

Performance of gaseous RICH with SiPMTs

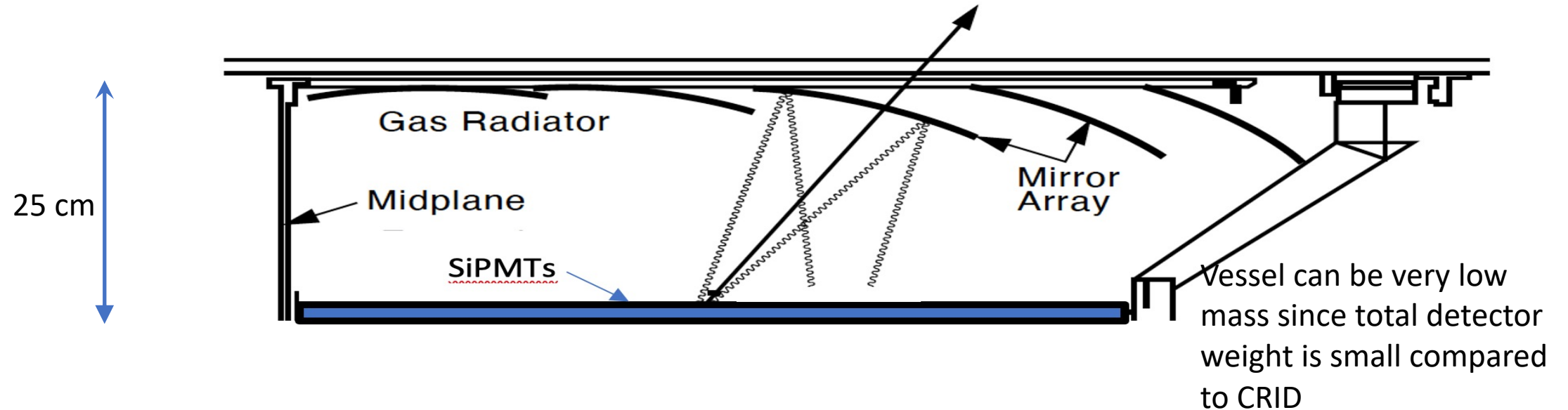
Jerry Vavra

Possible candidates

- Look in detail on PDE of SiPMT
 - What mirror to choose ?
 - What type of gas to use ?
 - What is the radial distance ?
-
- What I will not cover today is Cherenkov angle error.

