Wavelength shifter - state of art

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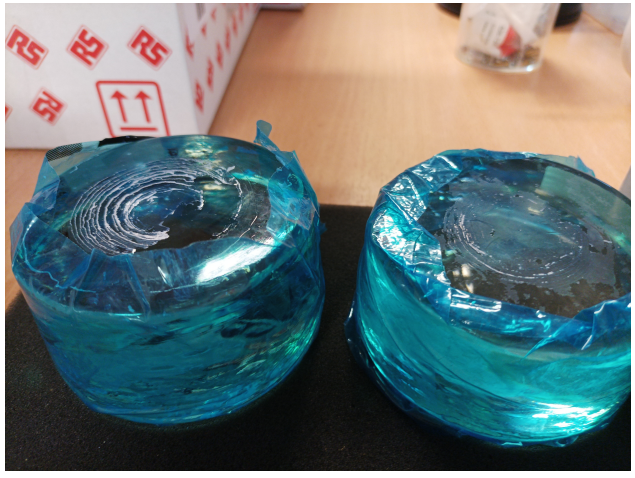
Plan

- general status
- sample production
- experimentation
- simulation

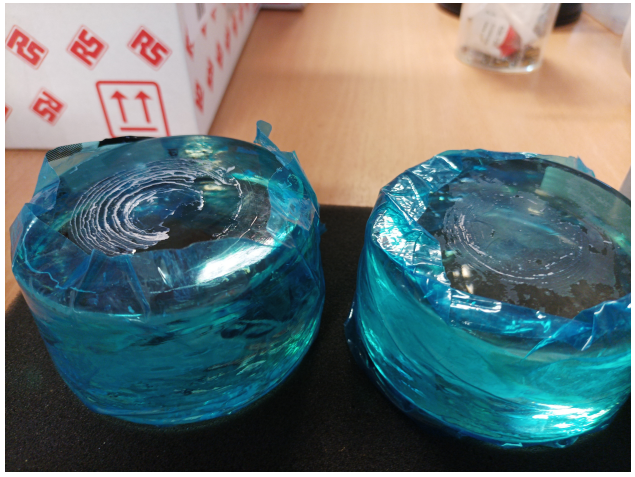
General Status

- before 2022: coating procedure by AstroCeNT
- early 2022: 6 glass samples sent by Nautilus (Steffen Pausch) to APC
- early 2022: 2 sent to AstroCeNT for coating
- spring 2022: coated samples received at APC
- july 2022: test in blackbox with Juande, Sergio and L3 students



Sample production

- coating procedure made for flat and regular surfaces
- samples from Nautilus: thick, irregular and slightly curved
- procedure not really adapted for those samples
- measurements still interesting



Experimentation - set-up

- light source (left):
  UV: 270 nm
  near UV (blue): 370 nm
- detector (right):
  spectrometer
- targets (middle):
  none/glass/coated glass
- wavelength shifting visible

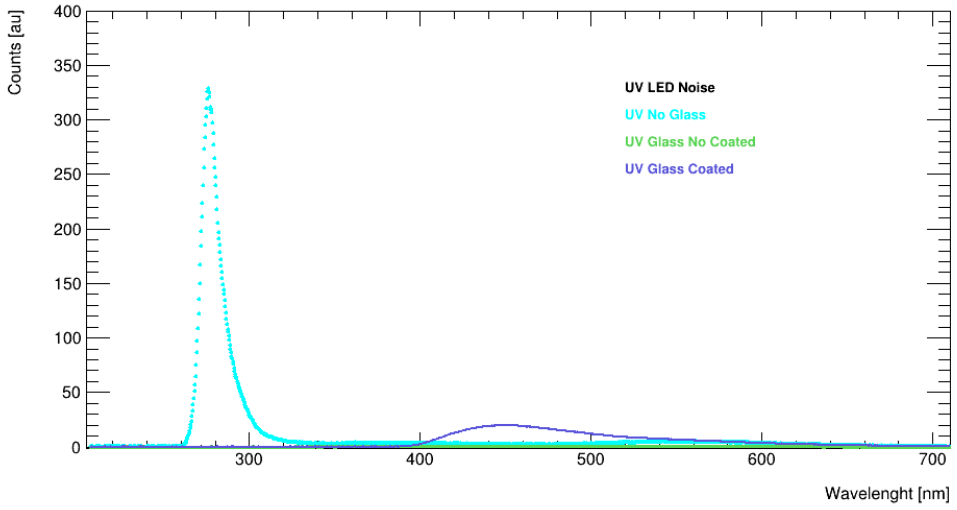
Experimentation - set-up

- light source (left):
  UV: 270 nm
  near UV (blue): 370 nm
- detector (right):
  spectrometer
- targets (middle):
  none/glass/coated glass
- wavelength shifting visible
- coating not uniform

