

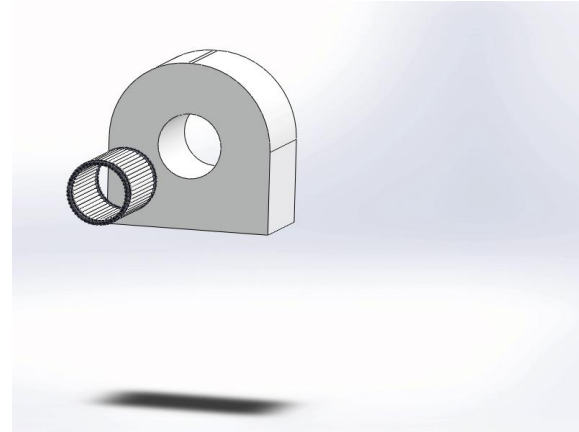
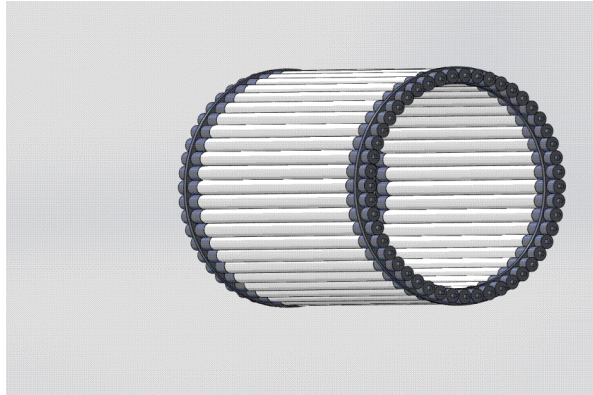


Novel plastic scintillators for the hybrid J-PET/MR tomograph

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2nd Jagiellonian Symposium
on Fundamental and Applied Subatomic Physics,
Kraków, June 4-9, 2017

HYBRID J-PET/MR TOMOGRAPH



More details were given in talk of Szymon Niedźwiecki, June 5th

Novel scintillators:

- better adjusted emission spectrum
- lower attenuation

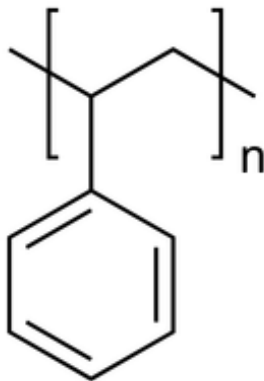
SCINTILLATORS FOR THE J-PET/MR SCANNER

- ✓ Emission spectrum
- ✓ Light attenuation
- ✓ Light output
- ✓ Rise and decay times

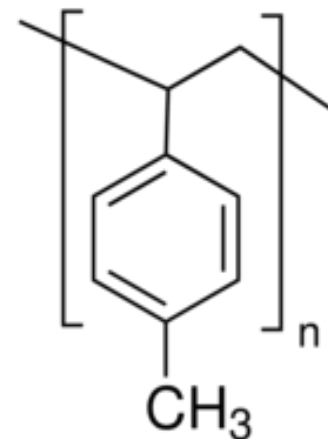
COMPONENTS OF PLASTIC SCINTILLATOR

- **POLYMERIC MATRIX**
- PRIMARY ADDITIVE
- SECONDARY ADDITIVE – WAVELENGTH SHIFTER

Polystyrene



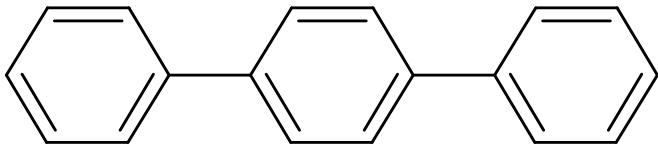
Polyvinyltoluene



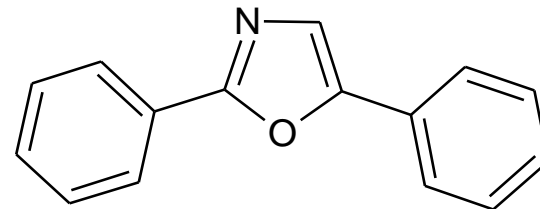
COMPONENTS OF PLASTIC SCINTILLATOR

- POLYMERIC MATRIX
- **PRIMARY ADDITIVE**
- SECONDARY ADDITIVE – WAVELENGTH SHIFTER

p-terphenyl (**PTP**)



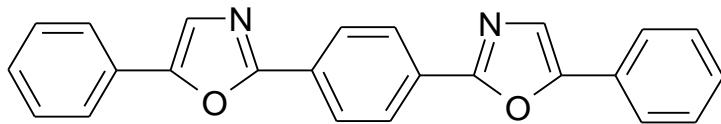
2,5-diphenyloxazole (**PPO**)



