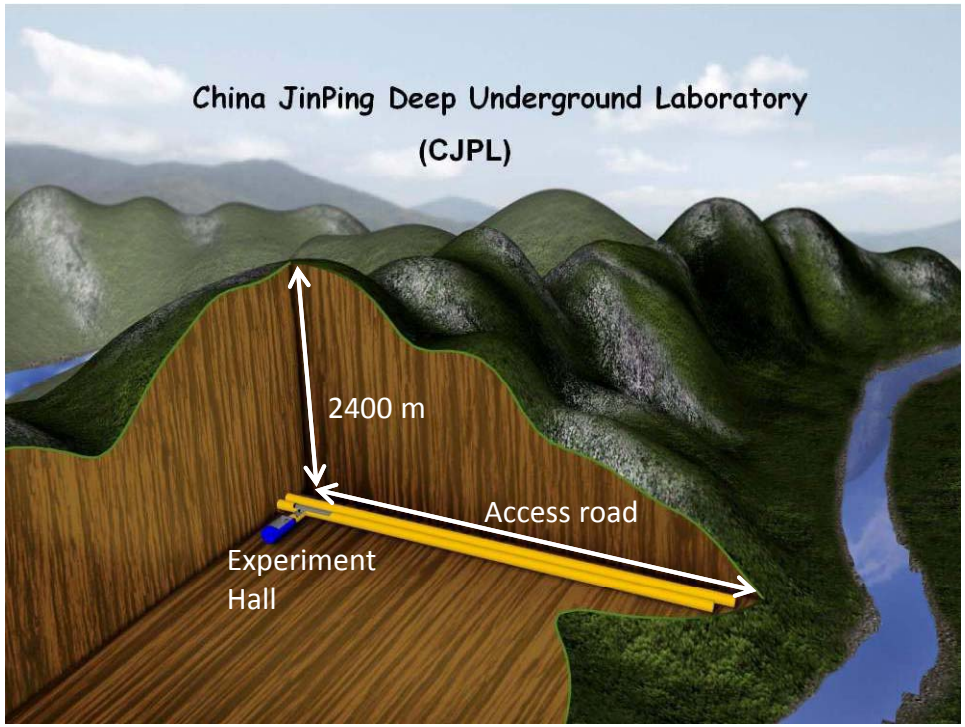
PANDA X

Status and Plans

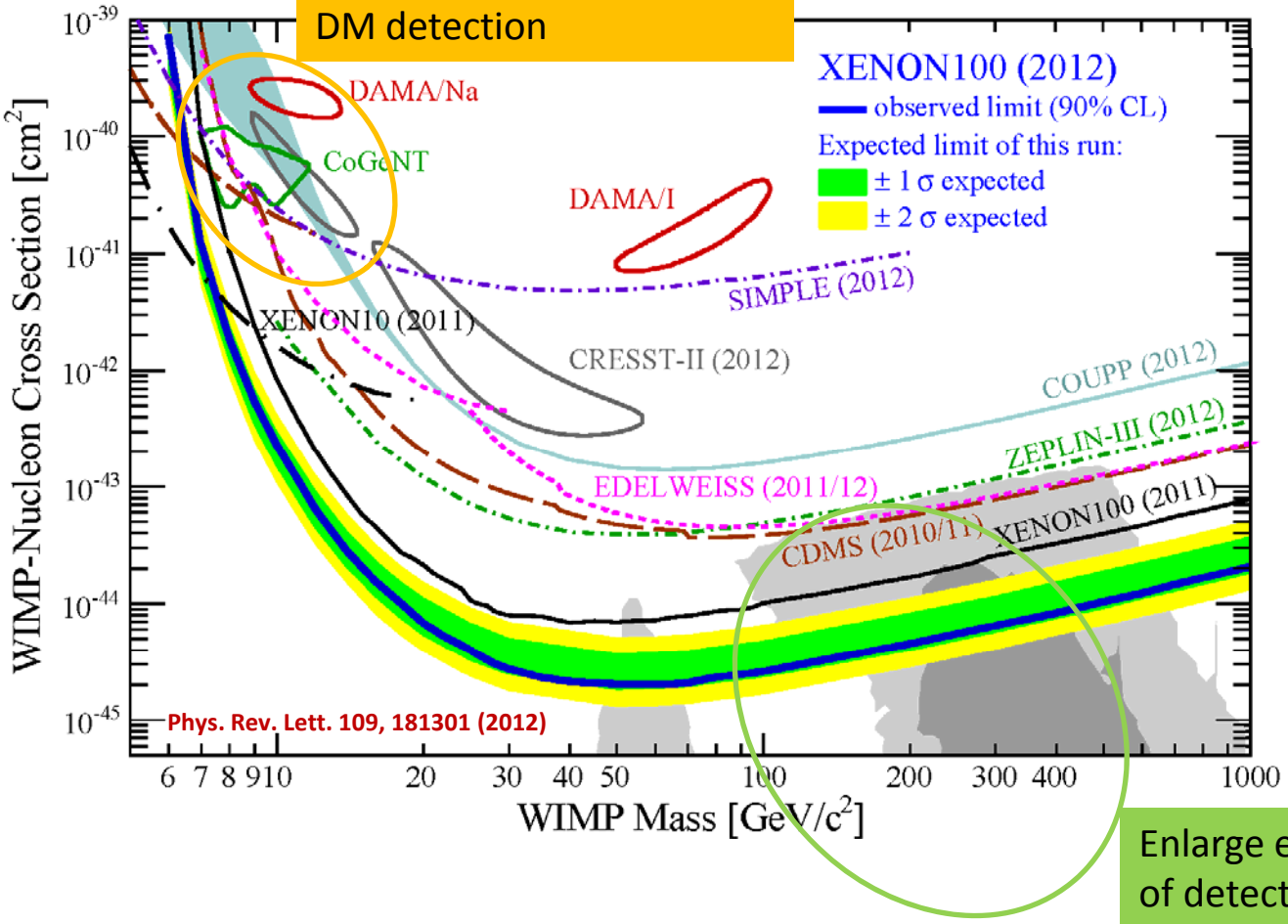


Wolfgang Lorenzon
University of Michigan
(on behalf of the PandaX Collaboration)

