Comments on Dual Readout Calorimeter

Tianchi Zhao
IHEP, Beijing
tianchi@u.washington.edi

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Roberto Ferrari

INFN – Sezione di Pavia

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Dual-Readout w/ Sampling Fibre Calorimeters

2003 DREAM

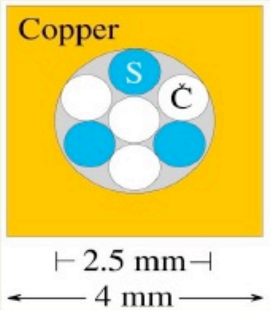
Richard Wigmans

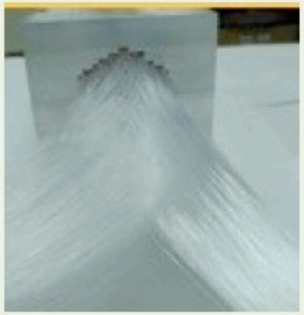
Copper

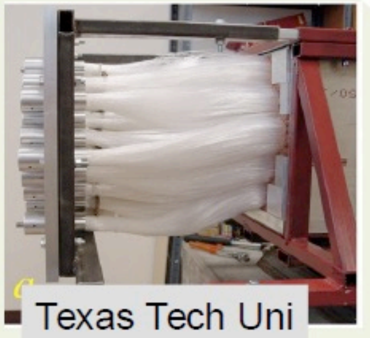
2m long, 16.2 cm wide

19 towers, 2 PMT each

Sampling fraction: 2%







2012 RD52

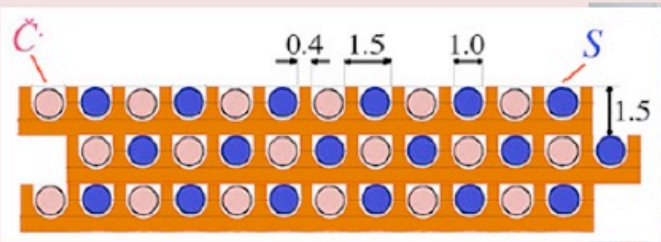
Copper, 2 modules

Finer sampling

Each module: 9.3 * 9.3 * 250 cm^3

Fibers: 1024 S + 1024 C, 8 PMT

Sampling fraction: 4.5%, 10 λ_{int}



2012 RD52

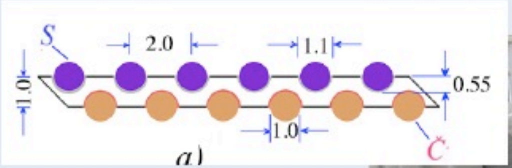
Lead, 9 modules

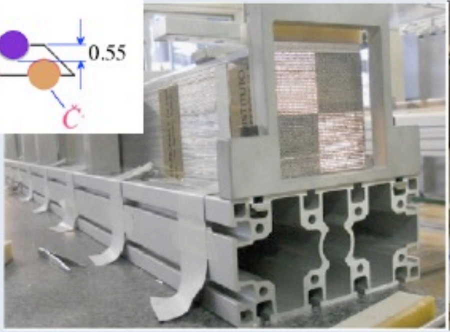
