Astrostats 2017

Sino-Italian Workshop on Astrostatistics

Junhui Fan

Ceter for Astrophysics

Sept. 08 2017

Statistics on the study of Blazars

Junhui Fan

CfA, Guangzhou University

Co-workers: Y. Liu, J.H. Yang, D. Bastieri, D. Costantin

Out Line

1. **Collaboration between GU and UP**
2. **Some Astronomical Facilities in China**
3. **Statistics on the study of Blazars**

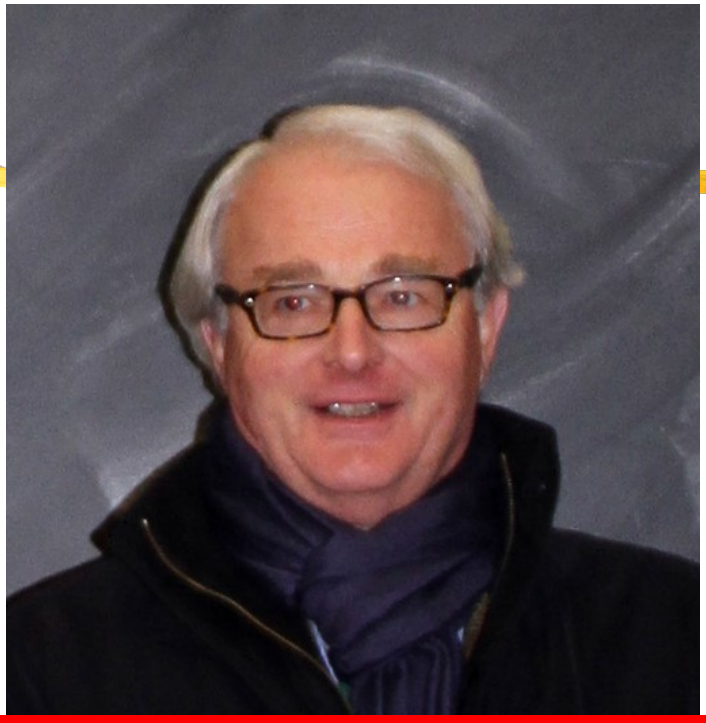
Development of Astronomy in China
中国天文的发展

Junhui Fan 樊 军 辉

Guangzhou University 广州大学

Nov-Dec 2013

Visiting the University of Padova



Vice-Rector of the University of Padua, Prof. Martin visited Guangzhou University Sept. 2013

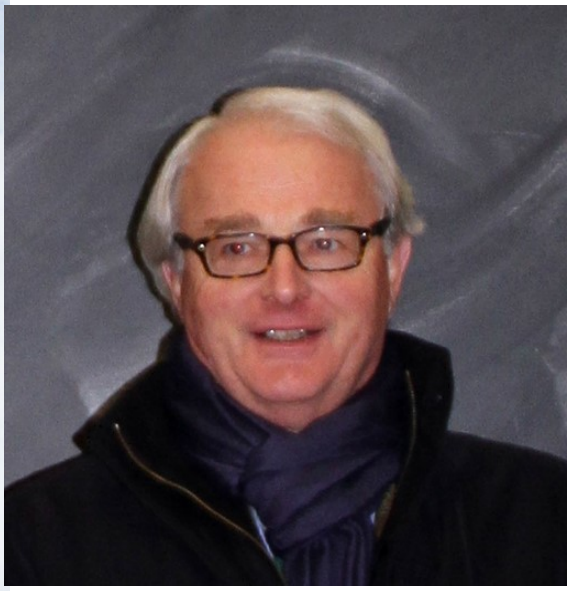
Collaboration on Astrophysics between GU and UP

Junhui Fan

Center for Astrophysics
Guangzhou University

Sept. 2nd, 2013

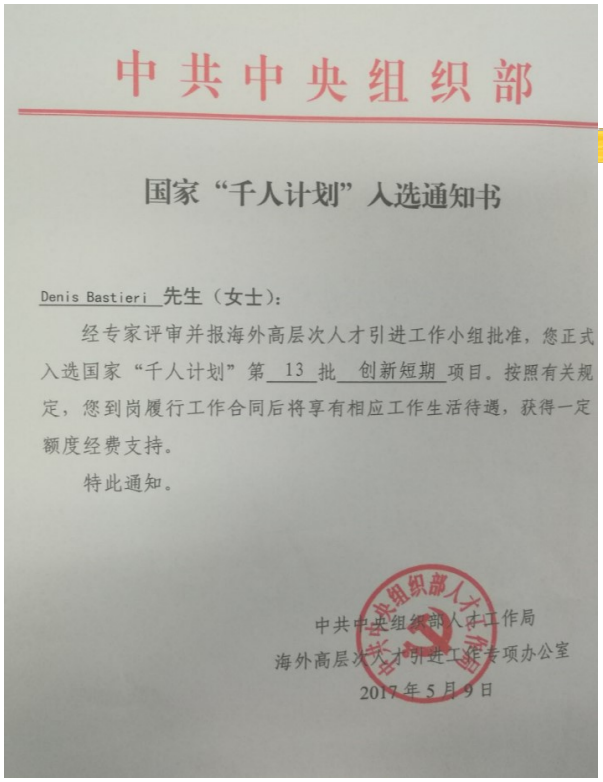

2013/11/27 19:56




Prof. Piero Rafanelli
2013/11/27 19:25

我校与意大利帕多瓦大学签署联合培养协议

Openning Ceremony of University of Padova-China Office (Guangzhou)
Nov-11-2016



中共中央组织部

国家“千人计划”入选通知书

Denis Bastieri 先生（女士）：

经专家评审并报海外高层次人才引进工作小组批准，您正式入选国家“千人计划”第 13 批 创新短期 项目。按照有关规定，您到岗履行工作合同后将享有相应工作生活待遇，获得一定额度经费支持。

特此通知。

中共中央组织部人才工作局
海外高层次人才引进工作专项办公室
2017年5月9日

Denis Bastieri was selected as one of the TOP ONE THOUSAND SCIENTISTS -- The Organizing Department of the Central Committee of the Communist Party of China

2017/9/8

Multiwavelength Variability of Blaazars
Sept. 22-24, 2010, Guangzhou, China

每10年召开一次，14个国家的学者参加会议

Variability of Blaazars:From Jansky to Fermi
Dec. 14-16, 2012, Guangzhou, China

“耀变体光变：从杨斯基到费米”国际学术会议
Variability of Blazars: From Jansky to Fermi(VBJF), December 14,— 16, 2012, Guangzhou, China

Symposium Organizers

Junhui Fan, China, *Chair*
Alok Gupta, India, *Co-Chair*
Denis Bastieri, Italy, *Co-Chair*
Zhiqiang Shen, China, *Co-Chair*

Scientific Organizing Committee

Margo Aller, USA
Denis Bastieri, Italy, *Co-Chair*
Jianshong Chen, China
Junhui Fan, China, *Chair*
Alok Gupta, India, *Co-Chair*
Omar Kurtanidze, Georgie
Tongxu Hua, China
Alan. Marscher, USA
Gustavo E. Romero, Argentina
Zhiqiang Shen, China, *Co-Chair*
Aimo Sillanpaa, Finland
Meg C. Urry, USA
Stefan Wagner, Germany
Paul Wiita, USA
Xuebing Wu, China
Youyuan Zhou, China

Local Organizing Committee

Yongheng Chen, *Chair*
Guoxun Dong
Junhui Fan, *Co-Chair*
Xiaohong Fan
Jiyang Fu
Yi Li
Yi Liu
Gaoyong Luo
Chun Qin
Hongguang Wang
Weixiu Wen
Haibin Yang

Out Line

1. **Collaboration between GU and UP**
2. **Some Astronomical Facilities in China**
3. **Statistics on the study of Blazars**

