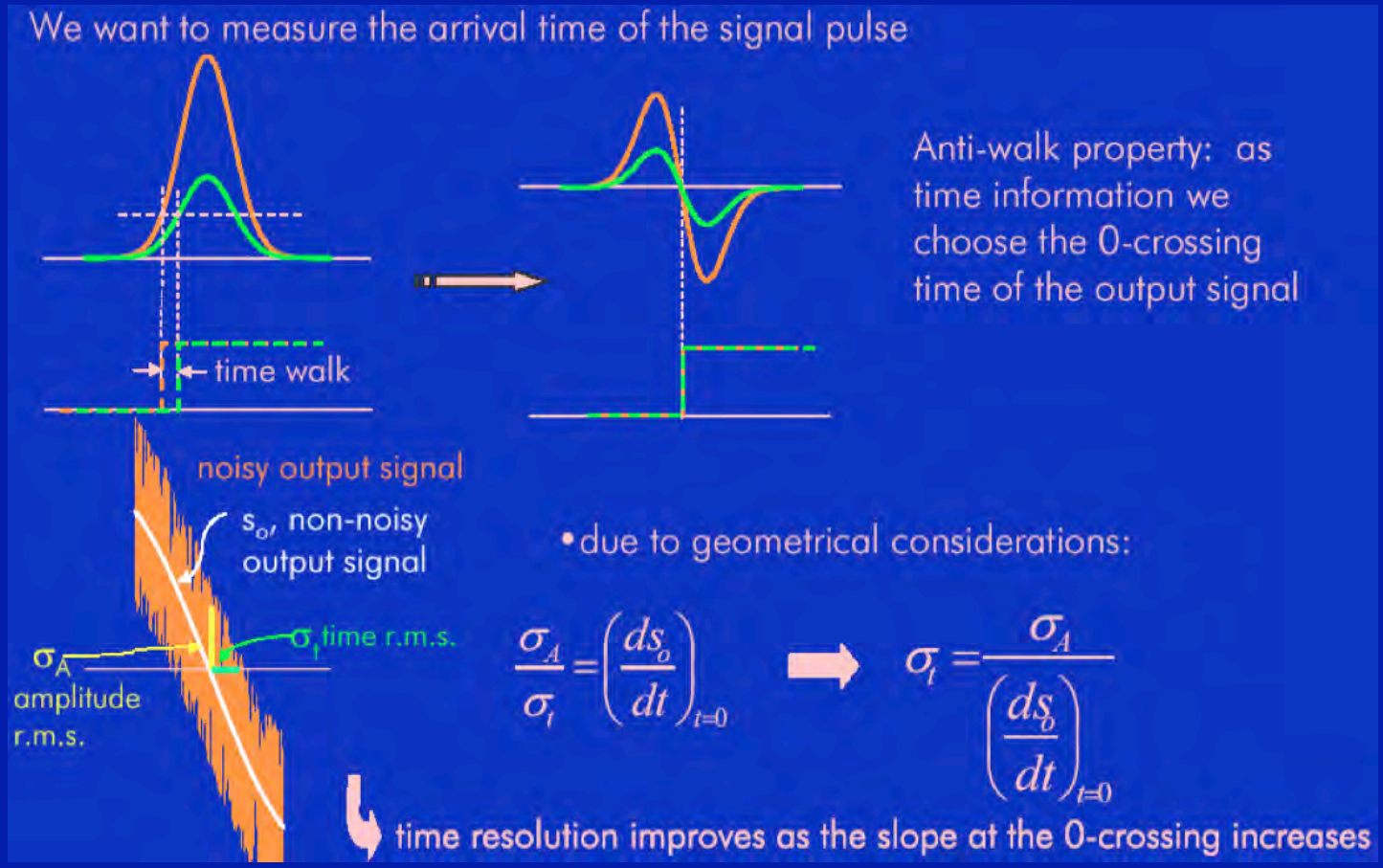
What BW do we need in practice for FDIRC ?

