Update on the CNGS beam

D.Autiero/IN2P3 Lyon, 22/6/06

- CNGS beam news
- Pending items on synchronisation and data exchange:
  - GPS intercalibration
  - fiber delay measurements
  - database access)
- CNGS geodesy

The last meeting:

CNGS START-UP

LNGS, 6th April 2006
14:00 'E. Majorana' lecture hall

CNGS Project: Primary Beam	(35')	M. Meddahi (CERN/AB)
CNGS Project: Secondary Beam	(35')	E. Gschwendtner (CERN/AB)
CNGS Simulated Beam Fluxes	(5')	P. Sala (INFN/Milano)
Timing and Data Exchange btw. CERN and LNGS	(30')	D. Autiero (IN2P3/Lyon)

Discussion

Today: continuation more focused on the events signatures of the CNGS beam in the LNGS experiments

Expected CNGS performance: 4.5 10^{19} pot/year

⇒"standard" SPS cycle: t = 16.8s = 12s FT + 4.8s MD

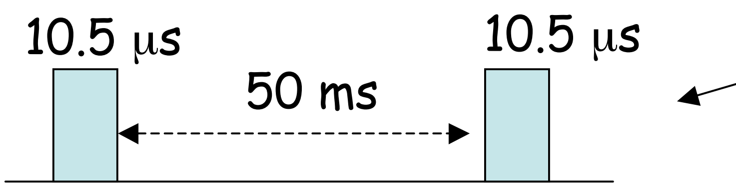
=> CNGS commissioning: t = 18.0s = 12s FT + 6s CNGS

=> CNGS low intensity: t = 18s = 12s FT + 6s CNGS (0.3 10^{19} pot)

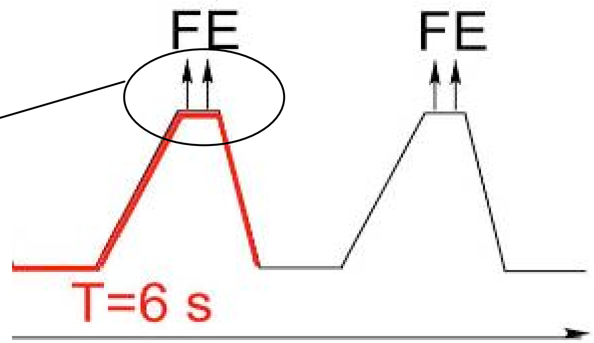
=> CNGS high intensity: t = 34.8s = 12s FT + 3 x 6 s CNGS + 4.8s MD (1 10^{19} pot)

pot for FT reduced to 40%

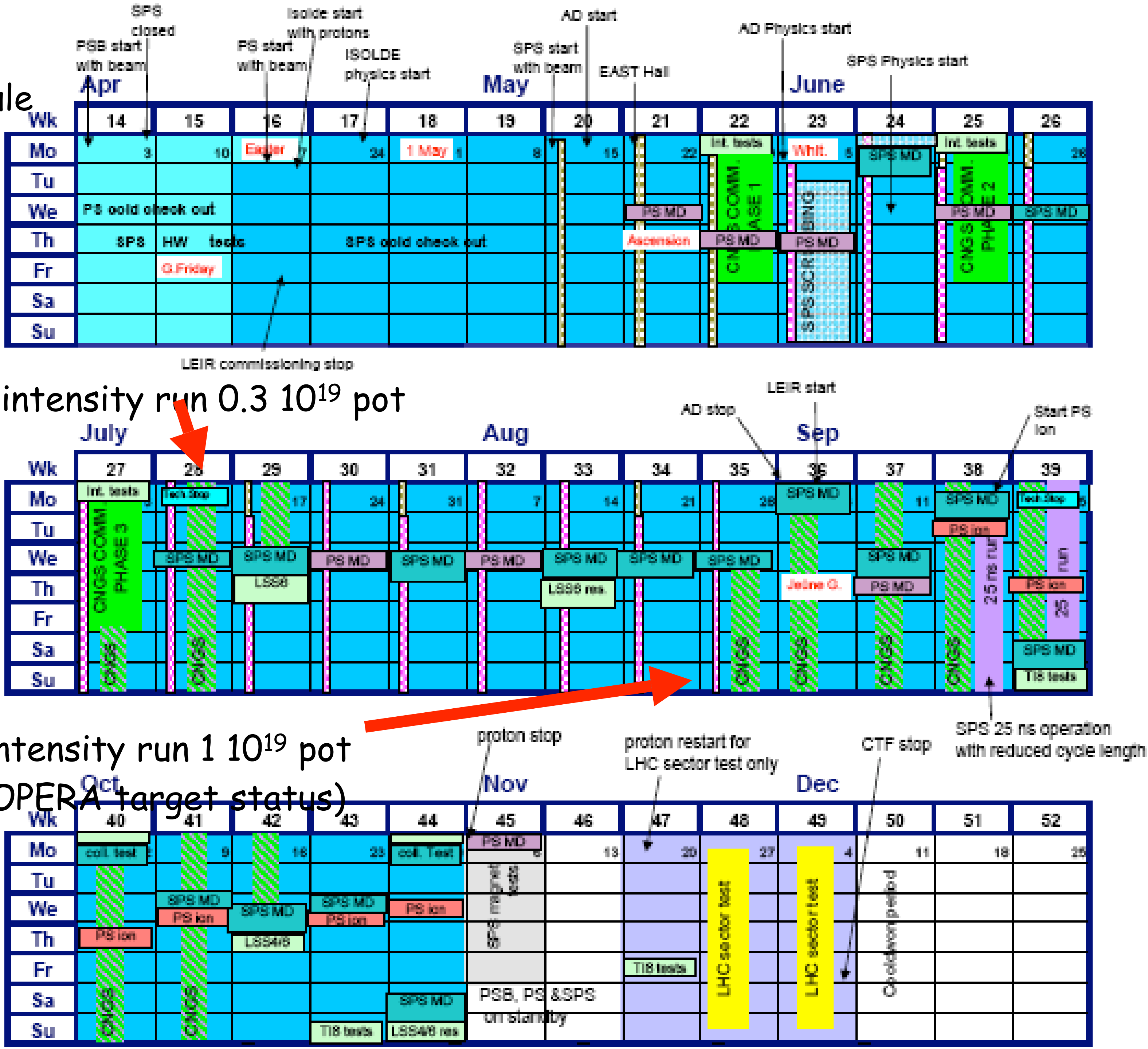
Beam parameters	Nominal CNGS beam
Nominal energy [GeV]	400
Normalized emittance [μm]	H=12 V=7
Emittance [μm]	H=0.028 V= 0.016
Momentum spread Δp/p	0.07 % +/- 20%
# extractions per cycle	2 separated by 50 ms
Batch length [μs]	10.5
# of bunches per pulse	2100
Intensity per extraction [10^{13} p]	2.4
Bunch length [ns] (4 σ)	2
Bunch spacing [ns]	5



CNGS cycles



Initial SPS 2006 schedule



CNGS low intensity run 0.3 10^{19} pot

CNGS high intensity run 1 10^{19} pot (subject to OPERA target status)

PS power supply fault 18/5/2006 C.Rembser (SPS coordinator)

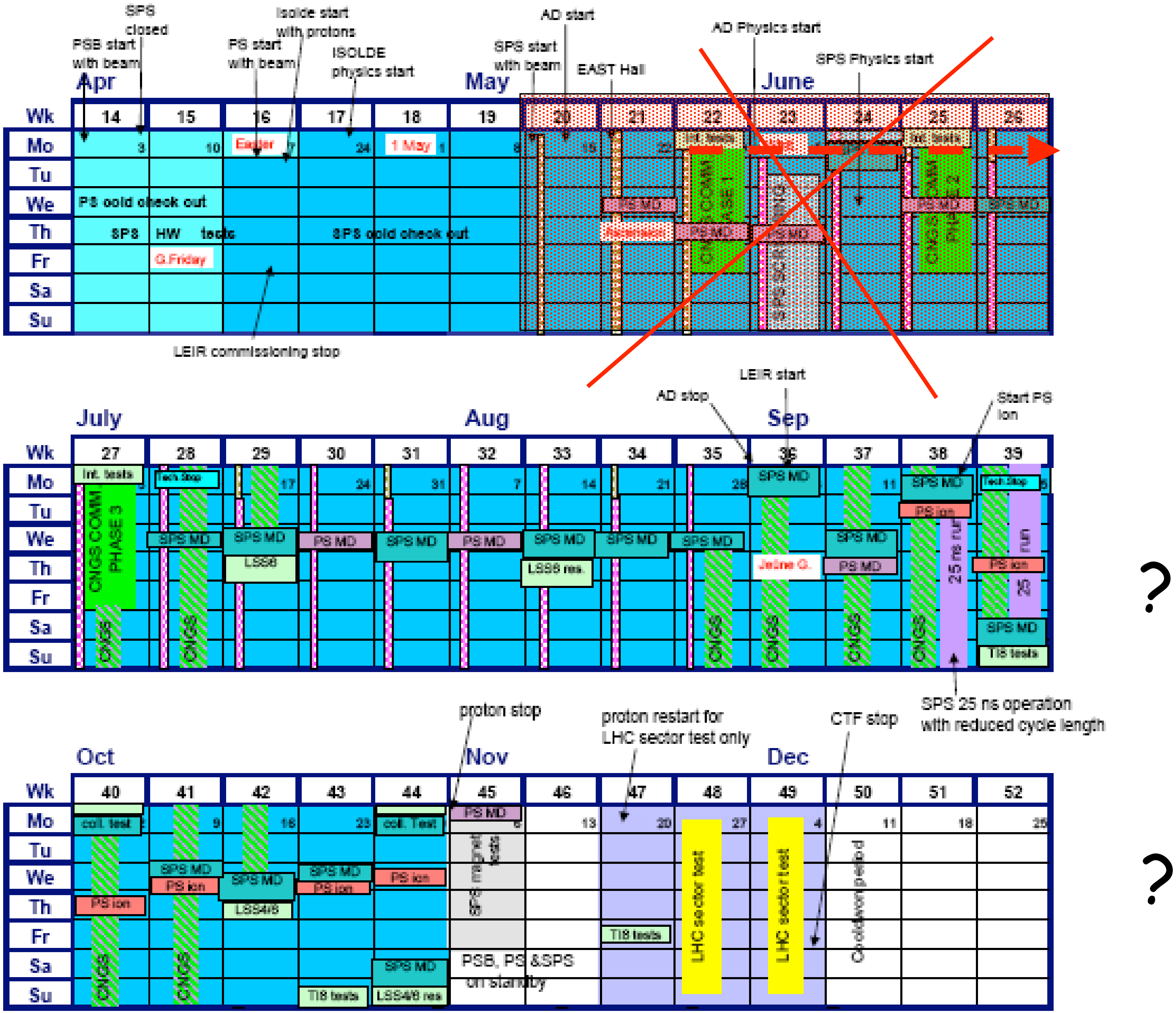
Dear Colleagues,

There is bad news I'm afraid.

During a technical stop of the accelerators yesterday, a major fault was discovered in the rotation motor-generator) of the PS main power supply. After opening its covers this morning the decision has been taken by AB/PO together with the Siemens expert to exchange the rotor. From when the Siemens team is on site the exchange will take around 4 weeks (plus re-start time). This implies no beam in the PS,SPS, AD etc. until around the end of June.

Thus the start of physics in the East Hall foreseen for coming Monday (May 22) has to be cancelled.
As well, the start-up of physics and beam-tests in the North Area will be delayed.

The commissioning of the CNGS neutrino beam facility will not start before end of June.



PSB start with beam
SPS closed
PS start with beam
Isolde start with protons
ISOLDE physics start
AD start
SPS start with beam
EAST Hall
AD Physics start
SPS Physics start
Apr
May
June
Wk
14
15
16
17
18
19
20
21
22
23
24
25
26
Mo
Tu
We
Th
Fr
Sa
Su
Easter
1 May
PS cold check out
SPS HW tests
SPS cold check out
G.Friday
PS MD
SPS MD
LEIR commissioning stop
LEIR start
AD stop
Start PS ion
July
Aug
Sep
27
28
29
30
31
32
33
34
35
36
37
38
39
Int. tests
Tech Stop
CNGS COMM PHASE 3
CNGS
SPS MD
PS MD
LSS6
LSS6 res.
Jeûne G.
PS ion
25 ns run
TI8 tests
?
SPS 25 ns operation with reduced cycle length
proton stop
proton restart for LHC sector test only
CTF stop
Oct
Nov
Dec
40
41
42
43
44
45
46
47
48
49
50
51
52
coll. test
coll. Test
LSS4/6
LSS4/6 res
TI8 tests
PS ion
SPS magnet tests
LHC sector test
Shutdown period
PSB, PS &SPS on standby
?

