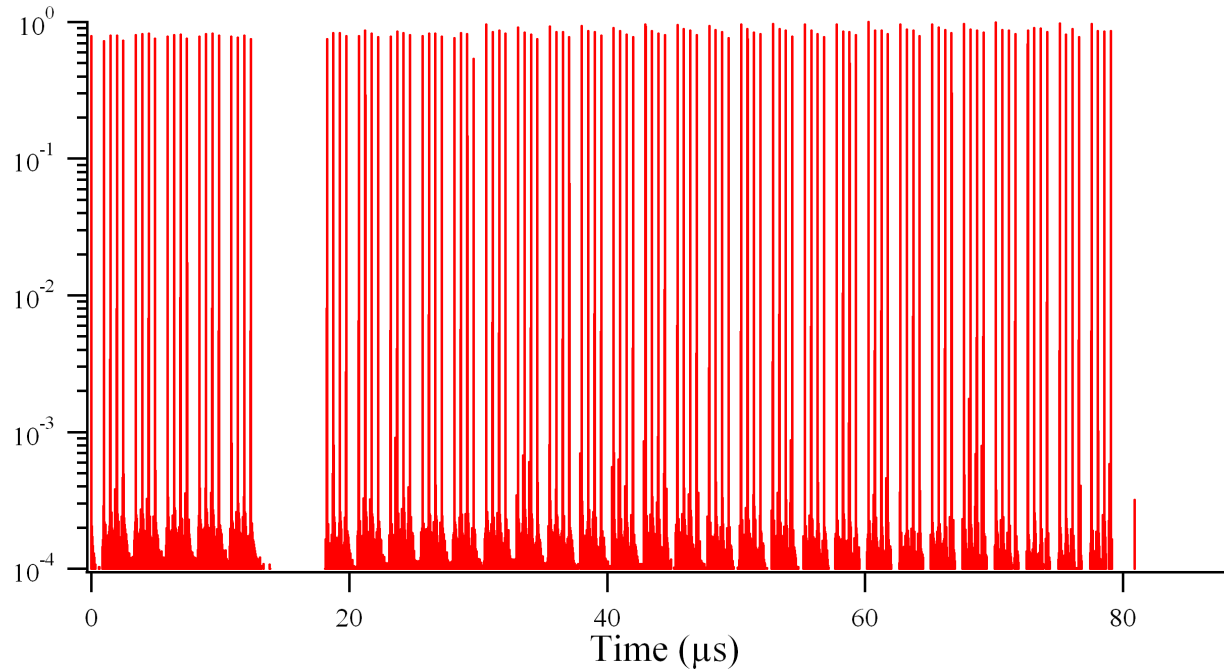


Ghosts and Satellites measured with the LHC LDM

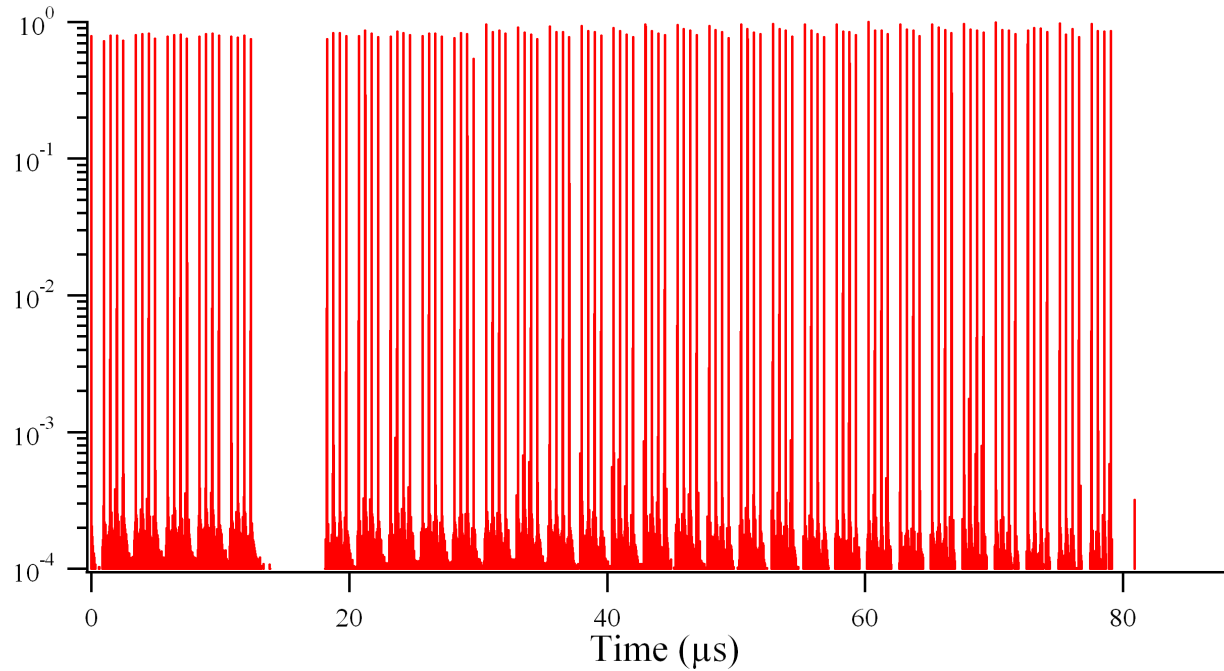
LUMI days 2012
CERN

Adam Jeff

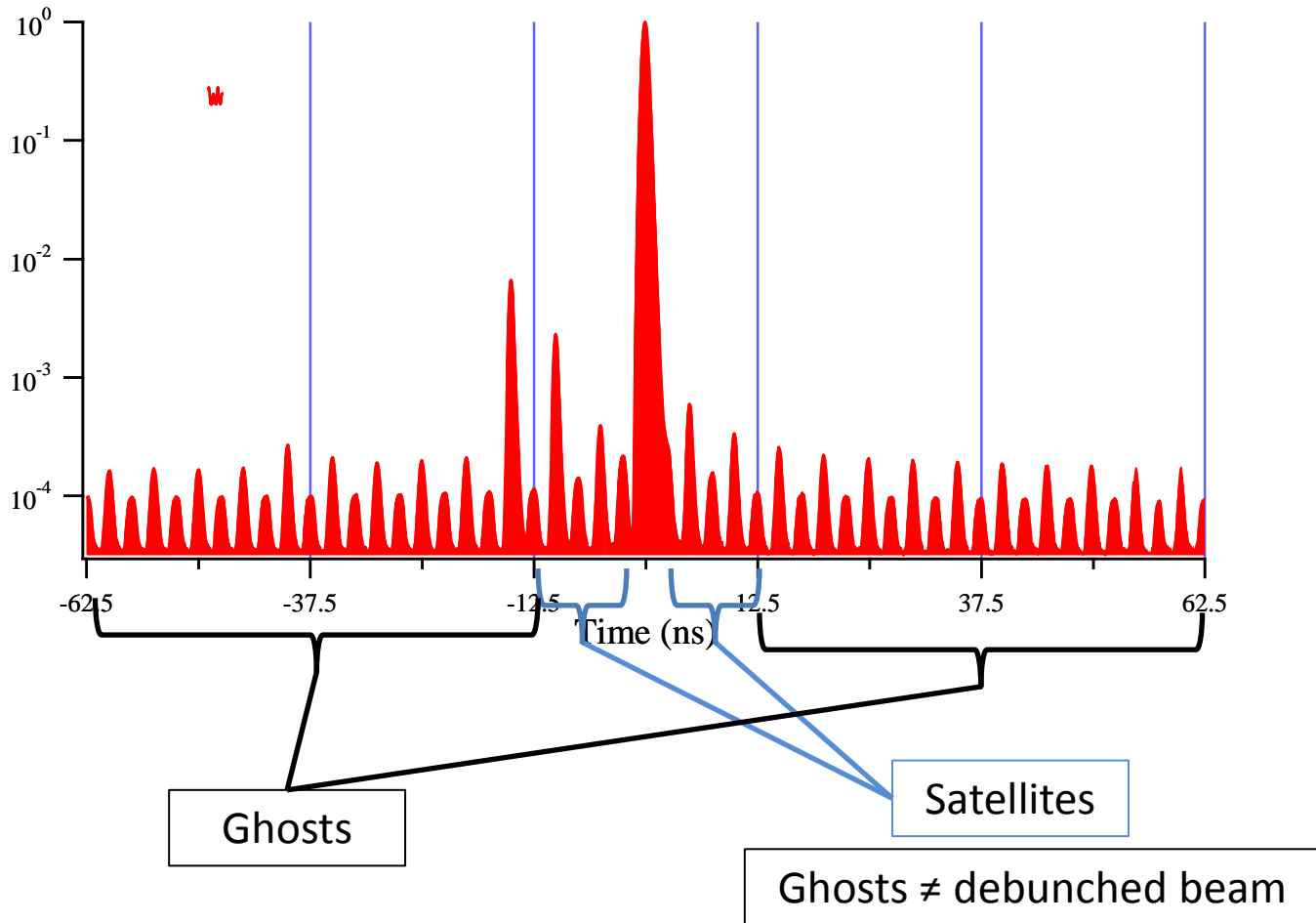
Satellites, Ghosts: definitions



Satellites, Ghosts: definitions



Satellites, Ghosts: definitions



