A novel WaveLength Shifter plastic foil optimized for IceCube

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Photon Detection Technique (PDT)

- LIGHT SOURCE

Critical Parameter:

Nr of photons produced/ energy deposited

- For ex:
  - Liquid scintillator:

    Photons produced by 100 KeV e- = ~1000
  - Cherenkov light:

    ~500 photons $\sin^2\theta$/cm

- LIGHT DETECTION

Critical Parameter:

Photons detection efficiency

- Photomultiplier Tube (PMT):
  - QE ~ 20-25 %

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PDT: How To Improve ?

- LIGHT SOURCE

New methods for light production

- LIGHT DETECTION

➢ Increase the QE of PMT
[new photocathode,
photo-electron collection eff. impr,
Avalange moltiplication impr.]

Expand the wavelength range of the PMT sensitivity in the Ultra-Violet

↓

- Quartz glass window .. Expencieve
- Application of a WaveLength Shifter (WLS)

Motivation: Physics Projects

➢ High Energy Neutrino Detector/Telescope

Method: Cherenkov light produced by charged particles passing through water or ice

- IceCube

[For Sea exp. like ANTARES: NO]

- Future Multi-tons detectors

[clean water=UV transparent water]

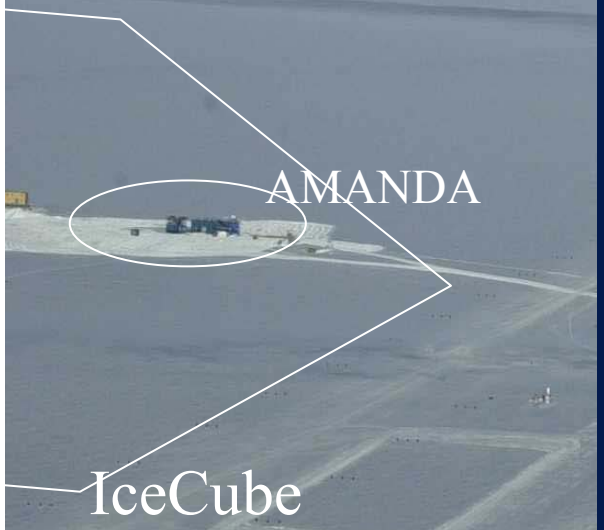
➢ Double-beta/Dark Matter exp

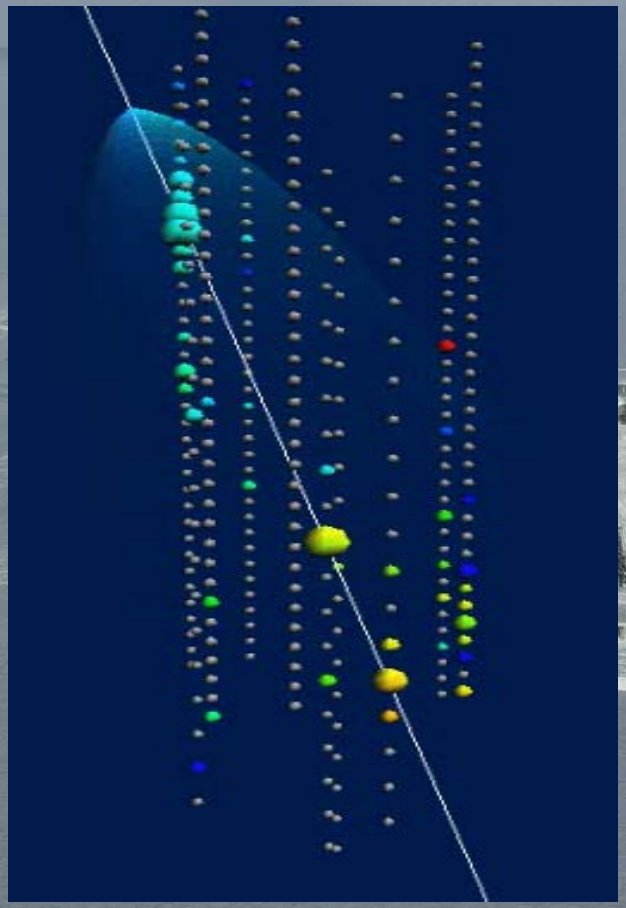
Method: Nobel gas scintillation counters [emission in the VUV]