2. Some Astronomical Facilities in China

2.1 65m—TM65mRT

2.2 FAST—500mRT

2.3 HXMT

2.4 LHAASO

2.5 1.26m-NAGIOT

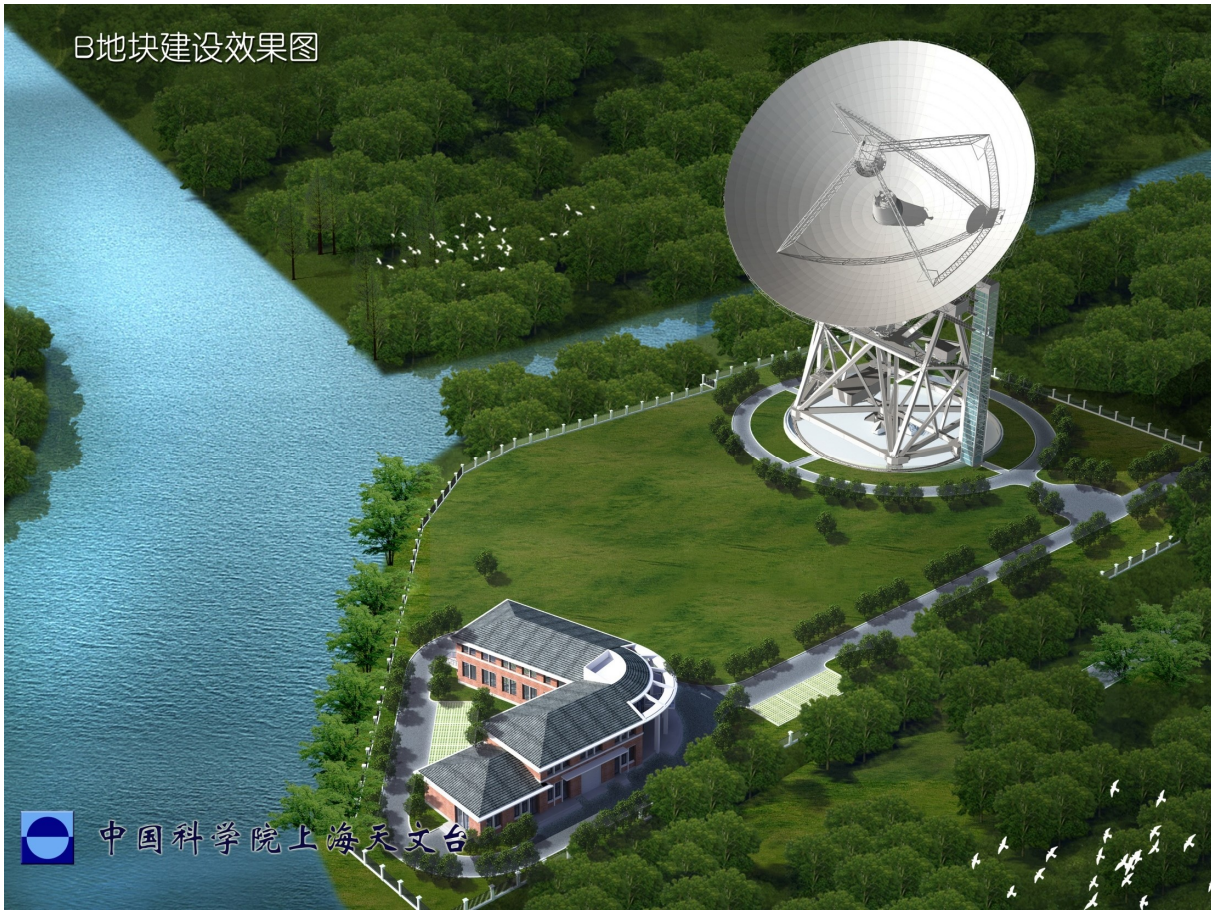
Thanks are given to

Prof. Zhiqiang shen, vice director of ShAO, CAS

Prof. Di Li, NAOC, CAS

Prof. Shuangnan Zhang, IHEP, CAS

Prof. WW Tian, NAOC, CAS



2.1 TianMa 65m Radio Telescope

(1) Location at Sheshan Town, Songjiang District, Shanghai.

(2) Covering 1 – 50 GHz with 8 bands

- L (1.6GHz), S/X (2.3/8.4GHz), C (5GHz), Ku (15GHz), K(22GHz), X/Ka (9/30GHz), Q (43GHz)

(3) Science Target with the TM 65m RT

- Astrometry
  - Celestial reference frame
  - High-accuracy astrometry, space tracking & navigation
- Astrophysics
  - High-resolution polarization-sensitive VLBI Observations
    - AGN and Jets
    - B-field in cluster of galaxies
    - Pol' n of galactic masers
  - Galactic and Extra-galactic masers
    - Physics of (high-mass) star formation
    - Structure, evolution of Galaxy and dark matter
    - Large scale structure (cosmological distance)
  - Survey/Search of spectral line emission
    - Molecular lines in Galaxy
    - Magamasers
  - High-z CO observations
  - Radio stars and variables

2. Some Astronomical Facilities in China

2.1 65m—TM65mRT

2.2 FAST—500mRT

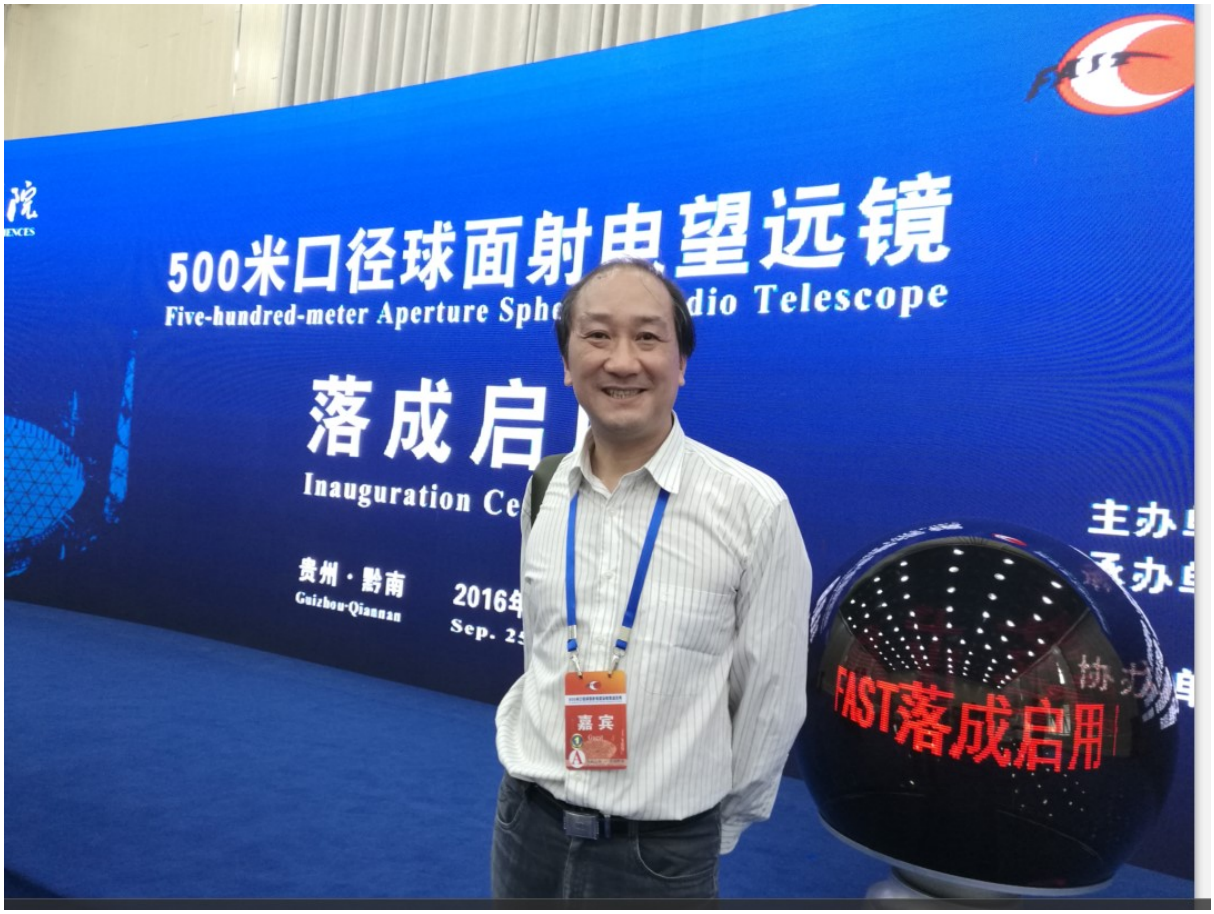
2.3 HXMT

2.4 LHAASO

2.5 1.26m-NAGIOT

2017/9/8

2.2 Five-hundred-meter Aperture Spherical radio Telescope -------FAST



2.2 FAST

(1) Location at

- Tai Wo Taipa,
- Pingtang County,
- Qiannan Buyei and Miao AutonomousPrefecture,
- Guizhou Province

