PRELIMINARY

Studies on Activation in the ATLAS cavern with MPX Detectors

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On behalf of the ATLAS MPX detector group

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Overview

- ❑ The ATLAS MPX-detector network
- ❑ Method of studying the activation (example MPX01)
  - Measured countrates during and after collisions
  - Modelling the decay of activated porducts
  - Adapting fit results to the measured data
- ❑ Overview over results for different detectors
- ❑ Summary

The ATLAS MPX detector network – Devices

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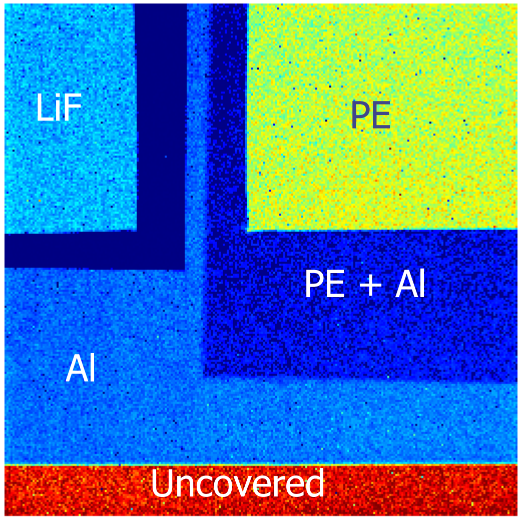
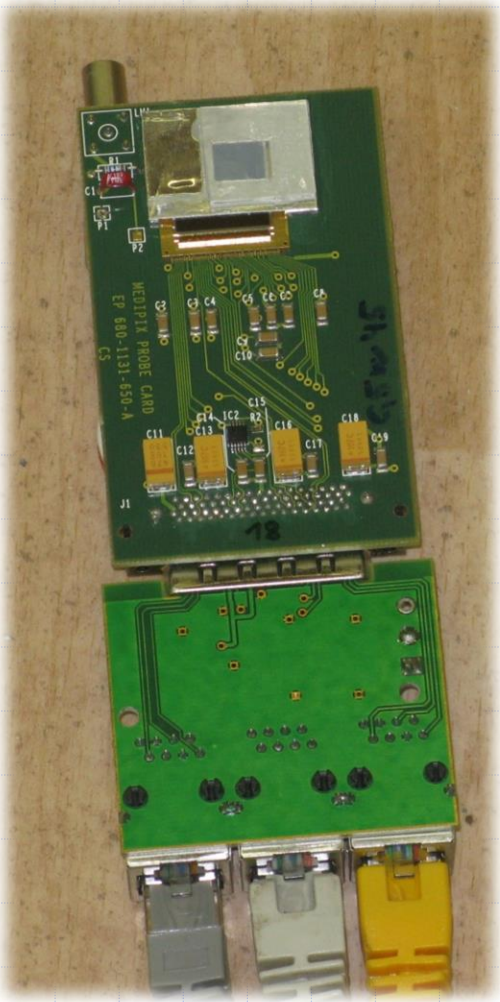
- Medipix 2 ASIC with 300µm Silicon layer
  - 256 x 256 pixel
  - Pixel pitch 55 µm
- Converter foils:
  - $^{6}Li(n,\alpha)^{3}H$: thermal neutrons
  - recoiled protons below PE: fast neutrons





The ATLAS MPX detector network – detected particle types

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- **Efficiencies** (for noncharged particles reduced by the conversion efficiency to detectable charged particles and geometry factors):
  - Charged particles (above 8 keV): 100%
  - X-rays (10 keV): ~80%
  - Gamma-rays (above 1 MeV): ~0.1%
  - Thermal neutrons (energy < 0.5 eV): ~1%
  - Fast neutrons (MeV range): ~0.1%

- **Device lifetime:**
  - Expected to withstand up to 10^{13} n/cm^2
  - Before installation: tested up to 1.5×10^{12} n/cm^2
  - Current integral number of high energy transfer particles (HETP) impinging on MPX01: 2×10^{10} HETP/cm^2

The ATLAS MPX detector network – MPX positions

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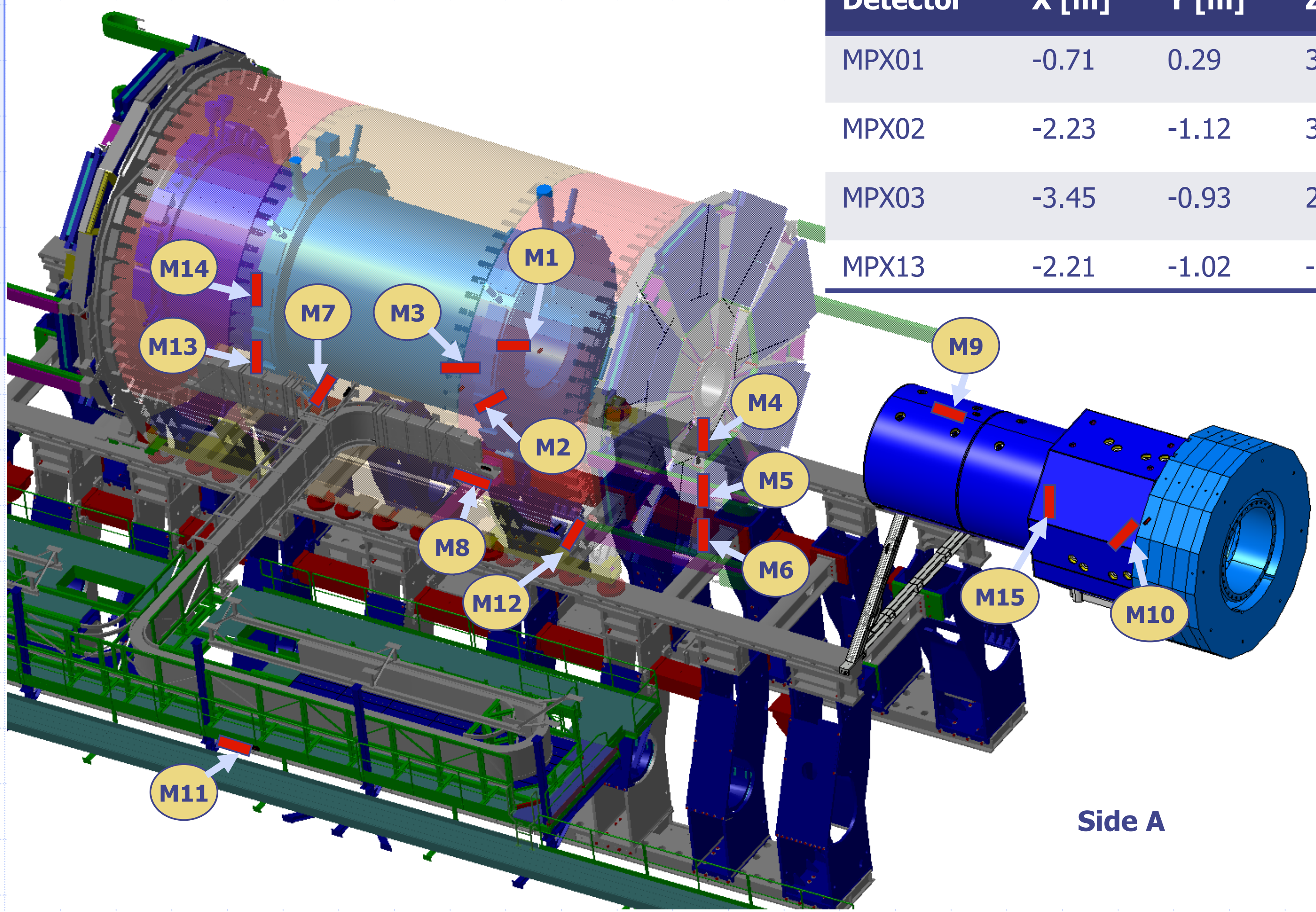
Detector	X [m]	Y [m]	Z [m]	R [m]
MPX01	-0.71	0.29	3.42	0.77
MPX02	-2.23	-1.12	3.42	2.50
MPX03	-3.45	-0.93	2.94	3.57
MPX13	-2.21	-1.02	-3.42	2.44



