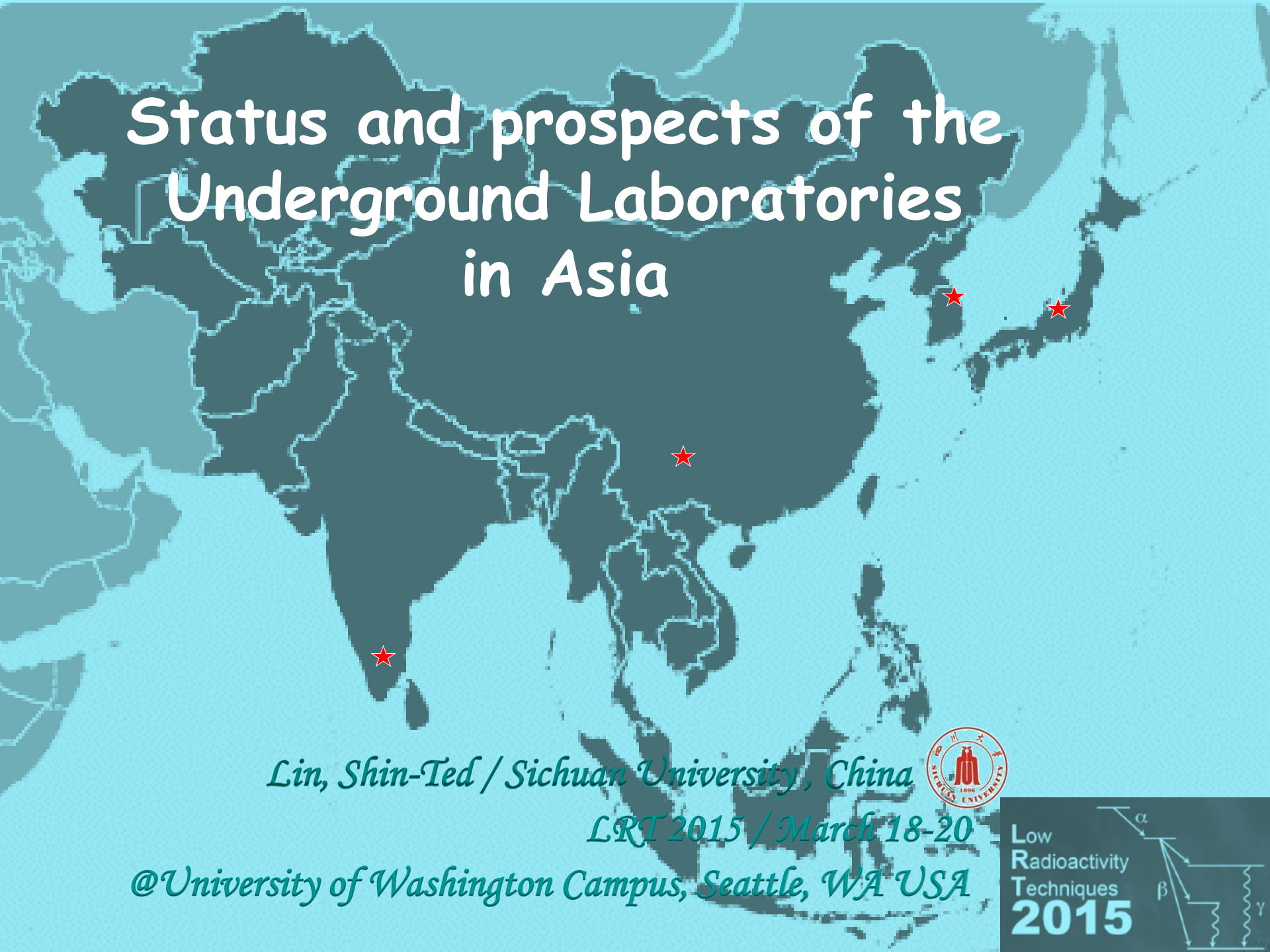
Status and prospects of the Underground Laboratories in Asia



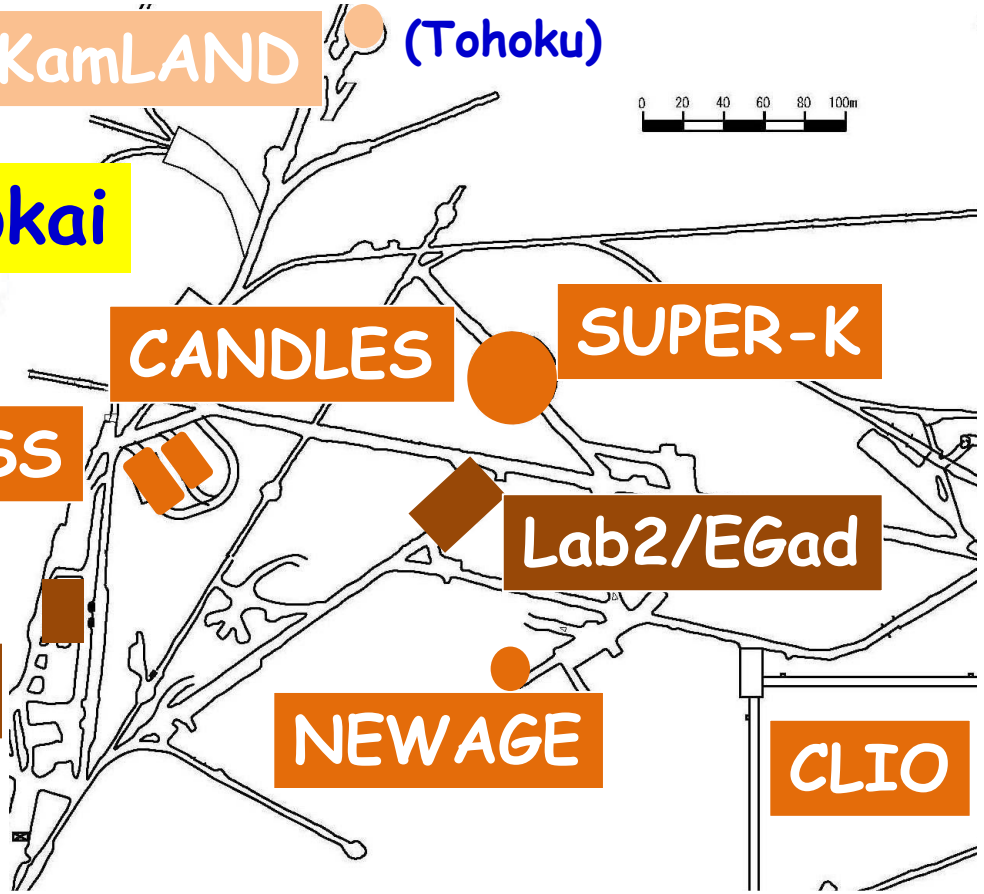
Lin, Shin-Ted / Sichuan University, China