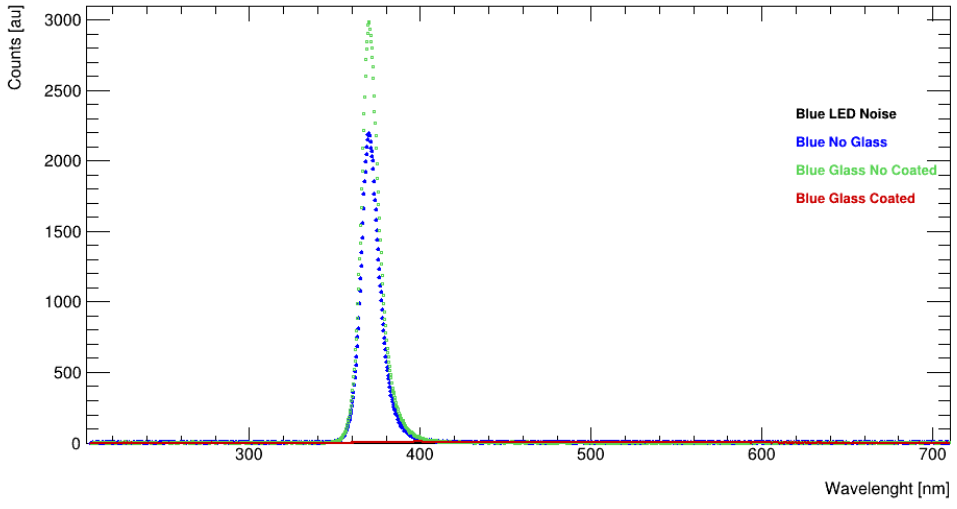
Experimentation - results

- as expected, UV light is almost fully killed by the glass
- near UV light (blue) is not attenuated by the glass but by the coating
- coating is re-emitting the photons at larger wavelength
- the ratio of re-emitted photons in direction of the detector is low

