IceCube computing

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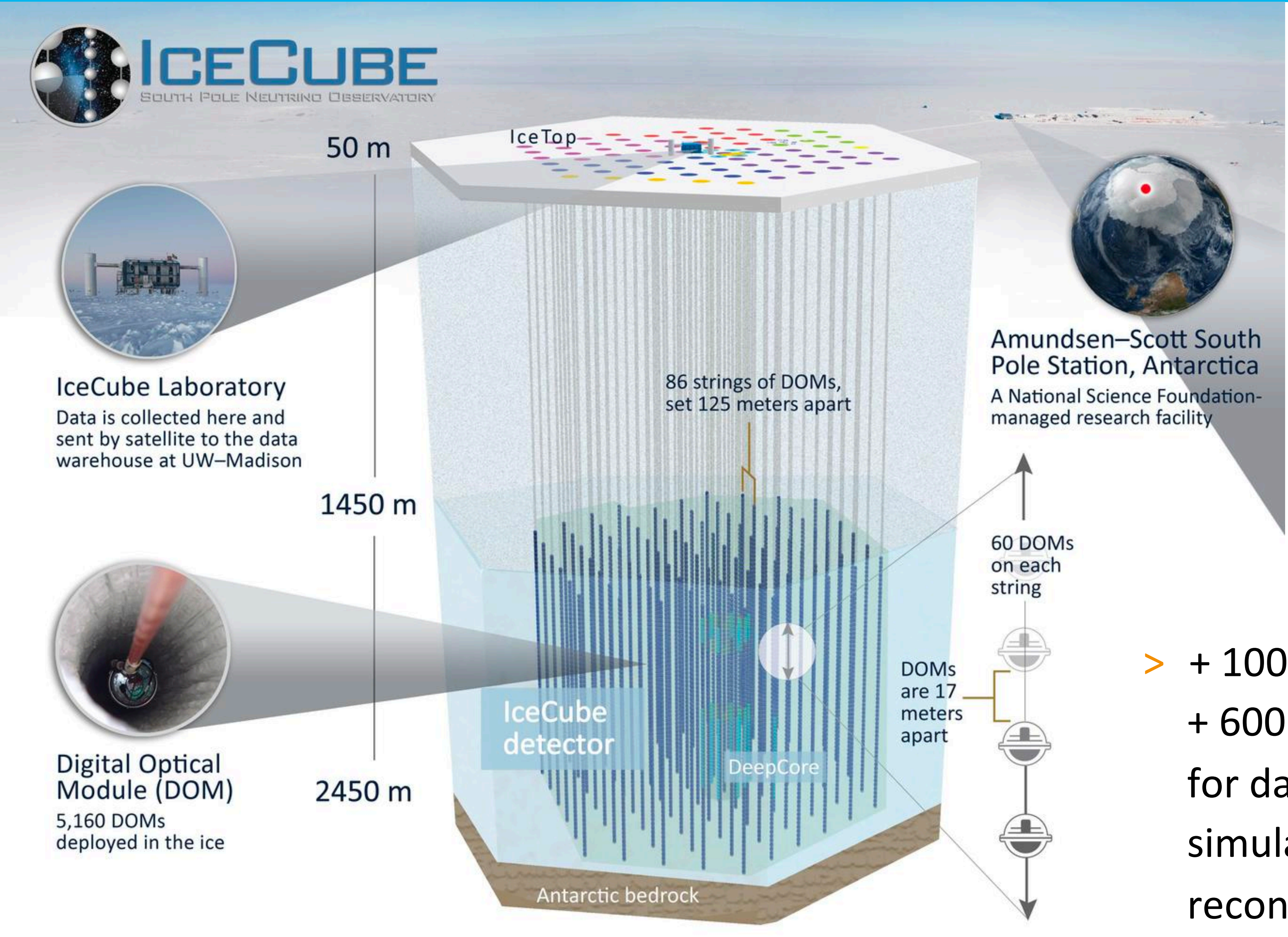
Initiative for a Data and Analysis Centre for
Astroparticle Physics
Karlsruhe, November 2nd, 2017

