Status of the AGIPD calibration activities, calibration concept.

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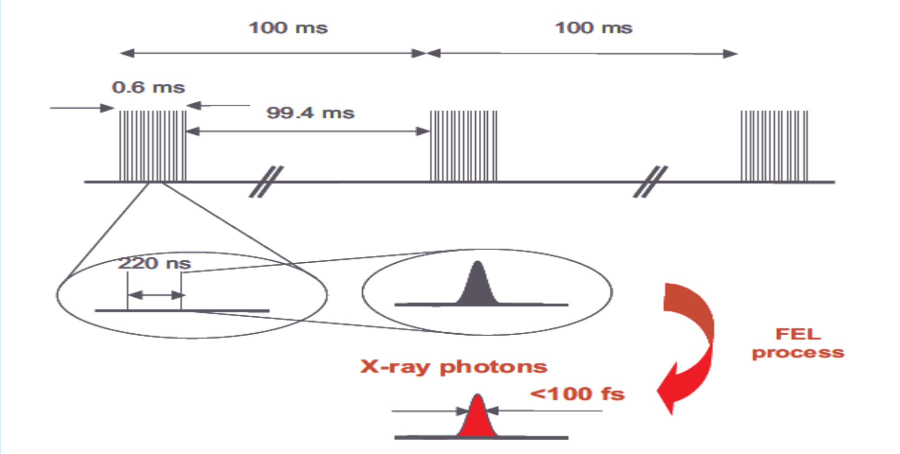
AGIPD Consortium Meeting
PSI, 03/04/2012

Outlook:

- Challenges of the calibration procedure
- Current options
- Sources & infrastructure needed
- Conclusions

Calibration main challenges:

Large energy range 10^4
Single photon resolution
4.5 MHz bunch timing (220ns between bunches)



Elements to be characterized :

- 352 cells/pixel
- 1 Million pixel
- Several points per cell
- 3 gains

~10^9 variables problem!

Need to optimize the procedure to make it fast and efficient.

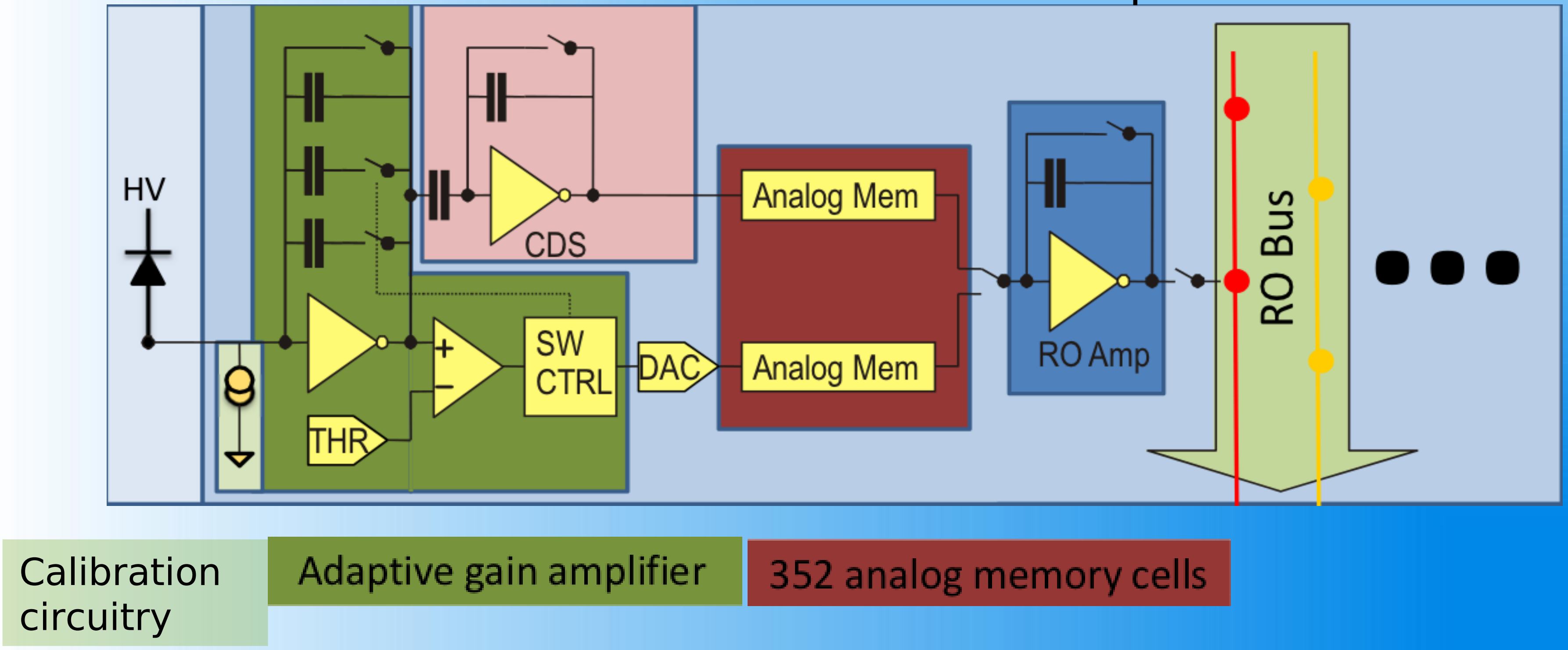
Hard to reproduce XFEL conditions without XFEL!

Elements to be characterized

Characterization needed:

- Calibration covering the 3 gain stages to convert ADC units to N of photons
- Droop check for 352 storage cells

ASIC pixel matrix



Calibration time requirements:

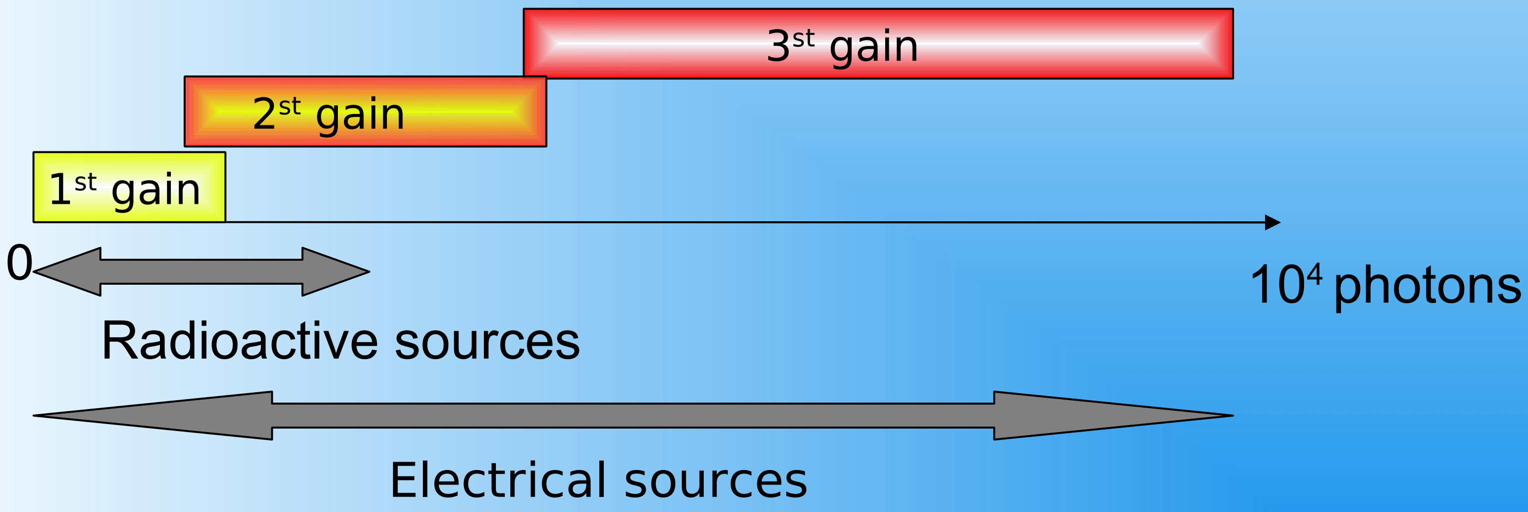
Some calibrations will need to be done more often:
each experiment: e.g. baseline, take dark images before and after experiments.

