

LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

MNM TEAM

lrz

# SuperMUC-NG

## ... und das Rennen um den schnellsten Computer der Welt

**Dieter Kranzmüller**

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# Tatort „Künstliche Intelligenz“

https://www.snowdenfilm.com

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The screenshot shows a website for 'Das Erste' with a navigation bar including 'Startseite', 'Sendungen', 'TV-Programm', 'Live', 'Mediathek', 'Teletext', 'Service', and 'Über uns'. The main content area features a large image for 'Tatort KI' with the headline 'Drehschluss für Münchner "Tatort: KI"'. Below this is a photo of the production team and a caption: 'Regisseur Sebastian Marka, Miroslav Nemeč, Janina Fautz und Udo Wachtveitl bei den Dreharbeiten zum neuen Münchner "Tatort: KI" (AT) (v.l.n.r.) | Bild: BR / Hendrik Heiden'. To the right, there are sections for 'SPRUNGMARKEN', 'DAS TEAM', and 'DIE FÄLLE'. A movie poster for 'SNOWDEN' is also visible on the right side of the page.

Das Erste

Startseite Sendungen TV-Programm Live Mediathek Teletext Service Über uns

tatort

Startseite Alle Fälle Vorschau Zeitreise Kommissare Ganze Folgen Extras

### Drehschluss für Münchner "Tatort: KI"

Wie verhört man eine künstliche Intelligenz?

Regisseur Sebastian Marka, Miroslav Nemeč, Janina Fautz und Udo Wachtveitl bei den Dreharbeiten zum neuen Münchner "Tatort: KI" (AT) (v.l.n.r.) | Bild: BR / Hendrik Heiden

SPRUNGMARKEN  
Worum geht es?  
Hinter der Kamera

DAS TEAM

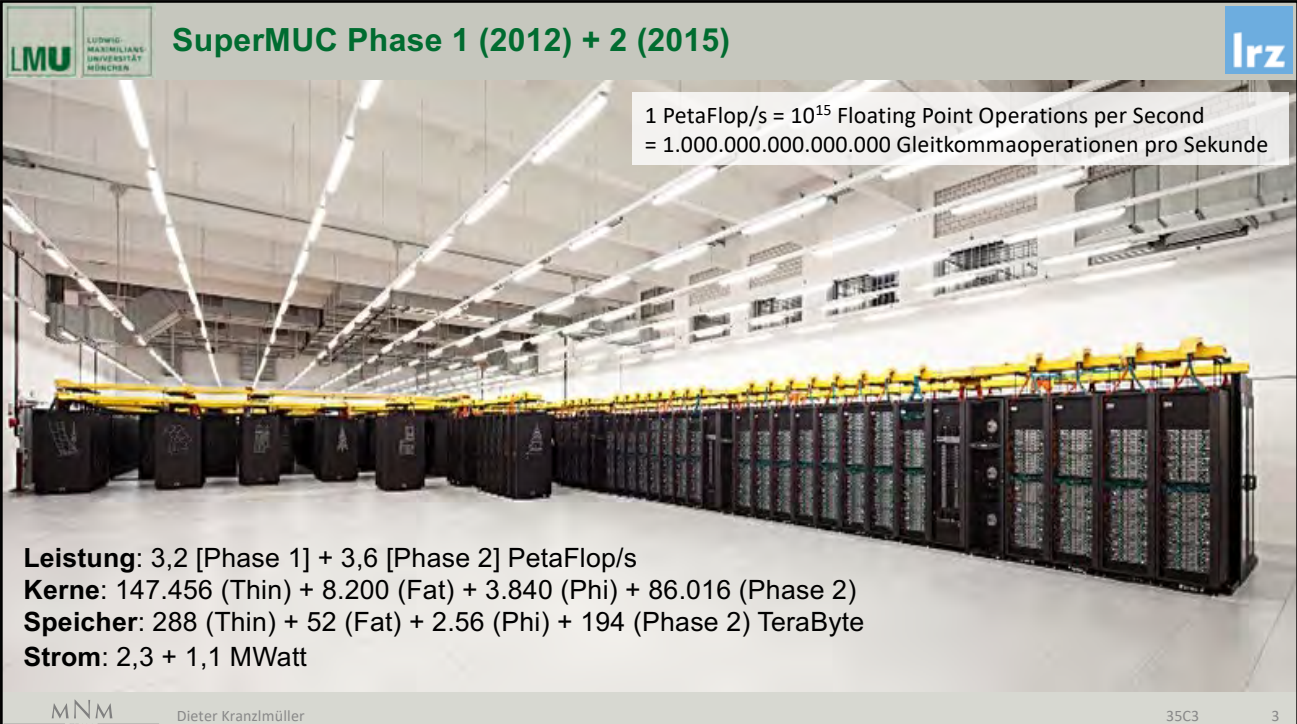
Batic und Leitmayr mit Team

DIE FÄLLE

https://www.daserste.de/unterhaltung/krimi/tatort/sendung/ki-102.html

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**LMU** LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN **SuperMUC Phase 1 (2012) + 2 (2015)** **lrz**

1 PetaFlop/s =  $10^{15}$  Floating Point Operations per Second  
 = 1.000.000.000.000.000 Gleitkommaoperationen pro Sekunde

**Leistung:** 3,2 [Phase 1] + 3,6 [Phase 2] PetaFlop/s  
**Kerne:** 147.456 (Thin) + 8.200 (Fat) + 3.840 (Phi) + 86.016 (Phase 2)  
**Speicher:** 288 (Thin) + 52 (Fat) + 2.56 (Phi) + 194 (Phase 2) TeraByte  
**Strom:** 2,3 + 1,1 MWatt

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**Leistung:** 26,7 PetaFlop/s  
**Kerne:** 311.040 Intel Xeon  
**Speicher:** 719 TeraByte

**GCS**  
Gauss Centre for Supercomputing

**Gauss Centre for Supercomputing e.V. (GCS)**

- Kooperation der nationalen Höchstleistungsrechenzentren (HLRS, JSC, LRZ)
- Ziel: **Höchstleistungsrechner für die Wissenschaft in Deutschland**
- Finanzierung: **Bundesministerium für Bildung und Forschung (BMBF)** + Baden-Württemberg, **Bayern**, Nordrhein-Westfalen

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**GCS**  
Gauss Centre for Supercomputing

**Projekt: SiVeGCS - Sicherstellung und erweiterte Verfügbarkeit der Supercomputing-Ressourcen des GCS im Rahmen der nationalen Höchstleistungsrechner-Infrastruktur (2017–2025)**

- Sicherstellung der Verfügbarkeit der leistungsfähigsten Höchstleistungsrechner in Deutschland und Europa,
- Bereitstellung modernster HPC-Technologien der höchsten Leistungsklasse für die Wissenschaft und Forschung
- Offener Zugang im wettbewerblichen Verfahren nach rein wissenschaftlichen Kriterien (Peer-Review Verfahren),
- Sicherstellung einer effizienten Nutzung,
- Effektive Ergebnisverwertung und
- umfassende Öffentlichkeitsarbeit.

