Towards
a rigorous framework
for
radial velocities computations.

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Motion of the Earth requirements

- BERV : Barycentric Earth Radial velocity :
projection of the observer velocity in the direction of the star.

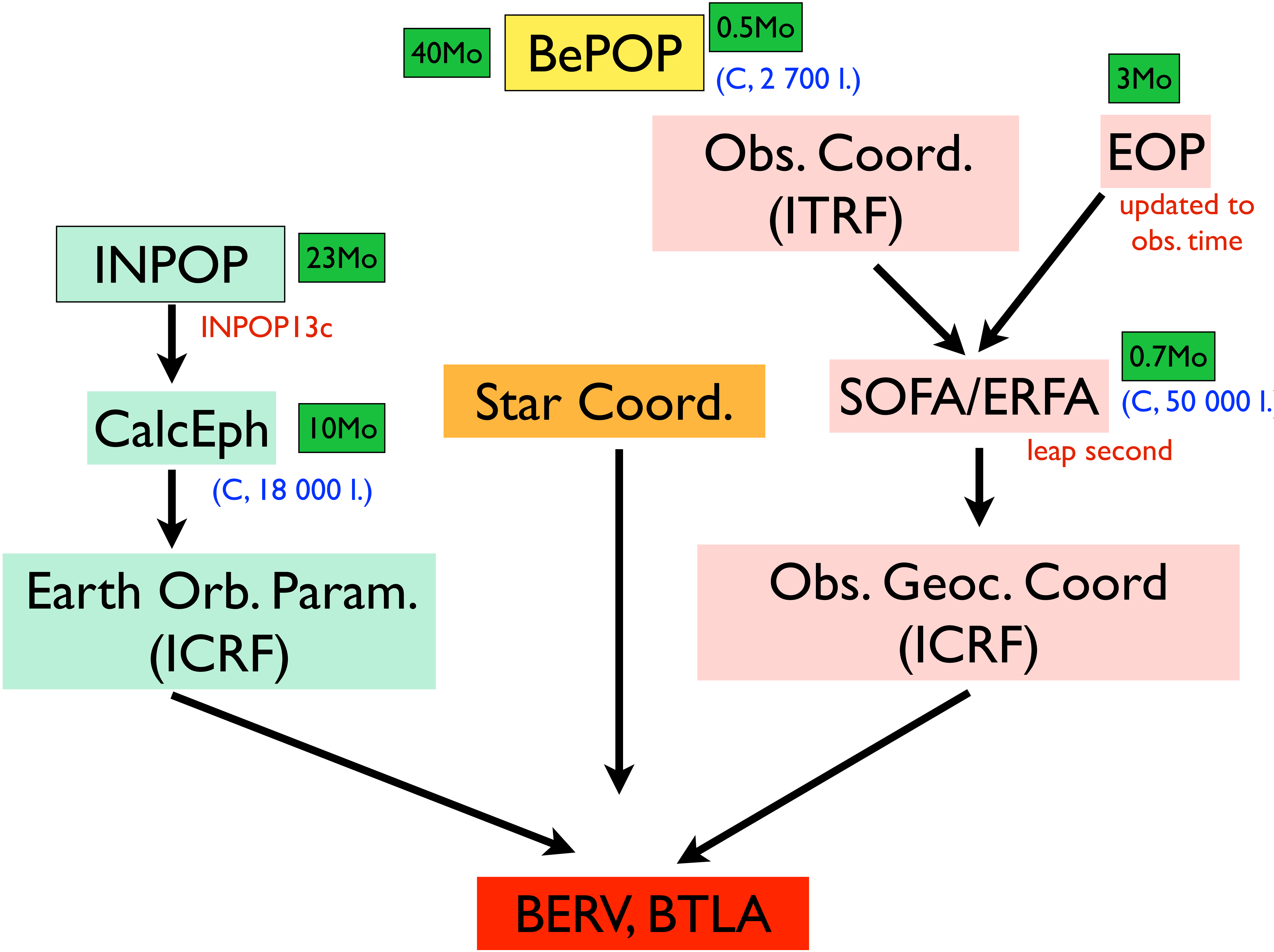
1 cm/s

- BTLA : Barycentric Time of Light Arrival:
time arrival of the photons at the barycenter of Solar System.

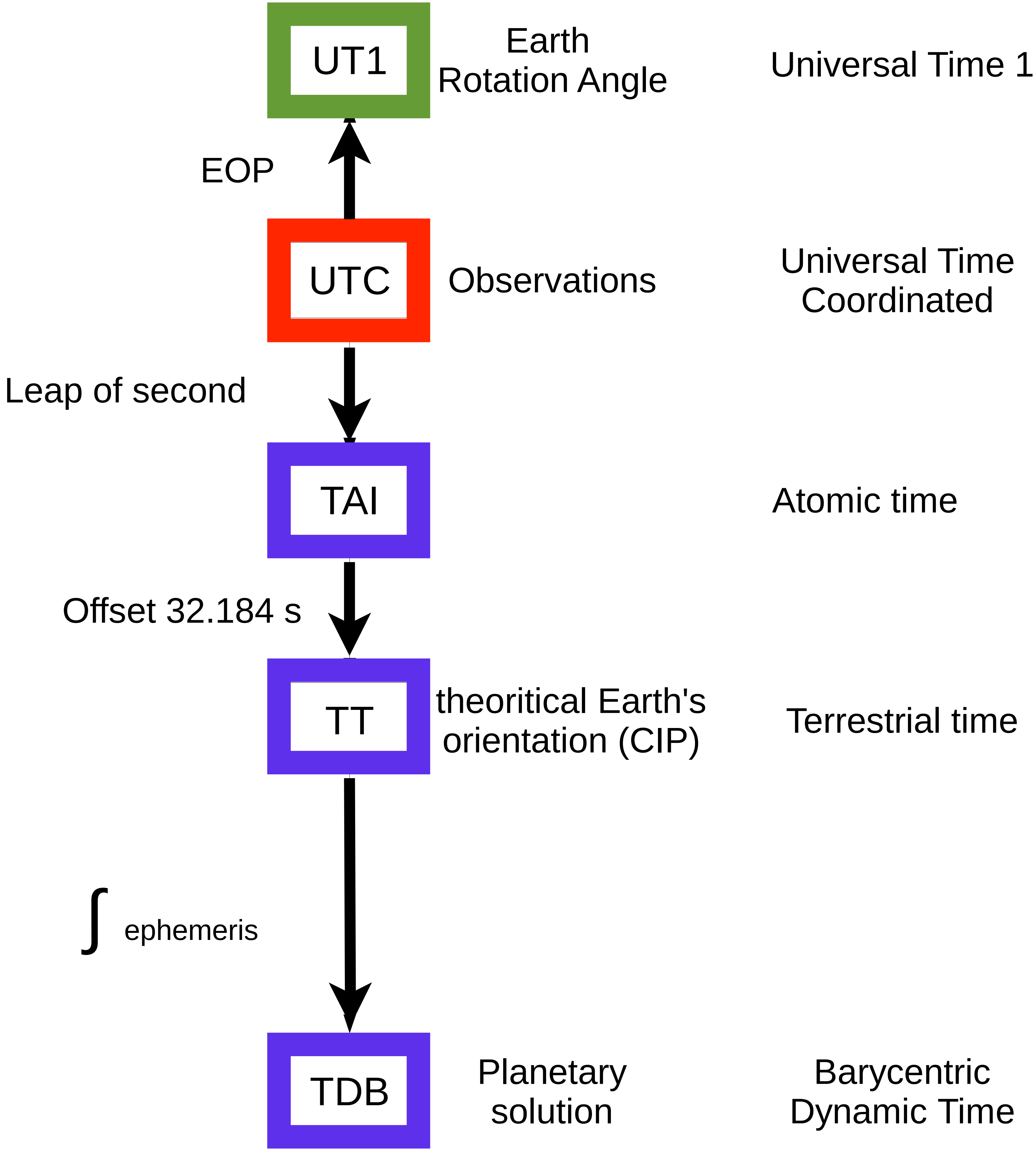
1 s

Motion of the Earth. requirements

- Position at J2000 and proper motion of the star
- Observation date (UTC)
- Geocentric position of the observer in the ITRF (lat,Long, h).