Installed in 1968

Rotation motor-generator for the PS:
The large load variations at the accelerator magnets (up to +- 60MW) are not being acceptable by the electricity supply network, which means that energy storage has got to be included in the PS main power supply.

The classical solution of this type of problem is to insert a rotation motor-generator set between the supply network and the load. The kinetic energy of the motor-generator represents the necessary energy storage. The weight of the generator rotor plus stator is 80t and it is operating at ~1000 rpm

Motor generator status (20/6/2006).

Good news:

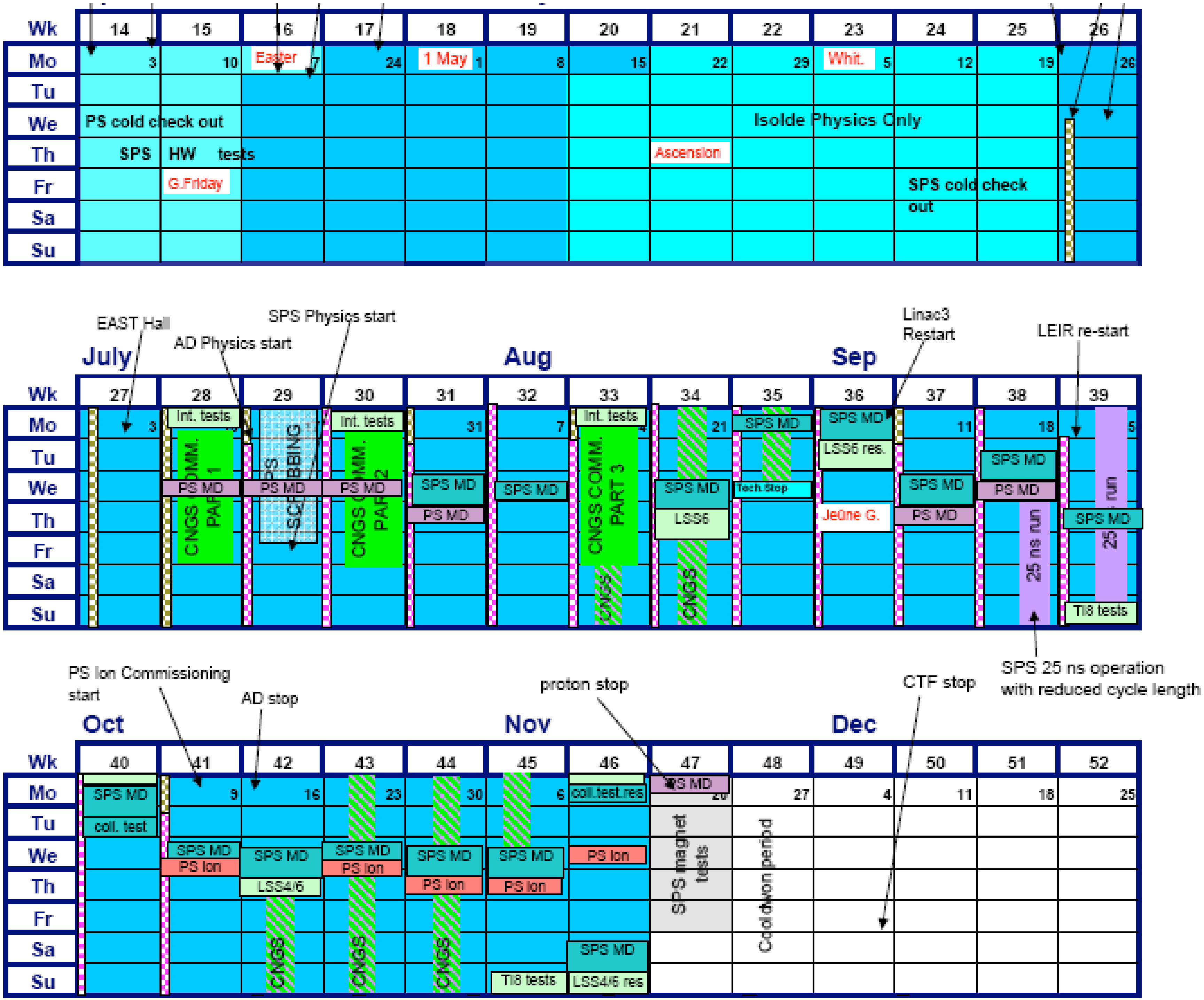
1) Replacement of the rotor progressing very well, presently 4 days ahead of schedule
2) Machine people managed to power the PS directly from the network, the beam is not good in quality and intesity but good enough to debug the machines and gain some time while the motor generator is being fixed
3) There are presently no indications against the **new schedule** being respected

New schedule:

Approved by the Research Board on 7/6/2006:

Beams restarting next week (26/6)
CNGS low intensity 18/8-30/8 (no MD cycle, Scycle=18s)
CNGS high intensity 20/10-8/11

http://sps-schedule.web.cern.ch/sps-schedule/



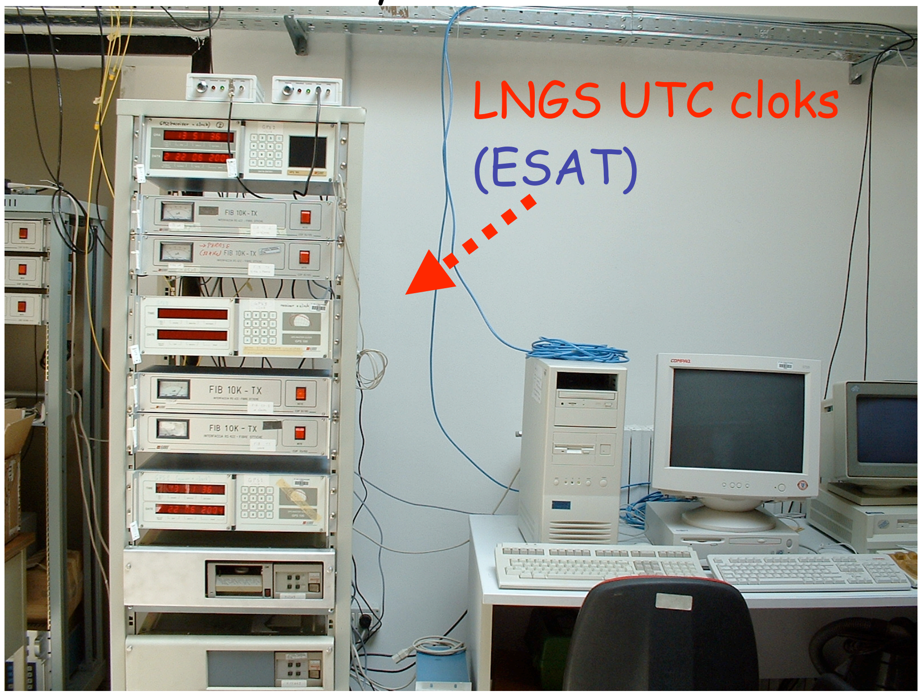
Wk
Mo
Tu
We
Th
Fr
Sa
Su
14 15 16 17 18 19 20 21 22 23 24 25 26
Easter
1 May
Whit.
PS cold check out
Isolde Physics Only
SPS HW tests
Ascension
G.Friday
SPS cold check out
EAST Hall
SPS Physics start
AD Physics start
Linac3 Restart
LEIR re-start
July
Aug
Sep
27 28 29 30 31 32 33 34 35 36 37 38 39
Int. tests
CNGS COMM. PART 1
PS SCRUBBING
CNGS COMM. PART 2
CNGS COMM. PART 3
PS MD
SPS MD
LSS6 res.
LSS6
Tech.Stop
Jeûne G.
CNGS
25 ns run
TI8 tests
SPS 25 ns operation with reduced cycle length
PS Ion Commissioning start
AD stop
proton stop
CTF stop
Oct
Nov
Dec
40 41 42 43 44 45 46 47 48 49 50 51 52
coll. test
PS Ion
LSS4/6
coll.test.res
SPS magnet tests
Cool down period
LSS4/6 res

CERN-LNGS UTC clocks intercalibration

For the neutrino spill syncronization both CERN and LNGS have a double unit (including a spare) UTC clock system, but from different manifacturers. The CERN system was calibrated by the Swiss metrology institute METAS.

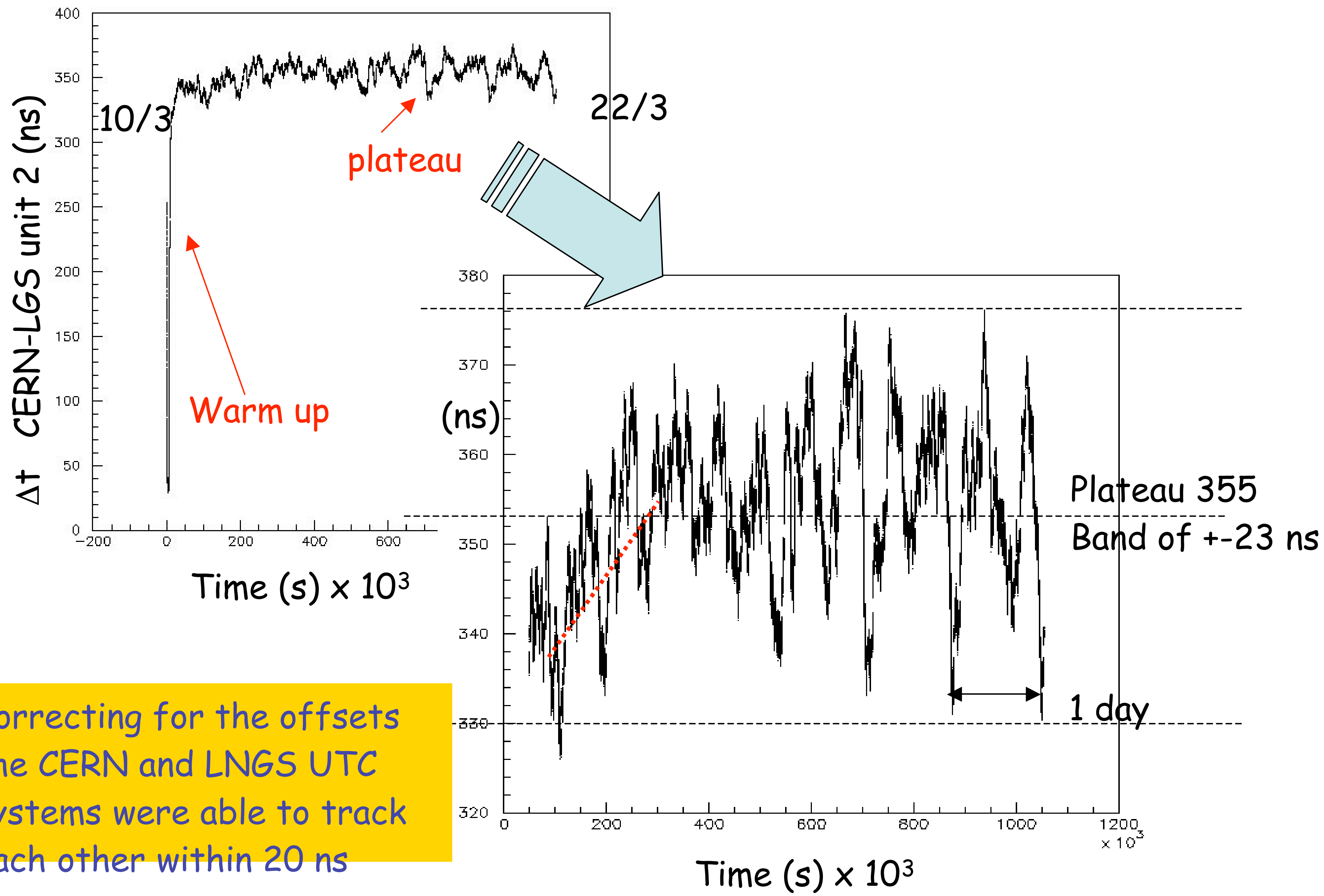
CERN and LNGS systems have comparable performance (<100 ns) and their single units are in both cases based on a GPS system + Rb clock.

