Feb 9, 2021

# Feature Recognition for Photogrammetry Calibration of the Super-Kamiokande Detector

Weekly update

Tapendra BC
bc-t@webmail.uwinnipeg.ca

Supervisor: Blair Jamieson

Github

# Outline

- Introduction
- Problem Statement
- Methods
- Result
- Future Work

# Introduction

## Neutrino

- Subatomic particle that is very similar to an electron but has no electrical charge.
- One of the most abundant particles in the universe.
- Incredibly difficult to detect.

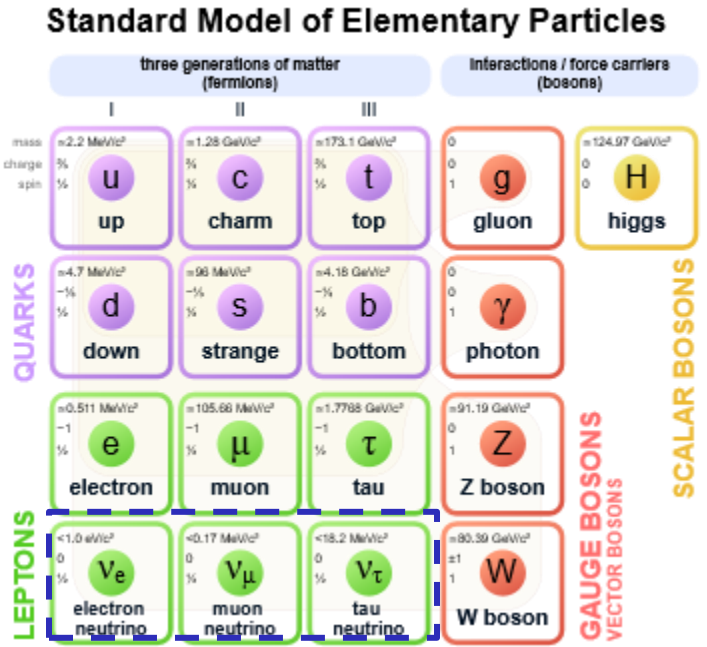



**Fig**: standard model[1]

How is neutrino detected?

# Super Kamiokande (Super-K)

1

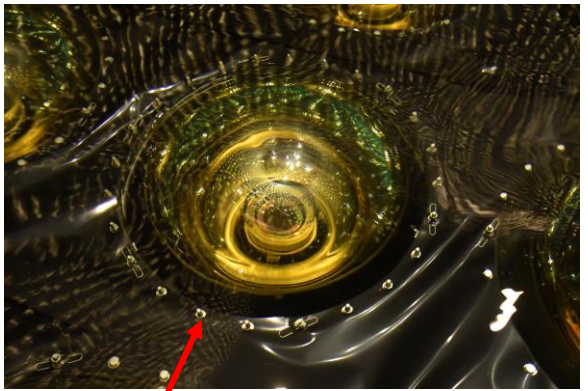
Fig: Model of Super-Kamiokande detector[2]

~11,000 PMTS

2

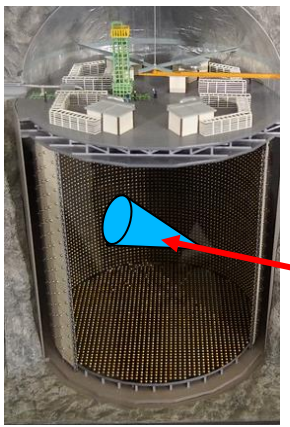
PMT[3]

3



Bolts for mounting PMT to wall.

4



Cherenkov radiation

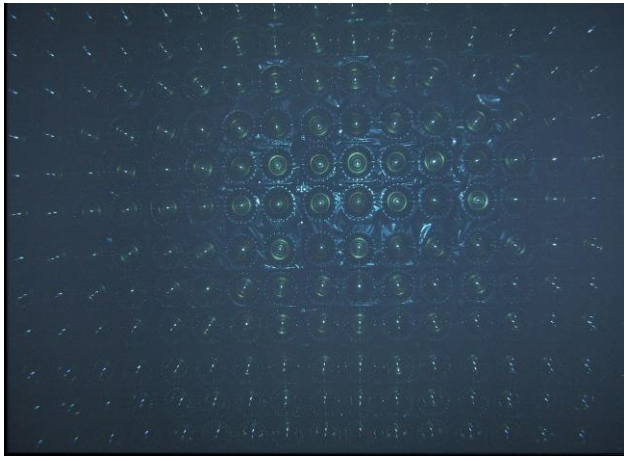
- Produced when charged particles move faster than speed of light in a medium(water).[2]

