Report from the Photodetectors Group:

October 7, 2015

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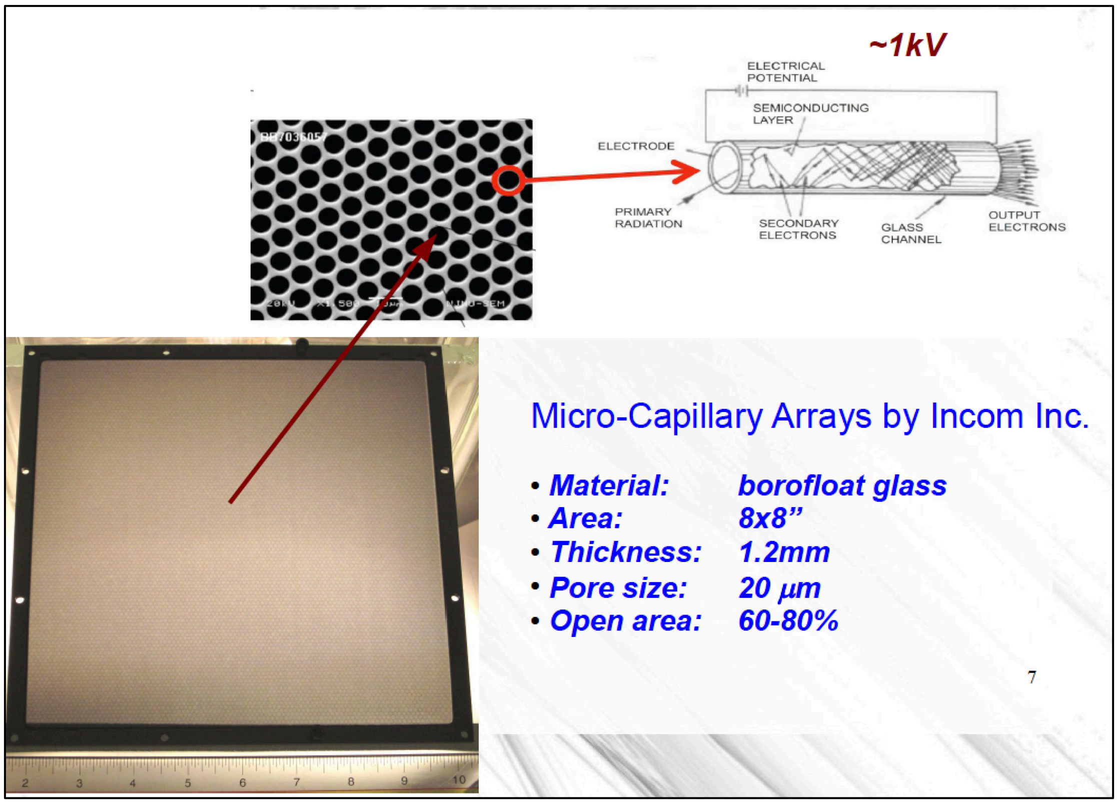
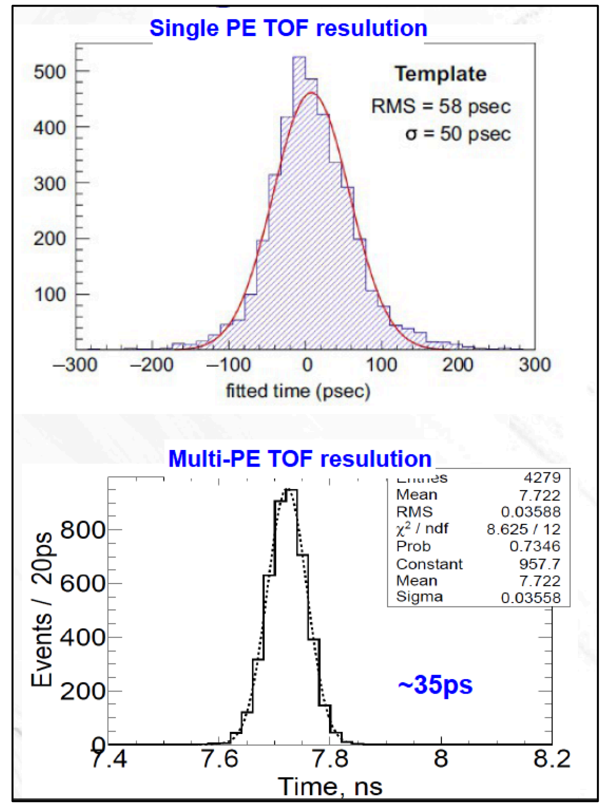
Brief Introduction

- Science Drivers
  - Neutrinoless Double Beta Decay
  - Higgs
  - CLFV
  - Dark Matter Direct Detection
  - Neutrino CP violation and Mass Ordering
  - Neutrino Astrophysics
  - Proton Decay
- Speed
- Spectral Sensitivity
- Cost
- Size
- Radiopurity
- Energy to Light Conversion

SPEED

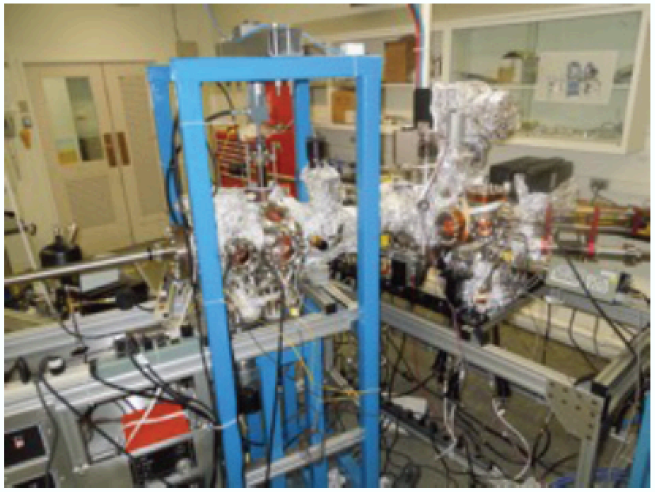
Large Area Picosecond Photodetectors (LAPPD's)





