

# Computing and Networking for the Belle II Experiment

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# Belle Computing deployed at PNNL in response to earthquake & tsunami

- ▶ Following the earthquake & tsunami of March 12, 2011, electrical power available to KEK was dramatically reduced, and most of Belle computing – centralized at KEK – was offline.
- ▶ DOE-supported Belle computing at PNNL came online July 2011.
- ▶ Belle Analysis Software Framework installed on 1500 core cluster with 1 pb disk/1 pb type  $\approx$  BCOMP KEK
  - Data + 1x Y(4S) + 1x Y(5S) MC sample populated via scp from KEK
  - 3x MC Y(4S) + 2x MC Y(5S) + 150x Rare MC generated at PNNL
  - 90+ Belle users with PNNL accounts



# Significant strength and depth in High Performance Computing and Computational Science

- ▶ Deep in data sciences; especially strong in visual analytics and real-time HPC
- ▶ Development of massively parallel simulation codes
- ▶ Critical mass in computer science and applied math – especially strong in performance, power and reliability
- ▶ Institutional hardware includes 160 TF Olympus HPC cluster and archive storage – available to ALL staff and their collaborators
  - Programs may buy nodes or storage, “own” those resources = priority usage
- ▶ Redundant access to ESnet
- ▶ LEED Gold-certified facility using groundwater heating and cooling



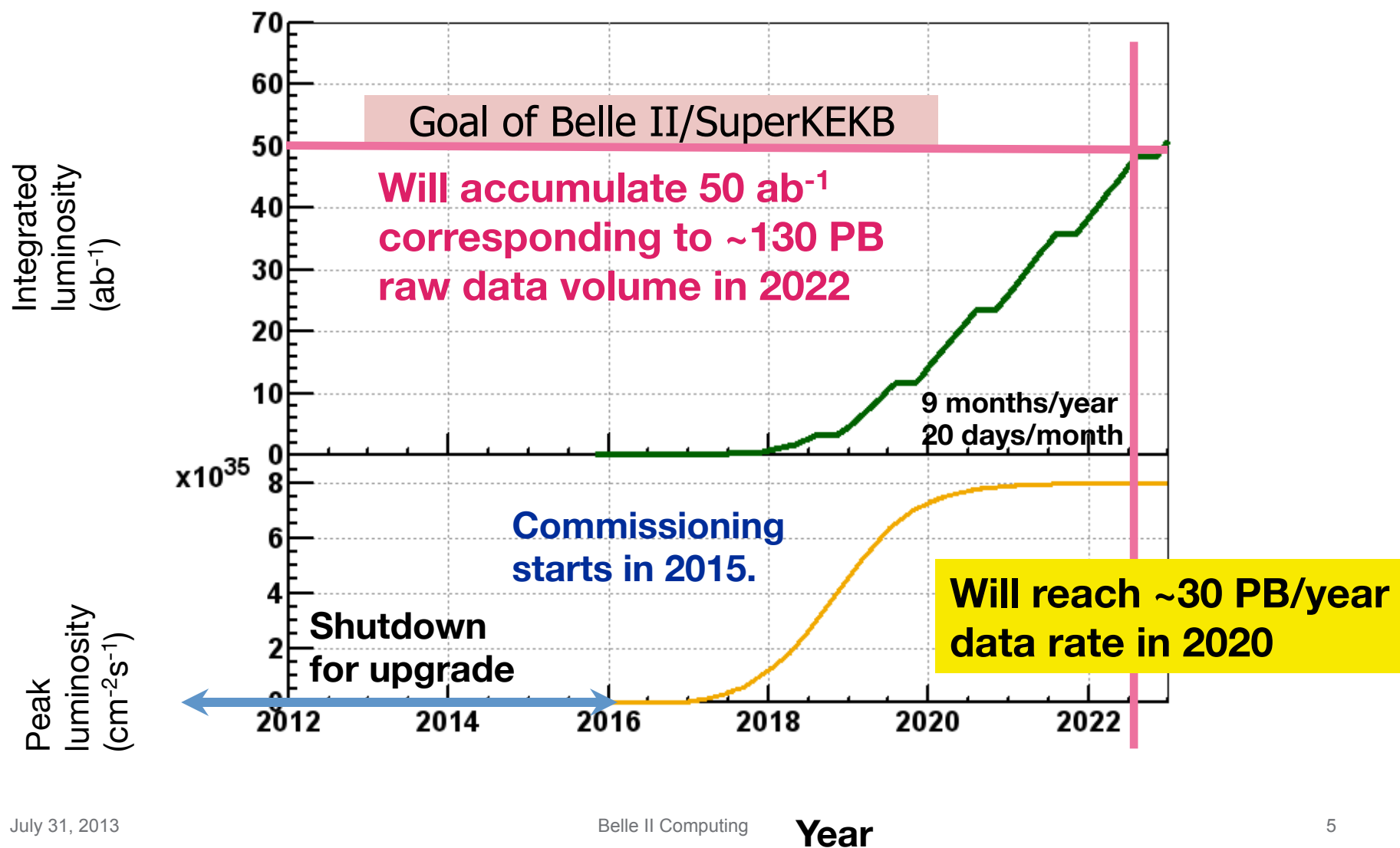
- 624 → 800 compute nodes
- 32 cores per node (20k cores)
- 2 GB of memory per core
- 4/3 PB of storage on disk/tape

