



National
Astronomical
Research
Institute of
Thailand

Introduction to Chalawan HPDA system

&

Getting Started on Workshop Hands-On computing

Utane Sawangwit

Researcher & Acting CIT Director



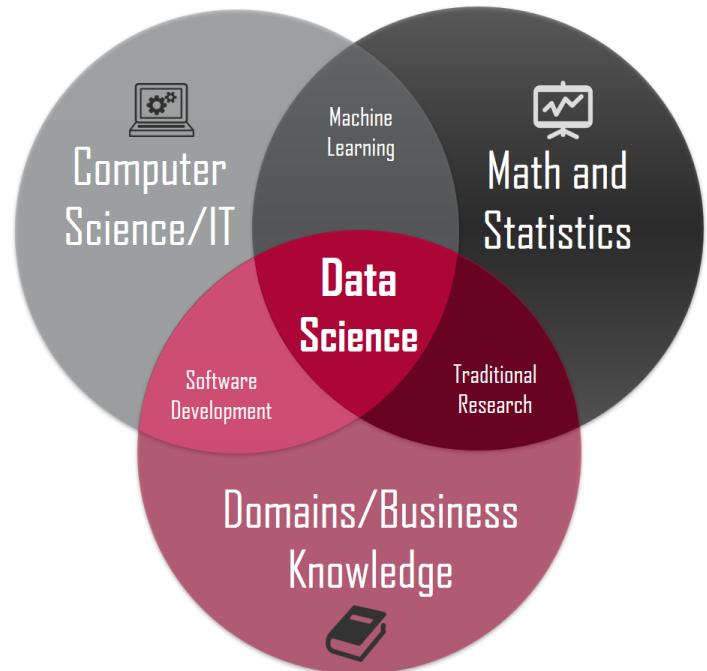
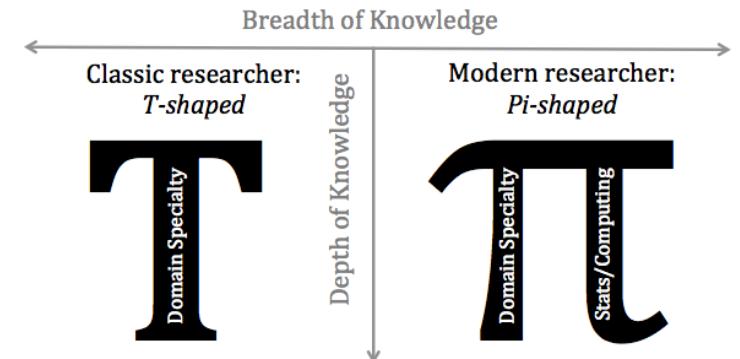
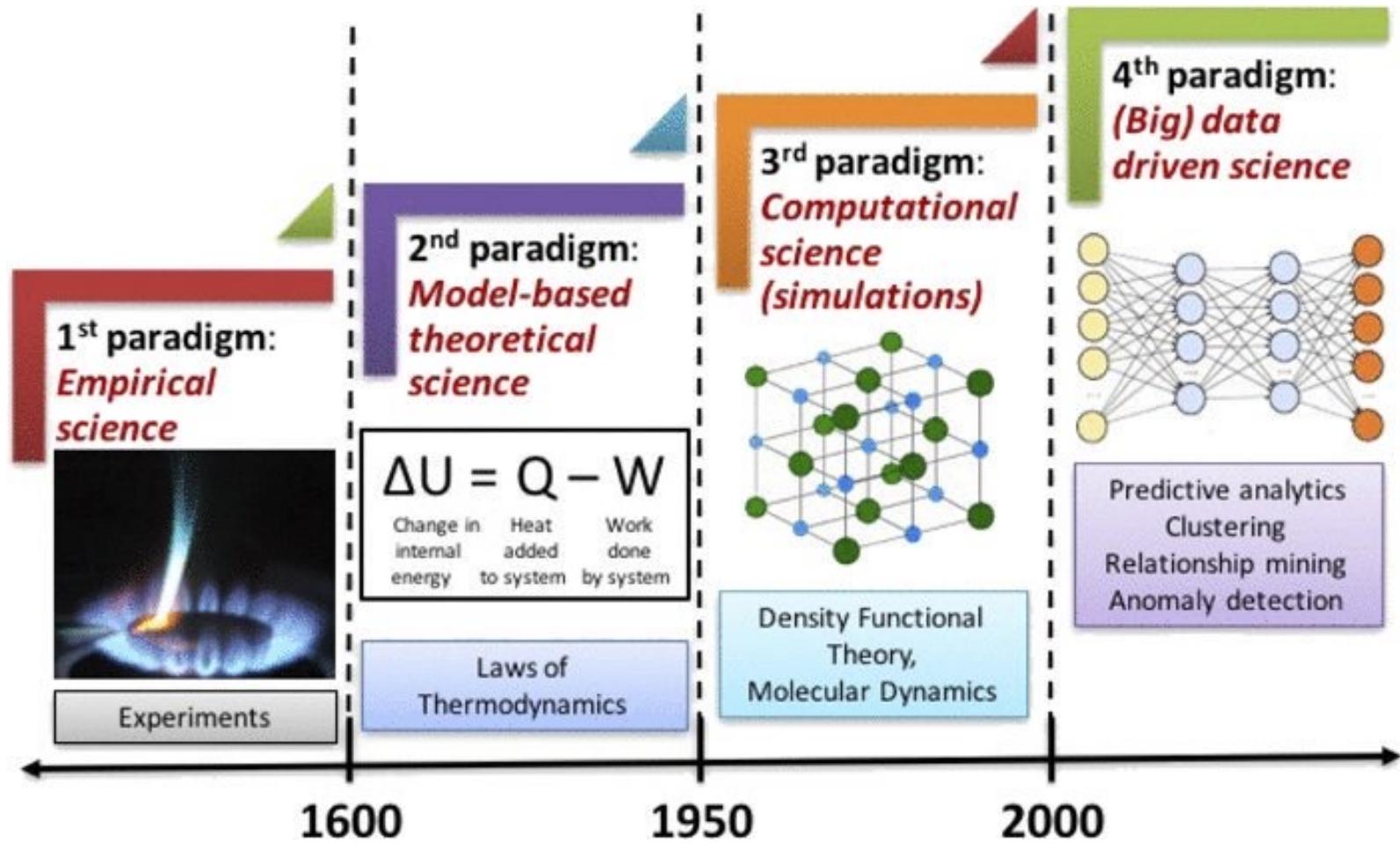
Thai
National
Observatory



CHALAWAN
High Performance Computing

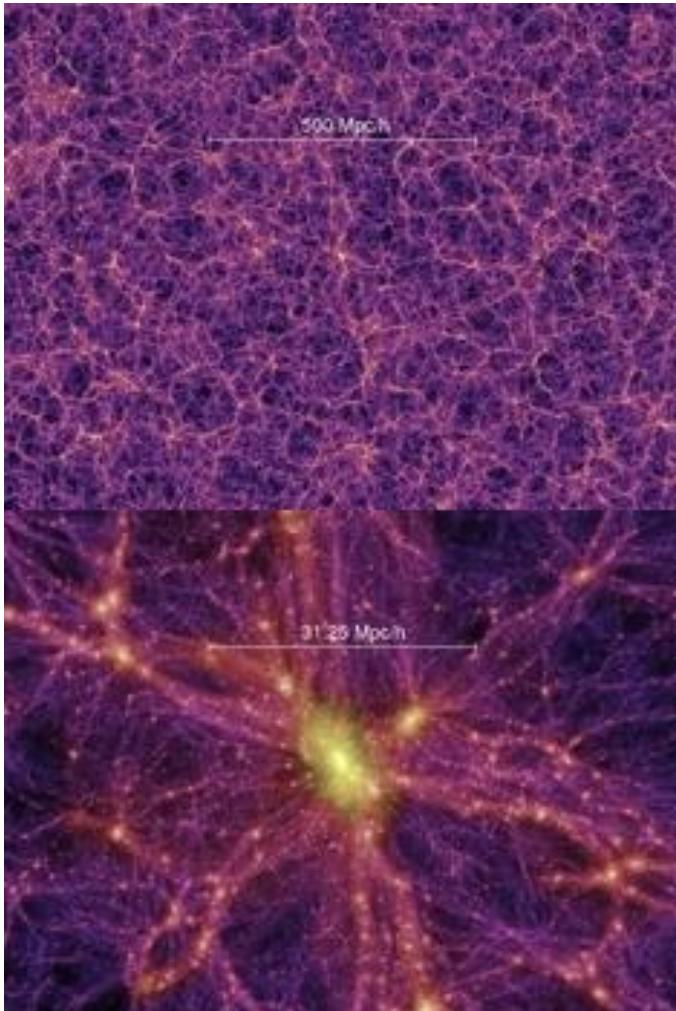


Paradigm shift in scientific research

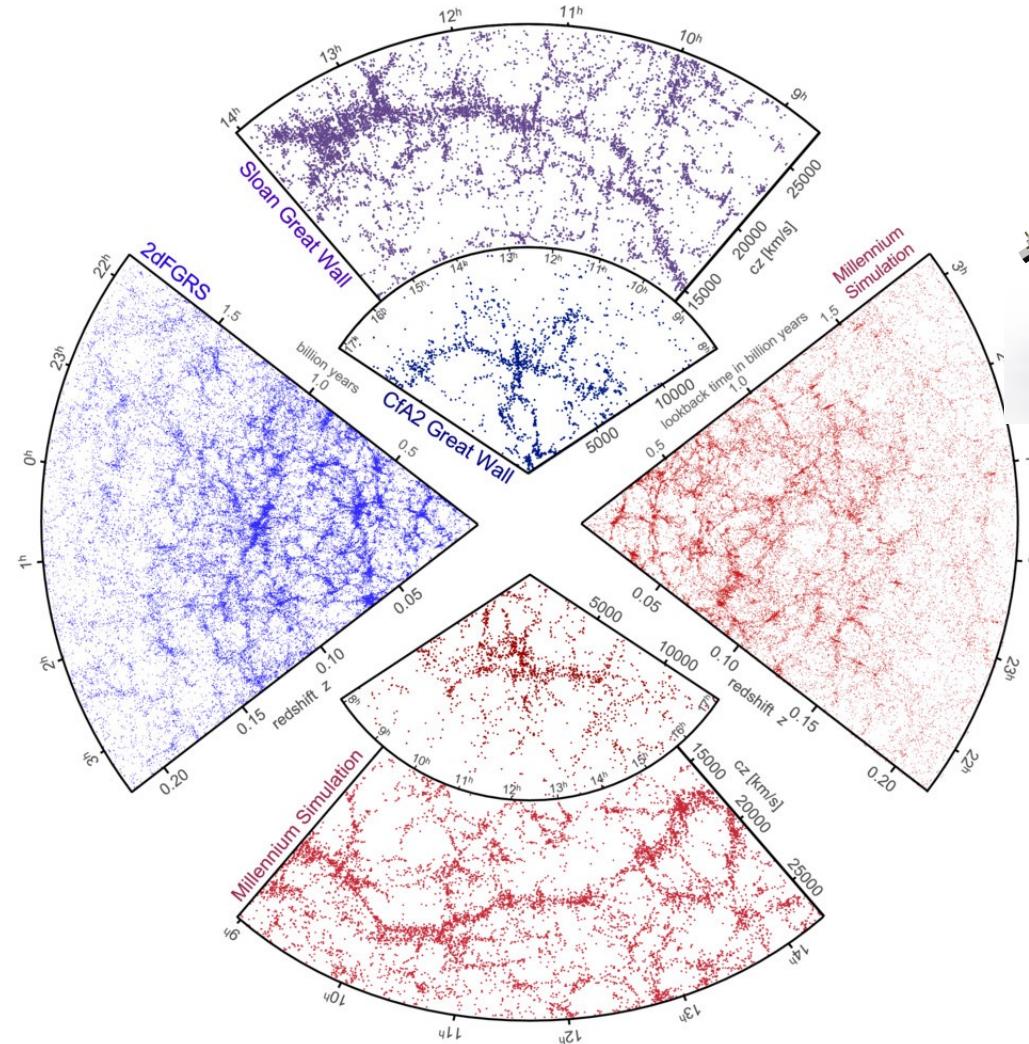


From Big Bang to Big Data

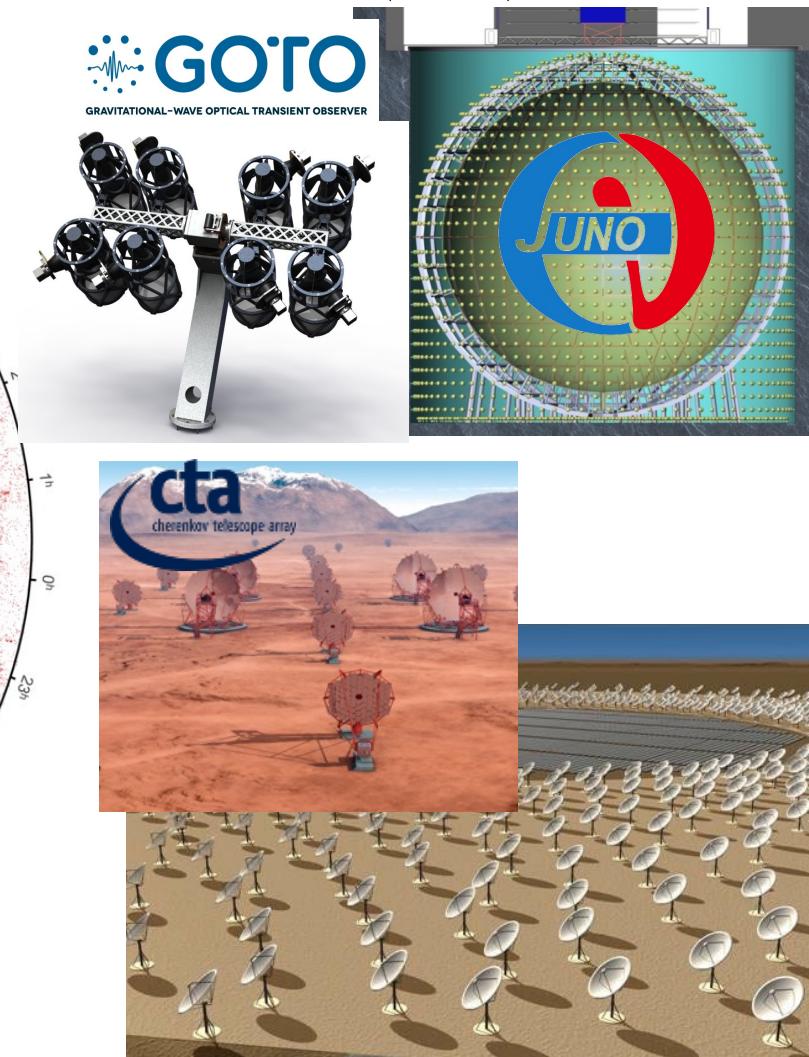
Millennium Simulation
(2000)



Real Universe versus Simulations
(2000s onwards)



Age of Data Deluge
(Now)



GW



ATHENA



X-ray +

UV



γ -ray



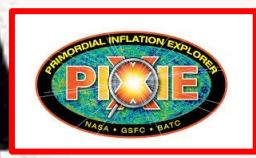
MW/MM

Neutrino

Radio

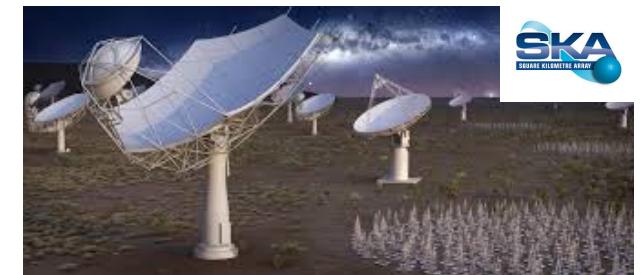
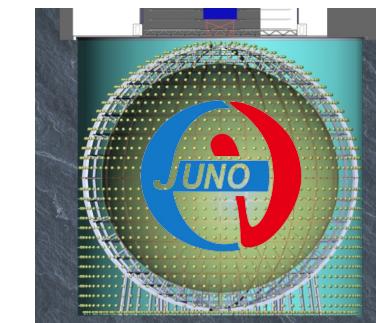
Optical +IR