- Double-beta new initiative @ MPIK-Heidelberg

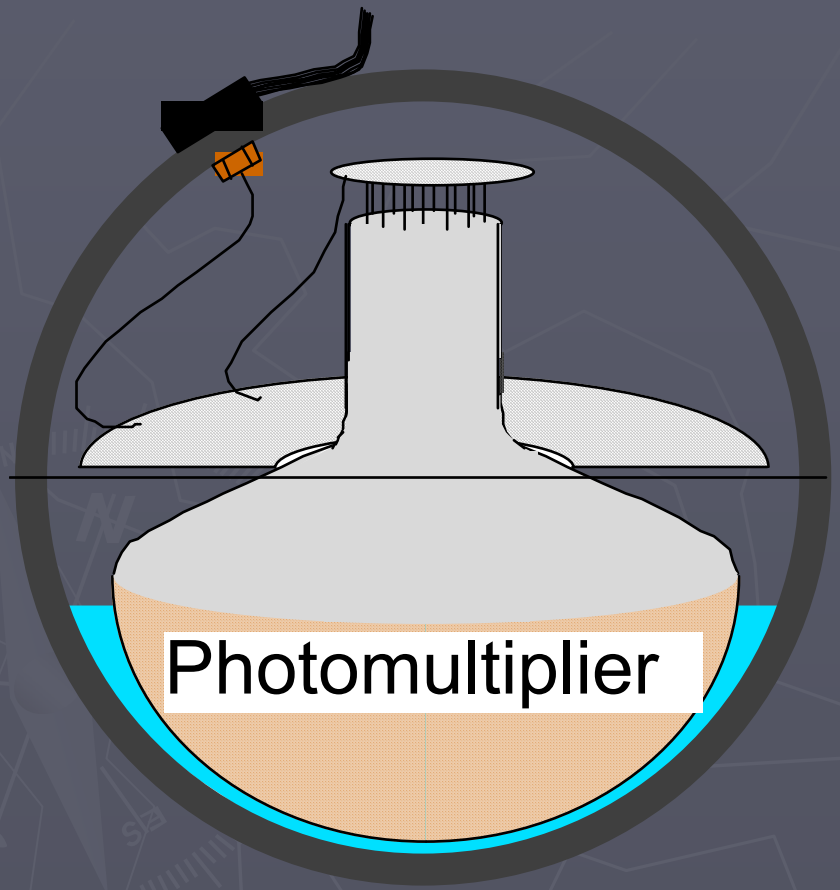
IceCube @ South Pole: 1Km^3 Neutrino Telescope

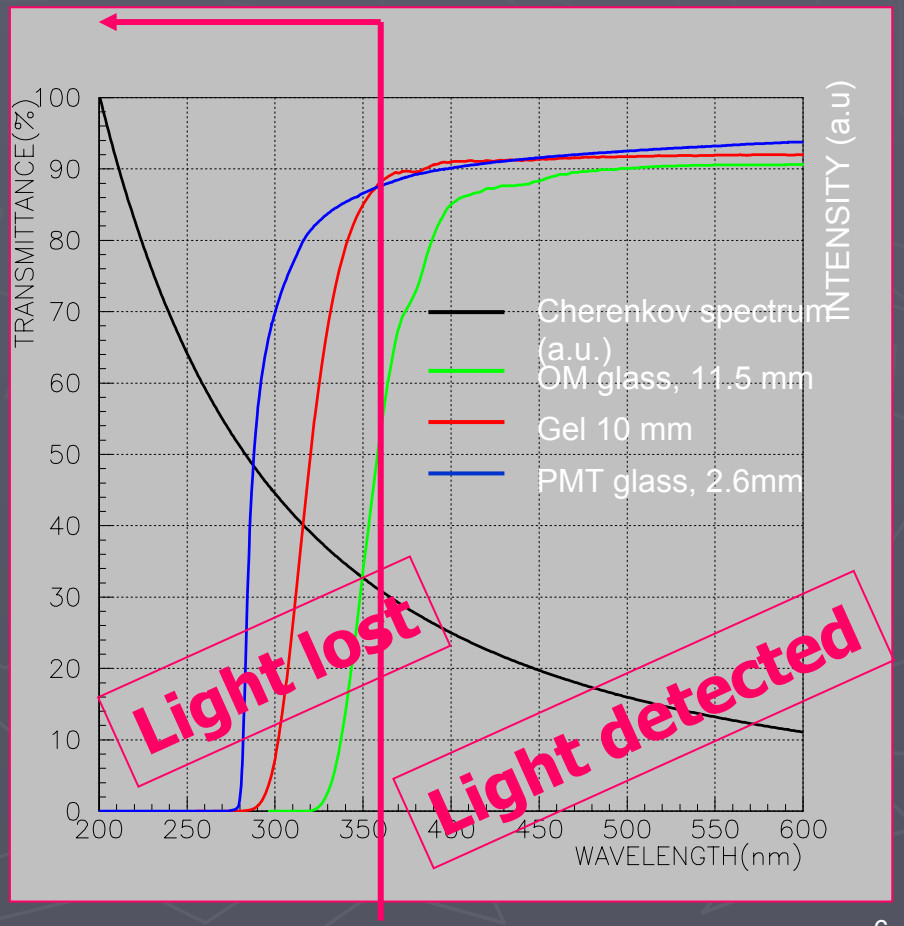
[see for ex. astro-ph/0209556]





