

Genuine λ -spectrum, Simulations, Pinholes, TOF spectra, Dead Time, and η -fit comparisons

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Pinholes.

What is genuine λ -spectrum to be used in simulations?

Pinhole data in November 2020 run

In Mike Kline study



Smallest pinhole
Back of magnet

Background →
Smallest pinhole
Front of magnet

2nd smallest pinhole
Front of magnet

Preferred by Mike

Run #	B, T	Title	Sequence ID	Start Time	Duration	Counts
37064		pinhole downstream no endcap on B4C tube	37055	2020/11/20 15:49:16 EST	0:21:25	1.08E+06
37063		pinhole downstream no endcap on B4C tube	37055	2020/11/20 15:22:38 EST	0:21:44	1.23E+06
37062		pinhole bkgd no endcap on B4C tube	37055	2020/11/20 14:53:48 EST	0:21:51	9.06E+05
37061		Smallest pinhole no endcap on B4C tube few mm beam right	37055	2020/11/20 14:28:34 EST	0:20:13	1.24E+06
37060		Smallest pinhole no endcap on B4C tube 4mm lower	37055	2020/11/20 14:04:01 EST	0:18:27	1.61E+06
37059		Smallest pinhole no endcap on B4C tube	37055	2020/11/20 13:39:37 EST	0:19:22	9.61E+05

- Pinhole peak region of detector PHR: $135 < X < 183$, $101 < Y < 152$
- All files have double peak in Y (37064 has second peak in X)
- 37060 is best, it has

-> smallest rms : $\sigma_x = 6.98 \text{ pix}$ $\sigma_y = 7.40 \text{ pix}$ in PHR

-> largest statistics

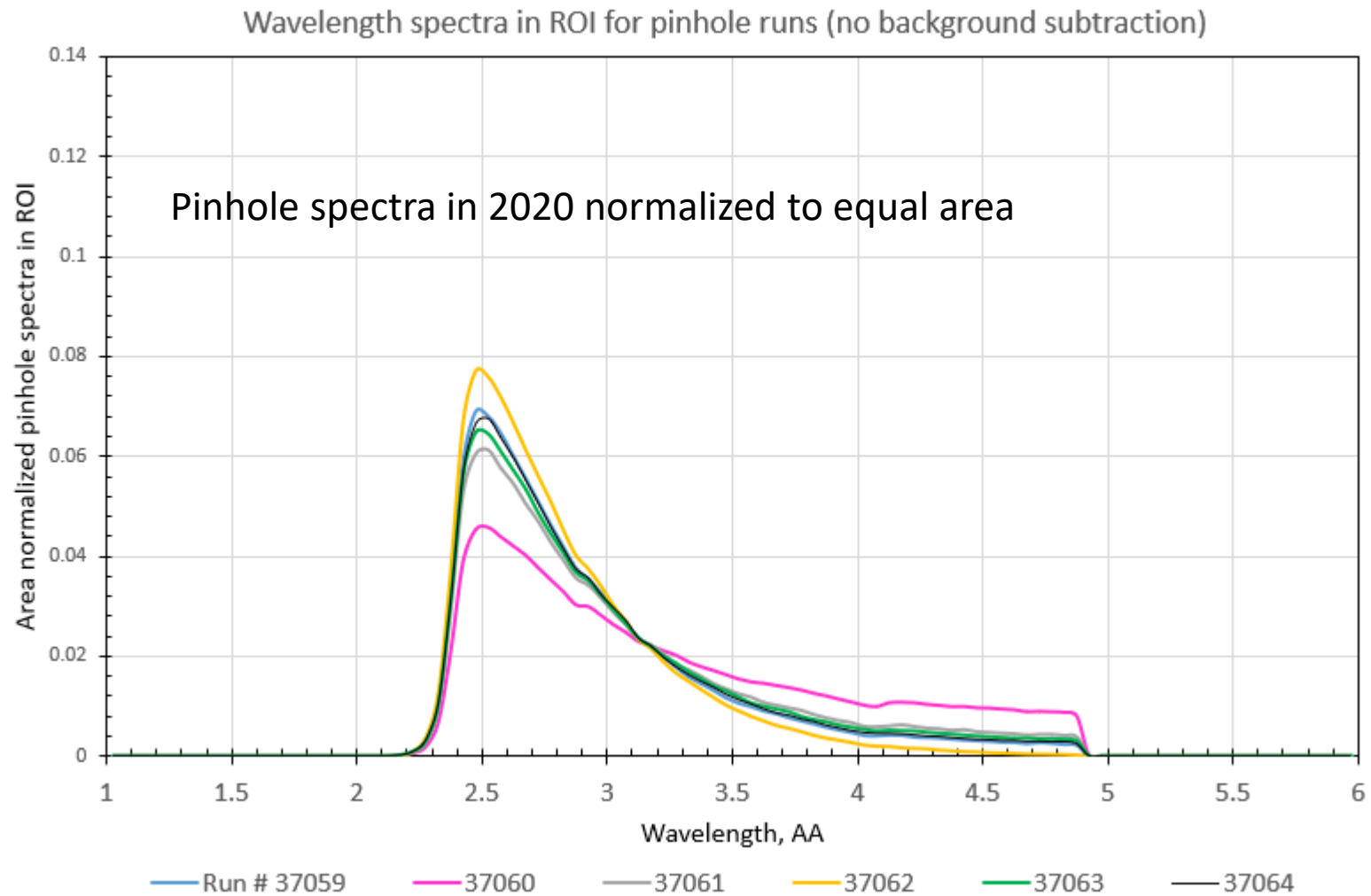
Pinhole runs in July 2019 at SNS power 1.05 MW

Run #	B, T	Title	Start Time	Duration	Counts	Wavelength
32483		10x10 8x6 no attenuator itty bitty pinhole 11Ang	2019/07/30 21:26:58 EDT	0:05:48	1.56E+03	11
32482		10x10 8x6 no attenuator itty bitty pinhole 8Ang	2019/07/30 21:15:37 EDT	0:08:43	1.02E+04	8
32481		10x10 8x6 no attenuator itty bitty pinhole 3.75Ang	2019/07/30 21:12:50 EDT	0:01:13	3.48E+04	3.75
32480		10x10 8x6 no attenuator itty bitty pinhole	2019/07/30 21:11:15 EDT	0:00:38	2.53E+04	3.25

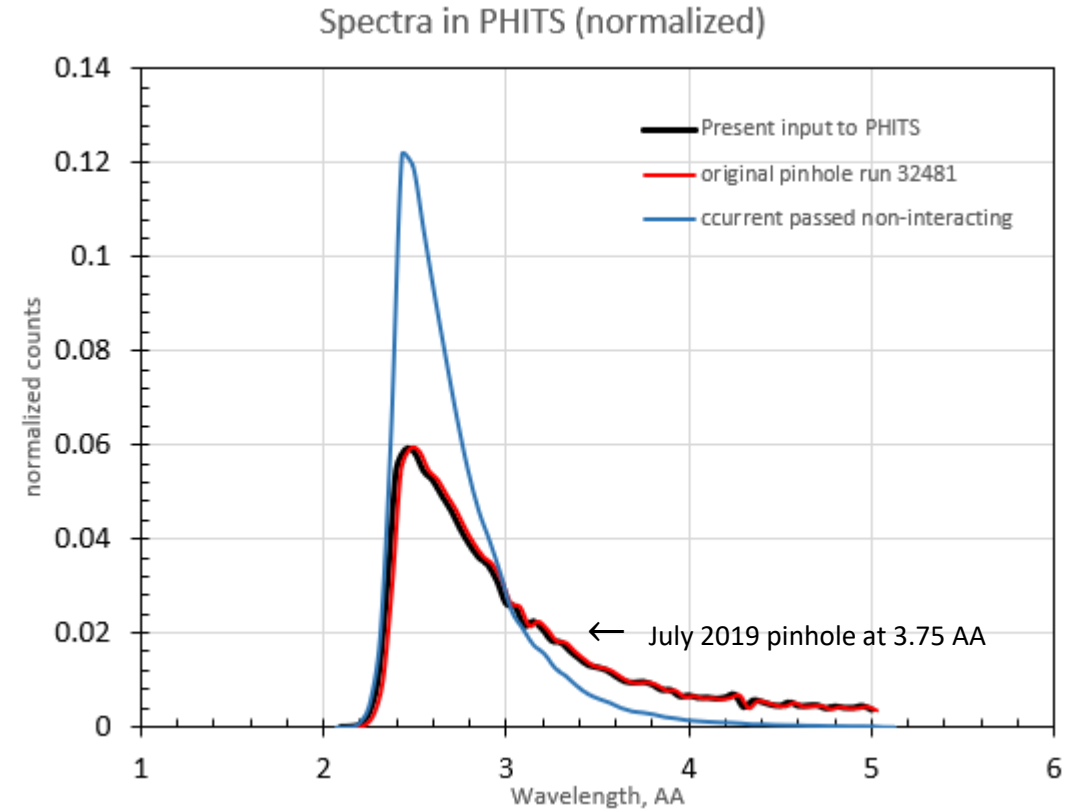
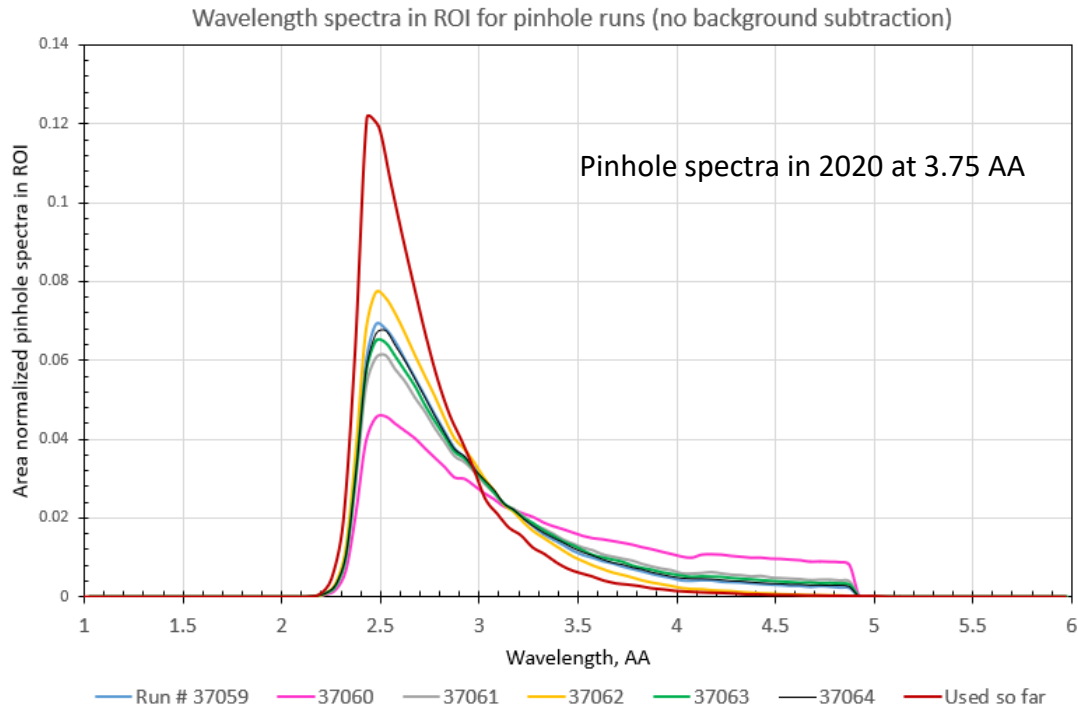


Smallest pinhole installed at sample position
 No Poly attenuators
 $S3 = 8 \times 6$ $S1 = 10 \times 10$ $\lambda = 3.25 \text{ \AA}$
 Run = 32480 $\sim 25k$ counts

Which pinhole spectrum from 2020 runs can be used for the simulations as a genuine spectrum?