**LRZ: Hochparalleles System für ein breites Anwendungsspektrum, insbes. aus den Anwendungsgebieten Astro-, Geo-, Lebens- und Umweltwissenschaften sowie aus versch. Bereichen der Physik, der Strömungsmechanik und der Chemie**

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LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN **Beschaffung SuperMUC-NG – Wettbewerblicher Dialog** lrz

- 8.12.2016: Europäische Vergabepattform SIMAP: Aufruf zur *Teilnahme am wettbewerblichen Dialog für die Vergabe des europäischen Höchstleistungsrechners SuperMUC-NG am LRZ*
  - Durchführung des Wettbewerblichen Dialogs
  - Bewerbungs- und Vertragsbedingungen
  - Description of Goods and Services
  - Decision Criteria and Benchmark Description
  - NDA-Benchmark Erklärung
  - Raum- und Kühlungspläne
- 23.01.2017: Bewerber erbringen Nachweis ihrer finanziellen und wirtschaftlichen Leistungsfähigkeit, benennen Referenzinstallationen und legen firmeneigene Konzepte zur Erhöhung der Energie- und Kühlungseffizienz dar
  - 1. Runde des Wettbewerblichen Dialogs: 5 Firmen
  - 2. Runde des Wettbewerblichen Dialogs: 2 Firmen

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LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN **Beschaffung SuperMUC-NG – Description of Goods and Services** lrz


**M 51:** Online measurements of the direct current (DC) **energy** consumption of individual compute nodes must be provided by means of monotonically increasing counters. Mandatory  
 The accuracy and measurement frequency must be specified.  
 Check here that this requirement will be fulfilled: [..]

**I 80:** Tools for reading out the node level energy and power counters should deliver energy values in units of Joules and power values in units of Watts. No additional calibration or transformation of values should be needed. Important  
 Reuse of system waste heat for the cooling of air or chilled water cooled system components will be positively evaluated.

**T 28:** Reuse of system waste heat to drive adsorption chillers is desired. If offered, the technical description of the implementation should be delivered and the cooling power that can be extracted should be specified.


[Insert text here]

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## Beschaffung SuperMUC-NG – Bewerbungs- und Vertragsbedingungen




- Erklärung Wettbewerblicher Dialog gemäß § 119 Abs. (1) und (6) GWB und § 14 Abs. (3) VgV sowie § 18 VgV
- ...
- **Total Cost of Ownership (TCO):**  
Summe aus Investitions-, Betriebs- und Wartungskosten darf die brutto zur Verfügung stehenden Mittel gemäß Anschreiben nicht überschreiten
- nur ein Hauptangebot je Bieter und keine Nebenangebote
- Installationszeitraum: Q3/2018 – Q4/2019
- ...
- Leistungsprüfung durch Leistungsmessungen
- Funktionsprüfung im Benutzerbetrieb
- ...
- Verhalten bei Bieterfragen



[https://www.lrz.de/presse/ereignisse/2017-12-14\\_supermuc-ng\\_vertrag/](https://www.lrz.de/presse/ereignisse/2017-12-14_supermuc-ng_vertrag/)


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<https://www.lrz.de/services/compute/supermuc/supermuc-ng/>

ComputeNodes	Thin Nodes	Fat Nodes	Total (Thin + Fat)
Processor	Intel Skylake	Intel Skylake	Intel Skylake
Cores per Node	48	48	48
Memory per node (GByte)	96	768	NA
Number of Nodes	6,336	144	6,480
Number of Cores	304,128	8,912	311,040
PEAK @ nominal (PFlop/s)	26.3	0.6	26.9
Linpack (PFlop/s)	TBD	TBD	19.476
Memory (TByte)	606	111	719
<b>Filesystems</b>			
High Performance Parallel Filesystem	50 PB @ 500 GB/s		
Data Science Storage	20 PB @ 70 GB/s		
Home Filesystem	256 TB		
<b>Infrastructure</b>			
Cooling	Direct warm water cooling		
Waste Heat Reuse	Reuse for producing cold water with adsorption coolers		
<b>Software</b>			
Operating System	Suse Linux (SLES)		
Batch Scheduling System	SLURM		
High Performance Parallel Filesystem	IBM Spectrum Scale (GPFS)		
Programming Environment	Intel Parallel Studio XE GNU compilers OpenHPC Software Stack		
Message Passing	Intel MPI, (OpenMPI)		

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## Top 500 Supercomputer – [www.top500.org](http://www.top500.org) – Platz 1 (Nov 2018)

Rank	System	Cores	Rmax (TFlop/s)	Rpeak (TFlop/s)	Power (kW)
1	<div style="border: 1px solid red; padding: 2px;">Summit</div> - IBM Power System AC922, IBM POWER9 22C 3.07GHz, NVIDIA Volta GV100, Dual-rail Mellanox EDR Infiniband, IBM DOE/SC/Oak Ridge National Laboratory United States	2,397,824	143,500.0	200,794.9	9,783

Rpeak – Theoretische Maximalleistung  
Rmax – Erreichte Maximalleistung im Linpack Benchmark

ORNL Launches Summit Supercomputer on June 8, 2018  
<https://www.flickr.com/photos/olcf/41941941904/in/album-72157683655708262/>

