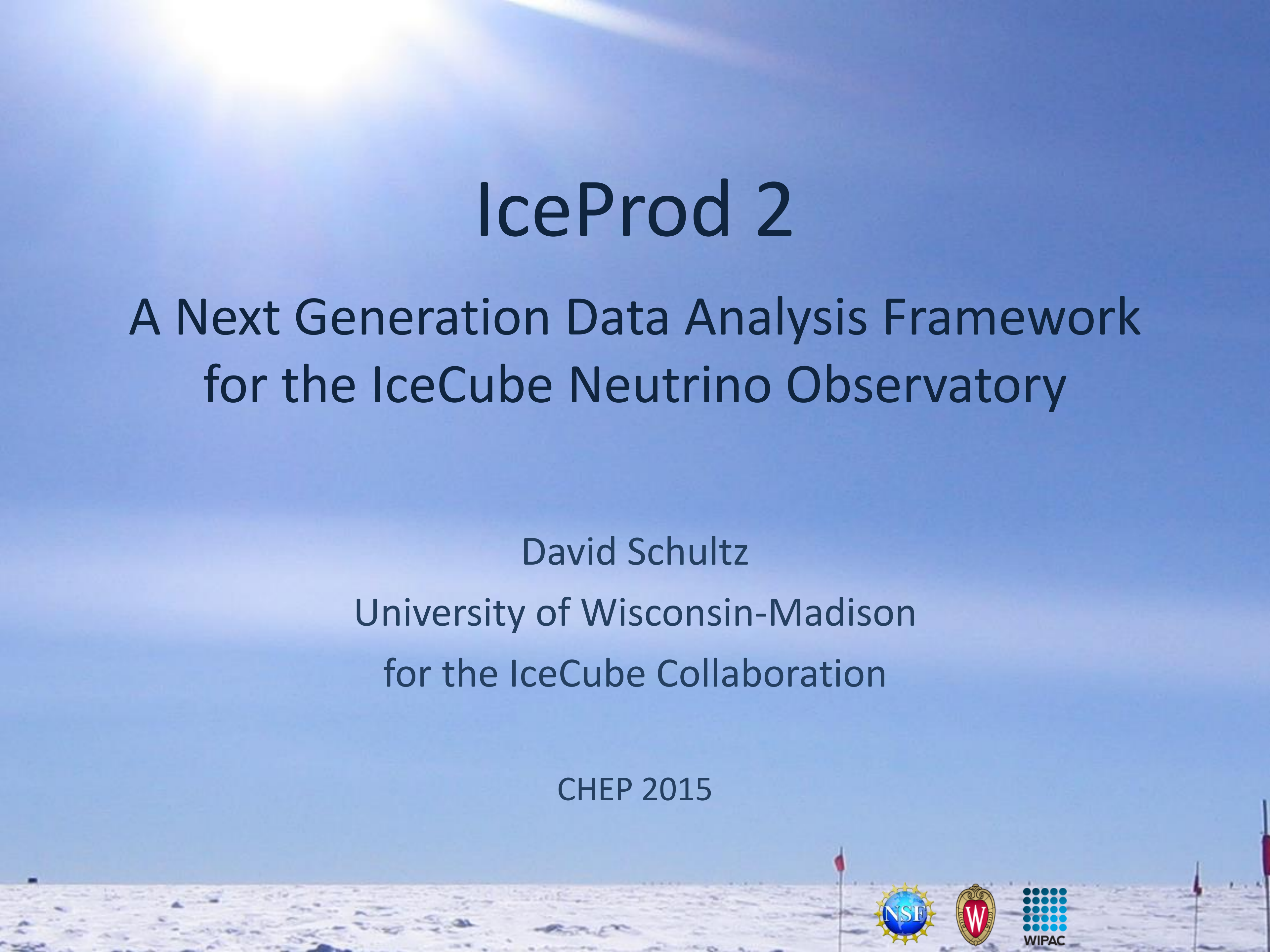

IceProd 2

A Next Generation Data Analysis Framework for the IceCube Neutrino Observatory

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for the IceCube Collaboration

