

# MicroBooNE photon collection system

1. Introduction
2. PMT unit
3. Installation
4. Performance
5. Conclusion

MicroBooNE PMT test stand  
(photo by Reidar Hahn, Fermilab)

Teppei Katori for the MicroBooNE collaboration  
Massachusetts Institute of Technology  
LIDINE2013, Fermilab, Batavia, IL, May 31 2013

# 1. Introduction

## 2. MicroBooNE PMT unit

## 3. Installation

## 4. Performance

## 5. Conclusion

# 1. Introduction

MicroBooNE is 170 ton liquid argon cryostat with 2.5m x 2.4m x 10.6m volume of TPC (under construction, beam data is expected from 2014) ← **tour on Friday afternoon!**

Prompt scintillation light from argon is faster ( $\sim$ ns) than electron drift ( $\sim$ ms), therefore detection of scintillation light allows to trigger the TPC

Large array of large photo-cathode PMT is the cheapest option to achieve this purpose

We took basic features of ICARUS T600 PMT system design and modified

MicroBooNE cryostat

MicroBooNE TPC



# 1. Introduction

## ICARUS T600 photon detection system

- ETL 12 stage 8-inch bi-alkali PMT with Pt-coating
- 54 of PMTs to cover T300 3.6m x 3.9m x 19.6m volume ( $\sim 0.5\%$  photo-cathode coverage)
- PMTs are located 5mm behind of collection wire plane
- PMT windows are sand blasted to spray TPB solution
- Negative HV operation, custom made base directly soldered on PMT
- PEEK rod PMT mount

Inside of half module of ICARUS T300



# 1. Introduction

## ICARUS T600 photon detection system vs MicroBooNE photon detection system

- ETL 12 stage 8-inch bi-alkali PMT with Pt-coating
  - Hamamatsu 8-inch tube
- 54 of PMTs to cover T300 3.6m x 3.9m x 19.6m volume (~0.5% photo-cathode coverage)
  - 0.85% photocathode coverage
- PMTs are located 5mm behind of collection wire plane
  - ~20cm behind of collection wire plane
- PMT windows are sand blasted to spray TPB solution
  - TPB plate equipped in front of PMT
- Negative HV operation, custom made base directly soldered on PMT
  - positive HV operation
- PEEK rod PMT mount
  - spring loaded wire mount

ICARUS T600  
MicroBooNE

1. Introduction

**2. MicroBooNE PMT unit**

3. Installation

4. Performance

5. Conclusion

## 2. MicroBooNE PMT unit

PMT unit mechanical model



Each PMT unit consists of 4 pieces

- PMT and base
- TPB plate
- PMT mount
- Cryogenic mu-metal shield

- PMT and base
- TPB plate
- PMT mount
- Cryogenic mu-metal shield

## 2. PMT and base

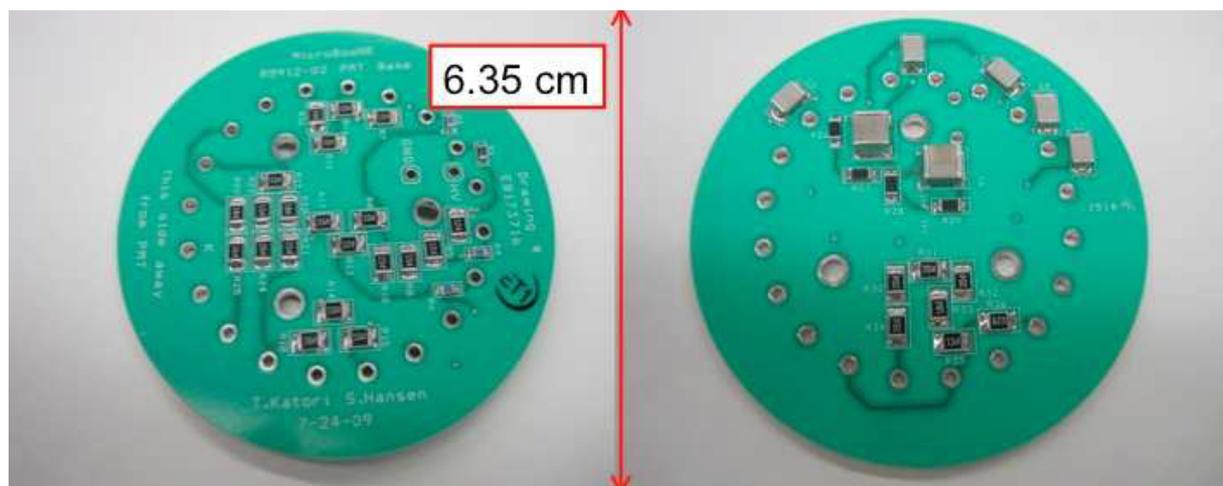
### Hamamatsu R5912-02mod

- 14 stage high gain, 8-inch hemi-spherical photocathode, Pt-coating
- 32 PMTs to cover 2.5m x 2.4m x 10.6m volume (0.85% photocathode coverage)
- All PMTs are tested at PMT test stand (next)

