TOF-PET Brain Imager : Estimate of the Trigger and DAQ Rates

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Trigger Counting Rates: Single Photons

- typical PET injection: 15mCi = 400MBq = $4 \cdot 10^8$ decays per second
- after injection radiactive tracer gets distributed over the whole body
- assume 100% acceptance for a full body imager of 1m,
- brain imager ring of 4cm would detect 4/100 of the total counting rate

$$r = 16 \cdot 10^6 \simeq 20MHz$$

- Current design has 36 boards —> 500 KHz per board
- only about half $(1 - (2/3)^2)$ of all decays have at least one photon out of the patient's body —> additional reduction by a factor of about 2.
- 250 KHz per board. On average, $4\mu sec$ between the 2 trigger signals coming from the single board. **This rate determines the trigger requirements**
- 30 kHz per DRS4 channel –> $30\mu sec$ between the events
- the time is roughly the same as the DRS4 readout time for 1024 channels at 33MHz

Trigger Counting Rates: coincidence events, or "doubles"

- about $4/100 * 410^8 \simeq 210^7$ *decays* per second can result in coincidences
- 1/9 of them have both photons out of the body
- the two photons go back-to-back, so the brain imager acceptance $A \simeq 4/(12.5\pi) \simeq 0.1$
- resulting rate of "doubles", the coincidence events:

$$r = 2 \cdot 10^7/10/10 \simeq 2 \cdot 10^5 \;=\; 200\ KHz$$

- for the fully efficient trigger this would be the aqcuisition rate
- this is 5 KHz per board and about 0.6kHz per channel

DAQ Rates

- DRS4: 12bit / cell
- assume that read only 2 signal channels and two trigger channels
- readout: 100 ns window is enough, at 5 GHz sampling rate it is 500 cells
- event size: 4*500*1.5 bytes = 3 KBytes
- DAQ data rate: $3 \text{ KBytes} * 2 \cdot 10^5 \text{ events/sec} \sim 600\text{MBytes/sec}$
- 2 GHz sampling rate: 200 cells, 1.2 KBytes / event, DAQ rate - 240 MBytes/sec
- 1 GBit ethernet line saturates at about 60 MBytes/sec, need at least 4 lines