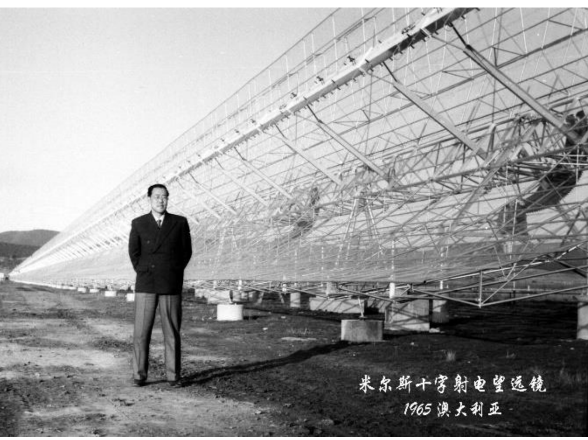
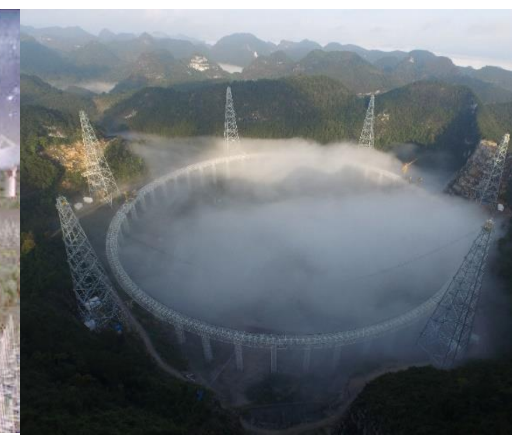
# History of radio astronomy in China:

## from early days to SKA and FAST



**Bo Peng @ IAU GA 2022**

*CAS Key Lab. of FAST, NAOC* ***August 5***

# Outlines

1 Early days Radio Astronomy in China

2 LT/SKA Initiating and Development

3 FAST Concept to telescope Operation

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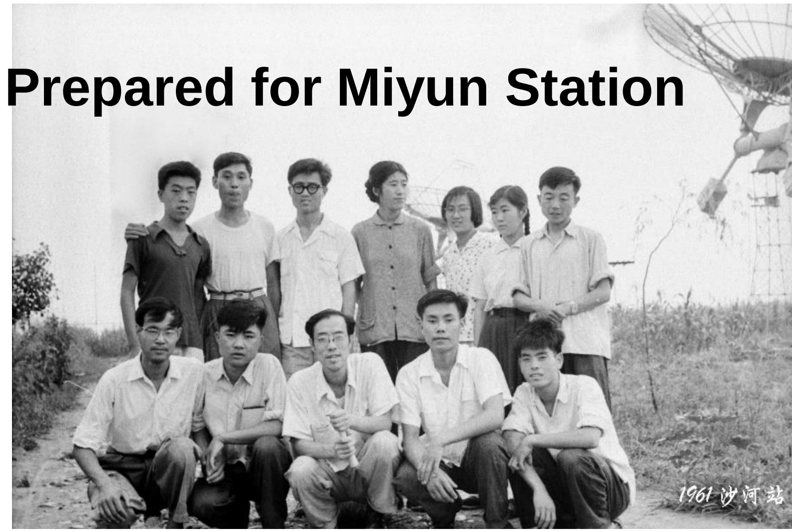
# 1st Radio Astronomical Observatory