Finer sampling

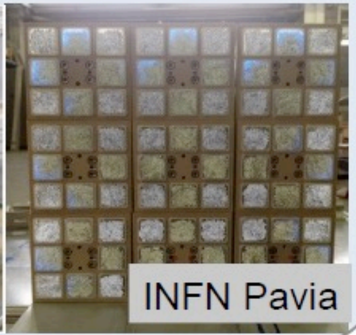
Each module: 9.3 * 9.3 * 250 cm^3

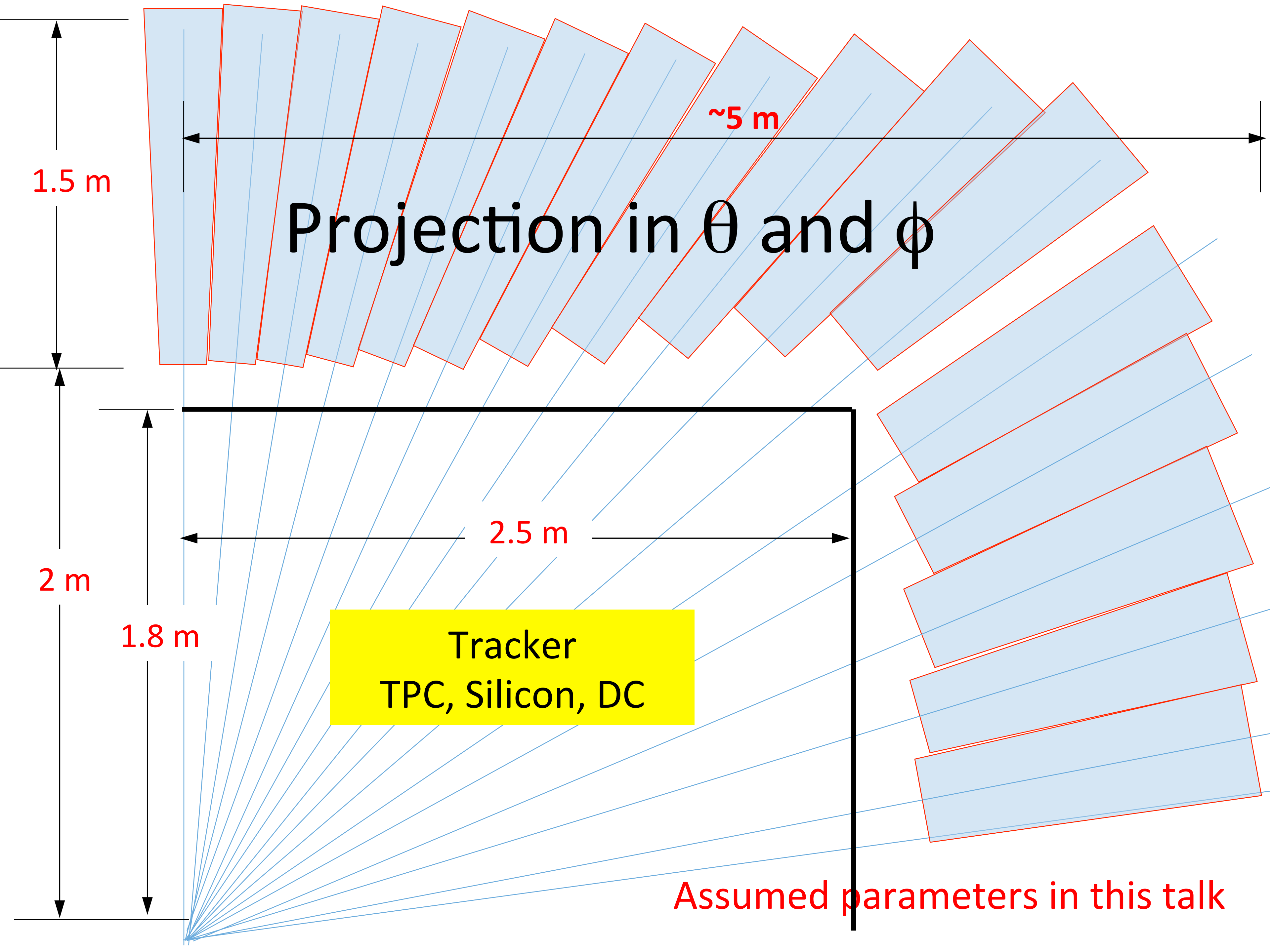
Fibers: 1024 S + 1024 C, 8 PMT

Sampling fraction: 5%, 10 λ_{int}



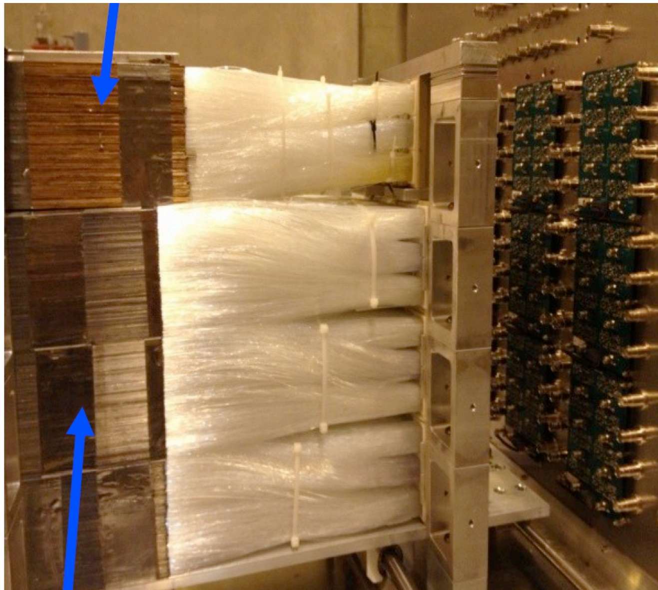





~5 m
1.5 m
Projection in θ and ϕ
2 m
1.8 m
2.5 m
Tracker
TPC, Silicon, DC
Assumed parameters in this talk

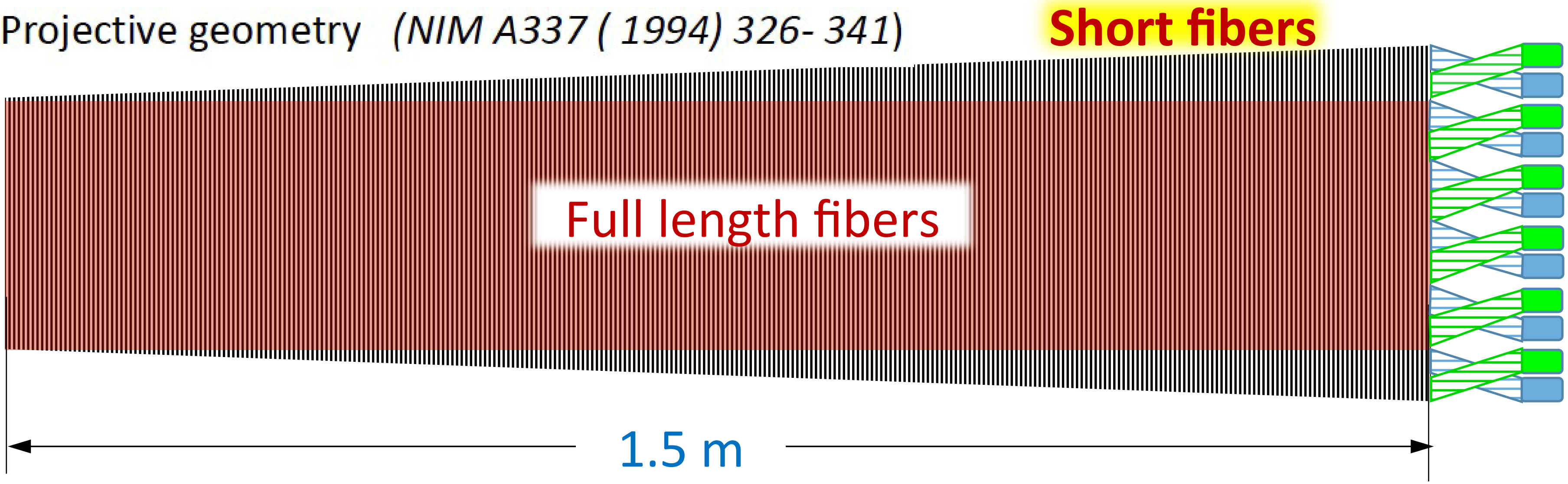
Main Issues to be Addressed for CDR

- Projective towers ?
- Depth of calorimeter?
  - Prototypes are 2 – 2.5 m long
- Pre-shower detector?
- Readout method?
  - SiPMs (or other method)
- Segmentation size
- Total number of readout channels



A Projective Tower of Dual Readout Calorimeter

Projective geometry *(NIM A337 (1994) 326- 341)*



Total area to be covered by PMT determined by OD and barrel length of calorimeter