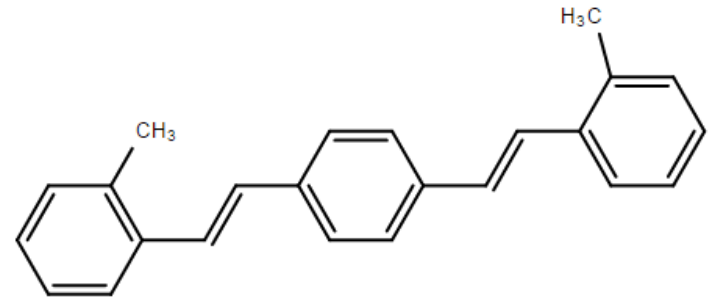
COMPONENTS OF PLASTIC SCINTILLATOR

- POLYMERIC MATRIX
- PRIMARY ADDITIVE
- **SECONDARY ADDITIVE – WAVELENGTH SHIFTER**

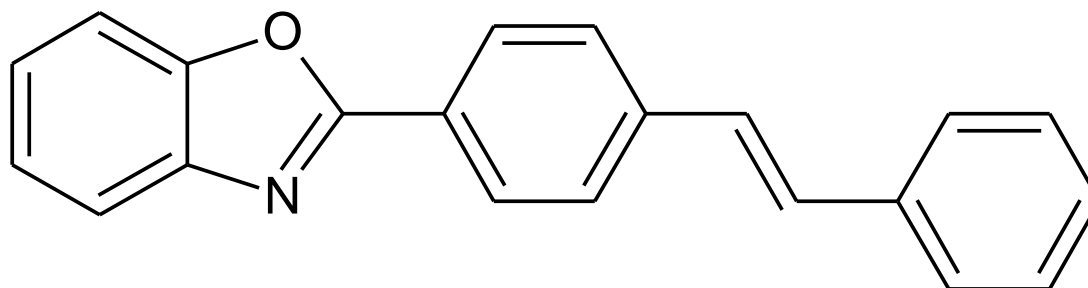
1,4-di(5-phenyl-oxazolo-2-yl)benzen (**POPOP**)



1,4-bis(2-methylstyryl)benzene (**Bis-MSB**)



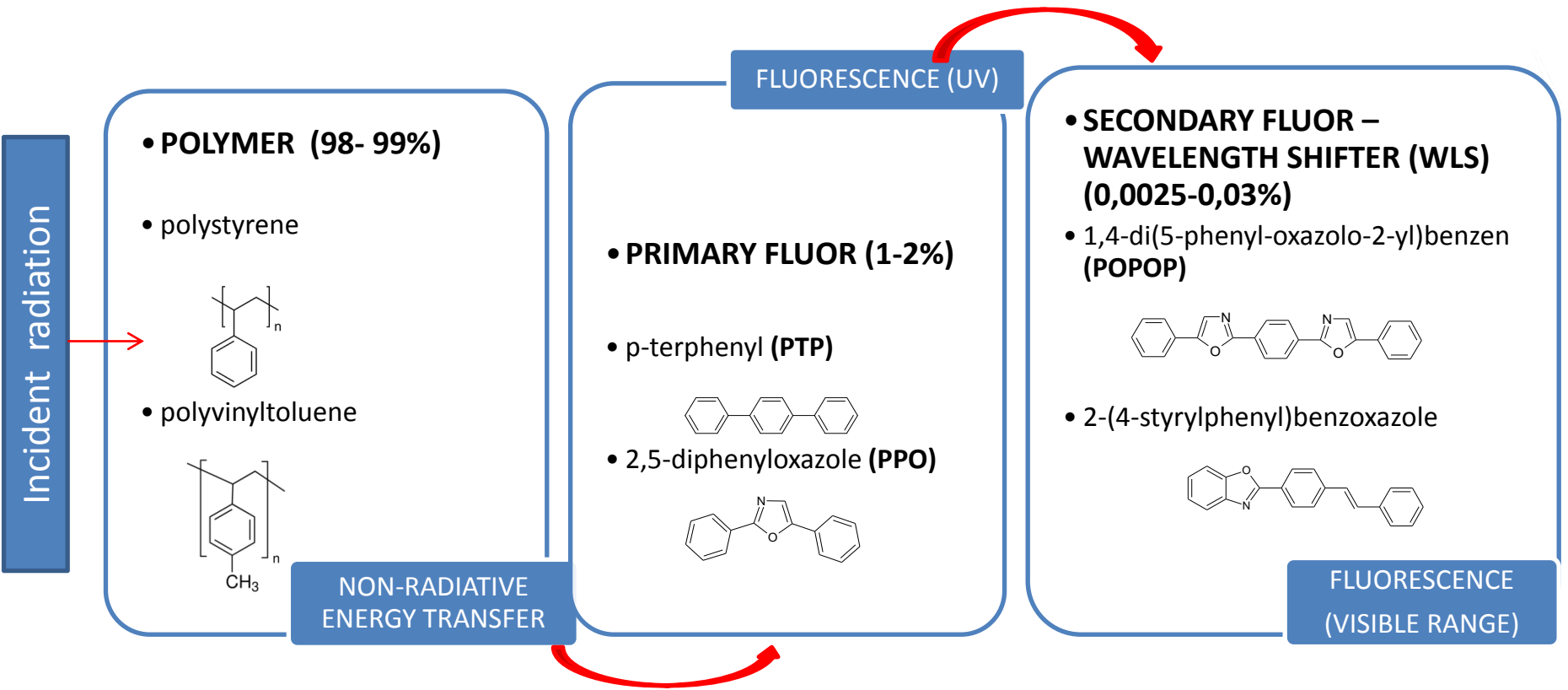
NOVEL WAVELENGTH SHIFTER IN J-PET SCINTILLATOR