U-M LDM 2013
Ann Arbor, MI
April 16, 2013

Direct Dark Matter Detection: The Path Forward

Decrease detection threshold and improve sensitivity for low-mass DM detection



Enlarge effective mass of detector, explore theoretical models

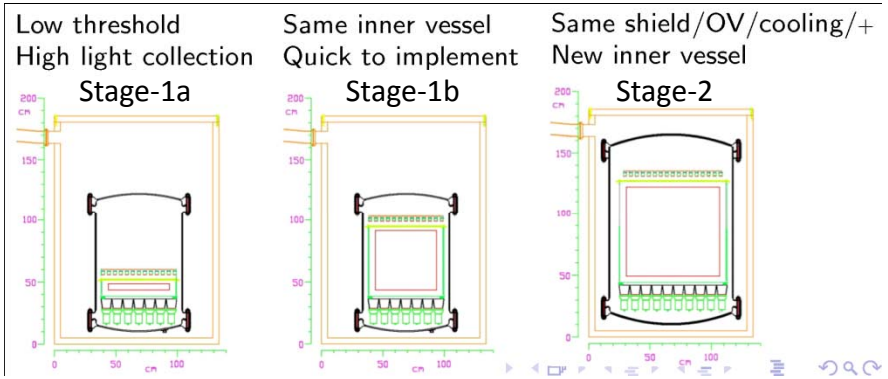
At the Brink of Discovery!

- Generation 2 experiments likely to produce a positive detection.
- PandaX will expand sensitivity in both directions: low mass and low cross-section
- PandaX heritage from pioneering experiments: XENON100, ZEPLIN…

The PandaX Experiment

(Particle AND Astrophysical Xenon TPC)

- A dual-phase xenon Dark Matter direct detection experiment
- Located at China JinPing underground Lab (CJPL) (covered with 2,400 m of marble)
- Probing WIMP-nucleon cross section
- A staged approach to reach ton-scale target mass
  - Stage-1a: Time Projection Chamber (TPC) design optimized for low mass dark matter: 25 kg (fid)
  - Stage-1b: increase the fiducial mass to 300 kg (~LUX)
  - Stage-2: increase the fiducial mass to 1 ton: optimized for high mass dark matter



Entrance to PandaX area

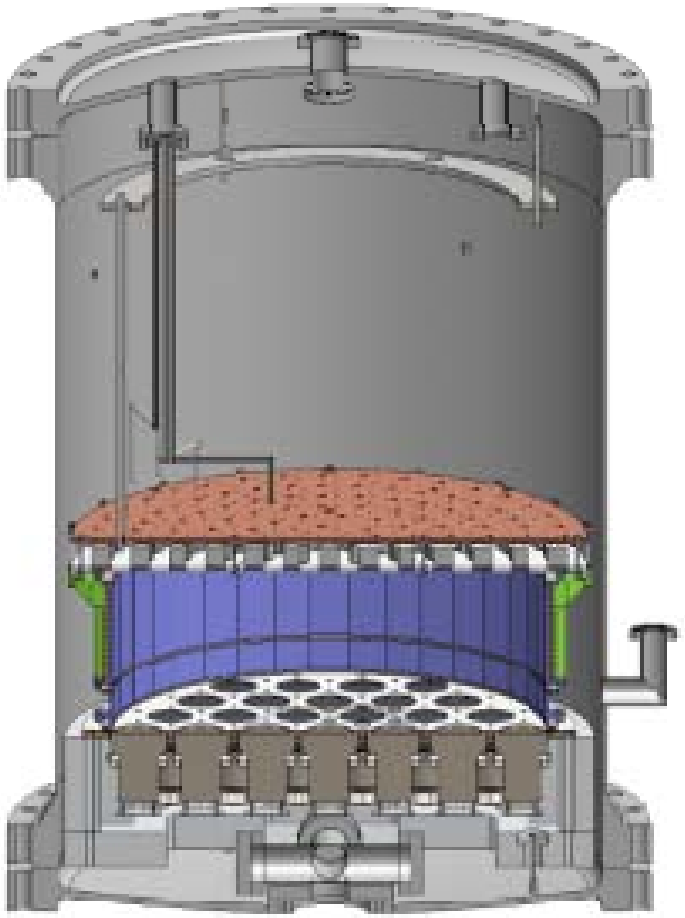
Jan 2013
(Stage-1a installation)

The PandaX Collaboration

Shanghai Jiao Tong University
Shanghai Institute of Applied Physics
Shandong University
Peking University
Yalong River Hydropower Development Company

University of Michigan
University of Maryland

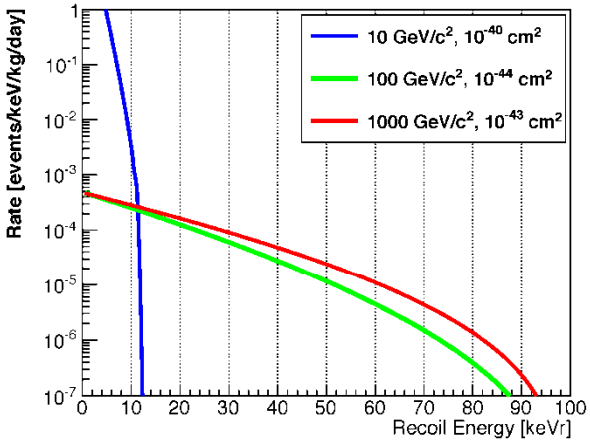
Stage-1a Design and Goals



- Design:
  - TPC diameter/length: 60/15.4 cm
  - Target Xe mass: 125 kg
  - Expected fiducial mass: 25 kg
  - Top PMT: 143 R8520
  - Bottom PMT: 37 R11410