Red spectrum is what is passing 18 pc plates
In high-stat simulations without interaction

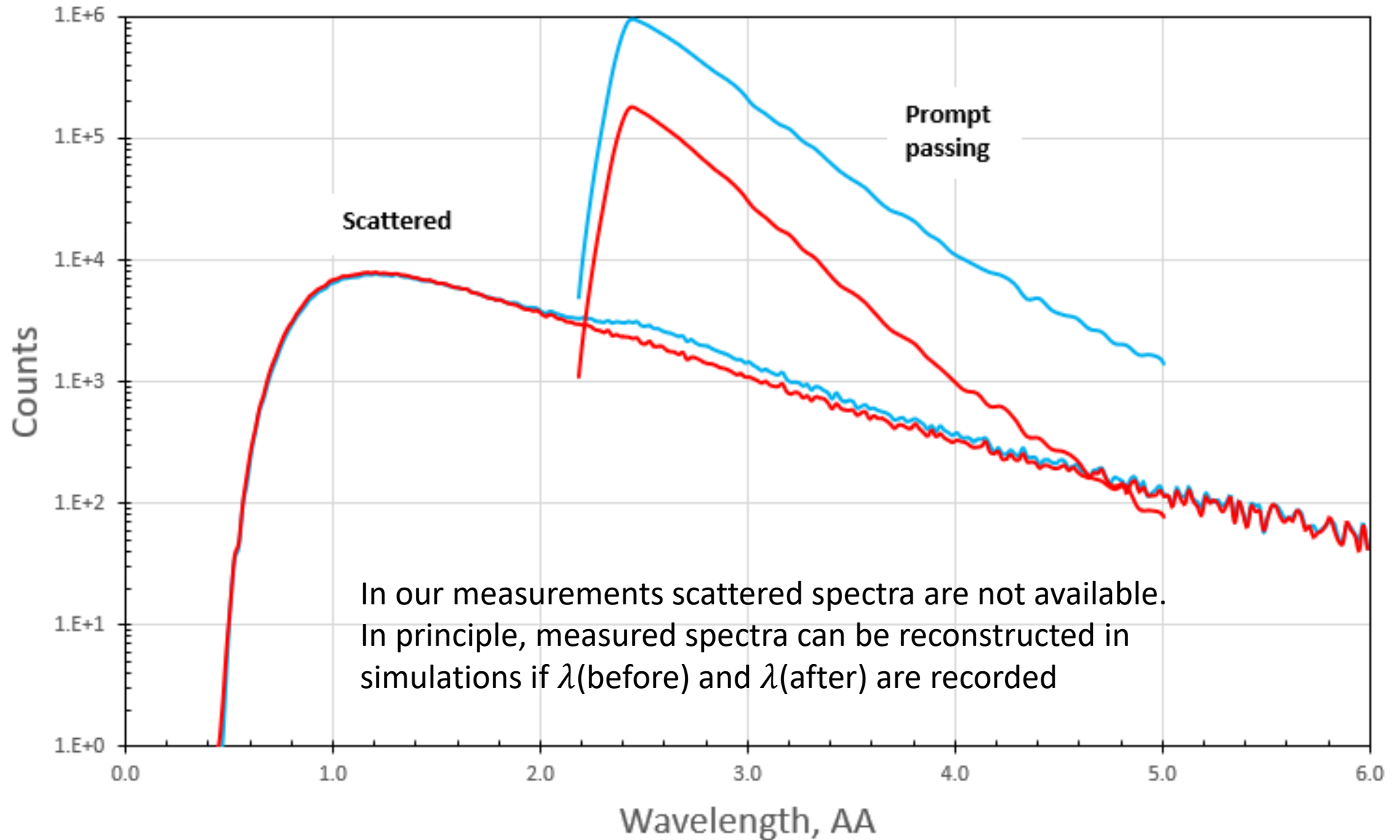


There is something wrong with spectrum of non-scattered in simulations: it doesn't coincide with the pinhole 2019 spectrum at simulation input.

More problems are revealed in simulations.

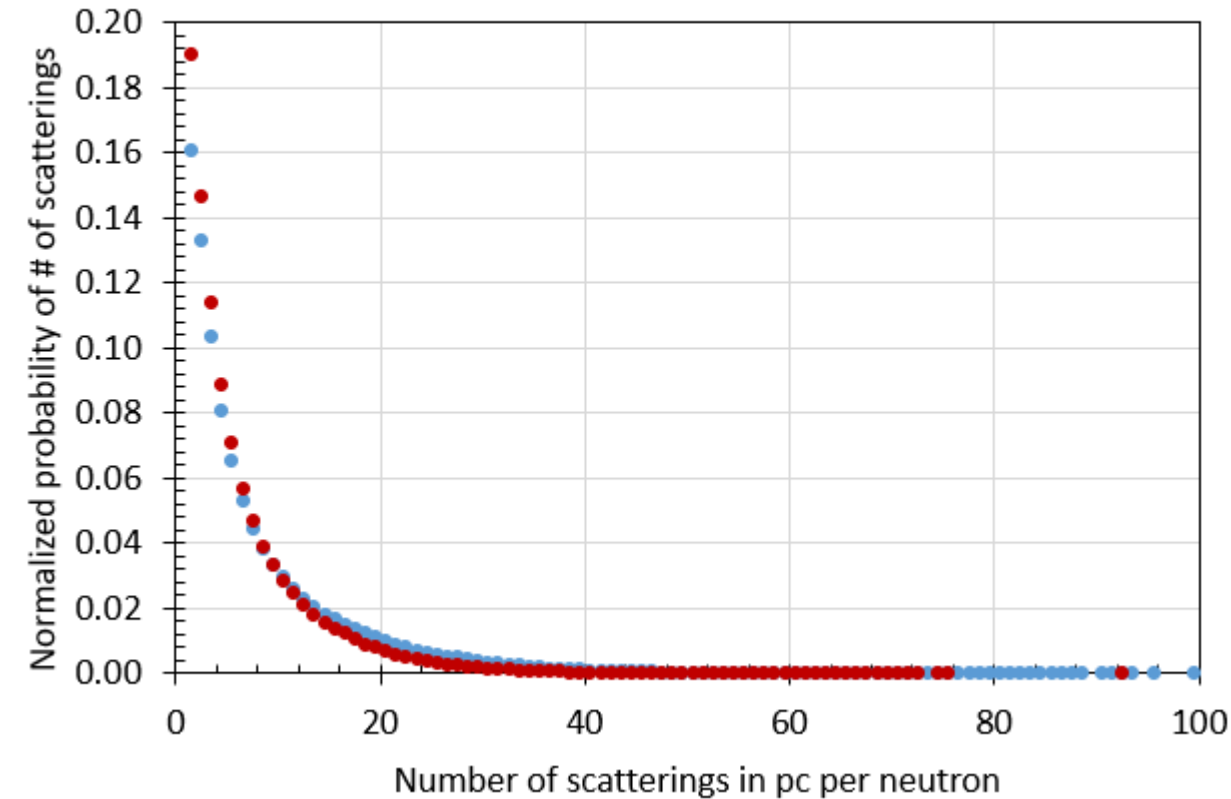
Simulations
L.H. Dec 2022

Wavelength spectra passed and scattered for 18pc and 24pc

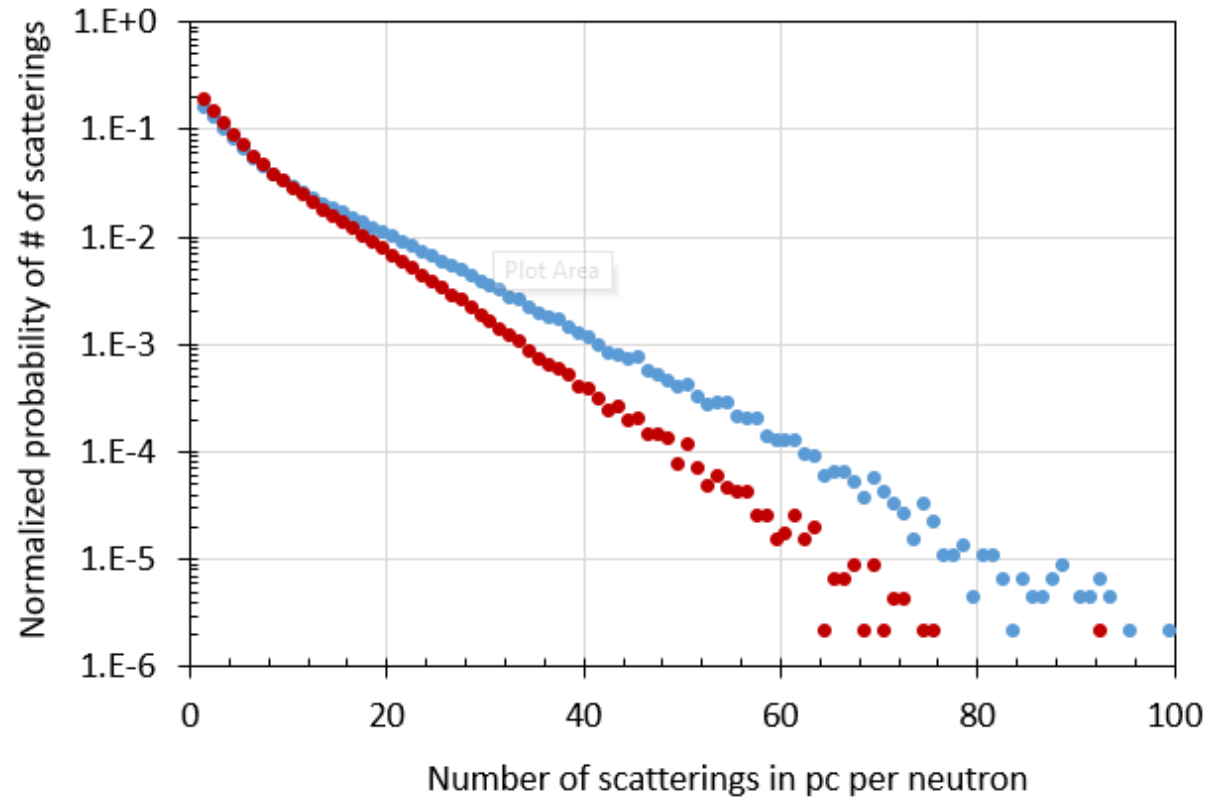


For initial $1.0E+10$ neutrons in high-stat simulations there are 458,585 (18 pc) and 449,646 (24 pc) scattered neutrons that hit the detector

