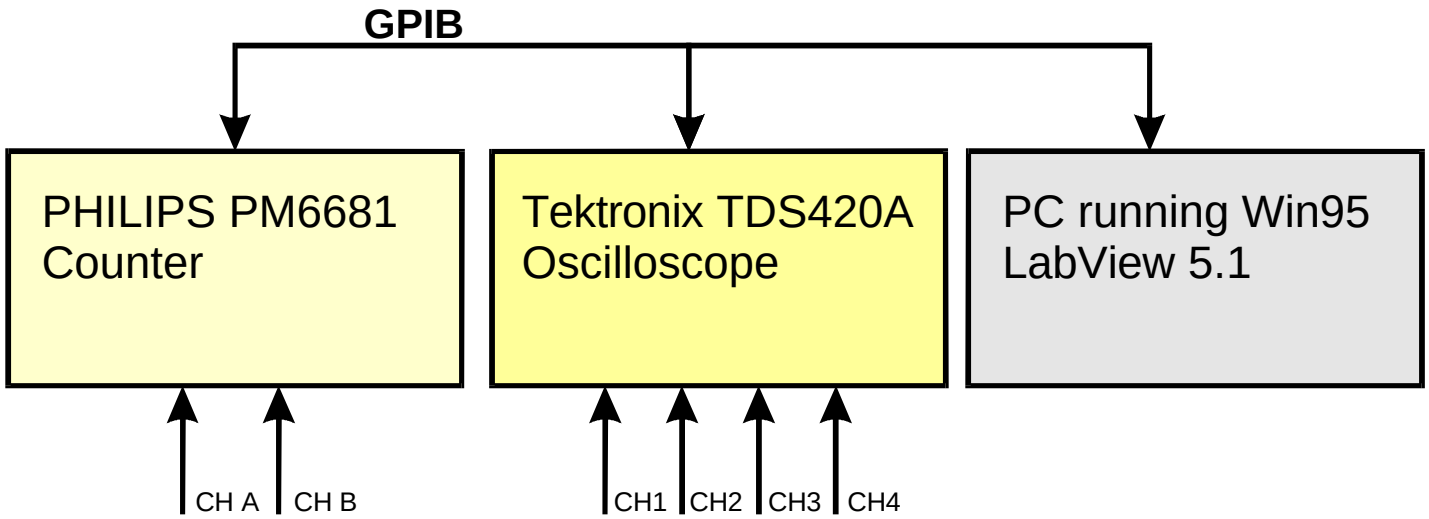
Purpose

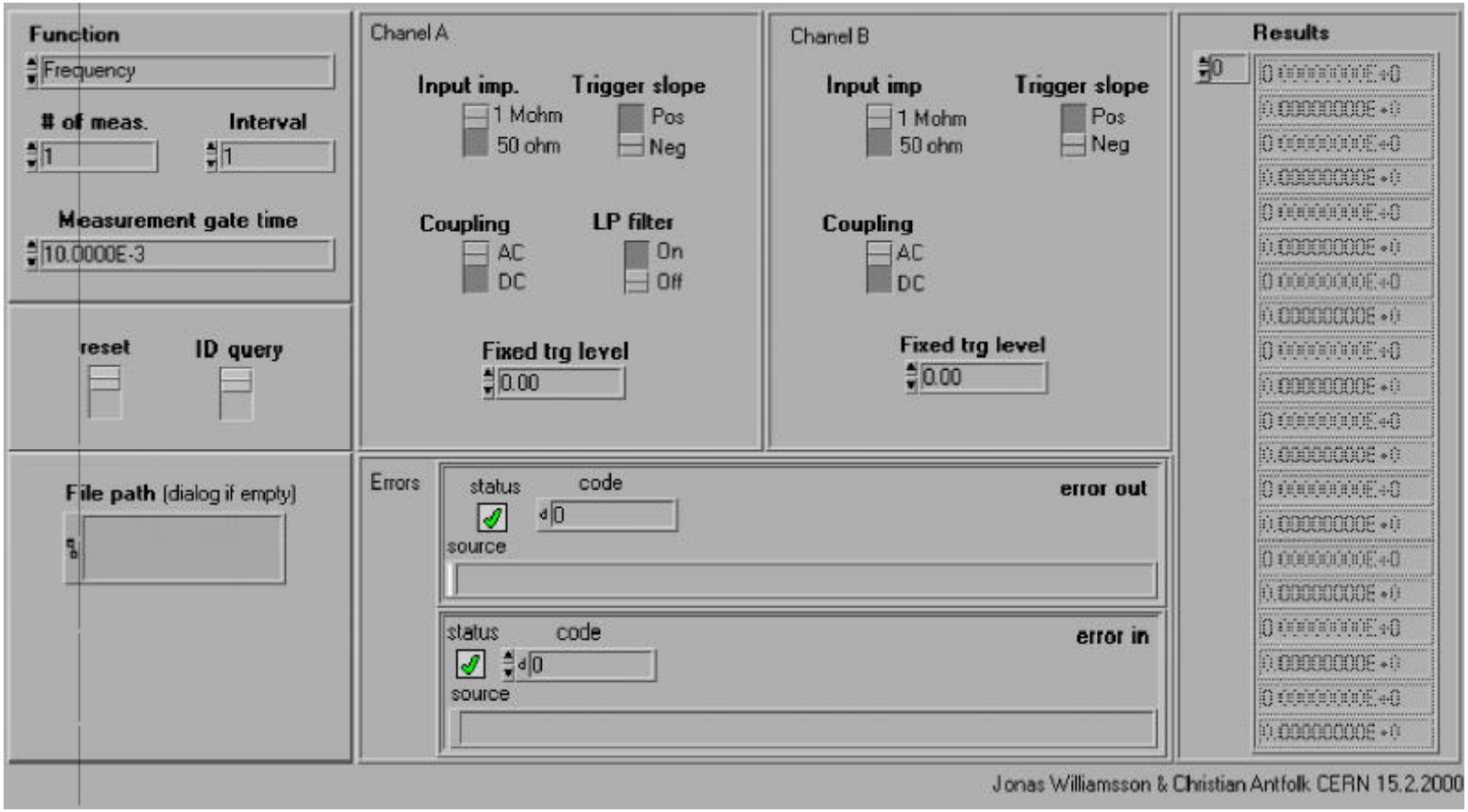
-To verify if the "off the shelf" GPS & IRIG-B equipment conforms to the manufacturers specifications

System set up



GPS for TimWG

Application in LabView for the counter



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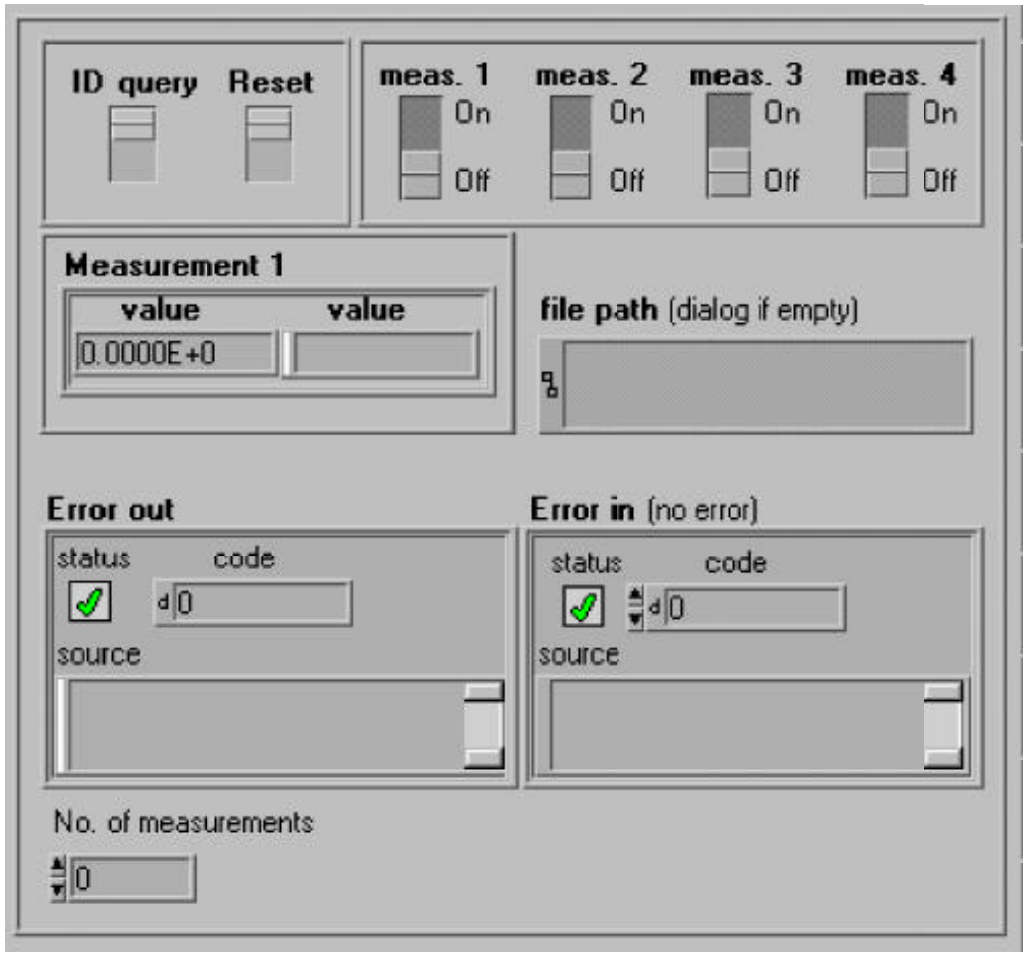
Application in LabView for the oscilloscope



