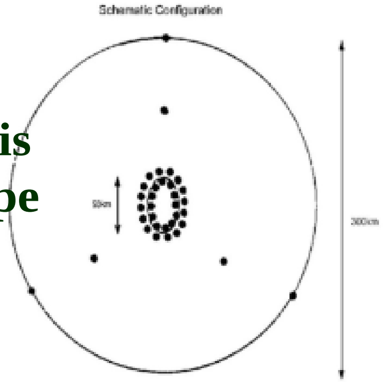
From SKA to FASTea

从平方公里阵到FAST扩展阵

Kilometre-square
Area
Radio
Synthesis
Telescope



Bo Peng

National Astronomical Observatories, CAS

Outlines

1 LT/SKA Initiation and Contribution

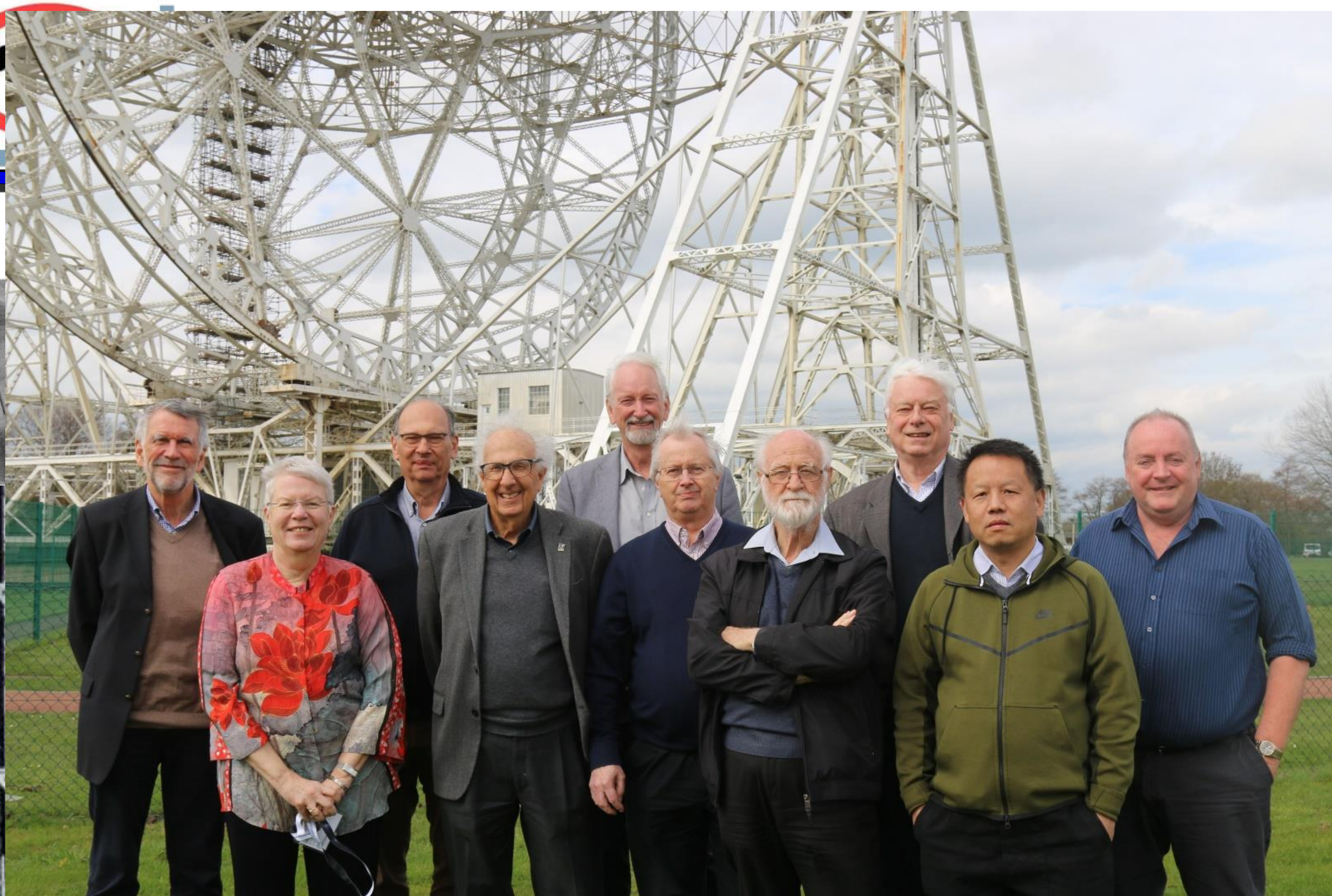
2 FAST Design and Construction

3 Discoveries from FAST Observations

4 FAST Expanded Array

WG)

ee (ISSC)



greement

cal Workshop held at Jodrell Bank

he SKA's superb resolving power-
n could extend to one milliarc-
d- and exceptional image quality
also provide crucial new inform-
on the formation and early history
rs, galaxies and quasars unaffected
scuring dust. Its enormously high
tivity will mean that, for the first
objects in the early Universe can be
ed in detail in the radio range. The
is thus the perfect scientific
lement to the large optical (e.g.
, ELT, OWL), infrared (NGST) and

Initiating LT/SKA

SKA Global Collaboration

MeerKAT Support Base
Feb. 2009

MeerKAT Delegation, July 2009

TDP/ASKAP/SPDO Delegation Jan.22 2010

Preparing for the SKA: Science and Technology, Nov.2-4,2011

Daejeon,Nov29 2011

JLRAT & CASS at NAOC
Dish Array Proto-Consortium
April 2012

SKA Funding + Engineering

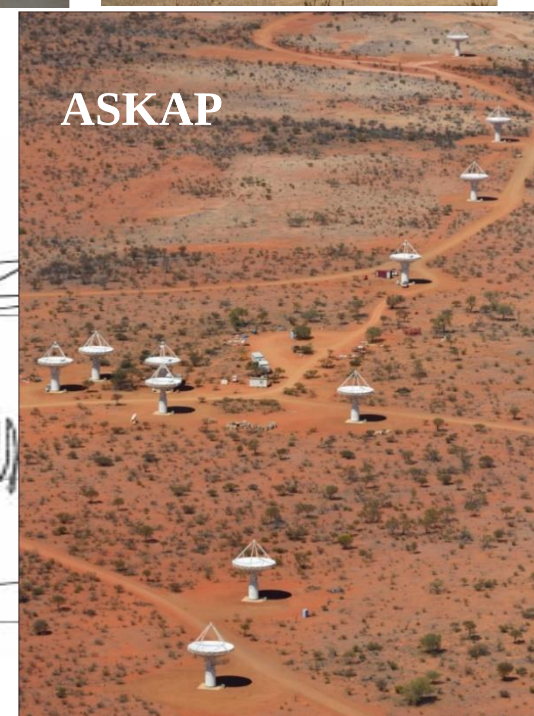
EXECUTED by
Signed by Patrick Kelly)
for and on behalf of)
Australian Department of
Innovation, Industry, Science)
and Research, Australia
Signature

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



Outlines

1 LT/SKA Initiation and Contribution

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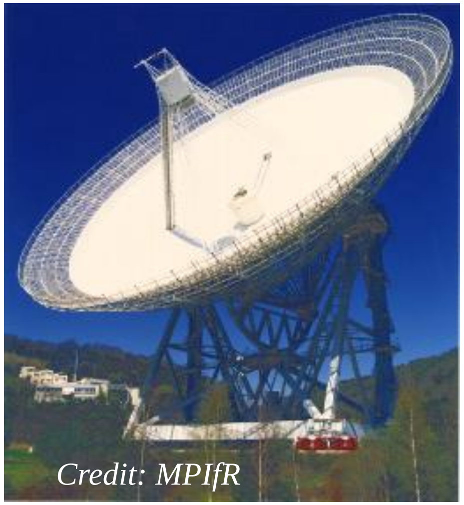
3 Discoveries from FAST Observations