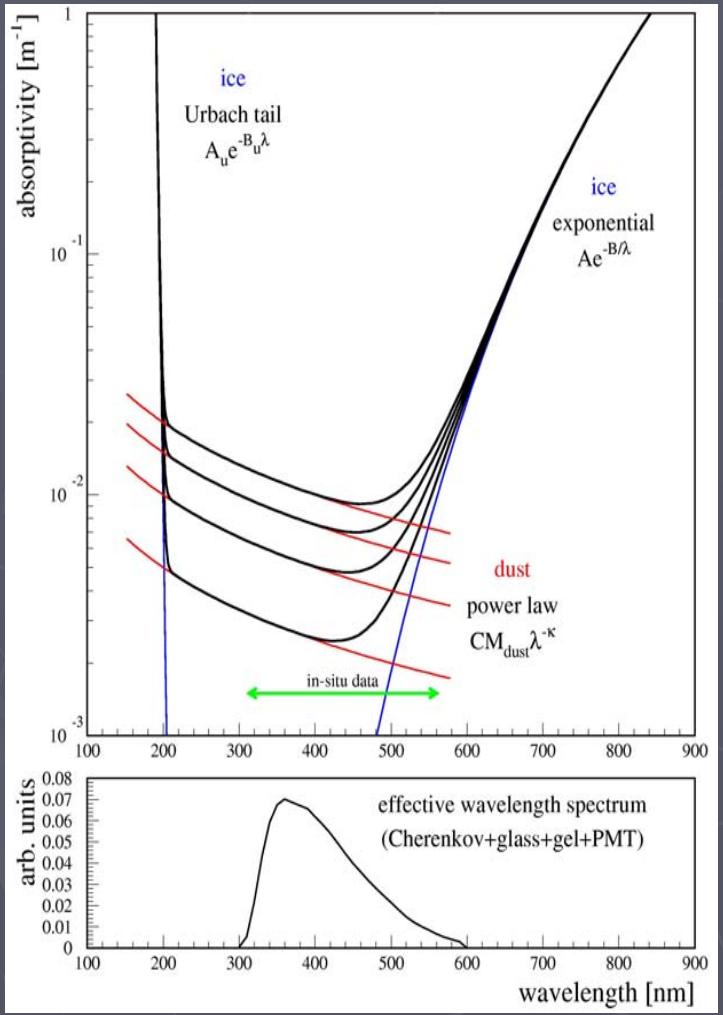
A WLS for IceCube: motivation





IceCube Ice (Model):

