Report of Time and Frequency Activities from INTI

Diego Luna

INTI Física y Metrología
Centro de Investigación y Desarrollo
en Física y Metrología

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Clocks and receivers

Organization of the Lab

Infrastructure

- 3 cesium clocks
- 3 GPS receivers
- 1 counter and 1 frequency generator for calibrations
- 1 phase comparison system (Multiplexer + counter)

Contribution to T&F networks

- SIM T&F, one clock
- UTC & UTCr, 3 clocks
- Red Nacional de Tiempo (RNT), 3 clocks

Activities 2015-2017. 8/15: CMC approved

Calibration and Measurement Capabilities

Time and Frequency, Argentina, INTI (Instituto Nacional de Tecnologia Industrial)

KCDB

Calibration or Measurement Service			Measurand Level or Range			Measurement Conditions/Independent Variable		Expanded Uncertainty						
Quantity	**Instrument or Artifact**	**Instrument Type or Method**	**Minimum value**	**Maximum value**	**Units**	**Parameter**	**Specifications**	**Value**	**Units**	**Coverage factor**	**Level of Confidence**	**Is the expanded uncertainty a relative one?**	**NMI Service Identifier**	**Comments**
Frequency	General frequency counter	Direct frequency measurement	5	5	MHz	Averaging time	600 s	9E-12	Hz/Hz	2	95%	Yes	102.02.03.05.00.001	Approved on 02 March 2015
Frequency	General frequency counter	Direct frequency measurement	5	5	MHz	Averaging time	3600 s	2E-12	Hz/Hz	2	95%	Yes	102.02.03.05.00.001	Approved on 02 March 2015
Frequency	General frequency counter	Direct frequency measurement	5	5	MHz	Averaging time	1 day	2E-12	Hz/Hz	2	95%	Yes	102.02.03.05.00.001	Approved on 02 March 2015
Frequency	General frequency counter	Direct frequency measurement	10	10	MHz	Averaging time	600 s	9E-12	Hz/Hz	2	95%	Yes	102.02.03.05.00.001	Approved on 02 March 2015
Frequency	General frequency counter	Direct frequency measurement	10	10	MHz	Averaging time	3600 s	2E-12	Hz/Hz	2	95%	Yes	102.02.03.05.00.001	Approved on 02 March 2015
Frequency	General frequency counter	Direct frequency measurement	10	10	MHz	Averaging time	1 day	2E-12	Hz/Hz	2	95%	Yes	102.02.03.05.00.001	Approved on 02 March 2015
Frequency	General frequency source	Direct frequency measurement	1E-06	225	MHz	Averaging time	1 h	6E-12	Hz/Hz	2	95%	Yes	102.02.03.05.00.003	Approved on 02 March 2015
Time interval	Period source	Time interval counter	20	1E+09	ns	Slewing rate	> 0.5 V/ns	4	ns	2	95%	No	102.02.03.05.00.002	Approved on 02 March 2015
Time interval	Time difference meter	Time interval counter	20	1E+09	ns	Slewing rate	> 0.5 V/ns	6	ns	2	95%	No	102.02.03.05.00.002	Approved on 02 March 2015

