ReFerence Photosensor

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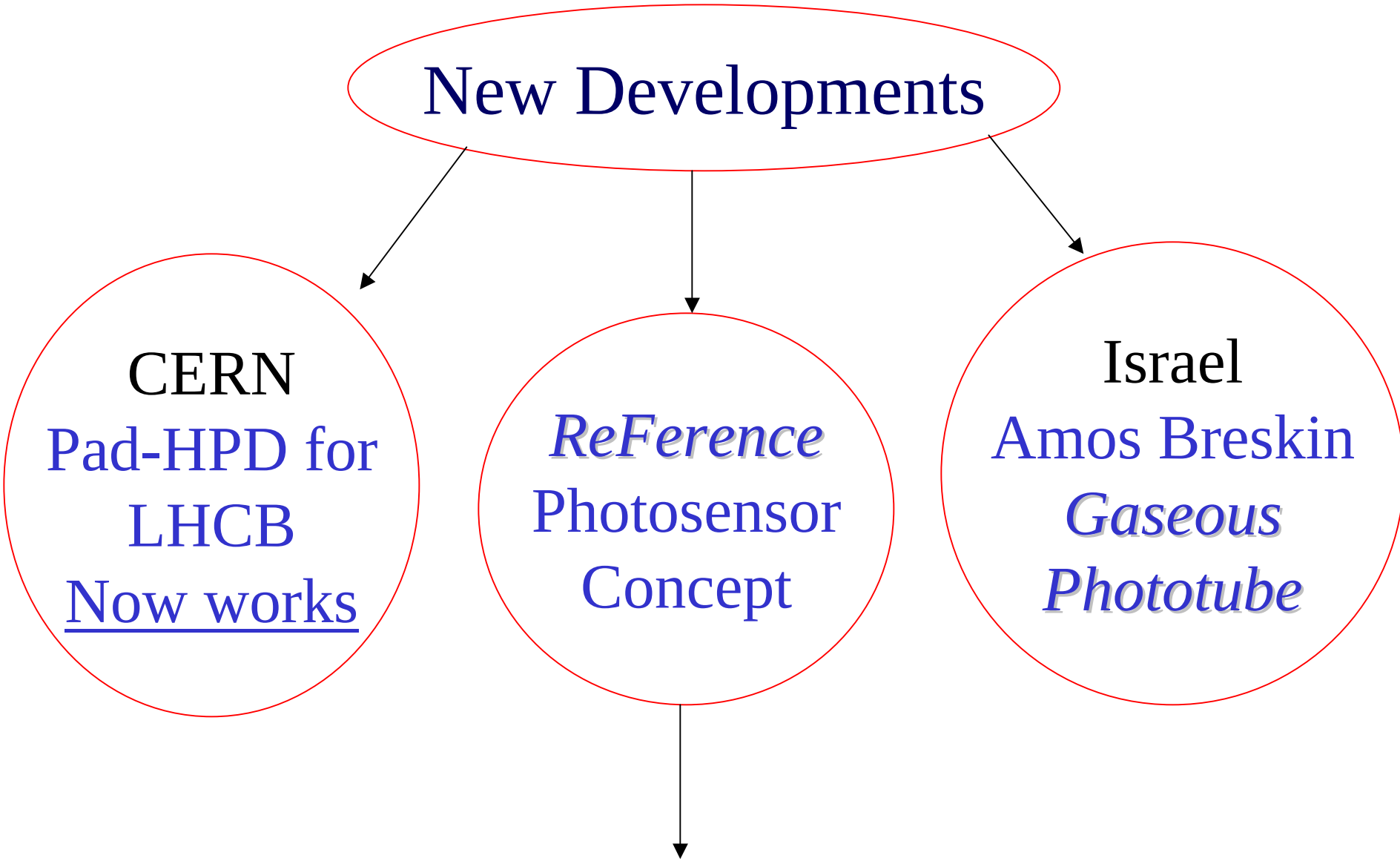
University of California Davis

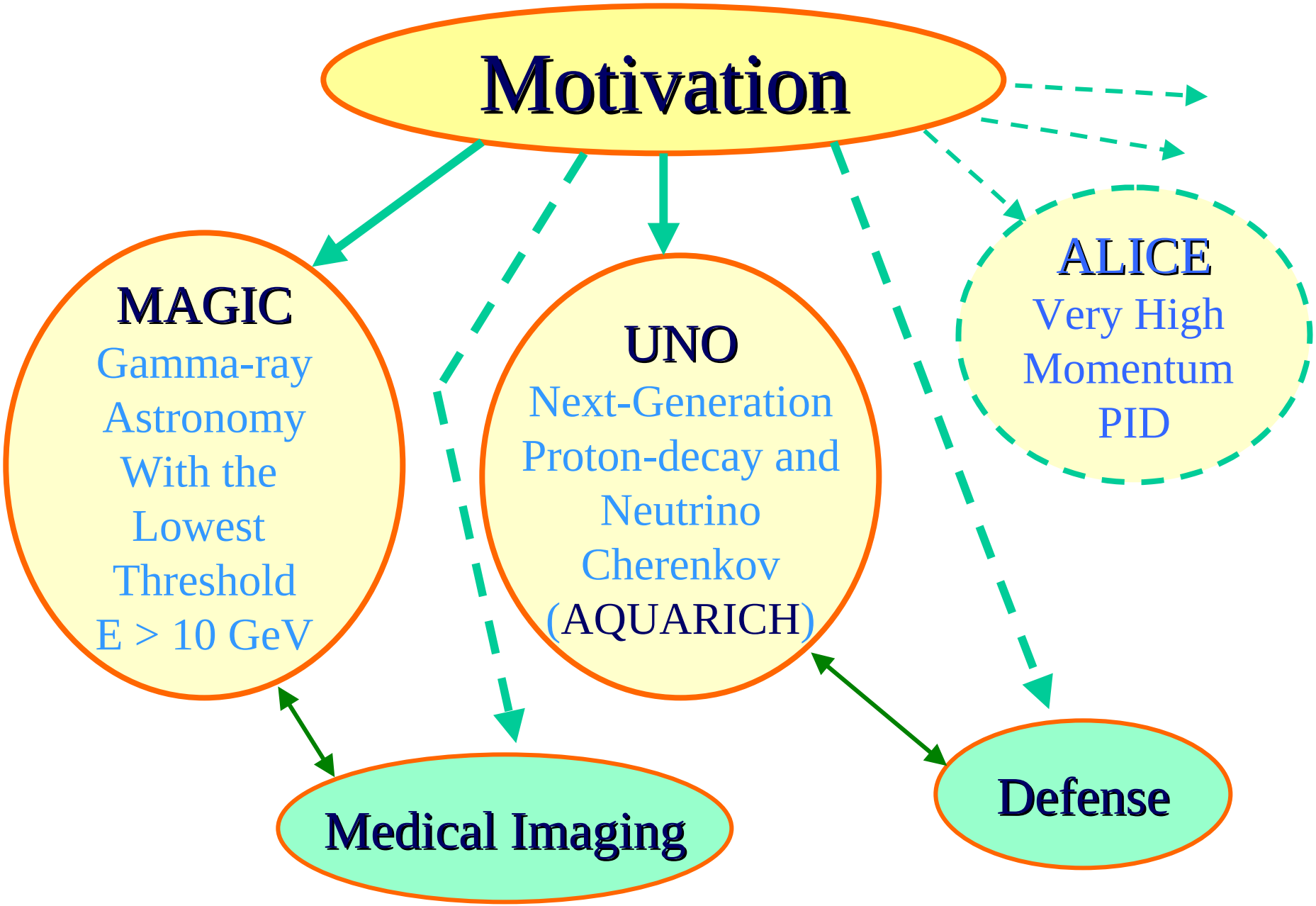
Supported in part by the

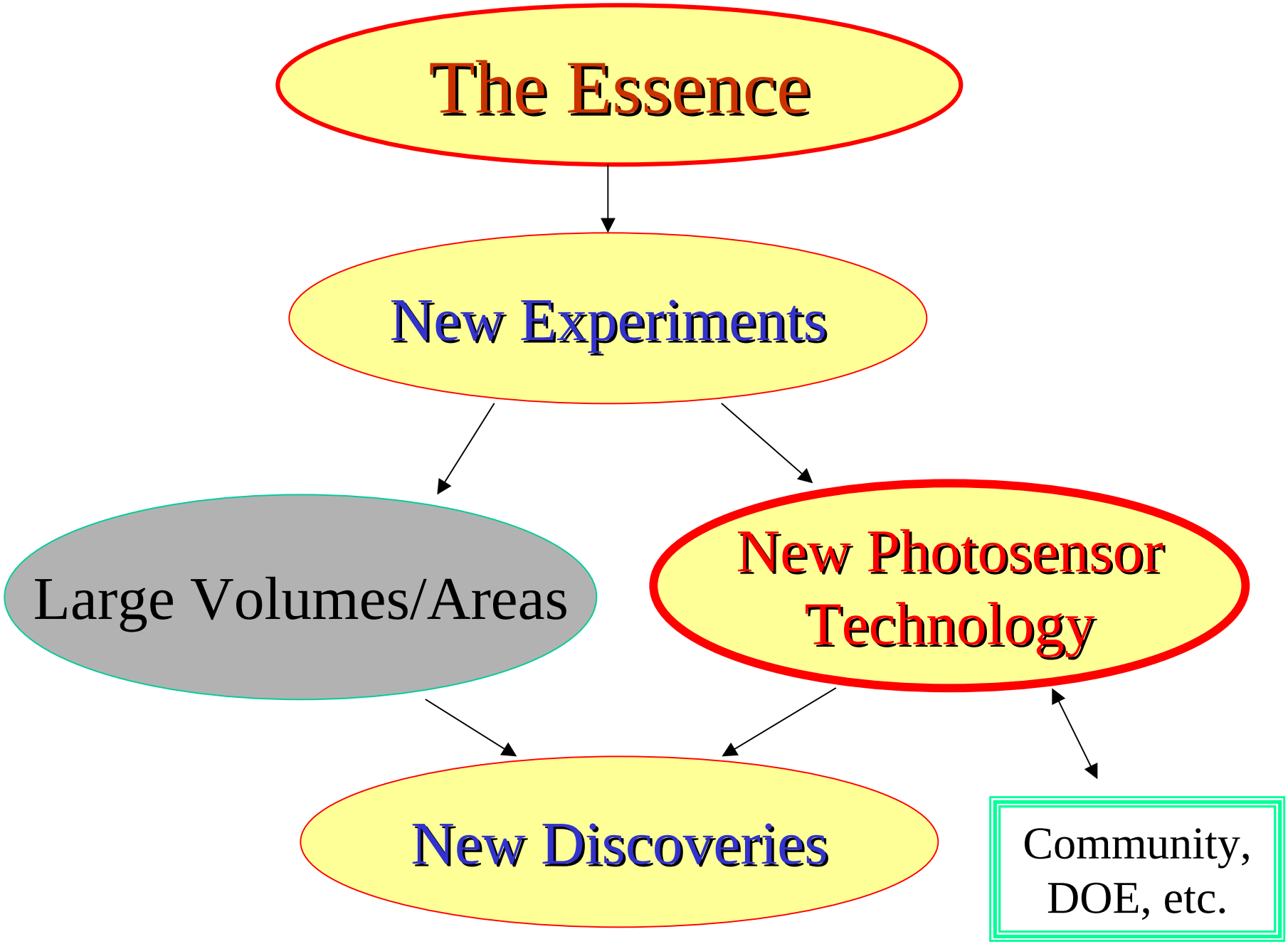
Advanced Detector Research Award

DOE/HEP

(Mike Procario)


New Developments
CERN
Pad-HPD for LHCB
Now works
ReFerence
Photosensor
Concept
Israel
Amos Breskin
Gaseous
Phototube


Motivation
MAGIC
Gamma-ray Astronomy With the Lowest Threshold E > 10 GeV
UNO
Next-Generation Proton-decay and Neutrino Cherenkov (AQUARICH)
ALICE
Very High Momentum PID
Medical Imaging
Defense


The Essence
New Experiments
Large Volumes/Areas
New Photosensor Technology
New Discoveries
Community, DOE, etc.

Outline

- *ReFerence* Photosensor Concept
- *TransReFerence* Concept:
  - Multiple Extension of Spectral Sensitivity Range
  - Single-Photon Color Sensitivity
- Proof-of-Concept – Results of the First *ReFerence* Prototype Test @ UC Davis (October 2001)
- Fully Functional Prototype(s) Development, in Collaboration with *ITT Night Vision Industries*
- Particular Benefits for NNN-Physics –

  New Configuration(s) - the *"Spectacles"*

  (after Tom Ypsilantis)

Photosensor Performance "Hyperspace"

- Quantum Efficiency
- Single-Photon Sensitivity
- Single-Photon Resolution
- Spatial Resolution
- Dead Area (Camera)
- Time Resolution and Jitter
- Angular Acceptance
- Spectral Width, Color Sensitivity
- Thermionic Noise (Cooling?)
- ***"Implosivity", COST,…***