Every few experiments: take just selected point to check if some drift occurred.

Every few months (?): droop check depend on radiation therefore should be checked after certain period of exposure.

General re-calibration with more points also from radiation sources. Less frequently or in case some drift is present.

Calibration from ADC units to N of photons



Different calibration strategies will be implemented to take into account accuracy and stability of the calibration and user-friendliness.

Calibration from ADC units to N of photons

Electrical sources & radiation sources, some examples:

Electrical sources

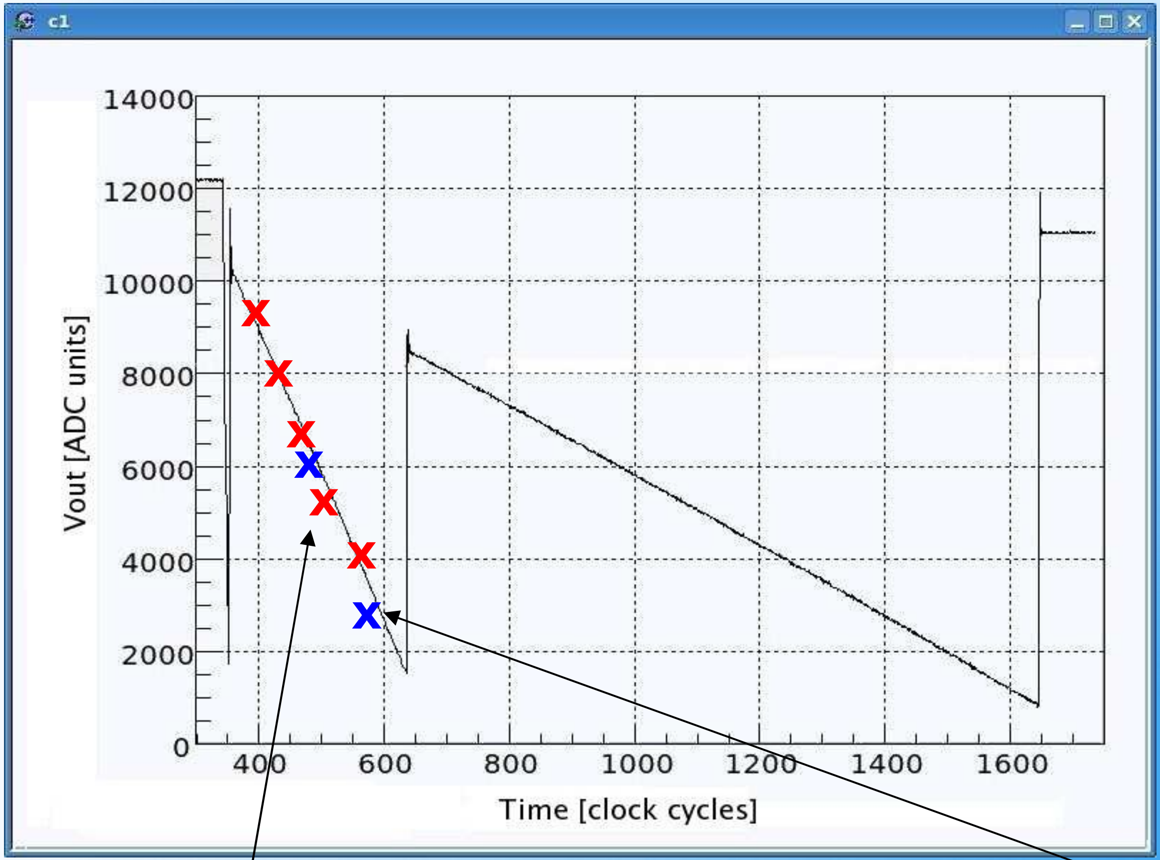
Dedicated calibration circuits for electrical calibration on pixel chip
+
global injection circuit to characterize over the pixel matrix
+

Radiation sources

uniform X-ray field which produces a common signal for all pixel and all module

NB : these are preliminary options

Calibration from ADC units to N of photons



Linear behaviour expected

Most points x collected with electrical source to extract slope & offset (quick procedure)

Fewer points x from radiation sources to cross check (slow procedure)

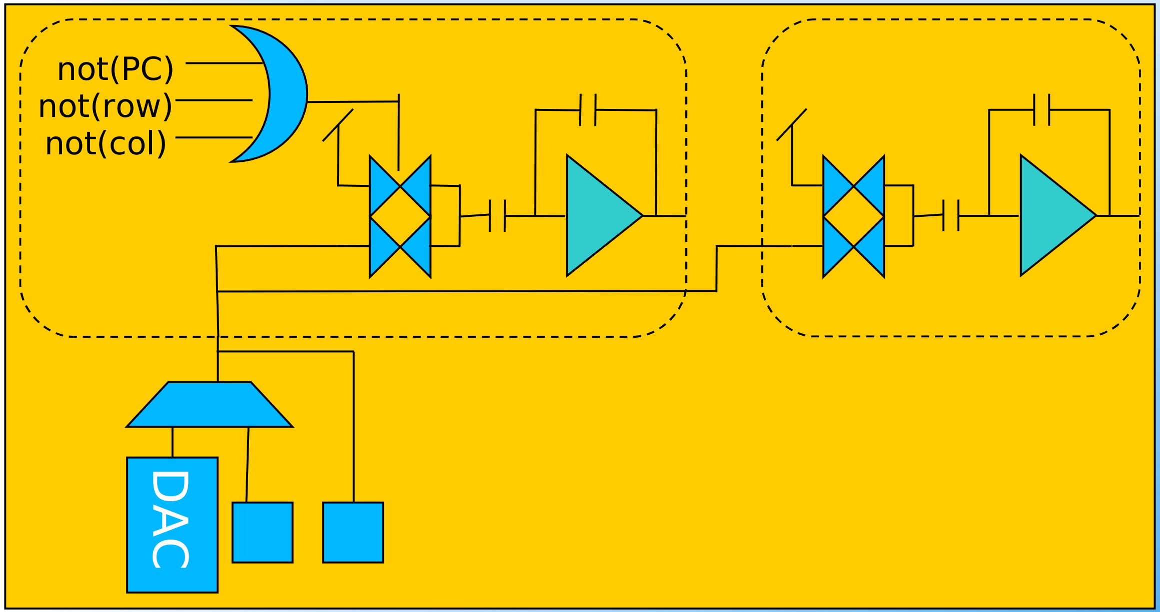
Calibration with electrical means

Some options for electrical calibration:

