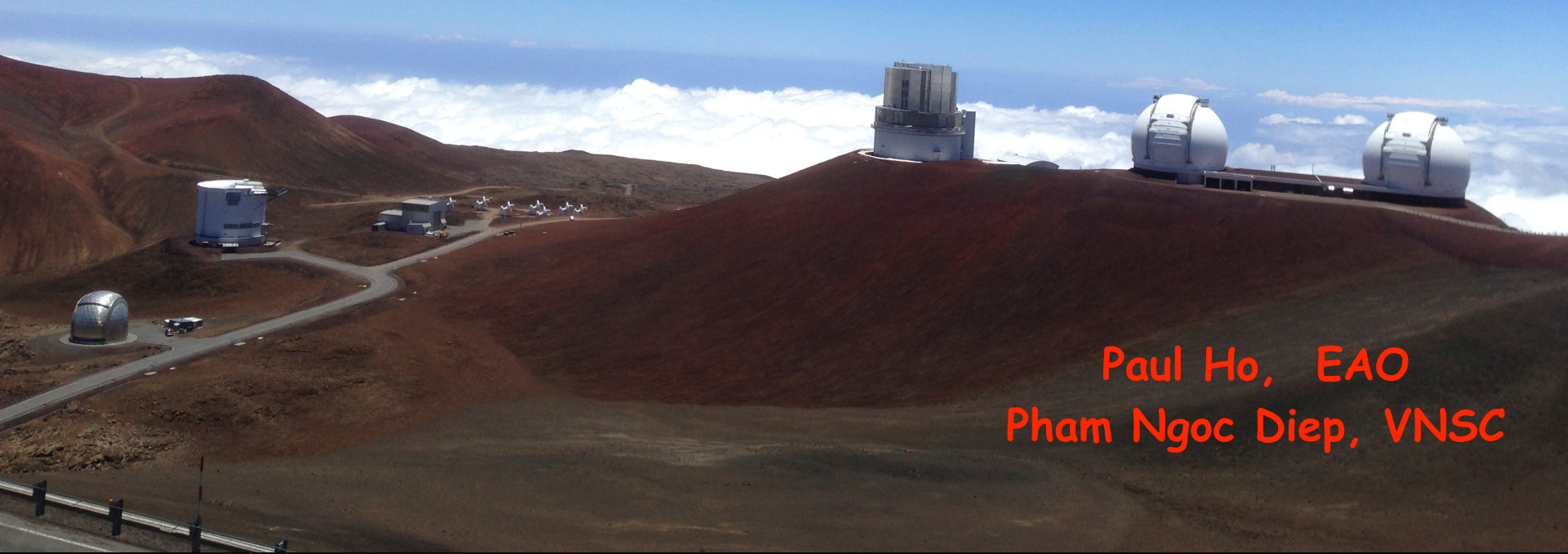


East Asian Astronomy and the EAO

— *a Joint Dream*



Paul Ho, EAO
Pham Ngoc Diep, VNSC

Why Astronomy?

- **Oldest Field of Science, Everywhere**
- **Why? The most fundamental question: Existence**
- **We Study: Largest Volume in Space (all)**
Largest Volume in Time (future and past)
Answers the Questions on “Origin”
- **Our Subjects can be understood/appreciated by**
Public
- **Our Science can stimulate the interests of the**
Youngest
- **Best Stimulus for Support of**
Science

EAO is a Project of EACOA: EACOA is a Dream for Asia

EACOA: NAOC, NAOJ, KASI, ASIAA



- **Timeline:** EACOA officially formed in 2005
- **Mission:** to Organize and Promote East Asian Astronomy
- **History:** Many Years of Efforts from Norio Kaifu
Cai-Ping Liu, Se-Hyung Cho, & Friends
- **Activities:** Meetings (**EAMA, EAYAM**), Workshops; EA VLBI Network; EA Site Surveys; EACOA Fellows; EACOA-CSO initiative, **East Asian Observatory**
- **Purpose?** **Increase Regional Resources: Funds, Manpower, Jobs**

East Asian Observatory

- **History of Development: Established 2014**
- **Model: Asian Counterpart to ESO**
- **EAO Members: NAOC, NAOJ, KASI, ASIAA**
- **Goals and Aspirations: Jointly Enable Future Dreams**
- **Current Status: Operating JCMT**
- **Current Plans: Adding more Facilities (Subaru)**
- **Future Plans: Expand EAO Membership**
(**Vietnam, Thailand, Malaysia ...**)

Vietnam and **Thailand** now Observer Status: Free Access

Vietnam can become Partner in the Future

Malaysia in process of joining as Observer

Goals of EAO

Mission Statement

The EAO (East Asian Observatory) is formed by EACOA (East Asian Core Observatories Association) for the purpose of pursuing joint projects in astronomy within the East Asian region. **In the era of very large scale astronomical instruments, East Asia will be competitive internationally by combining their funding resources, their technical expertise, and their manpower. The intention of EAO is to build and operate facilities, which will enhance and leverage existing and planned regional facilities. The intention of EAO is to raise funding and to build an observatory staff, separate from that of the EACOA institutions. As partners of the EAO, the EACOA institutes will help to establish the funding and to oversee the governance of EAO. The communities represented by the partners in EAO, would have full access to all EAO facilities.**



EAO is meant to benefit our regions “together”

