Ground motion studies at Fermilab

James T Volk

Fermilab

Types of ground motion

- There is fast ground motion > 1 hertz
  - Vibration due to pumps, LCW cryogens
  - Traffic near and far
  - Earth quakes
  - Monitored with seismometer, geophones ect
- There is slow ground motion < 1 hertz
  - Tidal motion Period of 12 hours
  - Sump pumps non periodic lasts several hours
  - Slow sinking of floor
  - Movement due to ramping of magnets
  - Monitored using water levels

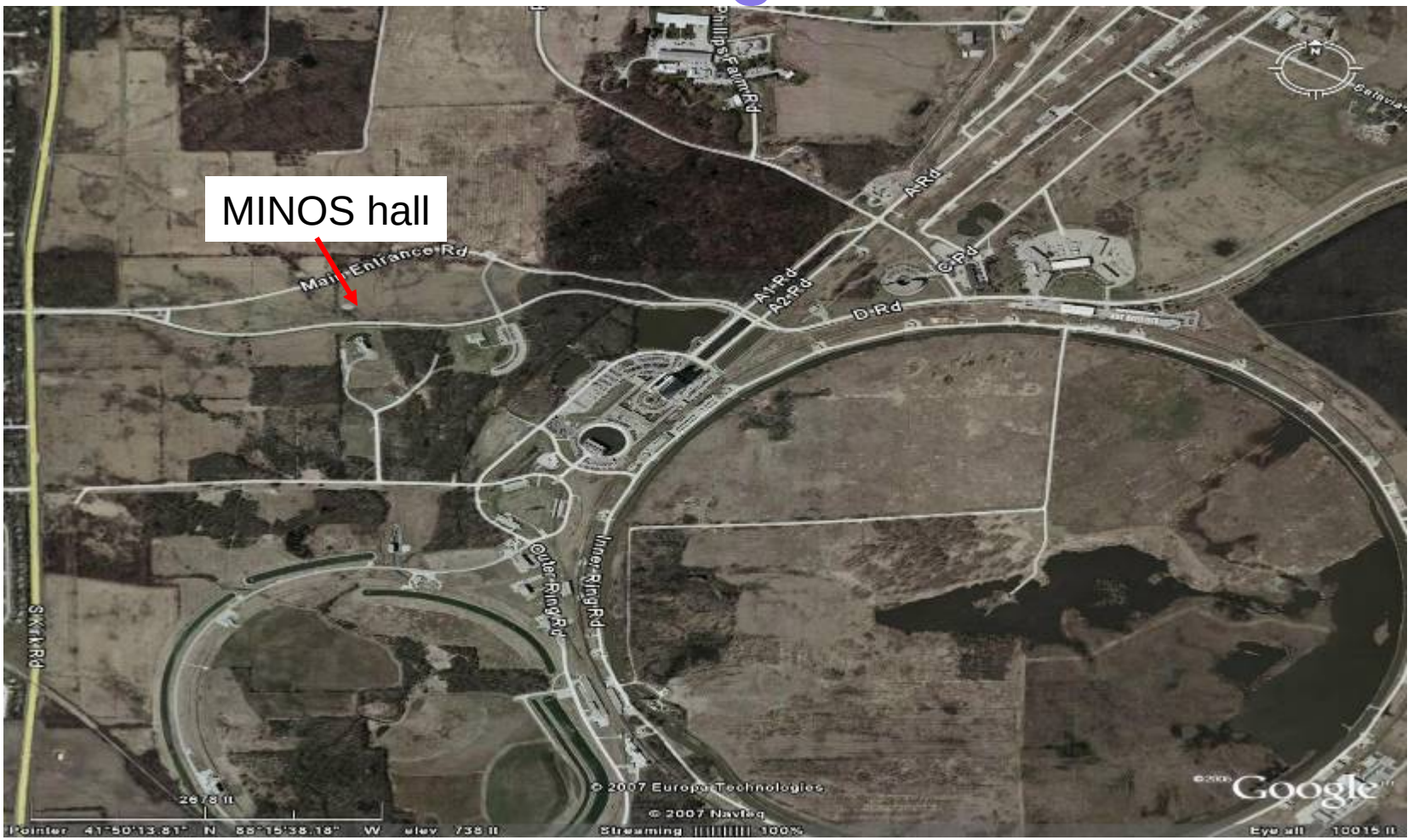
Goals of Fermilab studies

- Identify types of ground motion both fast and slow
- Identify sources of these motions
- Identify amplitudes of these motion
- Identify effects on ILC components
- Determine ways to eliminate or reduce these motions

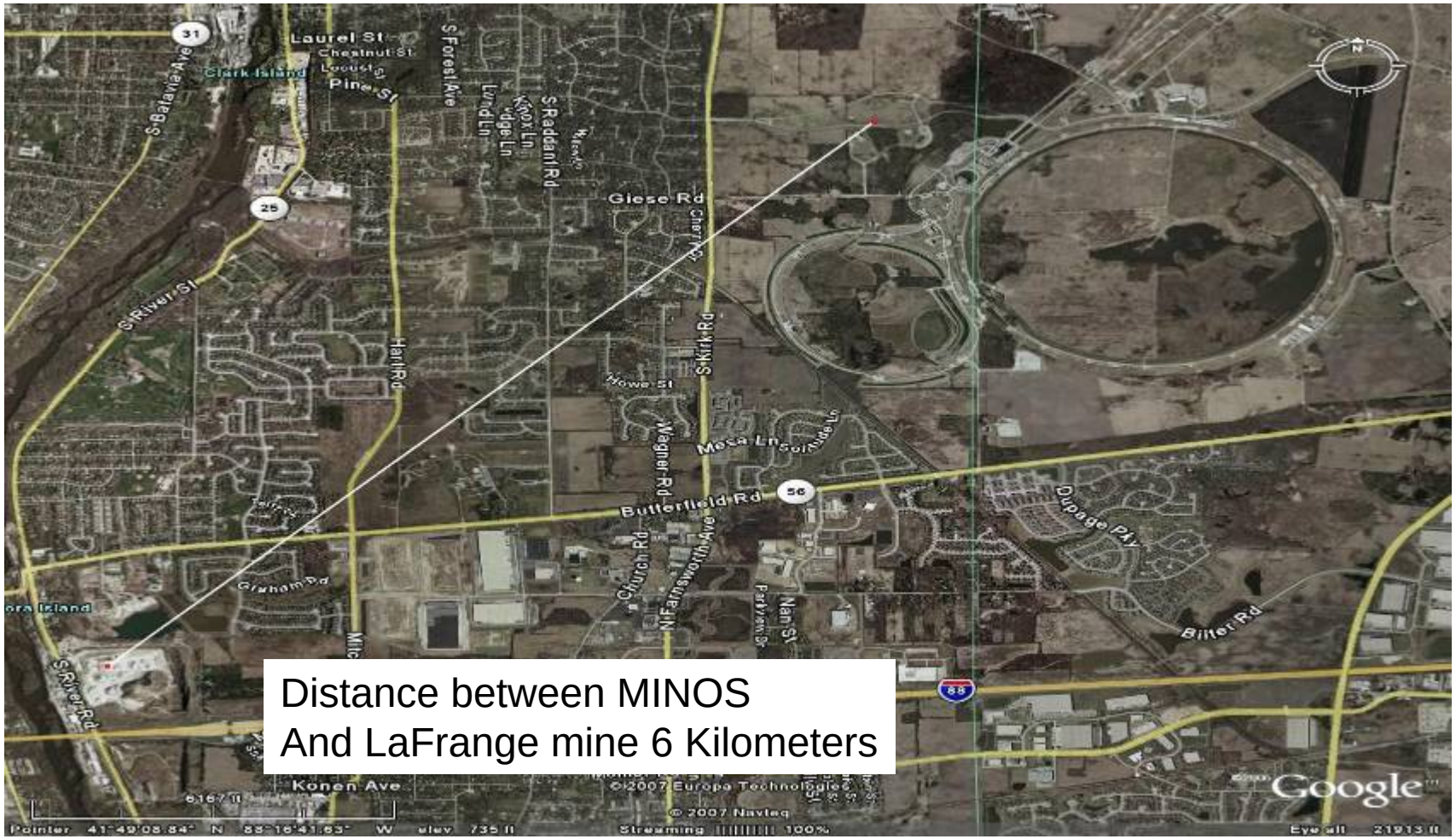
HLS systems in use at Fermilab

- There are two systems in use
- 4 Budker sensors in the MINOS hall 100 meters below grade running since December 1 2005
- 6 Budker sensors in use in the LaFrange mine (formerly Conco Western) in North Aurora Running since September 1 2006

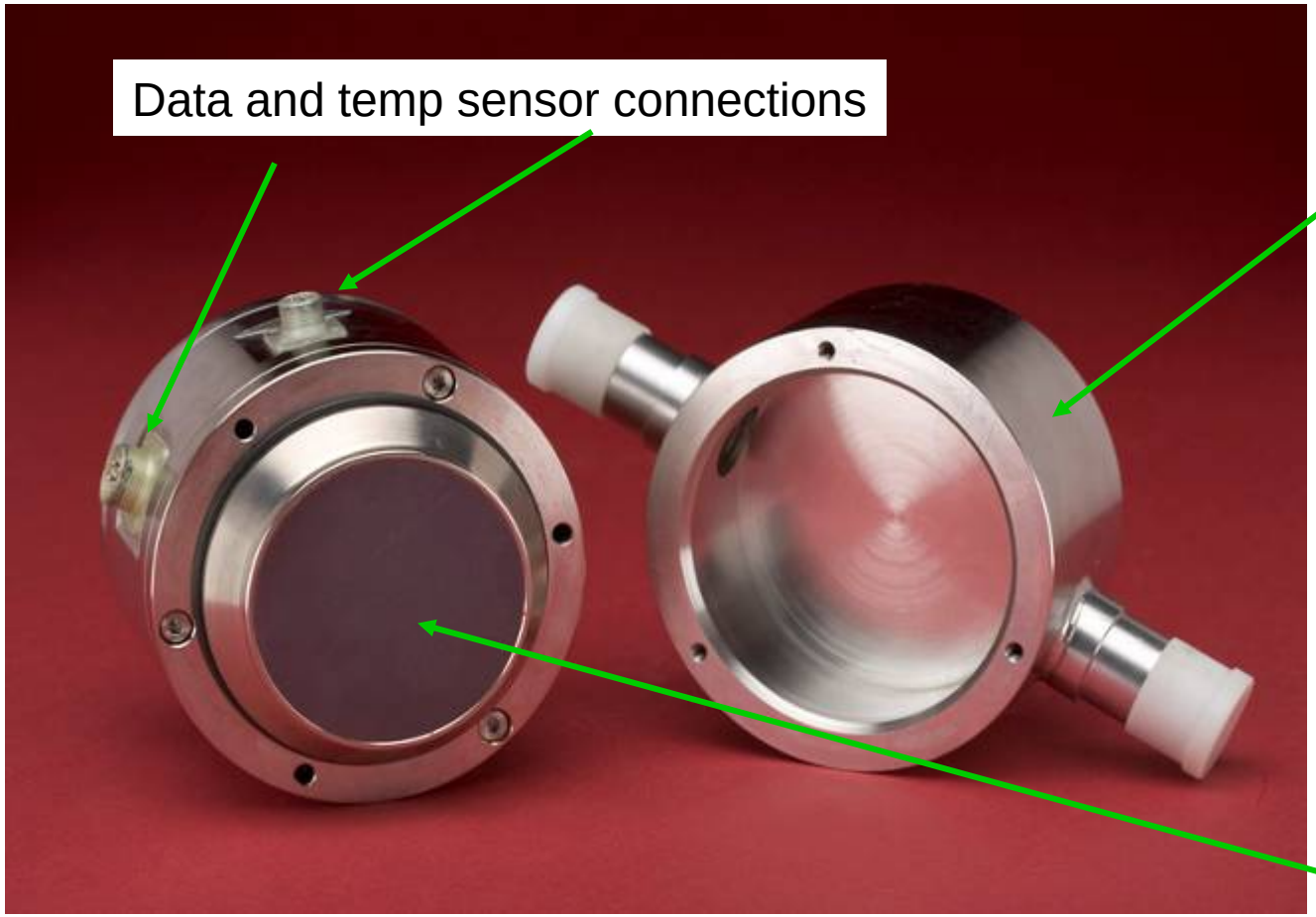
Location of MINOS hall 100 meters below grade



