The European Laser Timing Experiment and Data Centre

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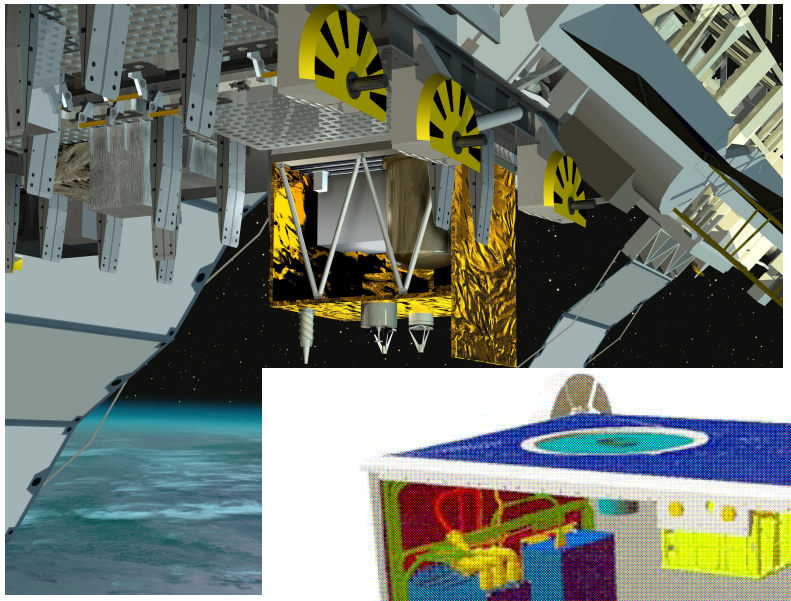
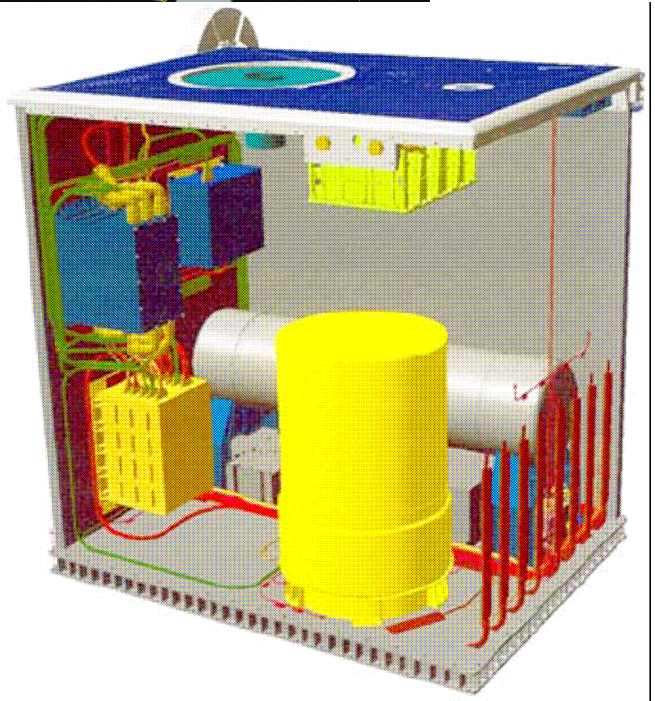
ACES
Atomic **C**lock **E**nsemble in **S**pace





Time generation:
Caesium fountain clock PHARAO
Active hydrogen maser SHM
Frequency comparison unit

Time transfer:
Microwave link MWL
Laser link ELT

GPS

ACES objectives

Test of new generation space clocks

- cold atoms in microgravity
- test of PHARAO frequency stability $10^{-13}x\tau^{-1/2}$ and accuracy $3x10^{-16}$
- test of SHM frequency stability $2.1x10^{-15}$ @ 1000 s

