

# PANDA-X

Particle AND Astrophysical Xenon  
Time Projection Chamber

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# PandaX Overview

## PandaX Experiment

- Direct detection experiment
- Dual-phase xenon TPC (gas/liquid)
- Chinese and US Collaboration
- At China JinPing Deep Underground Lab (CJPL)
- Probing WIMP-nucleon cross section



## Collaboration

### China

- Shanghai Jiao Tong University
- Shanghai Institute of Applied Physics
- Shandong University
- Peking University
- Ertan Hydropower Development Company

### USA

- University of Michigan
- University of Maryland



# PandaX Overview

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# PandaX - A 3D LXe DP TPC for DM DD

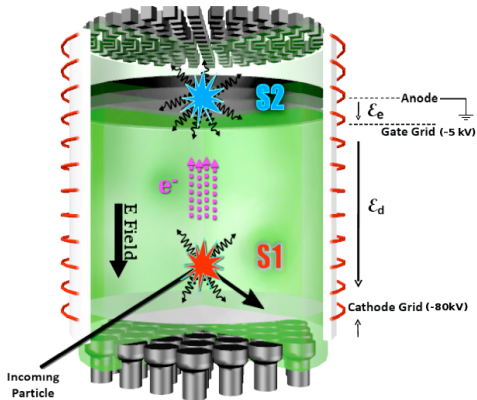
Particle AND Astrophysical Xenon experiment  
A Three Dimensional Liquid Xenon Dual-Phase Time Projection Chamber  
for Dark Matter Direct Detection

## Dual Phase Xe TPC

- 1 Interaction
- 2 First Scintillation (S1)
- 3 Second Scintillation (S2)
- 4 Event Reconstruction/Analysis

## DP Background Discrimination

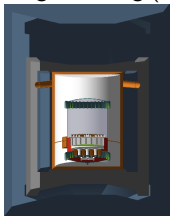
- Recoil: Nuclear (NR) or Electron (ER)
- NR is signal/ER is background
- NR and ER have differing S2/S1 ratios
- Must reduce NR background to  $\sim$ zero
- DP design cuts EM background at 99%-99.9% using S2/S1



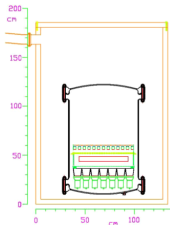
# PandaX - A Staged Approach

PandaX will progress through three stages.

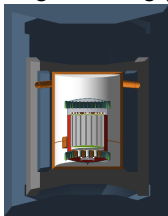
Stage Ia: 25kg (fid)



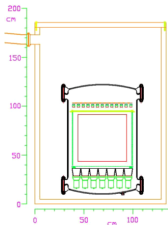
Low threshold  
High light collection



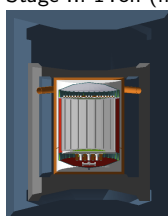
Stage Ib: 300kg (fid)



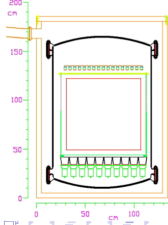
Same inner vessel  
Quick to implement



Stage II: 1Ton (fid)



Same shield/OV/cooling/+  
New inner vessel



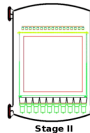
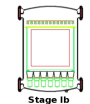
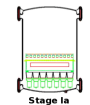
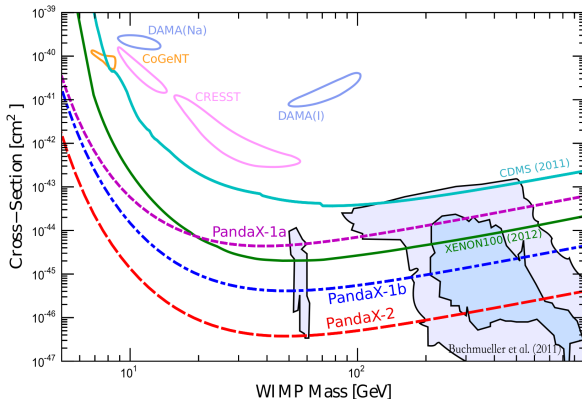
Built for Stage II  
from the Start

No change to:  
Shield,  
Outer Vessel,  
Cryogenics,  
Purification,  
General Infrastructure