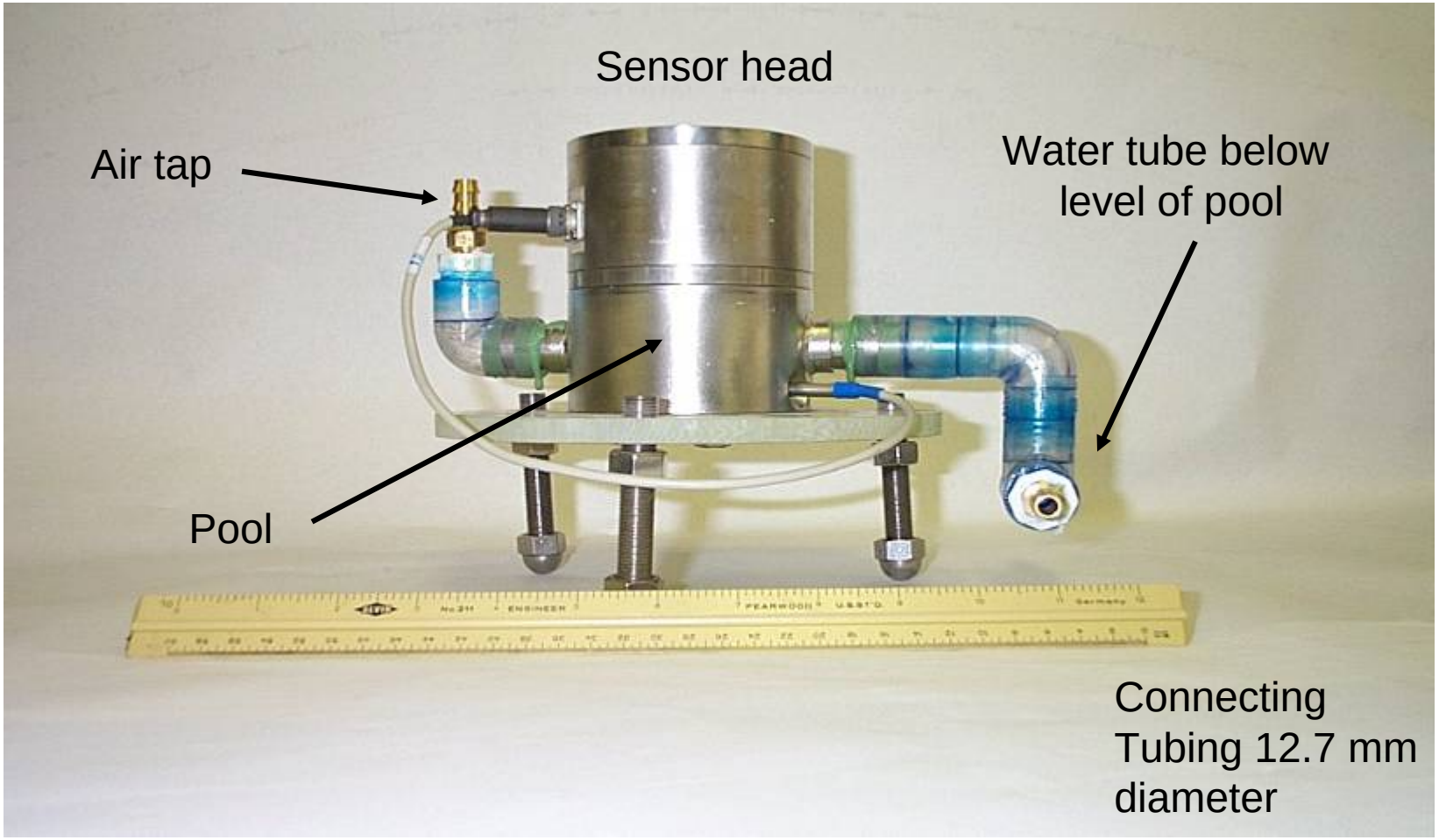
LaFrage Mine North Aurora Illinois



Budker sensors

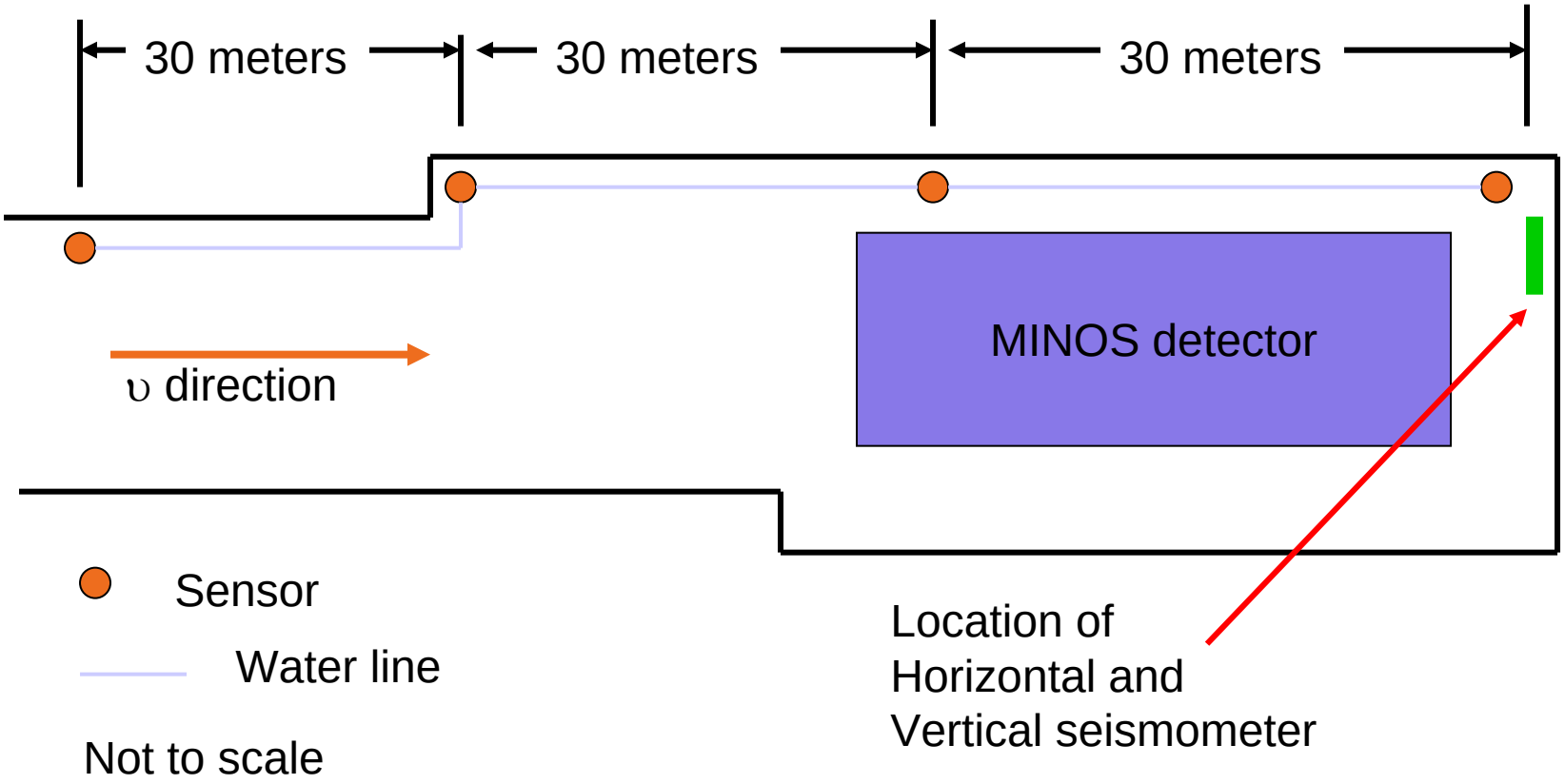


MINOS water level sensor



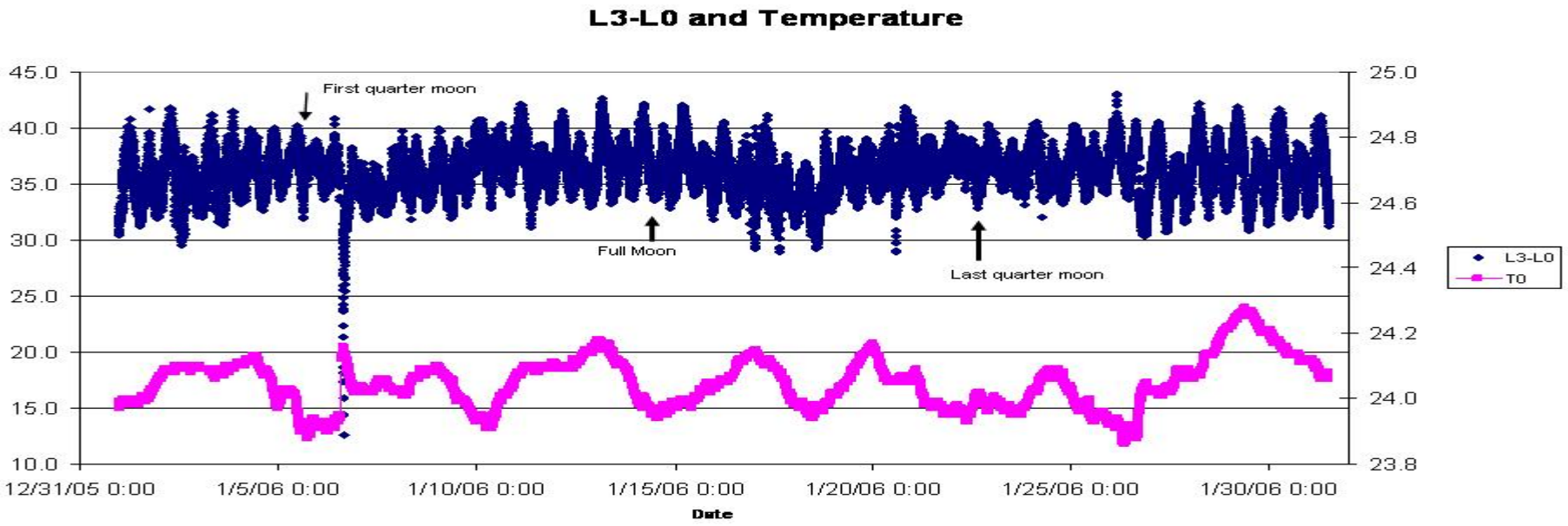
Layout of MINOS water level

Depth of floor 100 meters below grade
406 feet above sea level Maquoketa shale

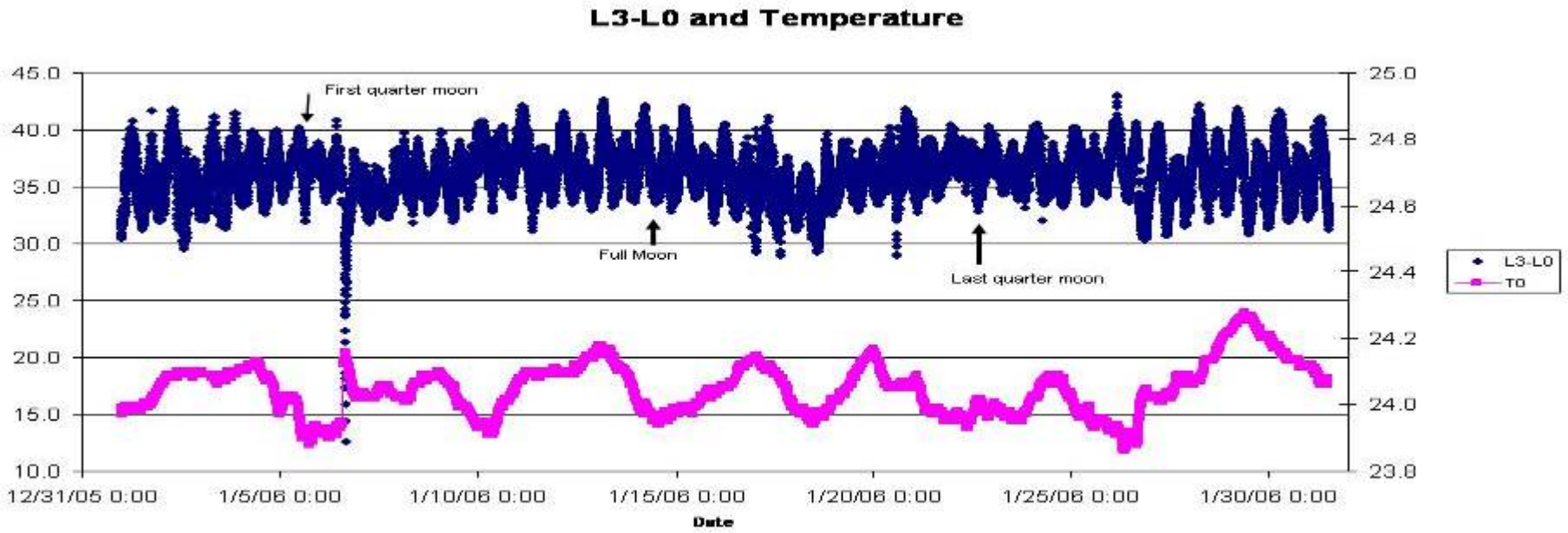


MINOS Detector

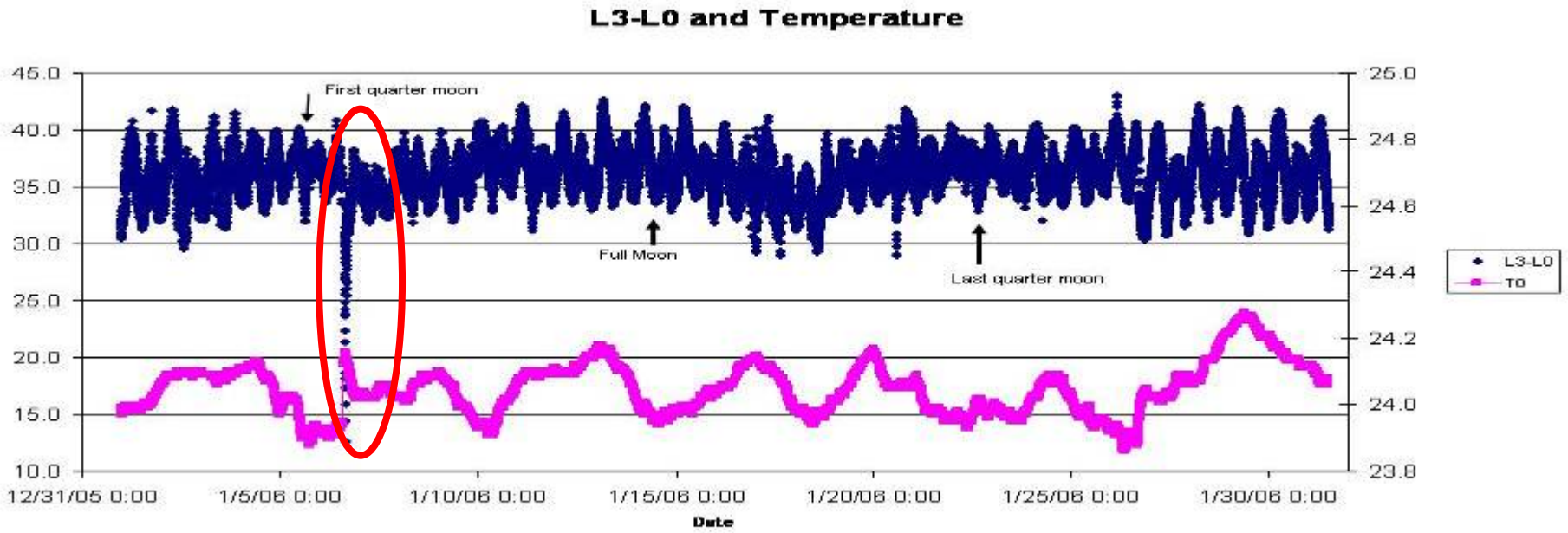
Difference in two sensors 90 meters apart MINOS hall



