Structure of Matter

Elementary Particle Physics
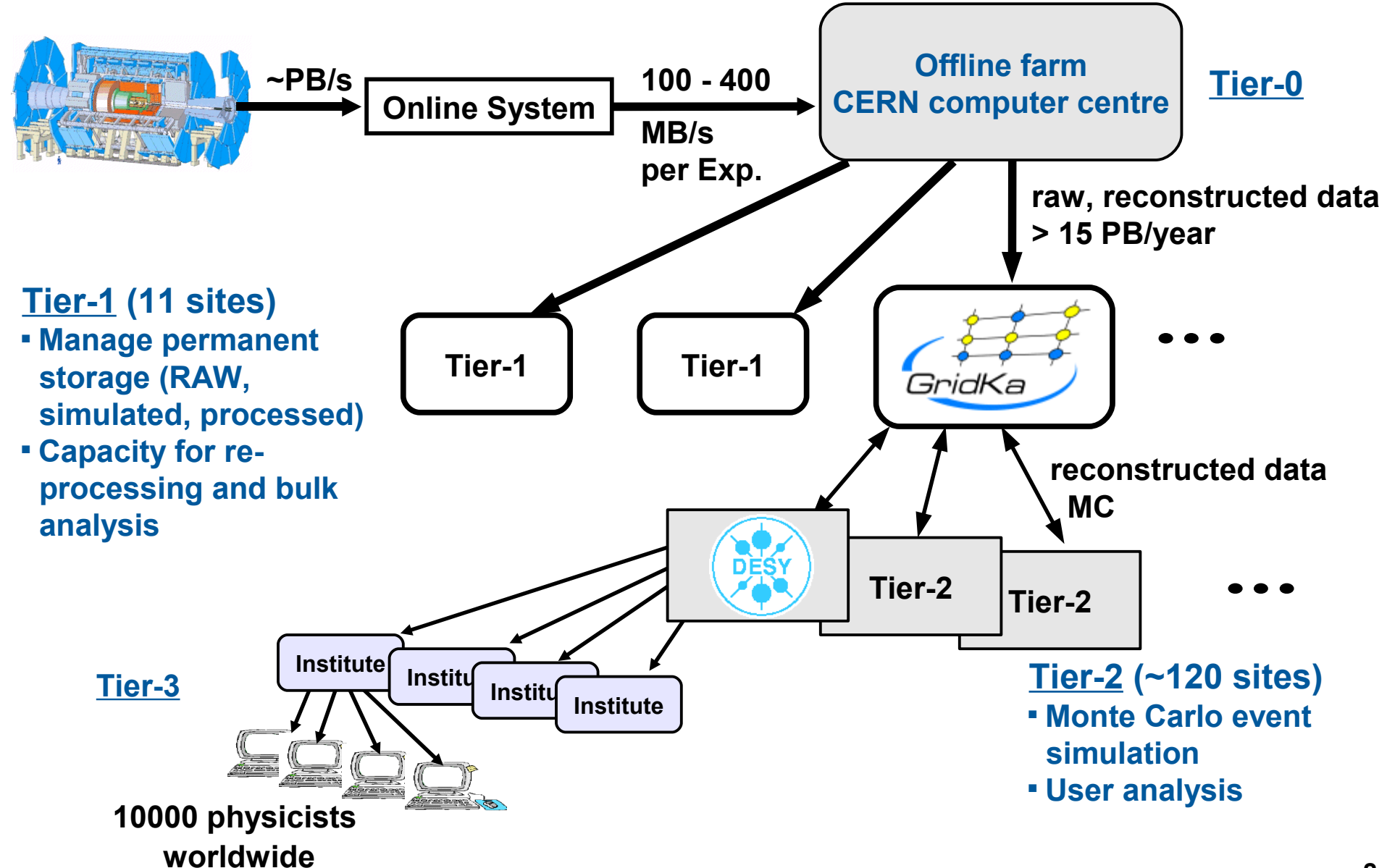
Large scale computing facilities at KIT and DESY

Volker Gülzow   Andreas Heiss

The Worldwide LHC Computing Grid (WLCG)

~PB/s

Online System

100 - 400 MB/s per Exp.

Offline farm CERN computer centre

Tier-0

raw, reconstructed data > 15 PB/year

Tier-1 (11 sites)
- **Manage permanent storage (RAW, simulated, processed)**
- **Capacity for re-processing and bulk analysis**

Tier-1

Tier-1

GridKa

reconstructed data MC

DESY

Tier-2

Tier-2

Institute
Institu
Institu
Institute

Tier-3

Tier-2 (~120 sites)
- **Monte Carlo event simulation**
- **User analysis**

10000 physicists worldwide

2

The Memorandum of Understanding (MoU) of the Worldwide LHC Computing Grid

- **Members, aims and organisation of the WLCG collaboration**

- **Tier-1 and Tier-2 centres**

  - **<u>Pledged resources</u> (CPU, disk, tape)**

  - **<u>Service levels</u>**

    - **24h x 7d operation**

    - **Response time on operational problems**

    - **Availability (≥ 98% for Tier-1 centres)**

- **Supported LHC experiments**

  - **GridKa supports <u>all</u> LHC experiments**

  - **DESY supports Atlas, CMS, LHCb**
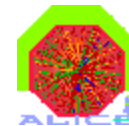
Tier-2 centres in Germany

3 average size Tier-2s for Atlas, 1.5 for CMS, 1 for LHCb and 1 for Alice have been requested for Germany.

DESY operates 1 average size Tier-2 each for:

- **Atlas   (federated with U Göttingen)**
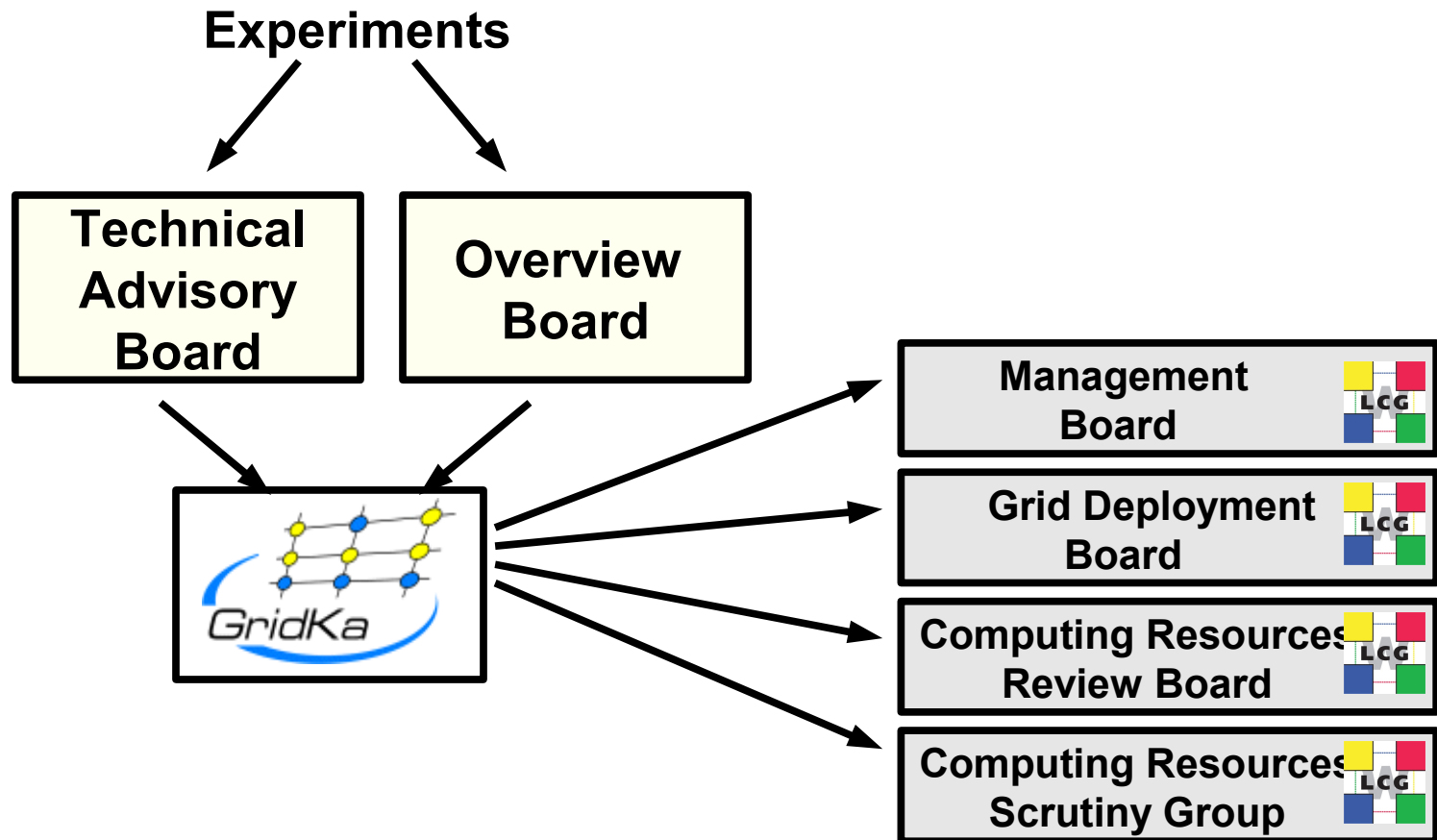- **CMS   (federated with RWTH Aachen)**
- **LHCb**