Goals:

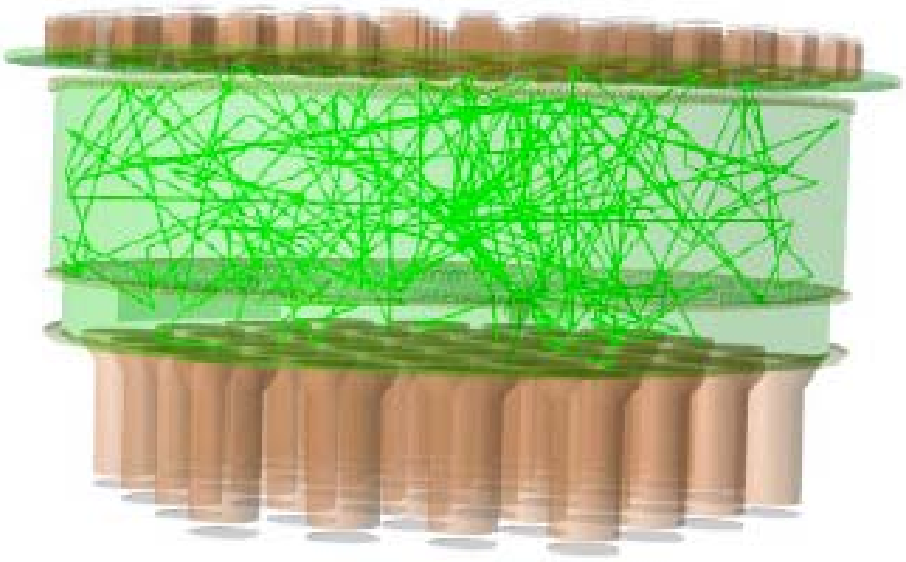
- Demonstrate high field operation for high ER background rejection
- Demonstrate efficient Xe purification and low Kr-contamination
- Low energy threshold for light WIMPs



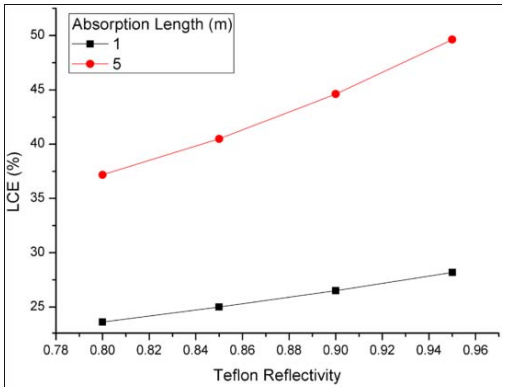
Key to Low Threshold - Light Yield

a 5 keV NR only produces
about 20 scintillation photons

Every photon is precious!



- Disk-like structure: increase PMT coverage
- Highly reflective Teflon walls
- Hexagonal Teflon reflectors for the bottom PMTs to avoid dead space
- Highly transparent wire planes
- Efficient purification to minimize photon absorption by impurity molecules, e.g. H_2O

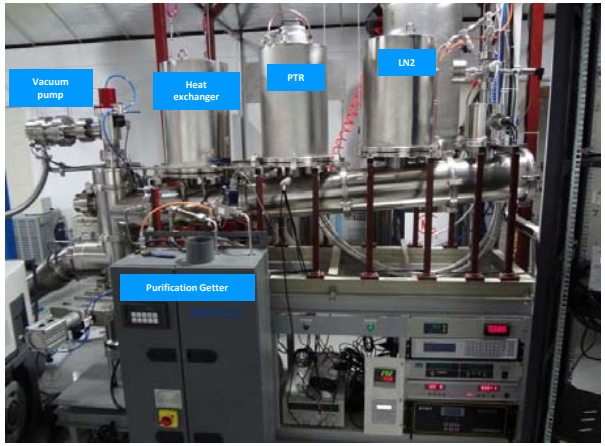


Assumptions:

Absorption length: 5 m
Teflon reflectivity: 90%
Scattering length: 40cm

Goal: achieve a 5 keVr NR threshold, equivalent to a light yield of 4-5 pe/keVee (with field)

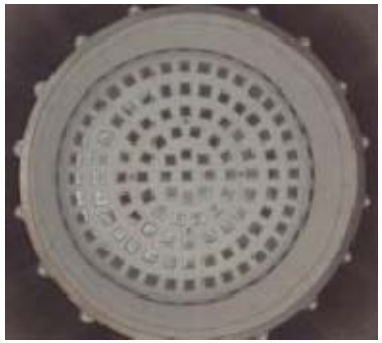
Stage-1a: Current Status

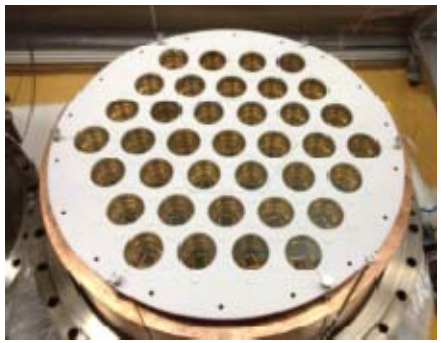


- Passive shield, cryogenics, and Kr removal system were designed for ton-scale experiment from the beginning
- Passive shield and cryogenic system are installed at CJPL.
- Kr removal system started operation at SJTU

