Development of wavelength shifters for the ArDM argon dark matter detector

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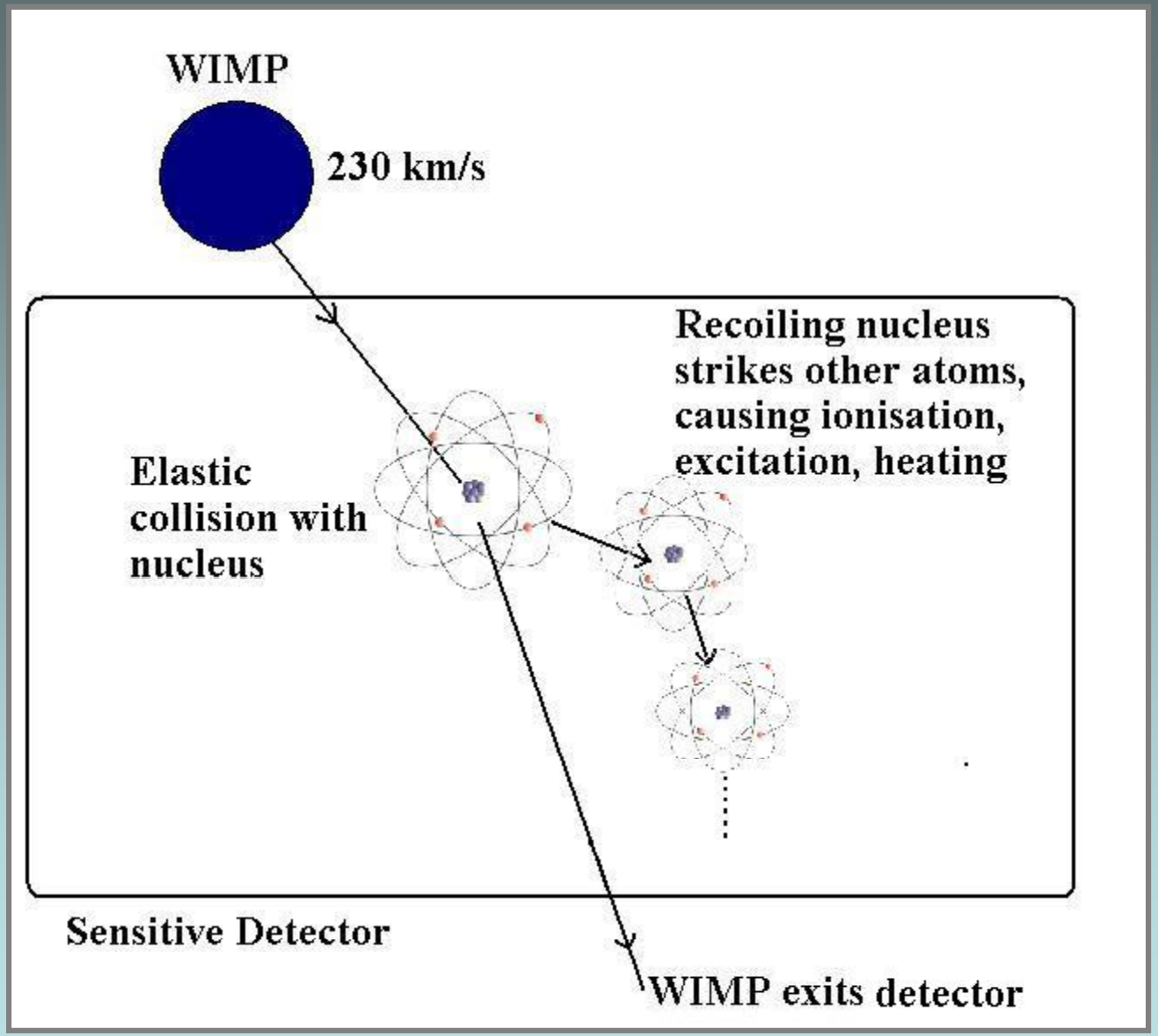
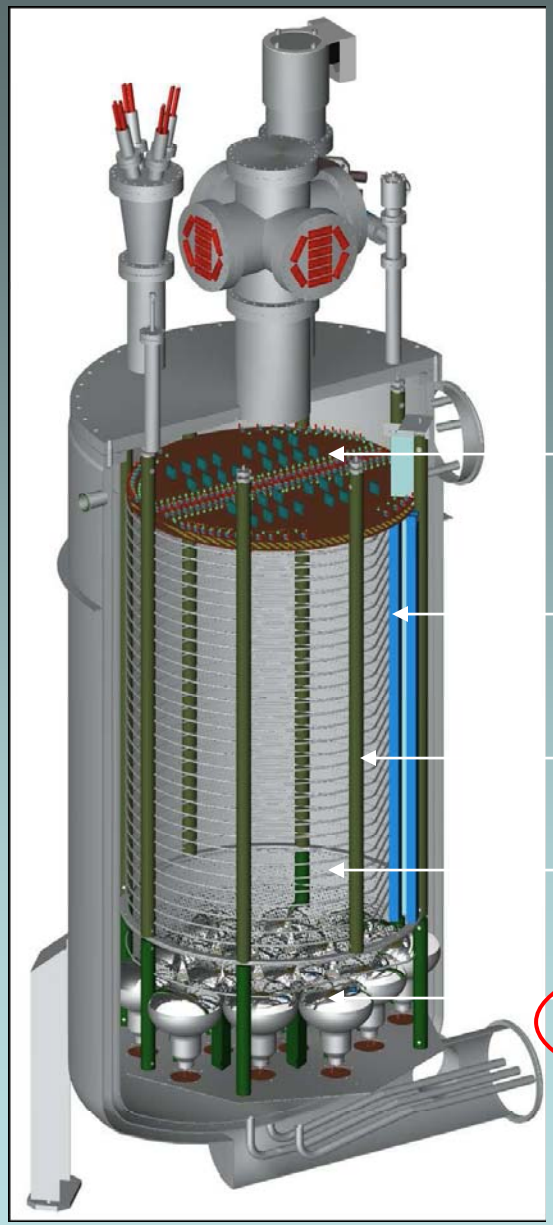
Talk outline