Rank	System	Cores	Rmax (TFlop/s)	Rpeak (TFlop/s)	Power (kW)
5	Piz Daint - Cray XC50, Xeon E5-2690v3 12C 2.6GHz, Aries interconnect, NVIDIA Tesla P100, Cray Inc. Swiss National Supercomputing Centre (CSCS) Switzerland	387,872	21,230.0	27,154.3	2,384
4	Trinity - Cray XC50, Xeon E5-2690v3 14C 2.3GHz, Intel Xeon Phi 7200 68C 1.4GHz, Aries interconnect, Cray Inc. DOE/NNSA/ANL/SNL United States	979,072	20,158.7	41,441.2	7,578
7	AI Bridging Cloud Infrastructure (ABCI) - PRIMERGY CX2570 ML, Xeon Gold 6148 20C 2.4GHz, NVIDIA Tesla V100 SXM2, Infiniband EDR, Fujitsu National Institute of Advanced Industrial Science and Technology (AIST) Japan	371,640	19,880.0	32,576.6	1,449
8	SuperMUC-NG - ThinkSystem S0530, Xeon Platinum 8174 24C 3.1GHz, Intel Omni-Path, Lenovo Leibniz Rechenzentrum Germany	305,856	19,476.6	26,873.9	
9	Titan - Cray XK7, Opteron 6274 16C 2.0GHz, Cray Gemini interconnect, NVIDIA K20x, Cray Inc. DOE/SC/Oak Ridge National Laboratory United States	540,640	17,590.0	27,112.5	8,209
10	Sequoia - BlueGene/Q, Power PC Q6 1.40 GHz, Custom, IBM DOE/NNSA/LLNL United States	1,572,864	17,173.2	20,132.7	7,890

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## Top 500 Supercomputer – [www.top500.org](http://www.top500.org) – Platz 1-5 (Nov 2018)

Rank	System	Cores	Rmax (TFlop/s)	Rpeak (TFlop/s)	Power (kW)
1	Summit - IBM Power System AC922, IBM POWER9 22C 3.07GHz, NVIDIA Volta GV100, Dual-rail Mellanox EDR Infiniband, IBM DOE/SC/Oak Ridge National Laboratory United States	2,397,824	143,500.0	200,794.9	9,783
2	Sierra - IBM Power System S922LC, IBM POWER9 22C 3.1GHz, NVIDIA Volta GV100, Dual-rail Mellanox EDR Infiniband, IBM / NVIDIA / Mellanox DOE/NNSA/LLNL United States	1,572,480	94,640.0	125,712.0	7,438
3	Sunway TaihuLight - Sunway MPP, Sunway NRCPC National Supercomputing Center in Wuhan China	2,397,824	143,500.0	200,794.9	9,783
4	Tianhe-2A - TH-IVB-FEP Cluster, Intel Xeon E5-2690v3 12C 2.6GHz, Aries interconnect, NVIDIA Tesla P100, Cray Inc. National Super Computer Center in Guangzhou China	2,397,824	143,500.0	200,794.9	9,783
5	Piz Daint - Cray XC50, Xeon E5-2690v3 12C 2.6GHz, Aries interconnect, NVIDIA Tesla P100, Cray Inc. Swiss National Supercomputing Centre (CSCS) Switzerland	387,872	21,230.0	27,154.3	2,384

<https://insidehpc.com/2018/11/update-piz-daint-fastest-supercomputer-europe/>

In this video from SC18 in Dallas, Michele De Lorenzi from CSCS in Switzerland provides an update on Piz Daint, the fastest supercomputer in Europe.

“Recently upgraded with two additional cabinets full of NVIDIA V100 GPUs, the Cray XC50 system comes in at #5 in the world with 21.23 Petaflops of performance on the LINPACK benchmark.”

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**Top 500 Birds of a Feather Session, 13. November 2018**

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Autoren der TOP500 Liste:


- Erich Strohmaier (NERSC/Lawrence Berkeley National Laboratory),
- Jack Dongarra (University of Tennessee, Knoxville),
- Horst Simon (NERSC/Lawrence Berkeley National Laboratory),
- Martin Meuer (Prometeus),
- Hans Meuer (Universität Mannheim) [1993-2014]

**LMU** LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN **Top 500 Supercomputer – [www.top500.org](http://www.top500.org) – SuperMUC-NG (Nov 2018)** **lrz**


Rank	System	Cores	Rmax (TFlop/s)	Rpeak (TFlop/s)	Power (kW)
8	SuperMUC-NG - ThinkSystem SD530, Xeon Platinum 8174 24C 3.1GHz, Intel Omni-Path <b>Lenovo</b> Leibniz Rechenzentrum Germany	<b>305,856</b>	<b>19,476.6</b>	<b>26,873.9</b>	

4	Tianhe-2A - TH-IVB-FEP Cluster, Intel Xeon E5-2692v2 12C 2.20GHz, TH Express-2, Memm-2009, NUDT National Super Computer Center in Guangzhou China	4,981,760	61,444.3	100,678.7	18,482
5	Pia Daim - Cray XC30, Xeon E5-2695v3 12C 2.60GHz, Arnes interconnect, NVIDIA Tesla P100, Cray Inc. Swiss National Supercomputing Centre (SCS) Switzerland	387,872	21,230.0	27,154.3	2,384
6	Trinity - Cray XC40, Xeon E5-2695v3 14C 2.30GHz, Intel Xeon Phi 7201 68C 1.4GHz, Arnes interconnect, Cray Inc. DOE/NNSA/LANL/SNL United States	979,072	20,158.7	41,461.2	7,578
7	AI Bridging Cloud Infrastructure (ABCI) - PROMETHEUS CX2550 M4, Xeon Gold 6148 24C 2.40GHz, NVIDIA Tesla V100 504C, InfiniBand EDR, Fujitsu National Institute of Advanced Industrial Science and Technology (AIST)	391,680	19,860.0	32,576.6	1,649
8	SuperMUC-NG - ThinkSystem SD530, Xeon Platinum 8174 24C 3.1GHz, Intel Omni-Path, <b>Lenovo</b> Leibniz Rechenzentrum Germany	<b>305,856</b>	<b>19,476.6</b>	<b>26,873.9</b>	
9	Trinity - Cray XC40, Xeon E5-2695v3 14C 2.30GHz, Intel Xeon Phi 7201 68C 1.4GHz, Arnes interconnect, Cray Inc. DOE/SCS/Oak Ridge National Laboratory United States	560,640	17,590.0	27,142.5	8,209
10	Sequoia - BlueGene/Q, Power PC 14C 1.60 GHz, Custom, IBM DOE/NNSA/LANL United States	1,572,864	17,173.2	20,132.7	7,890

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## Der LINPACK Benchmark - <https://www.top500.org/project/linpack/>




