
DUSEL and Gravitational Waves

Vuk Mandic

University of Minnesota

03/17/08

Outline

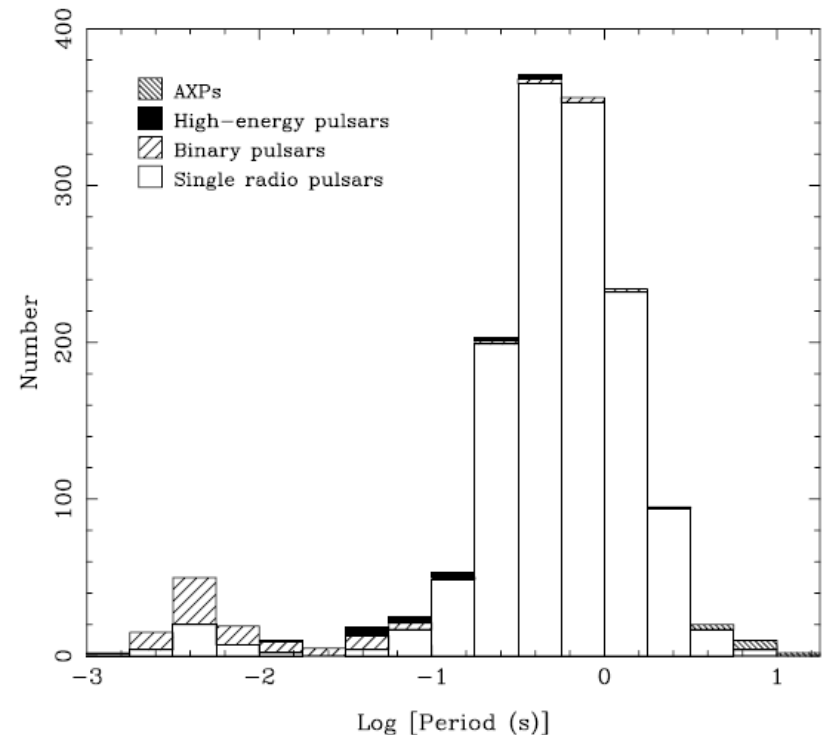
- 1 Hz region – why we care?
 - » Scientific motivation
- Why underground?
 - » Seismic and gravity gradient noise
- What is DUSEL?
 - » Concept, funding, time-line etc
- What can we do at DUSEL?
 - » First visit
 - » Meeting at Homestake, SD, April 23-26.

Why ~1 Hz?

Strong Scientific Case

- Binary inspirals:
 - » Increase the duration of the signal in the sensitive band.
 - » Probe systems with larger masses.
 - » Dark Energy: combining with EM observations, determine luminosity-distance relation for $z \sim 1$ objects.
- Periodic Sources:
 - » Majority of pulsars have period around 1 sec (~ 1 Hz).
 - » Currently out of reach.

Pulsar Period Distribution



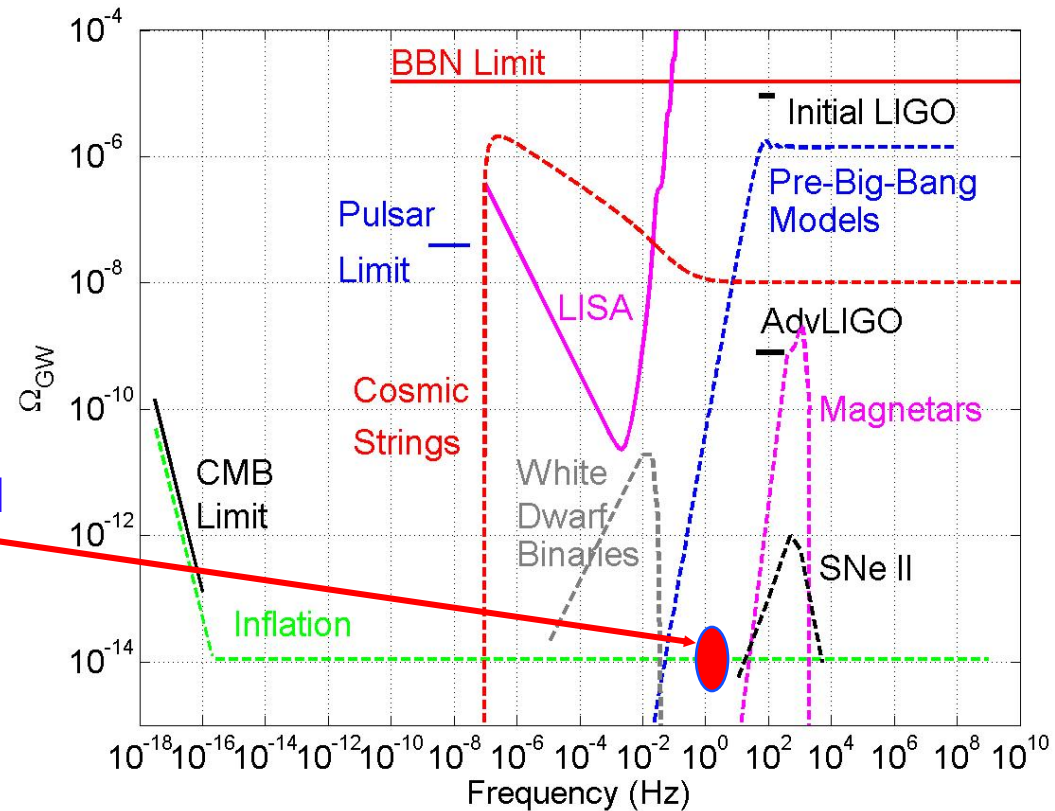
ATNF Pulsar Catalogue,
The Astronomical Journal 129, 1993 (2005)