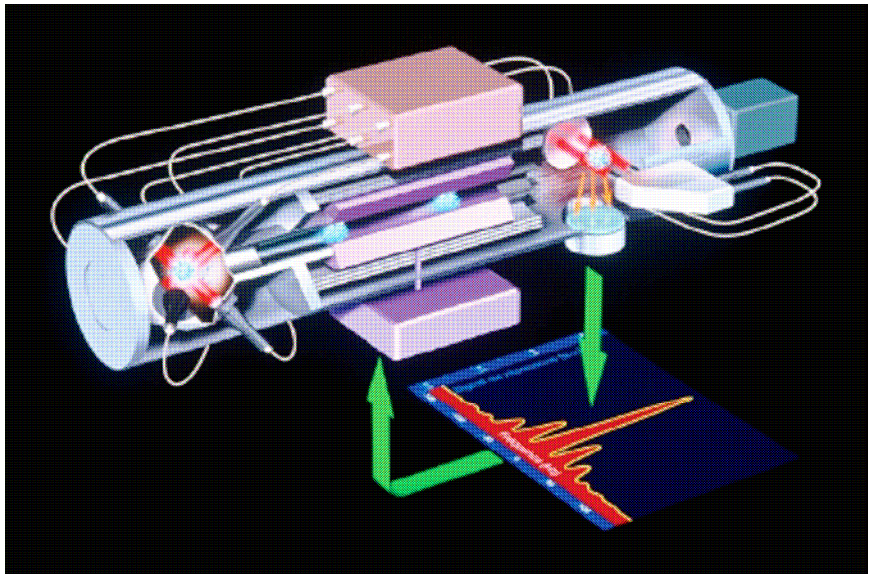
Freuquency transfer via MWL

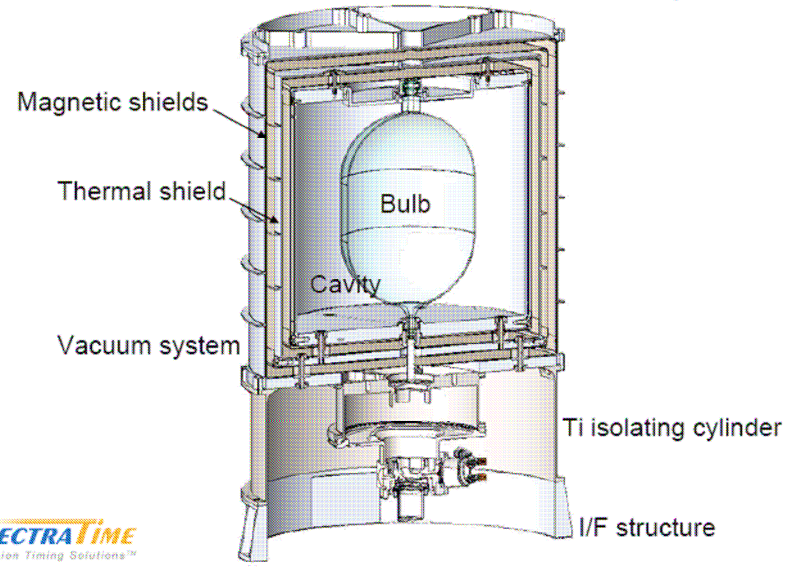
- test of the microwave performance 0.4 ps @ pass, 8 ps @ 1d
- common view comparison of ground clocks 1 ps @ pass
- non-common view comparison of ground clocks 3 ps @ 1000 s, 10 ps @ 10^4 s
- absolut synchronisation of ground clocks better 100 ps
- contribution to TAI