OD = 7 m, L = 6 m

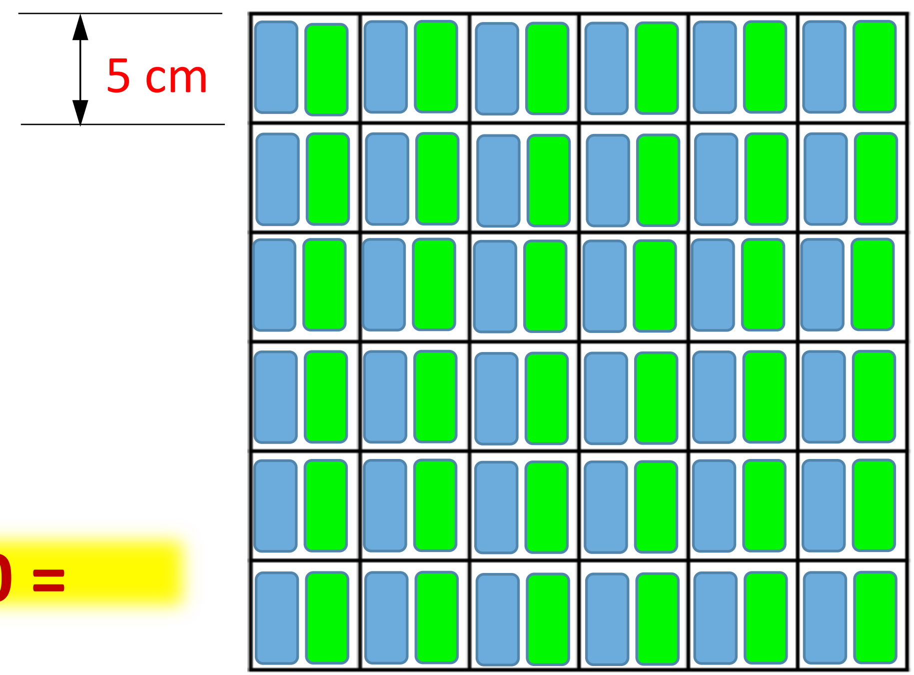
Total area = 190 m^2

Barrel = 130 m^2

End caps = 2 x 30 m^2

Total PMTs = 2 x 400 x 190 = 152000

2（6 x 6）PMTs



An Alternative Readout Scheme

Ternary Readout

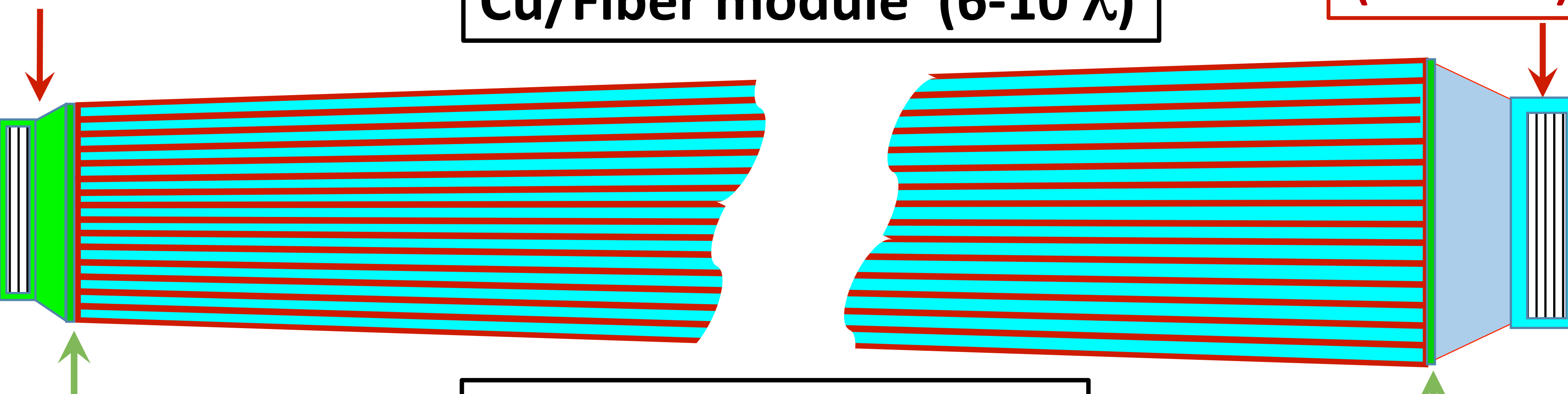
1. Scintillating light
2. Cherenkov light
3. Shower time profile

- Correct light attenuation
- Correct sampling ratio change
- Correct e/h change
- PFA friendly?

Fast PMTs (C-fibers)

Cu/Fiber module (6-10 λ)

Fast PMTs (UV-fiber)



plastic scintillator plate/light guide

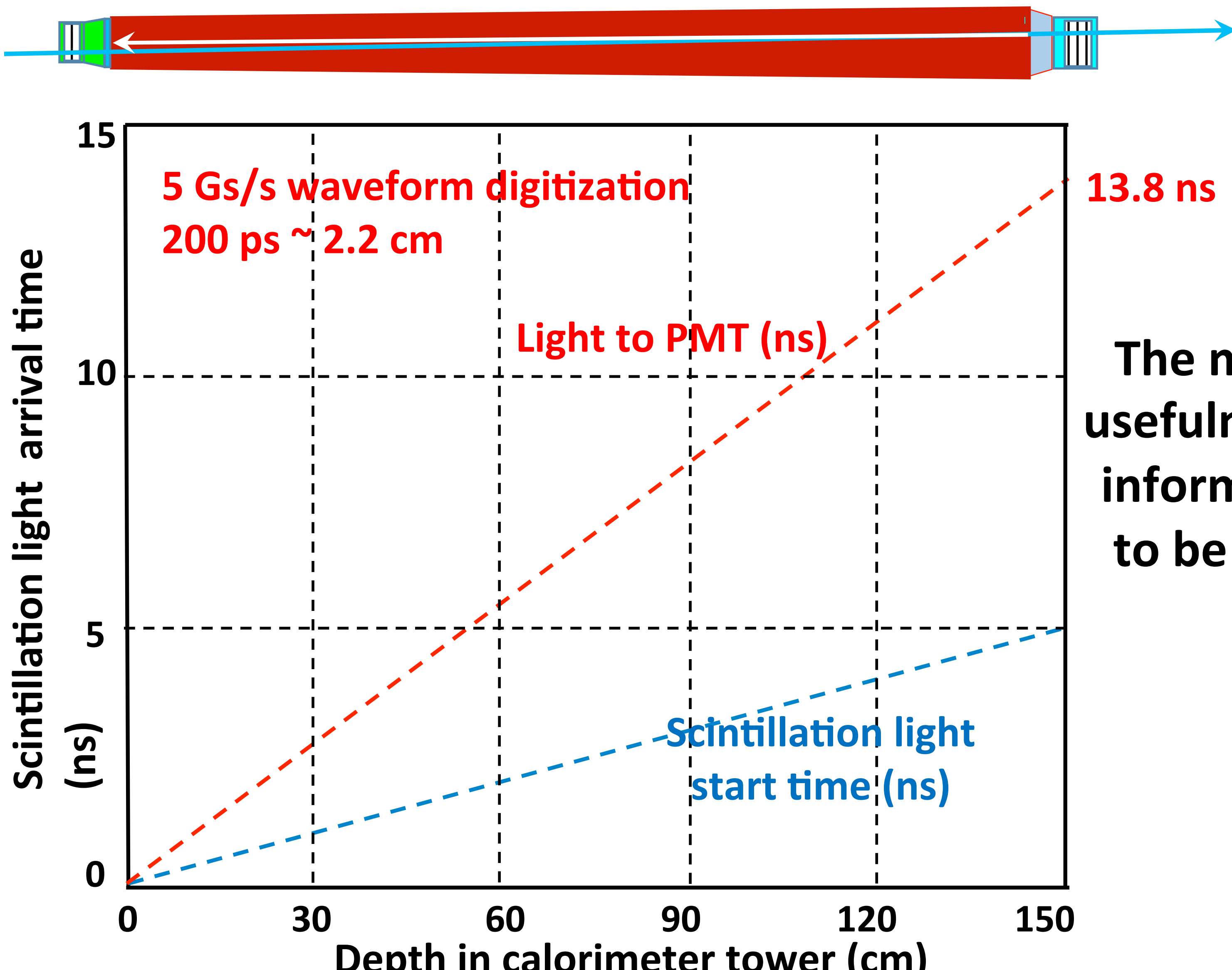
All full length fiber
Sampling ratio changes