One of the CERN UTC units was installed and running for one month in Gran Sasso in order to check for relative offsets and time stability of the two systems. Action was taken also to measure all the delays in the LNGS time distribution chain



CERN Symmetricom XL-DC unit installed at LNGS

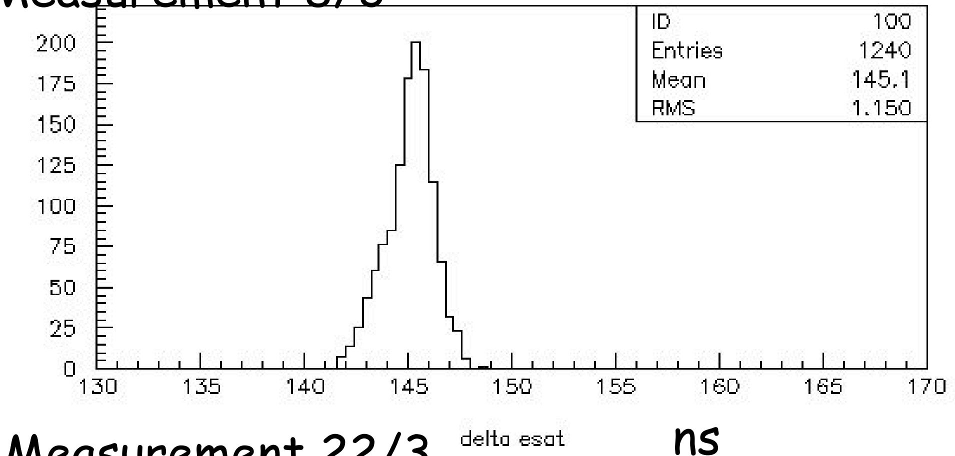
Time difference measured during 12 days with a time interval counter (300 ps accura



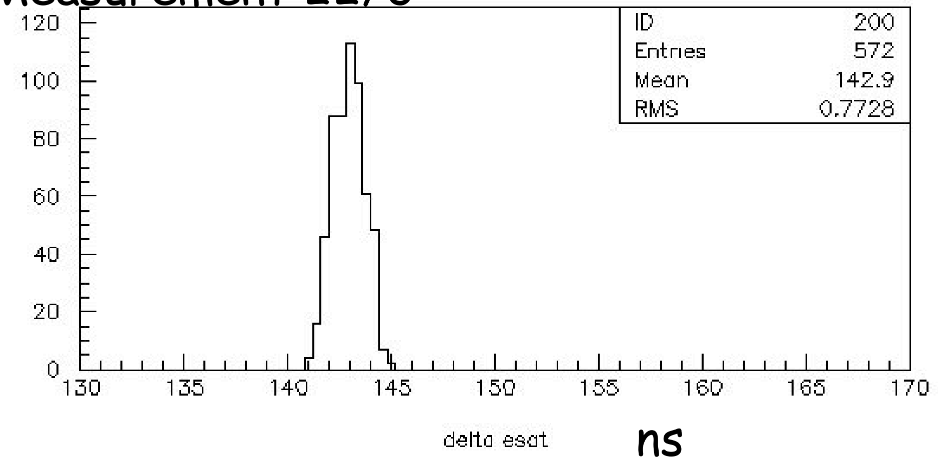
Correcting for the offsets the CERN and LNGS UTC systems were able to track each other within 20 ns

Discovered that the two LNGS UTC clocks which should be identical (clock2 and clock1) have an offset about of 140 ns. Different software configuration ? How the antenna cable delays are taken into account in the configuration of the two systems

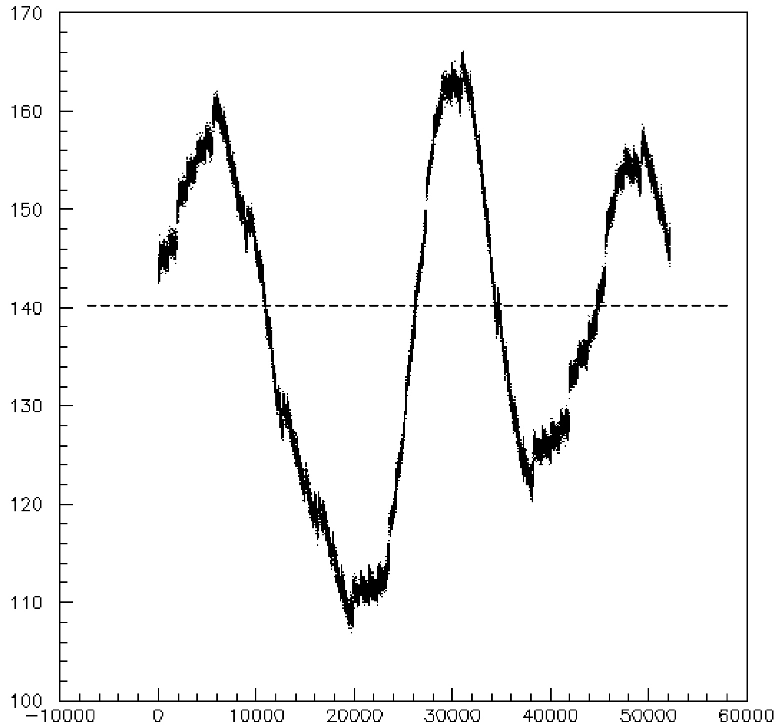
Measurement 8/3



Measurement 22/3



Clock1-clock2 monitored over 13 hours



Geodesy

The CERN system converged to the following coordinates:

N42° 25′ 15.4″
E13° 30′ 52.9″
Alt 1037 m asl WGS84

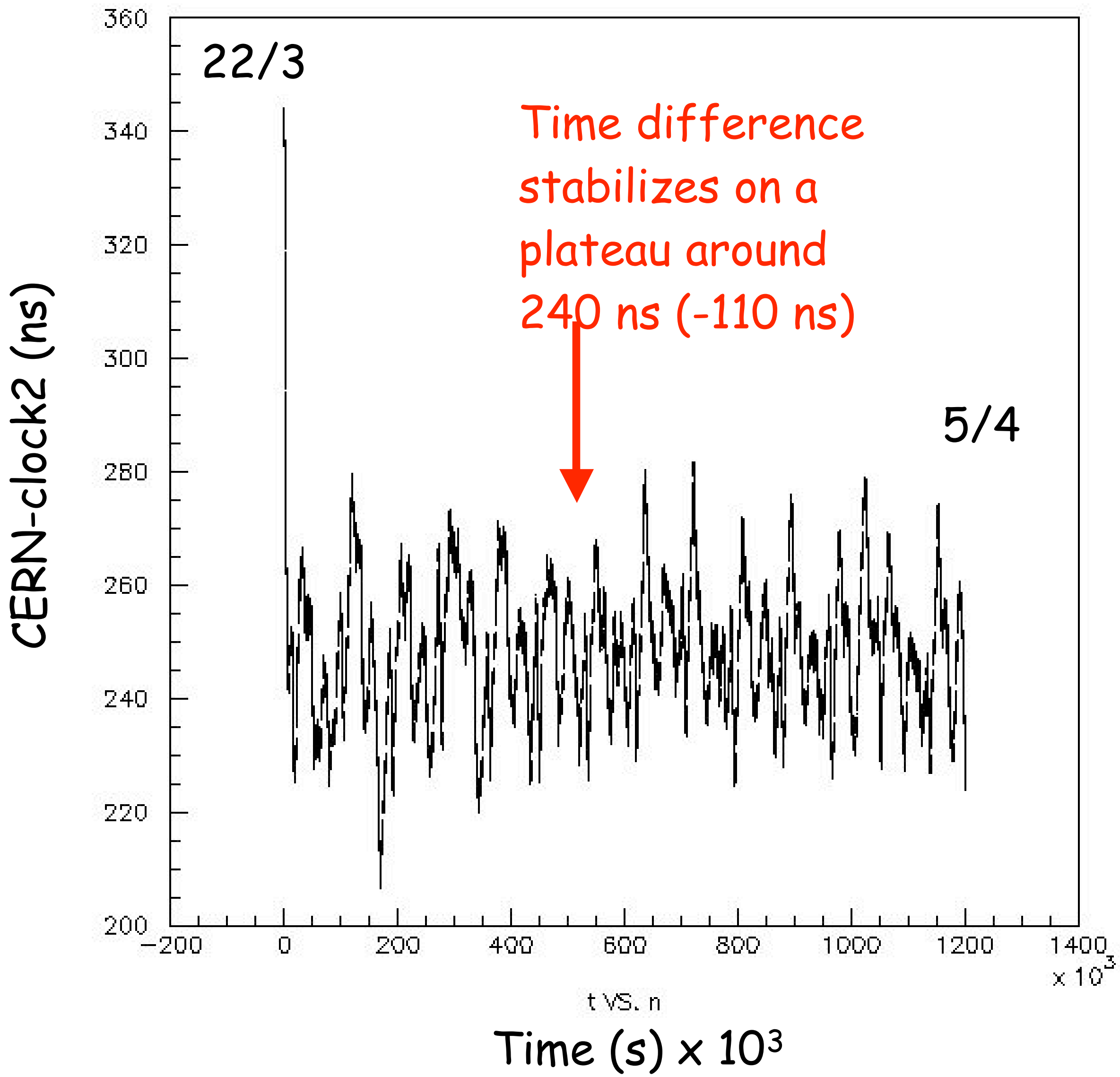
The coordinates of the antenna used by clock2 are known from precise measurements:

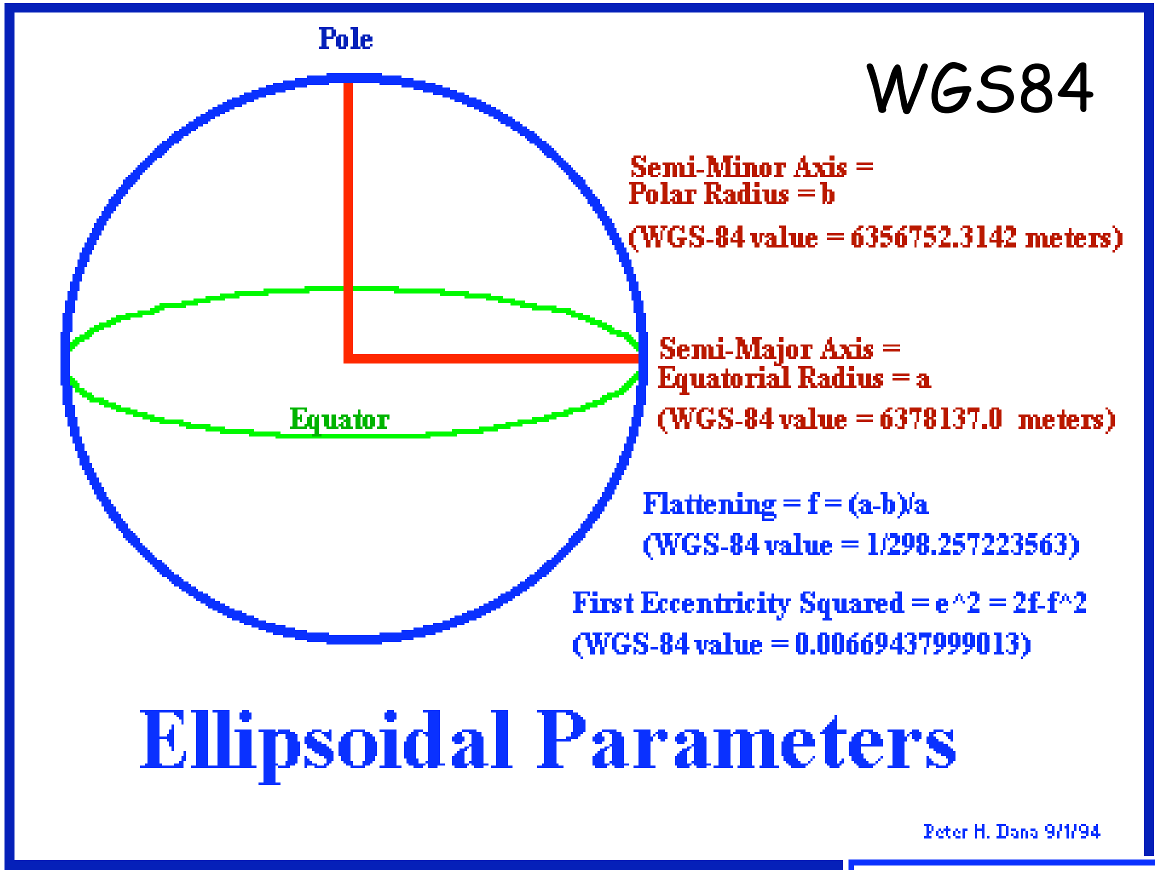
N42° 25′ 15.6″
E13° 30′ 52.8″
Alt 985 m asl WGS84

