Several detector concepts

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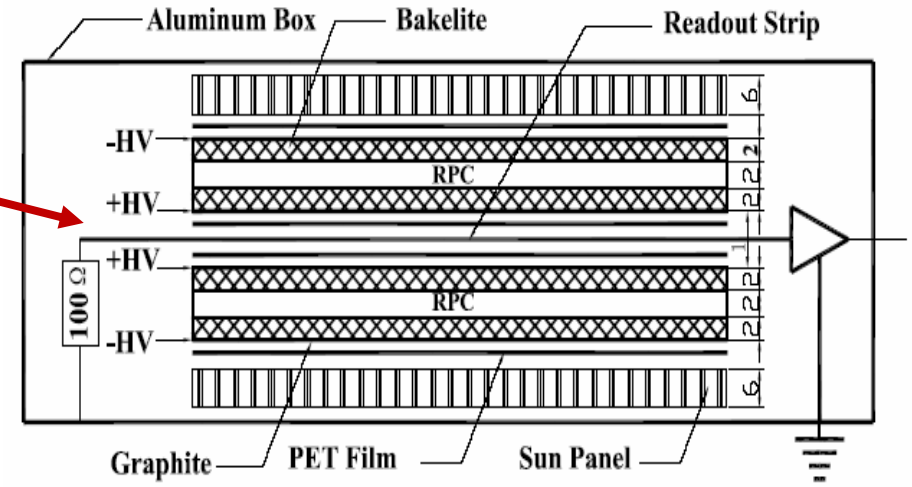
Outline

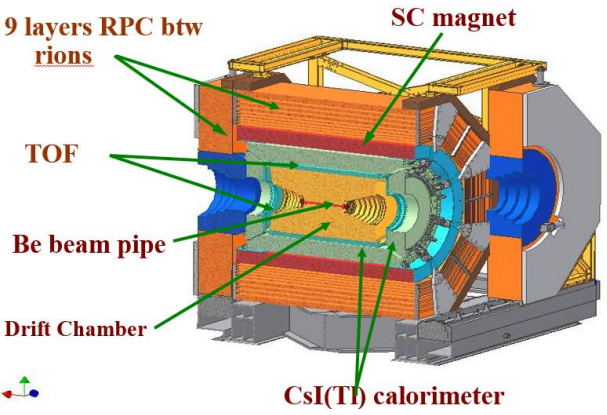
- Option 1: RPC
  - Several kinds of chamber structure
  - Module structure concept for LLP and layout
  - Price from Gaonengkedi co.
- Option 2: Liquid scintillator + WLSF + SiPM
  - Detector concept
  - Price estimate
- Option 3: Plastic scintillator + SiPM
  - Detector concept
  - Price estimate

RPC on the BESIII

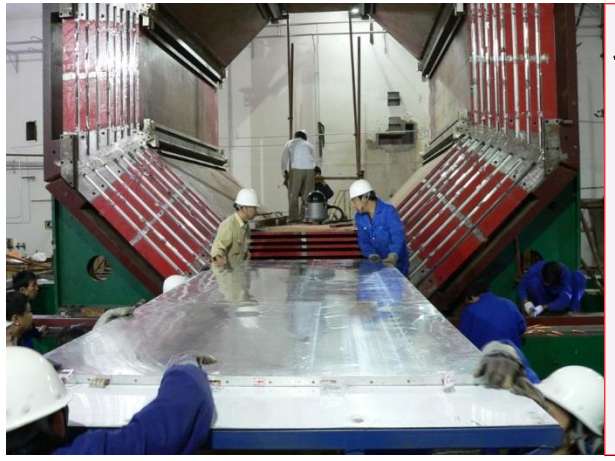
- **Chamber structure:**
  There are double layers of RPC in each module and the anodes and readout strips are placed in the middle. Each module can only give one dimensional position.
- **9 layers of RPC btw the iron block, each layer makes a cylindrical shape.**
- **5 layers of modules are to give the positon of Y and 4 are to give that of ϕ .**



