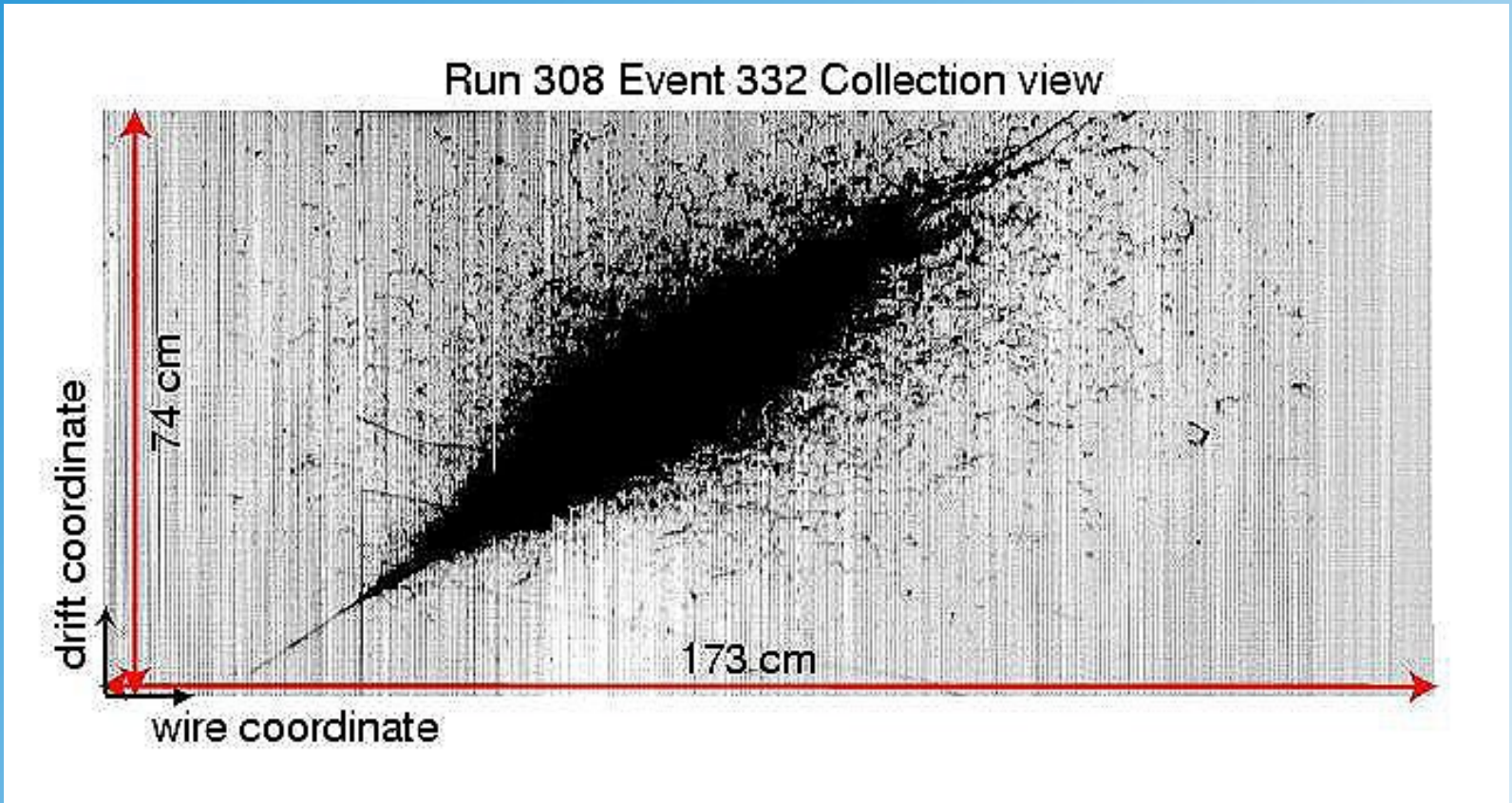
Detectors

Lecture 5

- Calorimeters
  - electromagnetic calorimeters
  - hadronic calorimeters
- Tracking Detectors
  - gaseous detectors
  - silicon detectors
- Other detectors
  - Scintillators
  - Cherenkov detectors

Electromagnetic Shower in Liquid Argon



Induced by radiative (cosmic) muon (ICARUS)

Electromagnetic Shower

Simulation:
5 GeV electron in lead glas

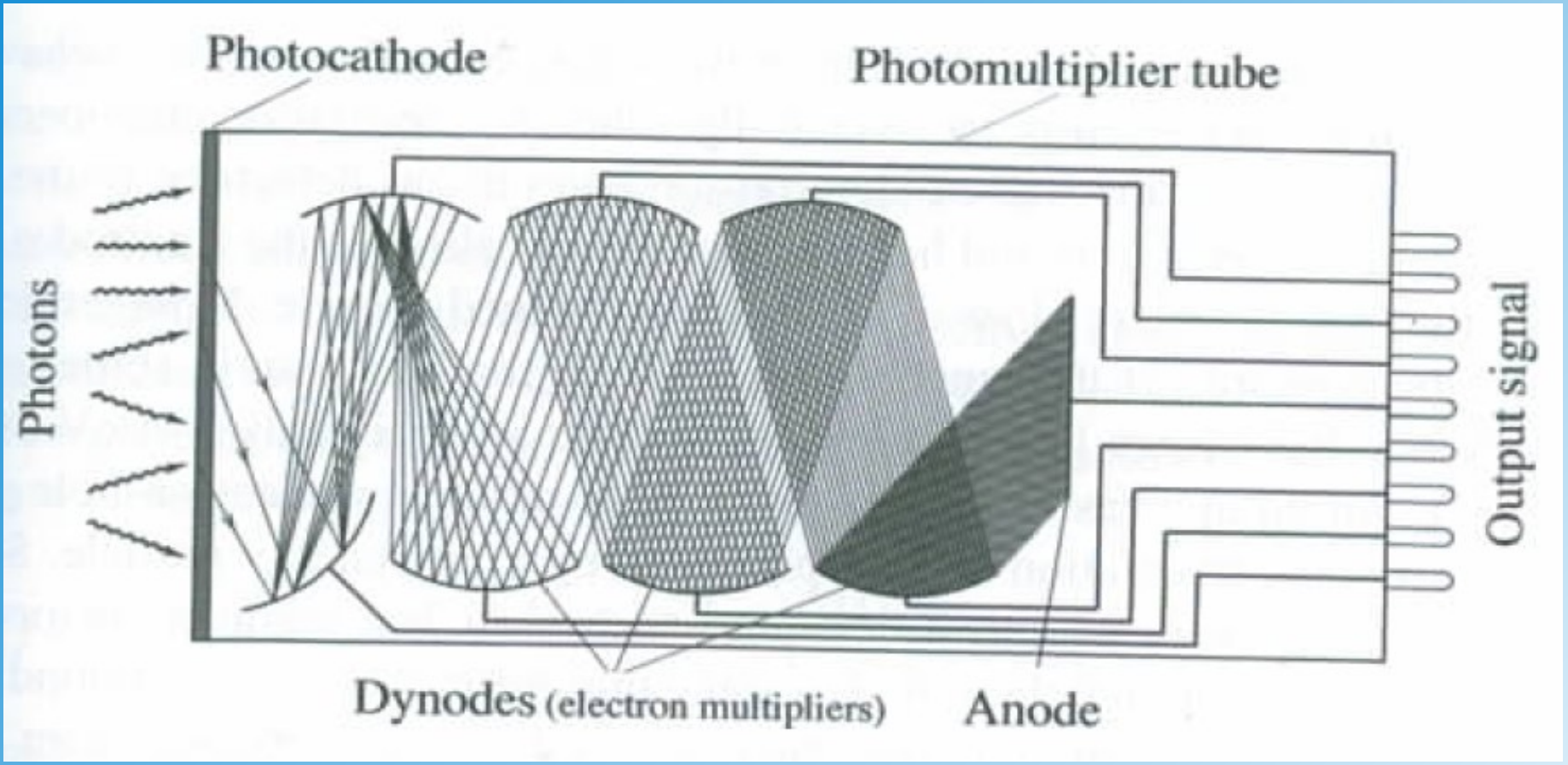
S.Menke, MPP München

Electromagnetic Shower

Simulation:
80 GeV electron in lead glas

S.Menke, MPP München

Photo-Multiplier



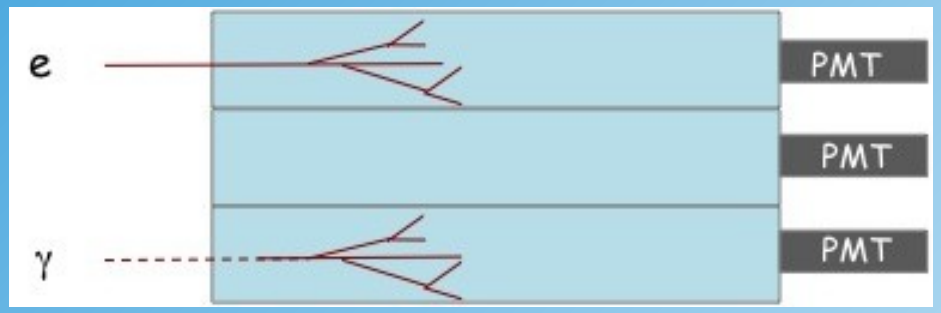
needs specialised cathodes for photon detection
→ high quantum efficiency