**Started from annular eclipse Obs.** April 1958 **Hainan** Island


ShaHe Observatory
1961 Beijing




Sydney Interferometry


Australia Supporters
1965

# Evolution of Solar Radio Astronomy

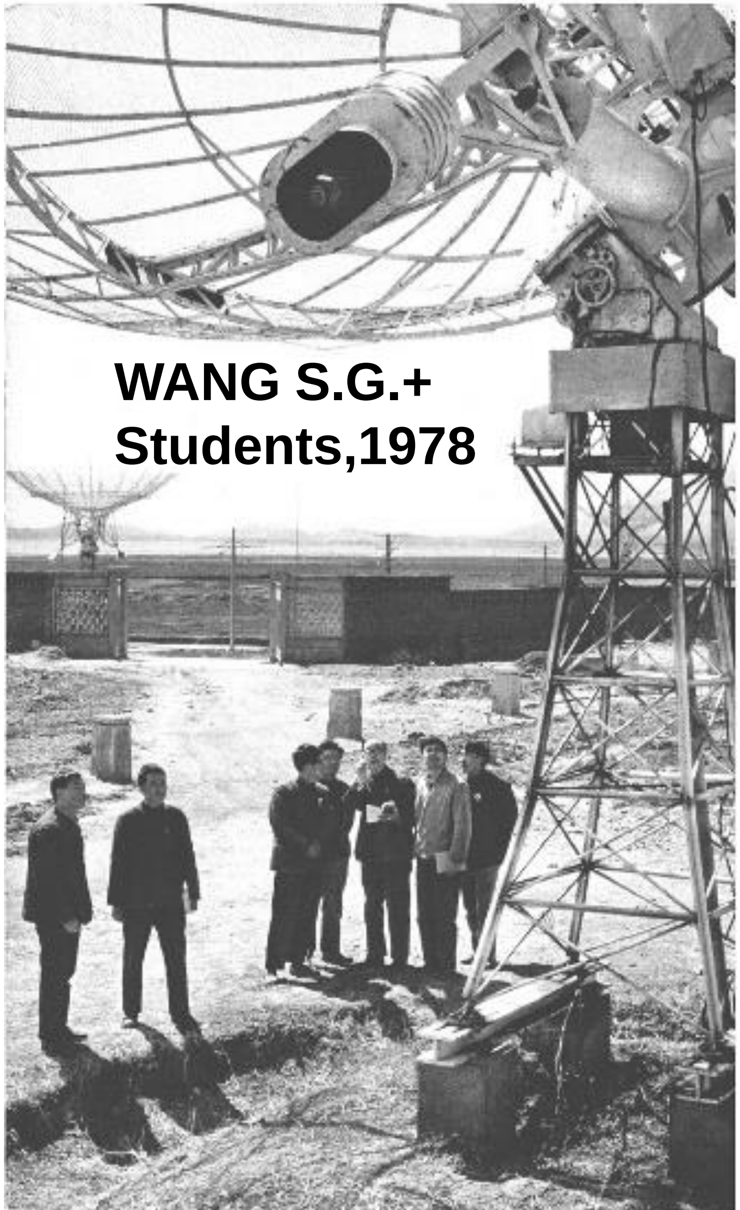
XingJiang Eclipse
1968

HuaiRou Station1999

MingAnTu 2018

MingAnTu Station 2010

# Early days … Miyun Station in Beijing





# Snapshot 3 generation dishes Miyun rooted

Miyun Synthesis Radio Telescope)

Miyun 50 m radio telescope


Students @ WANG Shouguan 90 yrs Birthday

MyFAST
Miyun FAST demonstrator

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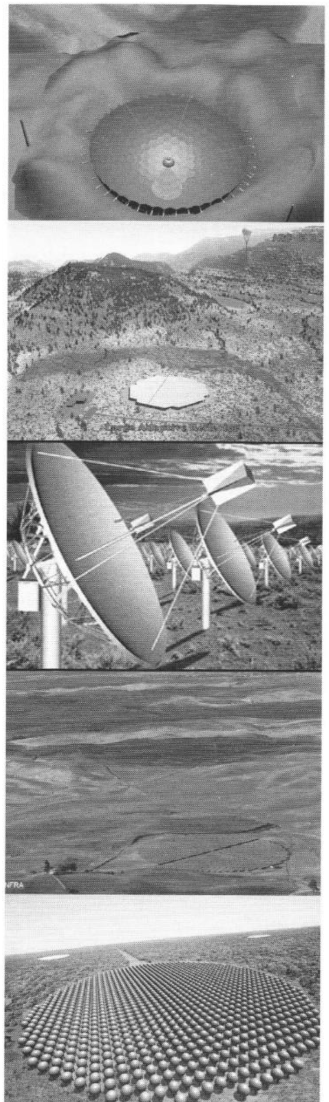
# LT/SKA Initiating




# SKA Site Survey in Guizhou

# 1st SKA Conference in China LTWG-3


# Large Telescope Working Group (LTWG)
# International SKA Steering Committee (ISSC)



# Astronomers Sign International Agreement to Plan Square Kilometre Array

Leading astronomers from Europe, North America, Asia and Australia will today sign an agreement jointly to plan a huge new radio telescope, the Square Kilometre Array (SKA), which will come into operation in the middle of the next decade. The General Assembly is an ideal opportunity to inaugurate the next stage of development of this truly global project.

The signing ceremony will take place at 17:30hrs in the Bragg Lecture Theatre in the Schuster Building at the end of the joint session on 'Future Observational Multi-Wavelength capabilities in Astrophysics', organized by the Working Group on Future Large Scale Facilities (WGFLSF) and IAU Division XI (Space and High Energy Astrophysics). The last part of the programme is a round-table discussion about the process of international co-operation and coordination.

