한국천문학계 전산자원 현황&미래

신지혜(KASI) & 장기발전위원회 자료 및 계산시설분과

김지훈(SNU), 김태선(Yonsei), 김주한(KIAS), 전명원(KHU), 김용휘(KISTI),
김민진(KNU), 김신영(KASI), 이보미(KASI), 김영민 (KASI), 이창희(KASI), 장서원(SNU)

발표순서

- 계산시설 및 계산과학
  - 독자적인 계산시설의 필요성
  - 해외사례 (미국, 일본, 유럽)
- 자료 공유 및 보존
  - 통합된 자료 공유 및 보존 시설의 필요성
  - 해외사례 (유럽, 미국, 호주)
- 학계에 필요한 자료/계산 시설
  - 우주전문센터
  - 특정 프로젝트 기반에서 통합된 시설로 확장
  - 우주청 신규과제 추진

국내 주요 HPC 현황

- KISTI 의 5호기 Nurion (6호기: 26년 상반기 서비스 시작)
- IBS 의 Olaf (우주전문센터 지정)
- KIAS 의 Grammar, RNA 등 (내부서비스)
- KASI, SNU, Yonsei, KHU 등 = 수백~ 수천 코어

	KISTI	IBS	KIAS	ETC
CPU	Intel Xeon Phi 7250 1.4GHz 68 Core	Intel 8360Y 2.4GHz, 36 Core*2EA	AMD Milan 2.8G 32Core *2EA	-
총메모리	797.3Tb	53Tb	57Tb	수 Tb
이론성능	25.3Pf (6.4Pf)	1.4Pf (~3Pf)	160Tf	< 수십Tf
노드수	8305	210	112	< 수십개
코어수	564,740	15,120	7168	< 수천개



KISTI - Nurion



IBS - Olaf



개별 연구팀

구분		사례 수	응답 비율(%)*				
			자체 구입	국가 슈퍼컴퓨팅센터 (KISTI)의 자원을 이용	KISTI 외 타기관 자원 유/무상 대여	국내·외 퍼블릭 클라우드 이용	기타
전체 합계		1,106	64.2	37.5	10.2	11.8	6.3
전략 분야	계산과학	848	64.3	42.1	9.3	8.7	5.8
	계산과학+AI	141	58.2	30.5	17.0	19.9	8.5
	AI	117	70.9	12.8	8.5	23.9	7.7
10대 전략분야	소재나노	214	65.0	62.6	7.5	5.6	3.7
	생명보건	212	67.5	29.7	10.8	9.4	9.4
	ICT:일반	222	55.0	29.7	9.5	23.0	5.0
	ICT:거대AI	117	70.9	12.8	8.5	23.9	7.7
	기상기후환경	89	62.9	47.2	18.0	5.6	5.6
	우주	27	66.7	48.1	7.4	0.0	3.7
	자율주행	30	56.7	36.7	6.7	10.0	3.3
	핵융합가속기	46	63.0	47.8	13.0	0.0	10.9
	제조기반기술	81	69.1	37.0	11.1	7.4	3.7
	재난재해	26	65.4	26.9	15.4	11.5	11.5
	국방안보	24	79.2	16.7	4.2	4.2	4.2
	기타	18	61.1	44.4	16.7	5.6	16.7

시뮬레이션과 관련된 연구진(팀) 현황

- ✓ 김웅태 (서울대) / ISM, 은하역학
- 이정훈 (서울대) / 우주론, 우주거대구조
- 황호성 (서울대) / 관측우주론
- 손주비 (서울대) / 관측우주론
- ✓ 김지훈 (서울대) / 은하형성 및 진화
- ✓ 이석영 (연세대) / 은하형성 및 진화
- 윤석진 (연세대) / 은하형성 및 진화
- ✓ 지명국 (연세대) / 중력렌즈, 은하단
- ✓ 김태선 (연세대) / 은하진화
- ✓ 전명원 (경희대) / 은하진화
- 송현미 (충남대) / 은하진화
- ✓ 최이나 (서울시립대) / 블랙홀 및 은하진화
- ✓ 신지혜 (천문연구원) / 은하형성 및 진화
- ✓ 이재현 (천문연구원) / 은하형성 및 진화
- 홍성욱 (천문연구원) / 은하형성 및 진화
- ✓ 박창범 (고등과학원) / 우주거대구조
- ✓ 김주한 (고등과학원) / 우주거대구조
- ✓ 김용휘 (KISTI) / 은하형성 및 진화

LSS simulations (cosmology) - **KIAS**, KASI

Galaxy simulations - **Yonsei**, **KASI**, **KIAS**, SNU, KHU, UoS

ISM simulations - **CNU**, Yonsei, KIAS, KASI

Plasma physics simulations - **UNIST**, KHU, Yonsei

GRMHD (BH+) simulations - **KASI**, KNU?

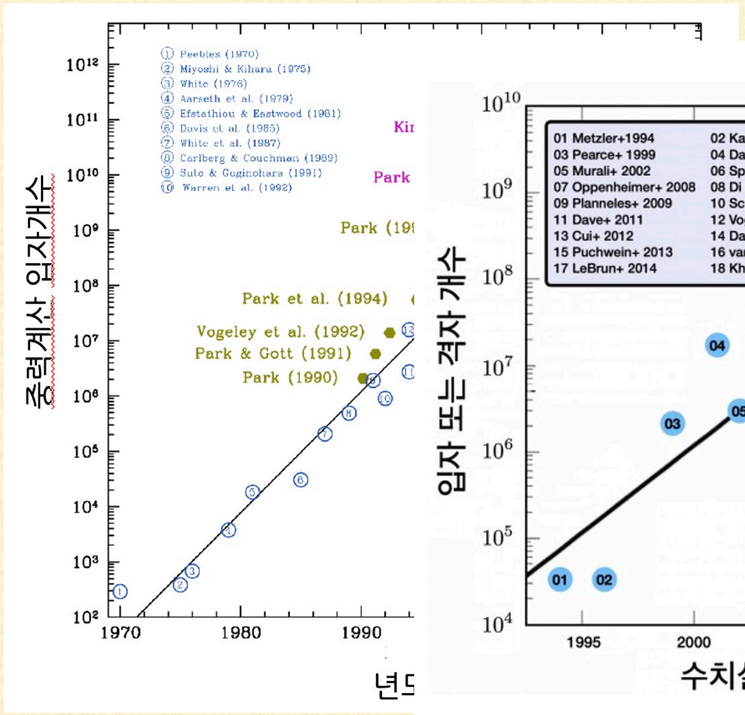
Solar physics - SNU, KHU, KASI

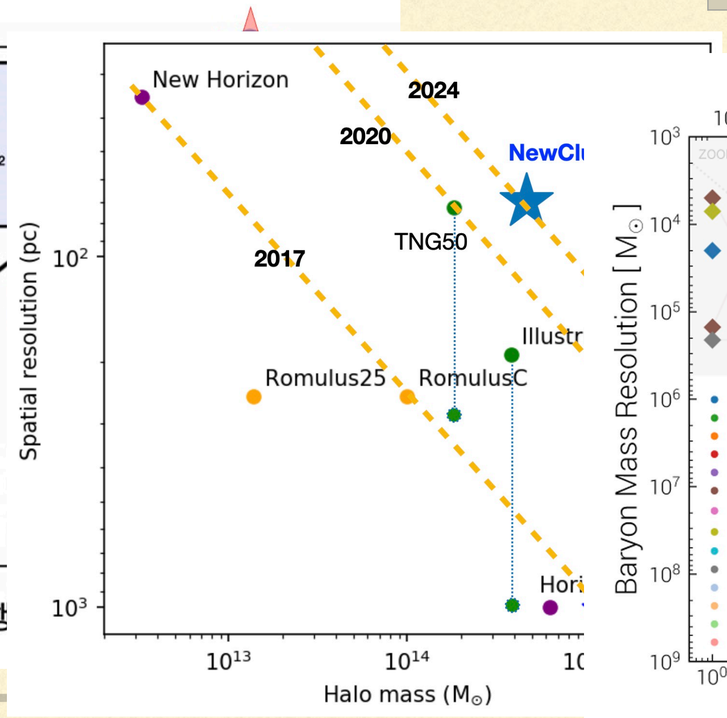
Planet simulations - ?

