PANDA-??
A New Detector for Dark Matter Search

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Seminar at KEK, Tsukuba Japan
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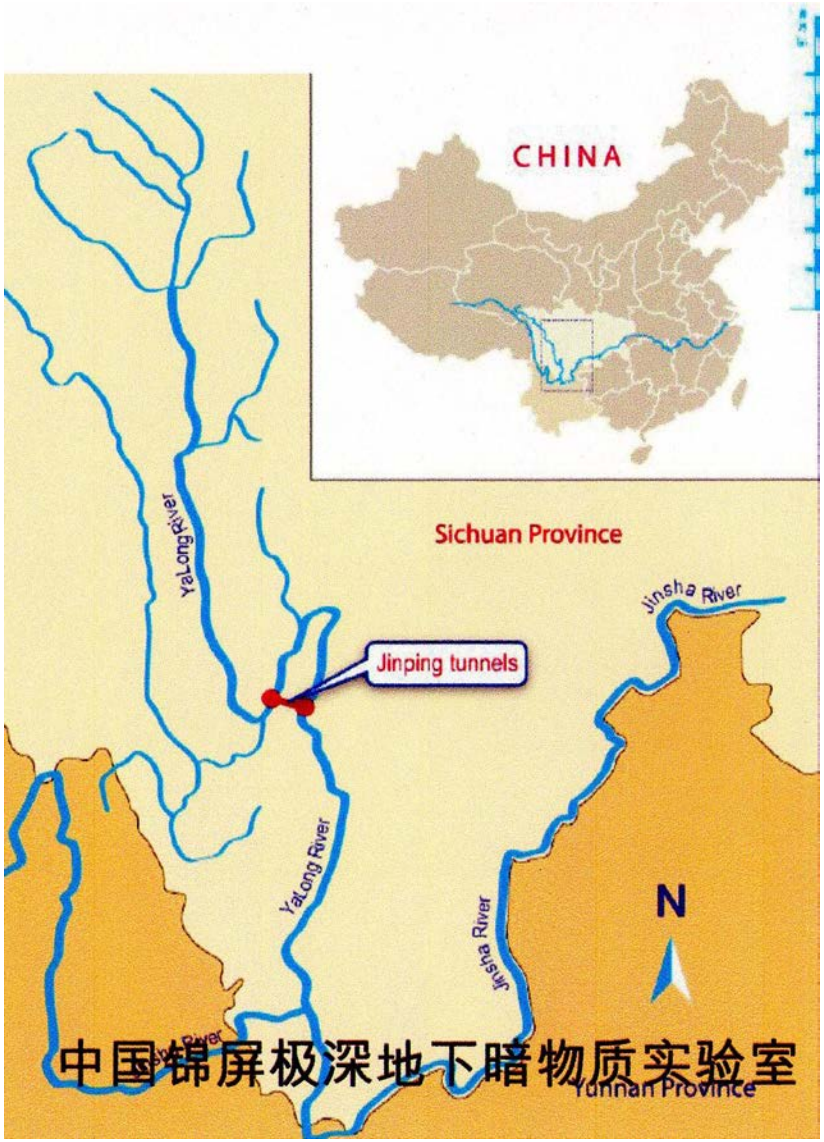
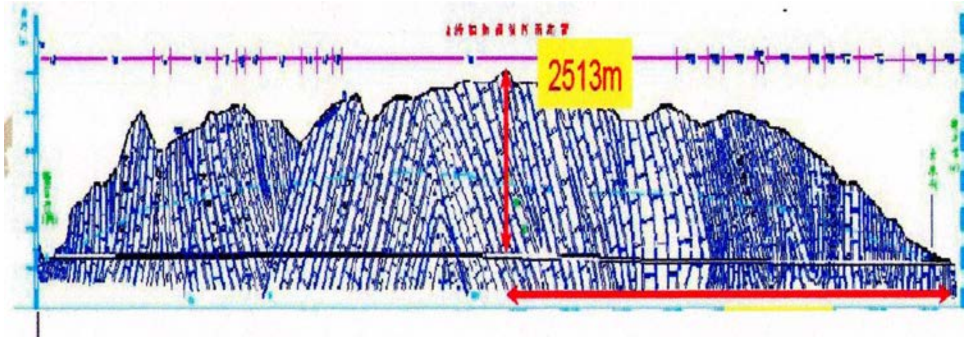
PANDA-X Dark Matter Search



Jin Ping Laboratory

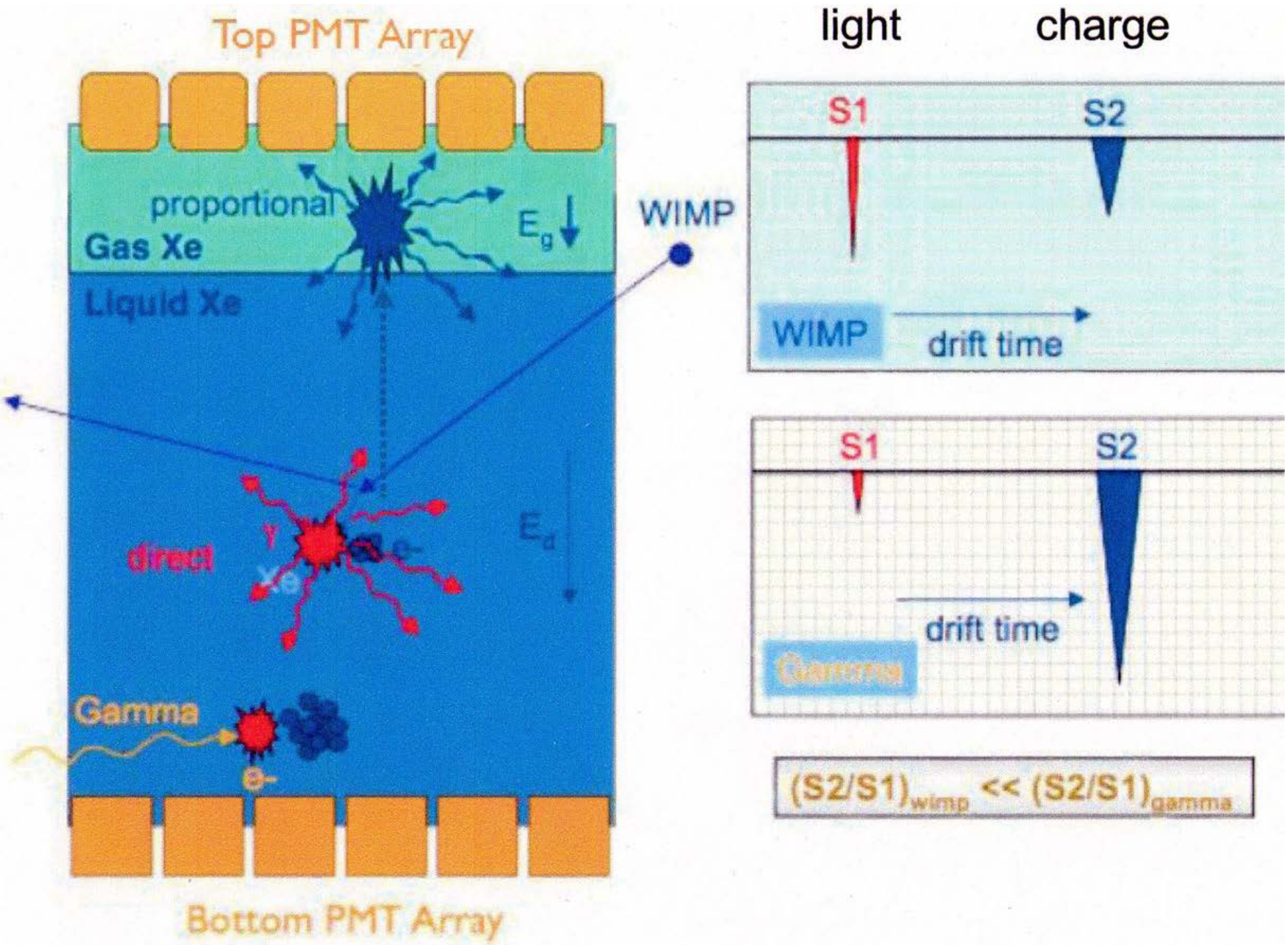
Newly constructed deep underground lab In the south of China, Sichuan Province



