Long Term Operating Experience at MiniBooNE

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Schematic Geography

4×10^{12} ppp @ 15Hz

5 pulses per second

Beryllium target

7 slugs each

0.48 cm radius

10.2 cm long

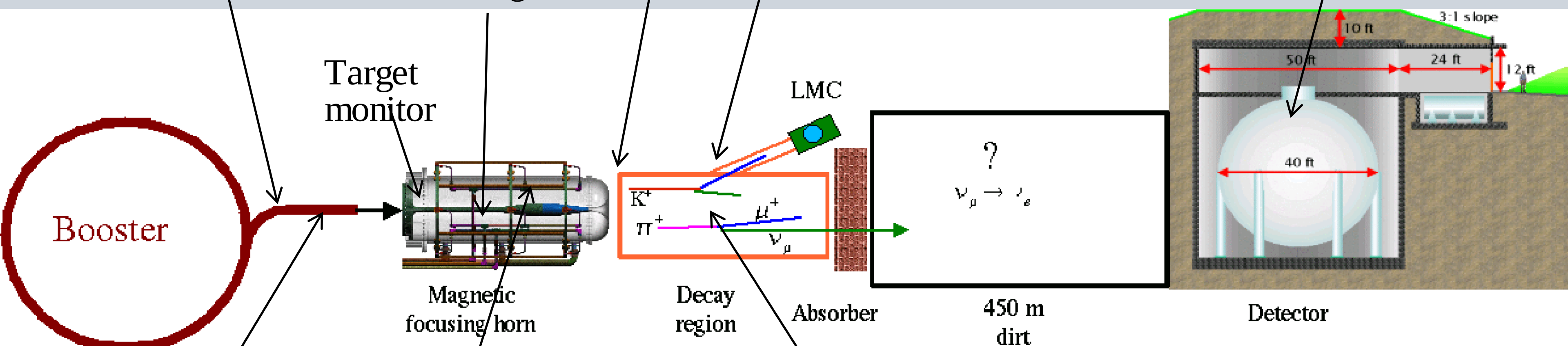
Collimation

25 m absorber

detector

800 T CH_2

541m from target



8 GeV beamline

Focussing magnetic

horn : 170 kA @ 15 Hz.

Designed for 5 pulses/s.

Decay region :

50 m long

90 cm radius

filled w air

Objectives of this talk

The goal we'll try to achieve is a presentation of some of the long-term operating experience of the M'BooNE detector.

The detector has been running since 2002 on a 24/7 basis, even when beam is not available. The detector is kept live as part of a supernova search, and data is continually recorded.

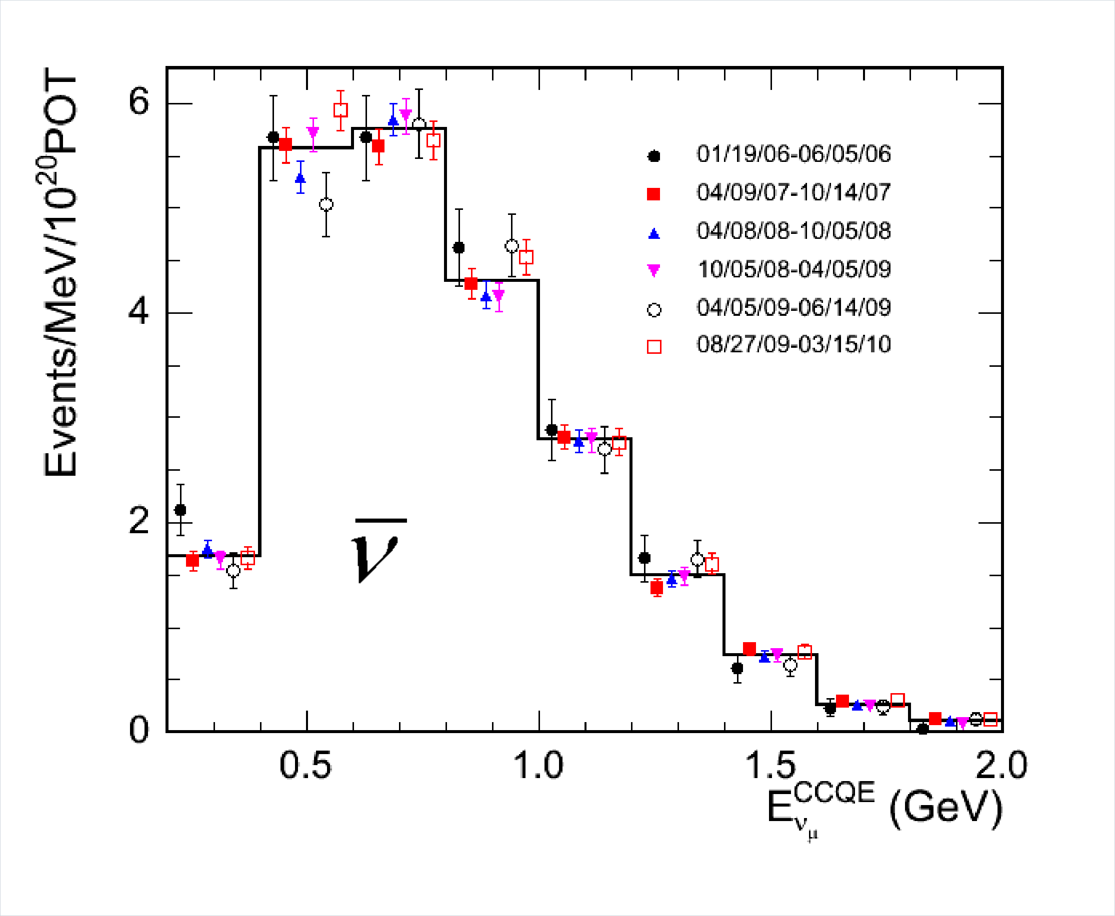
Short periods of computer upgrade, electronics maintenance and the like, have occurred.

The information presented here is meant to be a sample of the monitoring tools and archival data, and is not meant to be comprehensive.

M’ BooNE operating history with ν and $\bar{\nu}$ beams.