Micro wave

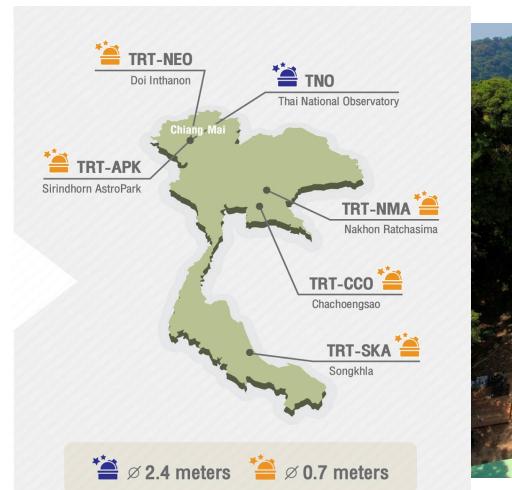


Expected data rate in the coming 1-3 years

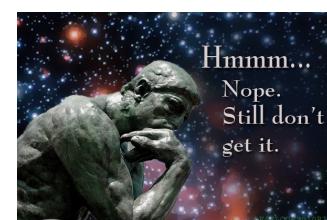
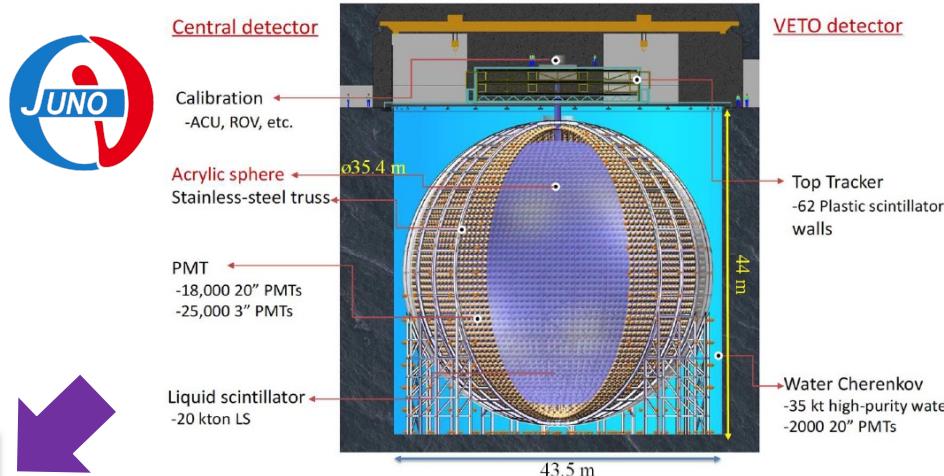
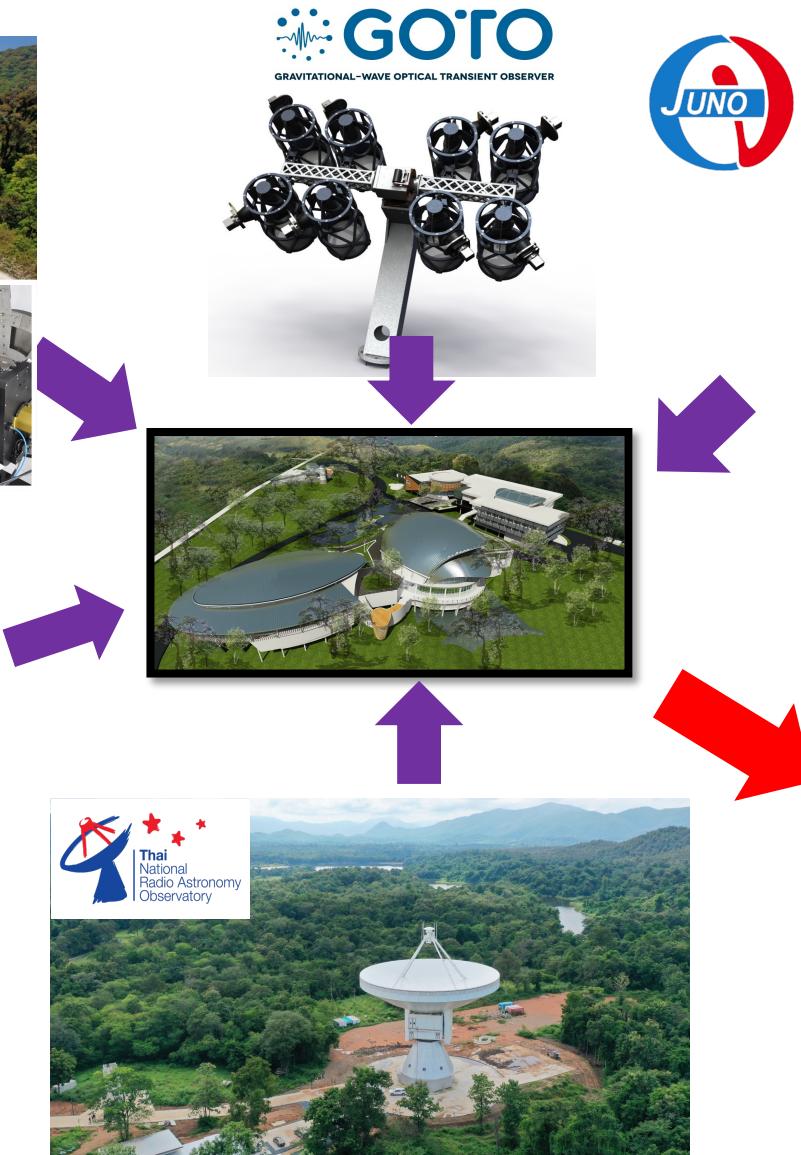
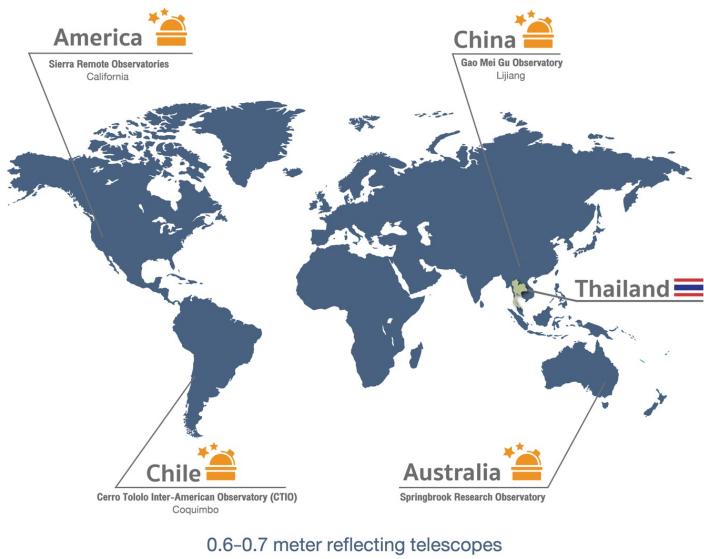
- Large Data volume, constantly require processing and analytics
 - GOTO: 150-300TB/yr
 - POLARBEAR: 10TB/yr
 - TNRT: 200-700TB/yr
 - JUNO: 200TB/yr (reconstruction and analysis data only)
 - CTA: 1GB/s/event
 - Other indep. Experiments & surveys
- **Future:** Opportunity for joining world-class experiments e.g. as a **regional data & processing centre node** for SKA (160TB/s) (**à la CERN-WLCG**)



Scientific & Engineering computing need @ NARIT



Thai Robotic Telescope Network



- Mission-critical analytics (experiments/surveys)
- Data Intensive analytics + ML & DL (observations/simulation)
- High-resolution data and model visualization
- Optimizations

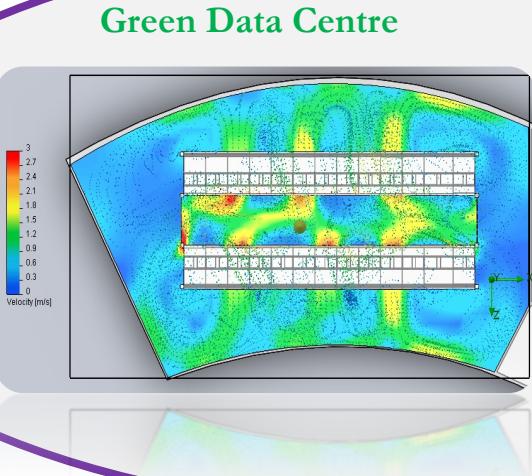
Why?: Our Objectives

HPC & Data Handling Advance Lab.



Complex Analysis & Simulations for Sci. Research

เพิ่มขีดความสามารถให้นักวิจัยไทย → นวัตกรรมใหม่ & งานวิจัยแนวหน้าของโลก



HPC Cluster



Time is Money

ให้บริการทั้งด้านการวิจัย วิชาการ และภาคธุรกิจ SME สำหรับระบบฮาร์ดแวร์ และการให้คำปรึกษาจากบุคลากรที่มีความเชี่ยวชาญ

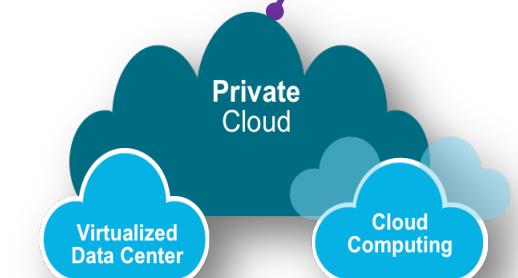
→ ลดเวลาในการนำความคิดไปปฏิบัติจริง ลดต้นทุน



Big Data Analytic & Machine Learning

การตัดสินใจด้านนโยบายและธุรกิจที่ใช้ข้อมูลขนาดใหญ่และสถิติขั้นสูง

→ ผลลัพธ์คุ้มค่ากับการลงทุน แก้ปัญหาถูกจุด



การให้บริการ HPC on Private cloud

→ เข้าถึงบริการได้ง่าย รวดเร็ว ปลอดภัย
ลดเวลาในการเตรียมการเพื่อ deployment



IT Oriented workforce

พัฒนาทรัพยากรบุคคลที่มีทักษะด้านเทคโนโลยีสารสนเทศและการวิเคราะห์ข้อมูล

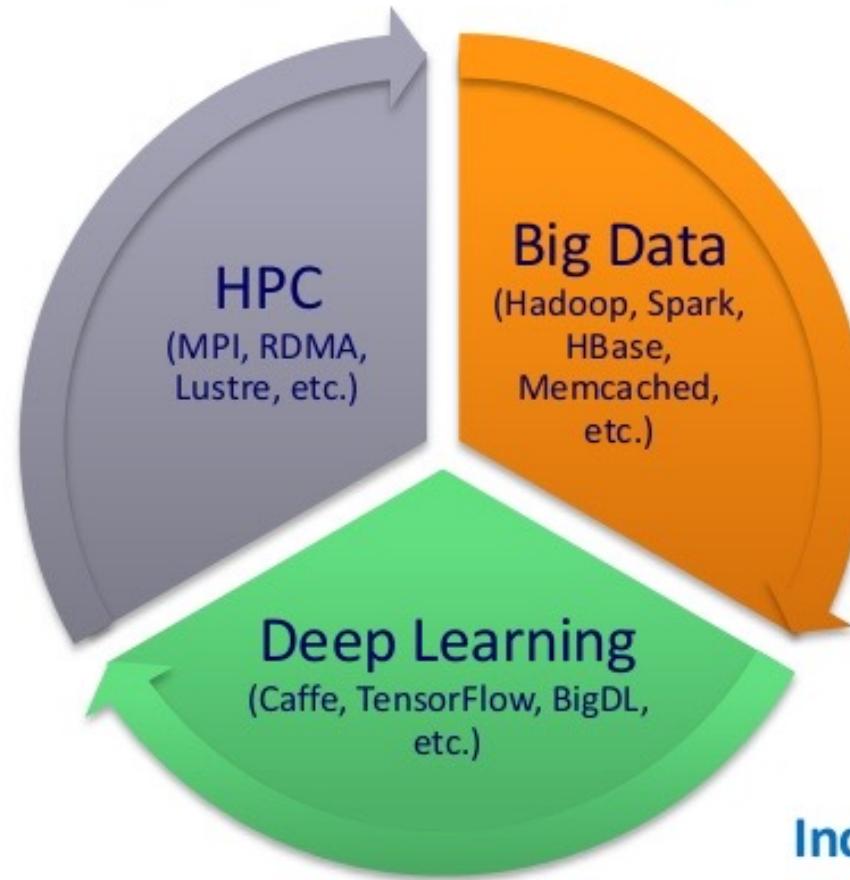
สูง → แรงงานคุณภาพสำหรับธุรกิจที่ขับเคลื่อนด้วย

innovation & Data driven

High-Performance Data Analytics (HPDA)

HPC + Big Data Analytics + AI → **HPDA**

Increasing Usage of HPC, Big Data and Deep Learning



Convergence of HPC, Big Data, and Deep Learning!

Increasing Need to Run these applications on the Cloud!!

Chalawan HPC Cluster



CASTOR
(2016)

- CPU Intel Xeon processor, ~ 560 cores
- RAM (TOTAL) ~ 2 TB

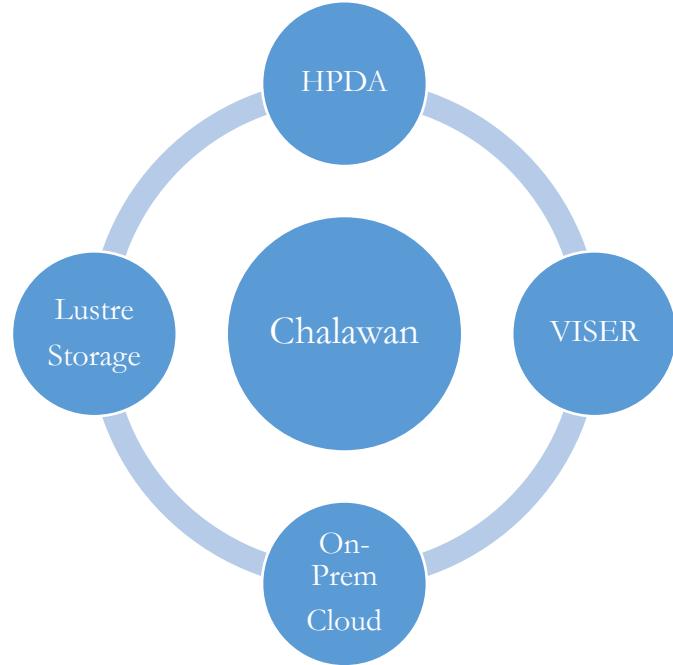
POLLUX
(2519)

- CPU Intel Xeon processor, ~ 100 cores
- GPU Nvidia Tesla V100, 12 cards
- RAM (TOTAL) ~ 1 TB

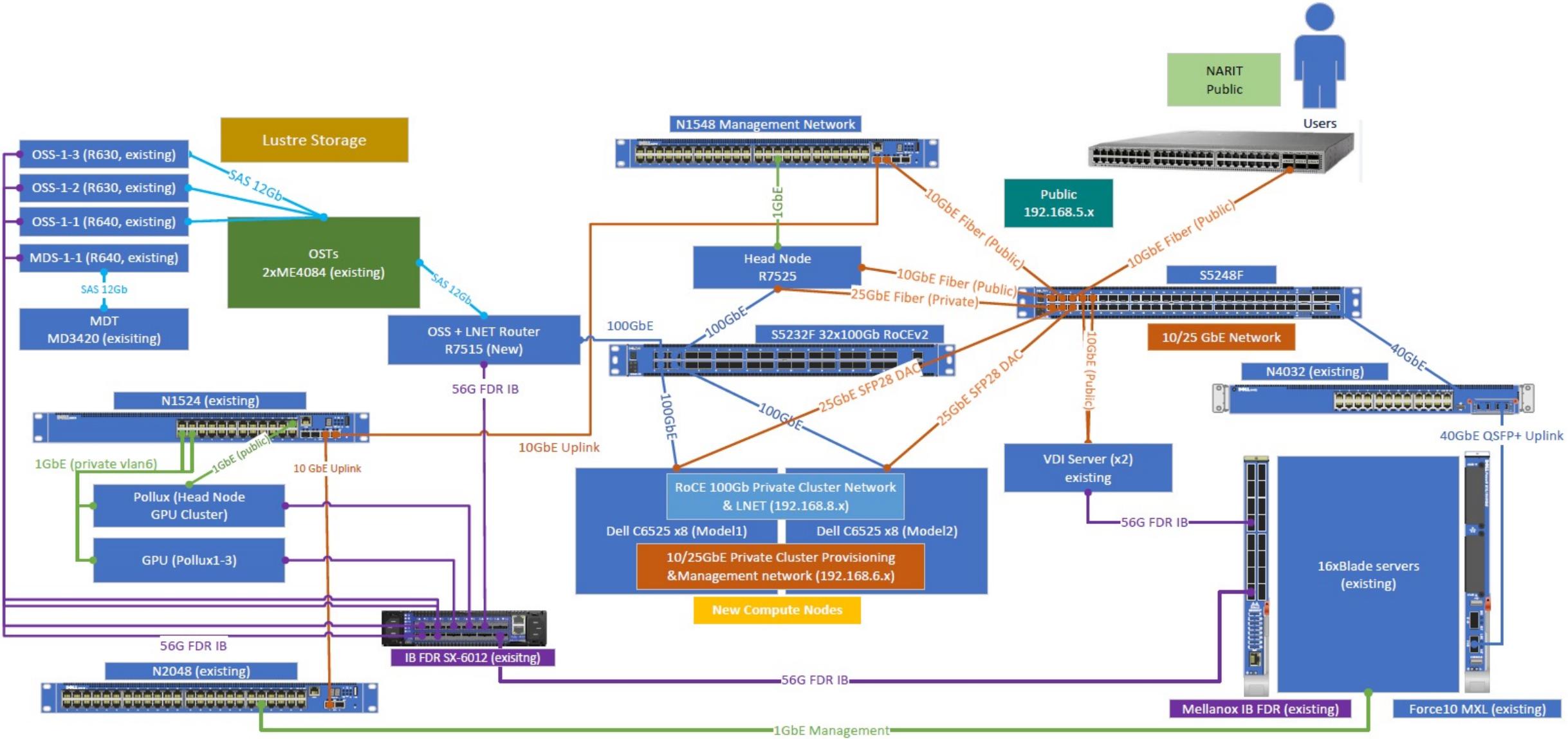
SPICA
(2522)