Depth: **7500 m.w.e.**
Low radioactivity rock

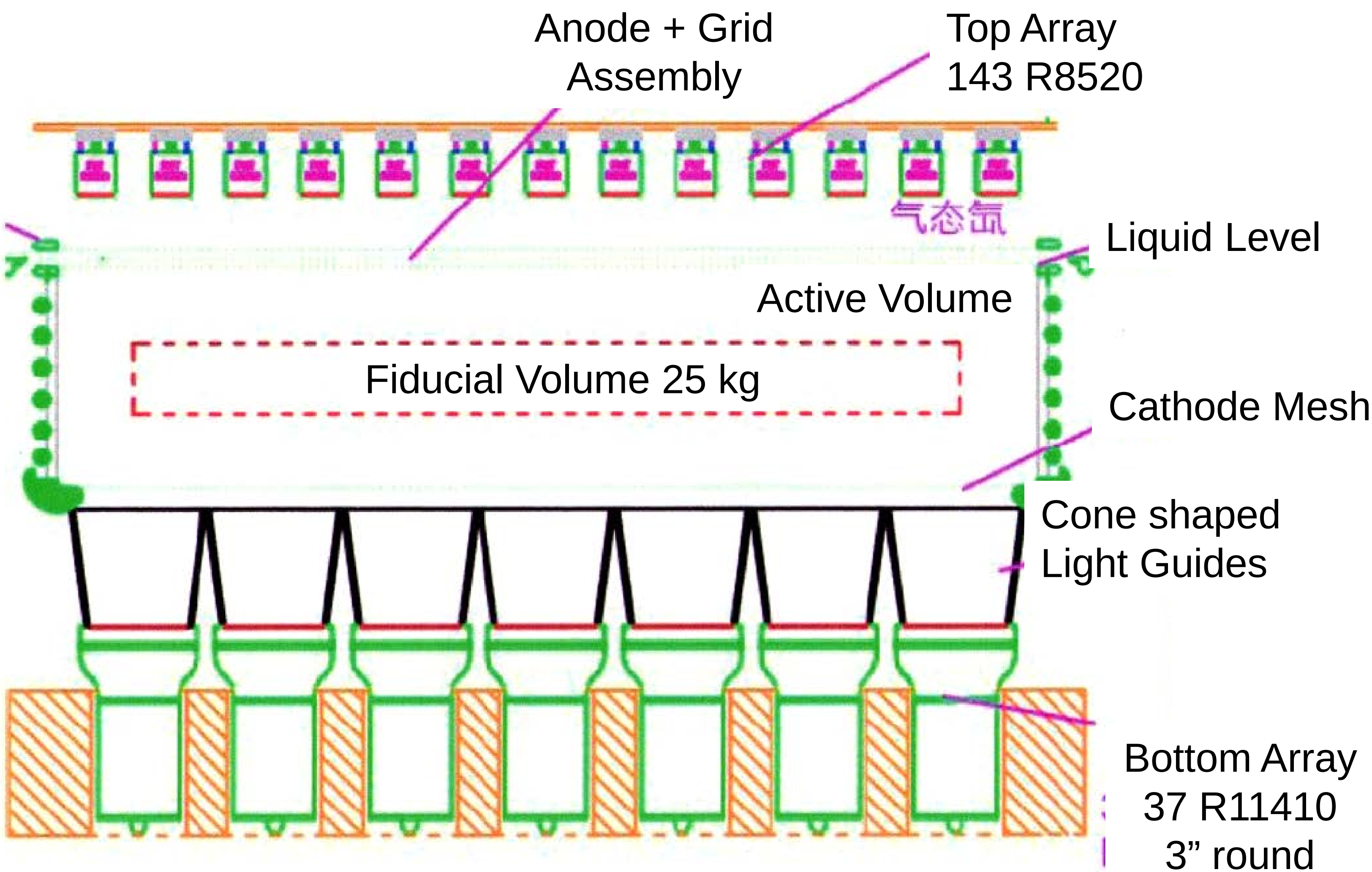
PANDA-X Dark Matter Search

Double Phase approach, i.e. discrimination by light and charge collection



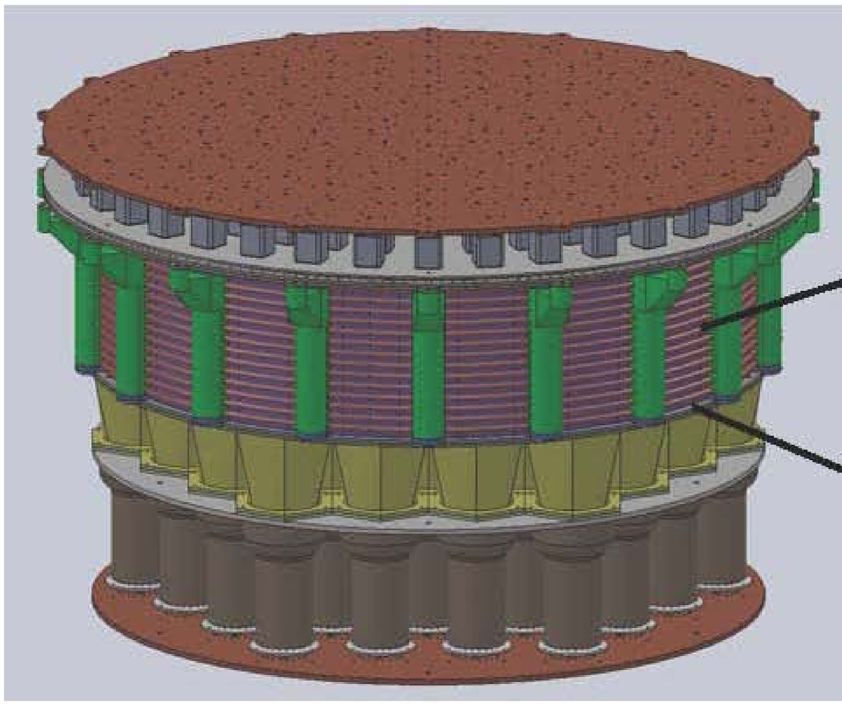
PANDA-X Dark Matter Search

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



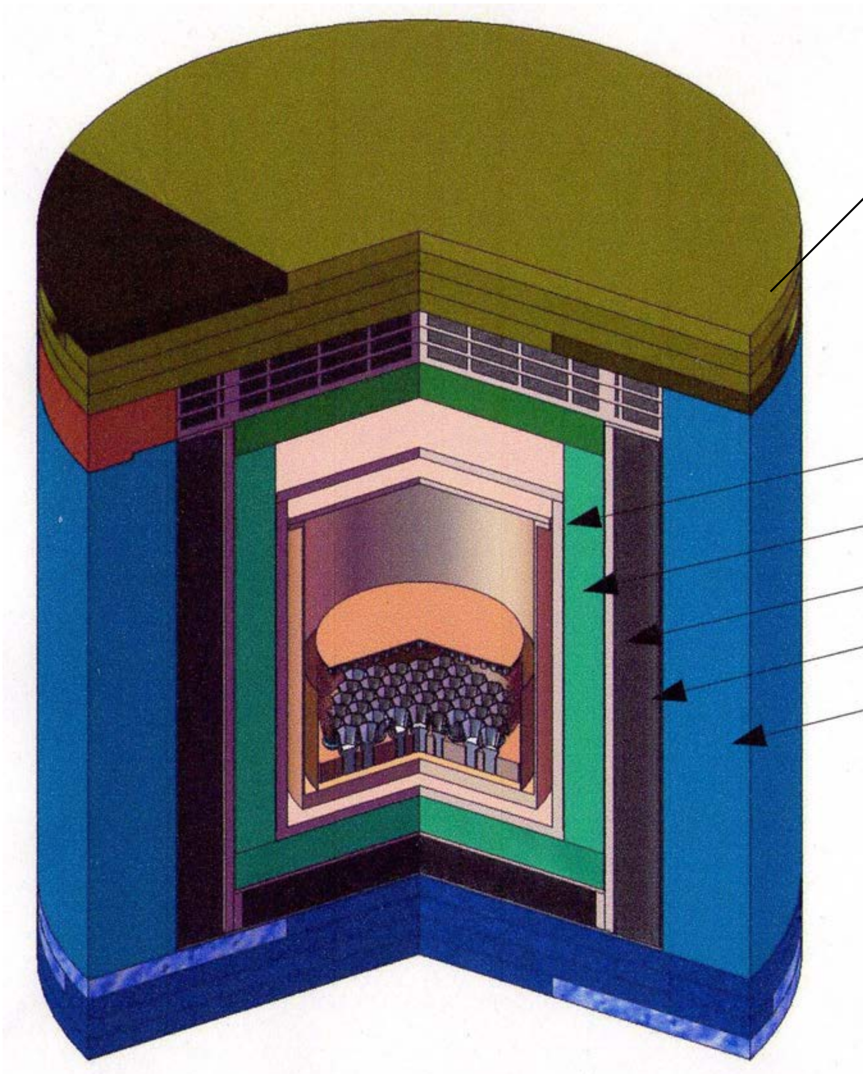
PANDA-X Dark Matter Search

Inner structure of Panda ready to be installed.



