承前人之卓著　啟後世之輝煌
Large Astronomy Facilities in China - Current Status and Future Projects

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2009-04-30 @ CUHK

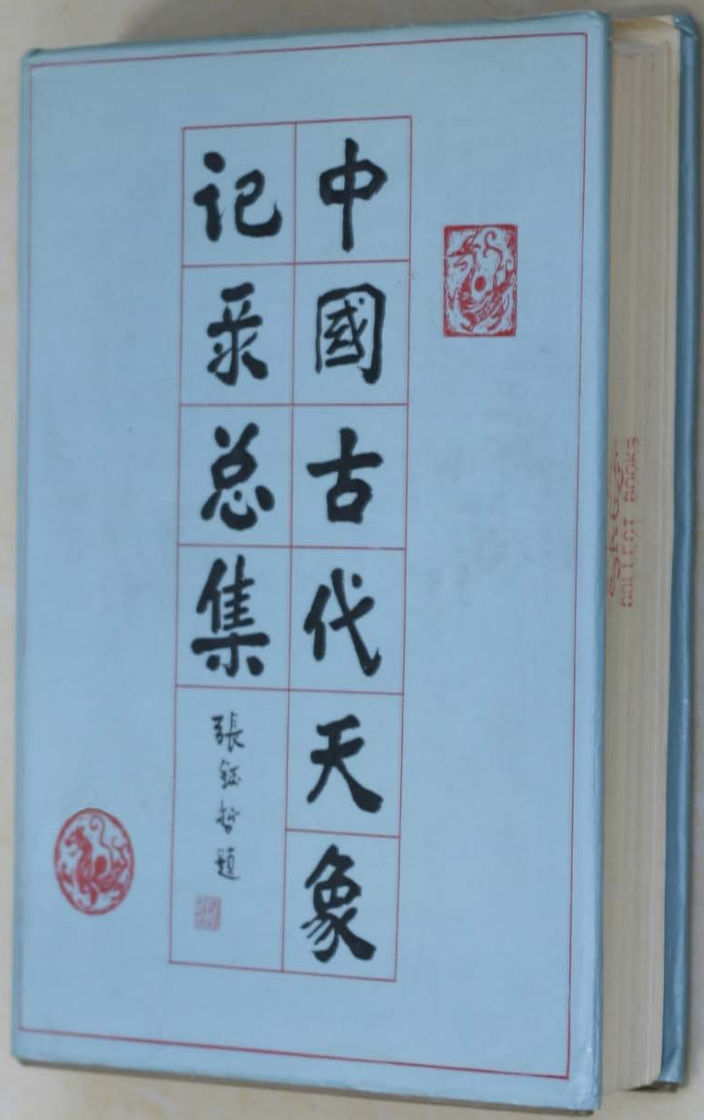
Outline

- Brief introduction of astronomy in China
  - Glory of Chinese ancient astronomy
  - Current status and development
- Ground-based facilities
- Space missions
- Large scientific projects in the future
- Brief summary

Brief Introduction

- Glory of Chinese ancient astronomy

With over 4,000 years' development, Chinese ancient astronomy experienced a lengthy period of spectacular prosperity. This precious history not only established a profound foundation for the development of Chinese astronomy and bequeathed to us as a priceless legacy, but also serves as an otherwise unavailable source of records for modern astronomical research.



<The collection of Chinese historical astronomical records>
1100 pages with 10000 records

The Division Project of Xia, Shang and Zhou Dynasties in 2000 (夏商周斷代工程): "Xia-Shang-Zhou Chronological Table"

夏商周年表（一）

朝代	王	年代（公元前）	年　数
夏	禹	2070－1600	
	启		
	太康		
	仲康		
	相		
	少康		
	予		
	槐		
	芒		
	泄		
	不降		
	扃		
	厪		
	孔甲		
	皋		
	发		
	癸		
商前期	汤	1600－1300	
	太丁		
	外丙		
	中壬		
	太甲		
	沃丁		
	太庚		
	小甲		
	雍己		
	太戊		
	中丁		
	外壬		
	河亶甲		
	祖乙		
	祖辛		
	沃甲		
	祖丁		
	南庚		
	阳甲		
	盘庚		

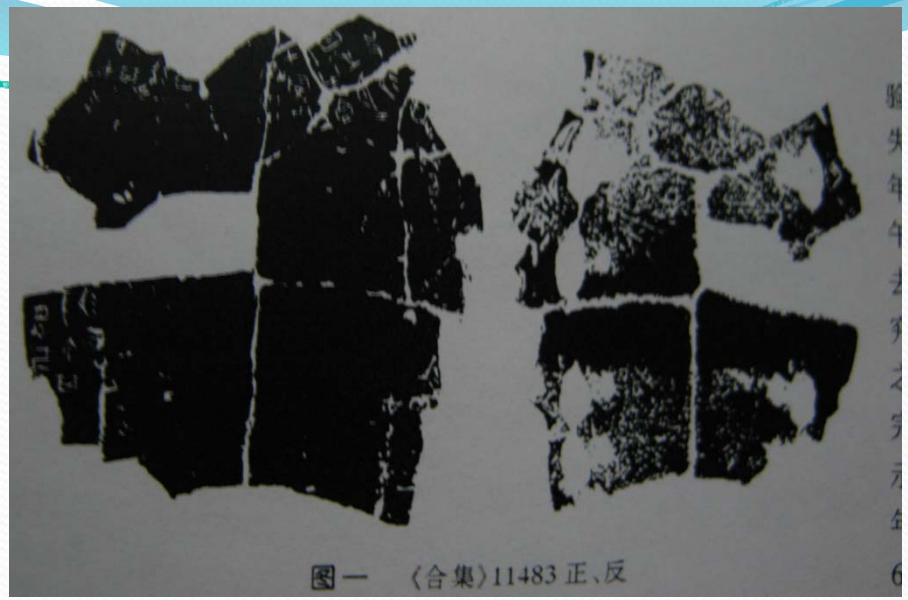
夏商周年表（二）

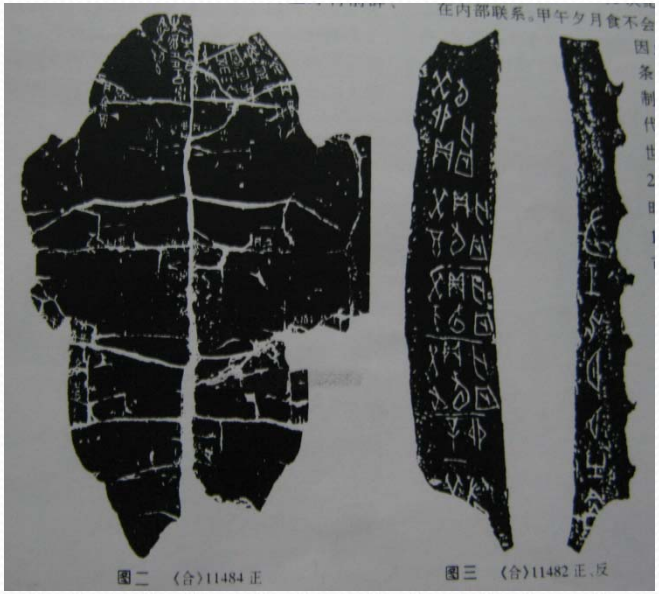
朝代	王	年代（公元前）	年　数
商后期	盘庚（迁殷后） 小辛 小乙	1300－1251	50
	武丁	1250－1192	59
	祖庚 祖甲 廪辛 康丁	1191－1148	44
	武乙	1147－1113	35
	文丁	1112－1102	11
	帝乙	1101－1076	26
	帝辛（纣）	1075－1046	30
西周	武王	1046－1043	4
	成王	1042－1021	22
	康王	1020－996	25
	昭王	995－977	19
	穆王	976－922	55（共王当年改元）
	共王	922－900	23
	懿王	899－892	8
	孝王	891－886	6
	夷王	885－878	8
	厉王	877－841	37（共和当年改元）
	共和	841－828	14
	宣王	827－782	46
	幽王	781－771	11

- Among the 22 periods published by the Table, 82% are derived through astronomical methods (in red), indicating the their enormous contributions.
- 2/3 of the Table is still unclear, waiting for further investigation

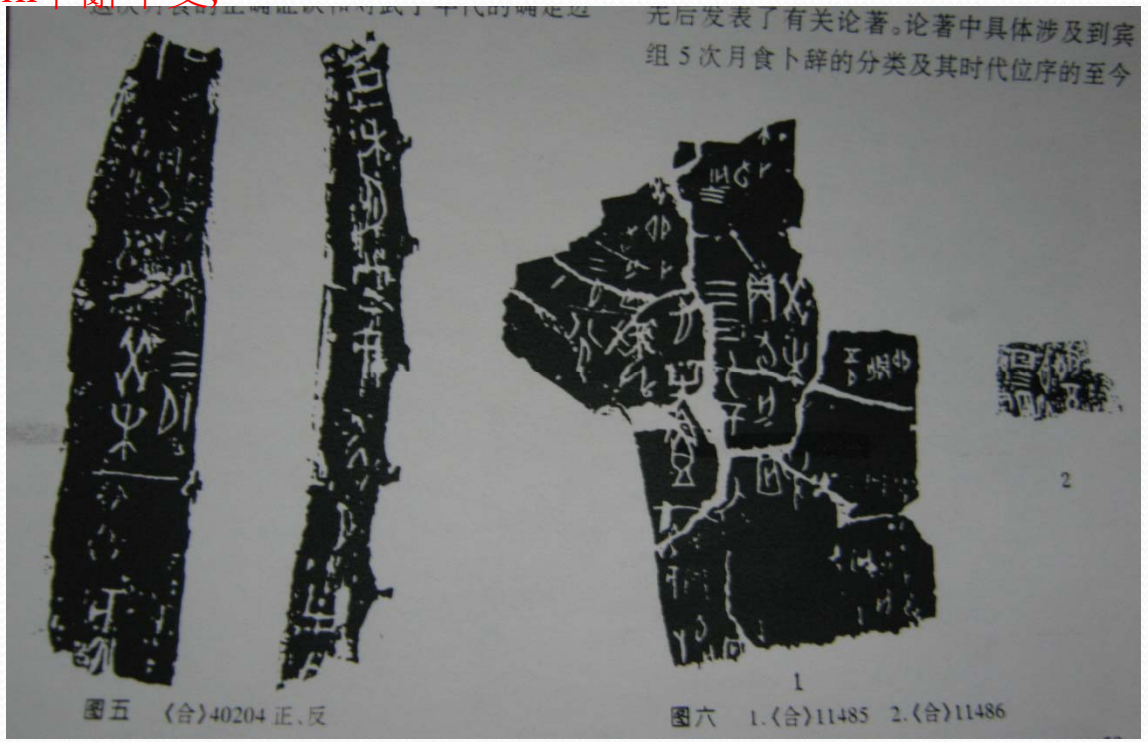
5 lunar eclipses in oracle bone inscriptions determine the period of Emperor Shang Wu Ding
五次甲骨文月食確定商王武丁年代

With astronomical and other researches, the Division Project of Xia, Shang and Zhou Dynasties concluded that the 5 lunar eclipses belong to the period less than 30 years, from late Wu Ding 武丁 through Zu Geng 祖庚. Based on astronomical computation, between 1500B.C. and 1000 B.C., only one set of result agree with Gan Zhi 卜辭干支, as well as lunar eclipse phases.


图一 《合集》11483 正、反


图二 《合》11484 正

图三 《合》11482 正、反


图五 《合》40204 正、反

图六 1.《合》11485 2.《合》11486

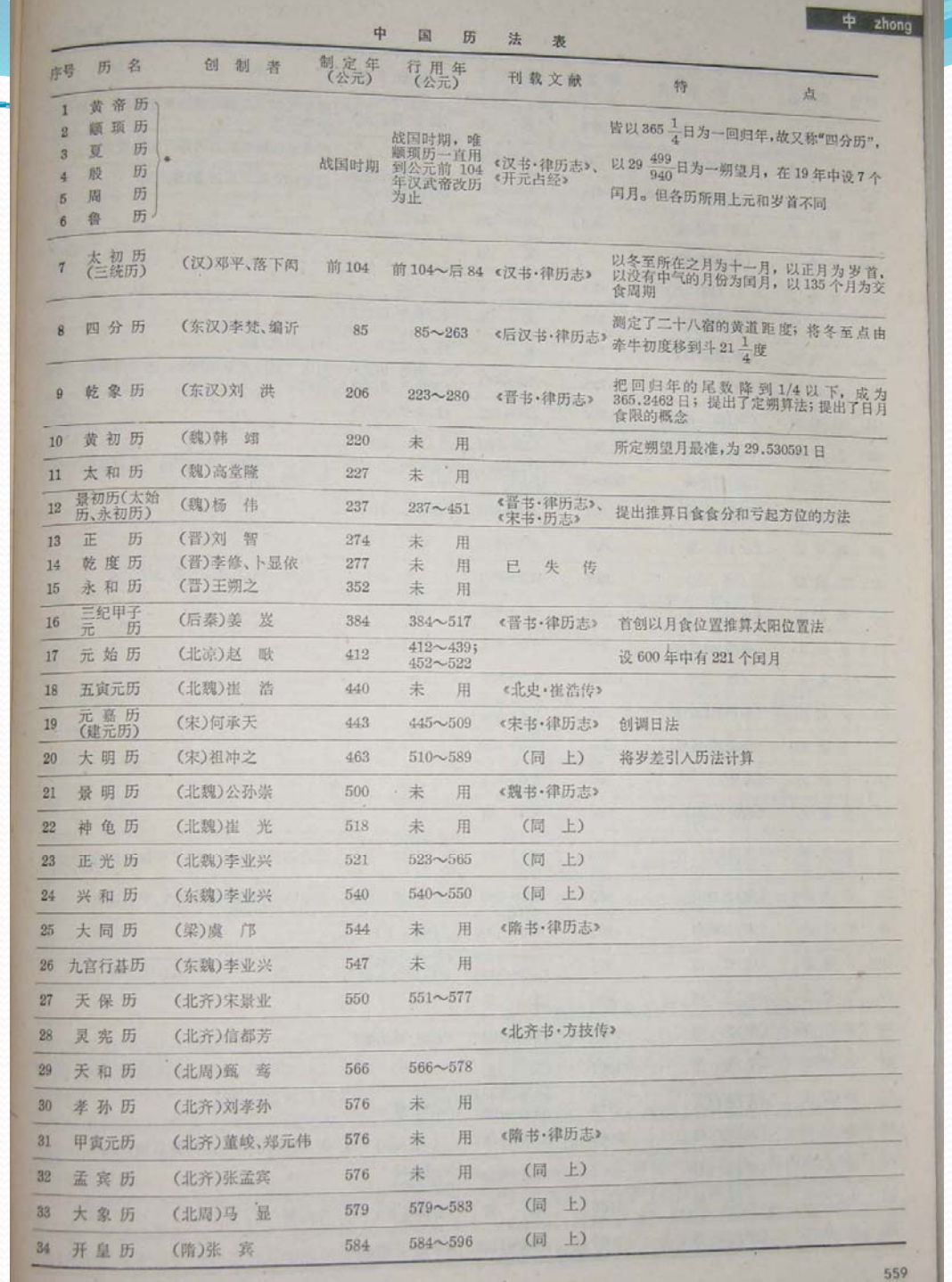
Four main contributions of ancient astronomy:

Observation of astronomical phenomena天象觀測, astronomical calendar 天文曆法, astronomical facility天文儀器, cosmological theory宇宙理論

- Astronomical calendar is the core, with great potential for further investigation.
- Ancient China has developed about 104 calendars during 3500 years, 58 of them were popularly used, which is rarely seen in human history

Ancient calendar in China

中國古代日曆



中 国 历 法 表

序号	历名	创制者	制定年(公元)	行用年(公元)	刊载文献	特点
1	黄帝历					
2	颛顼历					
3	夏历					
4	殷历					
5	周历					
6	鲁历		战国时期	战国时期，唯颛顼历一直用到公元前104年汉武帝改历为止	《汉书·律历志》、《开元占经》	皆以365 1/4日为一回归年，故又称"四分历"，以29 499/940日为一朔望月，在19年中设7个闰月。但各历所用上元和岁首不同
7	太初历(三统历)	(汉)邓平、落下闳	前104	前104～后84	《汉书·律历志》	以冬至所在之月为十一月，以正月为岁首，以没有中气的月份为闰月，以135个月为交食周期
8	四分历	(东汉)李梵、编诉	85	85～263	《后汉书·律历志》	测定了二十八宿的黄道距度；将冬至点由牵牛初度移到斗21 1/4度
9	乾象历	(东汉)刘洪	206	223～280	《晋书·律历志》	把回归年的尾数降到1/4以下，成为365.2462日；提出了定朔算法；提出了日月食限的概念
10	黄初历	(魏)韩翊	220	未用		所定朔望月最准，为29.530591日
11	太和历	(魏)高堂隆	227	未用		
12	景初历(太始历、永初历)	(魏)杨伟	237	237～451	《晋书·律历志》、《宋书·历志》	提出推算日食食分和亏起方位的方法
13	正历	(晋)刘智	274	未用		
14	乾度历	(晋)李修、卜显依	277	未用	已失传	
15	永和历	(晋)王朔之	352	未用		
16	三纪甲子元历	(后秦)姜岌	384	384～517	《晋书·律历志》	首创以月食位置推算太阳位置法
17	元始历	(北凉)赵歇	412	412～439；452～522		设600年中有221个闰月
18	五寅元历	(北魏)崔浩	440	未用	《北史·崔浩传》	
19	元嘉历(建元历)	(宋)何承天	443	445～509	《宋书·律历志》	创调日法
20	大明历	(宋)祖冲之	463	510～589	(同上)	将岁差引入历法计算
21	景明历	(北魏)公孙崇	500	未用	《魏书·律历志》	
22	神龟历	(北魏)崔光	518	未用	(同上)	
23	正光历	(北魏)李业兴	521	523～565	(同上)	
24	兴和历	(东魏)李业兴	540	540～550	(同上)	
25	大同历	(梁)虞邝	544	未用	《隋书·律历志》	
26	九宫行基历	(东魏)李业兴	547	未用		
27	天保历	(北齐)宋景业	550	551～577		
28	灵宪历	(北齐)信都芳			《北齐书·方技传》	
29	天和历	(北周)甄鸾	566	566～578		
30	孝孙历	(北齐)刘孝孙	576	未用		
31	甲寅元历	(北齐)董峻、郑元伟	576	未用	《隋书·律历志》	
32	孟宾历	(北齐)张孟宾	576	未用	(同上)	
33	大象历	(北周)马显	579	579～583	(同上)	
34	开皇历	(隋)张宾	584	584～596	(同上)	

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续表

序号	历名	创制者	制定年(公元)	行用年(公元)	刊载文献	特点
					隋·律历志》	用等间距二次差为插值来处理月亮运动的
					同 上）	用七差级数求和方法编行星位置表
36	大业历	(隋)张胄玄	597	597～618	《旧唐书·历志》、《新唐书·历志》	用定朔安排日用历谱；废闰周
		(唐)傅仁均、崔善为	619	619～664		
			665	665～728	（同 上）	
39	经纬历	(唐)瞿昙罗		未 用		
40	光宅历	（同 上）	698	未 用		
41	神龙历	(唐)南宫说	705	未 用	《旧唐书·历志》	
42	九执历	(唐)瞿昙悉达	718	未 用	《开元占经》	译自印度历法
43	大衍历	(唐)一 行	728	729～761	《旧唐书·历志》、《新唐书·历志》	用定气编排太阳运行表，创不等间距二次差内插法
44	至德历	(唐)韩 颖	758	758～762	《新唐书·历志》	
45	五纪历	(唐)郭献之	762	762～783	（同 上）	
46	符天历	(唐)曹士芳	780～783	行于民间，直至宋代	《新五代史·司天考》	以雨水为气首，以一万为天文数据的共同分母，废除上元积年
47	正元历	(唐)徐承嗣	783	784～806	《新唐书·历志》	
48	观象历	(唐)徐 昂	807	807～821	（同 上）	
49	宣明历	（同 上）	822	822～892	（同 上）	创日食三差(时差、气差、刻差)法
50	崇玄历	(唐)边 冈	893	893～938	（同 上）	
51	永昌历	(前蜀)胡秀林	909	909～911	《通鉴目录》	
52	正象历	（同 上）	912	912～925	（同 上）	
53	调元历	(后晋)马重绩	937	939～943；947～994		
54	中正历	(南唐)陈成勋	940	940～950		
55	齐政历	(南唐)	950	950～975		
56	明玄历	(后周)王处讷	952	未 用		
57	钦天历	(后周)王 朴	956	956～963	《旧五代史·历志》、《新五代史·司天考》	在计算行星位置时用了等加速度的公式
58	应天历	(宋)王处讷	963	964～982	《宋史·律历志》	每夜分五更，每更分五点，更点制自此始
59	乾元历	(宋)吴昭素	981	983～1000	（同 上）	
60	大明历	(辽)贾 俊	994	995～1125；1123～1136	《辽史·历象志》错录祖冲之大明历	
61	至道历	(宋)王 睿	995	未 用		
62	仪天历	(宋)史 序	1001	1001～1023	《宋史·律历志》	
63	乾兴历	(宋)张 奎	1022	未 用		
64	崇天历	(宋)宋行古	1024	1024～1064；1068～1074	《宋史·律历志》	
65	明天历	(宋)周 琮	1064	1065～1067	（同 上）	对历代历法有一较好的总结
66	奉元历	(宋)卫 朴	1074	1075～1093	李锐补修《奉元术》	
67	十二气历	(宋)沈 括	1086	未 用	《梦溪笔谈》	纯阳历
68	观天历	(宋)皇居卿	1092	1094～1102	《宋史·律历志》	