(贵州省黔南布依族苗族自治州平塘县大窝凼)

(2) Covering 70MHz~3GHz, continuous coverage

(3) Science Targets

a) **Hydrogen hyperfine structure 21cm line**

b) Pulsars

c) Molecular lines, masers, AGNs

(4) Data(planning)

FAST 'big data' stream

8bit x 104 x 2 x 4k x 19/s

1.6 GB/s

5.8TB/h

144TB/day

10-20PB/ year

2. Some Astronomical Facilities in China

2.1 65m—TM65mRT

2.2 FAST—500mRT

2.3 HXMT

2.4 LHAASO

2.5 1.26m-NAGIOT

2.3、中国慧眼

Hard X-ray Modulation Telescope mission-HXMT

硬X射线调制望远镜

2017-07-15:11:00

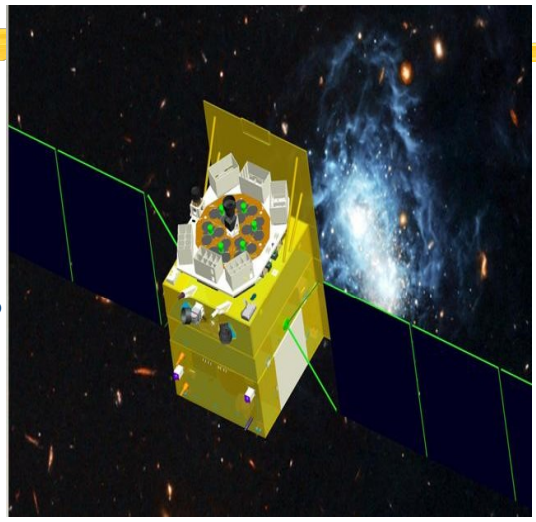

李惕碚院士
Member of Chinese Academy of Sciences


张双南教授
Shuangnan Zhang
东风


东风航天城

Hard X-ray Modulation Telescope (HXMT) satellite

- China's 1st X-ray astronomy satellite
- Selected in 2011
- Total weight ~2500 kg
- Cir. Orbit 550 km, incl. 43°
- Pointed, scanning and GRB modes
- Designed lifetime 4 yrs
- Launched on June 15th, 2017
- Dubbed "*Insight*"



Insight-HXMT core sciences

1. Galactic plan scan and monitor survey: finding more weak & short transients at hard X-rays
2. Pointed observations: high statistics observations of bright sources and high cadence XRB outbursts
3. GRB observations: up to 3 MeV with large area
4. Multi-wavelength observations

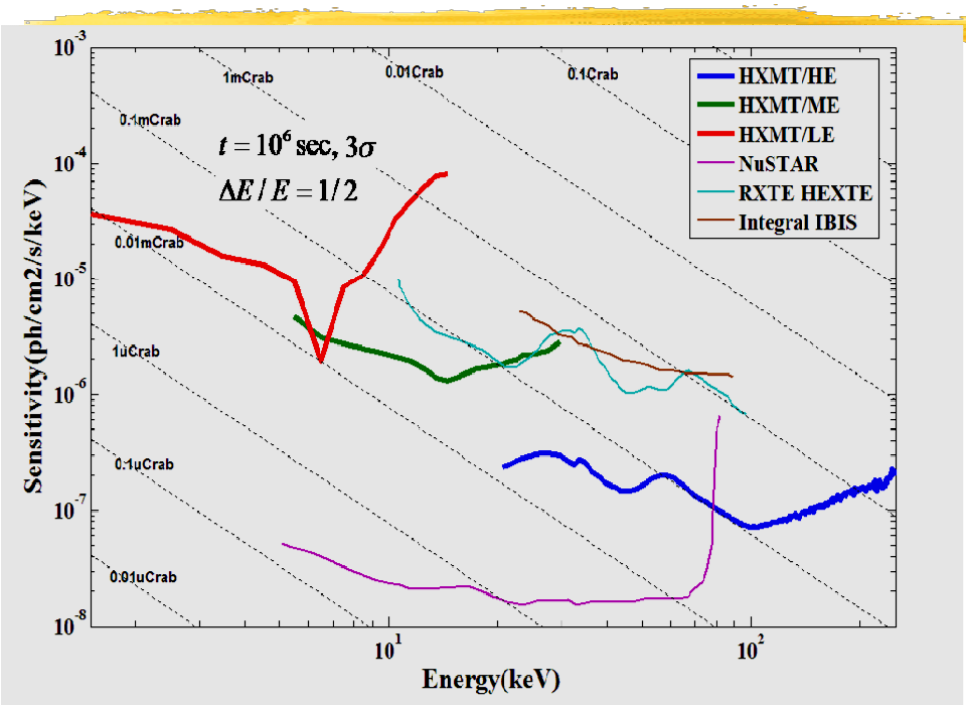
Energy Range

Low Energy X-ray Telescope (LE): 1-15 keV;
Medium Energy X-ray Telescope (ME): 5-30 keV;
High Energy X-ray Telescope (HE): 20-250 keV
GRB mode：200-3000 keV

Main characteristics of *Insight*-HXMT

Detectors	LE: SCD, 384 cm^2;ME : Si-PIN, 952 cm^2 HE : NaI/CsI, 5000 cm^2
Energy Range	LE: 1-15 keV;ME: 5-30 keV;HE: 20-250 keV GRB mode：200-3000 keV
Time Resolution	HE: 25μs; ME: 20μs;LE: 1ms
Energy Resolution	LE: 2.5% @ 6 keV ME: 8% @ 17.8 keV HE: 19% @ 60 keV
Field of View of one module	LE: 6° ×1.5° ; 6° ×4° ; 60° ×3° ; blind; ME: 4° ×1° ; 4° ×4° ; blind; HE: 5.7° ×1.1° ; 5.7° ×5.7° ； blind
Source Location	<1' (20σ source)

Insight-HXMT Sensitivity: pointed observation



Observations

Original Data: ~ 20 GB

260 GB/day

2. Some Astronomical Facilities in China

2.1 65m—TM65mRT

2.2 FAST—500mRT

2.3 HXMT

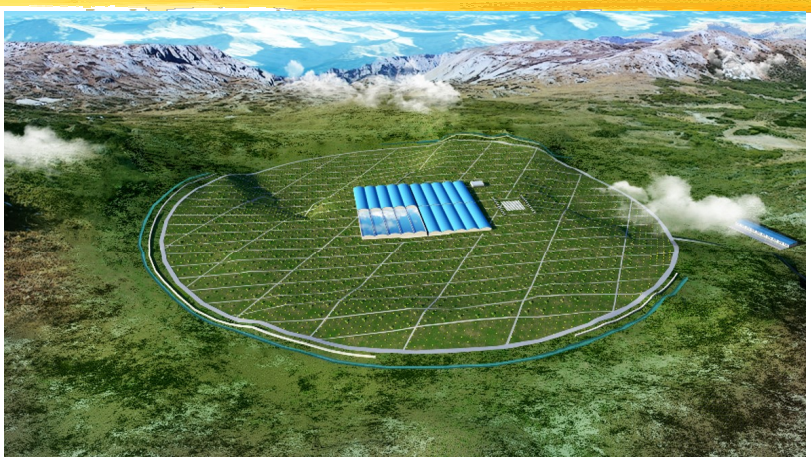
2.4 LHAASO

2.5 1.26m-NAGIOT

2017/9/8

2.4、 LHAASO-WCDA Detector

Large high Altitude Air Shower Observatory



- (1) Location at Haizishan mountain, Sichuan Province
- (2) The LHAASO-KM2A can extend the study of gamma-ray astronomy to the energy range >20 TeV with the unprecedented sensitivity.

