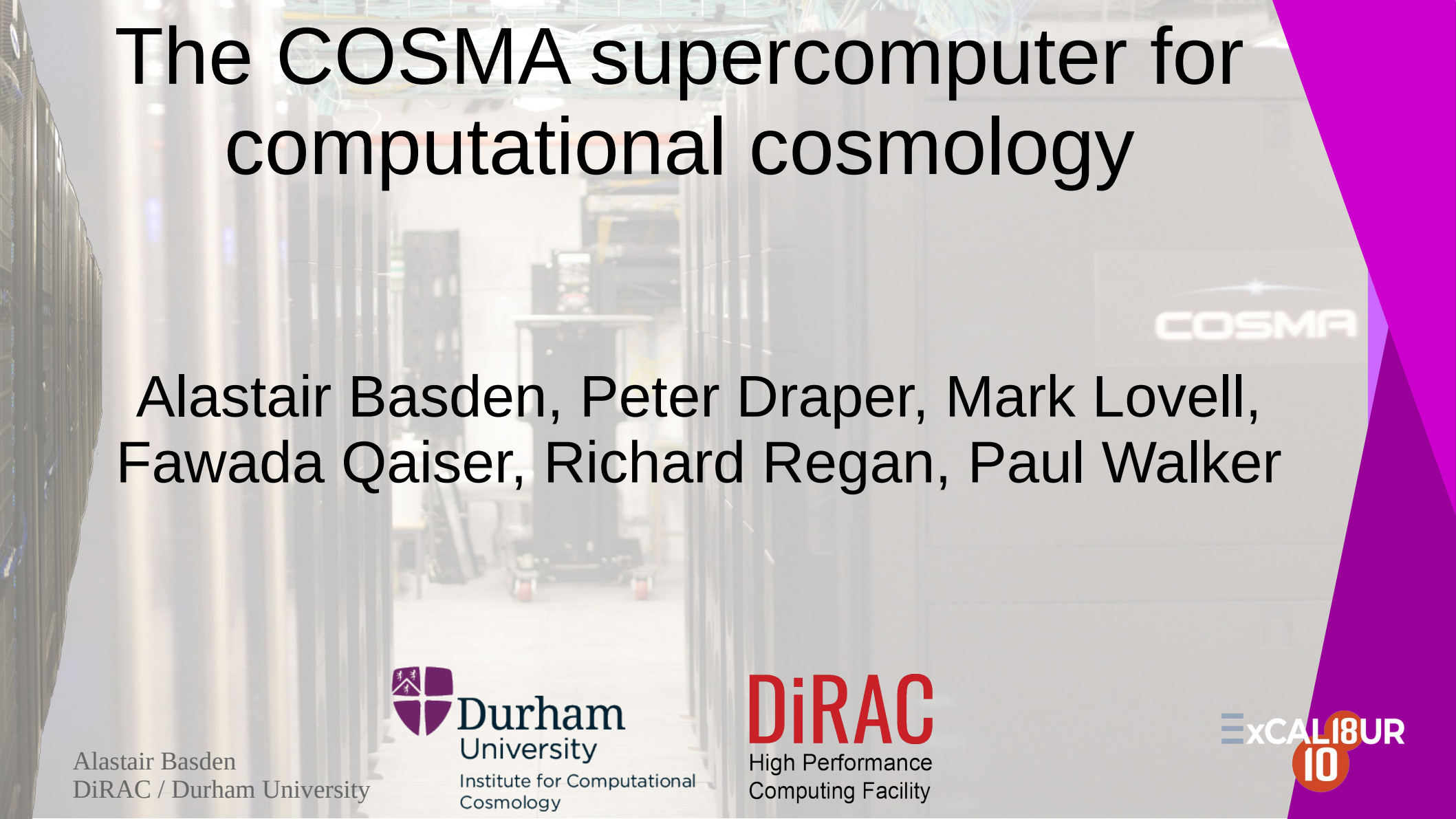
The COSMA supercomputer for computational cosmology



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DiRAC
High Performance Computing Facility

ExCALIBUR 10

COSMA

- The COSmology MAchine
  - In operation since 2001
  - Now in it’s 8th generation (COSMA8)
    - COSMA5, 7, 8 all operational
  - ~80,000 cores
  - >0.75PB RAM
  - >20PB storage

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DiRAC

- Established 2009
- Provides HPC to the STFC theory community
  - Including astrophysics, cosmology, astronomy
- Three services:
  - Extreme Scaling: GPU workloads, Edinburgh (TURSA)
  - Data Intensive: Mixed workloads, Cambridge and Leicester
  - Memory Intensive: High RAM, Durham (COSMA)
- Co-designed and tailored for specific workloads

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Bespoke design principles

- What does the science need to achieve?
- How can this be performed cost effectively?
  - A general purpose system would need to be much larger
- How can science outcomes be maximised?
- How can the lifetime CO2 be reduced?
- What will future requirements look like?

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COSMA: Designed for cosmology

- High RAM
  - To store the universe
- Fast check-pointing storage
  - To rapidly dump the state of long running simulations
- Large bulk storage
  - To store generated universes for future analysis
- Tape storage
  - Energy efficient archival and backup
- Non-blocking network fabric
  - To reduce network latency and congestion

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Net-zero

- HPC energy use is problematic
  - Embodied carbon even more so
    - Bespoke systems help to reduce this
- We are making small steps
  - ~£1m solar panels
  - Quarterly user emails
  - Idle node power-off (COSMA5, DINE)
  - Maintain high resource usage
  - Energy efficient cooling - DLC and Immersion
  - Mine water heat storage
- 2026 HPC Summer school focused on Net-zero for NETDrive: Durham

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Hardware prototyping

- Key to advising on the adoption of new technologies
  - HPC Hardware Laboratory @ Durham
    - Providing researcher access to the latest novel technologies
    - CPU, GPU, networking, storage, composability, quantum, etc
  - Benchmarking and performance testing
    - Key questions: Will codes work, is there scope for performance improvement, is it cost-effective?

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User facilities

- In addition to the main SLURM queues, COSMA includes:
  - Data analysis and login nodes
  - GPU sub-clusters
  - Database hosting facilities
    - EAGLE, VIRGO
  - Cloud-centric system coming soon
    - Primarily for IRIS

Data access

- Large datasets generated on the system need further analysis
  - On the system
  - Elsewhere
    - Data transfer enabled by several methods:
      - GLOBUS - bulk file transfer
      - COSMA-hosted Cloud-sharing
      - VIRGO Database
        - EAGLE and Millennium datasets
          - Flamingo to follow
        - Online data reduction and download

The future

- DiRAC-4
  - Technical case well underway
    - Not yet funded - should become clearer in the Autumn
  - Likely to include a 3PB RAM system:
    - COSMA9
- IRIS
  - Self-hosted Cloud system under development
- Hardware Lab
  - Continued investment

Conclusions

- COSMA:
  - Delivering cost-effective computational cosmology

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Questions?

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