# Monitor Issues

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MICHIGAN STATE UNIVERSITY

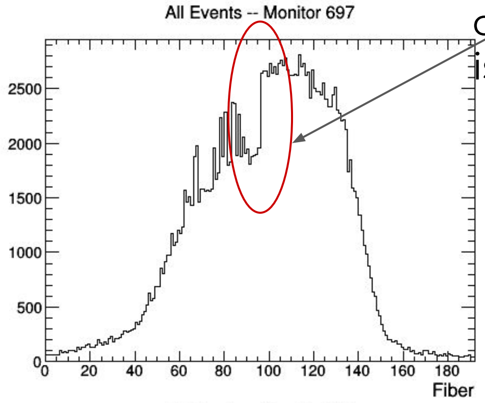
DUNE DEEP UNDERGROUND NEUTRINO EXPERIMENT

# Introduction

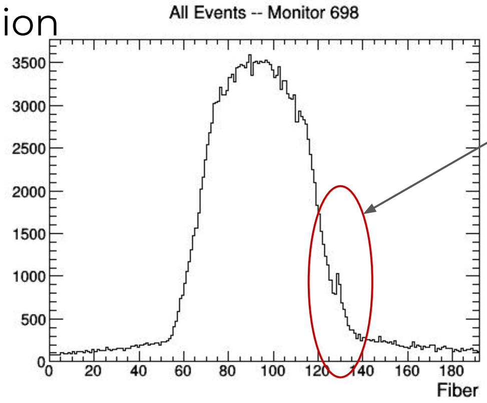
Recently: Found a few issues regarding the beamline profile monitors

- Strange jump in rate in first momentum spectrometer monitor
- Extra activations of fibers in some groups of fibers
  - Reminder: readout of the 192 fibers performed by 6 x 32-channel ASICs, encoded as 6 x 32-bit words in data
  - This issue is due to a software glitch

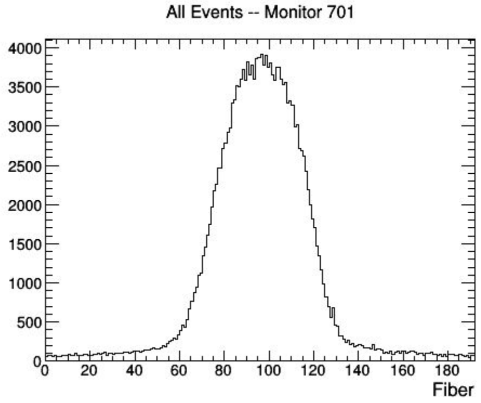
# 2 Separate Issues?

