universität freiburg

Bundesministerium
für Bildung
und Forschung

Photon Yield Response of 1-Cell WOM-LS Prototype Detector

3rd High-D Consortium Meeting

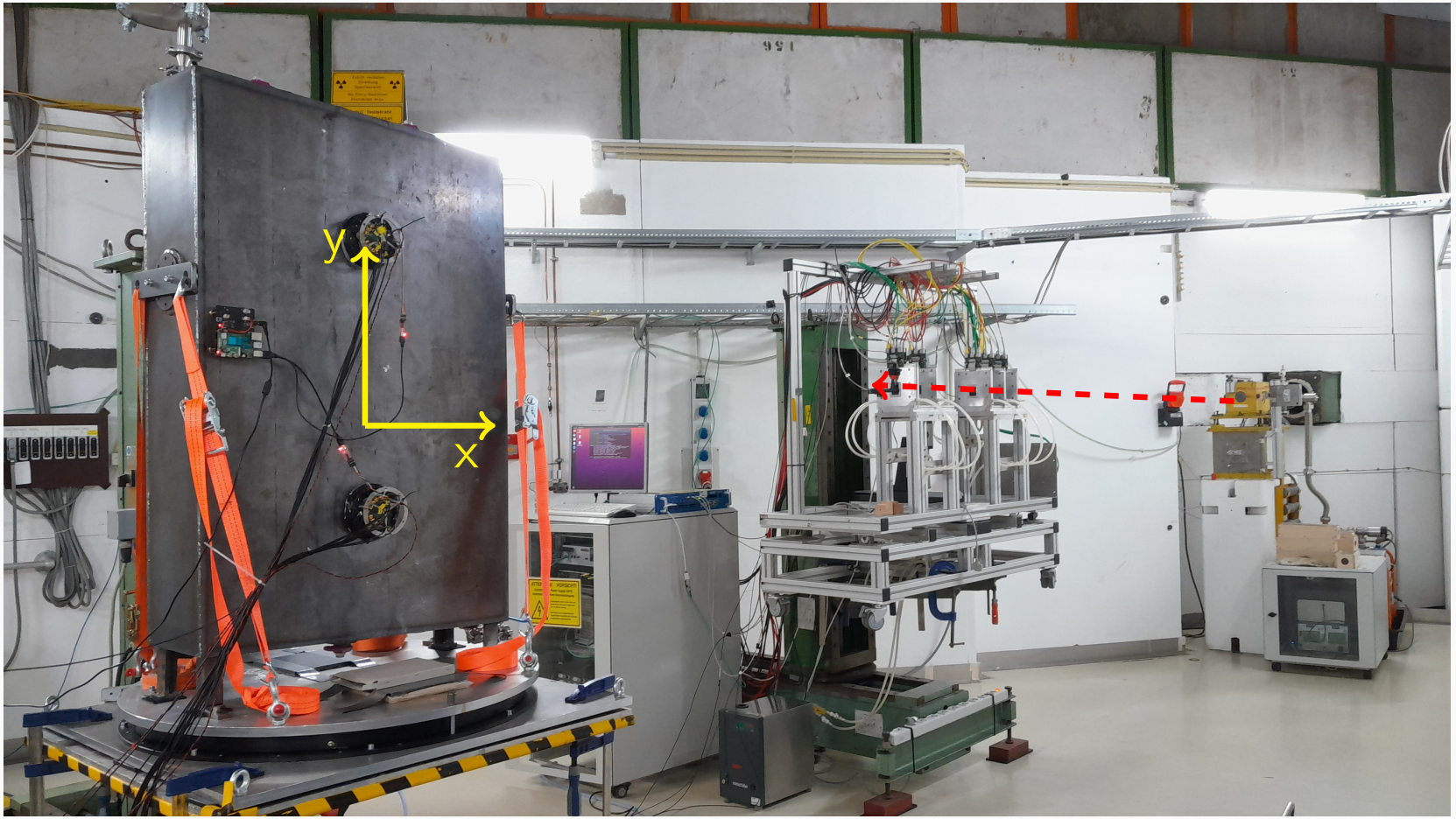
Fairhurst Lyons

February 9, 2023

Universität Freiburg

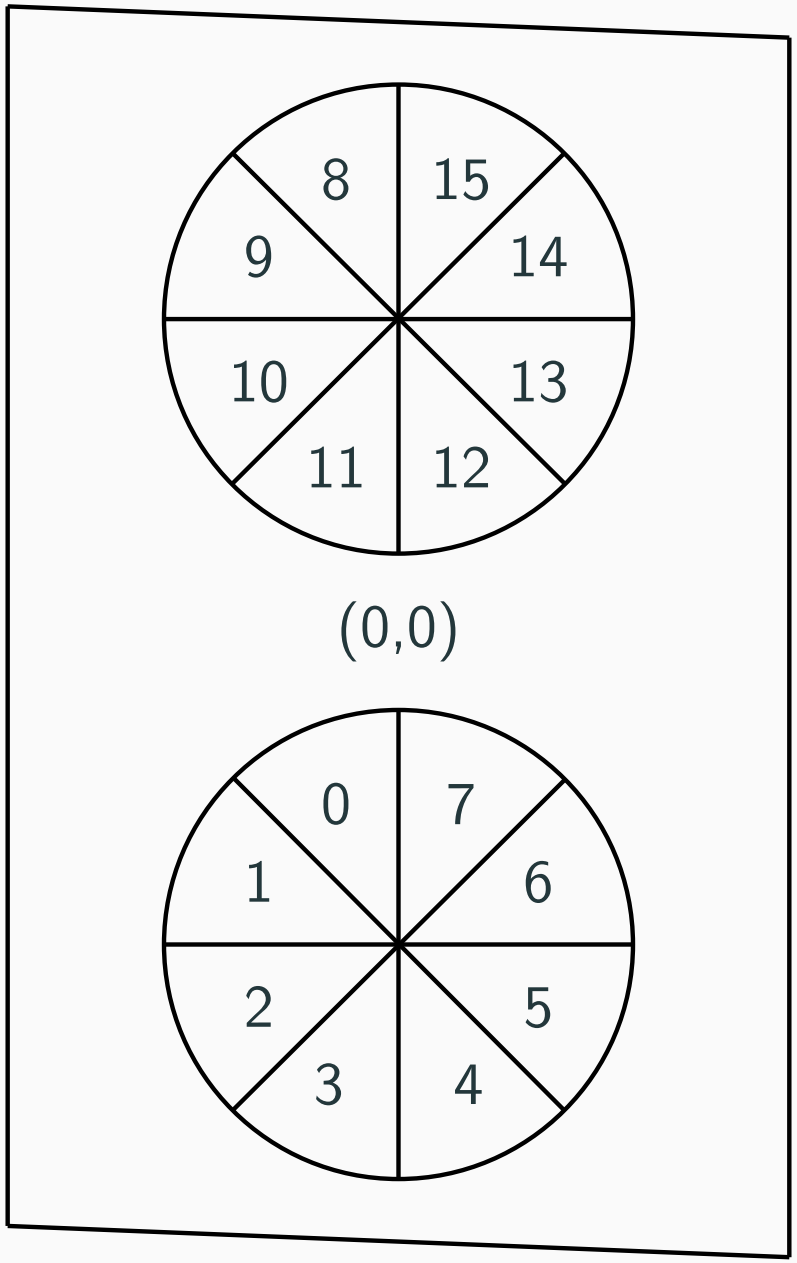
RWTH AACHEN UNIVERSITY

Testbeam Setup



- LS cell on turntable (y-rot.), on movable stand (x/y-trans.)
- Trigger $\rightarrow$ beam telescope: coincidence of 4 PMTs