Count rate at MPX01 site during and after collisions

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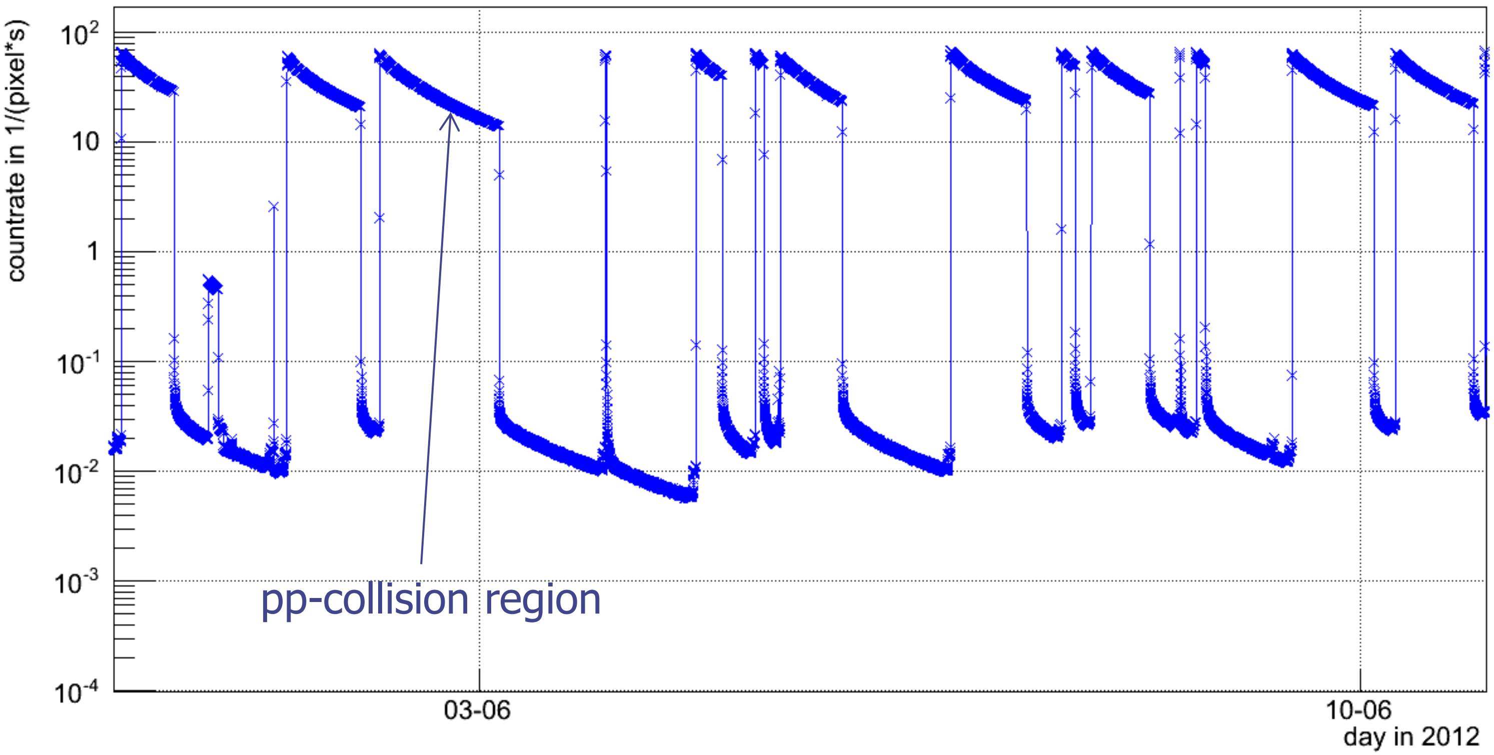
- Activation of surrounding material during collisions in the ATLAS detector
  - Luminosity monitoring with MPX devices: Background contribution
  - Dosimetric aspect: What is the time dependency of the ambient dose equivalent rate after the collisions?



Count rates of the whole investigated period (March – Dec 2012)

