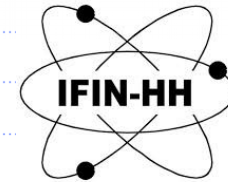


MINISTERUL CERCETĂRII ȘI INOVĂRII

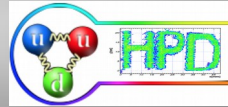
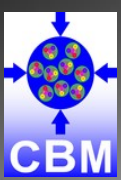


[www.ifin.ro](http://www.ifin.ro)

# *Measurements, Results & Performances for the Bucharest-solution of the CBM-TRD*

*Alex Bercuci for the Bucharest-TRD Group*

***CBM-TRD Retreat  
27-29 March 2019  
Schloß Waldthausen***

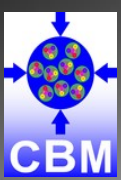


## TRD system readiness for (timely ordered):

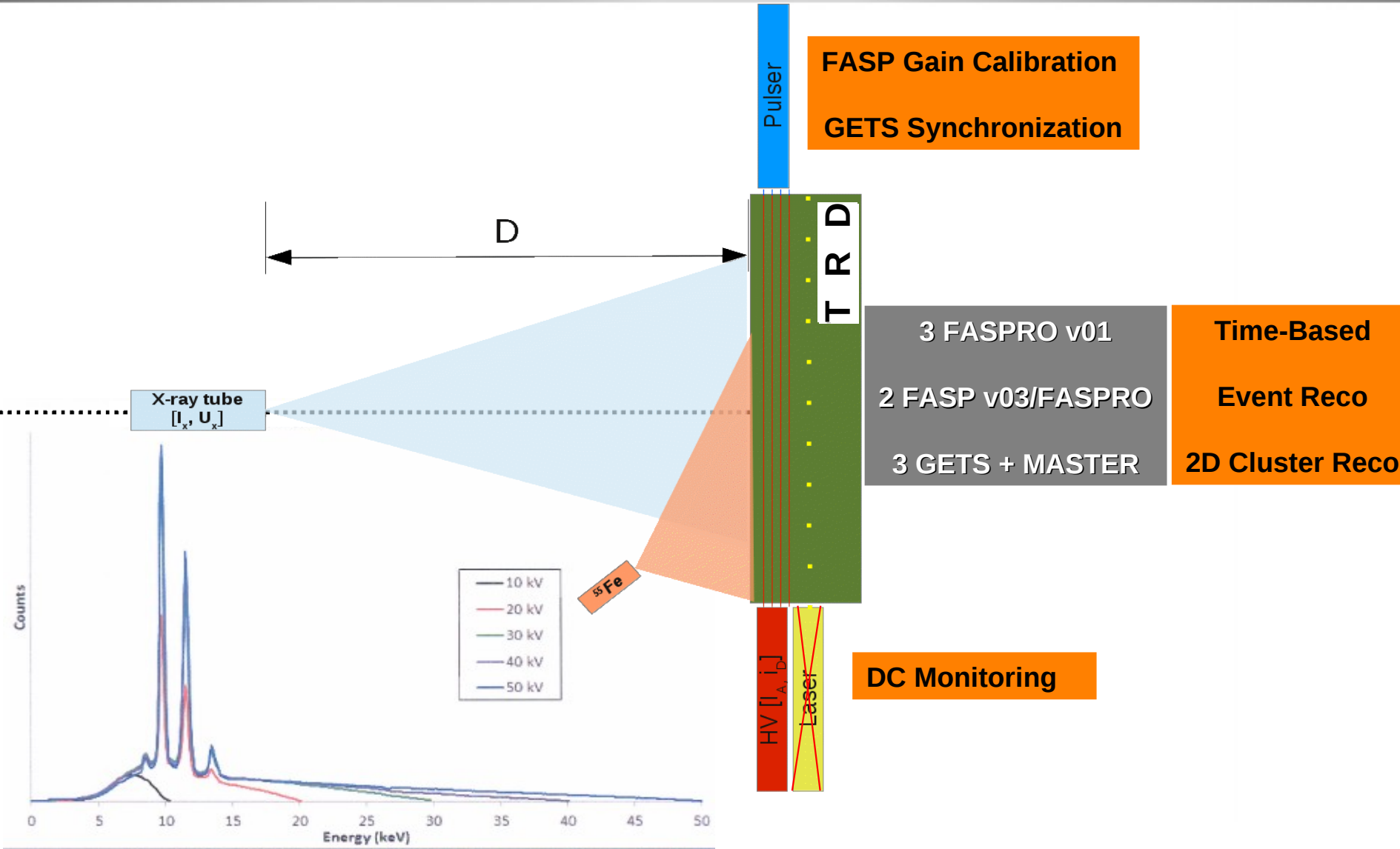
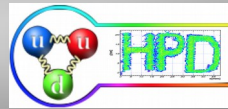
- ◆ TRD-TDR Addendum
- ◆ mCBM integration
- ◆ CBM-TRD construction
- Chamber design/features
  - ◆ Inner-zone of the TRD wall - Construction details for the Bucharest-solution (Wednesday 16:10)
- FEE based on FASP (v03)
  - ◆ FASP based data acquisition (today @ 18:45)
- CbmRoot Software
  - ◆ Simulating the Bucharest-solution for the mCBM setup (Friday @ 10:30)

