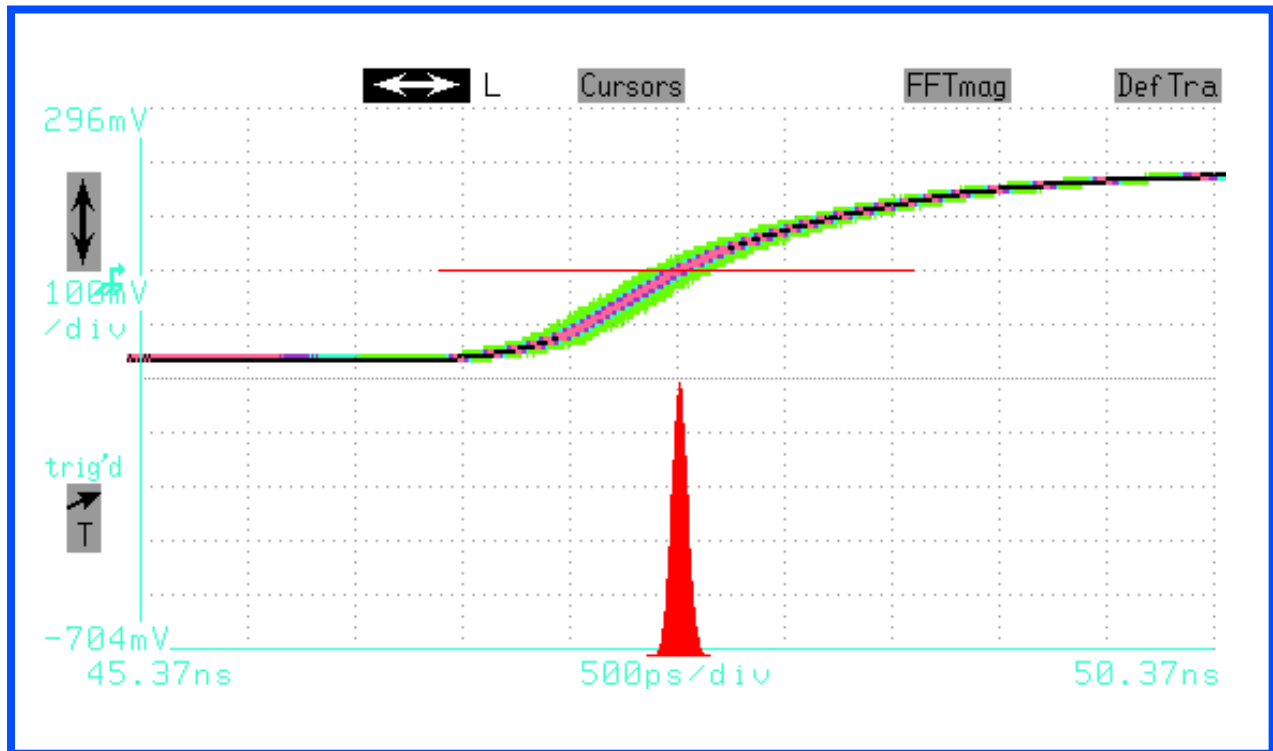


## ***General overview and status of TTC components***



*Bruce Taylor CERN/EP*

***LECC TTC Workshop***

*29 June 2001*

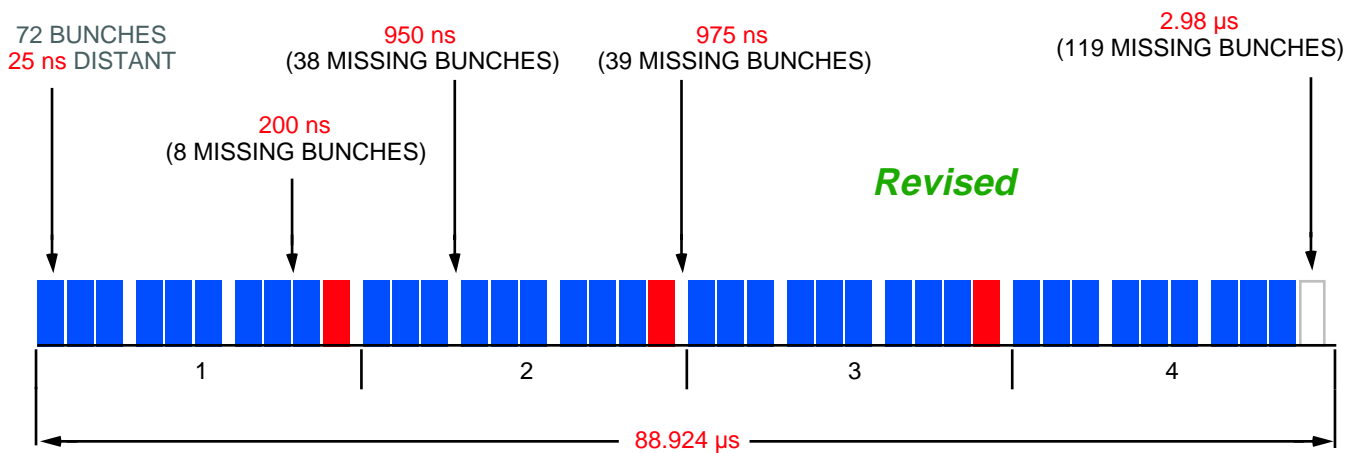
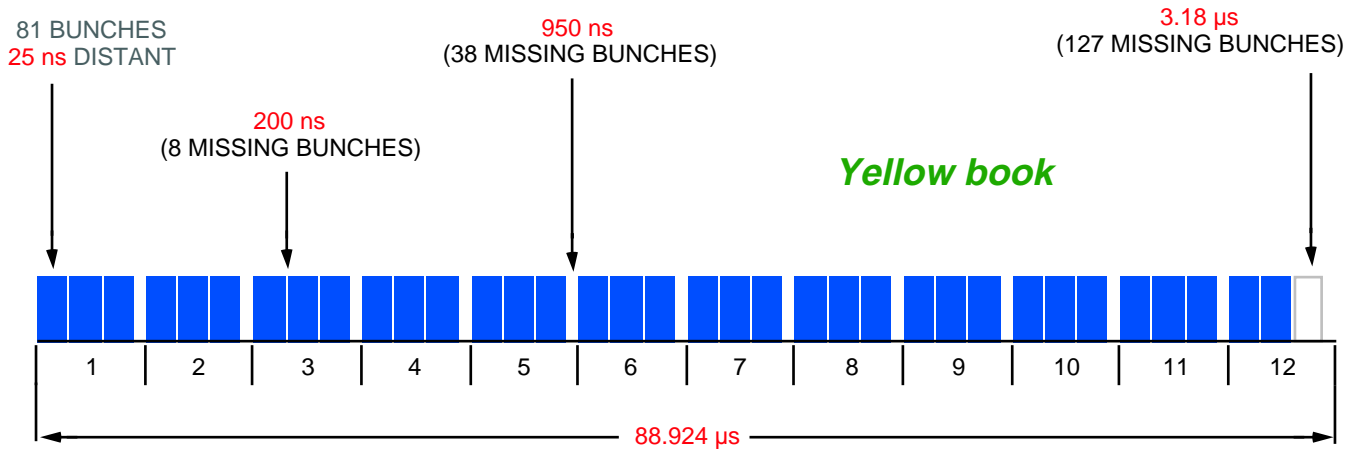
# ***RD12 TTC project collaboration***

<b><i>ALICE integration</i></b>	<b><i>O.V. Baillie, H.R. Schmidt</i></b>
<b><i>ATLAS integration</i></b>	<b><i>P. Farthouat</i></b>
<b><i>CMS integration</i></b>	<b><i>S. Cittolin, R.N.J. Halsall, W.J. Haynes</i></b>
<b><i>LHCb integration</i></b>	<b><i>J. Christiansen, R. Jacobsson</i></b>
<b><i>BI integration, TTCbi</i></b>	<b><i>J.-J. Savioz</i></b>
<b><i>TTCvi, TTCvx</i></b>	<b><i>P. Gällnö</i></b>
<b><i>TTCrx ASIC</i></b>	<b><i>A. Marchioro, P.R. Moreira, T.H. Toifl</i></b>
<b><i>TTCsr</i></b>	<b><i>J. Ferrer-Prieto</i></b>
<b><i>Synchronisation</i></b>	<b><i>J.C. Da Silva, J.Varela</i></b>
<b><i>System modelling</i></b>	<b><i>A. Racz</i></b>
<b><i>Event builder, LabVIEW</i></b>	<b><i>L. Pollet</i></b>
<b><i>Irradiation studies</i></b>	<b><i>P. Jarron</i></b>
<b><i>FERMI clock manager</i></b>	<b><i>J.-F. Genat</i></b>
<b><i>Subminiature connector</i></b>	<b><i>J.-C. Hubert, G. McFarlane</i></b>
<b><i>Receiver photonics</i></b>	<b><i>M. Ashton, J. Humphries</i></b>
<b><i>Spokesman</i></b>	<b><i>B.G. Taylor</i></b>
<b><i>SL associates</i></b>	
<b><i>Controls</i></b>	<b><i>G. Beetham</i></b>
<b><i>Hadron RF</i></b>	<b><i>Ph. Baudrenghien, D. Stellfeld</i></b>
<b><i>ST associates</i></b>	
<b><i>Elec engineering</i></b>	<b><i>L. de Jonge, O. Olsen</i></b>

# **A TTC Glossary**

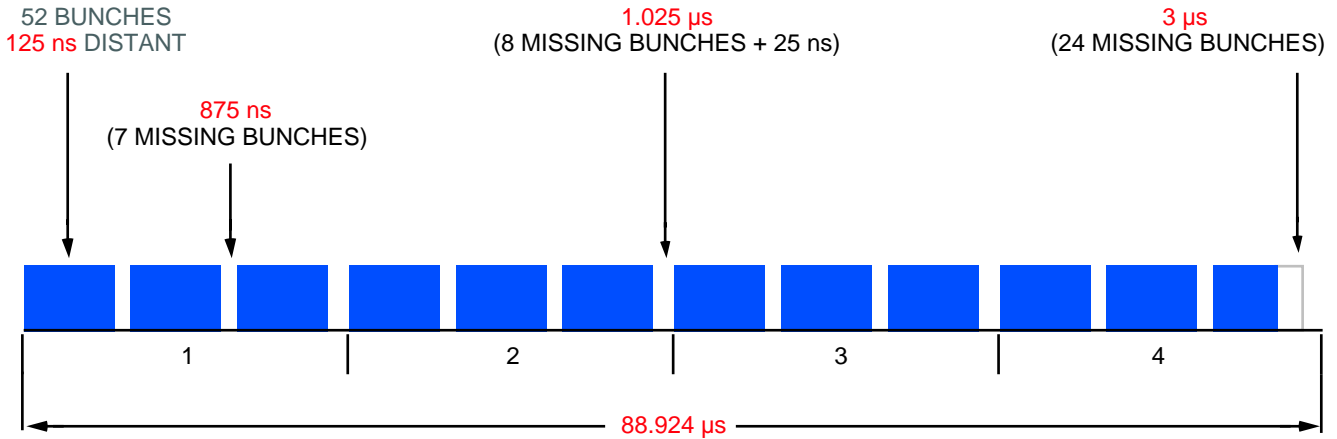
<b>TTC</b>	<b>Timing, Trigger and Control</b>
<b>TTCbi</b>	<b>Beam instrumentation interface</b>
<b>TTCcf</b>	<b>Clocks fanout</b>
<b>TTCcex</b>	<b>Laser encoder/transmitter</b>
<b>TTCmi</b>	<b>LHC machine interface</b>
<b>TTCmx</b>	<b>Laser minitransmitter</b>
<b>TTCpr</b>	<b>PMC receiver</b>
<b>TTCrx</b>	<b>Receiver ASIC</b>
<b>TTCsr</b>	<b>Simple receiver</b>
<b>TTCtx</b>	<b>Laser transmitter</b>
<b>TTCvi</b>	<b>VMEbus interface</b>
<b>TTCvr</b>	<b>VMEbus receiver</b>
<b>TTCvx</b>	<b>LED transmitter</b>
<b>BGA</b>	<b>Ball grid array</b>
<b>BM</b>	<b>Biphase mark</b>
<b>FBT</b>	<b>Fused biconic taper</b>
<b>LHCrx</b>	<b>LHC receiver</b>
<b>PCR</b>	<b>Prevessin control room</b>
<b>PLL</b>	<b>Phase locked loop</b>
<b>PRBS</b>	<b>Pseudo random binary sequence</b>
<b>TDM</b>	<b>Time division multiplex</b>
<b>VCXO</b>	<b>Voltage controlled xtal oscillator</b>

# LHC bunch structure (p)



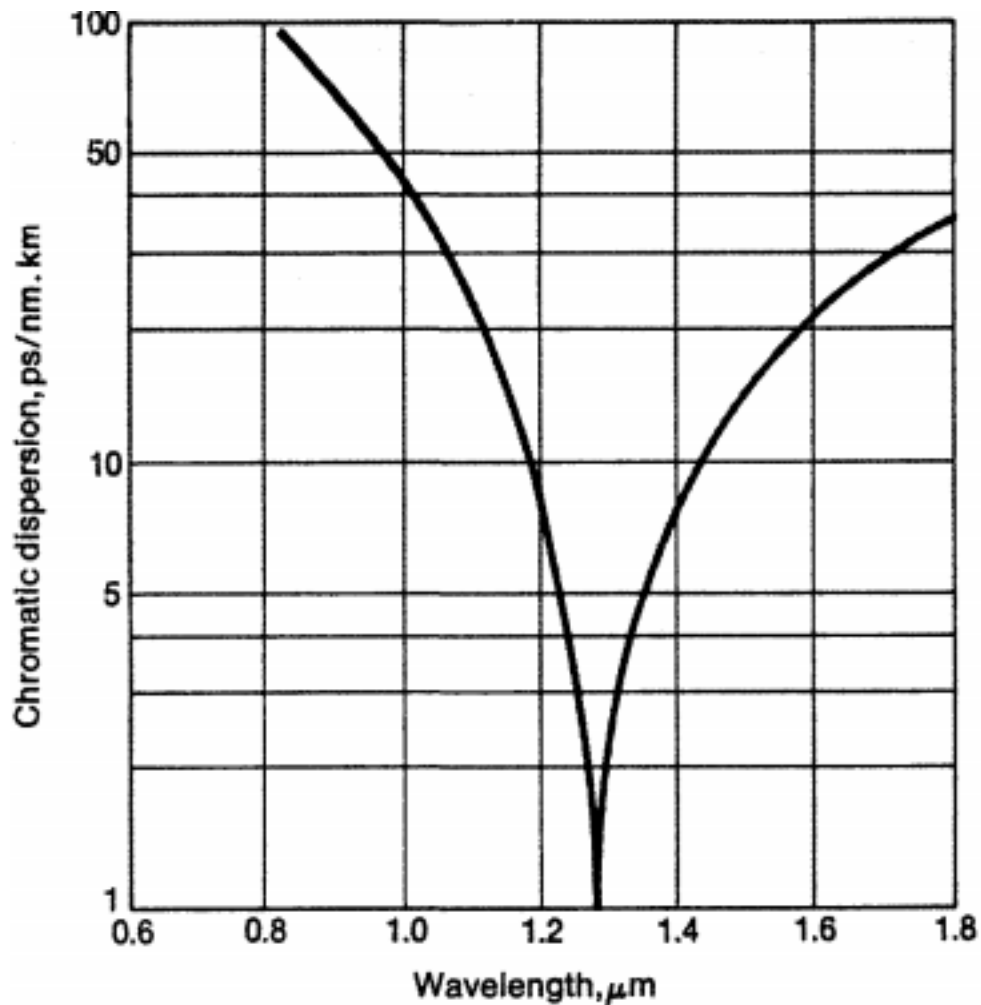
<b>Revolution time</b>	<b>88.924 μs</b>
<b>Revolution frequency</b>	<b>11.246 kHz</b>
<b>RF frequency</b>	<b>400.79 MHz (2 x SPS)</b>
<b>Bunch crossing rate</b>	<b>40.079 MHz</b>
<b>No of bunches/beam</b>	<b>2808</b>
<b>Filling factor</b>	<b>0.788</b>
<b>Bunch train length</b>	<b>72</b>
<b>SPS injection kicker gap</b>	<b>200 ns</b>
<b>LHC injection kicker gap</b>	<b>950 ns</b>
<b>LHC extraction kicker gap</b>	<b>2.98 μs</b>
<b>LHC filling time</b>	<b>4.3 min/ring</b>
<b>RMS bunch length</b>	<b>0.075 m</b>
<b>RMS collision length</b>	<b>0.053 m, 177 ps</b>
<b>Interbunch spacing</b>	<b>7.5 m, 24.95 ns</b>

# LHC bunch structure ( $Pb^{82+}$ )



<b>Revolution time</b>	<b>88.924 <math>\mu</math>s</b>
<b>Revolution frequency</b>	<b>11.246 kHz</b>
<b>RF frequency injection</b>	<b>400.784 MHz</b>
<b>RF frequency coasting</b>	<b>400.790 MHz</b>
<b>Bunch crossing rate</b>	<b>8.016 MHz</b>
<b>No of bunches/beam</b>	<b>608</b>
<b>Filling factor</b>	<b>0.853</b>
<b>Bunch train length</b>	<b>52</b>
<b>LHC injection kicker gap</b>	<b>875 ns</b>
<b>LHC extraction kicker gap</b>	<b>3 <math>\mu</math>s</b>
<b>LHC filling time</b>	<b>9.5 min/ring</b>
<b>Interbunch spacing</b>	<b>37.5 m, 124.75 ns</b>

## Chromatic dispersion of fibre



### Chromatic dispersion over 100m

(= material dispersion, neglecting waveguide dispersion)

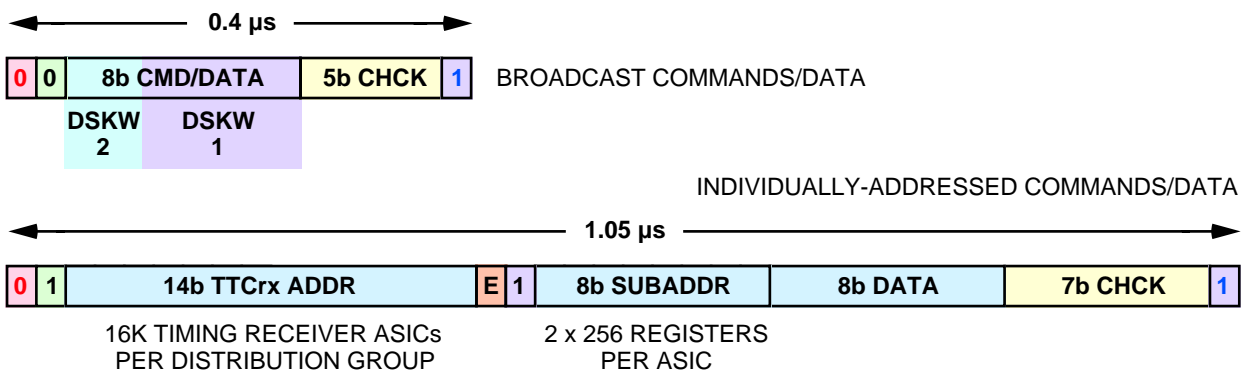
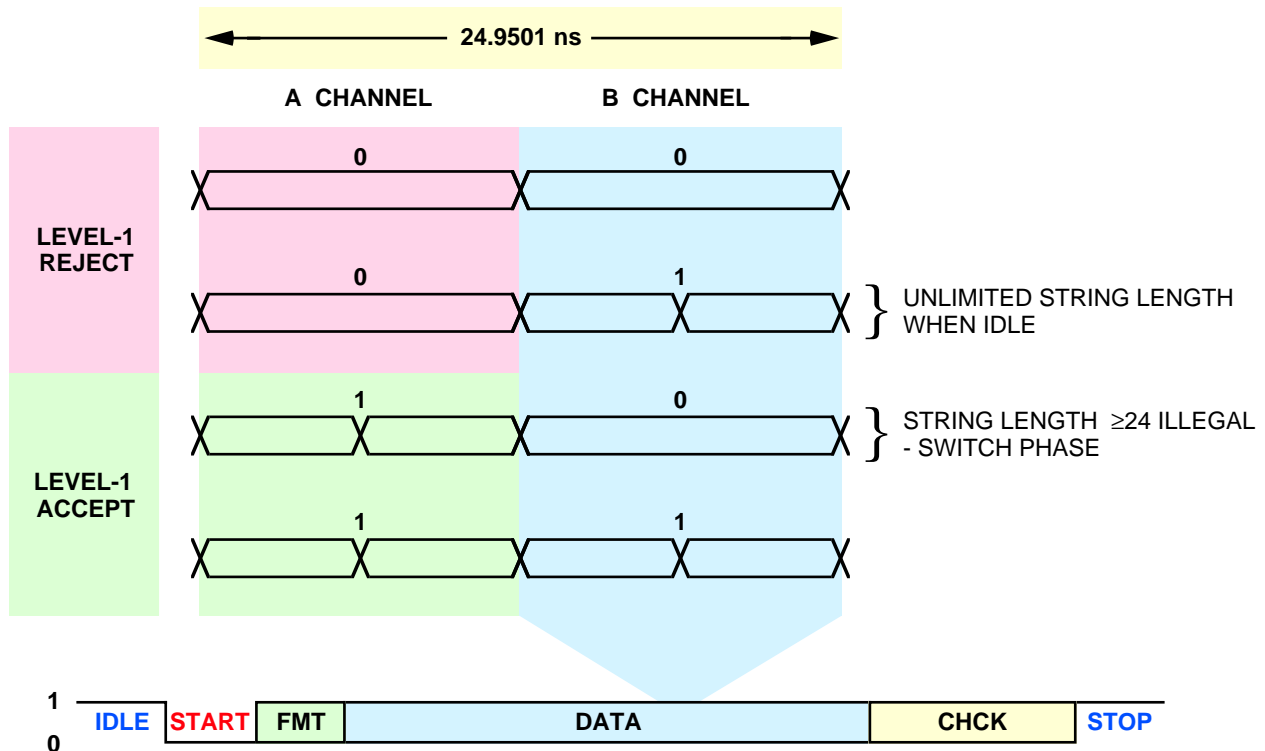
830 nm    1310 nm