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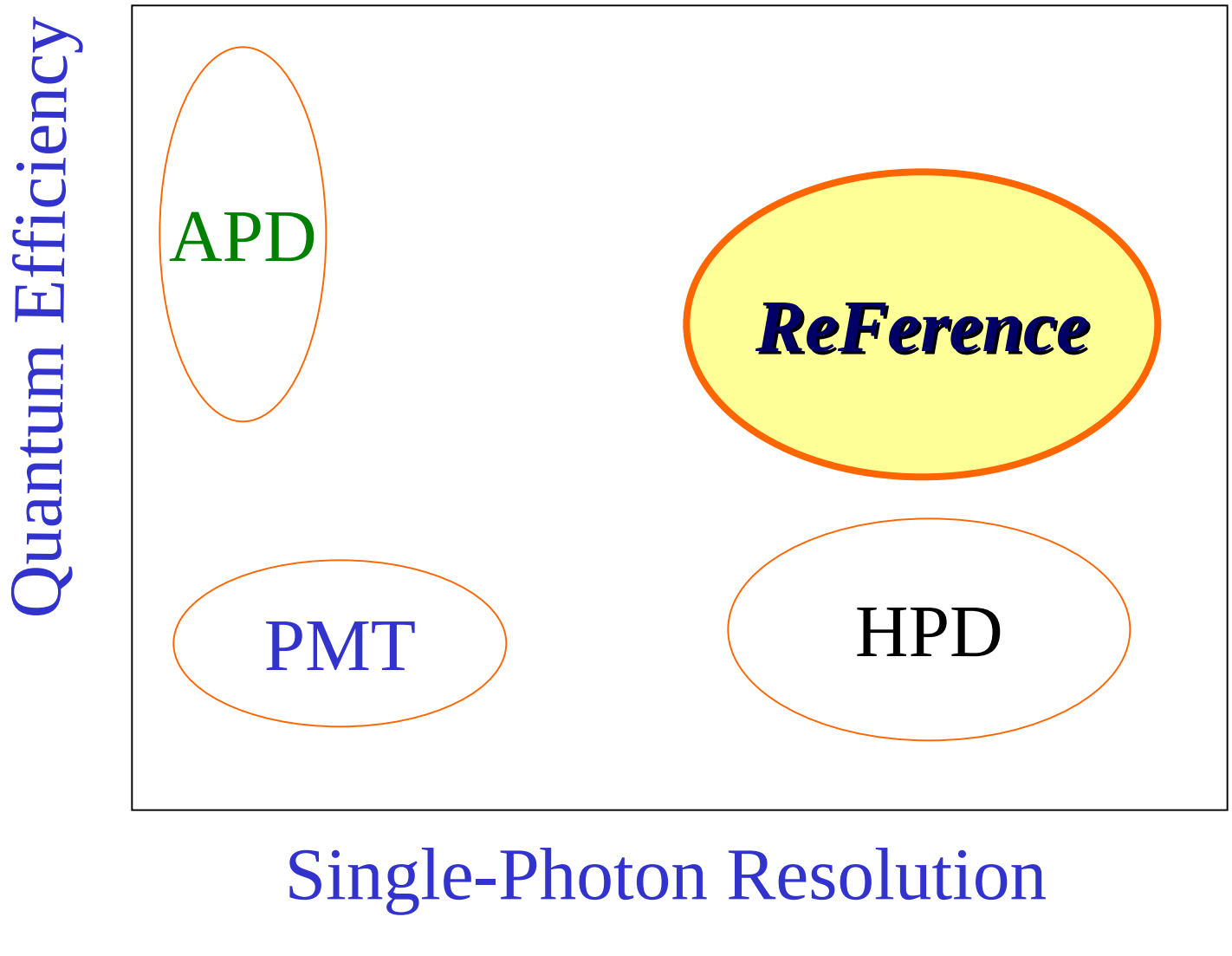
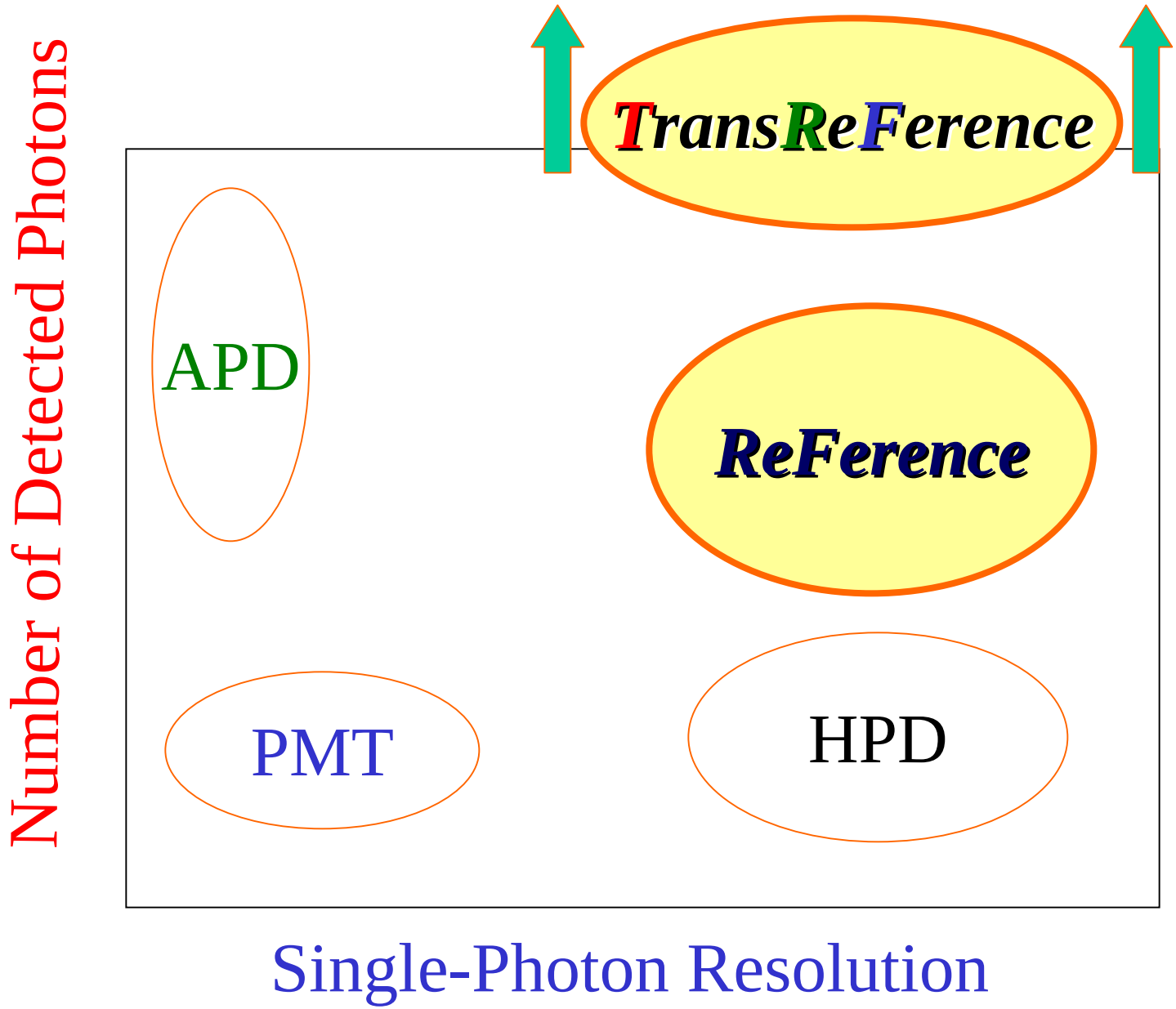
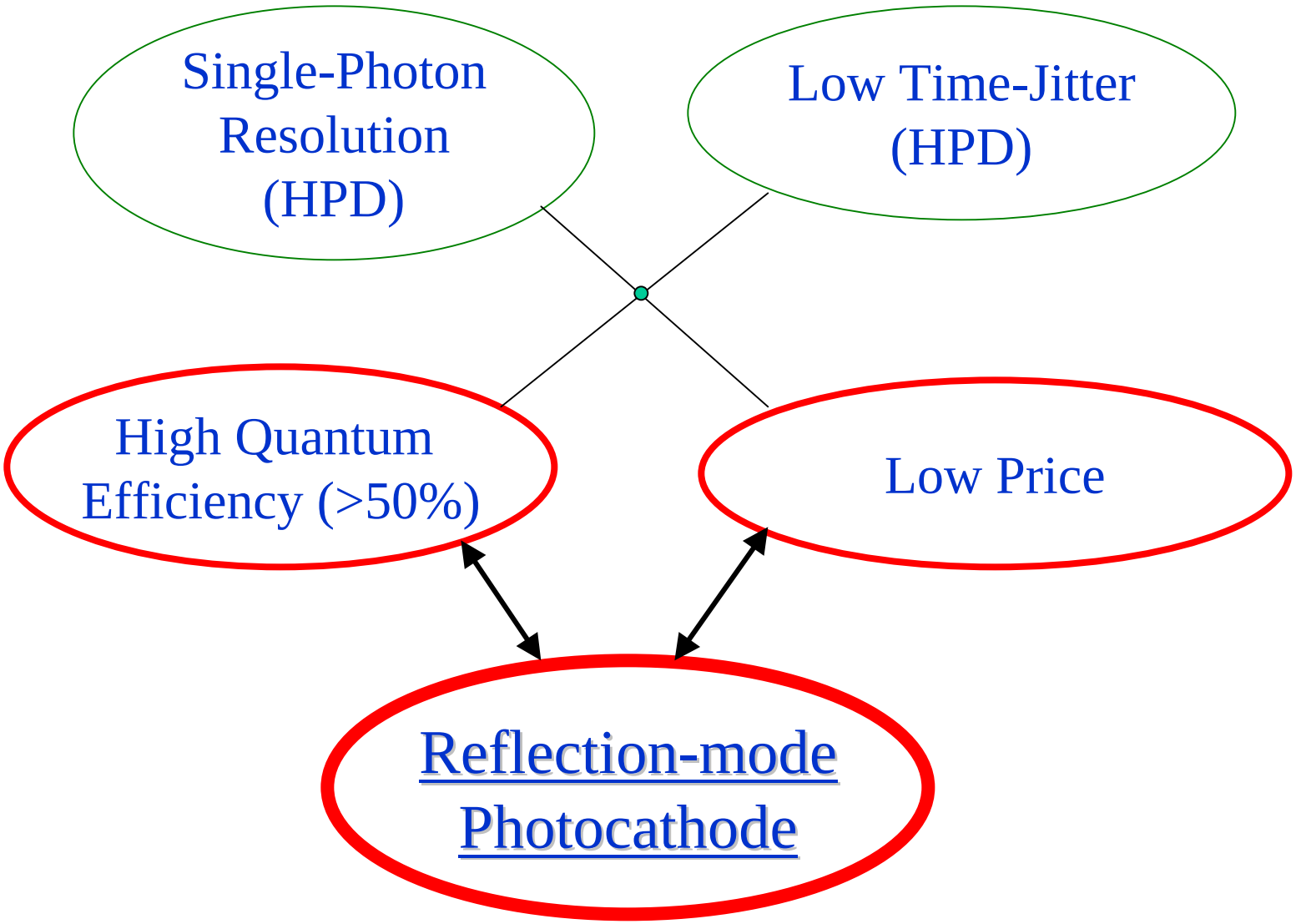
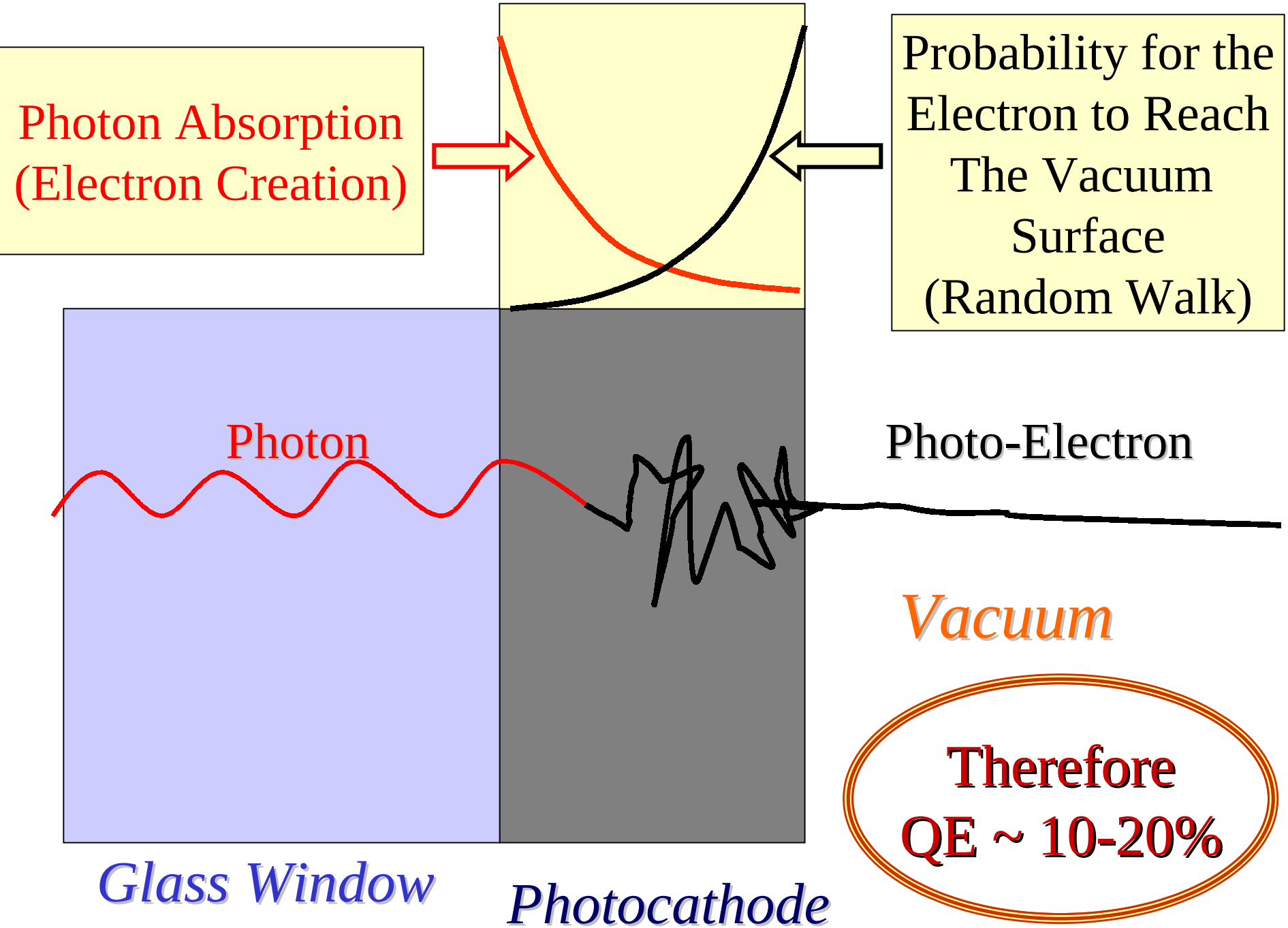
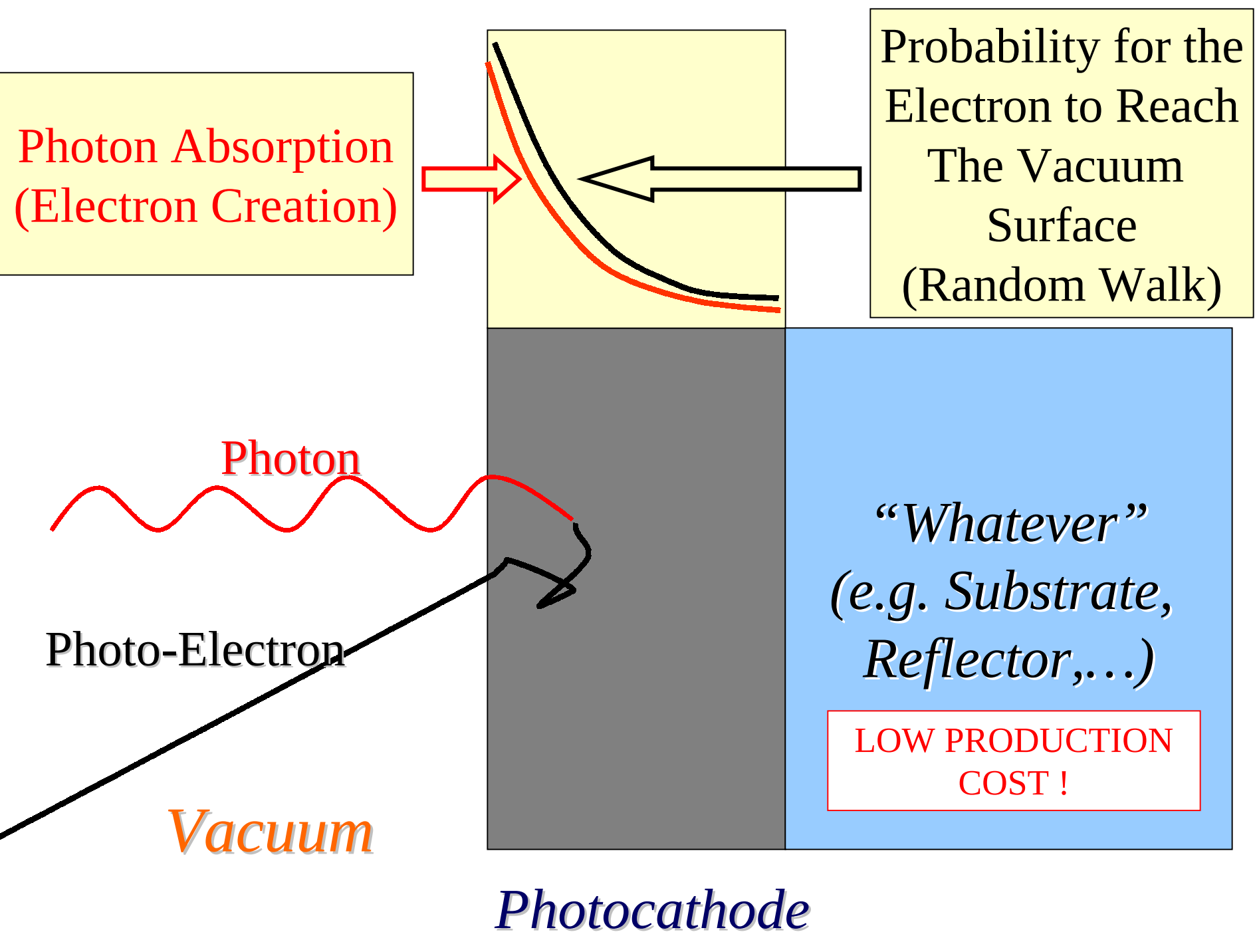

