Pilot SMA Mosaic Polarization Observations

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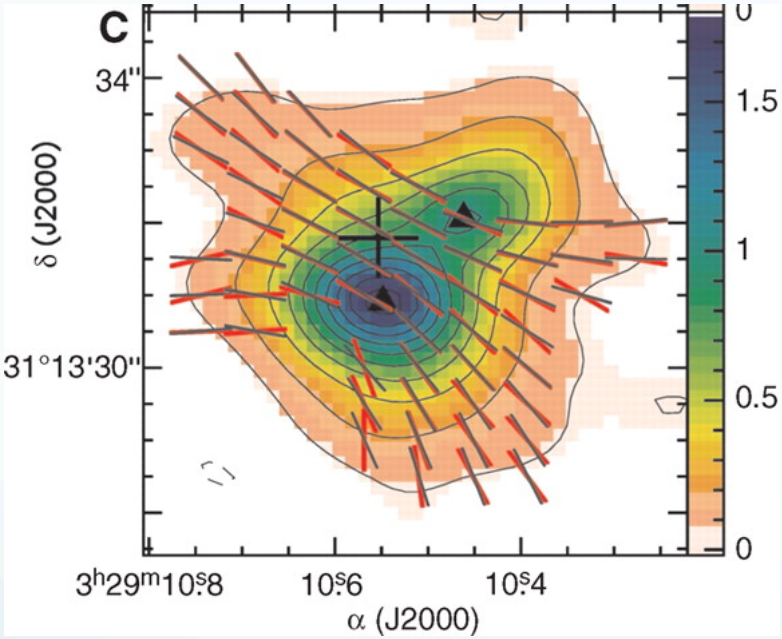
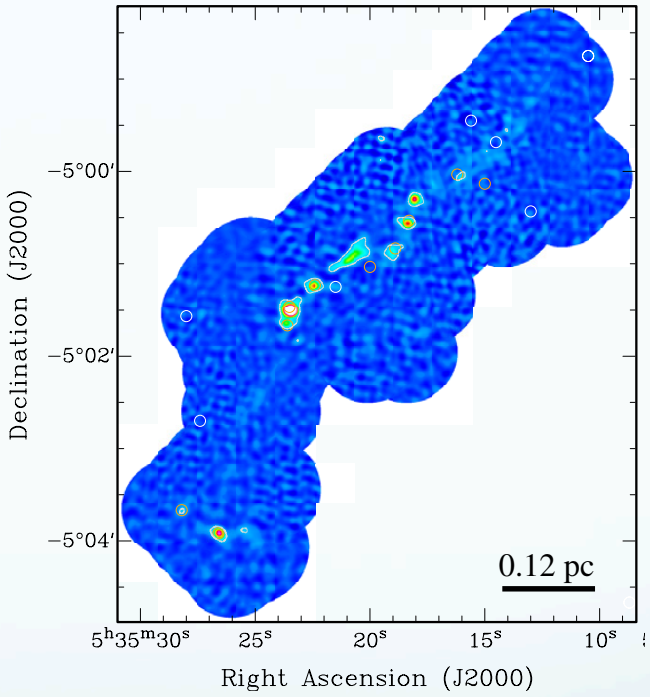
CfA: Qizhou Zhang, Ken Young, Glen Petitpas, Ryan Howie
Institue de Ciencies de l'Espai: Josep M. Girart

