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A Potential Near-Surface Americas Region ILC Site

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Why are we here?



- The recent discovery of the Higgs Boson at the LHC brings into focus the compelling science case for a staged ILC with a Higgs Factory as the first stage.
- PNNL is excited to contribute & to support the ILC where ever it is built
- The most formidable barrier to the construction of the ILC is cost
- Substantial cost savings could be realized by a near-surface site
- Seek information on the analysis of other at/near-surface construction options – Dubna, Nevada, Hanford
- PNNL campus is adjacent to the Hanford site, PNNL is in a position to represent and explore the details the site may have to offer the ILC
- Seek input to prioritize collection of missing site evaluation information.

Contents



Introduction and background

- Pacific Northwest National Laboratory Overview
- Hanford History
- HEP Program at PNNL
- A discussion of how the Hanford Site compares against the Criteria identified in the ILC Project Implementation Plan
- Very preliminary cost information
 - Construction
 - Operations
- Conclusion
- Discussion of the Path Forward

U.S. Department of Energy National Laboratories



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Pacific Northwest National Laboratory

Pacific Northwest

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- PNNL's origins date back to WW II, Manhattan Project
 - Today DOE Office of Science laboratory





PNNL facts & figures for FY2011



Environmental Science

Energy&

\$1.1 billion in R&D expenditures

- 70% funds from DOE
- More than 4800 staff, including 3000 technical staff
- 1000 peer-reviewed publications
- 50 patents issued



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- Among top 1% of research institutions in publications and citations in:
 - Chemistry
 - Geosciences
 - Physics
 - Engineering
 - **Biology and Biochemistry**
 - Environment/Ecology
 - Materials science
 - **Clinical medicine**
 - Microbiology





PNNL capability broadly applicable to High Energy Physics



PNNL HEP Program includes

- Intensity Frontier
 - Belle/Belle II
 - Mu2e
 - Project X
- Cosmic Frontier
 - CoGeNt/C4 Proposal
 - Seek role on CDMS, COUPP
- Energy Frontier
 - International Linear Collider
- Computing
 - Belle, Belle II, ILC

- HEP Related R&D
 - Neutrino Physics (DOE-SC-NP)
 - Fission TPC (DOE-NE)
 - Extending underground science capability
 - Underground laboratory, low background materials, assay, low noise electronics, radiochemistry, gas handling
 - Improved photocathode R&D
 - Ion processing of Cu, Al to mitigate electron cloud
 - Nuclear LQCD calculations
 - Generic Detector R&D
 - Electronics (rad hard & fast)

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Siting Criteria: ILC Project Implementation Plan

Category	Criteria
Configuration	Usable length and width of about 50km x 1km
	Flat, esp. at interaction region
	Accessible
Vibration and stability	Quiet, minimized natural and cultural
Site Infrastructure	Existing infrastructure to maximize construction and operational efficiency, shops, utilities, etc.
	300 MW, 3000 staff/visitors, cooling water, fuel, waste
	50 tonne transports. Construction logistics
Land Acquisition	Up to 50km x 1km
Environmental impacts	No constraining conditions
Safety and health	Existing local regulations followed.
Regional infrastructure	Construction and operational support. Utilities, access
Risk factors	Seismic faults, lightning, tunnel flooding.
Project and Host responsibilities	Permanent facilities (60% of CF), land, permitting, access easements, utility improvements, etc.
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Hanford Site Est. 1943



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Federally owned 1,517 km²





Hanford Site





- Cascades on the left
- Area scoured clean by Missoula flood ~15K years ago

Hanford Site





- Hydro electric production 13 major dams within 100 miles = 40% of U.S. hydropower production
- Columbia Generating Station 1,150 MW

Hanford Site – LIGO and Highway 240





PNNL is located immediately South East of the Hanford Site

Seas

- 20.000

Minor elevation variation

Figure S-21. Topography of the Hanford Site.





Potential site appears to have less than 50m elevation delta over 30km

An overall Hanford Site characterization completed in 1999.



Figure S-4. Hanford Surface Waste Site Locations (Past and Present).

Figure S-5. Distribution of Hazardous Chemicals in Groundwater within the Hanford Site.

re S-20. Hanford Site Land Ownership.







Minimal water related siting concerns

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Figure 4-13a. Hanford Site and Outlying Areas Water Table Map -- June 1998 (PNNL 1998).



Final HCP EIS

50km machine could be constructed entirely within the Hanford Site boundary



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Multiple configurations possible for 30km layout Pacific Northwest NATIONAL LABORATORY



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Tri-Cities-Access

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 Population of the Tri-Cities metropolitan area was 253,540 based on the 2010 Census
 In 2010, Kiplinger rated the Tri-Cities among the Top 10 best places to raise a family, and CNN/Money ranked the Tri-Cities one of the top 10 best bets for gains in housing value, due to its relatively stable economic conditions.