Schematic of Sensors (Back View)



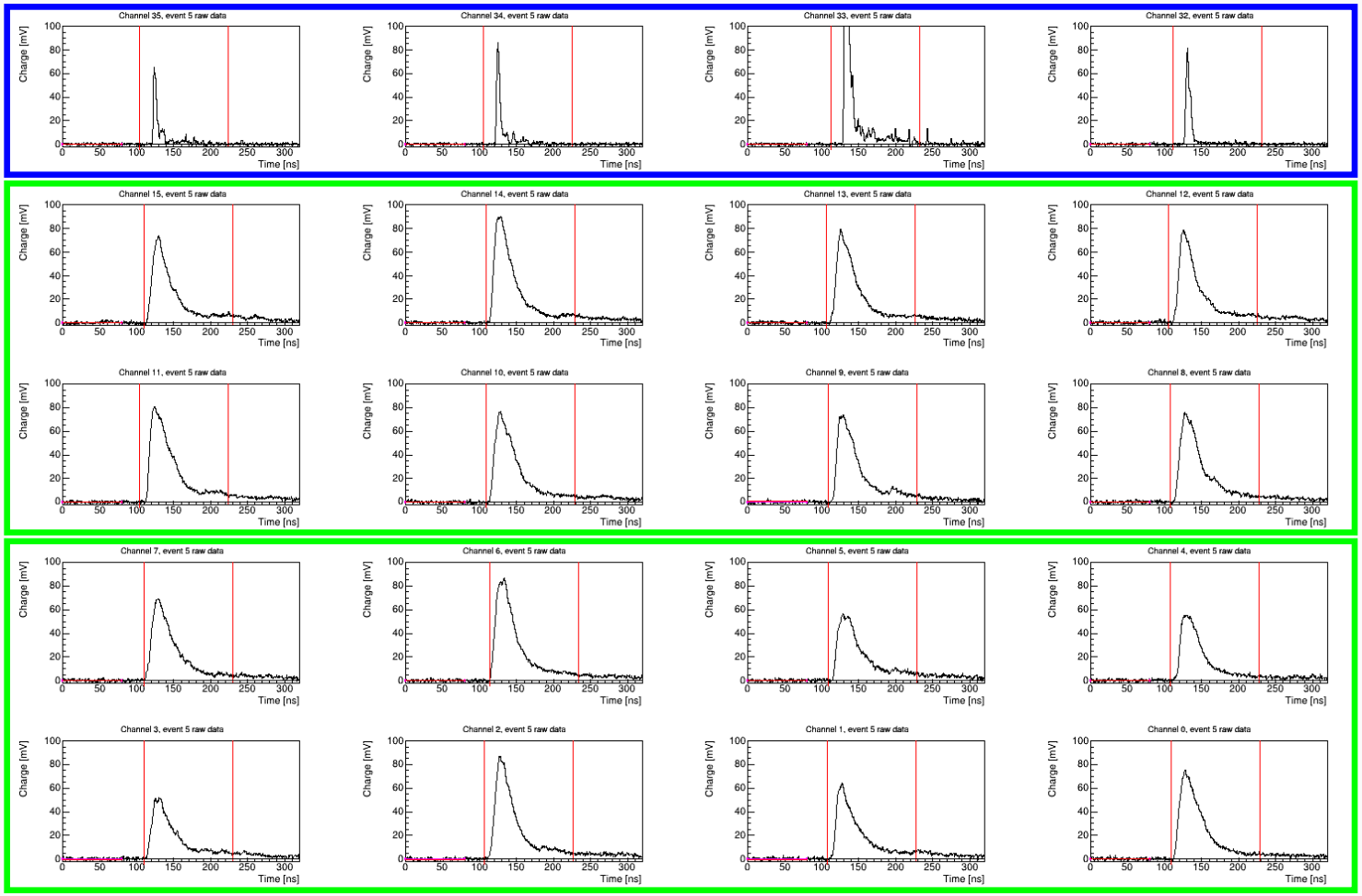
Raw Data

- Raw signal for 1 event: E = 1.4 GeV, beam at (0,0), 0°

PMTs

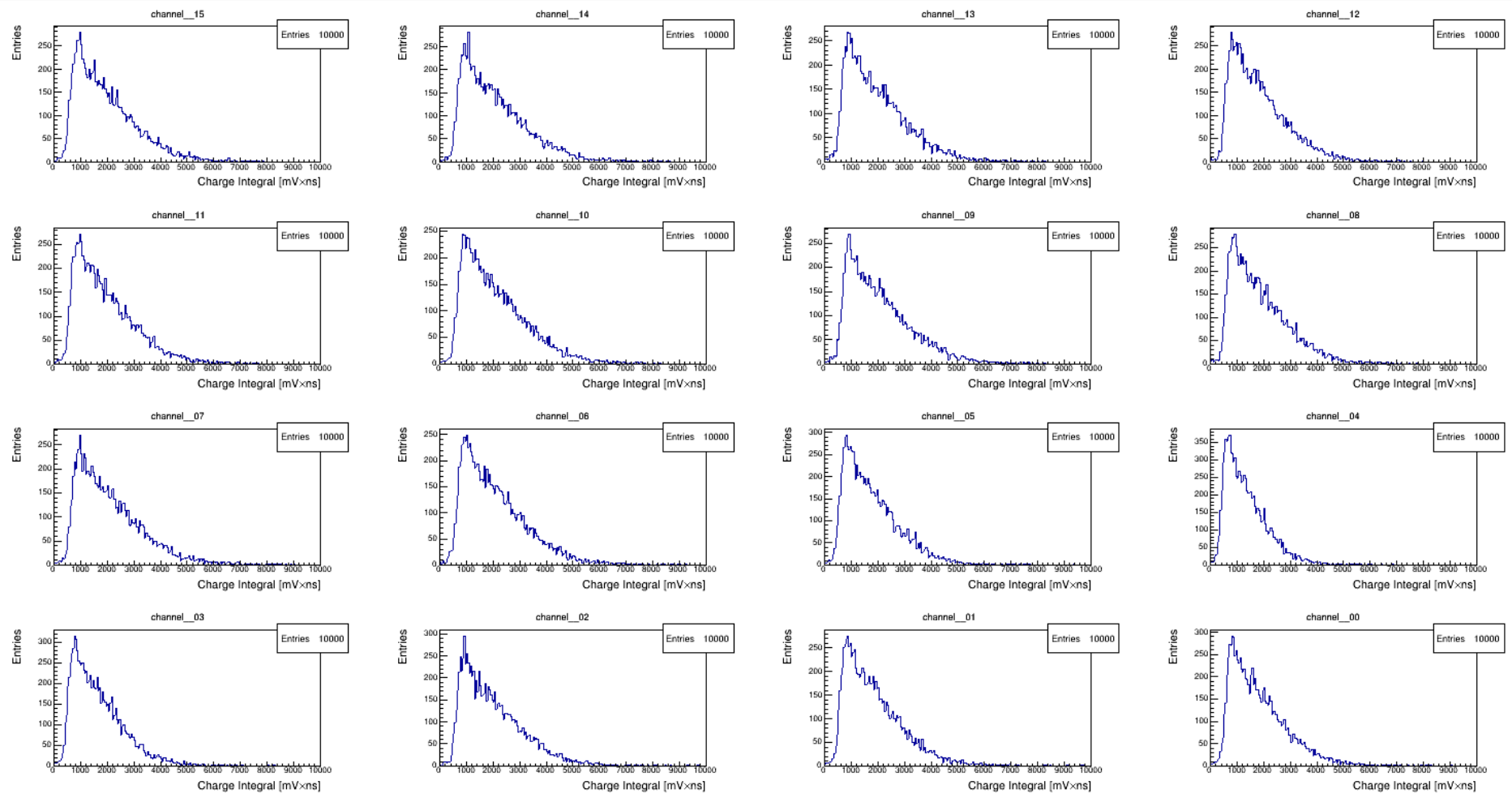
WOM up

WOM down



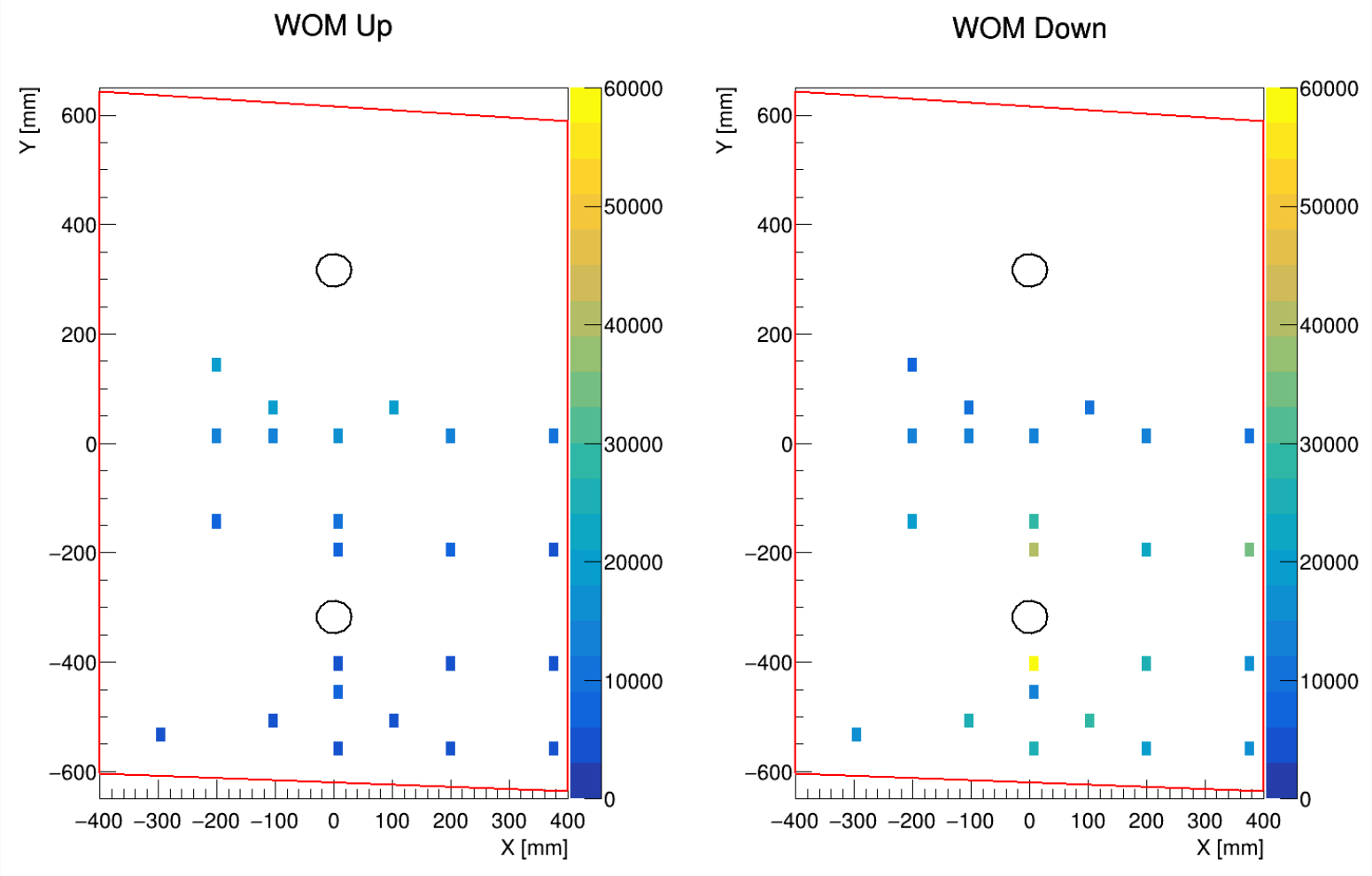