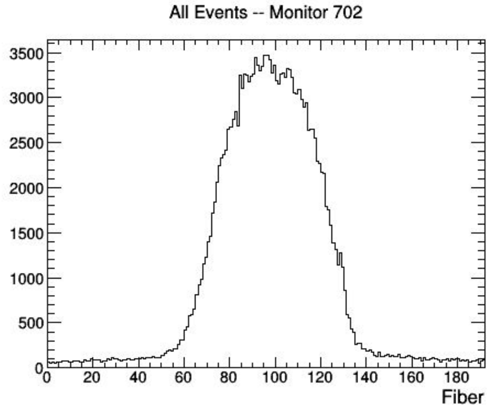


Comes from configuration issues



Software glitch



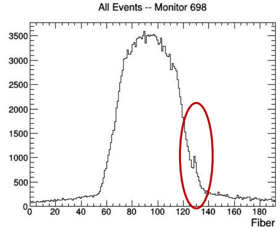


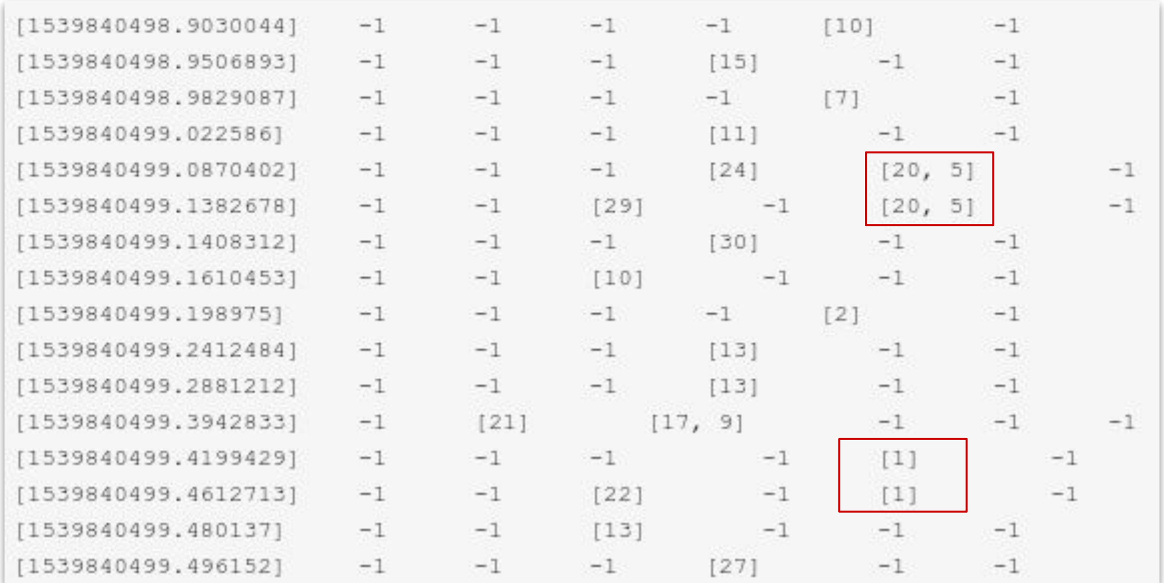
# Software Bug

Cursory glance: Found a couple instances of the 5th 32-bit word being repeated between subsequent events

I think the issue manifests itself as active fibers being 'held over' to another event

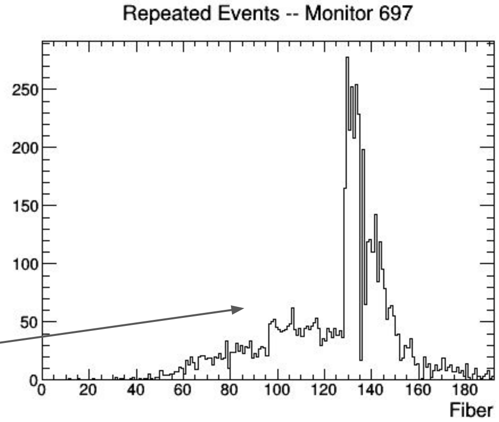
Single fiber repeating is possible/physical, but the fact that the **same 2** are repeated is highly unlikely



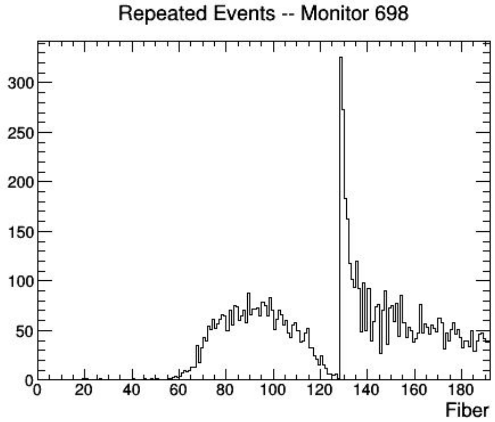


```
[1539840498.9030044]    -1      -1      -1       -1      [10]        -1
[1539840498.9506893]    -1      -1      -1       [15]        -1      -1
[1539840498.9829087]    -1      -1      -1       -1      [7]         -1
[1539840499.022586]     -1      -1      -1       [11]        -1      -1
[1539840499.0870402]    -1      -1      -1       [24]        [20, 5]         -1
[1539840499.1382678]    -1      -1      [29]         -1      [20, 5]         -1
[1539840499.1408312]    -1      -1      -1       [30]        -1      -1
[1539840499.1610453]    -1      -1      [10]         -1      -1      -1
[1539840499.198975]     -1      -1      -1       -1      [2]         -1
[1539840499.2412484]    -1      -1      -1       [13]        -1      -1
[1539840499.2881212]    -1      -1      -1       [13]        -1      -1
[1539840499.3942833]    -1      [21]         [17, 9]         -1      -1      -1
[1539840499.4199429]    -1      -1      -1           -1      [1]         -1
[1539840499.4612713]    -1      -1      [22]         -1      [1]         -1
[1539840499.480137]     -1      -1      [13]         -1      -1      -1
[1539840499.496152]     -1      -1      -1       [27]        -1      -1
```

