Status of the NuMI beam and target

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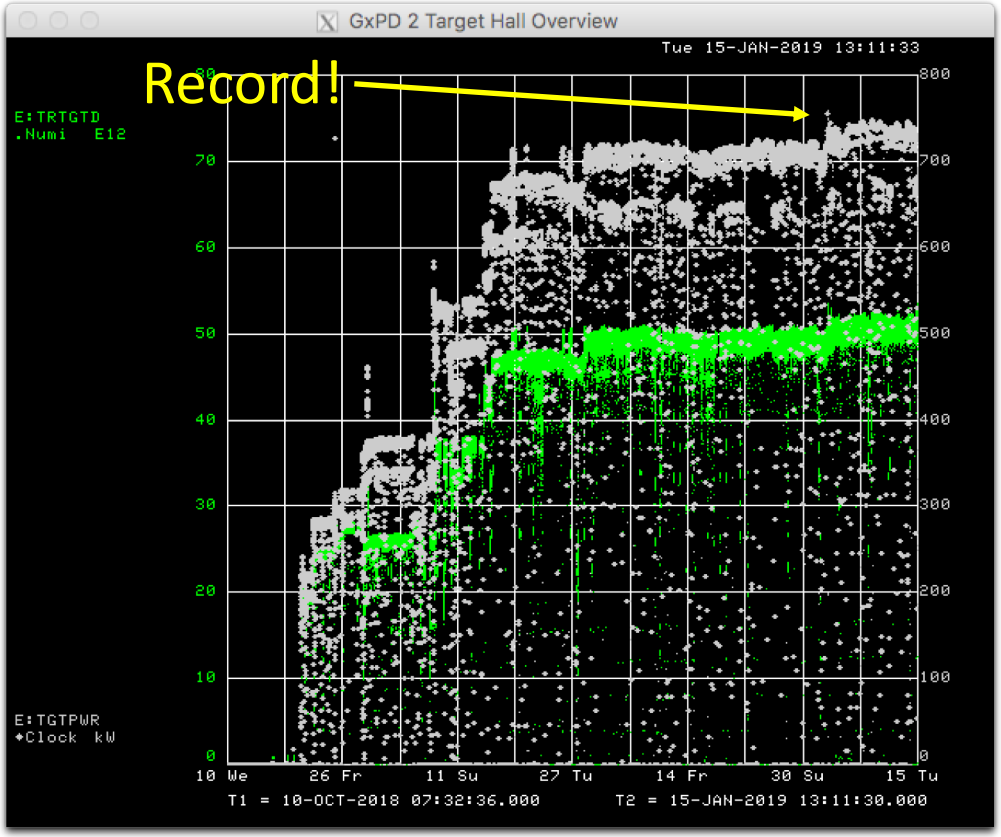
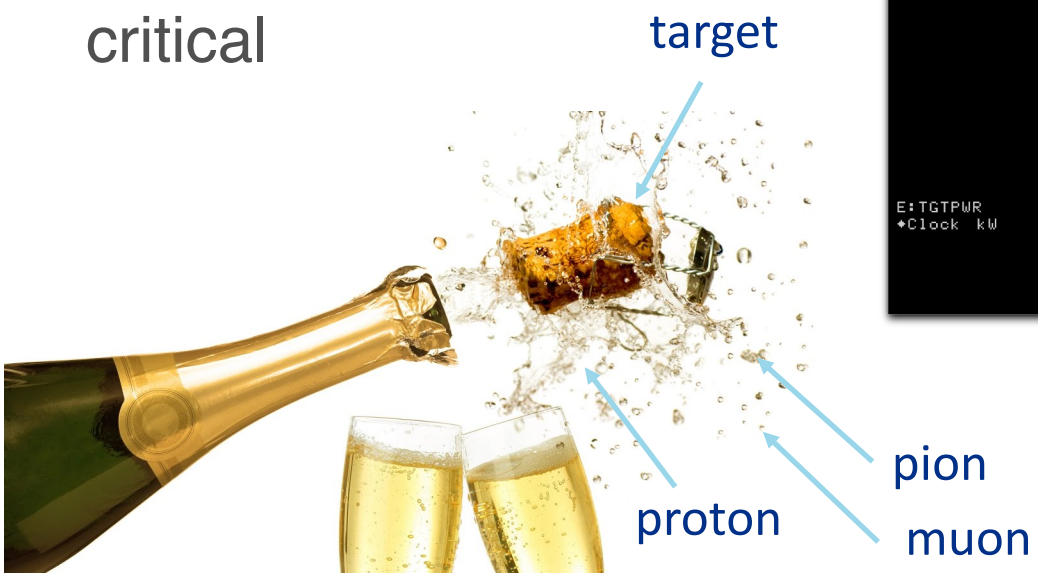
Present NuMI beam