4 FAST Expanded Array

What is FAST

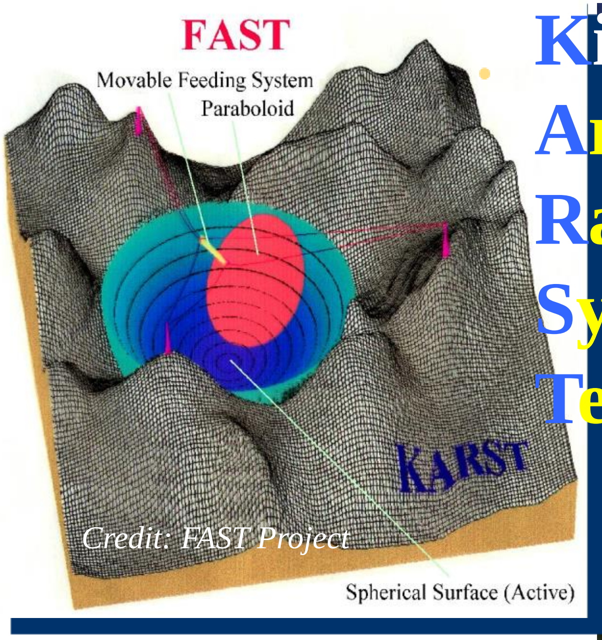
500米口径球面射电望远镜

Five hundred meter Aperture Spherical radio Telescope



Effelsberg 100 m

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

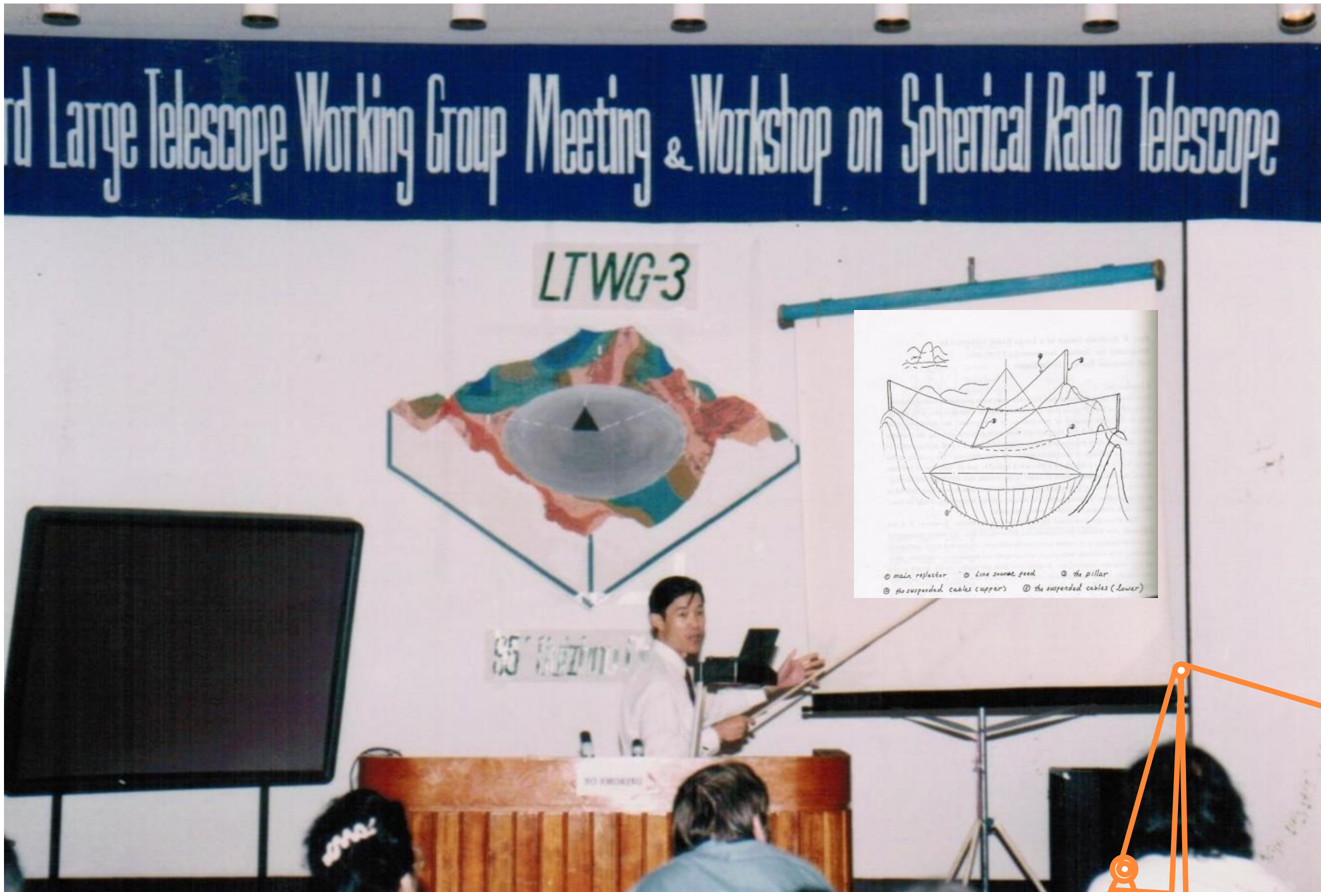


Kilometre-square
Area
Radio
Synthesis
Telescope

1st SKA Conference in China LTWG-3

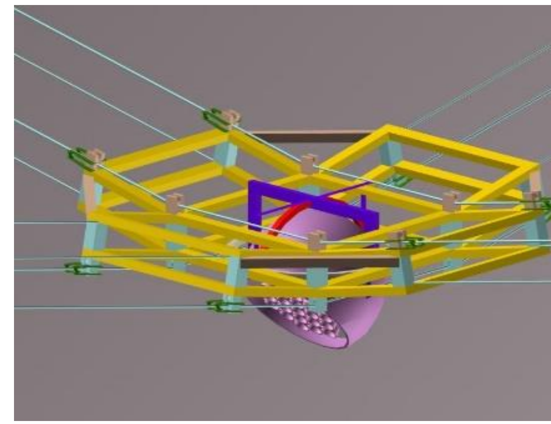
Huaxi Hotel, Guiyang 1995

Feed driven by cables 1995

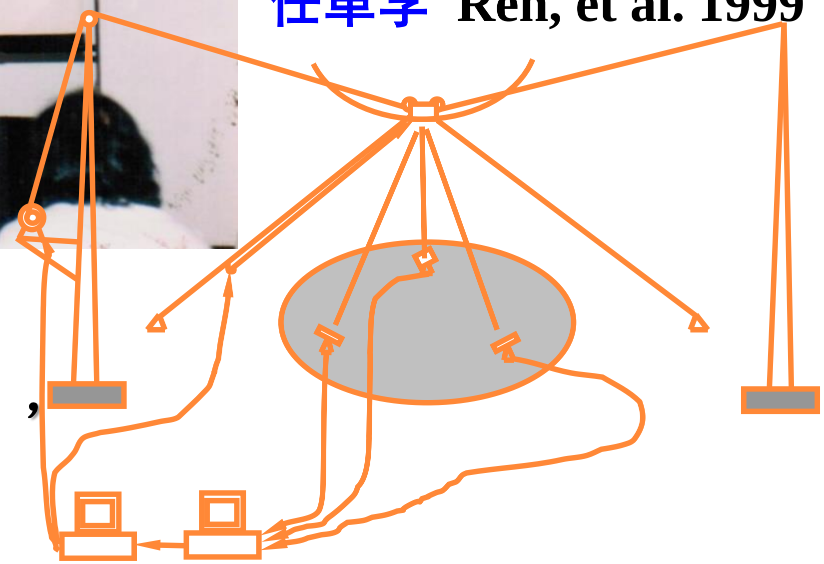


段宝岩 Duan, Zhao, Wang & Xu,1995

馈源指向与跟踪



任革学 Ren, et al. 1999



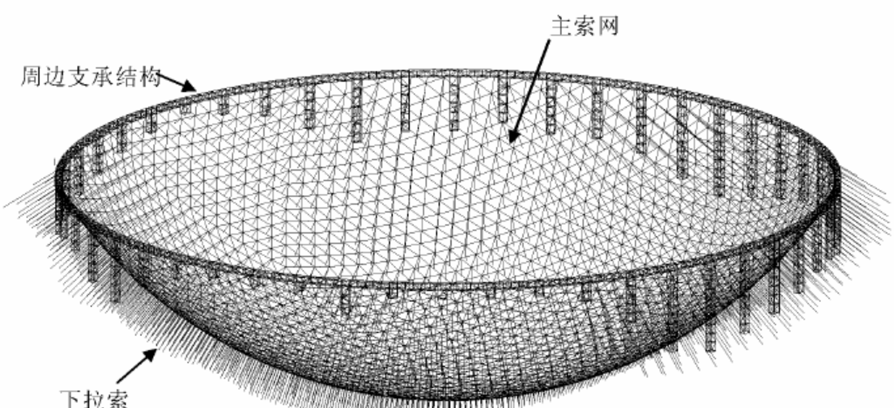
西电3/6塔（室内外），清华8/4/6塔（室内外），
北理工Stewart平台，中科院力学所，
中科院数学与系统所，国家天文台中德仿真

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

邱育海Qiu Y., 1998

南仁东 Nan, Ren, Zhu, Lu, 2003



四院士推荐信1998

中国科学院路甬祥院长：

我们谨向您推荐一项对射电天文学和航天深空通讯具有重要意义的新型天线方案(预计总投资约2亿人民币)，希望能在现阶段给予预研究经费（约320万元人民币）的支持。

这是几年来研究利用贵州喀斯特洼地，实现巨型射电望远镜的LT研究组最近作出的成果，在技术方法上有重要的创新。我们阅读了这个方案的研究报告（见附件“具有主动主反射面的巨型球面射电望远镜”）并进行了讨论，认为这个方案设计的，口径300米可以胜任大天区扫描的天线系统，在厘米波段上的功能较之当前国际上同类天线（在射电天文应用上[illegible]，在[illegible]应用上最大为[illegible]左右。到[illegible]可动[illegible]望远镜由于结[illegible]素，很难[illegible]过1[illegible]0米级。[illegible]国[illegible]期发展的[illegible]望远镜，利用地面洼坑铺成300米的球面反射面，实现了有效口径达到200米级，但它的球面像差使天线馈源变得非常复杂。而由于望远镜固

陈芳允、杨嘉墀、王绶琯、陈建生

米波段（这也是当前巨型射电望远镜主要的工作波段）工作的功效将较之今后相当长时间内可预见的国际上最大的同类望远镜强一个量级。因而其探测深度将跃进一个新的阶梯。（当前已发现射电天文目标的数目不及光学天文目标的 10^{-4}，而已发现的射电目标，当初几乎都是意外的重大发现）；

（2） 目前航天上深空通讯的地面系统，最大天线口径为 64 米，全球布局中这种望远镜有 3 台，正需要在中国土地上安放 1 台以填补这 3 台的空间覆盖的空白（西班牙与澳大利亚站之间）。

如上所述，我们的“最小”口径为 100 米而最大的为 300 米（可以随时选用）。设想用在 300 米模式上，通讯的信噪比将得到很大提高，尤其是在木星及更远目标的联络中，大接收面积将可缓解飞行体上的能源[illegible]了寿命。[illegible]际[illegible]，如果我们以这[illegible]无疑将有[illegible]的地位。特别是，如果我[illegible]自己的深空[illegible]个有效的地面站。

我们[illegible]一旦判断其可行，尽快地开展预先研究，[illegible]很重要的一个环节。

[illegible]以冒昧上陈，希望予以考虑支持，并

敬礼！

Feb. 5 1998

Feb. 26, 1998

陈芳允 陈芳允

杨嘉墀 杨嘉墀

王绶琯 王绶琯

陈建生 陈建生

1998 年 2 月 5 日

Experiments of Feed driven by cables

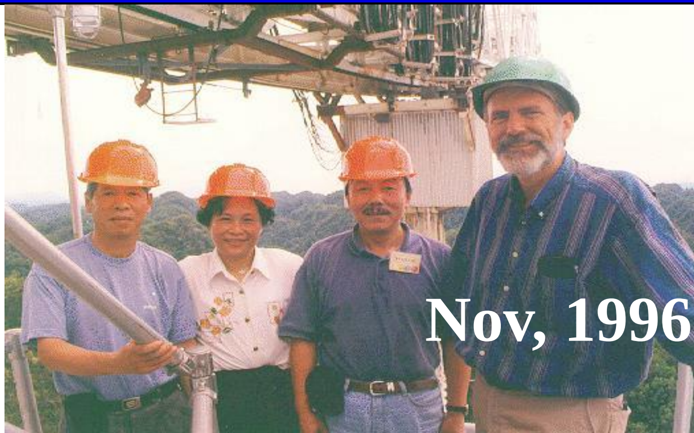
清华 20m

Tsinghua

Xidian西电 50m

BIT北理工机器人

中美天眼传承 2002



Peng Bo

发件人: Bill Gordon <bgordon@spacsun.rice.edu>
收件人: <pb@bao.ac.cn>
抄送: <71221.621@compuserve.com>

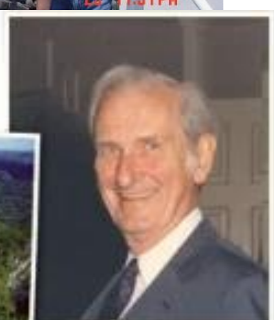
Peng Bo

发件人: Bill Gordon <bgordon@spacsun.rice.edu>
收件人: <pb@bao.ac.cn>
抄送: <71221.621@compuserve.com>
发送时间: 2002年9月2日 0:06
主题: FAST and your paper at the URSI Assembl

B. Peng and R.Nan,

I was pleased to read your paper in the March 2002 RADIO SCIENCE BULLETIN ABOUT "THE WORLD'S LARGEST SINGLE that the Arecibo Telescope currently holds. I wish you good luck in your efforts.

Whether you meet your design goals or not you should have valuable instrument. best of luck with your project,
Bill Gordon, "The father of Arecibo"



Bill Gordon

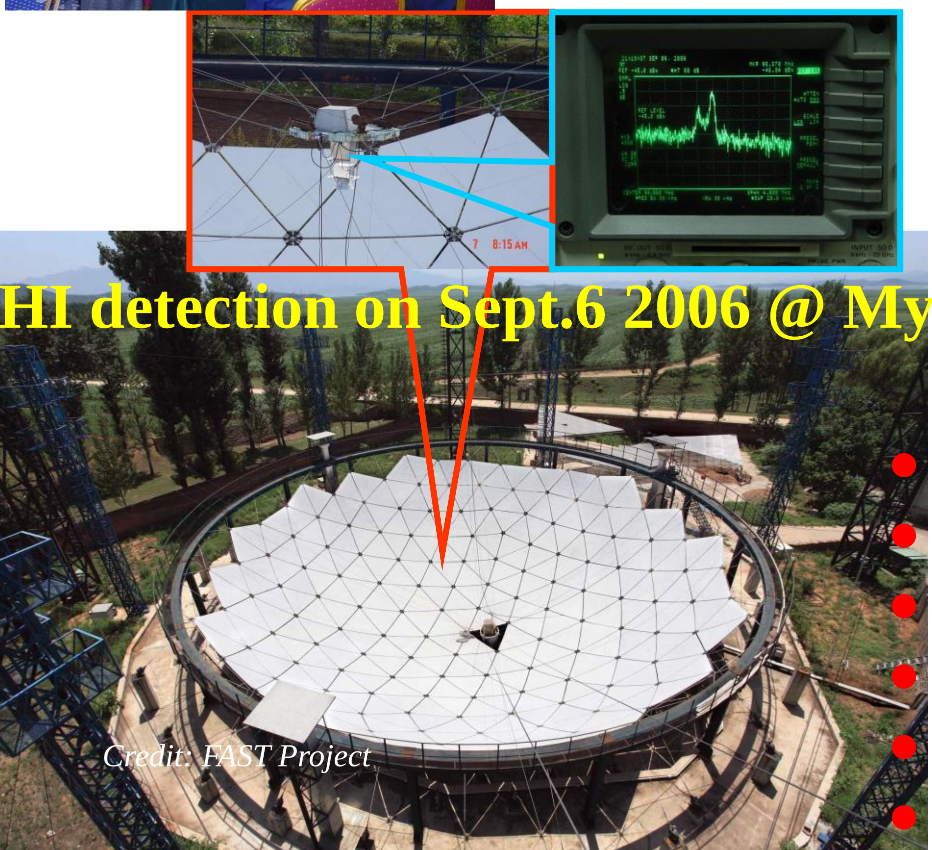
The father of Arecibo

Arecibo. As I understand your suspension system you are using that scheme.