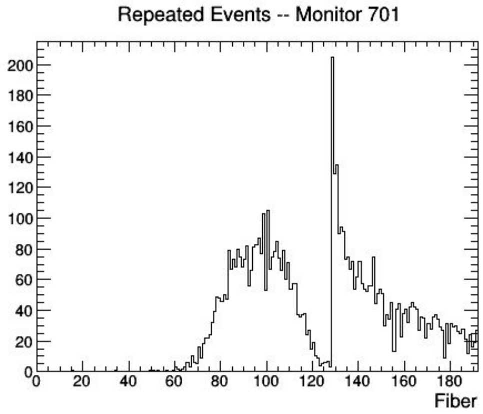
# Repeated Fibers

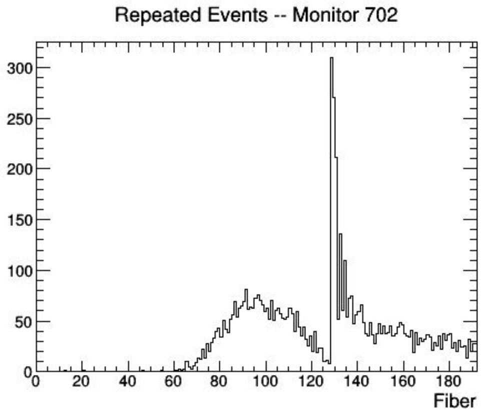

Repeated Events -- Monitor 697

Last 2 words are likely to be immediately repeated


Repeated Events -- Monitor 698

Related to other issue (later)


