Bundesamt für
Kartographie und Geodäsie

The AGGO geodetic fundamental station at La Plata

AGGO - Argentinean-German Geodetic Observatory

Dr. Hayo Hase, BKG-AGGO

Content

1. Fundamental station for geodesy
2. Instrumentation and Achievements
3. Outlook

FK5 - Fifth Fundamental Catalogue

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- 1988 most precise realization of celestial reference frame, <0.05“
- «inertial» system based on 1535 stars
- right ascension, declination, epoch
- proper motion
- mean errors (RA, DE)

Legend of FK5

See also:
I/175 : FK5, Part II (Extension).

Byte-by-byte description of the file: catalog

Bytes	Format	Units	Labels	Explanations
1- 4	I4	---	FK5	*[1/1670]+ FK5 number
6- 7	I2	h	RAh	Right ascension, hours, Equinox=J2000, Epoch=J2000
9- 10	I2	min	RAm	Right ascension minutes (J2000.0)
12- 17	F6.3	s	RAs	*Right ascension seconds (J2000.0)
19- 25	F7.3	s/ha	pmRA	Proper motion in RA (J2000.0)
27	A1	---	DE-	Sign of declination (Dec) (J2000.0)
28- 29	I2	deg	DEd	Declination degrees (J2000.0)
31- 32	I2	arcmin	DEm	Declination arcminutes (J2000.0)
34- 38	F5.2	arcsec	DEs	*Declination arcseconds (J2000.0)
40- 46	F7.2	arcsec/ha	pmDE	Proper motion in DE (J2000.0)
48- 49	I2	h	RA1950h	Right ascension, hours Equinox=B1950, Epoch=B1950
51- 52	I2	min	RA1950m	Right ascension minutes (B1950.0)
54- 59	F6.3	s	RA1950s	*Right ascension seconds (B1950.0)
61- 67	F7.3	s/ha	pmRA1950	Proper motion in RA (B1950.0)
69	A1	---	DE1950-	Sign of declination (B1950.0)
70- 71	I2	deg	DE1950d	Declination degrees (B1950.0)
73- 74	I2	arcmin	DE1950m	Declination arcminutes (B1950.0)
76- 80	F5.2	arcsec	DE1950s	*Declination arcseconds (B1950.0)
82- 88	F7.2	arcsec/ha	pmDE1950	Proper motion in DE (B1950.0)
90- 94	F5.2	a	EpRA-1900	*Mean Epoch of observed RA
96- 99	F4.1	ms	e_RAs	*Mean error in RA
101-105	F5.1	ms/ha	e_pmRA	Mean error in pmRA
107-111	F5.2	a	EpDE-1900	*Mean Epoch of observed DE
113-116	F4.1	carcsec	e_DEs	*Mean error in Declination
118-122	F5.1	carcsec/ha	e_pmDE	Mean error in pmDE
124-128	F5.2	mag	Vmag	*V magnitude
129	A1	---	n_Vmag	*[VvD] Magnitude flag
131-137	A7	---	SpType	*Spectral type(s)
139-144	F6.3	arcsec	plx	*?Parallax
147-152	F6.1	km/s	RV	*?Radial velocity
155-159	A5	---	AGK3R	AGK3R number (Catalog <I/72>)

Excerpt from FK5

J2000.0 / B1950.0

453	12 10 7.485	-0.512	-22 37 11.15	+1.35	12 7 32.949	-0.511	-22 20 30.31	+1.35	42.72	1.0	3.1	36.50	2.1	6.1	3.00	K0	+0.020	+4.9	105707	BD-21 3487	16618
454	12 12 11.917	+0.296	+77 36 58.51	+2.18	12 9 52.866	+0.303	+77 53 38.52	+2.18	40.07	4.1	12.8	26.20	1.9	5.7	5.14	A5	+0.027	-0.2	106112	BD+78 412	16672
455	12 15 8.683	-0.529	-58 44 56.08	-0.89	12 12 28.626	-0.525	-58 28 15.19	-0.89	54.84	2.9	10.5	44.14	2.9	9.3	2.80	B3		+26.4	106490	CP-58 4189	16724
456	12 15 25.560	+1.270	+57 1 57.42	+0.94	12 12 57.607	+1.280	+57 18 37.29	+0.93	52.10	1.4	5.1	37.61	1.7	4.2	3.31	A2	+0.052	-12.9	106591	BD+57 1363	16736
457	12 15 48.366	-1.124	-17 32 30.97	+2.33	12 13 13.876	-1.122	-17 15 51.89	+2.33	41.96	1.0	3.2	32.52	1.9	5.9	2.59	B8		-4.2	106625	BD-16 3424	16740
458	12 16 7.551	+0.147	+40 39 36.63	-3.17	12 13 37.493	+0.148	+40 56 18.37	-3.17	53.68	1.2	4.6	44.32	2.1	6.8	5.66	K5		-14.9	106690	BD+41 2284	16750
459	12 18 20.709	-1.724	-79 18 43.93	+1.75	12 15 22.159	-1.680	-79 2 5.26	+1.76	50.61	7.0	21.2	37.43	2.7	7.5	4.26	B5		+23.0	106911	CP-78 741	16775
460	12 19 54.358	-0.419	-00 40 0.51	-1.81	12 17 20.792	-0.419	-00 23 20.65	-1.81	38.86	0.7	2.3	24.96	1.4	4.1	3.89	A0	+0.010	+2.3	107259	BD+00 2926	16813
461	12 25 50.937	-0.672	+39 1 6.99	-3.19	12 23 23.382	-0.675	+39 17 45.07	-3.18	56.10	0.9	3.8	45.96	1.7	5.6	5.02	K0	+0.029	-3.5	108225	BD+39 2521	16948
462	12 26 35.871	-0.524	-63 5 56.58	-1.21	12 23 48.041	-0.519	-62 49 19.77	-1.21	33.71	6.1	13.4	29.33	4.2	9.9	1.33	B1		-11.2	108248	CP-62 2745	16952

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Analogy **Fundamental** Catalogue – Station