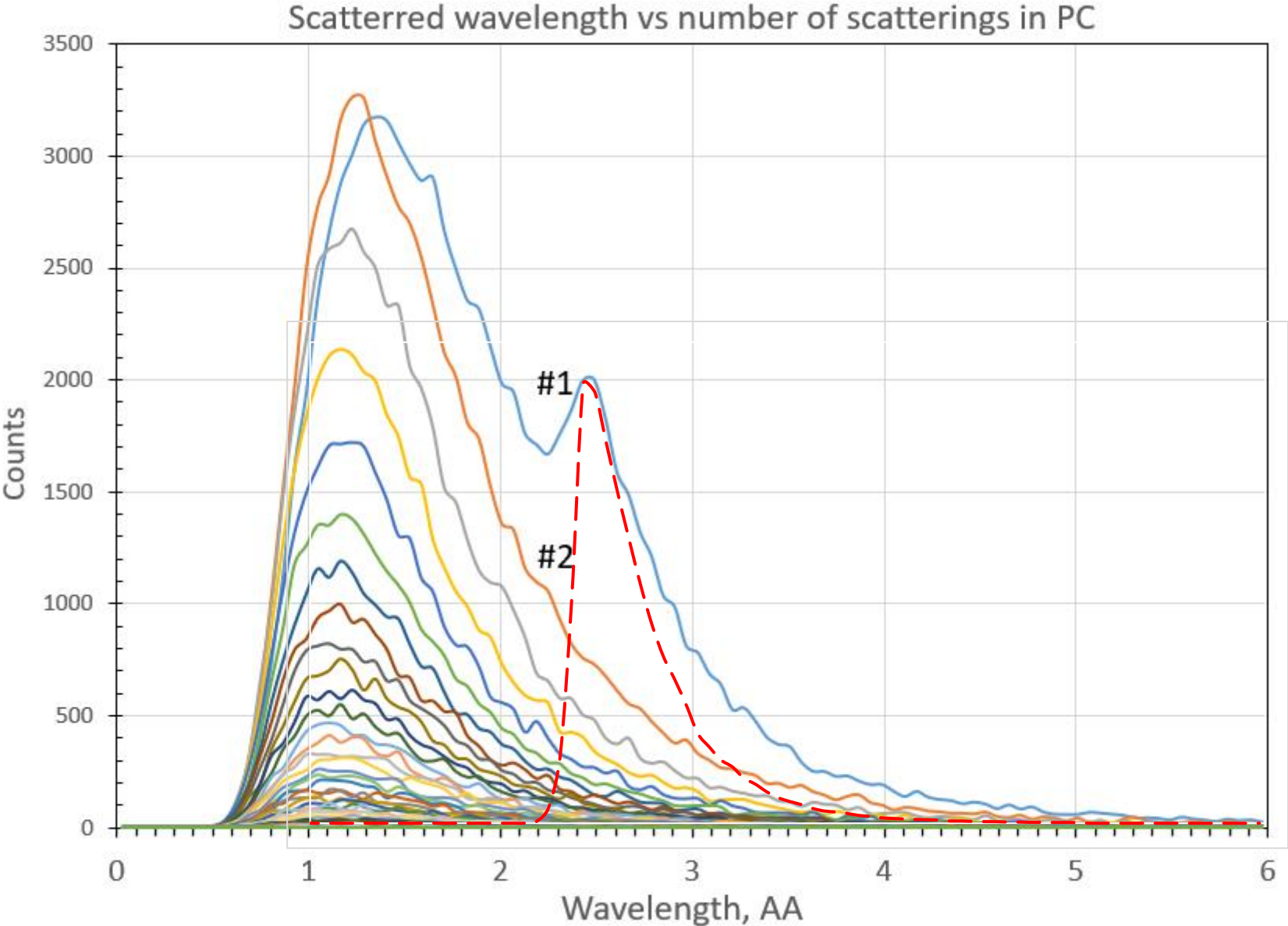
Number of scatterings in 18 and 24 pc stacks for scattered n hitting the detector



Number of scatterings in 18 and 24 pc stacks for scattered n hitting the detector

