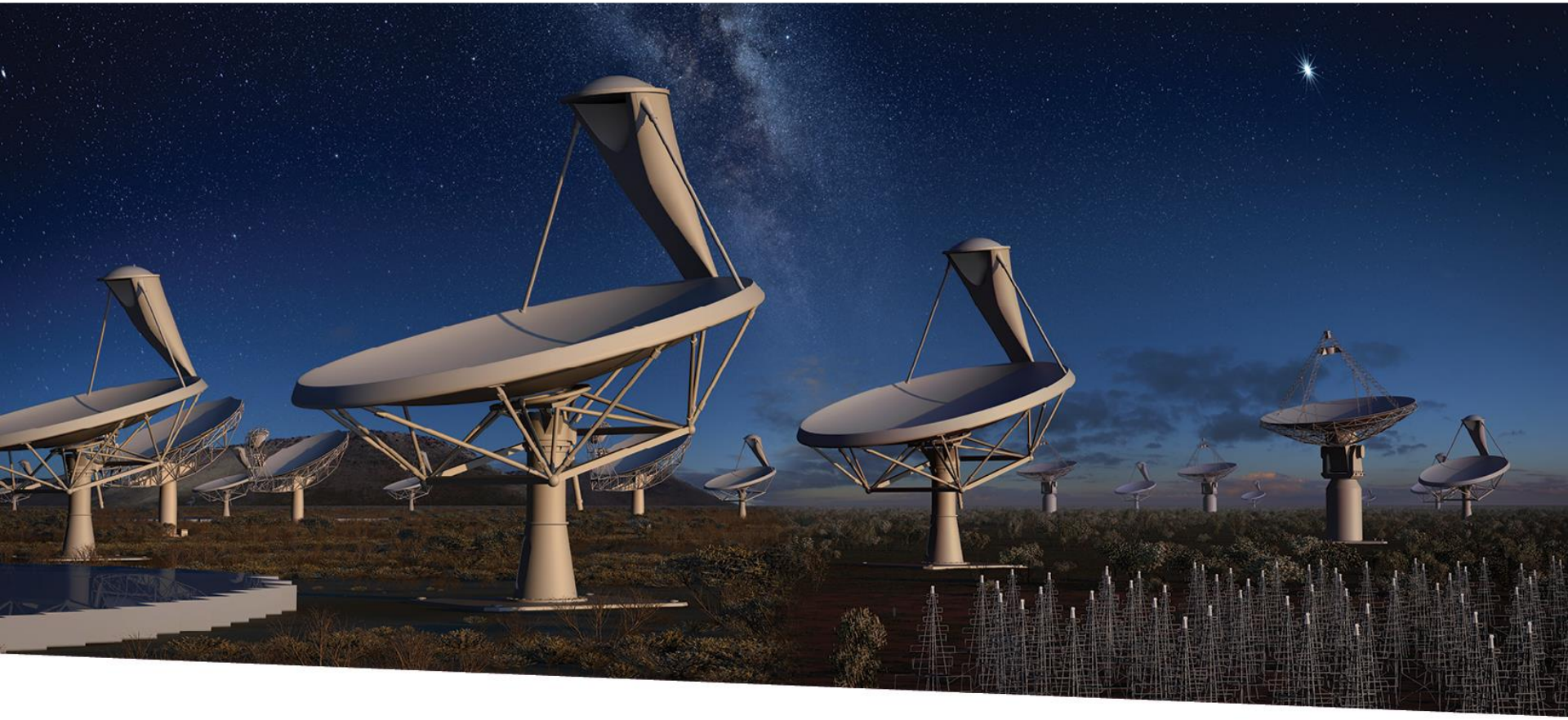
SKA and in Cooperation with China



SQUARE KILOMETRE ARRAY

Exploring the Universe with the world's largest radio telescope

Qiming Wang

22 November 2016

SKA: largest radio telescope in the world and an ICT-driven science facility

Square Kilometre Array

3 sites; **2** telescopes + HQ
1 Observatory

Design Phase: ~€170M; 600 scientists+engineers

Phase 1
Construction: 2018 – 2023
Construction cost: €674M (inflation-adjusted)
Operations cost: ~€130M/yr

MeerKat integrated
Observatory Development Programme

Regional Science Centres out of scope of centrally-funded SKAO


Phase 1: 200 15-m dishes across 150 km
Phase 2: ~2,000 dishes across southern Africa
SKA1-MID: Africa
350 MHz – 20 GHz
Lesotho
SKA Radio Telescope
Mthatha
East London
Port Elizabeth
Cape Town
Oudtshoorn
Kimberley
Welkom
Upington
Springbok
Alexkor
Graaff-Reinet
Knysna
Hermanus
Jeffreys Bay