Repeated Events -- Monitor 701

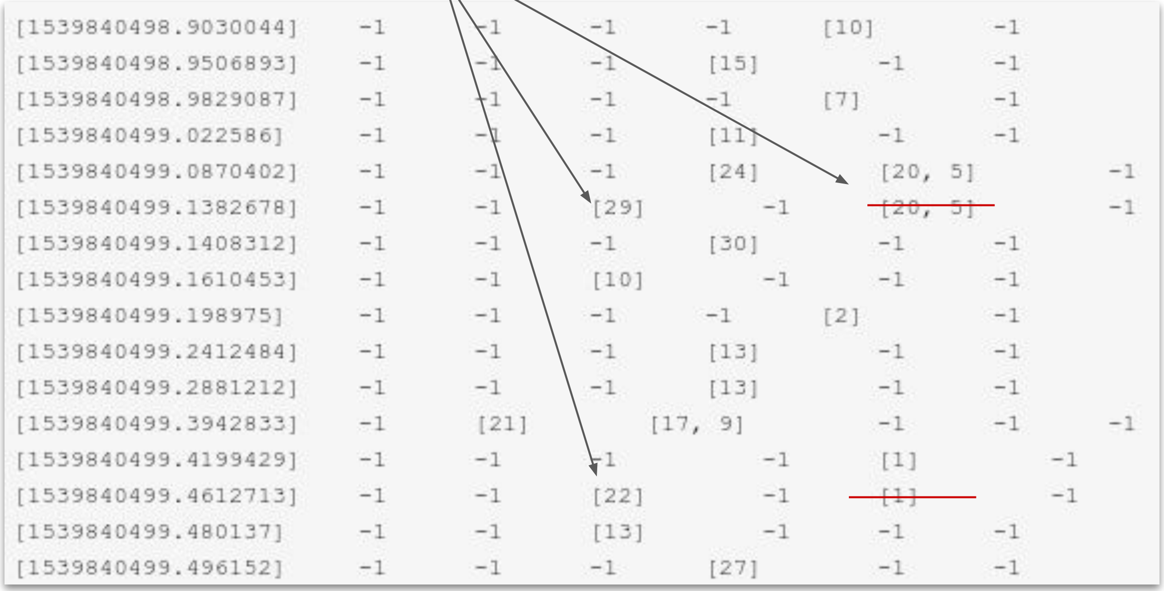

Repeated Events -- Monitor 702

# Mitigating the issue

Idea for software workaround:

For each monitor acquisition/trigger in the spill:

1. Check if any active fibers from words 5 & 6 were repeated from the previous trigger
2. Mask these/throw them out
3. Treat any other active fibers as “truly” active



```
[1539840498.9030044]    -1      -1      -1      -1      [10]        -1
[1539840498.9506893]    -1      -1      -1      [15]        -1      -1
[1539840498.9829087]    -1      -1      -1      -1      [7]         -1
[1539840499.022586]     -1      -1      -1      [11]        -1      -1
[1539840499.0870402]    -1      -1      -1      [24]        [20, 5]         -1
[1539840499.1382678]    -1      -1      [29]        -1      ~~[20, 5]~~         -1
[1539840499.1408312]    -1      -1      -1      [30]        -1      -1
[1539840499.1610453]    -1      -1      [10]        -1      -1      -1
[1539840499.198975]     -1      -1      -1      -1      [2]         -1
[1539840499.2412484]    -1      -1      -1      [13]        -1      -1
[1539840499.2881212]    -1      -1      -1      [13]        -1      -1
[1539840499.3942833]    -1      [21]        [17, 9]         -1      -1      -1
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[1539840499.4612713]    -1      -1      [22]        -1      ~~[1]~~         -1
[1539840499.480137]     -1      -1      [13]        -1      -1      -1
[1539840499.496152]     -1      -1      -1      [27]        -1      -1
```
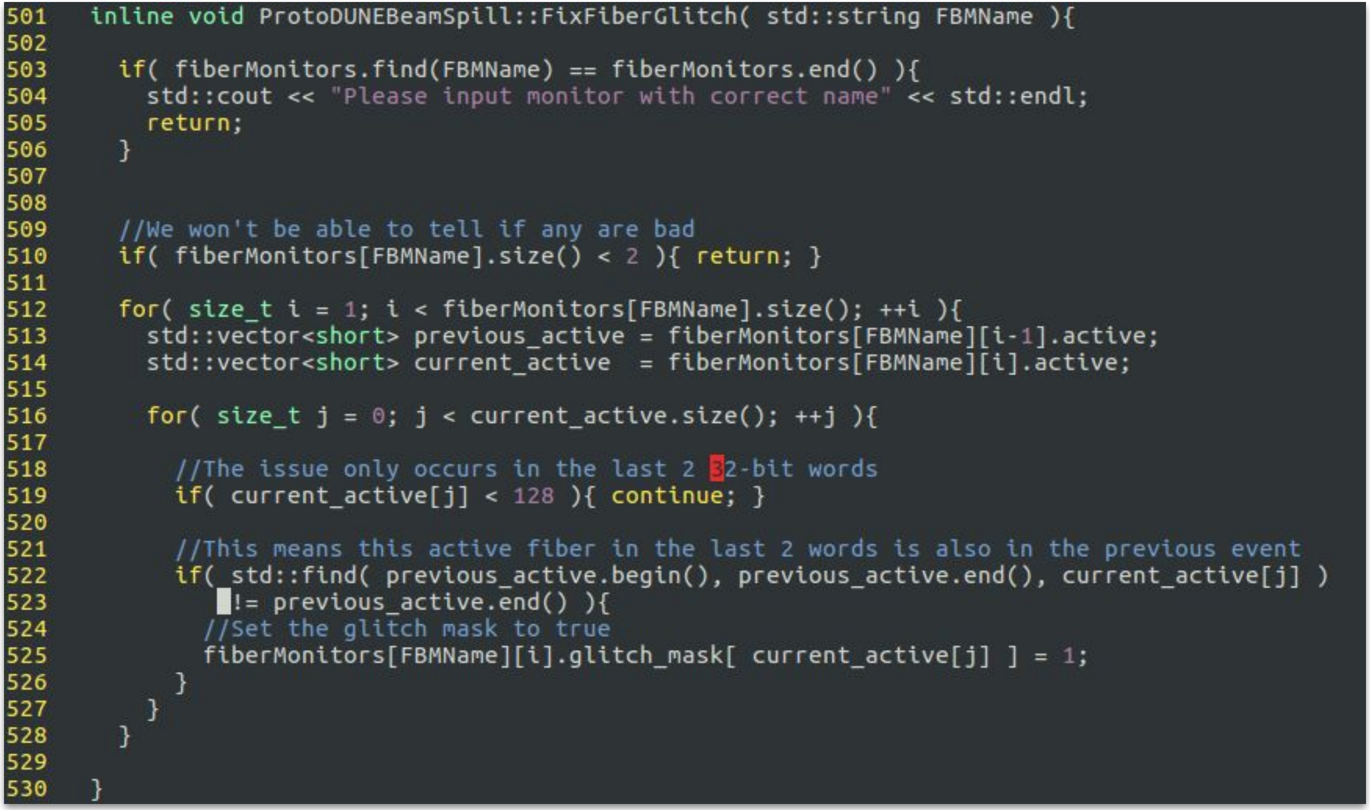
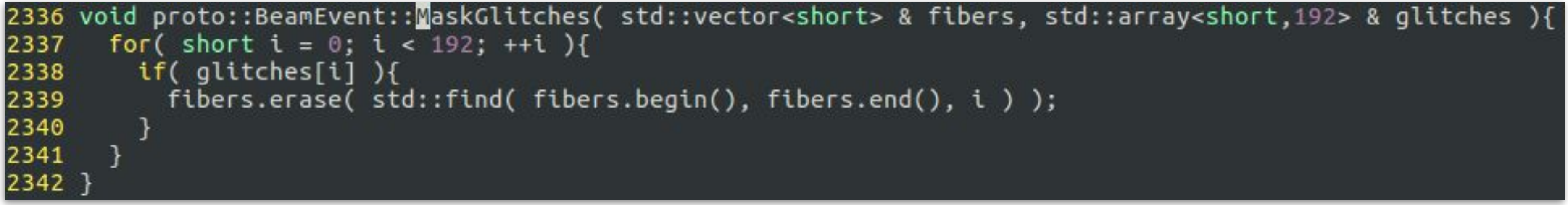

# Implementation in dunetpc



```cpp
inline void ProtoDUNEBeamSpill::FixFiberGlitch( std::string FBMName ){

  if( fiberMonitors.find(FBMName) == fiberMonitors.end() ){
    std::cout << "Please input monitor with correct name" << std::endl;
    return;
  }


  //We won't be able to tell if any are bad
  if( fiberMonitors[FBMName].size() < 2 ){ return; }

  for( size_t i = 1; i < fiberMonitors[FBMName].size(); ++i ){
    std::vector<short> previous_active = fiberMonitors[FBMName][i-1].active;
    std::vector<short> current_active  = fiberMonitors[FBMName][i].active;

    for( size_t j = 0; j < current_active.size(); ++j ){

      //The issue only occurs in the last 2 32-bit words
      if( current_active[j] < 128 ){ continue; }

      //This means this active fiber in the last 2 words is also in the previous event
      if( std::find( previous_active.begin(), previous_active.end(), current_active[j] )
          != previous_active.end() ){
        //Set the glitch mask to true
        fiberMonitors[FBMName][i].glitch_mask[ current_active[j] ] = 1;
      }
    }
  }

}
```