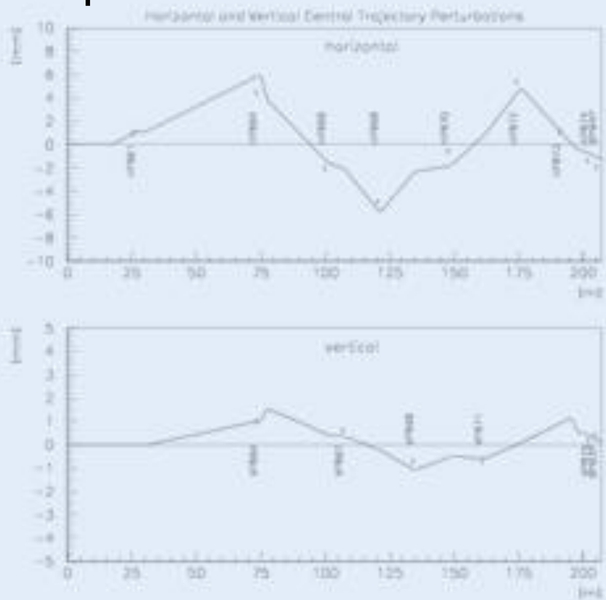
Name	Starting Run	Starting Time	Ending Run	Ending Time	Delivered POT [E20] (with data quality cuts applied)
1st Neutrino Mode Period Osc. Analysis	3539	Feb-03	12499	Oct-05	5.579
1st Neutrino Mode Period not in Osc. Analysis	12500	Oct-05	12842	Jan-06	0.05
1st Anti-Neutrino Mode Period 1st 0 Absorber Down	12843	Jan-06	14048	Jun-06	0.172
1st Anti-Neutrino Mode Period 1 Absorber Down	14049	Jun-06	14362	Aug-06	0.569
1st Anti-Neutrino Mode Period 2 Absorber Down	14363	Aug-06	15118	Apr-07	0.612
1st Anti-Neutrino Mode Period 2nd 0 Absorber Down	15119	Apr-07	15832	Oct-07	0.972
2nd Neutrino Mode Period	15833	Oct-07	17160	Apr-08	0.832
2nd Anti-Neutrino Mode Period	17161	Apr-08	18425	Sep-08	1.061
3rd Anti-Neutrino Mode Period	18426	Sep-08	20174	Jun-09	1.477
4th Anti-Neutrino Mode Period	22121	Aug-09	22779	Mar-10	0.798
Horn Off Runs	253 runs		-	-	0.292
Horn Quarter Runs	88 runs	-	-	-	0.158
Horn Half Runs	92 runs	-	-	-	0.153

Overall beam and detector stability



The E_{ν}^{ccqe} distributions taken during different run periods. This is a test of the stability over time of beam and detector together.

The 8 GeV beamline has an auto tune feature to keep the beam centered on the target with minimal expert interference.



Measured and predicted changes of central trajectory along beamline when HT860 (top) or VT862 (bottom) is changed.

target parameters

7 slugs, 0.48 cm in radius

10.2 cm in length

total length of 71 cm.

Power dissipated in target P = 600W

@ 10^{12} ppp; 5 batches/s.

closed air cooling system with

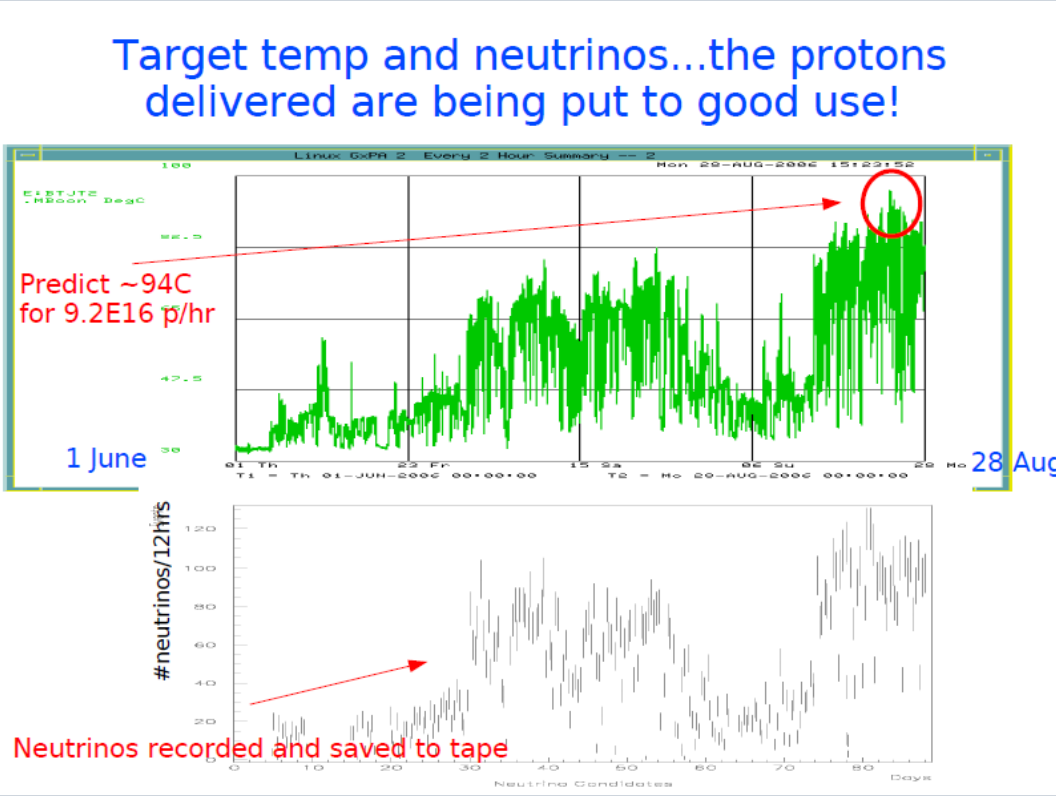
volumetric rate $dV/dt = 8 \bullet 10^{-3} m^3/s$.

$$T_{out} = T_{in} + P/(c_p \rho \, dV/dt)$$

$$\rho = 1.20 \text{ kg/m}^3$$

$$c_p = 10^3 \text{ J/(kg} \bullet \text{K)}$$

Target temperature follows beam intensity reasonably well.



