

Ground motion studies for the ILC

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Fermilab

Types of ground motion

- There is fast ground motion > 1 hertz
 - Vibration due to pumps, LCW cryogenics
 - 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

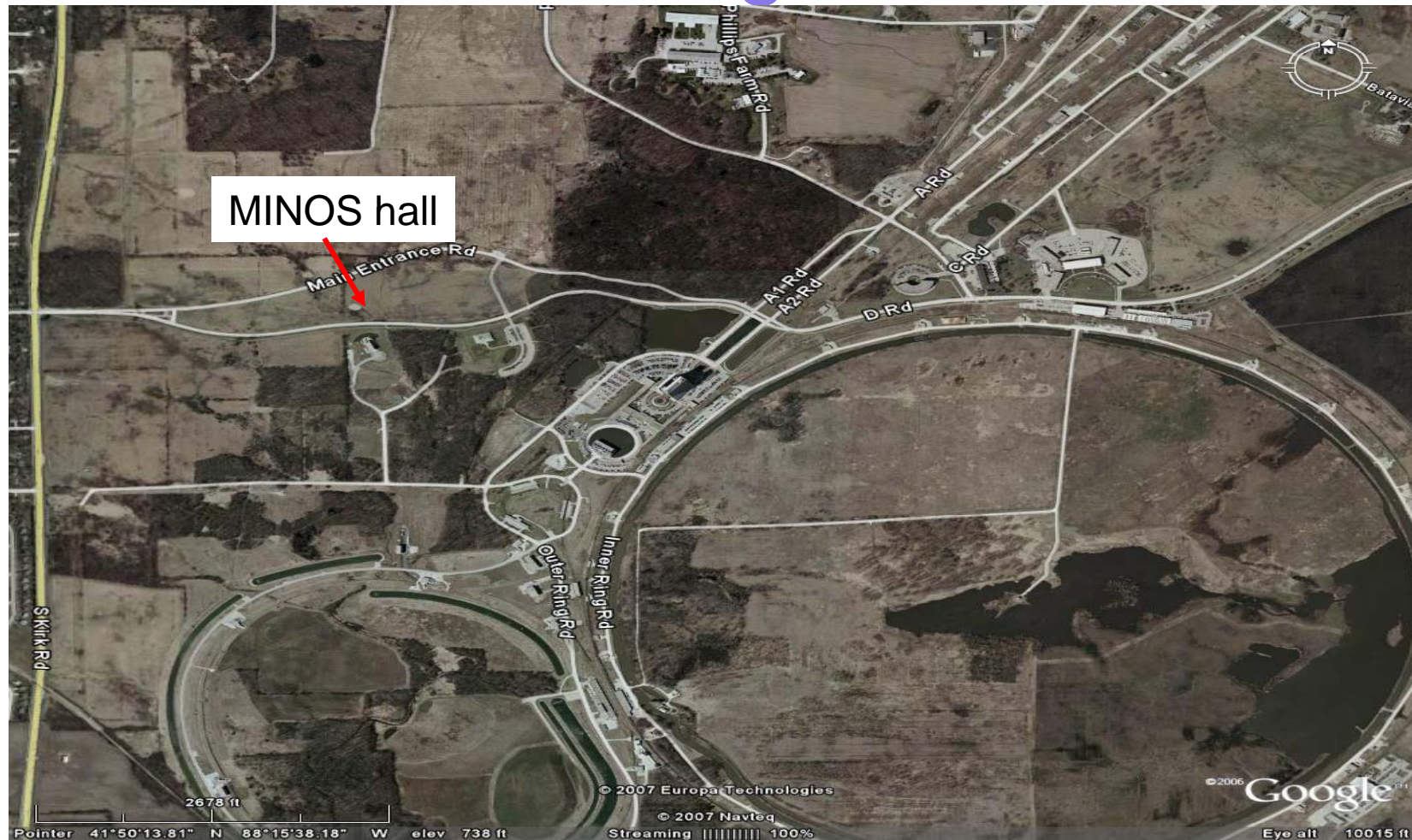
Goals of Fermilab studies

- 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

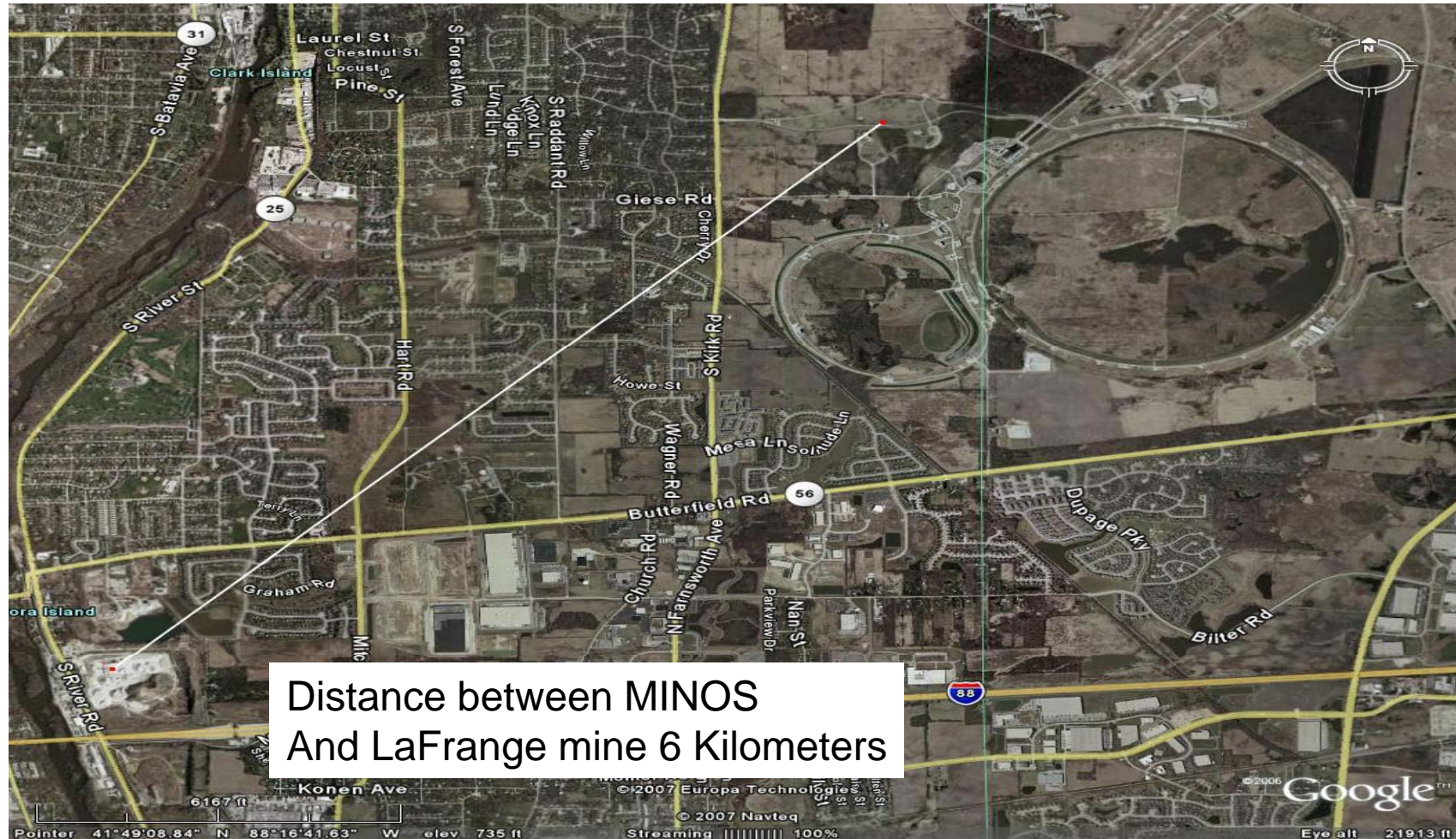
- There are two systems in use
- 4 Budker sensors in the MINOS hall 100 meters below grade running since December 1 2005
- 6 Budker sensors in use in the LaFrangé mine (formerly Conco Western) in North Aurora Running since September 1 2006