# Implementation in dunetpc



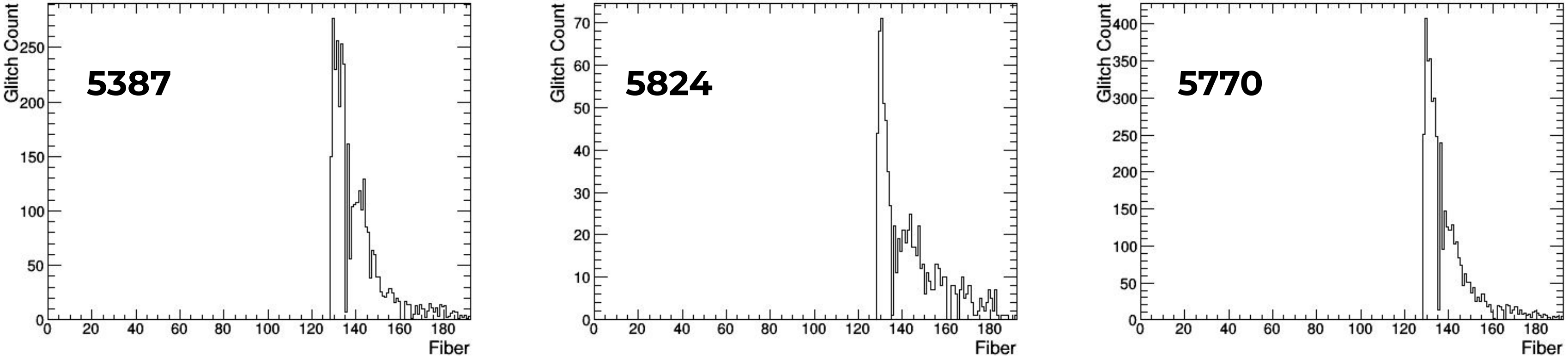
```
void proto::BeamEvent::MaskGlitches( std::vector<short> & fibers, std::array<short,192> & glitches ){
  for( short i = 0; i < 192; ++i ){
    if( glitches[i] ){
      fibers.erase( std::find( fibers.begin(), fibers.end(), i ) );
    }
  }
}
```

When reconstructing momenta/tracks: feed (copy of) active fibers and glitches to above function to remove the glitches from the active list.