Gaseous RICH for SiD

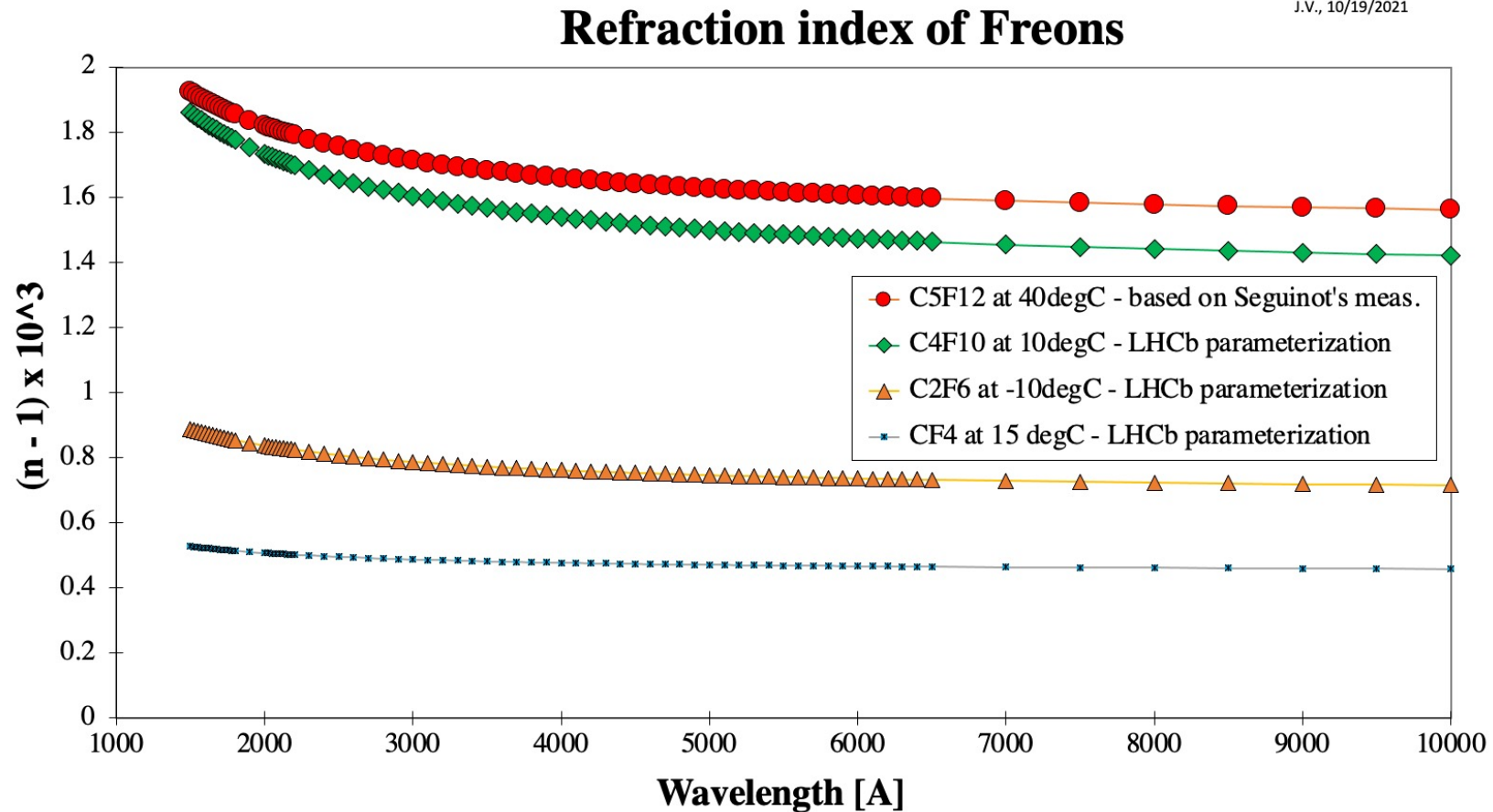
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- Pure C_5F_{12} at 1 bar requires a temperature of 40°C (boiling point 31°C at 1 bar).
- Pure C_4F_{10} at 1 bar can work at room temperature (boiling point -1.9°C at 1 bar).
- Pure C_2F_6 at 1 bar can work at room temperature (boiling point -70.2°C at 1 bar).

