# JUWELS BOOSTER

## The ~~last~~ most remarkable stop (for now) of the NVIDIA application lab at JSC

21.06.2022 I D. ALVAREZ

# BRIEF TIMELINE OF SOME GPU PRODUCTION SYSTEMS AT JSC

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2011 — 2012 — 2013 — 2014 — 2015 — 2016 — 2017 — 2018 — 2019 — 2020 — 2021

JUDGE
enters production

# BRIEF TIMELINE OF SOME GPU PRODUCTION SYSTEMS AT JSC

JURECA Cluster
enters production

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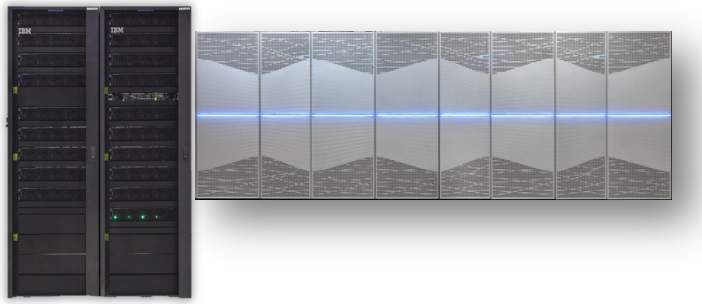
JUWELS Cluster
enters production



# BRIEF TIMELINE OF SOME GPU PRODUCTION SYSTEMS AT JSC

JURECA Cluster enters production

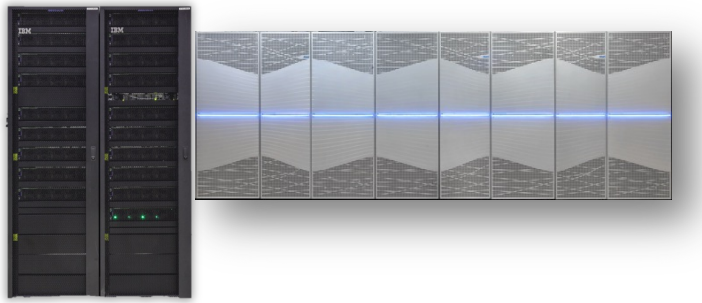
JUWELS Booster enters production

2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021

JUDGE enters production

JURON enters production

JUWELS Cluster enters production



# BRIEF TIMELINE OF SOME GPU PRODUCTION SYSTEMS AT JSC

JURECA Cluster enters production

JUWELS Booster enters production

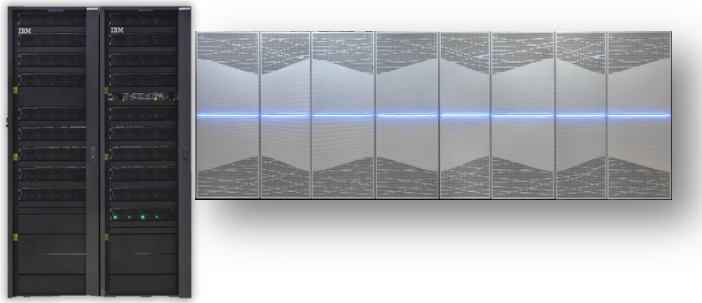
2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021

JUDGE enters production

JURON enters production

JUWELS Cluster enters production

JURECA-DC enters production



# BRIEF TIMELINE OF SOME GPU PRODUCTION SYSTEMS AT JSC

2011 Fermi is introduced

2012 JUDGE enters production

2013 Kepler is introduced

2014

2015 JURECA Cluster enters production

2016 Maxwell is introduced

2017 Pascal is introduced

2018 JURON enters production

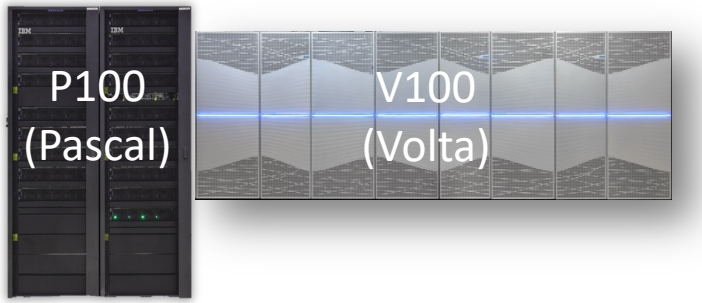
2019 Volta is introduced

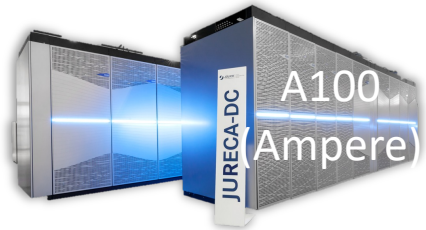
2020 JUWELS Cluster enters production

2021 JUWELS Booster enters production

Ampere is introduced

JURECA-DC enters production



TOP 500
The List.
CERTIFICATE
JUWELS Booster Module - Bull Sequana XH2000 , AMD EPYC 7402 24C 2.8GHz, NVIDIA A100,
Mellanox HDR InfiniBand/ParTec ParaStation ClusterSuite
Forschungszentrum Juelich (FZJ), Germany
is ranked
No. 7
among the World's TOP500 Supercomputers
with 44.12 PFlop/s Linpack Performance
in the 56th TOP500 List published at the SC2020 Virtual
Conference on November 16, 2020.
Congratulations from the TOP500 Editors
Martin Meuer
Prometeus
Horst Simon
NERSC/Berkeley Lab
Jack Dongarra
University of Tennessee
Erich Strohmaier
NERSC/Berkeley Lab
The
GREEN
500
CERTIFICATE
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Forschungszentrum Juelich (FZJ), Germany
is ranked
No. 3
among the World's TOP500 Supercomputers
with 25.008 GFlops/watts Performance
in the Green500 List published at the SC2020 Virtual
Conference on November 16, 2020.
Congratulations from the Green500 Editors
Wu-chun Feng
Virginia Tech
Kirk Cameron
Virginia Tech

#1 in TOP500 Europe
#1 in Green500 among the top 100 in HPL
#5 HPCG500
#4 HPL-AI

TOP 500 CERTIFICATE
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TOP 500
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is ranked
No. 18
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308 GFlops/watts Performance
Green500 List published at the ISC22
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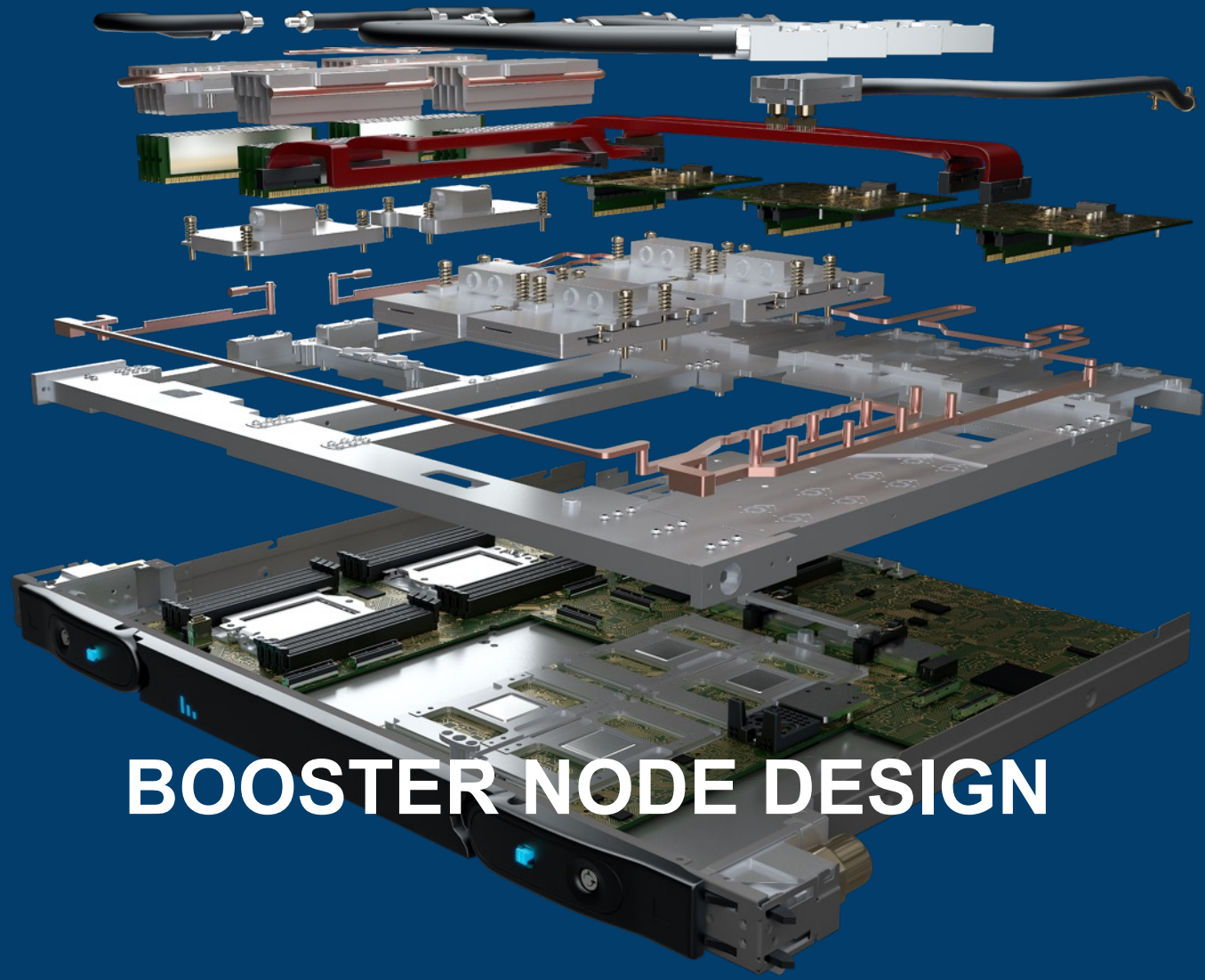
Strong push back from AMD-based GPUs!