续表

序号	历名	创制者	制定年(公元)	行用年(公元)	刊载文献	特点
69	占天历	(宋)姚舜辅	1103	1103～1105	李锐补修《占天术》	
70	纪元历	(同 上)	1106	1106～1127；1133～1135	《宋史·律历志》	首创利用观测金星来定太阳位置法
71	大明历	(金)杨 级	1127	1137～1181		
72	统元历	(南宋)陈德一	1135	1136～1167	《宋史·律历志》	
73	乾道历	(南宋)刘孝荣	1167	1168～1176	（同 上）	
74	淳熙历	（同 上）	1176	1177～1190	（同 上）	
75	重修大明历	(金)赵知微	1181	1181～1234；1215～1280	《金史·历志》	月亮的各种周期值和黄赤交角值都很准确
76	乙未元历	(金)耶律履	1181	未 用	（同 上）	
77	五星再聚历	(南宋)石 万	1187	未 用		
78	会元历	(南宋)刘孝荣	1191	1191～1198	《宋史·律历志》	
79	统天历	(南宋)杨忠辅	1199	1199～1207	（同 上）	回归年数值最准确，并且认为回归年长度在变化，古大今小
80	开禧历	(南宋)鲍澣之	1207	1208～1251	（同 上）	
81	西征庚午元历	(元)耶律楚材	1220	未 用	《元史·历志》	创里差法(类似"时区")
82	淳祐历	(南宋)李德卿	1250	1252		
83	会天历	(南宋)谭 玉	1253	1253～1270		
84	万年历	(元)札马鲁丁	1267	行于几个少数民族中间		可能即后来的回历
85	成天历	(南宋)陈 鼎	1271	1271～1276	《宋史·律历志》	
86	本天历	(南宋)邓光荐	1277	1277～1279		
87	授时历(大统历)	(元)郭守敬	1280	1280～1644	《元史·历志》	创三次差内插法，并用类似球面三角的公式解决太阳黄赤道坐标换算的问题
88	圣寿万年历	(明)朱载堉	1554	未 用	《乐律全书》	
89	黄钟历	（同 上）	1581	未 用	《古今图书集成·历法典》	
90	新法历(时宪历)	(明)徐光启等	1634	1645～1723	《崇祯历书》、《历象考成》	采用第谷宇宙体系和几何学、球面三角等
91	晓庵历	(清)王锡阐	1663	未 用	《晓庵新法》	
92	癸卯元历	(清)戴进贤	1742	1742～1911	《历象考成后编》	采用开普勒行星运动第一、第二定律
93	天 历	(太平天国)洪仁玕	1852	1852～1864	《己未九年改历诏旨》	大小月相间，不计朔望，不置闰月
94	公历(即格雷果里历)		1582	1912 至今		

* 从黄帝历至鲁历合称"古六历"。

（席泽宗 编）

zhongguo gudai rishi guance

中国古代日食观测 (ancient eclipse observations in China) 古代的日食观测是指十七世纪经典天文学诞生以前所进行的日食观测和记录。世界文明古国无论是巴比伦和埃及还是中国，对日食的观测和预报都极为重视。

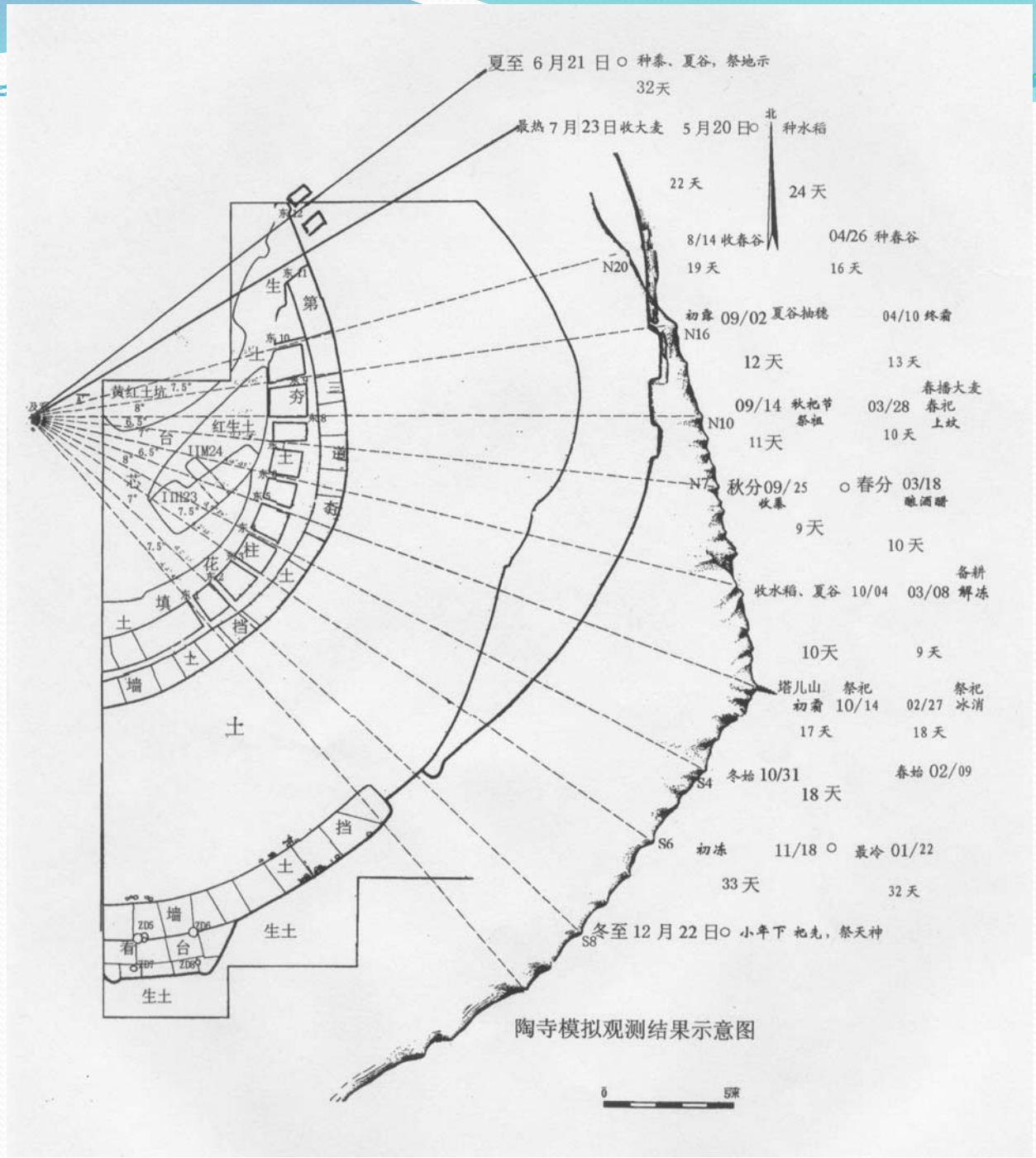
一般认为，世界上最古的日食记录是中国《尚书·胤征》篇中记载的夏朝仲康王时代的一次日食。国内外许多研究者对这次日食做过探讨，有的把这次日食发生的年代推算在公元前2165年，有的则推算在公元前1948年，相差颇远。由于对这条记录的真伪和内容解释有不同的看法，同时也涉及中国上古年代学中悬而未决的问题，因此还没有公认的结论。

然而，对于甲骨文中的日食记录却是公认的。例如《殷契佚存》第347片记载，"癸酉贞：日夕有食，佳若？癸酉贞：日夕有食，非若？"意思是说，癸酉日占，黄昏有日食，是吉利的吗？癸酉日占，黄昏有日食，是不吉利的吗？关于这次日食，虽然由于各研究者推算方法不同，所求得的发生日期不同，但大多认为发生在公元前1200年至

Taosi Ancient Observatory
陶寺觀象臺

- Chinese ancient astronomy has an early origin, there may existed astronomical observation before Xia,Shang and Zhou Dynasty. In recent years, a large construction site was found in Taosi Cultural Site of Xiangfen City, Shanxi Province山西襄汾陶寺文化遺址. The construction site is a semi-circle wall with 12 cracks, from which one can see the sunrise to ascertain the season. The Site has a history of about 4000 years. Preliminary analysis indicates it maybe one of the earliest observatories found in China.

- The period of the site agrees with that of Yao堯帝時代, while its location around ancient capital of Yao堯都, therefore it probably is the observatory in Yao period.



陶寺模拟观测结果示意图

Observation and time service 觀象授時

- Observation and time service is the top necessity of the archon. Calendar stands for the legality of dominion.
- 《尚書堯典》記載：乃命羲和，欽若昊天， 曆象日月星辰，敬授民時。
- Detection of the remnant of Taosi Observatory verifies the record of ancient literature

Langya Tai 琅琊台

- 琅琊台其名,史籍最早載於《山海經·海內東經》：“琅琊台在渤海間，琅琊之東。”《史記·秦始皇本紀》這樣解釋：“蓋海畔有山，形如台，在琅琊，故曰琅琊台。”
- 《吳越春秋》記載：“越王勾踐二十五年，徙都琅琊，立觀台以望東海。”
- Langya Tai was used as an astronomical observatory since that time.

- “始皇三巡不尋常，原來此中有深意。”
  - On April 11, 2008, experts in astronomical calendar demonstrated that Langya Tai in Jiaonan膠南琅琊台 which Emperor Qinshihuang had visited three times 始皇三巡 is probably the most ancient observatory in China.

Brief Introduction

- Growing community

- The past 30 years since the adoption of 'open door policy' have witnessed great advance in astronomical studies in China, especially in the last decade

	1997	2007
Research funding	~3 Million $	~30 Million $
Faculty	~ 600	~ 900
Ph.D.	~ 12 per year	~ 80 per year
Journal papers	~150	~650

Brief Introduction

- Astronomical research institutions
  - Chinese Academy of Sciences (CAS)
    - National Astronomical Observatories
    - Purple Mountain Observatory
    - Shanghai Observatory
    - Univ. of S & T of China
  - Ministry of Education
    - Nanjing University
    - Peking University
    - Tsinghua University
    - Beijing Normal University

    … …

National Astronomical Observatories

Nanjing University

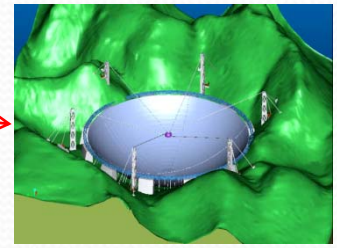












Distribution of the National Astronomical Observatories, China













Distribution of PMO, SHAO & Universities with Department of Astronomy or Research Group

Brief Introduction

- Publicity and Outreach

- With the development of science and technology, astronomy gradually becomes more popular
  - Astronomical societies for students, planetariums for amateurs, and so on
  - Build bridges among astronomers, amateurs and the public
  - A number of national-wide astronomical activities, e.g. Solar Eclipse in 2008, etc.
  - The International Year of Astronomy in 2009 would be a great opportunity to promote the publicity of astronomy

Brief Introduction

- Astronomical journals

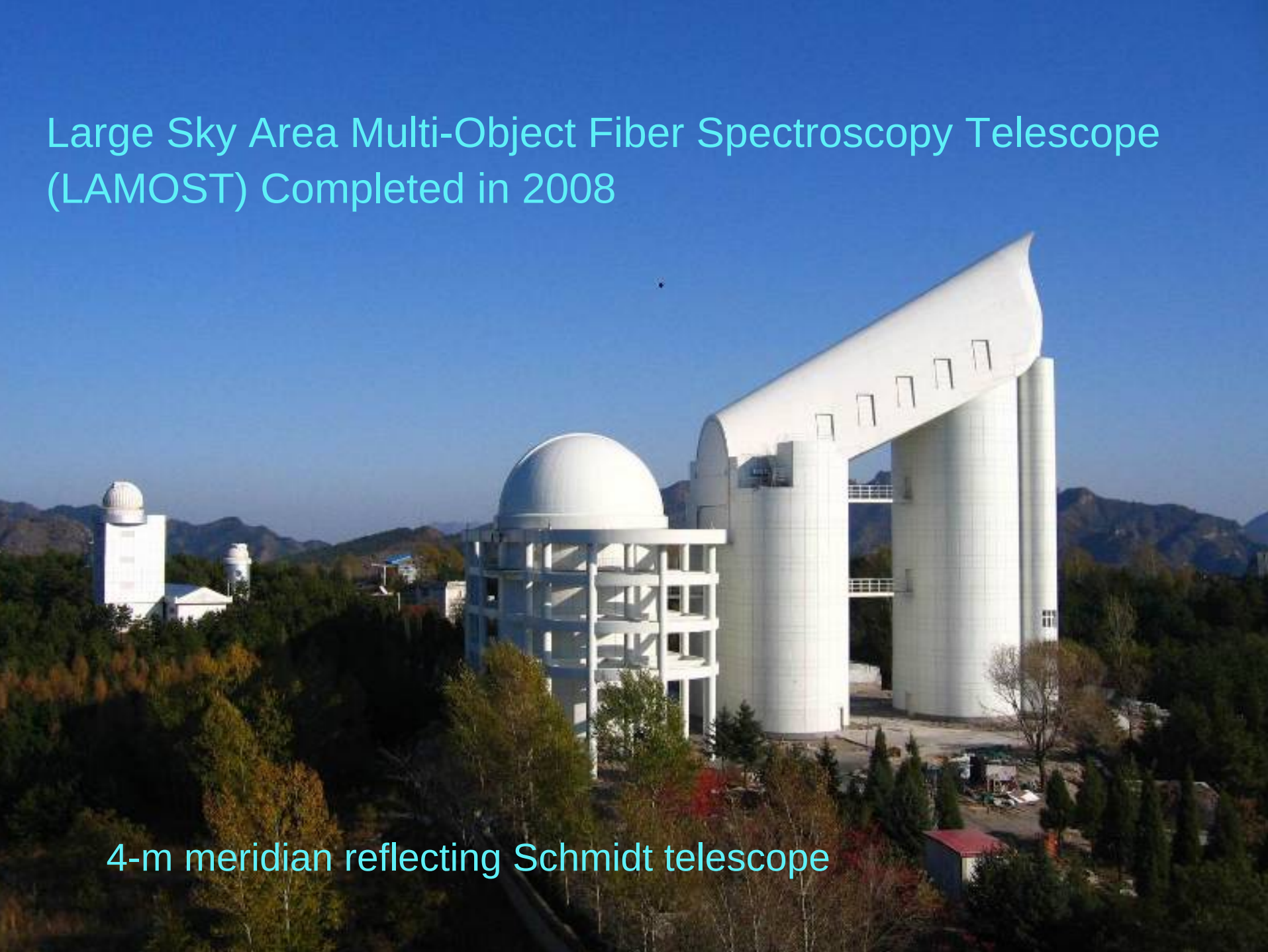
- Four professional journals
- Including one English journal
  - *Chinese Journal of Astronomy and Astrophysics*, ChJAA
  - *Research in Astronomy and Astrophysics* from 2009
- Two amateur astronomical magazines

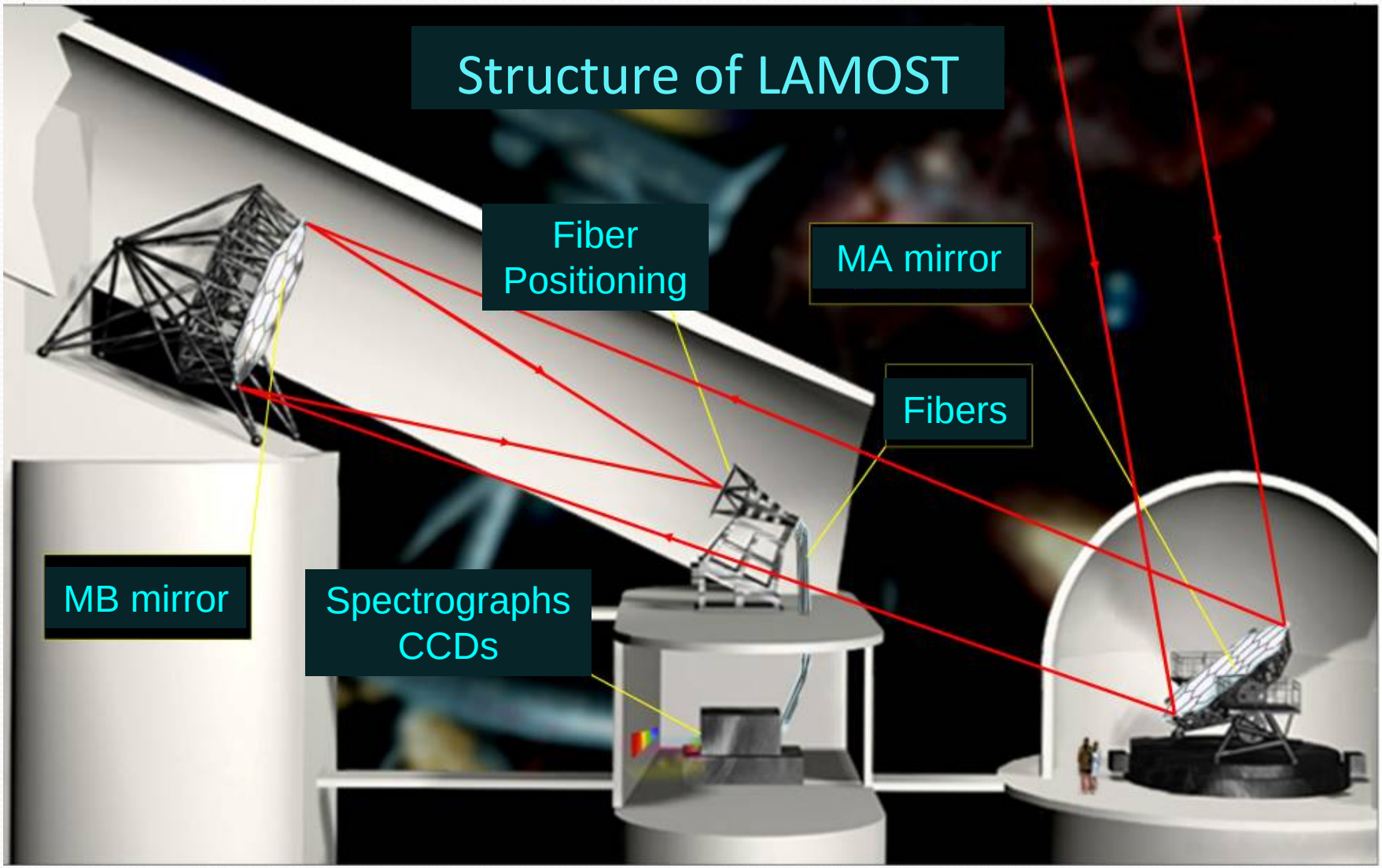
Brief Introduction

- China has been playing a more and more important role in the international astronomical community
  - Wider international collaborations.
  - The 28th General Assembly of the International Astronomical Union (IAU GA) will be held in Beijing in 2012. This milestone event would promote China's international status and enhance its presence in the astronomical community.
  - China also hosts more and more international symposiums, workshops, conferences etc.

Ground Based Astronomical Facilities

Progress of LAMOST, FAST, 21CMA, and CSRH

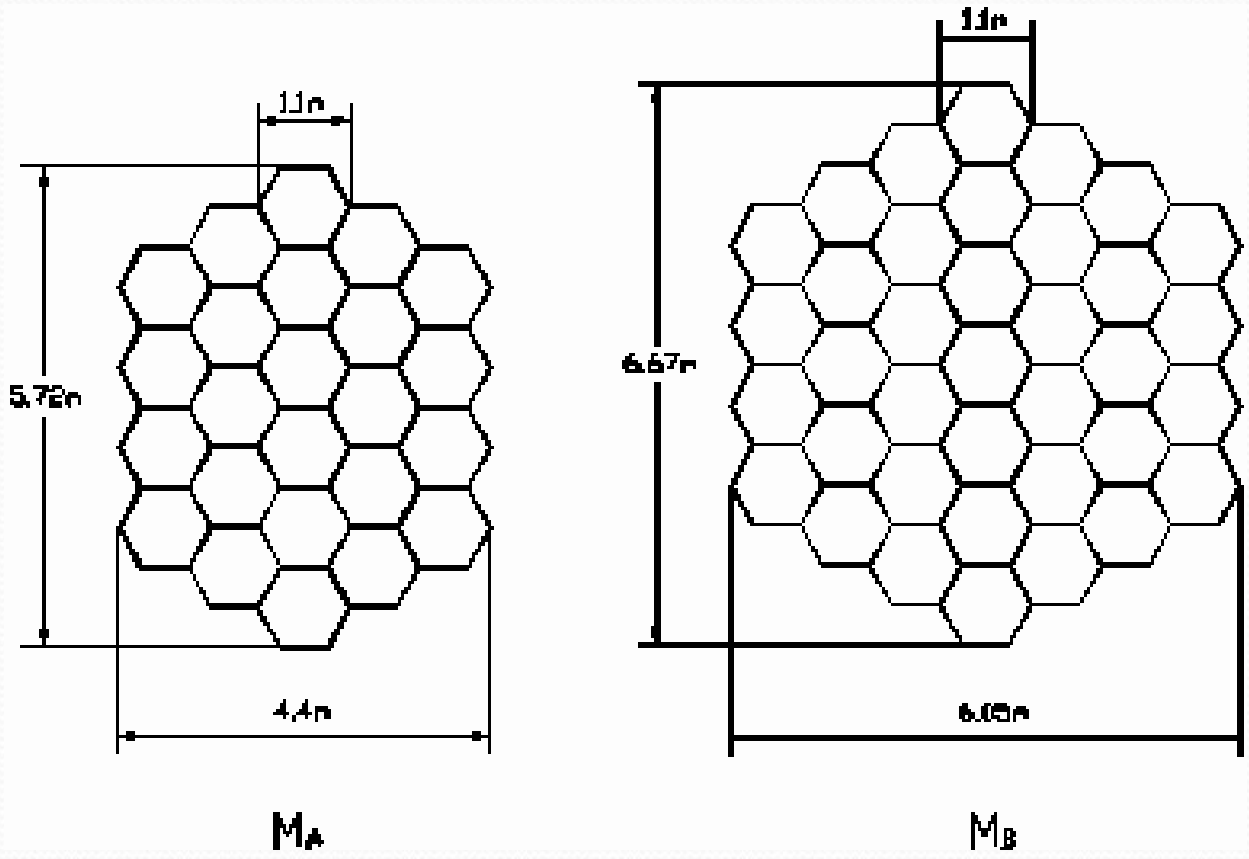

Large Sky Area Multi-Object Fiber Spectroscopy Telescope (LAMOST) Completed in 2008
4-m meridian reflecting Schmidt telescope


Structure of LAMOST
Fiber Positioning
MA mirror
Fibers
MB mirror
Spectrographs CCDs