Refraction index of Freons

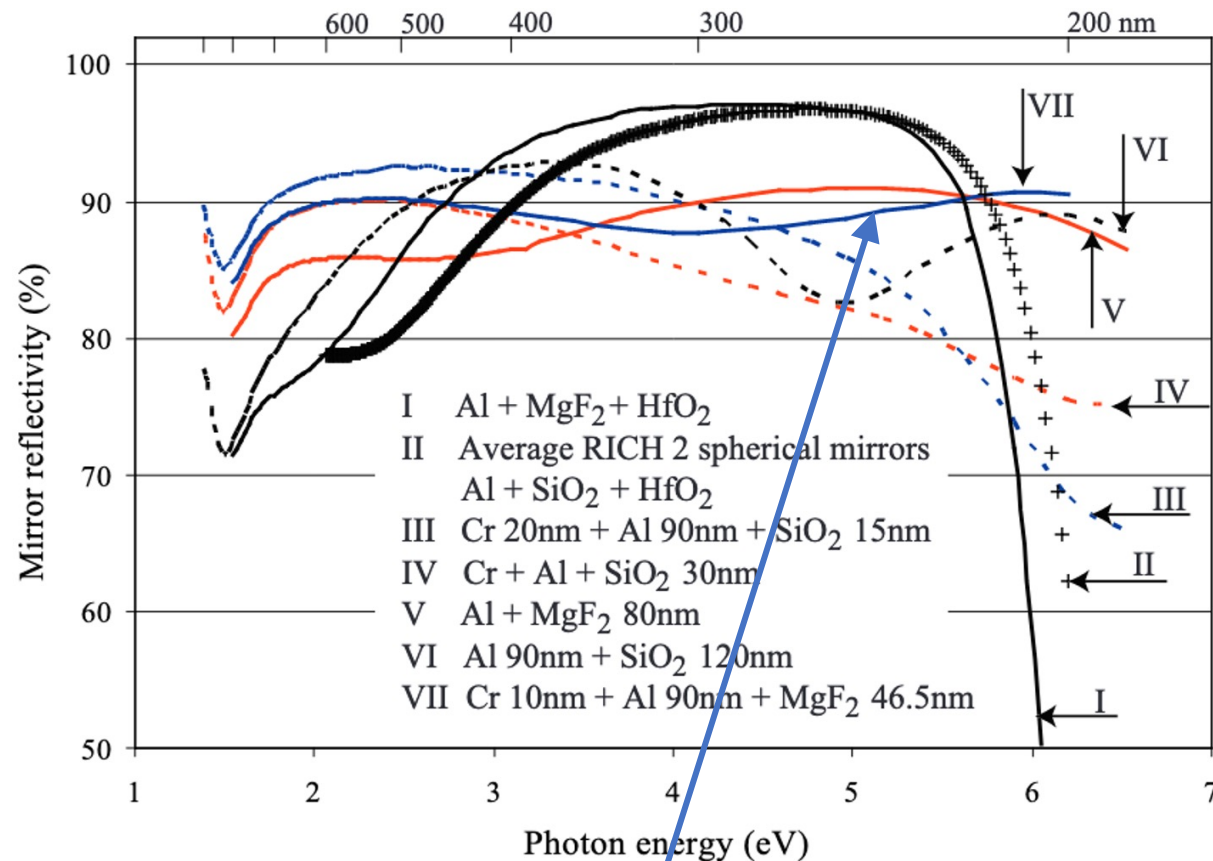
LHCb and J. Sequinot data



- C5F12 data input from J. Sequinot's liquid data; all other are LHCb parameterization

Mirror reflectivity

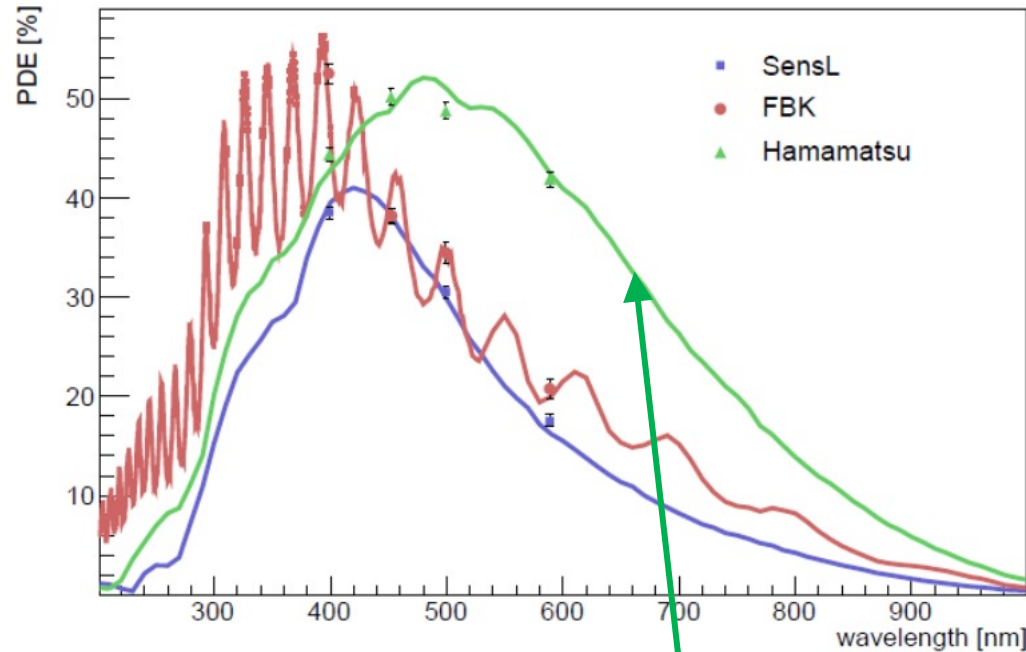
LHCb collaboration, JINST 3 S08005, 2008



- For calculations in this note I used Al+Cr+MgF₂ mirror coating. One can try other choices next.