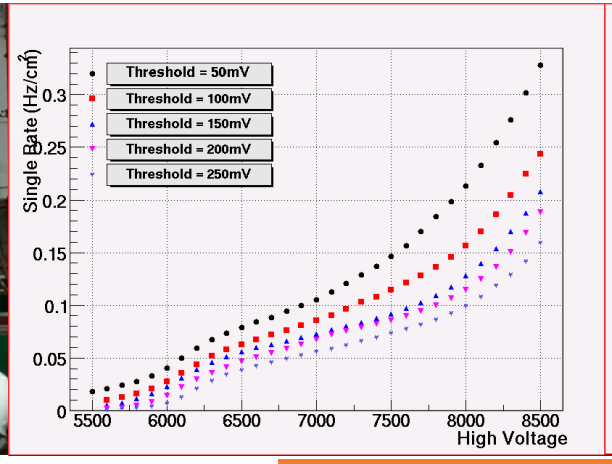
Chamber structure

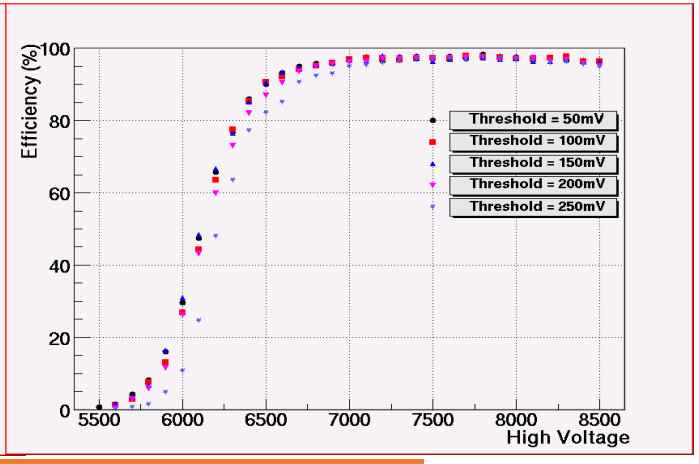


BESIII Detectors



RPC installing

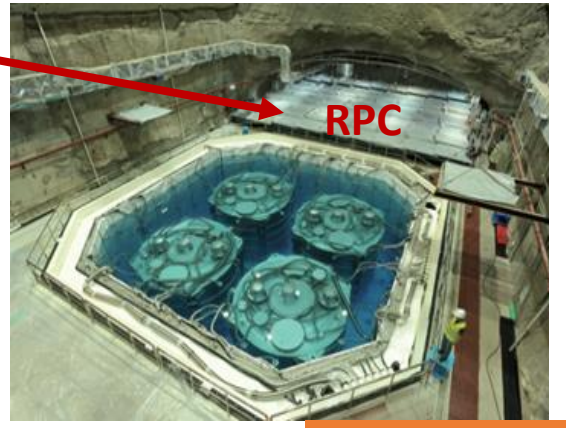


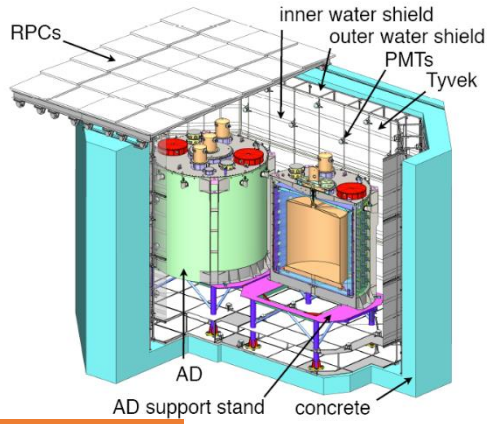


RPC single rate and efficiency VS HV

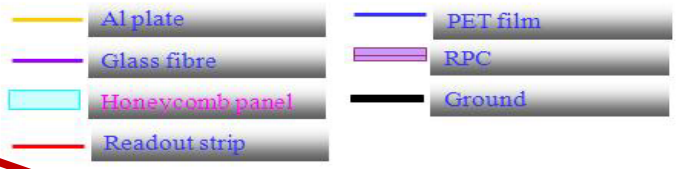
RPC on Daya Bay Neutrino Experiment

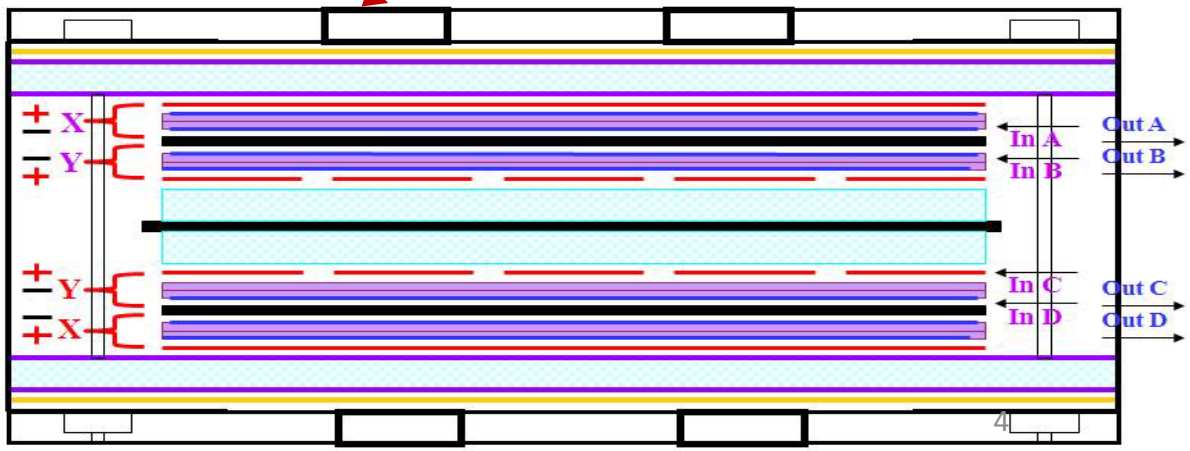
- **Three experimental halls**
  - Cover on the antineutrino detectors
  - Totally ~ 800 m^2
  - **Price: ~8 M¥ , 10000 ¥/ m^2 , including the RPC and readout electronics**
- **Chamber structure**
  - **2 groups of (X+Y) in one aluminum box**