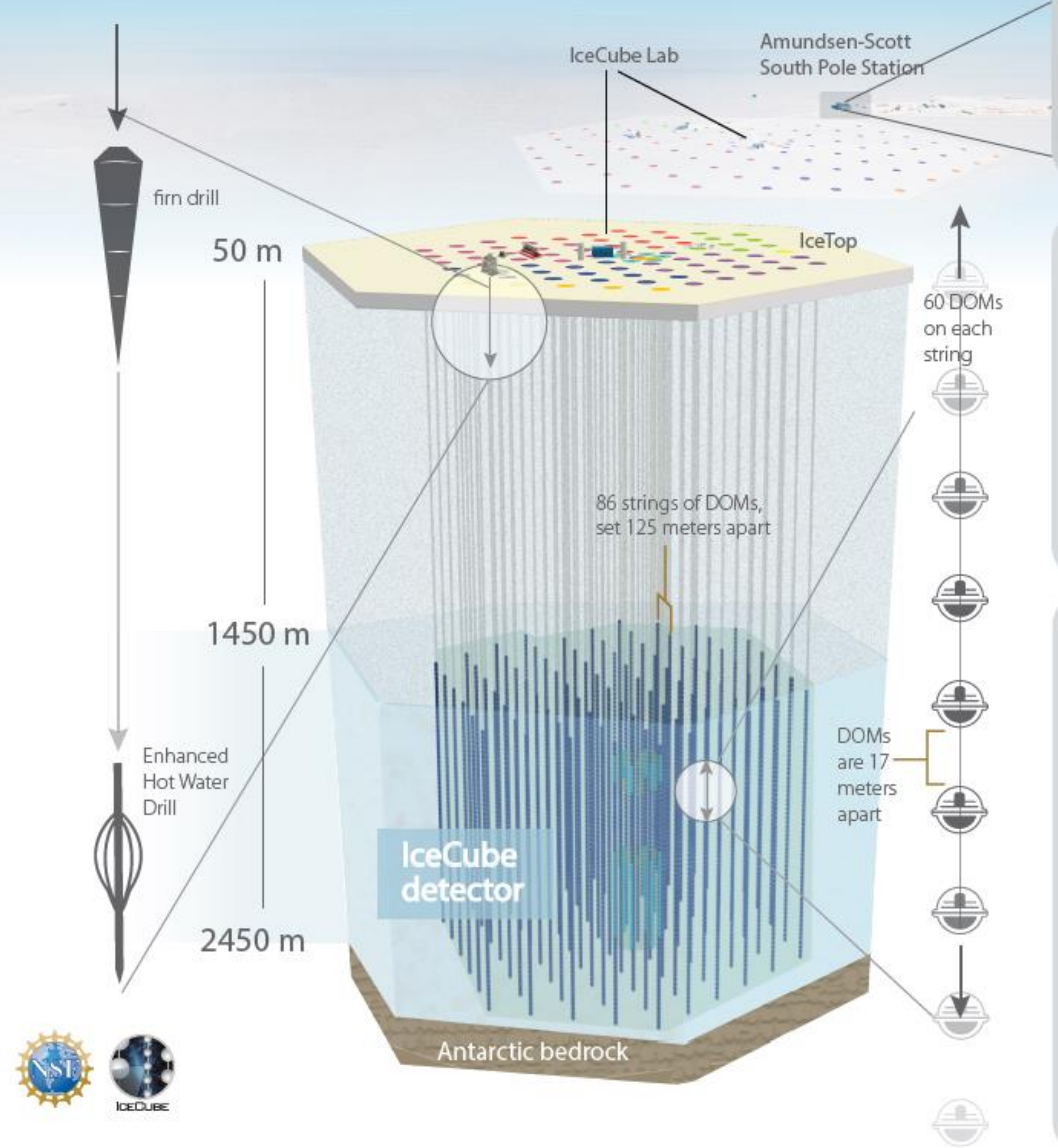
CHEP 2015

Outline

- IceCube and Computing
  - Requirements for a production system
- IceProd's Evolution
  - The long way from v1 to v2
- Status and Future Plans
  - Where do we go from here?

The IceCube Neutrino Observatory

Design and construction

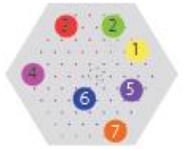


Detector Design

- 1 gigaton of instrumented ice
- 5,160 light sensors, or digital optical modules (DOMs), digitize and time-stamp signals
- 1 square kilometer surface array, IceTop, with 324 DOMs
- 2 nanosecond time resolution
- IceCube Lab (ICL) houses data processing and storage and sends 100 GB of data north by satellite daily