PDE of a single SiPMT

Input to PDE: P. Krizan et al., NIMA 990(2020)163804, and R. Klanner, arXiv:1809.04346v2, 2018



PDE = Photon detection efficiency:

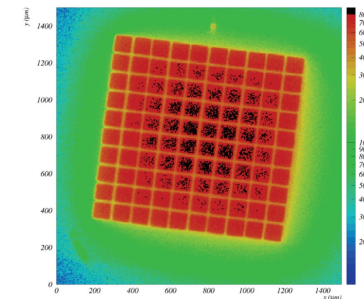
$$\text{PDE} = \text{FF} \times \text{QE}(\lambda) \times P_T(V_{\text{bias}}, \lambda)$$

QE(λ) – QE of Si

FF – Fill factor within one SiPMT

$P_T(V_{\text{bias}}, \lambda)$ – Trigger efficiency

However, this is not all. A SiPMT array has additional losses due to gaps between pixel elements ! In this talk I am using 65%:



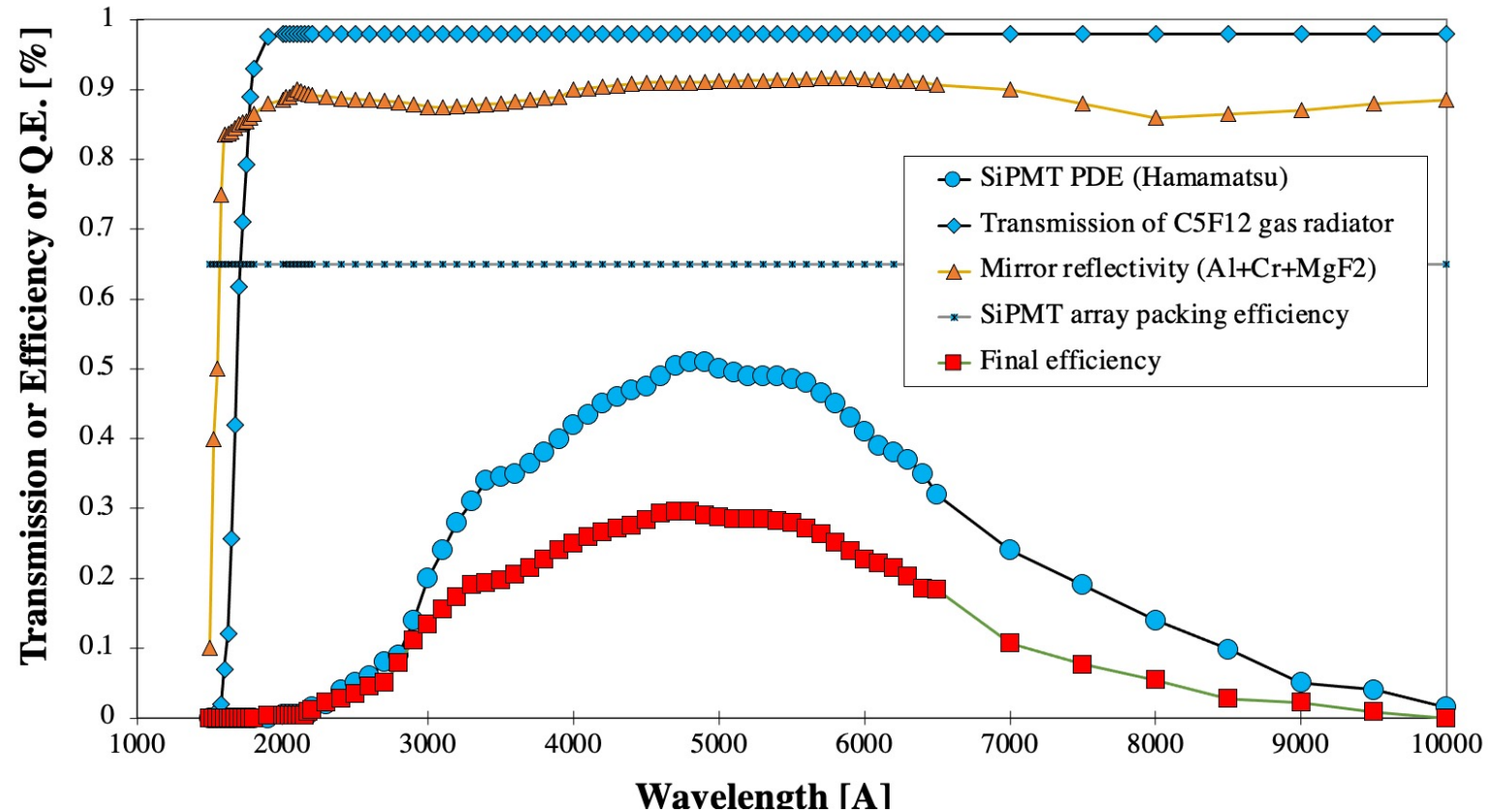
- I will use Hamamatsu PDE in all calculations

