

MACHINE LEARNING AND AI OUTCOMES

HOW SIMULATION, AI, AND ANALYSES GET RESEARCH DONE

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Director of Data Computing



TACC AT A GLANCE - 2022



Personnel

~185 Staff (~70 PhD)

Facilities

12 MW Data center capacity
Two office buildings, Three
Datacenters, two visualization
facilities, and a chilling plant.



Systems and Services

>Seven Billion compute hours per year
>5 Billion files, >100 Petabytes of Data,
NSF Frontera (Track 1), Stampede2
(ACCESS Flagship), Jetstream (Cloud),
Chameleon (Cloud Testbed) system

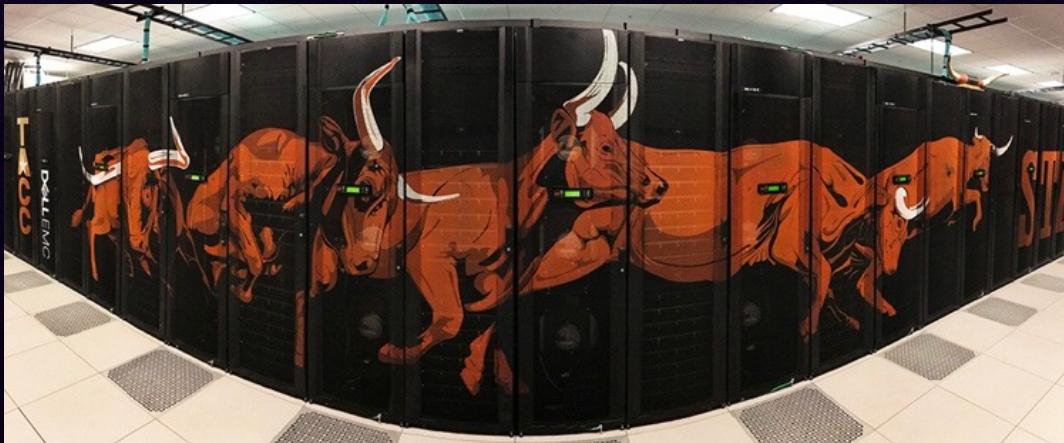


Usage

>15,000 direct users in >4,000 projects,
>50,000 web/portal users, User
demand 8x available system time.
Thousands of training/outreach
participants annually



TACC ROC DATACENTER



LEADERSHIP-CLASS
COMPUTING FACILITY

TACC
TEXAS ADVANCED COMPUTING CENTER





TACC SYSTEM SUMMARY

We operate the Frontera, Stampede-2, Jetstream, and Chameleon systems for the National Science Foundation

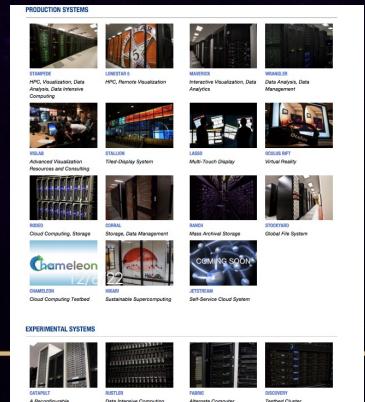
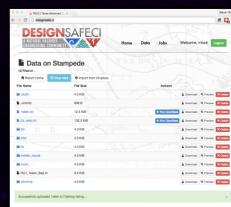
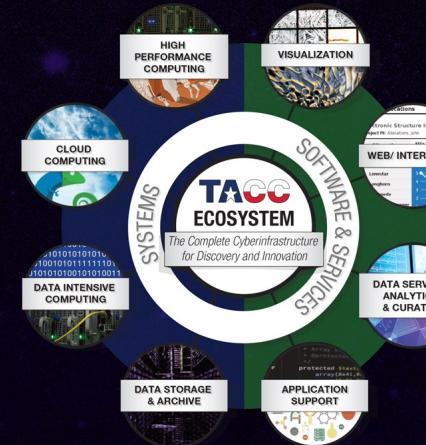
Longhorn and Lonestar-6 for our Texas academic and industry users.

Altogether, ~20k servers, >1M CPU cores, 296 A100 GPUs

About seven billion core hours over several million jobs per year.

WE ARE NOT JUST ABOUT THE BIGGEST SYSTEM

- ▶ TACC is not just about big computers, it's about people.
 - ▶ A partnership to do *whatever it takes* to do computational science and engineering at every scale.
 - ▶ Technologies + Team
 - ▶ Software, hardware, network, data, interface, curation, education, workforce collaboration.