# Expected data rates from the Belle II experiment are high. Expected to exceed the sum of the CERN Large Hadron Collider experiments

Experiment	Event Size [KBytes]	Rate [Hz]	Rate [MBytes/s]
High rate scenario for Belle II DAQ:			
Belle II	300	6,000	1,800
LCG TDR (2005):			
ALICE (HI)	12,500	100	1,250
ALICE (pp)	1,000	100	100
ATLAS	1,600	200	320
CMS	1,500	150	225
LHCb	25	2,000	50



# Projection of Data Volume/Rate at SuperKEKB

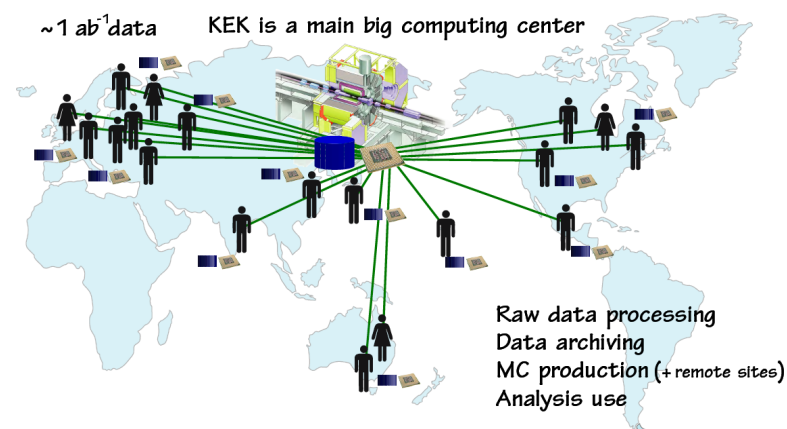


# Evolution from Belle to Belle II Computing

- ▶ Belle Experiment ran from 1999-2010 with computing centralized at KEK
- ▶ Belle II: 50 times more data requiring ~50 times more computing resources, distributed collaboration

Belle II Collaboration adopted a distributed computing model based on the grid

- ▶ More complicated, requires more effort to set up and maintain
- ▶ Allows Belle II members to contribute via computing facilities in their own country
- ▶ It provides redundancy
- ▶ The distributed infrastructure already exists → Use existing grid sites and services (gLite, EMI, OSG, DIRAC)



Profit from experience of LHC experiments and their well established and mature solutions