# Photographing detector wall with Underwater drone

1

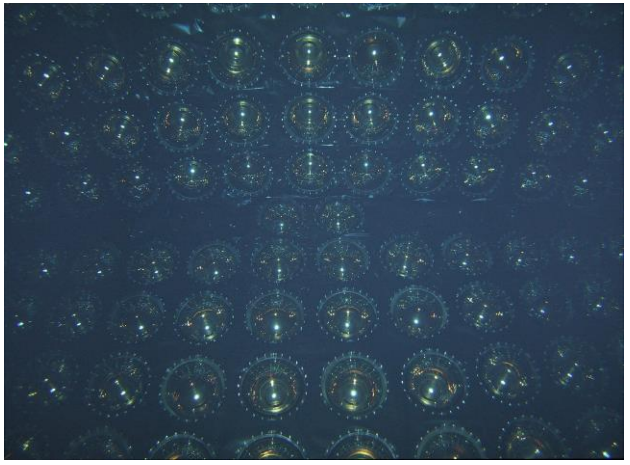
**>15000 img**

2



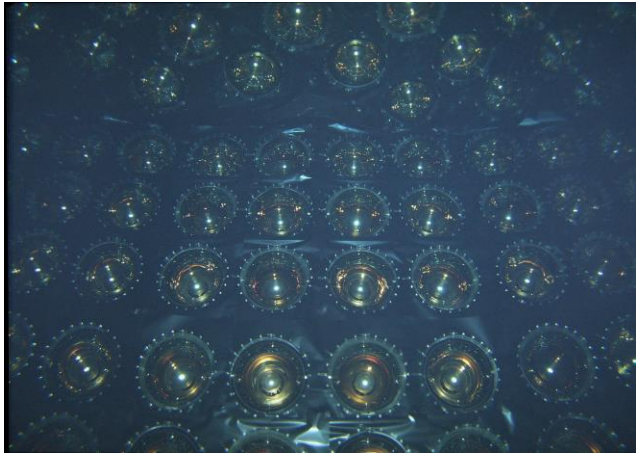
239.jpg

3



379.jpg

4



Need for automation?

# Problem Statement

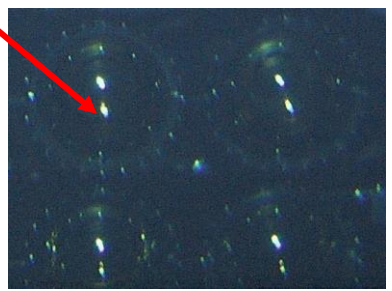
- Find Location of PMTs in detector wall using photographs taken.

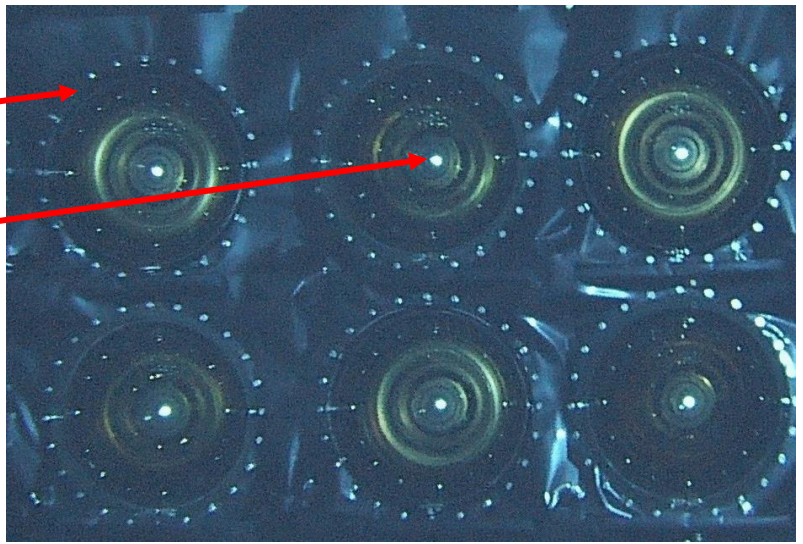
## Noticeable features

1) Bolts

2) Dynode centre

-Sometimes they are not the centre of PMT. Instead the reflection from dome.





## Noticeable Properties

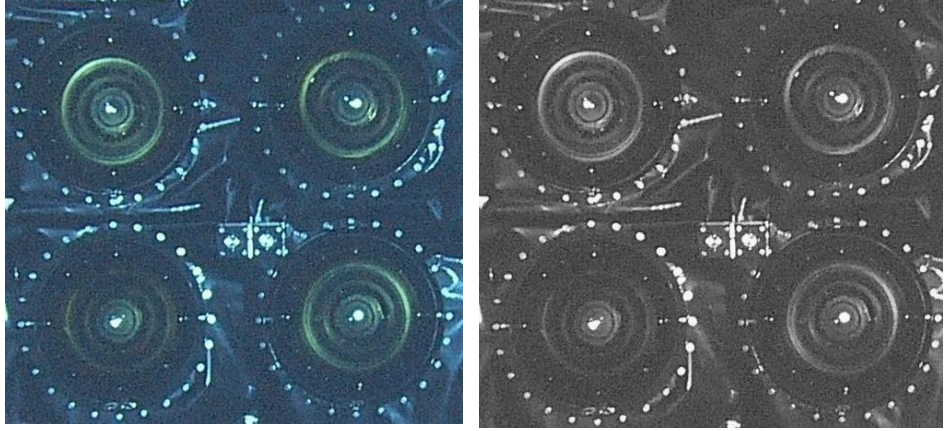
1)Bolts are evenly spread in circumference.

2)PMTs do not overlap with each other.

# Method

## 1.Bilateral Filtering

Removes noise in images while preserving sharp edges.