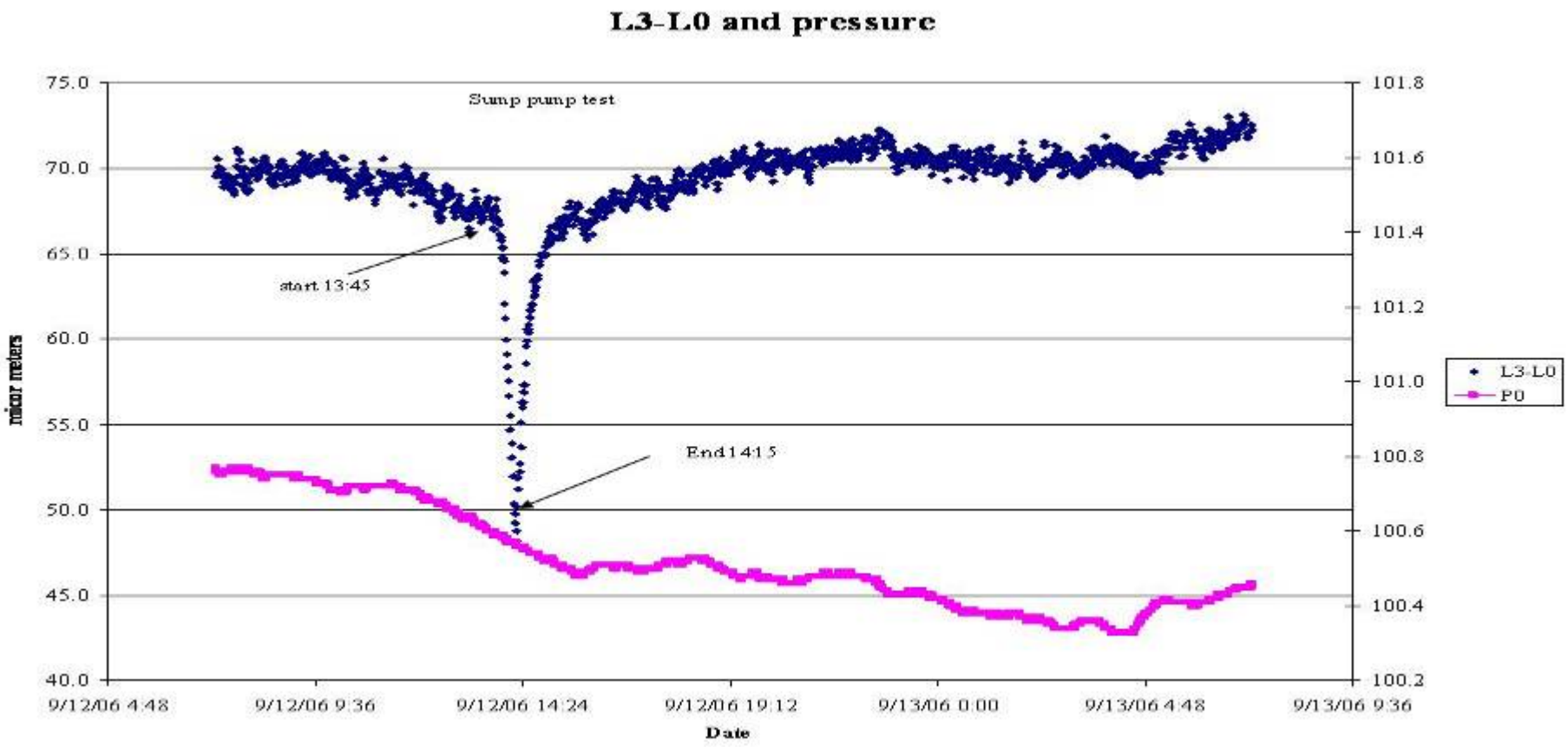
Two sensors 30 m apart MINOS hall



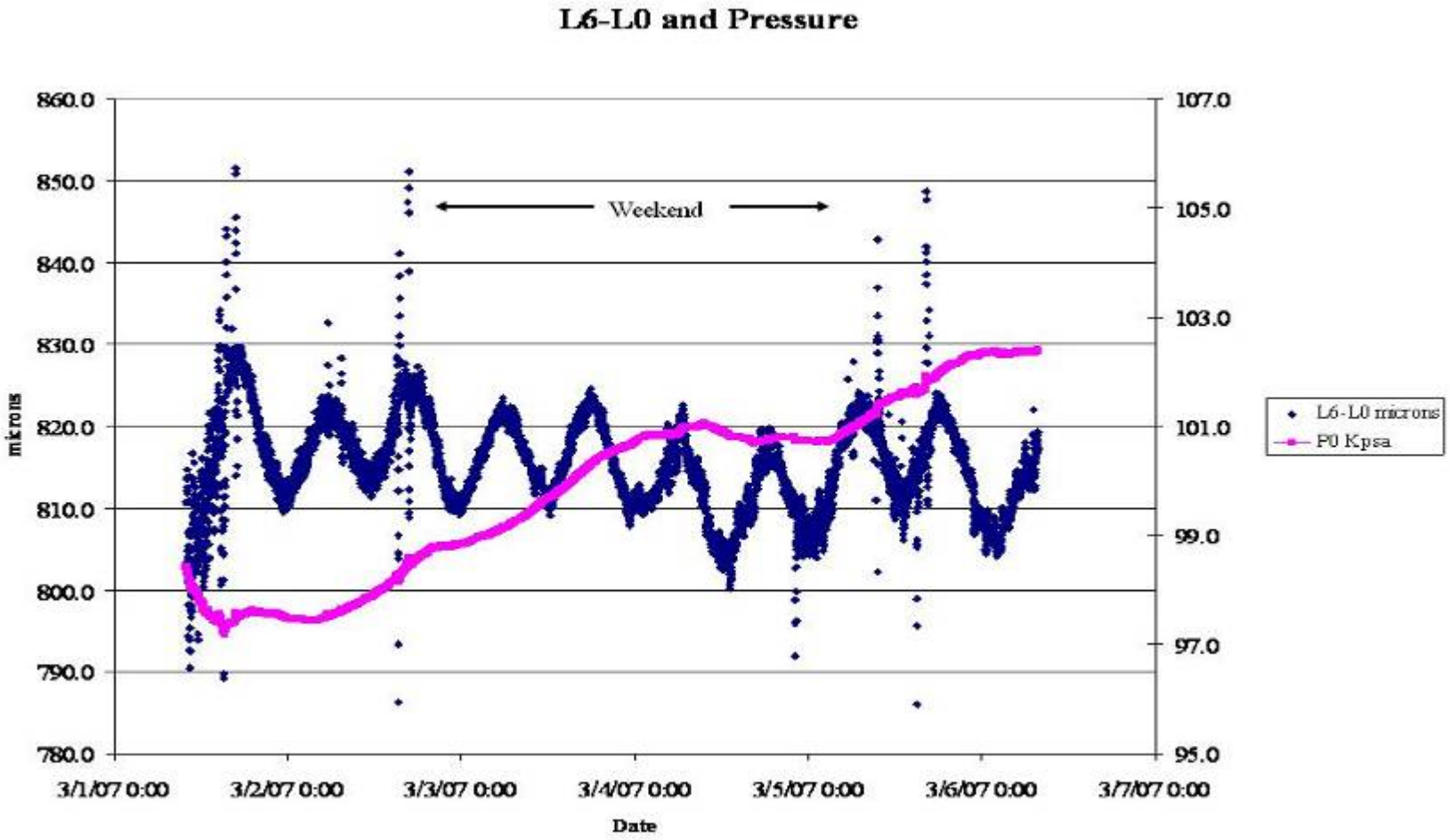
Two sensors 30 m apart MINOS hall



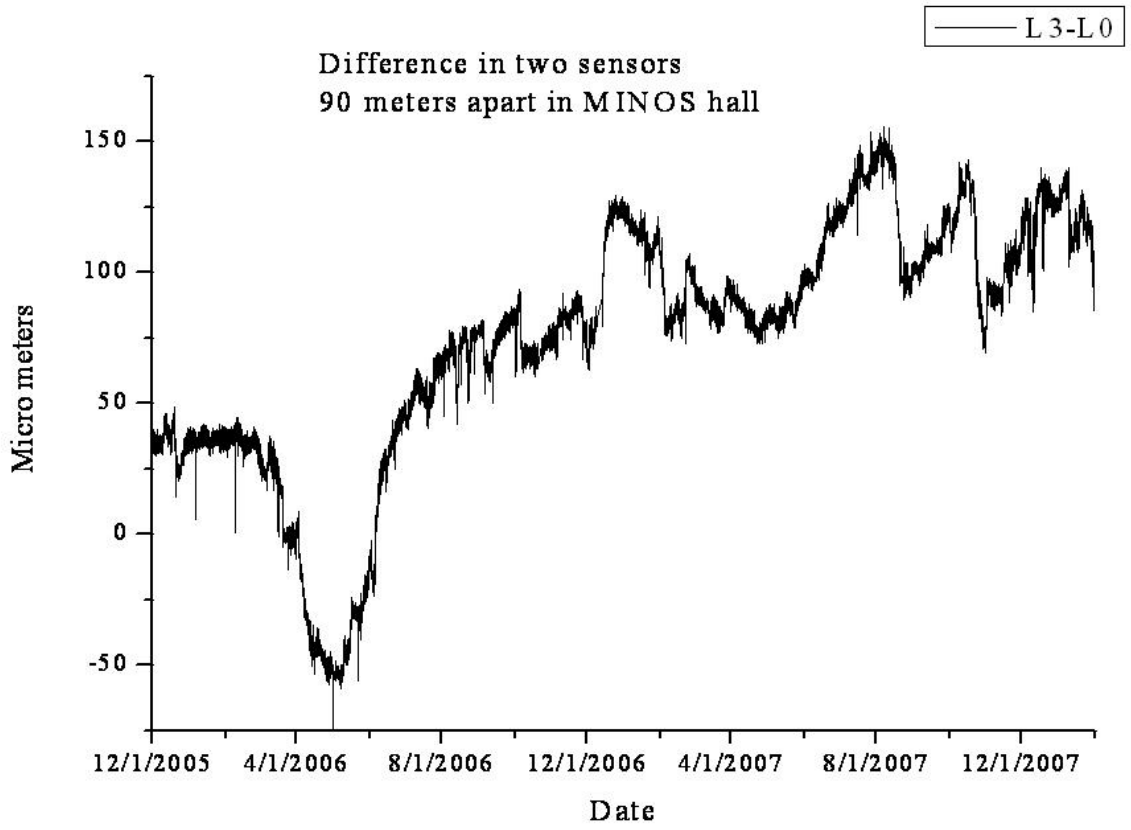
September 06 sump pump test