LED transmitter (80 nm wide)    640 ps    < 24 ps

Laser transmitter (8 nm wide)    64 ps    < 3 ps

1310 nm tolerates LEDs for small test setups

# TTC encoding and format



## 2 TDM channels

*No deadtime for commands and data*

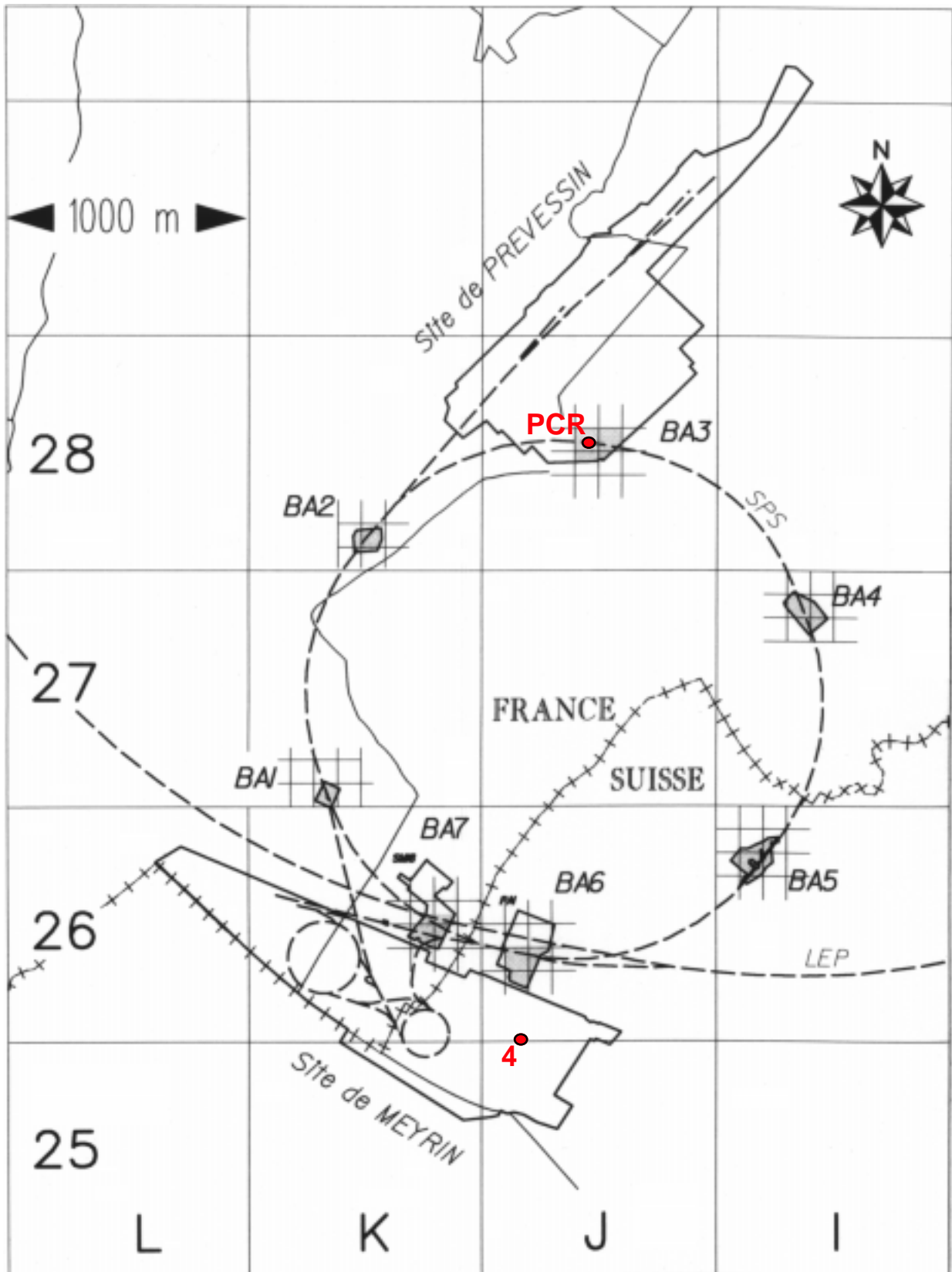
## Biphase mark encoding

*Balanced signalling, phase-stable extracted clock*

## Minimum trigger latency

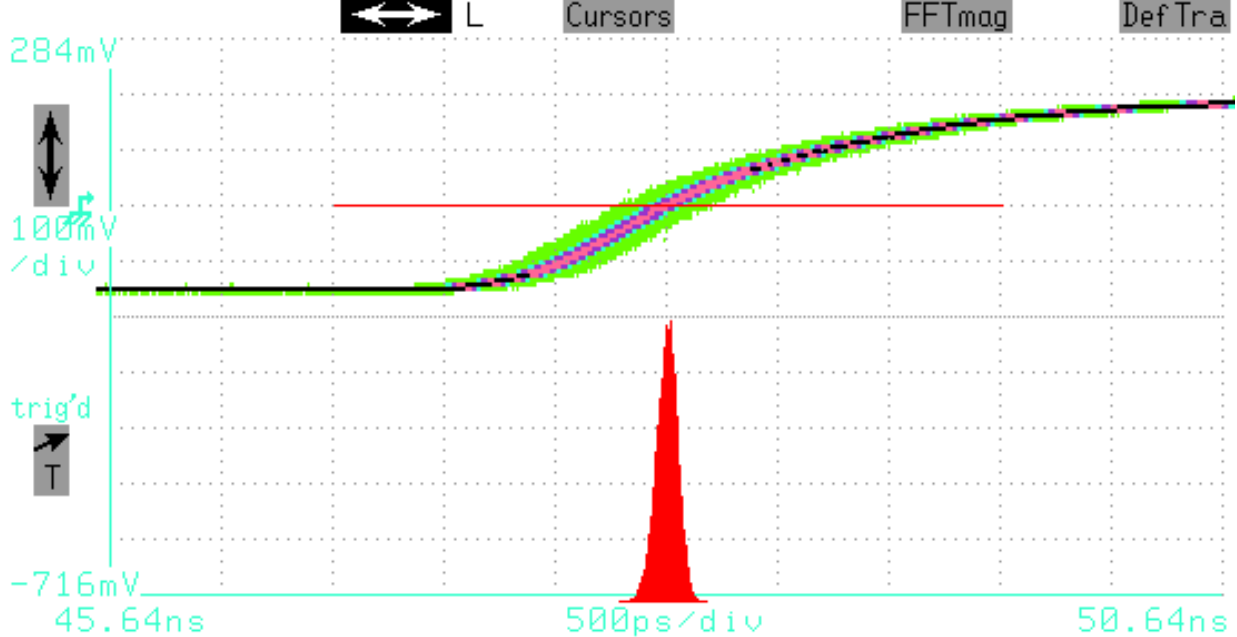
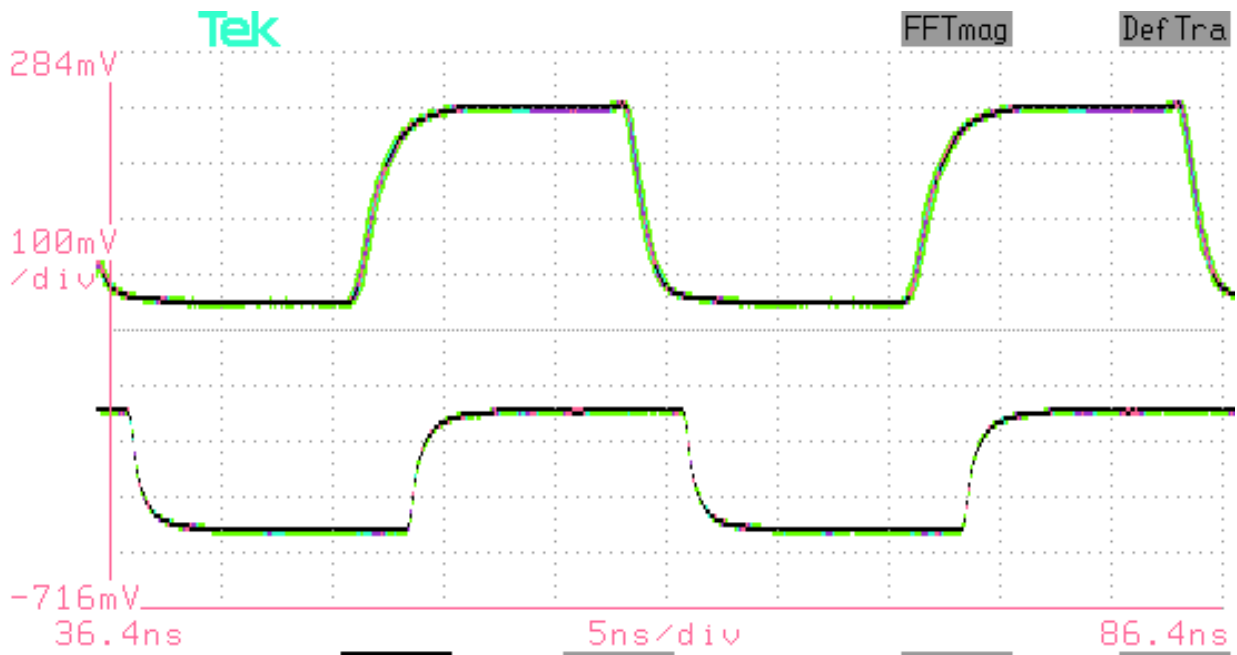
*No control header intercept delay*

# PCR - B4





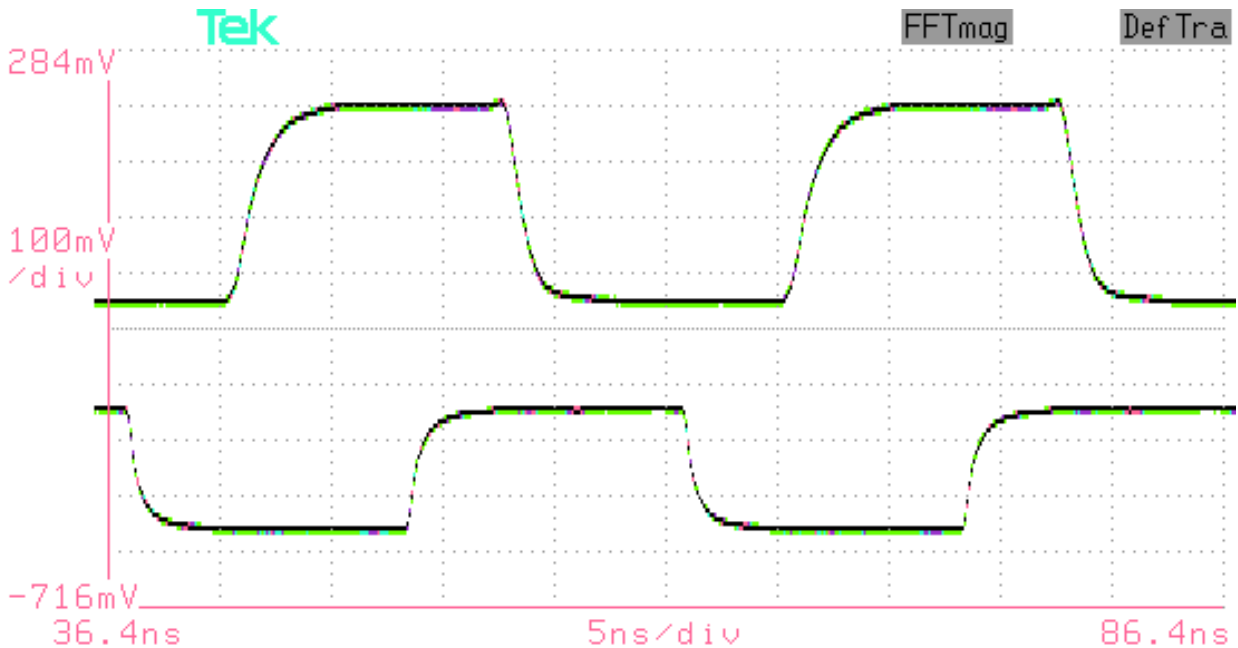
# B4 - PCR - B4 (13 km) 50/125 MMF (Restricted mode launch)



Top	-14mV	Mean	48.14ns	$\mu \pm 1\sigma$	73.49%	Window Size	
Btm	-14mV	RMSΔ	50.45ps	$\mu \pm 2\sigma$	96.021%	500ps/div	
Lft	46.65ns	PkPk	400ps	$\mu \pm 3\sigma$	99.667%	Window Pos	
Rgt	49.65ns	Hits	15003	Wfms	7804	45.58ns	
Persist/	Mask	Color Grad	Standard	Remove/Clr			
Histograms	Testing	Scale	Masks	Trace 1			
Color Grad	Count Off		User Mask	M3			
Continuous				Window			

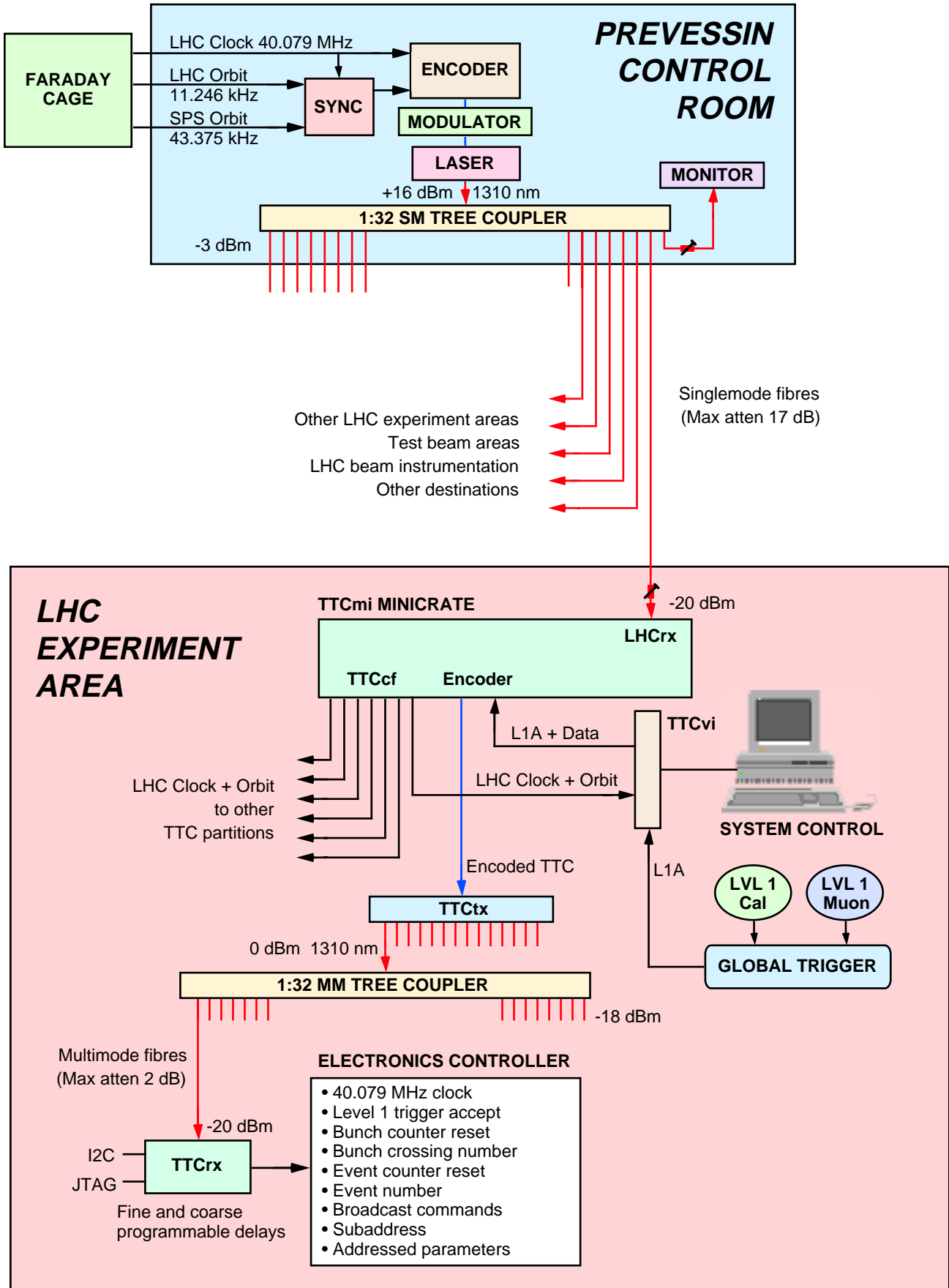
**RML bandwidth > OFL bandwidth**

# B4 - PCR - B4 (13 km) SMF



Top	-14mV	Mean	42.66ns	$\mu\pm 1\sigma$	89.857%	Window Size	500ps/div
Btm	-14mV	RMS $\Delta$	11.28ps	$\mu\pm 2\sigma$	98.882%	Window Pos	40.08ns
Lft	41.15ns	PkPk	90ps	$\mu\pm 3\sigma$	99.96%		
Rgt	44.15ns	Hits	15026	Wfms	7622		
Persist/ Histograms	Mask Testing	Color Grad Scale	Standard Masks	Remove/Clr Trace 1			
Color Grad Continuous	Count Off		User Mask	M3 Window			