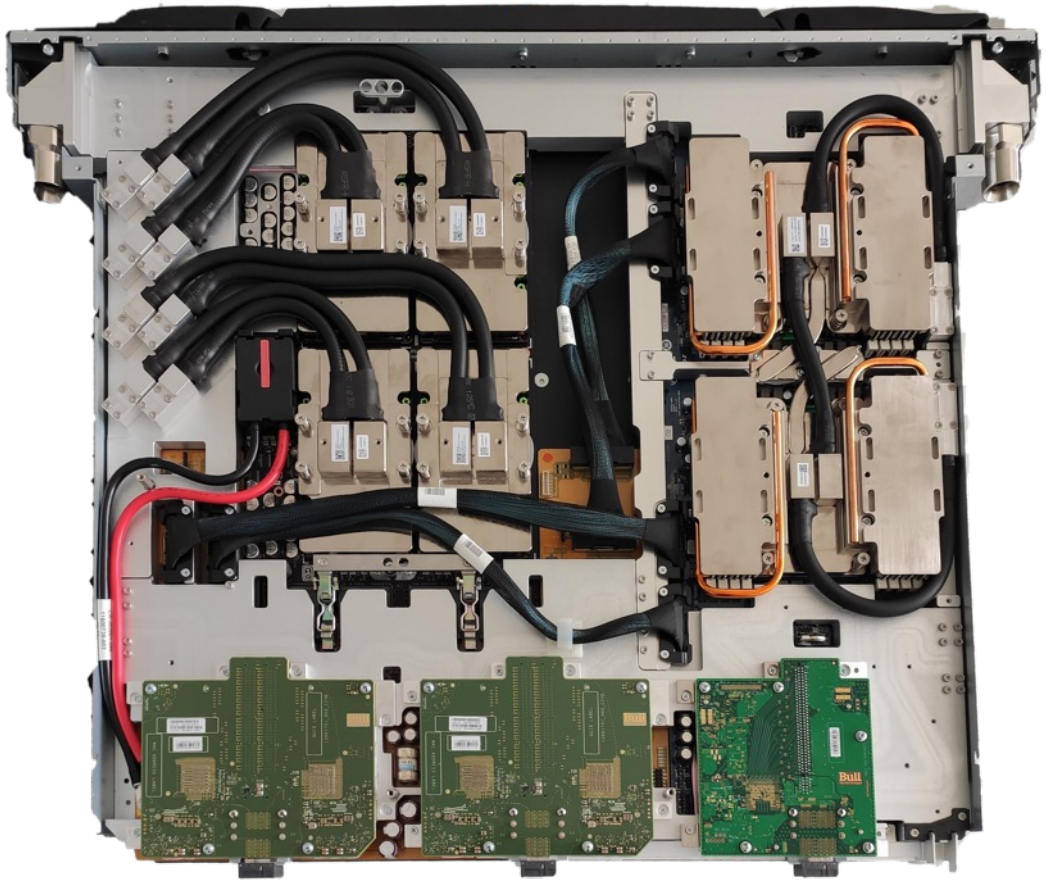


# BOOSTER NODE DESIGN

# JUWELS BOOSTER NODES

- 936 compute nodes
  - 2× 24-core AMD Epyc Rome CPUs
    - 2x 8 memory channels
    - 2x 256 GB DDR4 @ 3.2GHz
    - 96 PCIe Gen4 lanes
  - 512 GB DDR memory
  - 4× Nvidia A100 GPUs
    - 9.7 / 19.5 TF/s peak
    - 40 GB HBM2
    - 1.5 TB/s memory performance
    - NVLink3 full mesh
      - 4 links (200GB/s) between GPU pairs
    - PCIe Gen4 x32 (64 GB/s)
  - 4x HDR200 InfiniBand adapter (1 per GPU)

# BOOSTER NODES



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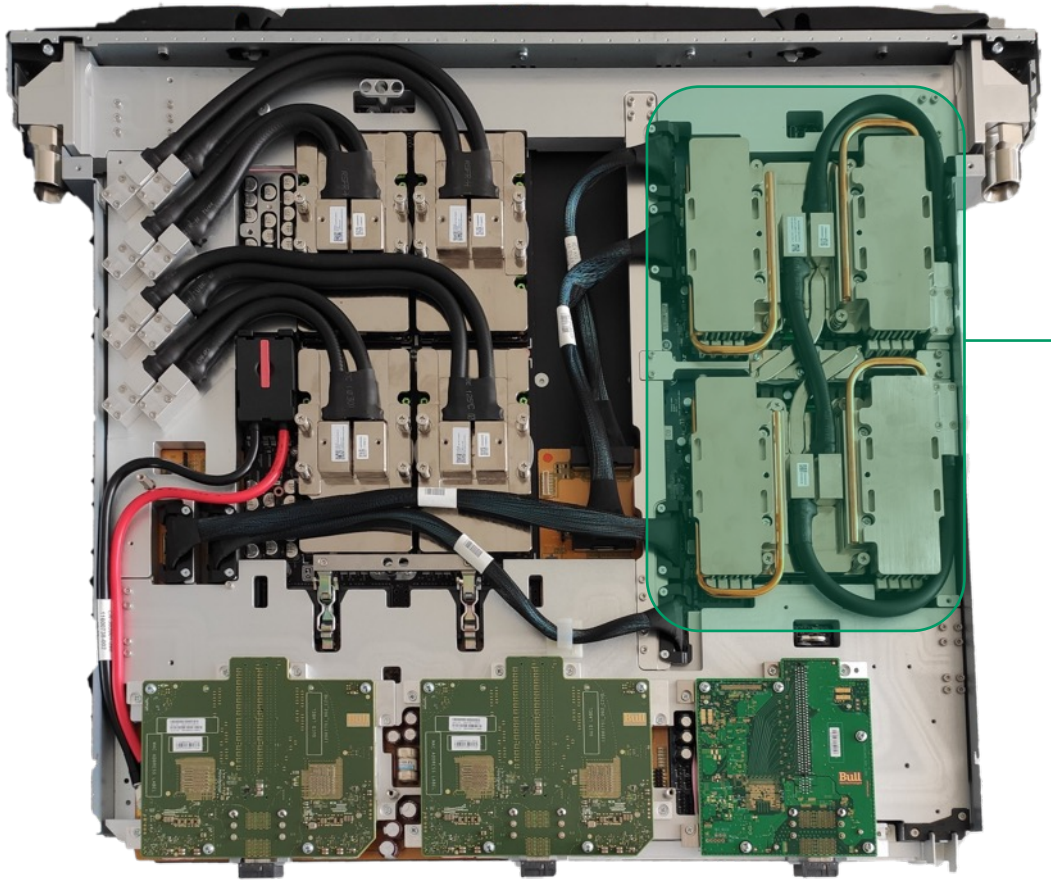
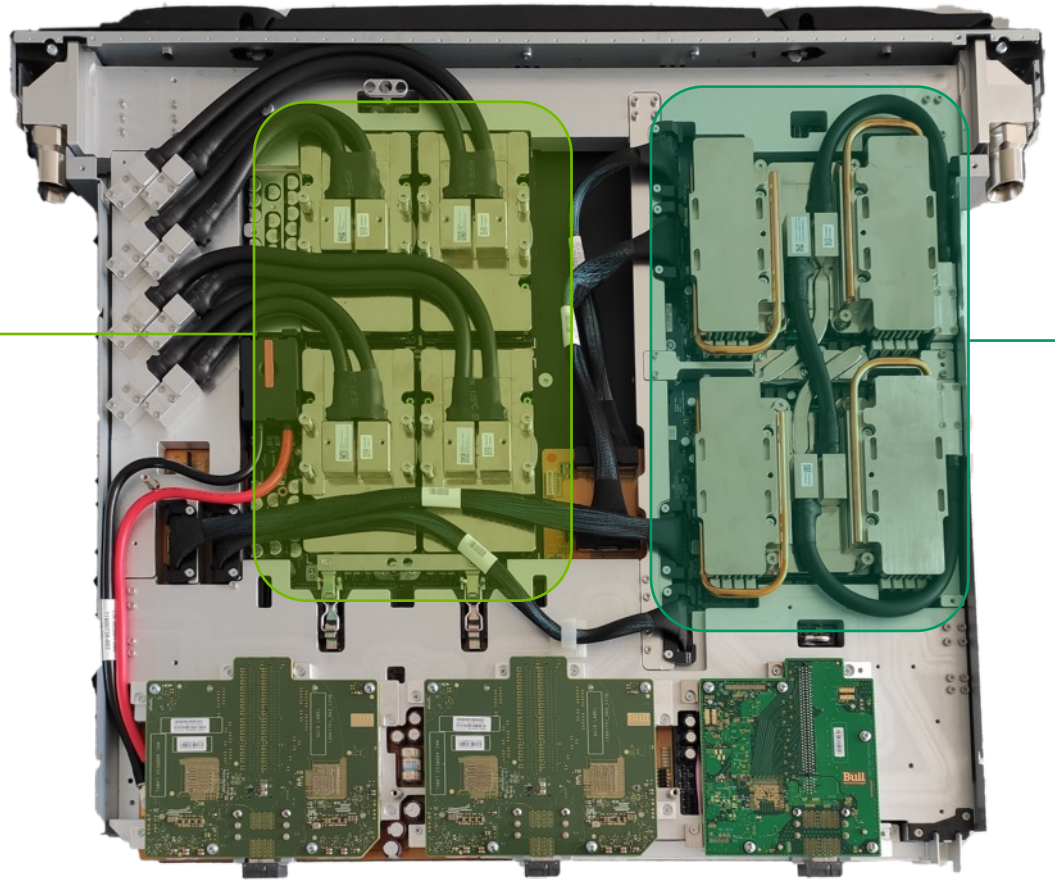