UV light



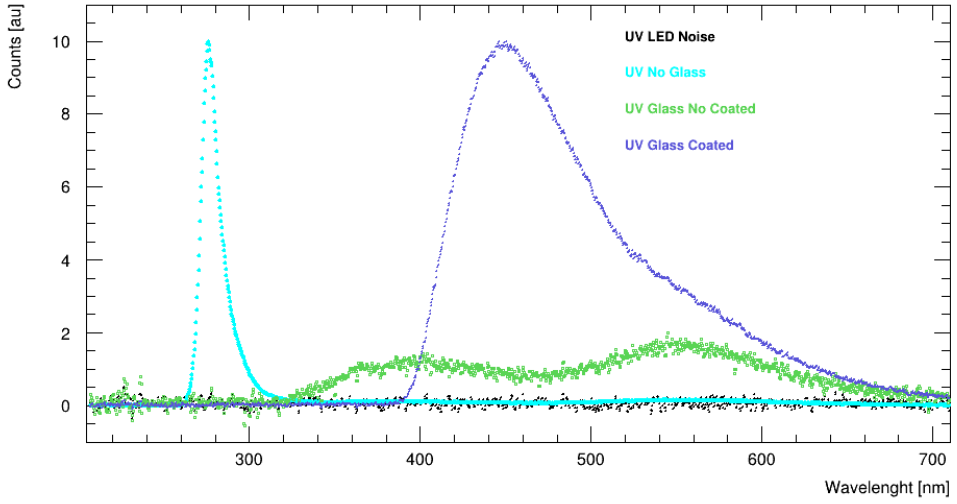
near UV light



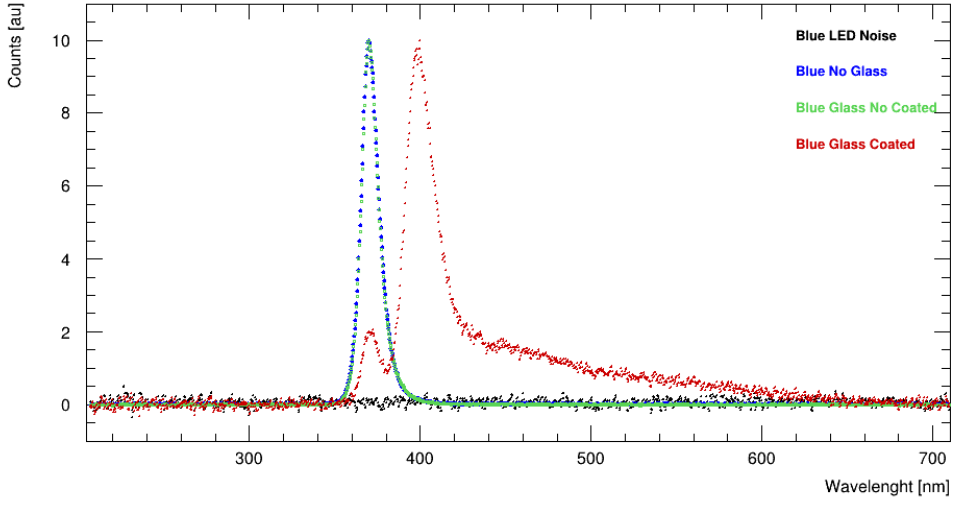
Experimentation - results

- for UV:
  - emission from the light source (2 green bumps)
  - shift of the peak by $\sim 180\,\text{nm}$
  - wider distribution
- for near UV:
  - small fraction transmitted (small red peak)
  - fraction shifted by $\sim 30\,\text{nm}$ (large red peak)
  - emission from the light source (tail)

UV light

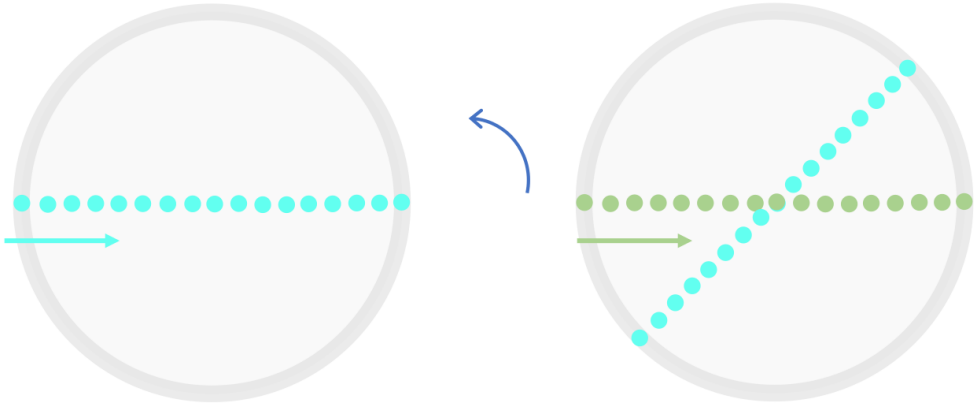


near UV light

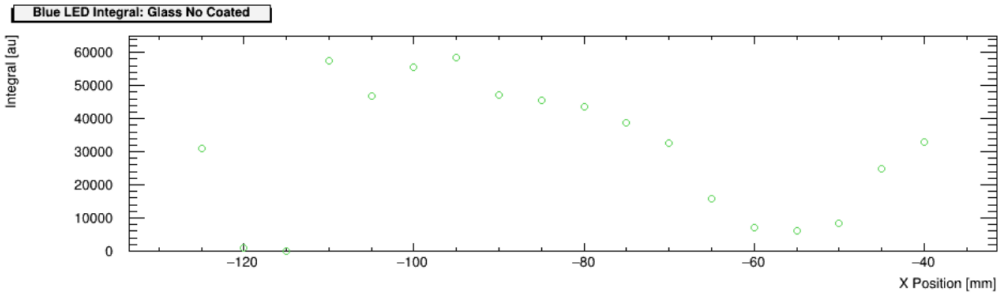


Experimentation - results

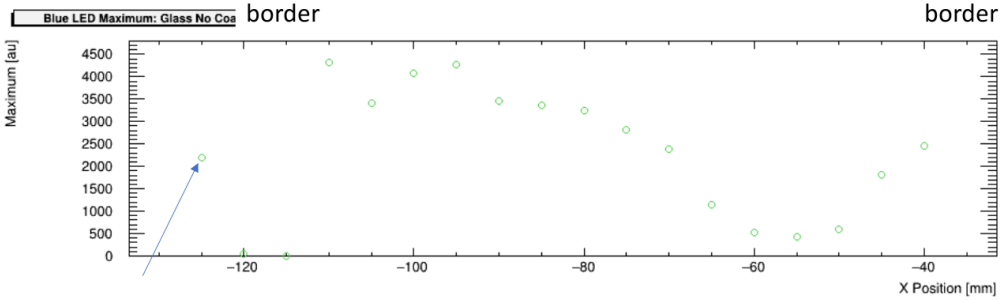
- scan from border to border
- step $\sim 5\,\mathrm{cm}$
- $\sim 45\,^{\circ}$ rotation
- variations due to glass lensing?