Manipulated Data

- Signal for all events: E = 1.4 GeV, beam at (0,0), 0°
- Charge spectrum integrated for each event → histogrammed



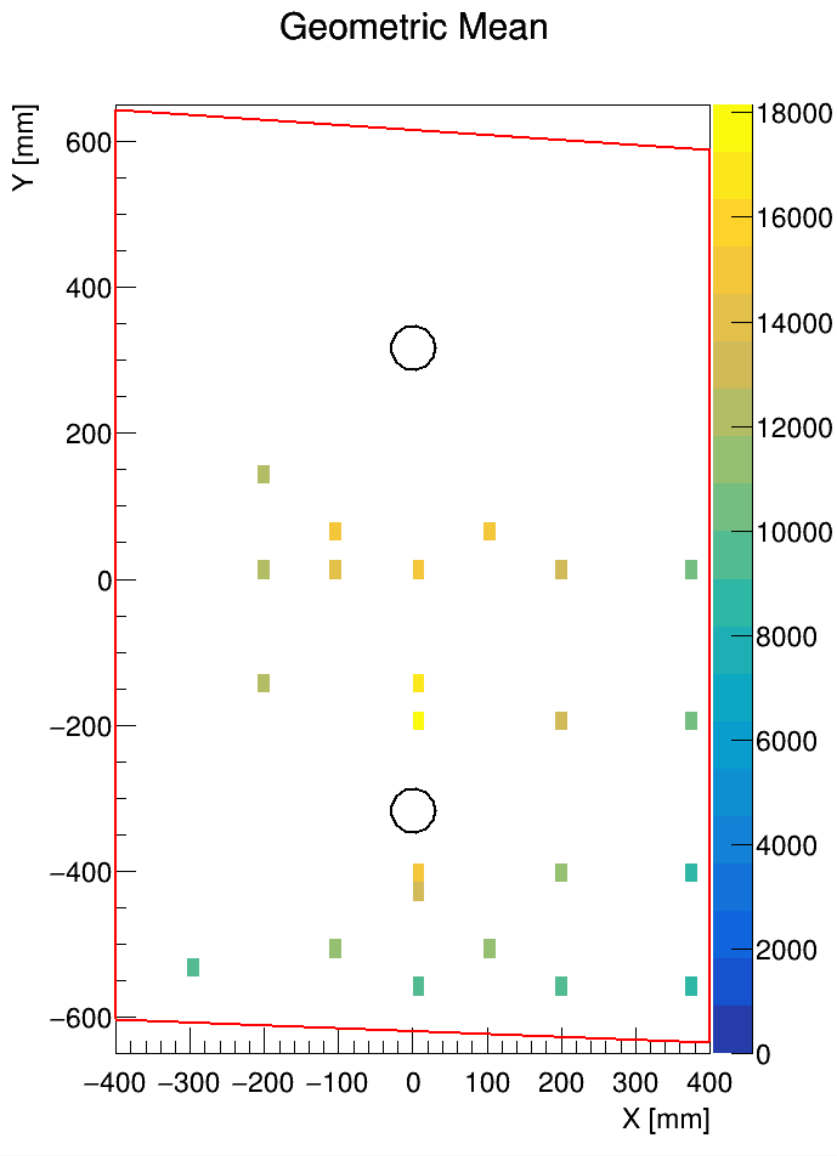
Data Overview at 0°, E = 1.4 GeV (Back View)