PANDA-X   Dark Matter Search

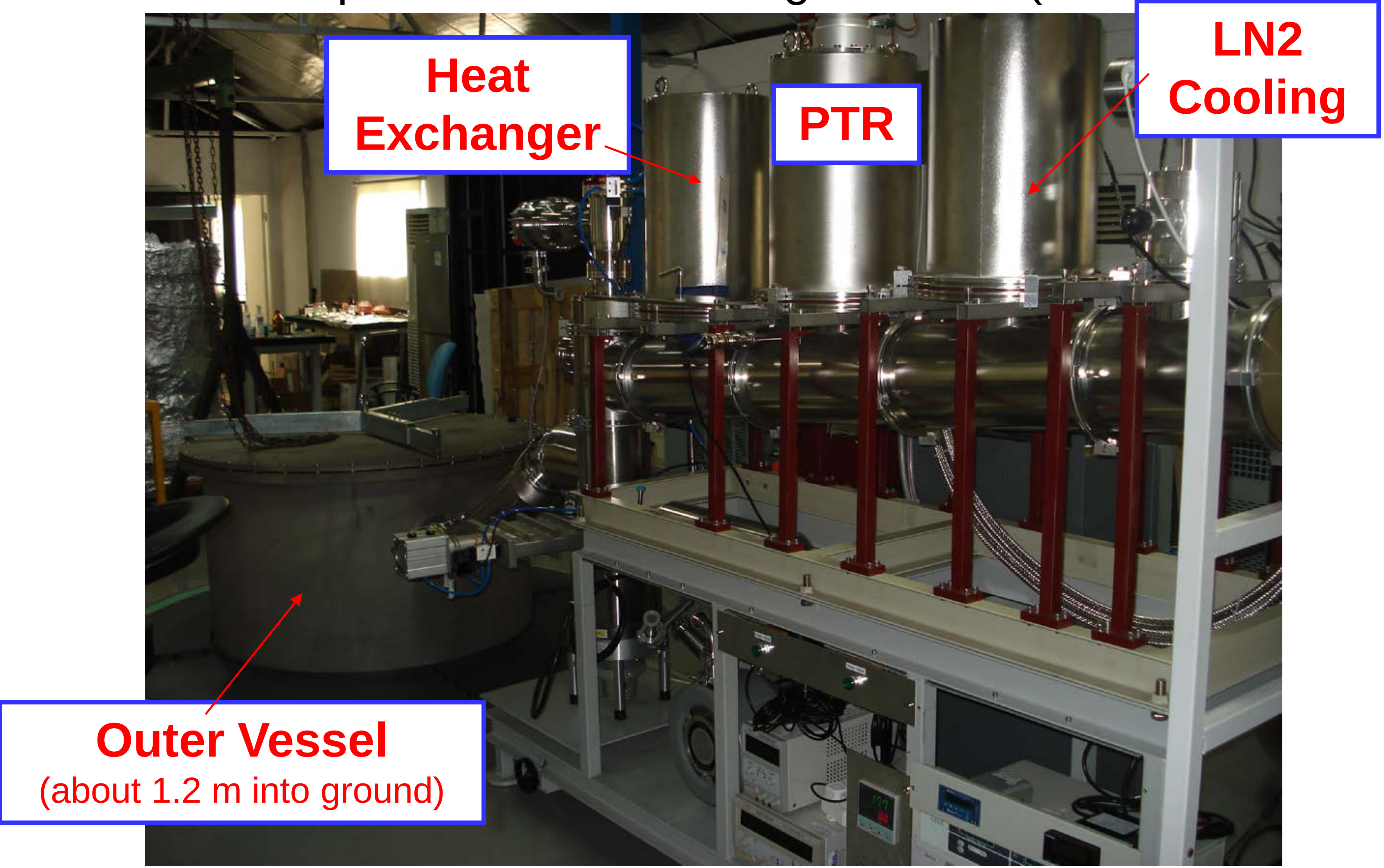
Panda in it's Shield



Shield construction will start in December (about 60 days)

PANDA-X Dark Matter Search

Test Set Up for Panda in aboveground lab (Shanghai).



PANDA-X Dark Matter Search

Gas Storage system. Only One 300 kg (80 bar) gas cylinder and dewar is now installed.

SAES Getter in background. All behind cryogenic system

PANDA-X Dark Matter Search

Inner vessel currently baking under vacuum.

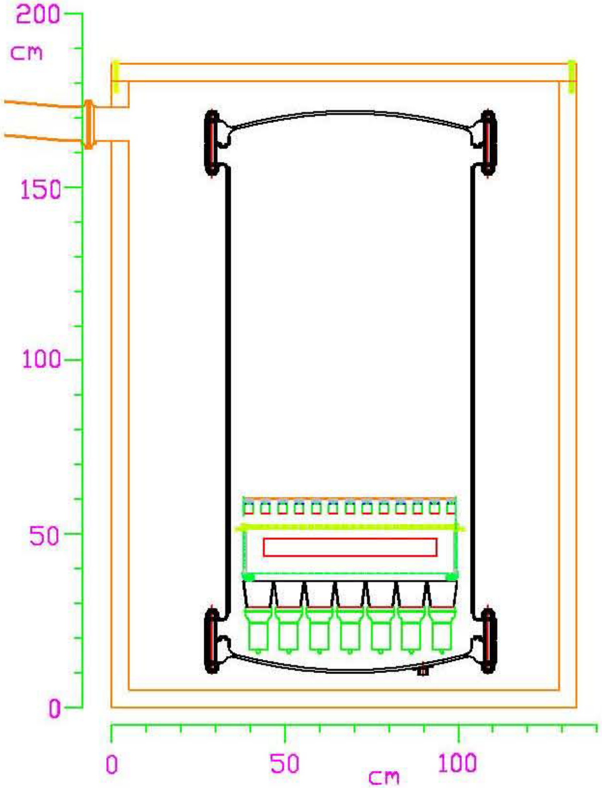
This SS vessel is only for tests. The final vessel will be Ti

PANDA-X   Development Plan

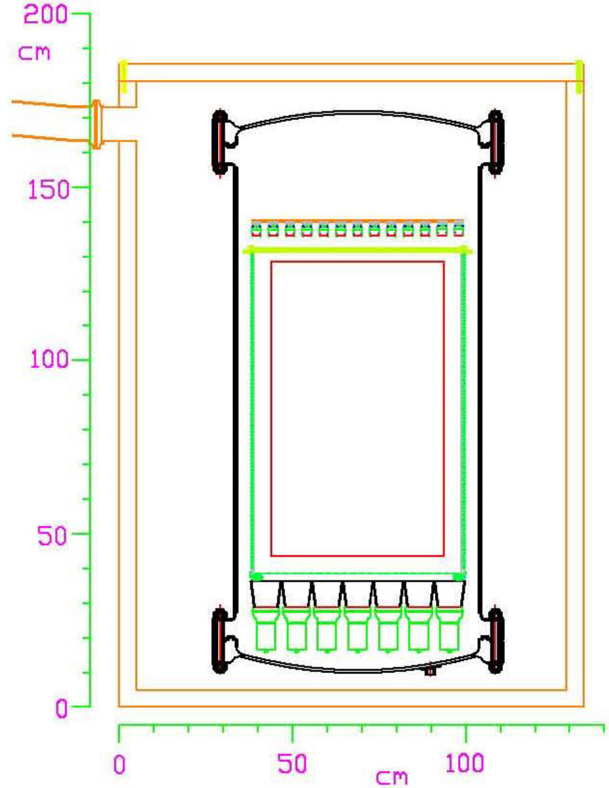
The shield and the outer vessel are sufficiently large

500 kg: PTFE panels, Shaping Rings to be replaced

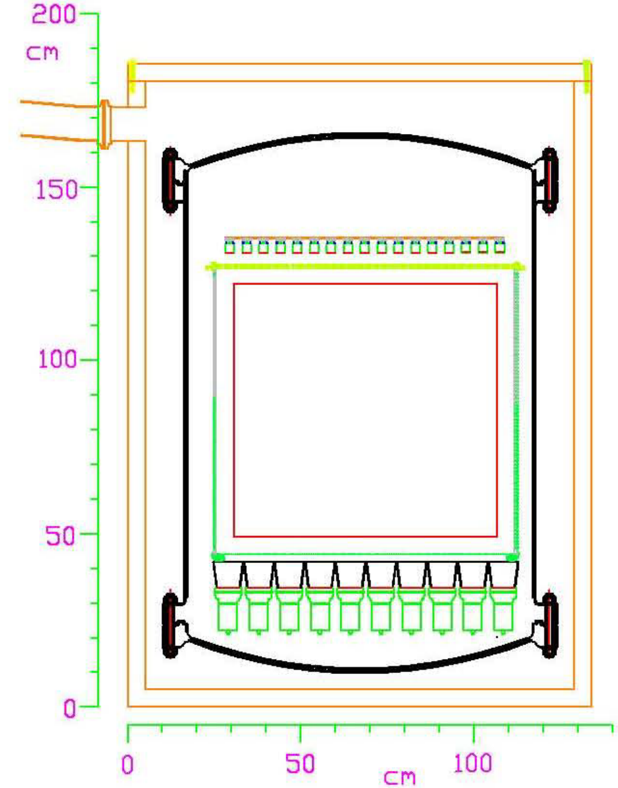
1000 kg: New detector structure in larger inner vessel



25 kg



500 kg



1000 kg

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.

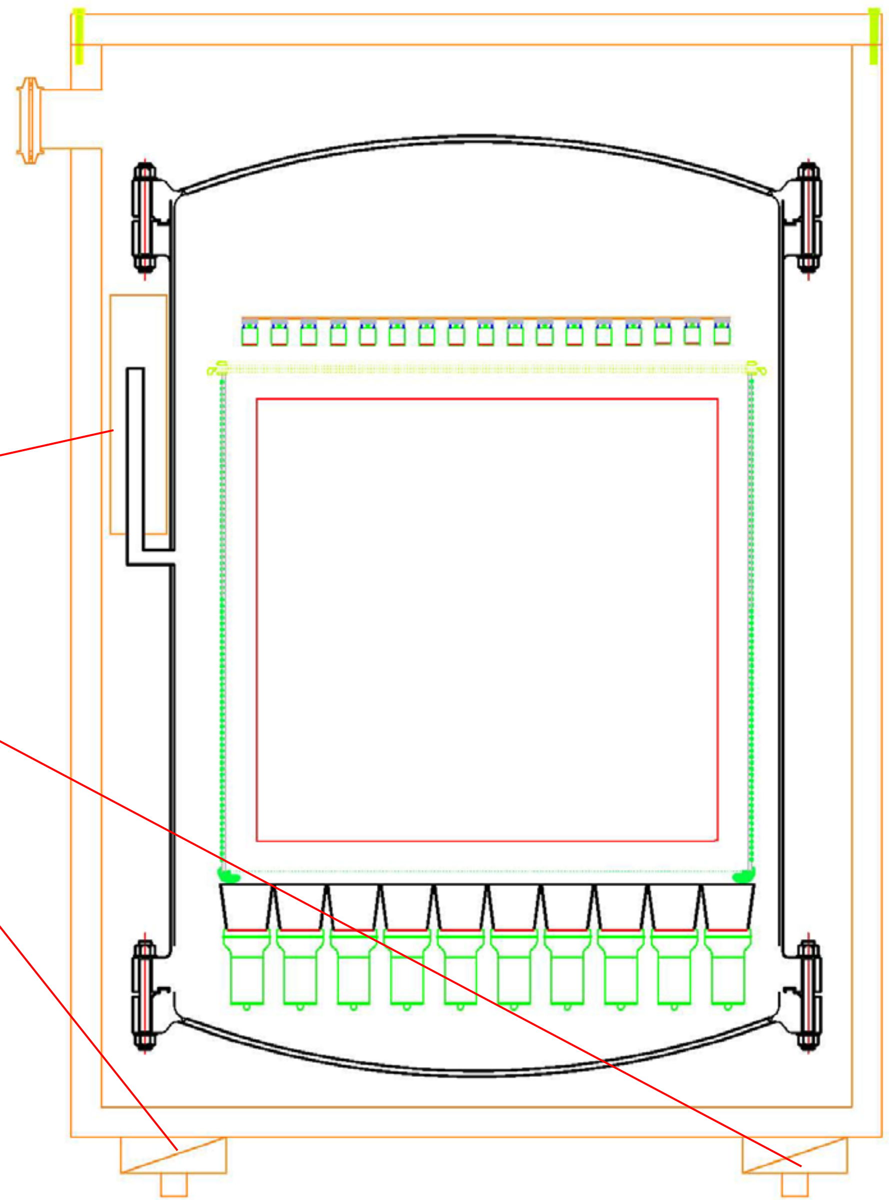
Space in JinPing lab, passive shield, and cryogenic system are already foreseen for 1 ton detector

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.