**Löser für lineares Gleichungssystem (Jack Dongarra):**

Rank	Pre	First	Firs	Name	Computer	Site	Manufactu	Country	Year	Segment	Total Co	Accelerz	Rmax [TFk	Rpeak [TFI	Nmax	
1	1	1	51	1	Summit	IBM Power S	DOE/SC/Oak	IBM	United States	2018	Research	2397824	2196480	143500	200794,88	16693248
2	3	51	3	Sierra	IBM Power S	DOE/NNSA/L	IBM / NVIDIA	United States	2018	Research	1572480	1382400	94640	125712	11902464	
3	2	47	1	Sunway Taihu	Sunway MPP	National Supr	NRCPC	China	2016	Research	1,1E+07		93014,5939	125435,904	12288000	
4	4	41	1	Tianhe-2A	TH-IVB-FEP	National Supr	NUDT	China	2018	Research	4981760	4554752	61444,5	100678,664	9773000	
5	6	40	114	Piz Daint	Cray XC50, X	Swiss Nation	Cray Inc.	Switzerland	2017	Research	387872	319424	21230	27154,3	3743232	
6	9	46	6	Trinity	Cray XC40, X	DOE/NNSA/L	Cray Inc.	United States	2017	Research	979072		20158,7	41461,15	12353536	
7	5	51	5	AI Bridging C	PRIMERGY C	National Instit	Fujitsu	Japan	2018	Research	391680	348160	19880	32576,6349	2918016	
8	8	52	8	SuperMUC-N	ThinkSystem	Leibniz Rech	Lenovo	Germany	2018	Academic	305856		19476,6	26873,856	8402688	

- 64 Bit Gleitkommaoperation (Addition oder Multiplikation)
- *“Performance of Various Computers Using Standard Linear Equations Software”*, Jack Dongarra, University of Tennessee, Knoxville TN, 37996, Computer Science Technical Report Number CS - 89 – 85, today’s date, <http://www.netlib.org/benchmark/performance.ps>
- **Amdahlsches Gesetz:** Geschwindigkeitszuwachs ist durch sequentiellen Teil beschränkt
- **Gustafsons Gesetz:** genügend großes Problem kann effizient parallelisiert werden


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## Do it yourself – LINPACK Benchmark

**App für Ihr Smartphone:**


- iOS: <https://itunes.apple.com/de/app/linpack/id380883195?mt=8>
- Android: <https://play.google.com/store/apps/details?id=com.sqj.linpack>
- Google „Linpack App“

**iPhone 7:**


- Max MFlop/s: 7014,18
- Avg MFlop/s: 6680,91


**Cray Y-MP Supercomputer (1988):**

- Max MFlop/s: 2664



By Dave Pape [Public domain], from Wikimedia Commons  
[https://commons.wikimedia.org/wiki/File:Cray\\_Y-MP\\_GSFC.jpg](https://commons.wikimedia.org/wiki/File:Cray_Y-MP_GSFC.jpg)




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## Top 500 Supercomputer – Leistungsentwicklung

<https://www.top500.org/statistics/perfdevel/>

**Platz 1:**

- Juni 1993:  
59,7 GFlop/s (CM-5) =  $59,7 \cdot 10^9$
- Nov 2018:  
122,3 PFlop/s (Summit) =  $122,3 \cdot 10^{15}$
- Leistungssteigerung:  
 $59,7 \cdot 10^9 \rightarrow 122,3 \cdot 10^{15} = \text{ca. } 2 \cdot 10^6$   
Zeitraum: 25 Jahre, 5 Monate
- Exponentielles Wachstum  
==> Mooresches Gesetz

**Projected Performance Development**

The graph shows performance on a logarithmic scale from 100 MFlop/s to 10 EFlop/s. Three lines represent the total performance (Sum), the top performer (#1), and the 500th performer (#500). All three show exponential growth over time.

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## Mooresches Gesetz

- Gordon E. Moore, „Cramming more components onto integrated circuits“, Electronics Magazine, p.4, 19.04.1965

**Log<sub>2</sub> of the Number of Components Per Integrated Function**

The graph shows a linear relationship between the year and the log<sub>2</sub> of the number of components per integrated function, illustrating Moore's Law.