- WIMP detection principle
- The ArDM project
- TPB -wavelength shifter (WLS)
- Wavelengh shifters (WLS) deposition methods
- Argon scintillation properties
- Experiments to optimize WLS
- Installation of WLS in ArDM target

WIMP detection principle



The ArDM project



- **The Argon Dark Matter (ArDM) is a 1-ton two phase liquid/gaseous argon scintillation/ionisation WIMP detector.**

Two-stage LEM for electron multiplication and readout to measure ionization charge

Greinacher chain: supplies the right Voltages to the field shaper rings and the cathode up to 500 kV

Field shaping rings

Cathode grid

14 PMTs below the cathode to detect the scintillation light

TPB - wavelength shifter

- **Tetraphenyl butadiene (TPB) is an aromatic compound which fluoresces when its pi orbital electrons are excited, either by UV radiation or ionization.**

- **TPB powder has been used which can absorb the 128 nm light and reemit it in the visible wavelength (~430 nm) which is within the sensitivity range of the PMTs.**

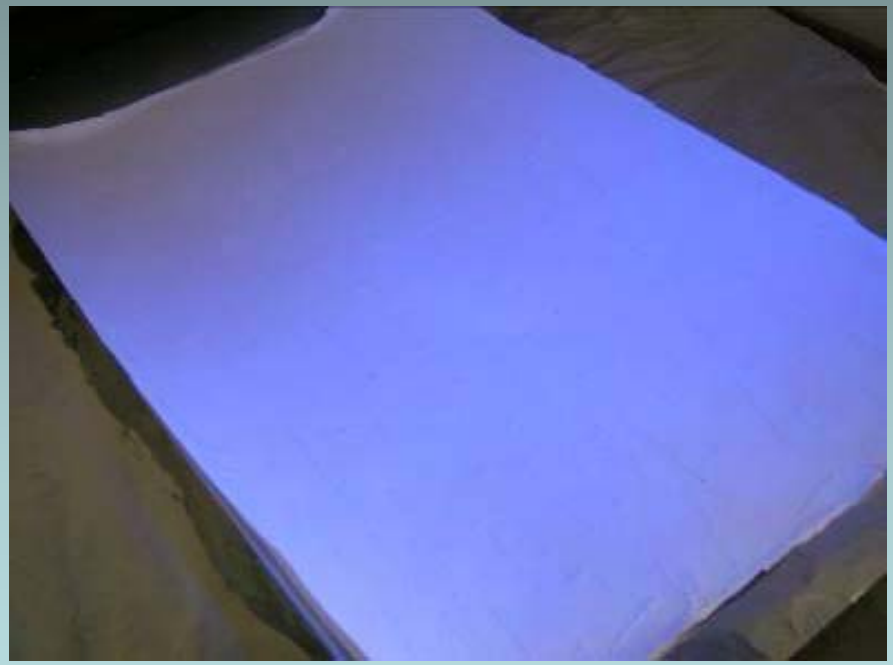
- **TPB powder can be deposited to PMT window/reflectors using evaporation, spraying and doping.**