HELMHOLTZ
ASSOCIATION

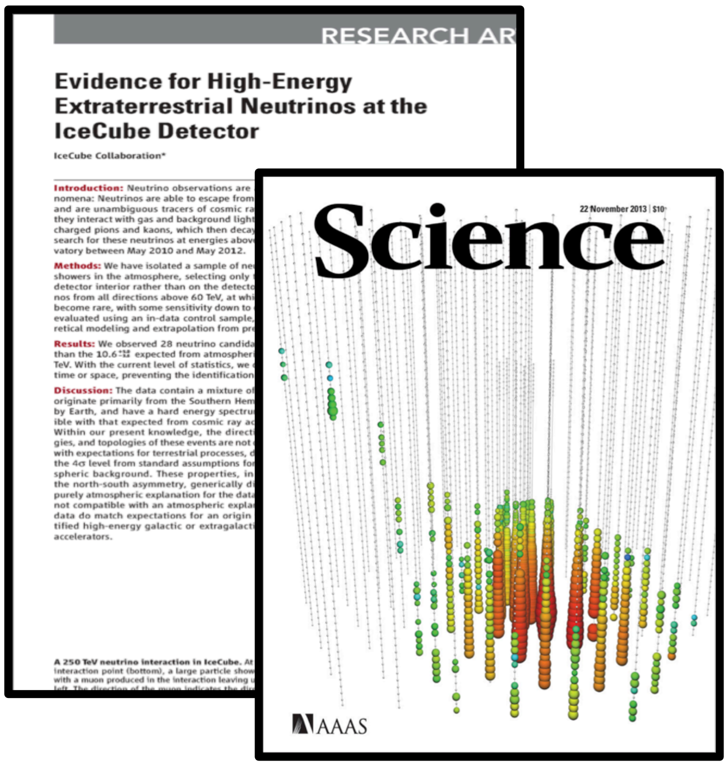
DESY

IceCube detector



- + 10000 CPU cores
  + 600 GPUs
  for data processing simulation & reconstruction

Nov 2013 - astrophysical neutrinos discovery



IceCube trigger ~ 3000 kHz, every year:

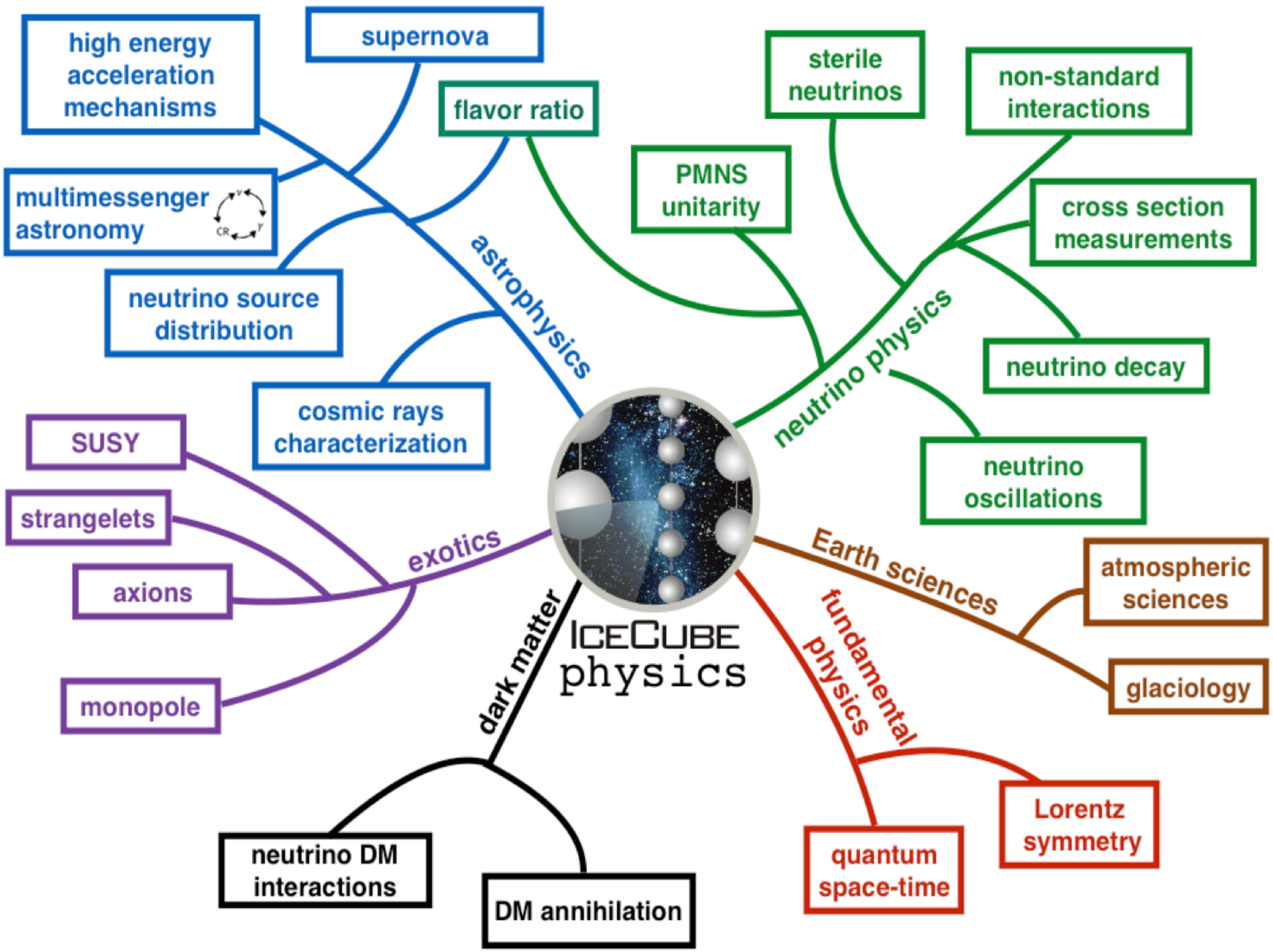
- ~ 100 billion (mostly) background atmospheric muons
- ~ 100,000 atmospheric neutrinos
- ~ 10-15 astrophysical neutrinos

Neutrino signal events need to be distinguished from a background of downgoing atmospheric muons based on the pattern of emitted Cherenkov light.

With ~ 7 years of data taken, IceCube is transitioning from discovery to precision measurement phase.

- Understanding of systematics is key
- An important one: **light propagation** through the the km^3 antarctic ice block