40Mo
BePOP
0.5Mo
(C, 2 700 l.)
3Mo
Obs. Coord. (ITRF)
EOP
updated to obs. time
INPOP
23Mo
INPOP13c
CalcEph
10Mo
(C, 18 000 l.)
Star Coord.
SOFA/ERFA
0.7Mo
(C, 50 000 l.)
leap second
Earth Orb. Param. (ICRF)
Obs. Geoc. Coord (ICRF)
BERV, BTLA

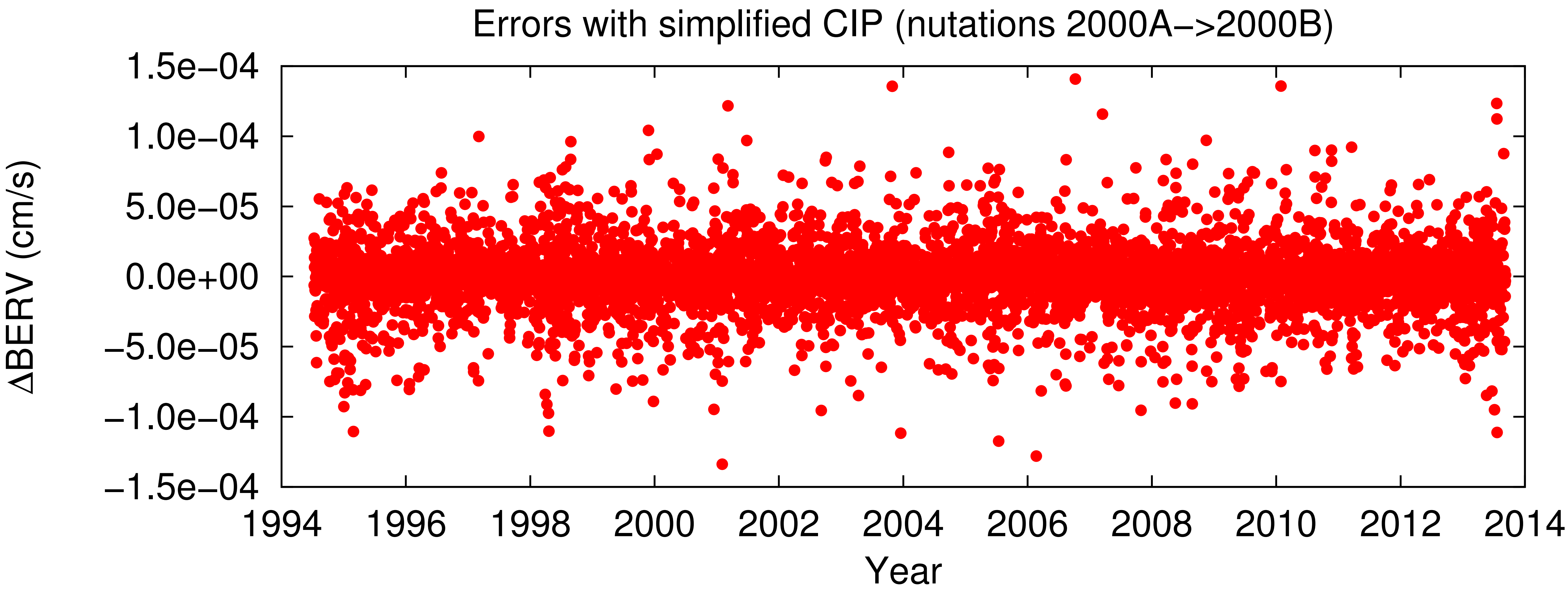
Time Scale


UT1
Earth
Rotation Angle
Universal Time 1
EOP
UTC
Observations
Universal Time
Coordinated
Leap of second
TAI
Atomic time
Offset 32.184 s
TT
theoritical Earth's
orientation (CIP)
Terrestrial time
∫ ephemeris
TDB
Planetary
solution
Barycentric
Dynamic Time