- All points at 0° inclination: mean charge/event [mV×ns]
- Points above $y = 153\,\text{mm}$ not possible due to table position
- Signals visible for all positions - including corners



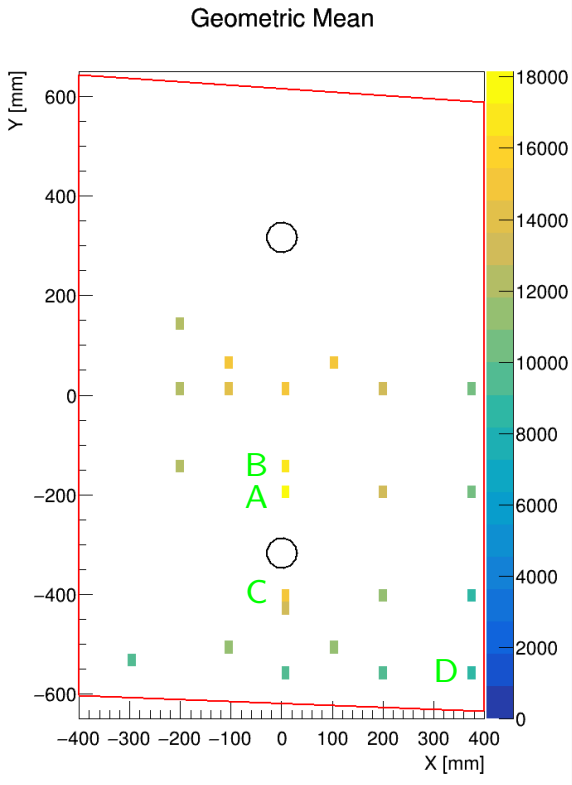
Light Yield at 0°, E = 1.4 GeV

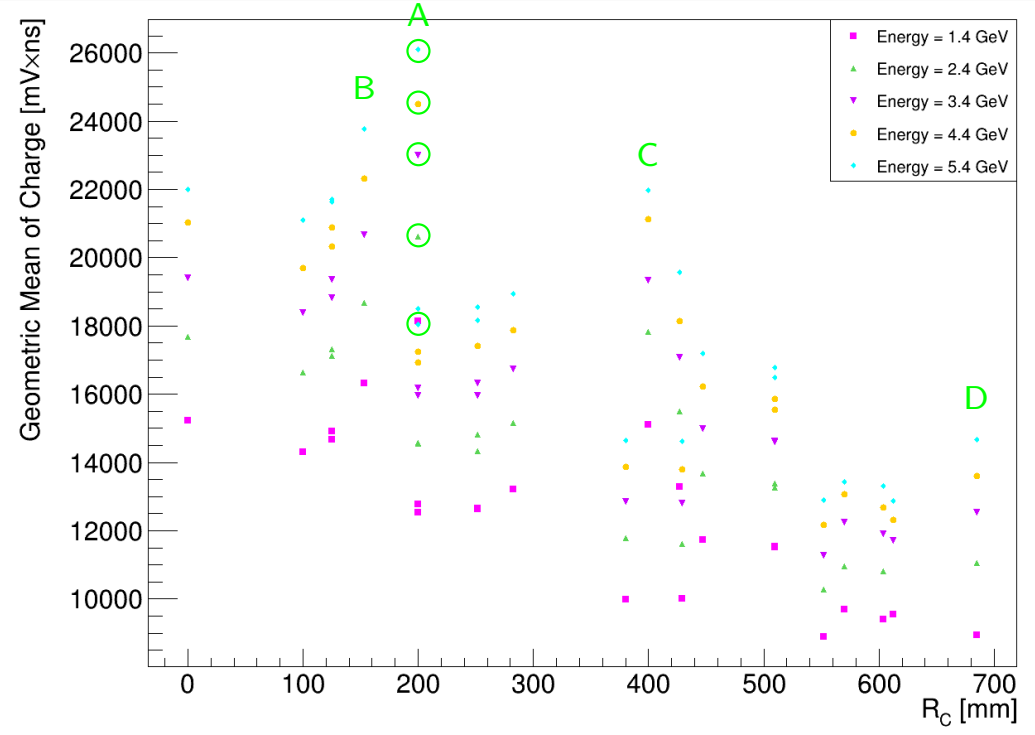
- Geometric mean = $\sqrt{Yield_{up} \times Yield_{down}}$