MODERN COMPUTATIONAL SCIENCE

Simulation

Computationally query
mathematical models of the world

Machine Learning/AI

Computationally query
data sets

Analytics

Computationally analyze
experiments

Today's research combines all three, sometimes intermingled



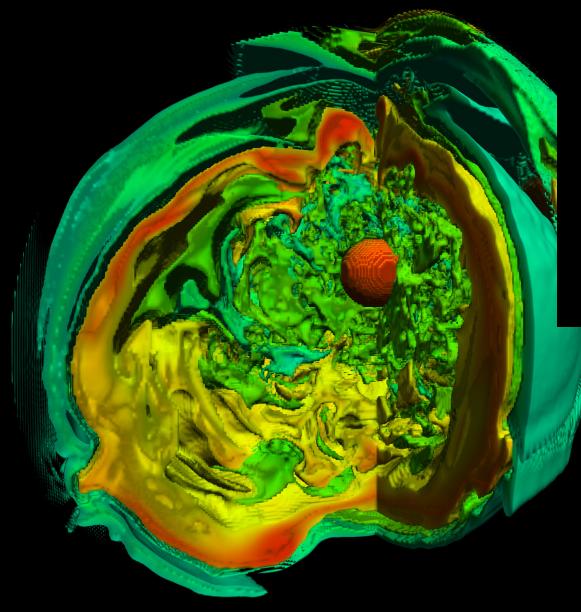
TODAY'S EXAMPLE: ASTROPHYSICS



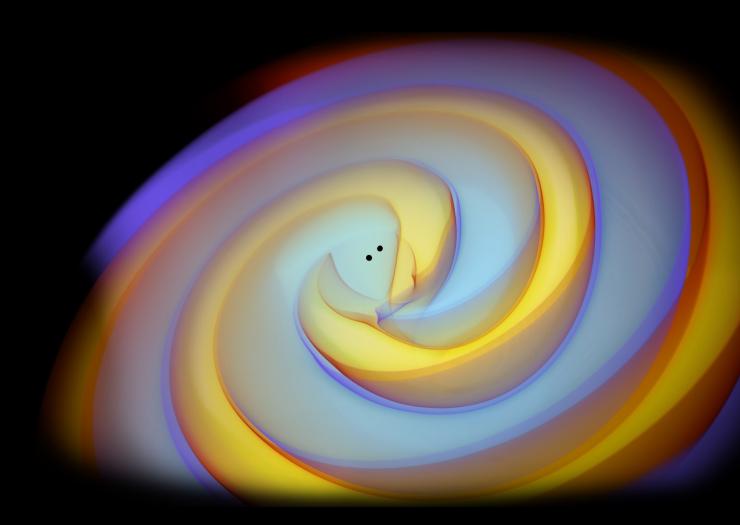
ASTRONOMY AND COMPUTING NOT NEW



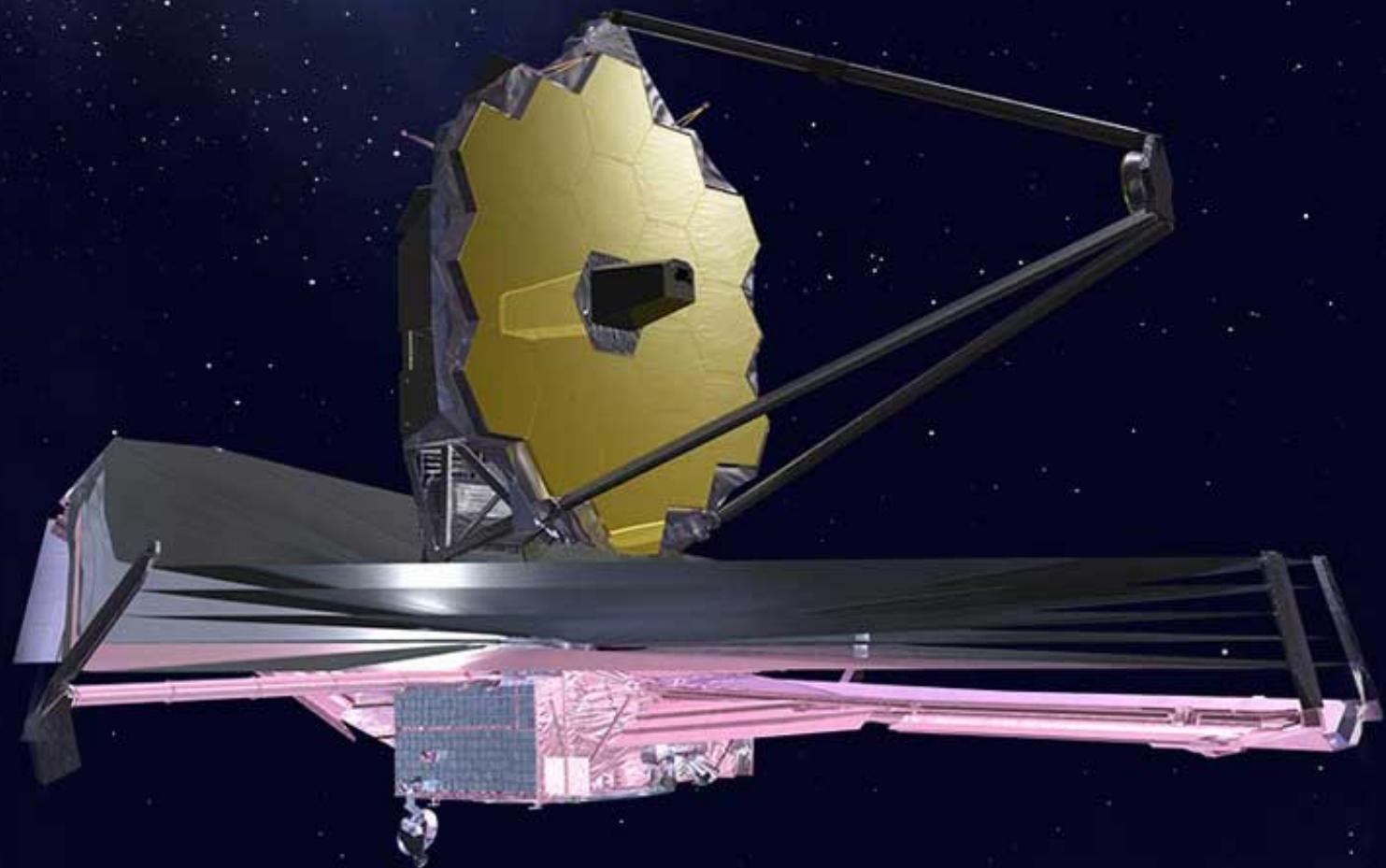