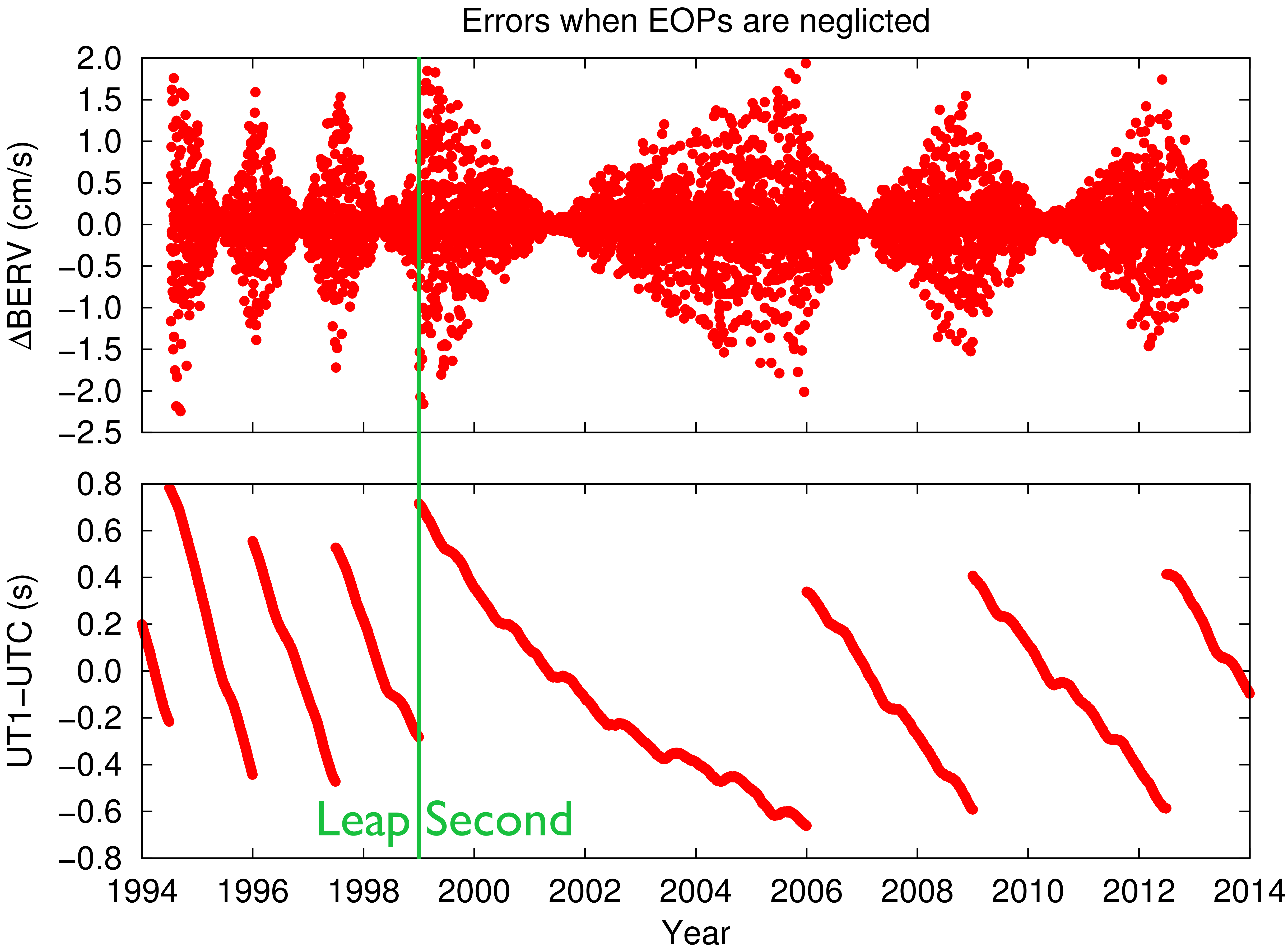
Motion of the Earth Spin

- 2000A : most accurate CIP model (1350 terms)
- 2000B : degraded CIP model (80 terms)

(For LLR 2000A is needed (2cm))

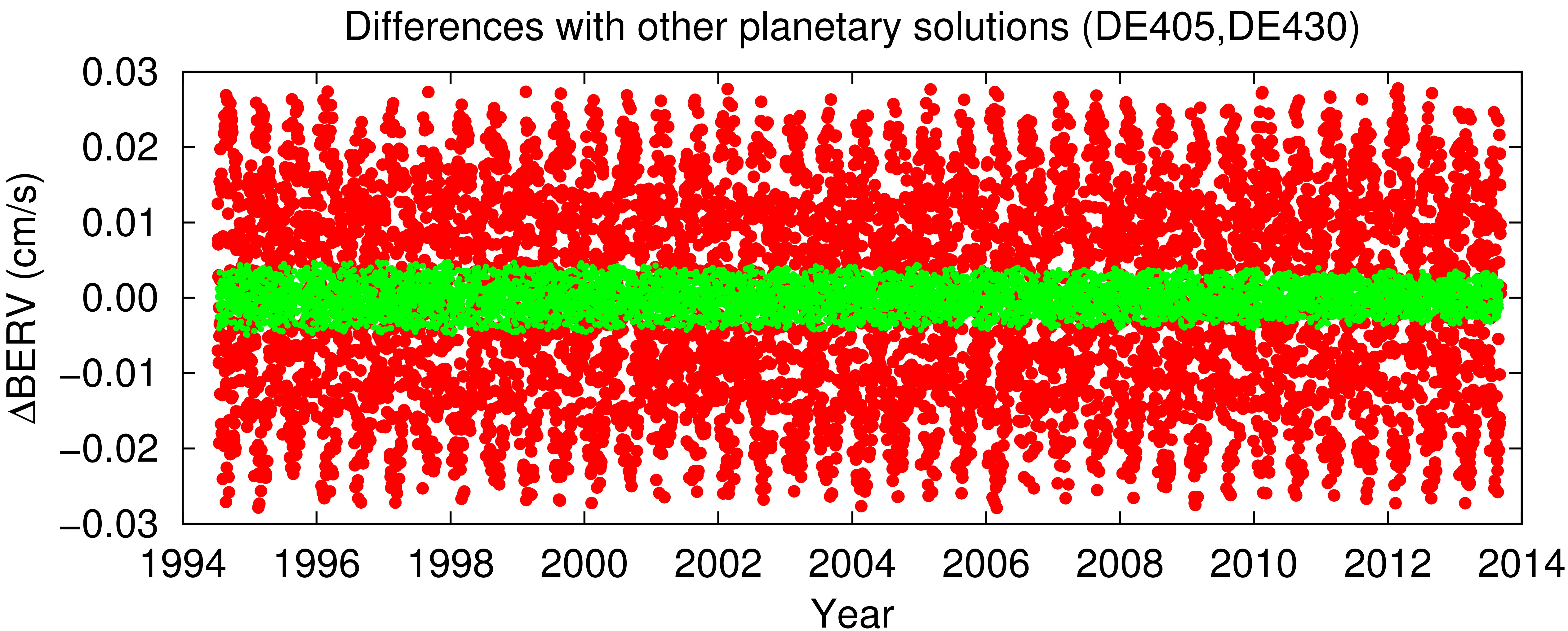


UT1-UTC



Errors when EOPs are neglicted
ΔBERV (cm/s)
2.0
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
−2.0
−2.5
UT1−UTC (s)
0.8
0.6
0.4
0.2
0.0
−0.2
−0.4
−0.6
−0.8
Leap Second
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
Year