- > 740 kW beam delivered to the NuMI target
- Found small gas & water leaks, and minor malfunction of devices, but none of them is critical





Neutrino in ND/FD

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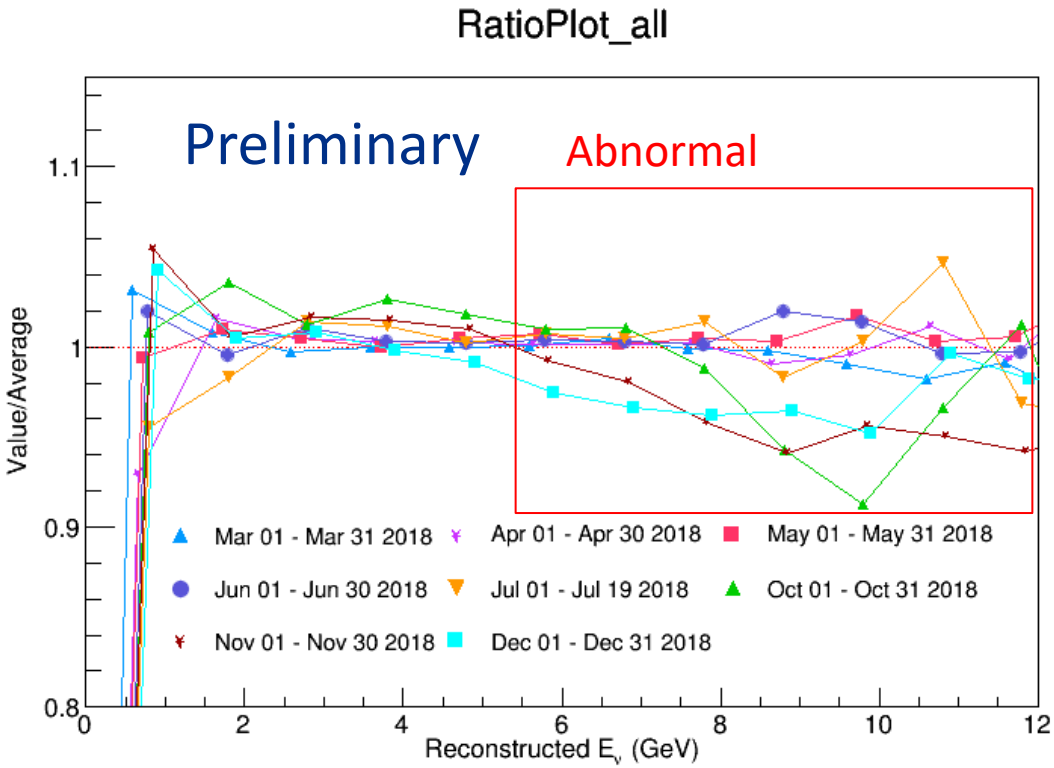
Issue on neutrino spectrum

- NOvA & MINERvA groups claimed that neutrino yield (RHC) at high energy region looks low in FY19 run
- Need systematic check
  - Target/Beam
  - Horn