SKA1-LOW: Australia

~130,000 antennas then 500,000 in Phase 2

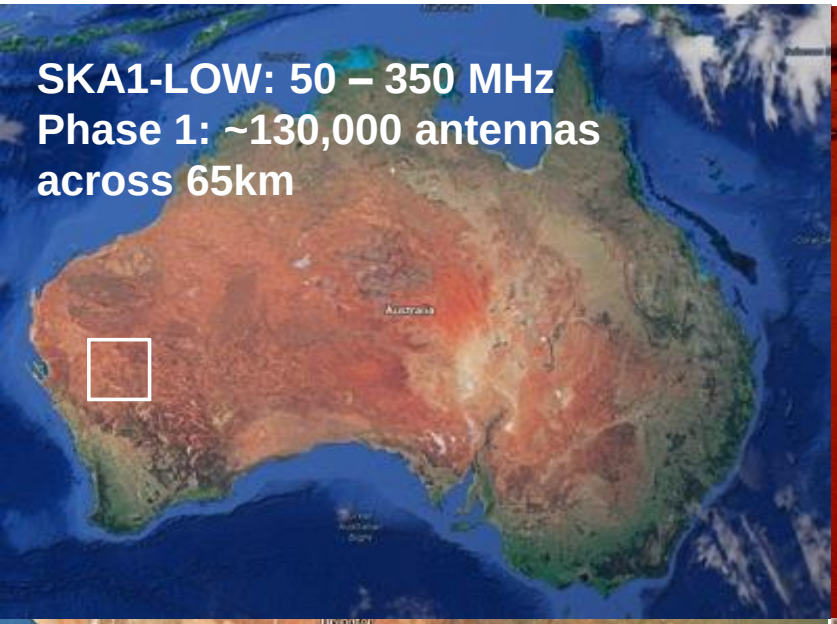
500 stations over 80 km

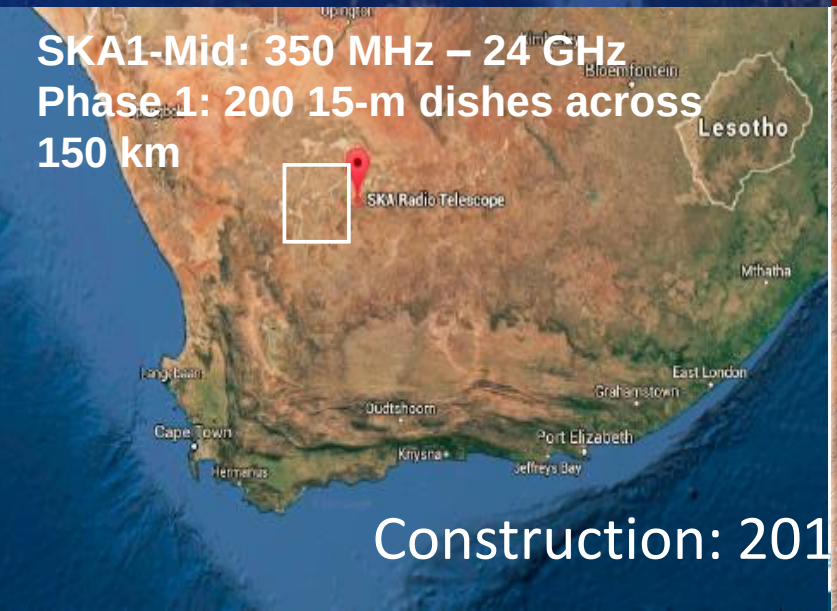
Raw data output: Tb/sec, ZB/yr

Huge engineering, computational and science challenge

Precursors: con

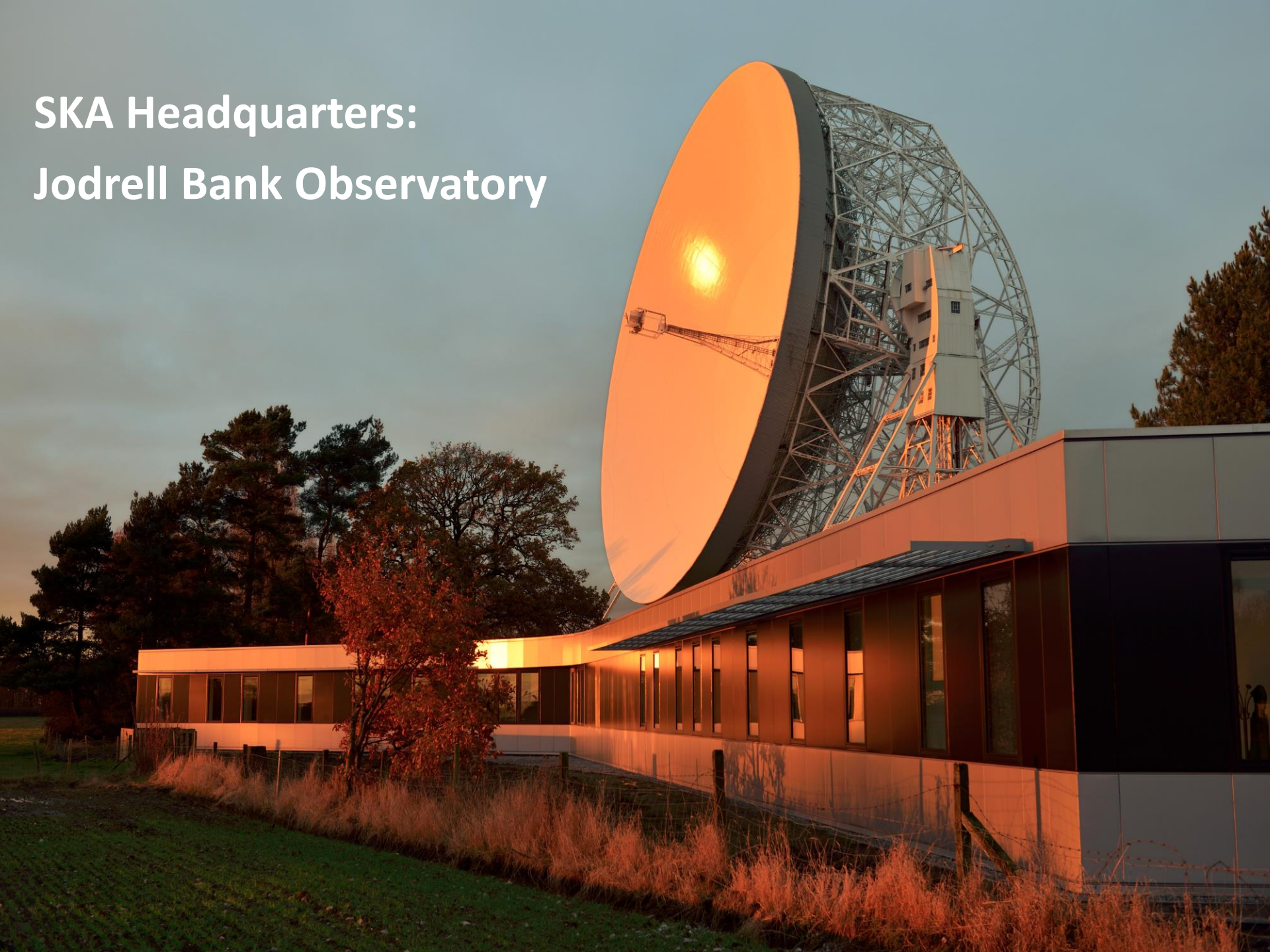
SKA: Telescopes in AUS & RSA





Construction: 2018 – 2024; Cost: €674M

SKA Headquarters:
Jodrell Bank Observatory



SKA HQ: Jodrell Bank, UK

Data Flow through the SKA

SKA1-MID

8.8 Tb/s

~50 PFLOPS

~5 Tb/s

100 PFLOPS

130 PB/yr

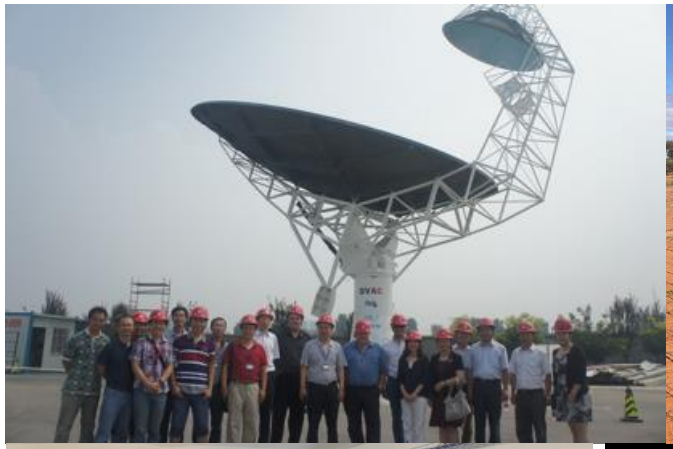
Users

7.2 Tb/s

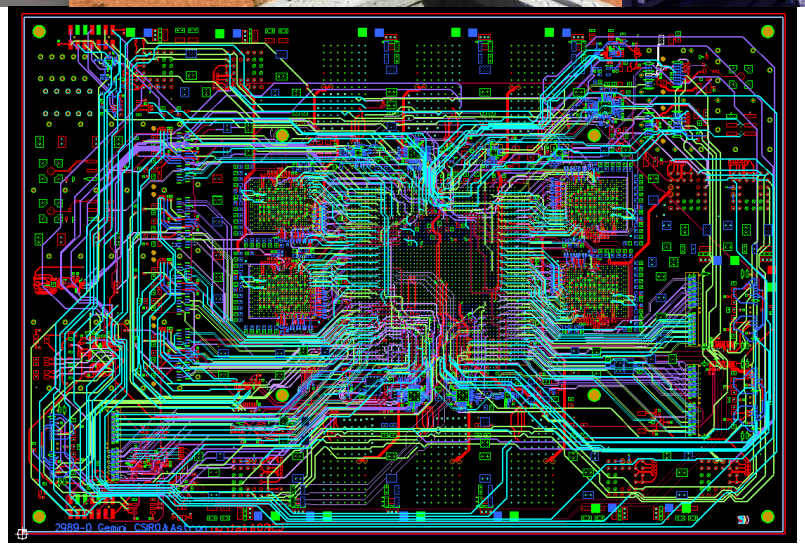
SKA1-LOW

~2 Pb/s

Prototypes

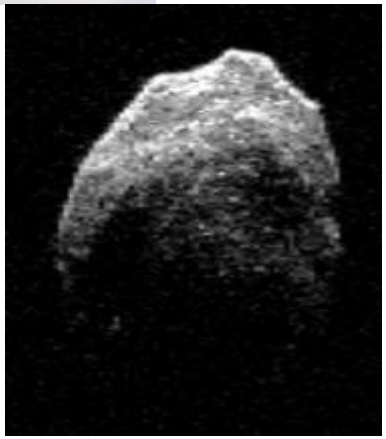



protoNIP-01
a GPU/FPGA based PSS prototype at the SKA1-MID site
Time Domain Team
Manchester - Oxford - Bonn
protoNIP-01



Impact of Radio Astronomy: examples

- Low-cost amplifiers → telecomms
- Radio imaging algorithms → medical imaging
- Measure Earth rotational parameters → GPS
- Near Earth Objects: radar astronomy.
- Space weather.
- Wifi: ~2 billion devices sold; >$600M income to CSIRO.



