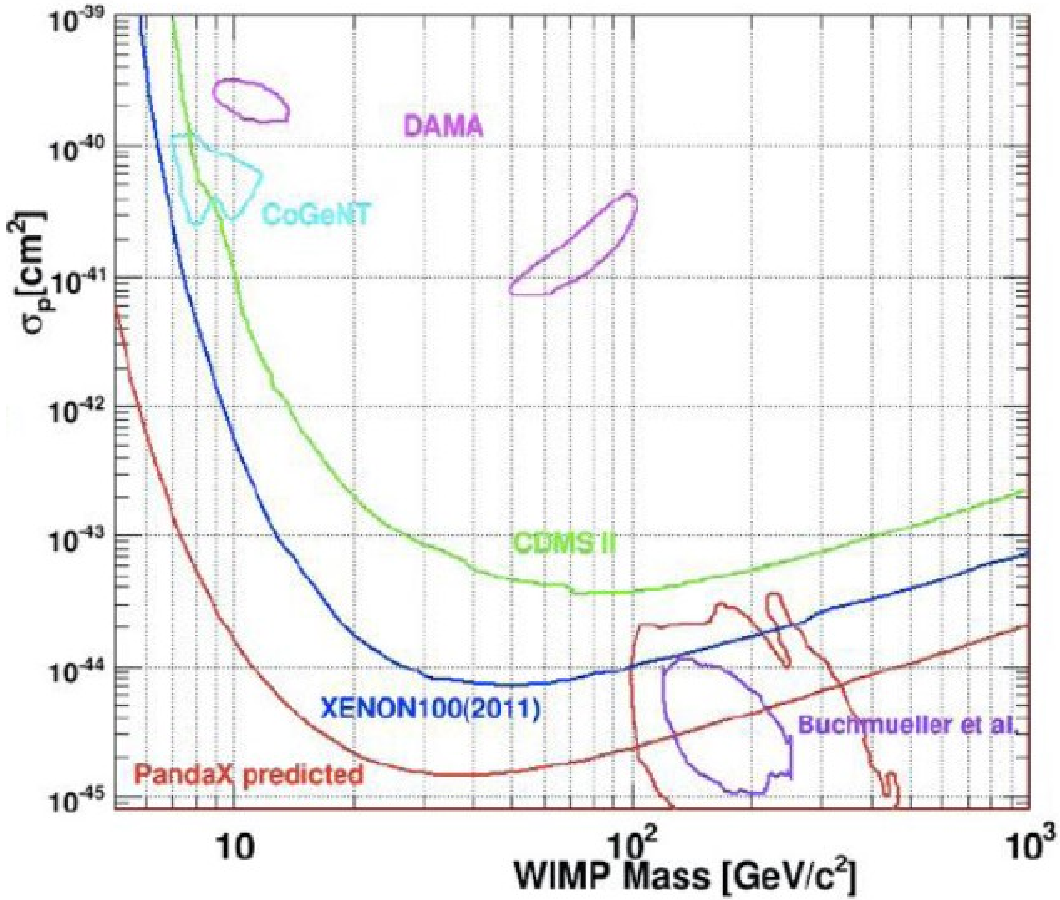
But,

No active Veto (unnecessary)

PANDA-X   Dark Matter Search



PANDA-X Projected Sensitivity



- light yield: 5.5 pe/keVee
- energy range: 3 - 30 pe
- exposure: 25 kg x 300 days
- NR acceptance: 0.35
- background: zero

PANDA-X Dark Matter Search

Schedule:

Civil engineering of underground lab completed

Major items ordered, incl. the vessels, cryogenic system, read out electronics, PMTs

Most of the equipment is expected in June

Surface lab at SJTU preparation completed

Surface tests of entire set up to start in June

Installation of shield underground is about to start

Counting facility to be assembled first

Underground installation of detector will start before year end

3.3 R&D at IHEP for next generation experiment: Crystal CsI (Na)

n/γ Separation (NIM A642(52-58), 2011)

