Toy Model For Hyperfine Measurement

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A brief introduction about the Monte Carlo

This Monte Carlo produces two `.root` files, that are a simulated dataset of the hyperfine spectrum of anti-hydrogen.

```
root [0]
Processing AnalysisLineShape.cpp...
+-----+----+------------+------+------------+
| Row | id | frequence  | Type | radius     |
+-----+----+------------+------+------------+
| 0   | 0  | -1.1593600 | 0    | 2.3544551  |
+-----+----+------------+------+------------+
| 1   | 1  | -1.1593600 | 0    | 2.3317903  |
+-----+----+------------+------+------------+
| 2   | 2  | -1.1593600 | 1    | 2.0915642  |
+-----+----+------------+------+------------+
| 3   | 3  | -1.1593600 | 1    | 2.3174902  |
+-----+----+------------+------+------------+
| 4   | 4  | -1.1593600 | 1    | 0.69147125 |
+-----+----+------------+------+------------+
| 5   | 5  | -1.1593600 | 1    | 1.2059323  |
+-----+----+------------+------+------------+
| 6   | 6  | -1.1593600 | 1    | 0.62781989 |
+-----+----+------------+------+------------+
| 7   | 7  | -1.1593600 | 1    | 1.7730544  |
+-----+----+------------+------+------------+
| 8   | 8  | -1.1593600 | 1    | 0.81372473 |
+-----+----+------------+------+------------+
| 9   | 9  | -1.1593600 | 1    | 1.4974816  |
+-----+----+------------+------+------------+
```

Figure: Structure of the dataset.

A brief introduction about the Monte Carlo

The Annihilation on the walls (N_{mix}) are generated using the two pdf of the transitions (c $\rightarrow$ b) and (d $\rightarrow$ a). The Annihilation on the residual gas (N_{gas}) are generated uniformly on the frequency spectrum. The definition of the important parameters of the simulation is in the following figure:

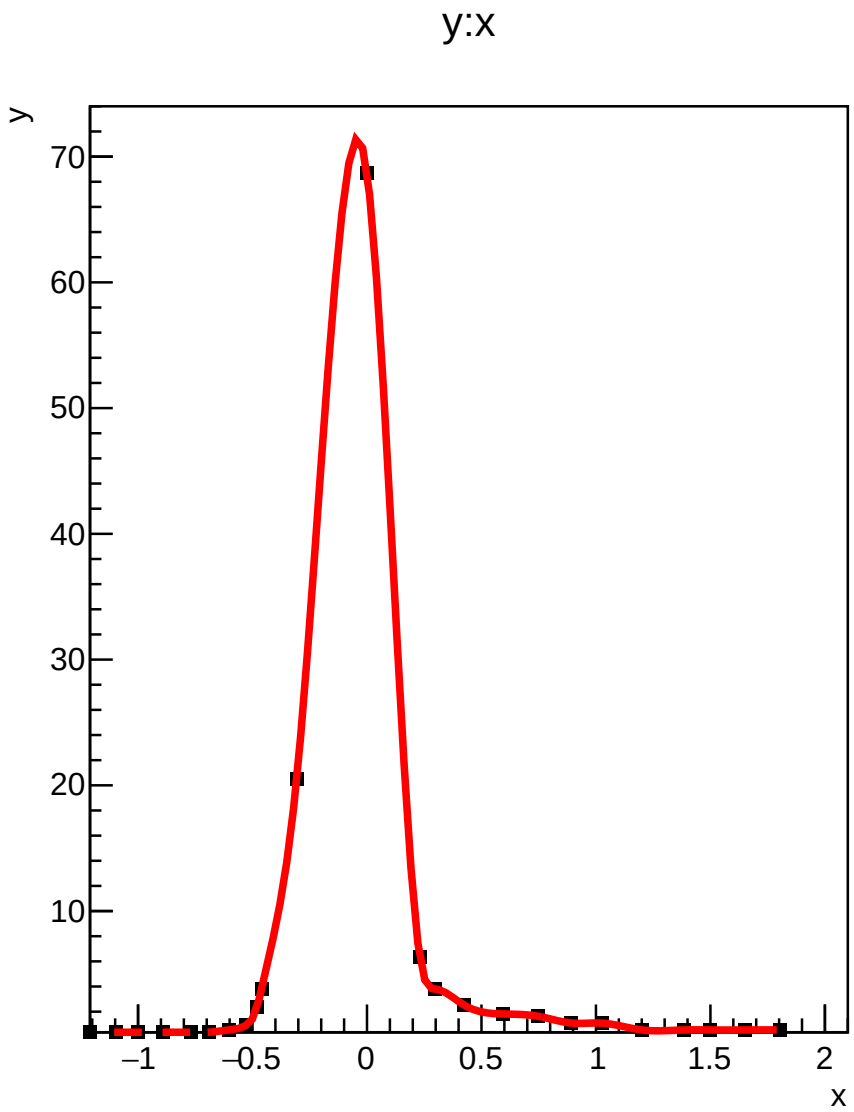
```
void toyLineShape(double Mix_c = 0.5, double Mix_d = 0.5, double C = 0.5, int NBin = 30, int NTOT = 10000){
        /* Parameters of the Simulation */
int Nbin = NBin;                  // Number of Bins
int Ntot = NTOT;                  // Number of Total Events
double Ncosmic = (0.492 * Nbin);// Number of Cosmic Events
double pWall_c = Mix_c;           // Weight annihilation on walls for pdf1 (transition c -> b)
double pWall_d = Mix_d;           // Weight annihilation on walls for pdf2 (transition d -> a)
double c = C;                     // Percentage of division two datasets
        /*                                  */

double d = 1 - c; double Nc = Ntot*c; double Nd = Ntot*d;
double pGas_d = 1 - pWall_d; double pGas_c = 1 - pWall_c;
```