Polarization Observation



NGC 1333 IRAS 4A
Girart et al. 2006

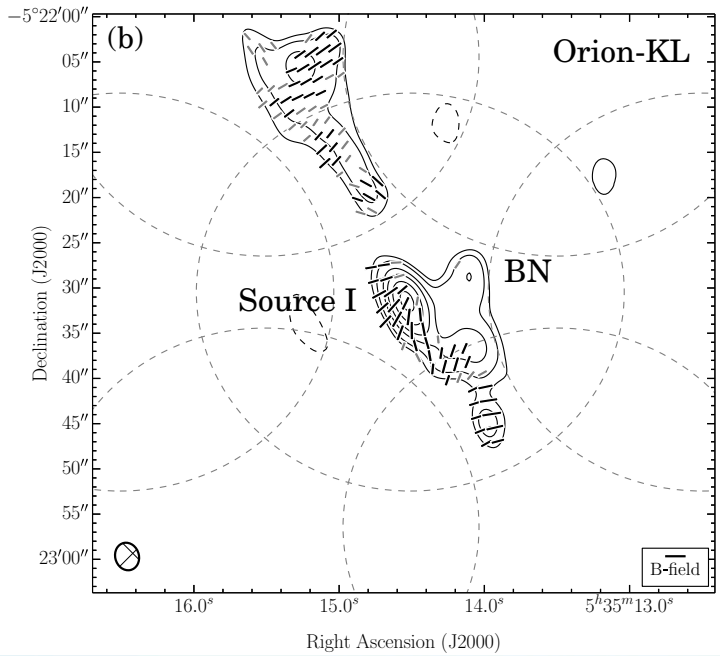
Mosaic Observation



Orion Filament
Takahashi et al. 2013

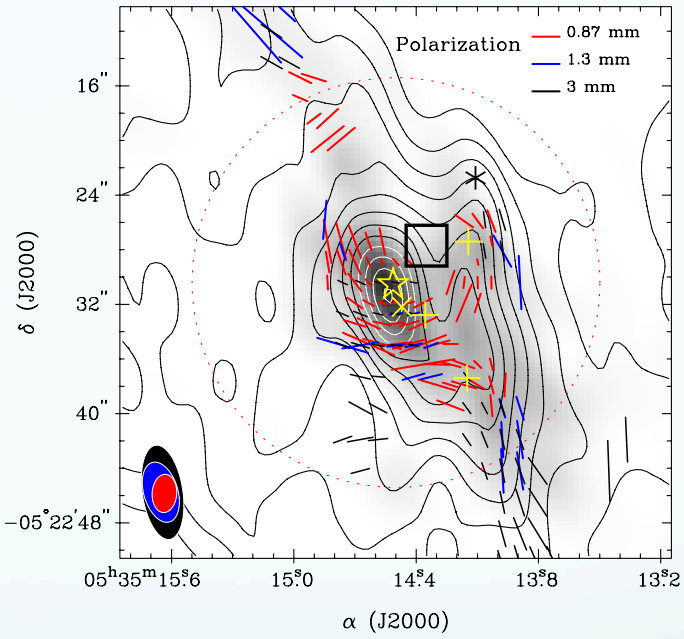
Mosaic Polarization Observation

Mosaic



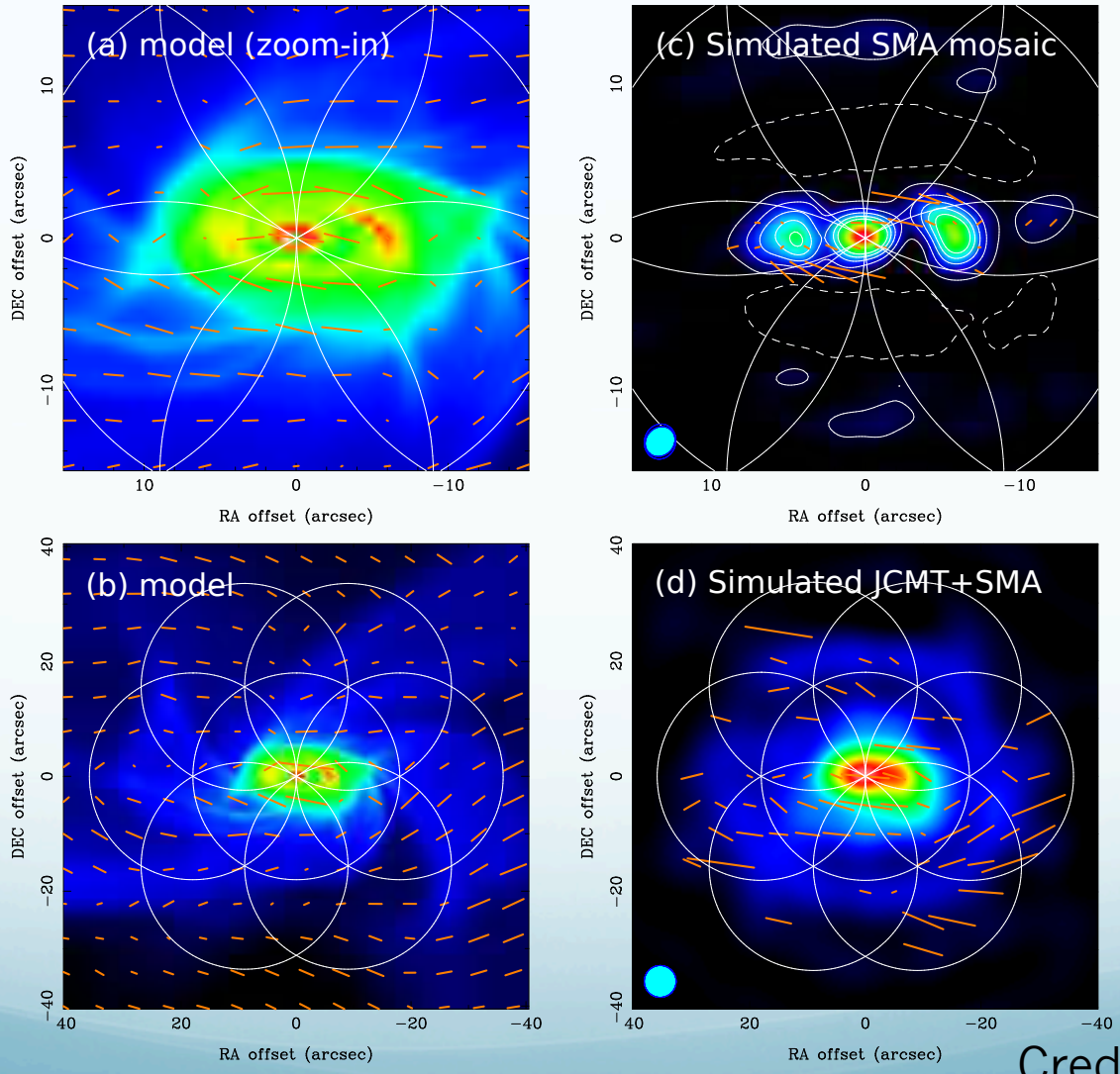
CARMA 1.3 mm
Hull et al. 2013

Single-pointing



SMA 0.87 mm
BIMA 1.3 mm; 3 mm
Rao et al. 1998
Tang et al. 2010

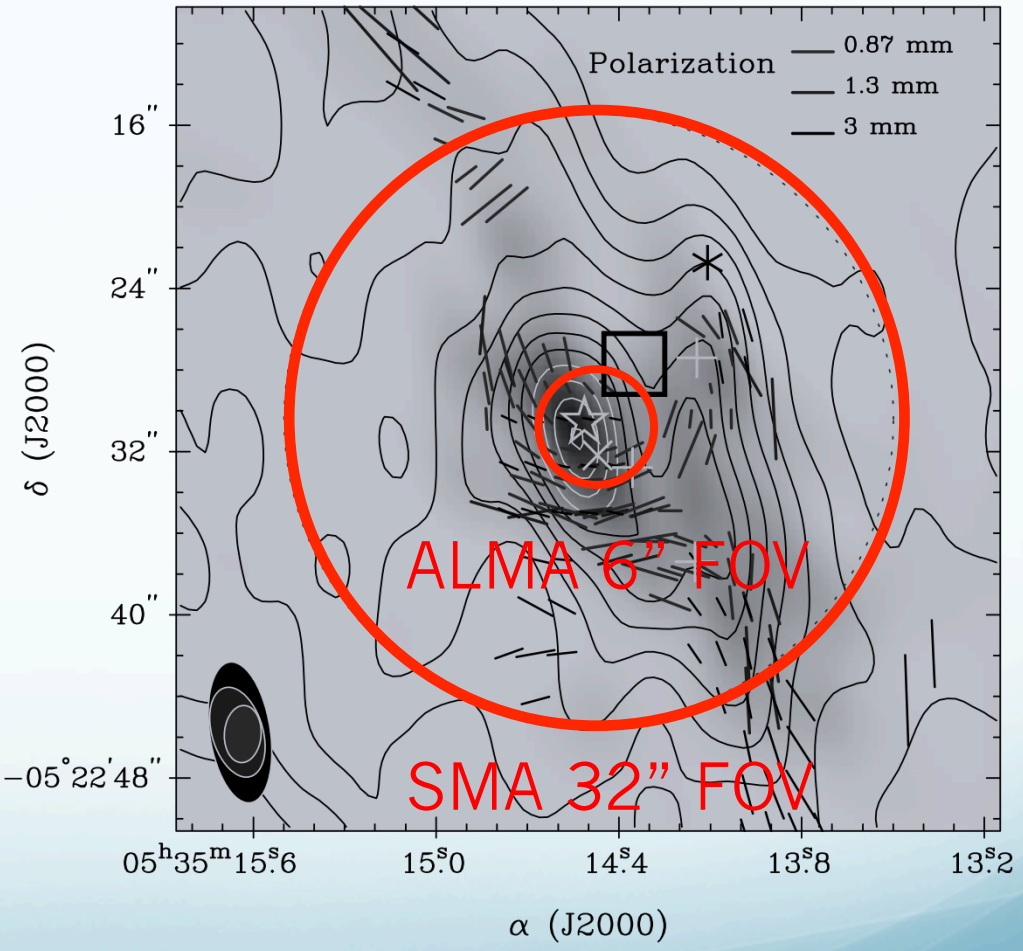
Simulated SMA + JCMT Mosaic Polarization Map



