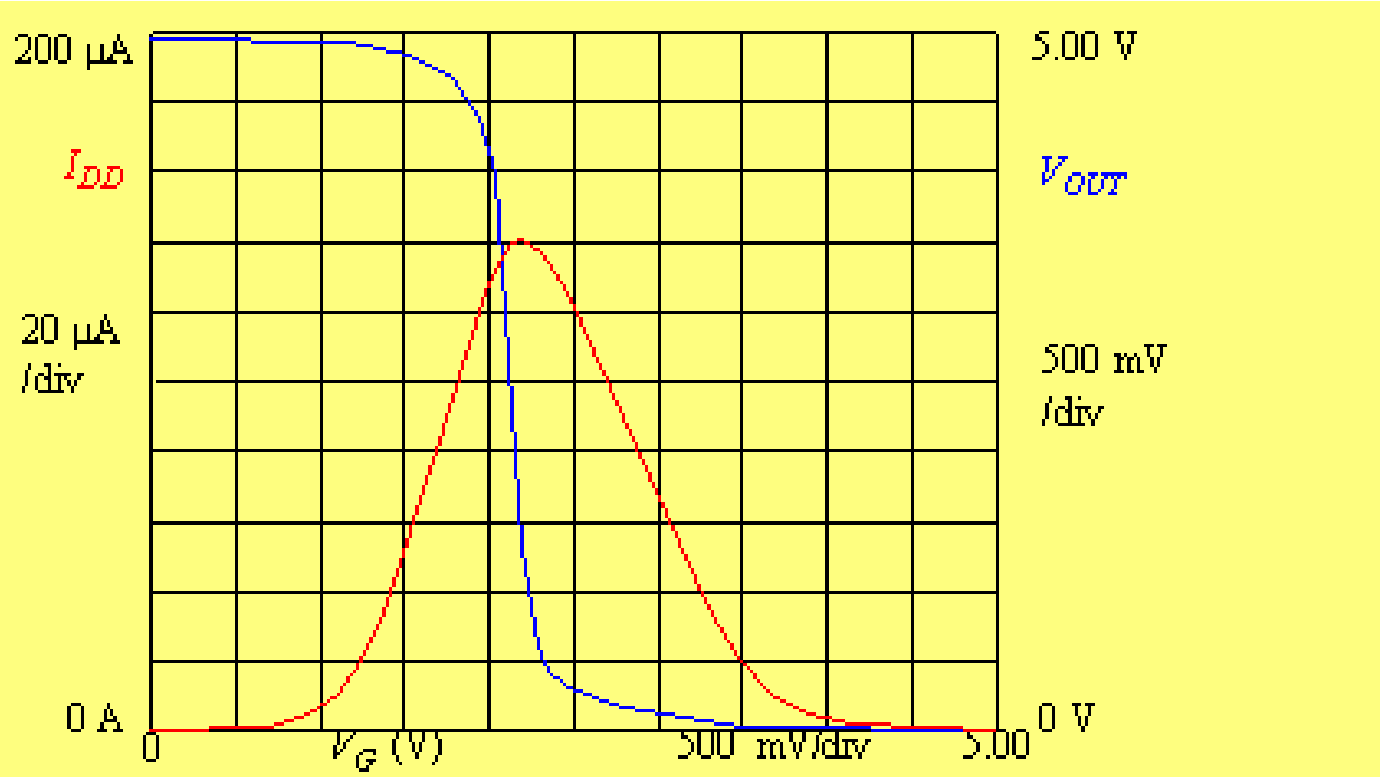
Dynamic Emission microscopy background

Philippe Perdu CNES Toulouse

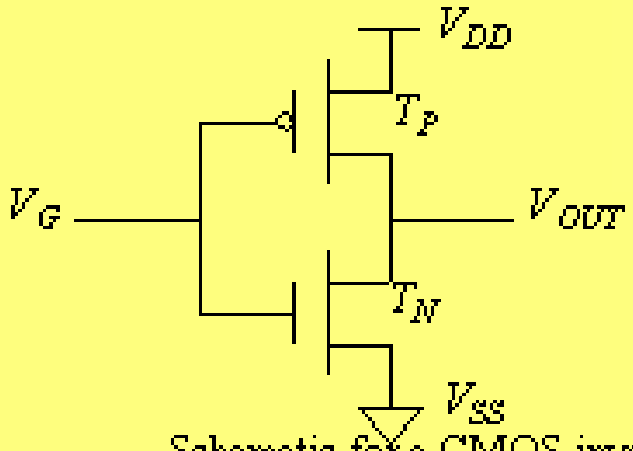
Outline

- *Dynamic emission principle*
- *Single points detectors*
- *Image detectors*
- *Applications*
- *Challenges*