Example of Filtering
(d=5, sigColor=2, sigspace=50)

## 2.Blob detection

**Blob:** *In computer vision, blob detection methods are aimed at detecting regions in a digital image that differ in properties, such as brightness or color, compared to surrounding regions.*

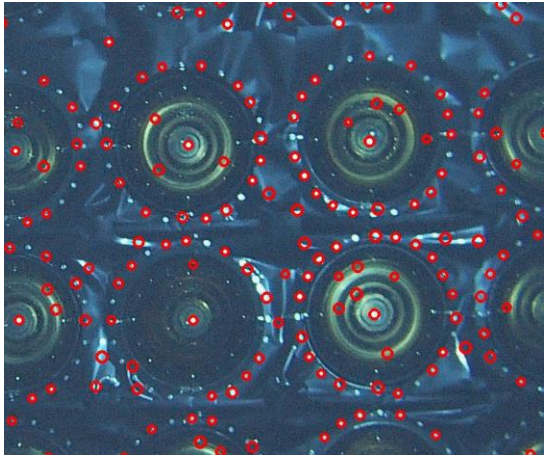
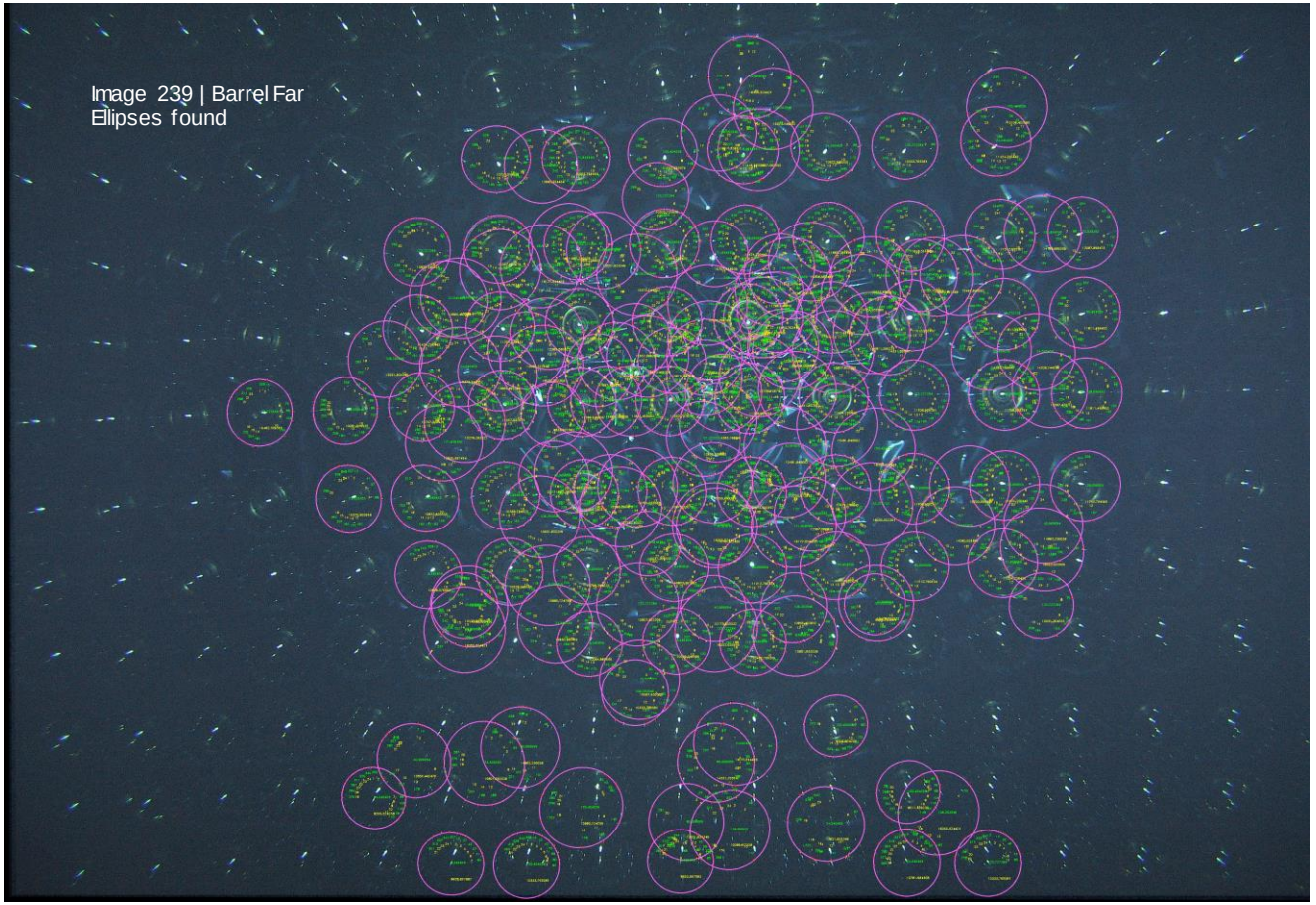


