China SRC team Introduction Role and Contributions

Tao An
China SKA Regional Centre team
Shanghai Astronomical Observatory

antao@shao.ac.cn
cnSRC operation:
shaoska@shao.ac.cn

Outline

1. China SRC：development (2015 - 2019)
2. China SRC：current status and SRCNet prototyping (2019 - 2024)
3. Summary (2024 -)

1. China SRC：development

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2016 SKA workshop on SDP&HPC

- First international workshop on SKA computing and data challenges
- Shanghai proposed ambitious plan to support SHAO in hosting the SKA Asian Science Centre
- Shanghai's commitment to playing a key role in this frontier science project

SKA亚洲科学中心建设项目已列入上海市科技创新“十三五”规划,希望上海市能成为承载SKA项目的重要城市

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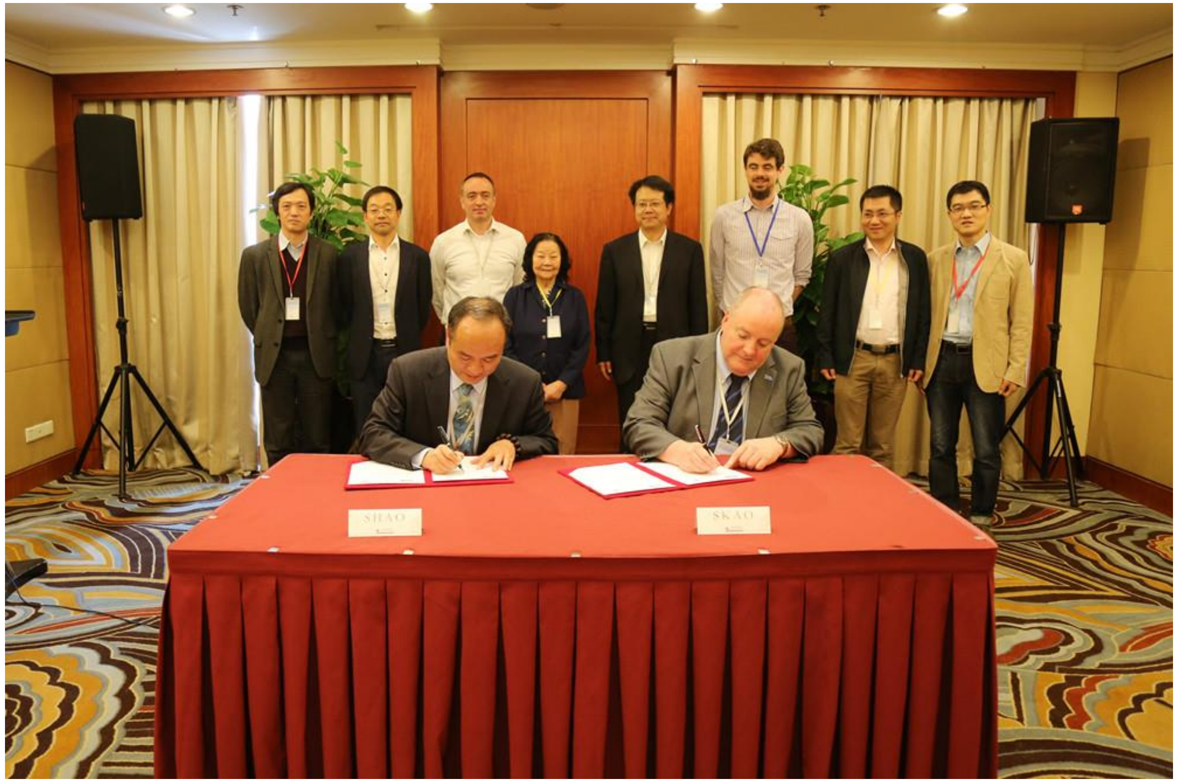
SHAO engages in SKA and SRC

Shanghai Observatory signed MoUs with SKAO and ICRAR. Solidifying Shanghai's participation and contributions in SKA Regional Centre



Pioneering SRCNet concept study: ERIDANUS

- ICRAR, SHAO, CSIRO
- Asia-Pacific SRC network concept - one of major conceptual programs
- Objectives:
  - foster academia-industry collaborations
  - Personnel training
  - Infrastructure preparation
- Outcomes
  - Aus-China SKA big data workshop
  - Successful 5Gbps data transfer bw Shanghai-Perth
  - personnel & expertise exchange

The ERIDANUS Project is a three year, **bottom-up**, design study aimed at deploying a prototype of data intensive research infrastructure and middleware between & within Australia and China, capable of addressing SKA-class data and processing challenges using SKA precursor science projects and telescopes.

2017/2018 SKA Big Data Workshops in Shanghai

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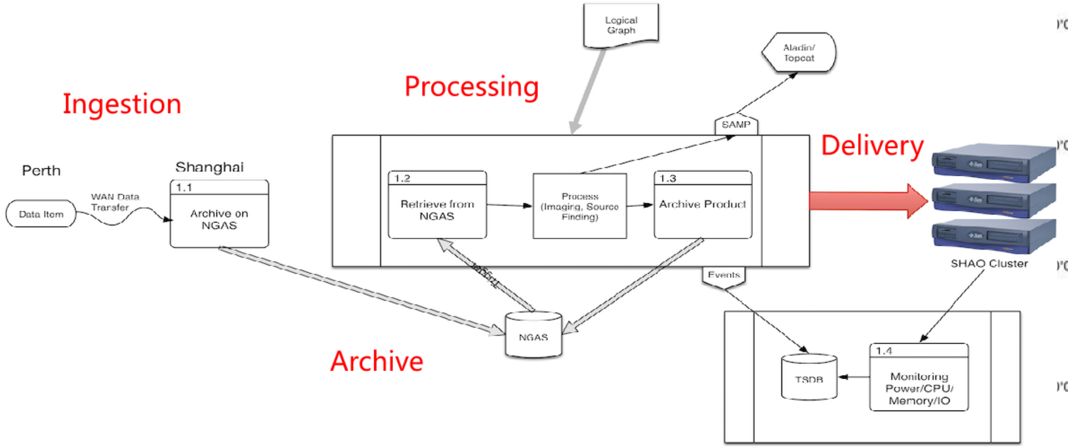
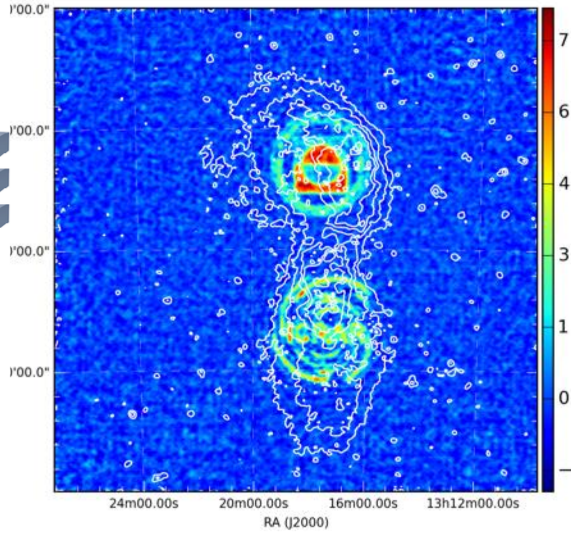
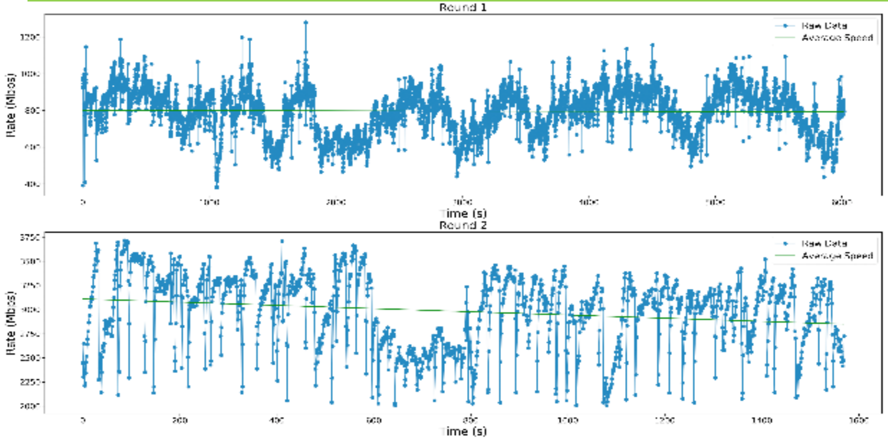


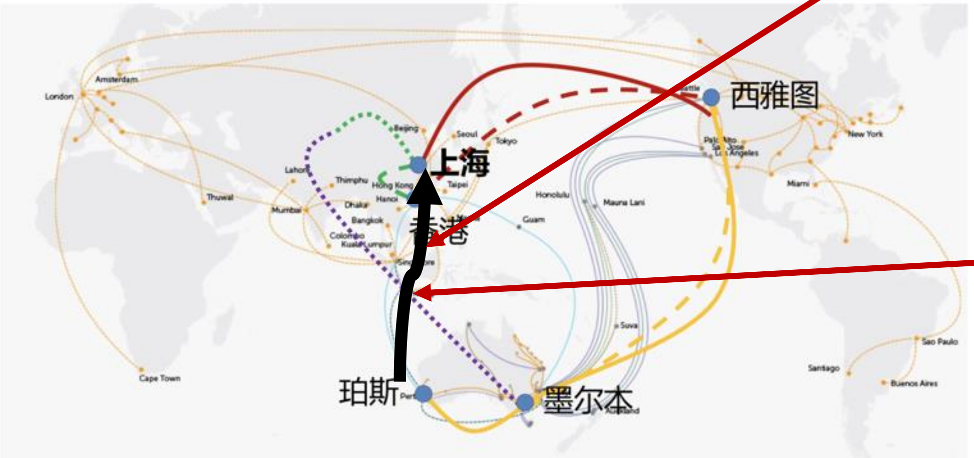


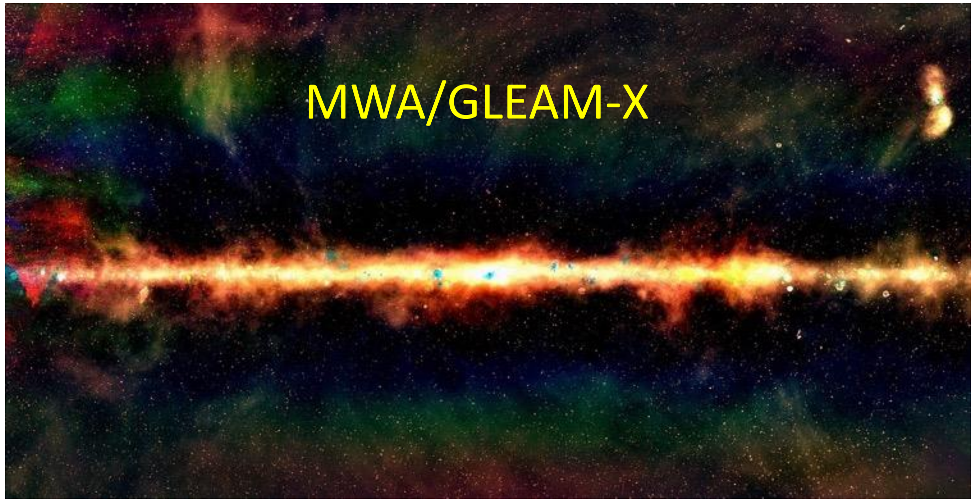
Transcontinental Big Data Transfer - Technical Challenges and Explorations for Future SRC Operations