2-(4-styrylphenyl)benzoxazole

International patent application: Use of 2-(4-styrylphenyl)benzoxazole and plastic scintillator, PCT/PL2015/050022, A. Wieczorek, A. Danel, T. Uchacz, P. Moskal

ENERGY TRANSFER IN PLASTIC SCINTILLATOR



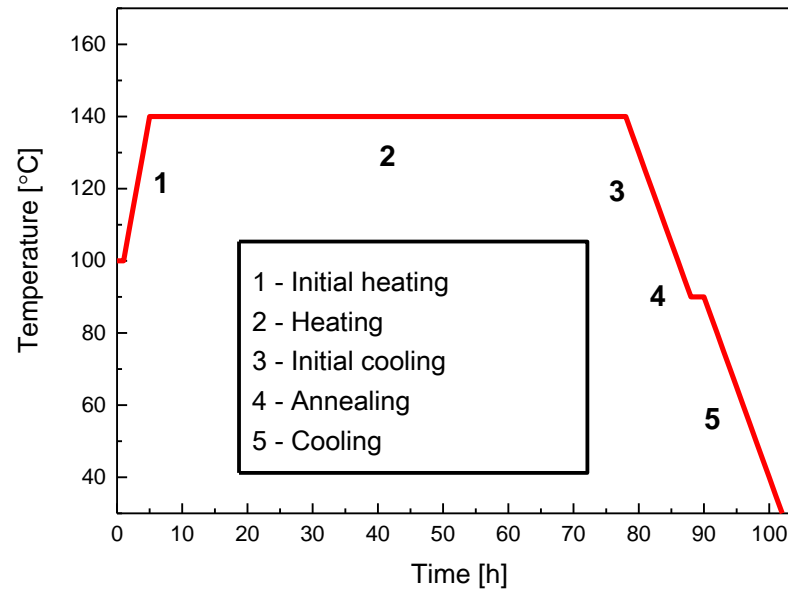
POLYMERIZATION OF SCINTILLATING MIXTURE

Bulk polymerization of vinyltoluene with dissolved scintillating additives

