Experimental study for an intraoperative probe for ^{18}F imaging with a silicon pixel detector

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Concept:

an intraoperative probe for ^{18}F positron imaging with a silicon detector

Solution:

a photon counting silicon pixel array detector

Technical:

256x256 pixels, 300 μm thick Si, 55 μm pitch, 1.98 cm^2 area (Medipix2)

^{18}F positrons (high detection efficiency):

250 keV average energy, 634 keV endpoint energy, $T_{1/2}$=109.7 min
max range in silicon: 1.64 mm
projected range in silicon: 0.55 mm

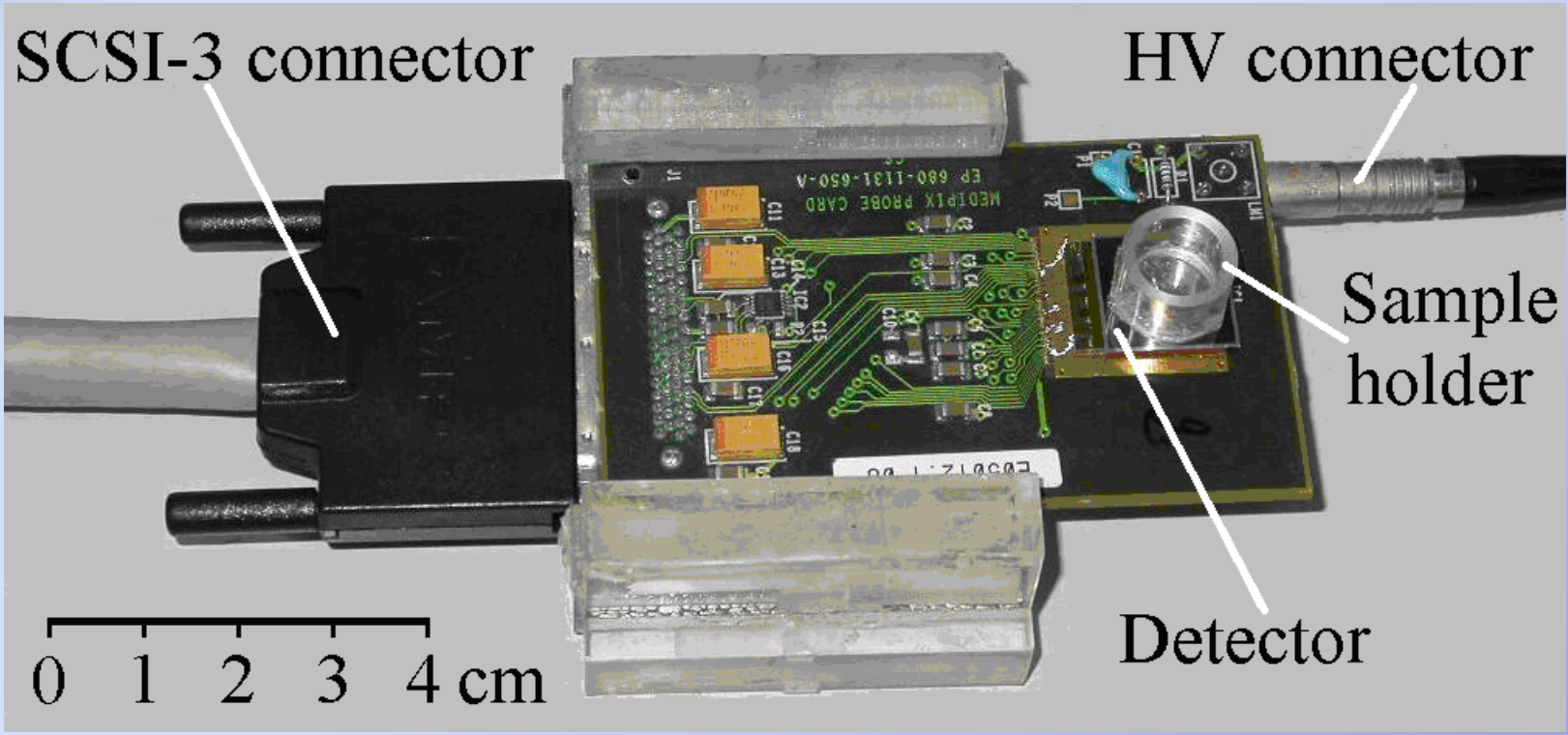
^{18}F gamma rays: 511 keV (low detection efficiency):