Shanghai – Perth 5 Gbps

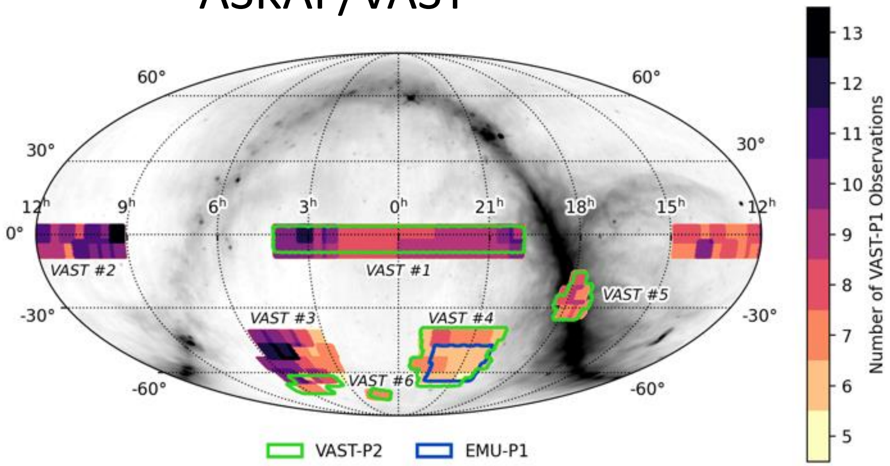


中国科技网(CSTNET)



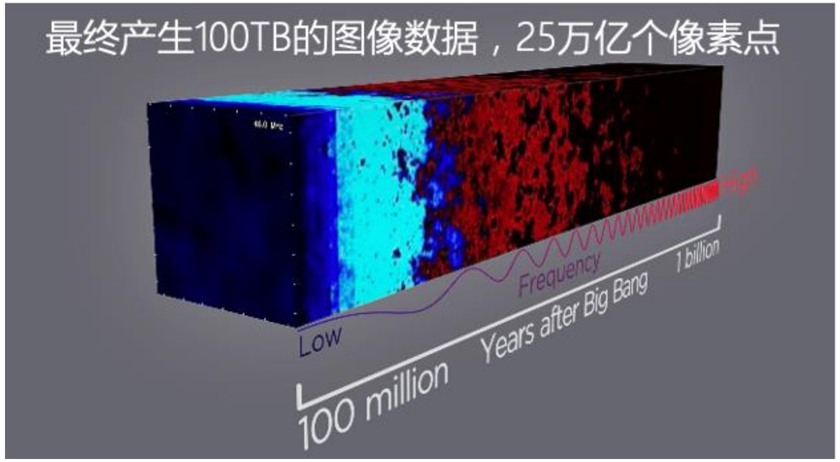


ASKAP/VAST



SKA shakes hands with SUMMIT

- **LARGEST** SKA workflow, the largest workflow in astronomy by ICRAR, ORNL, SHAO
- Simulated 6 hours of EoR observations, peak workflow required 99% of world's #1 SUMMIT (~200Pflops), SKA is a real big data challenge!
- "data acquisition (**SKA-Low**) - calibration - imaging - post-processing (**SDP**) - intercontinental transmission - deep imaging (**SRC**)" – showcase **SKAO-SRCNetwork**
- Scientists have technical tools for processing SKA big data!
- Recommended by DG, in **2020 Gordon Bell Prize ('Nobel Prize in HPC') finalist**



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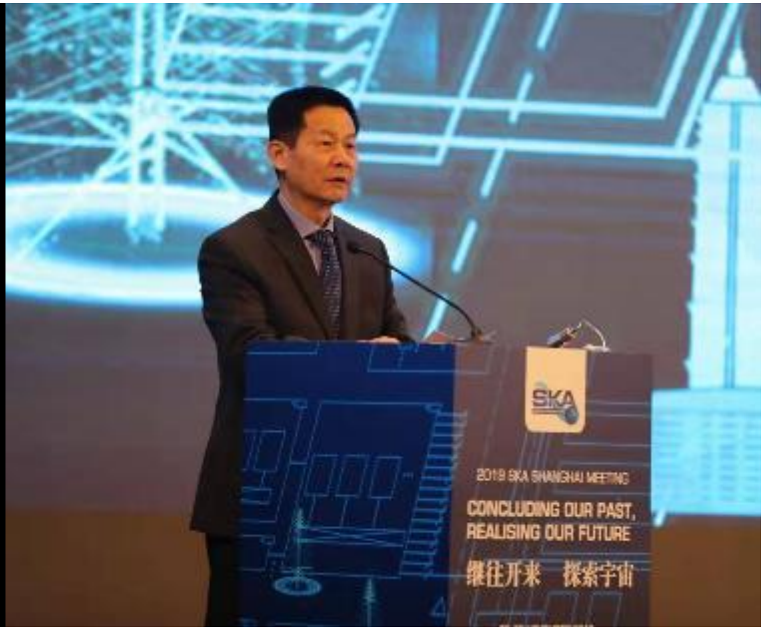
Milestone: first SRC prototype in 2019

- 2019 SKA Engineering Meeting, co-hosted by the SKAO and MOST
- 200+ scientists and engineers all together in Shanghai China
- **5 Days seminar + 2 telescope site visit + 1 Demon + 1 Prototype**
- Chinese major contributions: **first SKA-Mid antenna prototype, first SRC prototype**
- **A key milestone of SRC: Concept -> Prototype**



China SRC prototype: milestone

- China team exhibits China SRC prototype, high praise from community
- The prototype was recognized as the world's first dedicated SKA Regional Centre prototype, making a significant contribution to the SKA project.
- International review panel led by SKA D-G and SRC Chair acknowledged China's leading role in technical validation, standard setting and practice.


China SKA Regional Centre Prototype Review

Strengthen International Cooperations

Supporting Science Users

Powering Groundbreaking Discoveries

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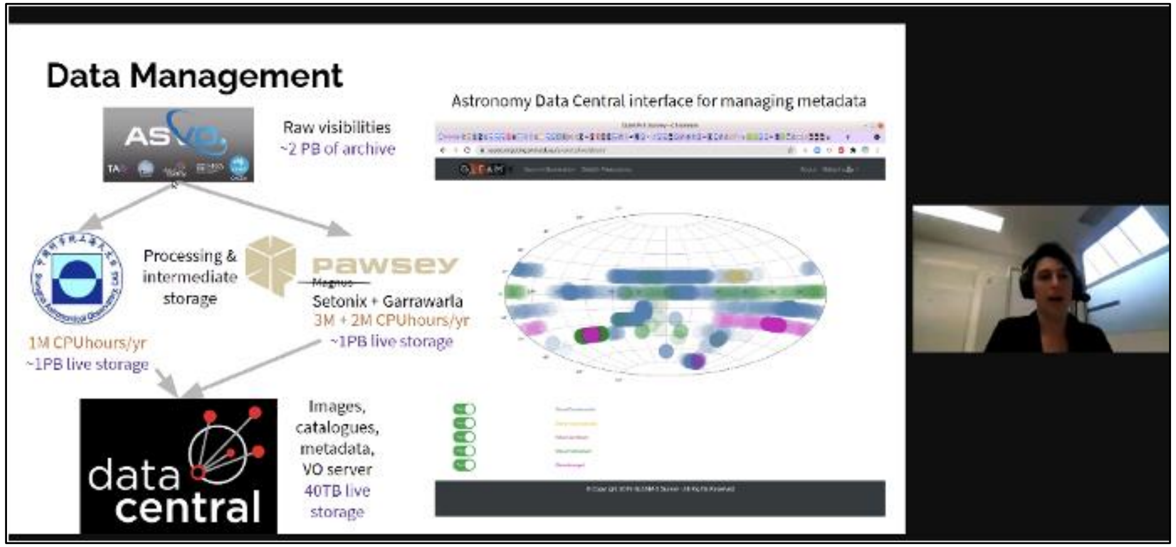
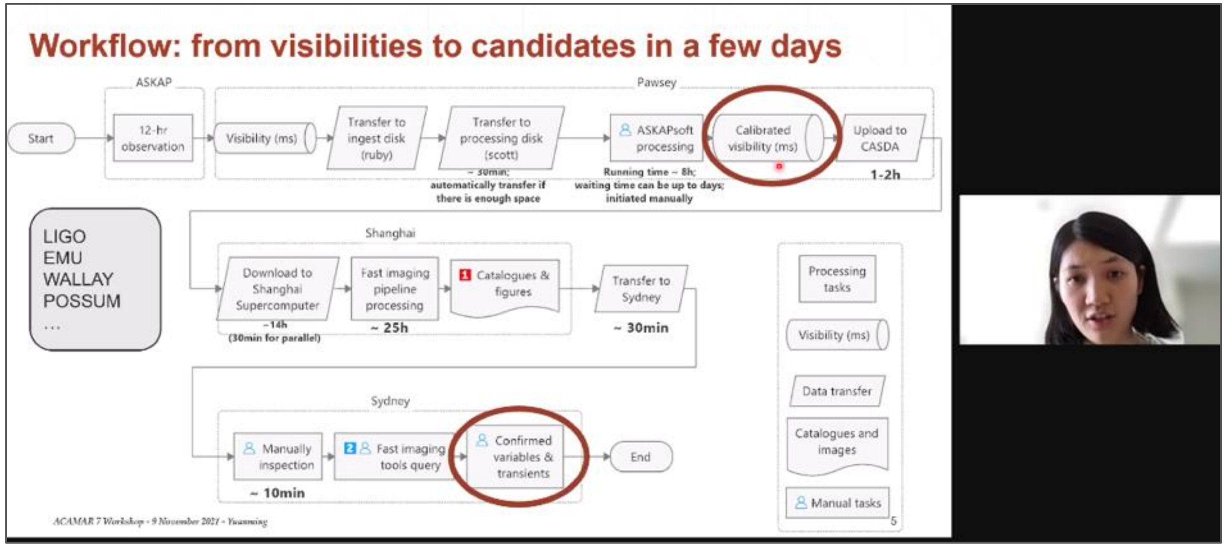
- MWA/GLEAM-X
- ASAKP/ VAST
- Others : ASKAP/FLASH, POSSUM, EMU





