



Eating VLBI: history, status, and perspectives

Marcello Giroletti
INAF Istituto di Radioastronomia

EAVN workshop, Ibaraki Univ., 25 September 2019

People



Prof. Giovannini

M. Orienti

F. D'Ammando

C. Migoni

A. Melis

E. Egron

R. Lico (now Bonn)

G. Principe

E. Kravchenko

...and more...

...and Kazuhiro Hada!



Outline

- Status in Italy
- Status in Europe (P. Colomer's talk)
- History and status of EATING VLBI ***MoA and Call for proposal!!!***
- Science with EATING VLBI - so far and what's next



VLBI in Italy

- National Institute for Astrophysics: operates two 32-m and one 64-m single dish (Medicina, Noto, Sardinia)
- Baseline length in range 580-893 km
- Frequency range between 1.4 and 43 GHz, potentially 86
 - currently able to do 1.6, 7 and 22 GHz for all three stations
- All connected electronically in real time to Bologna
- Bologna hosting data storage and software correlator facility

Sardinia, 64m

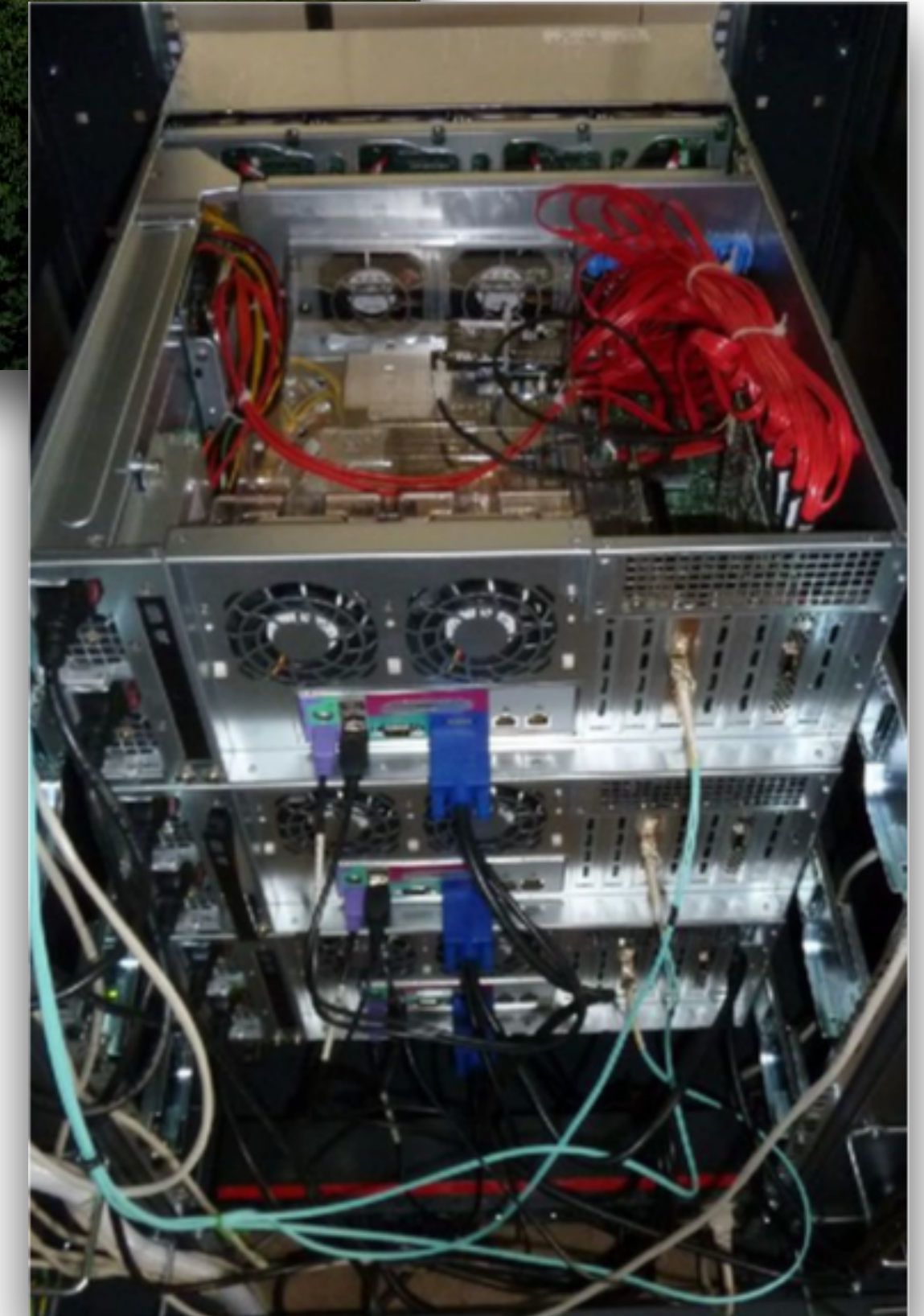


Medicina, 32m



Noto, 32m

Bologna,
DiFX correlator



Status tables, 2017



	Medicina (Mc)	Noto (Nt)	Sardinia (Sr)
diameter	32m	32m	64m
active surface	N	Y	Y
L	Y	Y/N (not operational)	Y
S/X	Y	Y	N
C	Y	Y	N/Y (designed)
C - high	Y (not cooled)	Y (not cooled)	Y
K	Y (2-beam)	Y	Y (7-beam)
Q	N	Y	N/Y (designed)
W	N	N (being considered)	N (being considered)
e-VLBI	Y	Y	almost!

	Mc	Nt	Sr	KVN-Ta
Mc		893*	592	8401
Nt	13.5		580	8639
Sr	5.5	6		8783
KVN-Ta	17	18	7.5	

↑
baseline length (km)
↓

←
K-band 5σ sensitivity (mJy)
[5min @1Gbps]
→

* same as T6-Ky!