J. Va'vra

SuperB collaboration meeting in Elba, May 2012

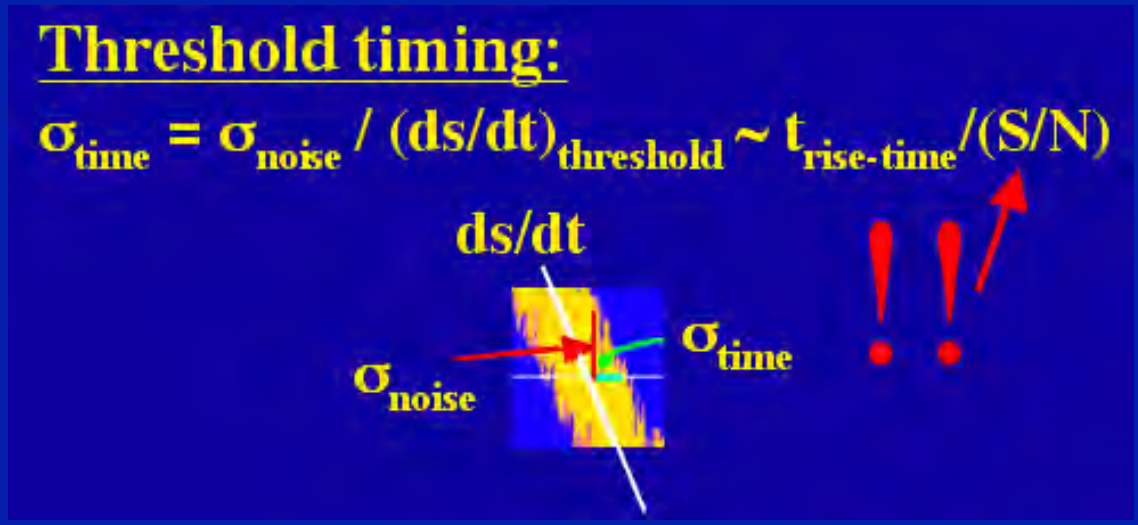
Error in timing measuement

V. Radeka, RICH 2004



- **The amplifier speed is important, but so is the amplifier noise!**

I would rewrite Radeka's equation as follows:



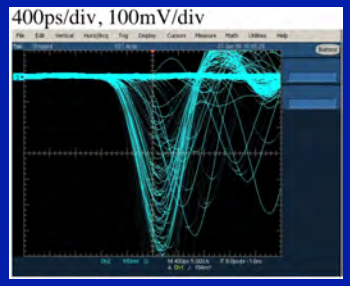
- **We often talk about BW only, but S/N is equally important !**

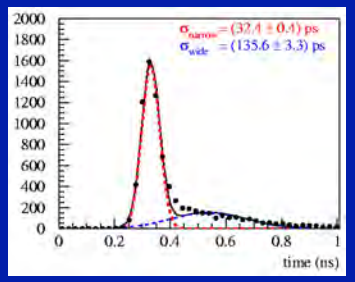
Single pe- results with 10μm-hole Photonis MCP-PMT

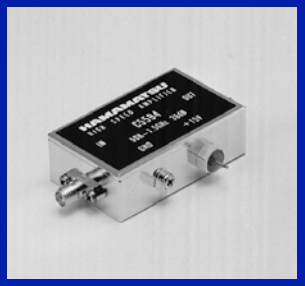
J.Va' vra, MCP-PMT log book 3

1) Hamamatsu C5594-44 amplifier, 1.5 GHz BW, 63x gain

(10 μm tube, 1ns SMA cable, patch panel, 2 ns SMA cable, amplifier, 40 ns BNC cable, **Philips 715 CFD**, CFD: 1 cm delay, LeCroy TDC)

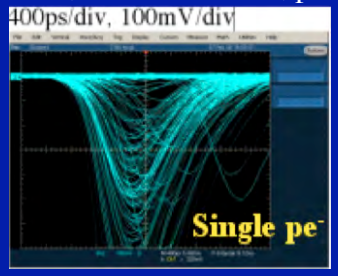


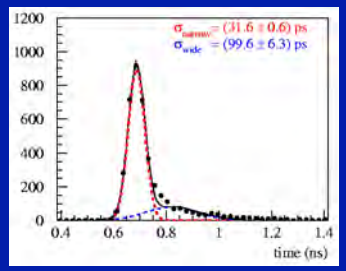




2) Ortec VT120A amplifier, ~0.35 GHz BW, 200x gain + 6dB (helps the noise reduction),

(10 μm tube, 1ns SMA cable, patch panel, 2 ns SMA cable, amplifier, 20 ns BNC cable, **Philips 715 CFD**, CFD: 1.5ns delay, LeCroy TDC)





PERFORMANCE

GAIN (10% gain tolerance on all versions):
A Version 200, noninverting.
B Version 200, inverting.
C Version 20, noninverting.

RISE TIME ≤1 ns.

NOISE ≤20 μV rms equivalent input noise.

BANDWIDTH 10 to 350 MHz.

