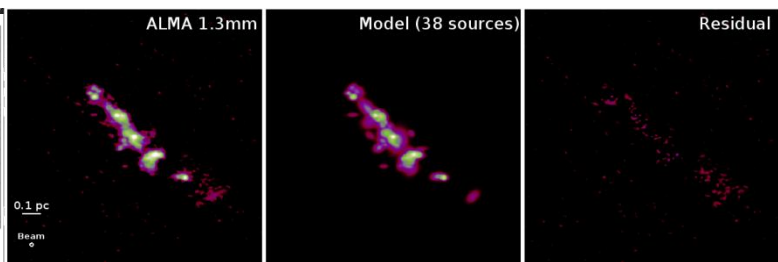
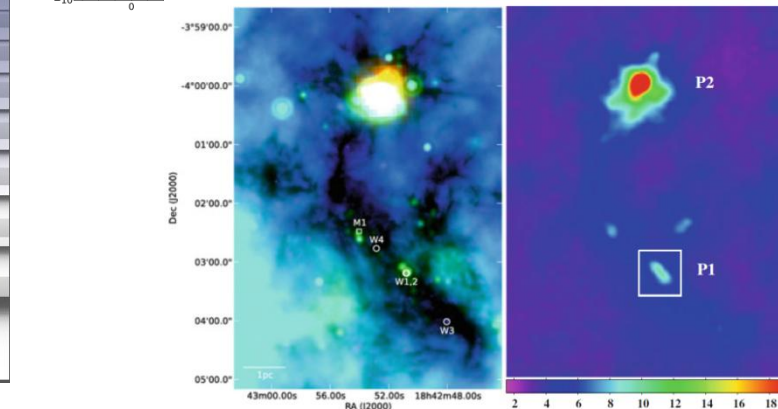
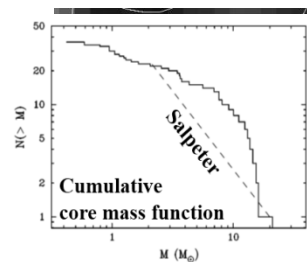
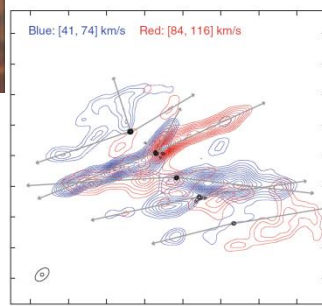
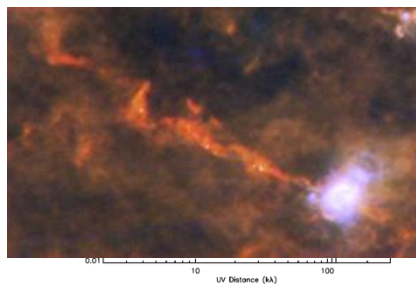
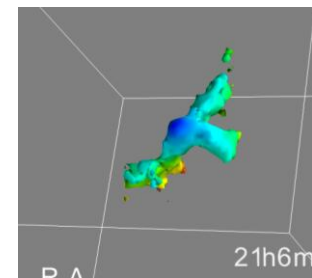
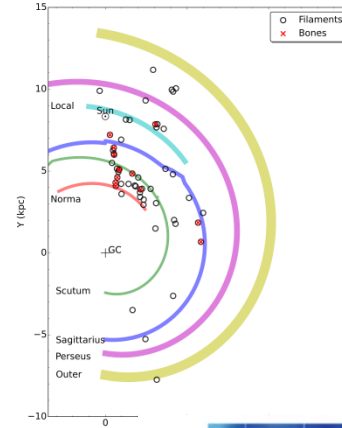
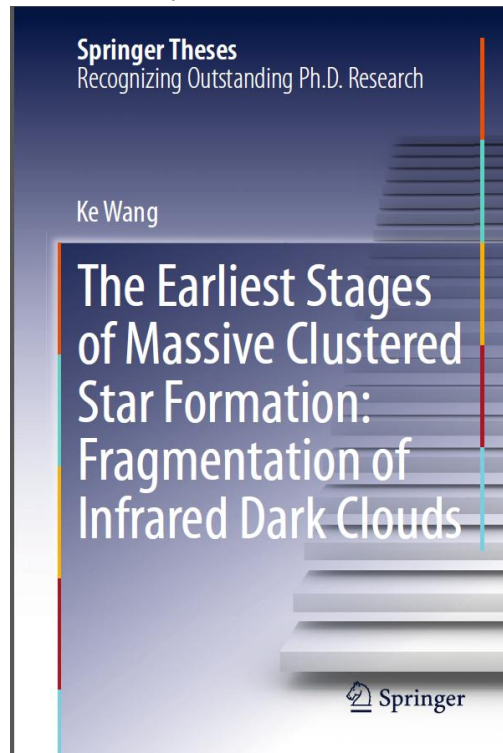
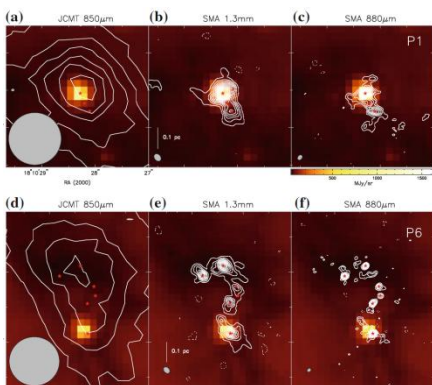
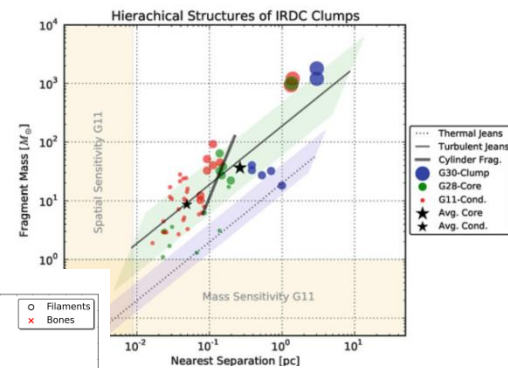
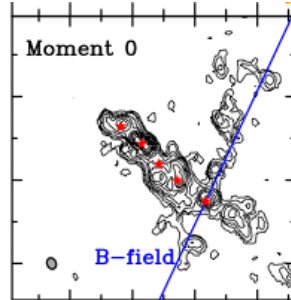
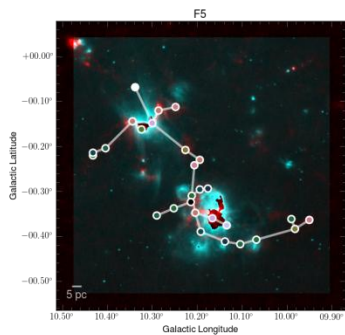
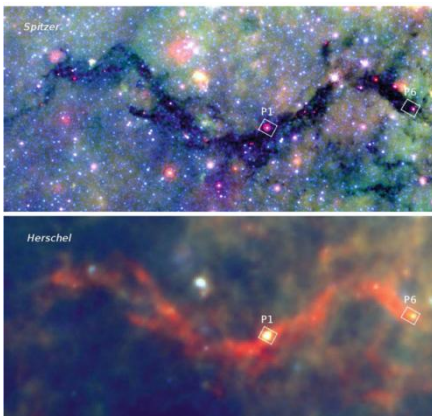