Status tables, 2019



	Medicina (Mc)	Noto (Nt)	Sardinia (Sr)
diameter	32m	32m	64m
active surface	N/Y (funded)	Y	Y
L	Y	Y	Y
S/X	Y	Y	N
C	Y	Y	N/Y (designed)
C - high	Y (not cooled)	Y (not cooled)	Y
K	Y (2-beam)	Y	Y (7-beam)
Q	N/Y (funded)	Y	N/Y (designed)
W	N/Y (funded)	N/Y (funded)	N/Y (funded)
e-VLBI	Y	Y	Y

	Mc	Nt	Sr	KVN-Ta
Mc		893*	592	8401
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← K-band 5σ sensitivity (mJy) [5min @1Gbps] →

Challenges and opportunities



- Stations active primarily in regular European VLBI Network activity and as single dish
- Few resources for coordination and support of nation-wide scale activities
- Other limits: three stations, low-mid frequency
- Science opportunities: mostly non-imaging: surveys, transients, alerts
- Great potential in sensitivity and angular resolution to be combined with other stations/networks:

- Europe, East Asia, Africa, space



P. Colomer's talk

The whole is more than the sum of its parts

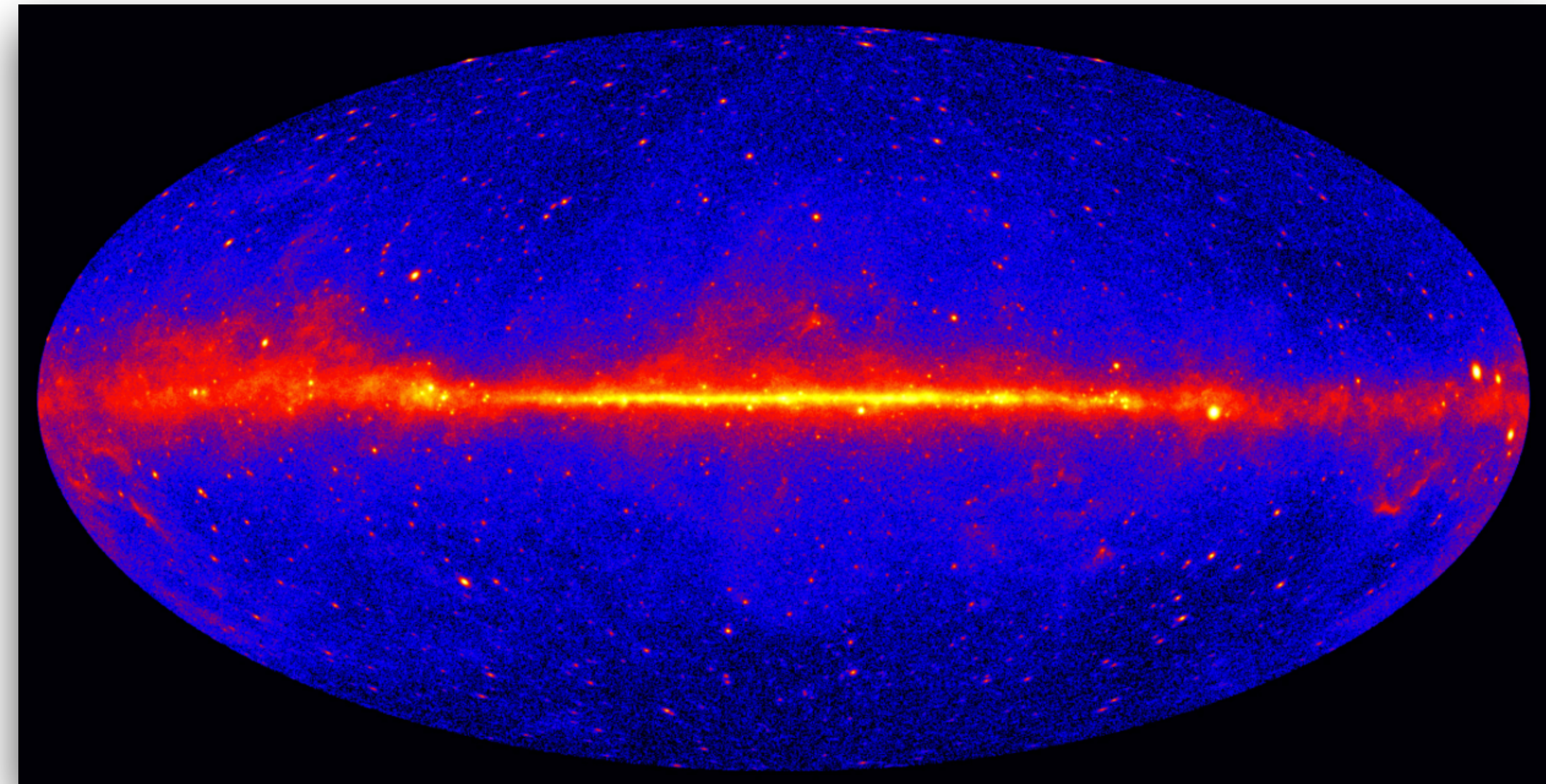


- From Italy-Japan to “East Asia To Italy: Nearly Global VLBI”
- Science, technology, and outreach activities
 - Frequency and baseline range
 - Science topics (high energy, NLS1, astrometry, transients; geodesy and time)
 - From one baseline to tens
 - Role of Nanshan, and other stations...