And the list of those "best of" lists that the Tri-Cities has made is impressive. They include: -- The Tri-Cities leads the nation in per capita Ph.D.'s, with 1,600 doctoral degrees among 7,000 scientists and engineers in the community, most of whom work PNNL in Richland. -- Kennewick's 7-Eleven store was acclaimed the Slurpee capital of world, besting Winnipeg's Slurpee outlet in 2009. The upset ended a nine-year reign by the Canadians.

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Tri-Cities Airport is ~20 minutes from the Hanford Site



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 Multiple daily direct flights
 Domestic service provided by major carriers
 International Connections to

Japan and Europe via Seattle and SFO

(July 2010 - June 2011) ^[3]		
Rank	City	Carriers
1	Seattle, WA	Alaska Airlines operated by Horizon Air
2	Salt Lake City, UT	Delta Connection
3	Las Vegas, NV	Allegiant
4	₩ Phoenix- Mesa, AZ	Allegiant
5	Los Angeles, CA	Allegiant
6	CO Denver, CO	United Express
7	🗽 San Francisco, CA	United Express
8	Minneapolis, MN	Delta Connection operated by Pinnacle and Skywest
9	Portland, OR	Alaska Airlines Operated by Horizon Air

Top nine busiest domestic routes out of PSC



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The Hanford Site has multiple established access routes

Access to the Hanford Site:

- By Road George Washington Way provides direct access to the site with I-82 approximately four miles west.
- By River Barge service is available on site via the Columbia-Snake River System.
 - The Port of Benton has a marine terminal on the Columbia River. A low dock barge facility is primarily used for off-loading United States Navy depleted nuclear submarine and surface ship reactor cores from the Port of Bremerton Naval Shipyards.
 - A high dock is located 100 yards north of the low dock.
- By Rail Rail service is located one mile west.
 - A short line railroad to the Hanford Site is operated via lease to Tri-City Railroad Company with links to Union Pacific and Burlington Northern Railroad.



Low dock and high dock barge offload facilities shown

Reactor core barge route to Hanford Site





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Disposal Site

Port of Benton

OREGON

Navy plans to dispose of USS Enterprise cores at Hanford 2013.





Underground Lab provides low backgrounds for measurements and materials synthesis



effective depth: ~30 mwe ~100 times fewer fast neutrons ~6-fold reduction in muon backgrounds **Electrochemical Purifications** Assembly Machining Measurements HB.

Physical Sciences Facility Shallow Underground Laboratory under construction





- Foundation is 45' below grade.
- Structure is 32'W x 21'H x 204'L.
- Concrete walls 3'; floor 4.5'; ceiling 4'.
- Pictured scope cost ~\$1.7M; excavation, design, steel, concrete



10/02/2008 15:20



Initial cost benchmarks support intuition: Tunneling is more costly than cut-and-cover.

- PNNL has recent cut-and-cover construction experience at the PSF underground Lab.
 - 30km <u>structure</u> like this with varying amounts of high density concrete for shielding would cost ~\$(1.4±0.4)B or, ~\$(14±4)K/ft

Excavation/ground work adds 5%

- Sound Transit Ulink project (Seattle) is building a twinbore segmentally lined 18' diameter tunnels
 - ~15K linear feet. Tunneling cost is \$495M or \$35K/ft.

■ 30km *project* like this would cost ~\$3.8B

- ICaution Exact scope of tunnel contract is not known
- ICaution Extrapolating from 200' to 30km

Electricity cost is a significant advantage of the Hanford site



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Subject Areas 포

Databas

Home 포

Midwest Informatio

Average Energy Pri

Chicago area consumers paid prices above utility (piped) gas in October 2011, as mea reported today. Electricity prices were 18.5 higher. In comparison, Chicago area utility Commissioner Charlene Peiffer noted that t (piped) gas prices narrowed while the diffe this release are not seasonally adjusted; ac



Source: Energy Information Administration, Form EIA-861, "Annual Electric Power Industry Report."

Table A. Average prices for electricity, gasoline, and utility (piped) gas, United States and Chicago area, October 2010 and October 2011, not seasonally adjusted

		October 2010			October 2011		
	United States	Chicago area	Percent difference	United States	Chicago area	Percent difference	
Electricity (per Kwh)	\$0.127	\$0.145	14.2	\$0.130	\$0.154	18.5	
Gasoline per gallon	2.843	2.966	4.3	3.521	3.561	1.1	
Utility (piped) gas per therm	1.069	0.833	-22.1	1.047	0.855	-18.3	

NOTE: A positive percent difference measures how much the price in the Chicago area is above the national price, while a negative difference reflects a lower price in the Chicago area.