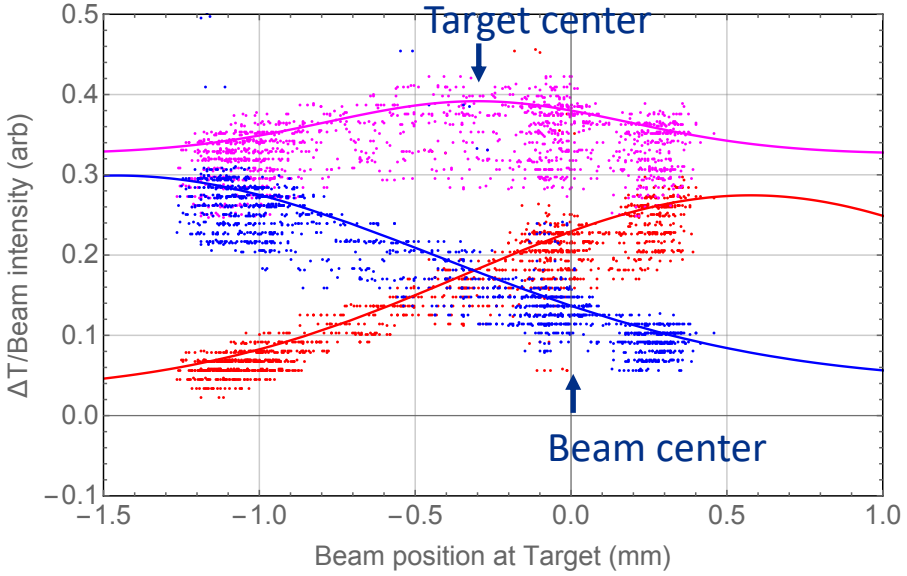


Horn parameters has been checked (current, field map) and found no outstanding sources to generate such a low yield of high energy neutrinos

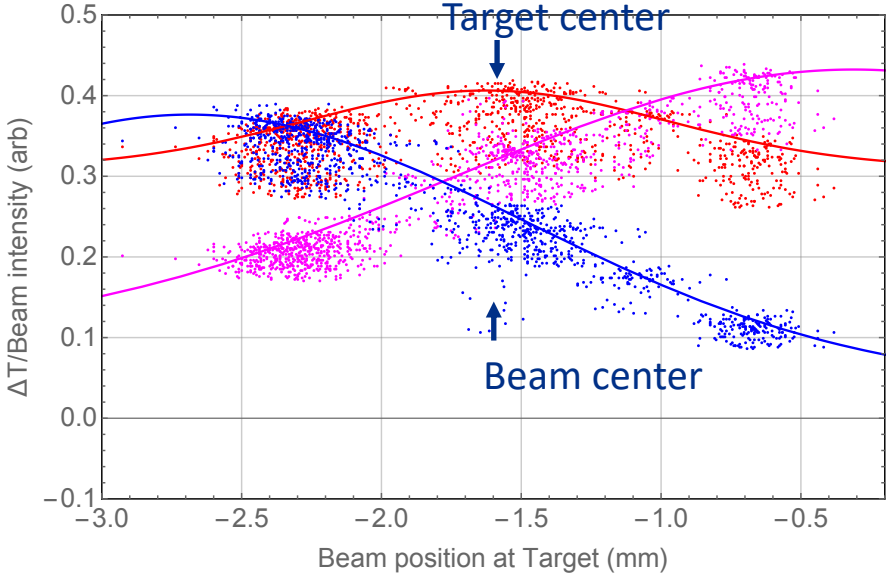
High intensity beam scan

- Three beryllium wires in x & y planes put in front of the target
- One wire is the target center and other two is separated by 1.3 mm
- Measure temperature change by thermocouple
- Move the beam position in x & y to find the target center
- Found beam position is too much right