Long term performance of the MB horn

Material	aluminum alloy 6061-T6
Inner conductor outer radius	2.2-6.54 cm
Outer conductor inner radius	30 cm
Length	185 cm
Peak current	170 kA
Maximum magnetic field	1.5 Tesla
Current pulse duration (half-period)	140 μs
Voltage on horn	3 kV
Skin depth	1.4 mm
Average (maximum) repetition rate	5 (15) Hz
Power dissipation by ohmic losses	2.5 kW
Power dissipation by beam deposition	0.8 kW
Cooling water flow rate	1 l/s
Design lifetime	10^8 pulses in 1 year at 97.5% CL

Table 3.1: *Horn mechanical and electrical design properties.*

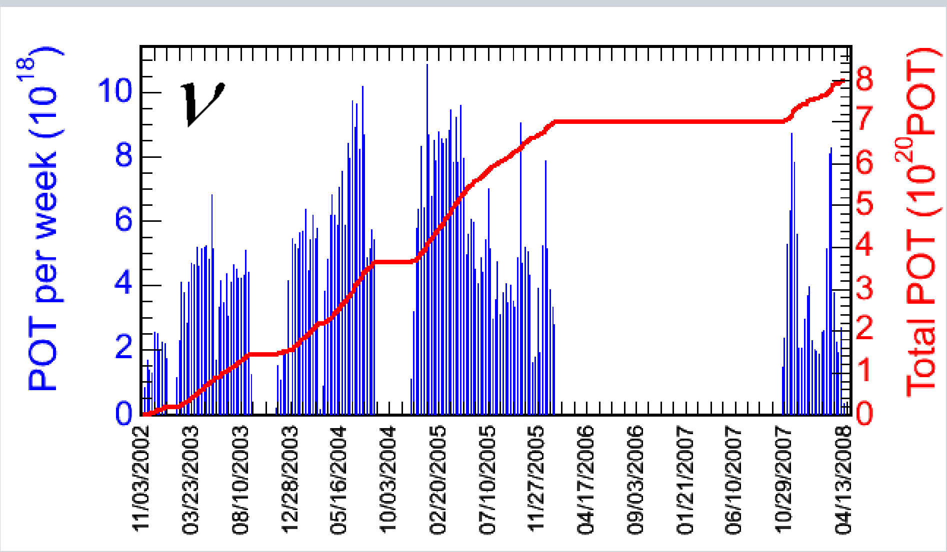
As of May 17th 2010 we had a total of 349.18M horn pulses with beam.

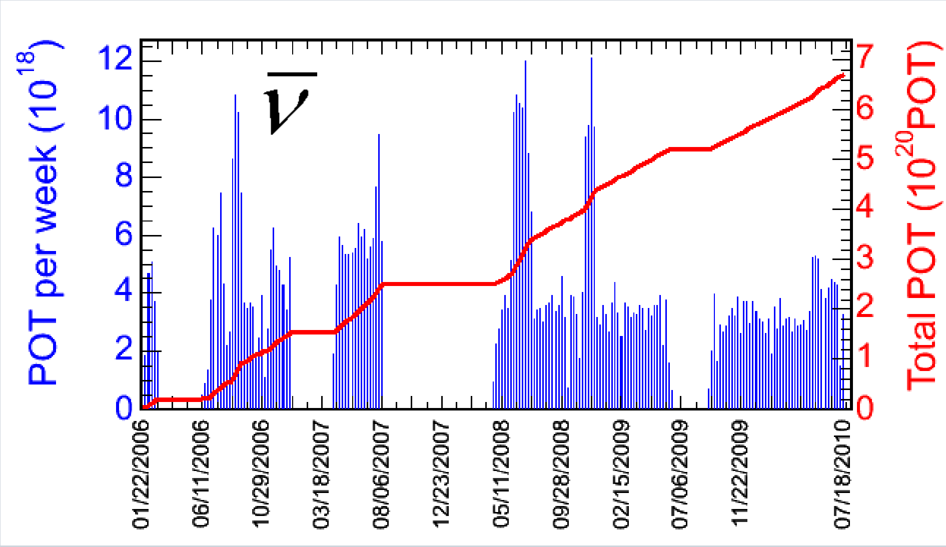
Horn 1 had 85M beam pulses.
Horn 2 has 264.18M beam pulses.

Summary of both ν and $\bar{\nu}$ operations.