Location of MINOS hall 100 meters below grade



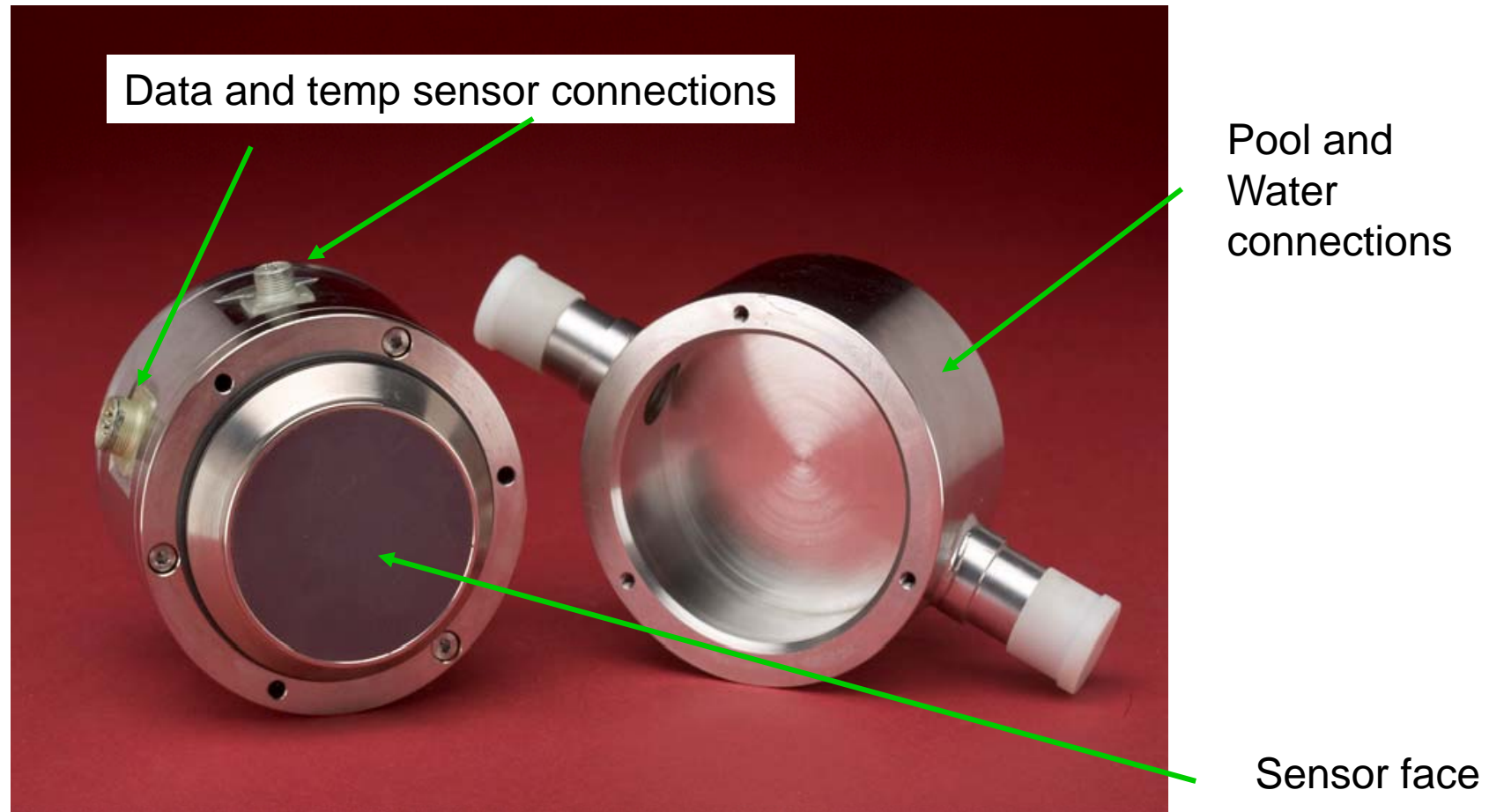
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LaFrange Mine North Aurora Illinois



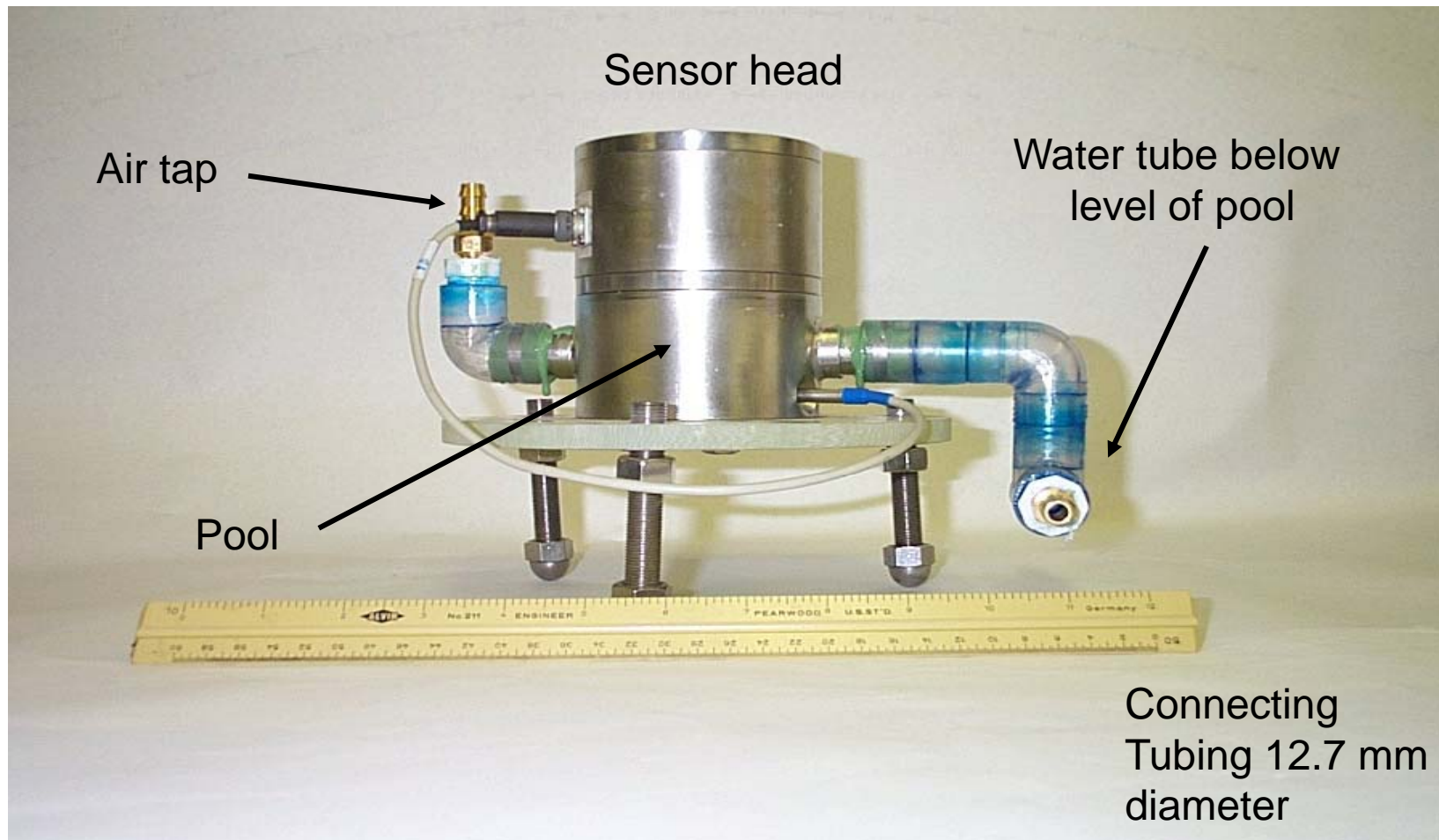
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Budker sensors