# Overall TTC Distribution (from BA3)

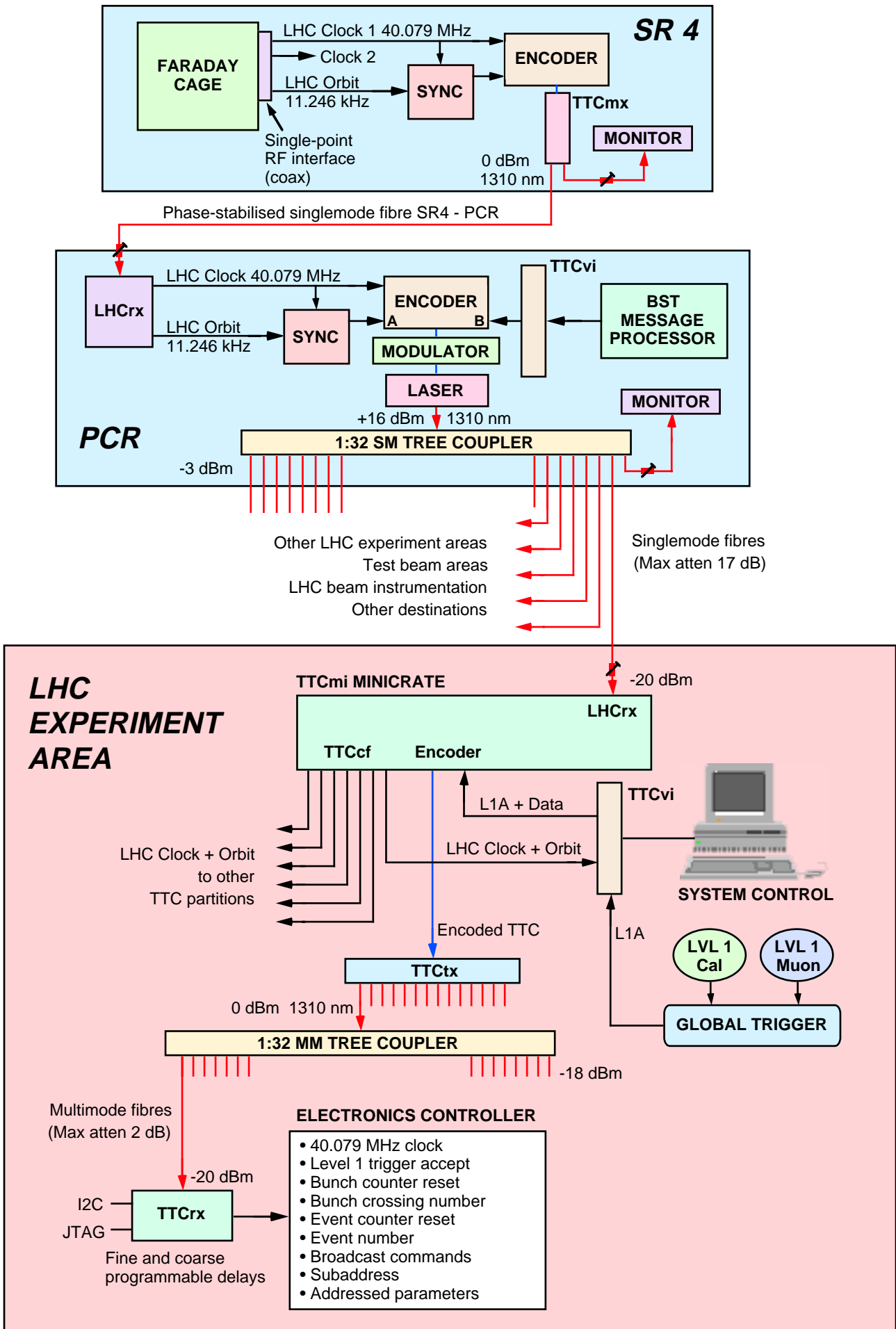


# Optical fibre lengths

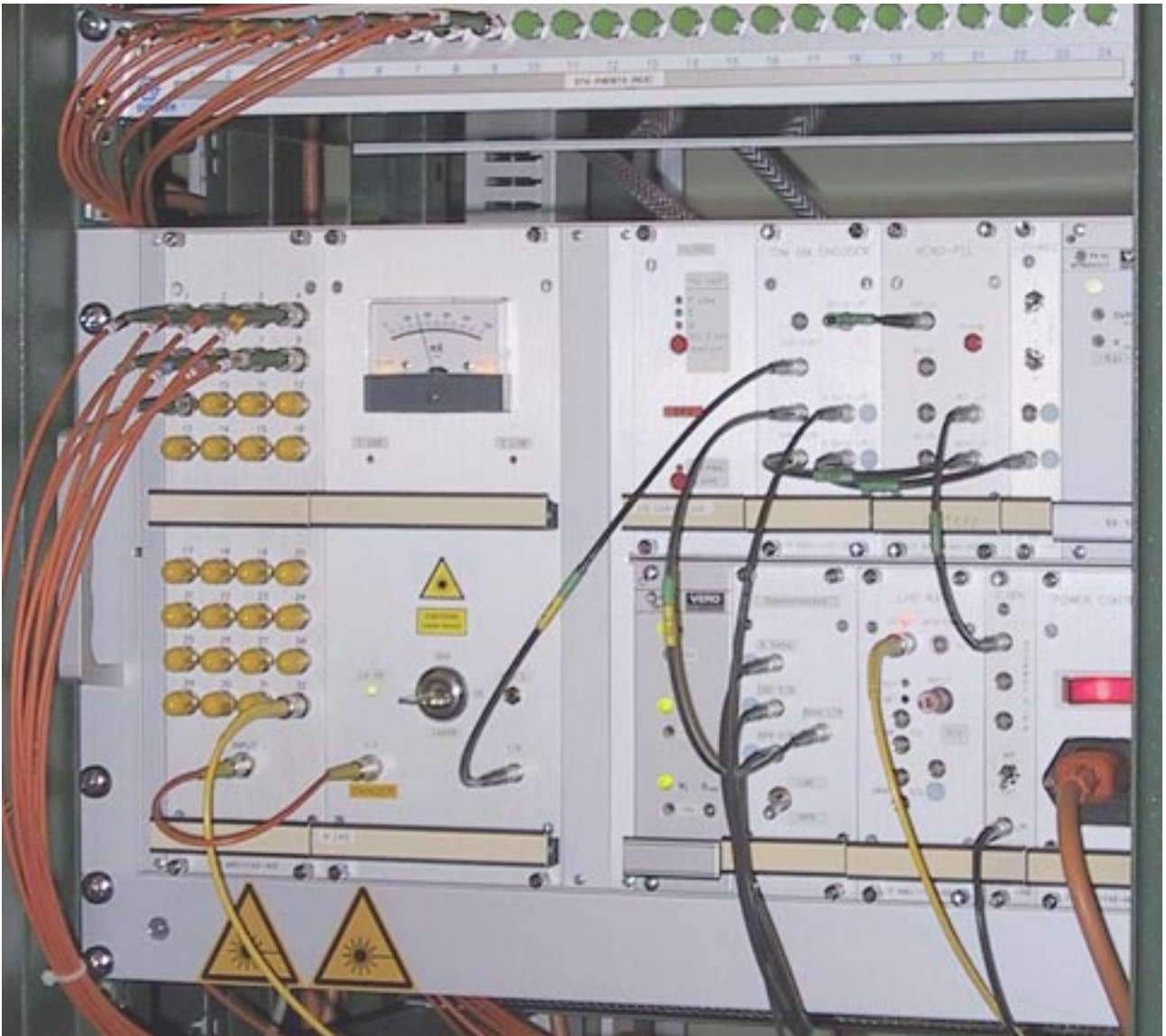


<b>SR4 (RF) – PCR</b>	<b>9.5 km</b>
<b>PCR – SR1 (ATLAS)</b>	<b>3.8 km</b>
<b>PCR – SR2 (ALICE)</b>	<b>5.4 km</b>
<b>PCR – SR5 (CMS)</b>	<b>10.1 km</b>
<b>PCR – SR8 (LHCb)</b>	<b>4.6 km</b>

# Overall TTC Distribution (from SR4)



# *PCR transmitter*



***OL364A-40 1310 nm laser diode (+16 dBm)***

***± 0.1 °C temp control***

***32 (+) singlemode outputs at -3 dBm***

***Receiver/decoder for link from SR4***

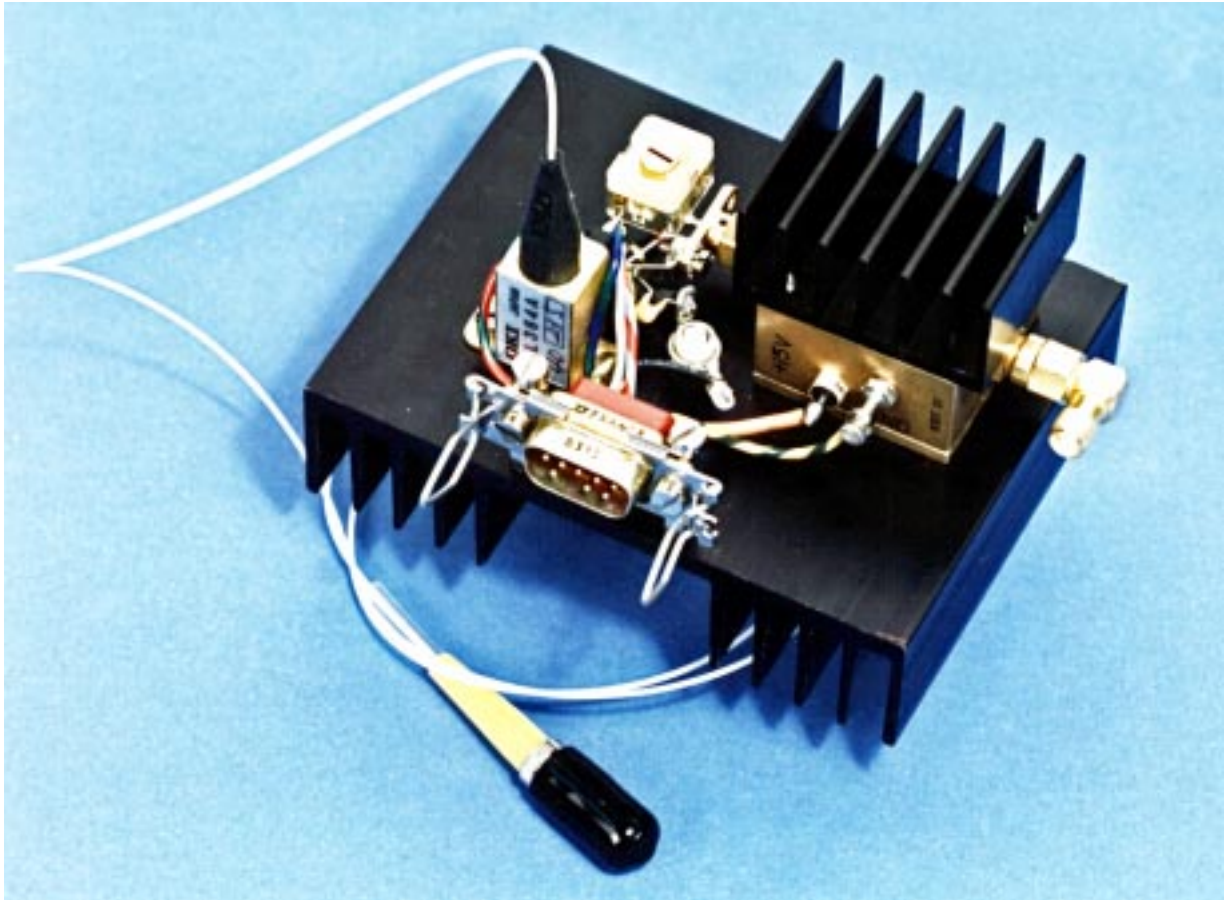
***PLL cleanup of clock***

***Synchronizer for LHC/SPS orbit inputs***

***Local monitor***

***LHC ring 1 + LHC ring 2 + SPS + Spare***

## *Laser head module*



***Singlemode or multimode***

***$\Delta\lambda$  typically 5 nm***

***2.4v 1.2A Peltier cooler***

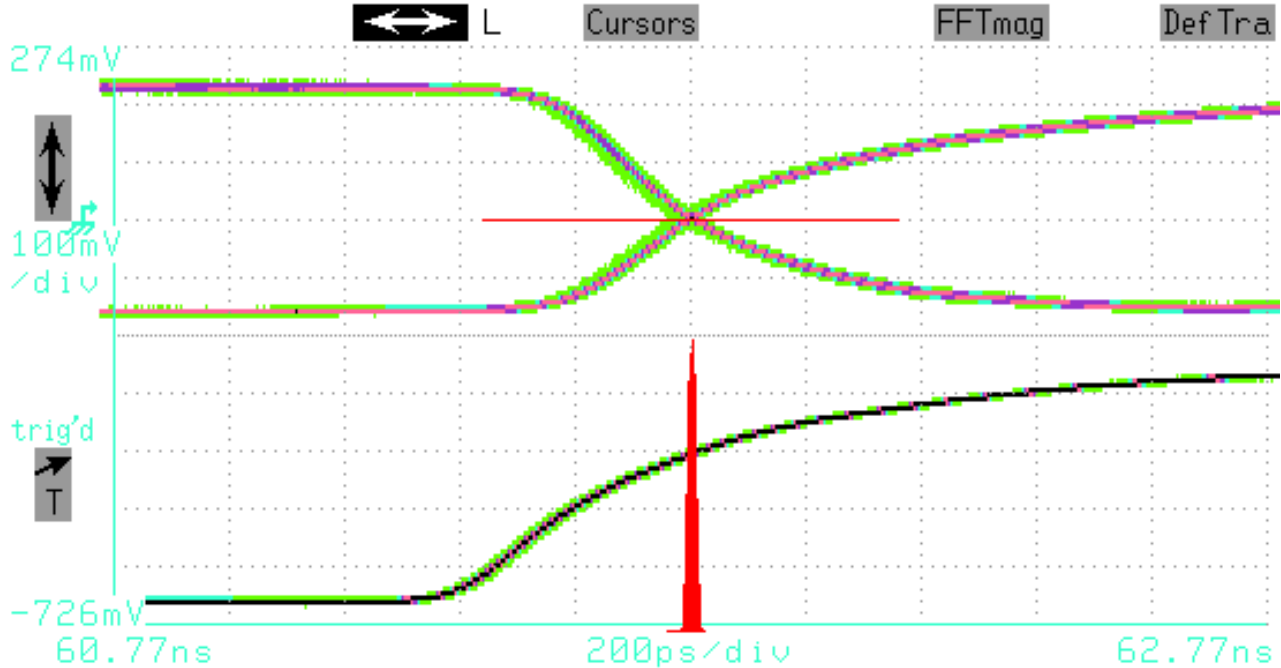
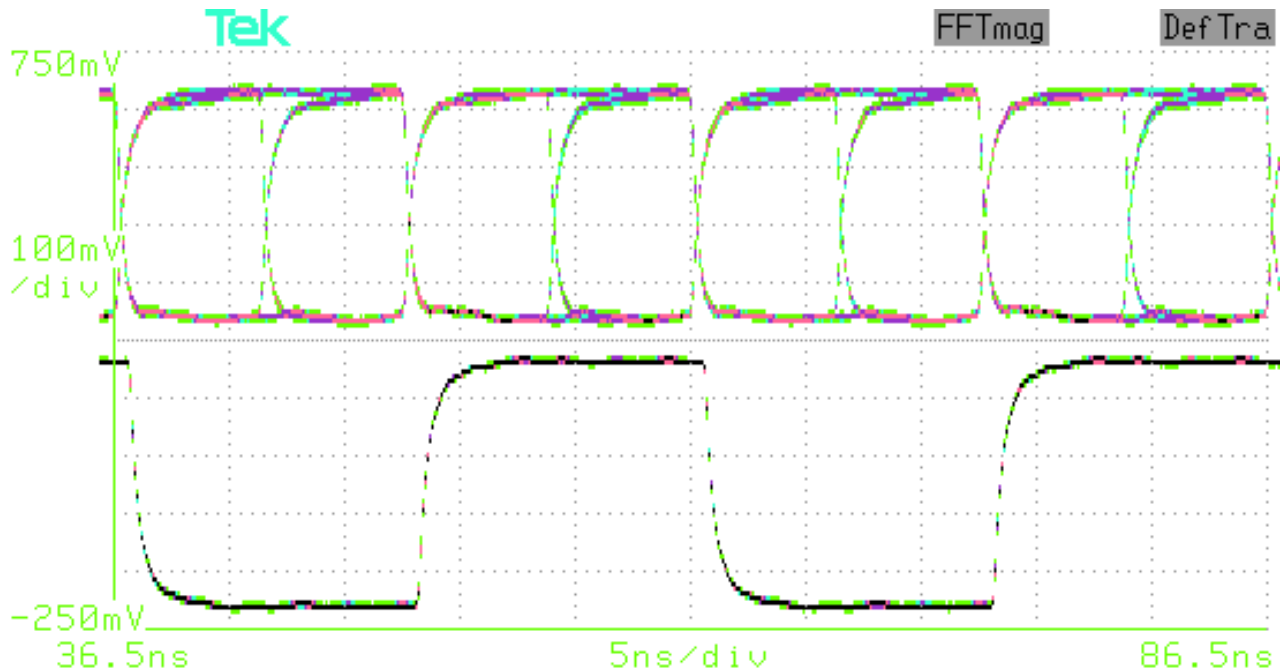
***Integrated thermistor***

***Ferrite bead bias  $T$ ,  $I_b$  160 mA***

***1 GHz 400 mW RF modulator***

***No failures since 1993***

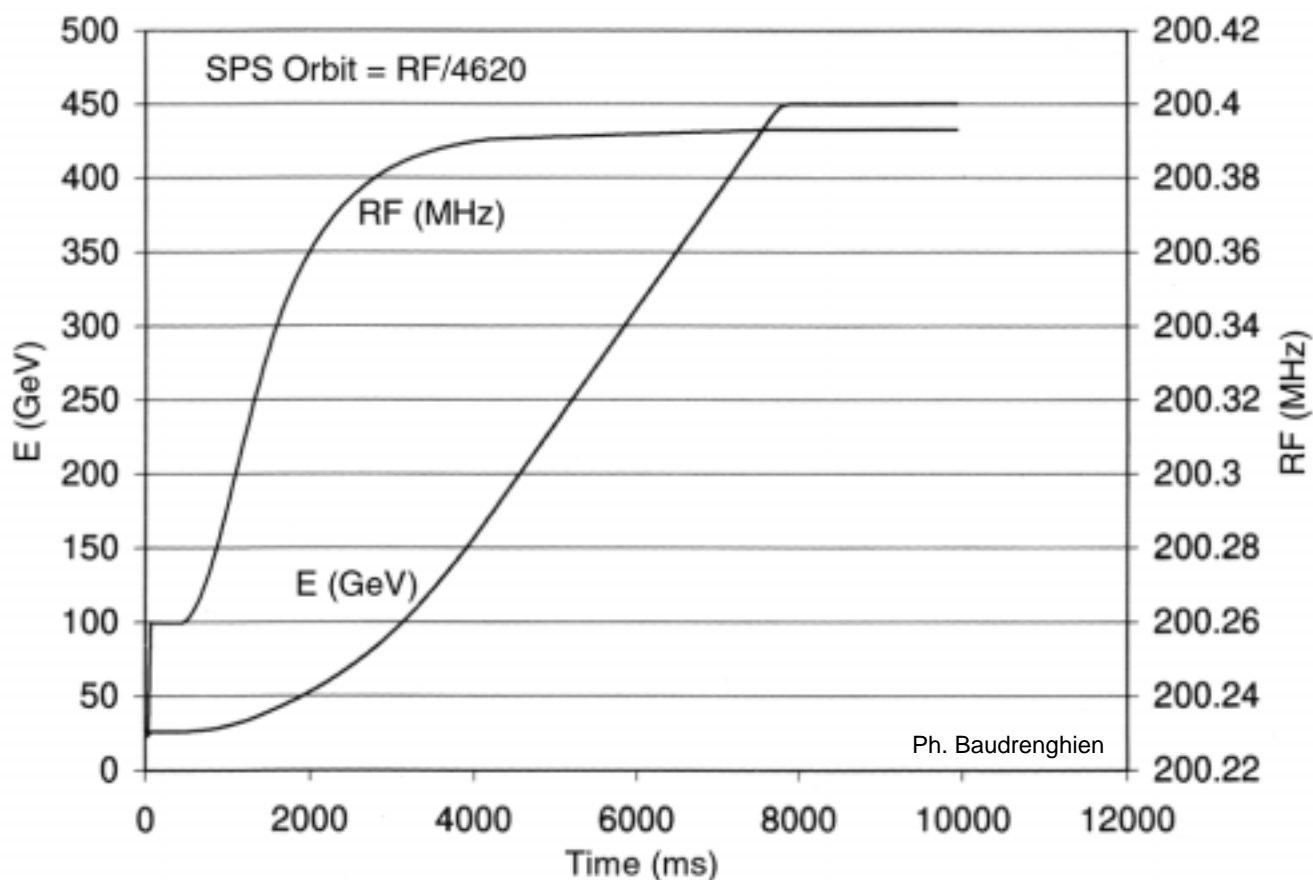
# Primary PLL + 160.32 MBaud TDM BM encoder jitter (PRBS data)



Top	-24mV	Mean	61.78ns	$\mu\pm 1\sigma$	83.253%	Window Size	200ps/div
Btm	-24mV	RMSΔ	6.992ps	$\mu\pm 2\sigma$	95.776%	Window Pos	60.75082ns
Lft	61.41ns	PkPk	68ps	$\mu\pm 3\sigma$	99.962%		
Rgt	62.13ns	Hits	84040	Wfms	53935		
Persist/ Histograms	Mask Testing	Color Grad Scale	Standard Masks	Remove/Clr Trace 1	M3	Window	
Color Grad Continuous	Count Off		User Mask				



## *LHC-structured test beams*



***Constant 40.079 MHz bunch clock***

***SPS rephased before extraction***

***- as for LHC injection***

***"Real" 43 kHz SPS orbit signal***

***- swings 29 Hz during acceleration***

***Synchronizer quantizes in 25 ns steps***

***No metastable glitches***

# **Clock holes**

## **SPS test beams**

***Constant frequency clock to experiments***

***SPS rephased to this clock before each spill***

***No clock holes if RF divider reset disabled***

## **SPS as injector**

***Sync SPS to required LHC injection phase***

***1 ms hole in SPS RF/5 and SPS Orbit signals***

***Occurs before each CPS -> SPS transfer***

## **LHC**

***Timing reset prior to each fill/ramp/collide run***

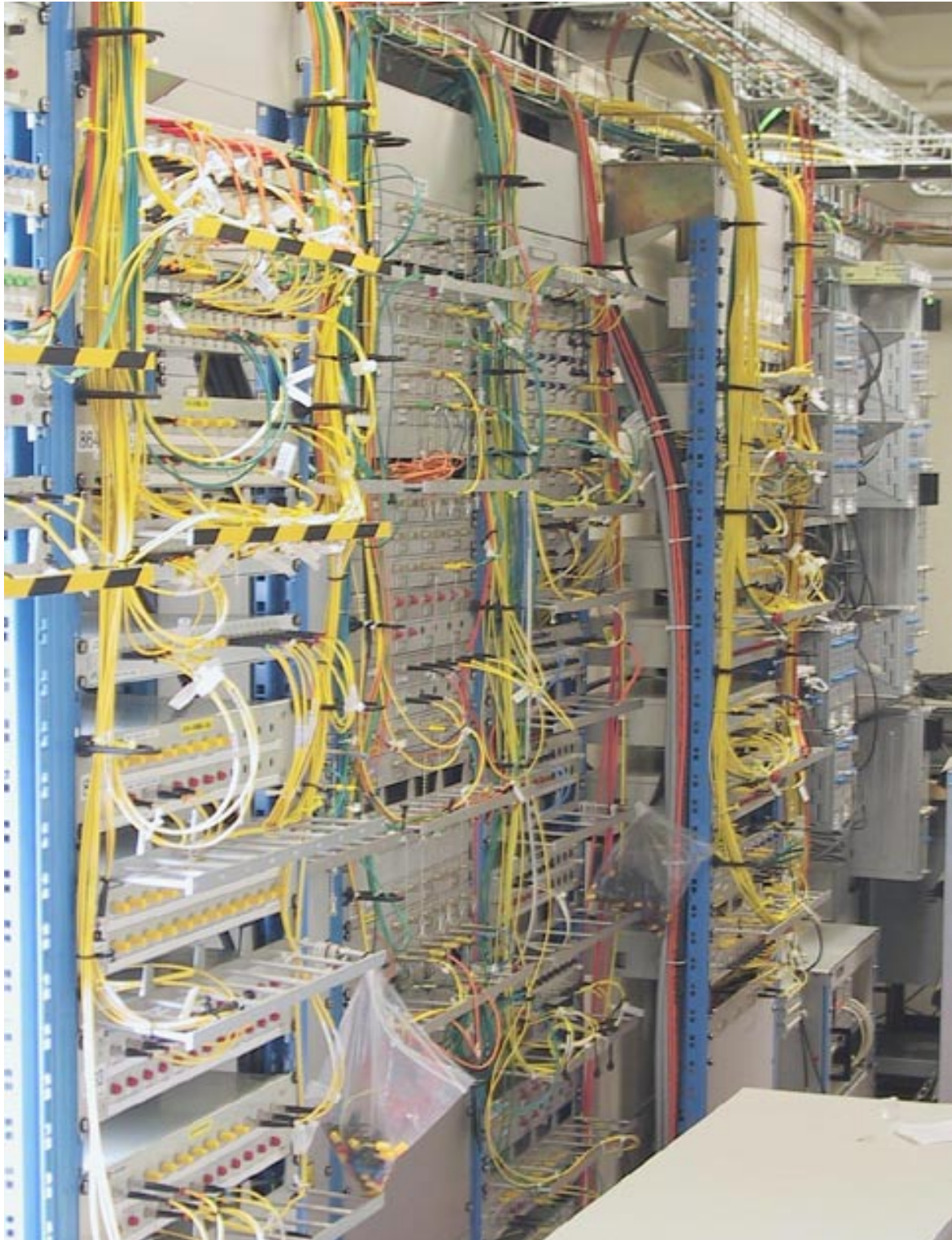
***1 ms hole in 40.08 MHz and LHC Orbit signals***