Quantum Efficiency
APD
ReFerence
PMT
HPD
Single-Photon Resolution

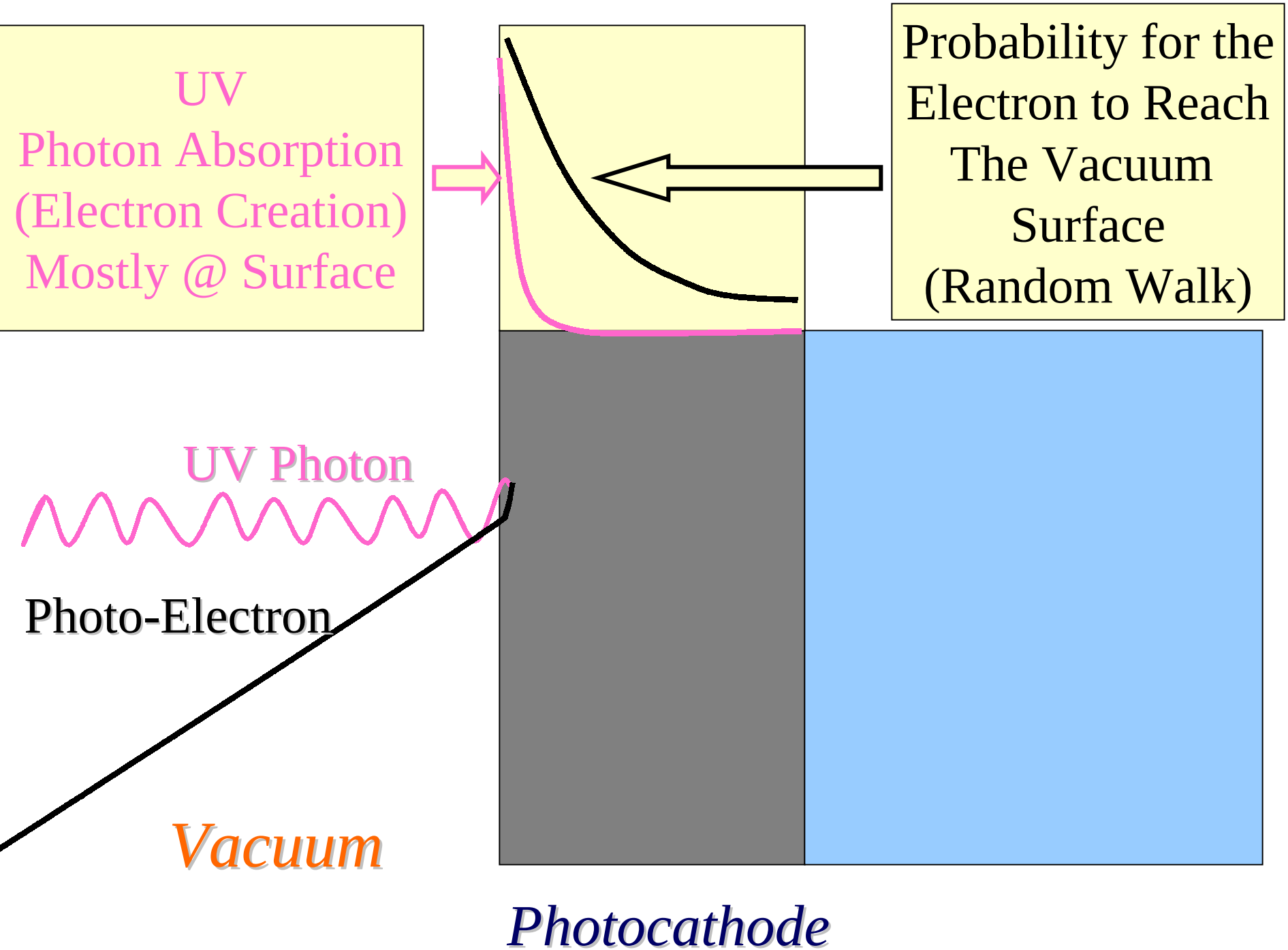

Number of Detected Photons
TransReFerence
APD
ReFerence
PMT
HPD
Single-Photon Resolution

The (Original) Dream

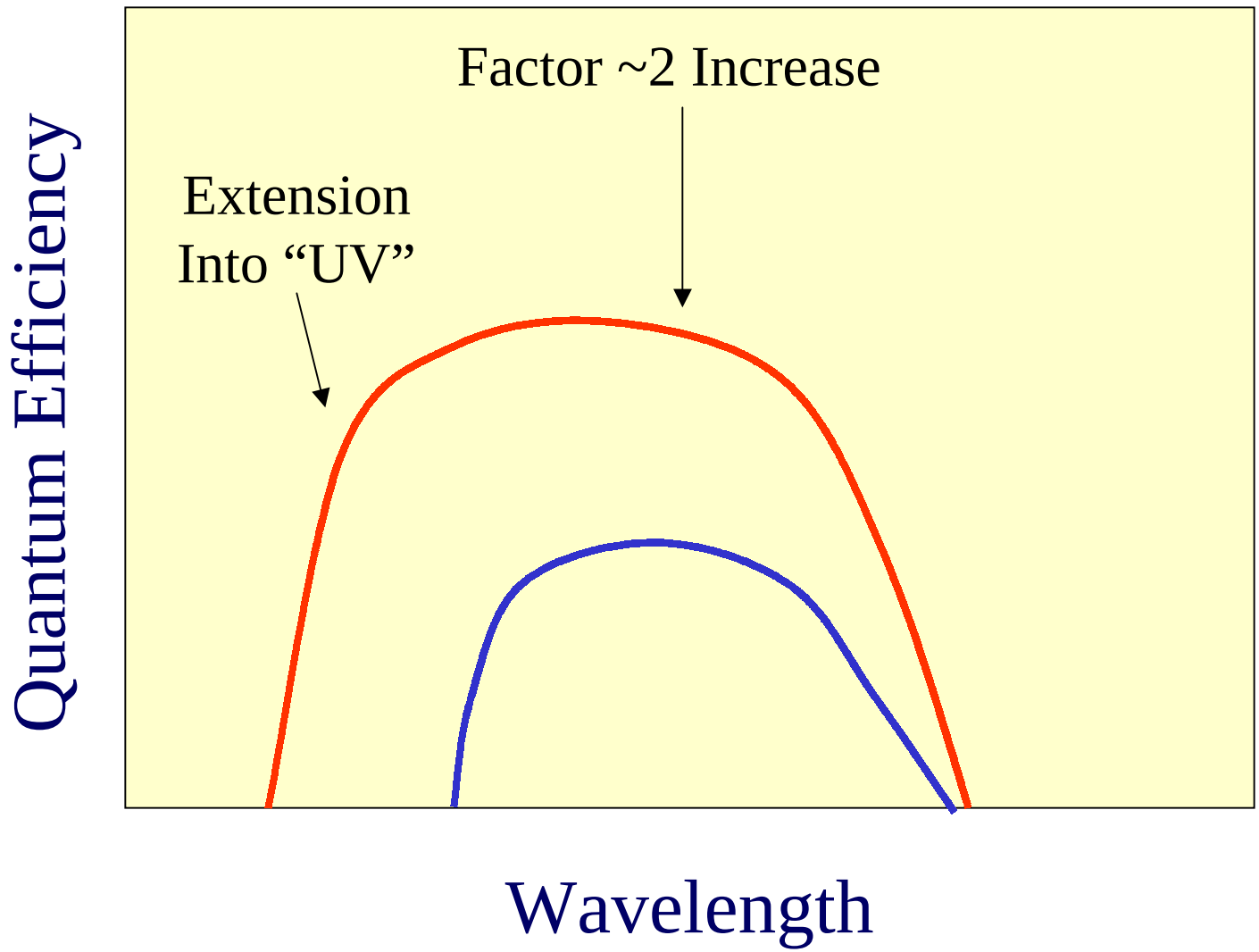



Photon Absorption
(Electron Creation)
Probability for the
Electron to Reach
The Vacuum
Surface
(Random Walk)
Photon
Photo-Electron
Vacuum
Therefore
QE ~ 10-20%
Glass Window
Photocathode

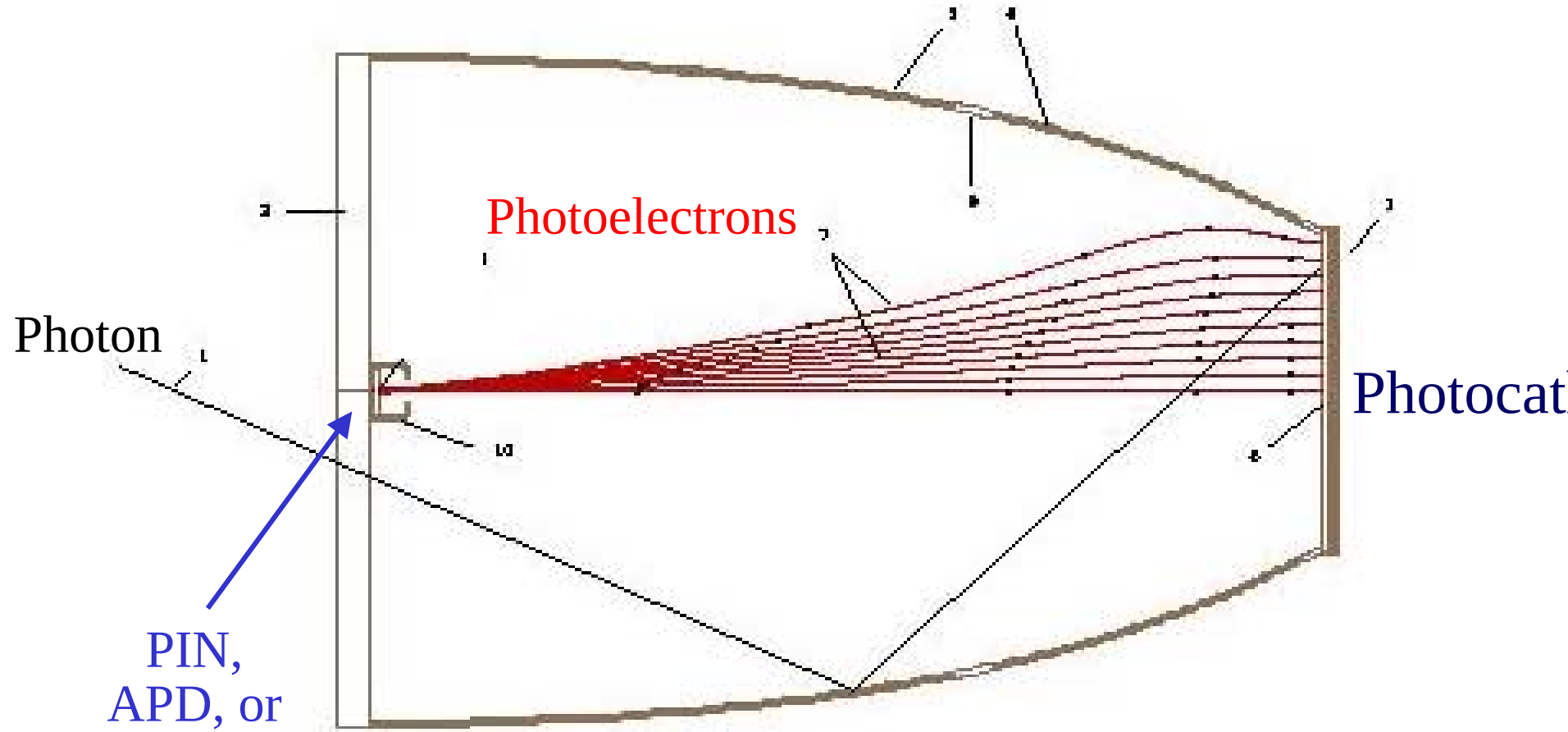

Photon Absorption
(Electron Creation)
Probability for the
Electron to Reach
The Vacuum
Surface
(Random Walk)
Photon
Photo-Electron
Vacuum
"Whatever"
(e.g. Substrate,
Reflector,…)
LOW PRODUCTION
COST !
Photocathode