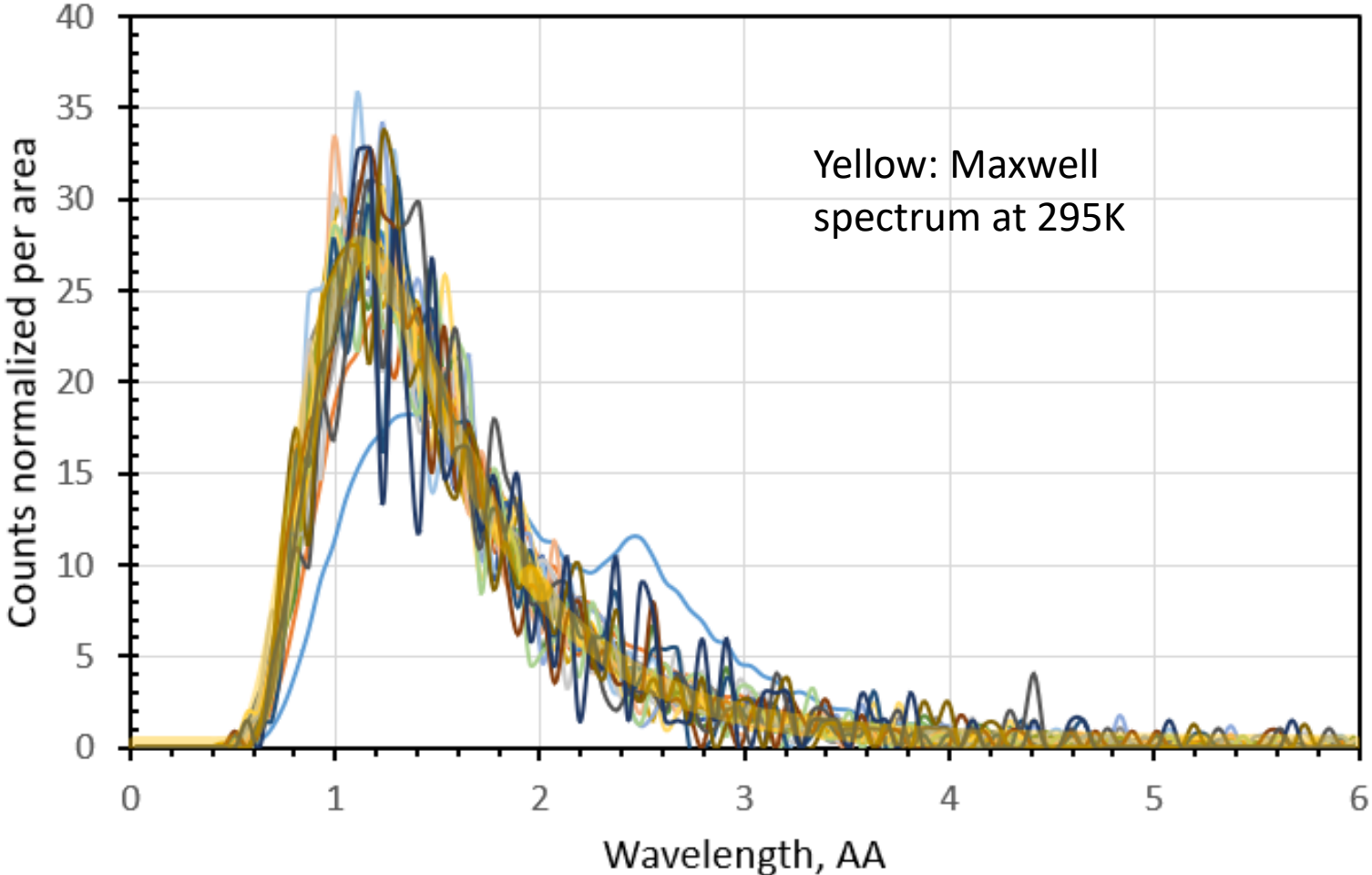


Simulations
L.H. Dec 2022

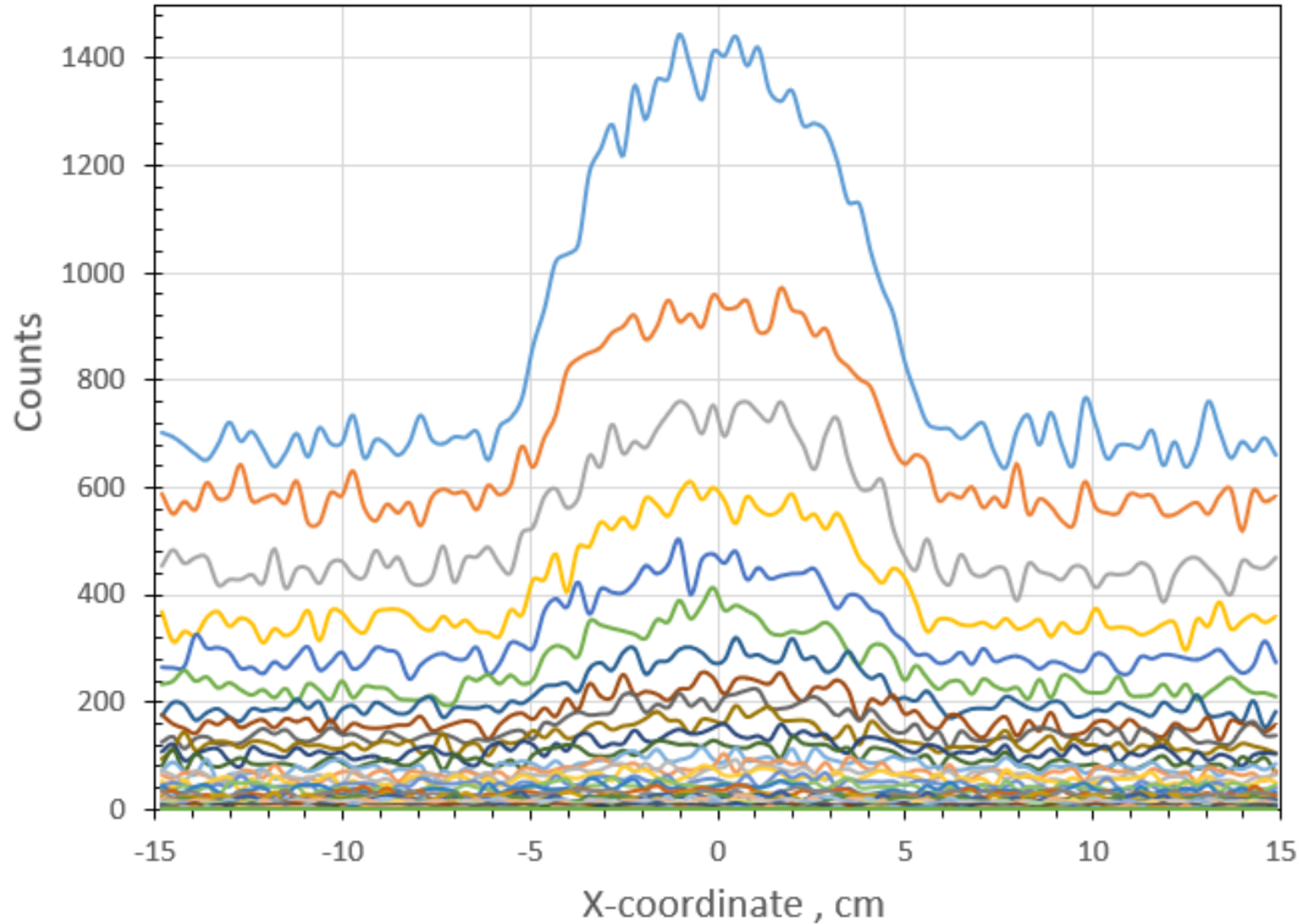


Simulations
L.H. Dec 2022

Wavelength for number of interactions ≤ 35 , normalized



X-distribution for # od scatterings in PC



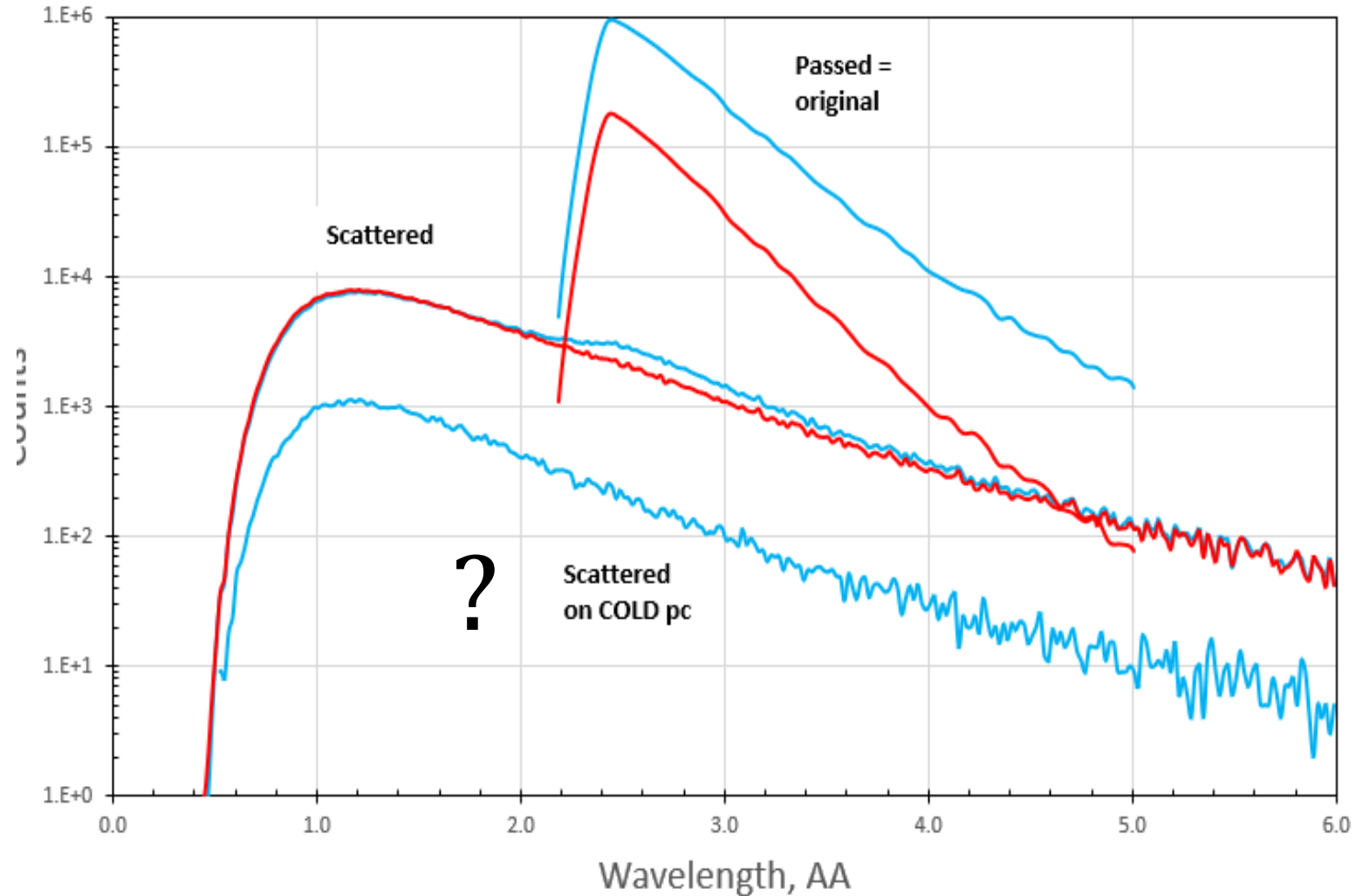
RMS of central bump in simulations
 $\sigma_x = \sigma_y = 30 \text{ mm} \approx 43 \text{ pix}$
It is the same for all PCs 18-24

In data-fit RMS is smaller
 $\sigma_x \cong 30 \text{ pix} \approx 21 \text{ mm}$
 $\sigma_y > \sigma_x$
Constancy of both σ_x, σ_y
is used by Cary as a constraint in
the data-fit together with
constant parameter $k = \sigma_y / \sigma_x$

