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Summary of the current solar calibration in the QA2 process and its problems/Single-Dish

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ALMA Single Dish (SD) imaging

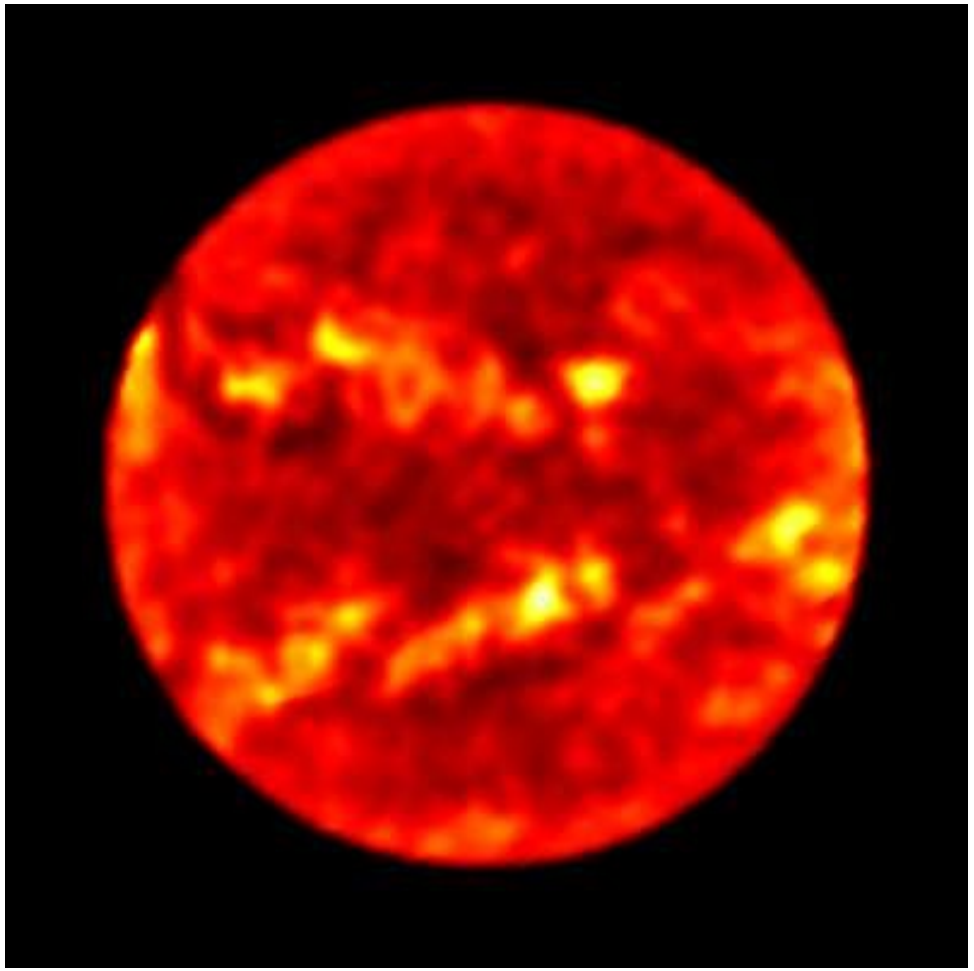
ALMA Single Dish (SD) imaging

- Total Power array
- 4 antennas, MELCO, PM01-04
- 12 m, direct drive, fast scanning
- Full-disk total power observations
- **Complement interferometry data** (large scale structures, background emission)
- **Stand-alone science** (e.g. Alissandrakis et al. 2017, Brajša et al. 2017, 2018, Selhorst et al. 2018)
- Solar commissioning campaigns 2014, 2015
- **White et al. (2017) Solar Phys. 292, 88.**