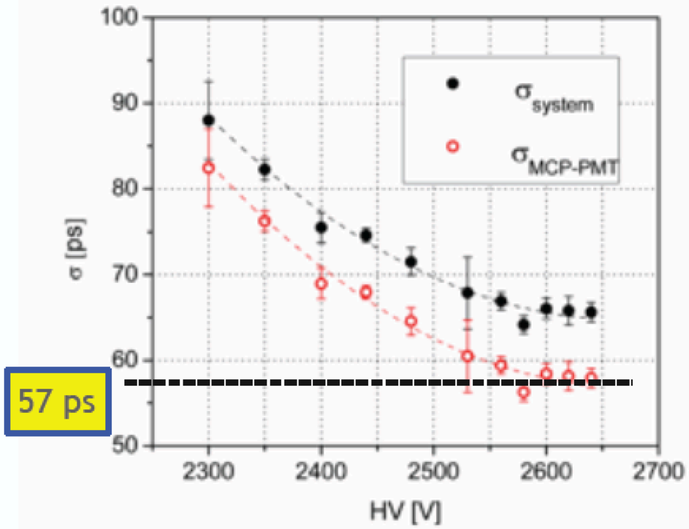
- ~1 device / 2 weeks

ANL is producing small quantities of 6 cm MCP's



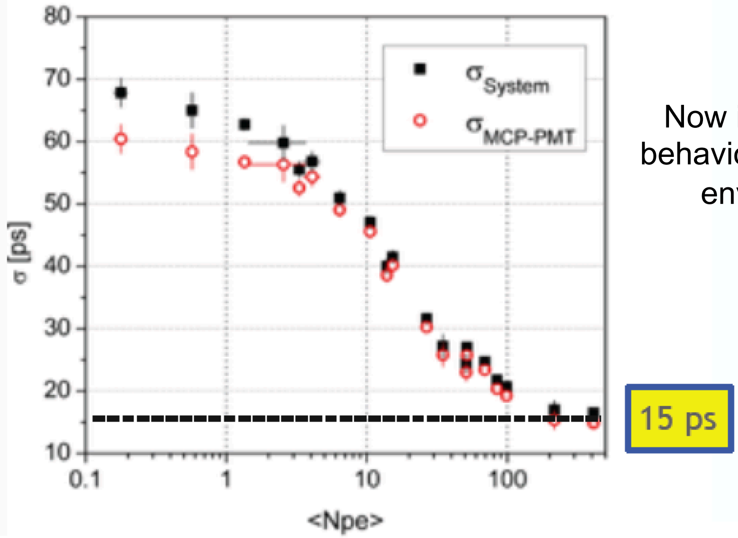
Argonne Small Tube Processing System

σ VS HV (<Npe> < 0.2)



σ VS <Npe>

HV=2560V



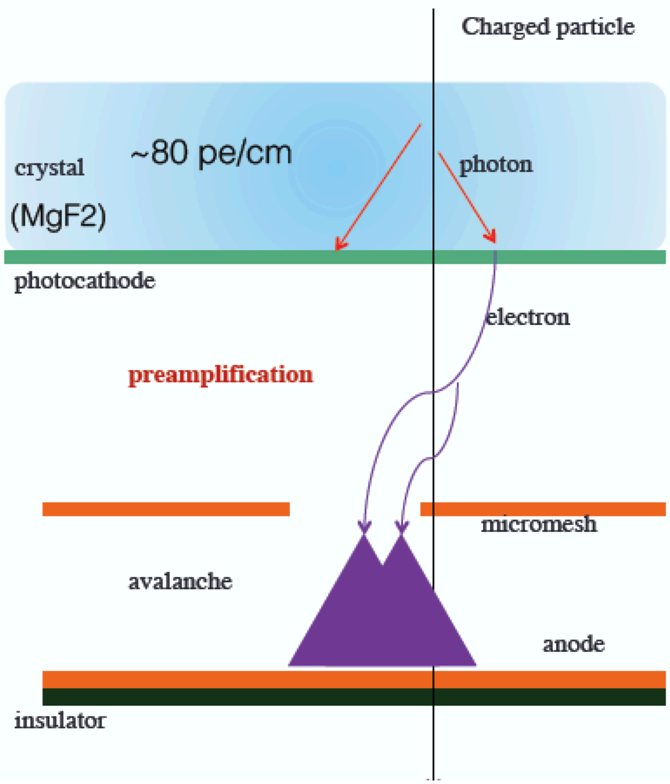
Now investigating behavior in cryogenic environment

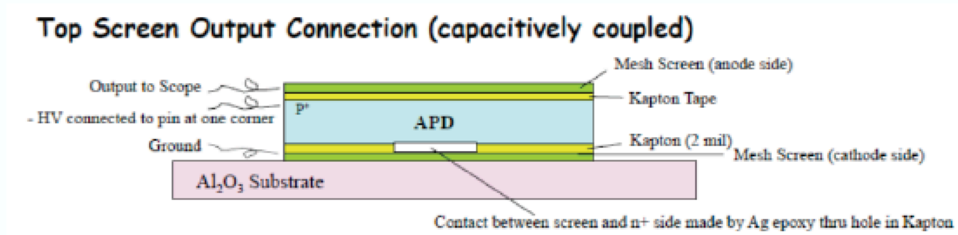
Large Area Photodetectors based on MicroPattern Sensors

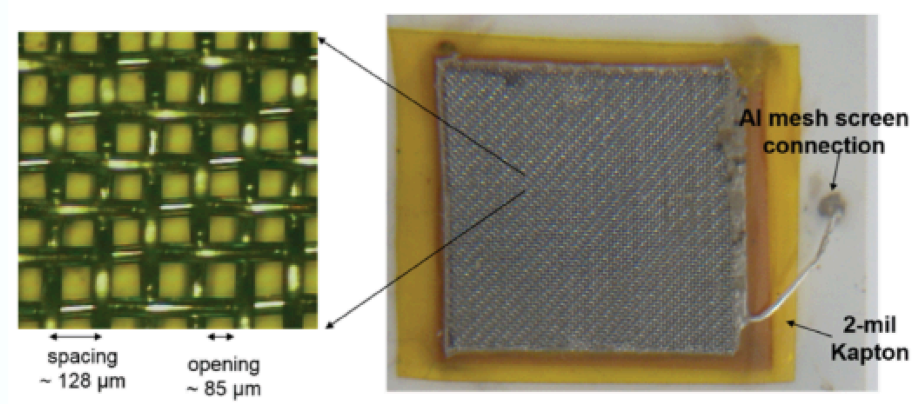
Sebastian White CERN/Princeton CPAD mtg. UT Arlington Oct 6, 2015