KURT WOSCHNAGG, UCB



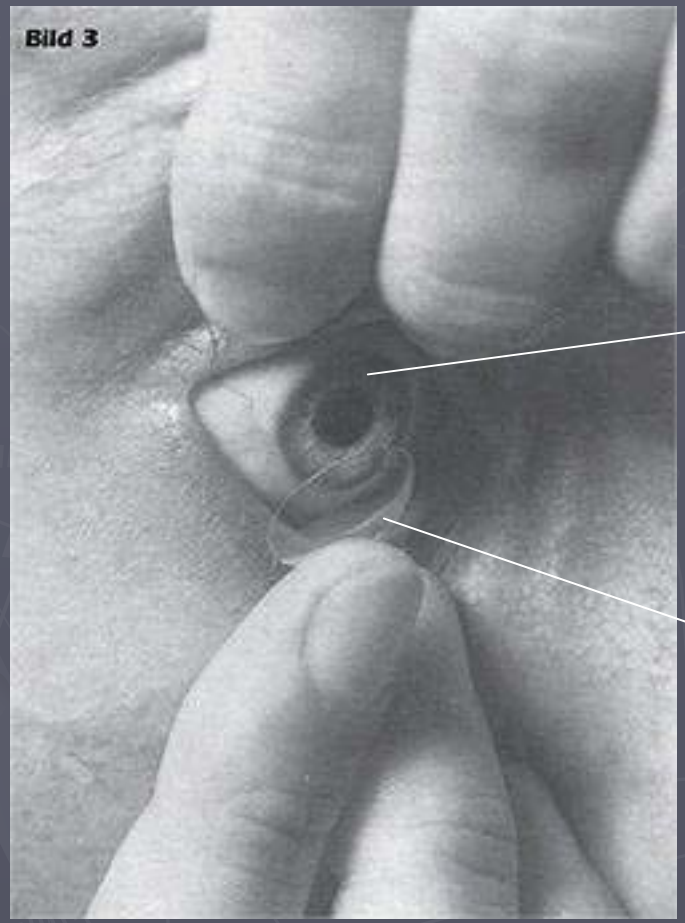
Empirical model
(L. Bergström, P.B. Price)

Ice extremely transparent
between 220 nm and 500 nm

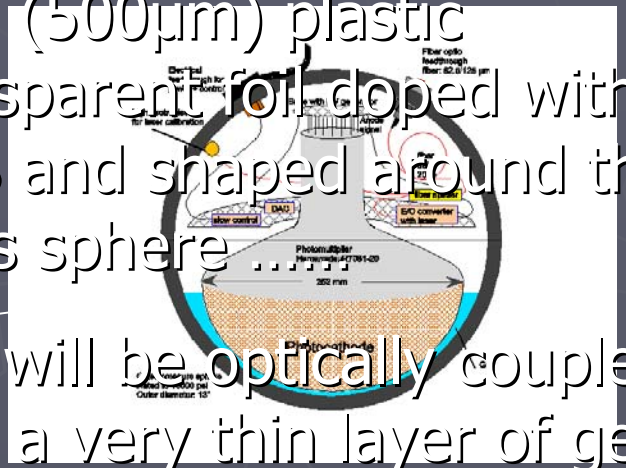
Absorption determined by dust
concentration in this range

Wavelength dependence of dust
absorption follows power law

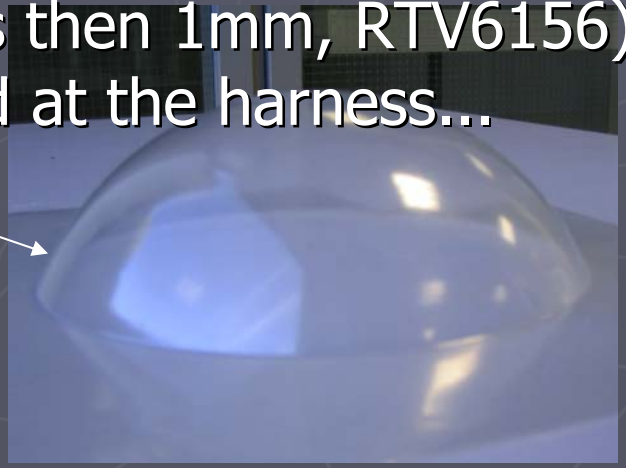
Implementation



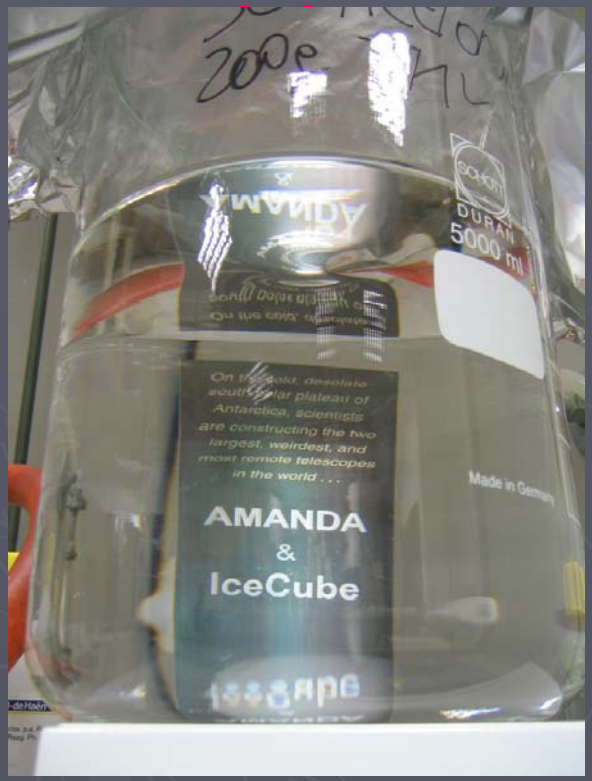
Thin (500µm) plastic transparent foil doped with a WLS and shaped around the glass sphere ...