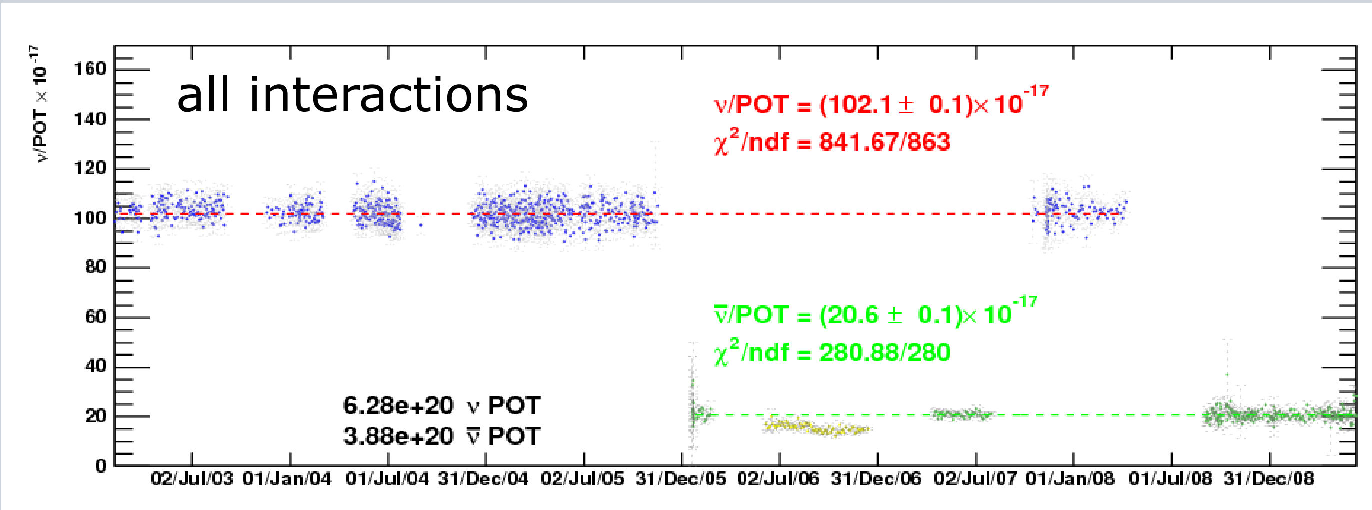
6.411×10^{20} protons in ν mode

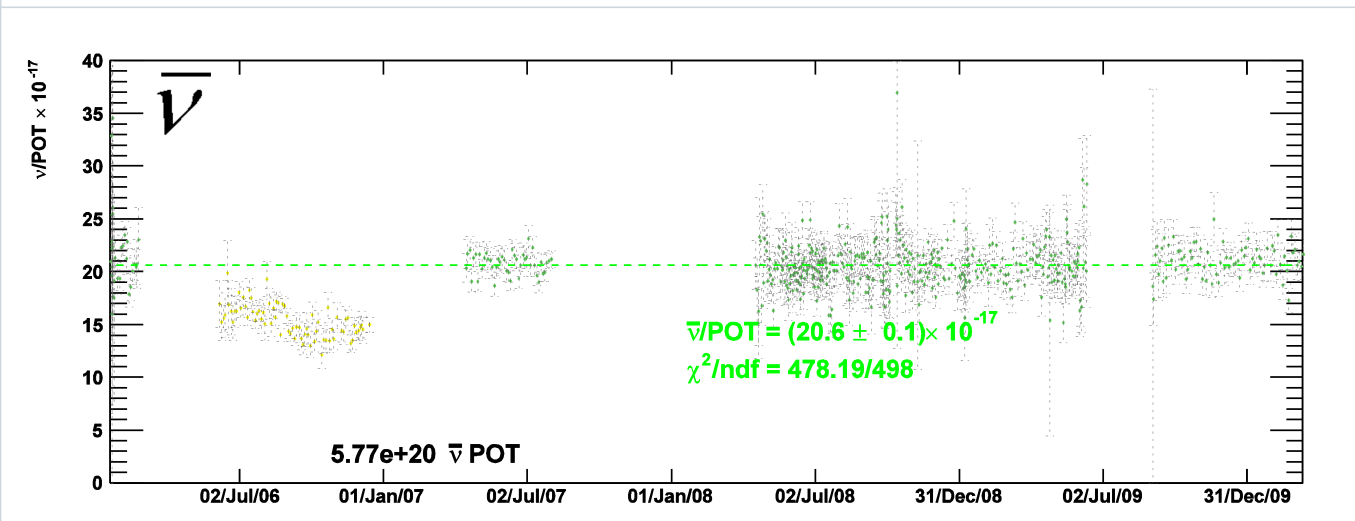
5.711×10^{20} protons in $\bar{\nu}$ mode