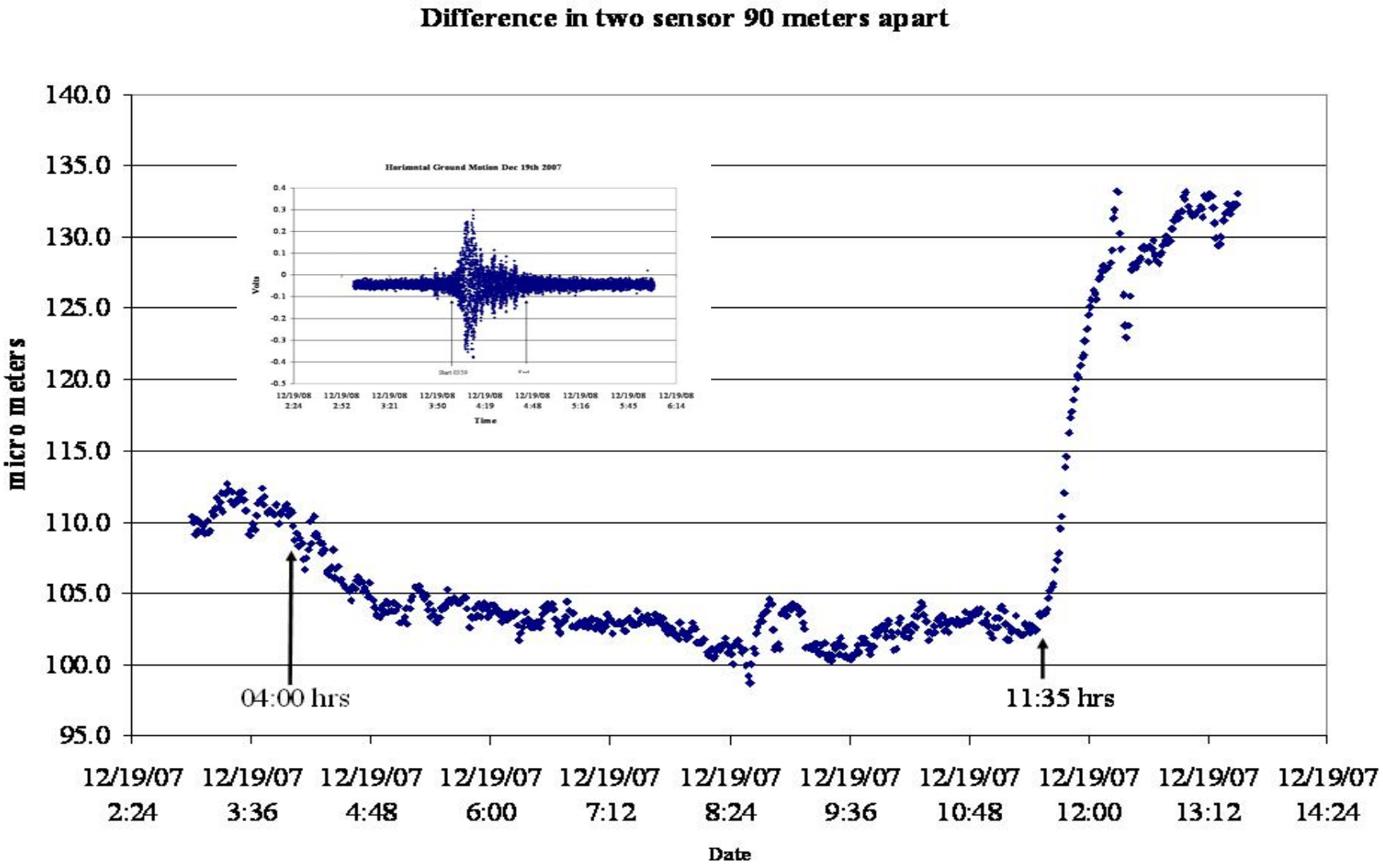
Difference in two sensors 150 meters apart in Aurora mine



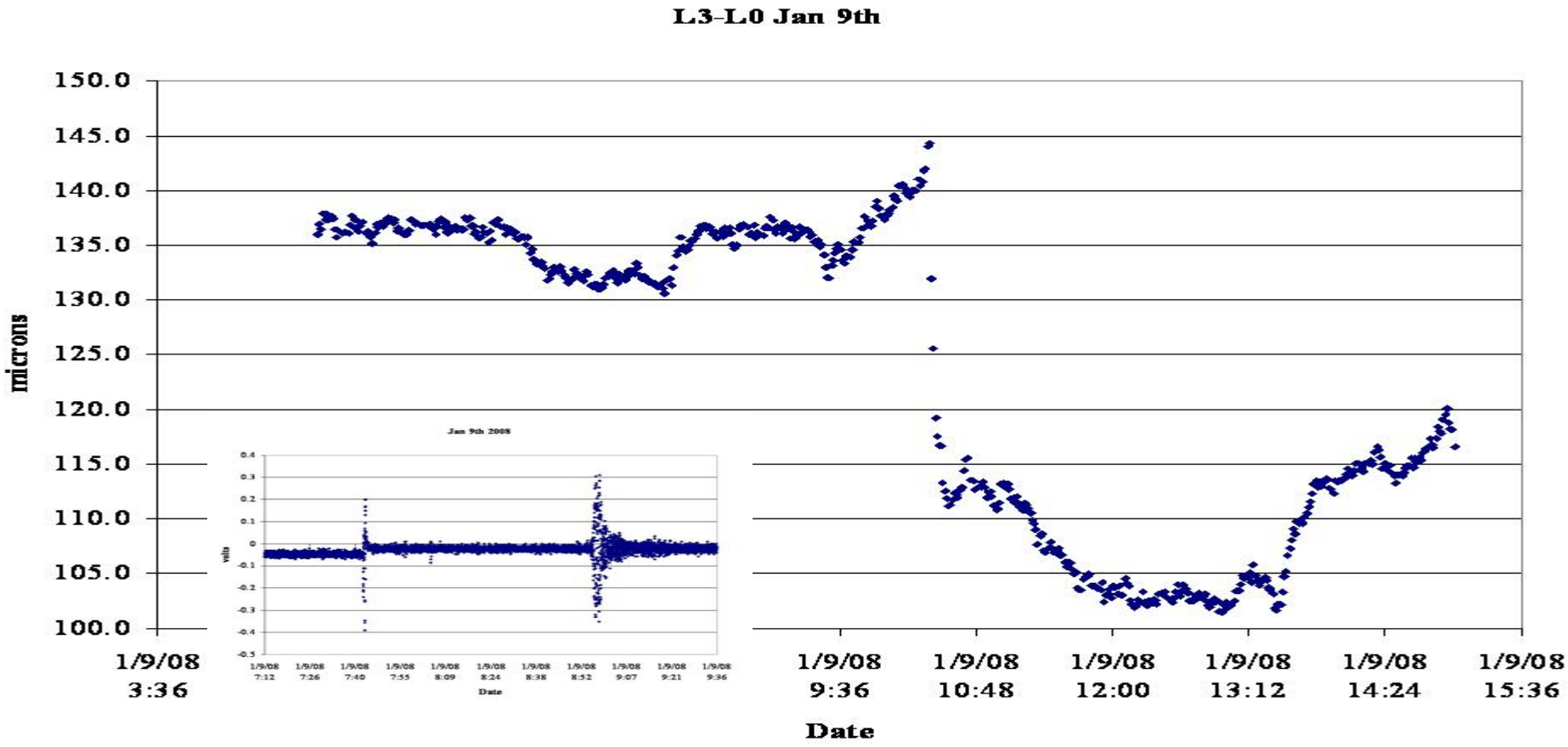
MINOS Hall tilt for 2 years



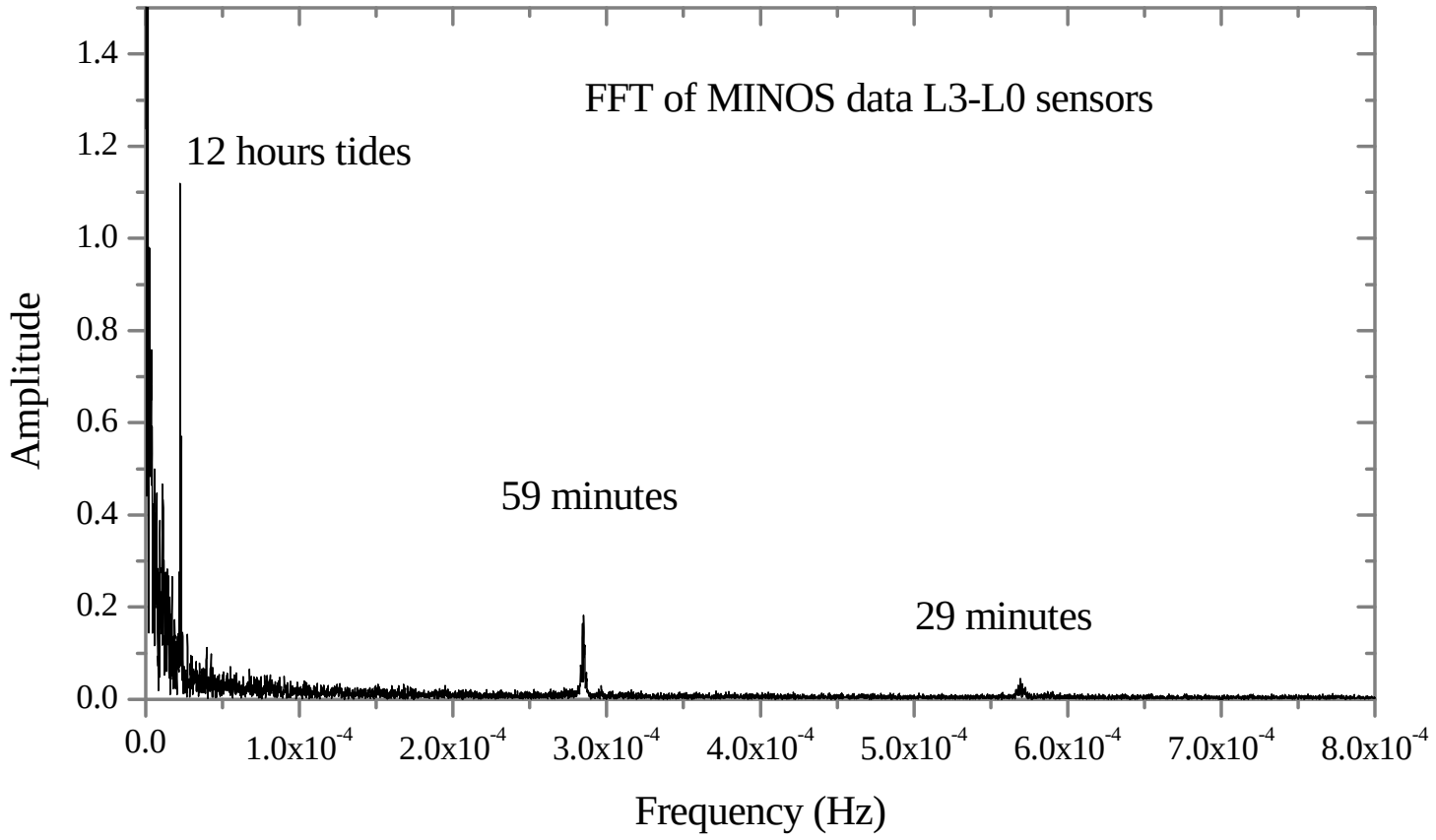
Dec 19th 2007 Ground Motion and Subsidence