Broad physics program

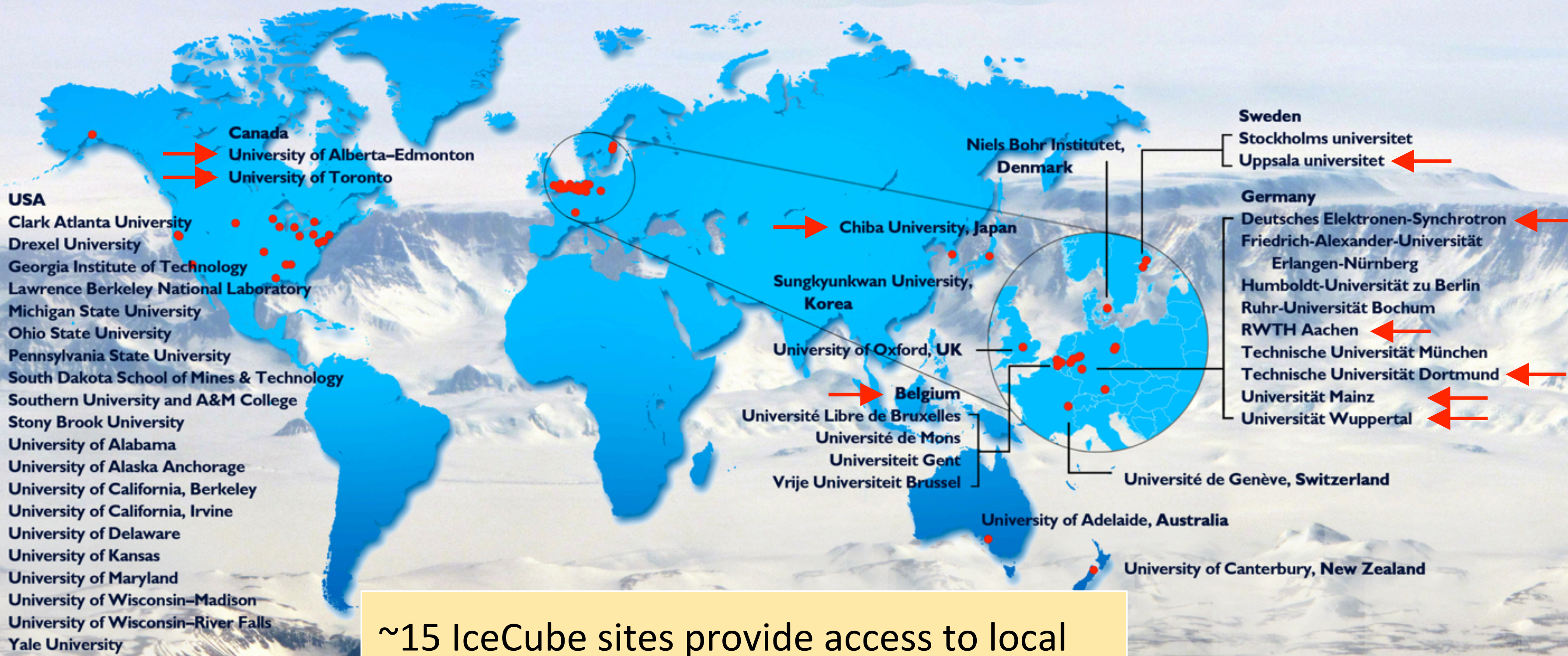


C.Argüelles

Important computing topics for IceCube

- GPU based parallel computing
  - Photon propagation in the ice already implemented, but optimizations possible
  - Potential other applications:
    - CORSIKA shower generation
    - Reconstructions / Likelihood calculations
- Parameter estimation via likelihood / other methods
  - Finding the best set of parameters (e.g. neutrino direction and energy losses in the detector) in a high-dimensional parameter space.
  - Calculation of parameter uncertainties in the presence of systematics
- Event classification and reconstruction via “deep learning” methods
- Statistical methods
  - Hypothesis testing
  - Incorporation of systematic uncertainties.