Credit: His-Wei Yen

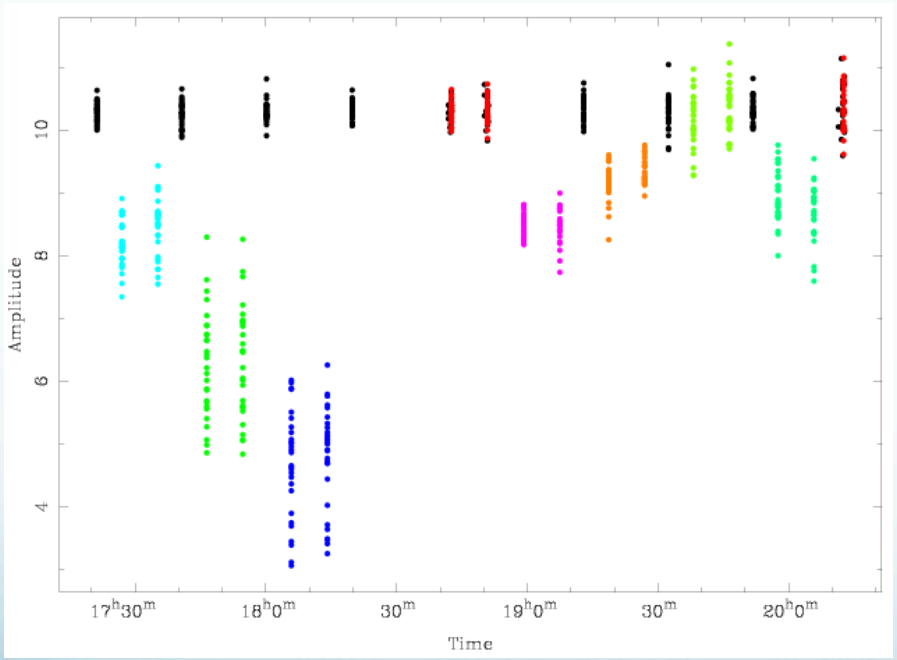
SMA v.s. ALMA

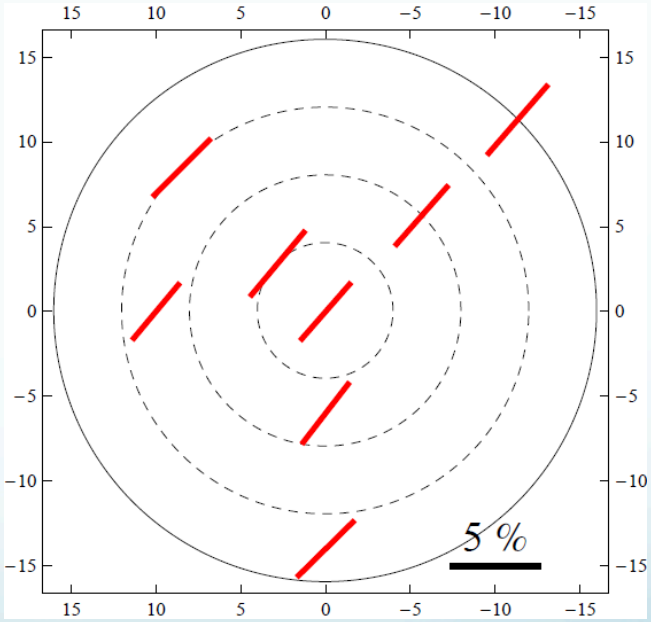
- ALMA Polarization
  - Sources must be centered (no positional offsets allowed)
  - FOV: 1/3 of primary beam
  - The minimum detectable degree of polarization is 0.1% for compact source and 0.3% for extended source
- SMA polarization FOV ~ 30x ALMA FOV



Off-axis polarization test

- Measure a standard polarization calibrator (quasar) at off-axis positions on SMA primary beam
- Apply on-axis polarization calibration to the off-axis positions and compare the polarization detections





