Los Alamos National Laboratory Photo of Trinity

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Telling a Visual Story within Big Data

Case Studies on Interactive Visualizations for Supercomputer Data

Dr. Claire McKay Bowen
Lead Data Scientist, Privacy and Data Security
cbowen@urban.org www.clairemckaybowen.com @ClaireMKBowen

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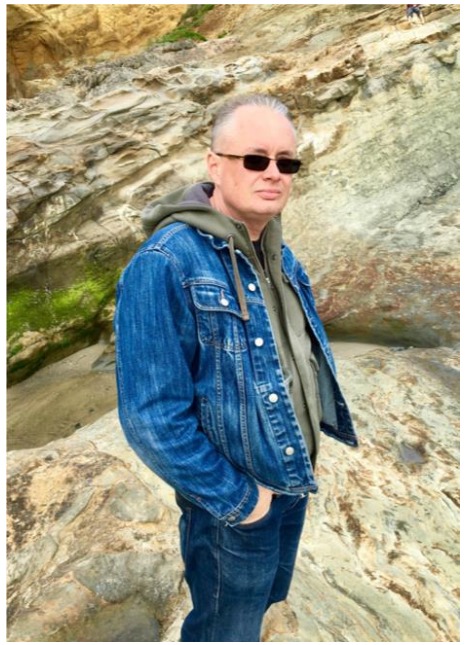
Acknowledgements

Nathan DeBardeleben, PhD
Ultrascale Systems Research Center



Sean Blanchard, PhD
Ultrascale Systems Research Center

Christine Anderson-Cook, PhD
Statistical Sciences Group

Overview

1. **Motivation:** How much does cosmic radiation affect supercomputers?
2. **Spatial Data:** Where do the faults occur on the supercomputers?
3. **Temporal Data:** How does time play a role in the number of faults?
4. **Spatial + Temporal Data:** Is there a “Fault Shower” effect?
5. **Future Work**

Motivation

What causes faults on supercomputers?

Image of Summit from Oak Ridge National Laboratory.

Some causes of faults on supercomputers

- Cosmic radiation
- Heating
- Hardware age
- Power fluctuations, cycles, etc.

Supercomputer	Institution	Rank	Cost (in millions)
Summit	Oak Ridge	1	$200
Sierra	Lawrence Livermore	2	$150
Frontera	University of Texas - Austin	5	$60
Trinity	Los Alamos and Sandia	7	$174
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Rank as of Nov. 2019

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What causes faults on supercomputers?

Cielo

- **Type**: Cray XE6 AMD Opteron system
- **Time**: 2011 – 2016
- **Rank**: 6th fastest upon installation
- **Cores:** 107,152

Trinity

- **Type**: Cray XC40 Intel Xeon Phi
- **Time**: 2015 – Present
- **Rank**: 6th fastest upon installation
- **Cores:** 979,072

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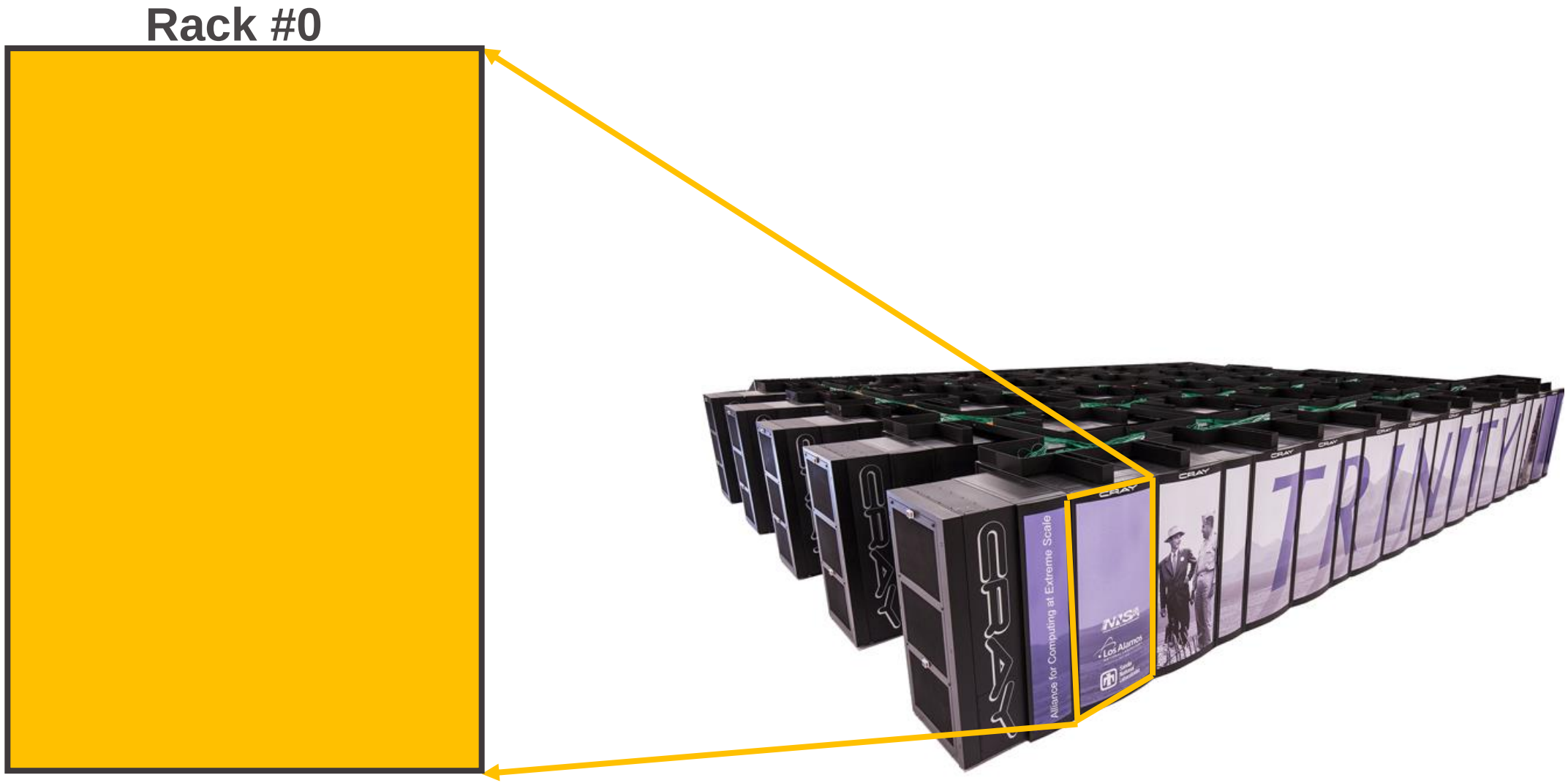