Fermi Large Area Telescope



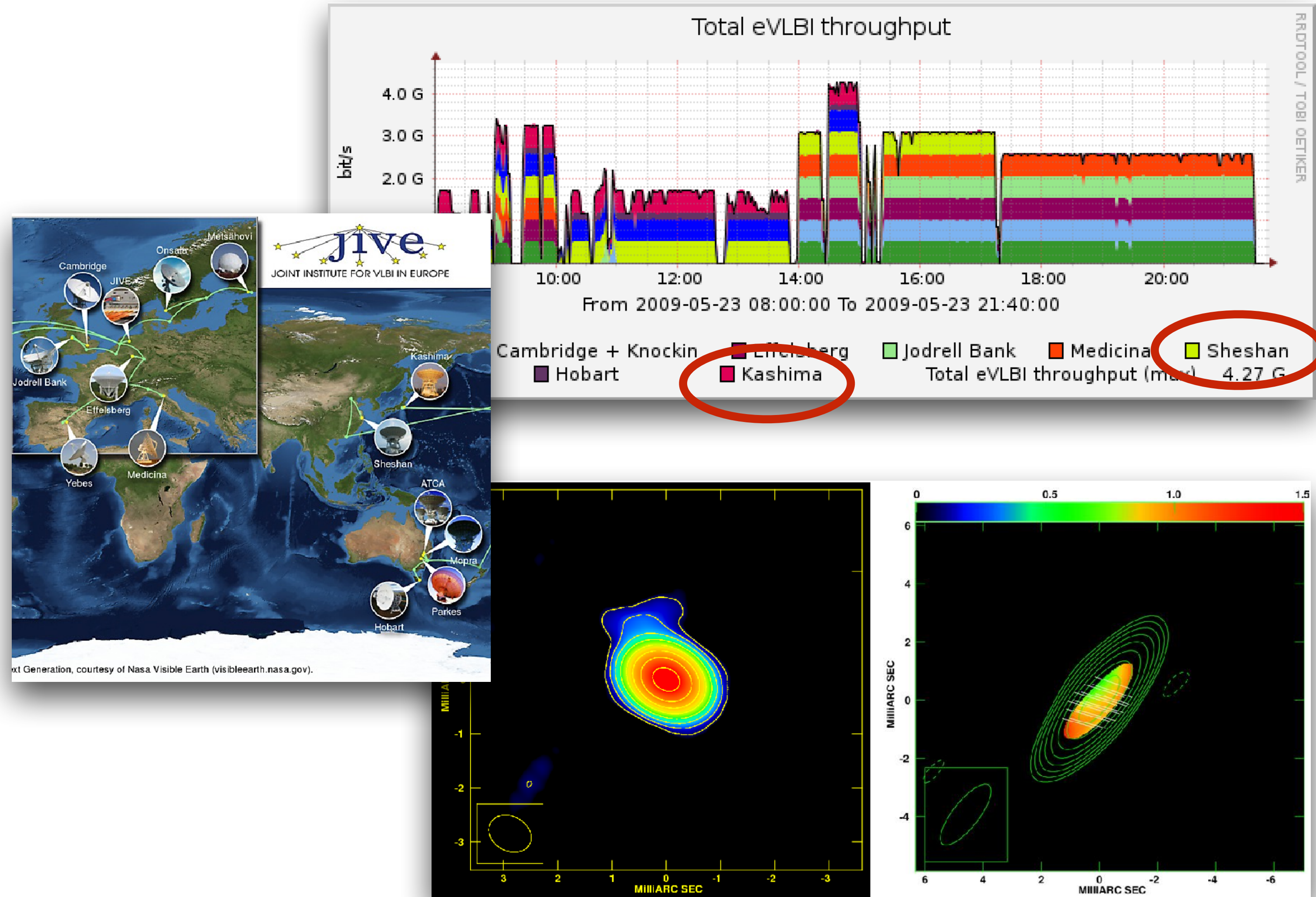
- PMN J0948+0022, global e-VLBI, first collaboration with East Asia
- 3C 84, bright Fermi source, collaboration with Nagai-san, and later the Radioastron Giovannini paper; also an Eating VLBI target (test and science)
- TXS 0506+056: flares, ToOs, Eating VLBI data - and now more neutrinos and more opportunities for science collaboration (and joint observations?)
- OJ287 (see P18 by Jee Won Lee), and FR0 radio galaxies, stellar evolution, and more...