### Cryogenic base

- Metal film resistor, NP0/C0G capacitor, glass reinforced PC board, Teflon cable, etc
- Layout is designed at Fermilab
- Positive HV operation → One cable carries both signal and HV
- Total heat ~ 0.5W

MicroBooNE PMT base



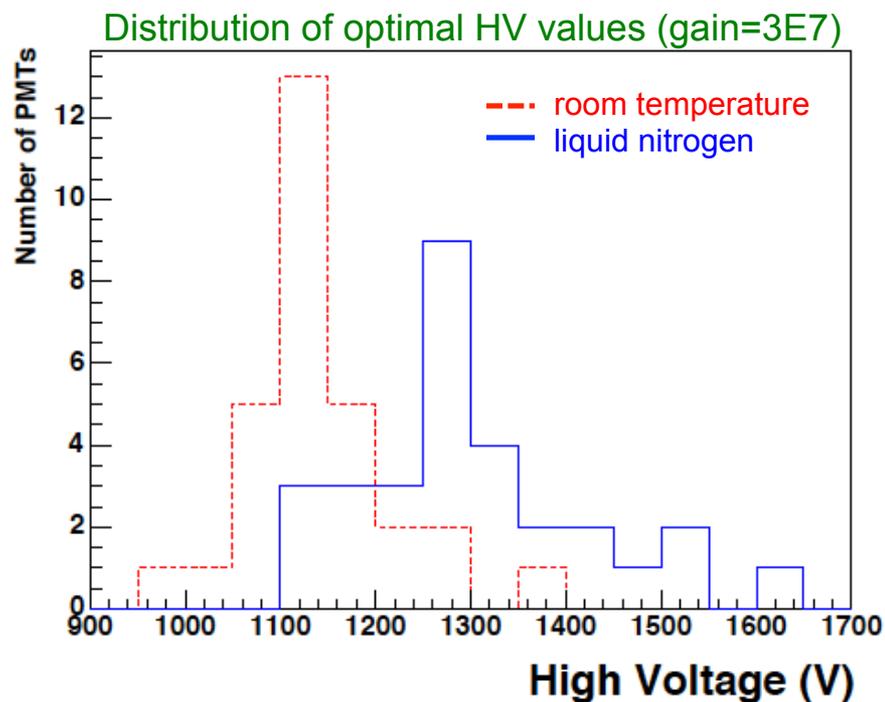
- PMT and base
- TPB plate
- PMT mount
- Cryogenic mu-metal shield

## 2. PMT test stand

### MicroBooNE PMT test stand

#### Open Dewar based PMT test stand

- Dark current and gain are measured both in air and liquid nitrogen (LN2).
- Operation HV values in cryogenic temperature are extracted.



- PMT and base
- **TPB plate**
- PMT mount
- Cryogenic mu-metal shield

## 2. TPB plate

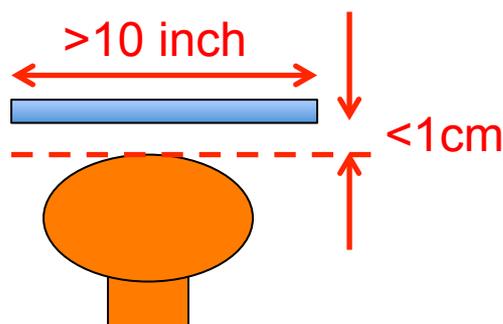
### TPB coated acrylic plate in front of PMT

- TPB + polystyrene solution is deposited on acrylic plate
- Cheaper and easier option than sand blast, vacuum evaporation, etc
- Our study shows geometric loss is small if the plate is close ( $<1\text{cm}$ ) and big ( $>10\text{ inch}$ )

### TPB plate production

- 50% TPB + 50% polystyrene by mass in Toluene solution is applied on acrylic plate by brush
- Easily produce  $\sim 30$  plates within 1 week

12 inch acrylic plate in front of the PMT will give order 1% global collection efficiency.