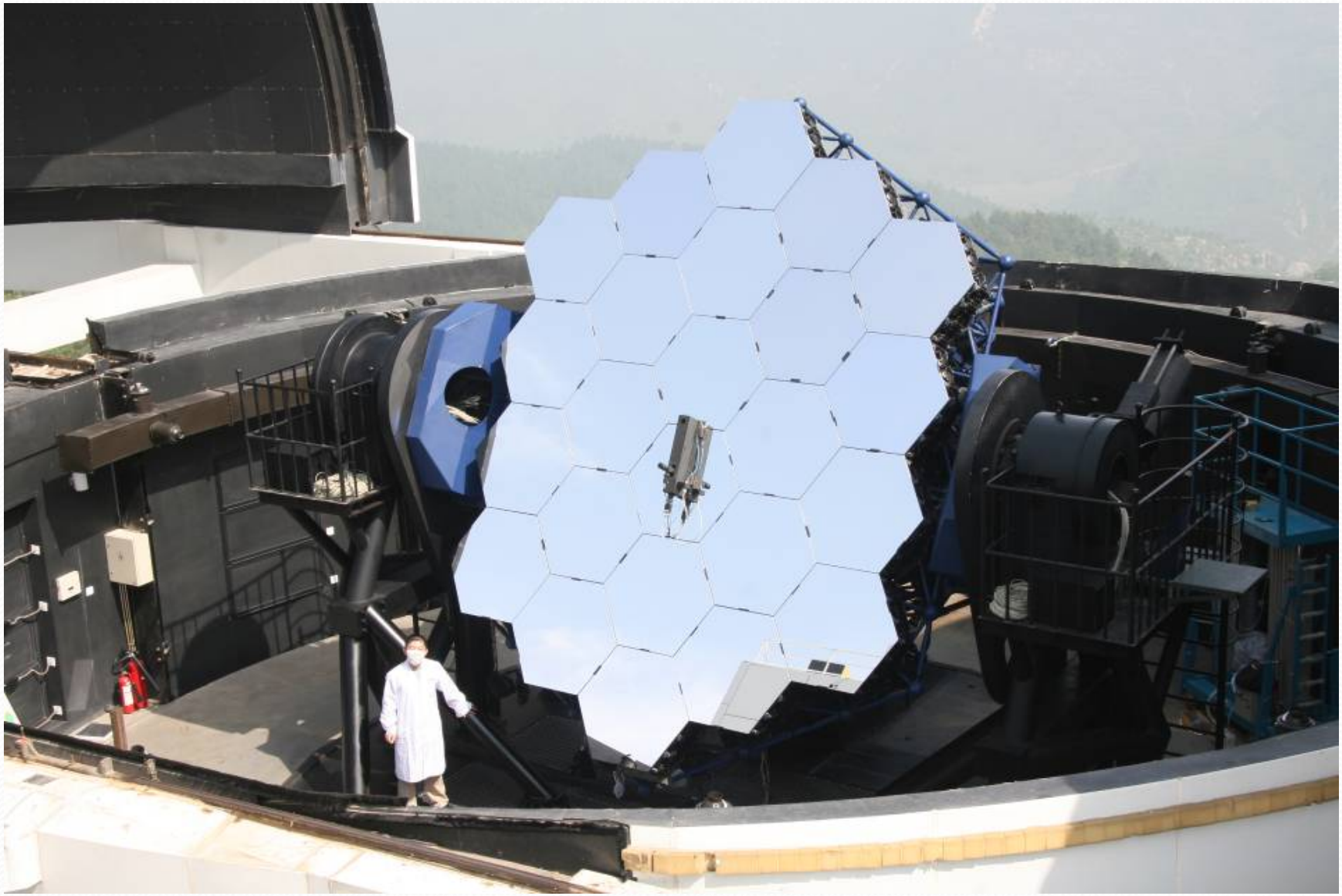
Basic parameters of LAMOST

- Schmidt telescope: 4.8m/6.1m
- Declination of observable sky area: -10° ~ +90°.
- FOV: 20 square degree
- Fibers: 4000
- Spectrum resolution:
  - VPH (Volume Phase Holographic) Grating
  - R = 1000, 2000; 5000, 10000

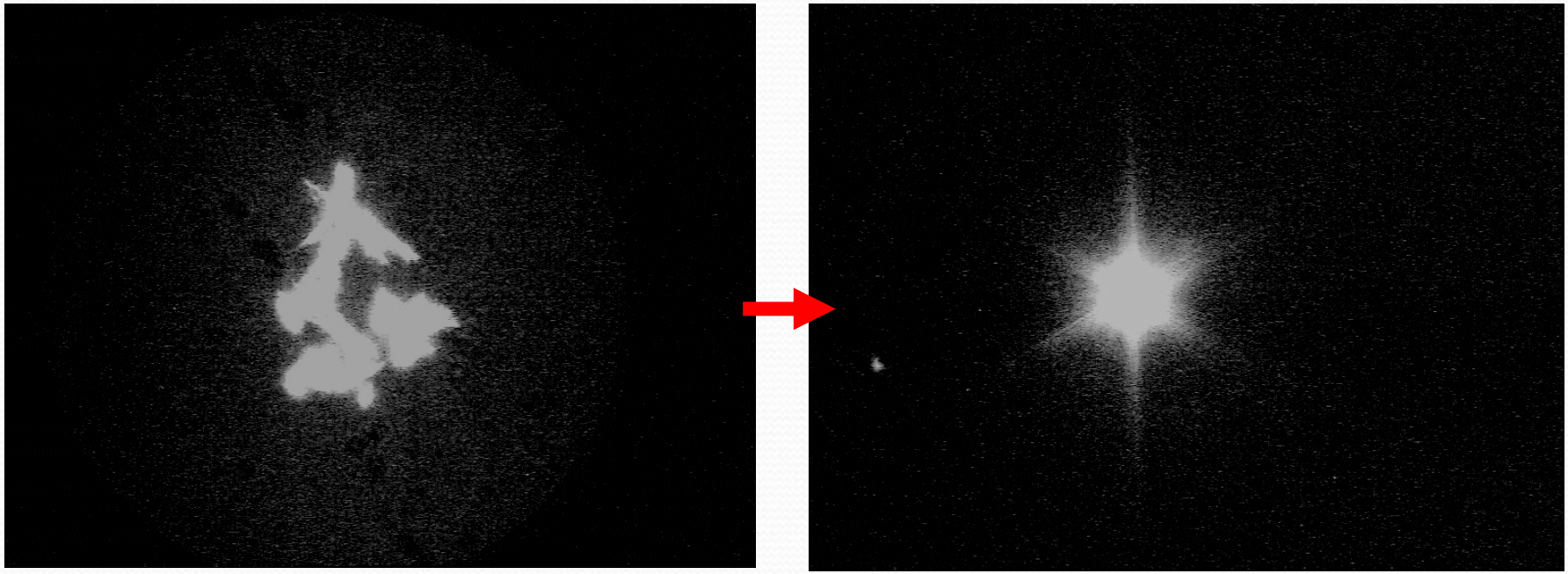
- Ma: reflecting corrector (24 sub-mirrors) ~ 4.8m
- Mb: spherical mirror (37 sub-mirrors) ~ 6.1m



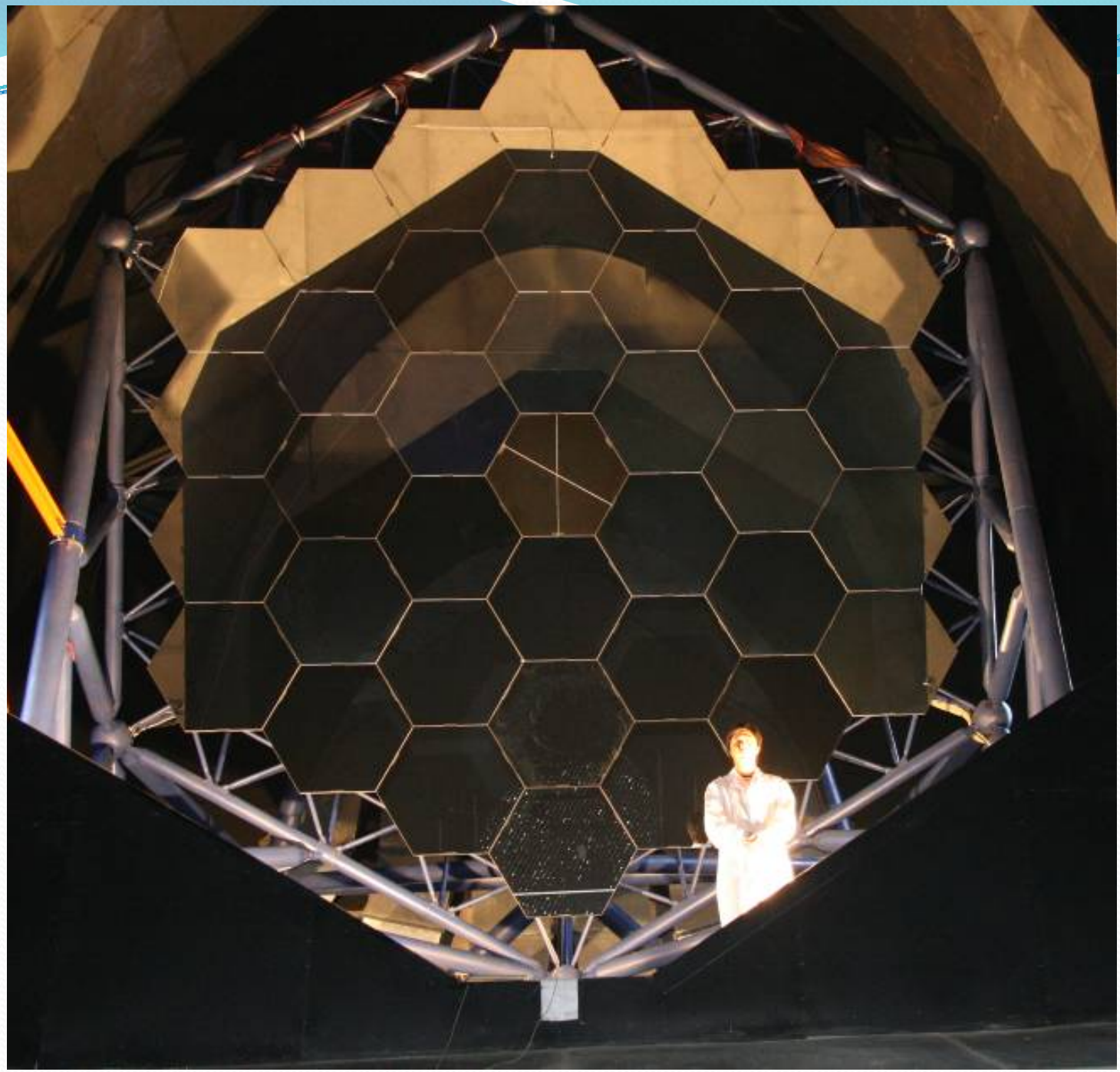
24 sub-mirrors of MA



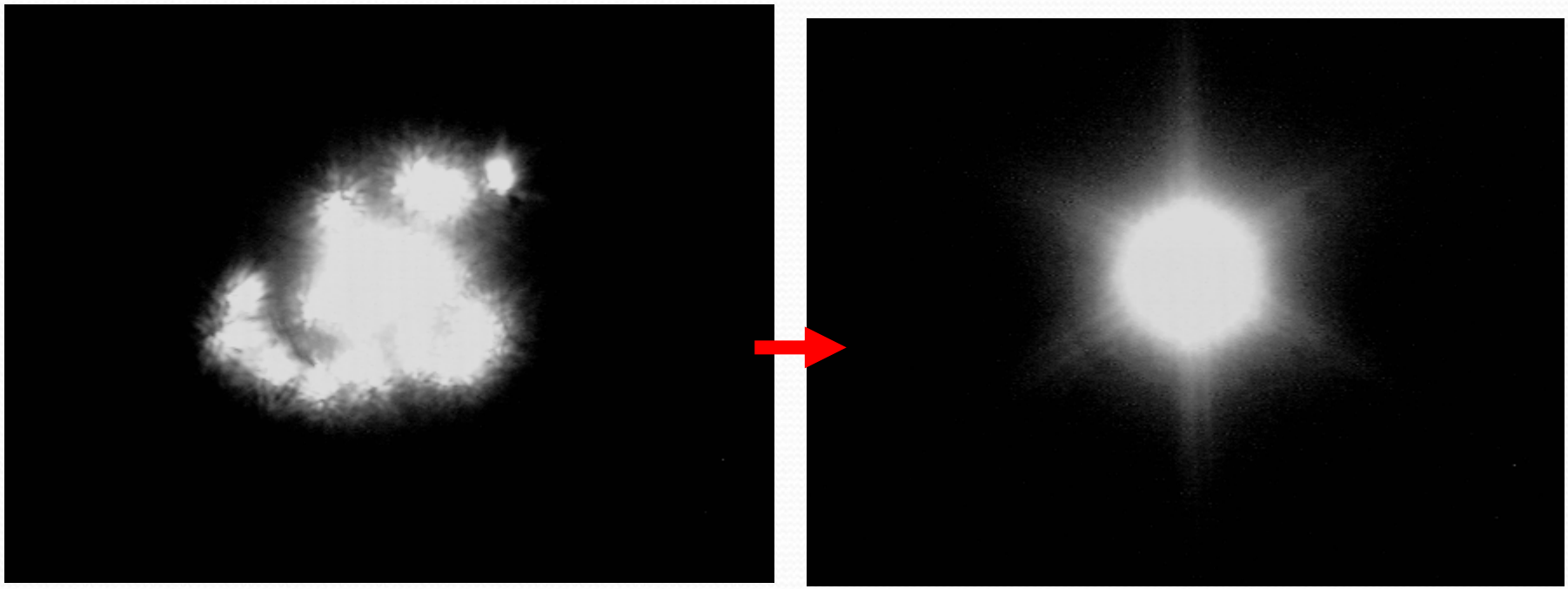
- 24 sub-mirrors of MA （Sept. 10, 2008)



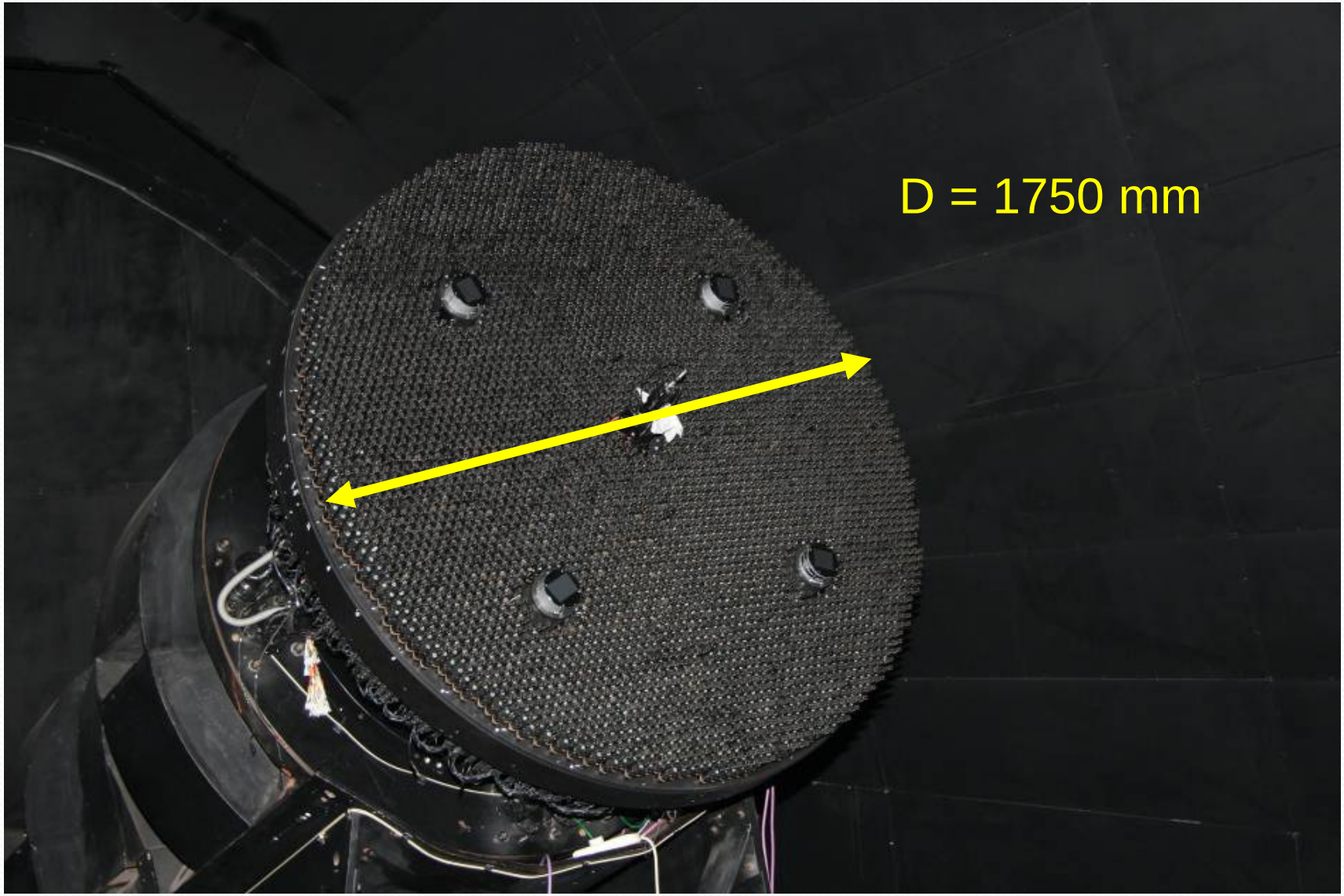
MB



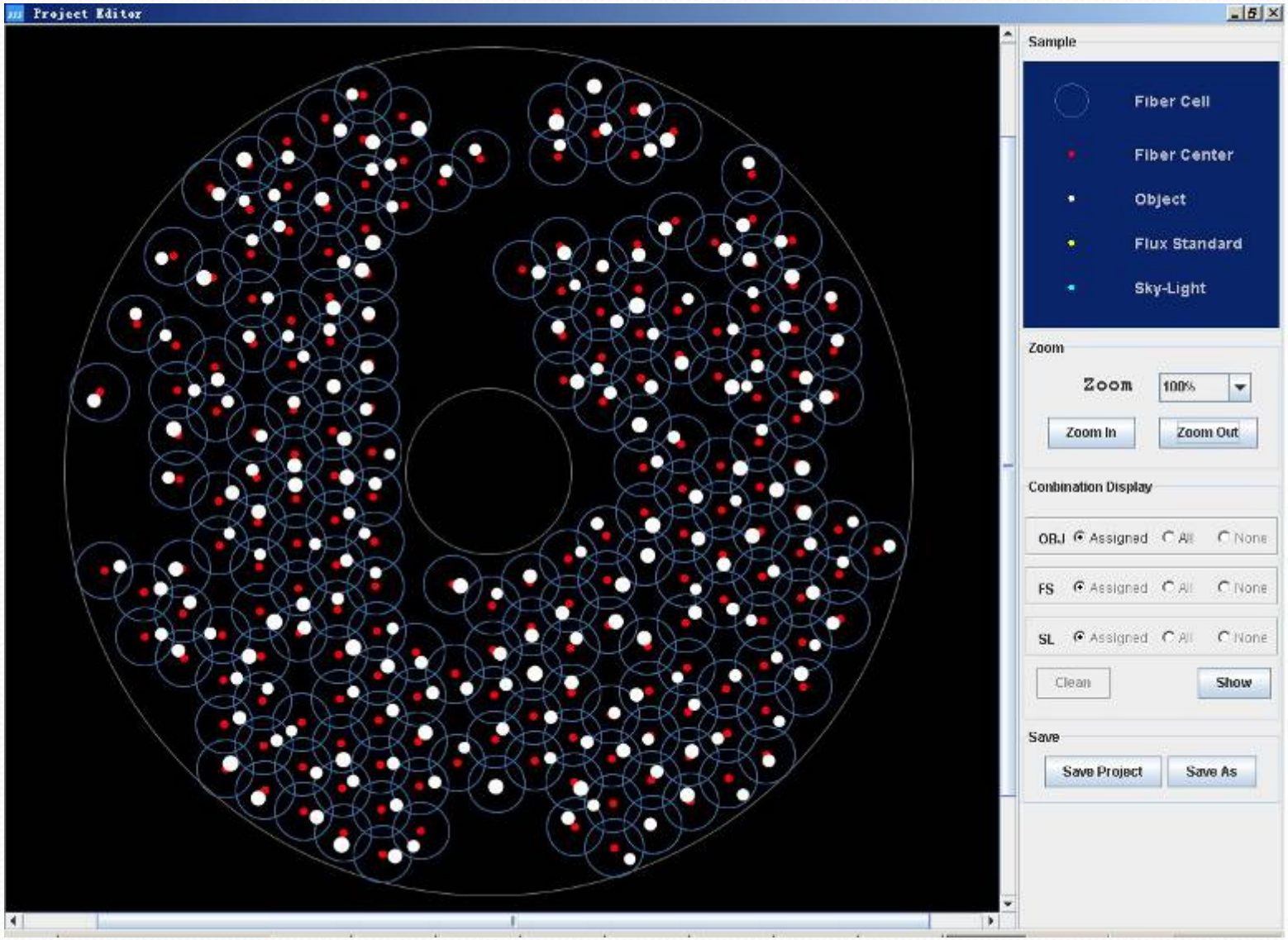
- 37 sub-mirrors of MB （July 13, 2008)



4000 optical fibers



Select the targets



Spectrographs

LAMOST-LRS Optical System

Blue (370~590nm)

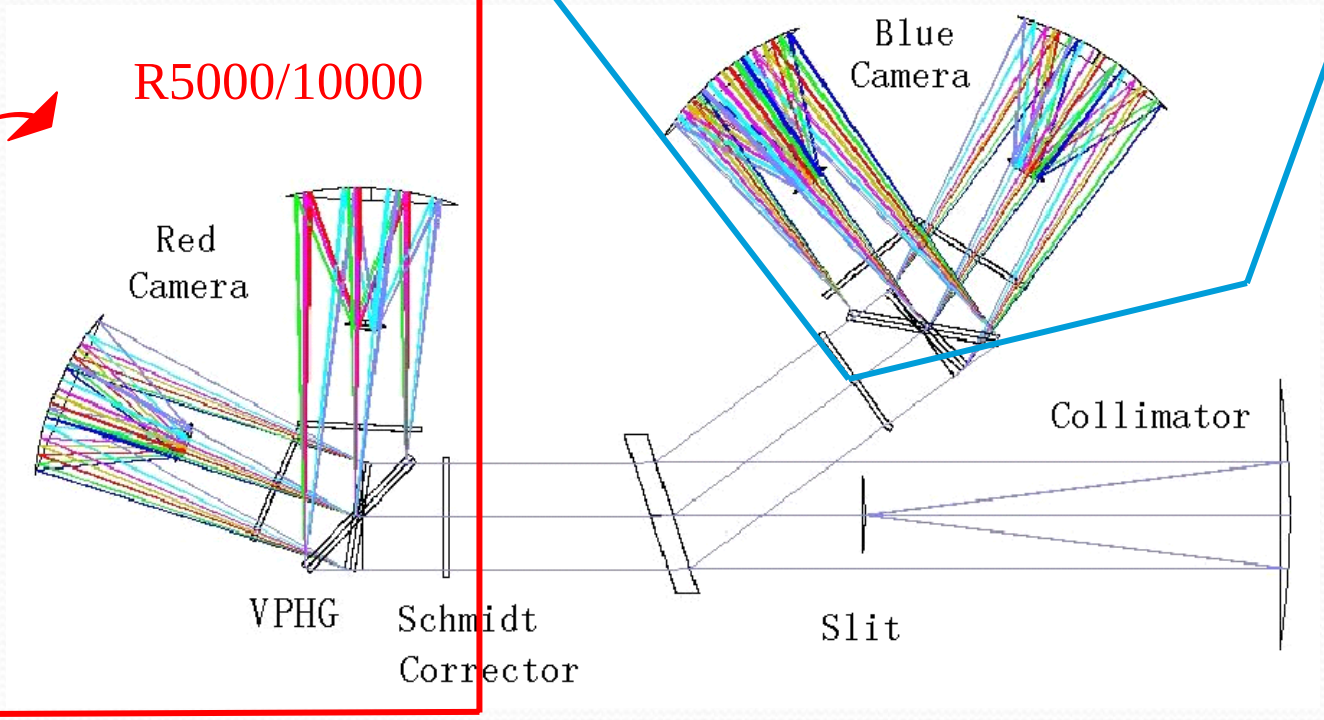
R5000/10000

R1000/2000

Red (570~900nm)

