Long Baseline Working Group

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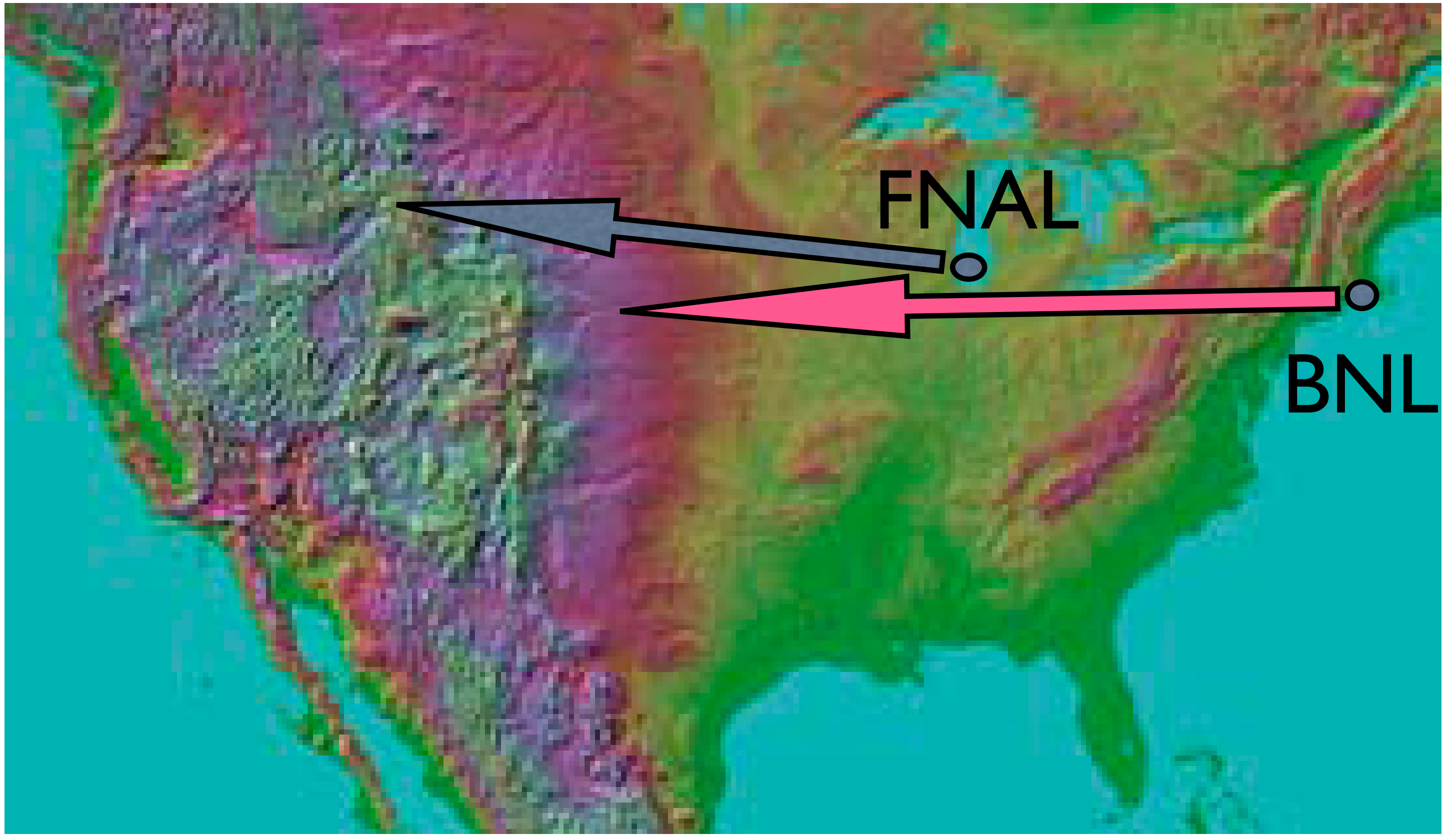
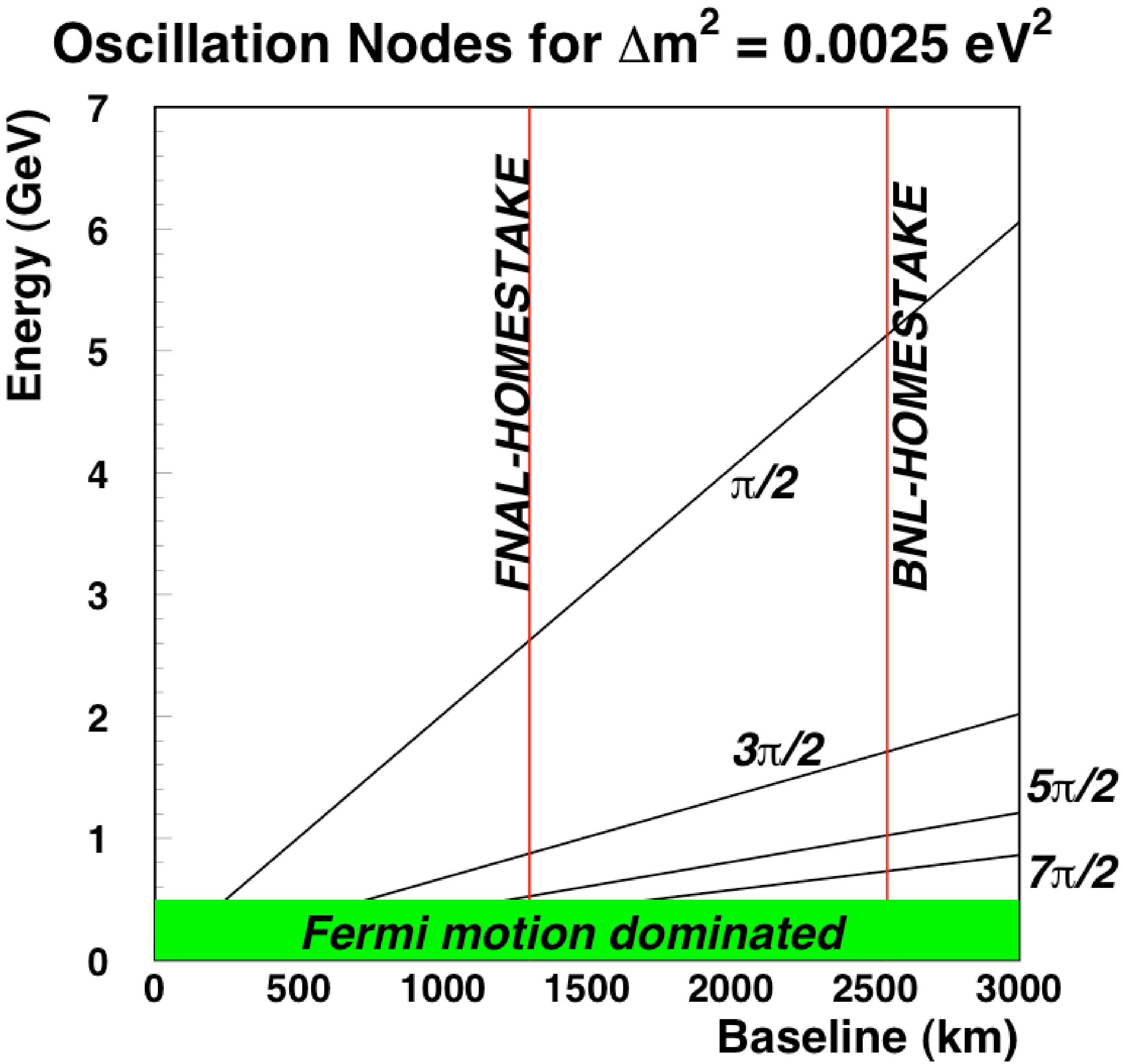
Experimental Concept