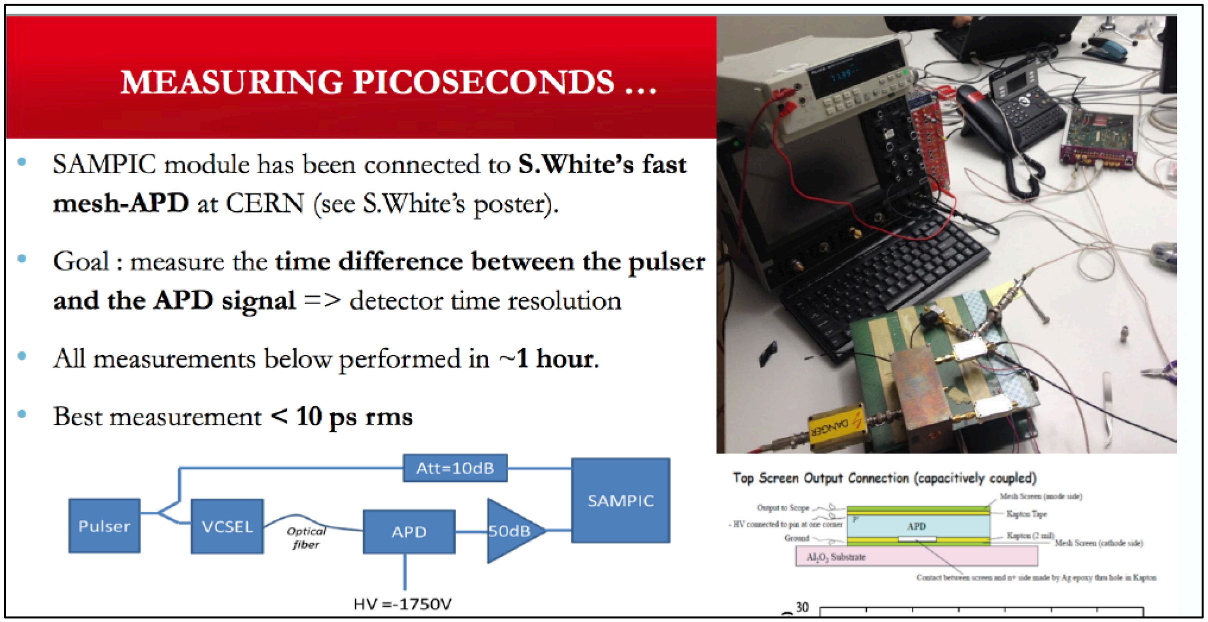
Gas MIP sensor retooled ->photosensor

Si photosensor retooled ->MIP sensor



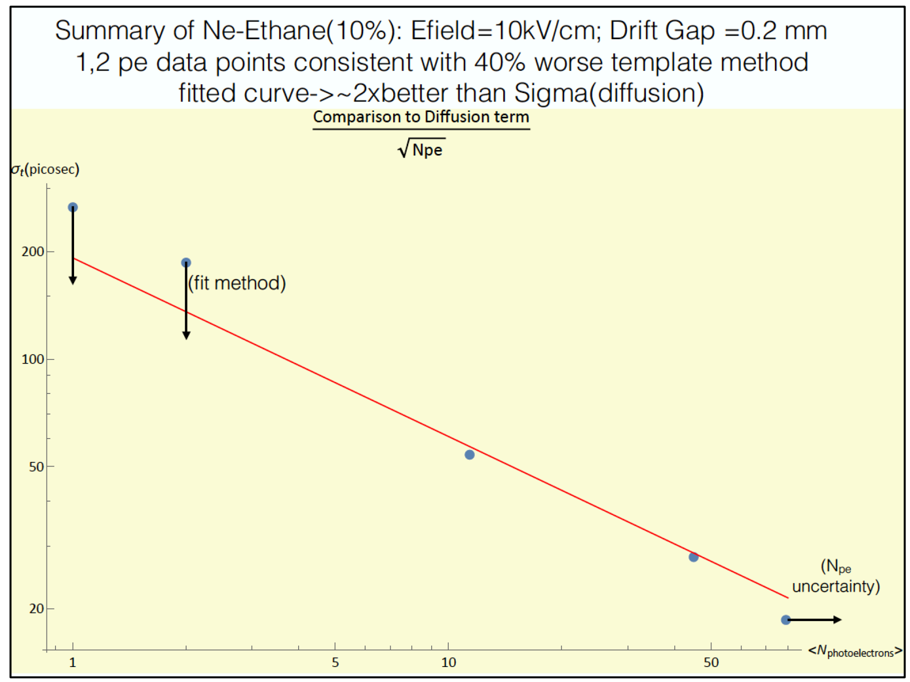




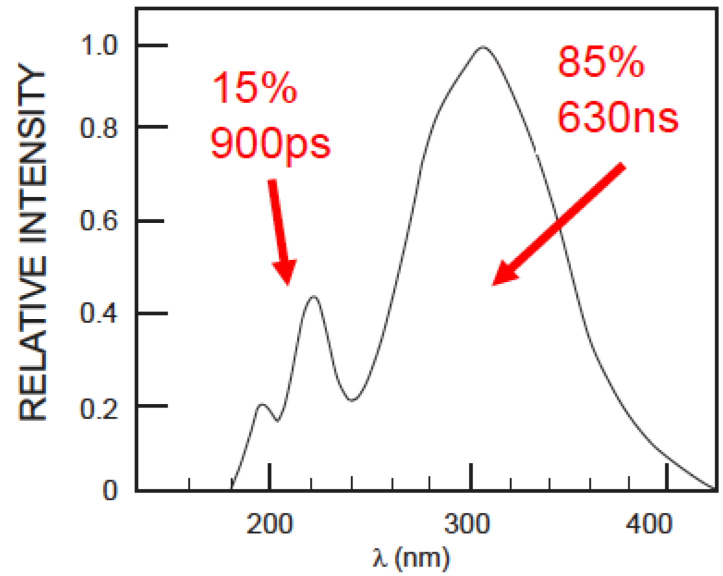


Timing of APD and Micromegas has been measured in the lab

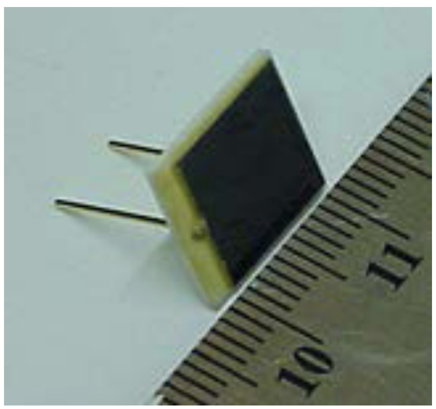
Talk has a discussion of low cost of production