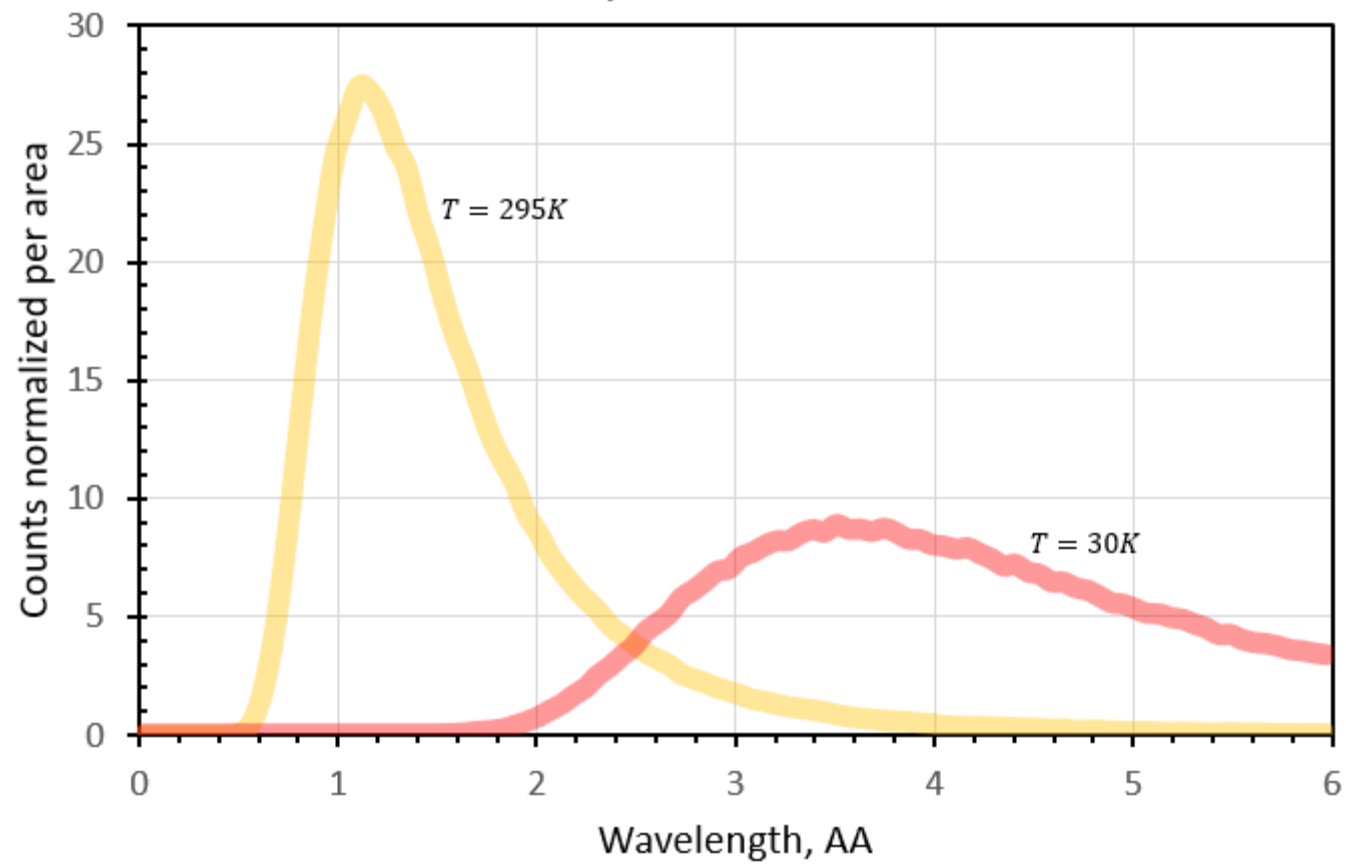
Problem with COLD PC simulations

Simulations
L.H. Dec 2022
and COLD
Sept 2022

Wavelength spectra passed and scattered
for 18pc and 24pc

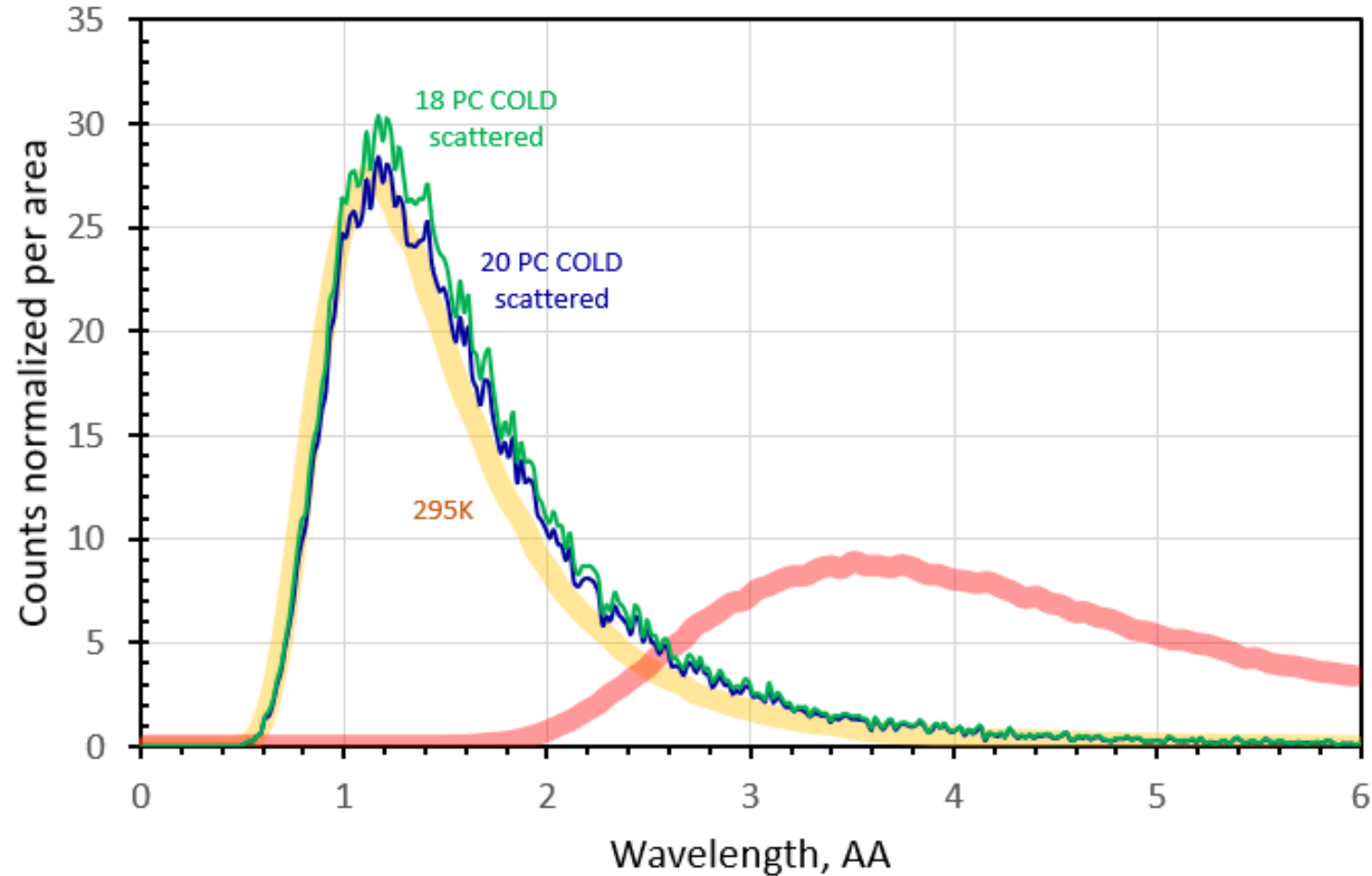


Maxwellian beam spectra at different temperatures



Simulations
L.H. COLD
Sept 2022

Maxwellian beam spectra at different temperatures



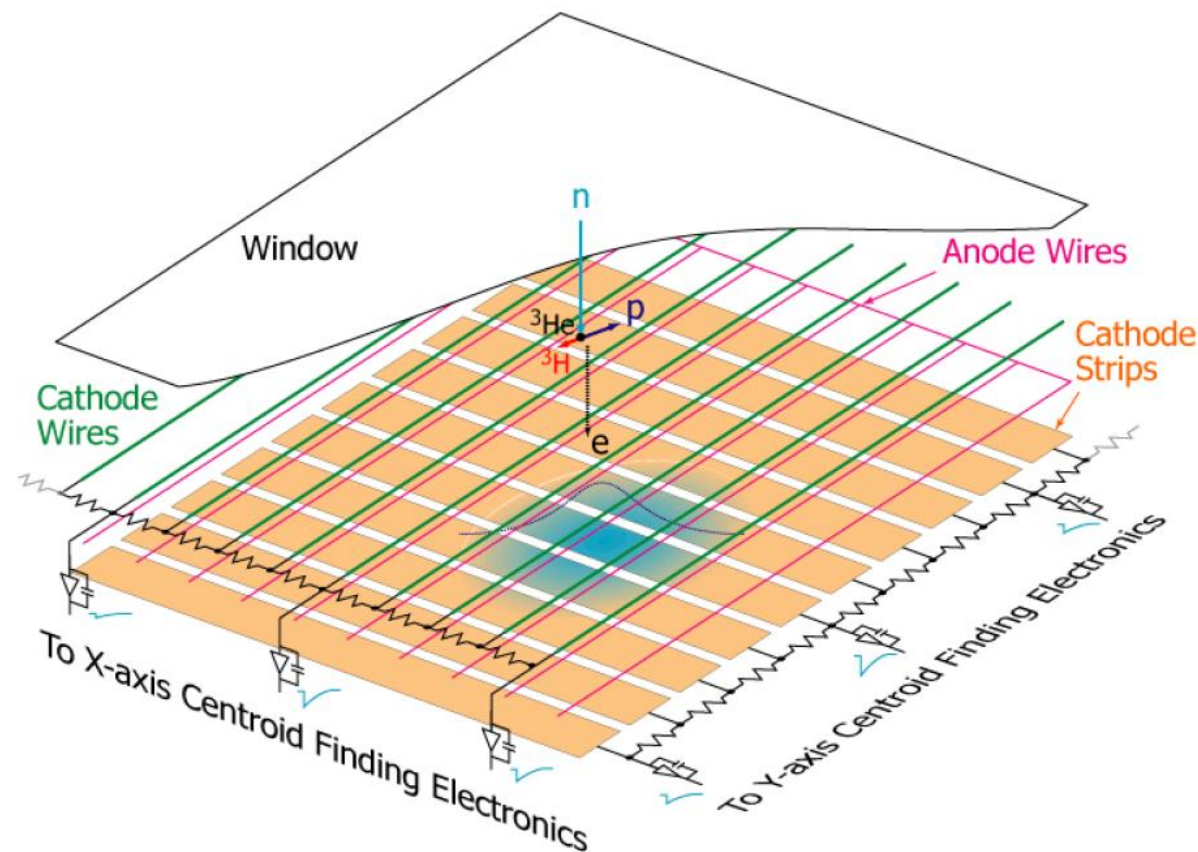
Lawrence is looking for the resolution of this problem

TOF spectra and dead-time correction

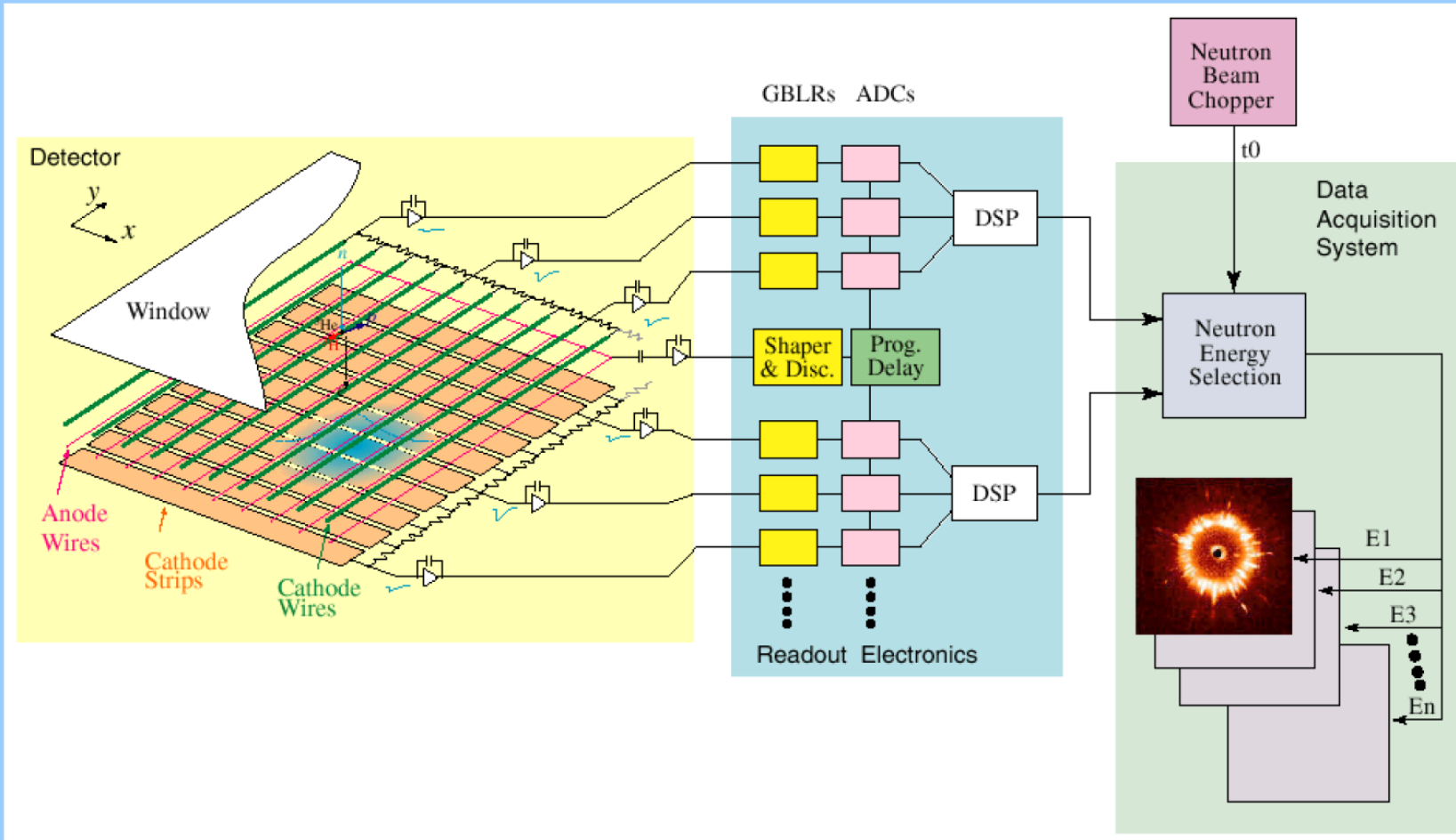
Let's look first at readout scheme

BNL information is nor specific for MAGREF detector but describes many similar detectors

Position Encoding with Interpolating Cathodes Multi-node Charge Division



Multi-Node Centroid Readout Detector for a Spallation Source Electronic Block Diagram



Detector deadtime can affect linearity of the rate measurements

- N – real random intensity (cps), N_D – detected intensity (cps)

Due to deadtime τ detector is paralyzed for some fraction of 1 sec, so that active time $t_a = (1. - \tau \cdot N_D)$. During that time detector counts $N_D = N \cdot t_a = N(1. - \tau \cdot N_D)$ or

$$N = N_D / (1. - \tau \cdot N_D) \quad \rightarrow \quad n_{corr}(ROI) = n_{non-corr}(ROI) / (1. - \tau \cdot N_D)$$

- $\tau = 4\mu s$ - source: Mike Fitzsimmons (consistent with BNL publications)
- Detector readout scheme demonstrates that effect of electronic readout deadtime is not local (i.e., depending on the position of pixel) but global for the whole detector
- Local deadtime effect could be possible in the proportional mode detector due to accumulation of positive ions near multiplication wires with slow drift to the cathode. Effect is small for low gas gain and low local rates (\rightarrow our case).