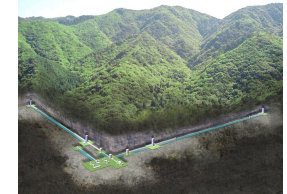
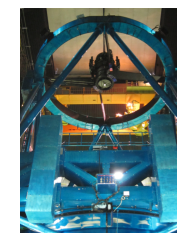
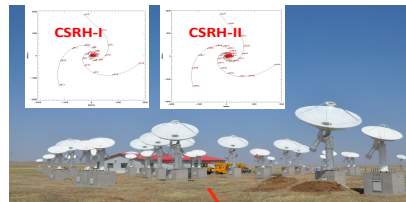
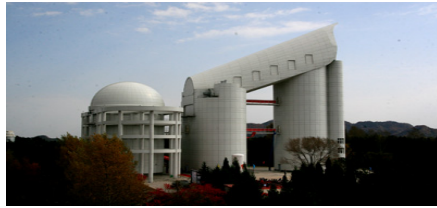
Lessons from ESO

- ESO Declaration (1954) predates EEC (1958) and EU (1993)
- ESO is more than 50 years old
- **ESO Annual Budget is at “Government Minister” Level**
- ESO Annual Budget is on the order of NAOJ or NAOC
- ESO Supports Large and Small Facilities
- ESO has “EU” Facilities and “Joint” Facilities (eg ALMA)
- ESO Facilities Complement Member Facilities
- ESO has ~730 staff members
- **EU Scientists are very mobile within EU**
- **ESO Budget : 2018 297M Euro**

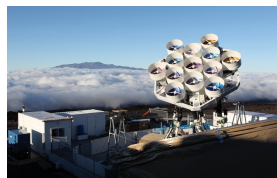
- EAO Founding Members are “**Better Prepared**” than ESO Founding Members in 1962 (technically, financially)
 - ➔ **We should be moving FASTER !**
- EAO has ~35 staff, 2018 Budget ~5.0M USD

East Asia **already has** Regional Facilities

(10~100M USD)



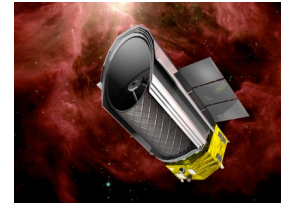
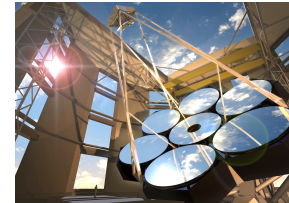
- **China:** LAMOST, FAST, 21CMA, CSRH, Silk Road, ...
- **Japan:** Subaru, Hinode, VERA, KAGRA, Nobeyama, Okayama, Kyoto NTT, TAO,
- **Korea:** Bohyunsan OAO, Sobaeksan OAO, KVN, KMTNet, Space Weather, CIBER, OWL,
- **Taiwan:** SMA, AMiBA, TAOS, TAOS-2, GLT, LOT



and Regional Large Scale Projects (> 1B USD)



- **ALMA:** Japan, Taiwan, Korea
- **TMT:** Japan, China
- **GMT:** Korea
- **SPICA:** Japan (Korea, Taiwan)
- **SKA:** China, Japan, Korea (Taiwan)