ASIC 345 GHz off-axis polarization

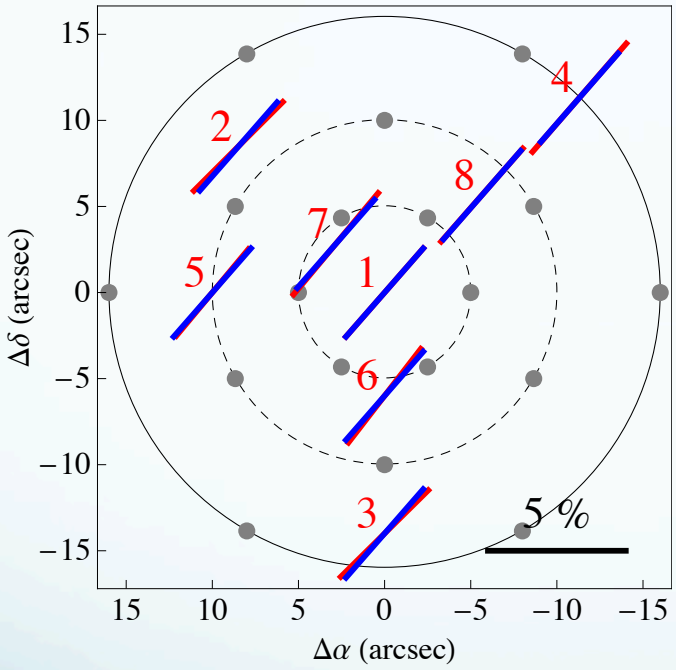
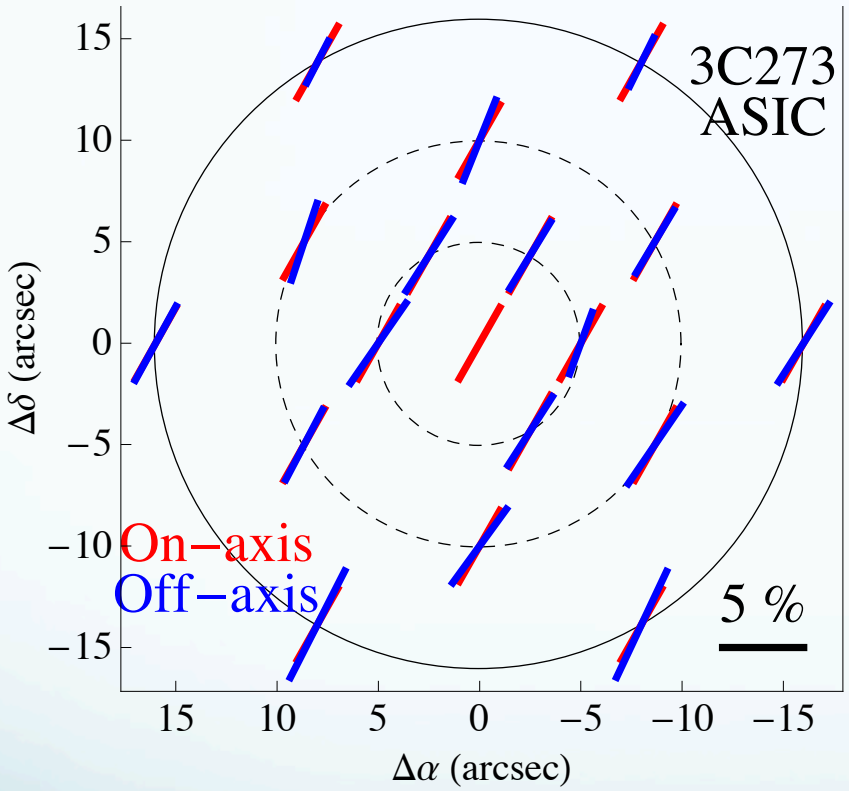


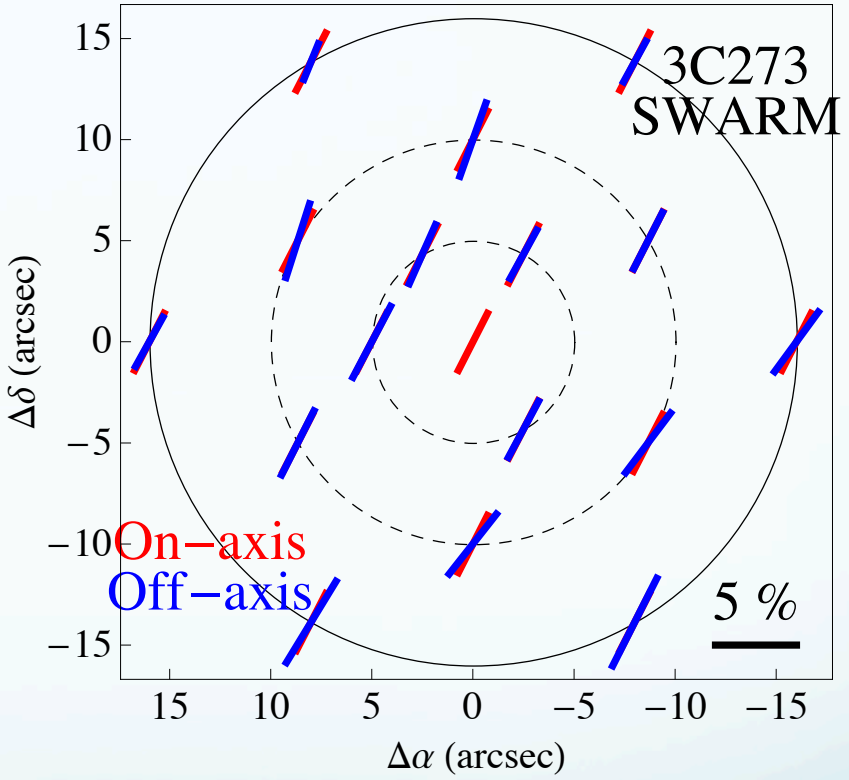
Table 1: SMA off-axis polarization measurements of 3C279

Position	Stokes Values (Jy/beam)			Pol (%)	PA (°)	Residual Polarization	
	I	*Q*	*U*			ΔPol (%)	ΔPA (°)
1	10.27	-0.059	-0.434	4.26 ± 0.08	138.9 ± 0.5	–	–
2	8.18	0.001	-0.373	4.56 ± 0.10	135.0 ± 0.6	0.30 ± 0.13	-3.9 ± 0.8
3	6.20	0.003	-0.277	4.47 ± 0.13	134.7 ± 0.8	0.21 ± 0.15	-4.2 ± 1.0
4	4.38	-0.033	-0.226	5.20 ± 0.18	139.2 ± 1.0	0.94 ± 0.20	0.3 ± 1.1
5	8.37	-0.062	-0.337	4.09 ± 0.10	140.2 ± 0.7	-0.17 ± 0.13	1.3 ± 0.8
6	9.14	-0.100	-0.380	4.30 ± 0.09	142.4 ± 0.6	0.04 ± 0.12	3.5 ± 0.8
7	9.98	-0.086	-0.471	4.79 ± 0.08	140.1 ± 0.5	0.53 ± 0.11	1.2 ± 0.7
8	8.45	-0.050	-0.376	4.49 ± 0.09	138.8 ± 0.6	0.23 ± 0.12	-0.2 ± 0.8

- $\Delta P = 0.3 \pm 0.1\%$
- Δ P.A. $< 5^0$
- Good performance of off-axis polarization in inner rings

