# Nuclear Emulsion Data Analysis

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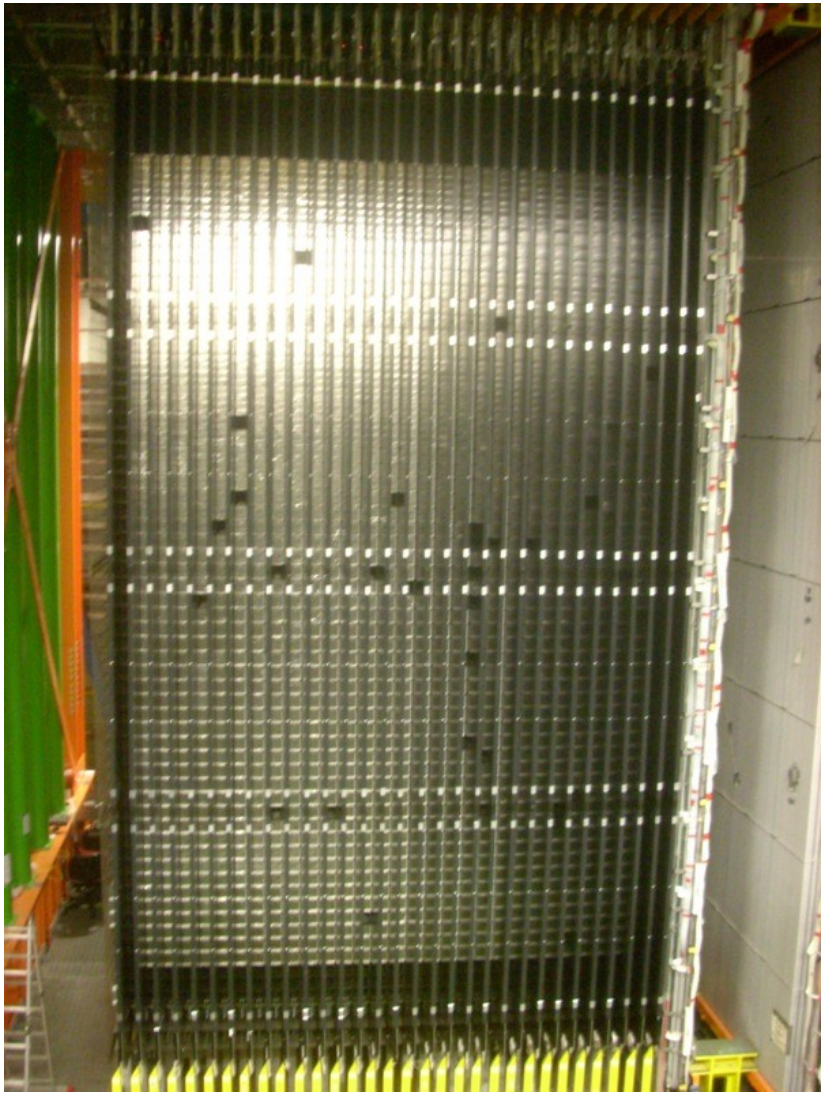
## Content

- Opera Experiment
- Data Acquisition
- Cutoff Analysis
- Resolution
- Efficiency
- Signal Discrimination
- Nuc Emulsion Application

# Opera Experiment

- **History of Emulsion**
  - Photo Emulsion(Bacquerel)
  - Emulsion Cloud Chamber
    - **BEBC, E653, CHORUS...**
- **Scientific Purpose**
  - Tau neutrino appearance in mu neutrino beam
- **Nuclear Emulsion bricks**
  - Lead & Emulsion
  - 2 Changeable Sheets
    - (45 + 210 + 45) um