Satellites, Ghosts: definitions

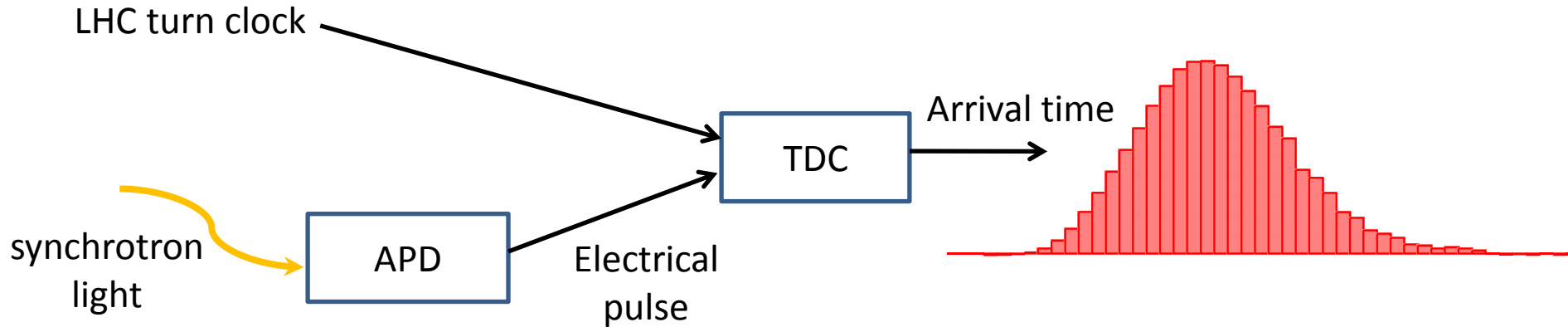
DCCT integrates **all** beam current
-> affects fast BCT normalisation

$$\cancel{\sum FBCT = DCCT}$$

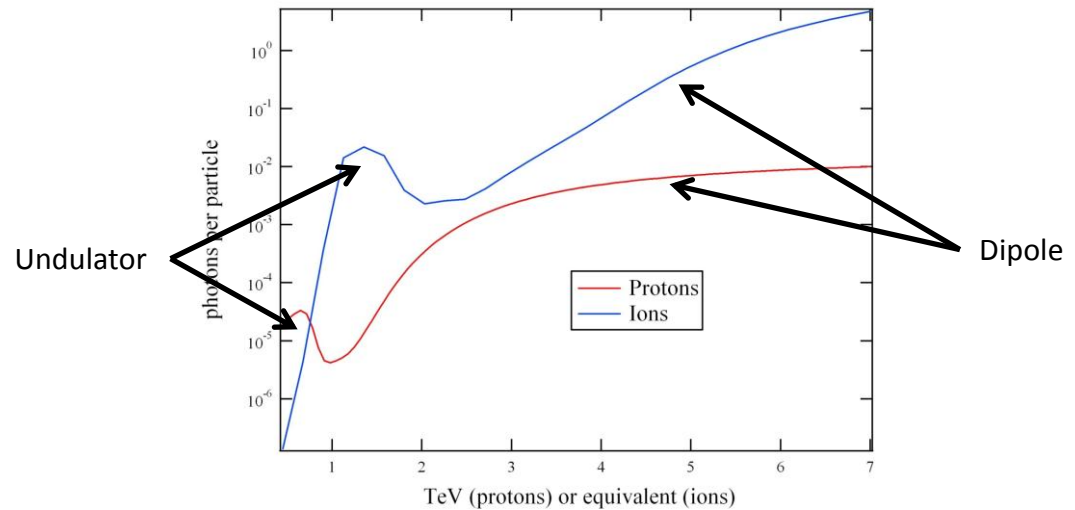
$$\sum FBCT + \sum \textit{Ghost charge} + \sum \textit{Debunched beam} = DCCT$$