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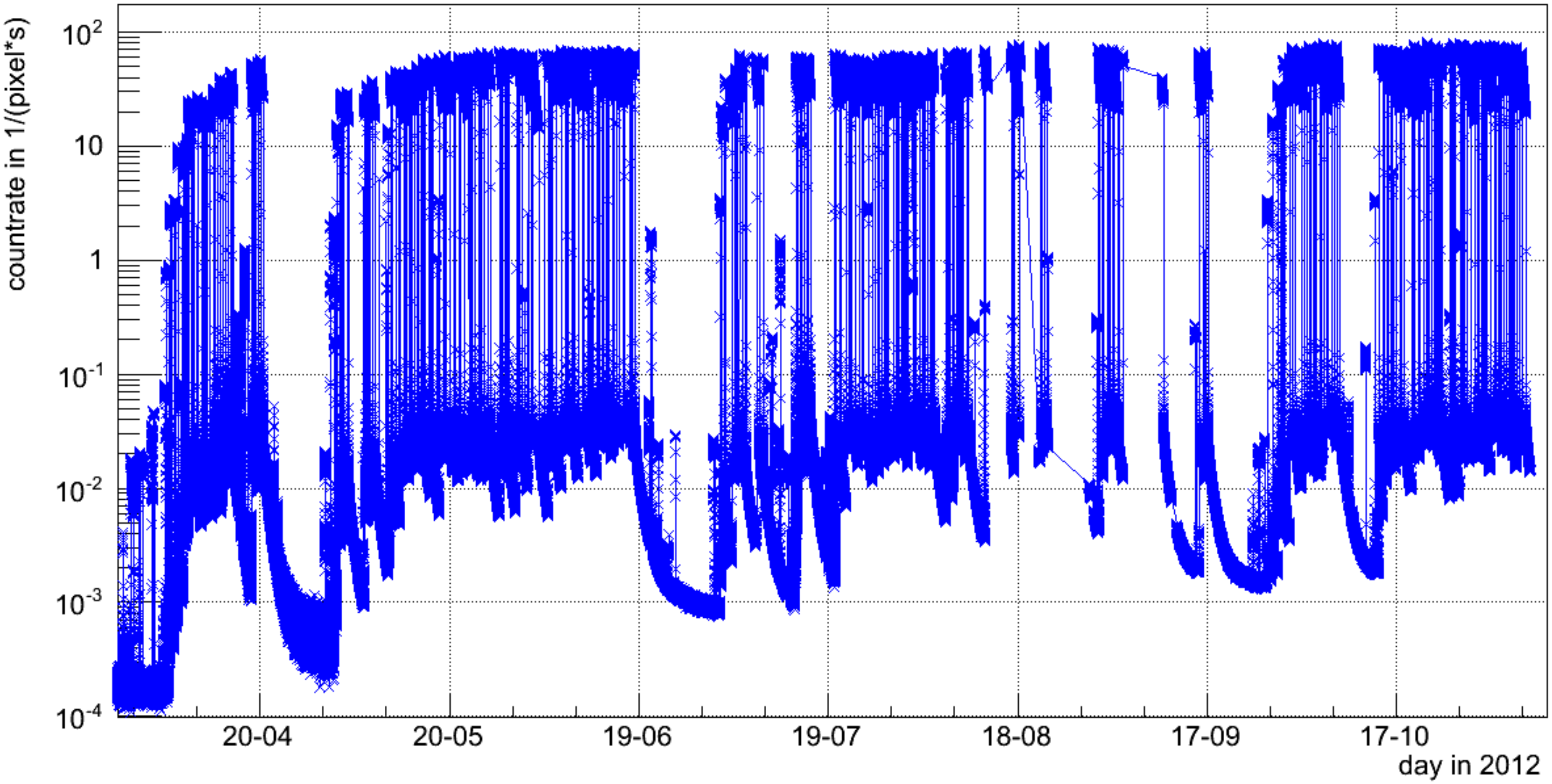
- Especially to determine the components with long half lifes it is necessary to use as long period as possible



Count rates at MPX01 site: decay period

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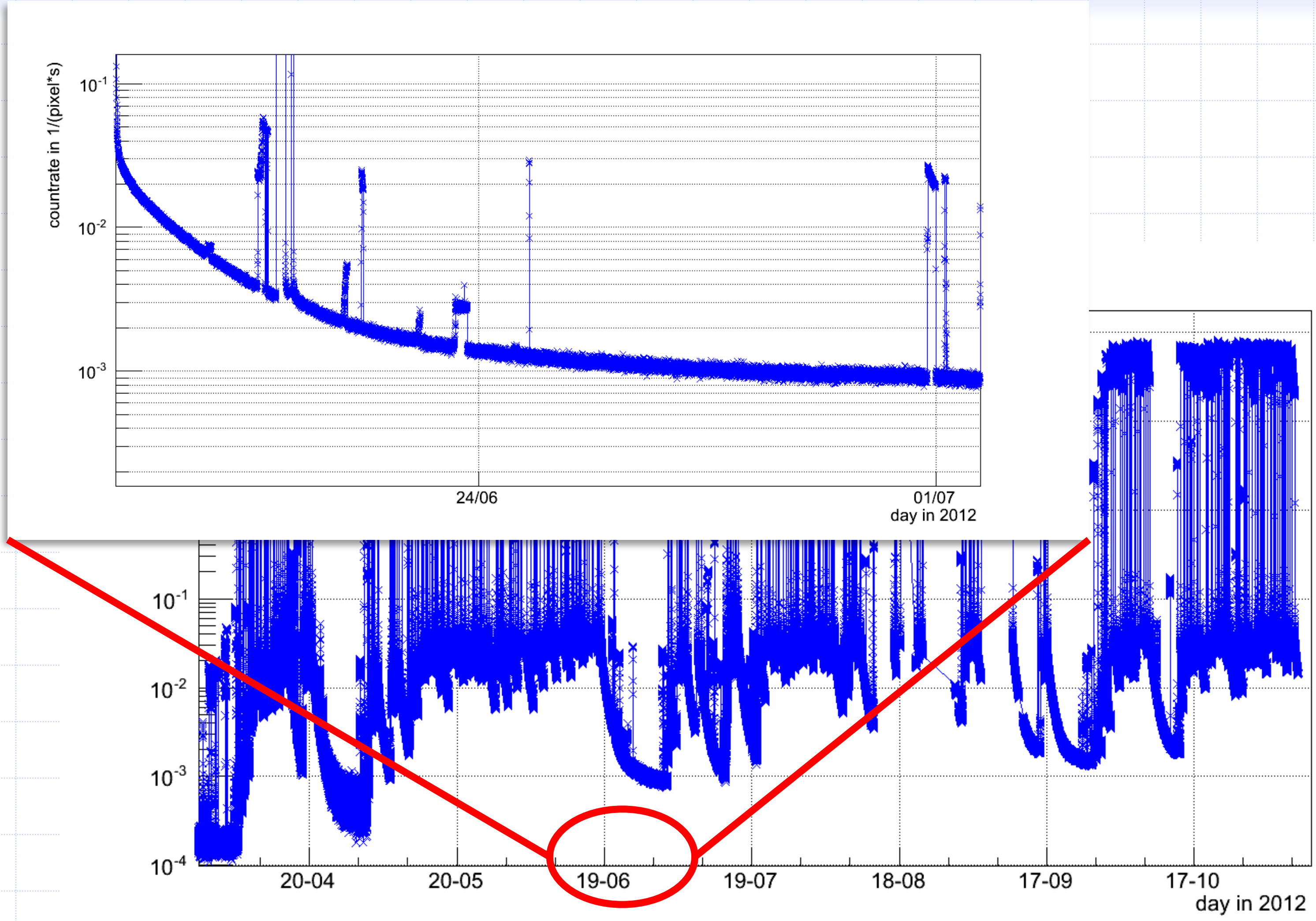