The IceCube Collaboration

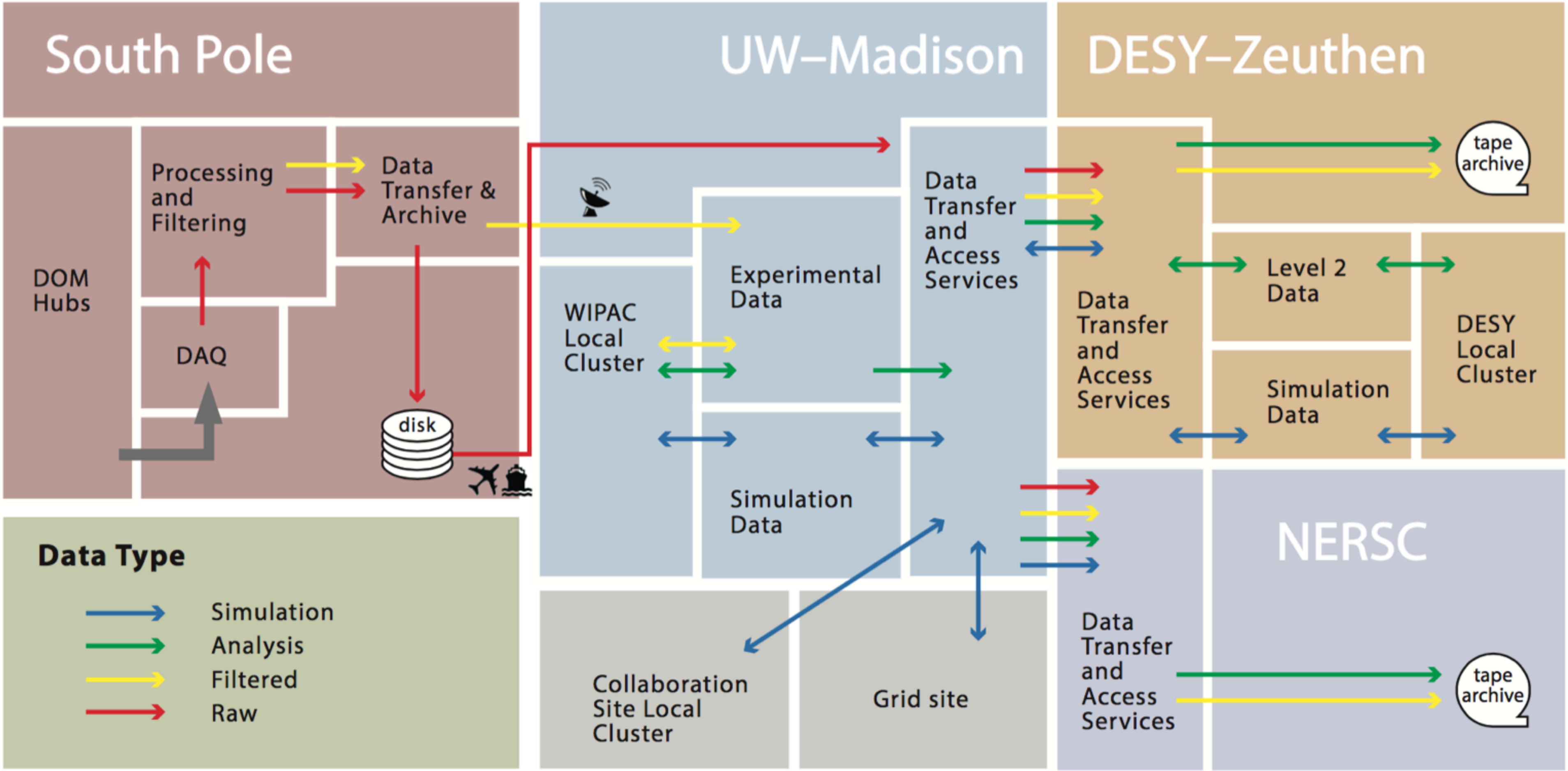


~15 IceCube sites provide access to local computing resources

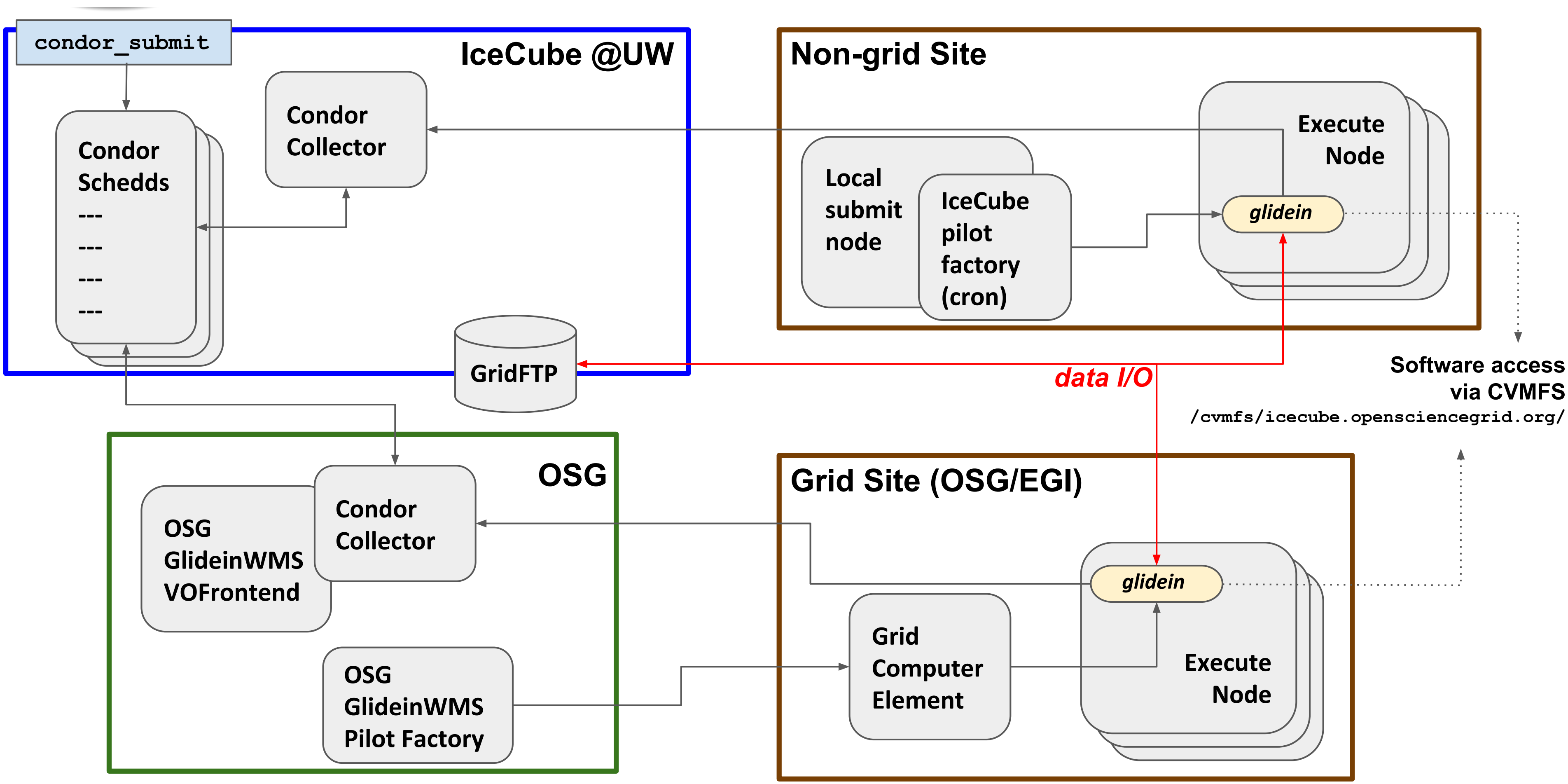
Funding Agencies

Fonds de la Recherche Scientifique (FRS-FNRS)
Fonds Wetenschappelijk Onderzoek-Vlaanderen (FWO-Vlaanderen)
Federal Ministry of Education & Research (BMBF)
German Research Foundation (DFG)
Deutsches Elektronen-Synchrotron (DESY)
Japan Society for the Promotion of Science (JSPS)
Knut and Alice Wallenberg Foundation
Swedish Polar Research Secretariat
The Swedish Research Council (VR)
University of Wisconsin Alumni Research Foundation (WARF)
US National Science Foundation (NSF)

Distributed computing model



Workload management at IceCube



Computing / storage requirements

Computing

	Simulation	Data processing	User analysis
kHS06	50	10	45
Location	10% UW Madison 20% DESY (Zeuthen) 70% other 15 IceCube sites	UW Madison	UW Madison Other sites
Increase/y	15%		20%

