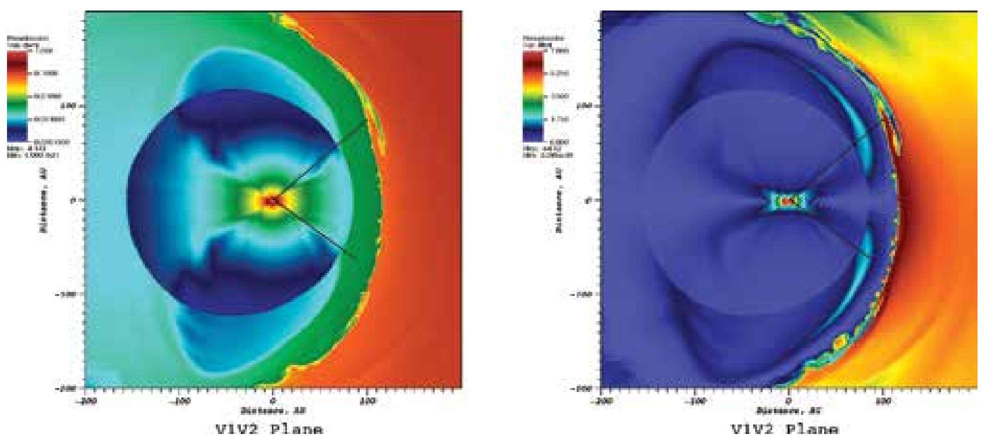

FIGURE 3: Distributions of the magnetic field strength (right panel) and plasma density (left panel) in the plane defined by the current directions of the Voyager 1 and Voyager 2 trajectories demonstrate the heliopause instability at V1 and signatures of magnetic reconnection at V2.

NEXT GENERATION WORK

On a next-generation Track-1 system in the 2019-2020 timeframe, we plan to extend MS-FLUKSS by adding the capability to perform local hybrid plasma simulations (particle ions and electron fluid) in the framework of the global MHD model. This will allow us to investigate micro-scale phenomena, e.g. particle acceleration and kinetic instabilities, in the realistic environment.

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DEPLOYMENT OF THE DARK ENERGY SURVEY WORKFLOWS

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Collaborators: Gregory Daues[1], Robert Gruendl[1], and Felipe Menanteau[1]

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EXECUTIVE SUMMARY

The Dark Energy Survey (DES) is performing a 5,000 square-degree wide field survey in five optical bands of the southern sky and a 30 square-degree deep supernova survey with the aim of understanding the nature of dark energy and the accelerating universe. DES uses the new three square-degree charged couple device (CCD) camera, DECam, installed at the prime focus on the Blanco four meter telescope to record the positions and shapes of 300 million galaxies up to redshift 1.4. During a normal night of observations, DES produces about 1 TB of raw data, including science and calibration images, which are transported automatically from Chile to NCSA to be archived and reduced. The DES data management system (DESDM) is used for the processing, calibration and archiving of this data, which has been developed by collaborating DES institutions led by NCSA. The DESDM team at NCSA has successfully deployed the DES Production Pipeline on Blue Waters. Over the course of a year of investigations, several software and network improvements were made by the Blue Waters team to accommodate our workflows, and we were able to commission our production framework successfully in the fall of 2015. Moreover, we were able to make use of the remainder of our initial allocation to process 10,814 DECam exposures on the XE Compute Nodes. This corresponds to 15% of the total data volume (over 70k exposures) that DESDM processed for the Y3A1 release.

INTRODUCTION

The goal of the DES is to understand the origin of cosmic acceleration and the nature of dark energy using four complementary methods: weak gravitational lensing, galaxy cluster counts, large-

FIGURE 1: An example of one of the 10,814 DECam exposures processed by Blue Waters in early 2016 using the FINALCUT pipeline during our initial DD time allocation.