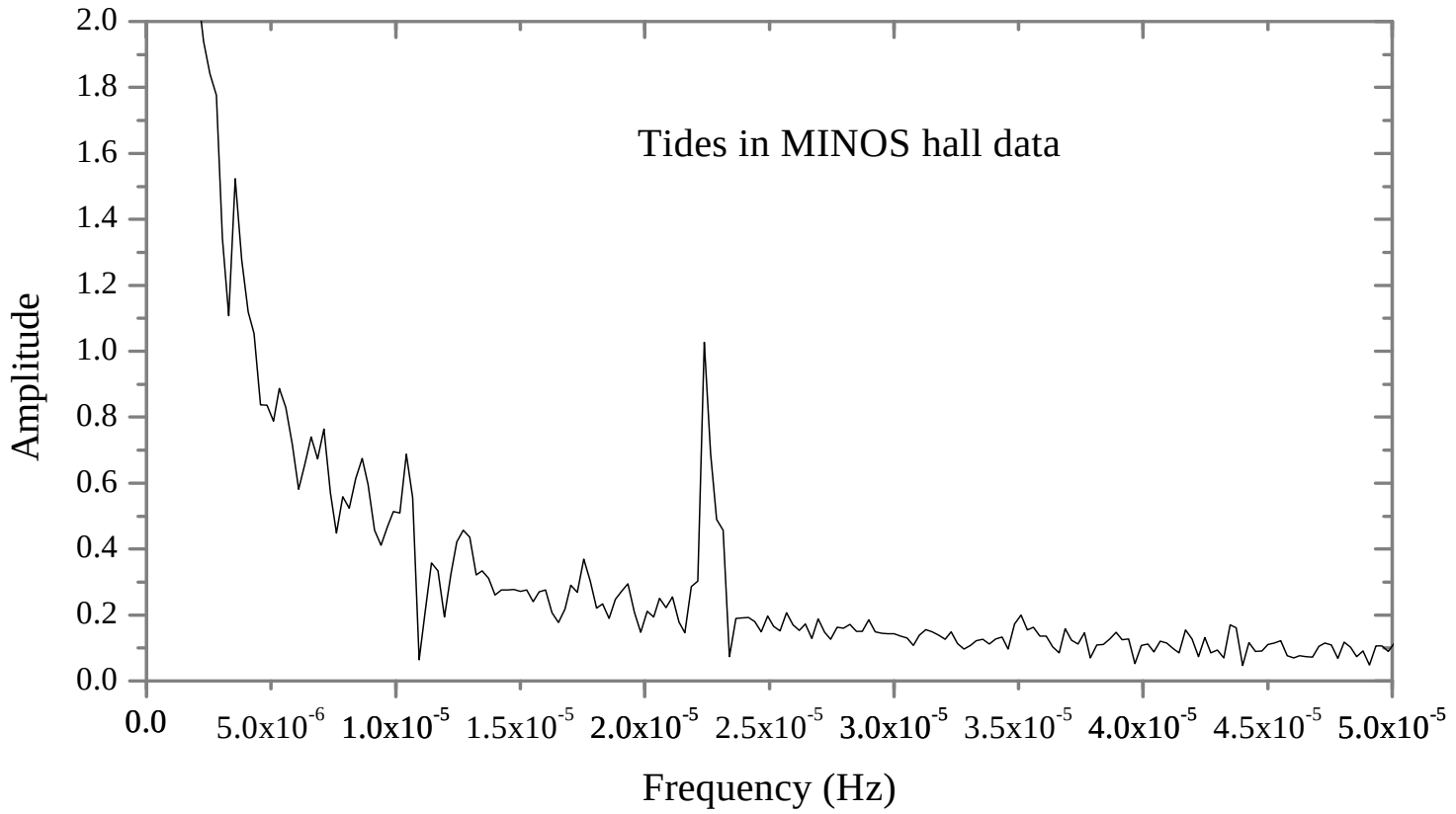
Jan 9th 2008 Subsidence



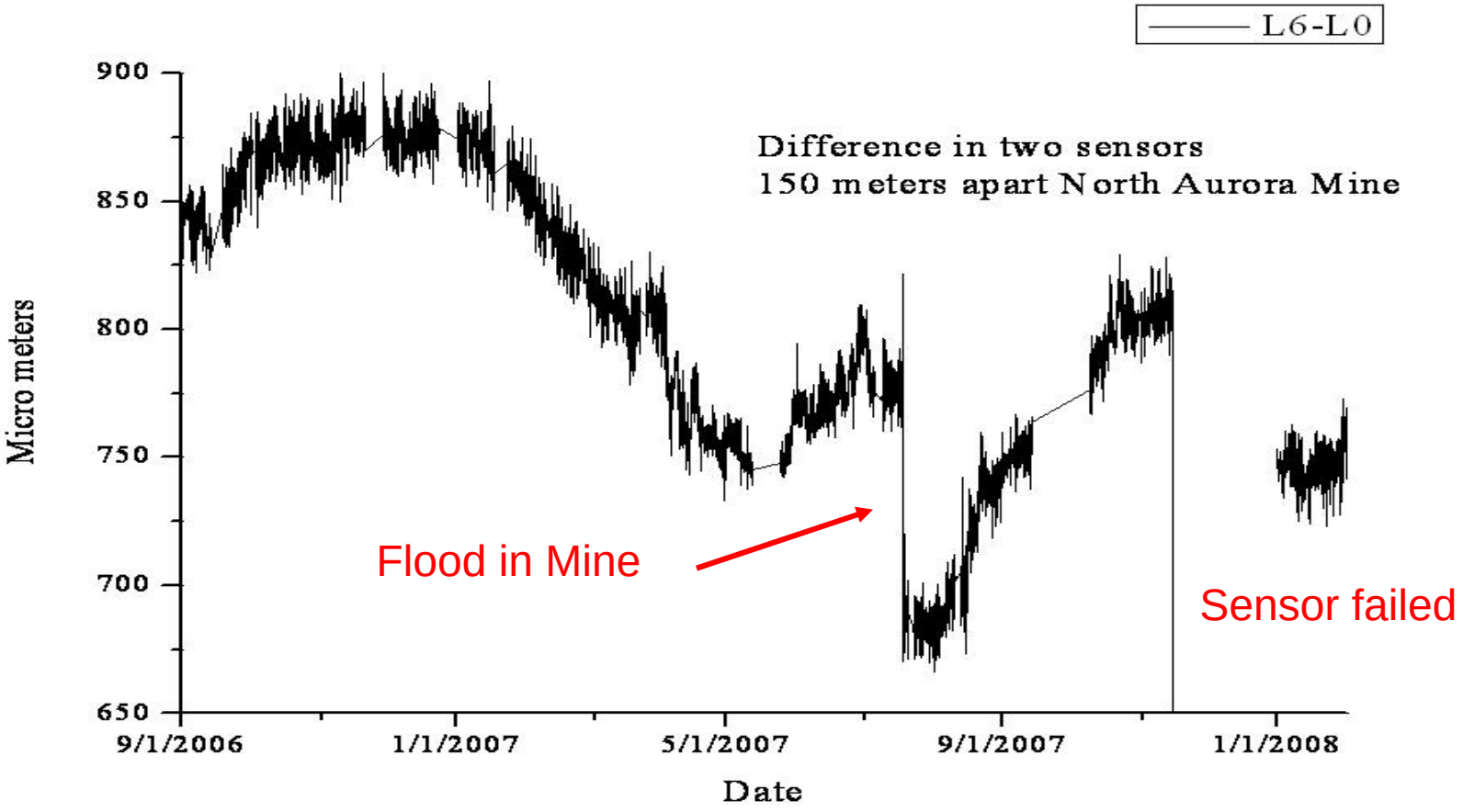
FFT of MINOS data difference between two sensors



Blow up of FFT showing tide peak



Lafarge Mine data two sensors 150 meters apart



Data from MINOS and Larange mine

- Data from MINOS has been collected at a rate of once per minute since December 2005 some occasional lost data
- Data from LaFrange mine has been collected since September 1 2006
- Data are available at http://dbweb1.fnal.gov:8100/ilc/ILCGroundApp.py/index

Example data from MINOS

Time stamp - 4 levels in micro meters – 4 temperatures in C - pressure

Measurement_Date	L0	L1	L2	L3	T0	T1	T2	T3	P0
1/1/2006 0:02	8521.3	8563.8	8502.7	8554.3	24	22.2	22.3	20.4	100.4
1/1/2006 0:03	8521.5	8563.3	8502.6	8554.3	24	22.2	22.3	20.4	100.4
1/1/2006 0:05	8521.9	8563.4	8502.3	8554.4	24	22.2	22.3	20.4	100.4
1/1/2006 0:06	8522.2	8563.2	8502.3	8554.2	24	22.2	22.3	20.4	100.4
1/1/2006 0:08	8522.2	8563.3	8502.6	8554	24	22.2	22.3	20.4	100.4
1/1/2006 0:09	8522.3	8563.3	8502.4	8553.8	24	22.2	22.3	20.4	100.4

The data are available as a comma separated file

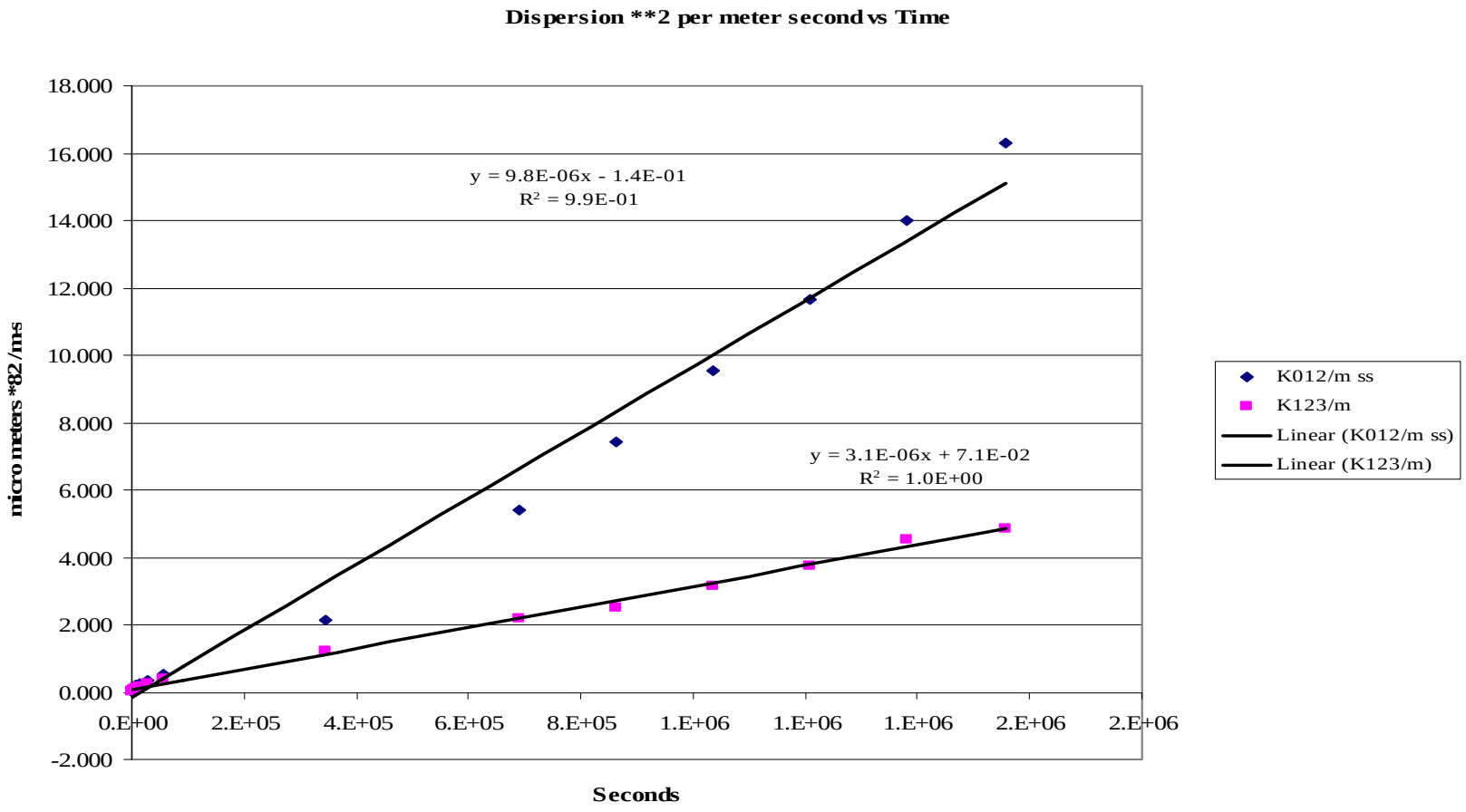
ATL Law

- Motion between two points can be described as <dis**2> = ATL
- Where A is a constant
- T is the time in seconds
- L is length between the points

Calculation of A

- Find the double differences between three sensors
- (D0-D1) – (D1-D2)
- Square the double difference
- Do this for different time slices from 1 minute separation to 14 days separation
- Find the mean of each time slice
- Plot versus time

ATL law extracted from MINOS data for November 2006



ATL law results

- Value for A is between $5\ 10^{-6}$ and $1.5\ 10^{-6}$ micro meters ^{2} per m-s
- Need to look at more data it may break down for time spans longer than a few months