Detector Construction

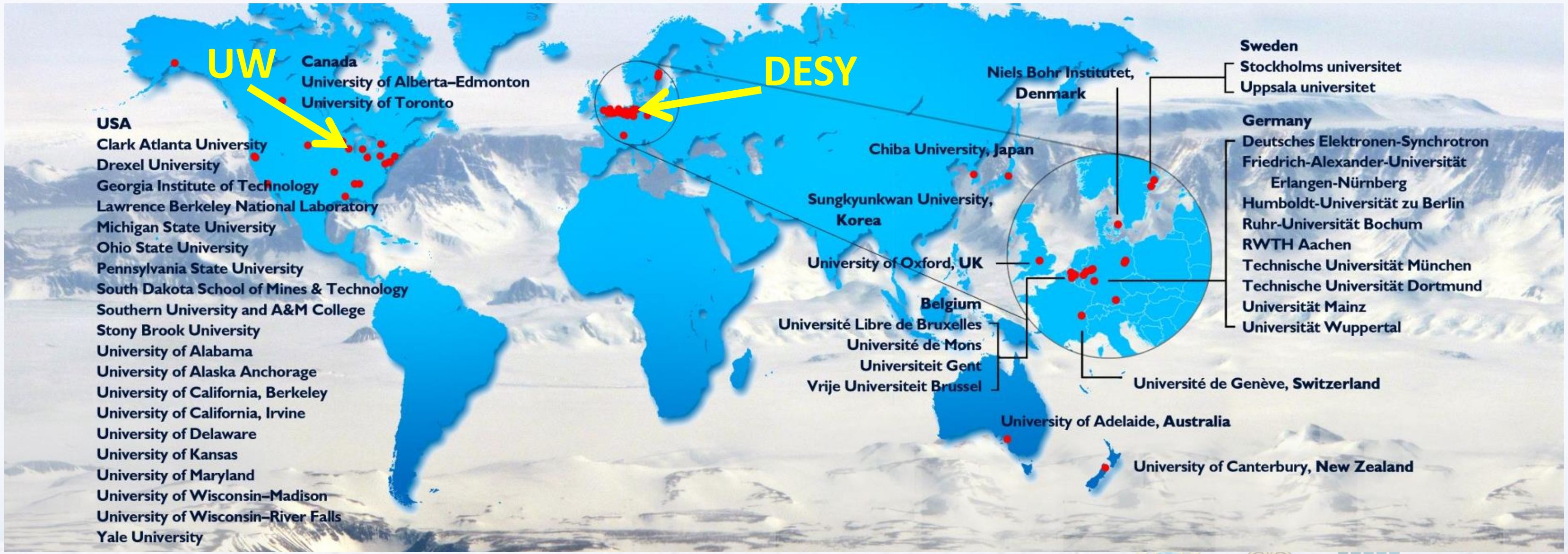
7 seasons of construction, 2004-2011



- 28,000 person-days to complete construction, or 77 years of continuous work
- 2.1 million kilograms of cargo was shipped, 0.5 million of which was the drill
- 48 hours to drill and 11 hours to deploy sensors per hole
- 4.7 megawatts of drill thermal power with 760 liters of water per minute delivered at 88 °C and 7,600 kilopascals

IceCube Computing

- Medium size collaboration
  - 2 data centers and several smaller clusters
  - Most CPU compute is opportunistic
  - We can’t mandate that package X be installed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IceCube Computing

- Diverse set of resources
  - Heavily invested in GPU accelerators
  - Some job types need:
    - 6+ GB of memory
    - 100 GB of disk
    - Long walltime

Some Requirements

1. Anything that requires root permission at a site is unlikely to work
   - We're not big enough to enforce policy, we only get an account on the submit node
2. Need more than just glideins
   - Many smaller sites don't have the setup for this
   - We do use it where we can

Some Requirements

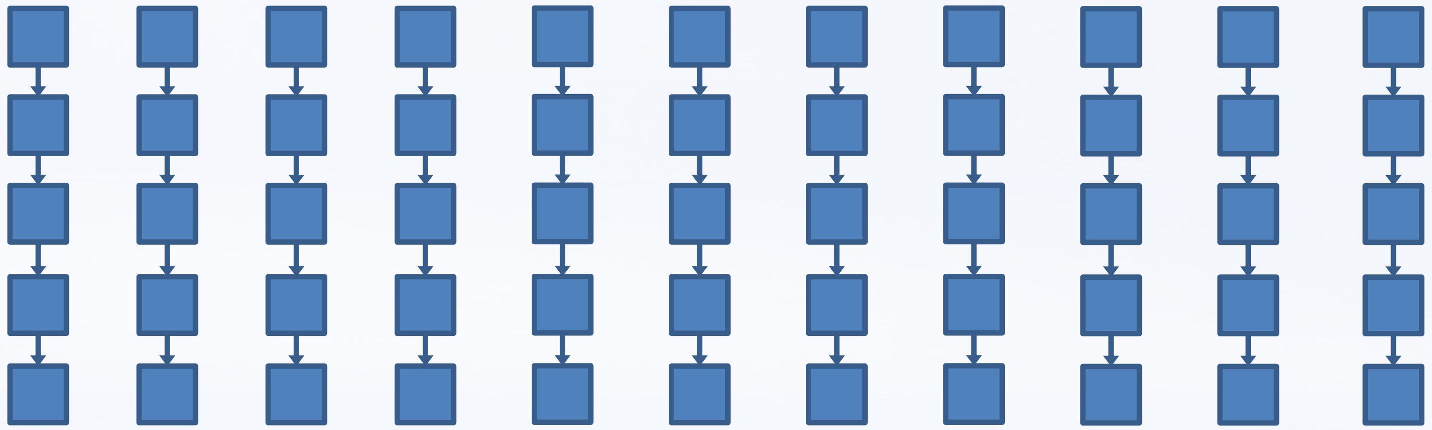
3. Must support multiple OS types, schedulers
   - SL, Ubuntu, SUSE; HTCondor, PBS, SGE, SLURM, …
4. Site-local disk mostly isn't available
5. Need to record all details about a job, forever
   - What is the configuration, where did it run, resource usage, efficiency, …