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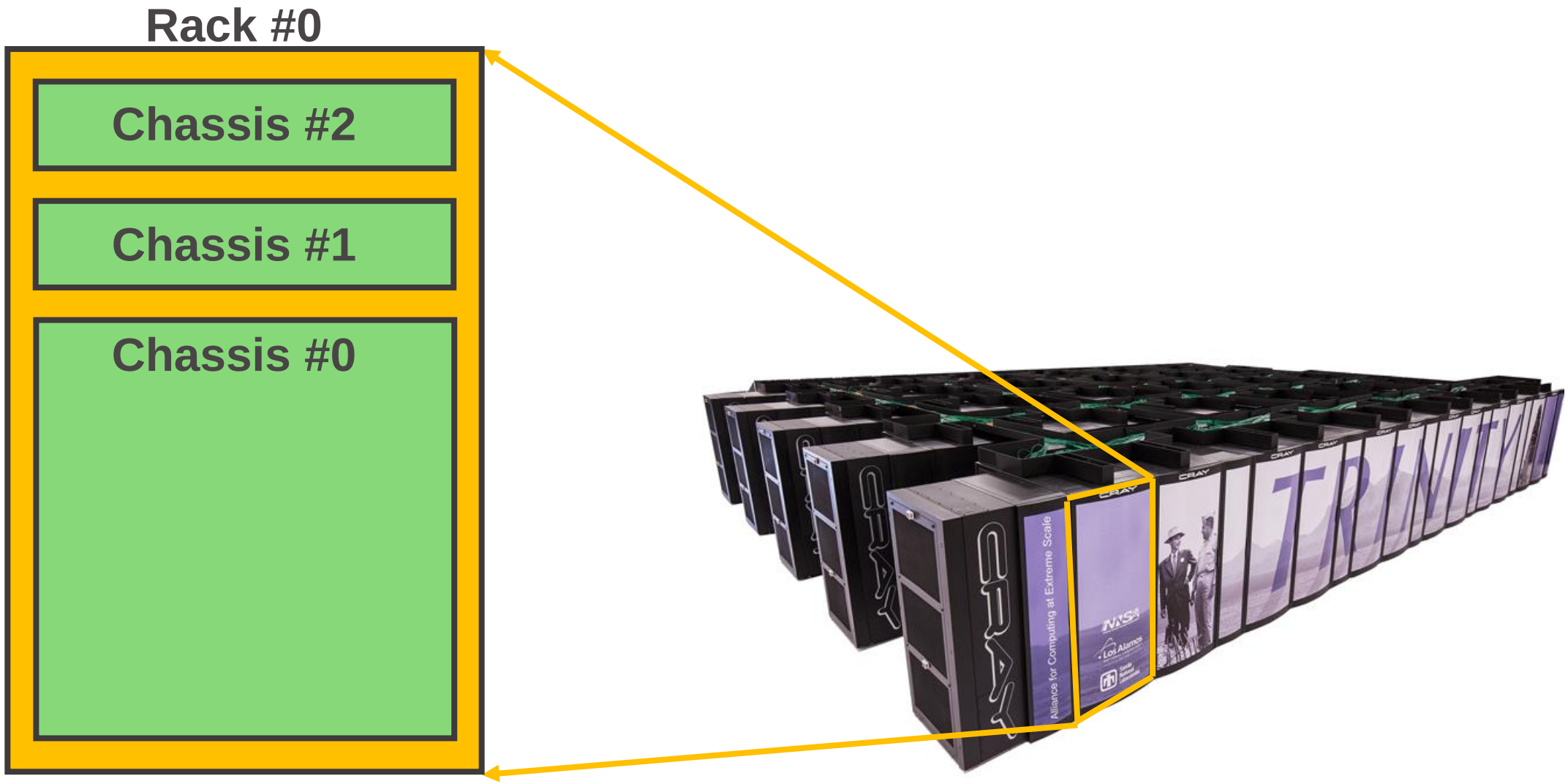

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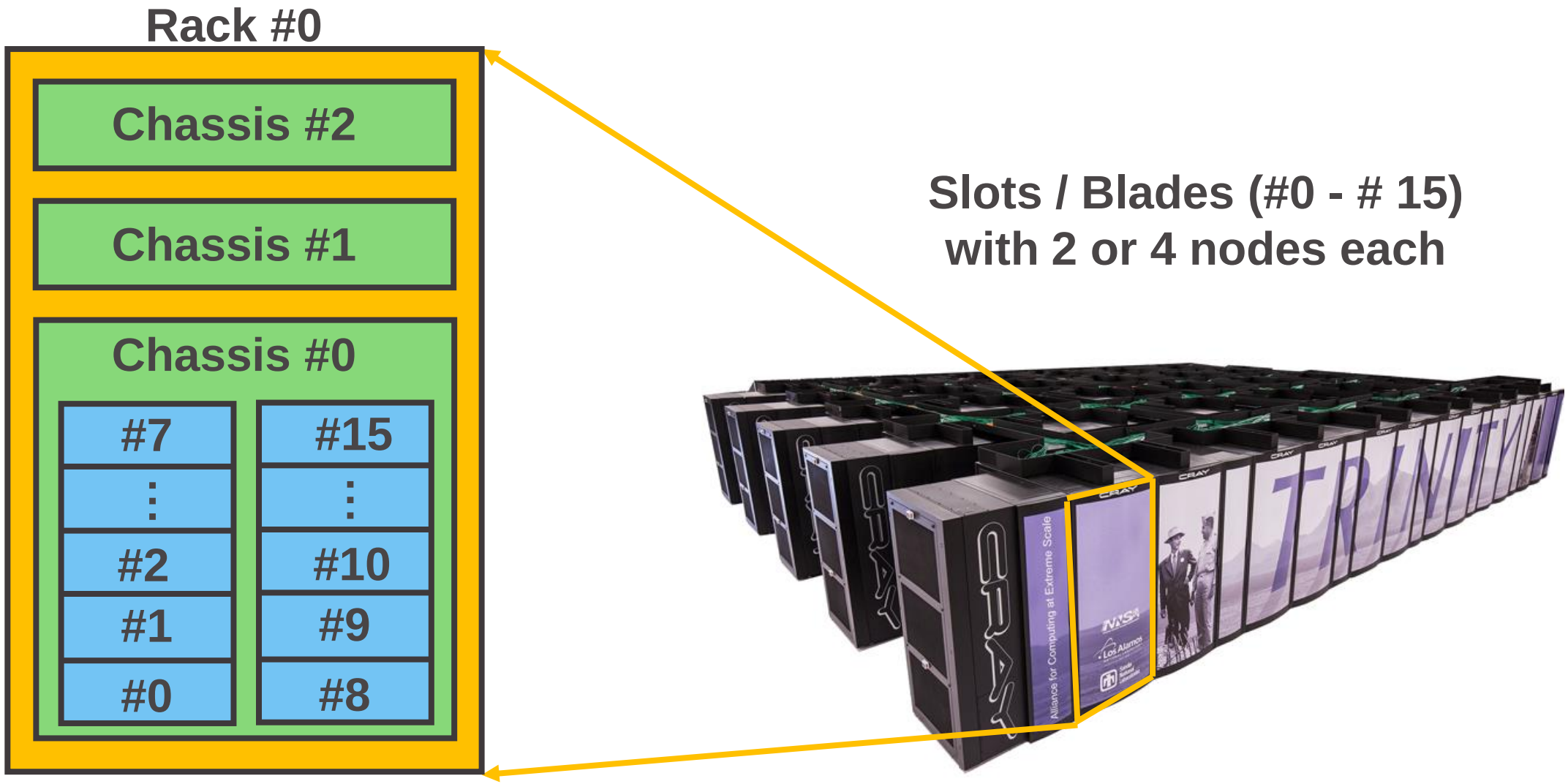

What is a transient fault?

Transient Fault: incorrect data are read from a memory location until the location is overwritten with correct data