Other Tier-2 centres

- **U Freiburg, U Wuppertal, LMU and MPIfP Munich:
  0.5 av. Tier-2 for Atlas each.**
- **RWTH Aachen: 0.5 av. Tier-2 for CMS**
- **(GSI : 1 av. Tier-2 for Alice)**

GridKa (project duration 2002 - 2022+)

- **WLCG Tier-1:**   **Alice, Atlas, CMS, LHCb**
- **non-LHC HEP:**   **CDF, D0, Babar, Compass, Belle**
- **non-HEP Grid communities:**   **Auger, Magic, Medigrid, ...**

Experiments

Technical Advisory Board

Overview Board

GridKa

Management Board

Grid Deployment Board

Computing Resources Review Board

Computing Resources Scrutiny Group

# DESY

- **WLCG Tier-2:**   **Atlas, CMS, LHCb**
- **non-LHC HEP:**   **H1, Zeus, ILC, CALICE, ILDG**
- **non-HEP Grid communities:**

   **IceCube, XFEL, XRAY, Biomed, ...**

Example: Monte Carlo production for ILC detector design

- development of grid tools (job submission scripts, web based production database)
- >50 M events fully simulated (geant4) and reconstructed Standard Model 'background' and new physics (Higgs/SUSY)
- ~70 TByte of storage at DESY Grid ('T0')
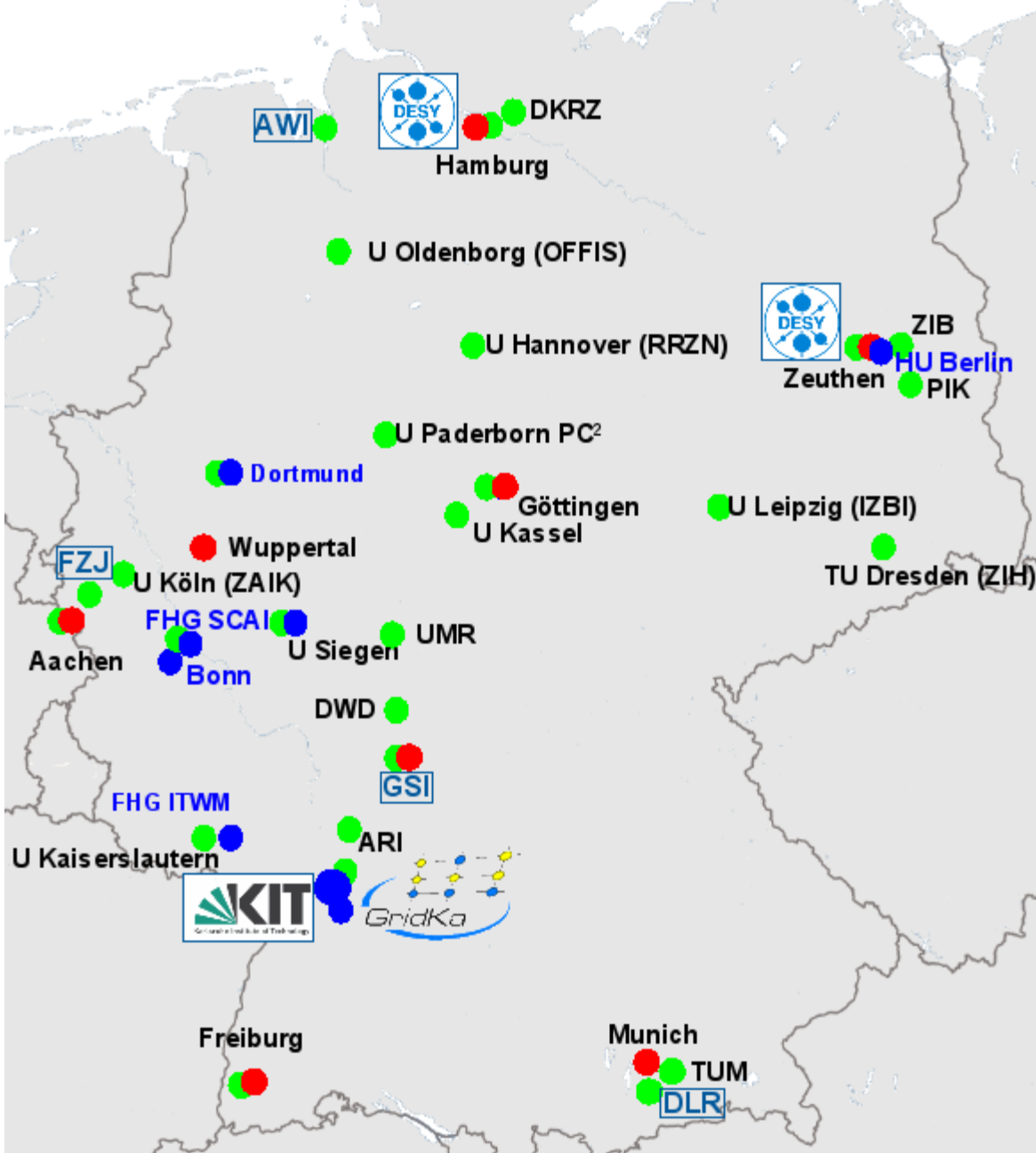- ~200 CPU-years
  DESY and other EU Grid sites (UK, F, ...)