UV
Photon Absorption
(Electron Creation)
Mostly @ Surface
Probability for the
Electron to Reach
The Vacuum
Surface
(Random Walk)
UV Photon
Photo-Electron
Vacuum
Photocathode

Reflection Mode vs Transmission Mode

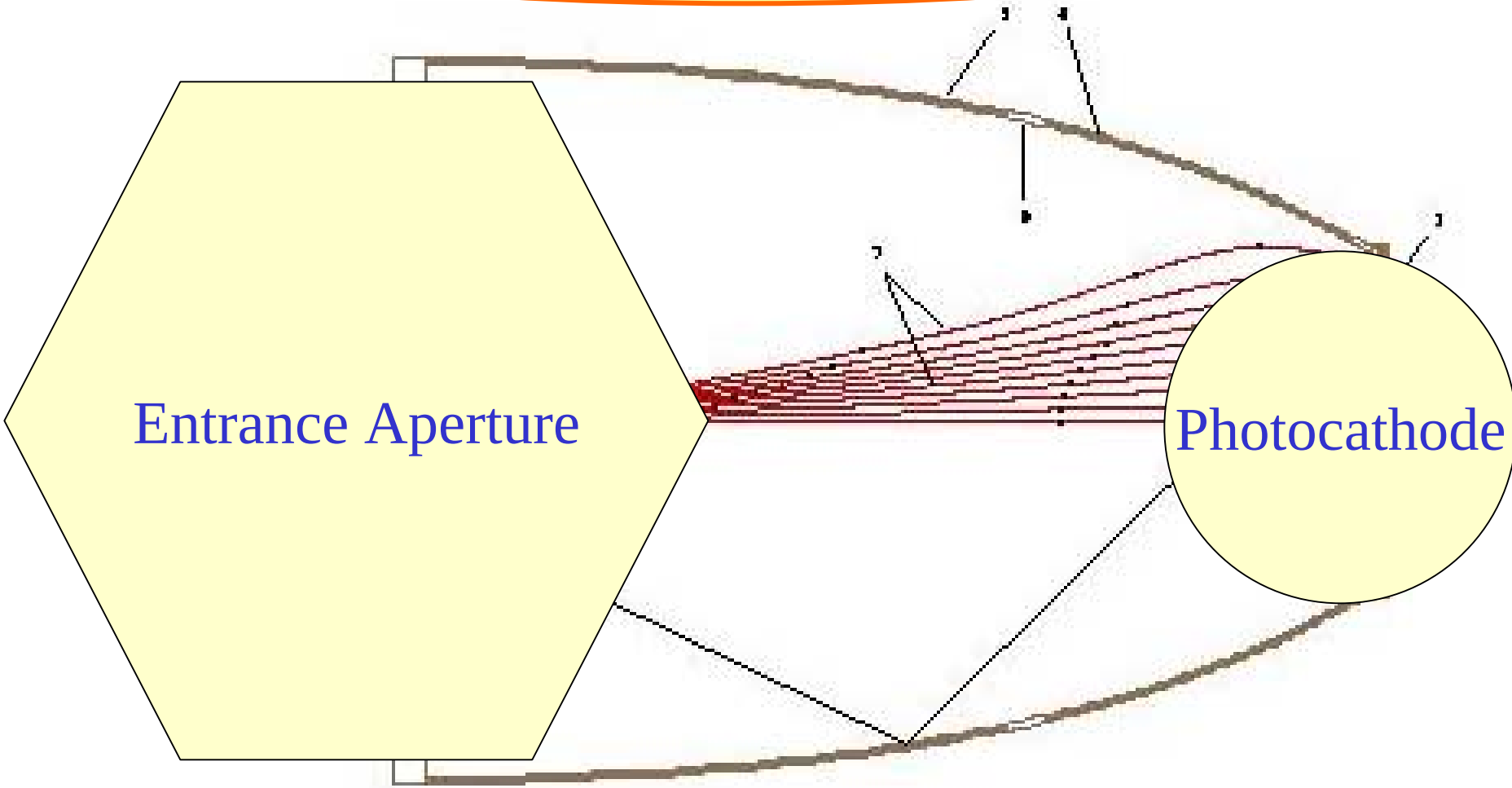


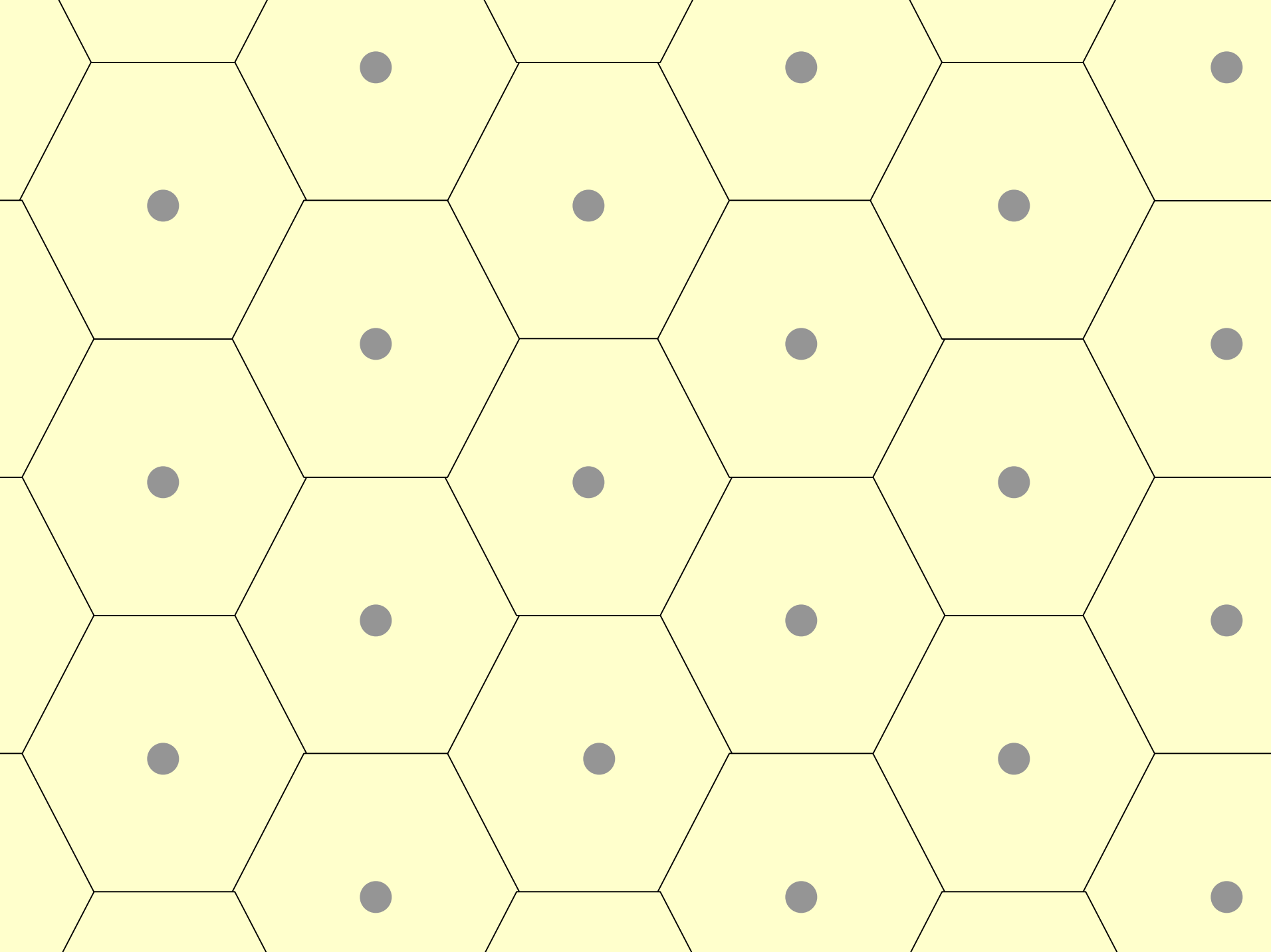
Ideal Light Concentrator



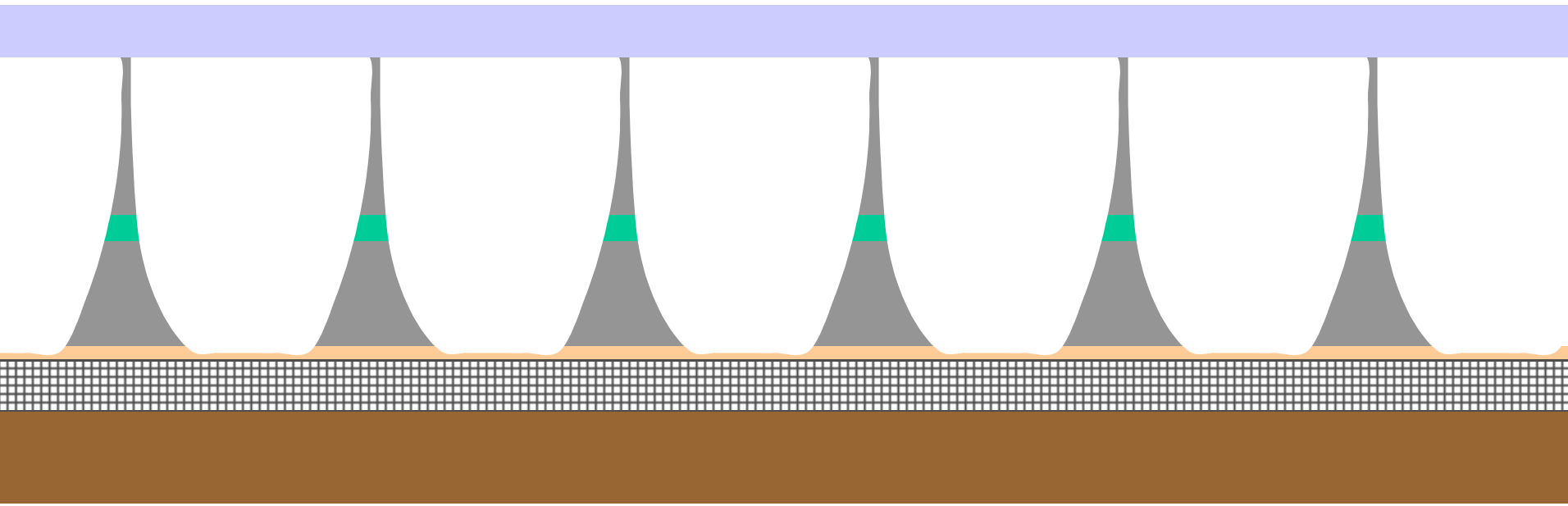
Optimal Electron Lens

Hexagonal Packing





Flat-Panel Honeycomb Camera Construction

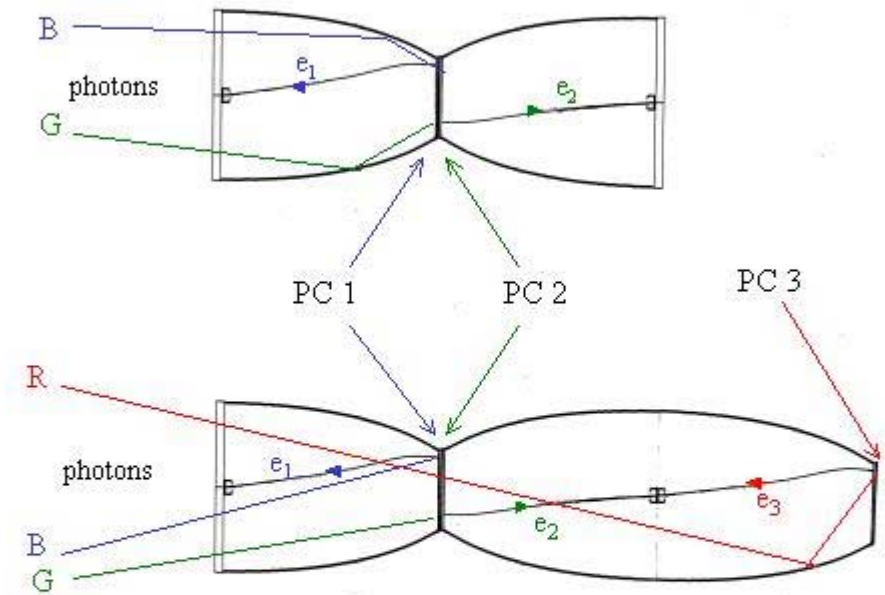


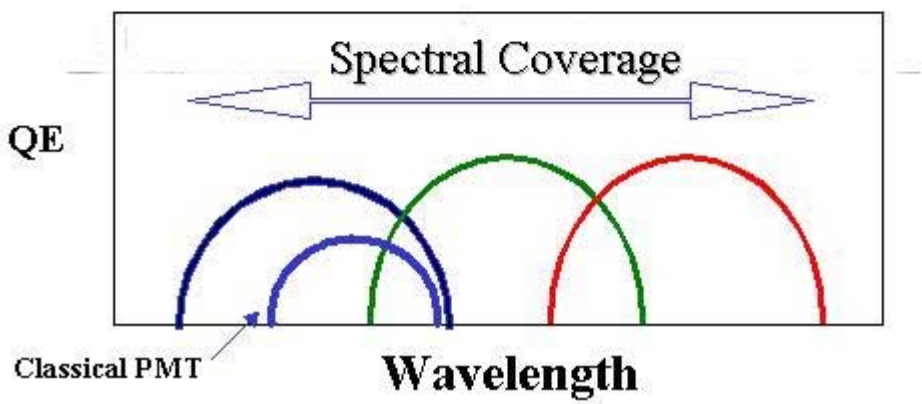
Industrial Production (no glass blowing etc.)