Whether you meet your design goals or not you should have a valuable instrument. best of luck with your project,
Bill Gordon, "The father of Arecibo"

Demonstration + Funds Approval

International Review and Advisory 2006



HI detection on Sept.6 2006 @ MyFAST

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）的建设对于提高我国天文学领域研究水平和国际地位具有重要意义，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

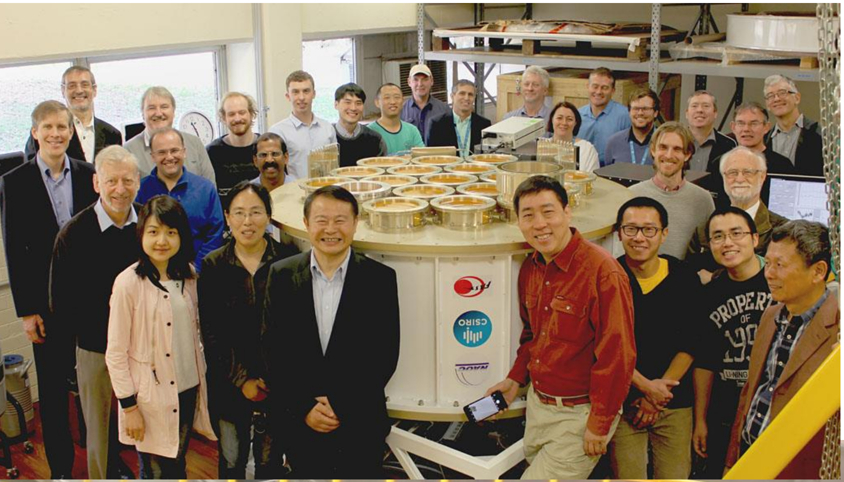
大窝凼 Dawodang 2007

it: FAST Project

"demaged" Scence 2011

Credit: FAST Project

Cooperate FAST 19-beam Receiver



CSIRO Lab

FAST Lab

Jeganathan Kanapathippillai,
Tasso Tzioumis，
Paul Doherty，
Mark Andrew Bowen

FAST Constructed

Credit: FAST Project

Outlines

1 LT/SKA Initiation and Contribution

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4 FAST Expanded Array

Three-Generation RT at Miyun Station

LTWG-3
Prep 1995

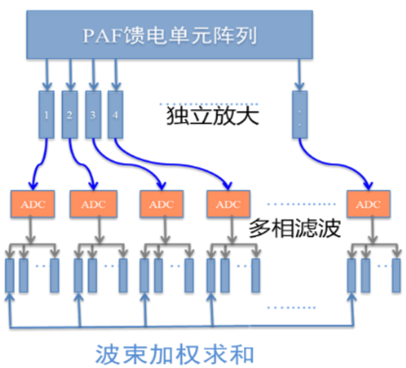
Miyun 50 m

MyFAST 30 m

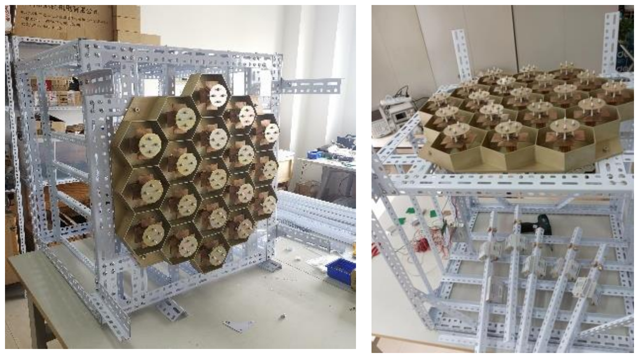
Miyun FAST demonstrator 2006

Research Overview

1 Technology R&D — Cryo-PAF, WBSPF, LNA, SKA prototype antenna, Electronics, Digital backend,Data processing and Intelligence algorithm,



PAF信号流程

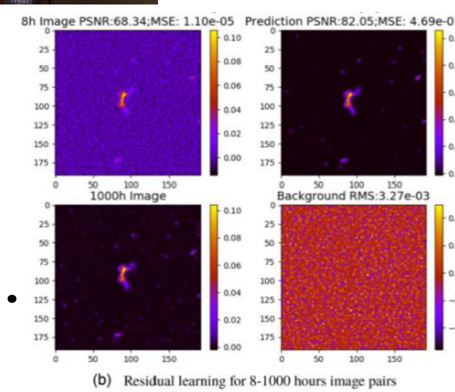


PAF前端馈电阵列

LNA

Filters

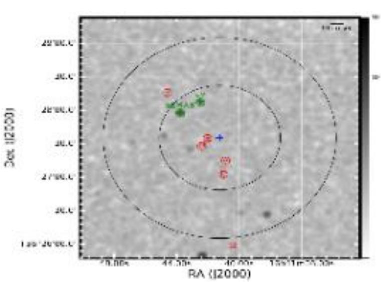
SKA-P望远镜



Yu,L.,et al.MNRAS, 2022,511,4305

基于SKA科学数据挑战一的深度学习算法

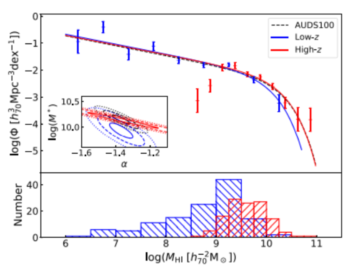
2 Astrophysics — Pulsars, HI, RRLs, IPS, GWs, .



球状星团M13脉冲星搜寻和计时

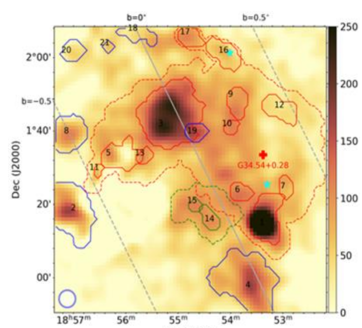
Wang, L.,et al.,ApJ,2020,892

Xi et al. 2021, MNRAS,501

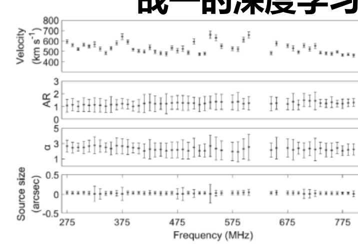


中性氢质量函数随红移的演化趋势

Liu, B.,et al,,PASA,2022



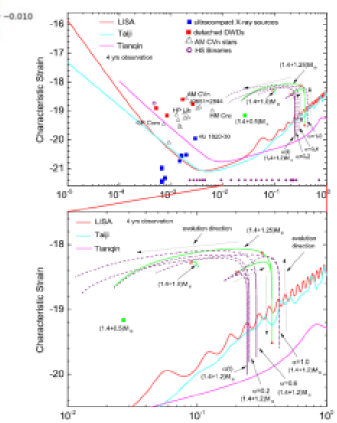
射电复合线观测研究



行星际闪烁观测研究

Liu,L.,et al.,MNRAS,2022,515

Liu,L.,et al.,MNRAS,2021,504



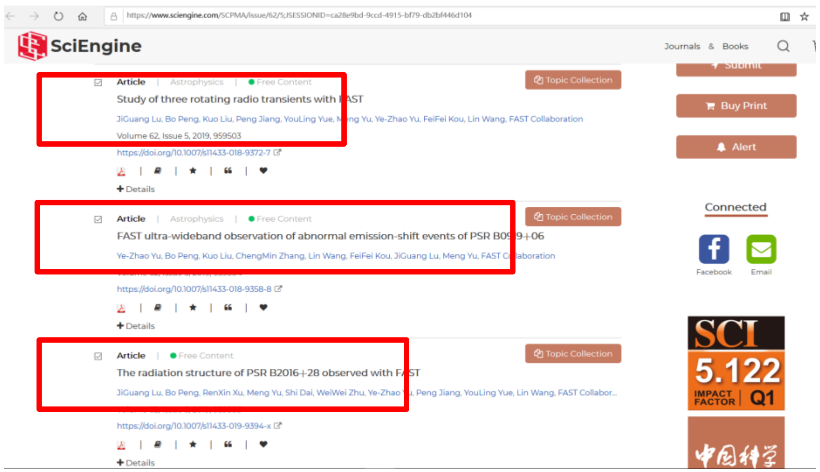
中子星-白矮星并合引力波信号

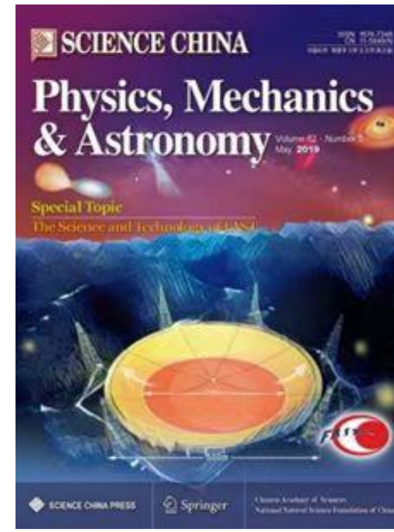
Yu, S.,et al.,MNRAS,2021

Contribute to 1st FAST Achievements

- **SCIENCE CHINA Physics, Mechanics & Astronomy, Volume 62, Issue 5, 2019**

Special Topic: The Science and Technology of FAST





SCIENCE CHINA
Physics, Mechanics & Astronomy
CrossMark

• Article •
Special Topic: The Science and Technology of FAST

May 2019 Vol. 62 No. 5: 959503
https://doi.org/10.1007/s11433-018-9372-7

Study of three rotating radio transients with FAST

JiGuang Lu[1,2*], Bo Peng[1,2*], Kuo Liu[3,1], Peng Jiang[1], YouLing Yue[1], Meng Yu[1], Ye-Zhao Yu[1,4], FeiFei Kou[1], Lin Wang[1,4], and FAST Collaboration

[1]*CAS Key Laboratory of FAST, National Astronomical Observatories, Chinese Academy of Sciences, Beijing 100101, China;*
[2]*Guizhou Radio Astronomy Observatory, Chinese Academy of Sciences, Guiyang 550025, China;*
[3]*Max-Planck-Institut für Radioastronomie, Bonn D-53121, Germany;*
[4]*College of Astronomy and Space Sciences, University of Chinese Academy of Sciences, Beijing 100049, China*

Received December 7, 2018; accepted February 21, 2019; published online March 19, 2019

Rotating radio transients (RRATs) are peculiar astronomical objects whose emission mechanism remains under investigation. In this paper, we present observations of three RRATs, J1538+2345, J1854+0306 and J1913+1330, carried out with the Five-hundred-meter Aperture Spherical radio Telescope (FAST). Specifically, we analyze the mean pulse profiles and temporal flux density evolutions of the RRATs. Owing to the high sensitivity of FAST, the derived burst rates of the three RRATs are higher than those in previous reports. RRAT J1854+0306 exhibited a time-dynamic mean pulse profile, whereas RRAT J1913+1330 showed distinct radiation and nulling segments on its pulse intensity trains. The mean pulse profile variation with frequency is also studied for RRAT J1538+2345 and RRAT J1913+1330, and the profiles at different frequencies could be well fitted with a cone-core model and a conal-beam model, respectively.

radiation mechanisms, radio, pulsars

PACS number(s): 95.30.Gv, 95.85.Bh, 97.60.Gb

SCIENCE CHINA
Physics, Mechanics & Astronomy
CrossMark

• Article •
Special Topic: The Science and Technology of FAST

May 2019 Vol. 62 No. 5: 959505
https://doi.org/10.1007/s11433-019-9394-x

The radiation structure of PSR B2016+28 observed with FAST

JiGuang Lu[1,2*], Bo Peng[1,2*], RenXin Xu[3], Meng Yu[1], Shi Dai[4,1], WeiWei Zhu[1], Ye-Zhao Yu[1,5], Peng Jiang[1], YouLing Yue[1], Lin Wang[1,5], and FAST Collaboration

[1]*CAS Key Laboratory of FAST, National Astronomical Observatories, Chinese Academy of Sciences, Beijing 100101, China;*
[2]*Guizhou Radio Astronomy Observatory, Chinese Academy of Sciences, Guiyang 550025, China;*
[3]*School of Physics and Kavli Institute for Astronomy and Astrophysics, Peking University, Beijing 100871, China;*
[4]*CSIRO Astronomy and Space Science, Australia Telescope National Facility, Epping NSW 1710, Australia;*
[5]*College of Astronomy and Space Sciences, University of Chinese Academy of Sciences, Beijing 100049, China*

Received February 20, 2019; accepted March 15, 2019; published online March 21, 2019