- Pulsed capacitor (in pixel voltage step generator) - fast
- Current source (on-chip, off-chip (?)) - slow $Q \propto T_{integ}$

Preliminary options

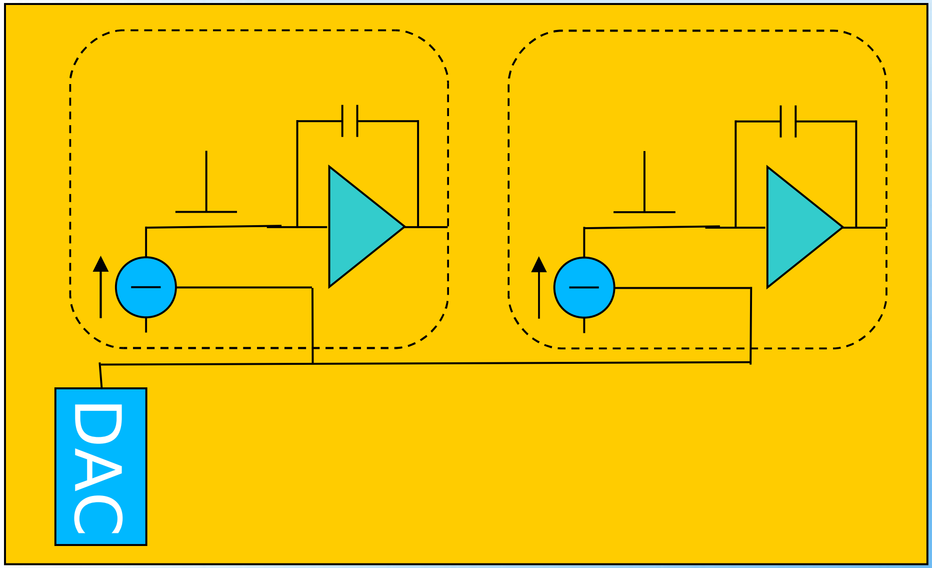
In-Pixel Pulsed Capacitor



In-pixel C pulsed by a in-chip (off-pixel) DAC. Possibility of using external voltage source

- $Q = C \Delta V$
- digitally programmable (internal DAC, 8~10 bits), external source possible; choppable in-pixel to Vdd
- can be used for ALL pixels at the same time, OR for matrix subsets (row-col addressable, down to 1 pixel at a time)
- to be used for low charge calibr. (1st gain and beginning 2nd gain)
- to be used for cross-talk estimation
- LIMITED to 200ph

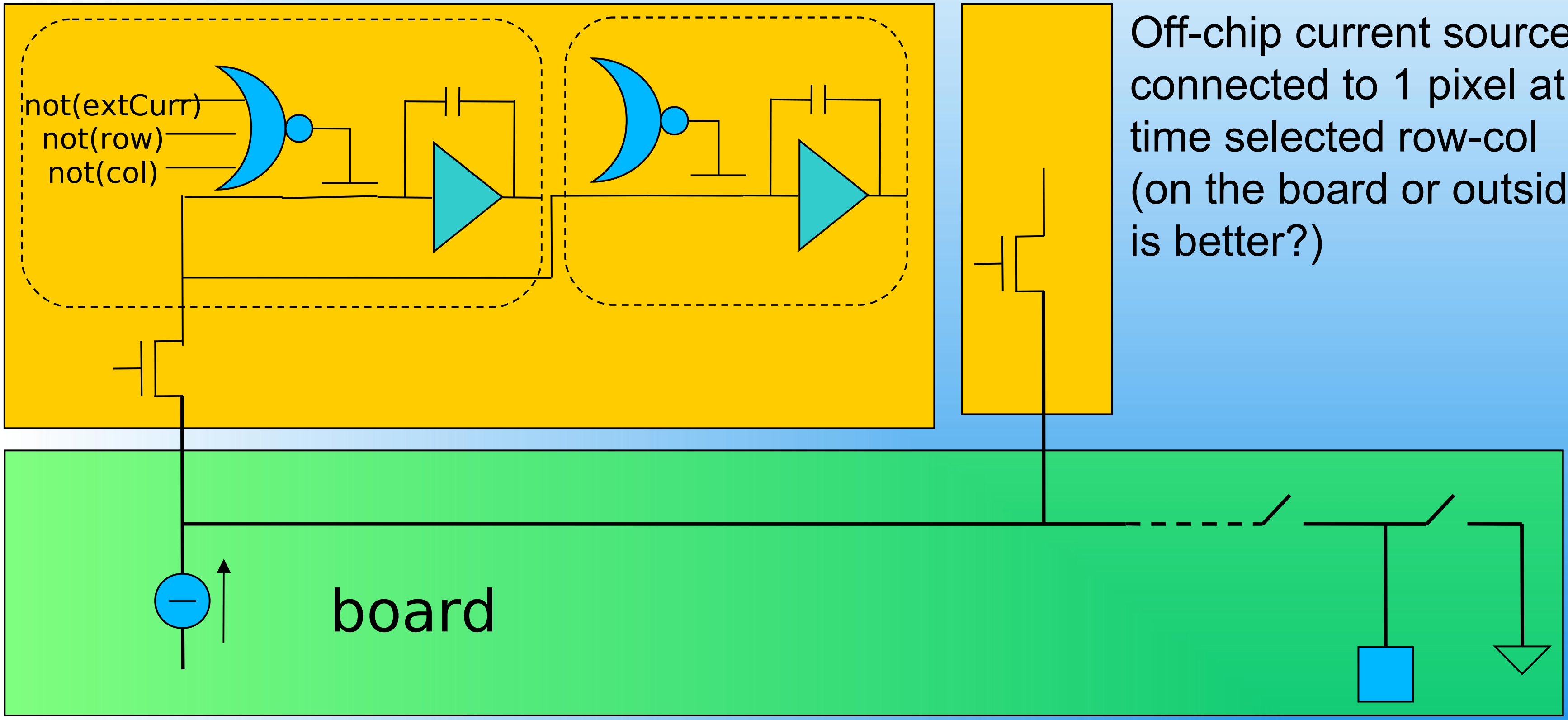
In-Pixel Current Source



In-pixel current source connected to all pixels in parallel through transmission gates

- Q=∫Idt
- digitally programmable (internal DAC, 8~10 bits) up to ~25uA
- when active, current is provided to ALL pixels at the same time
- to be used for fast (parallel) calibration , e.g.:
  - I=10uA, t=100clk@100MHz => ~18000 photons
  - I= 10uA, t=1clk@100MHz => ~180 photons (lowest setting, not many points to cross calibrate with external sources and pulsed capacitor)
  - NEED to be calibrated before use (device-to-device variations)
- <u>Issue: NEED to be verified if usable for low charges (Δt)</u>

External Current Source



Off-chip current source connected to 1 pixel at the time selected row-col (on the board or outside what is better?)