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GPS for TimWG

Statistics for two TrueTime VME-GPS, relative to each other	
Mean	12ns
Median	16ns
Standard deviation	172ns
Range	1542ns
Minimum	-769ns
Maximum	773ns
Measurements	50000

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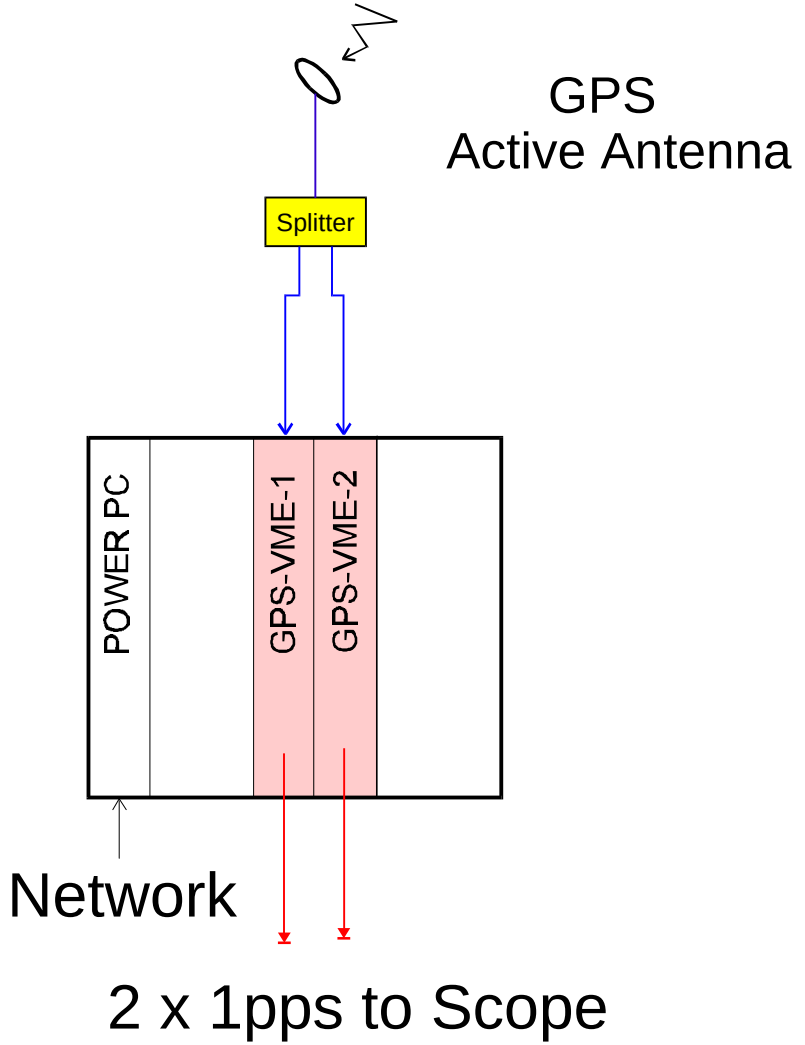
GPS for TimWG

Same antenna
- Antenna on top of building 864
- Jitter measured with oscilloscope



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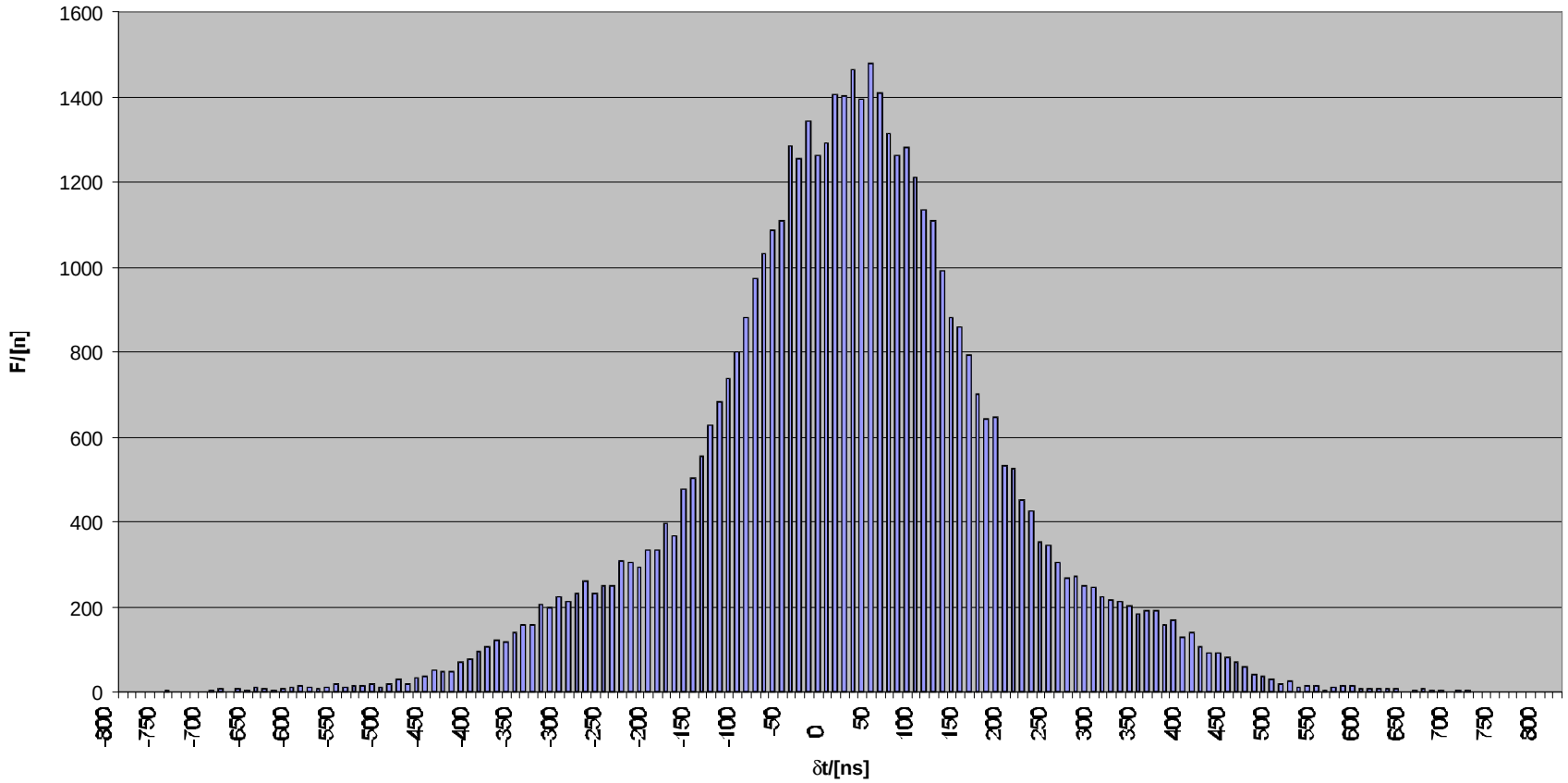
GPS for TimWG

Jitter between two GPS-engines using the same antenna



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GPS for TimWG

TrueTime®

-Designed for VME-bus
-Locks to a maximum of 6 satellites
-1PPS output (puse per second)
-Freeze input
-IRIG-B input
-IRIG-B output
-less than 1us, typically less than 500ns from UTC (Universal Time Coordinated)