  - **1 group X+Y: cathode in the middle to be shared, the other two sides have X or Y readout strips**
  - **Identification logic: 4 gaps, if 2 or 3 gaps have signals then the cosmic ray is identified**





RPC on the Daya Bay

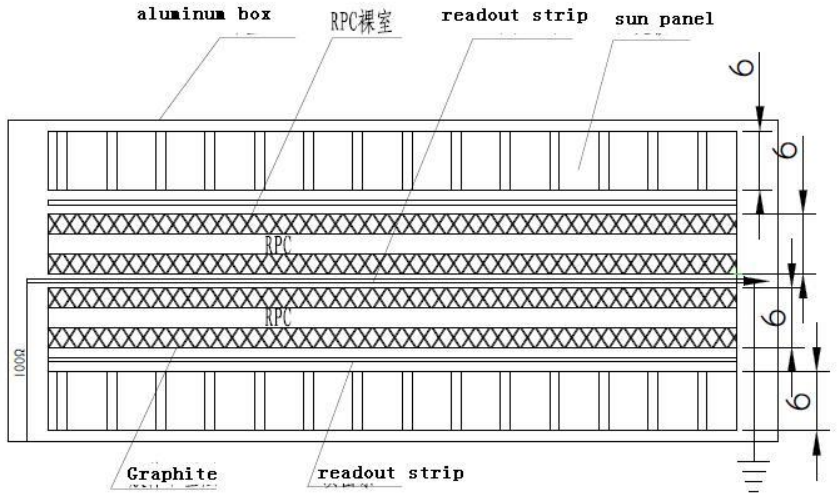




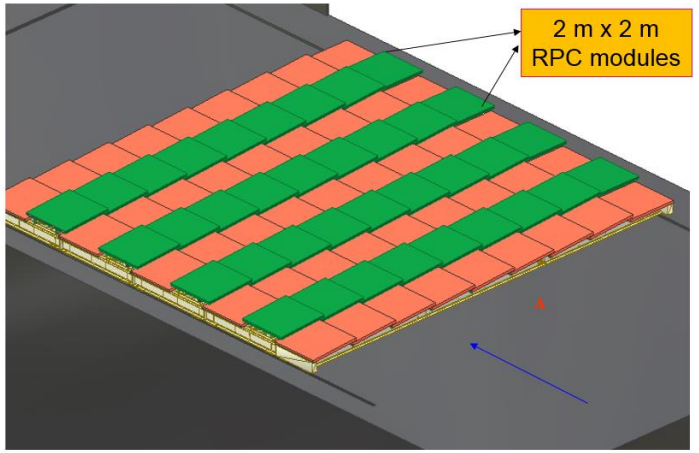
RPC module concept for LLP

- **Module structure concept:**
  - **Bakelite plates replace the glass,**
    Original size: 2. 4m X 1.2 m, cut the none-good side and the size will be about ~2.1m X 1.1m
  - **Double gaps, 2mm/gap**
  - **Cathode in the middle**
  - **X+Y anode readout strips on the top and bottom**
  - **Each aluminum box: 2m X 2m, 2 chambers inside**