FDG: Fluorodeoxyglucose

This study:

- linearity
- efficiency
- spatial resolution
- gamma-ray background evaluation
- noise background evaluation

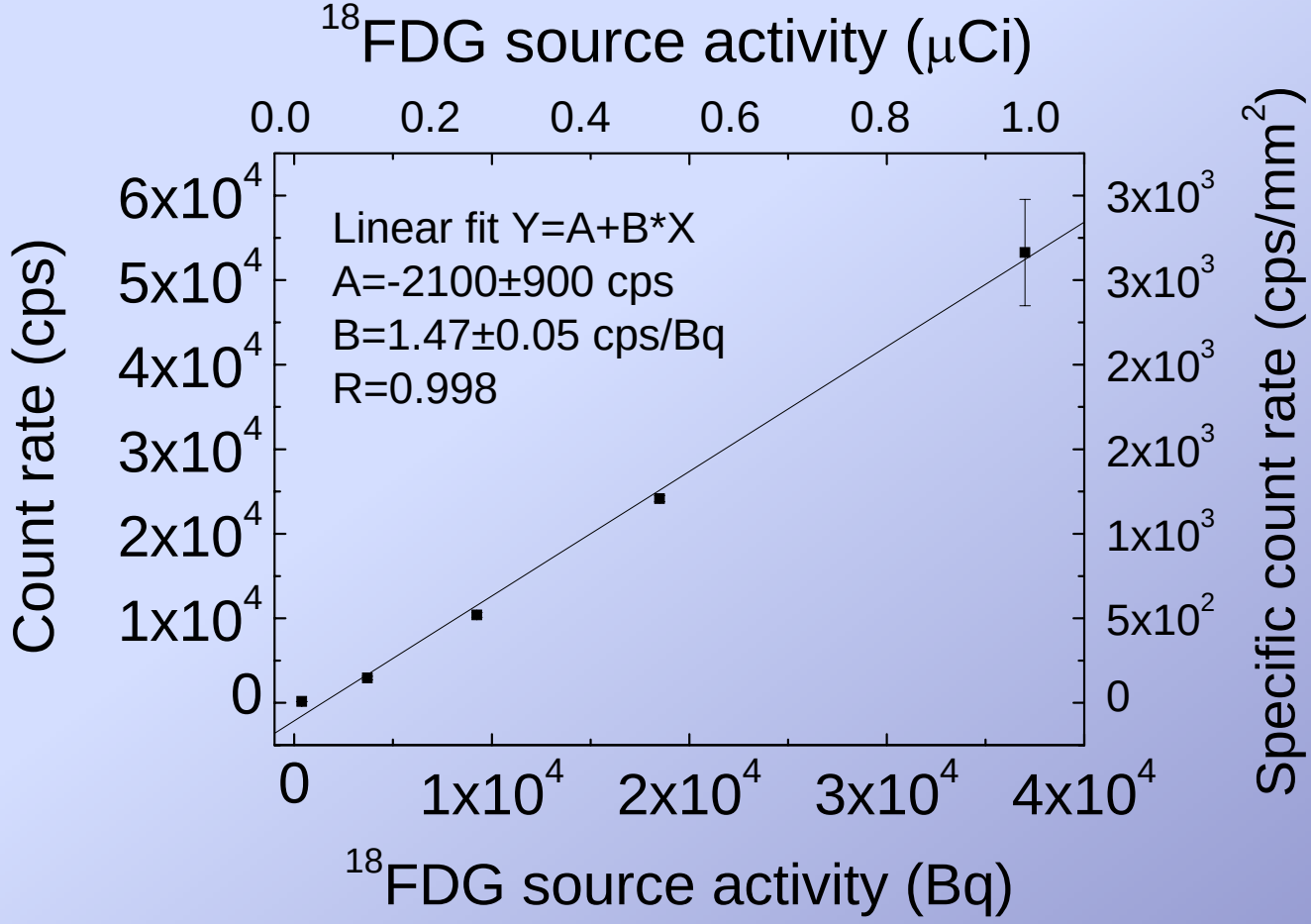
Experimental set-up



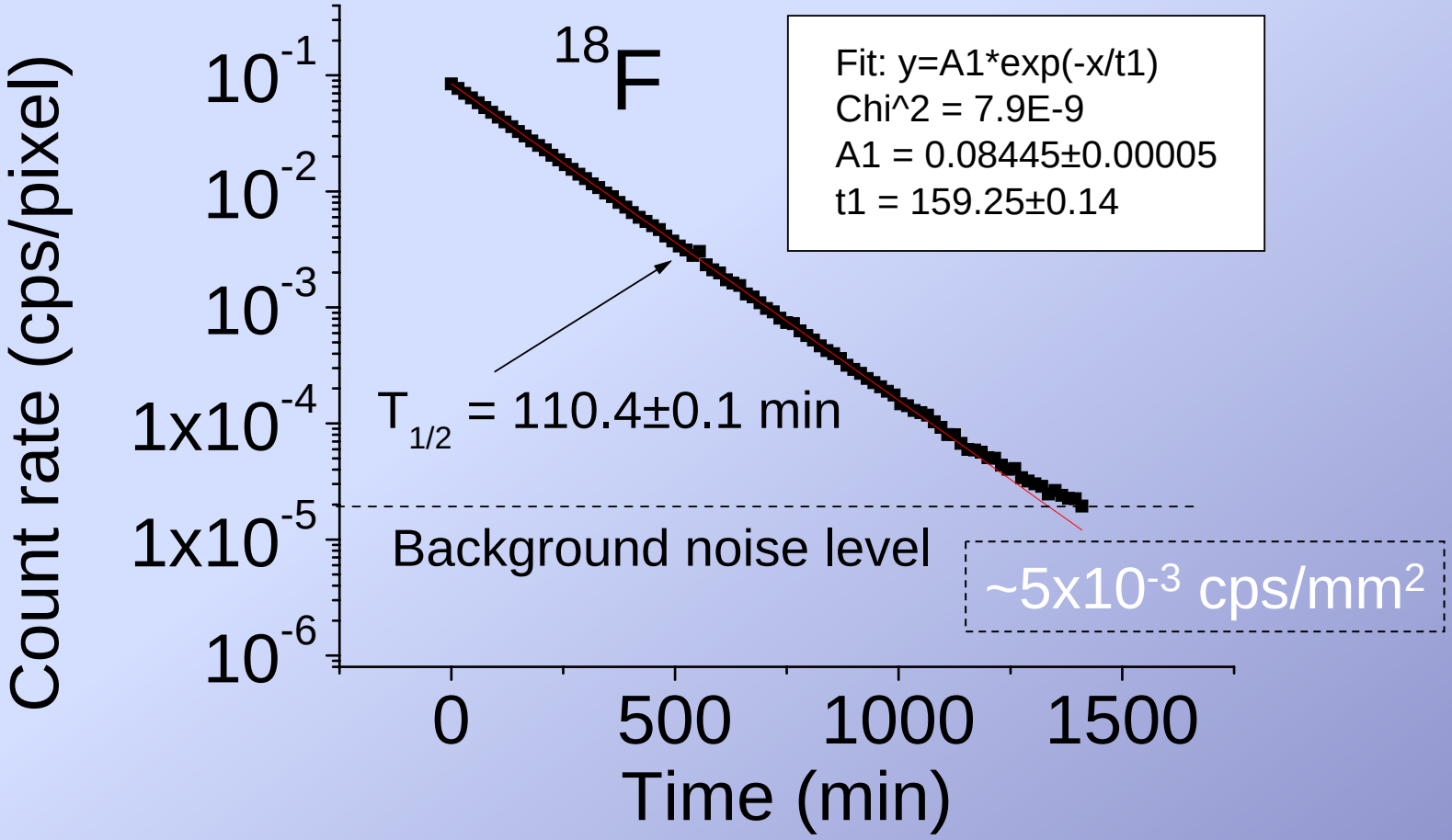
V_{bias} = 100 V
Detection threshold = 6 keV