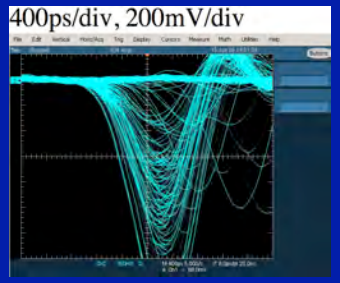
OUTPUT RANGE 0 to −5 V with 50- Ω load.

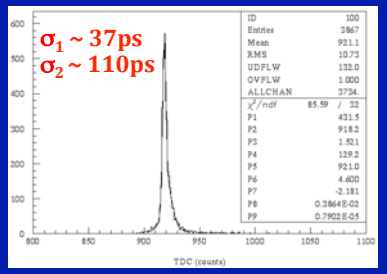
INPUT BNC connector; input impedance 50 Ω.

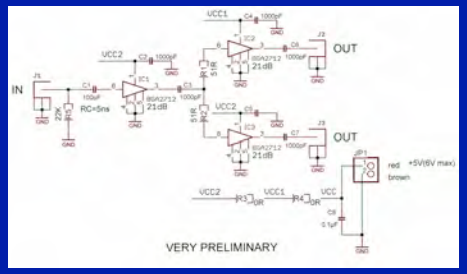
OUTPUT BNC connector; 0 to −5 V output with a 50- Ω load. Output impedance ≤1 Ω, ac-coupled.

3) Phillips BGA2712 amplifier, ~3.2 GHz BW, 10x10 = 100x gain

(tube, 1ns SMA cable, patch panel, 2 ns SMA cable, amplifier, 8 ns BNC cable, **Ortec 9307 CFD**, 1GHz BW scope)







Single photon timing resolution = f (amplifier bandwidth)

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Amplifier type	Amplifier bandwidth [GHz]	Total voltage gain	V_{pp} Noise/ Signal [mV]	CFD type	Resolution σ_{narrow}, σ_{wide} [ps]	Comment
Ortec VT120A + 6dB attenuator	0.35	100x	~1 / 450	Phillips 715	32 , 100	The best result
Hamamatsu C5594-44	1.5	63x	1-2 / 450	Phillips 715	32 , 136	Very good (a bit worse tail)
Ortec 9306	1.0	100x	~8 / 400	Ortec 9307	43 , 134	Not bad (worse S/N)
THS 4303 (Tandem of 2 chips)	~0.5	30-40x	~8 / 200	Phillips 715	47 , 120	Not good enough (fast, but bad S/N)
Philips BGA2712 (Tandem of 2 chips)	3.2	10x10		Ortec 9307	37, 110	Fastest amplifier I have tested

- In the "~30ps timing resolution domain" and for 10μm MCP-PMT, one can use somewhat slower amplifier if its signal/noise ratio is excellent !
- In this domain BW is not important

What happens if we increase Npe and timing resolution gets better ?

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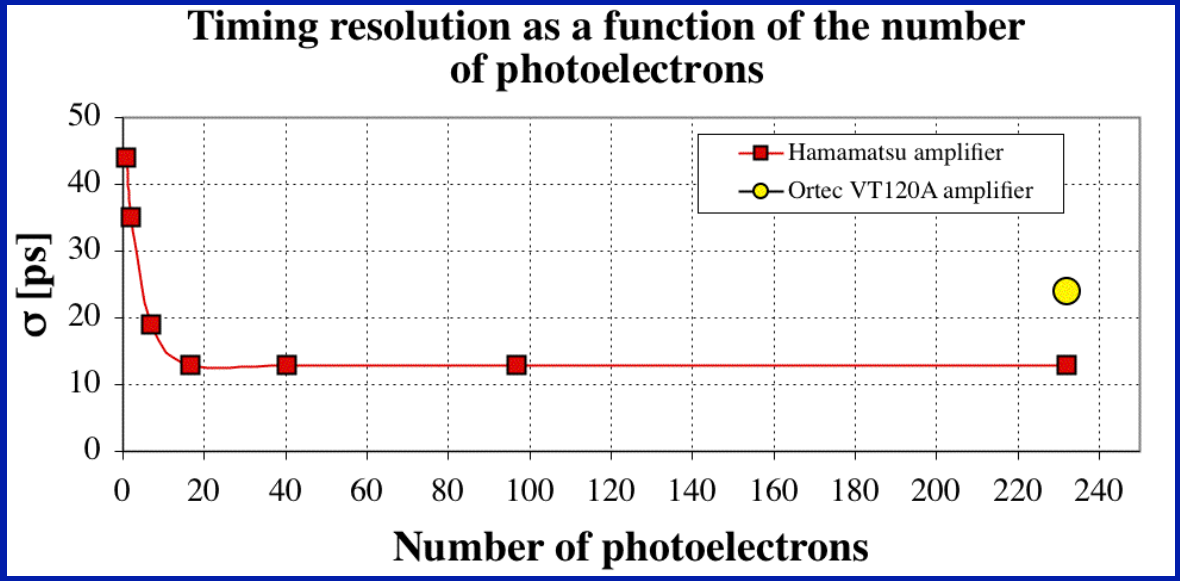
Hamamatsu **C5594-44** or Ortec VT 12- amplifiers, Phillips 715 CFD, CFD delay:1ns, LeCroy TDC