Dynamic emission principle (1)



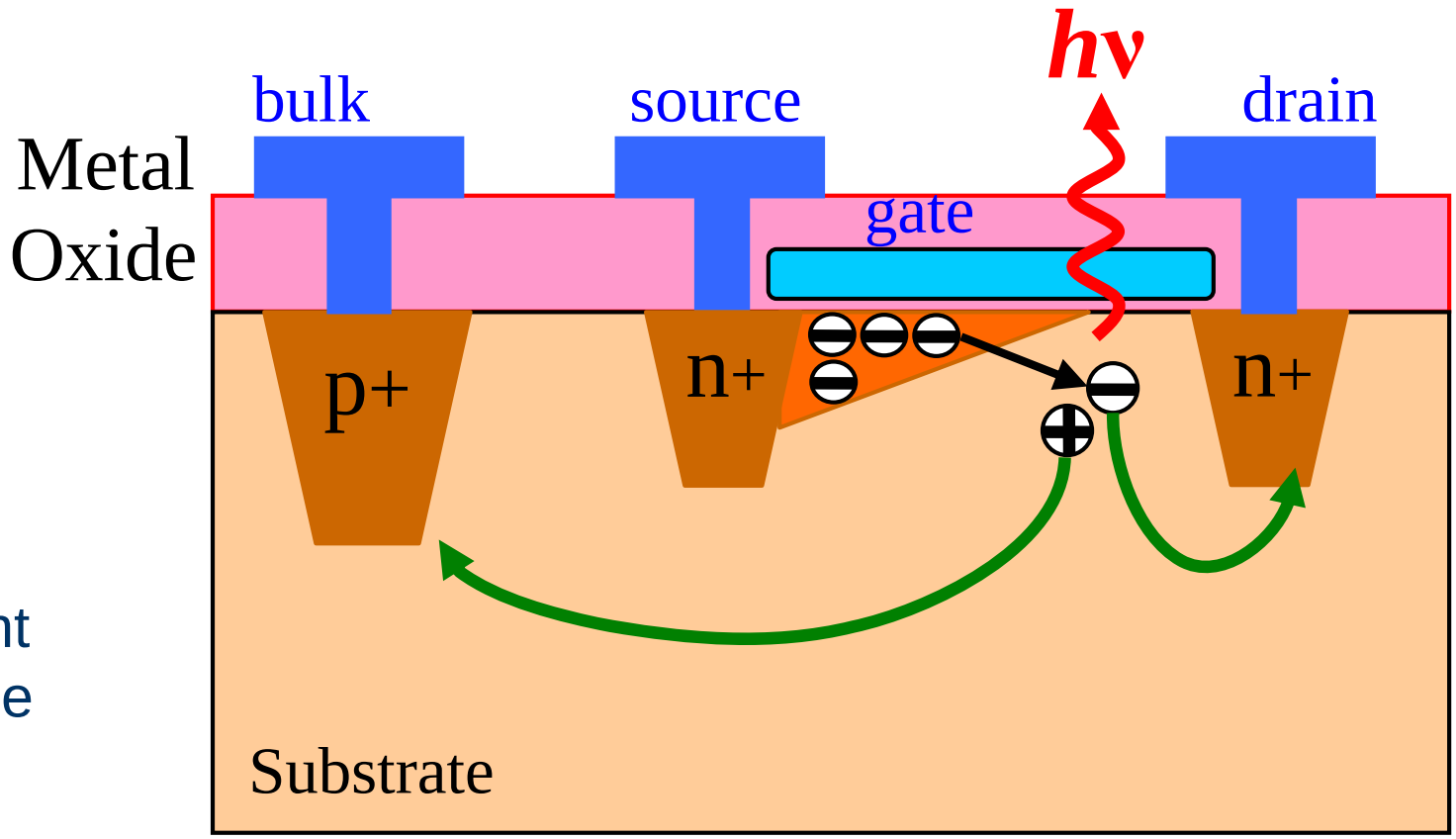
I_{DD} (red) and V_{OUT} (blue) as a function of V_G for an inverter showing the maximum emission regions for the n and p-channel transistors.