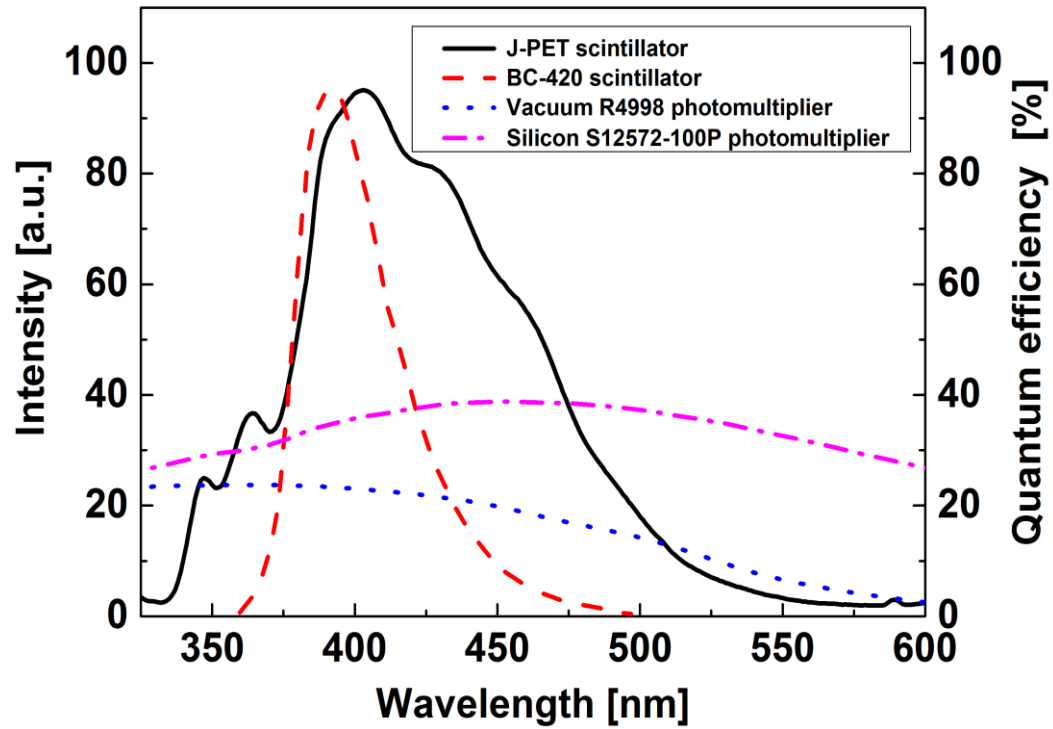
+ pure material

+ high degree of homogeneity

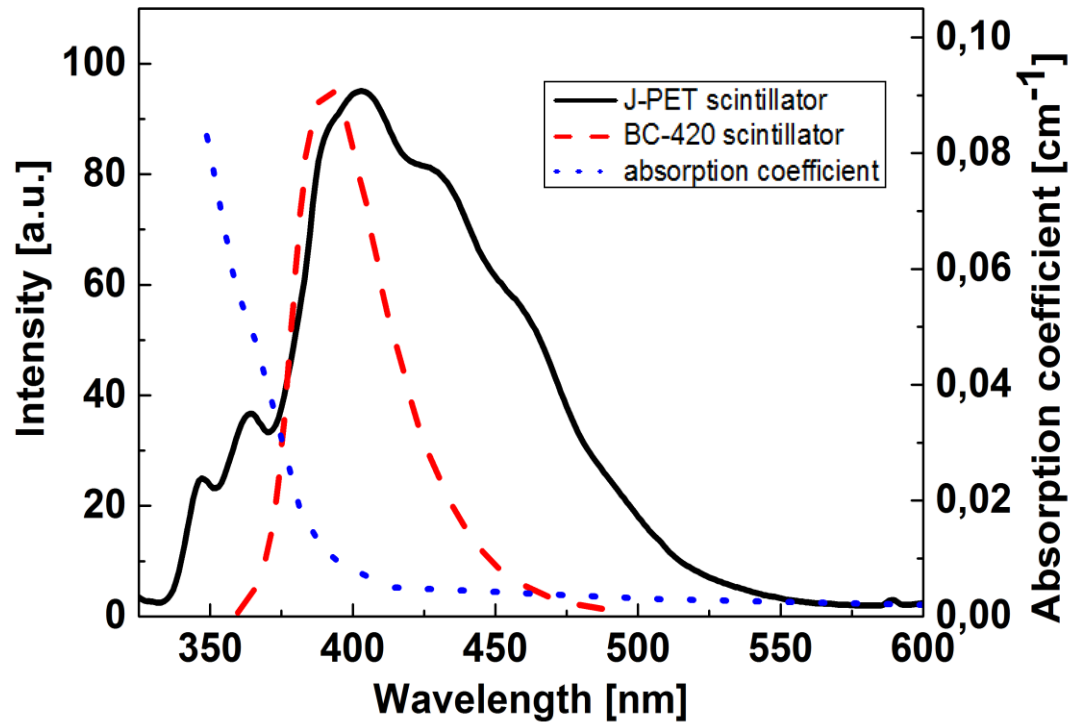
- Trommsdorff's effect: empty voids



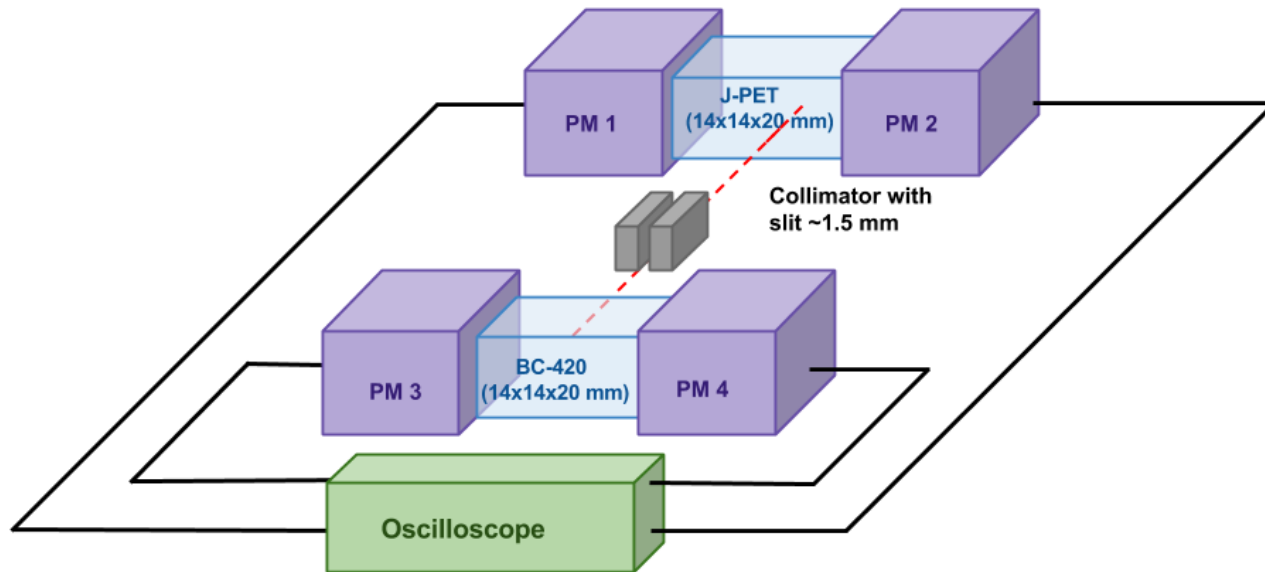
EMISSION SPECTRA



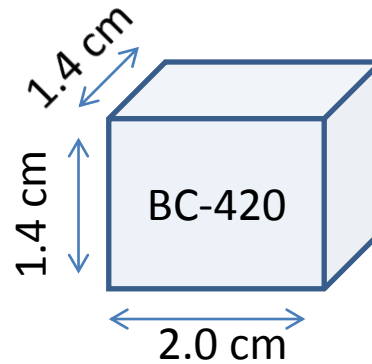
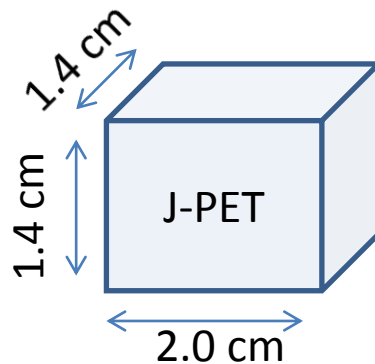
LIGHT ATTENUATION IN THE J-PET SCINTILLATOR