**Fig**: *Image of detector wall.*
*Red circle represents candidate bolt.*

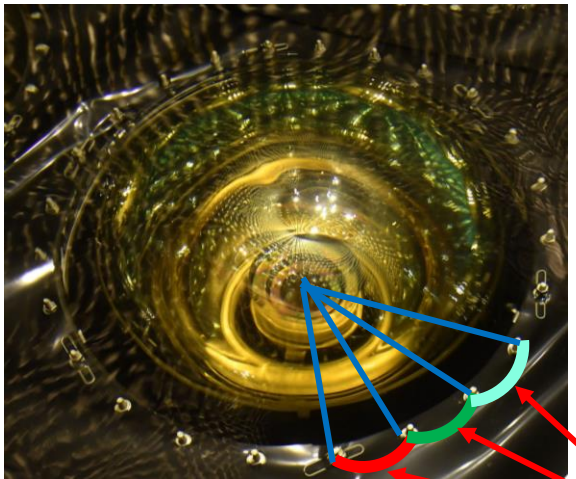
# 3.Hough-Ellipse Transform




- Finds many overlapping ellipses
- Need to remove overlapping ellipses and keep ones that are PMTs

# 4.Bolt angle cut

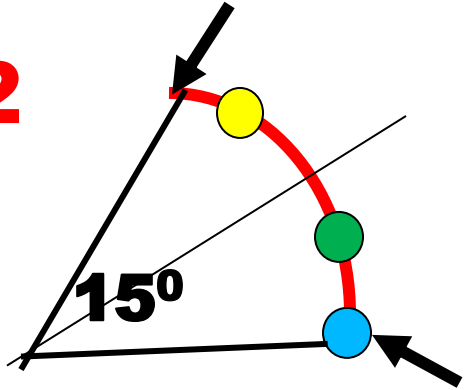
1



15⁰

2

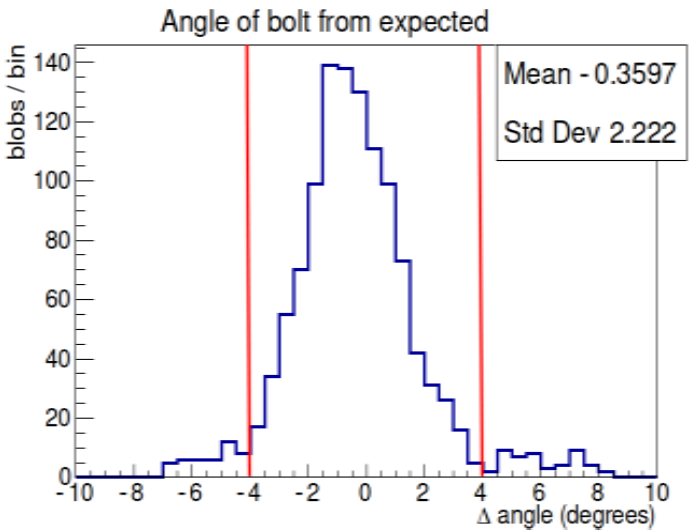
Next expected




3

Remove these

4




- Cut bolts that are more than ±4⁰ from expectation.
- If angle between two blobs is less than 7.5 = 15/2 remove the one with more deviation.

Shown for BarrelSurveyFar Image 239, for all ellipses found

# 5.Ellipse Overlap cut

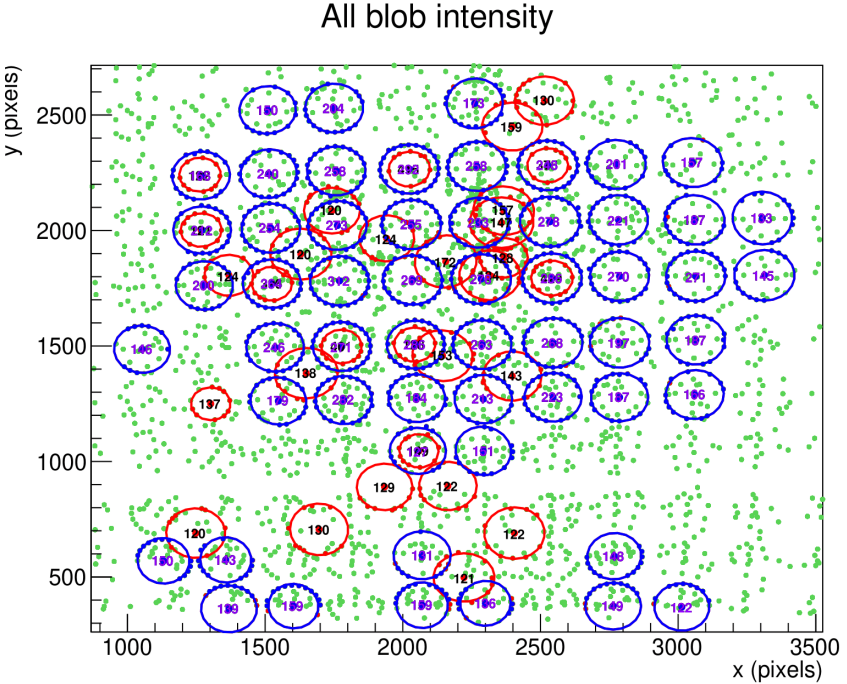
**PMTs shouldn't overlap.**

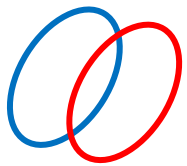
**<u>If two ellipses intersect:</u>**

- Correct ellipse is one with more of bolts.

