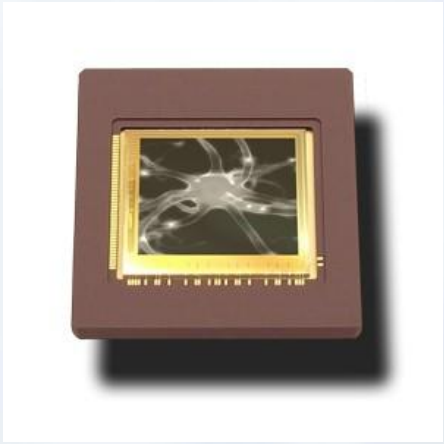
PHOTONIS | INDUSTRY | SCIENCE | MEDICAL

Photodetectors of PHOTONIS

Serge Duarte Pinto

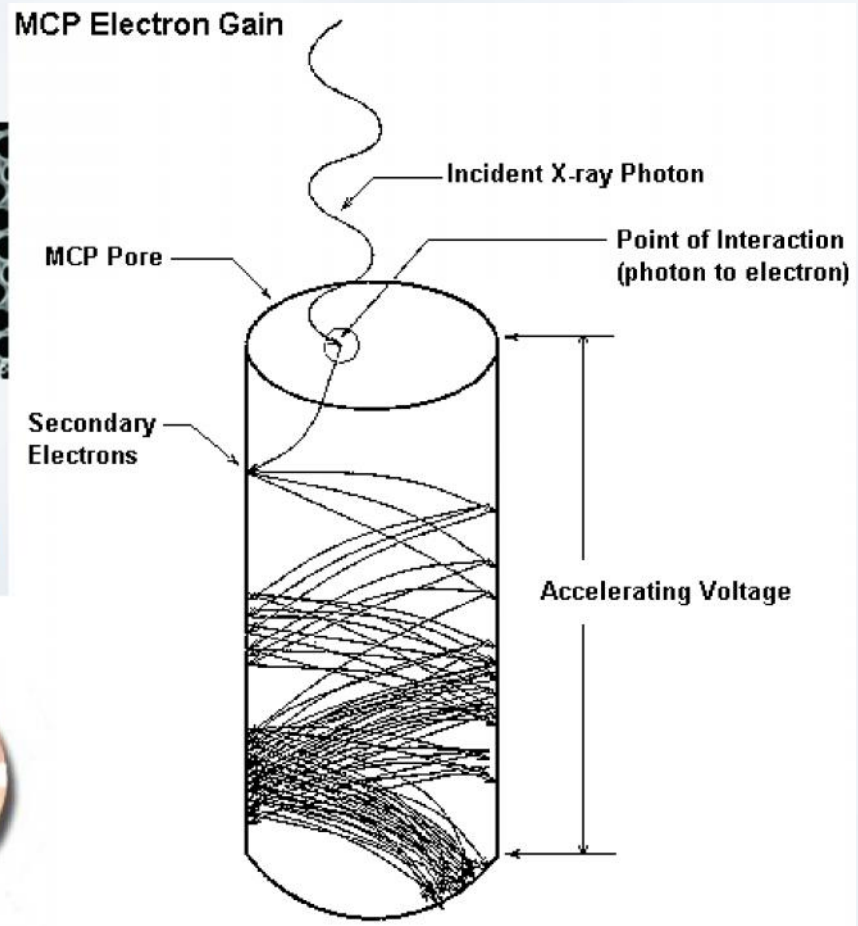
Overview of photodetection techniques

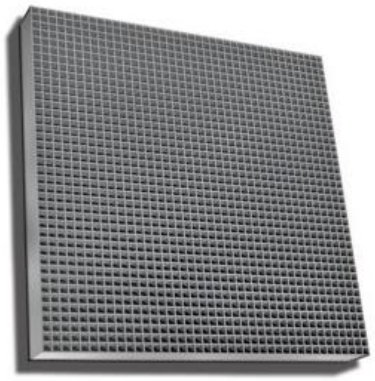
- Planacon family of square shaped photodetectors
- MCP-PMTs
- Photon (or ion) beam imagers
- Image intensifiers, fast gating
- Streak tubes
- Hybrid photo diodes
- Electron-bombarded CMOS

