# Earth Magnetic Field Compensation Coils System for JUNO

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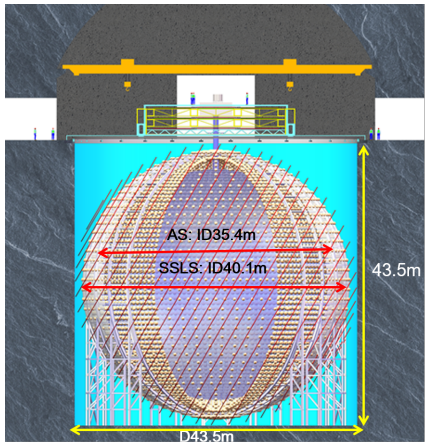
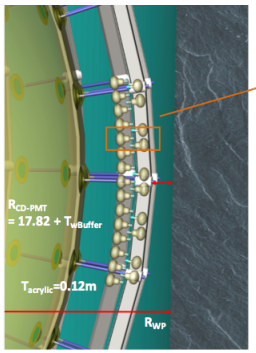
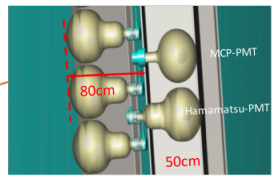
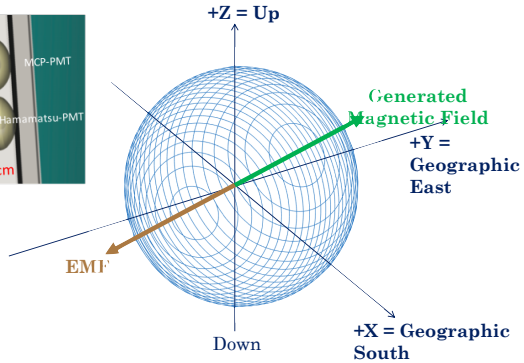
## Introduction

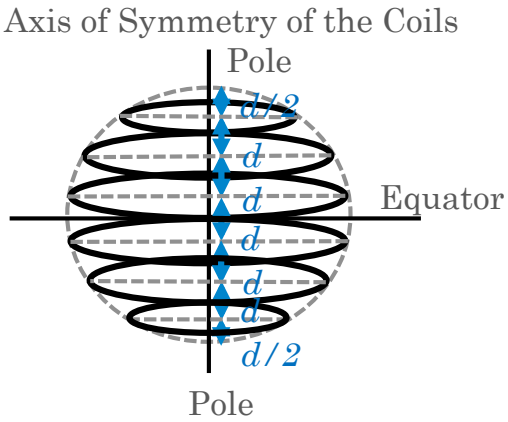
The JUNO is a multi-purpose neutrino experiment. The neutrino detector is a 20 kton liquid scintillator (LS) detector located 700 meters underground. The light emitted by the LS from neutrino induced interaction is detected by thousands of 20-inch photomultiplier tubes (PMTs) installed on a spherical structure around the Central Detector (CD) submerged in a water pool. Another set of PMTs around the CD facing out to detect the Cherenkov light from cosmic muons, acting as a veto detector.




The Earth magnetic field (EMF) intensity is about 0.5 gauss at the JUNO site. It could have significant negative impact on photoelectron collection efficiency of the 20-inch PMTs as shown in Fig. 1.

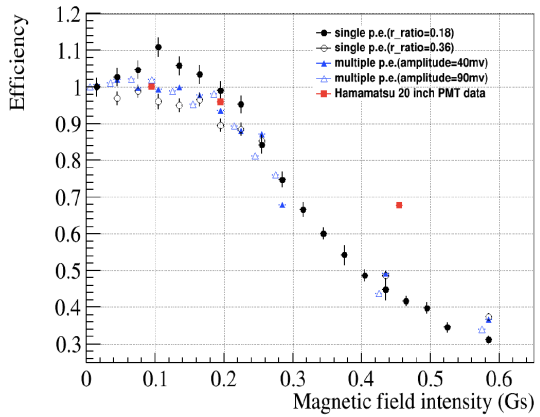



Fig. 1 Efficiency of PMT in magnetic field

Our aim is to reduce the residual magnetic field to be less than 10% of EMF at Jiangmen site (or < 0.05 G). The maximum residual magnetic field is defined as

$$B_{res}^{\max} = \left( \frac{B - EMF}{EMF} \right)_{\max} \times 100\%$$

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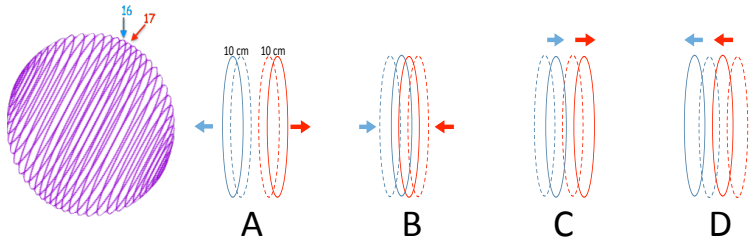
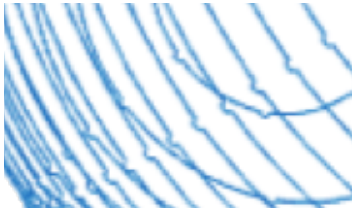
## Result (1): Installation errors due to misalignment

Shift the coil #16 and #17 (the largest) ±10 cm




| diameter (m) | Max of B-res to EMF (%) | | | | |
|---|---|---|---|---|---|
| | Perfect coil | A | B | C | D |
| 39.5 (CD) | 2.09 | 2.09 | 2.09 | 2.12 | 2.12 |
| 41.5 (Veto) | 10.81 | 10.81 | 10.81 | 10.84 | 10.84 |

## Result (2): Installation errors due to bumps (R = 20 cm) on coils



| diameter (m) | Max of B-res to EMF (%) | |
|---|---|---|
| | Perfect coil | With 128 bumps |
| 39.5 (CD) | 2.09 | 2.09 |
| 41.5 (Veto) | 10.81 | 10.85 |

## Result (3): EMF secular change

| diameter (m) | Max of B-res to EMF (%) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | -5° | -3° | -2° | -1° | Perfect coil | 1° | 2° | 3° | 4° |
| 39.5 (CD) | 10.48 | 7.02 | 5.28 | 3.55 | 2.09 | 3.54 | 5.27 | 7.01 | 10.49 |
| 41.5 (Veto) | 18.97 | 15.57 | 13.88 | 12.21 | 10.81 | 12.21 | 13.89 | 15.60 | 19.04 |

## Summary

- One set of 16 pairs of circular coils with equal spacing surrounded the central detector has been proposed and studied.
- The residual magnetic field in the CD region is less than 5%.
- The effects of small (±10 cm) installation misalignments are negligible.
- The effects of EMF secular variation over 20 yrs of JUNO operation are still less than 10%.