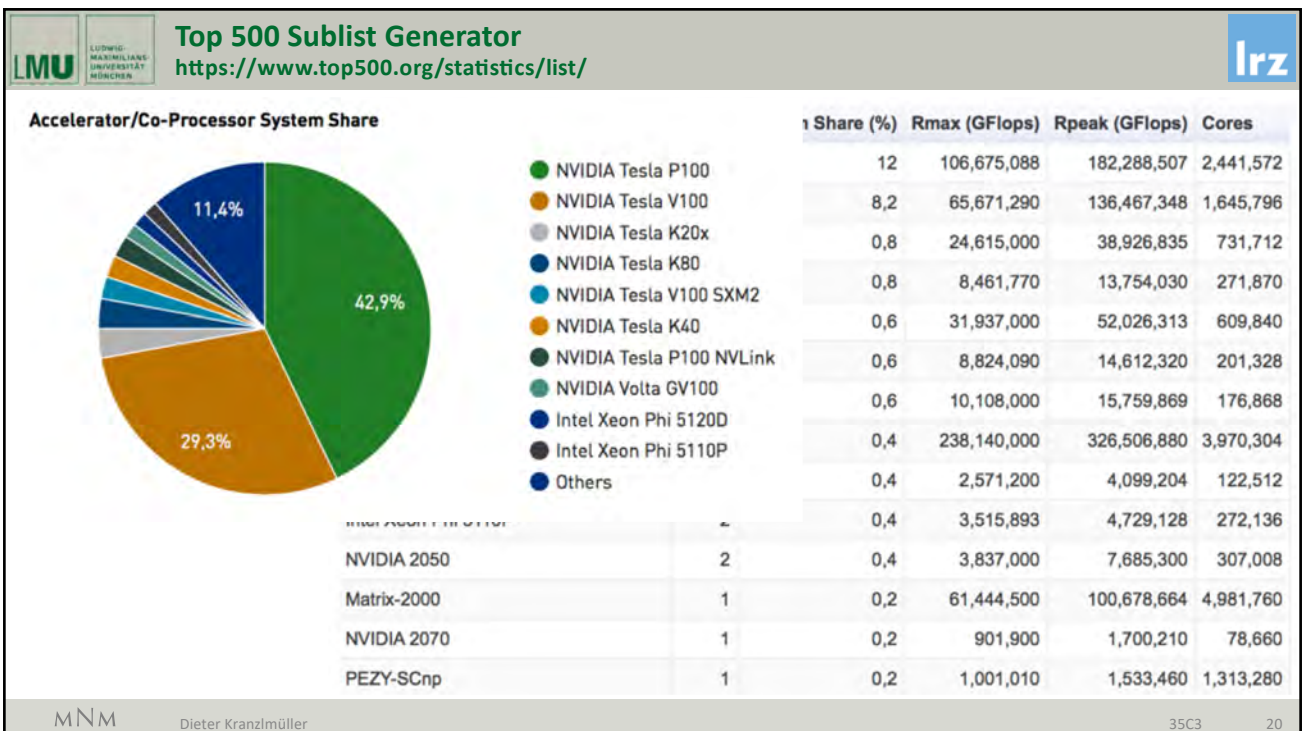
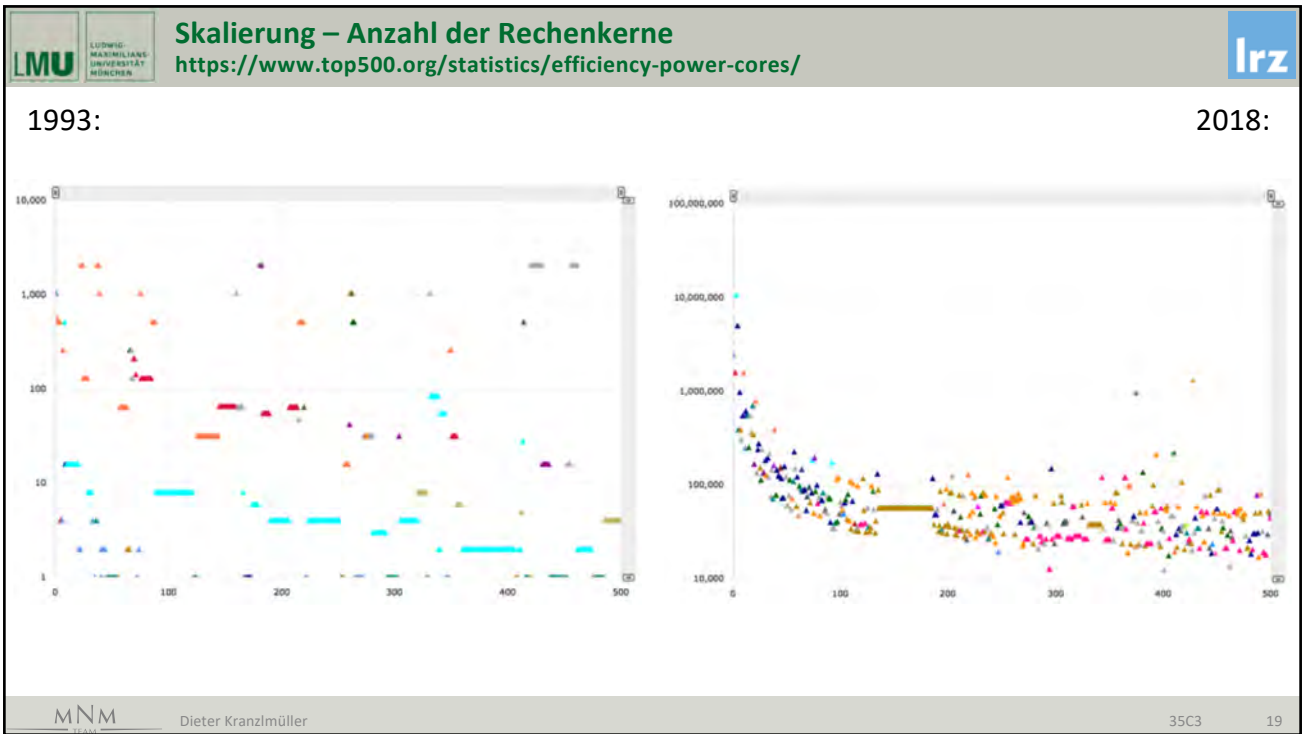
**Microprocessor Transistor Counts 1971-2011 & Moore's Law**

The graph shows transistor counts on a logarithmic scale from 2,300 to 2,600,000,000. A diagonal line represents Moore's Law, with a note: "curve shows transistor count doubling every two years".

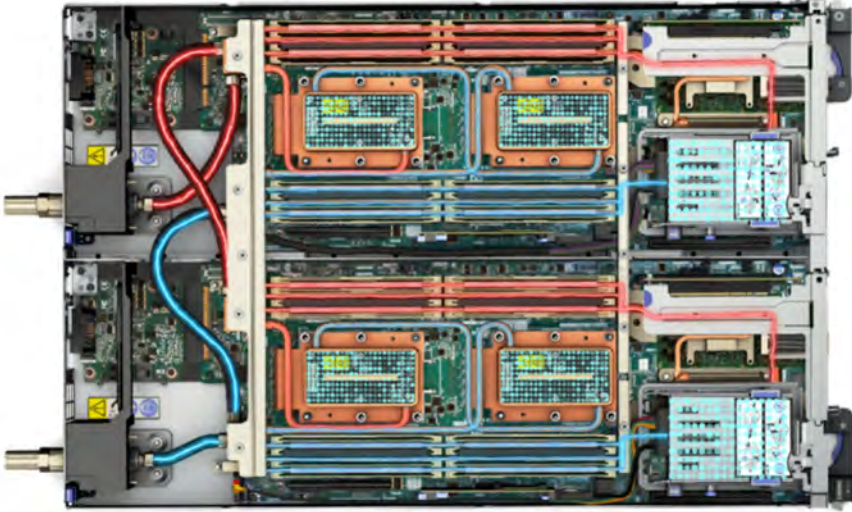

Von Wgsimon - Eigenes Werk, CC BY-SA 3.0  
<https://commons.wikimedia.org/w/index.php?curid=15193542>