GLEAM-X PI：
ChinaSRC is one of the data processing facility,
Nature publication

Optimize pipeline for VAST data processing
Faster, Image with better quality， more efficient
Integrable to large scale supercomputer
also fit in other ASKAP pipeline

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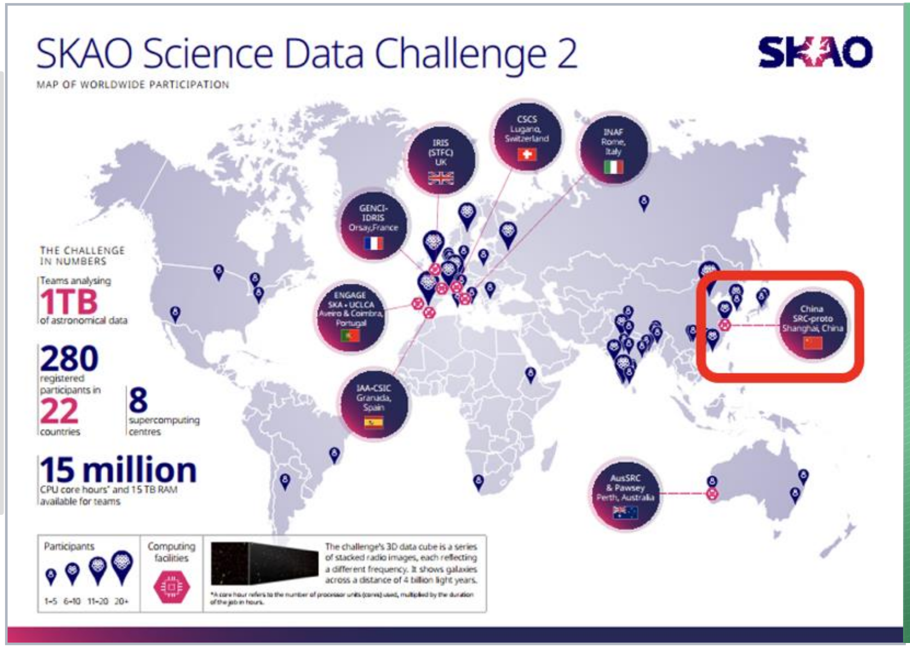
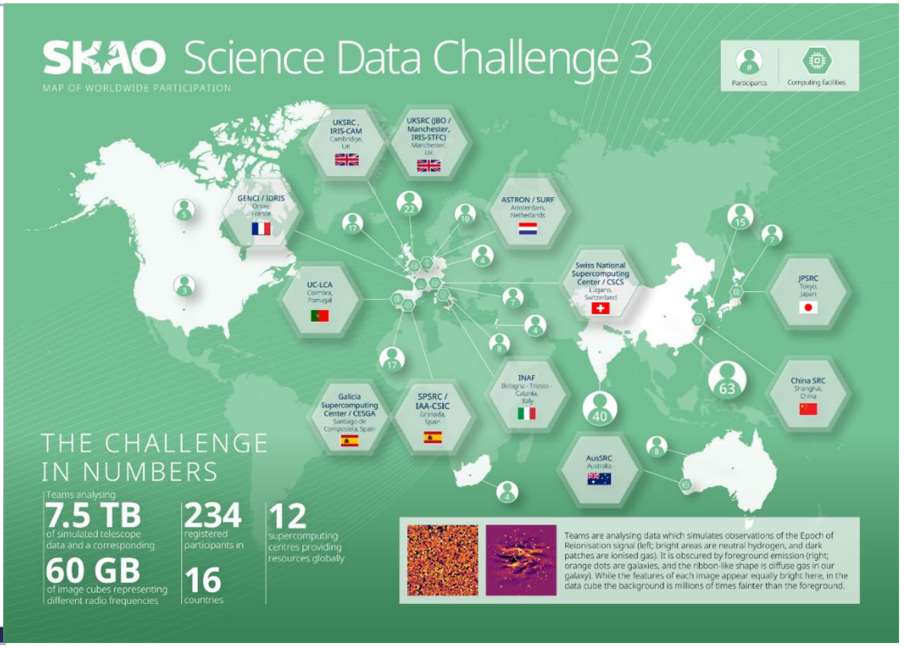
SKA Data Challenges

- SDC1: participation, Shanghai team obtained final highest score
- SDC2: support 5 teams, two submitted
- SDC3: China SRC support 3 teams, and 4 downloading only teams
- supported the largest number of teams and participants among the 12 global nodes

Table 5. $G_{\rm tot}$ and $A_{\rm tot}$ metrics for all teams, in order of decreasing $G_{\rm tot}$. $G^{*}_{\rm tot}$ is the total score achieved by the deadline of 30th April 2019, which determined the SDC1 leaderboard[7]

Teams	$G_{\rm tot}$	$G^{*}_{\rm tot}$	$A_{\rm tot}$
Shanghai	19112.8	-33226.1	19419.7
ARCIt-CACAO	17361.3	2733.58	24684.6
ICRAR	5265.56	5265.56	11691.1
EngageSKA	4160.33	4160.33	16666.6
IITK	-4.58427	-4.58427	0.746315
hs	-9325.29	-9325.29	684.933
JLRAT	-10625.9	-53069.4	64752.6
IPM	-196237	-196237	4356.57
IPM2	-533625	-	28973.2





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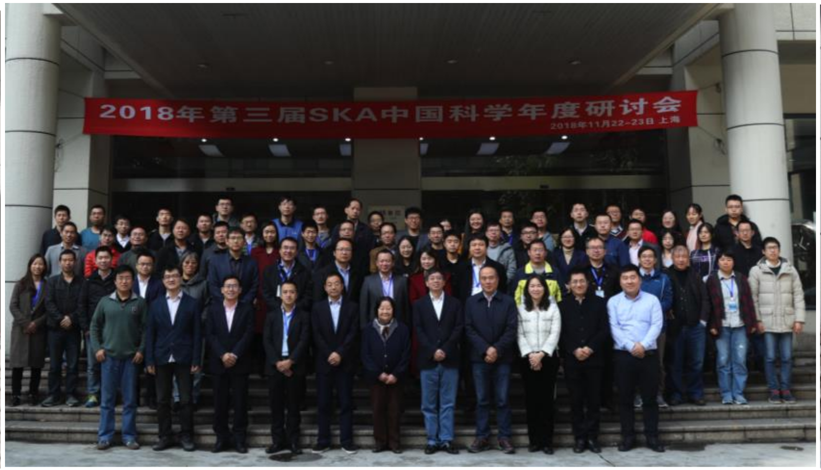
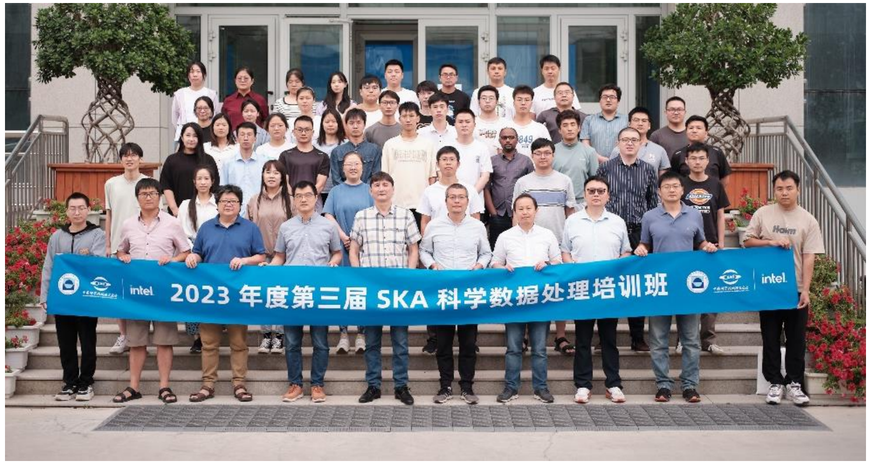
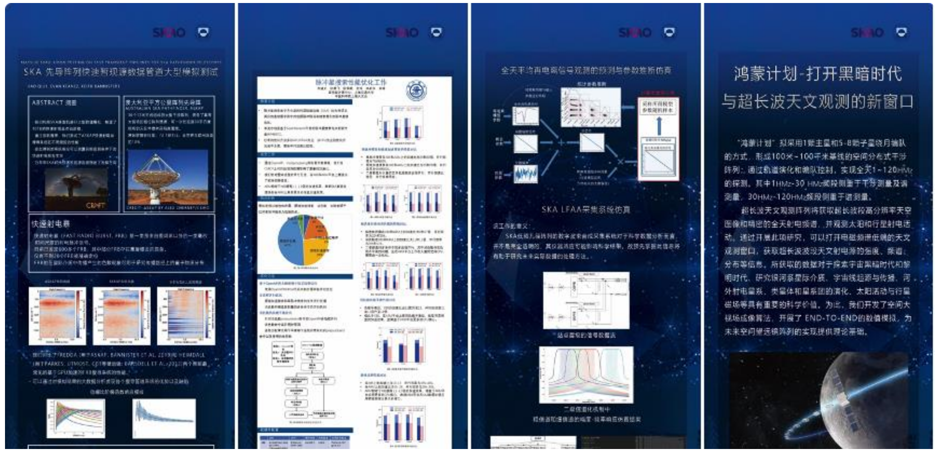
Summer Schools