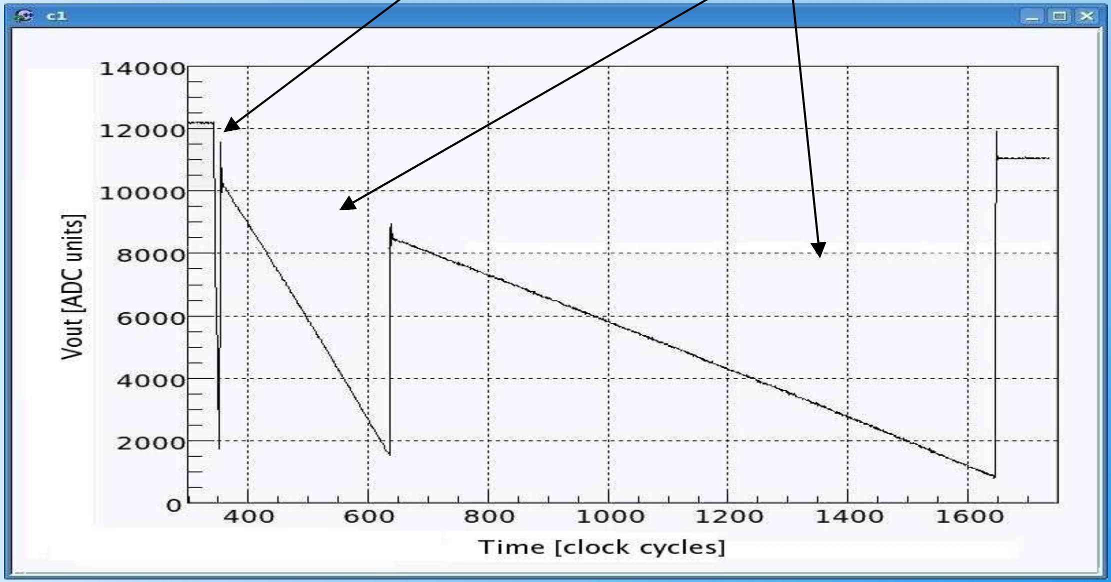
- Q=∫Idt
- MUST be connected to 1 pixel at a time
- to be used to cross-check internal sources in different chips

expected to be NOT reliable for low charges (Δt, parasitics)

Calibration from ADC units to N of photons

Pulsed capacitor 0-200 photons

Current source ~ 180-18000 photons



Pulsed capacitor + current source should cover the whole range

<u>The more they overlap the better!</u>

Radiation sources preliminary options:

Cross check of the calibration obtained with electrical sources:

- Radioactive sources:

- ^{133}Ba (KX-ray photons with energy about 31 and 35 keV)
- ^{55}Fe (5.89 keV, 6.49 keV)

alpha sources (to reach higher energies - 2nd gain) :

- ^{241}Am alpha en: 5.4 MeV (e.g. commercial source from Ortec: 0.1μCi (3700 counts/sec)

(Issue with radiation sources : low counting rate, long integration time, only 1st gain and half of the second covered).

Maybe use a mask in front of the detector to reproduce point source, (to avoid charge sharing).

- Light source: lamps (issue with the Al coating over the sensor, could be etched away(?). Possible for preliminary tests but difficult for routine checks during operation)

Radiation sources options:

X-ray sources:

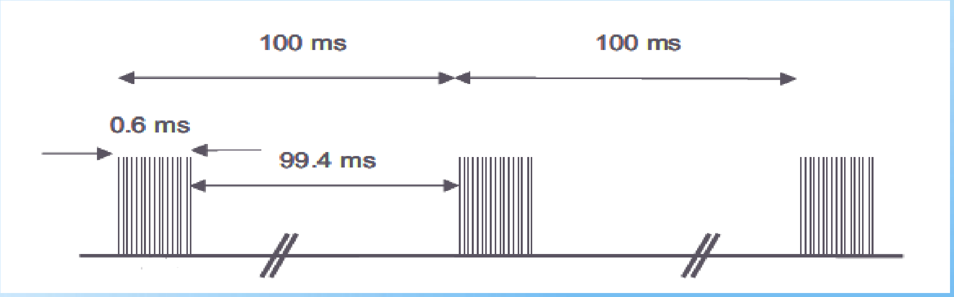
-standard x-ray tube to test general performances.
Flat field source (possible targets: Cu(8 keV), Mo(17.5 keV), Ag (22 keV))
High power x-ray fluorescence tube

e.g. commercial Amptek Mini-X with Ag target with filter (k_α line ~22keV)
(10^6 counts per second/mm^2 → 0.04 counts per microsec/pixel (1 pixel=0.04 mm^2) → too long integration time to cover the whole energy range (~ up to 250ms! x 10^4 photons), but still good for some test.

Preliminary options

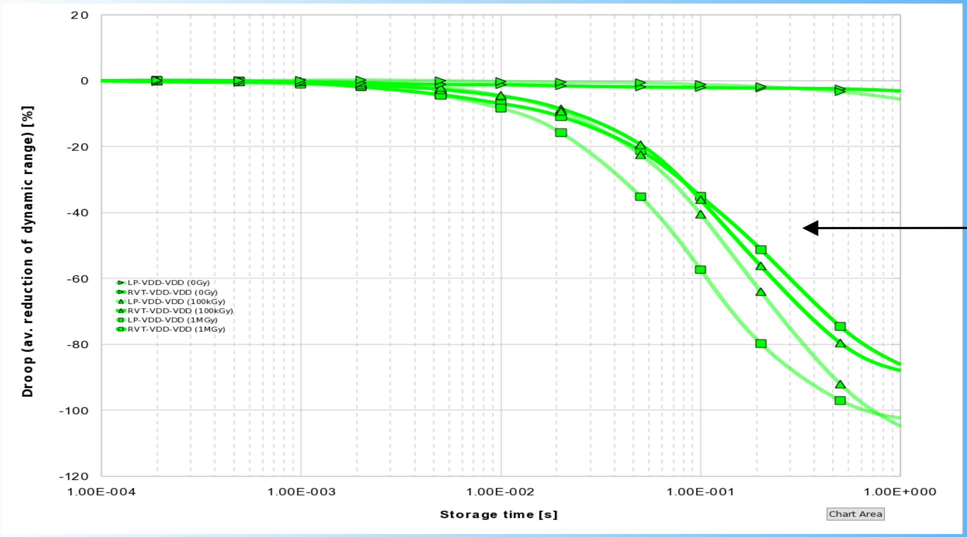
Droop check

Characterize the 352 analog cells over 100ms storage time between bunches and correct for possible charge loss effect.