R5000/10000

R1000/2000



Technical Challenges

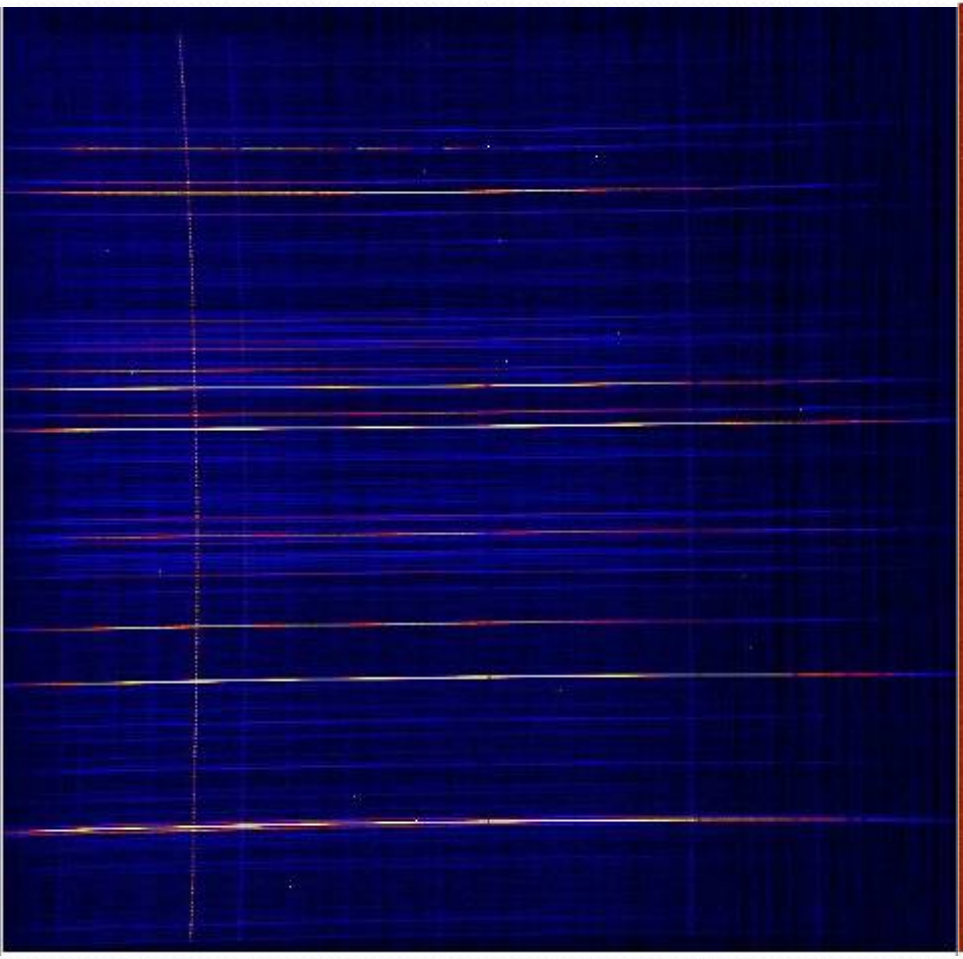
- Active optics
  - segmented thin mirror active optics in MA
  - segmented mirror active optics in MB
- Fiber positioning
  - LAMOST: 4000 fibers (China)
  - SDSS: 640 fibers (U.S.A.)
  - 2dF: 400 fibers (Australia)

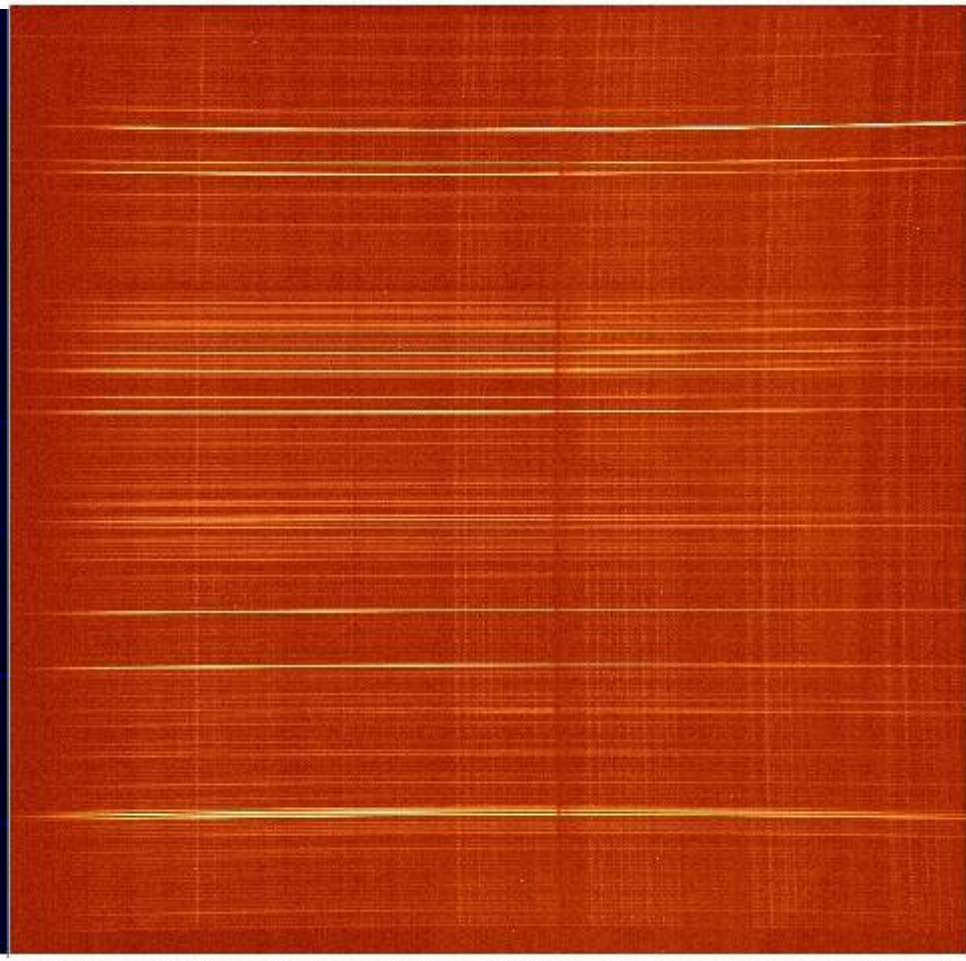
LAMOST milestones

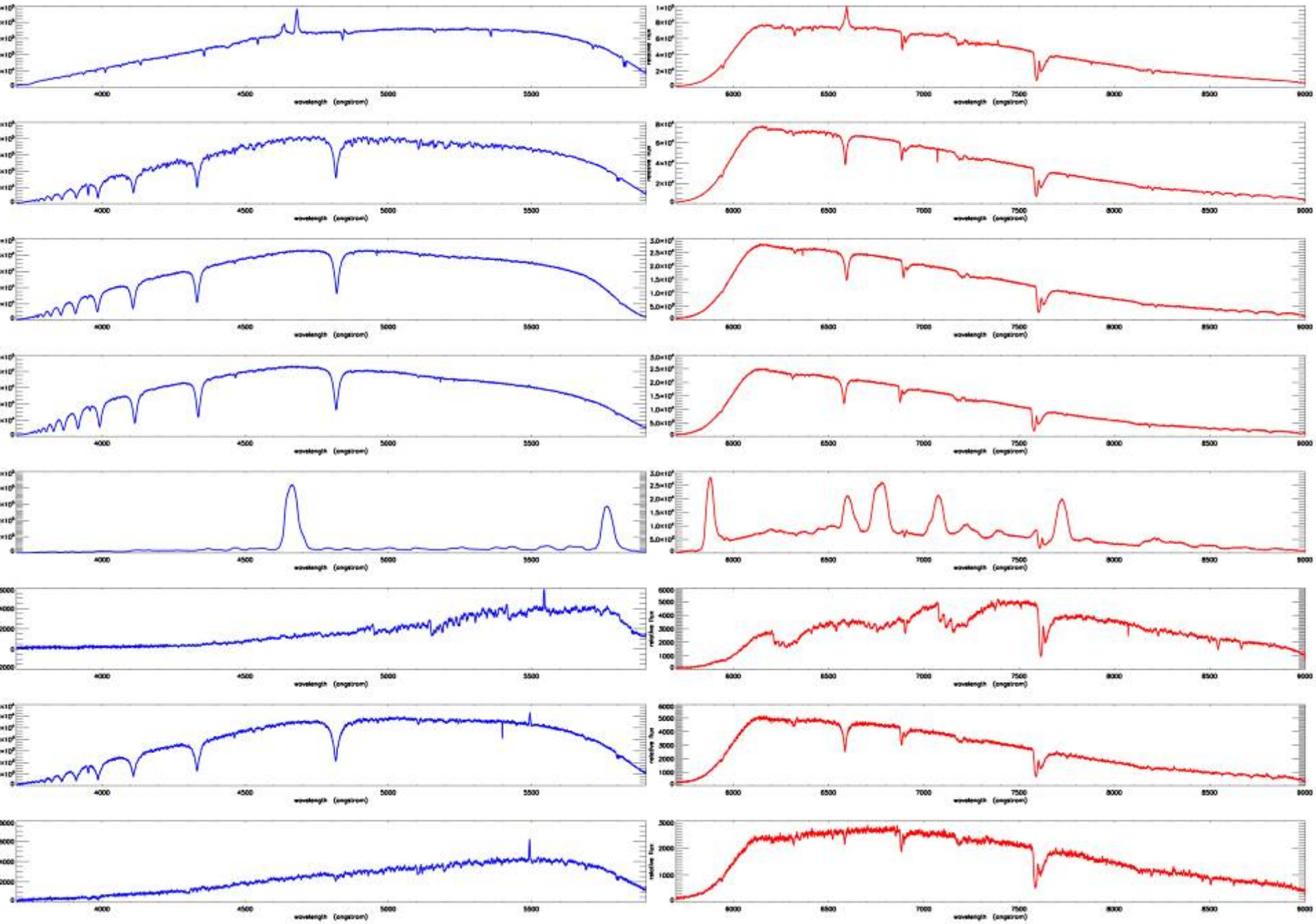
	reviewed	approved
Proposal	Nov. 1996	Apr. 1997
Feasibility Study	Jul. 1997	Aug. 1997
Preliminary Design	Apr.-May 1999	Jun. 1999
Detailed Design	Sep. 2001	
Construction	2001-2008	
First Light	May 20, 2008	
Completion	Oct. 2008	

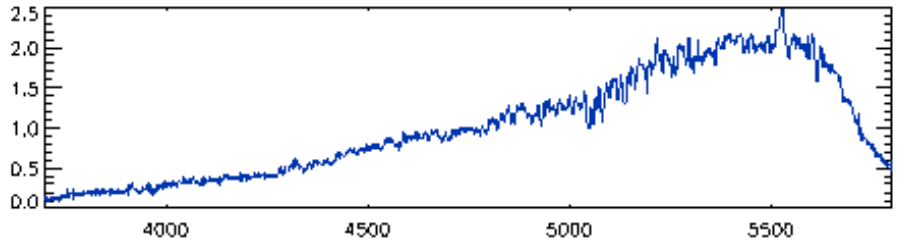
Inaugural of LAMOST completion
2008.10 @ Xinglong, China

Stellar Spectra in Commission（Sep. 28, 2008）






wavelength (angstrom)
relative flux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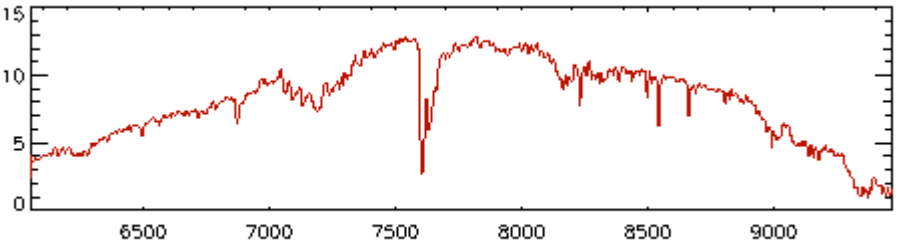
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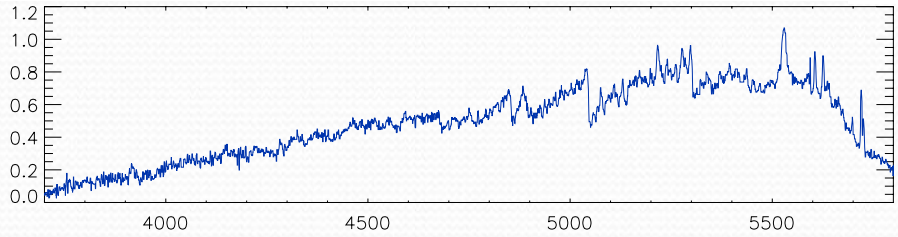
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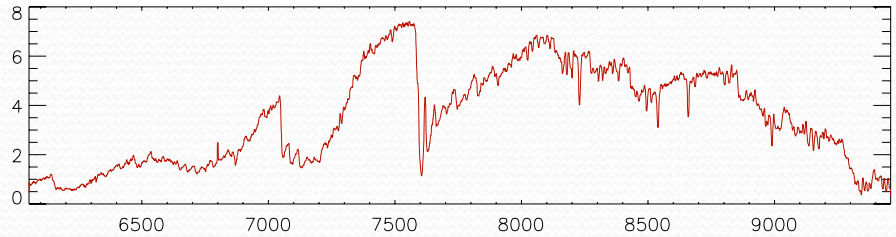
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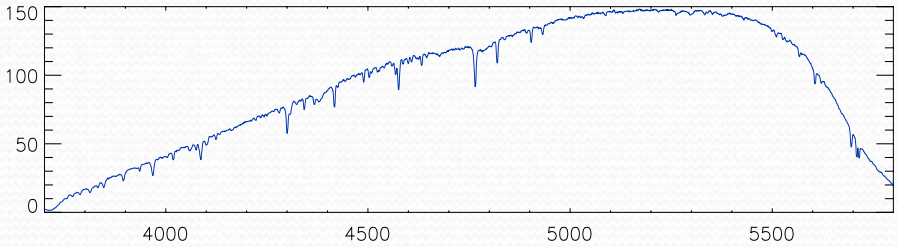
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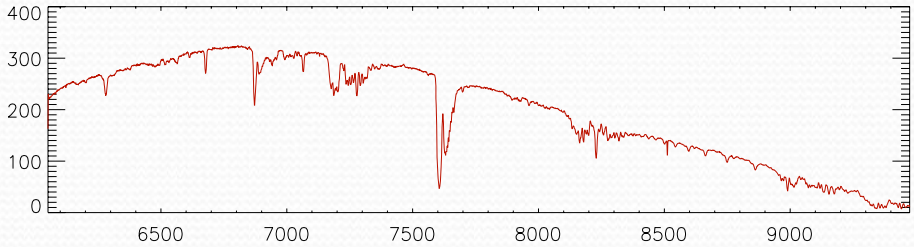
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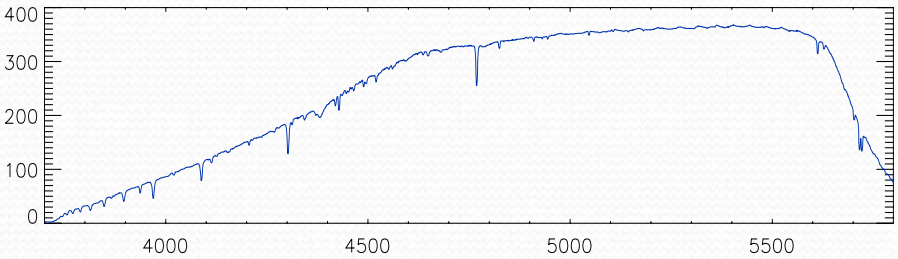
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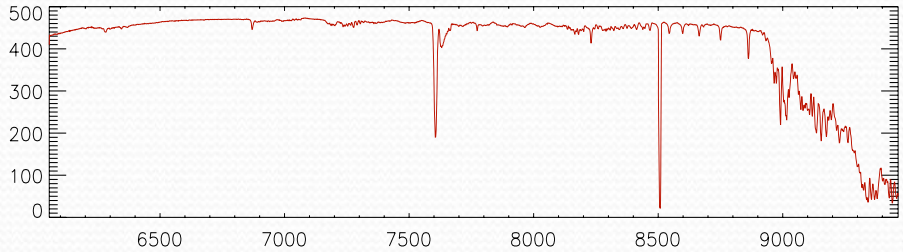
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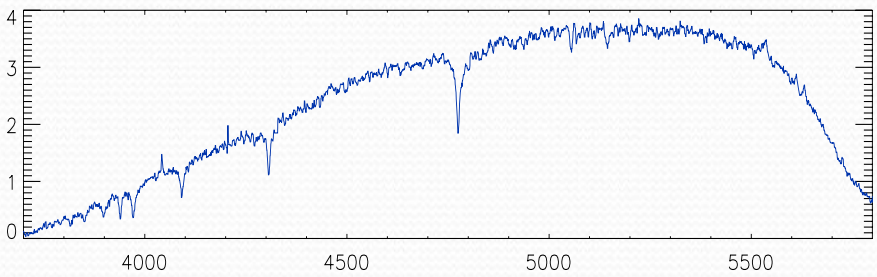
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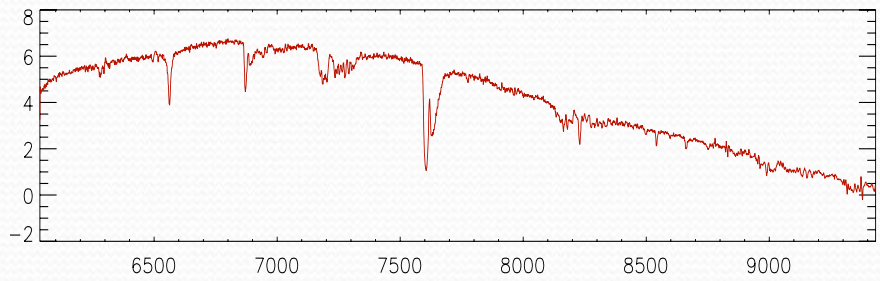
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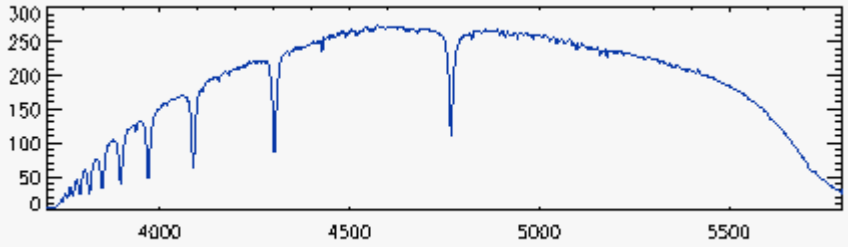
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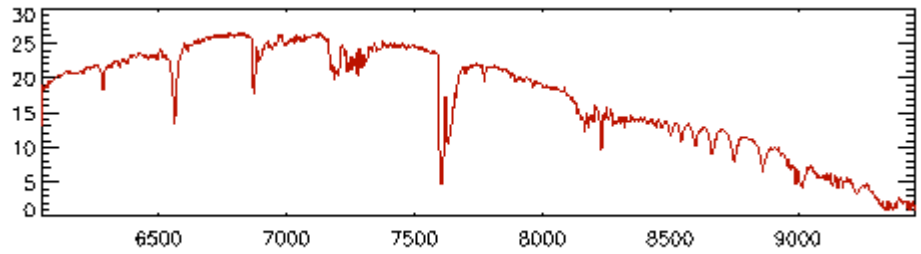
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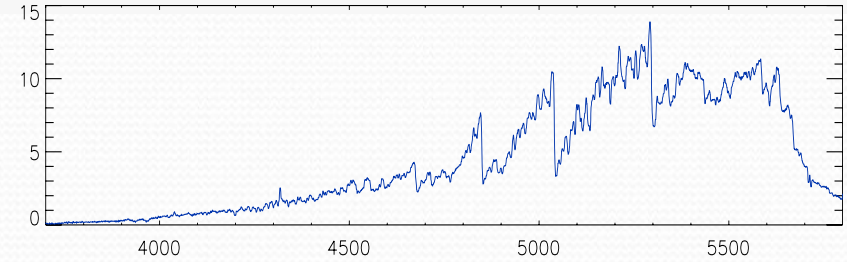
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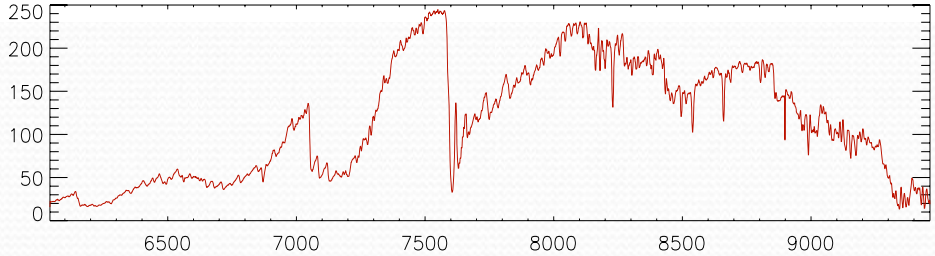
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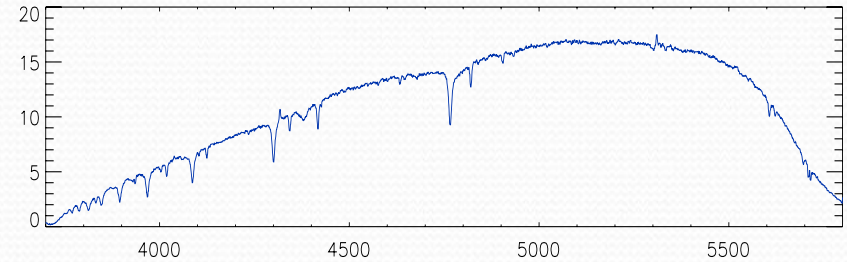
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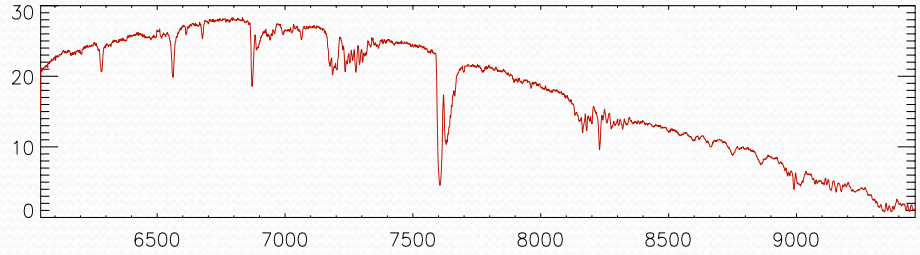
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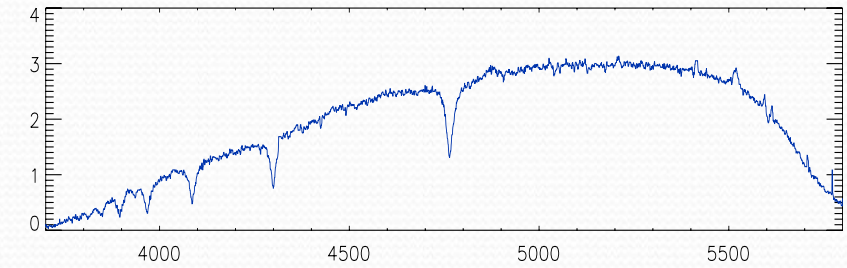
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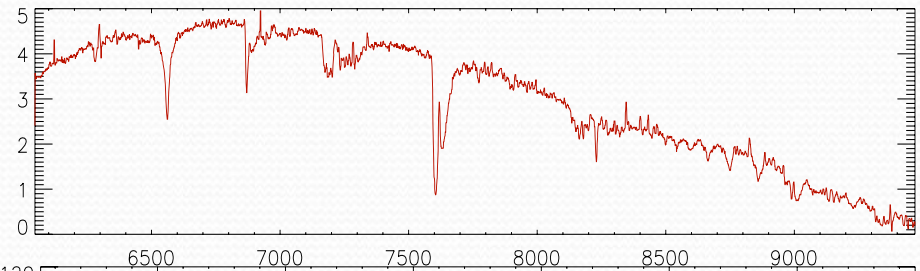
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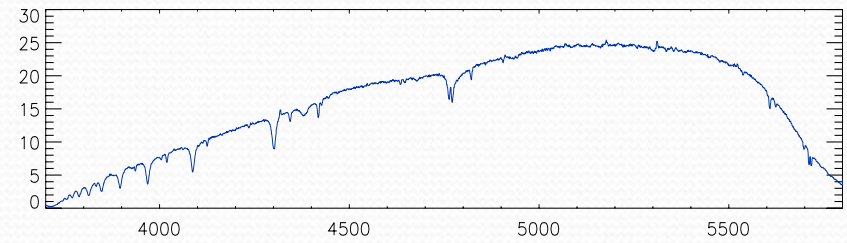
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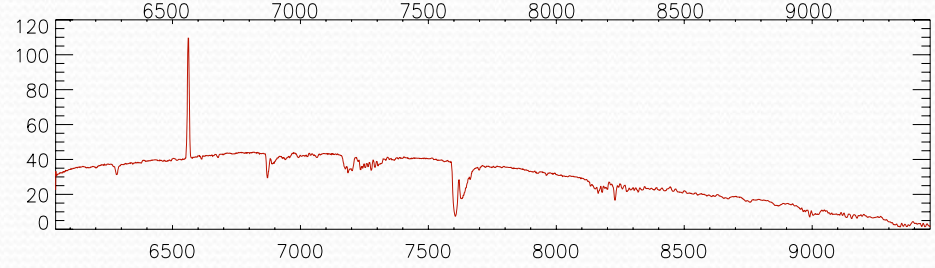
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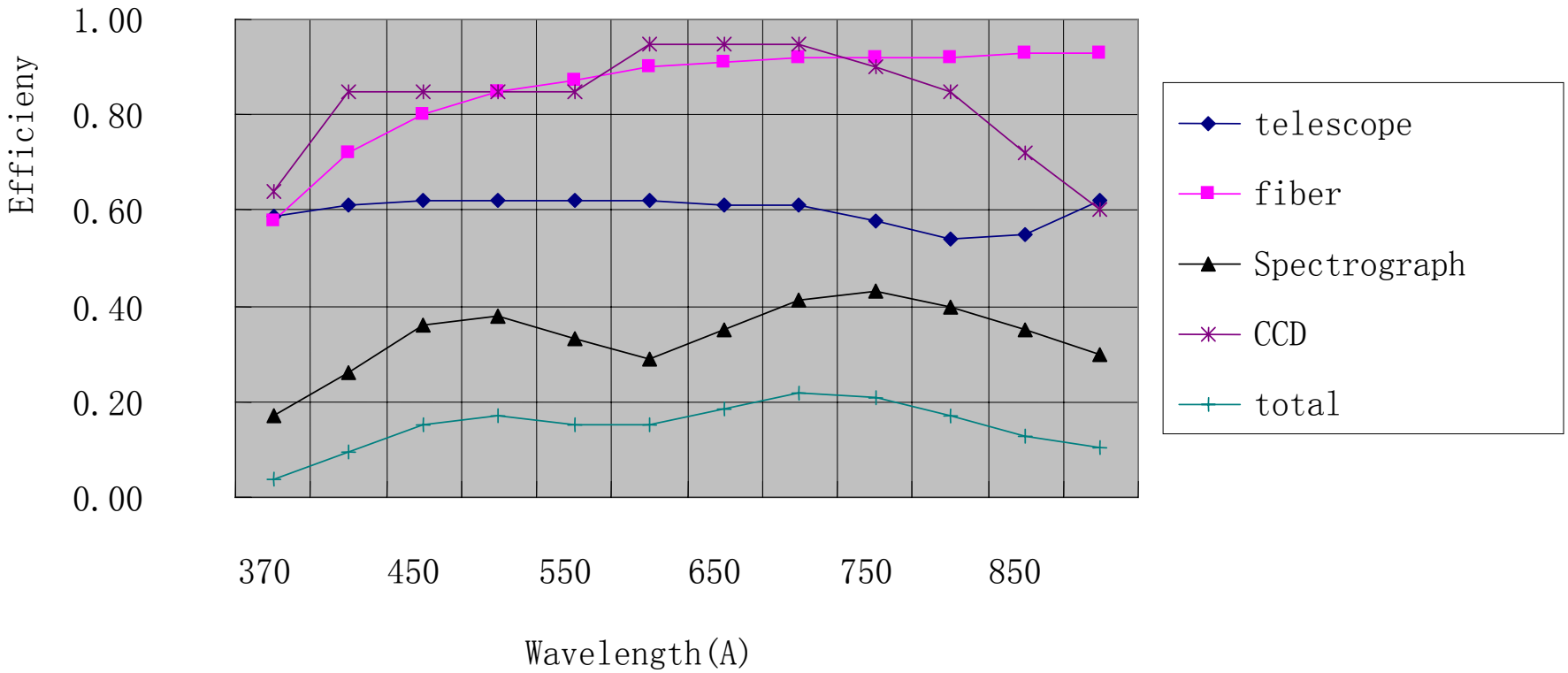
Component & Total Efficiency
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650
750
850
Wavelength(A)
telescope
fiber
Spectrograph
CCD
total