SAMPLING

ESO Public Survey towards *Planck* Galactic Cold Clumps

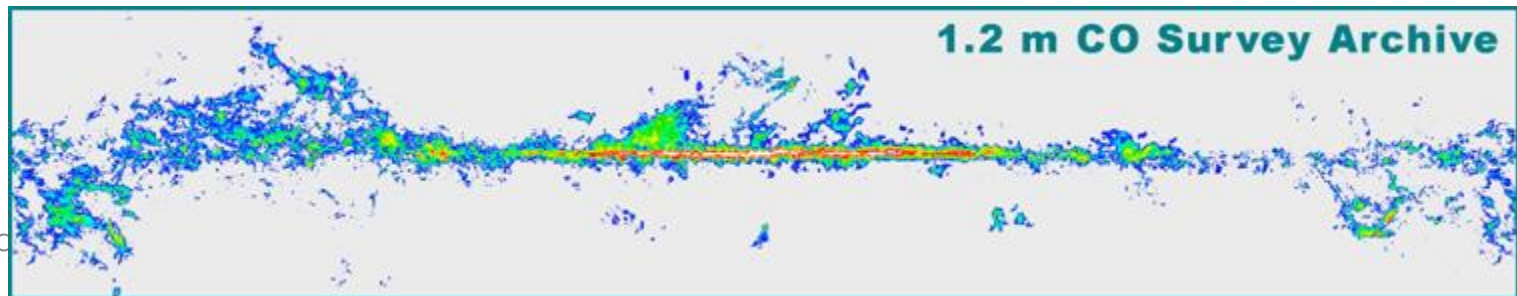
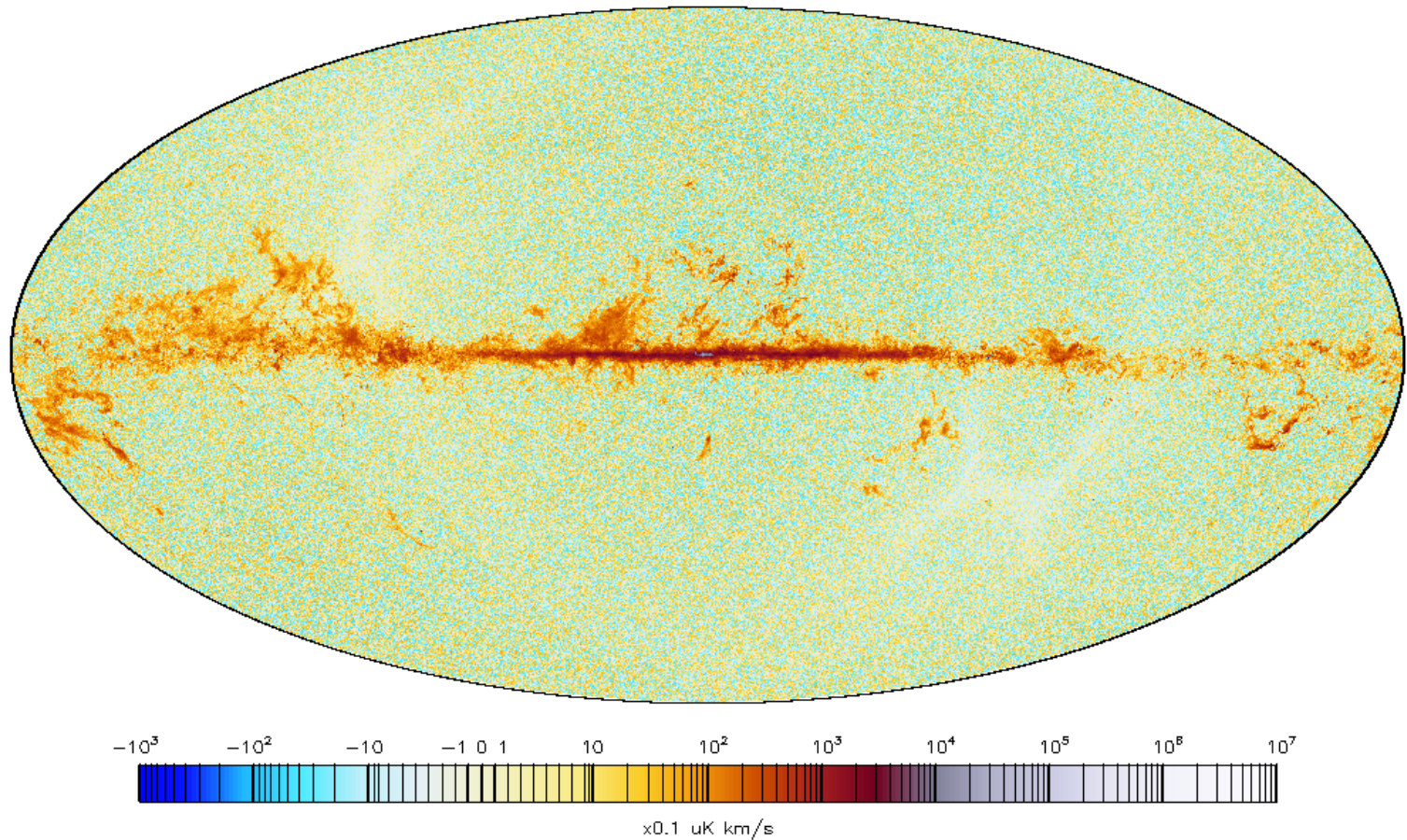
Ke Wang
& the *SAMPLING* team



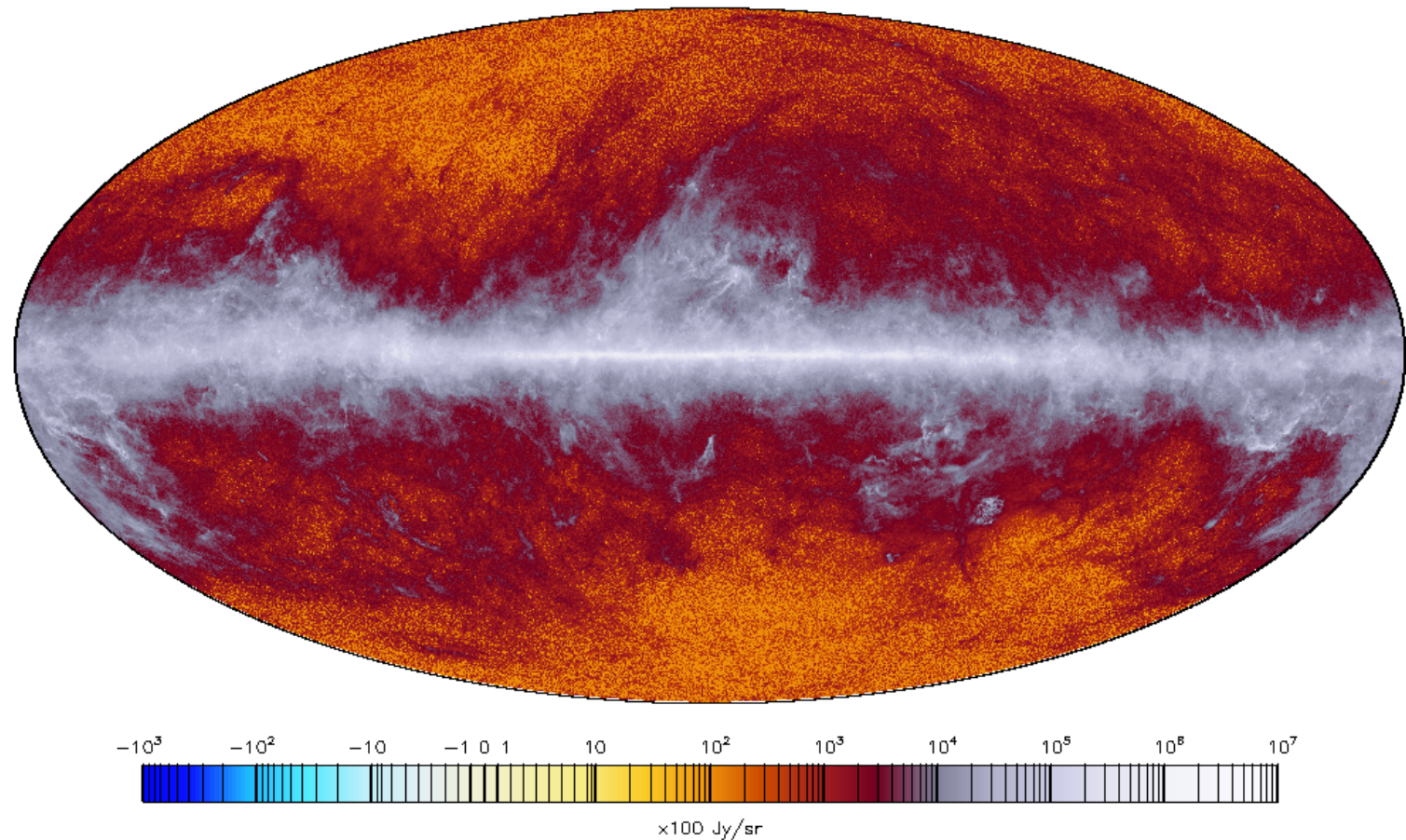


Ke Wang (ESO)