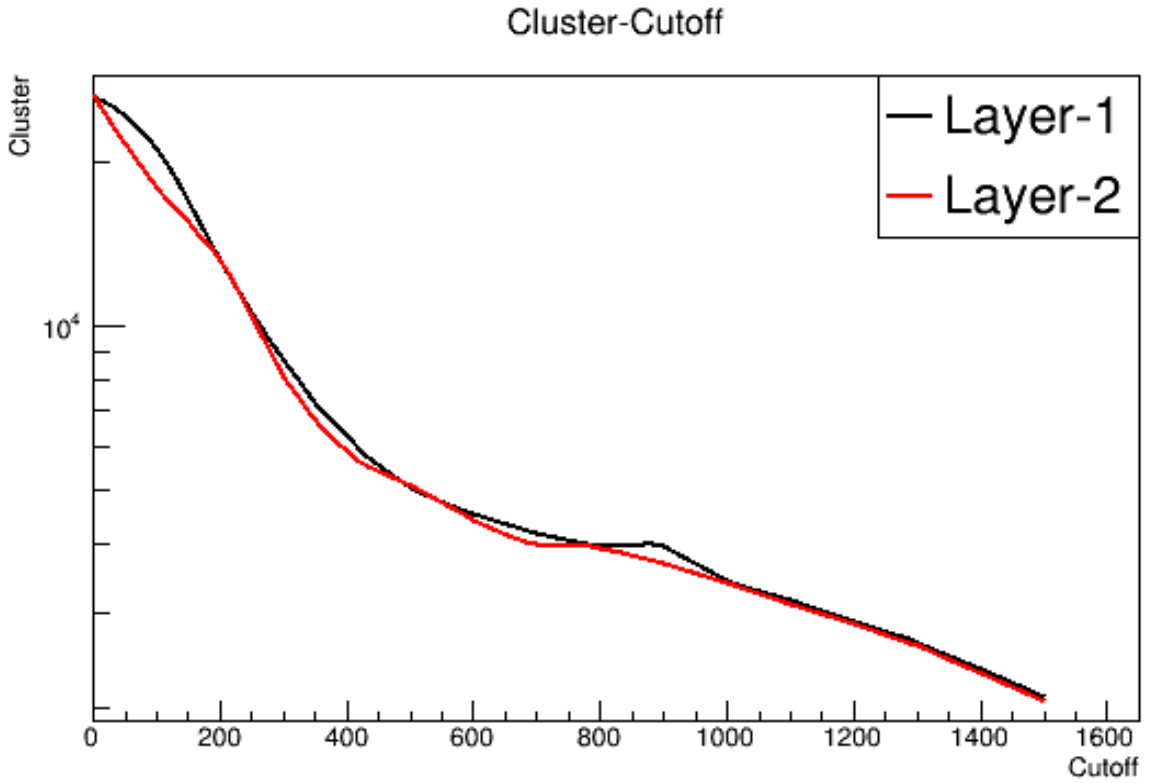
# Data Acquisition

- **Microscope**
  - Scan CS & Store the grains
- **Offline Analysis**
  - Grains into micro tracks
  - Micro tracks into base tracks
  - Base tracks into volume tracks

# Cutoff Analysis

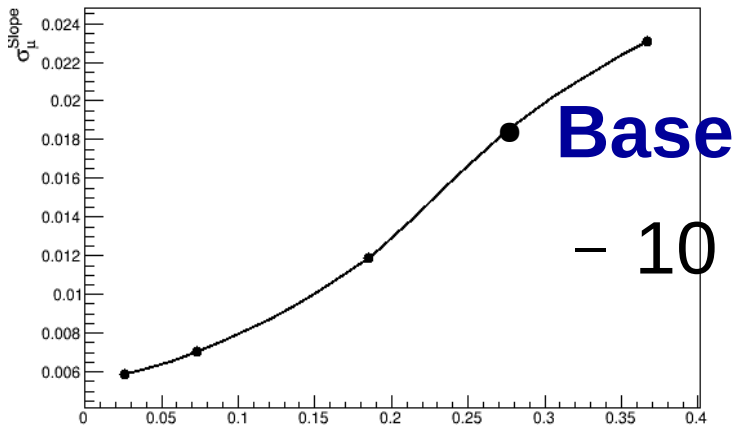
- To obtain a **constant grain number** for the **top** and **bottom** layer of which the luminosity is different, we need to give them different **cutoff**.