LHC Optical Private Network (OPN) Status
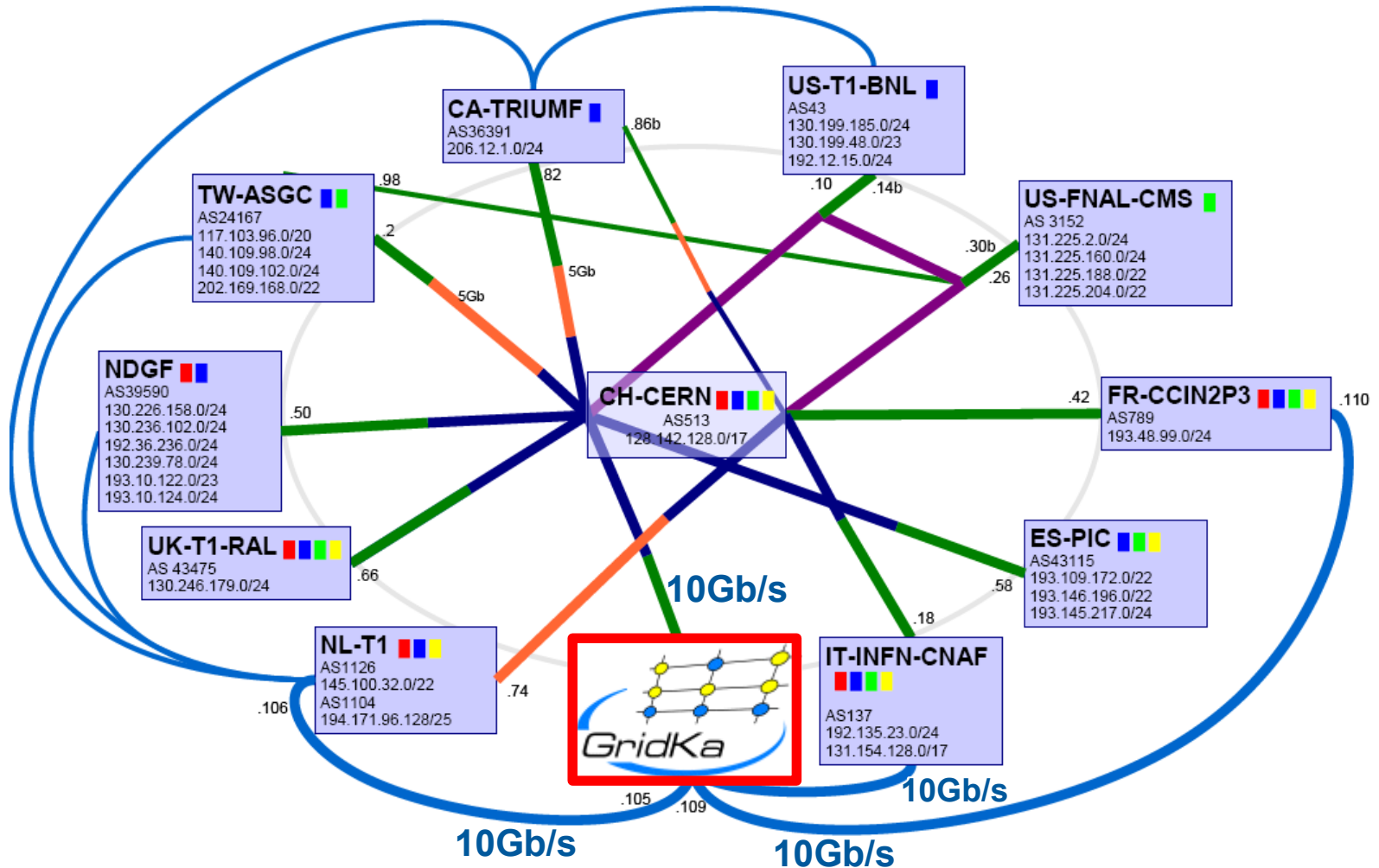
GridKa Tier-1 and associated Tier-2 sites

10 Gbit/s P2P link
1 Gbit/s P2P link
Connection via NREN backbone
D: DFN XWIN
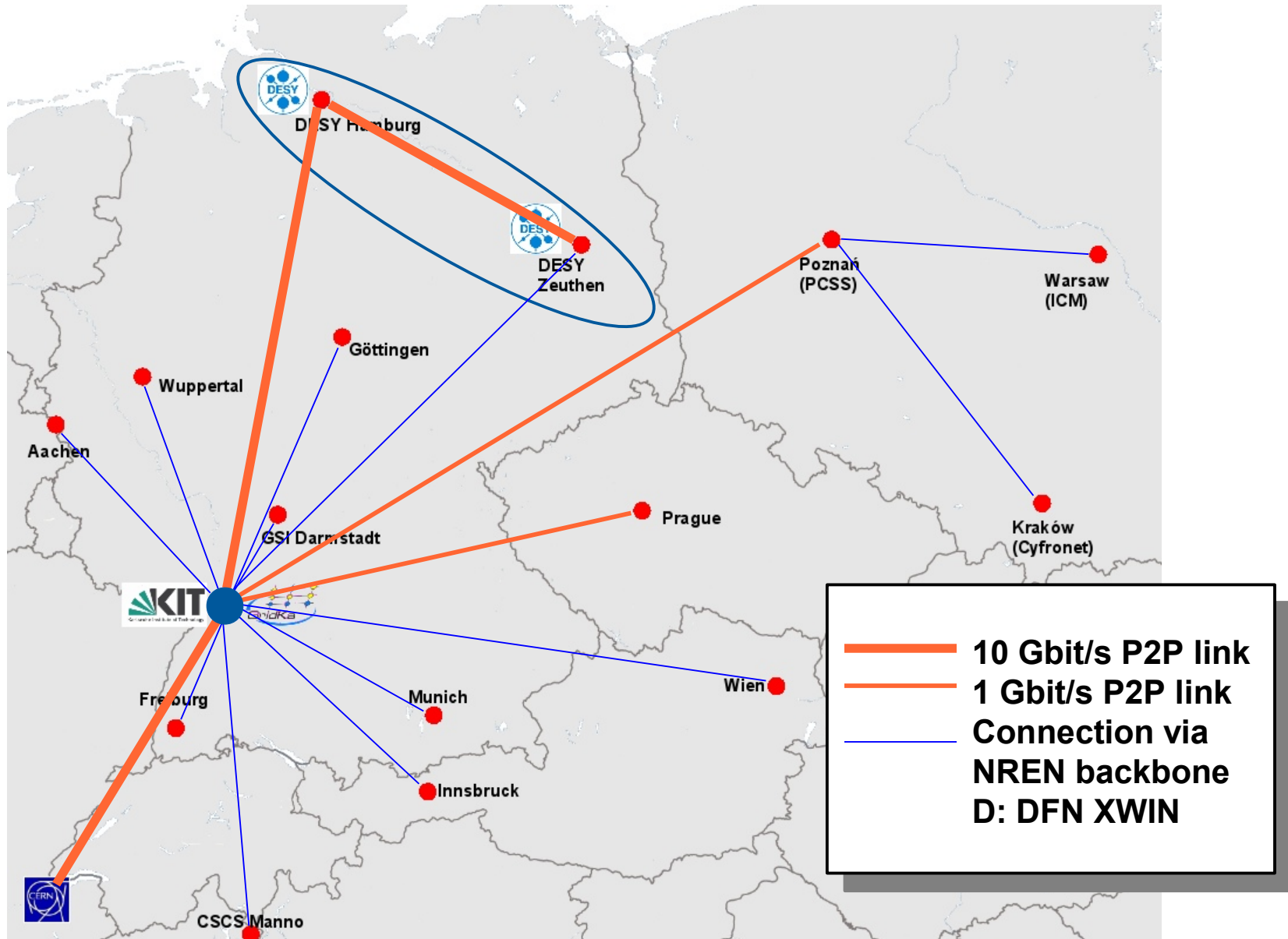
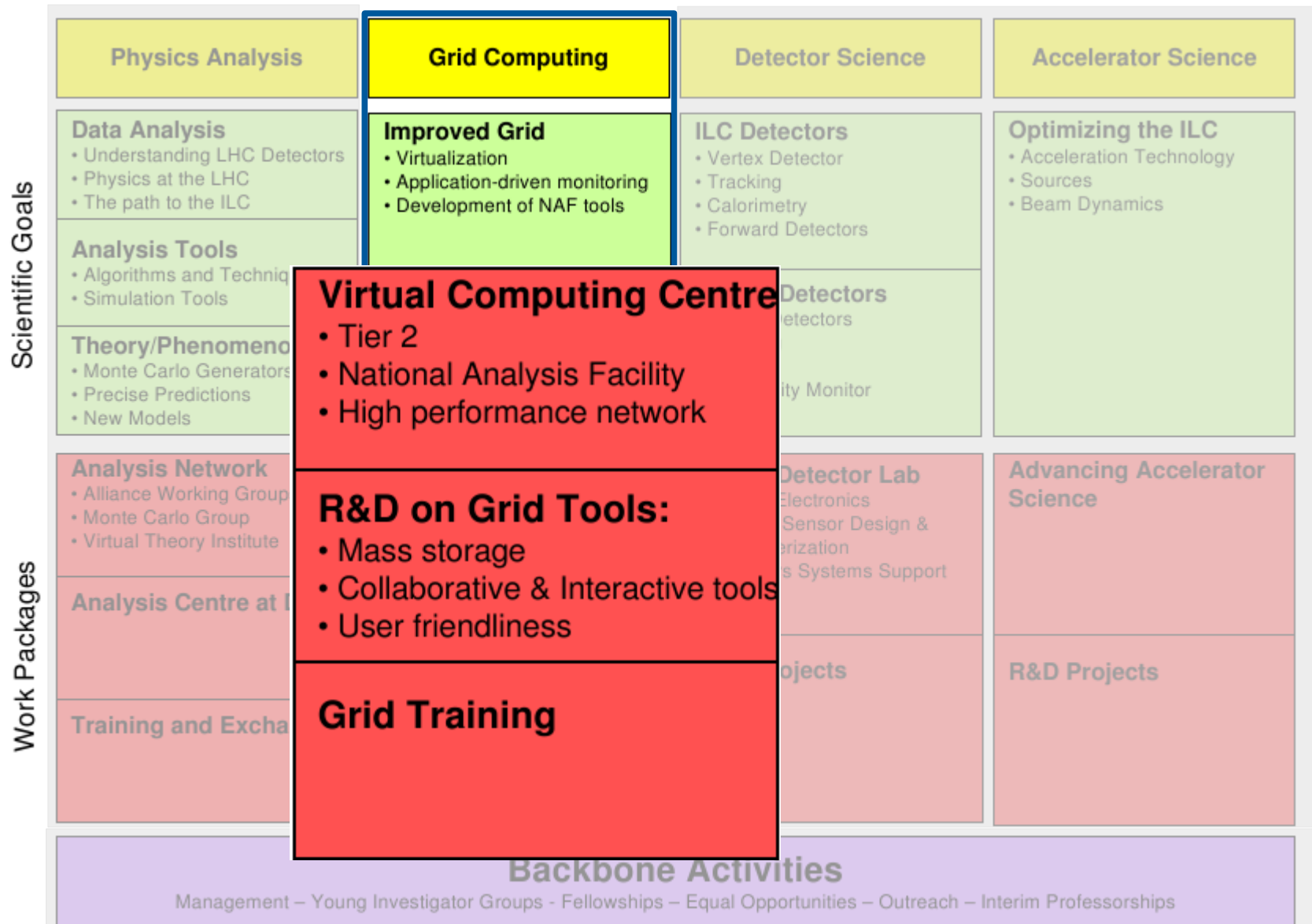# High visibility in national and international Grid projects