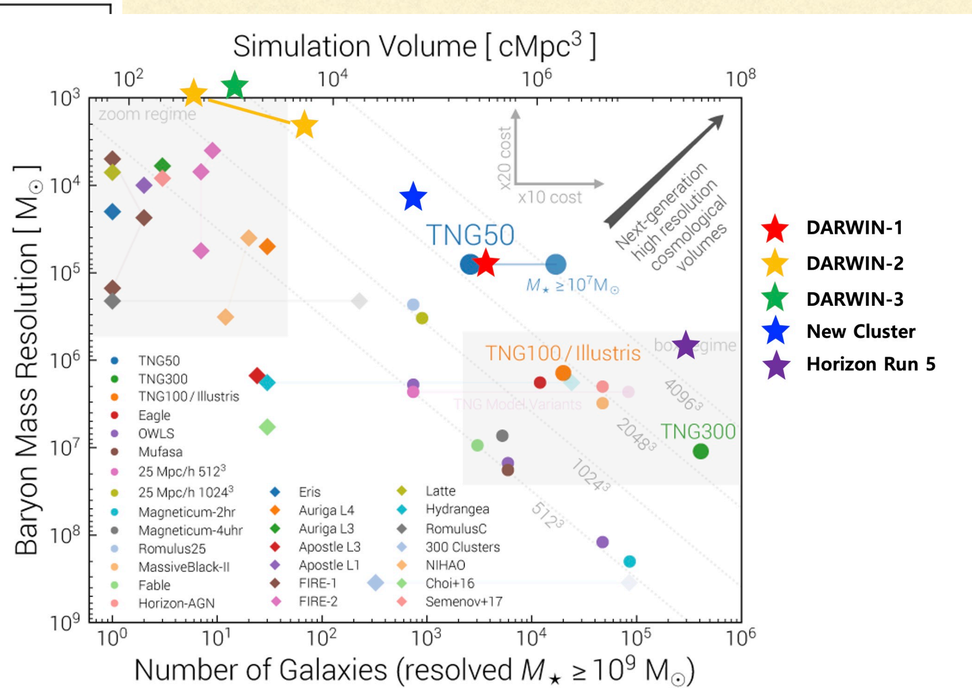
국내 대규모 시뮬레이션 프로젝트

- KIAS: HR 시리즈 (HR1~HR5)
- 연세대: YZiCs, NewHorizon, NewCluster
- DARWIN 연구팀: DARWIN-1, -2, -3

	CPU time (hours)	Date Storage
DARWIN-1	~15M (~40M)	~300TB (~400TB)
HR5	~150M	~1PB
NewCluster	~80M (~300M)	~400TB (~1PB)
TIGRESS	~20M	~200TB
그 외	<10M	<100TB







국내 대규모 시뮬레이션 프로젝트

KISTI

R&D 혁신지원으로 살펴보는 슈퍼컴퓨팅 인사이트

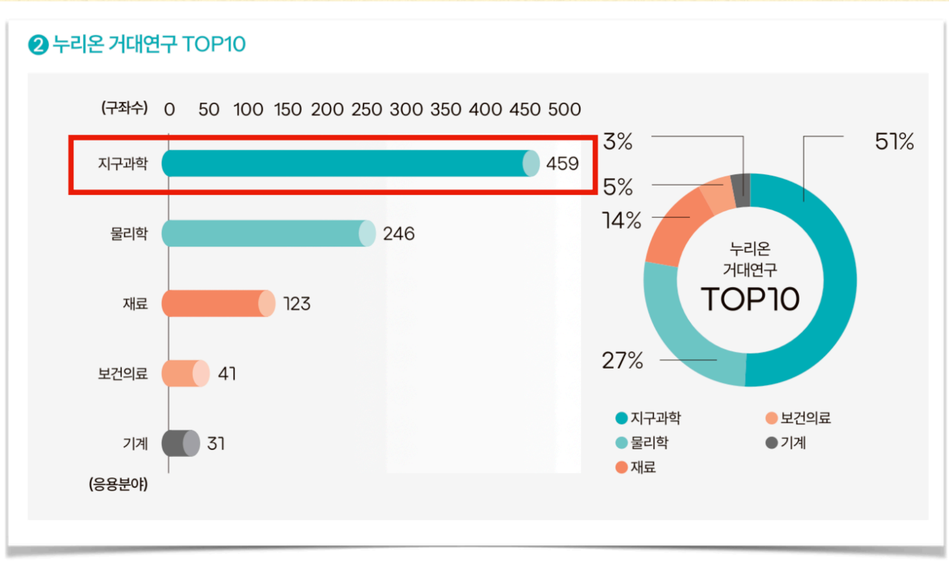
제3호

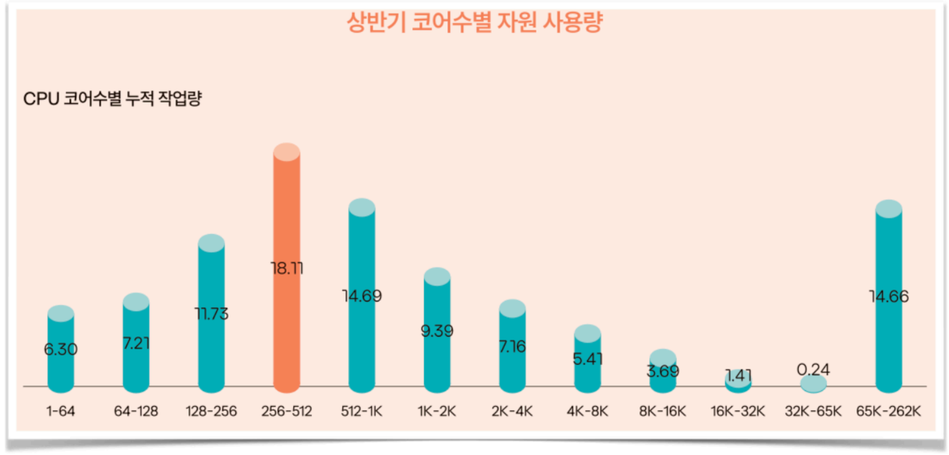
2024년 상반기
(2024-01-01 ~ 2024-06-30)



R&D 혁신지원 프로그램의
창의연구 사용자가 전체 사용자의
과반(56%)을 차지

창의연구 사용자 비율 56%





해외사례 - 대규모 시뮬레이션 프로젝트





Run nam

TNG50(−1

TNG100(−

TNG300(−

Virgo Consortium



- 3-5M CPU hours for each model
- Blue Waters, Frontera in USA

Table 1. *Core* suite of 23 primary galaxies/halos across 20 different simulations to $z = 0$; we release 39 full snapshots across $z = 0-10$. Each cosmological simulation zooms in on a single isolated halo, except the last set (*ELVIS on FIRE* suite) for which each simulation zooms in on a Local Group-like MW+M31-mass pair (Romeo & Juliet, Thelma & Louise, Romulus & Remus). We simulated m09, m10q, m10v, and m11b without spurious cosmic-ray heating at $z \gtrsim 10$ (see Section 3.1).