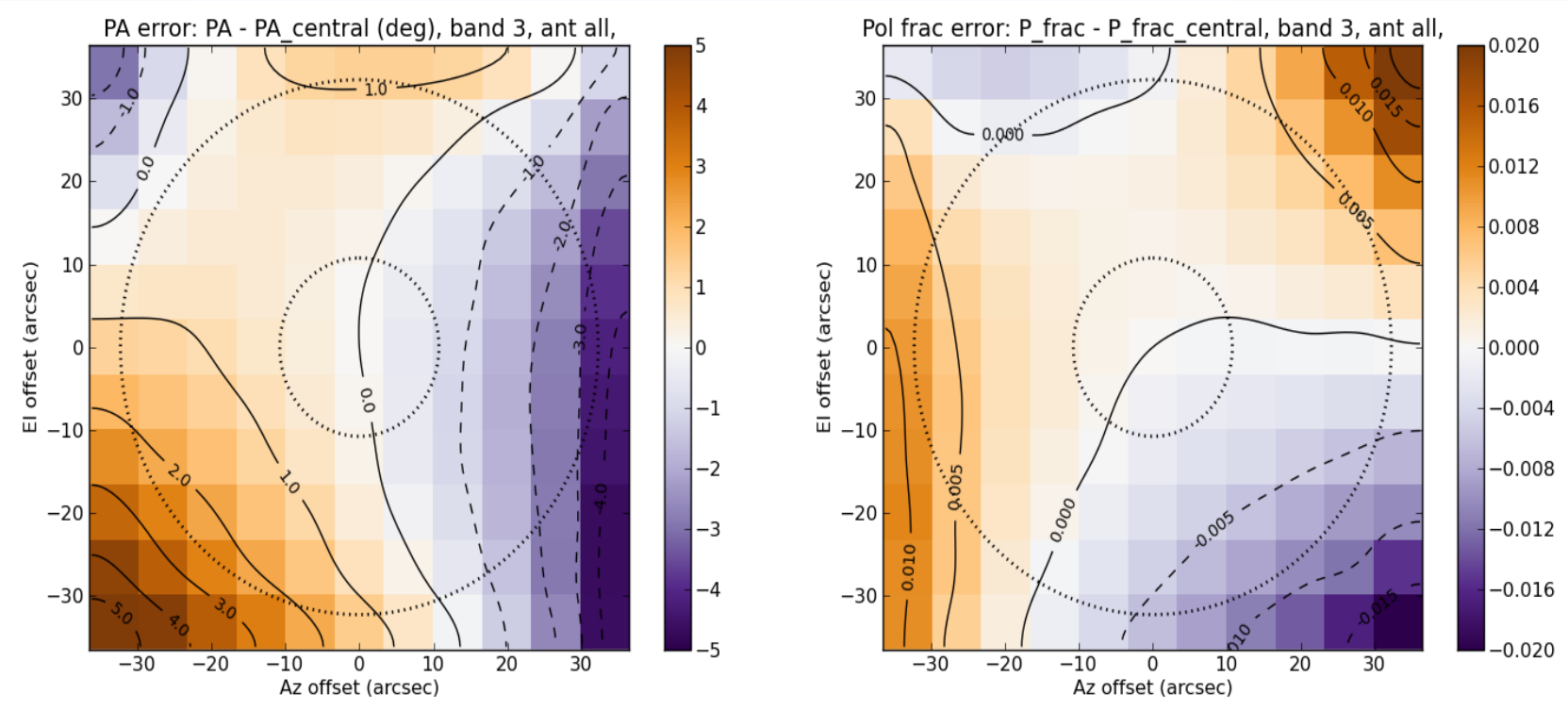
2016-05-27 230/240 GHz





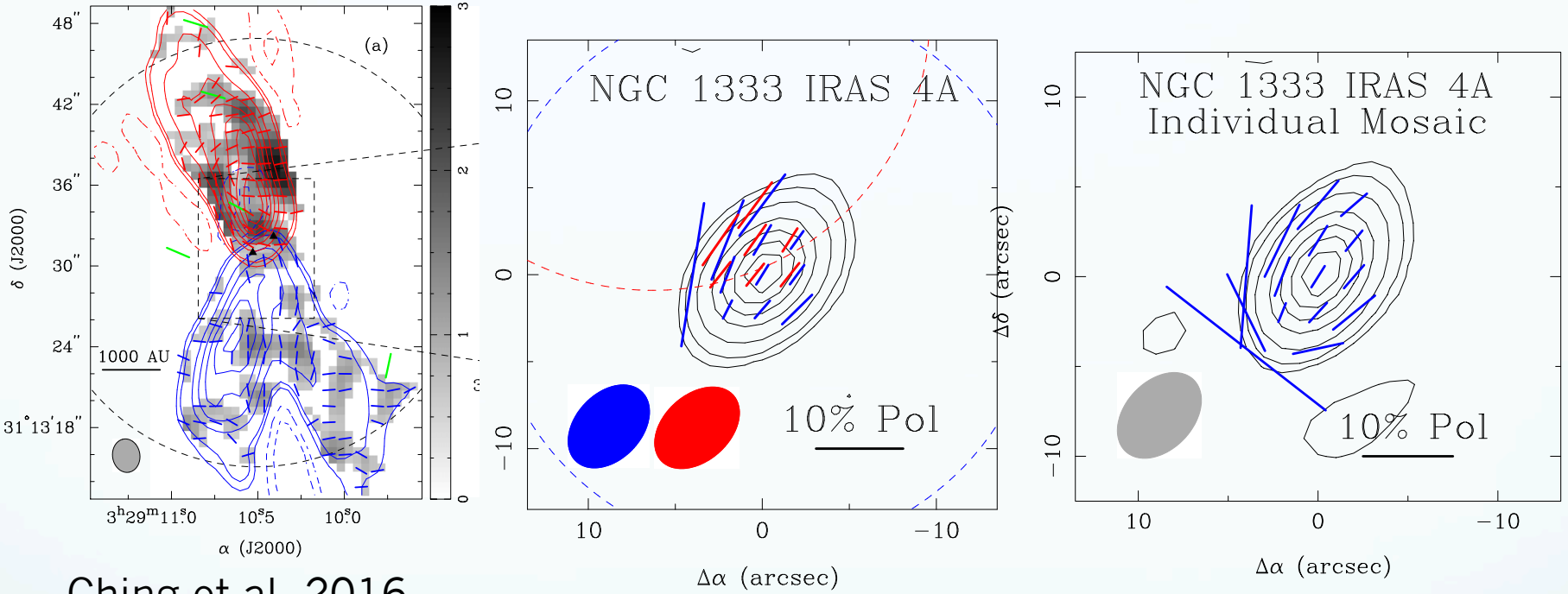
- Within a radius of 10”, the on-axis and off-axis polarization detections are consistent
- At a radius of 16”, the on-axis and off-axis polarization degrees can differ by 1-2%
- The SWARM polarization degrees are ~ 1% larger than ASIC