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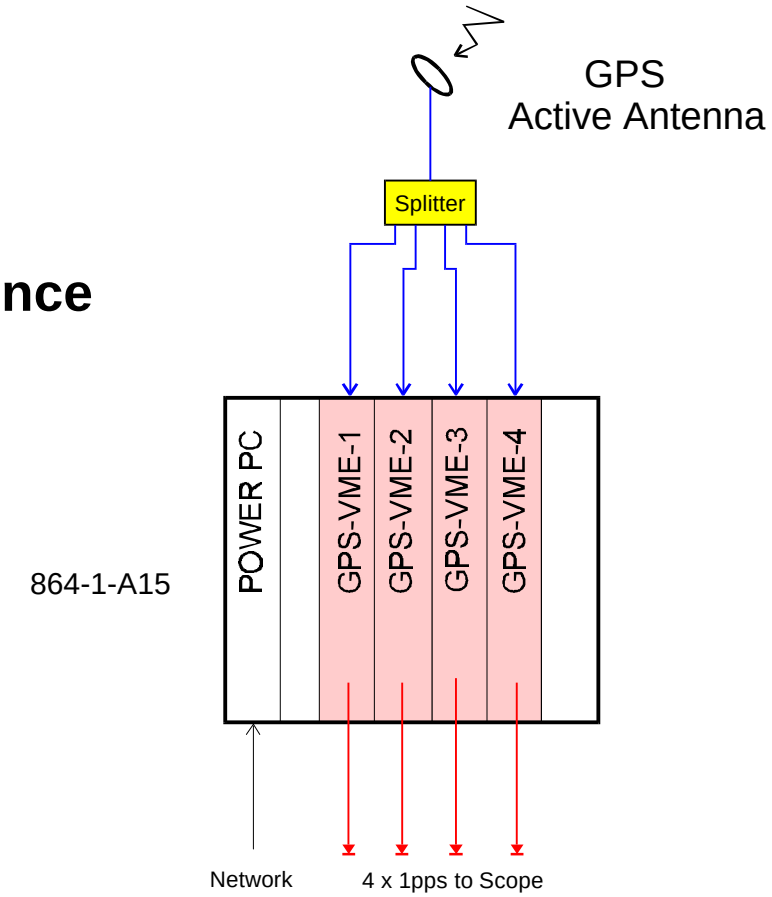
GPS for TimWG

- **Same antenna to all cards**
- **Antenna on top of building 864**
- **Jitter measured**
- **One of the cards worked as reference**



864-1-A15

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GPS for TimWG

Statistics for four TrueTime VME-GPS cards, relative to VME-GPS no:GPS21			
	GPS21→ GPS17	GPS21→ GPS13	GPS21→ GPS04
Mean	10ns	56ns	8ns
Median	12ns	46ns	9ns
Standard deviation	173ns	201ns	171ns
Range	1509ns	1638ns	1552ns
Minimum	-751ns	-788	-783ns
Maximum	758ns	850ns	769ns
Measurements	50000	50000	50000

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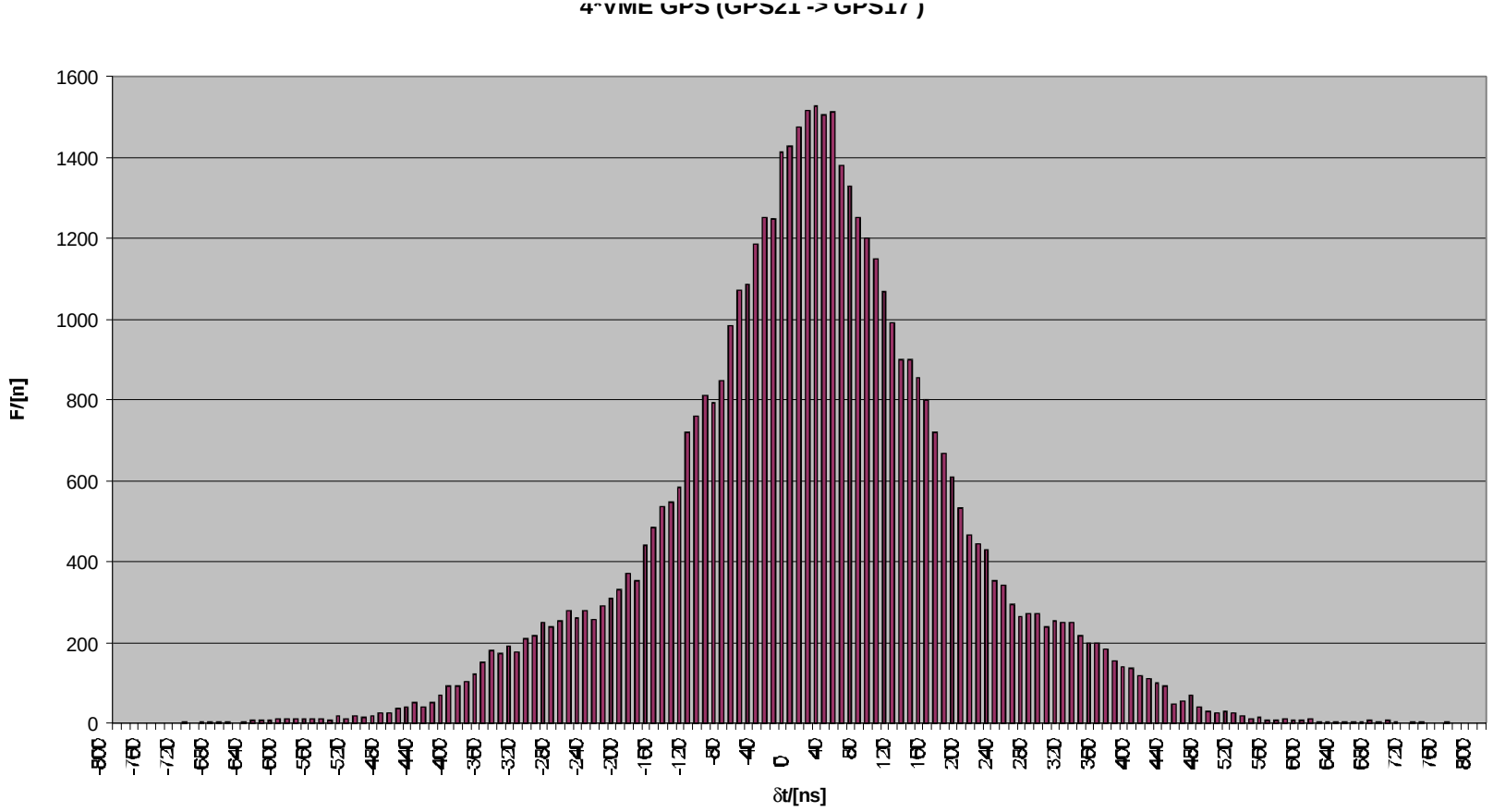
GPS for TimWG

GPS 21 -> GPS 17



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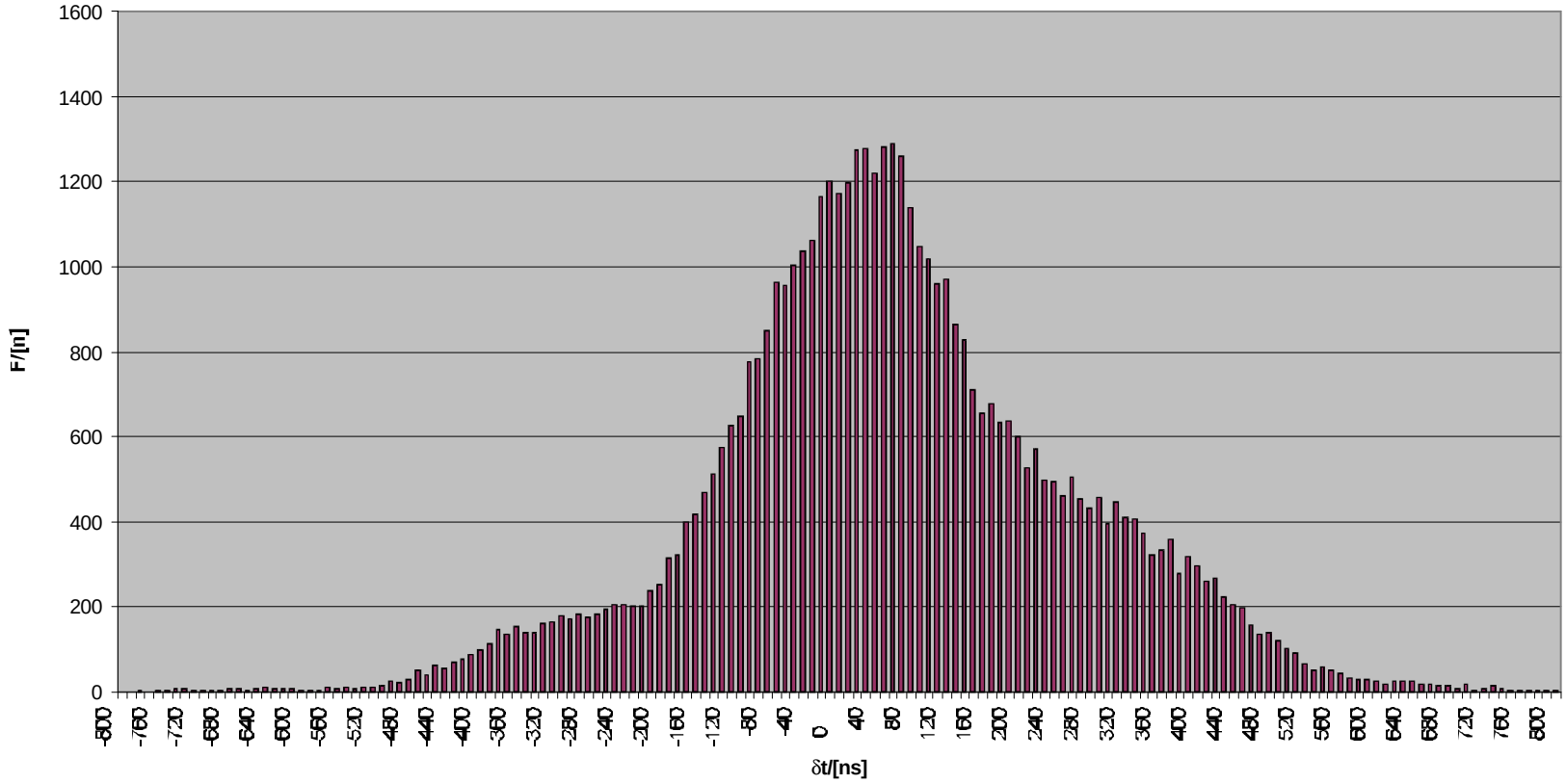
GPS for TimWG