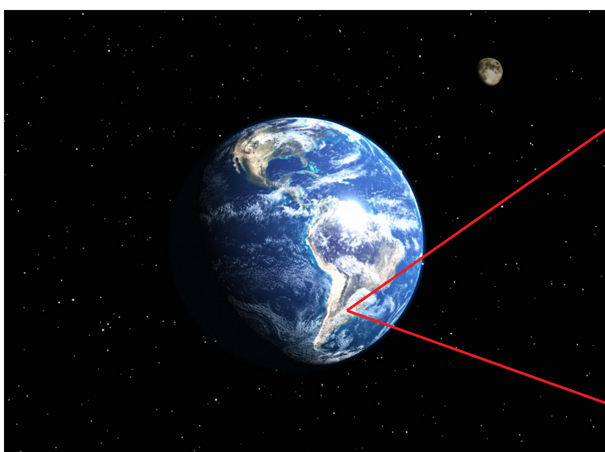
- 1988 most precise realization of celestial reference frame, <0.05“
- «inertial» system based on 1535 stars
- right ascension, declination, epoch ⟷ coordinates (x,y,z)
- proper motion ⟷ coordinate velocities
- mean errors (RA, DE) ⟷ mean errors (x,y,z)

- network of SLR and VLBI stations proved crustal dynamics
- global reference frames based on space geodesy network stations
- coordinates (x,y,z) — New!
- coordinate velocities — requests epoch!
- mean errors (x,y,z)

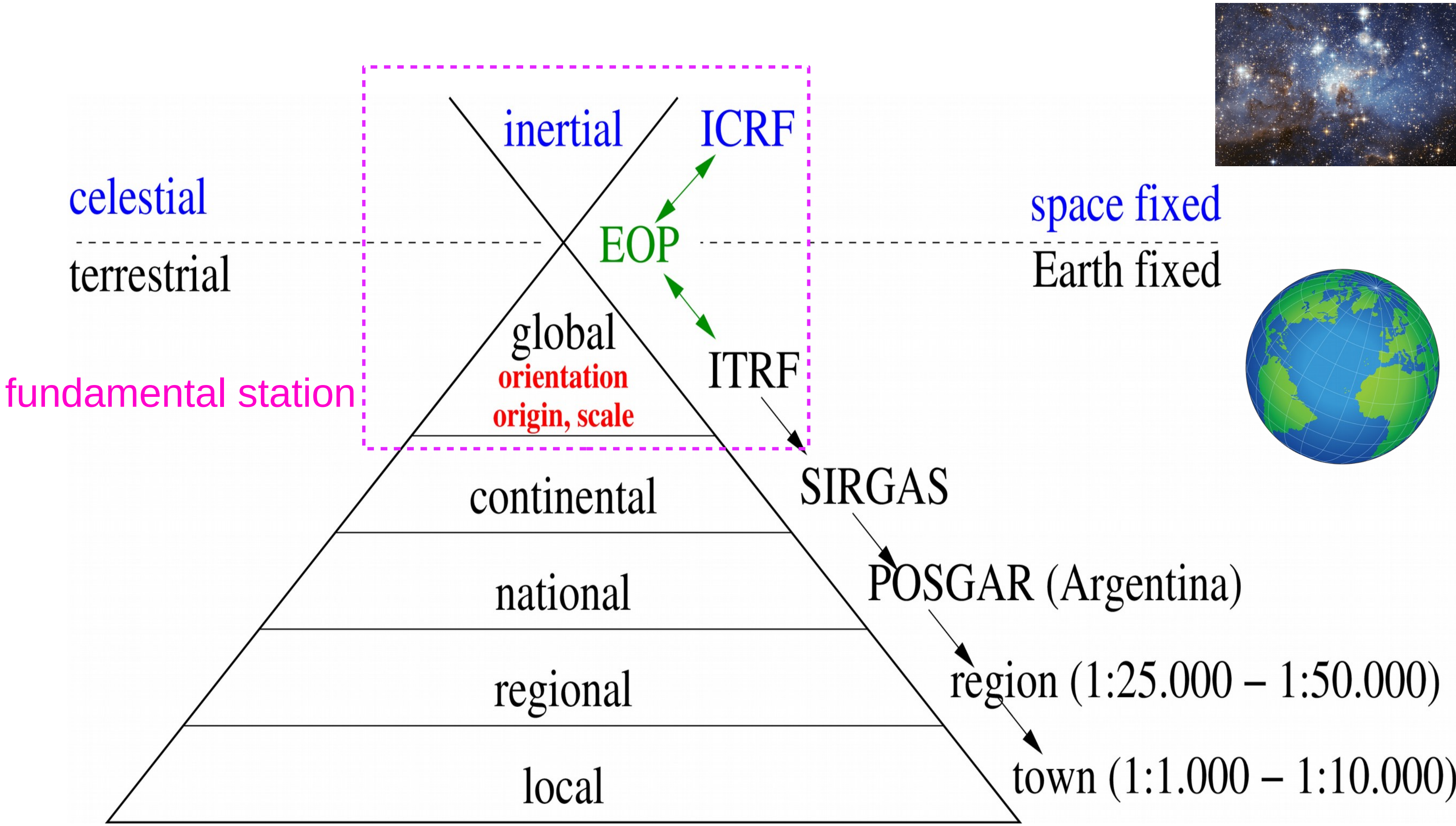
fundamental stars ⟷ fundamental stations

What is the task of a Fundamental Station for geodesy?

- provide a materialized reference point for the realization of a global terrestrial reference system
- provide a tie to a quasi-inertial celestial reference system
- deliver a complete set of observational data for consistent modelling of the physical conditions in a space-time-gravity continuum



Role of Fundamental Stations in a consistent hierarchy of reference systems



Fundamental Stations define orientation, origin and scale of global reference frames.

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Role of Fundamental Stations for Earth Monitoring

changes in Earth rotation

polar motion
length of day variation

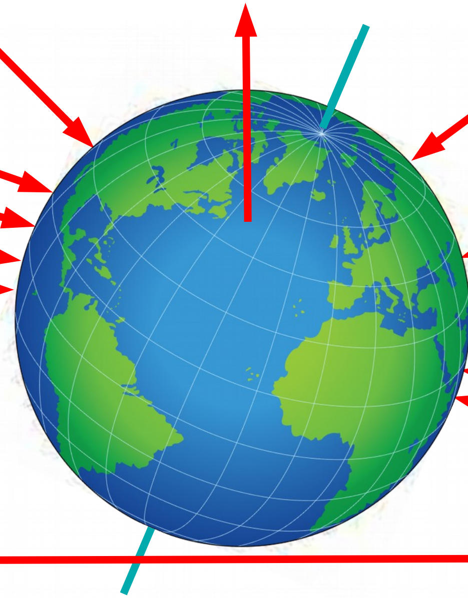
deformation of Earth body

gravitating objects in space
precession
nutation
Earth tides

angular momentum
ocean
atmosphere

pole tide

loadings
ocean
atmosphere
glaciers
groundwater



geophysical effects
plate tectonics
regional tectonic
Earth‘s interior
convection
vulcanism
earthquakes

local deformation

Fundamental Stations must be multi sensor measuring platforms.