Other Goals

- A tool for single analysis as well as production
  - Individual users often submit 1M+ jobs for an analysis now
- Production debugging
  - Get the same environment as production, but offline

A Note about Workflow

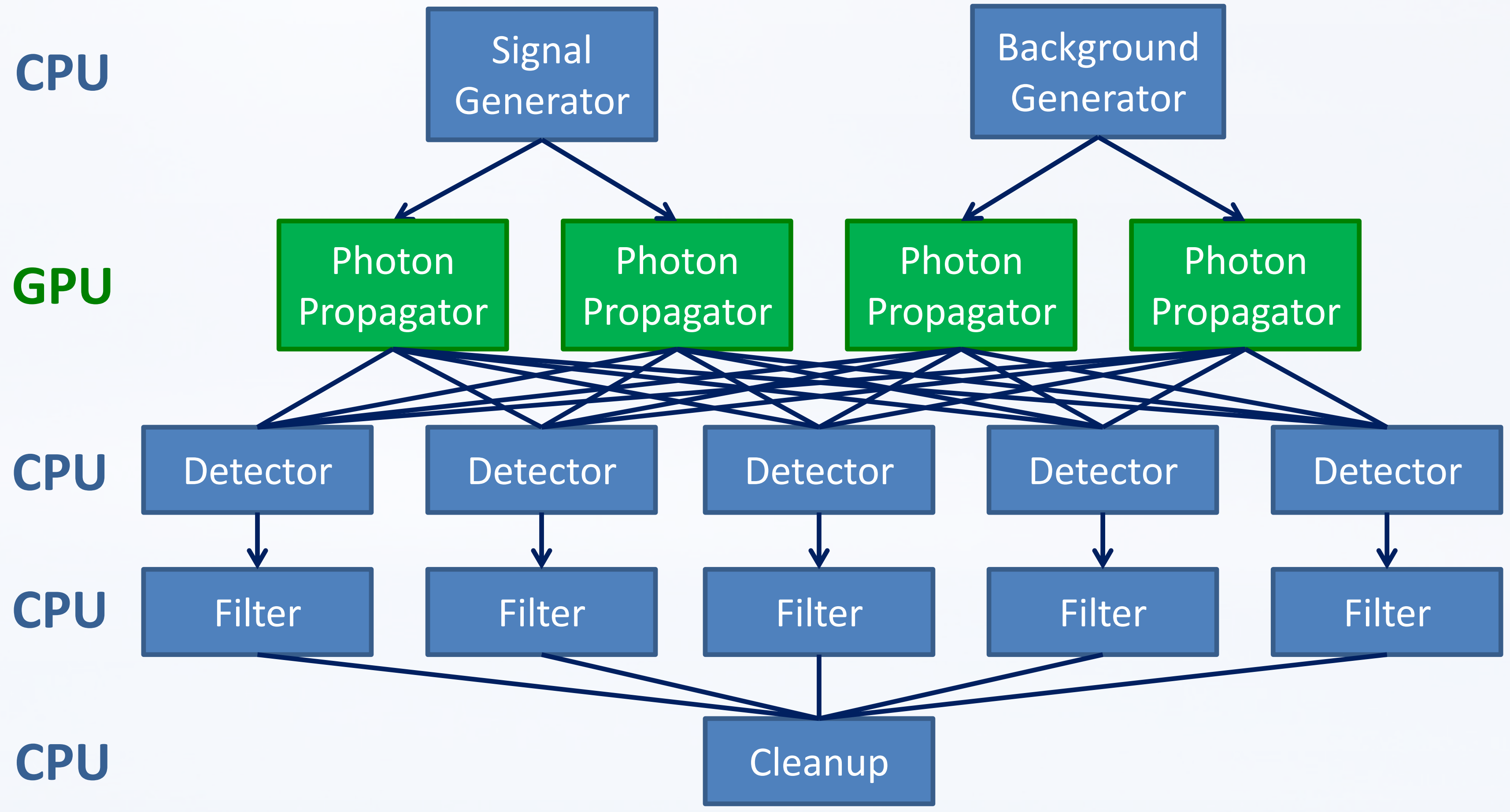
- Job sets are typically 1k - 100k parallel streams
  - Each stream has multiple jobs