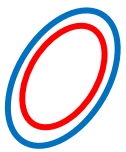
**<u>If ellipse is contained:</u>**

- False if contained with less bolts.



overlap

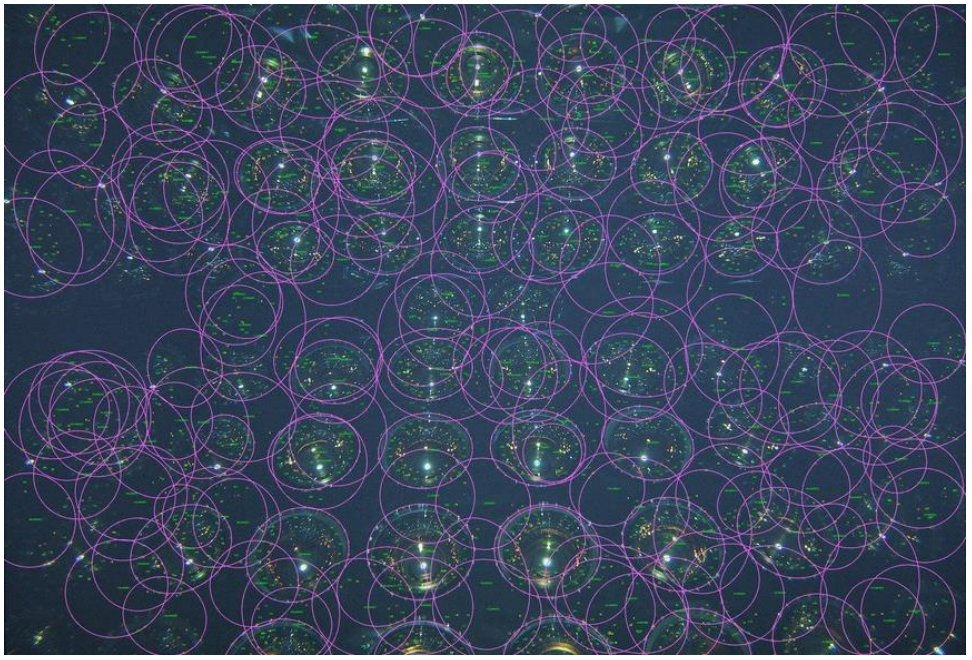


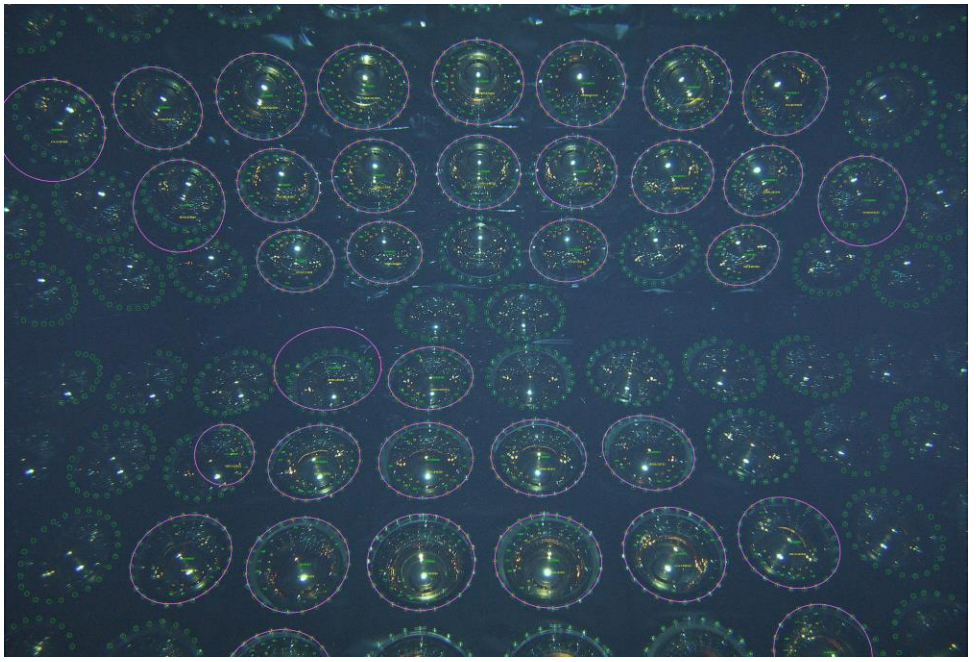
contained

- Two ellipses overlap.
- One ellipse Contain another.
- Sent corrections to algorithm that we followed – (non-peer reviewed) <u>publication</u> updated.