Planetary Solution



INPOP13c-DE405

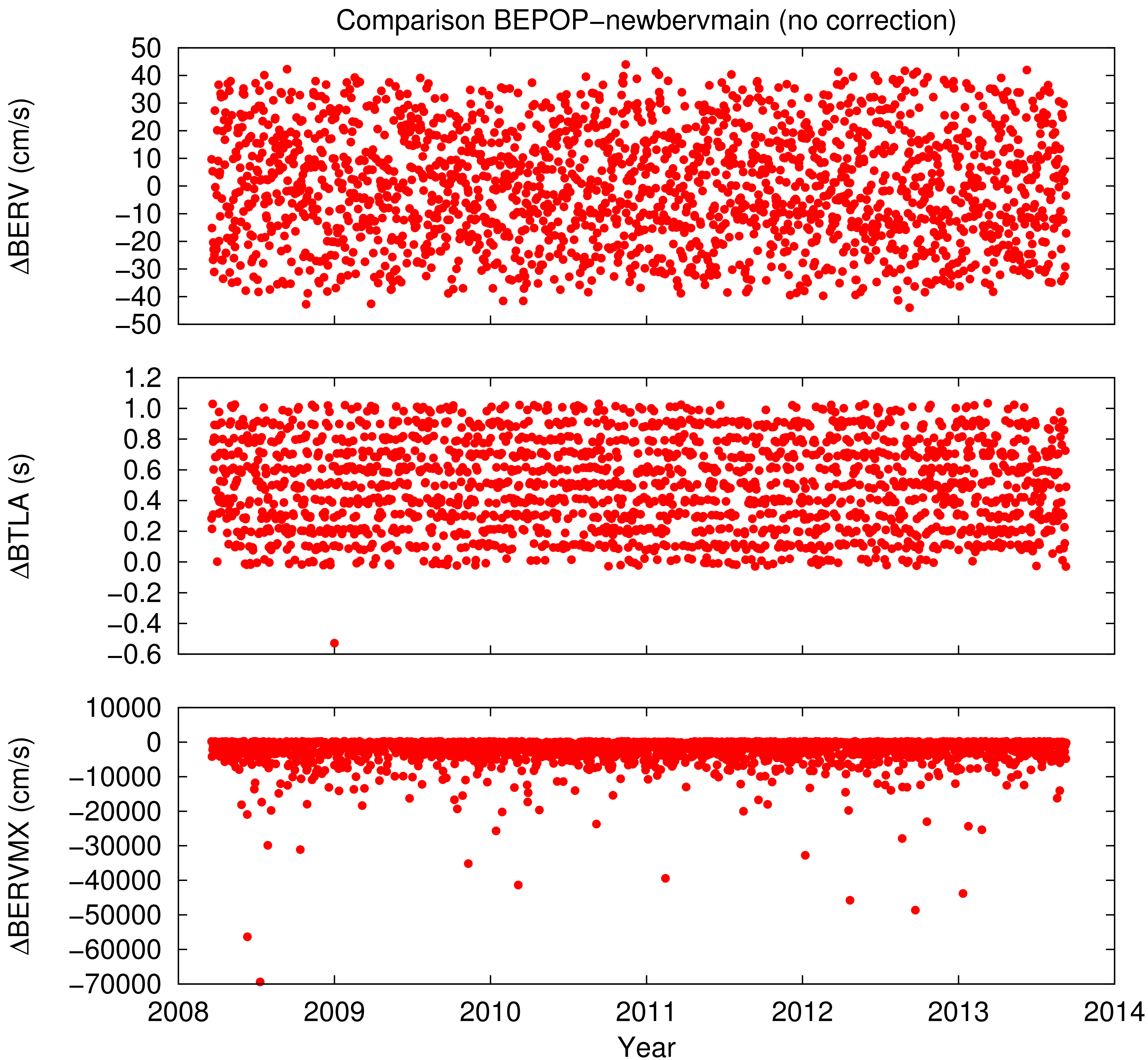
INPOP13c-DE430

Everything seems to be

well within

required uncertainty values

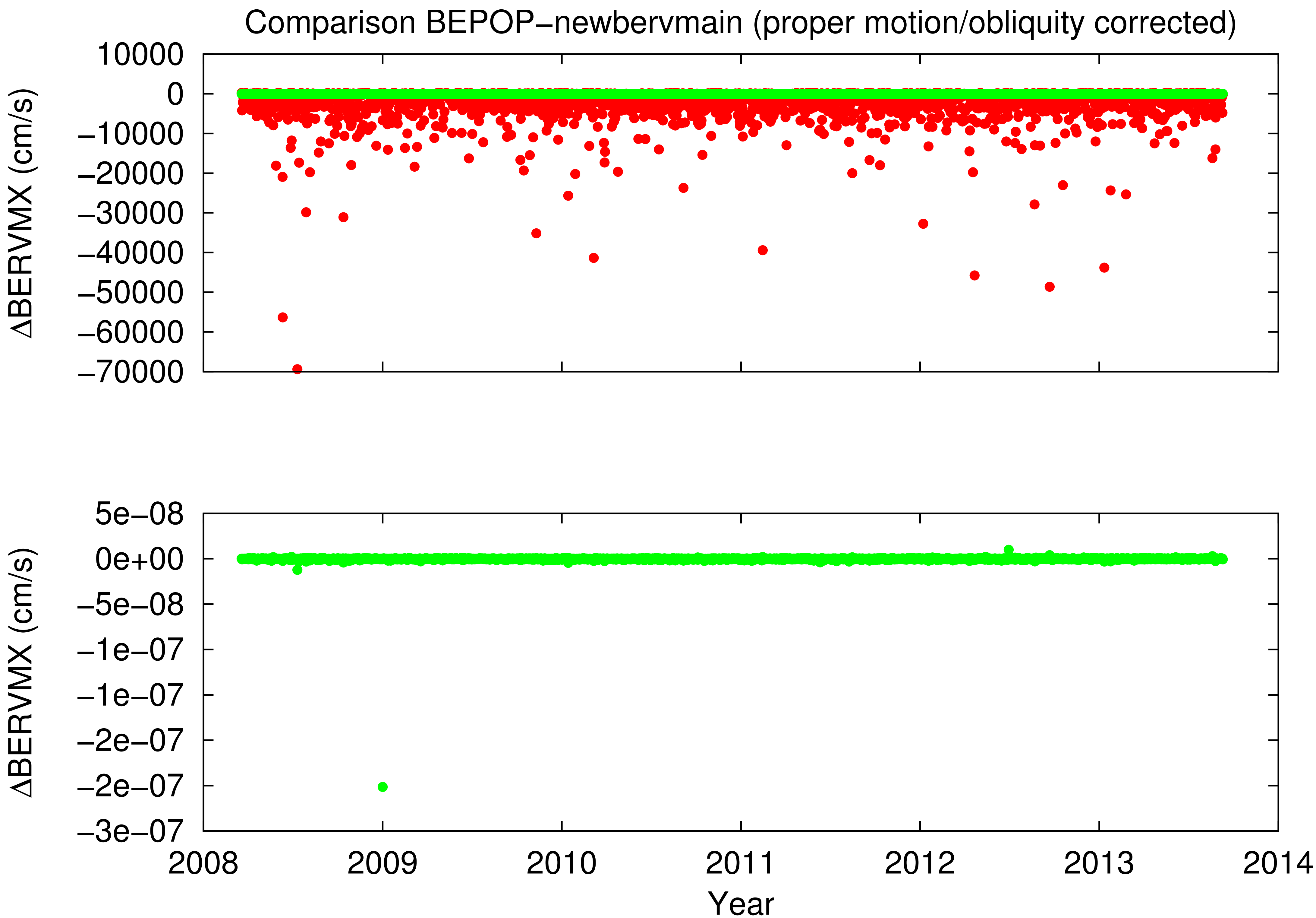
BePOP - newbervmain



observer at the surface on the Earth describing a circle orbit at uniform speed

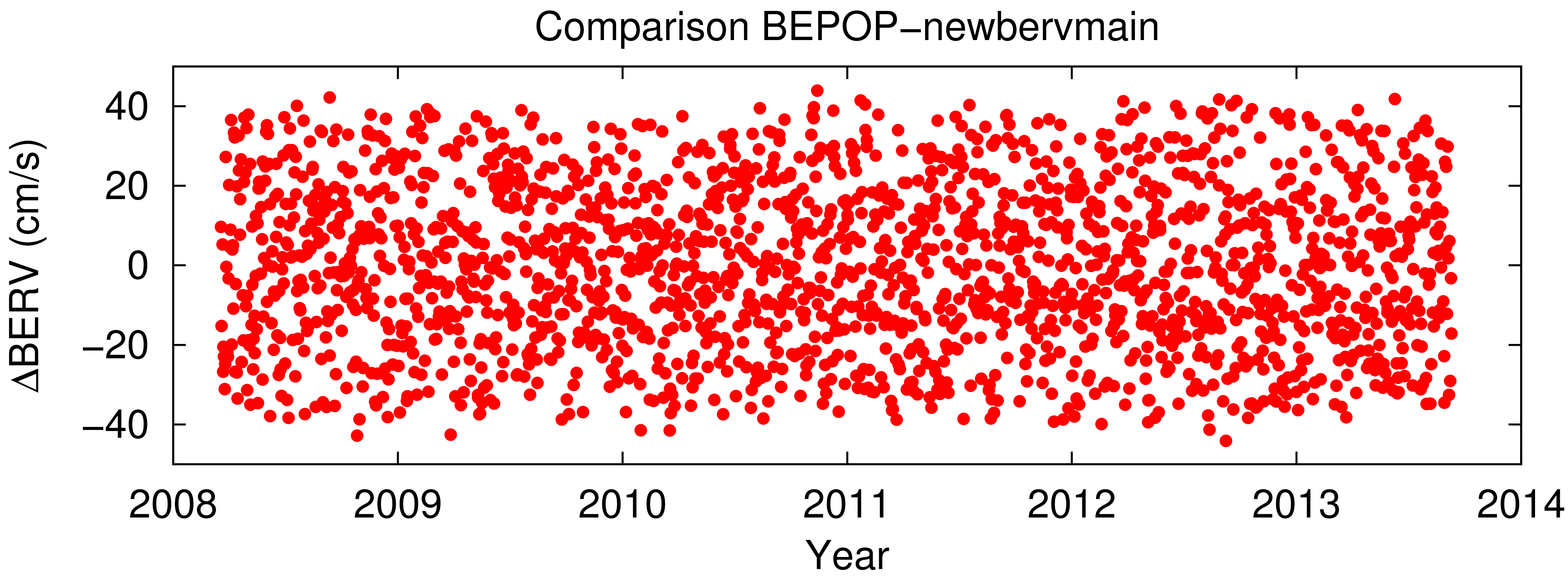
