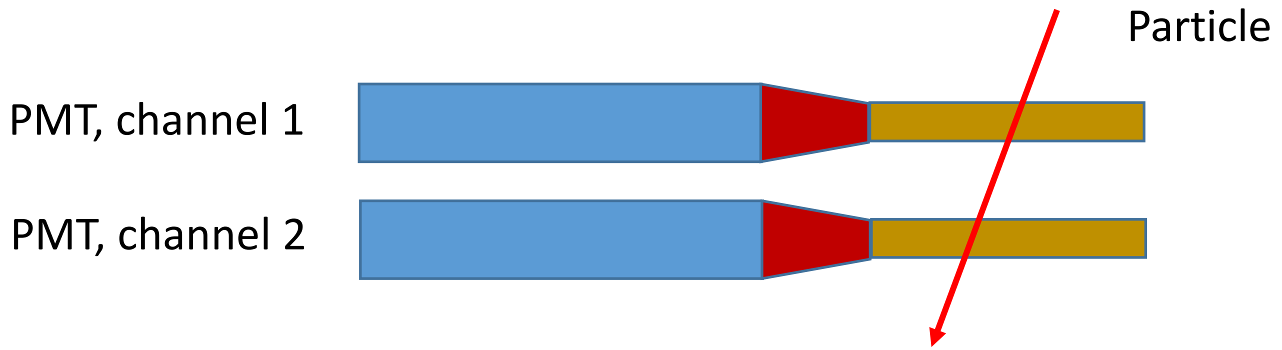
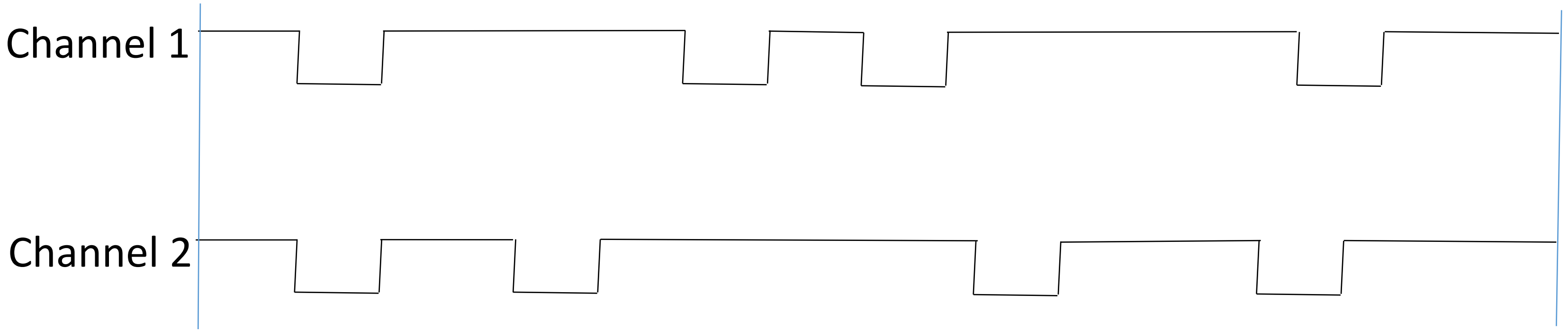
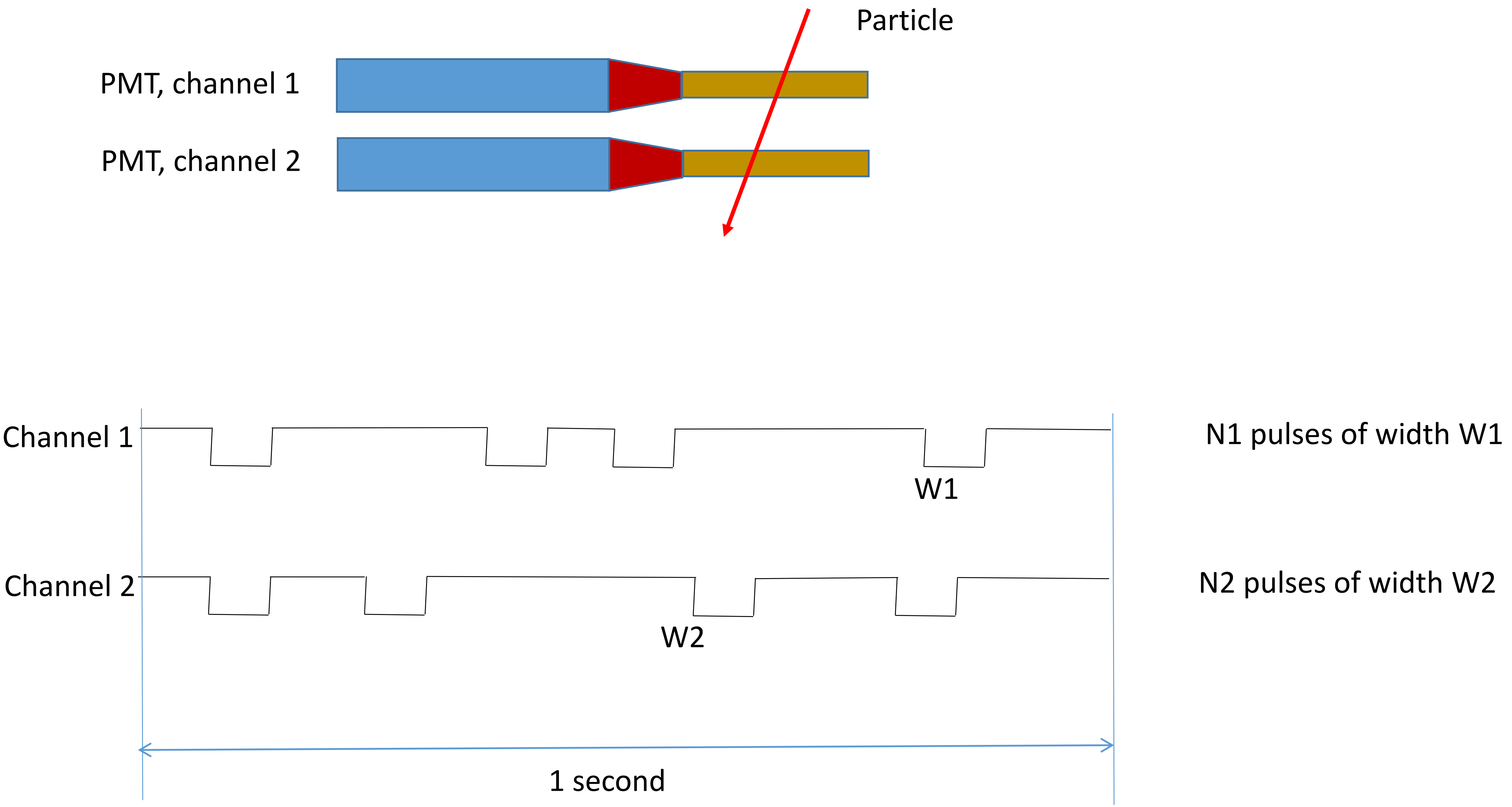