With the largest dish Five-hundred-meter Aperture Spherical radio Telescope (FAST), both the mean and single pulses of PSR B2016+28, especially including the single-pulse structure, are investigated in detail in this study. The mean pulse profiles at different frequencies can be well fitted in a conal model, and the peak separation of intensity-dependent pulse profiles increases with intensity. The integrated pulses are obviously frequency dependent (pulse width decreases by ~20% as frequency increases from 300 to 750 MHz), but the structure of single pulses changes slightly (the corresponding correlation scale decreases by only ~1%). This disparity between mean and single pulses provides independent evidence for the existence of the RS-type vacuum inner gap, indicating a strong bond between particles on the pulsar surface. Diffused drifting sub-pulses are analyzed. The results show that the modulation period along pulse series (P_3) is positively correlated to the separation between two adjacent sub-pulses (P_2). This correlation may hint a rough surface on the pulsar, eventually resulting in the irregular drift of sparks. All the observational results may have significant implications in the dynamics of pulsar magnetosphere and are discussed extensively in this paper.

radiation mechanisms, mathematical procedures and computer techniques, radio, pulsars

PACS number(s): 95.30.Gv, 95.75.Pq, 95.85.Bh, 97.60.Gb

SCIENCE CHINA
Physics, Mechanics & Astronomy
CrossMark

• Article •
Special Topic: The Science and Technology of FAST

May 2019 Vol. 62 No. 5: 959504
https://doi.org/10.1007/s11433-018-9358-8

FAST ultra-wideband observation of abnormal emission-shift events of PSR B0919+06

Ye-Zhao Yu[1,2*], Bo Peng[1*], Kuo Liu[3,1], ChengMin Zhang[1], Lin Wang[1,2], FeiFei Kou[1], JiGuang Lu[1], Meng Yu[1], and FAST Collaboration

[1]*CAS Key Laboratory of FAST, National Astronomical Observatories, Chinese Academy of Sciences, Beijing 100101, China;*
[2]*School of Astronomy and Space Sciences, University of Chinese Academy of Sciences, Beijing 100049, China;*
[3]*Max-Planck-Institut für Radioastronomie, Auf dem Hügel 69, Bonn 53121, Germany*

Received December 6, 2018; accepted January 19, 2019; published online March 13, 2019

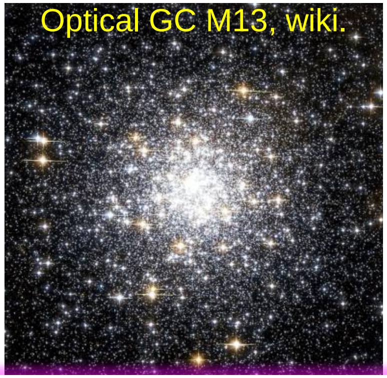
PSR B0919+06 is known for its abnormal emission phenomenon, where the pulse emission window occasionally shifts progressively in longitude and returns afterwards. The physical mechanism behind this phenomenon is still under investigation. In this paper, we present our ultra-wideband observation of this pulsar using the Five-hundred-meter Aperture Spherical radio Telescope (FAST), with simultaneous measurements in the frequency ranges 280-780 and 1250-1550 MHz. We have identified three abnormal events, each of which becomes less apparent as the frequency decreases. At 1400 MHz, the averaged profile slightly shifted after the first and third abnormal events, implying a relationship between abnormal event and profile variation. We also found a linear trend in the left-edge position of the averaged profiles between the first and third events as well as after the third event, suggesting the existence of a slow-drifting mode between the two major events. The second event has a comparatively small shift in phase and is thus categorized as a "small flare state". During the third event, a sequence of approximately nine pulses was seen to significantly weaken in all frequency bands, likely associated with the pseudo-nulling observed at 150 MHz. A three-component de-composition analysis of the normal averaged profiles shows that the trailing component is dominant at our observing frequencies, while the centre component has a comparatively steeper spectrum. We found the overall flux density in an abnormal event to slightly differ from that in an ordinary state, and the difference shows a frequency dependence. A comparison of the normal, abnormal and dimmed averaged profile indicates that the leading component is likely to be stable in all states.

pulsar, B0919+06, radio

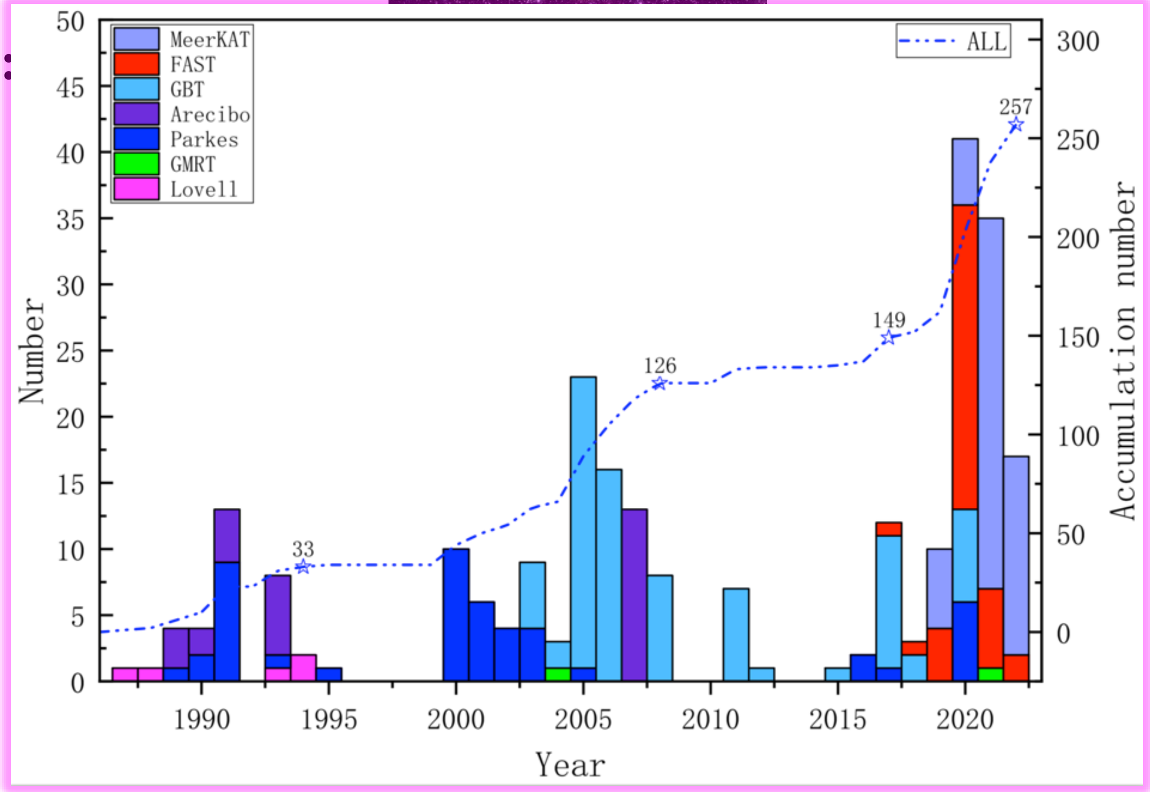
PACS number(s): 95.55.Jz, 95.85.Bh, 97.60.Gb

Pulsars in Globular Clusters (1/4)

1. **Environment in GCs**
   - Large number of stars gravitational bounded
   - Favorable environment for SF, recycling
   - Large fractional of MSPs, binary systems
2. **Individual system in GCs:**
   - EoS of dense matter
   - Tests of gravitational theories
3. **Cumulative population of psr:**
   - Structure and Dynamics of GCs,
   - GC magnetic field, Gas content



Parkes: **48** **(47 Tuc: 25)**
Arecibo: **28**
GBT: **81** **(Terzan 5: 38)**
FAST: 39 **(31 binaries)**
MeerKAT: **43**
Others (GMRT + Lovell): **7**



FAST: Wang et al. 2020
Pan et al. 2020, 2021, ApJL
Yan et al. 2021
Pan et al. RAA, 2021
Qian & Pan, 2021

257 pulsars discovered in 36 GCs by 202207. Yin et al. in prep

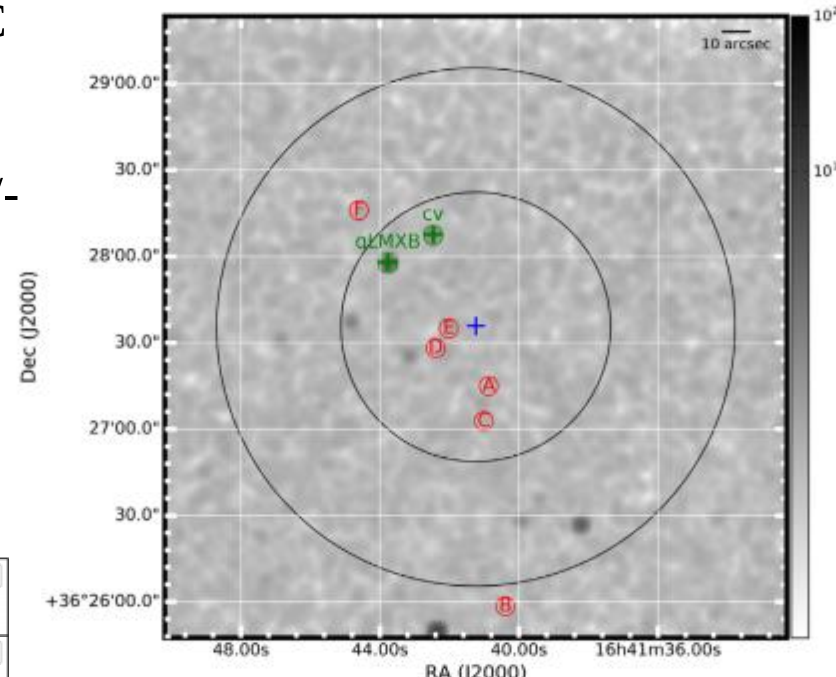
Searching+Timing pulsars in M13 (1/4)

GC M13

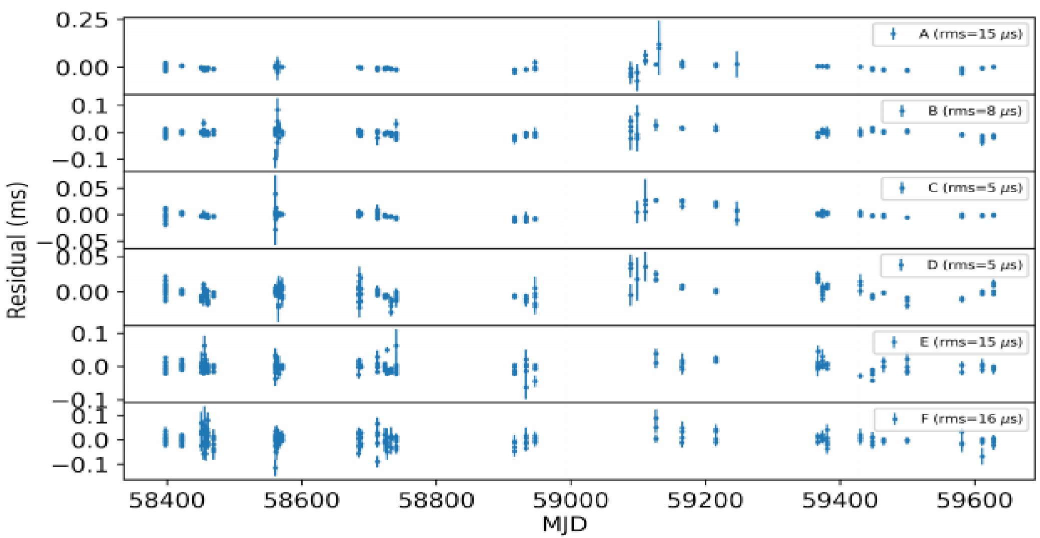
- New pulsar M13F discovered by FAST in this GC
- Update timing solution of M13A-E,
- Measure projected position of pulsars,
- HST observations→ companion of M13F: 0.23 +/- 0.03 solar masses（Cadelano et al. 2020),
- Combined with FAST timing solution (phase I)→ M13F ~ 2.4+/-0.5 solar masses.

Accurate mass measurement needs accumulation of timing data.