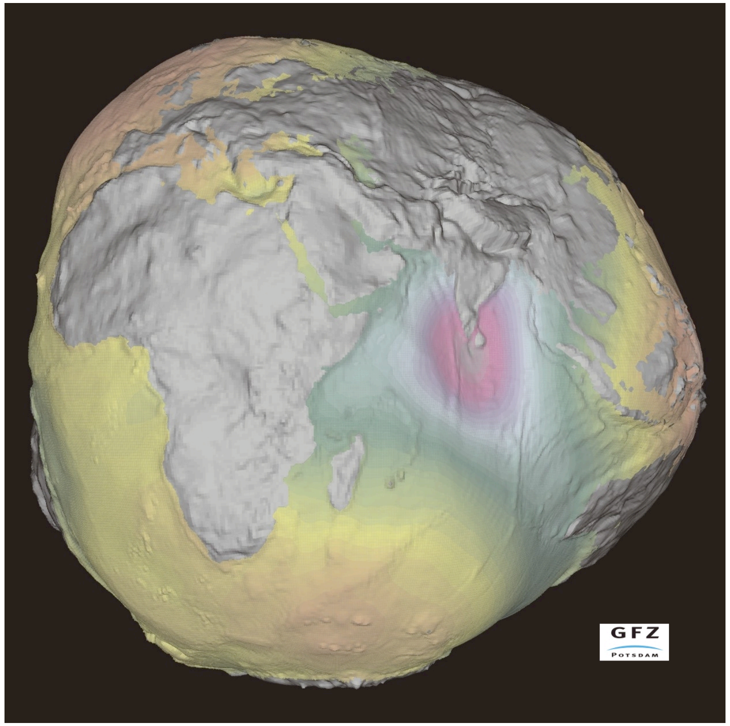
The CERN system if off by 50 m in altitude, it comes out that the same bias was noticed also at CERN (50m=167 ns). Both at CERN and LNGS this is confirmed also by other portable GPS systems

Apparently both systems refer to the geoid model WGS84.
Perform the same measurement with the CERN system in time only mode with forced LNGS coordinates

Long run in time mode with CERN system forced to known LNGS coordinates 22/3-5/4



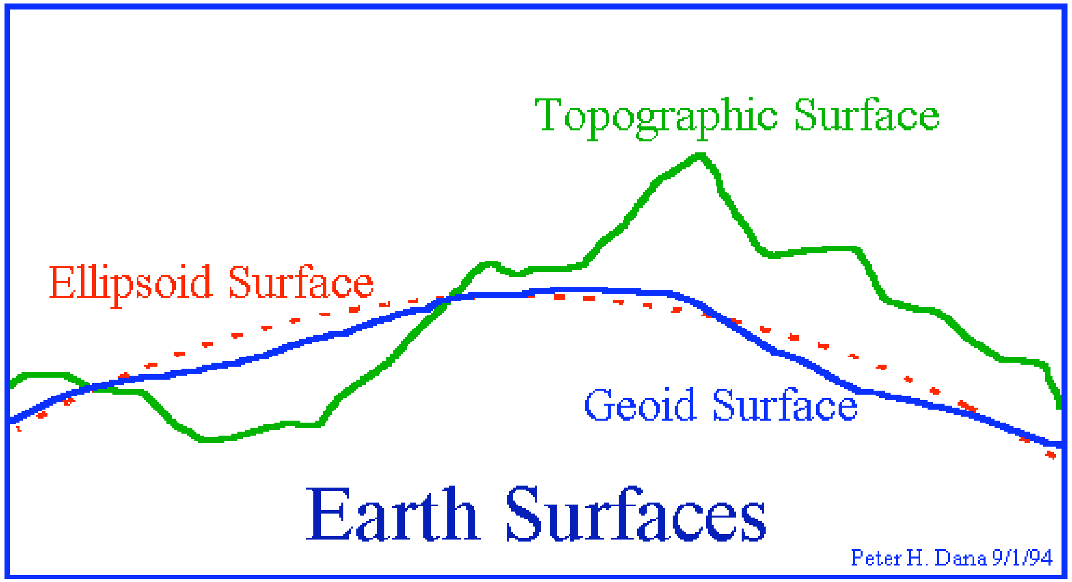




Geoid: more detailed description = equipotential surface corresponding to mean sea level

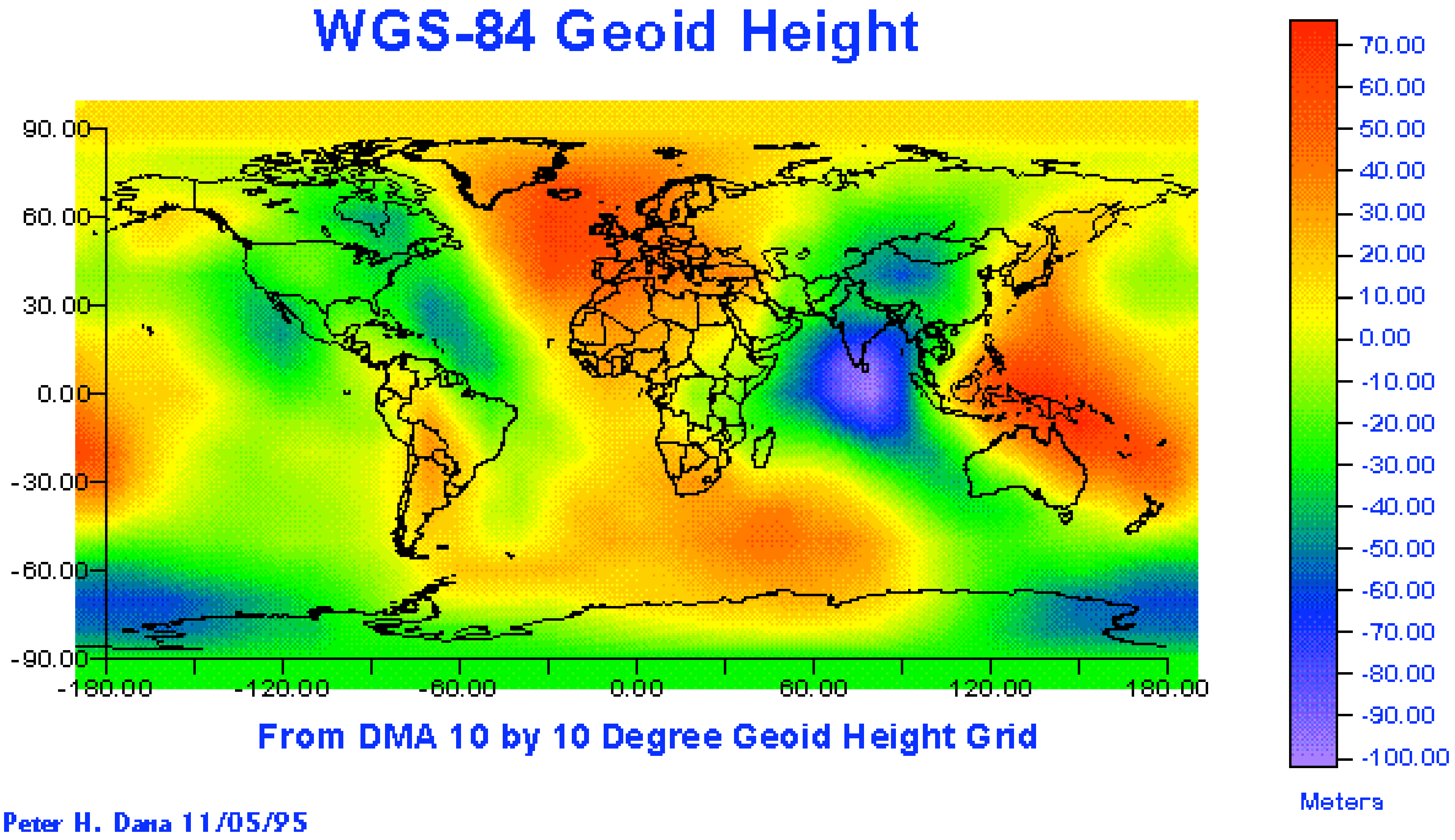
Note: WGS84 can mean both:

WGS84 ellipsoid
WGS84 geoid



World Geoid Separation

In Europe the geoid is about 50 m higher than the ellipsoid



CERN Coordinate System Coordinates with Geoidal Heights (Heights above Mean Sea Level)

Name	X	Y	H
GP 402	1232.08	4979.86	473.42

WGS84 System Coordinates with Ellipsoidal Heights (Heights above WGS84 Reference Ellipsoid)

Name	Phi			Lambda			He
	Deg	Min	Sec	Deg	Min	Sec	M
GP 402	46	15	27.0434	6	3	40.7073	523.457

Building 870 (next to CCC): pillar GP 303

CERN Coordinate System Coordinates with Geoidal Heights (Heights above Mean Sea Level)

Name	X	Y	H
GP 303	1172.25	4538.87	473.79

WGS84 System Coordinates with Ellipsoidal Heights (Heights above WGS84 Reference Ellipsoid)

Name	Phi			Lambda			He
	Deg	Min	Sec	Deg	Min	Sec	M
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Conversion factor geoid-ellipsoid for the LNGS location

Latitude = 42.421° N = 42° 25' 15.6" N
Longitude = 13.5146666666667° E = 13° 30' 52.8" E

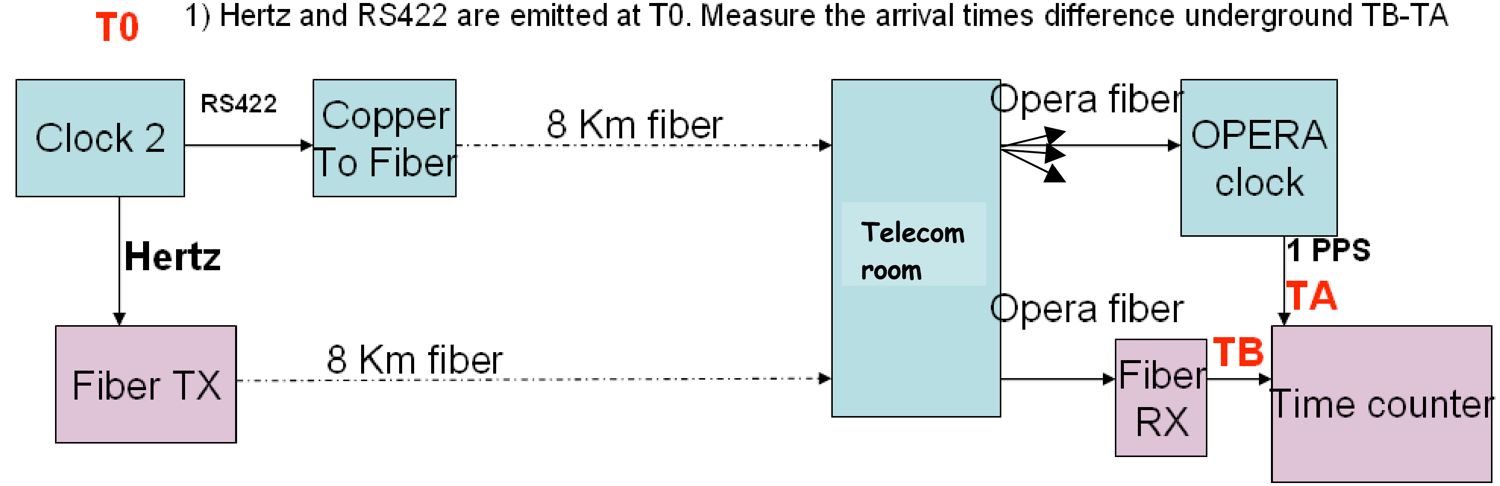
GPS ellipsoidal height = 1037 (meters)
Geoid height = 47.971 (meters)
Orthometric height (height above mean sea level) = **989.029 (meters)**

(note: orthometric Height = GPS ellipsoidal height - geoid height)