Challenge:

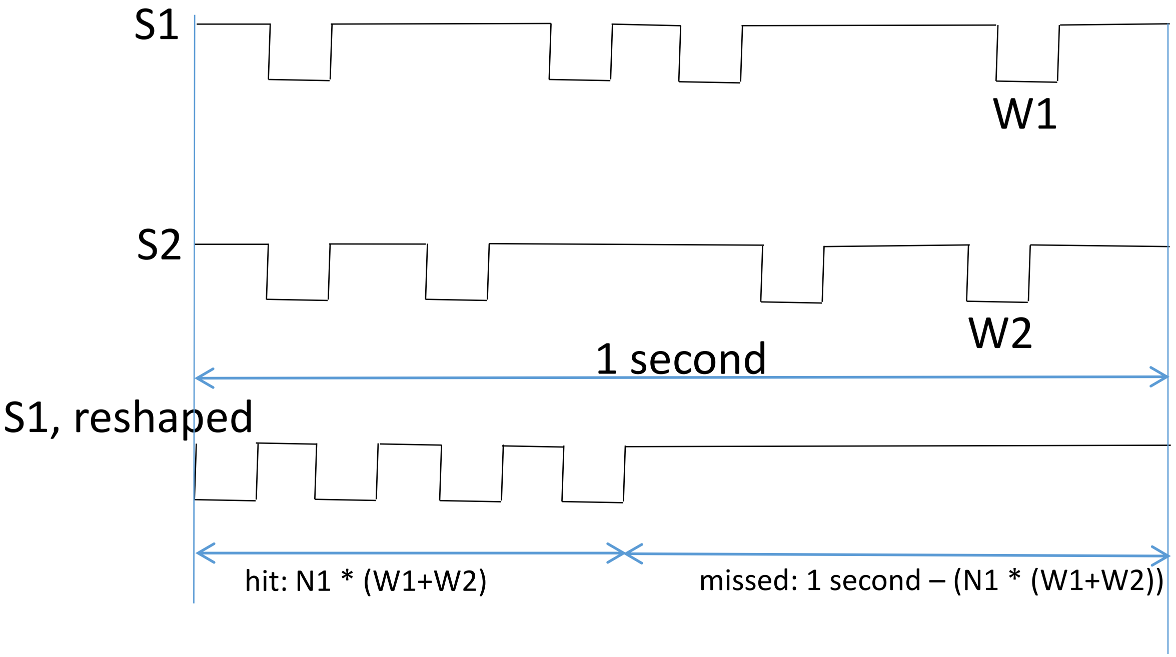
- Which parameters matter for the frequency of random coincidences?
- Devise a formula to compute the frequency of random coincidences
- How can the setup be modified to measure the frequency of random coincidences?