BERVMX

various corrections : Pi=3.1415, time from J2000 :AAAA+(M-1)/12+(J-1)/365.25, obliquity value, etc ...



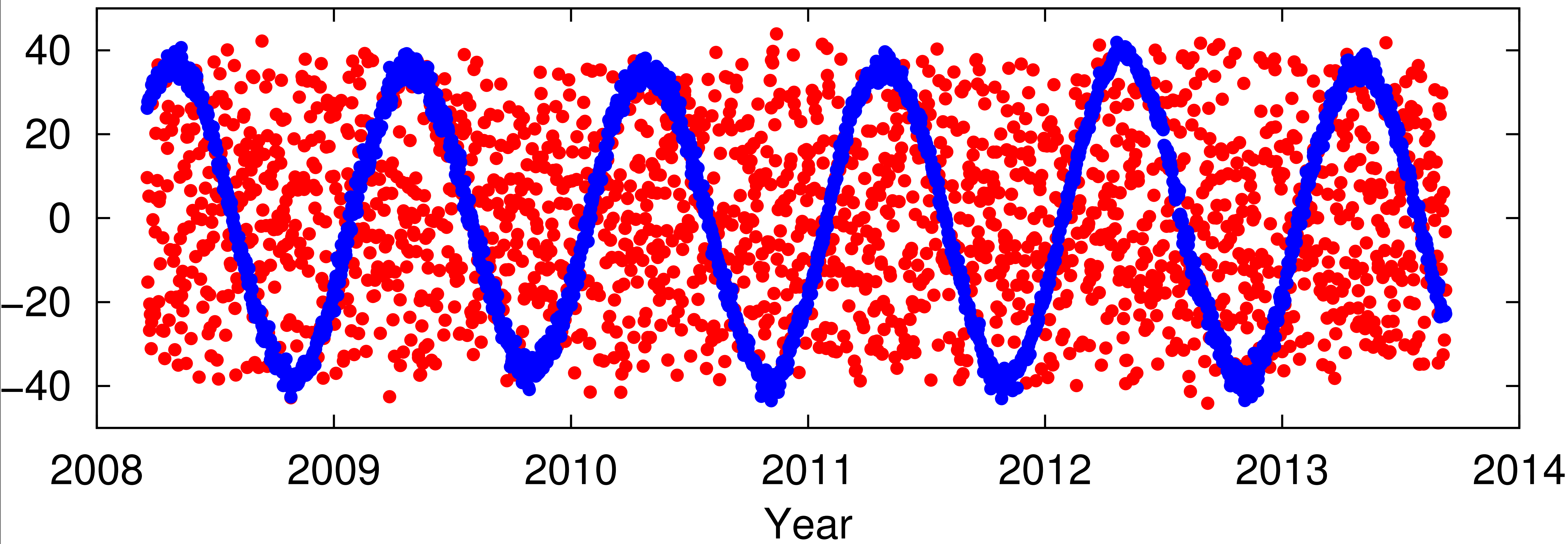
observer at the surface on the Earth describing a circle orbit at uniform speed

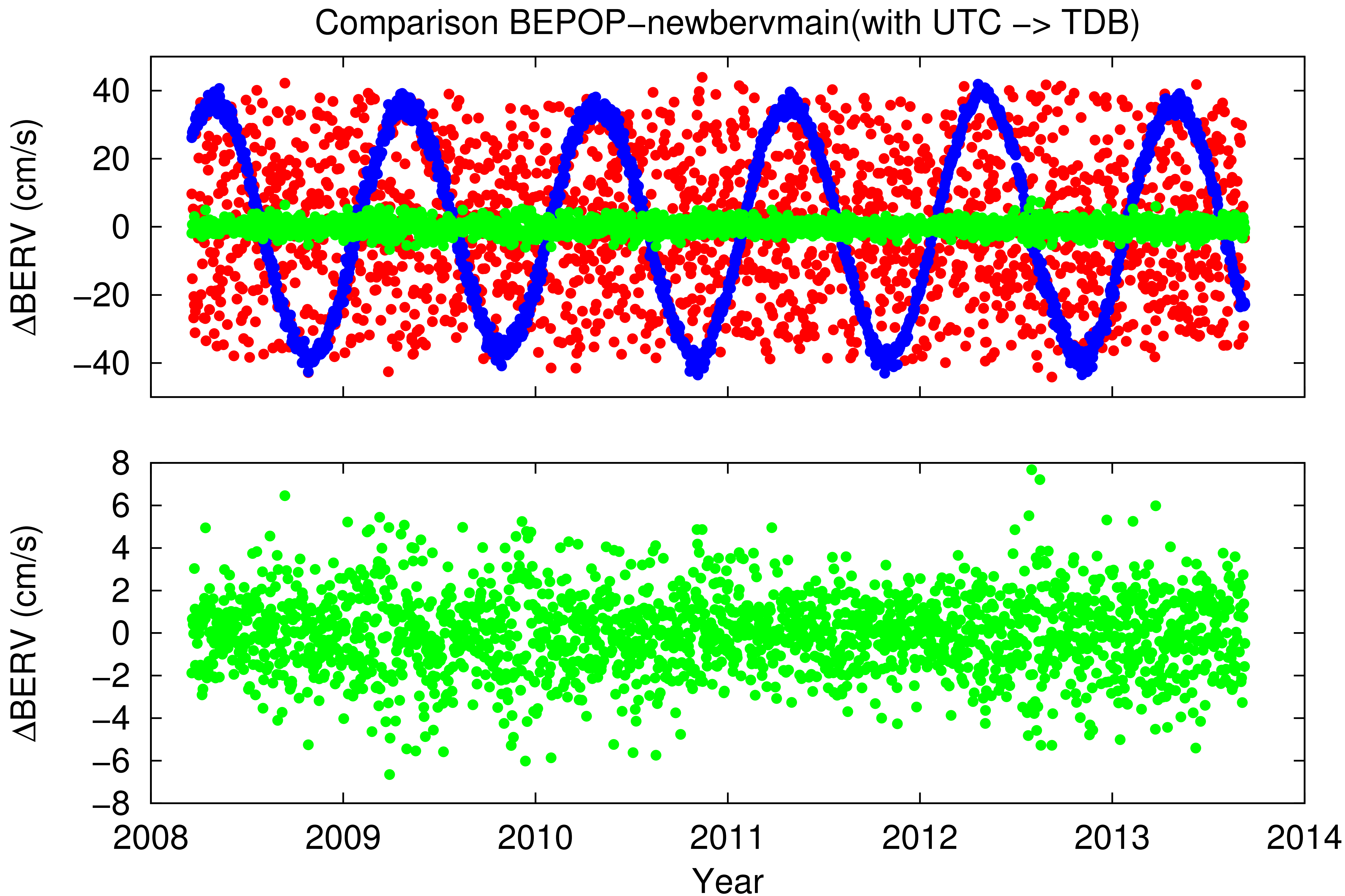
depends only on position and proper motion of the star