Instruments and Sensors of a Fundamental Station for Geodesy

- **Position in time, epoch (t)**
  - frequency standards, cesium normals
  - hydrogen maser
  - time transfer system
- **Position in space (x, y, z)**
  - Very Long Baseline Interferometry (VLBI)
  - Satellite Laser Ranging (SLR)
  - Global Navigation Satellite Systems (GNSS)
- **Position on the potential surface (g)**
  - absolute gravimeter
  - superconducting gravimeter (Δg)
- **Complementary sensors**
  - meteorological sensors (°C, %, p)
  - hydrological sensors
  - geodetic instruments for the local survey

+energy

+tools

4 Characteristics of a Fundamental Station

- **Permanency and continuity of the operation**
  considering timescales of geodynamic phenomena and guaranteeing monitoring of permanent changes in timeseries

- **Complementariness of geodetic methods**
  to obtain the best possible realization of a precise global reference system

- **Redundancy within selected instruments**
  for quality assurance of observational data by independently obtained results of the same observable

- **Determination of local spatial vectors**
  between the technique-specific reference points by a local survey

=> co-location of instruments!

→ Geodesy, networks and references systems,
Encyclopedia of Solid Earth Geophysics, Harsh Gupta (ed.), 2011

Time, the mother of our units

Definition: time second

The duration of 9,192,631,770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the (^{133}Cs) atom, measured at a temperature of 0 K, corresponds to one time second.

+

Definition: Velocity of light

The velocity of light in vacuum is defined by a universal constant of c=299.792.458 m/s.

=

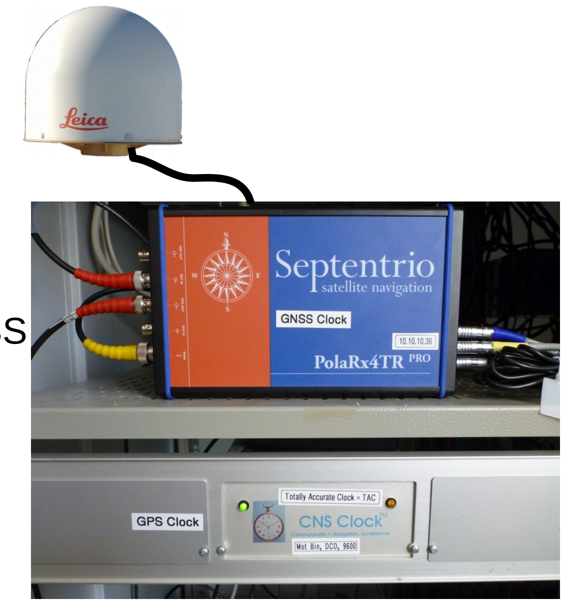
Definition: Meter

The length of the path travelled by light in a vacuum during a time interval of 1/299.792.458 of a second. (approx. 30.66 periods or 3.34ns)