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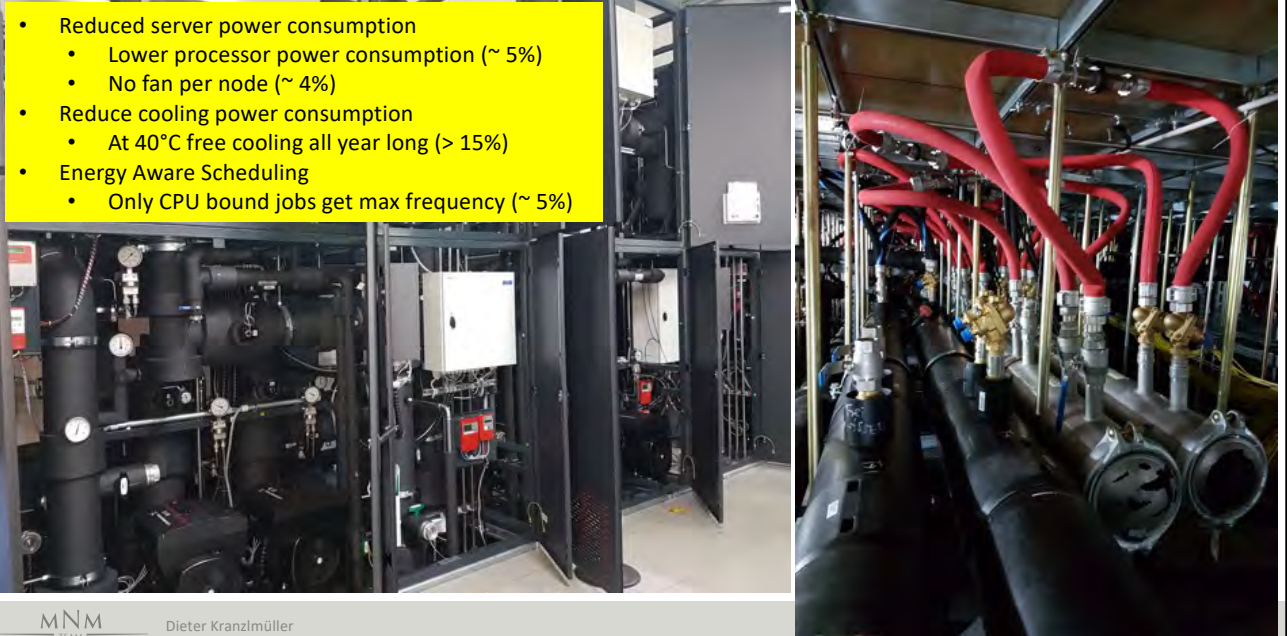


LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN		SuperMUC-NG Prozessoren (Intel Xeon Platinum 8174 Scalable Processors)		lrz
CPU		INTEL thin	INTEL fat	
Processor type		Intel Skylake	Intel Skylake	
Total number of nodes of this type		6336	144	
Number of islands with this node type		8	1	
Number of processors (sockets) per node		2	2	
Number of cores per processor		24	24	
Memory per node (GByte)		96	768	
Nominal frequency (GHz)		3,10	3,10	
Peak frequency (GHz)		3,90	3,90	
Floating point operations per core per clock (Fused MulAdd counts as 2)		32	32	
Peak floating point performance of one core @ nominal (GFlop/s)		99,20	99,20	
Peak AVX-512 floating point performance of one node (all cores active)		3533	3533	
Total		INTEL thin	INTEL fat	
Total CPU Cores		304128	6912	
Total Peak PFlop/s @ maximum AVX-512 frequency (all cores active)		22,38	0,51	
SUM PEAK PFlop/s @ maximum AVX-512 frequency (all cores active)			22,89	
Total Nodes			6480	

LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN		SuperMUC-NG Knoten – mit Heißwasserkühlung		lrz
<b>Lenovo Think System SD650:</b>				
				
<p>Bilder: Lenovo – Produkt: <a href="https://www.lenovo.com/de/de/data-center/servers/high-density/ThinkSystem-SD650/p/77XX7DSSD65">https://www.lenovo.com/de/de/data-center/servers/high-density/ThinkSystem-SD650/p/77XX7DSSD65</a></p>				
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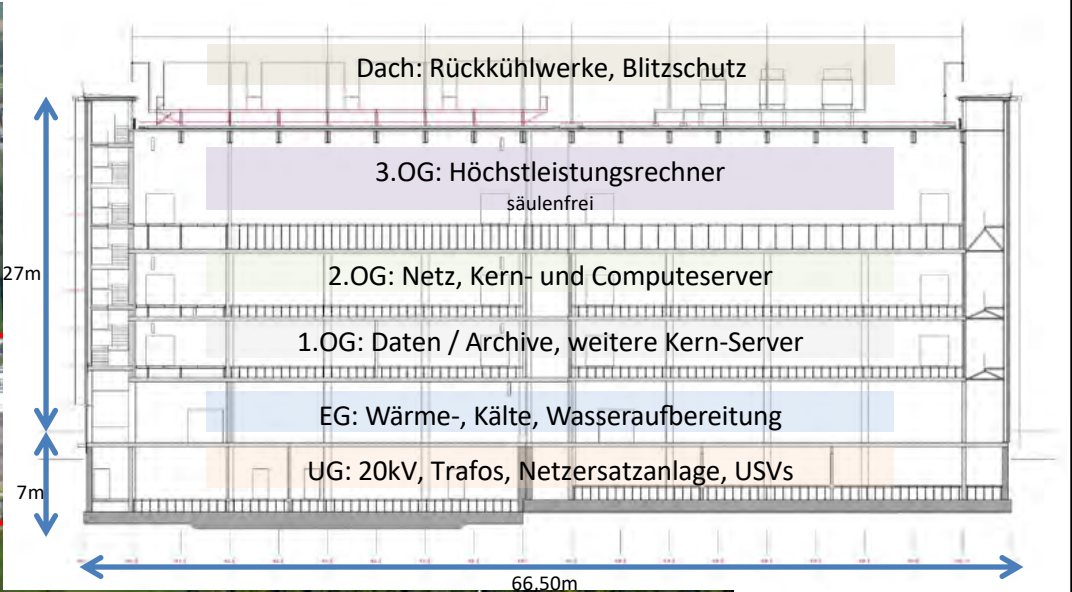
**LMU** LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN **SuperMUC-NG Cool Manager – Kühlwasser 3000 l/h pro Rack** **lrz**

- Reduced server power consumption
  - Lower processor power consumption (~ 5%)
  - No fan per node (~ 4%)
- Reduce cooling power consumption
  - At 40°C free cooling all year long (> 15%)
- Energy Aware Scheduling
  - Only CPU bound jobs get max frequency (~ 5%)



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**LMU** LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN **Leibniz-Rechenzentrum am Forschungsgelände Garching b. München** **lrz**

Dach: Rückkühlwerke, Blitzschutz

3.OG: Höchstleistungsrechner  
säulenfrei

2.OG: Netz, Kern- und Computeserver

1.OG: Daten / Archive, weitere Kern-Server

EG: Wärme-, Kälte, Wasseraufbereitung

UG: 20kV, Trafos, Netzersatzanlage, USVs

27m

7m

66.50m

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**Gesamtheitliche Sicht der Infrastruktur – 4 Säulenmodell**

Torsten Wilde, Axel Auweter, Hayk Shoukourian  
 „The 4 Pillar Framework for energy efficient HPC data centers“  
 Comput Sci Res Dev (2014) 29: 241.  
<https://doi.org/10.1007/s00450-013-0244-6>

**External Influences/Constraints**

Neighboring Buildings

Data Center (Goal: Reduce Total Cost of Ownership)

Utility Providers

Improve PUE (Power Usage Effectiveness)  
**Pillar 1**  
 Building Infrastructure