Renaissance Simulation
Blue Waters

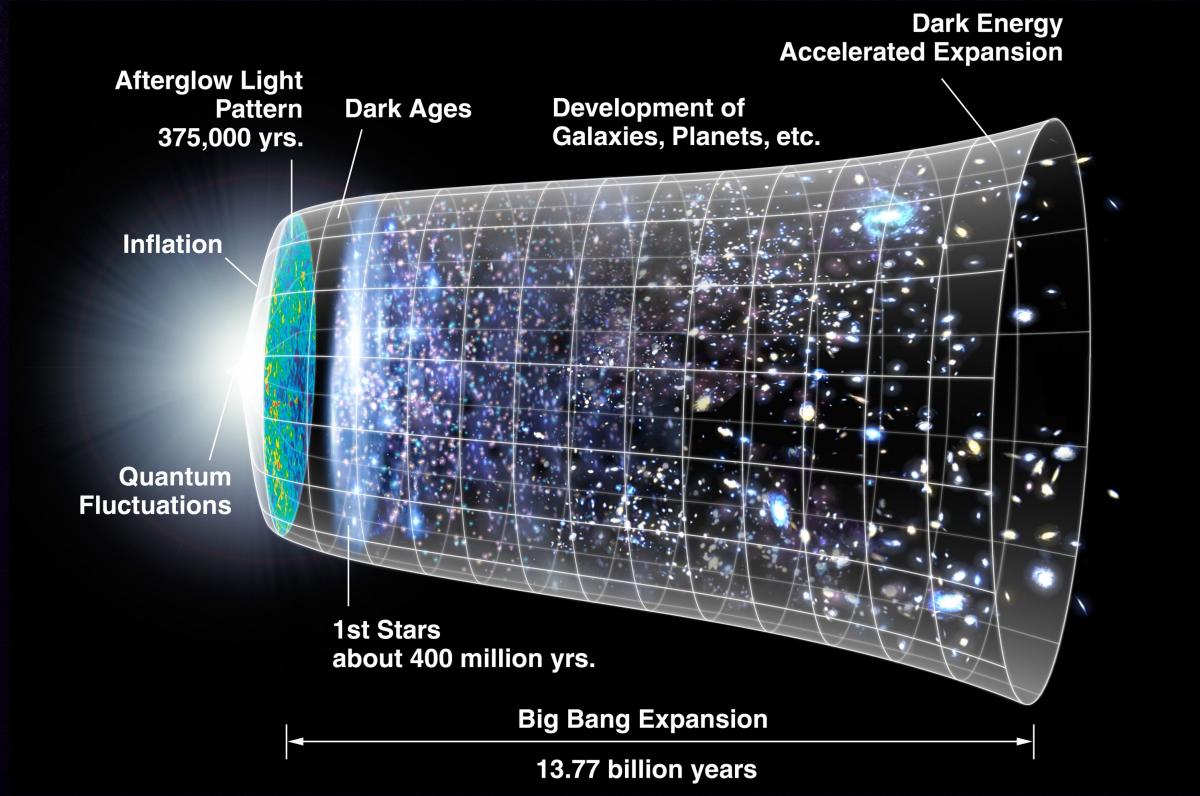


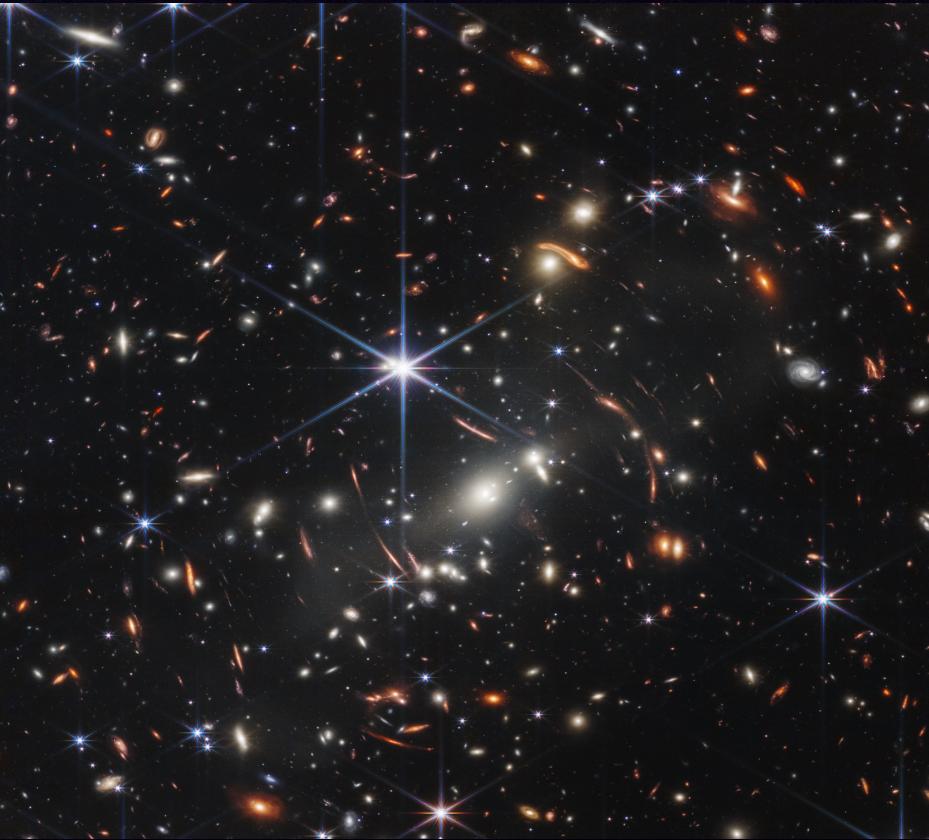
SciDAC
Terascale
Supernova
Initiative



Centre for Theoretical Cosmology
LIGO
and TACC







JWST FIRST LIGHT IMAGE

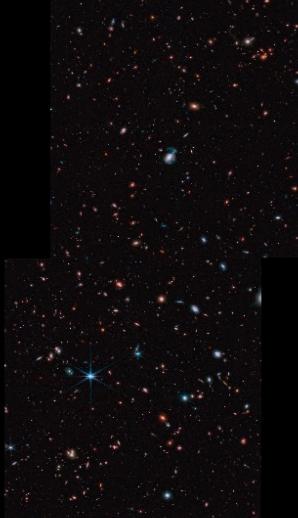
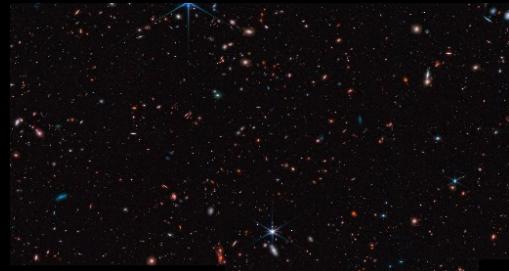
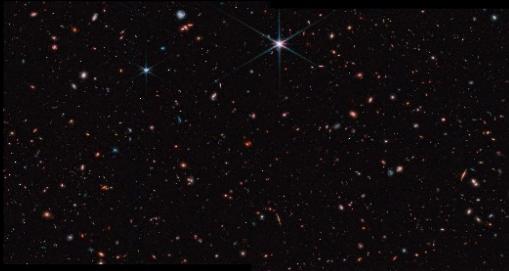
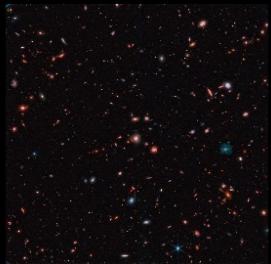
One of the deepest images taken at that time