LRT 2015 / March 18-20

@University of Washington Campus, Seattle, WA USA

Low Radioactivity Techniques 2015

Kamioka Underground Observatories



Kamioka Mine

~1000 m underneath Mt. Ikenoyama

Activities of Kamioka Underground Observatories

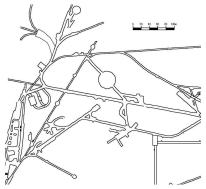
Three organizations

- Kamioka Observatory, Institute of Cosmic Ray Reseach, University of Tokyo
- Kamioka Satellite (Kavli Institute of the Physics and Mathematics of the Universe, UT)
- Research Center of Neutrino Science (RCNS, Tohoku University)

Major Achievements

- Super-Kamiokande - K: proton decay , K-II: observation of SN1987A , Super-K: Up-down asymmetry in the zenith distribution of atmospheric neutrino in 1998, Solar neutrino problem solved together with SNO in 2001 , K2K: Confirmation of neutrino oscillation 2004. T2K: first evidence for non-zero θ_{13} in 2011 …
- KamLAND – Determination of ν_{solar} parameters, ν_{geo} observed

Environmental Background

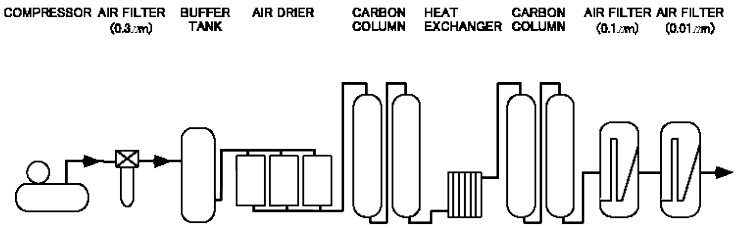


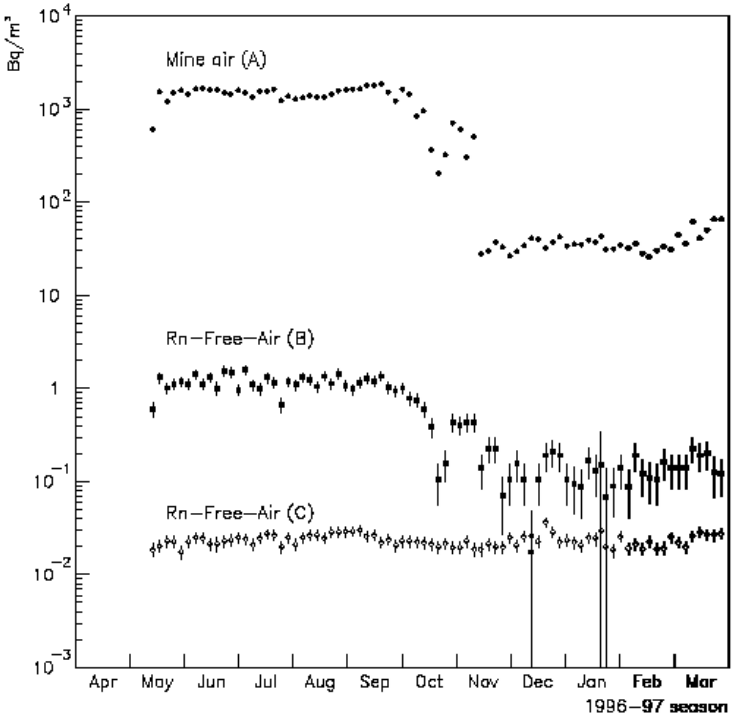
- ✓ μ flux : 250 μ/m²-day at a depth of 2700 km m.w.e.
- ✓ Neutron flux :

$$\phi_n^{thermal} = 8.3 \pm 0.6 \times 10^{-6}\,\mathrm{cm}^{-2}\,\mathrm{s}^{-1}$$

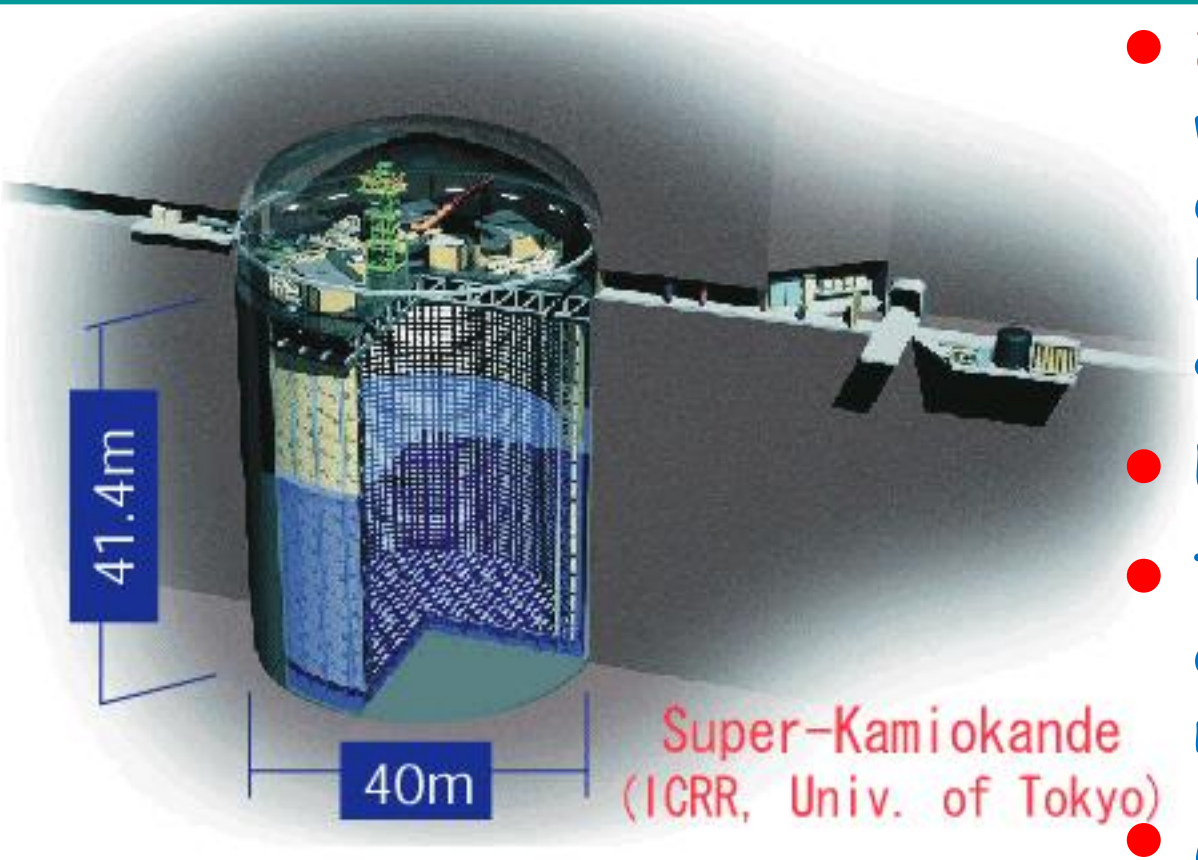
$$\phi_n^{non-thermal} = 1.2 \pm 0.1 \times 10^{-5}\,\mathrm{cm}^{-2}\,\mathrm{s}^{-1}$$