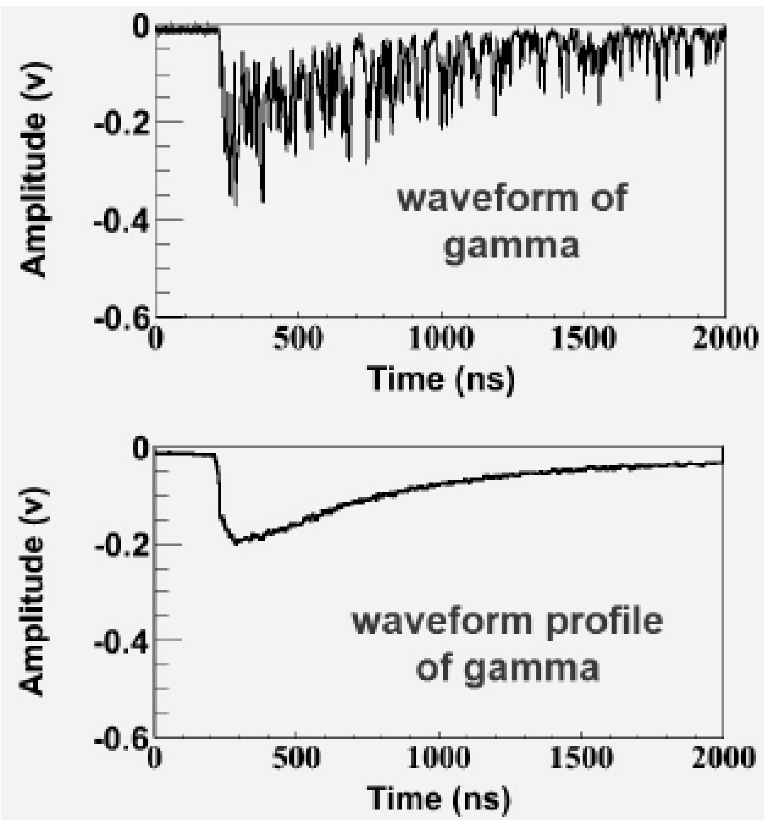


Fig. 7 A typical waveform of pure γ-ray (59.5 keVee) fr(50-60 keVee).

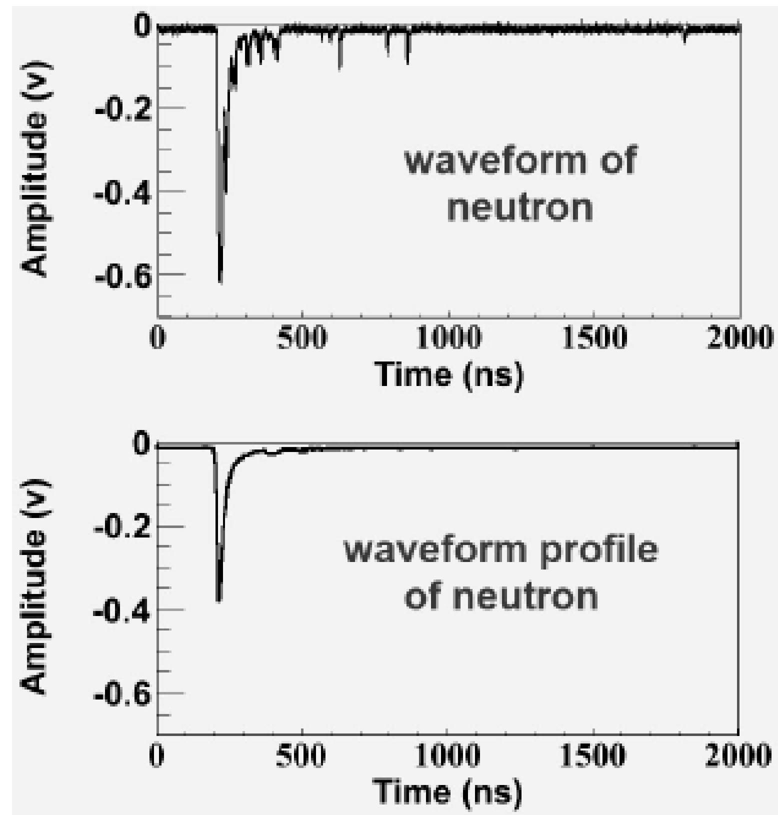


Fig. 8 A typical waveform of neutron (10 keVee) from (5-10 keVee).