Horizontal scan



Vertical scan



Beam 0.349 +/- 0.049 mm right side from target center

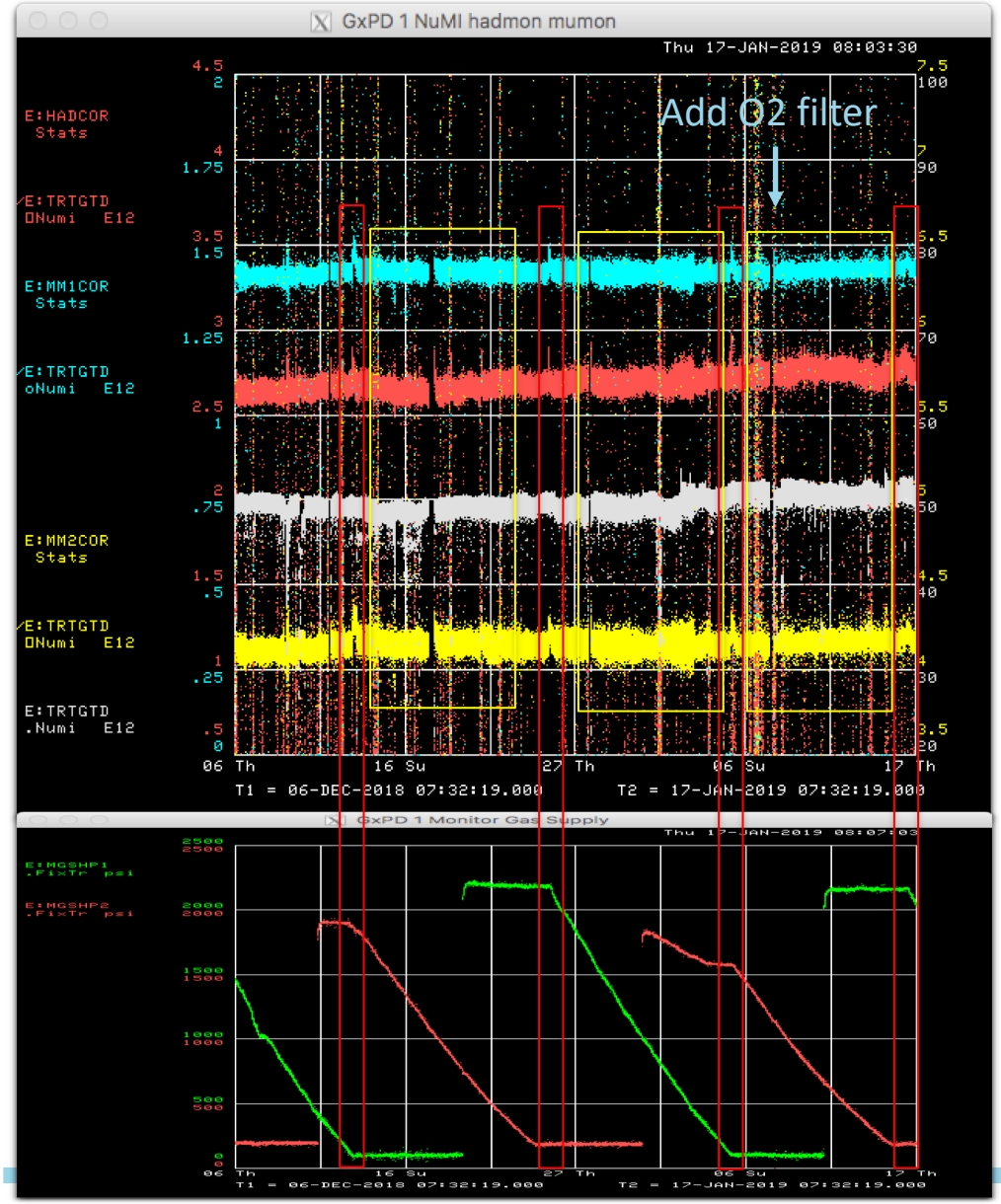
Beam 0.056 +/- 0.046 mm down side from target center

The beam position will be moved to strike the target center

Future prospect of muon monitor

- Muon monitor will play more important role than present to be the primary detector for maintaining the quality of neutrino beam when the MINOS ND is turned off
- It is crucial to reduce systematic error on muon monitor signal
  - Get rid of a blip on the signal
  - Recover linearity of signal gain
- It should also accept a 1-MW beam

Present issue on Muon Monitor signal



- A spike on the gain of Muon Monitor signal when gas bank is switched (see a red box)
- Cory, Mike and George added two Oxygen filters on 1/8/19
- Blip seems to become smaller!