Serial readout time ~ 20 ms
Max frame rate < 5 fps

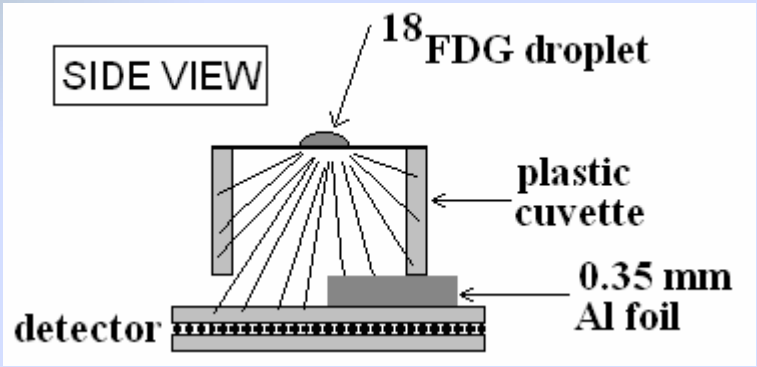
Linearity range

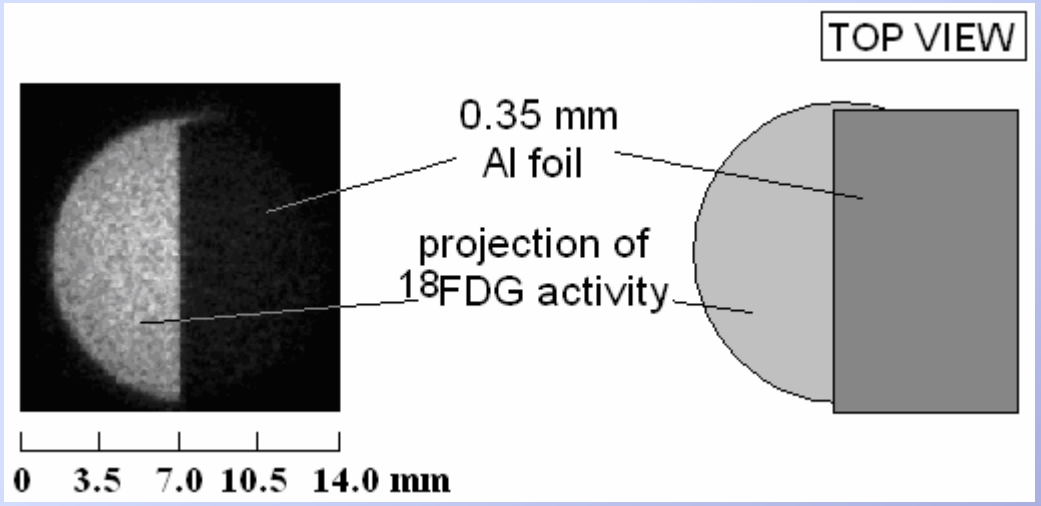


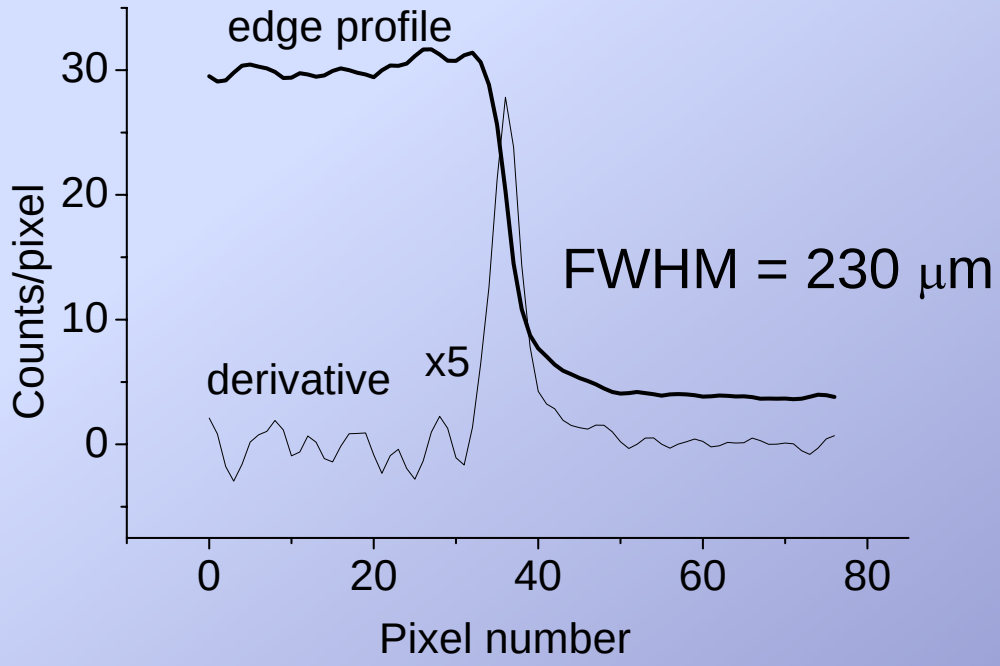
Decay curve & linearity



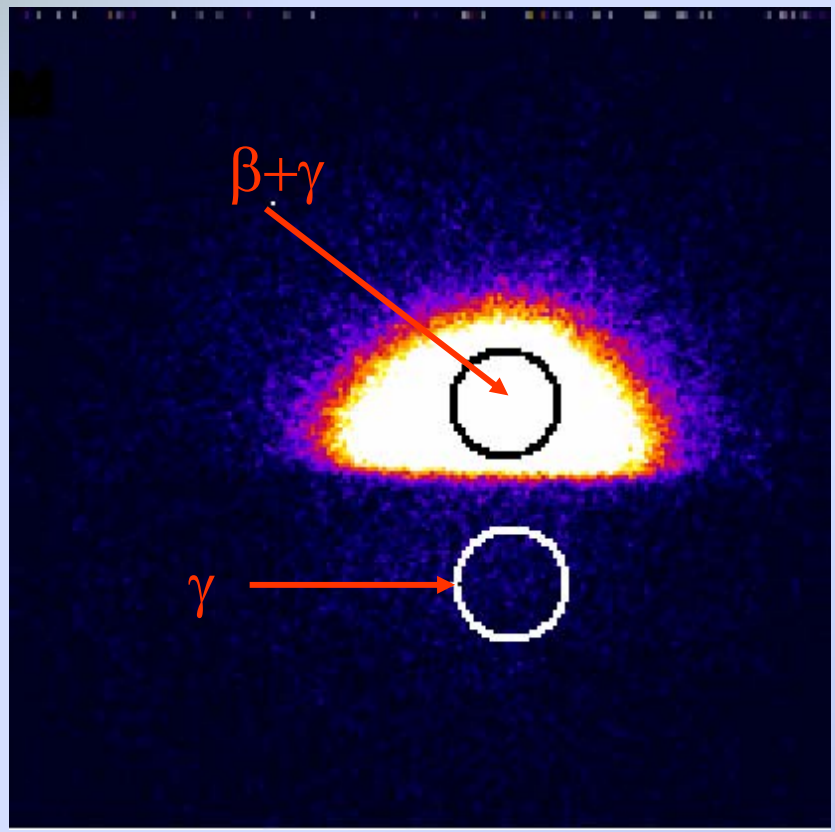
Spatial resolution







γ/β ratio

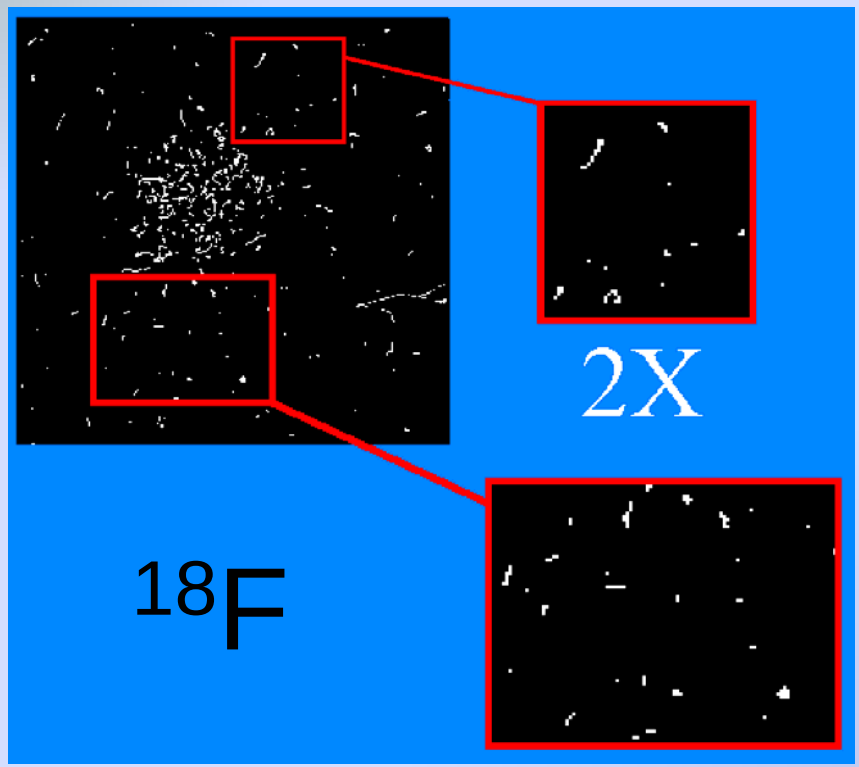


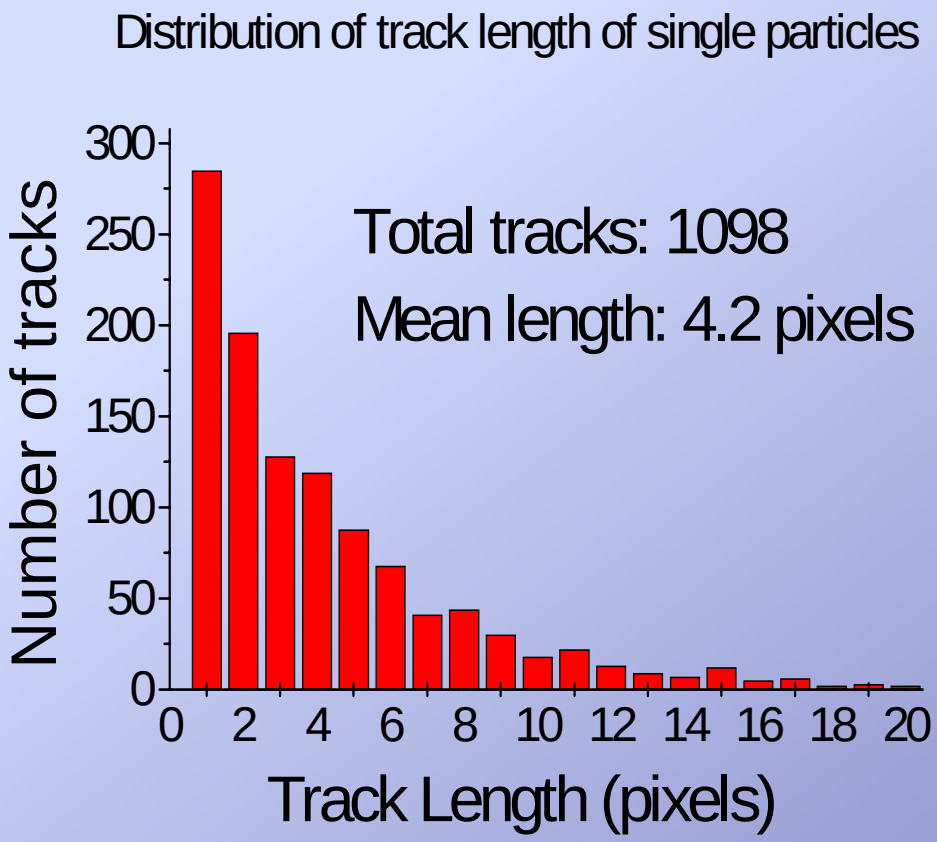
- 450 μm Cu shielding foil
- 1 μCi ^{18}FDG in 10 μl H_2O