Sites of the German national grid initiative D-Grid, funded by BMBF with Helmholtz sites as key players.

EGEE site (non Tier-2)

WLCG Tier-2 site (also EGEE)

Map labels:
AWI, DESY, DKRZ, Hamburg, U Oldenborg (OFFIS), U Hannover (RRZN), DESY Zeuthen, ZIB, HU Berlin, PIK, U Paderborn PC², Dortmund, Göttingen, U Kassel, U Leipzig (IZBI), FZJ, Wuppertal, U Köln (ZAIK), FHG SCAI, U Siegen, UMR, TU Dresden (ZIH), Aachen, Bonn, DWD, GSI, FHG ITWM, ARI, U Kaiserslautern, KIT, GridKa, Freiburg, Munich, TUM, DLR

Helmholtz Alliance 'Physics at the Terascale'

	Physics Analysis	Grid Computing	Detector Science	Accelerator Science
Scientific Goals	**Data Analysis** • Understanding LHC Detectors • Physics at the LHC • The path to the ILC **Analysis Tools** • Algorithms and Techniques • Simulation Tools **Theory/Phenomenology** • Monte Carlo Generators • Precise Predictions • New Models	**Improved Grid** • Virtualization • Application-driven monitoring • Development of NAF tools **Data Storage + Retrieval** • Mass storage • Data Access	**ILC Detectors** • Vertex Detector • Tracking • Calorimetry • Forward Detectors **(s)LHC Detectors** • Vertex Detectors • Tracking • Trigger • Luminosity Monitor	**Optimizing the ILC** • Acceleration Technology • Sources • Beam Dynamics
Work Packages	**Analysis Network** • Alliance Working Groups • Monte Carlo Group • Virtual Theory Institute **Analysis Centre at DESY** **Training and Exchange**	**Virtual Computing Centre** • Tier 2 • National Analysis Facility • High performance network **R&D on Grid Tools:** • Mass storage • Collaborative & Interactive tools • User friendliness **Grid Training**	**Virtual Detector Lab** • VLSI & Electronics • Support Sensor Design & Characterization • Detectors Systems Support **R&D Projects**	**Advancing Accelerator Science** **R&D Projects**

Backbone Activities

Management – Young Investigator Groups - Fellowships – Equal Opportunities – Outreach – Interim Professorships

10

Helmholtz Alliance 'Physics at the Terascale'

Physics Analysis	Grid Computing	Detector Science	Accelerator Science

Scientific Goals

Data Analysis • Understanding LHC Detectors • Physics at the LHC • The path to the ILC	**Improved Grid** • Virtualization • Application-driven monitoring • Development of NAF tools	**ILC Detectors** • Vertex Detector • Tracking • Calorimetry • Forward Detectors	**Optimizing the ILC** • Acceleration Technology • Sources • Beam Dynamics
Analysis Tools • Algorithms and Techniq • Simulation Tools		Detectors etectors	
Theory/Phenomeno • Monte Carlo Generators • Precise Predictions • New Models		ity Monitor	

Work Packages

Analysis Network • Alliance Working Group • Monte Carlo Group • Virtual Theory Institute		Detector Lab Electronics Sensor Design & rization s Systems Support	**Advancing Accelerator Science**
Analysis Centre at			
Training and Excha		ojects	**R&D Projects**

Virtual Computing Centre
• Tier 2
• National Analysis Facility
• High performance network

R&D on Grid Tools:
• Mass storage
• Collaborative & Interactive tools
• User friendliness

Grid Training

Backbone Activities

Management – Young Investigator Groups - Fellowships – Equal Opportunities – Outreach – Interim Professorships

11

The National Analysis Facility (NAF)

- Computing infrastructure for the Helmholtz Alliance Analysis Centre
- Built according to requirements from German Atlas, CMS and LHCb groups.
- Accessible by German research groups for LHC, Hera, Theory and ILC tasks to increase competitiveness.
- Size of ~1.5 average Tier-2 centres with additional storage
- Interactive analysis to improve scientific harvest
- Provides interactive PROOF farm request by physics groups
- Locality of analysis data is required → core facility at DESY
    - .. intended to be distributed.
- Initial investment provided by BMBF.

DESY storage and computing resources
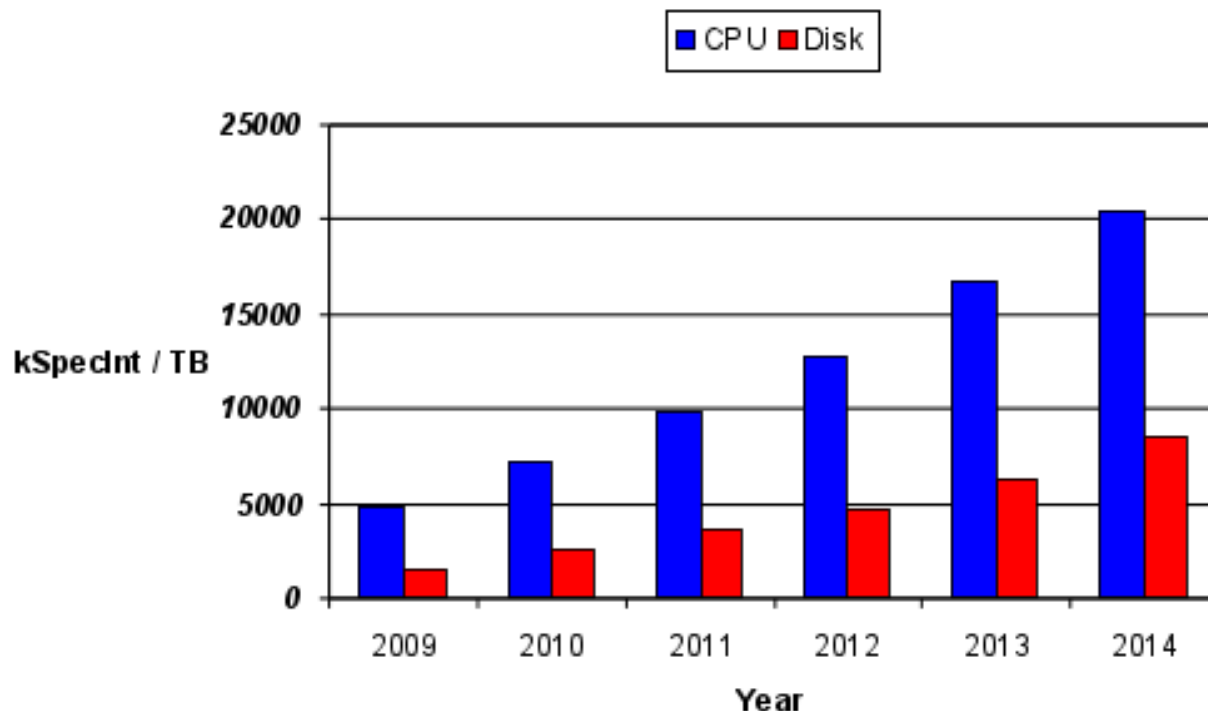
- Invest requested by capital investment

- Running costs covered by basic DESY fundings.

