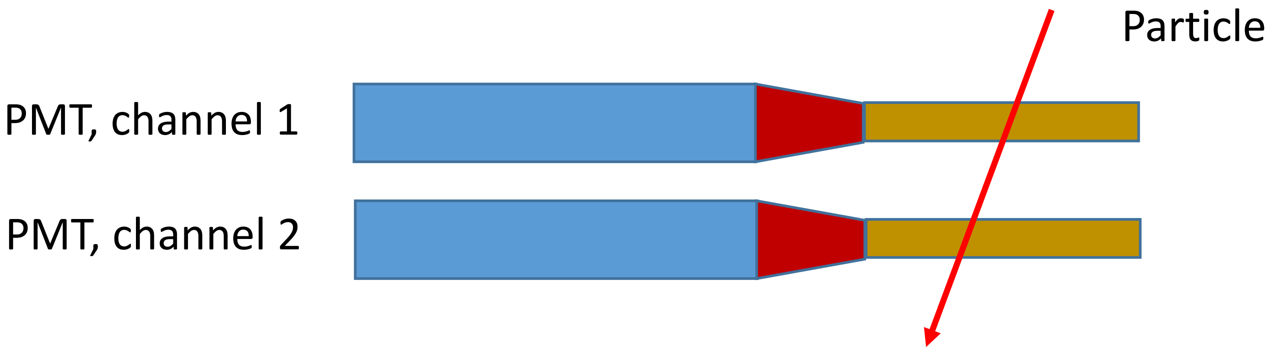
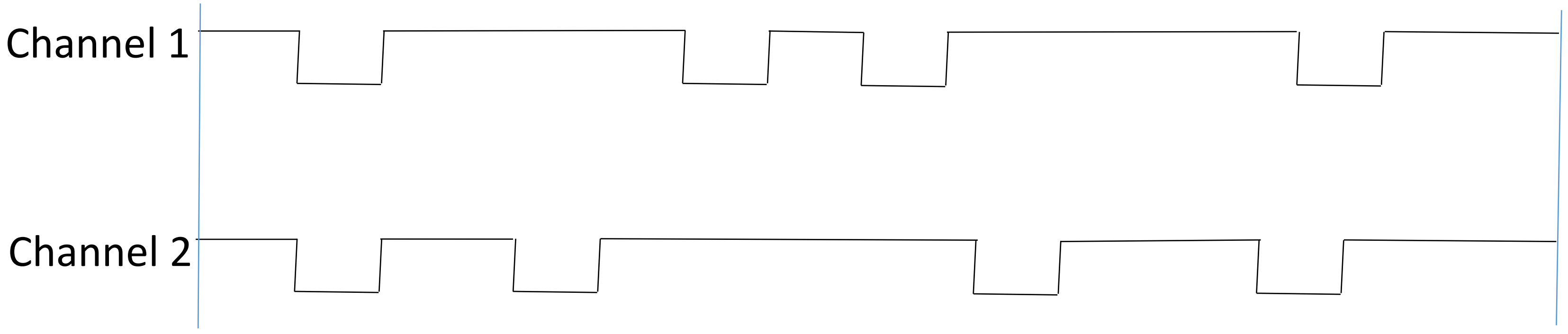
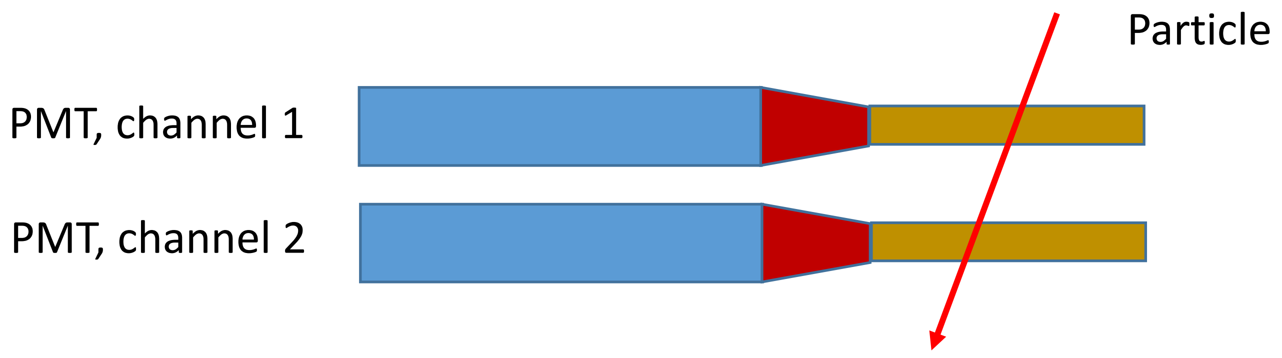
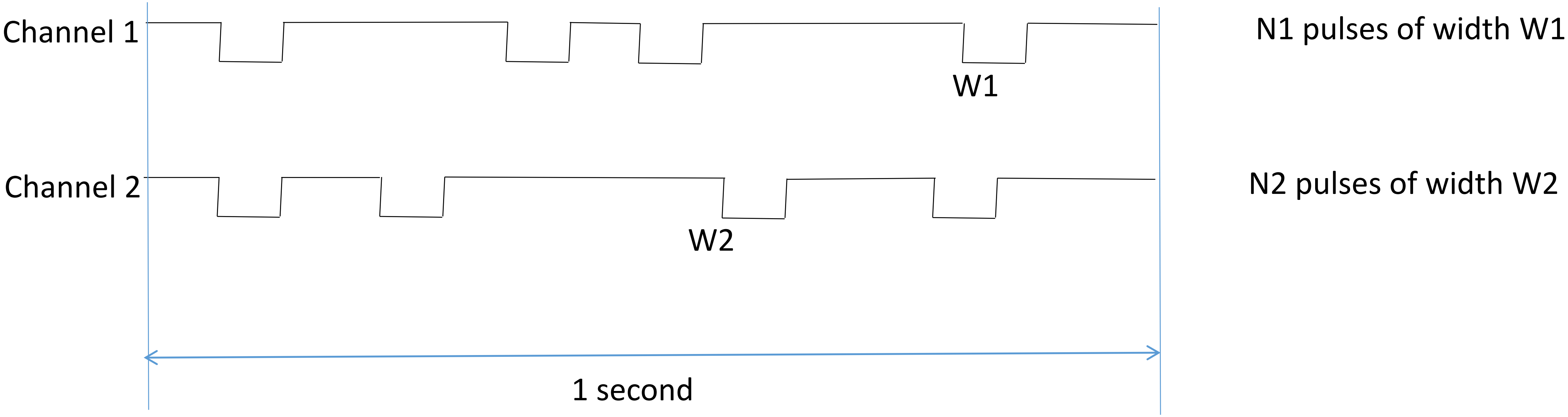