Cryostat: Two Versions

TPC: Three Versions

# PandaX - Sensitivity Goal



## Stage Ia

- light yield: 4-5 pe/keV<sub>ee</sub>
- S1 energy range: 3-30 pe
- exposure: 25 kg x 60 days
- NR acceptance: 0.35
- estimated bkg events: 0.5

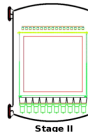
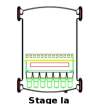
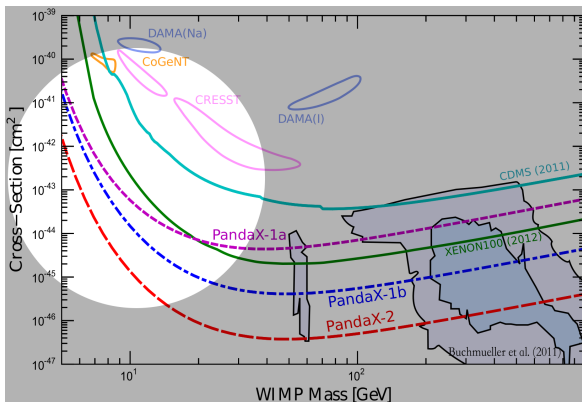
## Stage Ib

- light yield: 2.5 pe/keV<sub>ee</sub>
- S1 energy range: 3-30 pe
- exposure: 300 kg x 180 days
- NR acceptance: 0.35
- estimated bkg events: 0.5

## Stage II

- light yield: 2.5 pe/keV<sub>ee</sub>
- S1 energy range: 3-30 pe
- exposure: 1000 kg x 600 days
- NR acceptance: 0.35
- estimated bkg events: 1.3

# PandaX - Sensitivity - Low Mass



## Stage Ia

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

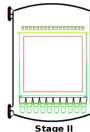
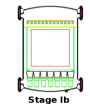
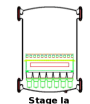
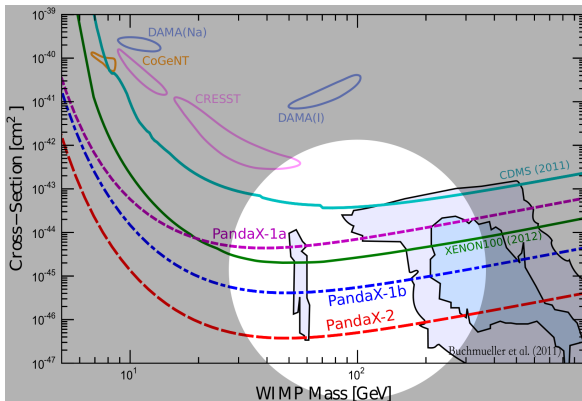
## Stage Ib

- light yield: 2.5 pe/keV<sub>ee</sub>
- S1 energy range: 3-30 pe
- exposure: 300 kg x 180 days
- NR acceptance: 0.35
- estimated bkg events: 0.5

## Stage II

- light yield: 2.5 pe/keV<sub>ee</sub>
- S1 energy range: 3-30 pe
- exposure: 1000 kg x 600 days
- NR acceptance: 0.35
- estimated bkg events: 1.3

# PandaX - Sensitivity - High Mass



## Stage Ia

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

## Stage Ib

- light yield: 2.5 pe/keV<sub>ee</sub>
- S1 energy range: 3-30 pe
- exposure: 300 kg x 180 days
- NR acceptance: 0.35
- estimated bkg events: 0.5

## Stage II

- light yield: 2.5 pe/keV<sub>ee</sub>
- S1 energy range: 3-30 pe
- exposure: 1000 kg x 600 days
- NR acceptance: 0.35
- estimated bkg events: 1.3



# Advantages of PandaX Design

## Environment and Design:

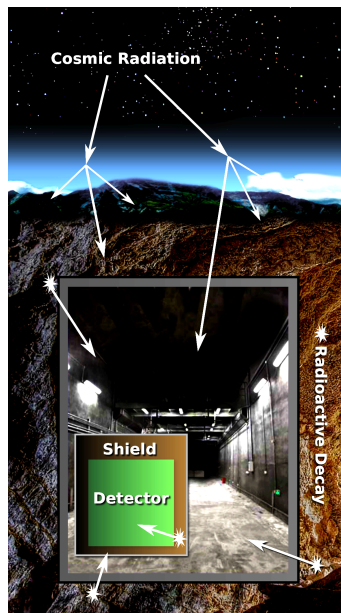
- Very Deep (low muon rate)
- Clean Rock (low radioactivity)
- Simple Shield (easy to service detector)
- Scalable Design (room to grow)