PANDA-X Problems with Design

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

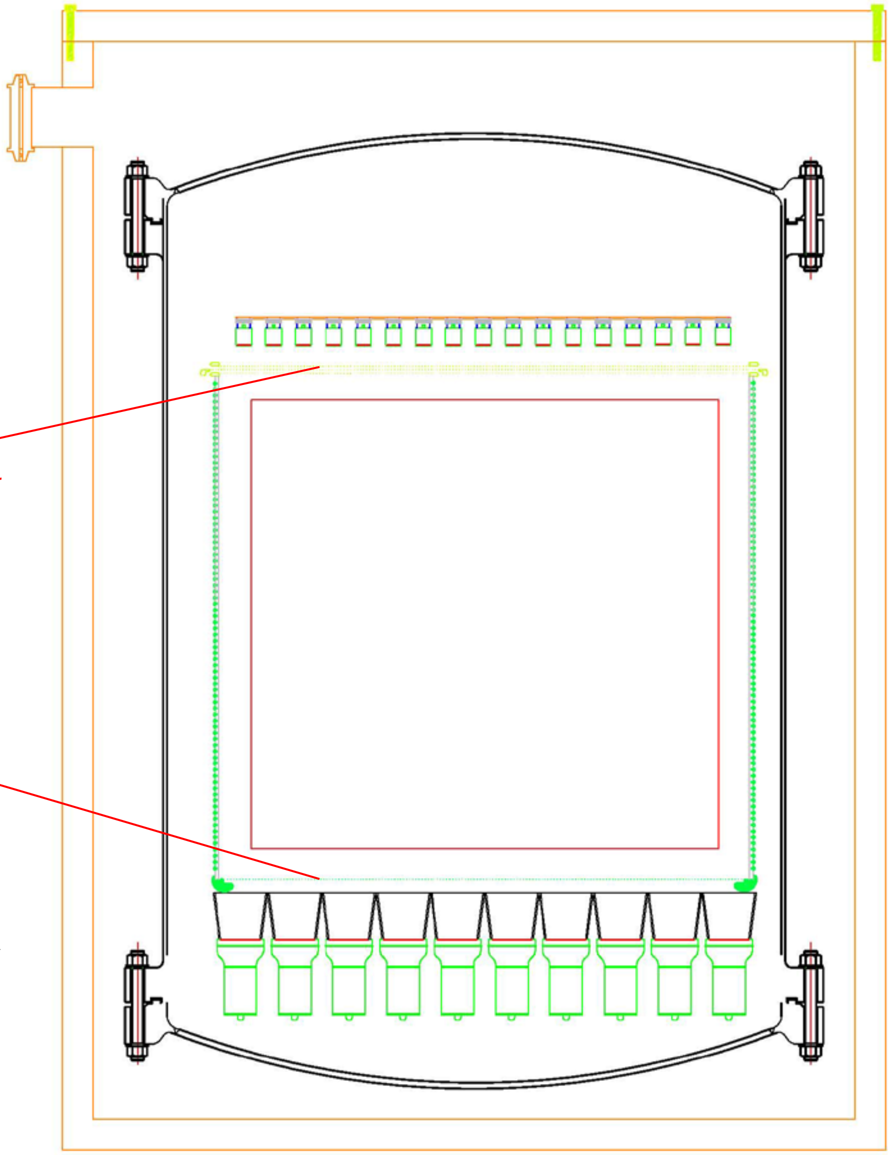
PANDA-X Problems with Design

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

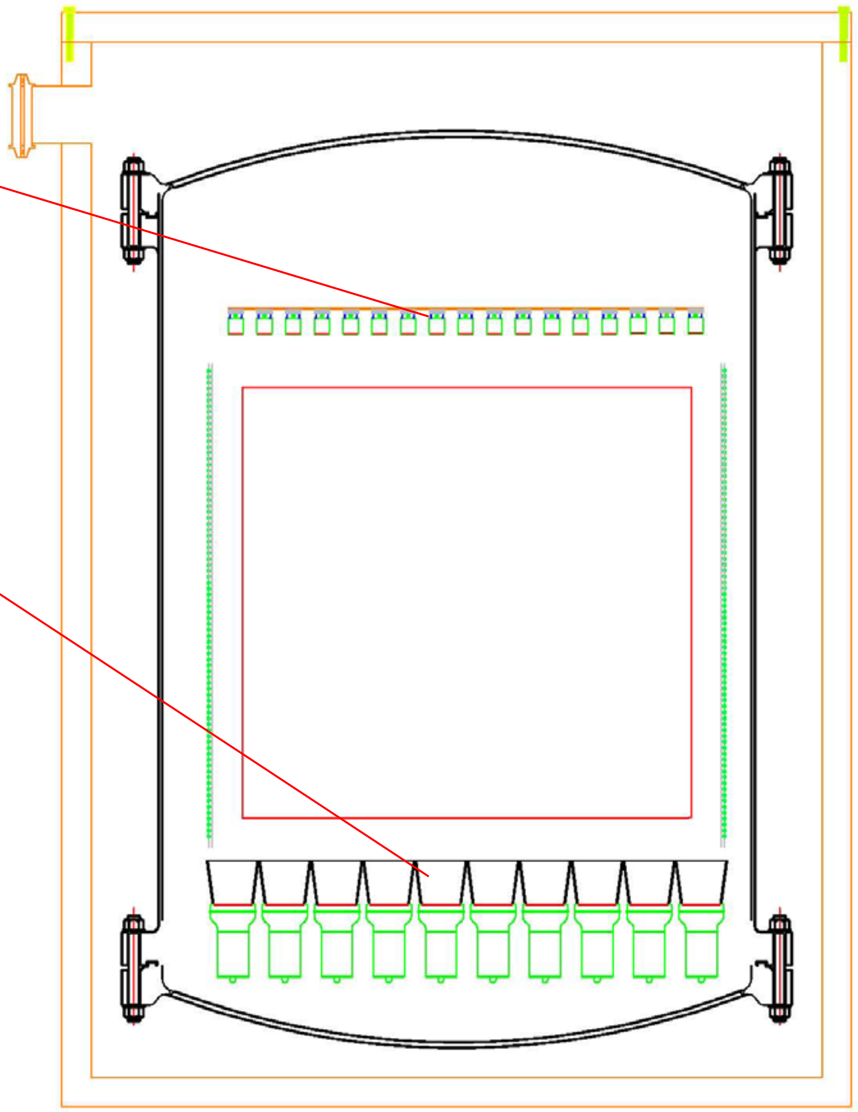


PANDA-X Problems with Design

Top PMT make too much background

Light guide cones less efficient than expected

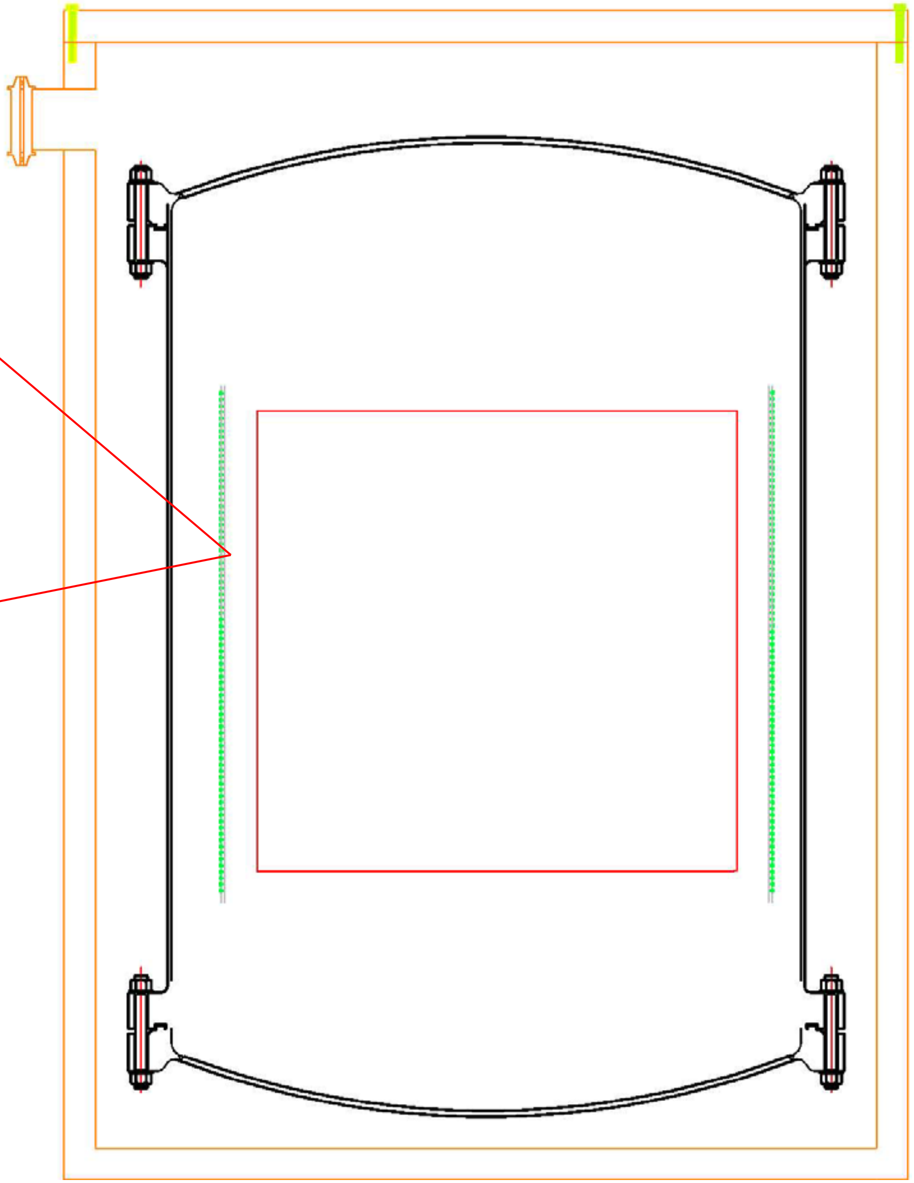
Too many PMTs on Top and Bottom.
Too many electronic channels
Background dominated by PMTs and bases
Too many cables



PANDA-X Problems with Design

Light efficiency reduced by PTFE reflector panels.