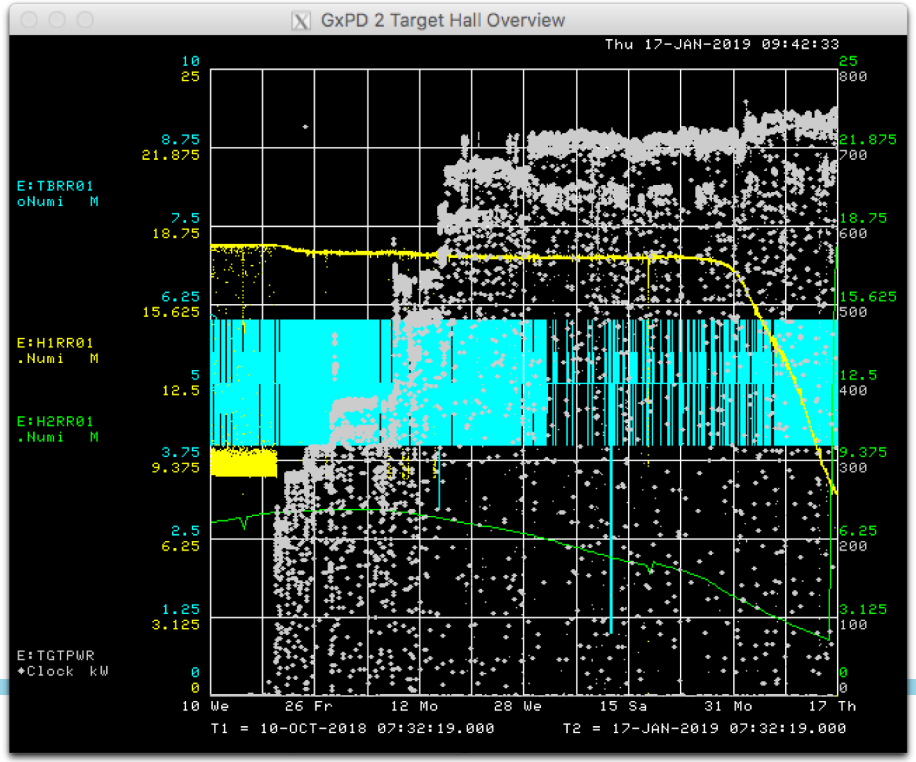
- The gain is also varied by the beam intensity (see a yellow box)
- Ion chamber seems to be piled up since the beam intensity is too high
- Further investigation is needed

Possible improvement

- Remove blip
  - Present result suggests that the blip is generated by impurity of Helium gas
  - We should look at the gas regulation system to avoid contamination
  - Or, impurity will be diluted by using a reservoir tank
- Recover linearity
  - Source of non-linear behavior can be a space charge
  - This is an intrinsic issue; no quick solution to handle plasma dynamics
  - Need to adjust a plate gap, bias voltage, gas pressure for high intensity operation

Ionization of RAW in NuMI target system

- Please note that we explore physics in the MW-class high-energy beam target system!
- > 200 kW power damped in the target
  - Study influence on a solid material, i.e. HiRadMat is essential
  - How about ambient gas and water?



- RAW resistivity in target, horn 1, and horn 2
- H1 RAW resistivity is drastically changed when the beam power is moved from < 720 kW to > 730 kW