Time & Frequency Laboratory

since May 2019
evaluation process
for UT-service
by BIPM

GNSS



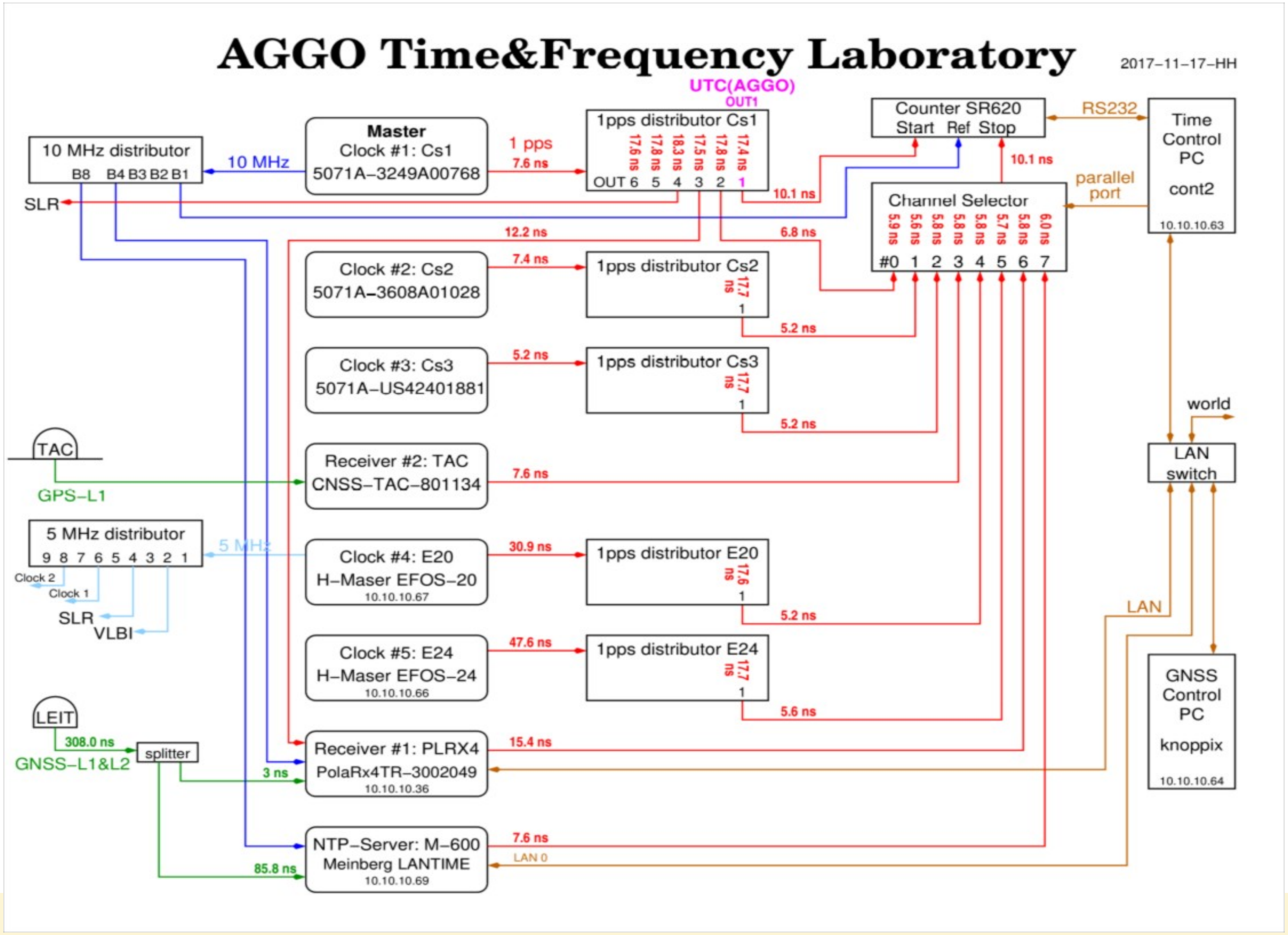
NTP

local time scale linked
to UT by GNSS
10^{-9}

H-Maser
used for VLBI and SLR
10^{-14}

Cesium normals
defining UTC(AGGO)
10^{-13}

Maintenance of Time Scale



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Space

Very Long Baseline Interferometry (VLBI)

IERS Domes No: 41596S002
CDP: 7641

6m radio telescope for VLBI

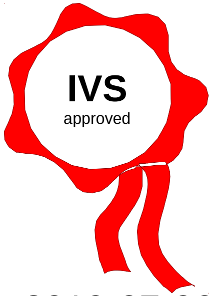
operational since 2019

- primary focus 6m offset radio telescope
  vel(Az)=6°/s, vel(El)=3°/s
- cryogenic dualband S/X receiver
- phase and delay calibration system
- data acquisition rack VLBA5
- data recording system Mk5B+
- optical fibre for e-transfer of VLBI data (bandwidth up to 1 Gbps)
- counter, oscilloscopes, spectrum analyzer, signal generator, GPS time receiver

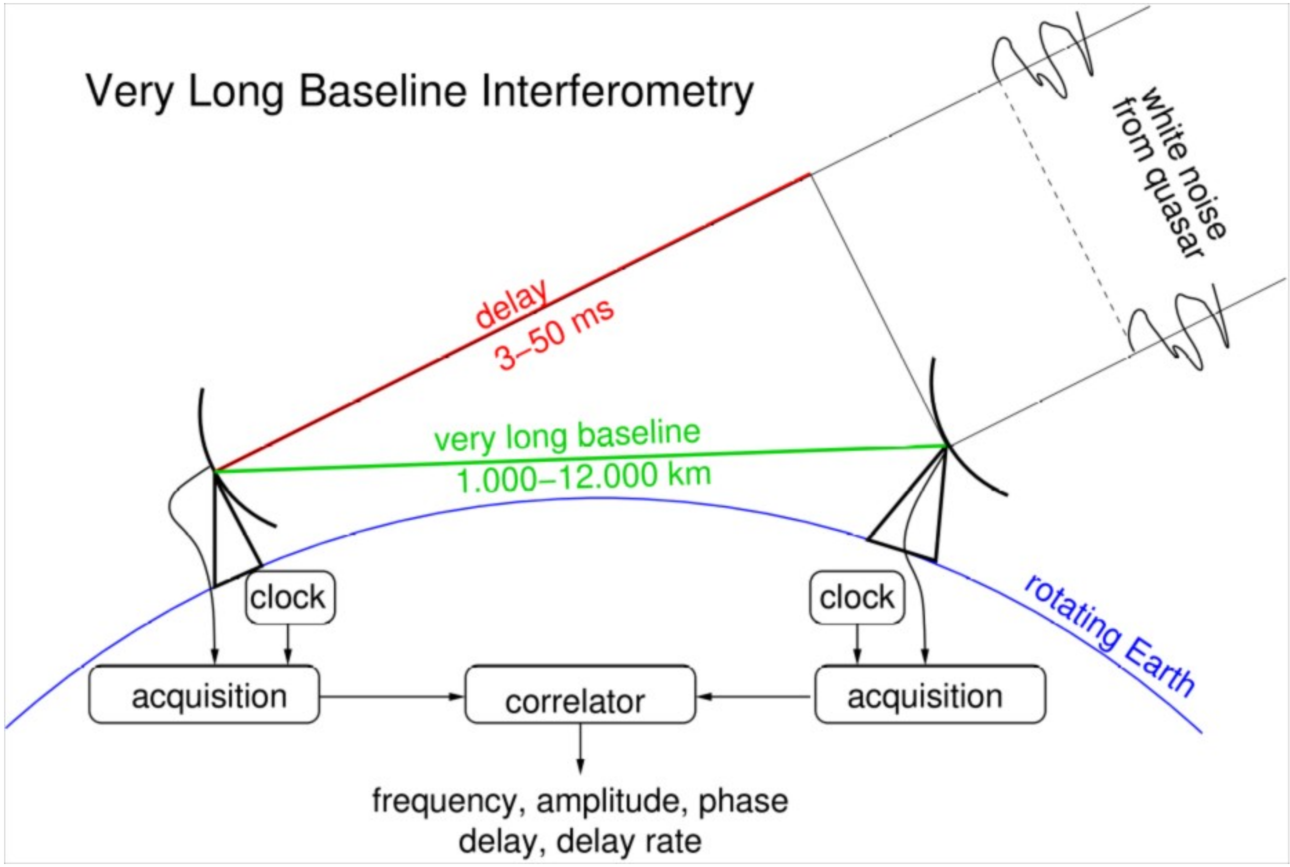
Very Long Baseline Interferometry (VLBI)