- ✓ Rock radioactivity contamination at a typical location:
  ~1.0 ppm for U, ~3.2 ppm for Th, 1.6 ppm for K
- ✓ Radon contamination :
  The concentration of radon in the air through this system is reduced to the order of $10^{-2}\,\mathrm{Bq/m}^3$ in all seasons.





A glance at Super-Kamiokande

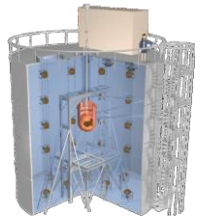


- 22.5 Kton fiducial mass water Cherenkov detector with read-out by inner 11146 20" PMTs & outer 1885 8" PMT.
- Excellent PID.
- Total data: >4500 days of atmospheric/solar neutrino searches.
- Multipurpose detector
  - Solar/Supernova/ Atmospheric neutrinos; Nucleon decay, far detector of T2K, CP phase for Hyper-K.

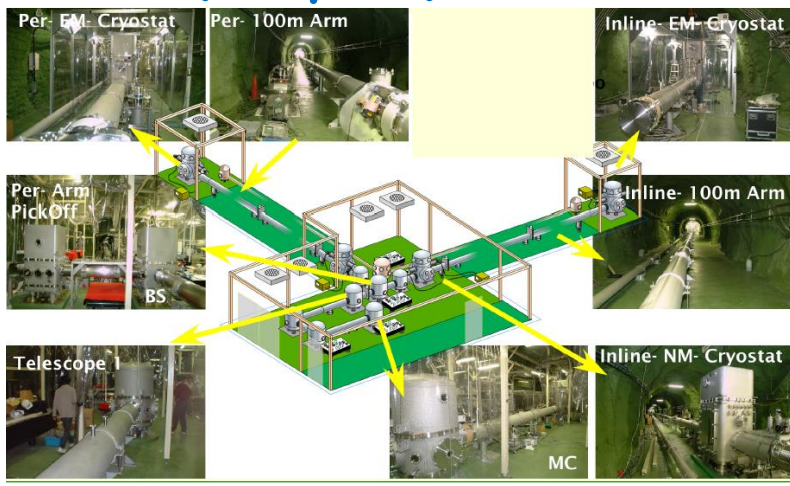
RUN periods :
SK-I (1996-2001)
SK-II (2003-2005)
SK-III(2005-2008)
SK-IV (2008-present)

Diversified Scientific Programs

- KamLAND-ZEN : 320 g of a 90% enriched ^{136}Xe-loaded liquid scintillator to measure $0\nu\beta\beta$ decay.
- XMASS : Multipurpose low-bkg & low-energy Threshold experiment with liquid Xenon. Ongoing for XMASS-1.5. [Talked by Prof. K. KOBAYASHI on March19]