TPB deposition methods: Evaporation

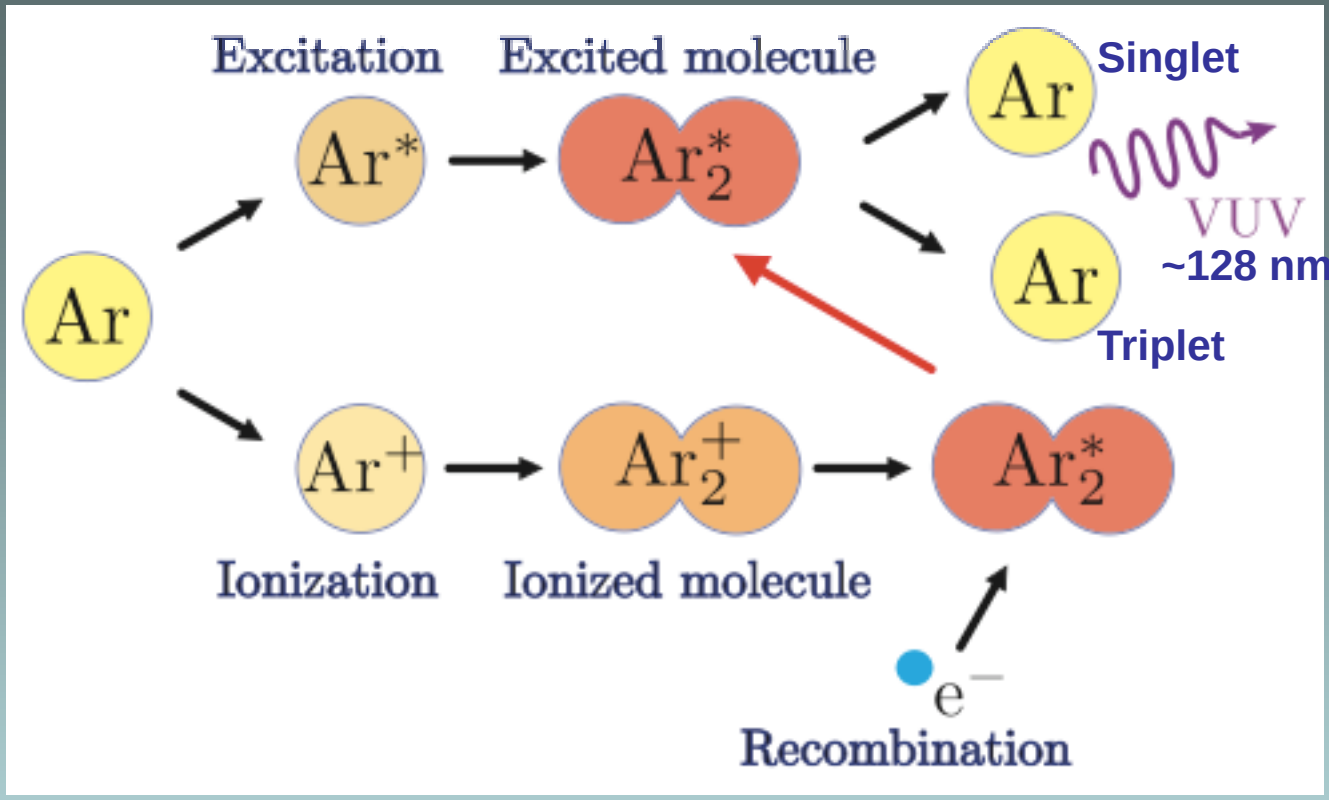
TPB evaporated samples on 3M foil (specular reflector)