The BIPM key comparison database, March 2015

1/1

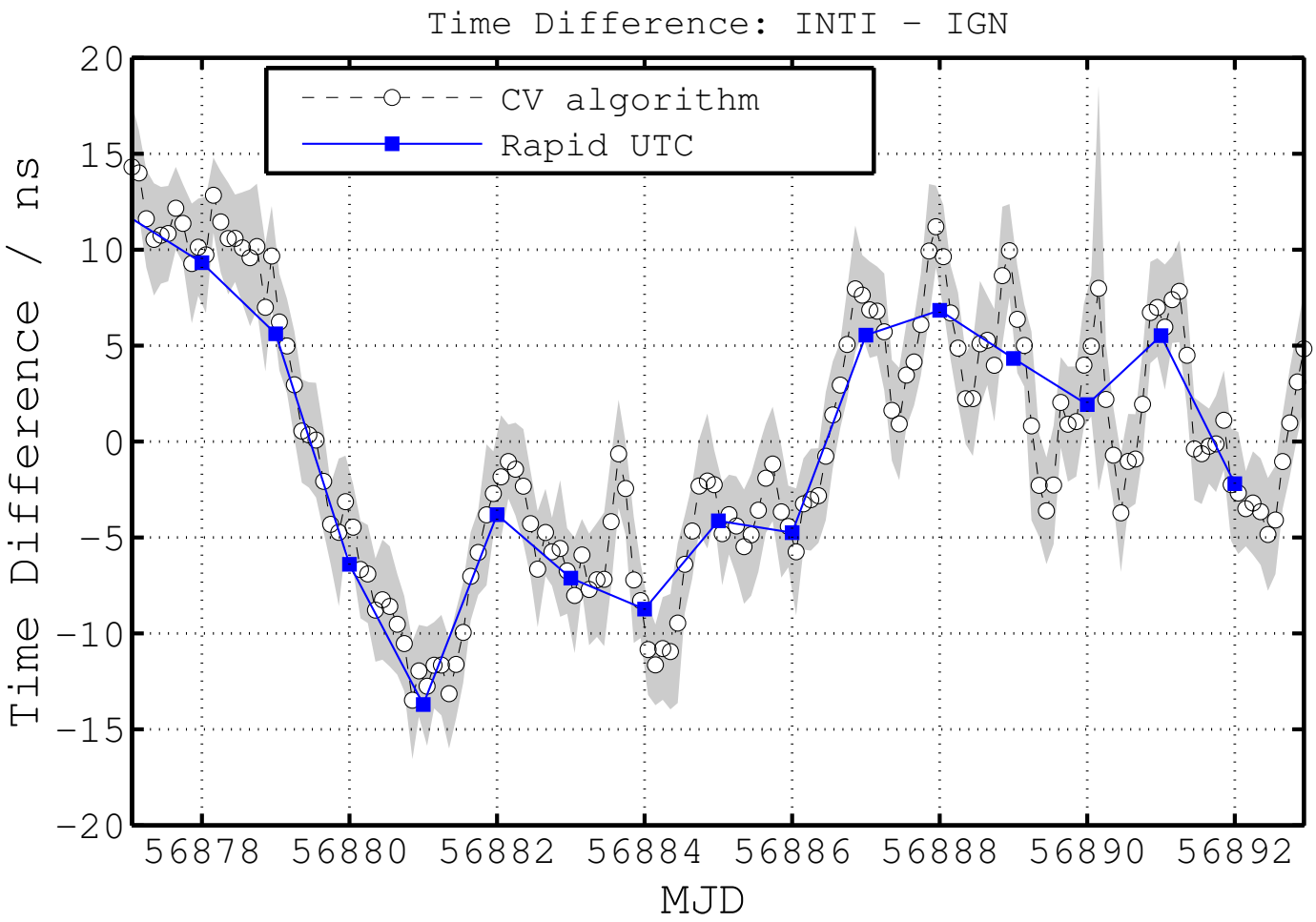
Activities 2015-2017

- 12/15: 10-day visit to CENAM
- 9/17: Peer Review (Felicitas Arias)
- 9/17: Workshop of T&F Laboratories of Argentina in AGGO, with Felicitas
- 2 Publications

Activities 2015-2017. 2015: CV measurements

- **INTI:** Instituto Nacional de Tecnología Industrial. NMI of Argentina
- **ONBA:** Observatorio Naval de Buenos Aires. (Official time)
- **IGN:** Instituto Geográfico Nacional
- **AGGO:** Observatorio Argentino-Alemán de Geodesia (since en 2016)

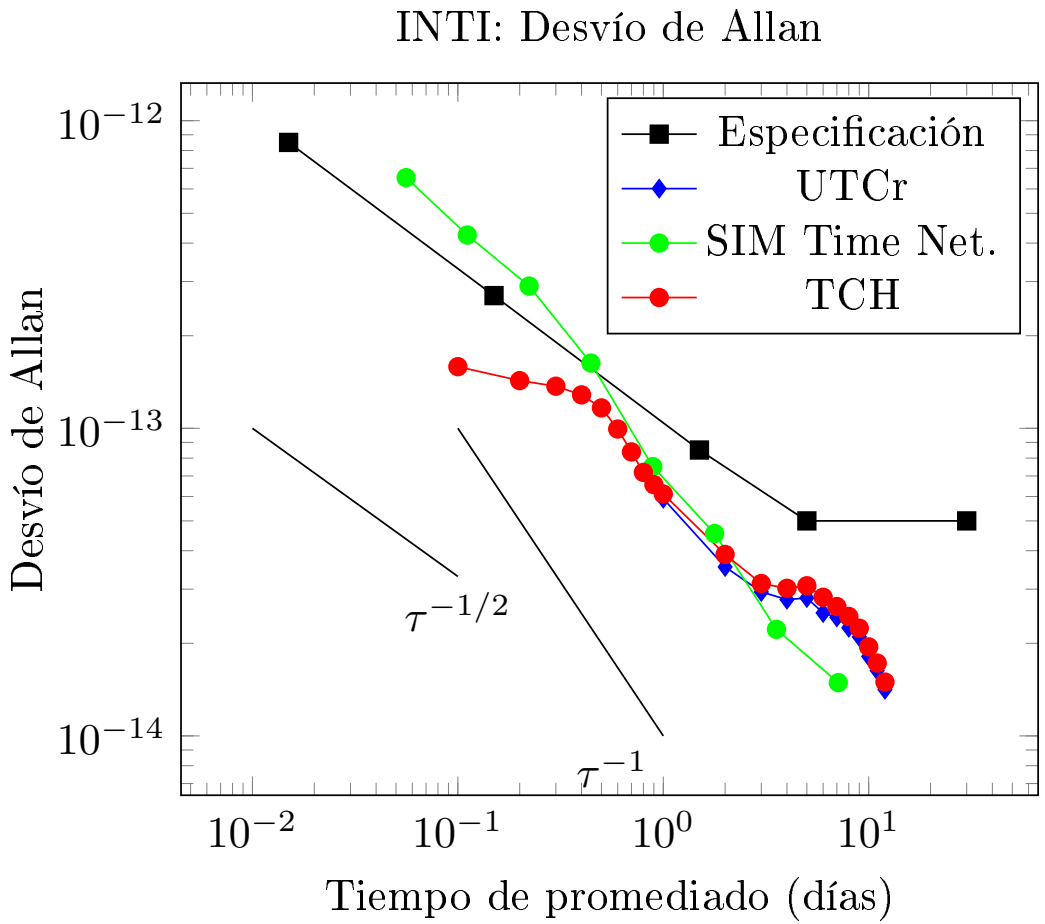
Activities 2015-2017. 2015: CV measurements