## Major Elements with No Changes:

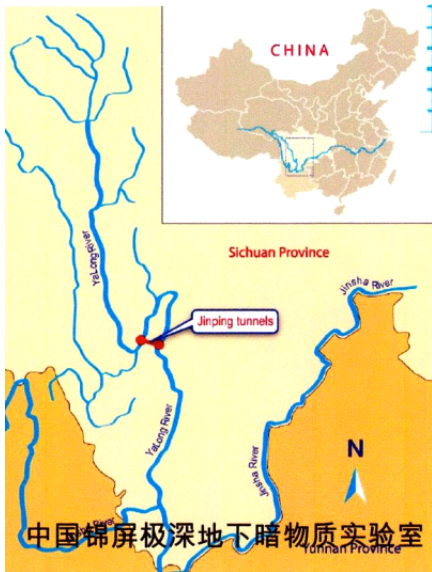
- Shield
- Outer Vessel
- Cryogenics, Purification
- General Infrastructure

## TPC Change from 1a to 1b:

- Same Basic TPC Structure
- Same PMTs
- Same Cabling
- Just Add Height
- Rapid Turn Around

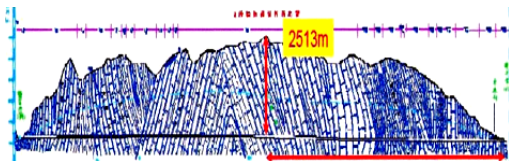


# Earthen Shield: CJPL

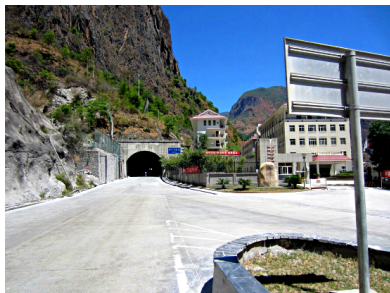
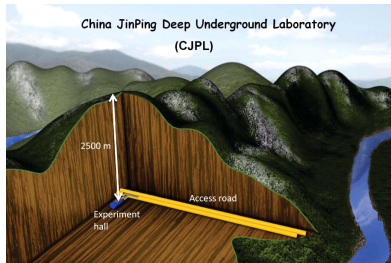


The China JinPing underground Laboratory (CJPL):

- Located in specialized lab added to hydroelectric service tunnels
- Deep lab at 2400 meters of marble ( $\approx 6600$  mwe)
- Easily accessed by road