AMD
2x EPYC 7402

# BOOSTER NODES

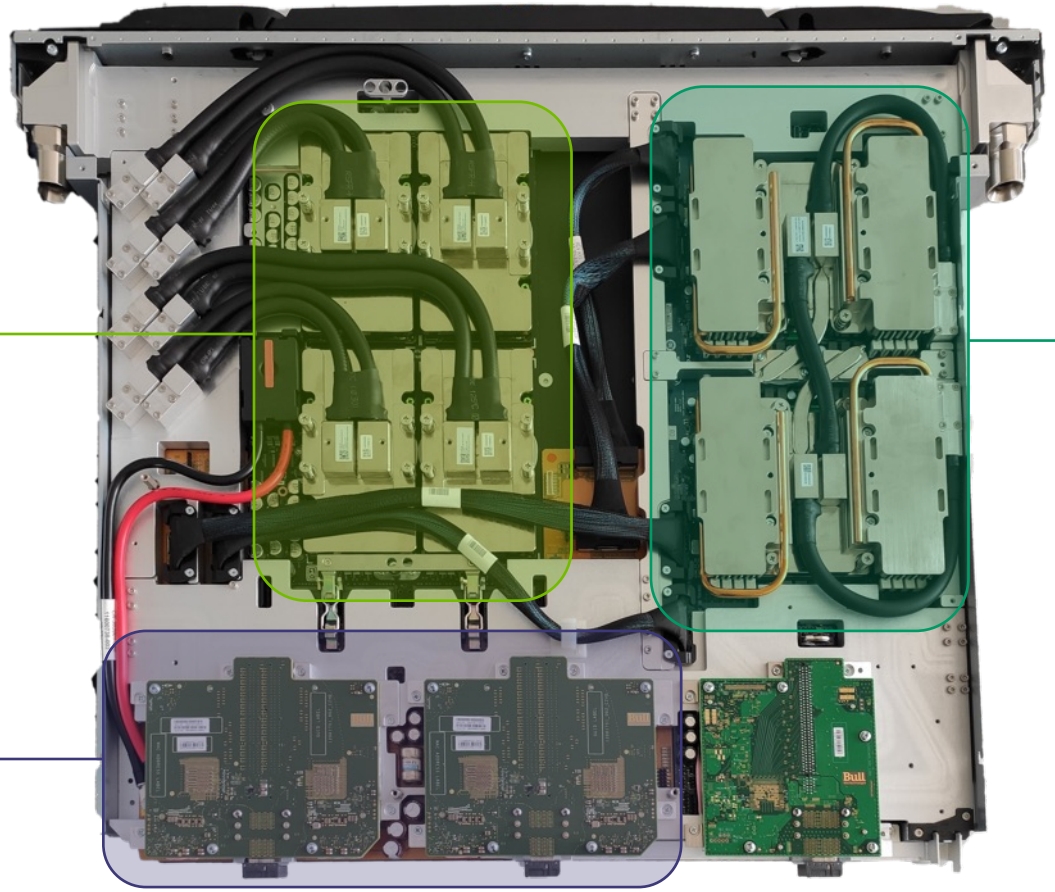
4x A100 40GB
1x “Redstone” board



AMD
2x EPYC 7402

# BOOSTER NODES

4x A100 40GB
1x “Redstone” board

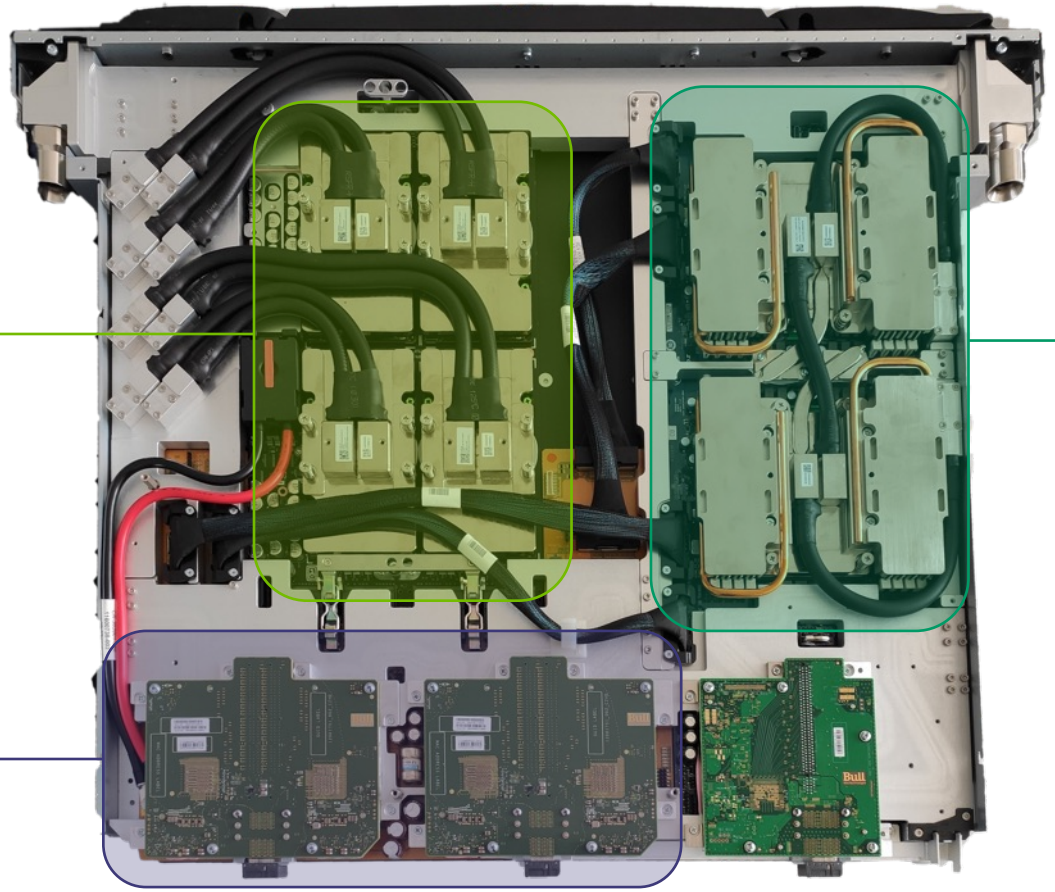


AMD
2x EPYC 7402

Atos Mellanox TECHNOLOGIES
2x boards
4x ConnectX-6

# BOOSTER NODES

4x A100 40GB
1x “Redstone” board