plastic scintillator plate/light guide

Forward particle speed ~ 30 cm/ns

Backward scintillation light speed ~ 17 cm/ns

Effective light speed ~ 11 cm/ns



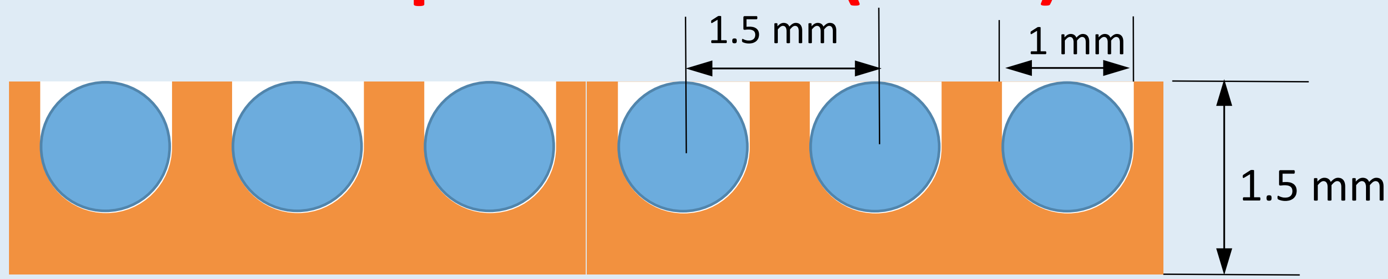
The meaning and usefulness of timing information needs to be understood

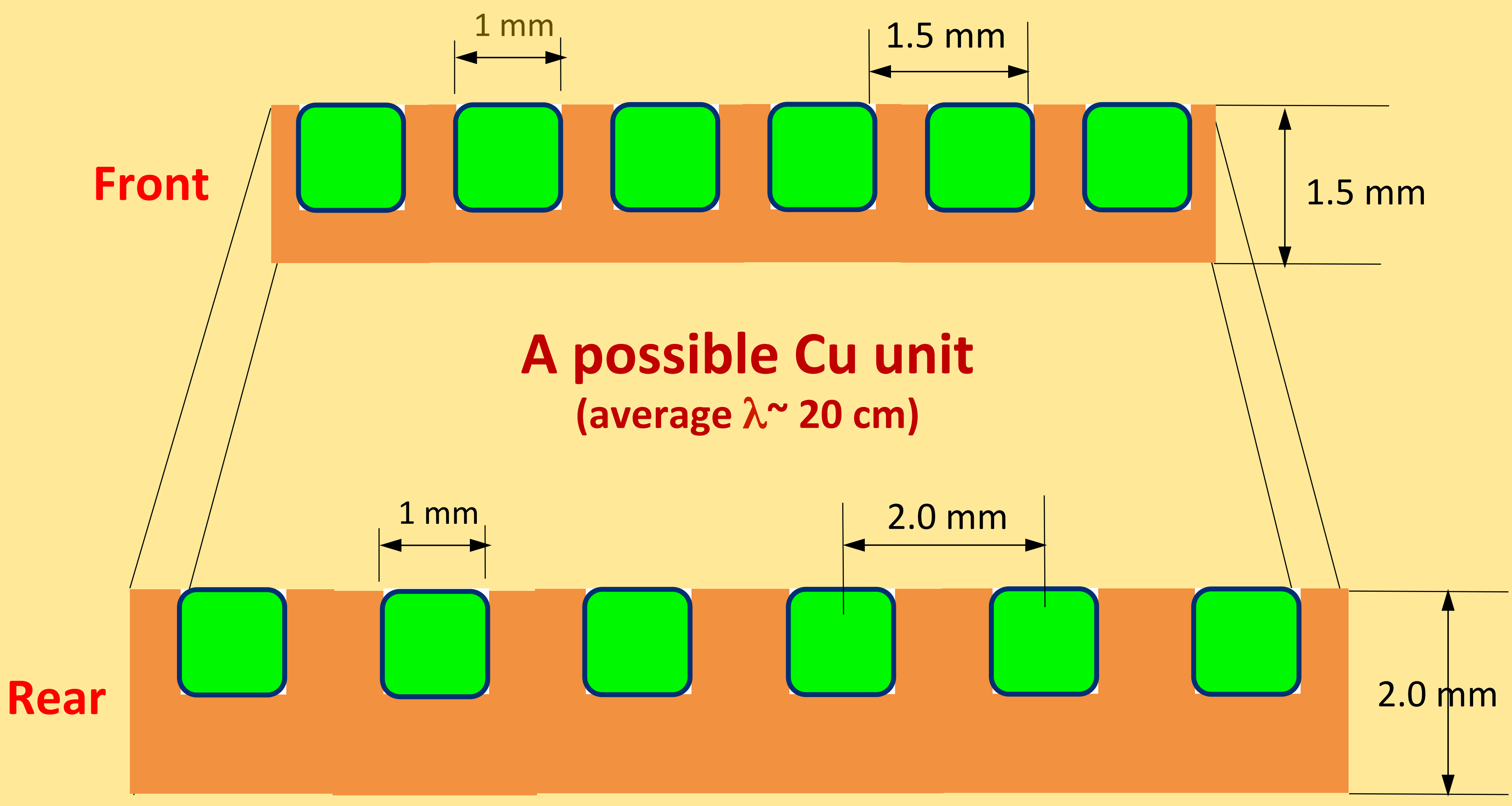
RD52 coper module (2012)