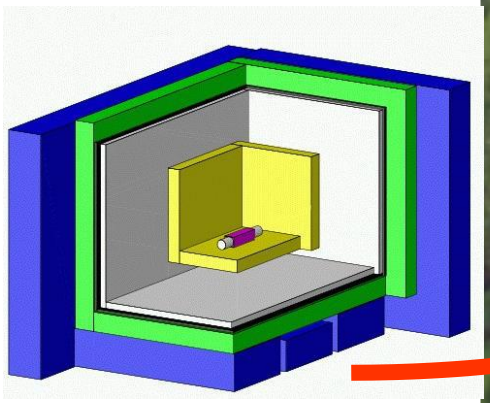


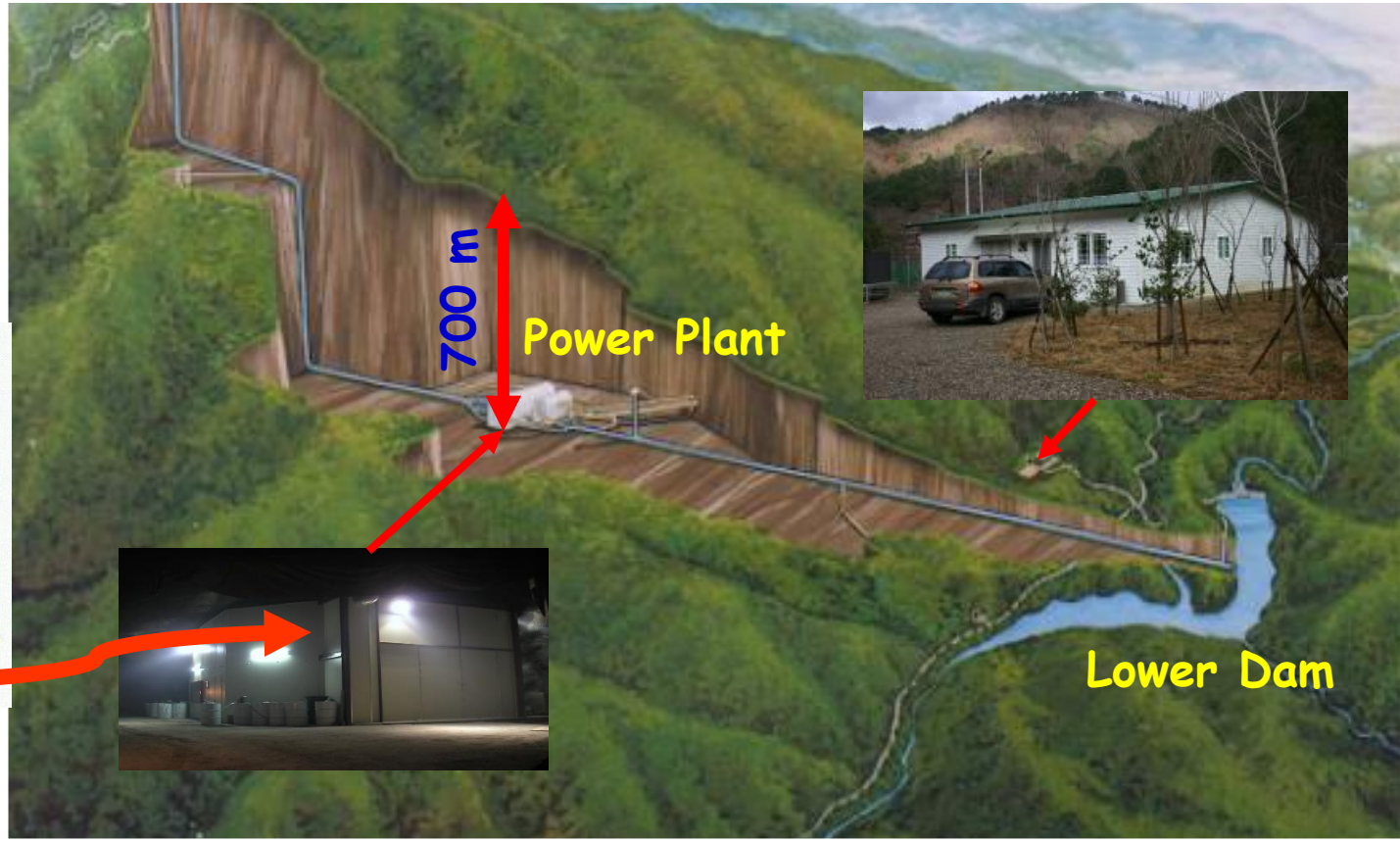
- CANDLES : CAlcium fluoride for studies of Neutrino & Dark matters by Low Energy Spectrometer ($0\nu\beta\beta$, Osaka)
- NewAGE : CF4 gas chamber using a TPC as the track for the directional dark matter searches. (Tokyo U)
- Large Scale Cryogenic Gravitational wave Telescope (LCGT)/ Cryogenic Laser Interferometer Obs,(CLIO) : Gravitational Wave measurement. CLIO is a prototype of LCGT.



Yangyang Underground Laboratory

- Hardware facilities with a depth of *700 m*, with a space of *100 m²* was done in 2003.
- Accessible to the lab by car. (~ 2 km)

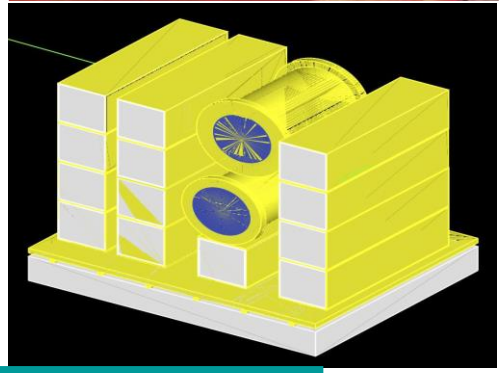




Yangyang Pumped Storage Power Plant

Scientific Programs & activities at Y2L

Korea Invisible Mass search (KIMS) experiment



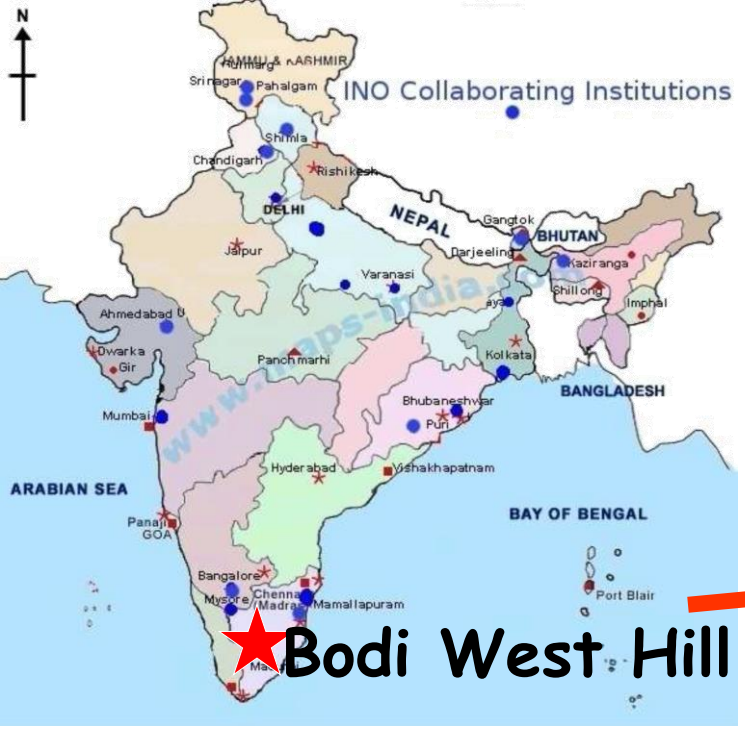
- DM searches with CsI(Tl) since 2000.
- Major dark matter physics results based on the data at the periods of (2005/12 – 2006/3 with the mass of ~35 kg)、(2009/9-2012/10 with ~104 kg)
- Projects of KIMS-NaI、KIMS-CMO (200 kg $CaMoO_4$) are being planned.
  [*Talked by Prof. H.S. LEE on March 19*]