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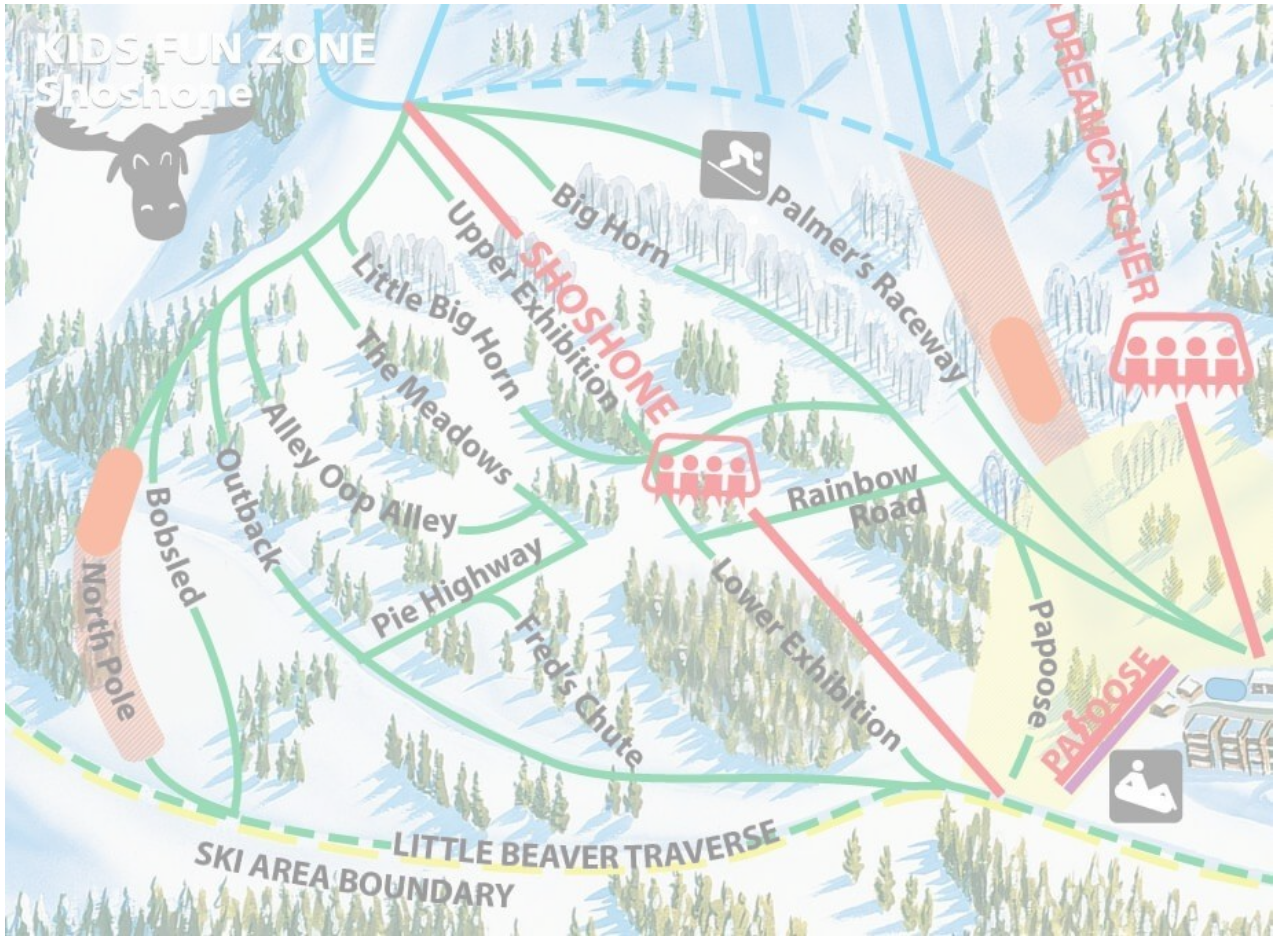

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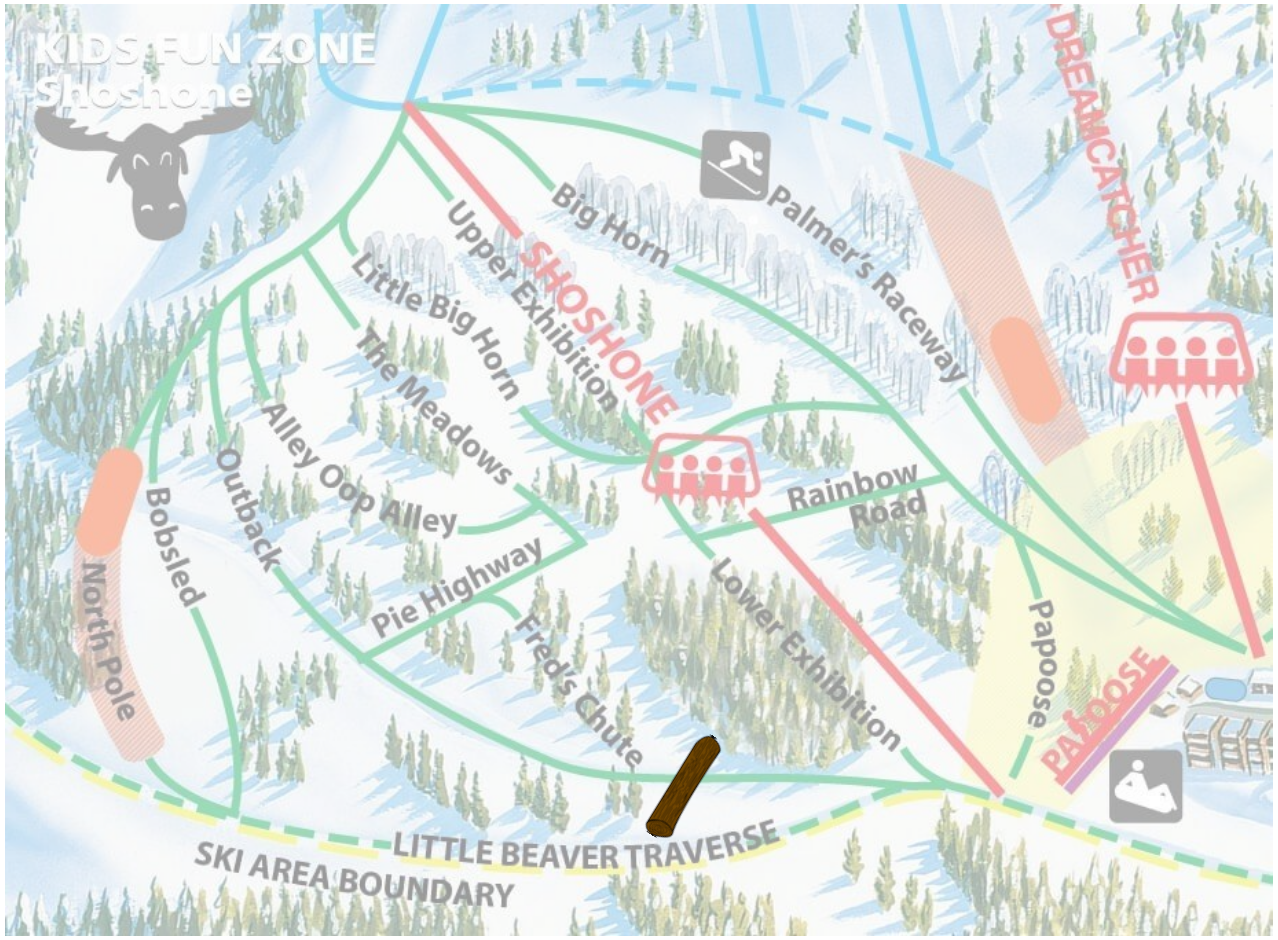