Radio astronomers regard the SKA as a paradigm for the organization of future global astronomy projects. The SKA was the first radio astronomy project to have been 'born global' following the guidelines for successful international collaboration discussed at the 1994 IAU General Assembly in The Hague. The current concept has grown out of discussions over the past six years within the URSI/IAU Large Telescope Working Group and the OECD Global Science Forum. An International SKA Steering Committee (ISSC) has now been constituted to promote and to oversee the planning of the project. The signing of a

**Dr. Jill Tarter:** United States SKA Consortium

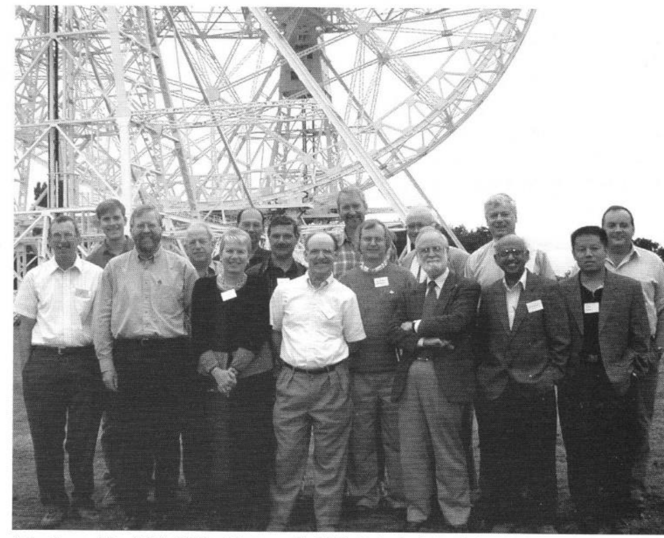
At present 24 leading institutions in ten countries have agreed to pool their research and development efforts, with each individual institution concentrating on only a part of the overall design. Their shared aim is to reach agreement on the fundamental design of the SKA by 2005 and to begin construction in 2010.

In order to achieve its ambitious astronomical goals, the design of the SKA will integrate computing hardware and software on a massive scale in a revolutionary break from current radio telescope designs. The SKA is a challenging project, and as Ron Ekers of the Australia Telescope National Facility says:

"Designing, let alone building, such an enormous technologically-advanced instrument is beyond the scope of individual nations, or even small groups of nations. The SKA is therefore being planned from the outset as a truly-global telescope project."

The SKA will be a uniquely sensitive instrument. Its collecting area will be 50 to 100 times larger than today's biggest radio imaging telescopes, the VLA and the GMRT, and 200 times larger than the pioneering Lovell Telescope at Manchester University's Jodrell Bank Observatory (which can be visited during the General Assembly).

The idea of the SKA sprang from



*Members of the SKA ISSC at last week's SKA Technical Workshop held at Jodrell Bank Observatory.*

quasars, pulsars, gravitational lenses, superluminal motion and the cosmic microwave background. It has led to three of the five Nobel prizes awarded for work in astrophysics, including all those awarded for observational work. Major advances in knowledge can be expected from a new radio telescope with the sensitivity of the SKA.

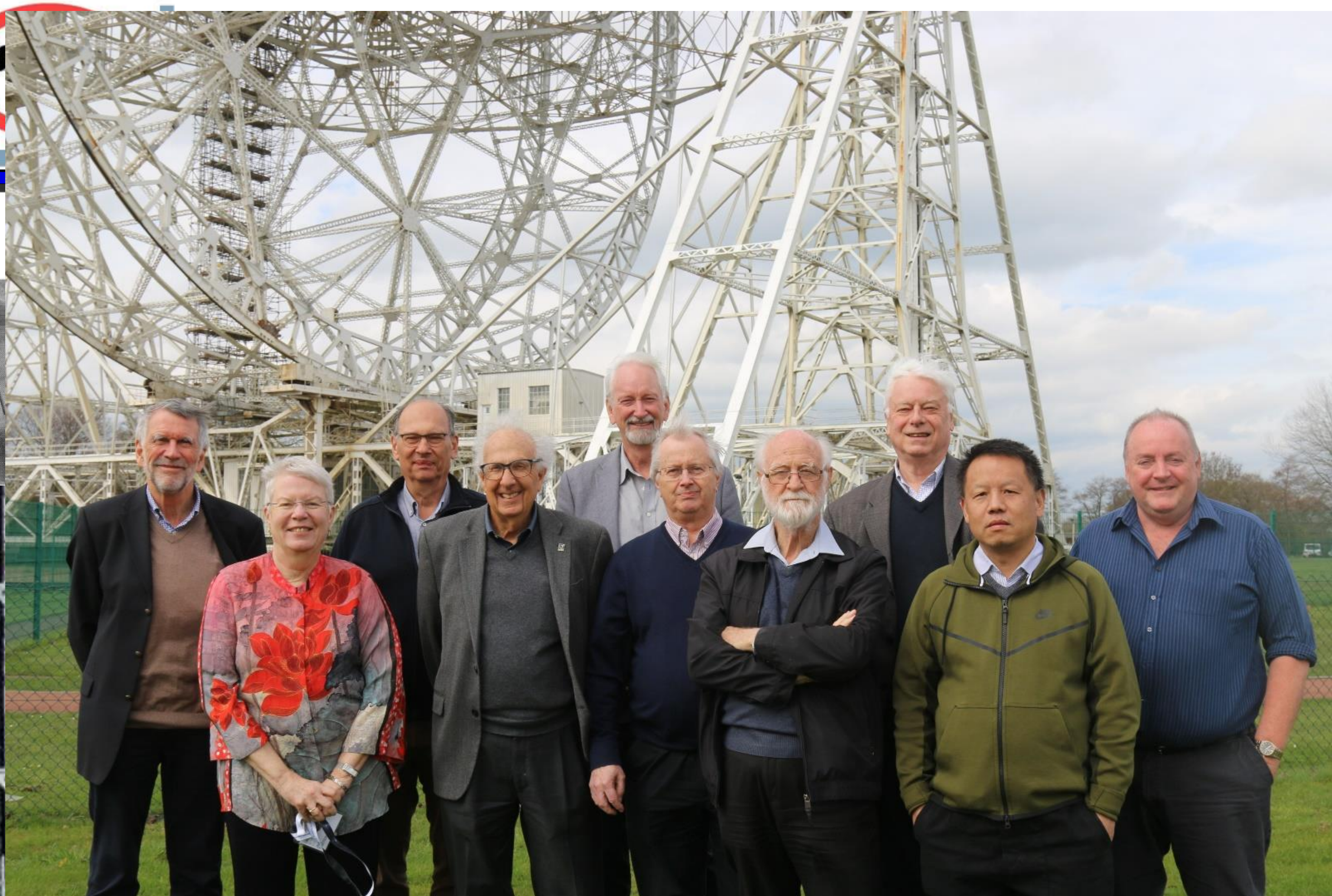
Radio telescopes have a big advantage over those operating at most other wavelengths, because they can see through cosmic dust. This dust often