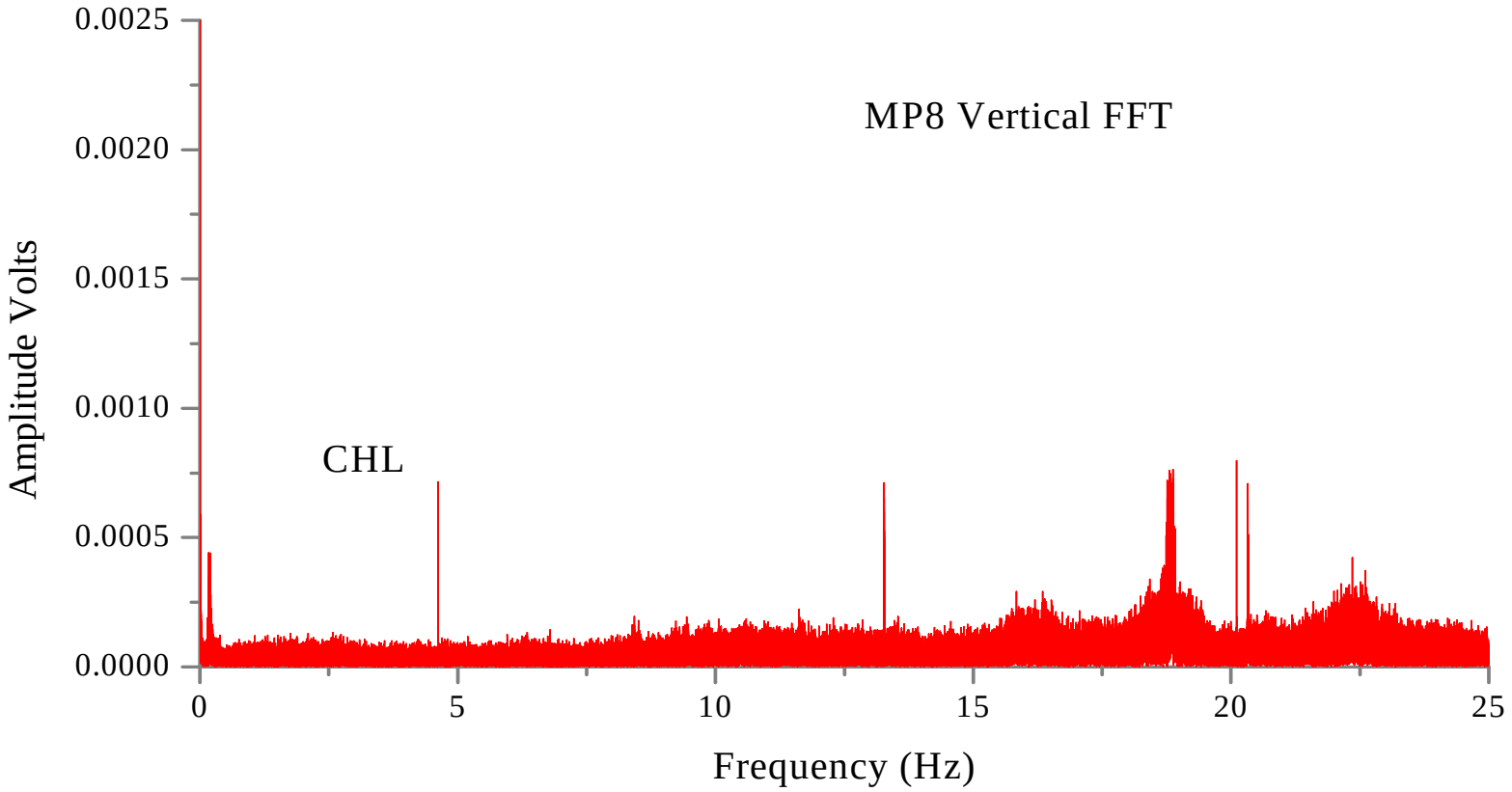
Future Work

- Continue slow motion studies of floor in Aurora Mine and MINOS hall
- Updata data base every month with new data
- Measure and identify sources of cultural fast cultural noise in Tevatron and MINOS hall
- Develop techniques to reduce eliminate vibration of accelerator components

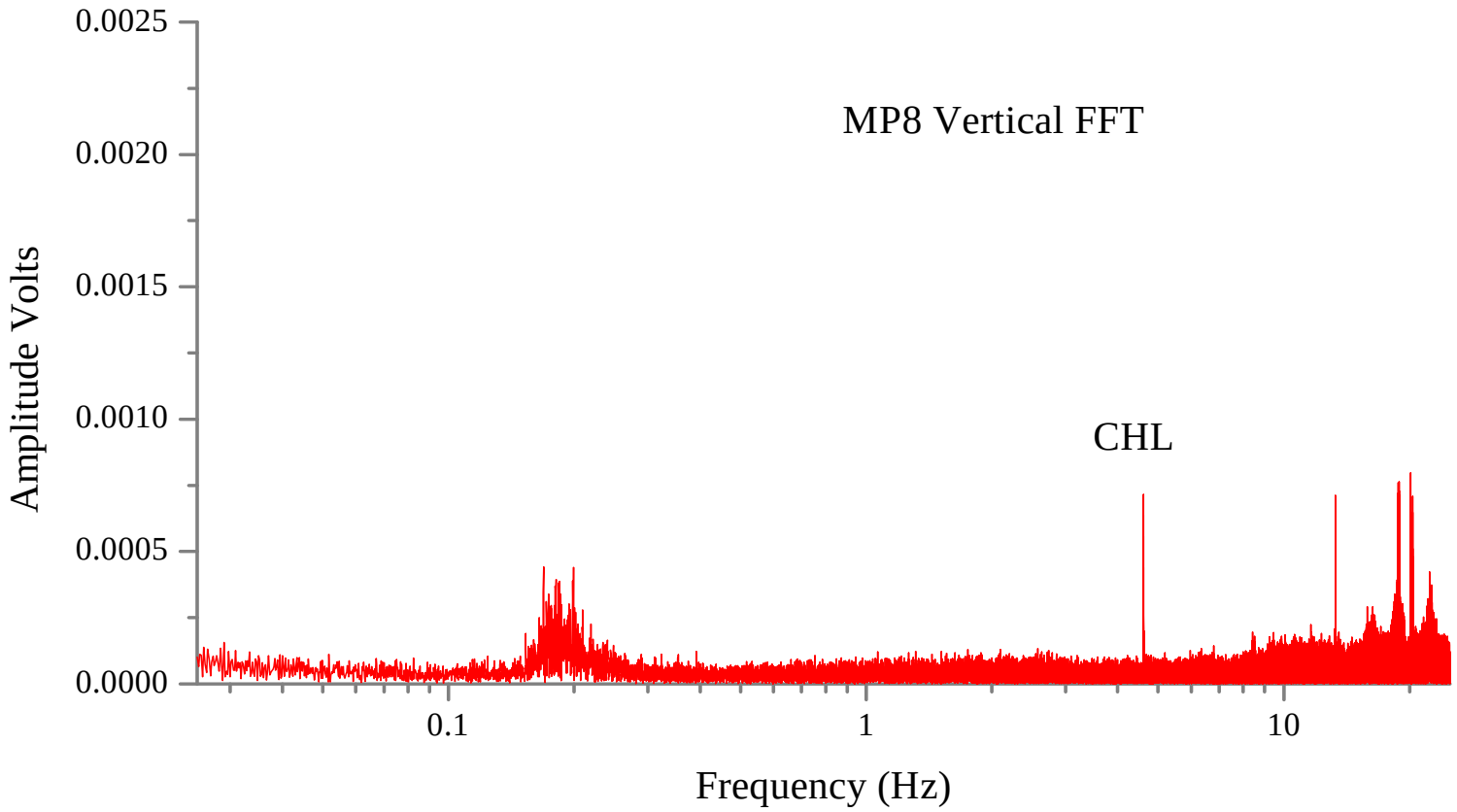
Seismic studies in and around Fermilab

- I have four Russian seismometers two measure vertical and two horizontal motions
- One vertical and One horizontal are installed in MINOS hall and data logged with ACNET system
- The others I move around site