PMTs nowadays often replaced by avalanche photodiodes

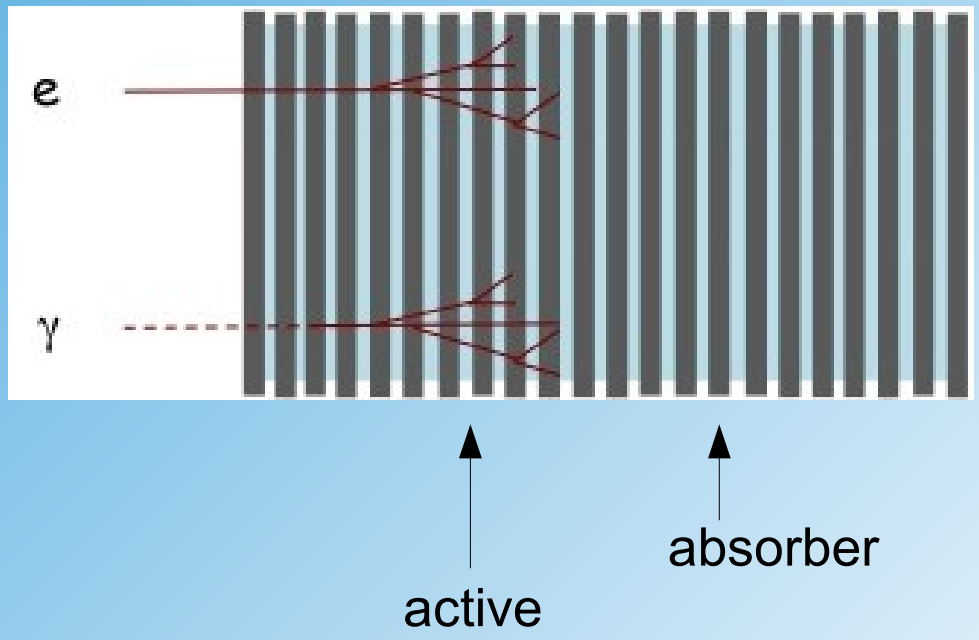
Electromagnetic Calorimeter

→ high Z needed to absorb photons and electrons

single glas/crystal
(e.g. lead glass)

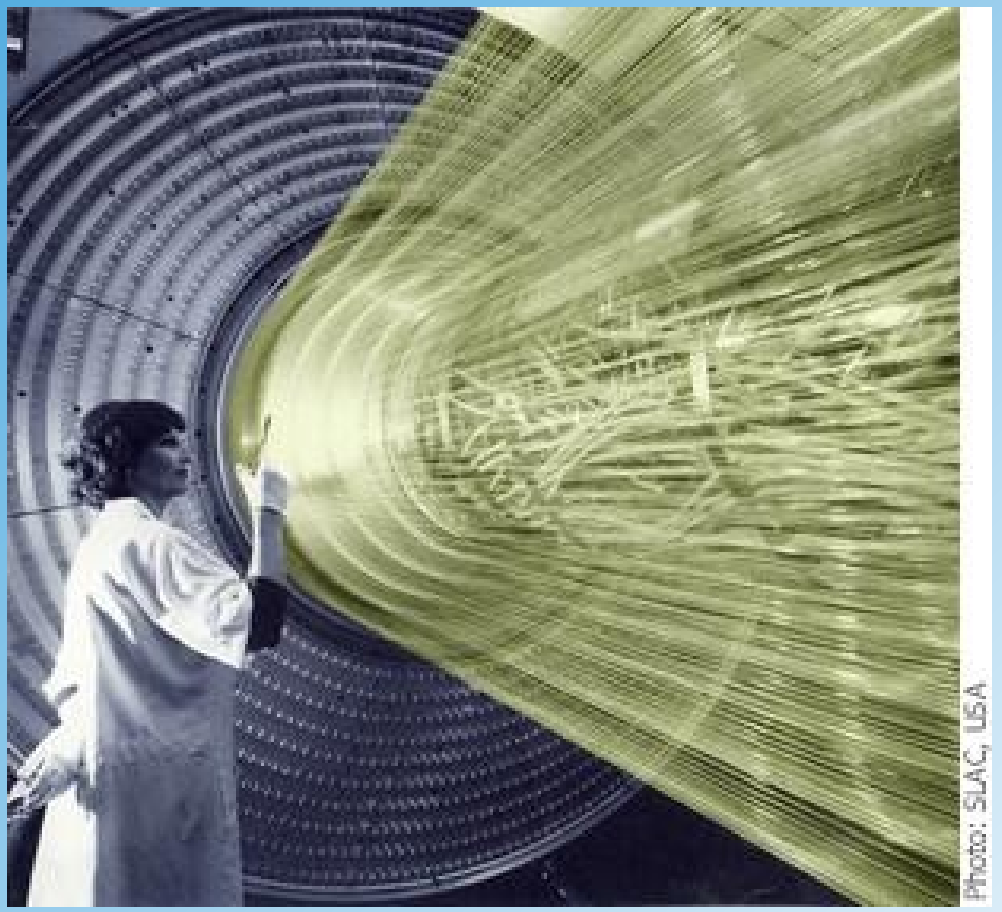


sampling
(e.g. LAr/Pb)