- Training SKA students and young researchers
- SKA summer schools



SKA Data Processing Summar School





2. China SRC: current status

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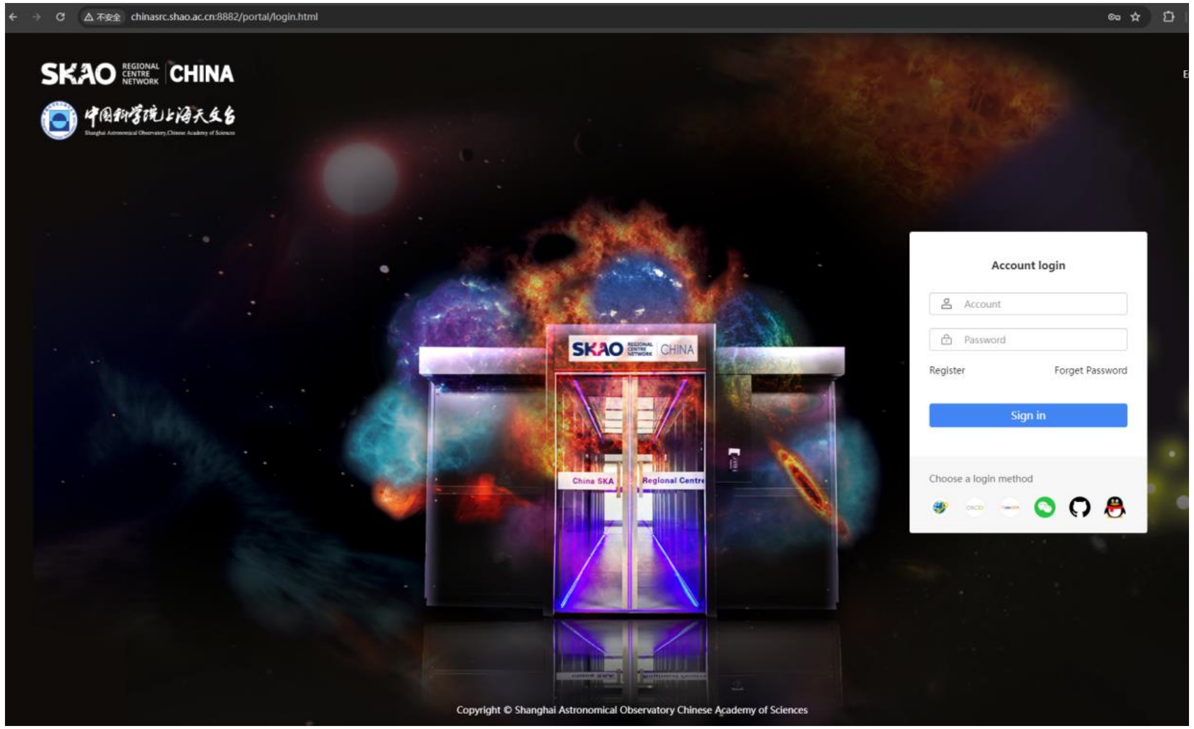
China SRC prototype: status (2024)

- Compute:
  - 35 Intel x86 CPU nodes -> 2400 cores
  - 12 ARM CPU nodes -> 1152 cores, max 96 cores/node
  - 4 GPU nodes -> 16 Nvidia V100, 8 A40
- Storage and file system: 9PB
- Inter-connection: 100-200Gb/s IB connection
- Memory: 84TB in total, 4TB/node (max), 36GB/core (max)
- Tran-continental internet:
  - 10 Gbps international network for datalake;
  - 100 Gbps to be considered by 2026;
  - 200 Mbps routine links with other SRC nodes




SKAO CHINA
China SRC
16:51 17
Friday
March 15, 2024
Hardware Resource
Compute Node 52 node
CPU Cores 3568 cores
Memory 84TB
GPU Cards 24 cards
Shared Storage 9PB
Computing Capability 985 Tflops
Resource Utilization
Worker Node (PCS) 20%
CPU (core) 2%
GPU (card) 0%
Memory Capacity (TB) 12%
Software Usage
The platform has installed a total of 42 shared softwares
Instance Software 4 PCS
Cluster Software 38 PCS
Instance Software
Cluster Software
Top 10 Instance Software
25
20
15
10
5
0
Centos 19
Docker 17
Difmap 13
PGPLOT 10
Jupyterlab 9
Gaussian 8
Windows 5
Public-Cluster-ARM 4
Public-Cluster 3
图形桌面 2
User Distribution
Registered Users 246 people
Research Team 78 PCS
Top 10 Registered Users Department
中国科学院上海天文台 54
28
中国科学院新疆天文台 25
中国科学院国家天文台 16
云南大学 15
上海交通大学 10
ICRAR/UWA 7
中山大学 6
skao 5
CSIRO 5
Running Information
Submitted Job 430353 times
Allocated Instance 123 PCS
CPU Running Time 418 10,000 Core Hours
GPU Running Time 2.7 10,000 Card Hours
Number Of Running Jobs 5
Number Of Running Instances 10
Number Of Pending Jobs 1
Number Of Queuing Instances 0
Average Computing Time 42 Minute
Average Queuing Time 75 Minute
Top 10 Submitted Jobs by Users TOP10
郭绍光 中国科学院上海天文台 228537
Yuanming Wang USYD悉尼大学 98807
张仲莉 中国科学院上海天文台 43828
顾俊骅 中国科学院国家天文台 14275
张仲莉 中国科学院上海天文台 13127
徐志骏 中国科学院上海天文台 5551
余婷 中国科学院上海天文台 5049
王俊义 桂林电子科技大学 4287
张仲莉 中国科学院上海天文台 3044
ywlee 悉尼大学 2765
Top 10 Department by Computing Hours TOP10
中国科学院上海天文台 2601577
中国科学院国家天文台 378072
桂林电子科技大学 274795
其他 170323
悉尼大学 112055
上海交通大学 111549
云南大学 71530
中国科学院新疆天文台 24498
Xinjiang Atronomical Observetory 17322
USYD悉尼大学 17301

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China SRC: Tailored for SKA's Data Processing Demands

- **Hybrid Heterogeneous Architecture**: a mixed architecture that can flexibly meet various resource requirements, including compute-intensive, data I/O-intensive, and memory-constrained tasks.
- **Data Constellation**: SKA bottleneck: data movement
  - Idea: Place compute close to data; Solution: Highly integrate compute, storage, and network to reduce data movement and improve efficiency
- **Optimized Efficiency**: optimized the system for computational efficiency, memory input/output capacity, and data input/output bandwidth.
- **High-Speed Network Interconnectivity**: 100/200Gbps, accelerates data processing for complex computations.

Example: China SRC prototype vs traditional HPC

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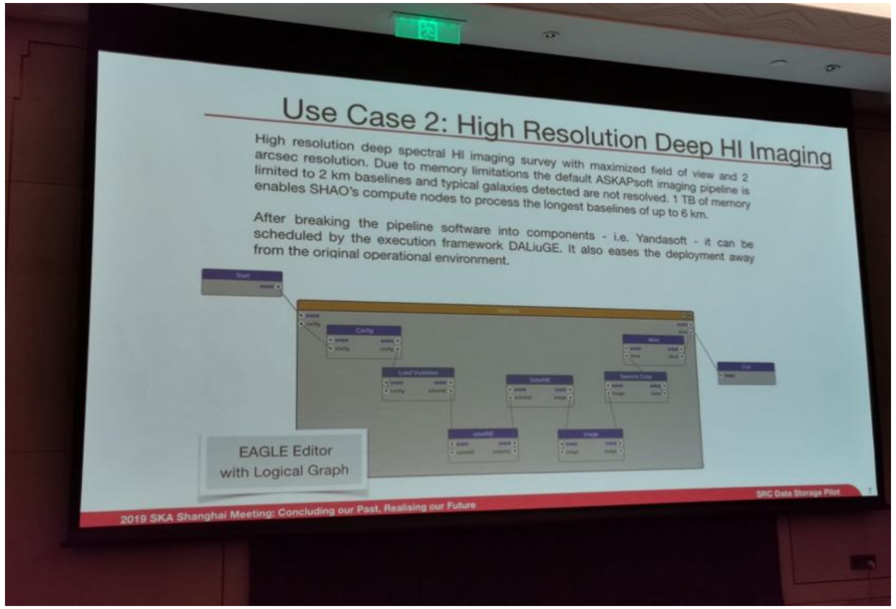
- Traditional HPC: compute intensive
- SKA: large data volumes, large file sizes, lots of small files -> Data intensive, memory constraints, I/O constraints ->
  - High performance computing nodes
  - Large memory size, memory bandwidth
  - parallel computing and scalable file systems, High bandwidth, low latency storage
  - High-bandwidth networking



ICRAR reports on China SRC prototype vs CSIRO servers during the 2019 SKA Engineering Meeting

- Example: 4 TB of memory per node enables SHAO's compute nodes to process the longest baselines of ASKAP up to 6 km.

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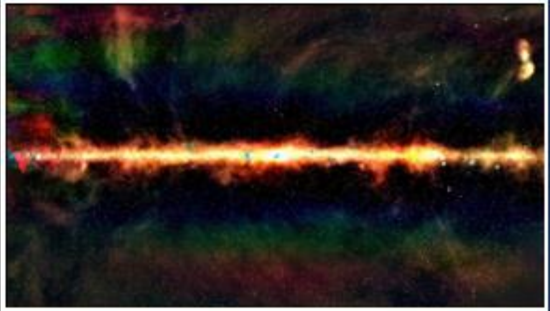
Sciense user case 1

The GLEAM pipeline and workflow in ChinaSRC

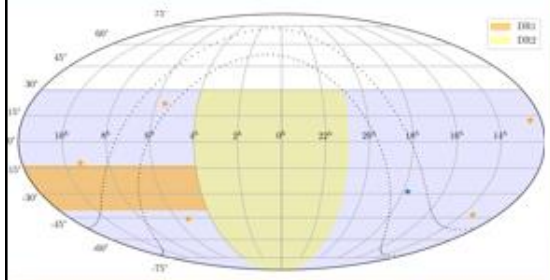
- The GLEAM survey is the largest radio continuum survey in the southern hemisphere, mapping the entire sky below 30° declination from 72 to 231 MHz.
- MWA Phase II doubled the observing tiles and baselines, enhancing sensitivity and resolution, but increasing data processing complexity.
- ChinaSRC has deployed the GLEAM-X pipeline and will support GLEAM-X and POGS-X projects, enabling groundbreaking discoveries in cosmological magnetism.



GLEAM and GLEAM-X

GLEAM (Hurley-walker et al. 2017)

- Sky coverage: 24402 deg^2
- Sources detected: 307456
- Astrometric offset: -4±16″ in R.A. and 0.1 ±3.6″ in Dec
- Rms noise: 11.3 ± 7.3 mJy $beam^{-1}$
- PSF size: 152 ± 25 arcsec (major), 134 ± 12 arcsec (min)



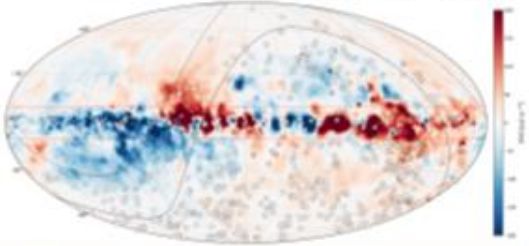
GLEAM-X DR1: (Hurley-walker et al. 2022)

- Sky coverage: 1447 deg^2
- Sources detected: 78967
- Astrometric offset: 14±700 mas in R.A. and 21 ±687 mas in Dec
- Rms noise: 1.3 ± 0.2 mJy $beam^{-1}$
- PSF size: 77 ± 12 arcsec (major), 61 ± 6 arcsec (min)

GLEAM-X pipeline: https://github.com/GLEAM-X/GLEAM-X-pipeline

The POGS series

The POlarised GLEAM Survey



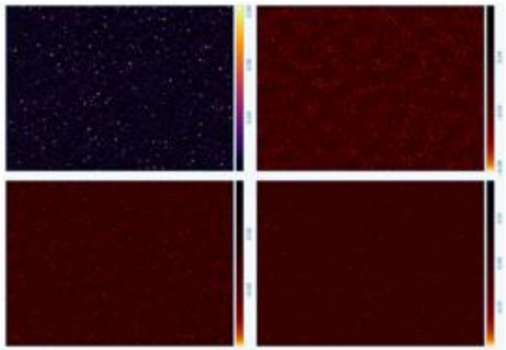
- Goals: All-sky precision RMs for precision magnetism science
- Discovered polarized radio sources:
  - 486 AGN
  - 33 pulsars