Table 1: Performance Figures

V. Radeka, 1994

Position Resolution (FWHM)	<0.4 - 2 mm
Number of Resolution Elements	from 128×128 to 1024×1024
Size	from 5×5 cm ² to 50×50 cm ²
Wavelength Range	1 - 20 Å
Detection Efficiency	50 - 80 %
Counting Rate (total)	10 ⁵ - 5×10 ⁵ sec ⁻¹ (single readout)
Counting Rate (single peak)	5×10 ⁴ sec ⁻¹
Integral non-linearity	2×10 ⁻⁴ to 10 ⁻³
Absolute Position Accuracy	30-100 μm
Stability of Origin	<50 μm
Stability of Response (efficiency)	<1%
Differential non-linearity	±3%
Dynamic Range	Single Neutron Detection
Timing Resolution	<250 ns

4μs → *2.5 × 10⁵s⁻¹*

TOF spectra of 2020 PC runs without any cuts

All runs are ~ 1200 sec

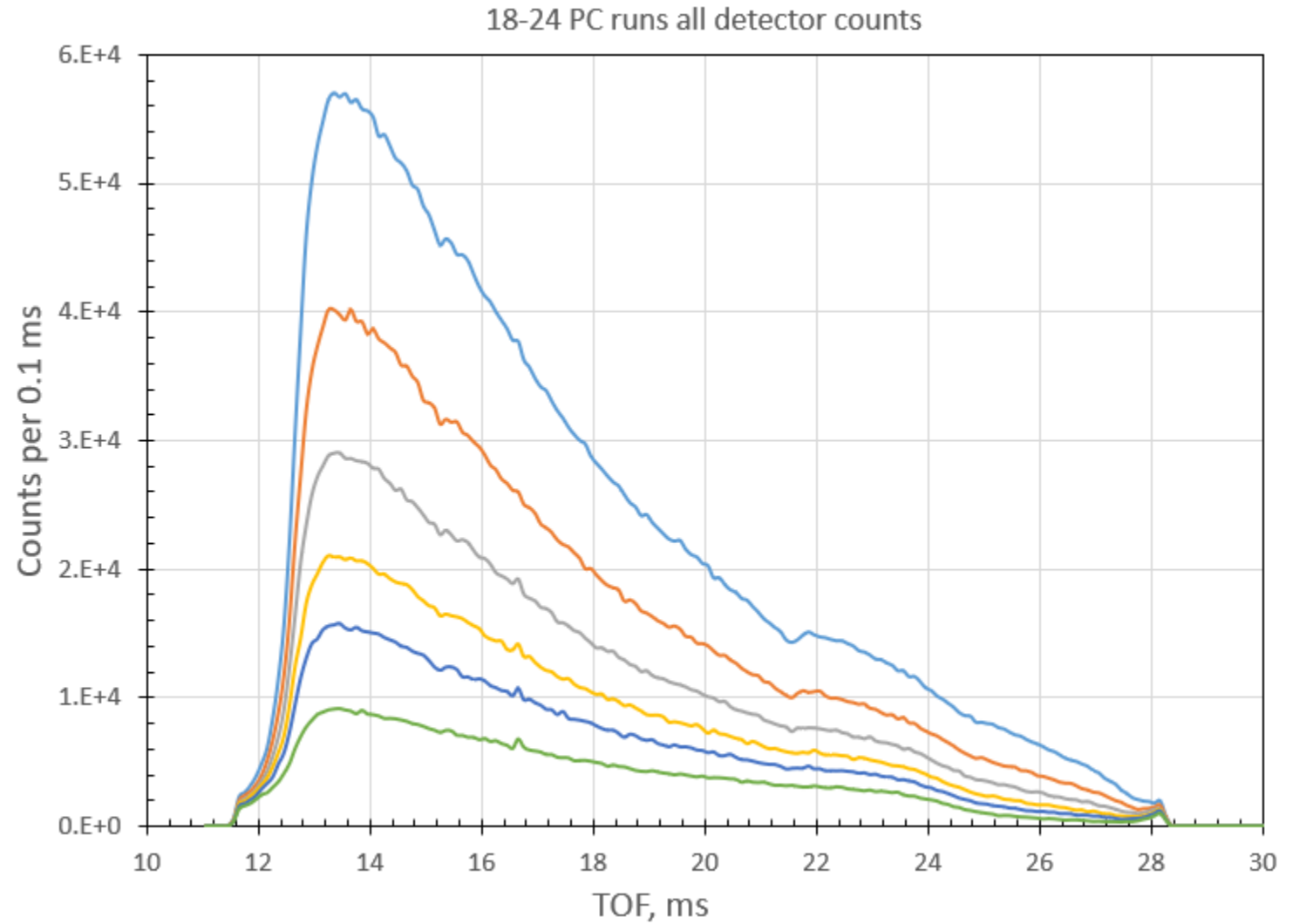
Bin width here in 0.1 ms

Bins are filled with 60 Hz

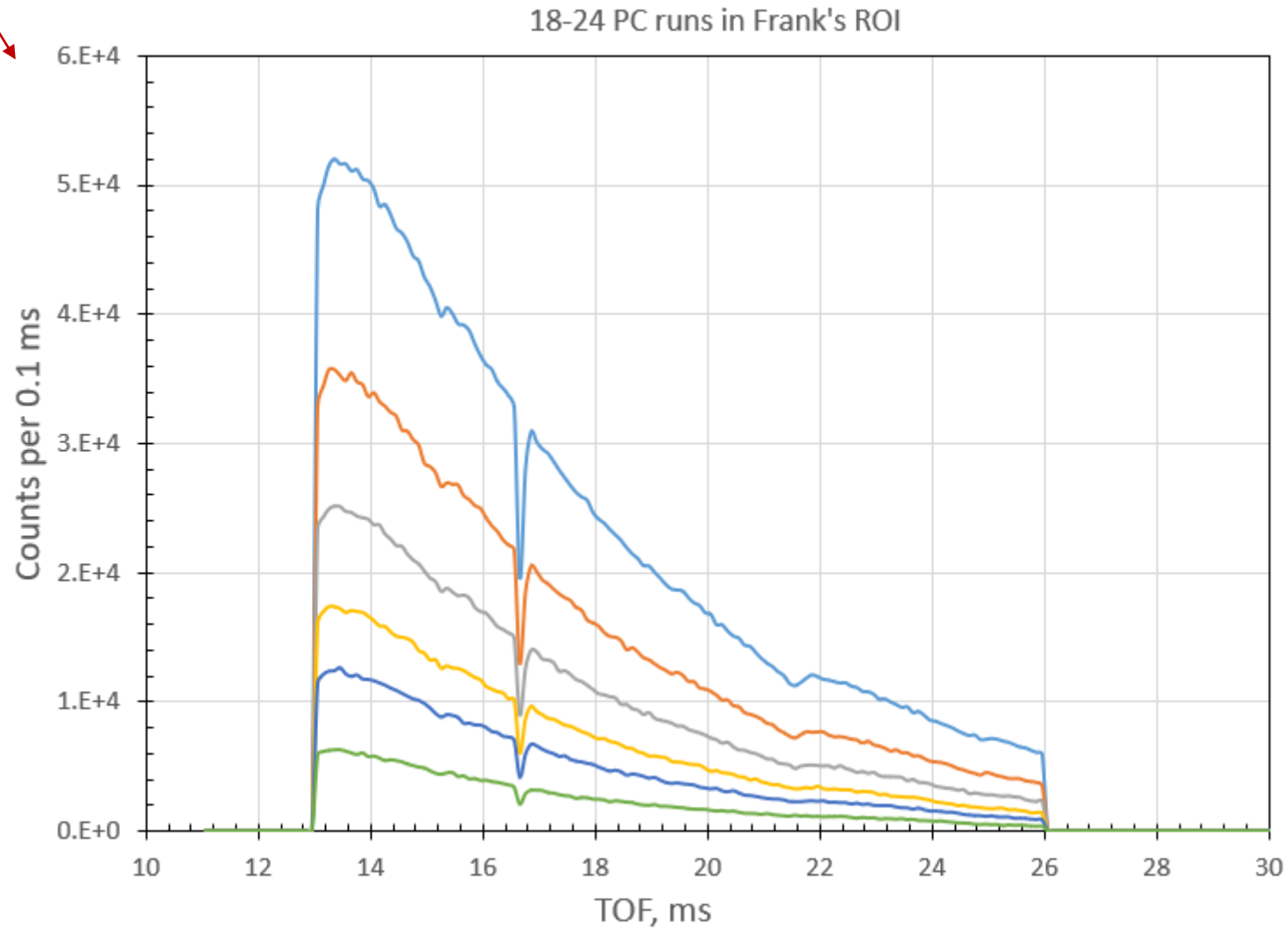
\rightarrow *Counting rates per 0.1 ms*



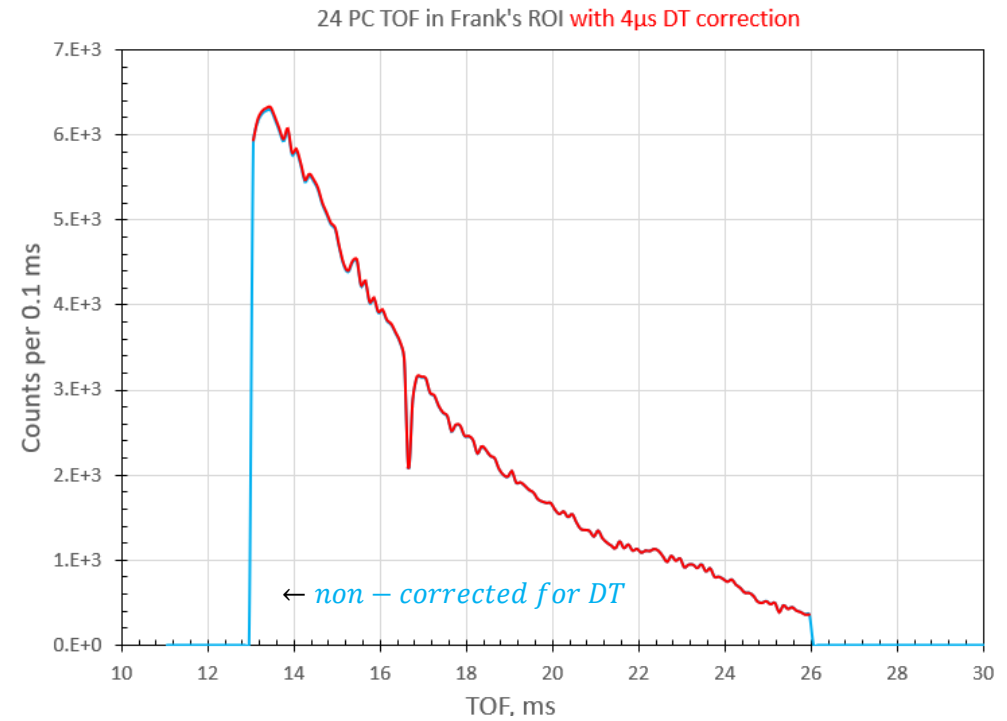
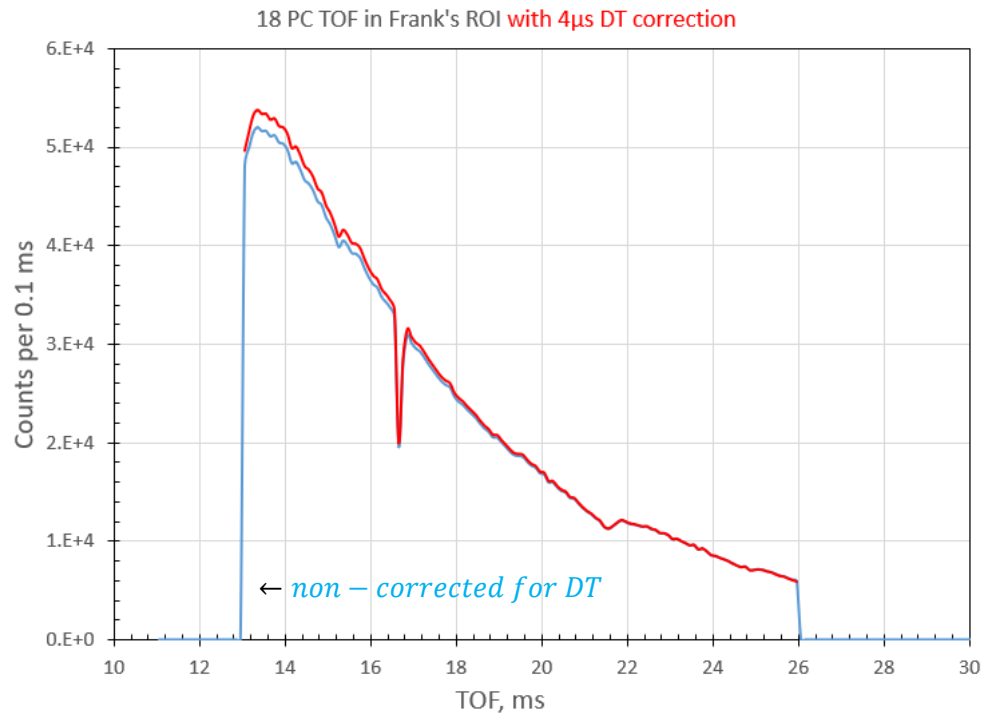
$$n_{corr} = n_{non-corr} / (1 - \tau \cdot N_D)$$



$$n_{corr} = n_{non-corr} / (1 - \tau \cdot N_D)$$



BTW:
Frank's TOF cut