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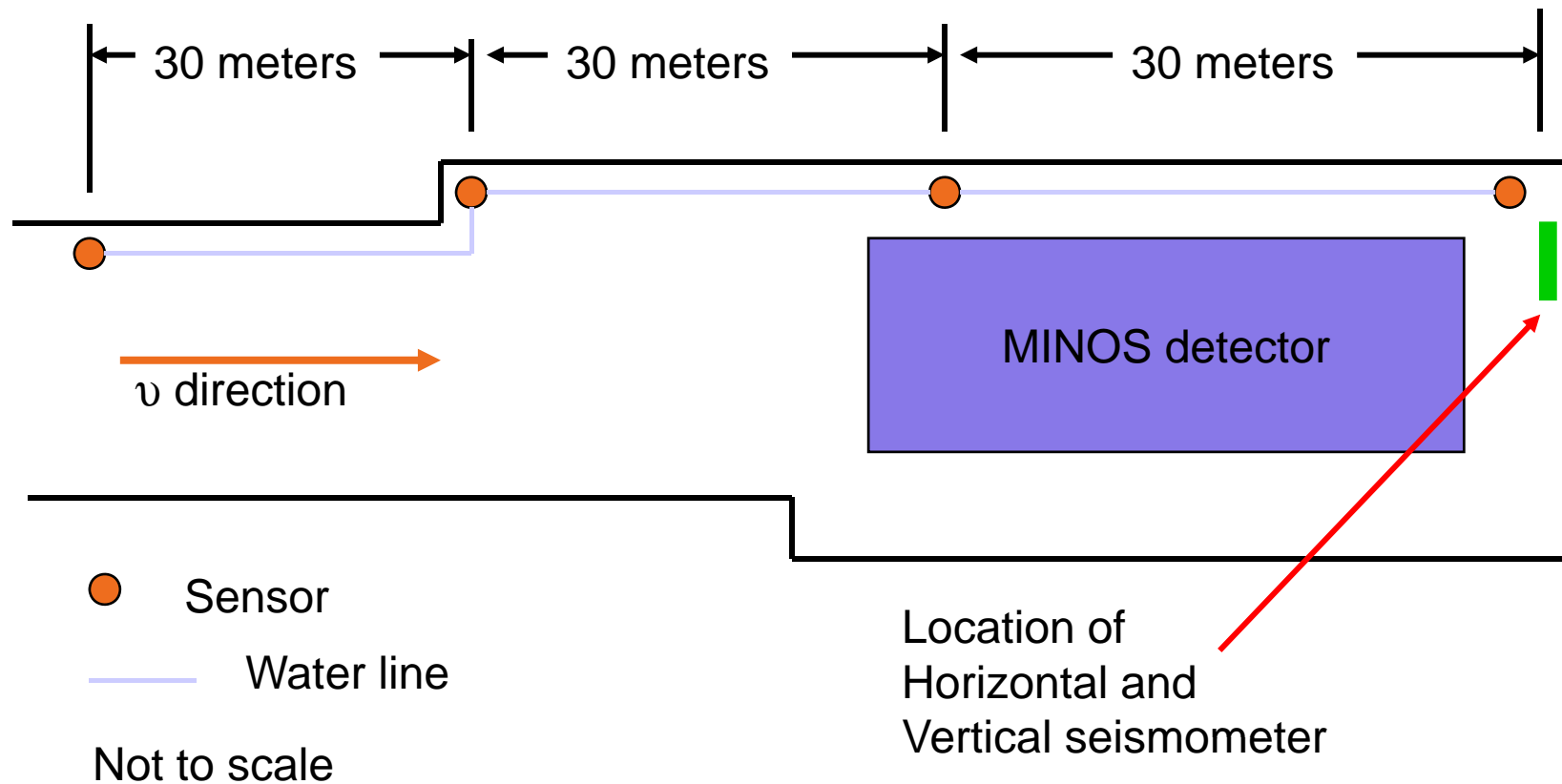
MINOS water level sensor