Mechanical Rigidity

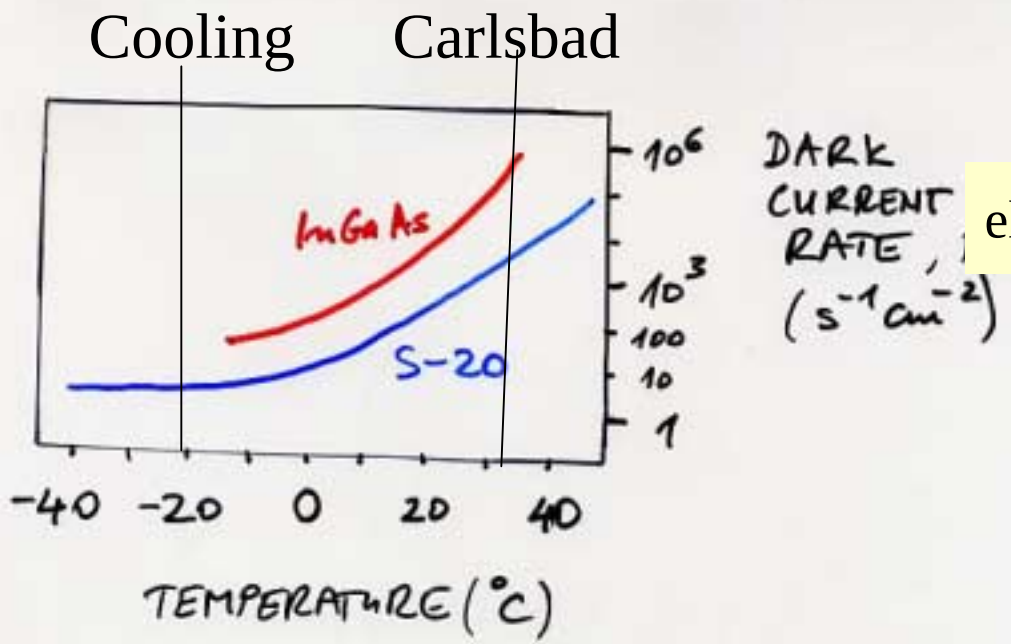
TransReFerence

Single-Photon Color Sensitivity

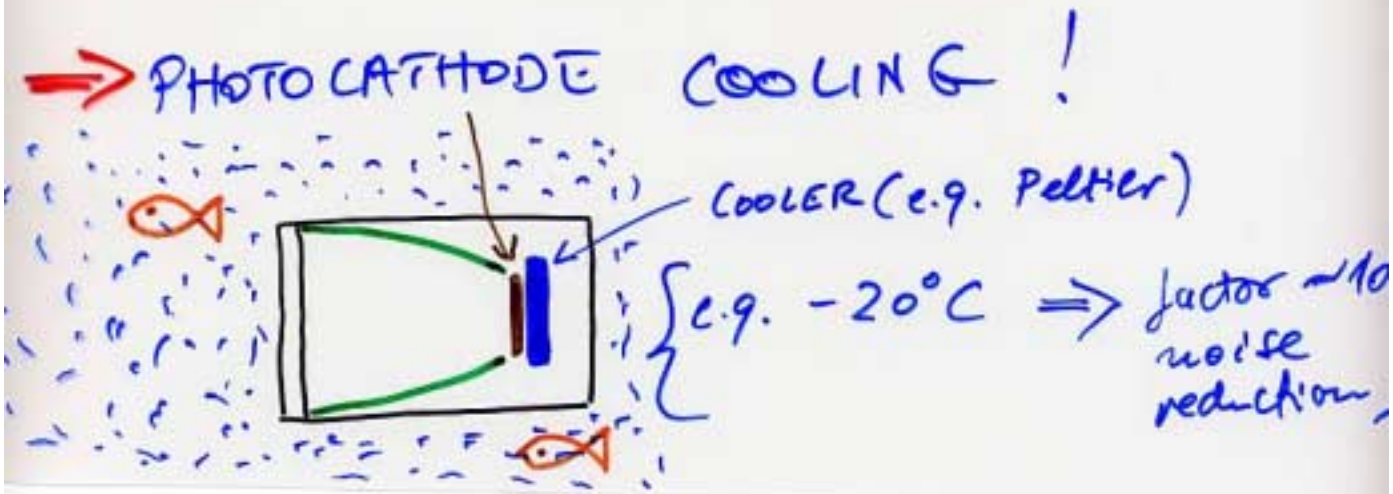




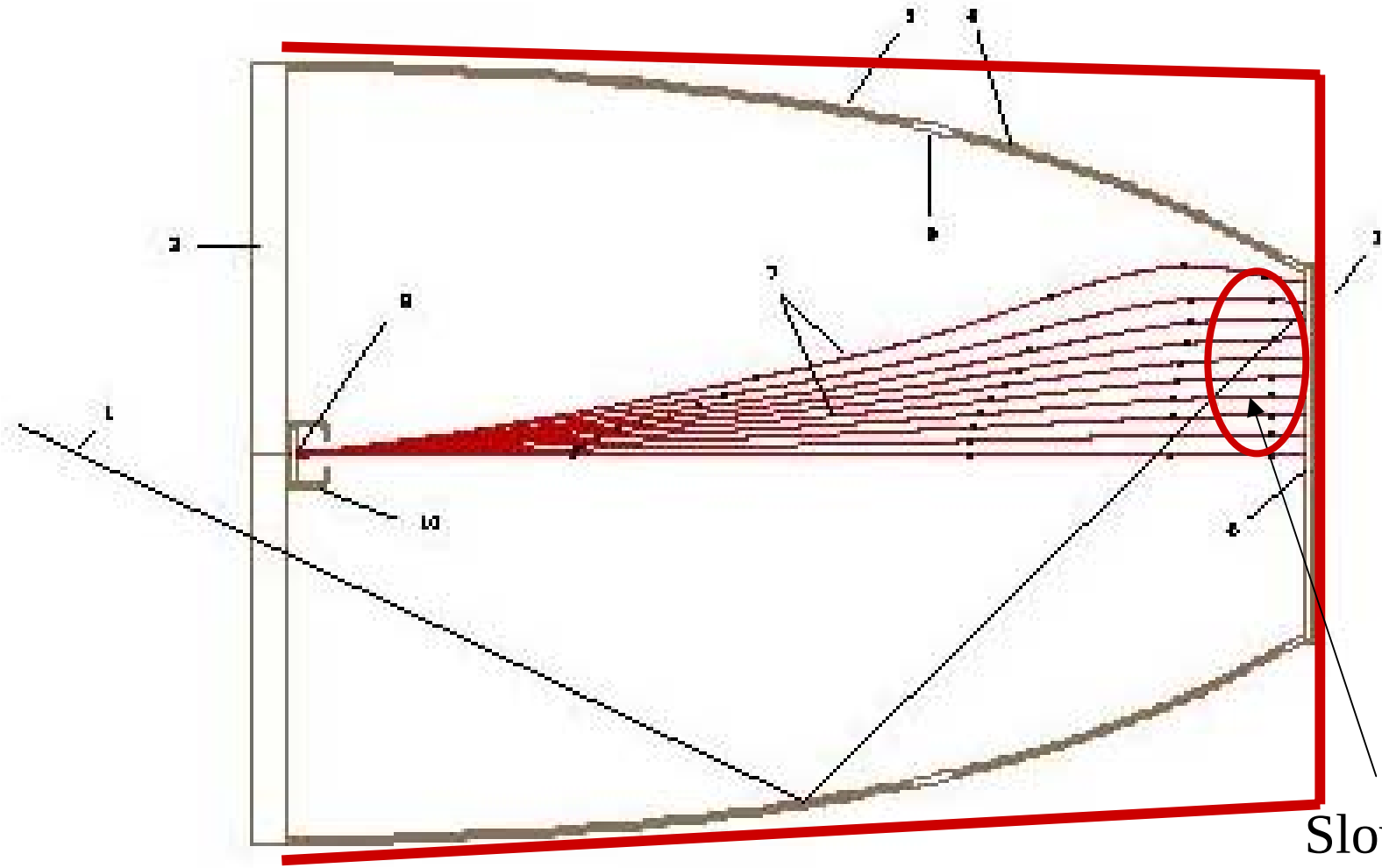
DARK CURRENT VS TEMPERATURE



electrons



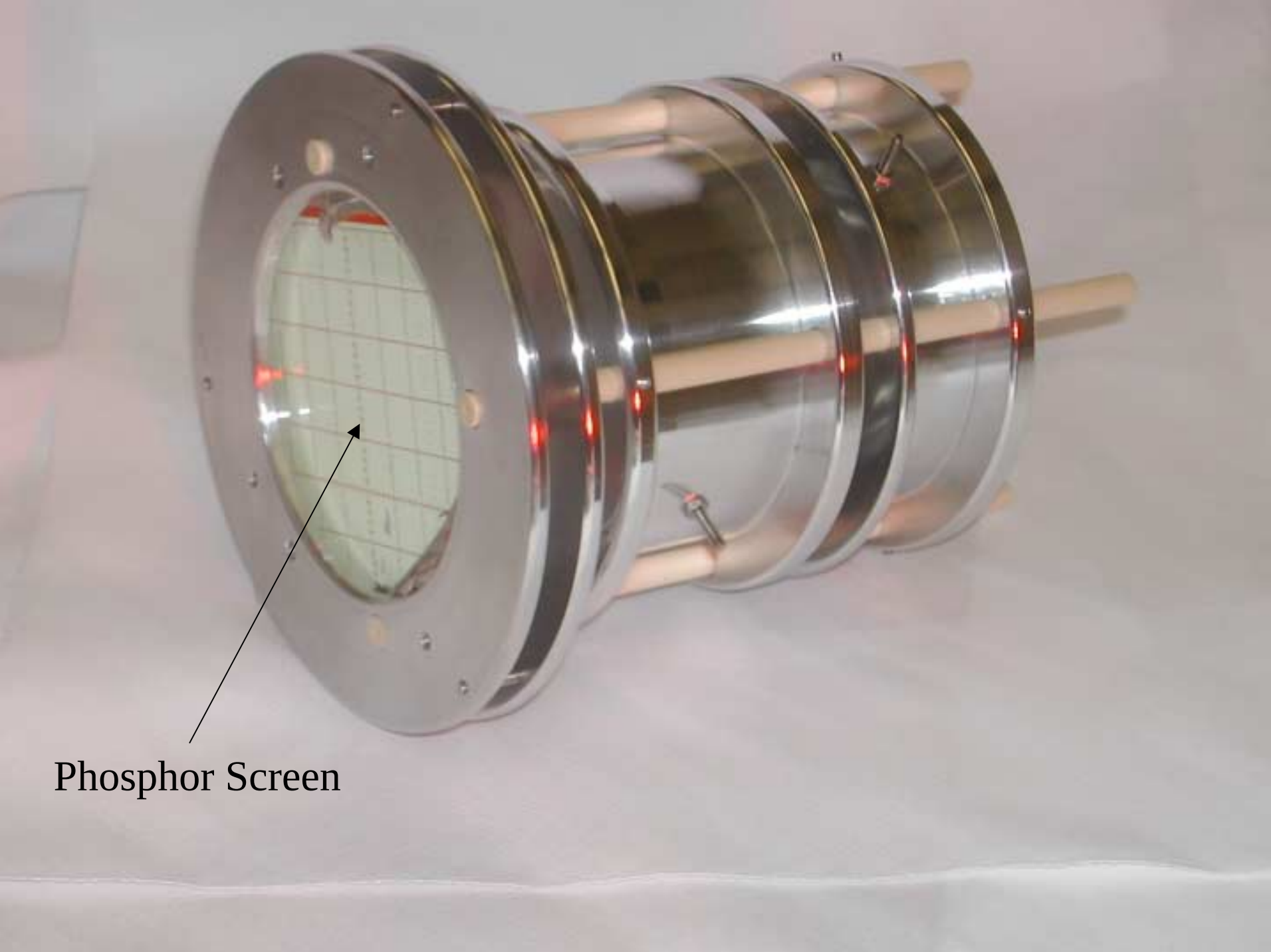
VERY EFFICIENT MAGNETIC SHIELDING



Slow electrons

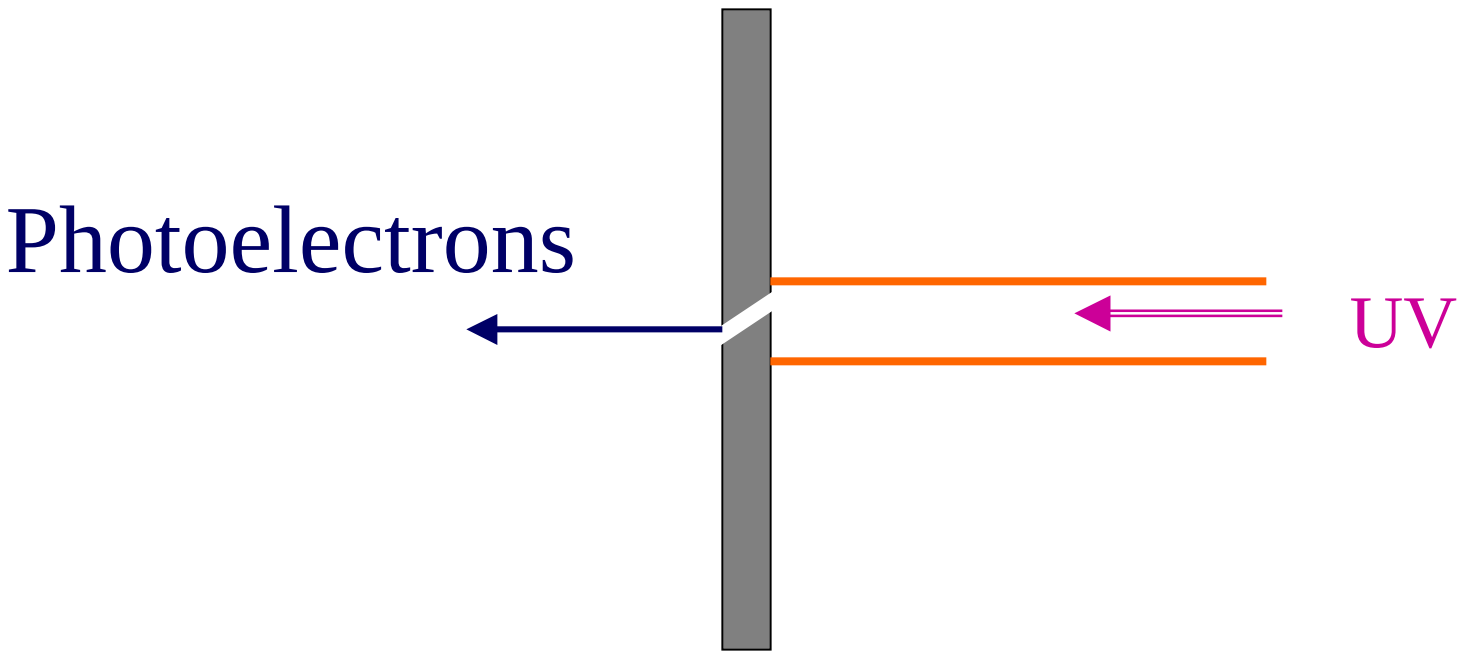