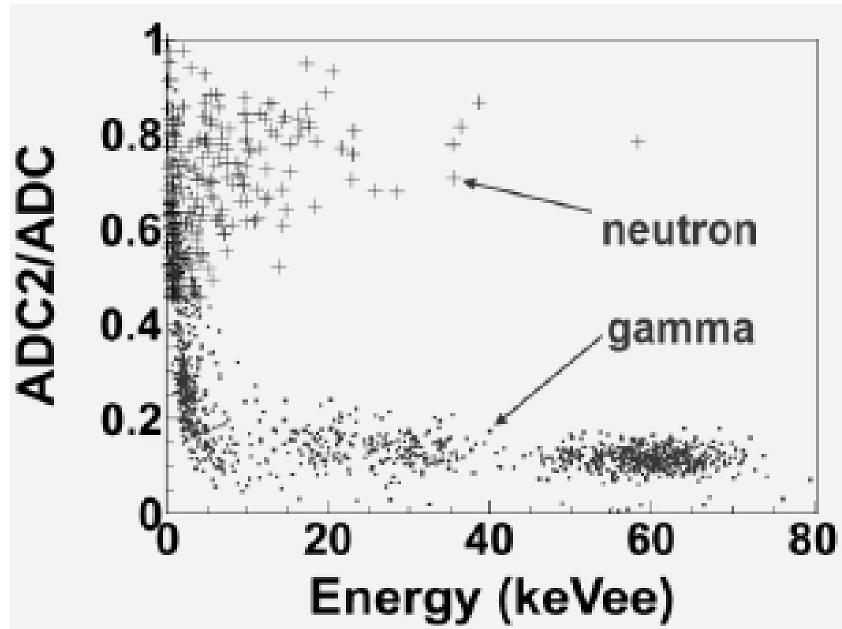


Fig. 9. Scatter plot of ADC2/ADC versus energy for neutron at a scattering angle of 50°.

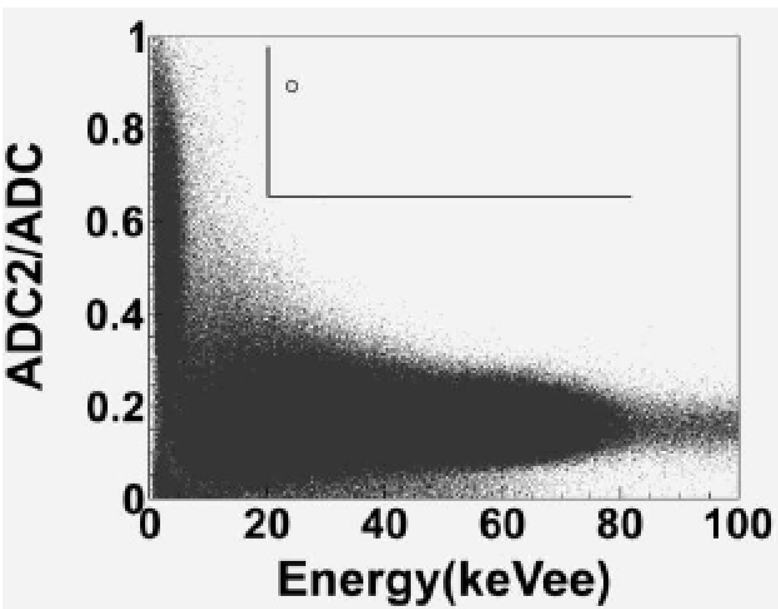


Fig. 10. Scatter plot of ADC2/ADC as a function of energy for γ-ray events. Only one event (in the small round circle) was seen in the region of ADC2/ADC > 0.65 and energy >20 keVee.