ALMA off-axis polarization



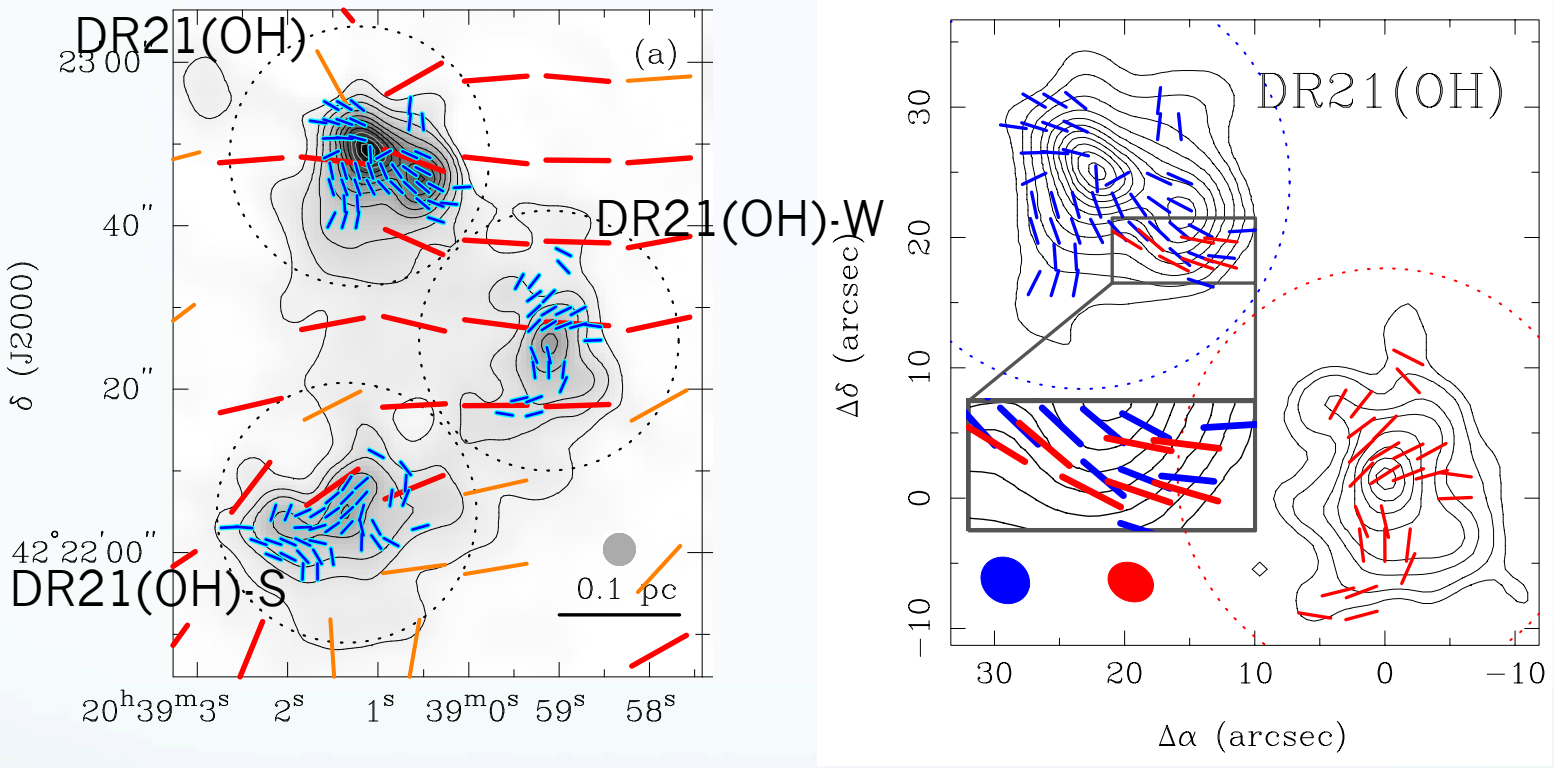
ALMA Polarization Commissioning
Credit: P. C. Cortes

Science Sources



Ching et al. 2016

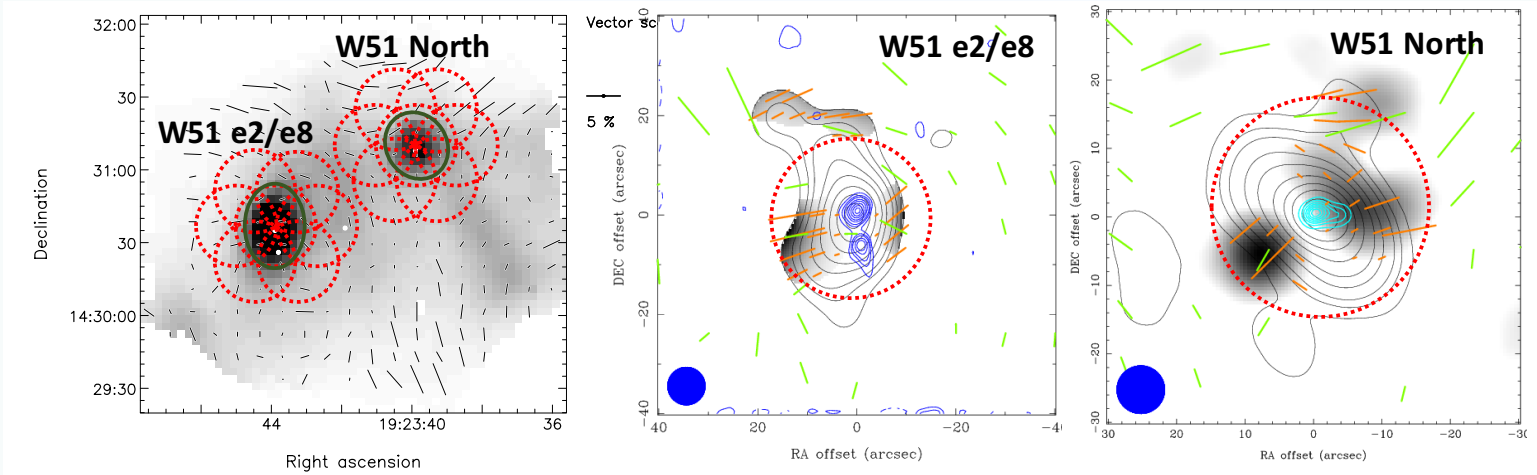
- At a positional offset of 16”
  - ΔPA = 6° ± 3° ~ PA $_{err}$ for 3-5 σ polarization detection
  - ΔPol = 0.5% ± 0.6%, in consistent with the 3C279 off-axis polarization test