near UV light - no coating



border border



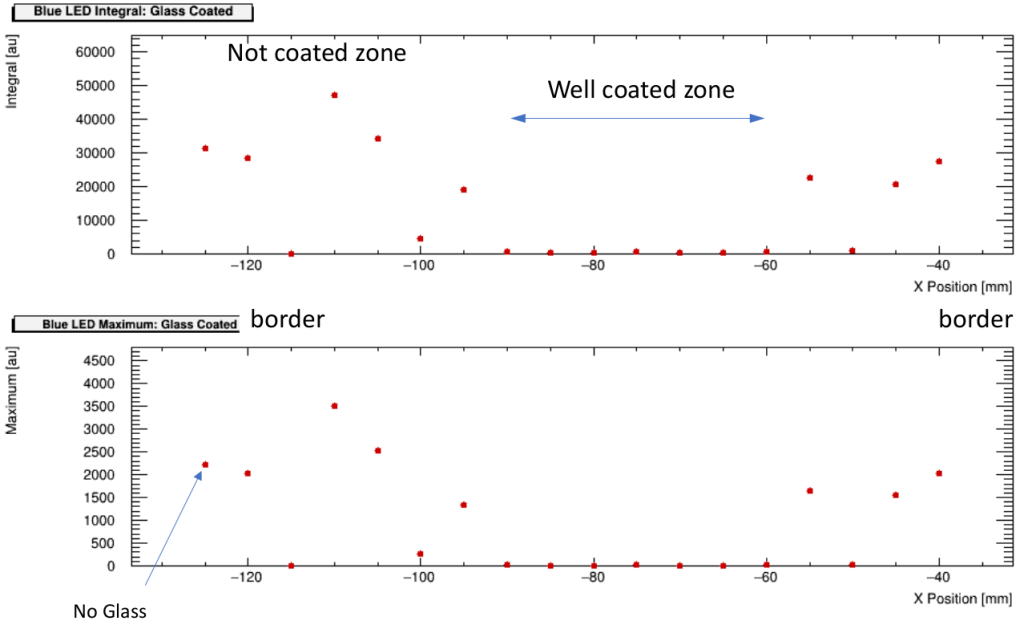
No Glass, i.e. direct light

Experimentation - results

- scan from border to border
- step $\sim 5\,\text{cm}$
- $\sim 45^\circ$ rotation
- absorption by the coating