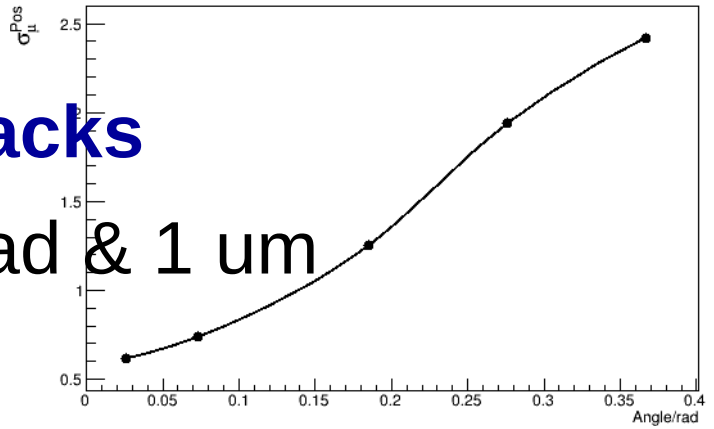
- Final **cutoff:**
  - **L1: 780**
  - **L2: 700**



# Resolution Analysis

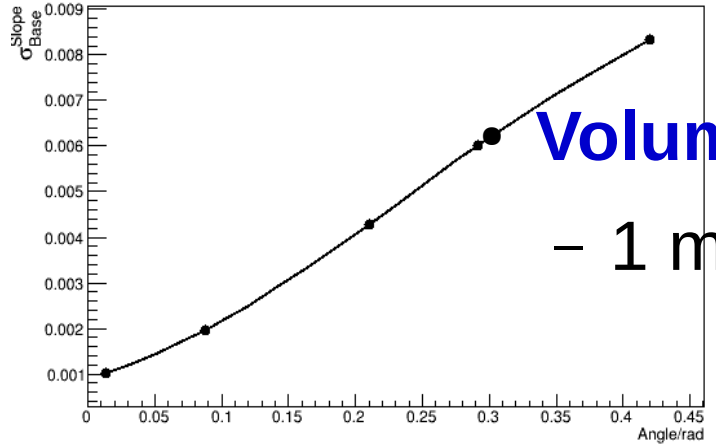
- The **resolution improves** as the **grains** are linked into **volume tracks**. For different **track slope**, the **resolution** is **different**, reaching to **um & mrad**:

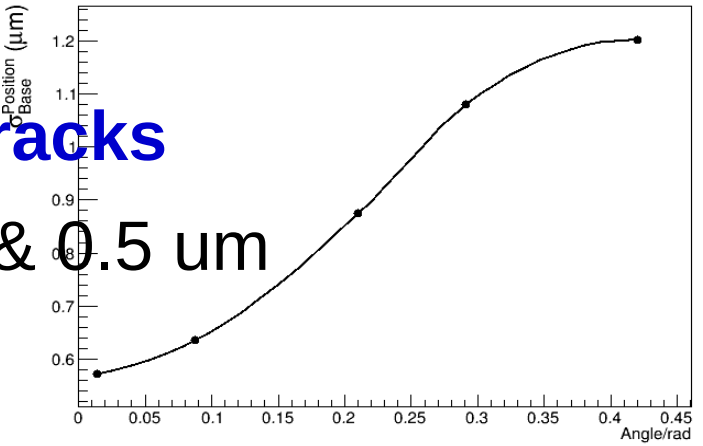



**Base Tracks**

– 10 mrad & 1 um



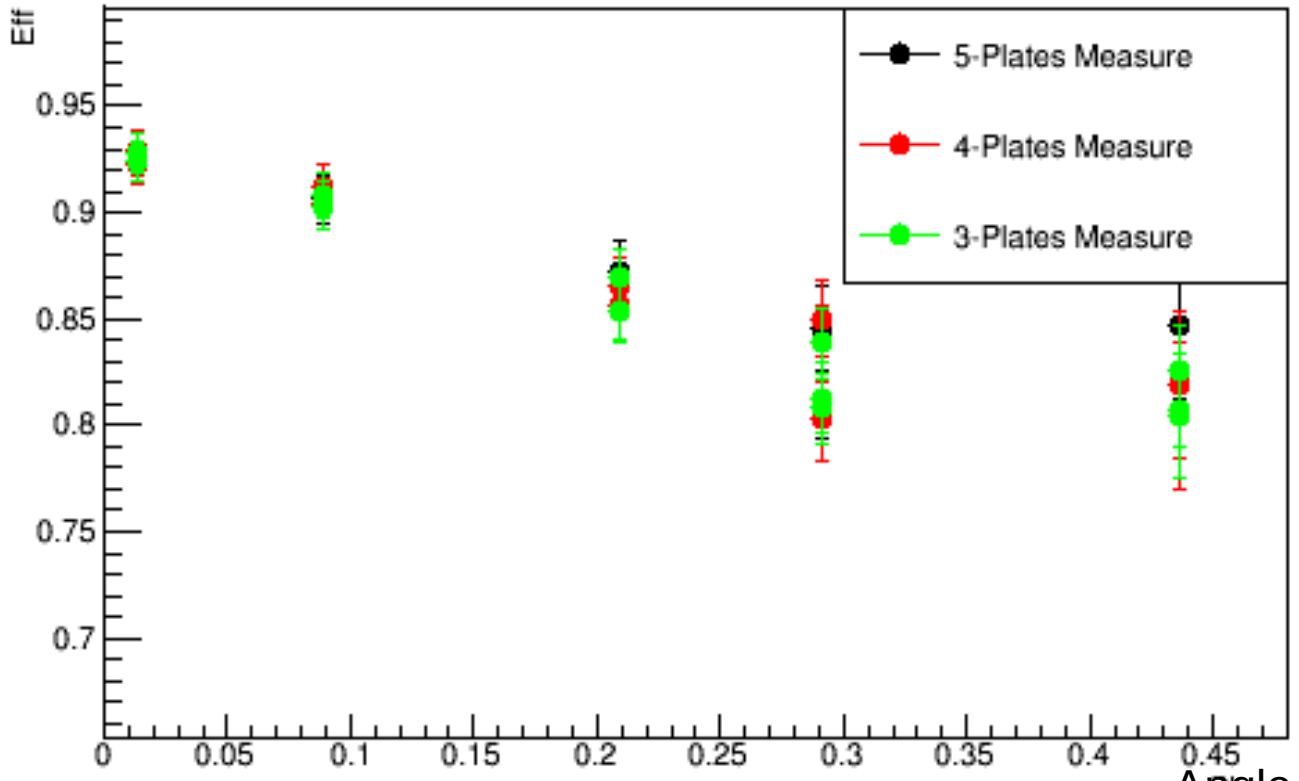




**Volume Tracks**

– 1 mrad & 0.5 um

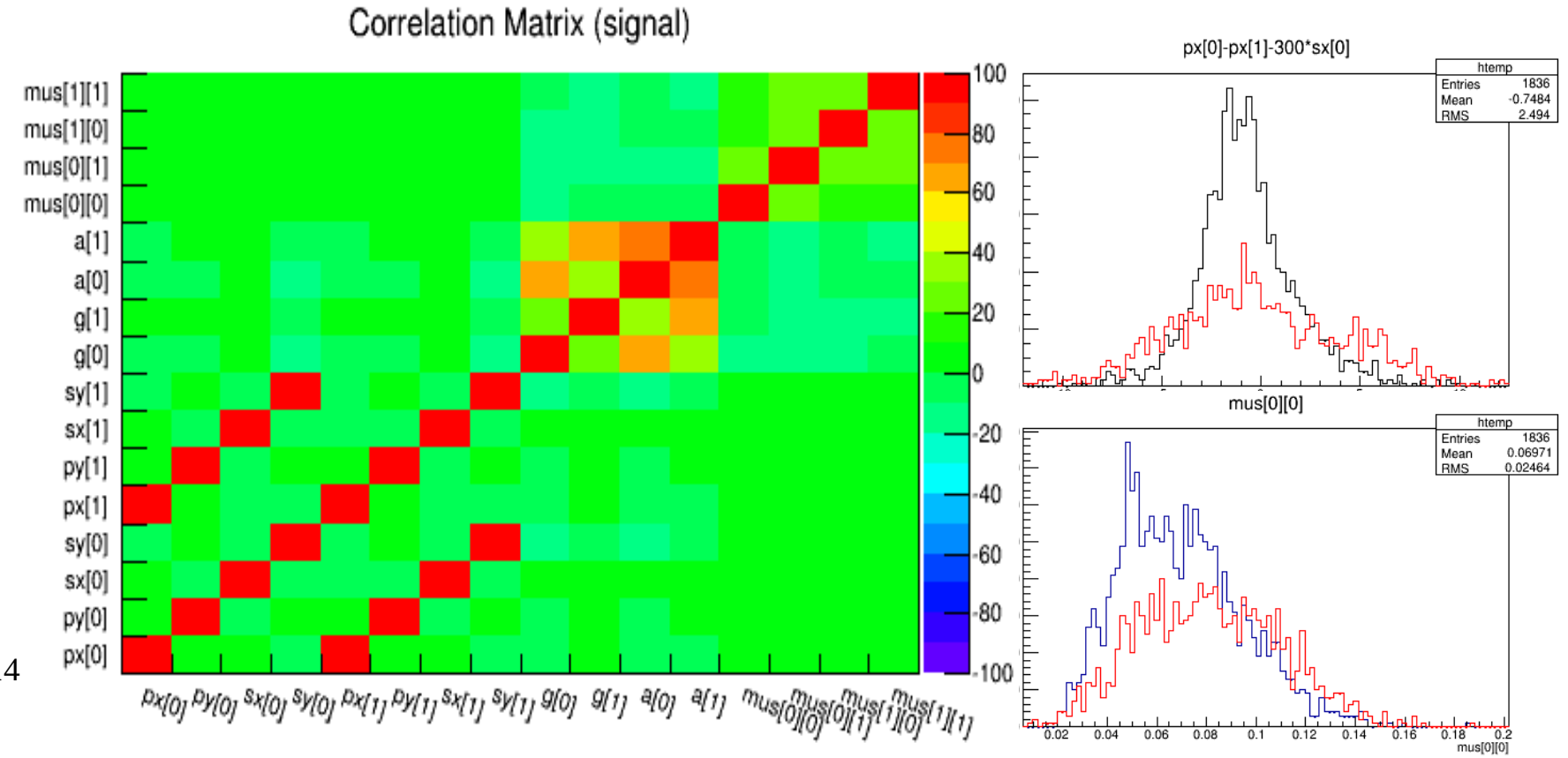
# Detection Efficiency Analysis

- With **3 or more** sheets, we can analyze the **efficiency** by **reconstructing