Commission Period

- Sep.-Dec., 2008
  - Fiber positioning units (to 4000 objects)
  - Spectroscopic calibration
  - Operation software
  - Pipelines for data processing
- 2009:
  - Stability (Active optics, Dome seeing)
  - Efficiency (Fibers, Spectrographs, CCDs)
  - Scientific test observations
    - Open clusters, nearby galaxies, selected area survey, …

Commission Period

- Aug, 2008 – Dec, 2009
  - Two working groups:
    - Extragalactic survey
    - Galactic survey
    - ➔ input catalog for LAMOST
- May 28-30, 2009
  - International evaluation for survey project proposed by working groups

Regular Spectroscopic Survey

- Jan. 2010 – Dec. 2014
  - Extra-galactic spectroscopic survey (~10^7 targets)—

    Galaxy and QSO red shift survey
  - Stellar spectroscopic survey (~10^7 targets)—

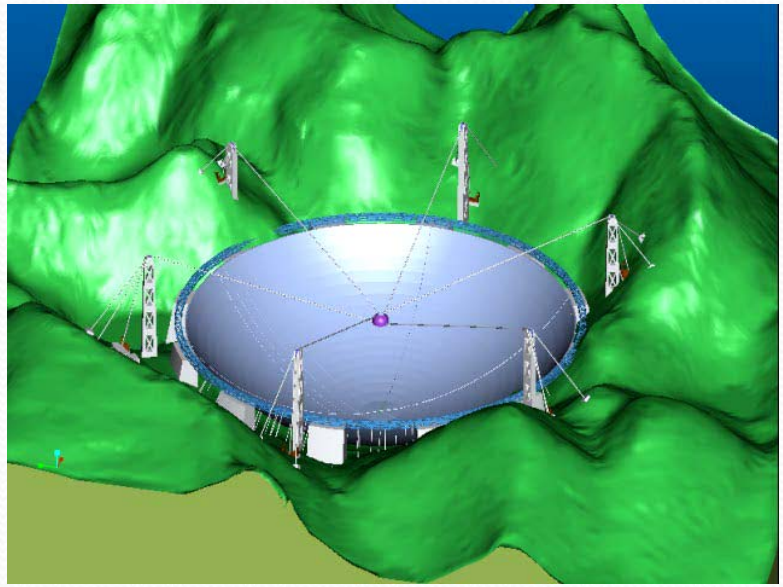
    Structure of the Galaxy, and so on
  - Cross identification of multi-waveband survey

more information please visit www.lamost.org

Project Manager - Prof. Yongheng ZHAO yzhao@lamost.org
Project Scientist - Prof. Yaoquan CHU yqchu@ustc.edu.cn
Chief Engineer - Prof. Xiangqun CUI xcui@niaot.ac.cn

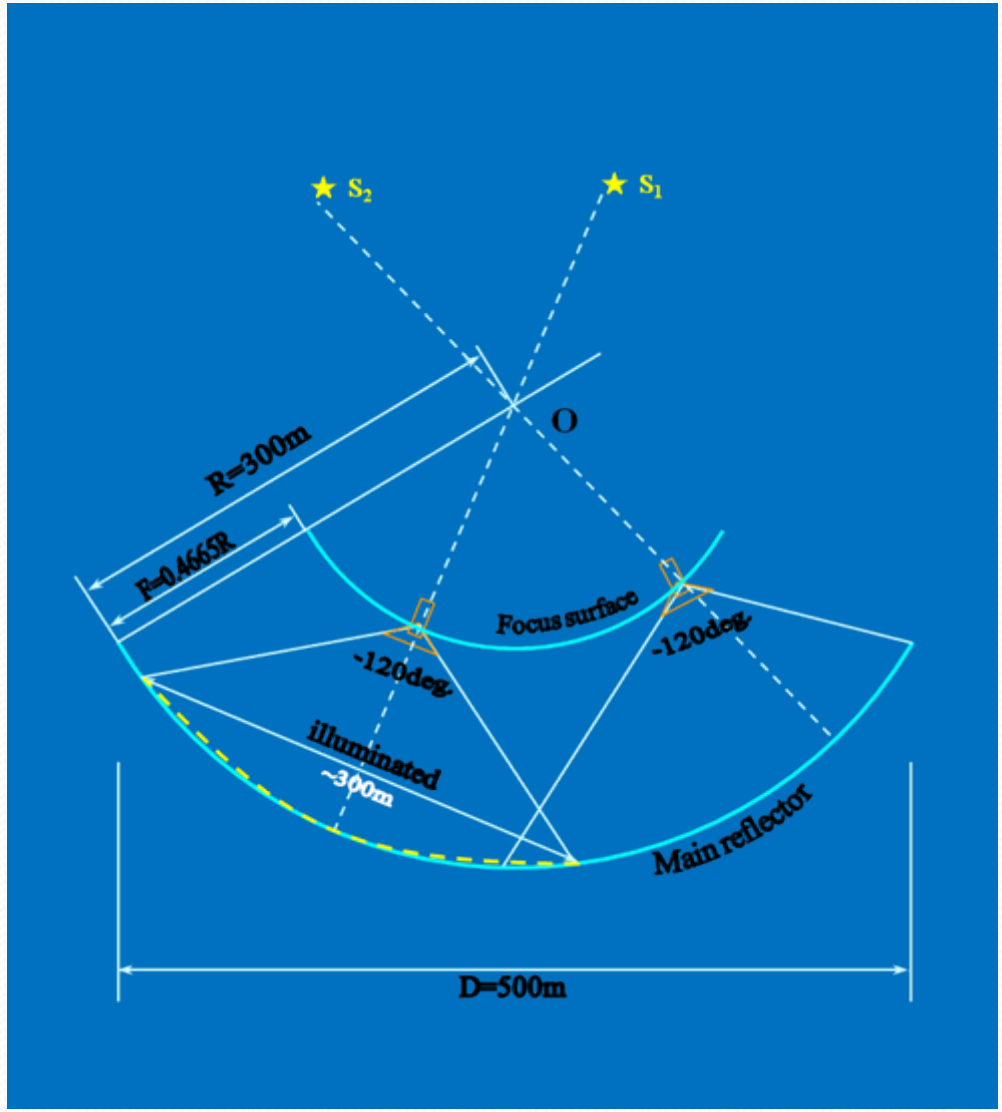
Five-hundred-meter Aperture Spherical Telescope - FAST

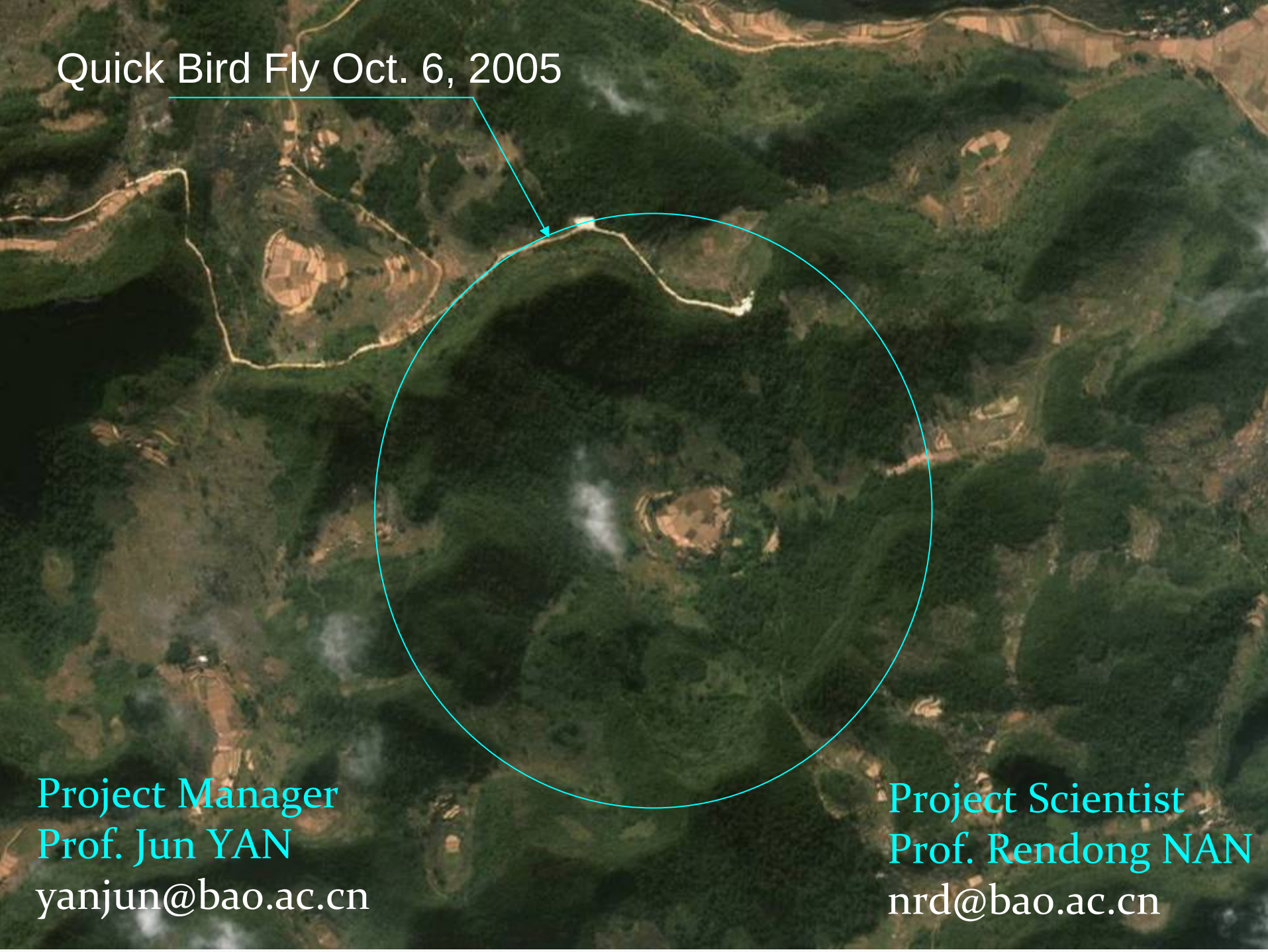
- Unique Karst depression as the site
- Active main reflector
- Cable - parallel robot feed support



Optical Geometry and Specs

- Reflector: R～300m, D～500m, opening angle: θ ～110-120°
- Illuminated aperture: D_{eff}=300m
- Sky coverage: maximum zenith angle: 40°
- Working frequencies: 70MHz-3GHz, up to C-, X-band
- Sensitivity 2000 ㎡/K
- Resolution 2.9'
- Multibeam 19
- Pointing Accuracy： 8″





Project Manager
Prof. Jun YAN
yanjun@bao.ac.cn

Project Scientist
Prof. Rendong NAN
nrd@bao.ac.cn

- Science Cases
  - HI surveys
  - Pulsar research
  - Hosting VLBI network
  - Molecular lines
  - SETI

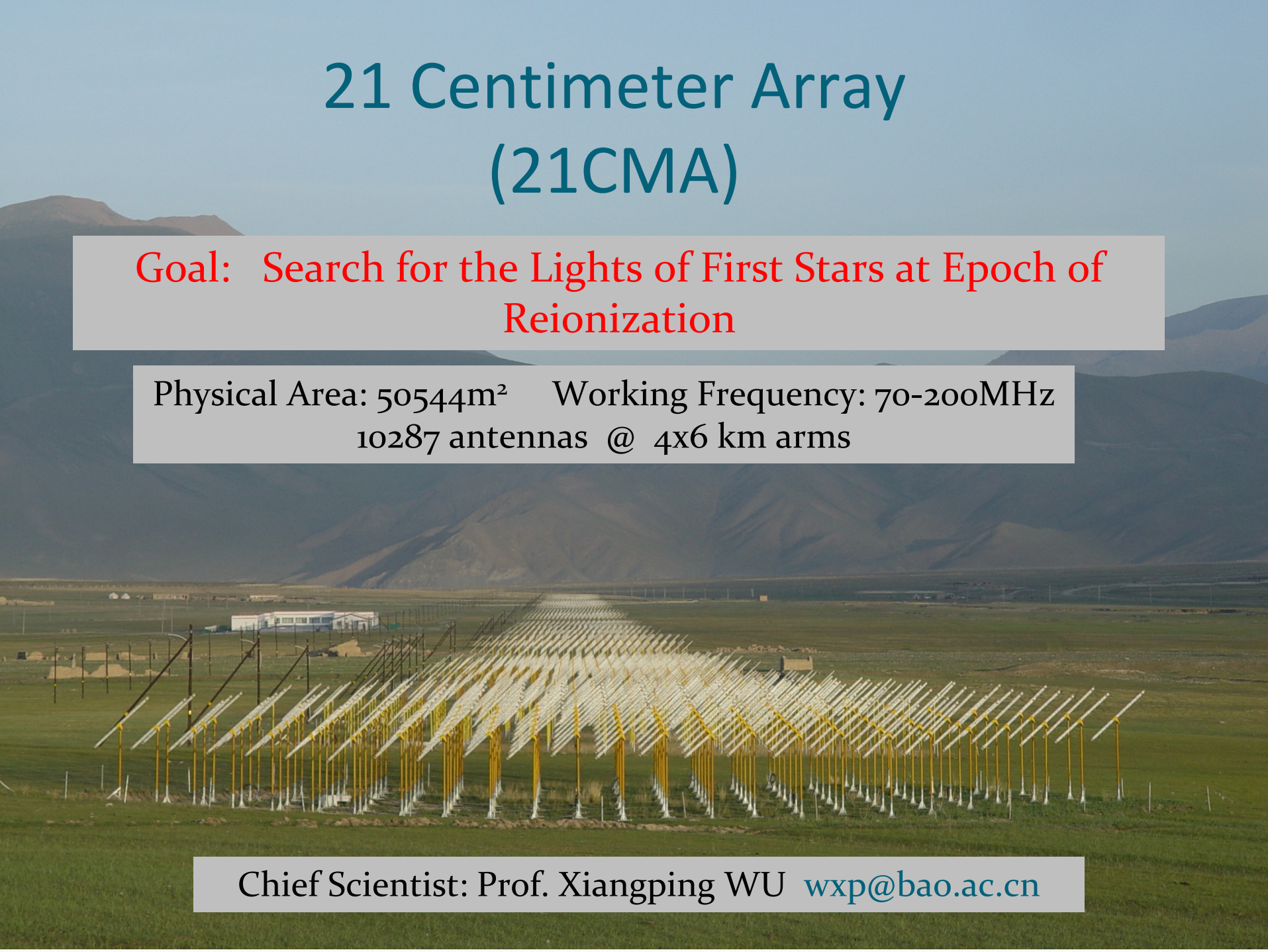
- FAST milestones:
  - Concept born together with SKA, back to 1993
  - Funding Proposal approved on July 10, 2007
  - Feasibility Study approved on Oct. 31, 2008
  - Preliminary Design evaluated on Dec. 15, 2008
  - Opening Foundation held on Dec. 26, 2008