**Final Image**

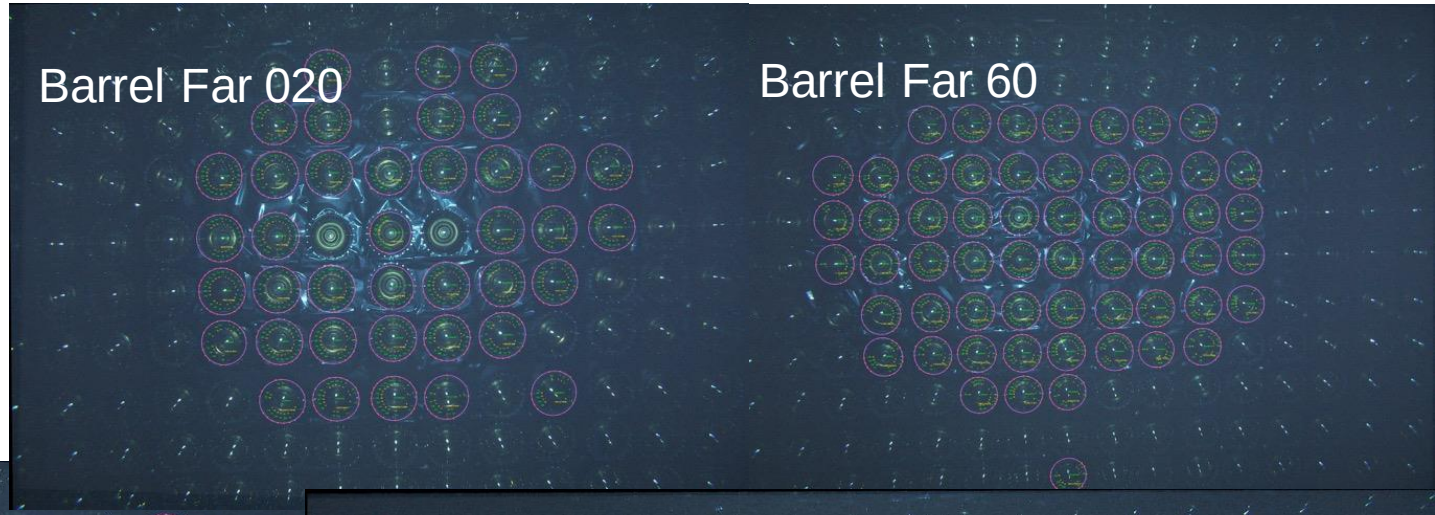
**(Barrel Far 239)**





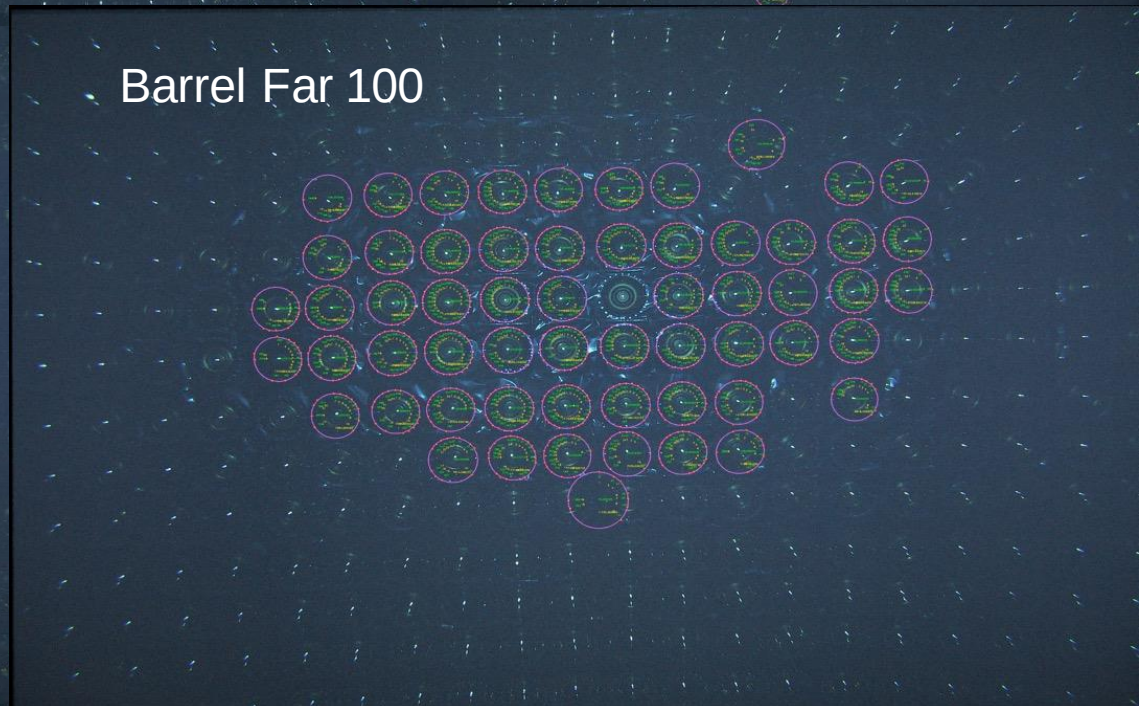
- **Fig**: Image 379 | BottomCornerSurvey
- Also works when PMTs are elliptical.