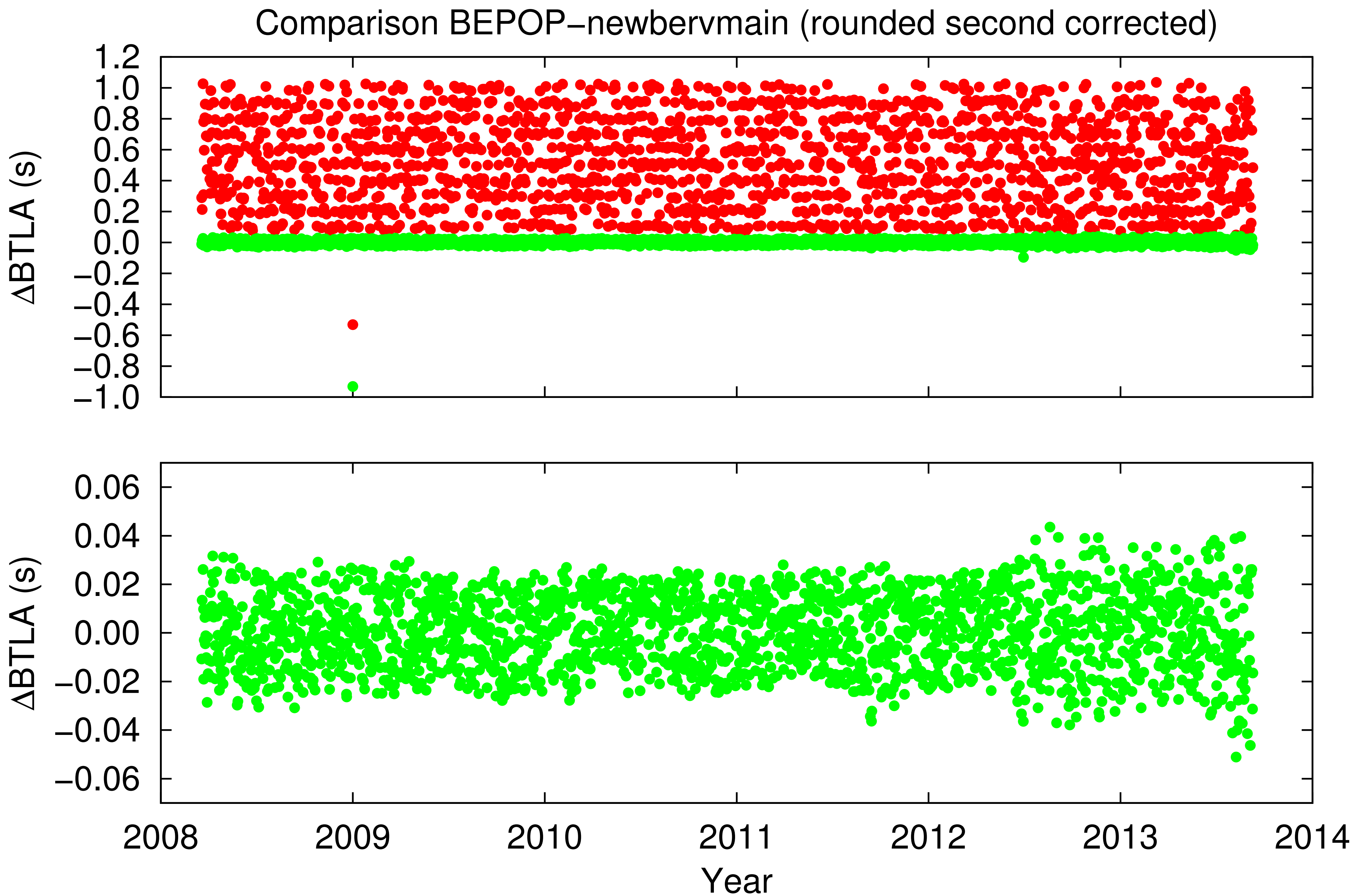


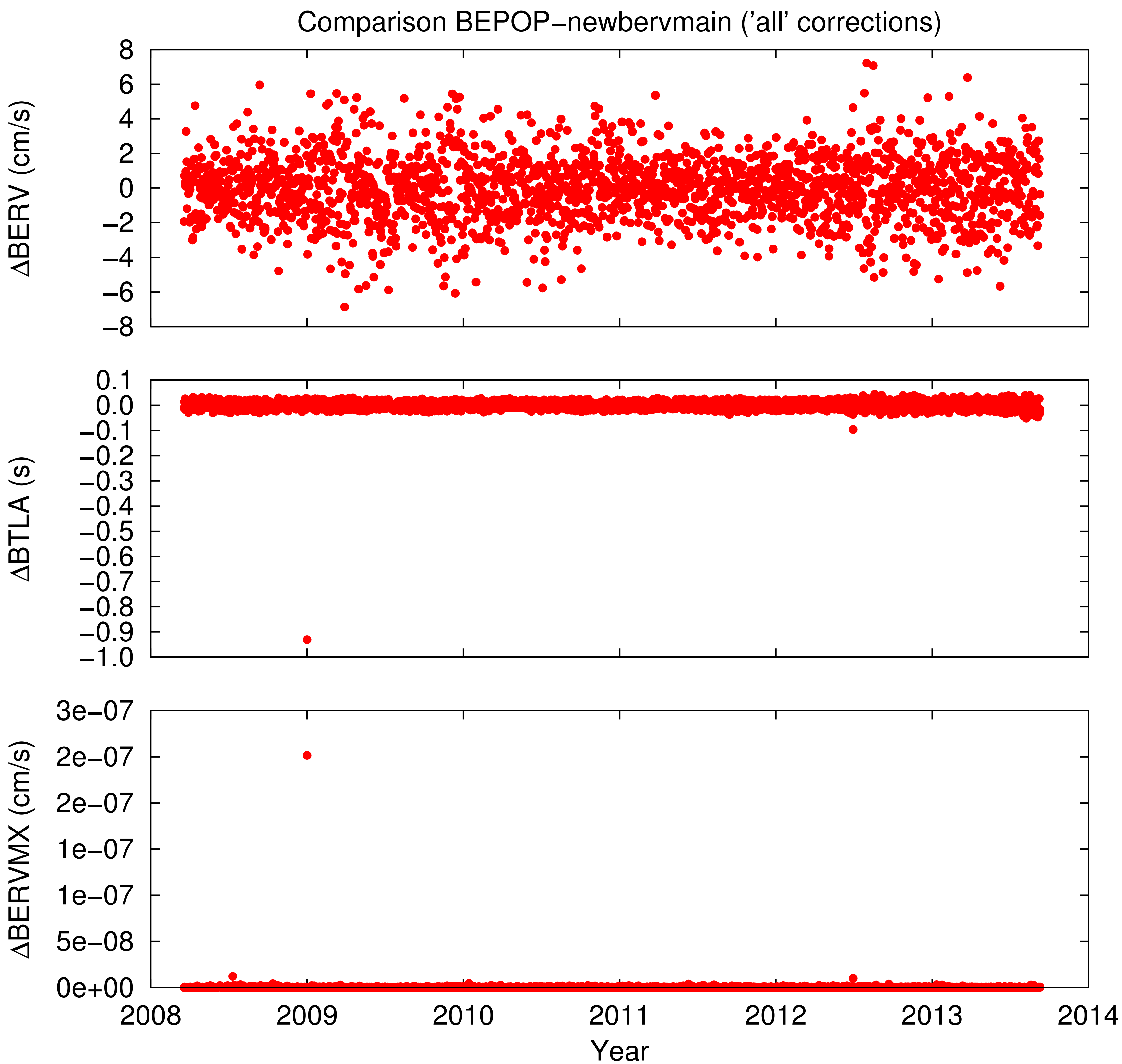
Comparison BEPOP−newbervmain
ΔBERV (cm/s)
40
20
0
−20
−40
2008
2009
2010
2011
2012
2013
2014
Year