Reduce Hardware Power Consumption  
**Pillar 2**  
 HPC System Hardware

Optimize Resource Usage  
 Tune System  
**Pillar 3**  
 HPC System Software

Optimize Performance  
**Pillar 4**  
 HPC Applications

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**SuperMUC Phase 1 – HPL Lastkurven**

The main graph plots Power (kW) on the left y-axis (0 to 4000) and Energy (kWh) on the right y-axis (0 to 50000) against Time (Clock) on the x-axis (16:30 to 12:00). The legend includes: Power (Machine Room, kW) in blue, Power (PDU, kW) in light blue, Power (infrastructure, kW) in orange, Energy (Machine Room, kWh) in red, and Integrated Power (PDU, kWh) in teal. Vertical dashed lines indicate HPL Start at approximately 21:00 and HPL End at approximately 9:00. The inset graph shows PUE (Power Usage Effectiveness) on the y-axis (0 to 3.0) against Time (Clock) on the x-axis (16:30 to 12:00).

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**LMU** LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN **LINPACK als Test für die Zuverlässigkeit der Infrastruktur** **lrz**



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**LMU** LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN **Stromversorgung: Trafo + Notstromaggregat + USV** **lrz**



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## Top 500 Supercomputer – [www.top500.org](http://www.top500.org) – SuperMUC-NG

Rank	System	Cores	Rmax (TFlop/s)	Rpeak (TFlop/s)	Power (kW)
8	<b>SuperMUC-NG</b> - ThinkSystem SD530, Xeon Platinum 8174 24C 3.1GHz, Intel Omni-Path , <b>Lenovo</b> Leibniz Rechenzentrum Germany	305,856	19,476.6	26,873.9	

**#1** Data-intensive applications **SSSP benchmark**

**#5** Data-intensive applications **BFS benchmark**

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## Bestimmung von Phylogenetischen Bäumen (A. Stamatakis, HITS)

Sequencing

ACGT  
 ACC  
 ACGG  
 AAGC

Alignment

ACGT  
 ACC  
 ACGG  
 AAGC

Phylogenetic Tree

Alexandros Stamatakis | Scientific Computing Group, Heidelberg Institute for Theoretical Studies (HITS)/Exelixis Lab

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## Anzahl der möglichen Bäume für 150 Arten

422651724780911225221961880237704280971893238344988  
 229428574798808314340321787590245367984919511683076  
 494692867414802738570221298292428457687814873455212  
 186186160080447460842662604444893669850056024681161  
 864412642274254407266766149279065406493602976397461  
 91746932675093119088924140669405460357666015625

$\approx 4.22 \times 10^{301}$

Alexandros Stamatakis | Scientific Computing Group, Heidelberg Institute for Theoretical Studies (HITS)/Exelixis Lab

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## Ergebnisse der Berechnungen auf SuperMUC-NG

Alexandros Stamatakis | Scientific Computing Group, Heidelberg Institute for Theoretical Studies (HITS)/Exelixis Lab

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## SeisSol – Numerische Simulation von seismischen Wellenphänomenen

Dr. Christian Pelties, Department für Geo- und Umweltwissenschaften (LMU)  
 Prof. Michael Bader, Institut für Informatik (TUM)

1,42 Petaflop/s auf 147.456 Rechenkernen von SuperMUC  
 (44,5 % of Peak Performance)  
[http://www.uni-muenchen.de/informationen\\_fuer/presse/presseinformationen/2014/pelties\\_seisol.html](http://www.uni-muenchen.de/informationen_fuer/presse/presseinformationen/2014/pelties_seisol.html)

Bild: Alex Breuer (TUM) / Christian Pelties (LMU)

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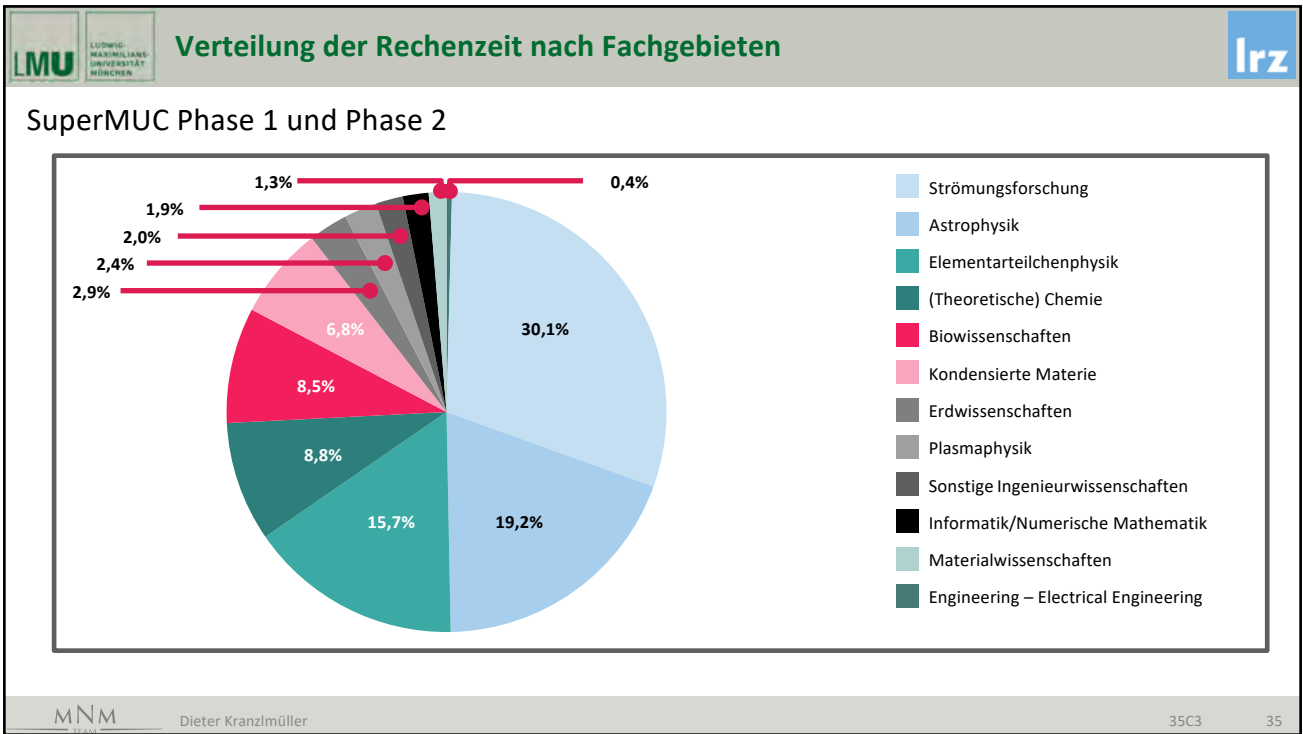
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## LRZ Anwendungsspektrum