Why ~1 Hz?

Strong Scientific Case

- Stochastic Background:
 - Extending the strain-sensitive band to lower frequencies quickly improves sensitivity to the energy density in gravitational waves.
 - Potentially reach 10^{-14} or 10^{-15} scale in Ω , accessing some of the most interesting theoretical models.

$$S(f) = \frac{3H_0^2}{10\pi^2} \frac{\Omega_{GW}(f)}{f^3}$$

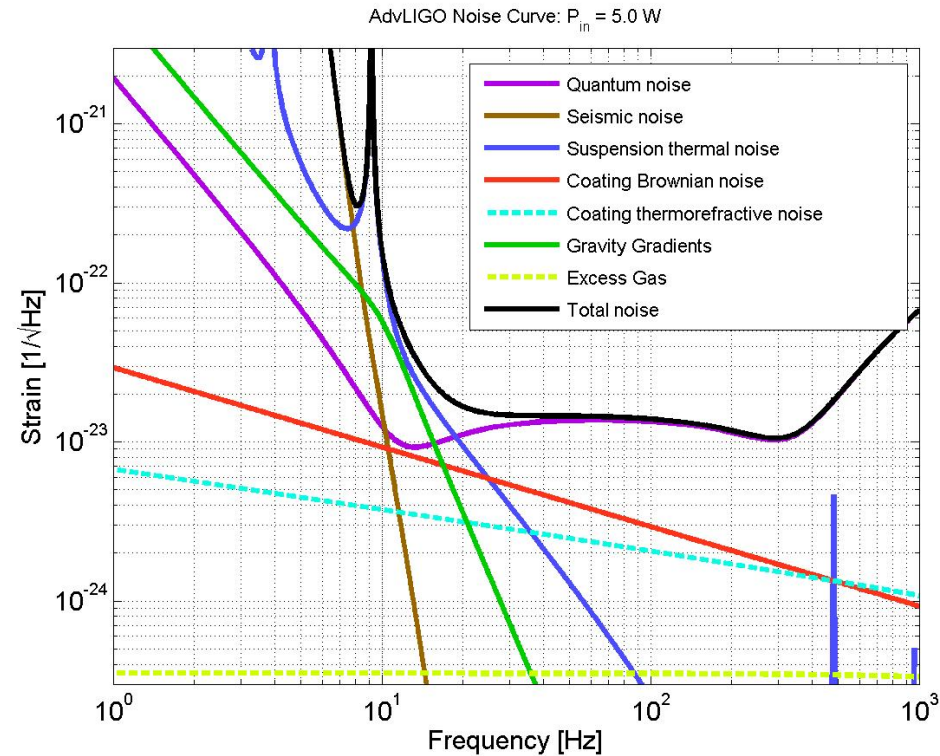


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Can We Probe ~1 Hz on Earth?