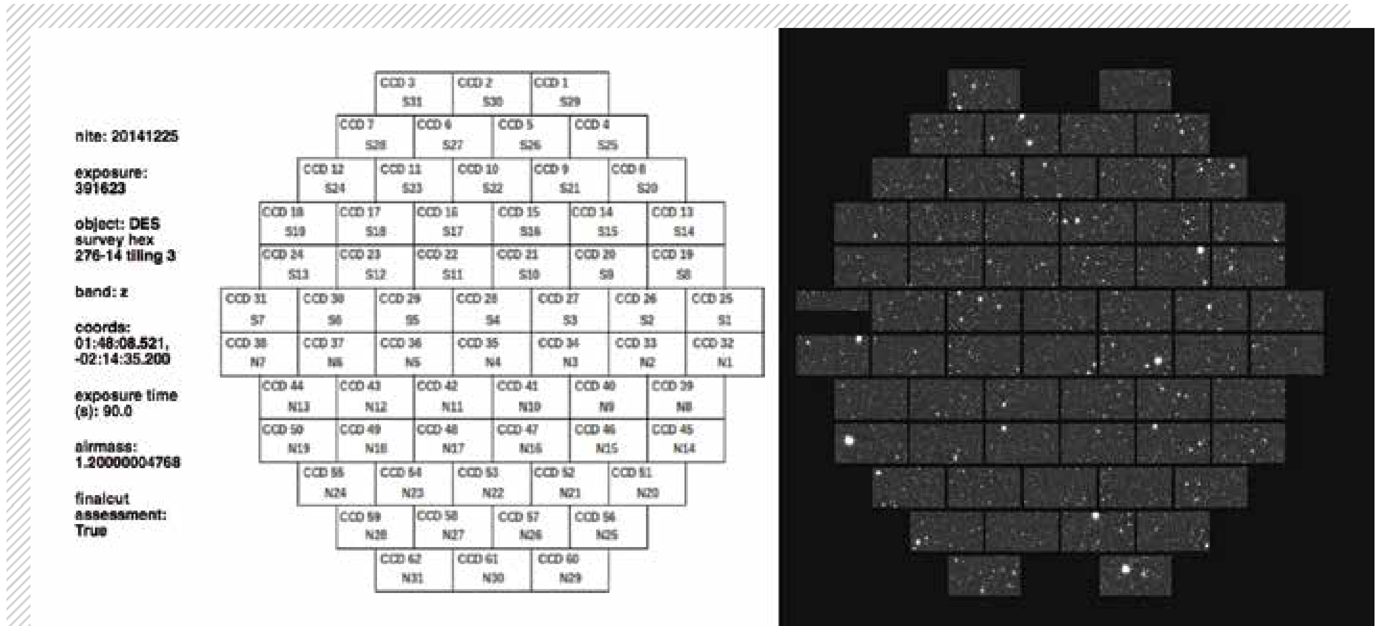

FIGURE 2: An example of a section near the rich galaxy cluster RXJ2248 from a deep stacked co-add tile color image using the *g,r,i* filters and that was generated using the DESDM pipeline.

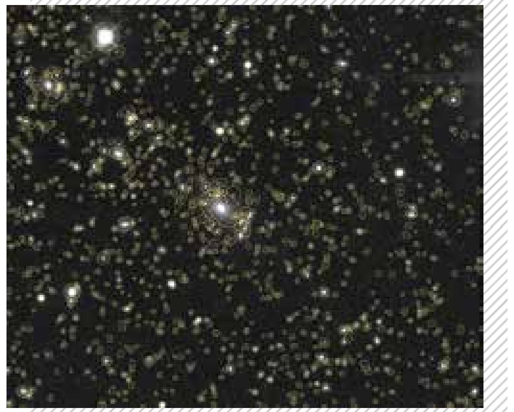

FIGURE 3: The same tile section showing ellipses for the objects detected and catalogued by the DESDM pipeline.

scale galaxy clustering (including baryon acoustic oscillations), and Type Ia supernovae. DES comprises two multi-band imaging surveys; a 5,000 square degree g,r,i,z,Y wide-survey of the southern sky to approximately 24th mag and a deeper time-domain 30 square-degree g, r, i, z deep DES Supernova (SN) Survey with a cadence of approximately five days.

DES uses the state-of-the-art three square-degree Dark Energy Camera (DECam), a 570 megapixel camera installed at the prime focus of the Blanco four meter telescope at the Cerro Tololo Interamerican Observatory (CTIO) in Northern Chile. DECam consists of 62 fully depleted, 250 micron thick 2048×4096 CCDs combined with four 2048×2048 guider and eight 2048x2048 autofocus CCDs.