name	M_{200m}	R_{200m}	$M_{star,90}$	m_{baryon}	m_{dm}	$\epsilon_{gas,min}$	ϵ_{star}	ϵ_{dm}	N_{dm}	size	cosmology	reference
	$[M_\odot]$	[kpc]	$[M_\odot]$	$[M_\odot]$	$[M_\odot]$	[pc]	[pc]	[pc]		[GB]		
m09	2.60×10^9	44	1.5×10^4	32	160	0.4	0.7	14	2.31×10^8	17	N	W19
m10q	8.23×10^9	64	4.8×10^6	33	160	0.4	0.7	14	1.24×10^8	11	A	W19
m10v	1.08×10^{10}	70	3.1×10^5	33	160	0.1	0.7	14	2.94×10^8	25	A	W19
m11b	4.65×10^{10}	114	4.5×10^7	2100	10,000	1.0	2.6	26	2.24×10^7	3.1	A	C18
m11i	7.77×10^{10}	133	9.2×10^8	7100	39,000	1.0	4.0	40	4.59×10^6	0.9	P	E18
m11q	1.63×10^{11}	174	3.7×10^8	880	4400	0.5	2.0	20	1.30×10^8	11	A	H18
m11e	1.68×10^{11}	171	1.4×10^9	7100	39,000	1.0	4.0	40	1.12×10^7	2.0	P	E18
m11h	2.07×10^{11}	184	3.6×10^9	7100	39,000	1.0	4.0	40	1.58×10^7	2.8	P	E18
m11d	3.23×10^{11}	213	3.9×10^9	7100	39,000	1.0	4.0	40	1.61×10^7	2.8	P	E18
m12z	9.25×10^{11}	307	2.0×10^{10}	4200	21,000	0.4	3.2	33	1.27×10^8	14	Z	G19a
m12w	1.08×10^{12}	319	5.7×10^{10}	7100	39,000	1.0	4.0	40	7.33×10^7	8.4	P	S20
m12r	1.10×10^{12}	321	1.7×10^{10}	7100	39,000	1.0	4.0	40	6.03×10^7	6.2	P	S20
m12i	1.18×10^{12}	336	6.3×10^{10}	7100	35,000	1.0	4.0	40	7.05×10^7	7.2	A	W16
m12c	1.35×10^{12}	351	5.8×10^{10}	7100	35,000	1.0	4.0	40	1.51×10^8	16	A	G19a
m12b	1.43×10^{12}	358	8.5×10^{10}	7100	35,000	1.0	4.0	40	7.45×10^7	8.4	A	G19a
m12m	1.58×10^{12}	371	1.1×10^{11}	7100	35,000	1.0	4.0	40	1.41×10^8	17	A	H18
m12f	1.71×10^{12}	380	7.9×10^{10}	7100	35,000	1.0	4.0	40	9.62×10^7	9.1	A	G17
Juliet	1.10×10^{12}	321	3.8×10^{10}	3500	19,000	0.7	4.4	32	3.06×10^8	33	P	G19a
Romeo	1.32×10^{12}	341	6.6×10^{10}	3500	19,000	0.7	4.4	32	3.06×10^8	33	P	G19a
Louise	1.15×10^{12}	333	2.6×10^{10}	4000	20,000	0.4	2.7	31	3.80×10^8	42	E	G19a
Thelma	1.43×10^{12}	358	7.1×10^{10}	4000	20,000	0.4	2.7	31	3.80×10^8	42	E	G19a
Remus	1.22×10^{12}	339	4.6×10^{10}	4000	20,000	0.4	3.8	31	2.97×10^8	33	E	G19b
Romulus	2.08×10^{12}	406	9.1×10^{10}	4000	20,000	0.4	3.8	31	2.97×10^8	33	E	G19b

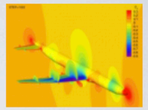
해외사례 (미국) - 주요 HPC

NASA Advanced Computing (NAS)

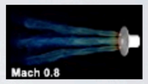
- Provides supercomputing, application optimization, data analysis, visualization, science data pipeline, online data portal, etc.

4. HEC SUPPORT TO AERONAUTICS RESEARCH MISSION DIRECTORATE 31
   4.1 Advanced Air Vehicles (AAVP) 34
   4.2 Airspace Operations and Safety Program (AOSP) 39
   4.3 Integrated Aviation Systems Program (IASP) 40
   4.4 Transformative Aeronautics Concepts Program (TACP) 43
5. HEC SUPPORT TO HUMAN EXPLORATION ALLOCATION GROUP 47
   5.1 Human Exploration and Operations Mission Directorate (HEOMD) 47
   5.2 NASA Engineering and Safety Center (NESC) 50
   5.3 Space Technology Mission Directorate (STMD) 52
6. HEC SUPPORT TO SCIENCE MISSION DIRECTORATE (SMD) 57
   6.1 Earth Science Division (ESD) 60
   6.2 Astrophysics 73
   6.3 Heliophysics 76
   6.4 Planetary Science Division (PSD) 80
   6.5 Biological and Physical Sciences Division (BPSD) 82

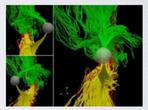
→ 31 million SBU



→ 26 million SBU



→ 53 million SBU (astro: 35 million)



Aitken Supercomputer → #132 in SC500 (Nov. 2024)

Aitken is a petascale supercomputer housed in the Modular Supercomputing Facility (MSF) at NASA's Ames Research Center. The MSF is situated on a one-acre site that has the potential to hold 16 modules for computing and data storage. Aitken's initial module and racks containing Intel Xeon Gold "Cascade Lake" nodes were installed in 2019. Since then, the system has been expanded with 16 racks containing AMD "Rome" nodes and four racks of AMD "Milan" nodes—making Aitken NASA's most powerful supercomputer.

System Architecture

- Manufacturer: HPE
- 4 E-Cells (1,152 nodes), 20 Apollo 9000 racks (2,560 nodes)
- 15.69 Pflop/s theoretical peak
- 9.07 Pflop/s LINPACK rating (#58 on June 2022 TOP500 list)
- 172.38 Tflop/s HPCG rating (#44 on June 2022 HPCG list)
- Total cores: 373,460
- Total memory: 1.31 PB



CPUs in Use
Used: 396496
Total: 416784
95%



Electra Supercomputer → #195 in SC500 (Nov. 20

Electra is NASA's first prototype modular supercomputing system. Originally constructed in 2016 and augmented in 2017, E environmentally-friendly modules located a short distance from the main NAS building at NASA Ames Research Center. The seven stars that make up the Pleiades open star cluster in the constellation Taurus.

System Architecture

- Manufacturer: SGI/HPE
- 32 compute racks (3,456 nodes)
- 8.32 Pflop/s theoretical peak
- 5.44 Pflop/s LINPACK rating (#78 on June 2021 TOP500 list)
- 65 Tflop/s HPCG rating (#63 on June 2021 HPCG list)
- Total cores: 124,416
- Total memory: 589 TB

Pleiades Supercomputer →

Pleiades is a distributed-memory SGI/HPE ICE cluster conn technology. Originally deployed in 2008, Pleiades has been powerful supercomputers.

The system contains the following types of Intel Xeon proce 2680v2 (Ivy Bridge), and E5-2670 (Sandy Bridge). Pleiades same name.

System Architecture

- Manufacturer: SGI/HPE
- 152 racks (10,410 nodes)
- 7.09 Pflop/s peak cluster
- 5.95 Pflop/s LINPACK rating (#90 on June 2022 TOP
- 175 Tflop/s HPCG rating (#43 on June 2022 HPCG li
- Total CPU cores: 228,572
- Total memory: 921 TB
- 2 racks (57 nodes total) enhanced with NVIDIA graph
  - 430,080 CUDA cores

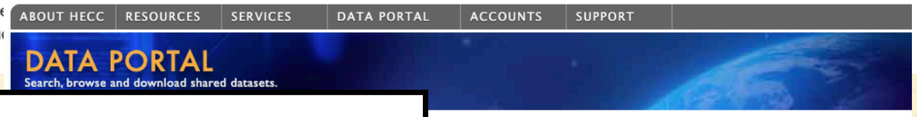
Cf. Nurion@KISTI: #91 in SC500 (Nov. 2024)

nas.nasa.gov/hecc/resources

Science Data Pipelines

NAS Division experts work with various science teams to provide and operate custom data pipelines that expedite the steps involved in processing the massive amounts of raw data obtained from NASA's ground- and space-borne observatories. These steps include: cleaning the data to correct errors, omissions, or inconsistencies; and visualizing, modeling, and analyzing the data.

The first and second generations of NAS data pipeline software were developed to support the Kepler ar operating p them, Kepl data produ world.



Search Datasets LOGIN

Search:

	Updated
5 SPH simulation snapshots.	Sep 13, 2024
ntains daily, monthly, and annual downscaled CMIP6 projections t 30-arcsecond horizontal resolution for maximum ... (Show more)	Mar 21, 2024
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ASA GEOS/ECCO Coupled Nature Run that Admits Clouds, and Tides.	Sep 18, 2023
visualizations showing the output of the ECCO Project's global on run at the 1/48th degree resolutions.	Sep 18, 2023
visualizations showing the output of a coupled atmosphere-ocean e atmosphere simulation used the GEOS5 ... (Show more)	Sep 18, 2023
ovides various climate impact indicators generated from the NASA e Global Daily Downscaled Projections (NEX-GDDP) data.	May 12, 2023
gh-fidelity inviscid modeling for aerodynamic design & optimization	Dec 08, 2022
2D Pic Simulation of Relativistic Plasma Turbulence — Vadim Roytershteyn — This dataset contains output of a two-dimensional particle-in-cell simulation of decaying turbulence in relativistic electron-positron plasma.	Nov 14, 2022

Oak Ridge National Lab

- **프런티어(Frontier)**: 엑사스케일 성능을 갖춘 슈퍼컴퓨터로, 4대 과학연구 지원 (우주론/나노과학/대기환경/핵융합)
  - 우주 연구를 혁신하고 초신성 폭발 시뮬레이션 등을 통해 인간의 기원을 이해하는 데 기여 (Exasky 프로젝트)

NERSC (National Energy Research Scientific Computing)

- **펄머터(Perlmutter)**: 미국 국립에너지연구과학컴퓨팅센터(NERSC)에 도입된 이 슈퍼컴퓨터는 엔비디아의 A100 텐서코어 GPU 기반으로 구축. 우주론/초신성/CMB/Deep Sky Image DB