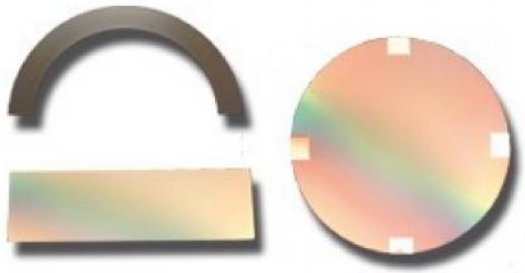


Microchannel plates

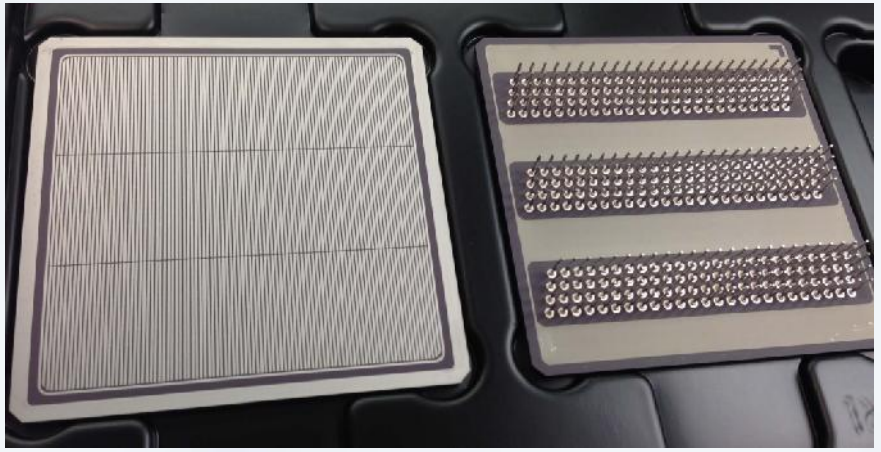
- Each channel is a continuous dynode chain: charge multiplication by typically a factor 1000
- Pore sizes 25 µm down to 2 µm
- Can be made in all sizes and shapes
- Transfer time spread ~10 ps
- Square channels and curved plates for collimation and focussing







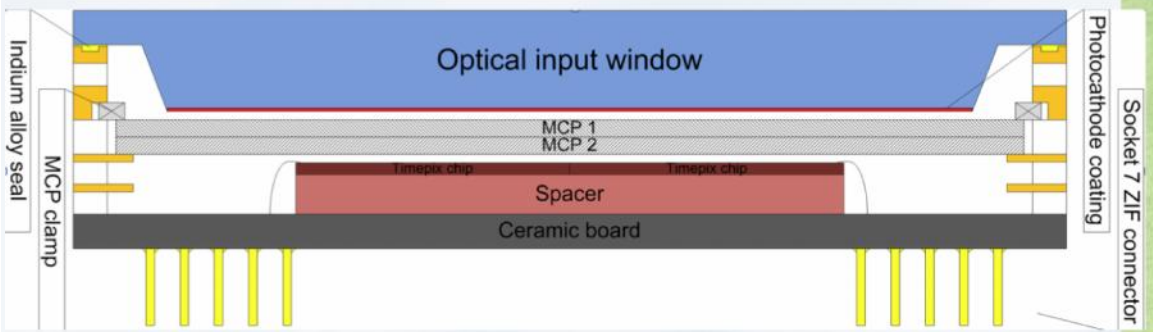
Planacon family of square shaped photodetectors