IERS Domes No: 41596S002
CDP: 7641

6m radio telescope
for VLBI



2019-07-06



Observing programs: IVS: R1, T2, OHIG Wettzell: W

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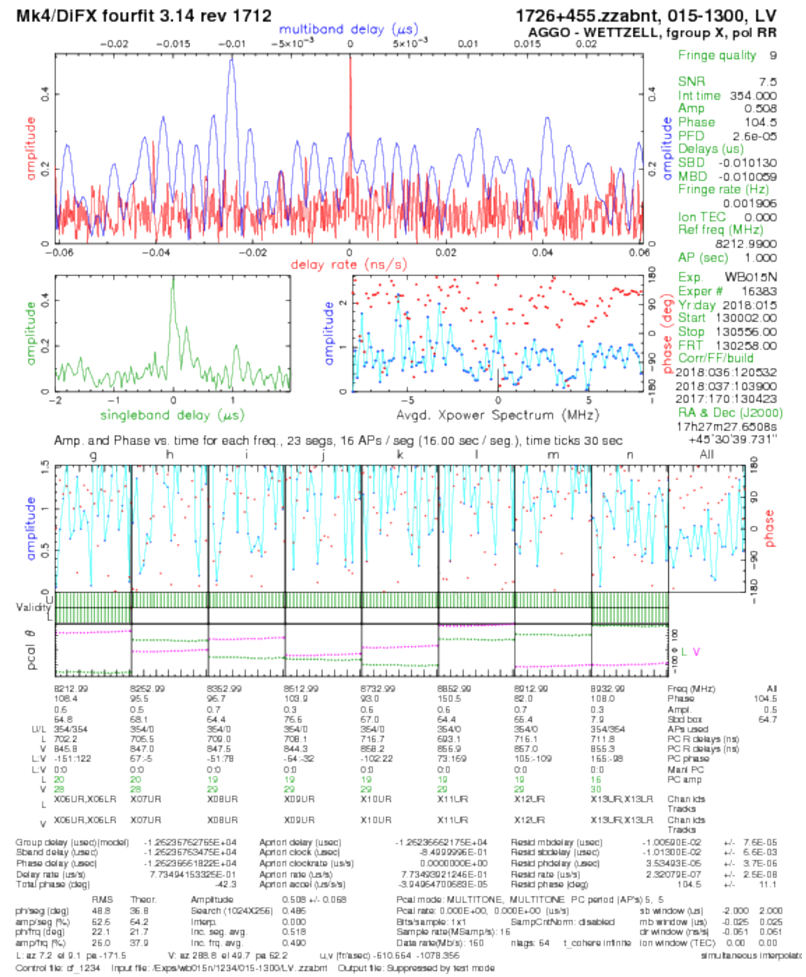
First fringes to AGGO, 2018-01-15 13:00 UT

Baseline AGGO-Wettzell, S-band, X-band



Satellite Laser Ranging (SLR)

IERS Domes No: 41596S001
CDP: 7408

optical telescope with 50cm aperture
laser system to measure distances

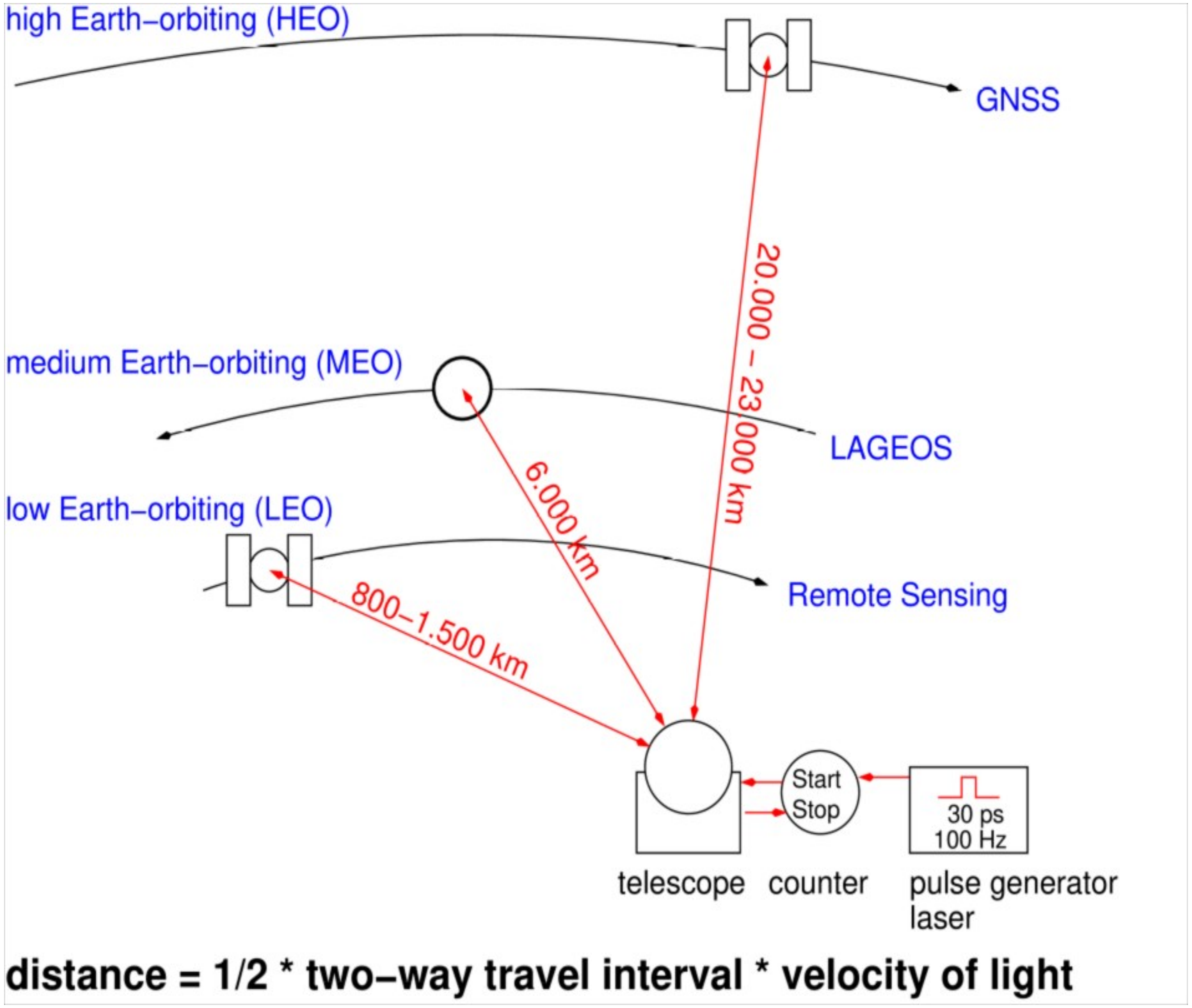
- 50cm optical telescop with Coude optic
  vel(Az) = 15°/s, vel(El) = 10°/s
- 2 colour Ti:Sapphire laser system
  λ_2 = 423.5nm, λ_1 = 847.0nm
- pico second event timer
- LEO, MEO, HEO satellite tracking
- aircraft detection system