e.g. UNO with Magnetic field

Prototype Development @ UC Davis

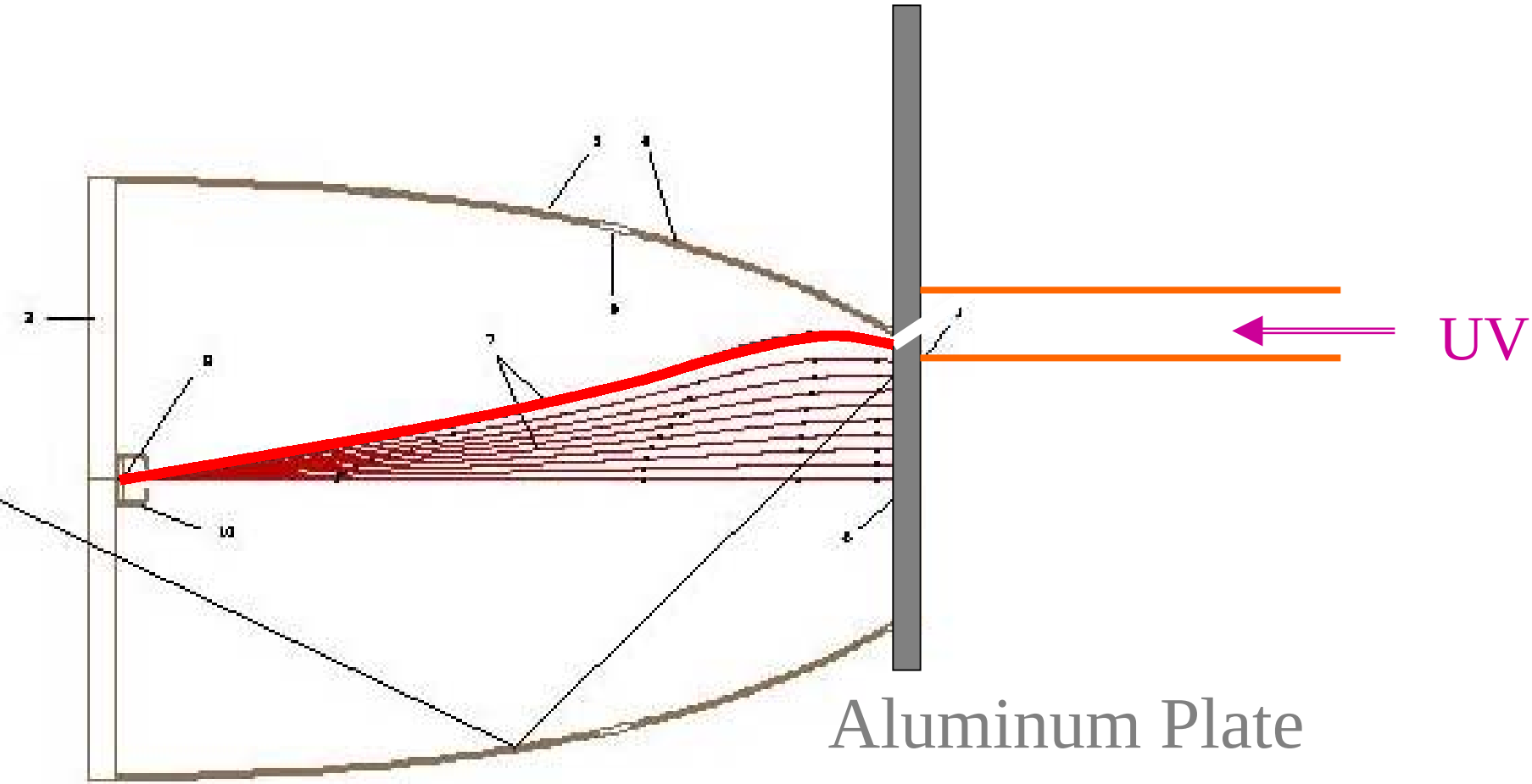

Phosphor Screen


Photocathode Aperture

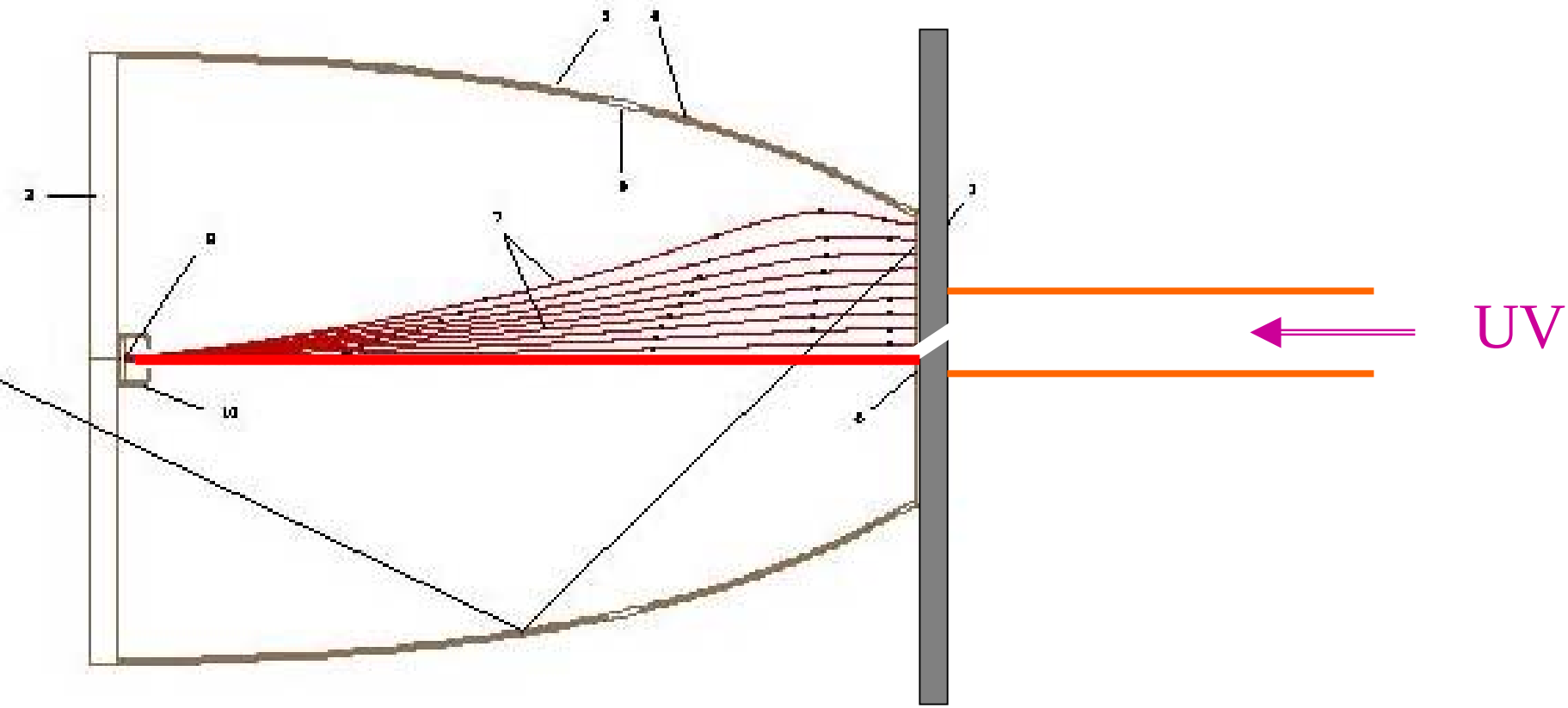
PHOTOCATHODE



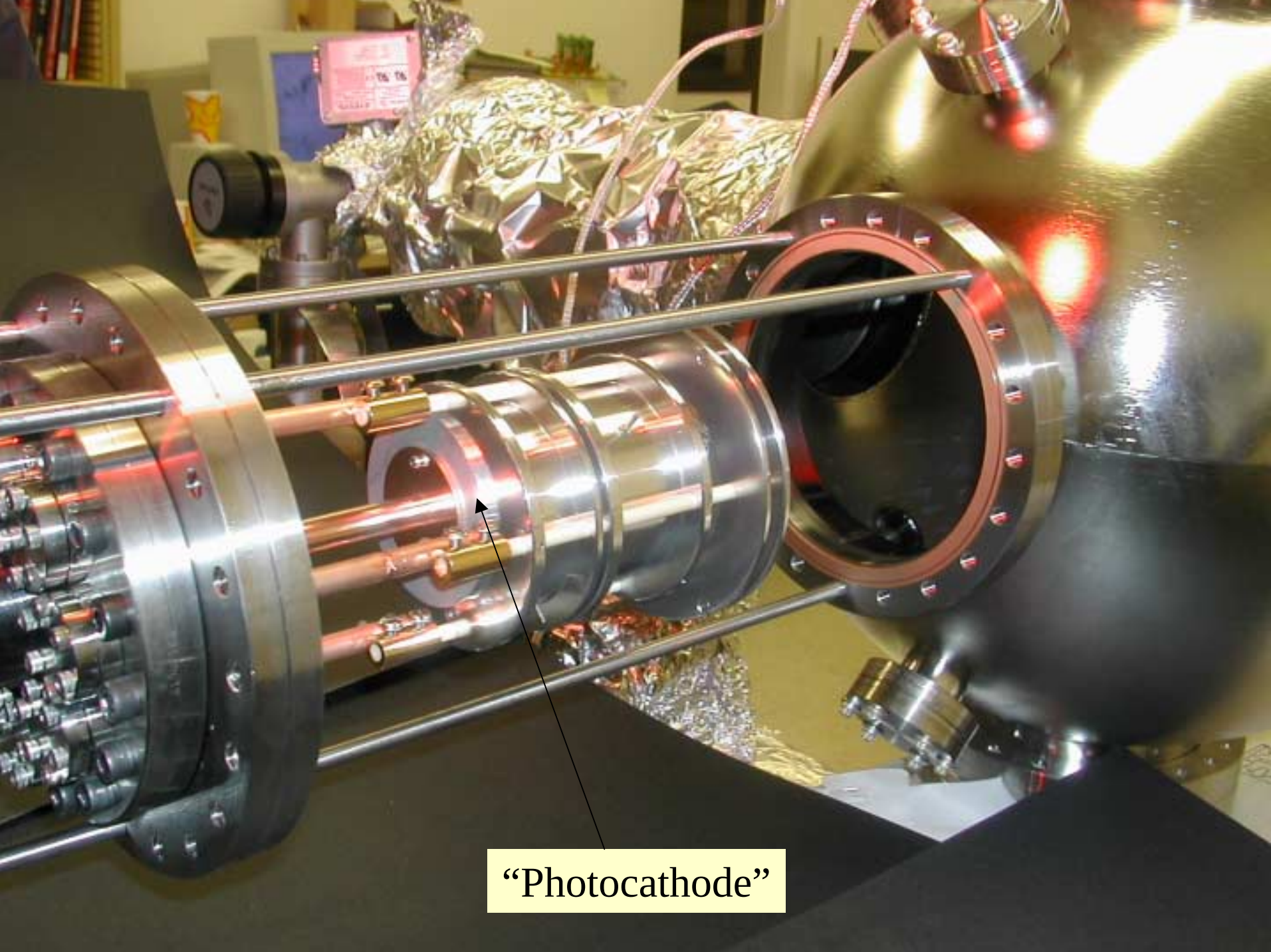
PHOTOCATHODE

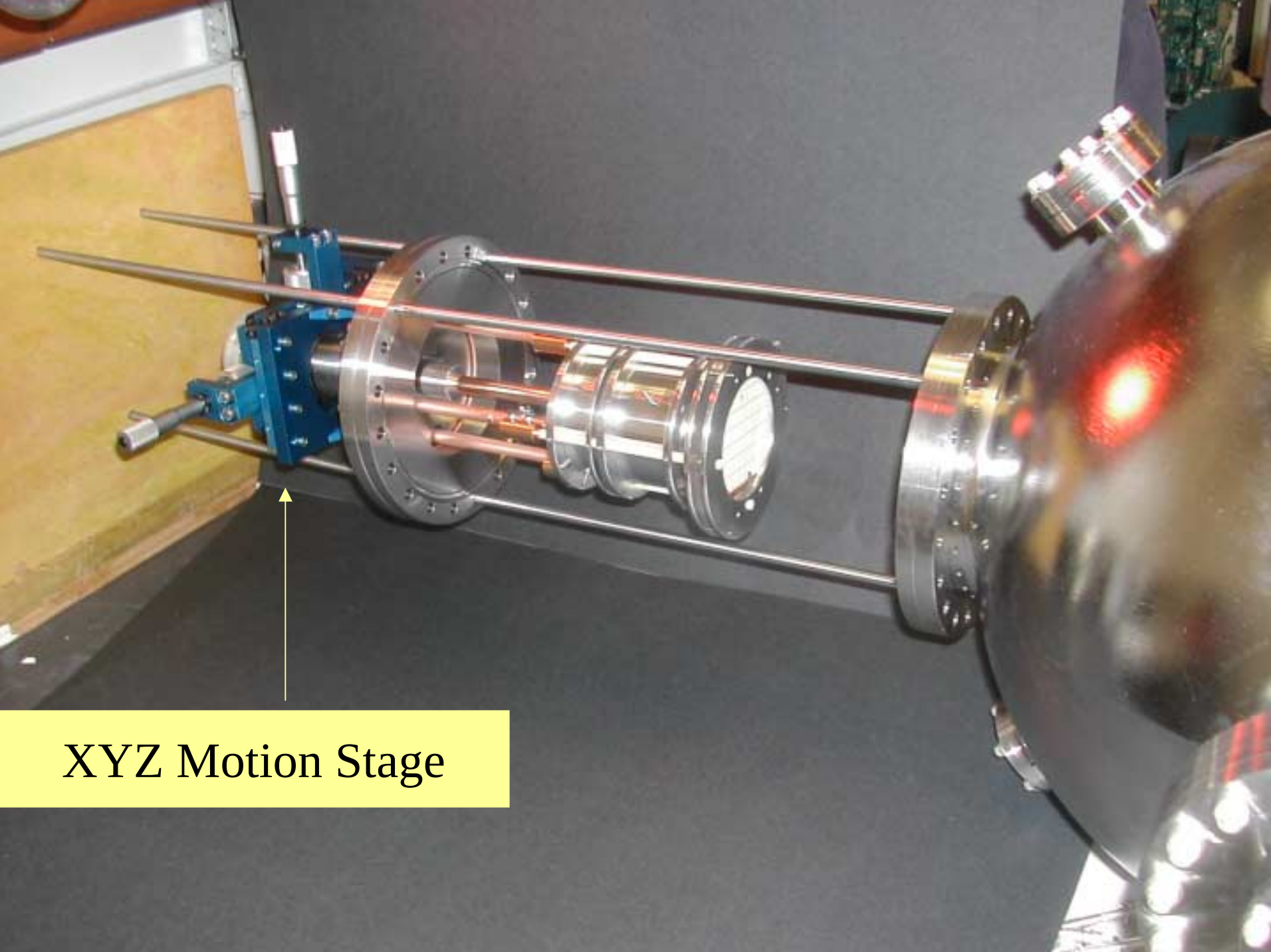


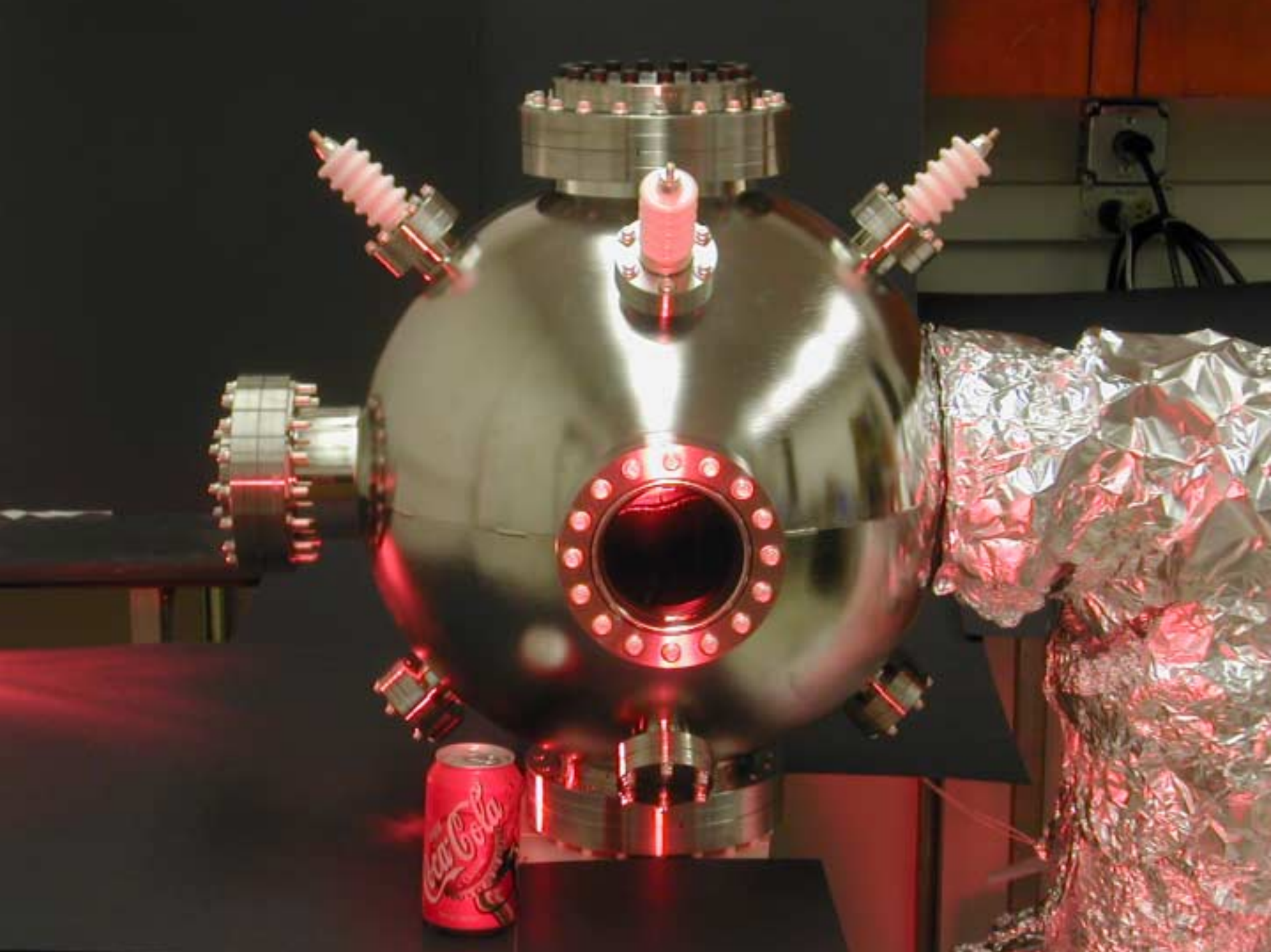
PHOTOCATHODE

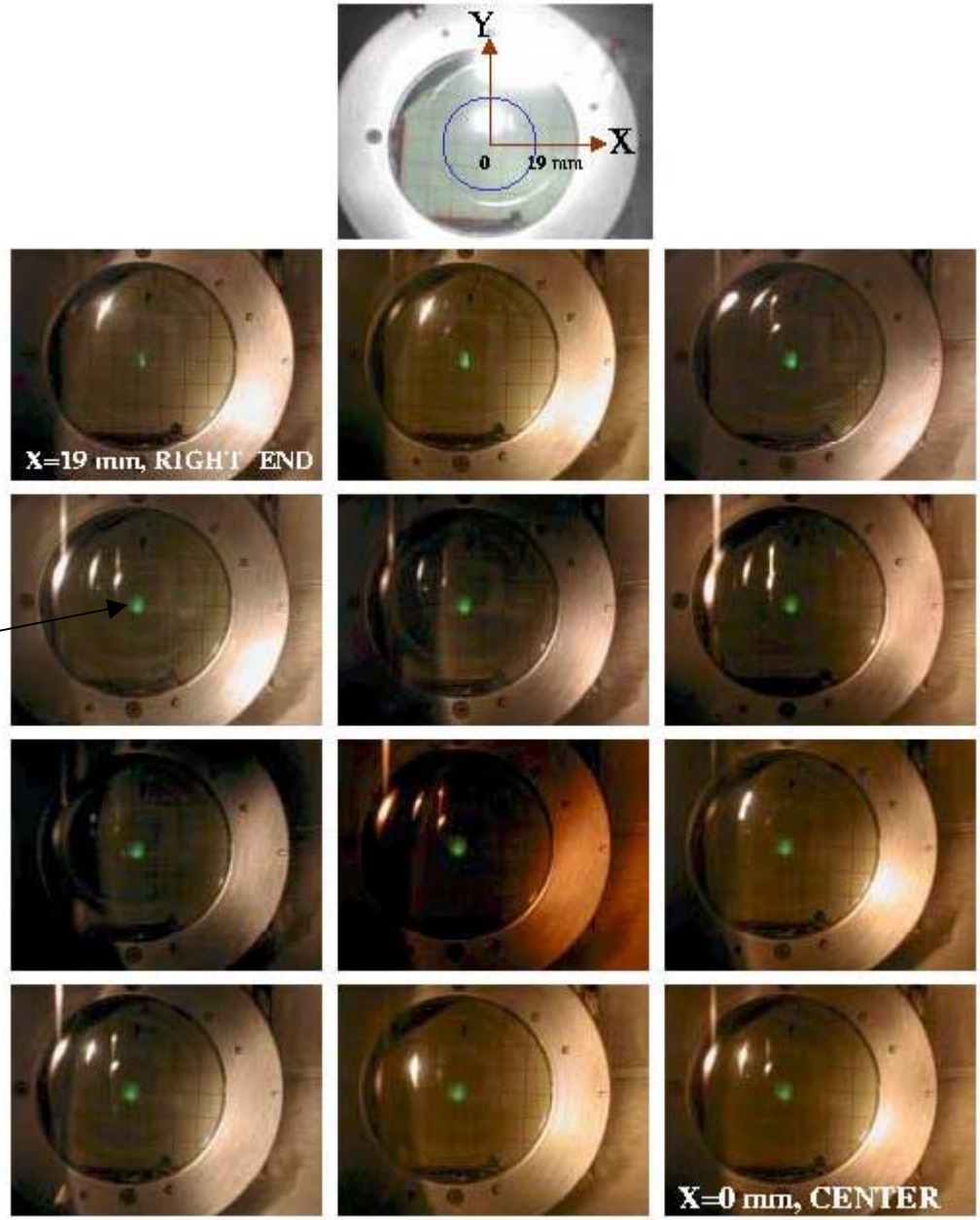