However, Better Coordination Needed

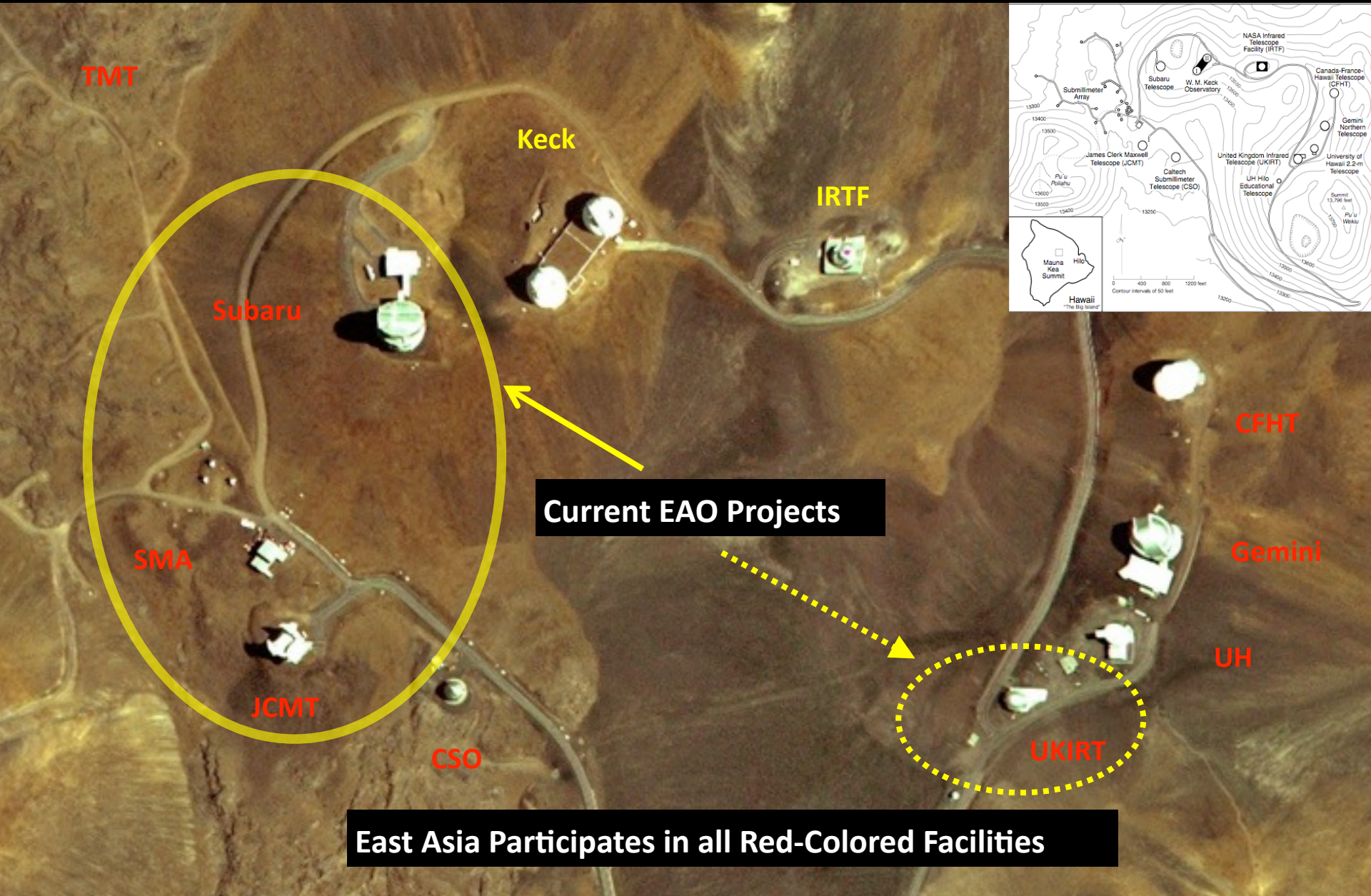
EACOA Directors Forms EAO 12.13.14



- **EAO incorporated on 09.14**
- **EAO took over JCMT operations on 03.15**

note: JCMT is about DUST SCIENCE

EAO Operates on top of Mauna Kea



**A New EA Submm Community is Built
via the EAO/JCMT**

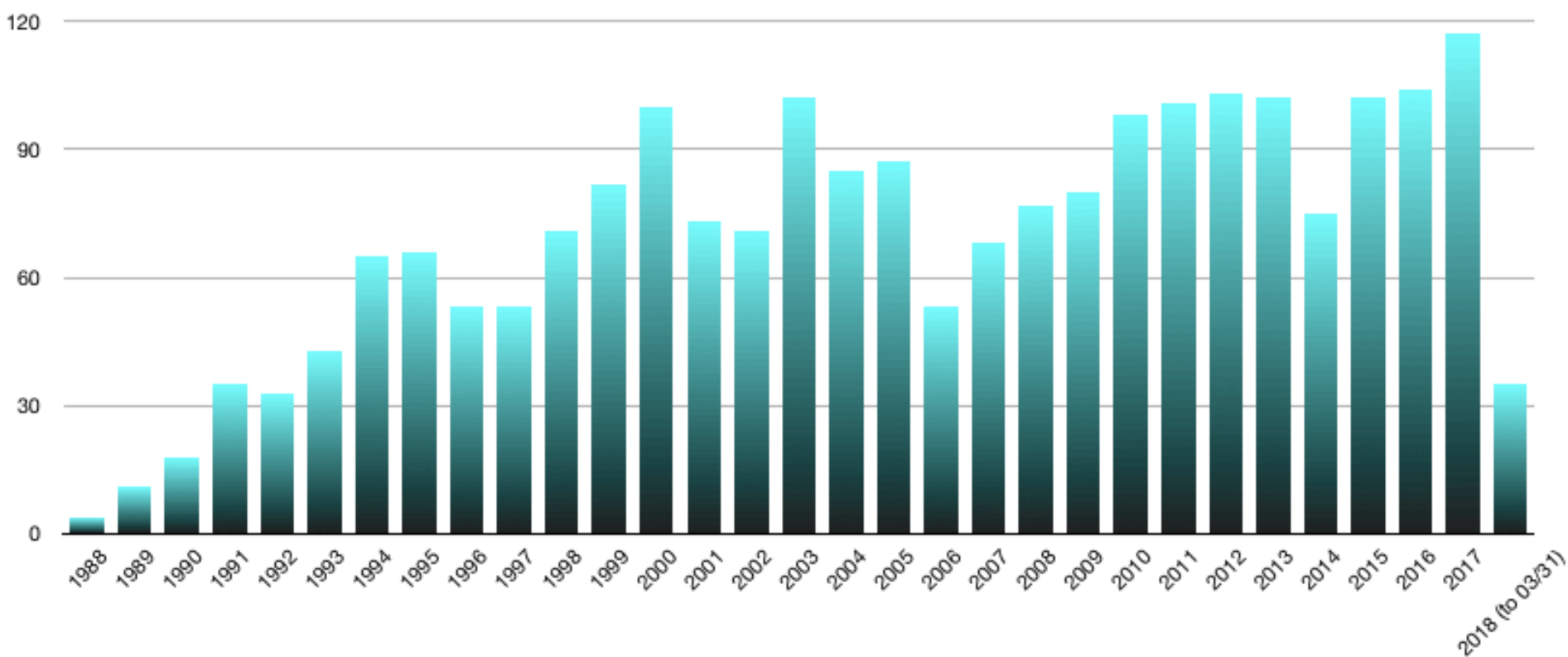


Publication Statistics

2015: 4 out of 104 papers from EA regions (3 more embedded overseas)