- Huge Detector at DUSEL. 100 kT to 500 kT
- Very intense neutrino beam at an accelerator laboratory: Brookhaven National Lab. or Fermi National Laboratory.
- Shoot neutrino beam to detector over >1000 km

Beams across the country



Distance Scale



For next generation experiment need to see multiple nodes

Importance of DUSEL for Long Baseline

- We want to do the science.
  - Precision measurements of known neutrino parameters.
  - See CP violation is possible.
  - Perform an ambitious experiment that could discover new unexpected effects.

Importance of DUSEL for Long Baseline

- Ability to house a large detector.
- Detector must achieve a scale of 1 mega-ton over a reasonable construction period (10 yrs).
- Detector must be multipurpose with a broad physics agenda.
- Broad agenda needs low backgrounds.

Discussion points

- Strategy: How ambitious should the experiment be ? What happens if some of the medium term experiments find the interesting effects. How to respond ?
- Size: Should we invest more in the beam intensity instead of the detector ?
- Depth: Can long baseline do without the depth ?

Discussion points

- Performance: How well can we do this with a water Cherenkov detector ?
- Issues: backgrounds, events rates, beam intensity and spectrum.
- Can one build a 100 kT liquid Argon detector underground ?
- Answer to all issues: Multipurpose detector? Detector can do more physics than only LBL.

Rough Costs

- Proton Driver $250 M
- Super Nu beam $100 M
- LBL site $50 M
- Large Detector $200 M
- Measuring neutrino CP : Priceless ?
- Must explore synergies with other science: Multipurpose detector.

Detector requirements

- Fiducial mass:

>500 kT if using "clean" events only.

>100kT if we can use "all" events.

- Threshold: ~5 MeV (Supernova+LBL)
- Dynamic range: contain 5 GeV muons
- Time res: 1-5 ns, Energy res: ~10%
- Muon/electron separation <1%
- Pattern recognition: 1 to 3 track separation.