No real time calculations. Data used with TCH technique

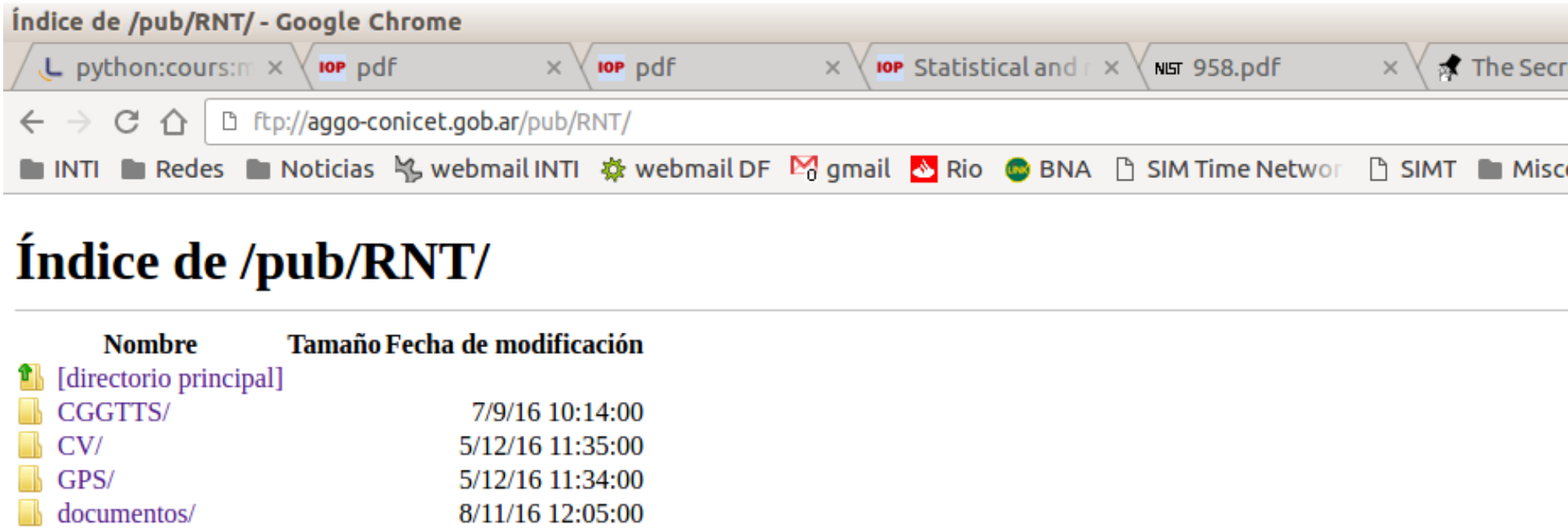
Stability: INTI-Cs1

Using TCH technique:

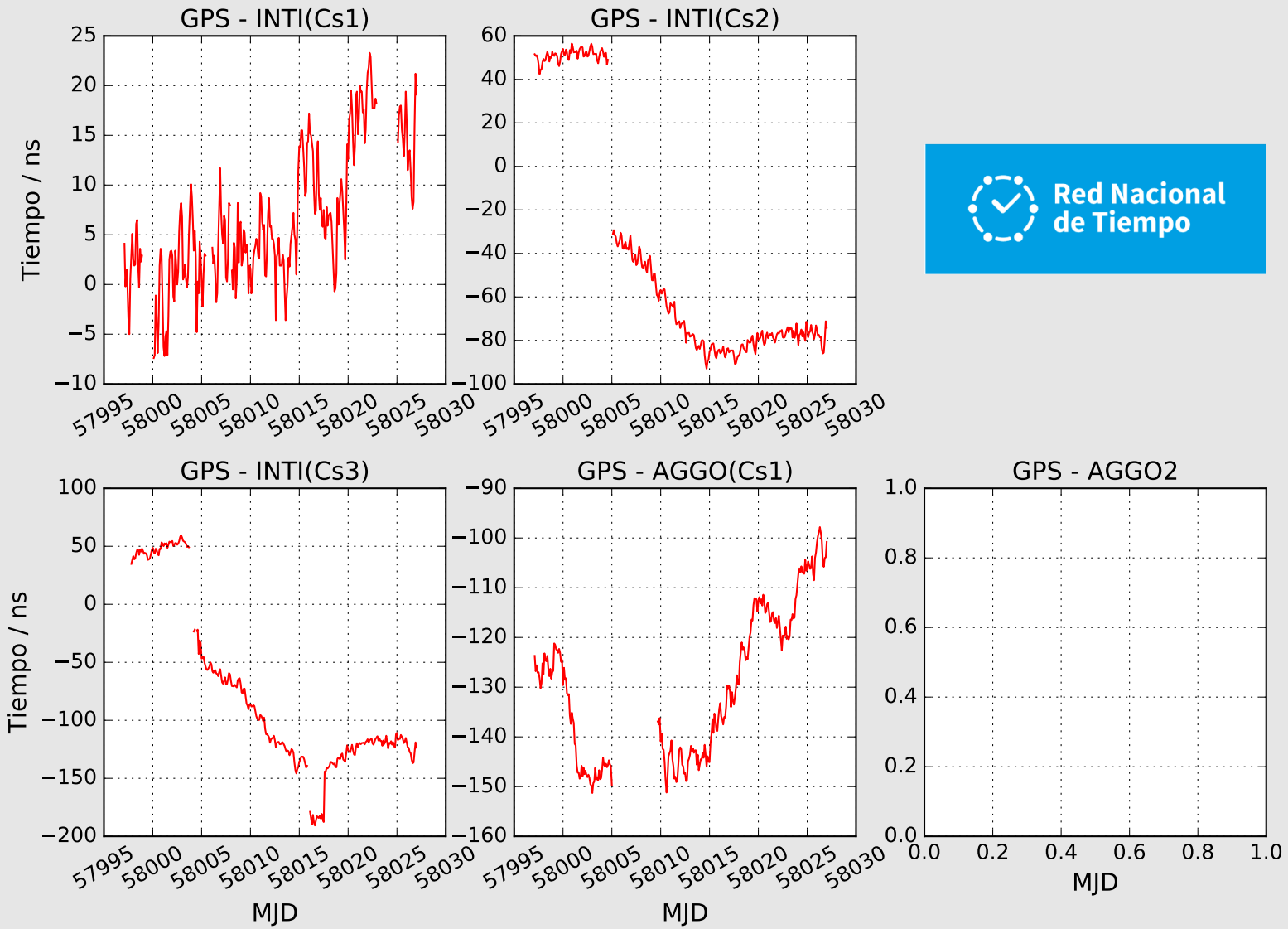


- Values OK with specs
- Consistent with UTCr
- τ^{-1} : Flicker Phase Mod.
  $\tau^{-1/2}$: White Freq. Mod.