Comparison BEPOP−newbervmain



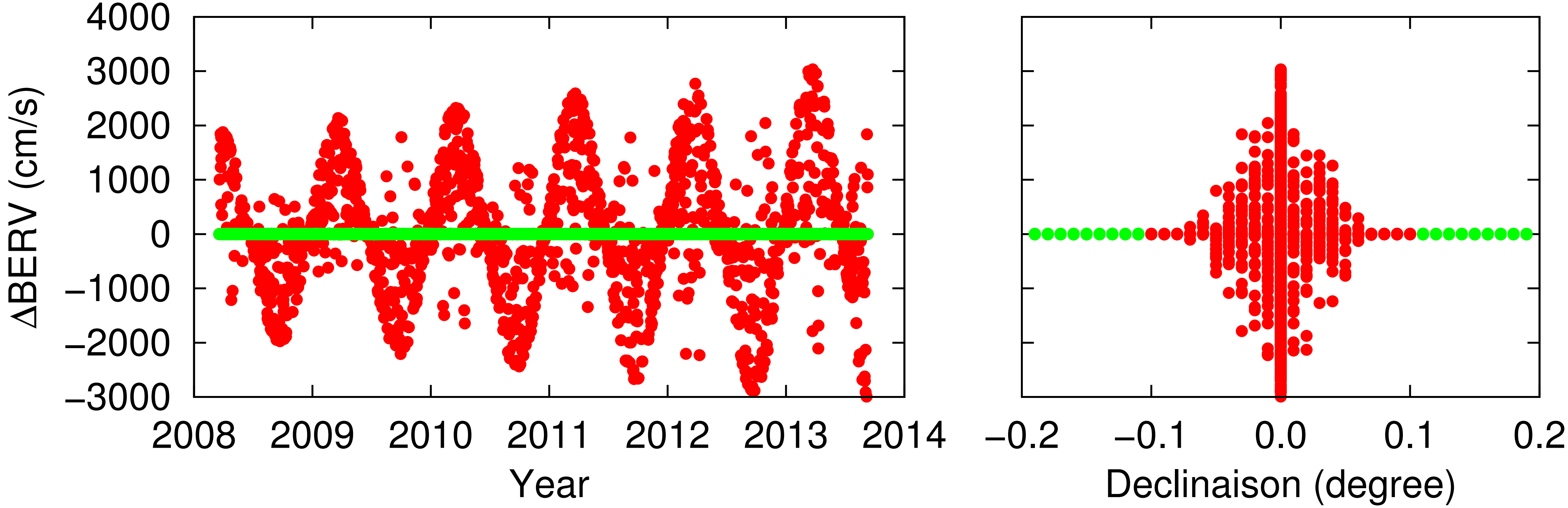

Comparison BEPOP−newbervmain(with UTC −> TDB)
ΔBERV (cm/s)
40
20
0
−20
−40
ΔBERV (cm/s)
8
6
4
2
0
−2
−4
−6
−8
2008
2009
2010
2011
2012
2013
2014
Year