LIGHT OUTPUT OF THE J-PET SCINTILLATOR



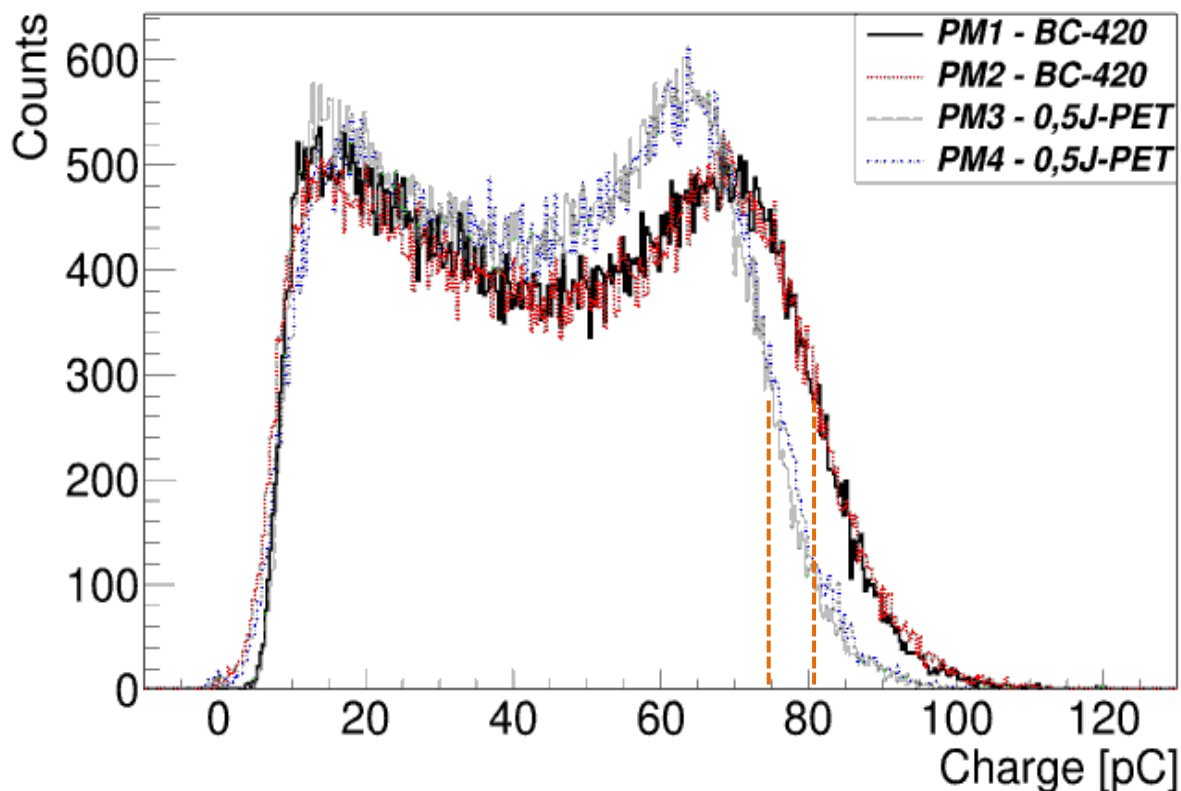
Scintillators
wrapped in
Vikuiti foil



LIGHT OUTPUT

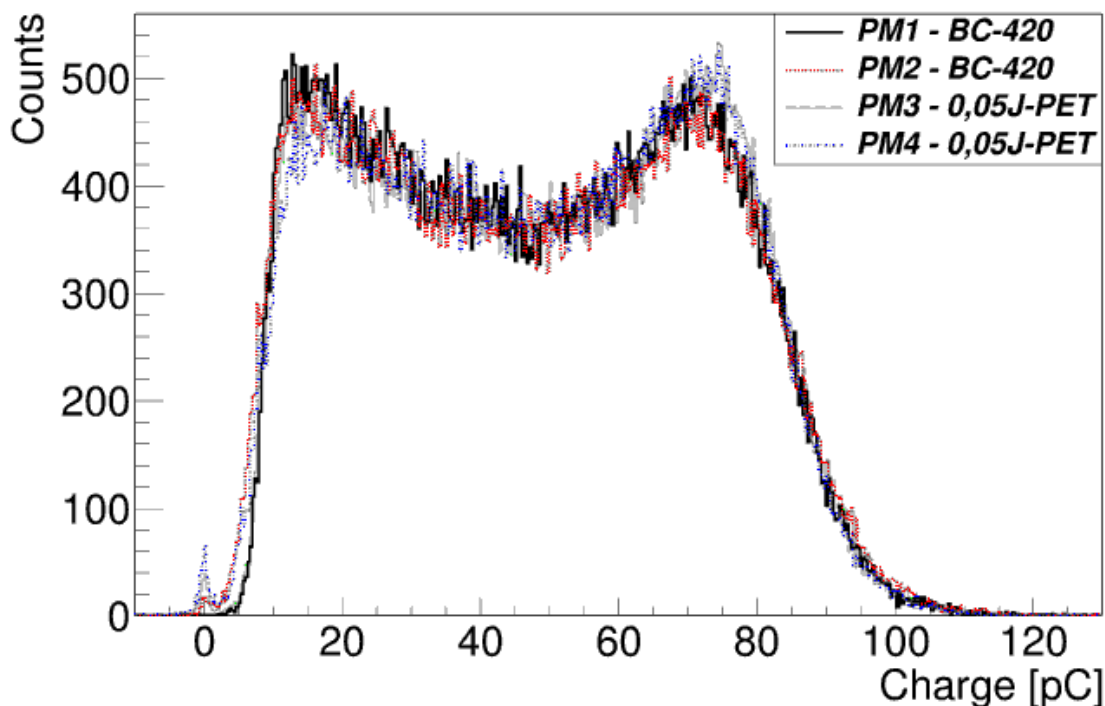
0.5J-PET=0.5‰ OF 2-(4-STYRYLPHENYL)BENZOXAZOLE

$$\text{LIGHT OUTPUT} = \frac{\text{NUMBER OF PHOTONS}}{\text{ENERGY DEPOSITED IN SCINTILLATOR}}$$