In addition: GPUs for photon propagation in ice: ~100 times faster than CPUs
Current required capacity: ~800 GPUs, 50% UW Madison, 50% other sites, Zeuthen ~100 GPUs

Storage growth per year (TB)

	Raw data (incl. filt., DST)	Simulation	User analysis
	600	500	50+
Location	100% UW Madison + copy LBNL/NERSC	UW Madison 50% DESY (Zeuthen)	UW Madison Other sites

UW Wisconsin data warehouse – 6PB disk storage (Lustre)

IceCube MoU DESY – UW Madison

18-May-2015

THE UNIVERSITY of WISCONSIN MADISON

Statement of Work
DESY
1 October 2015 – 31 December 2019

IceCube Maintenance and Operations

This amendment is to exhibit A of the Memorandum of Understanding for IceCube Maintenance and Operations effective January 1, 2015 between the Institutions of the IceCube Collaboration and the Board of Regents of the University of Wisconsin System.

Tier 1 datacenter at DESY

DESY agrees to act as a Tier-1 datacenter for the IceCube collaboration. The services DESY will provide to the IceCube collaboration are described in detail in the following paragraphs:

Appendix

Table 1 details the additions to computing and storage resources provided by DESY during each year of the duration of this MoU. These numbers are gross values and part of the newly purchased equipment will replace existing equipment that reaches the end of its designated lifespan.

Year	CPUs (CPU units)	GPUs (GPU units)	Disk Storage (TB) Data/Simulation	Tape storage (TB)	Budget limit (k€)
2015	200	50	100/350	220	180
2016	300	60	100/350	220	180
2017	500	20	100/450	220	160
2018	400	70	100/400	220	140
2019	300	50	100/450	220	120

Table 1: Additions to computing and storage resources provided by DESY
1 CPU Unit = core with an HEPSpec06 score of 17.
1 GPU Unit = Photon propagation performance of a nVidia GTX 680 card

In Table 2 the projected available total computing and storage resources at DESY related to this Tier-I agreement can be found (accounting for present resources and replacements):

Year	CPUs (CPU units)	GPUs (GPU units)	Disk Storage (TB) Data/Simulation	Tape storage (TB)
2015	900	110	700/520	1020
2016	1050	160	800/750	1240
2017	1400	180	900/1000	1460
2018	1600	210	1000/1220	1680
2019	1800	250	1100/1460	1900

Table 2: Projected available computing and storage resources at DESY.