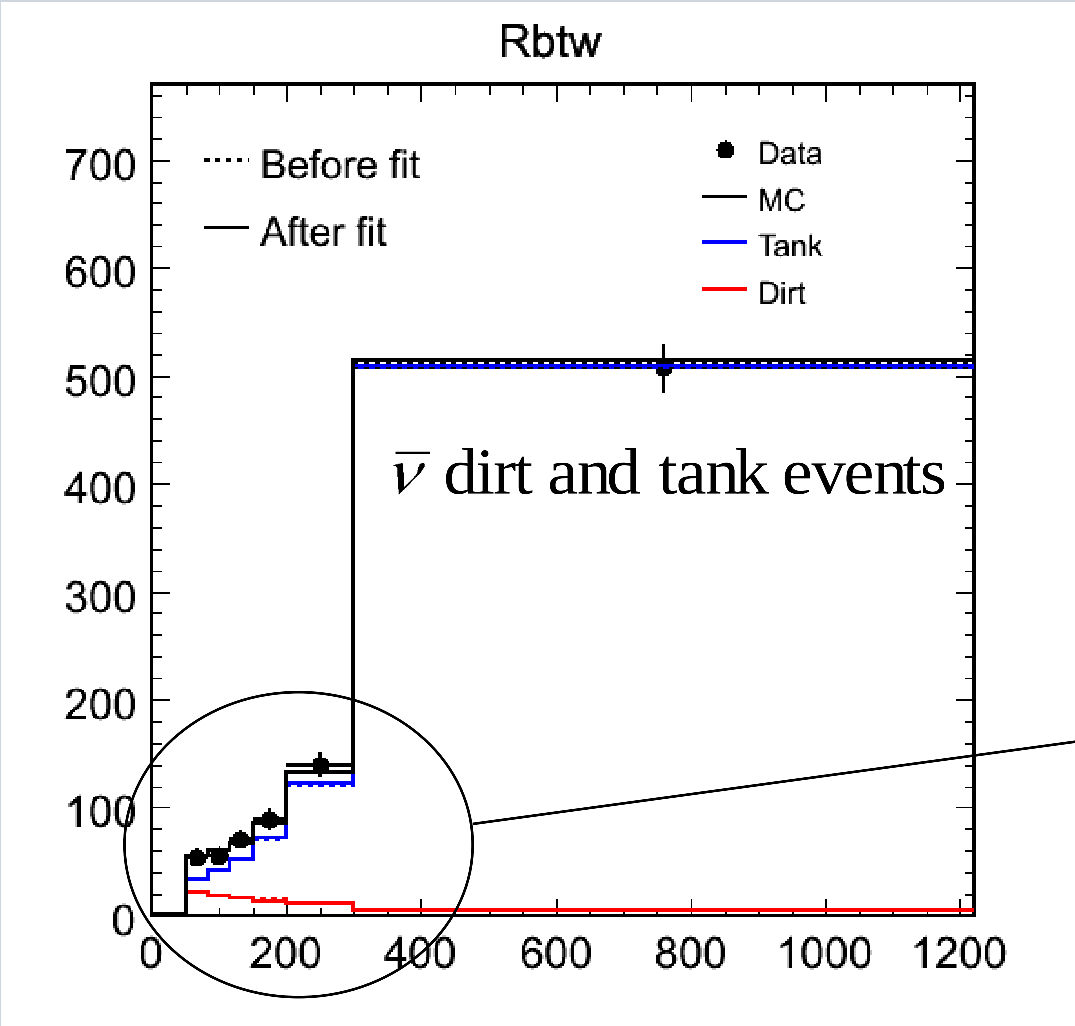


Stability of Interaction rate over the seven years of running





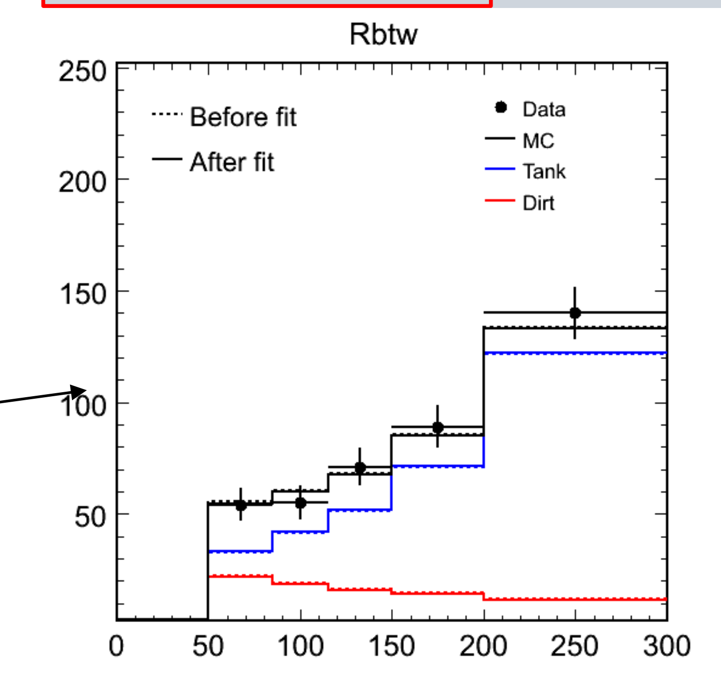
Detector operation: Comparison of data and simulation for events that originate outside of the detector volume.



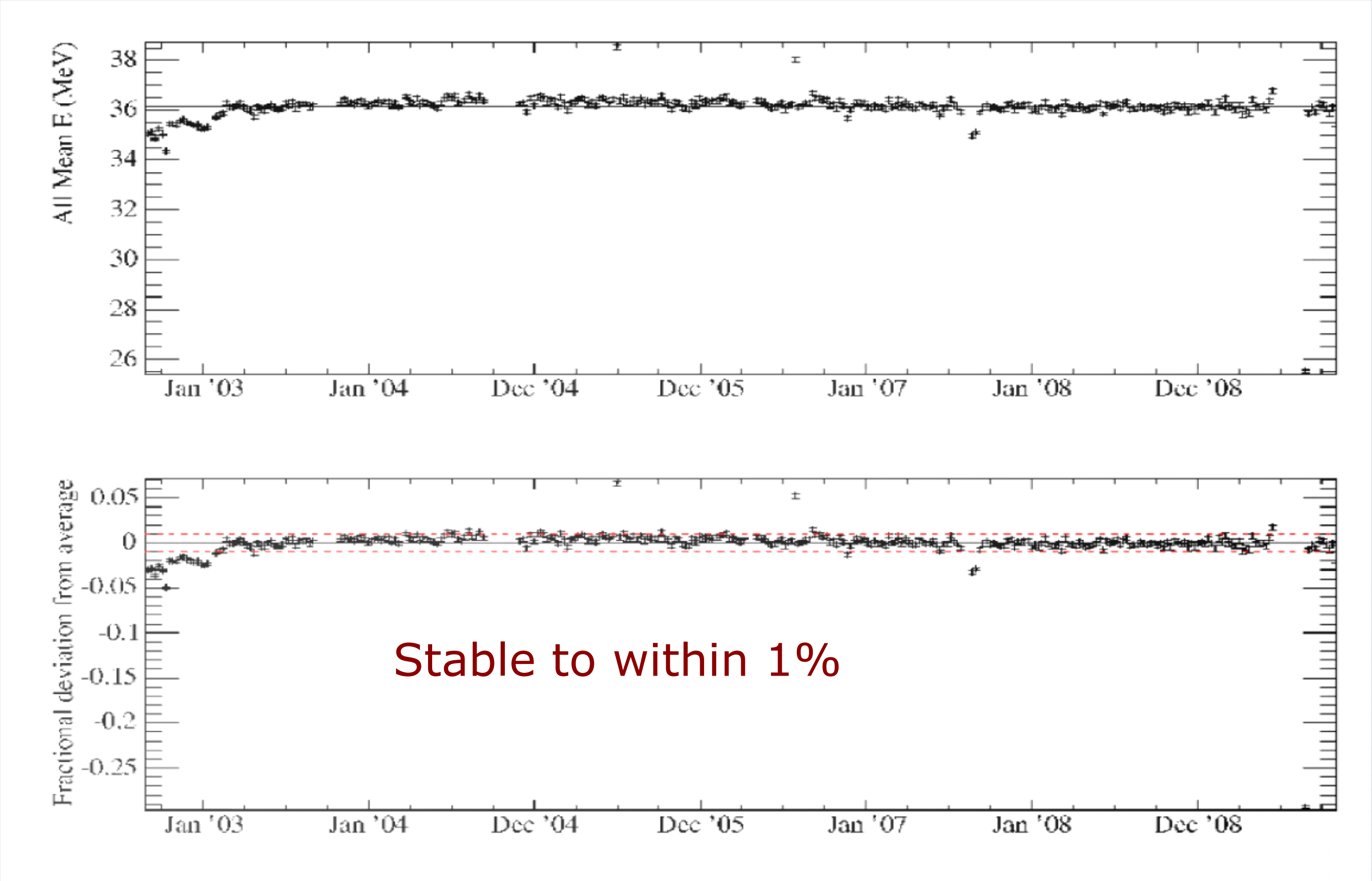
Rbtw = closest distance from event vertex to wall