ALMA Single dish examples

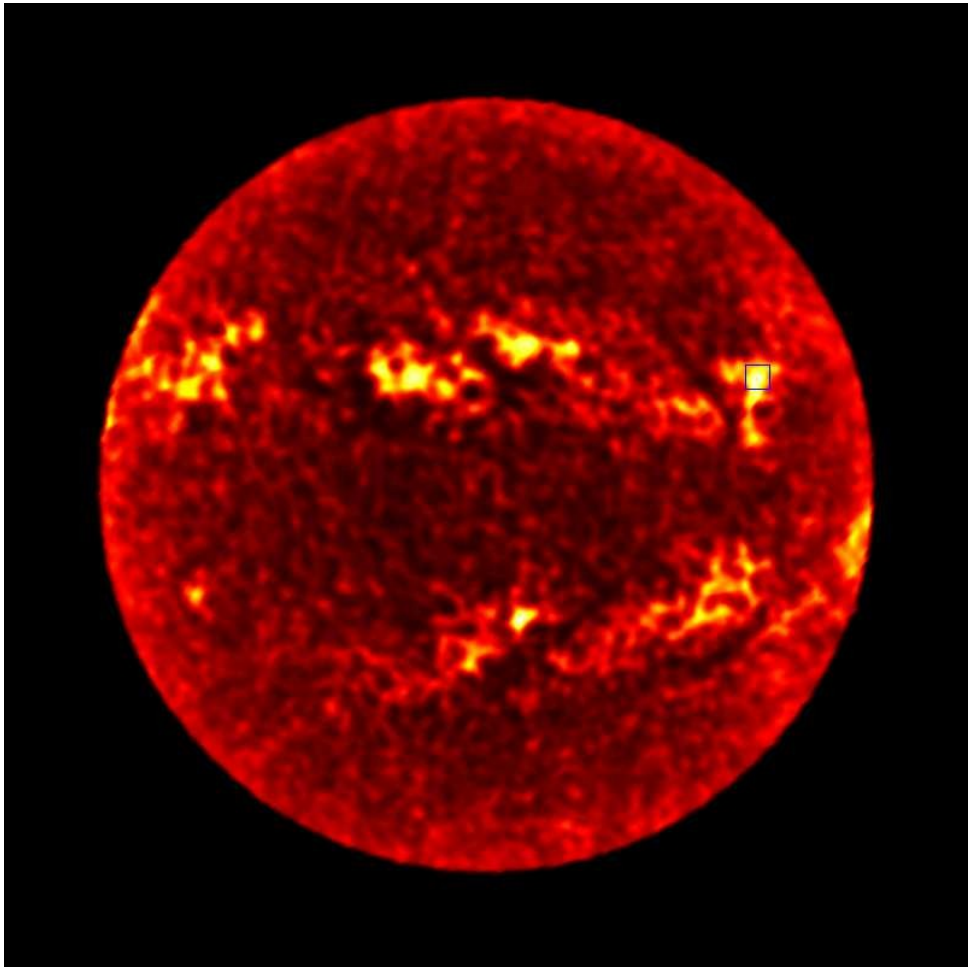
Band 3

100 GHz (3 mm), beam size 58”



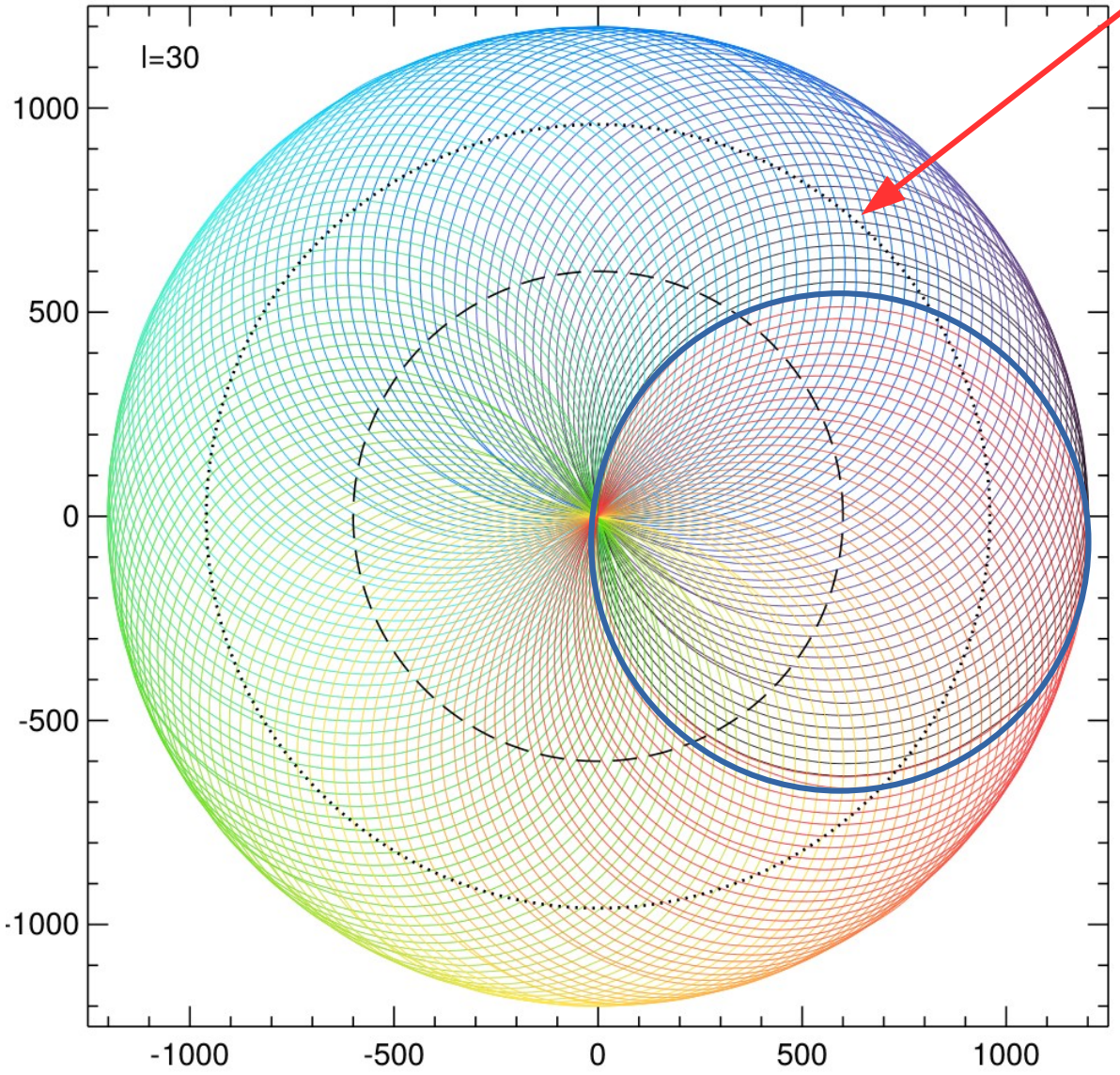
Band 6

239 GHz (1.2 mm), beam size 25”

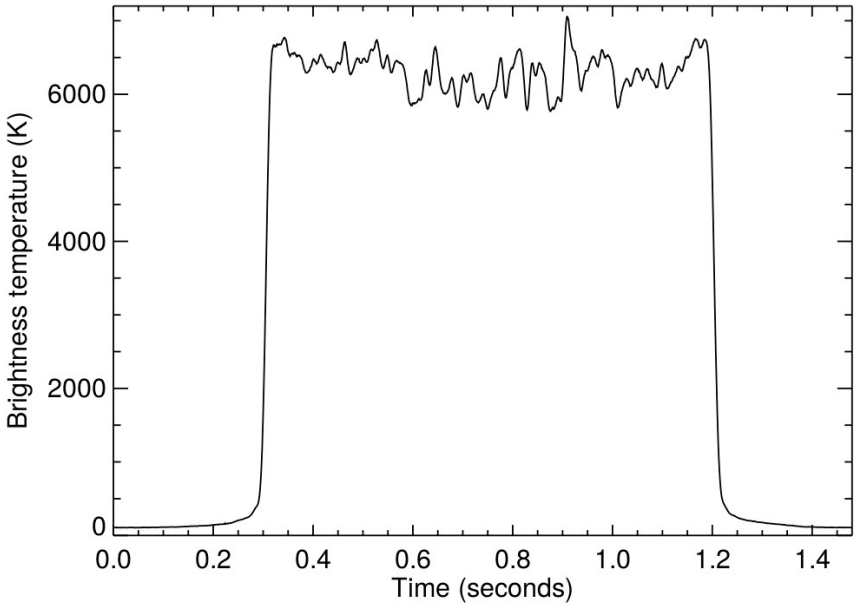


Double-circle pattern

average solar disk size



- sampling time 1 ms
- minor circle time 1.5 s
- sampling length:
  20” (B3), 10” (B6)
- duration 280, 560 s
- total duration 13, 17 min



White et al. (2017)

Current QA2 - SD Calibration - CASA

- QA2 = Quality Assurance, level 2
- ASDM import

```
importasdm(asdm=asdm, vis=mso, lazy=True, bdfflags=False,
           with_pointing_correction=True, asis='Antenna Station
           Receiver Source CalAtmosphere CalWVR CorrelatorMode
           SBSummary CalDevice')
```

- Optional flagging of bad data
- Generation of the Tsys cal table

```
gencal(vis=mso, caltable=mso+'.tsys', caltype='tsys')
```

Current QA2 - SD Calibration - CASA

- SD calibration into Kelvins

```
sdcal(mso, calmode='ps', spw='0,1,2,3', fluxunit='K',
      outfile=msc, outform='MS2')
```

- Or the new way:

```