해외사례 (일본) - 주요 HPC

JAXA Supercomputing System (JSS)

- Provides supercomputing, application optimization, data analysis, visualization, science data pipeline, onlin



#80 in SC500 (Nov. 2024)

	TOKI-SORA	TOKI-RURI		
		ST	GP	X
System Model	PRIMEHPC FX1000	PRIMERGY RX2540 M5	PRIMERGY CX2570 M5	PRIM RX25
Total #Nodes	5,760	375	32	
CPU Model	A64FX (Arm®v8.2-A SVE)	Intel Xeon Gold 6240		Intel Gold
#CPUs/node	1	2		
#Memory/node	32 GiB	192 GiB	384 GiB	6
Theoretical Peak Performance/CPU	3.3792 TFLOPS	2.99 TFLOPS		
#Cores/CPU	48+Assistant core×4	36		
GPU Model	—	NVIDIA Quadro P4000	NVIDIA Tesla V100(SXM2)	
#GPUs/node	—	1	4	
#Cores/GPU	—	1,792	5,120	
#Memory/GPU	—	8 GiB	32 GiB	
Interconnect Network	Tofu Interconnect D	InfiniBand HDR100×2 25GB/s× 2(Bidirectional)		

www.jss.jaxa.jp/en/ar/e2022/21915

- NAOJ
  - 아테루이 **II (ATERUI II)**: 일본 국립천문대(NAOJ) 계산천체물리센터의 천문학 전용 슈퍼컴퓨터로, 우주 생성 시뮬레이션 등 다양한 천문학 연구에 사용 (Wuchuu)
  - 아테루이 **III (ATERUI III)**: 2024년 12월 2일에 이와테현 오슈시 미즈사와캠퍼스에서 운용을 시작한 최신 천문학 전용 슈퍼컴퓨터로, 우주의 수수께끼를 해명하는 데 도전 (1.9Pflops)

- RIKEN
  - 후가쿠 (**Fugaku**): 일본 이화학연구소와 후지쓰가 2020년 6월에 구축한 세계 최고 성능의 슈퍼컴퓨터로, 연산 성능이 513페타플롭스(PF)에 달하며, 우주 진화 (뉴트리노와 거대구조)시뮬레이션 등 다양한 과학 연구에 활용

Specifications

Location	Mizusawa Campus (Hoshigaoka, Mizusawa, Oshu, Iwate, Japan)
Prime manufacturer	Cray Japan Inc.
Basic specifications of the Cray XC50 (massively parallel computer) system	Number of nodes: 1005 Intel Xeon Gold 6148 Processor (2.4 GHz, 20 cores) Total number of cores: 40200 (entire system) Theoretical peak performance: 3.087 Pflops Total main memory: 385.9 TB (entire system) Disk space: 6.5 PB

Basic specifications of ATERUI III

	ATERUI III (total)	ATERUI III (System M)	ATERUI III (System P)	ATERUI II (2018.6–2024.8)
Theoretical Peak Performance	1.99 Pflops	1.4 Pflops (6.8 Tflops)	0.57 Pflops (7.168 Tflops)	3.087 Pflops
CPU		Intel® Xeon® CPU Max 948	Intel® Xeon® Platinum 8480+	Intel® Xeon® Gold 6148
Core number	32,256	23,296 (112)	8,960 (112)	40,200
Node number	288	208	80	1,005
Memory bandwidth		665 TB/s (3200 GB/s)	98.24 TB/s (614 GB/s)	257.28 TB/s (256 GB/s)
Memory		26.6 TB (128 GB)	40.96 TB (512 GB)	385.9 TB (384 GB)

해외사례 (유럽) - 주요 HPC

PRACE PARTNERSHIP FOR ADVANCED COMPUTING IN EUROPE



System	Architecture	Site (Country)	Core Hours (node hours)	Minimum request (core hours)

— SuperStars - Self-consistent

Project Title: SuperStars – Self-c

Project Leader: Paolo Padoan, U

Multi-year Proposal: 3rd or 3 ye

Resource Awarded

- 3 700 000 core hours on J
- 19 400 000 core hours on

Multi-year Proposal: 3rd or 3 ye

Annual report **2023**



The UK's High Performance Super Computer facility for the STFC Particle Physics, Astrophysics, Cosmology, Solar System and Planetary Science and Nuclear Physics theory community.

five HPC clusters at our four current sites: the University of Cambridge; Durham; Edinburgh; Leicester.

GENCI
Le calcul intensif au service de la connaissance



Impact:

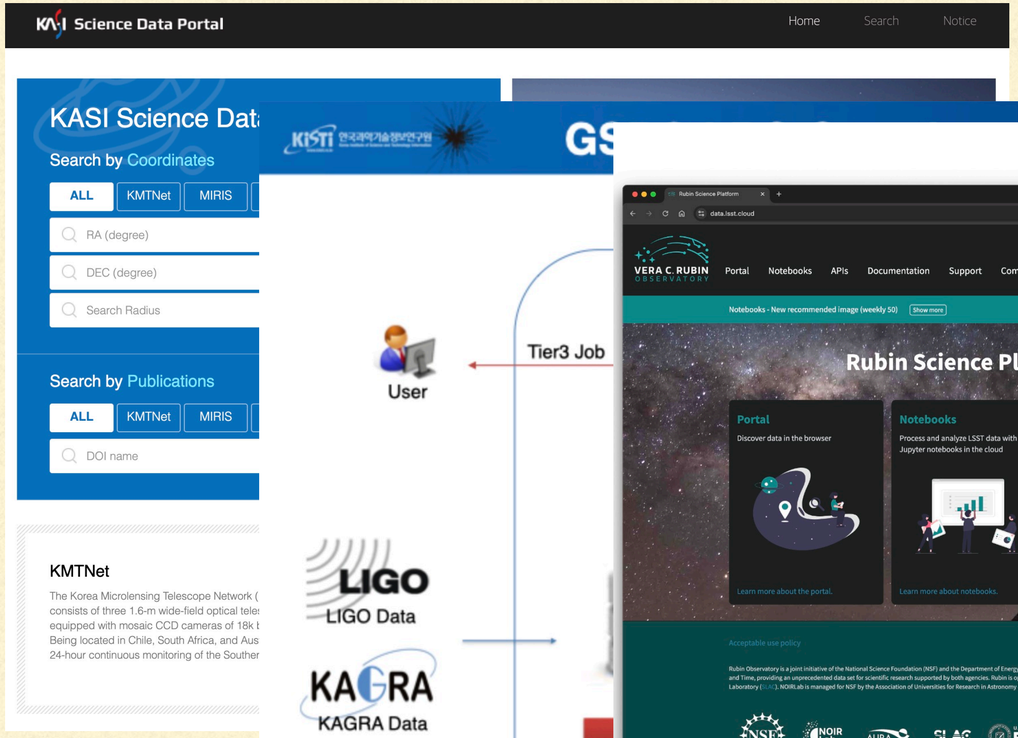
Scientific Discovery: Based on calculations performed using our resources, the STFC theory community publishes over **250 peer reviewed papers per year** in the top international journals

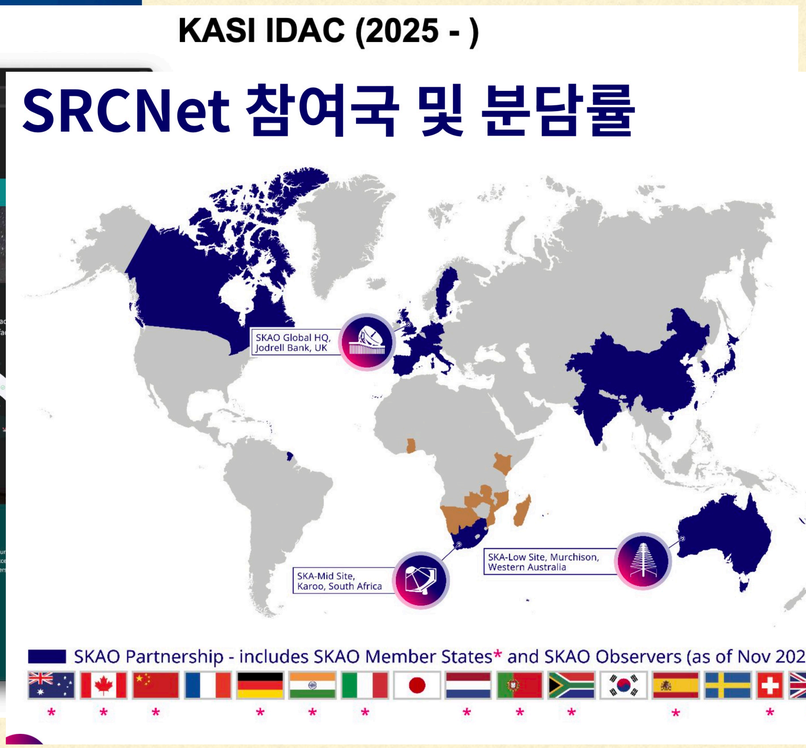
Investing in People: We train more than **100 early career researchers** in HPC skills annually, benefitting both the UKRI research community and the UK's wider economy by contributing to closing the digital skills gap.