- Typical to have 10s to 100s of job sets running at the same time

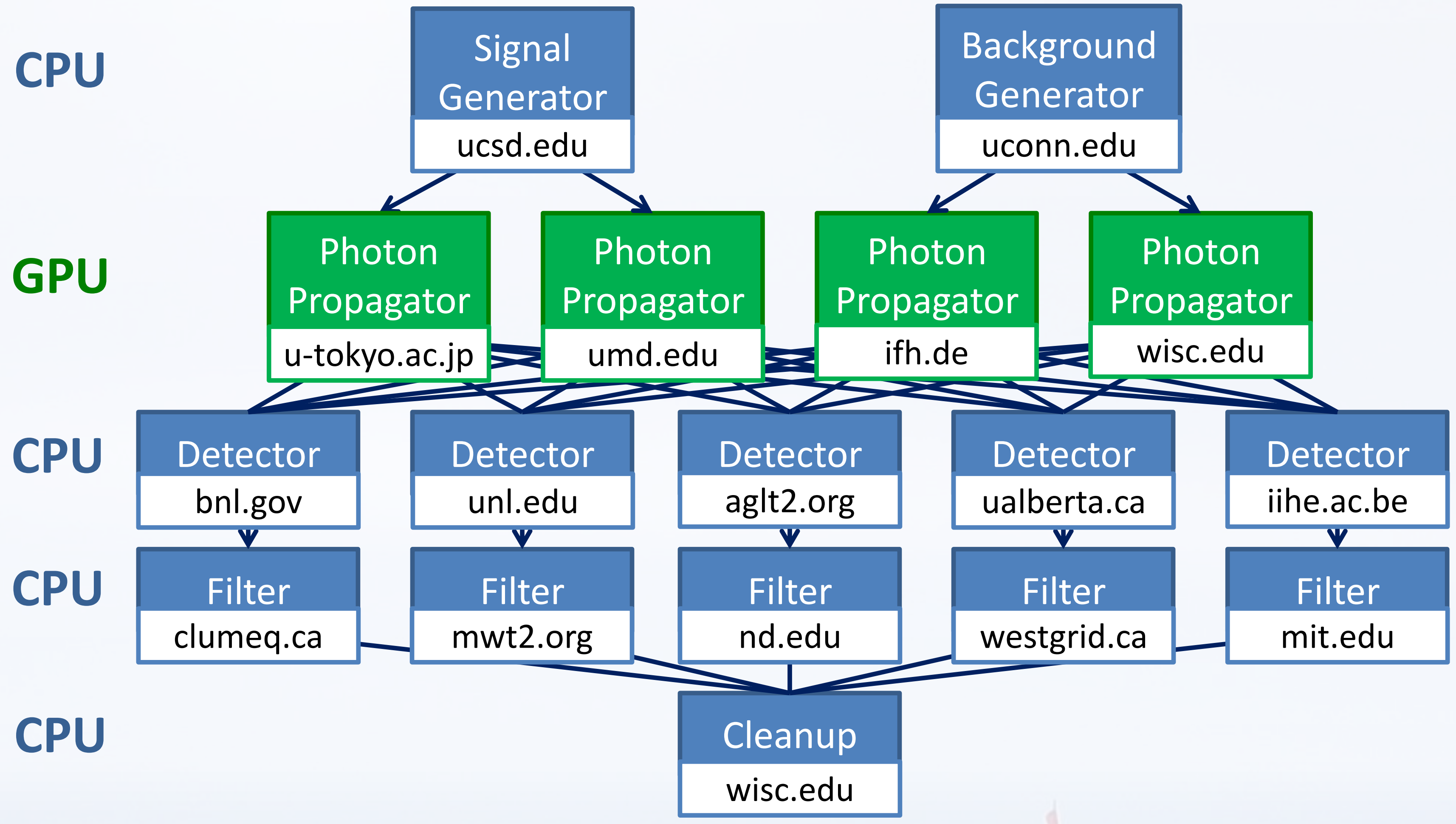
Job DAG

(directed acyclic graph)