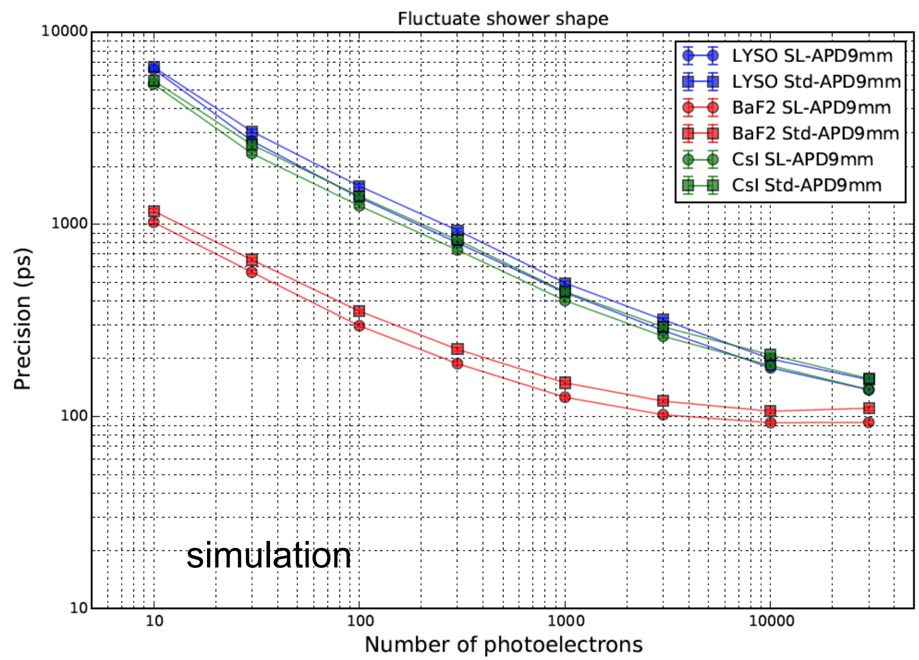
Development of a large area APD
for readout of Barium Fluoride crystals



- The baseline uses barium fluoride crystals:
  - Fast decay time ➡ short integration time, high rate capability
  - Good energy and time resolution
  - Radiation hardness
  - Suitability for a possible Mu2e upgrade



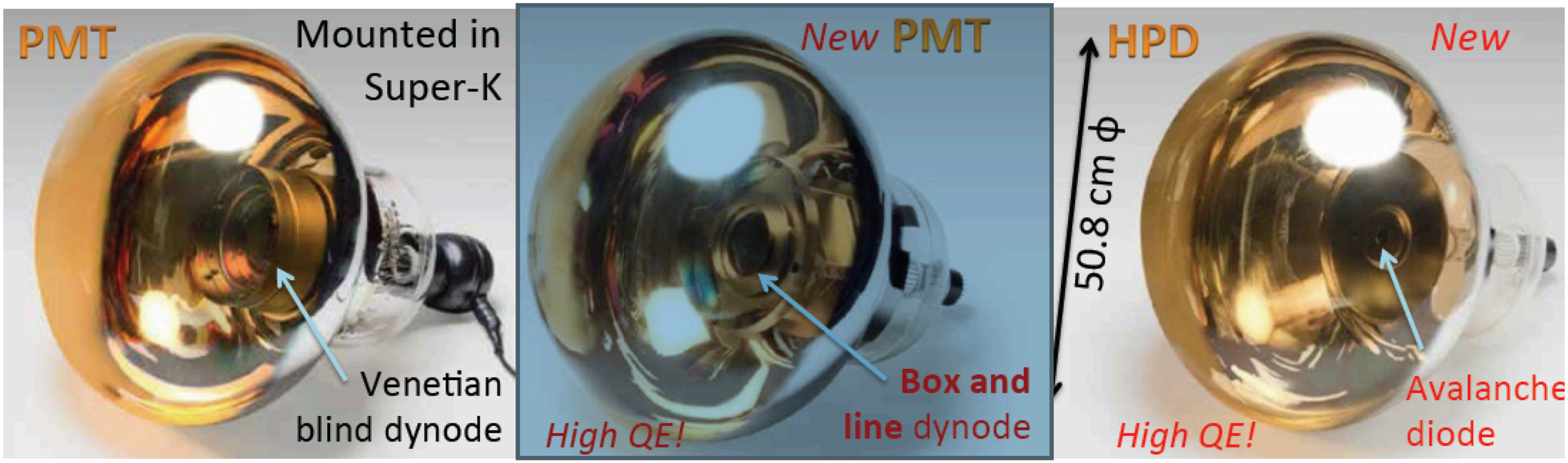
Modification of 9x9mm solar blind APD based on existing RMD device



New Photodetectors

By Hamamatsu Photonics K.K.

- New 50 cm Φ photodetectors developed for HK.