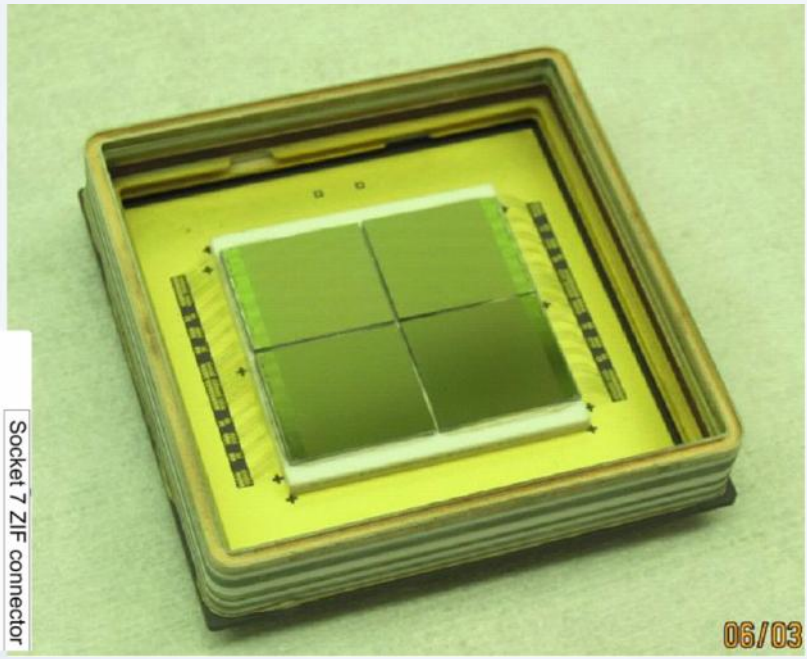


- 2” and 1” square versions
- 25 µm and 10 µm MCPs
- Tight package: 81% active area
- Various anode options: pads, strips
- Last few years: cathode lifetime improvement to ~10 C/cm^2
- Today: optimizing quantum efficiency
- Applications: Cherenkov detectors (RICH, DIRC, ToF), scintillator readout, imaging …
- Cathode and anode gaps can be reduced to improve time resolution and channel separation