Job DAG

(directed acyclic graph)



IceProd v1

- Site-local python daemons backed by a central database
- Plugins for each batch system
- gridftp/http directly to/from main data center
- XMLRPC to communicate with jobs
- Store configuration and statistics for every job

IceProd v1 Additions

- Initially, no concept of job inter-dependencies
  - Added about 3 years ago
  - Can do cross-site linking as of 1.5 years ago
- GPU-specific resources tacked on
  - Does not translate well to other resource types
- CPU/GPU normalization and reporting as of ~1 year ago

IceProd v1 Problems

- A long series of patches to increase functionality
- Early design decisions hampering new ideas
- Multiple bottlenecks appearing:

  DB - locking issues, queries per second

  Queue - designed for 100 jobs per hour, not 10k

IceProd v2

- Complete rewrite of codebase
  - Current usage is standard instead of extra feature
  - Focus on unit tests, documentation
  - Support for Python 3

Database

- Local SQLite database at each site
  - Can run completely standalone
  - Outage of master not a problem
  - Spread load out

Single-site

- Single-site installation in minutes
  - For individual users, or testing
  - Only requires Python
  - Installation as simple as:

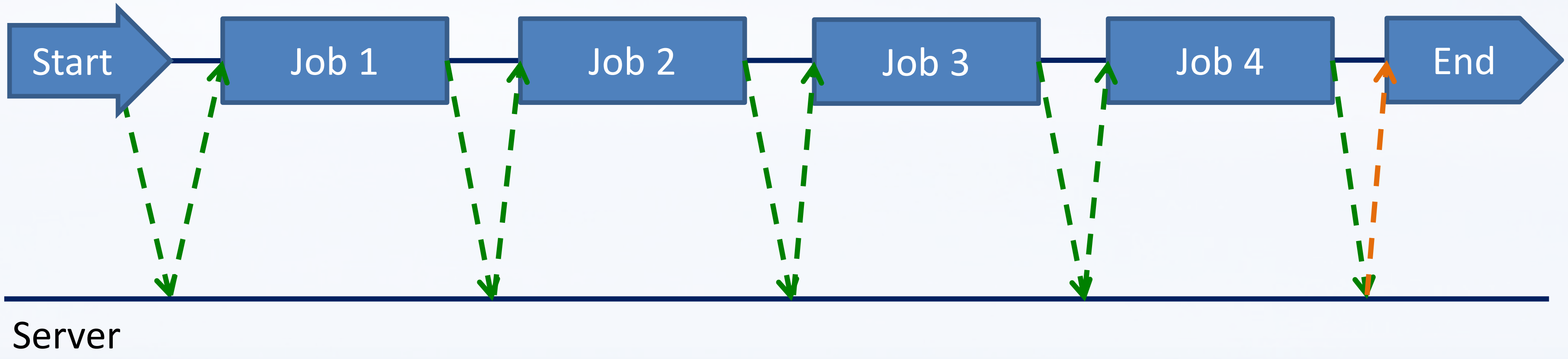
```
svn co iceprod; cd iceprod; bin/iceprod_server start
```

Software Distribution

- Better production software distribution
  - CernVM FileSystem (CVMFS) as primary method
    - Natively if possible (thanks to ATLAS/CMS)
    - Parrot user-level remote I/O otherwise
  - Software tarballs still accepted, but deprecated