POGS-X: Polarisation based on GLEAM-X data

- Challenges:
  1. A specific pipeline with polarization calibration still wait to be made
  2. Leakage and RM-grid calibration
     - Per channel data should be made and check (768 per band)
     - Huge resources needed (several PB storage, computing memory and hours)
  3. New Source finding technique needed

ChinaSRC put effort on POGS-X:

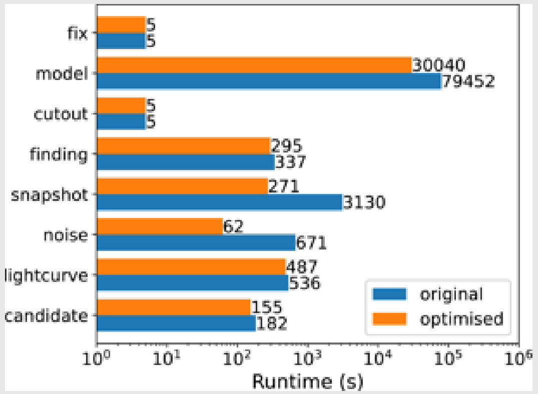
- Starting specified pipeline for polarization:
  - https://gitlab.com/ykzhang/gleamx-pipeline-chinasrc.git
- Extra resources
  - Newly deployed system for POGS-X



Sciense user case 2

An optimized transient detection pipeline for the ASKAP Variables and Slow Transients (VAST) survey

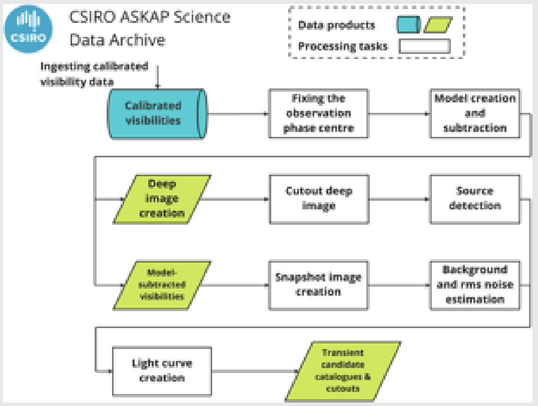
- The universe is full of high-energy transient events, offering insights into cosmological phenomena like gamma-ray bursts and fast radio bursts.
- Large-scale surveys like ASKAP's VAST are designed to detect and characterize a wide range of transient and variable objects across the electromagnetic spectrum.
- This paper presents an optimized transient detection pipeline for VAST, improving processing efficiency and imaging fidelity to handle ASKAP's vast data volumes effectively.



Pipeline Optimization

The document outlines the initial transient detection pipeline and the subsequent optimization process. The VAST team initially developed a pipeline that processed data from ASKAP's 36 beams independently, involving various steps like ingesting calibrated visibility data, fixing the observation phase center, creating deep sky models, and generating snapshot images. However, the most time-consuming step involved making a deep CLEAN model and subtracting it from the visibility data, which accounted for 93.98% of the total run time.

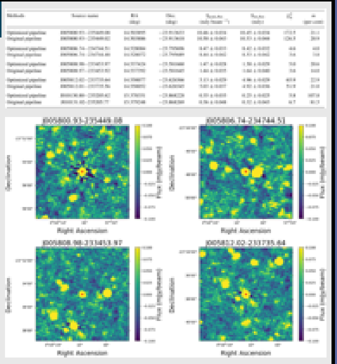
To address this, the team replaced the w-projection imaging algorithm with a w-stacking algorithm implemented in the WSClean software. This change resulted in a threefold increase in overall processing efficiency. The optimization also led to lower noise levels and fewer artefacts in the residual images, suggesting an enhancement in detection accuracy and imaging fidelity.



Experiments

SB9602 beam29

The images in the figure show a clear view of the central 200× 200 pixel region around each detected source (red cross).



DALiuGE

The optimized pipeline was integrated into the Data Activated Liu Graph Engine (DALiuGE), specifically designed for exascale graph processing and handling big data challenges posed by SKA-scale surveys. The implementation process involved AppDrop development, Logical Graph creation, and graph deployment, which was then translated into a physical graph template using the METIS algorithm for optimal resource utilization and pipeline efficiency.

Performance tests demonstrated that the DALiuGE-based execution of the optimized pipeline was faster, more stable, and scalable compared to traditional parallel methods like MPI and BASH. It managed to maintain consistent runtimes across varying data sizes, which showcases its suitability for processing the large-scale data expected from the SKA

Summary

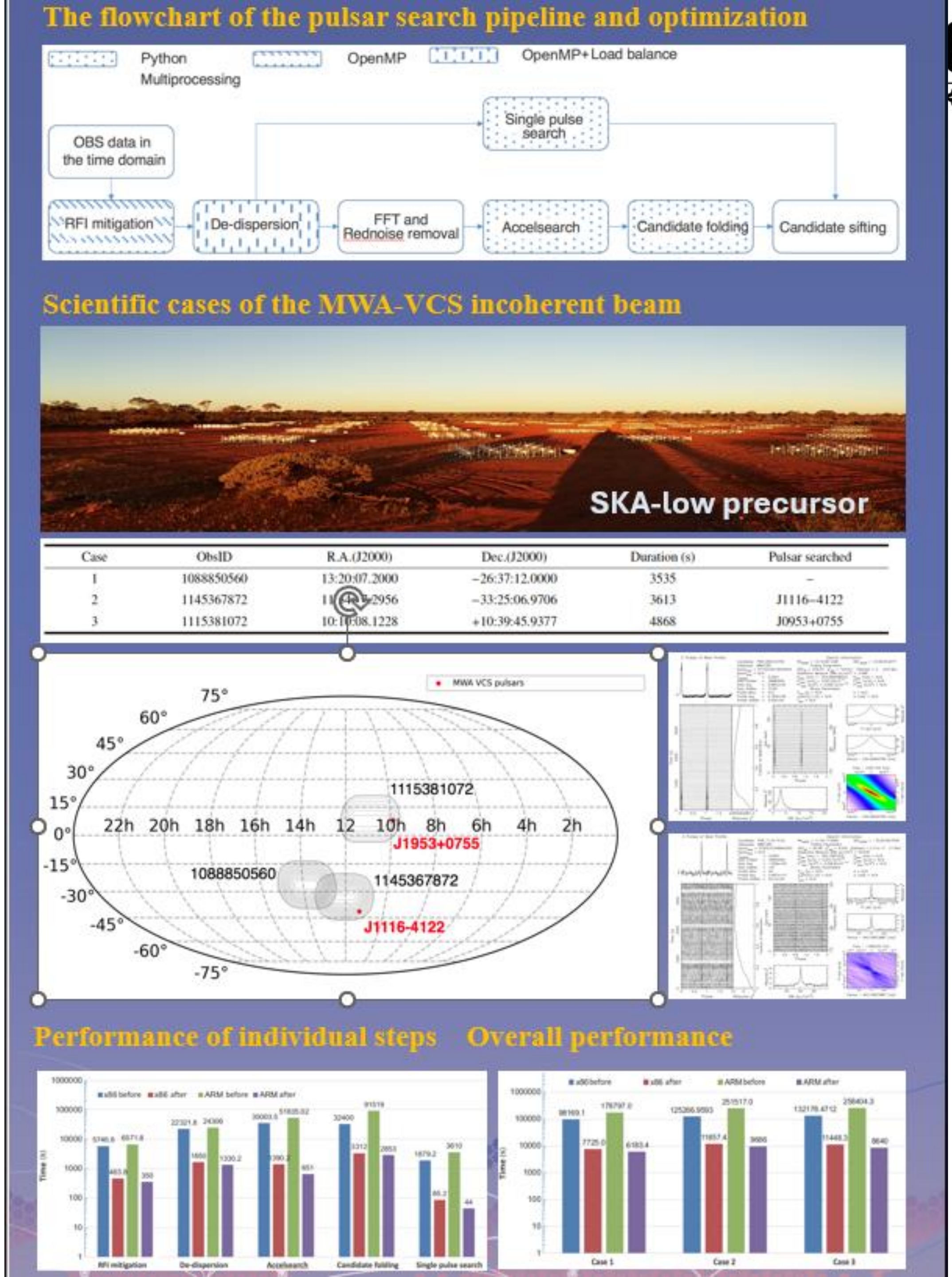
The optimized pipeline, now capable of being executed on the DALiuGE framework, marks a significant improvement in operational efficiency and data processing speed. This optimization not only benefits the VAST project but can also be applied to other ASKAP imaging surveys, such as EMU and POSSUM.

The study emphasizes that the method presented can efficiently exploit the massive data volumes produced by radio astronomy surveys, enabling more precise observations of the universe. As the document states, the ASKAP data used in this work can be accessed via the CSIRO ASKAP Science Data Archive, and the software packages utilized are available from public websites, ensuring transparency and reproducibility.

Sciense user case 3

A parallel optimization of pulsar search pipeline

An optimized PRESTO based pulsar search pipeline is deployed in CNSRC to greatly improve the pulsar search efficiency on both x86 and ARM nodes, speeding up the computing by factors of 10.4-12.2 and 24.5-25.8, respectively (Wei et al. 2023). The pipeline is applied to the southern-sky MWA rapid two-meter program, as well as other SKA pathfinders like Parkes, uGMRT, and FAST.