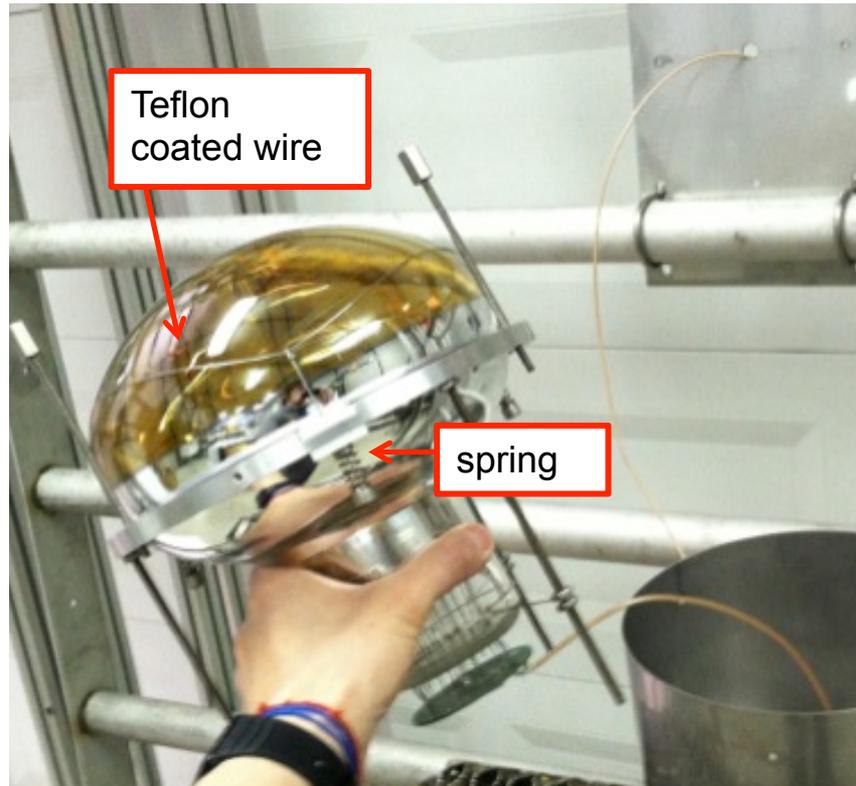
- PMT and base
- TPB plate
- **PMT mount**
- Cryogenic mu-metal shield

## 2. Mounting structure

### Spring loaded wire

- PMT is held in Teflon-aluminum structure by Teflon coated wire under tension by springs
- Thermal expansion/contraction is taken into account
- being produced at Fermilab machine shop

PMT unit mechanical model



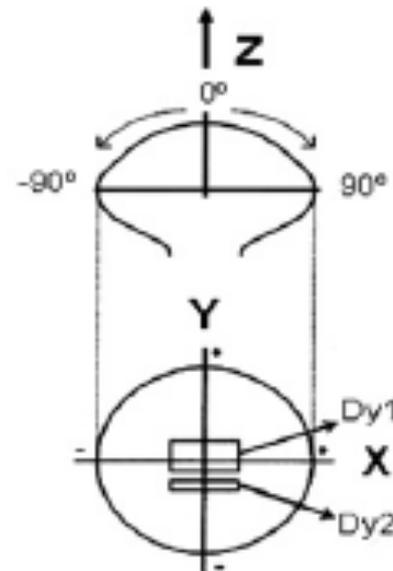
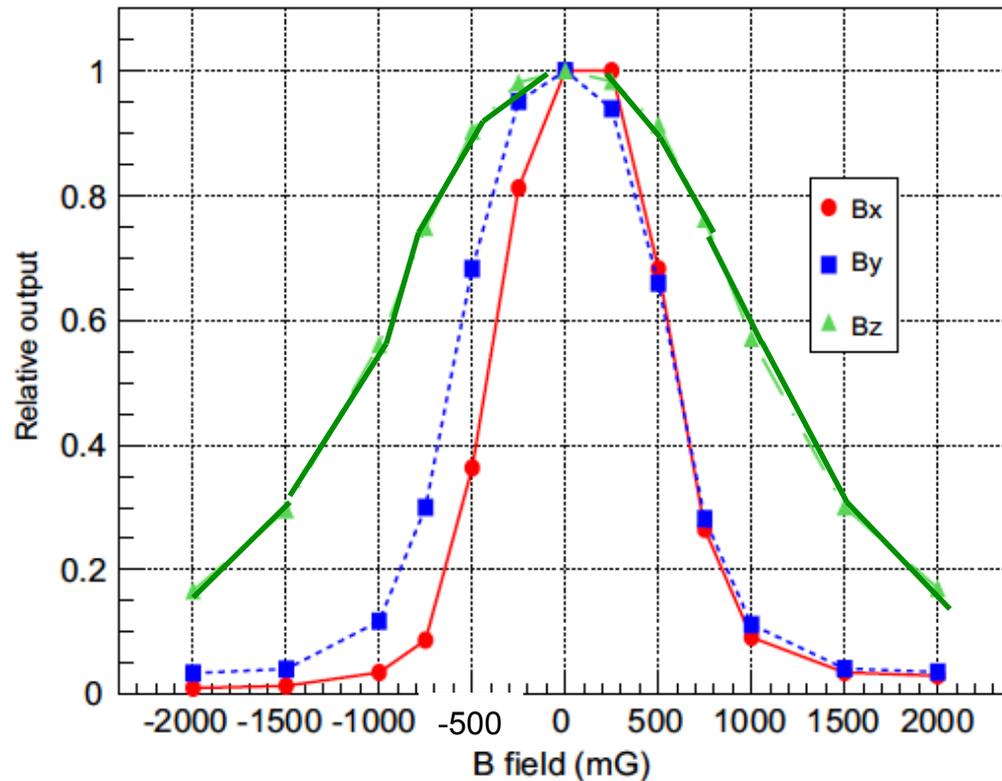
- PMT and base
- TPB plate
- PMT mount
- Cryogenic mu-metal shield

