PANDA-??
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

Depth: 7500 m.w.e.
Low radioactivity rock
Double Phase approach, i.e. discrimination by light and charge collection.
PANDA-X  Dark Matter Search

Schematic Lay out of the inner structure of Panda (25 kg)

- Fiducial Volume 25 kg
- Anode + Grid Assembly
- Top Array 143 R8520
- Liquid Level
- Cathode Mesh
- Cone shaped Light Guides
- Bottom Array 37 R11410 3” round
Inner structure of Panda ready to be installed.
Panda in it’s Shield

5 cm OFHC copper (outer vessel)
20 cm polyethylene
2 cm OFHC copper
20 cm lead
40 cm polyethylene

Removable Top Cover

Shield construction will start in December (about 60 days)
Test Set Up for Panda in aboveground lab (Shanghai).

- Outer Vessel (about 1.2 m into ground)
- Heat Exchanger
- PTR
- LN2 Cooling
Gas Storage system. Only one 300 kg (80 bar) gas cylinder and dewar is now installed.

SAES Getter in background. All behind cryogenic system.
Inner vessel currently baking under vacuum.

This SS vessel is only for tests. The final vessel will be Ti
PANDA-X Development Plan

The shield and the outer vessel are sufficiently large.

500 kg: PTFE panels, Shaping Rings to be replaced.

1000 kg: New detector structure in larger inner vessel.
PANDA-X  Summary

Panda-X is being assembled in lab aboveground
Installation underground in early spring 2012

Detector can be easily expanded from 25 kg up to 500 kg

1000 kg detector is planned. This detector requires new inner structure, new inner vessel and many more PMTs.

Space in JinPing lab, passive shield, and cryogenic system are already foreseen for 1 ton detector

However, scale up of LXe detectors is becoming increasingly difficult. Some details of the design have to be changed for the 1 ton (or larger) detector.
Leveling and Level Control
Make design much more
complicated.

Leveling and Level Control
are not desirable
Remove Overflow Chamber
and
Level Glides

Overflow chamber adds a
lot of material, i.e.
background
PANDA-X Problems with Design

Anode-Cathode distance: 84 cm
At 1 kV/cm: 84 kV
Max drift time: 415 µsec

Anode with typically 5 kV in gaseous xenon

Cathode HV too close to Bottom PMTs

HV feedthrough is not so easy to realize above 50 kV
PANDA-X Problems with Design

- Top PMT make too much background
- Light guide cones less efficient than expected
- Too many PMTs on Top and Bottom.
- Too many electronic channels
- Background dominated by PMTs and bases
- Too many cables
Light efficiency reduced by PTFE reflector panels.

PTFE makes problems with background
Everything else is okay and does not have to be changed!

We need a new, different concept for Panda ??
1 ton PANDA-X

Proportional Scintillation in **liquid** xenon with small test chamber

Very thin wire 4 µm

Proportional counter 6 mm diameter

HV up to 3 kV

Homogeneous field in drift space, radial field around anode wire.

*Miyajima et al., NIM160(1979)239*
Results with $\alpha$ - source

Charge gain observed at large fields

Charges nearly saturate at 1 kV, but increase again above 1.5 kV, when charge multiplication starts.

However, charge multiplication adds more fluctuations, i.e. loss in energy resolution. Limitation to Proportional Scintillation might be better.
Drifting electrons are accelerated in between collisions by the electric field. But, below a threshold energy they can not start an electron avalanche.

There is a plateau at no gain between 1 kV and 1.5 kV. The acceleration is not sufficiently strong to start an avalanche, but Xe atoms can be excited and photons can be created above a much lower threshold.
The energy resolution can get much worse due to charge multiplication.

But energy resolution not very important for WIMP search. A small charge gain can be tolerated.
Direct and secondary scintillation pulses at 1.6 kV and 3.0 kV.

The time scale is the same, but the amplitude scale is reduced by a factor 2.

Secondary scintillation pulses at 2.8 kV. The time scale is 200 nsec/iv.)
Light at different voltages. At 1.6 kV nearly no charge gain, but a factor 10 more light.

We do not need a large light gain.

A very large difference between primary and secondary light does require a very large dynamic range!
Different geometry, similar results, but also thicker wires.

Masuda et al., NIM160(1979)247
Energy resolution of Proportional Scintillation comparable to charge measurement with CSA.

However, energy resolution will be much better with Charge – Light combination.
We should operate just at the onset of charge multiplication.
At SJTU we will study Proportional Scintillation in liquid with a small test chamber.

System is ready to start tests.
1 ton PANDA-X

Pieces for the test detector are already prepared.

Simple gridded Ionization Chamber with Charge and Light Read Out
With Proportional Scintillation in liquid xenon, all the structure can be immersed.

Up and down are equivalent, and we can make several drift regions.

Example: 4 drift regions, 21 cm length each. Two cathodes and 3 anode – grid assemblies.

Liquid level far above top anode assembly.
The New and Improved PANDA-1T

Advantages:

1. Liquid level far above top anode

2. No leveling necessary

3. For 1 kV/cm total HV 21 kV instead of 85 kV

4. Cathode (HV) far from Bottom Photo Sensor
   a. No problem with high E-field
   b. No $\gamma$-rays interacting in front of PMT

5. Max. drift time 105 $\mu$sec instead of 420 $\mu$sec
   a. Less purity requirement
   b. Less dead time
   c. Less digitized data

6. No Anode HV in gaseous xenon.
Light Read Out for PANDA-1T

Arrangement of photo sensors in the LXe:

Top and bottom array fully symmetric:
Both will be used for S1 and S2 detection

Light cones not very effective (will be removed)

Sides have to be covered by sensors.

Usual requirements still valid:

a. Immersed in liquid
b. Operating temperature -110°C
c. Pressure > 3 bar
d. High $Q_e$ (and also Collection Efficiency)
e. Large coverage of areas
f. Low radioactivity
Simulation of Panda 25k shows that light collection is not symmetric. And the 25 kg is already the best case!
Only choice: **Gaseous Photo Multiplier**

- ThickGEM single stage
- Micromegas for additional gain
- CsI Photocathode
- Transparent Photocathode
- UV-Quartz Envelope

A lot of work development work already done by Amos Breskin (Weizman Institute) and others.

Main job left: Packaging

SJTU wants to join RD51 collaboration in February 2012
Light Read Out for Panda 1T

Size 8” x 8” (or 8” x 4”), Pixel size about 1” x 1”
Sides : 60 pieces (to be optimized)
Top, Bottom 30 + 30 pieces (to be optimized)
Ar- CF$_4$ - 95%-5%
Transparent Photocathode

UV Quartz Window  
CsI Photocathode  
ThGEM  
Micromegas
The New and Improved PANDA-1T

Final size, aspect ratio, and relative location in the vessel to be optimized.

Field shaping by wire rings hold in place by support structure.

A lot of work ahead, but no problems in principle.

Final performance to be evaluated with simulations.