Space

Satellite Laser Ranging (SLR)

IERS Domes No: 41596S001
CDP: 7408

optical telescope
with aperture of 50cm
and 2-colour laser system



Space

Global Navigation Satellite Systems (GNSS)

IERS Domes No: 41596M001

Leica GNSS antena
Septentrio PolaRxTR4 receptor

operational since 2017

- GNSS reference point estabished
- recognized by IGS, SIRGAS, POSGAR, (BIPM)

Station Details

Station: AGGO - AGGO / Argentina

General Information	
Projects	IGS
storedIn	IGS
Date Prepared	09.02.2017 00:00:00
Name	AGGO / Argentina
FourCharacterId	AGGO
Maps	Córdoba Santa Fe Rosario Uruguay Argentina Buenos Aires mapbox Leaflet | © Mapbox © OpenStreetMap Improve this map
DomesNumber	41596M001
Country	Argentina
TectonicPlate	SOUTH AMERICAN
XCoordinate	2765120.9000
YCoordinate	-4449250.2500
ZCoordinate	-3626405.6000
Email	uwe.hessels@bkg.bund.de;hayo.hase@bkg.bund.de
	Go
DisabledFrom	1000-01-01
DisabledTo	1000-01-01
Logfile Data	Click **here** to see the logfile data
UploadLogfile	

https://igs.bkg.bund.de/dataandproducts/showstationdetails/id/1001136

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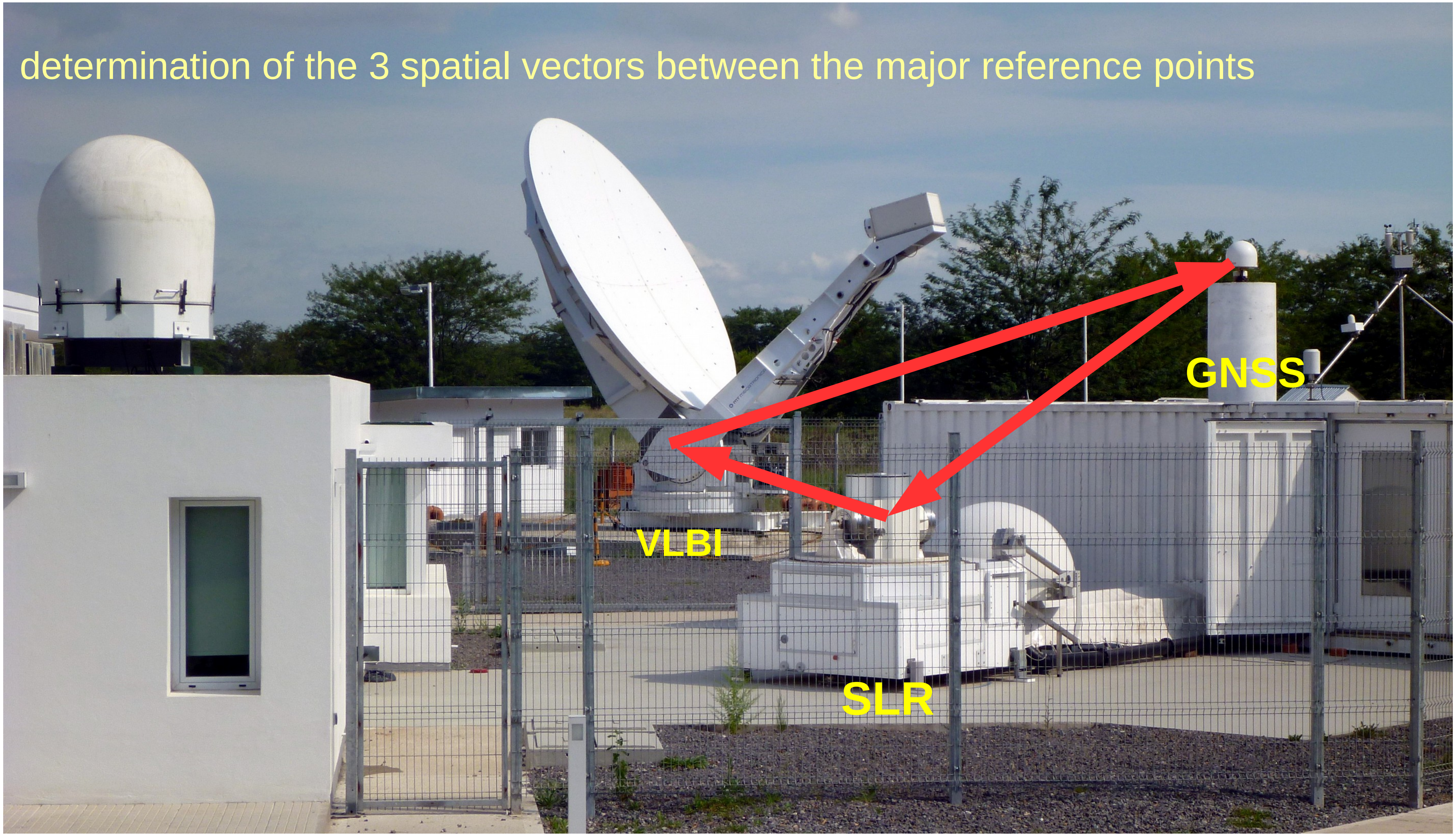
Space
Local Survey



Reference points: intersection of axes phase center

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Gravity
Absolute Gravimeter FG-5
Superconducting Gravimeter SG

absolute gravimeter FG-5, 2018 superconducting gravimeter SG, 2016

- 3 absolute reference points in gravimeter house offer the possiblity for calibration in AGGO. (January 2018)
- recognized by IGFS