## 2. Cryogenic magnetic field shield

### Cryogenic magnetic shield

- Double Chooz study shows earth magnetic field ( $\sim 0.5\text{G}$ ) reduces  $\sim 40\%$  light output
- MicroBooNE cryostat is made of non-magnetic stainless steel (SL304)

Double Chooz PMT B-filed response

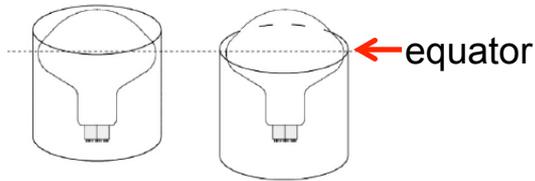


- PMT and base
- TPB plate
- PMT mount
- Cryogenic mu-metal shield

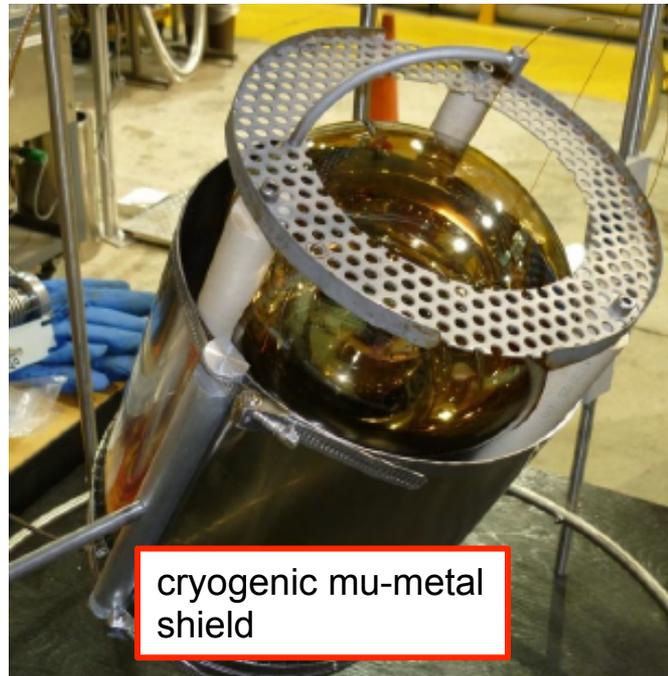
## 2. Cryogenic magnetic field shield

### PMT B-field test stand

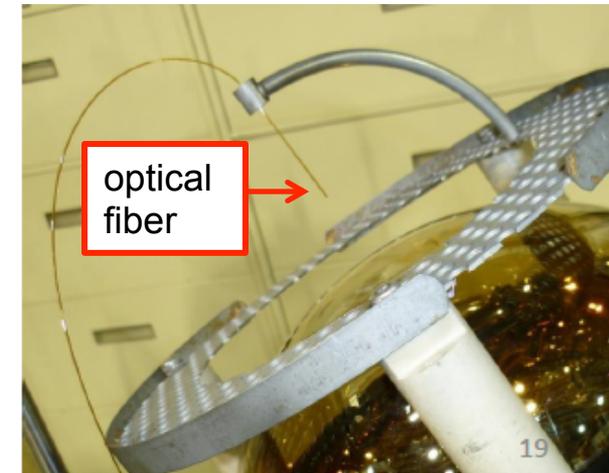
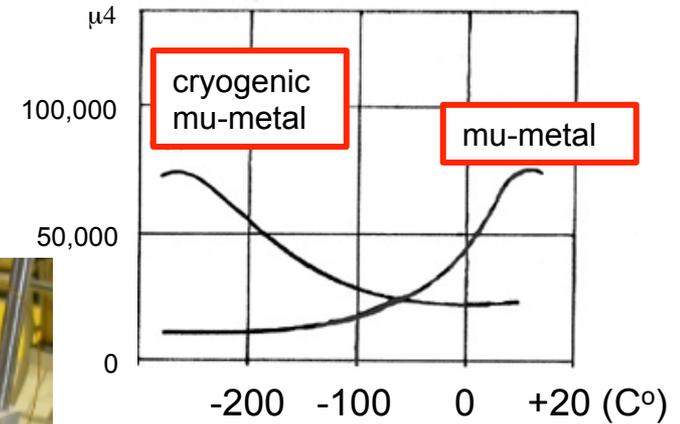
- We built a test stand to check the effect of earth magnetic field
- Cryogenic magnetic field shield prevent light yield variation due to PMT angle
- We apply the shield up to the equator