There are significant near term and life cycle cost advantages of locating and operating an accelerator at Hanford

Comparison between Richland and 5 other U.S. areas Initial construction Regional construction costs are 10%-15% lower at Hanford Estimate additional savings of shallow vs tunneling on Hanford could be ~\$(2.4±0.4)B for 30km Shallow construction costs ~(40±10)% of tunneling costs Life Cycle Operations Electricity – annual bill could be up-to 50% lower Regional price differential is 10% - 15% on non-PNNL labor. All other factors considered not materially different ES&H, staffing, user support

Regional price factors in DOE construction



Location Adjustment Method

- Derived "relative area cost factor" to adjust construction unit costs for regional price variations in materials and wages
 - SC-28 methodology using relative factor that enables easy comparisons within the data set
 - Oak Ridge, TN is the "cheapest" and serves as reference point



Key Findings (Continued)

Geographic location is the primary driver behind differences in

construction unit costs within the data set. Space types (e.g. office, lab, clean room, data center) and

- acquisition methods appear to be the primary drivers behind differences in construction unit costs between Third-Party and Line Item projects.
- Abnormal price escalation and volatile market conditions are tertiary drivers behind differences in construction unit costs within the data set:

Unprecedented period for construction costs 2005-2011

- Extreme rates of escalation 2007-2008
- Negative escalation 2009-2010 Depressed contractor bids 2008-2011

Coffice of Science

Summarv

Lab	Factor
ANL	1.4798
BNL	1.5264
FNAL	1.4491
JLAB	1.0712
LBNL	1.4975
ORNL	1.0000
PNNL	1.2341
PPPL	1.4162
SLAC	1.5899

Source: RSMeans "QuickCost Calculator" accessed Sept. 2012 at http://www.rsmeans.com/calculator/ index.asp?specialUser=FSONL *Note: Normalized to OakRidge (Zip: 37831)

Siting criteria – Hanford Site

Pacific Northwest

Category	Criteria	Hanford
Configuration	Usable length and width of about 50km x 1km	A 50km x 1km alignment exists within the Hanford Site boundary
	Flat, esp. at interaction region	Less than 50m variation over the 30km
	Accessible	Established highway and other access points adjacent to potential site
Vibration and stability	Quiet, minimized natural and cultural	Regional seismicity is minimal. Known fault does exist.
Site Infrastructure	Existing infrastructure to maximize construction and operational efficiency, shops, utilities, etc.	Several large/complex projects currently underway.
	300 MW, 3000 staff/visitors, cooling water, fuel, waste	Nuclear, Hydro power.
	50 tonne transports. Construction logistics	Barge, rail and trucking infrastructure to support construction up to 2,000 tonne capabale
Land Acquisition	Up to 50km x 1km	Land is currently controlled by DOE
Environmental impacts	No constraining conditions	ALE reservation to WTP present a full range of Environmental challenges
Safety and health	Existing local regulations followed.	National laboratory, high radiation work environments provide local safety and health experience
Regional infrastructure	Construction and operational support. Utilities, access	All typical construction and operational support infrastructure is available at the Hanford Site
Risk factors	Seismic faults, lightning, tunnel flooding.	Not significant factors
Project and Host responsibilities	Permanent facilities (60% of CF), land, permitting, access easements, utility improvements, etc.	National Laboratory, several large/complex projects underway

Conclusion



- PNNL is the largest DOE SC Laboratory with diverse capability and a nascent HEP program contributing to all three Frontiers
- PNNL is adjacent to the DOE owned Hanford site
- Hanford/near-surface site has many virtues
 - 50 km ILC fits on site
 - Site is well characterized seismically stable, very flat
 - EIS from Hanford Site Comprehensive Land Use Plan
 - Inexpensive power and below average labor costs
 - Construction and Transportation infrastructure
 - Estimate additional savings of near-surface vs tunneling on Hanford ~\$(2.4±0.4)B for 30km - shallow construction ~(40±10)% of tunneling costs
- We need your expertise, advice, and support to proceed to develop the near-surface ILC site evaluation
- Seek input to prioritize collection of missing site evaluation information

Technical issues affecting configuration

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	Double Tunnel	Single Tunnel	Near Surface
Distribution of Klystrons			
Klystron to Accelerator interface			
Life Safety			
Water control			
Egress			
Radiation control			
Environmental controls			
Access control			
Constructability			
Utility Connectivity			

- Does near-surface Hanford site enable technical decisions to be revisited to realize additional cost savings?
- Deep site construction rate limited by tunnel access. Does shallow site allow compressed time scale (and reduced cost)?

Shortcomings of Hanford Site



- 50km structure just barely fits on Hanford Site.
- No large resident Linear Collider community
- ALE and Waste sites border proposed alignment
- Shielding and environmental controls risks at surface
- Ease of access vs access control

Our knowledge is shallow – just scratching the surface. Is that deep enough?