....it will be optically coupled with a very thin layer of gel (less then 1mm, RTV6156) and fixed at the harness...



NEW Material: Production Steps



(2)

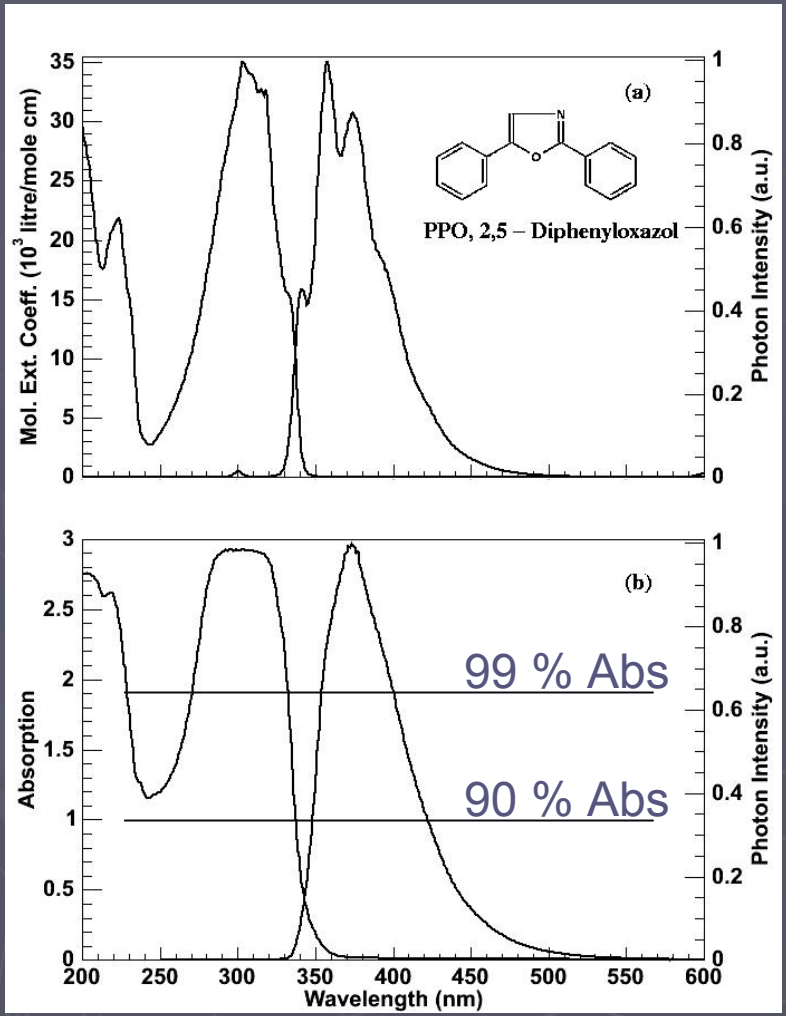
DESY

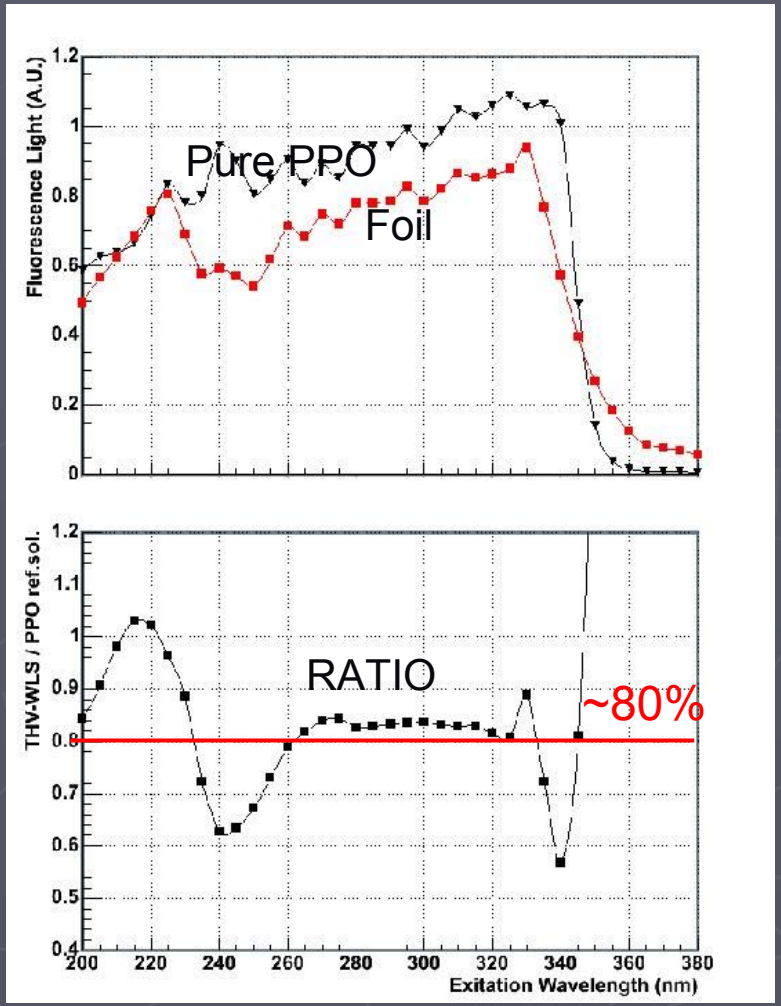
PATENT

NEW Material: Summary of the Performances

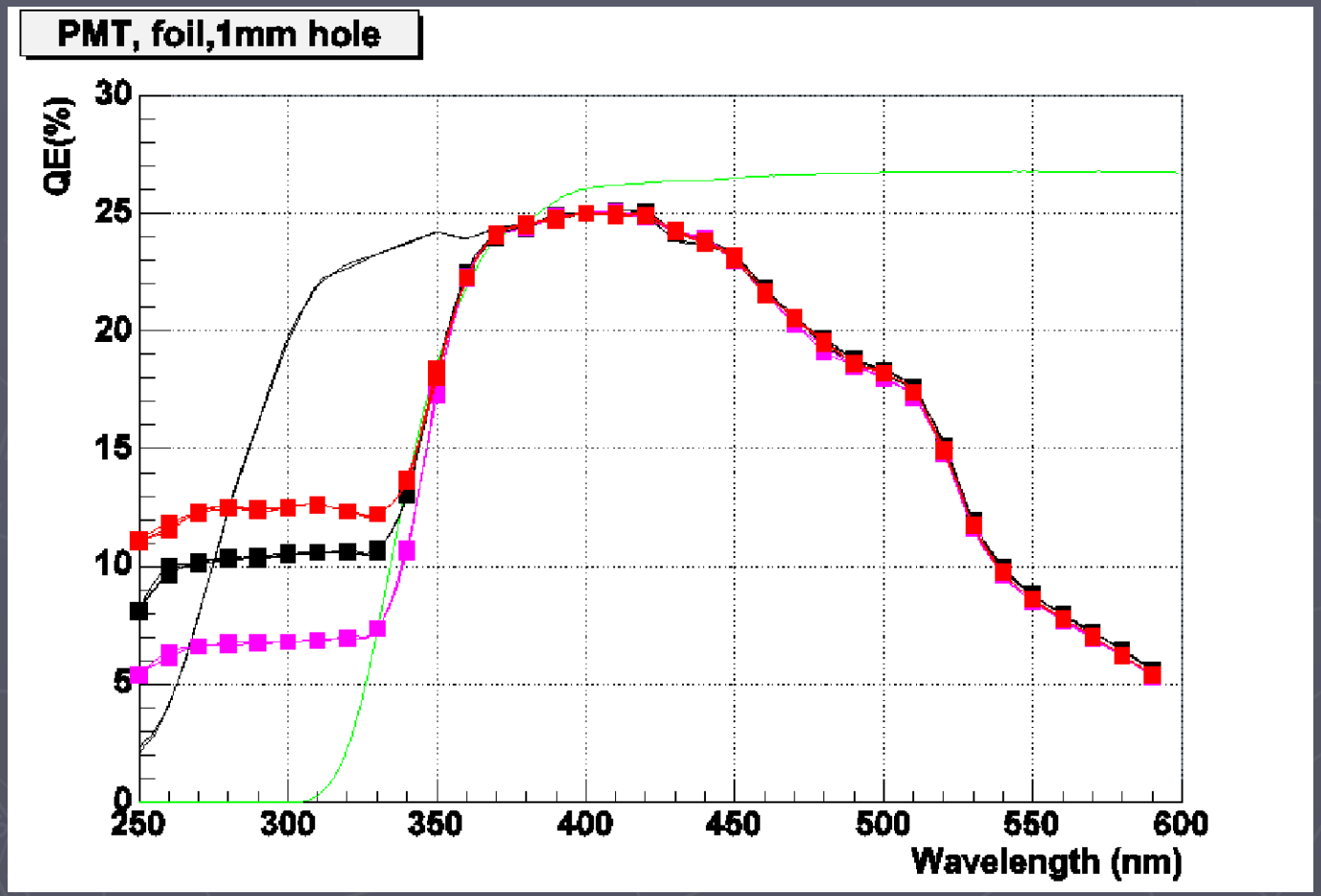
- Absorption and emission spectrum follows PPO's one
- Inert outside PPO absorption region (i.e. transparent)
- Fluorescence quantum yield: ~80% PPO
- Decay time: 1.4-1.8 nsec (OK for FAST photons detection)
- Uniform response in < 1%
- Stable response vs pure water, low T (down to cryogenic T), solvents
- Extrusion and thermoform possible