is < 24 ms.
My mistake.
Frank,
please use 26 ms



Integrated global correction factors to 18-24 PC points due to local dead time effect (used by Cary)

18	19	20	21	22	24
1.0205373	1.0142767	1.0106062	1.0077392	1.005843	1.003492

Do we have dead-time effects in pinhole runs?

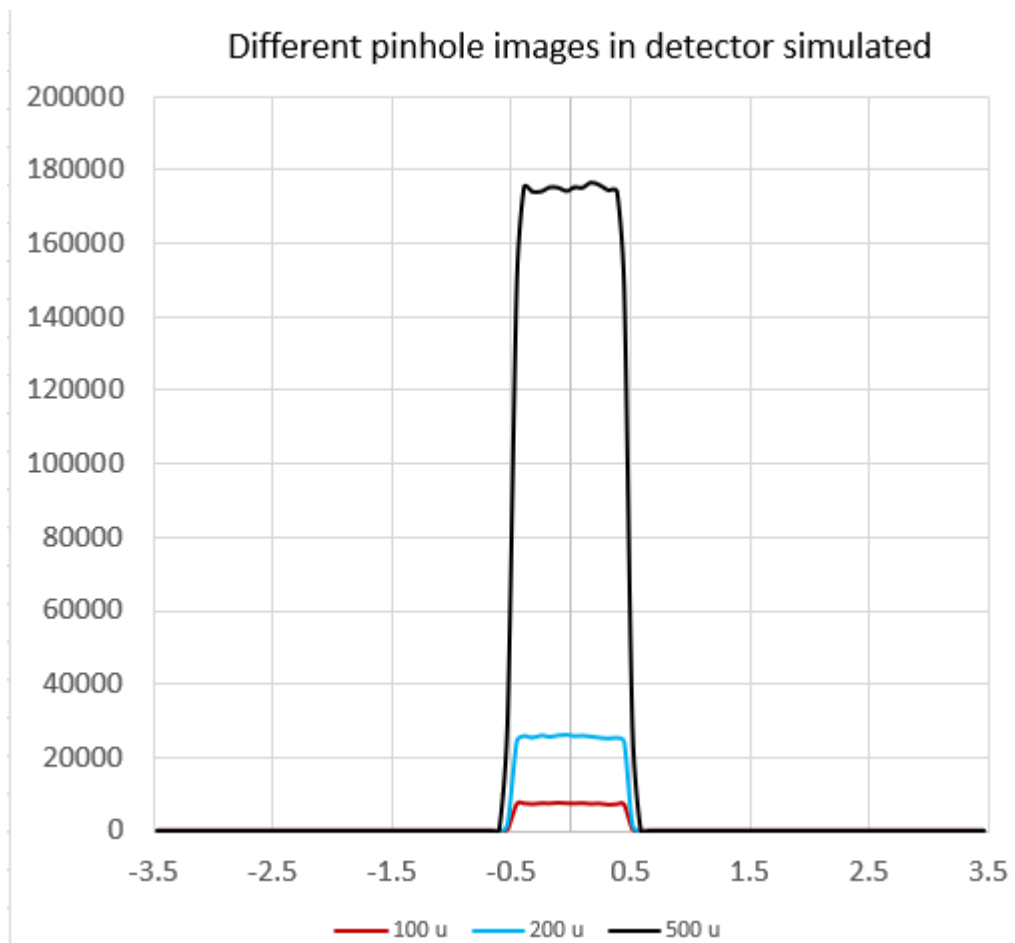
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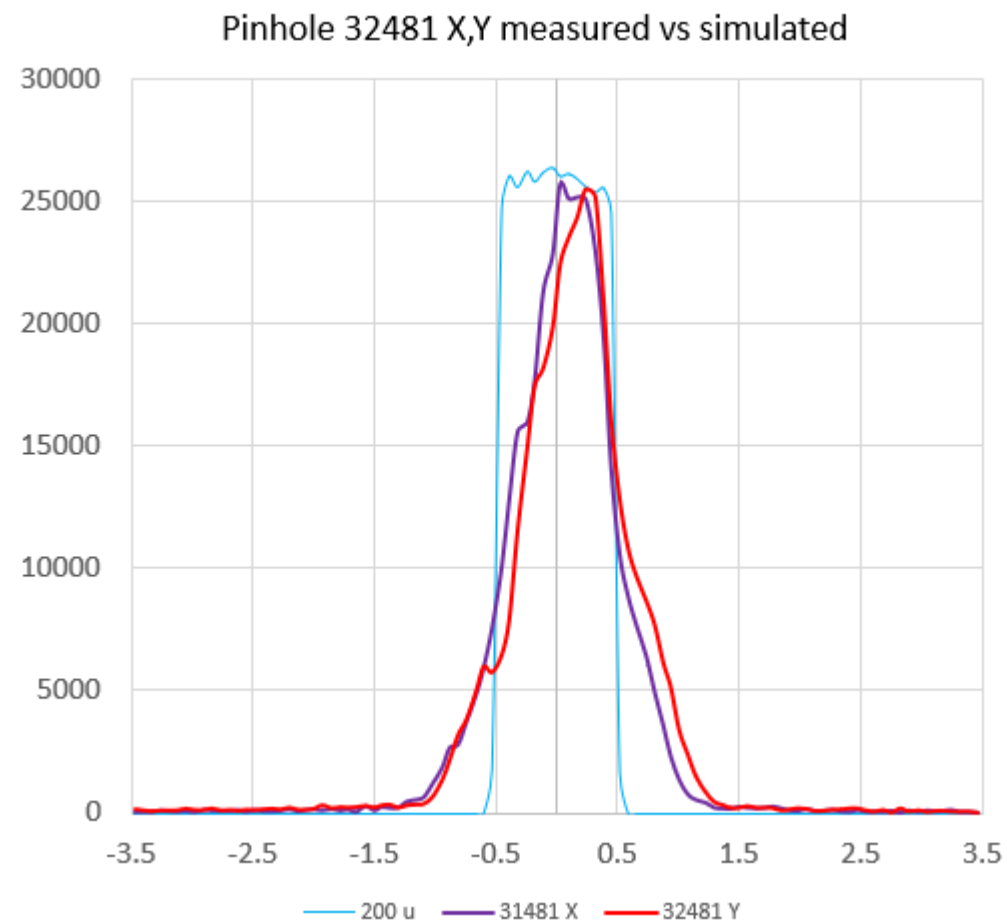


Smallest pinhole installed at sample position
 No Poly attenuators
 S3 = 8x6 S1 = 10x10 $\lambda = 3.25 \text{ \AA}$
 Run = 32480 ~25k counts

- Run 32841 (2019) smallest pinhole at 3.75 AA detector rate is 477 s^{-1}
- Run 37102 (2020) 18 PC attenuator at 3.75 AA detector rate is 3114 s^{-1}
- Run 37059 (2020) pinhole at 3.75 AA detector rate is 827 s^{-1}
- Run 37060 (2020) pinhole detector rate is 1454 s^{-1}
- Run 37061 (2020) pinhole detector rate is 1039 s^{-1}
- Run 37062 (2020) pinhole detector rate is 691 s^{-1}
- Run 37063 (2020) pinhole detector rate is 943 s^{-1}
- Run 37064 (2020) pinhole detector rate is 840 s^{-1}