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Layout of Minos water level

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

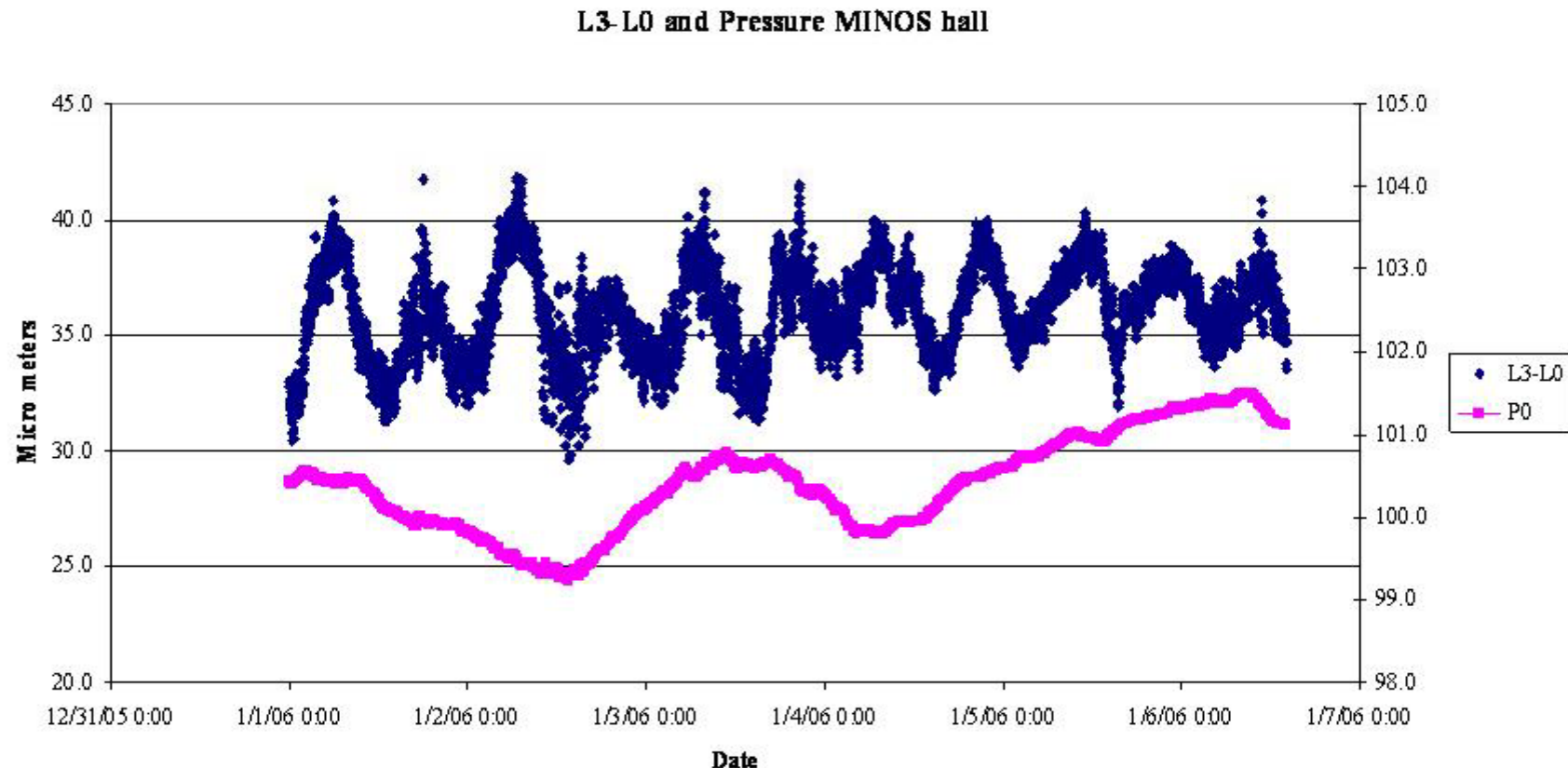


MINOS Detector

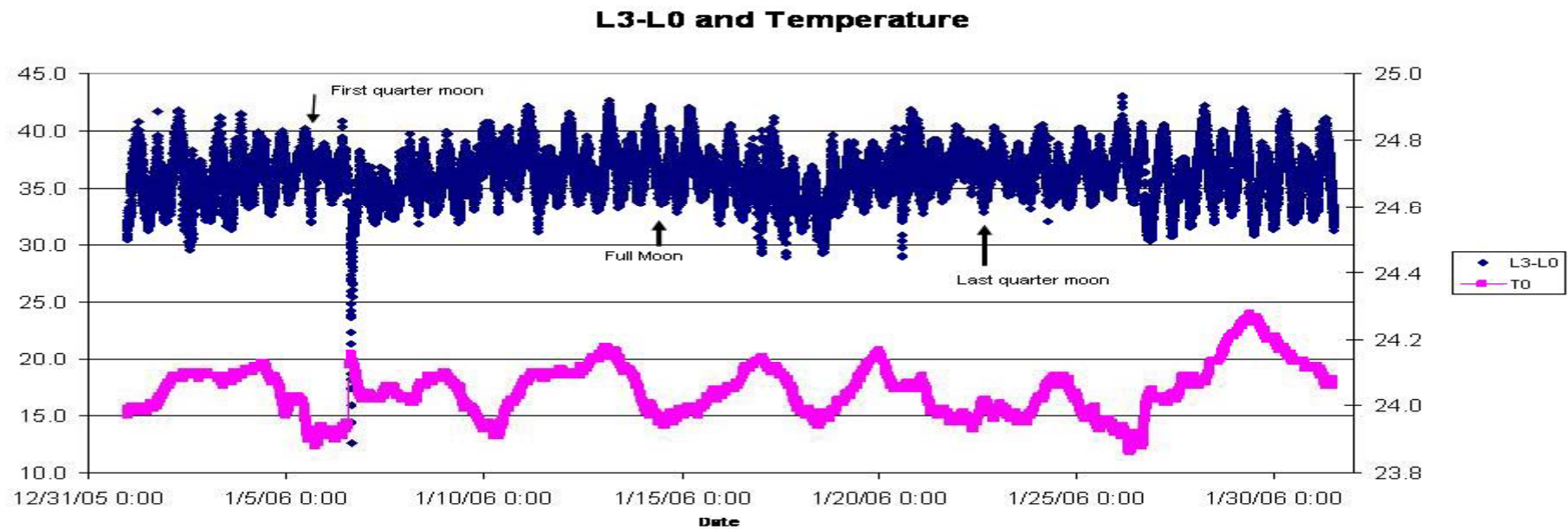


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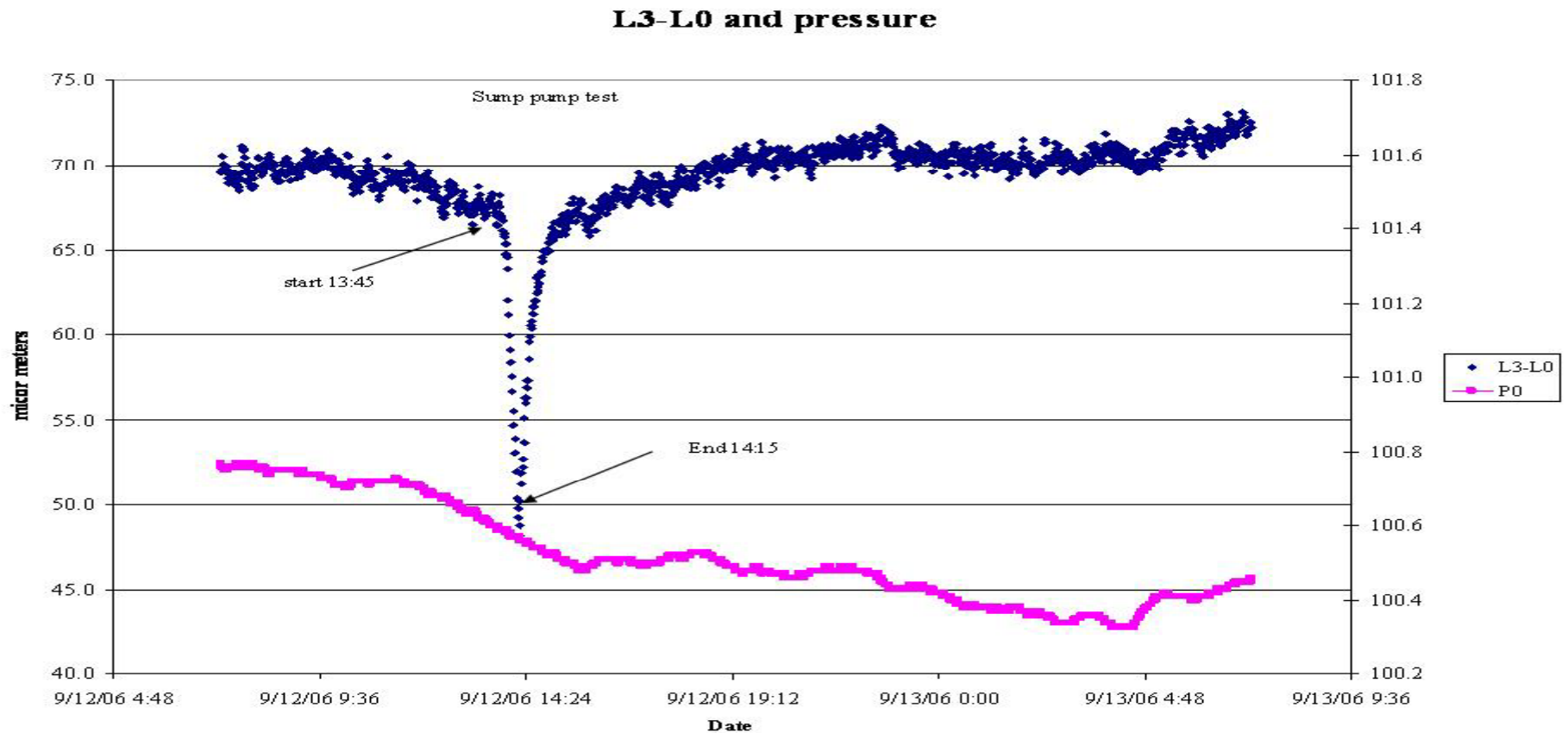
Difference between two sensors 90 meters apart in MINOS hall