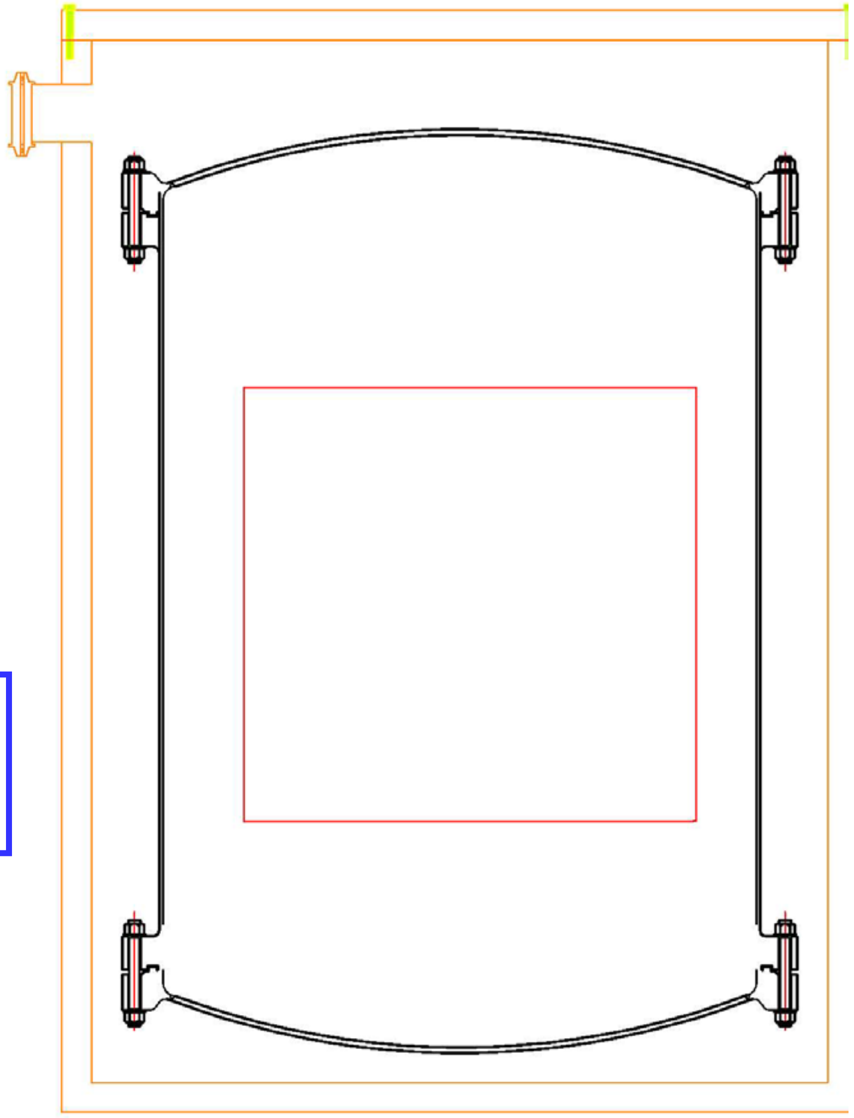
PTFE makes problems with background



1 ton PANDA-X

Everything else is okay and does not have to be changed!

We need a new, different concept for Panda ??



1 ton PANDA-X

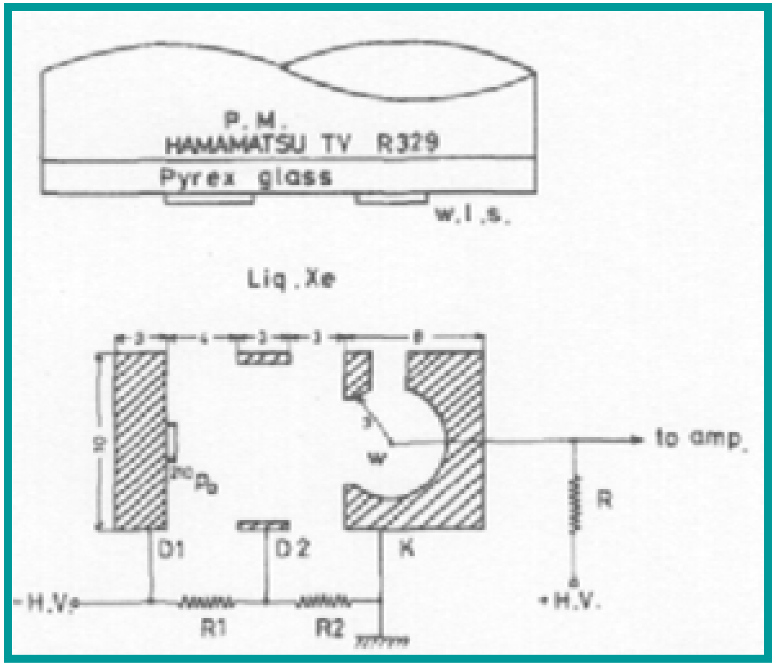
Proportional Scintillation in liquid xenon with small test chamber

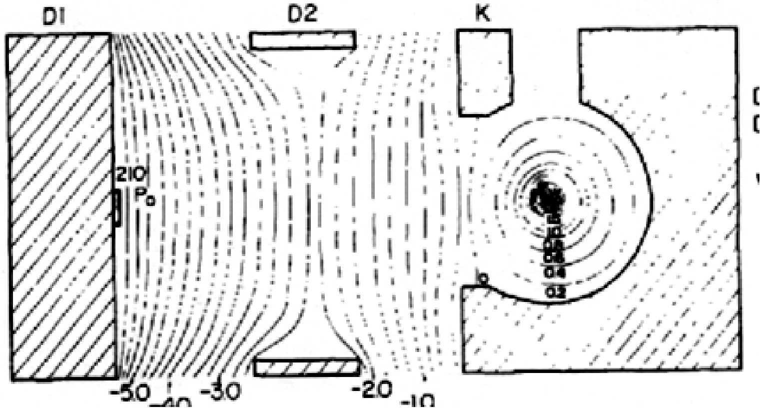
Very thin wire 4 μm

Proportional counter 6 mm diameter

HV up to 3 kV

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





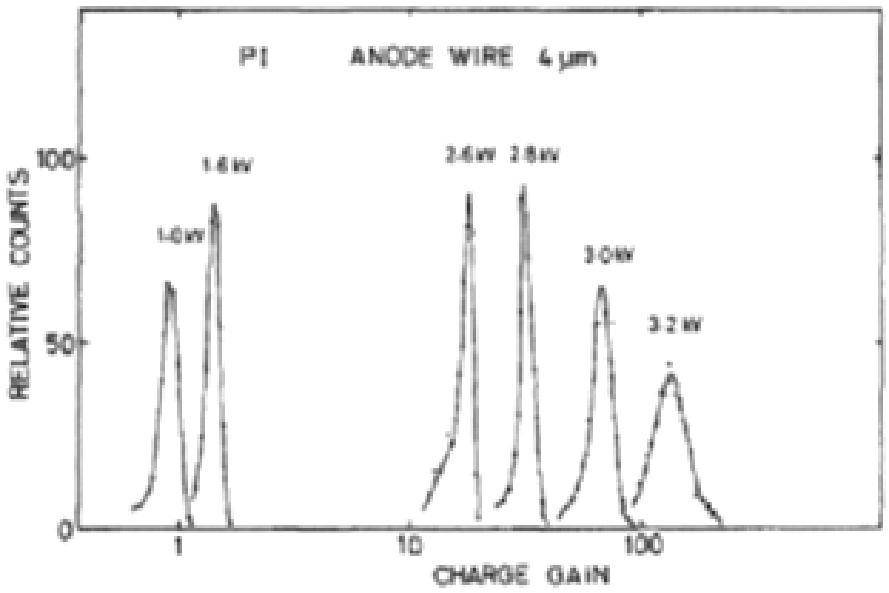
Miyajima et al., NIM160(1979)239

1 ton PANDA-X

Results with α - source

Charge gain observed at large fields

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

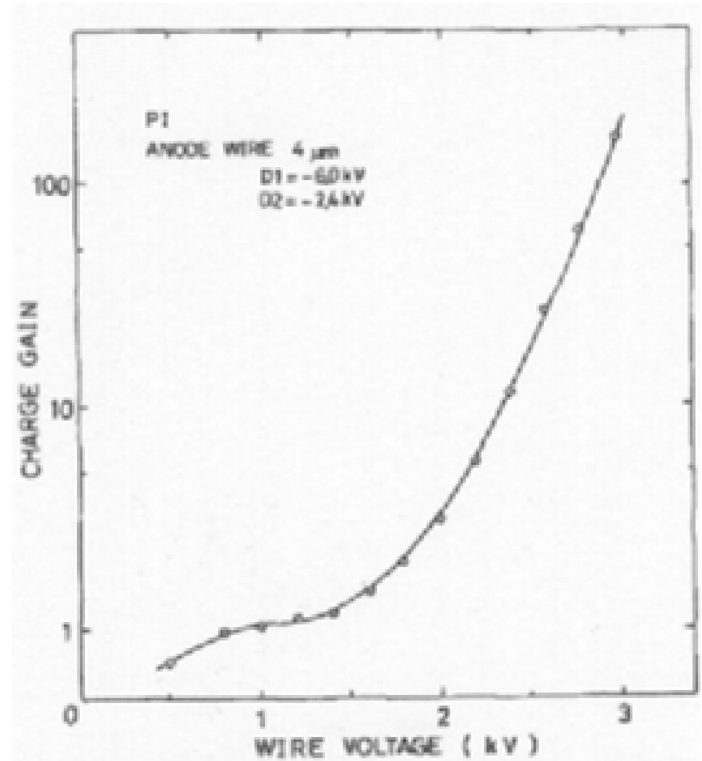


However, charge multiplication adds more fluctuations, i.e. loss in energy resolution. Limitation to Proportional Scintillation night be better