2008	Grid Hamburg (Tier-2, NAF, other HEP)	Grid Zeuthen (Tier-2, NAF, other HEP)	NAF non-Grid (batch/interactive)
CPU [kSI2k]	3000 (2000 cores)	700 (500 cores)	1200 (868 cores)
Disk [TB]	1350	460	

GridKa storage and computing resources
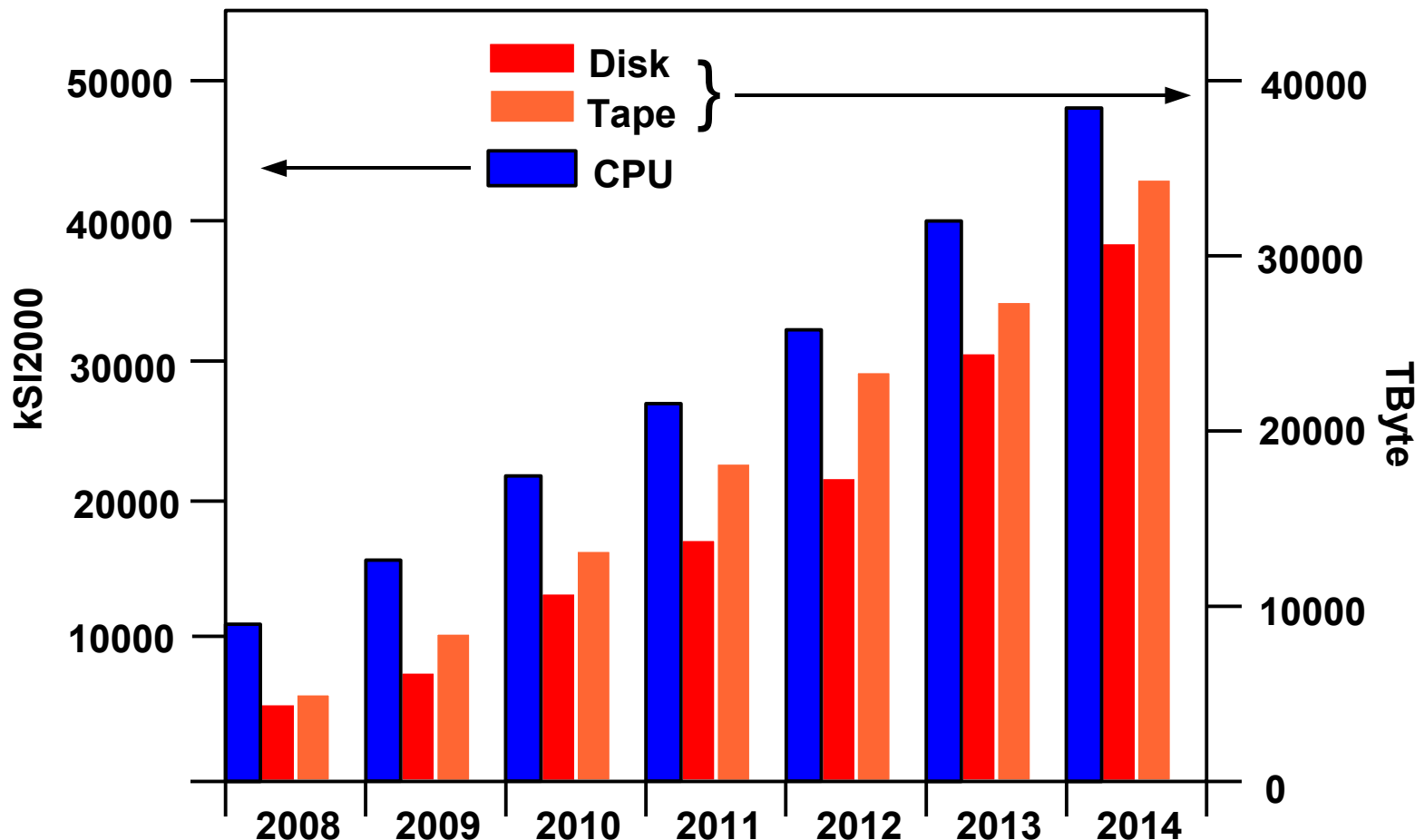
2008	HEP	Non-HEP (incl. D-Grid)	Total ∑
CPU [kSI2k]	7700	3100	10800 (6100 cores)
Disk [TB]	3890	410	4300
Tape [TB]	4500	380	4880

Fundamental Grid services provided for the whole HEP community
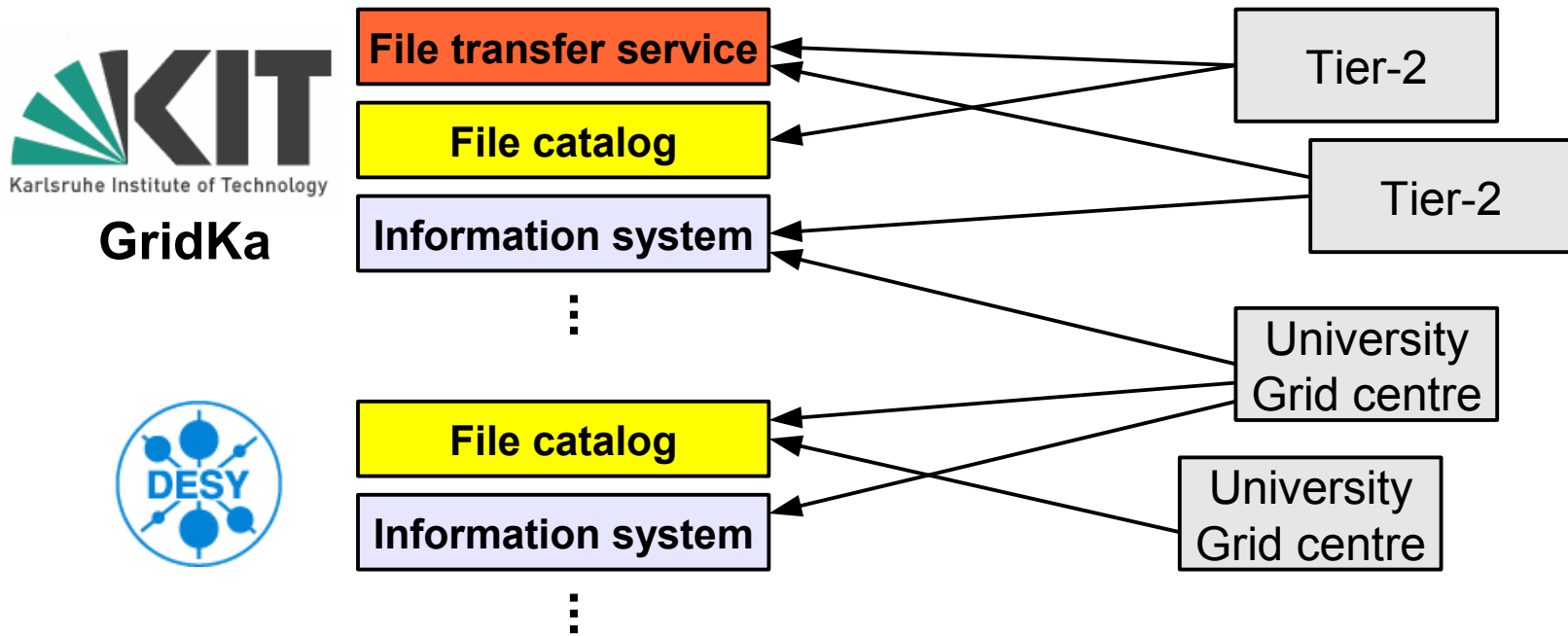
- **Used by Tier-2 and university Grid centres**
- **LHC Computing in Germany and Europe depends on regional core services**
- **Highest reliability necessary**