Two sensors 30 m apart MINOS hall

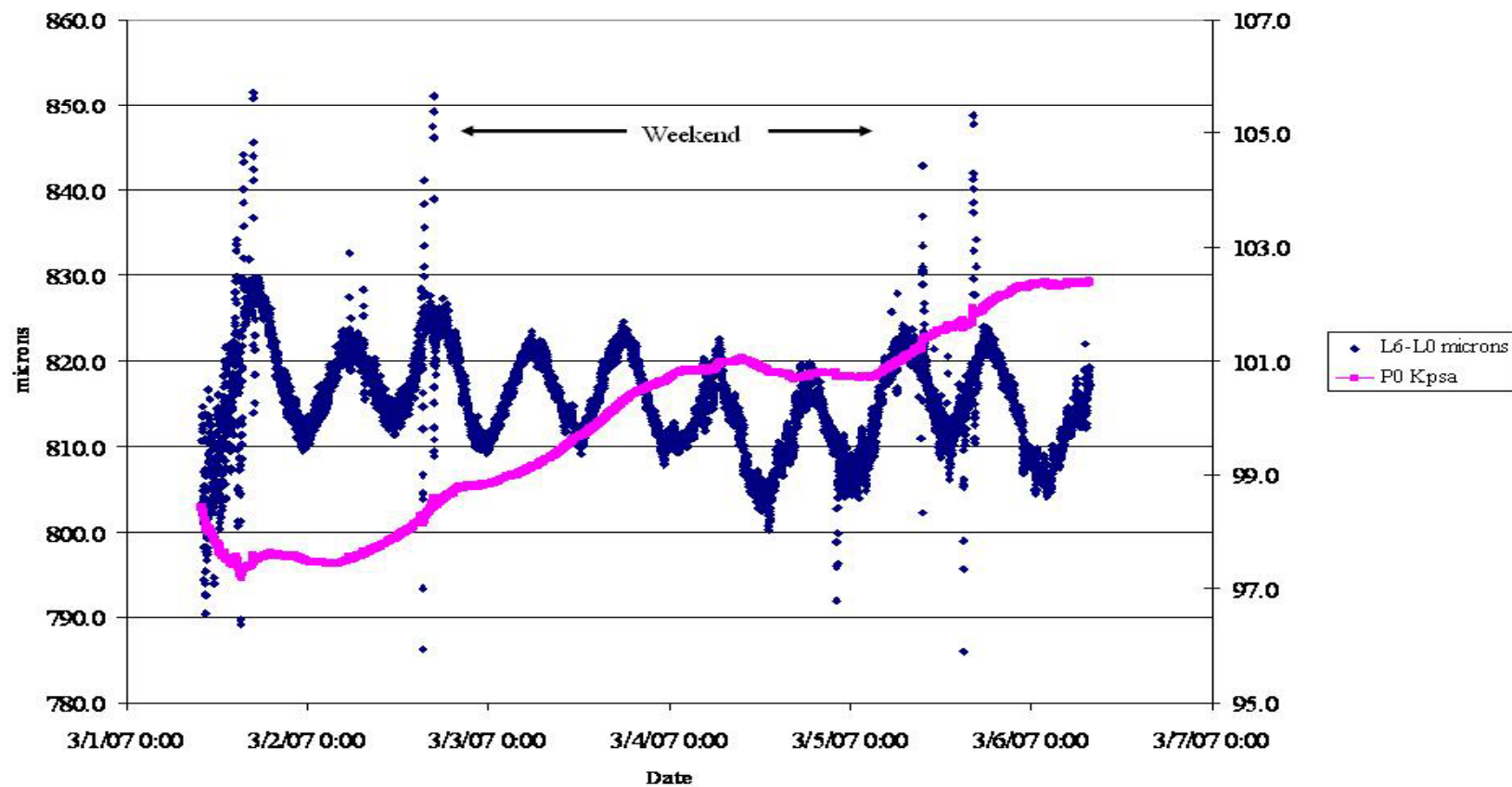


September 06 sump pump test



Difference in two sensors 150 meters apart in Aurora mine

L6-L0 and Pressure




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Data from MINOS and Lorange mine

- Data from MINOS has been collected at a rate of once per minute since December 2005 some occasional lost data
- Data from LaFrangé mine has been collected since September 1 2006
- Data are available at <http://rexdb01.fnal.gov:8081/ilc/ILCGroundApp.py/index>

Example data from MINOS

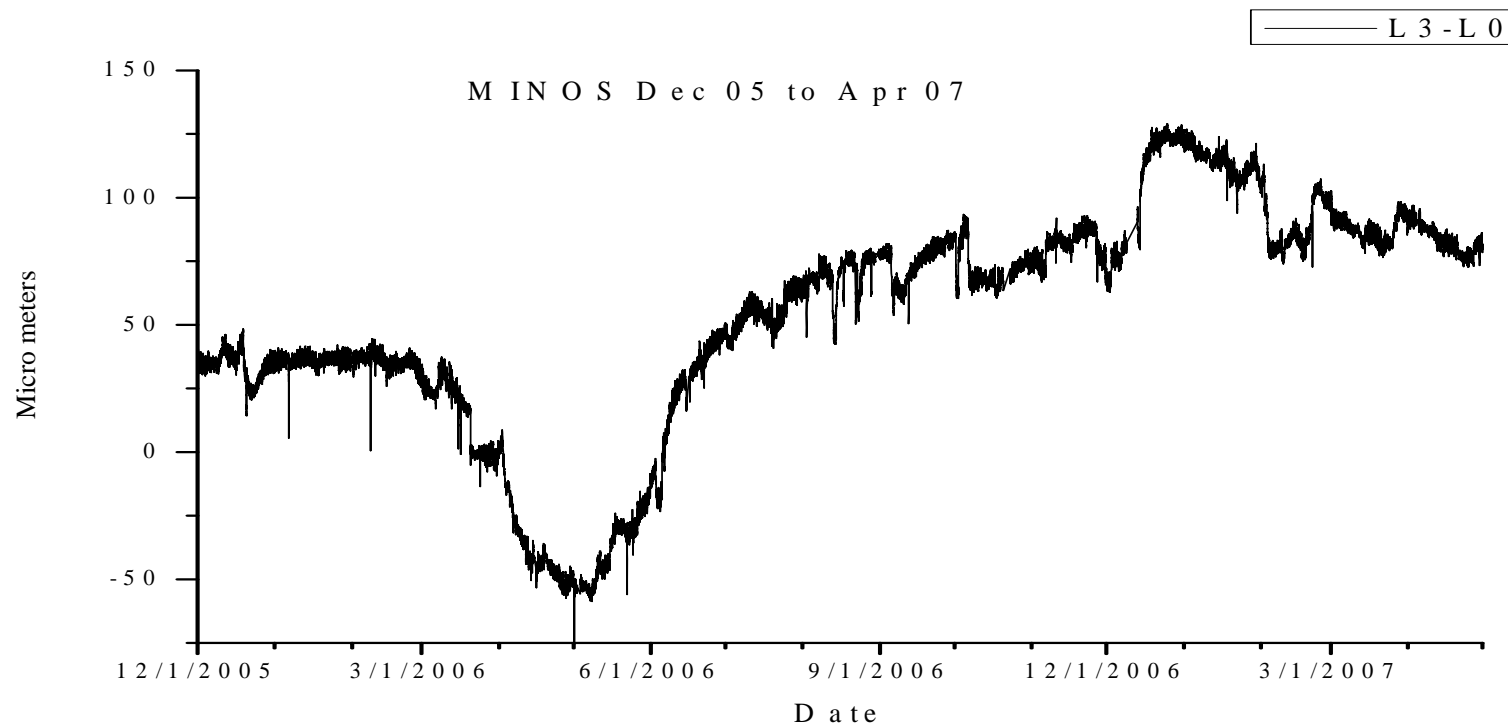
Time stamp - 4 levels in micro meters – 4 temperatures in C - pressure



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

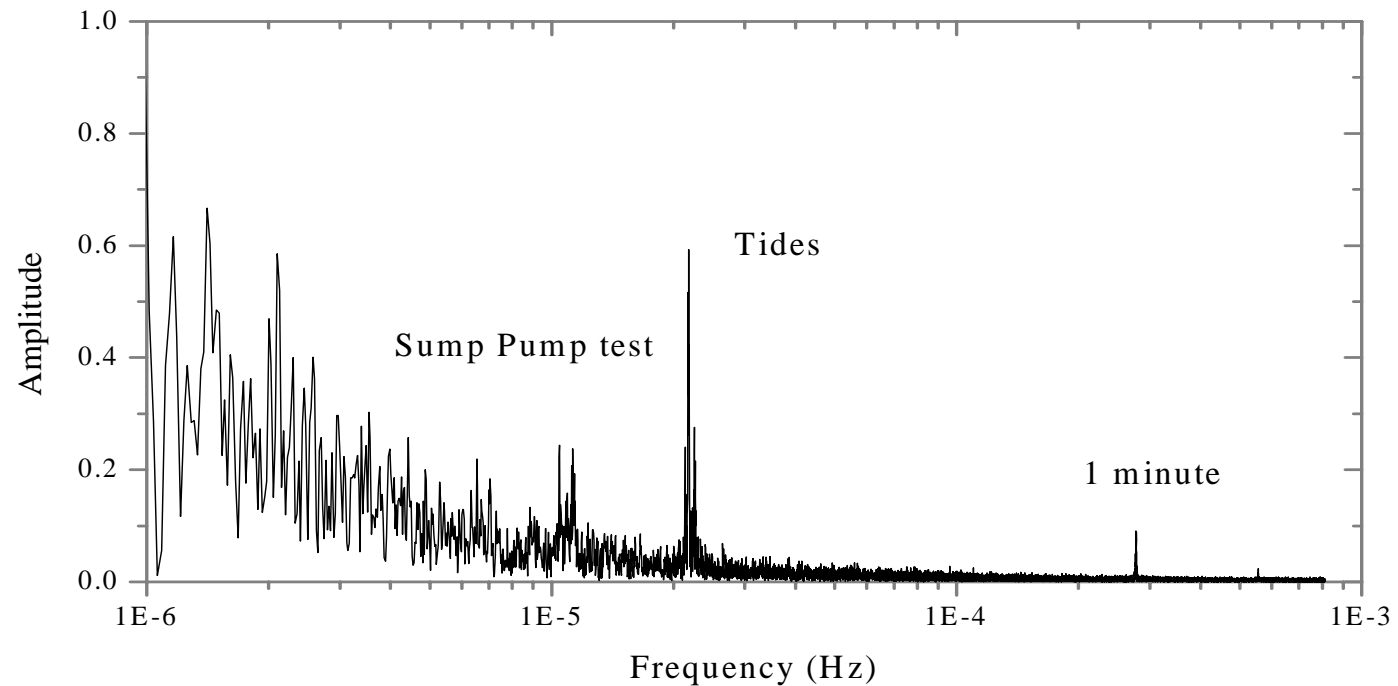
Difference between 2 sensors 30 meters apart MINOS hall 100 meters below grade