The SKA's superb resolving power- which could extend to one milliarc-second- and exceptional image quality will also provide crucial new information on the formation and early history of stars, galaxies and quasars unaffected by obscuring dust. Its enormously high sensitivity will mean that, for the first time, objects in the early Universe can be studied in detail in the radio range. The SKA is thus the perfect scientific complement to the large optical (e.g. CELT, ELT, OWL), infrared (NGST) and

WG)

ee (ISSC)

greement



cal Workshop held at Jodrell Bank

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, ELT, OWL), infrared (NGST) and

# Funding SKA/Chinese Development



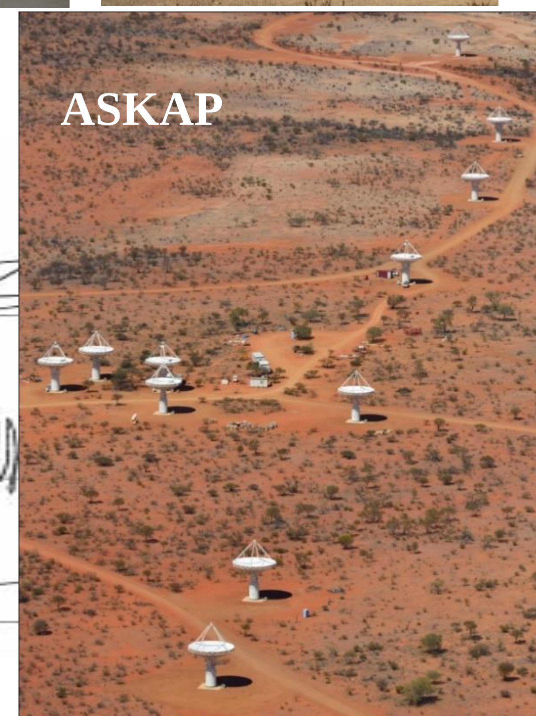

EXECUTED by
Signed by Patricia Kelly )
for and on behalf of )
Australian Department of
Innovation, Industry, Science )
and Research, Australia
Signature

EXECUTED by
Signed by Prof. Jun Yan )
for and on behalf of )
National Astronomical
Observatories, Chinese Academy )
of Sciences, China
Signature

EXECUTED by
Signed by Dr. Corrado Perna )
for and on behalf of )
the President of Istituto Nazionale
di Astrofisica, Italy, )
Prof. Giovanni F. Bignami
Signature

EXECUTED by
Signed by Prof. Dr. Jos Engelen )
for and on behalf of )
Nederlandse Organisatie voor
Wetenschappelijk Onderzoek, )
the Netherlands
Signature


Apr 2019



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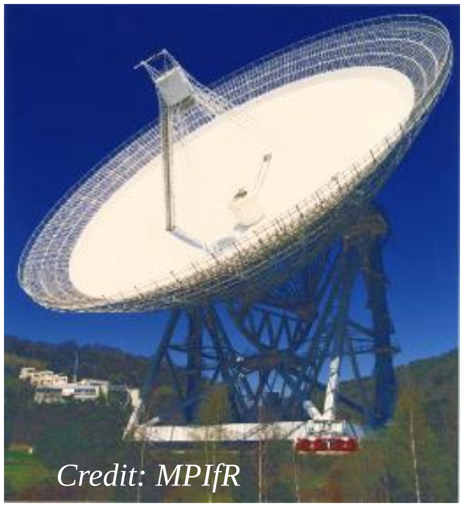
**3 FAST Concept to telescope Operation**