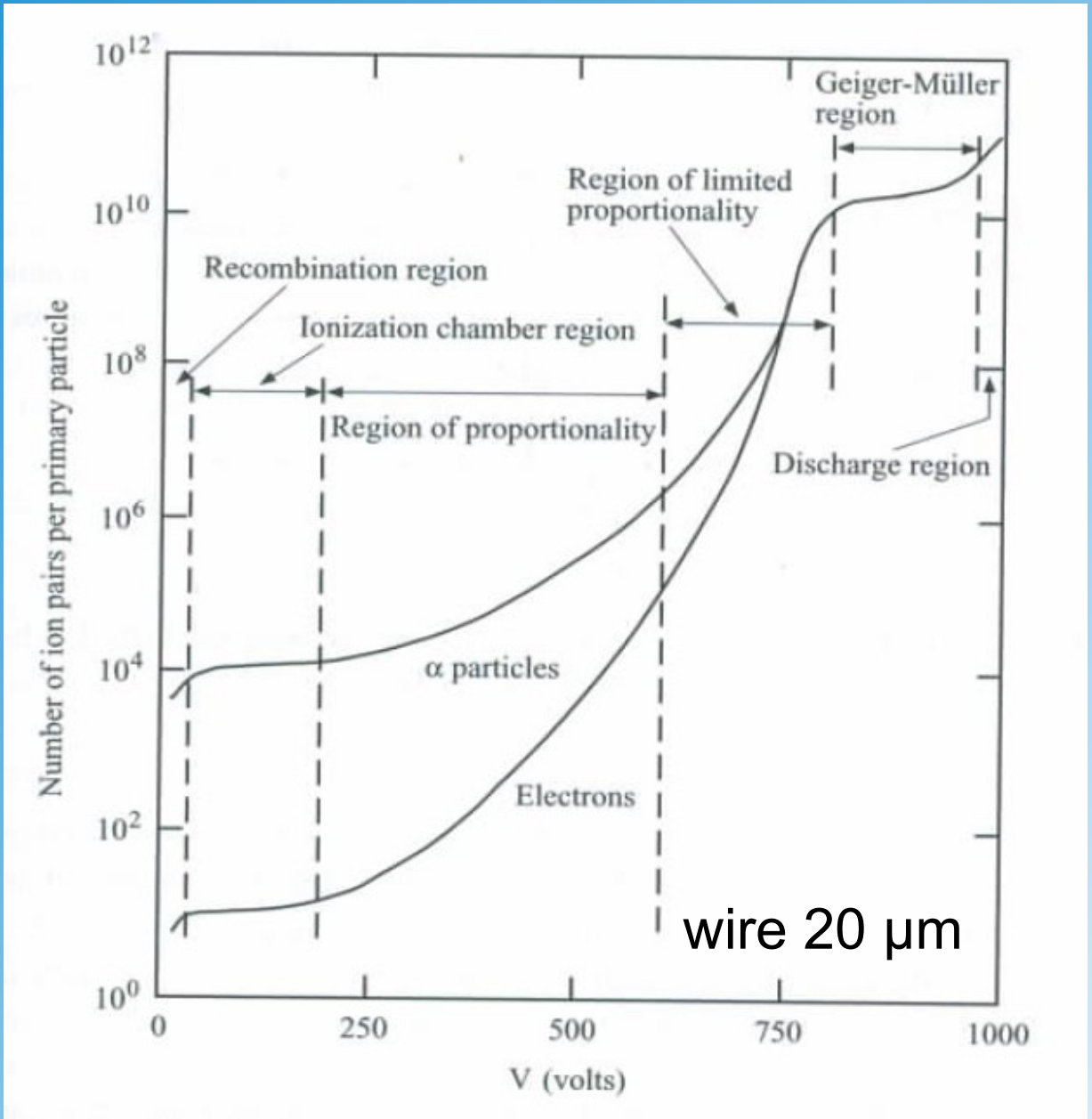


Drift Chambers

H1 Drift Chamber

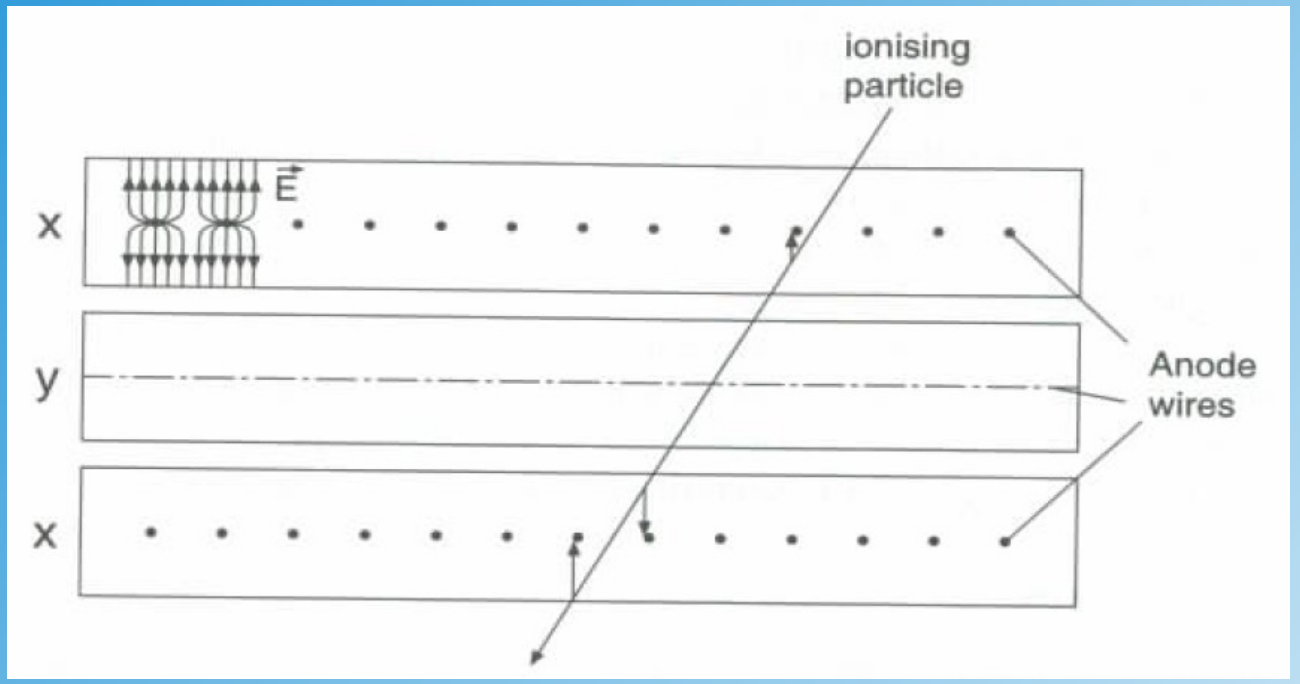


Gas Amplification

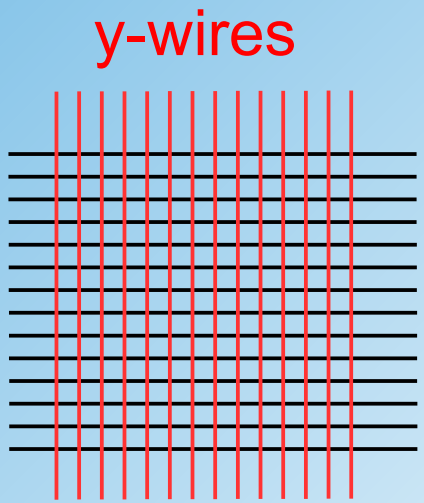


Proportional Chambers

side view:

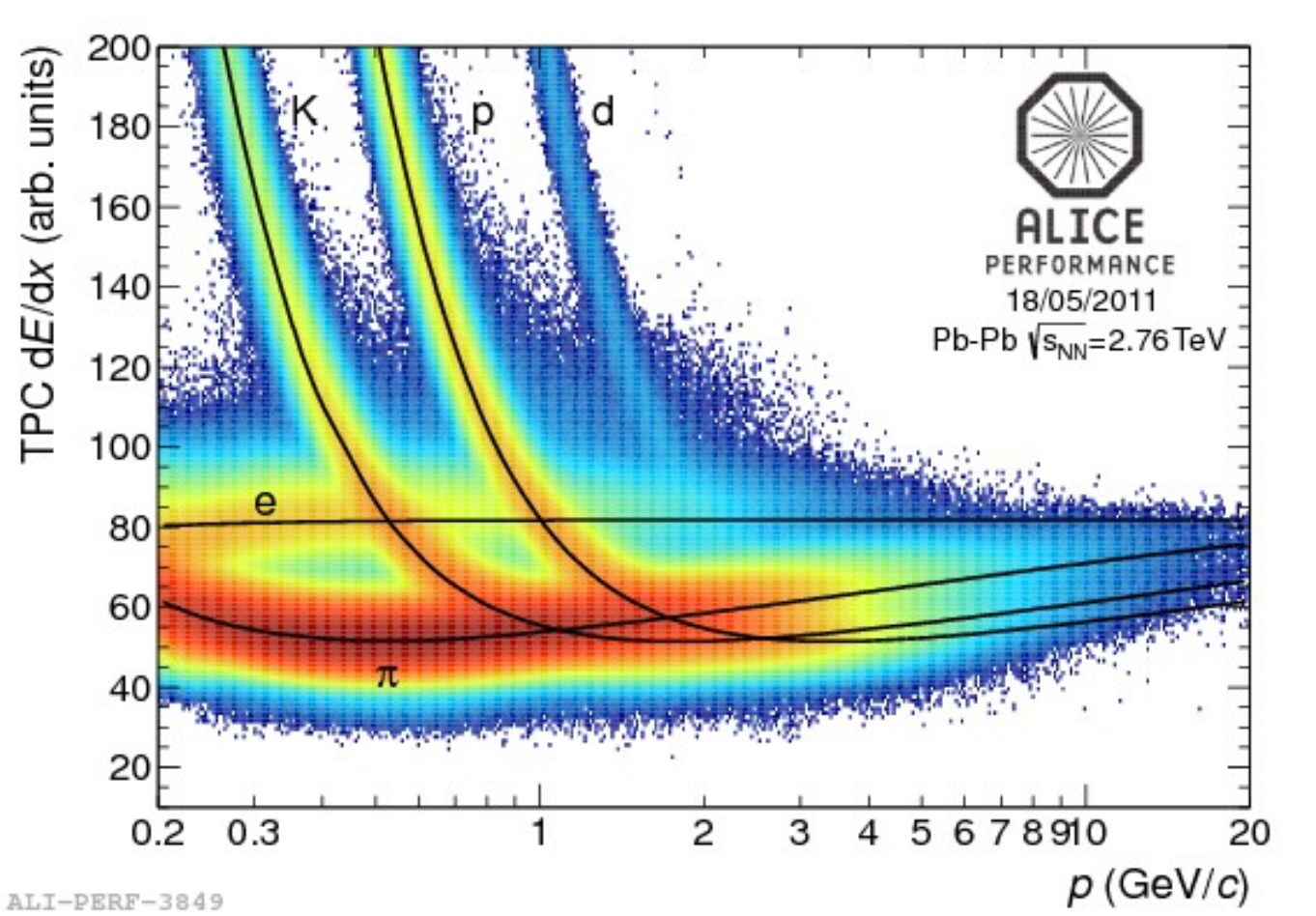


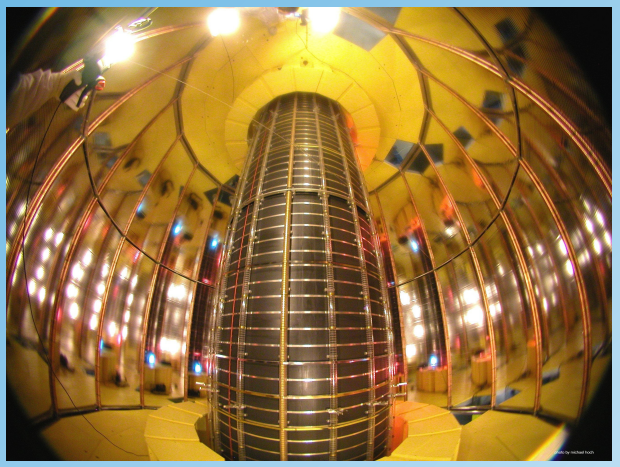
top view:



Particle Identification with dEdx

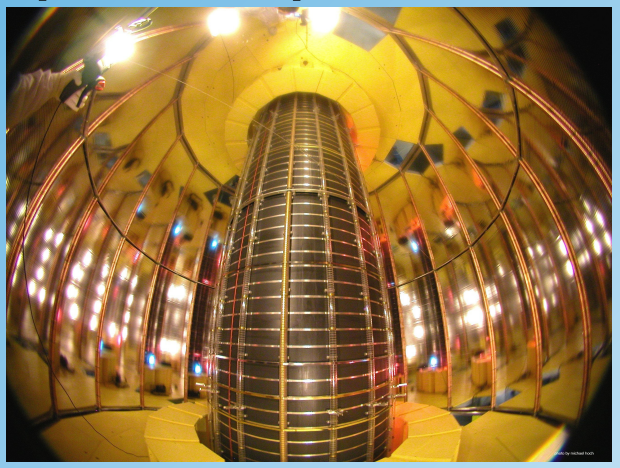
ALICE TPC



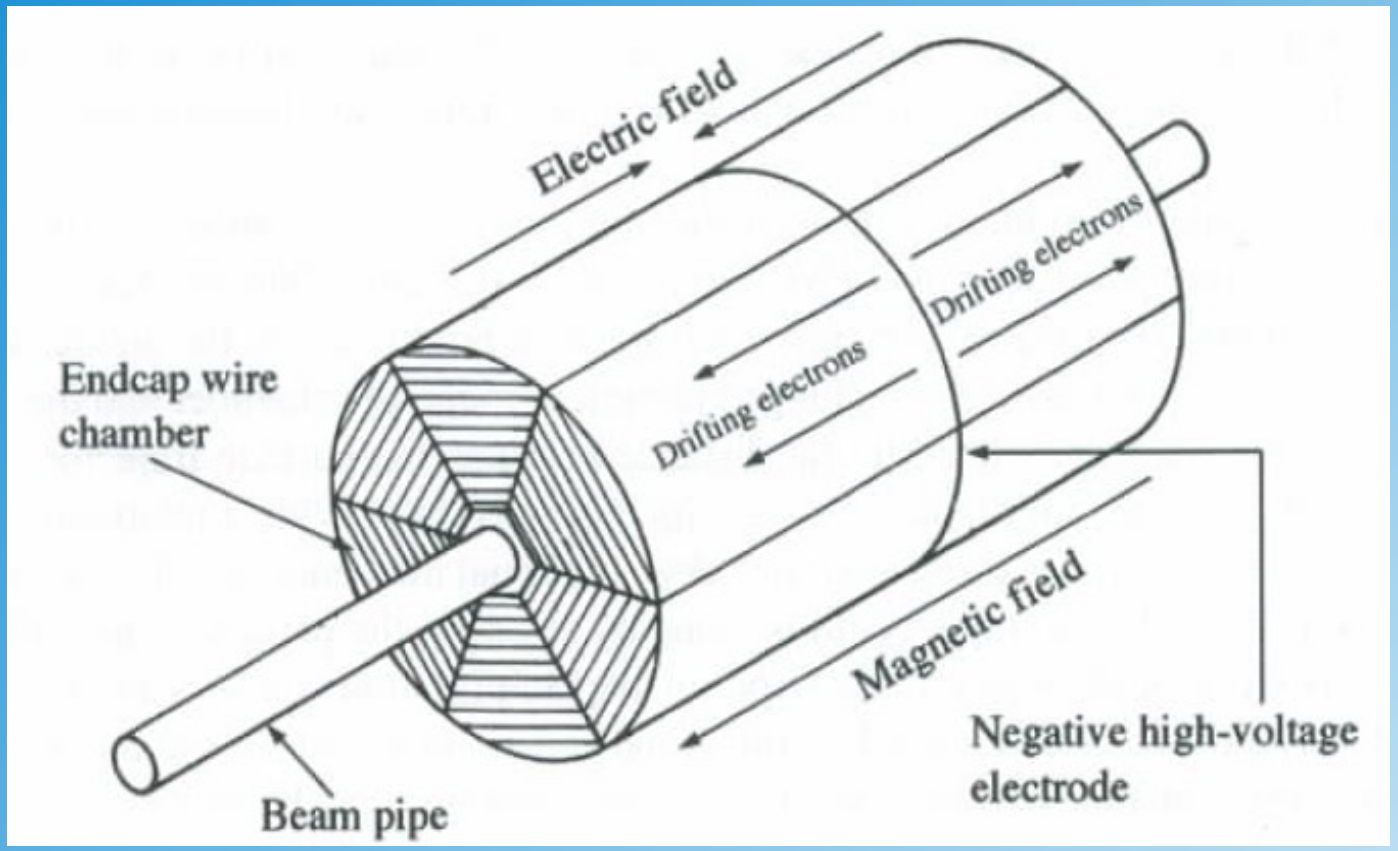


ALICE TPC

Time Projection Chamber (TPC)



ALICE TPC

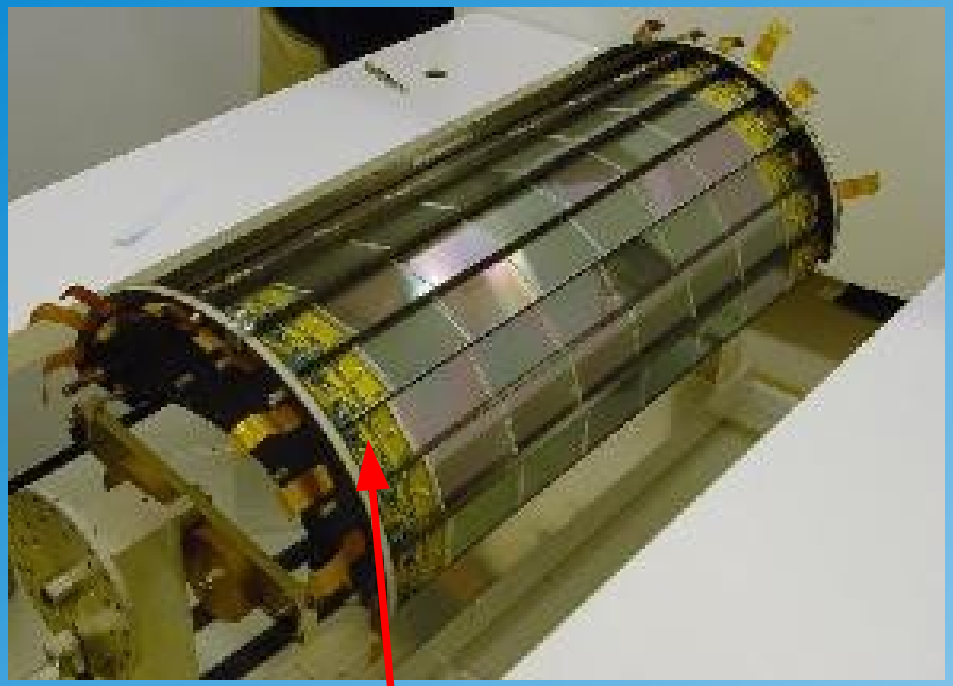


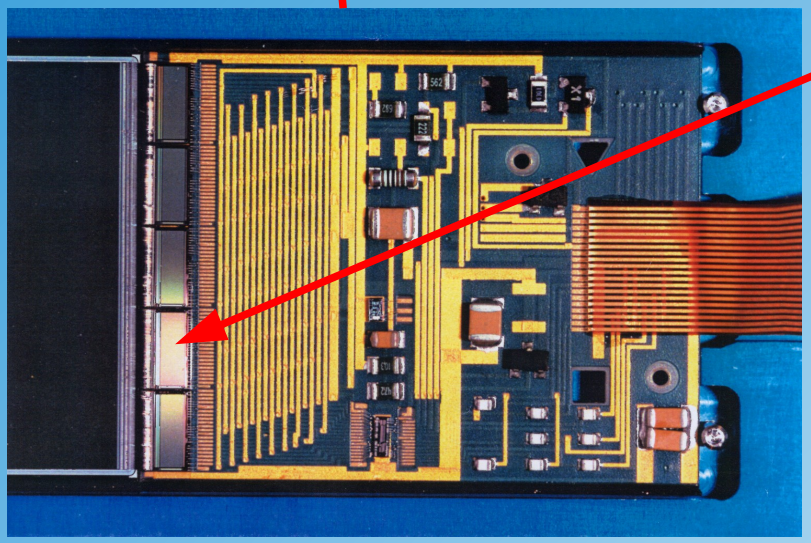
works only at low collision rates

electrons drift long distances O(1m) to anodes

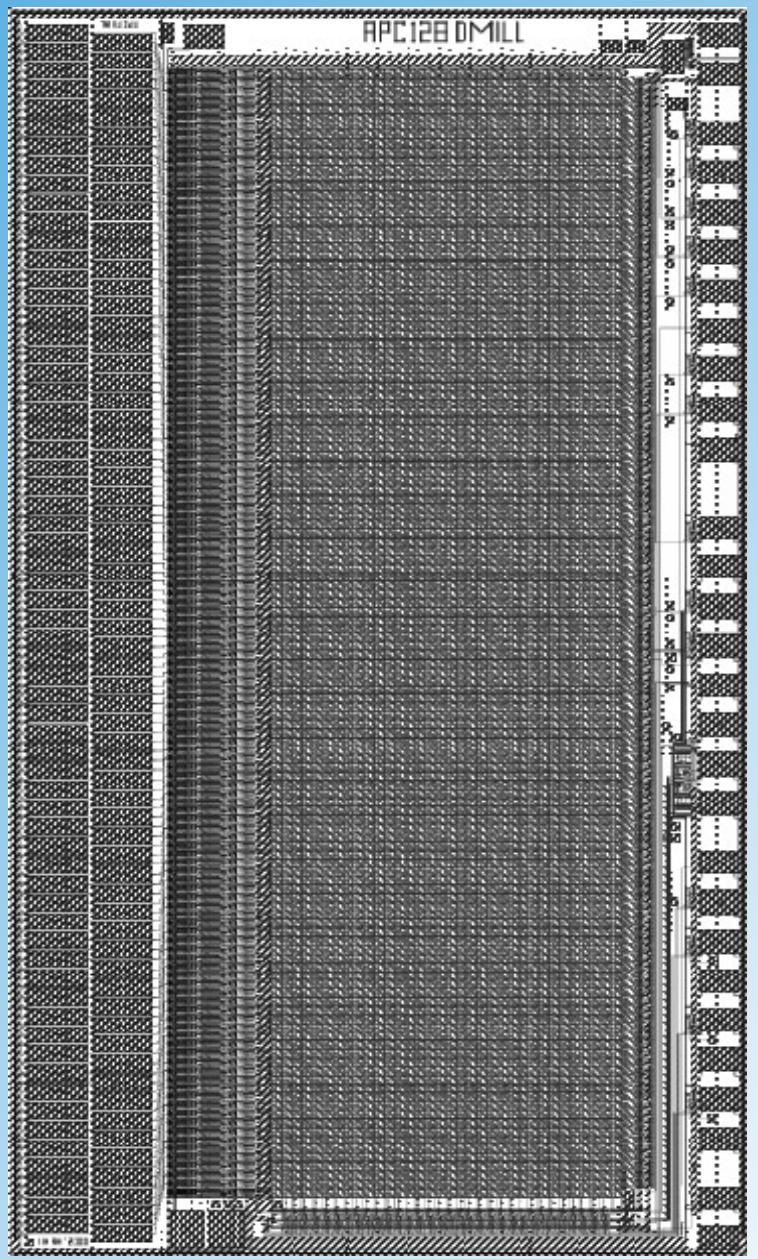
z-position measured by: $z_{drift} = v\, t_{drift}$