n/gamma separation is getting better for higher energy

（NIM A491(2002) 460）

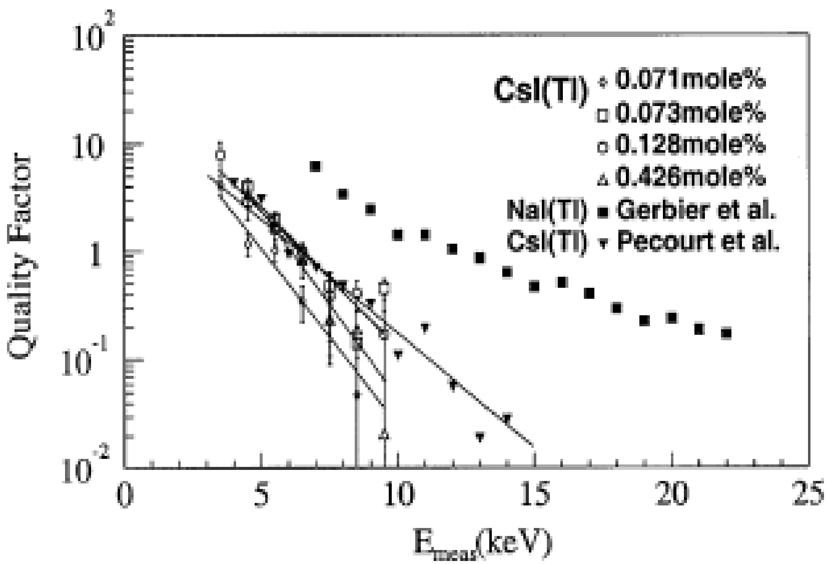


Fig. 10. Quality factors for various CsI(Tl). The errors are only statistical. The present results (open markers) are compared to the data of Pécourt et al. [10] and of Gerbier et al. [19].

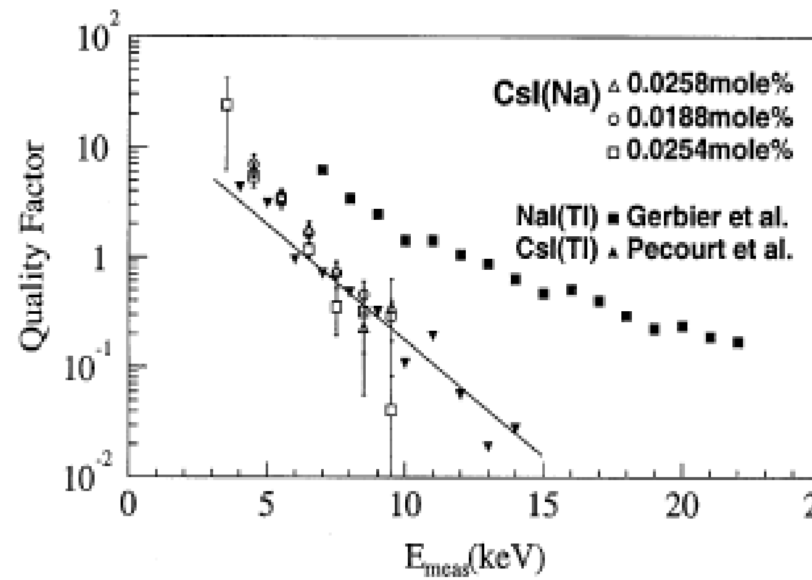
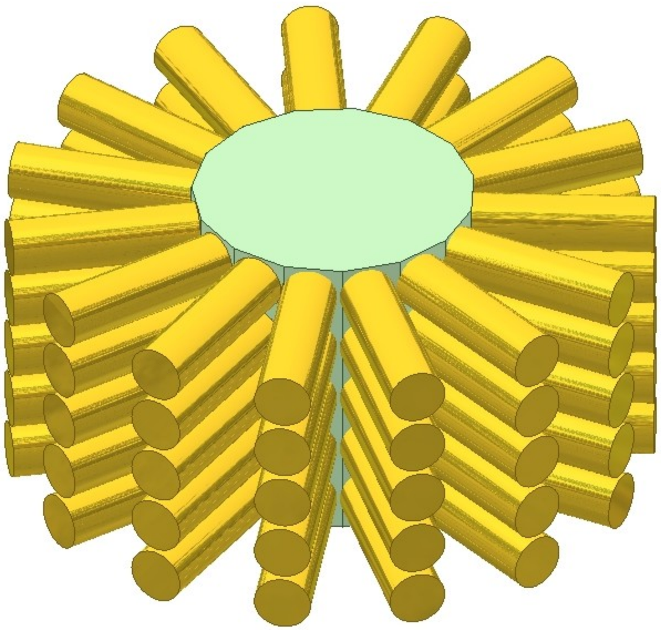
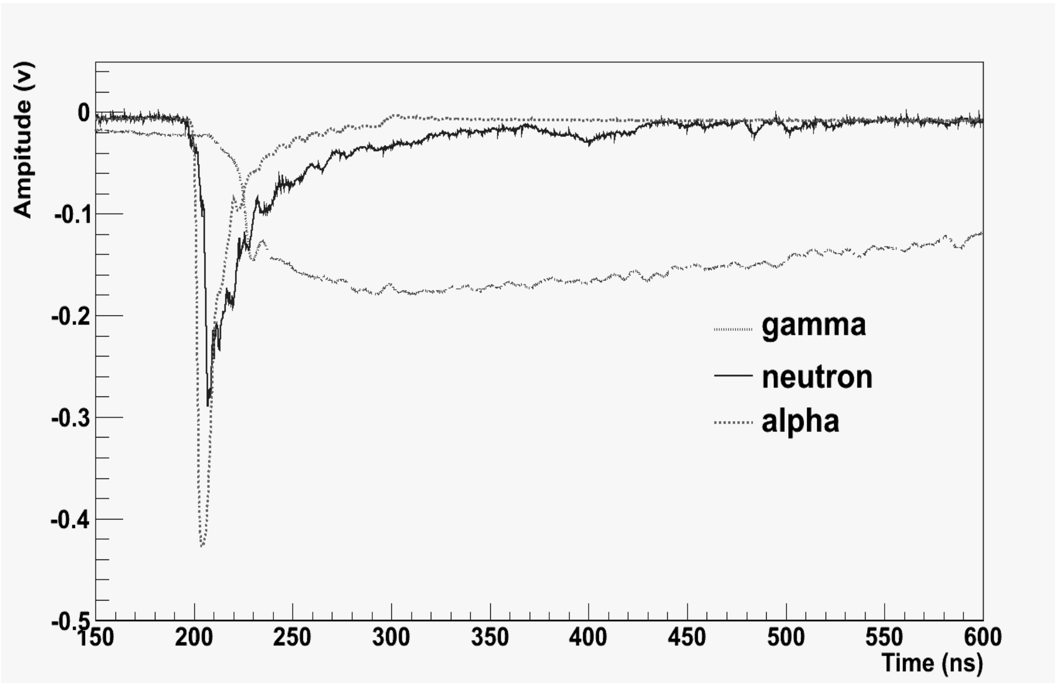