- (3) Science target

a. VHE gamma sky survey (100 GeV-30 TeV):

- Extragalactic sources & flares;
- VHE emission from Gamma Ray Bursts;
- Galactic sources;

b. Diffused Gamma rays.

- Cosmic Ray physics (10 TeV-10 PeV):
- Cosmic ray spectrum @ knee region with 1.5 inch PMT
- Anisotropy of VHE cosmic rays;
- Cosmic electrons;

c. Hadronic interaction models.

- Miscellaneous:
- Gamma rays from dark matter;
- etc

(4) Data(planning)

a. DAQ raw input:

100 bit/hit × 3600 hit × 35 kHz = 12 Gbps ~ 50 PB/yr.

b. Data volume after soft trigger:

128 bit/hit × (70 + 35 kHz ×2000 ns × 3120) hit × 63kHz = 3Gbps ~ 12 PB/yr.

2. Some Astronomical Facilities in China

2.5、1.26m--NAGIOT

NAOC-Guangzhou Univ. IR/Opt. Telescope

国家天文台-广州大学光学/红外望远镜

位置：河北省兴隆县连营寨（东经117度34.5分，北纬40度23分，海拔960米）

Position: Xilong Station
East Longitude:117° 34.5′
North latitude: 40° 23′
Height above Sea level: 960m

1985, Installed IR

1.26m,

f/30,

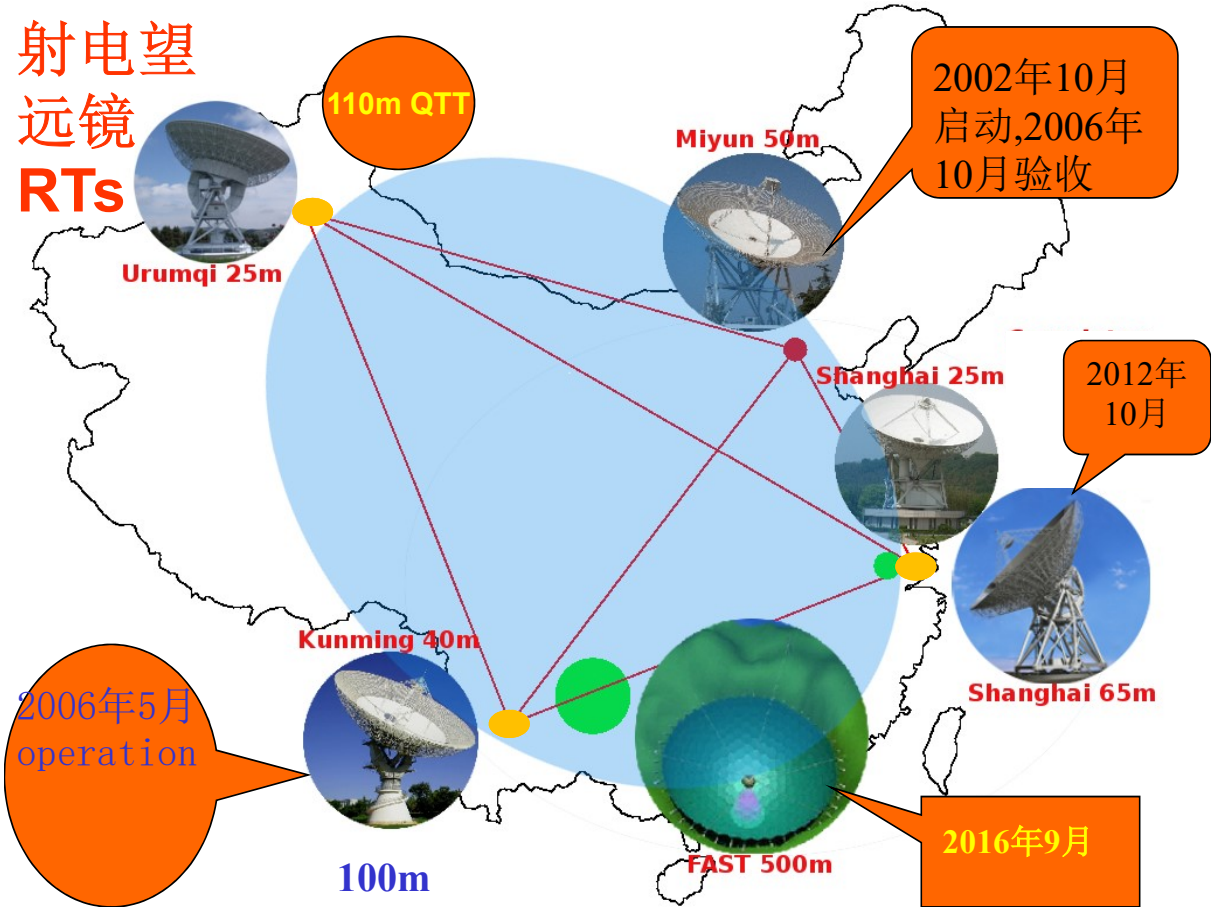
焦面比例尺： **5.5"/mm**

1.26m Infrared/Optical telescope

Re-designed.
Re-construction from 2011, and was completed at the end of 2013.

g-band
r-band
i-band

80 nights/year



Out Line

1. **Collaboration between GU and UP**
2. **Some Astronomical Facilities in China**
3. **Statistics on the study of Blazars**

3. Statistics on the study of Blazars

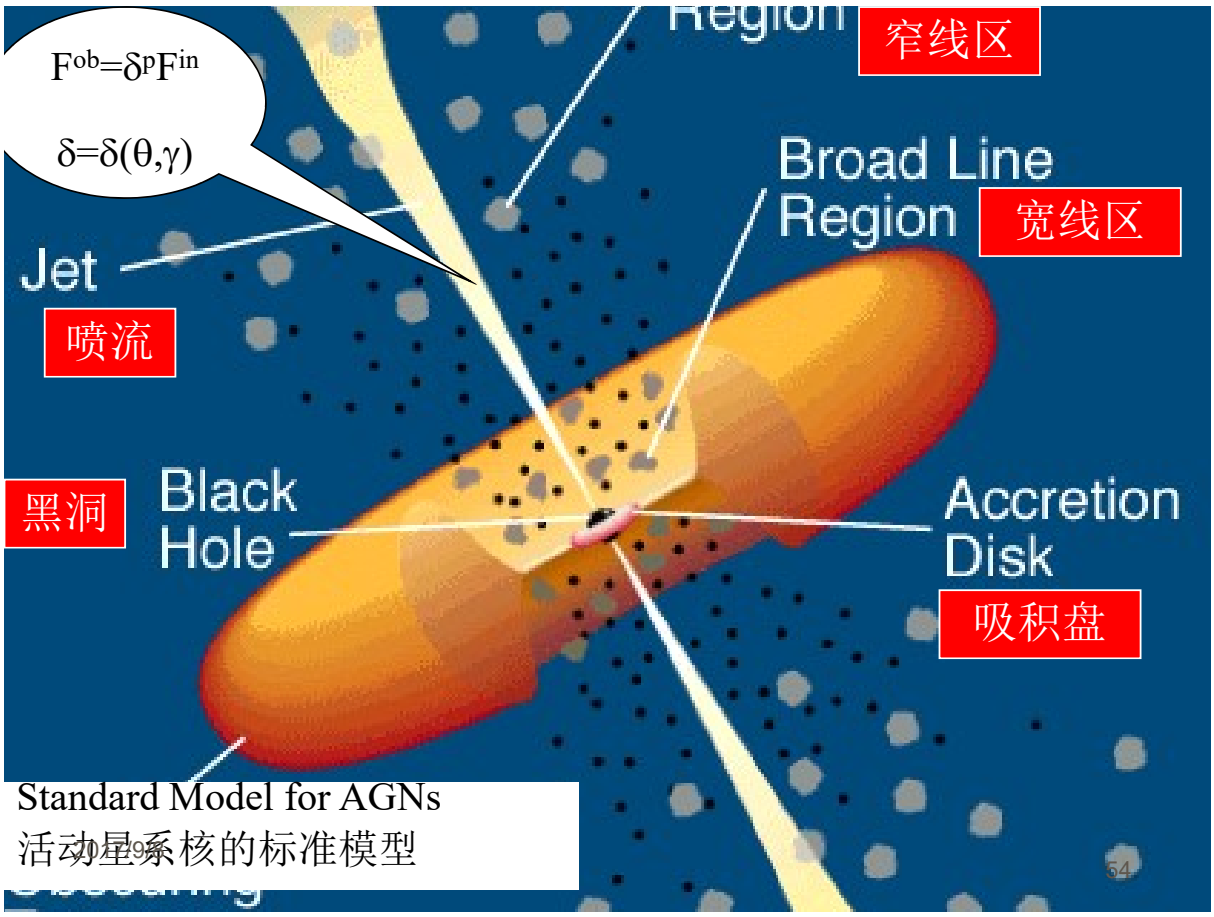
3.1 Classification of Fermi Blazars
3.2 Periodicity Analysis in Blazars
3.3 Scientific Center for Big Data

Objects with one of the above properties → BLAZARS

BLAZARS (BL Lacs and FSRQs)

Special subclass of AGNs:

extragalactic objects with rapid variability, high luminosity, high and variable polarization, have/no strong emission lines, gamma-ray emissions, or superluminal motions.