GPS 21 -> GPS 13



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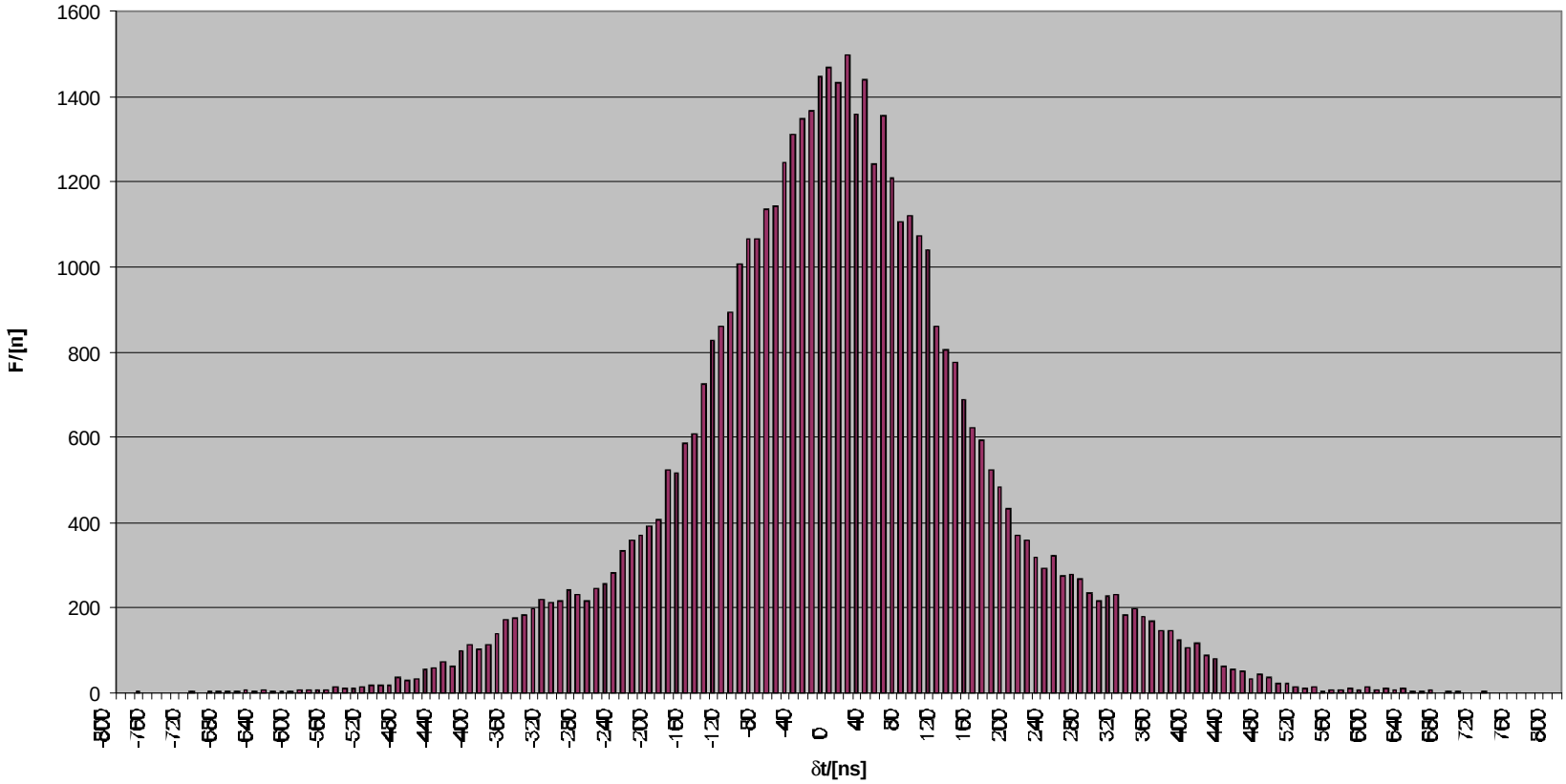
GPS for TimWG

GPS 21 -> GPS 04



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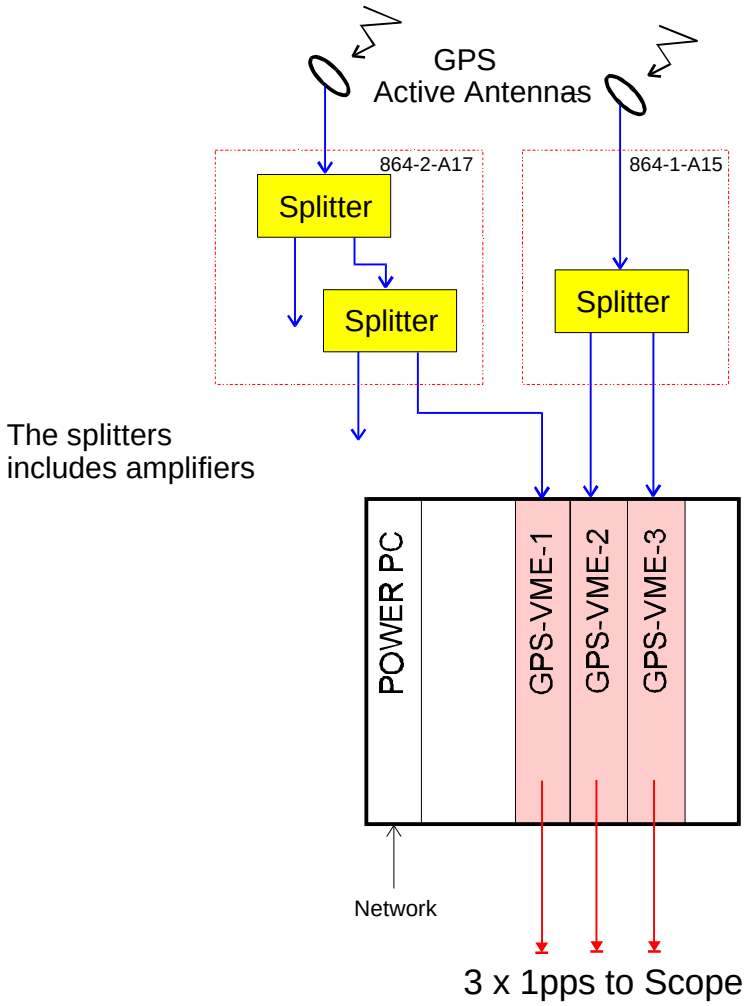
GPS for TimWG

- Two different antennas to each of the cards
- Antennas placed in top of building 864
- Jitter measured with oscilloscope
- The splitters includes amplifiers