- CPU AMD, ~ 1,024 cores (+A100 GPU)
- RAM (TOTAL) ~ 8 TB
- STORAGE ~ 2PB + (2PB upgrade in 2023)

- **HPDA Computes** (Gen1: Castor, Gen2: Pollux, Gen3: Spica)
 - 1600 CPU cores (2.5-2.6GHz, 28c,64c per node)
 - 12TB memory (128GB,512GB per node)
 - GPU: Nvidia 12xV100 (32GB), 1xA100 (80GB)
 - Local Storage: NVMe Flash
 - Interconnect: 56Gbps IB, 100Gbps RoCE
- **Lustre Storage:** 4.7 PB
- **Virtual Infrastructure for Scientific and Engineering Research computing (VISER)**
 - VDI: Horizon View 20CCU (virtual workstation: vWS)
 - vGPU: 2 x A40, 1 x A10
 - Storage: Local SSD and Lustre Storage
- **On-prem cloud (in development)**
 - OpenStack on top of Proxmox cluster
 - Ceph Storage: Block & CephFS

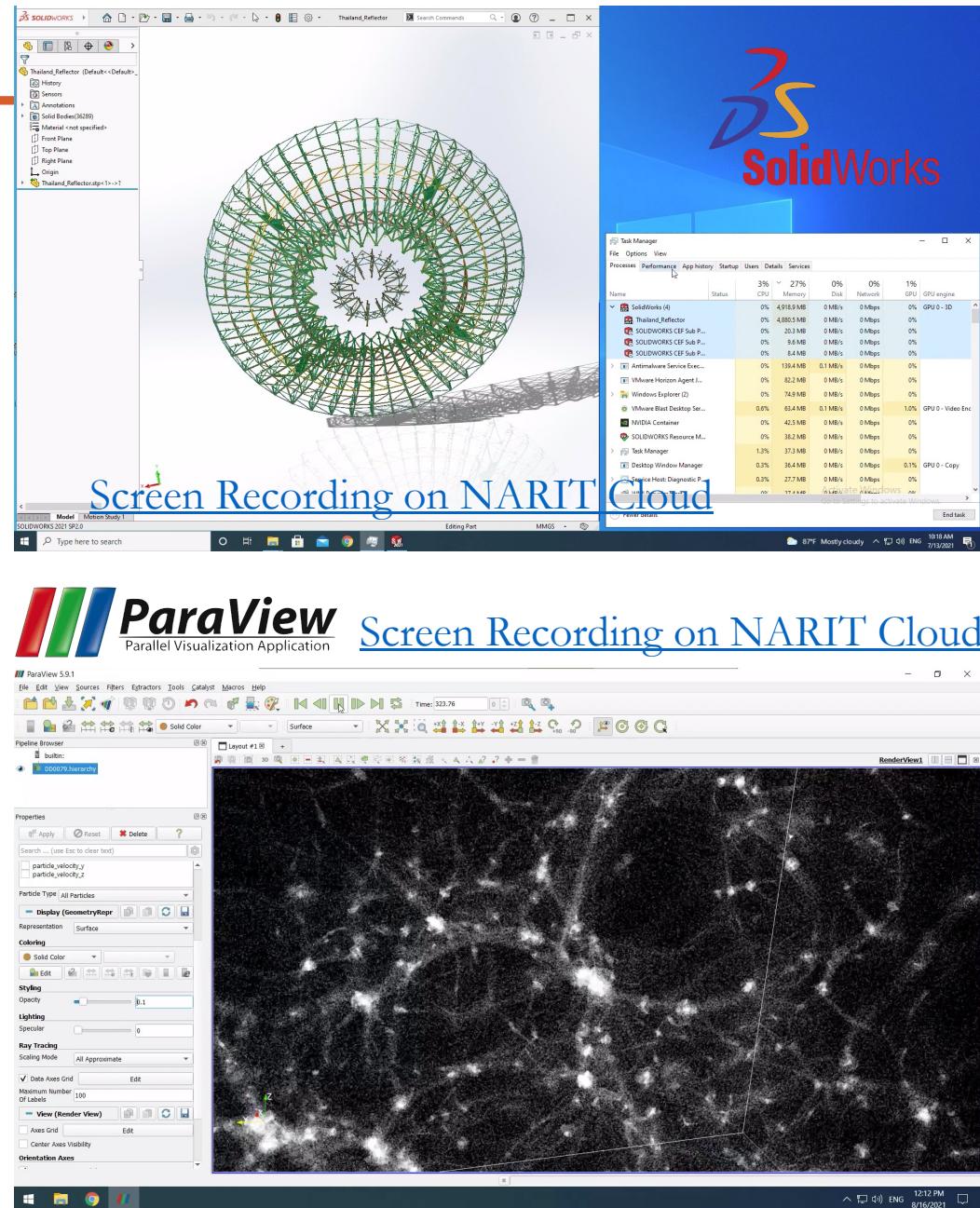
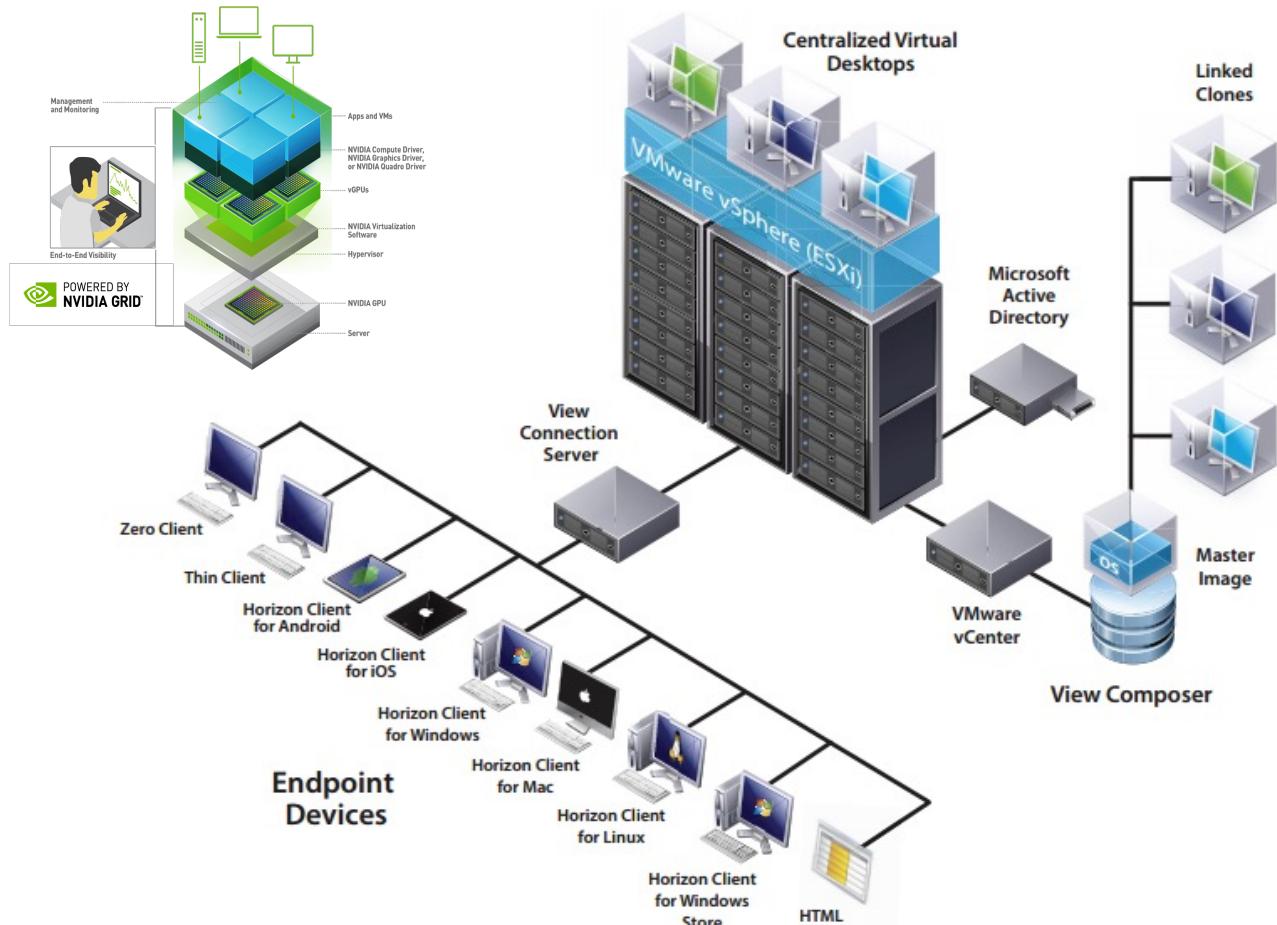


Chalawan Cluster (contd.)

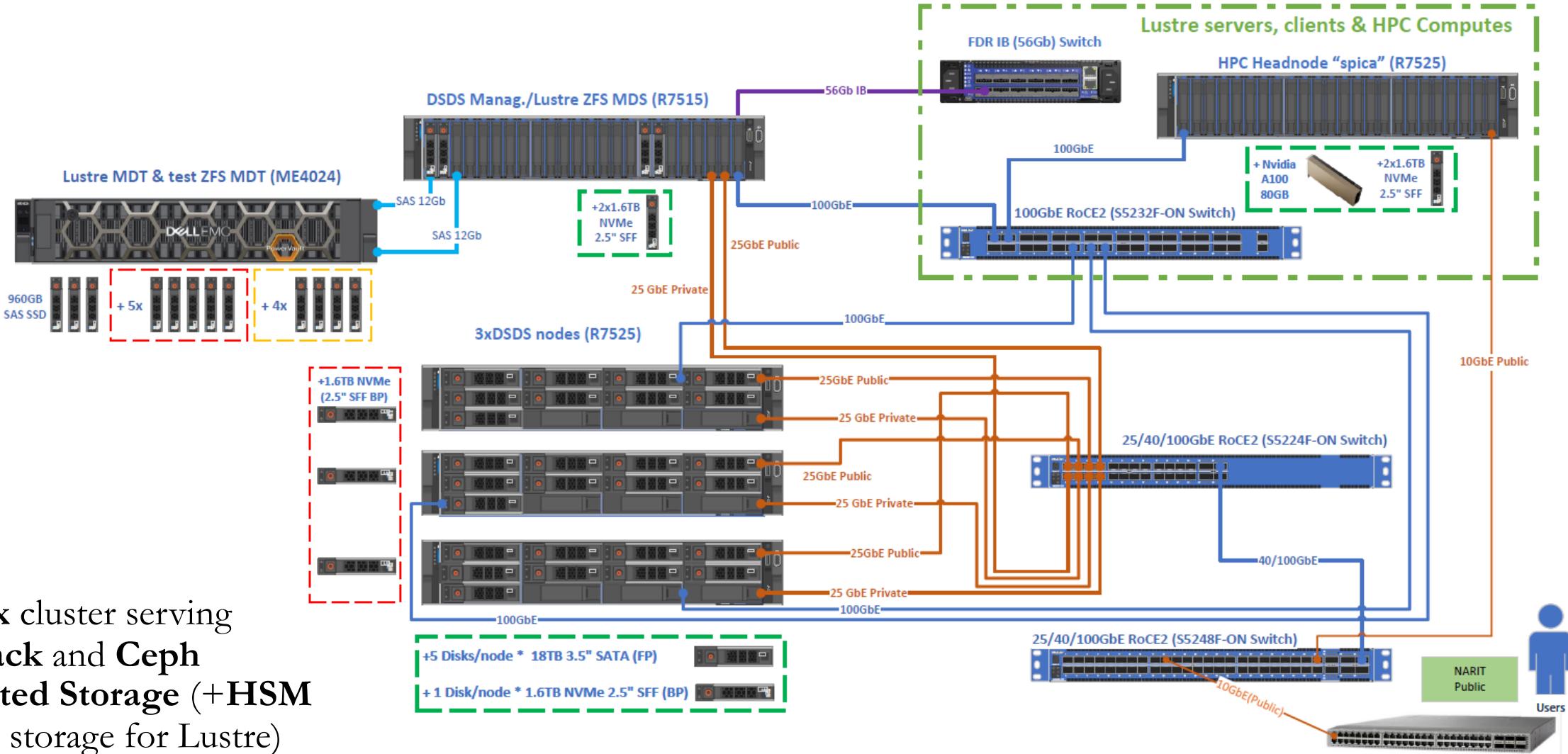




VISER



On-Prem Cloud (in development)



- Proxmox cluster serving OpenStack and Ceph Distributed Storage (+HSM cold-tier storage for Lustre)

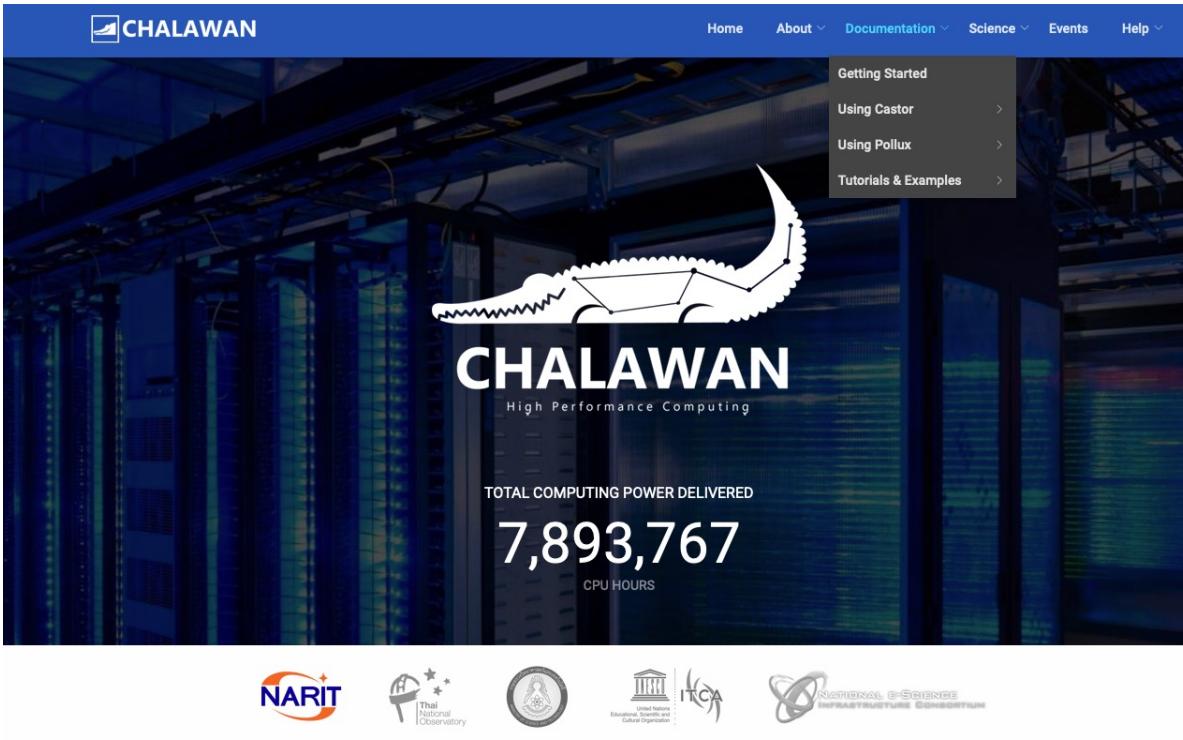
Monitoring system (Grafana + Influxdb + Telegraf)



Emphasize on easy access for users



- Online Tutorials and applying for an account @ <http://chalawan.narit.or.th>
- Available to Thai users outside NARIT via **National e-Science Consortium**



CHALAWAN

High Performance Computing

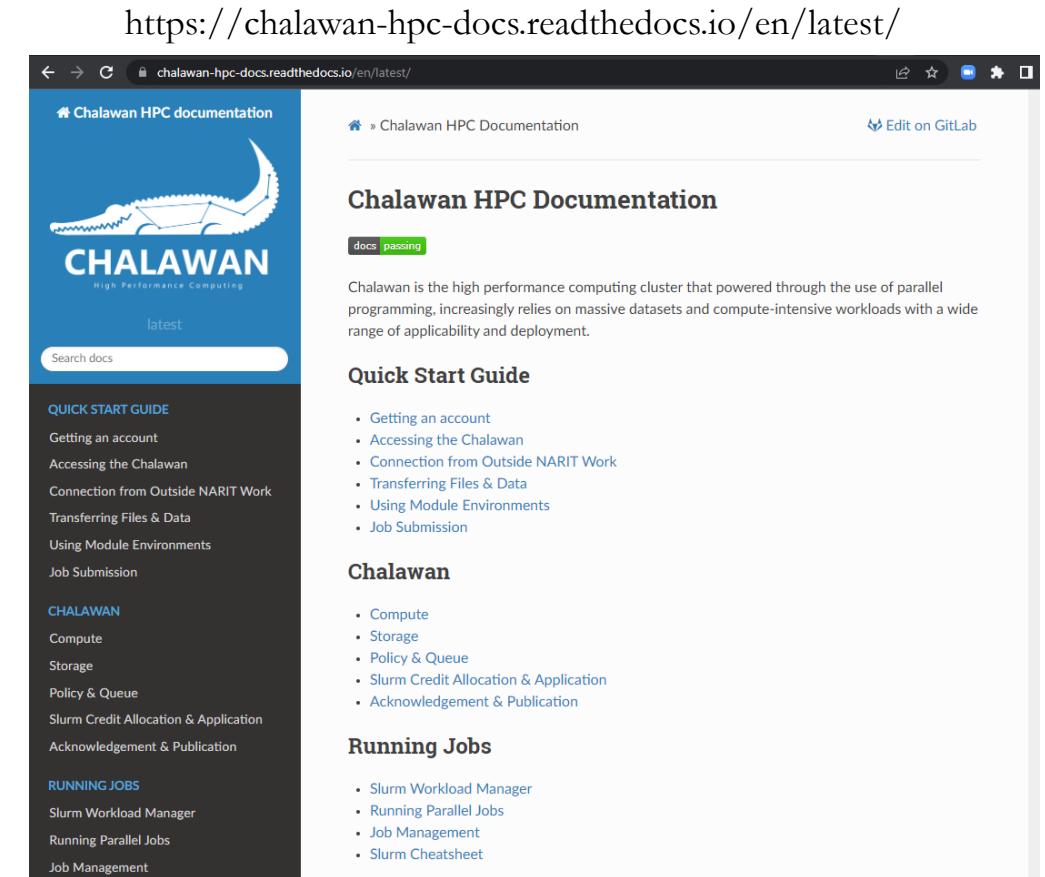
TOTAL COMPUTING POWER DELIVERED

7,893,767

CPU HOURS

NARIT

Chalawan Homepage and online proposal



https://chalawan-hpc-docs.readthedocs.io/en/latest/

Chalawan HPC documentation

Chalawan HPC Documentation

docs passing

Chalawan is the high performance computing cluster that powered through the use of parallel programming, increasingly relies on massive datasets and compute-intensive workloads with a wide range of applicability and deployment.