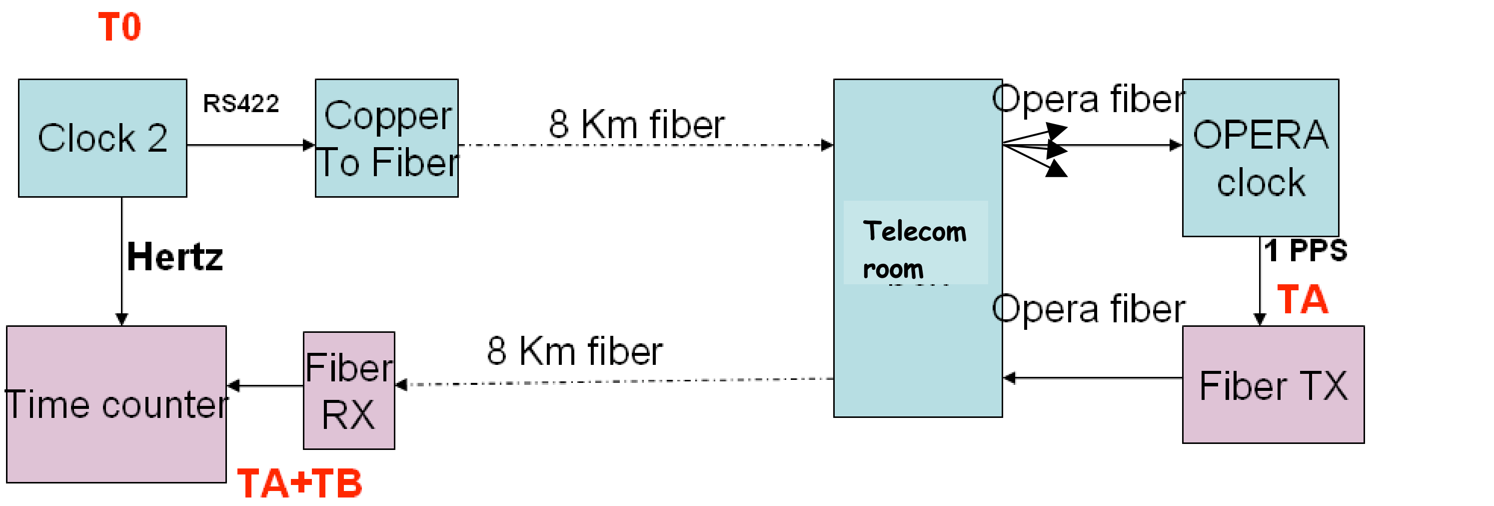
The CERN system refers to the ellipsoid, its position and time are correct, the certification provided by METAS is confirmed

Complete calibration of the time distribution chain:

1) Hertz and RS422 are emitted at T0. Measure the arrival times difference underground TB-TA



2) The components of the B arm are reshuffled to invert the direction the TB+TA is measured



All material found at CERN and sent here on 16/6. Contacts with LVD. Decide the date for the measurement

Conclusions for the UTC CERN-LNGS intercalibration :

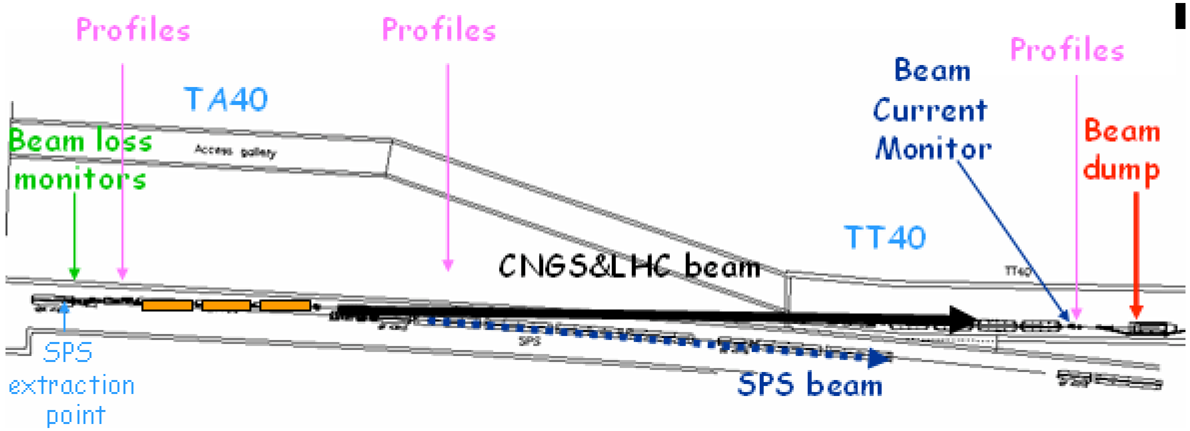
1) The two GS clocks differ by 140 ns, check with ESAT their software configuration and how the antenna cable delay is accounted for the two

2) The CERN system coordinates are now understood thanks to the geodesic service + METAS and are correct (WGS84 ellipsoid gives 50m more than the average sea level)

3) Once reached the plateau the two systems (XL-DC and clock2) are tracking each other in a band of 40 ns (+-20) and an offset of 356/248 ns coming from unaccounted cable delays + wrong geodesic system. This is a quite nice result. Now that things are clear we will correct for the offset of 356 ns

4) A viable scheme has been setup in order to complete the calibration of the LNGS time distribution system by measuring the delays (+jitter) of the chain. The components have been found we will perform soon the measurement

The CNGS-LNGS database



Needs:

1) Correlate the events recorded by the experiments with the beam spills windows (10.5 microseconds). This is done through the UTC times recorded at CERN and LNGS: T(LNGS)=T(kicker)+TOF, accuracy better than 100 ns. We need the list of spills UTC times from the CERN database
2) Have online some rough, synthetic spills quality informations (intensity, status word)
3) Full database of the beam conditions for physics analysis and comparison with the beam simulations, (e.g. NOMAD) important for numu->nue analysis
4) Record in the beam database the feedback of the far (LNGS) beam monitoring: muons from neutrino interactions in the rock, neutrino interactions in the detectors
5) Be able to consult at LNGS the beam status, like it was done at WANF

The CNGS database (ORACLE based) produces 1 TB/day of information, mostly technical and it is in the hidden accelerator controls network at CERN (LHC logging database)

After a few meetings among OPERA/CNGS and the CERN Database people it was decided to implement a new gataway server (ORACLE) on the public network in order to exchange the relevant informations among CERN and LNGS for the data-taking, beam monitoring and beam analysis:

The data will be available on the public gateway about 15 minutes after recording in the main database

The database is structured per CNGS cycles

The server will be bidirectional in order that also LNGS experiments will be able to write the events observed in correlation to the spills (some discussions started in OPERA and LVD)

A new server has been bougth

Database status:

Gateway machine available, with a good subset of the variables

Access being tested by OPERA (ORACLE9)

The user documentation (debugged) is available on the CNGS WEB site:

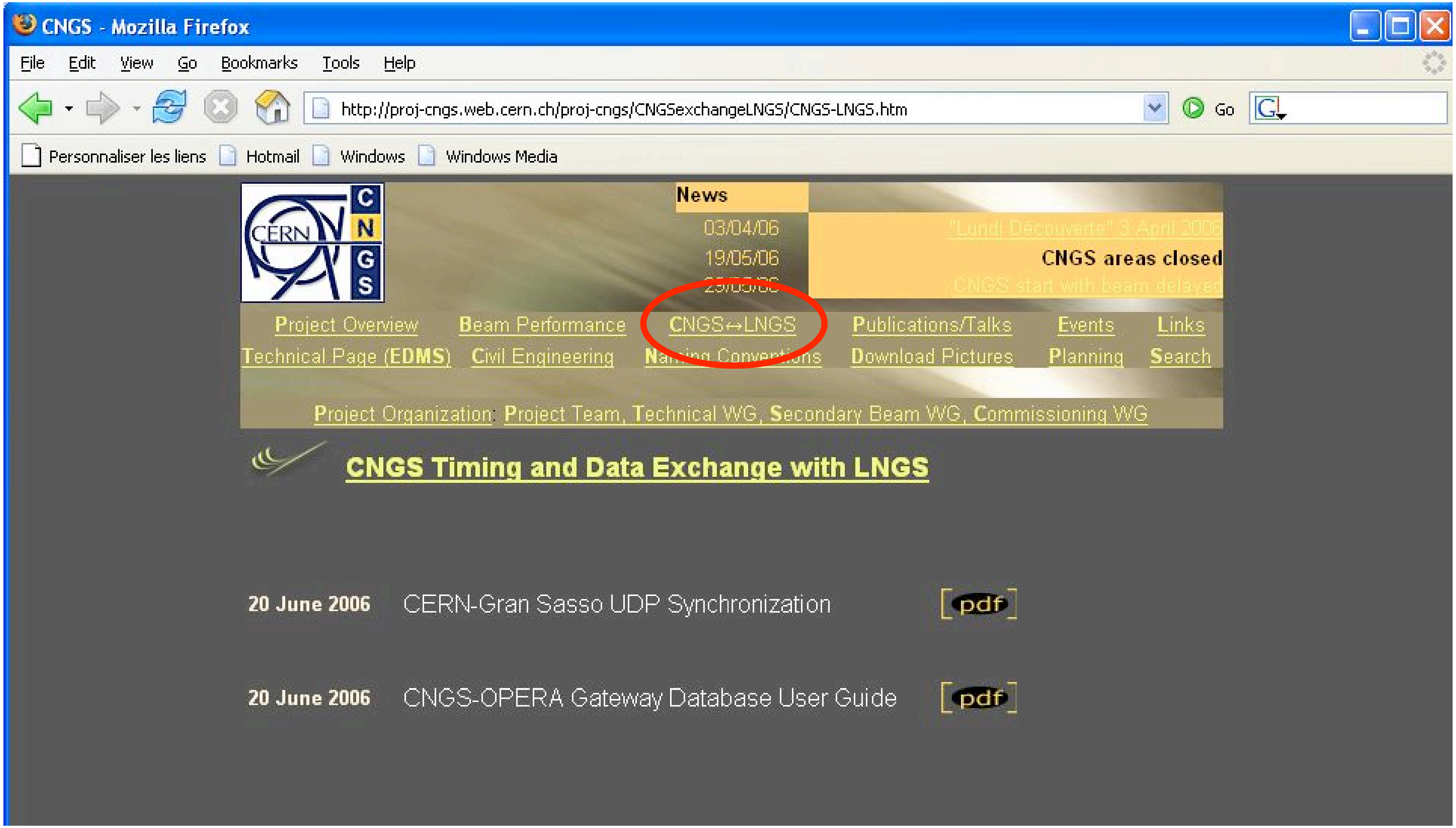
Logon procedure
Description of SQL commands

The complete list of variables will be put soon on the same web site

Early warning:

Already used by OPERA
Documentation on the CNGS site
Decide the list of machines which should receive the signal

WEB page for the CNGS-LNGS documentation



CERN
CH-1211 Geneva 23
Switzerland

the
Accelerator
& Beams
department

Project Document No.
LHC-CL-ES-0003 v.1.0

CERN Div./Group or Supplier/Contractor Document No.
AB - CO

EDMS Document No.
720103

Date: 2006-04-11

Note

LHC LOGGING ← → CNGS-OPERA GATEWAY DATABASE USER GUIDE

Abstract

As part of the CNGS project, data recorded in Gran Sasso (GS) needs to be correlated at GS with CNGS beam data and beam status data recorded at CERN, the key being the UTC timestamp. This data will be available in the LHC Logging Service (LS) provided by AB/CO. A small subset of data recorded in GS (muons) also needs to be recorded by the LS at CERN, twice per day.

In addition to the remoteness of GS with respect to CERN, computer and network security issues have to be considered. The LS (DB servers and Apps servers) will be on CERN's Technical Network (TN), which can be isolated from the General Purpose Network (GPN). Individual computers will be protected by firewalls.