H1 Silicon (Solid State) Detector





Hybrid with readout chips

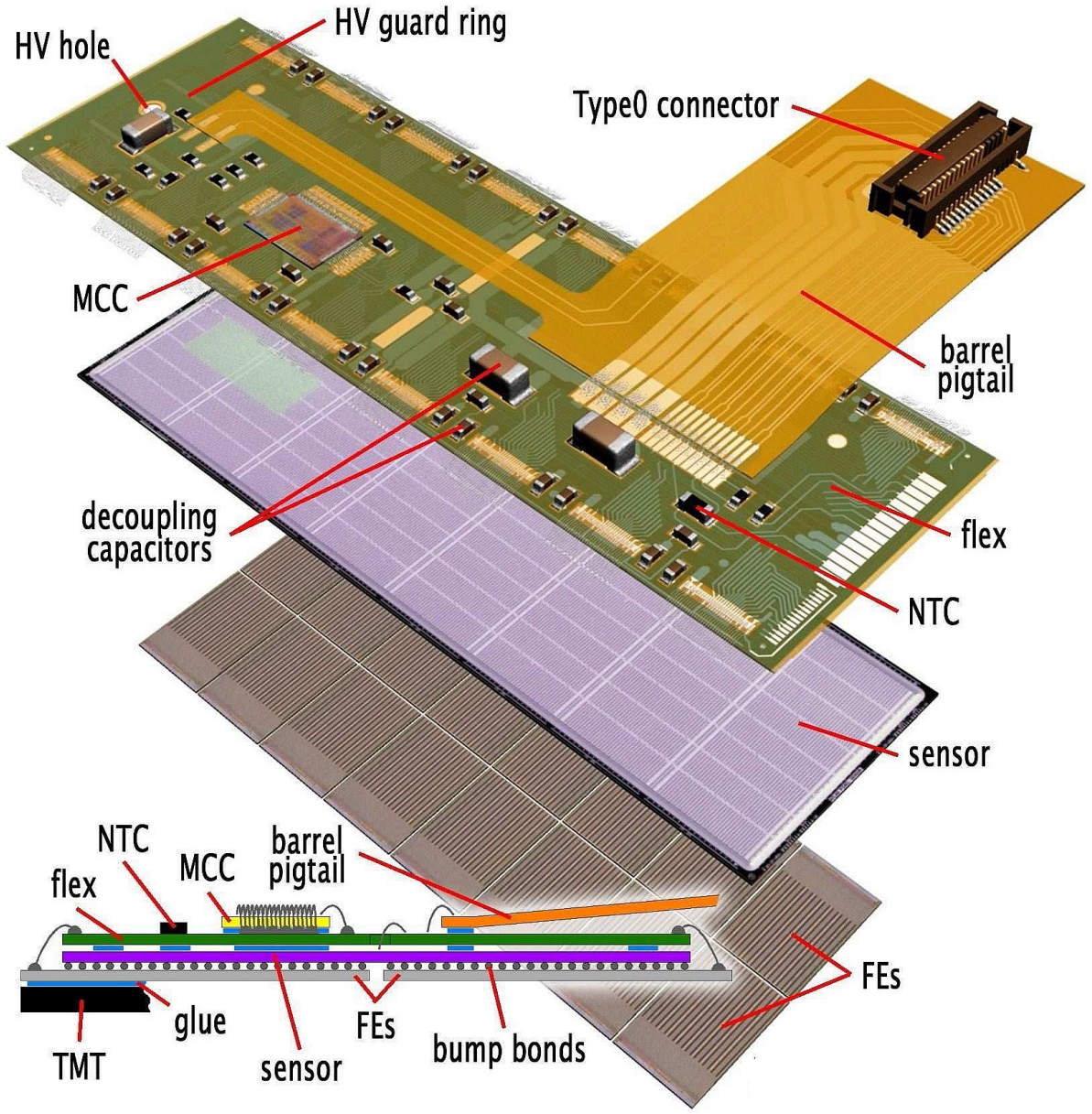


Analog Pipeline Readout Chip

CMS Silicon Detector at LHC

Large Scale Silicon Only Tracker

ATLAS Pixel Module (Hybrid)



Monolithic Pixel Chip

Mupix7 prototype (Heidelberg):

pixel array: 40 x 32

pixel size: 80 x 100 μm^2

thickness: 50 µm

fastest monolithic chip on the world!

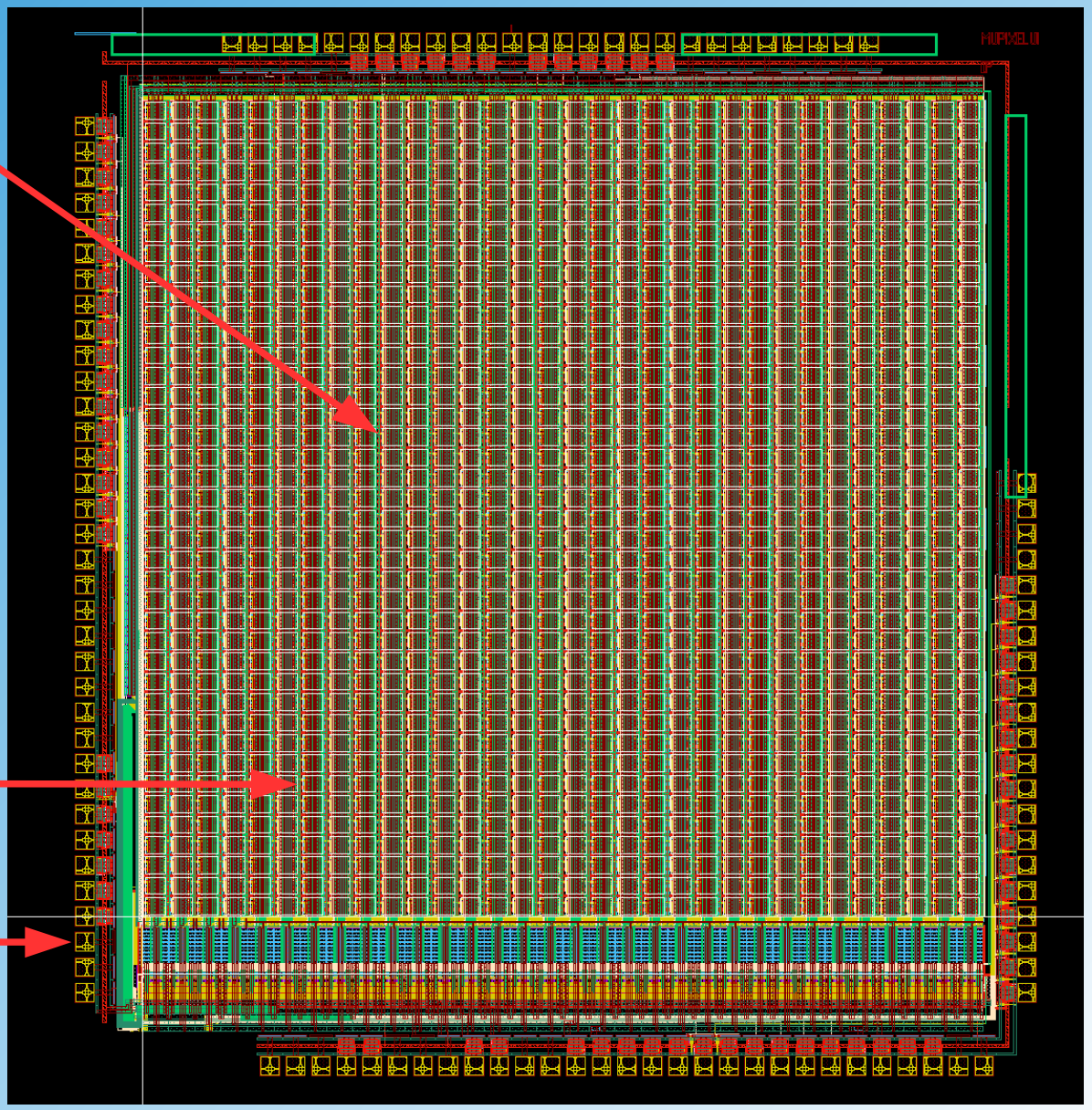
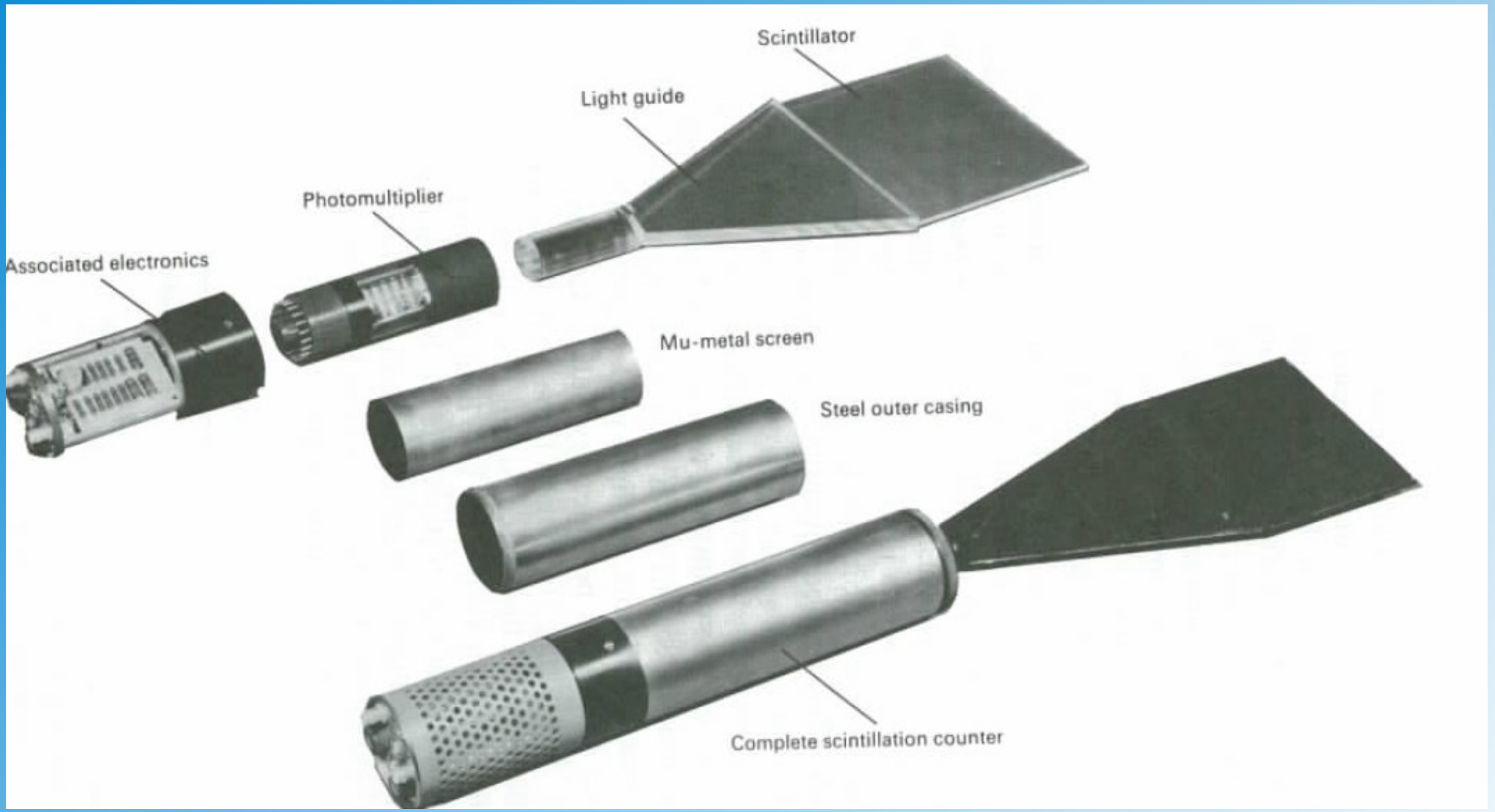