Schematic for a CMOS inverter

P max around VDS/2

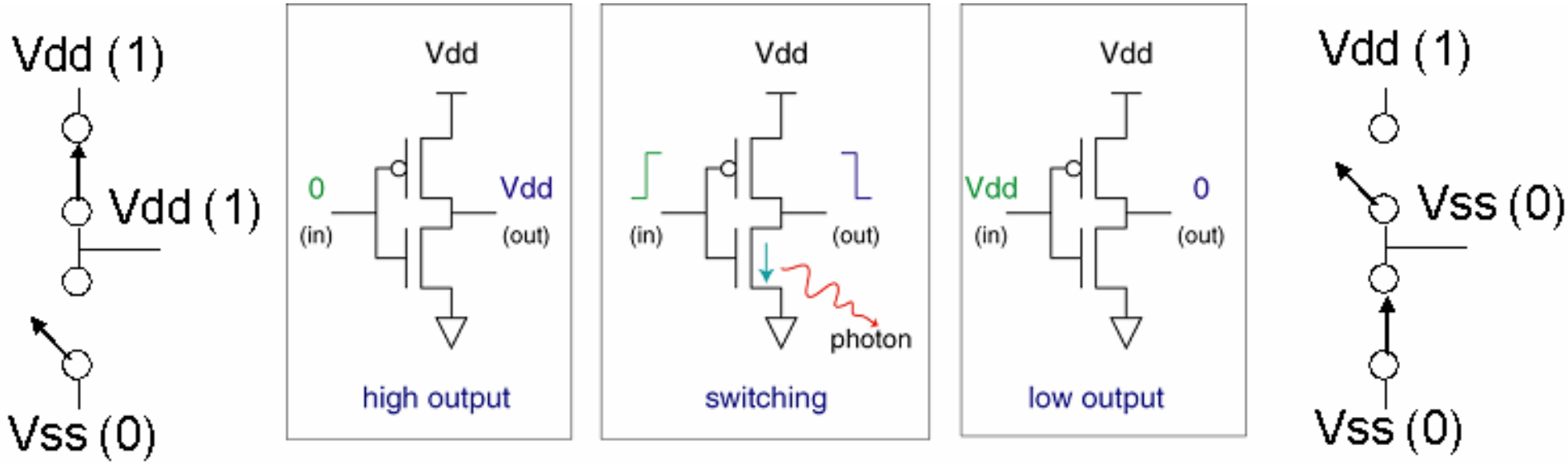
Dynamic emission principle (2)