FAST Opening Foundation

21 Centimeter Array (21CMA)

Goal: Search for the Lights of First Stars at Epoch of Reionization

Physical Area: 50544m² Working Frequency: 70-200MHz
10287 antennas @ 4x6 km arms



Chief Scientist: Prof. Xiangping WU wxp@bao.ac.cn

S

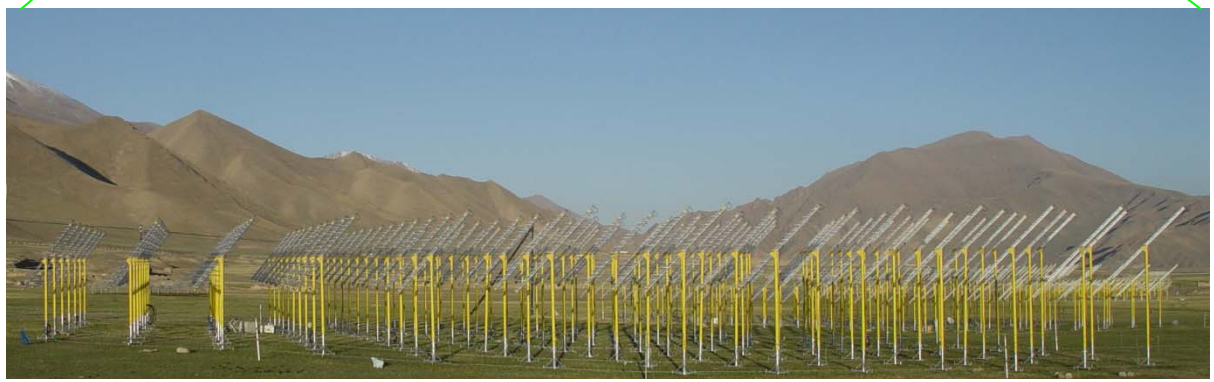
N

W

E

control room

1 pod=127 antennas



21CMA Layout

81 pods along two perpendicular arms (6km+4km)

Baselines: 3240 Freq channels: 4096

Total data size: 4 terabytes / day

Characteristics of 21CMA

Frequency coverage:

70 - 200 MHz

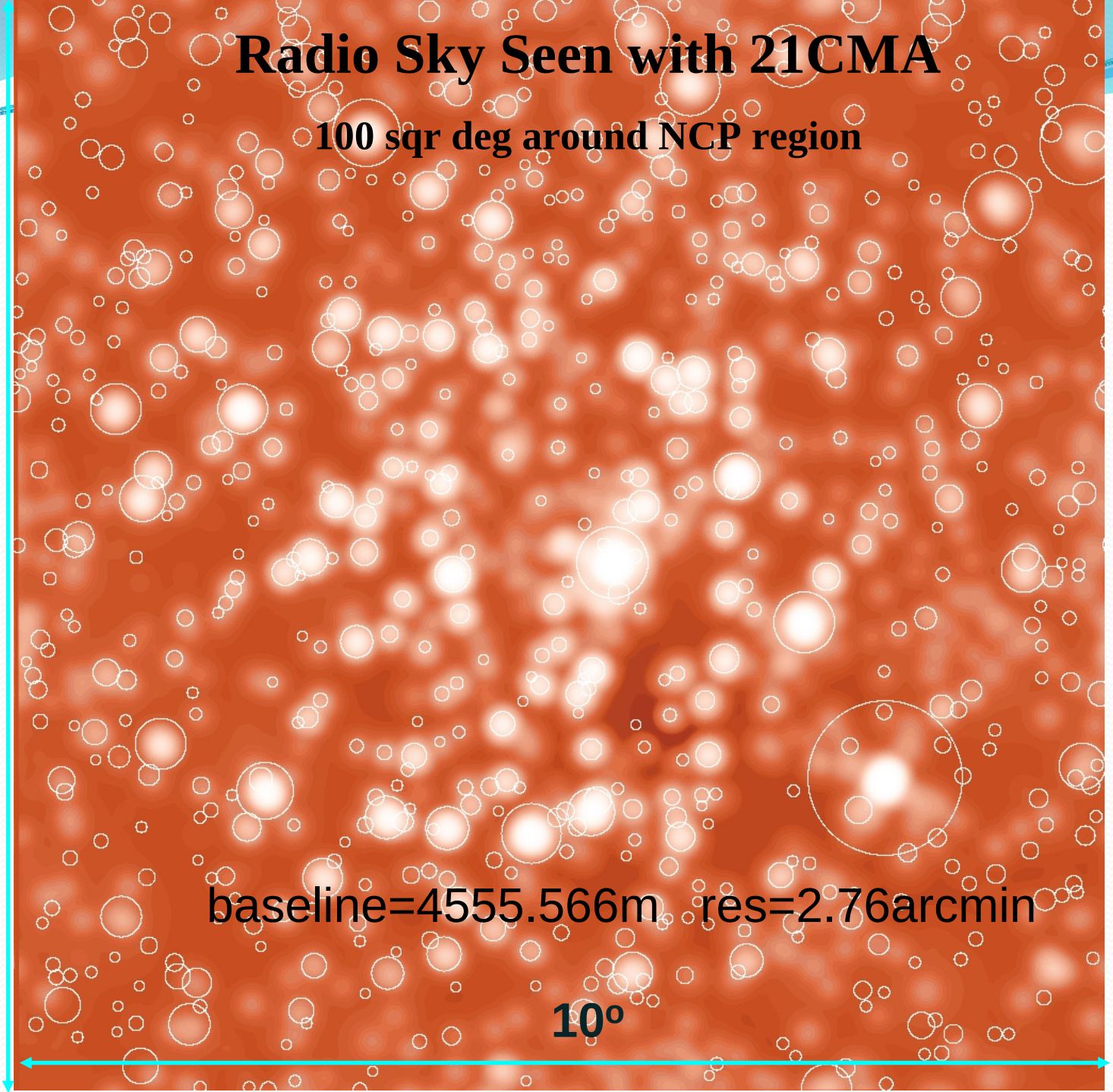
Redshifted 21cm Line:

$$\lambda = 21\text{cm}\ (1 + z)$$

z	λ (cm)	ν (MHz)
6	147	200
10	246	130
20	441	68

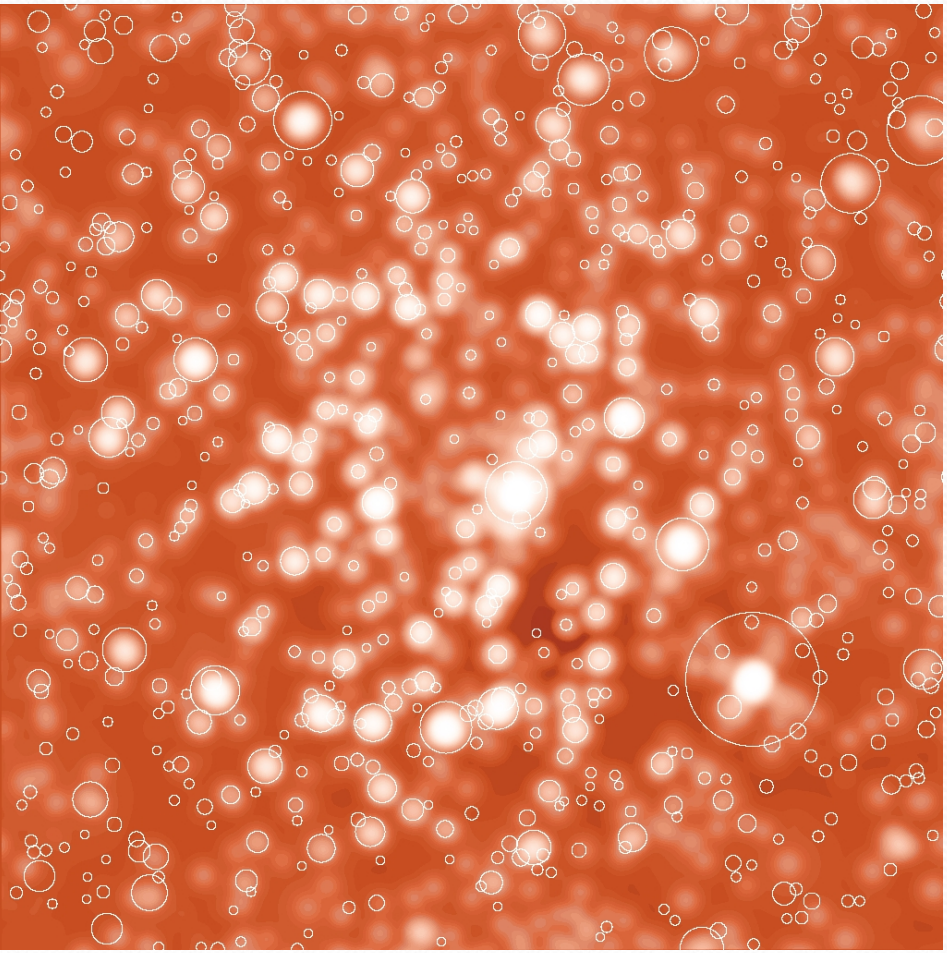
Radio Sky Seen with 21CMA

100 sqr deg around NCP region

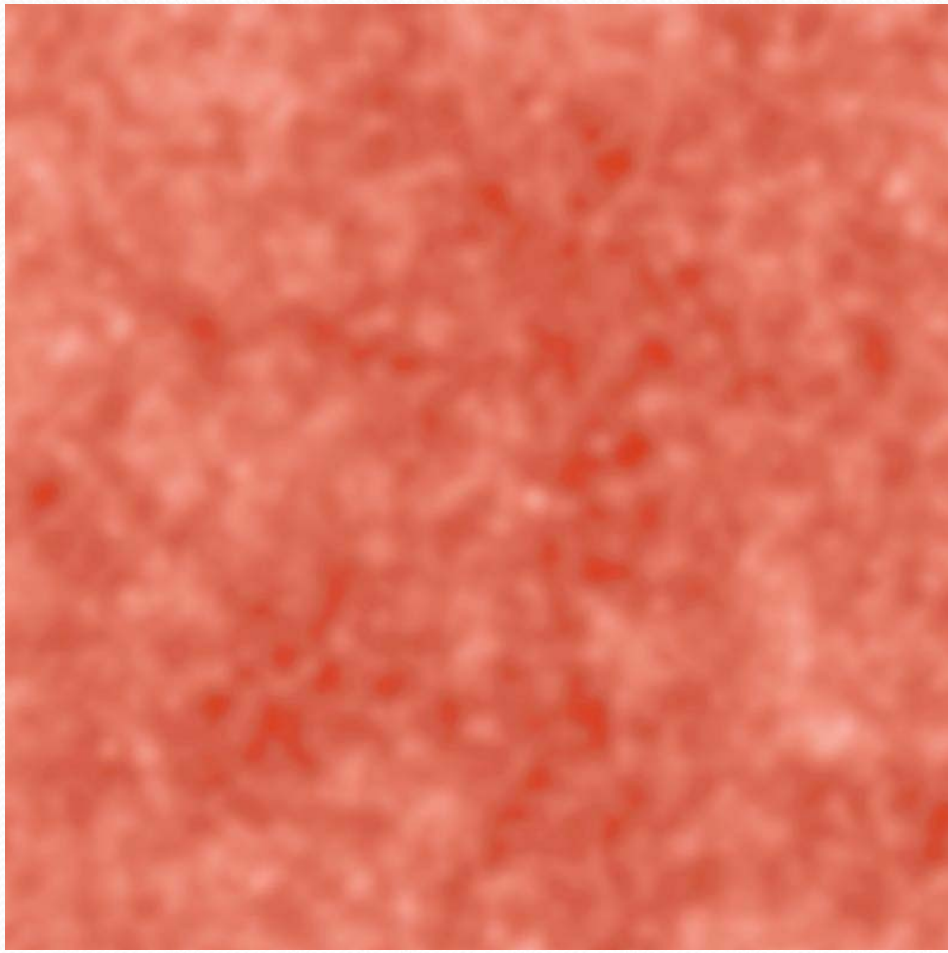


Strategy:

Remove foreground sources to “see” structures of reionization



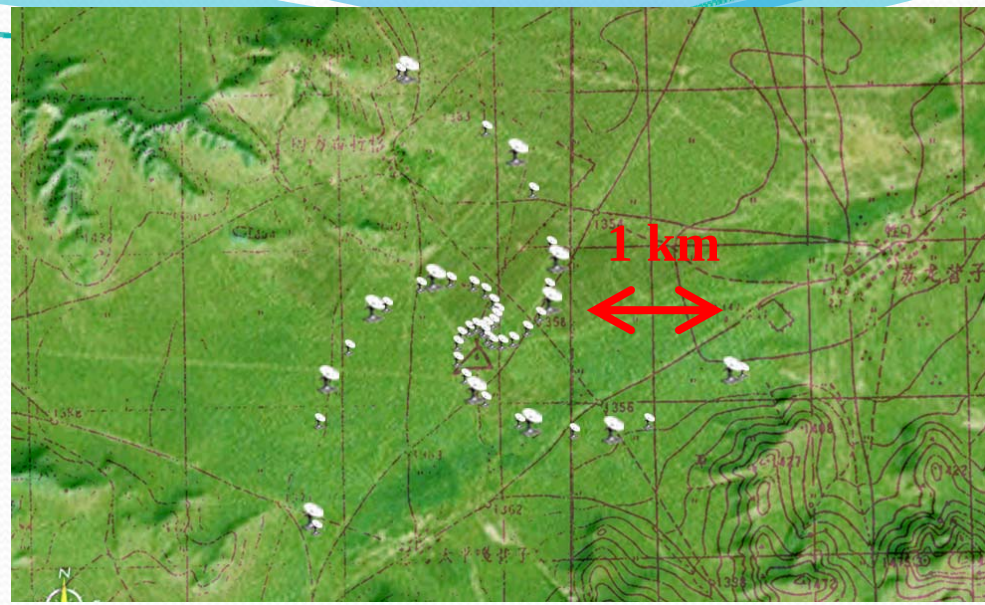
VHF Sky@21CMA



Residual Background

Chinese Radioheliograph Project (CSRH)

Imaging spectroscopy in dm-cm range, with high temporal, spatial, and spectral resolutions, is important for addressing fundamental problems of energy release, particle acceleration and particle transport



Array Configuration
Site: Inner Mongolia, China

Chief Scientist: Prof. Yihua YAN yyh@bao.ac.cn

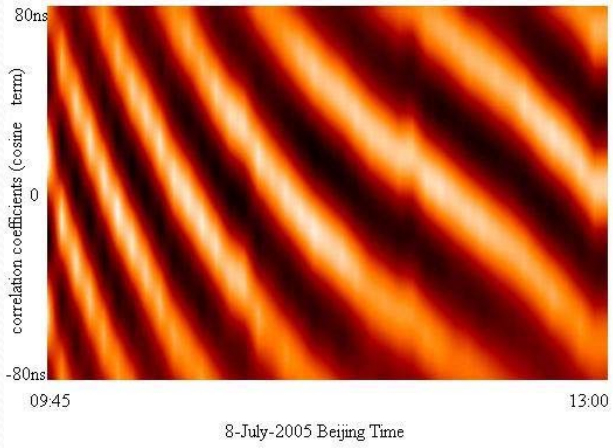
Low frequency array: CSRH-I during 2008-2010

High frequency array: CSRH-II during 2011-2013

CSRH Specifications

Freq. Range:	~0.4–15 GHz （λ： ~75 –2 cm）
Frequency Res.:	64 or 128 chan （I: 0.4-2 GHz）
	32 or 64 chan （II: 2-15 GHz）
Spatial Res.:	1.3”– 50”
Temporal Res.:	~<100 ms （0.4-15 GHz)
Dynamic Range:	25 dB （snapshot）
Polarizations:	Dual circular L, R
Array: I:	40×∅4.5m parabolic antennas
II:	60× ∅2m parabolic antennas
Max baseline:	3 km
Field of view:	0.6°– 7°

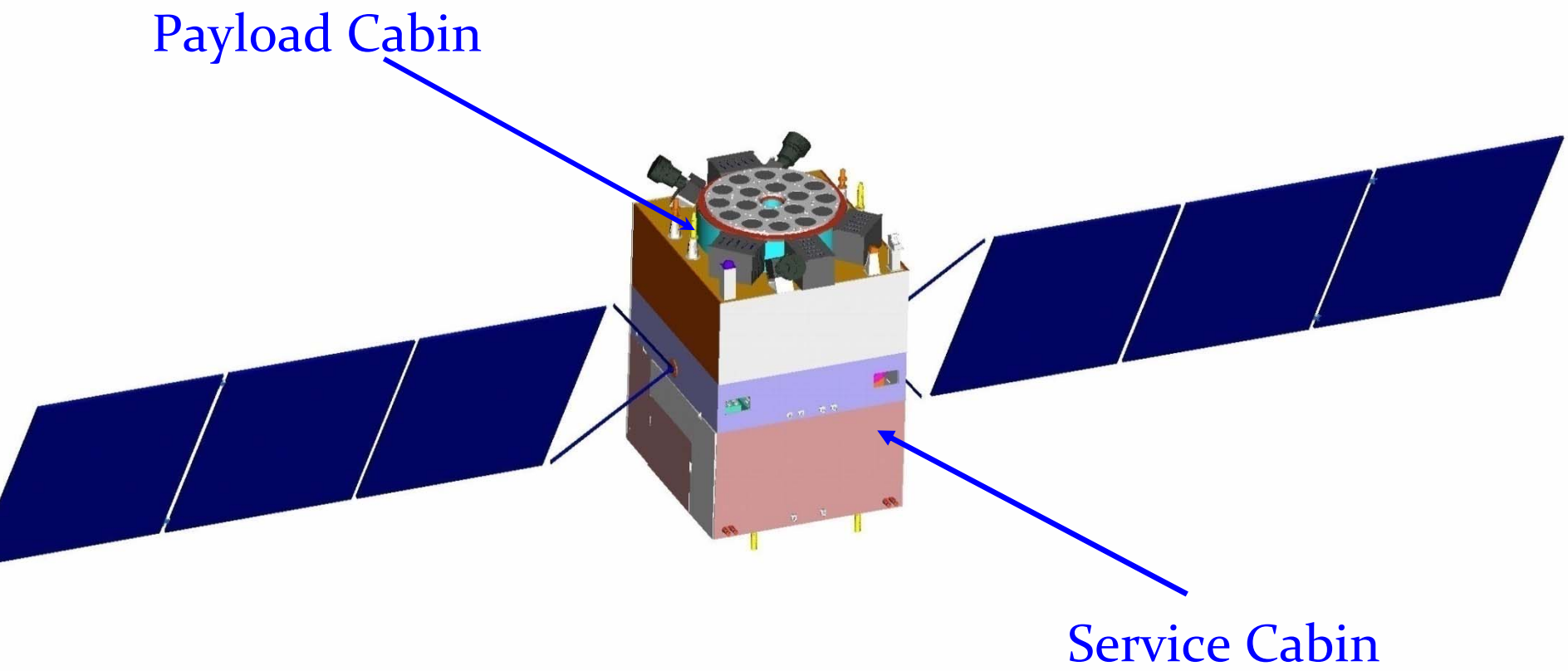
2-element prototype experiment in 2005 with Fringes of Solar Radio Signal at 1.6GHz for short baseline of 8 m →



Space Missions

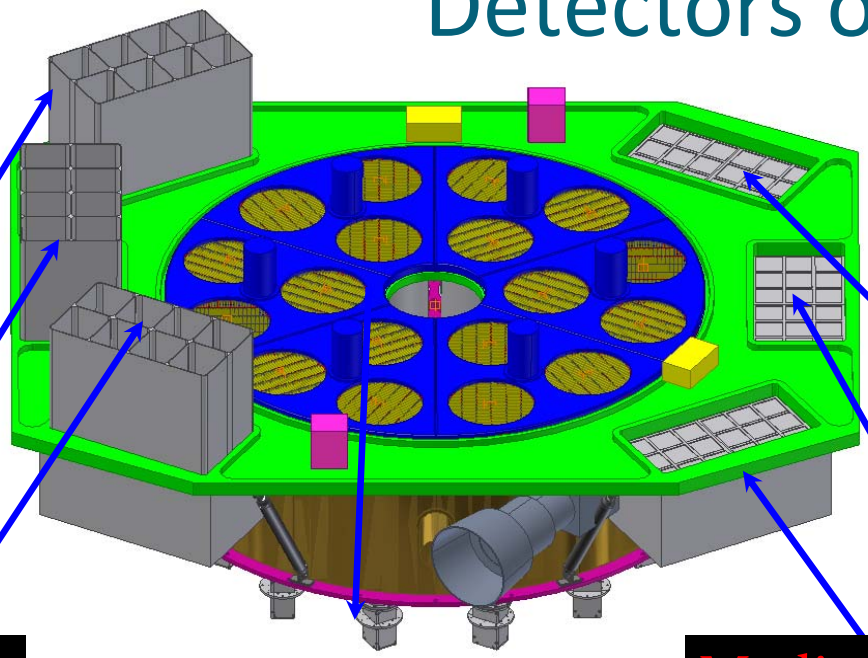
HXMT, SVOM, POLAR, WSO, SST, and SMESE

HXMT: planned for launch around 2011



Hard X-ray Modulation Telescope

Detectors onboard



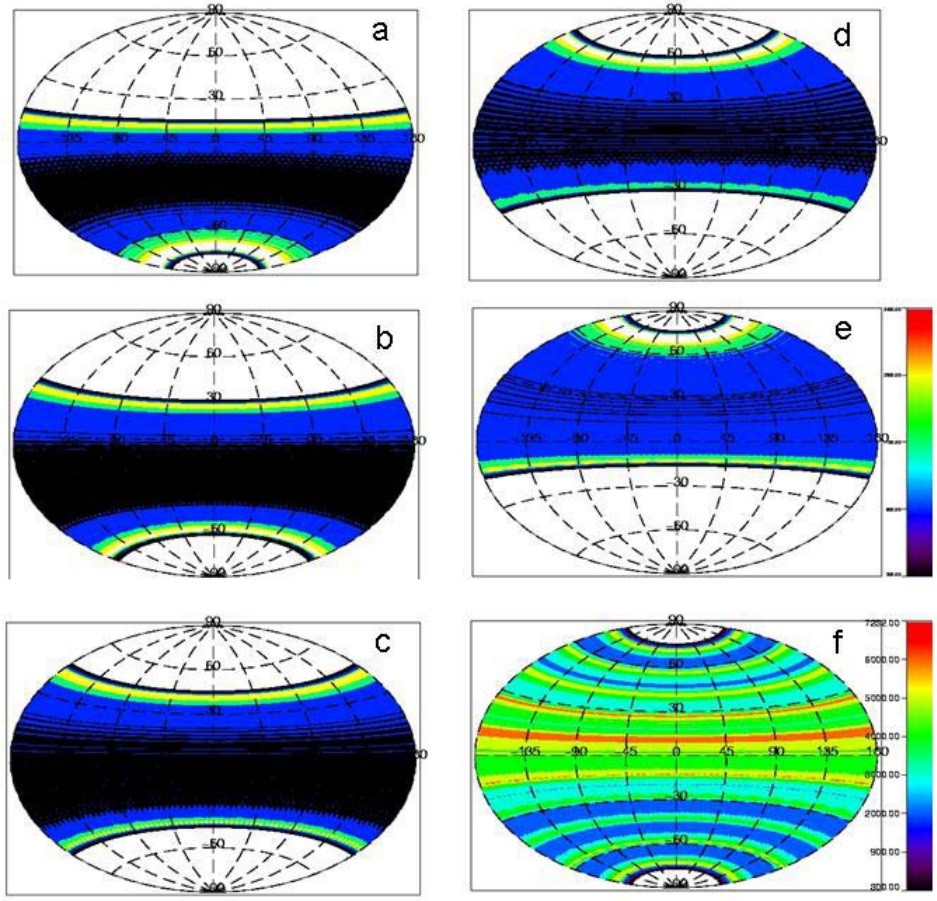
Low Energy X-ray Telescope (LE) (1-15 keV) SCD, 384 cm²)

Medium Energy X-ray Telescope (ME) (5-30 keV) (SiPIN, 952 cm²)

High Energy X-ray Telescope (HE) (20-250 keV, 18 modules, 5000 cm²)

HXMT full sky survey

1 year exposure map



Main science of HXMT

- Hard X-ray full sky survey with high sensitivity
  - Hard X-ray full sky map:
    - diffuse background and cosmic variance
  - Discover highly obscured supermassive BHs:
    - Galaxy formation and evolution
  - Discover new types of high energy objects:
    - usual surprises of new surveys

Main science of HXMT (cont.)