NEW Material: Performances (1)



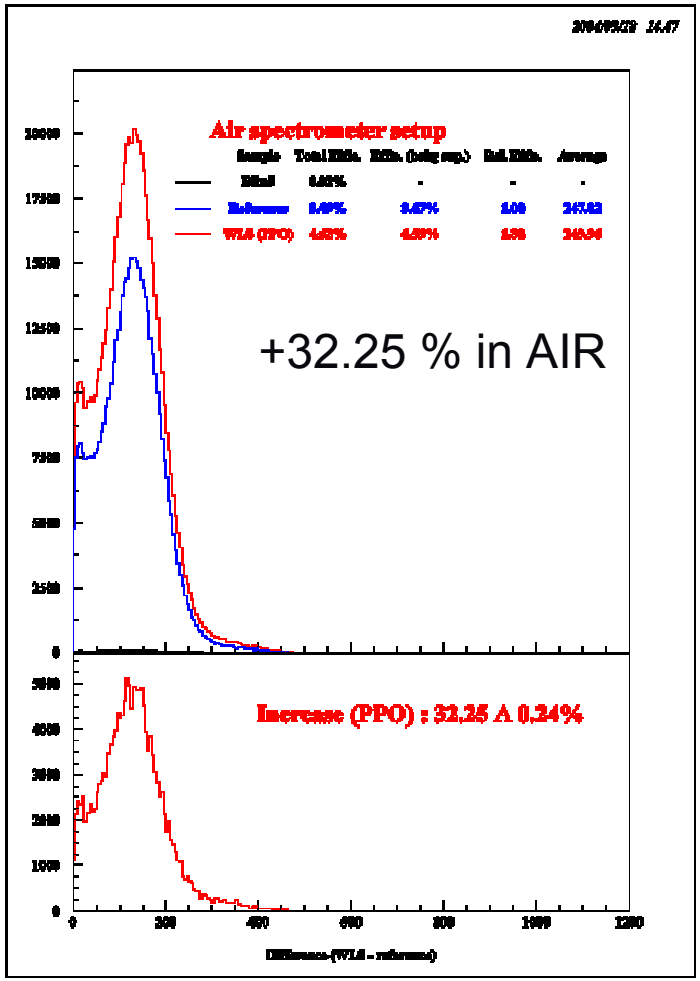


NEW Material + PMT



NEW Material + IceCube OM

[ULB, Mons, DESY, MPIK-Hd]



Conclusion

- A novel plastic material with Wavelength Shifting properties has been developed
- It is high efficient, versatile, uniform, stable … high potential for many applications
- For IceCube:
  - "contact lens" configuration proposed
  - net gain for Cherenkov light, sphere under water, realistic configuration …under measurement!