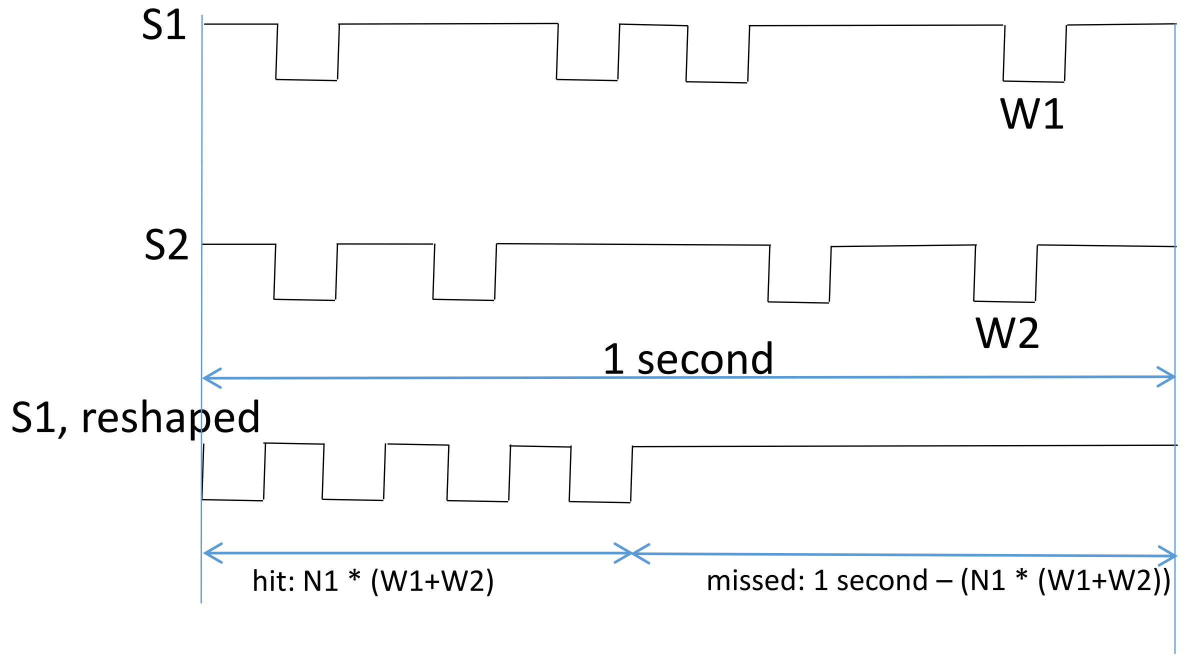




Challenge:

- 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

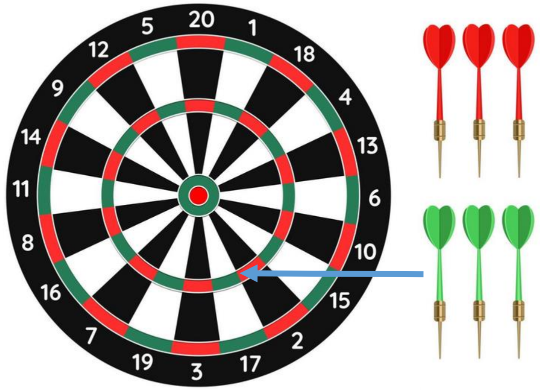

Channel 1
Channel 2
W1
W2
N1 pulses of width W1
N2 pulses of width W2
1 second




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"



N2 darts

N1 targets

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:

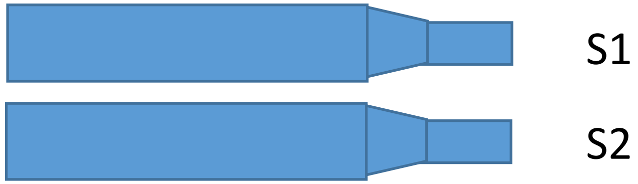
$$P = \frac{100 * 100 * (50 + 50) \text{ ns}}{1000000000 \text{ ns}} = 10^{-3}$$

This is one random coincidence every 1000 seconds.

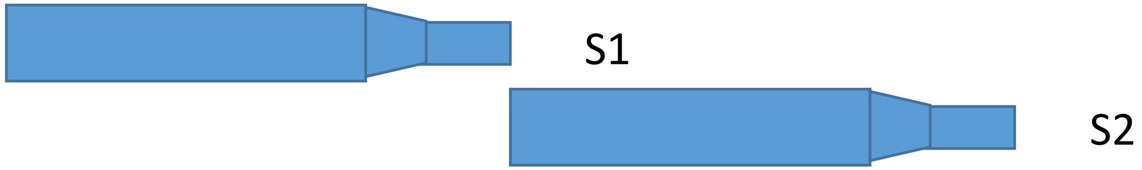
My formula for the rate (random coincidences per second) is: R = N1 * N2 * (W1 + W2)

See also: https://courses.washington.edu/phys433/muon_counting/statistics_tutorial.pdf

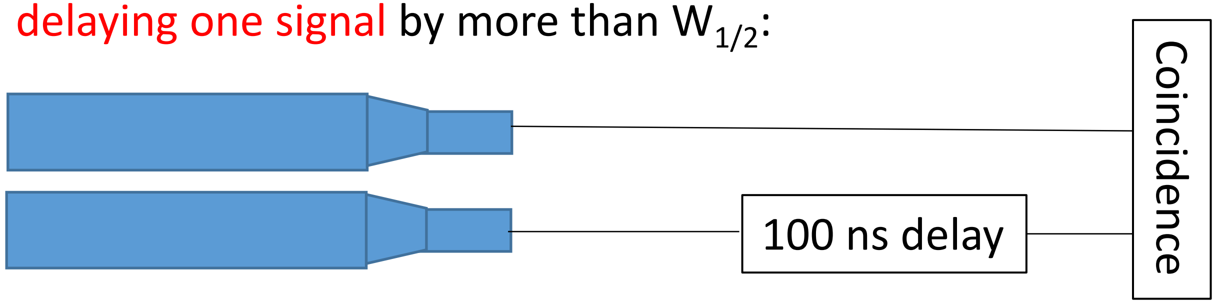
We still have to measure it. Lets imagine we have a detector made from 2 scintillators, one on top of the other. In a real experiment these detectors will see real particles (e.g. muons) and there will be noise on both channels.