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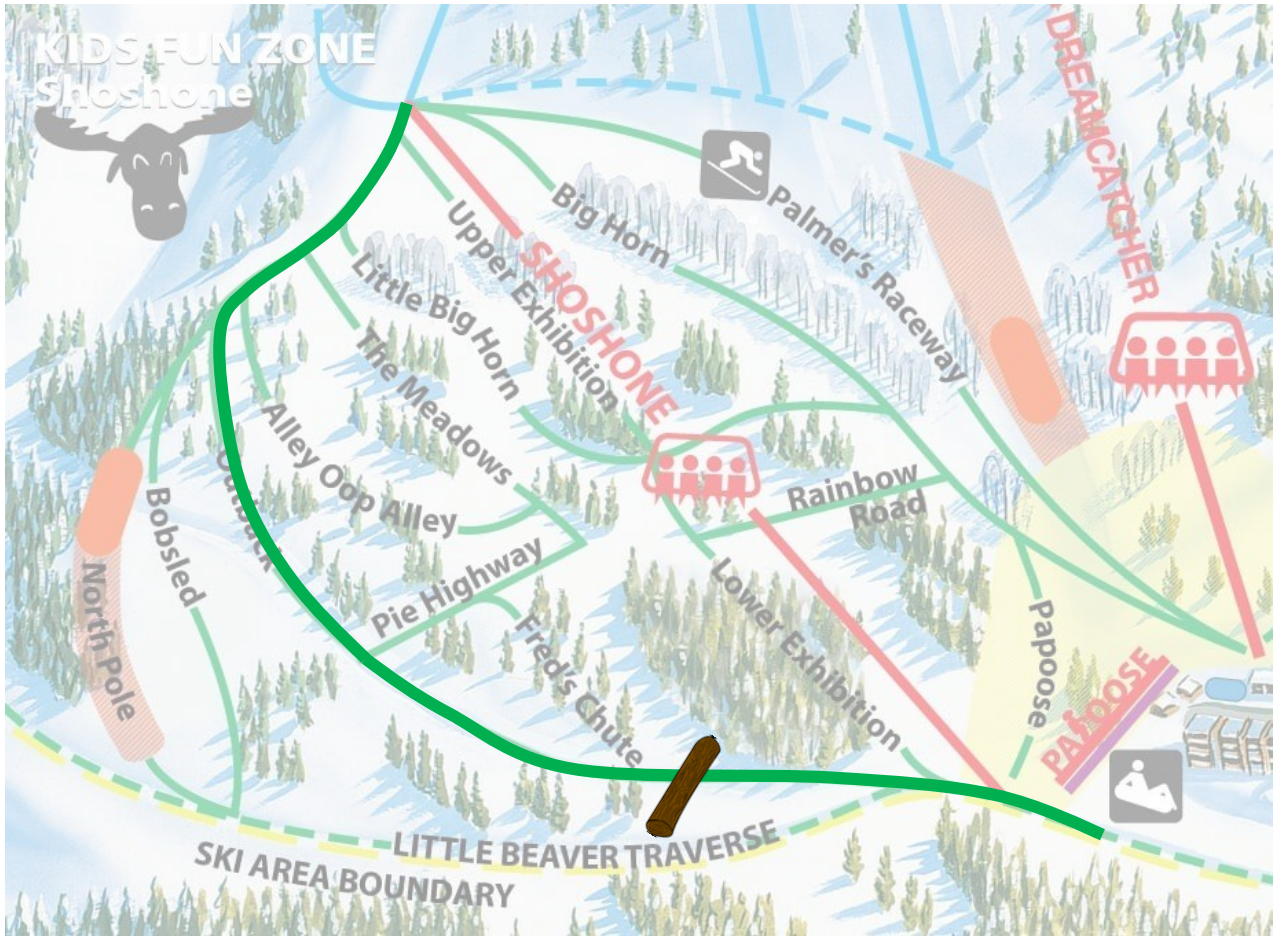

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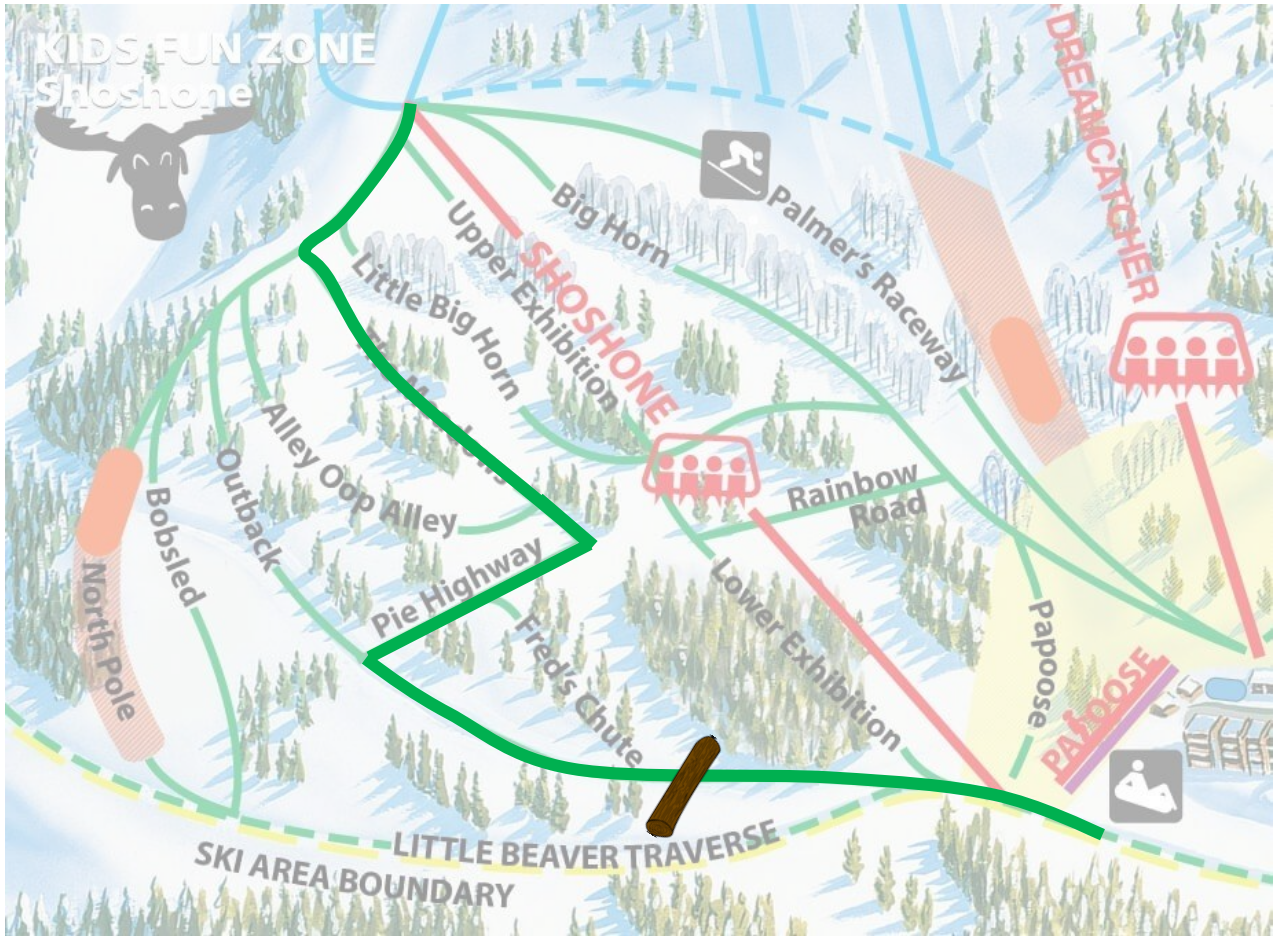

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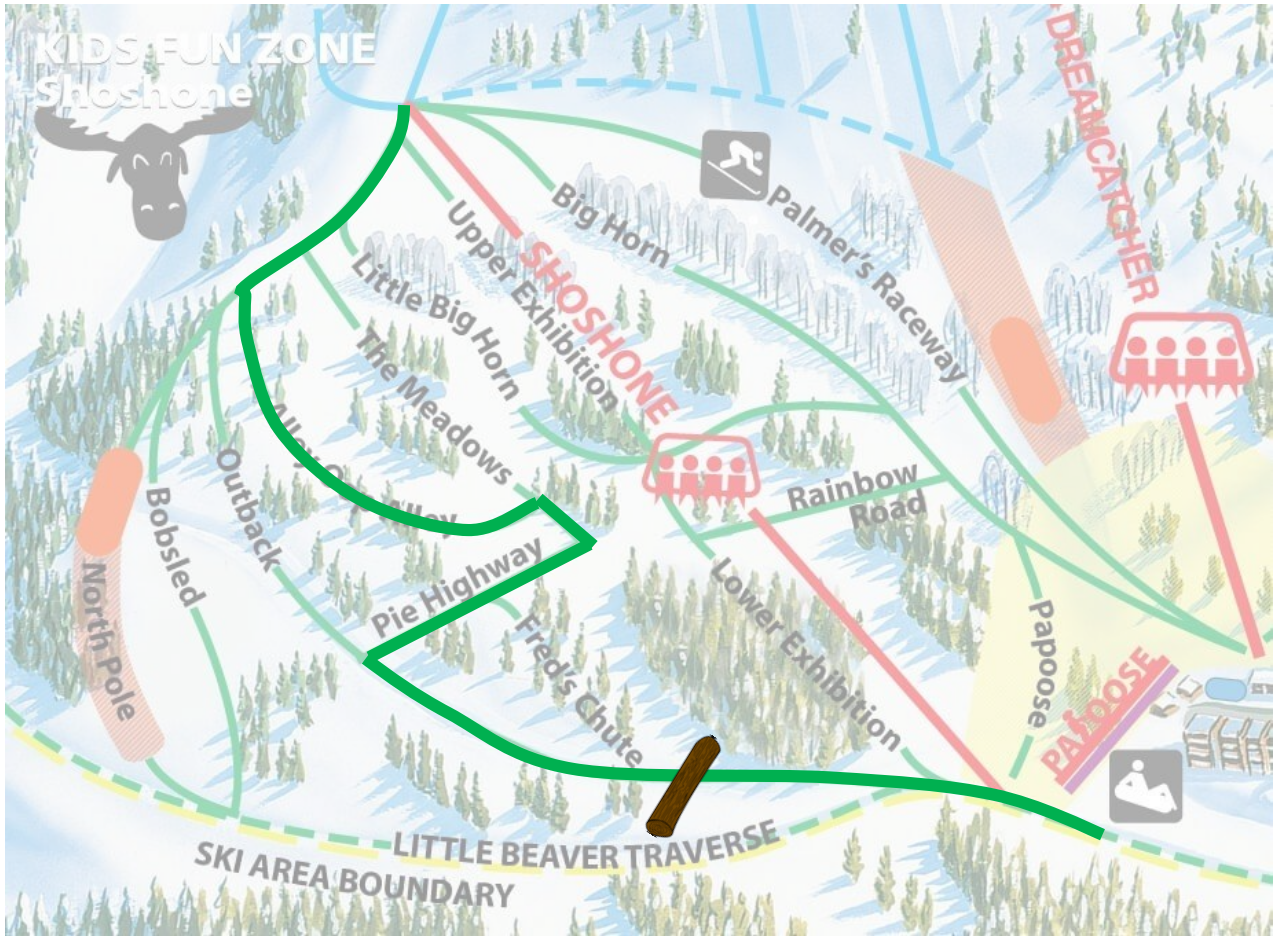