5.661x10^{20} POT

X_{Tank} = 1.00   0.04
X_{Dirt} = 0.96   0.24

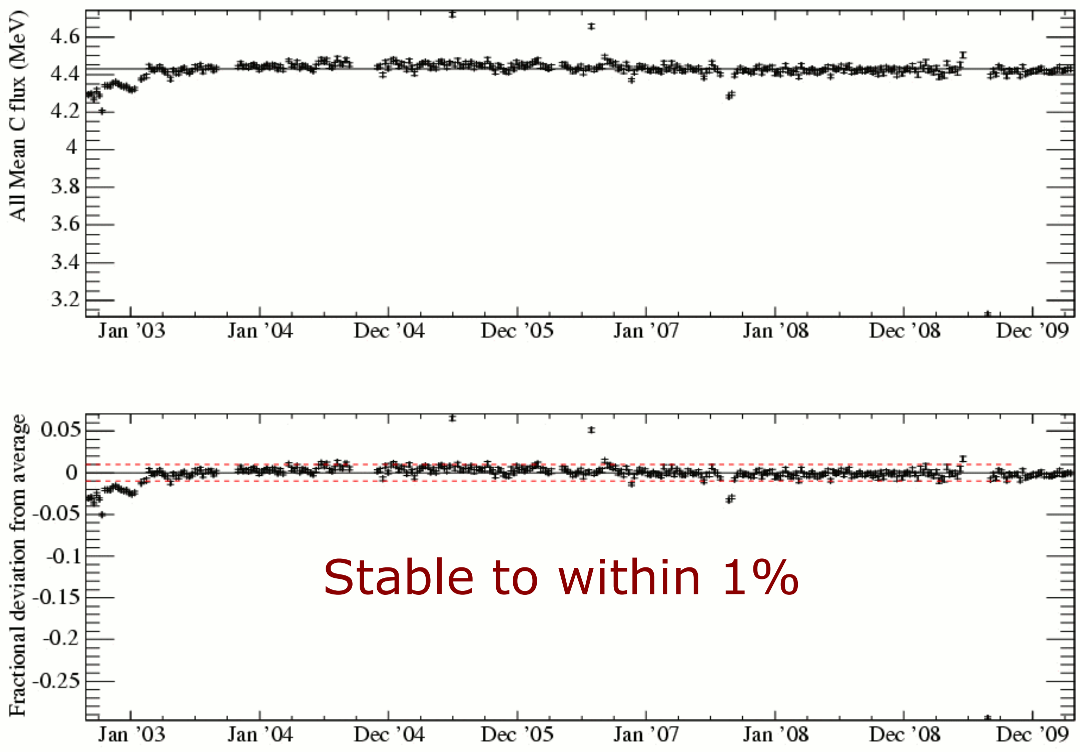


Detector stability: Michel Mean Energy from Jan03 to April10



Stable to within 1%

Detector stability: Mean Cherenkov Flux or early light as measured in the detector from Jan03 to April10



Began to operate with remote shifts. Neutrino operating experience differs from that of most other types of experiments.

Detector requires less attention than the accelerator, beam and horn.

Benefits include:

1. Savings on travel which saves funds, carbon footprint, and leads to better use of scientist's time.
2. Expands the pool of potential shifters.
3. All reporting done in electronic form, making information easily available over the internet.

Requires a comprehensive list of local experts that can be reached to fix problems, but detector must be able to run at >98% efficiency.

Over the last 10 months
36% of shifts were run remotely;
22% run by trained hired shifter;
42% run by collaborators on site at Fermilab.

The saga of the falling 25 m absorber plates

Beryllium target

7 slugs each

0.48 cm radius

10.2 cm long

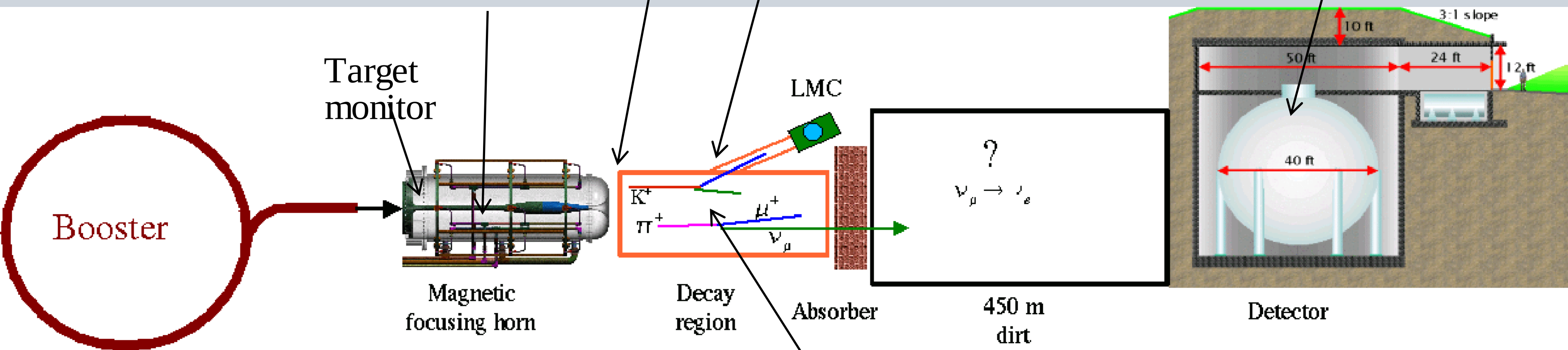
Collimation

25 m absorber

detector

800 T CH_2

541m from target



Decay region :