Fast BCT integrates **some** satellites
-> affects relative bunch currents

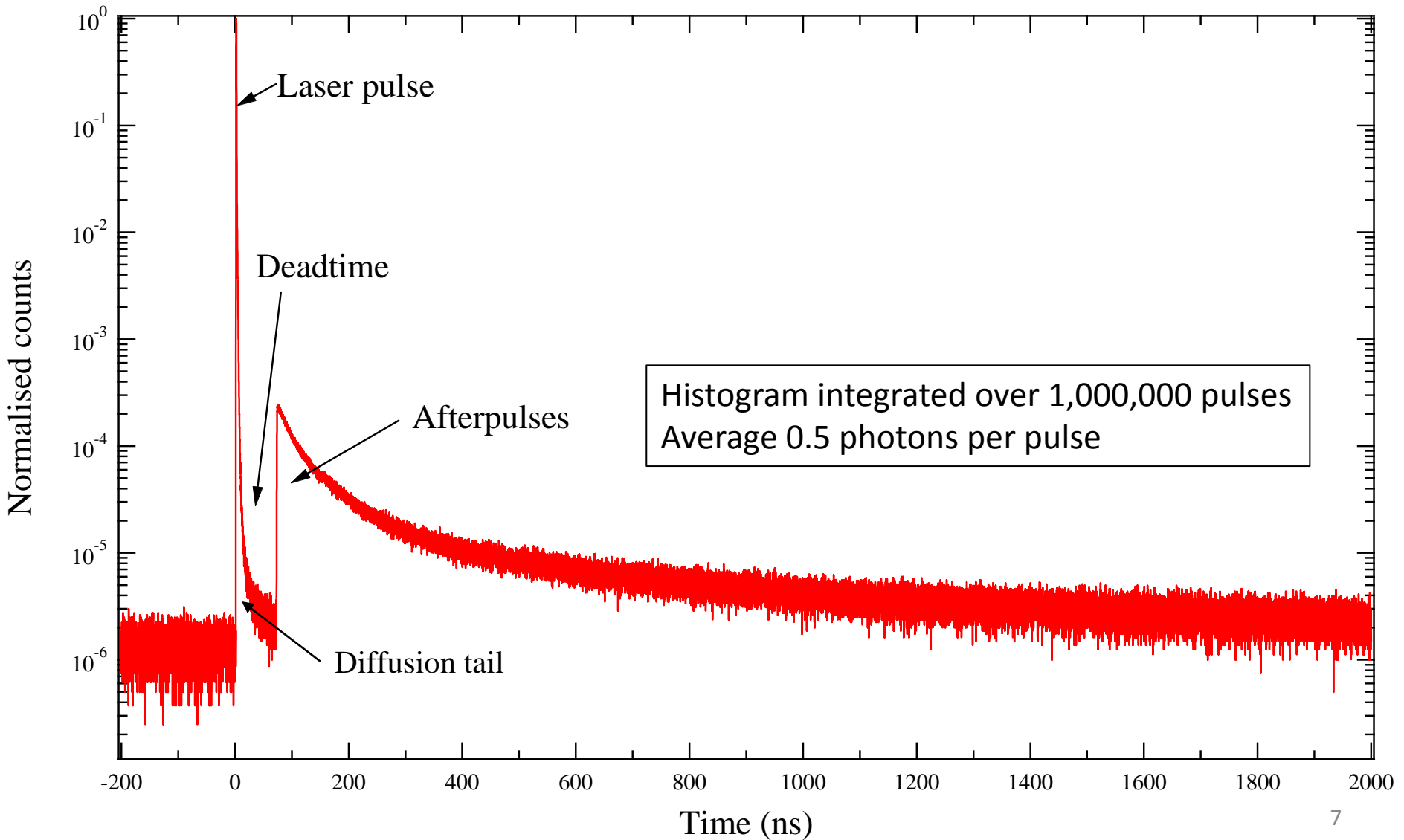
The LDM: how it works



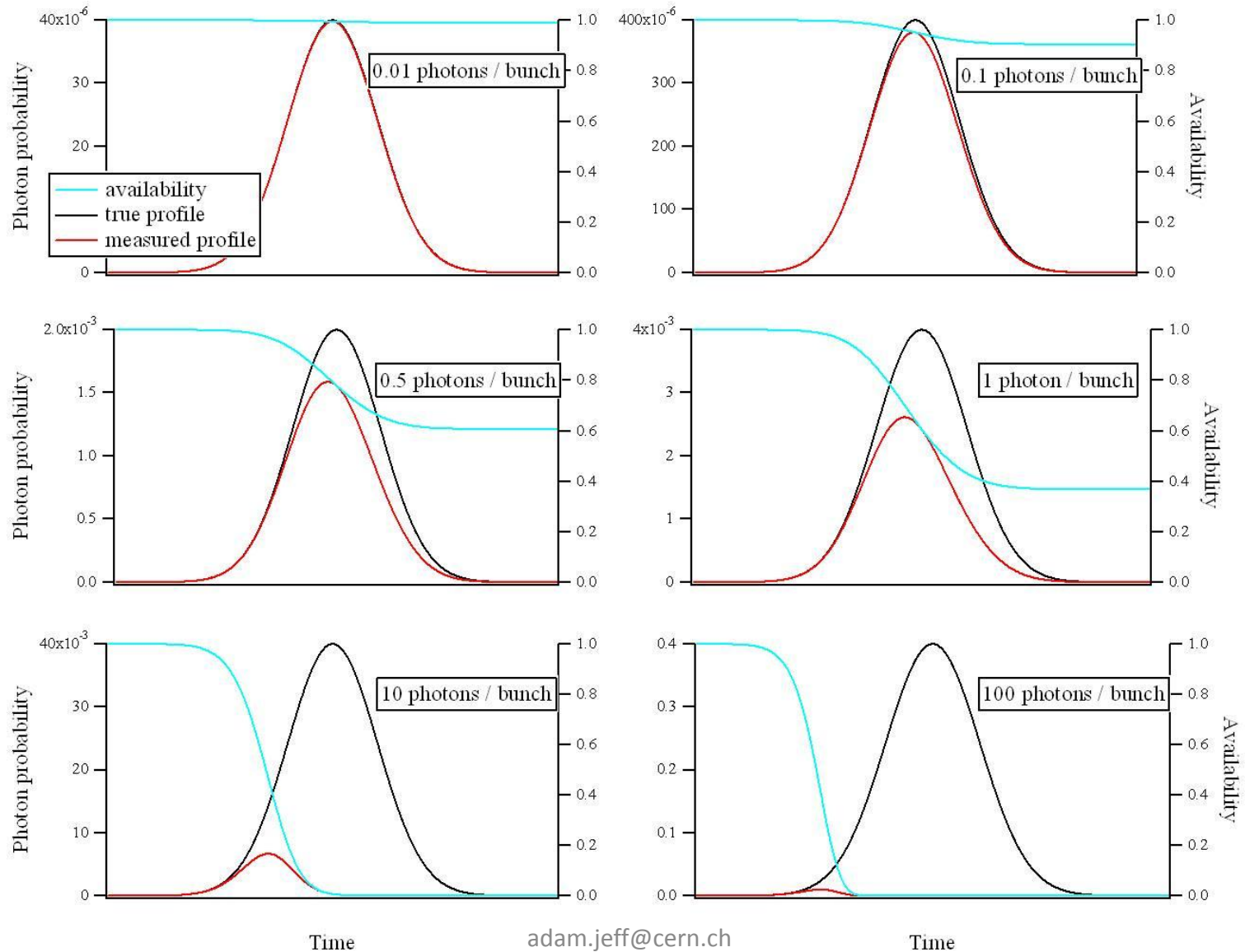
- Synchrotron light from BSRT
- Dipole and undulator at point 4
- Separate system for each beam



The LDM: instrument response



The LDM: count rate



The LDM: deadtime correction

Availability of the detector in bin i :