Standard Model for AGNs
活动星系核的标准模型

INTRODUCTION

1) BL Lacertae objects--BLs,

2) Flat Spectrum Radio Quasars—FSRQs

INTRODUCTION

BL Lacertae objects--BLs, { RBLs, XBLs

这种分类不是基于物理的

Classification of BL Lac Objects

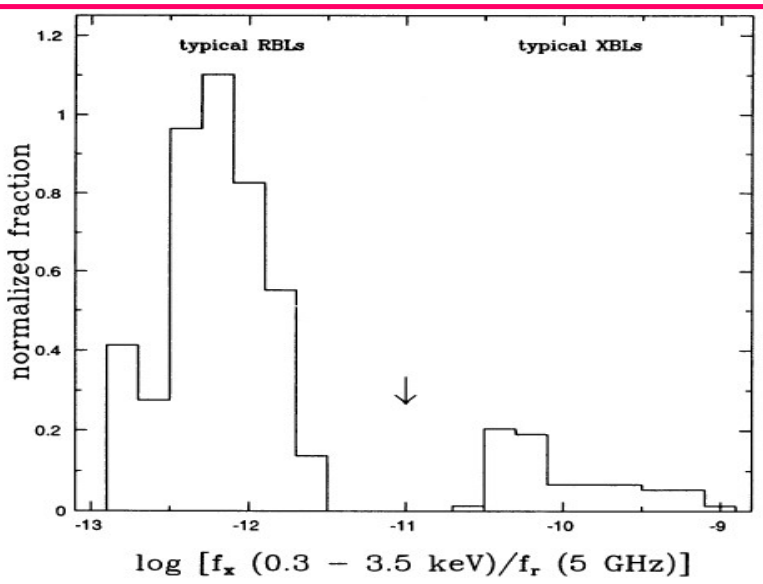
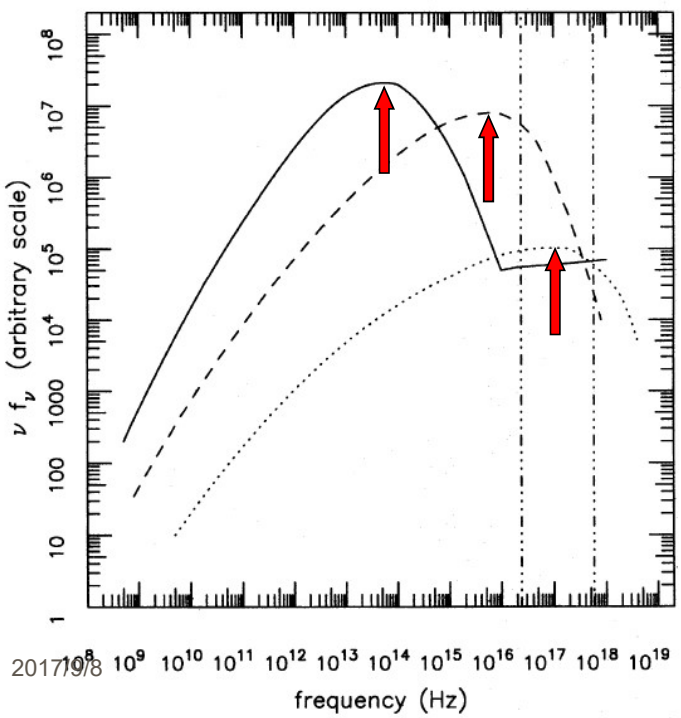


FIG. 2.—Assumed distribution of ratios of X-ray to radio flux for the whole L Lac population (see text for details). The arrow indicates the dividing line tween RBL-like and XBL-like objects. X-ray fluxes cover the 0.3–3.5 keV nge and are in units of ergs cm^{-2} s^{-1}, while radio fluxes refer to 5 GHz and e expressed in janskys.

基于物理的分类

Padovani & Giommi 1995, ApJ, 444

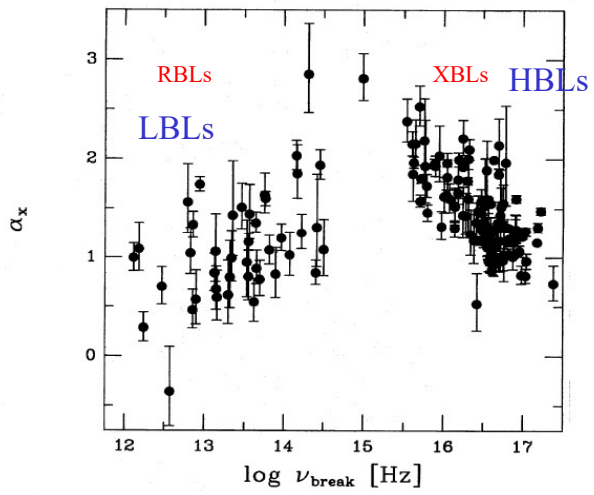
Classification of BL Lac Objects



Padovani & Giommi 1996

Classification of BL Lac Objects

提出用峰频分类



LBLs:

Low-frequency peaked

HBLs:

High-frequency peaked

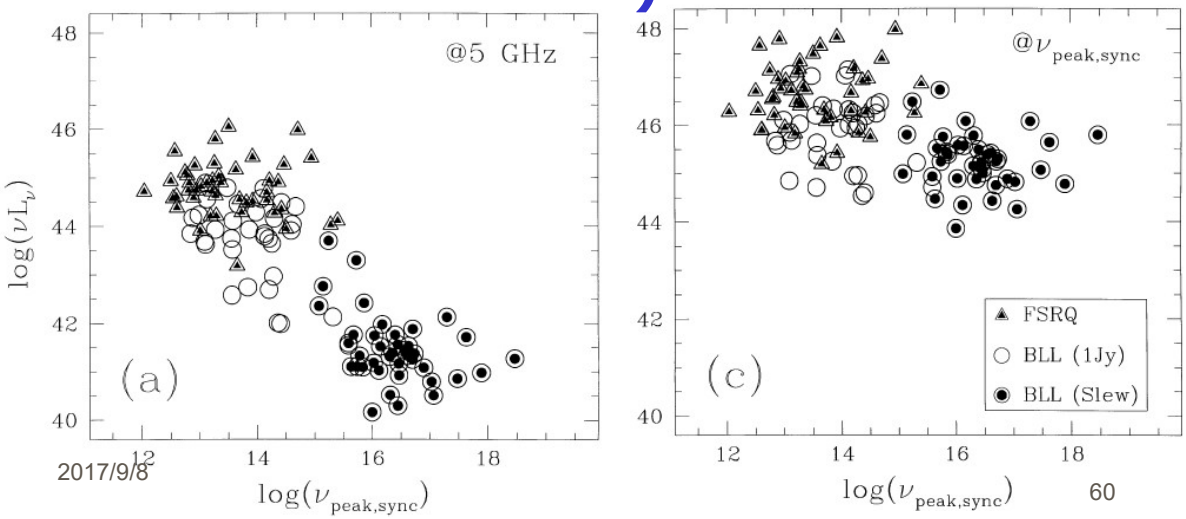
α_{ox}

XBL ⟺ HBL, RBL ⟺ LBL

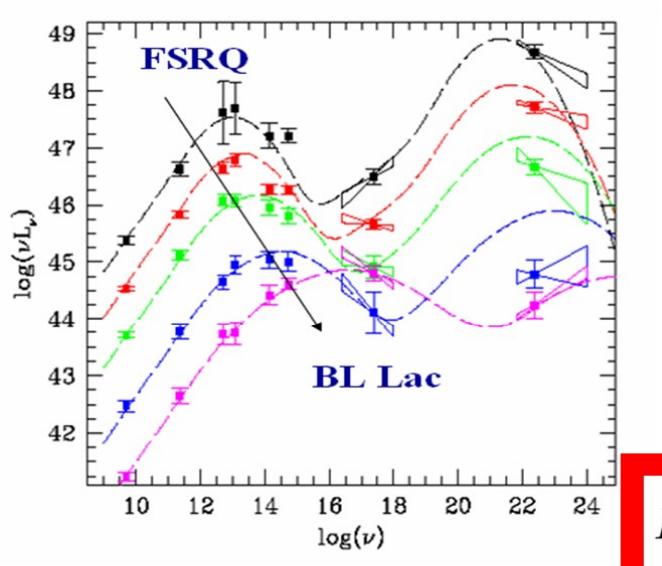
Padovani & Giommi 1996

SED of Blazars
Fossati et al. 1998

Compiled 3 subclasses of 126 blazars (RBLs. XBLs. FSROs)



Sequence of Blazars



提出Blazar序列

$$FSRQs \rightarrow RBLs \rightarrow XBLs$$

$$\nu_p^{FSRQs} < \nu_p^{RBLs} < \nu_p^{XBLs}$$

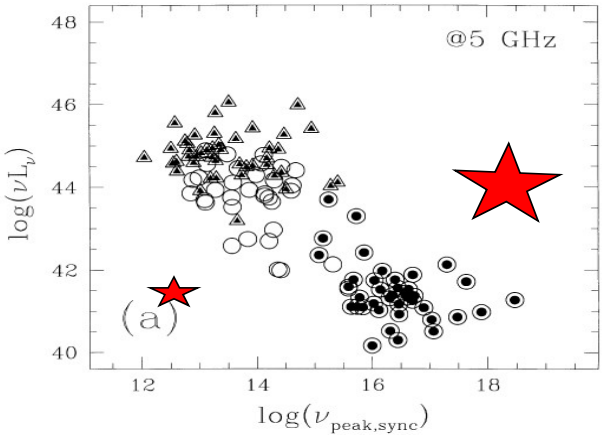
$$L_{\nu_p}^{FSRQs} > L_{\nu_p}^{RBLs} > L_{\nu_p}^{XBLs}$$

Giommi et al. 2005, A&A, 434, 385

Detected luminous high frequency BL Lacs

low frequency low luminosity BL Lacs

Contradic ”
since t s low
frequen ous BL Lacs
in Fossa



Niepploa et al. 2006, A&A, 445, 441

提出IBL

Calculated SEDs for 308 blazars and set roughly frequency boundary for subclasses of BL Lacs (based on P & G criteria).

LBLs: $\log\nu_{\rm p} < 14.5$

IBLs: $14.5 < \log\nu_{\rm p} < 16.5$

HBLs: $\log\nu_{\rm p} > 16.5$

$$\nu_{syn}^{FSRQs} \rightarrow \nu_{syn}^{LBLs} \rightarrow \nu_{syn}^{IBLs} \rightarrow \nu_{syn}^{HBLs}$$

Fermi/LAT

- Launch from Cape Canaveral Air Station 11 June 2008 at 12:05PM EDT
- Circular orbit, 565 km altitude (96 min period), 25.6 deg inclination.

Abdo, et al. 2010, ApJ, 715, 429

set frequency boundary for subclasses of ~ 48 blazars (based on P & G criteria, according to their position in the effective spectral index plot).

LSPs: $\log\nu_{\rm p} < 14.$

ISPs: $14. < \log\nu_{\rm p} < 15.$

HSPs: $\log\nu_{\rm p} > 15$

Lower, Intermediate, High Synchrotron Peak

提出不分FSRQs和BL天体

Boundaries for Classifications

LBL Log ν(Hz)	IBL Log ν(Hz)	HBL Log ν(Hz)	Ref
< 15		> 15	Padovani & Giommi, 1996
< 14.5	14.5 ~ 16.5	> 16.5	Nieppola et al. 2006
<14	14 ~ 15	> 15	Abdo et al. 2010

Non Consensus

3. Statistics on the study of Blazars

3.1 Classification of Fermi Blazars
3.2 Periodicity Analysis in Blazars
3.3 Scientific Center for Big Data

3.1 Fan et al 2016, ApJS, 226,20

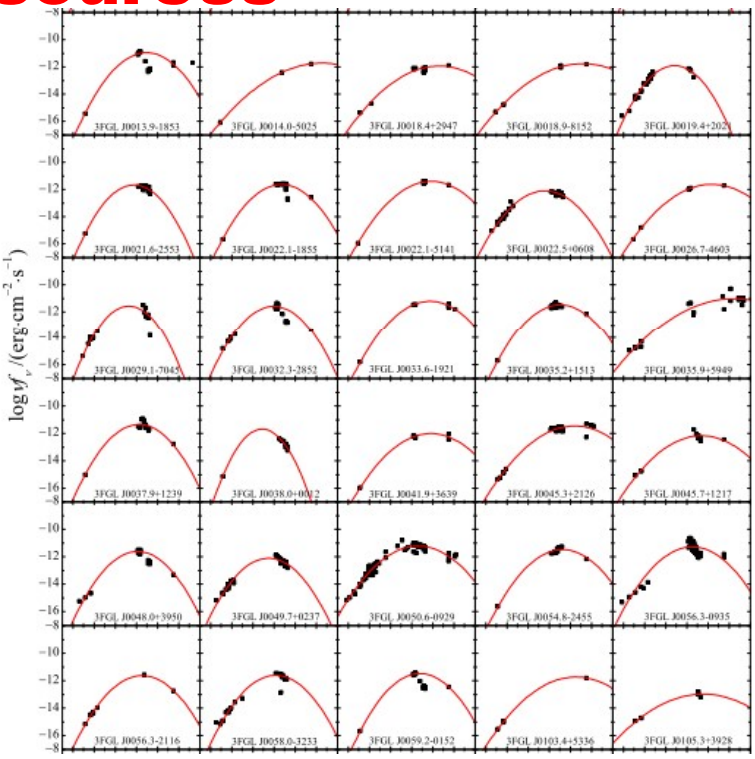
Calculating the SEDs for 1425 Fermi blazars from 3FGL using their multiwavelength flux density by fitting

$$\log\nu F_\nu = P_1(\log\nu - P_2)^2 + P_3$$

SEDs are successfully obtained for 1392 sources.