Describing the decay of activated products

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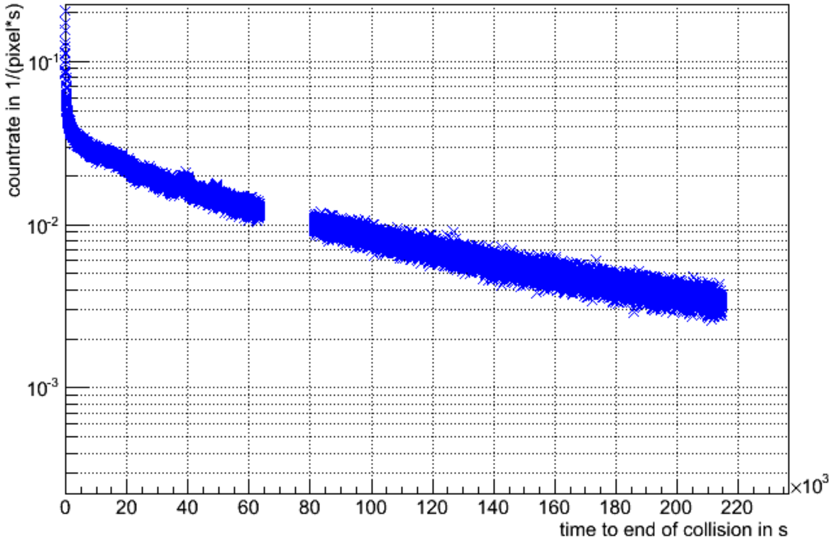
- Sum of radioactive decays of n isotopes:

$$f(t) = \sum_{i=1}^{n} k_i \cdot e^{-\frac{\ln(2)}{T^i_{\frac{1}{2}}} \cdot t}$$

- Fit of sum of exponetial is an ill-conditioned problem

1. Choose appropriate region without collisions (exclude collisions)
2. Fit sum of two exponential decays
3. Subtract faster decay component from data
4. Repeat steps 2. and 3. until all data is fitted



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2. Fit sum of two exponential decays (with range 0 to estimated half life times 10)
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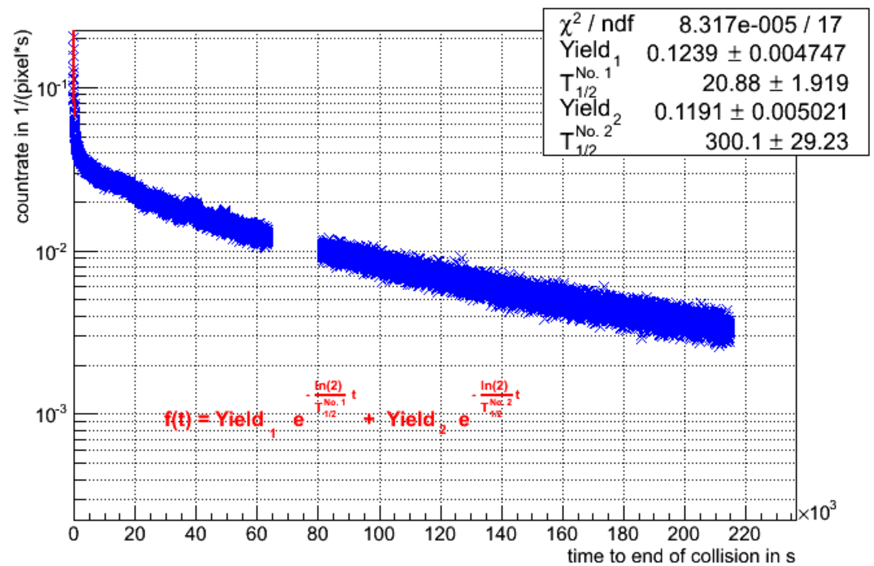

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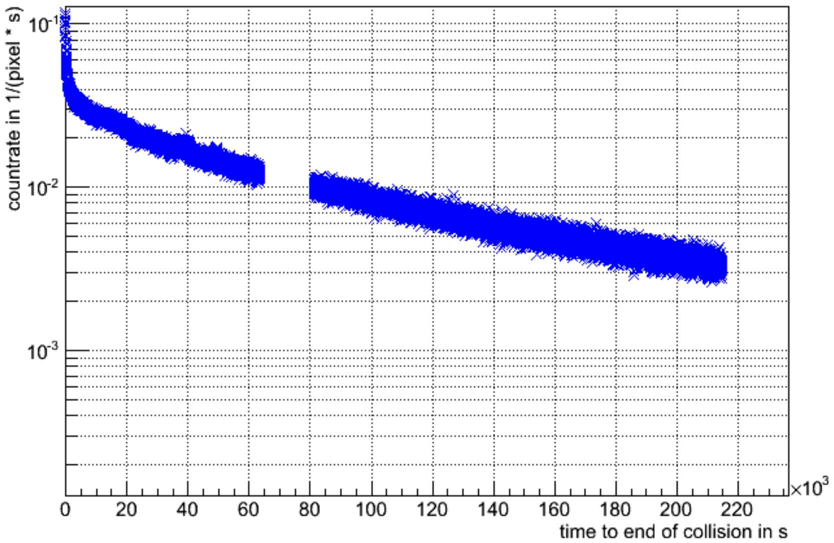

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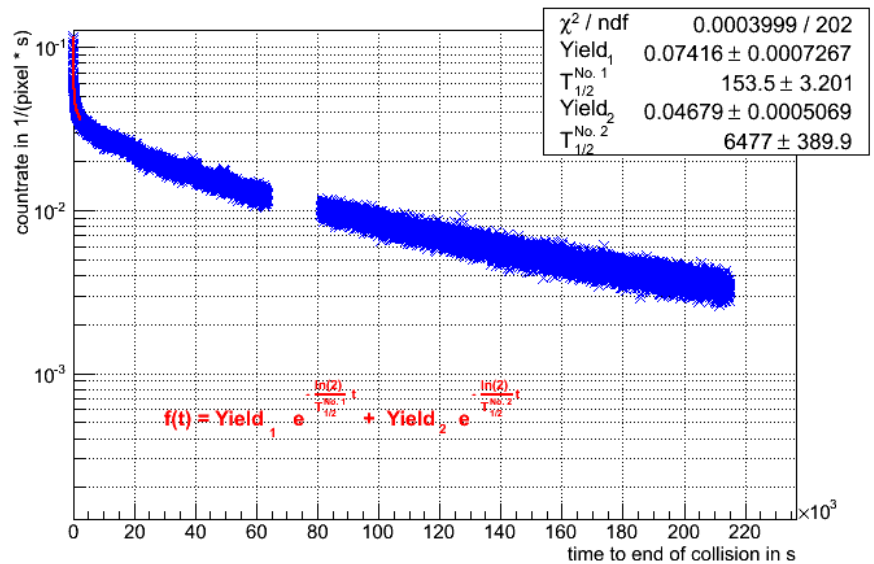