0.492 expected rate per bin.

The amount of events is splitted in two dataset, Nc for transition c to b and Nd for transition d to a.

Figure: Parameter of the Montecarlo.

Spline interpolation of the Spectrum.



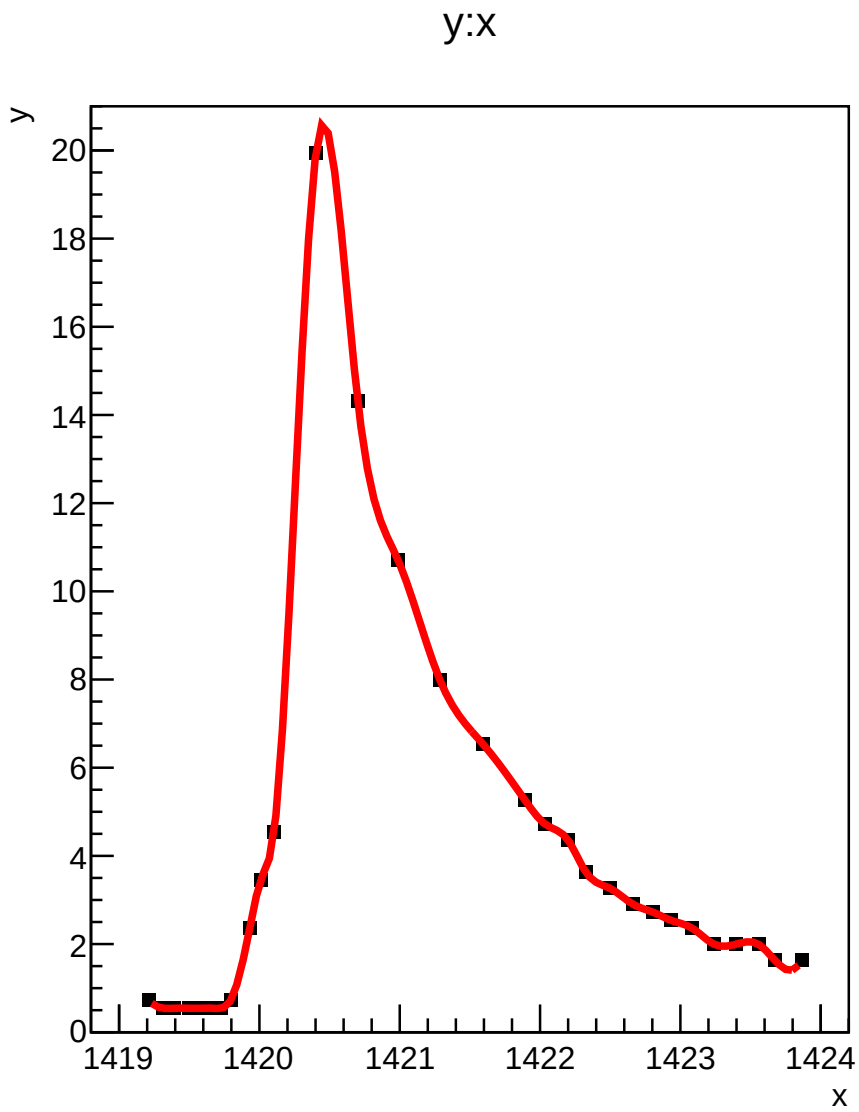