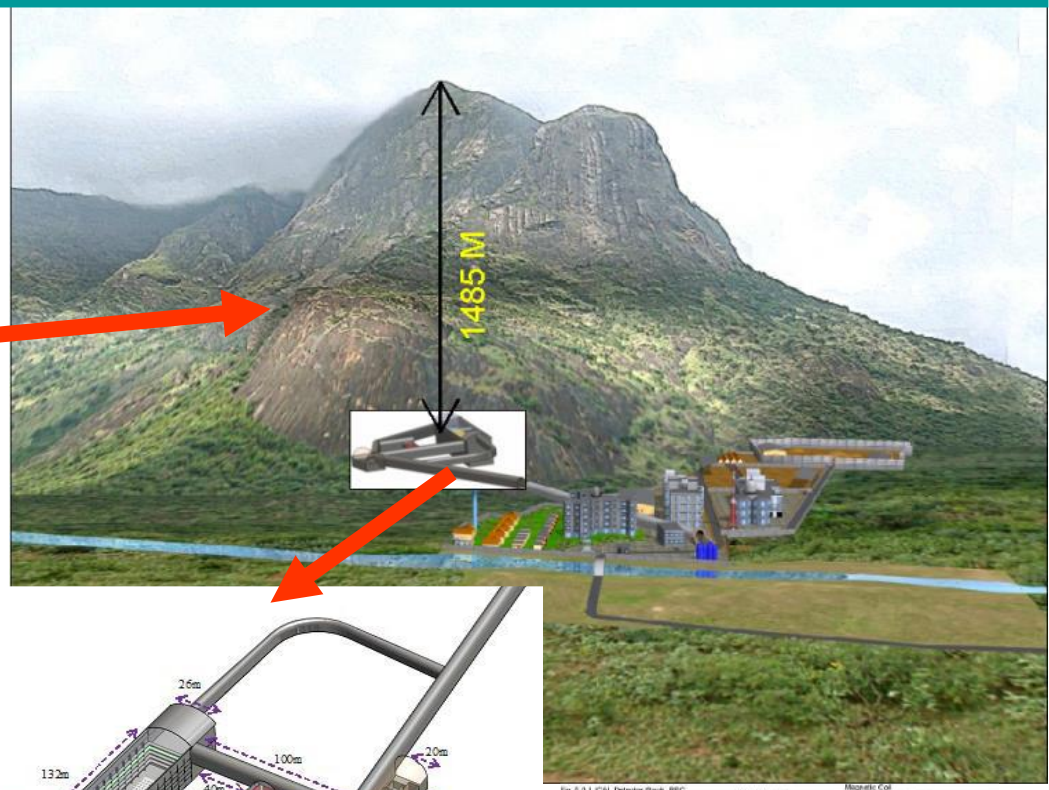
AMoRE

- AMoRE(Advanced Mo based Rare process Experiment) detector for $0\nu\beta\beta$ decay using molybdate crystal (eq. $CaMoO_4$) [Prof. H.J. KIM on March 19]

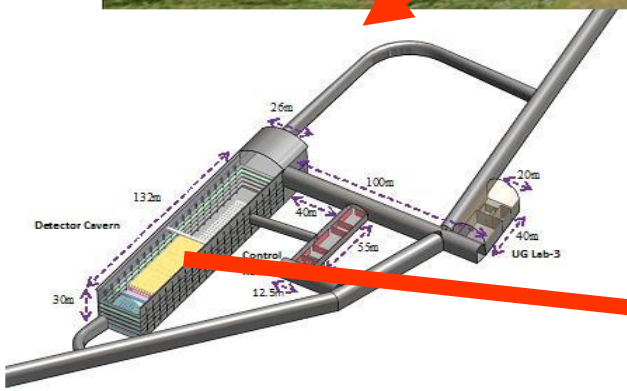
⚐ **CUNPA** Center of Underground Nuclear & Particle Astro-physics in Korea approved by IBS in 2013. (eq. SamCheok)

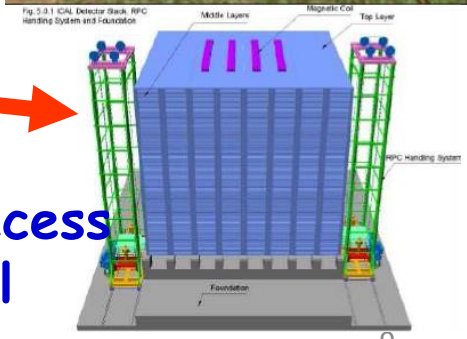
India-based Neutrino Observatory (INO) Site





Location : Pottipuram Village,
Theni District Tamil Nadu State





- INO Collaboration:

~100 scientists from
23 research institutes
& Universities in India.

~1km rock overburden access
through 2 km long tunnel

The INO Projects

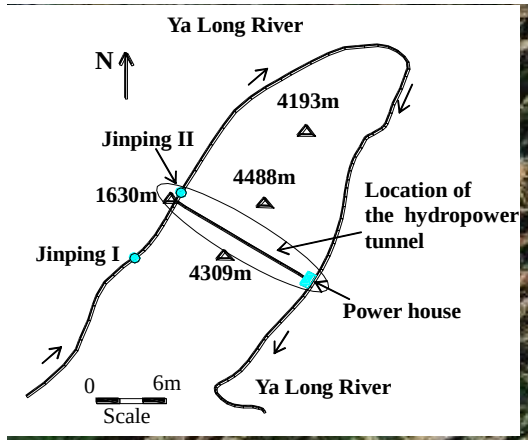
- Project has been approved by Indian science Departments.
- Short Goal : Create experimental facility to carry out experiments in the field of particle and astroparticle physics.
- Incorporate Inter-Institutional Centre for High Energy Physics(IICHEP) at Madurai, 110 km from INO site.
- Main Detector as Iron CALorimeter(ICAL) with the mass of 52 kton to primarily probe neutrino properties using atmospheric neutrinos.
- Develop a full fledged one over the years for diversified studies of Physics (such as $0\nu\beta\beta$ and dark matter searches), biology and geology.
- Education proposes.

Current Status

- **Pre-project activities** started with an initial grant of ~$10M
  - Site infrastructure development as well as tunnel and cavern (done in 2018/2019)

  - Development of INO centre at **Madurai** (moving fast)
  - Construction of an engineering prototype module (in 2017)
  - **ICAL Detector** (one module per year.)
- Detector R&D is now complete.
- DAQ system is ready.
- White paper on Physics is ready.
- Industrial production of RPC will start soon.