Reconstruct with the left-over fibers

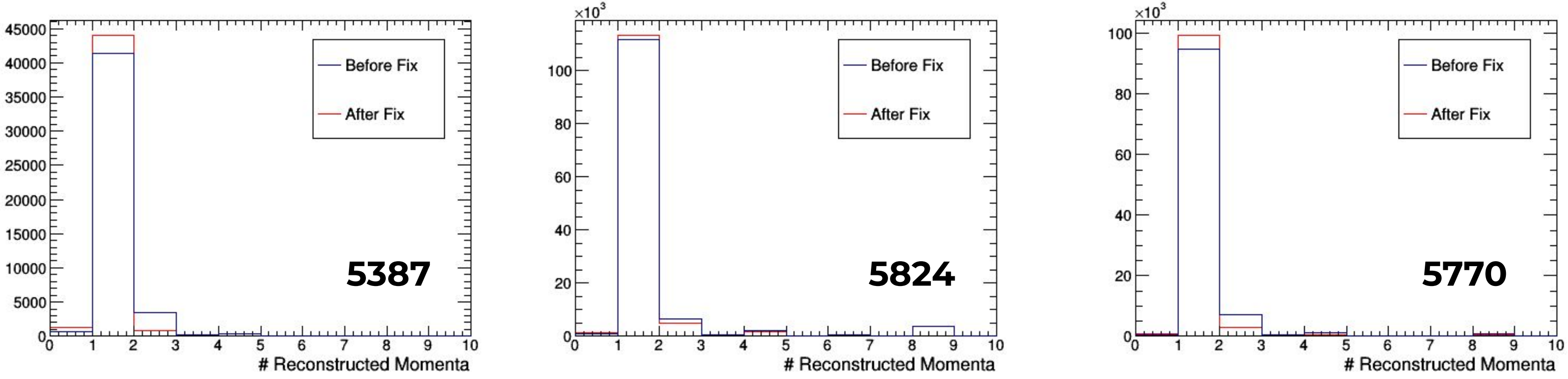
# Results

Below: glitches from the first profiler in momentum spectrometer



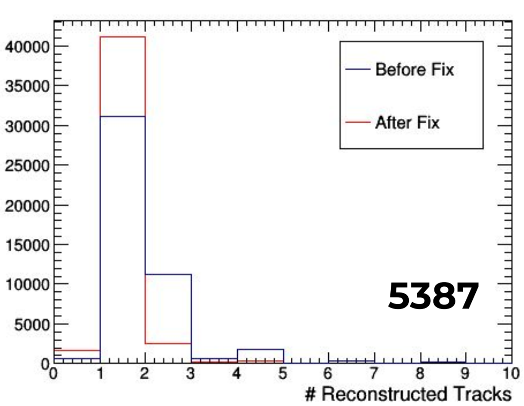
# Results

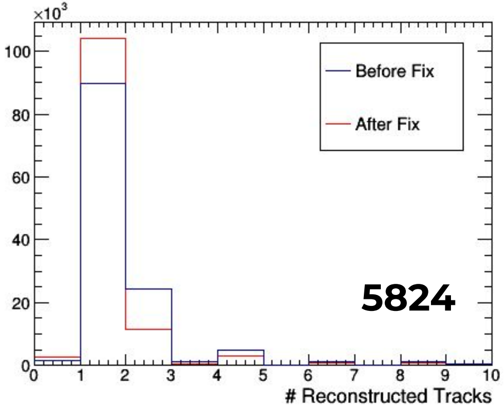
Number of reconstructed momenta per event
Note: 5824 was an electron run