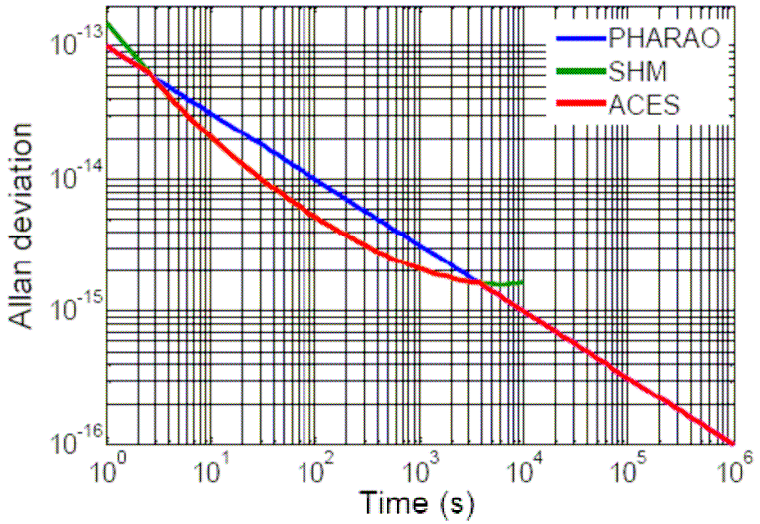
Fundamental Physics

- gravitational red-shift
- drift in fine structure constant
- anisotropy of light

ACES clocks





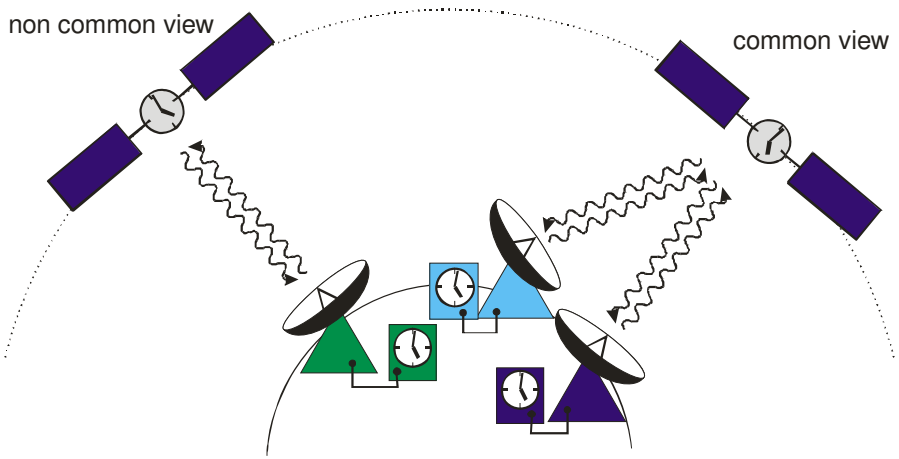


Two servo-loops:

Short-term servo-loop stabilizes PHARAO on SHM

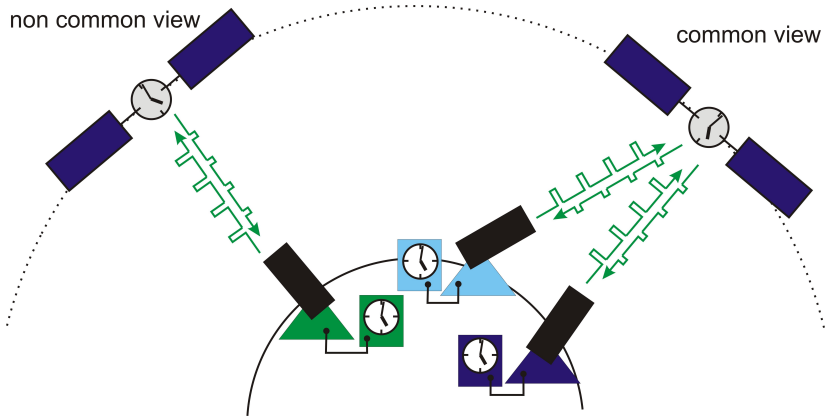
Long-term servo-loop stabilizes SHM on PHARAO