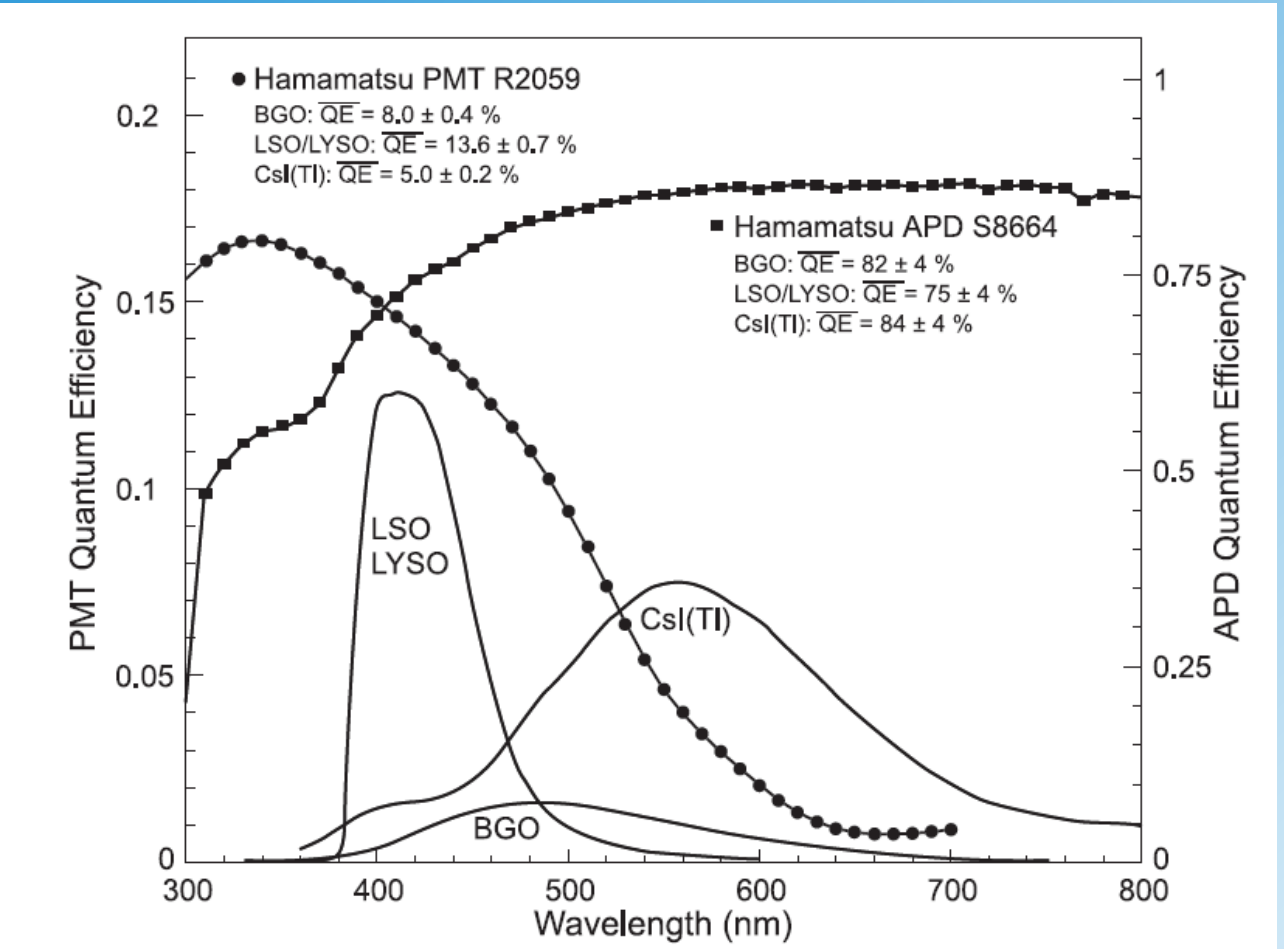
Photo Multiplier



scintillating panels used for charged particles
fast signals: used for timing measurements and trigger

Quantum Efficiency of PMs and APDs

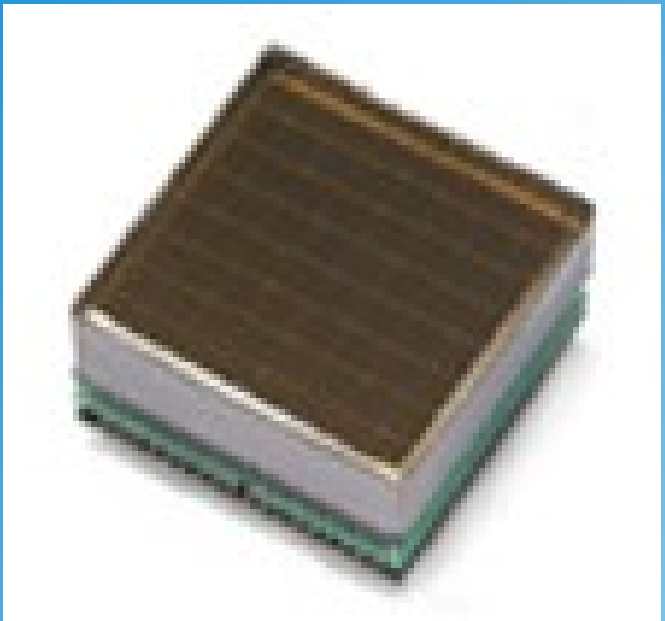
photomultiplier tubes and avalanche photodiodes