Projected position of pulsars



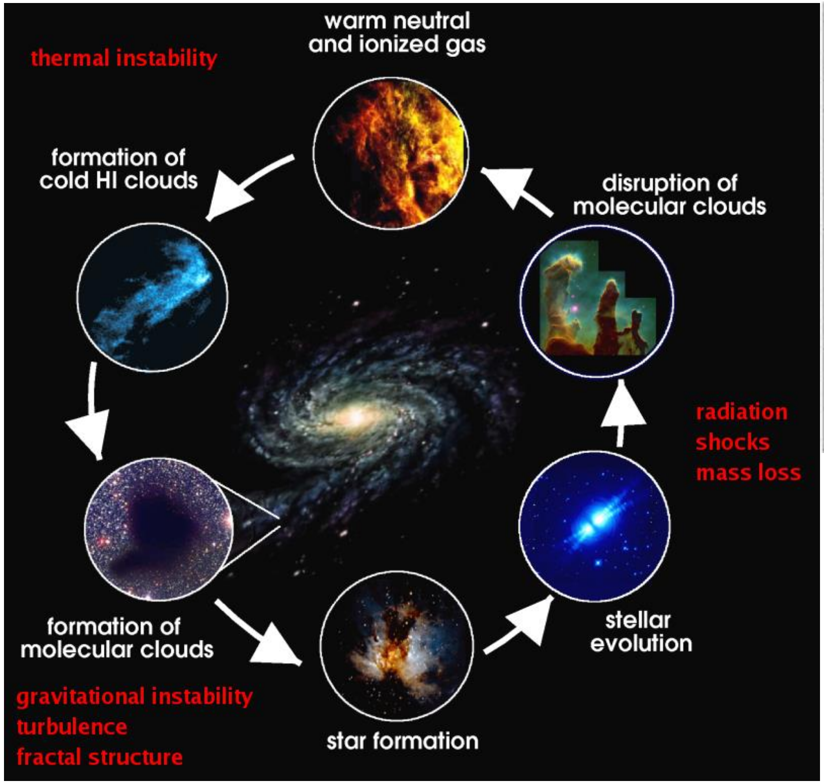
Wang, Peng, Stappers, ApJ, et al. 2020



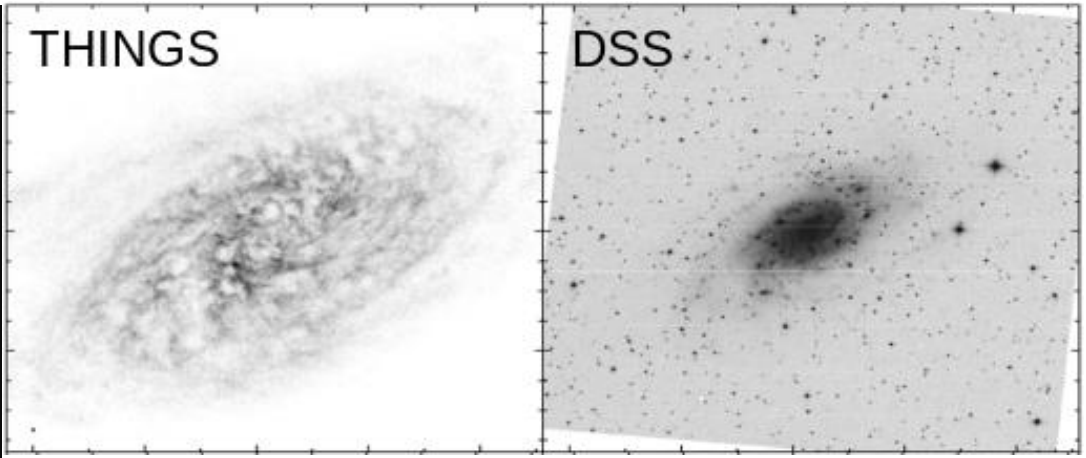
Timing residuals of 6 pulsars. Some binaries measured with post-keplerian parameters.

HI in galaxies (2/4)

Hydrogen, most abundant element, atom (HI), molecular (H2), ion (HII)
HI, most common form in late-type galaxies,
Feed molecular cloud, regulate star formation in galaxies;



http://soral.as.arizona.edu/HEAT/science/



THINGS (Walter et al. 2008)

more extended structure than stellar component, probe interaction between galaxies or between galaxy and CGM (circum-galactic medium).

Parameters HIMF and Ω_{HI} enable the comparison between observation and theory

HI blind surveys — completed (2/4)

Completed, limited in local universe, no evolution

Survey	Telescope	Sky coverage (deg^2)	Redshift coverage	Sensitivity (mJy/beam)	Detections
AHISS	Arecibo	65	0-0.025	0.75	66
AS	Arecibo	55	0-0.028	-	75
ADBS	Arecibo	430	0-0.027	-	265
HIJASS	Lovell	1775	-	-	396
HIPASS	Parkes	29338	0-0.042	13	5317
HIZAO	Parkes	1840	0-0.042	6	883
ALFALFA	Arecibo	7000	0-0.06	2.4	31500
AUDS	Arecibo	1.35	0.16	0.075	247

AUDS the first to detect HI beyond by 21 emission line.

HI surveys — ongoing (2/4)

On-going HI surveys focus on detecting distant HI galaxies.

depth	Survey	Telescope	Sky coverage (deg2)	Redshift coverage	Sensitivity (mJy/beam)	Total time
Medium	WALLABY	ASKAP	30940	0-0.26	1.6	9400
	CRASTS	FAST	22000	0-0.35	1.4	-
Deep	DINGO	ASKAP	210	0.1-0.43	0.04	7500
	FUDS	FAST	4.2	0-0.42	0.05	780
	CHILES	JVLA	0.5	0-0.45	0.05	1002
	MIGHTEE-HI	MeerKAT	20	0-0.5	0.001	1920
	LADUMA	MeerKAT	2	0-1.4	0.000068	3424

FAST Advantages: **large collecting area** and **multi-beam receiver**.
Demands **100 times** observing time to achieve by existing interferometers.

FAST Ultra-Deep Survey (2/4)

FUDS (~1000 HI galaxies)

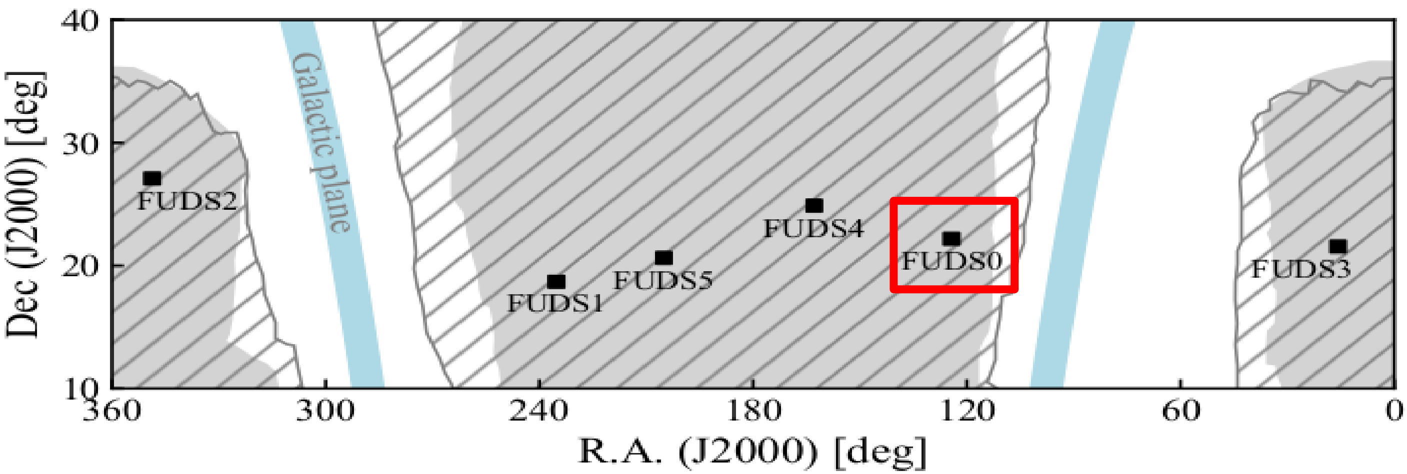
6 x 0.72 deg^2, 780 hrs (2019-);

50 uJy/beam, z ~ 0.42。

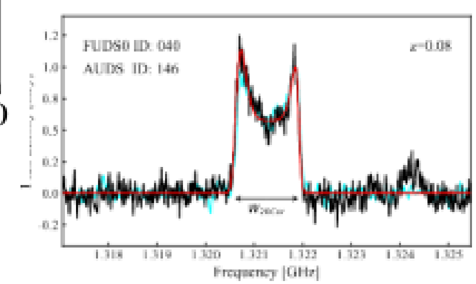
Gas evolution in galaxies;

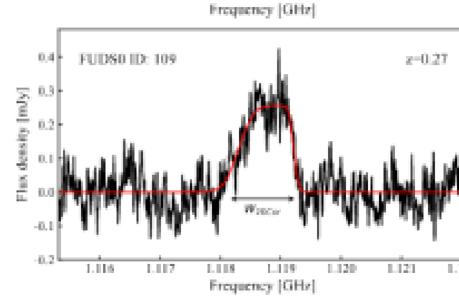
Measurements of comic HI density;

Evolution + environmental dependency of HIMF



Distribution of six fields in FUDS survey, Xi, Peng, Staveley-smith, et al. 2022,39,19





136 HI galaxies:

6 of z > 0.38;

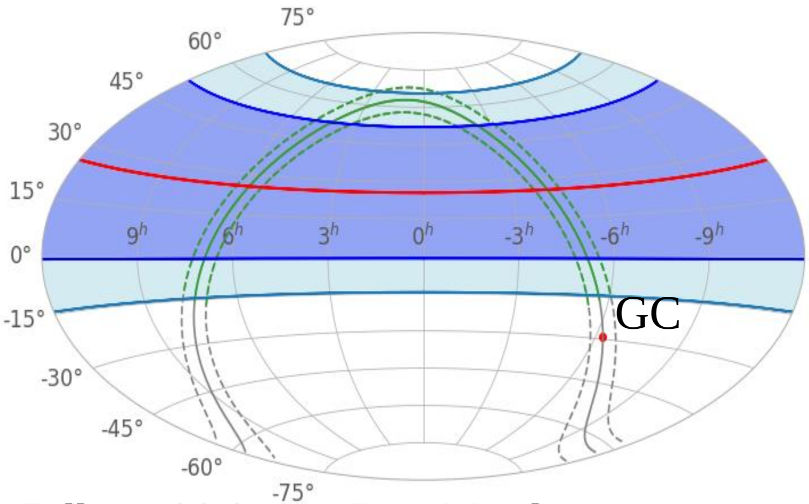
3 extreme faint HVC

RRLs on Galactic plane with FAST (3/4)

FARLS

FAST Recombination Line Survey
Liu B. et al. PASA 2022, 39, e050

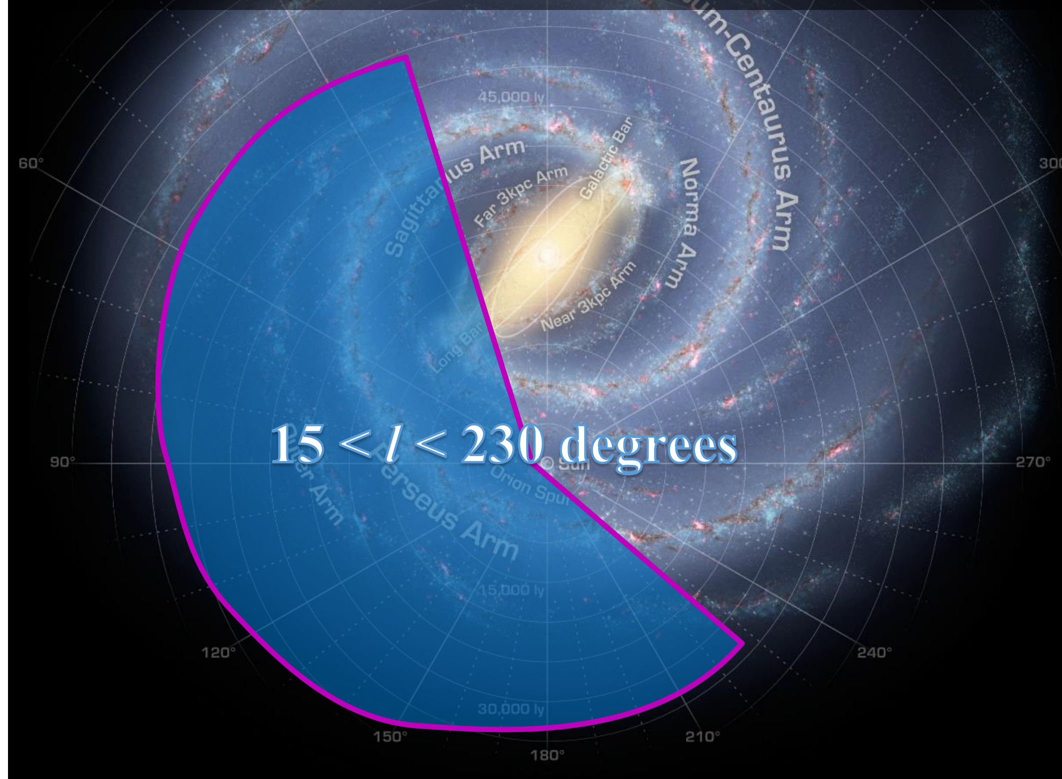
FAST Observable Galactic plane



Full sensitivity: *ZA* < 26.4 deg.
Redu sensitivity: 26.4 < *ZA* < 40 deg.