Describing the decay of activated products

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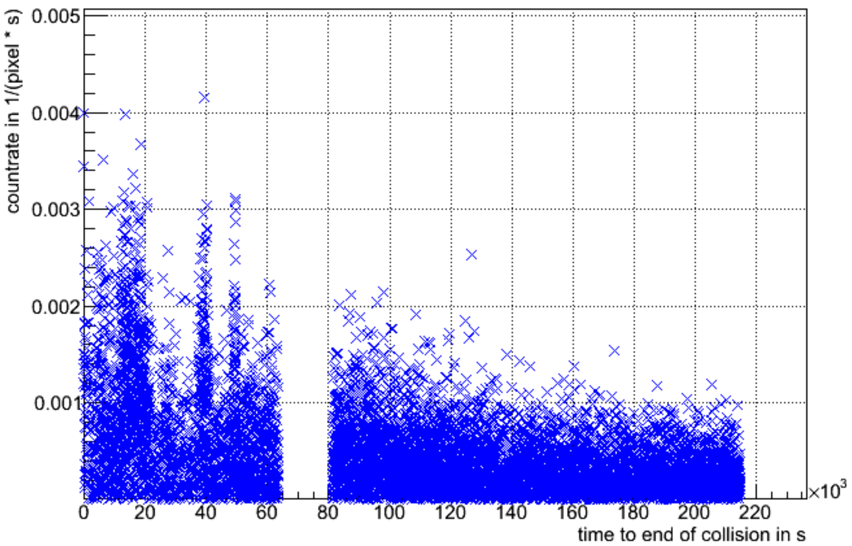

Modelling one decay region with the fitted half lifes

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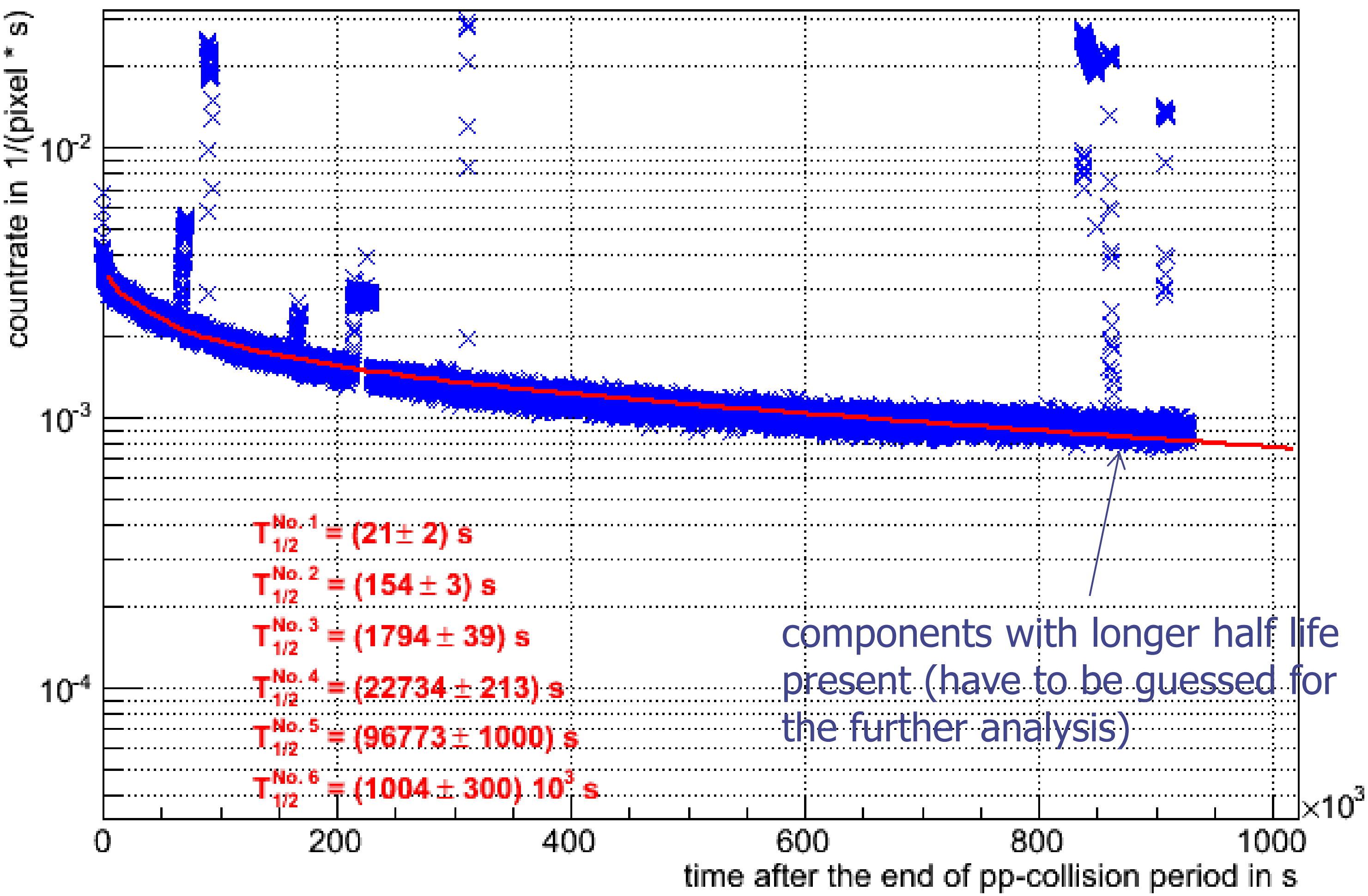


components with longer half life present (have to be guessed for the further analysis)

Equation to describe the whole set of data

$$M_{act}^{i} = \underbrace{\sum_{k=1}^{n} M_{act}^{i-1,k} \times e^{-\lambda_k t}}_{\text{Decay of atoms activated before i-th frame}} + \underbrace{\left(M_{tot}^{i} - M_{act}^{i-1}\right) \times \theta\left(M_{tot}^{i} - M_{act}^{i-1}\right) \times \sum_{k=1}^{n} Y_k \times \left(1 - e^{-\lambda_k t}\right)}_{\text{Activation during i-th frame (valid only during collisions)}}$$