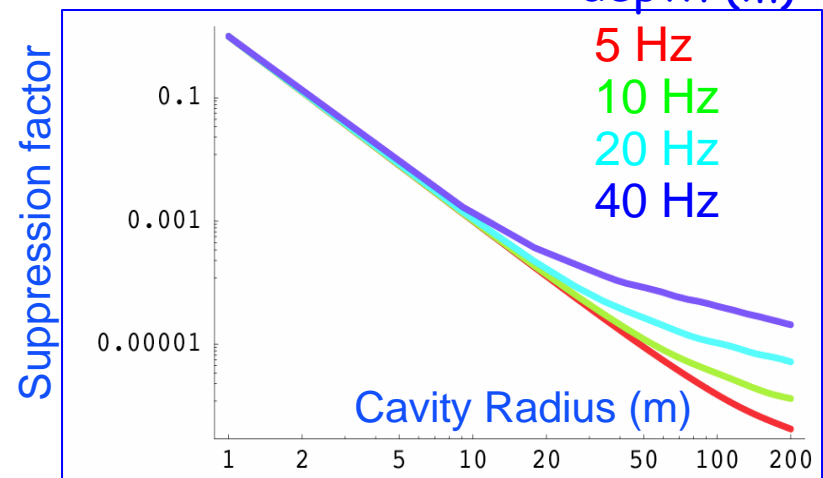
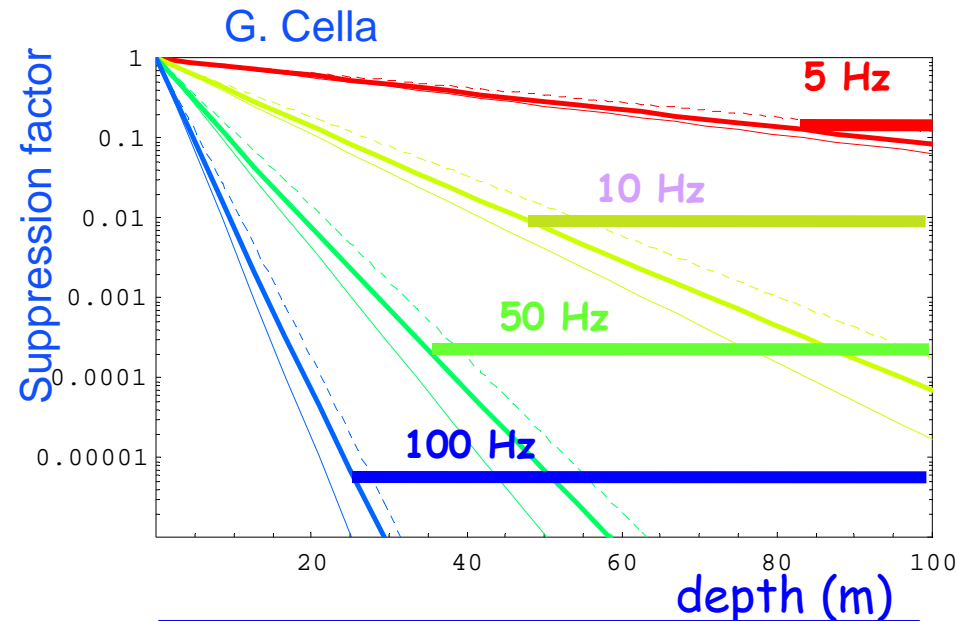
- Surface-based experiments are limited to >few Hz.
 - » May be reached by AdvLIGO in low power configuration.
- Probing below 10 Hz would probably require active suppression of gravity gradient noise.
 - » Array of seismometers feeding back to the mirrors...
 - » Also need to monitor atmospheric fluctuations...
- Still have to worry about thermal and quantum noise.



Difficult to probe <10 Hz!

Why Underground?

- Expect that the gravity gradient noise would benefit in several ways:
 - » No atmospheric fluctuations.
 - » Seismic noise suppressed, especially at higher frequencies.
 - » Can build large (50m diameter) caverns and put mirrors in the middle: 10^4 - 10^5 x suppression.
 - » Can implement active suppression (seismometer array).
- Combining these techniques *may* suppress gravity gradient noise above ~ 0.1 Hz.
- Could also imagine much longer suspensions, with resonant frequencies below 1 Hz.