Light Yield at 0°, E = 1.4 GeV

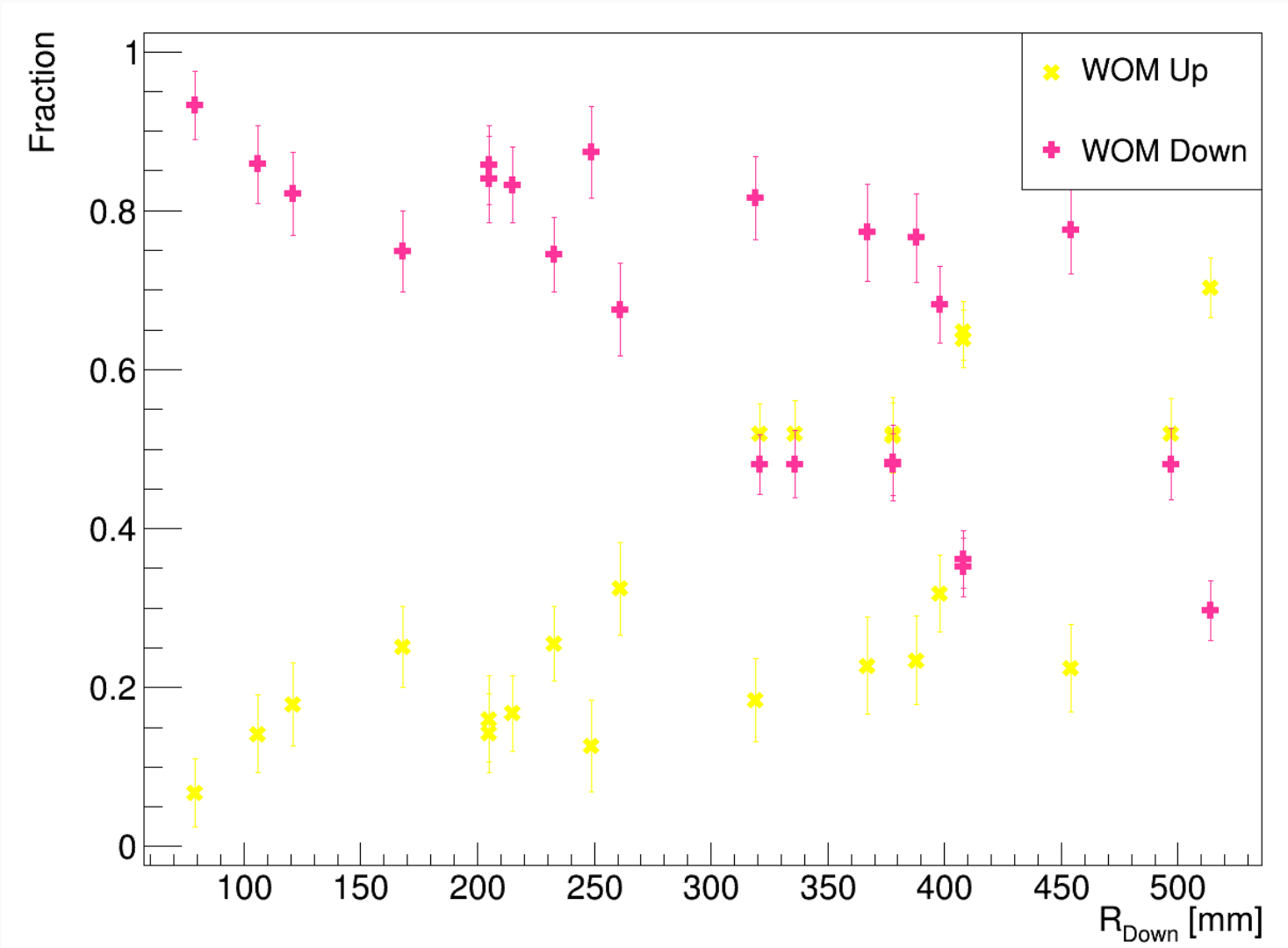
- Geometric mean higher when closer to WOMs as expected
- More light detected for higher beam energy





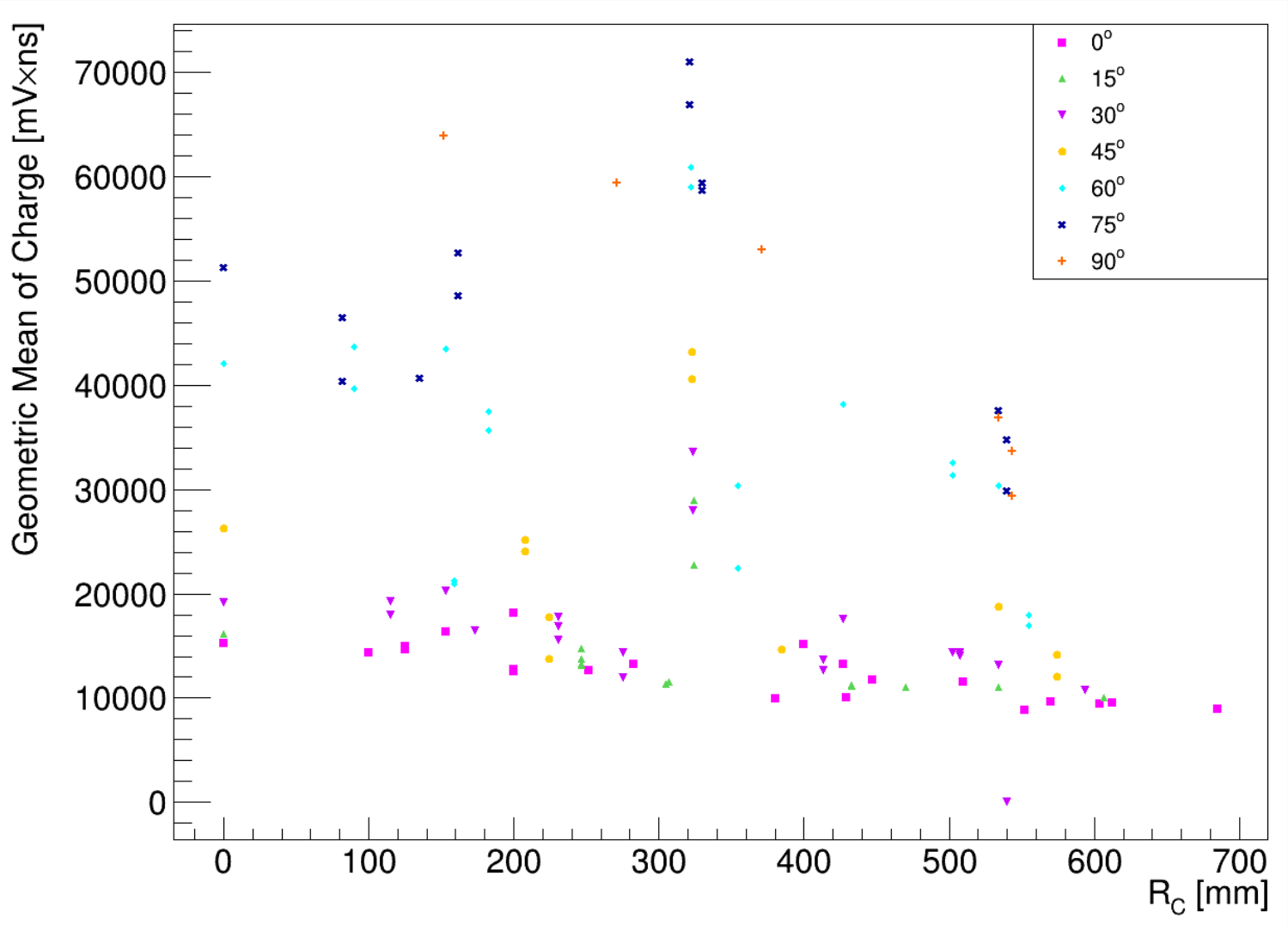
Light Share at 0°, E = 1.4 GeV

- Light share between WOMs varies widely with y-coordinate
- WOM down measures more light when $y < 0$ as expected