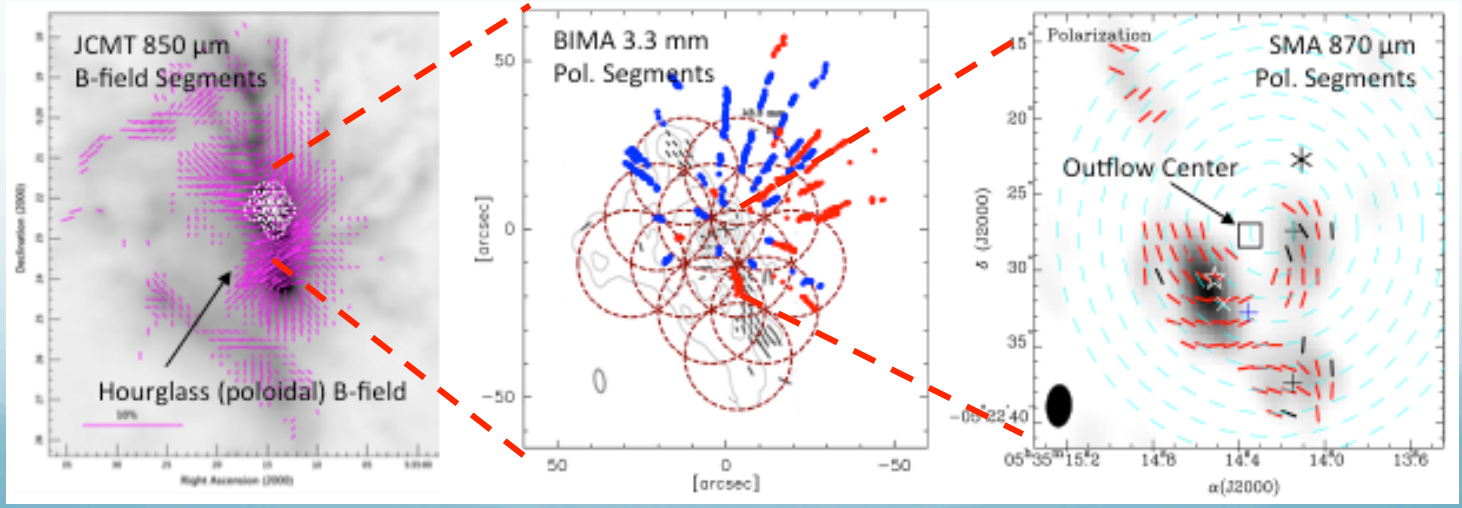
Girart et al. 2013
Ching et al. in prep.