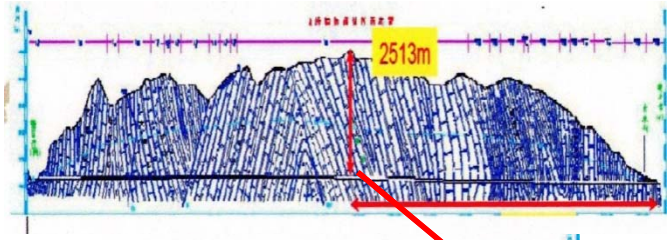
Stage-1a: Current Status - II

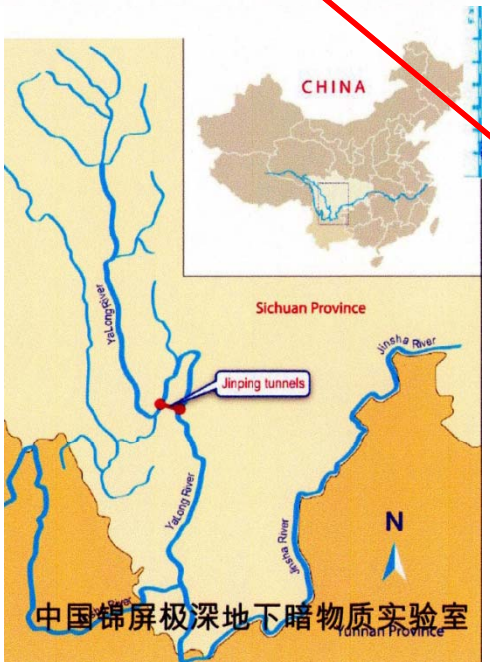
- Started commissioning at CJPL
  - currently 440 kg LXe in vessel
- Operation in 2013
- Planned exposure: 25-kg x 60-days
- Expected bkg (dominated by ERs from vessel and PMTs): 0.3 (after 99.9% rejection based on S2/S1)
- Expected threshold/NR acceptance: 1.5 keVee/35%
- Expected sensitivity (SI): 1×10^{-43} cm^2 at 10 GeV with 1,500 kg-day exposure

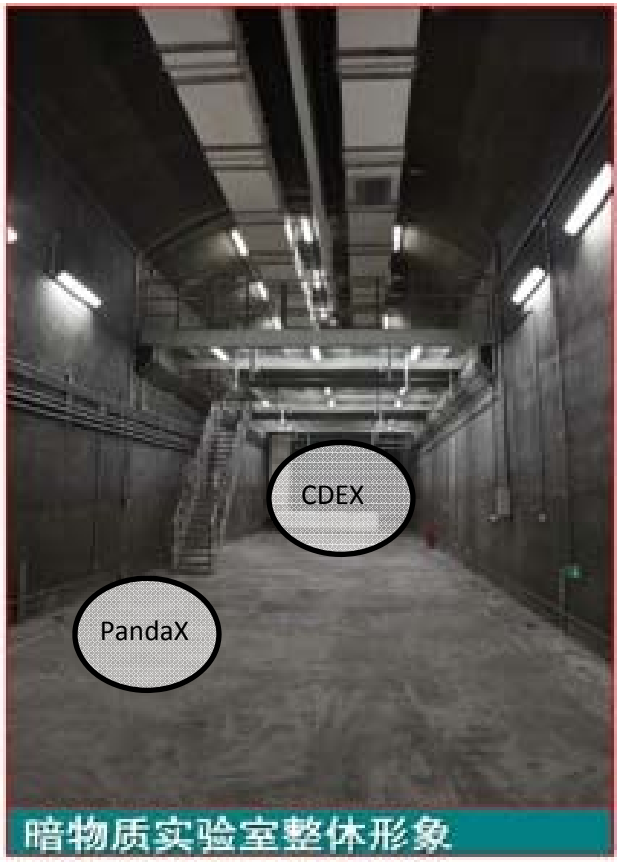




The PandaX Experiment at CJPL







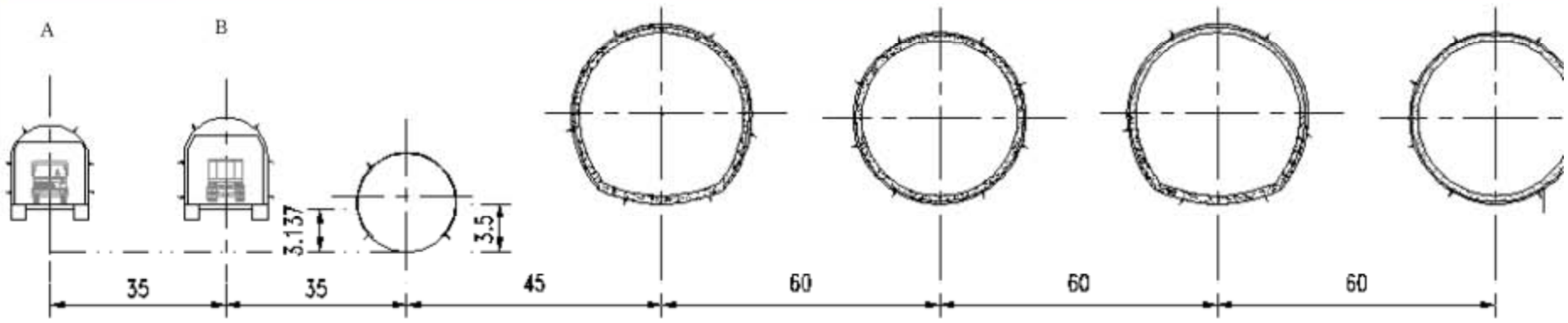
- Deepest lab in operation: 7,200 mwe (66 μ/m^2/yr) → μ veto shield unnecessary
- Radiopure "marble" mountain → water shield not needed
- Middle of 18 km tunnel → easy access by road
- Cavern floor and walls coated with Rn blocking paint
- Scalable design → room to grow

Tunnels at JinPing Mountain

- Four water tunnels: length of 16.67 km
  - two of diameter of 12.4 m: TBM
  - two of diameter of 13m: drilling and blasting,
- Two traffic tunnels: 5.5×5.7m、6×6.25m, length of 17.5km
- One drain tunnel with diameter of 7.2m, length of 17.5km

(only used during construction, and could be used for super big volume experiment!)