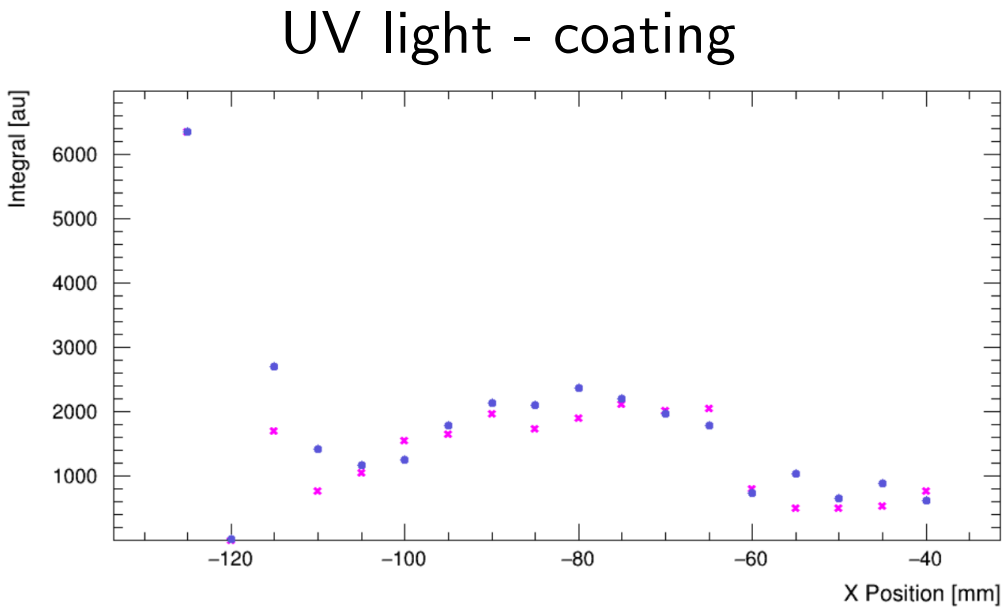
near UV light - coating

Blue LED with Coated Glass



Experimentation - results

- scan from border to border
- step $\sim 5\,\mathrm{cm}$
- $\sim 45\,^{\circ}$ rotation
- increase due to coating



Experimentation - Aging

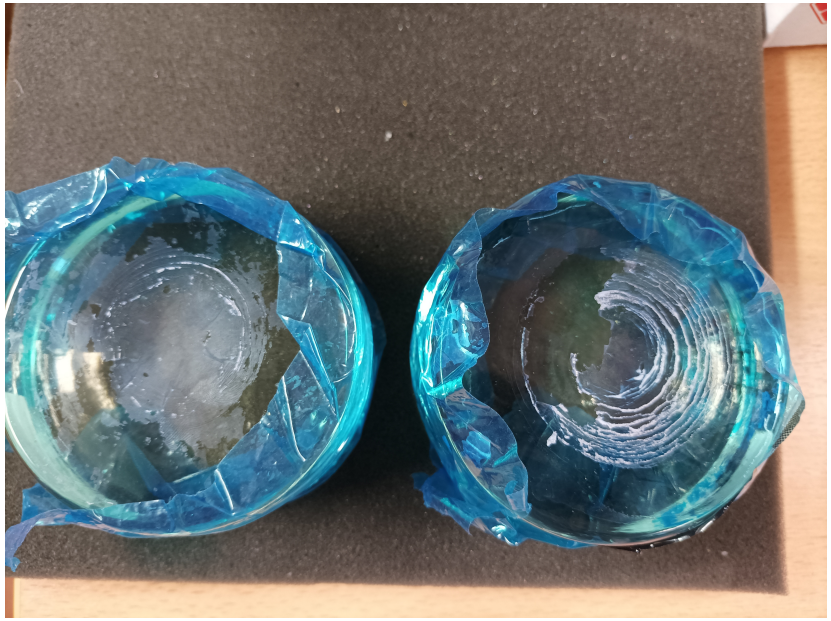
at reception

- white marks on one sample
- barely visible

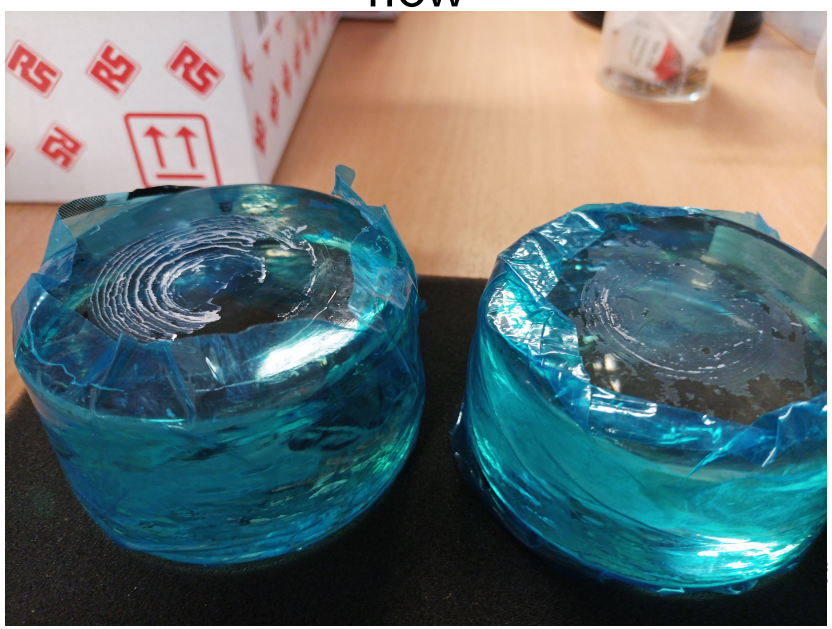
now

- white circle on both samples
- transmission getting worst with time
- it seems the coating is aging badly