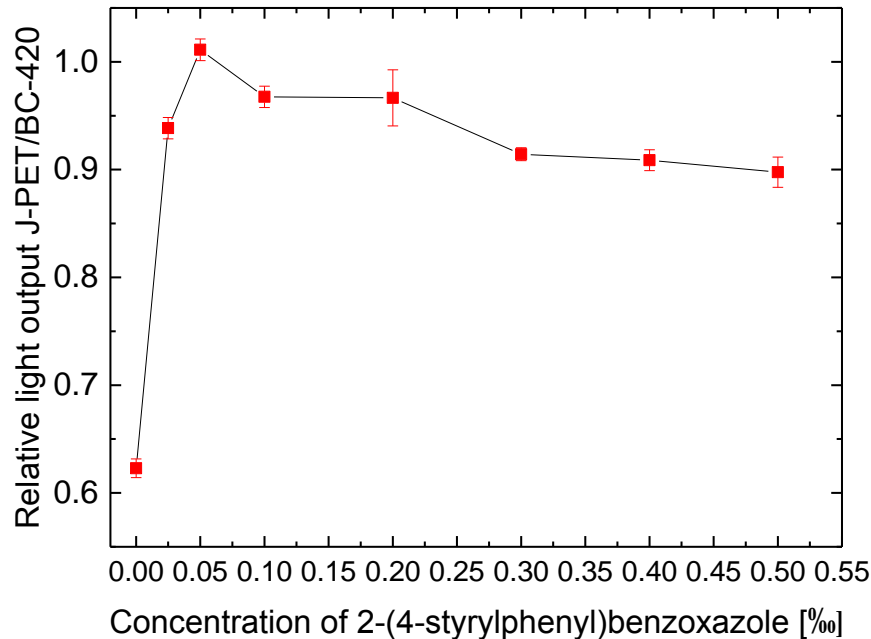
LIGHT OUTPUT

0.05J-PET=0.05‰ OF 2-(4-STYRYLPHENYL)BENZOXAZOLE



J-PET = BC-420 = 64% of anthracene light output

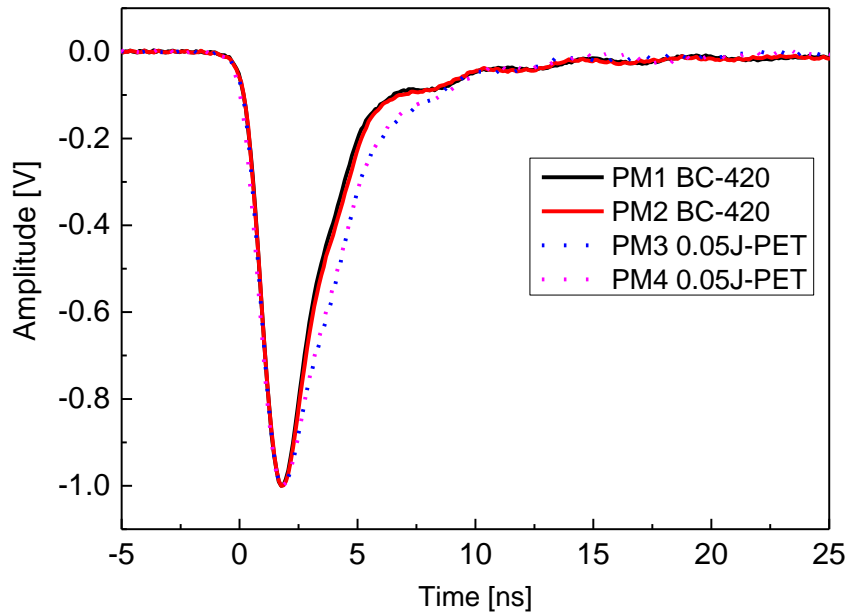
CONCENTRATION OF 2-(4-STYRYLPHENYL)BENZOXAZOLE IN THE J-PET SCINTILLATOR



Optimal
composition of 2 cm
long J-PET
scintillator