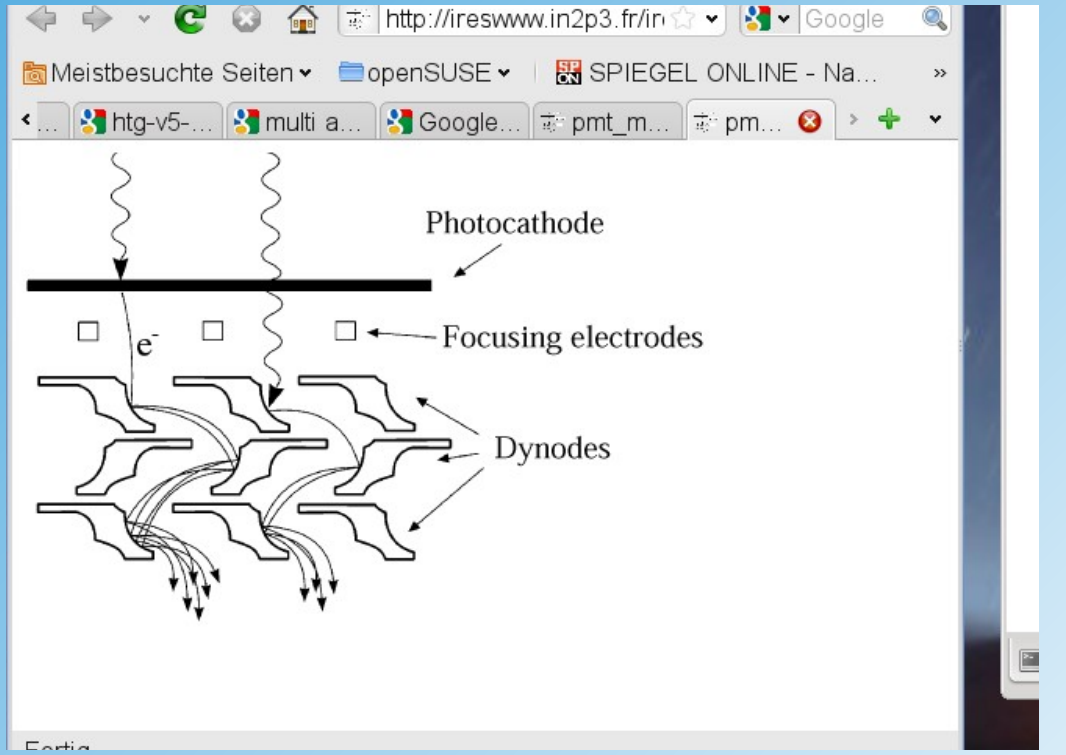


number of primary electrons generated by photon

Position Sensitive Multi-Channel (Anode) Photomultiplier

→ pixels





- cross talk
- noise
- quantum efficiency
- gain

PM Quantum Efficiency and Gain

Quantum Efficiency

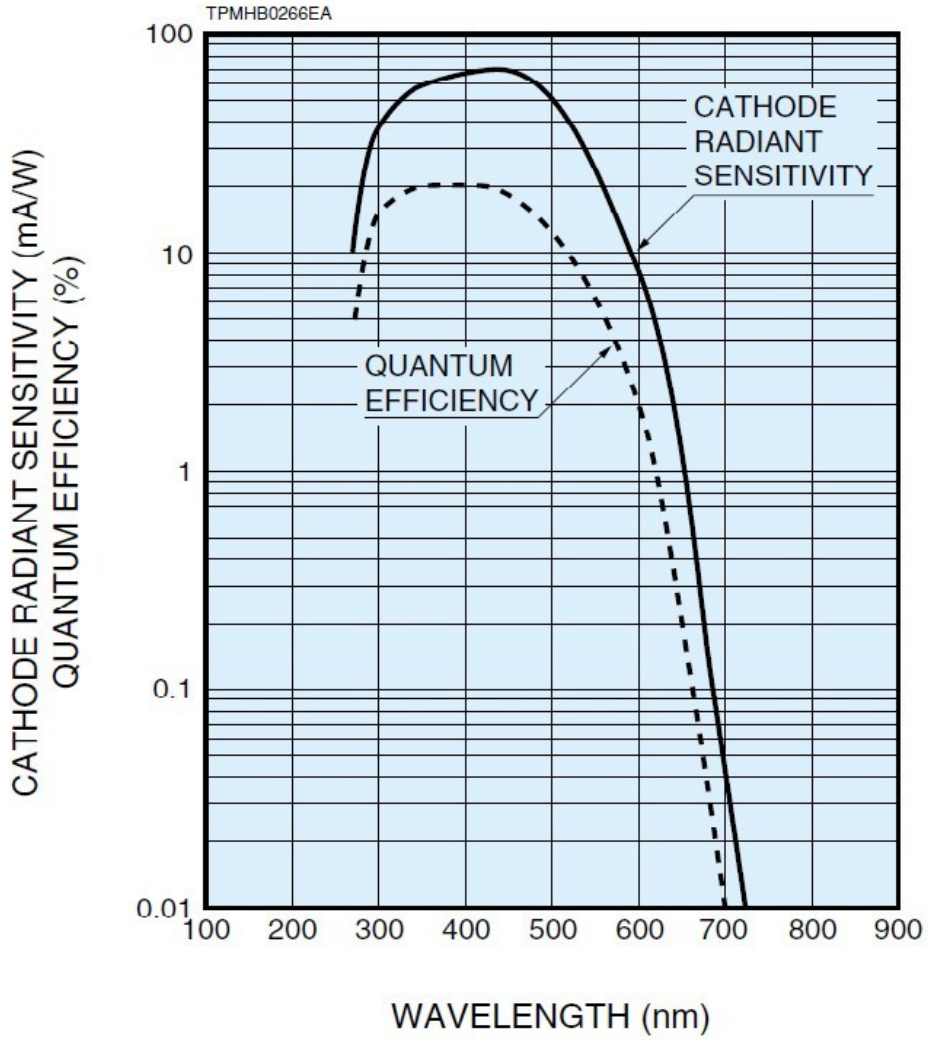
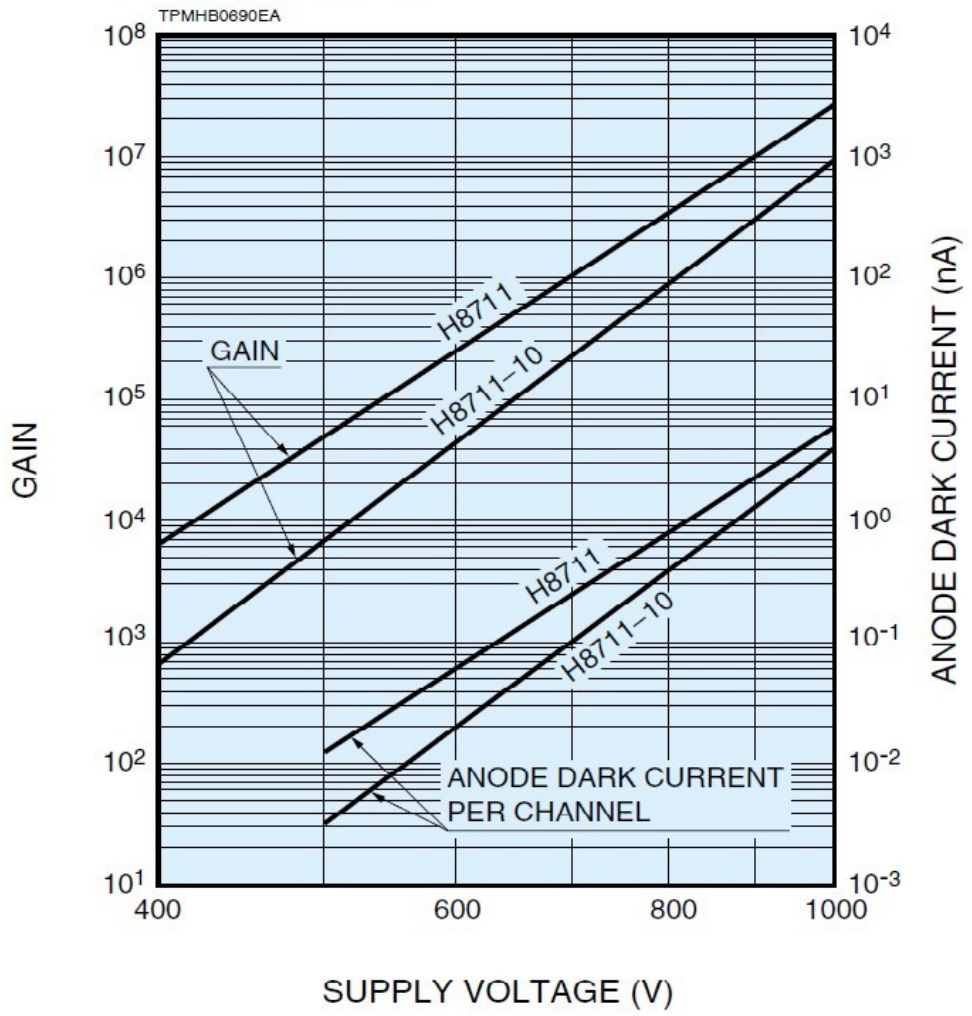
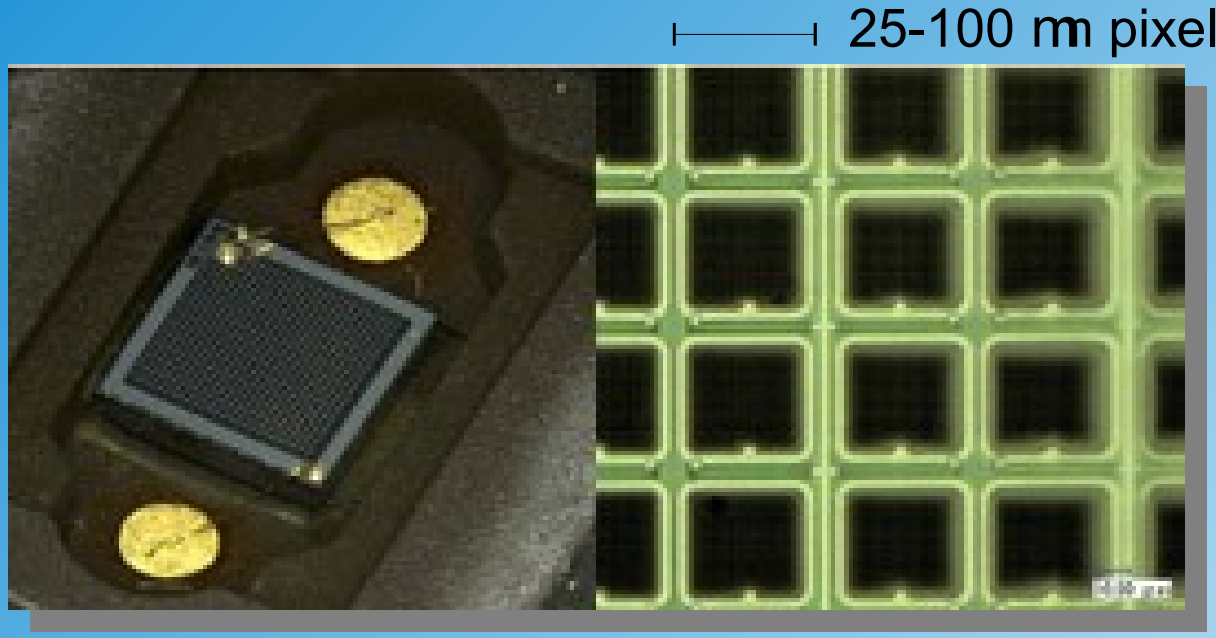