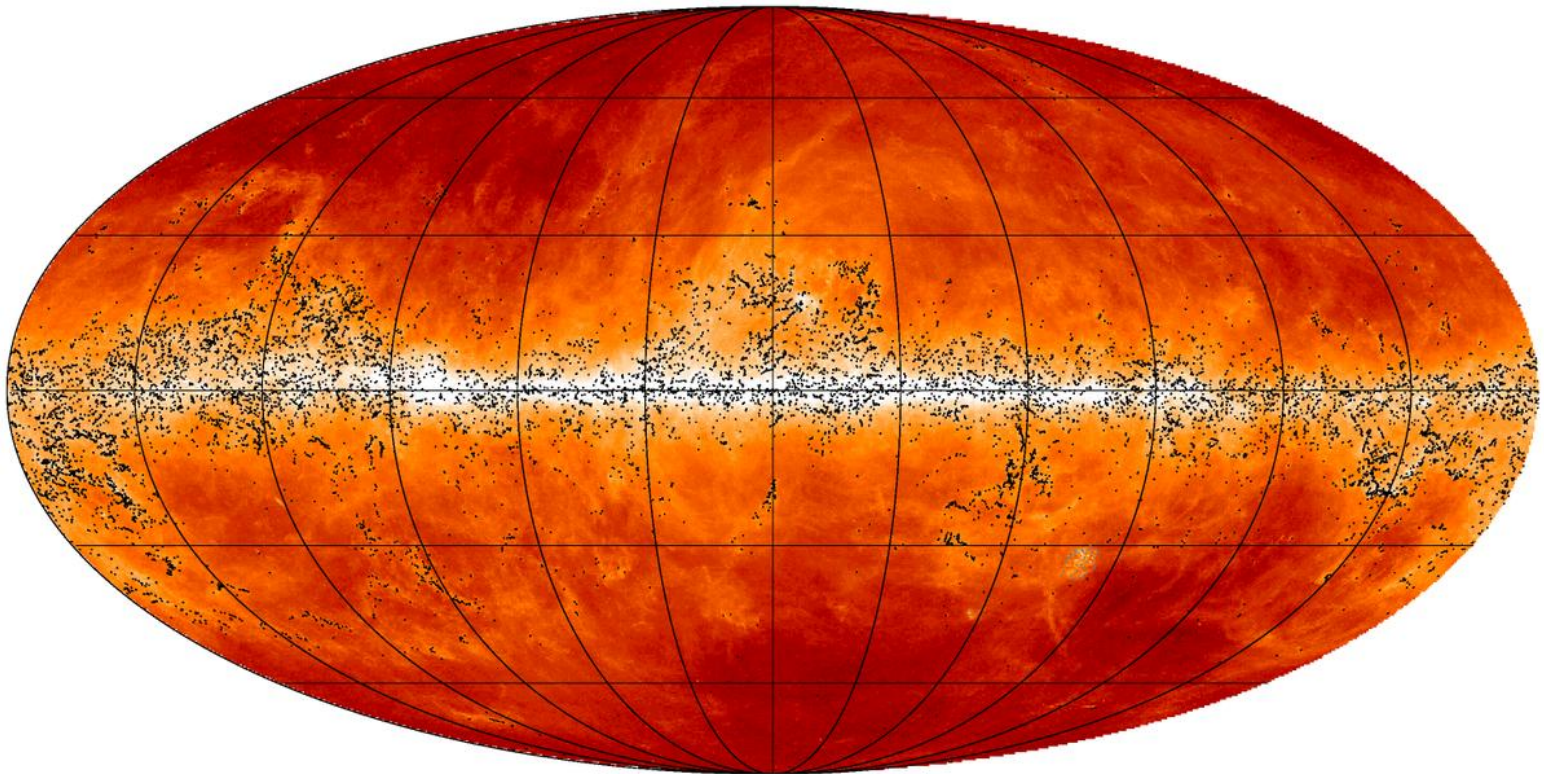
Planck CO(2-1) integrated



Planck thermal dust



13,188 PGCC



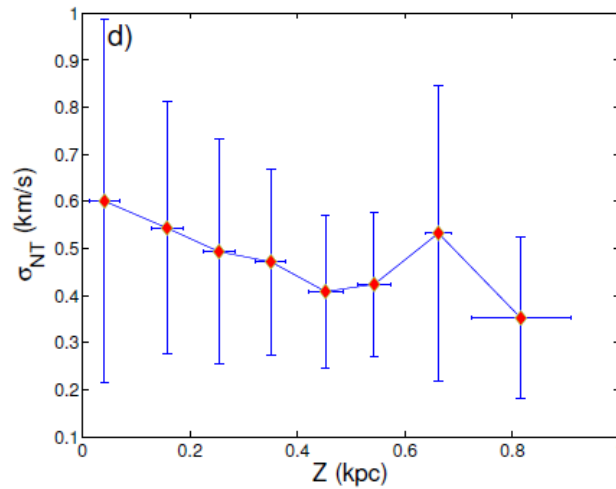
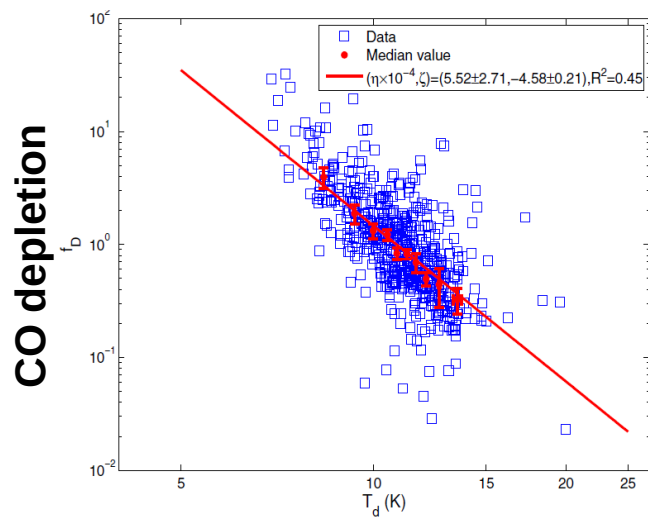
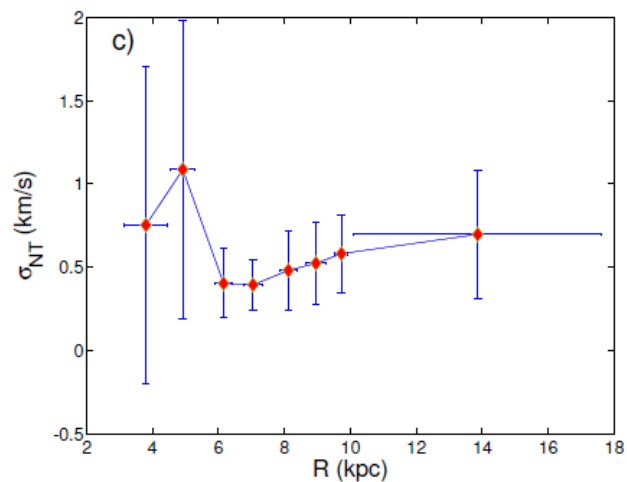
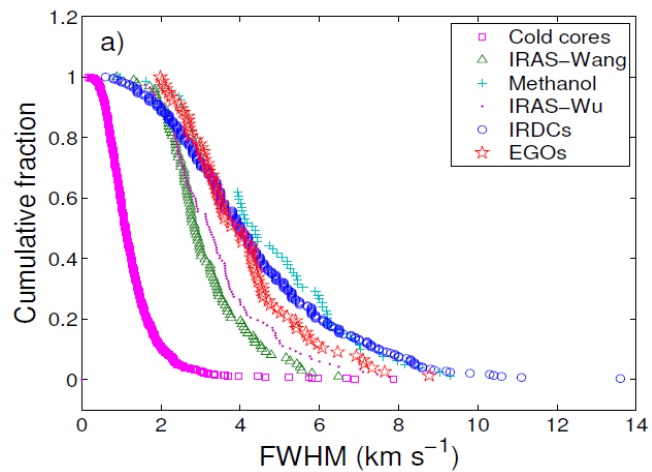
Continuum follow-up with *Herschel*

- Galactic cold cores (GCC), see Mika's talk
- Hi-GAL on Galactic plane
- Other key programs on local clouds and selected high-mass star-forming regions
- Resolution $\leq 36''$

Spectroscopic follow-up with PMO 14m*

- By the group of Prof. Yuefang Wu (Peking University, China)
- **674** sources observed in $^{12}\text{CO}/^{13}\text{CO}/\text{C}^{18}\text{O}$ (1-0) single-point and then mapping (Wu et al. 2012; in prep; Liu et al. 2013, Meng et al. 2014, Zhang et al. in prep)
- **621** sources observed in HCO^+ , HCN (1-0) single-point (Yuan et al. 2016)
- Resolution $\sim 1''$
- ➔ Provides position and V_{LSR} for SMT observations in $^{12}\text{CO}/^{13}\text{CO}$ (2-1)

* Other spectral follow-ups see Orsolya's talk and next talk "TOP-SCOPE"

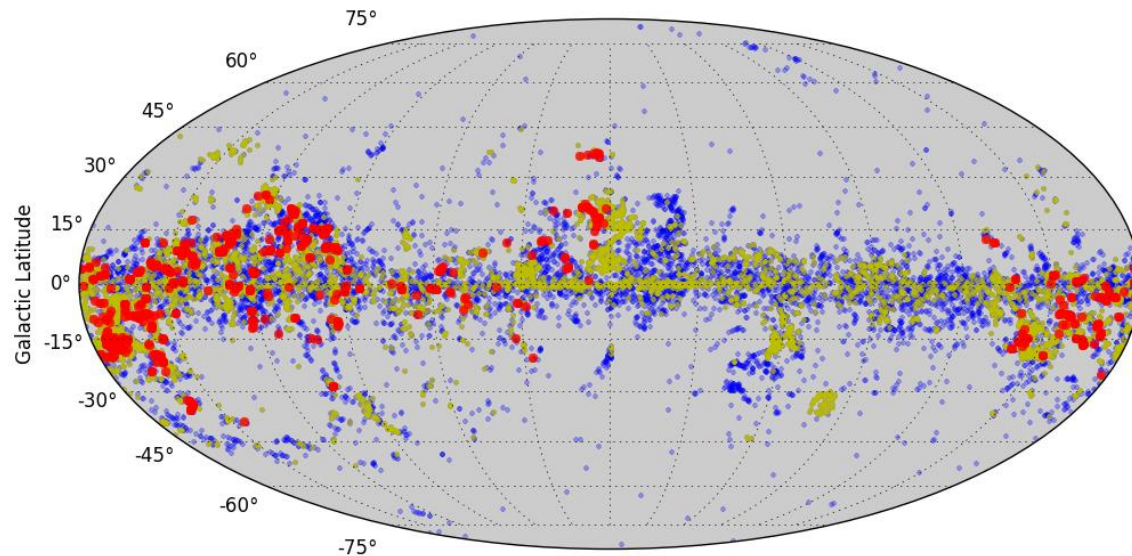


T_{dust}

Wu et al. 2012

The ESO Public Survey **SAMPLING** (2015-2018)