It took hours not days

The volume of data from JWST will be huge



COSMIC EVOLUTION EARLY RELEASE SCIENCE SURVEY (CEERS) ON FRONTERA

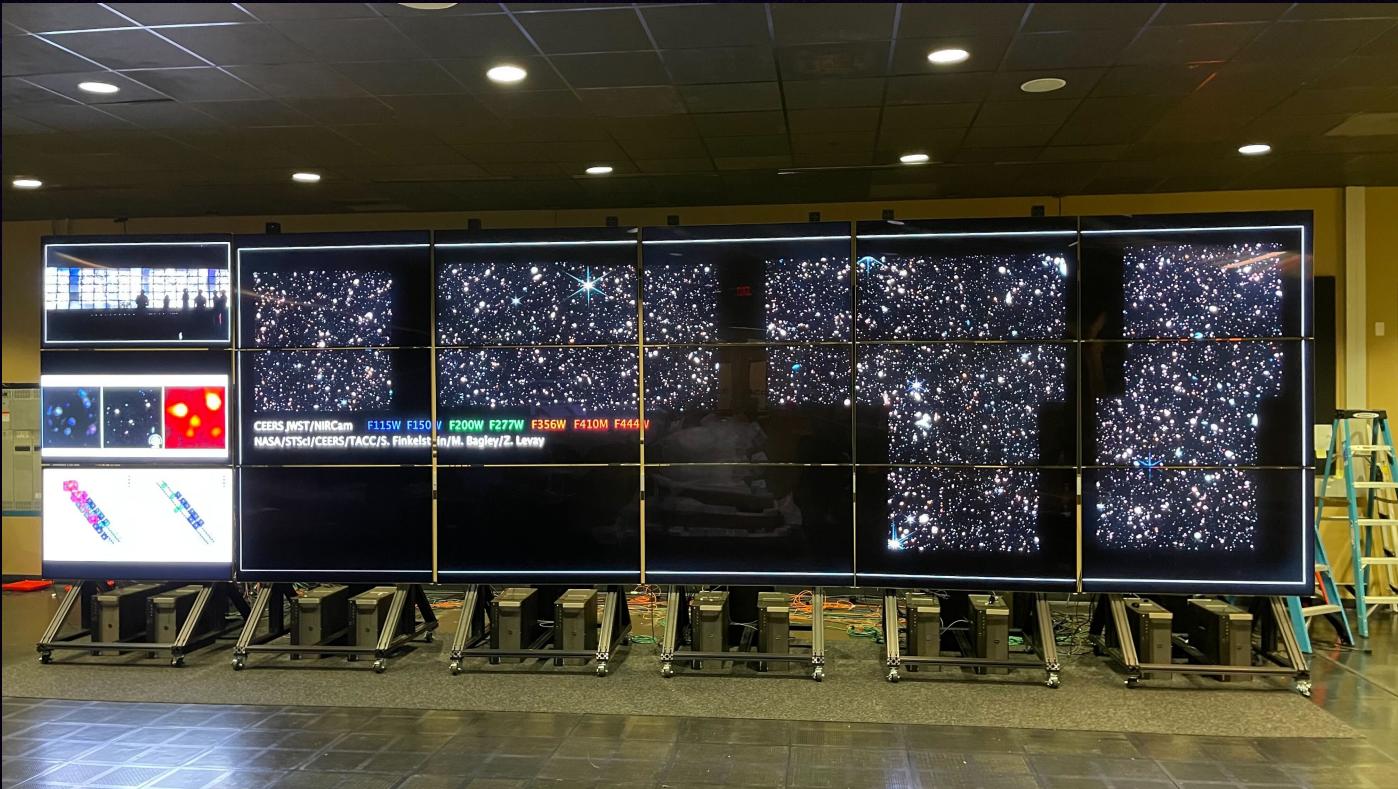


CEERS JWST/NIRCam F115W F150W F200W F277W F356W F410M F444W

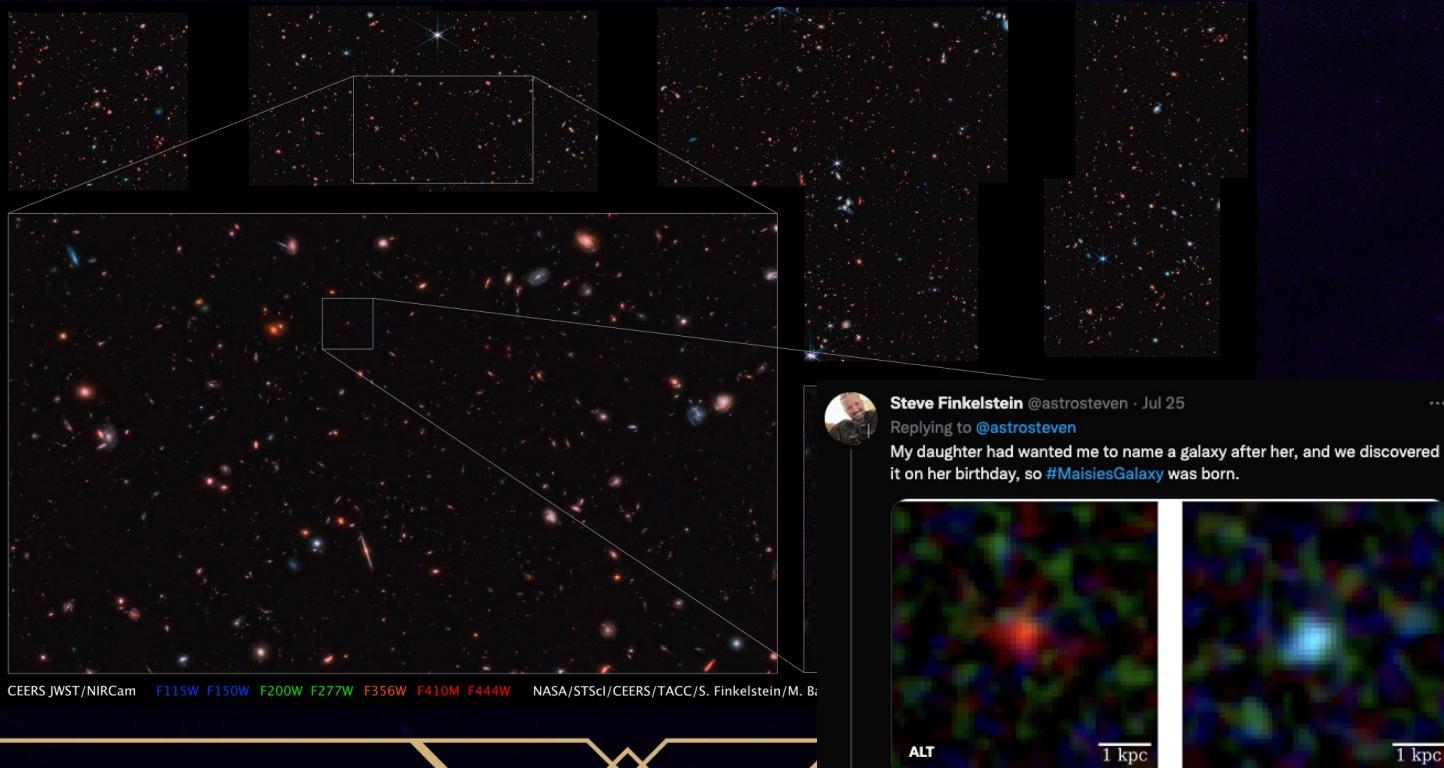
NASA/STScI/CEERS/TACC/S. Finkelstein/M. Bagley/Z. Levay

<https://ceers.github.io/ceers-first-images-release>

THOSE EARLY IMAGES WERE INTERESTING BUT...



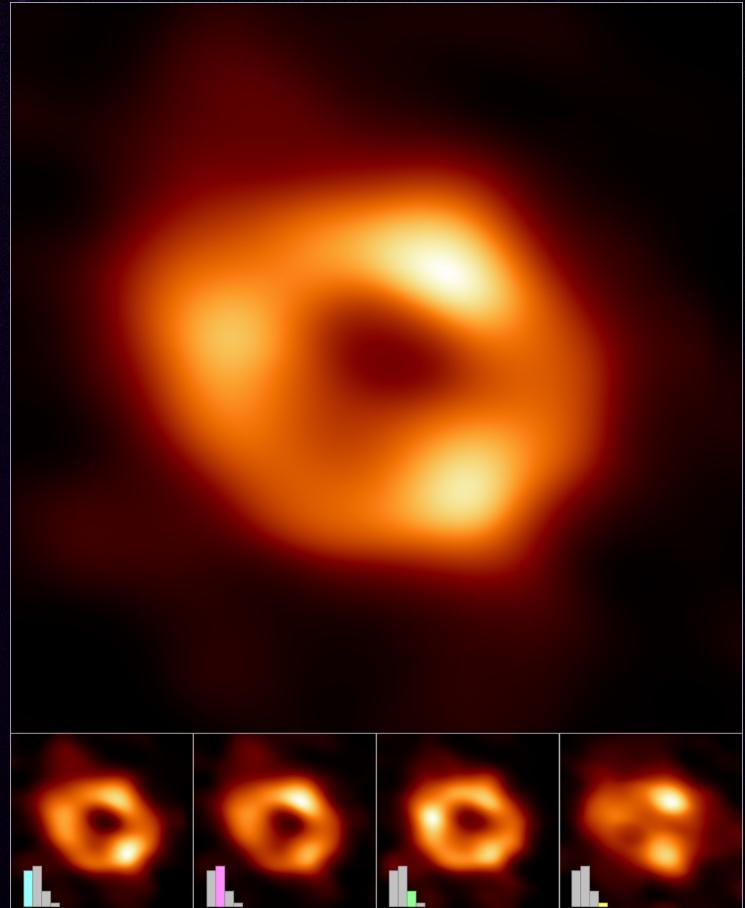
THE MOST DISTANT GALAXY FOUND (SO FAR)



EVENT HORIZON TELESCOPE

A hugely complex project with massive data and eight different telescope facilities.

- ▶ Four TACC projects at TACC alone contributed compute time, software, or expertise to this.
- ▶ Unlike M87's image, Sagittarius A* (the black hole at the center of our Galaxy) changes over the course of imaging it
- ▶ Design of the Cloud workflow on IU/TACC Jetstream system collaborating with SciVerse



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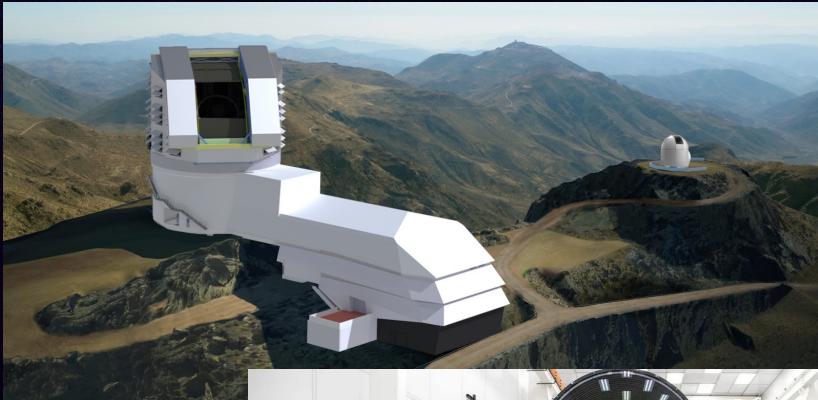
(driven by instruments that produce
lots of digital information)

WHAT IS AI

- ▶ Computation recognition when you do not have equations of state for a system
 - ▶ BERT recognizes language patterns and maps them to intent (and visa versa)
 - ▶ Computer vision maps images/movies to items in the real world (and their motions)
- ▶ Sometimes AI can recognize a state faster than simulation can compute it
 - ▶ Three body (Sun, Moon, and Earth orbits) problems 100x faster with AI