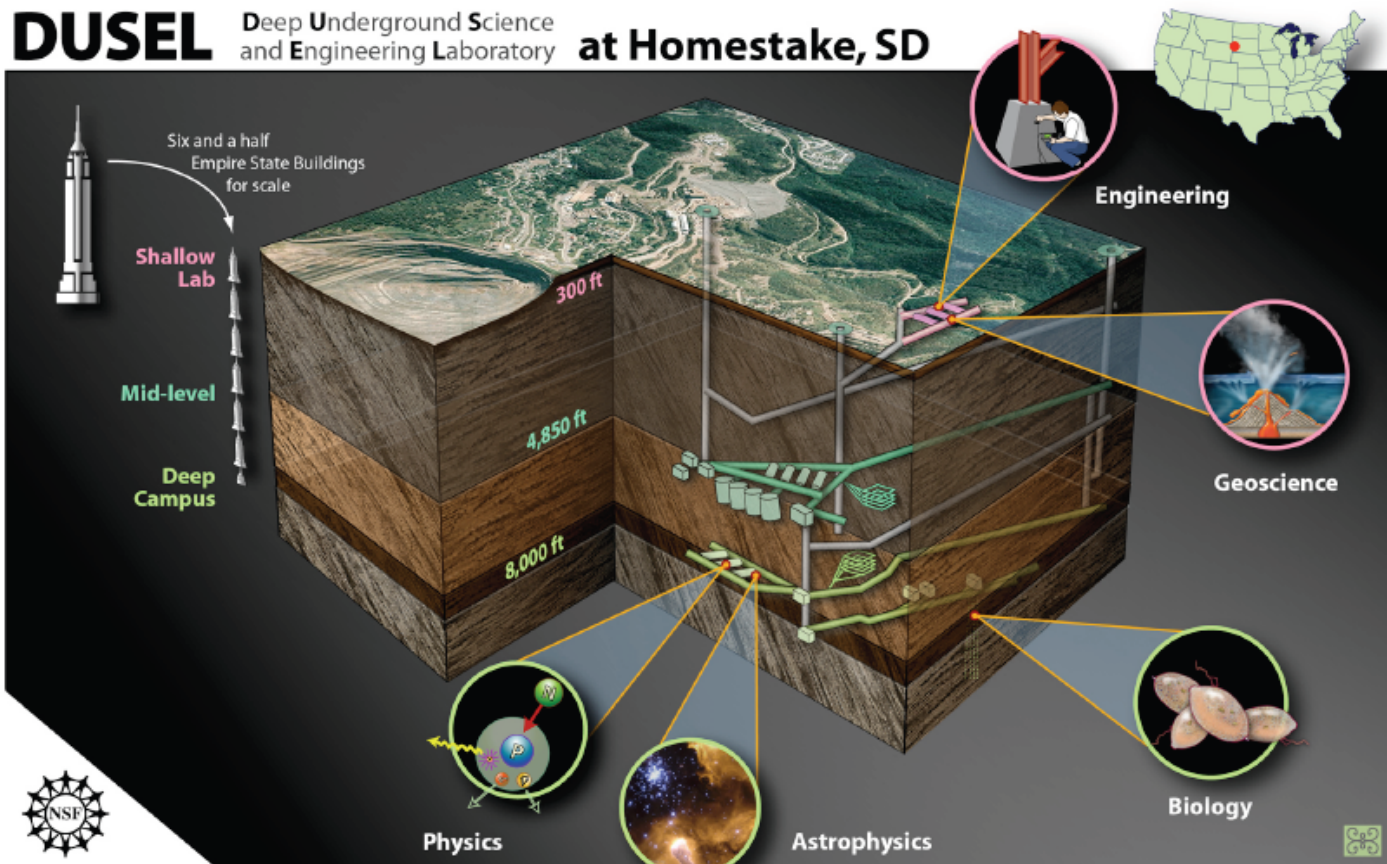


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What is DUSEL?

- DUSEL is an underground laboratory space providing infrastructure for science and engineering research (J. Kotcher, NSF).
 - » The primary motivation has been for fundamental physics research, exploiting the shielding from cosmic rays.



DUSEL Planning and Timeline

- Solicitation 3 (S3): technical facility design for an MREFC candidate (awarded to Homestake, U.C. Berkeley, Sep. 2007)
- Solicitation 4 (S4): in preparation, will call for proposals to develop project plans for the Initial Suite of Experiments (ISE) for DUSEL.
 - » Funds will go toward answering question: what resources do researchers need to execute the experiments they propose?
 - » Open to all disciplines.
 - » Anticipate \$15M total from Physics/MPS, over 3 (or more) years.
- S4 designed to help the community define its research goals and experimental program, and evaluate what their implementation will require – NOT R&D!
 - » Proposals due June 2008, awards expected October 2008.
- Taken together, S3 and S4 are intended to enable development of a comprehensive project plan for DUSEL: facility + experiments.
- Expected that resulting package will be put forward for MREFC consideration.