50 m long

90 cm radius

filled w air

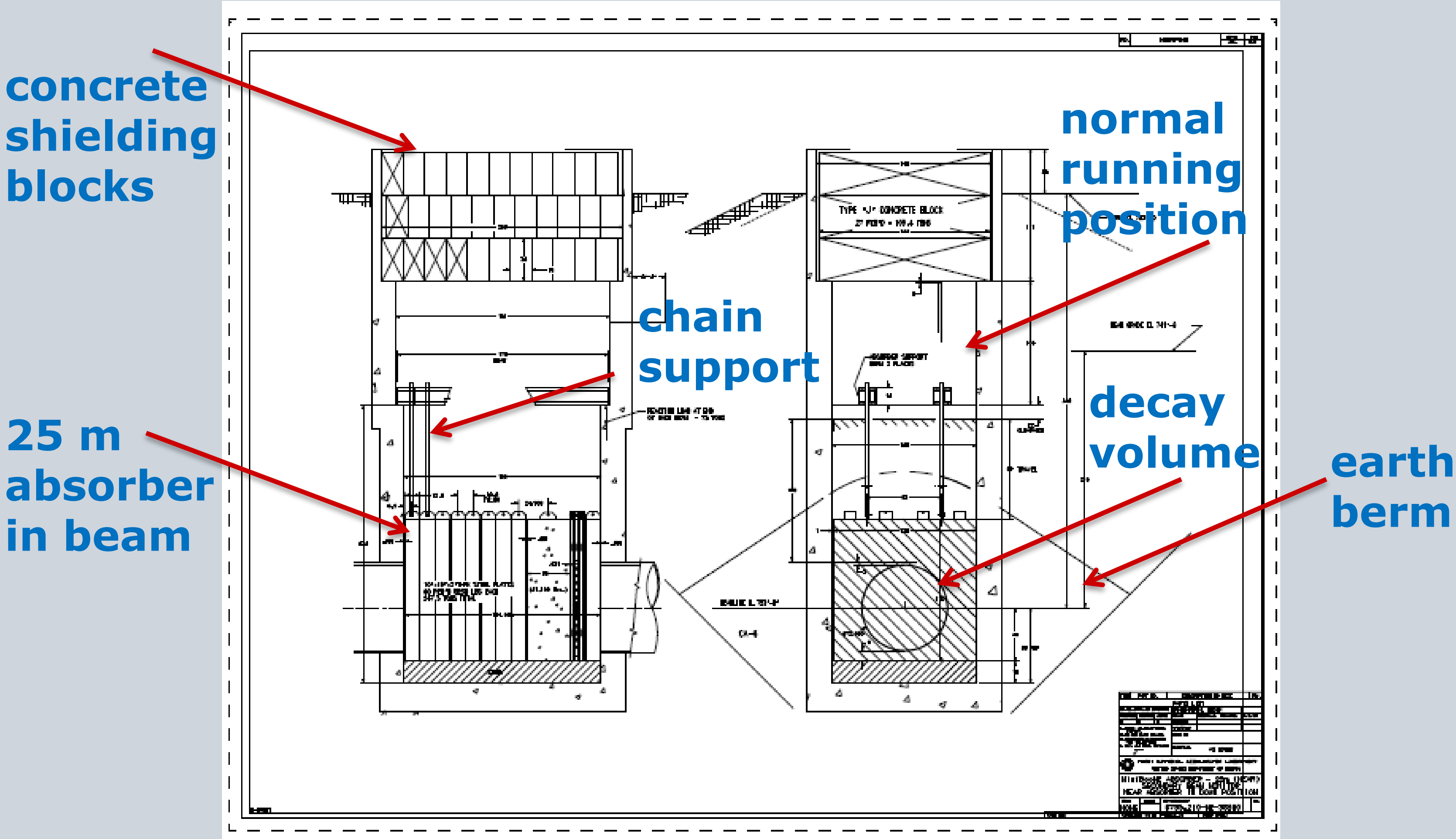
The saga of the falling 25 m absorber plates cont.

The difficulty occurred very near the start of an anti-neutrino run. Although we had some event rate information taken before the shutdown, it was difficult to interpret the slight decrease seen when beam returned.

The target, horn and detector were all operating normally, and were giving stable monitor rates. We investigated everything we could, but we felt that it was unlikely that anything could be obstructing beam in the decay volume.

Throughout this period, the LMC was showing unusual behavior, indicating that a problem existed perhaps upstream. Then at one point, the intensity at the LMC fell dramatically, just as the event rate also declined: It was time to open the 25m absorber enclosure!

The saga of the falling 25 m absorber plates, cont.



The saga of the falling 25 m absorber plates, cont.

From 6/5/2006 to 8/29/2006 one absorber plate fell into the beam.
On 8/29/2006 to 4/9/2007 a 2nd absorber plate fell into the beam.

The plates were held up by chains, a violation of engineering principles.
The failure was caused by compounds created in the interaction of the proton beam with the air in the decay volume; This lead to hydrogen embrittlement of the high grade steel composition of the chains. The chains have since been replaced by 4” ϕ stainless steel rods.