# Grid Sites in Belle II Collaborating Countries

Country	Sites	Belle VO	Comment
Australia	Tier 2/3	Supported	Cloud system planned
Austria	Tier 2		
China	Tier 2		DIRAC Server
Czech	Tier 2	Supported	
Germany	Tier 1/2	Supported	
India	Tier 2		New data center planned
Japan	KEK	Supported	
Korea	Tier 2	Supported	
Poland	Tier 2/3	Supported	Cloud system developed
Russia	Tier 2		
Slovenia	Tier 2	Supported	
Taiwan	Tier 1/2		
USA	OSG	Supported	PNNL site with DIRAC server

# Computing Tasks

## ▶ Raw data processing

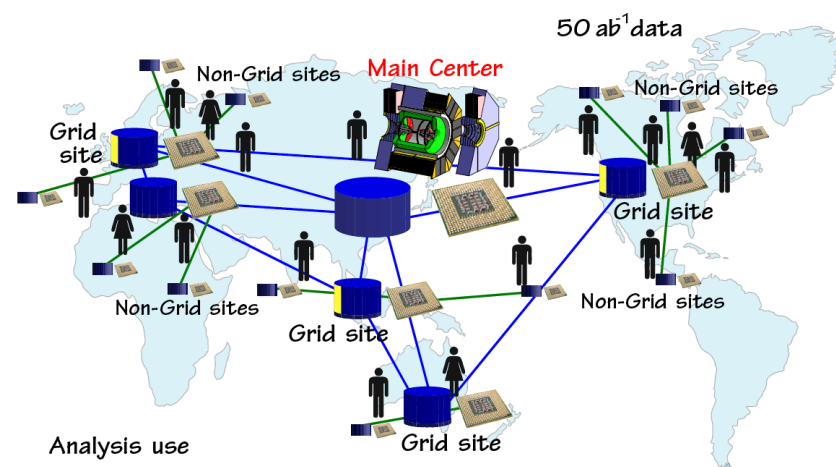
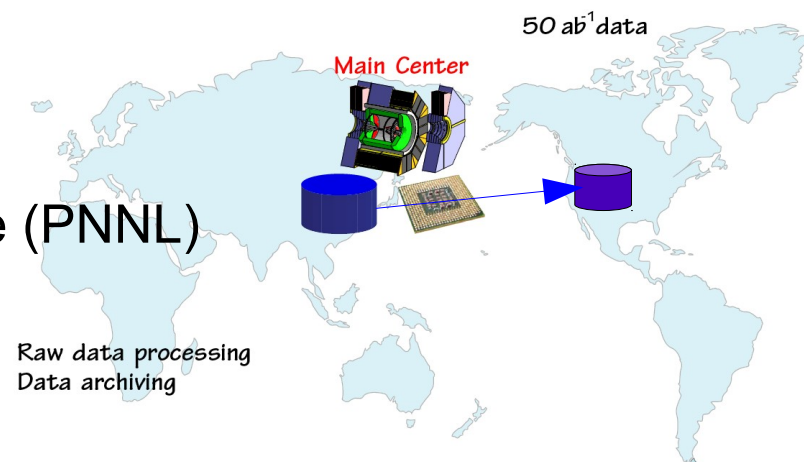
- Store (tape) and process at KEK
- Replication to just one remote site (PNNL)

## ▶ Monte Carlo Production

- 6 times the real data size
- Produced in managed way, (almost) no input data needed
- Well suited for a distributed environment, including cloud