Fig. 11. Quality factors for various CsI(Na). The errors are only statistical.

CINDMS: CsI(Na) Dark Matter Search



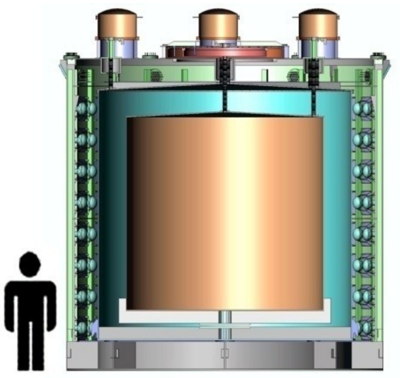
Single large crystal + PMT readout

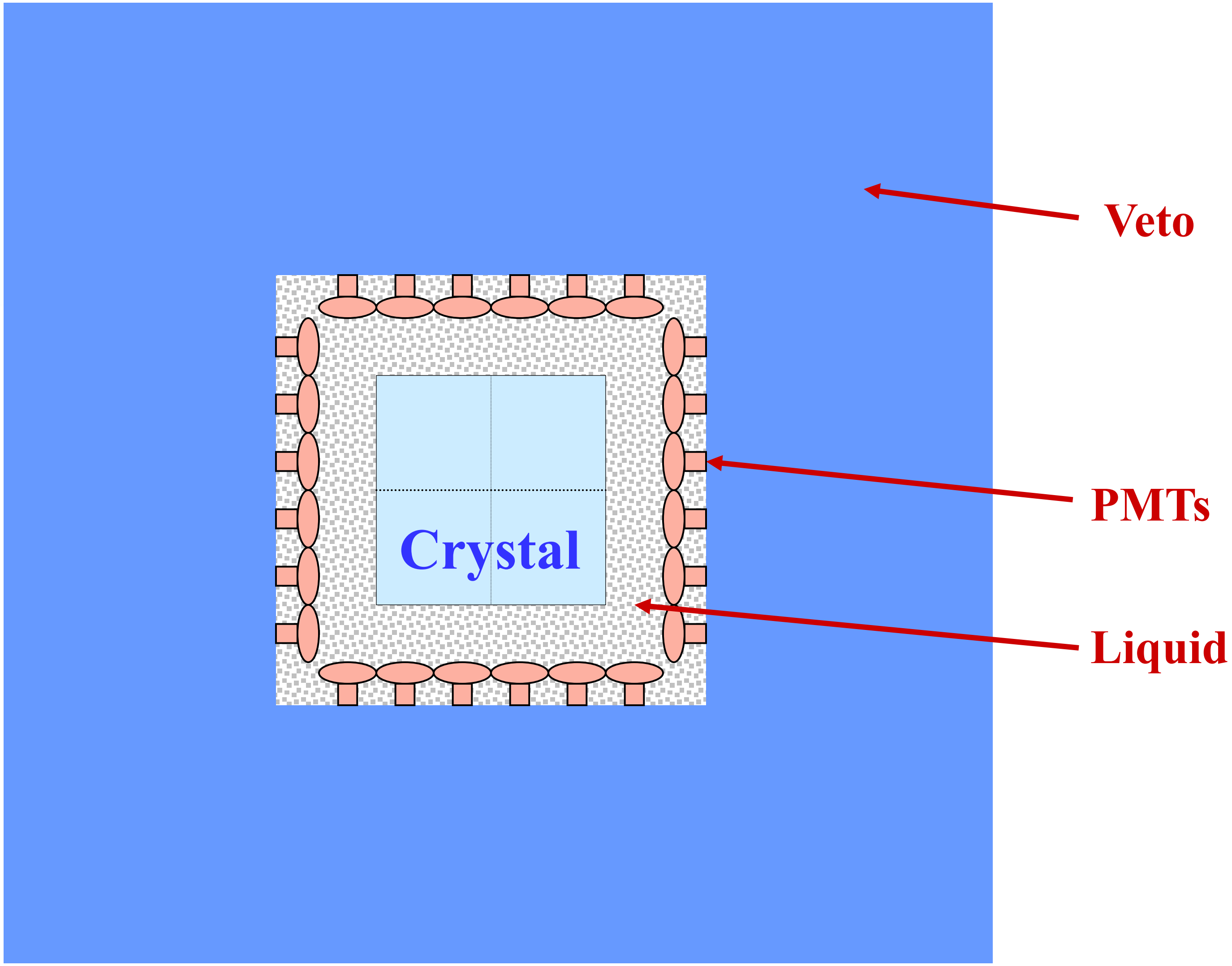


特点:

1. 波形测量和3D重建事例位置;
2. 实现探测器自屏蔽外来低能本底;
3. 排除晶体的表面效应事例对核反冲信号的污染;
4. 大晶体可标记中子多次作用事例，压低中子本底。
5. CsI(Na) 晶体本身具有独特的n/γ分辨性能，截面大，密度高，价格便宜，适合建造大质量探测器。

Another design





Advantage of new design

1. The mass of detector could be large by piling up several crystals （~ton 60x60x60cm^3）；
2. Thick enough liquid shielding can reduce outside background including PMT background;
3. Trigger by coincident of several PMTs could reduce PMT noise；
4. Main background will be radioactivity of crystal itself；
5. Higher reflector for PMT uncovered area;
6. More photon could be possible collected by 4π PMT coverage (compared with DAMA），lower threshold and better energy resolution would expected ；
7. Possible replace different crystal。

Good experiences from DayaBay reactor ν exp.

Remarks

- There is a long history of deep underground experiments in Japan.
- KIMS in Korea: data taking
- Taking advantages of Jinping UGL, dark matter direct search experiments in China try to catch up. R&D for next generation experiments are also under way.
- Next generation experiments require
  - Larger mass
  - New technology: more sensitive, less BG
  - Deeper UGL
- More cooperation are essential to meet great challenges in the dark matter search experiments.

Thank S. Moriyama, S.K.Kim, C.G. Yang for Slides.