Decay of atoms activated before i-th frame

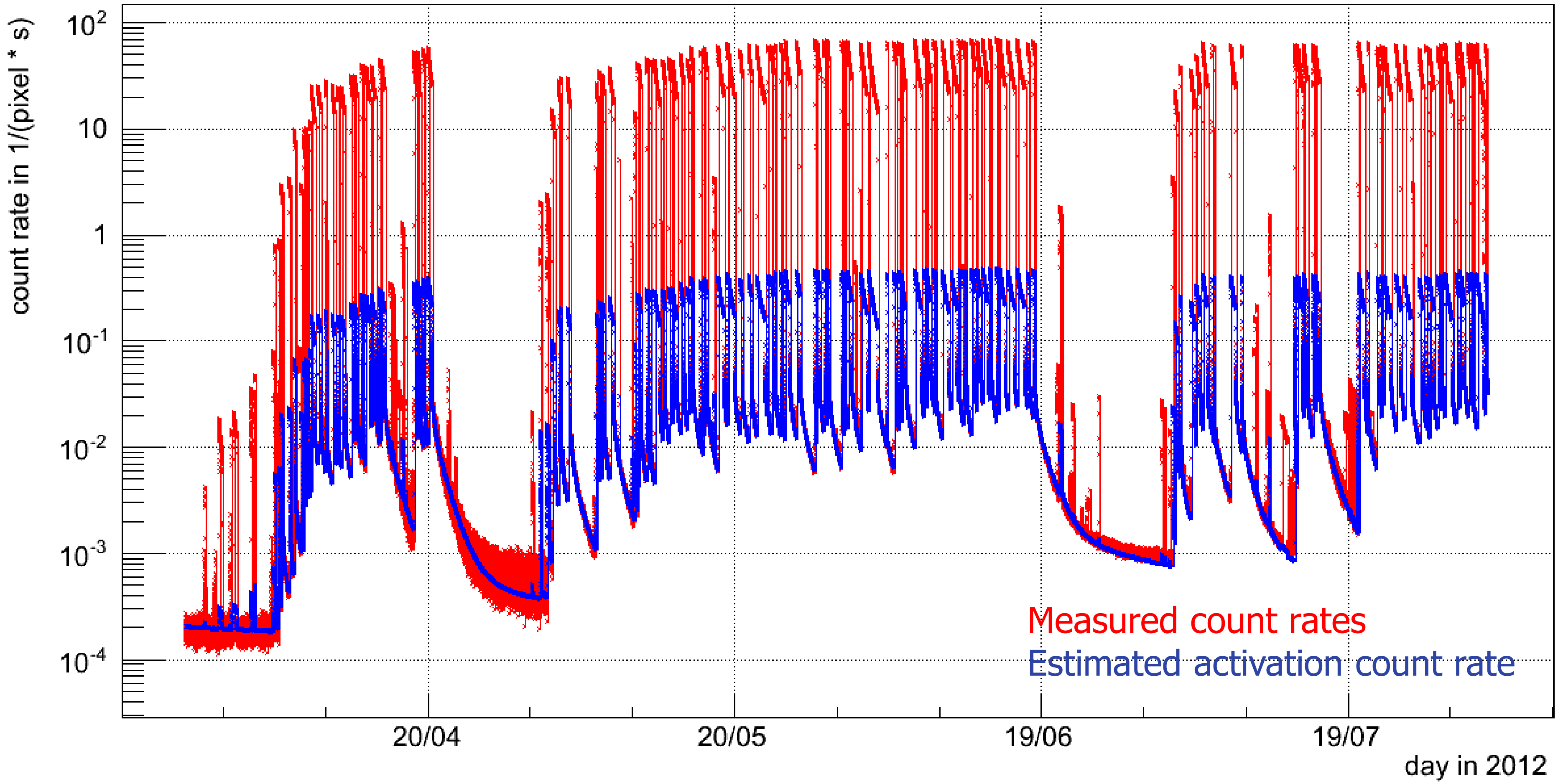
Activation during i-th frame (valid only during collisions)

M_{tot}	total count rate measured in the given MPX frame (normalized to unit time)
M_{act}	count rate caused by all activation products created until the end of the given (i-th) MPX frame
λ	decay constant, $\lambda = \ln(2)/T_{1/2}$; $T_{1/2}$ is the half-life
t	time period between the end of (i-1)-th frame and the end of i-th frame
Y_k	normalization constant, used to fit the growth/decay curve to the measured data

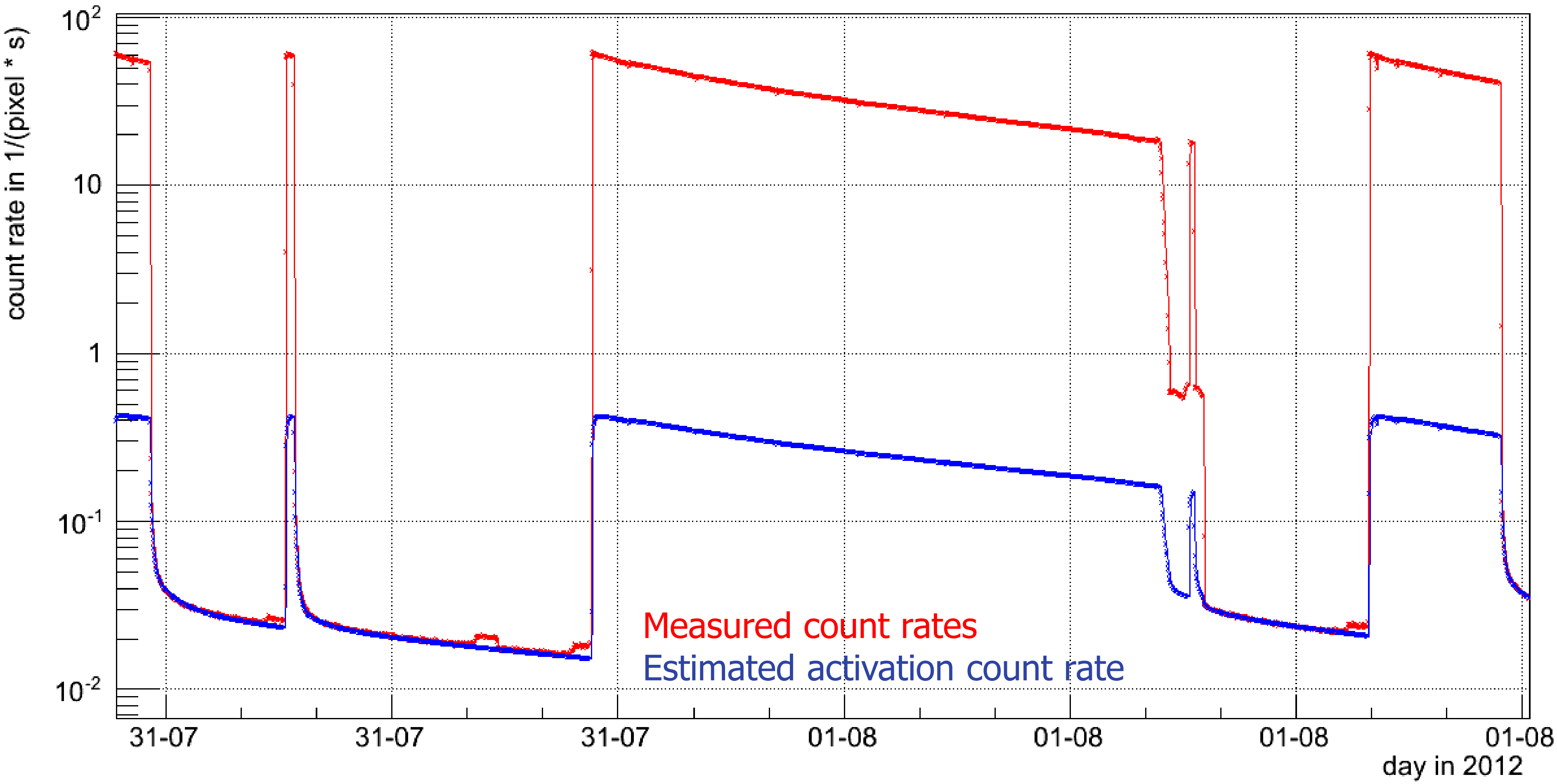
Deduced by Jaroslav Solc according laws of nuclear growth and decay