TPB deposition methods: Spraying

TPB sprayed samples on TTX cloth (diffuse reflector)



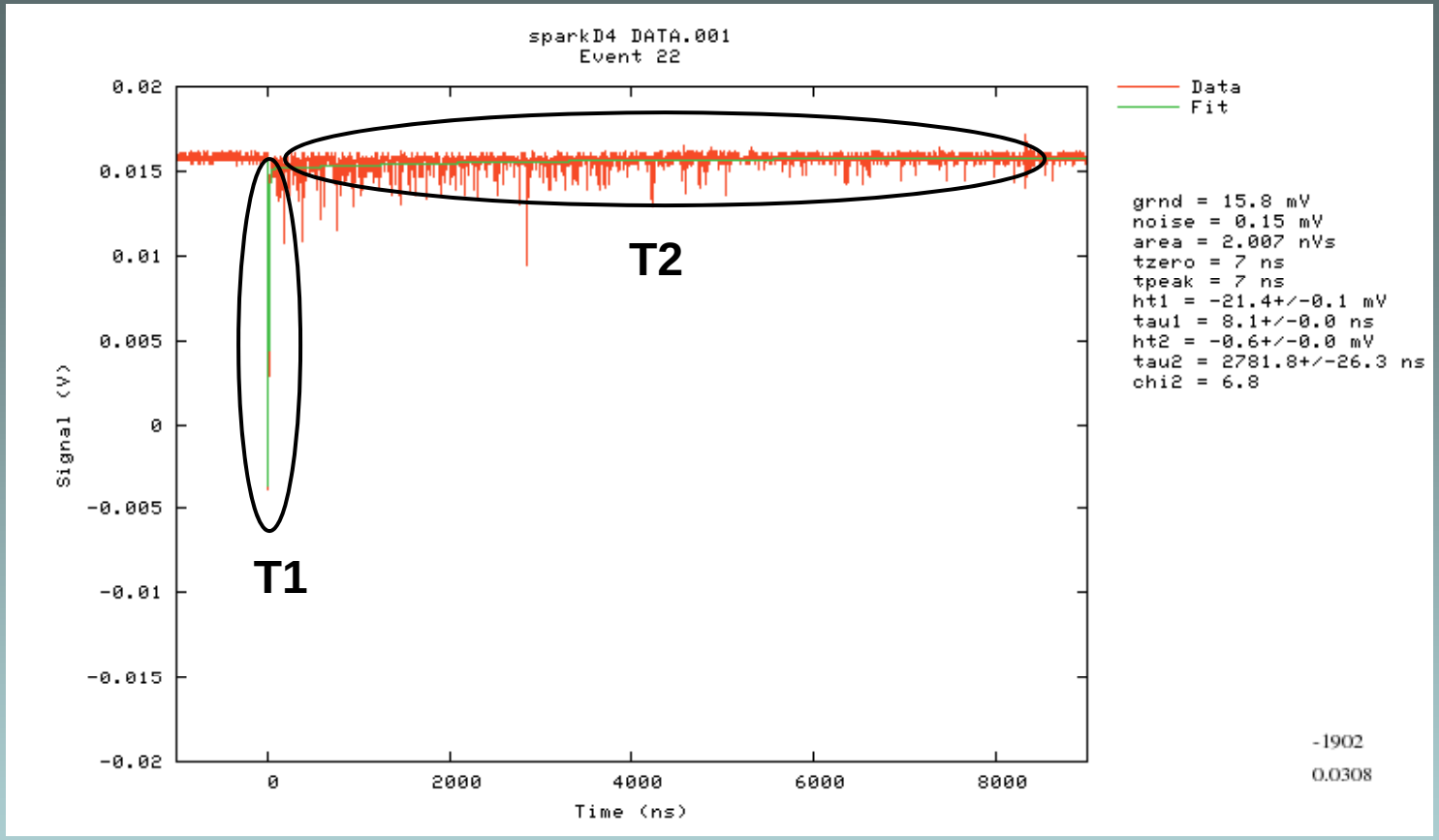
Argon scintillation



Processes induced by charged particles in Argon

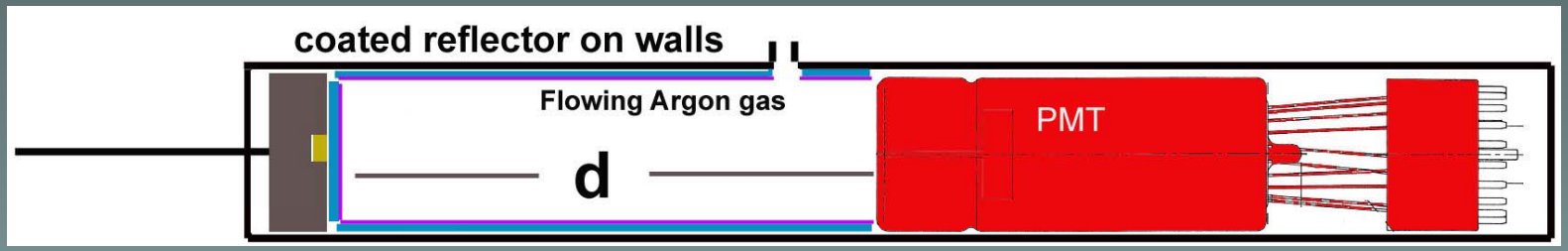
- **The argon excimers are created in three nearly degenerate spin states, two singlets ($^1\Sigma^-$ and $^1\Sigma^+$) and a triplet ($^3\Sigma^+$)** *[M.Suzuki et al. NIM (1982) 565]*.