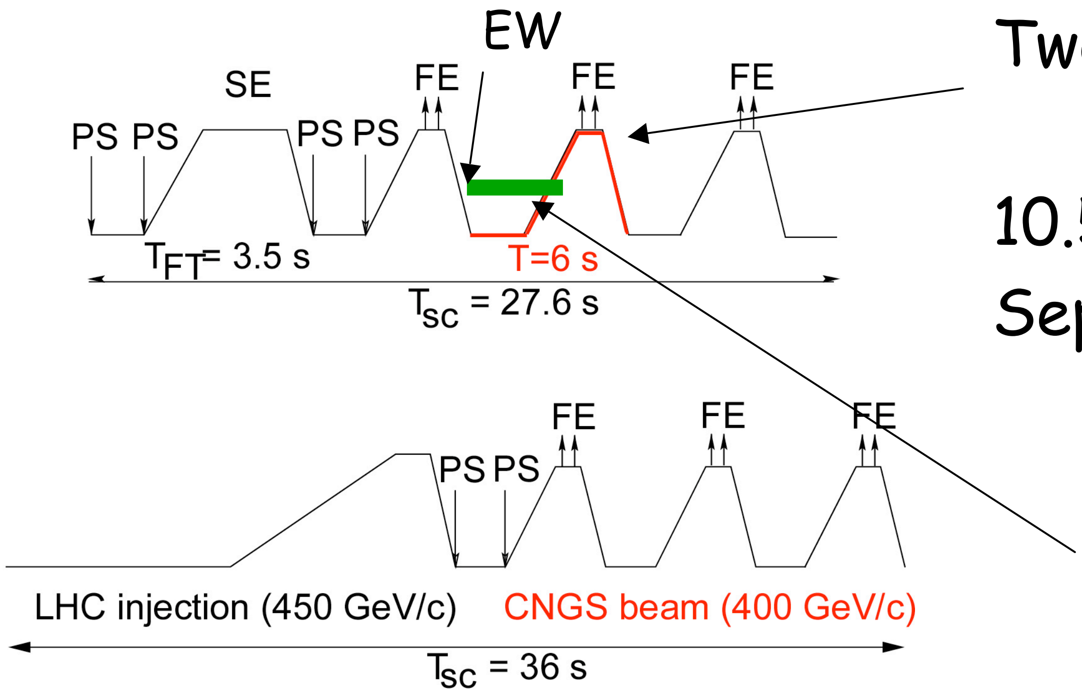
These requirements and constraints have been fulfilled by means of a gateway database. This note describes this gateway database and how it can be used to exchange data between GS and CERN.

Prepared by :	*Checked by :*	
Chris Roderick	**Ronny Billen**	
AB/CO	AB/CO	
Chris.Roderick@cern.ch	Ronny.Billen@cern.ch	

Early warning signal

It is useful to know in advance the arrival time of neutrinos in order to prepare the DAQ and prevent operations which could interfere with the neutrino events recording (e.g. OPERA from time to time performs calibrations with flashing LEDs)

The next neutrino spill time can be predicted in advance of several seconds. The information can be transmitted through the network



Two fast extractions/cycle

10.5 micro seconds

Separated by 50 ms

Window for calibrations

An experiment like OPERA is continously taking data, independently of the beam informations (data-base and early warning access through the network):

1) The beam informations are needed to validate the bricks extraction once per day

2) The calibrations can be conservatively skipped for some time in case the early warning signal does not arrive. In case the EW is there the calibrations will be performed till a conservative window around the neutrino spills

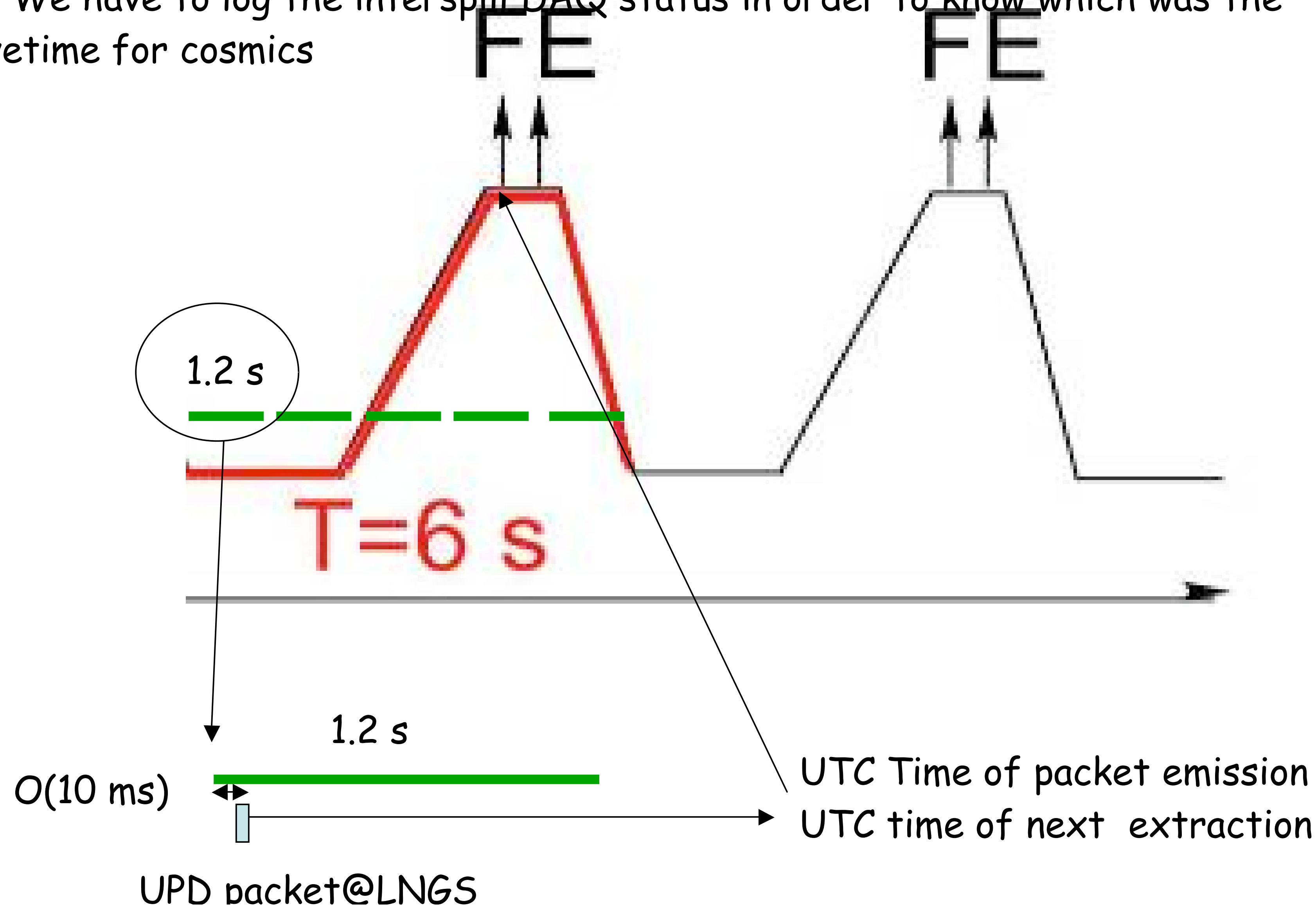
The transmission of the early warning from CERN to LNGS has been implemented and tested since the beginning of March by J.Lewis on the OPERA DAQ gateway computer

1) It is based on UDP packets. The transmission time is around 10 ms

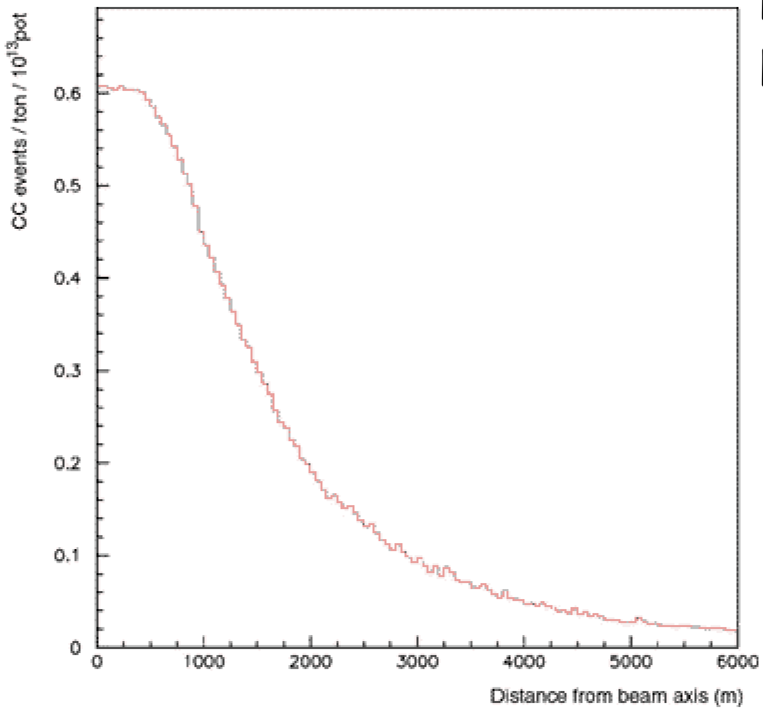
2) The packets are sent every 1.2 s (all possible SPS cycles are multiple of 1.2s which is the PS-booster cycle). The packets contain the date of the future neutrino extraction. This date can be the same for many packets of

3) The DAQ looks at the arrival time of the packet, compares to the extraction time written in the packet and decides if there is time or not to perform calibrations

4) We have to log the interspill DAQ status in order to know which was the livetime for cosmics



CNGS Geodesy:



Radial beam distribution at LNGS:

Full width at half maximum: 2.8 Km
Flat region at +- 500 m

effect on cc events	
horn off axis by 6mm	**< 3%**
reflector off axis by 30mm	**< 3%**
proton beam on target off axis by 1mm	**< 3%**
CNGS facility misaligned by 0.5mrad (beam 360m off)	**< 3%**

Angular accuracy of CNGS direction: 0.05 mrad -> 37 m over 730 Km
This uncertainty has practically no effect on the observed rates

Coming to another problem: It is known that the experimental halls were built in the direction of the future neutrino beam (apart from the zenith angle of 3.2 degrres), but with which accuracy ?

(OPERA is aligned at +- 5 mm over its length with respect to hall C axis)

Some investigation done thanks to the CERN geodesy service, P.Martella and M.Crespi

Underground network of reference points (C.Scalzini, 1989), connected to outside GPS points (C.Scalzini, M.Crespi, 1998)

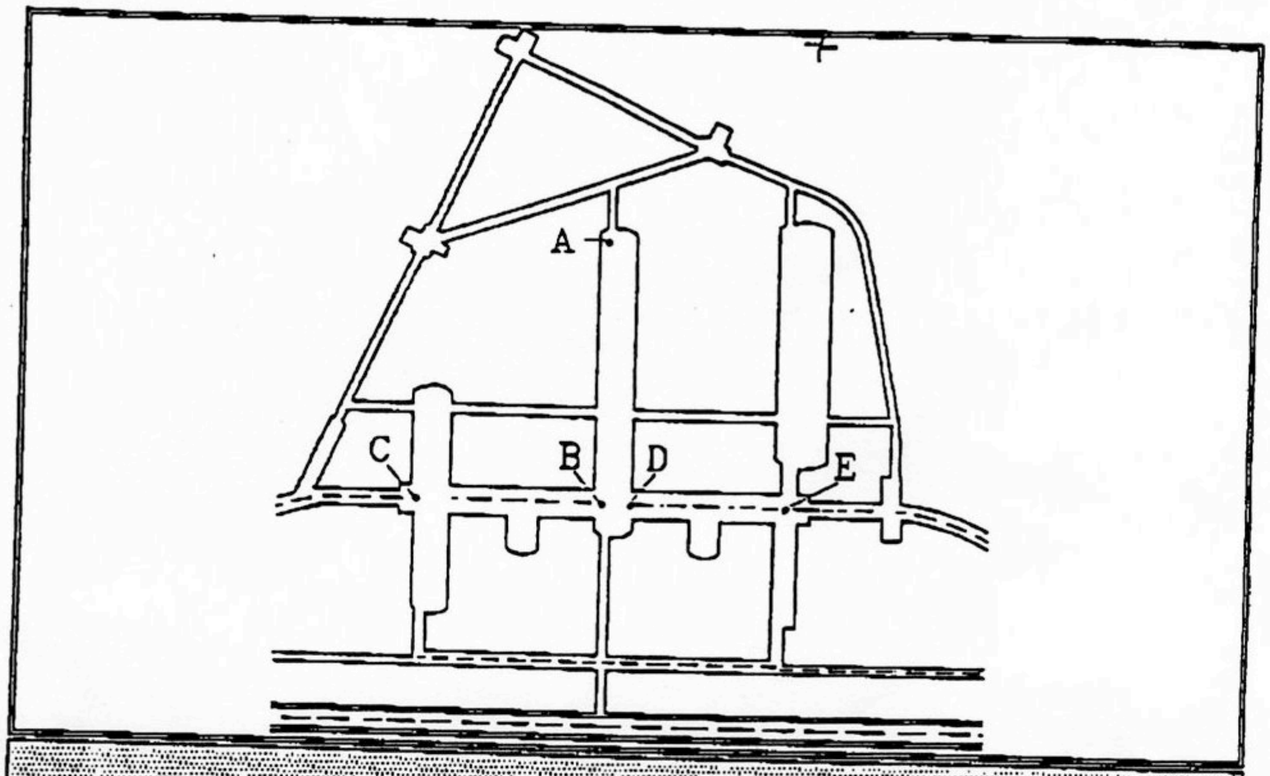


Fig. 1 - Punti rilevati

Points A-E expressed in the CERN reference system
CNGS beam centered midway in between A and B
Compute the direction AB, compare with the CERN-LNGS direction:

CERN-LNGS 98.1 gon
AB 98.3 gon

Beam angle with respect to hall B axis: 3.14 mrad Amazing precision in the construction of the halls !