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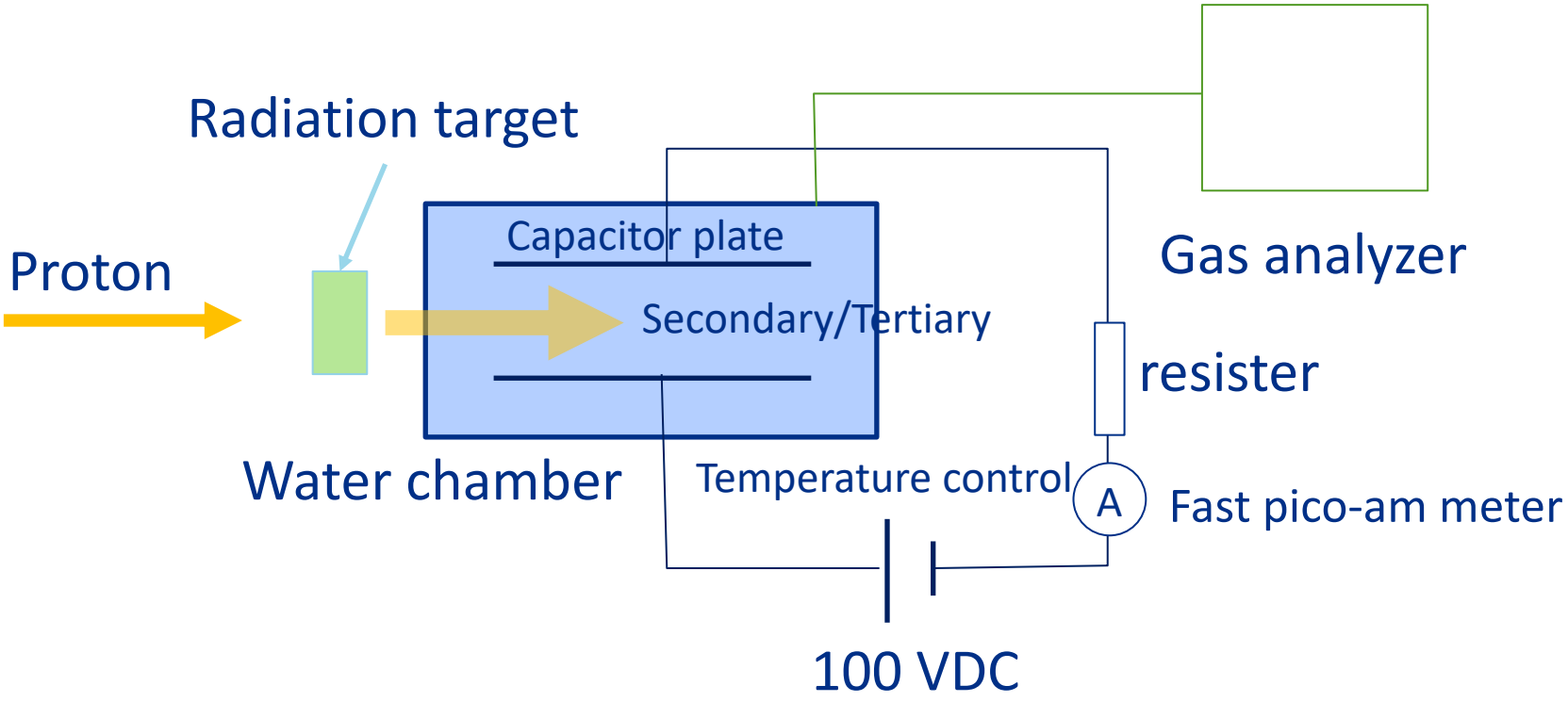
Mechanism of Ionization in water

- Radiolysis
  - Water decomposed by radiation
  - Products: e^-_{aq}, H, HO, (HO_2,) OH^-, H_3O^+, H_2, H_2O_2
  - Yields of productions depend on the size of Linear Energy Transfer (LET) and beam intensity
    - With high LET (NuMI target), molecular state is dominant
- Electrolysis
  - Water decomposed by electrical potential
  - Products: e^-_{aq}, H, HO, H^+, OH^-, H_3O^+, H_2, O_2
  - Yields of productions depend on the strength of potential field, but not depend on the beam intensity
  - Electrolysis may be catalyzed by radiolysis (see later slide)

Mechanism of RAW resistance change

- Hypothesis
  - Prompt resistance change due to a short lifetime productions of decomposed water, e.g. OH^-, H_3O^+, H_2O_2
  - Those amounts can be too small to detect
  - Baseline resistance change due to a long lifetime ions
  - Some metal atom can be knocked out and resolved in water by radiation (or by transmutation)

Proposed test stand for ionization study



- Compact water chamber containing a capacitor plate which measures a prompt RAW resistance
- Sampling gas and measure its H2, O2 abundance as a function of integrated beam intensity to measure the G-value