To do correlation analysis

3.1 Fitting Results for some sources



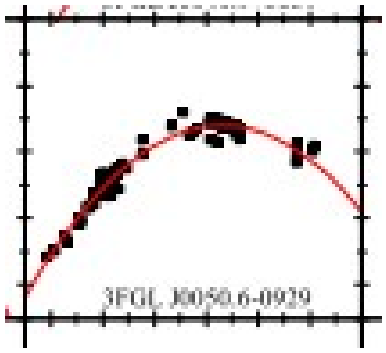


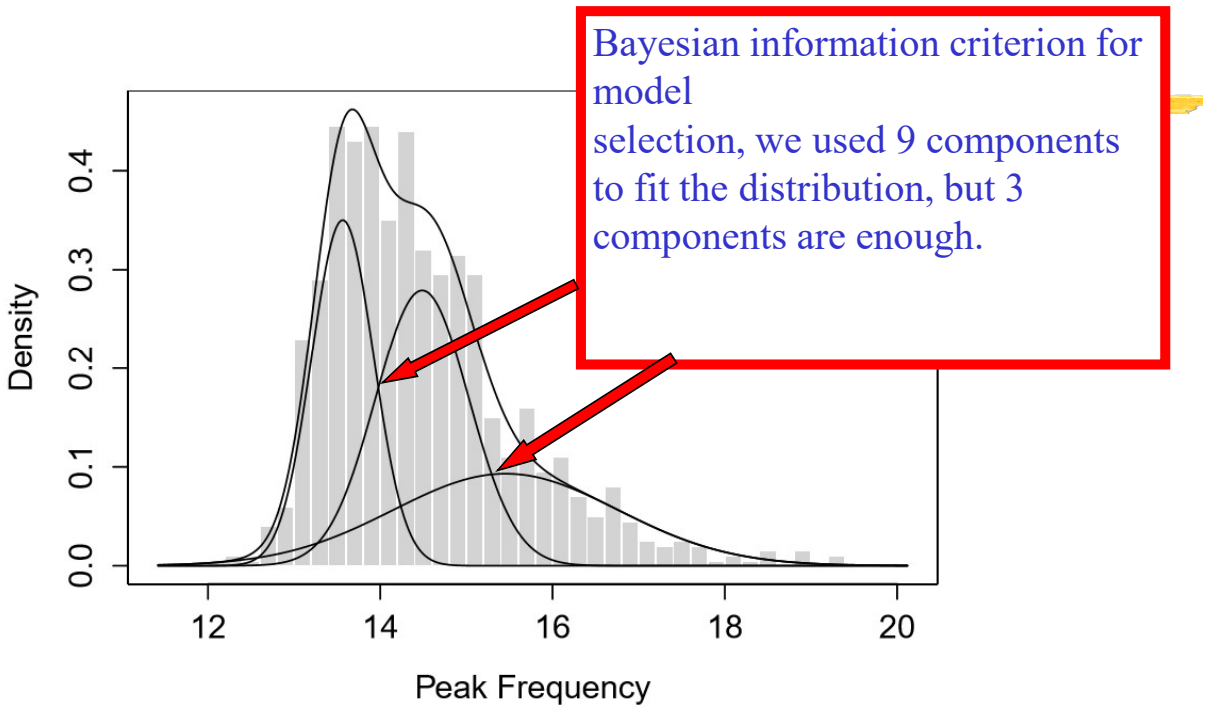
Table 1. Sample for blazars

3FGL name	z	C	L_R/σ_{L_R}	L_O/σ_{L_O}	L_X/σ_{L_X}	$L_\gamma/\sigma_{L_\gamma}$	$\alpha_{RO}/\sigma_\alpha$	$\alpha_{OX}/\sigma_\alpha$	P_1/σ_{P_1}	ν_p/σ_{ν_p}	L_p/σ_{L_p}	$L_{bol}/\sigma_{L_{bol}}$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
J0001.2-0748		HB	42.36/3.01	45.39/0.02		45.23/0.36	0.45/0.01		-0.12/0.01	14.37/0.12	45.35/0.03	45.71/0.05
J0001.4+2120	1.106	HU	42.97/3.01			45.79/0.41			-0.03/0.00	16.79/0.28	45.79/0.03	46.32/0.04
J0003.2-5246		HU			45.31/0.07	41.56/0.18			-0.03/0.01	17.79/0.18	45.47/0.11	45.76/0.14
J0003.8-1154	1.310	LU	43.44/3.01	45.54/0.01		45.59/0.12	0.52/0.01		-0.12/0.01	13.06/0.11	45.37/0.11	46.01/0.15
J0004.7-4701	3.880	IF		46.38/0.04	44.98/0.07	45.86/0.35		1.53/0.04	-0.12/0.01	14.14/0.09	46.20/0.06	46.59/0.09
J0006.4+3825	3.229	IF	41.98/3.01	44.53/0.01	43.41/0.07	41.41/0.06	0.54/0.01	1.40/0.01	-0.11/0.01	14.03/0.12	44.65/0.10	45.08/0.14
J0006.0+4713	3.259	IB	41.18/3.01		43.51/0.07	41.57/0.28			-0.12/0.00	14.52/0.07	44.46/0.04	44.85/0.06
J0008.6-2100	3.147	IB	40.38/3.01		43.72/0.05	43.08/0.42			-0.10/0.01	15.09/0.19	44.01/0.05	44.40/0.07
J0009.1+0530		LB	42.43/3.02	44.97/0.01		45.14/0.37	0.54/0.01		-0.09/0.03	13.69/0.51	44.42/0.17	44.83/0.24
J0009.6-3211	3.026	LU	39.87/3.01	44.48/0.01	44.53/0.13	41.91/0.10	0.47/0.01	2.09/0.06	-0.16/0.02	13.93/0.21	43.90/0.17	44.31/0.23
J0013.2-3954		LB	42.74/3.02	45.01/0.01		45.21/0.36	0.58/0.01		-0.19/0.01	12.95/0.11	45.53/0.09	45.79/0.13
J0013.9-1853	3.660	IB	39.80/3.02		43.72/0.03	42.88/0.41			-0.13/0.01	14.96/0.15	44.37/0.07	44.65/0.09
J0014.0-5025		HB			45.38/0.07	41.64/0.20			-0.03/0.00	18.55/0.33	45.38/0.06	45.94/0.07
J0015.7+3552		HU	41.90/3.01			41.93/0.39			-0.10/0.00	15.82/0.10	45.95/0.03	46.32/0.04
J0016.3-0333	1.577	IF	43.96/3.01	45.49/0.01	45.02/0.07	46.67/0.06	0.72/0.01	1.17/0.01	-0.09/0.01	13.58/0.10	45.58/0.04	46.12/0.06
J0017.2-0543		IU	41.91/3.01	44.82/0.01		41.87/0.39	0.48/0.01		-0.10/0.01	14.61/0.37	44.79/0.06	45.21/0.09
J0017.6-0942	3.227	IF	41.40/3.02	44.30/0.01	43.79/0.11	41.48/0.05	0.49/0.01	1.19/0.03	-0.11/0.01	14.48/0.13	44.63/0.13	45.02/0.21
J0018.4+2947	3.109	HB	40.00/3.01		43.51/0.07	42.51/0.43			-0.06/0.01	16.60/0.08	43.41/0.12	43.96/0.16
J0018.9-8152		HB			45.37/0.09	45.16/0.35			-0.03/0.01	17.16/0.46	45.33/0.07	45.90/0.07
J0019.1-5545		LU				41.88/0.39			-0.13/0.01	13.35/0.10	44.01/0.06	44.41/0.10
J0019.4+2021		LB	43.01/3.01	44.42/0.01		41.91/0.40	0.75/0.01		-0.17/0.01	12.81/0.09	45.19/0.06	45.50/0.10
J0021.6-2553		LB	41.88/3.01	45.09/0.14		45.14/0.39	0.43/0.03		-0.17/0.02	13.77/0.17	45.43/0.03	45.67/0.12
J0021.6-0835		IU			44.82/0.08	41.87/0.42			-0.09/0.01	14.90/0.13	45.47/0.04	45.92/0.05
J0022.1-1855		IB	41.39/3.02	45.60/0.02	44.76/0.11	45.13/0.05	0.24/0.01	1.18/0.05	-0.13/0.01	14.69/0.12	45.46/0.03	45.76/0.05
J0022.1-5141		HB			45.51/0.07	45.14/0.35			-0.09/0.00	15.86/0.16	45.69/0.03	46.07/0.05
J0022.5+0608		LB	42.57/3.01	44.64/0.04		45.68/0.38	0.53/0.01		-0.12/0.01	13.58/0.12	45.00/0.06	45.40/0.09
...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...