Fitting the formula to the data

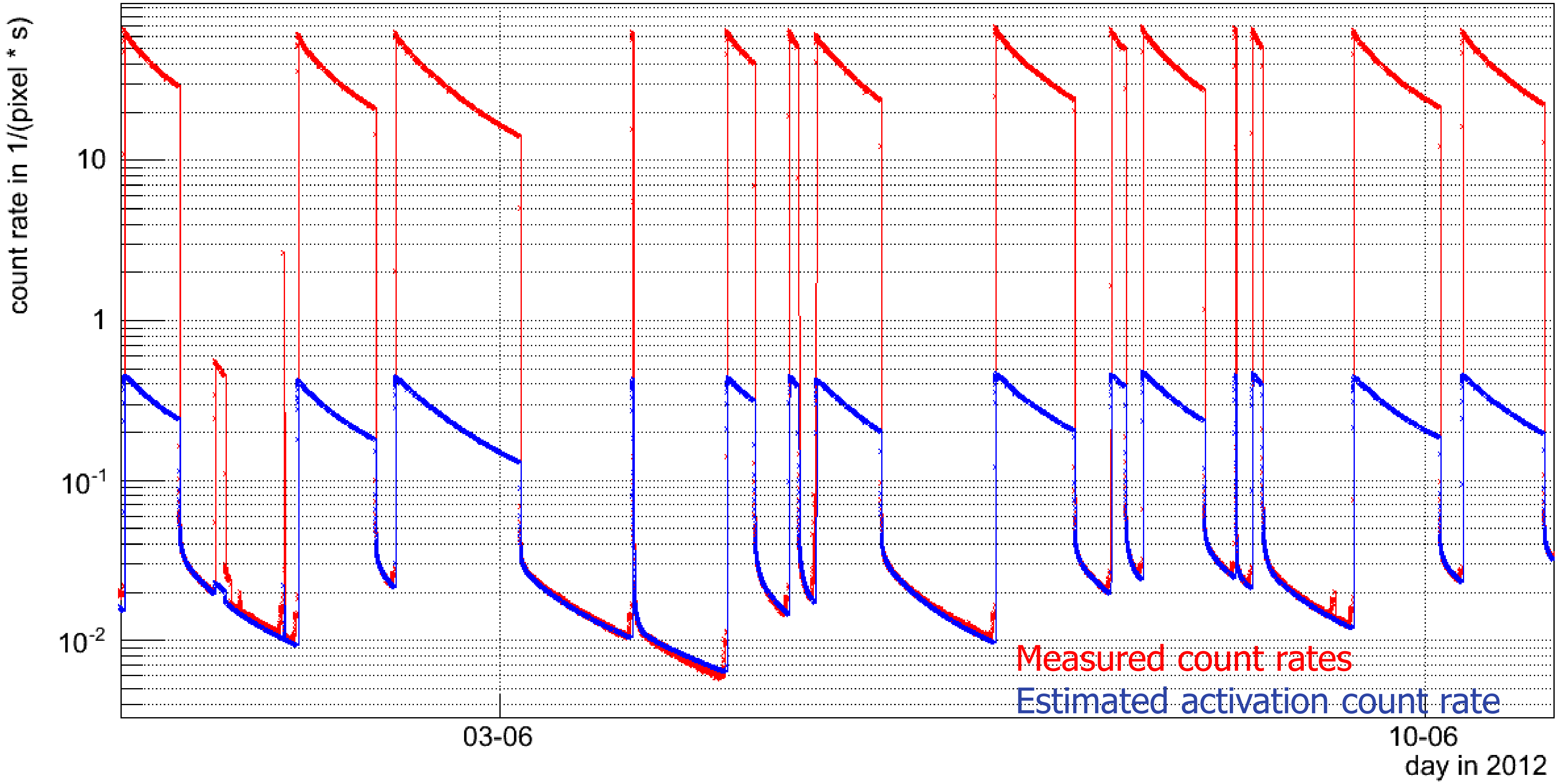
- Adapting half lifes from the fit and adding longer components
- Guessing the yields



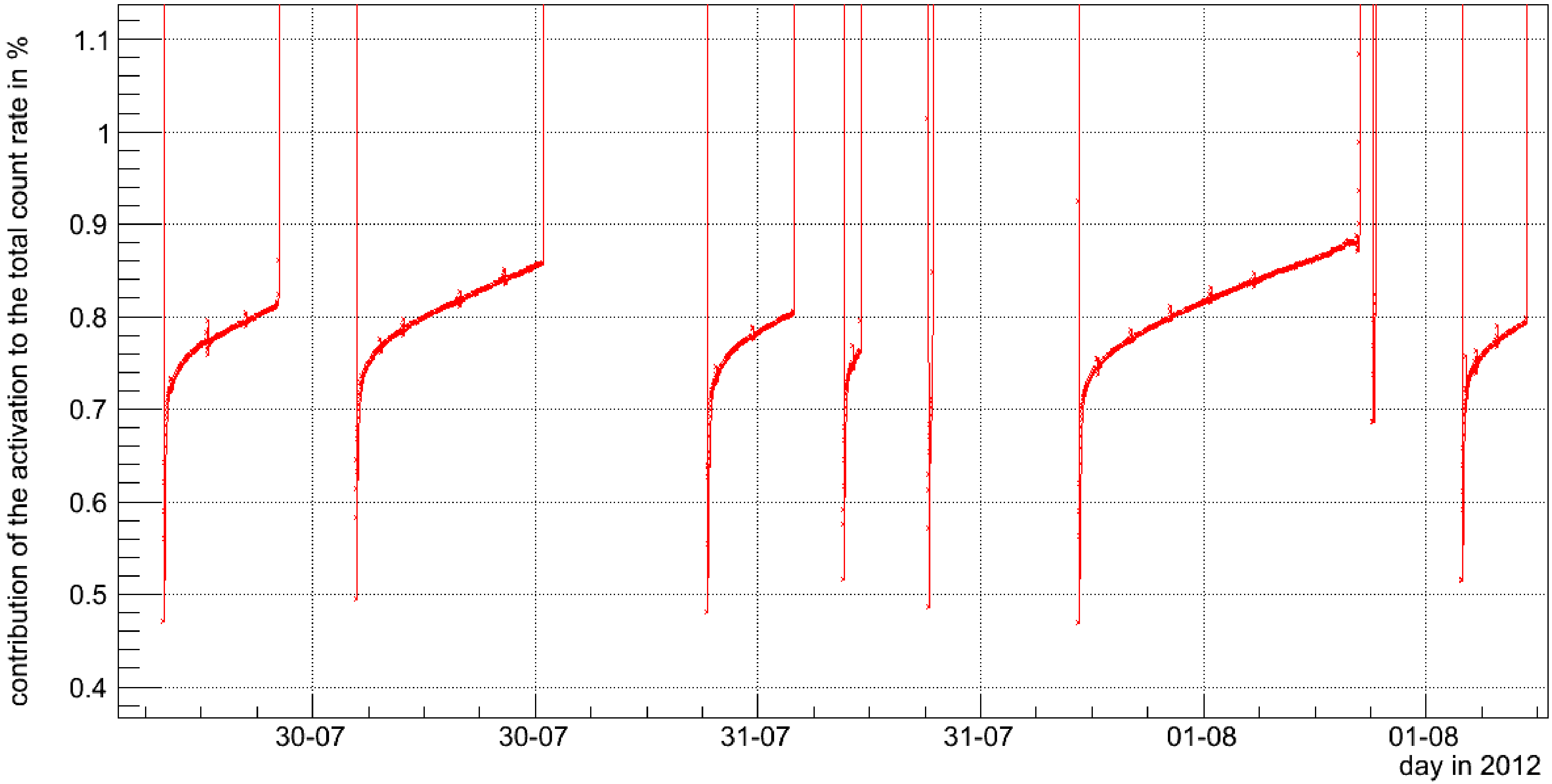
Activation – MPX01 (example 1)