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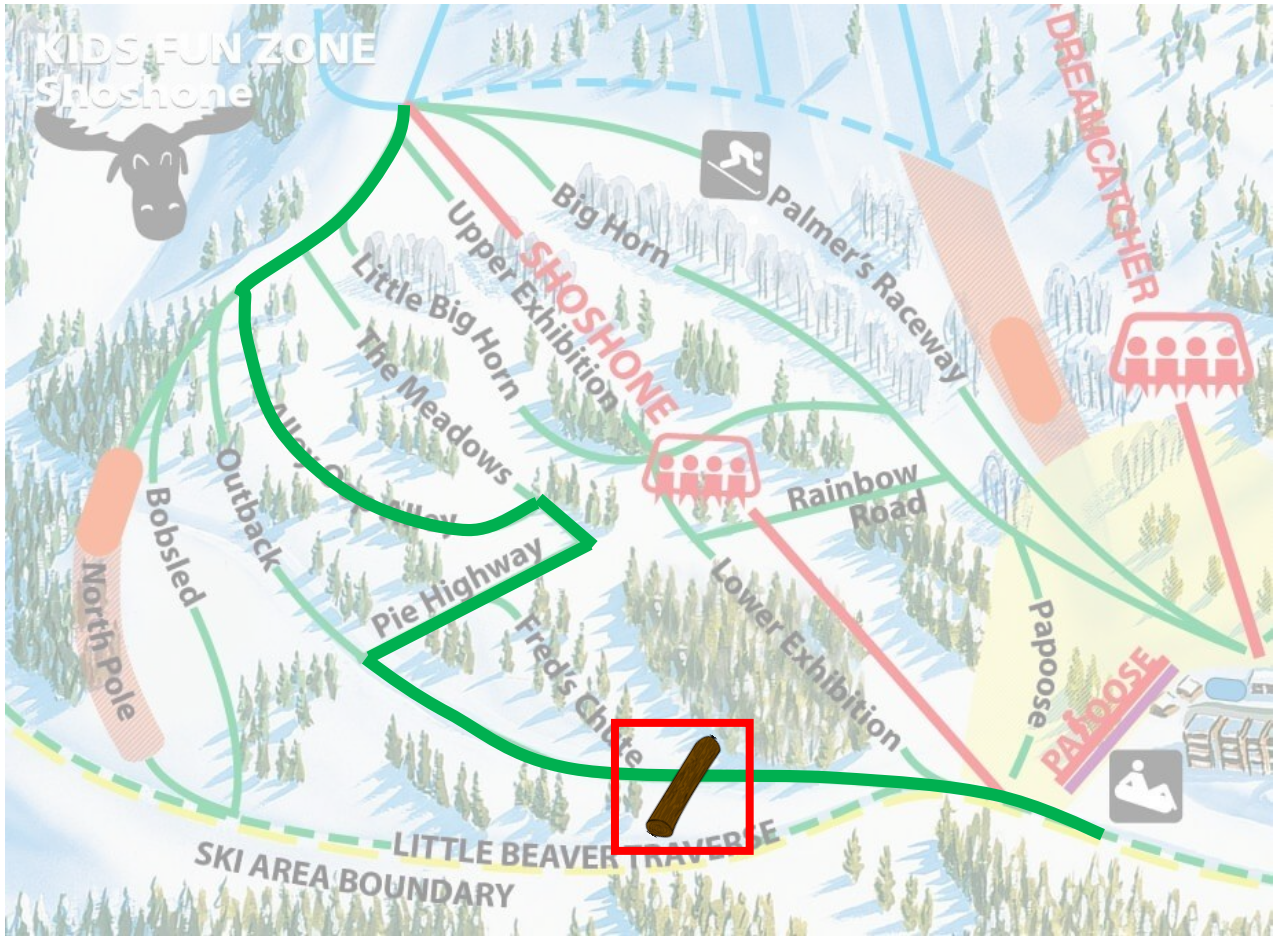

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What tools are used?