Write on analog cells

Read out during the 100ms between bunches



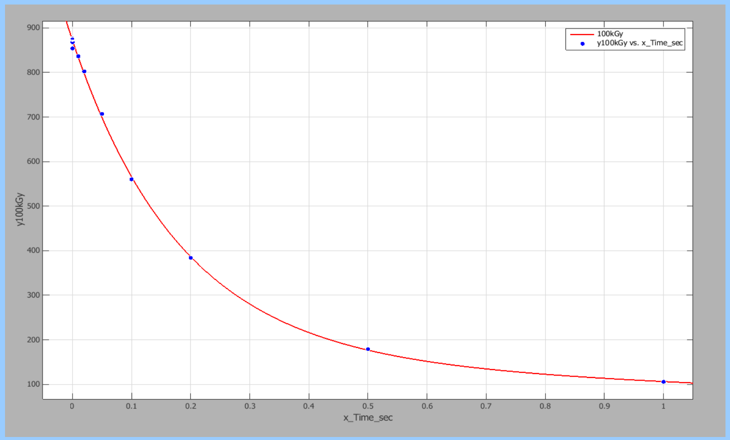
Take 10 points in 100ms for each of the 352 cells.

Droop online correction options

Every few months droop check run, extrapolate new parameters and store it
Then use the parameters for on-line correction.

2 choices to do the on-line check:

Function fit



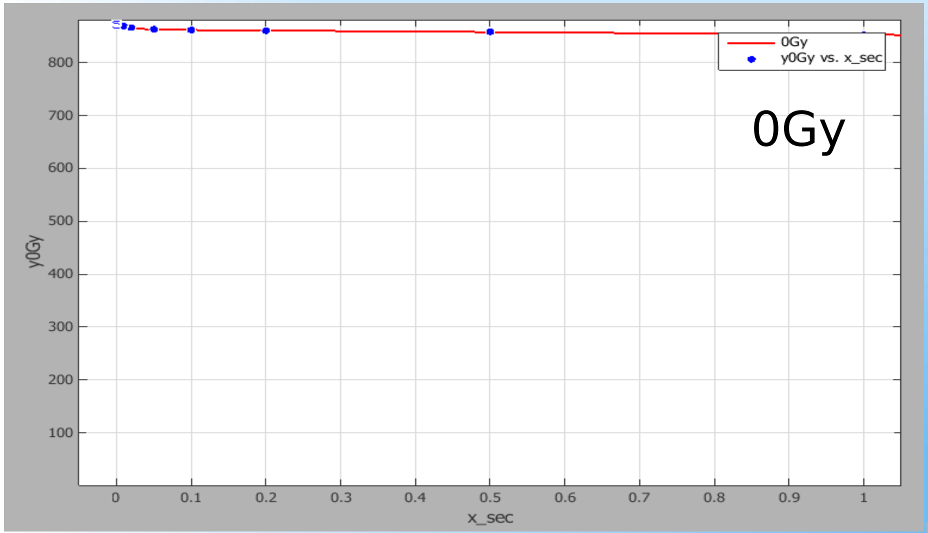
Parameters (function fit):
4 coeff. x 352 cells x 1M pixel
(i.e. two terms exponential function)

Look-up table

P1C1 %	P2C2 %	P3C1 %			
P1C2 %	P2C2 %	P3C2 %			
P1C3 %	P2C3 %				
P1C4 %	P2C4 %				
P1C5 %	P2C5 %				

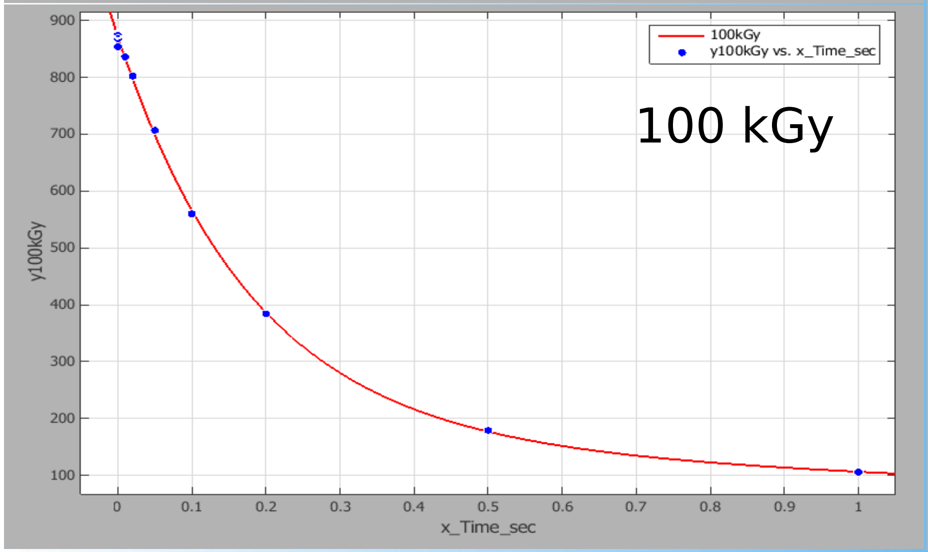
Parameters (look-up table):
100 points x 352 cells x 1M pixel