sdcal(infile=mso, calmode='ps,tsys,apply', spw='0,1,2,3')

split(vis=mso, spw='0,1,2,3', outputvis=msc,
      scan='6', # the OBSERVE_TARGET scan
      datacolumn='corrected', keepflags=True)
```

- Forward & Spillover efficiency correction (0.893 B3, 0.862 B6)

```
gencal(vis=msc, caltable=msc+'.eff.tbl', caltype='amp',
       spw='', parameter=[sqrt(0.862)]) #For Band6

applycal(vis=msc, gaintable=msc+'.eff.tbl')
```

Current QA2 - SD imaging - CASA

- SD imaging

```
sdimaging(infiles=msc, antenna=ant, field=field, spw=spw,
          nchan=1, imsize=imsize, intent='*ON_SOURCE*',
          cell=cell, outfile=sd_img, gridfunction='SF',
          convsupport=6, stokes='I', ephemsrcname='sun',
          outframe='lsrk', brightnessunit='K')
→ tsdimaging() # still experimental
```

- Parameters

```
cell=['6.0arcsec'] imsize=400 radius='40pix' qs=7300 # Band 3
cell=['3.0arcsec'] imsize=800 radius='80pix' qs=5900 # Band 6
```

- Rescaling the brightness temperature

```
res = imstat(sd_img, region=region)
expr = 'IM0*'+str(qs/res['mean'][0])
immath(imagename=sd_img, expr=expr, outfile=sd_img+'.rescl')
```

