PANDA-X
A New Detector for Dark Matter Search

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Jin Ping Laboratory

Newly constructed deep underground lab in the south of China, Sichuan Province

Now available for installation of detectors
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2500 m of rock overburden

About 7500 m.w.e.

25 – 50 Muons per year

A muon veto is unnecessary

25 – 50 Muons per year
The lab was designed and built by Tsinghua University, Beijing and ERTAN power company.

The lab is 40 m x 7 m and 6.5 m high.

PANDA – X will occupy the last 10 m, but we must leave half the width for trucks to pass.
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PANDA will have a passive shield in the classical form of

- 5 cm OFHC copper
- 20 cm polyethylene
- 20 cm lead
- 40 cm polyethylene

In an octagonal shape.

- No active shield!
- No water shield!
- No muon veto shield!

The innermost 5 cm of copper form a hermetic cylinder of 1.35 m diameter and 1.85 m height.

This is also the outer vessel of the vacuum cryostat.
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 fully developed at Jiao Tong.

The Panda team:
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Direct detection of Dark Matter (WIMPs)
Overview of present results
Charge and light yield depend on ionisation density.
## PANDA-X Dark Matter Search

### Advantages of Liquid Xenon

- High Density (3 g/cm³)
- Large Atomic Number (σ<sub>si</sub> prop. A<sup>2</sup>)
- Spin Independent + Dependent (¹³¹Xe)
- Easy Scale up to Large Detector Mass
- No Long-Lived Radioactive Isotopes
- Efficient Scintillator (80% of NaI(Tl))
- No Wavelength Shifter (178 nm)
- Transparent to Scintillation Light
- Dielectric Strength >few 10<sup>5</sup> V/cm
- Charge depends on Ionization Density

### Problems of Xenon

- Cryogenic (-100°C)
- <sup>85</sup>Kr contamination
- VUV light
- Expensive
Technologies which make large detectors possible

- PTR – Cooling: low maintenance, reliable, stability
- VUV - PMTs: optimized for Xe, high $Q_e$, low T, high P, low RI, fast
- Recirculation
  - Purification: electron drift times > msec
- Dual Phase: Charge measurement with proportional scintillation
- Liquid Distillation: Kr removal
- Combined Charge
  - Light Signal: very good energy resolution
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WIMP Detection Challenge:  Background Discrimination

Signal:  < 0.1 /kg/day (background 106 /kg/day < 100 keV
point like, no other feature

\[ \sigma_{\chi p} = 5 \times 10^{-7} \text{ pb} \]
Self-shielding effect can be easily seen in data from XENON100 (arXiv1005.0380)
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Additional Background discrimination by light and charge collection
Amplification of $s_2 \approx 100$

Enhanced discrimination due to Gamma – Neutron Band separation
Better position resolution (double hit resolution)
Less fiducial volume cut required

But:
- Large area grids
- Precise level control
- HV feedthroughs
- Grids must be leveled (parallel to liquid surface)
- High electric field
- Large dead time
- in gas space
- Large amount of digitizer data
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Higher drift field enhances the Gamma – Neutron band separation

XENON100 $E_{\text{drift}} = 0.5\text{kV/cm}$
99% gamma rejected

ZEPLIN-III $E_{\text{drift}} = 3.9\text{kV/cm}$
99.9% gamma rejected

PRD 80, 052010 (2009)
Example from XENON100: All 22 events in fiducial volume failed S2/S1 and single hit cut

XENON100
arXiv1005.0380
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Excellent position resolution: 2 mm perp. to el. Field
1 mm along el. field

Mean free paths:       MeV Gamma  3 cm
                      MeV Neutron 30 cm

XENON100
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
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Schematic Lay out of the inner structure of Panda

- **Anode + Grid Assembly**
- **Top Array**
  - 143 R8520
- **Liquid Level**
- **Cathode Mesh**
- **Cone shaped Light Guides**
- **Fiducial Volume 25 kg**
- **Active Volume**
- **Bottom Array**
  - 37 R11410
  - 3” round
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Panda in it’s Shield

Removable Top Cover

- 5 cm OFHC copper (outer vessel)
- 20 cm polyethylene
- 2 cm OFHC copper
- 20 cm lead
- 40 cm polyethylene
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Panda will have a high and uniform light collection efficiency
The high light collection efficiency at high fields assists in rejecting background.

- **XENON100**
  - $E_{\text{drift}} = 0.5\text{kV/cm}$
  - 99% gamma rejected

- **ZEPLIN-III**
  - $E_{\text{drift}} = 3.9\text{kV/cm}$
  - 99.9% gamma rejected
# PANDA-X  Dark Matter Search

## Comparison of Xenon based Experiments

<table>
<thead>
<tr>
<th></th>
<th>Zeplin III</th>
<th>XENON100</th>
<th>XMASS</th>
<th>LUX</th>
<th>PANDA-X</th>
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</thead>
<tbody>
<tr>
<td><strong>Fiducial Mass</strong></td>
<td></td>
<td></td>
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<tr>
<td>Total (kg)</td>
<td>12</td>
<td>270</td>
<td>800</td>
<td>300</td>
<td>120</td>
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<tr>
<td>Fiducial (kg)</td>
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<td>60</td>
<td>100</td>
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<td>25</td>
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<td><strong>Electron Recoil</strong></td>
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<tr>
<td>Rejection ( % )</td>
<td>99.9</td>
<td>99</td>
<td>0</td>
<td>99</td>
<td>99.9</td>
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<tr>
<td><strong>Energy Threshold</strong></td>
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<tr>
<td>(keVr)</td>
<td>10</td>
<td>9</td>
<td>20</td>
<td>10</td>
<td>5</td>
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<tr>
<td><strong>Sensitivity</strong></td>
<td></td>
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<tr>
<td>at 100 GeV (cm²)</td>
<td>10⁻⁴⁴</td>
<td>2x10⁻⁴⁵</td>
<td>10⁻⁴⁵</td>
<td>3x10⁻⁴⁶</td>
<td>4x10⁻⁴⁵</td>
</tr>
<tr>
<td>10 GeV (cm²)</td>
<td>&gt;10⁻⁴²</td>
<td>3x10⁻⁴³</td>
<td>&gt;10⁻⁴²</td>
<td>4x10⁻⁴⁴</td>
<td>10⁻⁴⁴</td>
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<td><strong>Status</strong></td>
<td>Science</td>
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<td>Operation</td>
<td>Surface Testing</td>
<td>Construction</td>
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<td>Run</td>
<td>Run</td>
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Comparison of Xenon based Experiments
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Schedule:

Civil engineering of underground lab completed

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

Most of the equipment is expected before end of March

Above ground lab at SJTU preparation nearly completed

Above ground tests of complete set up to start in June

Installation of shield underground to start end of March

Counting facility to be assembled before end of March

Underground installation of detector: September
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SJTU only recently started with xenon technology. A year ago rather few of infrastructure existed. In the mean time:

- Equipped a lab for the development of Panda.
- Set up a machine shop to support our activities
- Built small test system
- Set up gas supply system and recirculation for high flow rates
- Set up PMT test facility
- Started development of Kr removal column
- Started development of Read Out system
- Started development of counting facility in Jin Ping lab
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Some of the recent activities:

- Removable Top Cover
- Storage
- Purification
- Prototype detector
- Cryogenic testing
- PMT base
- PMT testing facility