Data manipulation
and statistical analysis

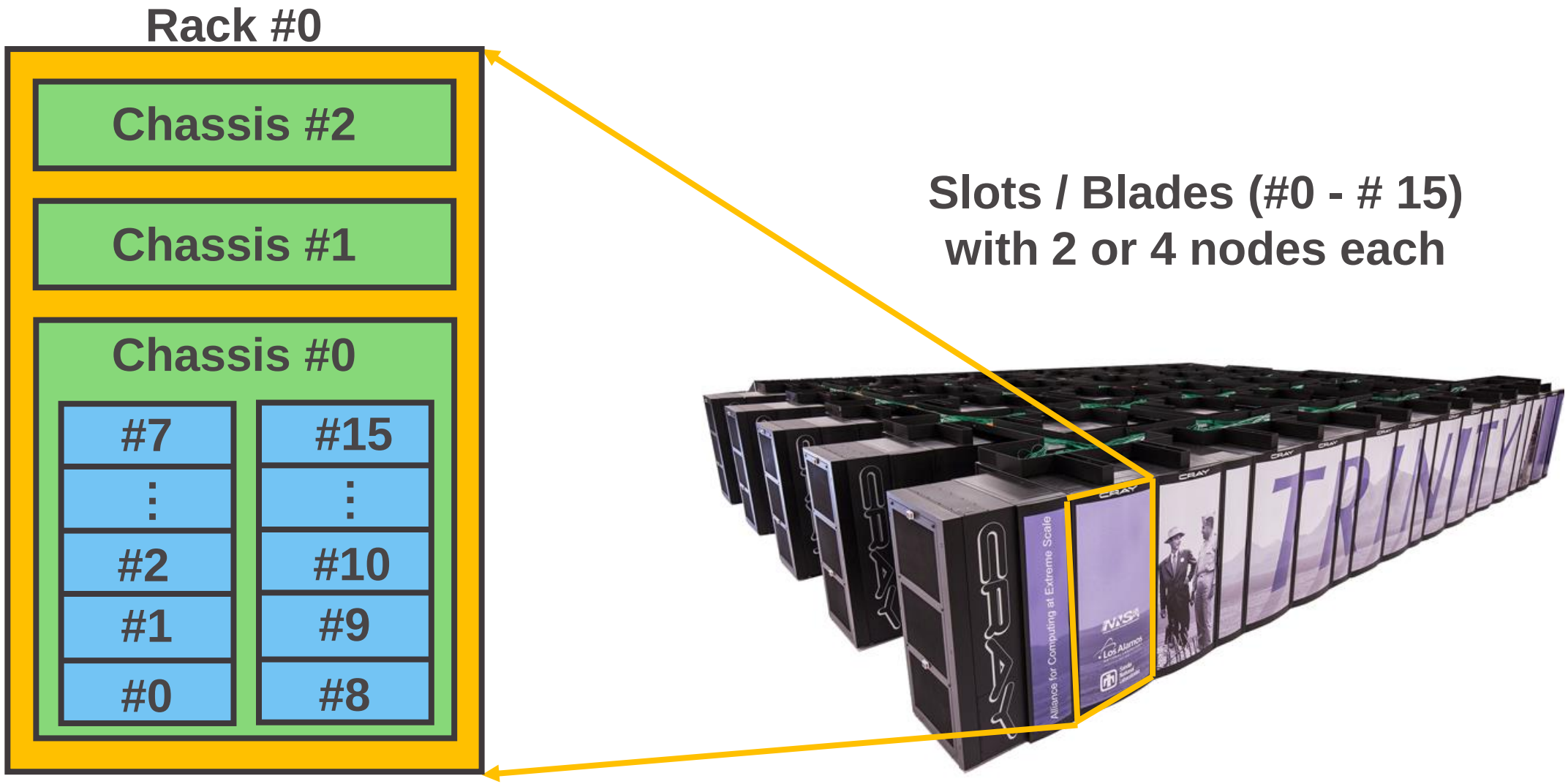
Data analytics and
visualization tools

Integrated development
environment for R

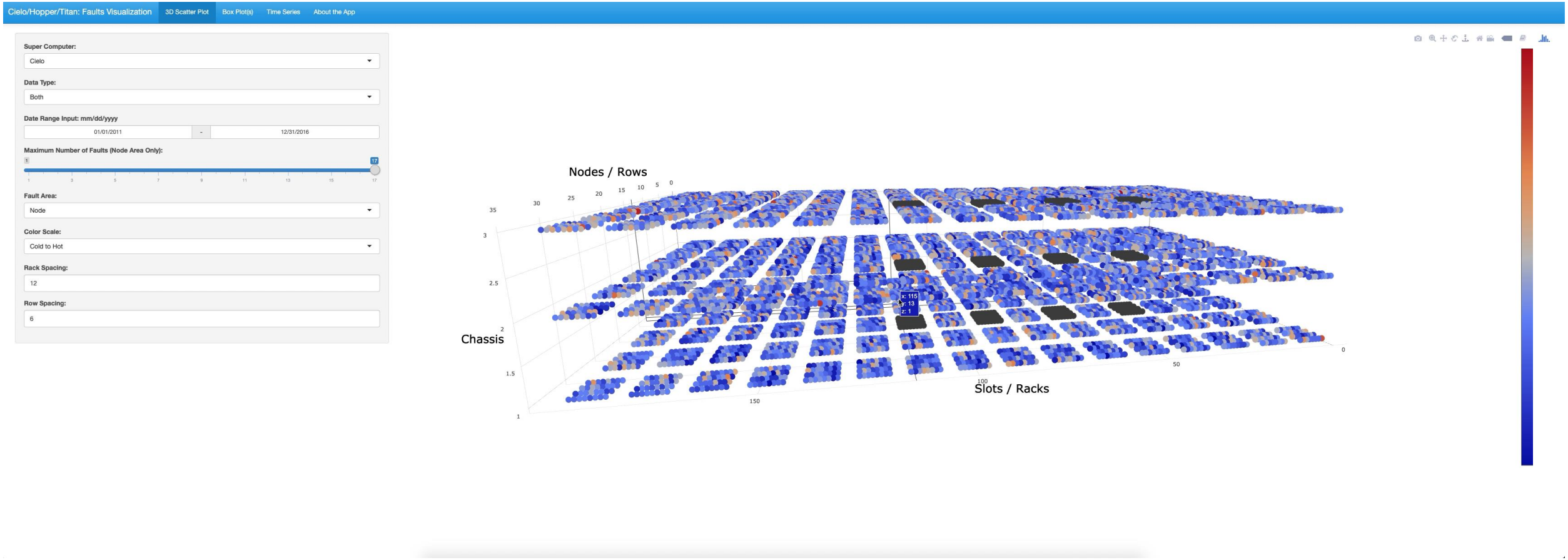
Interactive web applications
powered by R

Visualizing Spatial Data

What causes faults on supercomputers?



Where do faults occur on supercomputers?



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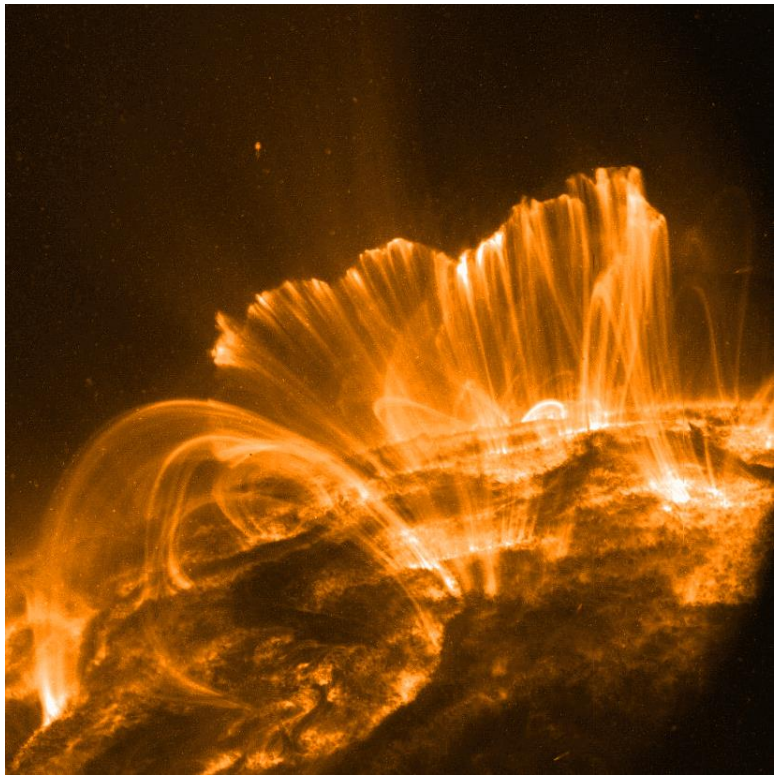
Visualizing Temporal Data

Do solar proton events (SPEs) shield the Earth?



"Post-eruptive loops in the wake of a solar flare, image taken by the TRACE satellite (photo by NASA)." – from Wiki Page

Problem: Cosmic rays **cause faults** on computers, but, due to rarity, are only considered on large supercomputers.

Known: Changes in the solar cycle can effect the rates of cosmic rays striking the Earth's atmosphere.

Solar Proton Event (SPE): Protons from the Sun that penetrate the Earth's magnetosphere after greatly compressing the magnetic field. The compression **protects the surface of the Earth** from cosmic rays.

"Natural" Solution?: Do SPEs affect the number of faults observed on supercomputers?