Gas argon scintillation



- Scintillation light from argon has two distinct decay times - a slow component, T2 (triplet), and a fast component, T1 (singlet). The slow component, T2, can be used as a measure of the purity of the Argon. The purest gas argon has a T2 of about 3200 ns.

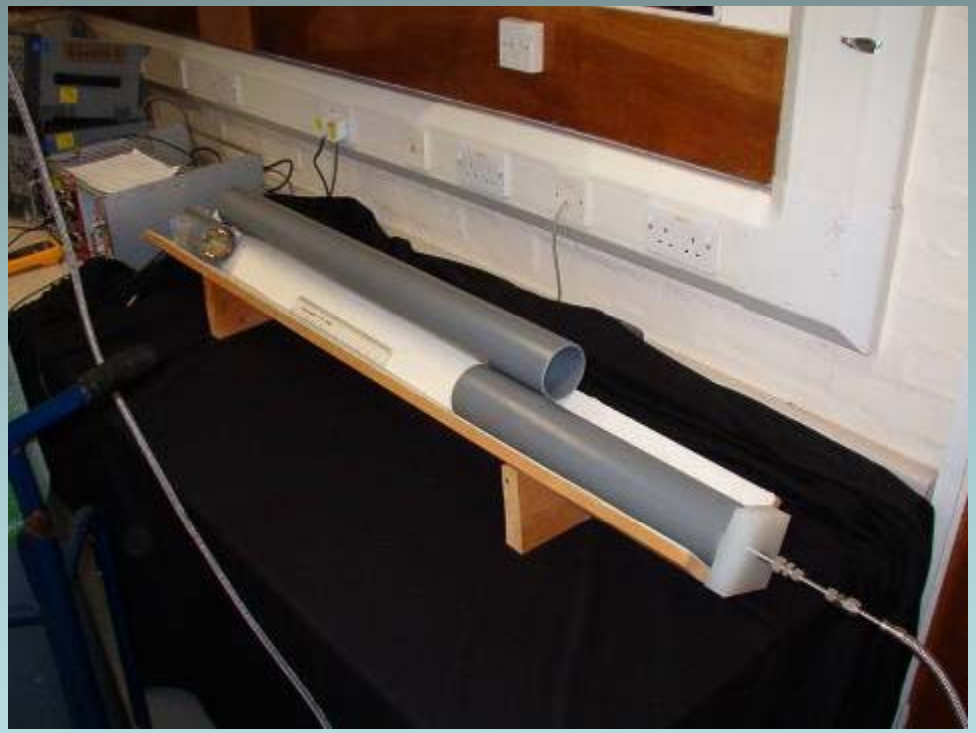
The gas argon apparatus 1(a)