The Board of Regents of the University of Wisconsin System

12/11/2015
Prof. Dr. Kael Hanson — Date
IceCube Project Director

Prof. Dr. Francis Halzen — Date
IceCube Principal Investigator

12/15/2015
Robert Gratzl — Date
Managing Officer, RSP

DESY

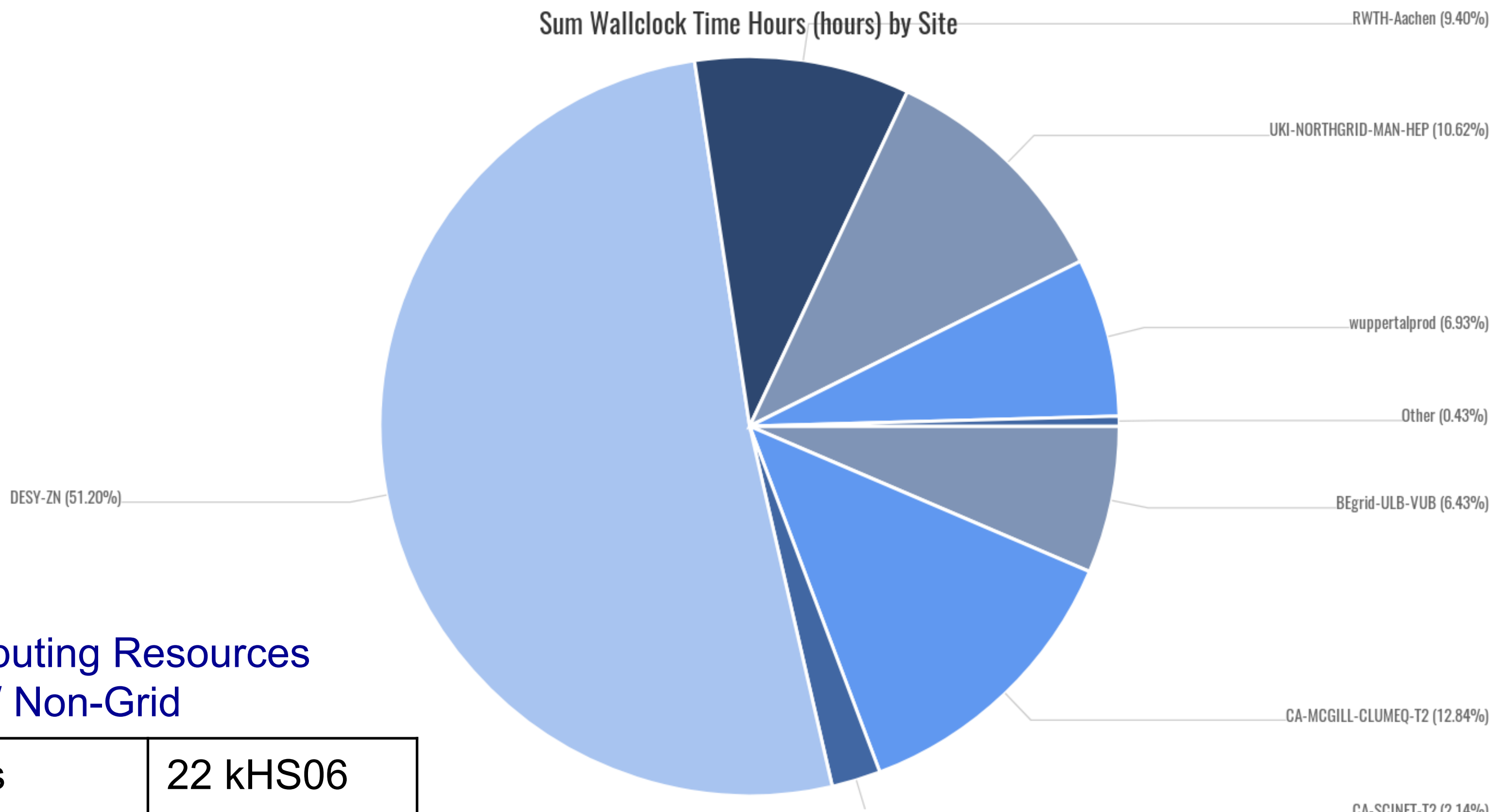
Prof. Dr. Helmut Dosch — Date
Chairman of the DESY Directorate

C. Harringa — Date
Acting Director of Administation

Dr. Peter Wegner — Date
Technical Representative

DESY IceCube Tier1 – CPU/GPU ressources

EGI grid computing (per grid site)



Computing Resources
Grid / Non-Grid

CPUs	22 kHS06
GPUs	80 (NVIDIA)

DESY IceCube Tier1 – Storage

Data type	Subtype	Growth (TB/y)
Experimantal	SuperDST	70
	Filtered	40
	Level 2	100
Simulation	Level 2	400 (50%)

Local data, accumulated

dCache	1.5 PB
Lustre	370 TB

Summary

Discovery of astrophysical neutrinos - new era of Neutrino Astronomy started.

Beyond 5 years after construction ended, IceCube keeps improving its uptime

- A rich physics program ahead
- Transition from discovery to precision measurement phase

Simulation is essential - light propagation in the ice & related systematics

- Strongly rely on distributed computing
  - Benefiting a lot of common areas with LHC: CVMFS, opportunistic access to WLCG sites …
  - Infrastructure based in HTCondor components - user interface is HTCondor
- GPUs a critical platform for IceCube