This is a 10 minute average of the data from Dec 05 to April 07

FFT of the difference between the two sensors in last graph

Difference in two sensors in MINOS hall
90 meter apart Dec 05 through Apr 07



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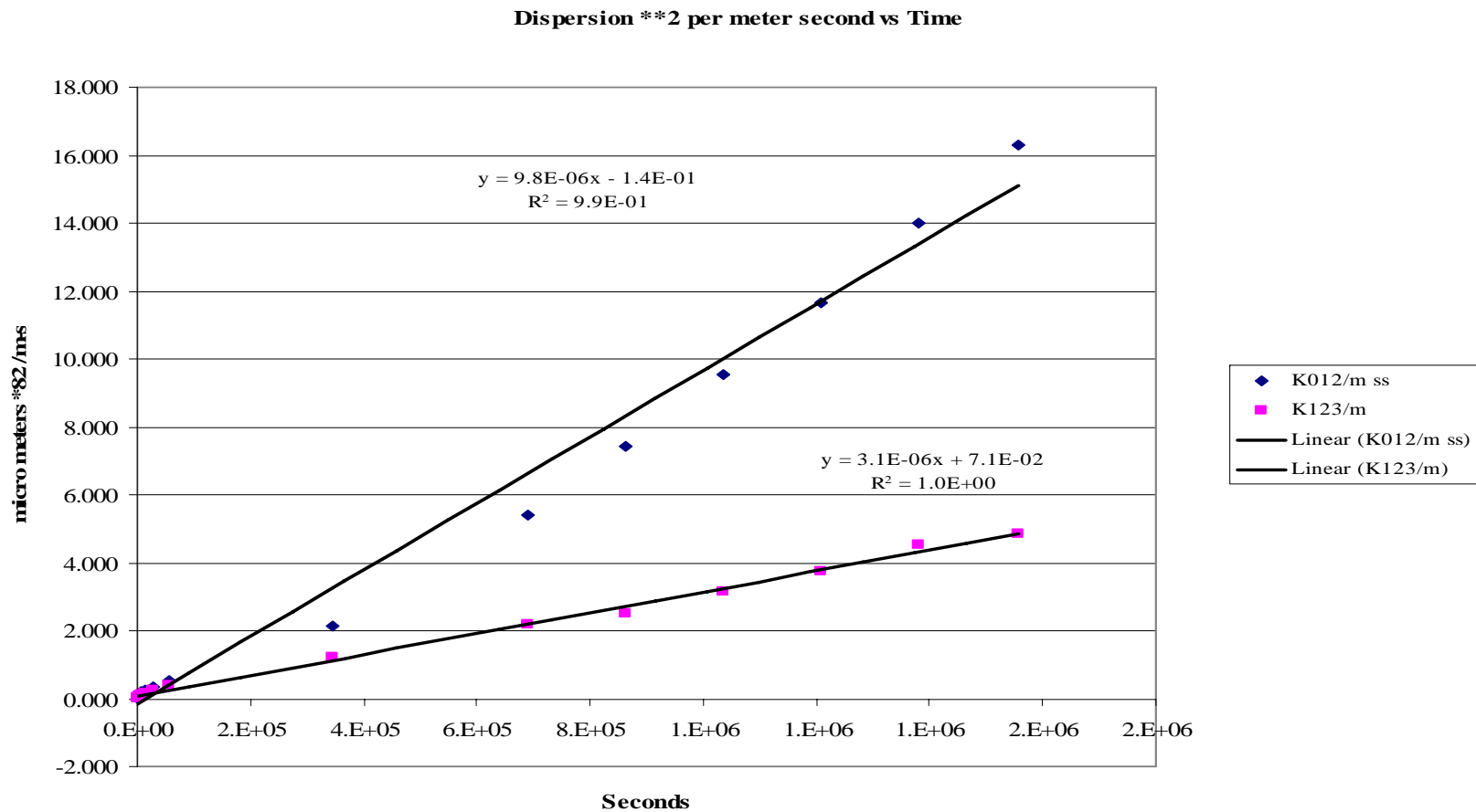
ATL Law

- Motion between two points can be described as $\langle \text{dis}^2 \rangle = ATL$
- 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



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ATL law results

- Value for A is between $5 \cdot 10^{-6}$ and $1.5 \cdot 10^{-6}$ micro meters² per m-s
- Need to look at more data it may break down for time spans longer than a few months

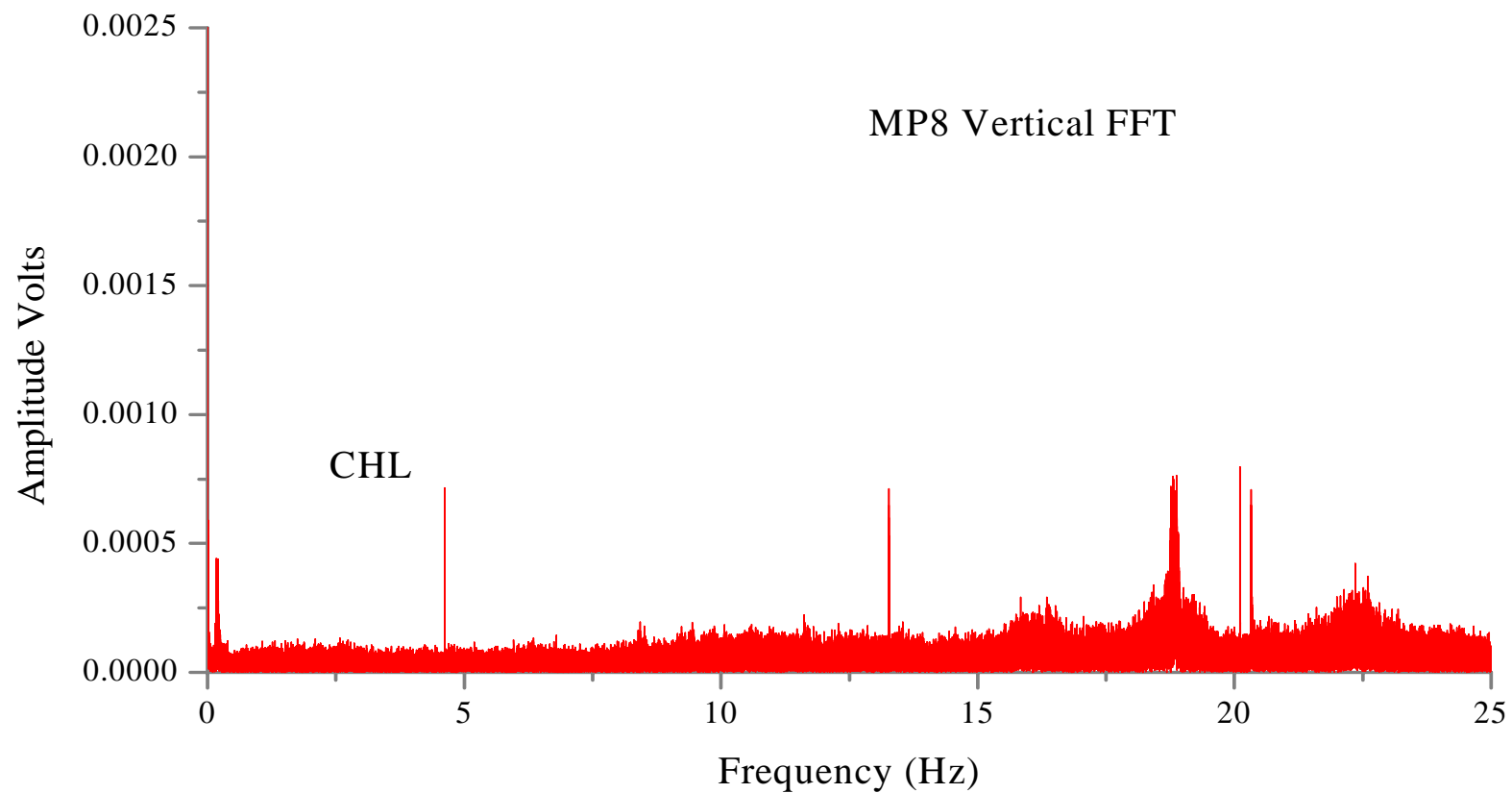
Future Work

- Continue slow motion studies of floor in Aurora Mine and MINOS hall
- Update 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