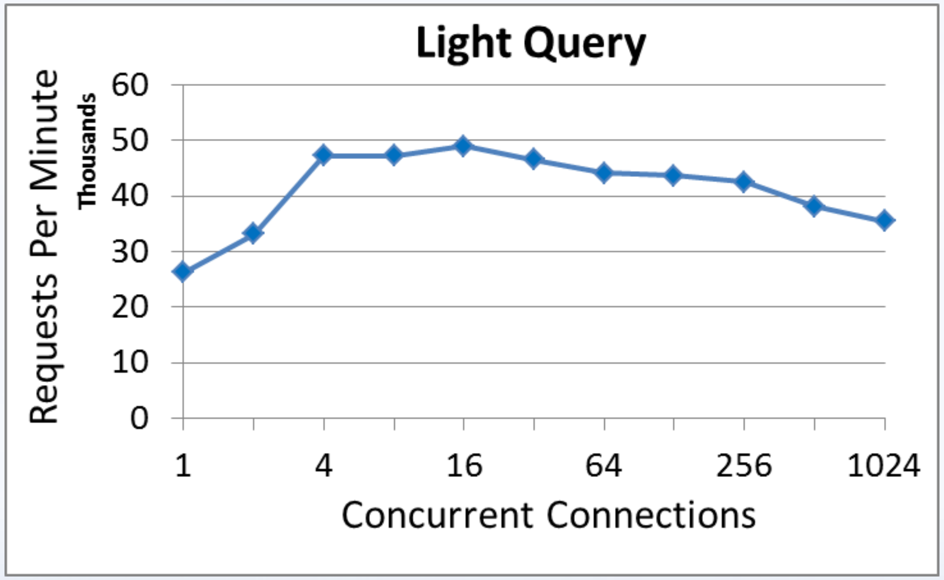
Job Optimization

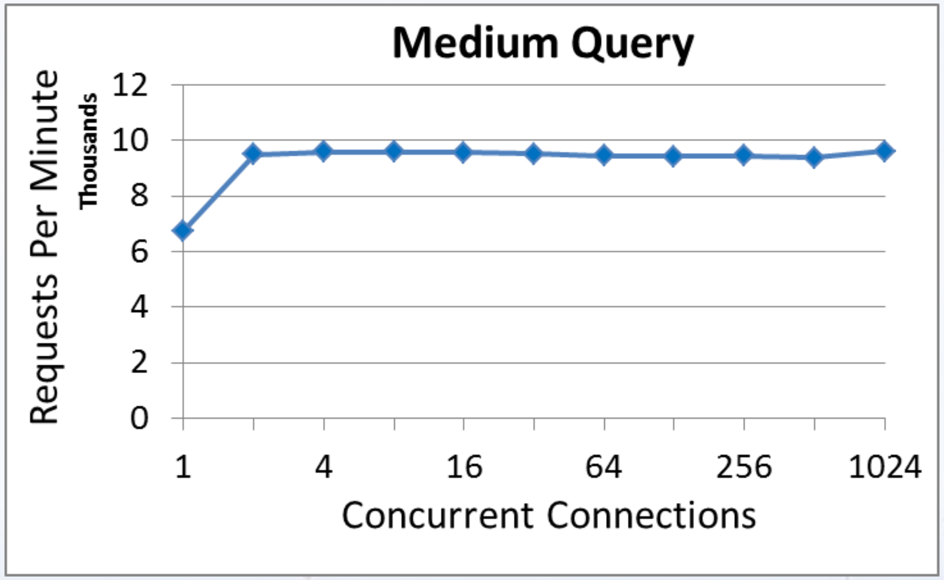
- Pilots
  - Run multiple shorter jobs serially without taxing the batch system
  - Better match between jobs and node resources



Scalability

- High-volume communications
  - Web server able to handle more than 10k connections per minute in a single thread





Users and Priority

- Multiple users
  - IceProd v1 doesn't have a concept of users, if you can log in you can do anything
  - IceProd v2 needs to support analyzers who shouldn't be able to modify other users' jobs
- Fair-share Priority
  - One set of jobs shouldn't completely starve all other jobs of resources

Web API

- JSON API
  - Many operations available either read-only or with authentication
    - Job set submission, monitoring, editing, removal
    - Job statistics (summary or for each job)
- Web / Mobile Focus
  - Integrated support for phones and tablets for management tasks

Status and Plans

- Currently in beta, initial deployment in the next few months

- Future:
  - Get analyzers in the collaboration to join
  - Work with other projects to adopt IceProd
    - Currently existing MoU with High Altitude Water Cherenkov (HAWC) gamma-ray observatory
    - We welcome others