Time transfer

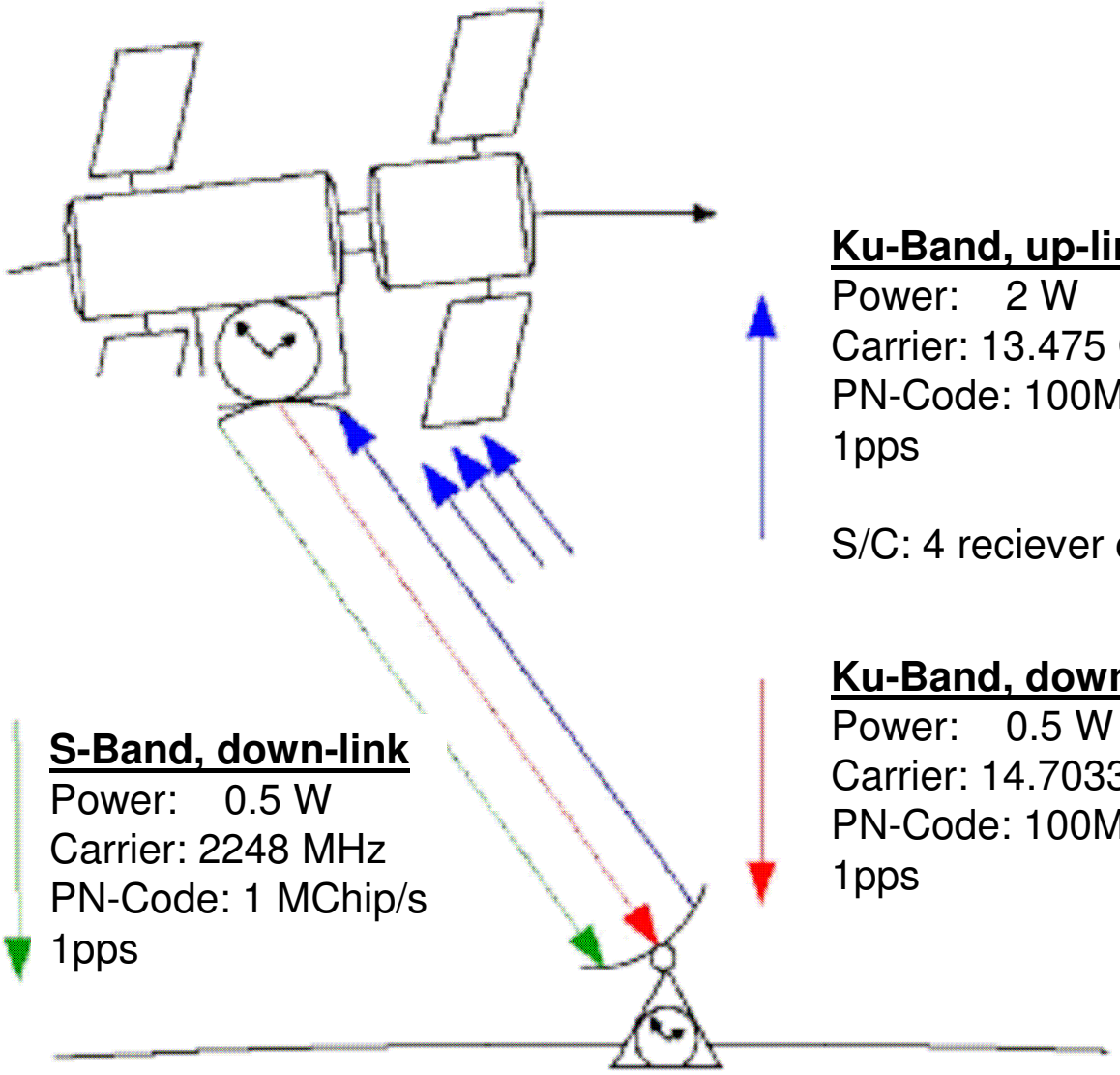


MWL –
Micro**W**ave **L**ink

ELT –
European **L**aser **T**iming
Experiment



Microwave Link (MWL)