China Jin-Ping Underground Laboratory(CJPL) Site

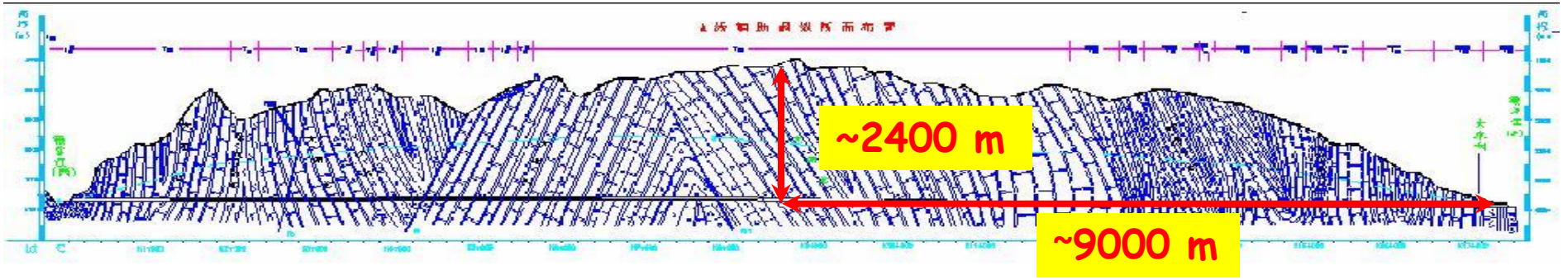


Tunnel

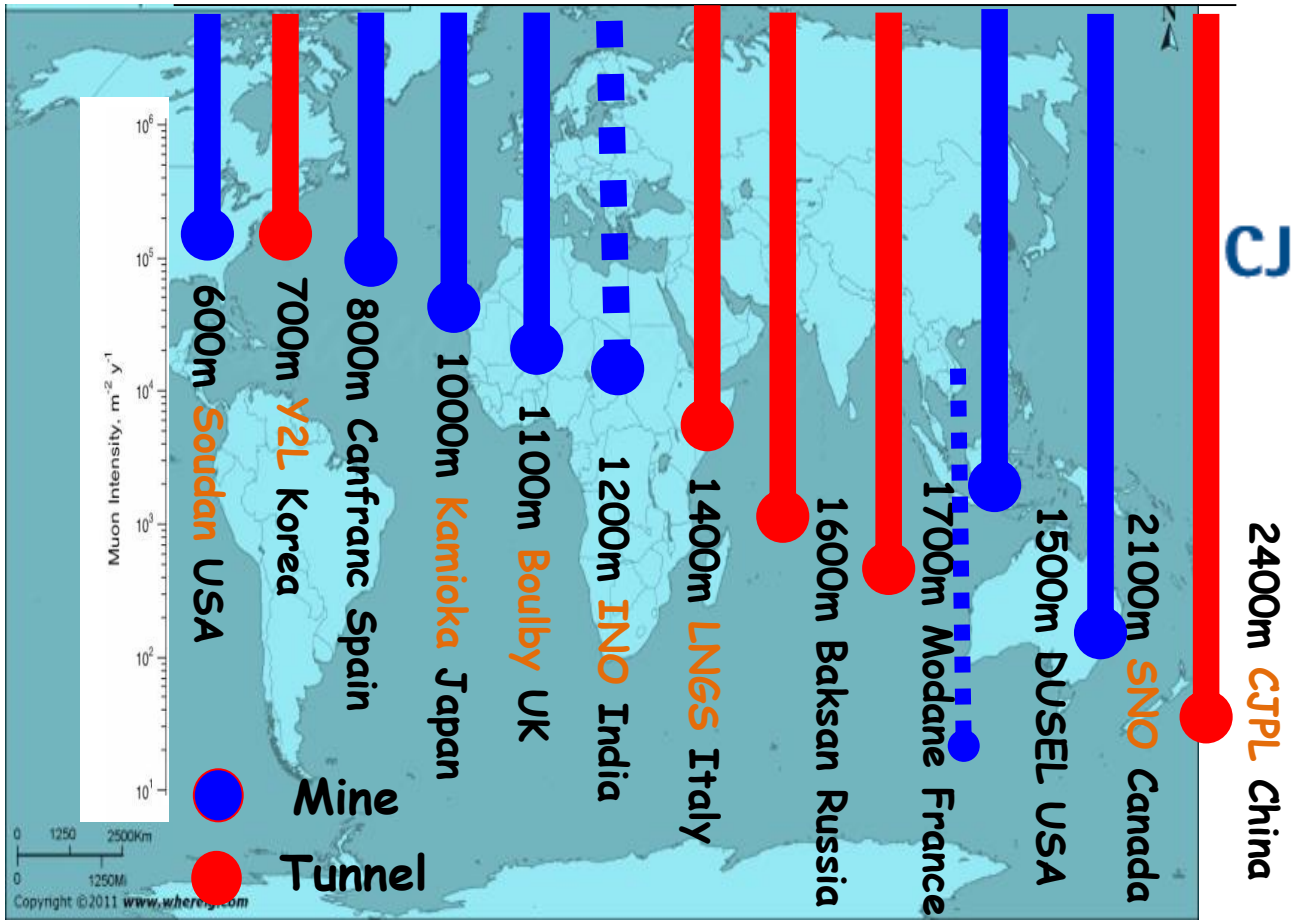
120km

50min from Chengdu By Air

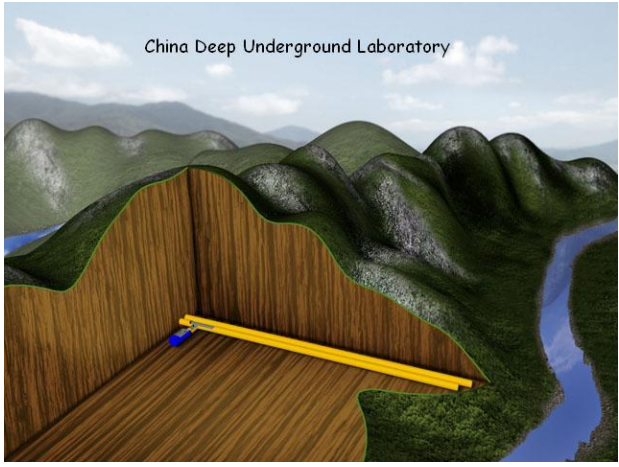
XiChang



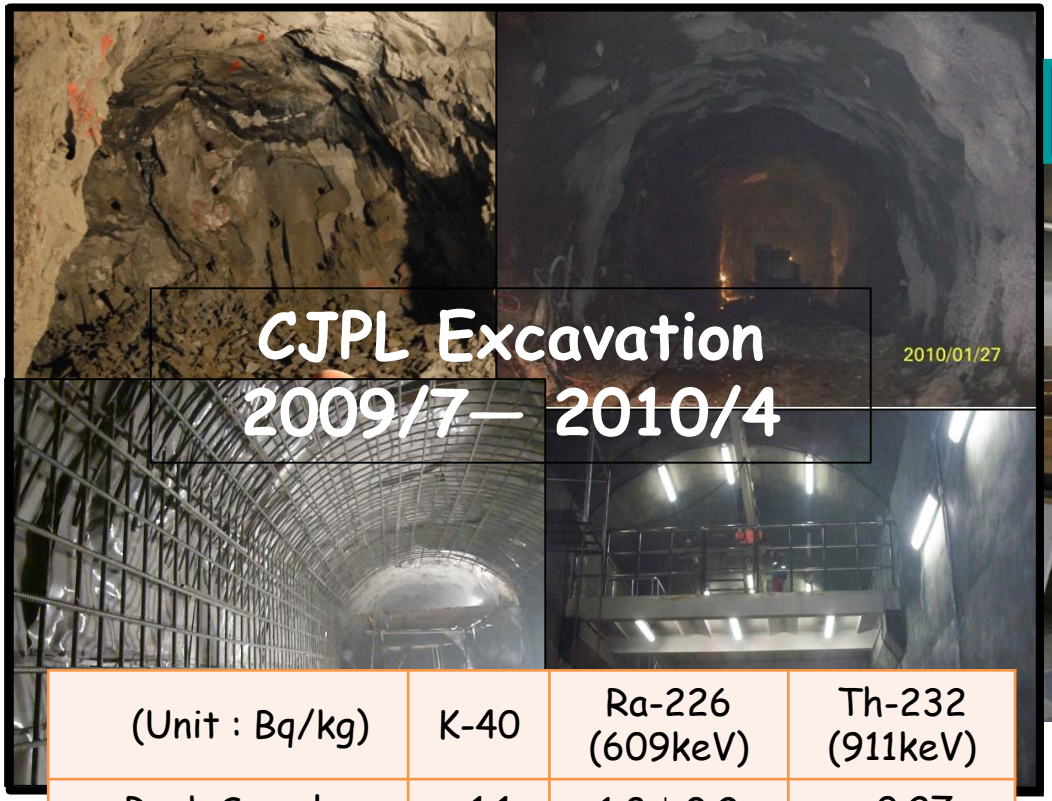
◎ 2400+ m rock overburden, drive-in road tunnel access