2016: 19 out of 105 papers from EA regions (6 more embedded overseas)

2017: 32 out of 117 papers from EA regions (3 more embedded overseas)



In 2017, EA lead 49% of JCMT Partnership 1st Author Papers

Publication Statistics

2015: 4 out of 108 papers from EA

2016: 19 out of 105 papers from EA

2017: 32 out of 117 papers from EA



In 2017, EA lead 49% of JCMT Partnership 1st Author Papers

2018 (to 04/30)

EAO Status: 2015-2018

- **Operate JCMT more efficiently than ever**
- **Built EA JCMT Submm community (~350 PIs)**
- **Introduced new JCMT Polarization Capabilities (POL-2)**
- **JCMT is now part of Event Horizon Telescope consortium**
- **JCMT Large Programs lead to New Science Initiatives**
- **By 2017, EA Community leads ~50% of JCMT Partners 1st Author papers**
- **JCMT operations extended to 2024**
- **EAO Access to SMA, UKIRT, Subaru**
- **EAO working with Southeast Asian countries**

Future: Next EAO Projects?

- **Subaru (for access to 8m to 10m class optical telescope)**
- **SMA (for access to submm interferometry in northern hemisphere, and also to prepare for ALMA)**
- **VLBI (to establish EA VLBI effort to contest for EHT)**
- **UKIRT (to access wide-field IR imaging)**
- **CFHT (for possible participation on MSE)**
- **Instrumentation Projects (improve all receivers in sensitivity by 10 times); detector development**
- **site surveys in Asia, given Mauna Kea situation**

- **ALL SUCH INITIATIVES DEPEND ON JCMT SUCCESS**

How EAO Works?

- **Infrastructure Funding aims to be based on ratio of GDP.**
- **Project Funding aims to be based on regional interests.**
- **Regional Manpower are deployed to EAO, either via posting or direct hiring. EAO facilitates visa for international staff.**
- **EAO helps regional scientists to access facilities, prepare science proposals, participate in experiments, reduce data.**
- **EAO helps regional scientists to collaborate on Large Programs.**
- **EAO conducts workshops and schools in the regions.**
- **EAO welcomes regional students and scientists to be in residence at EAO. EAO provides housing support.**
- **EAO welcomes regional participation in instrument development.**
- **What is Role for Vietnam?**

New Partners?

Asian Regional GDP

	2018	2023	5-YR
	GDP (IMF): B \$	Projected GDP	Growth Rate: %
USA	20,413	24,537	20
CHINA	14,093	21,574	53
JAPAN	5,167	5,962	15
SOUTH KOREA	1,693	2,155	27
TAIWAN	613	660	8
INDONESIA	1,075	1,549	44
THAILAND	484	650	34
MALAYSIA	365	568	56
VIETNAM	241	373	55

- South East Asian Economies are Expanding
- South East Asia also has Large Population
- East Asia + South East Asia >> U.S. or EU

Proposed Contributions ~ Ratio of GDPs

Summary

- **EAO provides a Working Model for “Action” beyond “Planning”**
- **EAO provides a Working Model for Regional Coordination**
- **EAO provides a Working Model for Sharing Cost and Manpower**
- **EAO demonstrates that Joint Efforts can be Competitive with the West**
- **Astronomy in South East Asia can also Grow Rapidly**
- **Astronomy in South East Asia can access Frontier Facilities**
- **EAO seeks to stimulate and support the Growth of Astronomy in all of Asia**
- **EAO seeks to be a model for Regional Engagement**

Basic Issue: Why EAO?

“What is the Role of Asia in the World?”

“Can Asia Participate, Contribute, **Lead?”**

“Can we Improve? How?”

- **Goal:** Compete and Preserve most important “Resource”:
Brain Power
- **How:** Attract **Next** Generation into Exciting Science
- **Method:** **Cross** “Institutional Boundaries”, “Discipline/Field Boundaries”, “Cultural Boundaries”, “National Boundaries”
———*thereby increase possible solutions*———

Our Model: ESO

- **Timeline:** **1953** First Discussion of European Observatory
1954 ESO Declaration by 6 Countries
1962 ESO Convention Signed (Belgium, France, Germany, Netherland, Sweden)
1964 ESO Convention Ratified (France, Germany, Netherland, Sweden)
1965 La Silla Observatory Starts Construction
1966 ESO 1m Operates
1967 Belgium, Denmark Joins ESO
1976 ESO 3.6m Operates
1982-2009 8 more Countries Join ESO
1987 ESO to build VLT
2003 ESO to build ALMA
2012 ESO to build E-ELT
2012 ESO 50th Anniversary
- **Budget:** **2018 297M Euro** (members: 2.0 - 43.5M Euro)