Ku-Band, up-link
Power: 2 W
Carrier: 13.475 GHz
PN-Code: 100MChips/s
1pps

S/C: 4 reciever channels

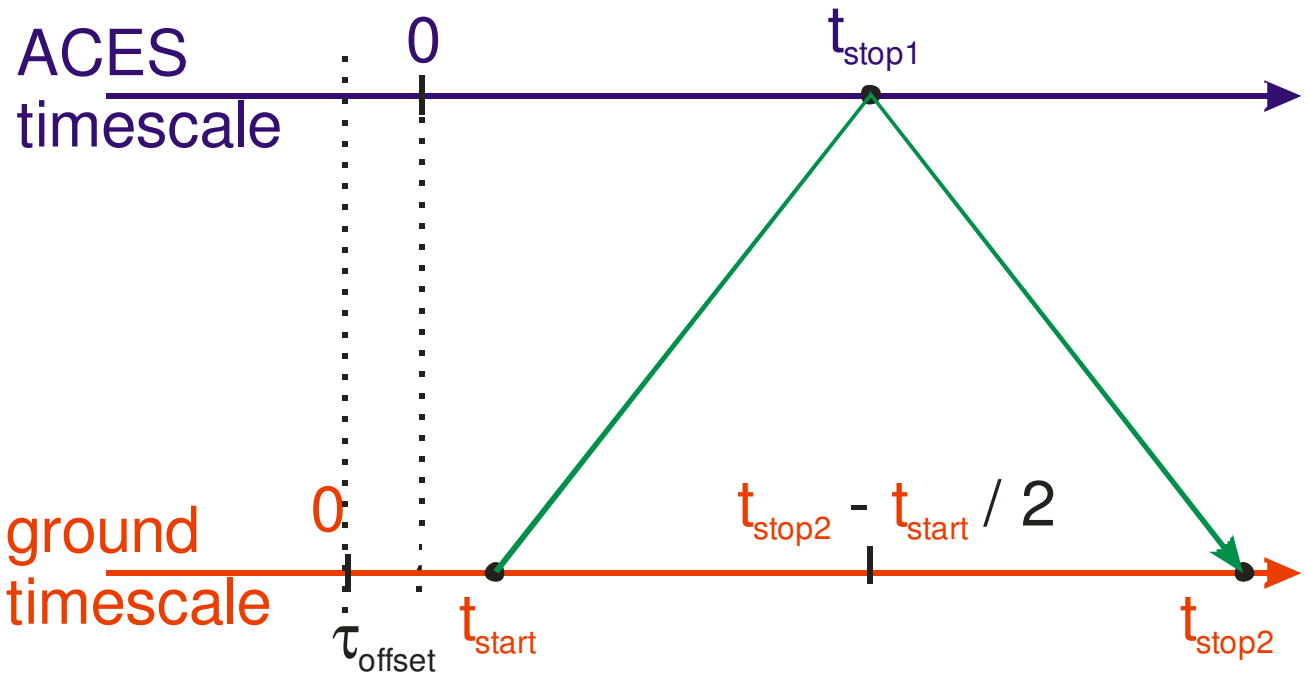
Ku-Band, down-link
Power: 0.5 W
Carrier: 14.70333 GHz
PN-Code: 100MChip/s
1pps

S-Band, down-link
Power: 0.5 W
Carrier: 2248 MHz
PN-Code: 1 MChip/s
1pps

Requirements:

230 fs @ 300 s
1.2 ps @ 5000 s
8 ps @ 1 d
10 ps @ 10 d

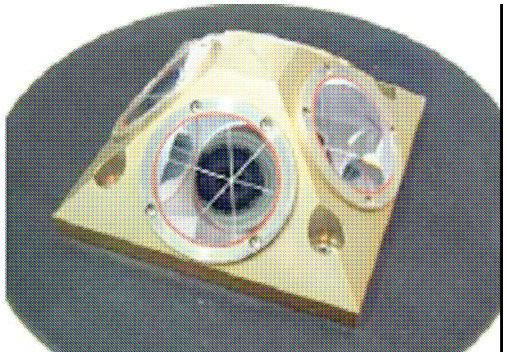
ELT
European Laser Timing Experiment



$$\tau_{offset} = t_{stop2} - t_{start} / 2 - t_{stop}1 + \tau_{Relativity} + \tau_{Atmosphere} + \tau_{Geometry}$$

We need fullrate data with ps resolution of t_{Start} !!!