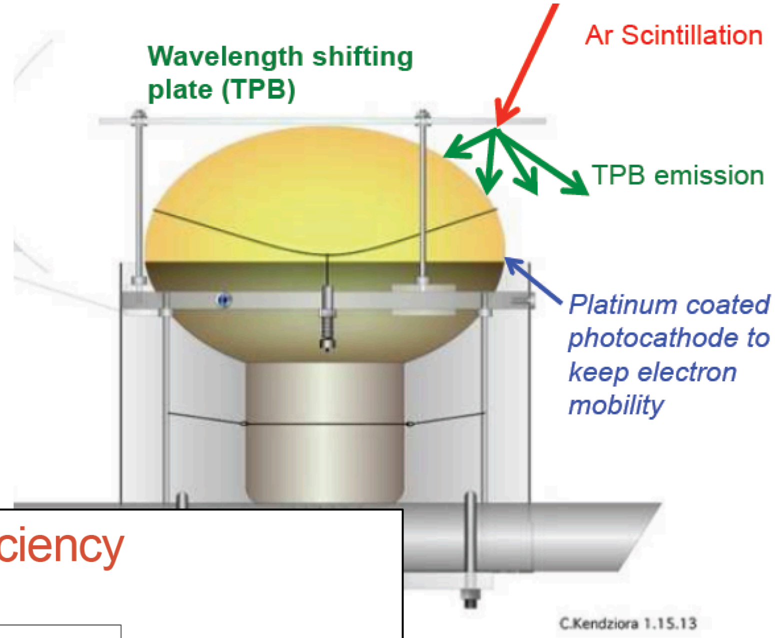


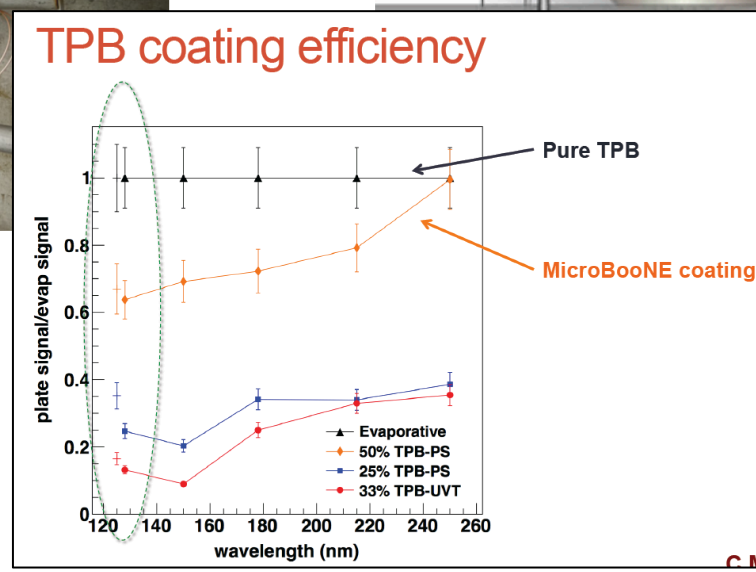
Model	R3600 (Used for 2-30 yrs)	R12860	R12850
Amplification	Venetian blind dynode	Box and line dynode	20mmΦ Avalanche diode
Q.E.	~22%	~30%	~30%
C.E. Φ46 (Φ50)	67% (61%)	95% (85%)†	93% (76%) w/ 5ch AD†
T.T.S. (FWHM)	5.5 ns	2.7 ns	0.75ns (w/o Preamp.)
Bias voltage	2 kV bias	2 kV bias	8 kV bias + AD bias (<1kV)
Proof test	1.8 yrs for HQE	0.8 yrs now from Sep.2014	> 0.5 yrs expected

† still in R&D

SPECTRAL SENSITIVITY

MicroBooNE uses Hamamatsu 5912 PMT's modified for cryogenic environment. Solve spectral response problem with TPB