The global e-VLBI campaign on NLSy1 0948+0022



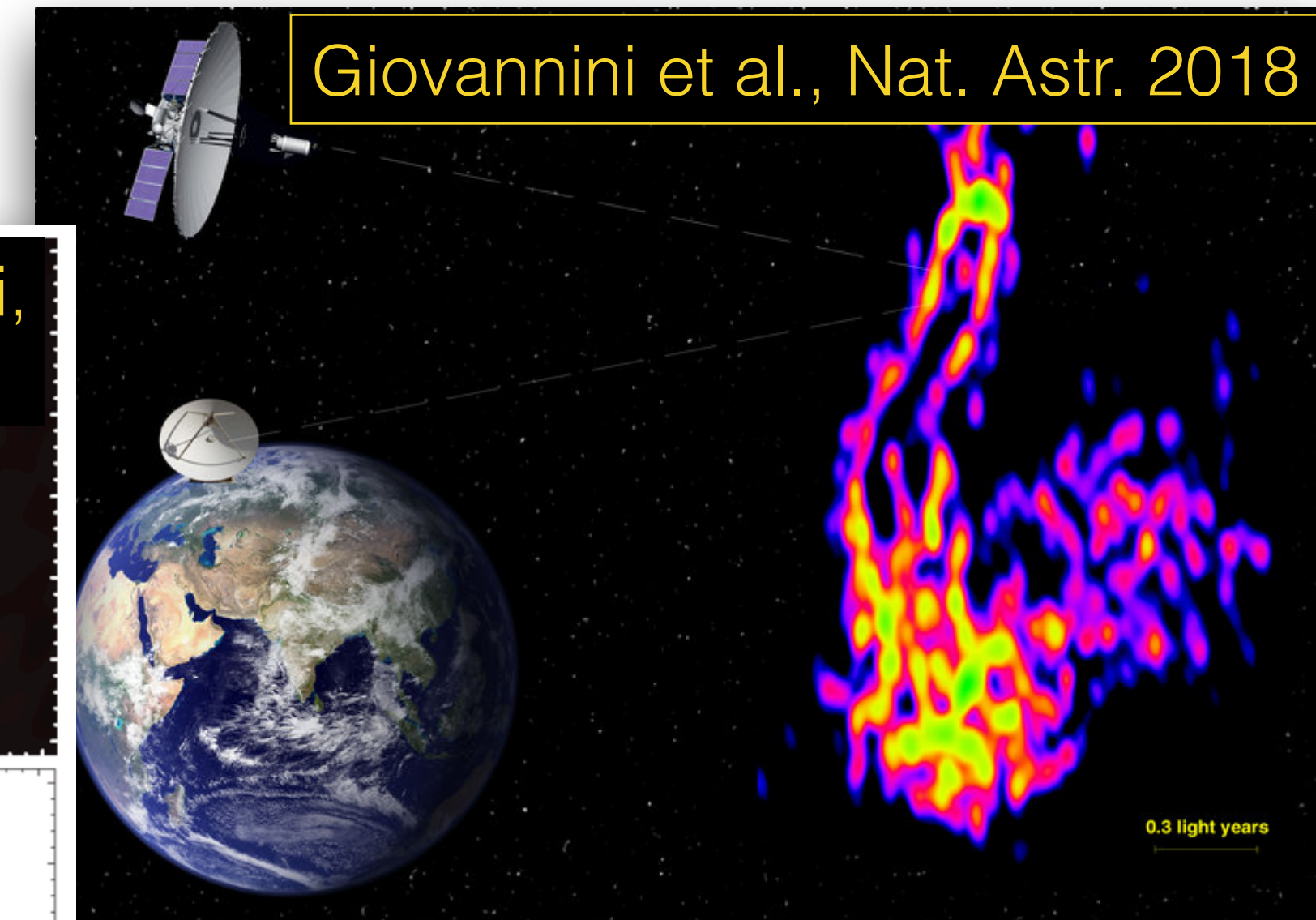
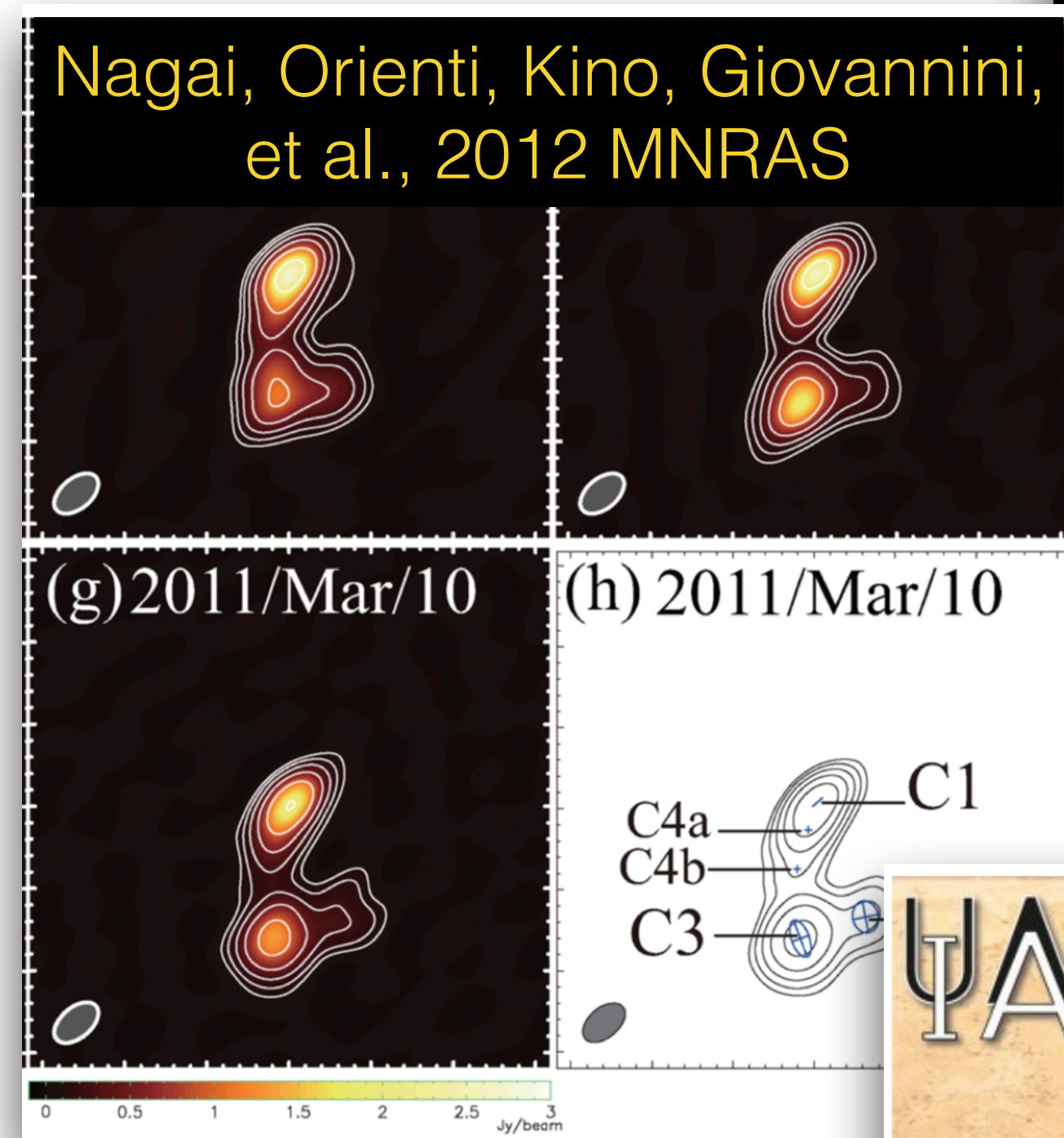
- First global e-VLBI campaign
- Australia, Japan, China, Europe (pre-KVN!)
- $\nu=22$ GHz, full pol, 3 epochs
- Important early constraints on new class of gamma-ray sources
- Giroletti, ..., Doi, Colomer, Kino, Phillips, et al. A&A 2011



3C 84, from GENJI to Radioastron



- A compact radio source, young/restarted, bright and interesting to model
- Turned out to be a bright gamma-ray source, too
- Target of dense monitoring with VERA, up to Space VLBI
- Subject of 2018 Noto IAU symposium “Perseus in Sicily”, with important Italy-East Asia leadership (SOC: Giroletti, Nagai, Asada, Bower, Yung)