Particle
PMT, channel 1
PMT, channel 2
Channel 1
Channel 2
N1 pulses of width W1
N2 pulses of width W2
W1
W2
1 second

You can find an explanation of the random coincidence at these URLs:

http://oftankonyv.reak.bme.hu/tiki-index.php?page=Single+rate%2C+pile-up%2C+dead+time+and+random+rate
https://edu.caen.it/experiments/random-coincidence-2/
https://courses.washington.edu/phys433/muon_counting/statistics_tutorial.pdf

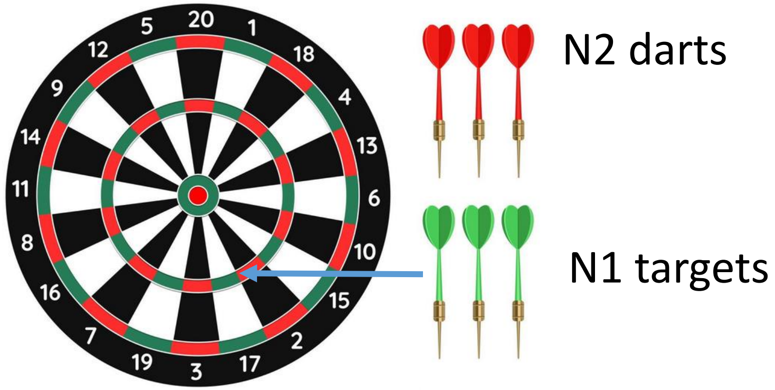
On the next slides you will see how I "visualize" the problem for myself in order to better understand it.



N1 pulses of width W1

N2 pulses of width W2

Step 1: we have 2 channels. We call channel 1 the “dart disk” and channel 2 the “darts”



Step 2: We cut the dart disk in pieces and assemble it in such a way that we have a large target area on the left and no target on the right

Step 3: We take one of the N2 darts and throw it at the disk. The probability for a hit is:

$$\frac{N1 * (W1 + W2)\ \text{ns}}{1000000000\ \text{ns}}$$

Example: with W1=W2=50 ns and N1 = 100 we get:

$$\frac{100 * (50 + 50)\ \text{ns}}{1000000000\ \text{ns}}$$

That is 10^{-5} random coincidences per second or one in 27 hours.

If we throw N2 arrows the probability will be proportionally higher:

$$P = \frac{100 * 100 * (50 + 50)\ \text{ns}}{1000000000\ \text{ns}} = 10^{-3}$$

This is one random coincidence every 1000 seconds.

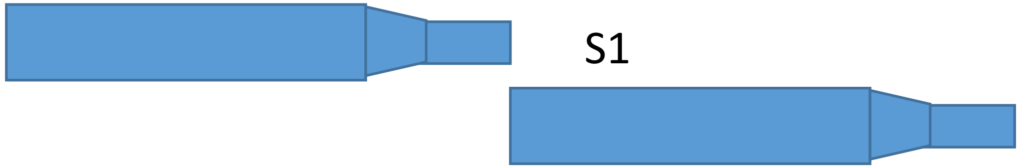
My formula and the formula cited in the papers on slide 3 are the same: N1 * N2 * (W1 + W2)

We still have to measure it. Lets imaging we have a detector made from 2 scintillators, one on top of the other. In a real experiment these detectors will see real particles (e.g. muons) and there will be noise on both channels.

S1

S2

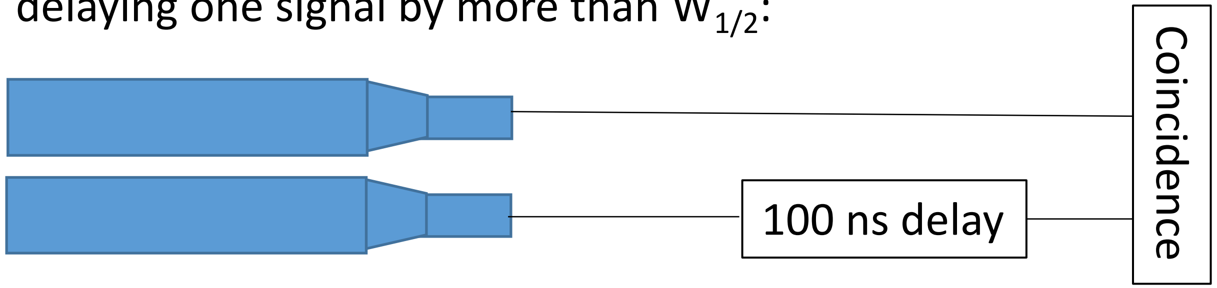
In order to measure the random coincidences, we have to get rid of the physical coincidences. The most simple solution would be separating the detectors:



S1

S2

This may not be possible with a real detector, but we can be smart and kill the physical coincidences by delaying one signal by more than $W_{1/2}$:



Due to the delay, the coincidence will not see the muons signals any longer at the same time (i.e. within the coincidence window) and the muons "disappear". The noise, however, will not notice the delay due to its random nature