Cu~60%
Fiber~ 35%
Air~5%

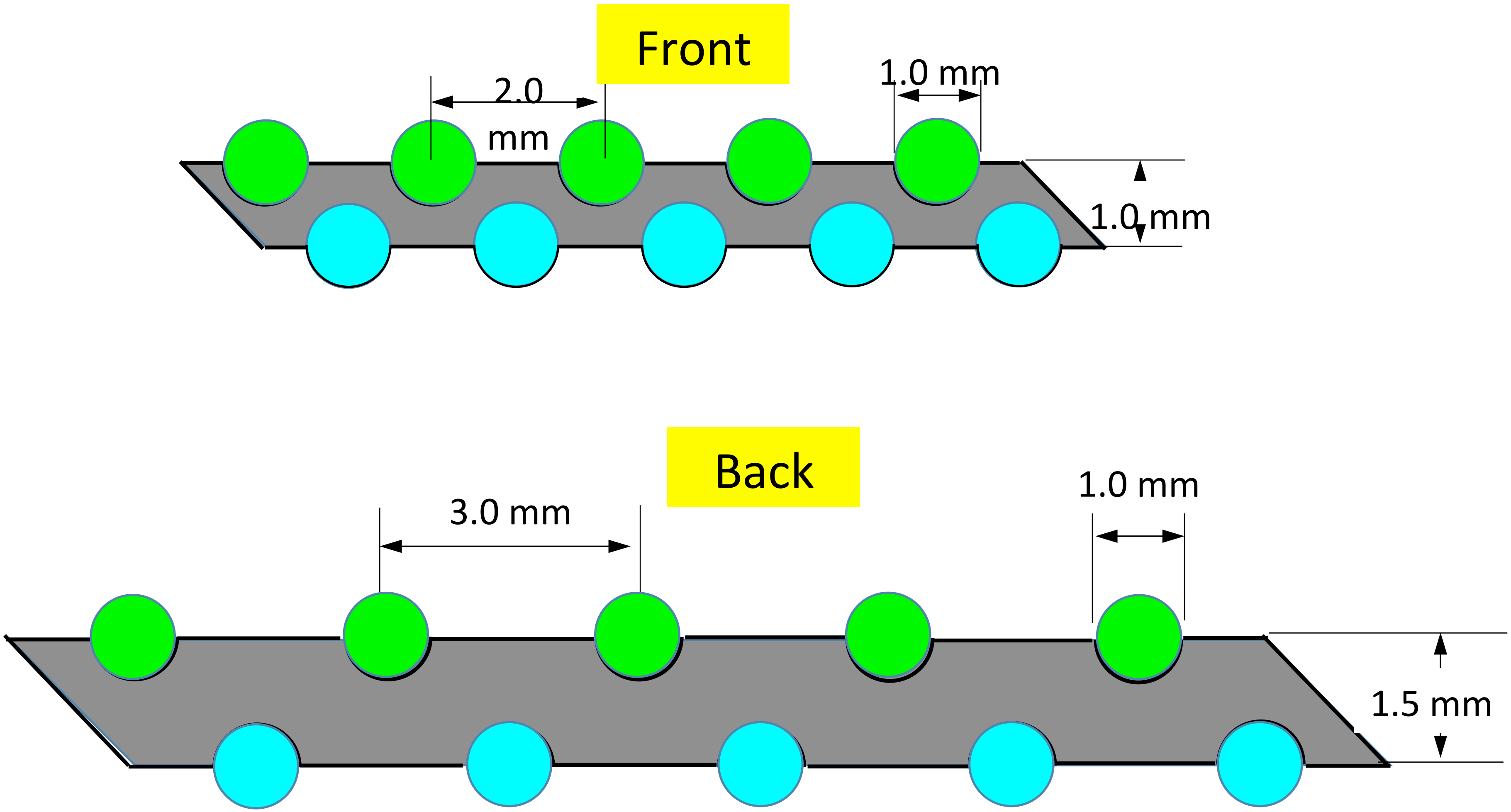
$X_0 \sim 2.4$ cm

$\lambda_{int} \sim 25$ cm





Another RD 52 Dual Readout Calorimeter Cell



Area to be Covered Determine by

1. Inner surface area of the calorimeter barrel and two end caps
2. Readout segmentation

Take

R_{in} = 2 m

Barrel Length = 5 m

Crude estimation： $2 \times (\underbrace{65\ m^2}_{\text{Barrel area}} + 2 \times \underbrace{12.5\ m^2}_{\text{End cap area}}) = 180\ m^2$

5 cm x 5 cm → **72,000 PMTs**

2.5 cm x 2.5 cm → **288,000 PMTs**

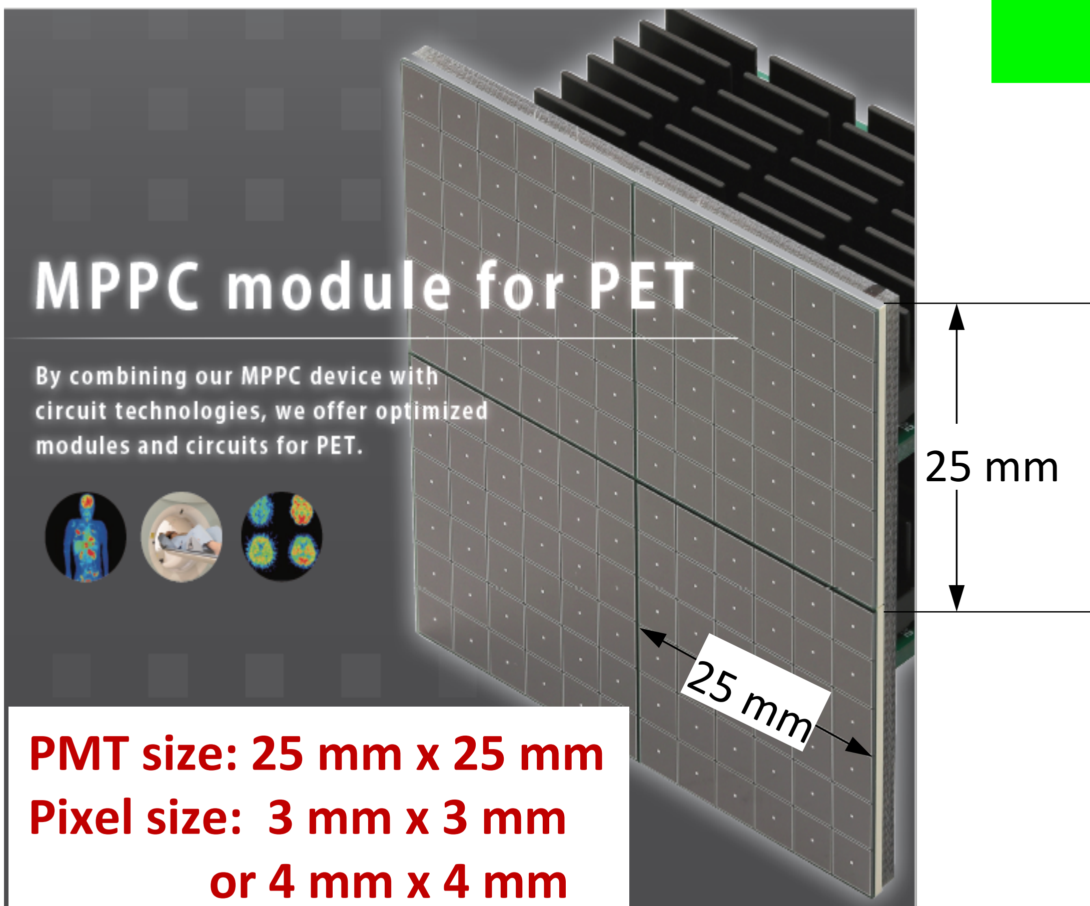
SiPMs

For TDR, we do not have time to do prototypes. We need a scheme that is likely to work