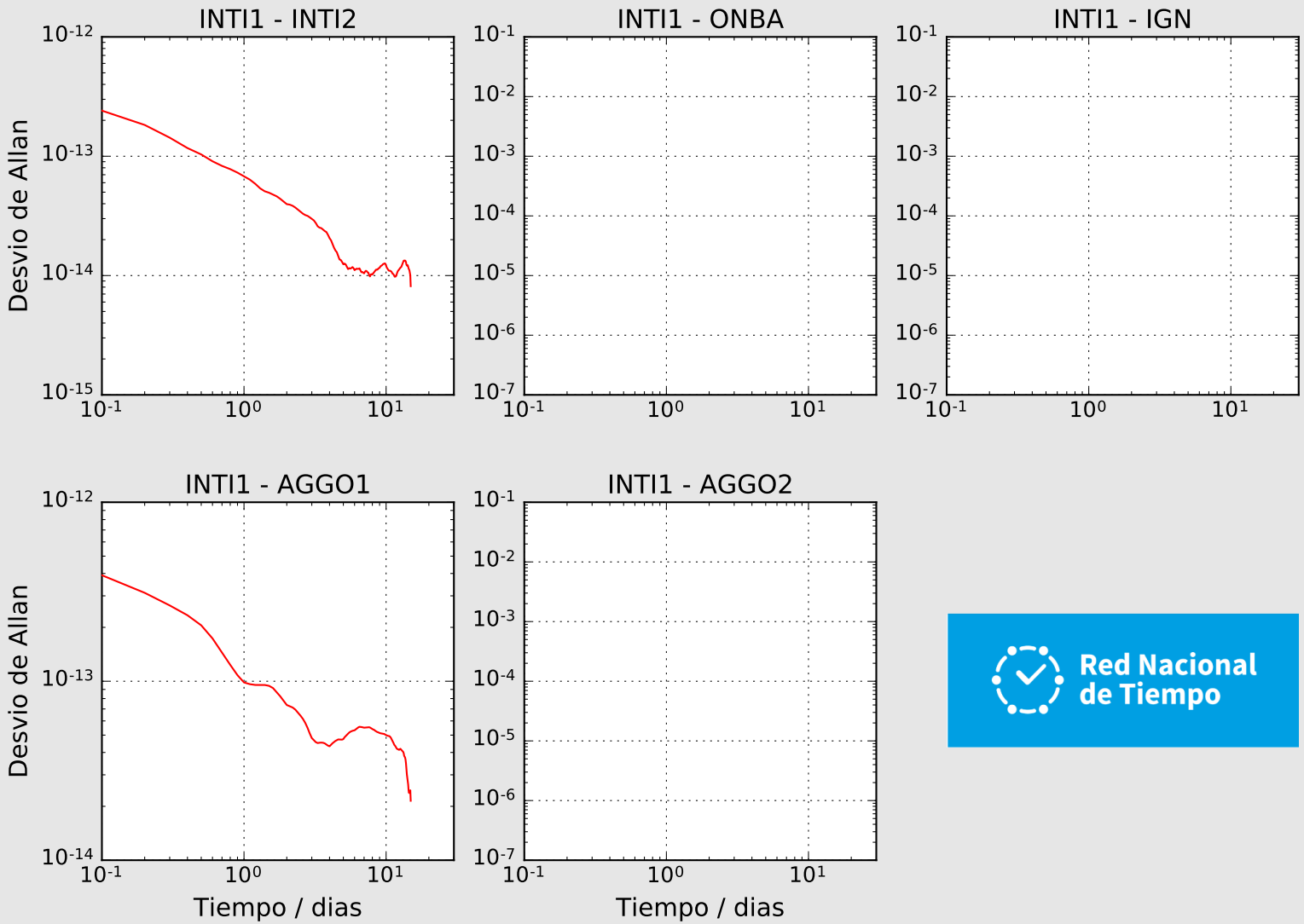
Next Step: "Real" time computation



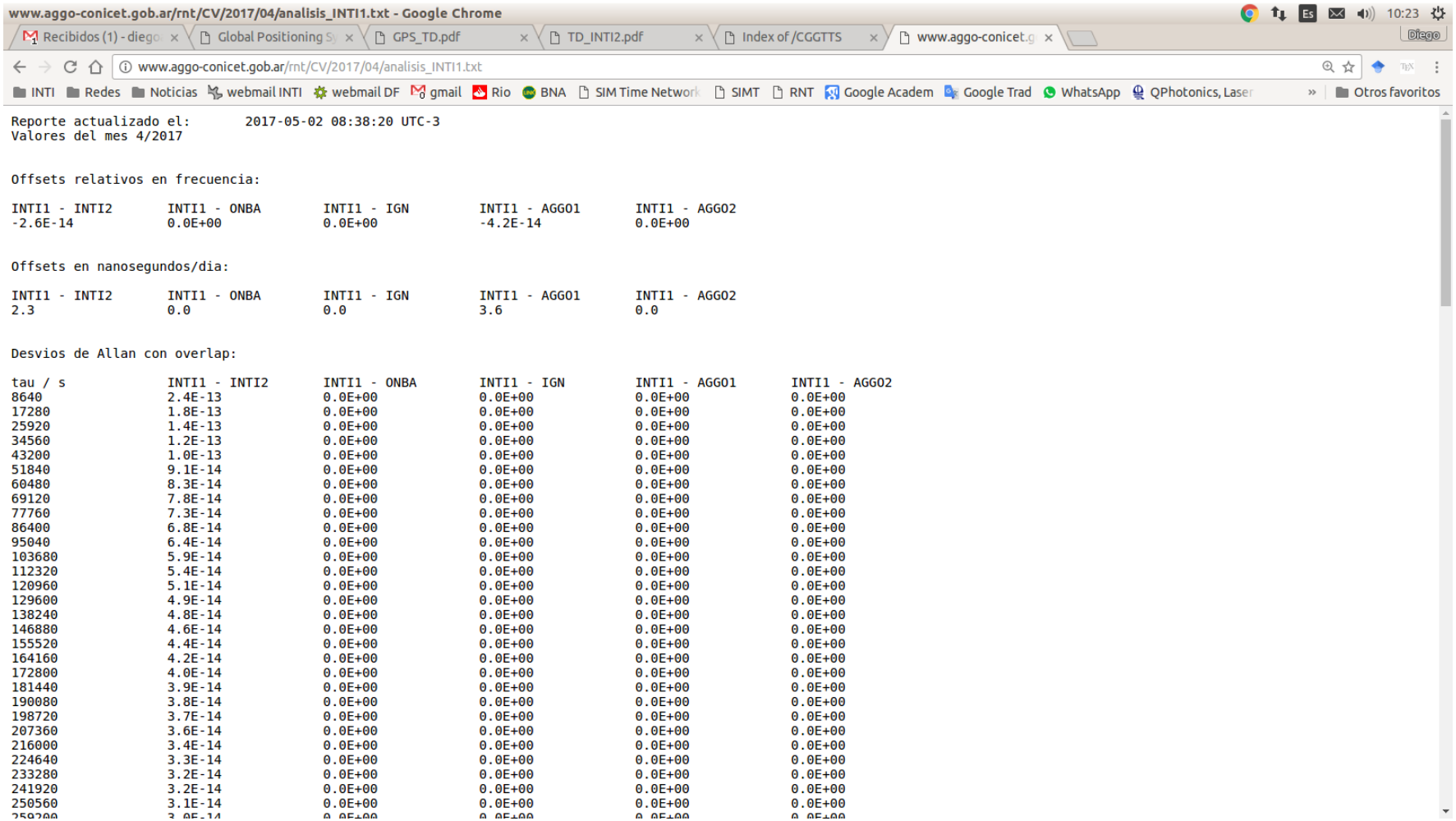
Next Step: "Real" time computation



Next Step: "Real" time computation



Daily report sample



www.aggo-conicet.gob.ar/rnt/CV/2017/04/analisis_INTI1.txt - Google Chrome

www.aggo-conicet.gob.ar/rnt/CV/2017/04/analisis_INTI1.txt

Reporte actualizado el: 2017-05-02 08:38:20 UTC-3
Valores del mes 4/2017

Offsets relativos en frecuencia:

INTI1 - INTI2	INTI1 - ONBA	INTI1 - IGN	INTI1 - AGGO1	INTI1 - AGGO2
-2.6E-14	0.0E+00	0.0E+00	-4.2E-14	0.0E+00

Offsets en nanosegundos/dia:

INTI1 - INTI2	INTI1 - ONBA	INTI1 - IGN	INTI1 - AGGO1	INTI1 - AGGO2
2.3	0.0	0.0	3.6	0.0

Desvios de Allan con overlap:

tau / s	INTI1 - INTI2	INTI1 - ONBA	INTI1 - IGN	INTI1 - AGGO1	INTI1 - AGGO2
8640	2.4E-13	0.0E+00	0.0E+00	0.0E+00	0.0E+00
17280	1.8E-13	0.0E+00	0.0E+00	0.0E+00	0.0E+00
25920	1.4E-13	0.0E+00	0.0E+00	0.0E+00	0.0E+00
34560	1.2E-13	0.0E+00	0.0E+00	0.0E+00	0.0E+00
43200	1.0E-13	0.0E+00	0.0E+00	0.0E+00	0.0E+00
51840	9.1E-14	0.0E+00	0.0E+00	0.0E+00	0.0E+00
60480	8.3E-14	0.0E+00	0.0E+00	0.0E+00	0.0E+00
69120	7.8E-14	0.0E+00	0.0E+00	0.0E+00	0.0E+00
77760	7.3E-14	0.0E+00	0.0E+00	0.0E+00	0.0E+00
86400	6.8E-14	0.0E+00	0.0E+00	0.0E+00	0.0E+00
95040	6.4E-14	0.0E+00	0.0E+00	0.0E+00	0.0E+00
103680	5.9E-14	0.0E+00	0.0E+00	0.0E+00	0.0E+00
112320	5.4E-14	0.0E+00	0.0E+00	0.0E+00	0.0E+00
120960	5.1E-14	0.0E+00	0.0E+00	0.0E+00	0.0E+00
129600	4.9E-14	0.0E+00	0.0E+00	0.0E+00	0.0E+00
138240	4.8E-14	0.0E+00	0.0E+00	0.0E+00	0.0E+00
146880	4.6E-14	0.0E+00	0.0E+00	0.0E+00	0.0E+00
155520	4.4E-14	0.0E+00	0.0E+00	0.0E+00	0.0E+00
164160	4.2E-14	0.0E+00	0.0E+00	0.0E+00	0.0E+00
172800	4.0E-14	0.0E+00	0.0E+00	0.0E+00	0.0E+00
181440	3.9E-14	0.0E+00	0.0E+00	0.0E+00	0.0E+00
190080	3.8E-14	0.0E+00	0.0E+00	0.0E+00	0.0E+00
198720	3.7E-14	0.0E+00	0.0E+00	0.0E+00	0.0E+00
207360	3.6E-14	0.0E+00	0.0E+00	0.0E+00	0.0E+00
216000	3.4E-14	0.0E+00	0.0E+00	0.0E+00	0.0E+00
224640	3.3E-14	0.0E+00	0.0E+00	0.0E+00	0.0E+00
233280	3.2E-14	0.0E+00	0.0E+00	0.0E+00	0.0E+00
241920	3.2E-14	0.0E+00	0.0E+00	0.0E+00	0.0E+00
250560	3.1E-14	0.0E+00	0.0E+00	0.0E+00	0.0E+00

According to specs, the accuracy of a std. cesium clock must be $\pm 50 \frac{ns}{day}$

Time Scales: Escala Argentina de Tiempo (EAT)