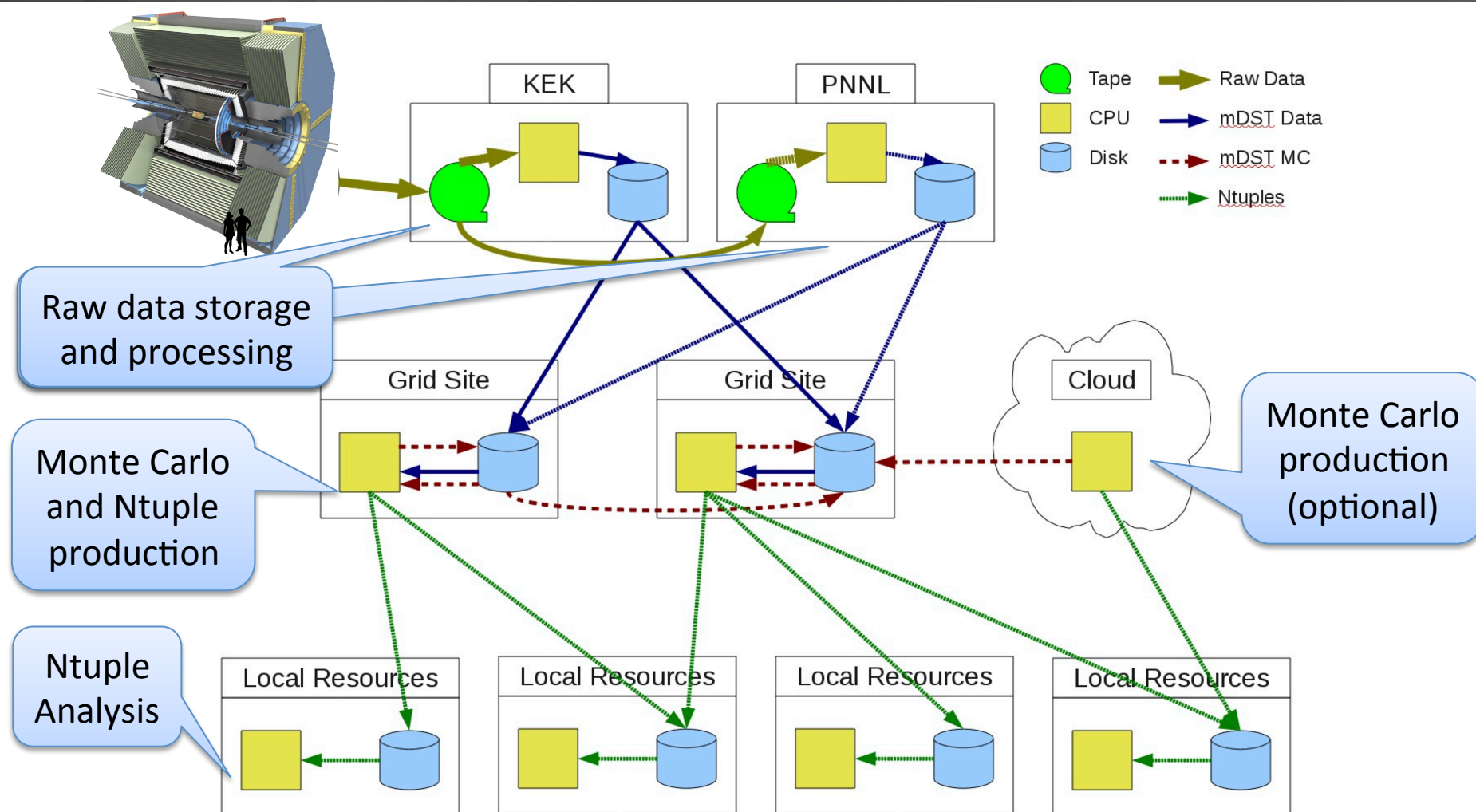
## ▶ Physics Analysis

- Random, uncoordinated access
  - Store input data on disk
- Ntuple analysis on local resources for fast turn-around





# The Belle II experiment will use a distributed computing model



# PNNL-KEK-KIT-OSG January 2012 Workshop

- ▶ Joint computing workshop held at PNNL January 25-26, 2012
- ▶ Objectives:
  - Establish and reinforce relationships between PNNL, KEK
  - Show PNNL computational capabilities
  - Share KEK and PNNL plans for computational aspects of Belle II collaboration
  - Discuss formal agreements for collaboration
- ▶ Outcomes:
  - PNNL and KEK working jointly on formal Memorandum of Understanding
  - PNNL will establish pilot Grid site supporting Belle II
  - PNNL investigating possibility of acting as backup site for all Belle experimental data
    - 200 additional petabytes by 2020
    - Japan – US Bandwidth needs (~2 GB/sec) may tax existing infrastructure
    - DOE HEP will be target funding agency