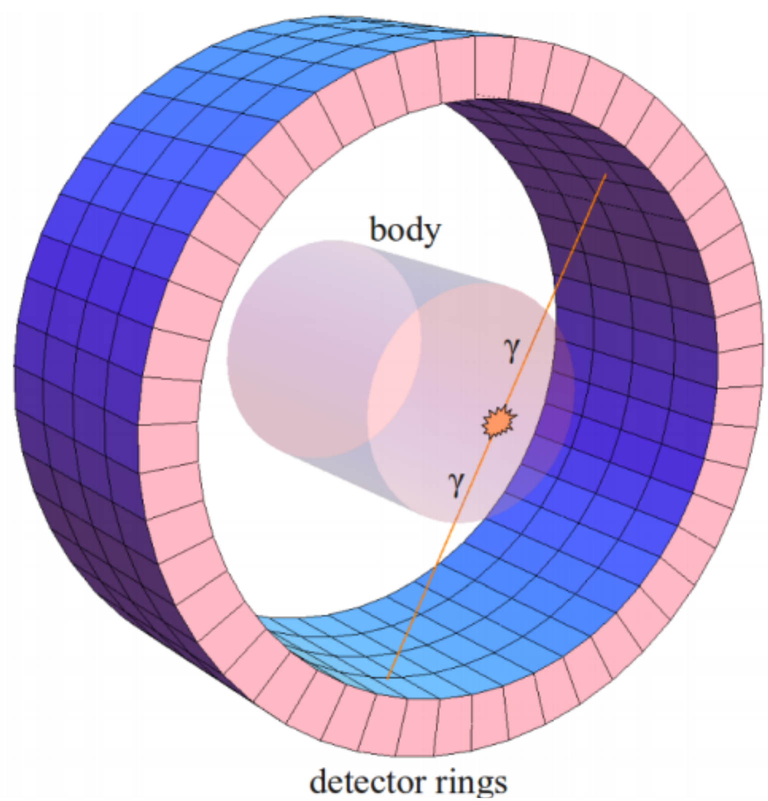
A PET ring typically ~0.2 m^2

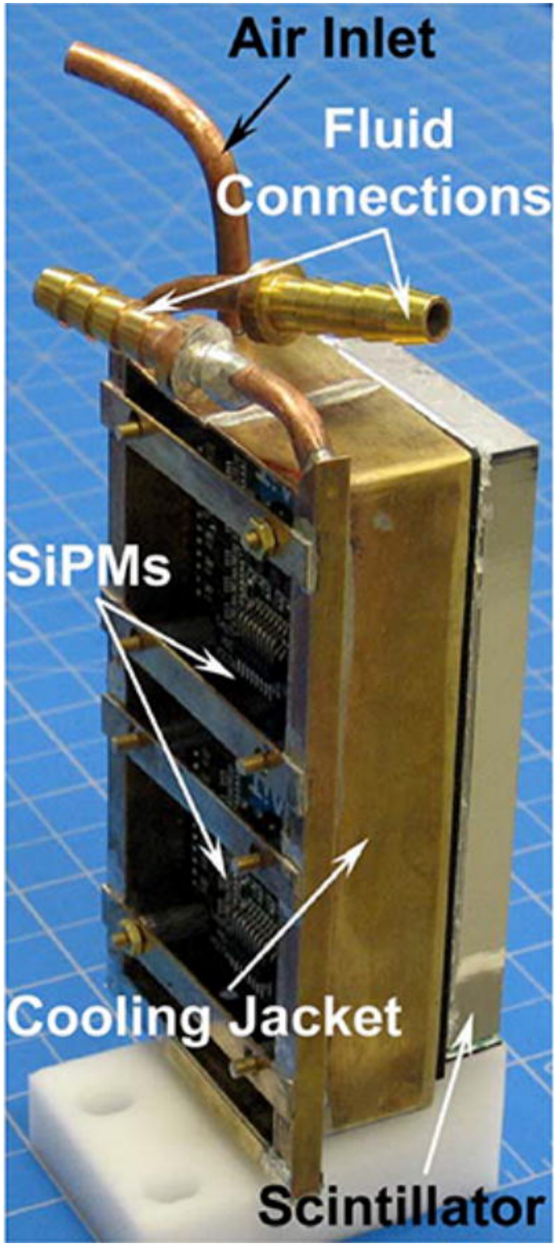
One CEPC calorimeter ≈ 1000 to 2000 medical PET scanners