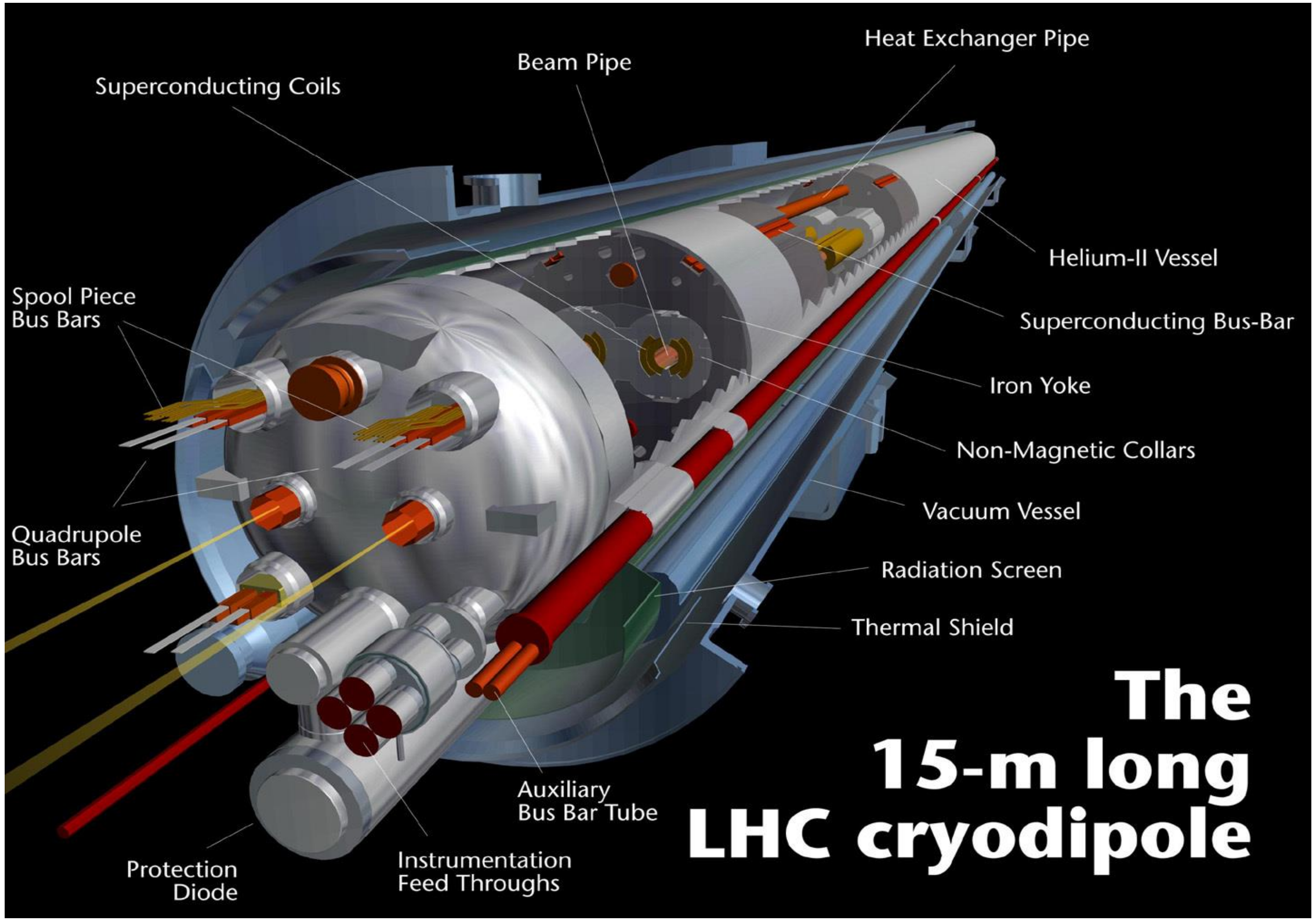

In order to measure the random coincidences, we have to get rid of the physical coincidences. The most simple solution would be separating the detectors:




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


Heat Exchanger Pipe
Beam Pipe
Superconducting Coils
Helium-II Vessel
Spool Piece
Bus Bars
Superconducting Bus-Bar
Iron Yoke
Non-Magnetic Collars
Vacuum Vessel
Quadrupole
Bus Bars
Radiation Screen
Thermal Shield
The
15-m long
LHC cryodipole
Auxiliary
Bus Bar Tube
Protection
Diode
Instrumentation
Feed Throughs