Refer to : "RPC Experience: Belle, BaBar and BESIII", By Changguo Lu, slac-pub-11744.



Chamber structure concept



Layout to reduce the dead area

RPC production at Gaonengkedi Co.

- **Gaonengkedi co.**
  - **Produced the RPC for BESIII and Daya Bay in 10-15 years ago, but not including the readout electronics.**
  - **Produced the PCB readout strips for CMS through Beijing Univ.**
- **Quoted price lately: ~2000 $ / 2m X 2m module, without HV/electronics**
  - **If use glass instead of bakelite, the price may reduce ~ 300$**

NAME	Specifications	amount	prince (RMB)
RPC	2000x1000x6	2	6400
readout Strip	2000x1000x0.3	3	1600
Aluminum BOX	2100x1100x30	1	2000
High voltage line signal line gas pipeline system		1套	1500
Assembly			1000
Packing and transportation			1000
TOTAL:			13500

Table of quoted price

Old pictures of producing the RPC

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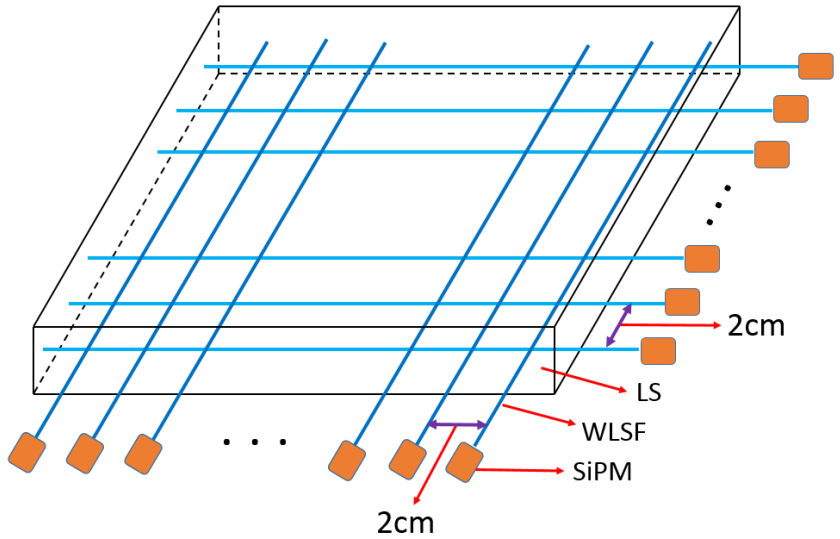
LS + WLSF + SiPM

Module Box

- Filled with LS: 2m X 2m X 1 cm
- Vertical muon deposit energy: ~ 2MeV, ~20000 photons of original light output

WLSF+ SiPM

- Fiber Type: Kuraray Y-11
  - Light transportation ability: 4.2%
  - Attenuation length ~1.5m
  - Fibers: 2 cm span, X: 100, Y: 100
- Readout: SiPM + Front end elec.
  - Photoelectron number: ~10
  - Charge measurement: Center gravity method to get position precision of ~1cm
  - Time measurement: ~1ns