***Occurs only before 1st SPS -> LHC transfer***

**SPS and LHC TTC systems will fill 40.08 MHz holes**

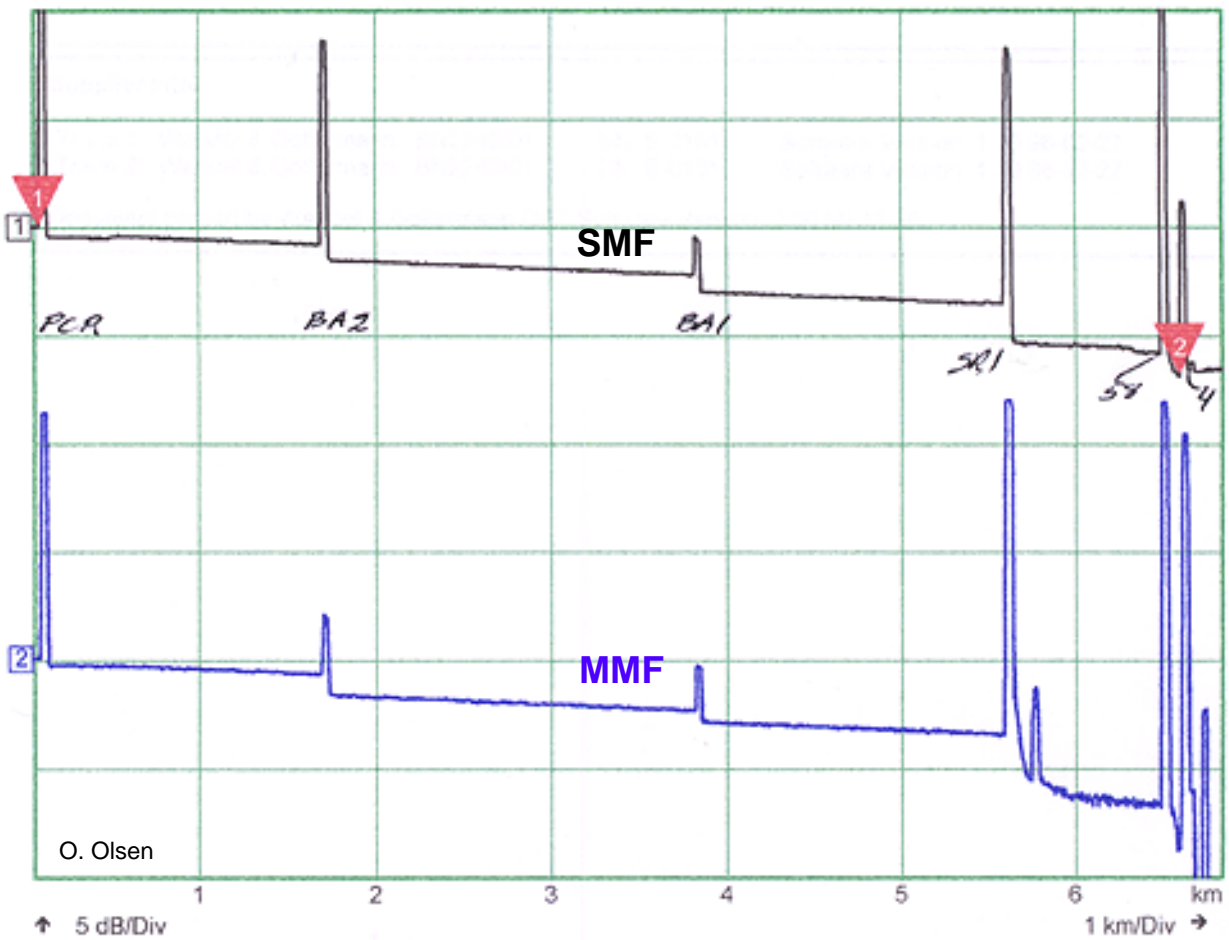
***- but possible phase perturbation on resync***

## *PCR optical patchpanel*



# Optical distribution fibres

## PCR - B4



# TTC machine interface (TTCmi) crates

```

110 CERN SL
SPS-Protons updated: 22-05-00 17:49:29
CYCLE Type 529: 450 GeV/c
Flat top: 2010 ms length: 14.4 s
RATE#E11:
37 17.2 15.9
CPS RAMP SSE
to beam dump: 1.3
Targ p/pE11 Mul %Sym Expmt Singles Spill
T1 3.9 9 a 52 CMS 2.6E+03 0
LHCb 4.3E+02 0
T2 4.1 9 a 78 NA59 0.0E+00 0
CMS 6.5E+02 0
T4 6.5 9 a 87 ATLAS 0.0E+00 0
T6 0.1 13 0 NA58 0.0E+00 0
T10 0.0 none 0.0E+00 0
Comments 22-05-00 14:47h :
EA:CRN operator: 75566 / 160137

```

## ALICE

Lab  
1 TTCmi

H4 (North area)  
HF (+ ECAL)  
1 TTCmi

## ATLAS

H8 (North area)  
SCT (+ Pixels + TRT)  
1 TTCmi

## LHCb

X7 (West area)  
Calorimeter (+ Vertex)  
1 TTCmi

## CMS

X5 (West area)  
Tracker  
Upgraded minicrate  
H2 (North area)  
Muon-RPC (+ HCAL)  
1 TTCmi

## RD12

Lab (Meyrin)  
1 TTCmi

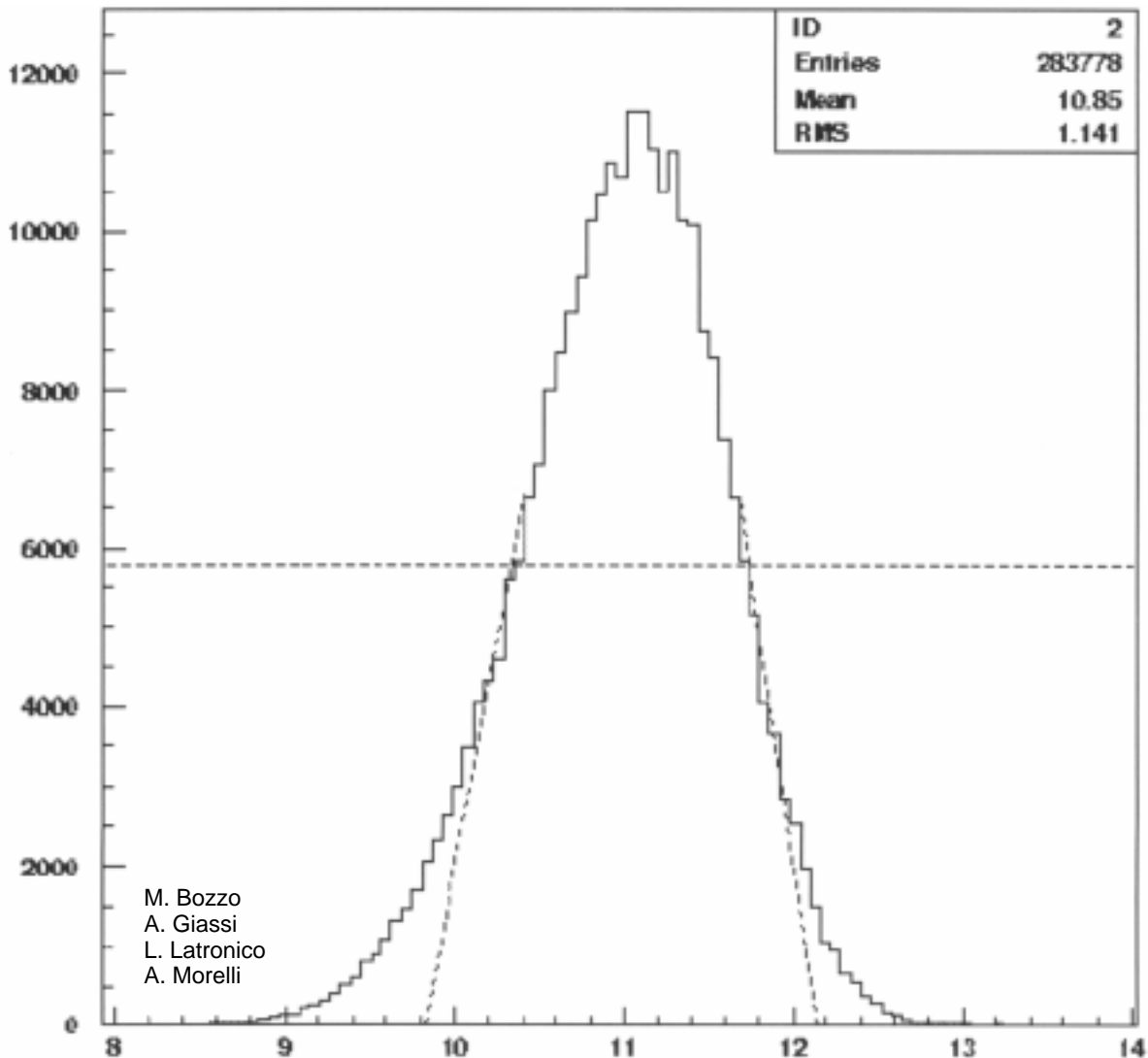
## SL/BI

Lab (Prevessin)  
2 reduced TTCmi

## ESS

Lab (Meyrin)  
1 reduced TTCmi

## *X5 test beam monitor*



00/05/25 11.49

***Muon arrival time w.r.t. TTCmi bunch clock***

***~10<sup>4</sup>  $\mu$ /spill (2 s spill)***

***Expected bunch length 2.5 ns***

***Measured 2.3 ns***

## ***TTC machine interface (TTCmi)***



***Standardised TTC interface to LHC machine***

***Distribution to multiple trigger partitions***

***PLL cleanup of recovered 40.08 MHz clock***

***Orbit phase correction***

***Local clock generator and monitor Rx***

***Encoder for first partition***

***Electrical and/or optical outputs***

***Easy upgrade from old transmitter minicrates***

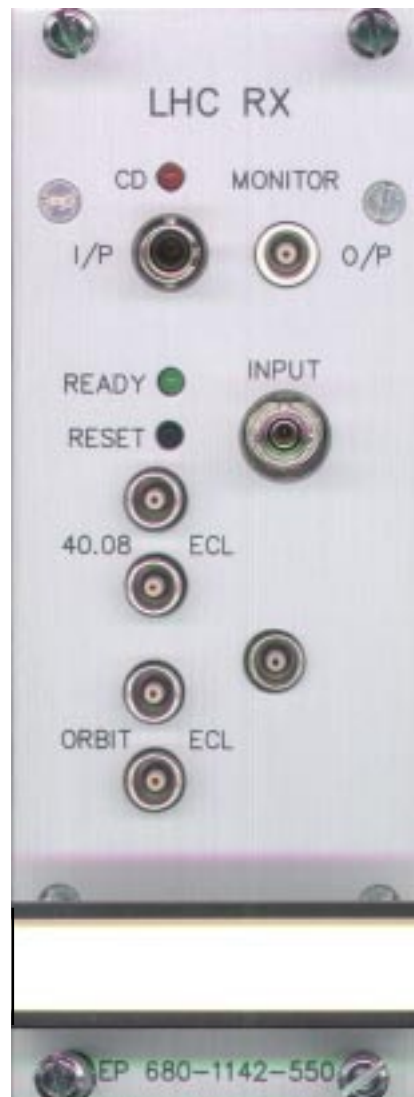
***10 produced (May 2001)***

***User Manual on TTC website***





# *LHC Receiver (LHCrx)*



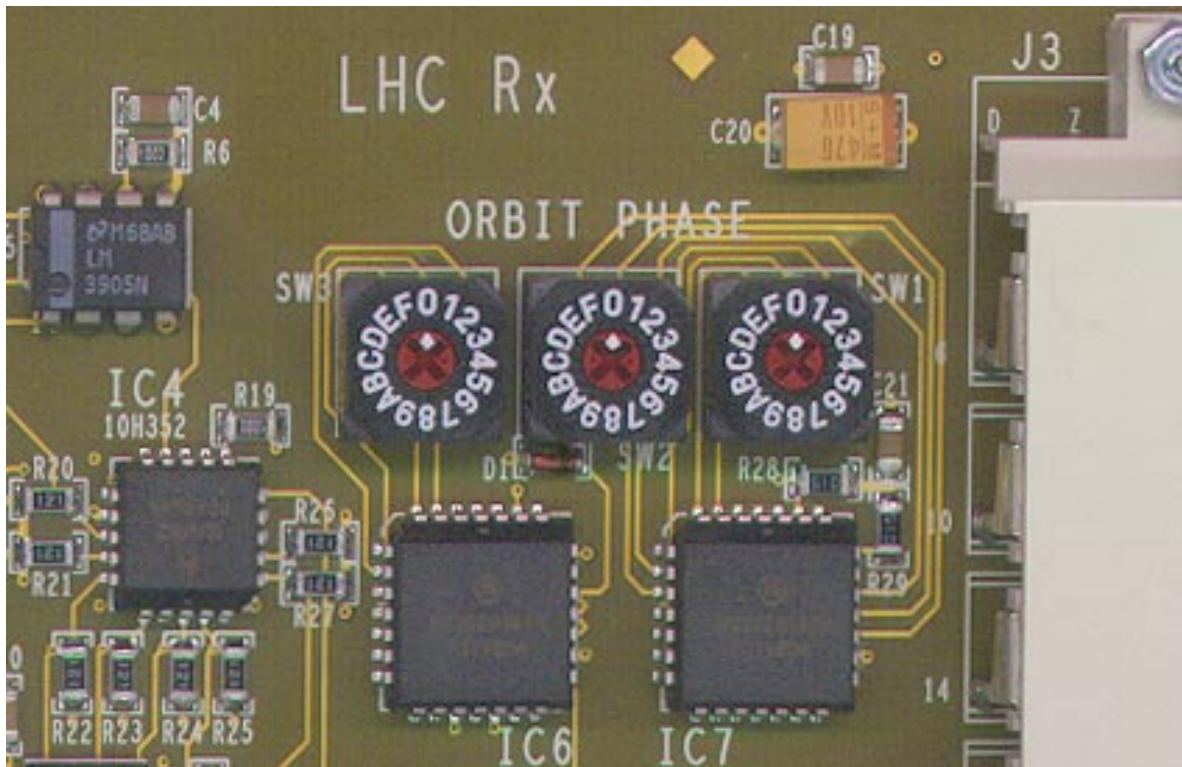
***Receives optical timing signals:***  
***from SR4 at PCR***  
***from PCR at LHC experiments and testbeams***

***Global orbit phase adjust 25 ns x 3564***

***Monitor function***

***16 being upgraded with TTCrx 3.2 ASICs***

## *Orbit phase adjustment*



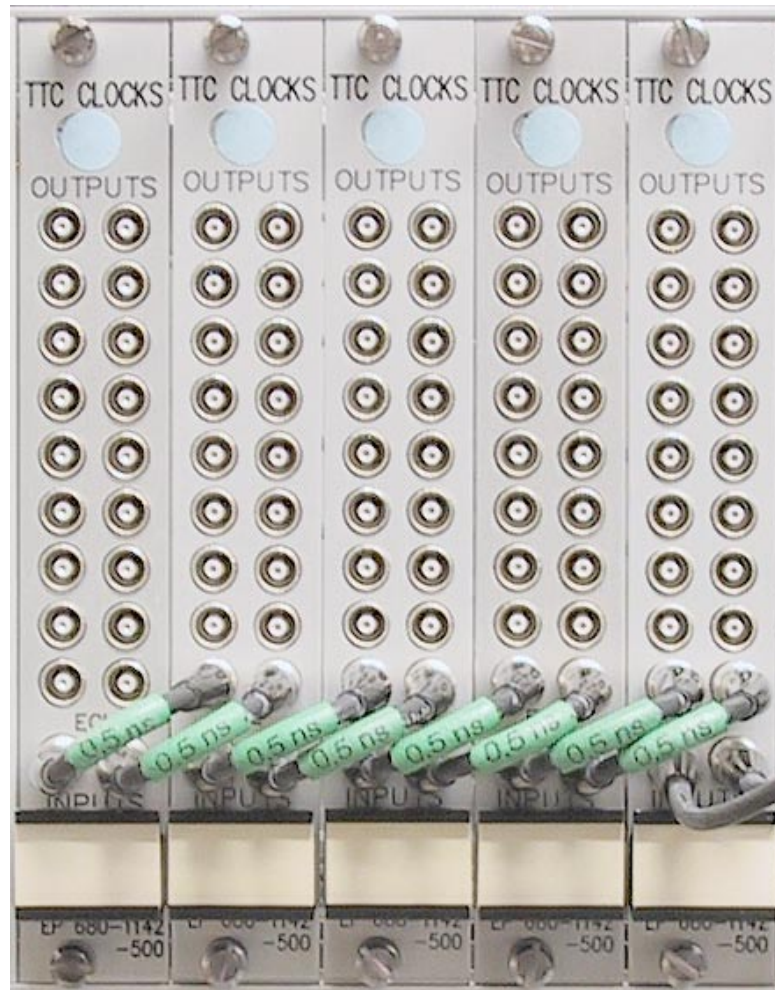
***Digital adjuster driven by 40.079 MHz clock***

***SW1      25 ns steps***

***SW2      16x25 = 400 ns steps***

***SW3      16x0.4 = 6.4  $\mu$ s steps***

## *TTC clocks fanout (TTCcf)*



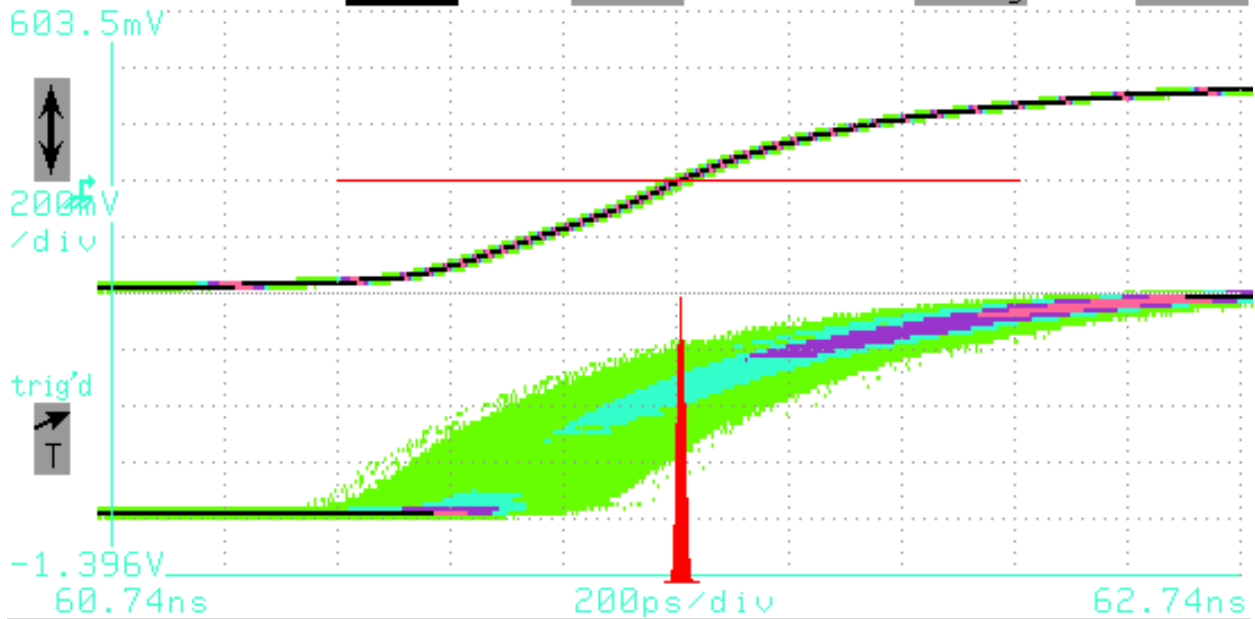
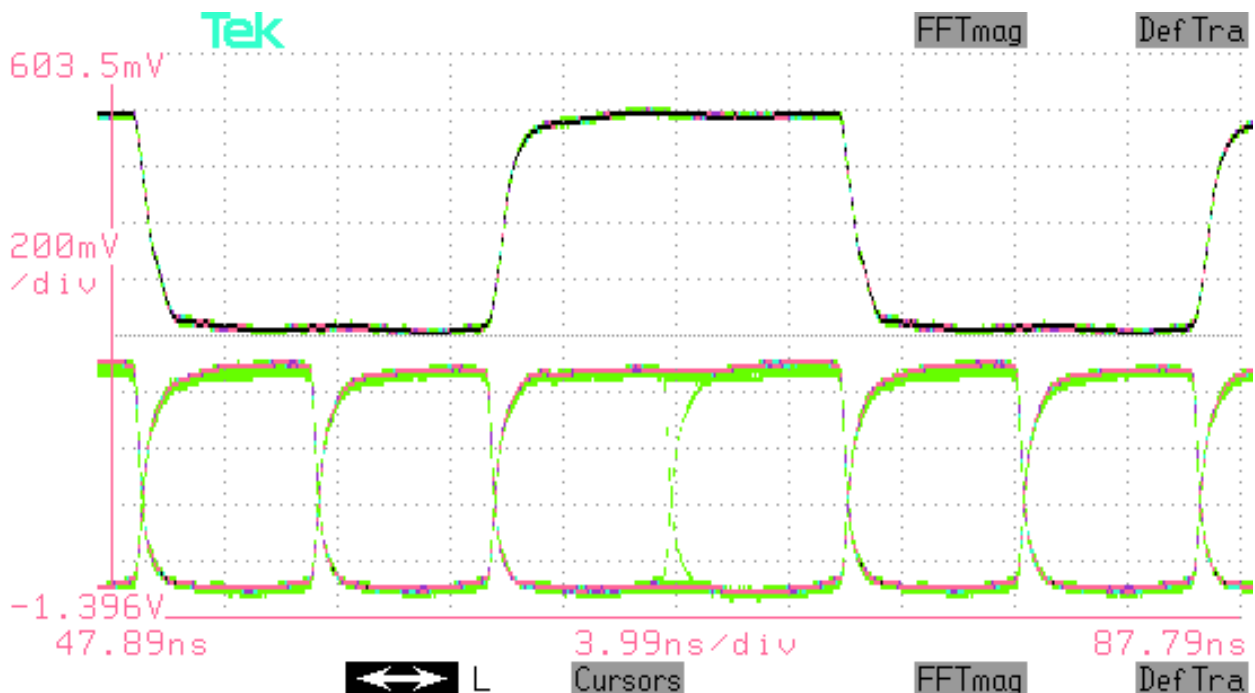
*Low-jitter ECL bunch and orbit clocks*