### MicriBooNE PMT rotator



permeability with function of temperature

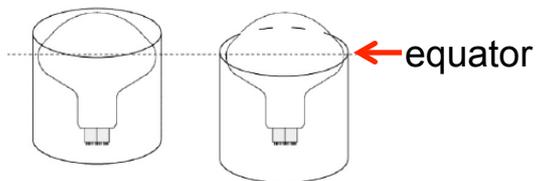


- PMT and base
- TPB plate
- PMT mount
- Cryogenic mu-metal shield

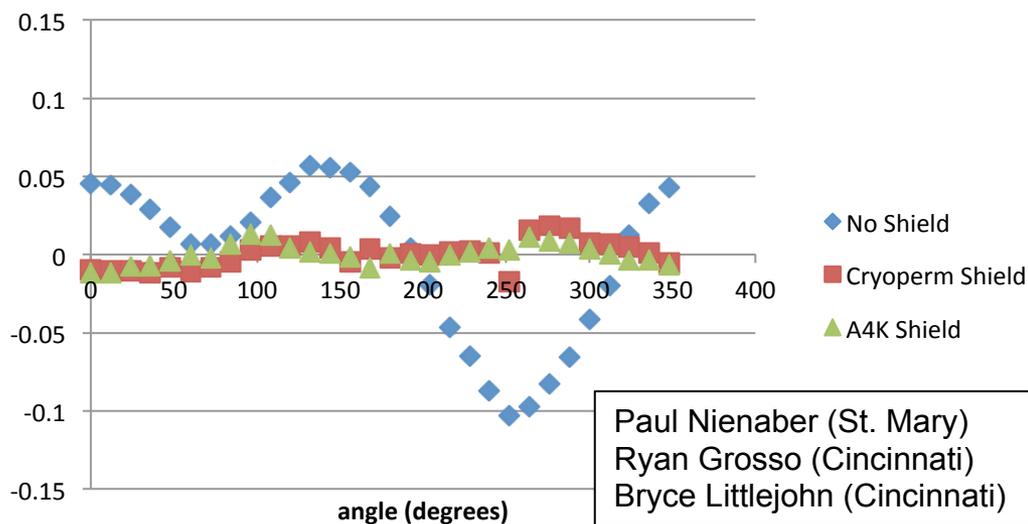
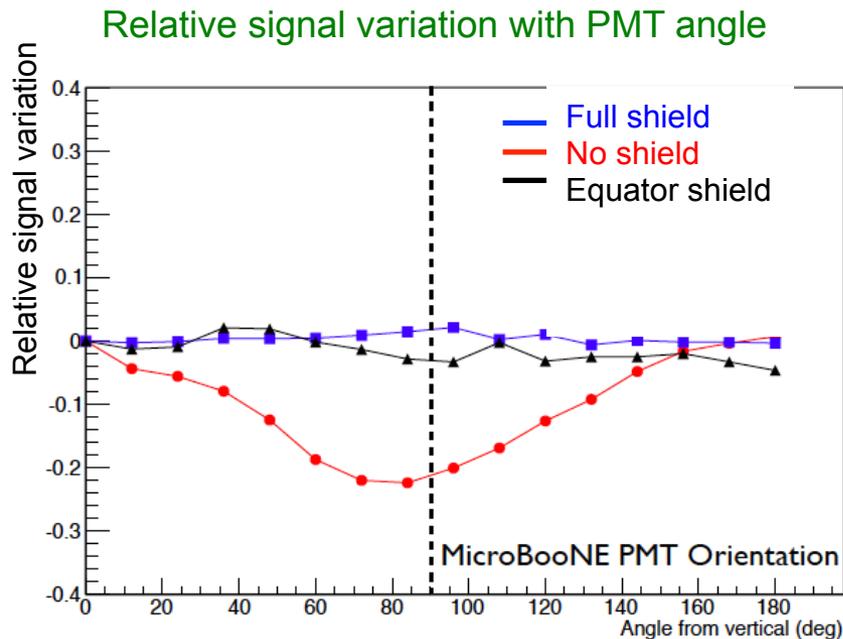
## 2. Cryogenic magnetic field shield

