Note on the Precision of the Coordinate Service based on SLALIB

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SLALIB description is available at
http://star-www.rl.ac.uk/star/docs/sun67(htx/sun67.html

**The code is in fortran there but we have the one in C.**

We solved copyright agreements with the inclusion in the release of the C library, but we have the C code (given by the author). Much of the C code is on the WEB (a search with google returns much of it eg.
http://isdc.unige.ch/~isdc_lib/delivery/headers/sla_c_headers_list.html). Copyright is not an issue and Juancarlos set up things so that we are completely fine with this.

Below I discuss the precision of the algorithm which is at the level of 5e-3 deg. More than enough for IceCube purpose.

The entire code is in double precision.

**Calculation of Equatorial coordinates (galactic from equatorial are just trivial equations).**

**Input is UTC from data,** zenith and azimuth (the precision varies track by track of course on these inputs)

SLADH2E: from azimuth, elevation, detector latitude => hour angle and declination

To get right ascension from hour angle:
SLAGMST = from UT 1 to GMST
In the code: UTC -> Greenwich Mean Sidereal Time = Local Sidereal Time of the Greenwich Meridian
**Only approximation is that we use UTC and not UT1 which means <0.9 sec = 4e-3 deg on RA (see below explanations on UTC, UT1)**

LST = GMST corrected for detector longitude => apparent right ascension
From apparent coordinates to mean (J2000): nutation and precession matrix corrections applied (SLAPRENU). Input Terrestrial Time bound to TAI: SLADTT from UT to TT

The matrix method is the most precise one (a less precise method can be used too, see Duffett-Smith book pag 56). The precision varies with the EPOCH and time. I report the example in the book to show an example of how much apparent and mean coordinates may differ.

If we compare the low precision method and the high precision one:
Apparent (ra,dec) = (137.679167deg,14.390278deg)
Going from 1979.5 to 1950.0 (mean):
(ra',dec') = (138.08529deg,14.268842deg) with the low precision method
(ra",dec")= (138.083991deg,14.268792deg)with the high precision
In this example in the book the 2 methods give very close values but it can vary.

*Universal Time* UT, or more specifically UT1, is in effect the mean solar time. It is continuous (*i.e.* there are no leap seconds) but has a variable rate because of the Earth's non-uniform rotation period. It is needed for computing the sidereal time, an essential part of pointing a telescope at a celestial source. To obtain UT1, you have to look up the value of UT1-UTC for the date concerned in tables published by the International Earth Rotation Service (http://www.iers.org/iers/products/eop/dut1.html); this quantity, kept in the range by means of UTC leap seconds, is then added to the UTC. The quantity UT1-UTC, which typically changes by 1 or 2 ms per day, can only be obtained by observation, though seasonal trends are known and the IERS listings are able to predict some way into the future with adequate accuracy for pointing telescopes.

The last announcement in Feb 2005:
http://hpiers.obspm.fr/eoppc/bul/buld/bulletind.dat
From the
17 March 2005, 0h UTC
until further notice, the value of DUT1 to be disseminated with the time signals will
DUT1 = -0.6 s.
It used to be even less
http://hpiers.obspm.fr/eop-pc/

I think we can live with this uncertainty given IceCube resolution. Unless we do not want to introduce a correction that is <0.9s and that appears in these bulletins with a difficult format to be introduced automatically. But if you think not then this correction should be continuously monitored and updated and ‘by hand’.

See also how bulletins change in time
http://hpiers.obspm.fr/eoppc/bul/buld/

Comparison with others in AMANDA (but I tested them also against independent codes in ANTARES and MACRO):

Proposed check:
zenith = 55.8857deg azimuth = 16.2570deg
date=940429 secs=15*60*60+10*60+35.41;

With Mike Stamatikos:

We agreed at the 4th digit and when he used UT1 the difference was in the 4th digit
(at that time UT1-UTC was 0.09 s)

With RDMC (check with Chiwha Song)
RDMC from Galactic to Equa:
   Equ:  158.732913 -34.114300

This code:
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equatorial coords:
   right asc.  = 1.587957e+02
   declination = -3.414186e+01

   Differences in RA = 6.3e-2 deg dec = 2.8e-2deg

Precision of Moon/Sun position
SLALIB RDPLAN based on the Meuus Algorithm: precision 10” = in longitude 0.0417 deg and 3” in latitude = 0.0125 deg

Time in input = Terrestrial Time tied to Atomic time TAI by TAI + 32s.184

Comparison with JPL http://ssd.jpl.nasa.gov/cgi-bin/eph/

Eg.
For JD = 2449472.13194444
   JPL             SLALIB
Mean coordinates:
   RA (J2000) = 272.0135549 deg 272.0084 deg  |Delta RA|=7.12e-3deg
   DEC(J2000) = -19.2350016 deg -19.24212 deg  |Delta Dec|=5.15e-3deg

   Apparent coordinates
   RA = 271.9372271deg 271.9285deg  |DeltaRA|=8.73e-3deg