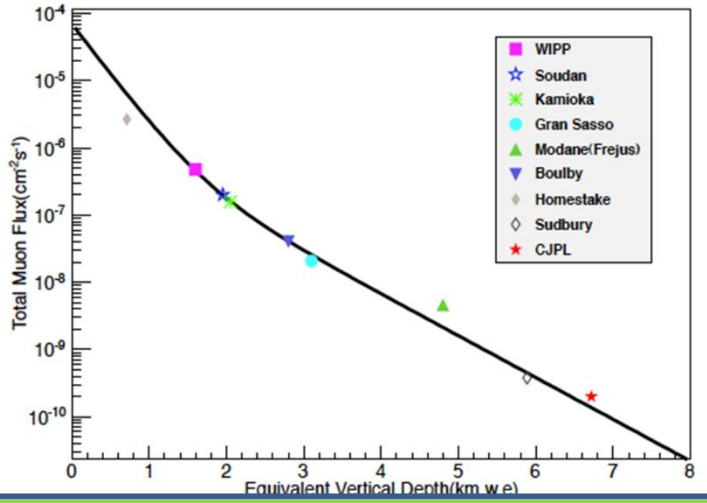
CJPL 中国锦屏地下实验室 China Jinping Underground Laboratory



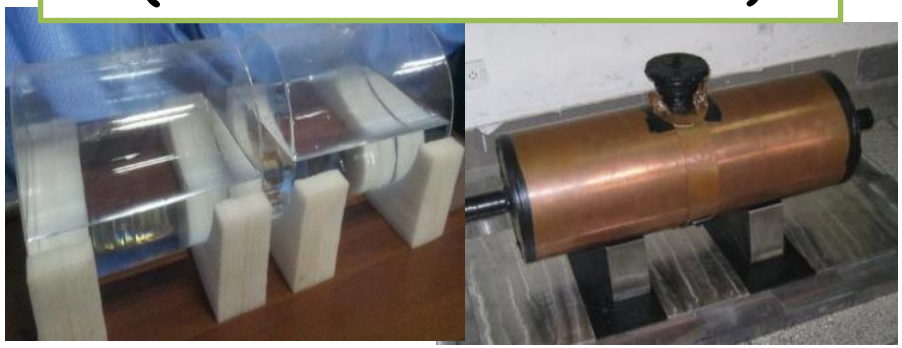
Environmental Background



(Unit : Bq/kg)	K-40	Ra-226 (609keV)	Th-232 (911keV)
Rock Sample	< 1.1	1.8±0.2	< 0.27
Ground Level (BJ)	~600	~25	~50



Fast neutron measurement :
(Gd-load L.S. detector)