Detector Concept

COST Estimate per Module of 4 m^2

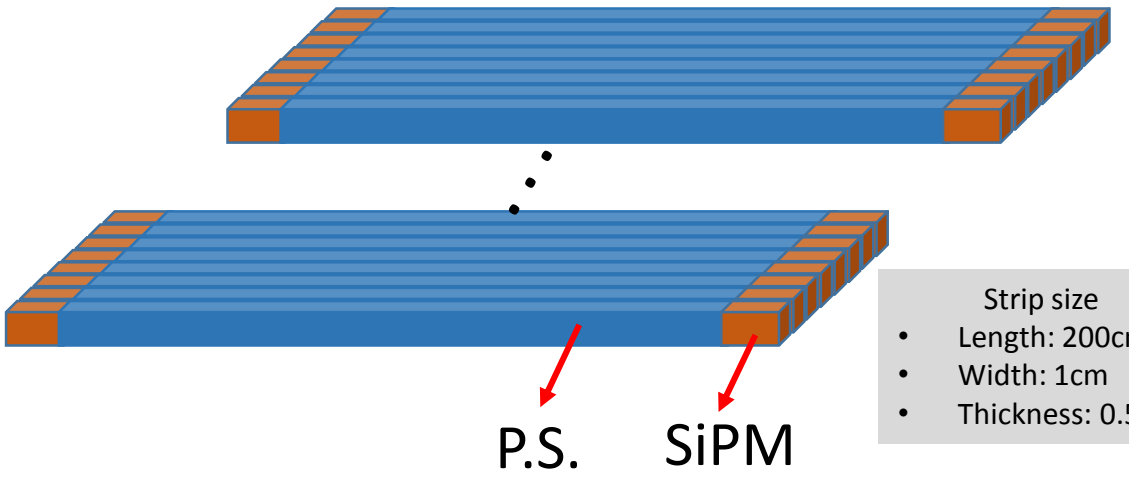
- Box and fiber feedthrough: 500 $
- Liquid Scintillator: 2000 $/$m^3$ X 0. 04 m^3 = 80 $
- WLSF 400m* 2 $/m = 800 $
- SiPM 200 * 1.5$ = 300 $
- Elec.: ~ 200 channels, sharing? ASIC? Not sure

Totally: ~ 1700$ + Elec.

Plastic Scintillator + SiPM

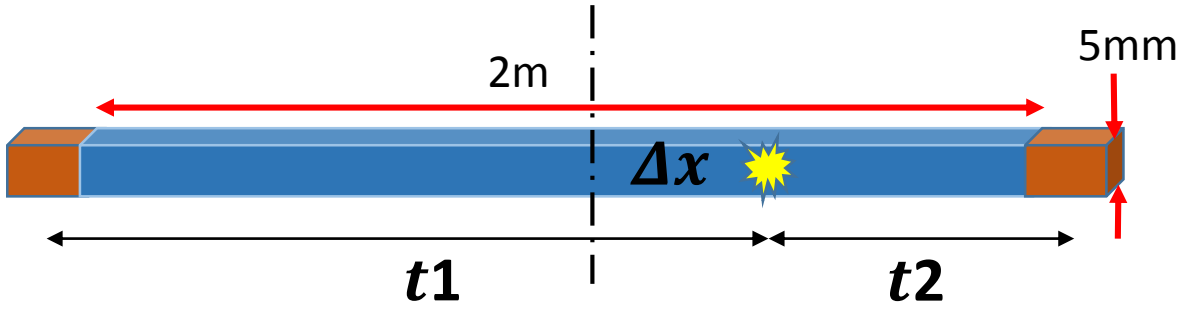
Module

- Size: 2m X 2m
- Plastic scintillator strip: 0.5cmX1cmX200cm
- Vertical muon: 1 MeV deposit energy, ~10000 photons of original light output
- Two end readout: fast SiPM, for example S14160, time resolutionis about 70 ps
- Position resolution
  - Strip width: 1cm
  - Along strip by timing method: ~1cm



Strip size
- Length: 200cm
- Width: 1cm
- Thickness: 0.5cm

Detector Concept



$Positionning$: $\Delta x = c\,\Delta\, t/2$

COST Estimate per Module of 4 m²

- Box: 100 $
- Plastic Scintillator: 50 $/kg X 20 kg = 1000 $
- SiPM: 400 * 1.5$ = 600 $
- Elec.: ~ 400 channels, sharing? ASIC? Not sure

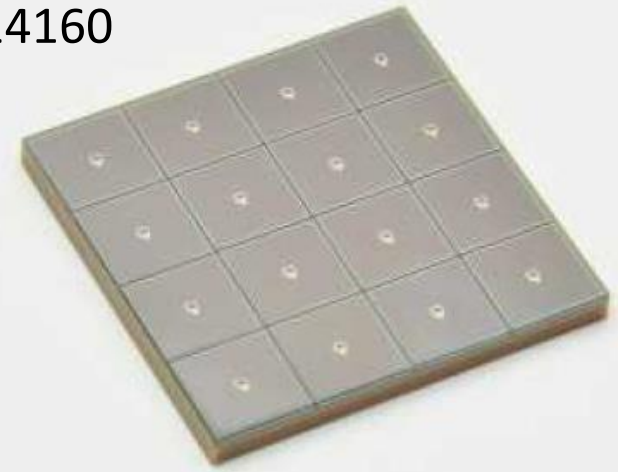
Totally: ~ 1700$ + Elec.