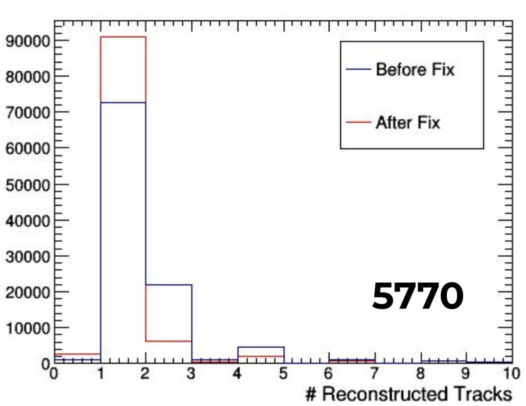


# Results

Number of reconstructed tracks per event

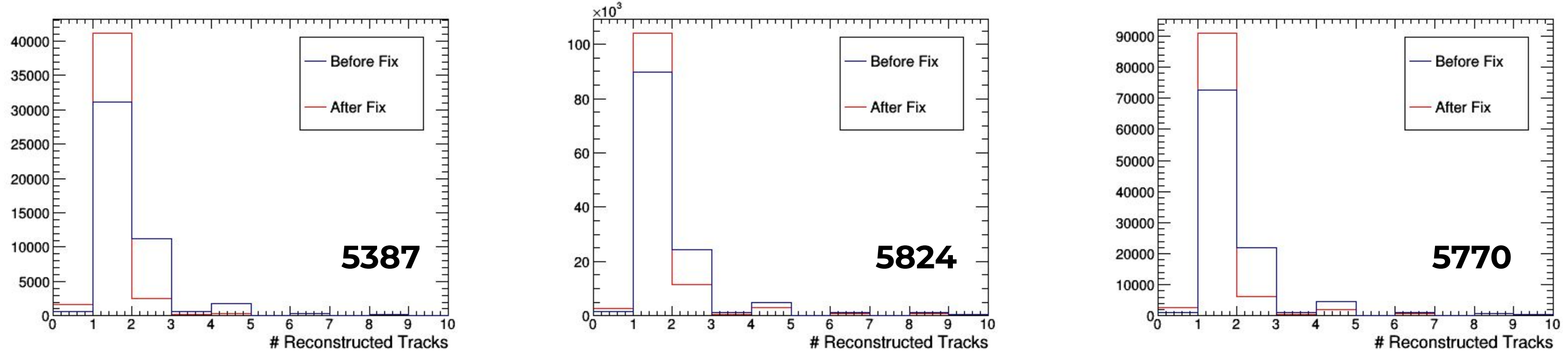






# Results

Number of reconstructed tracks per event



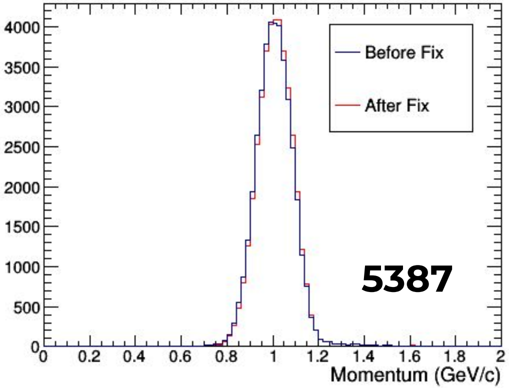
# Results

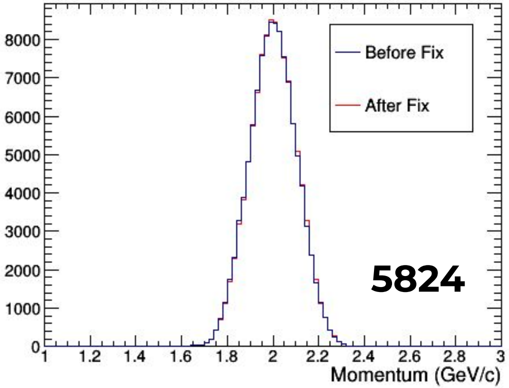
| Run | Single Track | Single Momentum | Both Good |
|---|---|---|---|
| 5387 | 66% → 88% | 88% → 95% | 59% → 84% |
| 5824 | 70% → 82% | 88% → 89% | 64% → 75% |
| 5770 | 69% → 87% | 90% → 94% | 63% → 82% |

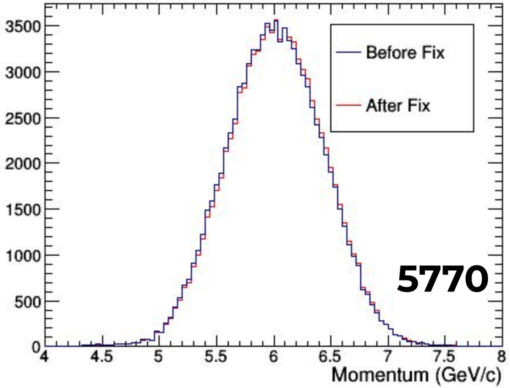
Note: Percentages above are relative to the total number of pion-like triggers in 5387, 5770 or e-like triggers in 5824

# Results

The reconstructed momentum spectra shifted slightly higher (< 1%)







# Conclusion

Implemented fix to profiler software glitch within dunetpc.

Results of testing show an increase in the number of single track and momentum events

Will be included in the next production

# Thanks for listening