now



now

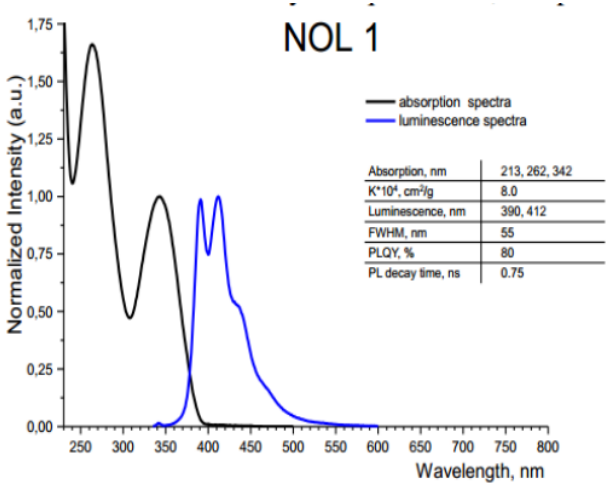


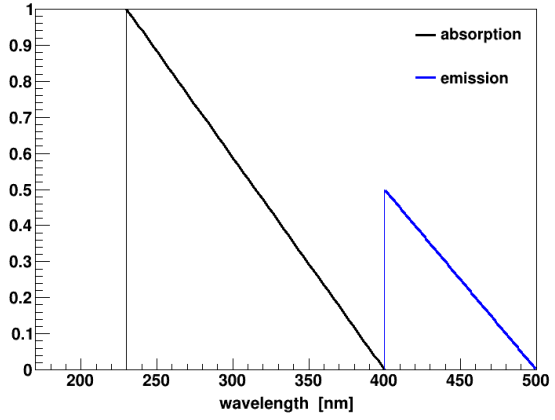
Experimentation - Conclusions

- wavelength shifter works as expected
- re-emission is over 4π steradians
- the photon gain is hard to estimate
- the delay of re-emission has not been studied and is crucial for us
- only 2 wavelengths tested, we need more for implementation in the simulation
- problem of coating stability

Simulation - Wavelength shifter

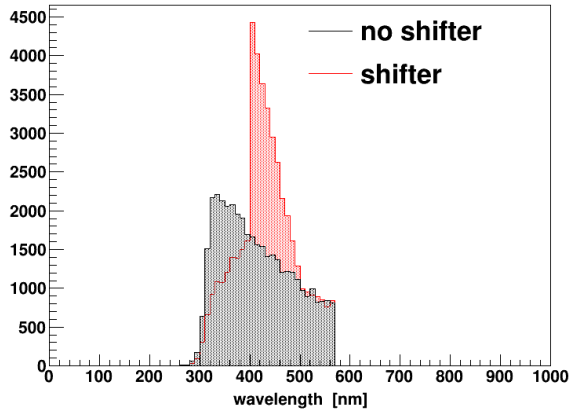
- inspired from NOL1 (extremely rough)
- no thickness - no index
- no reflection - no refraction - no diffusion
- just absorption/emission
- if absorption: 1/2 killed and 1/2 re-emitted
- if not: continue to the glass





Simulation - photons on PMT

- propagation through glass, glue, structure, $\cdots$
- no PMT effect here (no QE, no CE)
- the shifter effect is clear
- small lost at low λ
- large increase in the re-emission zone
- integrated:
  without shifter: 38476
  with shifter: 45480
  increase of: $+18\%$



Next steps

- better estimate of the absorption/emission curves
- implementation of the refraction/diffusion coefficients
- take the PMT properties into account
- compare to measurements

Take home message

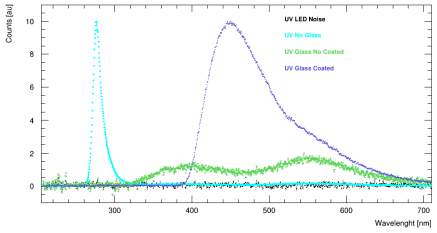
experimentation

- tested for 270 nm and 370 nm
- shift of the peak (by $\sim$ 180 nm and $\sim$ 30 nm)
- re-emission is over 4π steradians
- photon gain estimated with simulation
- delay of re-emission not studied

Simulation

- propagation through glass, glue, structure, $\cdots$
- no PMT effect here (no QE, no CE)
- integrated: increase of: $+18\%$

UV light



near UV light