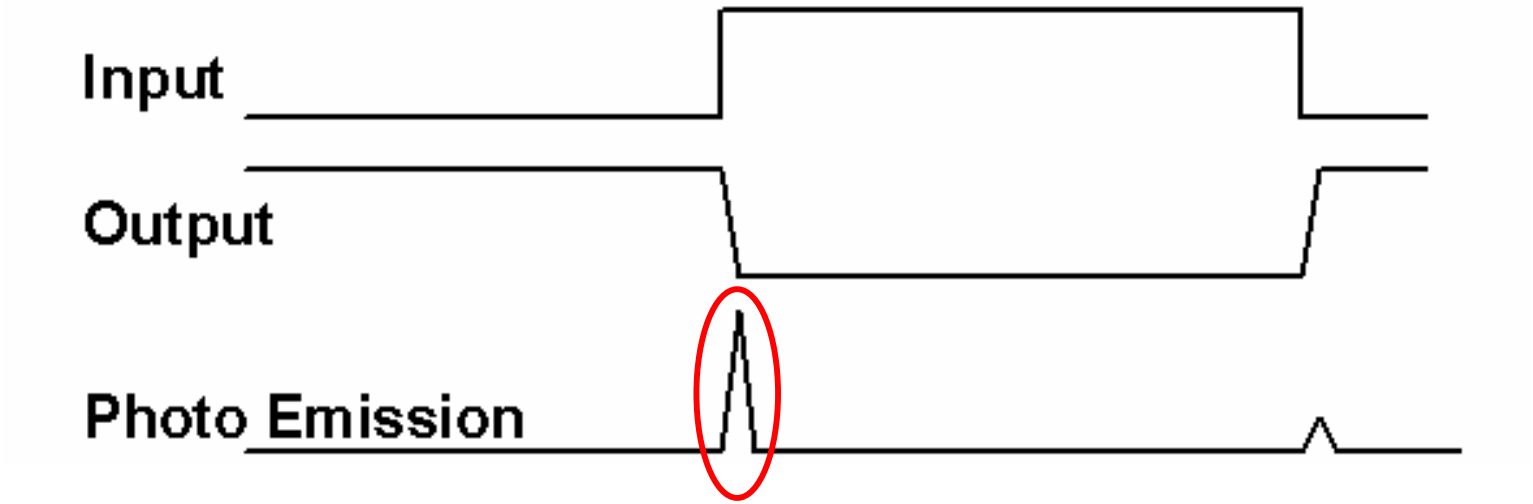


Need
- Current
- Voltage

$$N_{ph} = A\frac{I_S}{q}\left(V_{DS} - V_{DSsat}\right)\exp\left(-\frac{B}{V_{DS} - V_{DSsat}}\right)$$

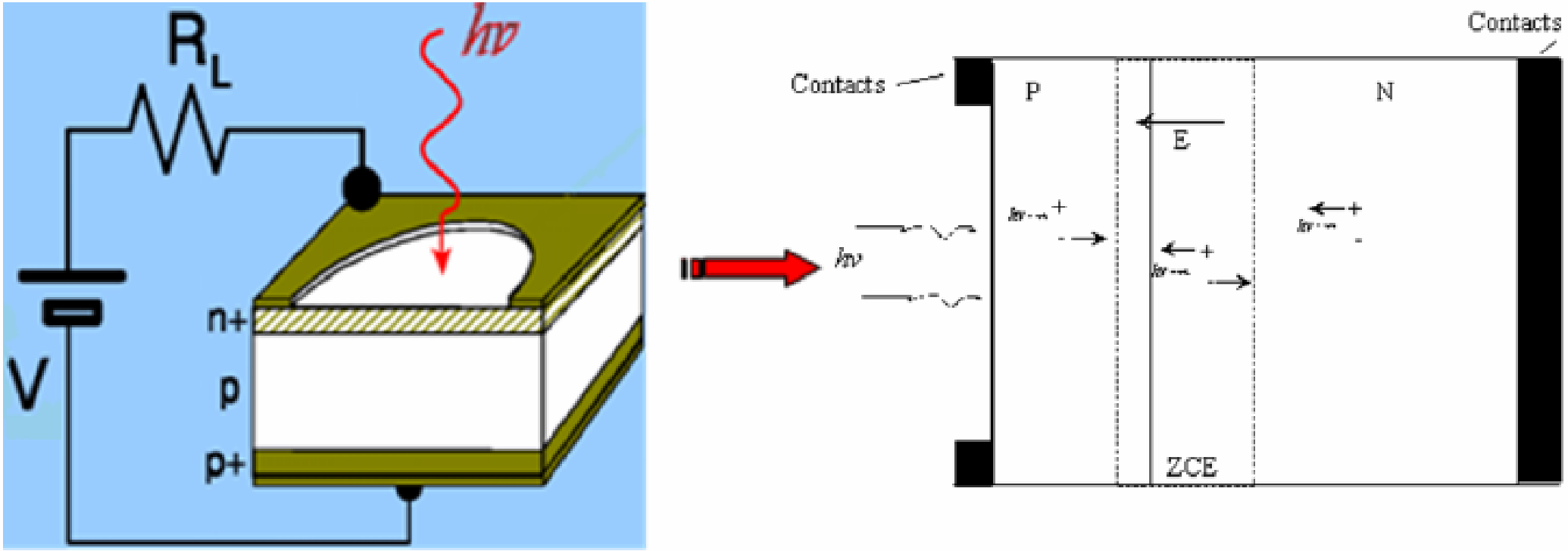
Dynamic emission principle (3)