Technical requirements for Water Cherenkov

- Smallest size chamber necessary: 50 m diameter by 50 meters high: ~96 kT
- Chambers need to be larger for many reasons.
- Water chilling (can we chill to 0 deg. ?) and purification for 1 MT of water.
- Power requirement for 100000 to 200000 Photo-multipliers.

Technical requirements for Liquid Argon.

- Best done by the experts.
- 100 kT of cryogenic liquid.
- Power for 200000 channels of electronics.
- Safety: outer containment in case of breach ?

Final Comments

- Rely on existing documents:
  - Neutrino Facilities Assessment Committee (NRC report). Key Recommendation for next generation: > 1000 km
  - Physics of the Universe report: Interagency response to Quarks and the Cosmos.
  - DOE facilities 20 year plan.

A 21st Century Frontier for Discovery

The Physics of the Universe

A Strategic Plan for Federal Research at the Intersection of Physics and Astronomy

About this Report

In this report the Interagency Working Group on the Physics of the Universe responds to the National Research Council's (NRC) 2002 report, *Connecting Quarks with the Cosmos: Eleven Science Questions for the New Century*. The Physics of the Universe group examines the status of the Federal government's current investments aimed at answering the eleven questions in the NRC report. Based upon that assessment, the group prioritized the new facilities needed to advance understanding in each of these areas. Consistent with a goal of the President's Management Agenda to manage Federal R&D investments as a portfolio of interconnected activities, this report lays out a plan for exciting discovery at the intersection of physics and astronomy.

Summary of Recommendations

Ready for Immediate Investment and Direction Known

Dark Energy

* NASA and DOE will develop a Joint Dark Energy Mission (JDEM). This mission would best serve the scientific community if launched by the middle of the next decade. Studies of approaches to the JDEM mission undertaken now will identify the best methodology.

* A high-priority independent approach to place constraints on the nature of Dark Energy will be made by studying the weak lensing produced by Dark Matter. This is a scientific goal of the ground-based Large-aperture Synoptic Survey Telescope (LSST). Significant technology investments to enable the LSST are required, and NSF and DOE will begin technology development of detectors, optical testing, and software algorithms leading to possible construction with first operations in 2012. NASA will contribute their expertise as appropriate.

* Another priority method to constrain Dark Energy will be to use clusters of galaxies observed by ground-based Cosmic Microwave Background (CMB) and space-based X-ray observations. A co-
...ınd NASA effort using this technique ...ependent verification and increase the ...overall measurements.

...trinos, and Proton Decay

...lead agency for concept develop- ...erground facility. NSF will develop a ...derground science by the end of 2004.

...vill work together to identify a core ...experiments. This will include ...velopment needs for specific experi- ...d technology needs, physical specifi- ...liminary cost estimates.

...d DOE will strengthen numerical ...ch in order to more accurately simu- ...of gravitational waves.

...ade of Laser Interferometer Gravitational wave Observatory (LIGO) and execution of the Laser Interferometer Space Antenna (LISA) mission are necessary to open this powerful new window on the universe and create the new field of gravitational wave astronomy.

Next Steps for Future Investments

Origin of Heavy Elements

* DOE and NSF will generate a scientific roadmap for the proposed Rare Isotope Accelerator (RIA) in the context of existing and planned nuclear physics facilities worldwide.

* DOE and NSF will develop a roadmap that lays out the major components of a national nuclear astrophysics program, including major scientific objectives and milestones, required hardware and facility investments, and an optimization of large-scale simulation efforts.

Birth of the Universe Using Cosmic Microwave Background

* The three agencies will work together to develop by 2005 a roadmap for decisive measurements of both types of CMB polarization. The roadmap will address needed technology development and ground-based, balloon-based, and space-based CMB polarization measurements.

High Density and Temperature Physics

* In order to develop a balanced, comprehensive program, NSF will work with DOE, NIST, and NASA to develop a science driven roadmap that lays out the major components of a national High Energy Density Physics (HEDP) program, including major scientific objectives and milestones and recommended facility modifications and upgrades.

* NNSA will add a high energy high-intensity laser capability to at least one of its major compression facilities in order to observe and characterize the dynamic behavior of high-energy-density matter.

* DOE and NSF will develop a scientific roadmap for the luminosity upgrade of the The Relativistic Heavy Ion Collider (RHIC) in order to maximize the scientific impact of RHIC on High Energy Density (HED) physics.

Acronyms are defined in the text and in Appendix III.

Dark Matter, Neutrinos, and Proton Decay

* NSF will be the lead agency for concept development for an underground facility. NSF will develop a roadmap for underground science by the end of 2004.

* NSF and DOE will work together to identify a core suite of physics experiments. This will include research and development needs for specific experiments, associated technology needs, physical specifications, and preliminary cost estimates.