$$a_i = 1 - \sum_{j=i-\tau}^{i-1} \frac{x_j}{N}$$

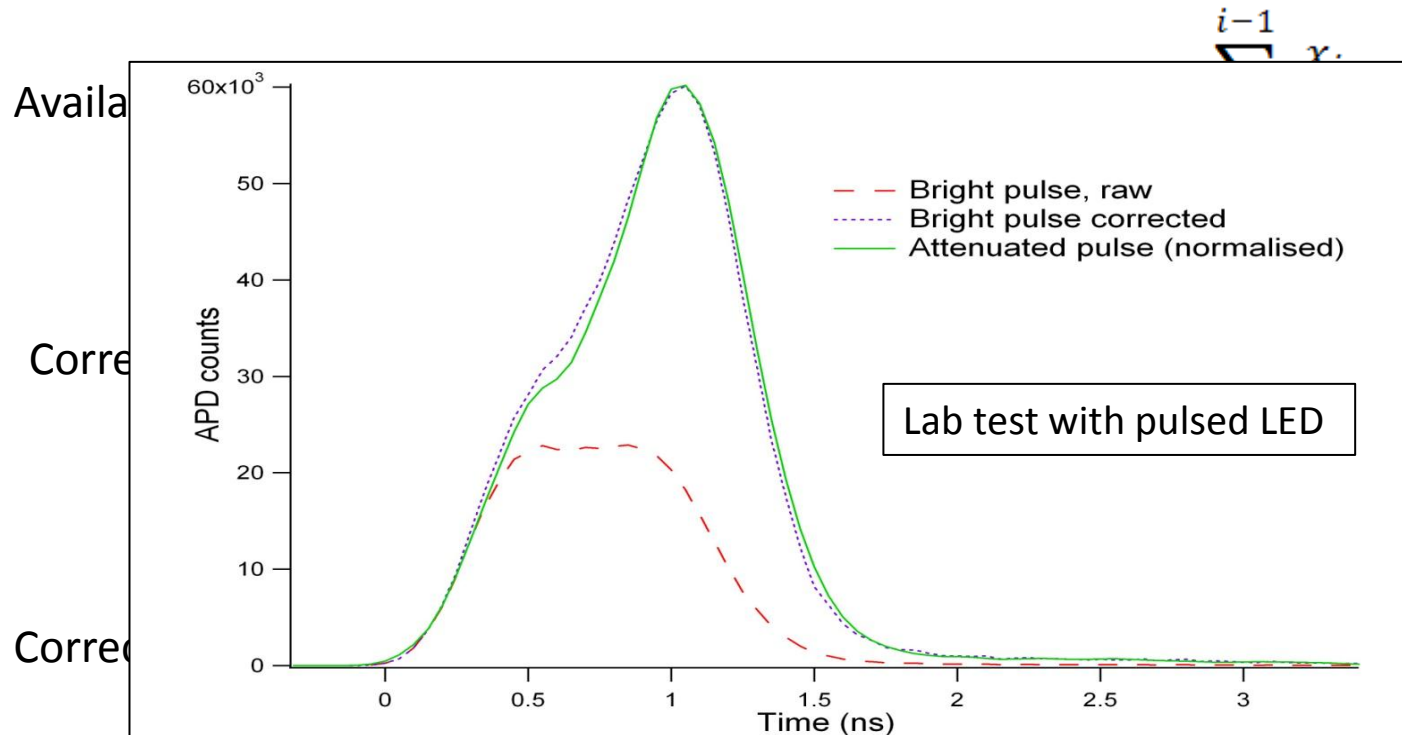
Correction for deadtime:

$$c_i = \frac{x_i}{a_i}$$

Correction for deadtime and pile-up:

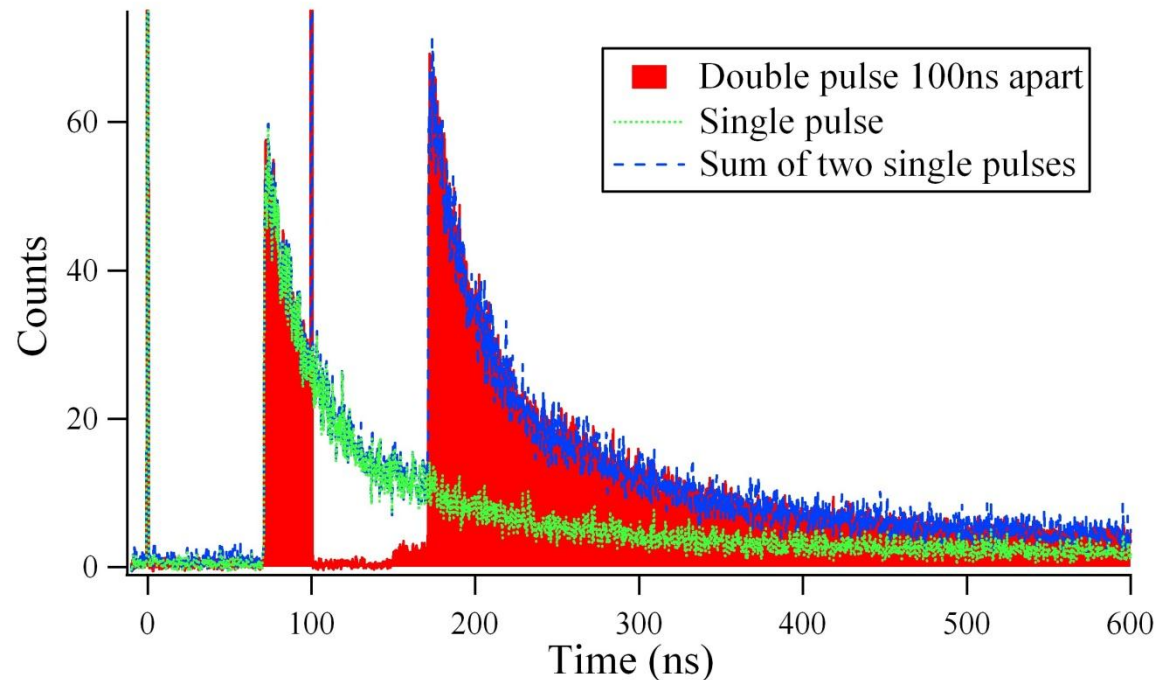
$$C_i = -N \ln \left(1 - \frac{x_i}{a_i N} \right)$$