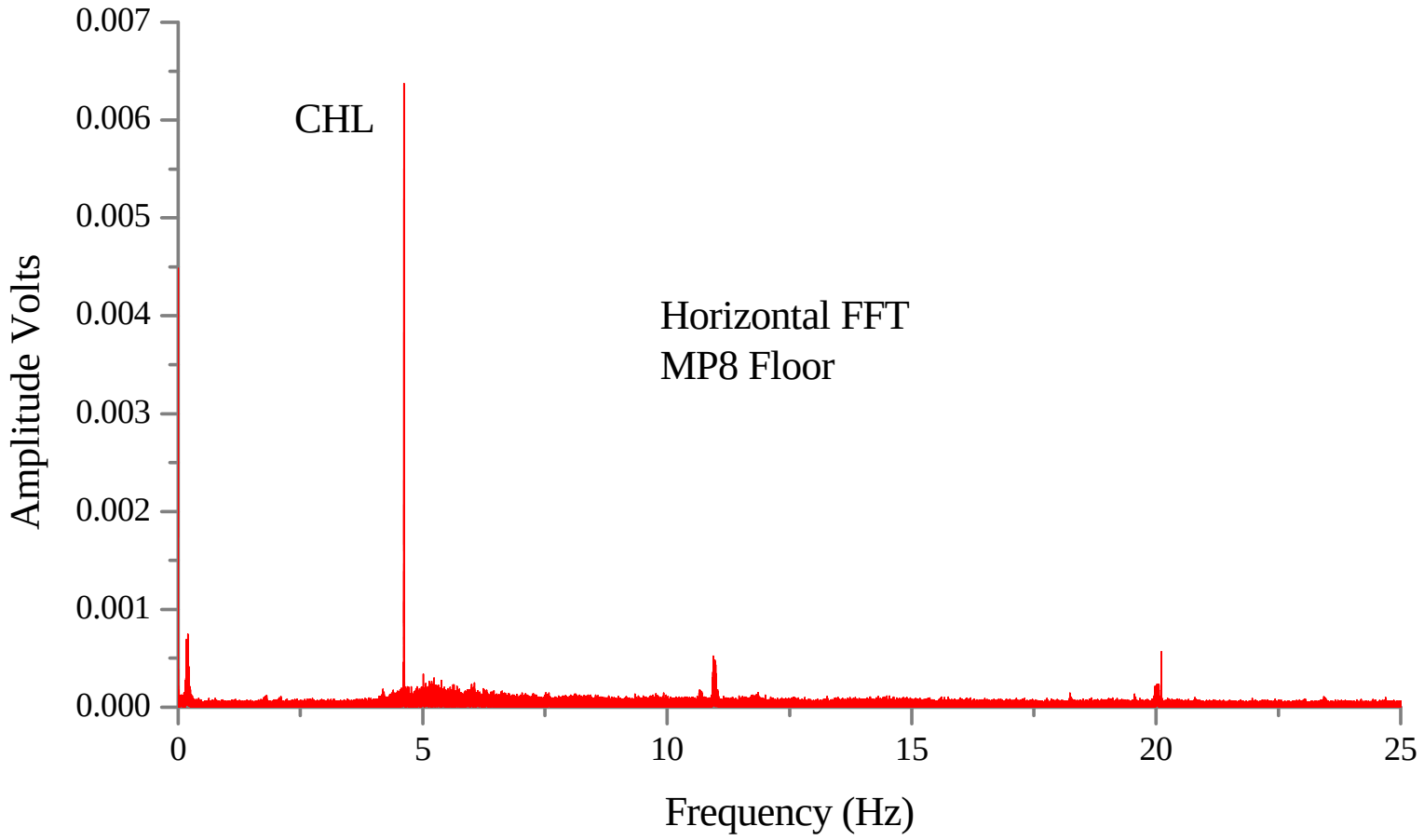
Vertical motion at grade Fermilab



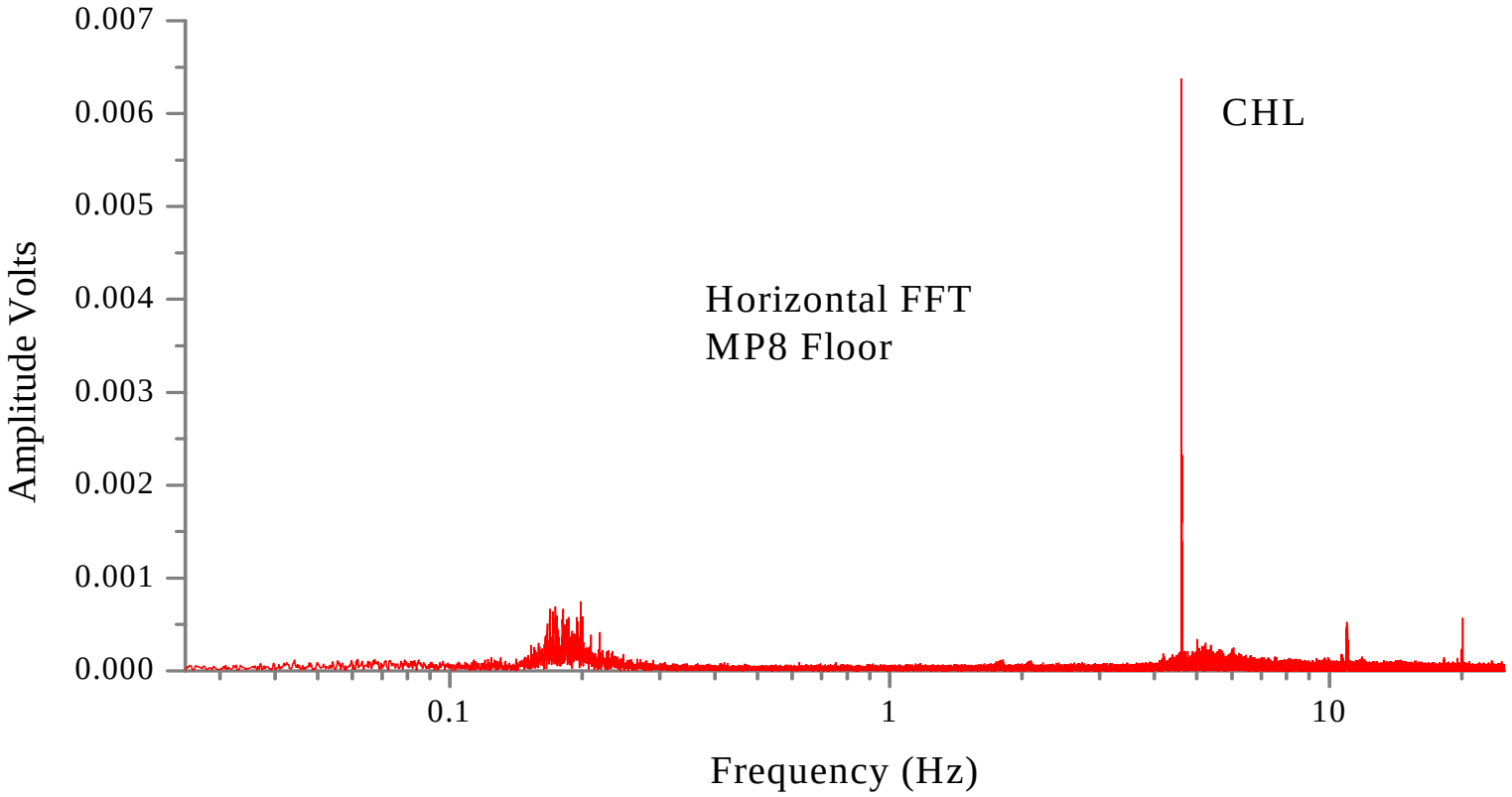
Vertical motion at grade Fermilab log scale



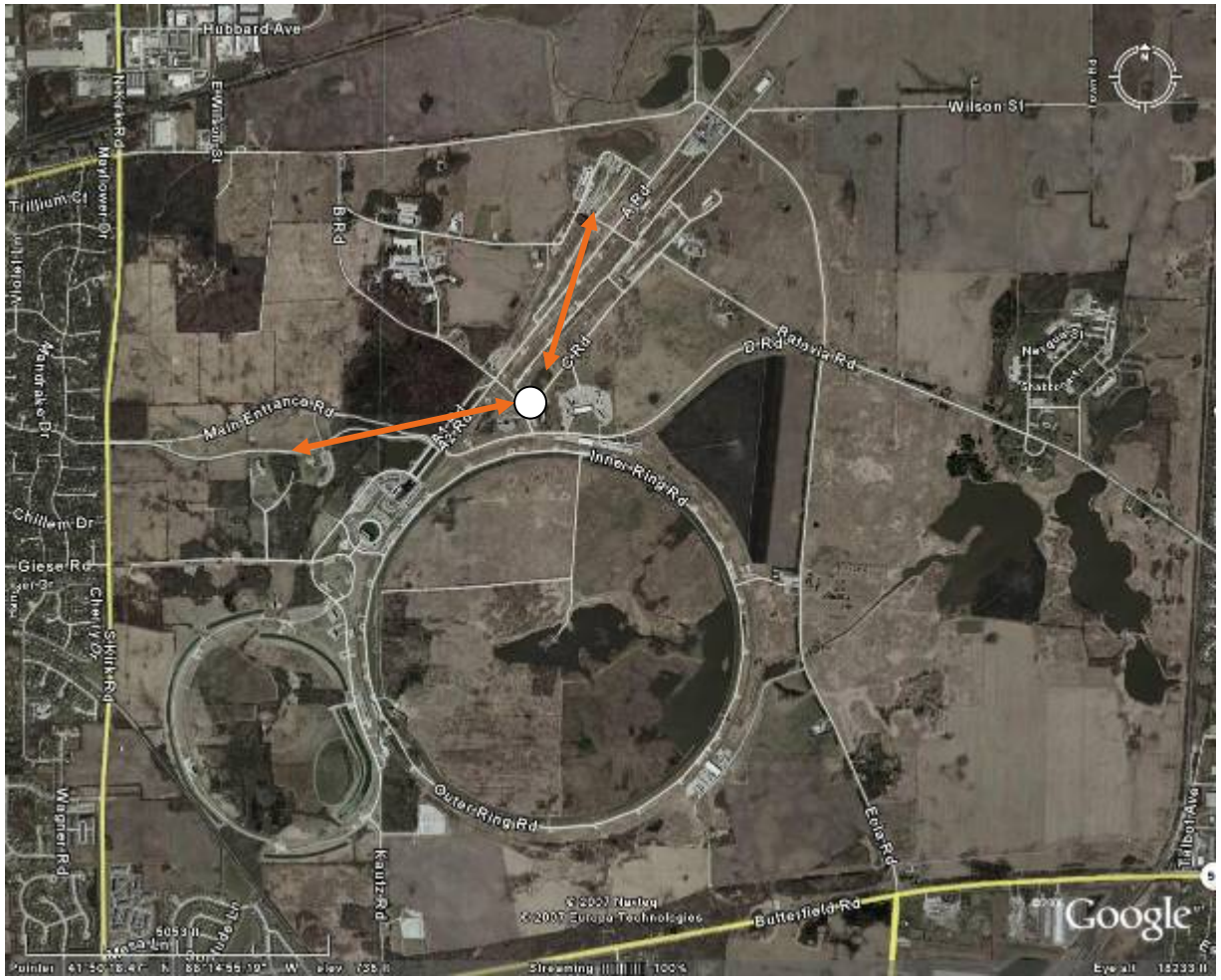
Horizontal motion at grade Fermilab



Horizontal motion at grade
Fermilab log scale



Location of MINOS, MP8 and CHL



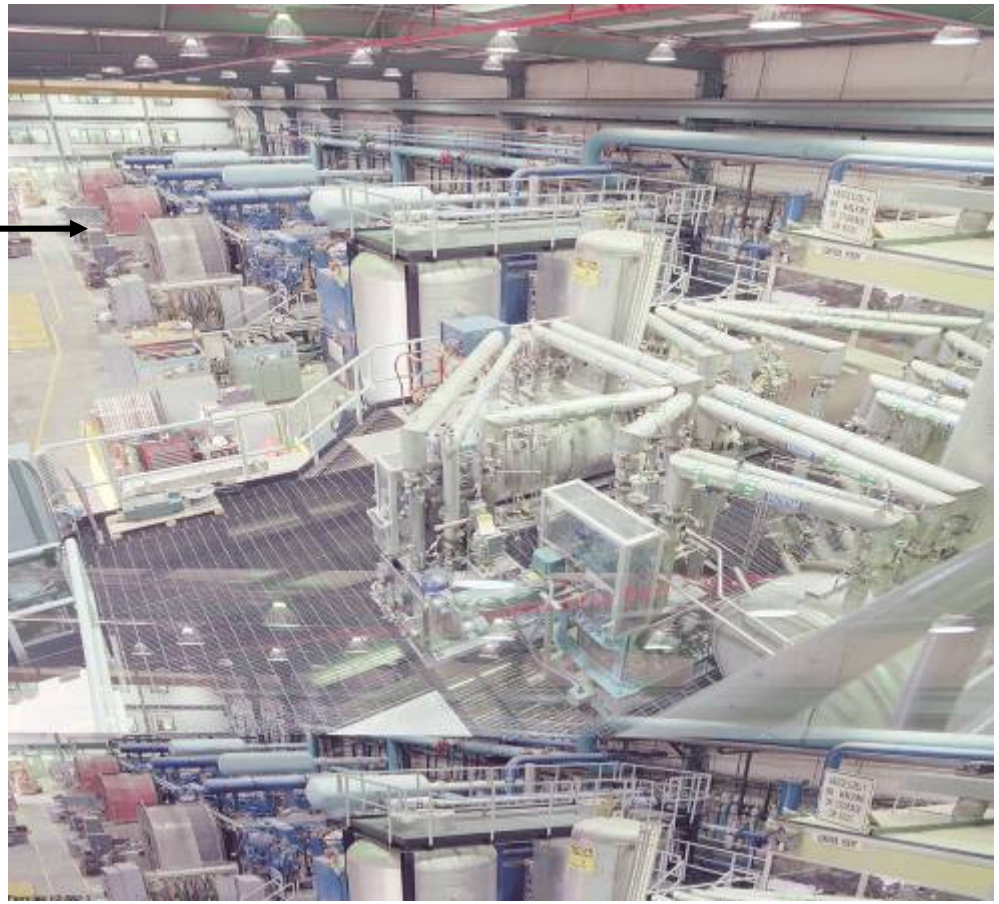
The White dot is
Central He Liquefier
There are 3 large
Screw compressor
At CHL for liquid He

CHL to MP 8 tunnel
1.2 km This is tunnel
On grade

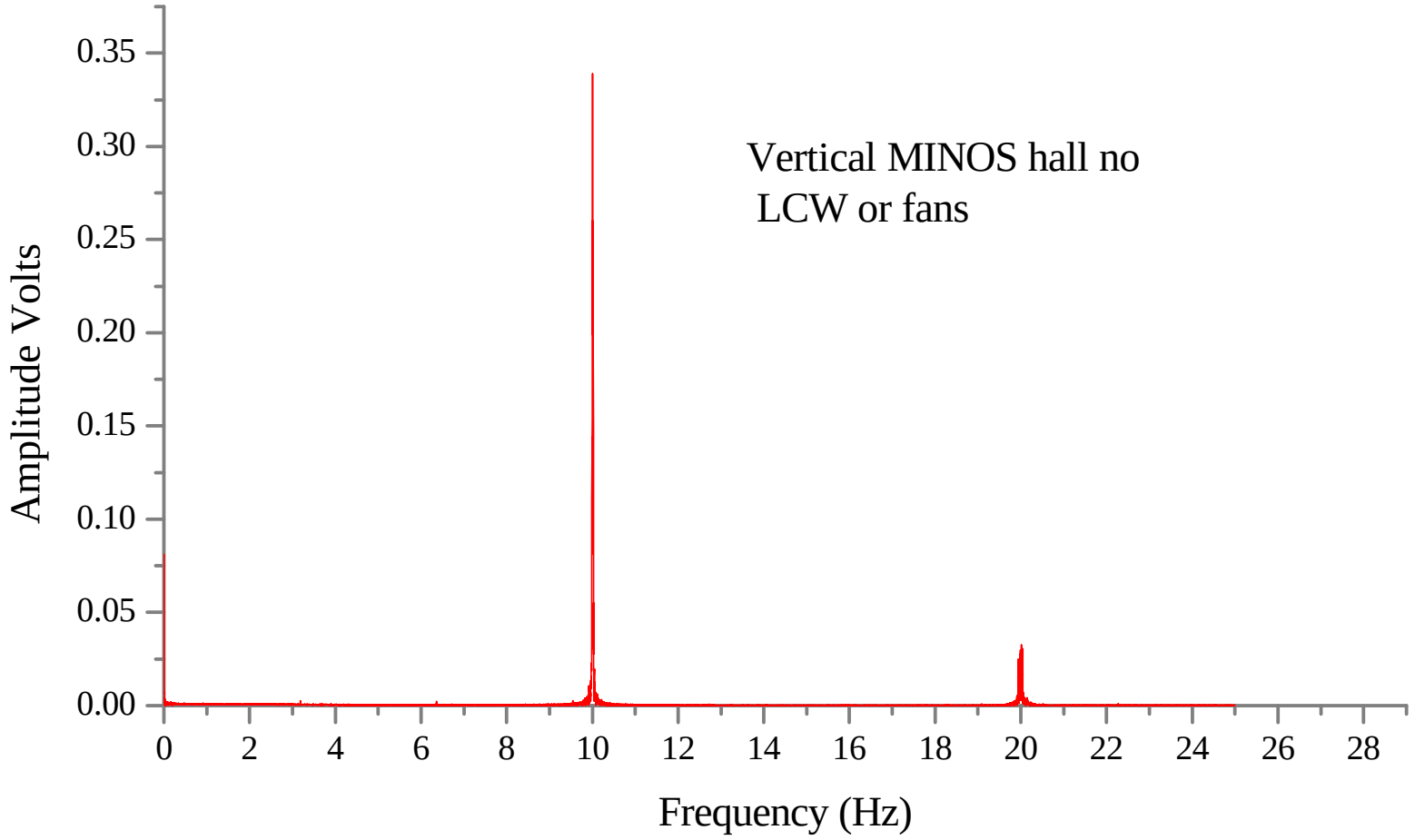
MINOS to CHL
1.4 km This is tunnel
100 meters below
grade