### PMT B-field test stand

- We built a test stand to check the effect of earth magnetic field
- Cryogenic magnetic field shield prevent light yield variation due to PMT angle
- We apply the shield up to the equator



### fractional deviation from mean Q vs. angle, liquid nitrogen



Paul Nienaber (St. Mary)  
 Ryan Grosso (Cincinnati)  
 Bryce Littlejohn (Cincinnati)

1. Introduction

2. MicroBooNE PMT unit

**3. Installation**

4. Performance

5. Conclusion



# 3. Installation

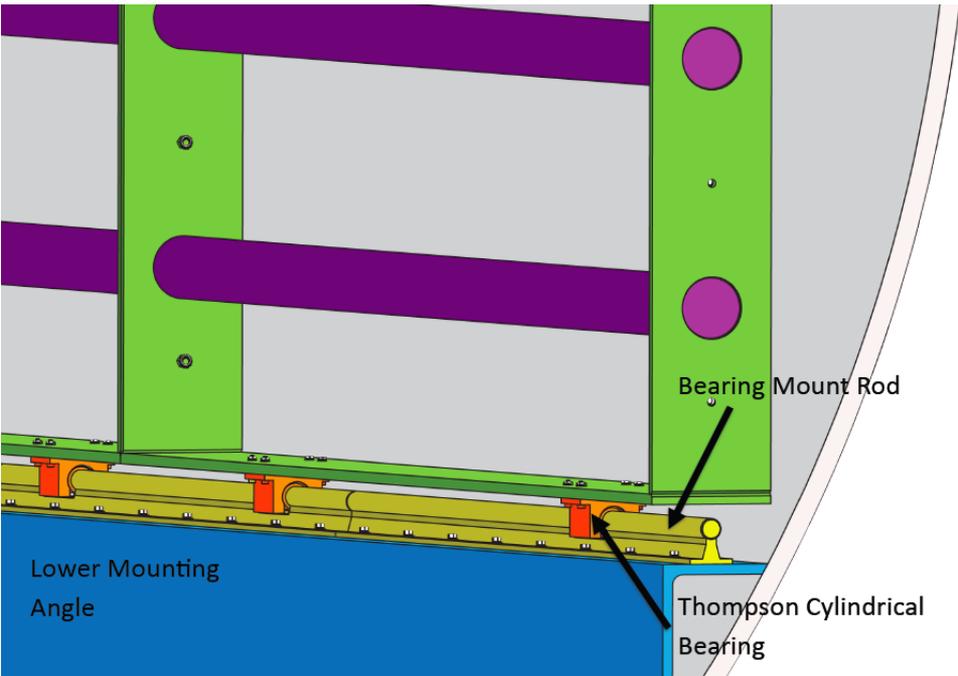
In ICARUS, PMTs need to be installed first, and sit months  
→ there is a worry of degradation of TPB coating...

See Jenn VenGemert's talk (May 30 afternoon)