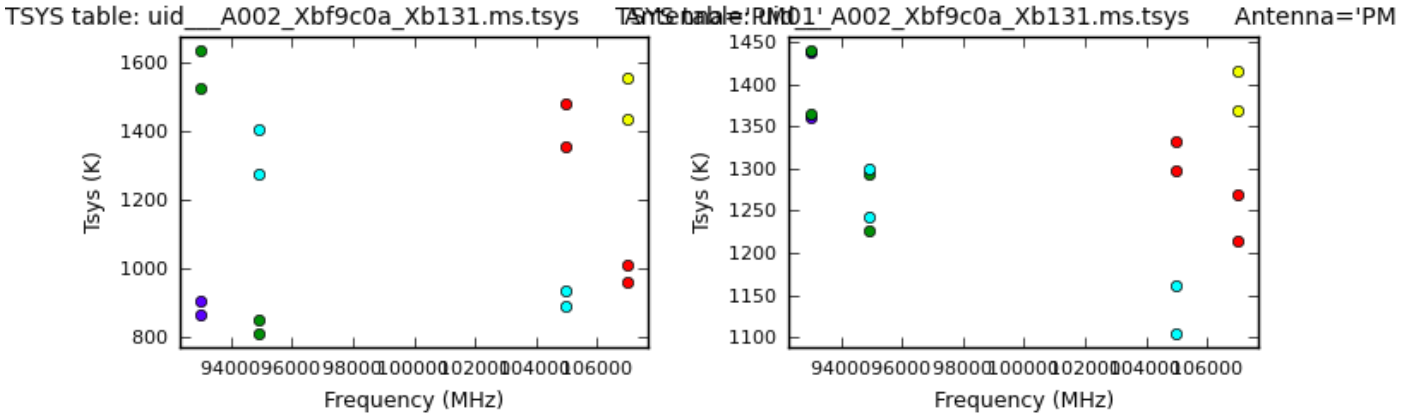
- FITS export

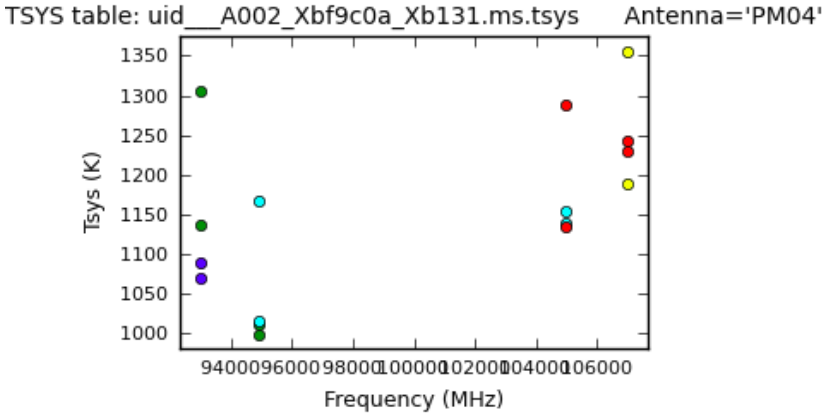
```
exportfits(imagename=sd_img+'.rescl', fitsimage=sd_img+'.rescl.fits')
```

Current QA2 - Criteria

- **Tsys < 2500 K**

```
plotcal(caltable=mso+'.tsys', xaxis='freq', yaxis='tsys',subplot=221,
iteration='antenna', figfile=mso+'.tsys.plots/'+mso+'tsys.plots.png')
```