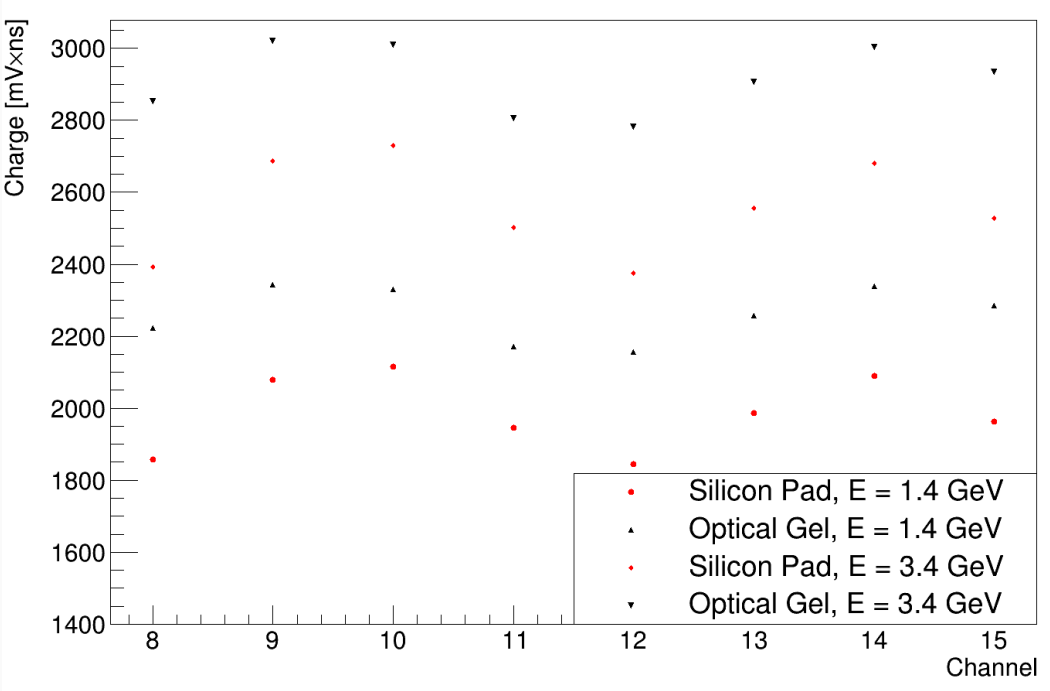
Light Yield at Angles, E = 1.4 GeV

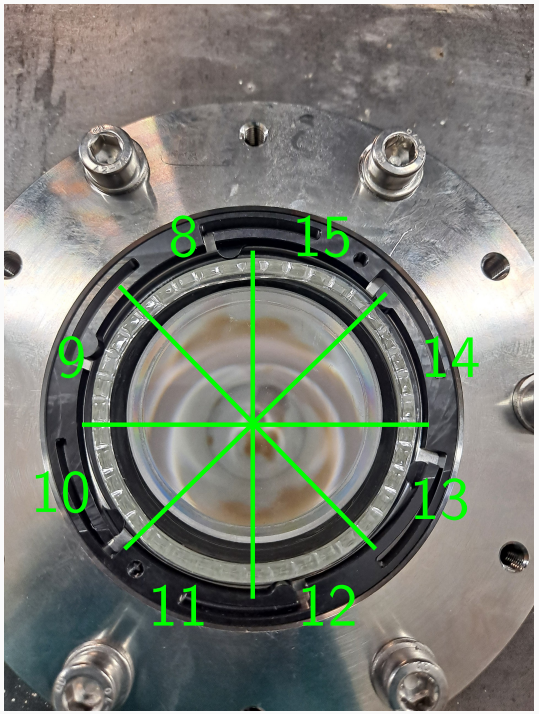
- Larger angle → particle travels further in scintillator
- Light yield increases with angle as expected



Silicon Pad WOM Up

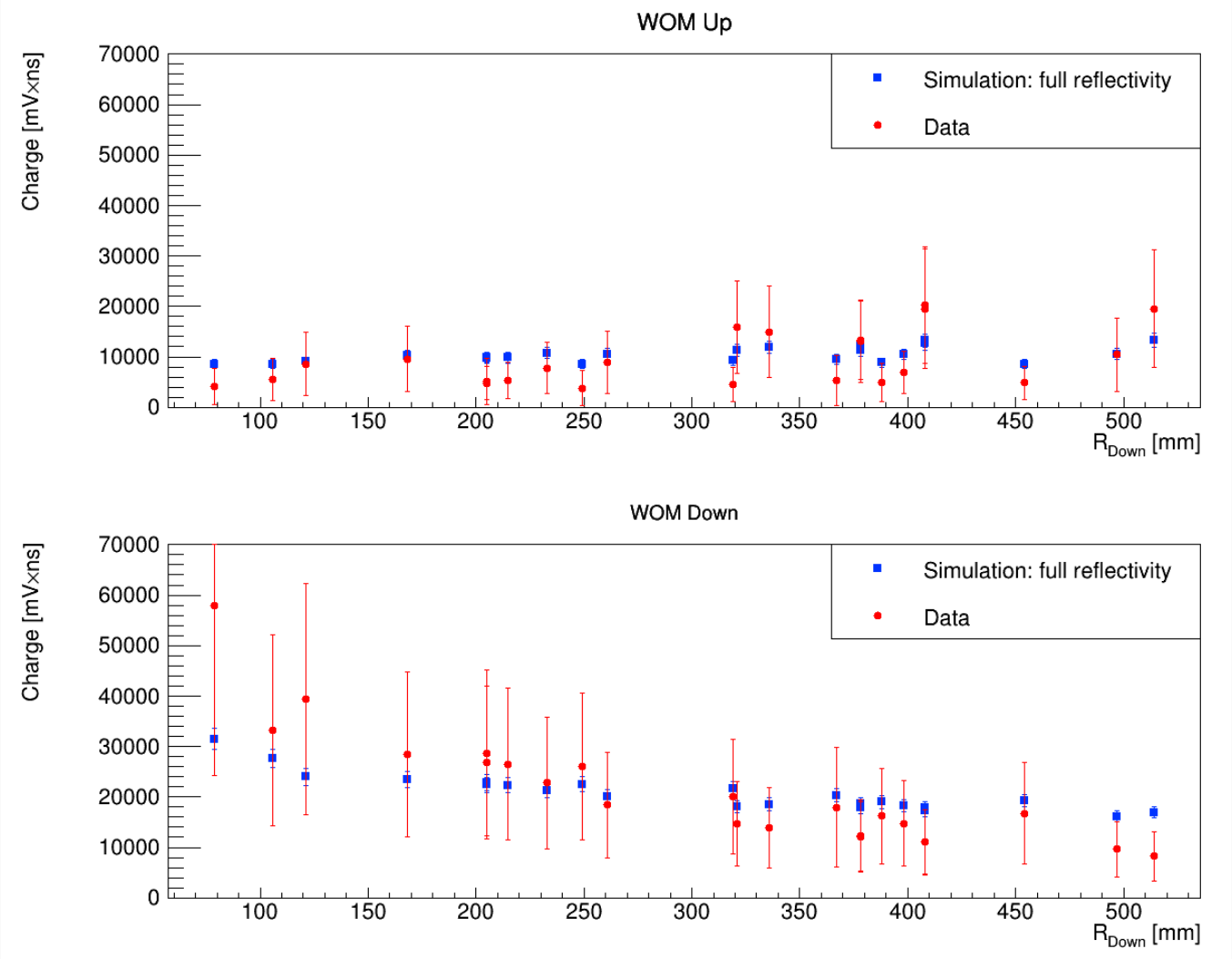
- Mean charge/event: E = 1.4/3.4 GeV, beam at (0,0), 0°
- Silicon pad → difficult to line up properly with WOM
- Optical gel performs ≈ 10% better than silicon pad
- Silicon pad after removing SiPM array (right)