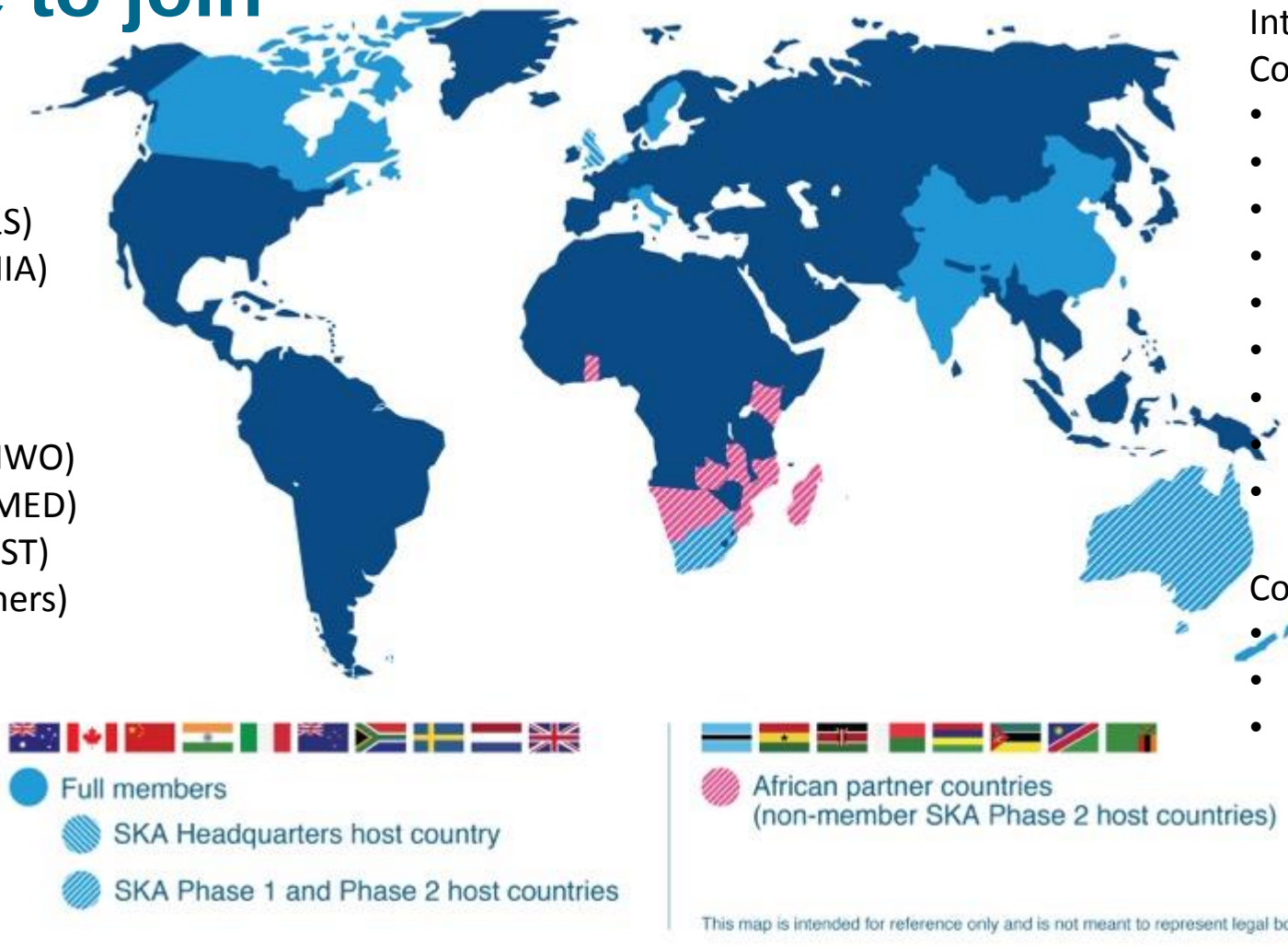
- SKA impact:
  - Data analytics
  - High-precision timing across networks
  - Low-power, low-cost, robust systems
  - +…...

SKA: its managing structure

Evolving from a company to IGO

SKA Organisation: 10 countries, more to join

Australia (DoI&S)
Canada (NRC-HIA)
China (MOST)
India (DAE)
Italy (INAF)
Netherlands (NWO)
New Zealand (MED)
South Africa (DST)
Sweden (Chalmers)
UK (STFC)



Interested Countries:

- France
- Germany
- Japan
- Korea
- Malta
- Portugal
- Spain
- Switzerland
- USA

Contacts:

- Brazil
- Ireland
- Russia

SKA Ltd structure

Will evolve to Inter-Governmental Organisation

Strategy and Business Development Committee

Finance Committee

Executive Committee

Science and Engineering Advisory Committee

Members

Board of Directors

Director-General

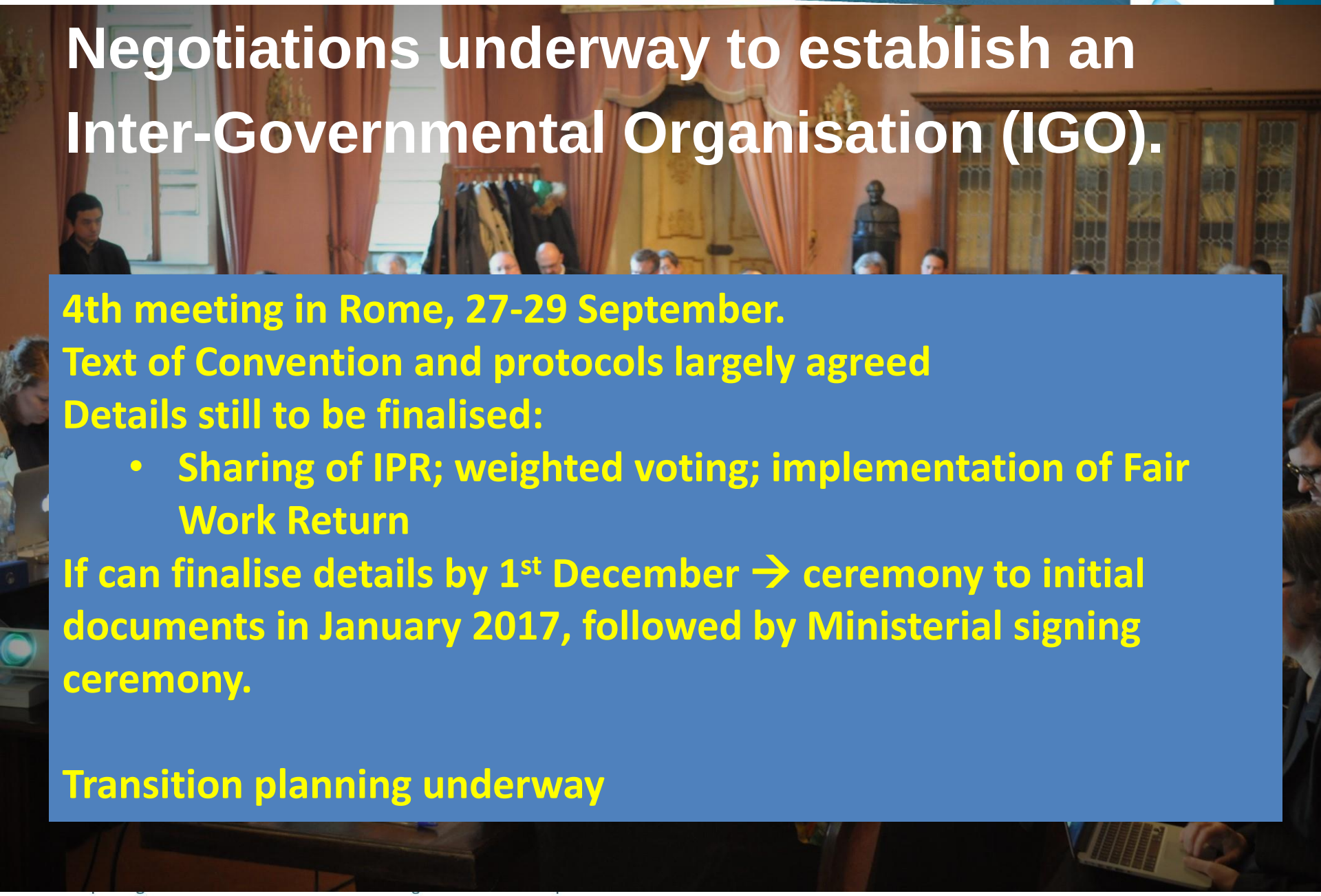
SKA Office

Cash contribution

In-Kind contribution

~ €170M committed to design phase

Negotiations underway to establish an Inter-Governmental Organisation (IGO).



4th meeting in Rome, 27-29 September.

