Randoms Correction Techniques on the Gen II System

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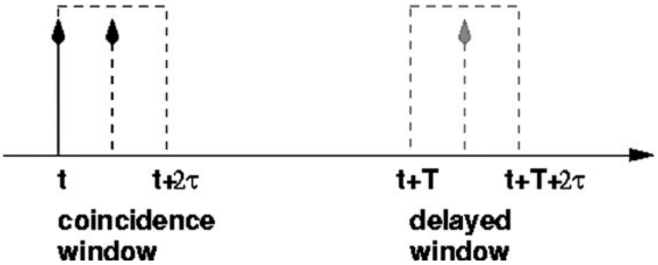
Randoms Correction

- How many of the coincidences measured on a certain LOR are 'random coincidences?'
- We use this information to advise image reconstruction.

Methods

- Delayed-Window (DW)
- Singles-Rate (SR)
- Singles-Prompts (SP) - 2016, new to our group
- Singles-Prompts with Multiple Coincidence Correction - new

Delayed-Window (DW)



- Every time you open a prompt window, also open a delayed window.
- A count in the DW = random coincidence on that LOR.
- Currently implemented on hardware.

Singles-Rate (SR)

$$R_{ij} = 2\tau S_i S_j$$

coincidence window

singles in crystal i

singles in crystal j

- Estimates random coincidences from # singles counts.
- Requires singles acquisition.

Singles-Prompts (SP)

prompts in crystal i

$$R_{ij}^{SP} = \frac{2\tau e^{-(\lambda+S)\tau}}{(1-2\lambda\tau)^2}\left(S_i - e^{(\lambda+S)\tau}P_i\right)\left(S_j - e^{(\lambda+S)\tau}P_j\right)$$

Solution to $2\tau\lambda^2 - \lambda + S - Pe^{(\lambda+S)\tau}$

- Estimates random coincidences from # singles counts *and* prompts counts.
- Requires singles acquisition.
- Incorporates prompt information for improved accuracy (second order).

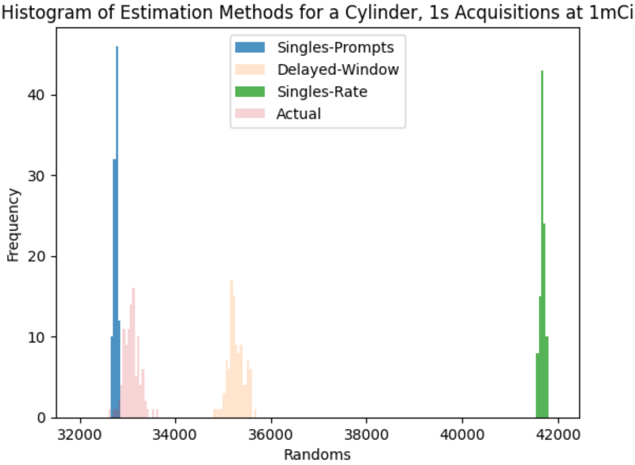
Singles-Prompts Extension

sum over all crystals k

$$R_{ij} = R_{ij}^{SP} \cdot \frac{\prod_k e^{-S_k \tau^2 / T}}{e^{-S_i \tau^2 / T} e^{-S_j \tau^2 / T}}$$

- Note: typically a "downwards" correction.

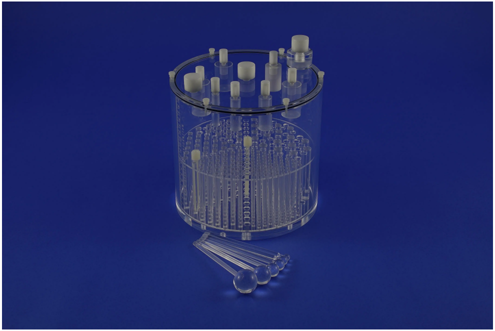
Cylindrical Simulated Source - Sum over Crystals



Cylindrical Source - SP Extension

- SP nearly always underestimates R_{ij}, downcorrection unhelpful.
- Downcorrection was extremely small $\approx 10^{-4}$.
- Not worth using?

Flangeless Esser PET Phantom



- $48\mu Ci$ over fillable capsules
- $1.5mCi$ in large volume

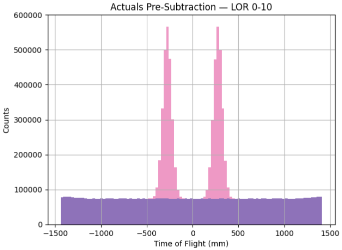
Methods for Removing Randoms

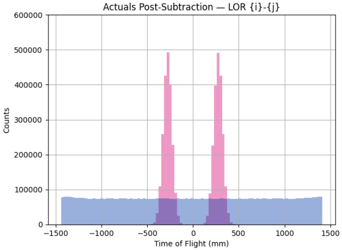
1. Subtraction Method: Remove coincidences on same LOR closest to TOF
2. Contamination List: $\frac{\text{num of randoms on LOR}}{\text{num of prompts on LOR}}$

(1) is compatable with CUDA Recon (current model), (2) requires parallelproj.