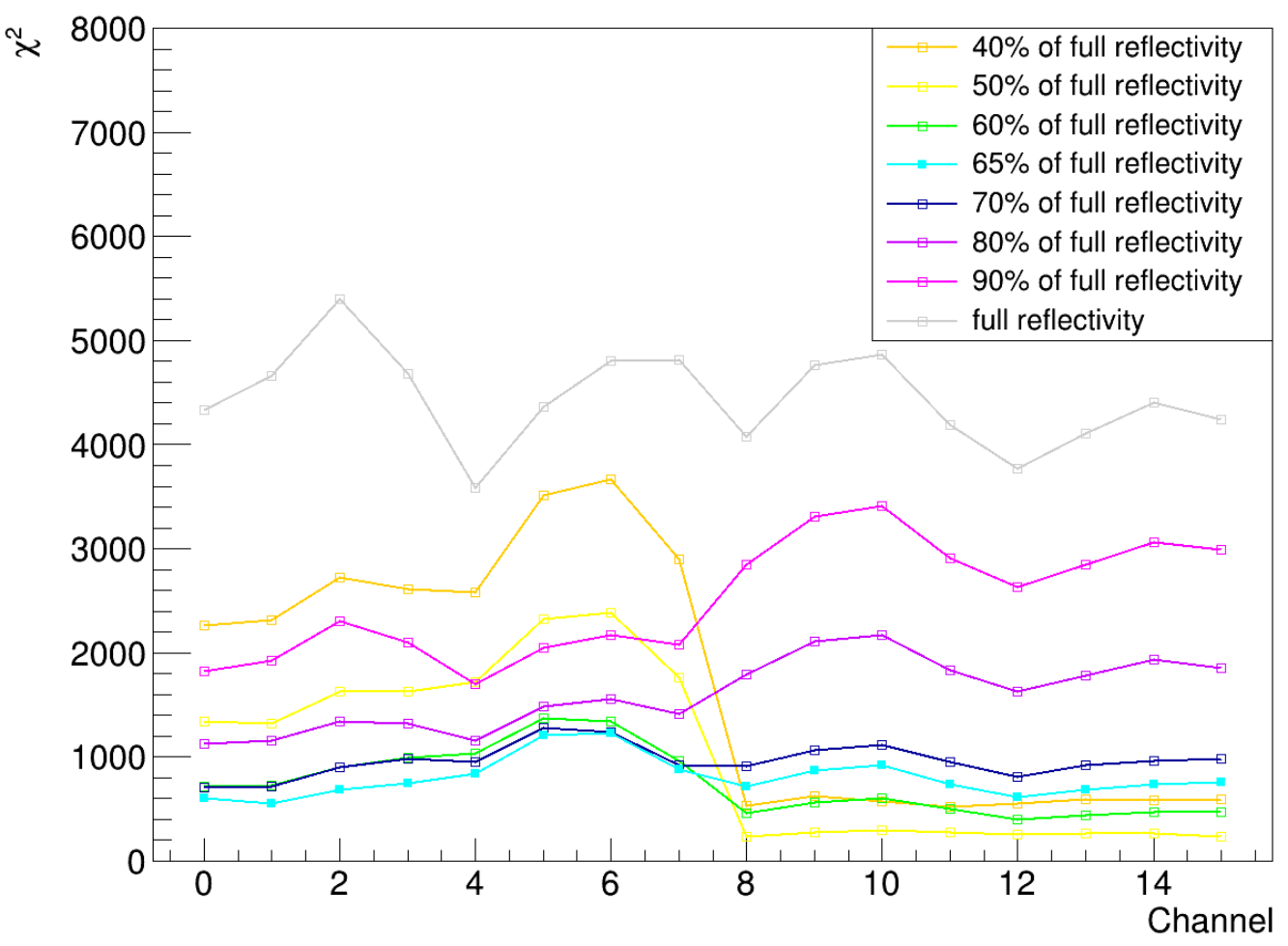
Comparison to Simulation

- Simulation has more consistent light yields for all points
- Reduce wall reflectivity to better match data



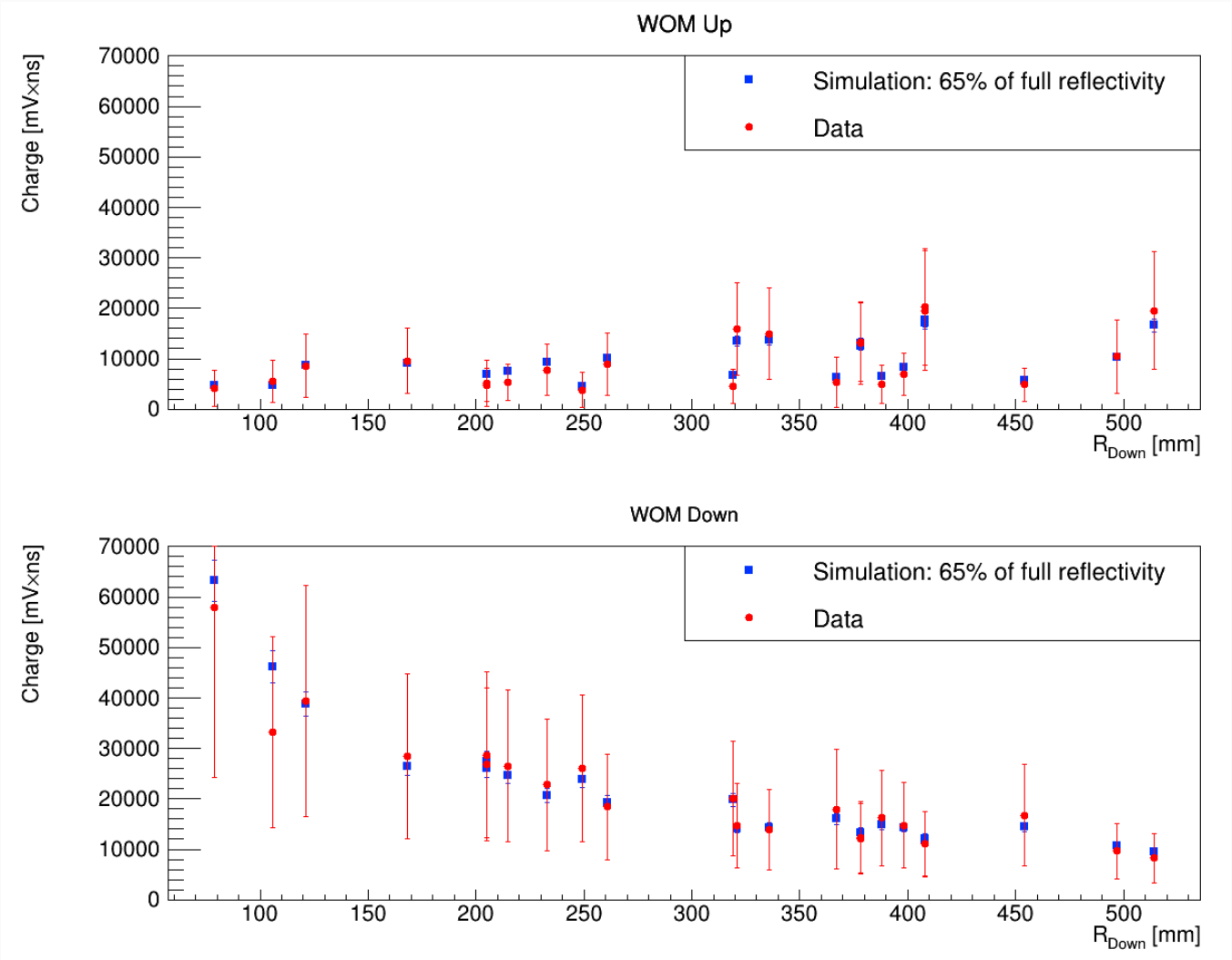
Comparison to Simulation: Changing Reflectivity