Overall efficiency of SiPMT array

J. Va'vra

J.V., 10/18/2021

Gas RICH Performance - C5F12 gas radiator & SiPMTs



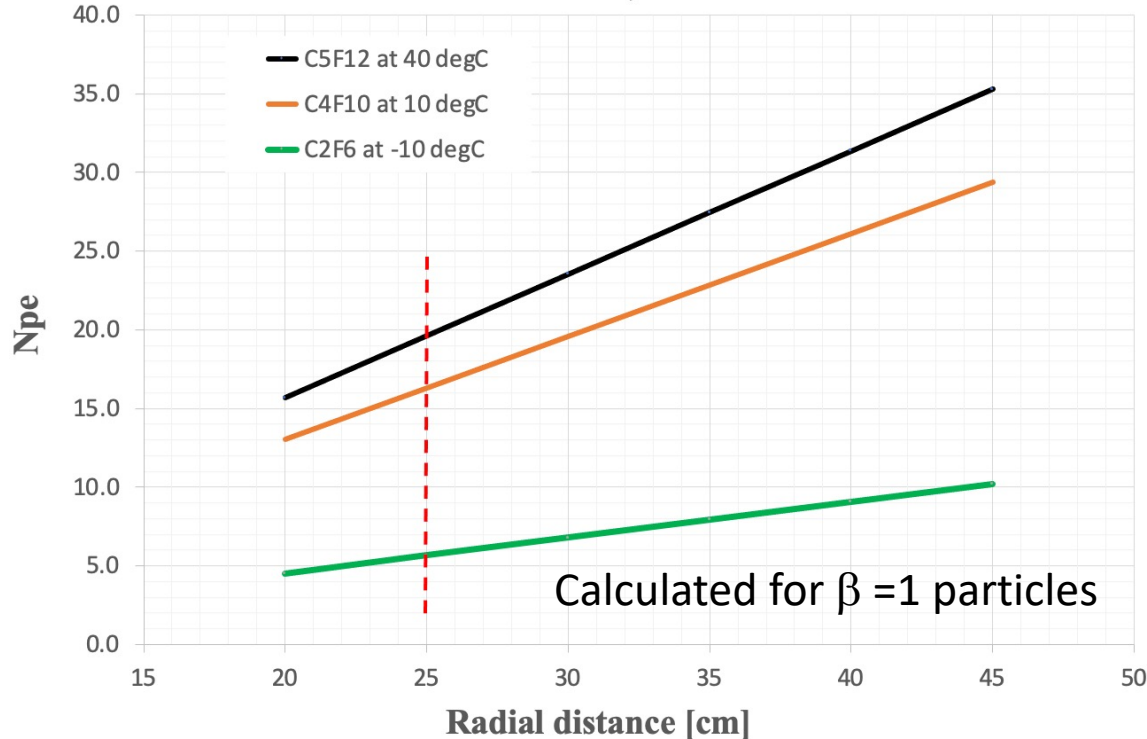
- For now, I assume that SiPMT packing efficiency is 65% !