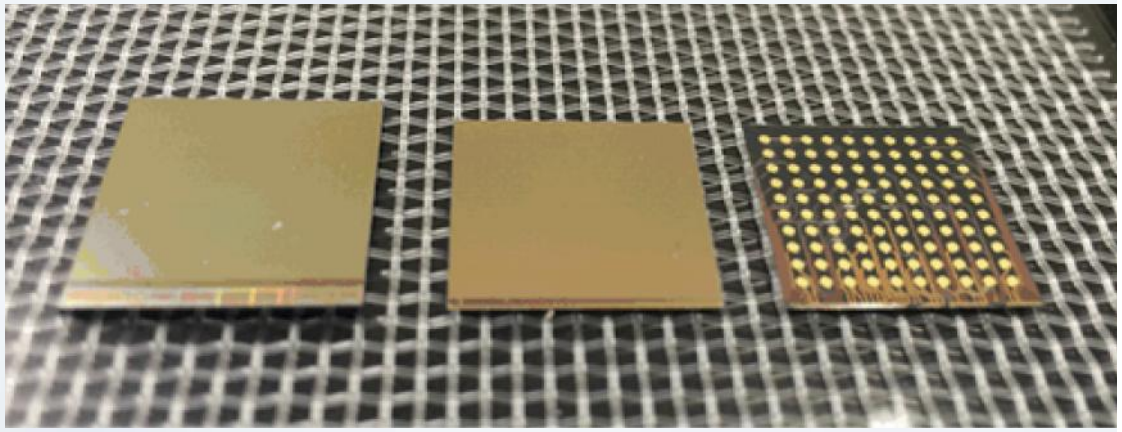
Planacon with quad Timepix readout

Work done in collaboration with UCB and CERN





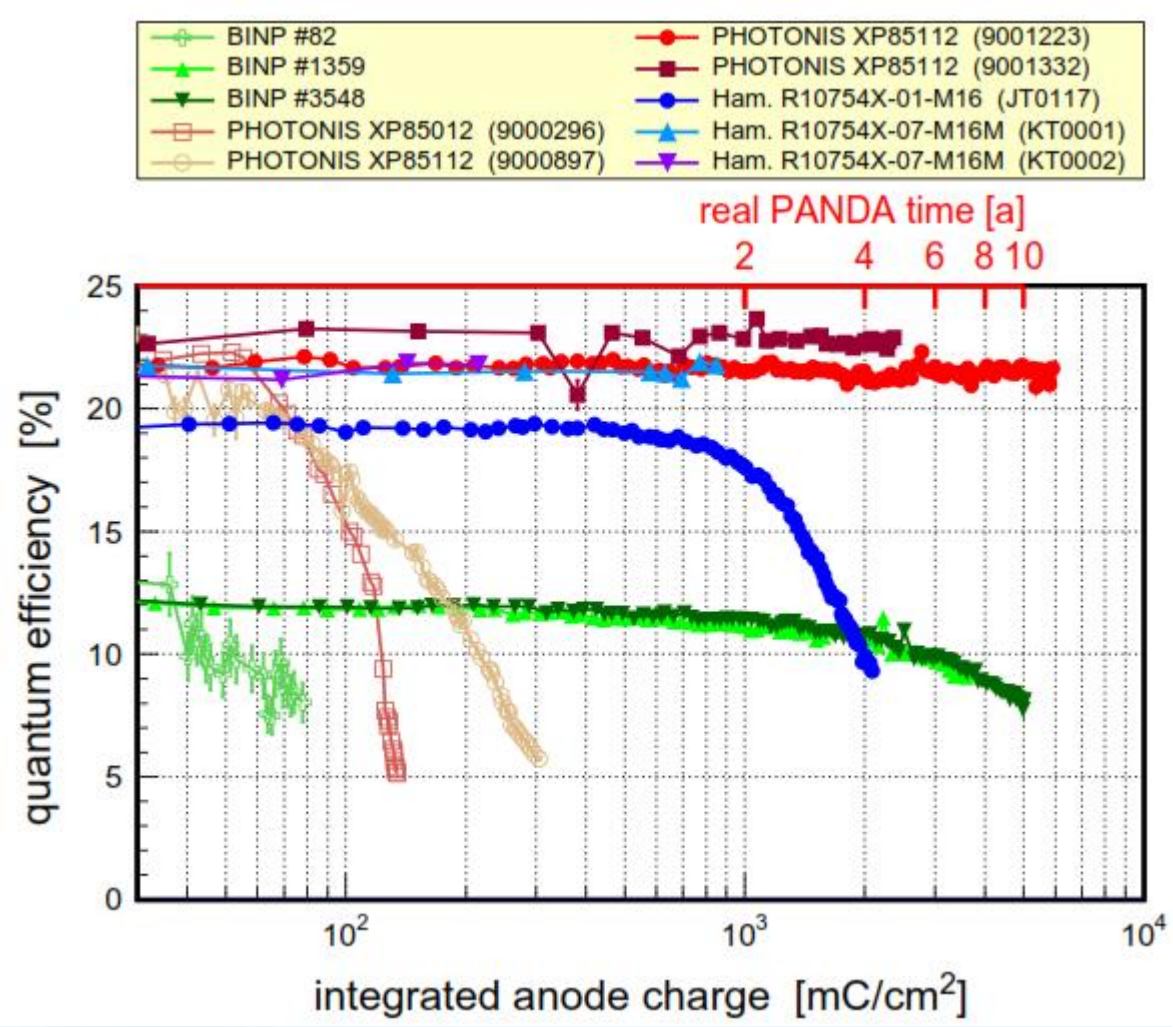
With Timepix3 and through silicon vias (TSV) 9 chips would fit in a body