Service reliability measured by WLCG

GridKa Tier-1
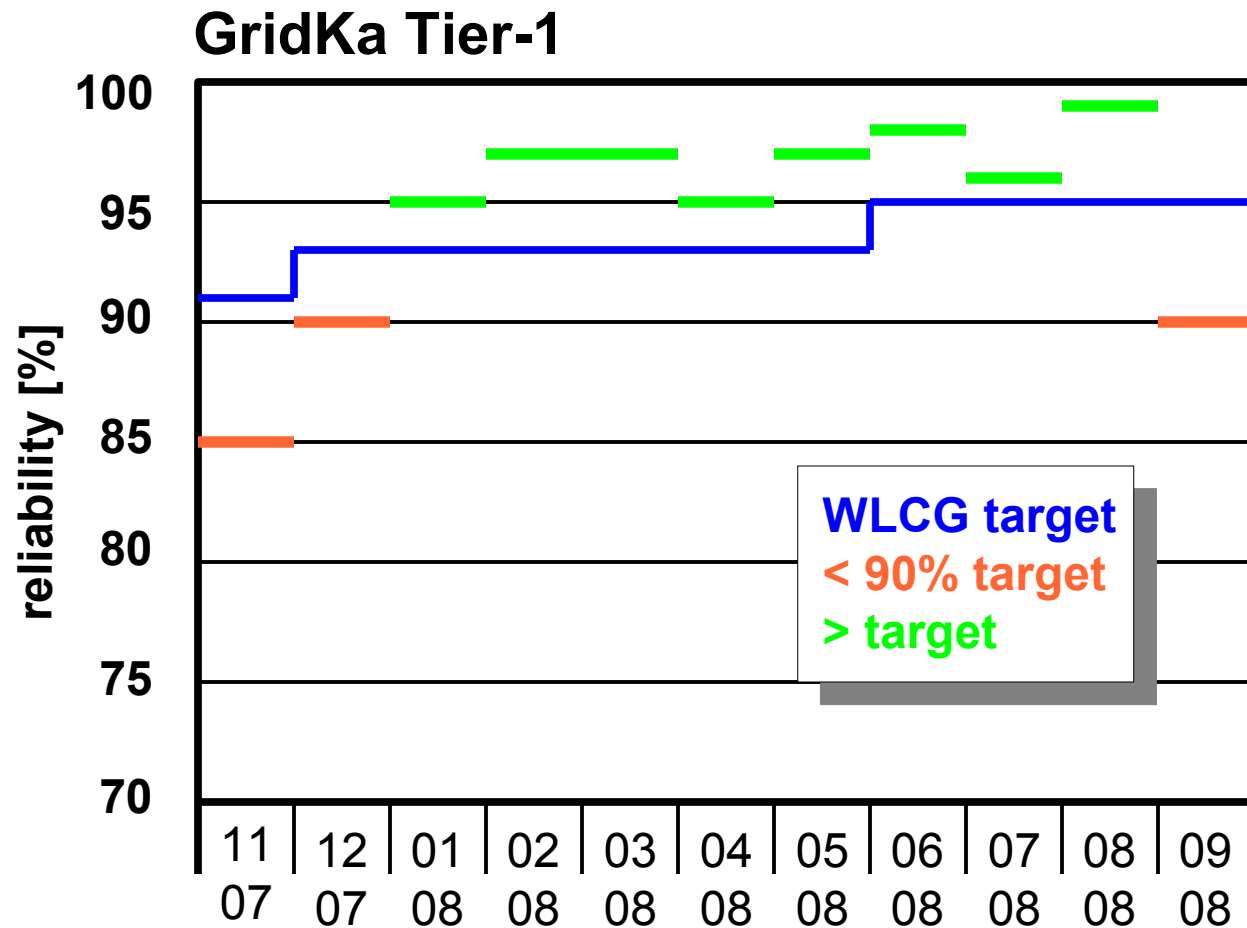
Service reliability measured by WLCG

DESY Atlas and CMS Tier-2

		Jan 09		Oct-Dec 08		
DE-DESY-ATLAS-T2 (Germany ATLAS Federation, DESY)						
DESY-HH	2,018	97 %	97 %	97 %	94 %	98 %
DESY-ZN	450	100 %	100 %	100 %	98 %	100 %
DE-DESY-RWTH-CMS-T2 (Germany, CMS Federation)						
DESY-HH	2,018	97 %	97 %	97 %	94 %	98 %
DESY-ZN	450	100 %	100 %	100 %	98 %	100 %
RWTH-Aachen	2,024	86 %	86 %	77 %	90 %	95 %

→ Excellent service quality by provided Helmholtz centres

Major development contributions

dCache mass storage system

- Developed in collaboration between **DESY**, Fermilab, and the Nordic Data Grid Facility (NDGF)
- Close collaboration with GridKa (large dCache installation, testing)
- dCache will hold the largest share of LHC data outside CERN
- dCache is distributed by EGEE gLite and US Open Science Grid Virtual data tool (VDT)
- dCache is in production at **8** WLCG Tier-1 sites and **~40** Tier-2s
  → **High support effort**
    - DESY (international and national)
    - Helmholtz-Alliance 'Physics at the Terascale' (national)
    - D-Grid (national)

Major development contributions

Global Grid User Support (GGUS)
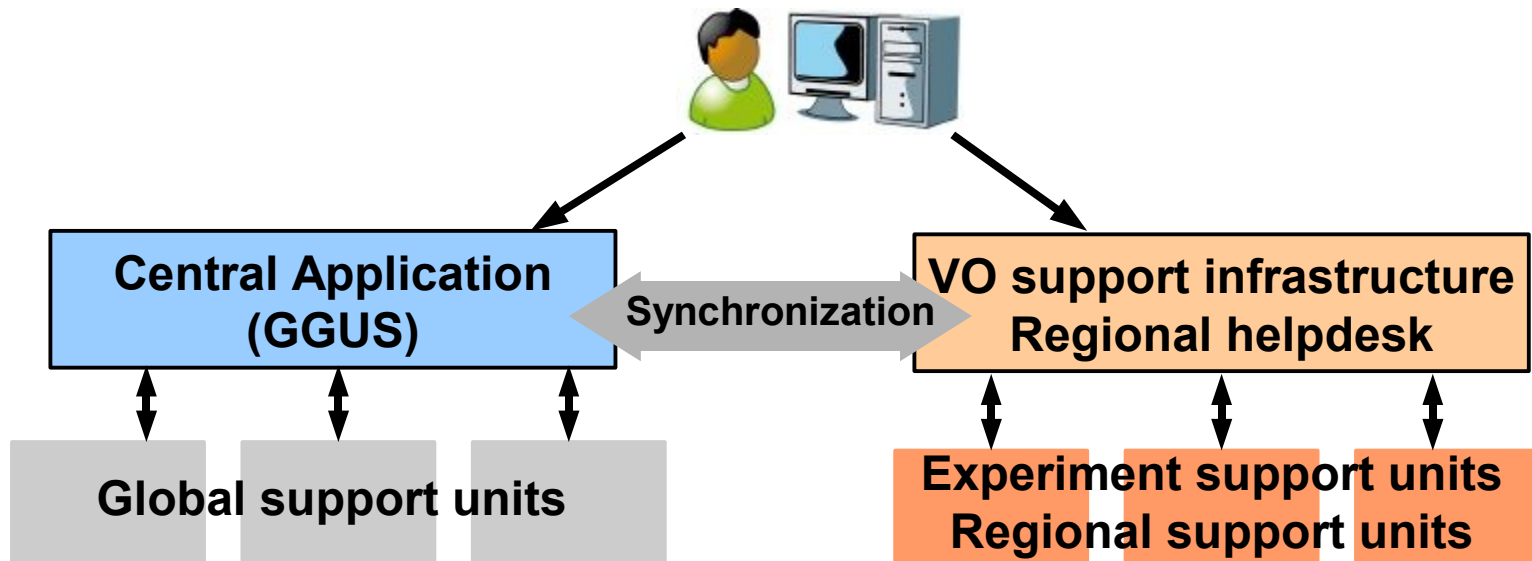
- Central Grid helpdesk system developed at **KIT** for EGEE
- Adapted and extended to WLCG/HEP specific needs
- Single point of entry for all trouble tickets
- **59** support units
- ~**1000** supporters on **5** continents
- **10** regional helpdesks connected and synchronized
- ~8000 tickets processed last year