- All 23 points at 0°, E = 1.4 GeV used
- χ^2 between channels used to compare reflectivities
- 65% of measured reflectivity gives best results



Comparison to Simulation: 65% Reflectivity

- Modified simulation to be used for training reconstruction
  - For more info → M. Jadidi



Further Improvements

- Based on results from simulation $\rightarrow$ full reflectivity leads to $\sim 3\times$ higher photon yield than 65% reflectivity
- Better optical coupling can improve light yields

Data Comparison to Simulation

- Calibration - too much noise to resolve single photons
  - Cosmics?
  - Radioactive source?
  - Separate calibration needed for each channel

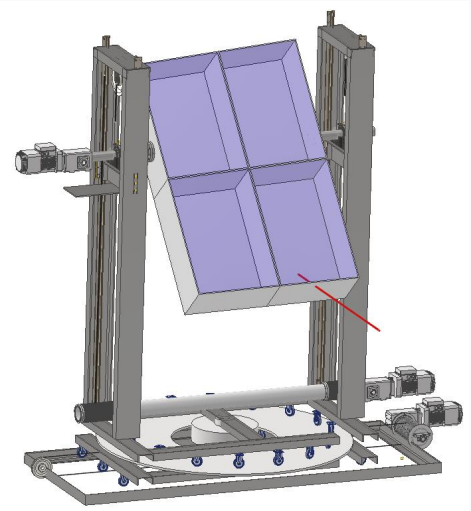
Next Steps

Upcoming Deadlines

- 4 cells $\rightarrow$ CERN μ test beam: late 2023

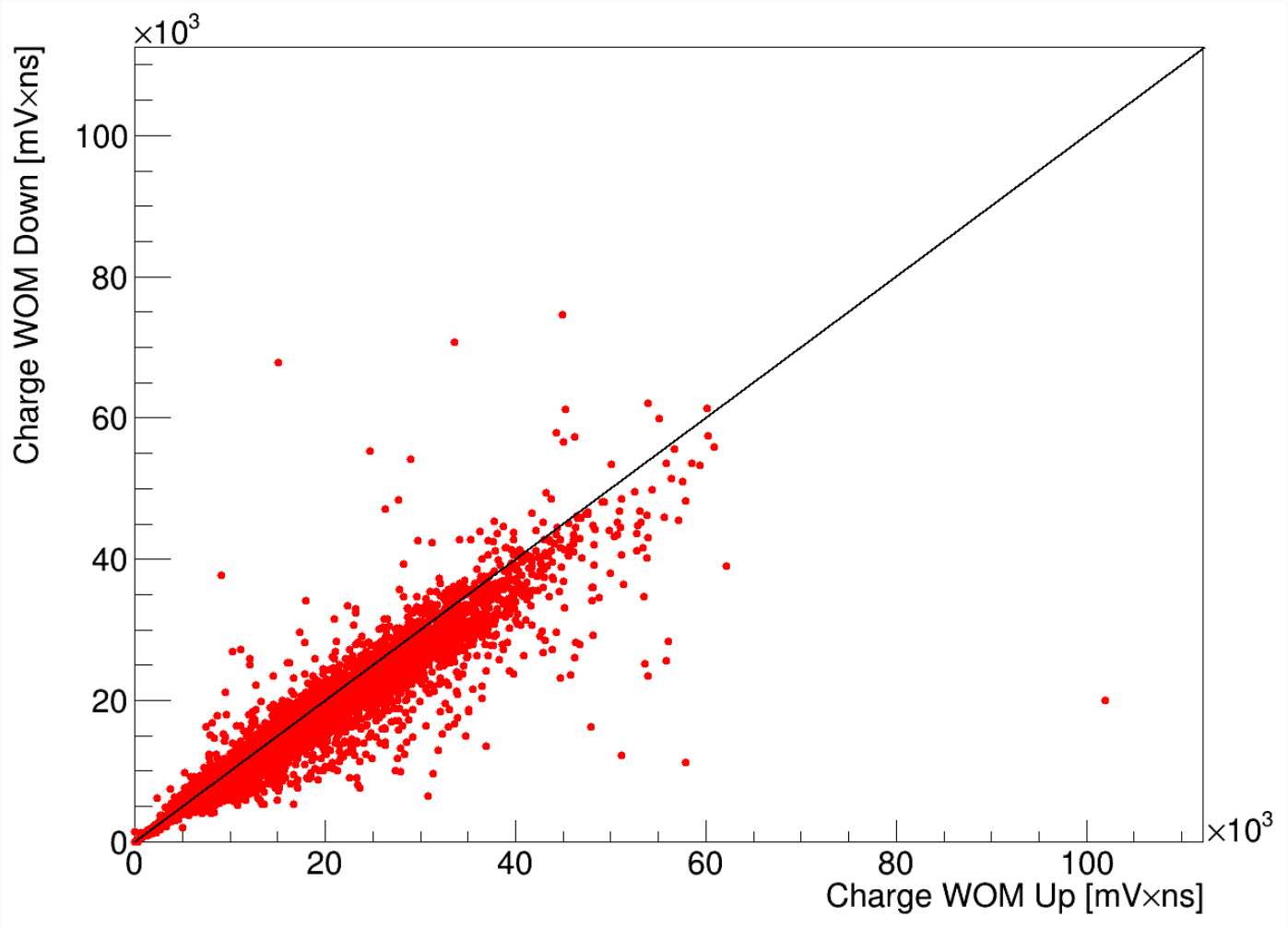
Ongoing R+D

- Simulation: detector response, WOMs, reconstruction
- Mechanics: WLS optimisation, cell coating, support structure
- Electronics: SiPMs, PCBs, signal shaping + digitisation



Data: WOM Up vs Down at (0,0), 0°, E = 1.4 GeV

- Systematic effect leading to higher light yield in WOM up
- Large fluctuations give large σ on yields



Simulation: WOM Up vs Down at (0,0), 0°, E = 1.4 GeV

- Direct correlation between light yield in both WOMs
- Smaller fluctuations give small σ on yields