Number of photoelectrons per ring

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Gas RICH with C₅F₁₂, C₄F₁₀ and C₂F₆

J.V., 10/19/2021



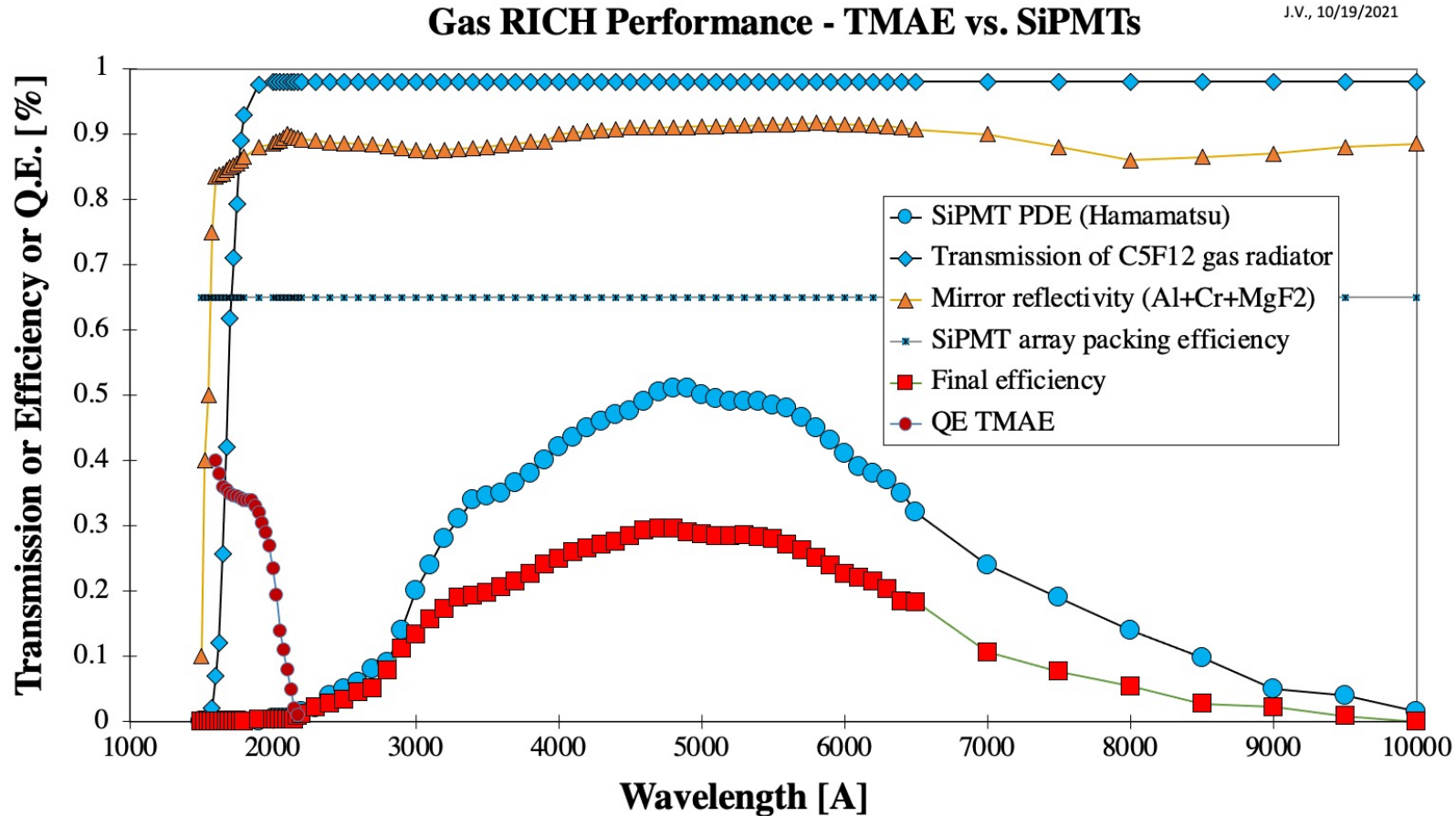
$$N_{pe} = 370 \text{ eV}^{-1} \text{ cm}^{-1} L \int \text{Eff}(E) [\sin(\theta_c(E))]^2 dE$$