For 525 nights, between 2013-2018, DES is scanning the sky to perform a 5,000 square-degree wide field survey. Over five observing seasons, DES will measure shapes, positions, fluxes, and colors for approximately 300 million galaxies and will discover and measure light curves for 3,500 supernovae and use these measurements to deliver powerful, new constraints on cosmic acceleration and dark energy. Each image arrives from CTIO in Chile to NCSA within minutes of being observed and it is usually processed by the nightly processing pipeline within 24 hours.

METHODS & RESULTS

One of main goals of the DESDM Project within the DES collaboration is the operation of the data reduction pipelines using high-performance computing (HPC) facilities to generate the survey data products. The DESDM data reduction process is composed of several pipelines or workflows that, starting from raw images, remove known instrumental signatures and sky background, masks defects, and detects and measures properties of objects to produce catalogs and calibrated images.

In 2014, we requested a Blue Waters allocation to explore the feasibility of running DESDM software and workflows on a shared Track-1 system. After nearly a year of investigations, where several software and network improvements were made by the Blue Waters team to accommodate our workflows, we were able to successfully deploy our production framework in the fall of 2015.

After each observing DES season, all DECam exposures meeting the survey data-quality criteria are systematically reprocessed using the FINALCUT and COADD pipelines. During the first trimester of 2016, we needed more computing resources to process the single-epoch FINALCUT campaign for the year three annual release (Y3A1) and used the remainder of our allocation to process 10,814 DECam exposures on the XE Compute Nodes. This corresponds to 15% of the total data volume (over 70k exposures) that DESDM processed for the Y3A1 data release. In Figure 1, we show an example of a DECam exposure processed using Blue Waters. In Figures 2 and 3, we show a section of a deep stacked co-add DES tile near the center of the cluster RXJ2248.

The DESDM system relies on the HTCondor software (CHTC UW-Madison) to manage jobs within a directed acyclic graph-based workflow. Porting this to Blue Waters represents a new and novel use of this system. Lessons from our implementation could serve as a model for other astronomy projects and pipeline that are not currently using Blue Waters.

WHY BLUE WATERS

The yearly re-processing campaigns of DESDM impose large seasonal variations in the demand for computing resources. The petascale size of Blue Waters, coupled with the perfectly parallel nature of our pipelines, allows DESDM to elastically expand its working pool of compute nodes to accommodate the burst in demand arising from the year annual processing for the collaboration.

DESDM is led by NCSA, where all images are archived and served in the community. Data processing on Blue Waters at NCSA is more robust and preformat than distributing workloads to remote sites. Moreover, the proximity between DESDM scientists and Blue Waters staff enables rapid feedback and clear communication, which are important for the success of complex implementations.

NEXT GENERATION WORK

We would like to continue production of our yearly annual releases on Blue Waters, which will continue to increase in size with each observing season. Our last data release is scheduled for 2021.

We want to improve the level of automation of HTCondor-based workflow on Blue Waters for the subsequent production campaigns.

We are also interested in the use of User Defined Images (UDI) for standard deployment of our software stacks to HPC systems.

AB INITIO MODELS OF SOLAR ACTIVITY

Allocation: NSF PRAC/9.01 Mnh
PI: Robert Stein[1]
Co-PIs: Mats Carlsson[2], Aake Nordlund[3], William Abbett[4], and Bart De Pontieu[5]
Collaborators: Viggo Hansteen[2]

[1]Michigan State University
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[4]University of California Berkley
[5]Lockheed-Martin Space Sciences Lab

EXECUTIVE SUMMARY

The goal of this project is to understand how solar magneto-convection forms and controls solar active regions–how magnetic flux emerges through the solar surface and how that contributes to the heating of the chromosphere and corona and the acceleration of charged particles into the interplanetary medium.

INTRODUCTION

This project is motivated by society's vulnerability to harmful space weather. X-ray bursts and the high-energy particles associated with intense solar activity can harm astronauts, disable satellites, and hamper terrestrial systems for communication, guidance, and power distribution. Earth's heliospheric environment is controlled by magnetic fields produced by a subsurface convective dynamo. Some of the fields produced emerge through the solar surface into its atmosphere. Convective motions move these field foot points around in the photosphere. This tangles them and causes reconnection higher in the sun's atmosphere, heating the chromosphere and corona. Reconnection of active region fields produce X-rays and accelerate charged particles to high energies and drives them from the Sun into the heliosphere.