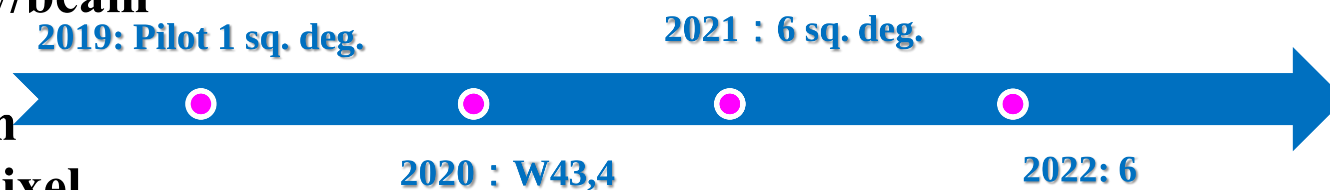
Motivations:

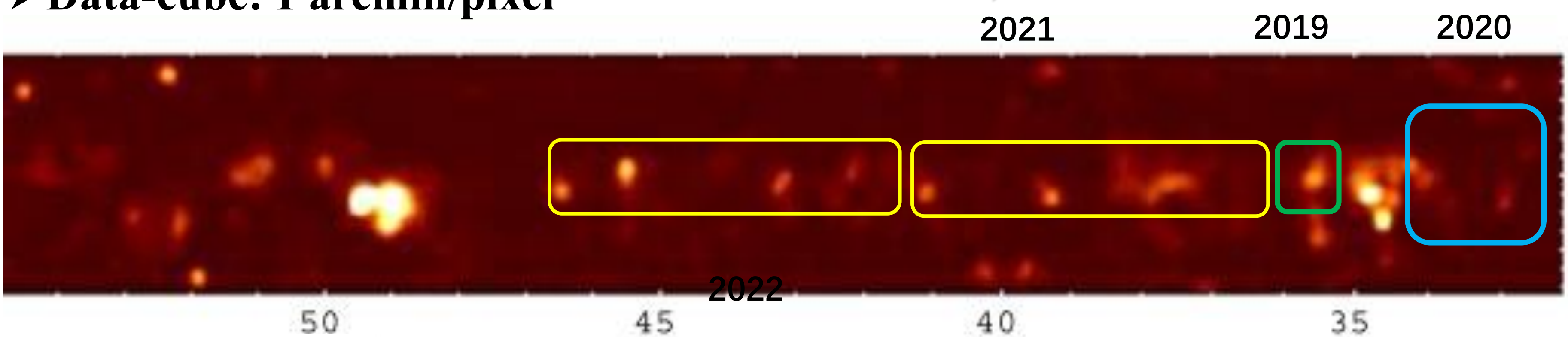
1. WIM/DIG distribution in the disk of Milky way
   - Kinematics of DIG
   - Te, Ne gradients *vs* Rg
2. Connections between WIM/DIG and HII regions
   - How does UV photos leak from HII regions, and travel through WIM?

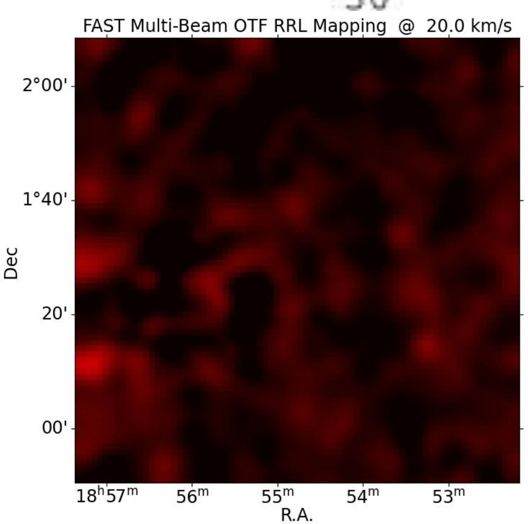


FAST Galactic RRL Mapping (3/4)

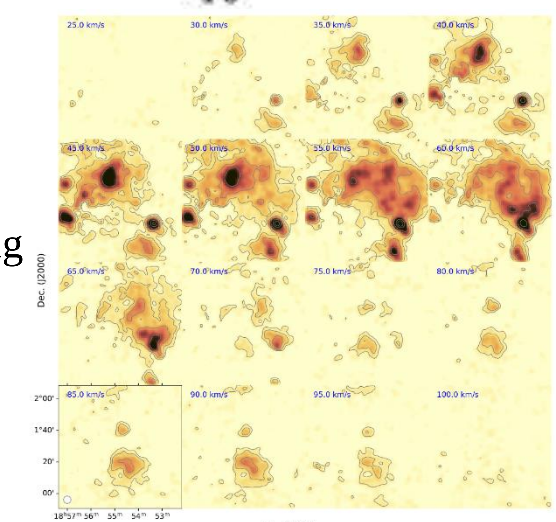
- ➢ **Freq bandpass: 1050 – 1450 MHz**
- ➢ **Sensitivity: s ~ 0.5 mJy/beam**
- ➢ **Velocity res. : 0.5 km/s**
- ➢ **Spatial res.: ~ 3 arcmin**
- ➢ **Data-cube: 1 arcmin/pixel**





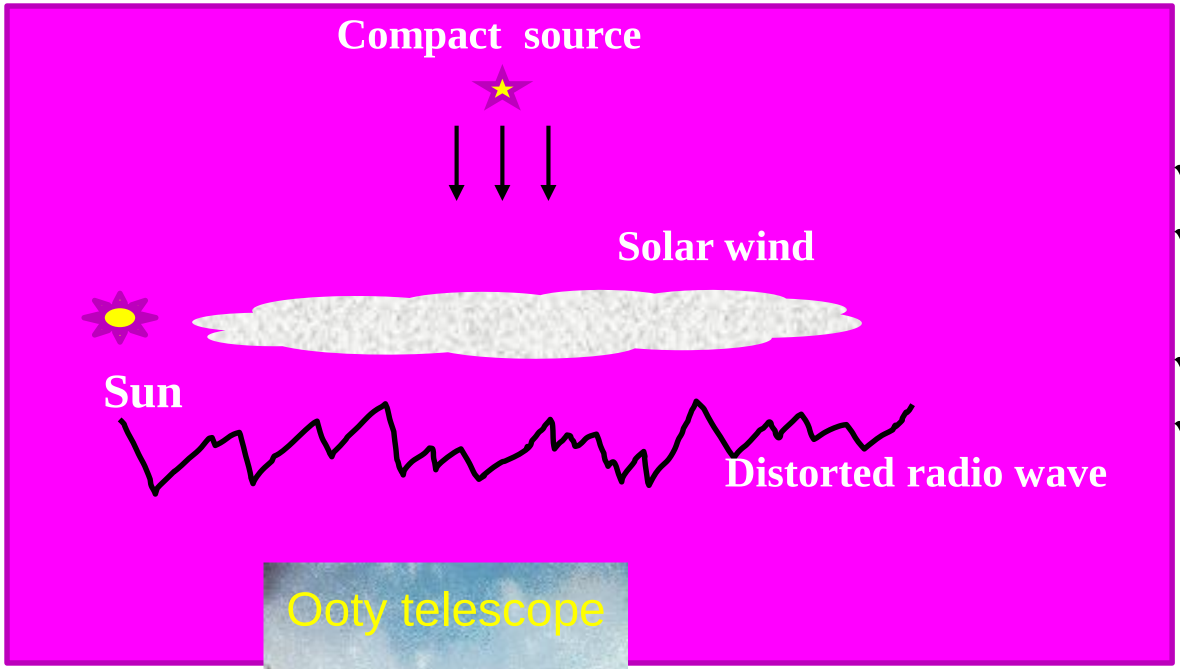


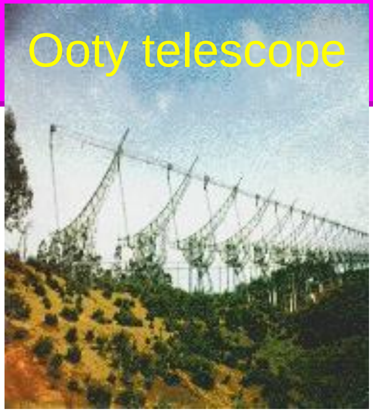
1 sq. deg. RRL mapping with FAST 19-beam



Interplanetary Scintillation (4/4)

Interplanetary Scintillation: Radiation from compact source scattered by density irregularities in solar wind plasma. Motion of the irregularities converts the diffraction pattern into intensity fluctuations

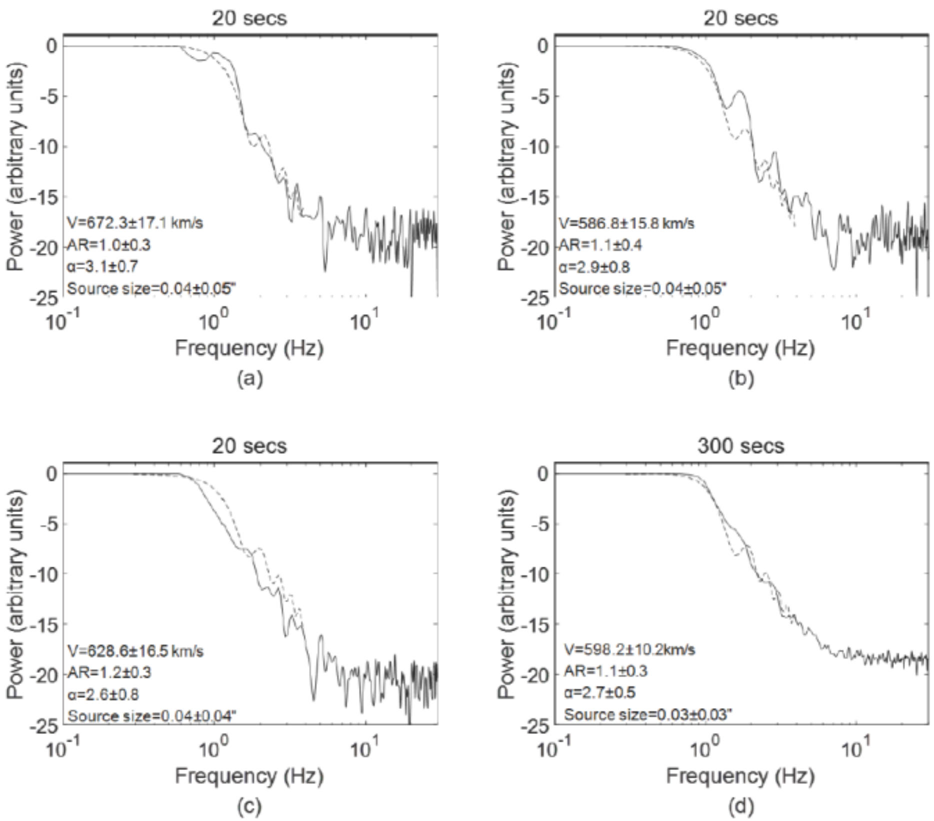




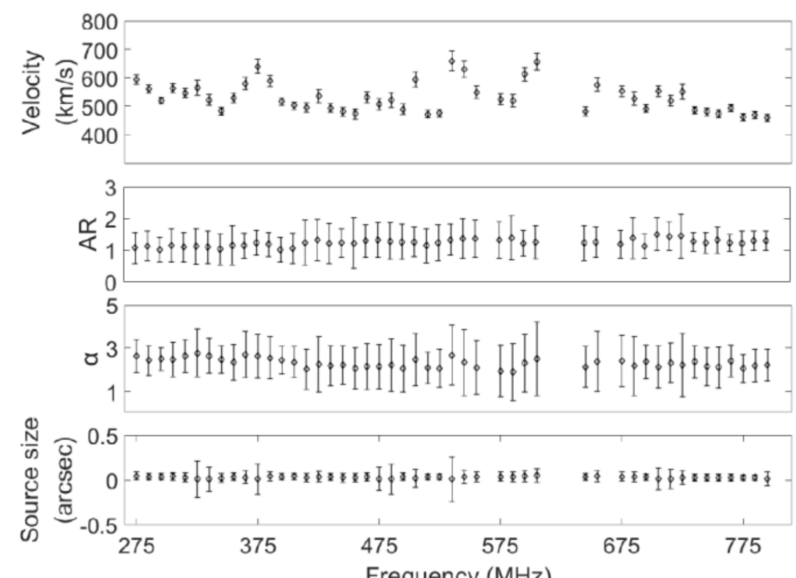
- ✓Monitor **solar wind**
- ✓Measure **structures of distant compact radio sources**
- ✓Estimate arriving time of **CME**
- ✓Forecast **space weather**

Although indirect, giving information on solar wind **out of the ecliptic plane**+ **close to Sun**, where spacecraft measurements are not possible.