<p><b>Computational Fluid Dynamics</b>                  Optimisation of turbines/wings, noise reduction</p> <hr style="border-top: 1px dotted #ccc;"/> <p><b>Fusion</b>                  Plasma in a future fusion reactor (ITER)</p> <hr style="border-top: 1px dotted #ccc;"/> <p><b>Astrophysics</b>                  Origin and evolution of stars and galaxies</p> <hr style="border-top: 1px dotted #ccc;"/> <p><b>Solid State Physics</b>                  Superconductivity, surface properties</p> <hr style="border-top: 1px dotted #ccc;"/> <p><b>Geophysics</b>                  Earth quake scenarios</p> <hr style="border-top: 1px dotted #ccc;"/> <p>...</p>	<p><b>Material Science</b>                  Semiconductors</p> <hr style="border-top: 1px dotted #ccc;"/> <p><b>Chemistry</b>                  Catalytic reactions</p> <hr style="border-top: 1px dotted #ccc;"/> <p><b>Medicine and Medical Engineering</b>                  Blood flow, aneurysms, air conditioning</p> <hr style="border-top: 1px dotted #ccc;"/> <p><b>Biophysics</b>                  Properties of viruses, genome analysis</p> <hr style="border-top: 1px dotted #ccc;"/> <p><b>Climate research</b>                  Currents in oceans</p> <hr style="border-top: 1px dotted #ccc;"/> <p>...</p>
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**LRZ Anwendungsspektrum**

**Computational Fluid Dynamics**  
Optimisation of turbines/wings, noise reduction

**Fusion**  
Plasma in a future fusion reactor (ITER)

**Astrophysics**  
Origin and evolution of stars and galaxies

**Solid State Physics**  
Superconductivity, surface properties

**Geophysics**  
Earth quake scenarios

...

- > 7.6 billion compute hours consumed
- > 5.6 million jobs processed
- > 750 research projects carried out
- > 1,995 researchers as clients

**High Performance Computing**  
in Science and Engineering  
Garching/Munich 2018

Get your digital copy  
of the results book on SuperMUC projects

**SuperMUC-NG Next Gen Science Symposium**  
<https://www.lrz.de/presse/ereignisse/SuperMUC-NG-Science-Symposium/>

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## Top 500 Supercomputer – [www.top500.org](http://www.top500.org) – SuperMUC-NG

Rank	System	Cores	Rmax (TFlop/s)	Rpeak (TFlop/s)	Power (kW)
8	<b>SuperMUC-NG - ThinkSystem SD530, Xeon Platinum 8174 24C 3.1GHz, Intel Omni-Path , Lenovo</b> Leibniz Rechenzentrum Germany	305,856	19,476.6	26,873.9	
4	Tianhe-2A - TH-FV5-FEP Cluster, Intel Xeon E5-2692v2 12C 2.20GHz, TH Express-2, Matrox-2000 , NUGT National Super Computer Center in Guangzhou China		4,981,740	61,444.5	100,678.7
5	Piz Daint - Cray XC30, Xeon E5-2690v3 12C 2.60GHz, Arries interconnect , NVIDIA Tesla P100 , Cray Inc. Swiss National Supercomputing Centre (CSCS) Switzerland		387,872	21,230.0	27,154.3
4	Trinity - Cray XC40, Xeon E5-2670v3 14C 2.30GHz, Intel Xeon Phi 7200 68C 1.4GHz, Arries interconnect , Cray Inc. DOE/NNSA/ANL/SNL United States		979,072	20,158.7	41,461.2
7	AI Bridging Cloud Infrastructure (ABCI) - PRIMER1 CK2570 M4, Xeon Gold 6148 20C 2.4GHz, NVIDIA Tesla V100 SXM2, Infiniband EDR , Fujitsu National Institute of Advanced Industrial Science and Technology (AIST) Japan		371,640	19,880.0	32,576.6
8	<b>SuperMUC-NG - ThinkSystem SD530, Xeon Platinum 8174 24C 3.1GHz, Intel Omni-Path , Lenovo</b> Leibniz Rechenzentrum Germany		305,856	19,476.6	26,873.9
9	Titan - Cray XK7, Opteron 6274 16C 2.200GHz, Cray Gemini interconnect, NVIDIA K20x , Cray Inc. DOE/SC/Dak Ridge National Laboratory United States		540,640	17,570.0	27,112.5
10	Sequoia - BlueGene/Q, Power RGC 14C 1.40 GHz, Custom , IBM DOE/NNSA/LLNL United States		1,572,864	17,173.2	20,132.7

Bild: Morio, Nico Rosberg 2013 Catalonia test (19-22 Feb) Day 3.jpg  
[https://commons.wikimedia.org/wiki/File:Nico\\_Rosberg\\_2013\\_Catalonia\\_test\\_\(19-22\\_Feb\)\\_Day\\_3.jpg](https://commons.wikimedia.org/wiki/File:Nico_Rosberg_2013_Catalonia_test_(19-22_Feb)_Day_3.jpg)

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LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN **Letzte Worte** lrz

**Worüber ich nicht sprechen konnte, weil die Zeit nicht gereicht hat:**

- Der nächste Schritt: Exascale – die Exaflop/s Barriere  
*Wer kommt zuerst an: China, USA oder doch Japan?*
- Der europäische Höchstleistungsmaschner (EuroHPC)  
*Wie die EU Kommission in die Top 3 vorstoßen will?*
- Die europäische Prozessorintia (EuroHPC)  
*ru einen eigenen Prozessor bauen möchte?*
- ...
- Nutzung der Rechnerabwärme – Absorptionstemaschinen am LRZ  
*Wir brauen Bier mit dem heißen Wasser aus SuperMUC?*



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LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN **SuperMUC-NG am Leibniz-Rechenzentrum (LRZ)** lrz



**Tag der offenen Tür**  
am Forschungsgelände Garching b. München  
→ Oktober 2019  
<https://www.lrz.de/wir/tag-der-offenen-tuer/>

**SuperMUC-NG Next Gen Science Symposium:**  
<https://www.lrz.de/presse/ereignisse/SuperMUC-NG-Science-Symposium/>

**SuperMUC Berichtsband:**  
<https://www.lrz.de/services/compute/supermuc/magazinesbooks/>

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