## System Performance

- FEE CALIBRATION
- ENERGY
  - ◆ Gain, Spectra Fe & X-rays
- POSITION 2D
  - ◆ Image reconstruction
- RATE
  - ◆ Targeting the 100k particle/cm<sup>2</sup>/s

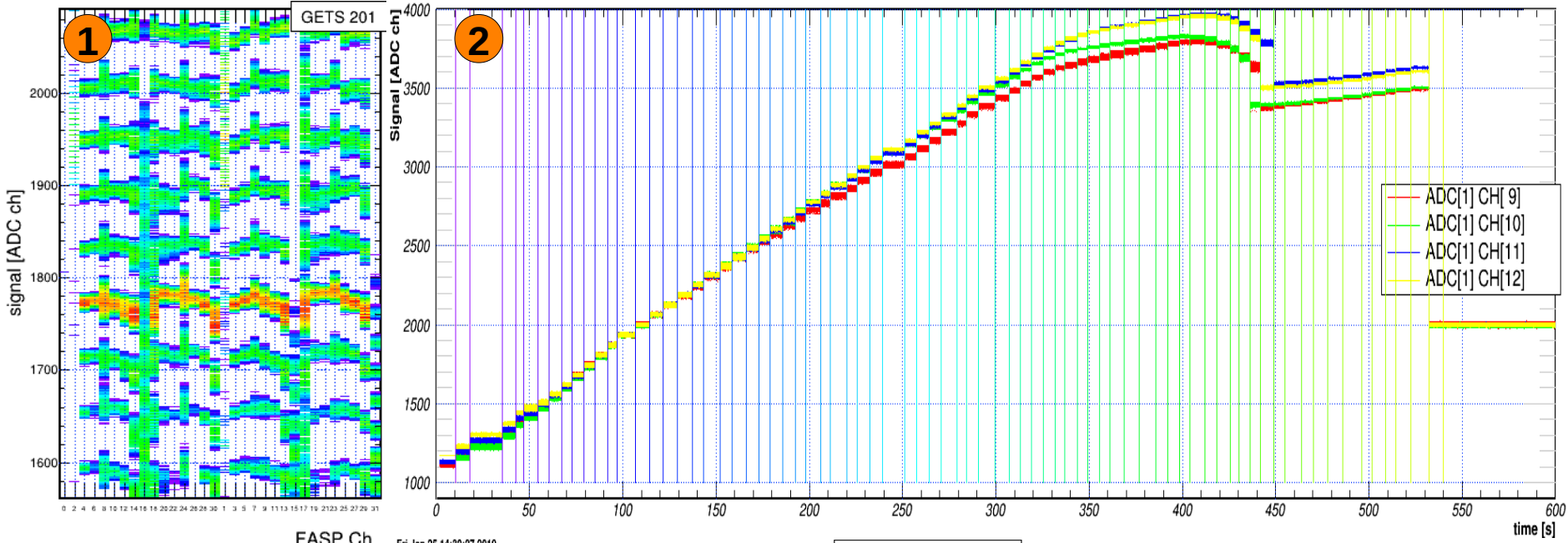
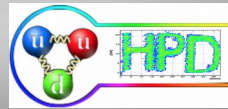