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GPS for TimWG

Statistics when two different antennas were used (TrueTime xxxx and xxx xxxx)			
	GPS04→ GPS21 Diff. antenna	GPS04→ GPS17 Diff. antenna	GPS21→ GPS04 Same antenna
Mean	-64ns	-52ns	13ns
Median	-68ns	-50ns	17ns
Standard deviation	169ns	175ns	171ns
Range	1461ns	1763ns	1503ns
Minimum	-809ns	-941ns	-732ns
Maximum	652ns	822ns	771ns
Measurements	50000	50000	50000

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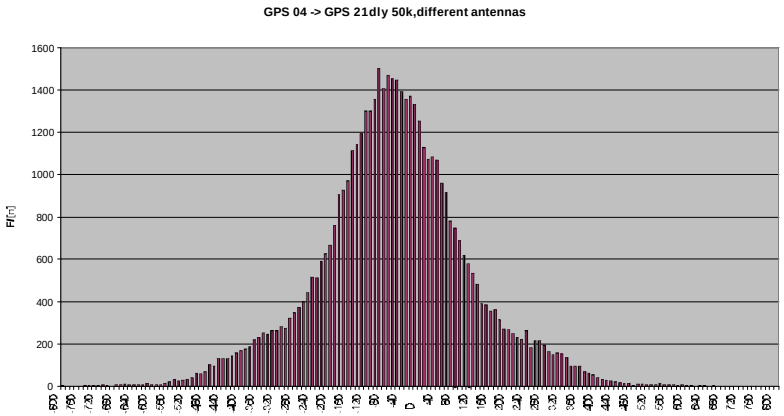
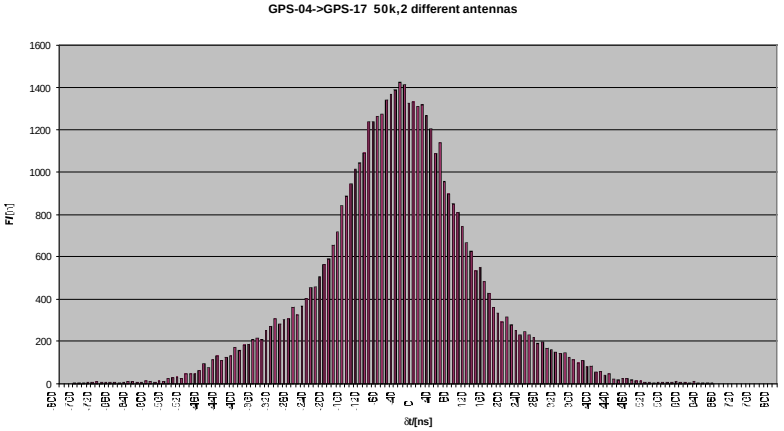
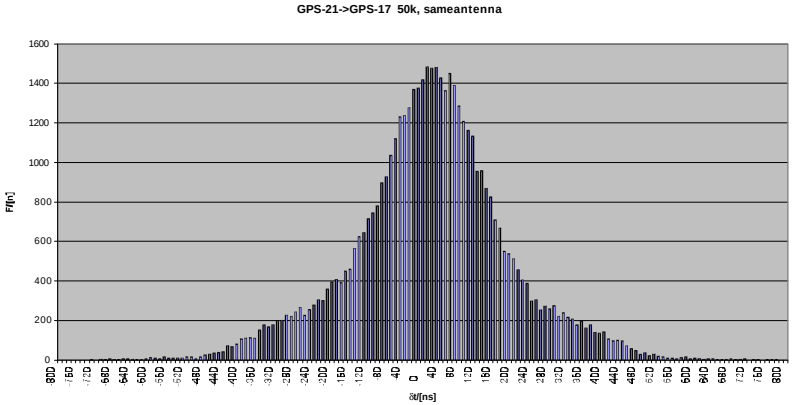
GPS for TimWG

Different antennas





Same antenna



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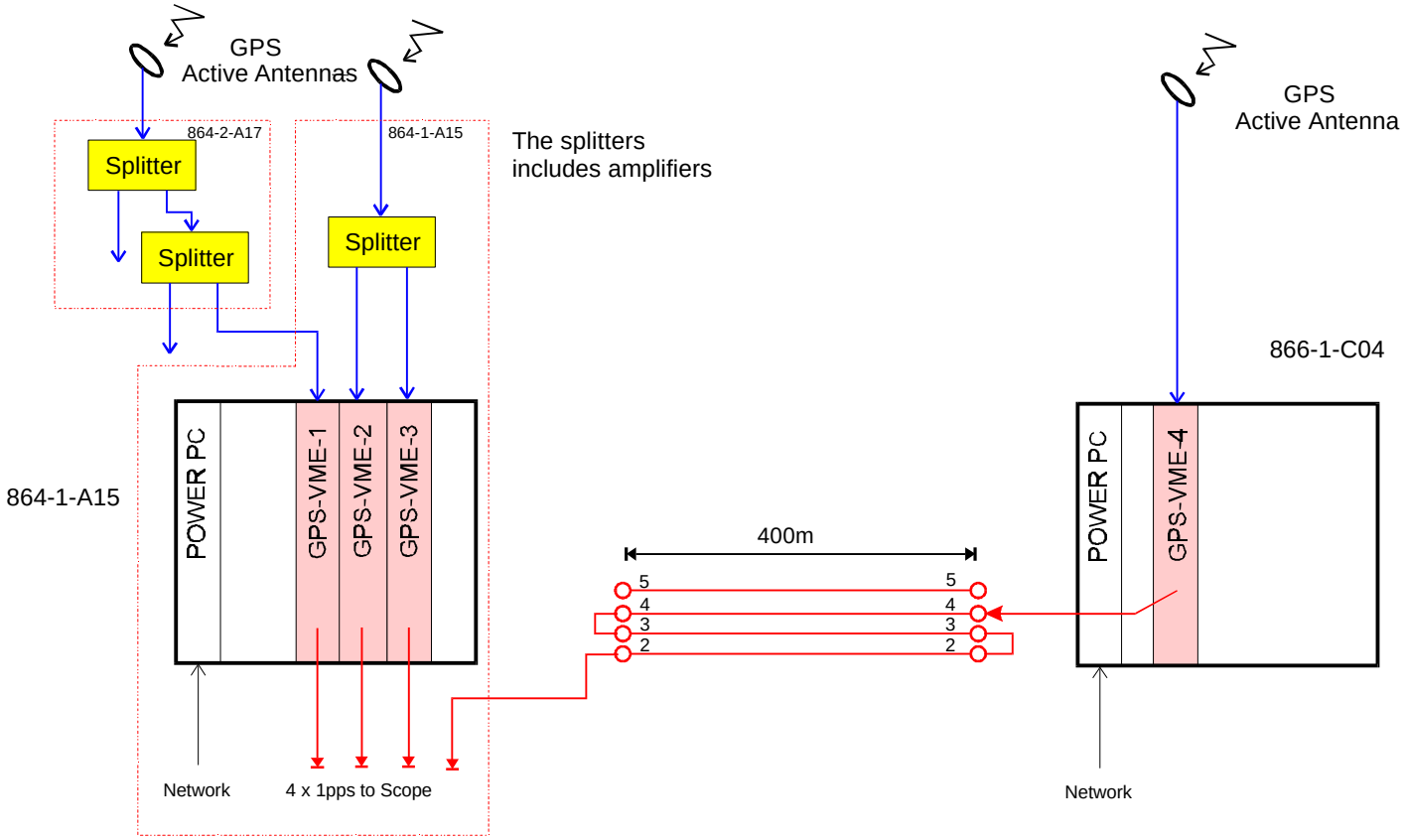
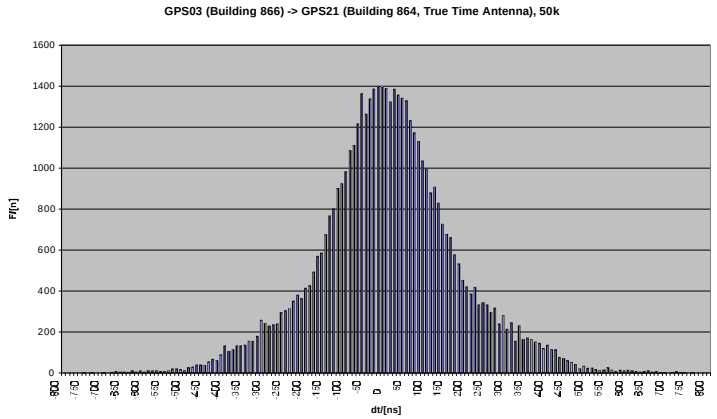
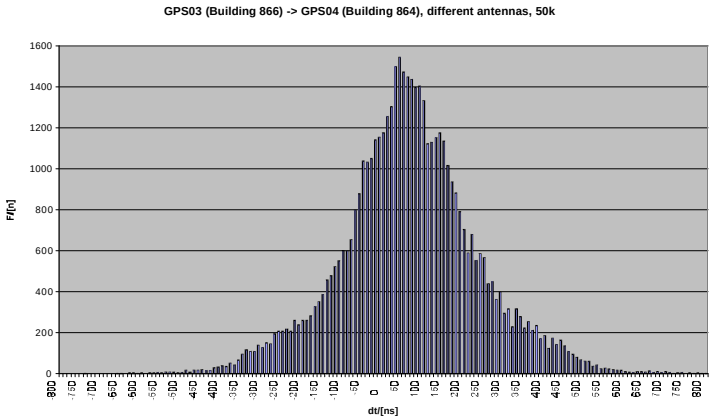
Different locations of the antennas