- At a distance of 25”, ΔPA = 9°

- SMA 2016A 2016B proposals PI: T.-C. Ching
  - W51 e2/e8 & W51 north



  - Orion BN/KL

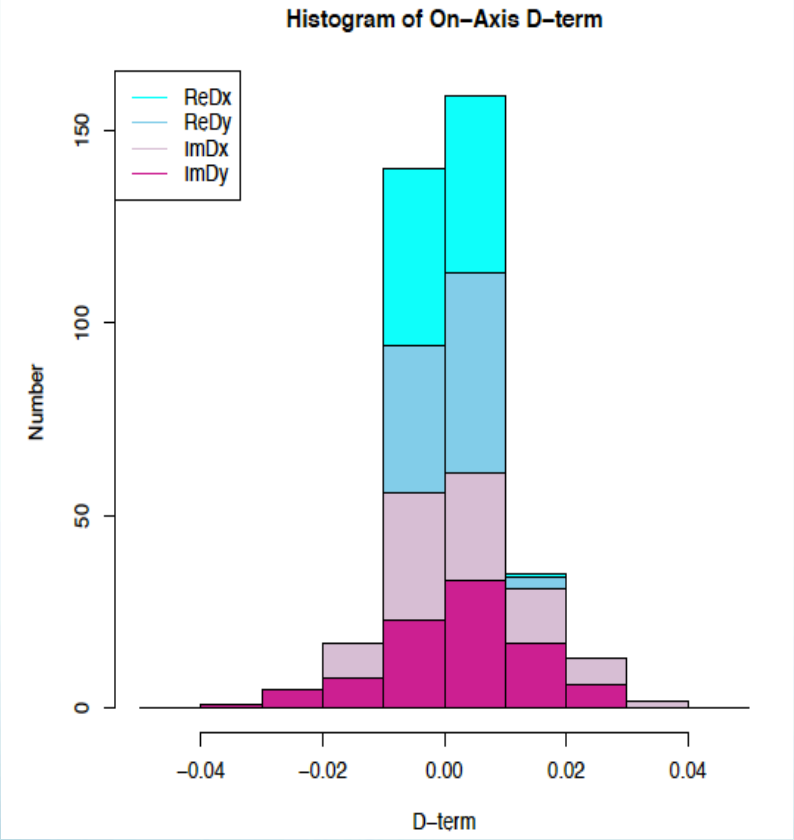


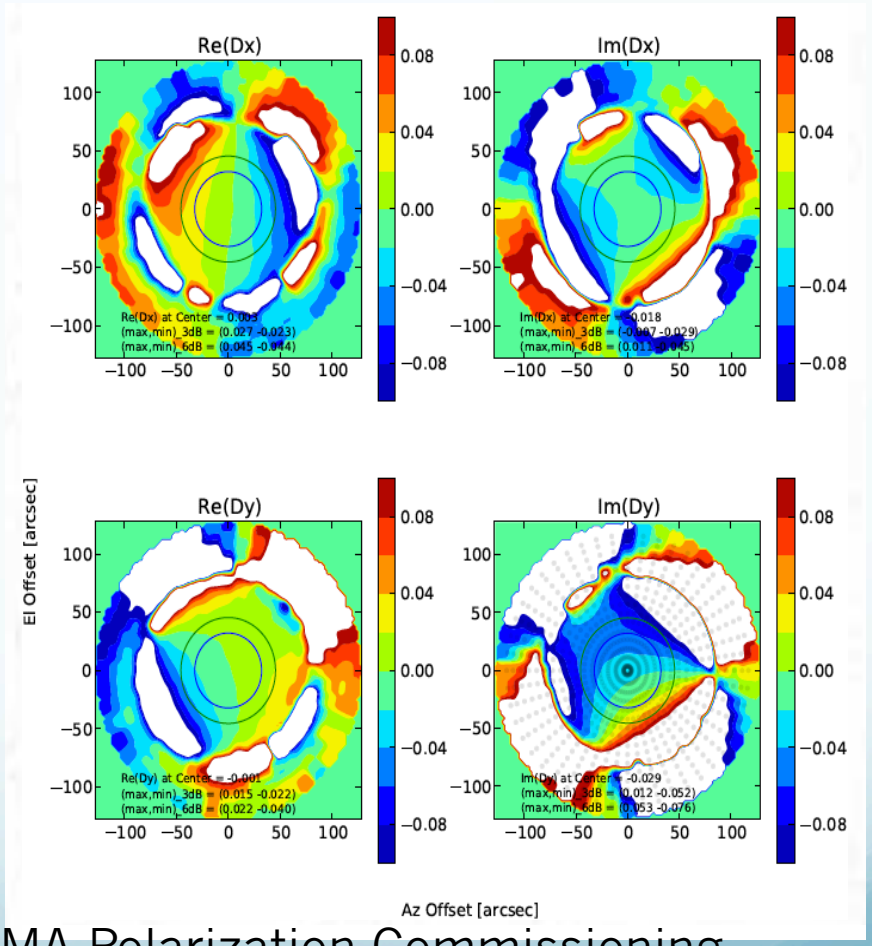
SMA Mosaic Polarization observations

- Science topics
  - B-field structures from clouds to cores
  - The relative importance between B-field and turbulence
  - Dust property in ISM
  - Outflow and B-field interaction
  - Galaxy, CMZ ?
- The advantage of SMA
  - The off-axis instrumental polarization of SMA is comparable to ALMA
  - FOV is 30x ALMA FOV
  - wSMA 4x bandwidth
  - JCMT polarization data is ready
  - ALMA full polarization in Cycle 6

Position	Stokes Values (Jy/beam)			Pol (%)	PA (°)	Residual Polarization	
	I	Q	U			ΔPol (%)	ΔPA (°)
On-axis	9.70	0.227	-0.314	3.96 ± 0.52	-27.1 ± 3.7	–	–
2	8.92	0.165	-0.259	3.40 ± 0.56	-28.8 ± 4.7	-0.56 ± 0.76	-1.7 ± 6.0
3	8.04	0.217	-0.240	3.98 ± 0.62	-23.9 ± 4.5	0.02 ± 0.81	3.2 ± 5.8
4	9.06	0.252	-0.375	4.96 ± 0.55	-28.0 ± 3.2	1.00 ± 0.76	-0.9 ± 4.9
6	9.05	0.198	-0.301	3.94 ± 0.55	-28.3 ± 4.0	-0.02 ± 0.76	-1.2 ± 5.4
7	9.90	0.229	-0.316	3.91 ± 0.51	-27.1 ± 3.7	-0.05 ± 0.73	0.0 ± 5.2
8	9.81	0.369	-0.297	4.80 ± 0.51	-19.4 ± 3.0	0.84 ± 0.73	7.7 ± 4.8
9	7.93	0.313	-0.221	4.79 ± 0.63	-17.6 ± 3.8	0.83 ± 0.82	9.5 ± 5.3
10	6.74	0.180	-0.243	4.43 ± 0.74	-26.7 ± 4.8	0.47 ± 0.90	0.4 ± 6.1
11	7.44	0.083	-0.344	4.71 ± 0.68	-38.2 ± 4.1	0.75 ± 0.86	-11.1 ± 5.5
12	9.72	0.125	-0.434	4.62 ± 0.52	-37.0 ± 3.2	0.66 ± 0.74	-9.9 ± 4.9
13	10.42	0.145	-0.454	4.55 ± 0.48	-36.2 ± 3.0	0.59 ± 0.71	-9.1 ± 4.8
14	10.27	0.159	-0.251	2.85 ± 0.49	-28.8 ± 4.9	-1.11 ± 0.71	-1.7 ± 6.1
15	6.64	0.118	-0.116	2.37 ± 0.75	-22.2 ± 9.1	-1.59 ± 0.91	4.9 ± 9.8
16	4.40	0.085	-0.137	3.48 ± 1.14	-29.0 ± 9.4	-0.48 ± 1.25	-1.9 ± 10.1
17	4.86	0.133	-0.258	5.88 ± 1.04	-31.4 ± 5.0	1.92 ± 1.16	-4.3 ± 6.2
18	7.57	0.273	-0.371	6.05 ± 0.67	-26.8 ± 3.1	2.09 ± 0.85	0.3 ± 4.8

ALMA D-terms





ALMA Polarization Commissioning
Credit: P. C. Cortes

- **Full Polarization** measurements using TDM and FDM modes will be offered in Cycle 4 for 12-m Array observations only in Bands 3, 6 and 7. This is a non-standard mode, limiting the total time available for such observations. Sources must be centered (no positional offsets allowed) and have a user-specified largest angular structure that is less than one-third of the 12-m Array primary beam at the frequency of the planned observations. The expected minimum detectable degree of polarization is 0.1%(1%) for compact sources and 0.3%(3%) for extended sources for TDM (FDM) observations, respectively. Observations must be single-field, but measurements of several individual sources within one Science Goal are possible (one field per source; see below). Full polarization is not offered in spectral scan mode. The frequency settings for continuum polarization measurements can be specified by the user, but the OT supplies default setups as detailed in Table A.5. For FDM mode polarization observations any frequency setting within Bands 3, 6 and 7 is allowed, and the spectral setup has to be the same for the polarization calibrator and the science target.

- ambitious, 連自己人都不懂 polarization observation, mosiac observation
- what interferometer polarization mosaic can do
- sma fov and alma fov
- alma D-terms, 1%(0.1%) restrict, 3% (0.3%)
- sma off-axis leakage test
- sma off-axis D-terms
- sma science results
- future works