Jan Oort was 53

Our Model: ESO

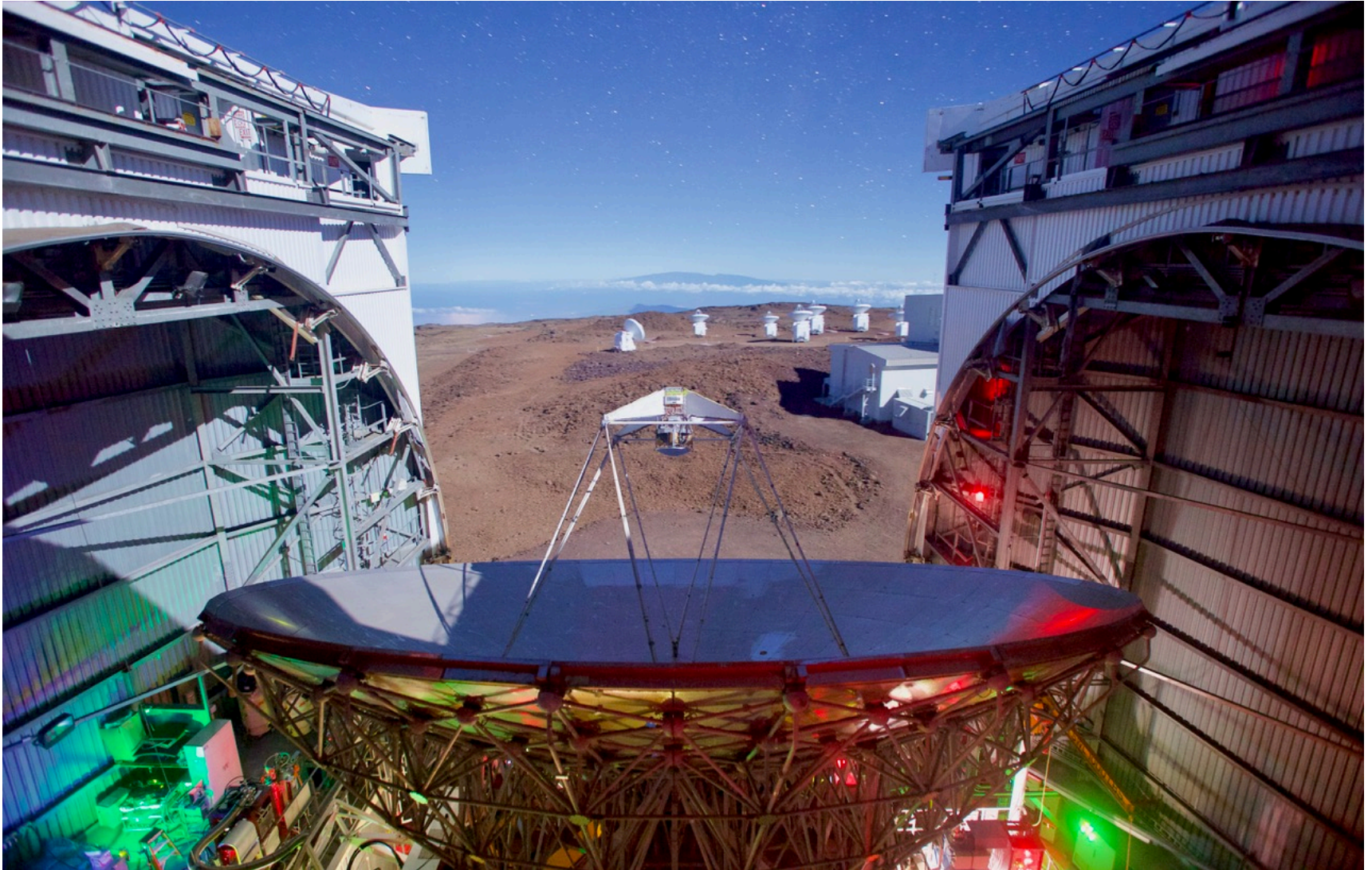
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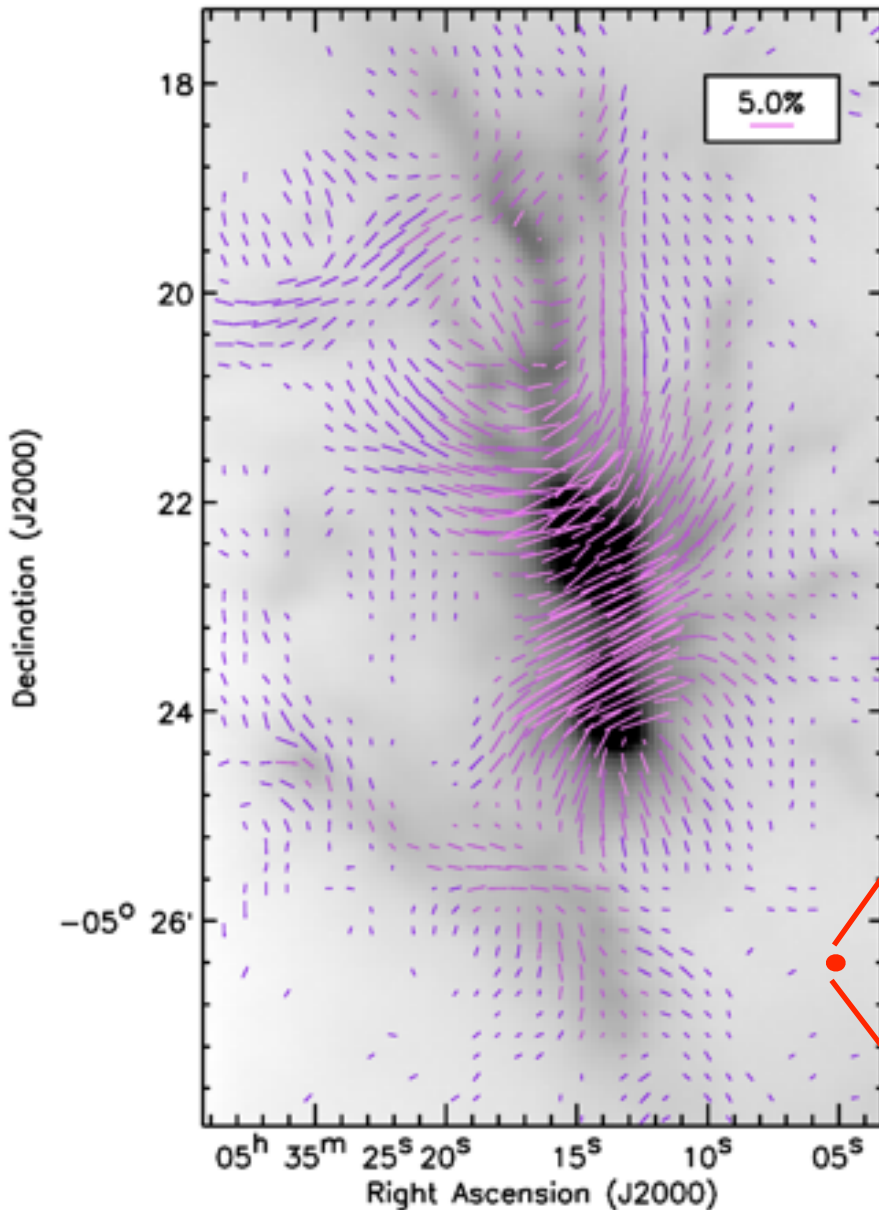
Jan Oort was 53