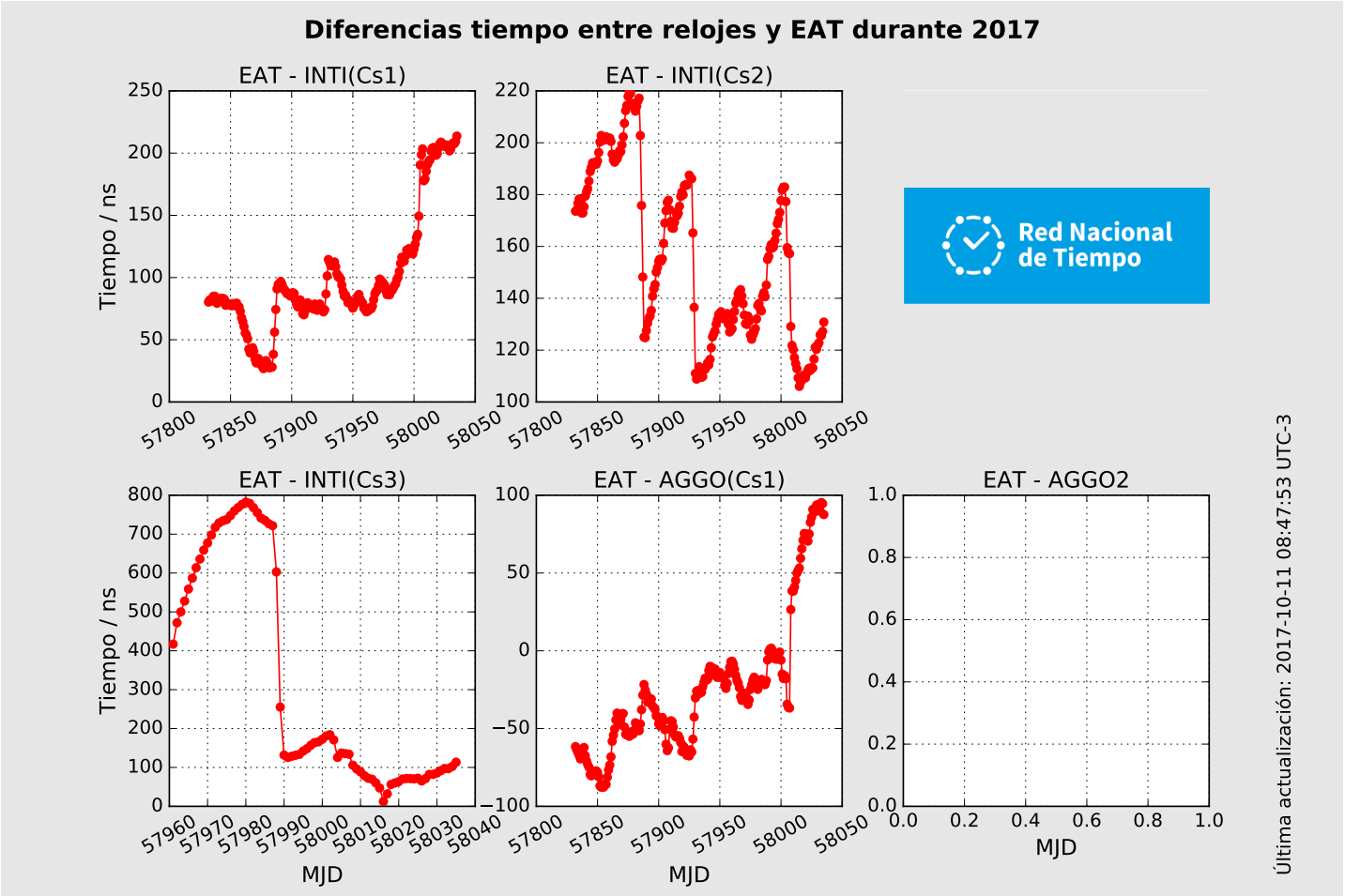
Specs

- Computations started in January 2017
- Based on the algorithm described in Azoubib, J., Nawrocki, J., & Lewandowski, W. (2003). Independent atomic timescale in Poland—organization and results. Metrologia, 40(3), S245.
- Uses 4 clocks: INTIx3 + AGGOx1
- CV comparisons + Kalman filter (for noise reduction)
- Weights as $\omega_i \propto \frac{1}{\sigma_i(\tau)}$, with $\tau = 10$ days
- Computed weekly, one point per day
- No physical output is generated

Time Scales: Escala Argentina de Tiempo (EAT)

- $EAT(t) = \frac{\sum_{i=1}^{N} \omega_i [H_i(t) + A_i + D_i(t - t_0)]}{\sum_{i=1}^{N} \omega_i}$
- $H_i(t)$: reading of clock i at time t
- A_i : time correction
- D_i : last frequency value estimated over the previous interval of computation
- ω_i weight of clock i

Time Scales: Escala Argentina de Tiempo (EAT)



- The scale started in January, but INTI-Cs3 was added in July
- We still need to know how to deal with steps
- Much more refinement is necesary

Time Scales: TA(INTI)

Specs

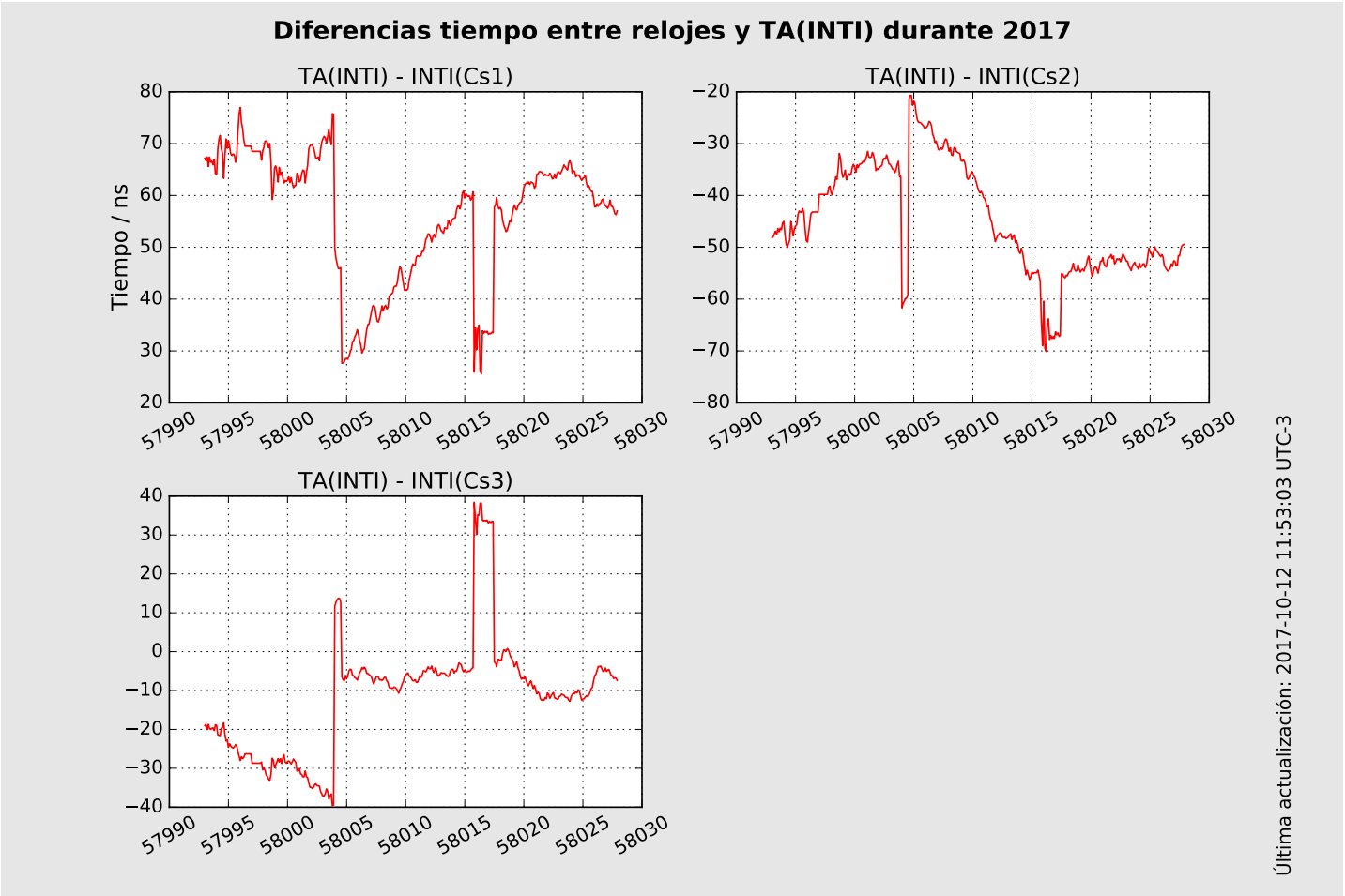
- Computations started in August 2017
- Based on the algorithm described in Azoubib, J., Nawrocki, J., & Lewandowski, W. (2003). Independent atomic timescale in Poland—organization and results. Metrologia, 40(3), S245.
- Uses the three clocks from INTI
- Time difference comparisons with SR620

- For the moment, $\omega_i \equiv 1/3$
- Computed daily with 10 points for each day.