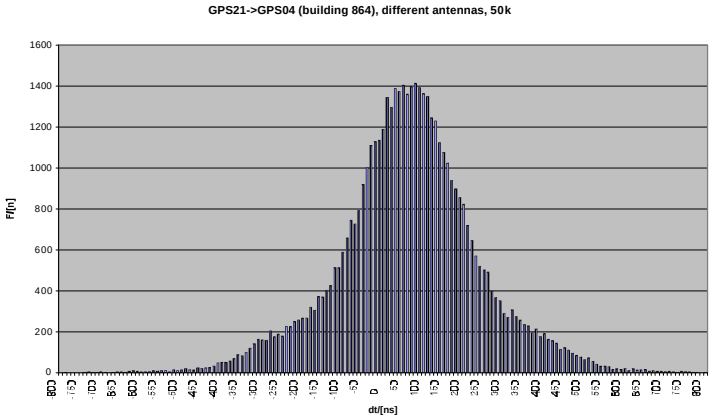
GPS for TimWG

Different buildings





Same building, different antennas



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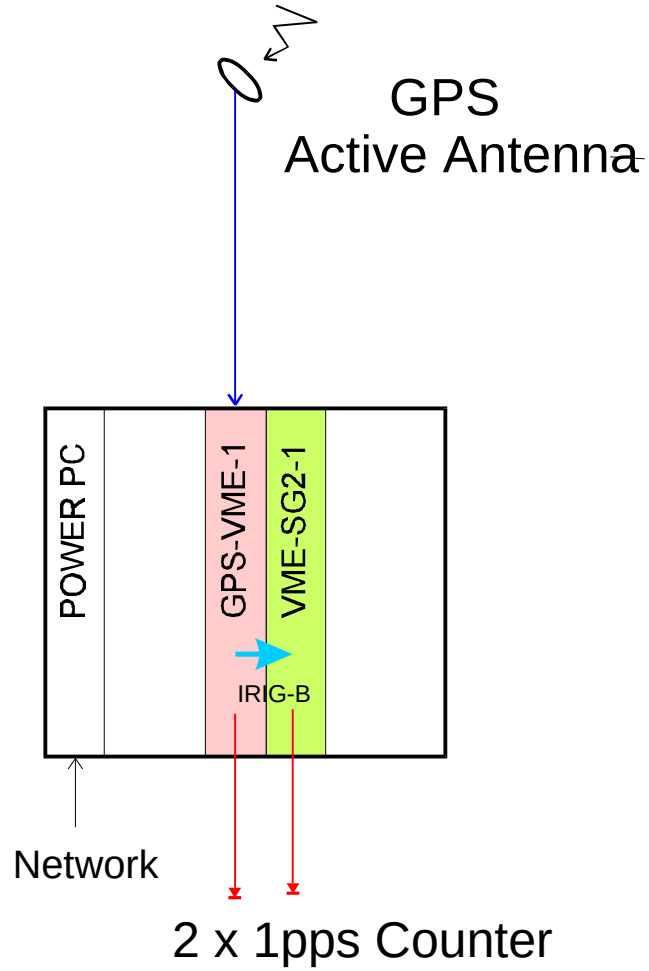
GPS for TimWG

Time distributed by IRIG-B

- Less accurate than with antenna
- Distributed in LEP (LHC)
- Used for longer distances



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GPS for TimWG

Statistics for TrueTime VME-GPS → VME-SG		
Mean	3189ns	89ns
Median	3145ns	45ns
Standard deviation	418ns	418
Range	3730ns	3730ns
Minimum	1688ns	-1412ns
Maximum	5470ns	2370ns
Measurements	29364	29364

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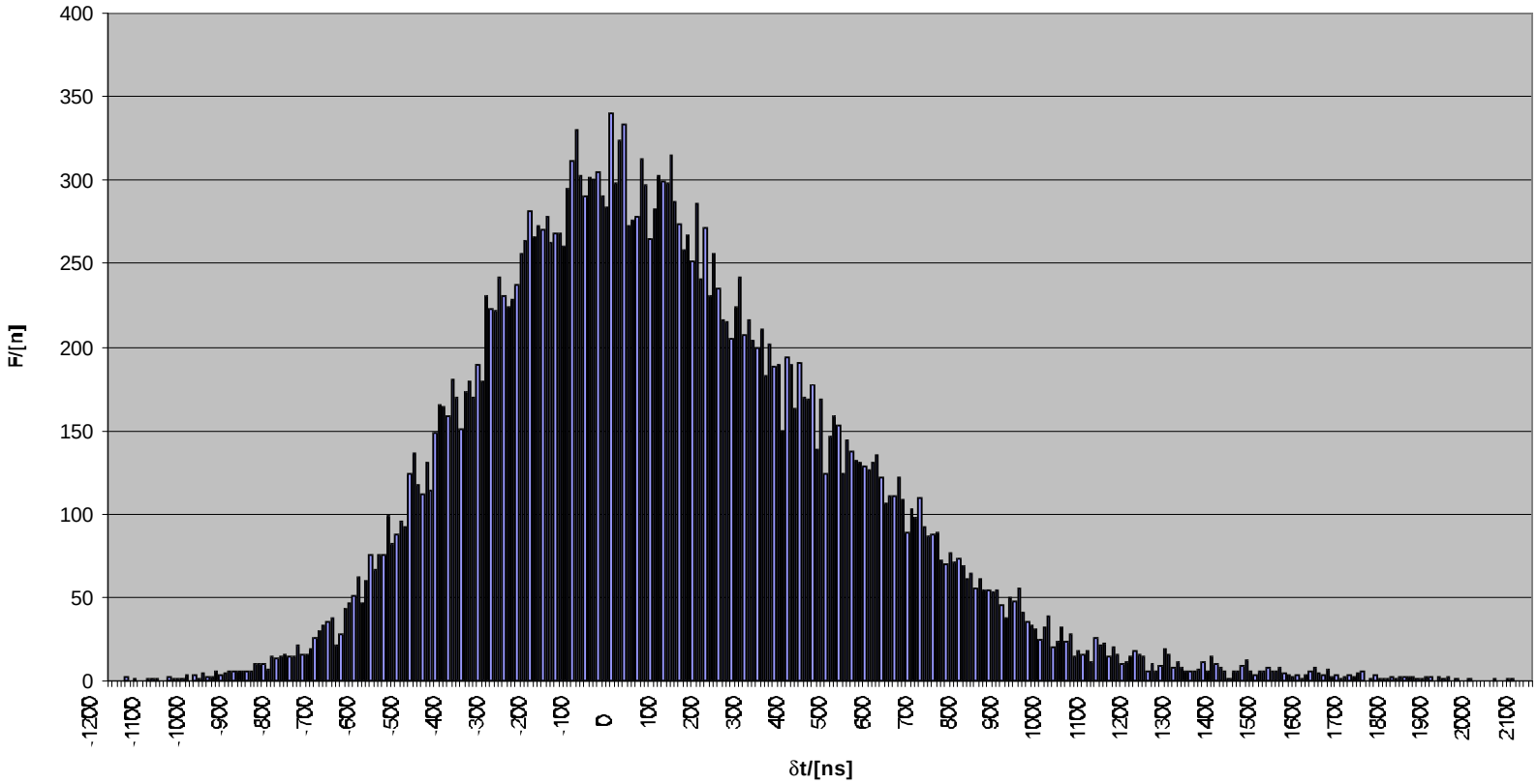
GPS for TimWG