# System/Experimental set-up





# Calibration



1. Pulser FEE calibration run

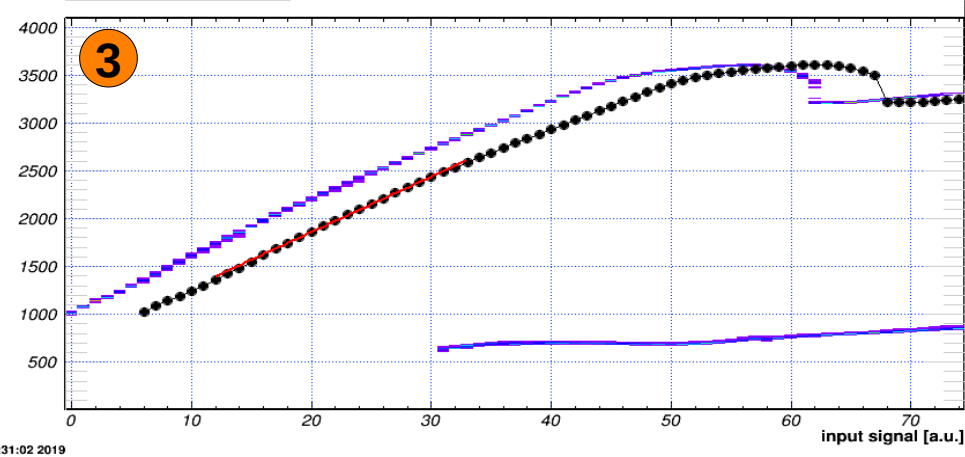
2. Time expansion of Pulser run

3. Ch-wise FASP-gain identification

FEE calibration

Yield [ADC.chs.]

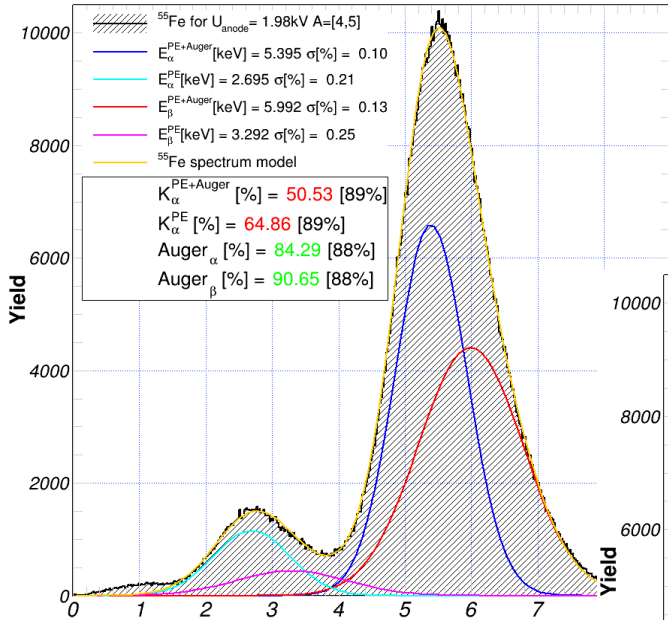
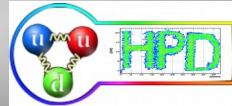
ADC[1] CH[21]