**Gallery of Success**

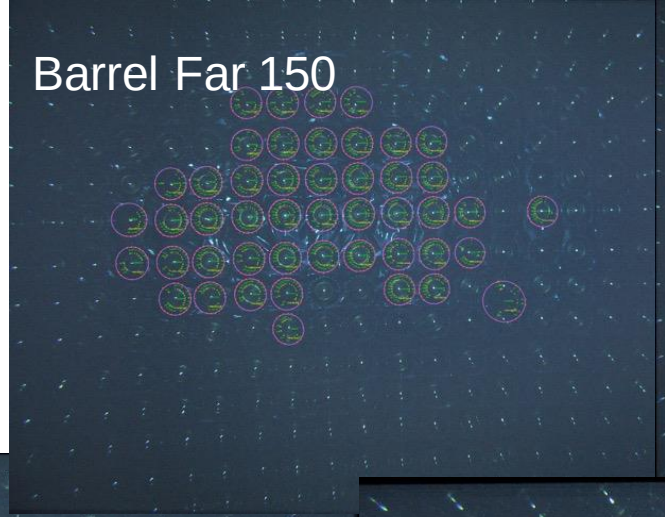


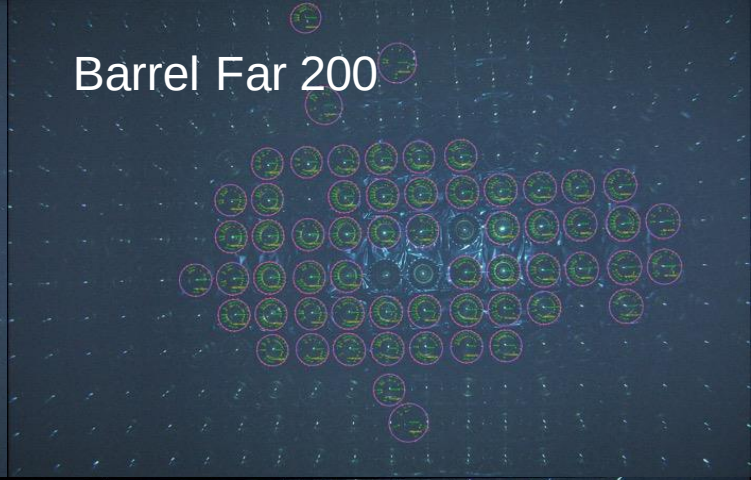


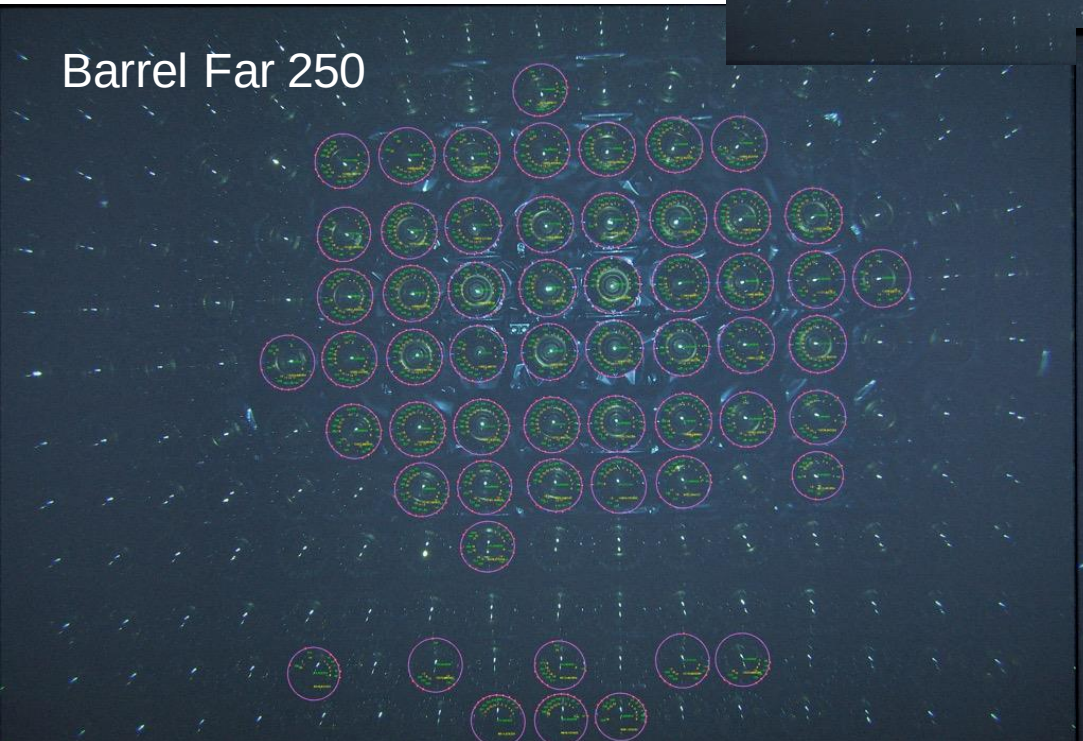


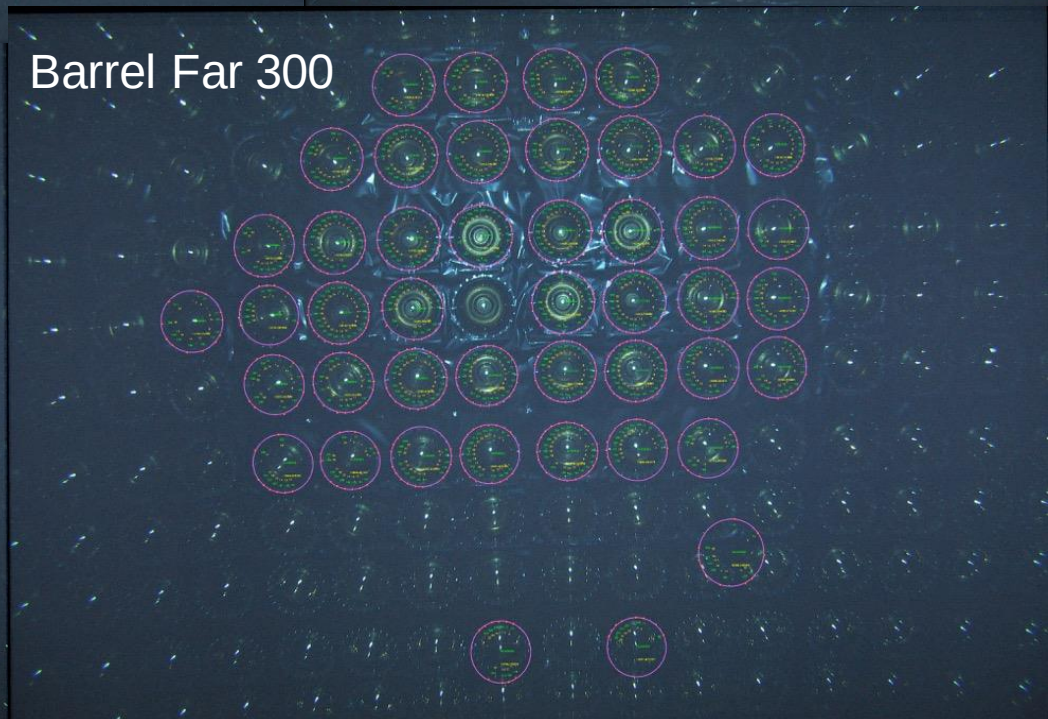



**Gallery of Success**



# Future Work

- Process all images and reconstruct the geometry of whole Super-K detector.

# References

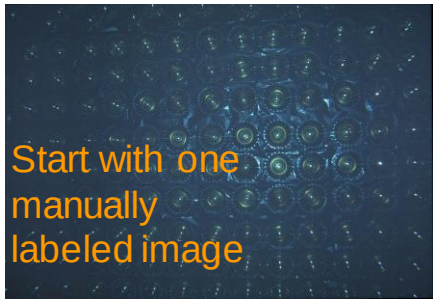

[1] "Standard model of elementary particles" by chriswalf, is licenced under CC-BY-SA-3.0

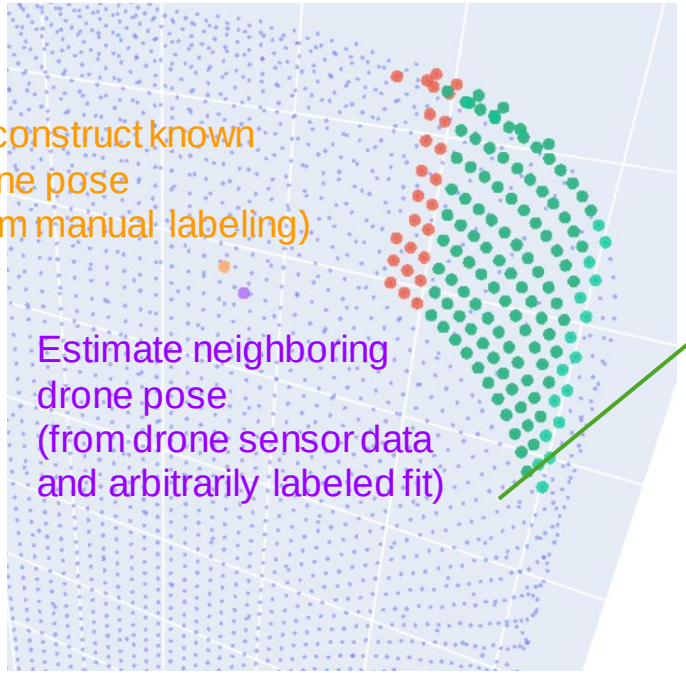
[2] "スーパーカミオカンデタンク内公開 Super-Kamiokande_insidetank" by nvslive is licensed under CC BY-NC 2.0

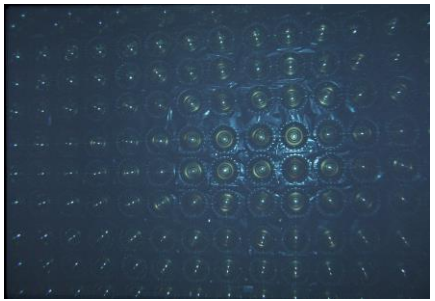
[3] "Photomultiplier Tube (PMT) at Kamioka SkyDome" by kawanet is licensed under CC BY 2.0

# Appendix

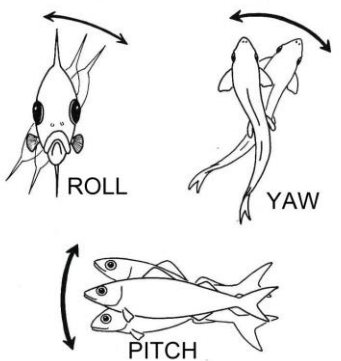
# PMT Labeling



Project PMT labels onto neighboring photo




Drone sensor gives drone pose( yaw, pitch, roll angle heading and depth ).

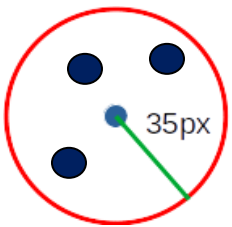
- Developing an algorithm to automatically label all the PMTs and bolts (or super-modules) in the whole photo set.

# 3.Blob density cut

**Problem:**

- More unwanted features.
- Images from corner of tank.

- *Unwanted features are clustered.*




*Count no. inside circle.*