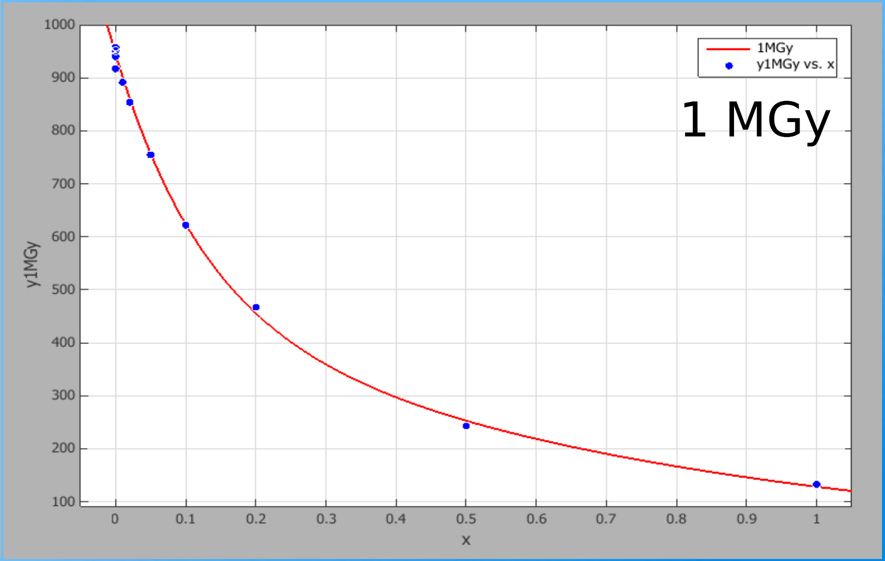
Droop and dose



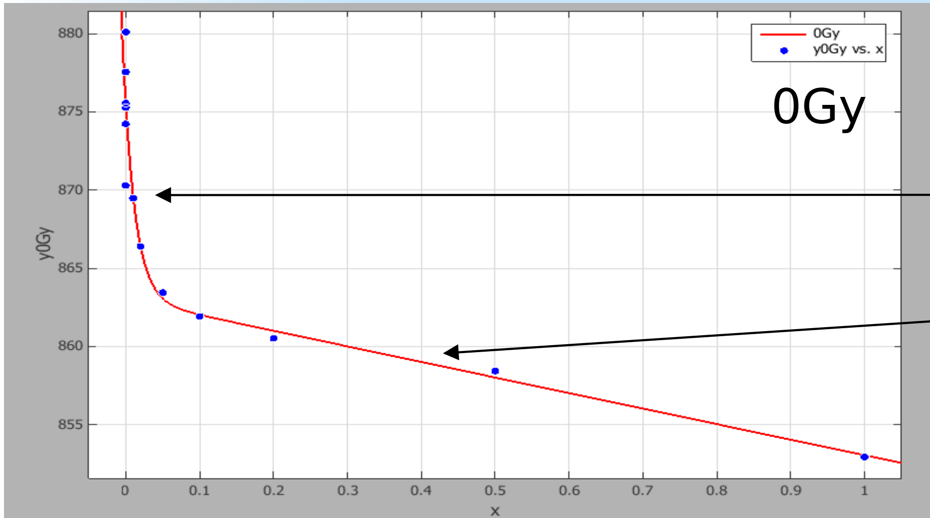
Preliminary analysis:

2 terms exponential fit



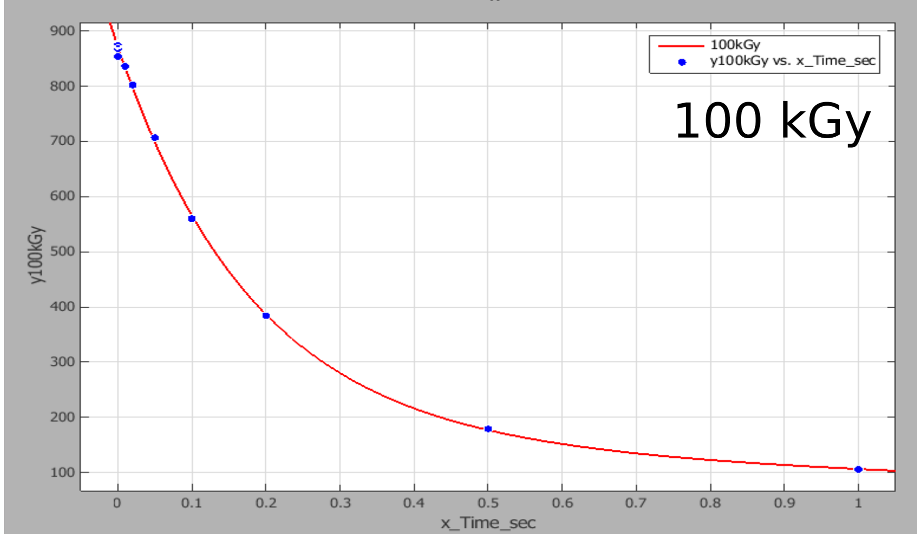


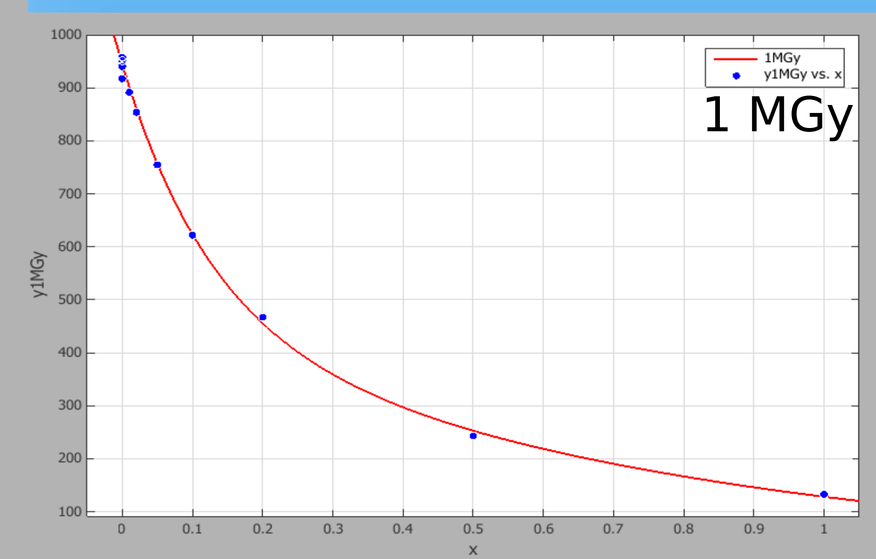
Droop and dose



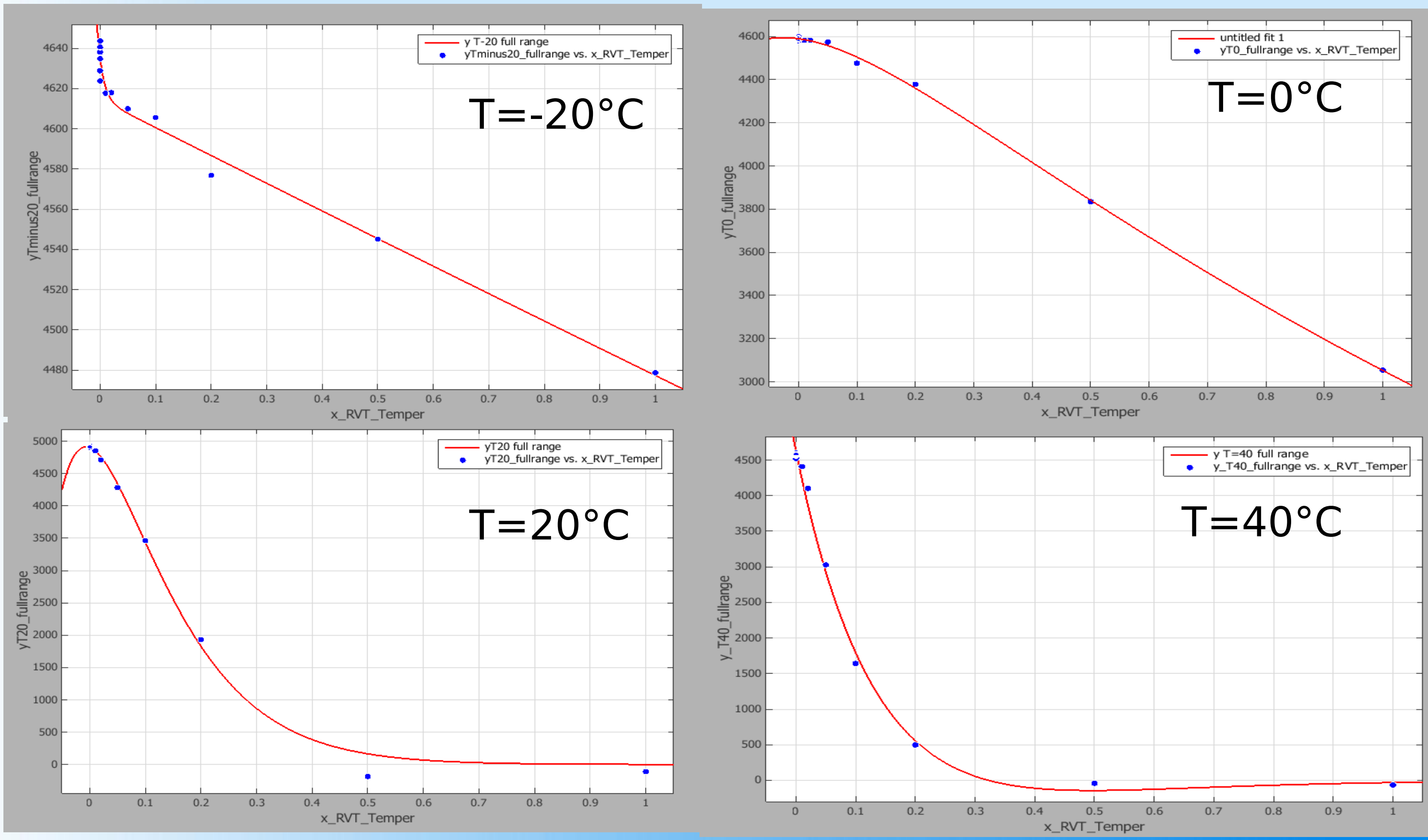
faster component

slower component





Droop and temperature



2 terms exponential fit

Possible fictitious effects outside the fit intervals (not present with single exponential)

Droop check

Some indication about timing:

Write:
Simultaneously charge i.e. only ¼ of the pixels.
Write cell n.1 in all the 1M pixel in 4*220ns=880ns. (~1µs) → 1 point of the function
Then write cell n.2 in all 1M pixel (another 1µs)
To write on all 352 cells → 352 µs.
To have 10 points in 352 cells: 3520 µs = 3.52 ms.

Read:
Read 1 point in all 352 cells of all 1M pixel in 100ms
Read 10 points in 352 cells in 1M = 1s

<u>To write and read 10 points in all 352 cells in 1M → 1003.52ms → ~1sec</u>
(or 100 points in 10 sec...)

This is only to write and read, plus there will be computing time for online correction

Possible other infrastructure needed:

- Access to storage ring/beam line (PETRA, FLASH?).
  Good to have bunches of photons with the right time structure for test/commissioning (PITZ?).
  Also needed for initial general checks (train builder...)

- Electronic detector lab on site (Schenefeld) for routine maintenance and checks

Conclusions

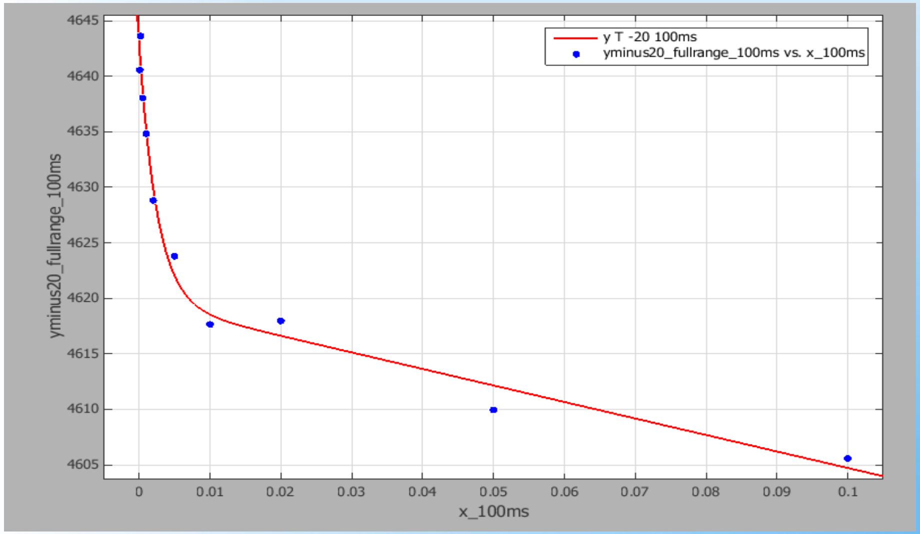
Some preliminary options open to discussion have been presented.

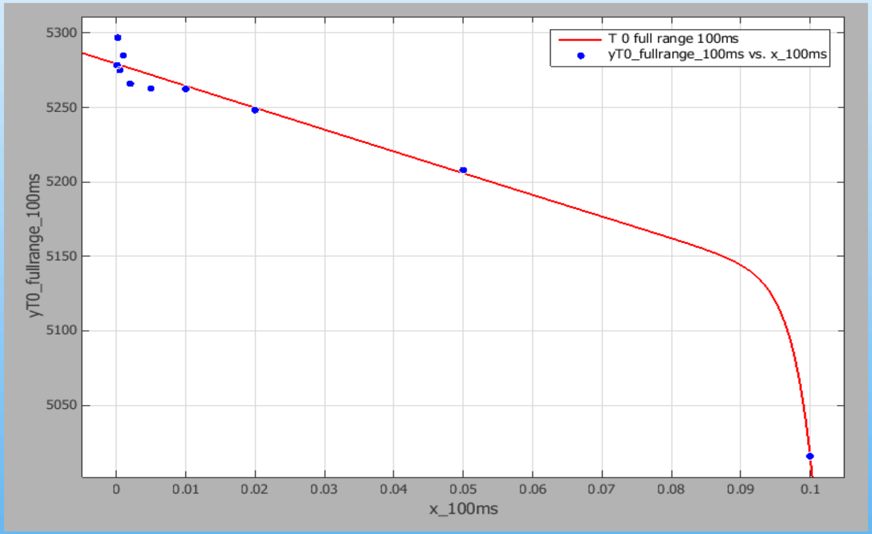
Several calibration structures used in parallel to cover the whole photon range and for (crucial!) cross-calibration.