IAU Perseus in Sicily IAUS 342
from black hole to cluster outskirts
Noto, May 13 -18, 2018

TOPICS

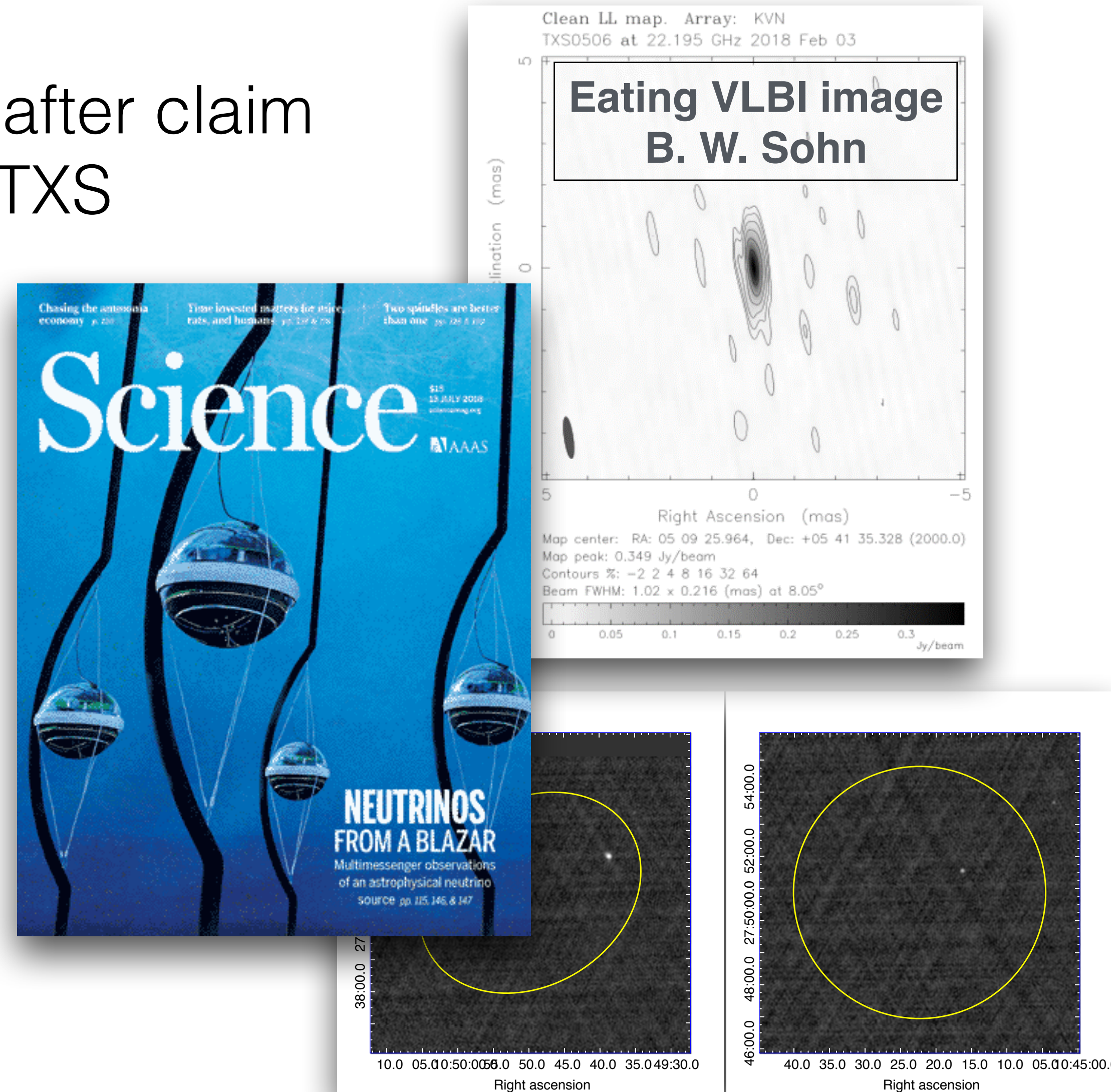
Supermassive Black Holes and accretion
Methods to measure BH mass and spin
Images from the event horizon telescope
Radiatively efficient vs inefficient accretion flows
Jets and outflows in 3C 84 and other AGNs
Ground and Space VLBI imaging
Emission from low-luminosity AGNs
Site of HE and VHE emission in blazars
Leptonic vs hadronic processes
Production mechanism
MHD processes & particle acceleration
Numerical simulations of jets and outflows

Perseus and other Clusters
Hitomi X-ray high resolution spectroscopy
High angular resolution X-ray observations