Attendees: **KEK:** Mitsuaki Nozaki, Koichi Murakami, Go Iwai, Hiroyuki Matsunaga, Takanori Hara, Takashi Sasaki. **KIT:** Thomas Kuhr. **PNNL:** Jerry Johnson, Mike Thompson, David Asner, Kevin Regimbal, Dave Cowley, Shaun O'Leary, Jim Schroeder, Tim Carlson, Jason Jensen  
**OSG:** Chander Sehgal, Gabriele, Garzoglio. **US Belle:** Romulus Godang, Leo Piilonen



# “Pacific Network & Computing Requirements” Workshop hosted by PNNL - Oct 17-18, 2012

Organized by PNNL-KEK-ESNET

The purpose of this workshop was to begin preparation for addressing the wide-area networking requirements for science in general and of the Belle II experiment in particular. Objectives include: developing a common understanding of Belle II science objectives, discovery workflows, cyber-infrastructure requirements, and data models; discussing challenges posed by Belle II data rates; and developing a concrete plan for establishing a Belle II grid site at PNNL and assuring that adequate capabilities for data transport (including monitoring and measurement infrastructure) are in place and thoroughly tested before they are needed by the experiment.

## Belle-II Experiment Network Requirements

Belle-II Experiment Collaboration  
Energy Sciences Network

October 17–18, 2012



[http://www.es.net/assets/pubs\\_presos/Belle-II-Experiment-Network-Requirements-Workshop-v18-final.pdf](http://www.es.net/assets/pubs_presos/Belle-II-Experiment-Network-Requirements-Workshop-v18-final.pdf)

# Belle II Computing Requirements – CY15-20

Note: Integrated data volume doubles CY20 to CY22

## ► KEK Site

Fiscal Year	2015	2016	2017	2018	2019	2020
Tape/Disk [PB]	2.8/3.0	2.8/3.0	9.6/4.6	27/13	52/22	77/42
CPU [kHEPSpec]	40	40	94	168	185	196
WAN [Gbit/s]	2.5	4.0	9.7	18.8	24.3	25