Planacon lifetime studies

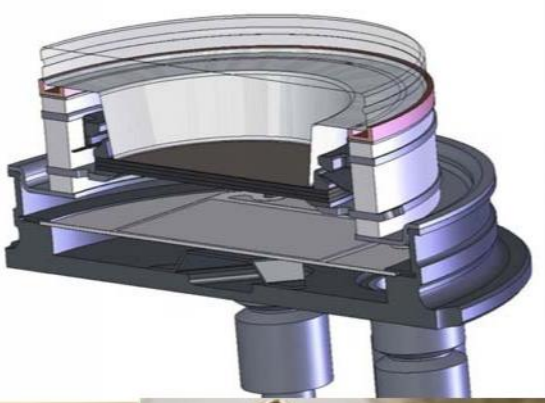
- Lifetime beyond 8 C/cm² demonstrated
- This leap makes MCP-PMTs comparable in lifetime to (Ma-)PMTs
- Not only a matter of ALD
- Measured at 372 nm
- BINP and Hamamatsu tubes had much smaller active area

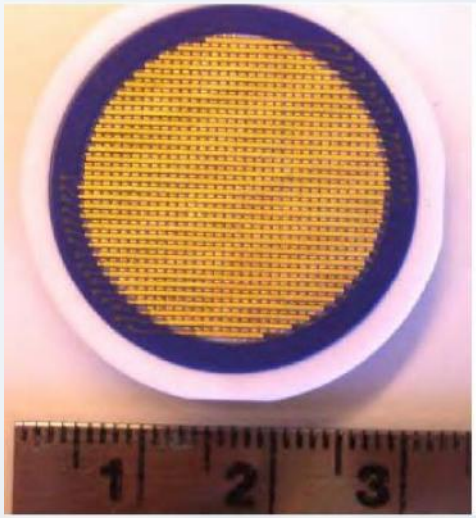
From: Lehmann et al. (2014). Improved lifetime of microchannel-plate PMTs. *NIM-A 766*, 138–144.

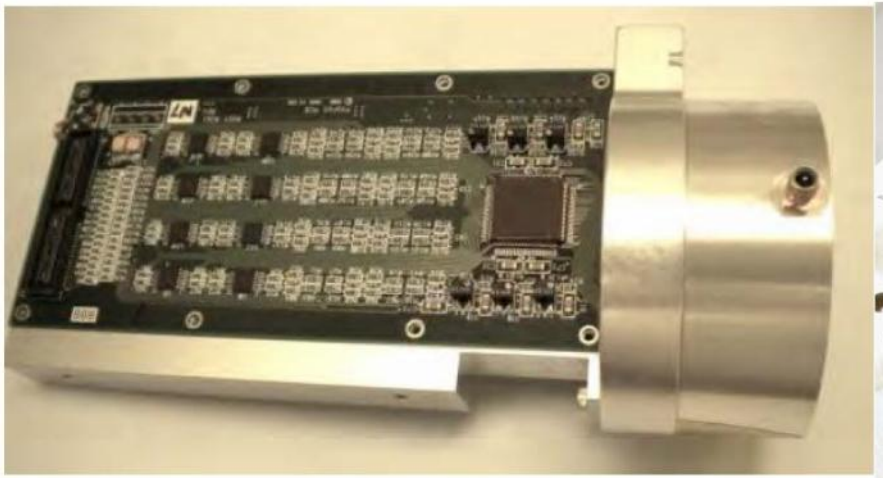


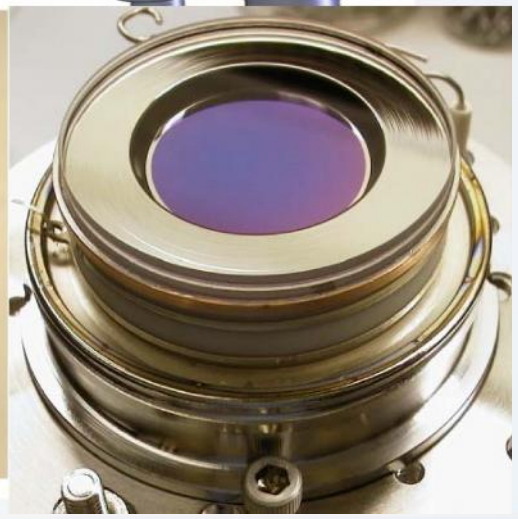
Imaging Photon Counter

- MCP-PMT with fine-pitch strip readout
- Centroiding electronics improves spatial resolution: <15 µm
- Time resolution <50 ps for single photons