Towards multi-messenger astrophysics



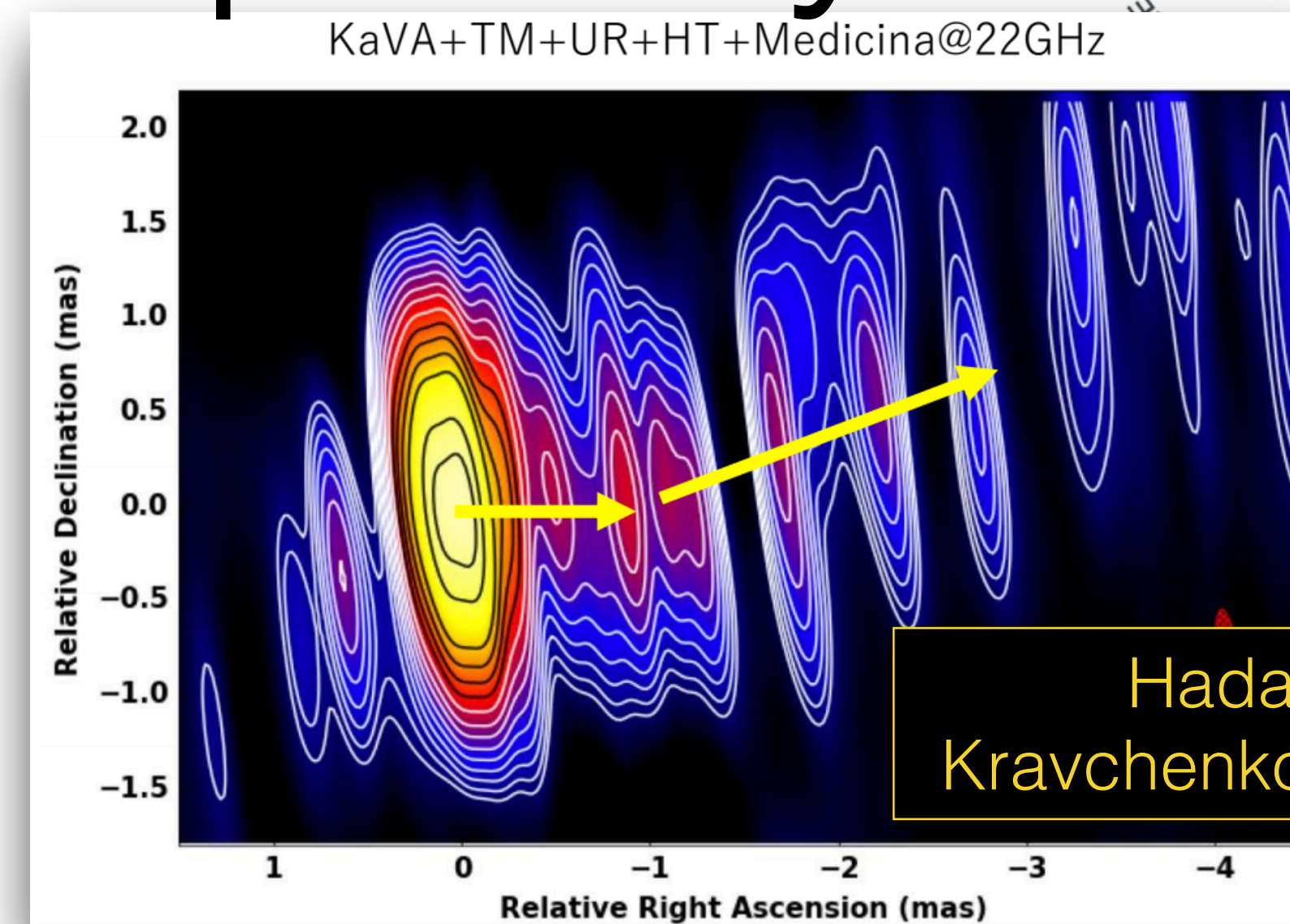
- Renewed interest in blazar parsec scale jets after claim of association to astrophysical neutrino from TXS 0506+056
- Observed with Eating VLBI, KVN, VLBA, and other MWL data
- More sources reported later: complex framework, important to obtain data for more sources
- Other multi-messenger (GW) and transient-related opportunities for collaboration



Astrometry and high frequency



- Italian stations add east-west angular resolution to EAVN imaging of M87
- Multi-epoch observations in 2017-18-19: some technical challenges but promising results and progress
- Part of a larger picture ranging from EVN to EHT
- Astrometry in Mrk501 (Koyama et al.)



Hada,
Kravchenko, et al.

EAVN/EATING campaign 2019

Obs. Code	Date	UT time	Target	Freq.	KaVA	Tianma	Urumqi	NRO	Medicina (M87)	Noto (M87)	Sardegna (M87)
a19mk02a	1/30	16:50 – 23:50	M87	K	●	●	●			●	●
a19mk02b	2/1	15:40 – 22:45	M87	Q	●	●					
a19mk02c	2/17	15:10 – 22:10	M87	Q	●	●					
a19mk02d	2/19	15:00 – 22:00	M87	K	●	●	●		●		●
a19mk01a	2/27	19:45 – 1:45	SgrA	Q	●	●		●			
a19mk02e	2/28	13:55 – 20:55	M87	K	●	●	●		●		●
a19mk02f	3/1	13:55 – 20:55	M87	Q	●	●					
a19mk01b	3/9	18:50 – 0:50	SgrA	Q	●	●					
a19kh01a	3/22	12:00 – 0:00	M87+SgrA	Q	●	●					
a19kh01b	3/23	12:25 – 0:25	M87+SgrA	K	●	●	●		●	●	●
a19kh01c	3/29	11:30 – 23:30	M87+SgrA	Q	●	●		●			
a19kh01d	3/30	11:55 – 23:55	M87+SgrA	K	●	●	●	●	●		●
a19kh01e	4/10	11:15 – 13:15	M87+SgrA	K	●	●	●		●	●	●



Other milestones

- Meetings
- Visits, students
- Outreach activities: video, exhibits
- Upgrade of INAF stations to high frequency (part of)
- MoA INAF-KASI, 30 hours per semester for joint observations. CALL NOW!!!
 - goal of making it full “Eating VLBI” array
- IAU Lol for GA 2021 focus meeting “Physics of relativistic jets on all scales” (SOC Chairs: Orienti, Sohn)”



Eating VLBI workshops



- 2012, 2014, 2017, 2019; Bologna, Jeju
- Growth in attendance and diversity in age, provenance, gender, and **science interests**
- April '19: 60 participants, 40 talks, 10 sessions, from transients to measurements of time



≡ EATING VLBI WORKSHOP ≡
"East-Asia to Italy:
Nearly Global VLBI"

Bologna 2019 April 15-17
CNR Research area

<https://sites.google.com/a/inaf.it/eating-vlbi-workshop-2019/home>

Scientific Organising Committee:
Tao An, SHAO
Keiichi Asada, ASIAA
Gabriele Giovannini, Bologna University
Marcello Giroletti, INAF-IRA
Kazuhiro Hada, NAOJ
Min Sun Kim, KASI
Motoki Kino, KUTE-Tokyo
Monica Orienti, INAF-IRA
Bong Won Sohn, KASI
Gabriele Scuris, INAF-OACagliari

