Thoughts on Photodetection Options for IOTA

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Required Input to Find Optimal Solution

- Expected photon rate
  - I assume it’s low (e.g. <1kHz)
- Maximum allowed dark count rate (photo-cathode induced noise)
- Expected wavelength range
  - My current assumption is ~1000 nm now and ~500nm later
- QE
  - I assume that 5-30% is acceptable
- Required position resolution
  - 1/400, i.e. ~100μm for PLANACON-size device and 0.5-1mm for LAPPD-size
- Required timing resolution
  - Doesn’t seem to be important (but is, for example, 100ns OK?)

Option 1: LAPPD with properly working 60-channel readout electronics

Expect ~700μm position resolution over 20x20cm (also single PE timing is ~50ps)

Cons:

- Visible light only - can not be used for IR photons
- Larger dark box is needed
- Electronics is not ready yet

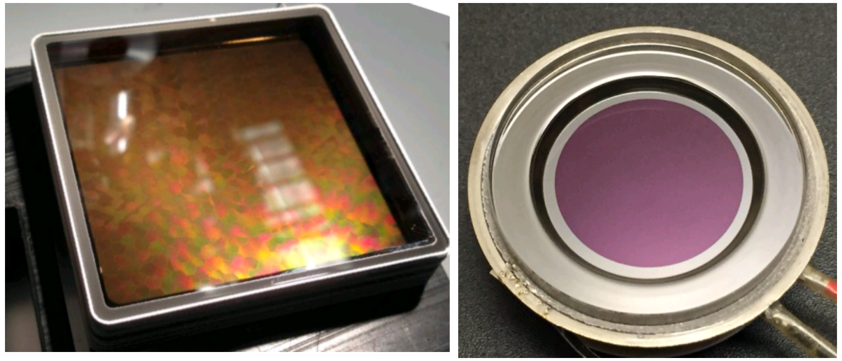
Pros:

- There are several LAPPDs already at Fermilab
  - E.g. Tile-51 was purchased from Incom with IOTA in mind
- Huge progress on electronics over the last month
  - Evan Angelico has done great job
  - The same electronics is needed for ANNIE (now a dedicated firmware expert is working on it in UK)
  - The same electronics is needed for the TOF setup at the TestBeam

I believe this is the fastest option IF visible light photons were available now

Option 2: Acquire PLANACON-type device with cross delayed line anode (4 channels) through SSL Berkeley or Photonis

Expect <100μm position resolution over 5x5cm (timing varies)



Cons:

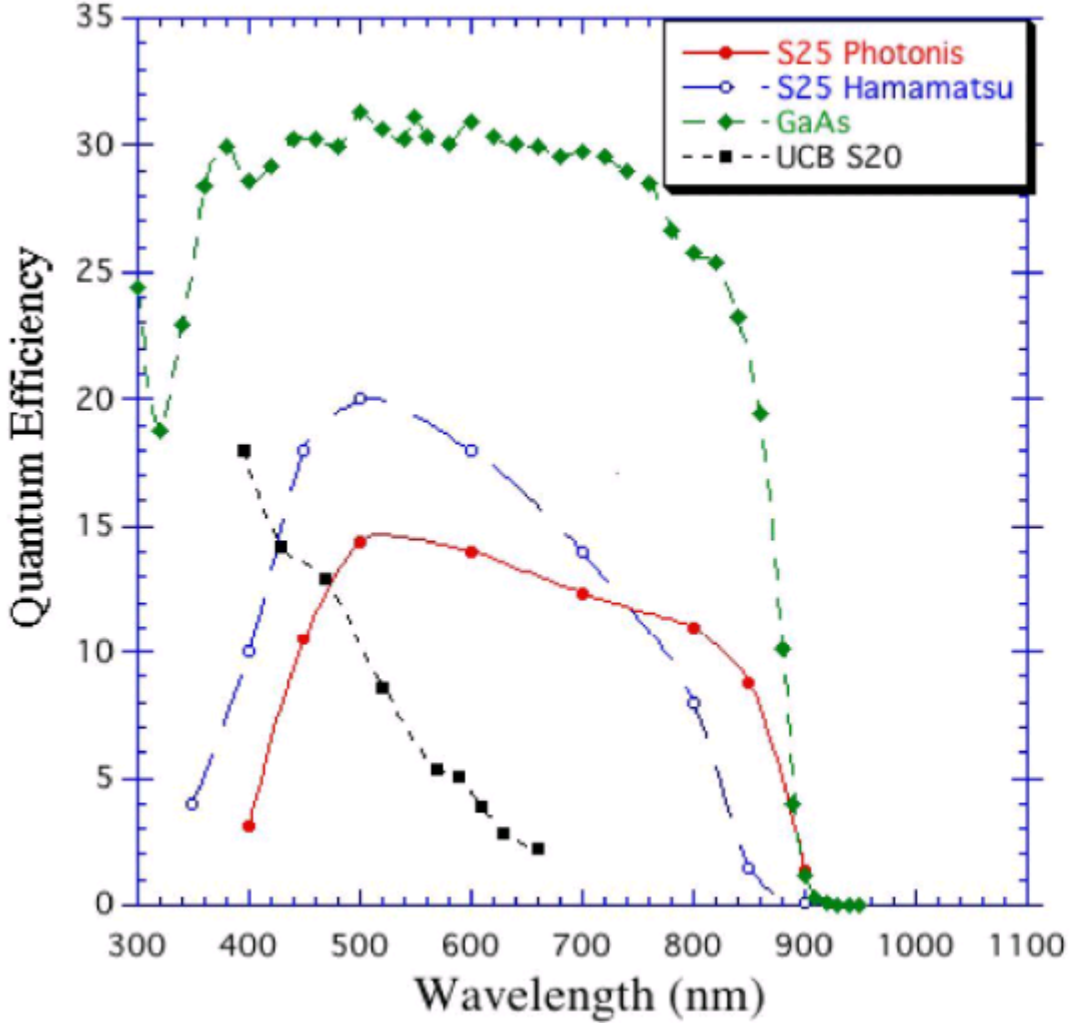
- Could be expensive to get (working on estimate)
- Potentially a long lead time order (will find out)

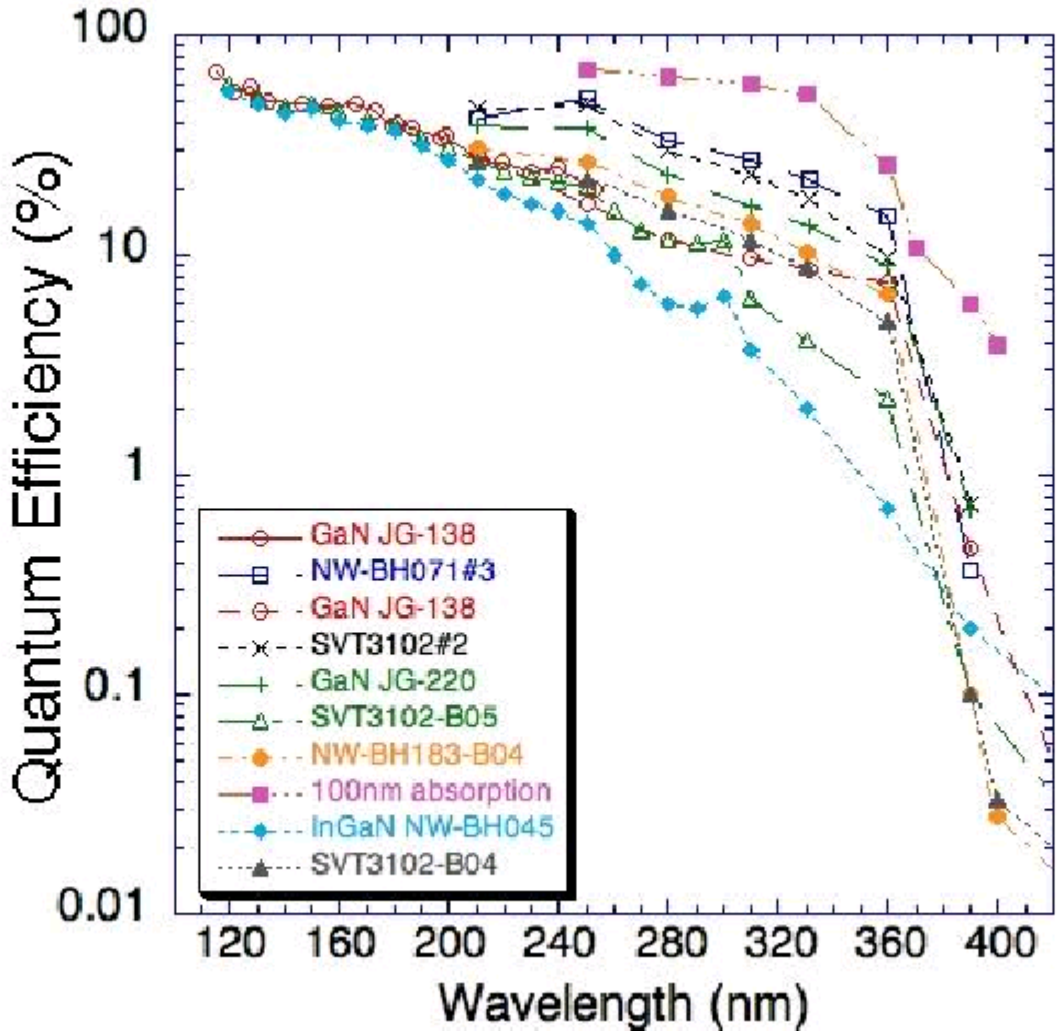
Pros:

- Available in red and IR light
- Smaller footprint for the dark box
- Low number of electronics channels (e.g. 4)
- Several ‘identical’ modules can be ordered

I believe this is the best option for red and IR photons

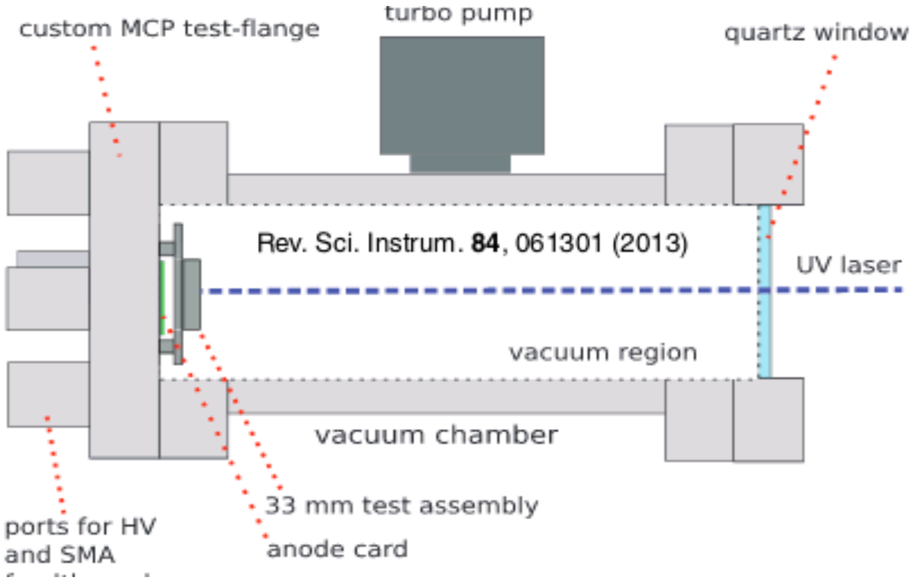
Examples of photo-cathodes for the Option 2:





Option 3: An actively pumped vacuum chamber with 2 Quantar sub-modules consisting of MCPs + the “four-corners” resistive anode. A custom Cs-Sb photo-cathode would be synthesized separately by UC ‘air-transfer’

Expect <100μm position resolution. Sub-module active area is ~3cm in diameter.



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Cons:

- Photo-cathode synthesis is tricky…
  - QE won’t be high at the first try
  - Unexpected delays are common when starting from scratch
- Won’t be cheap (but it’s money for on-site labor)
- Larger footprint for the dark box

Pros:

- Could be a perfect match to UC goals to bring ‘air-transfer’ process to Fermilab
- Tunable and adjustable if the requirements change
- The ‘four-corners’ resistive anodes + MCP stack are available commercially
- Low number of electronics channels

This would be very exciting for me, but it may not be the best option for IOTA