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New Polarization Capabilities Introduced via JCMT POL-2



BISTRO: B-Fields in Star-forming Region Observations

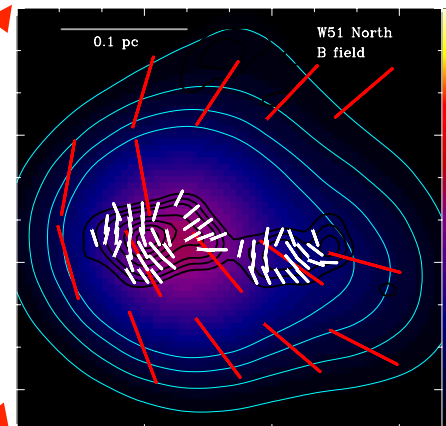


Orion A:

- Survey paper: Ward-Thompson et al. 2017, ApJ in press
- Chandrasekhar-Fermi and energetics analyses: Pattle et al. 2017, ApJ submitted.

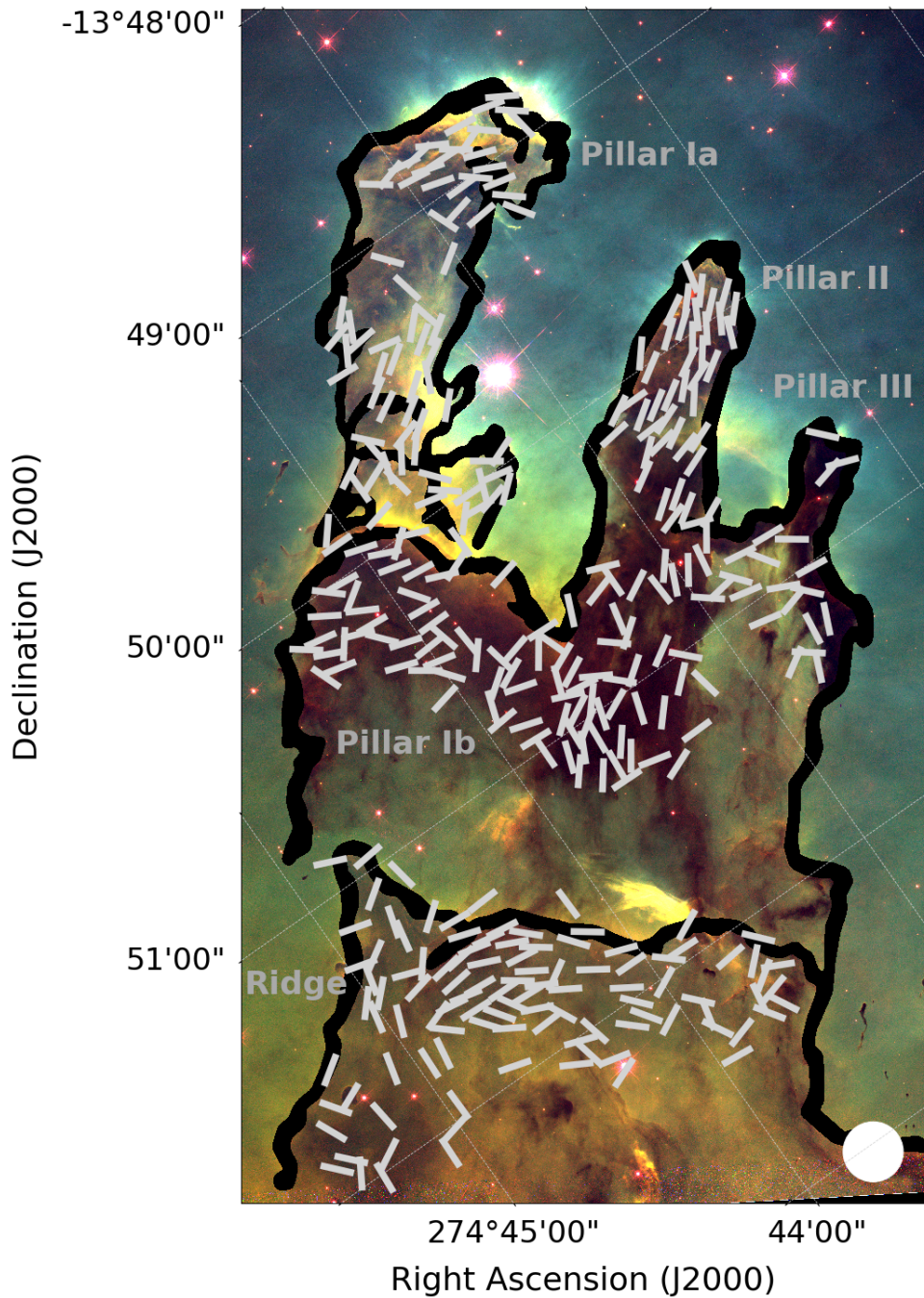
**Tracking B-Fields
into Faint Regions:**