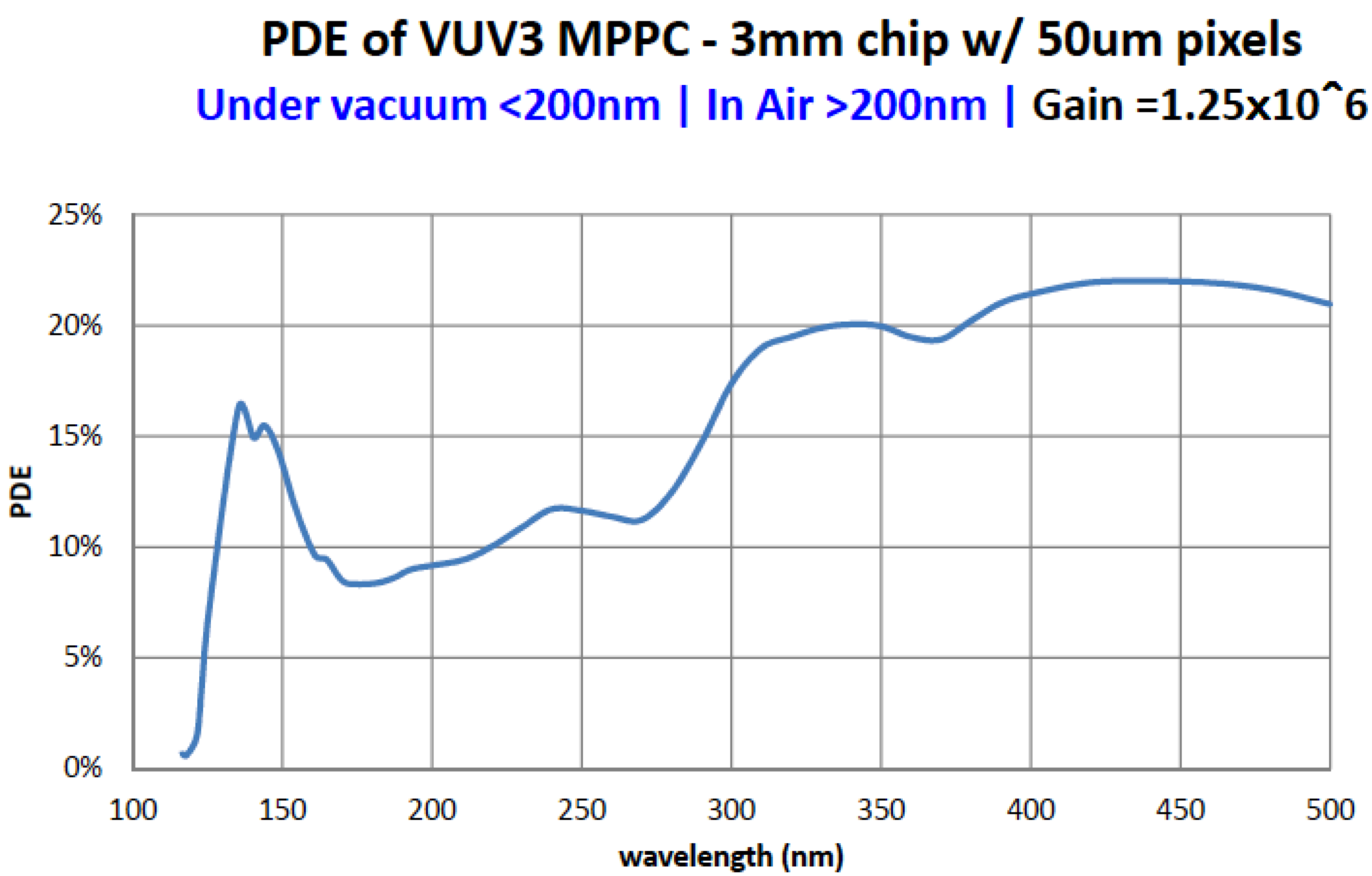




Hamamatsu work on direct VUV detection

HAMAMATSU
PHOTON IS OUR BUSINESS

MPPC for direct detection of VUV



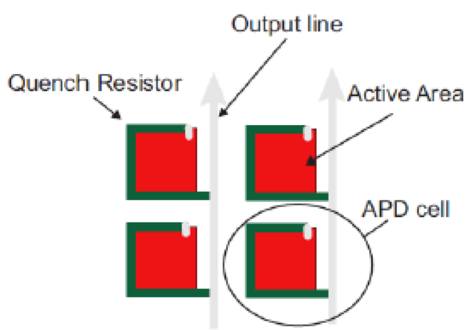
COST

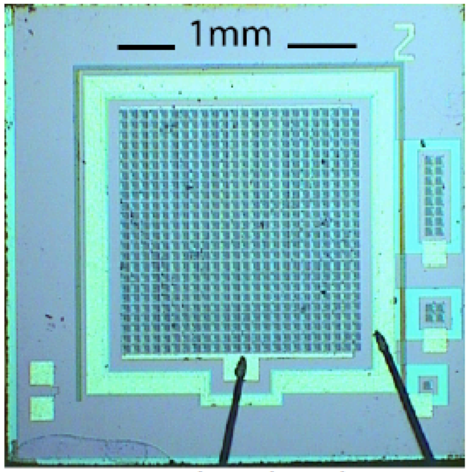
standard PMT costs about $0.02/mm^2

to be **low cost**, that is the goal you must reach

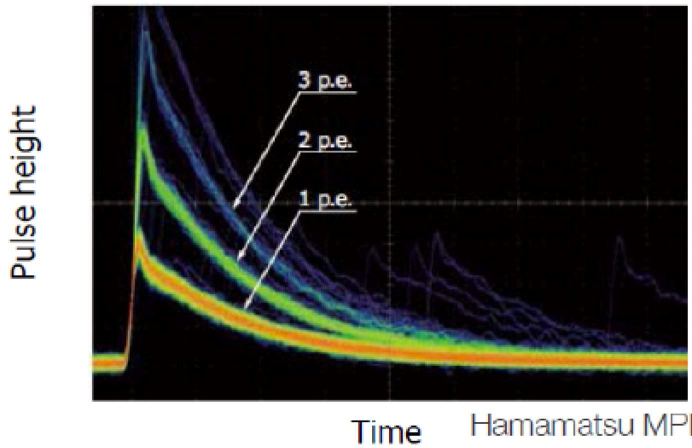
SIZE

The SiPM





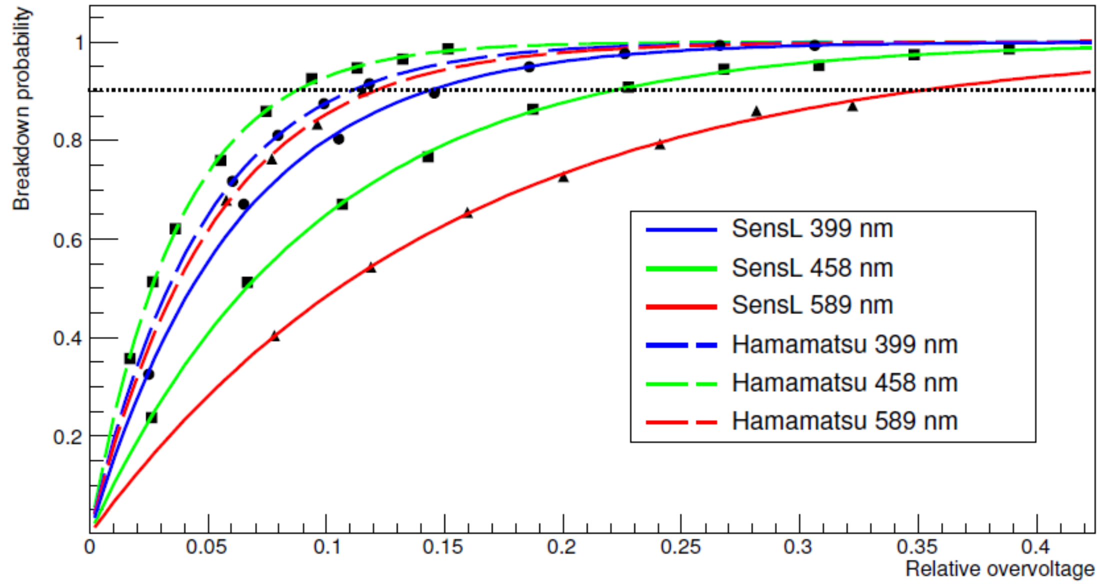
MEPhI/Pulsar SiPM 2004

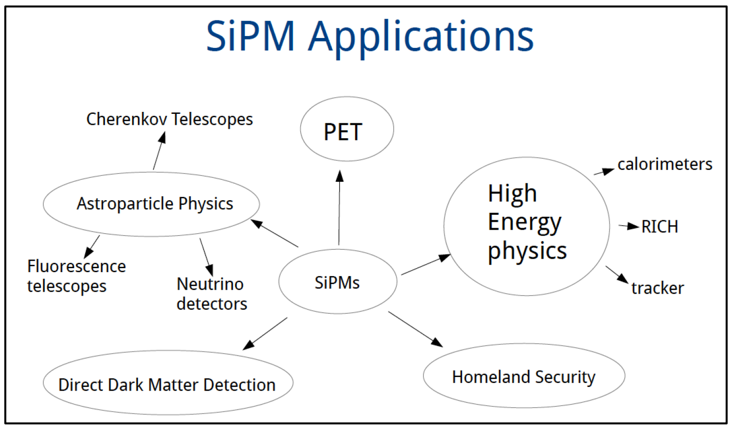


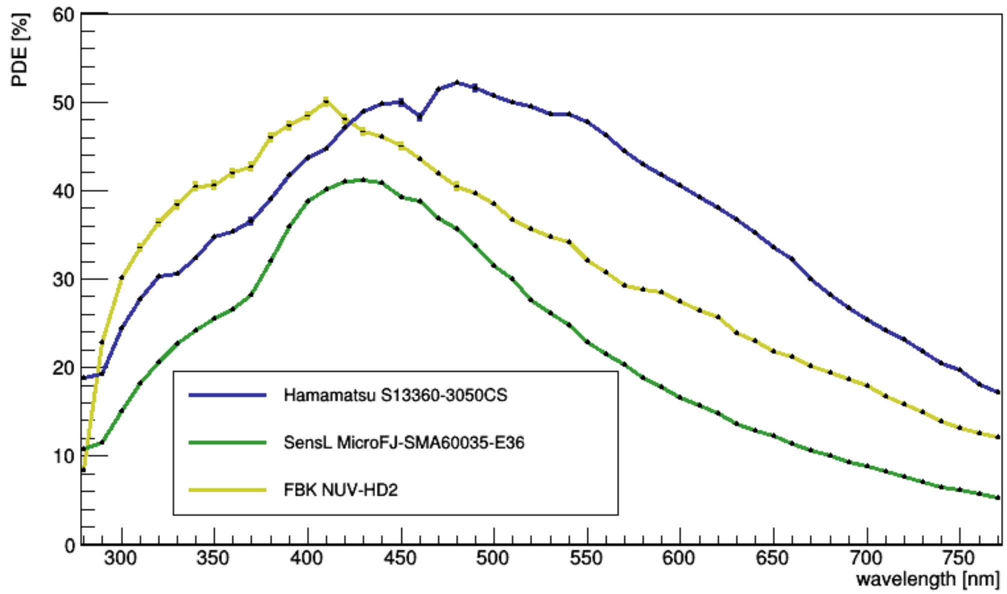
Hamamatsu MPPC techinfo

The SiPM concept provides multi-photon resolution:

Due to widespread application the commercial development has proceeded rapidly in terms of efficiency and cost







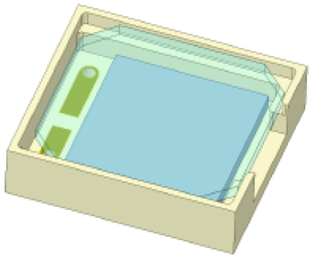
RADIOPURITY

MPPC Packaging: Ultralow RI materials

For direct detection of VUV (128 or 175nm)

Window material: synthetic silica (quartz) for 175nm I none for 125nm

Package material candidates: ceramic, synthetic sapphire, quartz + TGV, intrinsic silicon, etc.



Example: ceramic package + quartz window

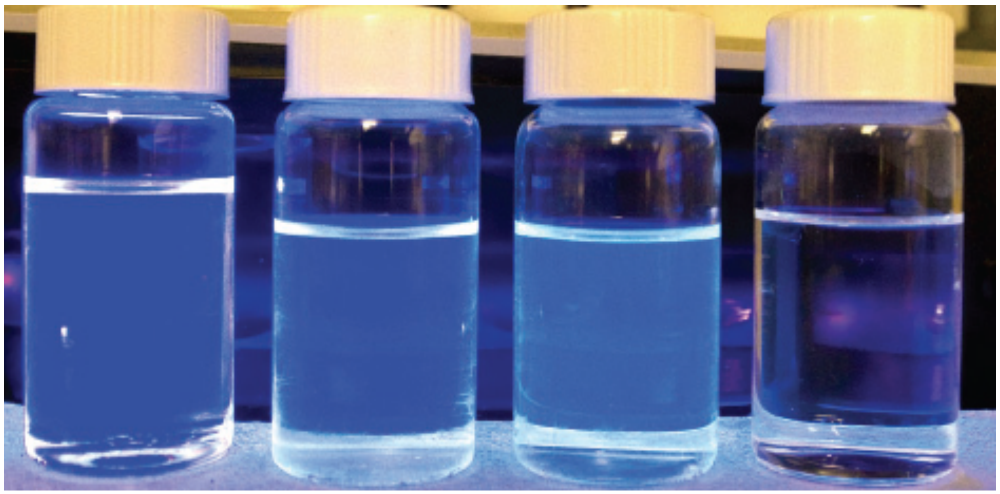
For detection of wavelength-shifted 420nm signal

Window material: various kinds of resin

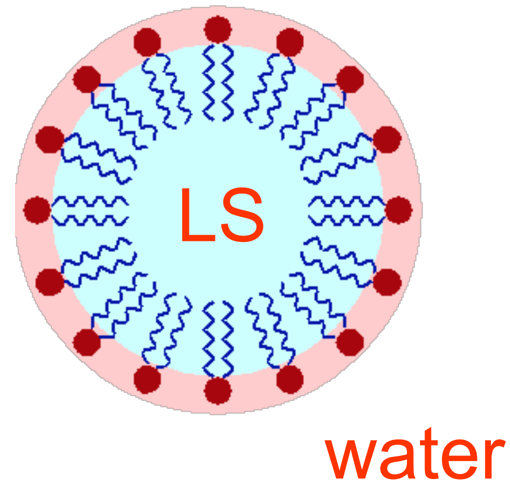
Package material candidates: various kinds of resin