*Coax fanout to TTCex and TTCvi modules*

*Up to 2 x 40 outputs per TTCmi*

*28 produced*

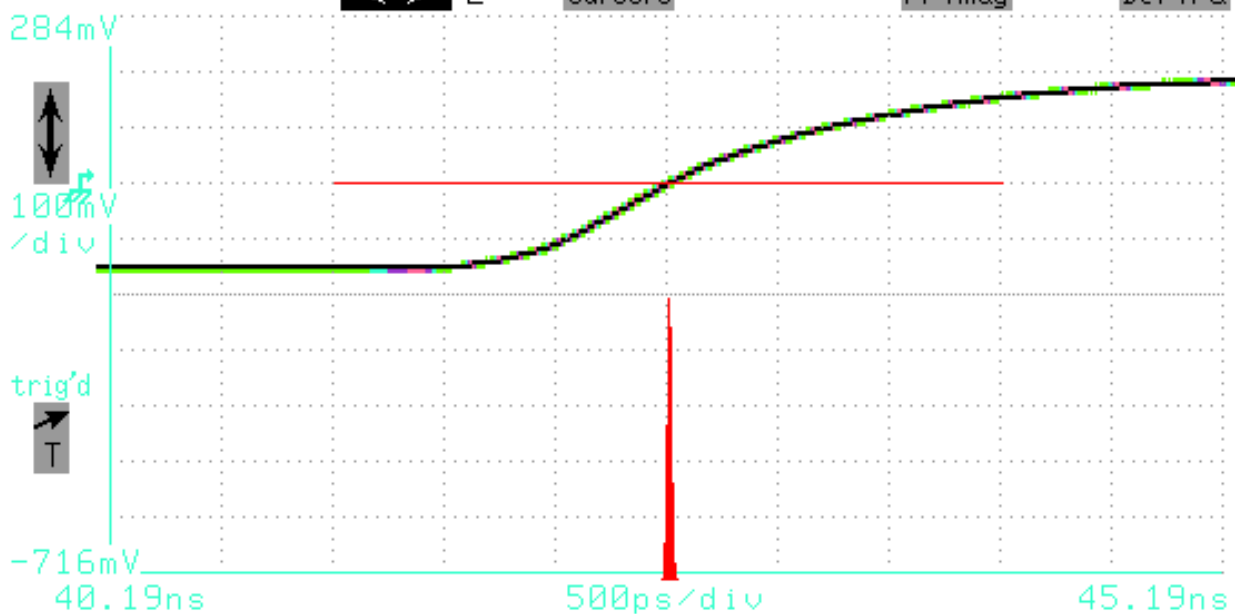
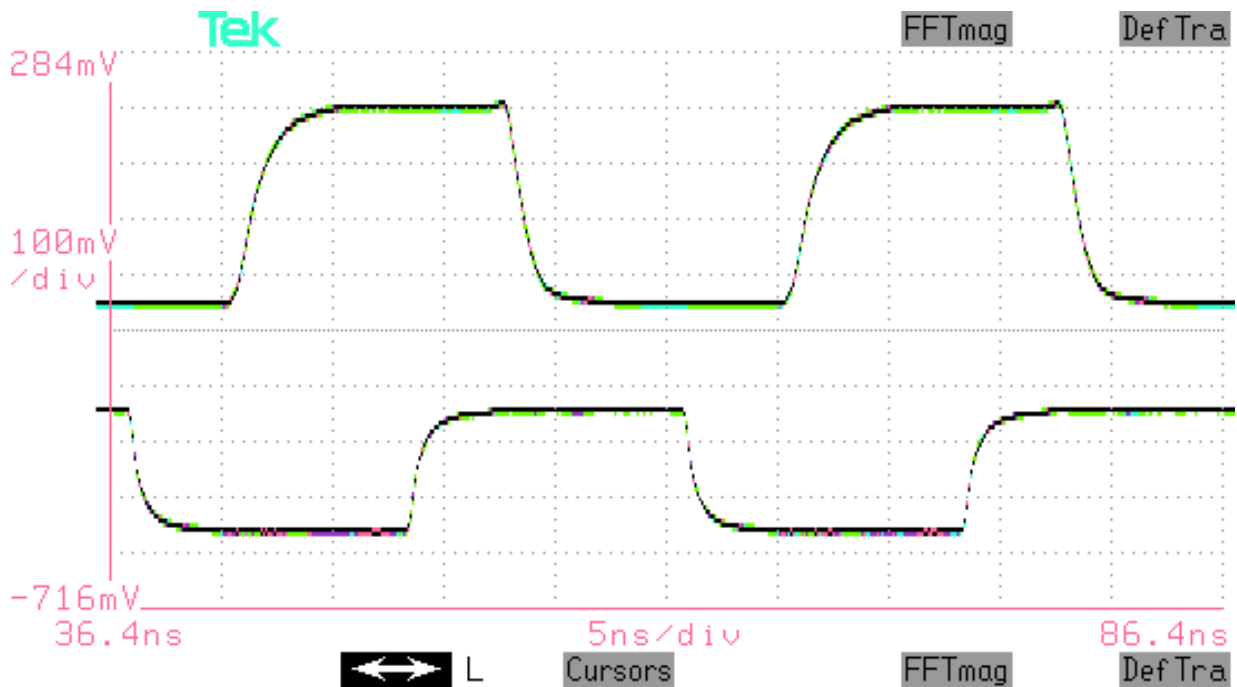
# TTCmi performance (13 km)



Top	7.5mV	Mean	61.75ns	$\mu \pm 1\sigma$	71.143%	Window Size	
Btm	7.5mV	RMS $\Delta$	7.049ps	$\mu \pm 2\sigma$	97.218%	200ps/div	
Lft	61.14ns	PkPk	64ps	$\mu \pm 3\sigma$	99.951%	Window Pos	
Rgt	62.35ns	Hits	113777	Wfms	49781	60.7202ns	
Persist/ Histograms	Mask Testing	Color Grad Scale	Standard Masks	Remove/Clr Trace 1			
Continuous	Count Off		User Mask	M3 Window			

# B4 - PCR - B4 (13 km) SMF

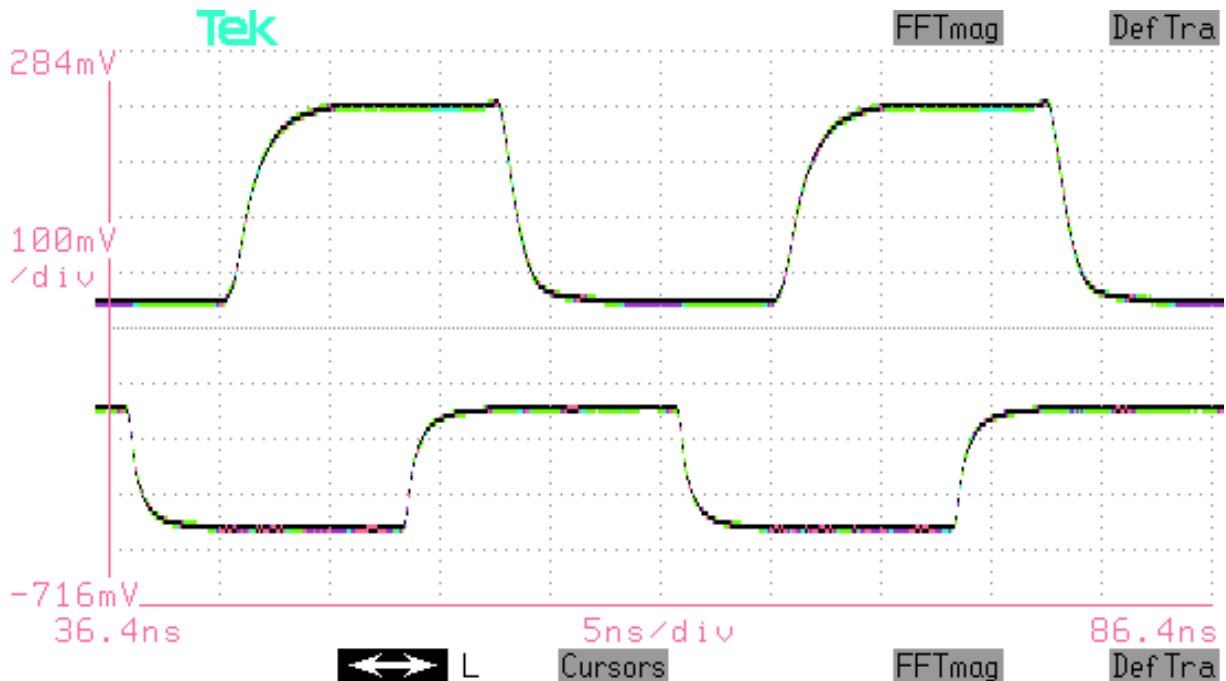
## Phase stability Time 0



Top	-14mV	Mean	42.7ns	$\mu \pm 1\sigma$	81.405%	Window Size	
Btm	-14mV	RMS $\Delta$	11.19ps	$\mu \pm 2\sigma$	97.572%	500ps/div	
Lft	41.2ns	PkPk	80ps	$\mu \pm 3\sigma$	99.901%	Window Pos	
Rgt	44.2ns	Hits	5068	Wfms	2585	40.13ns	
Persist/ Histograms	Mask Testing	Color Grad Scale	Standard Masks	Remove/Clr Trace 1			
Color Grad Continuous	Count Off		User Mask	M3 Window			

# B4 - PCR - B4 (13 km) SMF

## Phase stability Time 0 + 112h



Top	-14mV	Mean	42.61ns	$\mu\pm 1\sigma$	71.132%	Window Size
Btm	-14mV	RMSΔ	10.34ps	$\mu\pm 2\sigma$	99.561%	500ps/div
Lft	41.2ns	PkPk	80ps	$\mu\pm 3\sigma$	99.98%	Window Pos
Rgt	44.2ns	Hits	5009	Wfms	2627	40.13ns
Persist/ Histograms	Mask Testing	Color Grad Scale	Standard Masks	Remove/Cln Trace 1		
Color Grad Continuous	Count Off		User Mask	M3 Window		

# ***Phase stability of fibres***

## ***PCR – B4***

***6.5 km normal singlemode fibre***

***50 ps diurnal***

## ***PCR – PS***

***4.6 km normal singlemode fibre***

***50 ps diurnal + 50 ps seasonal***

***<1998 with 269m on surface: 150 ps***

## ***PCR – SR4***

***9.5 km normal singlemode fibre***

***8 ns seasonal***

## ***PCR – SR4***

***9.5 km temperature stabilised singlemode fibre***

***320 ps seasonal***

***Starting diurnal tests***

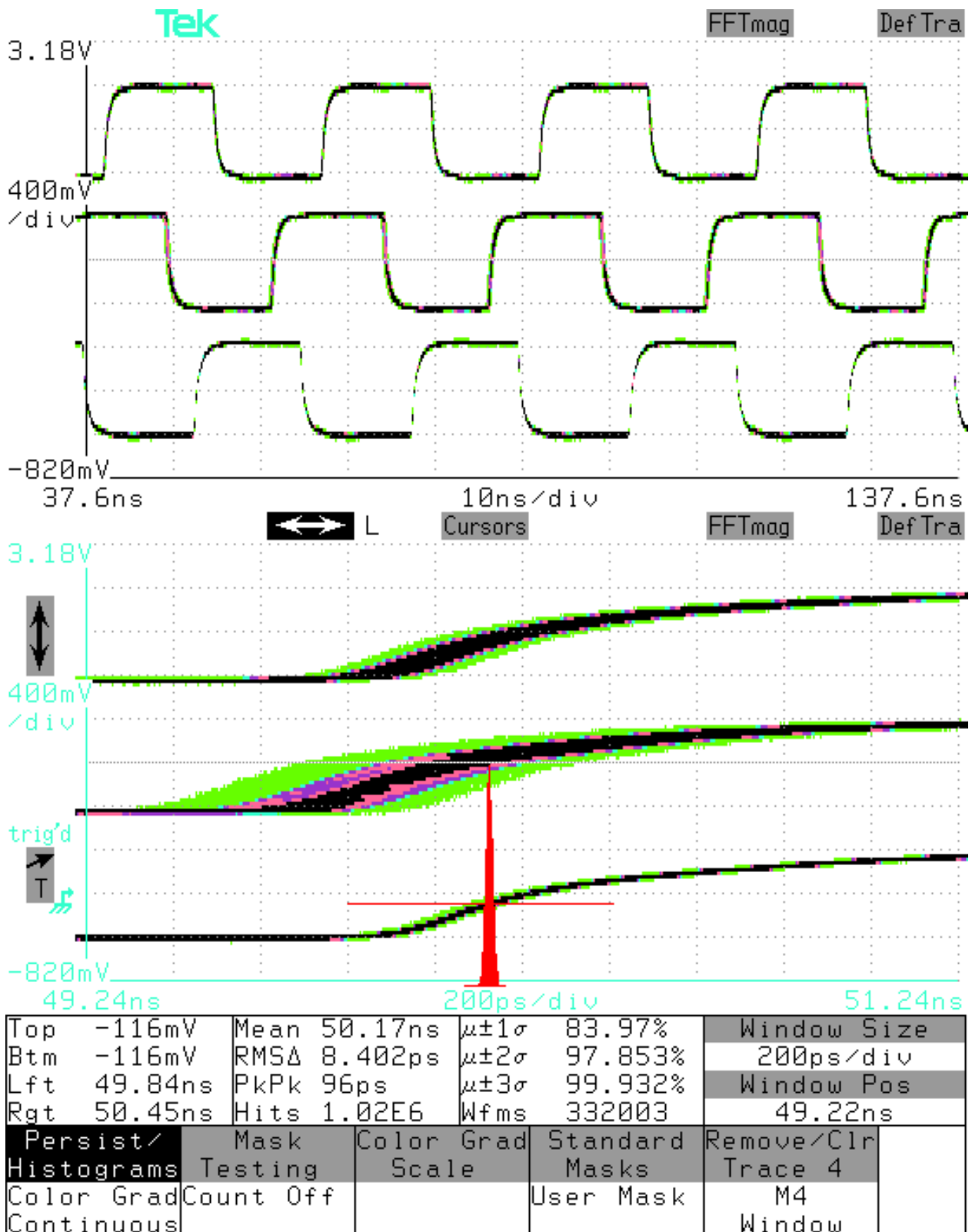
***Seasonal variation - slow compensation***

***Diurnal variation - few fine deskew steps***

***Installation depth ~ 1m***

***Each PCR – LHC experiment link will be tested***

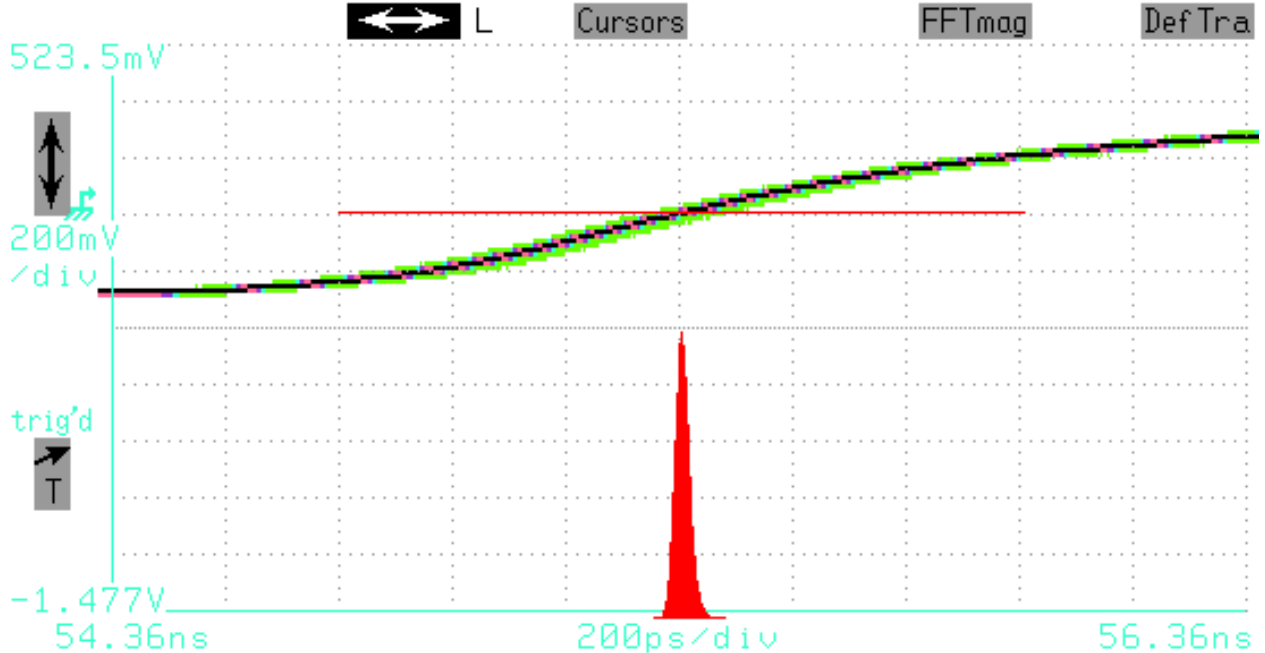
# PLL stability check - independent clock link



**Zero phase slips in testing for several days**



# Bunch clock distribution



Top	-68.5mV	Mean	55.37ns	$\mu\pm 1\sigma$	76.079%	Window Size	200ps/div
Btm	-68.5mV	RMSΔ	13.99ps	$\mu\pm 2\sigma$	96.068%	Window Pos	54.34ns
Lft	54.76ns	PkPk	128ps	$\mu\pm 3\sigma$	99.151%		
Rgt	55.97ns	Hits	136505	Wfms	32000		
Persist/ Histograms	Mask Testing	Color Grad Scale	Standard Masks	Remove/Clr Trace 1			
Color Grad Continuous	Count Off		User Mask	M3 Window			

# ***TTC VMEbus interface (TTCvi)***

<b><i>Clock selector</i></b>	<b><i>External or internal</i></b>
<b><i>Orbit selector</i></b>	<b><i>External or Clock/3564</i></b>
<b><i>Trigger selector</i></b>	<b><i>External triggers</i></b> <b><i>VME trigger</i></b> <b><i>Random trigger generator</i></b> <b><i>Calibration trigger</i></b>
<b><i>Commands/data</i></b>	<b><i>Broadcast or individually addressed</i></b> <b><i>Short or long format</i></b>
<b><i>Async cmnds/data</i></b>	<b><i>On VME write or external signals</i></b> <b><i>On L1A: Trigger type from CTP +</i></b> <b><i>Event/Orbit No. from 24-bit counter</i></b>
<b><i>Sync commands</i></b>	<b><i>4 chans with priority arbitration</i></b> <b><i>External or VME B-Go</i></b> <b><i>Prog inhibit delay and duration</i></b> <b><i>256 FIFO per channel</i></b> <b><i>Single/sequence/repetitive (BCR)</i></b> <b><i>Burst mode for BI use</i></b>