Case	ObsID	R.A.(J2000)	Dec.(J2000)	Duration (s)	Pulsar searched
1	1088850560	13:20:07.2000	−26:37:12.0000	3535	–
2	1145367872	[illegible]2956	−33:25:06.9706	3613	J1116−4122
3	1115381072	10:1[illegible]:08.1228	+10:39:45.9377	4868	J0953+0755

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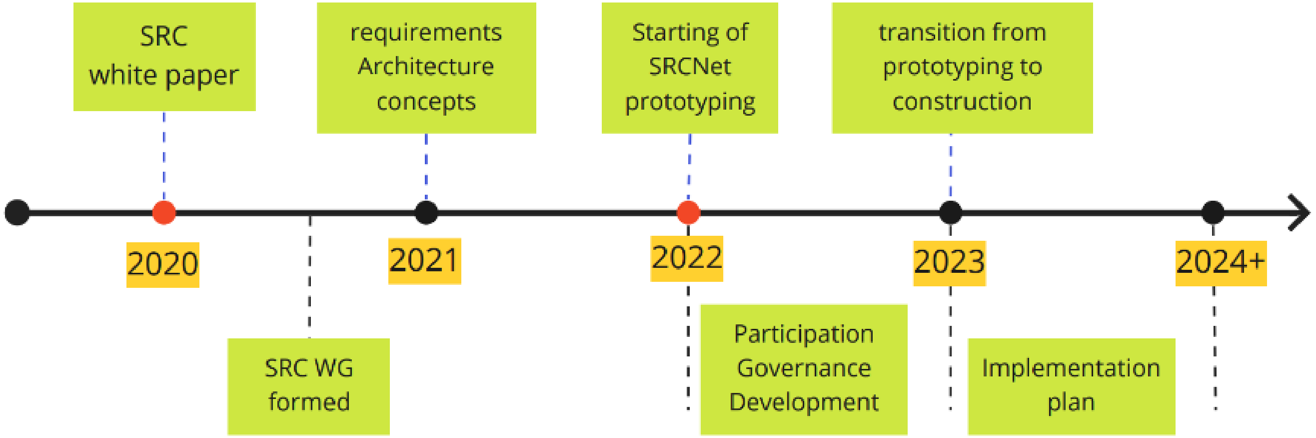
SRC Steering Committee

SKA Regional Centre white paper

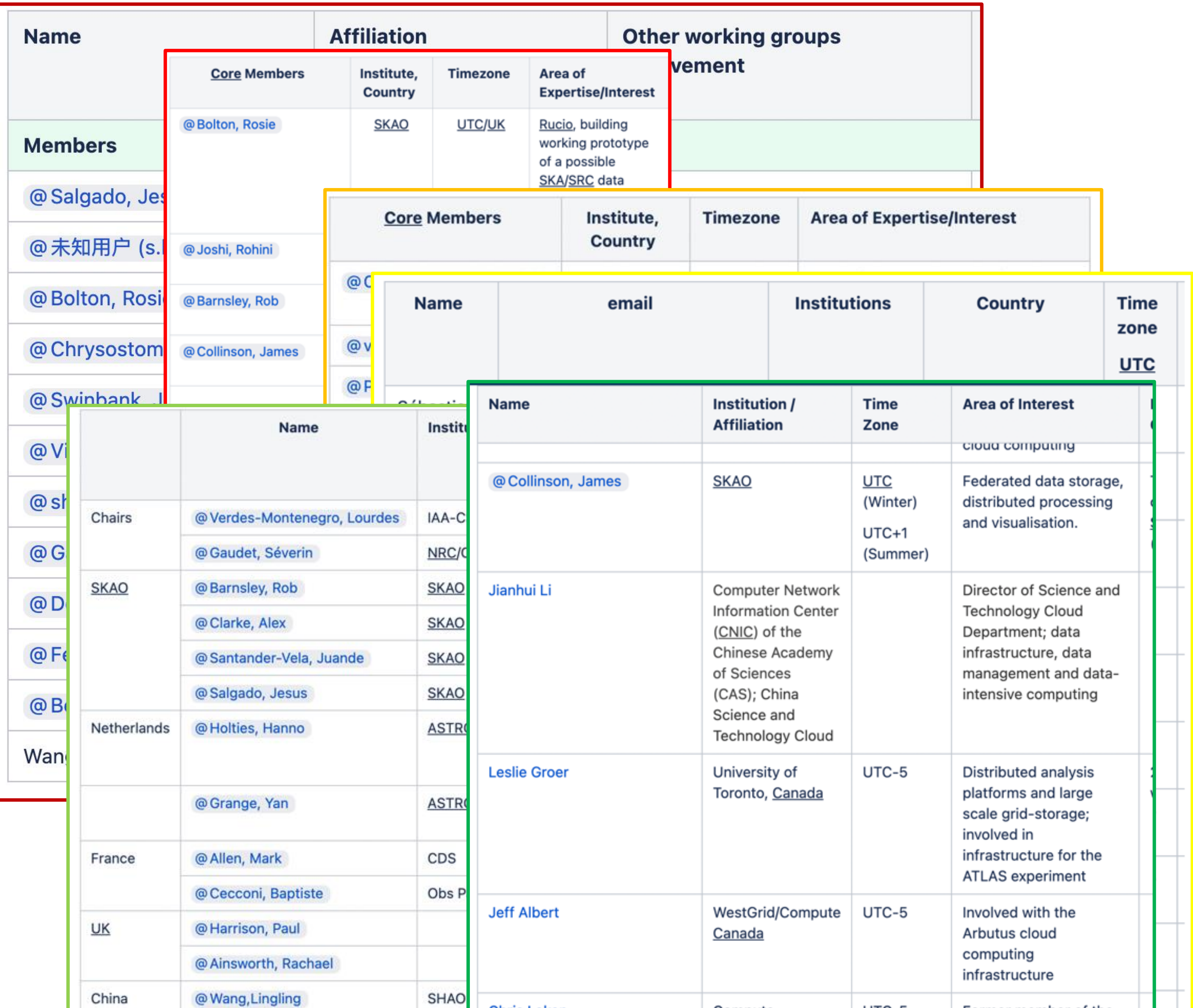
Chinese SRC team building

SRC working groups

2nd f2f meeting, Shanghai



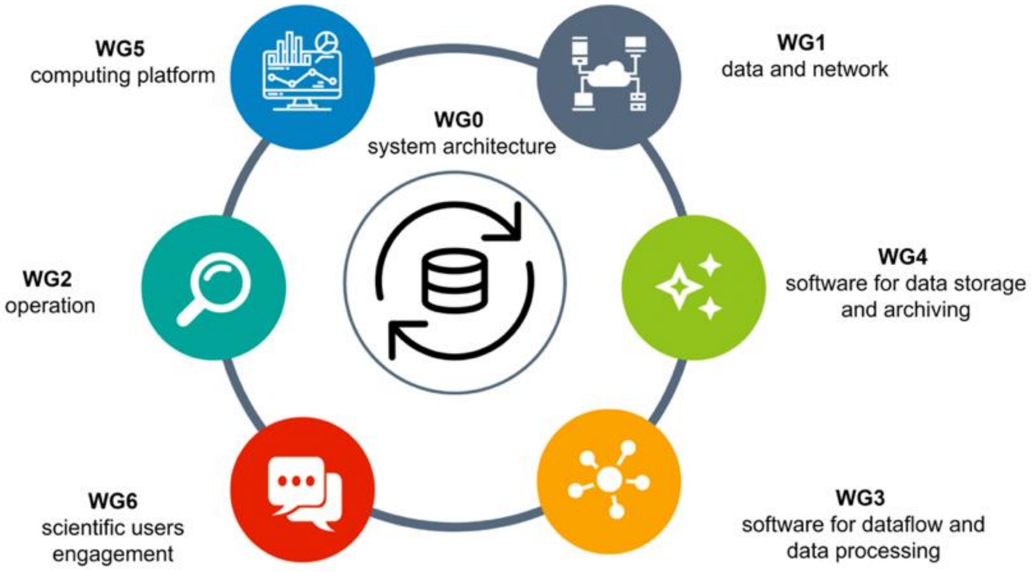
SRC working groups



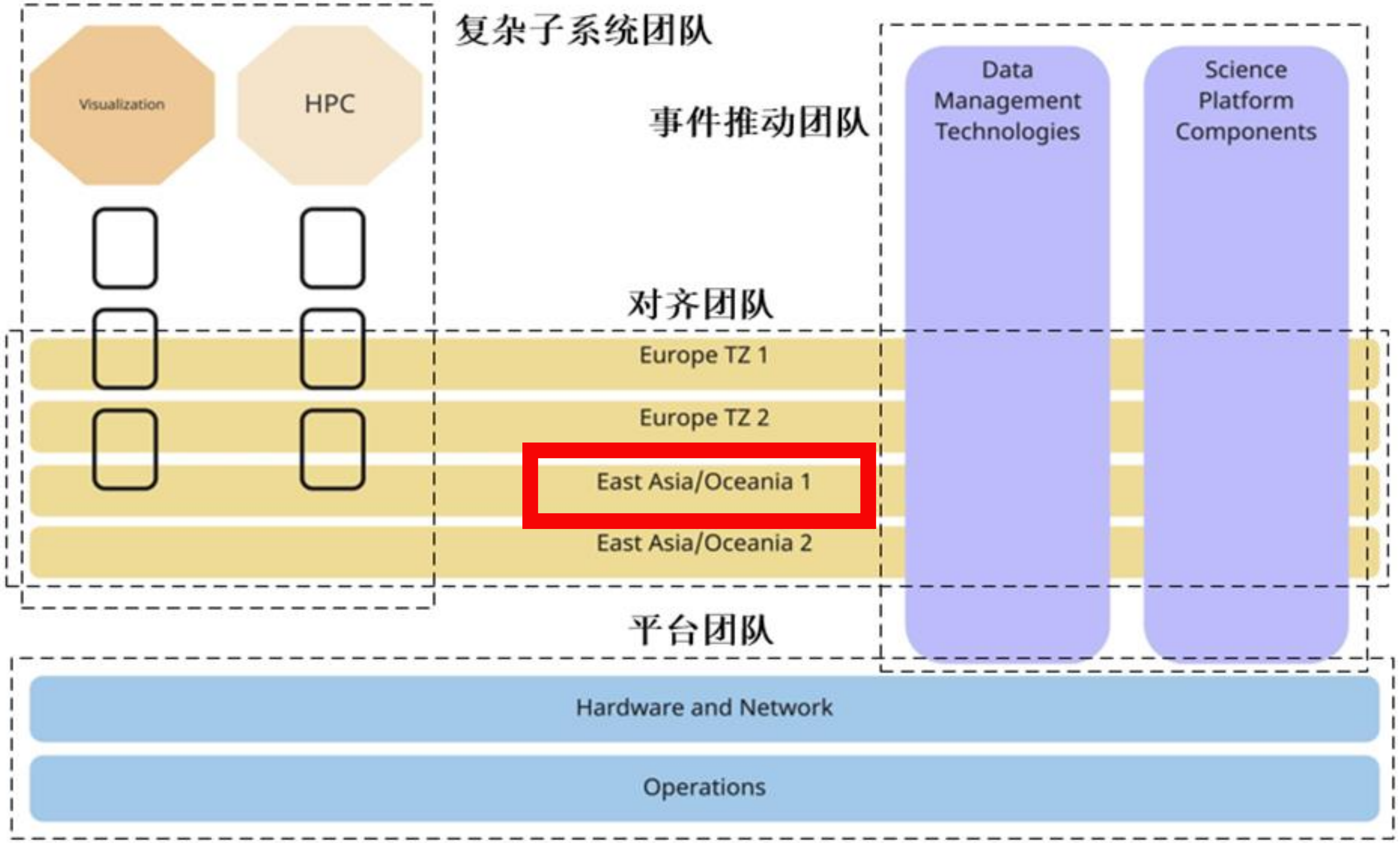
Name	Institution / Affiliation	Time Zone	Area of Interest
			cloud computing
@Collinson, James	SKAO	UTC (Winter) UTC+1 (Summer)	Federated data storage, distributed processing and visualisation.
Jianhui Li	Computer Network Information Center (CNIC) of the Chinese Academy of Sciences (CAS); China Science and Technology Cloud		Director of Science and Technology Cloud Department; data infrastructure, data management and data-intensive computing
Leslie Groer	University of Toronto, Canada	UTC-5	Distributed analysis platforms and large scale grid-storage; involved in infrastructure for the ATLAS experiment
Jeff Albert	WestGrid/Compute Canada	UTC-5	Involved with the Arbutus cloud computing infrastructure