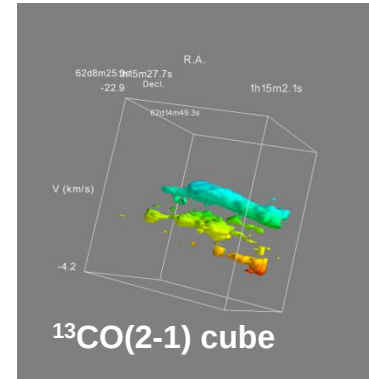
SMT "All-sky" Mapping of *PLanck* Interstellar Nebulae in the Galaxy



Planck catalog

With distance

SAMPLING targets



- High-resolution (35") spectral-imaging of 600+ molecular clouds revealed by the unbiased *Planck* all-sky Galactic cold clumps catalog.
- The survey will provide the first major step forward to characterize molecular clouds and star formation on *truly Galactic scales*.
- Currently 1/3 completed (~220 h); first data release planned in **September 2016**. Real-time progress at project website <http://sky-sampling.github.io>
- Survey team is comprised of 60+ researchers from Europe, Asia, Australia, and Americas (PI: Ke Wang, ESO).



Arizona Radio Observatory



Photo courtesy: Dave Harvey

SMT

The **ARO** offices are centrally located in the [Steward Observatory](#) building on the campus of the [University of Arizona](#) in Tucson Arizona.

ARO's New 12 m: The European ALMA Prototype Antenna Arrives at Kitt Peak

ARO has a new 12 Meter telescope. In March 2013, an agreement was signed with ESO that

The **Arizona Radio Observatory (ARO)** owns and operates two radio telescopes in southern Arizona: A 12 Meter Alma Prototype Telescope located 50 miles South-West of Tucson on [Kitt Peak](#) and the Submillimeter Telescope ([SMT](#)) located on [Mt. Graham](#) near Safford, Arizona.

Combined, the two telescopes routinely cover the entire millimeter and submillimeter windows from about 4.6 mm to about 0.6 mm, and at the **SMT** observations can be made all the way to 0.3 mm with PI instruments.

The telescopes are operated around-the-clock for about 9 to 10 months per year for a combined 10,000 hours per observing season (about 1500 hours are dedicated to sub-mm wavelengths at the **SMT**).



Photo: Thomas Folkers

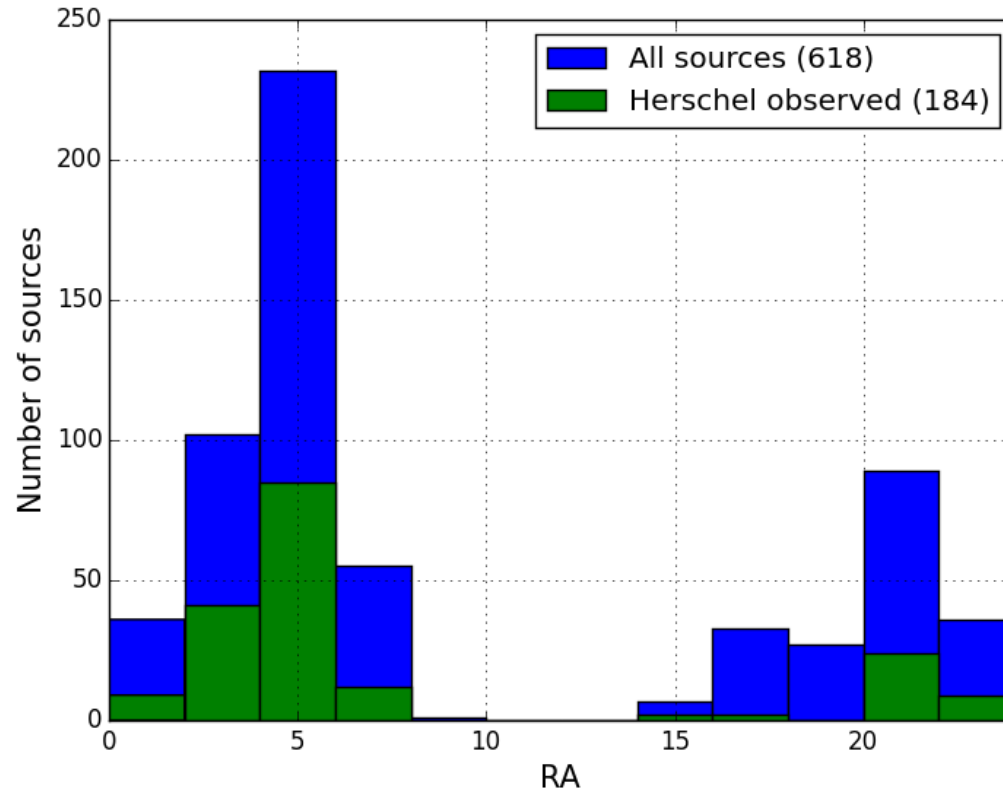
(NEW) KP12m

1 Title: Probing the Early Stages of Star Formation: Unravelling the Structure of *Planck* Cold Clumps Distributed Throughout the Sky

PI: K. Wang (ESO Garching, Germany)
CoIs: L. Testi, A. Ginsburg, S. Zahorecz, Z.Y. Zhang, K. Immer (ESO Garching, Germany)
P. Caselli, J. Pineda, V. Sokolov, S.-Y. Feng, G.X. Li (MPE, Germany)
H. Beuther, Th. Henning (MPIA, Germany)
T. Pillai (MPIR, Germany)
A. Meng, X. Guan (Universität zu Köln, Germany)
T. Liu, C.W. Lee, K.T. Kim, M.C. Lee (KASI, Korea)
Y.F. Wu, C.P. Zhang, P. Chen, T.W. Zhang, X.C. Liu, R.J. Hu (Peking University, China)
D. Li, J.H. Yuan (NAOC, China)
J. Yang (PMO, China)
K.P. Qiu (Nanjing University, China)
S.L. Qin (Yunnan University, China)
S.Y. Liu, N. Hirano, H.B. Liu, Y.W. Tang (ASIAA, Taiwan)
H.R. Chen, S.P. Lai (National Tsing Hua University, Taiwan)
K. Tatematsu, P. Sanhueza (NAOJ, Japan)
F. van der Tak (SRON, The Netherlands)
E. Falgarone (LERMA, ENS, France)
I. Ristorcelli, L. Montier, A. Hughes (IRAP, France)
M. Beltran, F. Fontani, M. Walmsley (INAF Arcetri, Italy)
M. Juvela (University of Helsinki, Finland)
L.V. Tóth (Eötvös University Budapest, Hungary)
Y. Wang (Univ. Geneva, Switzerland)
A. Rivera-Ingraham (ESA/ESAC, Spain)
G. Fuller (University of Manchester, UK)
M. Thompson (University of Hertfordshire, UK)
I. Jimenez-Serra (University College London, UK)
S. Longmore (Liverpool John Moores University, UK)
N. Peretto (Cardiff University, UK)
R. Galvan-Madrid (UNAM, Mexico)
L. Ziurys, B.E. Svoboda (Arizona Radio Observatory/University of Arizona, USA)
Q. Zhang, X. Lu, C. Battersby (Harvard CfA, USA)
P.F. Goldsmith (NASA/JPL, USA)
J. Tan, S. Kong (University of Florida, USA)
J. Malinen (Florida State University, USA)
P. McGehee, R. Paladini (IPAC, Pasadena, USA)
F.J. Du (University of Michigan, USA)
M. Cunningham, P. Jones, V. Lowe (University of New South Wales, Australia)
J. Rathborne (CSIRO Astronomy and Space Science, Australia)
D. Mardones, L. Bronfman, L. Zhu, N. Lo (University of Chile, Chile)