ELT - Payload



Requirements:

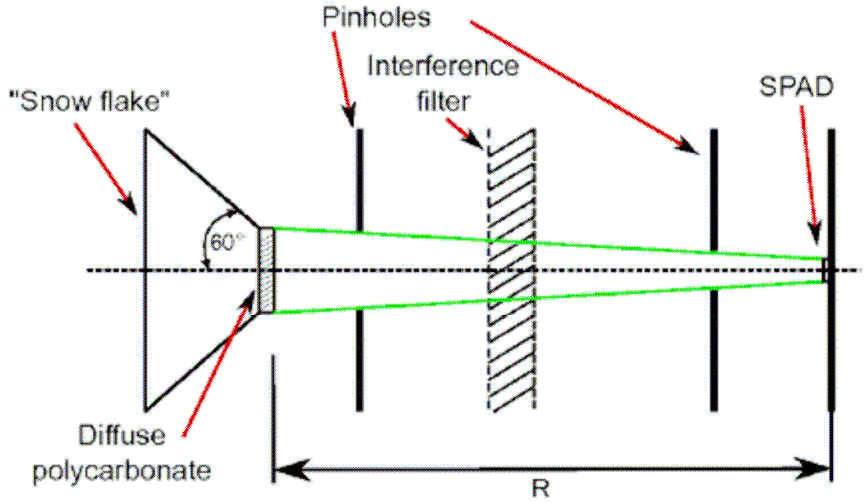
$\sigma_x(10\ s < \tau < 300\ s) = 60x10^{-12}\tau^{-1/2}$

$\sigma_x(300\ s < \tau < 10^4\ s) = 4x10^{-12}$

$\sigma_x(10^4\ s < \tau < 10^6\ s) = 7x10^{-12}$

Absolut calibration delay < 50 ps

ELT - detector



- K14 SPAD 100µm
- Filter 532 +- 3 nm
- Pinholes blocking non axial photons
- Narrow bandwidth filter blocks background photons
- Ground glass for attenuation
- Snowflake shield for angular independent attenuation
- Gating locked to 10pps (100pps) on ACES timescale
- Single photon mode

ELT objectives

- Space to ground comparison of clocks 4 ps @ pass, 7 ps @ 10^6 s, accuracy 50 ps
- Common view comparison of clocks 6 ps
- Non-common view 6 ps @1000 s, 7 ps @10^4 s
- Clock synchronisation 50 ps
- Comparison of ranging techniques
- Analysis of atmospheric propagation delays