Figure: Data Obtained with PlotDigitizer

Probability $pMix = 50\%$

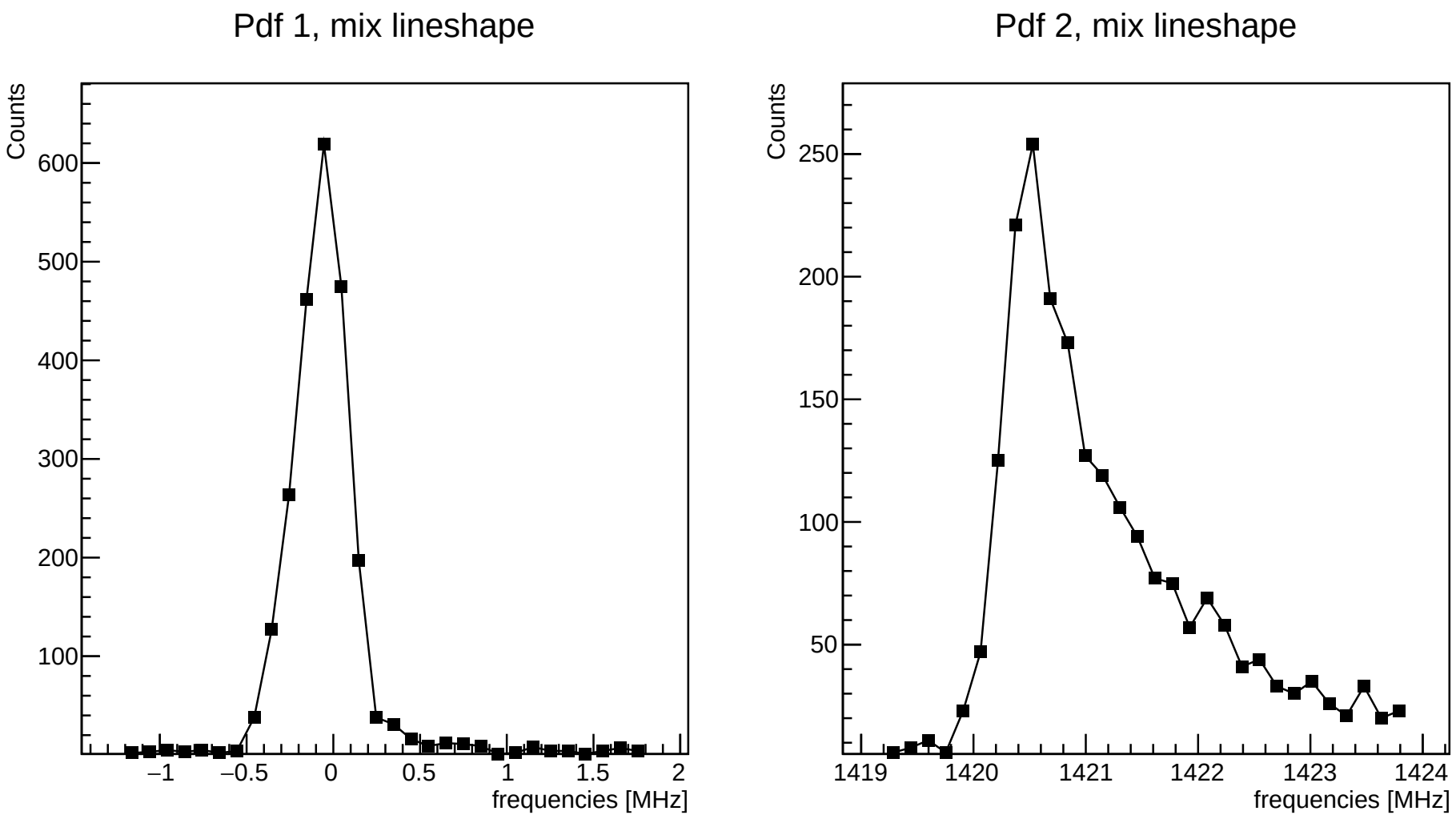


Figure: Events per frequency generated with for Pdf 1 (left) and Pdf 2 (right). The Data include **only** the annihilation on the walls (mixing).