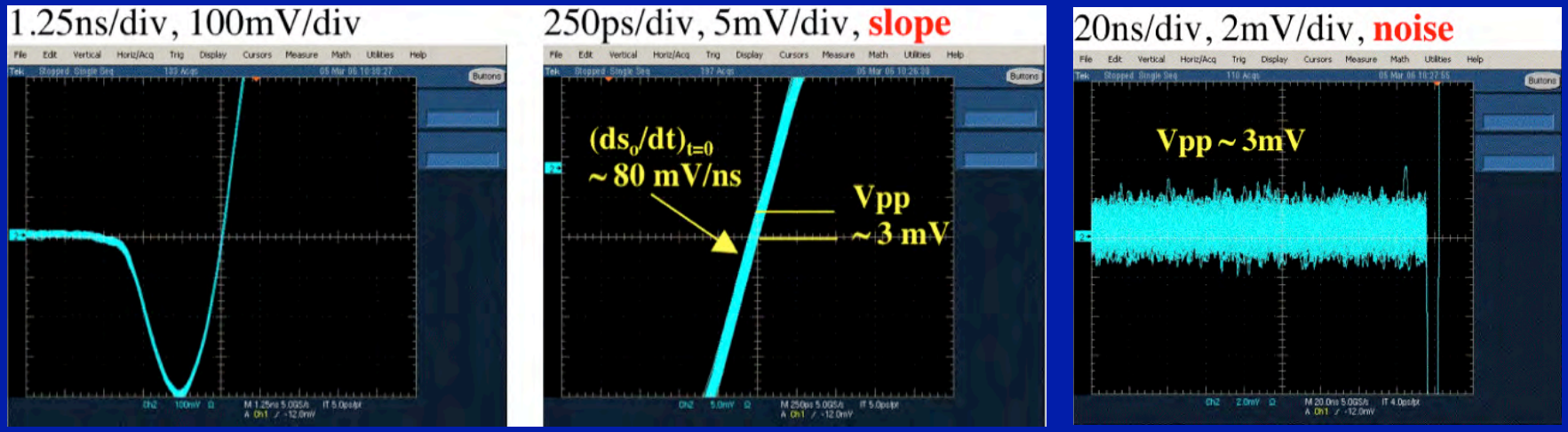


- Achieved σ ~12-13ps for N_{pe} >20.
- 10μm hole 64 pad Burle MCP-PMT 85012-501, -2.80kV
- Excellent result with the Hamamatsu C5594-44 amplifier
- Very similar results achieved with Ortec 9306 amp.
- However, with a slower VT120A, get worse resolution (σ >20ps).

=> In the "10ps timing resolution domain", the amplifier BW is <u>crucial to success.</u>

Continuing from the previous page: Let's see what our naive equation is predicting

Zero-crossing point (Hamamatsu C5594-44):



Hamamatsu amplifier (1.5GHz BW):

-Noise at the zero-crossing point: Vpp ~ 3 mV

- Noise at the zero-crossing point: $\sigma_A \sim Vpp/\sqrt{12} \sim 0.8$ mV
- Slope: $(ds_o/dt)_{t=0} \sim 40mV/500ps = 80mV/ns$
- $\sigma_t \sim \sigma_A/(ds_o/dt)_{t=0} \sim 0.8$ mV/(40mV/500ps) ~ **10 ps**

- With slower VT120A we obtained $\sigma_t \sim$ **17ps**

=> In a "10 ps timing domain" amplifier BW is important

Conclusion

- **In the "30ps timing resolution domain" the amplifier BW is not that important. It starts to be important in the "10ps timing resolution domain".**
- **For FDIRC, it is important to match the speed of the amplifier to the speed of the tube (you do not want to be much faster that the tube). In my opinion an amplifier with ~0.5GHz BW and good S/N ration is just fine for H-8500 tube.**