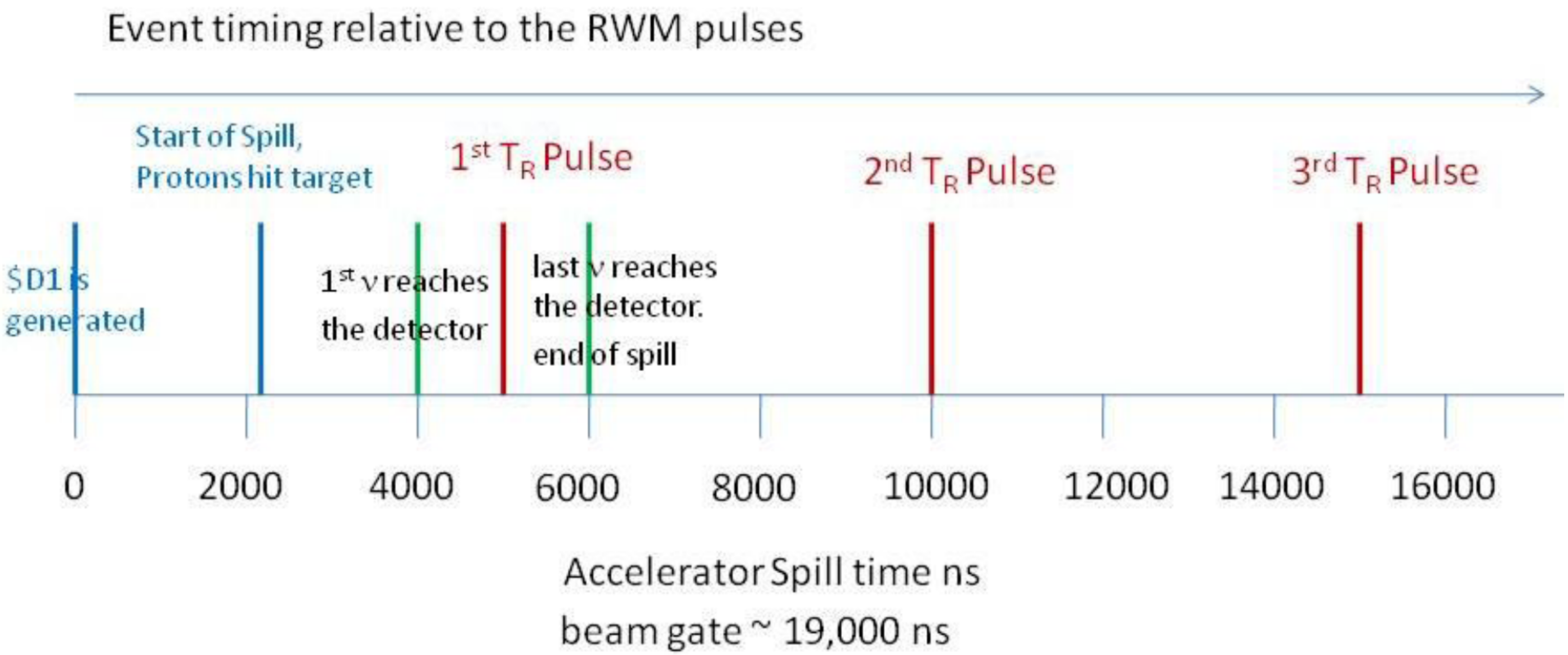
Broken Chain From Plate #10

Chain working load 17T (25T blocks), tested to x2, break point at x4 working load

Analysis of the Resistive Wall Monitor Data

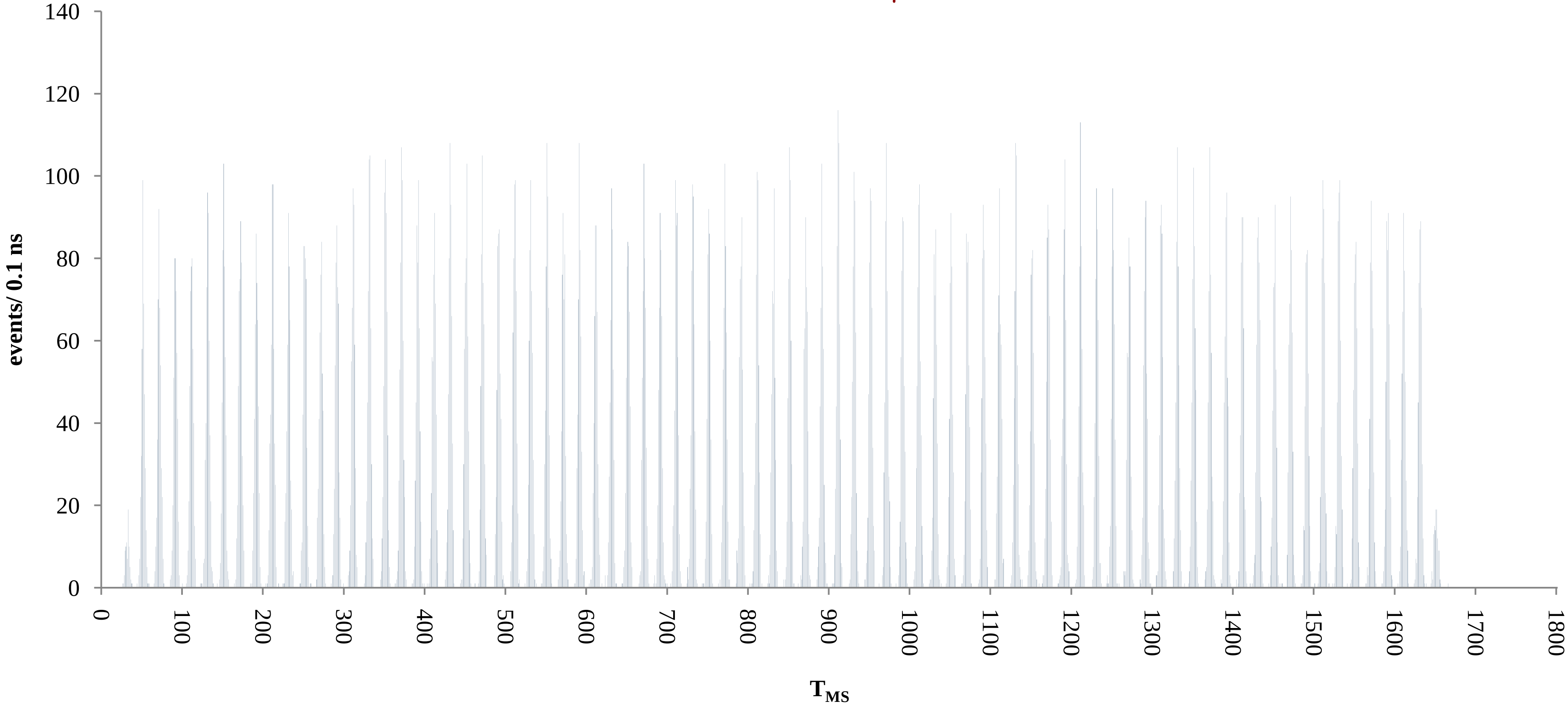
In the figure, The red pulses symbolically represent the three RWM pulses received by the DAQ. The 1st is the actual pulse generated by the RWM and sent to the detector. The arrival time of this pulse relative to the accelerator clock is recorded, and a portion is sent back to MI12 – the refection travels back the detector building and is recorded as the 2nd pulse. A portion of this pulse is also sent back to MI12, and its reflection is recorded as the 3rd pulse.

The cable length between the detector building and MI 12 is about 2 ½ μs, so the 3 pulses are seperated by about 5 μs.



The RF structure as seem from the RWM data.
This graph is composed of CCQE ν_μ reconstructed event after standard cuts, and reconstruction.

This represents ~1/2 of the ν_μ data.



Summary:

The M'BooNE detector has been a reliable and user friendly bit of equipment.

But we've learned to stay away from rusty chains!!