- Broad band and large collection area pointed observations of high energy objects
  - Space-time in strong gravitational field:
    - dynamics and radiation near BH horizons of stellar mass and supermassive BHs
  - High energy particle acceleration:
    - AGN, SNR, shock and relativistic jets
  - Large scale structure:
    - through hard X-ray detection of galaxy clusters

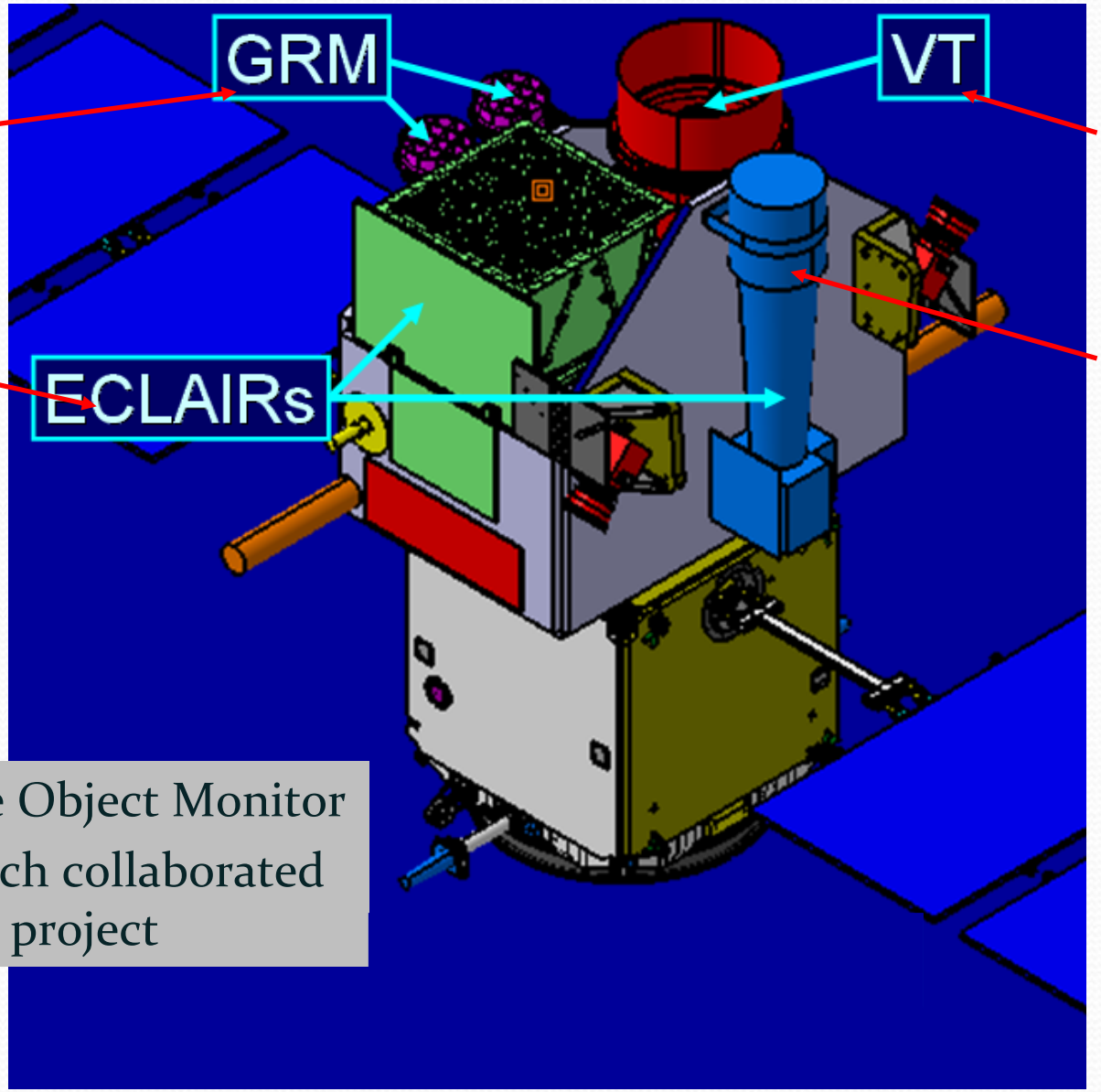
Project Scientists: Prof. Tipei LI litp@mail.ihep.ac.cn
Prof. Shuangnan ZHANG zhangsn@tsinghua.edu.cn

A multi- λ GRB project: SVOM

China:
30keV-5MeV

France:
4 -150keV

Launch time:
2012 - 2013



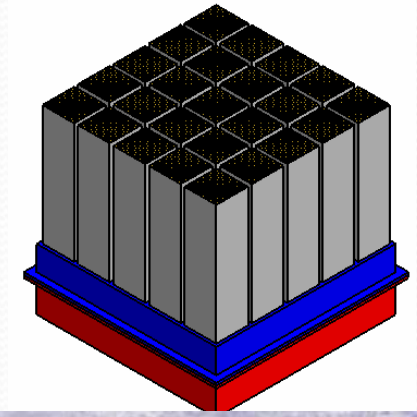
China: 45cm diameter

France:
0.5 - 10keV

Space Variable Object Monitor
Chinese-French collaborated space project

Gamma-ray burst polarization experiment onboard China's Spacelab: POLAR

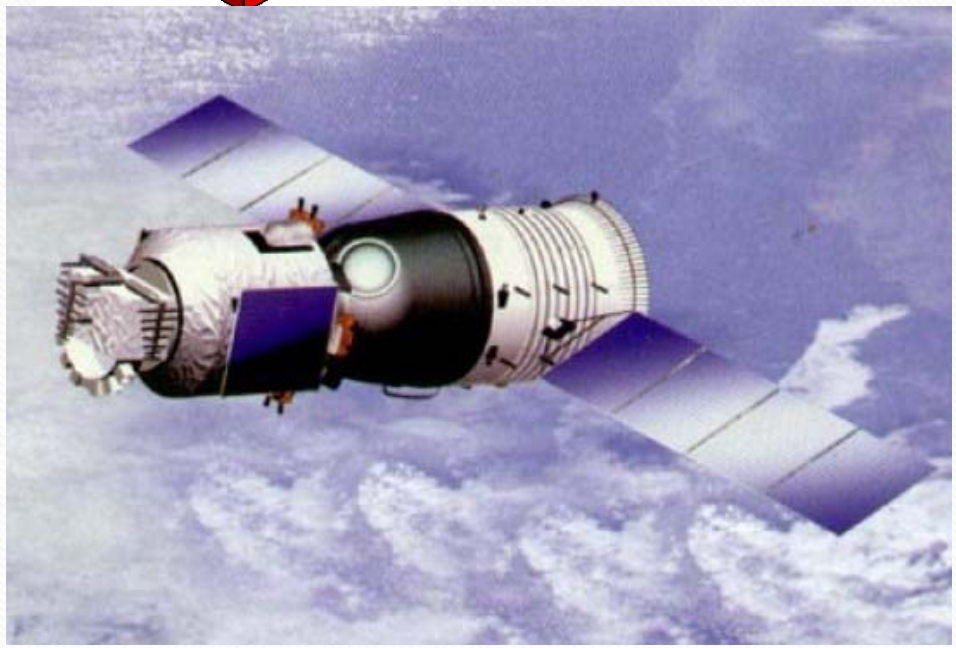
- Instrument concept proposed by N. Produit, et al., NIM (2005)
- Onboard China's spacelab TG-2: launch time 2012
- A China-led international collaboration
- FOV of POLAR: ~½ sky
- *Requires directionality and energy spectrum known after the fact*



Tian-Gong

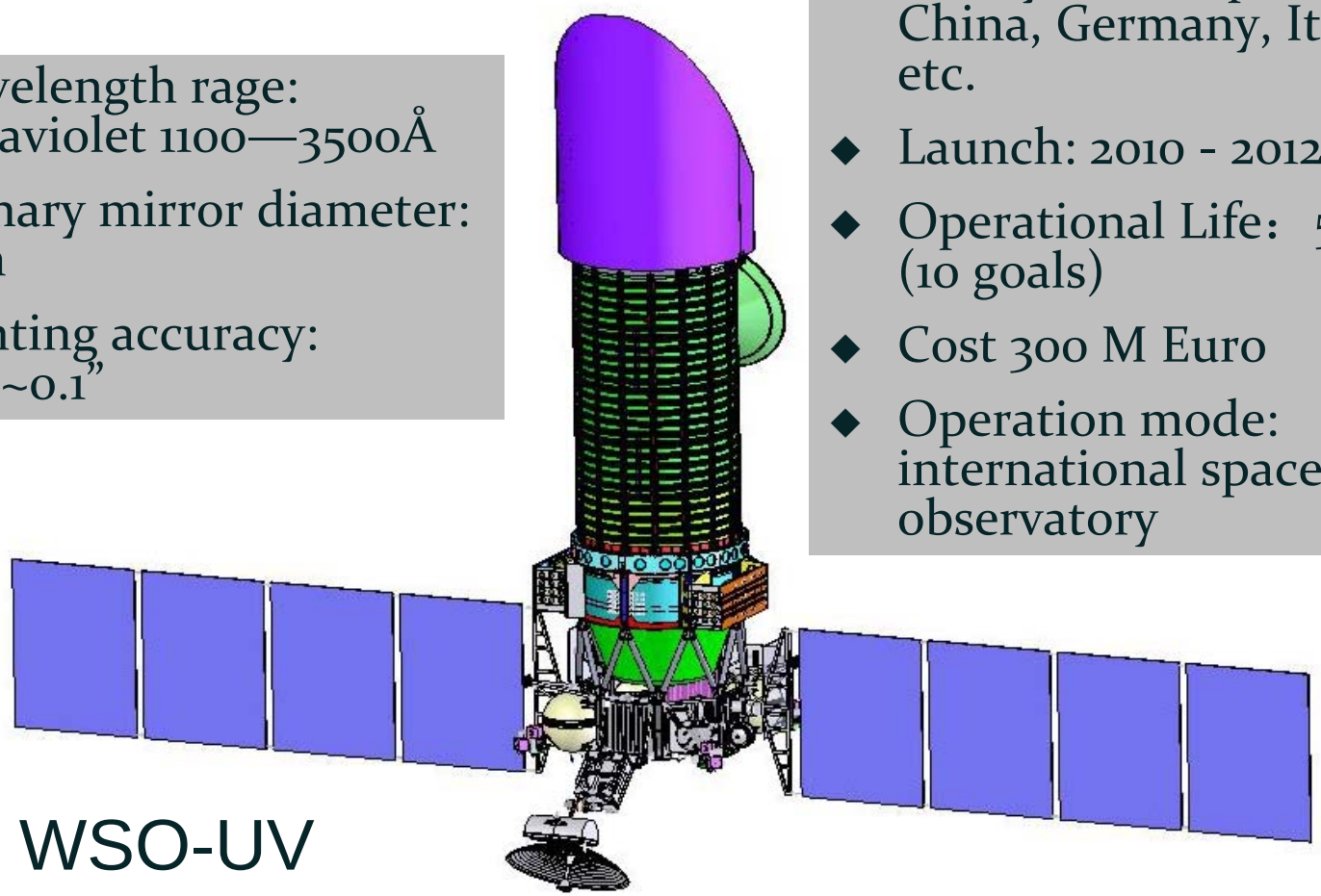
天宫

Palace in Heaven



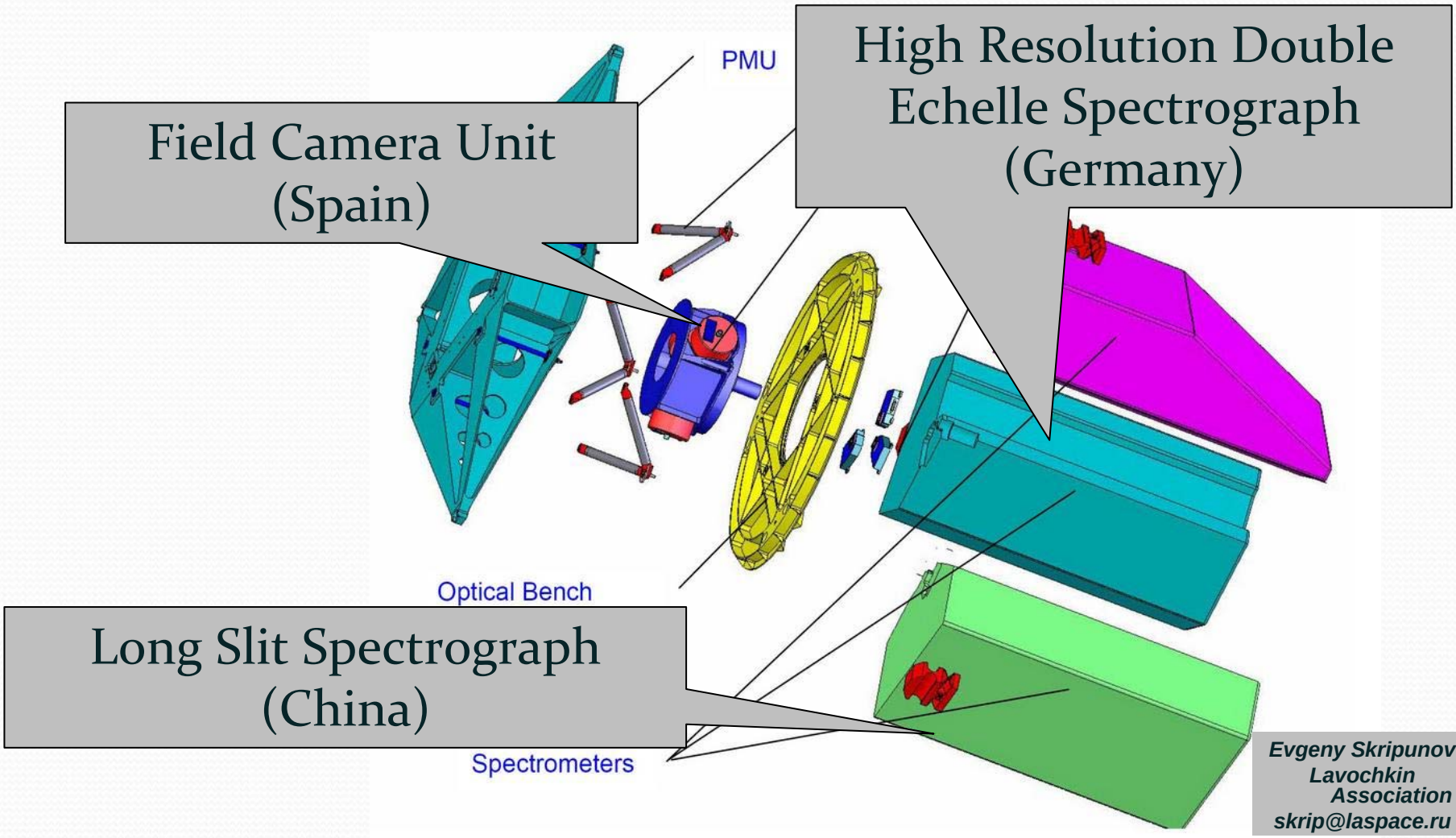
World Space Observatory - Ultraviolet

- Wavelength rage: Ultraviolet 1100—3500Å
- Primary mirror diameter: 1.7m
- Pointing accuracy: 0.05~0.1"



- Led by Russia, participated by China, Germany, Italy, Spain, etc.
- Launch: 2010 - 2012
- Operational Life： 5 years (10 goals)
- Cost 300 M Euro
- Operation mode: international space observatory

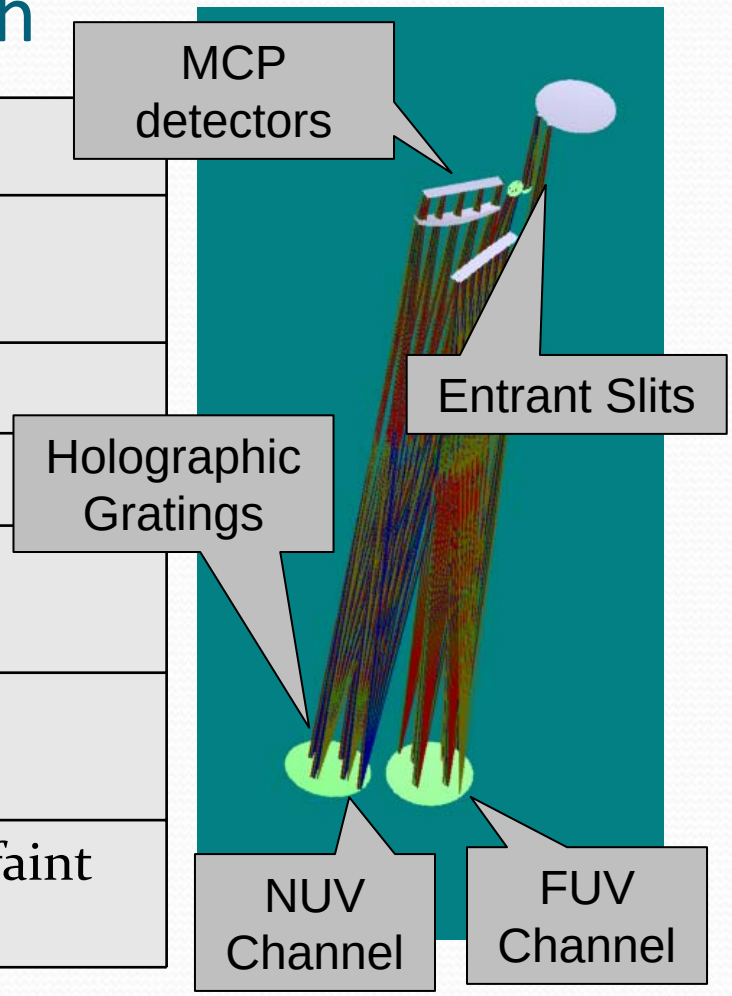
WSO-UV's Three Science Instruments



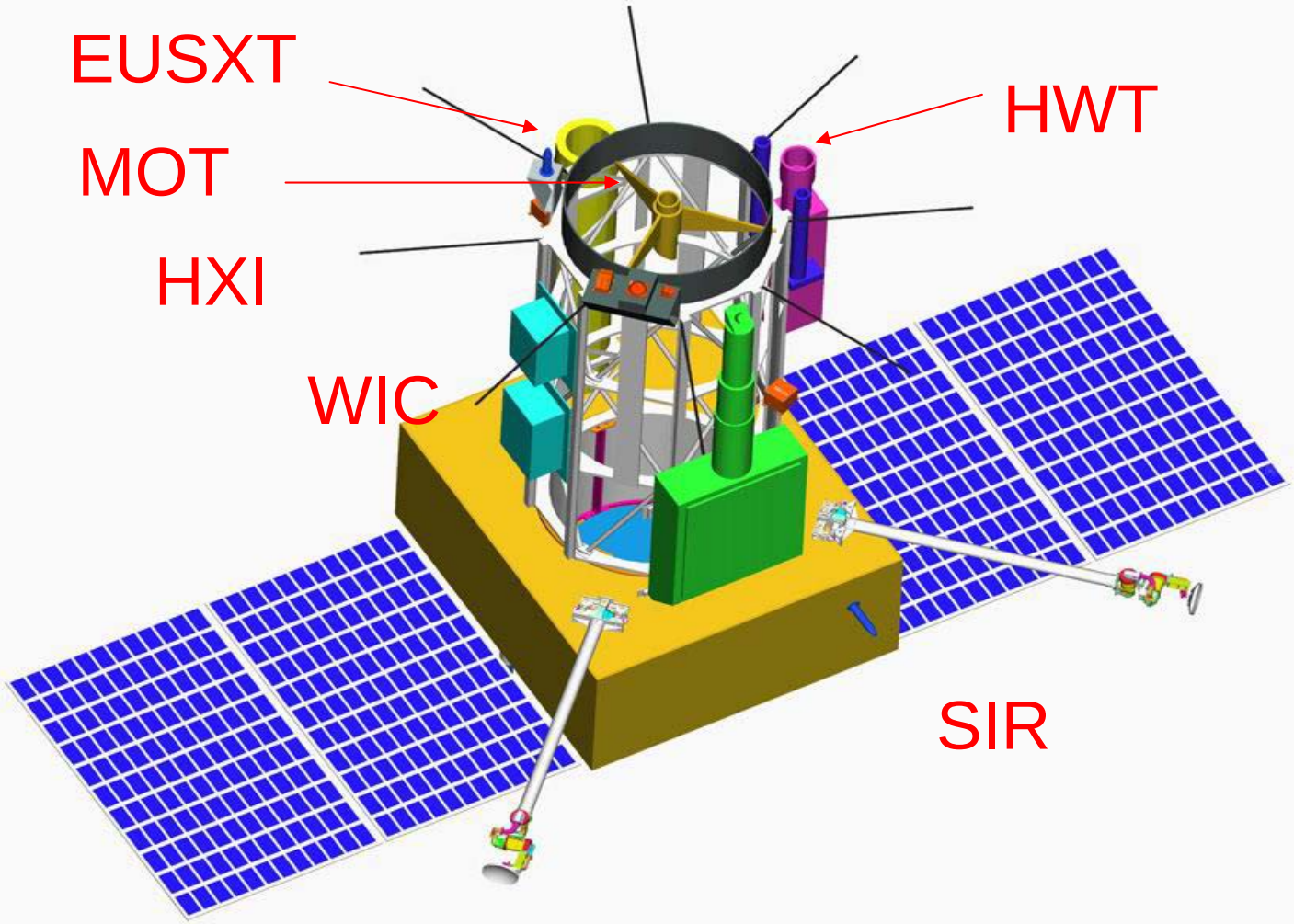
Evgeny Skripunov
Lavochkin Association
skrip@laspace.ru