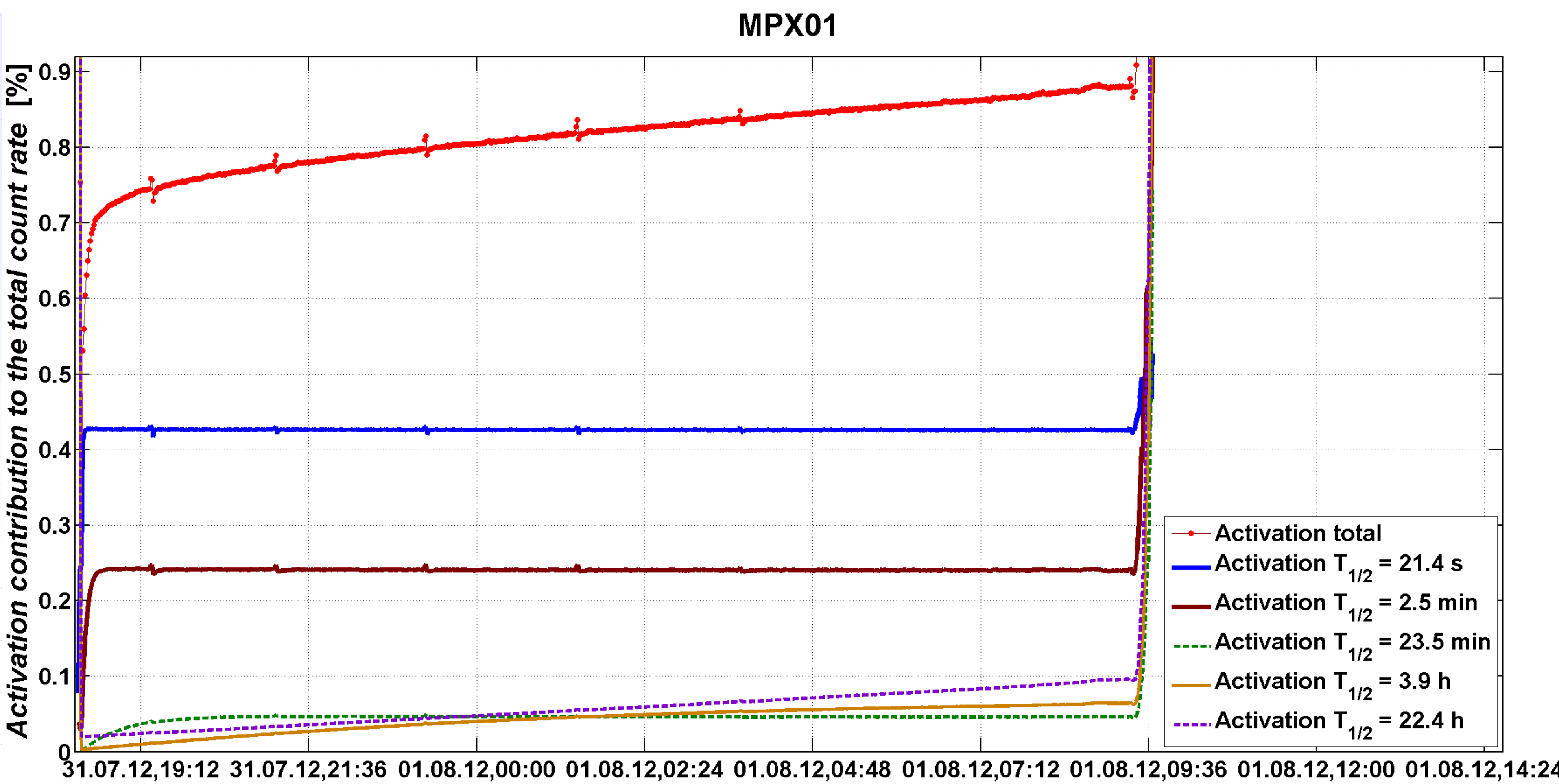
Activation – MPX01 (example 2)



Activation contribution to total count rate during collisions (MPX01)



Activation contribution to total count rate during collisions (detail)



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Overview – Half lifes and yields

MPX01

Activation component	1	2	3	4	5	6	7	8
Half-life	21.4 s	2.7 min	24 min	3.9 h	20 h	7 d	104 d	350 d
Yield	4.292E-03	2.413E-03	4.491E-04	4.860E-04	8.298E-04	6.472E-05	6.472E-05	0.000E+00

MPX02

Activation component	1	2	3	4	5	6	7	8
Half-life	21.4 s	2.7 min	24 min	3.9 h	21 h	7 d	32 d	350 d
Yield	3.816E-02	1.373E-02	2.396E-03	3.623E-03	2.667E-03	4.025E-04	1.421E-04	9.471E-05

MPX03

Activation component	1	2	3	4	5	6	7	8
Half-life	21.4 s	2.7 min	24 min	3.9 h	22 h	7 d	32 d	350 d
Yield	3.816E-02	1.318E-02	2.941E-03	3.410E-03	4.091E-03	7.103E-04	3.315E-04	9.471E-05

MPX13

Activation component	1	2	3	4	5	6	7	8
Half-life	21.4 s	2.7 min	24 min	3.5 h	19 h	7 d	111 d	350 d
Yield	3.816E-02	1.785E-02	2.832E-03	5.114E-03	3.576E-03	5.327E-04	1.894E-04	9.471E-05

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Summary

- A method was described to estimate the count rates of activated products during and after collisions
  - Estimate the background due to activation for the luminosity analysis
  - To predict time dependence of count rates after the beam is off (using known conversion factors the ambient dose equivalent rate can be obtained)
- Procedure was done for MPX01, MPX02, MPX03, MPX13 within the ATLAS-MPX detector network
  - Similar half lifes were obtaines for all detectors

Thank you for your attention!