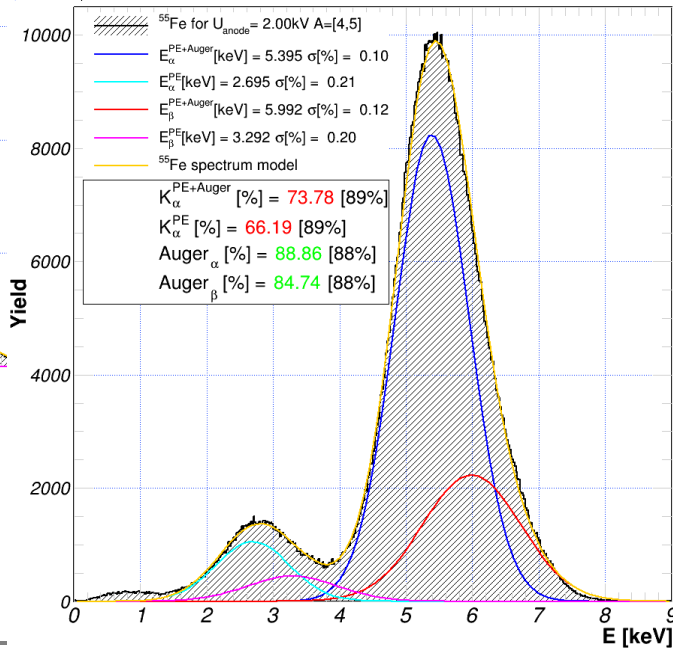
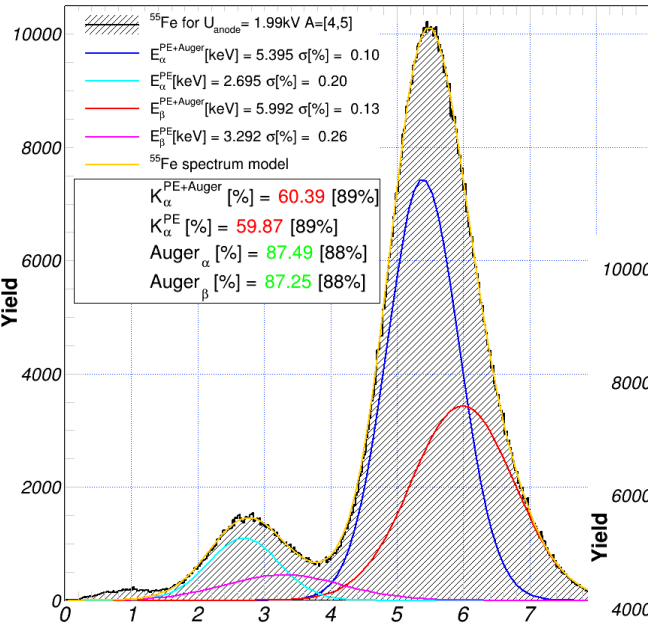
Wed Jan 30 10:31:02 2019



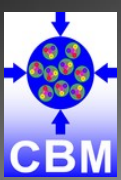
# ENERGY – <sup>55</sup>Fe Spectrum



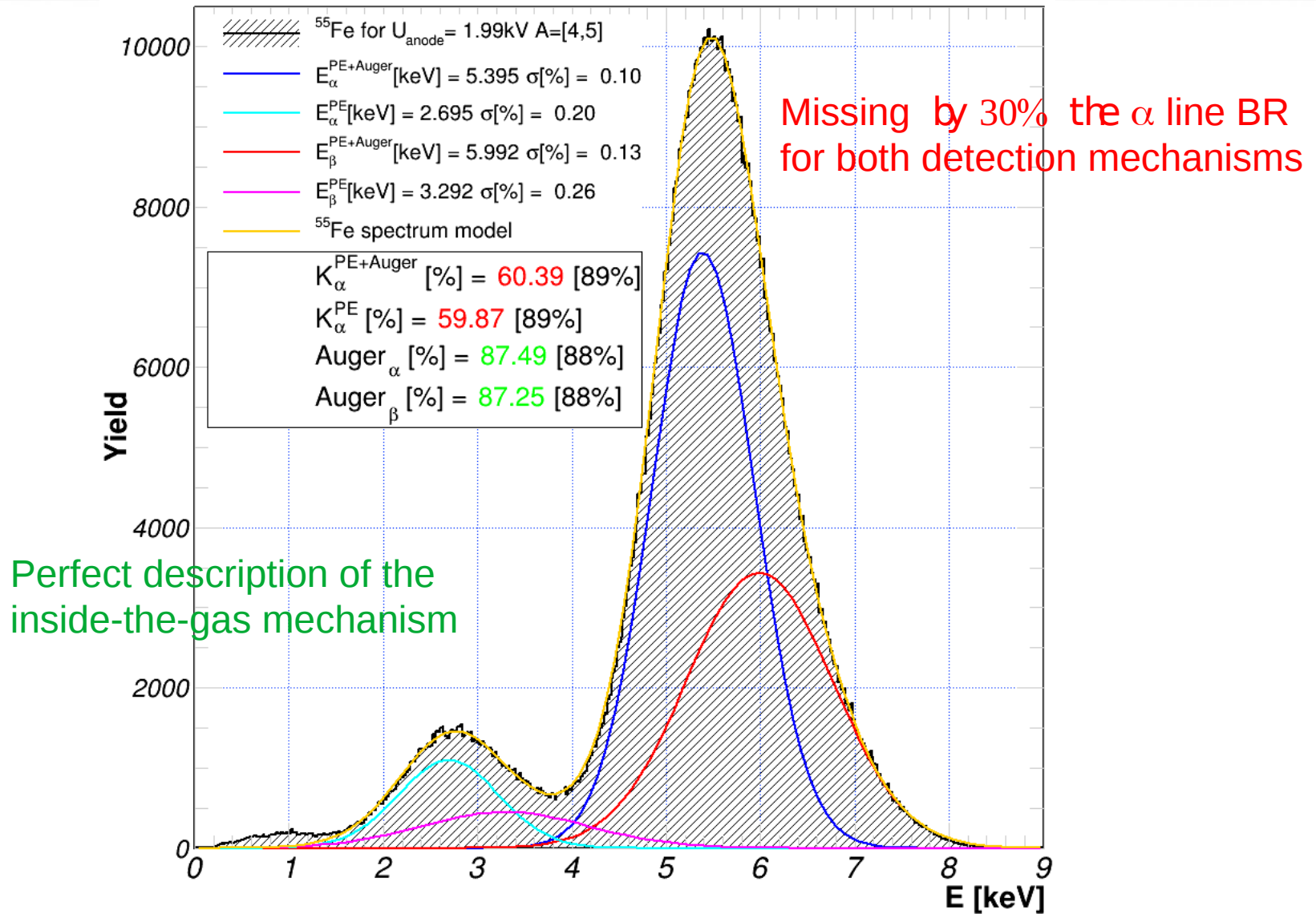
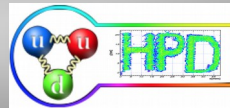
Identification of the  $\alpha$  and  $\beta$  lines of <sup>55</sup>Fe  
 Identification of detection mechanism (PE, AE)