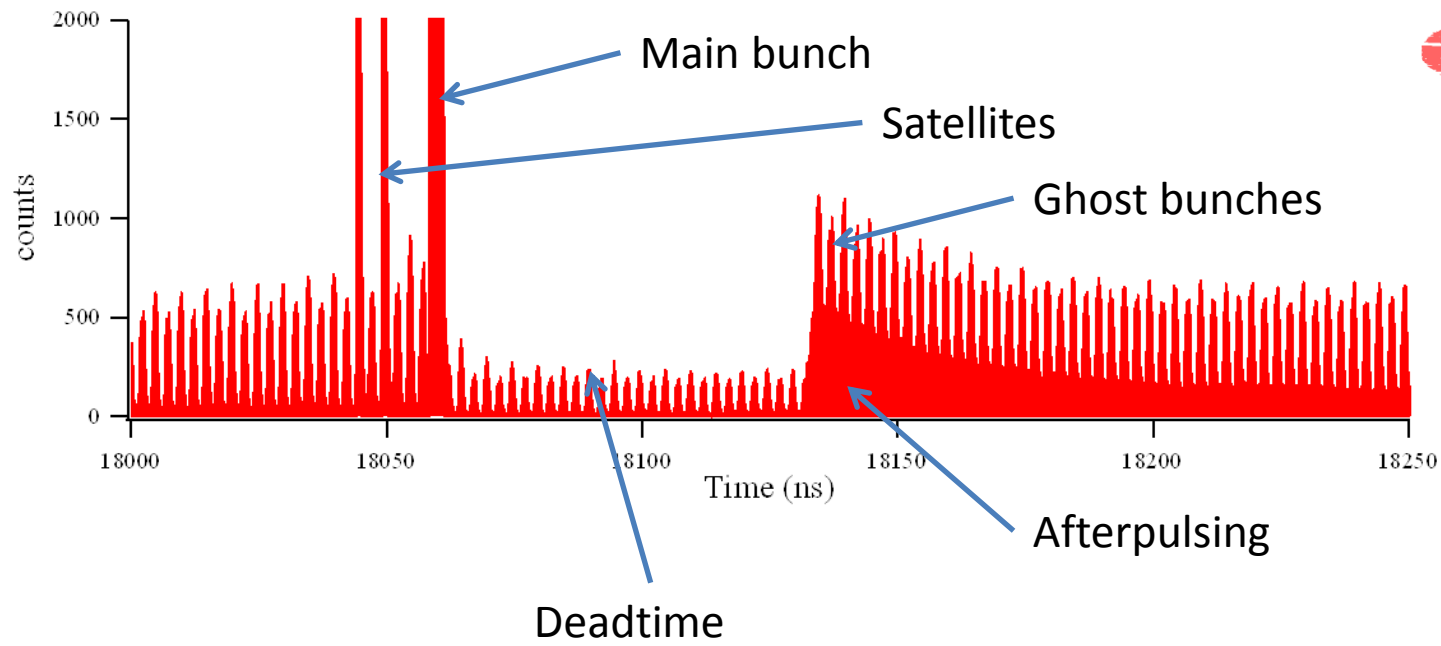
The LDM: deadtime correction

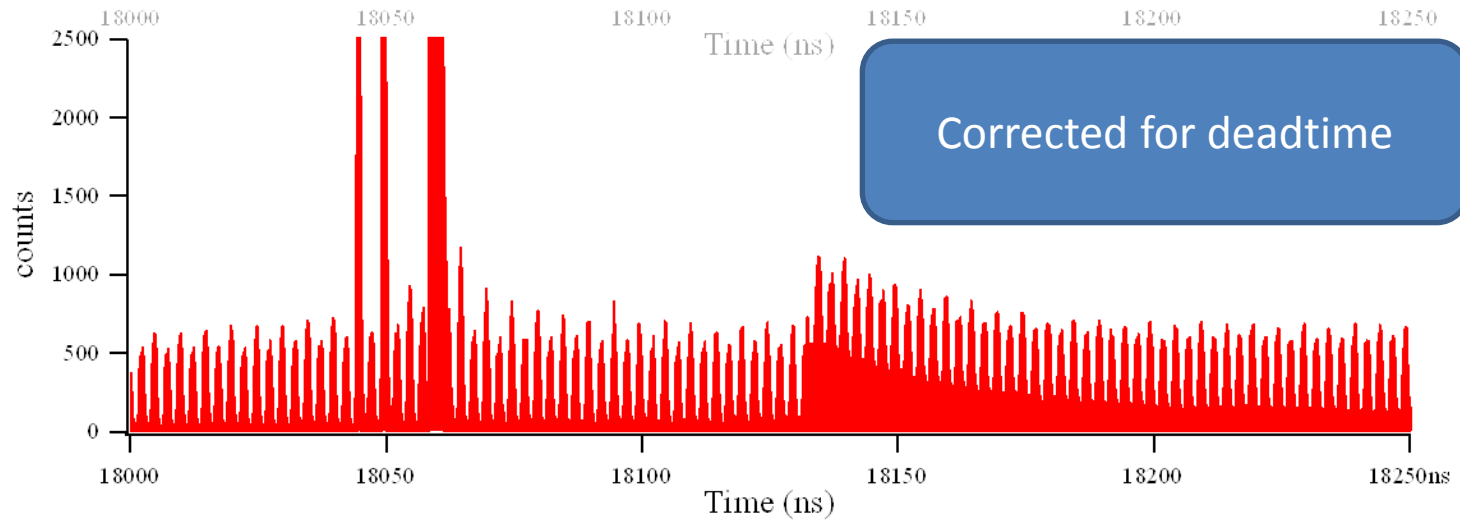
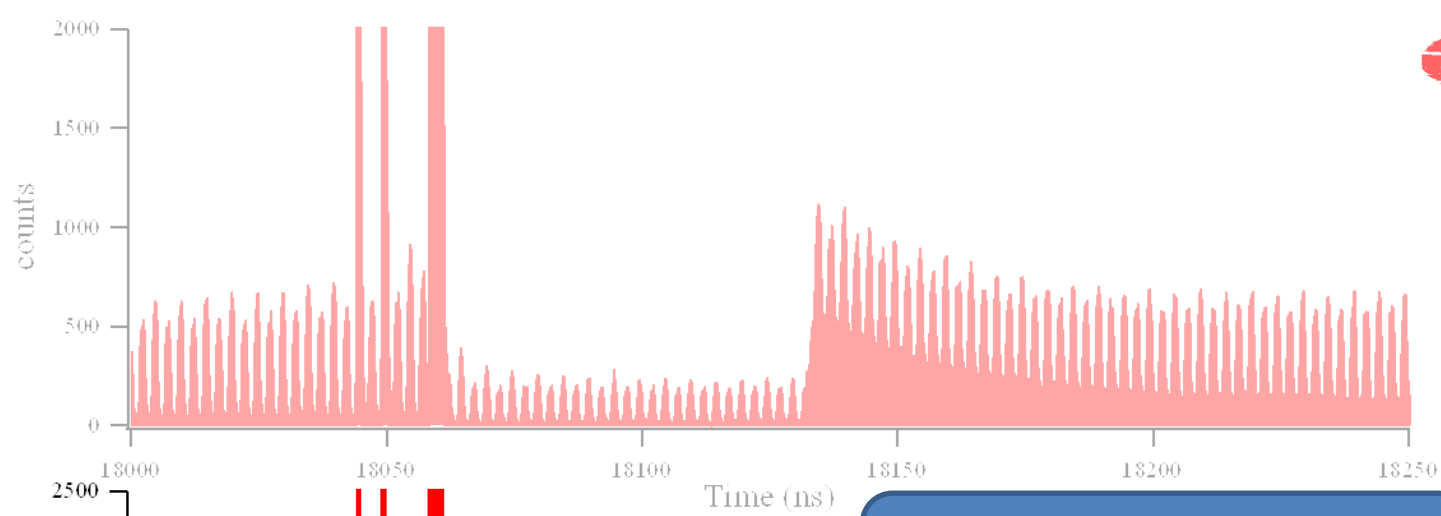