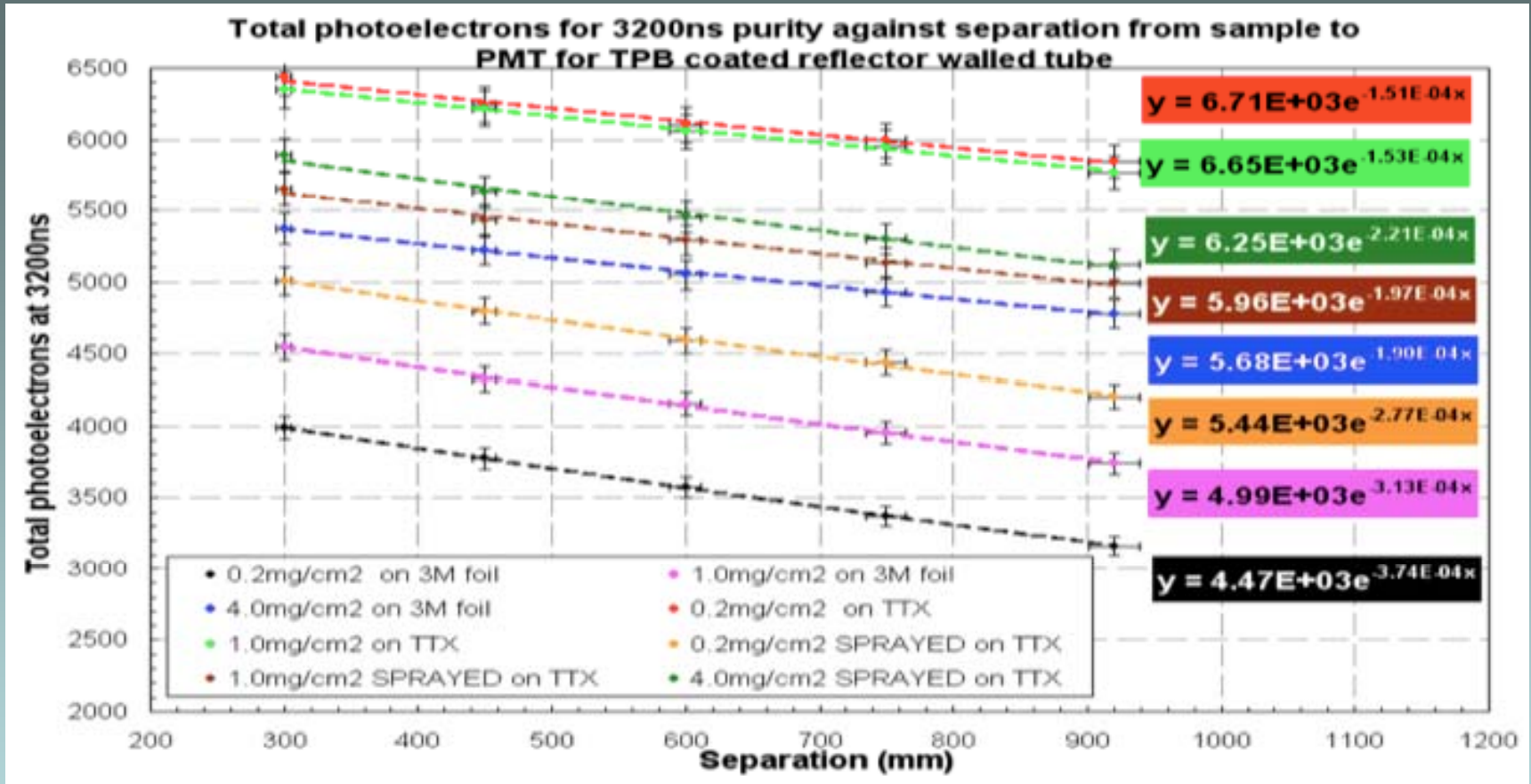
- This apparatus consisted of a sealed PVC tube containing a PMT. 3M foil (multilayer polymer film, which is a specular reflector) and TTX (PTFE cloth, which is a diffuse reflector) coated with TPB (wavelength shifter that shifts 128 nm to 420 nm) were placed around the interior walls of the tube. An alpha source was placed within the tube at a fixed distance from the PMT.

- Measurements were taken for a range of thicknesses of TPB from 0.2 mg/cm^2 to 4.0 mg/cm^2 deposited both via evaporation and spraying. Additionally the distance of the alpha source from the PMT was altered in order to investigate the consequence of the solid angle on the light collection of the shifted light. We recorded the effect of each separation on the number of photoelectrons collected at the PMT by plotting the slow component decay time (T2) against light collection for increasing distance d.