$$\cos \theta_c(\lambda) = \frac{1}{n(\lambda) \beta} = \frac{1}{n(\lambda) \sqrt{(1 - 1/\gamma^2)}}$$

- **I am surprised that the performance is this good.** Much better performance than with TMAE in CRID TPC.
- A choice of C₄F₁₀ at 10°C with SiPMT readout is a possible solution even for 20-25 cm radial distance.

Why SiPMTs are so much better than TMAE ?

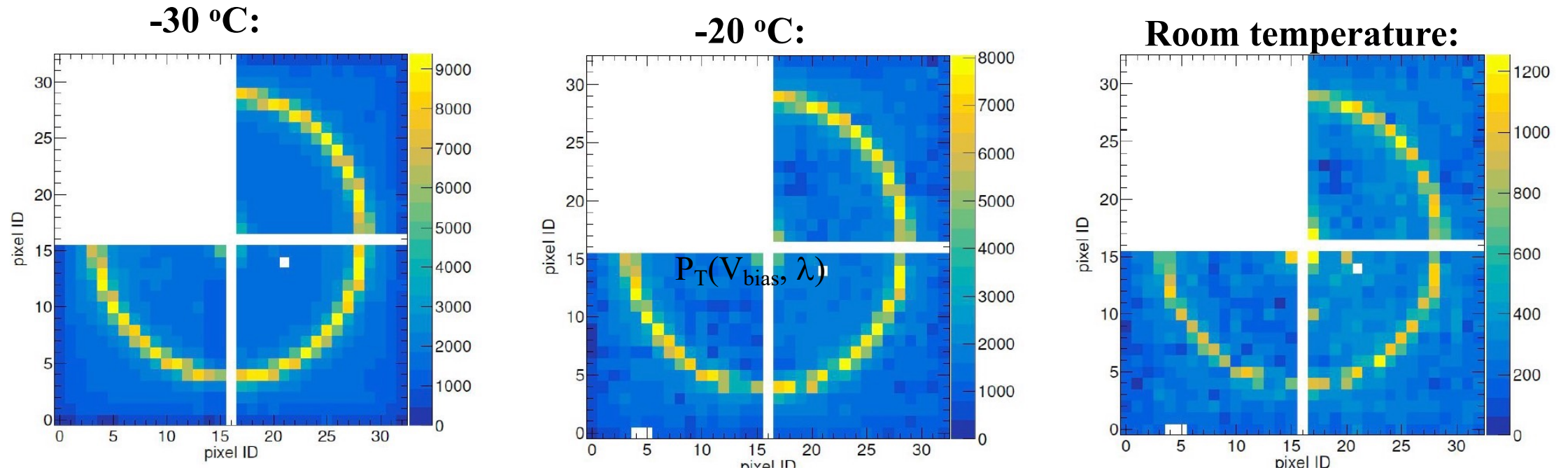
J. Va'vra



- QE of TMAE is much smaller than PDE of SiPMTs !

SiPMT noise = f(Temperature)

EIC mRICH, C.P. Wong et. al., NIM A 871, 13 (2017)



- Do not know what timing window they used to integrate SiPMT noise.
- **Question:** Can one tolerate SiPMT noise at 10°C with very tight TOF cut ?

Conclusion

- C_4F_{10} or C_5F_{12} gas choices give good result.
- However, they prevent running SiPMT at low temperature below 0°C .
- Can one reduce the SiPMT noise by applying a tight timing cut ?
- New Si detectors may solve this problem.