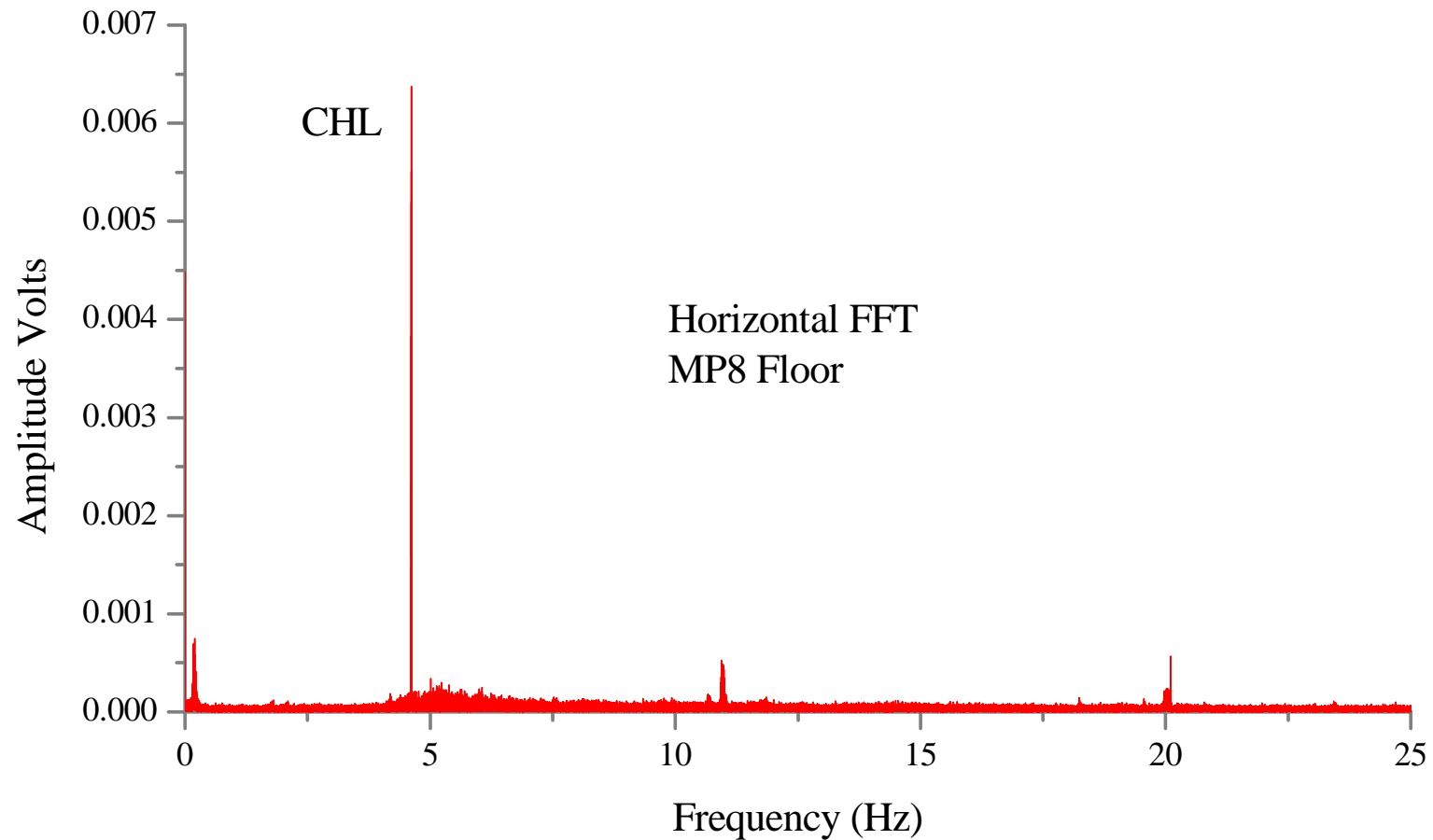
- I have four Russian seismometers two measure vertical and two horizontal motions
- One vertical and One horizontal are installed in MINOS hall and data logged with ACNET system
- The others I move around site

Vertical motion at grade Fermilab



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Horizontal motion at grade Fermilab



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Location of MINOS, MP8 and CHL



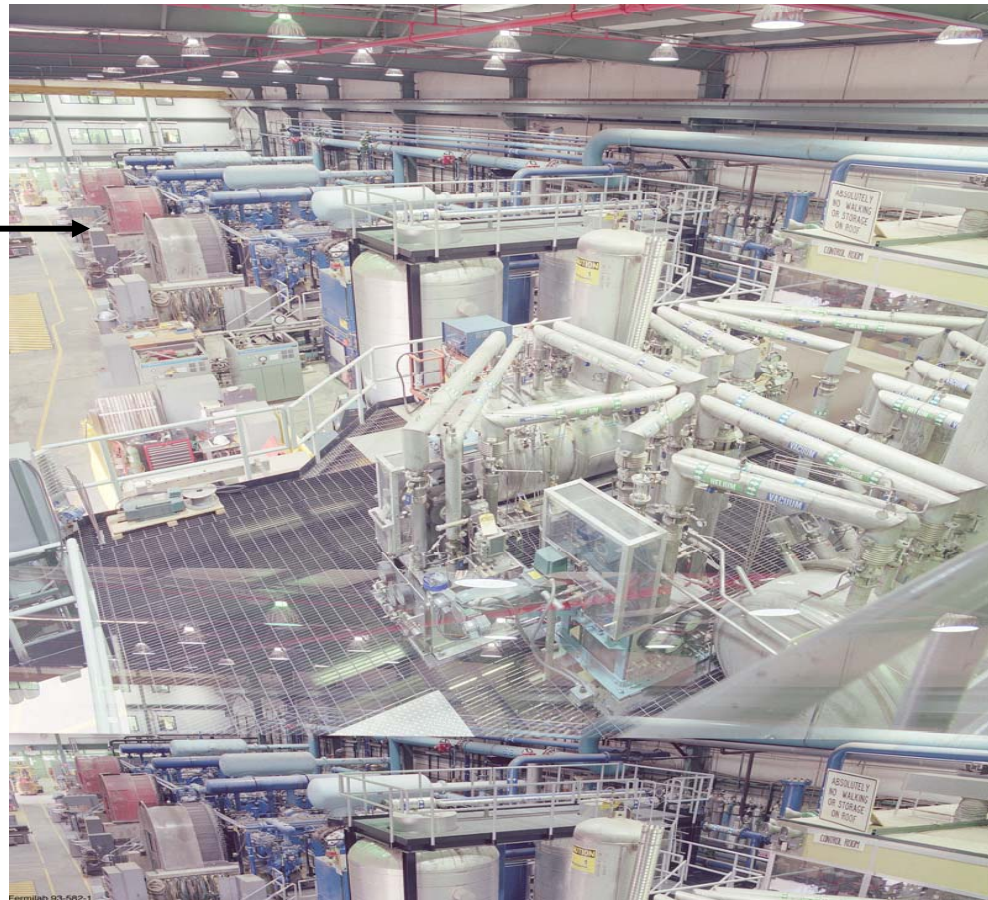
The White dot is
Central He Liquefier
There are 3 large
Screw compressor
At CHL for liquid He