THE AI ASTRO FUTURE



Vera Rubin
Observatory



LIGO



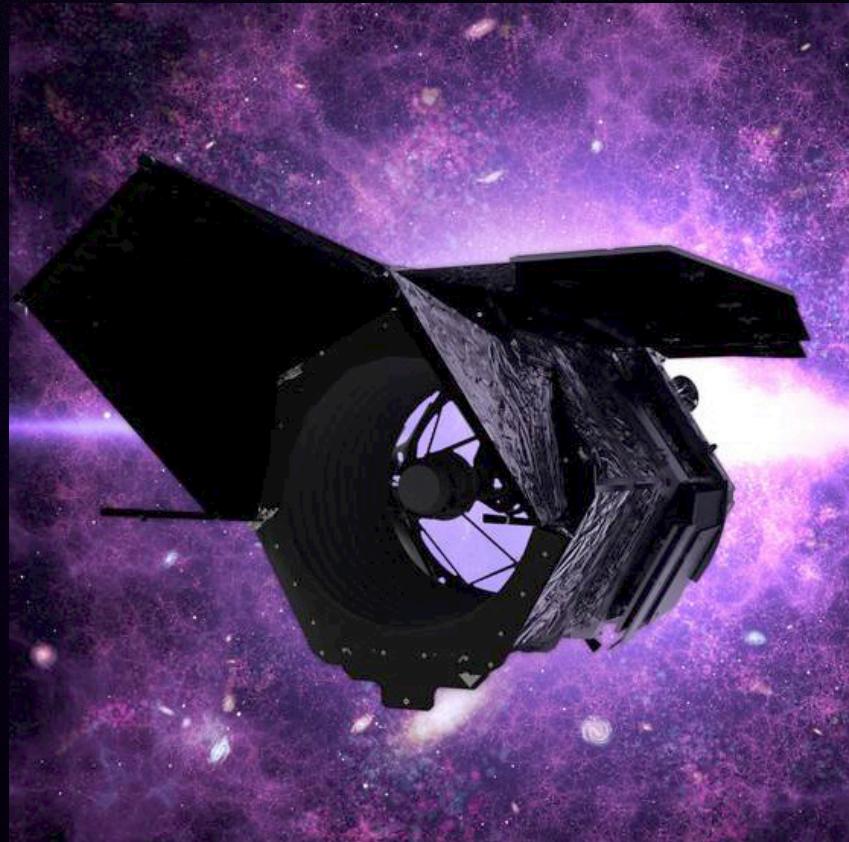
Ice Cube Observatory

ROMAN TELESCOPE

Same size telescope as HST but with 200x the field of view

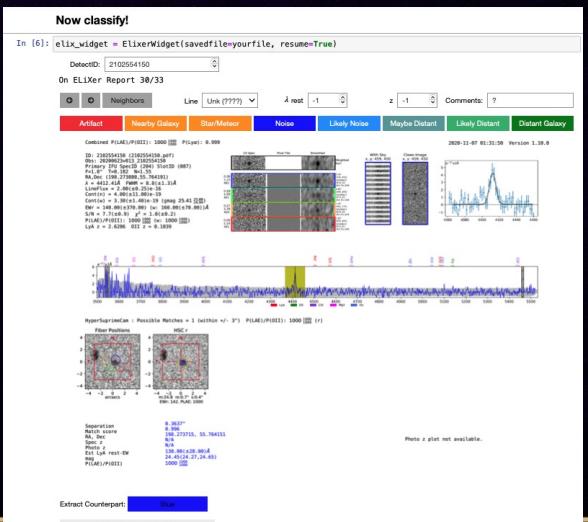
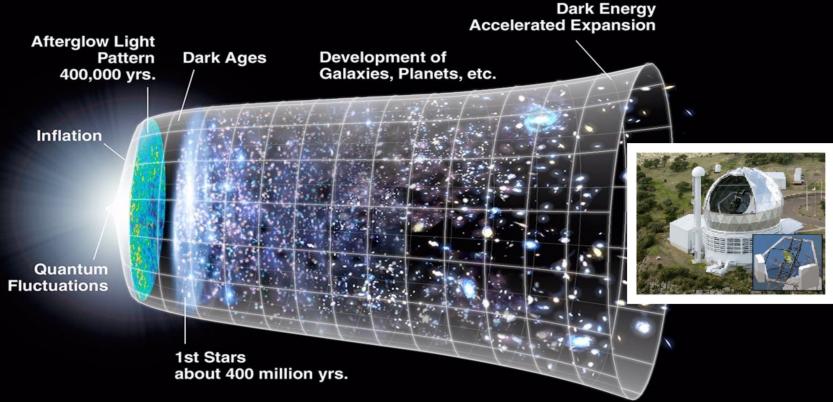
Looking deeper into the early universe with more data and more galaxies

There won't be 200x the astronomers to do the analysis so AI will be key to maximizing the science output of the observatory



HETDEX AT TACC

- ▶ Currently all the HETDEX data are stored on Corral
 - ▶ Data streamed directly from the telescope and reduced in near real time
 - ▶ Accessible to all HPC systems to copy to scratch and work locally
 - ▶ Accessible directly from Jupyter Hub environment with specialized Python3 kernel and prebuilt exploratory notebooks
 - ▶ Future may include large database hosted on Corral with fast backing store and/or other hosted data services (not just files on disk)
 - ▶ Usable by researchers and by students helping train AI algorithms

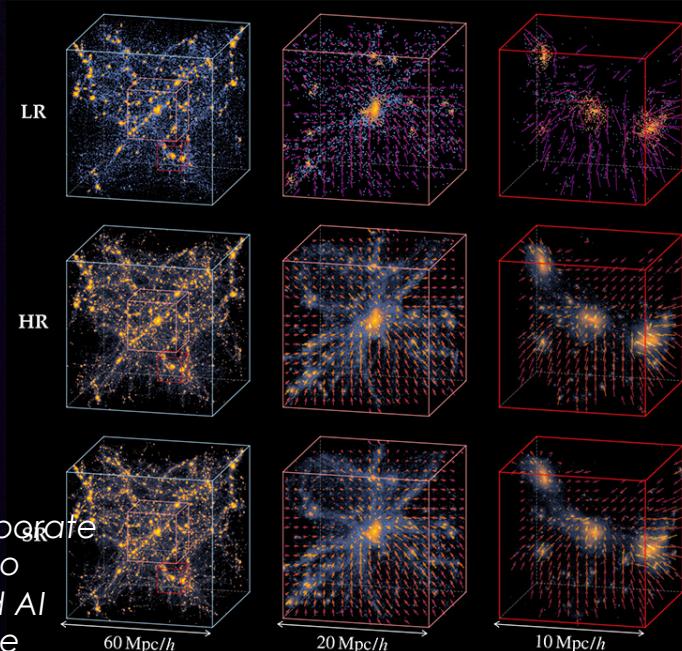


ARTIFICIAL INTELLIGENCE JUST REMOVED ONE OF THE BIGGEST ROADBLOCKS IN ASTROPHYSICS

TIZIANA DI MATTEO, CMU AND YIN LI, FLATIRON

- ▶ Use a Neural net trained on low-res and high-res images of sections of the galaxy.
- ▶ Feed the net low-res images to upscale.
- ▶ 500x the computational efficiency.
- ▶ Published in PNAS, May 2021.

"Our goal is to create models of the entire observable Universe that incorporate information from higher resolution models of individual galaxies," Di Matteo continued. "Frontera is ideal for this: allowing us to couple the physics and AI running on GPUs and CPUs, and enable us to reach detail which would be otherwise impossible."