The gas argon apparatus 1(b)

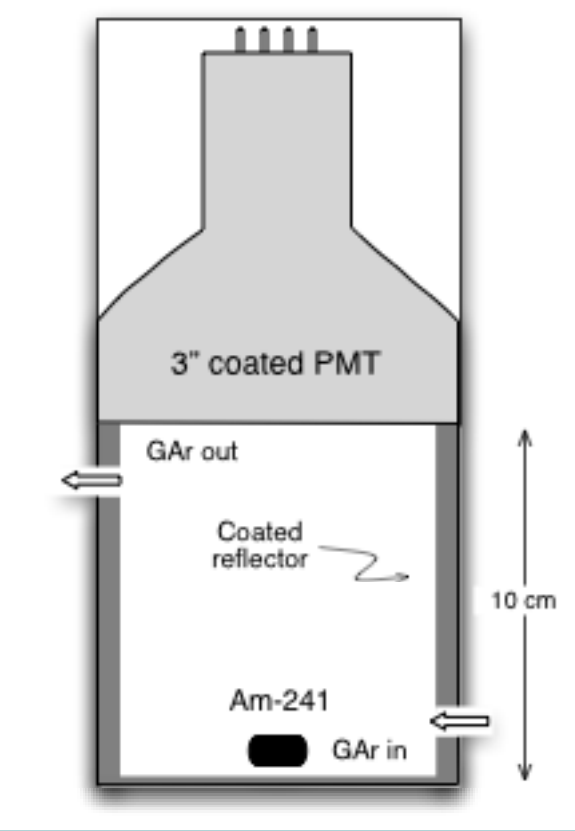


The gas argon apparatus 1(c) -Results



- **The best wavelengh-shifter found to be 0.2 mg/cm² TPB thickness evaporated on TTX cloth!**