# What is FAST

## 500米口径球面射电望远镜

## Five hundred meter Aperture Spherical radio Telescope


Credit: MPIfR

Effelsberg 100 m

- **Unique Karst depression** (limestone sinkhole)
- **Active main reflector**
- **Cable suspension-** parallel robot feed support

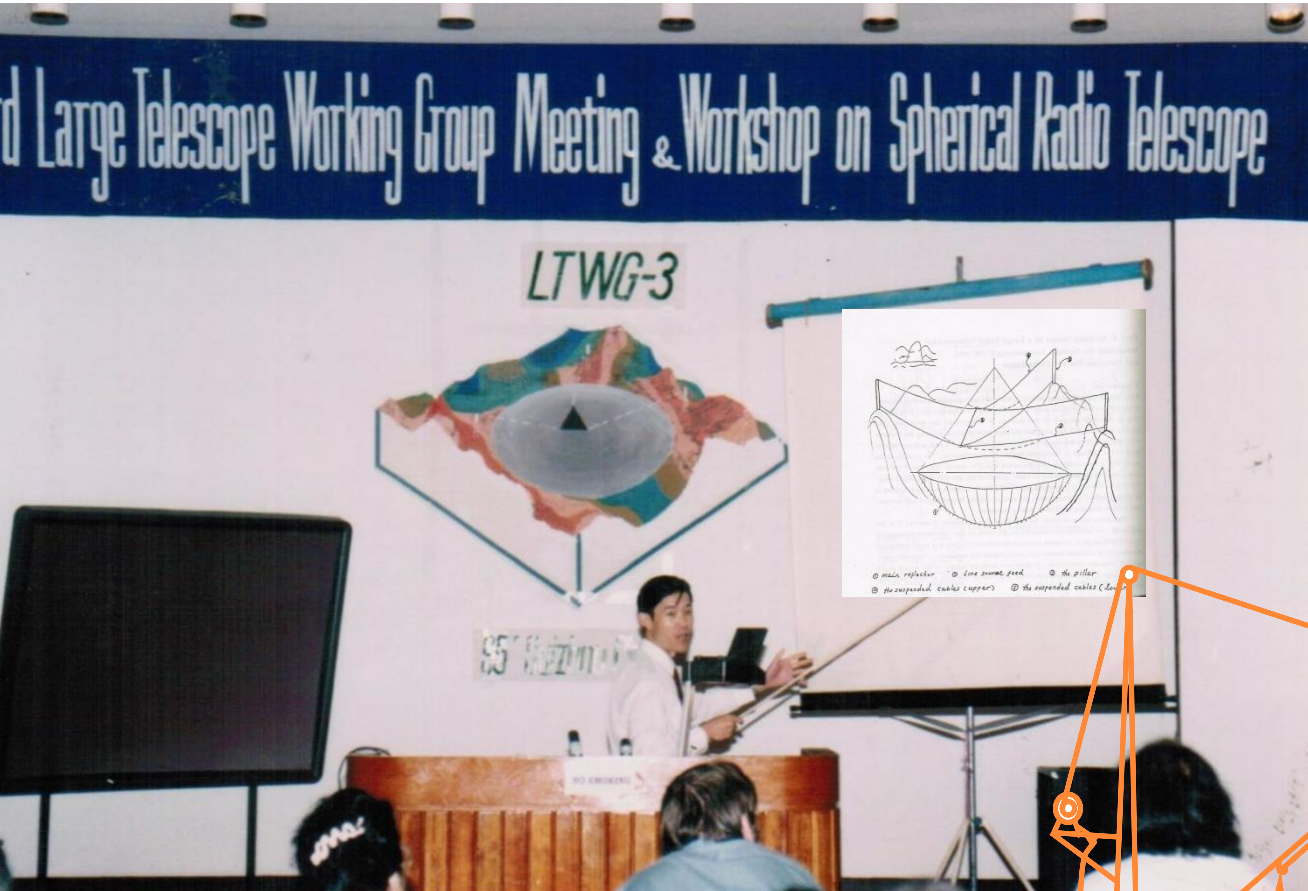
Credit: FAST Project

**Kilometre-square**
**Area**
**Radio**
**Synthesis**
**Telescope**


Arecibo 300 m

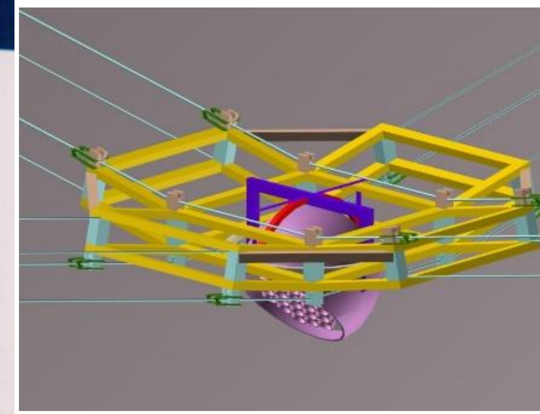
Credit: Arecibo Observatory

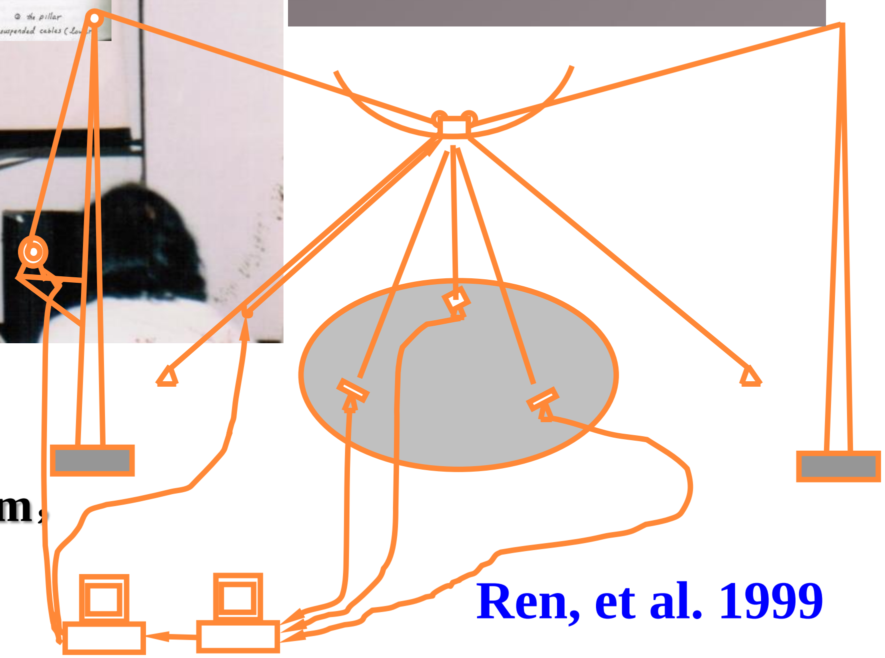
# Focus cabin driven by Cables1995




Duan, Zhao, Wang & Xu,1995

**Feed Pointing + Tracking**





**Xidian 3/6，Tsinghua 8/4/6，BIT Stewart Platform，**
**CASMI，NAOC-UTDEtE Simulation**

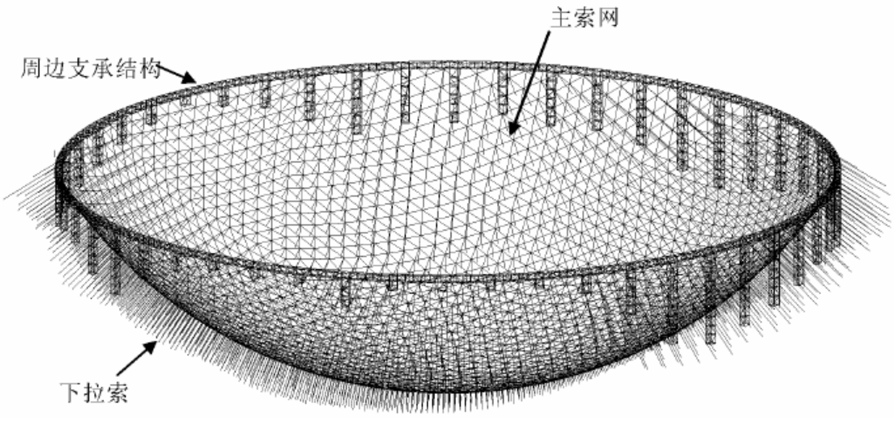