***User manual on TTC website***

## ***TTC VMEbus interface (TTCvi)***



***Only one failure***

***Questionnaire to 60 users - 10 replies***

***Internal orbit divisor corrected***

***Upgraded to Mk II + BI mods***

***80 produced at CERN***

***Market survey - 19 (12) replies***

# ***TTC laser transmitter (TTCtx)***



***Compact module for experiments***

***1 or 2 partitions per module***

***Configurable 32 to 448 destinations***

***Daisy chain expansion***

***Temp-compensated bias/modulation***

***Rear facet automatic power control***

***SYSFAIL interlock***

***Standard (+5v) VMEbus power***

***User manual on TTC website***

***Per crate -***

***8960 destinations***

***1 to 40 partitions***

# ***TTC laser encoder/transmitter (TTCex)***



***Dual encoders***

***Common VCXO/PLL***

***1 or 2 partitions per module***

***Configurable 32 to 320 destinations***

***Expansion by TTCtx modules***

***Temp-compensated bias/modulation***

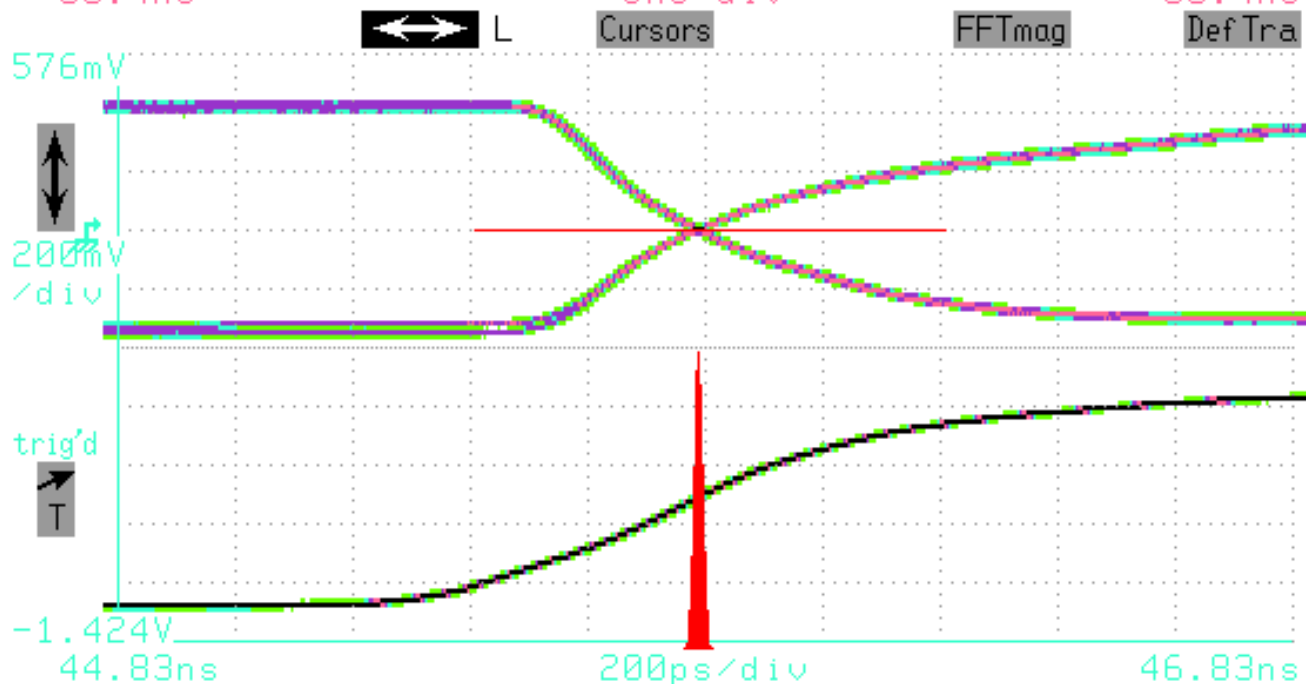
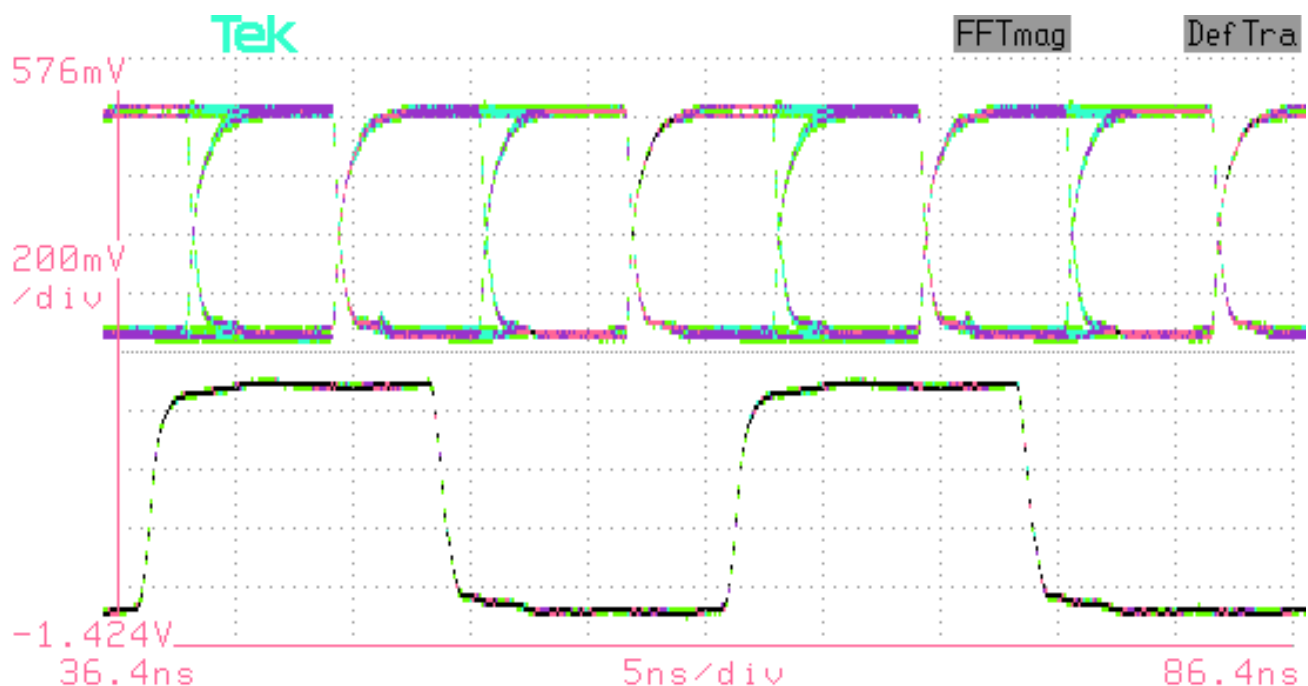
***Rear facet automatic power control***

***SYSFAIL interlock***

***Standard ( $\pm 12v$ ,  $+5v$ ) VMEbus power***

***User manual on TTC website***

# TTCex encoder jitter (PRBS data)



Top	-20mV	Mean	45.82ns	$\mu\pm 1\sigma$	68.278%	Window Size
Btm	-20mV	RMS $\Delta$	7.631ps	$\mu\pm 2\sigma$	96.273%	200ps/div
Lft	45.44ns	PkPk	52ps	$\mu\pm 3\sigma$	99.972%	Window Pos
Rgt	46.24ns	Hits	10759	Wfms	5044	44.81ns
Persist/ Histograms	Mask Testing	Color Grad Scale	Standard Masks	Remove/Clr Trace 1		
Continuous	Count Off		User Mask	M1 Window		

## ***TTC laser mini-transmitter (TTCmx)***



***Laser output for TTCmi or repeaters***

***Configurable 32 to 128 destinations***

***Daisy chain expansion x 5 modules***

***Temp-compensated bias/modulation***

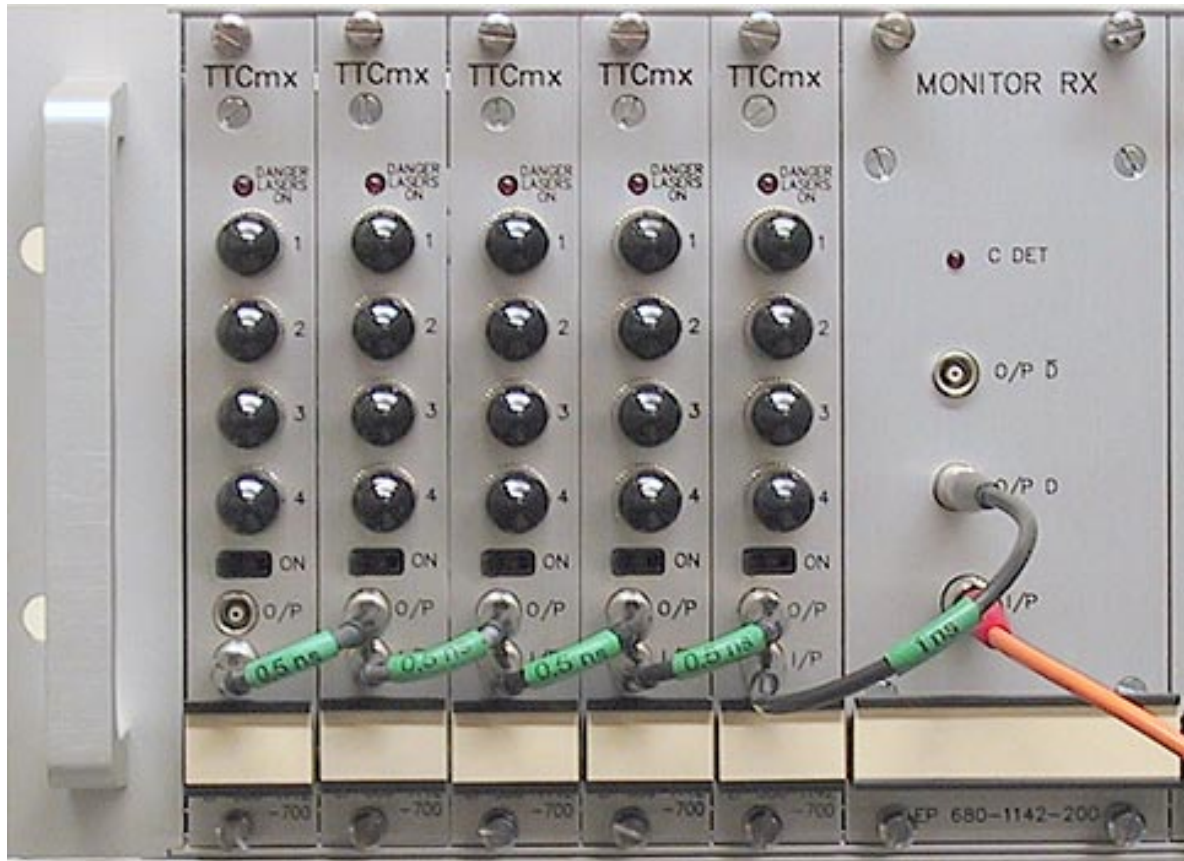
***Rear facet automatic power control***

***Interlock provision***

***Standard (+5v) minicrate power***

***User manual on TTC website***

# *TTC repeater*



***Inexpensive minicrate with 5v power only***

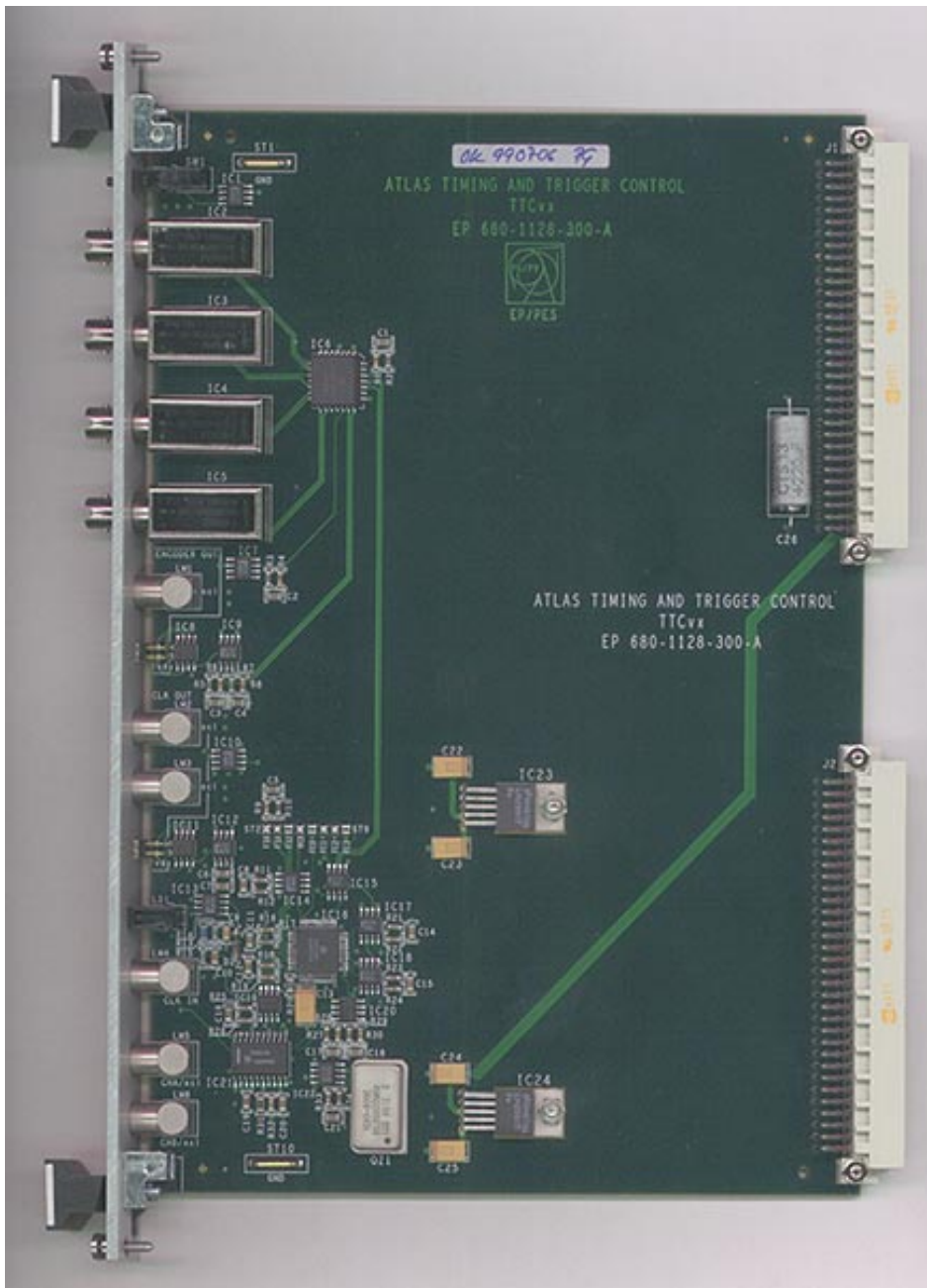
***Receives optical TTC signal from PCR***

***Re-broadcast without decoding***

***4 outputs at 0 dBm per TTCmx module***



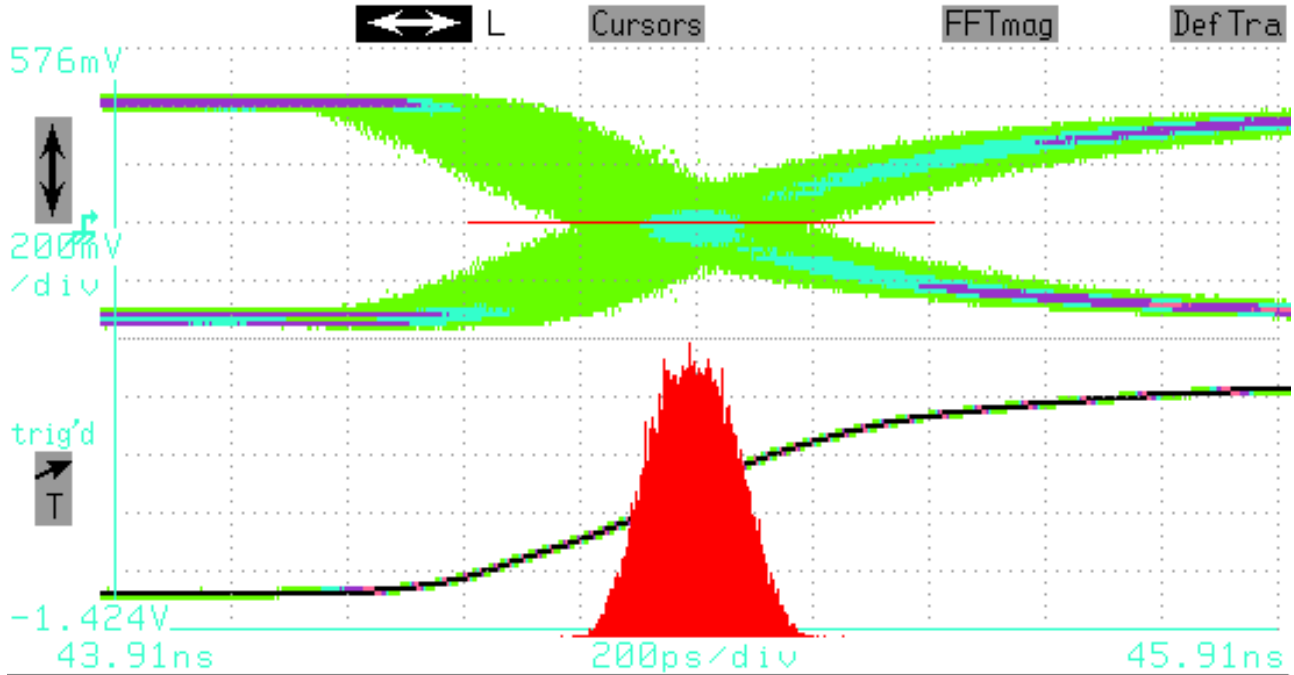
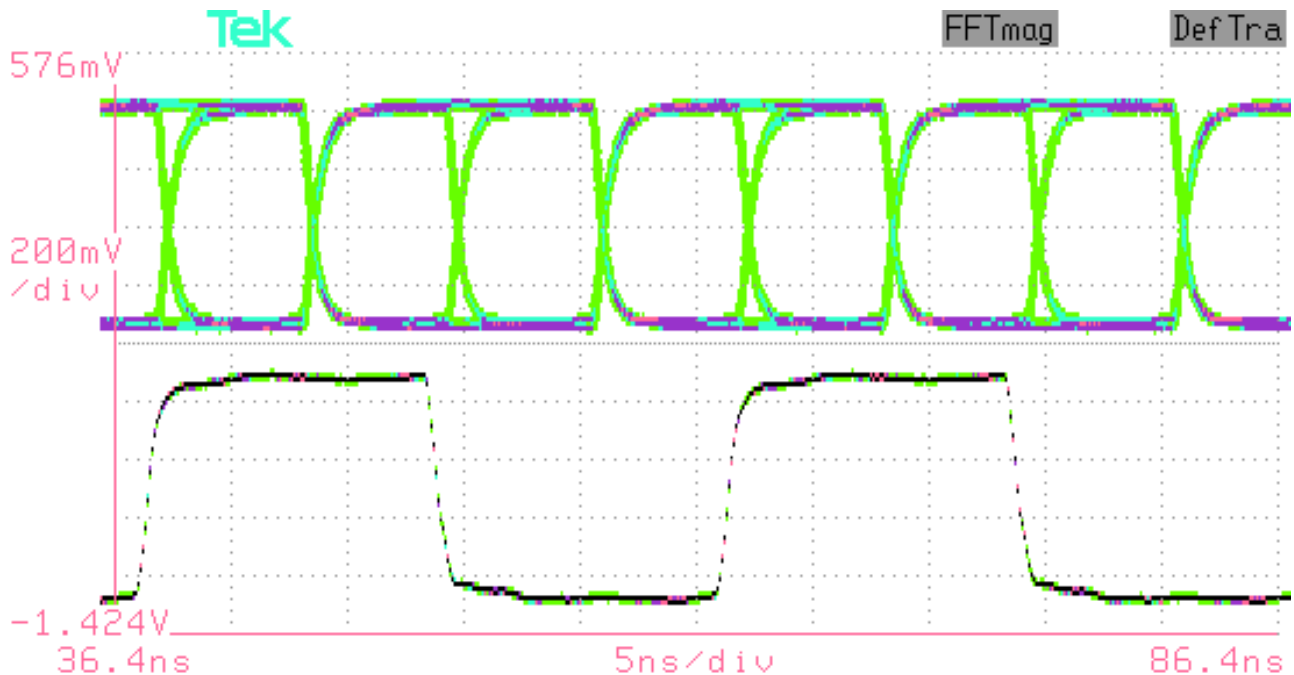
# ***TTCvx LED transmitter***



***Low-power module for development work***

***Up to 4 destinations***

# TTCvx encoder jitter (PRBS data)



Top	-20mV	Mean	44.91ns	$\mu \pm 1\sigma$	67.227%	Window Size	
Btm	-20mV	RMS $\Delta$	71.47ps	$\mu \pm 2\sigma$	96.931%	200ps/div	
Lft	44.52ns	PkPk	488ps	$\mu \pm 3\sigma$	99.976%	Window Pos	
Rgt	45.32ns	Hits	12544	Wfms	5016	43.89ns	
Persist/ Histograms	Mask Testing	Color Grad Scale	Standard Masks	Remove/Clr Trace 1			
Color Grad Continuous	Count Off		User Mask	M1 Window			