Delivering UK-wide Innovation: Innovation is at the heart of the DiRAC facility, enhancing our service provision for the UK's world-leading STFC science theory programme and underpinning co-design relationships with our external partners.

국내 관측 데이터 아카이빙 & 보존

- 통합된 데이터 서버 및 스토리지 자원이 없음 (한계: 소규모, 분산, 일시성, 비효율성)
- 주요 센터의 지원이 없는 소규모 프로젝트의 데이터 관리 통합 필요
- SKA, Rubin LSST, SPHEREx, K-DRIFT, K-SPEC, 7DS 등등 (+태양, 달탐사, 우주환경, KVN 등등)

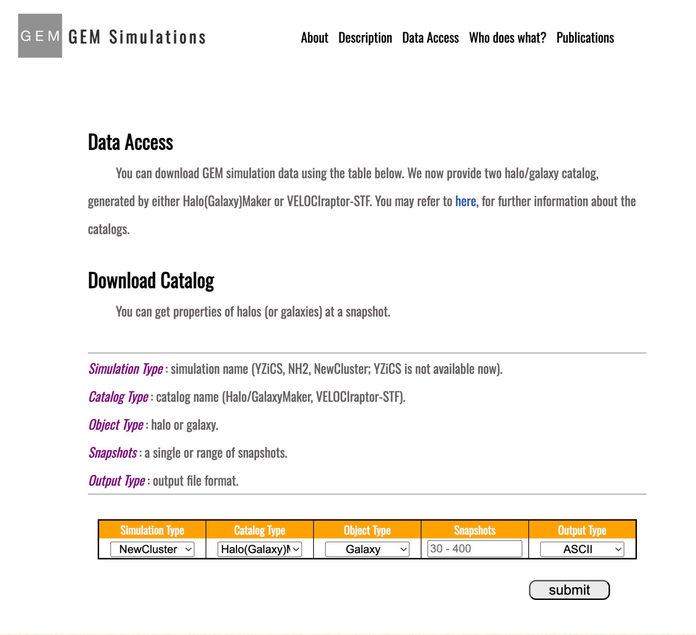


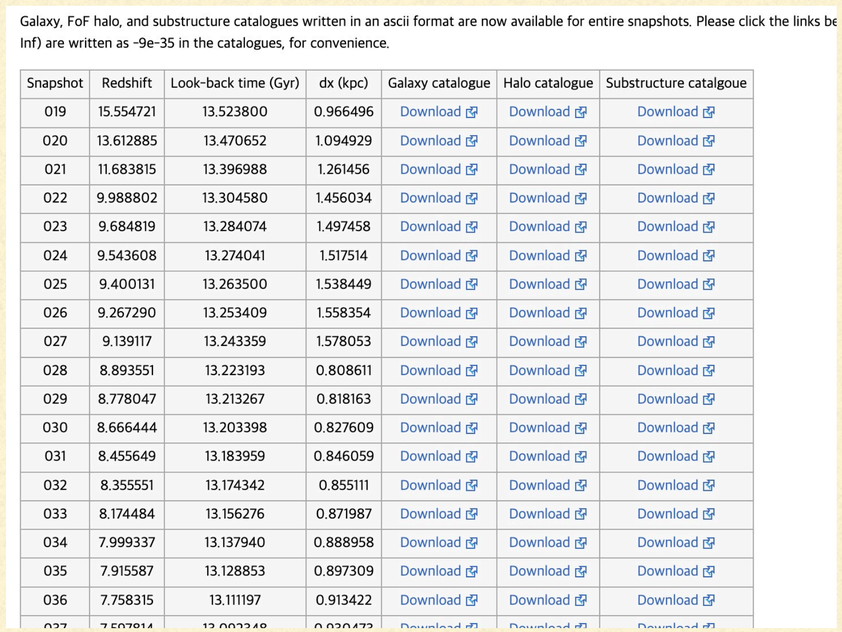


참여국	분담률 (%)	저장장치 (PB)	연산능력 (PFLOPS)
영국	19	201.4	6.65
남아공	18	190.8	6.30
호주	18	190.8	6.30
중국	10	106.0	3.50
캐나다	7	74.2	2.45
이탈리아	6	63.6	2.10
인도	5	53.0	1.75
프랑스	3	31.8	1.05
네덜란드	2	21.2	0.70
일본	2	21.2	0.70
스페인	2	21.2	0.70
포르투갈	2	21.2	0.70
스위스	2	21.2	0.70
스웨덴	2	21.2	0.70
한국	1	10.6	0.35
독일	1	10.6	0.35
합계	100	1060	35.0

국내 시뮬레이션 데이터 아카이빙 & 보존

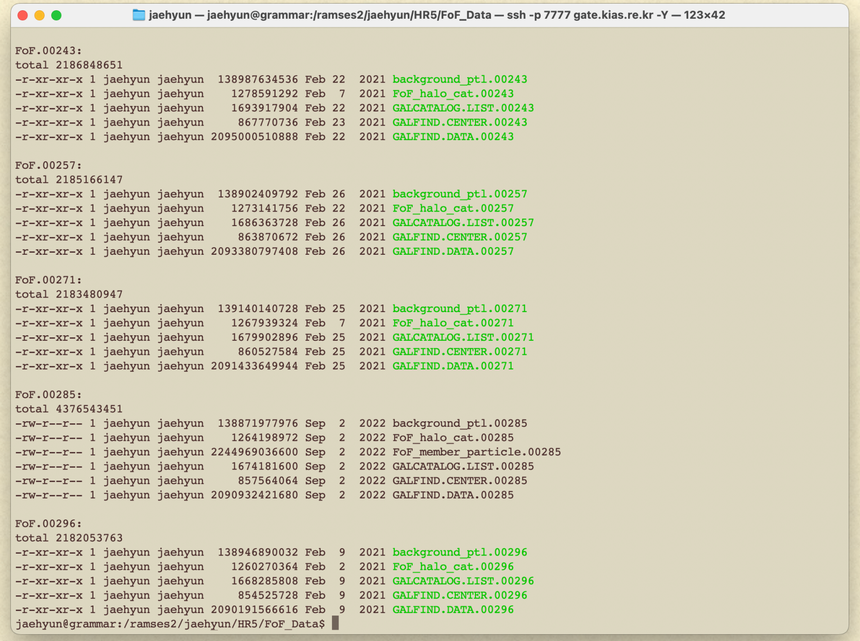
- 이석영교수님 연구그룹: 데이터 아카이빙 서비스 제공
  - NewHorizon, NewCluster,YZiCs (catalog, branch, raw data, mock image)
- HR5 공동연구자들을 대상으로 데이터 공유
  - 위키: catalog, 스토리지서버: raw data





Galaxy, FoF halo, and substructure catalogues written in an ascii format are now available for entire snapshots. Please click the links be
Inf) are written as -9e-35 in the catalogues, for convenience.