ENERGY TO LIGHT CONVERSION

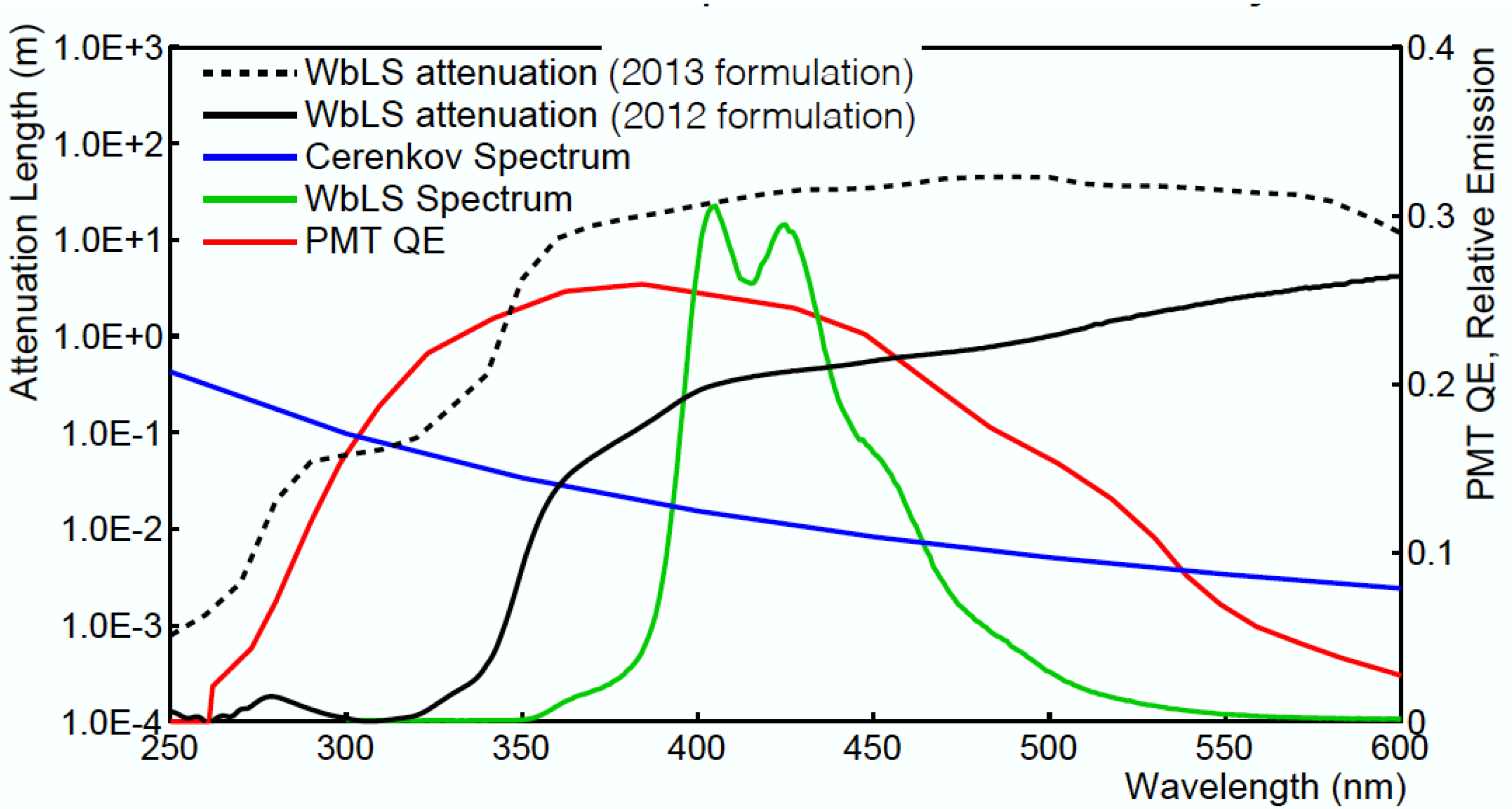
Water-based Liquid Scintillator



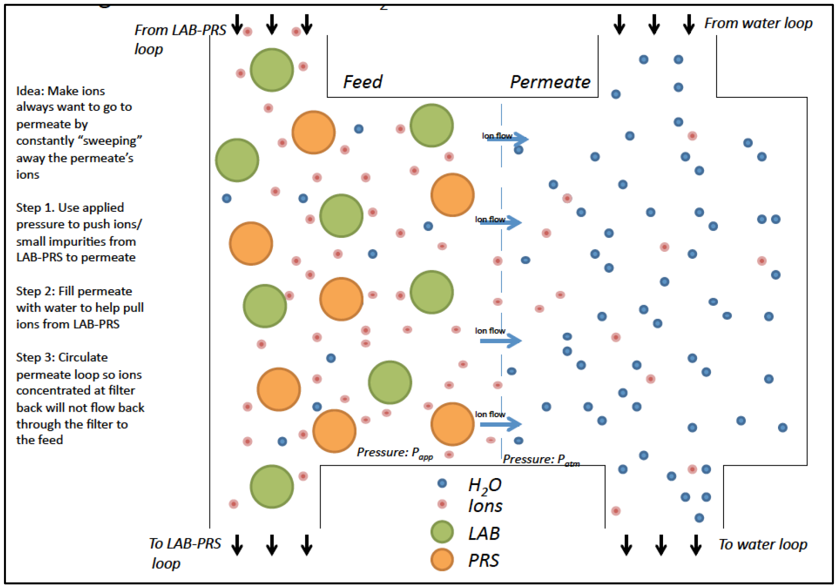
Brookhaven National Lab



Big News is that this now exists in 100 liter quantities



Light yield for these processes is comparable for <10% concentration WbLS. Disentangling them and understanding the details of wavelength-dependence is the main focus of R&D.

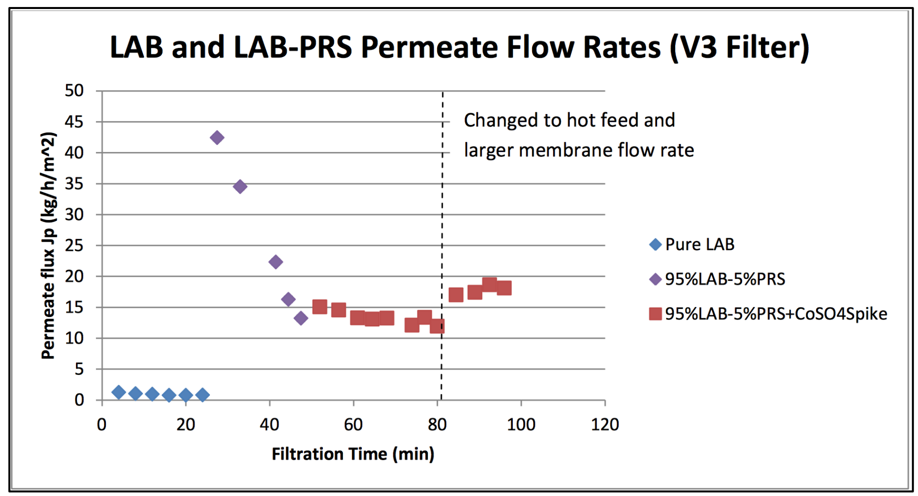


Related Problem: how to purify LS and WbLS in-situ?

R&D on use of NanoFiltration (NF) on organic LS and WbLS

Issues:

Surface charge effects
Concentration Gradients
Flow rates



surfactant compatible materials have been identified that give adequate flow

Findings

- The development of new photosensors and scintillators has far-reaching application in virtually every area of High Energy Physics
- Speed, Spectral Response, Radiation Hardness, Cryogenic Adaptation, Size, and Cost all important.
- My opinion: any individual device does NOT have to solve all possible problems. ***Specialization*** for a specific use seems more productive. E.g. SiPM's are not low cost compared to PMT's and perhaps never will be. It is performance that is the selling point if cost is not a major part of the cost of the experiment.

Recommendations/Comments

- Broad applicability of photosensors both in high energy physics and in industry makes it a natural area for SBIR and other partnership-based efforts
- If you develop a good photosensor, there is almost certainly bound to be a good use in HEP
- Expect development to be *difficult!*
- Allow for R&D proposals to compete! (e.g. recent INP FOA discourages rather than encourages R&D – a bad precedent). Not supporting R&D is mortgaging the future. E.g. do we need N+1 LAr prototypes, or a large, fast photosensor?