Shaping Molecular Outflows?



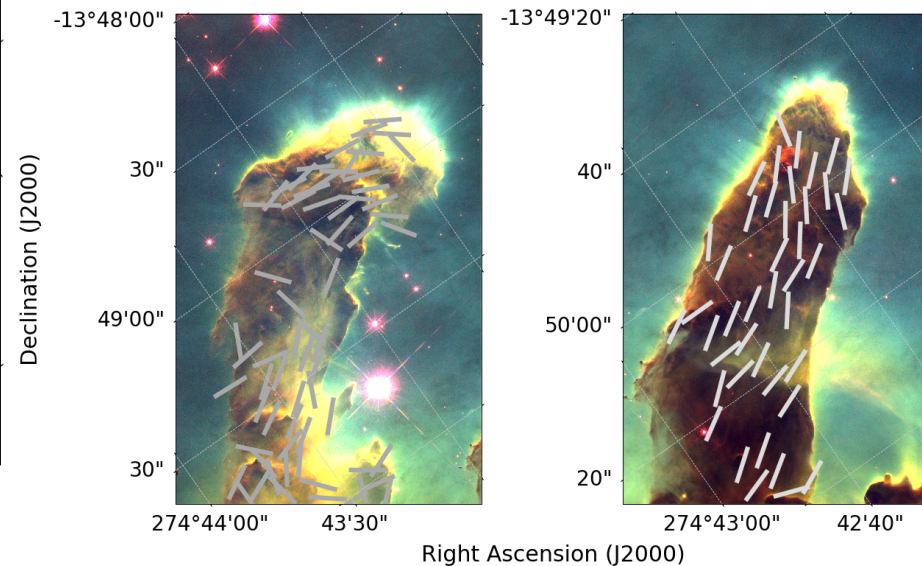
W51: SMA





**BISTRO-2 results from Pattle et al.
 2018 Submitted**

magnetic field morphology
 observed in the dense gas of the
 Pillars of Creation inside of the
 Eagle Nebula (M16) with
 POL-2, overlaid on the HST
 images



JCMT is part of EHT

JCMT and EHT participated in ALMA Cycle 4 (Cycle 5)