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

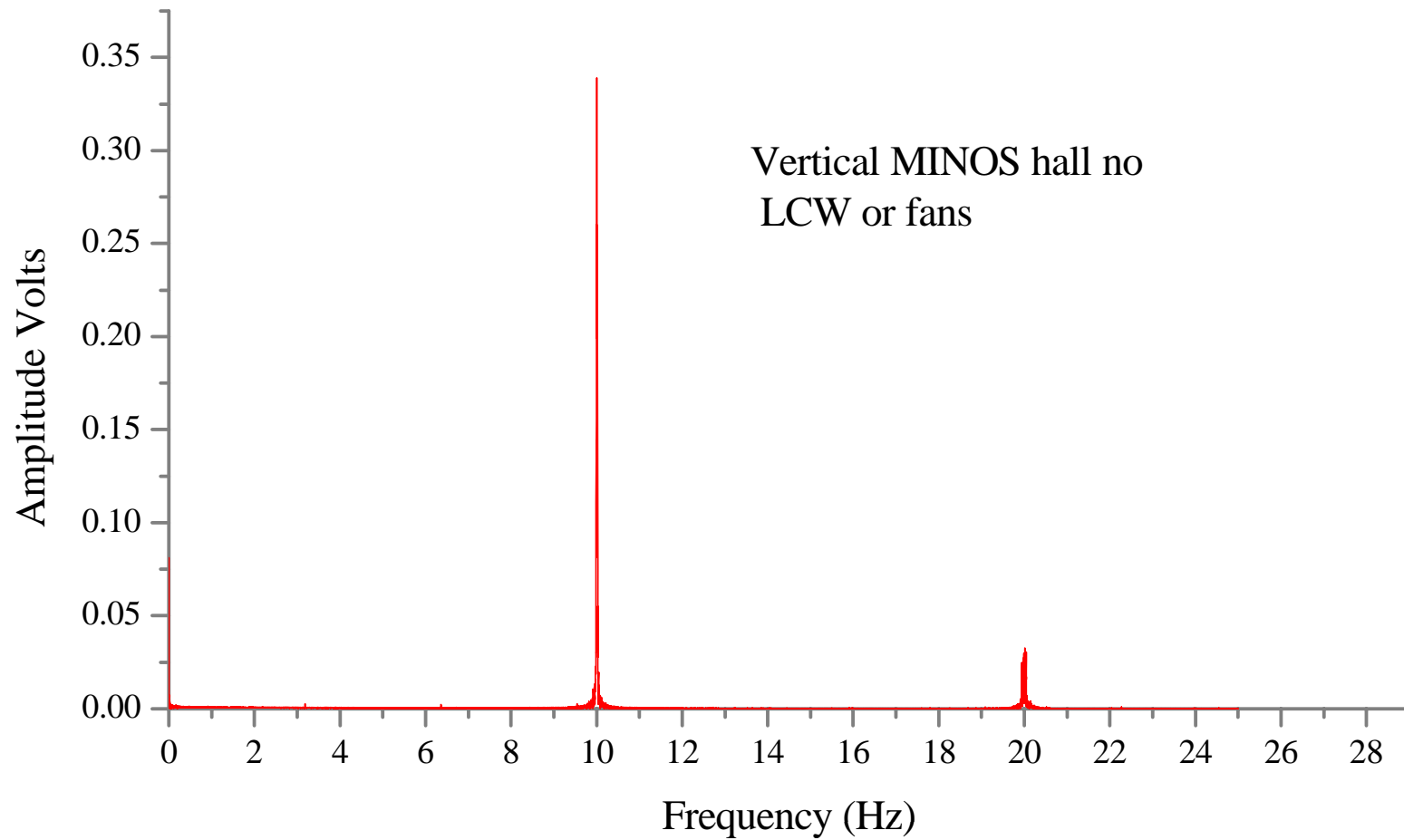
Inside of CHL

Three screw
compressors



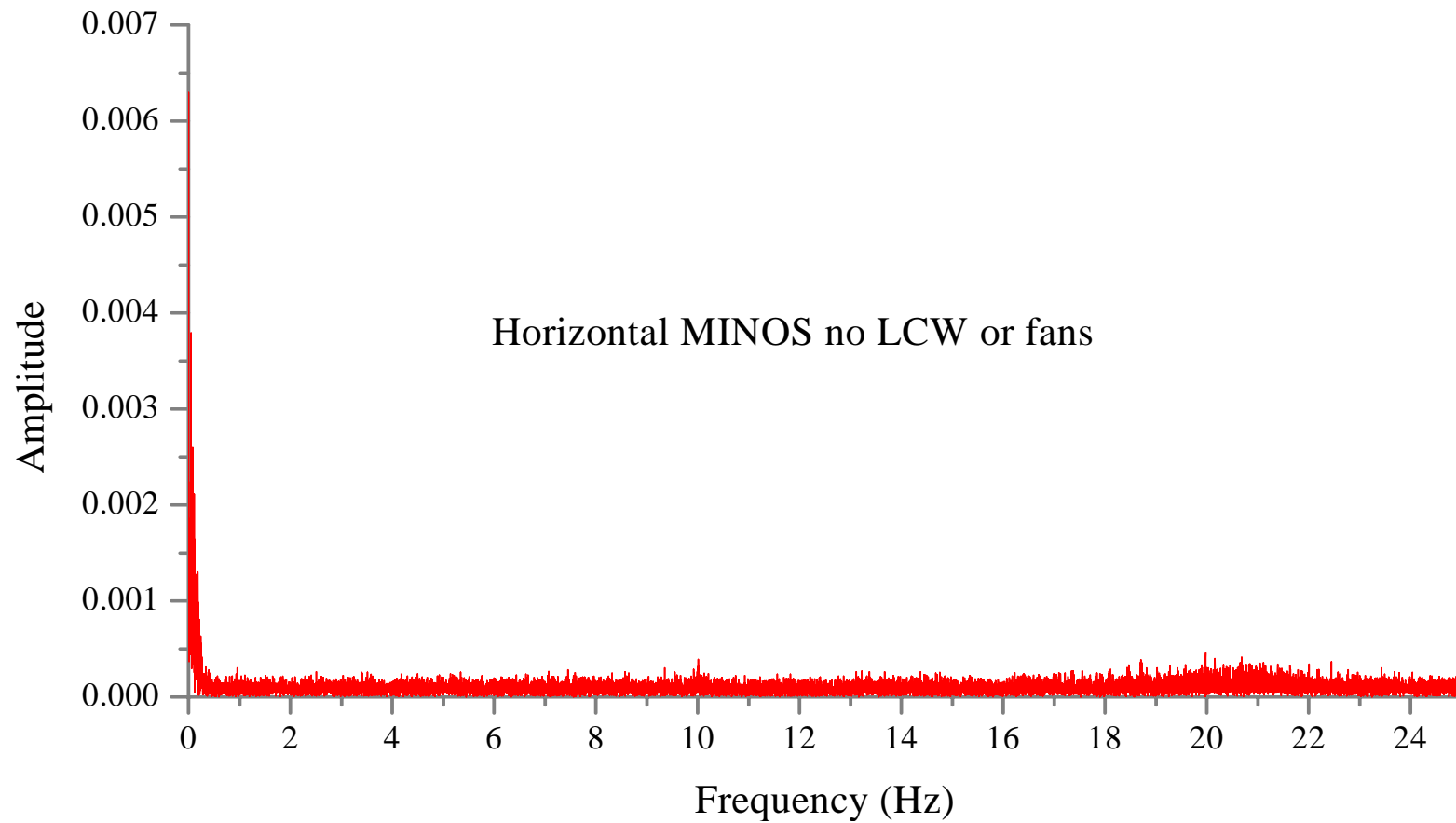
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Vertical motion MINOS hall



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Horizontal motion MINOS hall



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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