**Ren, et al. 1999**

# Reflector deformed by actuators

**BAO** 北京天文台
**TJU** 同济大学
**NIAOT** 南京天光所
**BHU** 北航
**Tsinghua** 清华大学
**HIT** 哈工大
**NAOC** 国家天文台

**Qiu Y., 1998**

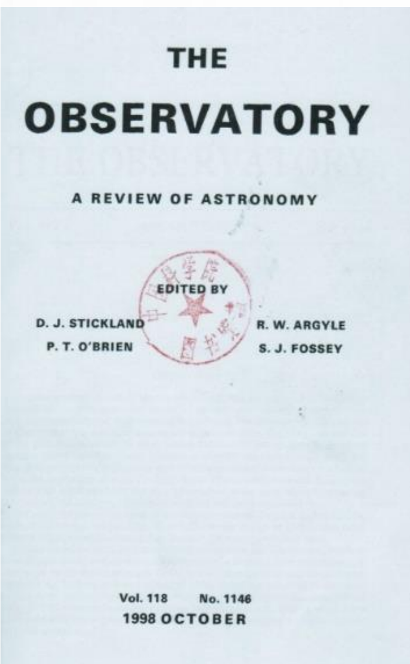
Nan, Ren, Zhu, Lu, 2003




# Concept announced概念问世1998

*The President*. Thank you very much once again. It is my v
to welcome a delegation of Chinese astronomers to the RA
They will give us two short presentations. The first of the
the *FAST* prototype for the *KARST* radio interferometer
*Radio Synthesis Telescope*) and will be given by Dr. Peng B
Astronomical Observatory.