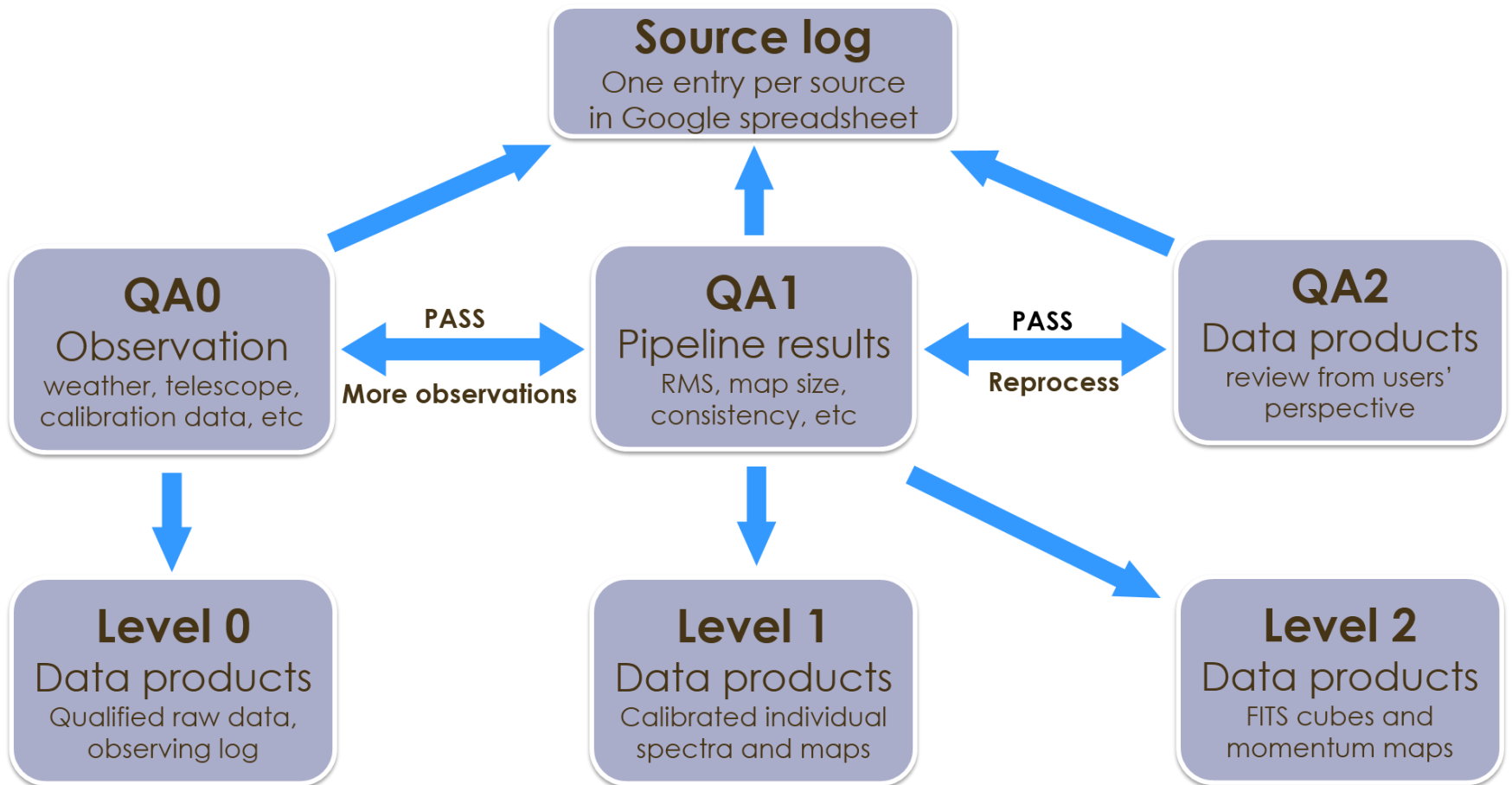
Technical Goals

- **618** clumps from ~500 PGCCs, selected from the “most reliable” 915 ECCs, mapped with PMO 14m in CO (1-0) isotopologues
- 618 hours allocated for 3 years (2015–2018)
- 0.33 km/s channel width x 128 channels
- 5'x5' OTF maps in $^{12}\text{CO}/^{13}\text{CO}$ (2-1)
- rms 0.2 K, dual polarization
- SMT beam $\sim 35''$, comparable to *Herschel* 500 μm beam



- Scheduling prioritized to sources already observed by *Herschel* (GCC and other key programs) and JCMT/SCUBA in continuum

Data Quality Assurance



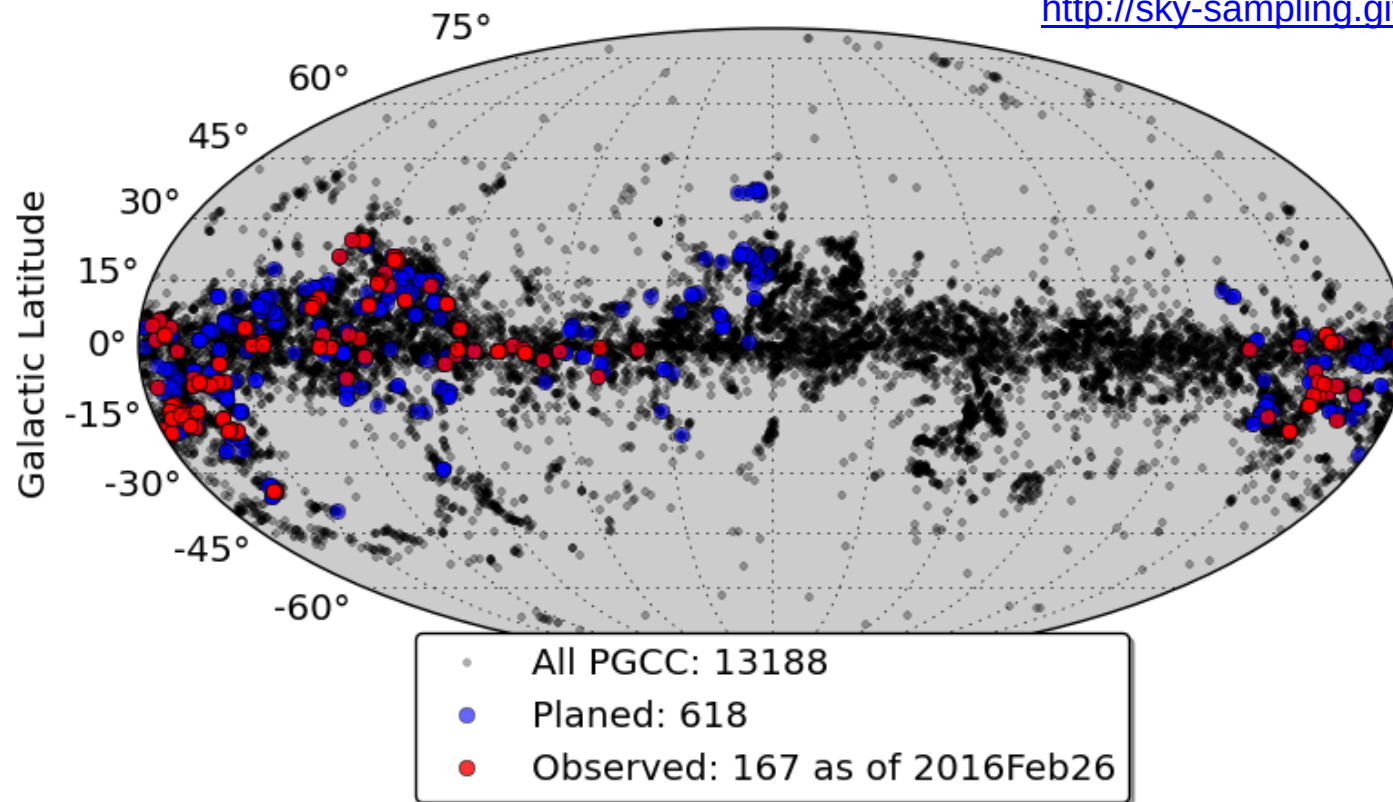
Data QA team

Table 1: Data Quality Assurance Team

Member Name	QA0 Observation	QA1 Reduction	QA2 Review	Operated SMT	Operated Telescopes	Time Zone
Izaskun Jimenez-Serra	✓	✓	✓		✓	Europe UTC+1
Ke Wang	✓	✓	✓		✓	UTC+2
Sarolta Zahorecz	✓	✓	✓		✓	UTC+2
Yuan Wang	✓	✓	✓		✓	UTC+2
Zhiyu Zhang	✓	✓	✓	✓	✓	UTC+2
Maite Beltran			✓	✓	✓	UTC+2
Francesco Fontani			✓		✓	UTC+2
Vlas Sokolov	✓	✓	✓		✓	UTC+2
Alana Rivera	✓	✓	✓		✓	UTC+2
Annie Hughes	✓	✓	✓		✓	UTC+2
Viktor Toth	✓	✓	✓		✓	UTC+2
Siyi Feng	✓	✓	✓		✓	UTC+2
Mika Juvela	✓	✓	✓		✓	UTC+2
Jiame Pineda			✓		✓	UTC+2
Thushara Pillai		✓	✓		✓	UTC+2
Katharina Immer	✓	✓	✓		✓	UTC+2
Baobab Haiyu Liu	✓				✓	UTC+2
Gary Fuller		✓	✓		✓	UTC+2
Adam Ginsburg		✓	✓		✓	UTC+2
Asia-Pacific						
Yuefang Wu			✓		✓	UTC+8
Vivien Chen	✓	✓	✓	✓	✓	UTC+8
Keping Qiu	✓	✓	✓		✓	UTC+8
Naomi Hirano	✓			✓	✓	UTC+8
Jinghua Yuan	✓	✓	✓		✓	UTC+8
Xing Lu	✓	✓	✓		✓	UTC+8
Tie Liu	✓	✓	✓		✓	UTC+9
Patricio Sanhueza	✓				✓	UTC+9
Maria Cunningham	✓	✓	✓		✓	UTC+10
Americas						
(ARO) Brian Svoboda	✓	✓	✓	✓	✓	UTC-7
Roberto Galvan-Madrid	✓	✓	✓		✓	UTC-5
Shuo Kong			✓	✓	✓	UTC-4
Lei Zhu	✓	✓	✓		✓	UTC-3
Subtotal	24	24	29	6	30	