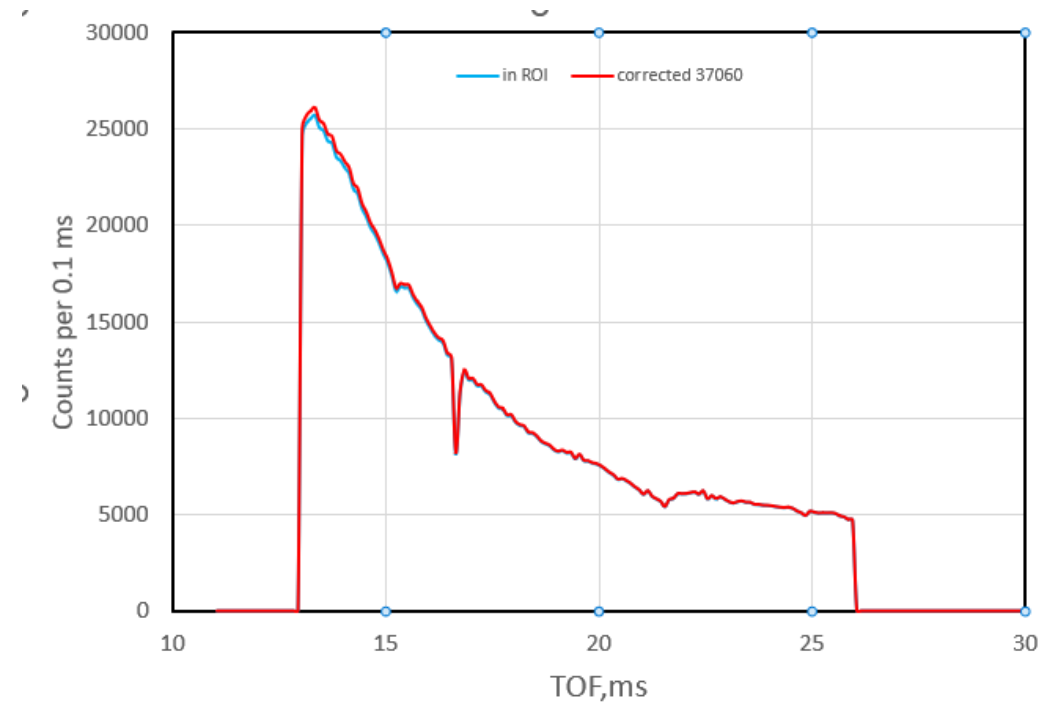
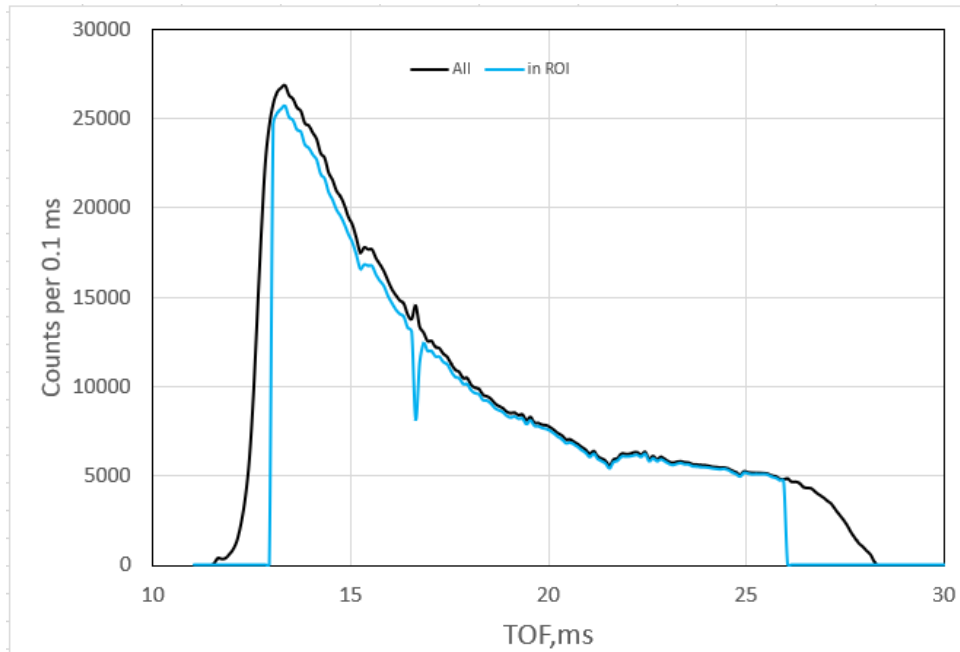
Integrals 100 μ : 200 μ : 500 μ = 1.0 : 3.43 : 23.2



Beam divergence (but not pinhole diameter) defines the area of the pinhole image in detector

Local DT correction for the most intense 2020 pinhole in run 37060

Total counts in the detector and counts in ROI



Global DT correction factor for most intensive pinhole run 37060: **1.009088**

η values comparison

Fit parameter η (6 points fit, 2 parameters) for 2020 data

	η	χ^2/DOF
Calculated (above)	$0.6362 \pm ??$	-
Present simulation thermal	0.6067 ± 0.0026	0.49
Various Cary's fits	0.669 ± 0.002	0.3-0.9
Mike Kline η (<i>TOF</i>)	Av. $0.67 \pm ?$?

The difference between measured and simulated η can be stated.
There might several reasons for this difference

η value



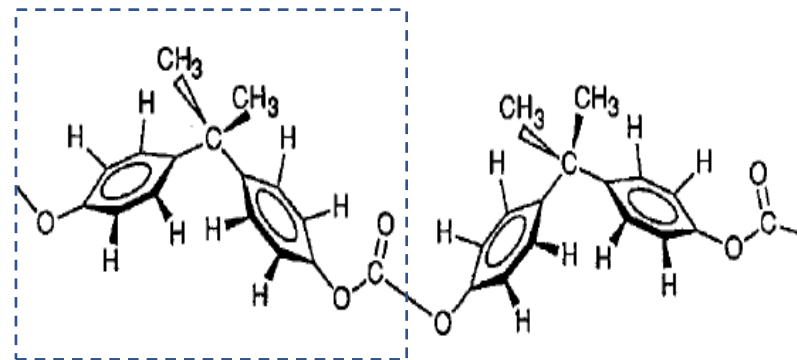
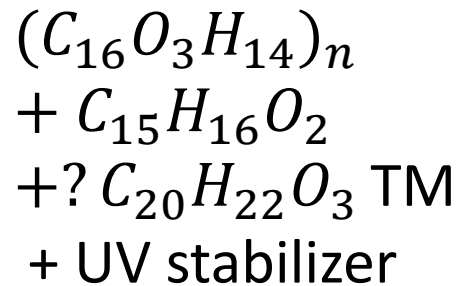
Calculation for average λ in spectrum was made in 2021 after Matt's PC weight/thickness revision

density	1.195	g/cm3	thick	1.27	mm	1 u	1.66E-27	kg	lambda ave	3.216Å
				u/mol	x-sec, b	abs, b	abs_x	# at/cm2	nΣi	
C	16	12.0107	u	192.1712	5.551	0.0035	0.0062598	5.75E+21	0.0319591	
O	3	15.999	u	47.997	4.232	0.00019	0.0003398	1.08E+21	0.00456368	
H	14	1.00784	u	14.10976	82.02	0.3326	0.5948551	5.03E+21	0.41571912	
				254.278	g/mol	6.02E+23	#/mol	tot nΣ	0.4522419	
2021	YK			0.151765	g/cm2	3.59E+20	#	exp(-nΣ)	0.63620025	

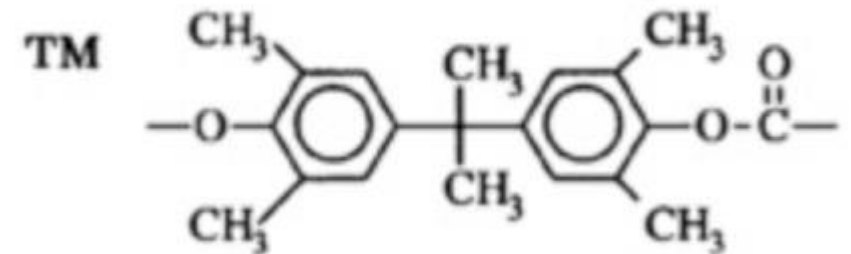
Comment:
We do not know exact chemical composition of Home Depot PCs

Polycarbonates do not have a unique [resin identification code \(RIC\)](#) and are identified as "Other", 7 on the RIC list. Products made from polycarbonate can contain the precursor monomer [bisphenol A](#) (BPA) $C_{15}H_{16}O_2$

<https://www.creativemechanisms.com/blog/everything-you-need-to-know-about-polycarbonate-pc> calls polycarbonate as $C_{15}H_{16}O_2$



H-BPA-PC



2020 intensity calibration

- Is practically finished (see Cary's talk) including systematic errors of background subtraction
- Fit using 6 points and 2 parameters for counts integrated in FROI (Coulomb and dead-time corrected)
- Up scattering corrections still need to be applied from thermal/cold simulations.
We have it from the previous simulations, but it needs to be rechecked again in view of recent observations.

New simulations plan

- PC position of 2020 (57") to be used (shift ~ 70 cm upstream)
- More accurate measurements of PC thickness and density (Matt) will be implemented
- S3 collimator thickness 0.25" B4C (instead of 1 mm Cd)
- Non-scattered spectrum error should be corrected (to remain pinhole-like)
- Cold scattering spectrum should look like Cold ~ 30 K (not like 295K)

- Two new sets of data thermal/cold with initial statistics "1E+9"
for 0,18,19,20,21,22,24 PC to be produced.
- The goal will be determining more reliably correction factor for F_0 .
Currently it is $\times 1.5530 \pm 0.1109$

Role of Cd

- Beam catcher
- Pinhole measurements

What was the thickness of Cd in pinhole plate?

1 mm Cd scatters 3% of the beam.
 $\sigma_{sc} = 6.5 b$

Figure 1. Evolution of (n, n') system in a 3.5 mm Cd absorber for $\Delta m = 300$ neV, $\theta_0 = 10^{-2}$ and 10^{-3} , and for velocity $v = 1000$ m/s. The averaged density matrix at the entrance of the Cd absorber after passing 3 m in air is used as an initial condition. Magnetic field is $B = 0$. Neutron components ρ_{nn} are shown in light/dark blue and mirror neutron component $\rho_{n'n'}$ in light/dark red colors.