Note: for subtraction with SP, we assume a uniform distribution across TOF.

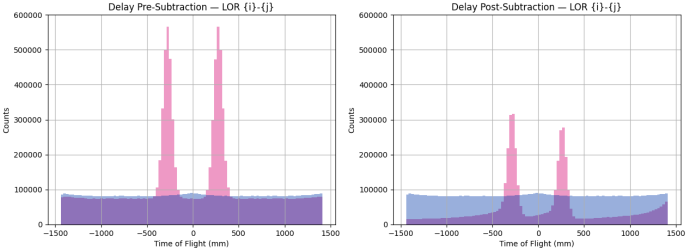
Annulus: ‘True’ Subtraction (Sampled LOR 0-10)





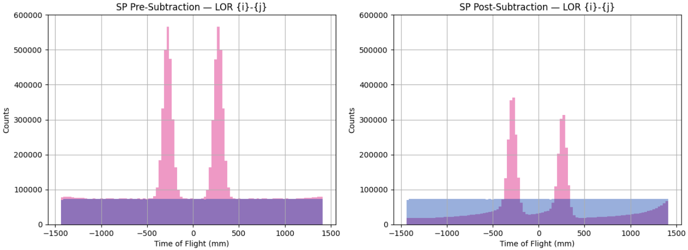
- Pink: coincidences
- Blue: estimated random coincidences

Annulus: DW Subtraction



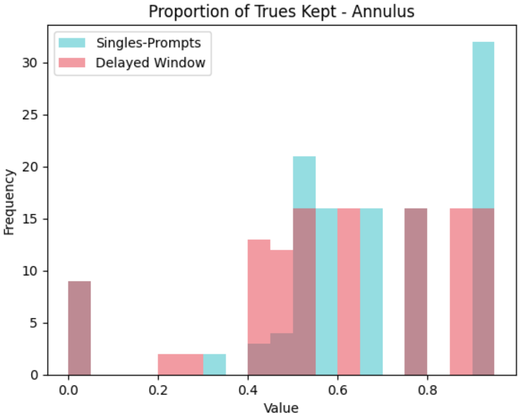
- Pink: coincidences
- Blue: estimated random coincidences

Annulus: SP Subtraction



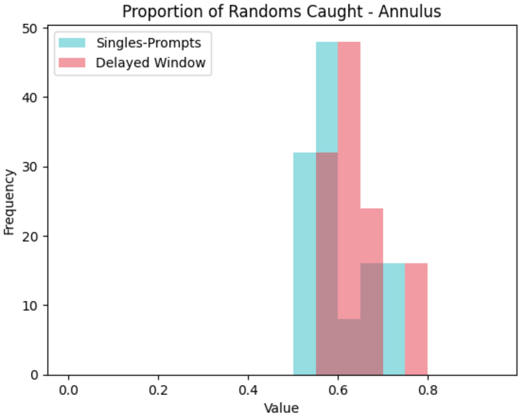
- Pink: coincidences
- Blue: estimated random coincidences

Annulus: Trues Kept



Mean: 0.645 (SP), 0.602 (DW)

Annulus: Randoms Caught



Mean: 0.604 (SP), 0.641 (DW)

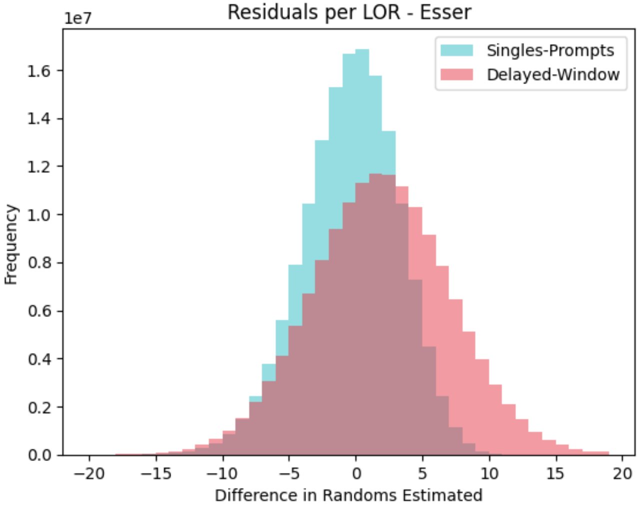
Subtraction - Esser Phantom

Mean values:

	SP	DW
Trues Kept	88.1%	86.5%
Randoms Caught	52.0%	50.8%

Marginal improvement.

Contamination Analysis - Esser Phantom



Contamination Analysis - Esser Phantom

	SP	DW
Mean	-0.33	1.43
STDev	3.57	5.18

Key Findings

- SP and DW methods have similar performances when using our current subtraction method (SP marginally better).
- With the use of the contamination list method, SP has a slight advantage.

Next Steps

- Reconstruct the relevant images with both methods, need to ensure parallelproj works properly.
- Calculate SNR, other stats from those images to see if the difference using contamination list is worth collecting singles.

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