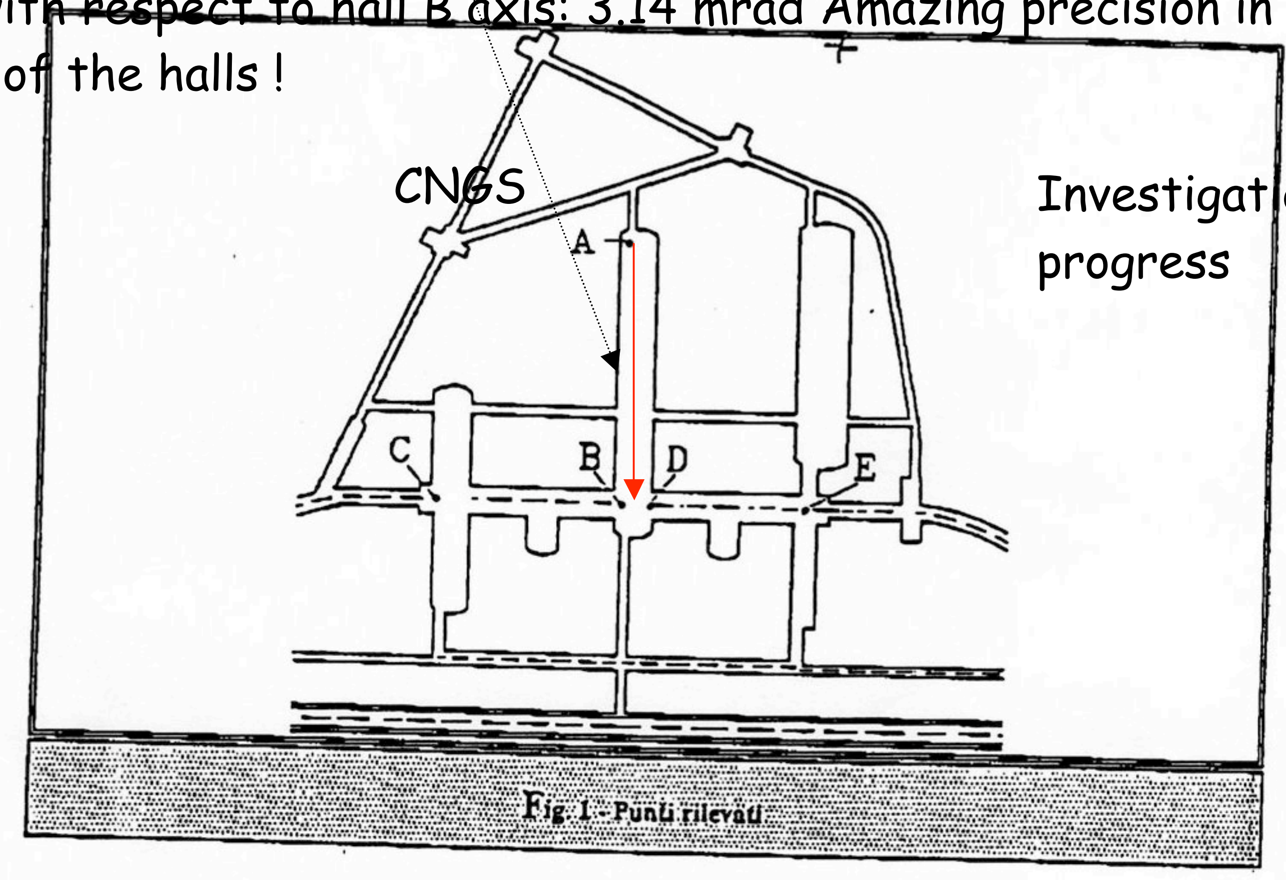
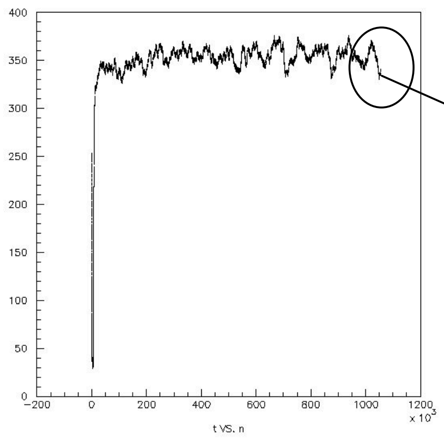
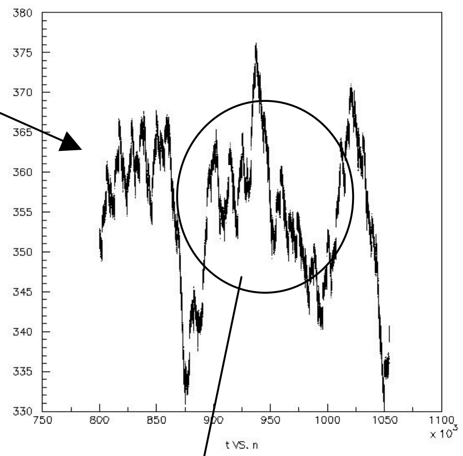


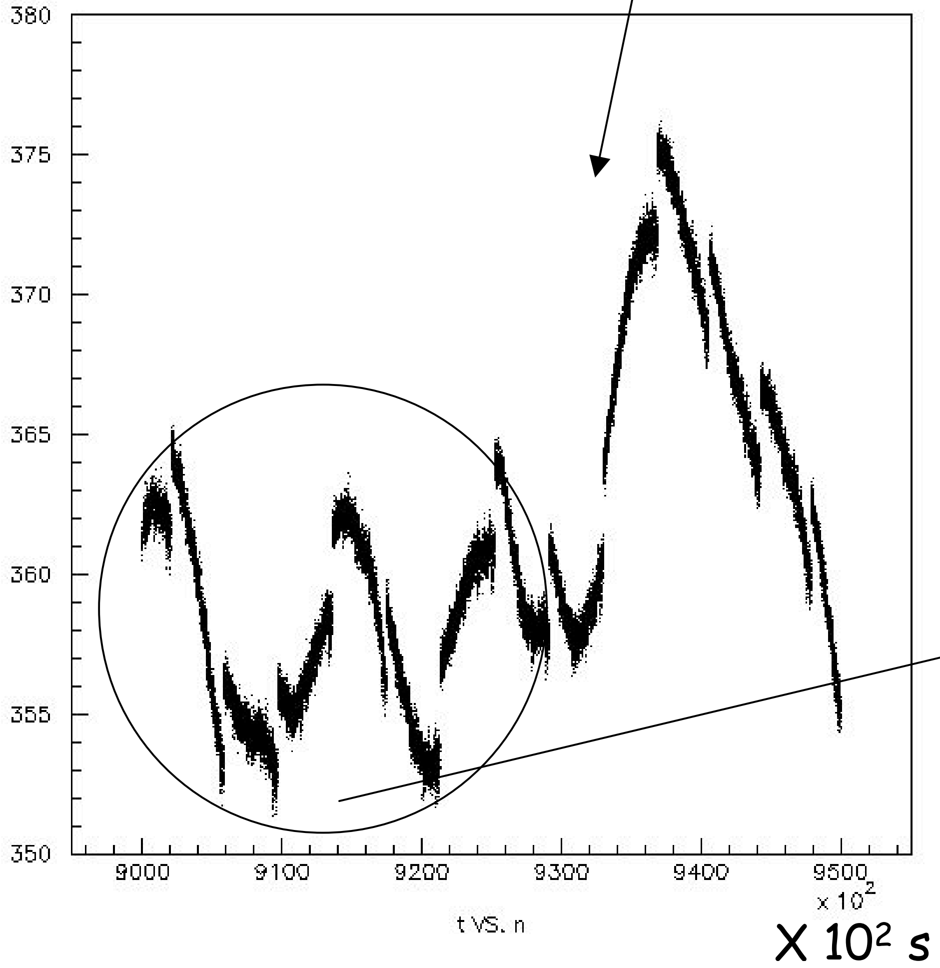
Fig. 1 - Punti rilevati

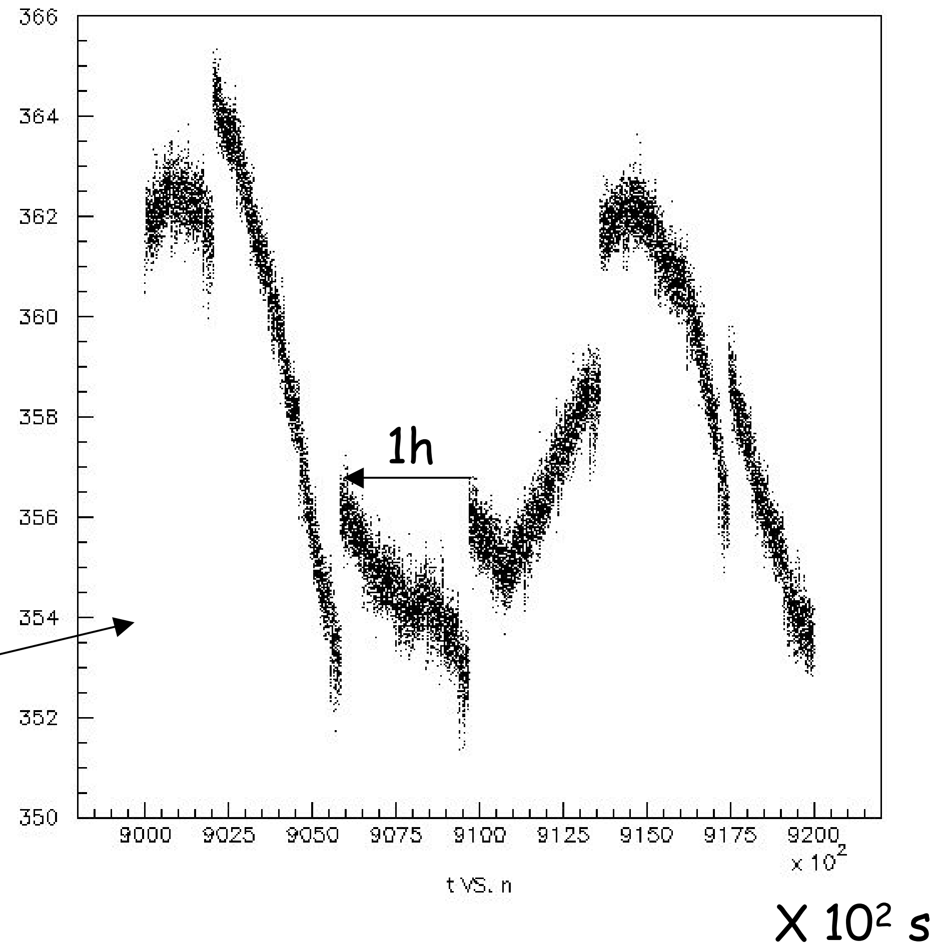
Investigation in progress

Fine details of the time difference evolution (1 measurement/s)