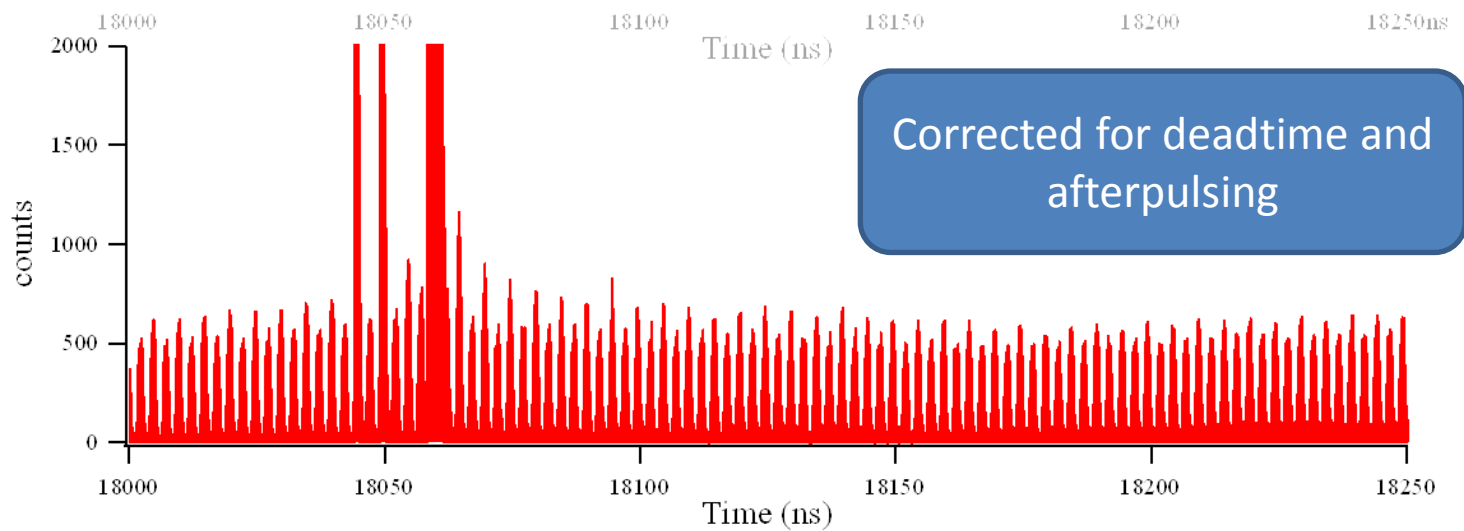
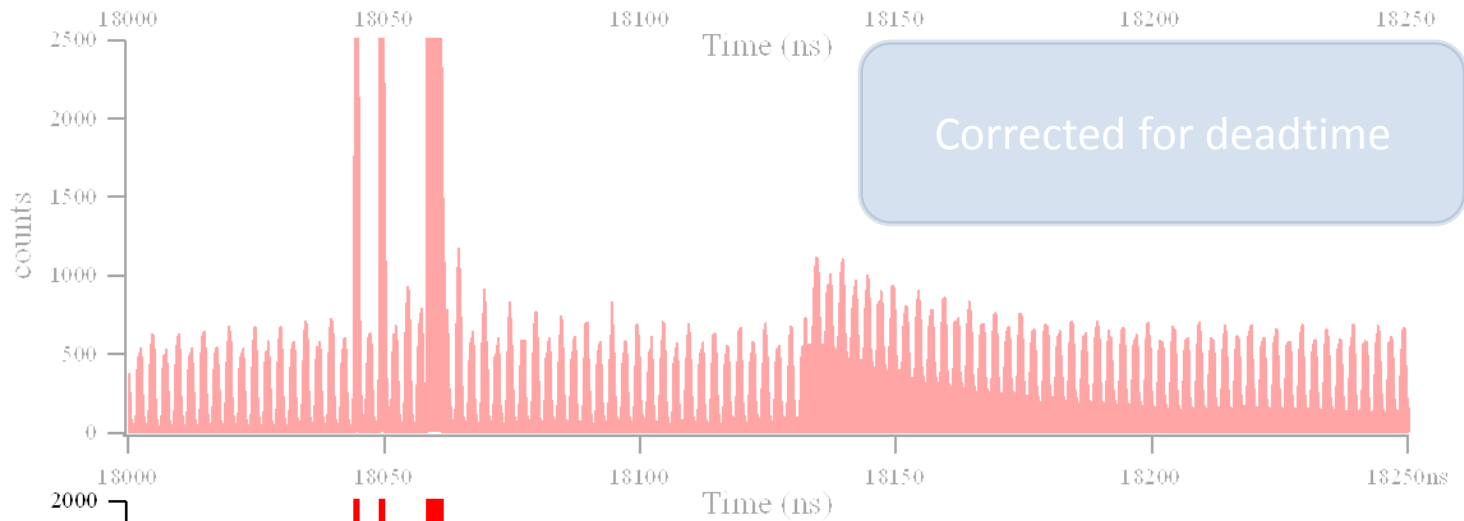
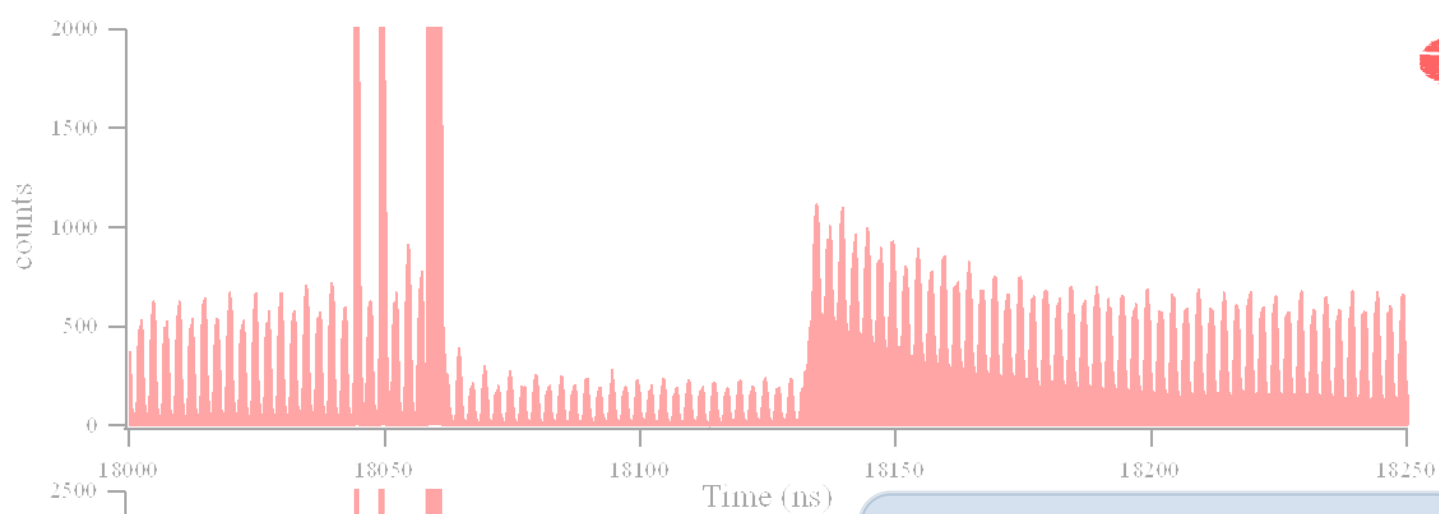
The LDM: afterpulse correction

- Trapped charge carriers can generate a false avalanche
- Happens at the end of the deadtime or some time after:
 - multiple exponential decay, half-life 100ns to few μ s
- Parameters found by experiment
- Correct by subtracting multiple IIRs

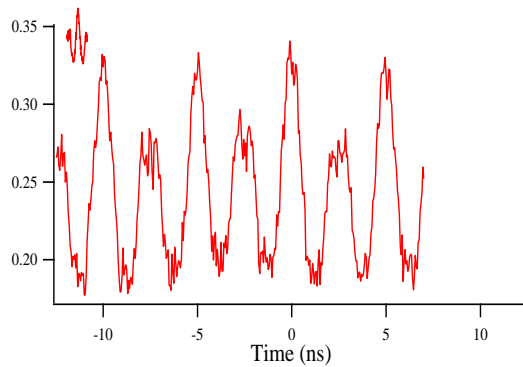
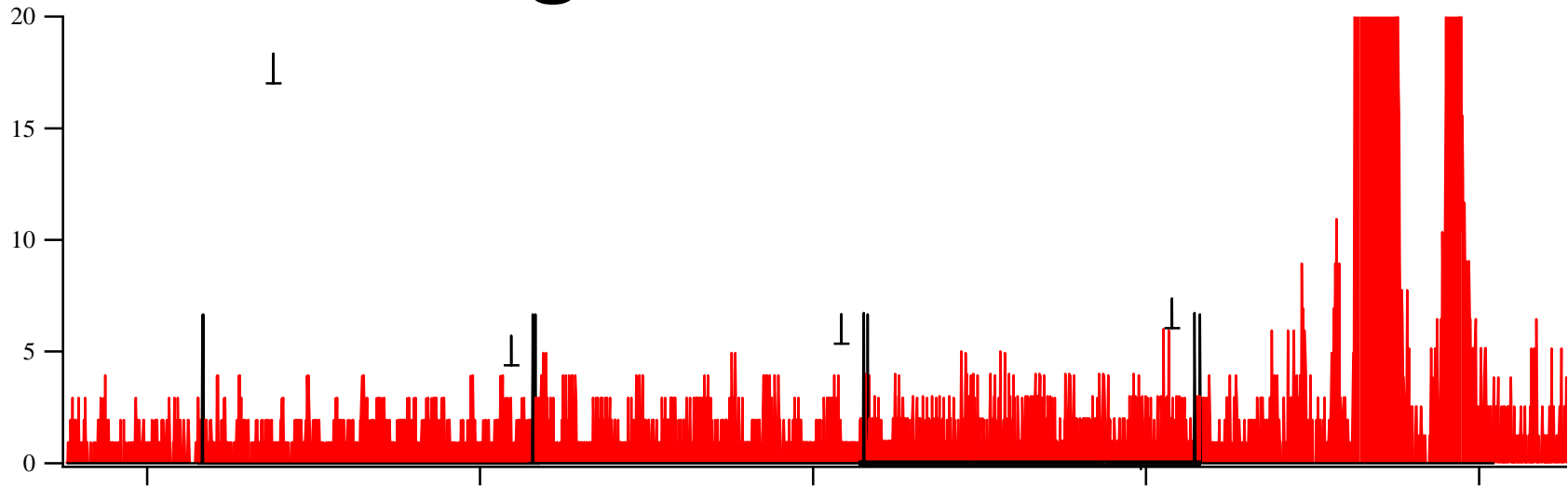