*Dr. Peng Bo*. One way to realize the *Large radio Telescope* (L
tive collecting area approaching one square kilometre, contin


THE
OBSERVATORY
A REVIEW OF ASTRONOMY
EDITED BY
D. J. STICKLAND R. W. ARGYLE
P. T. O'BRIEN S. J. FOSSEY
Vol. 118 No. 1146
1998 OCTOBER

## RAS Speeches & Visit 1998


第 18 卷 第 2 期 天 体 物 理 学 报 Vol.18 No.2
1998 年 4 月 ACTA ASTROPHYSICA SINICA April 1998

· 研 究 快 报 ·

### 具有主动主反射面的巨型球面射电望远镜*

邱 育 海

(中国科学院北京天文台 北京 100080)

提 要

提出一种新颖的大球面射电望远镜的设计方案. 以往球面射电望远镜的设计方案是利用各种复杂馈源系统, 如 Arecibo 三反射面系统来克服球差, 而我们拟实时地改变被馈源照明的部分球反射面的形状以最大限度地拟合旋转抛物面, 从而用传统的抛物面馈源照明来实现宽带与偏振观测. 此设计有天空覆盖范围大及可实现独立多瓣观测等优点. 文中还对 500 m 口径的球面射电望远镜 (曲率半径 300 m) 以及 300 m 可用口径的具体实例提出了实施方案.

**关键词** 球面射电望远镜 — 旋转抛物面天线 — 主动主反射面

1 引 言

电望远镜的接收面积在射电天文发展上起决定性的作用. 其主要类型 "全可动" 天线的口径, 迄今最大能做到 100 米级 (工作波长为厘米级). 利用 Karst 凹地天线的球面射电望远镜, 由于取消了主反射面的运动而改用馈源移动来跟踪目

Christiansen 1998

# Demonstration + Funds Approval


*International Review and Advisory 2006*


**HI detection on Sept.6 2006 @ MyFAST**

*Credit: FAST Project*

办公厅文件
第001306号 [2007]

国家发展和改革委员会文件

发改高技〔2007〕1538 号

国家发展改革委关于 500 米口径球面射电望远镜
国家重大科技基础设施项目建议书的批复

中国科学院、贵州省发展改革委：

你们《关于报送国家重大科技基础设施－500 米口径球面射电望远镜项目建议书的函》（科发计字〔2006〕271 号）及《中国科学院贵州省人民政府关于国家重大科技基础设施 500 米口径球面射电天文望远镜项目建议书建设内容调整的函》（科发计字〔2007〕129 号）均悉。经研究，原则同意所报调整后的项目建议书，现批复如下：

一、根据国家科教领导小组第三次会议审议确定的国家重大科技基础设施建设规划，鉴于 500 米口径球面射电望远镜（FAST）

义，原则同意将FAST项目列入国家高技术产业发展项目计划。

***NDRC Approval on FAST Funding Proposal on* July 10 2007**

- **R～300m,D～500m, $D_{eff}$=300m**
- **Maxi zenith angle 40°**
- **Freq.  70MHz-3GHz up to X-band**
- **Sensitivity 2000 ㎡/K**
- **Resolution 2.9’;**
- **Multibeam 19**