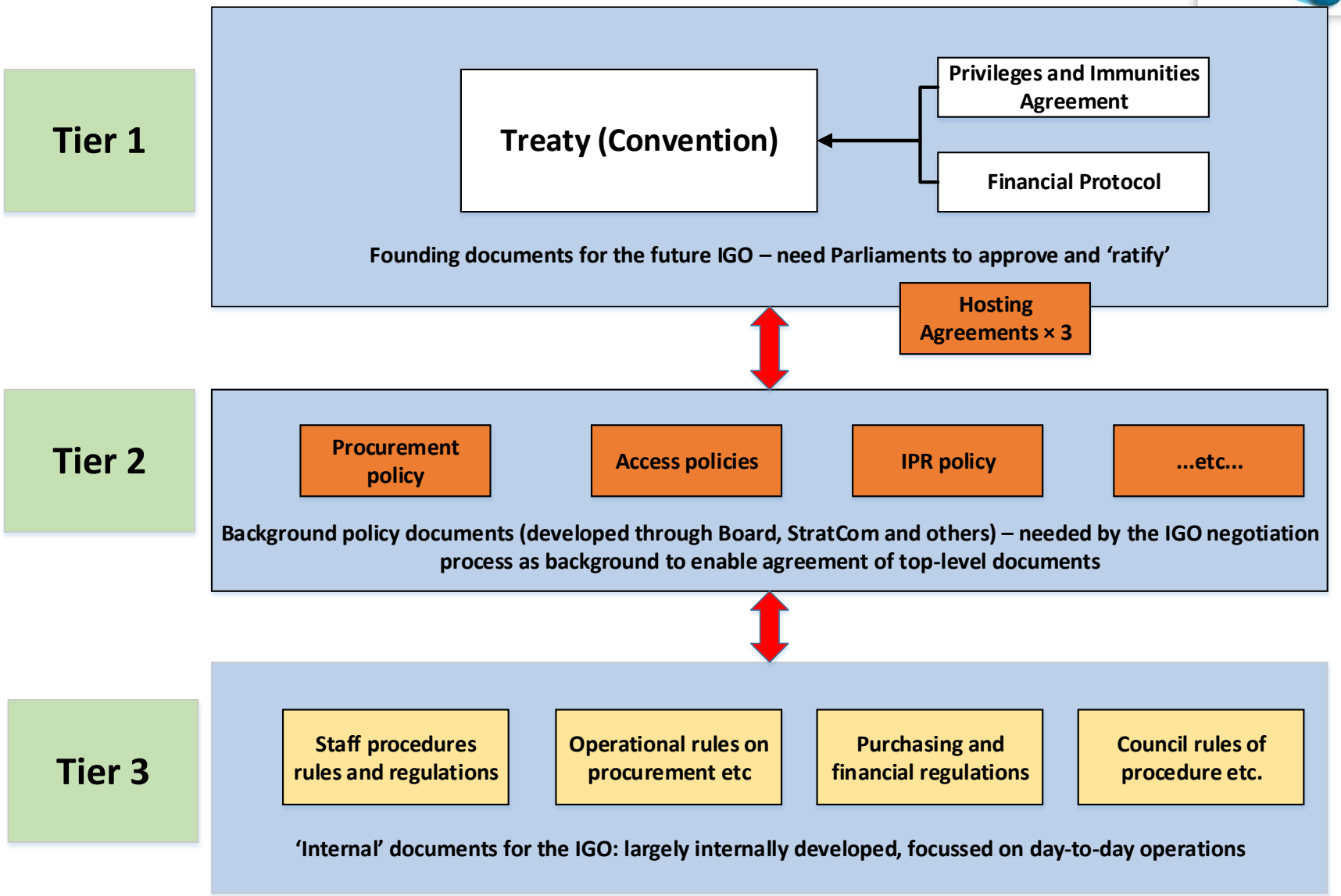
Text of Convention and protocols largely agreed

Details still to be finalised:

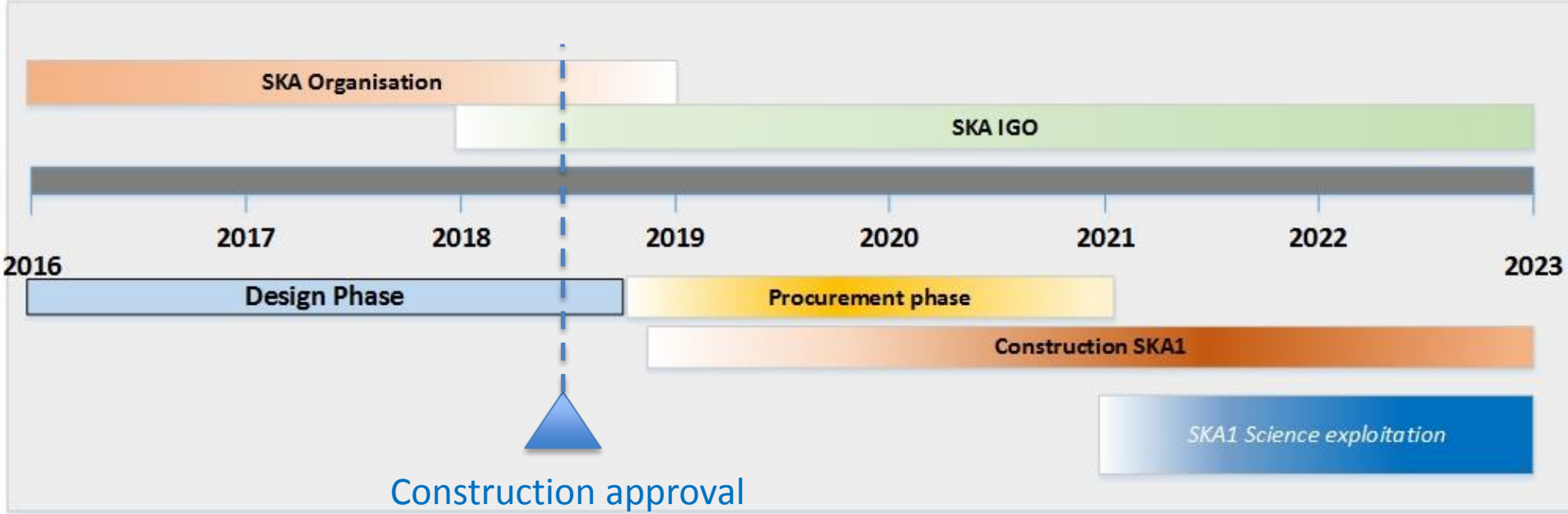
- Sharing of IPR; weighted voting; implementation of Fair Work Return

If can finalise details by 1st December → ceremony to initial documents in January 2017, followed by Ministerial signing ceremony.

Transition planning underway


Tier 1
Treaty (Convention)
Privileges and Immunities Agreement
Financial Protocol
Founding documents for the future IGO – need Parliaments to approve and 'ratify'
Hosting Agreements × 3
Tier 2
Procurement policy
Access policies
IPR policy
...etc...
Background policy documents (developed through Board, StratCom and others) – needed by the IGO negotiation process as background to enable agreement of top-level documents
Tier 3
Staff procedures rules and regulations
Operational rules on procurement etc
Purchasing and financial regulations
Council rules of procedure etc.
'Internal' documents for the IGO: largely internally developed, focussed on day-to-day operations

Overall project timeline



Key dates:

- Convention agreed Q4 2016
- CDRs Q4 2017
- IGO in force Q1 2018
- SKA1 Construction approval Q3 2018

SKA: in cooperation with China

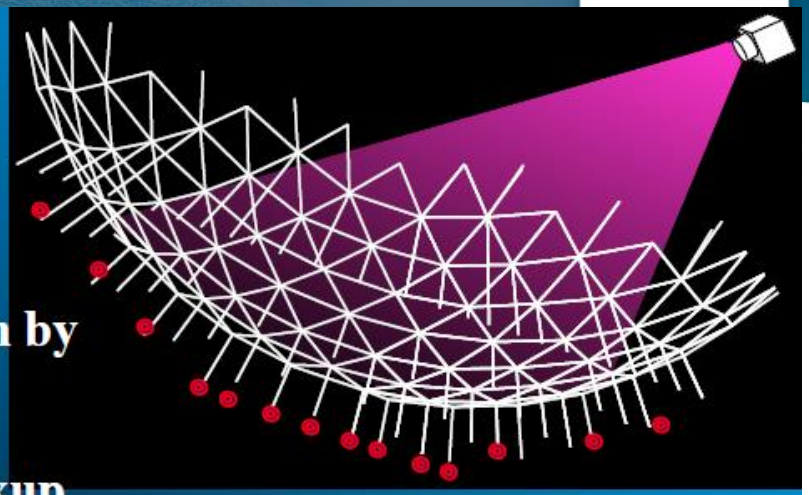
China’s ‘Sky Eye’