Polymeric base	Primary additive	Novel wavelength shifter
~ 98 %	2 %	0.05 ‰

RISE AND DECAY TIMES OF LIGHT PULSES IN THE J-PET SCINTILLATOR



RISE TIME

J-PET t_{10-90} : 0.5 ns

BC-420 t_{10-90} : 0.5 ns

DECAY TIME

$$i(t) = f_G(t) * (e^{-t/\tau} - e^{-t/\tau_1})$$

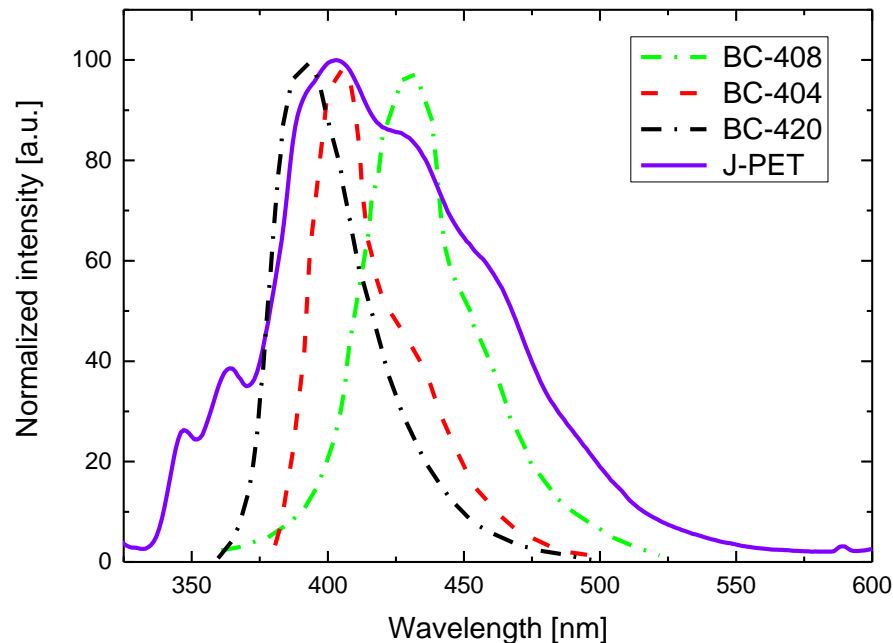
J-PET: 1.91 ns

BC-420: 1.49 ns

(1.5 ns declared by Saint Gobain)