# JinPing Mountain



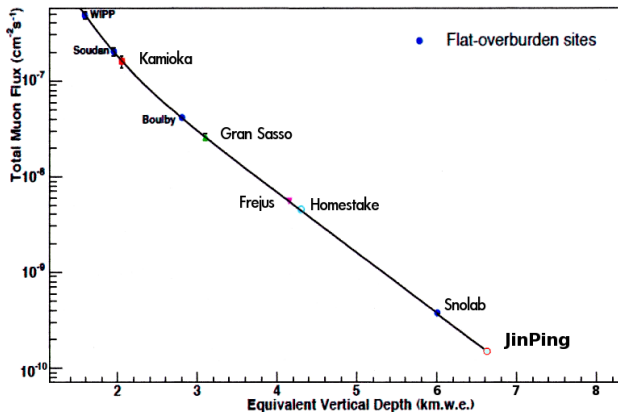
# CJPL Experimental Hall - a while ago



# JinPing Lab: A Low Background Facility

Low cosmic muon background

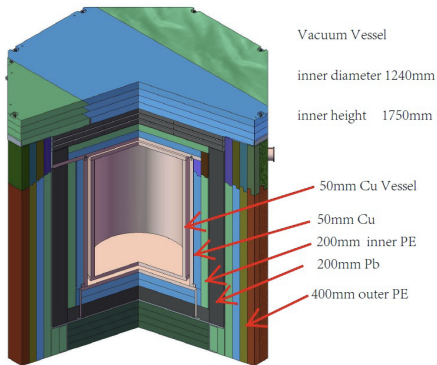
Low radioactivity from rock



Facility	Depth [m.w.e.]	$\mu$ Flux [events/(m <sup>2</sup> ·year)]	Rock	<sup>238</sup> U [Bq/kg]	<sup>232</sup> Th [Bq/kg]	<sup>40</sup> K [Bq/kg]
Jinping (PandaX)	6,600	66	marble	1.8 ± 0.2	< 0.27	< 1.1
Homestake	4,500	950	rhyolite	100	45	900
Grand Sasso – Hall B	3,500	8,030	dolomite	5.2	0.25	4.9

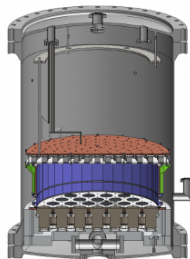
The 66 muons/m<sup>2</sup>/year is an estimate based on 33 days of measurement, less uncertainty soon

# Detector Shield and Ia/Ib Vessel Configuration

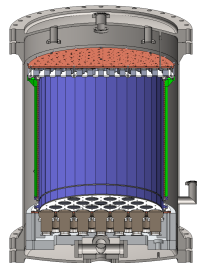


- Low Z (PE) to attenuate  $n$ 's
- High Z (Pb,Cu) for  $\gamma$ 's
- Same shield/outer vessel for all stages

## Stage Ia



## Stage Ib



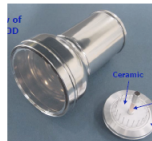
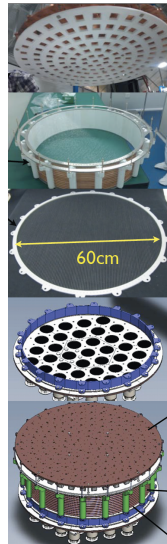
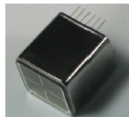
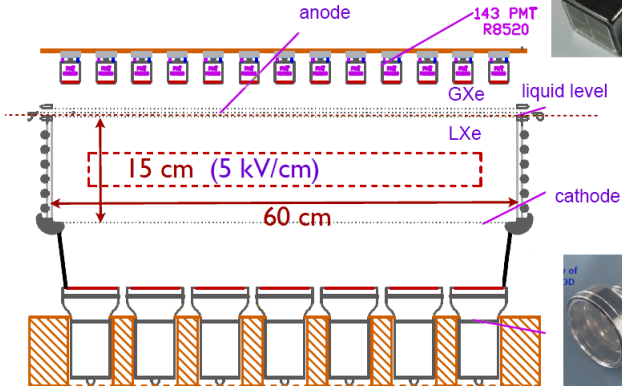
- Same inner vessel for Ia/Ib
- PandaX Ia - 15x60cm 'Pancake'
- PandaX Ib - 60x60cm

# Detailed Stage 1a

**PANDAX: a LXe detector with high field & high light yield**

sensitive mass : 123 kg

fiducial mass: 25 kg



37 R11410 PMT

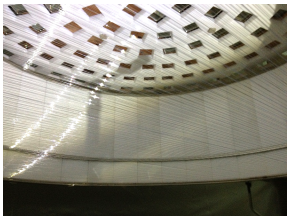
## PandaX in 2012

- Shield constructed at CJPL
- All major components tested at SJTU
- TPC assembled
- Cryogenic system operating
- DAQ testing
- Krypton distillation tower operation
- Move to CJPL started





# Current Status - Stage Ia



PandaX Stage Ia:  
Currently undergoing  
commissioning:

- Major components at CJPL
- Clean room environment: TPC assembled
- Slow control in place
- Cryogenic system operating
- Xenon on site
- Small xenon fill and liquefaction so far
- DAQ installed
- Personnel on site daily