Quick Start Guide

- Getting an account
- Accessing the Chalawan
- Connection from Outside NARIT Work
- Transferring Files & Data
- Using Module Environments
- Job Submission

Chalawan

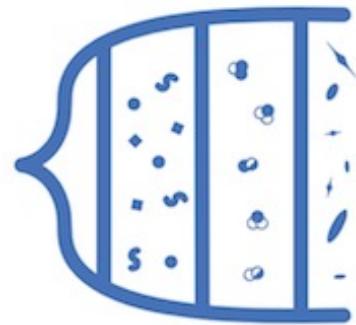
- Compute
- Storage
- Policy & Queue
- Slurm Credit Allocation & Application
- Acknowledgement & Publication

Running Jobs

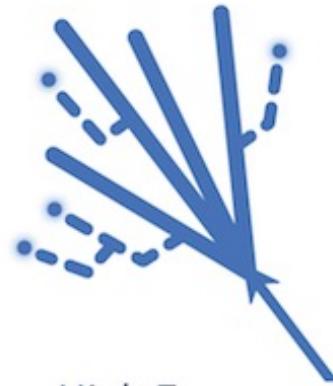
- Slurm Workload Manager
- Running Parallel Jobs
- Job Management
- Slurm Cheatsheet

Online documentation and user guide

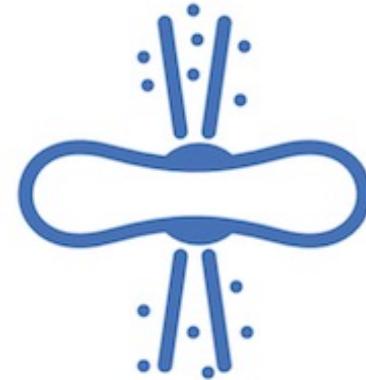
Research and Development Highlights



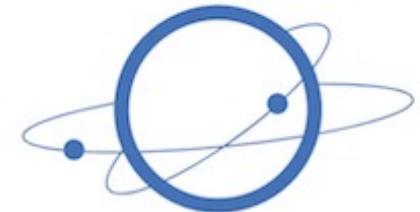
Cosmology



High Energy
Astrophysics



Active Galactic
Nuclei & Black Hole



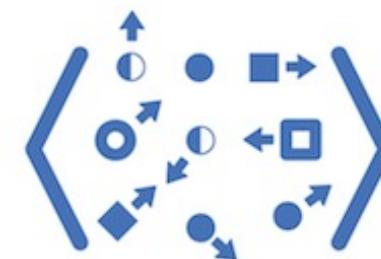
Exoplanet



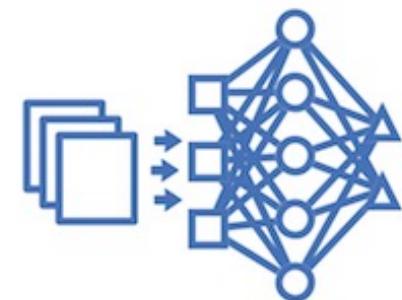
Atmospherics
Science



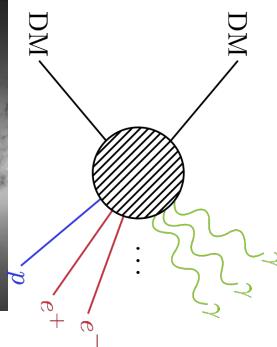
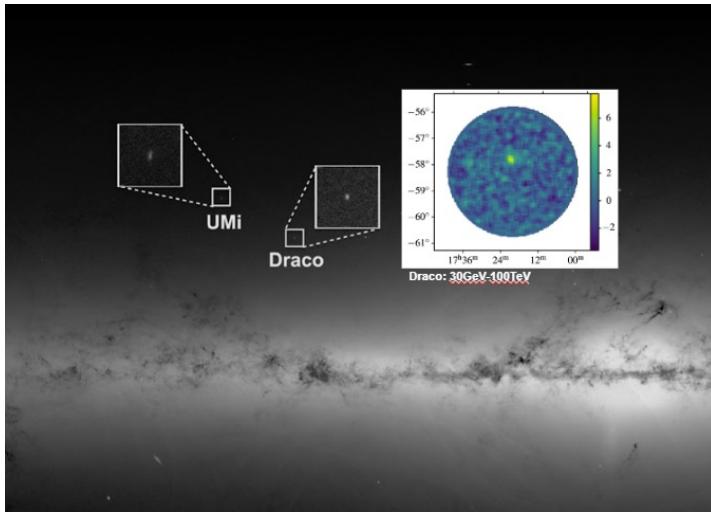
Condensed
Matter Physics



Statistical
Mechanics

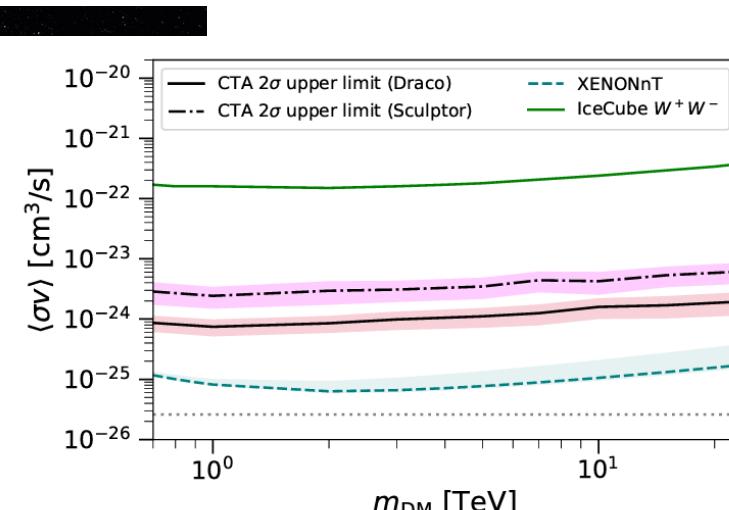
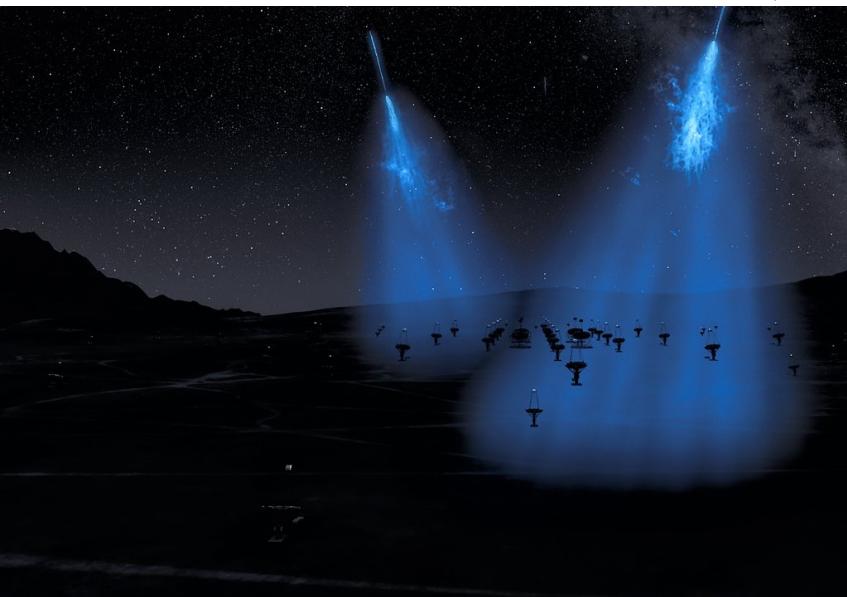


Big Data &
Machine Learning



1st Thai-led CTA Sci paper

“CTA sensitivity on TeV scale-dark matter models with complementary limits from direct detection”, Journal of Cosmology and Astroparticle Physics (JCAP), 05, 038, 2022



PAPER

CTA sensitivity on TeV scale dark matter models with complementary limits from direct detection

C. Duangchan¹, C. Pongkitivanichkul², P. Uttayarat³, A. Jardin-Blicq^{4,5}, M. Wechakama¹, T. Klangburam^{2,5}, W. Treesukrat³, D. Samart², U. Sawangwit⁵, A. Aguirre-Santaella^{6,7}

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Journal of Cosmology and Astroparticle Physics, Volume 2022, May 2022

Citation C. Duangchan *et al* JCAP05(2022)038

Article PDF

Article information

Abstract

With ever increasing pressure from collider physics and direct detection experiments, particle physics models of TeV scale dark matter are gaining more attention. In this work, we consider two realizations of the class of scalar portal dark matter scenarios — the inverse seesaw model and the inert doublet model. Observations by the Cherenkov Telescope Array (CTA) of very-high-energy γ rays from dark matter annihilation in the context of these models are simulated for the Draco and Sculptor dwarf spheroidal galaxies, and later analyzed using *ctools*. We study the potential of CTA for the 5 σ detection of a dark matter annihilation signal. In the absence of a signal, we also derive the 2 σ upper limits on the annihilation cross-section. We compare our projected CTA sensitivity against the projected sensitivity of the next generation of direct detection experiment, i.e. XENONnT. Although the limits from CTA are significantly improved compared with the previous generations of γ -ray experiments, they are still \sim 2 orders of magnitude above the thermal relic cross-section for the considered targets.

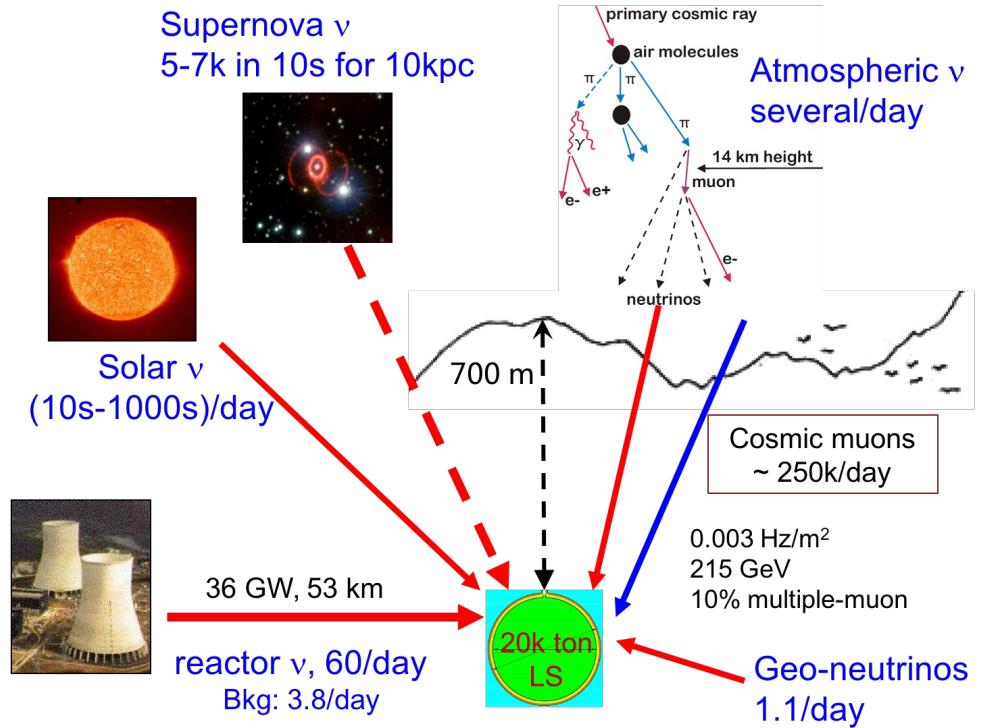
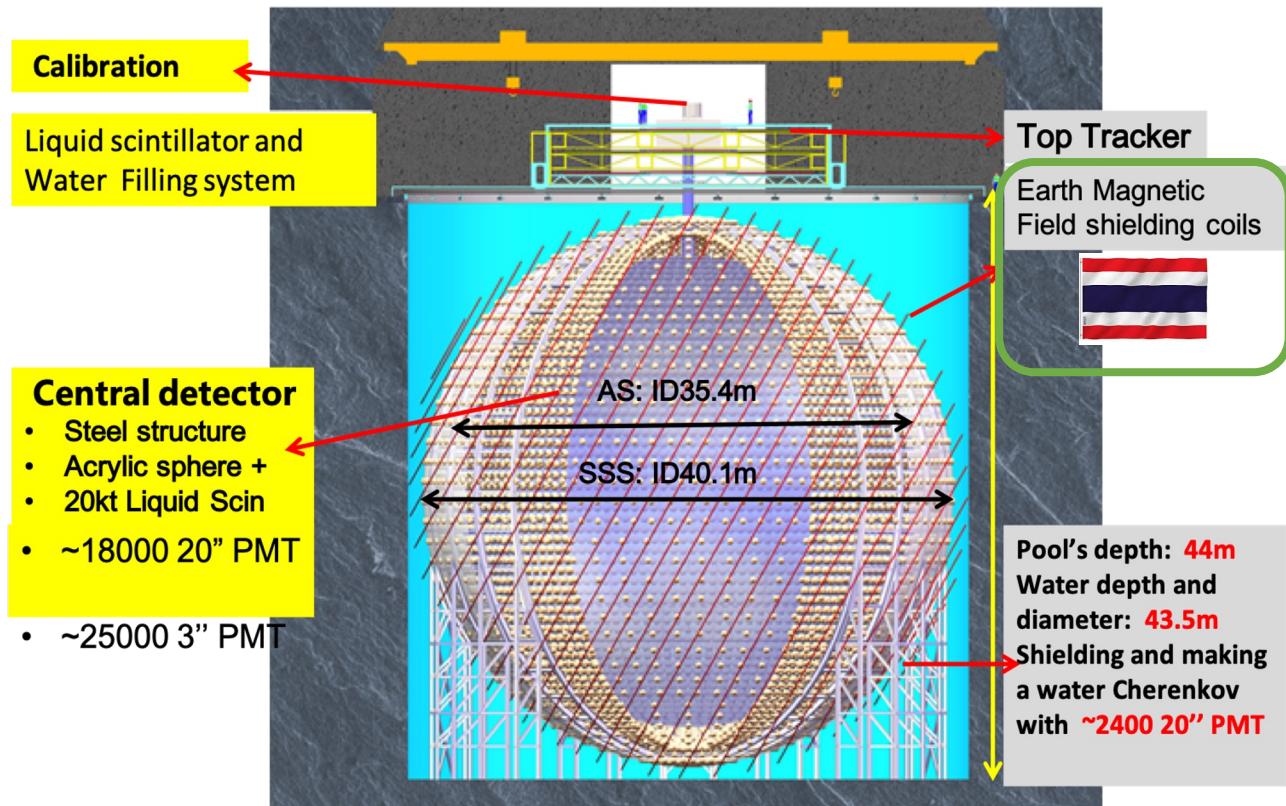
JUNO Experiment