- maximum Overburden 2525m



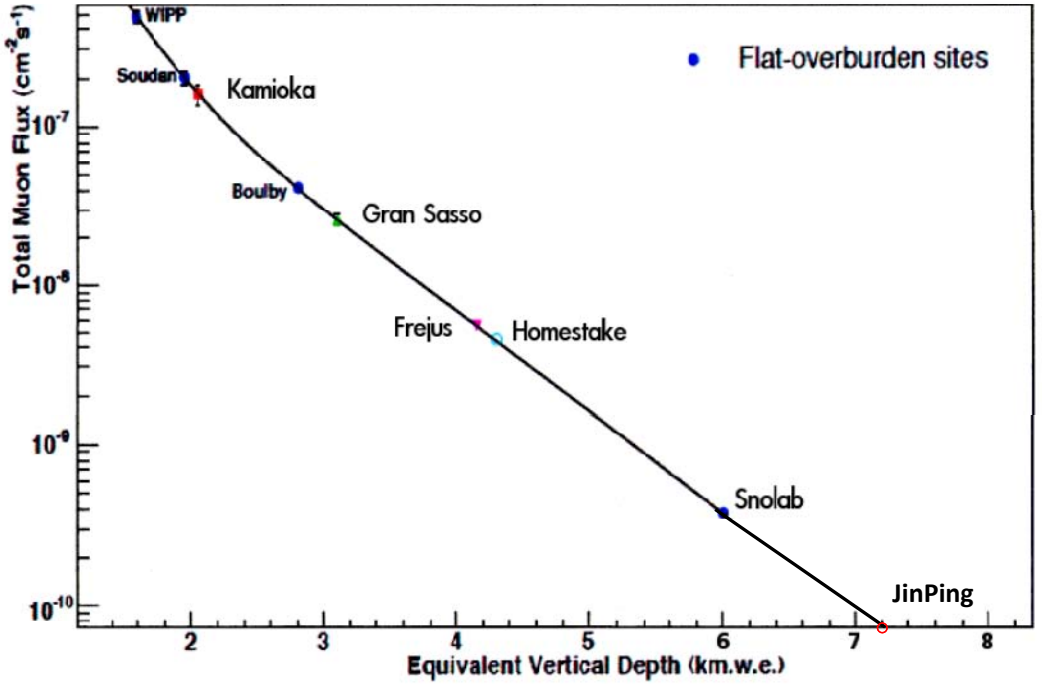
JinPing Mountain

Yalong river

steep mountains

CJPL: A low Background Facility

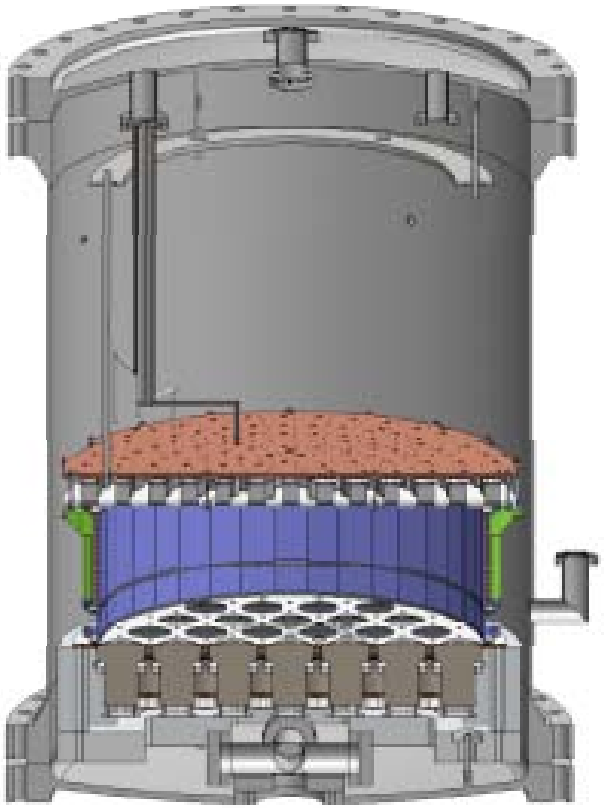
low muon flux



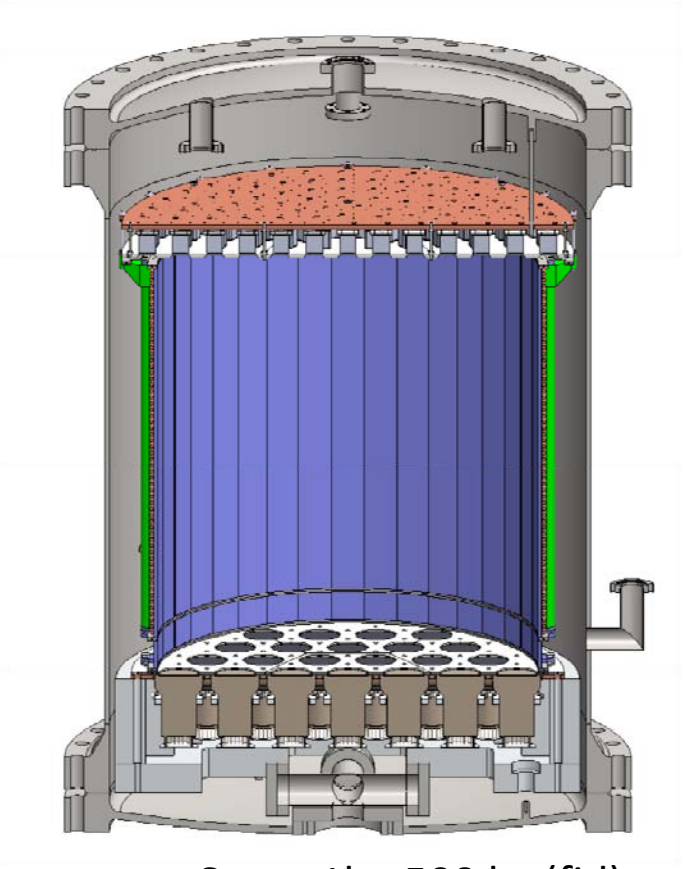
radio-pure rock

facility	depth [mwe]	μ flux [events/m^2/yr]	rock	^{238}U [Bq/kg]	^{232}Th [Bq/kg]	^{40}K [Bq/kg]
Jinping (PandaX)	7,200	66	marble	1.8 ± 0.2	< 0.27	< 1.1
Homestake (LUX)	4,500	950	rhyolite	100	45	900
Grand Sasso – Hall B (XENON)	3,500	8,030	dolomite	5.2	0.25	4.9