Education and training activities

GridKa school
- 2003: 30 students
- 2008 in cooperation with the Helmholtz Alliance
- 2008: 170 participants (14 countries) from science and industry
- Highly visible, international event

dCache trainings
-   strong involvement of DESY dCache experts and support people of the Helmholtz Alliance (KIT, LMU Munich, RWTH Aachen)

Summary

- **The Helmholtz-Centres KIT and DESY build-up and operate large scale computing facilites which are crucial for elementary particle physics research in Germany and Europe.**

- **Support of Tier-2 centres and universities with Grid services and know-how.**

- **The NAF is a key element for the data analysis at the universities.**

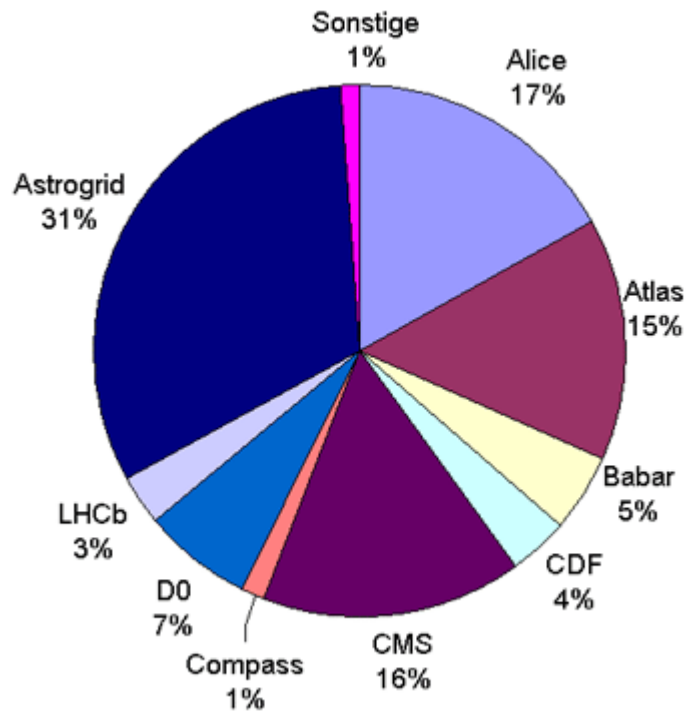- **Important contributions to Grid development and training activities.**

Challenges

- Immense increase of computing resources necessary during the coming years to fulfil the requirement of LHC data processing.

- Providing services with high level of quality and reliability.

- Support universities in Grid computing for particle physics.
  - application / middleware support
  - education and training

- Continue dCache / GGUS development, international support.

- Long term data preservation.
  - LHC raw data: end of LHC + min. 10 years

- Continue to support new communities on the Grid.
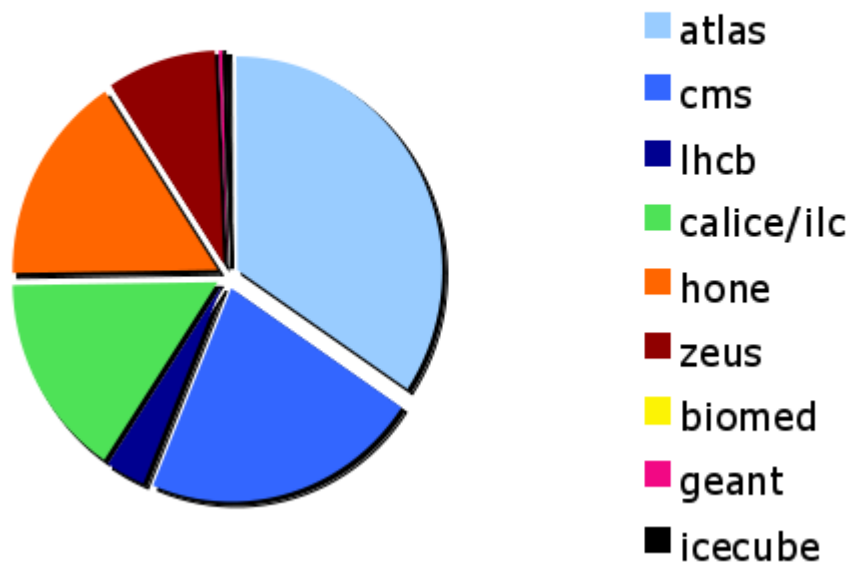
Backup Slides

CPU utilization of GridKa and DESY Grid

GridKa 1.1. - 31.12.2008
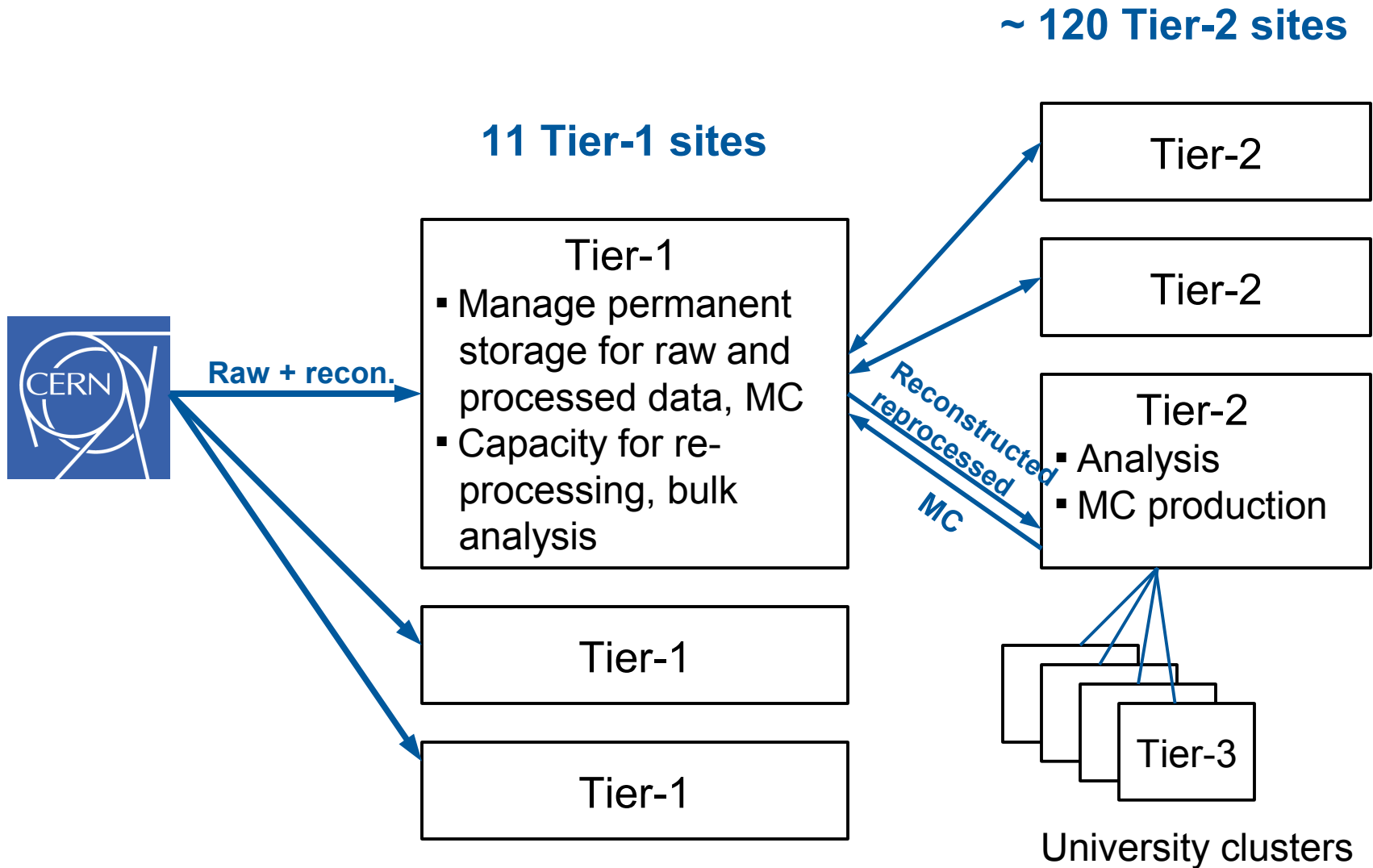28177745 CPU hours

- Sonstige 1%
- Alice 17%
- Atlas 15%
- Babar 5%
- CDF 4%
- CMS 16%
- Compass 1%
- D0 7%
- LHCb 3%
- Astrogrid 31%

CPU utilization DESY Grid
(1.4.08-29.9.08)

- atlas
- cms
- lhcb
- calice/ilc
- hone
- zeus
- biomed
- geant
- icecube

The LHC computing model

~ 120 Tier-2 sites

11 Tier-1 sites

Raw + recon.