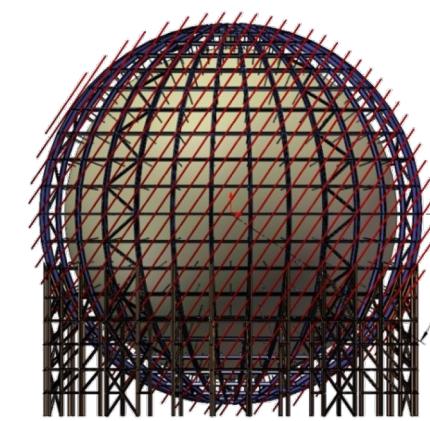
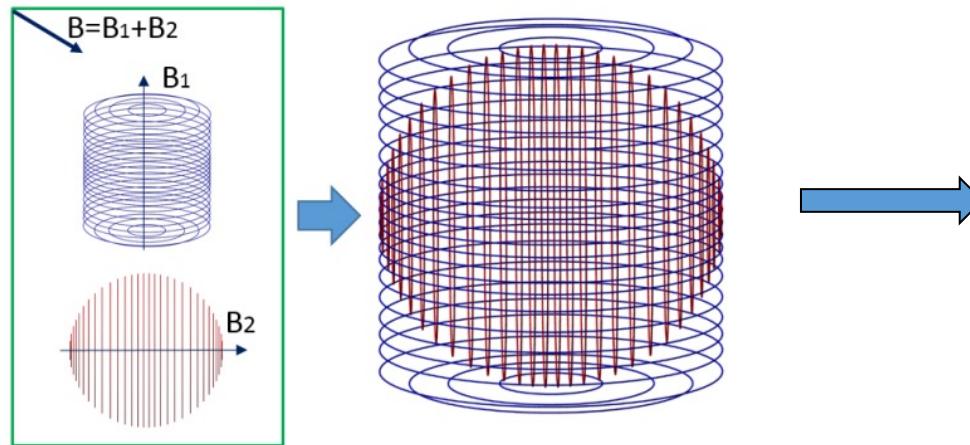
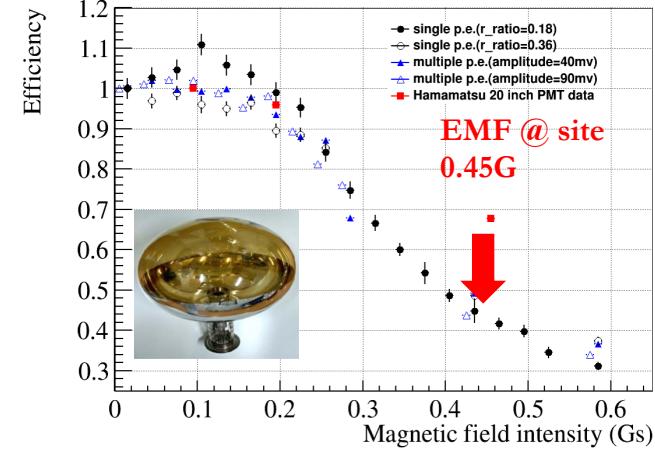
Jiangmen Underground Neutrino Observatory

- A multiple-purpose neutrino experiment, 300M\$ budget (led by IHEP, China)
- 77 member institutes from 17 countries
- Thai-JUNO Consortium (NARIT, SUT & Chula)
- Thai contribution: Design and cost for the EMF shielding system (12M THB)

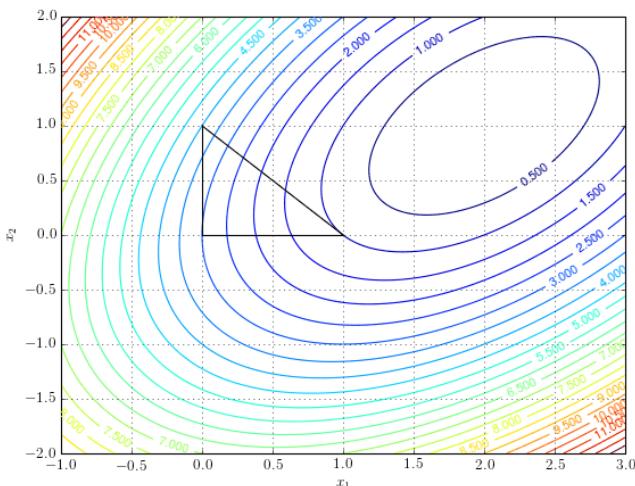
- 20 kton LS detector
- 3% energy resolution
- 700m underground
- Rich physics & High-Energy Astrophysics possibilities



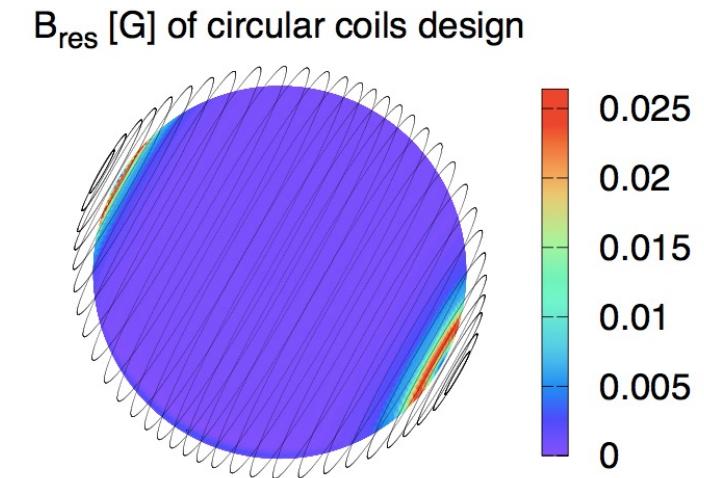
EMF Shielding Coil Optimization (2017 – 2019)



- A lot of study was done, use different geometries and distance of the coils.**
- One set/two set of coils.**
- We chose one sets of coils :**
 - Installation : there are no big difference between one sets or two sets coils (we can have support structure on SS frame)
 - Coils and installation work quantity reduce ~50%; save cost ;
 - One sets of coils performance are better than two sets as left figure shown.



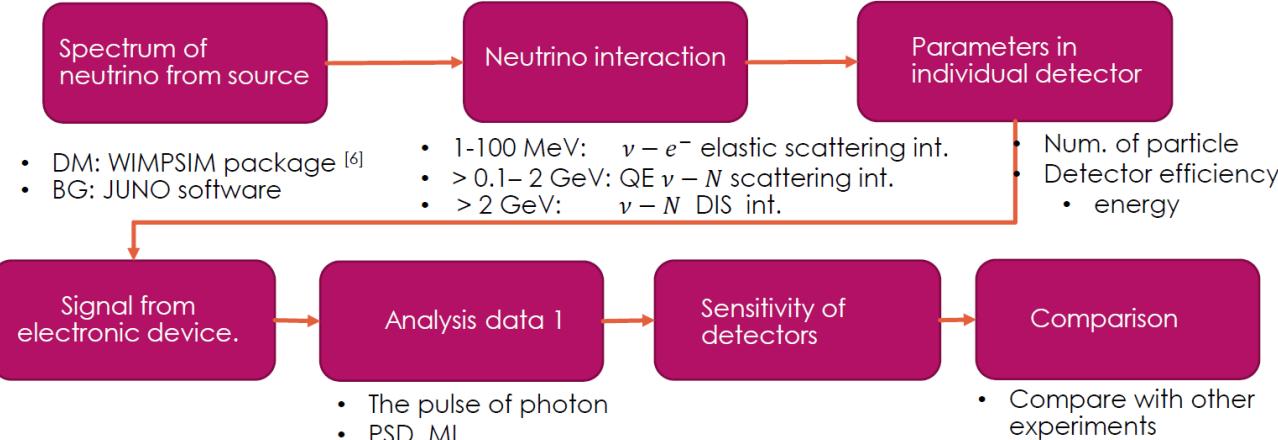
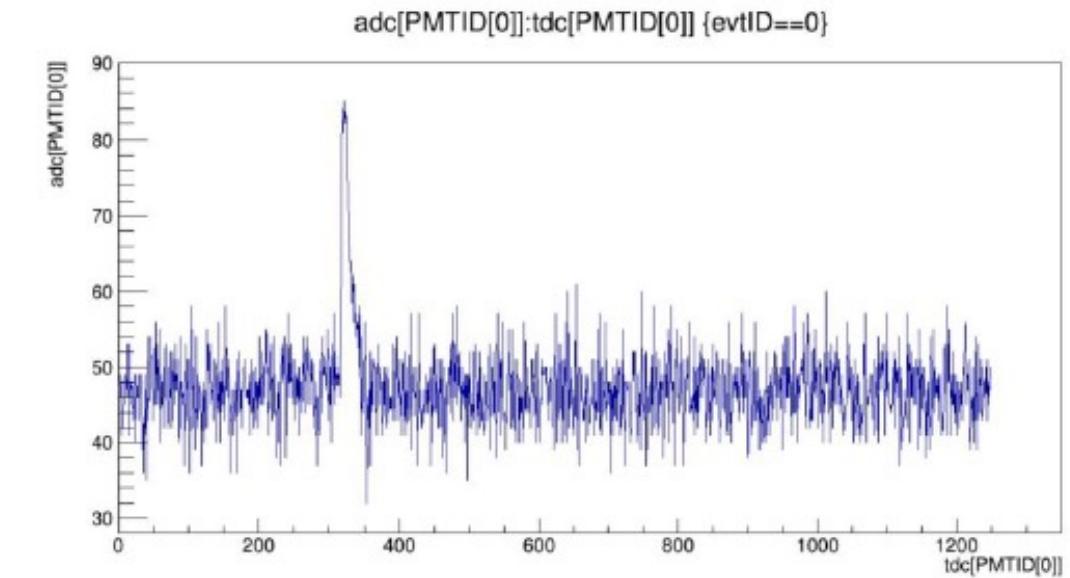
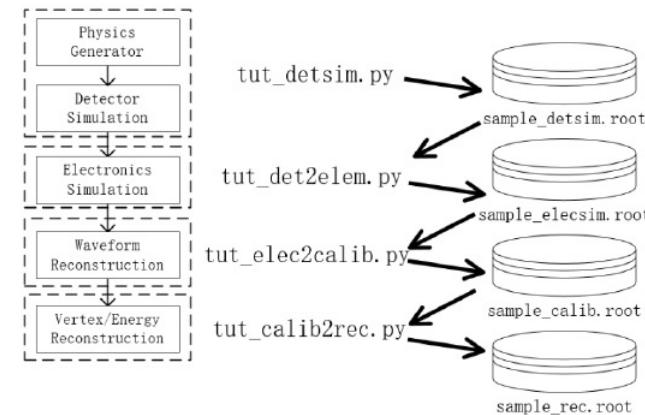
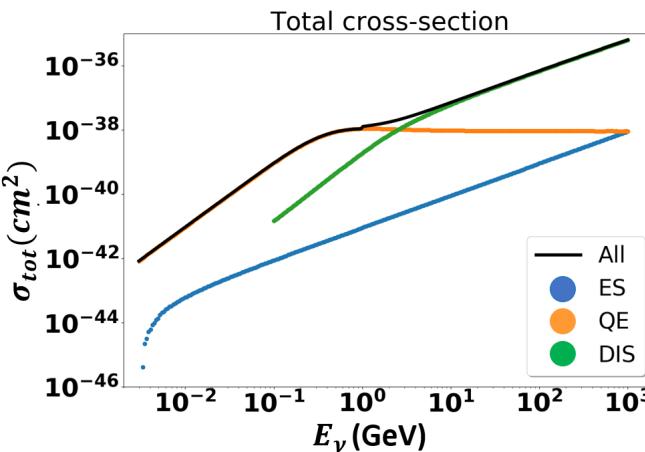
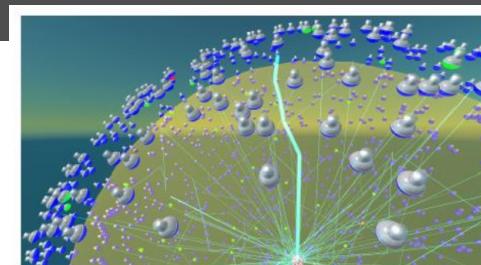
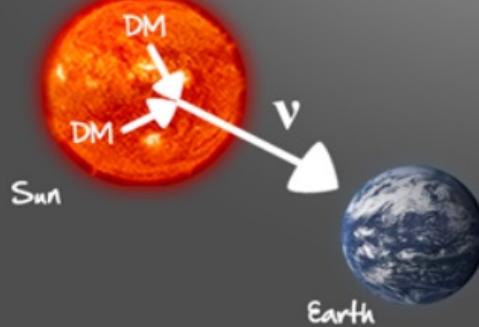
Simplex Method (Nelder and Mead)

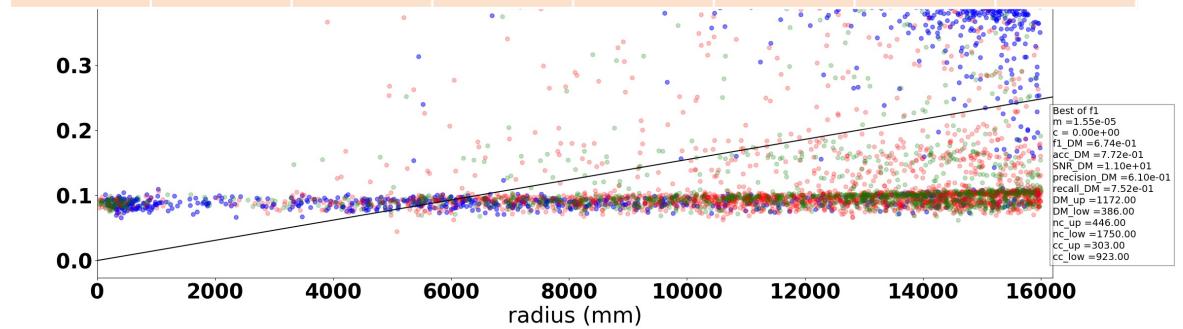
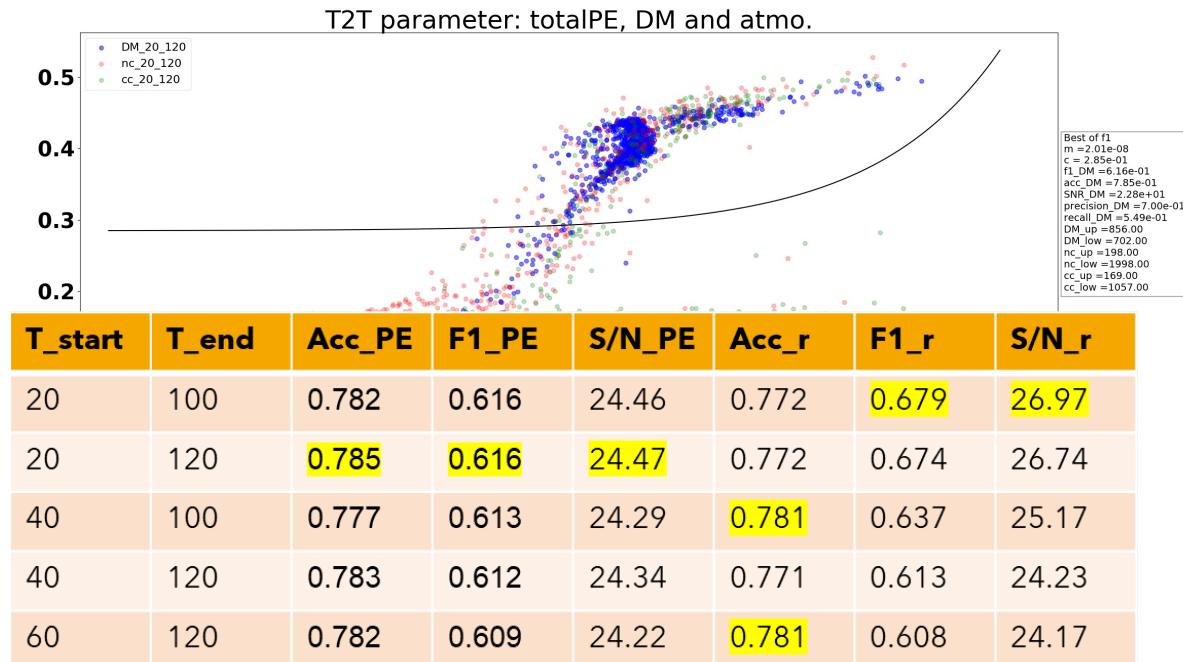
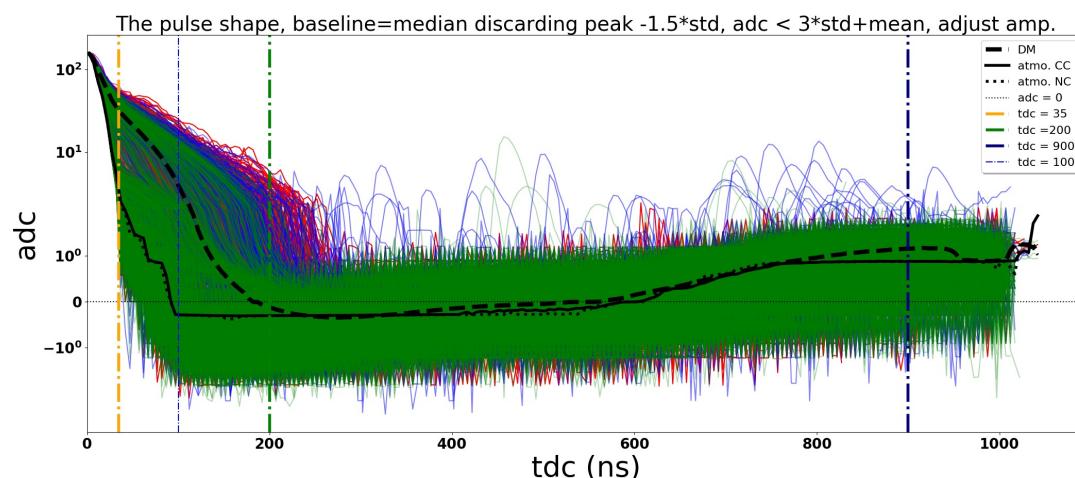
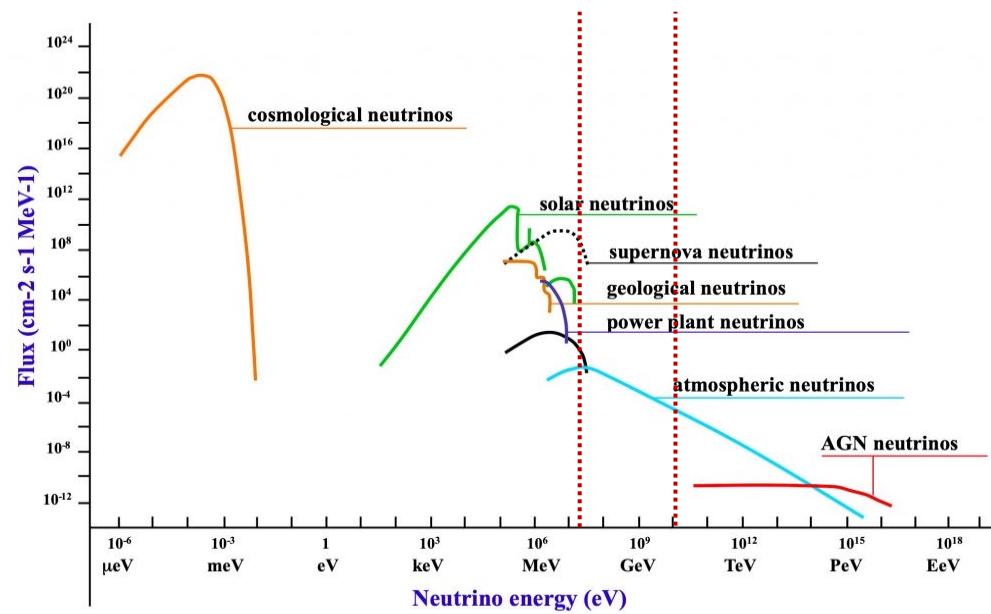