# ***Laser TTC transmitters***

***COMPASS - TTCtx***

***ALICE - (TTCex, TTCmx)***

***ATLAS - TTCex, TTCmx***

***CMS - TTCex, TTCmx***

***LHCb - TTCtx, TTCmx***

***RD12 - TTCex, TTCtx, TTCmx***

***SL/BI - TTCmx***

***SL/CO - TTCtx***

***EP/ESS - TTCex, TTCtx***

# Optical tree couplers



**FBT technology**

**Coupling loss (1x32) 15.1 dB**

**MM for experiments (single fusion)**

**Excess loss 2 dB**

**SM for PCR (cascaded 1x2, 1x4, 1x4)**

**Excess loss (1x32) 4 dB**



# Latency

## **Transmitter - receiver channel**

**(to TTCrx O/P with baseline PIN/Preamp)**

**TTCex: 68 ns + fibre**

**TTCtx (1 ns from TTCex encoder): 73 ns + fibre**

**TTCmx (1 ns from TTCmi encoder): 61 ns + fibre**

**- with internal TTCrx deskews set to minimum!**

## **Daisy chaining**

**TTCtx: 2 ns + 0.5 ns coax**

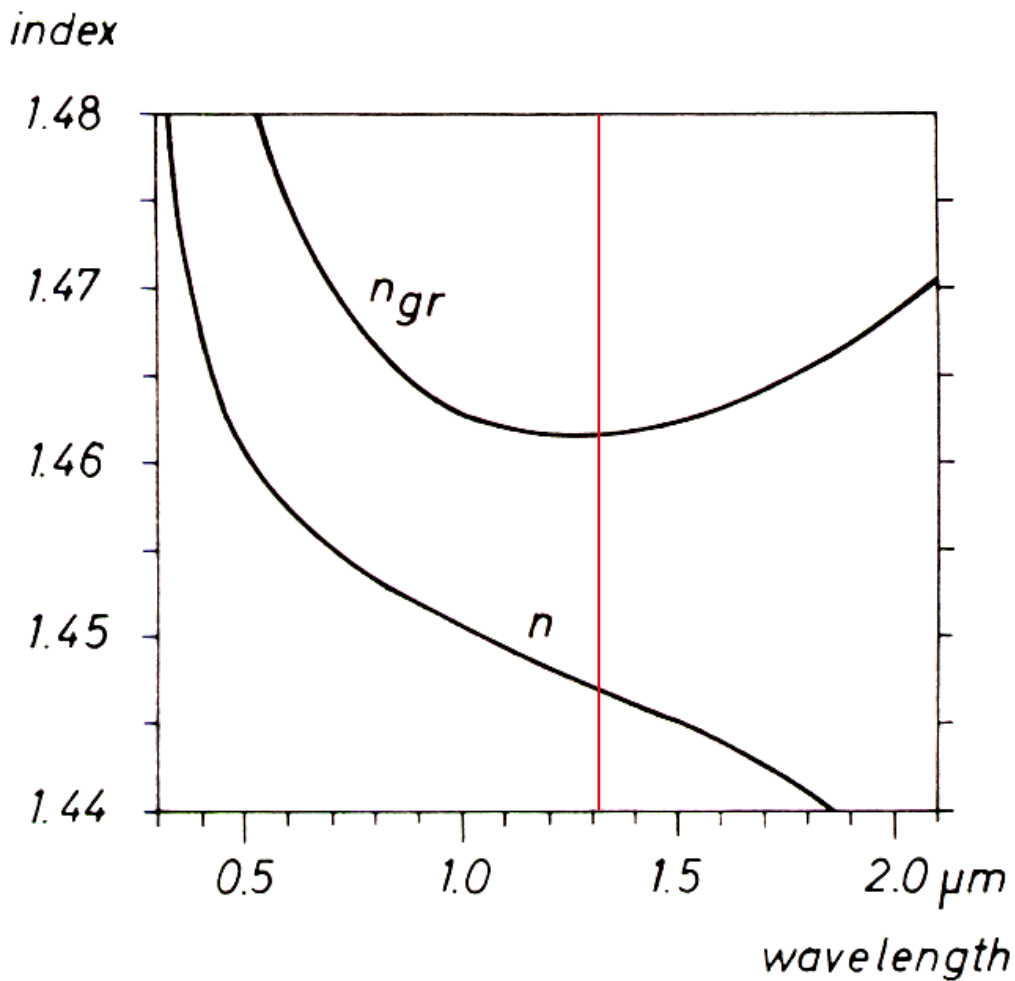
**TTCmx: 1.5 ns + 0.5 ns coax**

## **Fibre**

**4.9 ns/m at 1310 nm**

**1:32 couplers 11 ns now -> 5 ns later**

# Group velocity



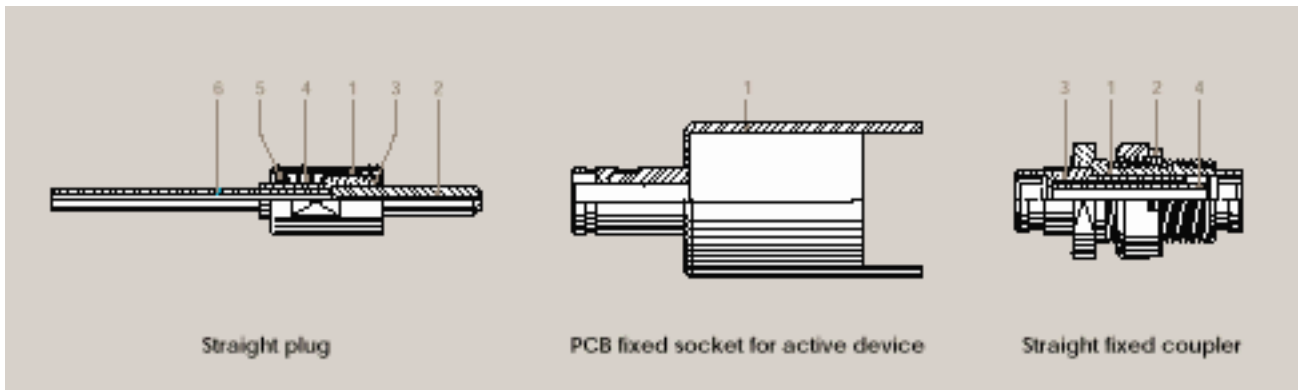
**Group index  $n_{gr} = (n - \lambda dn/d\lambda) = 1.462 @ 1310 \text{ nm}$**

**Group velocity factor =  $1/n_{gr}$**

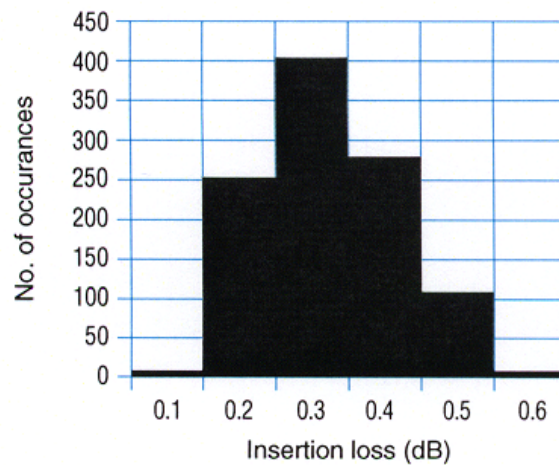
	<b>Velocity factor</b>	<b>100m delay</b>
<b>Solid dielectric coax</b>	<b>0.66</b>	<b>505 ns</b>
<b>Optical fibre 1310 nm</b>	<b>0.68</b>	<b>490 ns</b>
<b>Small dia. cellular coax</b>	<b>0.69</b>	<b>484 ns</b>
<b>Large dia. cellular coax</b>	<b>0.82</b>	<b>407 ns</b>



# Subminiature RD12 optical connector



## Multimode insertion loss



Std Deviation = 0.09 dB  
Mean = 0.27 dB  
Fibre = 50/125  $\mu\text{m}$

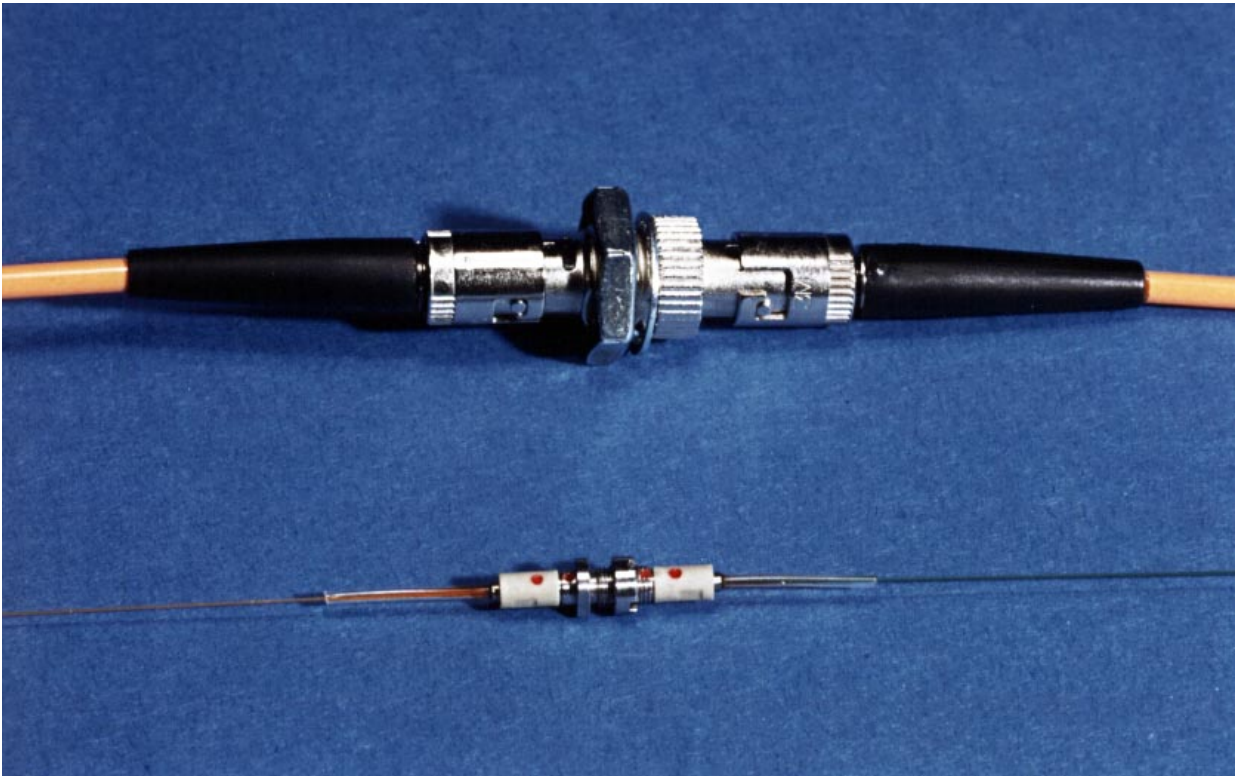
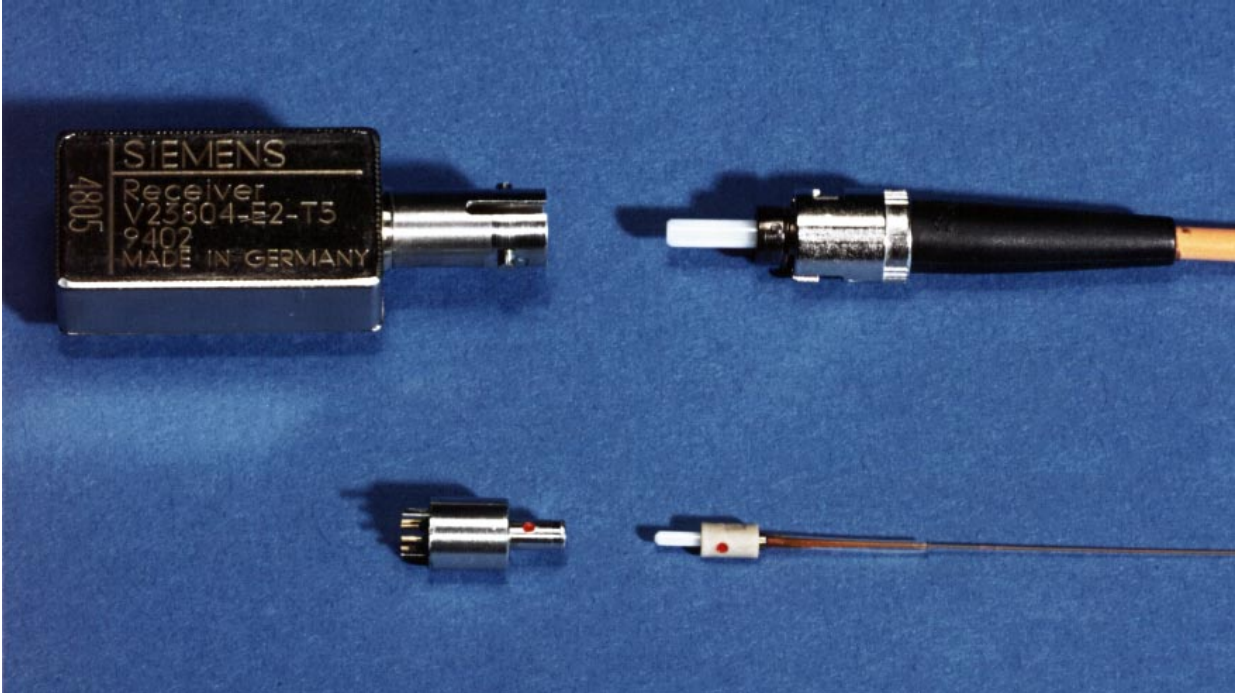
***Boeing + helicopter tests passed***

***Transferred to Ecublens***

***<http://www.lemo.ch>***



# *Subminiature RD12 optical connector*




## RD12 connector

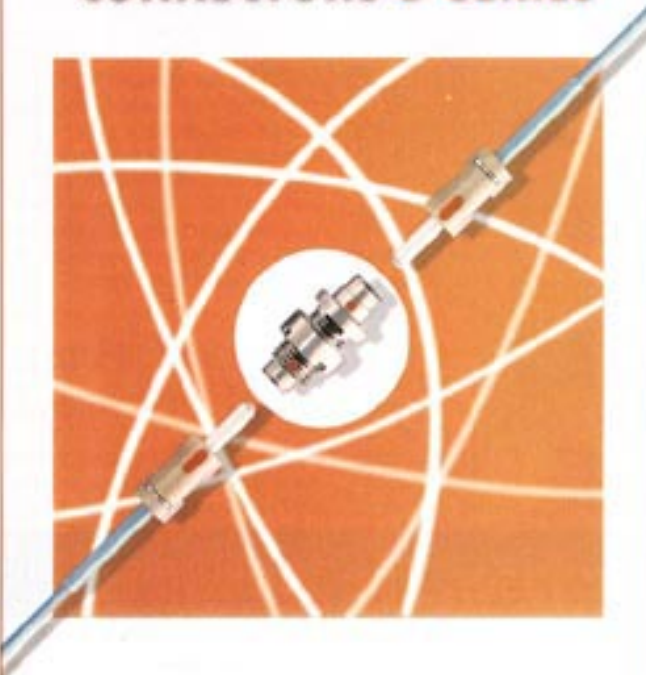
**"The world's  
smallest  
snap-on  
fiber optic  
connector"**

**- Lemo SA**

R1/00

**REDEL**

### MINIATURE FIBER OPTIC CONNECTORS D SERIES




The Redel D Series connector is the world's smallest snap-on fiber optic connector. It is an ideal choice wherever space and weight are at a premium.


- Snap-on latching system
- Compact size (ø 3.2 mm)
- Fully floating ferrule for 9/125 µm singlemode and 50/125 µm or 62.5/125 µm multimode fiber
- Singlemode insertion loss (mean) - 0.09 dB
- Multimode insertion loss (mean) - 0.12 dB
- Return loss (UPC polishing) > 45 dB
- Fast and simple termination (Epoxy)

Scale 1/1

---

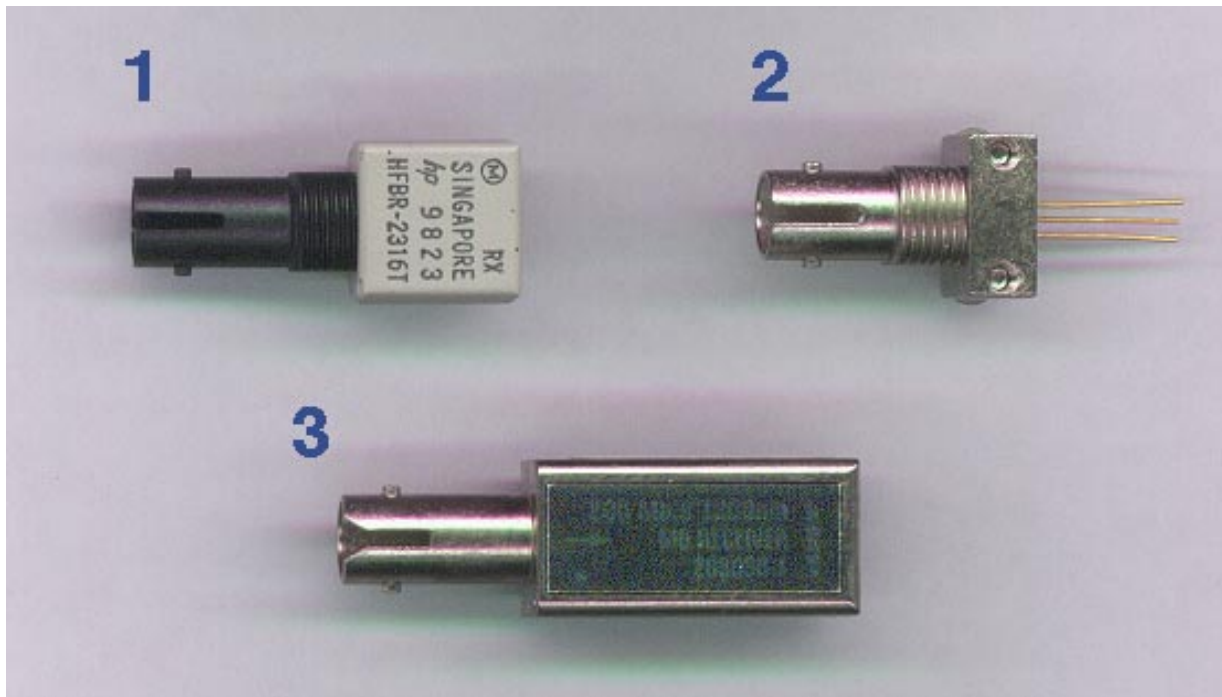
Distributed by:

**LEMO**



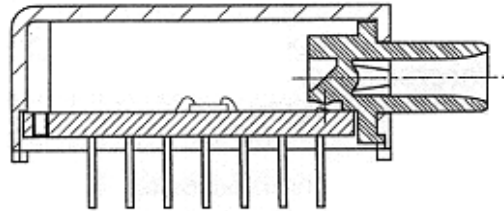
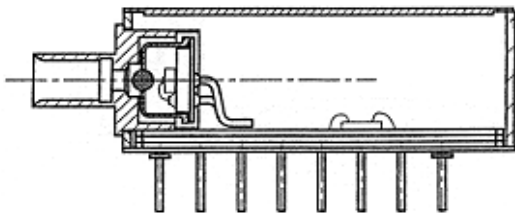
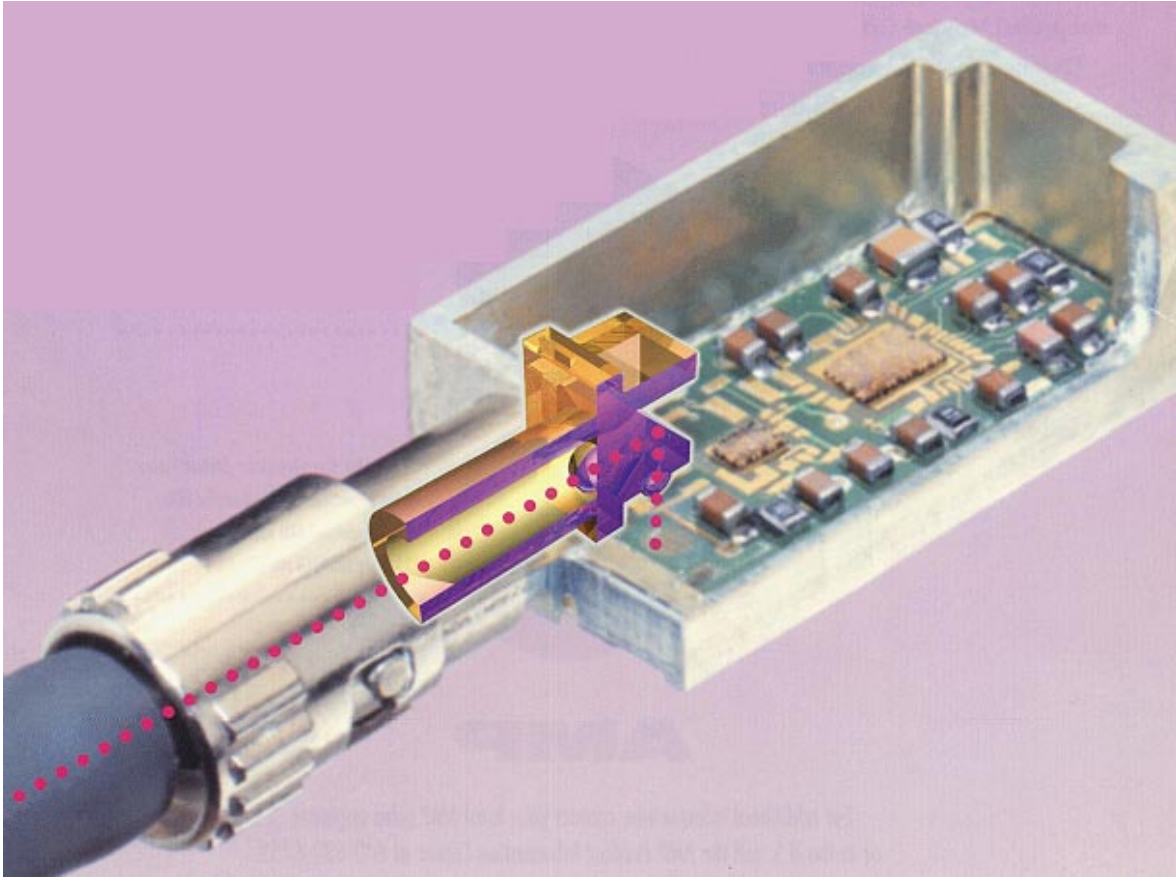
Chemin des Champs-Courbes 28 CH-1024 Ecublens  
Tél: (+41 21) 695 16 00 - Fax (+41 21) 695 16 01  
info@lemo.ch - <http://www.lemo.com>

# Optoelectronic receivers



- 1** **Agilent HFBR-2316T**  
*InGaAs PIN diode + Si bipolar preamp*  
*Low-cost datacom device*  
*Present baseline choice*
- 2** **Honeywell/Lytel HFD8005-002/YBA**  
*InGaAs PIN diode + GaAs preamp*  
*OC3 telecom spec*  
*Wide dynamic range*
- 3** **Tyco 269052-1**  
*Complete modular receiver*  
*ECL bus for multiple TTCrx*  
*"Molded-Optronic" technology*