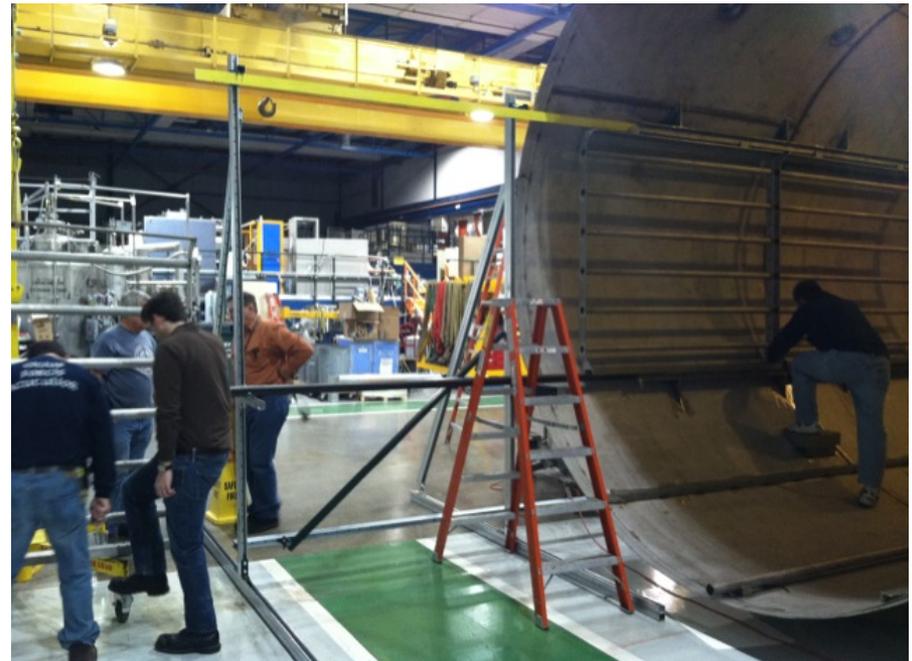
## Oil-free linear (Thomson) bearing

- Racks slide in and out by Teflon coated Thomson bearing
- PMTs can be installed after TPC is installed

PMT rack bottom linear bearing structure



PMT installation practice



### 3. Installation

In ICARUS, PMTs need to be installed first, and sit months  
→ there is a worry of degradation of TPB coating...

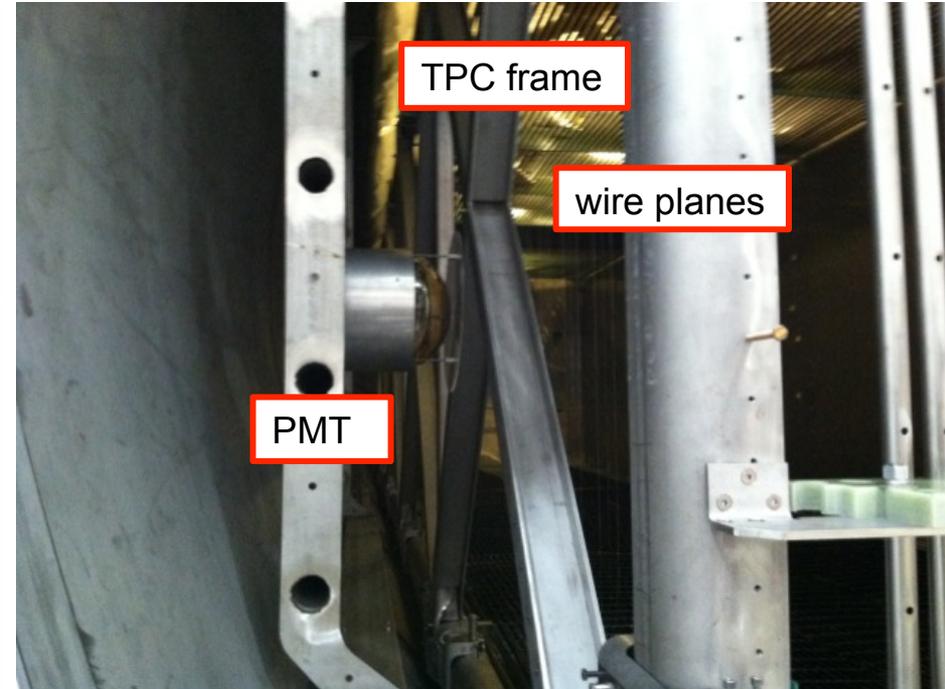
#### Oil-free linear (Thomson) bearing

- Racks slide in and out by Teflon coated Thomson bearing
- PMTs can be installed after TPC is installed

Inside of half module of ICARUS T300



MicroBooNE PMT mock set up



MicroBooNE photon detection system will be installed in the cryostat in summer 2013