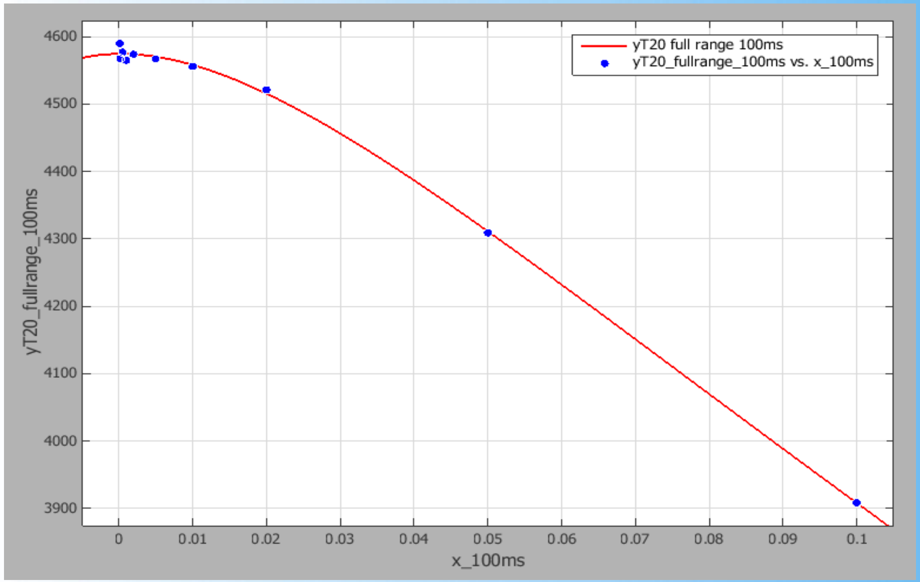
Thanks!

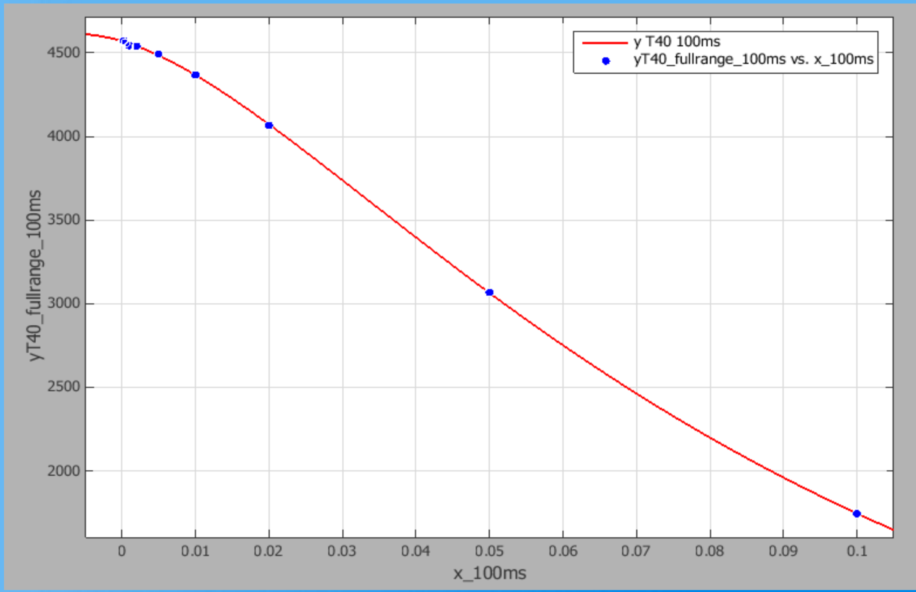
BACKUP

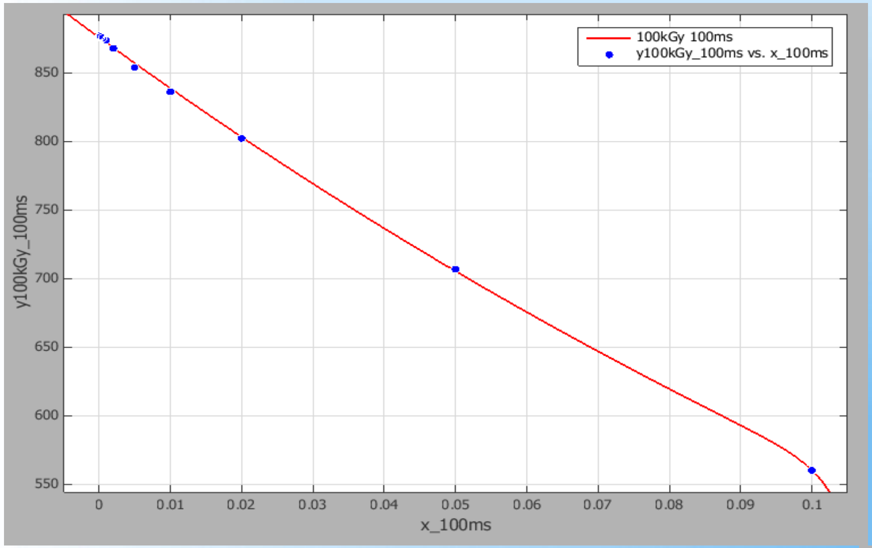
Droop and temperature 100ms range

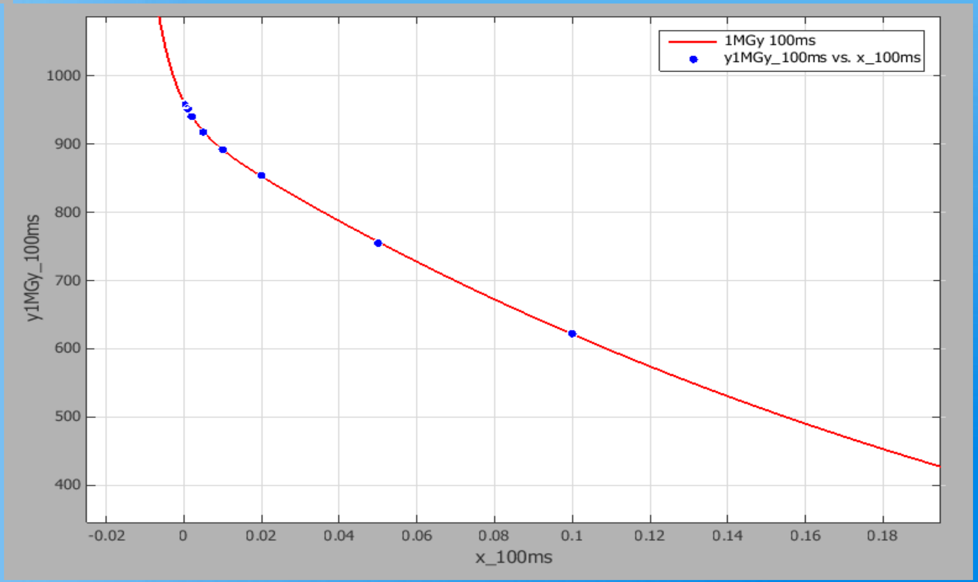









100kGy 100ms
y100kGy_100ms vs. x_100ms
y100kGy_100ms
x_100ms
850
800
750
700
650
600
550
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.1


1MGy 100ms
y1MGy_100ms vs. x_100ms
y1MGy_100ms
x_100ms
1000
900
800
700
600
500
400
-0.02
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.16
0.18