# *Molded-Optronic technology*

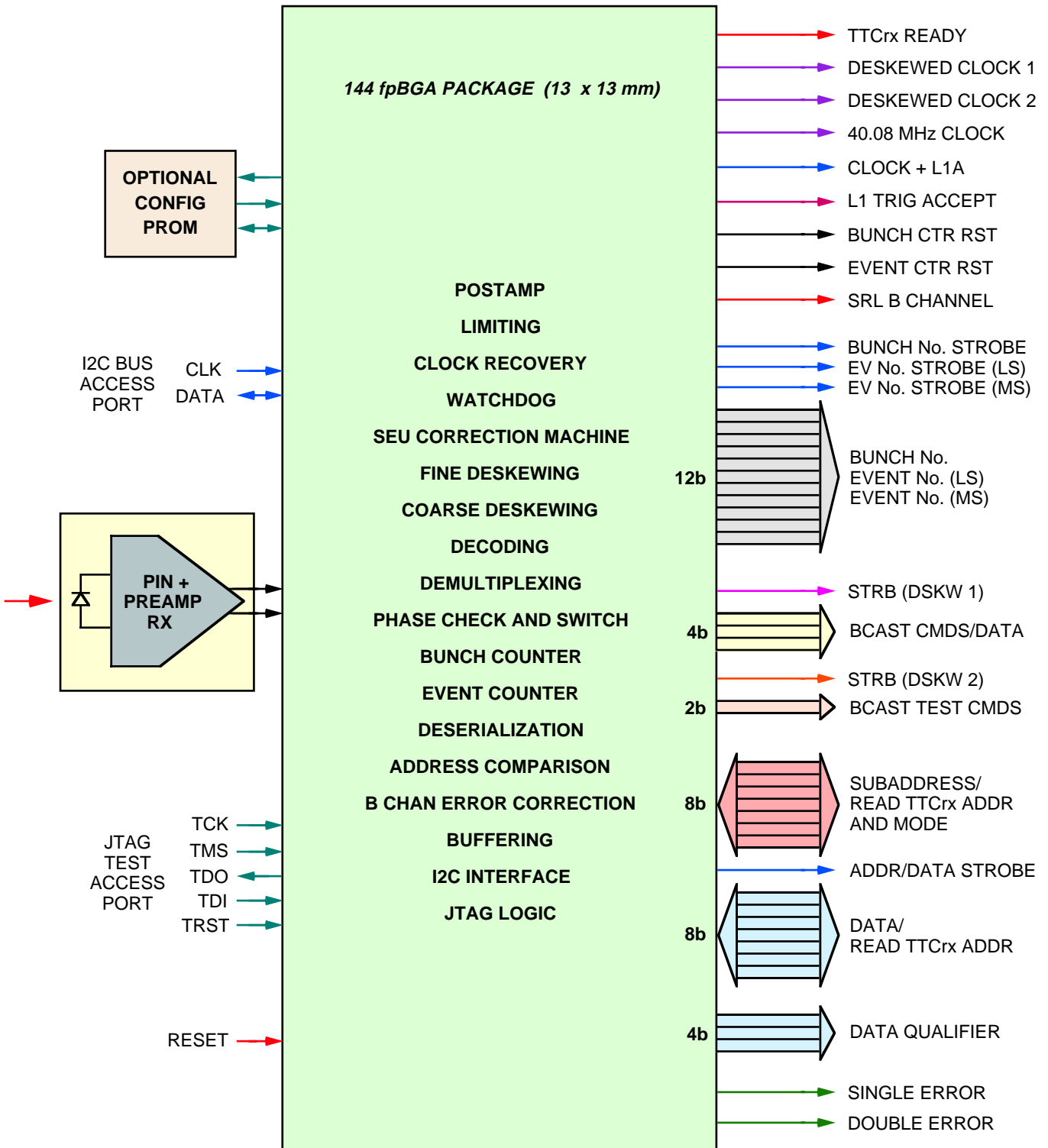


***Integrated lens/receptacle***

***Alignment, light coupling and bending***

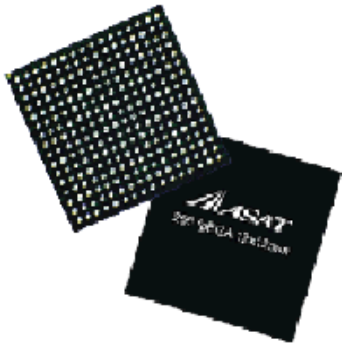
***Reduced parts count and assembly cost***

# TTC timing receiver ASIC (TTCrx)



**Rev. 3 (DMILL) TTCrx**

# TTCrx development



## **1 $\mu\text{m}$ ES2 TTCrx**

**Remaining 78 BGA samples:**

**MIC: 8, PCR+TTCmi: 10,**

**LHC experiments: 60**

## **DMILL TTCrx**

**20 received Feb 2000 (some PGA)**

**Fully functional. +40 option taken**

**Yield 80%**

## **Radiation hardness**

**8 Mrad,  $5 \times 10^{13}$  n and SEU tests**

**No degradation of fine deskewing**

**Mod to mitigate photodiode SEU effects**

## **Engineering run (ATMEL)**

**Split proven (3.1) + modified (3.2) design**

**8 wafers (2880 chips) received Jan 2001**

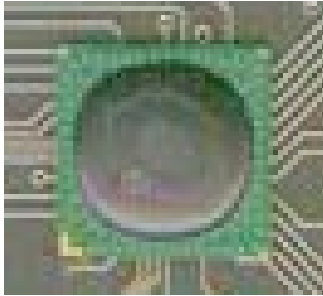
**Testing by CERN/MIC and ATLAS**

## **Production run**

**New reticule with 3.2 only?**

**Single run in late 2001?**

# *TTCrx packaging*



## **100 BGA**

**15 x 15 mm, 1.27 mm pitch**

**IBM Vimercrate \$3.9 (10K qty) + \$10,000 NRE**

**-> Celestica \$40 (10K qty) + \$15,000 NRE**



## **144 fpBGA**

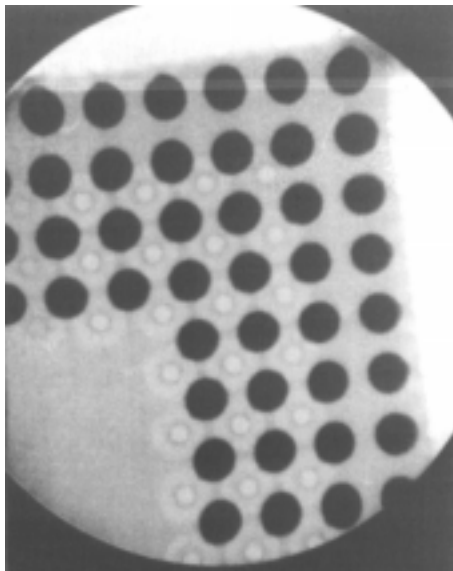
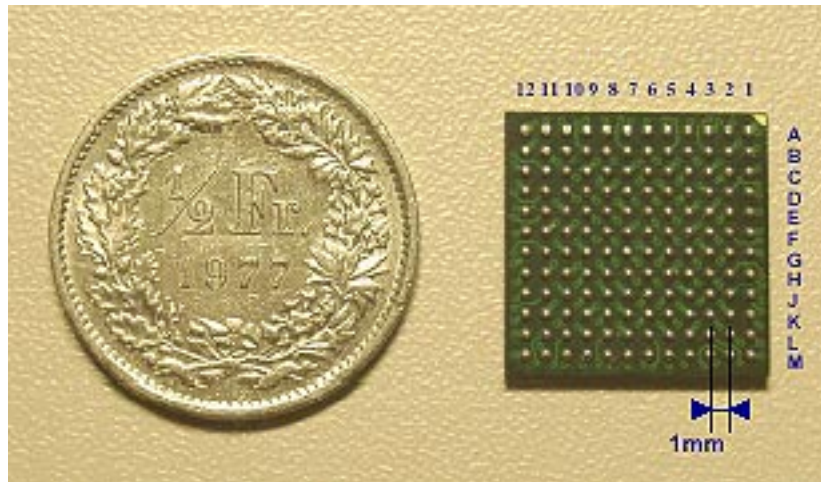
**ASAT 13 x 13 mm, 1 mm pitch**

**\$1.58 (10K qty) + \$0.04 shipping trays**

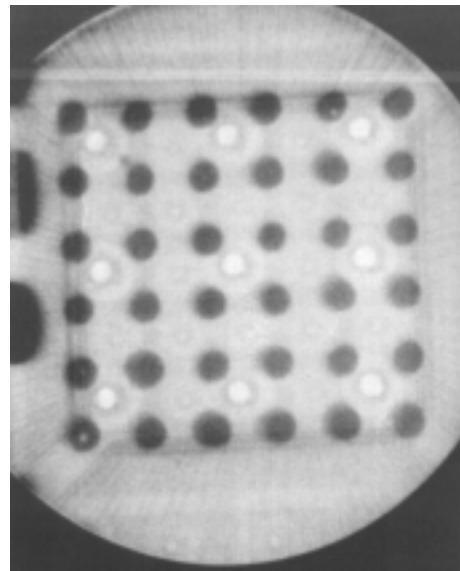
**10 days for first assembly lot**

**New mezzanine board layout**

# *BGA mounting*



***Good***



***Bad***

***Ardelec (F)***

***100% radiography control***

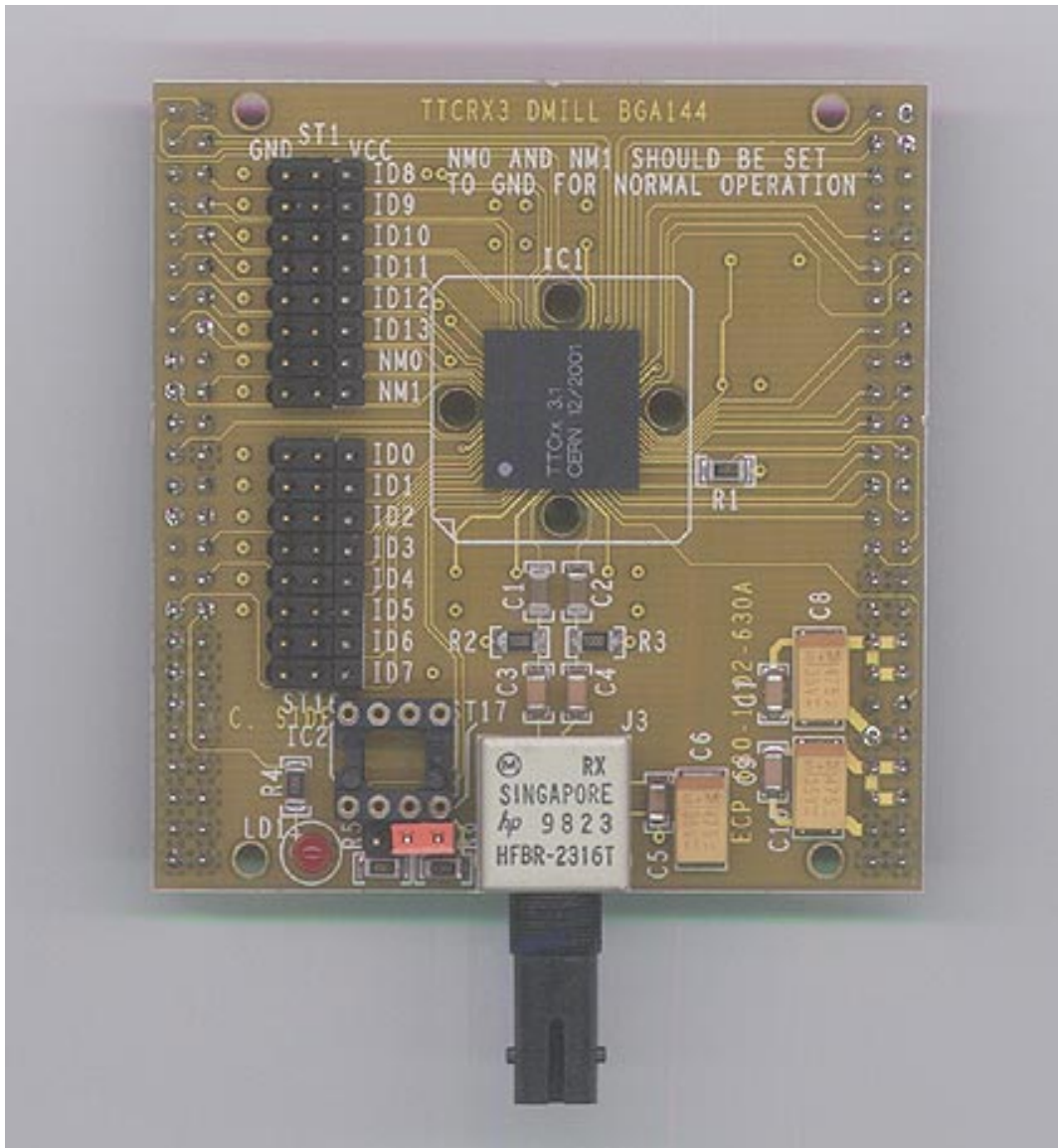
***Individually certified***

***Correction of defective assembly***

***Scolari (CH)***



# *TTCrx mezzanine test board*



***Convenient carrier for initial tests or evaluation***

***Accepts different PIN/Preamps***

***New version for DMILL 144 fpBGA TTCrx***

# *TTC VME receiver (TTCvr)*



***General-purpose VME module***

***Accepts TTCrx mezzanine***

***User-programmable Xilinx XC4006E***

***A24/D32 VME interface and buffers***

# *TTC PMC receiver (TTCpr)*



*Developed by ANL*

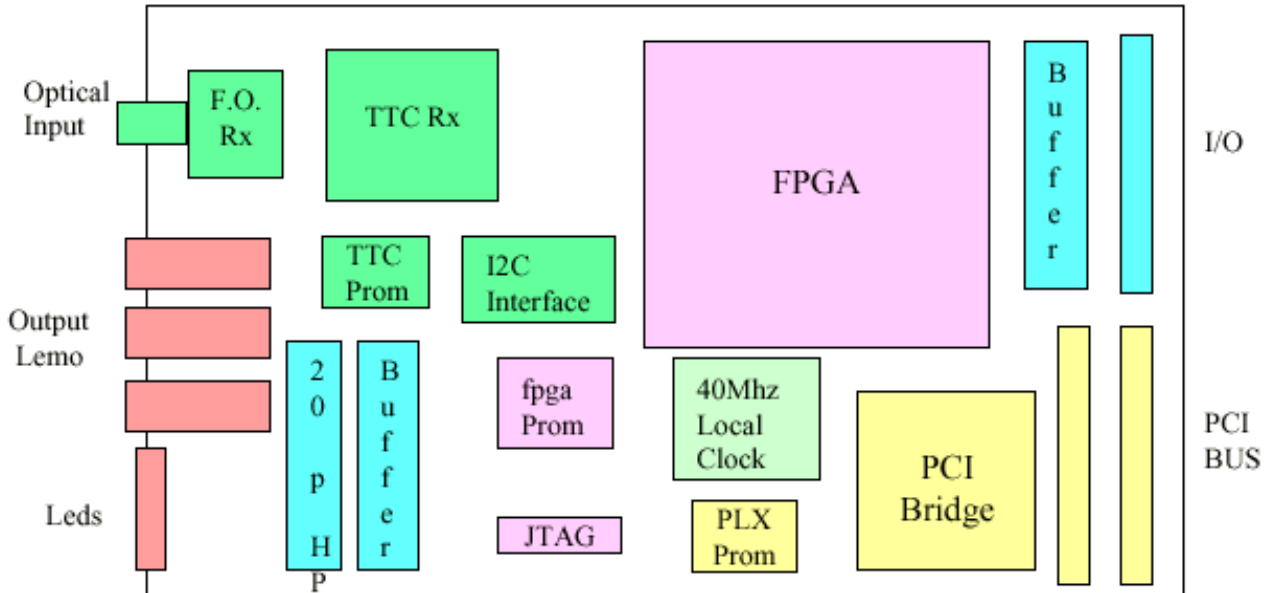
*PMC for ATLAS tile calorimeter DAQ  
(available to other groups)*

*User-programmable Altera 10K30A*

*4 blocks of 8K x 16b FIFO*

*Mk II in development*

# *TTC beam instrumentation interface (TTCbi)*



***IEEE P1386.1 PMC slave card***

***Standard BST interface to LHC BI***

***256 bytes dual-port RAM***

***Experiments can use to receive LHC machine info***

***4Q01***

# ***LHC info via TTCbi***

***Uses B-channel long format broadcast from PCR Tx***

## ***LHC machine events***

***e.g. Start ramp***

***Dump***

***Post mortem***

## ***LHC status messages***

***Part of 32-byte BST messages***

***e.g. Mode (Filling, adjusting, ramping, physics)***

***Beam type***

***Mean current per bunch***

***No. of bunches***

***Beam energy***

***GPS absolute time***

# TTC laser safety



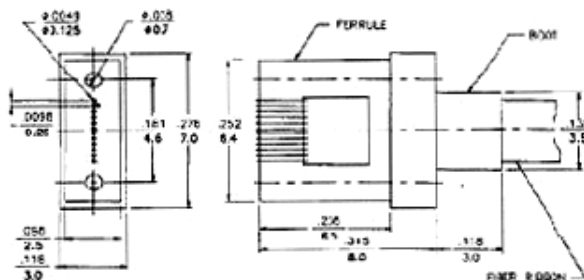
**CERN IS 22, CDRH 21CFR1040, IEC 60825**

**Class 1 after root coupler**

**1310 nm – 8.8 mW**

**850 nm – 0.4 mW**

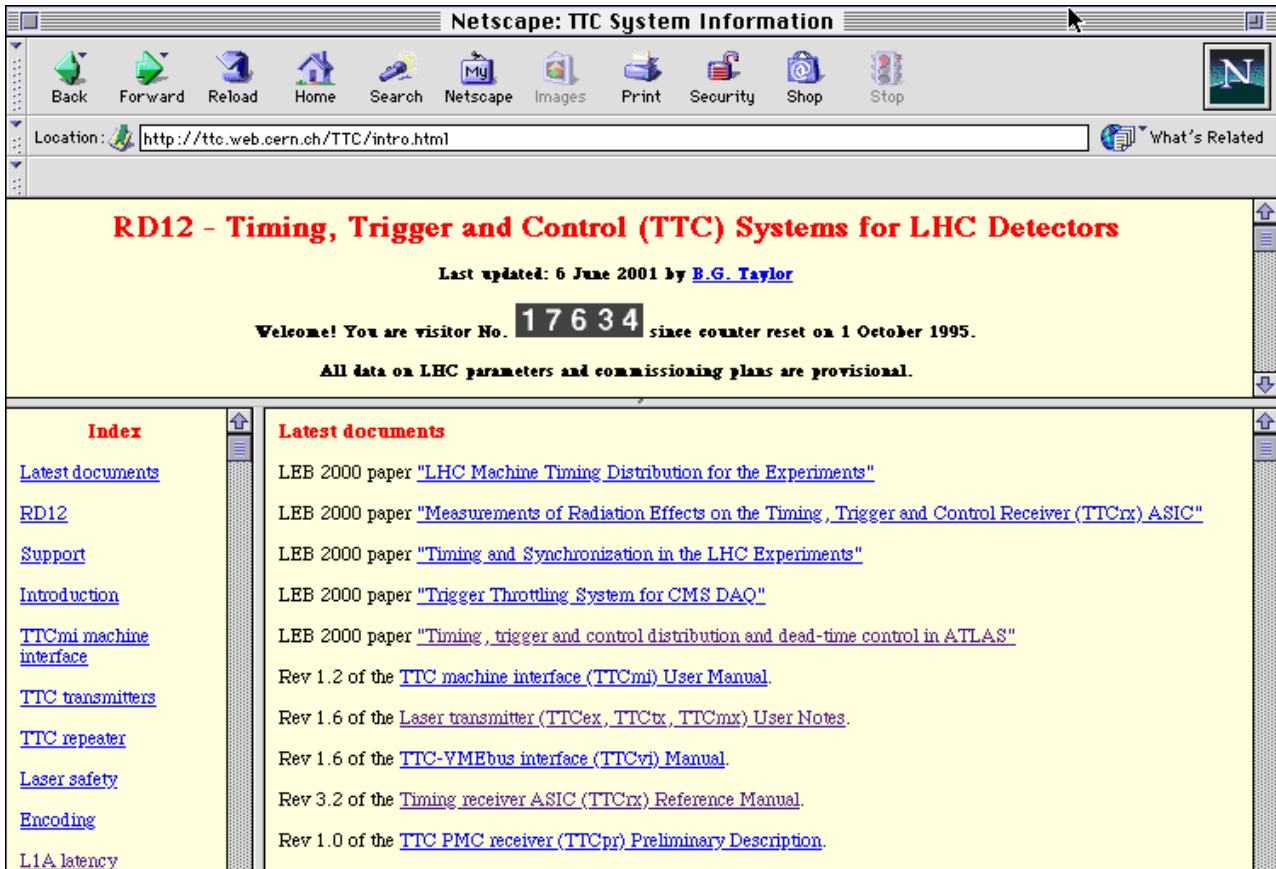
**- But no ribbon connectors for Tx outputs!**



**Class 3B in PCR transmitter racks**

**- "Controlled access" area**

# Internet



## **TTC website**

**<http://www.cern.ch/TTC/intro.html>**

## **TTC mailing list**

**[TTC news and information-sharing](#)**

**[RD12 participants available](#)**

**[ListServer@listbox.cern.ch](mailto:ListServer@listbox.cern.ch):**

**[subscribe lhc-exp-ttc \[email address\]](#)**

**Post to:**

**[lhc-exp-ttc@listbox.cern.ch](mailto:lhc-exp-ttc@listbox.cern.ch)**

**Assistance:**

**[owner-lhc-exp-ttc@listbox.cern.ch](mailto:owner-lhc-exp-ttc@listbox.cern.ch)**