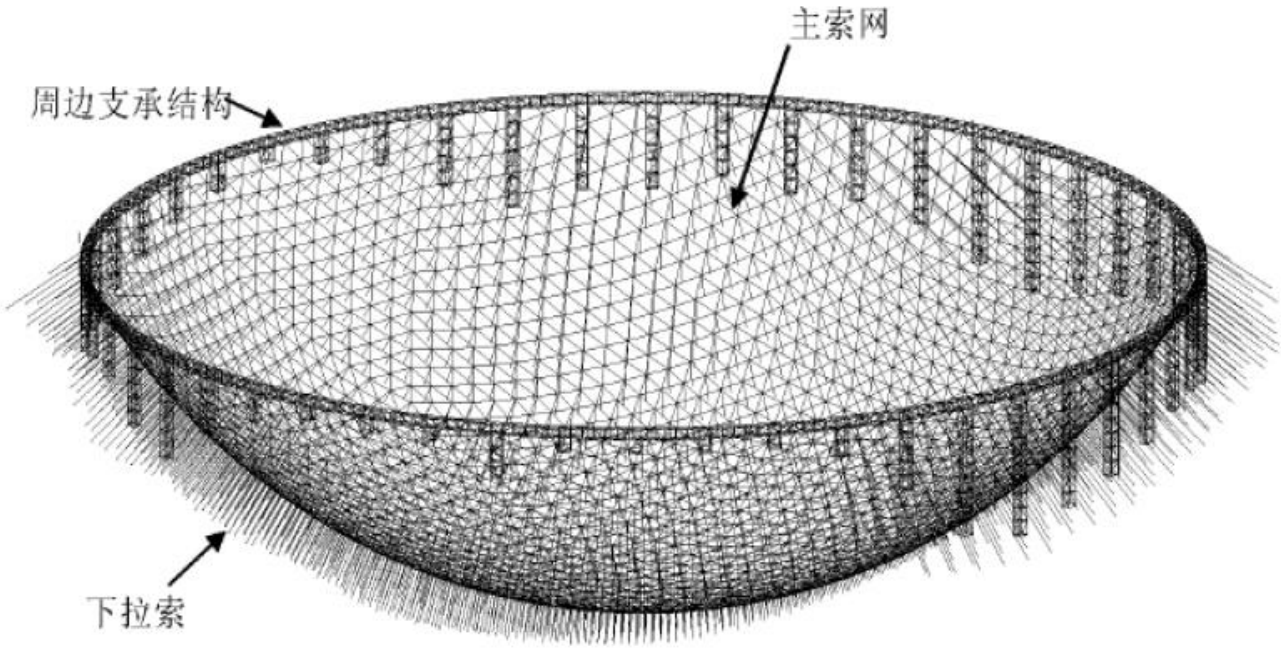
Exploring the Universe with the world's largest radio telescope

Structure of active reflector

- 500m girder built around hills
- Backup consists of ~6670 steel strands
- actuated by ~2225 down tied cables driven by winches anchored into ground
- ~ 4300 triangular panels on the cable backup

Errors: 5mm r.m.s





Organisation Structure of SKA-China

	Structure of SKA-China		Funds (total ¥ 26.71M up to 2015)
Leading department	Ministry of Science and Technology of China (MOST)	Dept. of Int'l Cooperation, Division of Int'l Organisations	¥ 6.63 M (MOST Int'l Coop. Programme)
		Dept. of Basic Research	¥ 11.73 M (973 Programme)
	National Remote Sensing Centre, affiliated to MOST	Division of Satellite Navigation	
	Multi-departmental Coordination Mechanism		
	National Science Foundation of China (NSFC)		**Funded**
NSFC	Dept. of Int'l Cooperation	Int'l Exchange Programme	¥ 7.25 M (NSFC Int'l Coop. Programme)
	National Astronomical Observatory (NAO)		**Funded**
Chinese Academy of Sciences (CAS)	JLRAT (NAO Joint Lab with CETC 54)	CAS Key Projects	¥ 2.40 M (CAS)

China Involvement in Consortia Workpackages

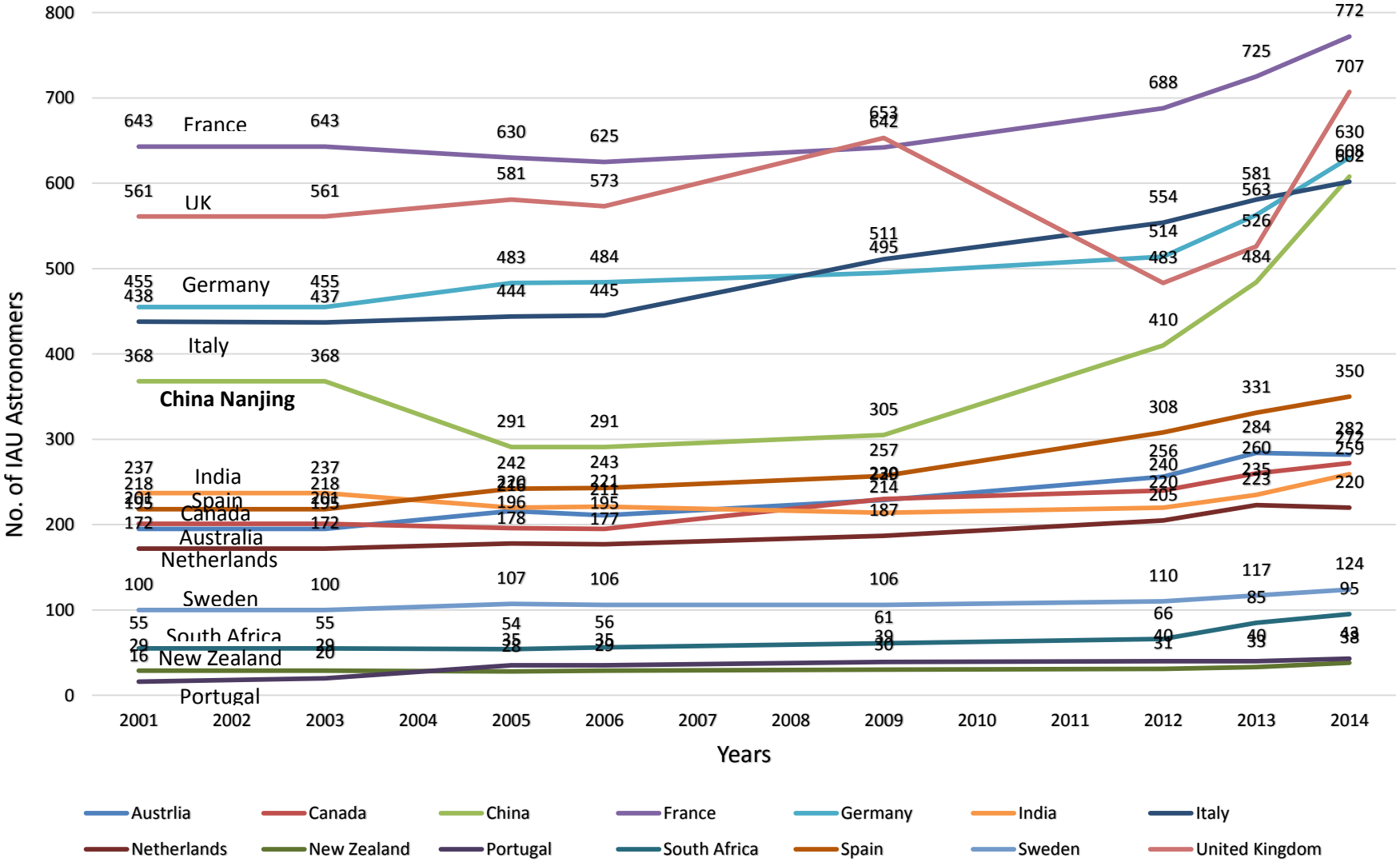
	China Institutions	R&D Involved	Contributions
Dish structure	JLRAT (NAO and CETC 54)	DVAC design, prototype, integration	¥ 18.51M cash € 6.66M in-kind
Wide Band Single Pixel Feed (WBSPF)	JLRAT (NAO and CETC 54)	Low Noise Amplifier (LNA) 0.3-2.0 GHz	¥ 8.20M cash € 1.00M in-kind
Low & Mid Frequency Aperture Array (LFAA, MFAA)	KALAASA (CETC 38)	LNA, Antenna	€ 3.54M in-kind
Signal and Data Transport (SaDT)	Tsinghua University Peking University	Time synthesizer	€ 275K in-kind
Science Data Process (SDP)	Shanghai Jiaotong University China Inspur, CETC 32, NAO	Super-computing Cloud-data treatment	€ 3.66M in-kind

¥60 M (€ 7.5 M) newly added cash contribution by MOST in 2016 on SKA-P.