IRIG-B distributed to a synchronized generator



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GPS for TimWG

Statistics for three TrueTime GPS-VME cards, relative to System 2000						
	System 2000 → GPS04		System 2000 → GPS12		System 2000 → GPS21	
	SA on	SA off	SA on	SA off	SA on	SA off
Mean	332ns	347ns	317ns	329ns	334ns	345ns
Median	329ns	344ns	303ns	310ns	333ns	340ns
Standard deviation	154ns	120ns	158ns	127ns	155ns	121ns
Range	1438ns	840ns	1377ns	886ns	1373ns	862ns
Minimum	-401ns	-66ns	-331ns	-115ns	-343ns	-86ns
Maximum	1037ns	774ns	1046ns	771ns	1030ns	776ns
Measurements	50000	50000	50000	50000	50000	50000

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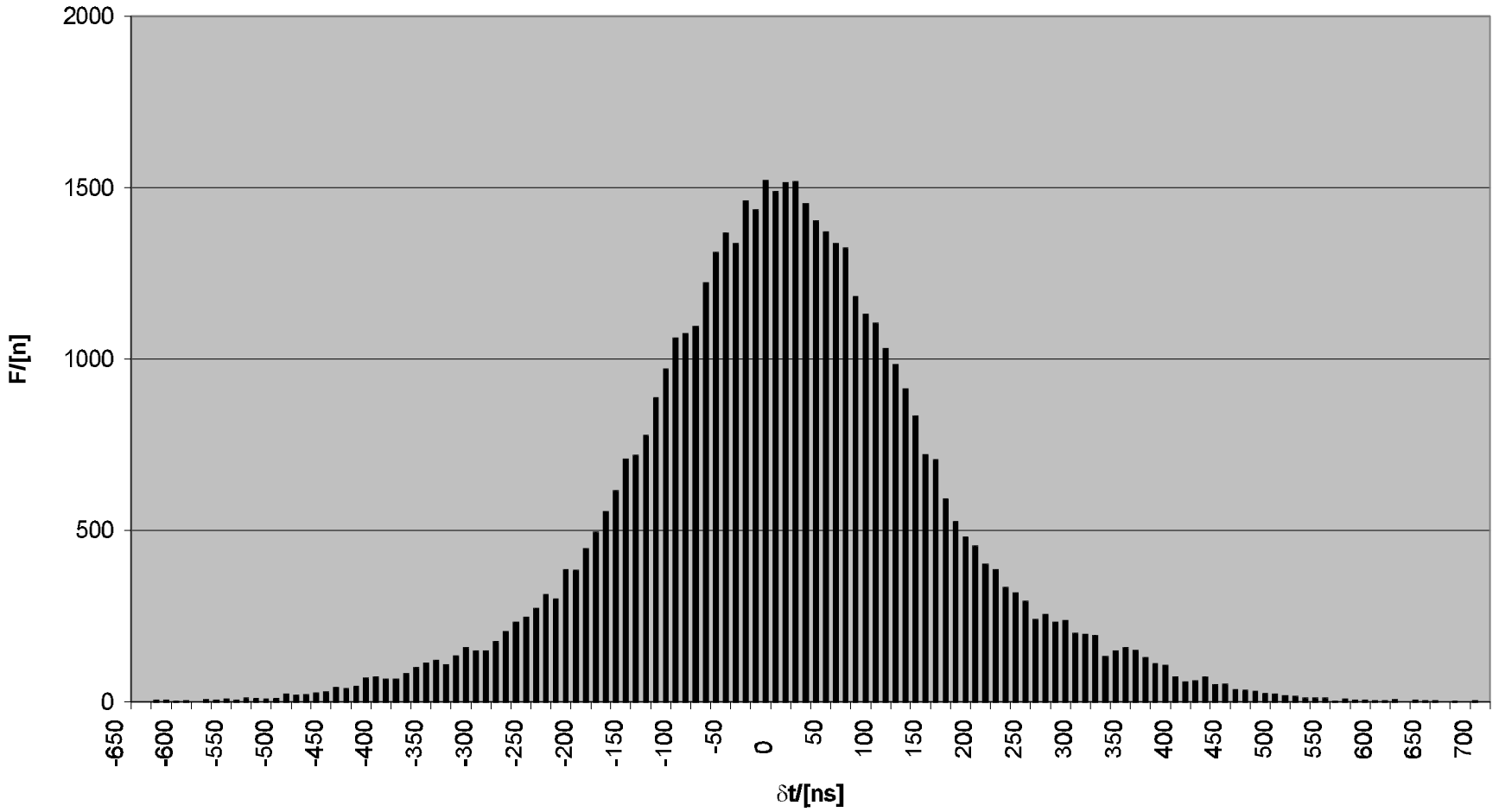
GPS for TimWG

Sys2000->GPS21, 50k meas, 10 ns bins, SA on. Oscilloscope.



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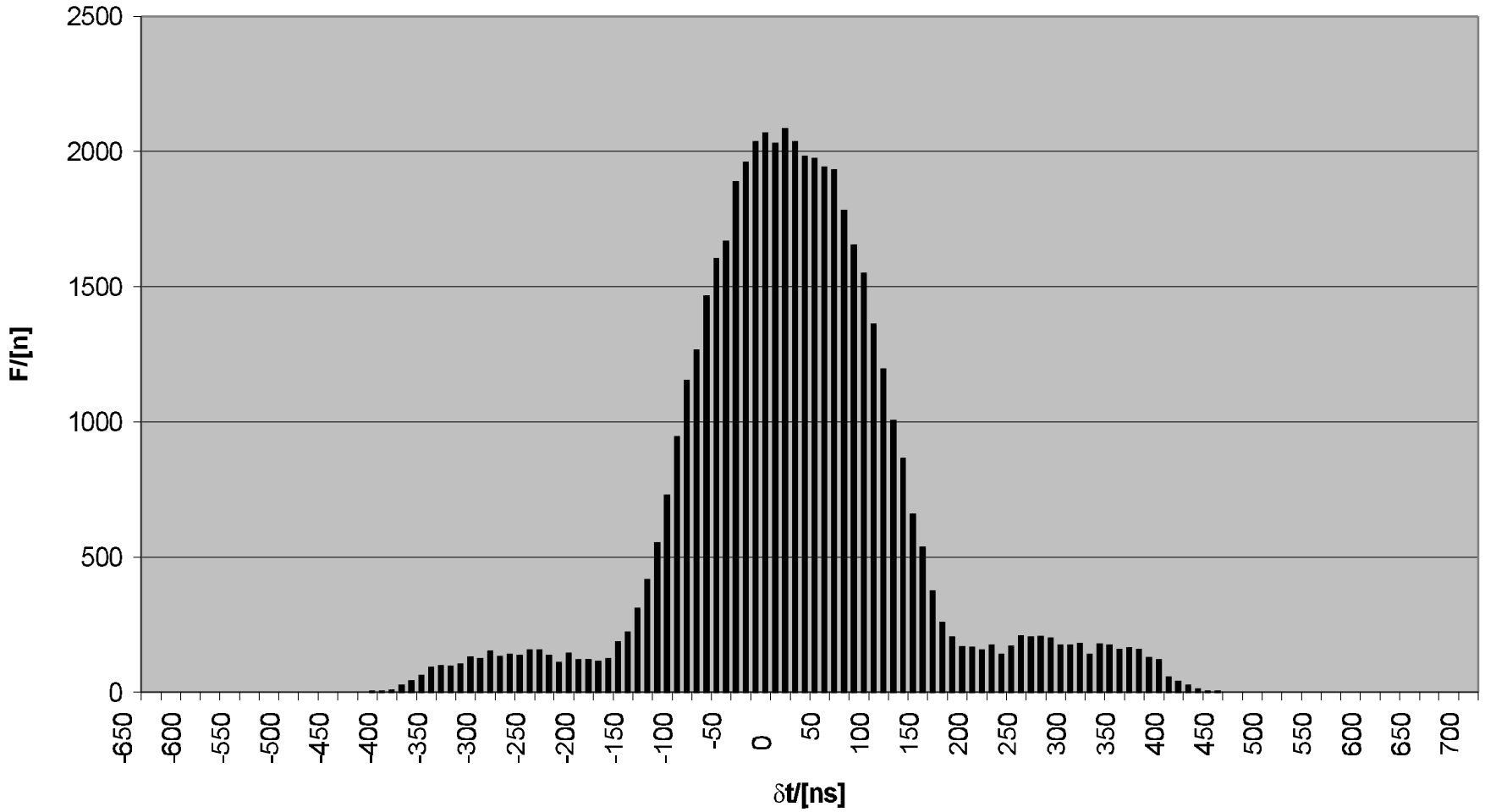
GPS for TimWG