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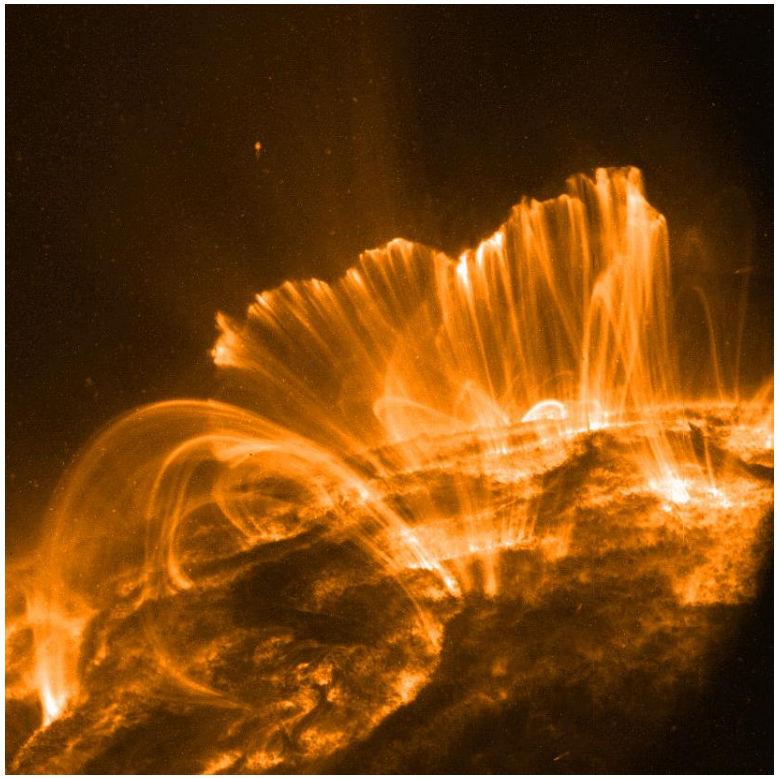

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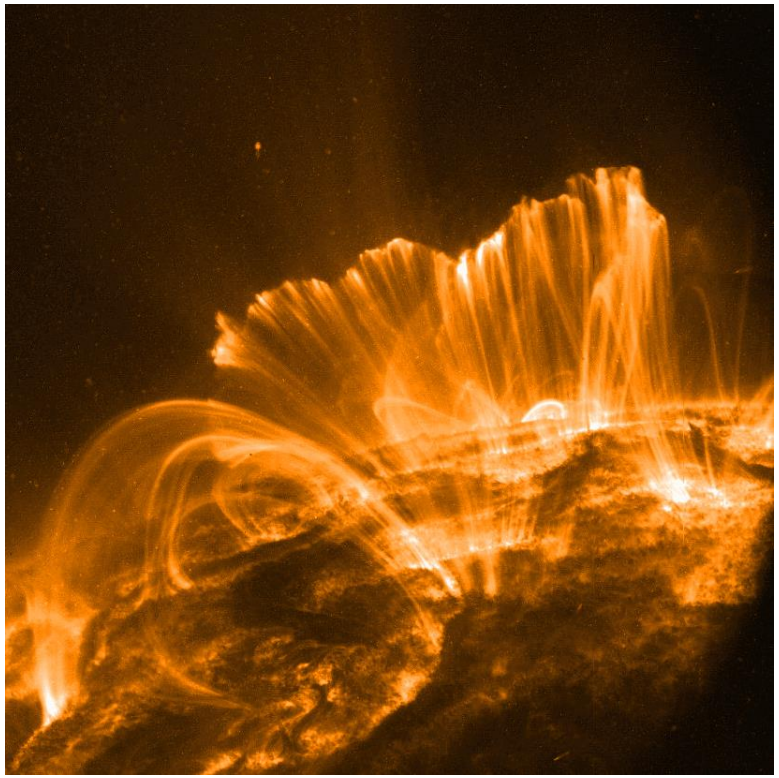

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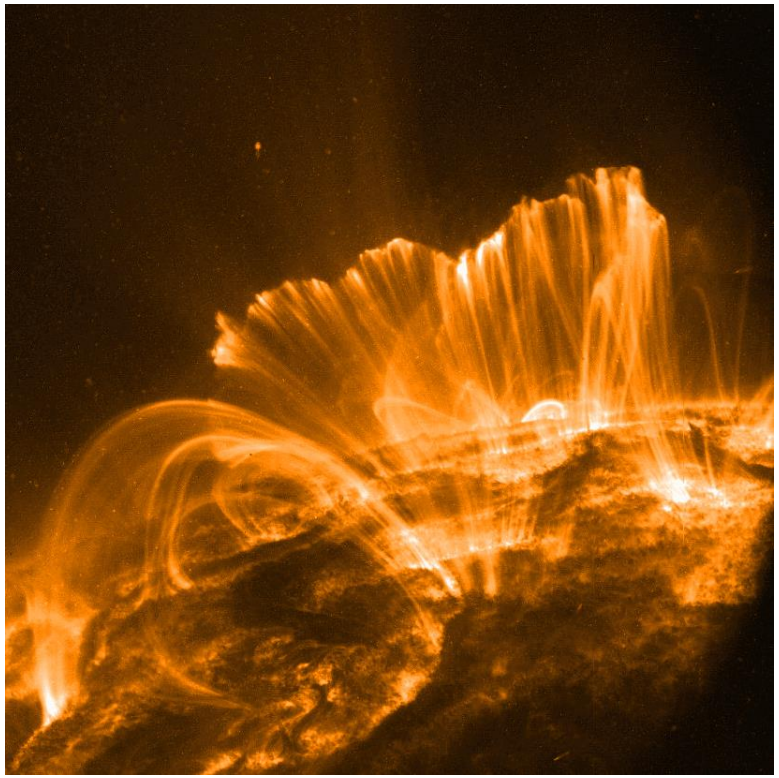

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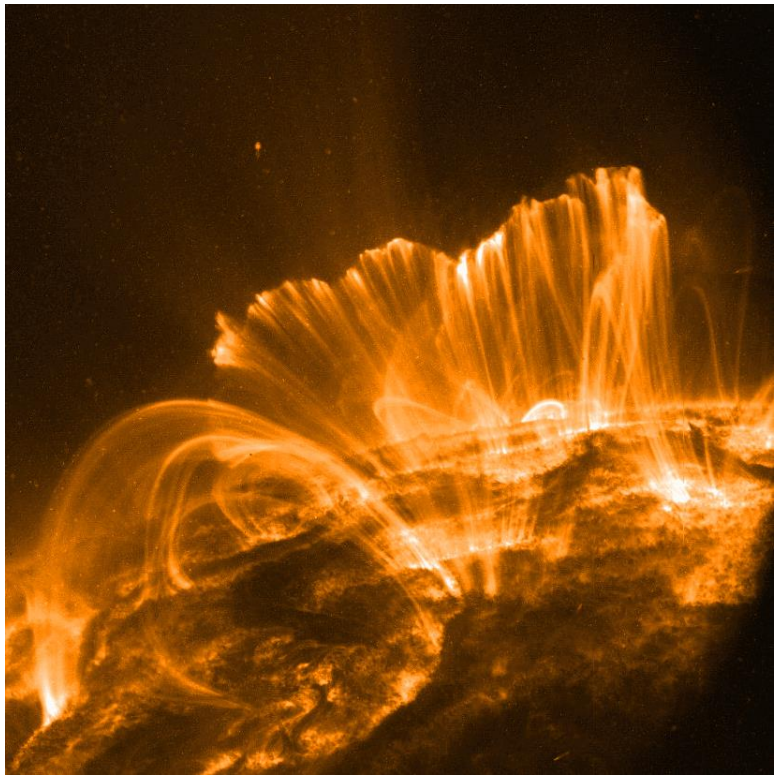

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How does time play a role in the number of faults?