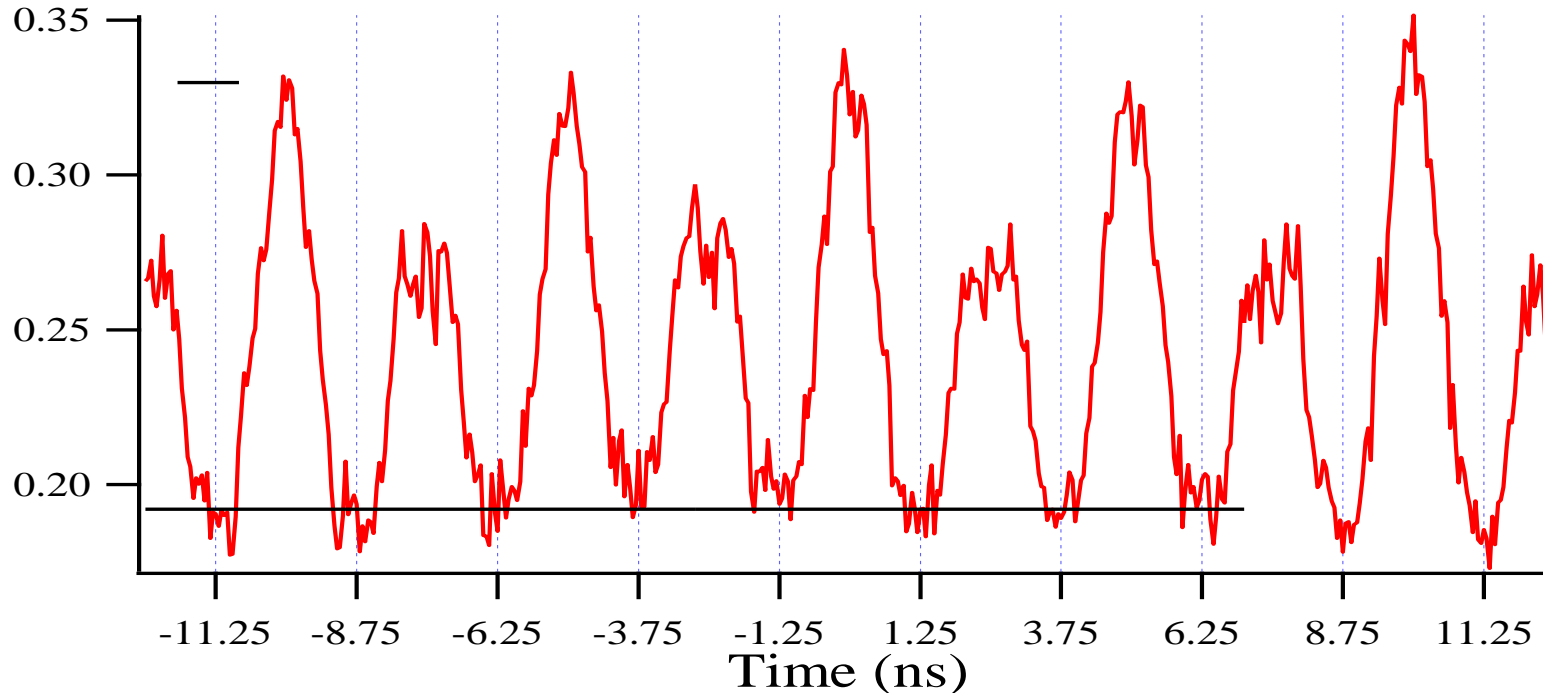




Average slots & Baseline



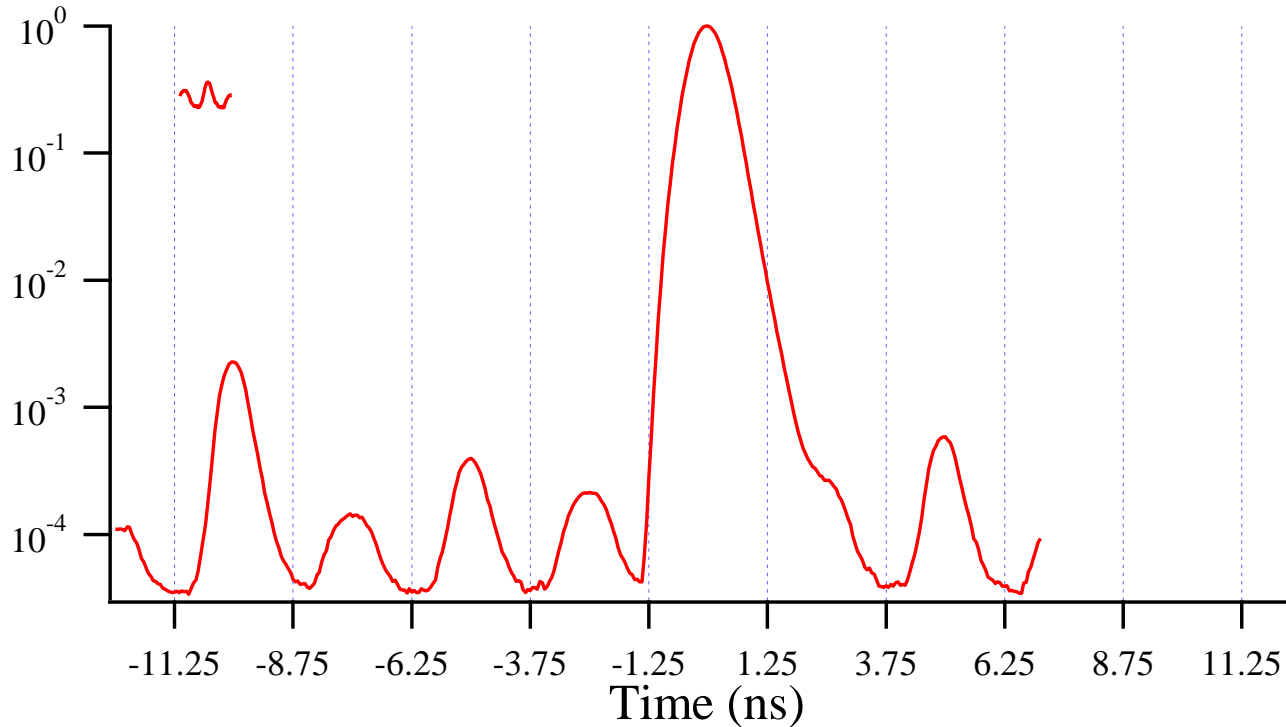
Average slots & Baseline



- Mostly due to under- / over- correction of afterpulsing
- Not equal around the ring – but we are only interested in average

Time (ns)

Average slots & Baseline



Average full slot:

The +1 bucket is swamped by the diffusion tail of the main bunch.
 -4 to -1 and +2 to +5 are counted as satellites.