# Summary

## CJPL - A Clean, Deep Site:

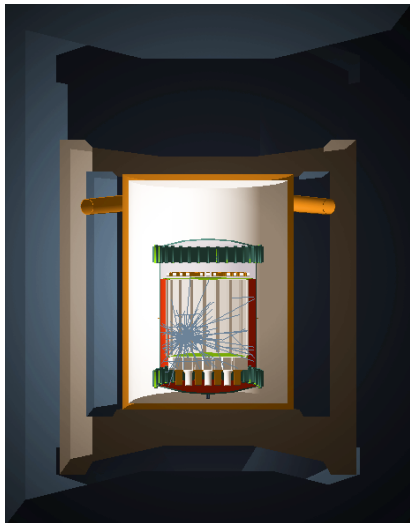
- 6600 m.w.e. → deepest lab
- $66 \mu/\text{yr}/\text{m}^2$ , no  $\mu$  veto needed
- Radioquiet
- Surface accessible

## PX Three Stage Approach:

- PandaX Ia – 25kg (fid) - Low Mass Region
- PandaX Ib – 300kg (fid) - High Mass Region
- PandaX II – 1Ton (fid) - few  $\times 10^{-47} \text{cm}^2$  level

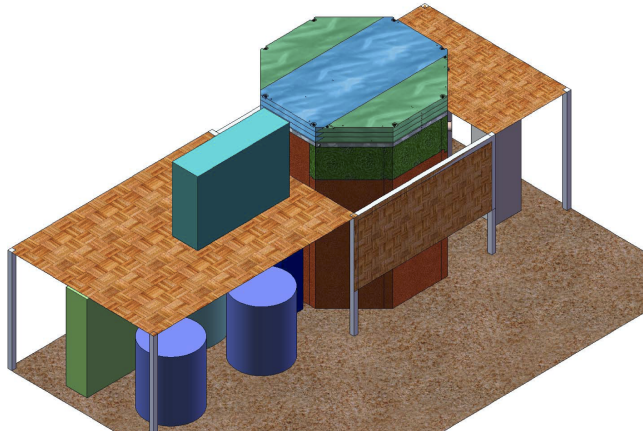
## Rapid Pace:

- Built for Stage II from the beginning
- Installing Stage Ia now
- Probing new parameter space within the year
- Stage II starts in  $\sim 2$  years



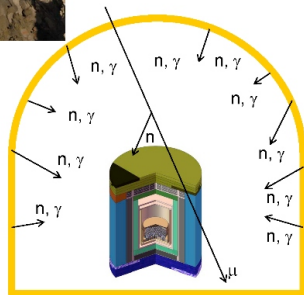


Thank you



## Backup

# CJPL Background



## Background Sources

Rad. Level, CPUL, Bq/kg

	<sup>238</sup> U	<sup>232</sup> Th	<sup>40</sup> K
Rock	1.8	<0.27	<1.1
Concrete aggregate	2	0.7	-
Concrete	60	25	130

Rad. Level, external shield material

mBq/kg

	<sup>238</sup> U	<sup>232</sup> Th	<sup>60</sup> Co	<sup>40</sup> K	<sup>210</sup> Pb
OFC	<0.07	<0.03	<0.0045	<0.06	-
PTFE	0.23	<0.094	<0.89	0.7	
Pb	<0.92	<0.72	<0.12	14	530

- simulated m flux:  $8 \times 10^{-11}/\text{cm}^2/\text{s} = 25/\text{yr}/\text{m}^2$
- measured m flux:  $6/\text{m}^2/33\text{days} = 66/\text{yr}/\text{m}^2$  (compared 100 Hz/m<sup>2</sup> at sea level)

facility	depth [mwe]	$\mu$ flux [events/yr/m <sup>2</sup> ]	rock	<sup>238</sup> U [Bq/kg]	<sup>232</sup> Th [Bq/kg]	<sup>40</sup> K [Bq/kg]
Jinping (PandaX)	7,500	66	marble	$1.8 \pm 0.2$	< 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

# UM PandaX Group



**Wolfgang Lorenzon**



**Greg Tarle**



**Tom Schwarz**



**Tim Chupp**



**Dave Gerdes**



**Michael Schubnell**



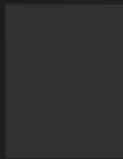
**Richard Raymond**



**Scott Stephenson**



**Dan Marley**



**Lu Ma**

**PandaX  
Michigan  
Group**



**Curtis Weaverdyck**



**Jon Ameal**

**Mykola Murskyj  
Ronak Mehta  
Zack Jackson  
Fiona?**

**Undergrads**



# PandaX - Krypton Distillation Tower



# PandaX - EM Background Spectrum