IPS pilot Study with FAST (4/4)



Model-fitting example of source 3C 286 with SSSF mode observed by UWB receiver of FAST on Nov13, 2017 @ 285 MHz.

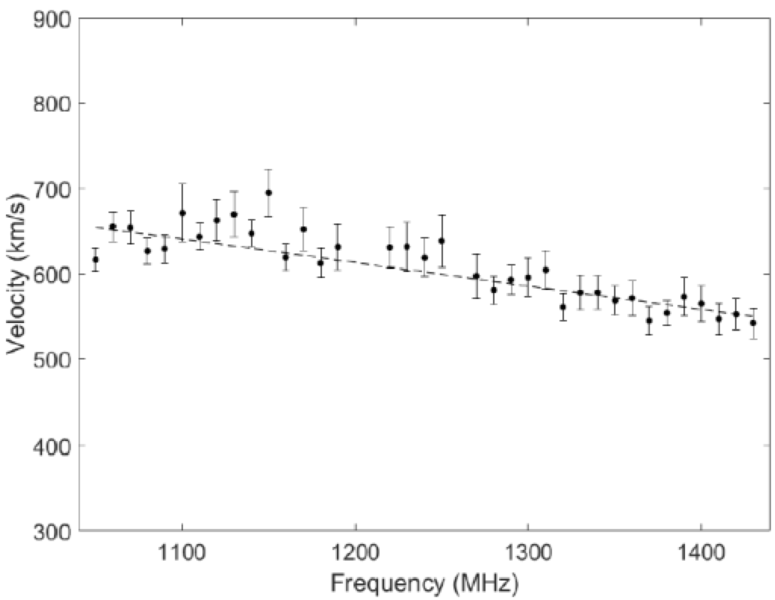


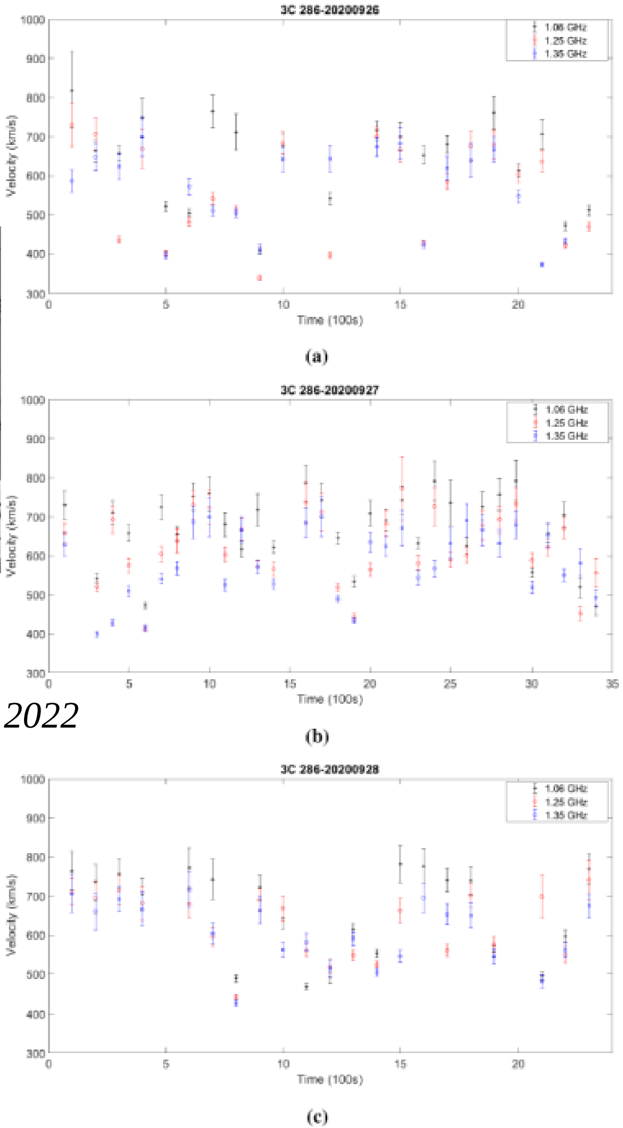
Liu, Peng, Yu et al., MNRAS 2021

Solar wind parameters of 3C 286 from 10 MHz sub-bands using 20 s time length. parameters, velocity, AR, α, and $\theta 0$ shown from top to bottom

Linear change+minutes variability (4/4)

Solar wind velocities through sub-bands. 3C 286 observed by FAST on Sept 27, 2020. The dots and vertical lines are the fitted solar wind velocities and errors, dashed line the linear fit of velocities with error.





Liu, Peng, Yu et al., MNRAS 2022

Solar wind velocity variations through Sept 26-28, 2020. Black dots, red circles, blue squares represent velocities obtained at 1.06, 1.25 and 1.35 GHz

Outlines

1 LT/SKA Initiation and Contribution

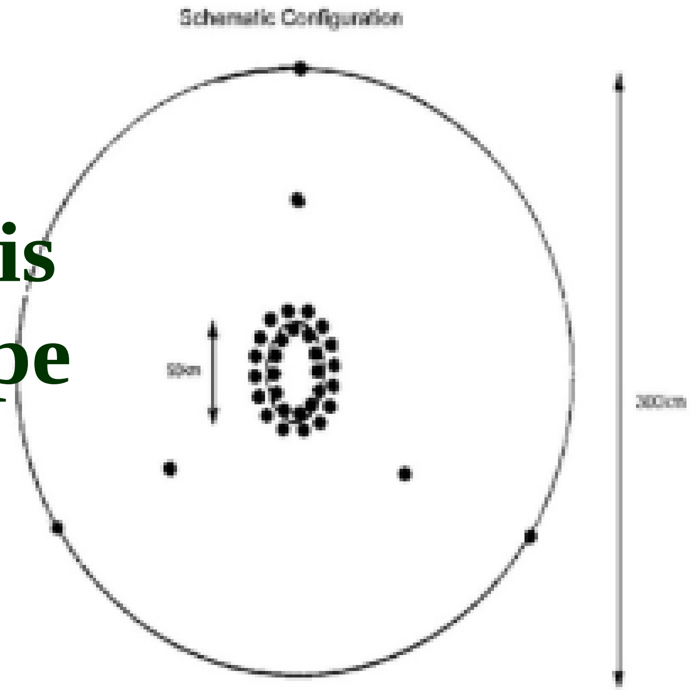
2 FAST Design and Construction

3 Discoveries from FAST Observations

4 FAST Expanded Array

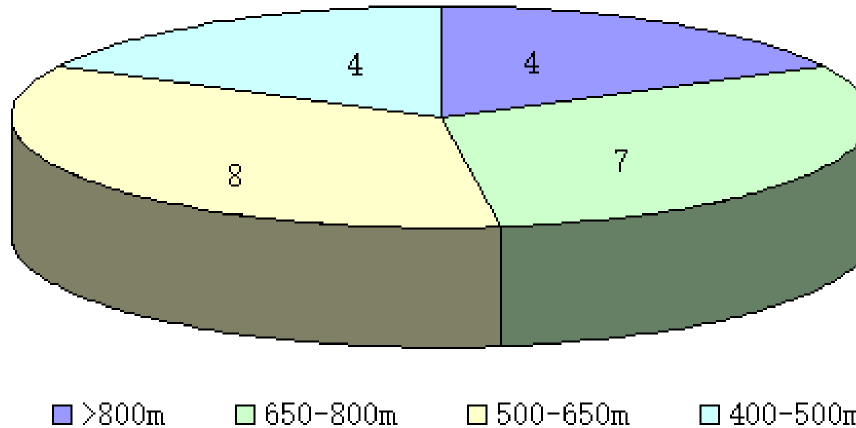
SKA concept

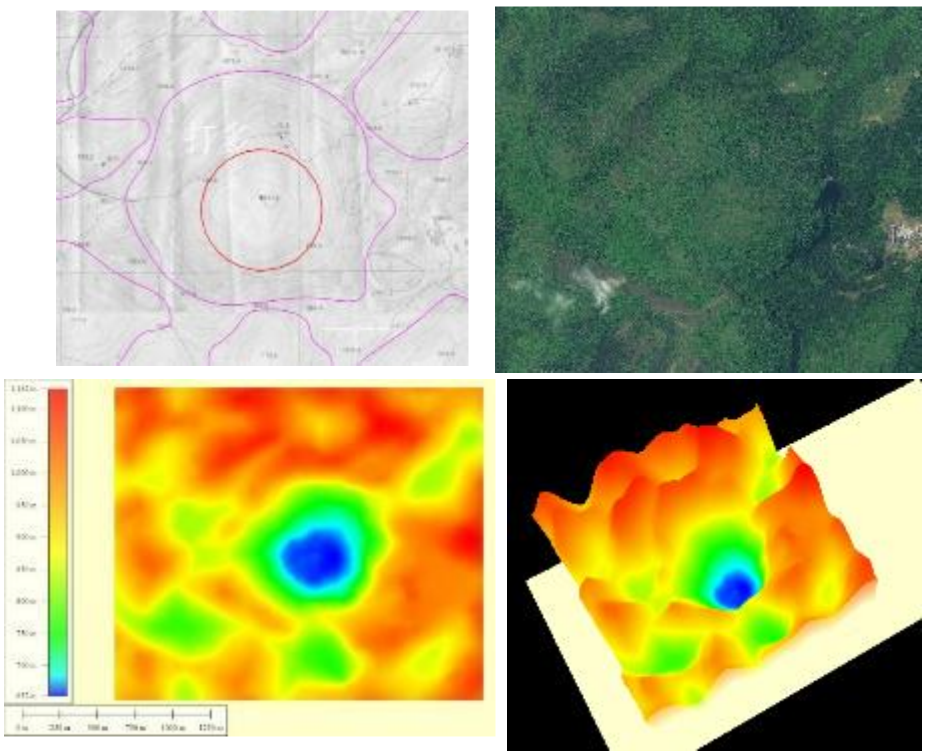
Kilometre-square
Area
Radio
Synthesis
Telescope