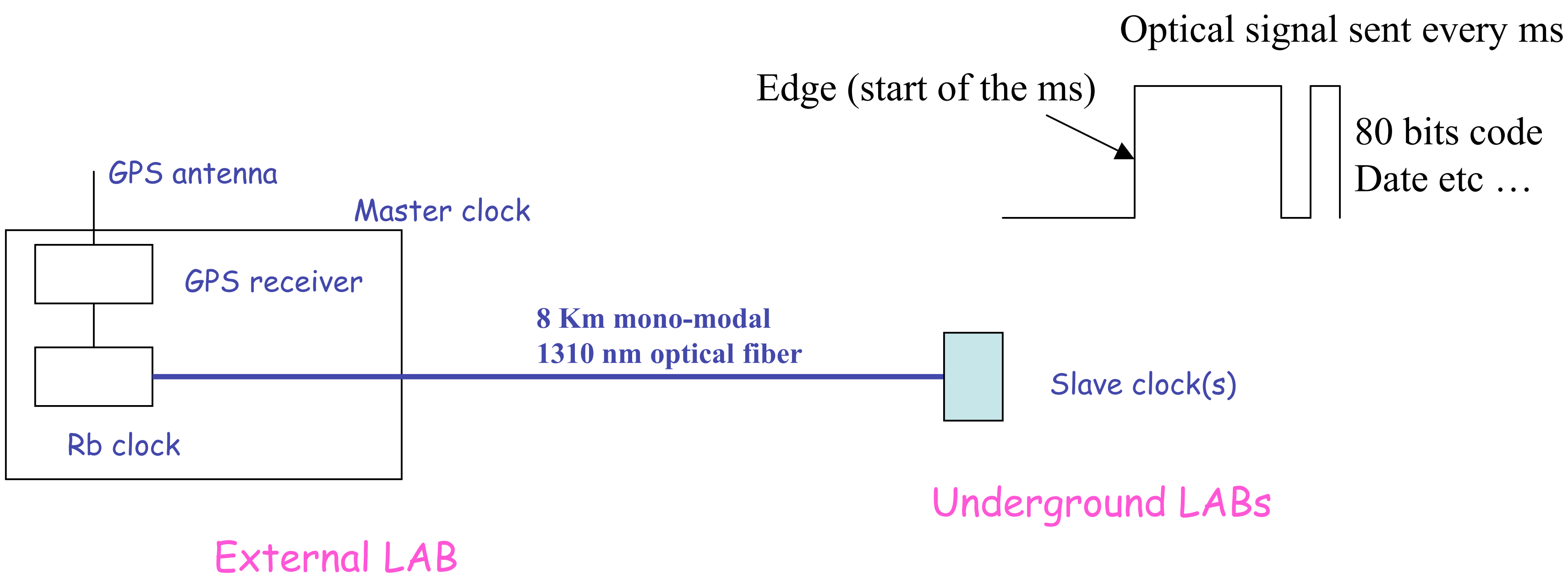






LNGS time distribution system to underground labs:

2 independent master clock units are installed in the external laboratory. The UTC time scale is known at better than 100 ns. Every ms (1000 better than the 1 PPS standard) a synchronization pulse and the time/date string are sent through the 8 Km long monomodal optical fiber (1310 nm) to slave clocks in the caverns. The ligth pulse is converted in electric serial pulses.

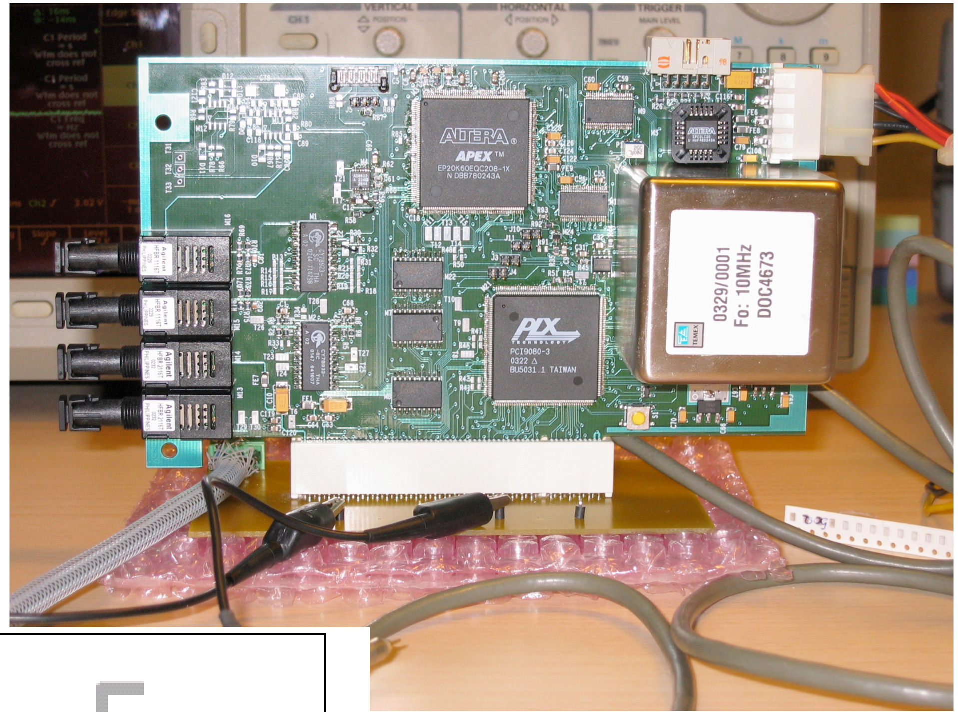


Propagation time is measured once and subracted systematically at the syncronization level

The OPERA master clock card

PCI cards replacing the old slave clock and providing the clock system in OPERA
Totally compatible with the LNGS clock system (ESAT consultancy)

Developed at IPN Lyon in 2003
Operative at LNGS since beginning of 2005



PPmS from optical fiber

10 MHz ovenized quartz local oscillator (reset every ms) almost a Rb clock:

Allan variance $2*10^{-12}$ over 1s
T stability $5*10^{-11}$ 0°-50°
Aging $7*10^{-8}$ over 5 years

Master clock signal edge tracing within 20 ns

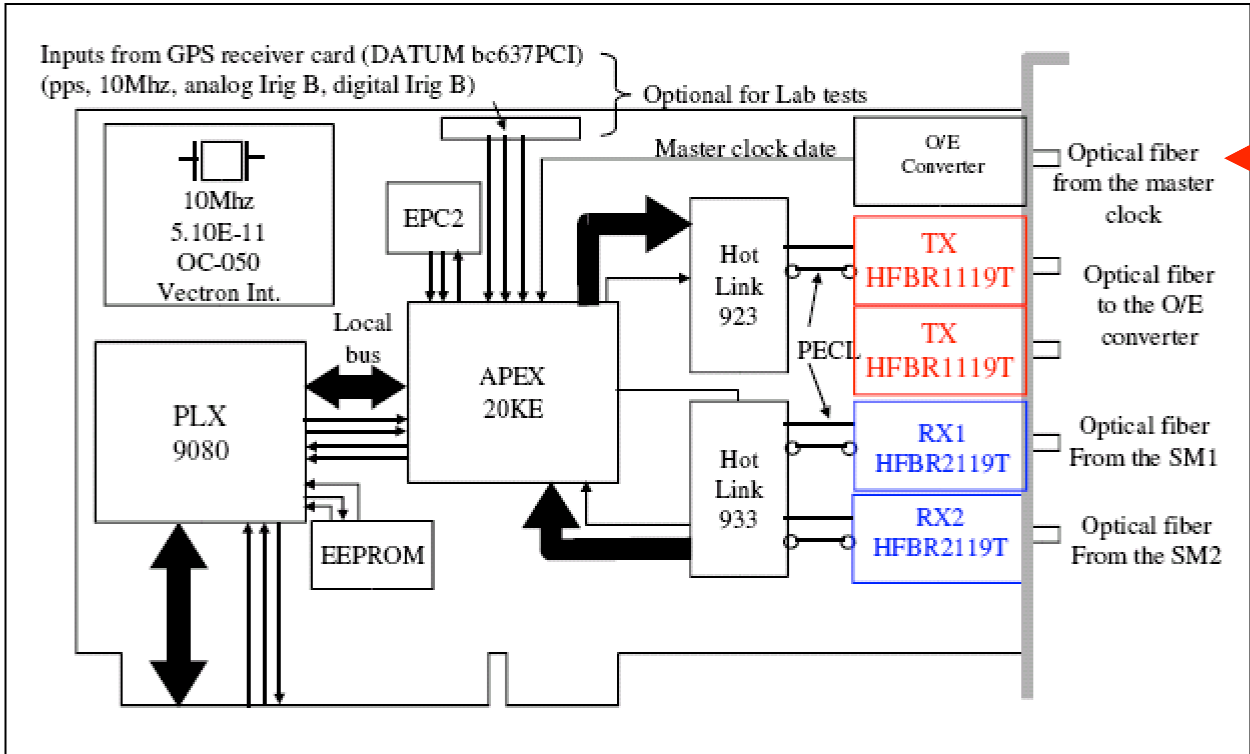
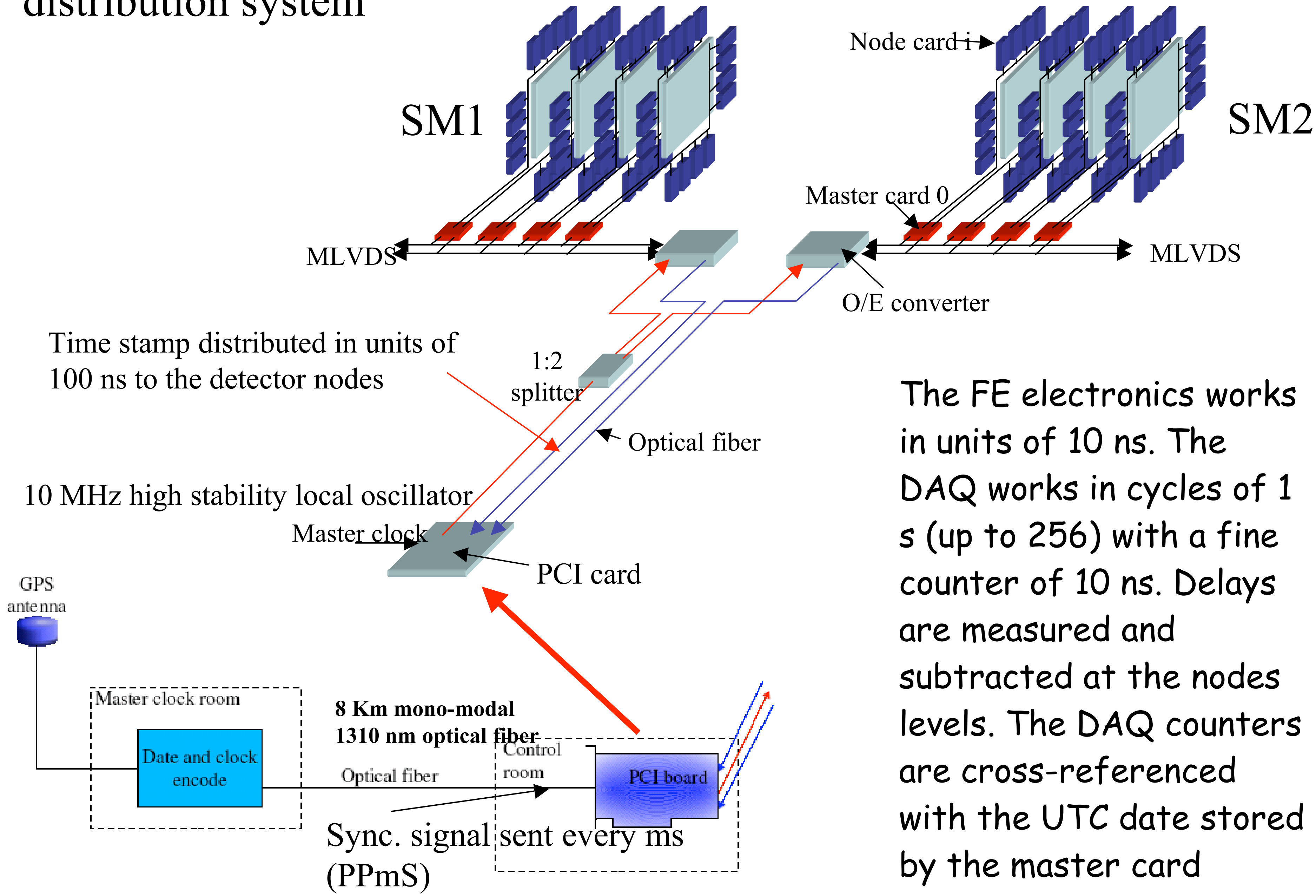


Figure 5 : PCI board architecture

The OPERA clock distribution system



The FE electronics works in units of 10 ns. The DAQ works in cycles of 1 s (up to 256) with a fine counter of 10 ns. Delays are measured and subtracted at the nodes levels. The DAQ counters are cross-referenced with the UTC date stored by the master card