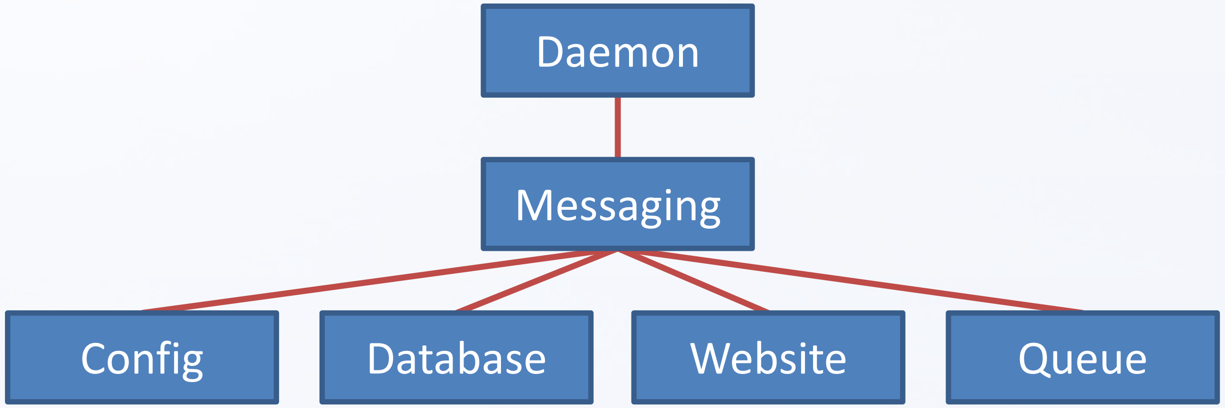
Summary

- IceCube has heterogeneous, uncontrolled resources and diverse job types
- IceProd2 can work on all of these
  - Easy to install user-level middleware
  - Simple to manage and monitor large sets of distributed jobs
  - Designed to scale from tens to millions of jobs

Questions?

Backup

Server Layout



- Each module in its own process
- ZeroMQ messaging between modules
- Hot config changes

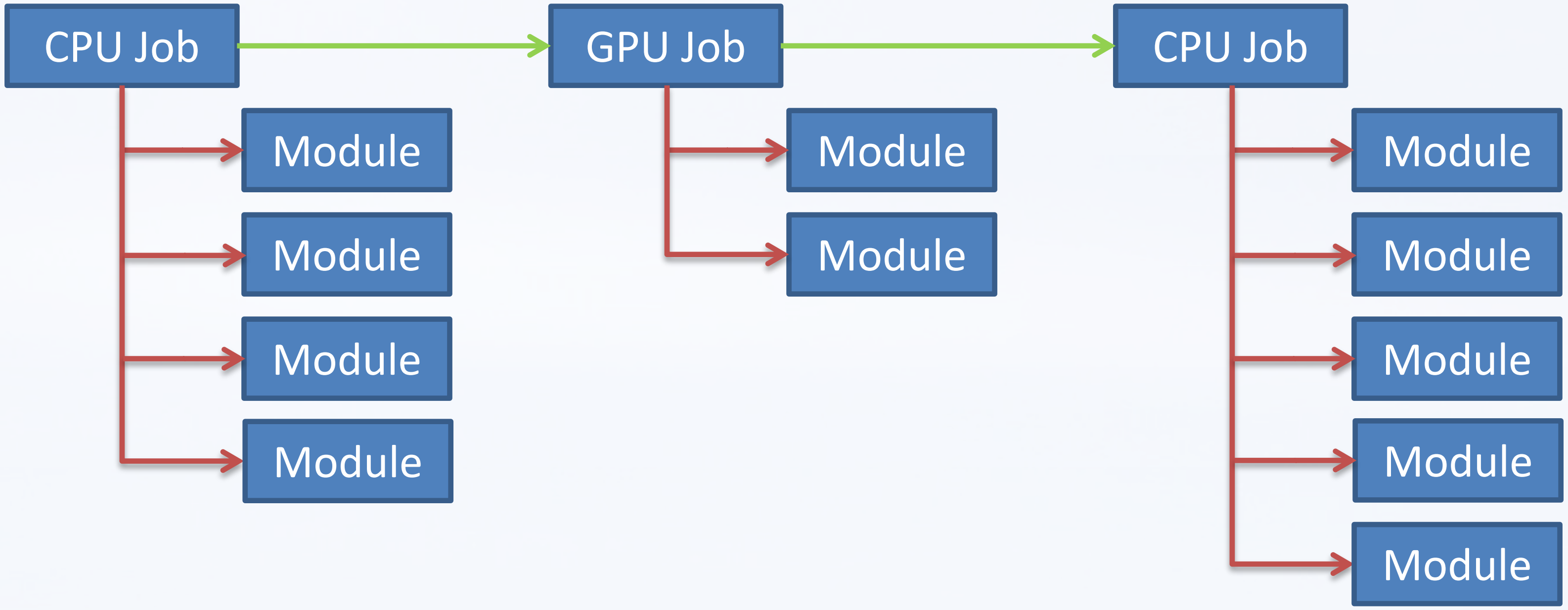
Pilot

- Can run a job config, or ask the server for jobs

```
if config
    run config
else
    check node resources
    loop forever
        ask for job matching resources
        run job or exit if no job
```

Modules

- Each job can be broken up into modules
  - Modules easily reordered, copied to other jobs


CPU Job
GPU Job
CPU Job
Module
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