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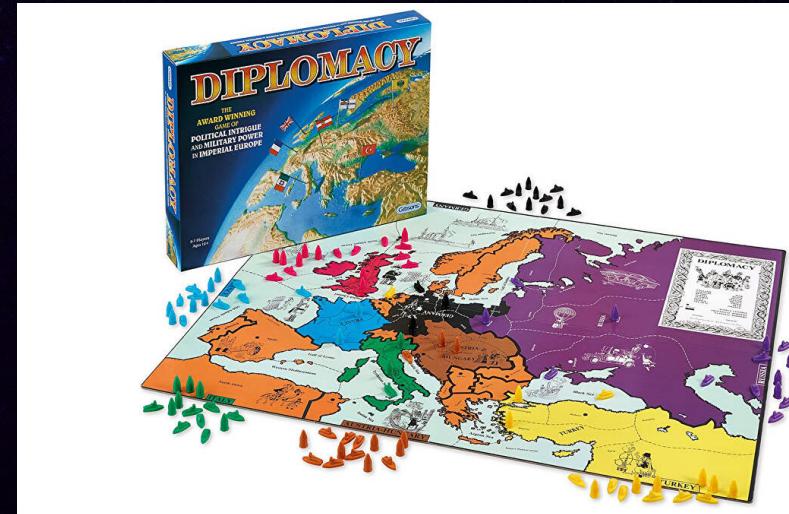
Computationally analyze our
experiments
(driven by instruments that produce
lots of digital information)

AND THAT'S JUST IN ASTRONOMY...



DARPA'S VERSION OF EXPLAINABLE AI

- ▶ Diplomacy is a game with simple rules around strategy and no limit of complications in human interaction
 - ▶ Well-trained AI's can win diplomacy in "no press" mode (aka no negotiations)
 - ▶ But that's no fun...



Diplomacy



**Destroying
Friendships**

since 1959

DARPA SHADE

- ▶ TACC along with UMD are building the AI-Gym for training, playing, and evaluating full press Diplomacy bots
- ▶ Seven teams with differing methods of training bots to play full press Diplomacy
 - ▶ Leveraging existing AI no-press bots, creating new AI bots, and creating bots around pure game theory
 - ▶ Bots must negotiate and apply deception, collusion, profiling, and other real-world features (and know that they are doing that) to improve their winning ability.
 - ▶ Include expression and tone in messaging ("please do not attack London from Holland" vs. "I demand that you never to attack London from Holland" have different impacts or interpretations
 - ▶ Will play against other bots and in tournaments with real diplomacy players.
- ▶ And this being DARPA...we have 18 months to do it.



THE REAL GOAL

- ▶ The game is a simple set of rules and actions that are a simple proxy for warfare in the real world
 - ▶ The goal here is to create agents who can be taught the rules of the game and, based on limited experience, advise humans on negotiation to improve outcomes (not just on the battlefield but in all the diplomatic relations around the world)
 - ▶ People have been doing this throughout history, can AI help overcome biases
 - ▶ Can you identify behavioral patterns in people to best work with them (This person accepts the first good proposal that comes along so be quick)
 - ▶ Can you detect when someone is being deceptive to gain an advantage they otherwise would not get (This other person asked me to do this, but don't worry we are still allies)
 - ▶ Can you find when best to deceive or collaborate with others to optimize outcomes (Even though breaking our deal with this person now would help, longer term it will not)
 - ▶ Can you detect negotiations between other parties and use that to your advantage (This player seems to be helping this other one but will probably be betrayed in a turn, I should tell them)

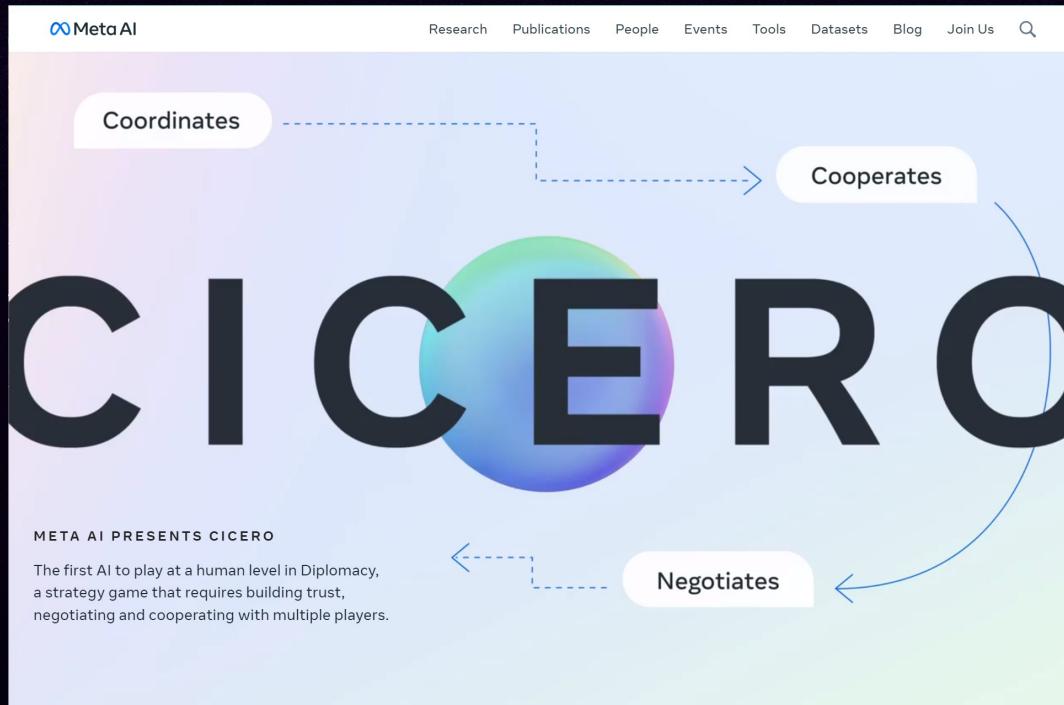


CURRENT STATUS

- ▶ All teams have working bots that speak a common language (DAIDE)
- ▶ Have a tool to convert to (and from in some cases) English to and from DAIDE
- ▶ We had our first demonstration of all bots negotiating at the end of October
 - ▶ Some were very good in specific situations
- ▶ Deception is not lying