# Foundation+ Impossible Engineering

*FAST Break Ground Dec. 26 2008*

大窝凼 Dawodang original 2007

*Credit: FAST Project*

Scientific Beauty 2016

*Credit: FAST Project*

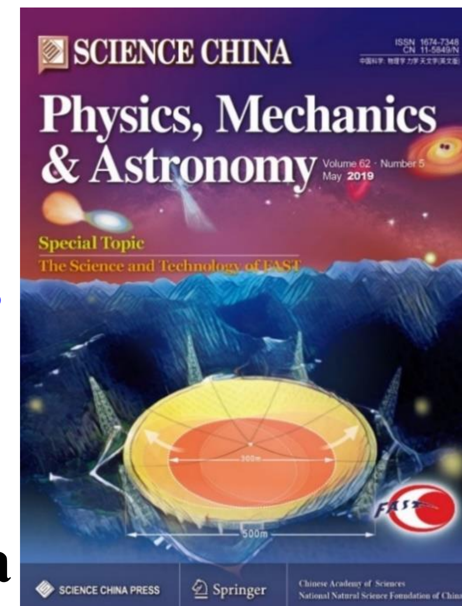
"demaged" Scence 2011

*Credit: FAST Project*

# Commission to Operation 2017-2022

Observing Time > 5000 hours/yr since 2020

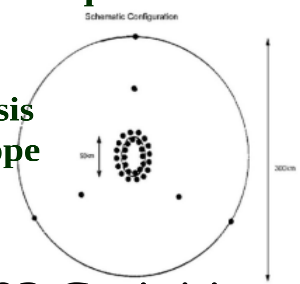
- **Pulsar candidates confirmed > 660**
  - Aug.22, 2017, First pulsar discovered
- **Jan 2019 VLBI fringe with TM**
- **Apr. 2019 Shared-risk observation**
  - 113 proposals asking for > 2200 hrs vs 400 hrs
  - May 2019 Early Science published



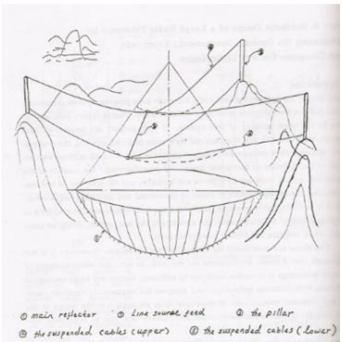

- **Key Science Projects (Feb.2020) 50% FAST Time**
  - Commensal multi-beam drift-scan sky survey, GPPS, CPTA Pulsar Physics, HI mapping and pulsar searching in M31, FRB
- **Repeating FRB180301 & SGR1935+2154 *(FRB200428)***
  - Nature 586 Nov., Nature Dec.2020, Science, 2021, Nature 2022
- **Apr. 2021 CfP opened to world, 10% first oversea**
  - 216 proposals asking for > 7000 hrs vs 4500 hrs, 15 countries

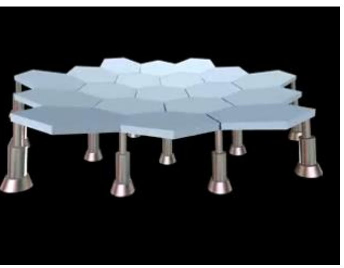
# Long March to an Earth Landmark

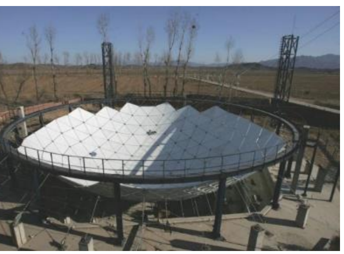

Kilometre-square
Area
Radio
Synthesis
Telescope




**We were young enough that we didn't know we couldn't do it. If you dream, have big dreams. And have talented supporters to help you**





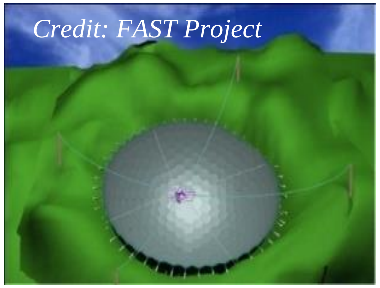


1993 Co-initiator of LT at URSI
1994 Site Survey and first RFI measurements
1995 LTWG-3 Guizhou and LTPC established
1996 Engineering Concept KARST finalized
1997 FAST Concept forming
1998 Concept finalized/announced in UK/China
1999 Experiments funded by Innovation Project
2000 FAST funding proposal submitted to MOST
2006 Site Selection + Int'l Advisory Review
2007 Funding Approval
2008 Feasibility Study Report Acceptance
2009 Preliminary Design Review Acceptance
2011 FAST Construction Start
2016 Inauguration by FAST Firstlight
2020 Operation Acceptance by NDRC
50 yrs' science discovery

**March forward**

***regardless of hardship***

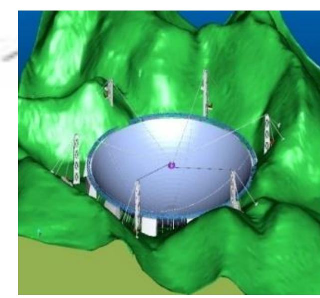
# Dream continues towards KARST

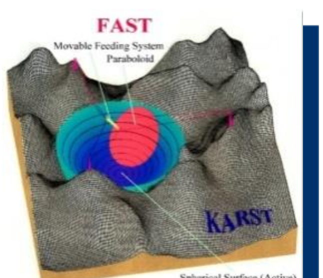



**Add 8 FAST-like dishes at SKA1 cost,**
**100% SKA sensitivity @ 600 km,**
**60 deg. ZA, Up to X-band**



**Add 100 SKA-dish at FAST cost,**
**2000 FAST resolution @ 600 km,**
**80 deg. ZA, Up to 24 GHz**




**Expanded Array: FAST-like +small dishes**