Requirement Reduce EMF @ experiment to < 10% (0.045G)



Indirect Method

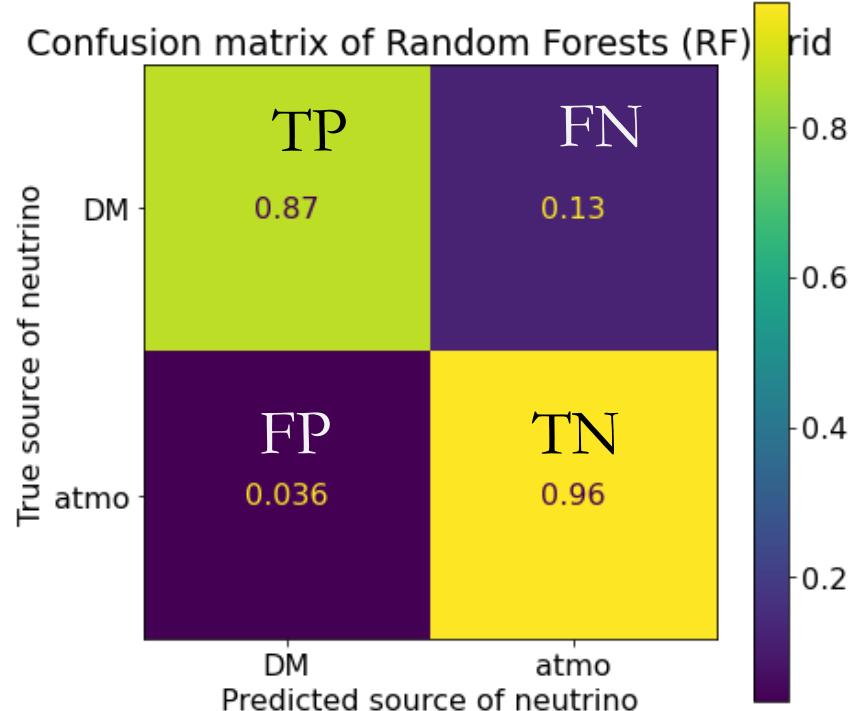




$$\text{Tail to total} = T2T = \frac{\int_{t_{start}}^{t_{end}} \text{adc}}{\int \text{adc}}$$

Application of Machine Learning

- Machine Learning (ML) is used to classify the source of neutrino by many parameters.
- The algorithm of classification:
 - Support Vector Machine (SVM)
 - Decision Tree (DT)
 - Random Forest (RF)
 - K-nearest neighbor (KNN)
- The training : test = 80 : 20.
- The dataset of atmo. $\sim 3,000$ and DM. $\sim 1,500$ but both source generate from $\sim 2,000$ neutrino events.



t2t	avgfwhm	avgfwtm	avgsnr	edep	totalPE	rec_x	rec_y	rec_z	rec_r	rec_t	label
0.088016	12.43918	26.72496	8.621387	3270.438	4546137	3780.269	10148.83	-1589.33	10946.01	75.97283	atmo
0.251026	19.63414	51.80563	7.443627	237.1081	337709	-2759.03	-11581.7	9036.714	14946.91	216.639	atmo
0.124321	13.75763	30.68443	8.418034	37.42637	23317	5681.028	-8821.68	-125.831	10493.43	158.0702	atmo
0.315048	22.26553	58.2368	7.41682	353.5436	440749	2690.307	-13075.2	1381.208	13420.41	187.137	atmo
0.095424	12.38672	26.493	8.574283	105.4499	110068	-8981.42	-3343.99	1125.98	9649.66	57.47731	atmo
0.103059	12.52885	26.55711	8.573019	550.2937	659049	-6886.27	3497.977	8289.013	11329.8	167.69	atmo
0.104565	12.87998	27.68803	8.646714	2242.681	3192779	-6322.04	-6629.24	12463.32	15467.69	192.1136	atmo

$$\text{Accuracy} = \frac{\text{TP} + \text{TN}}{\text{TP} + \text{FN} + \text{FP} + \text{TN}}$$

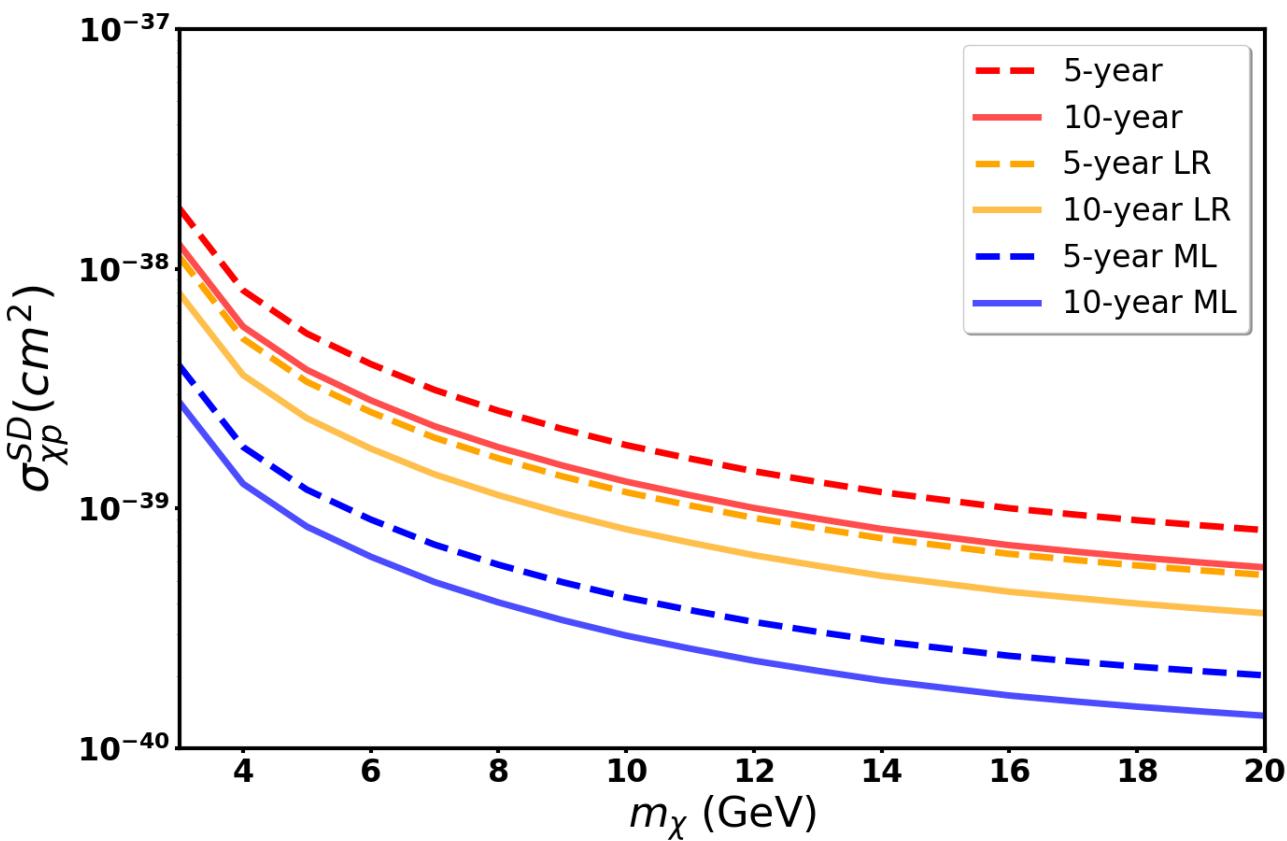
$$\text{F1 score} = \frac{2 \times \text{Precision} \times \text{Recall}}{\text{Precision} + \text{Recall}}$$

$$\text{Precision} = \frac{\text{TP}}{\text{TP} + \text{FP}}$$

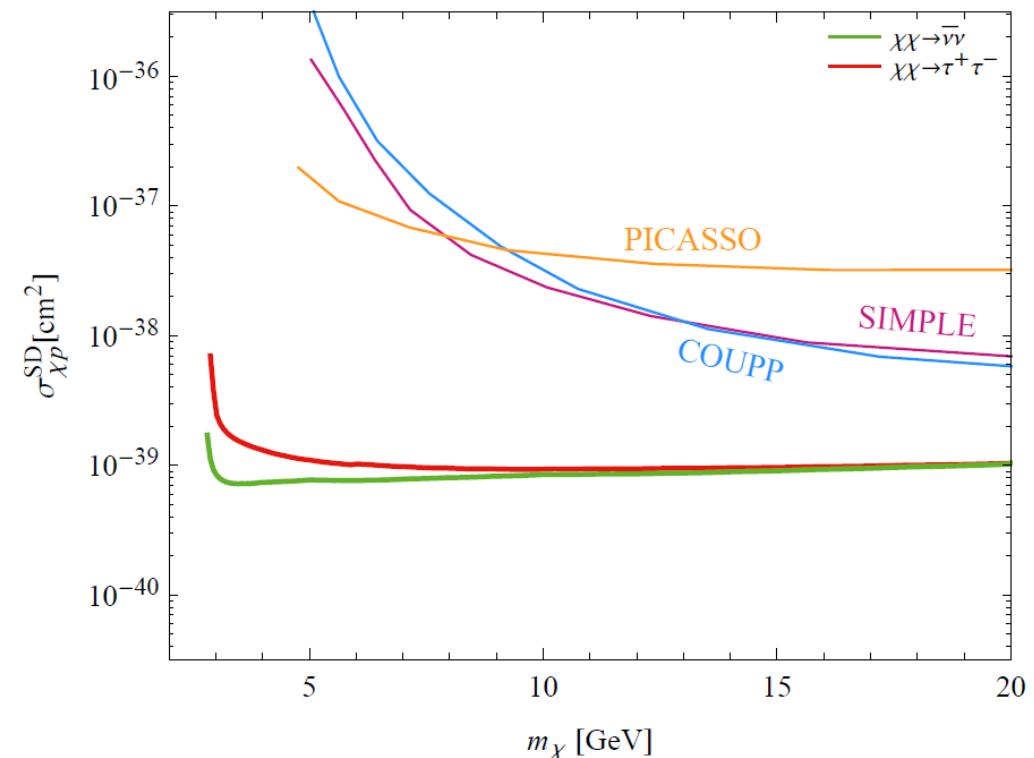
$$\text{Recall} = \frac{\text{TP}}{\text{TP} + \text{FN}}$$

WIMP Sensitivity: 5 & 10-year experiments

This Work



Ann et al (2016)
“JUNO Yellow Book”



The Team

Partner Institutes



The
University
Of
Sheffield.



UNIVERSITY OF
PORTSMOUTH



- Alumni
(Japan)

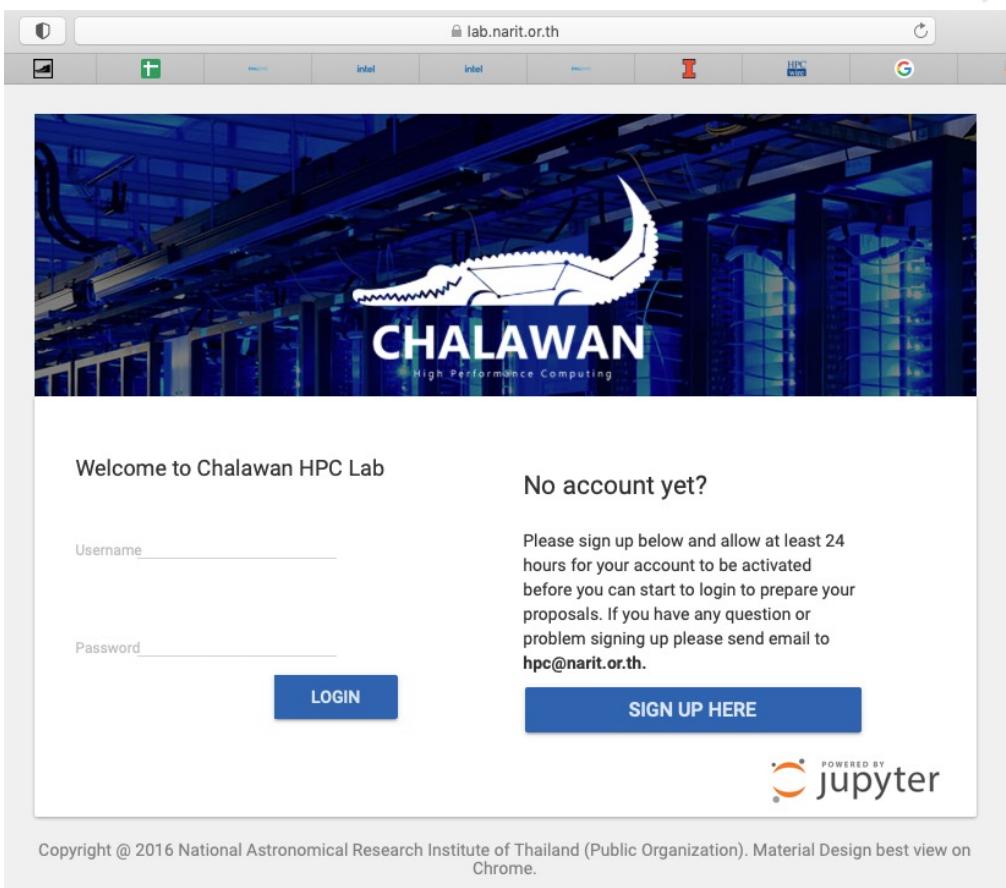
+2 new members
(PostDoc & RA)



- Alumni
(CU) - Alumni
(UK)

- Alumni
(S. Korea)

Chalawan on the Cloud



Welcome to Chalawan HPC Lab

No account yet?

Please sign up below and allow at least 24 hours for your account to be activated before you can start to login to prepare your proposals. If you have any question or problem signing up please send email to hpc@narit.or.th.