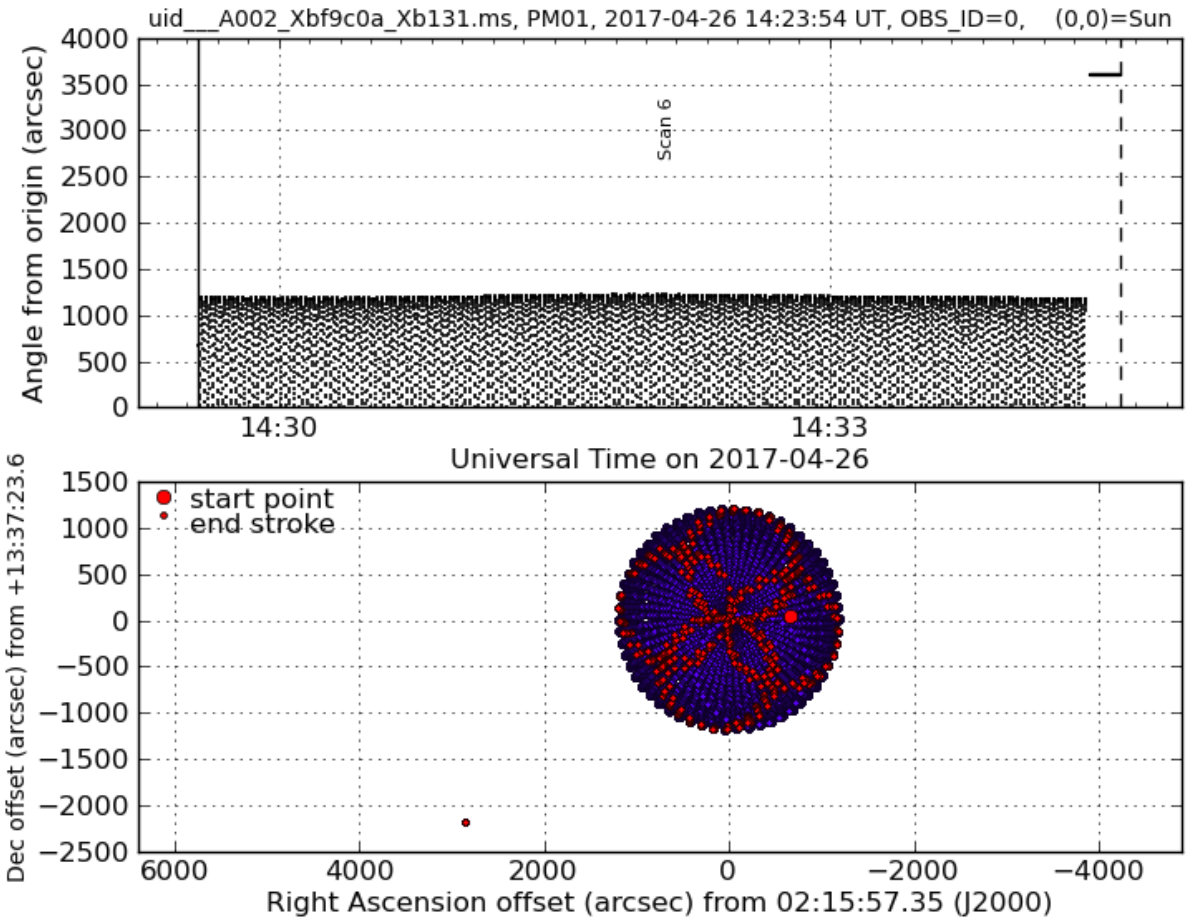




Current QA2 - Criteria

- Scan pattern and image OK

```
import analysisUtils as aU
aU.getTPSampling(vis=mso, showplot=True,
                 plotfile=mso+'.sampling.png')
```



Current QA2 – Standard scripts

- World-wide QA2 standards, updated per cycle (M. Bárta, CZ ARC):

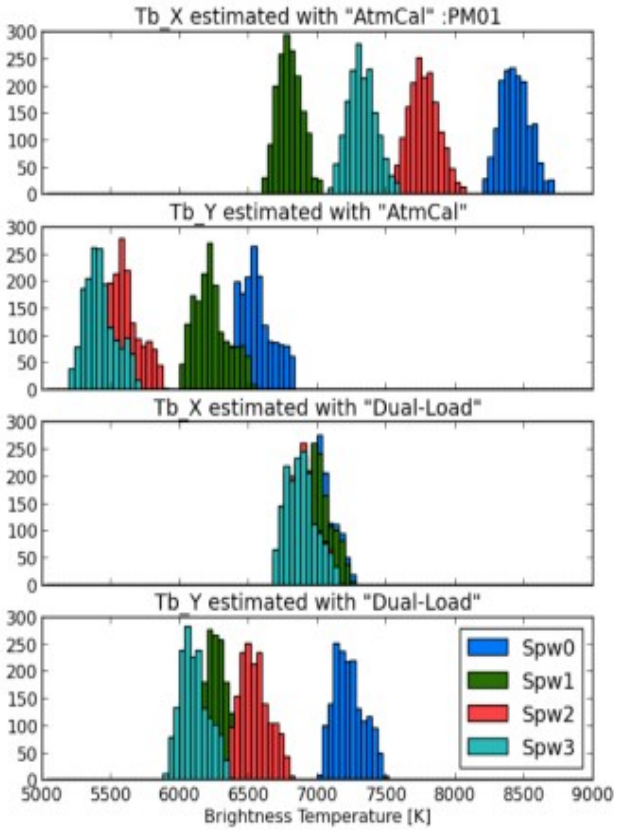
  https://wikis.alma.cl (needs login, for data analysts)

- Calibration
  - Semi-automated procedure for the entire SB processing
  - Calibration template + simple script generator
- Imaging
  - Script with auto-detection of observing band
  - Auto adjustments based on detected band
- Next steps: fully automatic scripts for pipeline processing

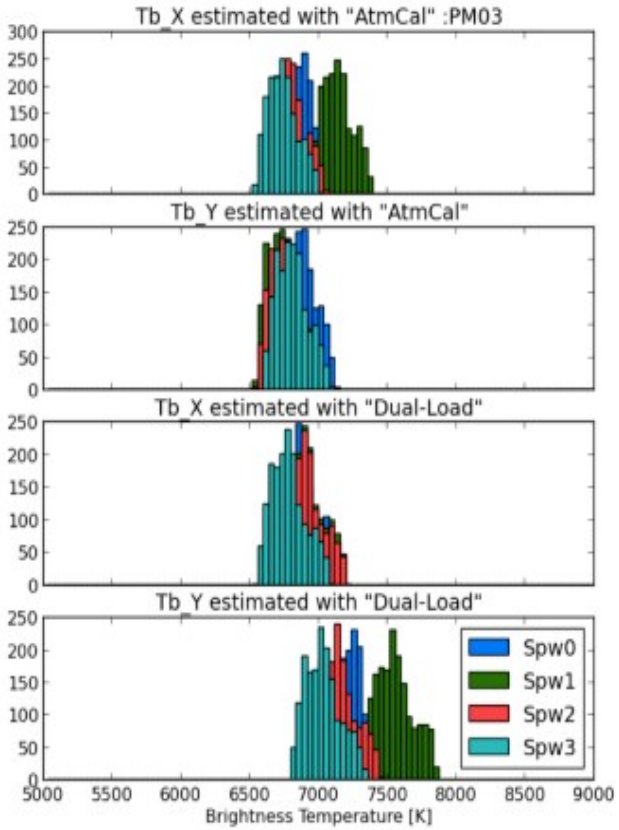
SD Calibration – Dual load method

- S. White et al. (2017) – Dual load method (IDL), better results
- M. Shimojo (ISSI, 2018) – Dual load method (CASA)