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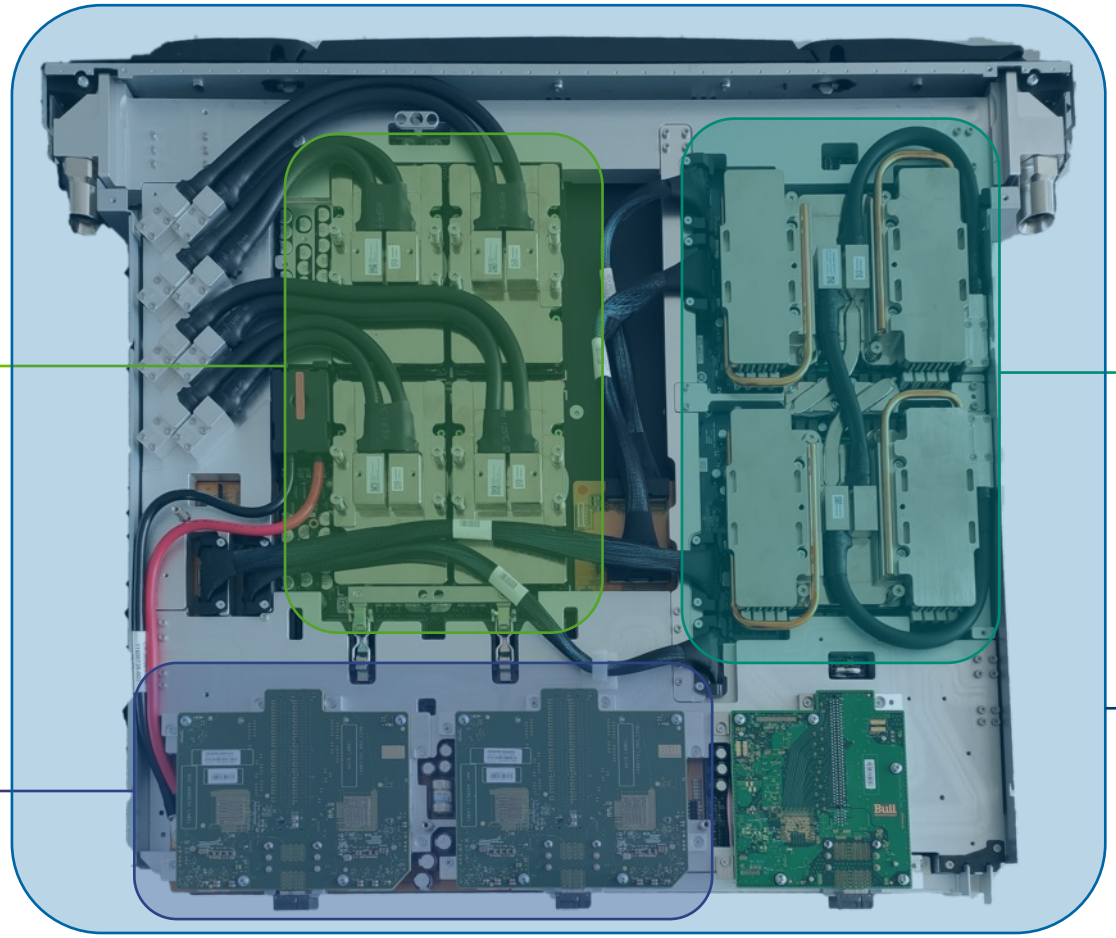
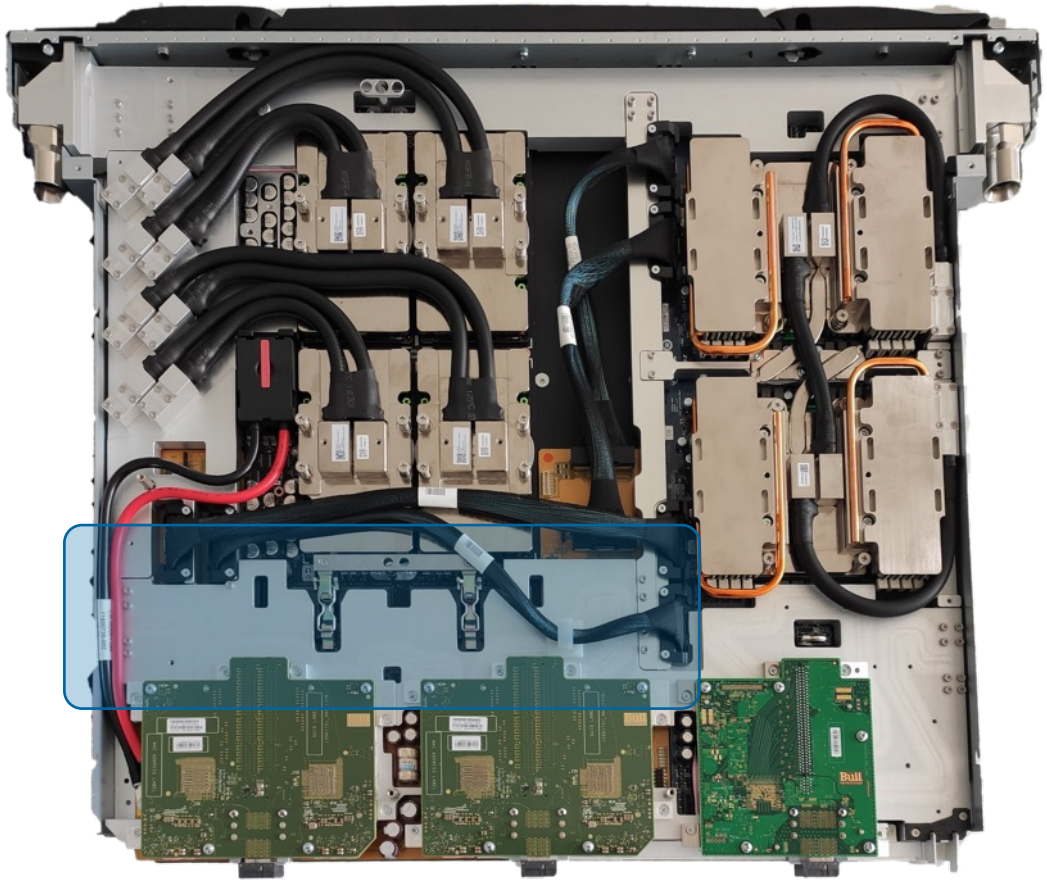


AMD
2x EPYC 7402

Atos
1x node

# BOOSTER NODES

## Past challenges

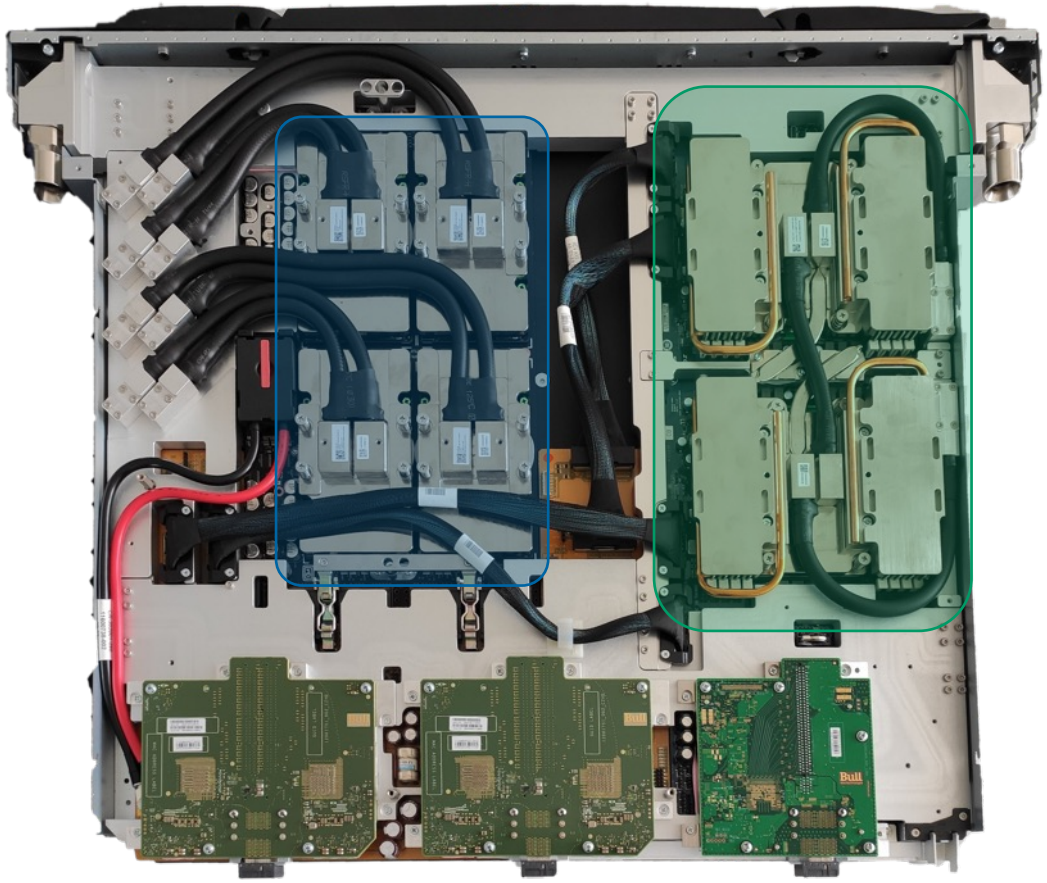


- Solved thanks to the close collaboration with some of the members of this application lab