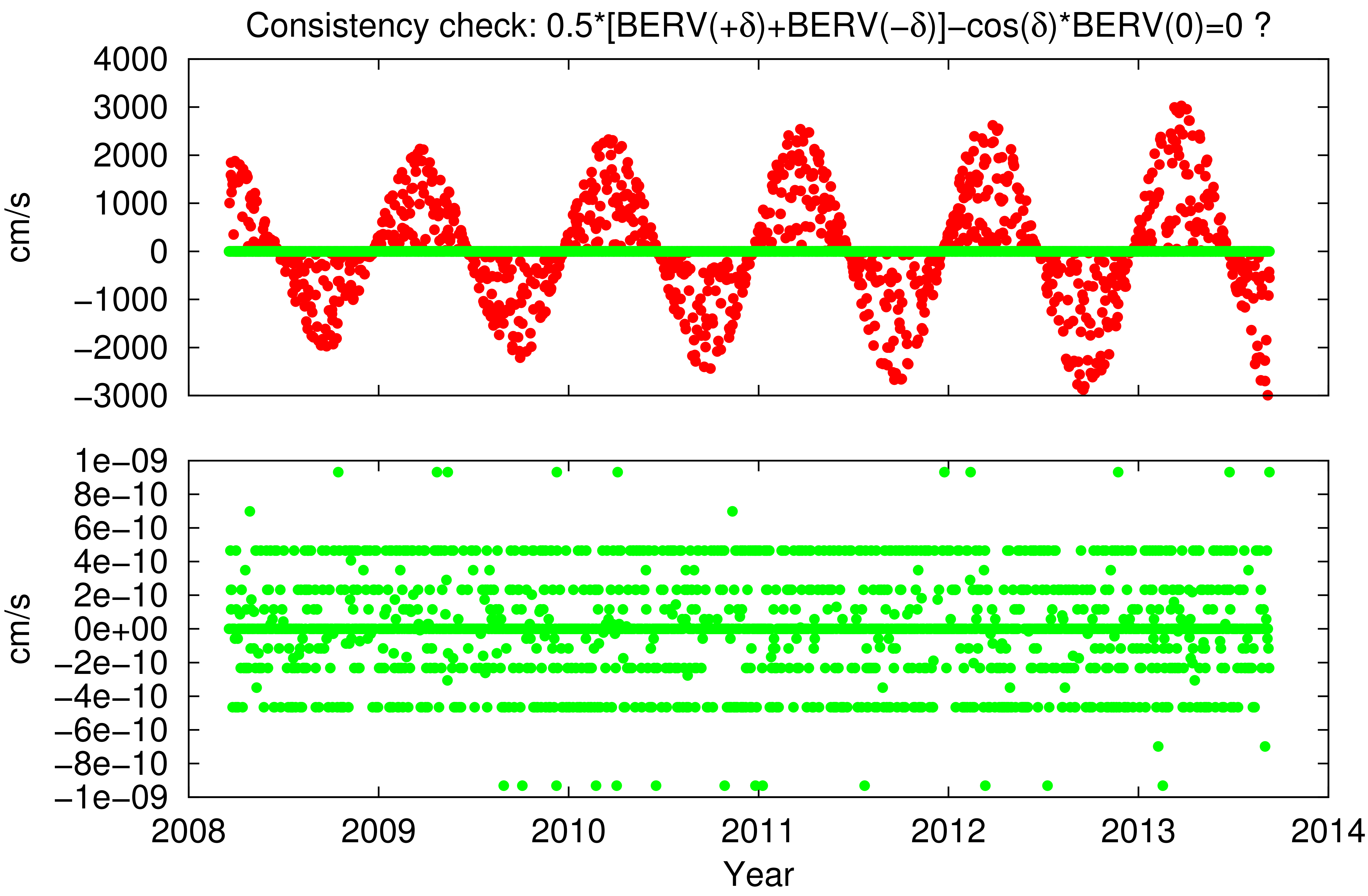

Comparison BEPOP−newbervmain (rounded second corrected)
ΔBTLA (s)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
−0.2
−0.4
−0.6
−0.8
−1.0
ΔBTLA (s)
0.06
0.04
0.02
0.00
−0.02
−0.04
−0.06
2008
2009
2010
2011
2012
2013
2014
Year



VSOP accuracy ?

Comparison BEPOP−newbervmain (problem at low declinaison)




Consistency check: 0.5*[BERV(+δ)+BERV(−δ)]−cos(δ)*BERV(0)=0 ?
4000
3000
2000
1000
0
−1000
−2000
−3000
cm/s
1e−09
8e−10
6e−10
4e−10
2e−10
0e+00
−2e−10
−4e−10
−6e−10
−8e−10
−1e−09
cm/s
2008
2009
2010
2011
2012
2013
2014
Year

```c
#include <stdio.h>
#include "bepop.h"

int main ( void )
{
  /* pointer to a derived type containing the parameters of the model */
  typeParamBEPOP * ptrBEPOP = NULL ; /* must be initialized at NULL to avoid errors */
  /* structure containing the output of BEPOP_compute routine */
  typeOutBEPOP resBEPOP ;

  /* Initialisation of the pointer to default parameters */
  ptrBEPOP=BEPOP_initDefault(1,ptrBEPOP) ; /* 1: most precise model (all nutations terms, all EOPs ta
  BEPOP_checkInit( ptrBEPOP); /* checks if all fields are consistent (should be useless when using BE

  /* Computes the quantities used for the radial velocities data reductions */
  BEPOP_compute( 6.31, 20.4, 0.001,-0.003,                        /* source coordinates */
                 2007, 5, 17, 23, 41 , 43.66 ,                       /* date and time */
                 10.0,41.5,2300.4 ,                                /* station position */
                 ptrBEPOP,                                         /* model parameters */
                 &resBEPOP);                                       /* results          */

  /* Prints the results */
  printf("  Barycentric Earth Radial Velocity (in km/s)            : %10.6f\n",resBEPOP.BERV) ;
  printf("  maximum value of BERVMX (in km/s)                      : %6.2f\n",resBEPOP.BERVMX) ;
  printf("  Barycentric Time of Light Arrival, in julian day (TDB) : %20.12f\n",resBEPOP.BTLA) ;
  printf("  Barycentric Observer's Velocity (in km/s)              : %10.6f\n",resBEPOP.BOV) ;
  printf("  Sun-Earth distance (in km)                             : %16.6f\n",resBEPOP.SED) ;


  ptrBEPOP=BEPOP_close(ptrBEPOP) ; /* close the pointer and free memory */
  return (0);
}
```

BePOP Licences

```
/*-----------------------------------------------------------------------*/
/* License  of this file :
 This file is "triple-licensed", you have to choose one  of the three licenses
 below to apply on this file.

    CeCILL-C
        The CeCILL-C license is close to the GNU LGPL.
        ( http://www.cecill.info/licences/Licence_CeCILL-C_V1-en.html )

 or CeCILL-B
        The CeCILL-B license is close to the BSD.
        (http://www.cecill.info/licences/Licence_CeCILL-B_V1-en.txt)

 or CeCILL v2.0
      The CeCILL license is compatible with the GNU GPL.
      ( http://www.cecill.info/licences/Licence_CeCILL_V2-en.html )
```

Release soon !

Resolution No. TBD#1
Recommended Nominal Conversion Constants for Selected Solar and Planetary Properties

Proposed by IAU Inter-Division A-G Working Group on Nominal Units for Stellar & Planetary Astronomy

June 13, 2015

The XXIXth International Astronomical Union General Assembly,

Interdivision Working group on nominal units

Div G : Star and stellar physics
Div A : Fundamental astronomy
support from
Div F : Planetary Systems and Bioastronomy
Div H : Interstellar matter and local Universe
Div J : Galaxies and Cosmology

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C25: Astronmical photometry and polarimetry; C26 : Doubles and miltiple stars;
C27 : variables stars; C36 : stellar atmospheres; C42 Space & High energy Astrophysics;

SOLAR CONVERSION CONSTANTS		
$1\mathcal{R}^{\mathrm{N}}_{\odot}$	=	6.9566×10^{8} m
$1\mathcal{S}^{\mathrm{N}}_{\odot}$	=	1361 W m^{-2}
$1\mathcal{L}^{\mathrm{N}}_{\odot}$	=	3.828×10^{26} W
$1\mathcal{T}^{\mathrm{N}}_{\mathrm{eff}\odot}$	=	5772 K
$1(\mathcal{GM})^{\mathrm{N}}_{\odot}$	=	1.3271244×10^{20} m^{3}s^{-2}
$1\mathcal{M}^{2010}_{\odot}$	=	1.988547×10^{30} kg

PLANETARY CONVERSION CONSTANTS		
$1\,\mathcal{R}^{\mathrm{N}}_{e\mathrm{E}}$	=	6.3781366×10^{6} m
$1\,\mathcal{R}^{\mathrm{N}}_{p\mathrm{E}}$	=	6.3567519×10^{6} m
$1\,\mathcal{R}^{\mathrm{N}}_{e\mathrm{J}}$	=	7.1492×10^{7} m
$1\,\mathcal{R}^{\mathrm{N}}_{p\mathrm{J}}$	=	6.6854×10^{7} m
$1\,(\mathcal{GM})^{\mathrm{N}}_{\mathrm{E}}$	=	3.986004×10^{8} m^{3} s^{-2}
$1\,(\mathcal{GM})^{\mathrm{N}}_{\mathrm{J}}$	=	1.2668653×10^{11} m^{3} s^{-2}

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