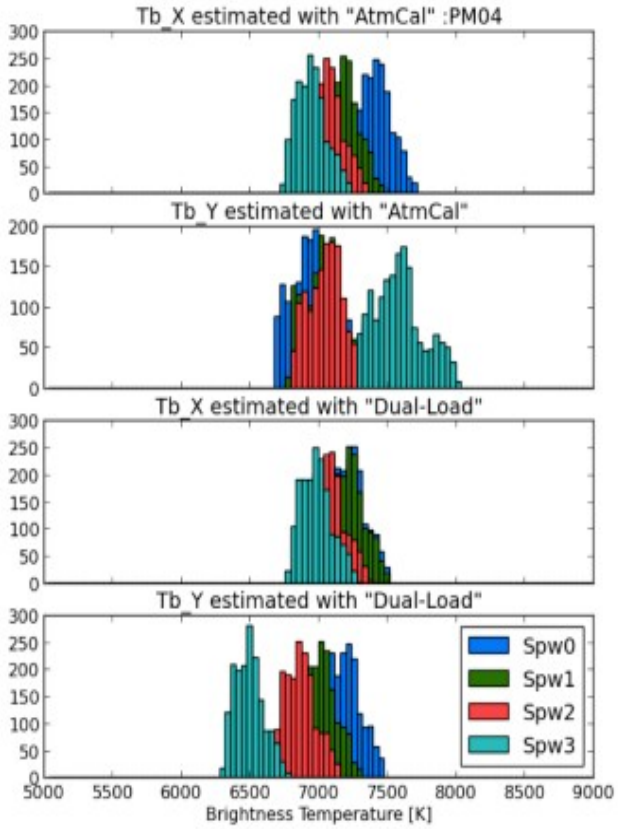
PM01



PM03

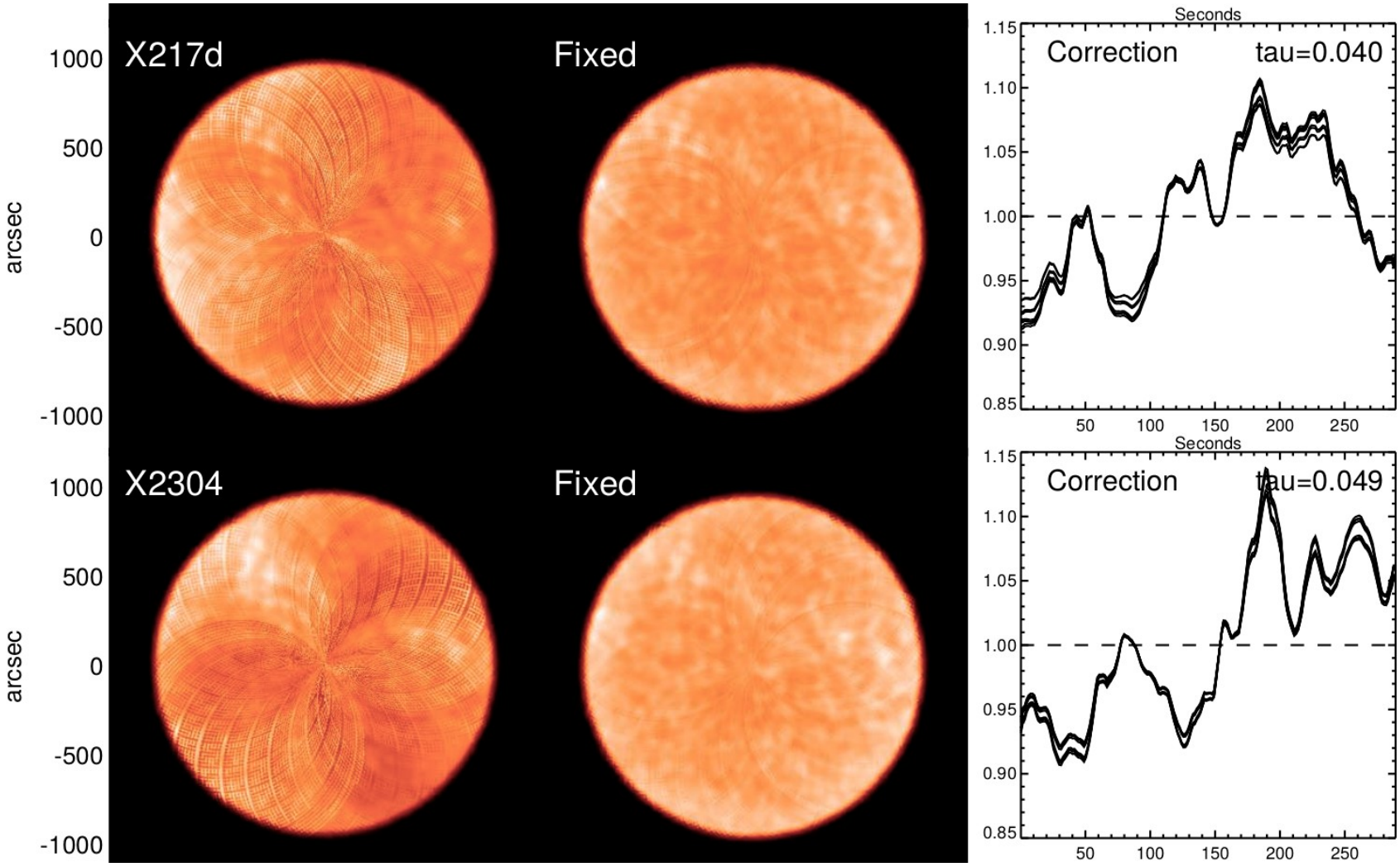


PM04



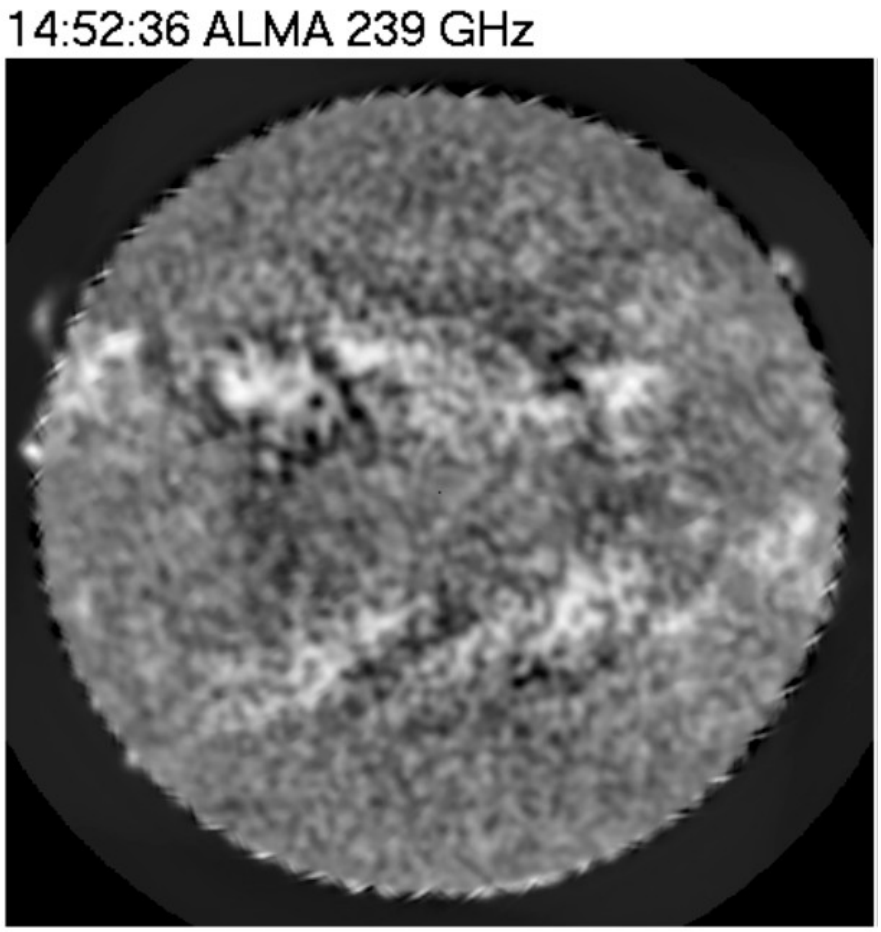
SD Problems – Scan patterns visible

