Single Dish imaging bug for EBs with different antenna positions in common antenna names and IDs

We have discovered a bug in CASA single-dish imaging with the task of sdimaging and tsdimaging. The issue is present in all the CASA releases before CASA 5.7/6.1 and it affects the brightness distribution and flux density in the combined image since the coordinates are not correct for some fraction of the data set. The number of MOUS suffered from the issue is 40 (3.2% out of total 1250 MOUS), including products in the ALMA Archive, and the all are set to QA3. We have fixed the bug in CASA 5.7/6.1, and it is being used for ALMA Cycle 8 data reduction, including the ALMA pipeline.

A detailed description of the problem is given below.

Detailed description:

Problem: When executing (t)sdimaging with more than one measurement sets (MSs), if the same antenna name and ID as the previously loaded MS are used, the antenna position information of the MS is not updated. In the ALMA operations, it happens that the same antenna name and ID are assigned even if the antenna position at the pad has changed. In this case, the coordinates of the image of the corresponding data are not correct since the antenna position is used for converting the coordinates from AZ-EL to RA-DEC. The amount of the positional offset depends on the difference between the correct antenna position relative to the incorrect antenna position used in (t)sdimaging and the elevation angle of the target at the time of the observation.

To illustrate the bug effect easier, an image of M100 (Science Verification Data) is referred in figure 1. Both images in figure1 use the same 2 MSs which contain data obtained with PM03 (ID=1 and antenna position = T701). In order to simulate the effect of the bug, antenna position of PM03 in one of the MSs is manually changed from T701 to A133. The left panel in figure 1 shows image produced with sdimaging before bug-fix (pre-fix) and right panel shows image with sdimaging after bug-fix (post-fix). With the pre-fix, the image of MS modified antenna position is shifted to the upper-left because the wrong antenna positional information is used for the coordinate transformation due to the bug. On the other hand, with the post-fix, the image regions of the both MSs are matched because the antenna positional information is updated whenever MS is loaded.

Occurrence condition of the bug:

This bug is triggered only when:

a)   More than one measurement set (MS) are given as the input in (t)sdimaging,

b)   Different positions with the same antenna name among the MSs,

and

c)   The above antenna has the same antenna ID

Furthermore, the order in which the data is loaded in (t)sdimaging ultimately determines whether or not it is affected by the bug but note that the order is different from that of user input. The number of MOUS affected by the issue is eventually 40 (3.2% out of total 1250 MOUS).
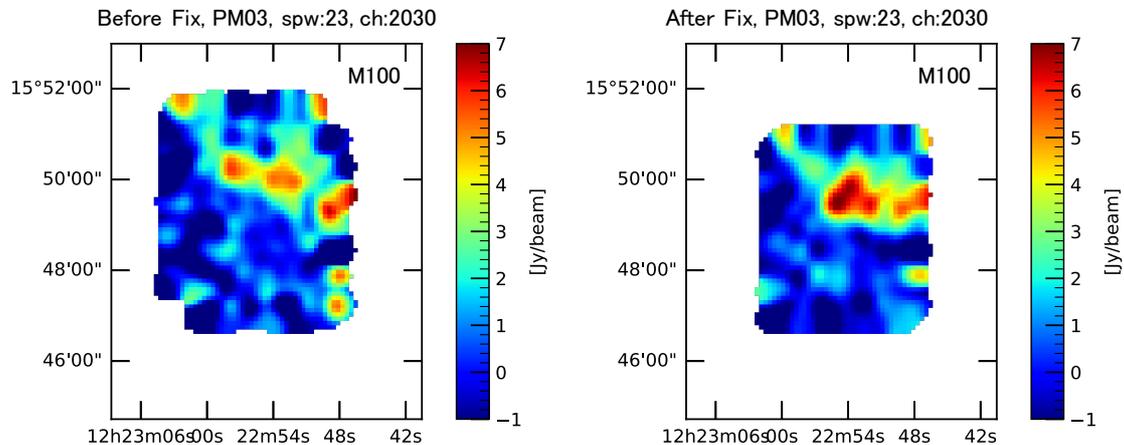

Figure. 1 *Simulated images of M100 (ALMA Science Verification data). Two MSs are used for the image and an antenna position of one of the MSs is modified so as to cause the bug. (left) Image of M100 at ch=2030 produced with sdimaging before bug-fix. (right) Same as left but with sdimaging after bug-fix.*

Solution:

We recommend users to update to CASA 5.7/6.1.

The workaround for using CASA before CASA 5.7/6.1 is to make images for each MS with (t)sdimaging and combine the produced images with immath. For instance, after running sdimaging on each measurement set (e.g., EB1.ms and EB2.ms), image and weight products are produced (e.g., EB1.ms.sd and EB1.ms.sd.weight for EB1.ms).

Using all the image and weight data, produce the combined image ('combined.image.sd') as follows,

```
immath(imagename=['EB1.ms1.sd', 'EB2.ms.sd',
                  'EB1.ms.sd.weight', 'EB2.ms.sd.weight'],
    mode='evalexpr', expr='(IM0*IM2+IM1*IM3)/(IM2 + IM3)',
    outfile='combined.image.sd')
```

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