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Visualizing Spatial + Temporal Data

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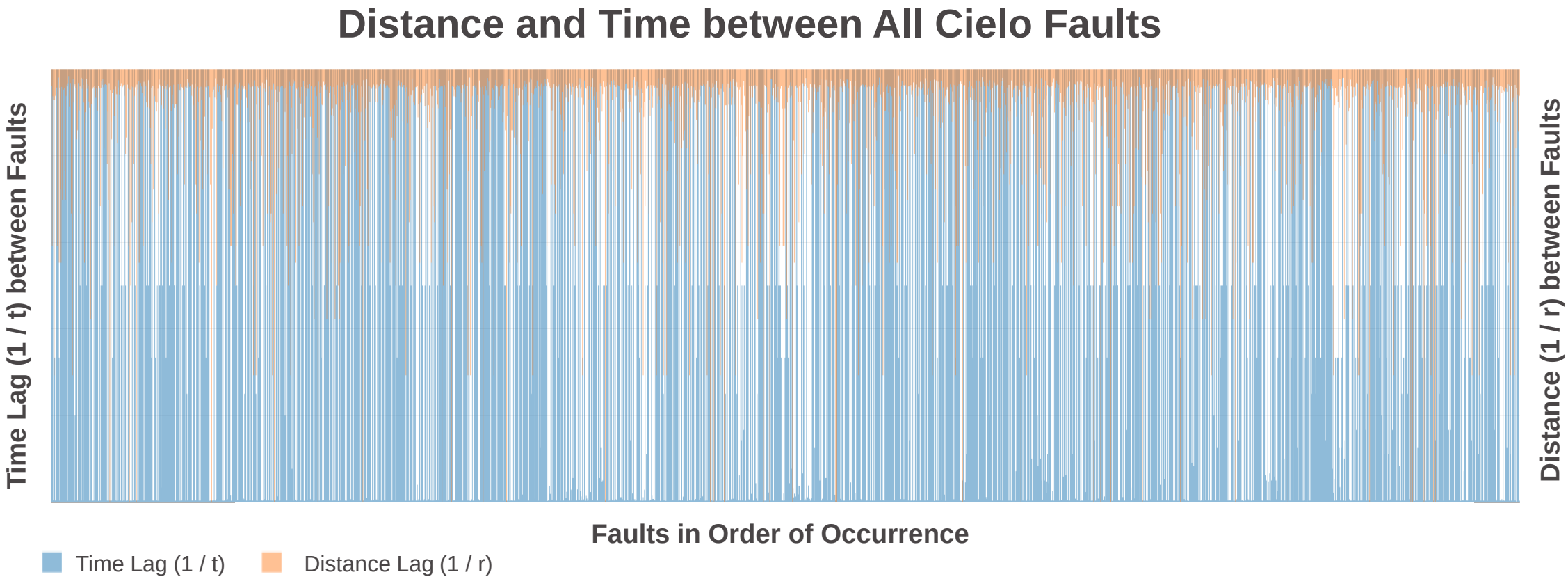

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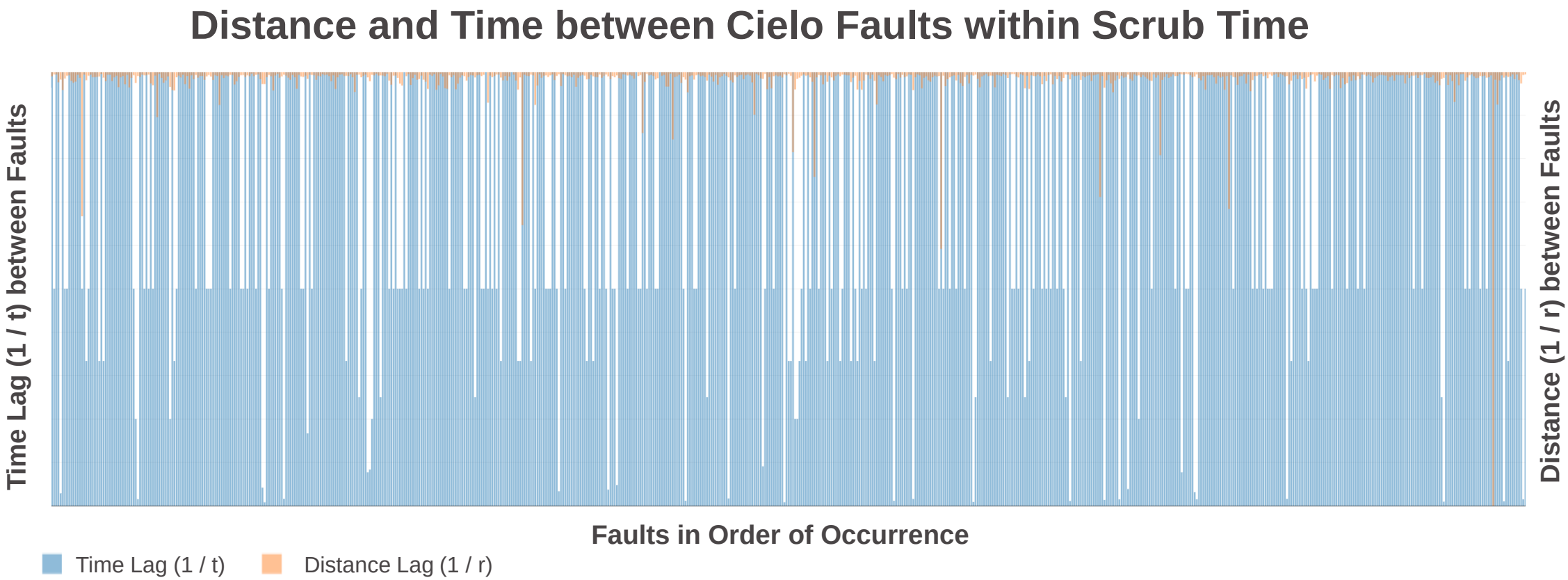

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Future Work

Continued Work

Exploring “Fault Showers” and other possible correlations with faults.

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How much does heat contribute to faults on supercomputers?

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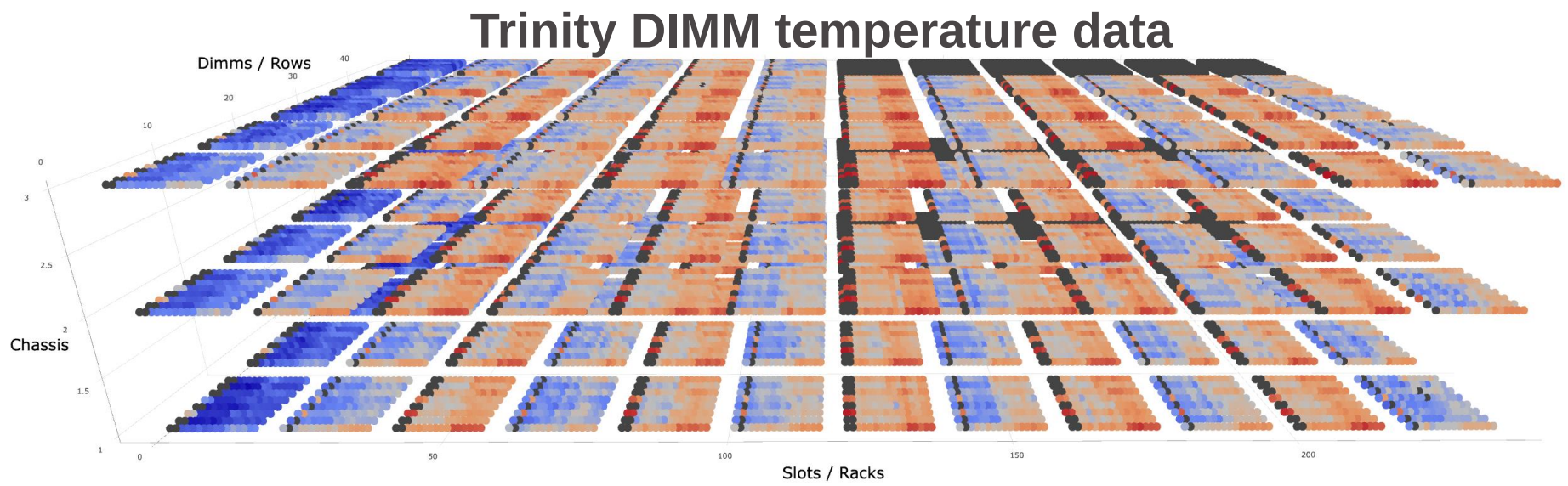

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Summary

- Supercomputers
  - Importance
  - Geometry
- Transient faults
- Interactive Visualizations of Spatial and Temporal Data
  - 3D Scatterplots
  - Layered Time Series
  - “Double” Histograms

Contact Me

cbowen@urban.org

www.clairemckaybowen.com

/in/bowenclaire

@ClaireMKBowen