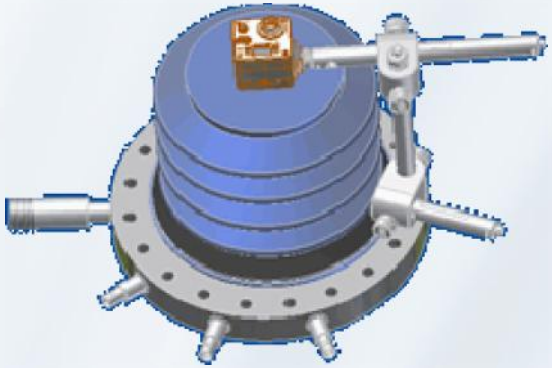






Beam imager

- For beams of photons, ions, electrons
- MCPs with phosphor readout, frit-sealed to a vacuum flange, read out with a camera
- The input face of the MCP can be coated with CsI, KBr, MgO, MgF_2, Au or CuI, depending on the radiation to be imaged



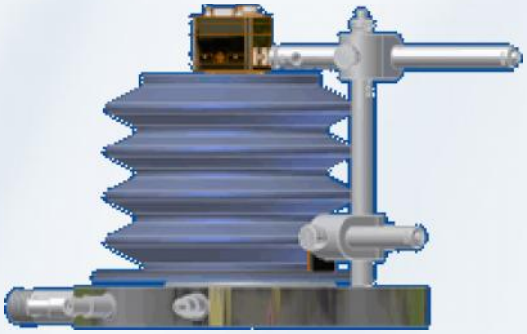
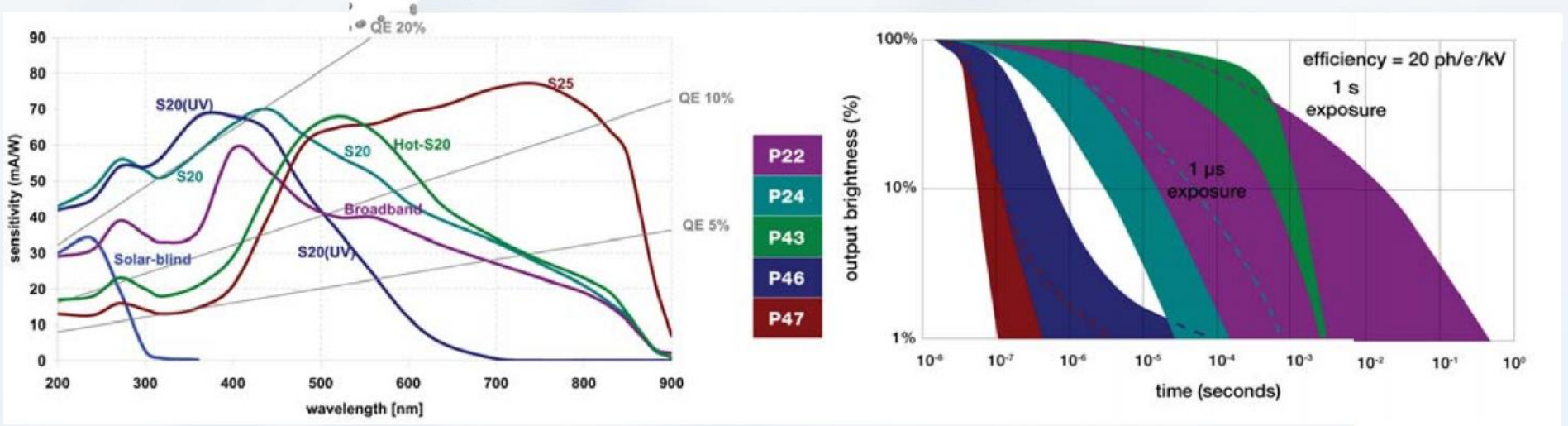