J-PET vs commercial scintillators

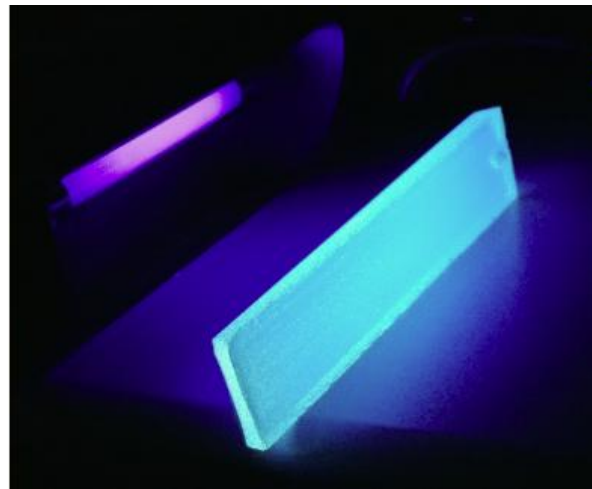
PROPERTIES	J-PET	BC-420	BC-404	BC-408
Light output, [% of Anthracene]	64	64	68	64
Rise time [ns]	0.5	0.5	0.7	0.9
Decay time [ns]	1.9	1.5	1.8	2.1
Maximum of emission wavelength [nm]	404	391	408	425



J-PET SCINTILLATORS OF LARGE SIZES

Technology under development:

- Conditions of polymerization
- Optimization of wavelenth shifter concentration

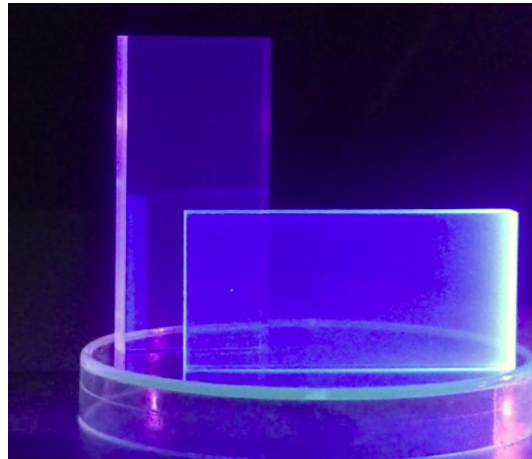


18 cm long J-PET plastic scintillator

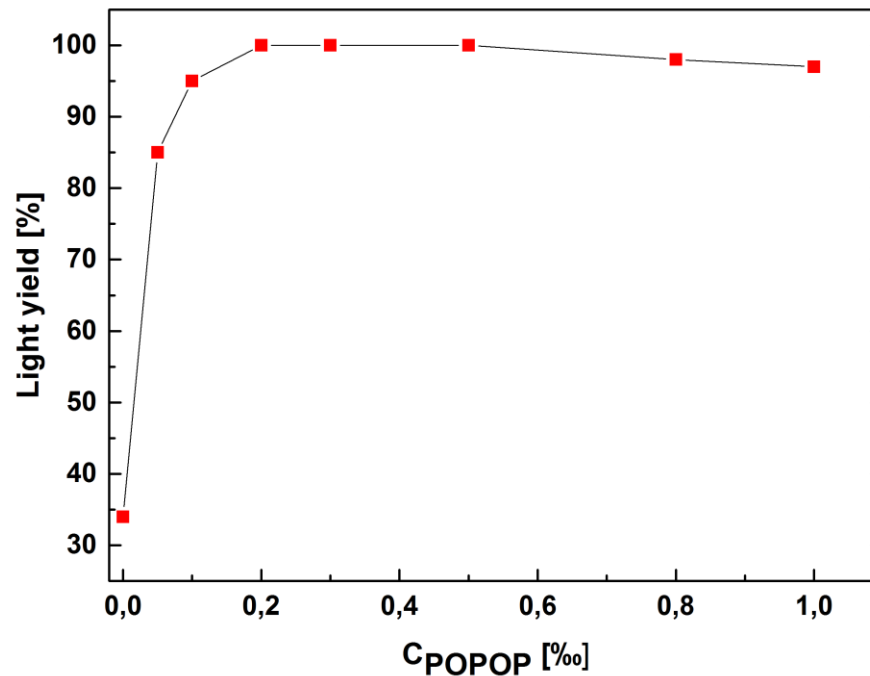
CONCLUSIONS

- ✓ J-PET scintillator is adjusted to J-PET/MR scanner
- ✓ New wavelength shifter provides weaker absorption of light in scintillating material
- ✓ Light output of J-PET scintillator is comparable to light output of commercial scintillators
- ✓ Timing properties of J-PET scintillators are comparable with corresponding properties of commercial scintillators

THANK YOU FOR YOUR ATTENTION!



CONCENTRATION OF COMMERCIAL WAVELENGTH SHIFTER: POPOP IN PLASTIC SCINTILLATOR



A.F. Adurov et al., Nuclear Instruments and Methods in Physics Research A 599 (2009) 167