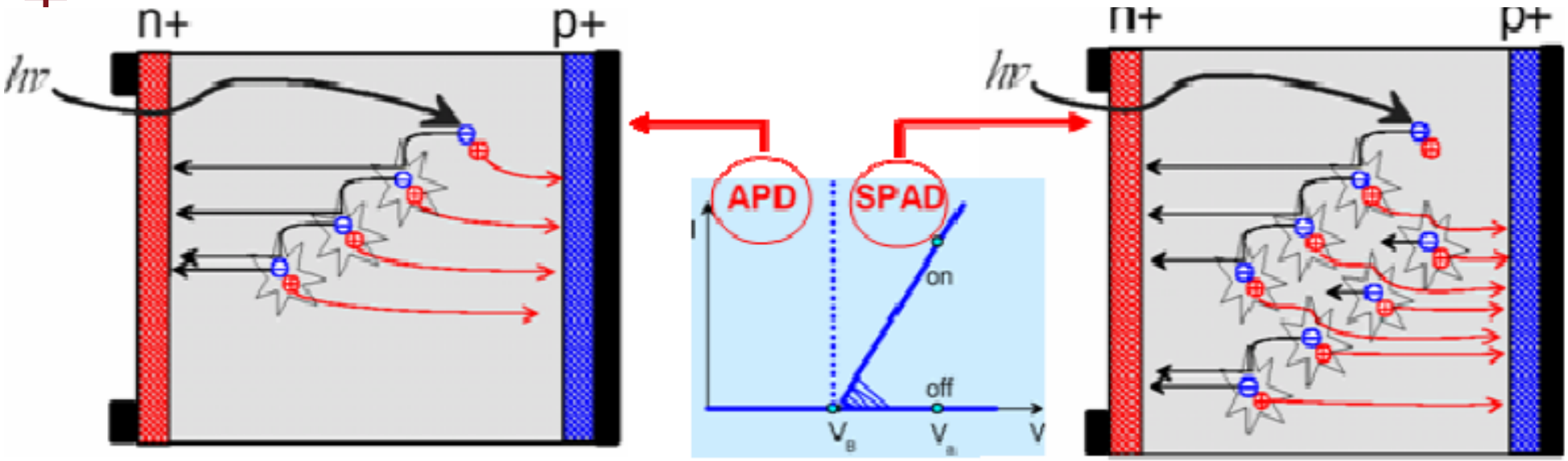


Single points detectors (1)

- *Photodiodes: photon / current conversion*



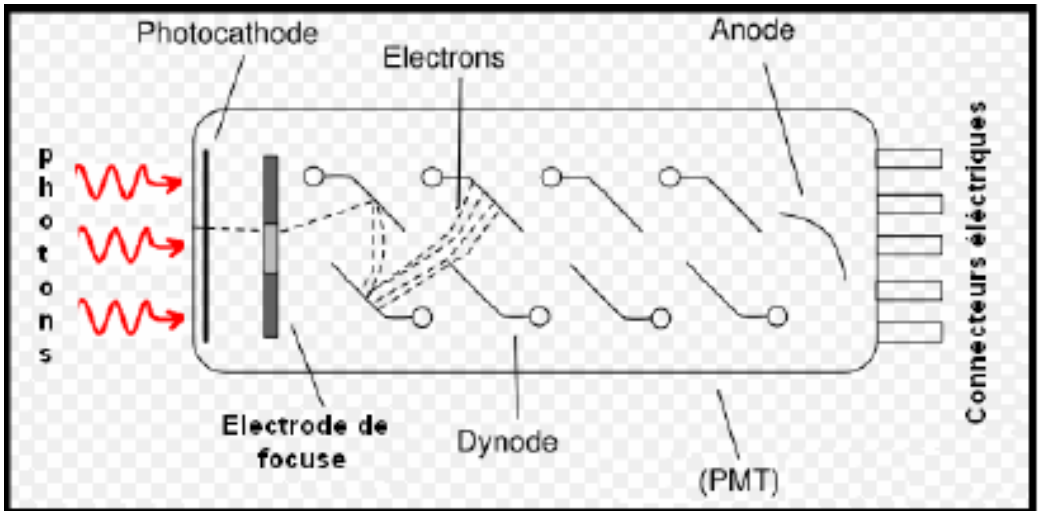
Single points detectors (2)