the tracks**. The detection efficiency can be as high as **0.9**.

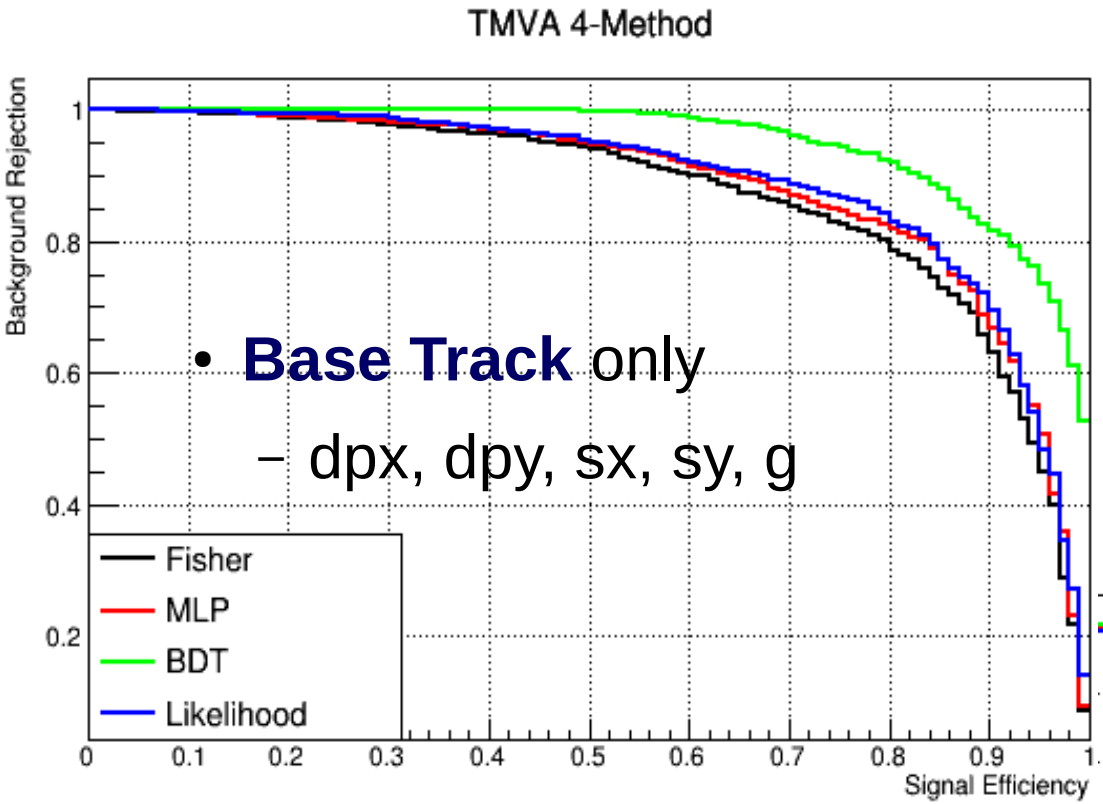


# Signal Discrimination

- Instead of using **manual check** for the linked tracks, a **TMVA method** is applied aiming to tell the true tracks apart from the false ones.
- **Input variables:**