Figure 2: Typical Gain and Anode Dark Current per Channel



Silicon Photomultipliers

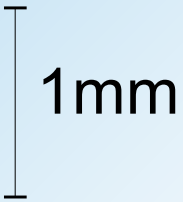
- electron amplification (avalanche) in silicon



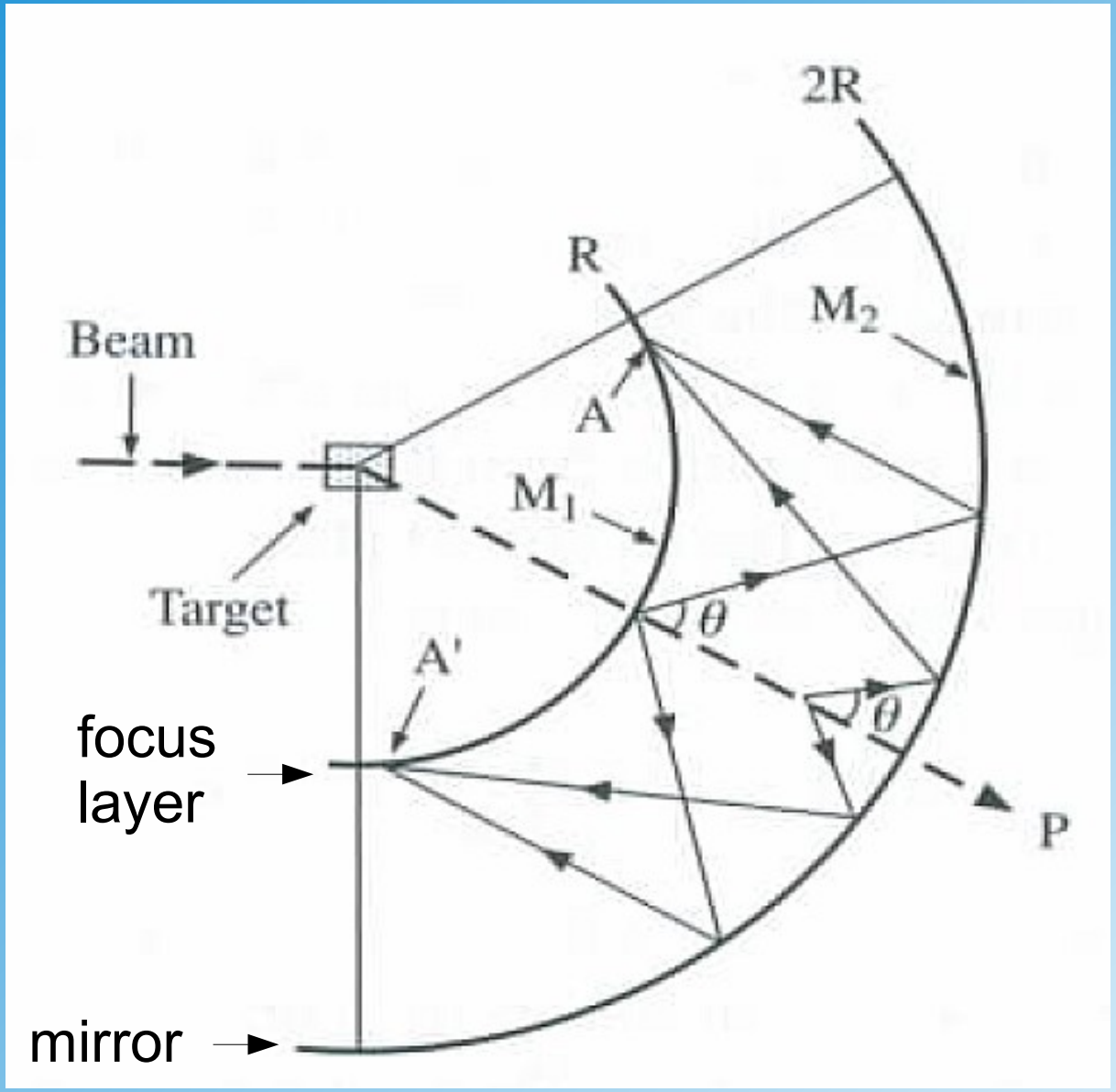
digital and
position sensitive

high gain 10^5-10^6
and fast > 1MHz

can be used to digitise photons from scintillating fiber trackers:

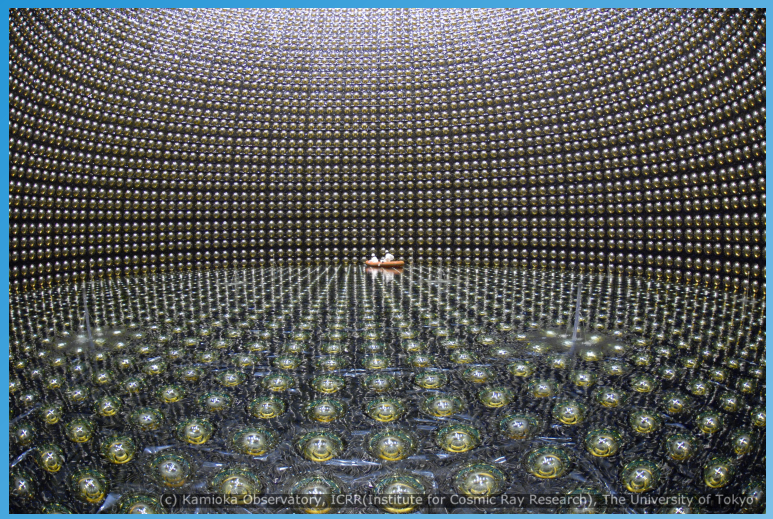


Cherenkov-Counter

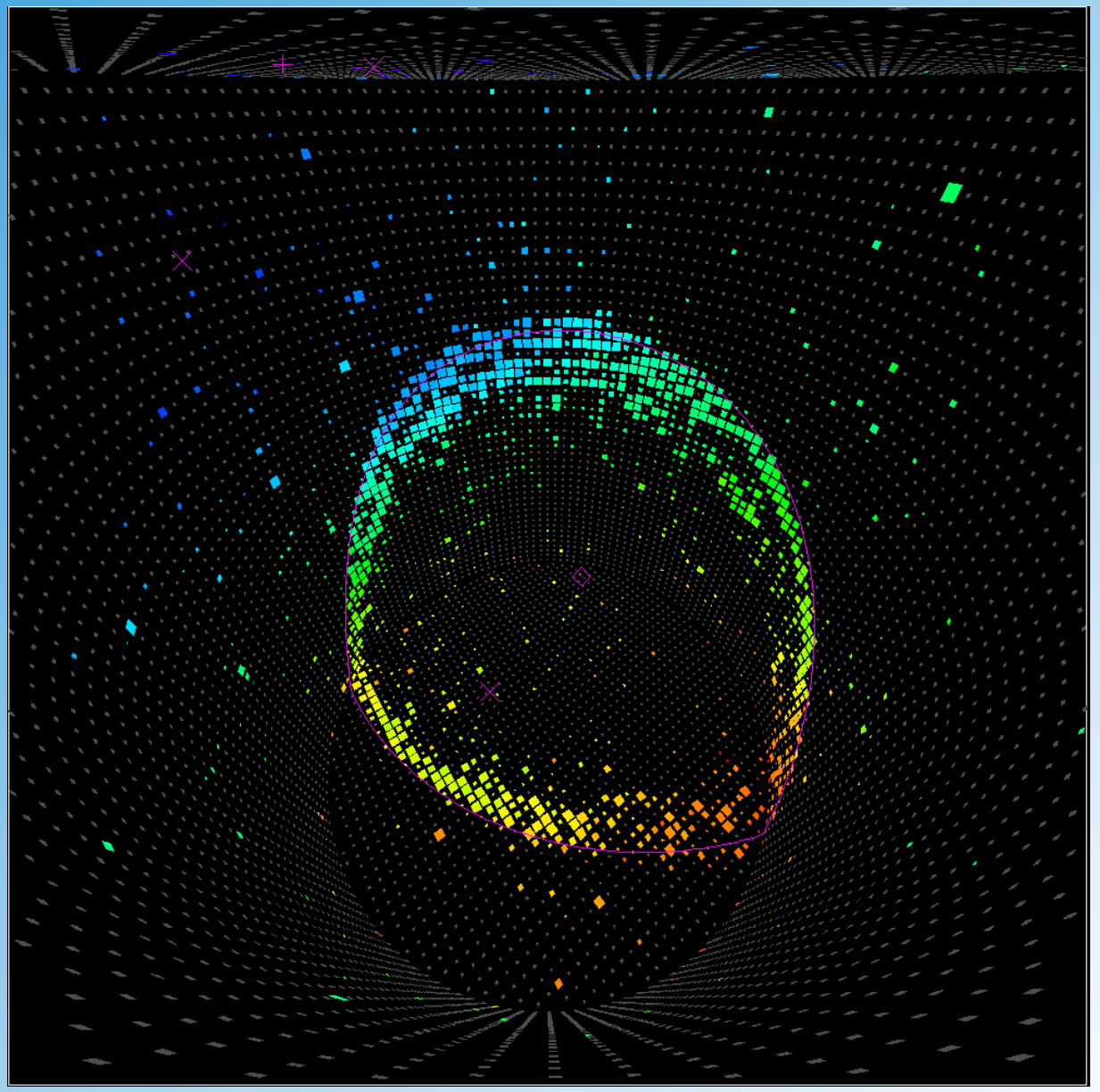


Super-Kamiokande

Neutrino Experiment



Cherenkov light
in water tank by
625 MeV muon



Detector Shell Structure