China's Long Slit Spectrograph

Parameter	specification
Wavelength coverage	102~320 nm two-channel design
Width of slit	1″ ≈ 82 μm
Length of slit	75″ ≈ 6.2 mm
Spectral resolution	1500~2500
Spatial resolution	0.5”~1”
sensitivity	Optimized to observe faint sources



Space Solar Telescope (SST)



Payloads of SST

- MOT: Main Optic Telescope (1 Meter)
  - 0.1″, 2.8′×1.5′, 8 channels, two lines
  - polarization measurement accuracy ~ 2×10^{-4}
- EUSXT: Extreme Ultraviolet and Soft X-ray Telescope
  - 0.8″, 7′×7′, 2 EUV channels (19.5, 160 nm) + SXR
- WIC : White-light Inner-corona Coronagraph
- HXI : Hard X-ray Imager
- HWT: Hα and White Light Telescope
  - 1″, 0.7° × 0.7°, Full disk
- SIR: Solar & Interplanetary Radio Spectrometer
  - 2-50 MHz, 0.1s resolution

Scientific Objectives of SST

- Through coordinated, wide spectral coverage, high resolution and continuous observations
  - Study the evolution of multi-scale transients and various phenomena in the solar atmosphere
  - Investigate the heating mechanism of the chromosphere and the corona
  - Study the mechanism of the energy build-up and release in solar flares and CMEs

Project Scientist: Prof. Hongqi ZHANG
hzhang@bao.ac.cn

SMESE (SMall Explorer for Solar Eruptions)

Chinese-French Collaborated Space Project

Payloads:

- Ly α Imager (up to 1.15 $R_\odot$)
- EUV Imager (Fe XII 19.5 nm)
- Far IR Telescope (35 & 150 μm)
- Ly α Coronagraph (1.1-2.5 $R_\odot$)
- X-ray Spectrometer (10-300 keV)
- γ -ray spectrometer (0.2-600 MeV)

To detect solar flares and CMEs

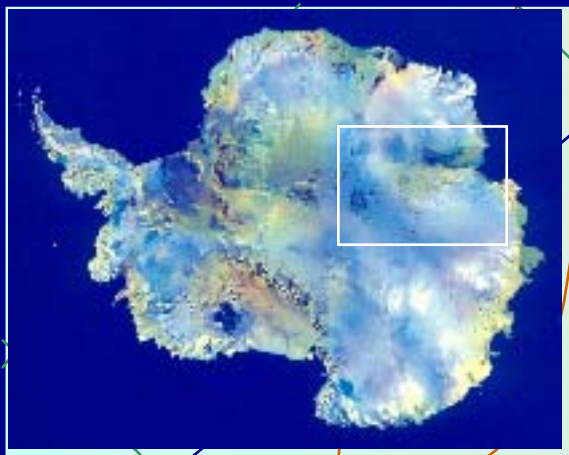
Expected to launch in 2012-2013

Project Scientist: Prof. Cheng FANG
fangc@nju.edu.cn

Large Projects in the Future

- Chinese Antarctic Observatory
- Participation in 30m Class Telescope Projects

Chinese Expedition in Antarctica



E60°

MGA

Mawson

E70°

Prince Charles Mountain

Prydz Bay

Grove Mountain

Zhongshan

1996/1997

Davis

E80°

1997/1998

DOME A

1998/1999

About 1228km

Princess Elizabeth Land

2004/2005

80°

75°

70°

Chinese Center for Antarctic Astronomy

- On Jan. 18, 2005, led by Professor Yuansheng LI, Chinese group reached Dome A
- Dome A（昆侖站）– the inland peak of the Antarctica
  - altitude of 4100m
  - 60km x 10km “drop” shape
- China’s aspiration to build the Antarctica station and carry out related scientific researches

First Chinese Observation in Dome A

Report from *Nature*

Chinese astronomers look to Antarctic

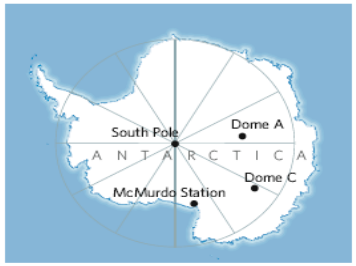
A Chinese expedition returned last week from a 14-day crawl across the East Antarctic ice sheet in cargo containers, pulled by tractors, that doubled as living quarters. The trip, sponsored by the Polar Research Institute of China, completes only the second traverse to Dome A — the highest point on the eastern ice cap and the place where China intends to start building a research base next year.

The team also set up a suite of research instruments to study the atmosphere and sky above Dome A, most notably a remotely operated observatory called PLATO, which will assess how good the skies are for astronomical 'seeing'. PLATO includes four 14.5-centimetre telescopes, built in China, that will take advantage of more than three straight months of darkness during the Antarctic winter. "We think Dome A is the best site on Earth for astronomy," says Xiangqun Cui of the Nanjing Institute of Astronomical Optics and Technology.

The hope is that the desolate plateau, which sits 4,100 metres above sea level, will boast conditions unrivalled elsewhere on the planet — even at the French/Italian base at Antarctica's Dome C, 1,200 kilometres away, which set up its own automated test observatory in 2003 and has since ramped up to larger projects.

Proponents of Antarctic astronomy have looked to Domes A and C as alternative sites to the South Pole, above which 300 metres of turbulent air cause observations of stars to jitter and blur[1]. Dome C, by contrast, has only additional 100 metres is very important because

Cold comfort: China has set up a remotely operated observatory on Dome A, the summit of East Antarctica's ice cap.



Such conditions make Dome A attractive to Chinese astronomers, who have begun work on a suite of three 0.5-metre telescopes that they hope to deploy at the site in 2009. They are also eyeing the location for a potential US$40-million, 4-metre infrared and optical telescope. A proposal on that may be submitted this summer to the Chinese Academy of Sciences.

The true potential of Dome A may lie in observations outside optical wavelengths. The efficiency of infrared astronomy is particularly sensitive to temperature, and winter nights that drop as low as –90 °C will eliminate much of the noise from the atmosphere and the telescope itself, researchers say.

Report from *Science*

SCIENCE & TECHNOLOGY, 2005

...ites *Indicators* con-...orise that its author-...s the volume, is that ...exceedingly expen-...' he writes.

...s to zoos; how math ...ng fields and multi-

...ning and employer

...outside academia, ...of S&E jobs.

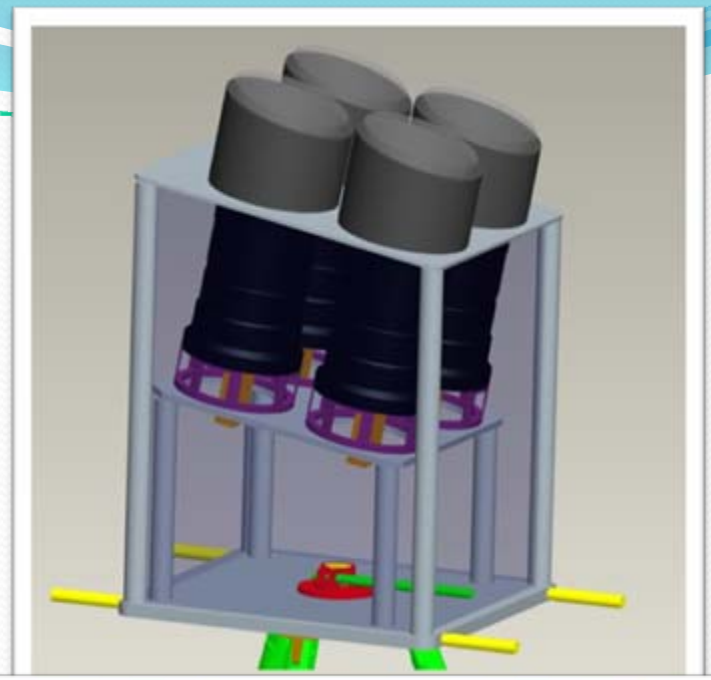
China Reaches Dome A

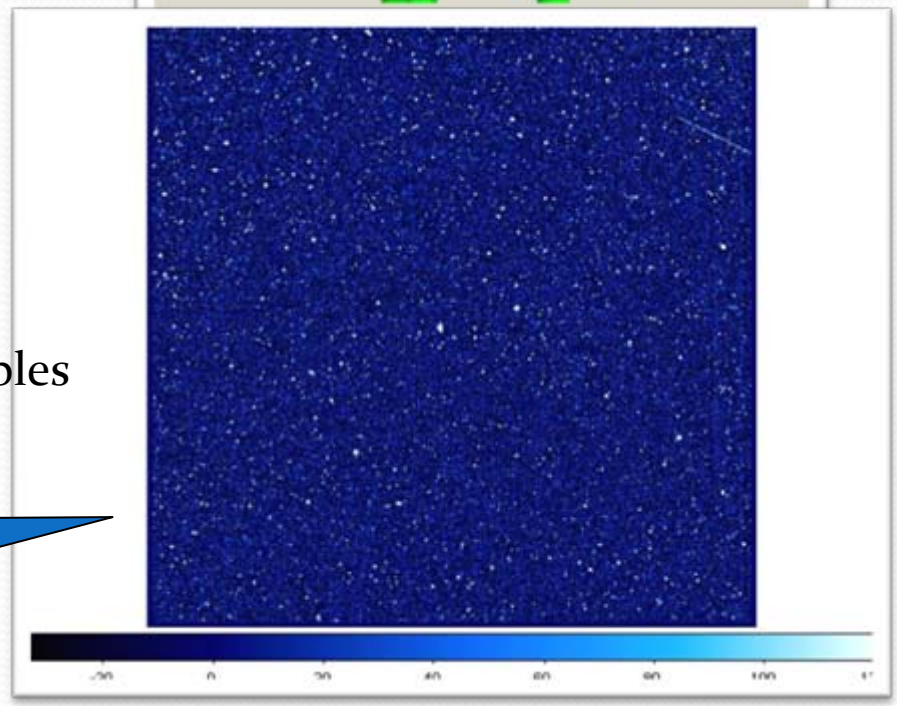
BEIJING—A 17-person team led by the Polar Research Institute of China last week struck camp at the highest bulge on the East Antarctic Ice Sheet in search of the best astronomical viewing on Earth. The team is installing an automated suite of instruments to measure atmospheric turbulence, moisture, and other parameters and is setting up four 14.5-centimeter optical telescopes that will start snapping images after night falls in March. "Everything is going smoothly," says Cui Xiangqun, an astronomer at the Nanjing Institute of Astronomical Optics and Technology, which built the telescopes. China hopes to have a year-round base at Dome A up and running by 2010. **–RICHARD STONE**

This astronomical investigation suggests that Dome A could be one of best astronomical sites in the world

CSTAR: 4 x 14.5cm telescope array

- To construct 4 CCD photometric telescope, with 4 colors, radius of 14.5cm and FOV ~ 20 deg^2
- Scientific goals:
  - Variance in luminosity and colors of ~8000 objects
  - To detect supernova, nova, etc.
  - To search for exo-planets
  - Light curves of variables
  - Statistical number of Antarctic variables
  - Site evaluation

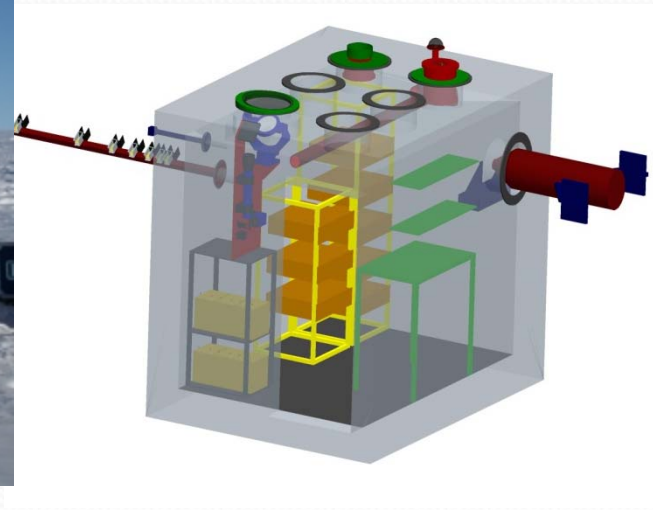




The first star map of the southern sky observed by Chinese astronomers

PLATO (Plateau Observatory, collaboration with Australia and U.S.)

Facilities inside PLATO: MASS, Lunar SHABAR, SNODAR, Nigel, Gattini Dome A, Pre—HEAT, etc.



Scientific Strategy

- Comprehensive site evaluation of Dome A
- Establish observation platforms in optical/infrared, sub-millimeter/THz astronomy led by Chinese astronomers and with international collaborations
- Build optical/infrared wide field survey and sub-millimeter/THz telescopes
- Study the frontier of observational astronomy, including searching for exo-planets and supernova, monitoring transient objects, dark matter and dark energy, stellar and galactic formation and evolution, etc.

Road Map of Chinese Antarctic Observatory

- 2006-2008:
  - site survey
  - preliminary observation – CSTAR, PLATO(Pre-HEAT(THz), SNODAR, etc)
- 2008-2012:
  - comprehensive site survey (accurate measurement of atmosphere turbulence, seeing, transparency, temperature, wind speed, etc.)
  - further observation – CSTAR, Pre-HEAT, HEAT, FTS, Antarctic Schmidt Telescope (AST3)

Road Map of Chinese Antarctic Observatory

- 2011-2014:
  - 3-5m millimeter/THz telescope
- 2011-2016:
  - 4m wide field optical/infrared telescope
- 2015-2020:
  - 10-15m large THz/FIR telescope
  - 8-10m infrared spectroscopic survey telescope (super LAMOST) or optical/infrared telescope with superb imaging capability

Participation in 30m Class Optical/Infrared Telescope Projects

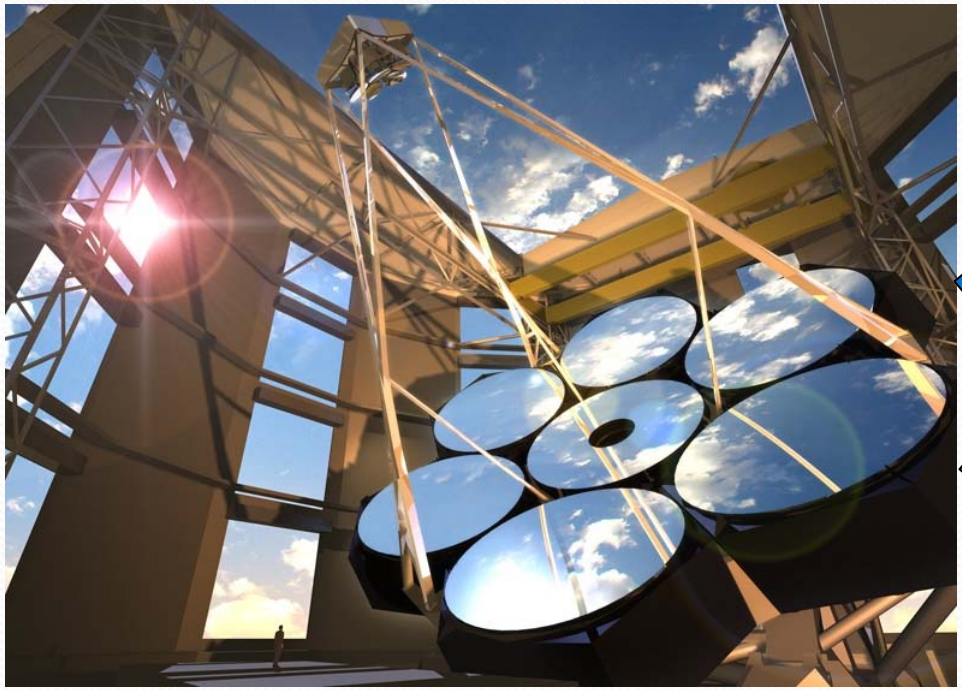
30m Class Optical/Infrared Telescopes

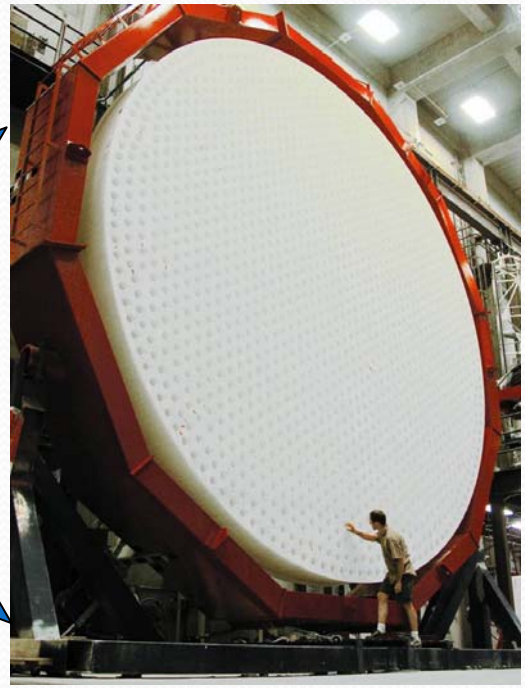
The Giant Magellan Telescope (GMT)

Thirty Meter Telescope (TMT)

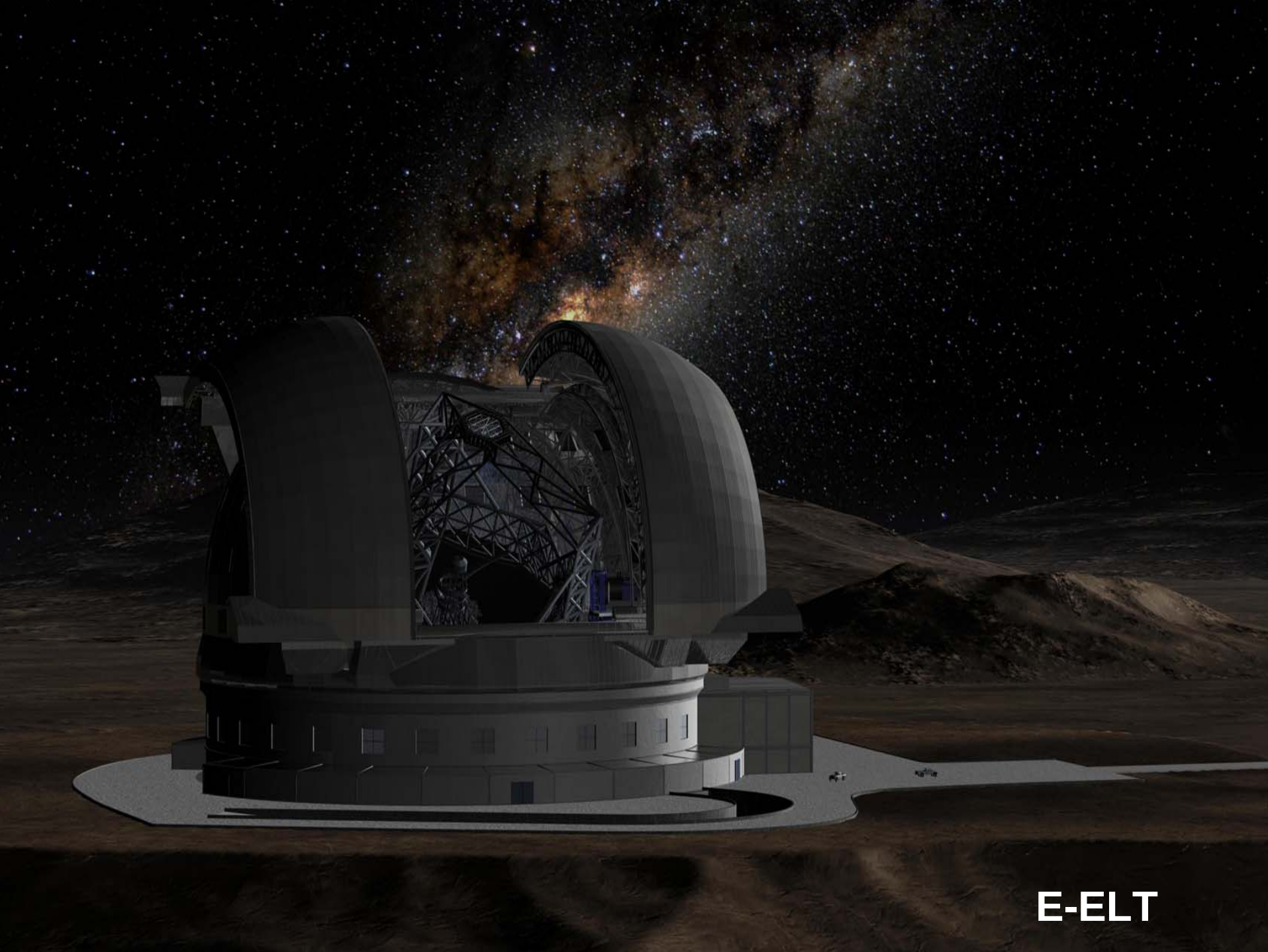
European Extremely Large Telescope (E-ELT)

GMT






TMT


E-ELT

Motivation and Strategy

- Promote Chinese astronomical scientific and technical research, comprehensively and effectively
- Achieve breakthrough in frontiers of modern astronomy
- Exploit the most advanced resources available
- Cultivation of the next generation of Chinese astronomers
- Complement and collaborate with China's key astronomical projects
  - Large spectroscopic survey facility: LAMOST
  - Large radio telescope: FAST
  - High energy space telescope: HXMT

Current Effort and Status

- The Chinese astronomical community has reached the consensus that China should participate in one of the 30m class telescope projects
- Establishing joint working groups with GMT, TMT, and E-ELT to negotiate on China's potential partnership
  - Opportunities and possibilities for China to expand our technical capability
  - Percentage of the project to finance
  - Feasible ways to invest in the separate project
- Chinese astronomers and technical experts alike are working together to promote and advance the project

Brief summary

- During the last decade, astronomy in China has experienced enormous advances, among which the most significant progress is reflected by the construction and development of large astronomical facilities.
- Ground-based and space facilities have been or are planned to be built in recent years, e.g., LAMOST, FAST, 21CMA, HXMT, WSO, SST and so on.
- Future large astronomical projects in China will put even more emphasis on regional collaborations, and we are expecting invaluable perspective, advice and input from our colleagues in Hongkong.

Postface

- China is still a developing country and its astronomy still has a long way to go
- With the rapid economic growth, China has the determination and is more capable to make significant contributions to astronomical development as we did in ancient history
- We look forward to wider and closer collaborations with international astronomers, which will benefit not only to the regional area, but to the whole world as well
- Meantime, we sincerely hope that more and more young people could join us, to make joint efforts for the take-off of Chinese astronomy

Thanks!

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