Tier-1
- Manage permanent storage for raw and processed data, MC
- Capacity for re-processing, bulk analysis

Tier-1

Tier-1

Tier-2

Tier-2

Tier-2
- Analysis
- MC production

Reconstructed reprocessed

MC

Tier-3

University clusters

German Science Network XWIN
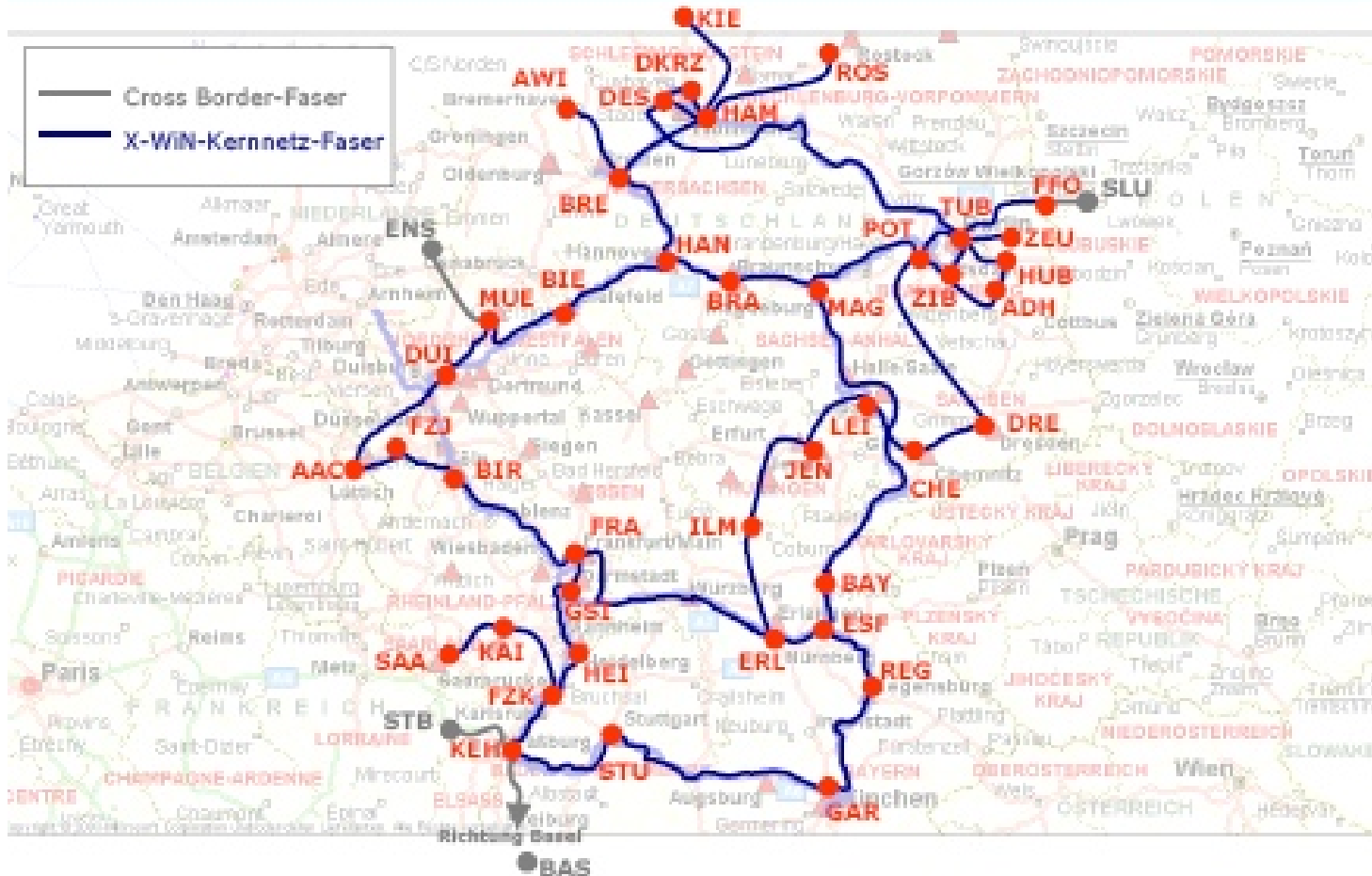
GridKa project organization

Technical Advisory Board (TAB)
- Discusses and reviews requirements of the VOs
- Discusses technical realization of GridKa
  - VO representatives
  - Tier-2 representative
  - DESY representative
  - KET, KHK (physics comitees)
  - Project leader

Overview Board (OB)
- Discusses the project planning
- Discusses financial requirements
  - VO representatives
  - Tier-2 representative
  - TAB chairman
  - DESY representative
  - KET, KHK (physics comitees)
  - BMBF representative
  - Head of the institute
  - Member of the FZK board of directors
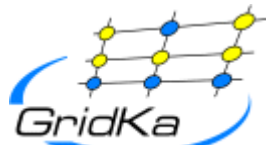
GridKa
- Planning
- Development
- Technical realization
- Operation

LCG

| Management Board | Grid Deployment Board | Computing Resources Review Board | Computing Resource Scrutiny Group |

Fundamental Grid services provided by FZK and DESY for the whole HEP community

Service	FZK/GridKa	DESY
Compute elements (CE)	X	X
Information systems (BDII)	X	X
Workload management systems (WMS)	X	X
File catalogs (LFC)	X	X
File transfer service (FTS)	X	
Storage elements (SE)	X	X
VO management (VOMS)	X	X
VO specific services (VOBox)	X	X

Very high reliability required for central (regional) services!

Service reliability measured by WLCG / EGEE

GridKa Tier-1

Milestone		ASGC	CC IN2P3	CERN	DE-KIT	INFN CNAF	NDGF	PIC	RAL	SARA NKHEF	TRIUMF	BNL	FNAL
Tier-1 Sites Reliability - June 2008													
Tier-1 Sites Reliability above 95% Considering each Tier-0 and Tier-1 site	Jan 93%					70	92		92	57		91	
	Feb 93%					20	84			84		67	85
	Mar 93%					86		88				80	
	Apr 93%					76	84			90			92
	May 93%					88							
	June 95%					86							93
Average of Best 8 Sites above 97% Average of eight sites should reach a reliability above 97%		Averages of the 8 Best sites Jan-Jun 2008 Jan 96 - Feb 96 - Mar 96 - Apr 96 - May 98 - Jun 96											
Tier-1 Sites Reliability - Dec 2008													
Tier-1 Sites Reliability above 97% Considering each Tier-0 and Tier-1 site	Jul 95%		94			79	88			91			
	Aug 95%						43						

GridKa

- Requirement by LHC and other international particle physics experiments
- Project proposed and started 2001
- Project planning oriented at the 3 phases (W)LCG timeline

LCG-1, LCG-2, principal services

Computing model(s)

Services in production

2001-2005	2005-2008	2008 …

Development and contruction of prototypes

Installation of LHC computing production facility

Full LHC service

Experiments

OB

GridKa

TAB

Management Board

Grid Deployment Board

Computing Resources Review Board

Computing Resources Scrutiny Group