Calibrated data distributed to EHT Imaging Teams

Event Horizon Telescope

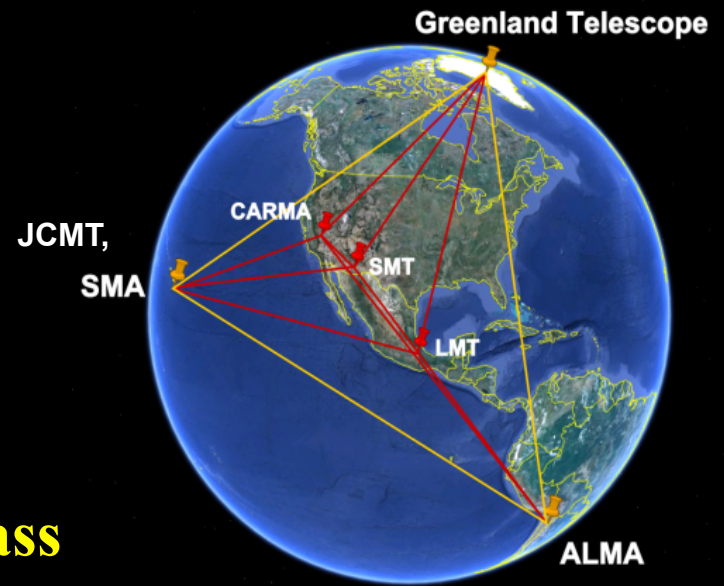
JCMT is part of EHT

D ~ 9000 km

resolution ~ 10 μ as

Goal: Resolve Black Hole

Shadow; measure spin and mass

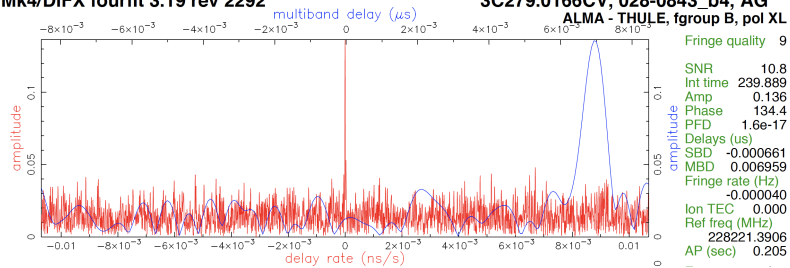


JCMT tests enabled GLT/ALMA Fringe

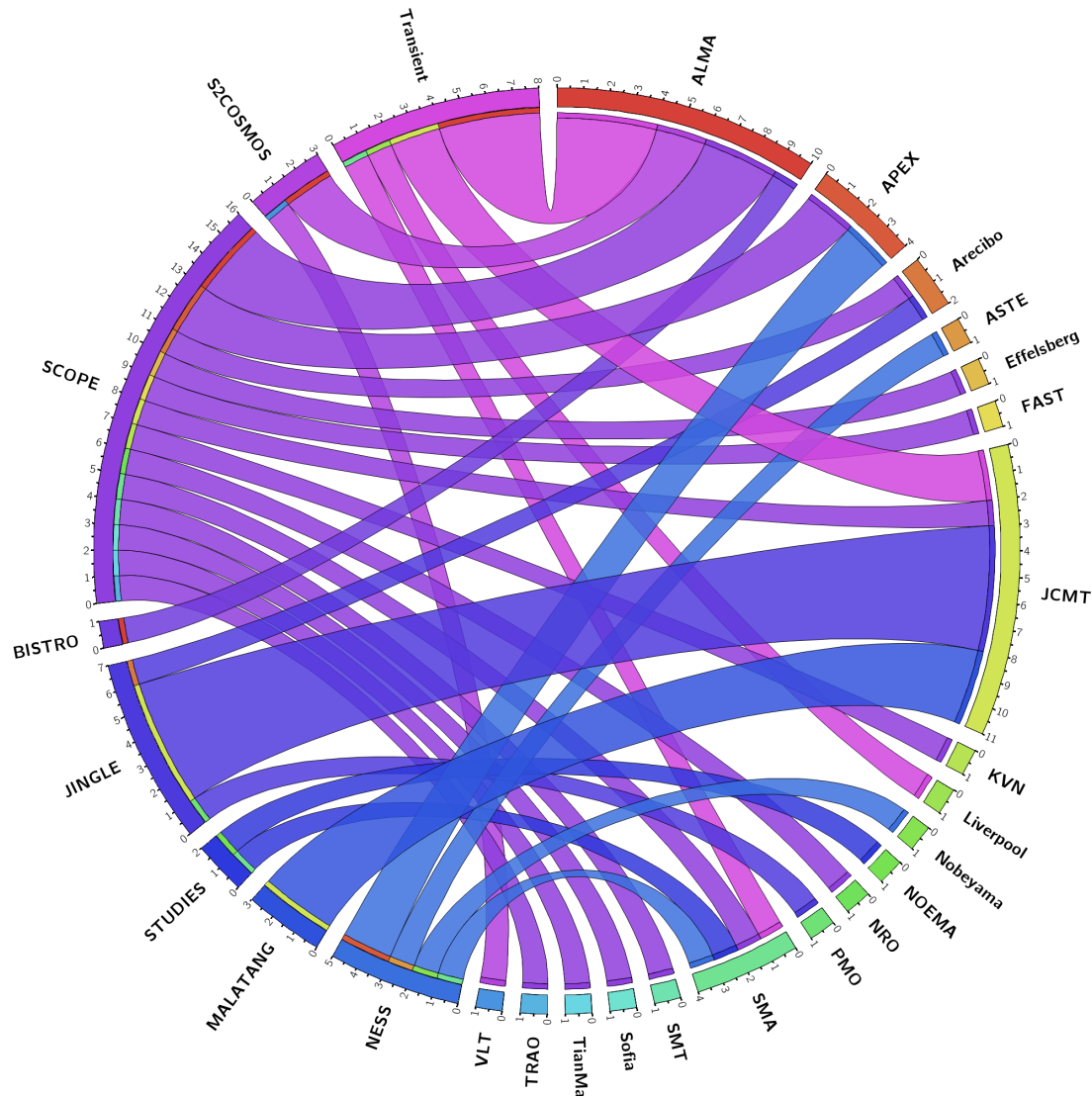


Mk4/DiFX fourfit 3.19 rev 2292

3C279.0166CV, 028-0843_b4, AG
ALMA - THULE, fgroup B, pol XL



Successful Proposals at other Observatories due to JMCT Large Programs



Instrument Project summary

Instrument	Type	Frequency	Pixels	Pols	Bandwidth	Tsys/ NEFD	F.O.V. (arcmin ²)	Map speed (x)	Timescale
RxA (230 - current)	Heterodyne	219 - 272 GHz	1	1	3 - 9 GHz	140	0.1	1.0	
New 230 receiver	Heterodyne	210 - 275 GHz	1	2	4 - 10 GHz	100	0.1	3.9	2018
HARP (345 - current)	Heterodyne	325 - 375 GHz	16	1	3 - 5 GHz	250	2.3	1.0	
New 345 receiver	Heterodyne	320 - 375 GHz	45	2	4 - 8 GHz	200	7.1	8.8	Nov. 2021
SCUBA-2	Continuum	850/450 μ m	5120	-	-	93	30.1	1.0	
SCUBA-2+	Continuum	850/450 μm	6400	-	-	35	48.4	11.3	Dec 2016 / Nov 2020

KEY: Improve SPEED by ~10x