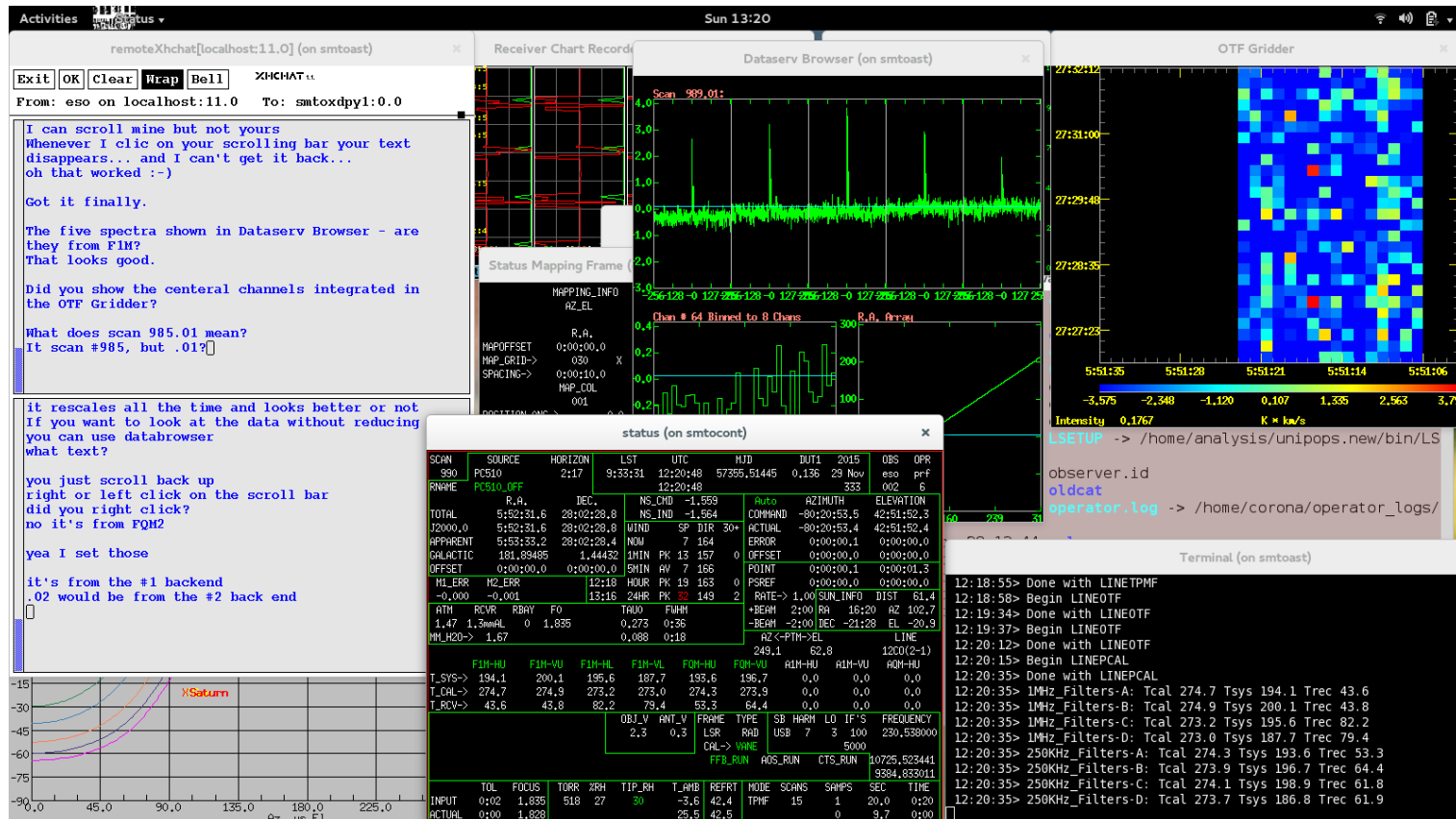
1st year progress

<http://sky-sampling.github.io>



- 26 observing shifts, Nov 2015 -Feb 2016
- 1.11 h per source on average
- rms 0.16-0.18 K
- QA0: completed (12 observers), QA1: 70% completed; QA3: 0

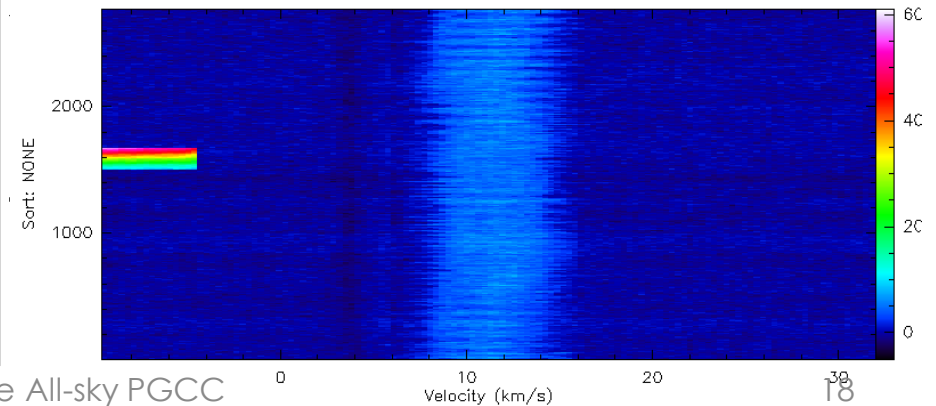
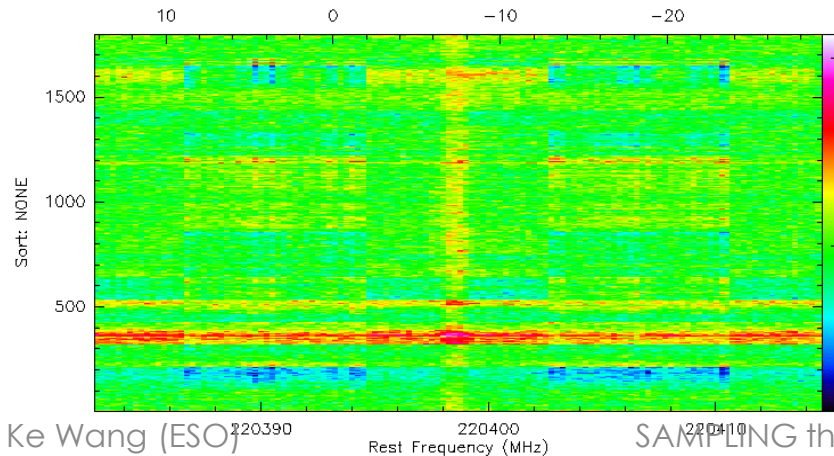
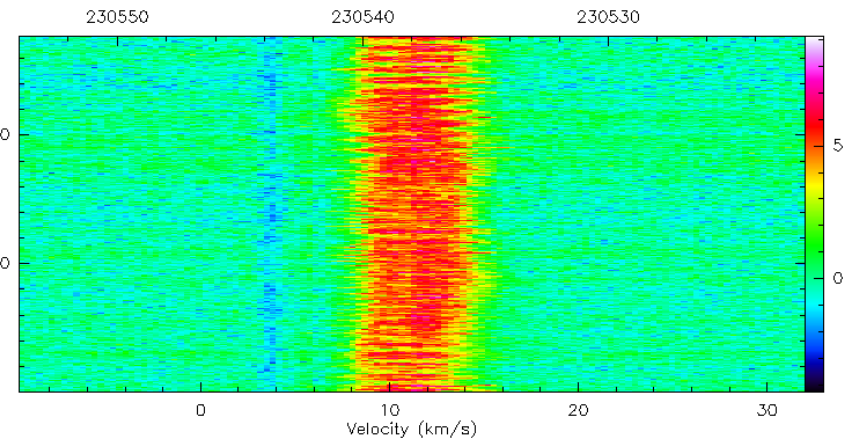
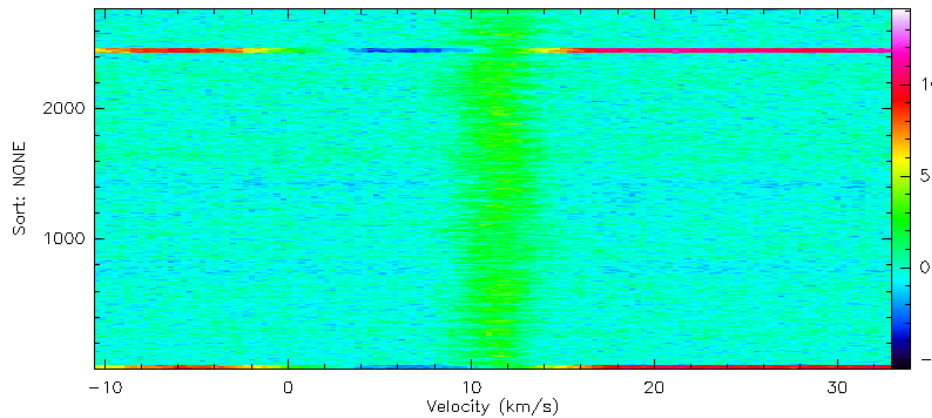
Remote observations