The Next Step: Stage-1b



Stage-1a: 25 kg (fid)

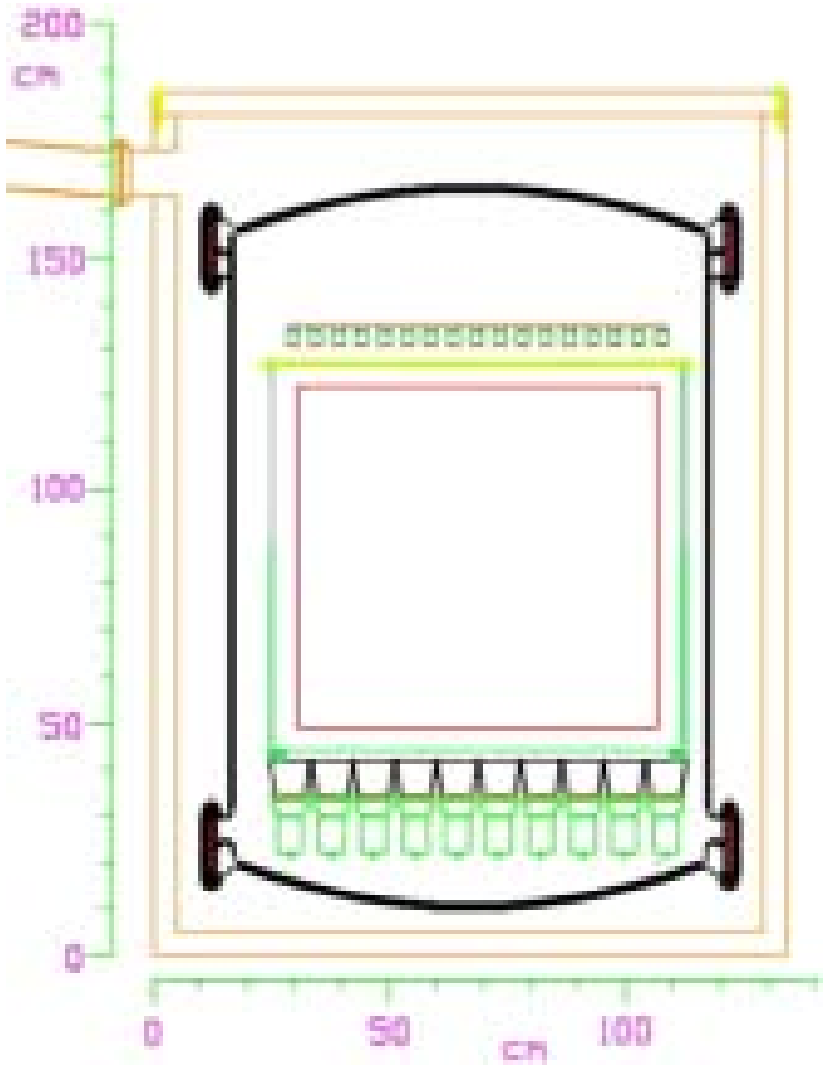


Stage-1b: 500 kg (fid)

- same detector vessel and PMT arrays
- only increase TPC height (and add more Xe)
- NO change to shield, outer vessel, cryogenics, purification and general infrastructure
  → quick to implement

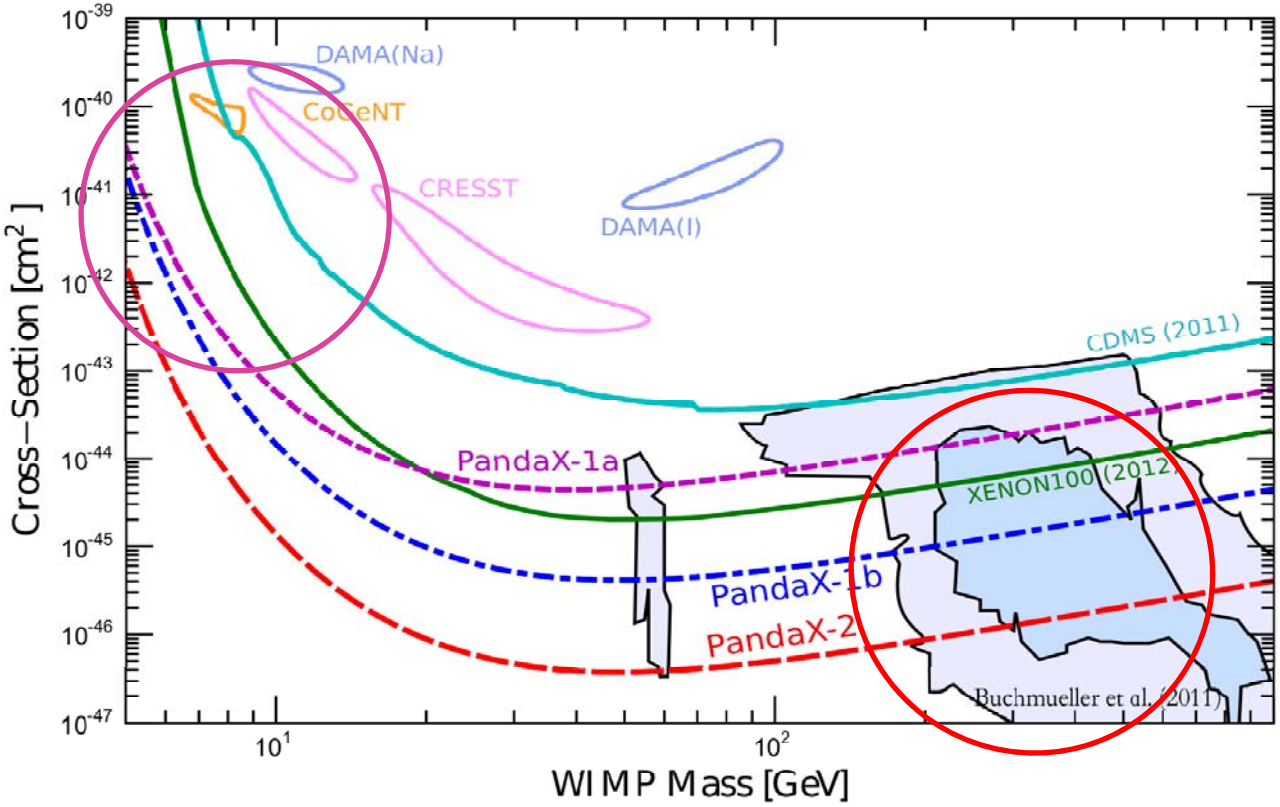
- Goal:
  - Construction: 2013
  - Commission/Operation: 2014
  - Sensitivity reach: 4×10^{-46} cm^2 at 100 GeV with 54,000 kg-day exposure