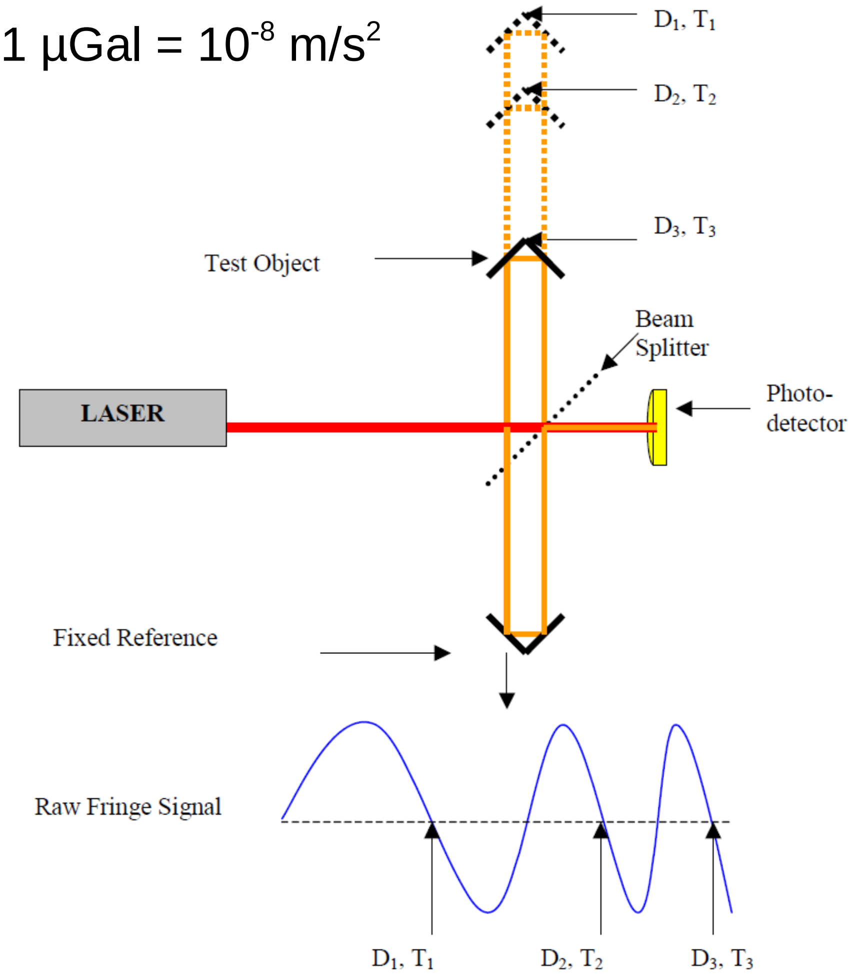
IGFS
approved

Gravity

Absolute Gravimeter

absolute gravitmeter FG5

1 µGal = 10^{-8} m/s^2

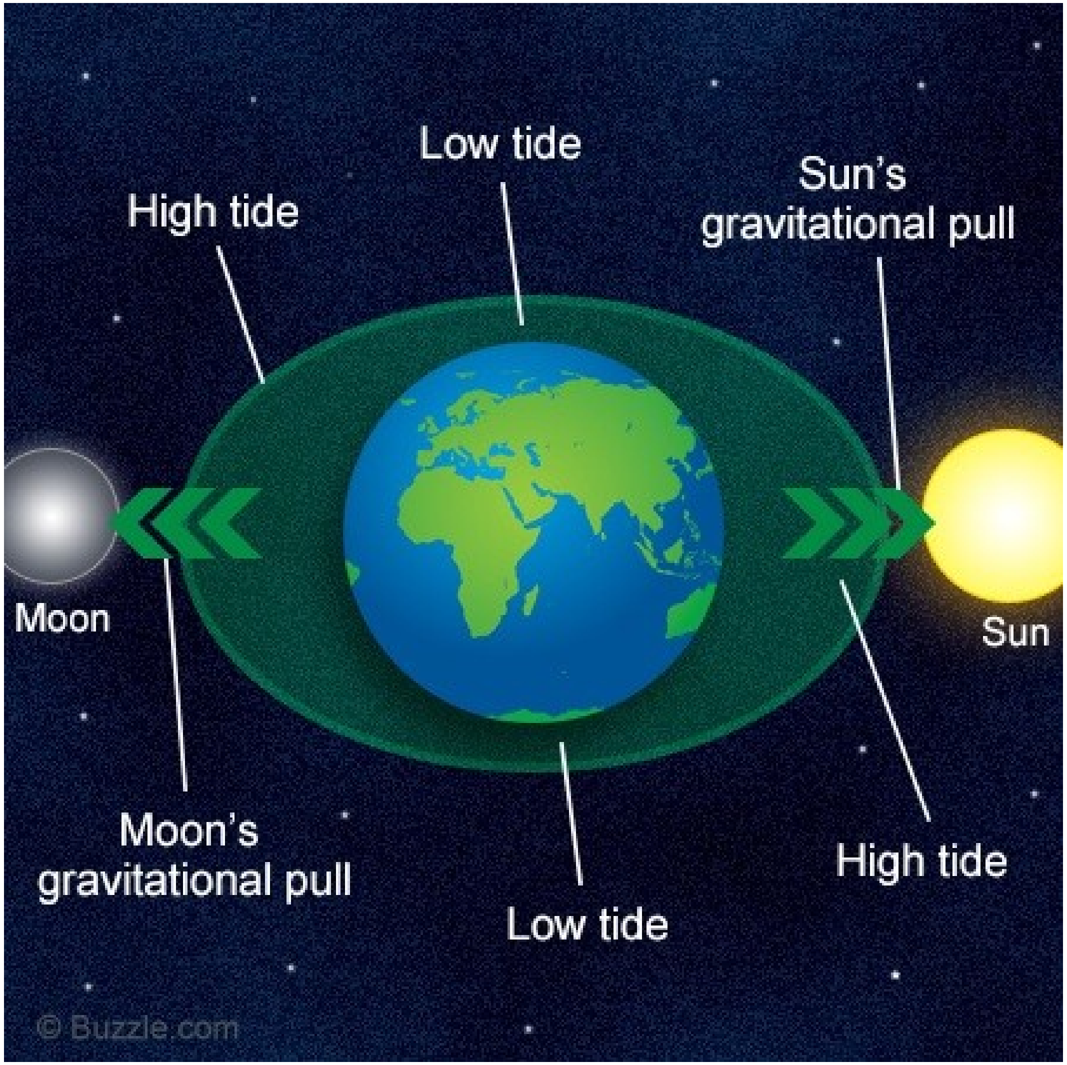


Principle of free falling mass

Gravity

Earth Tides measured by superconducting gravimeter

superconducting
gravimeter



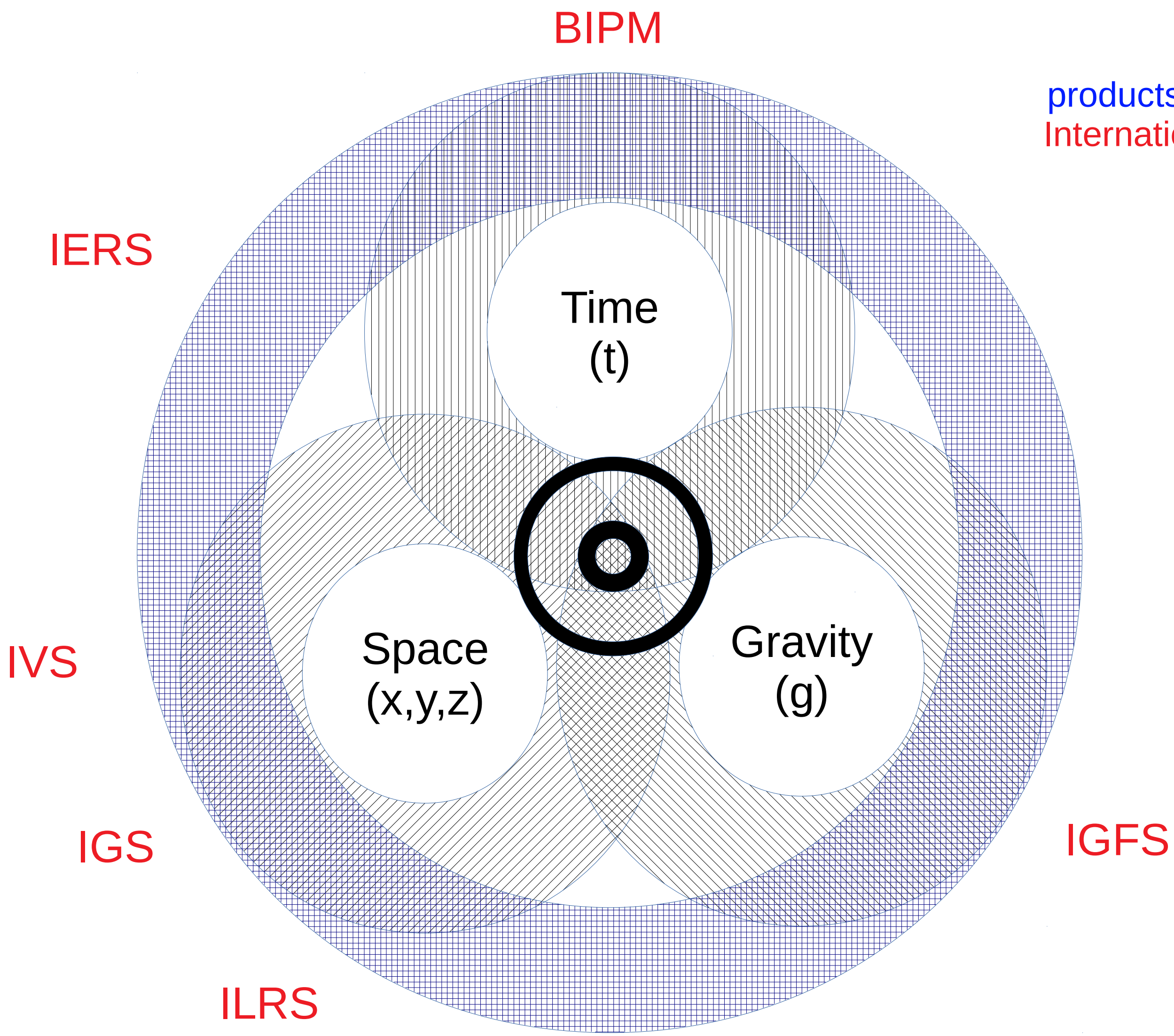
International Services

AGGO represents Argentina in 6 International Services:

- **IERS**, International Earth Rotation and Reference System Service
- **IVS**, International VLBI Service for Geodesy and Astrometry
- **ILRS**, International Laser Ranging Service
- **IGS**, International GNSS Service
- **BIPM-UT**, Universal Time Service
- **IGFS**, International Gravity Field Service

AGGO is part of the global infrastructure for geodesy and is unique of its category in Latin America.

AGGO
a truly Reference Point for Geodesy



A fundamental reference point is a position (x,y,z) with an epoch (t) and a value for gravity (g).

Why Germany works in the Southern hemisphere?

- **UN Resolution 69/266**, February 26, 2015
  “A global geodetic reference frame for sustainable development”
  http://www.un.org/en/ga/search/view doc.asp?symbol=A/RES/69/266
- **Directive 2007/2/EC of the European Parliament and of the Council**, “Establishing an Infrastructure for Spatial Information in the European Community (INSPIRE)”, March 14, 2007
  https://eur-lex.europa.eu/legalcontent/EN/TXT/PDF/?uri=CELEX:32007L0002&from=EN
- **Bundesgeoreferenzdatengesetz – BGeoRG** (National law on the duties of BKG) : “Gesetz über die geodätischen Referenzsysteme, -netze und geotopographischen Referenzdaten des Bundes”
  http://www.gesetze-im-internet.de/bgeorg/BGeoRG.pdf

- Geodesy is always a global issue.

Outlook

- SLR to become operational very soon (2020).
- Energy situation will improve by an UPS for the entire observatory (2020) and extension of the solar power system (2020).
- Installation of new sensors:
  - tide gauge at La Plata river (2020-2021)
  - water vapour radiometer (2020)
  - ceilometer (2020)
- With more office space for AGGO-staff the operation will move from containers to the operations building to make AGGO permanent (2020-2022).
- To become VGOS compatible AGGO needs a new and larger VGOS radio telescope.

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