VdM results: ghost charge

	Beam 1		Beam 2	
November 2010	n/a		2.5	+2.5/-0.6
March 2011	n/a		0.6	+0.6/-0.2
May	0.18	+0.18/-0.04	0.40	+0.4/-0.1
October	0.69	+0.7/-0.2	0.71	+0.7/-0.2
December f2335	3.1	+3.1/-0.8	2.8	+2.8/-0.7
December f2337	2.1	+2.1/-0.5	2.3	+2.3/-0.6

Definition: % of total beam population which is outside the filled slots

VdM results: satellites

	Beam 1		Beam 2	
November 2010	n/a		0.4	+/- 0.1
March 2011	n/a		0.1	+0.05/-0.03
May	0.02	+0.03/-0.01	0.12	+/- 0.03
October	0.21	+0.06/-0.08	0.57	+0.17/-0.12
December f2335	0.38	+/- 0.1	0.34	+0.1/-0.08
December f2337	0.28	+0.08/-0.06	0.29	+0.08/-0.06

Definition: % of filled slot population which is outside the filled bucket or the following bucket

Averaged for whole time of scan and for all filled slots – results for a subset of bunches can be calculated if you ask nicely.

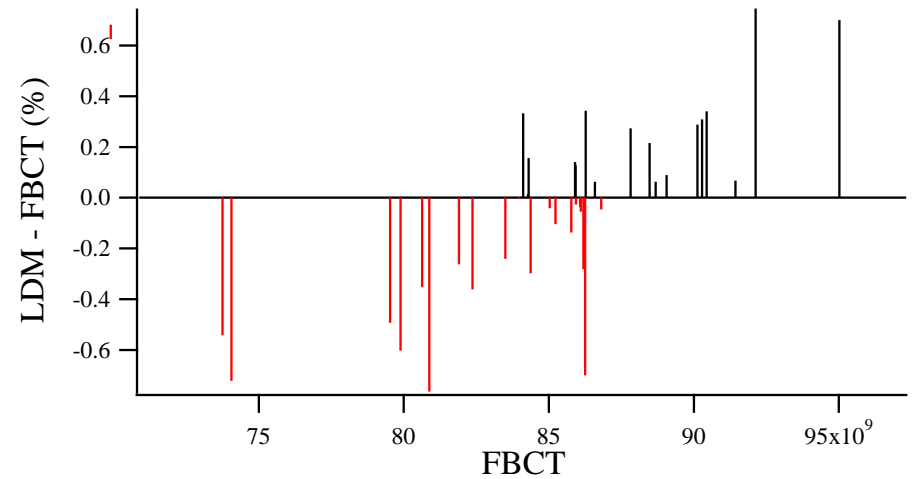
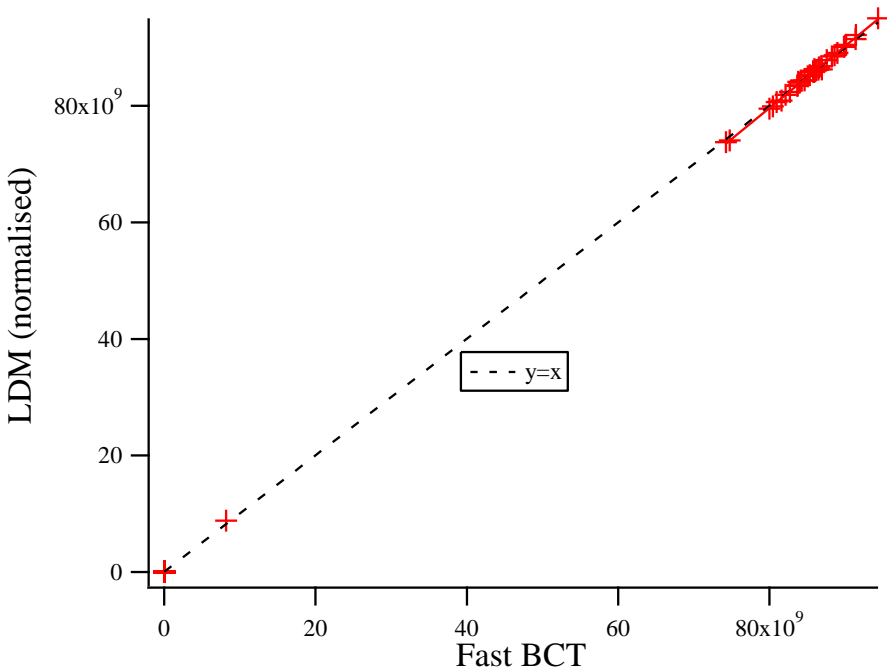
Error inventory

	Error for ghost charge	Error for Satellites
Statistical	10 %	5 %
Baseline uncertainty	12 %	3 %
Emittance dependence	20 %	20 %
Debunched beam	100 % ?!	25 % ?!
Total	-25% / +100%	-20% / + 30%

Typical values - 68 % CL

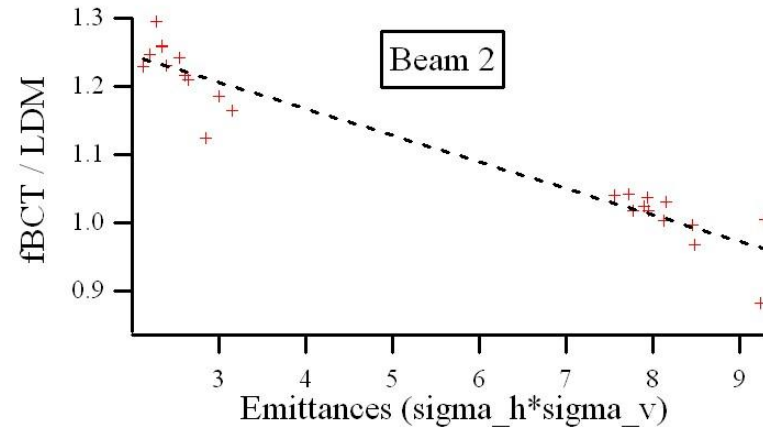
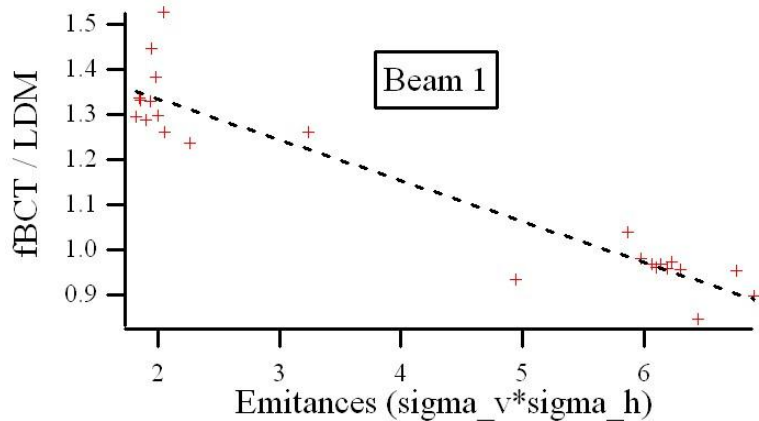
LDM baseline correction assumes zero debunched beam
 - consistent with beam gas and abort gap monitor

LDM vs fBCT



Disagreement between LDM and fast BCT on main bunch populations is usually $<2\%$
Occasionally up to 5%, probably due to emittance spread.

Emittance dependence



- Active area of APD is only 50 microns
- Beam spot size ~ 300 microns
- Samples only part of the beam spot
 - >>> Measured bunch population depends on transverse size

Thanks for your attention