Monochromatic Luminosity

Effective spectral index

Fitting Results P1,P2,P3



3.1 Classifications of Fermi Blazars

$$\log \nu_{\rm p}({\rm Hz}) \leq 14.0 \text{ for LSPs},$$

$$14.0 < \log \nu_{\rm p}({\rm Hz}) \leq 15.3 \text{ for ISPs},$$

$$\log \nu_{\rm p}({\rm Hz}) > 15.3 \text{ for HSPs}.$$

Boundaries for Classifications

LBL Log ν(Hz)	IBL Log ν(Hz)	HBL Log ν(Hz)	Ref
< 15		> 15	Padovani & Giommi, 1996
< 14.5	14.5 ~ 16.5	> 16.5	Nieppola et al. 2006
<14	14 ~ 15	> 15	Abdo et al. 2010
<14.0	14.0 ~ 15.3	>15.3	This work

Our results are similar to those by Abdo et al. 2010

3. Statistics on the study of Blazars

3.1 Classification of Fermi Blazars

3.2 Periodicity Analysis in Blazars

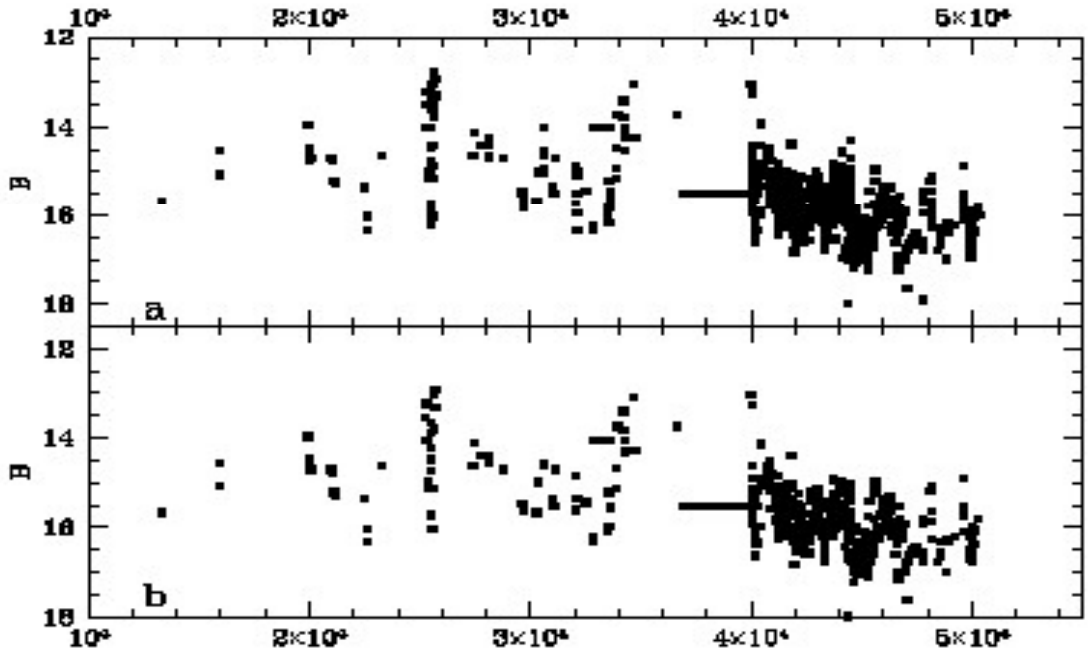
3.3 Scientific Center for Big Data

Variable as mentoined by SUVEGES Maria this morning

3.2 Periodicity Analysis in Blazars

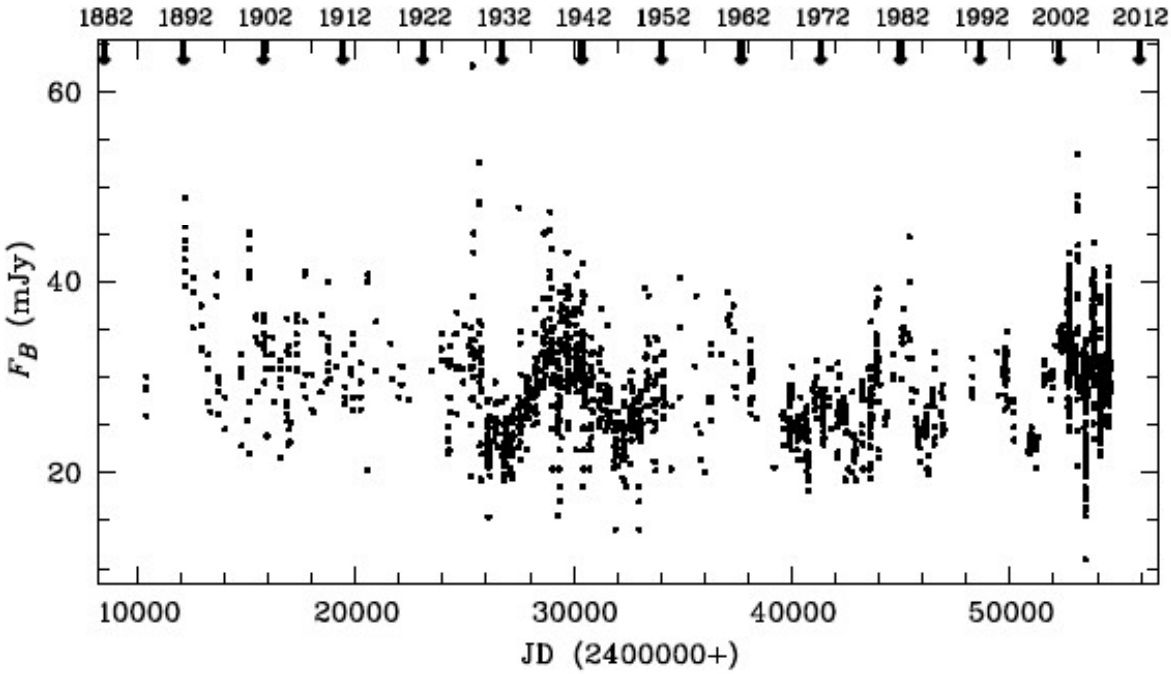
Individual Sources-BL Lac

Fan, et al. 1998, ApJ, 507



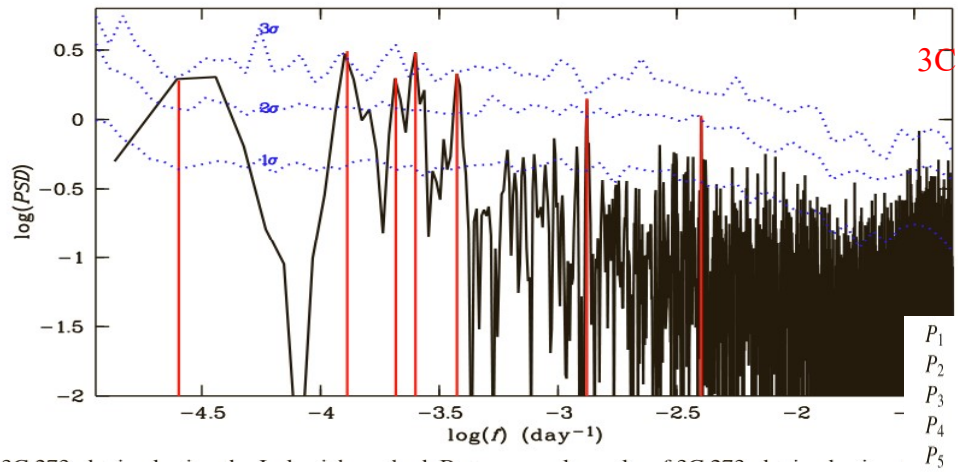
3.2 Periodicity Analysis in Blazars

Light Curve of 3C 273



3.2 Periodicity Analysis in Blazars

Periodicity Analysis Results



3C 273

P_1	21.10
P_2	10.90
P_3	7.30
P_4	13.20
P_5	108.30
P_6	2.10
P_7	0.68

Fan, J.H. et al. 2014, ApJS, 213

3.3 Scientific Center for Big Data

Prof. Denis Bastieri and I discussed to set up the Scientific Center for Big Data in Guangzhou Univ. for there are so many new facilities in China and in the world.

It has been now set up and has got financial support from the Central Government and Guangzhou Univ. We are apply for support from Guangdong Province

Suggestion

We propose to host the 2nd workshop on Statistics and Astronomy 2018 in Guangzhou.

Welcome all of you to join the workshop 2018 in Guangzhou.

Summary

1、The collaboration between GU and PU is fruitful, with further collaboration in all subjects.

2、Introduction for some Chinese facilities

3、We used statistics for the periodicity analysis and classification of Fermi blazars

4、A propose for next workshop in GU.

Thank you for your attention!

祝各位健康、平安、进步！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May-28-2016

2017/9/8