Outreach activities and added social value



Cultural/social aspects of the project

- Fruitfulness of a worldwide cooperation (and wonders in some of its aspects, such as the observations schedules)
- Diversity and contact points of cultural backgrounds

A public outreach event in Bologna fair on “Astronomy beyond... culture, tradition, and borders” (02/18)



The charm of the scientific contents

- Black holes!
- Creation or adaptation of educational materials




**MEMORANDUM of AGREEMENT
BETWEEN
THE ISTITUTO NAZIONALE DI ASTROFISICA
AND
THE KOREA ASTRONOMY AND SPACE SCIENCE INSTITUTE
ON JOINT VLBI OBSERVATIONS**

The Istituto Nazionale di Astrofisica (hereafter referred to as INAF) headquartered at Viale del Parco Mellini n.84, 00136 Roma, Italy and represented by its President, Prof. Nicolo' D'Amico, and the Korea Astronomy and Space Science Institute (hereafter referred to as KASI), headquartered at 776 Daedeok-daero, Yuseong-gu, Daejeon 34055, the Republic of Korea and represented by its President, Dr. Hyung Mok Lee,

Article 7

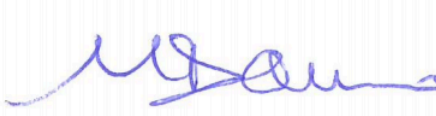
This Memorandum shall come into effect on the day of signing by both parties and will continue for 5 years. Its actions can be temporarily or completely stopped, by either Party with written notification six months in advance.

Date: *April 9, 2019*
Dr. Hyung Mok Lee



President.
Korea Astronomy
and Space Science Institute

Date:
Prof. Nicolo' D'Amico



President,
Istituto
Nazionale di Astrofisica



Type: Regular guest large long NAPA ?

DDT ?

ToO ?

Title: ?

Hours requested: • Total This Semester (long only) ?

Select Obs Mode: Single Dish Interferometry ?
Pay attention to the consistency of the selected configurations.

Telescopes: Medicina Noto SRT ?

Receivers: Receivers: Receivers:

<input type="checkbox"/> L band	<input type="checkbox"/> L band	<input type="checkbox"/> P band
<input type="checkbox"/> S/X band	<input type="checkbox"/> S band	<input type="checkbox"/> L band
<input type="checkbox"/> C-low band	<input type="checkbox"/> C-low band	<input type="checkbox"/> C-high band
<input type="checkbox"/> C-high band	<input type="checkbox"/> C-high band	<input type="checkbox"/> K band
<input type="checkbox"/> K band	<input type="checkbox"/> X band	
	<input type="checkbox"/> K band	

Back-ends: Back-ends: Back-ends:

<input type="checkbox"/> DBBC2	<input type="checkbox"/> DBBC2	<input type="checkbox"/> DBBC2
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EATING VLBI: No Yes ?

Request DiFX: No Yes ?

I Confirm: to have checked for the needed Equipment/Support. ?

NOTICE: Details on the offered receivers and back-ends can be found [here](#)

from INAF Call for Proposal

Submission deadline is **October 3rd 2019 at 12:00 CEST**

https://www.radiotelescopes.inaf.it/proposal_main.html

6. EATING VLBI

*According to the MoA between INAF and KASI up to 30 hours of observing time in VLBI mode are allocated to approved **EATING VLBI projects**. These projects have to be submitted both to the Italian and Korean TACs with the standard form selecting "EATING VLBI" mode in the project type. Approved projects will be observed up to 30 hours/semester. Projects exceeding 30 hours will be scheduled together with all other projects according to their relative grades. **Pls of these proposals must be associated with INAF or KASI.***

Status tables, 2022?



