LIGO Laboratory

- Hanford, WA Observatory Site

Gravitational Wave Searches

- Merger of Neutron Star, Black Hole (NS-NS, NS-BH, BH-BH)
  - » Signal is minutes-long and characteristic shape
- BH birth from Supernova, Starquake in NS
  - » Short, unknown signal profile
- Periodic Sources (from rotating pear-shaped compact objects)
  - » Very faint, requires highly directed search
- Primordial GW
  - » Correlation between multiple observatories

LIGO Organization

- LIGO Laboratory (Tier I)
  - » Laser Interferometer Gravitational Wave Observatory
  - » Caltech/MIT principals under NSF Cooperative Agreement
  - » Sites at Hanford, WA and Livingston, LA
- LSC (Tier II)
  - » LIGO Scientific Collaboration
  - » >26 institutions, ~350 people
- LDAS
  - » LIGO Data Analysis System - developed by LIGO Laboratory in concert with the Collaboration

LIGO Data Analysis System

Welcome to the LDAS Hanford Web Site

SOFTWARE
LDAS Software Index
LDAS/LSC Software Development
LDAS Problem Reporting System
User Access Tools
LDAS Bulletin Board

HARDWARE
Coming Soon

GETTING STARTED
How to Build LDAS
How to Configure LDAS
How to Test LDAS
LDAS Operator Commands
LDAS User Commands

DATA
Frame Archive
LDAS Database

LOG TOOLS
LDAS API Run Status
Electronic Logs

Present Site | LIGO LDAS Site | LSC LDAS Site | LIGO Laboratory Site

LDAS Hanford Log Files	Current	Previous	Past
controlmonitor API	View	View	View
datacondition API	View	View	View
eventmonitor API	View	View	View
frame API	View	View	View
lightweight API	View	View	View
manager API	View	View	View
metadata API	View	View	View
mpi API	View	View	View
wrapper API	View	View	View

LIGO Data Growth

- LIGO I Engineering Runs: 1999 - 2002
  - » 15 TB and growing
- LIGO I Science Run: 2002 – upgrade shutdown
  - » 200 - 300 TB/yr
- LIGO Upgrade: 2006(?) +
  - » several PB/yr

What are the Data?

- Continuous Time series
  - » 16 kHz, 160 Hz, 1 Hz....
- 1% Gravitational wave strain channel, plus ...
  - » 99% other channels (5000+ channels)
    - – Environmental -- ***Seismic, Acoustic, Meteorological, Electromagnetic, Cosmic ray***, ...
    - – Engineering, Housekeeping, Health, Status, ...
- Analysis performed in both Time/Fourier domains
  - » Single or few channels over a long time vs. many channels over a short time span
  - » Need to cache, catalog, replicate, this virtual data

Data processing challenges

- Signal Processing of “all data”
  - » [5-50 Mflop/byte] for compact binary coalescence search of GW channel
  - » x [0.2 TB/yr] total cleaned GW channel for LIGO 1
  - » System pipelines, Menu supported analyses, Personal analyses
  - » Estimation of required resources, cost, time to delivery, etc.
- LIGO archive (200 - 300 TB/yr)
  - » Transposed, Reduced, Filtered & other caching
  - » Metadata replicas [2 TB]
  - » Clients requesting data
  - » Clients adding data

Data processing challenges

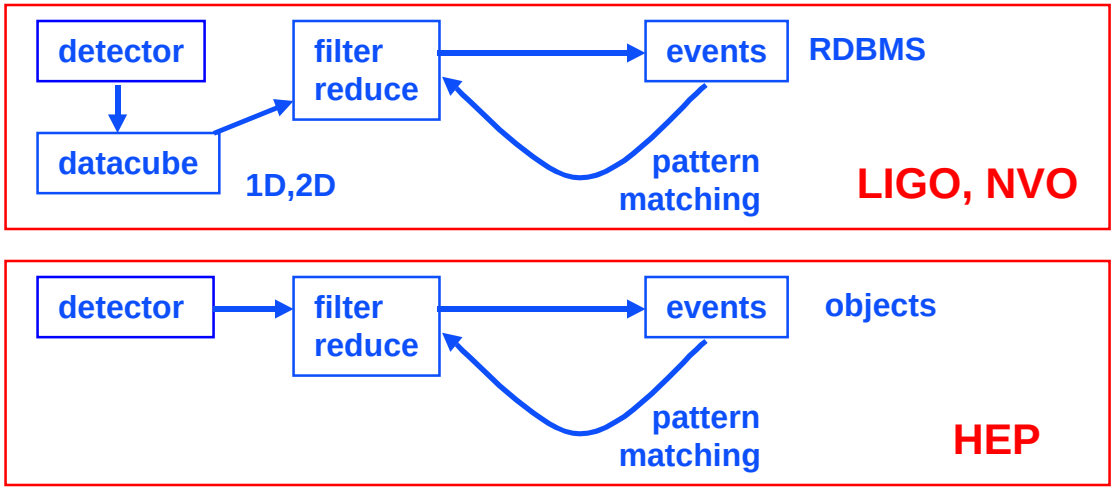
- Blind all-sky search for periodic sources
  - » Need to transform data for every sky direction, frequency, d^n/dt^n [frequency], (n=1,2,3..)
  - » Petaflop+ problem if the full scientific content of the data is to be exploited
- Global gravitational wave detector array
  - » Establish a network of interferometers
  - » Coincidence analysis using a phased array and coherent signal processing
    - – Phased array introduces new parameters into the analysis -- increases dimensionality of the search 10X - 100X
    - – Sky position sensitivity to searches
    - – Wave polarization
    - – Cross-spectral correlations of noise
  - » Virgo (France/Italy), GEO (Germany/UK)