Probability $pMix = 50\%$

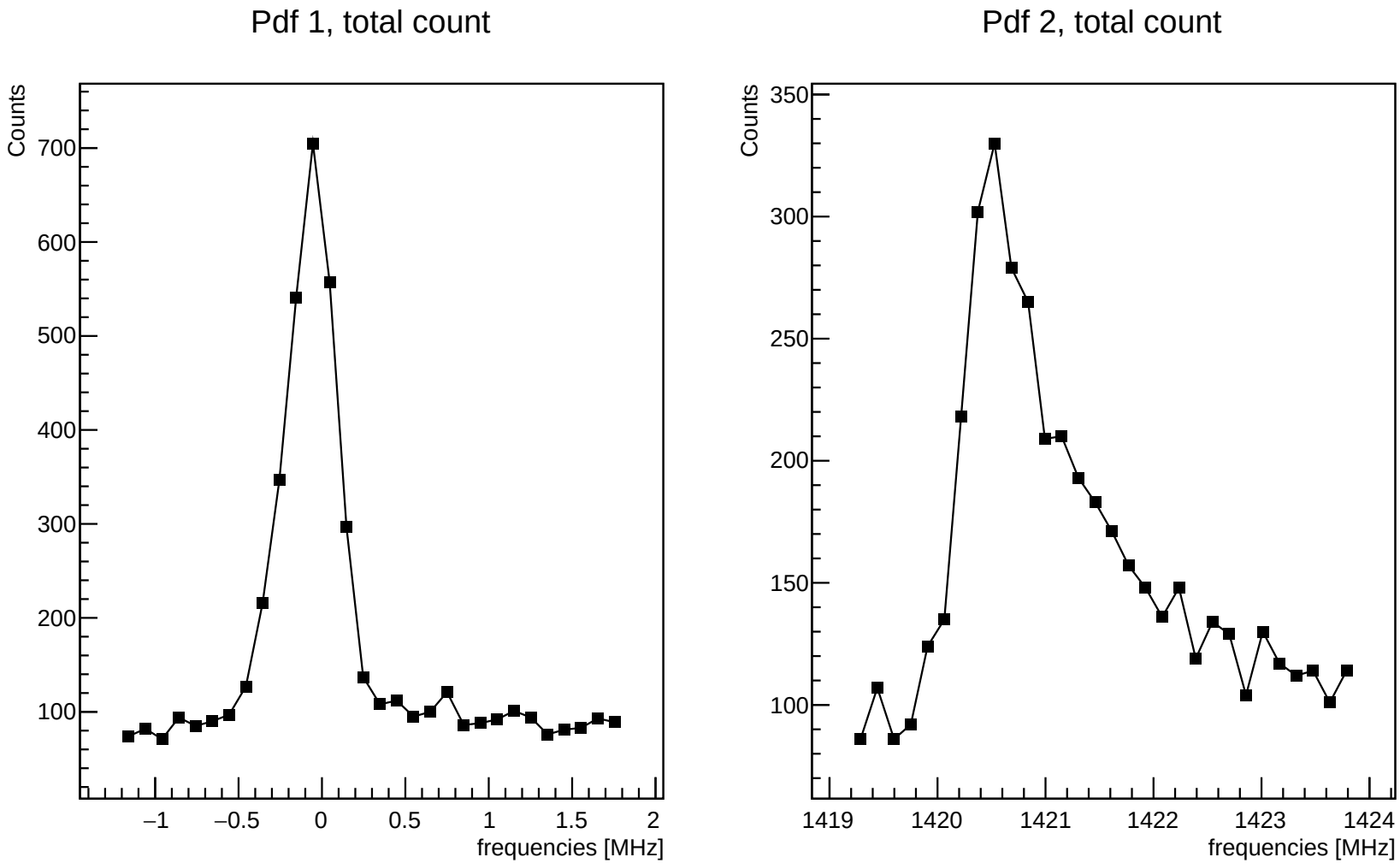


Figure: Events per frequency generated with for Pdf 1 (left) and Pdf 2 (right).
The Data include the annihilation on the walls (mixing) together with the annihilation due to residual gas and cosmic background.