Snapshot	Redshift	Look-back time (Gyr)	dx (kpc)	Galaxy catalogue	Halo catalogue	Substructure catalgoue
019	15.554721	13.523800	0.966496	Download	Download	Download
020	13.612885	13.470652	1.094929	Download	Download	Download
021	11.683815	13.396988	1.261456	Download	Download	Download
022	9.988802	13.304580	1.456034	Download	Download	Download
023	9.684819	13.284074	1.497458	Download	Download	Download
024	9.543608	13.274041	1.517514	Download	Download	Download
025	9.400131	13.263500	1.538449	Download	Download	Download
026	9.267290	13.253409	1.558354	Download	Download	Download
027	9.139117	13.243359	1.578053	Download	Download	Download
028	8.893551	13.223193	0.808611	Download	Download	Download
029	8.778047	13.213267	0.818163	Download	Download	Download
030	8.666444	13.203398	0.827609	Download	Download	Download
031	8.455649	13.183959	0.846059	Download	Download	Download
032	8.355551	13.174342	0.855111	Download	Download	Download
033	8.174484	13.156276	0.871987	Download	Download	Download
034	7.999337	13.137940	0.888958	Download	Download	Download
035	7.915587	13.128853	0.897309	Download	Download	Download
036	7.758315	13.111197	0.913422	Download	Download	Download



```
jaehyun — jaehyun@grammar:/ramses2/jaehyun/HR5/FoF_Data — ssh -p 7777 gate.kias.re.kr -Y — 123×42

FoF.00243:
total 2186848651
-r-xr-xr-x 1 jaehyun jaehyun  138987634536 Feb 22  2021 background_ptl.00243
-r-xr-xr-x 1 jaehyun jaehyun     1278591292 Feb  7  2021 FoF_halo_cat.00243
-r-xr-xr-x 1 jaehyun jaehyun     1693917904 Feb 22  2021 GALCATALOG.LIST.00243
-r-xr-xr-x 1 jaehyun jaehyun      867770736 Feb 23  2021 GALFIND.CENTER.00243
-r-xr-xr-x 1 jaehyun jaehyun 2095000510888 Feb 22  2021 GALFIND.DATA.00243

FoF.00257:
total 2185166147
-r-xr-xr-x 1 jaehyun jaehyun  138902409792 Feb 26  2021 background_ptl.00257
-r-xr-xr-x 1 jaehyun jaehyun     1273141756 Feb 22  2021 FoF_halo_cat.00257
-r-xr-xr-x 1 jaehyun jaehyun     1686363728 Feb 26  2021 GALCATALOG.LIST.00257
-r-xr-xr-x 1 jaehyun jaehyun      863870672 Feb 26  2021 GALFIND.CENTER.00257
-r-xr-xr-x 1 jaehyun jaehyun 2093380797408 Feb 26  2021 GALFIND.DATA.00257

FoF.00271:
total 2183480947
-r-xr-xr-x 1 jaehyun jaehyun  139140140728 Feb 25  2021 background_ptl.00271
-r-xr-xr-x 1 jaehyun jaehyun     1267939324 Feb  7  2021 FoF_halo_cat.00271
-r-xr-xr-x 1 jaehyun jaehyun     1679902896 Feb 25  2021 GALCATALOG.LIST.00271
-r-xr-xr-x 1 jaehyun jaehyun      860527584 Feb 25  2021 GALFIND.CENTER.00271
-r-xr-xr-x 1 jaehyun jaehyun 2091433649944 Feb 25  2021 GALFIND.DATA.00271

FoF.00285:
total 4376543451
-rw-r--r-- 1 jaehyun jaehyun  138871977976 Sep  2  2022 background_ptl.00285
-rw-r--r-- 1 jaehyun jaehyun     1264198972 Sep  2  2022 FoF_halo_cat.00285