Services from a Grid

- Distributed Computing Power
  - » Code development sandbox
    - – Also menu & parameter driven processing
  - » Compute-intensive background jobs
    - – “Pulsar@GriNhyN” project
  - » How to make code portable, migratable within a grid
- Virtual Data
  - » Data, Catalog, Reduced Data, Mirror
  - » From browsing to “all data”
  - » Data transformations

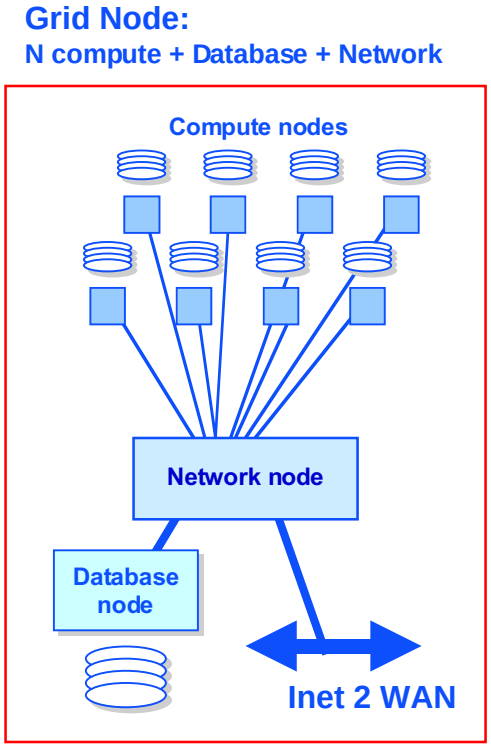
LIGO vs NVO vs HEP

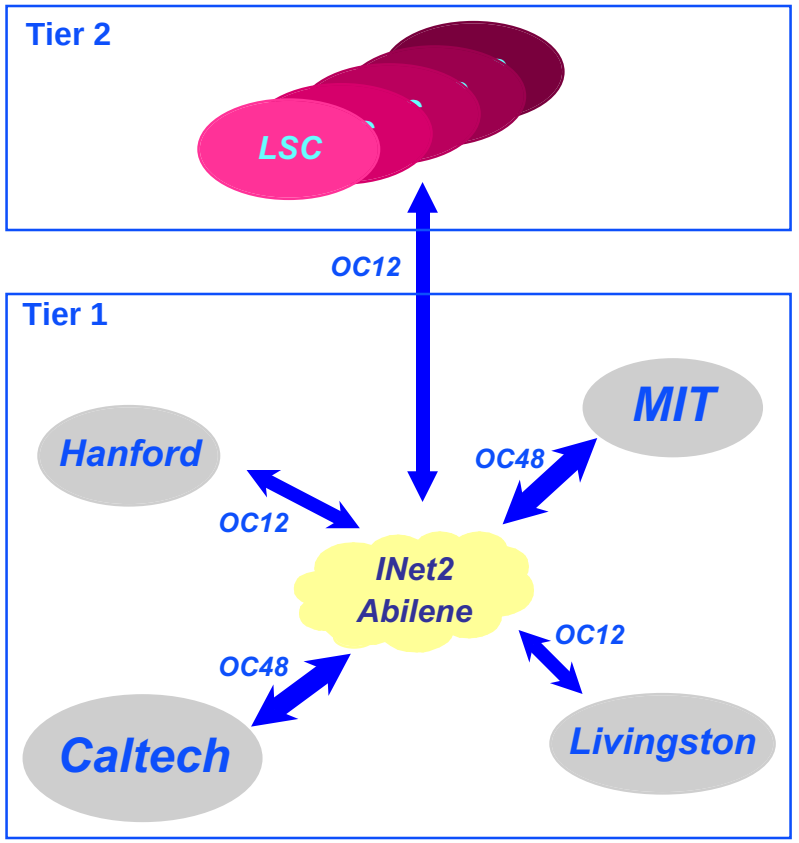
- Processing



- Network
  - » NVO is **federation**, LIGO is **coincidence**
  - » In both cases **registration** is important

Architecture





Needs

- **Infrastructure to enable dispersed groups of collaborators to work without barriers**
  - Need for “trickle down” of resources to smallest universities
  - Data mirroring to reduce time-to-access, cost-to-access
  - High bandwidth connections
- **Infrastructure support personnel**
  - Multiple Tier 2 centers imply some level of redundant support infrastructure needed
    - IT staff
    - Programming staff
    - Research staff
  - The price for distributed vs. monolithic computing infrastructure
  - Benefits outweigh costs