Username _____

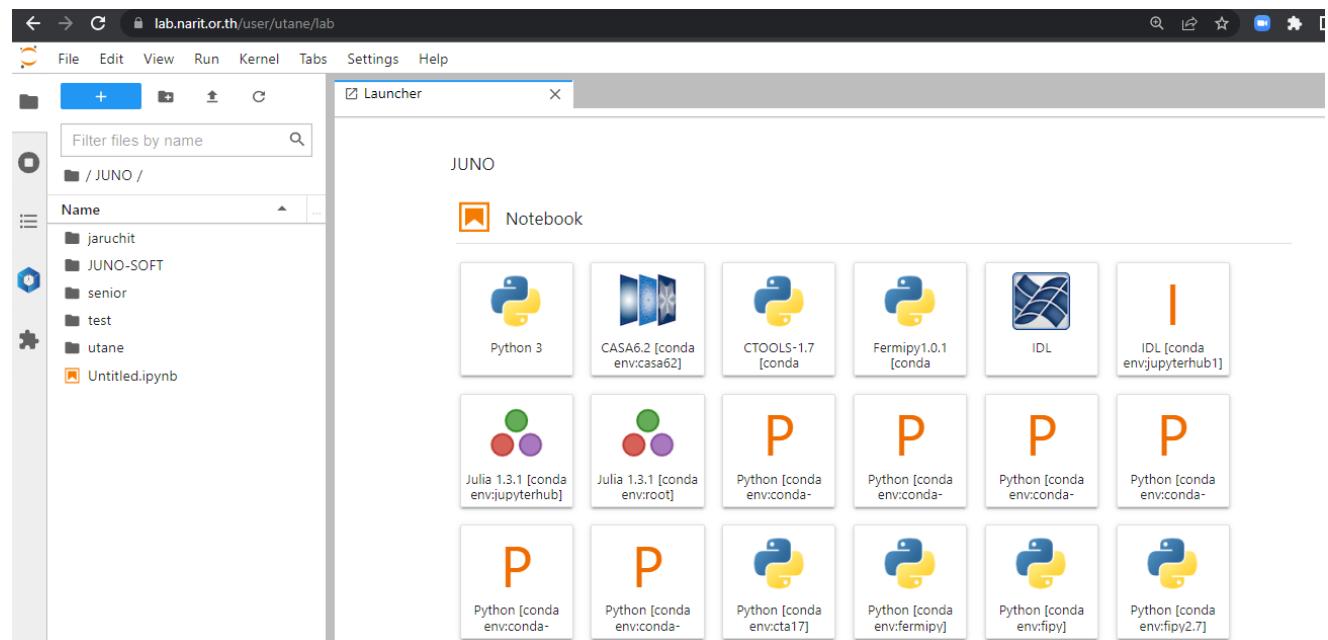
Password _____

LOGIN

SIGN UP HERE

 POWERED BY jupyter

Copyright @ 2016 National Astronomical Research Institute of Thailand (Public Organization). Material Design best view on Chrome.



File Edit View Run Kernel Tabs Settings Help

+ C lab.narit.or.th/user/utane/lab

Launcher

Filter files by name

/ JUNO /

Name

- jaruchit
- JUNO-SOFT
- senior
- test
- utane
- Untitled.ipynb

Notebook

 Python 3	 CASA6.2 [conda env:casa62]	 CTOOLS-1.7 [conda]	 Fermipy1.0.1 [conda]	 IDL	 IDL [conda env:jupyterhub]
 Julia 1.3.1 [conda env:jupyterhub]	 Julia 1.3.1 [conda env:root]	 Python [conda env:conda-]	 Python [conda env:conda-]	 Python [conda env:conda-]	 Python [conda env:conda-]
 Python [conda env:conda-]	 Python [conda env:conda-]	 Python [conda env:ctools17]	 Python [conda env:fermipy]	 Python [conda env:fipy]	 Python [conda env:fipy2.7]



Chalawan on the Cloud (contd.)



CHALAWAN Home Token Admin utane Logout

Select a job profile:

Advanced Slurm Job config

Choose Node type: GPU node (pollux**)

Parallel job type (for a serial job use "Shared memory")

Shared memory (single node)

Number of CPU cores (tasks): 1

Required Memory per node (in GBytes; leave empty for the default 2GB/CPU core)

Job duration (hh:mm:ss):

Number of total GPU (max 12; leave empty if not required):

if any, leave empty otherwise.

Slurm Account: leave empty for default.

Slurm Reservation: if any, leave empty otherwise

START

Welcome to SciPy Python 3

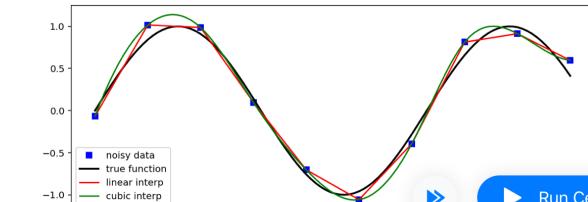
```
In [79]: n = arange(0, 10)
x = linspace(0, 9, 100)

y_meas = f(n) + 0.1 * randn(len(n)) # simulate measurement with noise
y_real = f(x)

linear_interpolation = interp1d(n, y_meas)
y_interp1 = linear_interpolation(x)

cubic_interpolation = interp1d(n, y, kind='cubic')
y_interp2 = cubic_interpolation(x)
y_meas
```

```
In [80]: fig, ax = plt.subplots(figsize=(10,4))
y_real
ax.plot(n, y_meas, 'bs', label='noisy data')
ax.plot(x, y_real, 'k', lw=2, label='true function')
ax.plot(x, y_interp1, 'r', label='linear interp')
ax.plot(x, y_interp2, 'g', label='cubic interp')
ax.legend(loc=3);
```



Run Cell

Keyboard and Command Line Interface (CLI) interface for a Jupyter Notebook environment, showing code execution and visualization.

File Edit View Run Kernel Tabs Settings

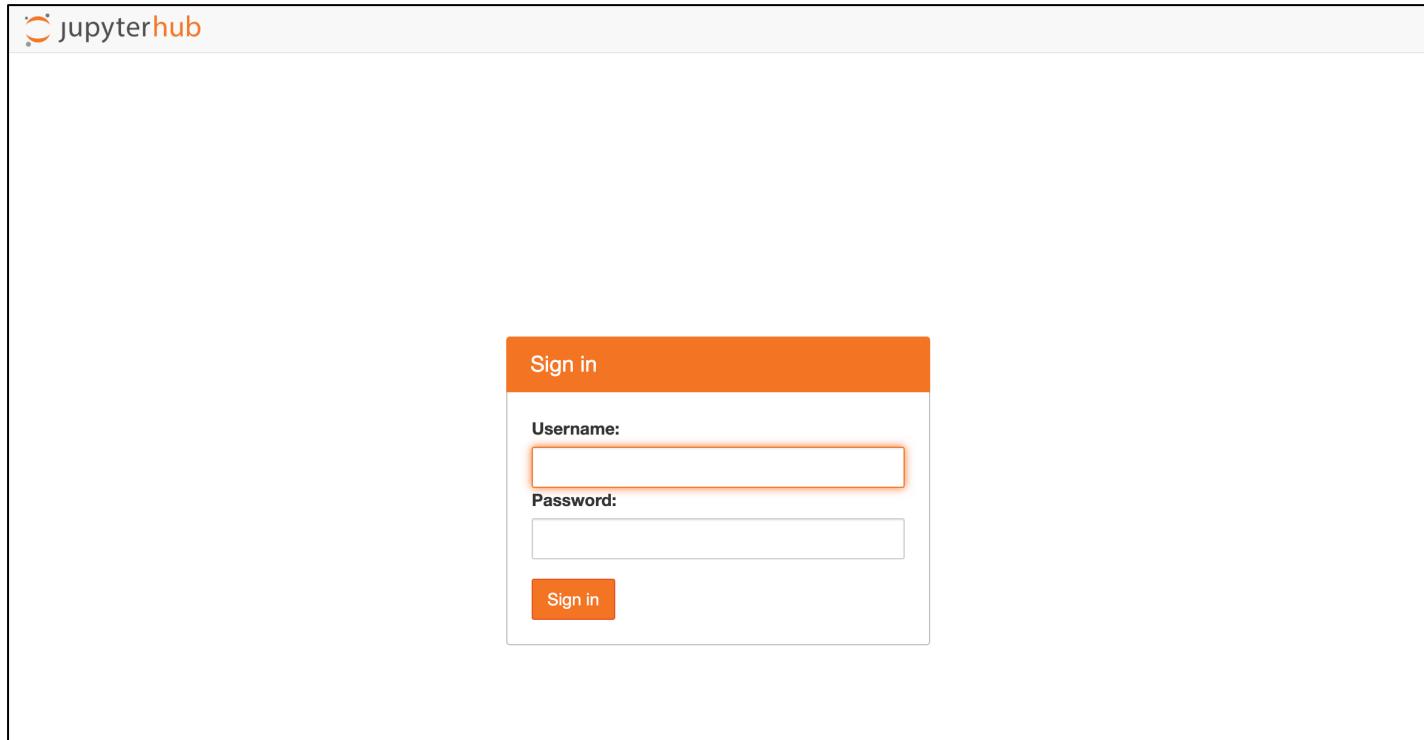
Search available modules... Launcher

LOADED MODULES: anaconda/3.7, autotools, gnu8/3.0, ohpc, openmpi3/4.0.2, prun/1.3

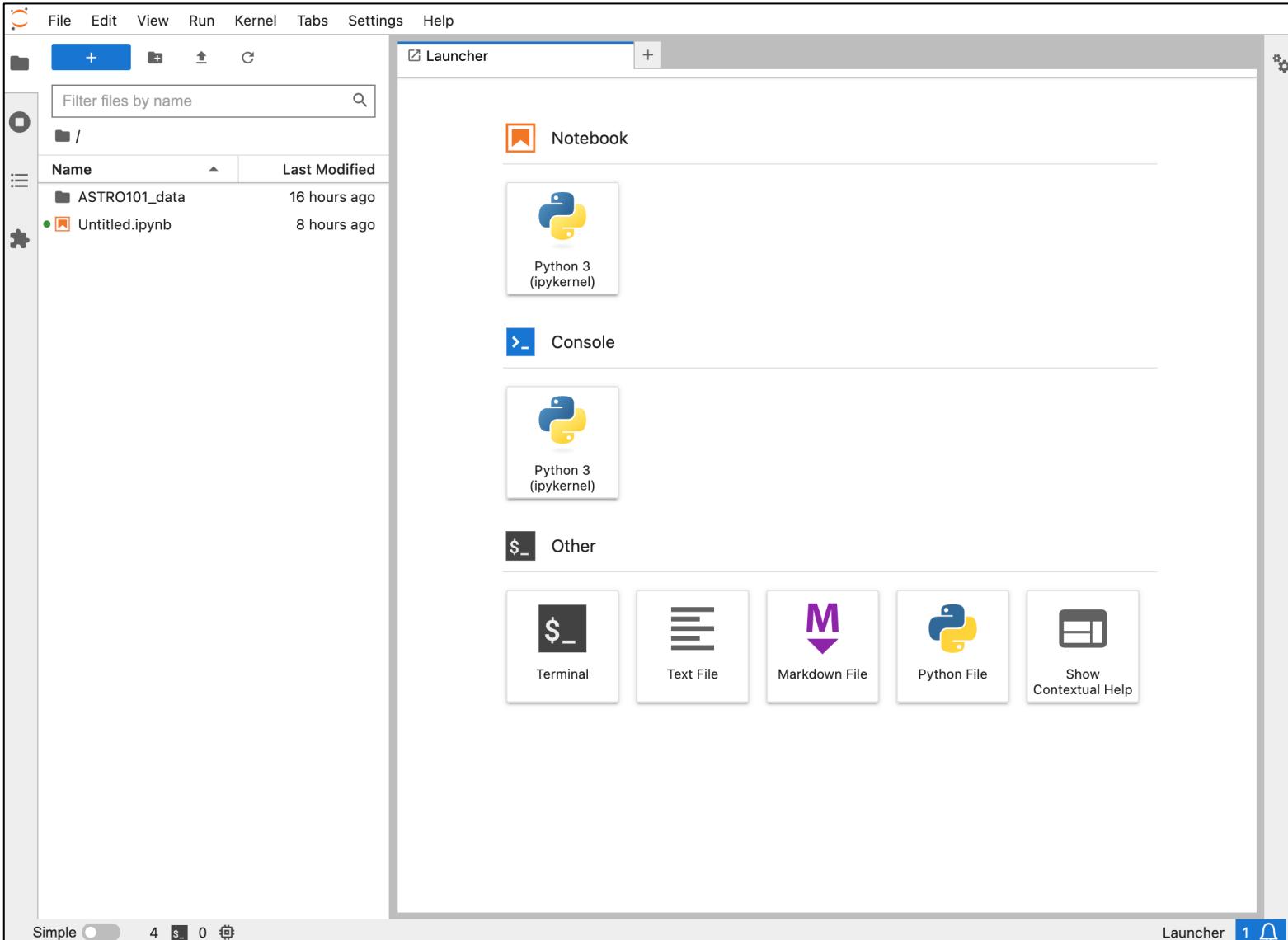
AVAILABLE MODULES: 2LPTic/2018, CosmoMC/19.10, DTFE/1.1.1, EasyBuild/3.8.1, IDL/7.0, IDL/8.8, N-GenIC/2003, R/3.5.2, adios/1.13.1, anaconda/2.7, blas/3.8.0, boost/1.69.0, cgal/4.13.1, charliecloud/0.9.7, Simple

For this workshop

- <https://lab1.narit.or.th>
- <https://lab2.narit.or.th>
- Each with 64 CPU cores,
512GB RAM, Lustre
Parallel Filesystem

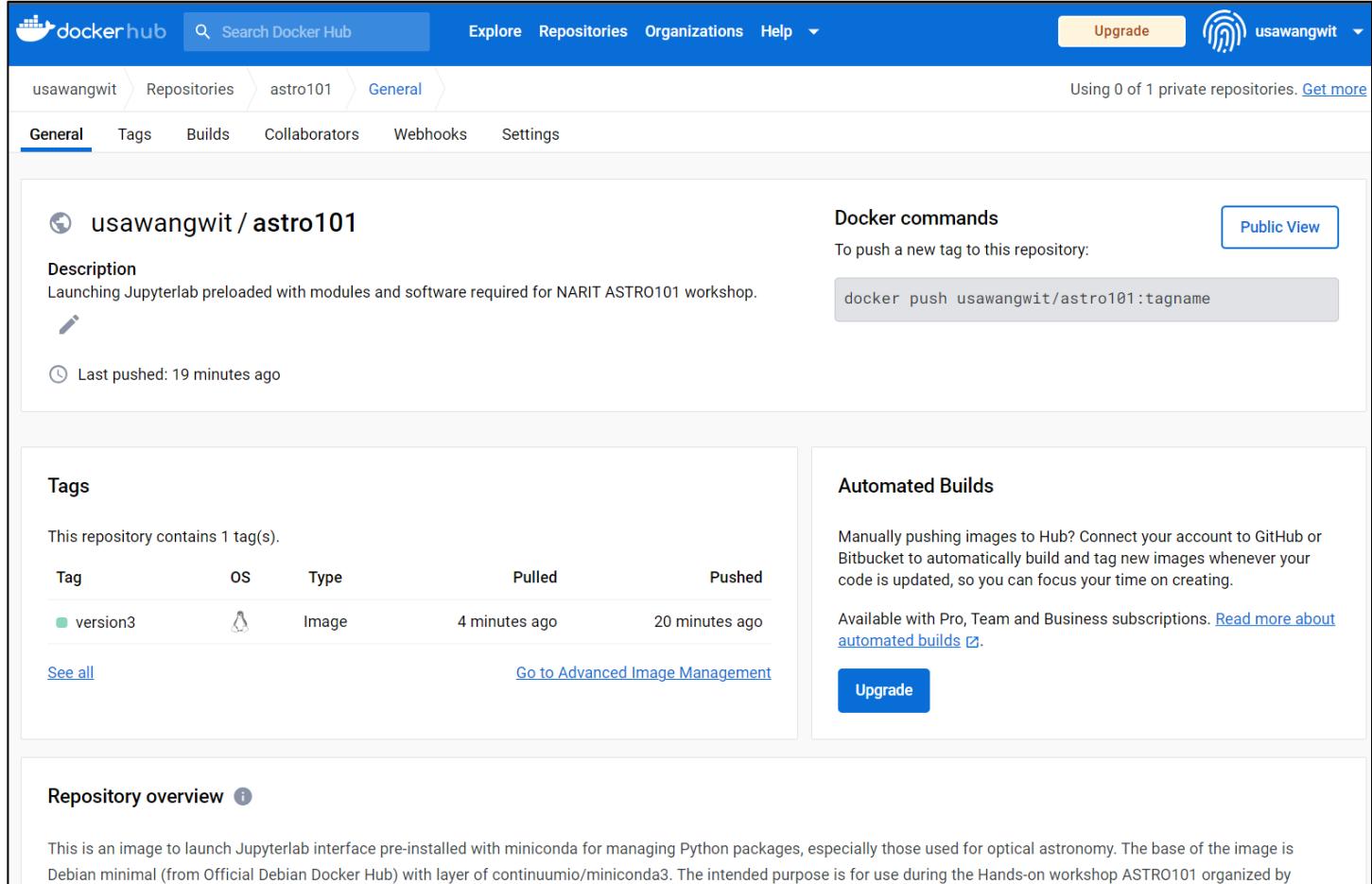


For this workshop



Docker Hub Repository

- <https://tinyurl.com/usawangwitrepo>
(Full URL
<https://hub.docker.com/repository/docker/usawangwit/astro101/general>)
- *\$docker pull usawangwit/astro101:version3*



The screenshot shows the Docker Hub repository page for the user `usawangwit` and the repository `astro101`. The page has a blue header with the Docker Hub logo, search bar, and navigation links: Explore, Repositories, Organizations, Help, Upgrade, and a user icon for `usawangwit`.