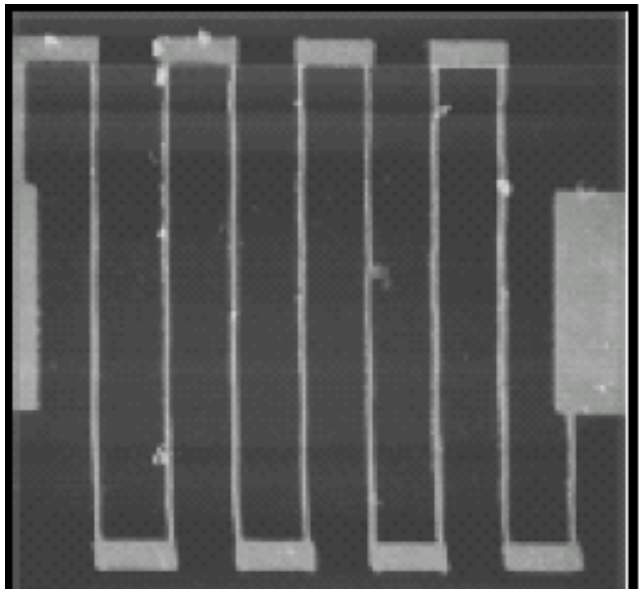
- *2 principles*
  - Geiger mode (SPAD)
    - ultra sensitive: QE = 100%
    - Very instable, lot of noise
  - Avalanche mode
    - Reverse biased, close to Vb
    - Quite instable, more noise than linear mode
- *Need quenching (passive or active)*

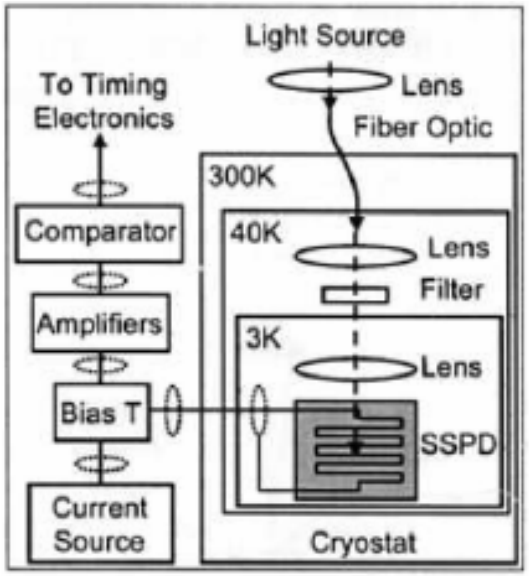
Best choice InGaAs APD
- Backside
- Bandwith up to 1.7 µm

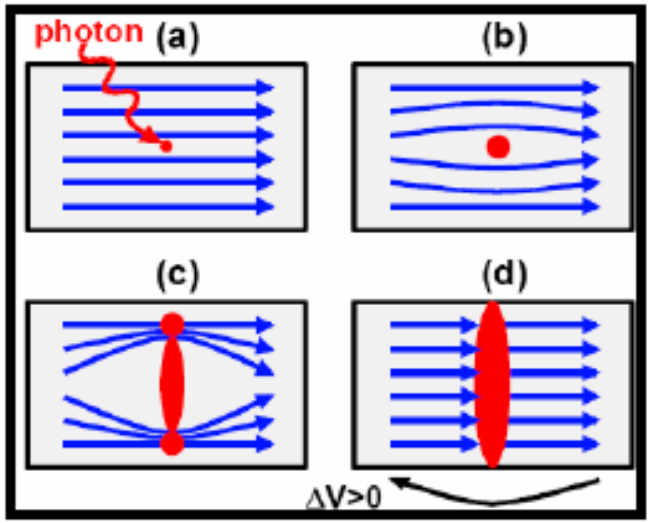
Single points detectors (3)