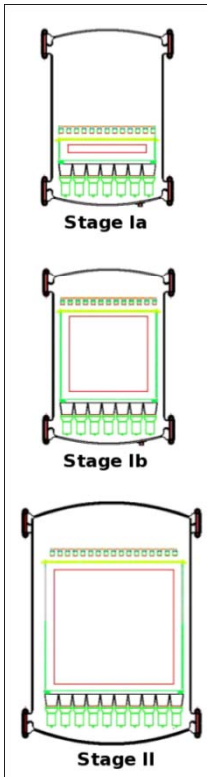
Stage-2: Design and Plans



- Design:
  - TPC diameter/length: 100/100 cm
  - Target Xe mass: 2.4 ton
  - Exp. Fiducial mass: 1.4 ton
  - Top PMTs: 151 R8520 or R11410
  - Bottom PMTs: 151 R11410
- Plan:
  - Start construction in 2014 (depends on funding)
  - Commission/operation: 2015-2017
  - Sensitivity reach: 3×10^{-47} cm^2 at 100 GeV with a 600,000 kg-day exposure

PANDAX expected sensitivity





PandaX Stage 1a:

- light yield: 4-5 pe/keV$_{ee}$
- S1 energy range: 3-30 pe
- exposure: 25 kg x 60 days
- NR acceptance: 0.35
- estimated bkg events: 0.3

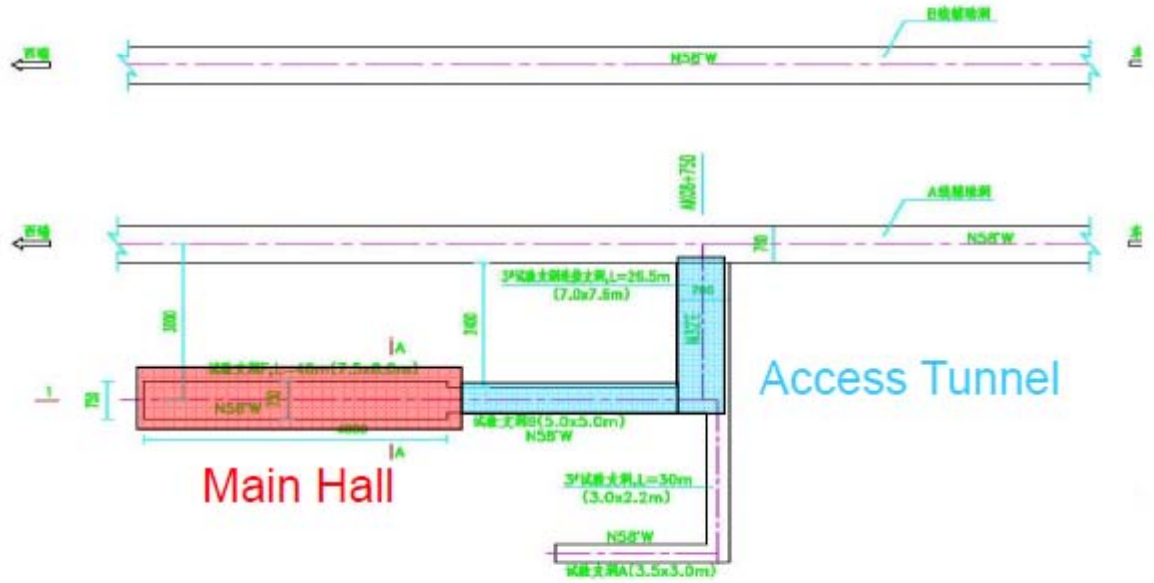
PandaX Stage 1b:

- light yield: 2.5 pe/keV$_{ee}$
- S1 energy range: 3-30 pe
- exposure: 300 kg x 180 days
- NR acceptance: 0.35
- estimated bkg events: 0.5

PandaX Stage 2:

- light yield: 2.5 pe/keV$_{ee}$
- S1 energy range: 3-30 pe
- exposure: 1000 kg x 1000 days
- NR acceptance: 0.35
- estimated bkg events: 1.2