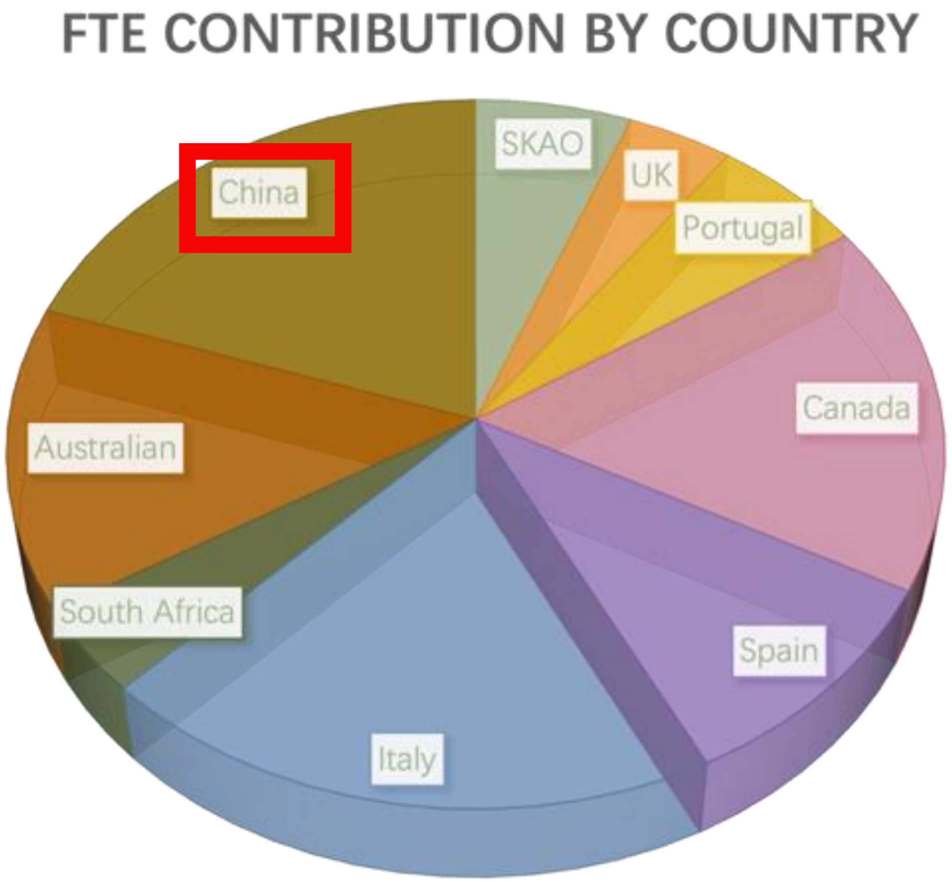
CNSRC Co-chair WG1 data and network

Participate all other WGs



SRCNet Prototyping





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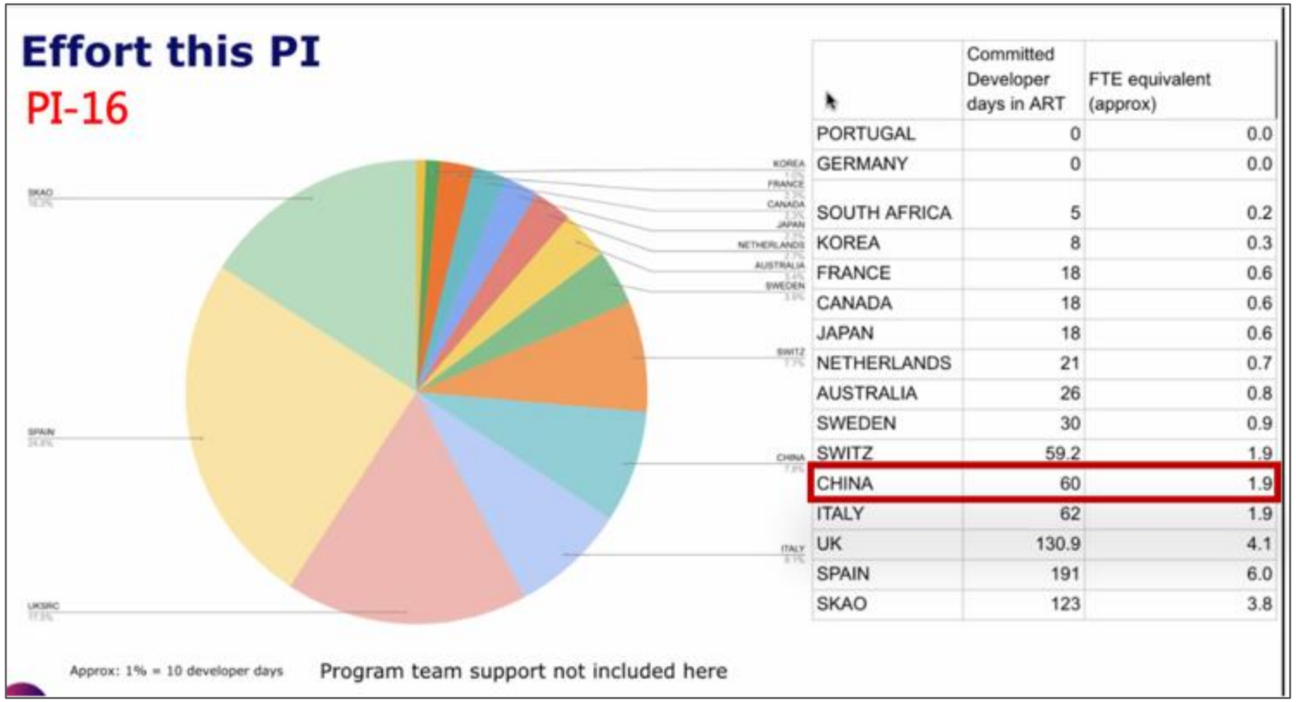
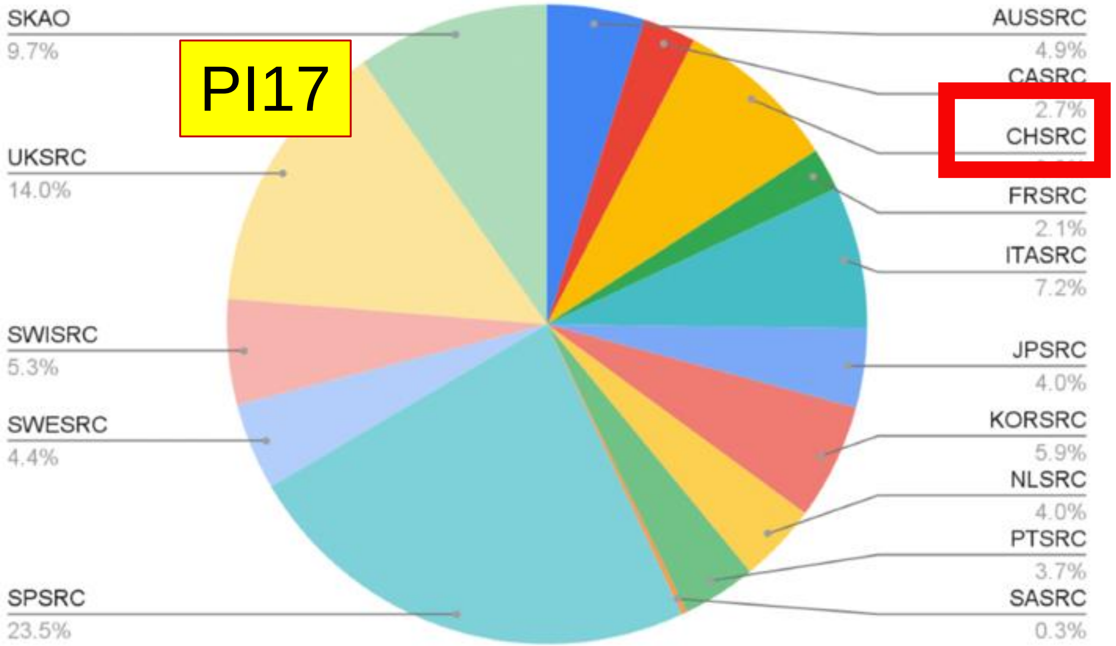
SRCNet Prototyping PI15-22



	Committed Developer days in ART	FTE equivalent (approx)
PORTUGAL	0	0.0
GERMANY	0	0.0
SOUTH AFRICA	5	0.2
KOREA	8	0.3
FRANCE	18	0.6
CANADA	18	0.6
JAPAN	18	0.6
NETHERLANDS	21	0.7
AUSTRALIA	26	0.8
SWEDEN	30	0.9
SWITZ	59.2	1.9
CHINA	60	1.9
ITALY	62	1.9
UK	130.9	4.1
SPAIN	191	6.0
SKAO	123	3.8

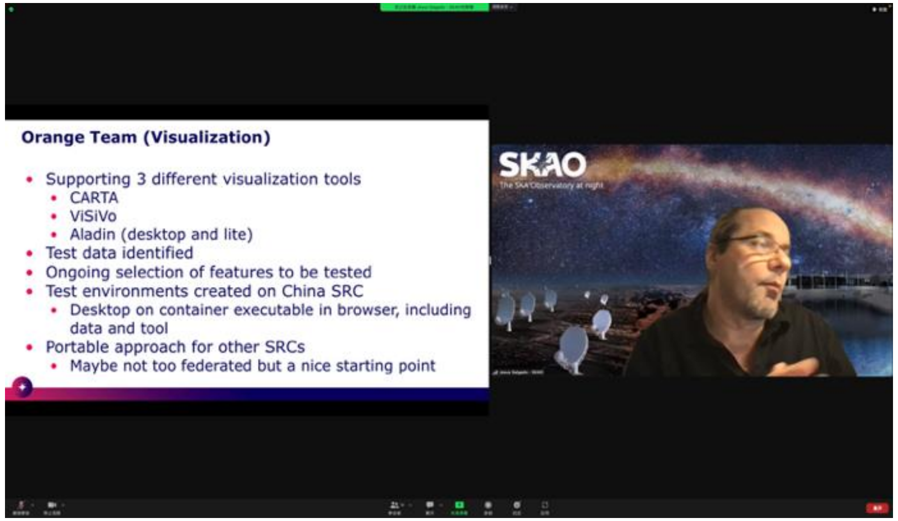


Blue-lavender team → Gold team (International + National level)