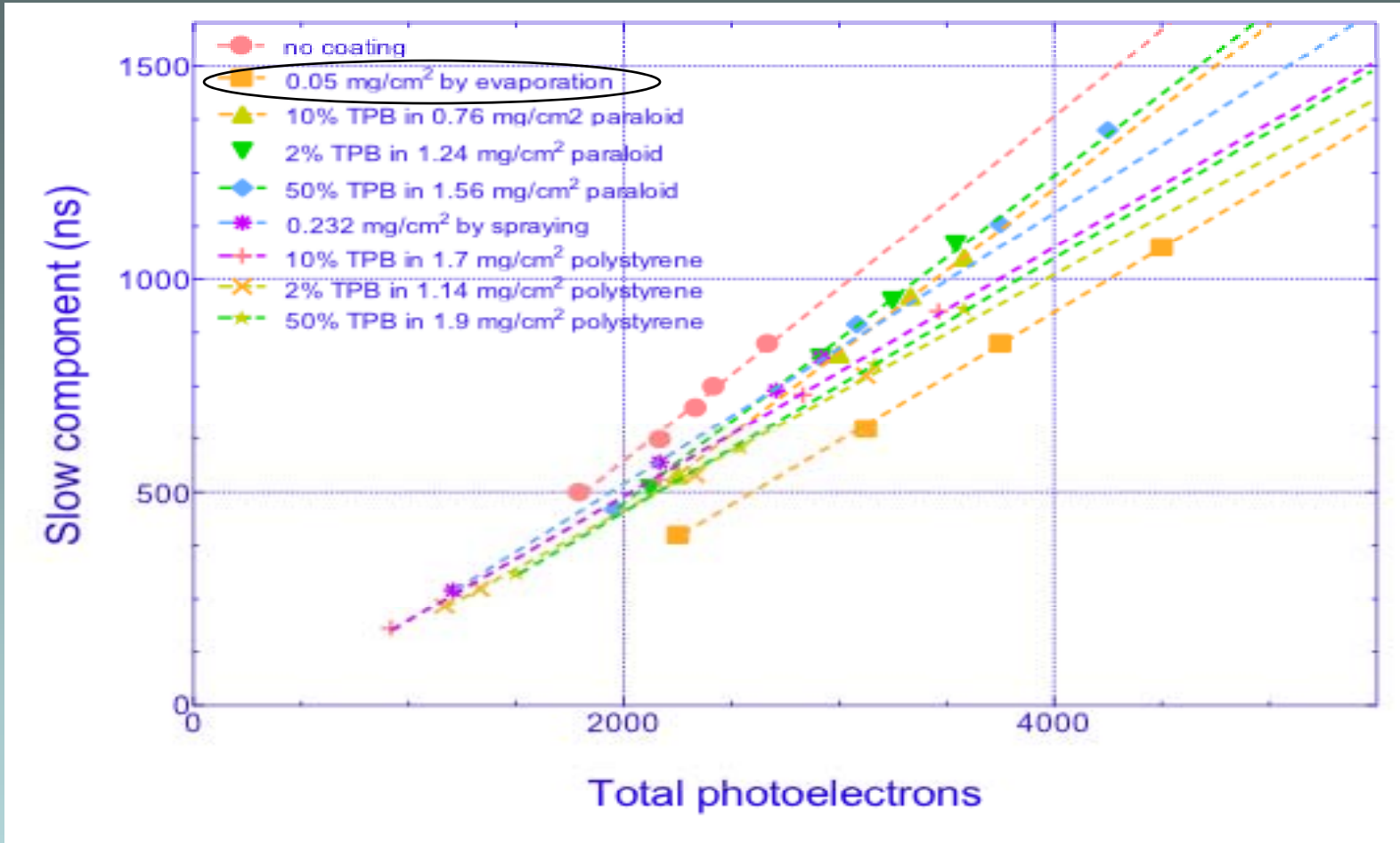
GAr apparatus 2 -PMT window coating



- The second gas argon apparatus was constructed based on the actual geometry of the full scale ArDM target. The experiment consisted of a sealed PVC tube containing a 3" PMT which was coated with TPB powder of various thickness and with various deposition methods. The sides and bottom of the PVC tube were covered with 3M foil reflector which was coated with 1 mg/cm2 TPB powder. An alpha source was positioned 10 cm away from the PMT window.

- We recorded the effect of various PMT window coatings on the number of photoelectrons collected at the PMT by plotting the slow component decay time against the total light collection.

PMT window coating results

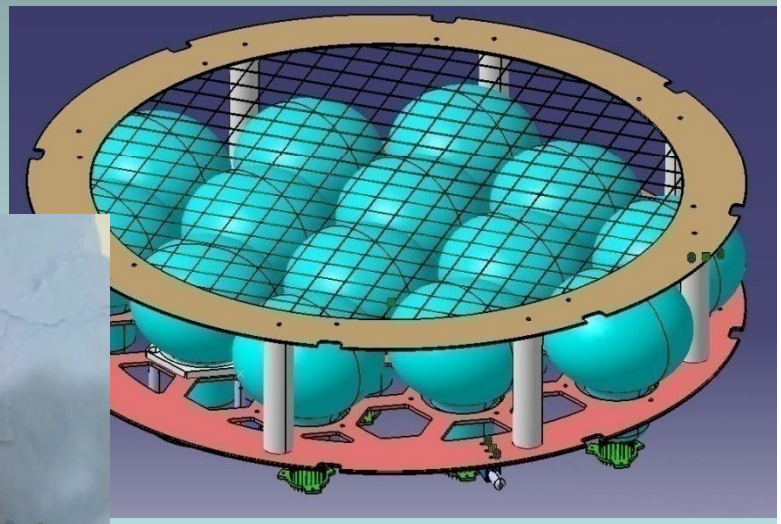


- **The best wavelength shifter will be the one at which at a given purity (slow component) the scintillation pulse has more area!**

Installing the WLS in ArDM target

TPB powder evaporated on TTX cloth

- **Reflectivity @430nm ~97%**
- **Shifting eff. 128 nm → 430nm >97%**



Summary & Conclusions

The ArDM project: a 1-ton two phase liquid/gaseous argon scintillation/ionisation WIMP detector.

The primary VUV scintillation light of argon (wavelength 128 nm) needs to be shifted to visible light in order to match the sensitivity range of the PMTs.

TPB powder wavelength shifter was used.

TPB powder deposition methods were: evaporation, spraying and doping.

Two gas argon apparatus were constructed in order to optimize the WLS.

The best coated reflector was TTX cloth with 0.2 mg/cm^2 TPB deposited by evaporation.

The best coating of PMT window found to be 0.5 mg/cm^2 TPB deposited by evaporation.