The main content area shows the `General` tab selected. It displays the repository name `usawangwit / astro101`, a brief description: "Launching Jupyterlab preloaded with modules and software required for NARIT ASTRO101 workshop.", and a note that it was last pushed 19 minutes ago.

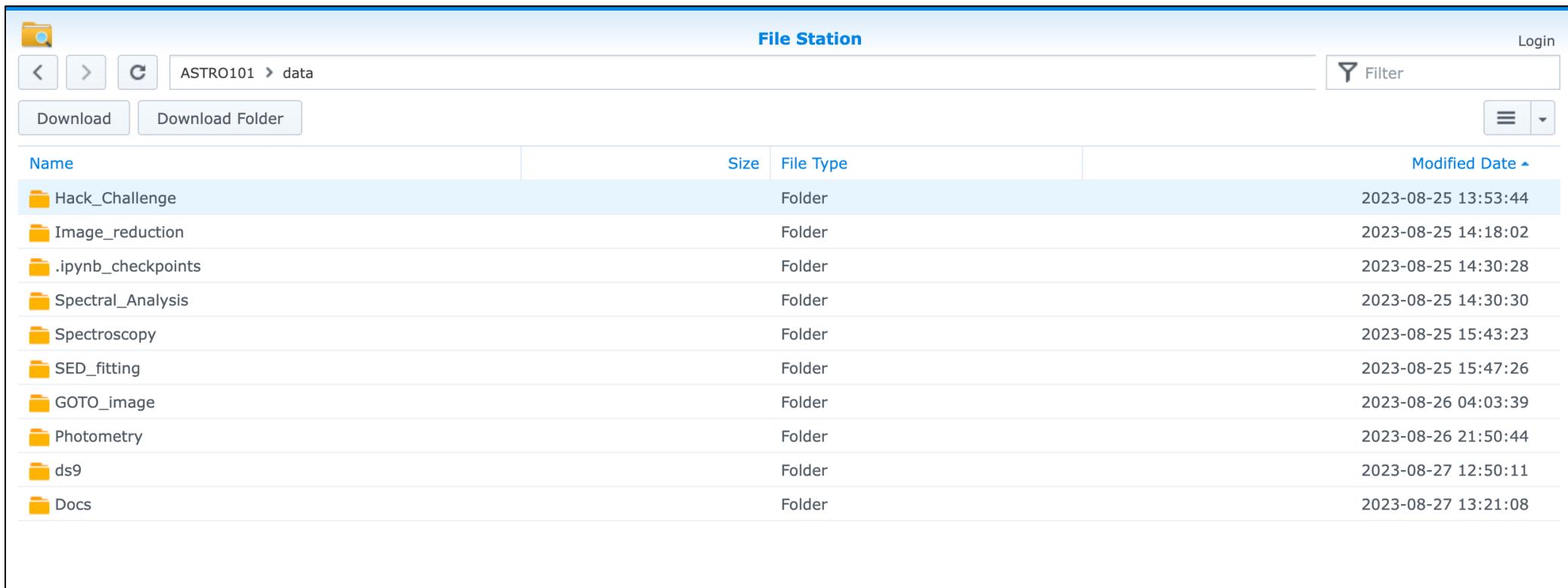
On the right side, there's a "Docker commands" section with a button to "Push a new tag to this repository" and a command box containing `docker push usawangwit/astro101:tagname`. There's also a "Public View" button.

Below the main content, there are two boxes: "Tags" and "Automated Builds". The "Tags" box lists one tag: `version3`. The "Automated Builds" box explains how to automatically build images and provides a link to "Read more about automated builds".

At the bottom, there's a "Repository overview" section with a detailed description of the image's purpose: "This is an image to launch Jupyterlab interface pre-installed with miniconda for managing Python packages, especially those used for optical astronomy. The base of the image is Debian minimal (from Official Debian Docker Hub) with layer of continuumio/miniconda3. The intended purpose is for use during the Hands-on workshop ASTRO101 organized by NARIT".

Data Access for Online Participants

- <http://gofile.me/4gxKb/QZFL5N7jA>



The screenshot shows a "File Station" interface with a blue header bar. On the left, there are navigation icons (back, forward, refresh), a breadcrumb path ("ASTRO101 > data"), and download buttons ("Download", "Download Folder"). On the right, there are "Login", "Filter" (with a magnifying glass icon), and a sorting dropdown menu. The main area is a table listing ten folders:

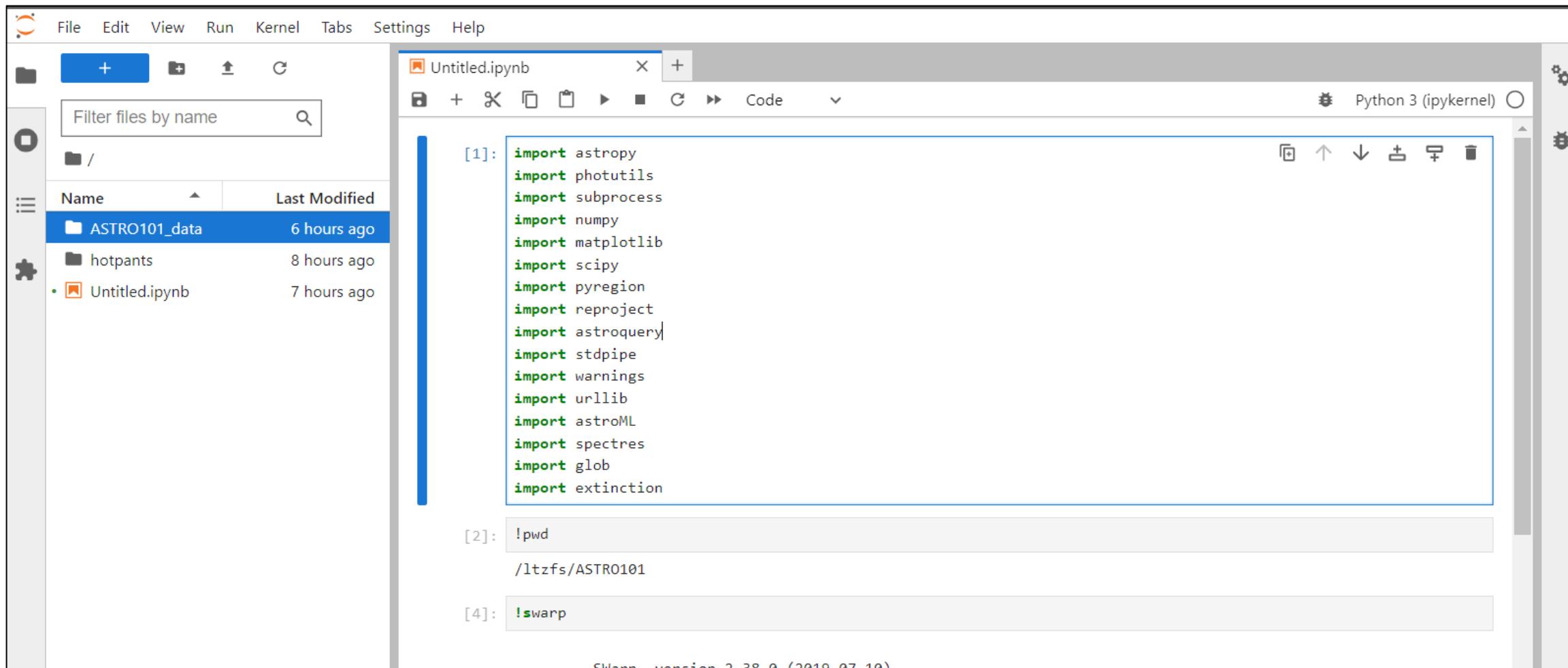
Name	Size	File Type	Modified Date
Hack_Challenge		Folder	2023-08-25 13:53:44
Image_reduction		Folder	2023-08-25 14:18:02
.ipynb_checkpoints		Folder	2023-08-25 14:30:28
Spectral_Analysis		Folder	2023-08-25 14:30:30
Spectroscopy		Folder	2023-08-25 15:43:23
SED_fitting		Folder	2023-08-25 15:47:26
GOTO_image		Folder	2023-08-26 04:03:39
Photometry		Folder	2023-08-26 21:50:44
ds9		Folder	2023-08-27 12:50:11
Docs		Folder	2023-08-27 13:21:08

Docker Run

```
$ docker run -i -t -p 8888:8888 -v /PATH_TO/ASTRO101/data/:/ltzfs/ASTRO101/ASTRO101_data  
usawangwit/astro101:version3
```

- Copy and Paste to your browser

```
(base) utane@LAPTOP-RB2EJHT4:~$ docker run -i -t -p 8888:8888 -v /mnt/c/Users/Utane/ASTRO101/ASTRO101/data/:/ltzfs/AS  
TR0101/ASTR0101_data usawangwit/astro101:version3  
/bin/bash: /opt/conda/lib/libtinfo.so.6: no version information available (required by /bin/bash)  
[I 2023-08-28 00:31:52.442 ServerApp] Package jupyterlab took 0.0000s to import  
[I 2023-08-28 00:31:52.450 ServerApp] Package jupyter_lsp took 0.0070s to import  
[W 2023-08-28 00:31:52.450 ServerApp] A '_jupyter_server_extension_points' function was not found in jupyter_lsp. Ins  
tead, a '_jupyter_server_extension_paths' function was found and will be used for now. This function name will be dep  
recated in future releases of Jupyter Server.  
[I 2023-08-28 00:31:52.453 ServerApp] Package jupyter_server_terminals took 0.0029s to import  
[I 2023-08-28 00:31:52.453 ServerApp] Package notebook_shim took 0.0000s to import  
[W 2023-08-28 00:31:52.453 ServerApp] A '_jupyter_server_extension_points' function was not found in notebook_shim. I  
nstead, a '_jupyter_server_extension_paths' function was found and will be used for now. This function name will be d  
eprecated in future releases of Jupyter Server.  
[I 2023-08-28 00:31:52.454 ServerApp] jupyter_lsp | extension was successfully linked.  
[I 2023-08-28 00:31:52.456 ServerApp] jupyter_server_terminals | extension was successfully linked.  
[I 2023-08-28 00:31:52.459 ServerApp] jupyterlab | extension was successfully linked.  
[I 2023-08-28 00:31:52.578 ServerApp] notebook_shim | extension was successfully linked.  
[W 2023-08-28 00:31:52.587 ServerApp] WARNING: The Jupyter server is listening on all IP addresses and not using encr  
yption. This is not recommended.  
[I 2023-08-28 00:31:52.587 ServerApp] notebook_shim | extension was successfully loaded.  
[I 2023-08-28 00:31:52.589 ServerApp] jupyter_lsp | extension was successfully loaded.  
[I 2023-08-28 00:31:52.589 ServerApp] jupyter_server_terminals | extension was successfully loaded.  
[I 2023-08-28 00:31:52.590 LabApp] JupyterLab extension loaded from /opt/conda/lib/python3.11/site-packages/jupyterla  
b  
[I 2023-08-28 00:31:52.590 LabApp] JupyterLab application directory is /opt/conda/share/jupyter/lab  
[I 2023-08-28 00:31:52.590 LabApp] Extension Manager is 'pypi'.  
[I 2023-08-28 00:31:52.592 ServerApp] jupyterlab | extension was successfully loaded.  
[I 2023-08-28 00:31:52.592 ServerApp] Serving notebooks from local directory: /ltzfs/ASTR0101  
[I 2023-08-28 00:31:52.592 ServerApp] Jupyter Server 2.7.1 is running at:  
[I 2023-08-28 00:31:52.592 ServerApp] http://localhost:8888/lab?token=ddc6305ba44e0f34f6805f9f931e20a20c14fb91604b6a3  
3  
[I 2023-08-28 00:31:52.592 ServerApp] http://127.0.0.1:8888/lab?token=ddc6305ba44e0f34f6805f9f931e20a20c14fb91604  
b6a33  
[I 2023-08-28 00:31:52.592 ServerApp] Use Control-C to stop this server and shut down all kernels (twice to skip conf  
irmation).  
[C 2023-08-28 00:31:52.595 ServerApp]
```



The screenshot shows a Jupyter Notebook interface with the following details:

- File Menu:** File, Edit, View, Run, Kernel, Tabs, Settings, Help.
- Toolbar:** Includes icons for creating new files, opening files, saving, and running cells.
- Search Bar:** "Filter files by name" with a search icon.
- File Explorer:** Shows a directory structure:
 - ASTRO101_data (selected folder)
 - hotpants
 - Untitled.ipynbwith columns for Name and Last Modified.
- Code Editor:** Untitled.ipynb notebook, Python 3 (ipykernel) kernel.
 - Cell [1]:

```
import astropy
import photutils
import subprocess
import numpy
import matplotlib
import scipy
import pyregion
import reproject
import astroquery
import stdpipe
import warnings
import urllib
import astroML
import spectres
import glob
import extinction
```
 - Cell [2]:

```
!pwd
```

/ltzfs/ASTRO101
 - Cell [4]:

```
!swarp
```
- Bottom Status Bar:** "Swarm version 2.38.0 (2019-07-10)"

Untitled.ipynb X photometry.ipynb X +

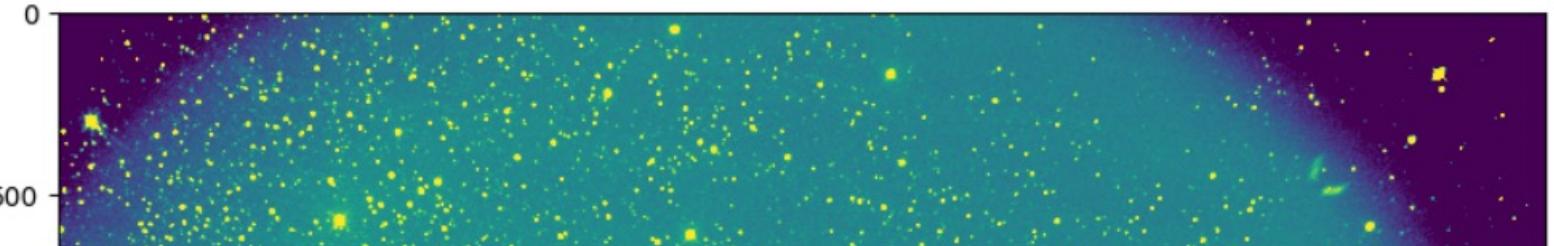
File + X Back Forward Cell Run Markdown Python 3 (ipykernel)

```
[3]: from astropy.io import fits
import matplotlib.pyplot as plt
%matplotlib inline
import os

# Move to the data directory for our analysis
data_dir = '/ltzfs/ASTRO101/ASTRO101_data/Photometry/data/'
imageName = 'aC0_20181013-174714-557.wcs.proc.cr.fits'
f = fits.open(data_dir + imageName)
data = f[0].data #This is the image array
header = f[0].header

#Compute some image statistics for scaling the image plot
mean, median, sigma = sigma_clipped_stats(data)

#plot the image with some reasonable scale
plt.figure(figsize=(10,10))
plt.imshow(data, vmin=median-3*sigma, vmax=median+3*sigma)
plt.show()
```



[Docker Desktop](#)[Upgrade plan](#) Search for images, containers, volumes, extensions and more...

Ctrl+K



usawa...

[Containers](#)[Images](#)[Volumes](#)[Dev Environments](#) BETA[Docker Scout](#) EARLY ACCESS[Learning center](#)

Extensions

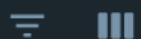
[Add Extensions](#)

Images Give feedback

[Local](#)[Hub](#)[Artifactory](#)[EARLY ACCESS](#)

2.05 GB / 0 Bytes in use 2 images

Last refresh: 10 hours ago

 Search

<input type="checkbox"/>	Name	Tag	Status	Created	Size	Actions
<input type="checkbox"/>	usawangwit/astro101 826fc145d161	version3	In use	7 hours ago	2.05 GB	
<input type="checkbox"/>	continuumio/miniconda3 a101d1f8cd1c	latest	Unused	1 month ago	520.02 MB	

Showing 2 items



RAM 2.65 GB CPU 0.13% Connected to Hub

v4.22.1

Docker Desktop

Upgrade plan

Search for images, containers, volumes, extensions and more...

Ctrl+K



usawa...



Containers

Images

Volumes

Dev Environments BETA

Docker Scout EARLY ACCESS

Learning center

Extensions •



+ Add Extensions

Containers [Give feedback](#)

Container CPU usage i

0.05% / 800% (8 cores allocated)

Container memory usage i

213.7MB / 7.44GB

Show charts ▼

Search



Only show running containers

<input type="checkbox"/>	Name	Image	Status	CPU (%)	Port(s)	Actions		
<input type="checkbox"/>	flamboy 99096037	usawangwit/astro101:version3	Created (128)	0%	8888:8888			
<input type="checkbox"/>	cool_sin 7f126d55	usawangwit/astro101:version3	Exited (137)	0%	8888:8888			
<input type="checkbox"/>	kind_vis 7502ec3d	usawangwit/astro101:version3	Running	0.05%	8888:8888			

Showing 3 items



RAM 2.67 GB CPU 0.13% Connected to Hub

v4.22.1

**WITH THE RIGHT TOOLS YOU CAN BUILD ANYTHING,
WITH THE RIGHT TECHNOLOGY YOU CAN BRING INNOVATIONS TO LIFE**

ขอบคุณครับ
THANK YOU