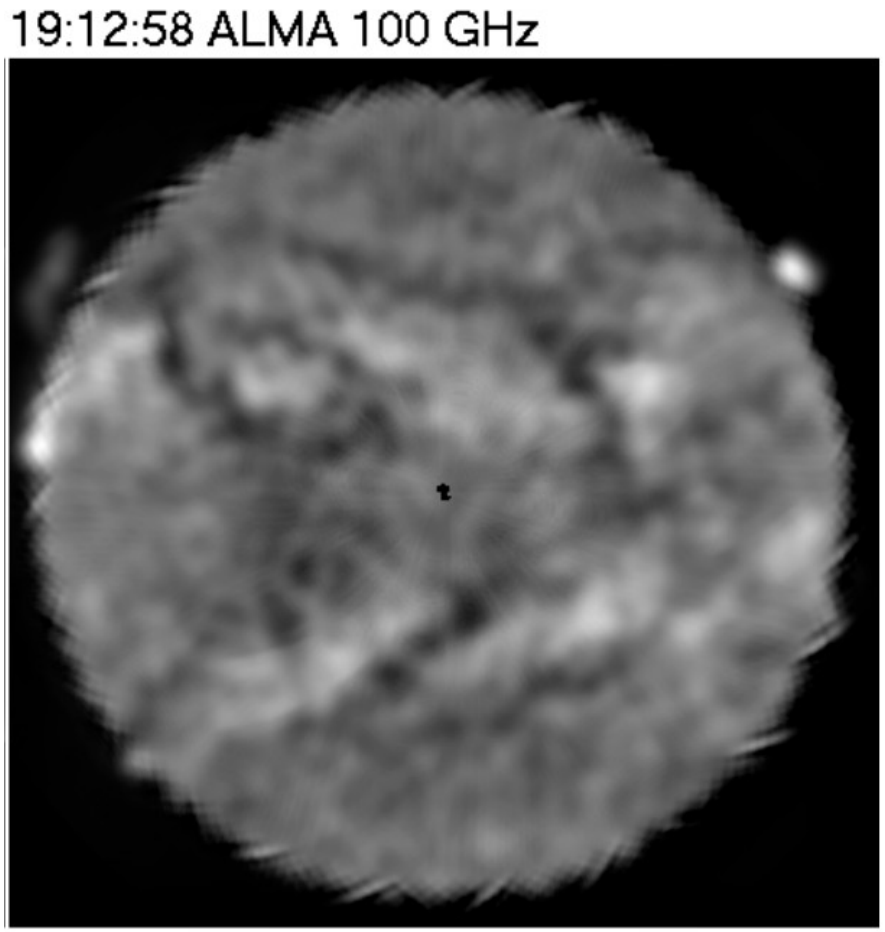
- S. White – can be largely corrected using disk center scans
- See also CASA task **`sdgaincal`**



SD Problems – Scan patterns on limb

- Timing or antenna position issue?