FAST Expanded Array

20 FAST centralized sites in radius of 10 km， D >450 m





Daduo Depression (K6) landform

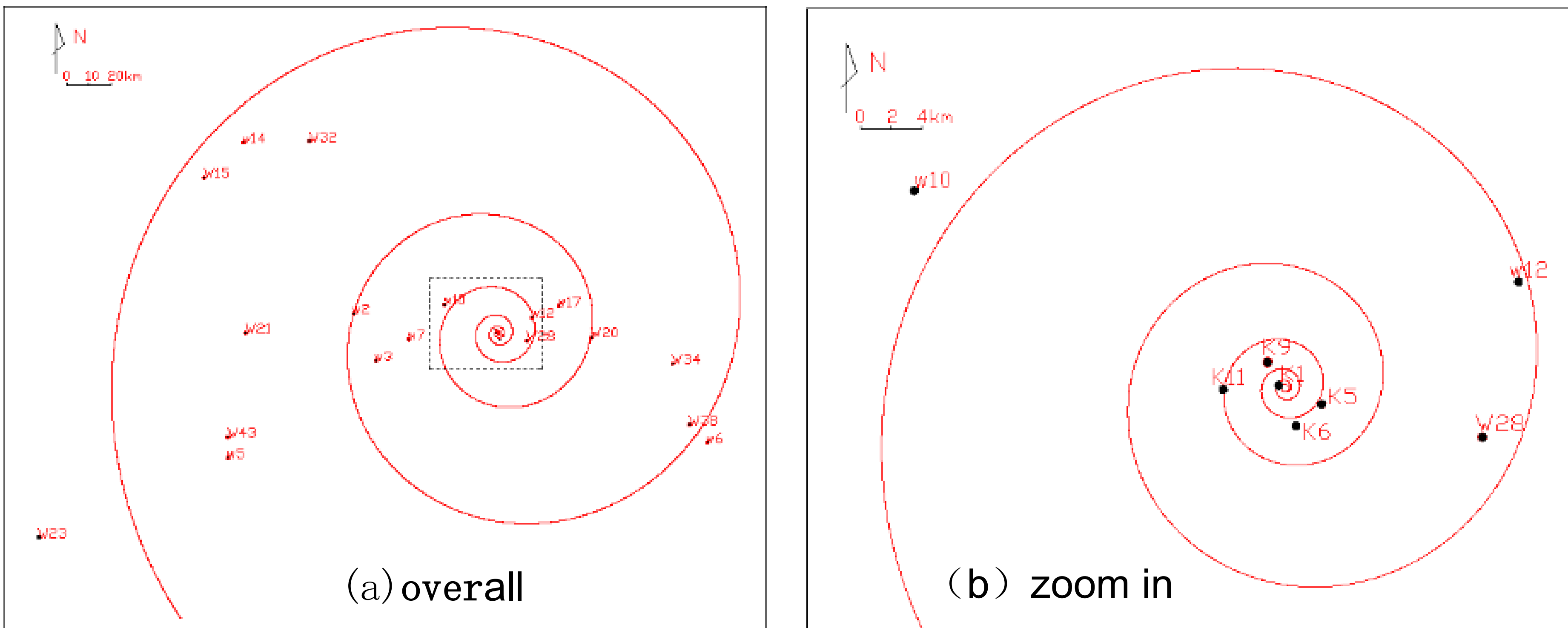
Southeast Dawodang, R=2.5 km
D ~ 900 m，
d > 200 m

FASTea Configuration

Log Spiral centered at Dawodang, r= 260 m

$$r = a_0 e^{k(\theta - \theta_0)}$$

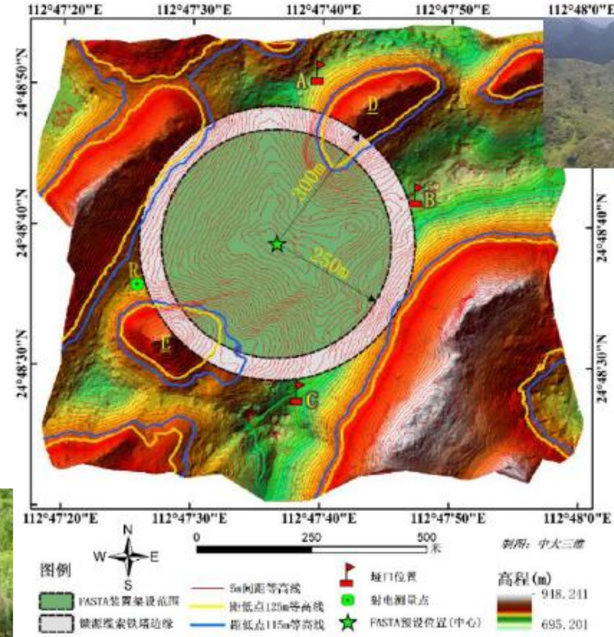
r 旋臂半径；α_0 起始半径；
θ、θ_0 旋转角和起始角；k系数。



(a) overall （b） zoom in

Depression distribution（a_0=260，k=0.15，θ_0=-140.14°，W2、K11、K1、K5、W20 and K6）

Siting FASTea in GuangDong Province

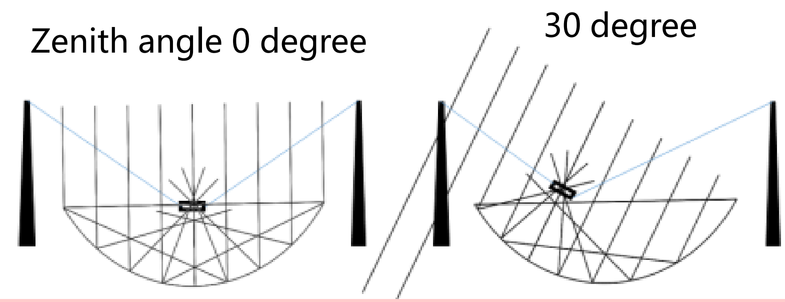


2022年7月27-30日,**3个点踏勘**，2021年10月17-19日 **2个**点RFI，**5个**点**无人机激光雷达测绘**

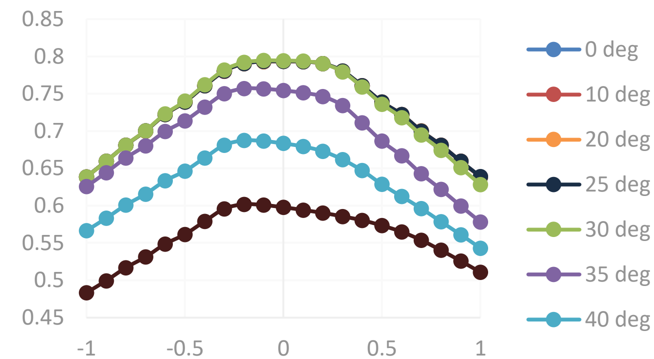
Large Aperture Sphere Telescope + PAF

- PAF *(Wang J. et al. to be submitted)*
  - ✓ Feed unit: 12cm; Radius: ~4.5-5m
  - ✓ edge illumination： 4.4dB @ 56.4degree
  - ✓ Unit number: 85 X 85
- Energy intercepted by PAF： 79.3%
- 30 degrees Z.A., the energy received by each unit of PAF changes slightly.
- With defocusing angles, energy received by PAF changes slightly, no significant defocusing.

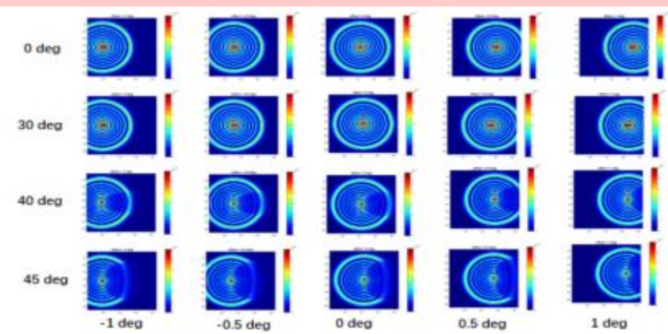
- FoV reach+/- 1 degree at 40 degrees, and the efficiency decreases by less than 20% (1dB).
- Enlarging PAF size further expand FoV
- System T. ~20K
- Dynamic beamforming to compensate position residual of PAF receiver



Schematic diagram of large spherical reflector + PAF



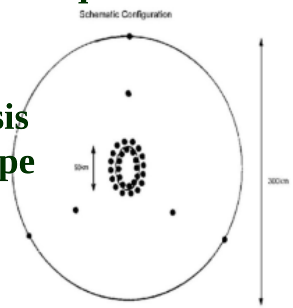
Efficiency of combination of PAF and FAST neutral planes at Z.A. and defocusing angles



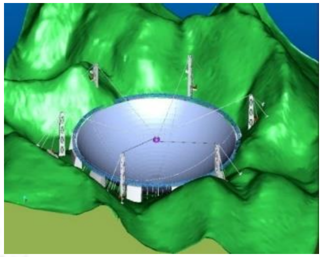
Distribution of PAF received energy at Z.A. defocusing angle

Dream continues towards KARST = FASTea

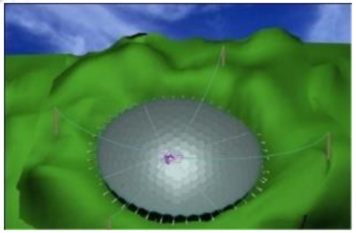
Kilometre-square
Area
Radio
Synthesis
Telescope

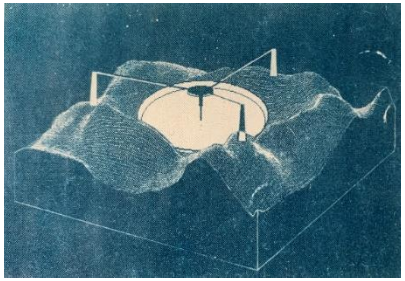


Add 8 FAST-like dishes *at SKA1 cost,*
100% SKA sensitivity *@ 600 km,*
60 deg. ZA, *up to X-band*



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





FASTeA: FAST expanded Array: FAST-like + small/large dishes

大射电望远镜 记忆

王绶琯		天文	— 2021
南仁东		天文	—2017
石雅镠	先	地学	—2016
吴盛殷	逝	VLBI	—2013
陈宏升	者	微波	—2012
朴廷彛		电子	—2010
S. von Hoerner		结构	—2003
罗 罡		地学	—1996
李维星		地学	—1996

发件人: Richard Schilizzi [mailto:Richard.Schilizzi@manchester.ac.uk]
发送时间: 2016 年 9 月 26 日 12:53
收件人: pb
抄送: Richard Schilizzi
主题: Long March to FAST

Dear Bo,
It was a splendid show and a fitting celebration of all the work you and Nan have put into this landmark project for China and the world. It all went very well and we learnt a great deal about the telescope and how people enjoy their lives here (including eating good food and drinking toasts to each other!). It was a privilege to be here and thanks again for the invitation.

You may remember that I would like a copy of your presentation yesterday for the SKA history project, and a summary of the information about the start of FAST that you told the media and me. It will be very useful for the China strand of the SKA story. Ron Ekers, Peter Hall and I will come back to you and Nan with some more specific questions as the SKA book project makes progress.

It's good to hear your son is now studying in Manchester. Please let me have his contact details and we'll invite him to our house.

I hope you find time for a bit of a holiday after all the excitement.

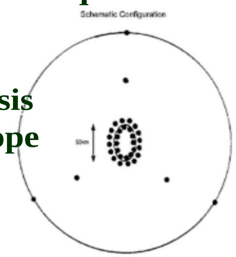
Look forward to seeing you in Manchester.

Cheers
Richard

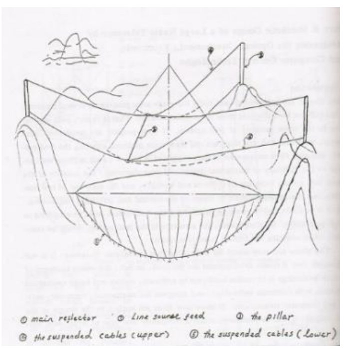
Have put into this landmark project for China and the world

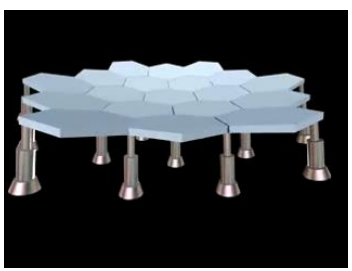
New Landmark FAST

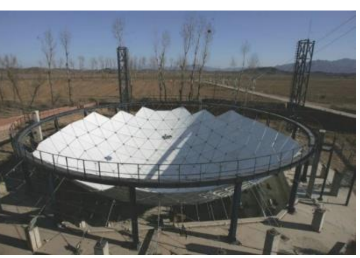
Kilometre-square
Area
Radio
Synthesis
Telescope



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 FAST Finalized/Announced in UK
1999 Experiments funded by Innovation Project
2000 FAST funding proposal to the MOST
2006 Site Selection + Int'l Advisory Review
2007 Funding Approval **风雨兼程大家庭**
2008 Feasibility Study Report Acceptance
2009 Preliminary Design Review Acceptance
2011 FAST Construction Clock on
2016 Inauguration with FAST First Light
2020 Operation Acceptance by NDRC
50 yrs' discovery trip to Nobel Prizes