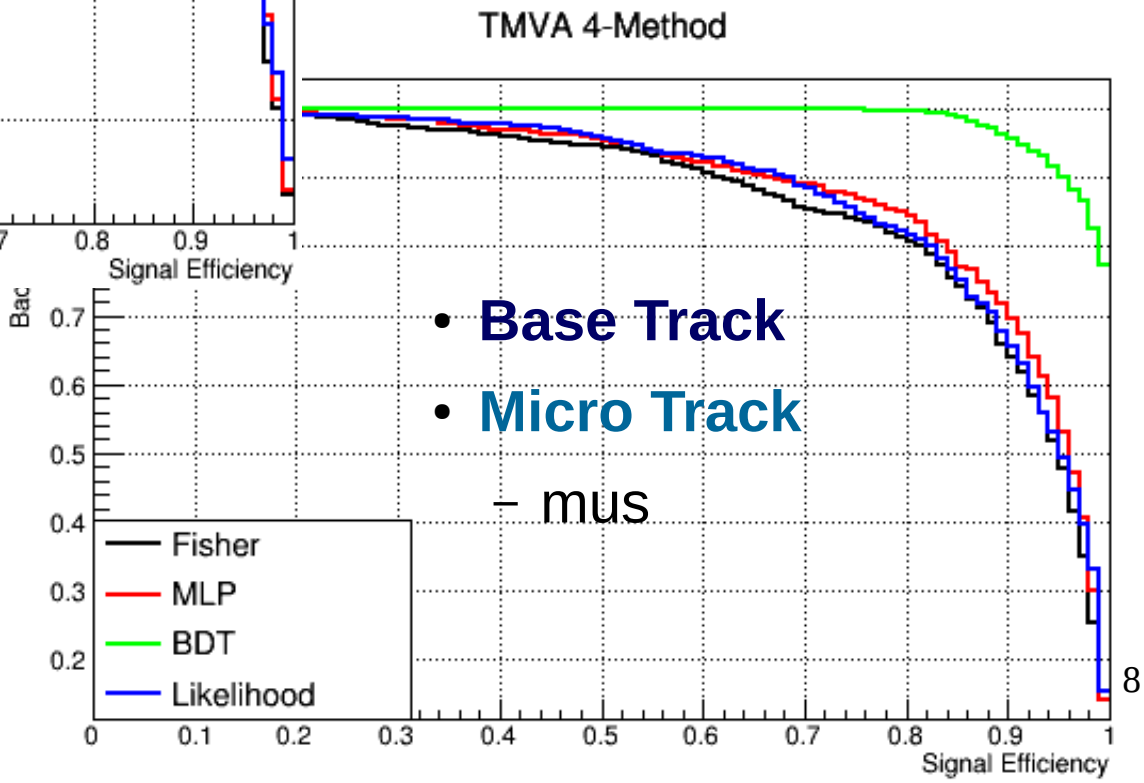


# Rejection and Efficiency




- **Base Track** only
  - dpx, dpy, sx, sy, g

- **Improvement** in rejection power, especially for **BDT** method.




- **Base Track**
- **Micro Track**
  - mus

- **Fisher**
- **MLP**
- **BDT**
- **Likelihood**

# Prospect for Nuclear Emulsion

- **Dark Matter Detection**
  - **N**uclear **E**mulsion **W**IMP **S**earch (Directional)
  - Spatial resolution ~ 100 nm, ~ 10 degree
  - Emulsion – Optical Scope – X-ray Scope
- **Geological Detection**
  - Cosmic ray muon tomography
    - **Unzen (Japan), Stromboli (Italy), Teide (Spain)** volcanoes
- **Medical Detection**
  - Hadron therapy