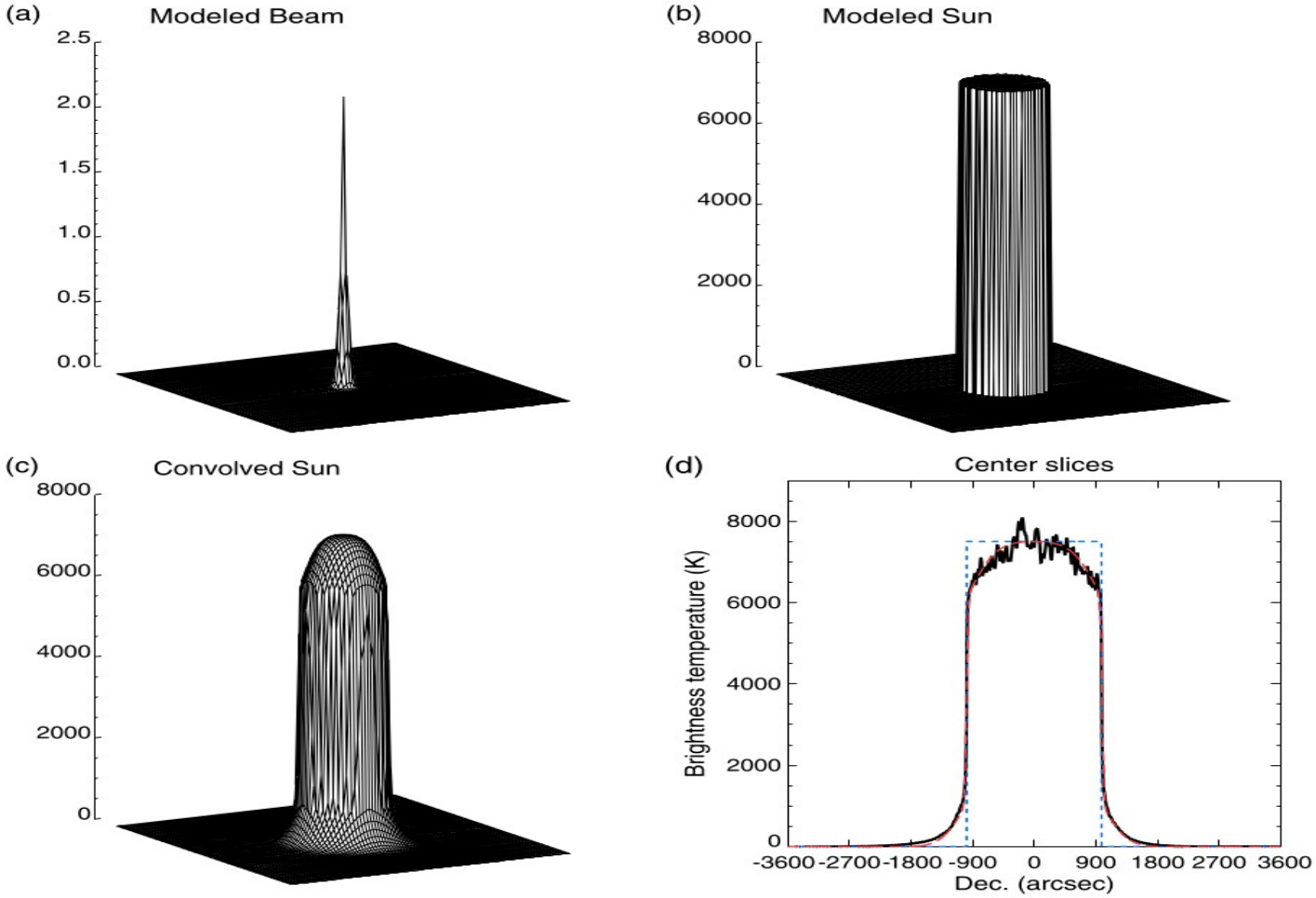




Alissandrakis et al. (2017) A&A 605, A78

SD Problems – Beam, side lobes, PSF

- How to measure it - Iwai et al. (2017) Solar Phys 292:22
- K. Iwai warns: "the ALMA TP maps include the beam pattern of the TP antenna and the derived amount of limb brightening and center-to-limb variations are lower limit."



SD - Other problems and ideas

- Tb rescaling in the center → could be improved (D. Sudar)
- Combination TP + INT → currently **feathering**, better solutions? (T. Bastian report)
- Using center scanning data for other things (beam efficiency, estimation of noise from the atmosphere) (S. White, H. Hudson)
- More automatic scripts, better FITS keywords, solar coordinate systems (M. Bárta, I. Skokić, UiO)
- Differences in subbands/spw/polarizations
- Calibration precision → new beacon (S. White, R. Hills, H.Hudson), satellite at L1 (M. Bárta)
- Regional scanning, flares (one recorded in 2014)
- SD sub-arrays? (simultaneously observing in 2 bands)
- **Other suggestions? Ideas?**