1 ton PANDA-X

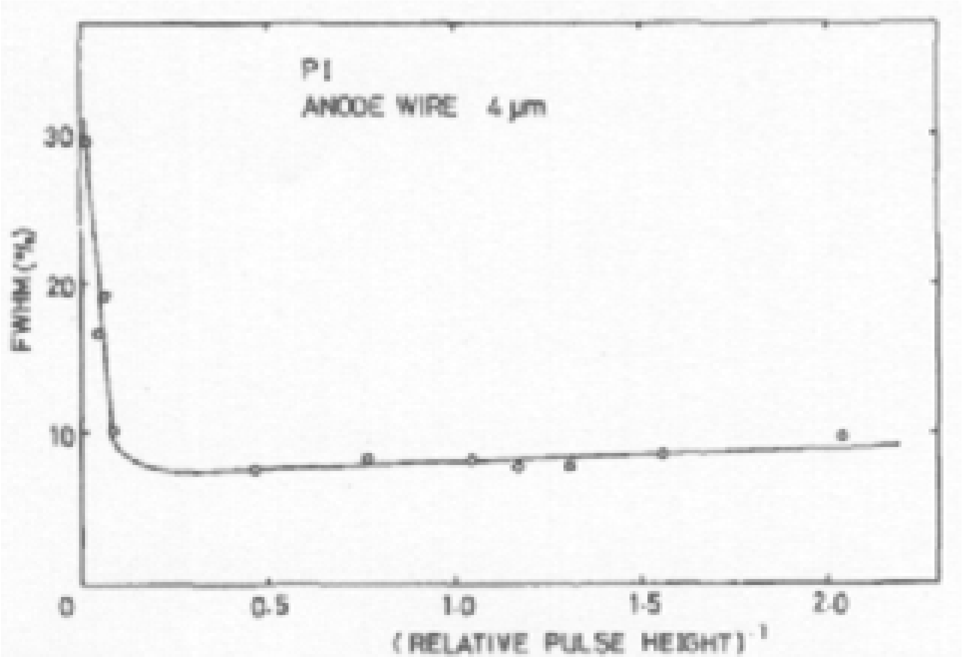
Drifting electrons are accelerated in between collisions by the electric field. But, below a threshold energy they can not start an electron avalanche.

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.



1 ton PANDA-X

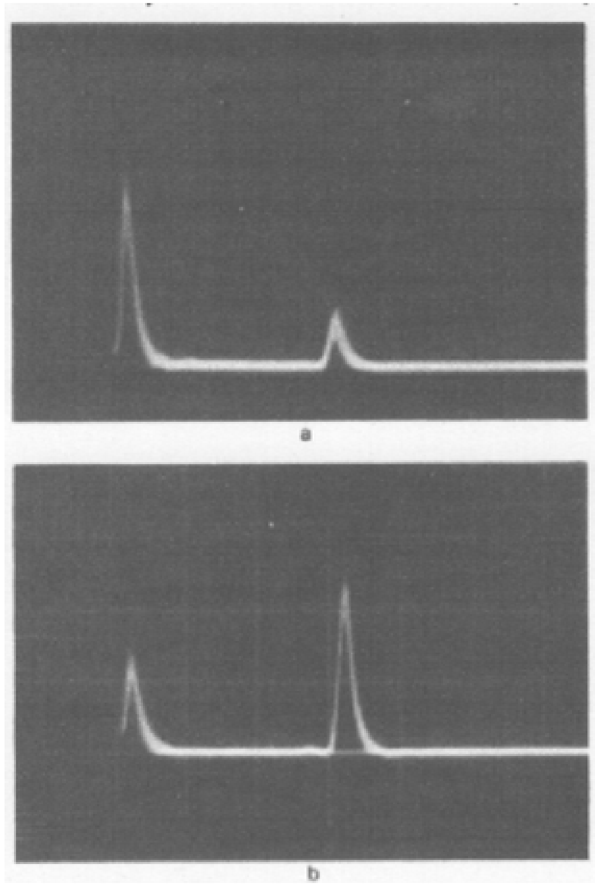
The energy resolution can get much worse due to charge multiplication.



But energy resolution not very important for WIMP search. A small charge gain can be tolerated

1 ton PANDA-X

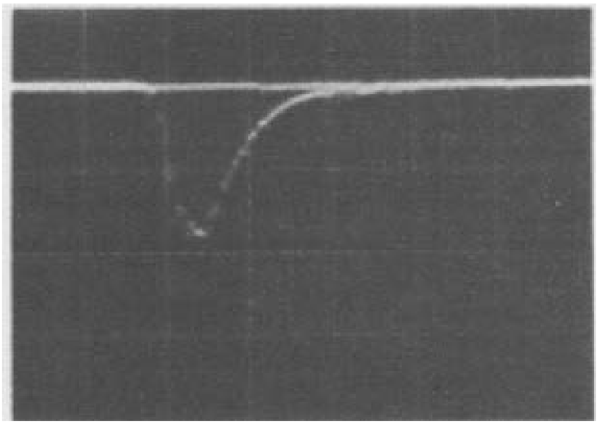
Direct and secondary scintillation pulses at 1.6 kV and 3.0 kV.



1.6 kV

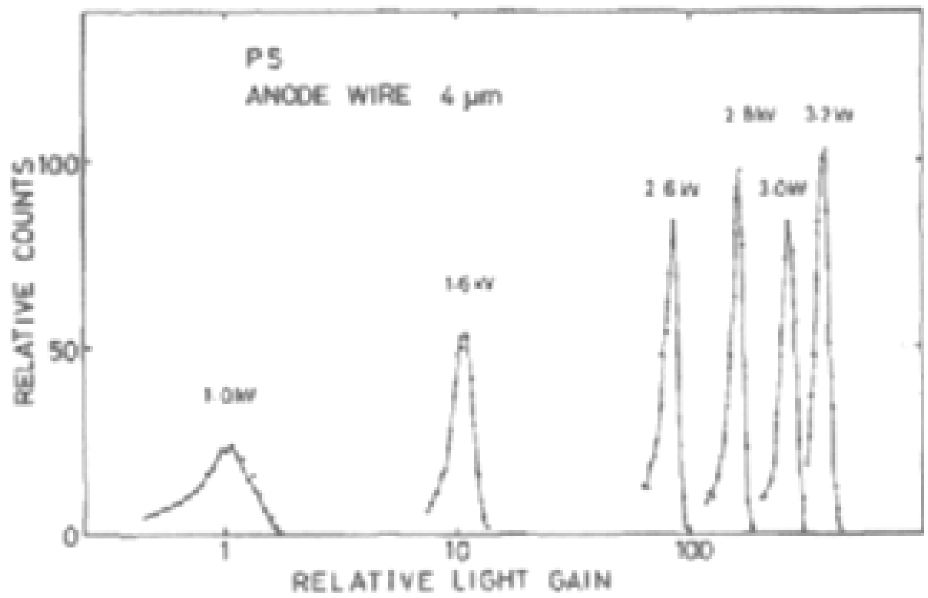
3.0 kV

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.)

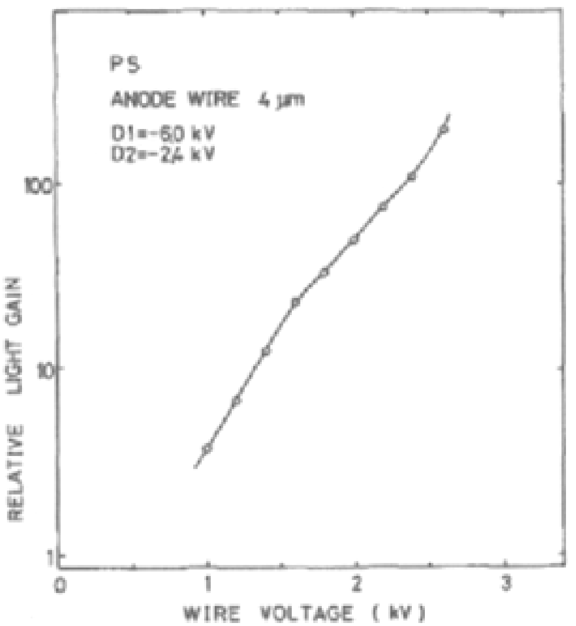
1 ton PANDA-X



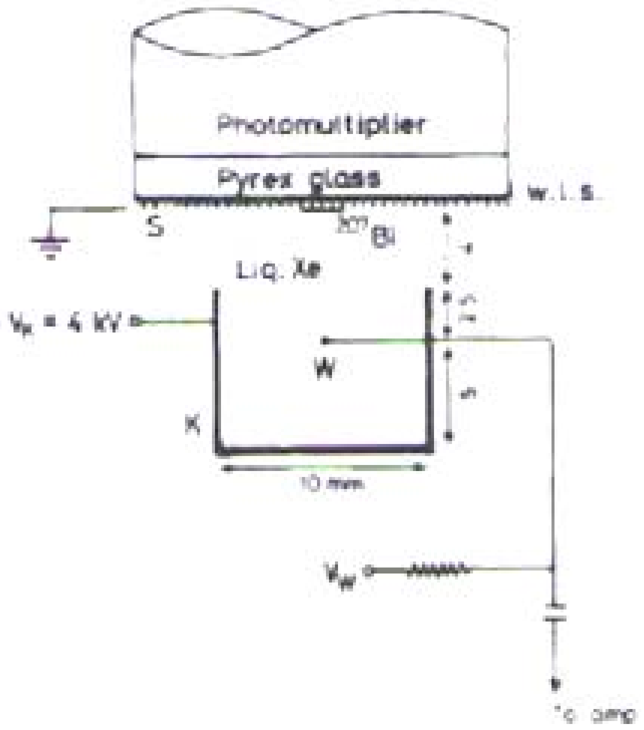
Light at different voltages. At 1.6 kV nearly no charge gain, but a factor 10 more light.