DUSEL Planning and Timeline

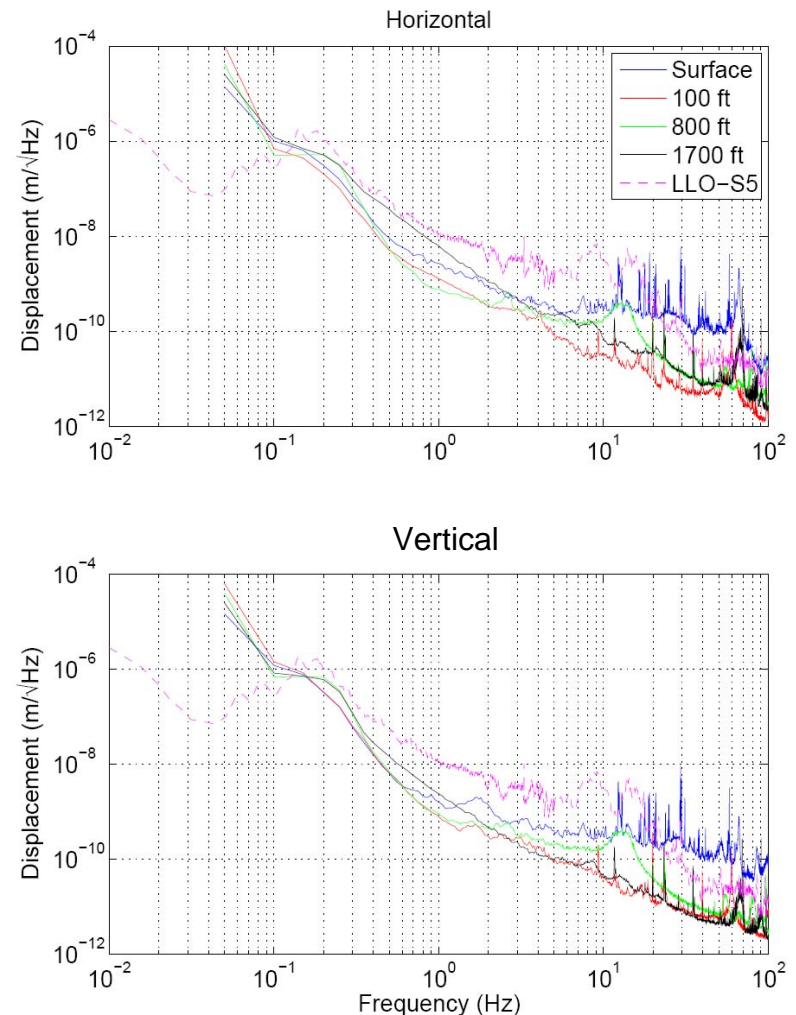
- At this early stage, Physics Division uses following rough planning targets:
 - » \$500M for initial phase MREFC, split evenly between facility and experiments.
 - » 7-8 year construction period, experiments interleaved as they are ready.
 - » Project will be reviewed ~ yearly and brought forward for Preliminary Design Review (construction start) when ready.
- Preliminary Design proposals due ~May 2009.
 - » Initial Suite of Experiments announced in ~July 2009.
 - » Assembly of MREFC and submission for funding, ~December 2009.
- Earliest construction start FY 2011, probably FY 2012.
- Planning assumes facility costs would be borne by NSF.
 - » Partnerships with DOE & others will be sought & encouraged for initial suite of experiments.

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R&D Directions

- Preliminary studies:
 - » Study the geological surveys of Homestake: rock/earth structure impacts the seismic performance.
 - » Measure seismic noise as a function of depth, and estimate the gravity gradient noise.
- Made first “quick-and-dirty” measurements in Feb 2008.
 - » Borrowed Guralp from LHO.
 - » Portable data acquisition.
 - » Measurements look promising, but we know they were compromised.
- Plan a more careful campaign in the summer.









R&D Directions

- Build a gravity gradiometer underground:
 - » \$1-2M
 - » Possibly “portable”, move it to various depths etc.
 - » Can we reach the necessary sensitivity?
- More ambitious: Prototype interferometer:
 - » ~\$10M
 - » 10-100 meters long arms, not necessarily orthogonal.
 - » Measure gravity gradients, try active suppression techniques.
 - » Act as a test facility for other noise suppression techniques:
 - Thermal, quantum?
- Preliminary design proposal to be submitted in the summer 2009.
 - » Aggressive, but everyone is in the same situation.
 - » NSF will help the process – Meeting at Homestake in April 2008.
 - » Even this process would allow construction in ~2012.

How can you help?

- Strengthen the scientific case:
 - » New sources/models that could be accessible?
 - » Improvements in data analysis techniques for “standard” sources?
 - » Complementarity with Advanced LIGO and Virgo?
- Join us at the informal lunch meeting tomorrow:
 - » **Tues 03/18, 1-2pm.**
 - » **351/352 W Bridge.**
- Join us at the April meeting in Lead, SD:
 - » http://homestake.sdsmt.edu/April_20-26/meeting.htm
 - » April 23-26, 2008 (financial assistance is possible).
 - » Important to demonstrate our interest (as a community) in DUSEL.