Time Scales: TA(INTI)

- $TA(INTI)(t) = \frac{\sum_{i=1}^{N} \omega_i [H_i(t) + A_i + D_i(t - t_0)]}{\sum_{i=1}^{N} \omega_i}$
- $H_i(t)$: reading of clock i at time t
- A_i : time correction
- D_i : last frequency value estimated over the previous interval of computation
- ω_i weight of clock i

Time Scales: TA(INTI)



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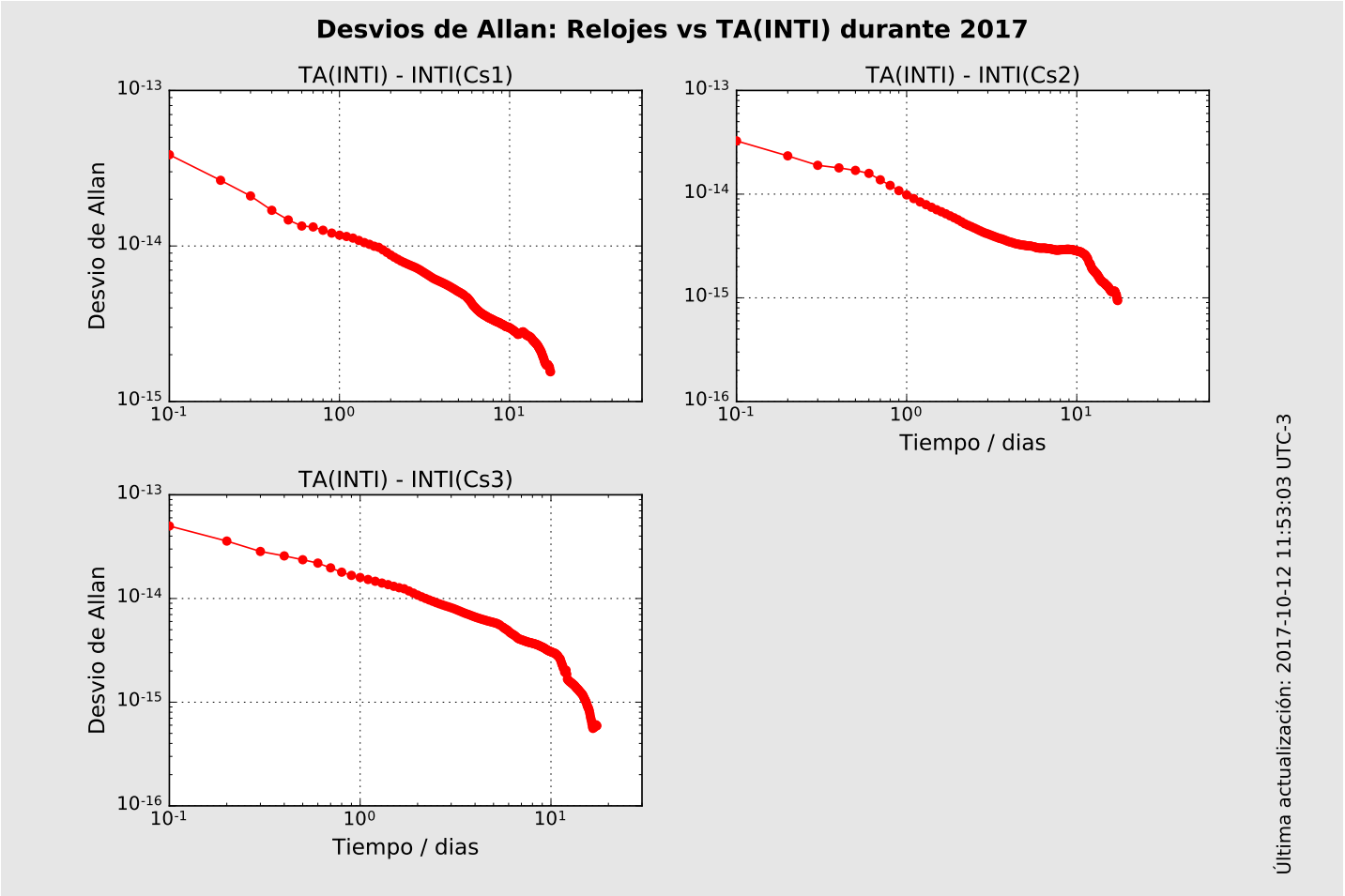
Time Scales: TA(INTI)



- Despite of the steps, Allan deviations are OK, consistent with specs.

Whats next?

2017-2019

- More work on the two timescales

- Add clocks to the network "Red Nacional de Tiempo "

Red Nacional de Tiempo

- 24 hour temperature + humidity + pressure monitor

ARDUINO

- Build low cost GPS receivers (?)

That's all

Thanks!