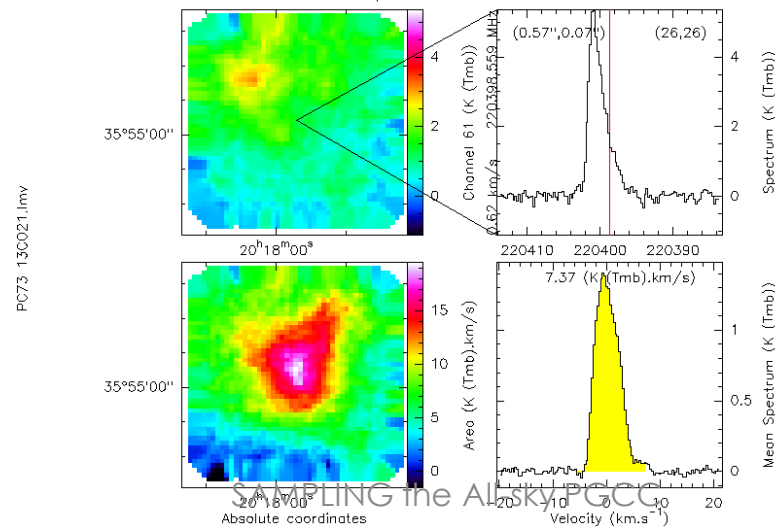
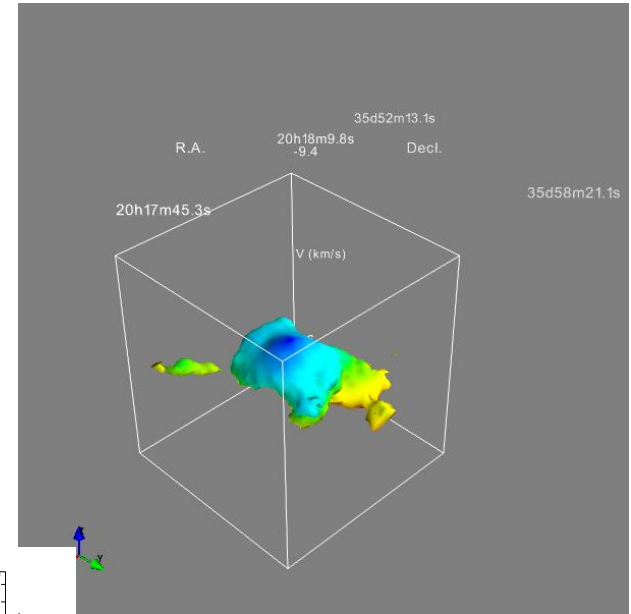
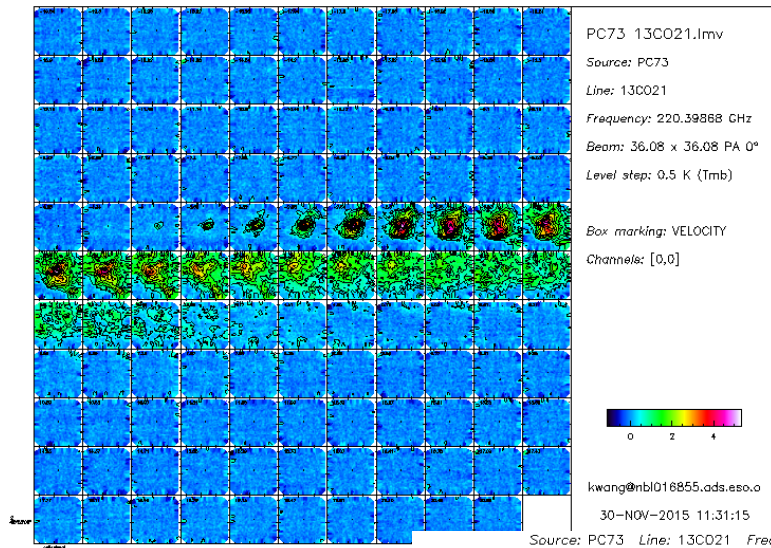
Flagging bad data

PC71 RA: 20:14:50.000 DEC: 31:59:00.00 Eq 2000.0
 Scan: 7195-7277 O: from 03-JAN-2016 to 03-JAN-2016
 Nspectra: 2772 Offset ranges: (-189.5:+189.0) (-190.4:+188.1)
 N: 128 IQ: 64.5 VQ: 11.2 Dv: 0.340 LSR
 13CO(2-1) FO: 220398.686 Df: -0.25
 Bef: 1.00 Fef: 1.00 Fi: 230676.950 Gim: 0.000

PC71 RA: 20:14:50.000 DEC: 31:59:00.00 Eq 2000.0
 Scan: 7195-7277 O: from 03-JAN-2016 to 03-JAN-2016
 Nspectra: 2772 Offset ranges: (-189.5:+189.0) (-190.4:+188.1)
 N: 128 IQ: 64.5 VQ: 11.2 Dv: -0.325 LSR
 12CO(2-1) FO: 230537.990 Df: 0.25
 Bef: 1.00 Fef: 1.00 Fi: 220537.990 Gim: 0.000

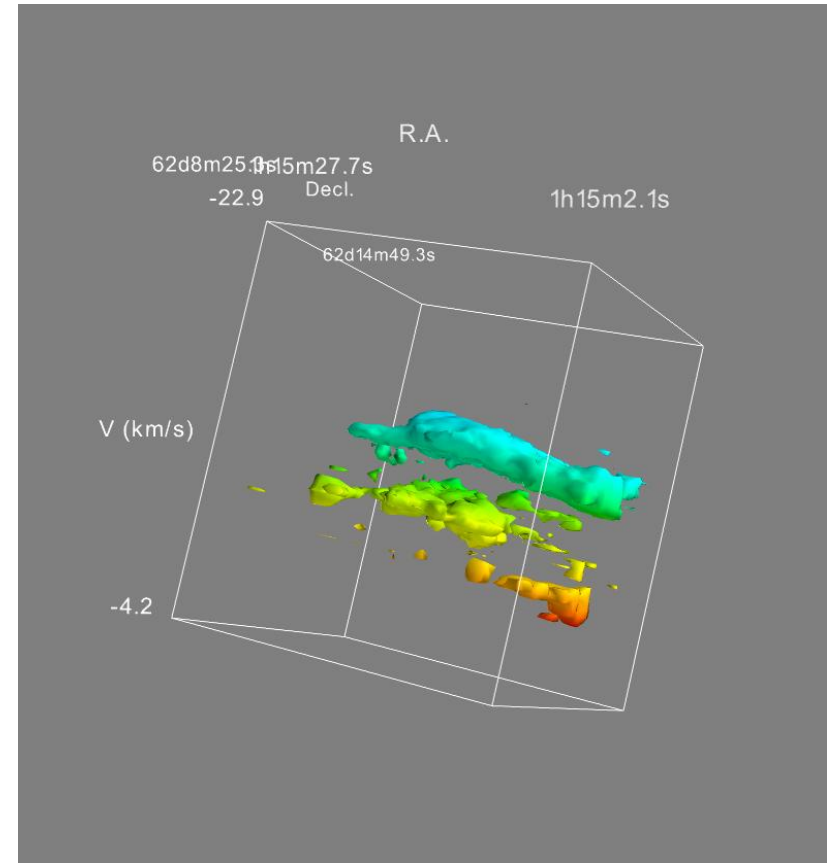
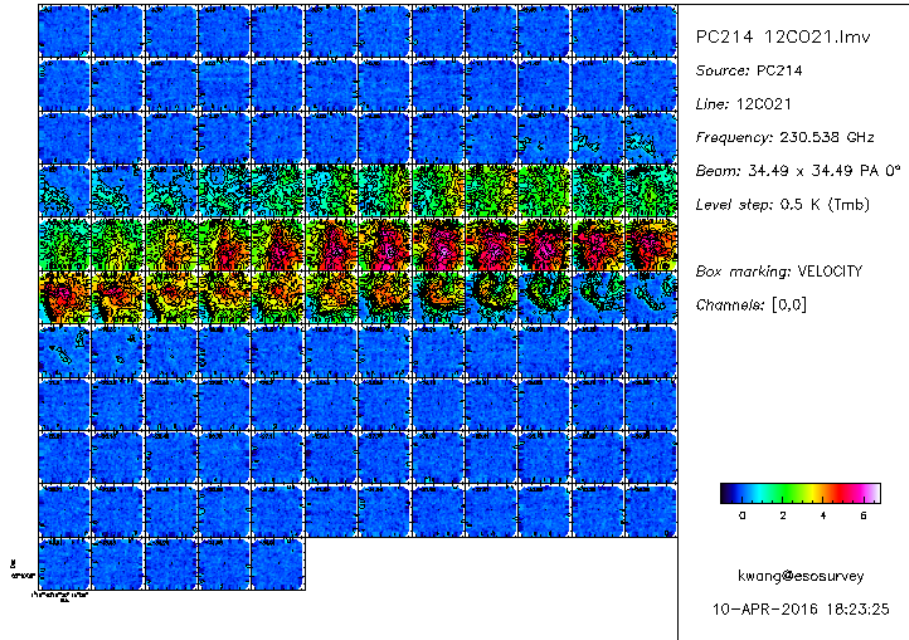