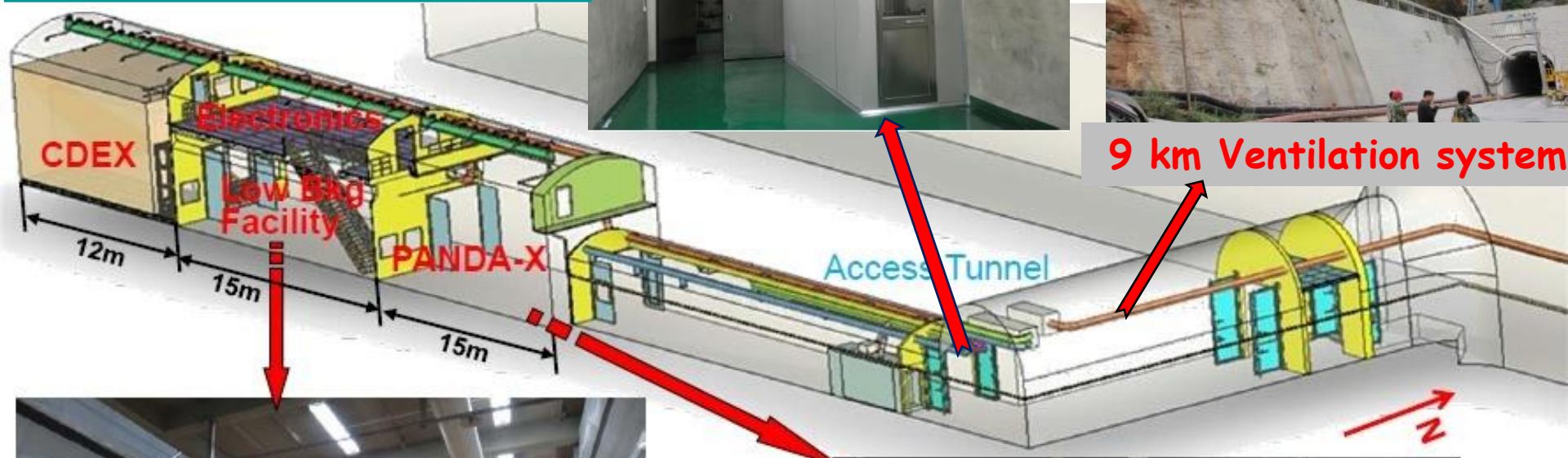


- μ flux ~ 60 /year/m^2

Ref: Chinese Physics C 37, 8 (2013) 086001

Internal layout of CJPL-1 (6mx6mx40m)

9 km Ventilation system



Scientific Program at CJPL-1

✓ CDEX

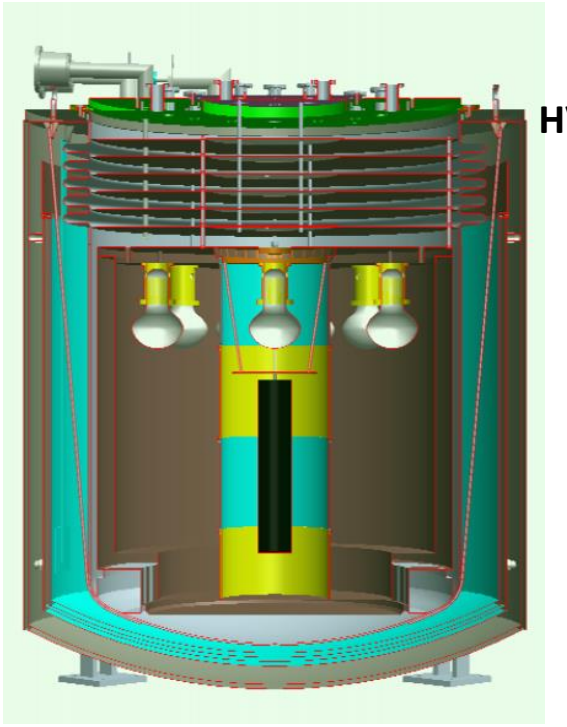
✓ CJPL-LBF

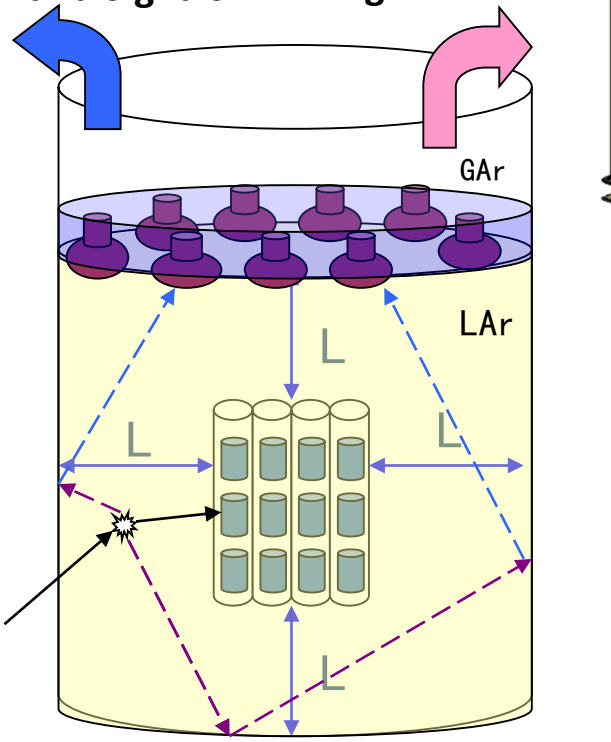
✓ PandaX

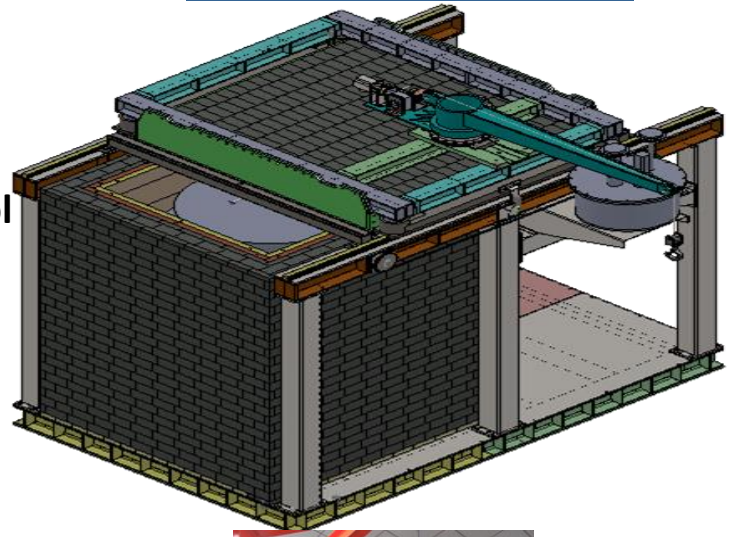
[*Talked by Prof. C. Fu on March 20*]

CDEX-10 experiment (9 kg Ge array + 1 ton LAr_2)

LAr: Passive shielding + Active shielding.
Ge: Encapsulated into copper vacuum tube.
WLS: Transferring 128nm light to~420nm.







Plan of CJPL-II

- Four 12m*12m*150m tunnel
- Plan to be finished in 2015