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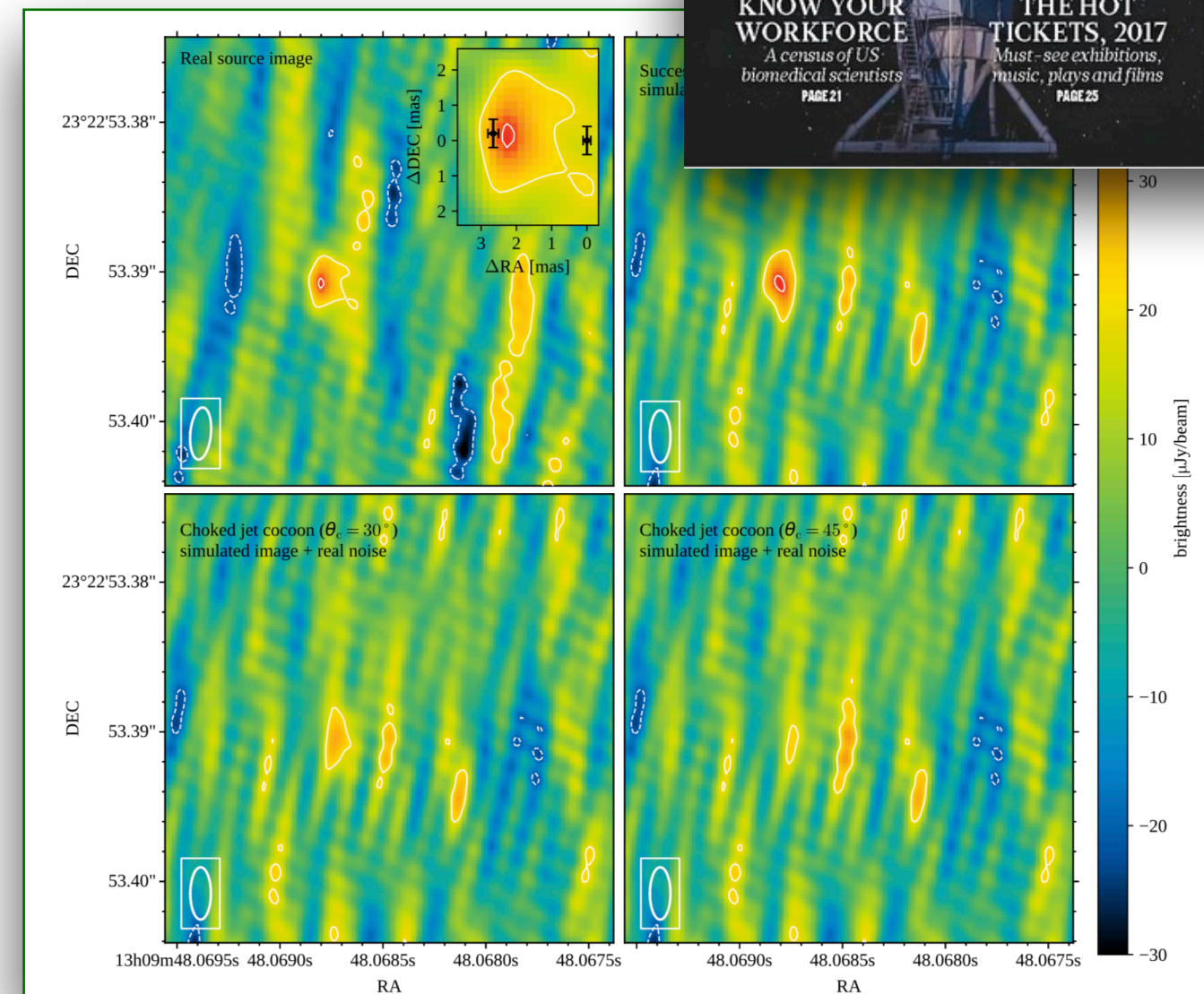
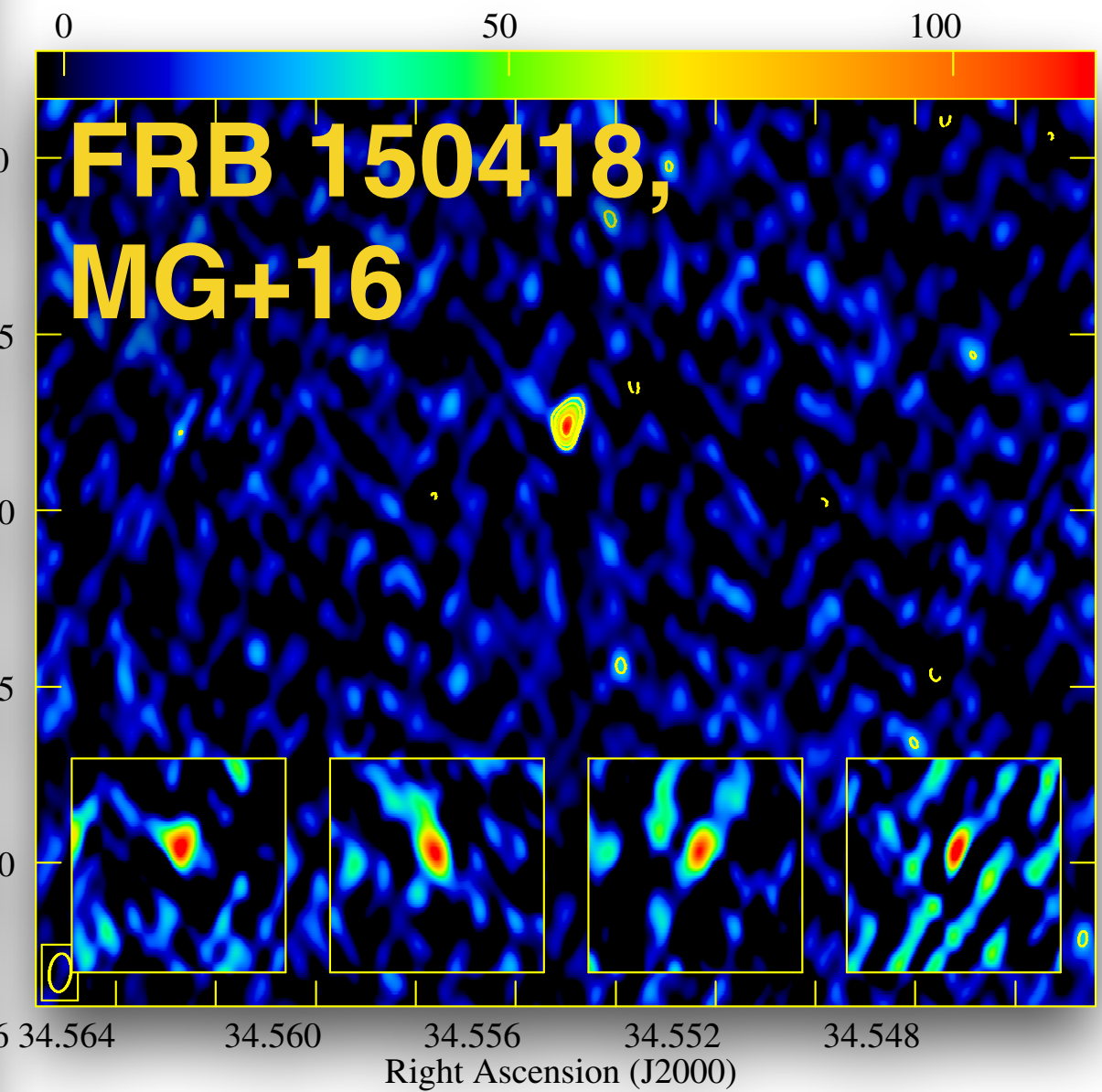
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← K-band 5σ sensitivity (mJy) [5min @1Gbps] →

What's next? The revolution of transients



- Fast radio bursts (FAST???) Li's talk
- Gamma-ray bursts: EAVN
ToO an interesting experience and an important scientific result An's talk
- GW - a challenge to the sensitivity of MWL observations



Challenges

- Wide field instruments offering immense possibilities and demanding huge resources
- What's VLBI to offer? T. An's talk
- What's Eating VLBI to offer?
 - High frequency niche - needs developments
 - Real time on long baselines - coordination is key (recent steps forward)
 - Training and broadening of horizons - here we are!