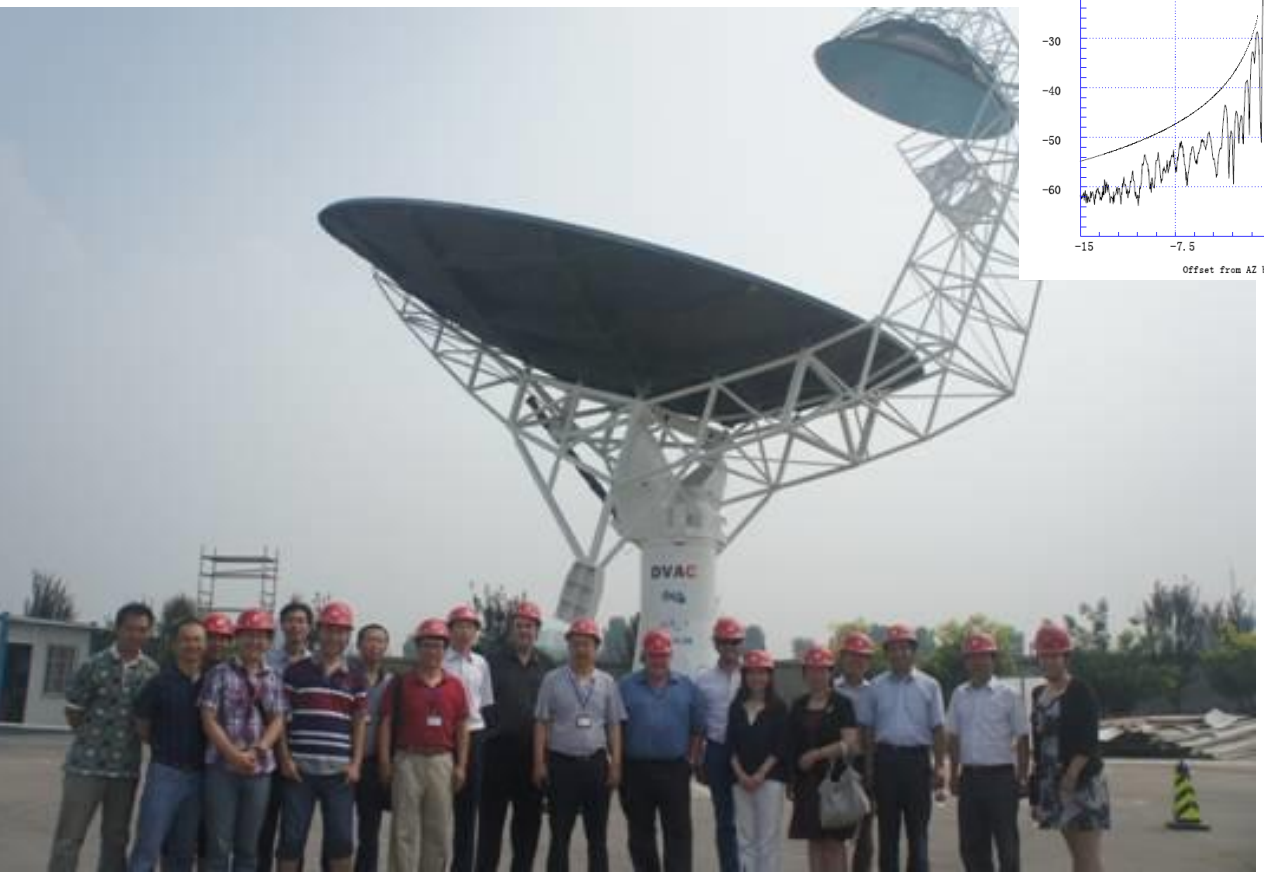
Key Persons in Charge

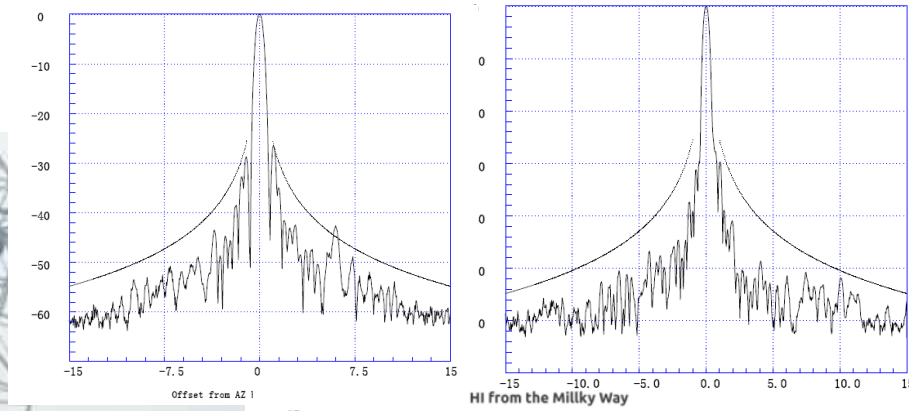
- Dr. YIN Hejun, Vice Minister of MOST, responsible for international cooperation and hi-tech development;
- **Mr. CHEN Linhao**, Deputy Director-General, Department of Int'l Cooperation, China representative for SKAO Members;
- **Mr. CAI Jianing**, Deputy Counsel, Dept. of Int'l Cooperation, Voting Director of SKA Board;
- Ms. WANG Rongfang, Director, Division of Int'l Organisations, Dept. of Int'l Cooperation, MOST;
- **Dr. PENG Bo**, NAO, Science Director of SKA Board, also deputy general manager of FAST project.

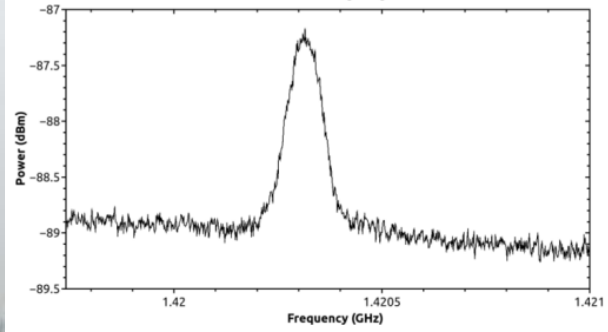
Trends in Number of IAU Astronomers of SKAO Member States Between 2001 and 2014