Aluminum Plate


“Photocathode”


XYZ Motion Stage


Coca-Cola



Electron Focus

PROOF OF CONCEPT

Prototype Development In Collaboration with *ITT-Night-Vision*

"SMALL"

Diameter = 2.5 cm

the same as of

Standard Night Vision Devices

GaAs Photocathode

Reflection AND

Transmission Mode

For gamma-astronomy

1 Month (!)

"LARGE"

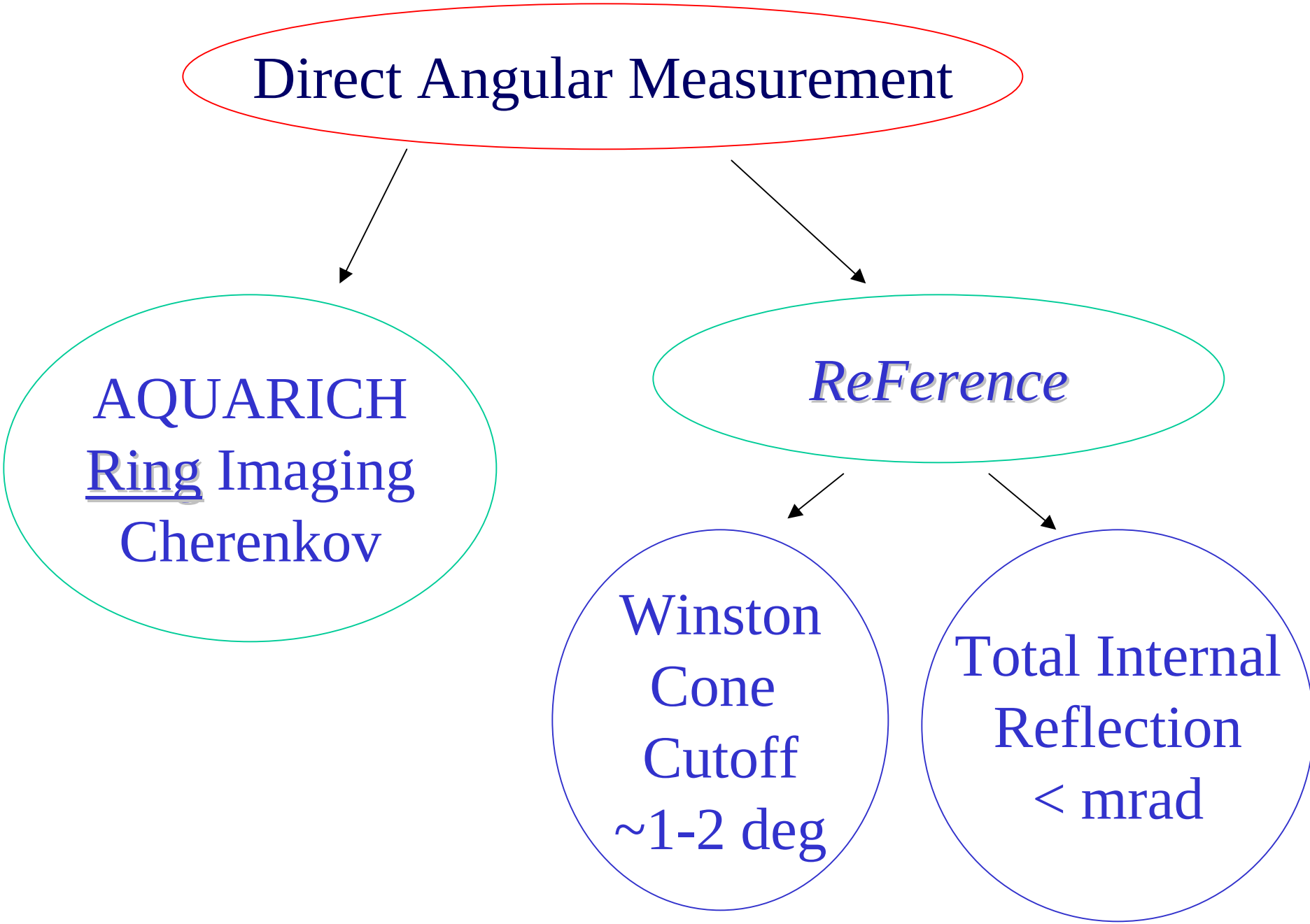
Diameter > 5 in.