Current Layout of CJPL



- Main hall: 6.5*6.5*40m
- Total Volume: ~4000m^3

Rapid Development at CJPL

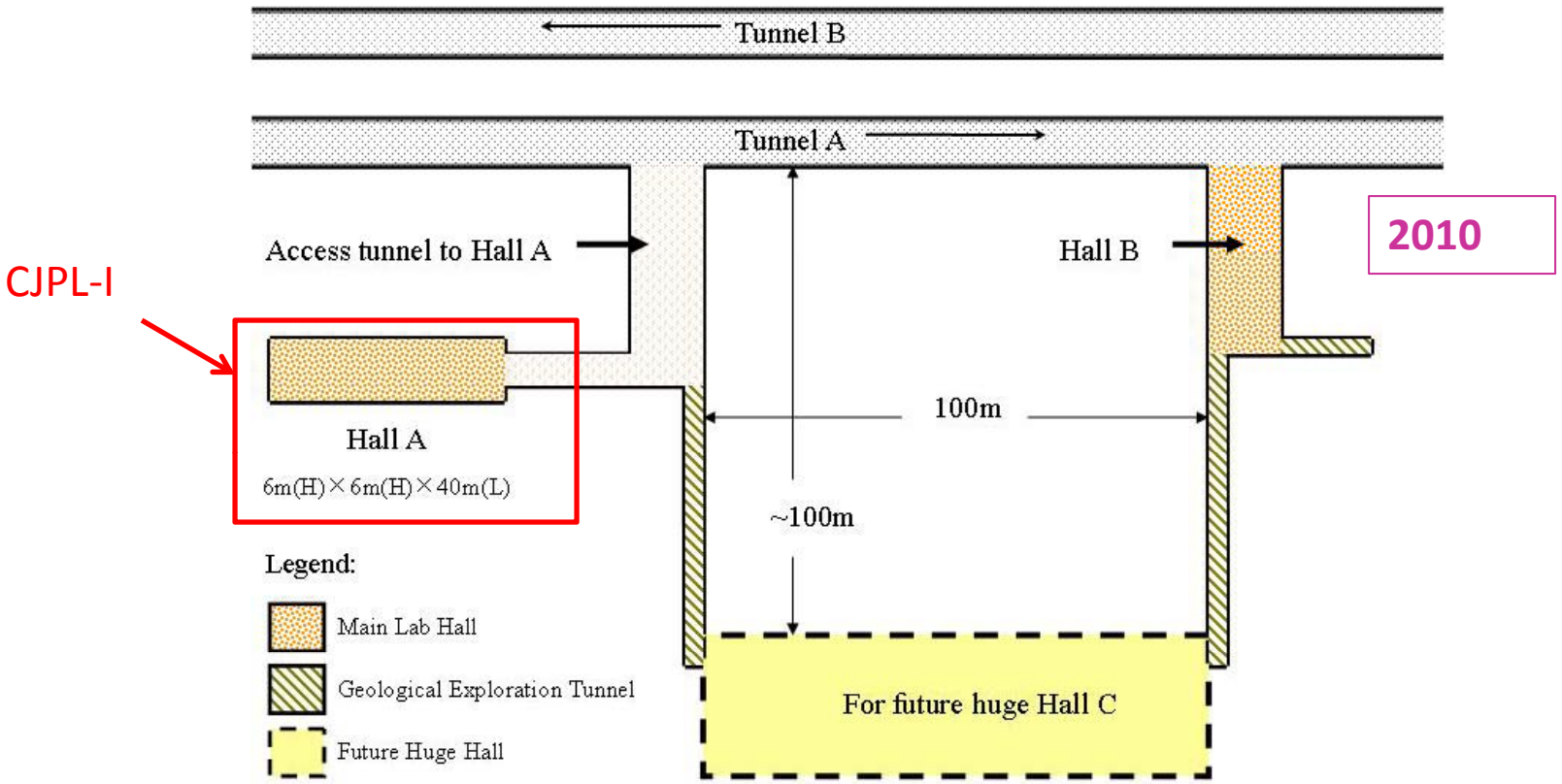
Nov 2009

May 2011
(under renovation)

Oct 2011
(after renovation)

Jan 2013
(stage-1a installation)

Future plans: CJPL-II



- CJPL-I: plans shown in 2010 for future development (shape & location flexible)
- CJPL-II: finalizing plans to build 8 caves each 12m (W) x 12m (H) x 60m (L)
  - start excavation in late 2013
  - operational by end of 2015
- Owner of lab (YRHDC) is supporting underground science
  - much larger experiments possible in the future
  - multi-ton DM experiment
  - $0\nu\beta\beta$ with only slightly modified detector (enrich Xe)

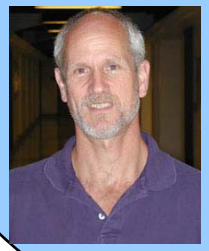
Michigan Team

Exp. Faculty


Gregory Tarlé


Wolfgang Lorenzon


Tom Schwarz


Tim Chupp


Dave Gerdes

Undergraduate Students


Zach Jackson


Max Hawley


Mykola Murskyj

Research Scientists


Michael Schubnell


Richard Raymond

Postdoc


Kirill Pushkin

Professional Staff


Curtis Weaverdyck


Jon Ameel

Graduate Students

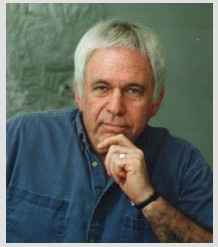

Scott Stephenson


Dan Marley

Theorists


Kathryn Zurek


Aaron Pierce


Gordy Kane


Katy Freese

Conclusions

- XENON 100 has demonstrated the power of LXe for DM searches
- Jinping Lab provides an excellent environment to carry on DM searches
- PandaX (stage-1a) will target light DM starting in mid-2013
- R&D underway for ton-scale PandaX
- Pending successful completion of stage-1, infrastructure in-place to proceed rapidly towards stage-2 (greater sensitivity)