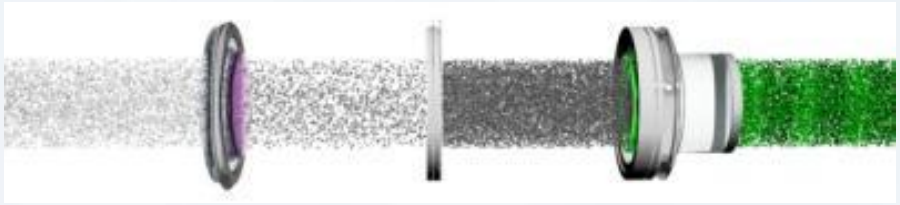
Image intensifiers

- Photocathode-MCP-phosphor

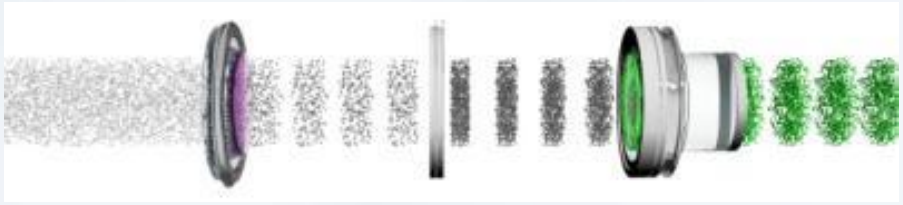


Fast gating image intensifiers

Continuous mode



Gated mode



Gating times can be sub-ns.
Mesh under photocathode

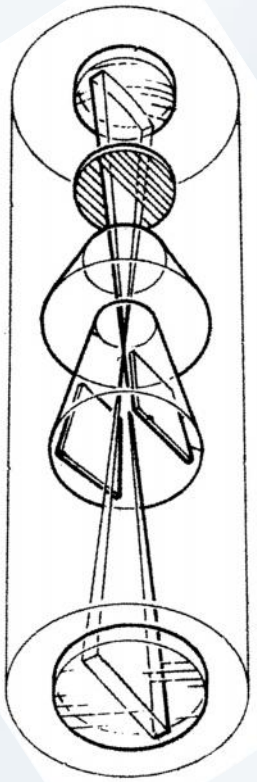
Applications

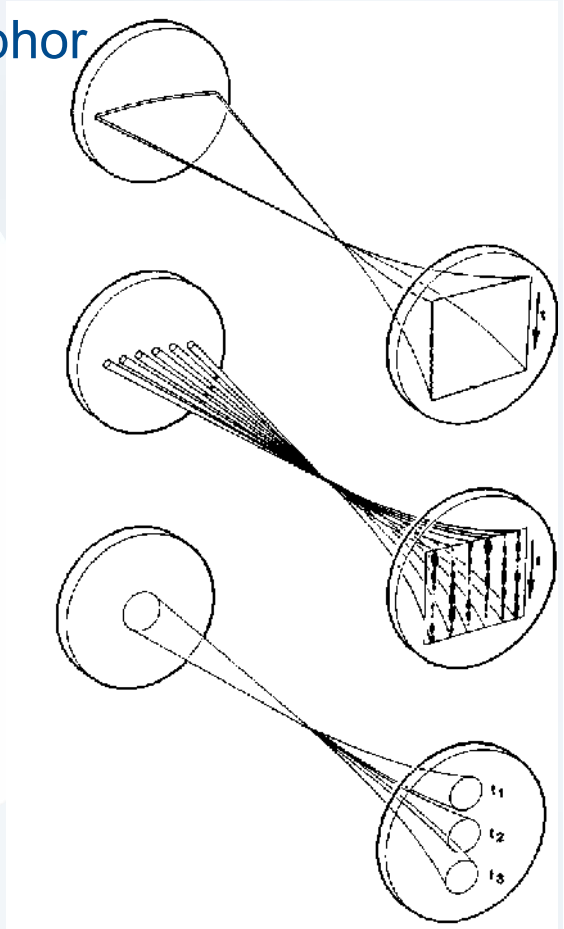
- High speed photography
- High speed camera
- Plasma expansion dynamics
- Range gating
- Fusion Reaction Diagnostic
- Fluorescence lifetime (FLIM)