- 60 s exposure

$\gamma/[(\beta+\gamma)-\gamma]$ = 1472 cps / 74613 cps= 0.02

γ/β = 2.0%

Track length analysis





+ background
900 s exposure time
~ 0.1 nCi

Conclusions

1. Linearity range: **0.01÷1 μCi**
2. Estimated efficiency: **1.47±0.05 cps/Bq**
3. Noise background: **~5x10^{-3} cps/mm^2**
4. Spatial resolution: **230±5 μm**
5. γ/β^+ ratio: **2.0%**
6. Multiplicity of event: **4.2 hit pixels/particle**

	Area	Mean	StdDev	Min	Max	XM	YM	IntDen	%Area	Slice	XStart	YStart
1	3	0	0	0	0	190.500	5.500	0	100	1	190	4
2	1	0	0	0	0	9.500	5.500	0	100	1	9	5
3	9	0	0	0	0	2.278	9.056	0	100	1	0	6
4	4	0	0	0	0	20.750	7.750	0	100	1	20	6
5	10	0	0	0	0	246.700	9.200	0	100	1	247	6
6	3	0	0	0	0	84.833	10.167	0	100	1	84	9
7	1	0	0	0	0	127.500	10.500	0	100	1	127	10
8	3	0	0	0	0	240.500	10.500	0	100	1	239	10
9	2	0	0	0	0	253.500	15	0	100	1	253	14
10	1	0	0	0	0	11.500	15.500	0	100	1	11	15