- PCI switch
  - Insufficient bidirectional bandwidth
    - Triggered by a bug in the PCI switch FW
  - Dead switches
    - Triggered by a bug in the VR for the PCI switch

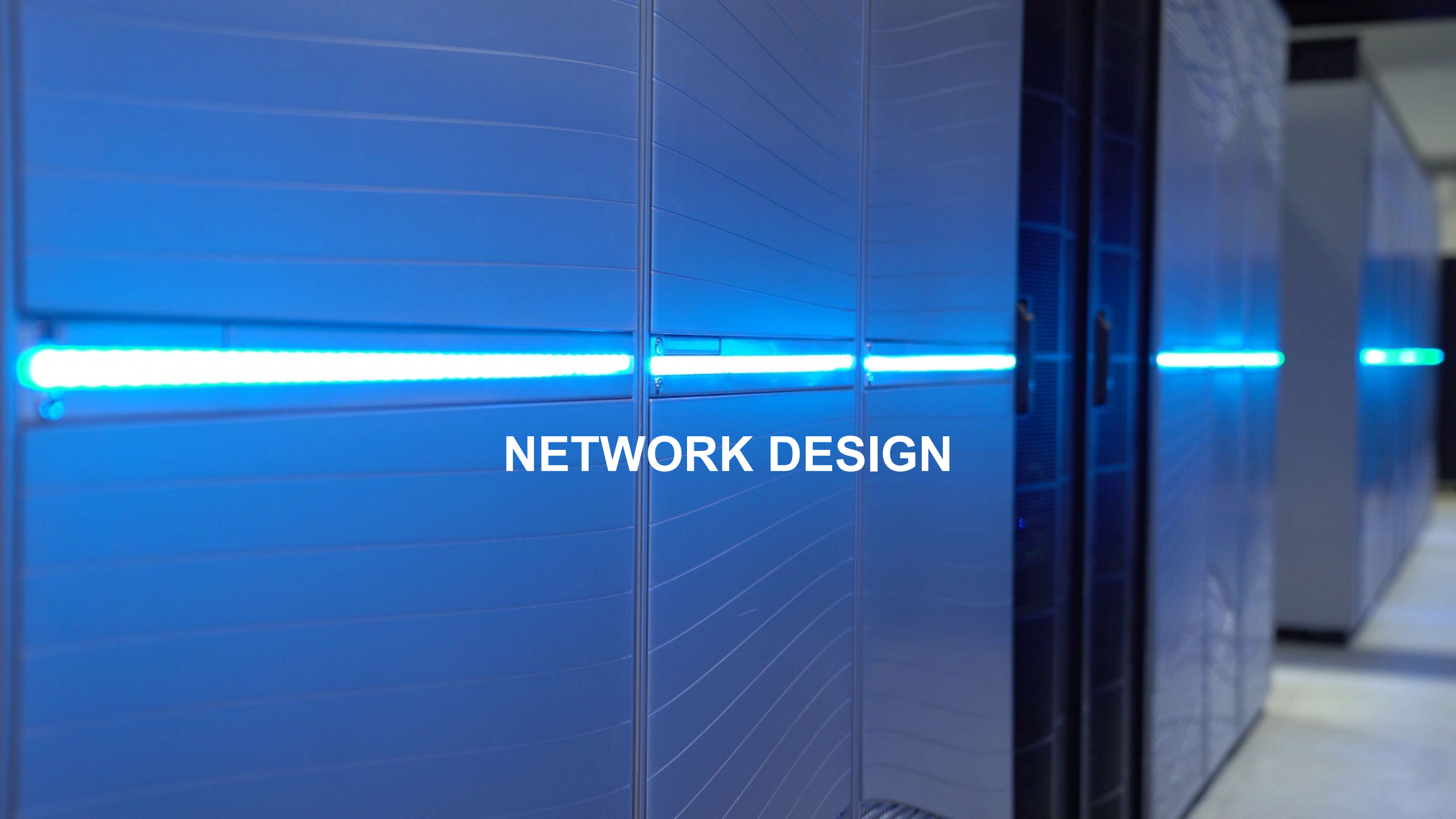
# BOOSTER NODES

## Current challenges



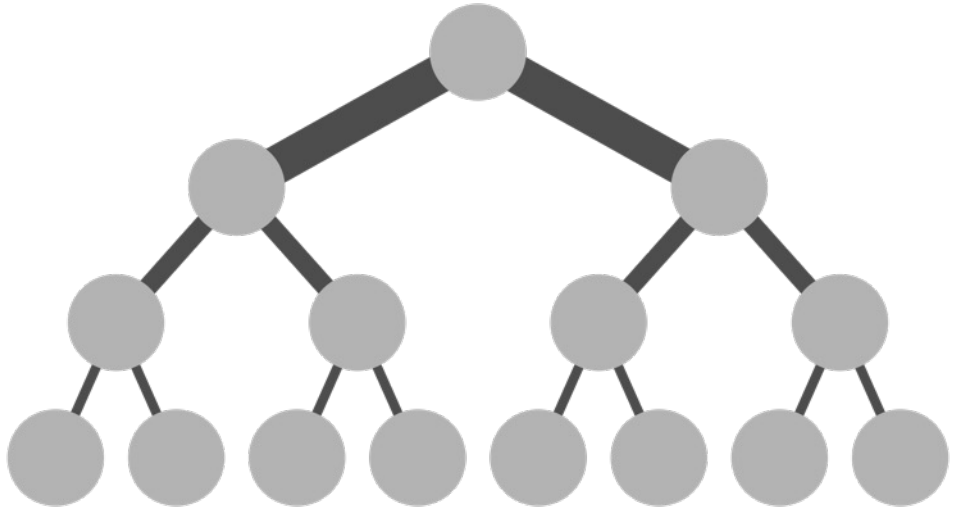
- Being solved thanks to the close collaboration with some of the members of this application lab

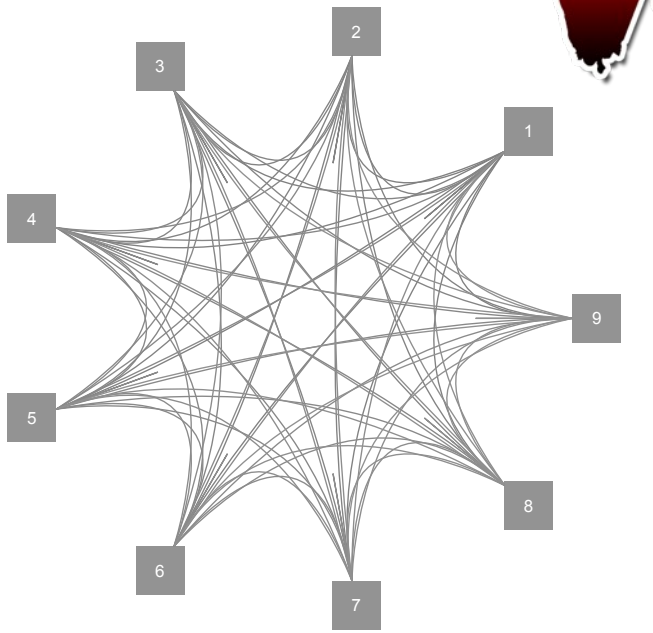
- GPU overheating
  - Currently affecting node availability
    - Fix coming in the next 2-3 months
      - Implies changing the water blocks of the whole system
  - Corrupt L3 caches
    - 1 code triggers data corruption under very specific circumstances
      - Still being analyzed