CN | SRC
SKAO Regional Centre China

SRCNet Prototyping PI15-22

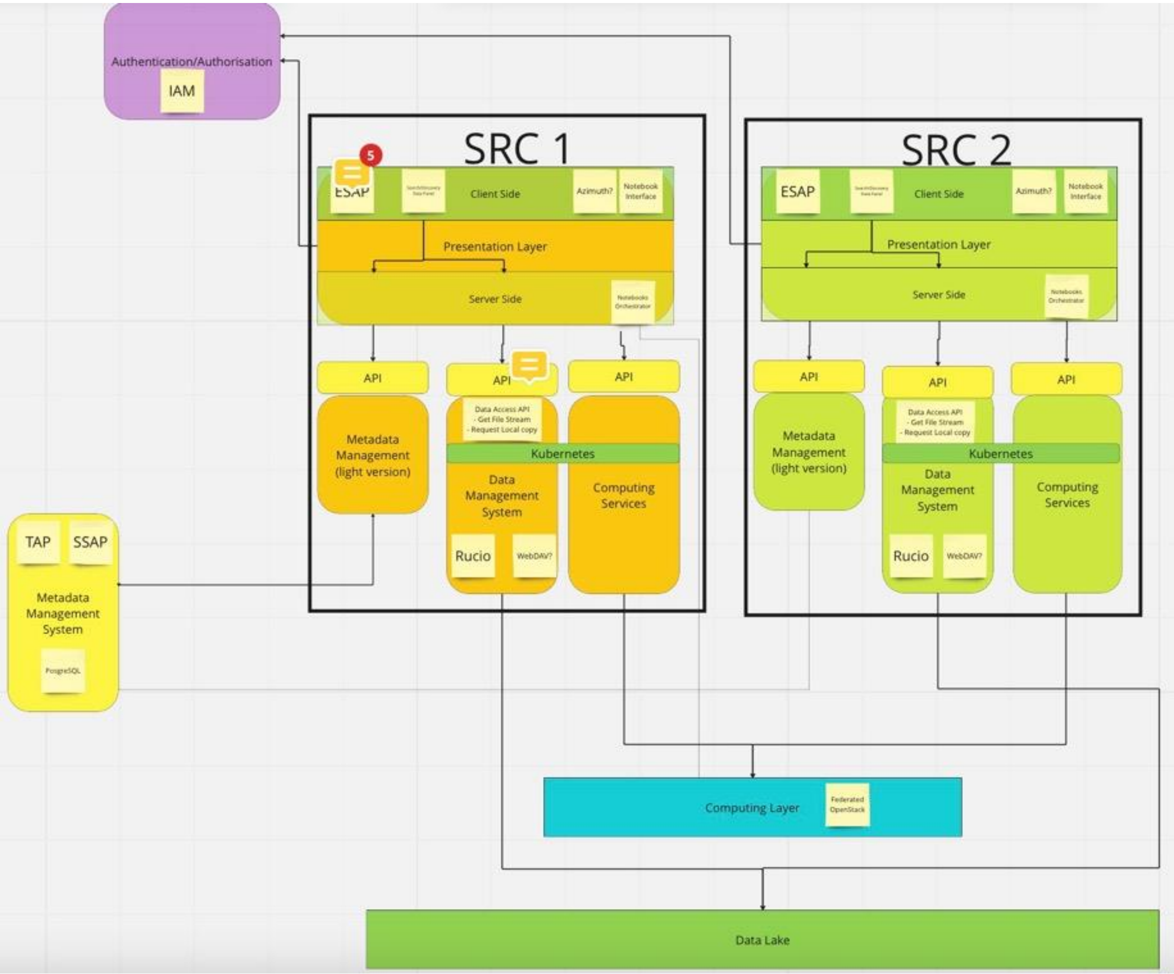
Rucio – network of data lakes
China SRC is one of the nodes

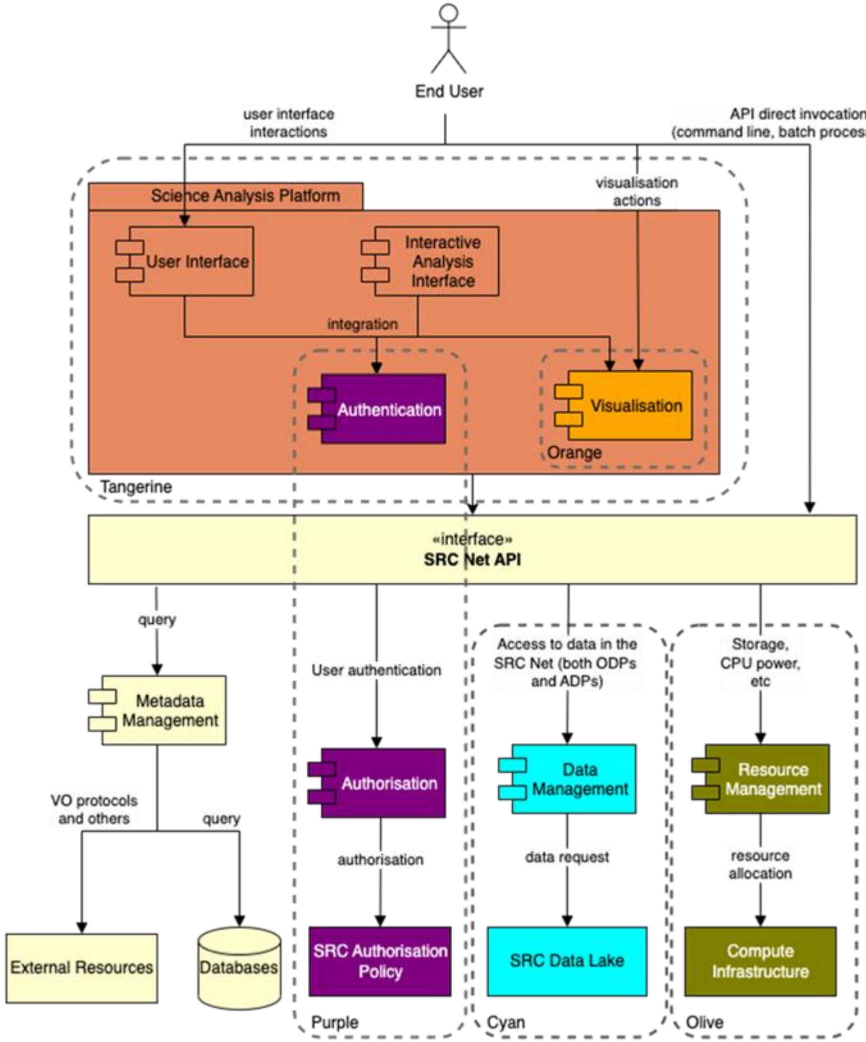


Rucio Storage Integration SP-2632 - Integrate ChinaSRC/AusSRC storage in the Prototype 1a testbed DONE	@Guo, Shaoguang (BLUE-LAVENDER)

CN | SRC
SKAO Regional Centre China

SRCNet prototype -> mini-SRC -> SRCNet v0.1





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China SRC and user community team

中国科学院国家天文台 NATIONAL ASTRONOMICAL OBSERVATORIES, CAS

中国科学院上海天文台 Shanghai Astronomical Observatory, Chinese Academy of Sciences

中国科学院新疆天文台 XINJIANG ASTRONOMICAL OBSERVATORY, CAS

中国科学院紫金山天文台 Purple Mountain Observatory, Chinese Academy of Sciences

中国科学院云南天文台 YUNNAN OBSERVATORIES, CHINESE ACADEMY OF SCIENCES

中国科学院计算机网络信息中心

上海交通大學 SHANGHAI JIAO TONG UNIVERSITY

雲南大學 YUNNAN UNIVERSITY

清華大学 Tsinghua University

中山大學 SUN YAT-SEN UNIVERSITY

北京師範大學 BEIJING NORMAL UNIVERSITY

中国科技网 China Science & Technology Network

之江实验室 ZHEJIANG LAB

貴州師範大學 Guizhou Normal University

貴州大學 GUIZHOU UNIVERSITY

桂林電子科技大学 GUILIN UNIVERSITY OF ELECTRONIC TECHNOLOGY

中国科学院国家授时中心 National Time Service Center, Chinese Academy of Sciences

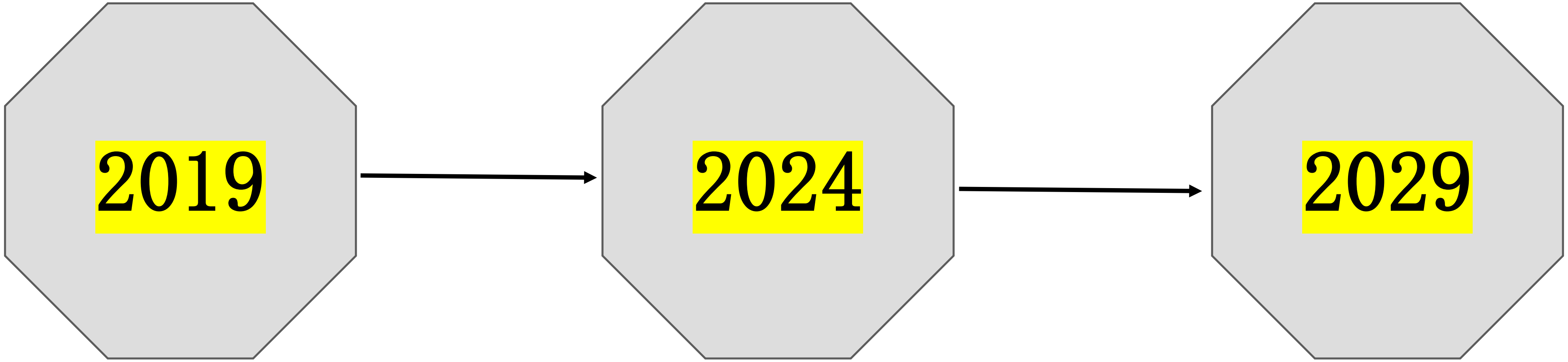
西安電子科技大學 XIDIAN UNIVERSITY

西安理工大学 XI'AN UNIVERSITY OF TECHNOLOGY

東北大學

广州大学 GUANGZHOU UNIVERSITY

Summary



- 回顾过去，我们经历了两个重要时刻，都与上海有不解之缘。
- Two important moments in past years, both tied to Shanghai
- 2019年，SKA工程会议见证了首个SRC原型机的建立，推进了从概念研究到原型建造的过渡。2019 SKA Engineering Meeting, SRC: conceptual study -> prototype contruction
- 2024年的SRCNet研讨会将进一步推动从原型系统到实体运行的进程，标志着SRC发展历程中的另一个重要里程碑。2024 SRCNet, SRC: prototype -> operation

2024 SKA SRCNet Development Workshop