AND THEN TWO WEEKS AGO



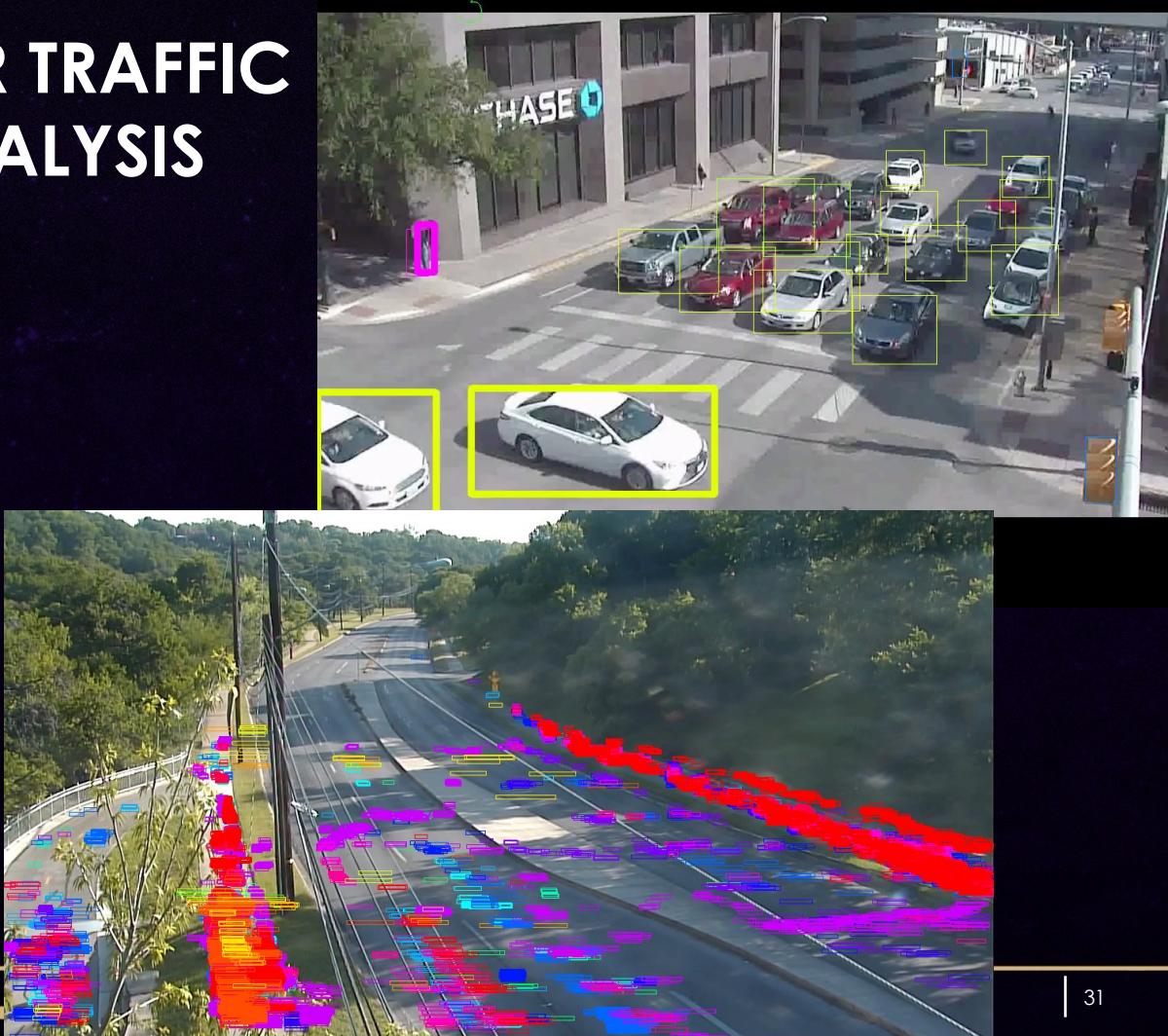
OUR GOALS ARE DIFFERENT

- ▶ Can you identify behavioral patterns in people to best work with them (This person accepts the first good proposal that comes along so be quick)
- ▶ Can you detect when someone is being deceptive to gain an advantage they otherwise would not get (This other person asked me to do this, but don't worry we are still allies)
- ▶ Can you find when best to deceive or collaborate with others to optimize outcomes (Even though breaking our deal with this person now would help, longer term it will not)
- ▶ Can you detect negotiations between other parties and use that to your advantage (This player seems to be helping this other one but will probably be betrayed in a turn, I should tell them)
- ▶ Will continue with both bot and human games focusing on the core goals (its not about “winning the game” but “winning the negotiations”)



DEEP LEARNING FOR TRAFFIC CAMERA VIDEO ANALYSIS

- Traffic Camera Video Analysis Project (City of Austin & CTR)
 - ▶ Use deep learning methods to automatically recognize moving objects from video stream, e.g. car, pedestrian, cyclist, bus
 - ▶ Convert video into indexed objects that can be searched / analyzed later
 - ▶ Traffic volume estimation, location based safety study.