NETWORK DESIGN

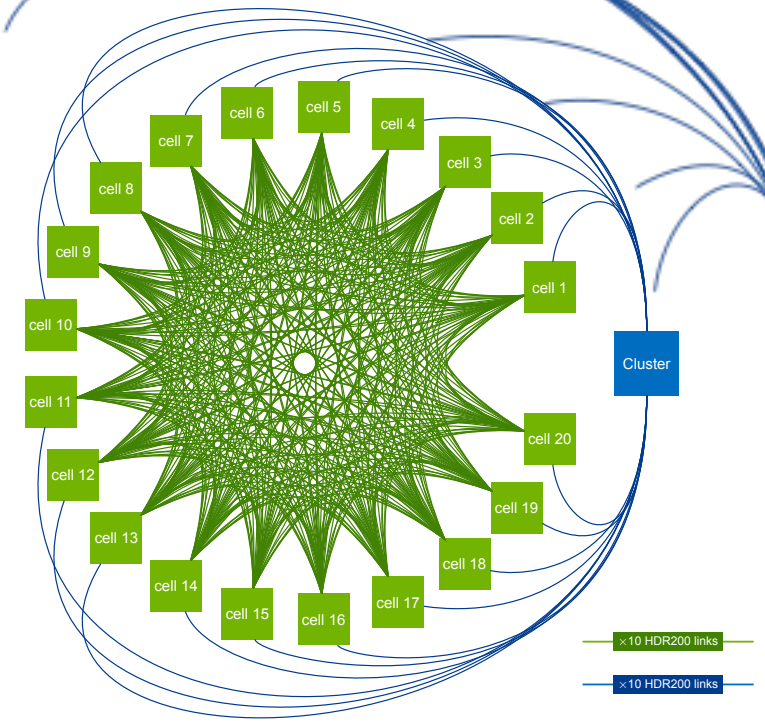
# BOOSTER TOPOLOGY CHOICE

- 4 HCAs per node, 936 nodes = 3744 end points
- Fat tree, 40 ports switches, no pruning:
  - 199 L1 switches
  - 200 L2 switches
  - 100 Top level switches
  - ~7488 copper cables
  - ~3744 optical cables
  - Expensive
  - Best performance
- DragonFly+
  - 199 L1 switches
  - 200 L2 switches
  - ~7488 copper cables
  - ~400 copper cables
  - Cheaper
  - Good performance
  - Needs adaptive routing



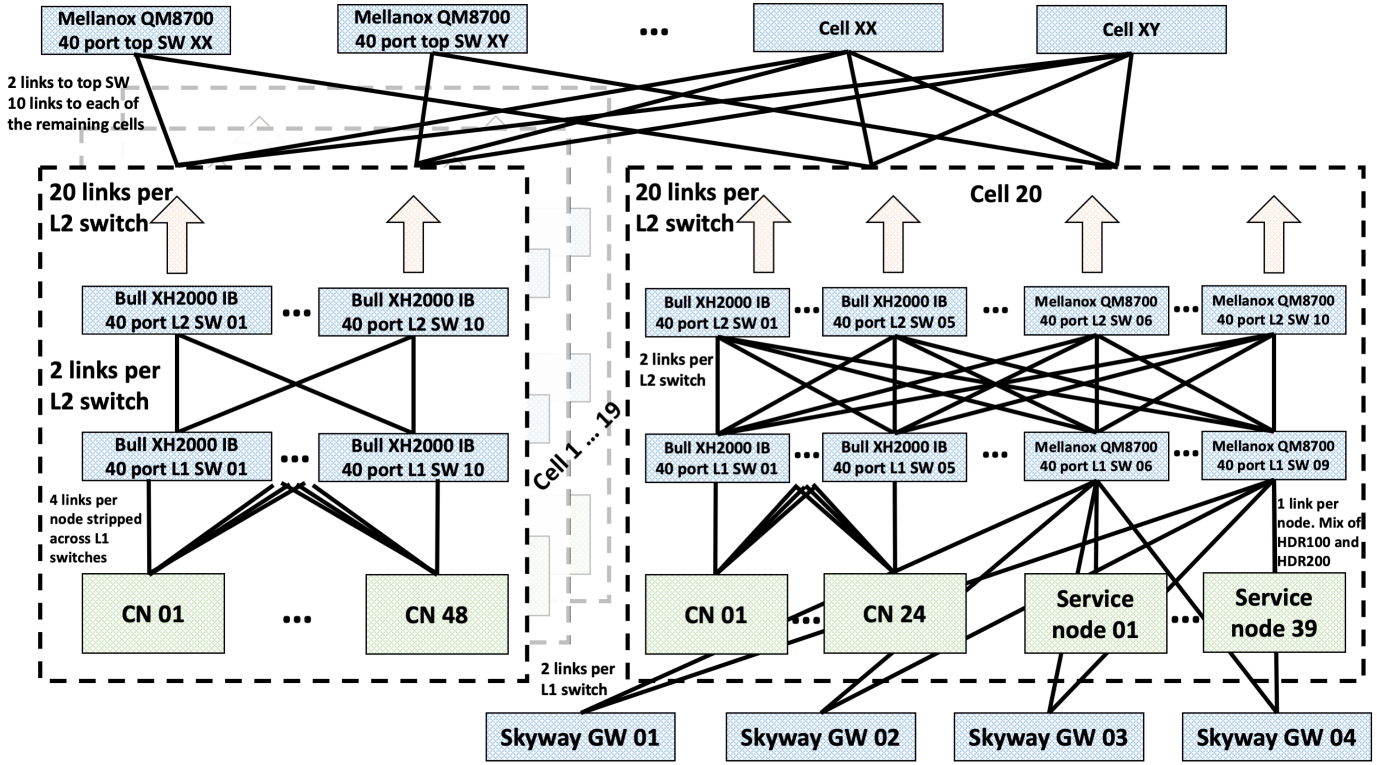


# BOOSTER TOPOLOGY CHOICE




- 10 links between each cell
  - 250 GB/s
- Non-minimal adaptive routing to avoid congestion
- 200 links (10 per cell) to Cluster
  - 5 TB/s

- Fat tree as DragonFly group topology
- 48 nodes per cell (two racks)
  - 4× links striped over L1 switches



# JUWELS IB FABRIC

## Welcome to the jungle

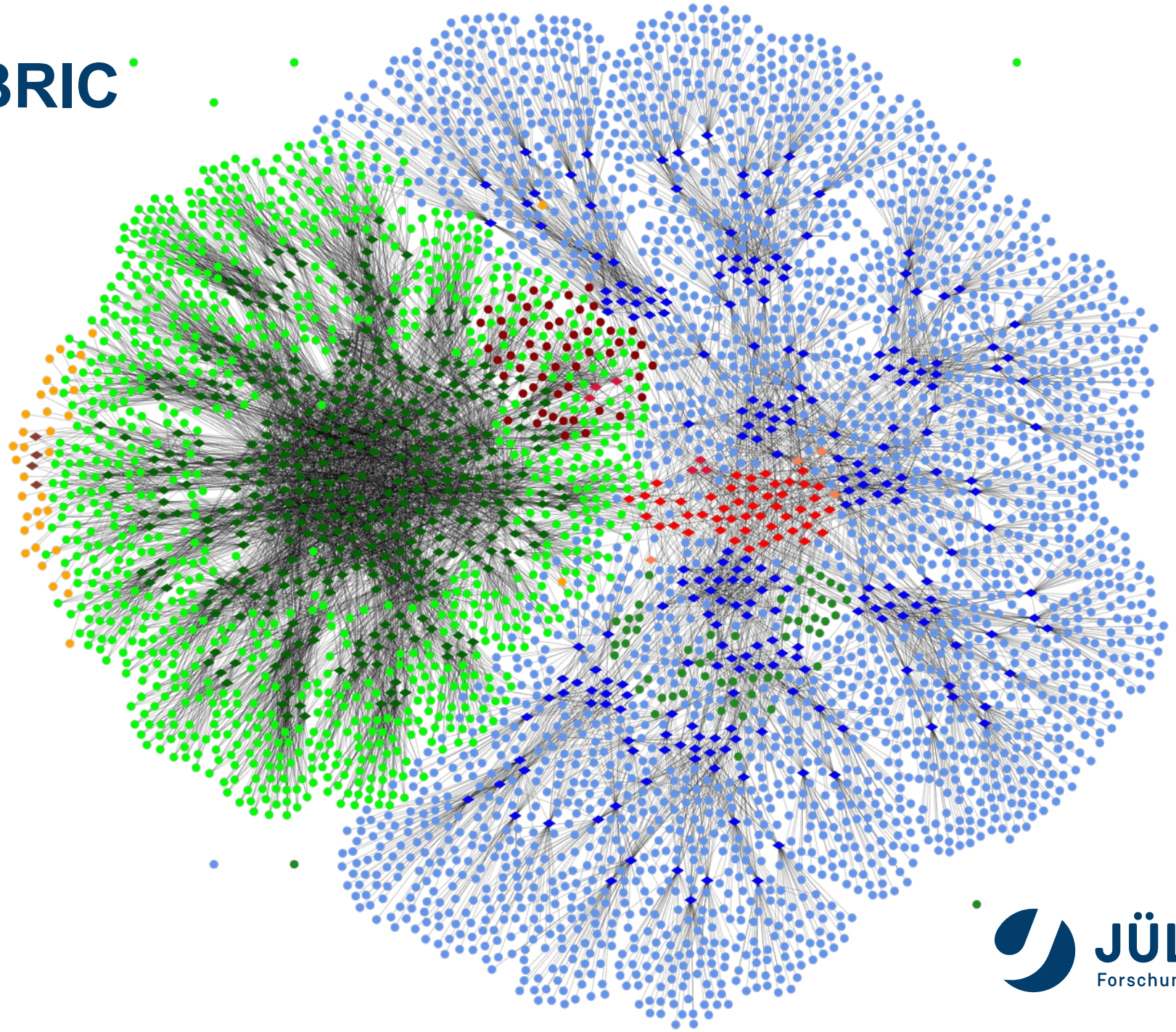
Cluster node
Cluster GPU node
Cluster switch
Cluster gateway