Sys2000 -> GPS21, 50k meas, 10ns bins, SA off. Oscilloscope



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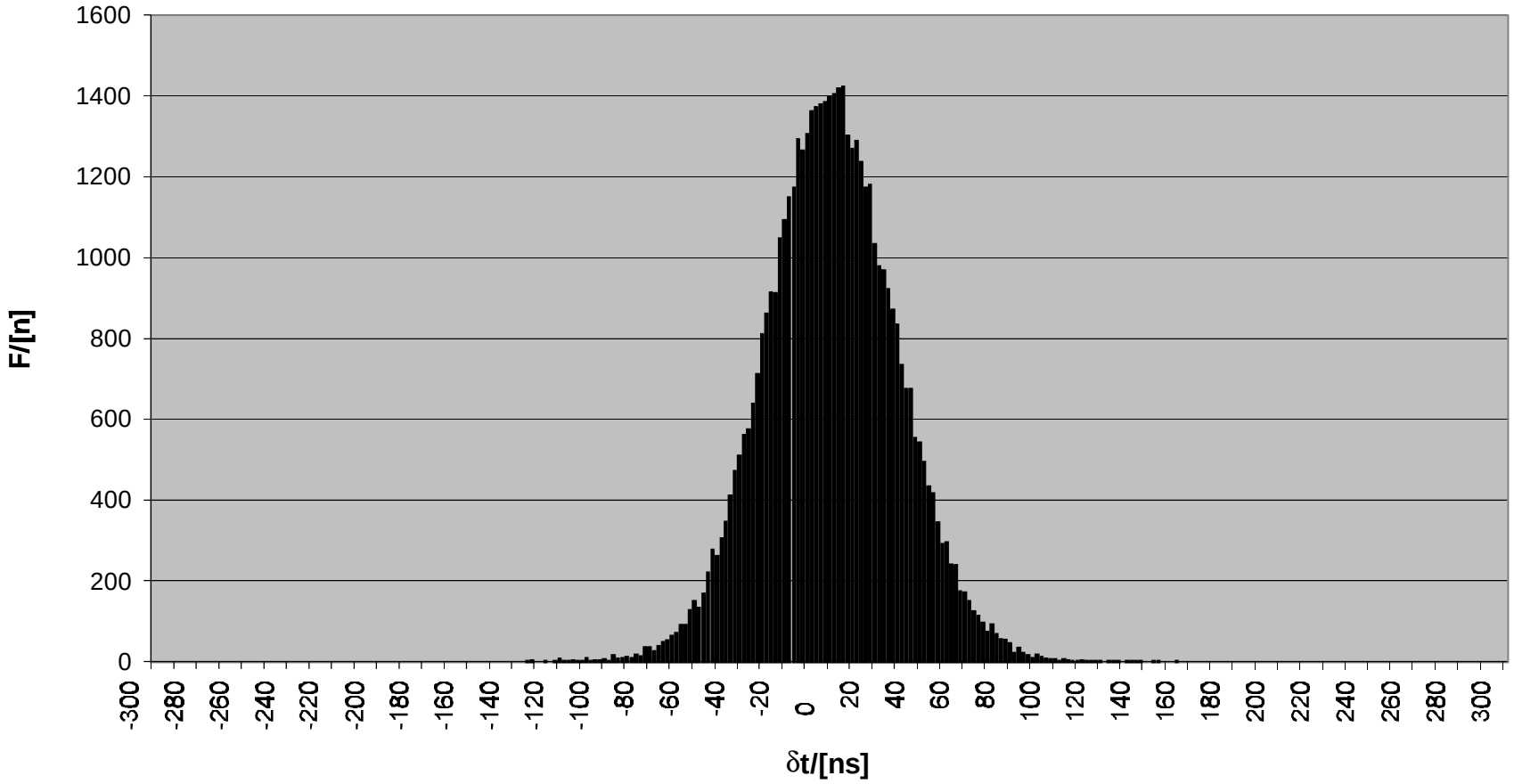
GPS for TimWG

Sys 2000 -> NovAtel, 50k meas, 10 ns bins, SA off. Counter



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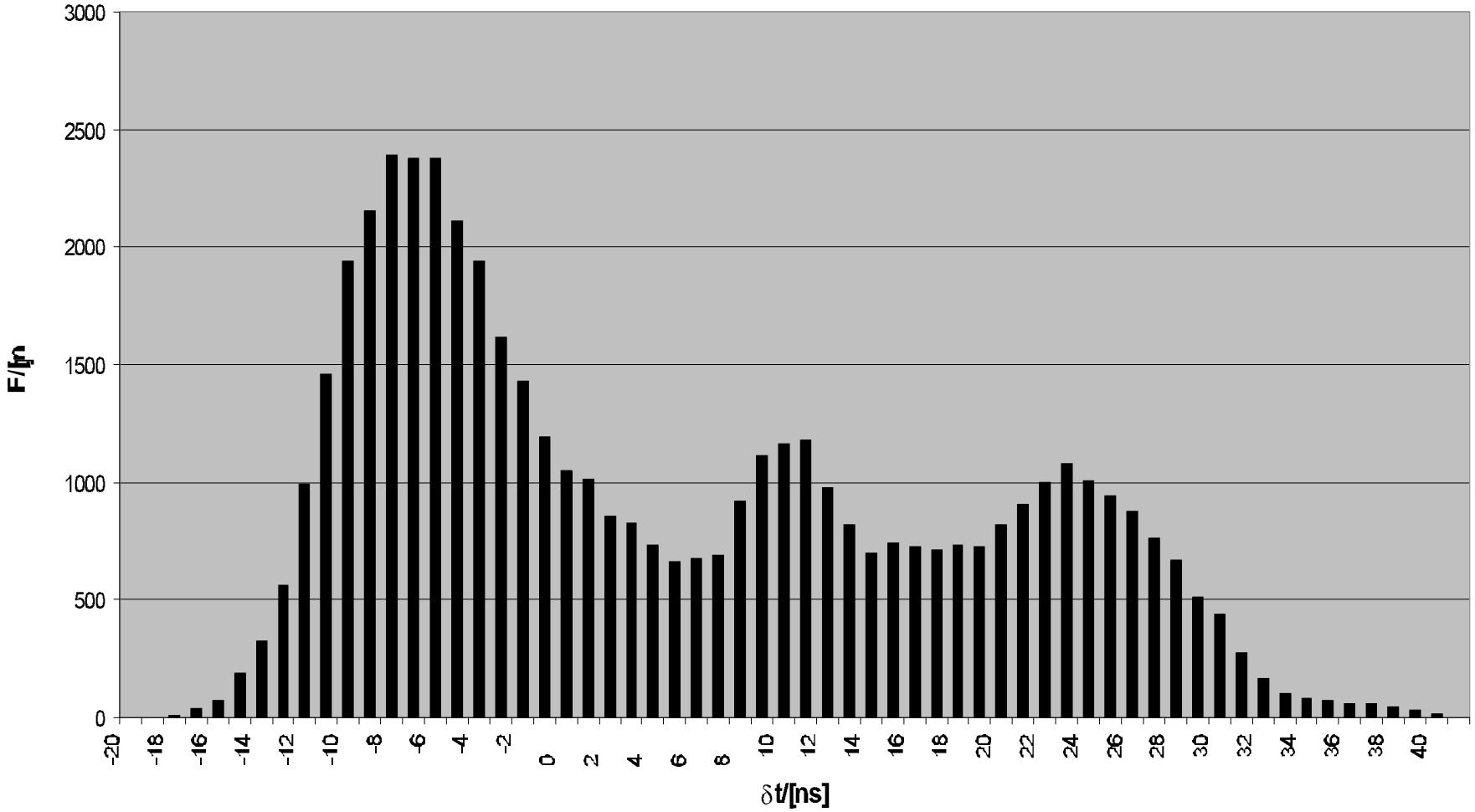
GPS for TimWG

System 2000 -> TimeSource 100, 50 k meas, 1 ns bins, SA off, counter



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GPS for TimWG

System 2000 as reference, SA off			
	TrueTime GPS	NovAtel	Symmetricom
Mean	345ns	1146ns	244ns
Median	340ns	1146ns	241ns
Standard deviation	121ns	29ns	13ns
Range	862ns	288ns	59ns
Minimum	-86ns	1011ns	220ns
Maximum	776ns	1299ns	279ns
Measurements	50000	50000	50000
Price (FS)	6000	3000	450

Conclusions

GPS

- Using present day commersially available GPS equipment one can quarantee a time of day referenced to UTC within less than 1 μs throughout the CERN complex.

Conclusions

IRIG-B

- Our tests have proven that using IRIG-B synchronised to GPS can provide a time referenced to UTC with a error of less than 2 µs.

Conclusions

Future

- GPS is evolving quickly
- Technology is progressing, price decreasing
- Evaluate the current systems now but wait before deciding on the specific LHC hardware