SiPM modules used in TOF-PET

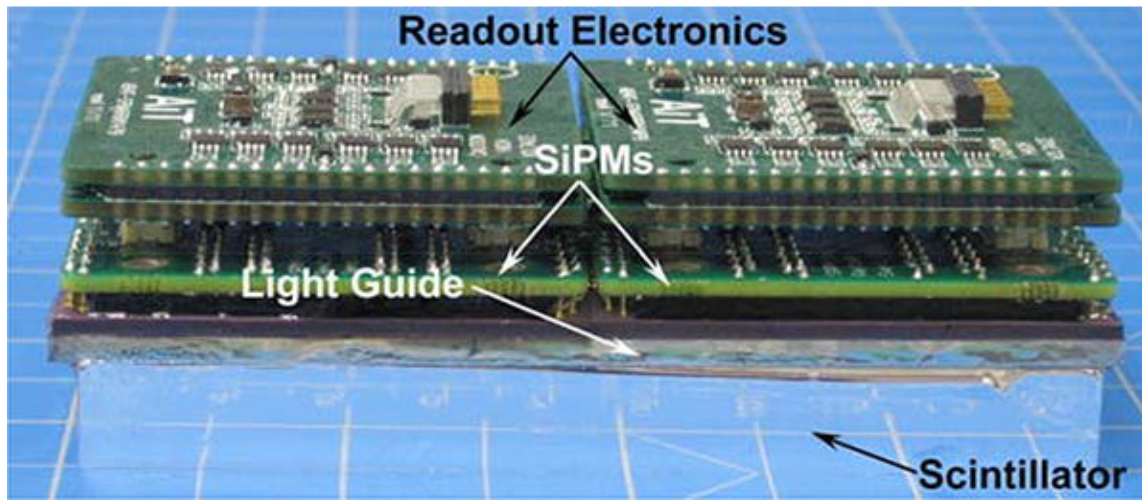


PMT size: 25 mm x 25 mm
Pixel size: 3 mm x 3 mm
or 4 mm x 4 mm

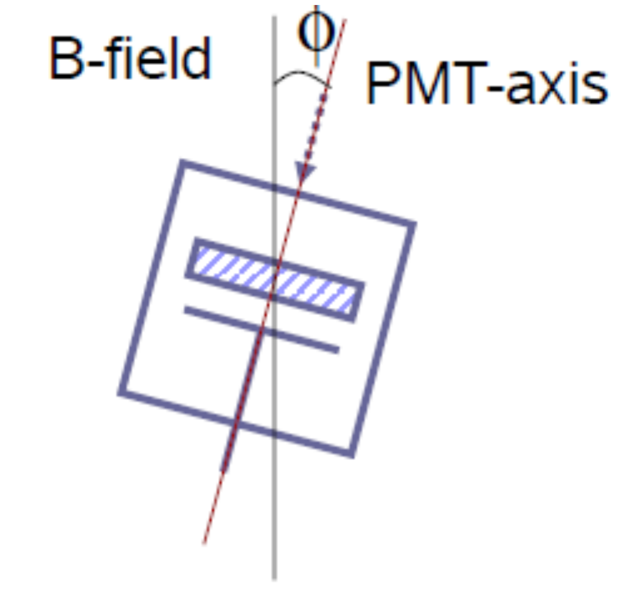




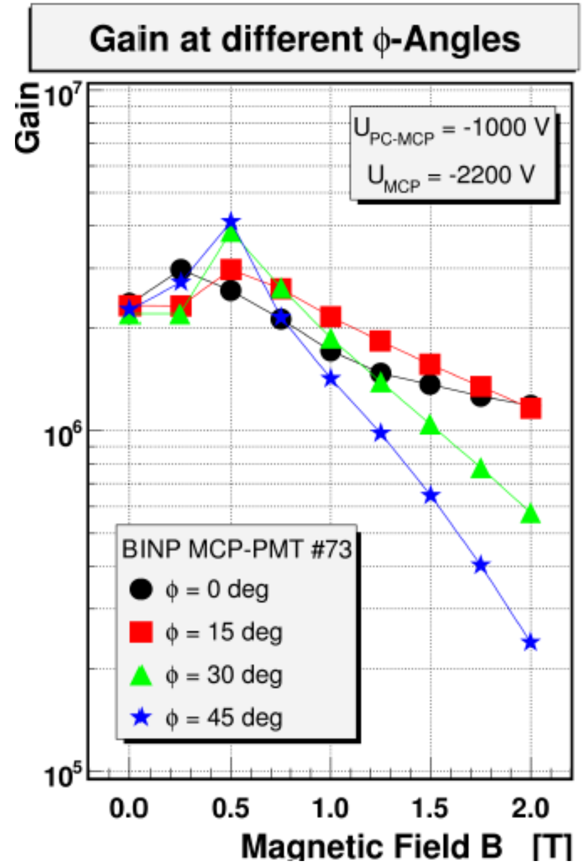
Example of SiPM Modules used in TOF-PET



MCP-PMT

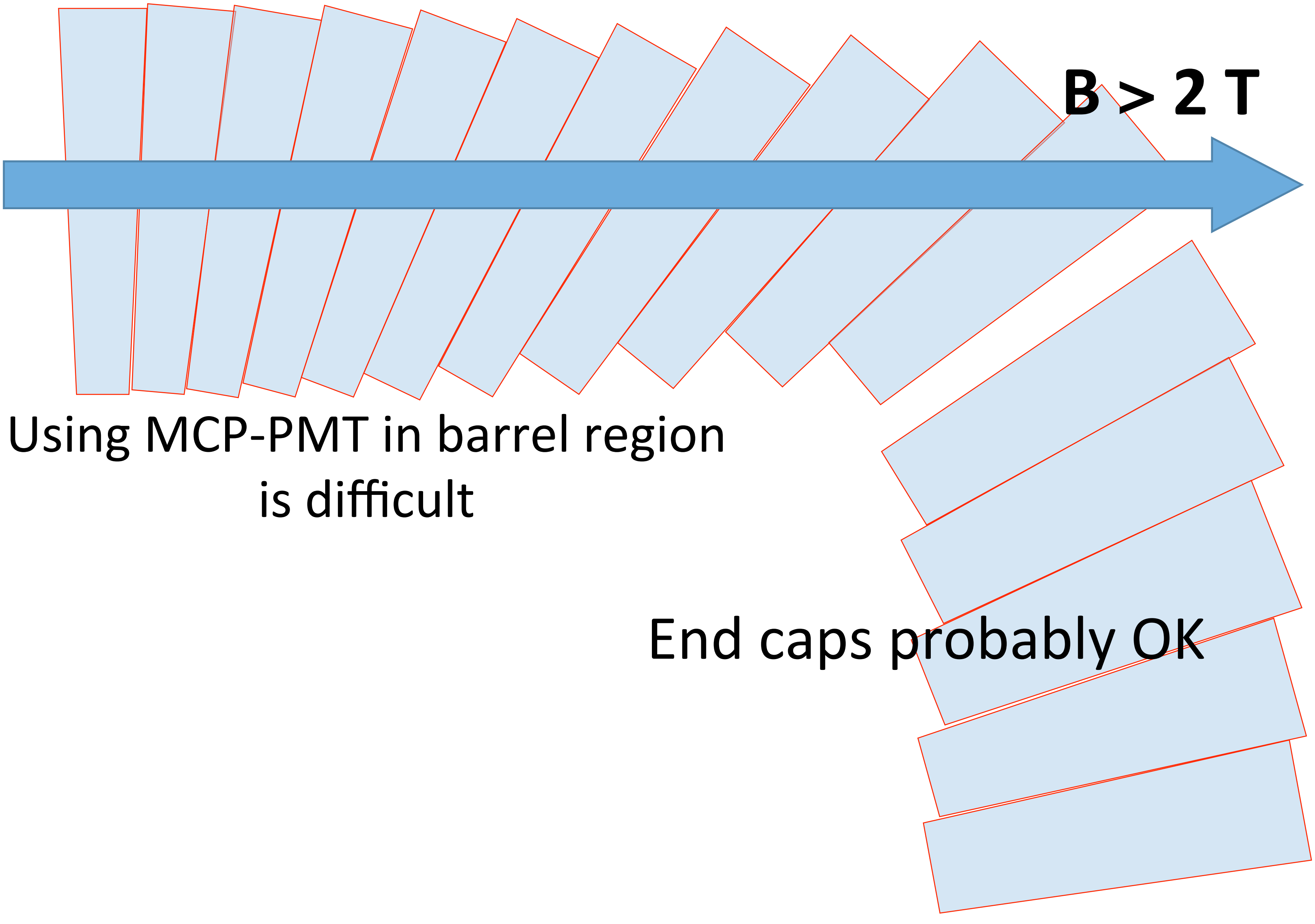


BINP #73 (6 μm)