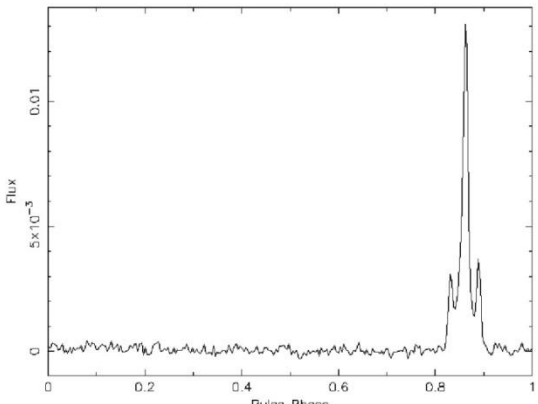


May 2015: DVA-C testing complete



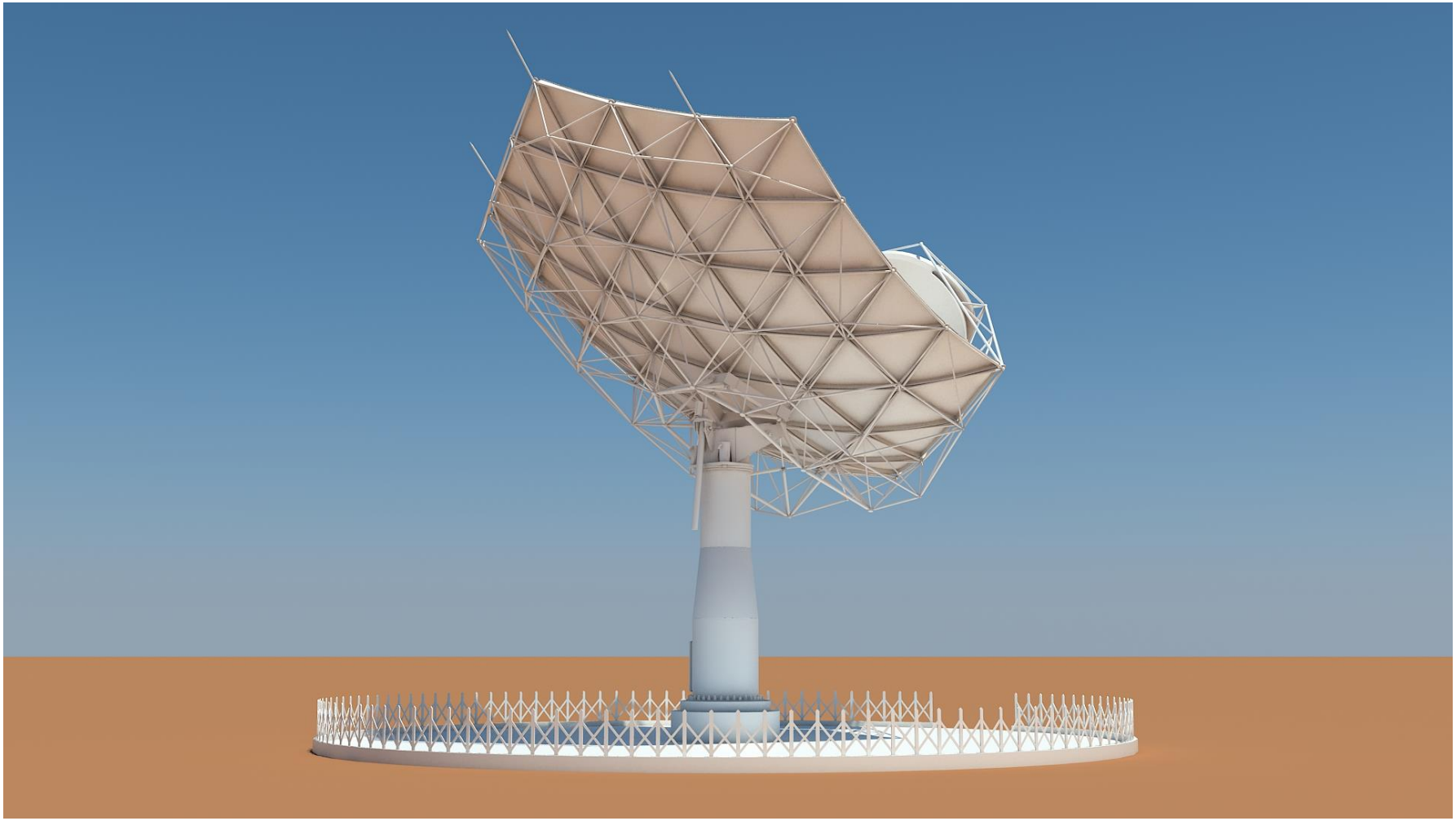




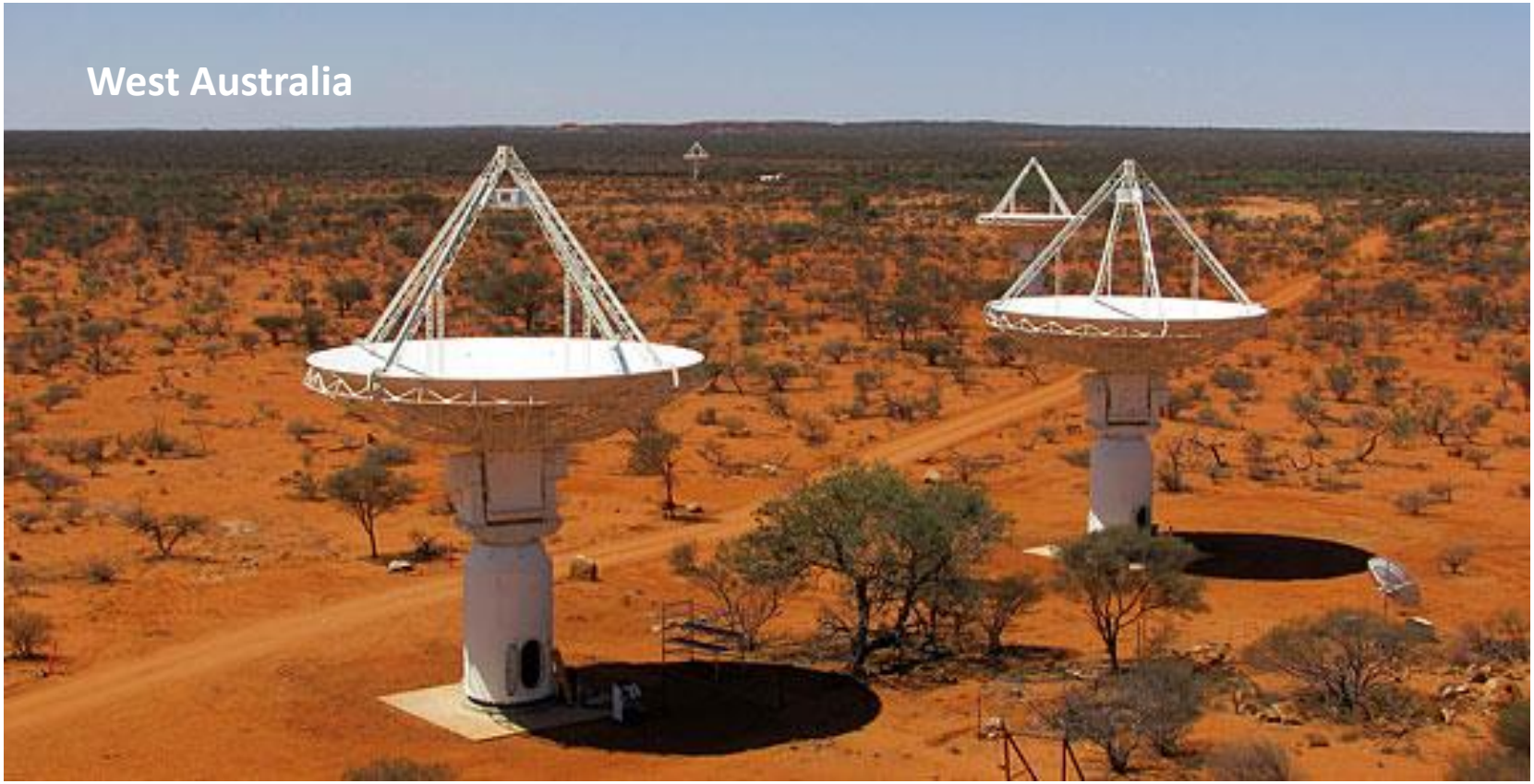


DVA-P: CETC54/MTM design

Panelled Space Frame Supported Metal Reflector（PSM)



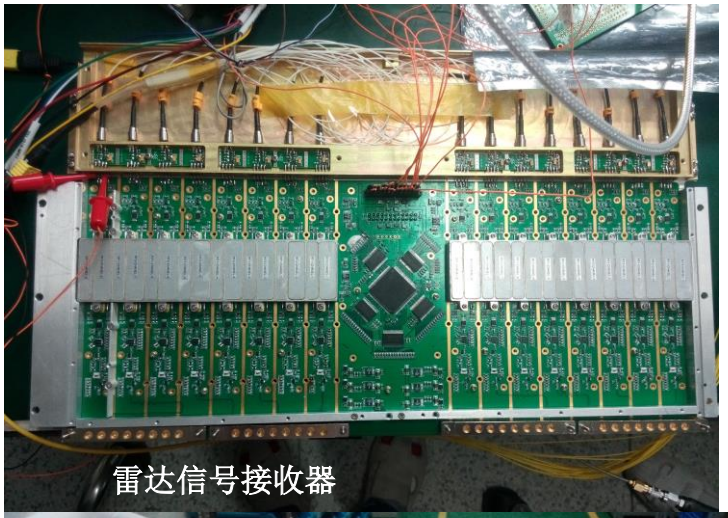
Australian SKA Precursors (AKSAP)