Top level switch

Booster node
Booster switch
Booster gateway

JUST-IME node
JUST-IME switch

Service node



# JUWELS IB FABRIC

## Welcome to the jungle

FDR/EDR/HDR100/HDR200

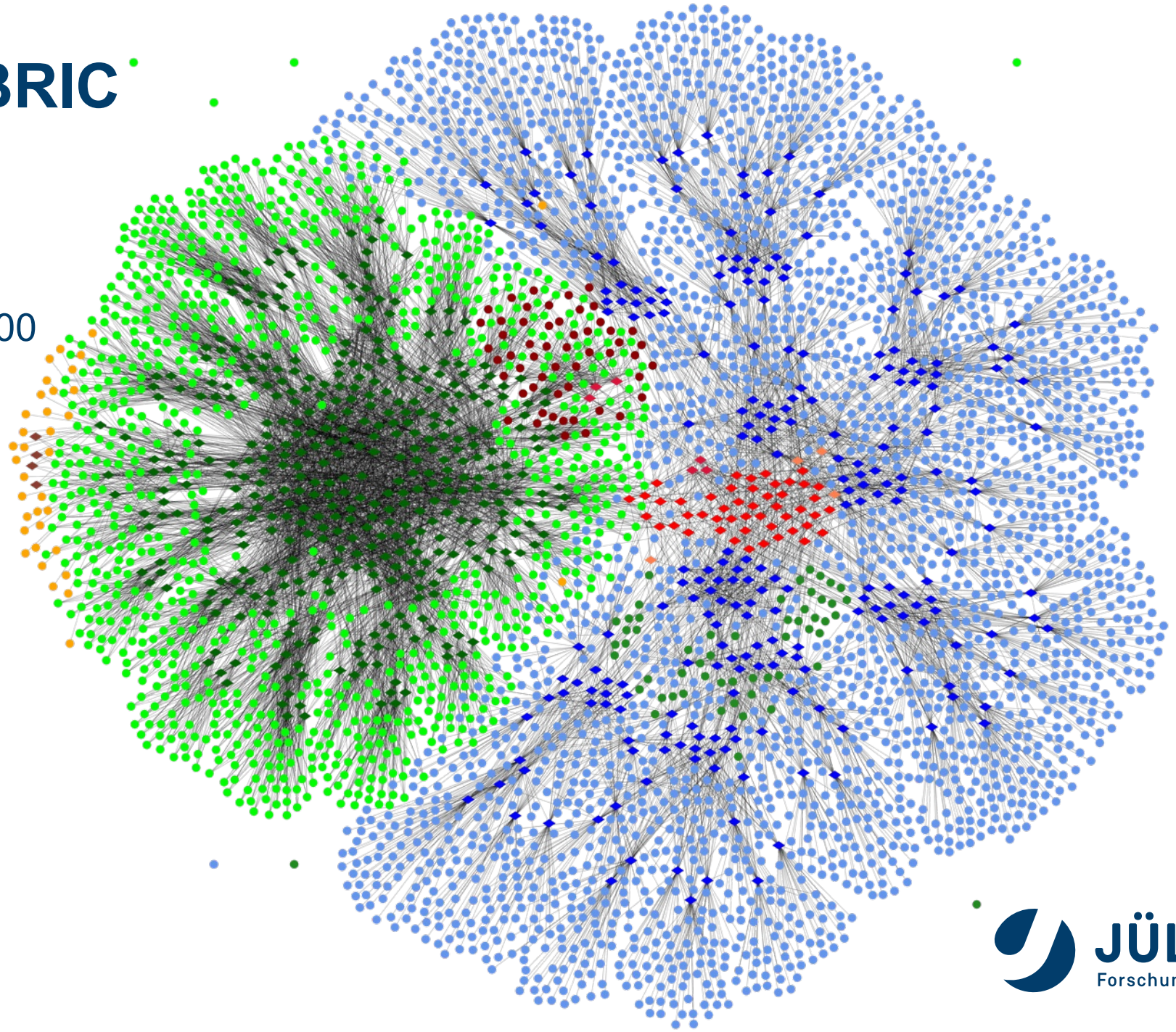
35000 ports

8 gateways

693 switches

6500+ endpoints

3 routing algorithms

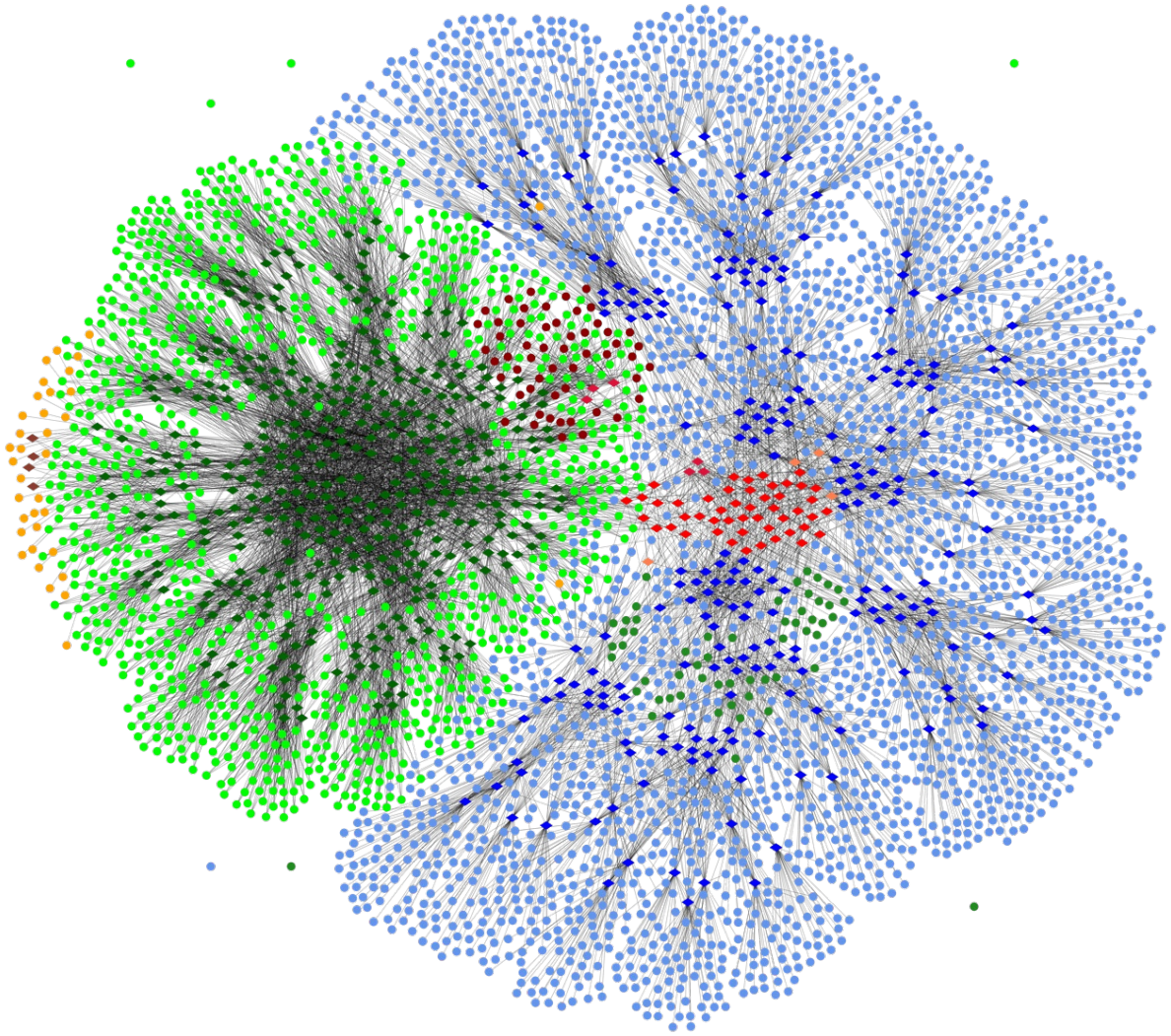


# JUWELS IB FABRIC

## Near future plans

- Introduce new IB-Ethernet gateways
  - Better resiliency in case of GW failure
  - Side effect: 2x BW to storage