## ► PNNL Site

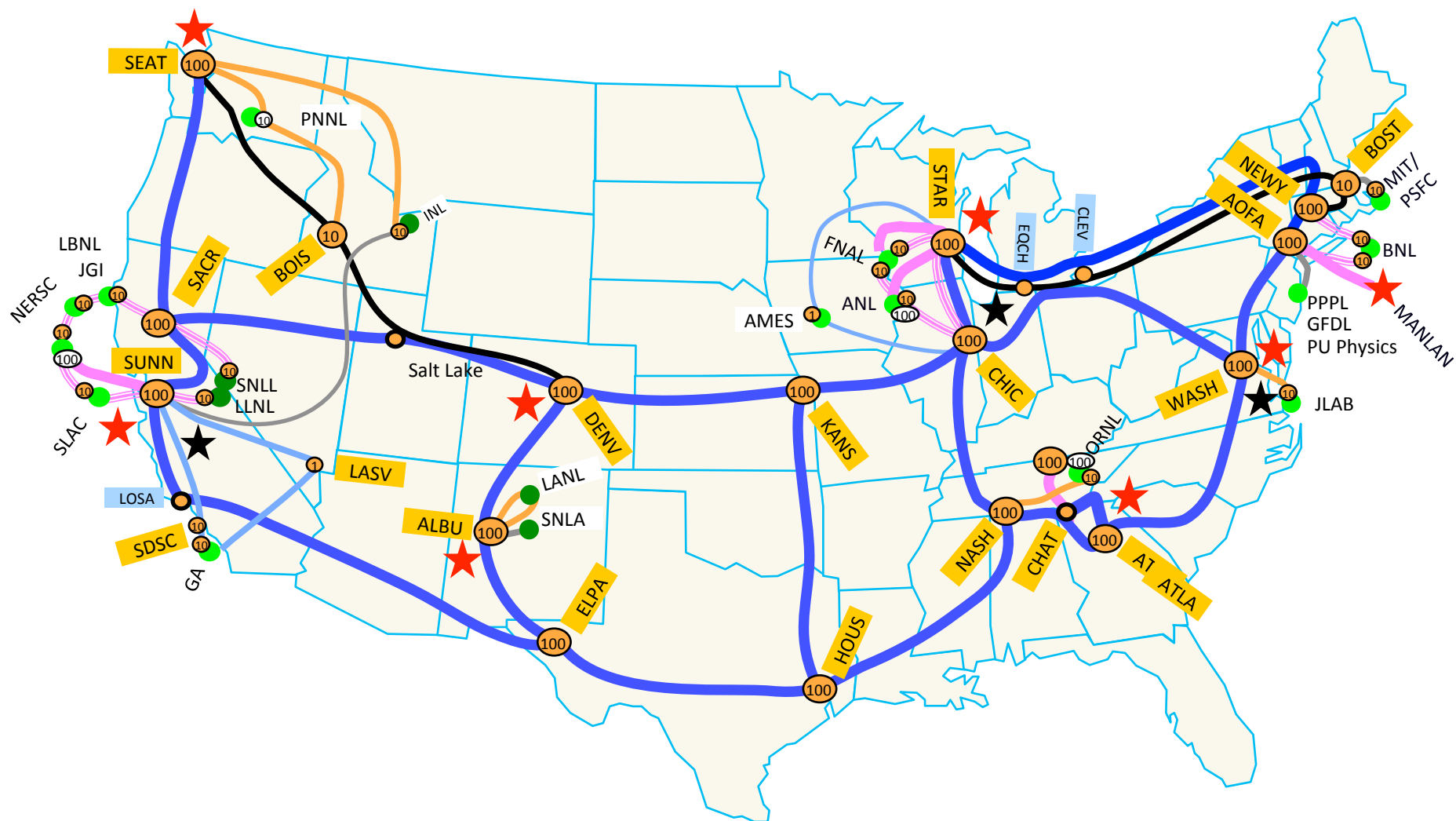
Tape/Disk [PB]	0.0/2.0	0.0/5.0	9.6/12	27/17	52/22	77/27
CPU [kHEPSpec]	10	15	59.1	95.8	76.6	82.7
WAN [Gbit/s]	2.5	4.0	8.7	15.8	19.3	19.4

## ► Regional Site

Disk [PB]	0	0.3	3.2	9.1	15.2	21.4
CPU [kHEPSpec]	0.7	4.3	41.4	72	72	78
WAN [Gbit/s]	0.04	0.3	2.7	3.6	3.9	4.0



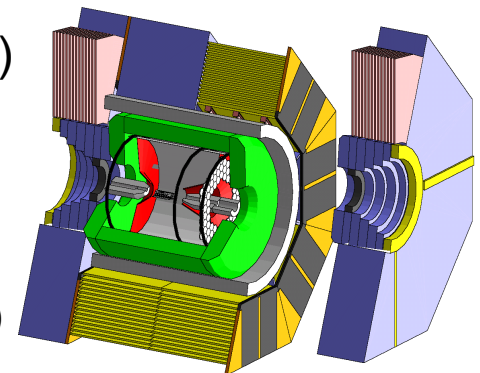
# Esnet Network Infrastructure



# Summary



- ▶ Belle II experiment at SuperKEKB will search for New Physics with  $O(50)$  times more data than Belle
- ▶ Huge data volume is a challenge for network & computing
  - Sustaining very high (1.8 GByte / second) data rates  
In Japan, Across the Pacific, In the US
  - Handling (re)processing tasks in US (as well as Japan)
  - Distributed computing system based on existing technologies and infrastructures
  - Formation of grid sites federation in progress
    - 3 logical layers (main centers, grid sites, local resources)
- ▶ Distributed computing user interface: gbasf2
  - Workflow abstraction with projects and datasets
  - Easy transition from offline software framework: basf2
- ▶ Scientific program requires upgrade of software & computing system to complement the accelerator and detector upgrade projects



<http://belle2.kek.jp>