-rw-r--r-- 1 jaehyun jaehyun 2244969036600 Sep  2  2022 FoF_member_particle.00285
-rw-r--r-- 1 jaehyun jaehyun     1674181600 Sep  2  2022 GALCATALOG.LIST.00285
-rw-r--r-- 1 jaehyun jaehyun      857564064 Sep  2  2022 GALFIND.CENTER.00285
-rw-r--r-- 1 jaehyun jaehyun 2090932421680 Sep  2  2022 GALFIND.DATA.00285

FoF.00296:
total 2182053763
-r-xr-xr-x 1 jaehyun jaehyun  138946890032 Feb  9  2021 background_ptl.00296
-r-xr-xr-x 1 jaehyun jaehyun     1260270364 Feb  2  2021 FoF_halo_cat.00296
-r-xr-xr-x 1 jaehyun jaehyun     1668285808 Feb  9  2021 GALCATALOG.LIST.00296
-r-xr-xr-x 1 jaehyun jaehyun      854525728 Feb  9  2021 GALFIND.CENTER.00296
-r-xr-xr-x 1 jaehyun jaehyun 2090191566616 Feb  9  2021 GALFIND.DATA.00296
jaehyun@grammar:/ramses2/jaehyun/HR5/FoF_Data$
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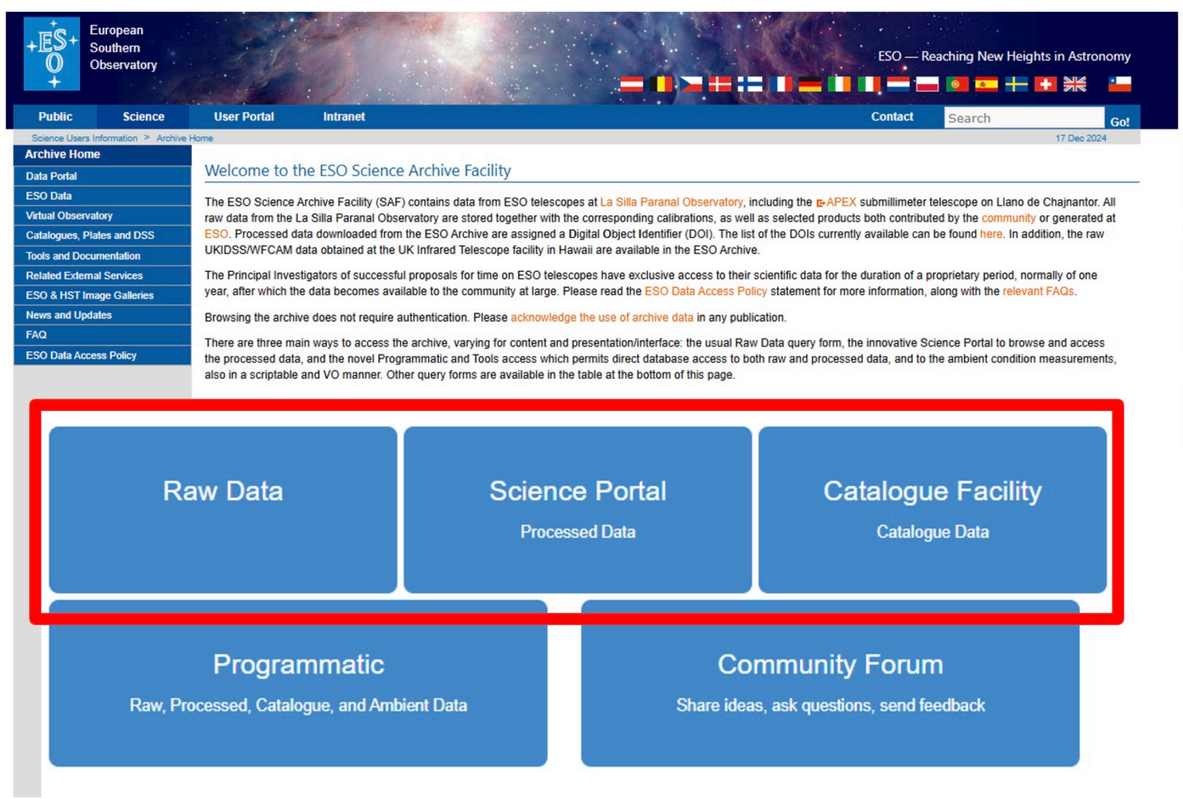
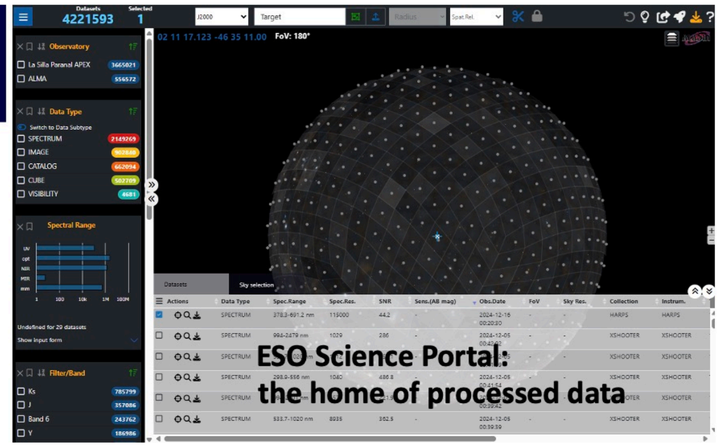
해외사례 (유럽) - 데이터센터

- ESO Science Archive Facility



https://archive.eso.org/cms.html
https://www.eso.org/public/science/archive/



- ESO OIR+radio: ~ 160 TB/yr
- Datasets: 4,221,593
- 64 catalogues
  - ESO public survey
  - Large programme
  - Other
- ALMA: >300 TB/yr?

해외사례 (미국) - 데이터센터

- NOIR Lab's Astro Data Archive, IPAC and IRSA

+ ANTARES, Gemini Observatory Archive, Software …



Provides access to *data* taken with more than 40 telescope and instrument combinations

>1.85 PB

About

NOIRLab Astro Data Archive

The NOIRLab Astro Data Archive (formerly NOAO Science Archive) provide to data taken with more than 40 telescope and instrument combinations, in those operated in partnership with the WIYN, SOAR and SMARTS consorti semester 2004B to the present. In addition to raw data, pipeline-reduced d products from the DECam, Mosaic and NEWFIRM imagers are also availab as advanced data products delivered by teams carrying out surveys and o observing programs with NSF OIR Lab facilities.

Holdings

Total holdings 19,829,288 | Total volume 1,853,233 GB

Telescope/Instrument	Total images	Vol
bok23m - 90prime	292,021	0.7
ct09m - ccd_imager	1,000,584	0.0
ct13m - andicam	2,591,254	0.1
ct13m - cpapir	46,039	0.0
ct15m - ccd_spec	323,473	0.0
ct15m - chiron	475,405	0.1
ct15m - echelle	575,055	0.2
ct1m - y4kcam	372,326	0.2
ct4m - arcoiris	49,025	0.0
ct4m - ccd_spec	17,101	0.0
ct4m - cosmos	36,828	0.0
ct4m - decam	7,333,423	93.
ct4m - hlsp_mosaic_2	1,113	0.0
ct4m - ispi	157,341	0.0

https://astroarchive.noirlab.edu/about/

Full length article

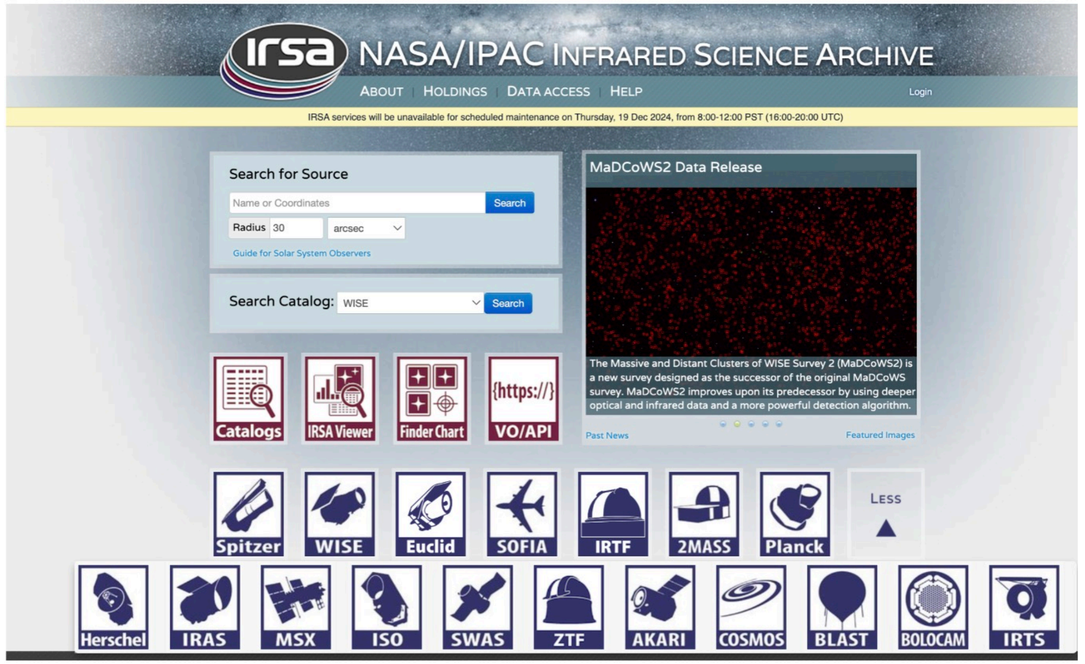
Data Lab—A community science platform

R. Nikutta, M. Fitzpatrick, A. Scott, B.A. Weaver

- Open-access science