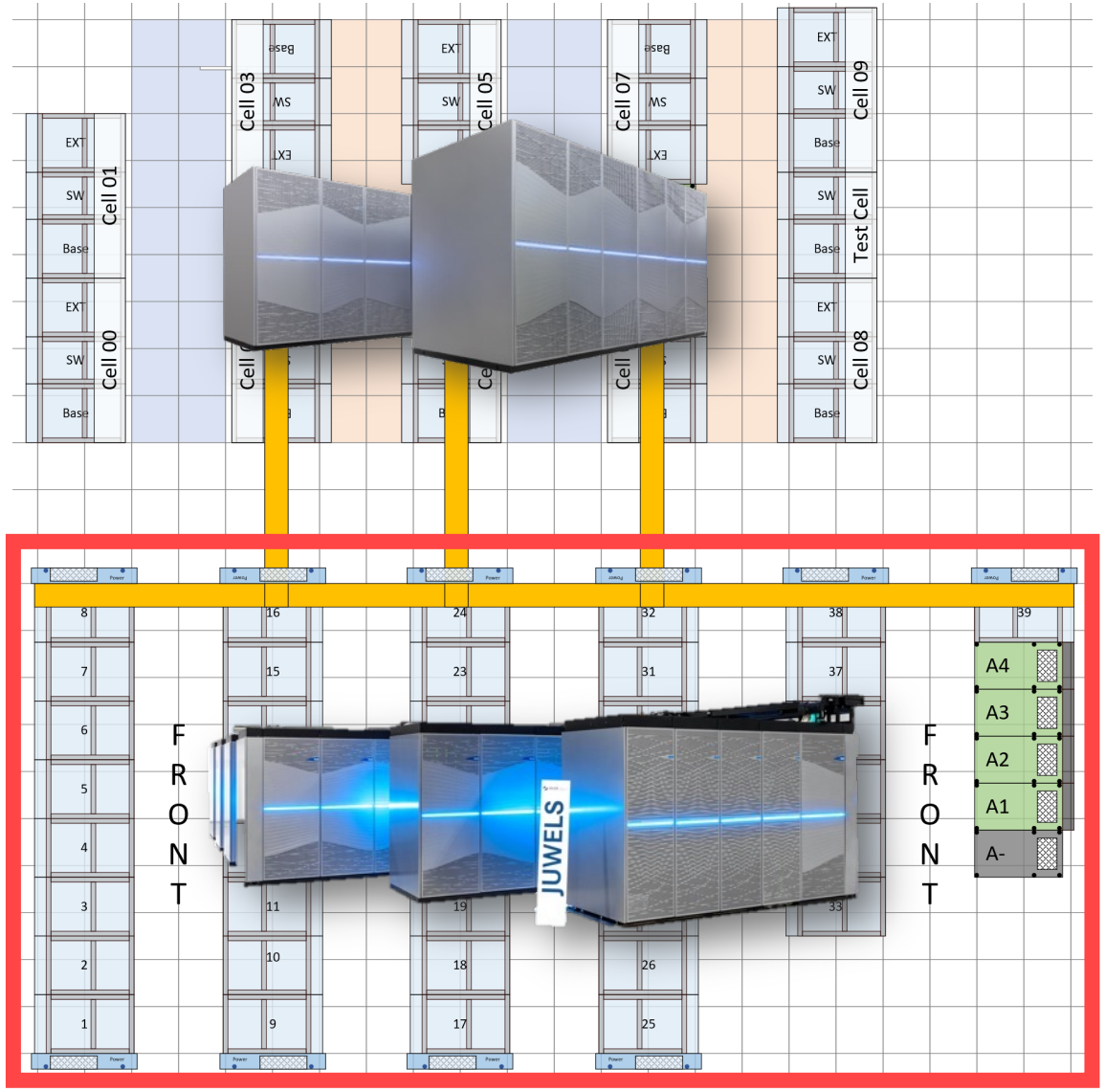
- Enable SHARP/HCOLL MPIs
  - In the wish list for some time
  - Should be stable enough now (multiple switch FW bugs in the past)
  - Need to be assessed



JÜLICH
INFRASTRUCTURE

# JUWELS INFRASTRUCTURE

- Booster:
  - 39 Sequana XH2000 racks
  - 6 rows
- Transformers 1 & 2 full utilized
- Direct warm-water cooling
  - 34 - 37 °C facility-side inlet temperature
  - Now with dry coolers!
    - Much more efficient
    - Sorry for the service interruptions!



Welcome to
Juelich Wizard
for
European Leadership
Science

# SOFTWARE

# KEY ENABLING SOFTWARE

**”Power is nothing without control"**

- Ansible as provisioning system
- SLURM as scheduler
- ParaStation Modulo as resource manager/health checking
- EasyBuild as scientific software package management
- RHEL (service nodes internal storage in Ceph)
- Rocky Linux 8

# KEY ENABLING SOFTWARE

## Near future plans

- Enable GPU frequency locking on job prologue, to a user specified frequency

# KEY ENABLING SOFTWARE

## Near future plans

- Enable GPU frequency locking on job prologue, to a user specified frequency
- Enable topology plugin
  - Help to keep nodes in a job together and minimize job fragmentation
  - Not straight forward due to network topology/multiple HCAs per node

# JUWELS BOOSTER

## The last ~20 months in (some) numbers

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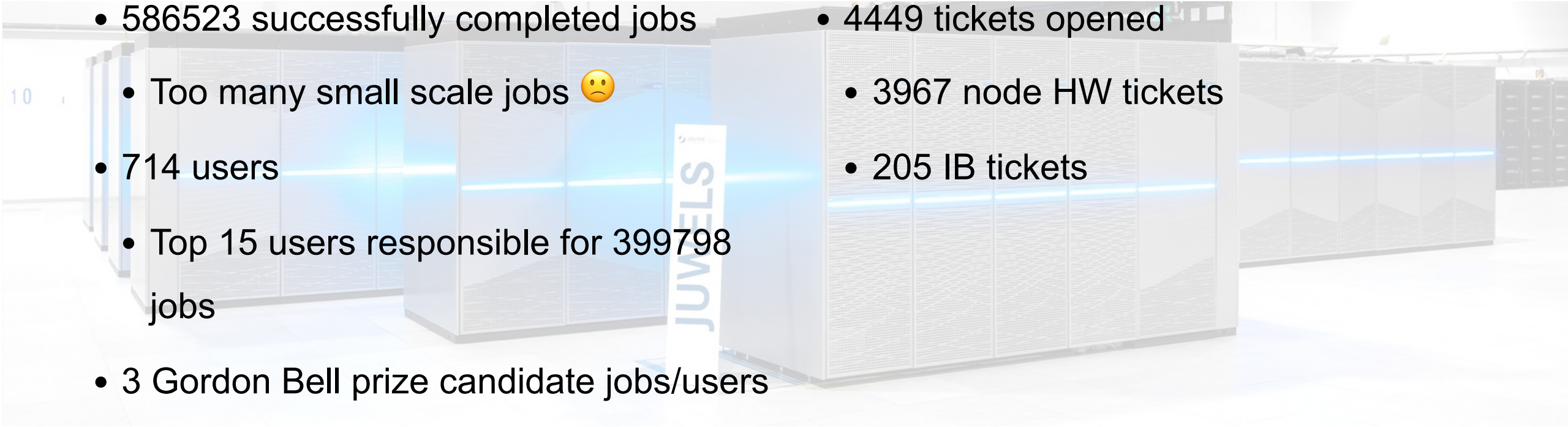


- 586523 successfully completed jobs
  - Too many small scale jobs 😕
- 714 users
  - Top 15 users responsible for 399798 jobs
- 3 Gordon Bell prize candidate jobs/users
- 4449 tickets opened
  - 3967 node HW tickets
  - 205 IB tickets

THANK YOU