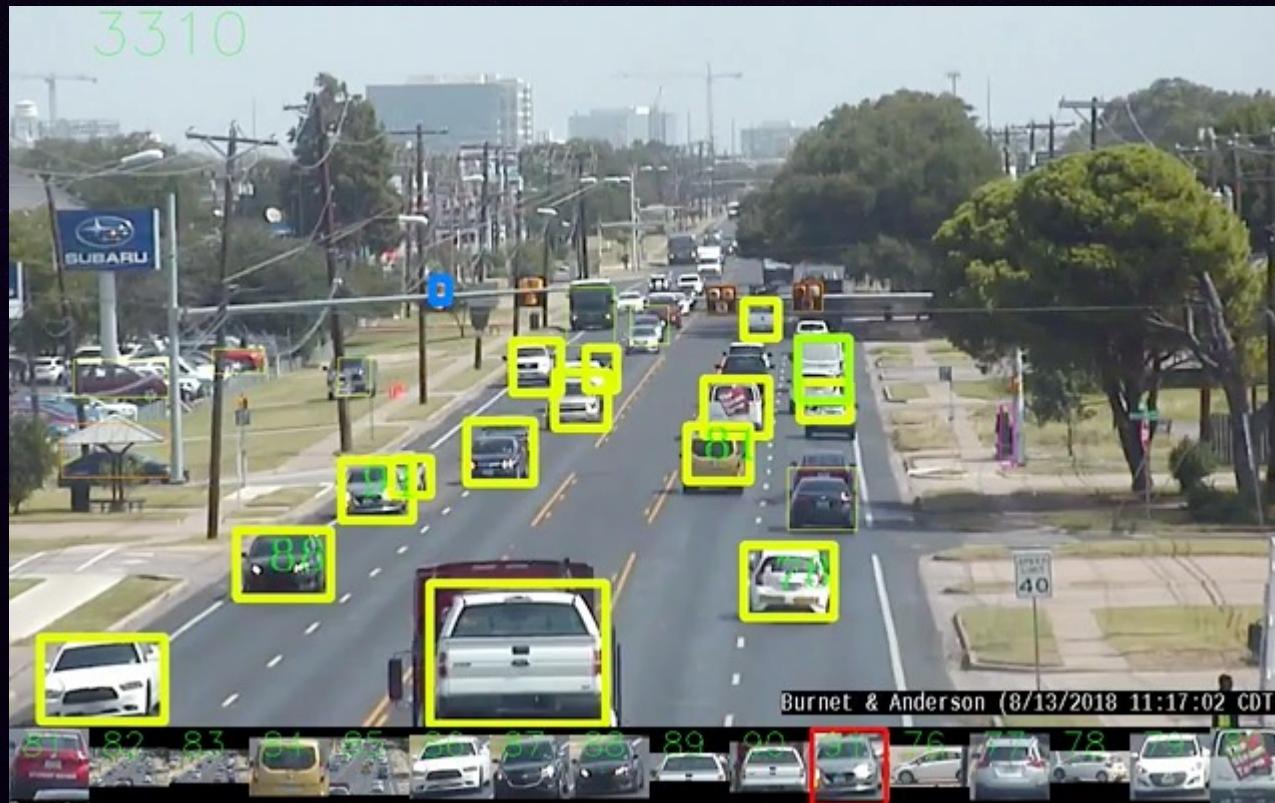


DETECT THE UNEXPECTED

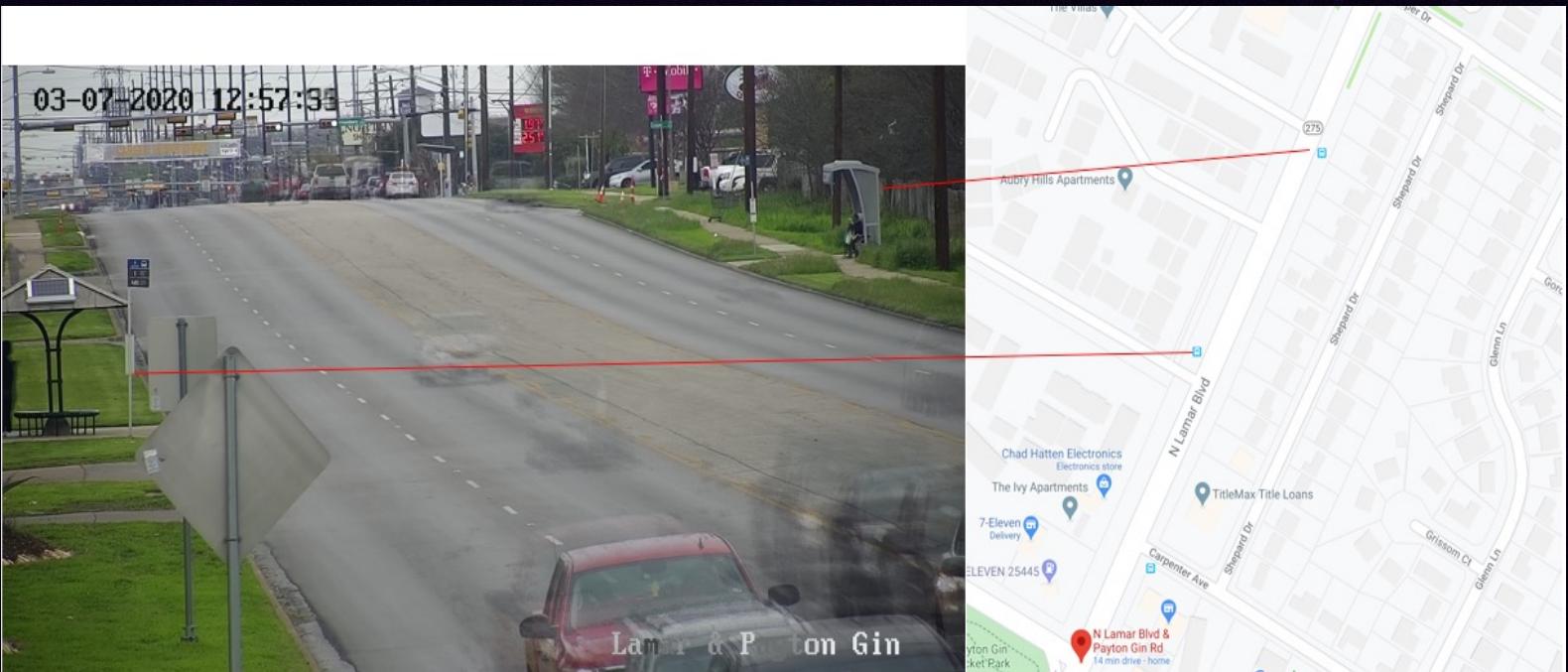


Burnet & Anderson (8/13/2018 CDT)

THE ANSWER WAS...



USE CASE 2: BUS USAGE DEMANDS INFERENCE



VISUAL SUMMARY OF PERSON DETECTION

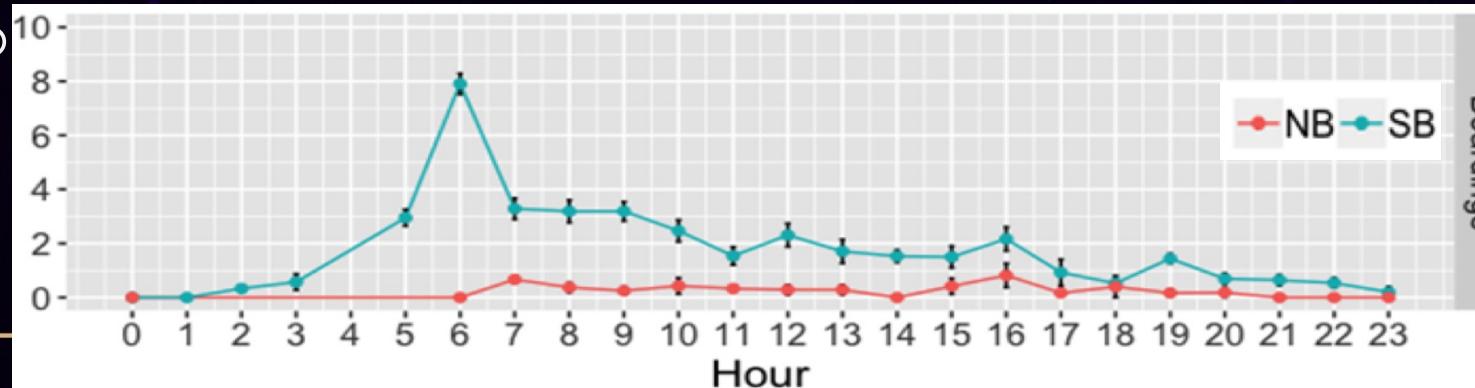


HOW MANY PEOPLE ARE WAITING FOR BUSES?

► Prediction

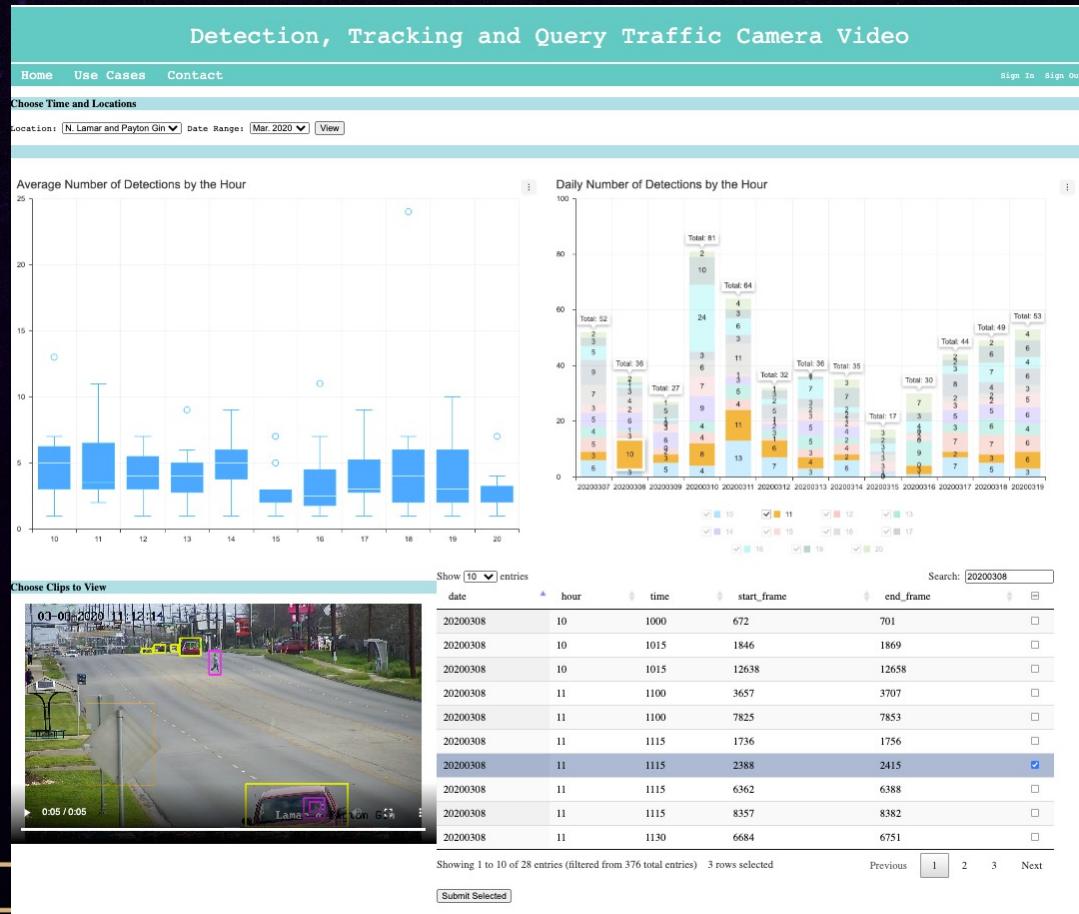
V.S.

► CapMetro



GETTING ANALYSIS TO DECISION MAKER VIA WEB PORTAL

- ▶ AI analysis on traffic video camera to assist traffic studies at specific locations
- ▶ Collaboration with ATD on turning traffic camera into summarized and queryable information to support traffic status studies.
- ▶ With protected web user interface for web portal for traffic manager and researchers to review



THE FUTURE AND AI

- ▶ AI is not new, its just our computational power has caught up with its initial potential to inform us better than we could do so without it
- ▶ Explainable AI will be key to the future of AI and its acceptance
 - ▶ We should know why AI made this conclusion and help it when it is wrong
- ▶ Data volume and management are the backbone of good AI
- ▶ Statistics never lie...data and data biases do





THANK YOU!
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