MWL contra ELT

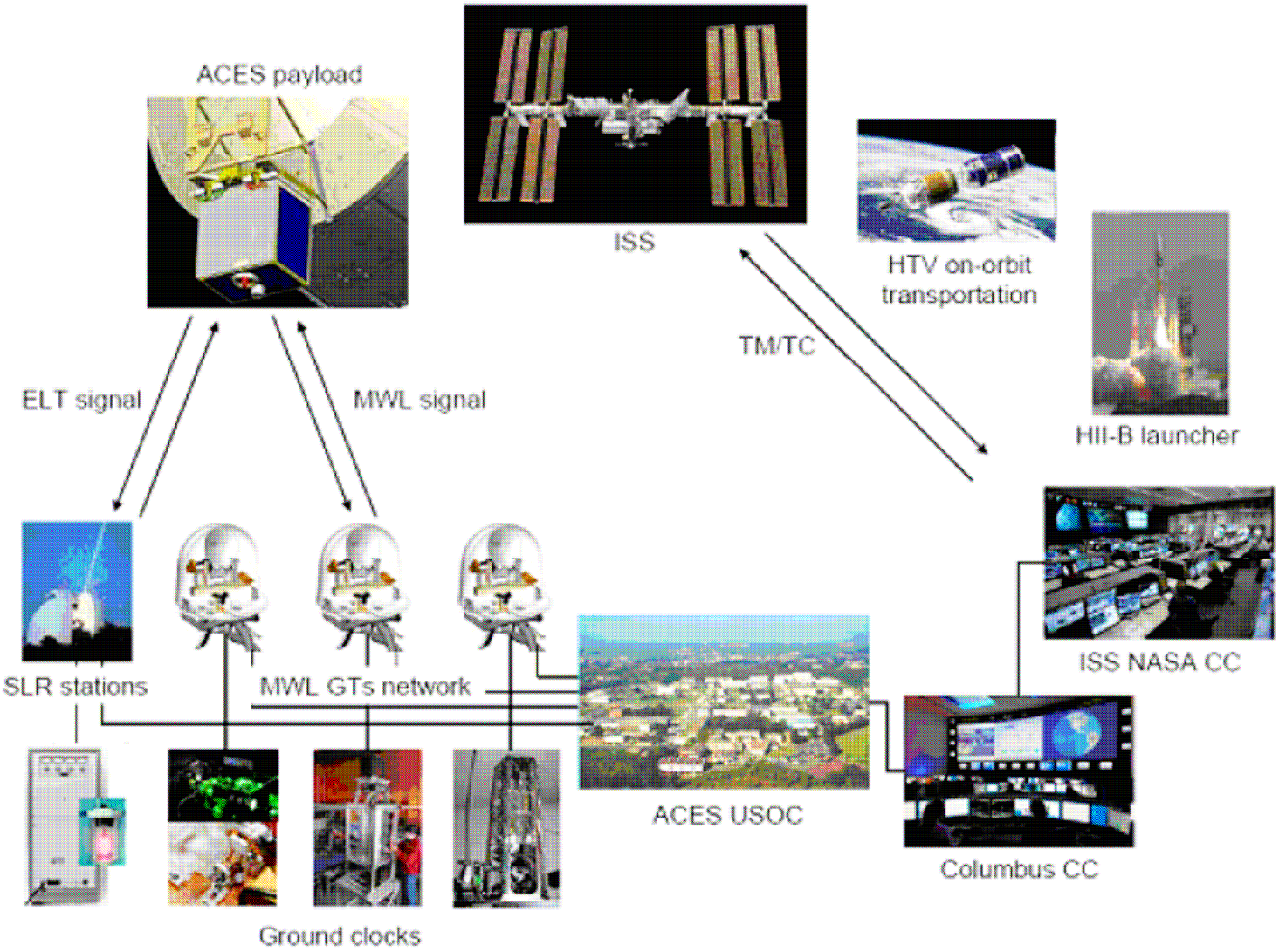
MWL

- All weather
- High availability
- Time proven
- Easy to operate

ELT

- Low dispersion
- Single shot
- Accurate time tagging
- Used to calibrate MWL

ACES Ground Segment



ELT – Data Center

communication center

network interface

data center (ACES, SLR)
ILRS and SLR stations ("real time" feedback)
ESA and cooperating partners
data users
fundamental physics community

communication plattforms

internet
bulletin
call for participation
data server

common-view campagnes

emphasis on VLBI/SLR stations

scientific mission center

predictions

definition of products, data processing

support for SLR stations

comparison of TT methodes

MW, GNSS, optical, and VLBI

monitoring of space instruments calibration campagne

clock modelling, time scale

Products

Shadowing

For each station (including MWL-Terminals) entrance and exit of the shadowing of the ACES module by solar panels or orientation.

Quick look

For each ELT station sending high accuracy fullrate data an analysis of time triples and a detection rate. Warning for not being in single photon mode!!

Detector performance

Space-ground-TTF

Common-View TTF

Per-revolution Non-Common-View TTF

Once per revolution of the ISS a clock offset between all the stations successfully tracked ACES is calculated.

Longtime Non-Common-View TTF

For monitoring ground clocks the time evolution of the time-offset to ACES timescale is calculated.

Laser ranging Performance

MWL calibration

Signal delays MWL-ELT for atmospheric analysis

Performance of SLR stations

- Fullrate data with ps resolution of start puls and should be send within one houre after the pass
- clock with frequency stability comparable to ACES
- Station has to time the laser firing better 1 µs (active/active laser)
- Tracking of low satellites
- Predictions every 90 min
- Single photon mode

ACES ready for Take off beginning of 2014!!

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