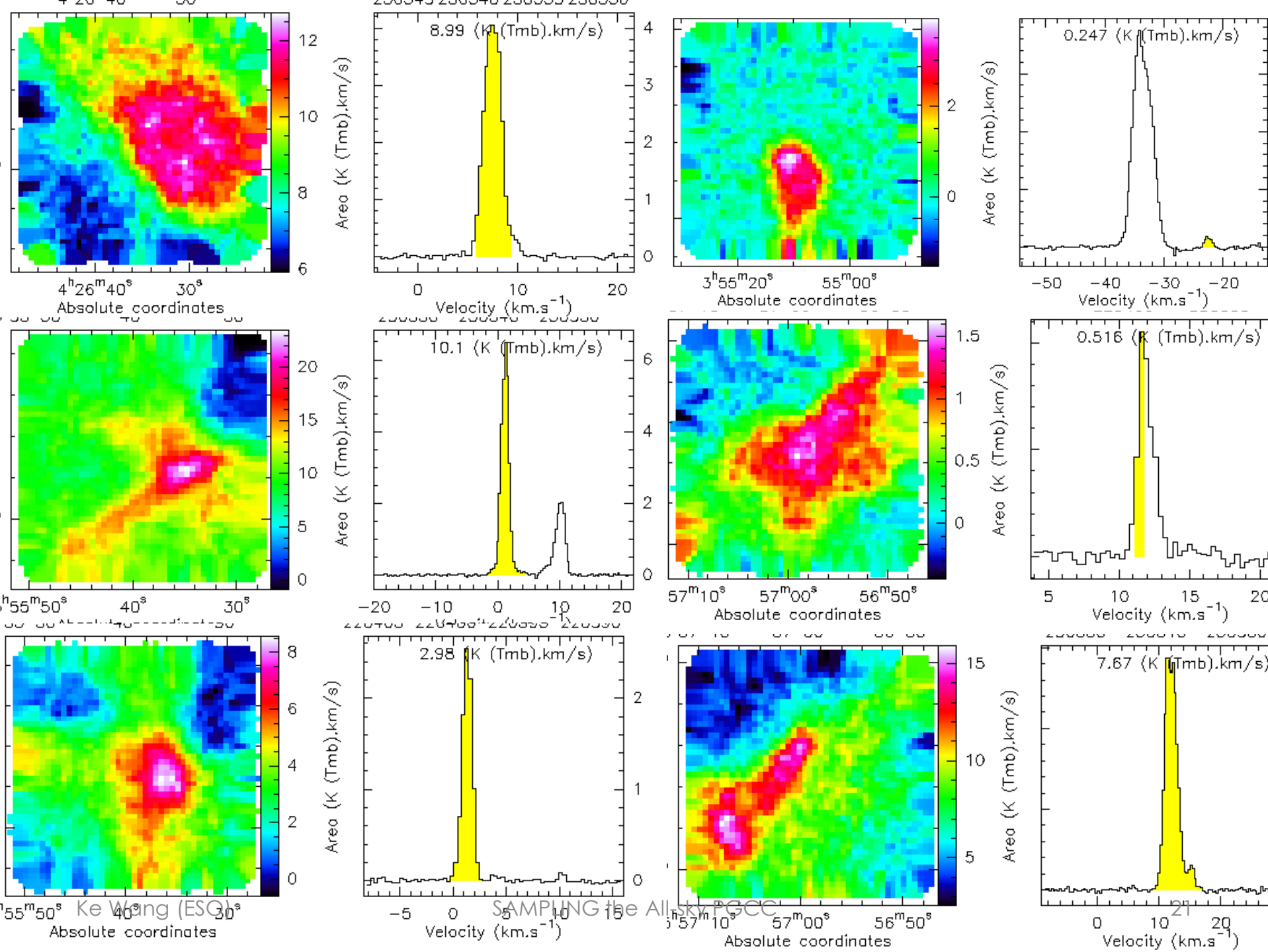
Example source PC73



cf. Jorma's talk

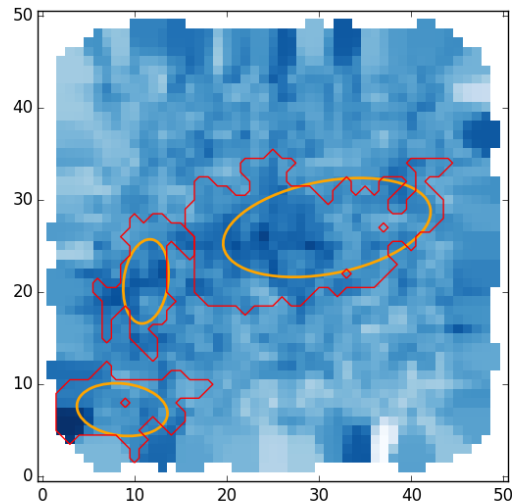
Example source PC214



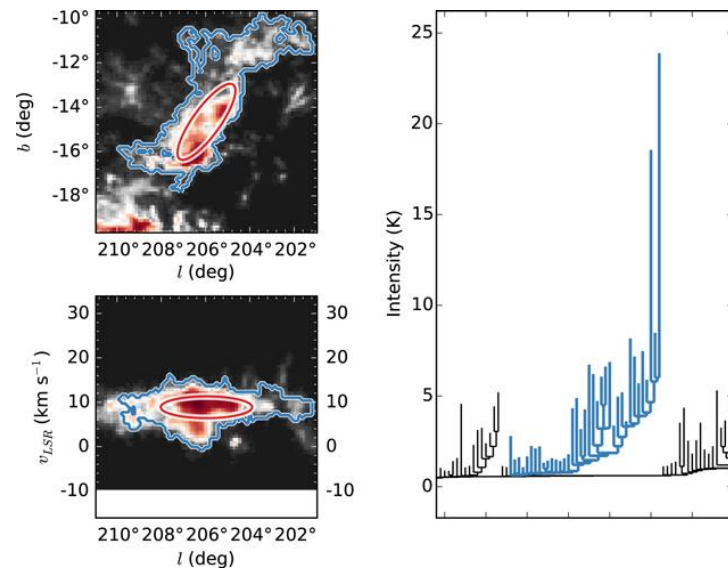


Discussion: to-do items

- Source extraction
 - Should be automatic, easy to reproduce
 - provides **PPV position, flux, size, linewidth**
 - Tried 3D **dendrogram**, OK; other ideas?



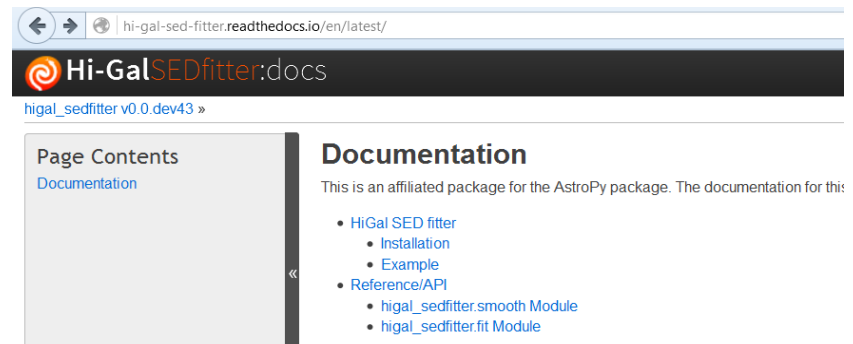
Example source



Rice et al. 2016

Discussion: to-do items

- Distance assignment
 - 6 types of distances reported in the PGCC catalog, with diverse robustness (cf. Viktor)
 - Idea: for GP sources use the new Bayesian distance estimator (Reid et al. 2016; <http://bessel.vlbi-astrometry.org/bayesian>); for nearby, high-latitude sources use dust extinction (cf. GCC team; Dough's talk). Suggestions welcome
- Column-density map from *Herschel* SED fitting (Wang et al. 2015, <http://hi-gal-sed-fitter.readthedocs.io>), resolution $\sim 36''$, matched to SMT
 - Useful for CO abundance and depletion
 - already available for GCC sources



Discussion: your favorite science

- Kinematics, turbulence, stability
 - Star formation efficiency: synergy with all-sky YSO catalogs (cf. Gabor's work)
 - CO spectral line energy distribution (SLED) for excitation analysis (synergy with *Herschel* SED)
 - CO abundance, CO depletion
 - Properties of clouds in the extreme outer arm
 - Atomic → molecular transition in high-latitude clouds (synergy with Arecibo HI survey)
 - ... **your ideas!**
- ➔ Big question: How do these properties vary with Galactic environment?

Summary

- **SAMPLING** is making progress as expected (!)
- ~200 sources observed, including ~100 GCC sources.
 $^{12}\text{CO}/^{13}\text{CO}(2-1)$ maps, 5'x5' OTF, rms <0.2 K
- DR1 in September 2016, but you don't have to wait – contact us if you want the data!
- Think about what **science** you can do with the data. *Your favorite sources may have been observed.* Check with me (kwang@eso.org).
- Updates will be announced at <http://sky-sampling.github.io>

THANK YOU

KÖSZÖNÖM