We do not need a large light gain.

A very large difference between primary and secondary light does require a very large dynamic range!

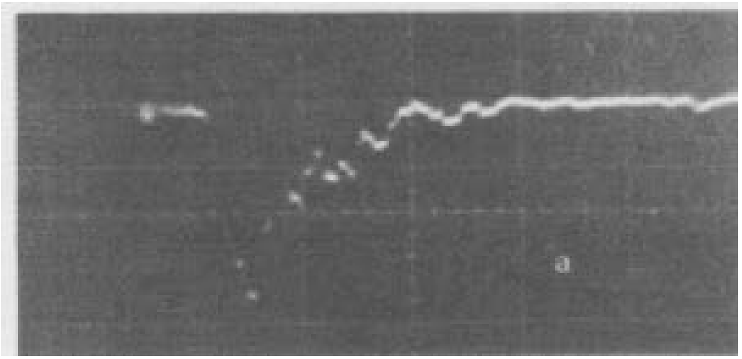


1 ton PANDA-X

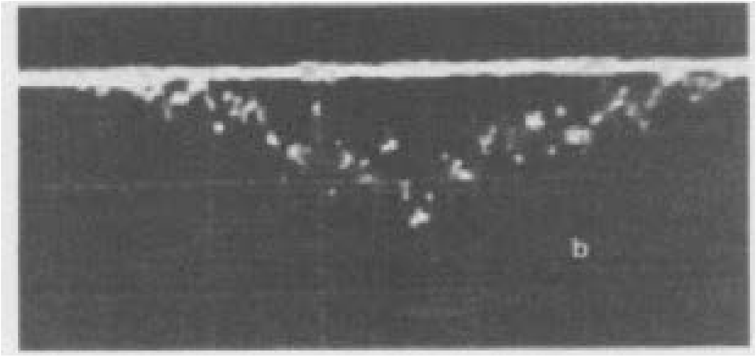


Different geometry, similar results, but also thicker wires.

Masuda et al., NIM160(1979)247



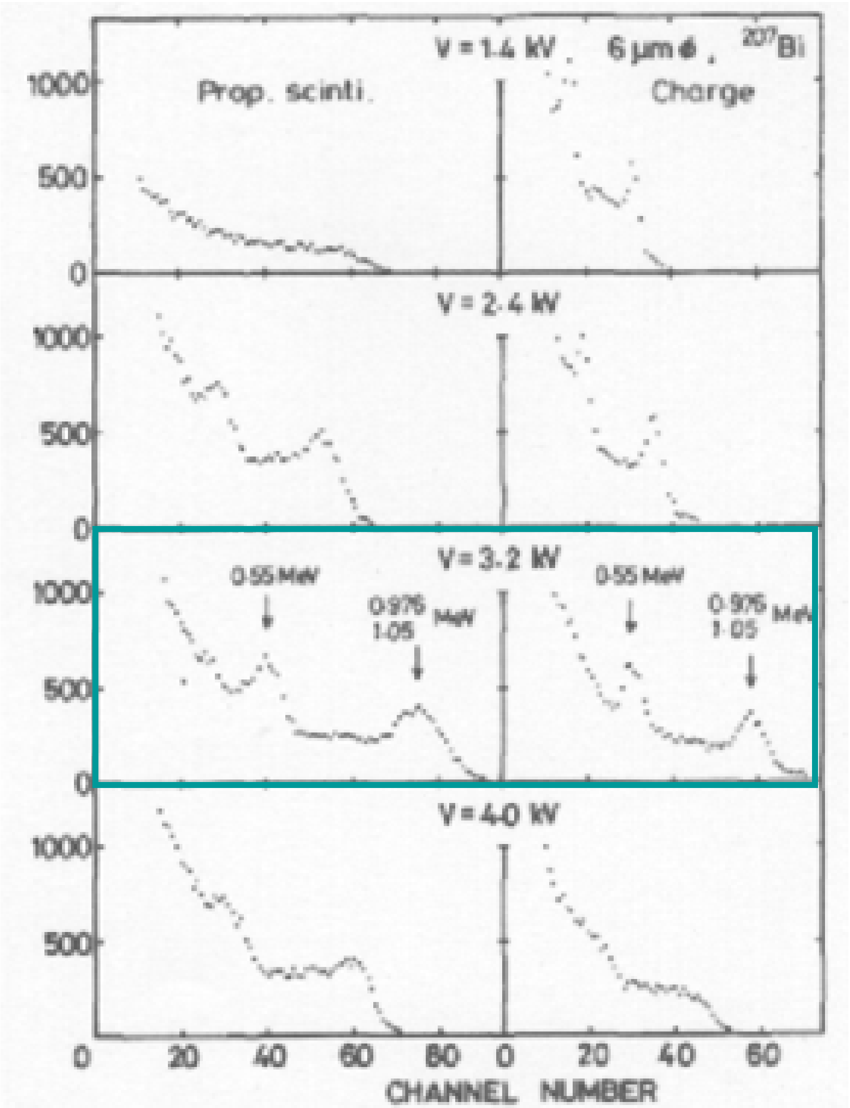
Typical direct scintillation pulse. (50 nsec/div)



Secondary scintillation pulse. (200 nsec/div)

1 ton PANDA-X

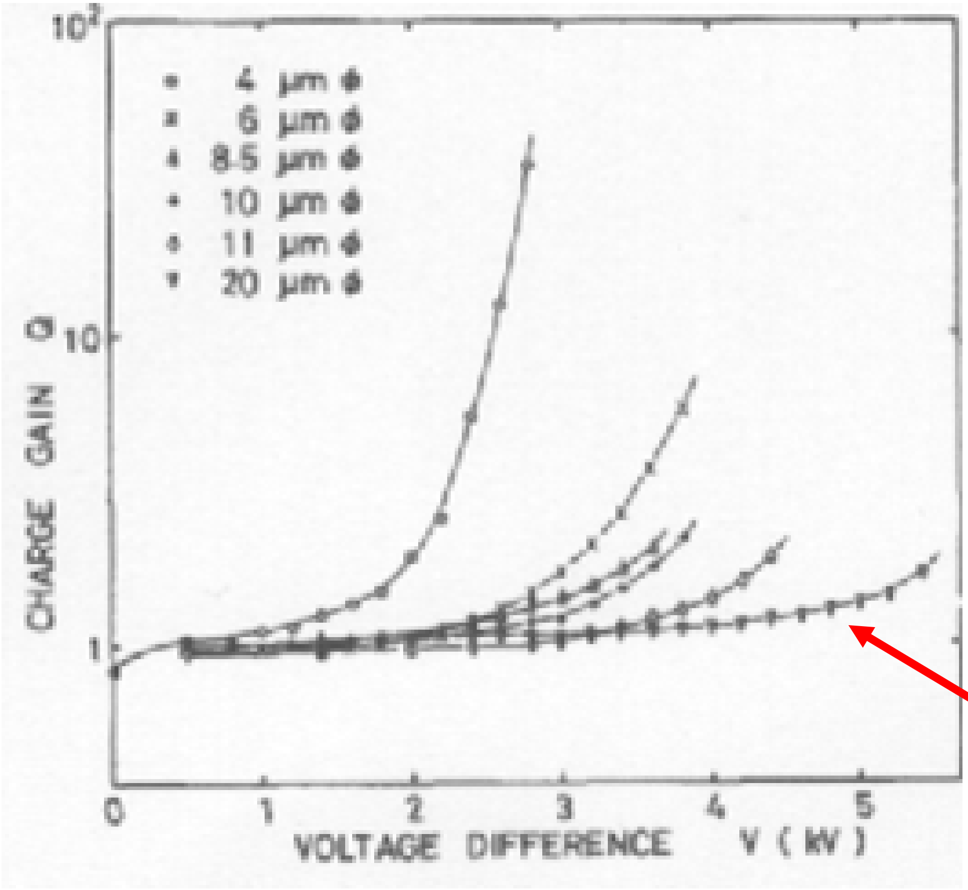
Energy resolution for
Prop. Scintillation and **Charge**



Energy resolution of Proportional Scintillation comparable to charge measurement with CSA.