Inside of CHL

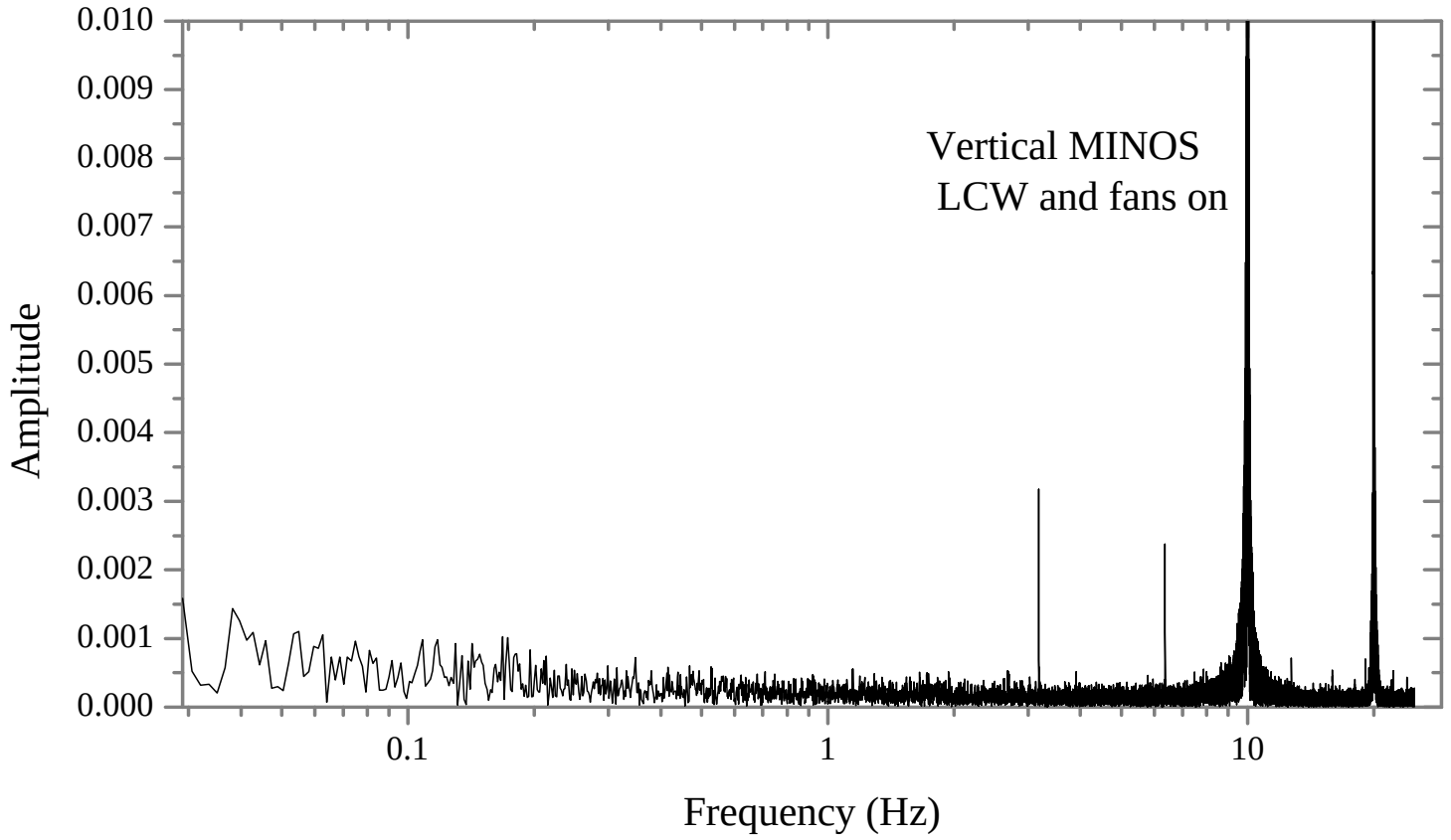
Three screw compressors



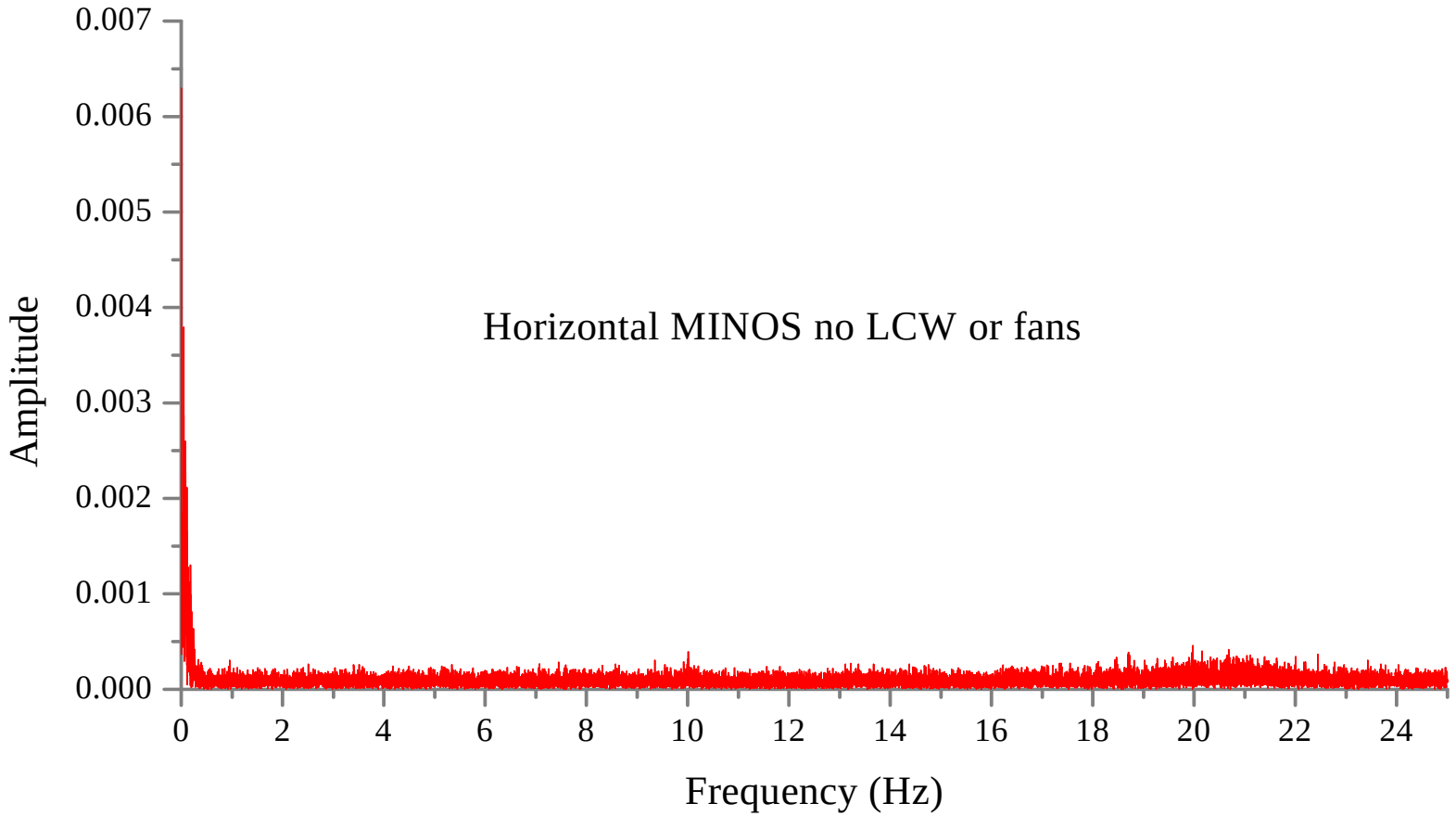
Vertical motion MINOS hall



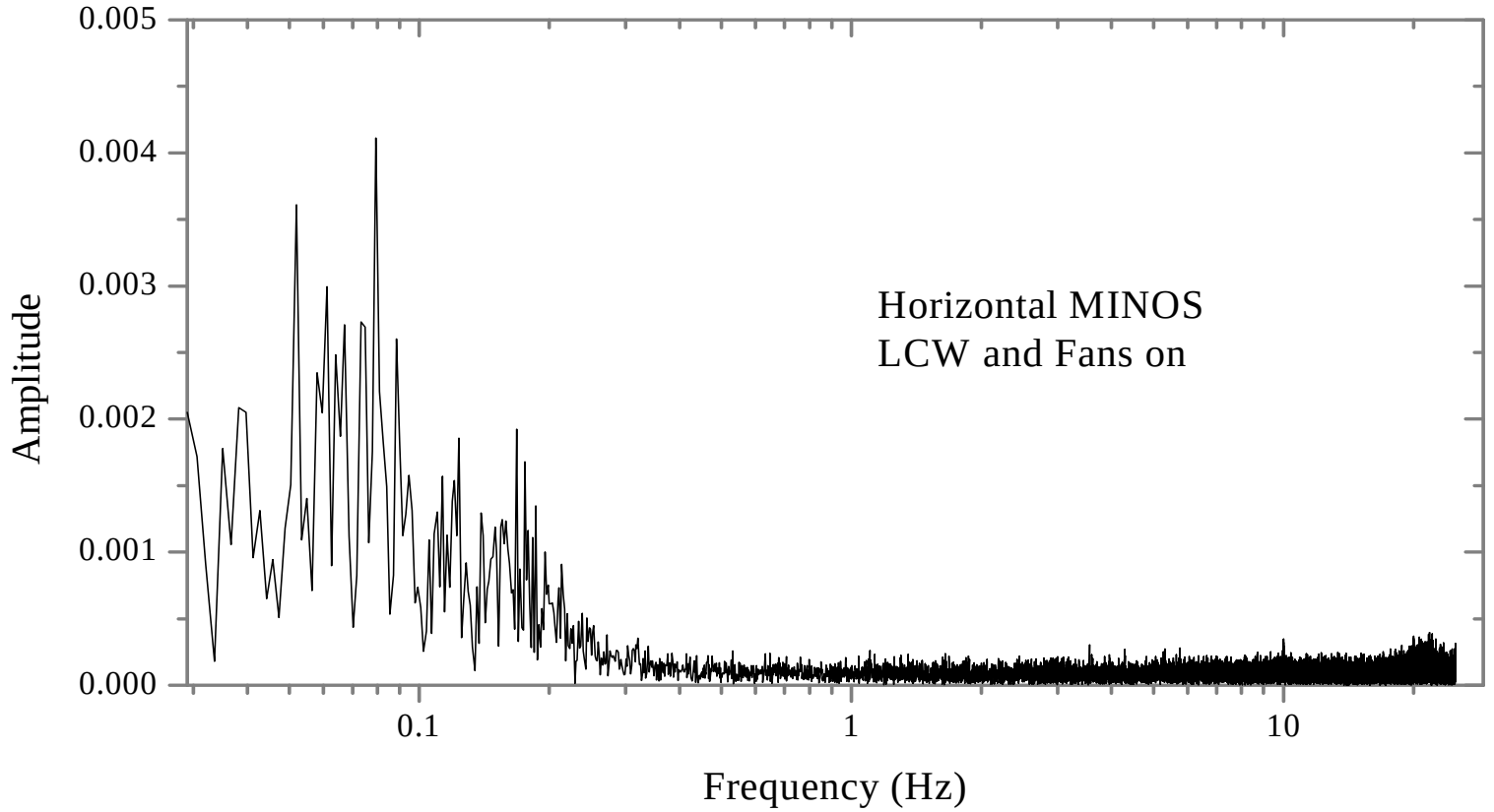
Vertical motion MINOS hall log scale



Horizontal motion MINOS hall



Horizontal motion MINOS hall log scale



More seismic studies

- We are looking at seismic data from MINOS
- Also data from Meson Detector building where the capture cavities are being tested
- Need to understand sources of noise
- During August September 07 shutdown we maybe able to turn off various sources to check