Streak tubes

Fastest detectors in the world: sub-ps time resolution

Sweep electron beam from photocathode over phosphor





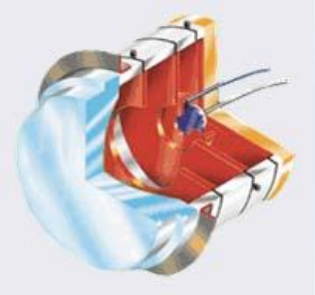
PHOTONIS | INDUSTRY | SCIENCE | MEDICAL

Hybrid photo diodes

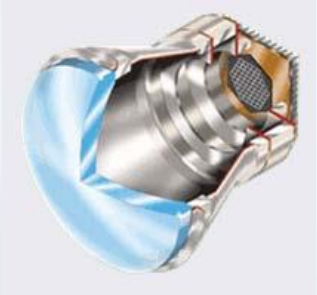
Each photoelectron is accelerated towards a silicon sensor. There it releases a well-specified number of electron-hole pairs.

Hundreds of HPDs installed in the ring imaging Cherenkov counters of LHCb at CERN

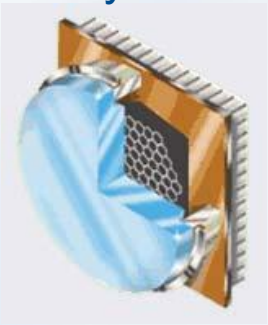
Single channel



Multi pixel

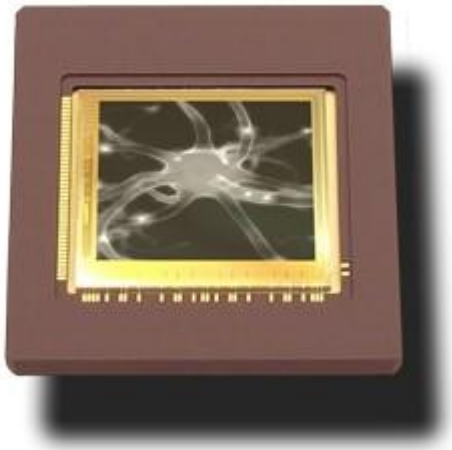


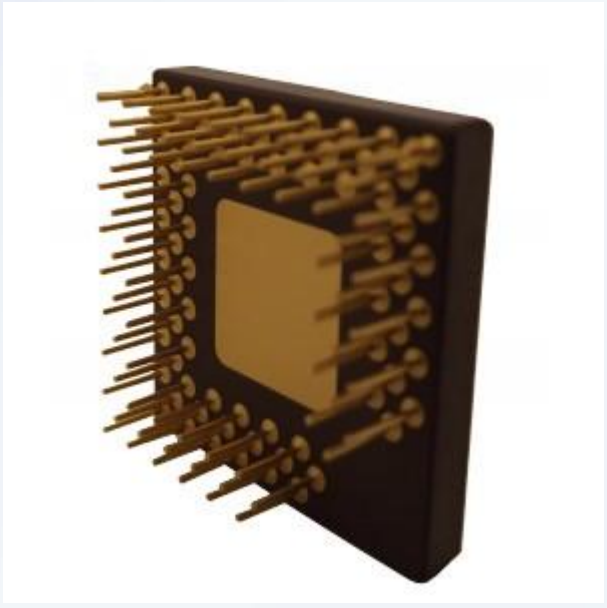
Proximity focusing



Digital imaging

- Lynx sensor for low light level digital imaging: 4 e- readout noise
- Nocturn: a compact camera based on this sensor
- Auto gain control ranges from daylight to “quarter moon”
- Can also be used with a photocathode, like an HPD





A cathode in a can

- K_2CsSb cathode on a metal substrate
- Stably emits a current of 35 mA
- Pics in bottom right show removal of the cap
- A very cold electron source