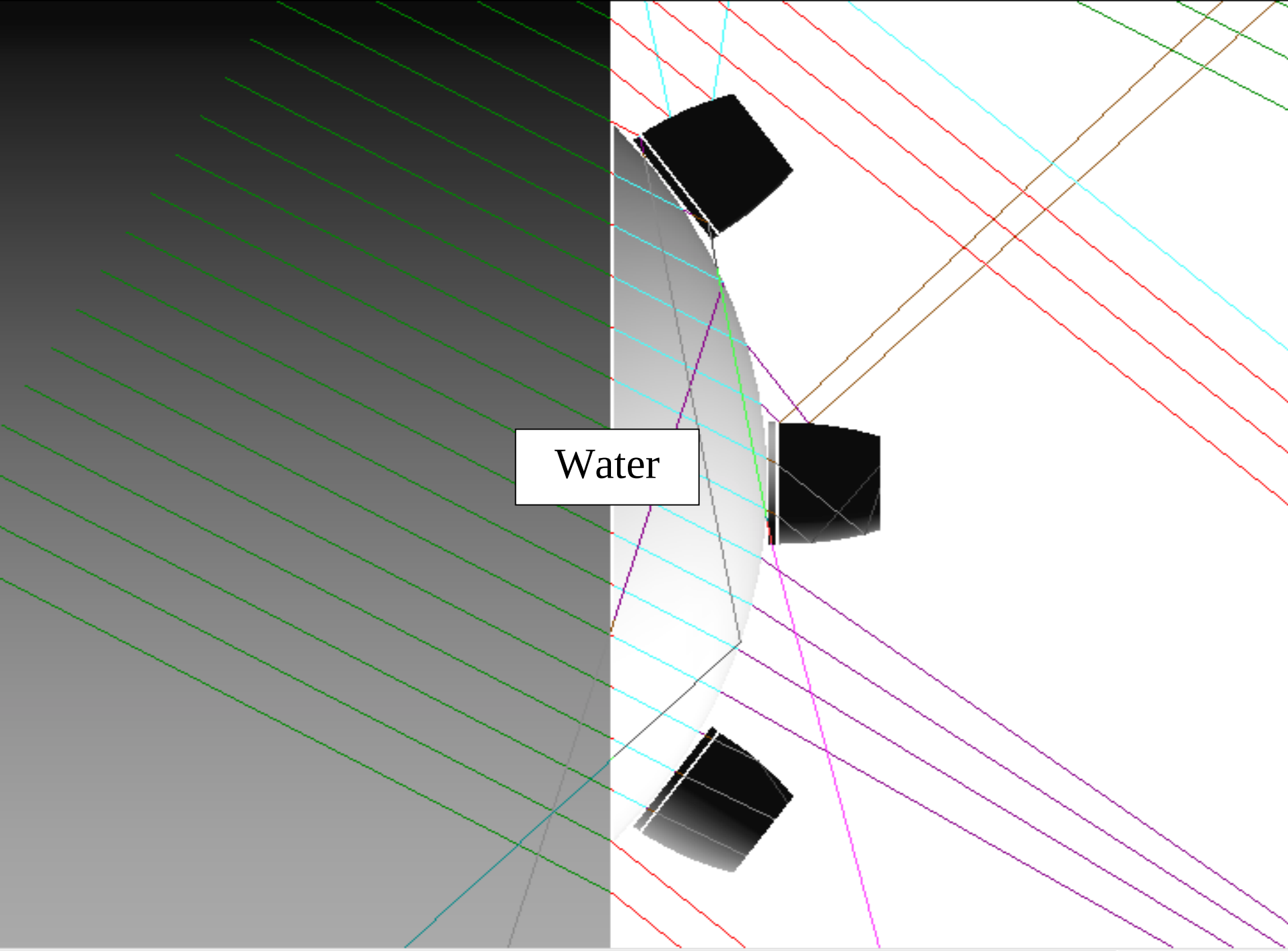
For UNO

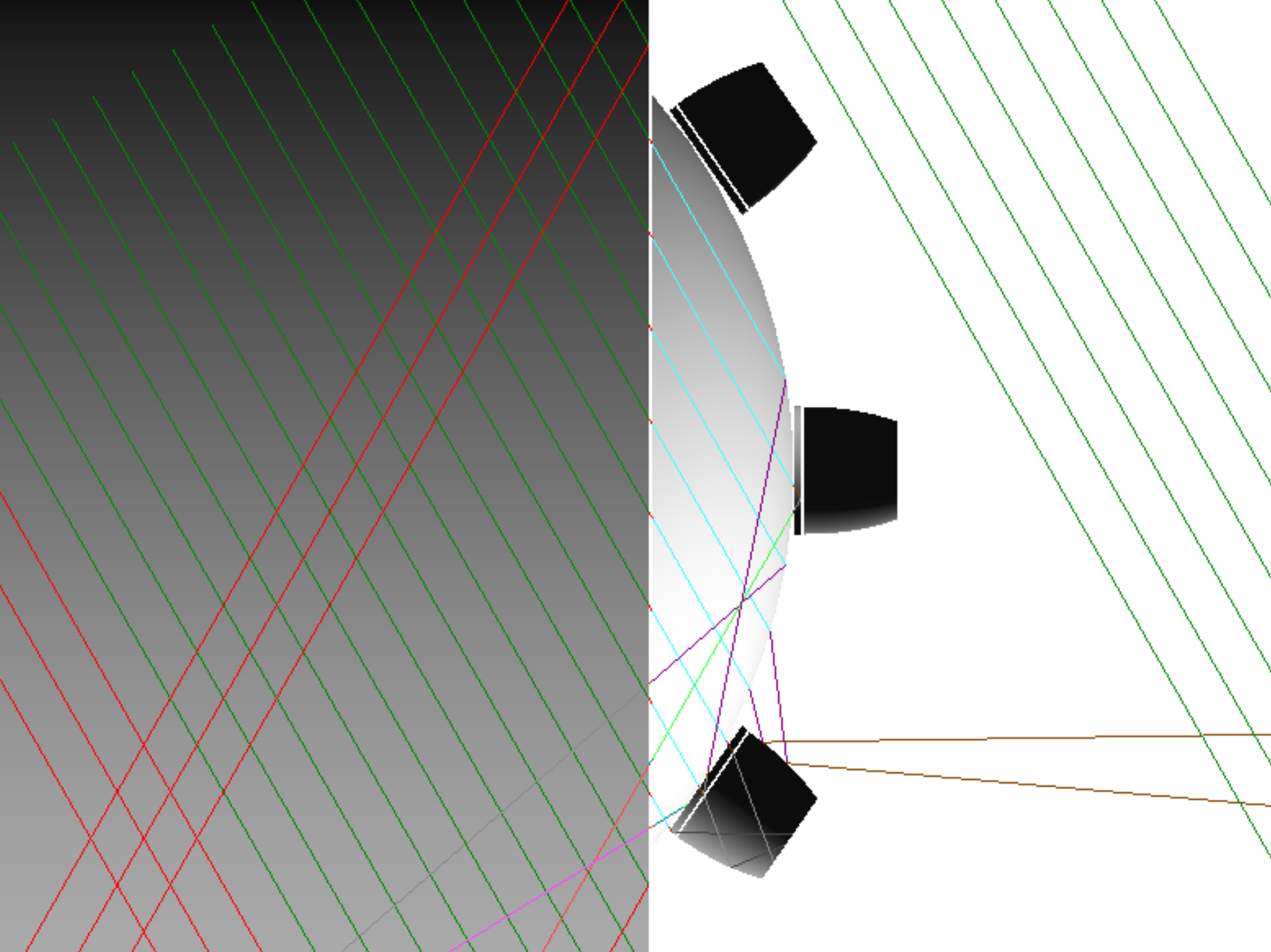
(or NNN- physics)

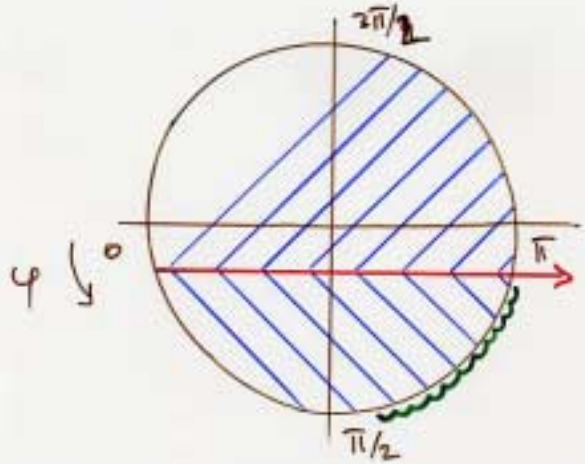
"Spectacles" for Spectacular Discoveries

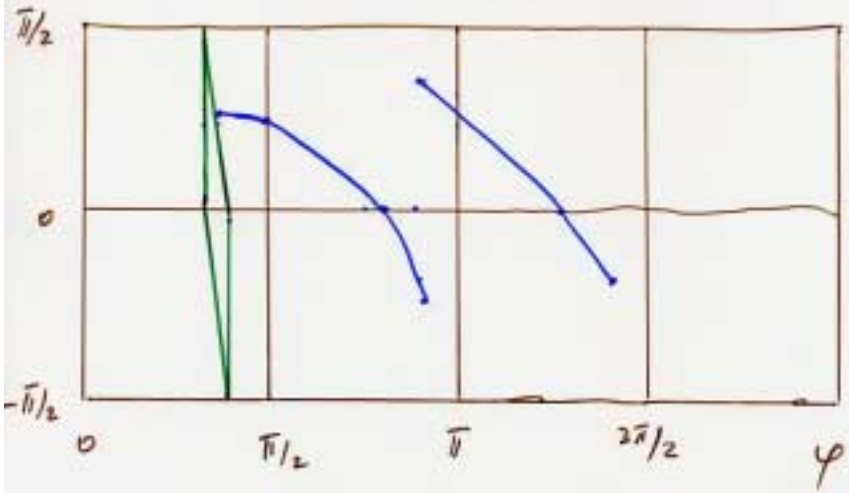
The number of ideas for a new detector configuration still increases;
The Flavor …


Direct Angular Measurement
AQUARICH
Ring Imaging
Cherenkov
ReFerence
Winston
Cone
Cutoff
~1-2 deg
Total Internal
Reflection
< mrad

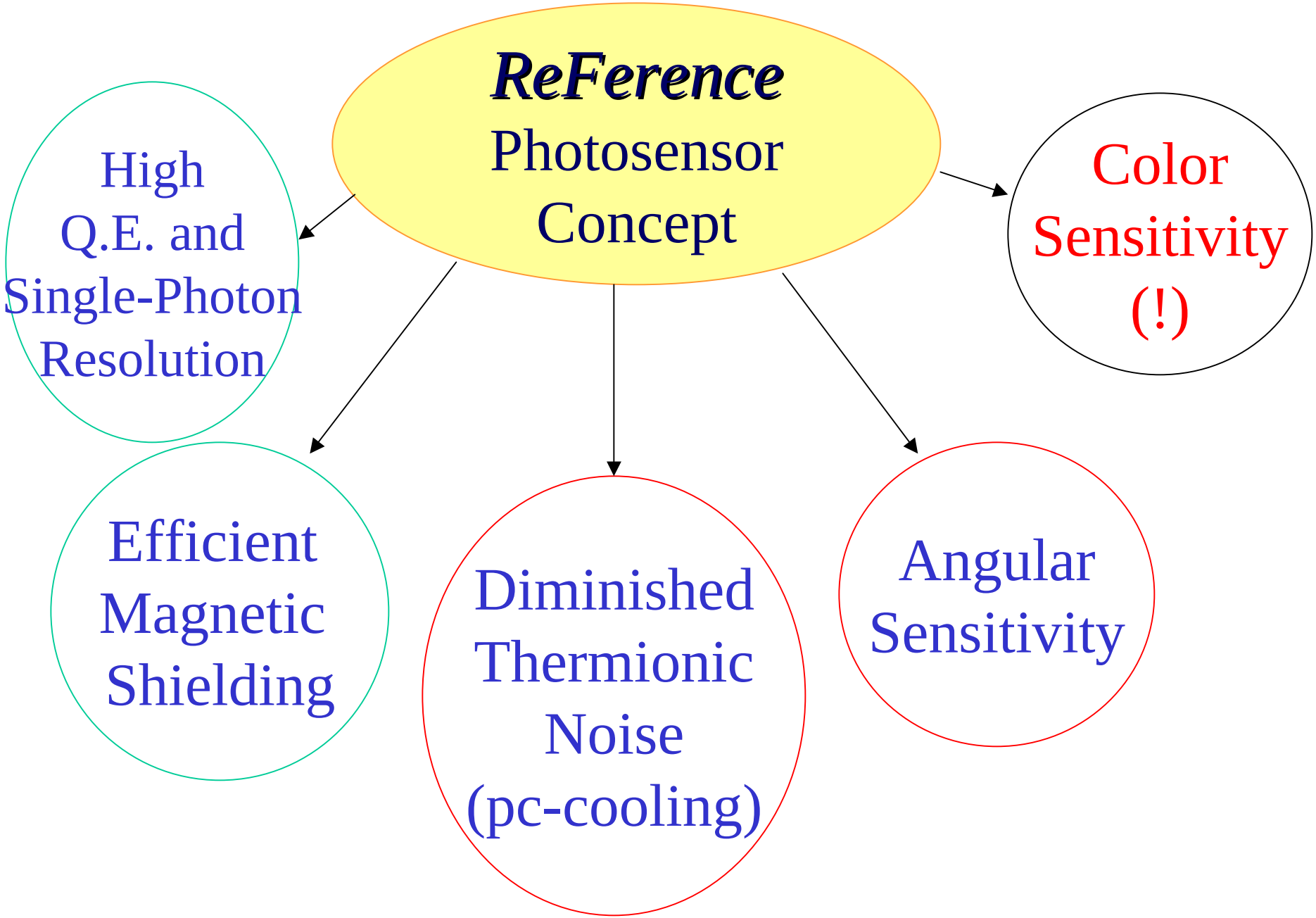

Water







{ SPHERICAL MULTIANGULAR RECORDING TRACKER "SMART" }


ReFerence
Photosensor
Concept
High
Q.E. and
Single-Photon
Resolution
Color
Sensitivity
(!)
Efficient
Magnetic
Shielding
Diminished
Thermionic
Noise
(pc-cooling)
Angular
Sensitivity

ReFerence Photosensor

- Simple, mechanically stable (honeycomb camera structure)
- 2 x Higher Quantum Efficiency in Reflection Mode (and more for UV)
- Optimal usage of photocathode surface
- Excellent Time-Resolution, although flat photocathode
- Flat photocathode – III-V epitaxially grown photocathodes (GaAs, GaAsP, InGaAs…)
- Photocathode Cooling – Diminished Noise
- Efficient magnetic shielding