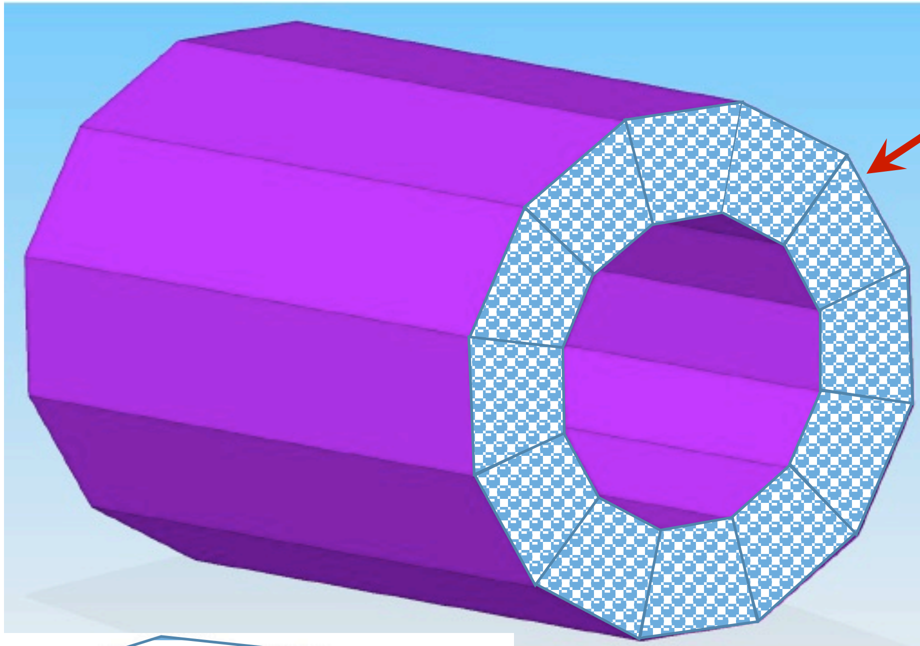


We believe we can develop and make MCP-PMTs at an affordable cost in China

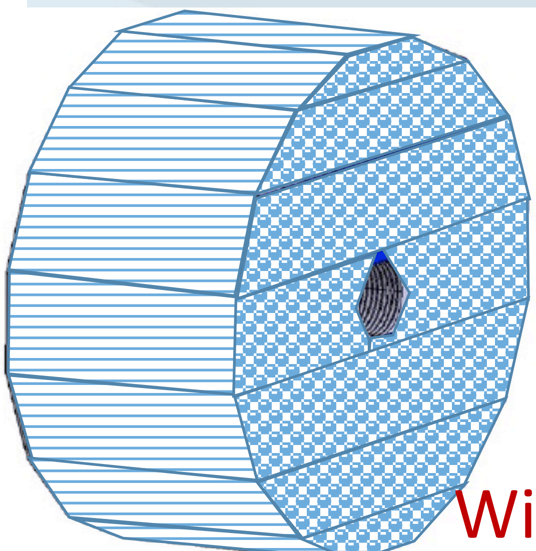
MCP-PMTs that work in 2 T magnetic field and in all directions may not be possible

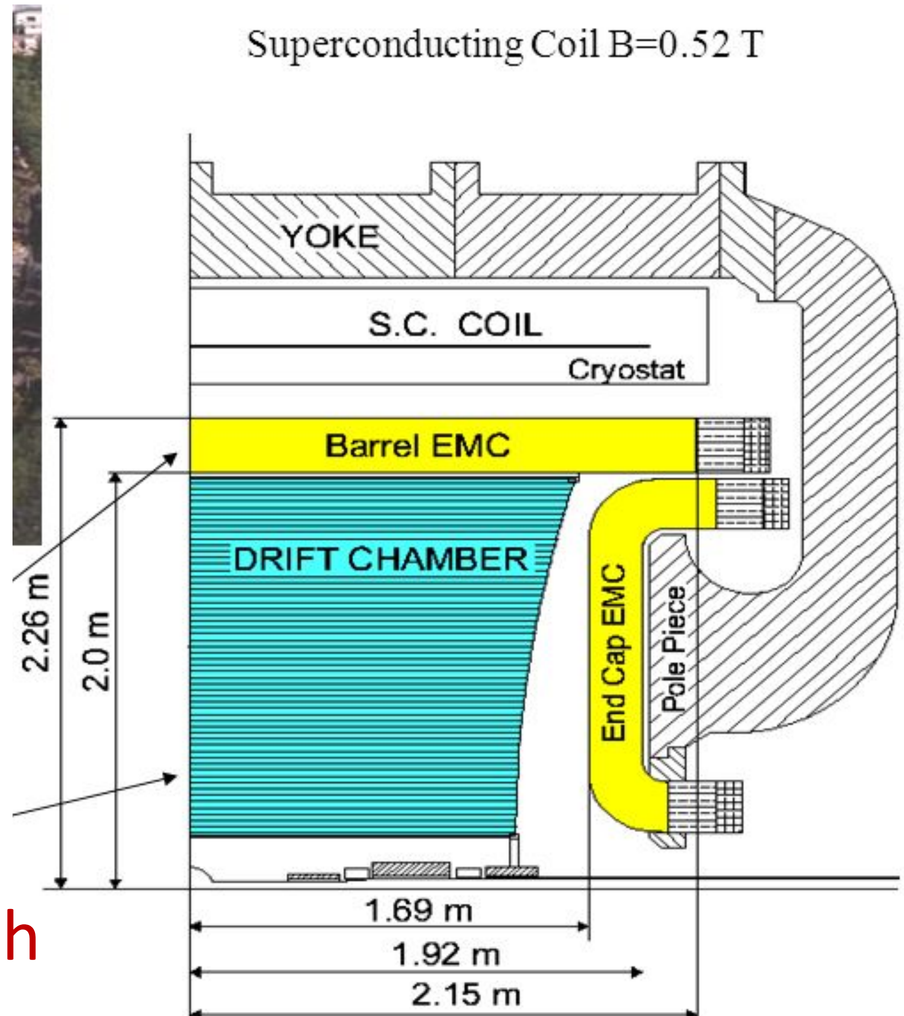

B > 2 T
Using MCP-PMT in barrel region
is difficult
End caps probably OK

Go back to KLOE EMCal configuration



Fibers along the barrel
MCP-PMTs at two ends





Will it work in high energy collider?