However, energy resolution will be much better with **Charge – Light** combination

1 ton PANDA-X



20 μm wires

We should operate just at the onset of charge multiplication

1 ton PANDA-X

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

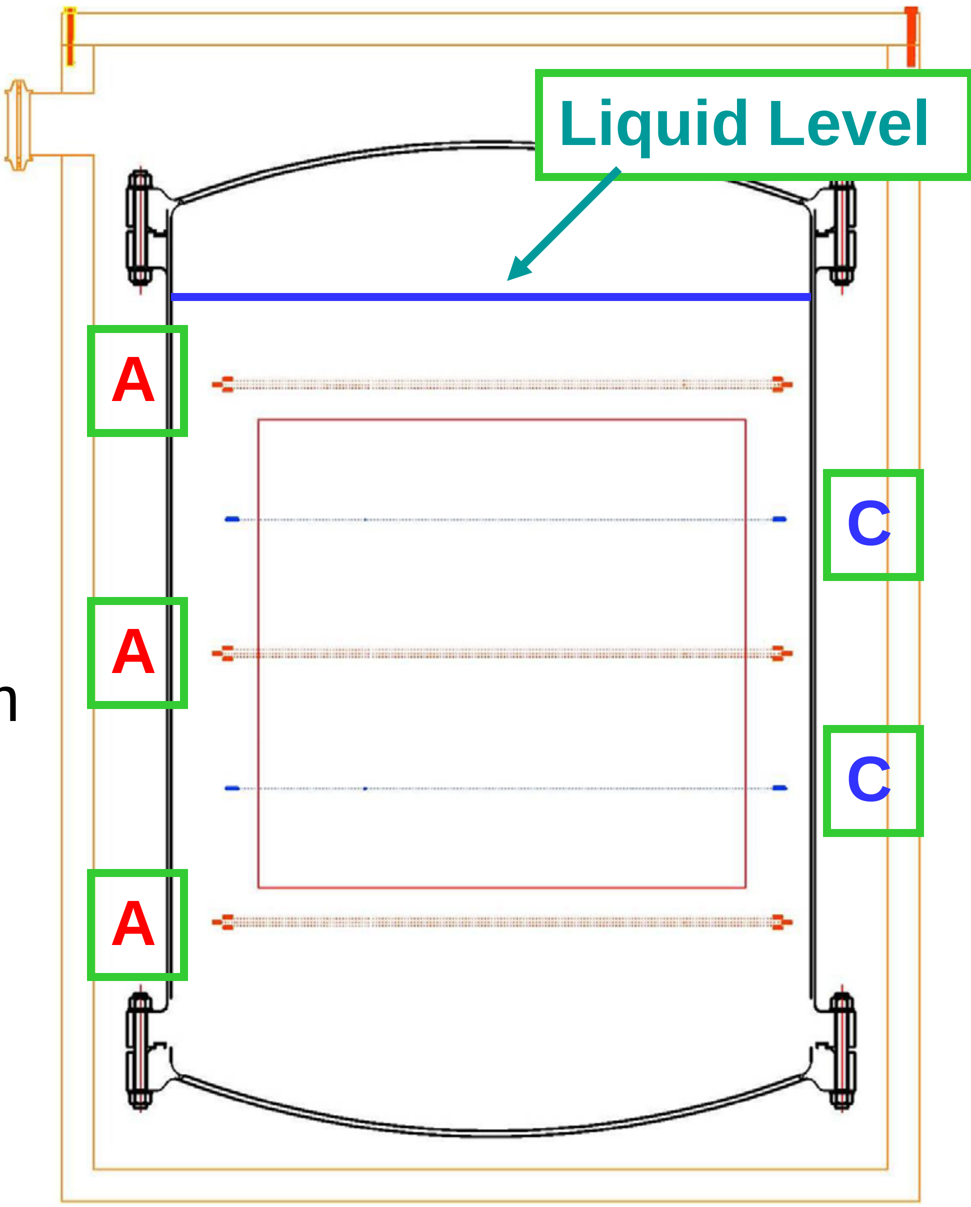
1 ton PANDA-X

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 γ-rays interacting in front of PMT
5. Max. drift time 105 μsec instead of 420 μsec
   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)

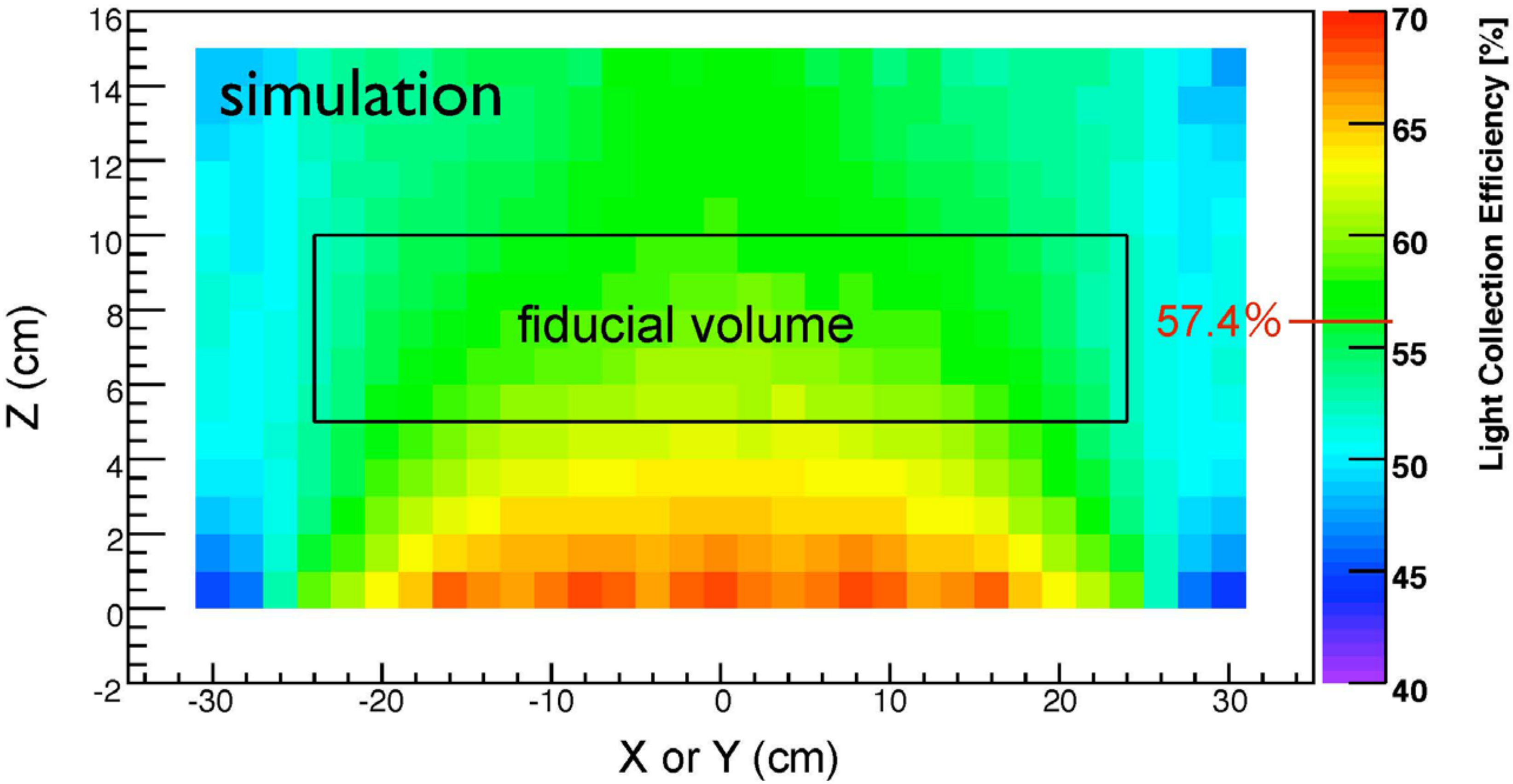
Sides have to be covered by sensors.

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

Light Read Out for PANDA-1T

Simulation of Panda 25k shows that light collection is not symmetric. And the 25 kg is already the best case!



Light Read Out for Panda 1T

Only choice: **Gaseous Photo Multiplier**

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

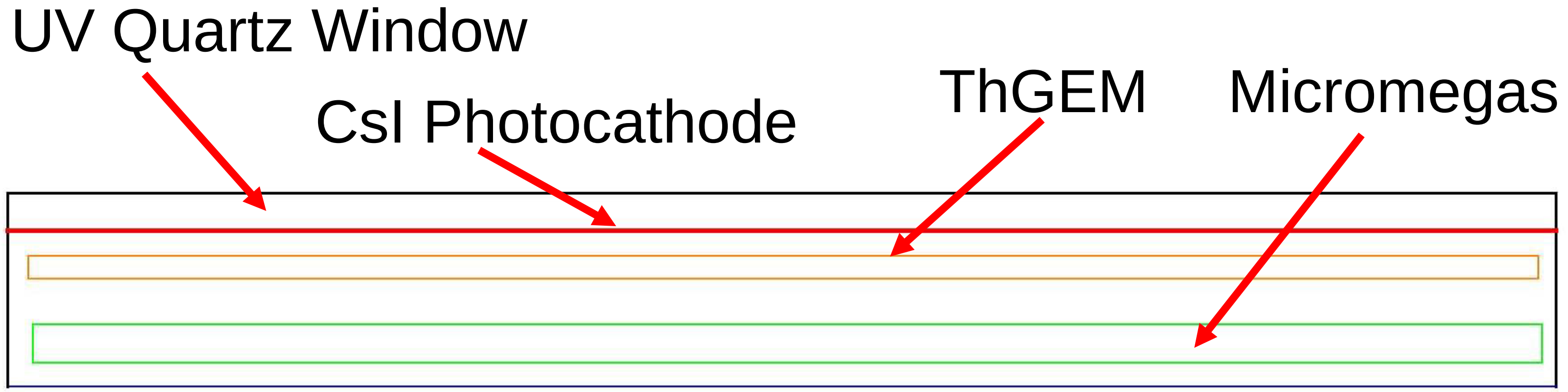
A lot of work development work already done by Amos Breskin (Weizman Institute) and others.

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



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