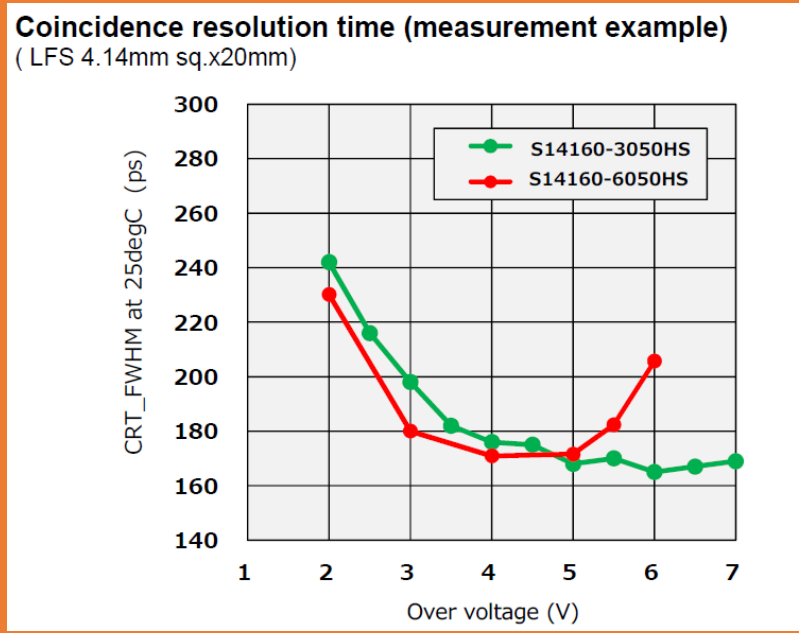
Plastic Scintillator / Fast SiPM

SiPM S14160 and its timing performance

Single channel	PDE	Gain	CRT(Coincidence resolution time)	peak sensitivity wavelength
3x3 mm^2	50%	2.5*10^6	170ps	450 nm

S14160





Fast plastic scintillator performances

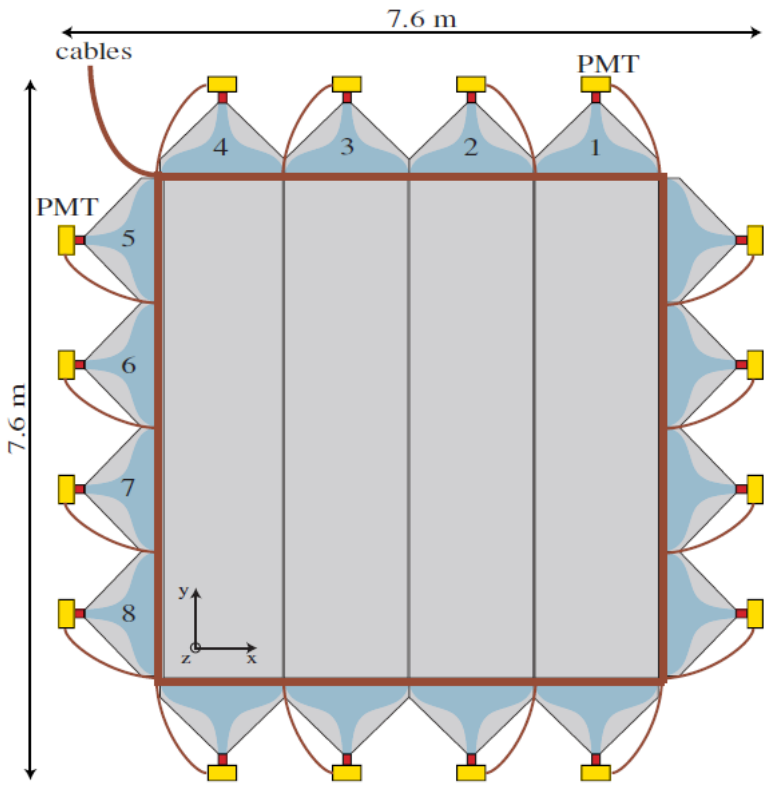
Scintillator	Light Output % Anthracene[1]	Wavelength of Maximum Emission, nm	Decay Constant, ns	Bulk Light Attenuation Length, cm
BC-400	65	423	2.4	250
BC-404	68	408	1.8	160
BC-408	64	425	2.1	380
BC-412	60	434	3.3	400
BC-416	38	434	4.0	400
BC-418	67	391	1.4	100
BC-420	64	391	1.5	110