1. Introduction

2. MicroBooNE PMT unit

3. Installation

**4. Performance**

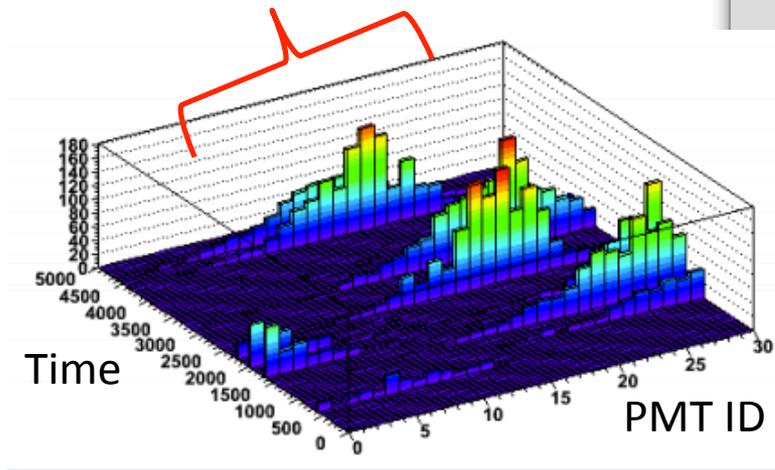
5. Conclusion

# 4. Performance

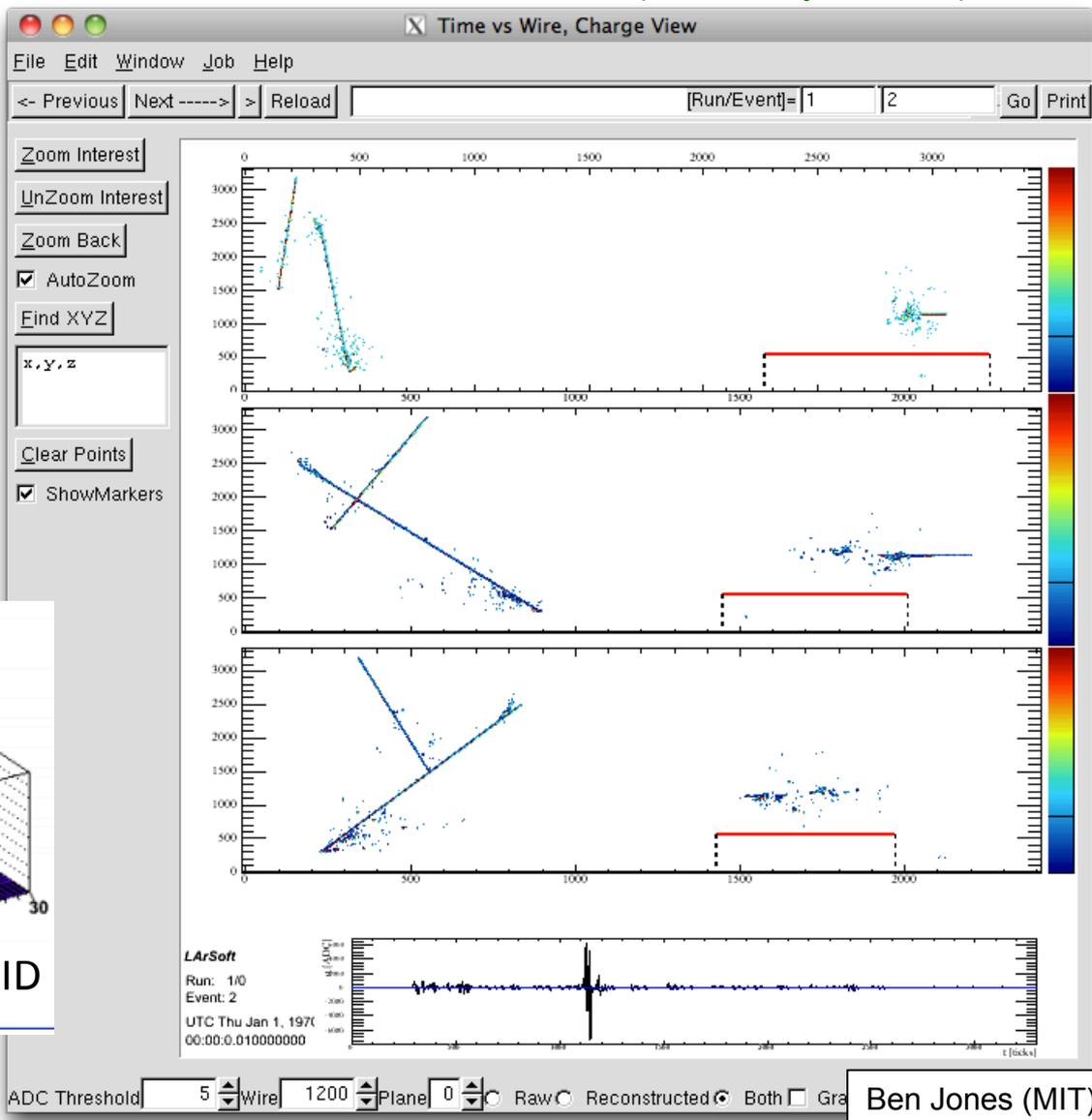
## Flash Finder

- Time and coordinate cluster of PMT pulses can find neutrino related activity in the sea of cosmic rays (~20 cosmic rays per TPC window)

cluster of PMT pulses  
→ "flash"



## MicroBooNE simulation (cosmic ray overlaid)



## Conclusion

MicroBooNE photon detection system consists of 32 cryogenic PMTs and 4 lightguides

PMT unit consists of 4 pieces; PMT and base, TPB plate, PMT mount, and cryogenic mu-metal shield

System is well-understood, and ready to install in the MicroBooNE cryostat in this summer



**Thank you for your attention!**