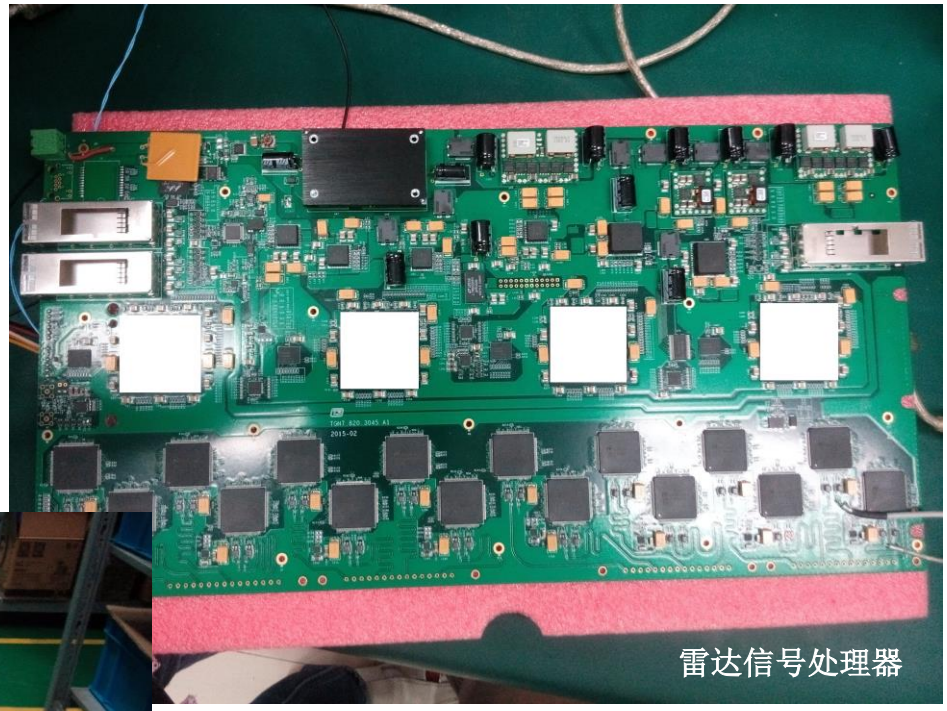
36 Dishes manufactured and installed by CETC 54, 2008-2013

时钟同步仪——南非测试现场

CETC 38: Signal Processing



雷达信号接收器

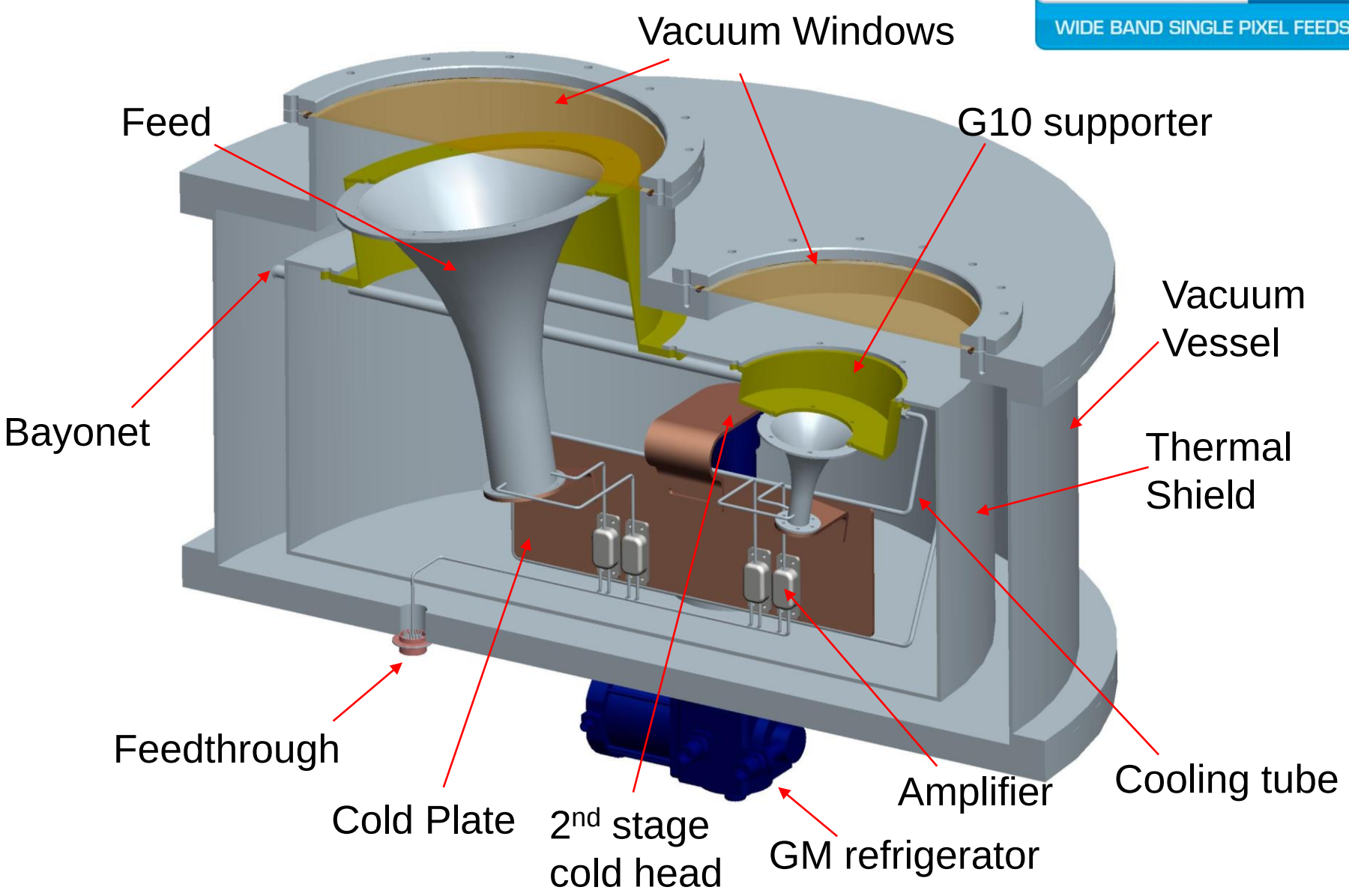


雷达信号处理器

Tile Processing Module (TPM), TPM-v1.0
with 32 receiving channels

功耗低，信道多，处理速度快

WIDE BAND SINGLE PIXEL FEEDS



China's interests in investing SKA project

- Help **CETC 54** go out to world market with competence in dish design, manufacturing, integration and world-class testing capability;
- Opportunity for **Tsinghua University** to produce Time Synthesizer in scale production;
- Help **CETC 38** sale its own developed radar chips in world market;
- China takes SKA the last chance for China to join world level collaboration on radio telescope in the 21 century;
- Opportunity for Chinese scientists to achieve scientific outcomes that could potentially win **Nobel prize** or with importance to that level;
- **Innovation** in next generation of super-computing, data transport, cloud data storage and treatment, software and algorithms development that may accelerate technologies spinning-out for social and economic development;
- Opportunity for **training** Chinese scientists.

Weakness in China

- China's radio astronomy developed rather late since 80's; only four universities have arranged under-graduate courses in astronomy, with students graduation about 120 each year;
- China considers itself weak in radio science publications, middle ranking in SCI publications and **low ranking on citations**;
- Radio science community has a **weak link** with industry on design and production of telescope's key components, such as PAF, WBSPF, LNA etc.;
- Capability in handling **big data treatment**, algorithms and software development is low for Chinese radio astronomers;
- Diversified objectives of China's radio astronomical roadmaps, **lack in highlight of strength**.

Important issues that will affect China decision-making

- Evolving to an **international organisation** of SKA Observatory by 2018, ahead challenges of timeline and government ratification process;
- Targeted **10% contribution** too high, given the reality of China's science capacity proxy. 8-9% would be more appropriate to reflect China's current capacity;
- **Science return** should be proportional to the country's financial contribution in the case of allocating observing time and computing access;
- Weakness in Chinese scientist's capability in data treatment, algorithms and software development may affect China's capacity on science return.

Suggestion on SA-China Cooperation

- Need a clear strategy – from design to build and then more importantly to research – to achieve what, realistic in near term, but looking on long term – goal, budget, HR …
- The strategy has to serve the goal for FAST - SKA collaboration in terms of science between SA and China: HI, pulsar, EoR …
- The strategy needs to focus on how the science discoveries of FAST/SKA can be achieved: data processing, algorithms development, data mining, image mapping…, identifying strength in both
- From scientist exchanges moving on towards establishing joint labs

SQUARE KILOMETRE ARRAY

Exploring the Universe with the world's largest radio telescope

Thank you

www.skatelescope.org