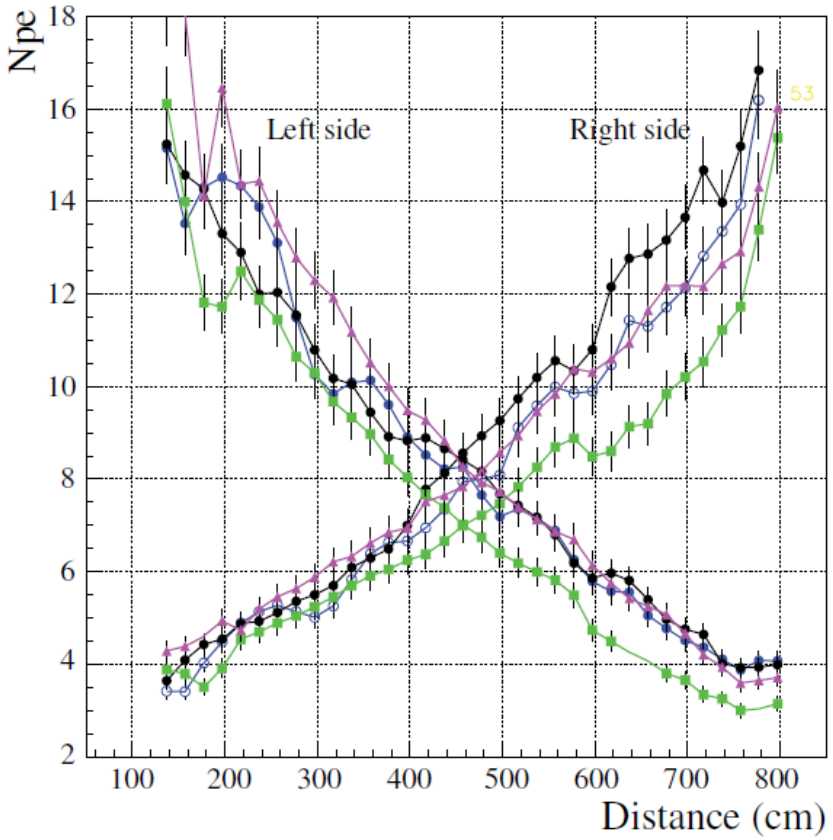
Thank you for your attention!

Backup: Daya Bay RPC

- Bakelite : 20℃ resistivity between 0.5~2.5*10^{12}Ωcm
- Gas mixture is Argon: F134A: Isobutane=53:43:4 (DYB-doc-1752-v2)
- The baseline gas mixture is Ar/R134a/Isobutane/SF6 (75.5/20/4/0.5 volume ratios), as used in the OPERA experiment.
  - In addition, 0.4% of water vapor will be added to reduce aging of the bakelite RPCs.
  - Isobutane gas mixtures are nonflammable if the isobutane fraction is lower than certain limit.
  - 75% argon · low operating voltage, but need UV quenching.
  - R134A = C2H2F4 and SF6 provide the quenching.
  - The global-warming-potential index of the OPERA gas mixture is smaller than that of the BaBar mixture (35% R134A) and comparable to that of the Belle mixture (30% R134A).
- Why we didn't use SF6?
  1. The mass control system has only 3 channels works(one broken).
  2. It's hard to calibrate 0.5 %(1 sccm) low flow rate.
  3. Either gas mixture can measure the performance of RPCs competently.

Backup: OPERA experiment





The OPERA experiment Target Tracker,
arXiv:physics/0701153v1 [physics.ins-det] 12 Jan 2007