IRSA: In the mid-90s, NASA designated IPAC as the US science support center for their infrared and sub-millimeter projects and missions. In response, IPAC formed the **NASA/IPAC Infrared Science Archive (IRSA) .**

Since its founding, IRSA has evolved to become the data center for a large number of space missions, including ISO, MSX, Spitzer, WISE/NEOWISE, Herschel, Planck, as well as ground-based telescope facilities such as 2MASS, PTF and ZTF.



해외사례 (호주) - 데이터센터

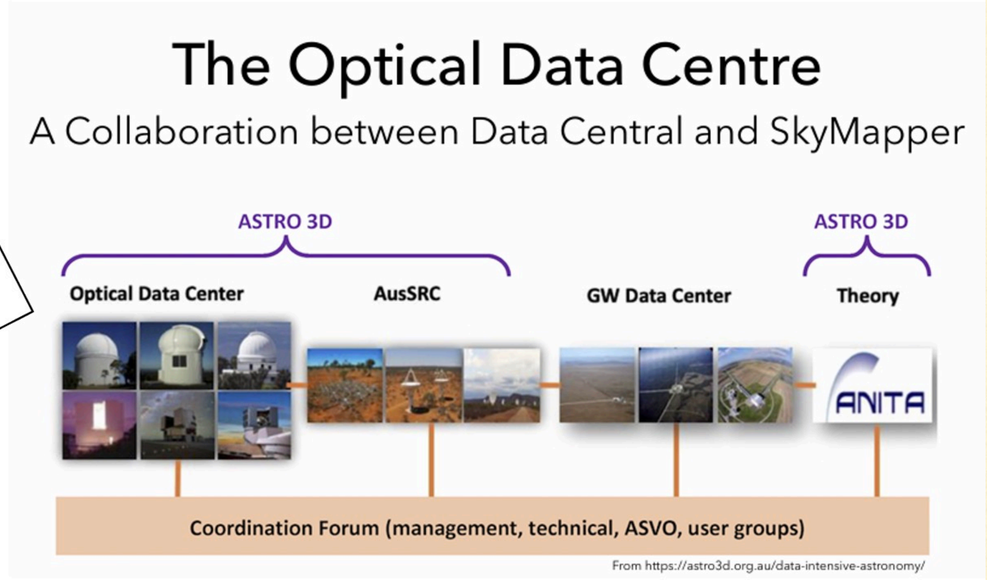
- All-sky Virtual Observatory & ODC



National eResearch Collaboration Tools and Resources (NeCTAR): https://asvo.org.au/

https://www.science.org.au/files/userfiles/support/reports-and-plans/2015/wg2_3-report.pdf

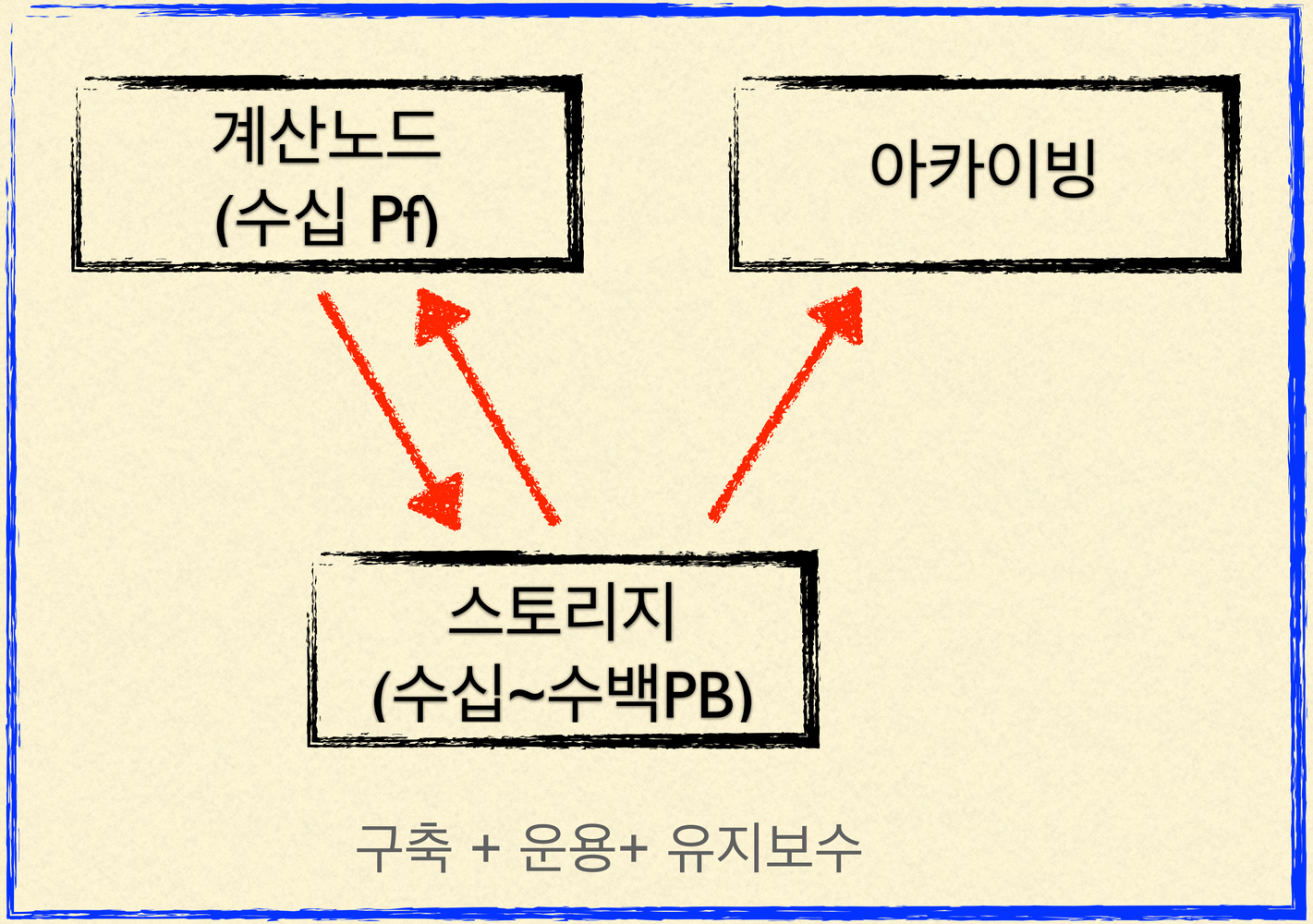
The decadal plan for Australian astronomy 2016–2025



The overarching goal of the ODC is to make all optical and infrared surveys conducted using the many different Australian facilities publicly available

필요한 전산시스템

- 통합된 데이터 저장, 처리, 관리
- 커뮤니티에 데이터 공유
- 데이터 생성
  - 시뮬레이션 데이터 생성
  - 관측 분석 데이터 생성



1. IBS 우주전문센터

- 우주 분야 초고성능컴퓨팅 전문센터로 지정 (22년 7월)
  - 과학기술정보통신부
- 국가 초고성능컴퓨터 활용 및 육성에 관한 법률 (약칭: 초고성능컴퓨터법)
  - 11년 제정, 22년 시행: 초고성능컴퓨팅 활용 고도화사업(DARWIN), 전문센터(IBS)
- 우주청 산하 우주전문센터?
  - 과기부로부터 예산을 받지 못한 상황
  - 의무만 있는 상황
  - 센터장의 의지가 큼 (과기부 관계자와 컨택 예정)

2. SKA 데이터 센터

- 우주청 25년 신규사업으로 예산 확정
  - 커뮤니티의 통합 데이터 센터로 확장 가능성
    - 연산능력을 확장한다면, 계산용으로 활용 가능

SKAO 지역센터 네트워크

- **SKA 과학 아카이브를 호스팅**
- SKAO 참여국 전역에 글로벌하게 분산된 **SKAO 지역센터들의 협력적이고 연합된 네트워크**
- **데이터 저장·처리 및 협업 공간을 제공**
- SKA 과학 커뮤니티를 지원 및 교육
- SKA의 과학적 생산성과 영향을 극대화

한국 SKAO 지역센터

- **SRCNet 한국 노드 구축 및 운영**
- SRCNet 전산자원의 **1% 분담**
- 국내 연구자의 **SKA 데이터 접근 및 분석 환경 제공**
- 국내 SKA 과학 커뮤니티 지원 및 교육
- 우수한 과학적 성과 창출을 위한 환경 조성

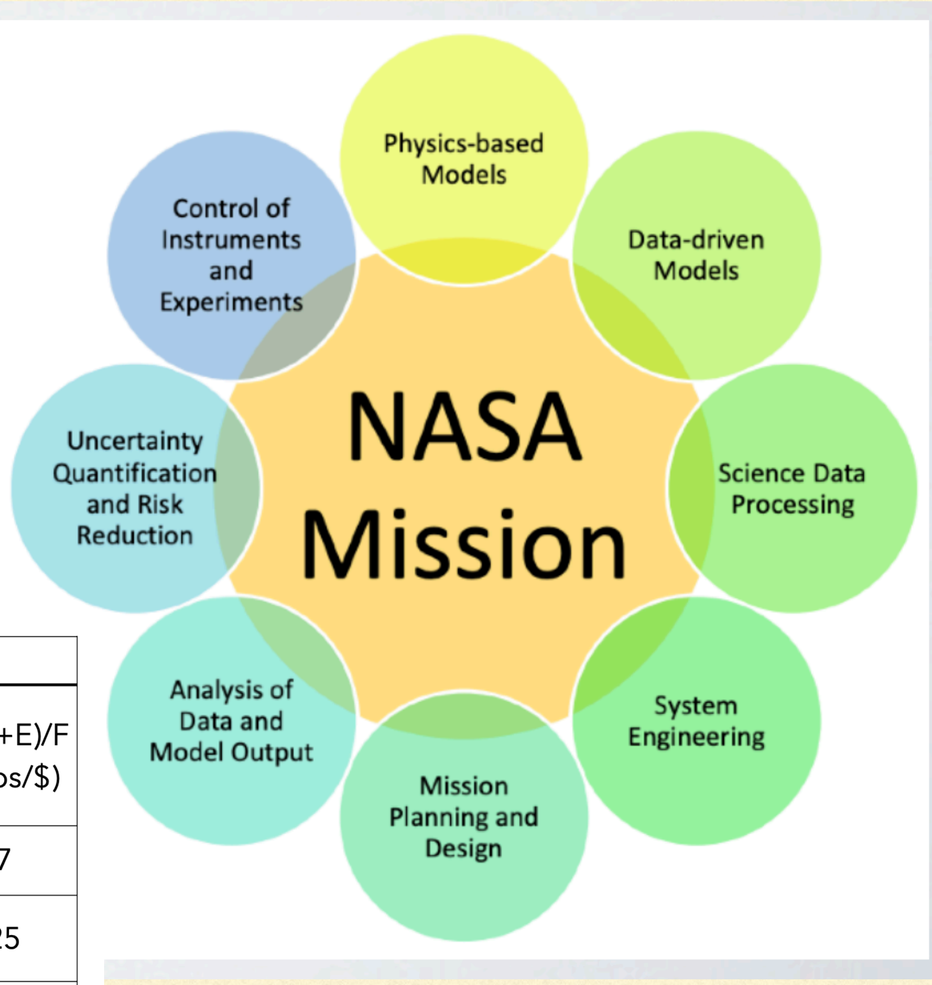
krSRC 자원 확보 계획

년도		2025	2026	2027	2028	2029*	2030	2031	2032	2033	2034
연산능력 (TFLOPS)		7	35	52.5	175	350	420	490	560	630	700
저장장치** (PB)	Tier 0 (cached)	0.01	0.05	0.08	0.26	0.53	1.2	1.8	2.4	3.0	3.6
	Tier 1 (online)	0.21	1.06	1.59	5.3	10.6	10.6	10.6	10.6	10.6	10.6
	Tier 2 (near-line)	-	-	-	-	10.6	21.2	31.8	42.4	53.0	63.6

– SRCNet 분담률(~1%)에 따른 자원 요구량

3. 우주청 26년 신규사업 신청

- 장기발전위원회 차원에서 2월말까지 제안
  - 전산데이터센터 구축: 자료시설 / 전산시설
  - NASA, JAXA 사례



	A	B	C	D	E	F			
	천문학 전용머신 (Pflops)	우주과학 전용머신 (Pflops)	합 (A+B) (전용머신) (Pflops)	슈퍼컴 (천문학 프로젝트) (Pflops)	공용머신 (Pflops)	GDP (Trillion $)	C/F (kflops/$)	(C+D)/F (kflops/$)	(C+D+E)/F (kflops/$)
미국		35.78/AMES	35.78	1,600/Frontier	89.4/Perlmutter	22.3	1.6	73	77
일본	5/NAOJ	20.64/JAXA	25.64		513/Fugaku	4.3	6.0	6.0	125
영국	3/COSMA		3		28/Archer2	3.3	0.9	0.9	9
호주	2/PSRC		2		10/Gadi	1.7	1.2	1.2	7
한국	0	0	0		17.5/Nurion +2/ Olaf + 1/ Grammar	1.7	0	0	12