PMT
- Low QE and noise
- no Quenching



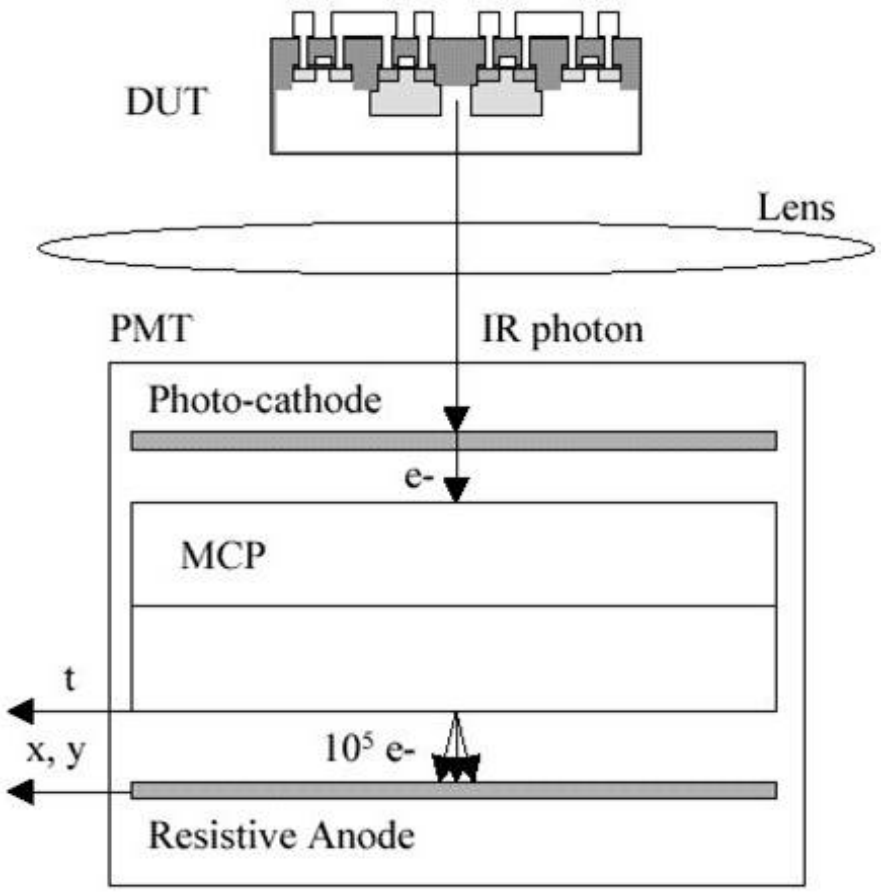


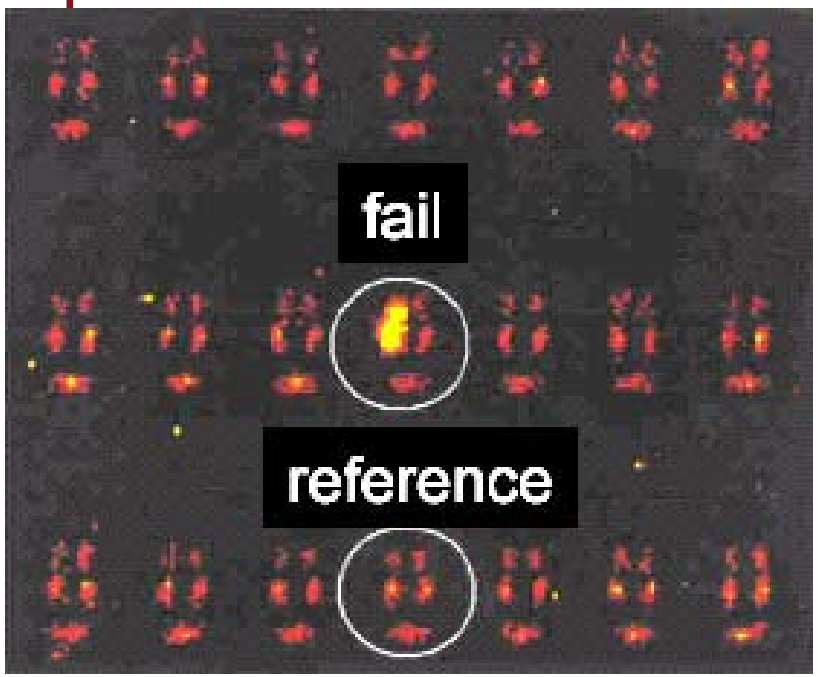


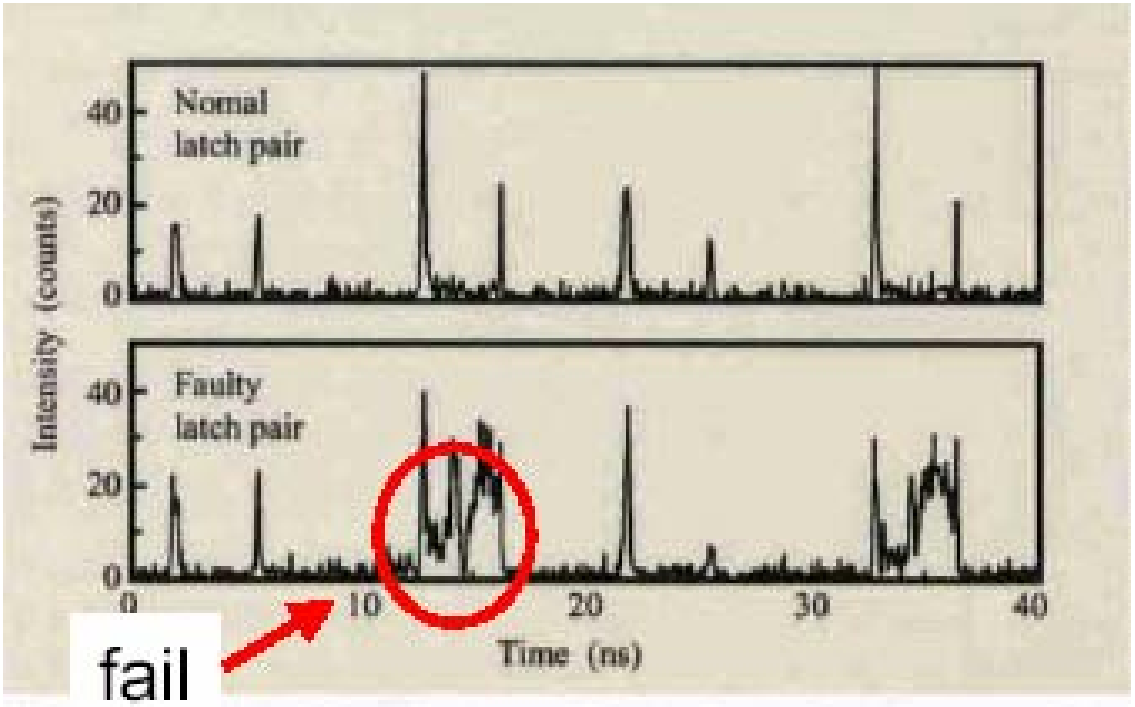
SSPD (NbN) faster

Image detector

- *Single point (Time Resolved Emission)*
- *Image mode (based on PMT) except:*
  - MCP (Multi Channel Plate) to keep the position
  - Resistive Anode (to detect the position)
- *PICA (Picosecond Imaging Circuit Analysis)*
  - Mepsicron 2 (S25)
  - Limited to 900 nm
- *Time Resolved Tmaging*
  - InGaAs Photocathode







- *Light emission coming from a shift register activated by a test pattern that demonstrates the defect*
- *From Freescale*
- *Optical waveforms of the reference gate from the golden device and of the faulty one*
- *Other applications (image modes)*

Challenges

- *Emission of photons decreases strongly with the lowering of VDD power supply*
- *Long acquisition time needed to get the right SNR*
- *Where to probe?*
  - Lack of hypothesis or CAD
  - No emission (why? Bad node probed or detection issue)
  - Time Resolved Imaging can help a lot