Asses Energy reconstruction quality by  
 Relative ratio between spectral components



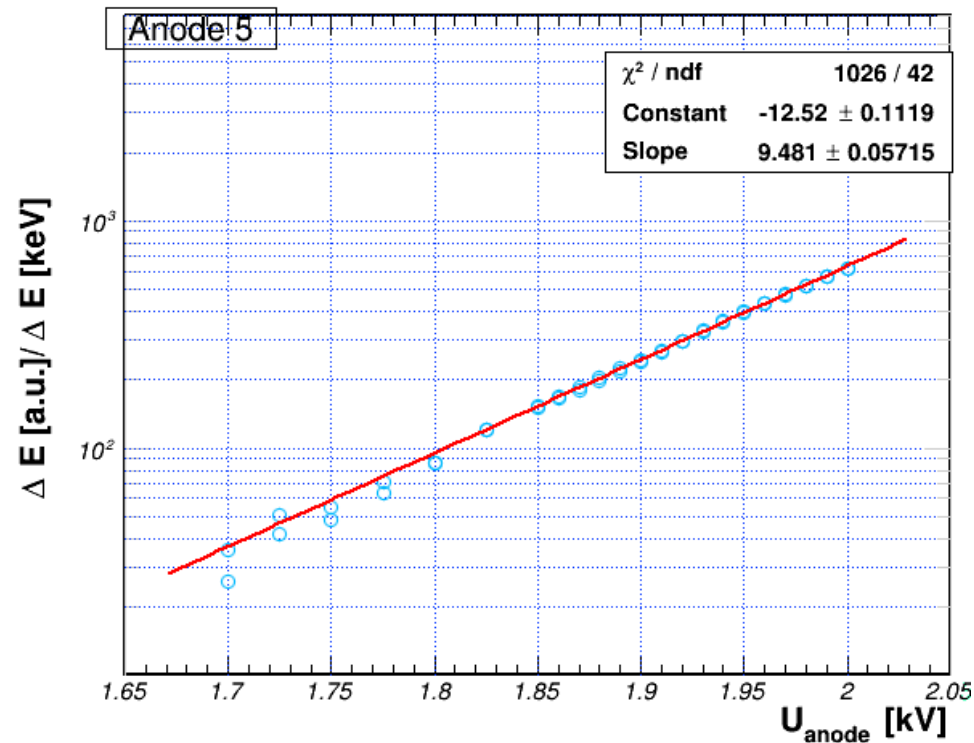
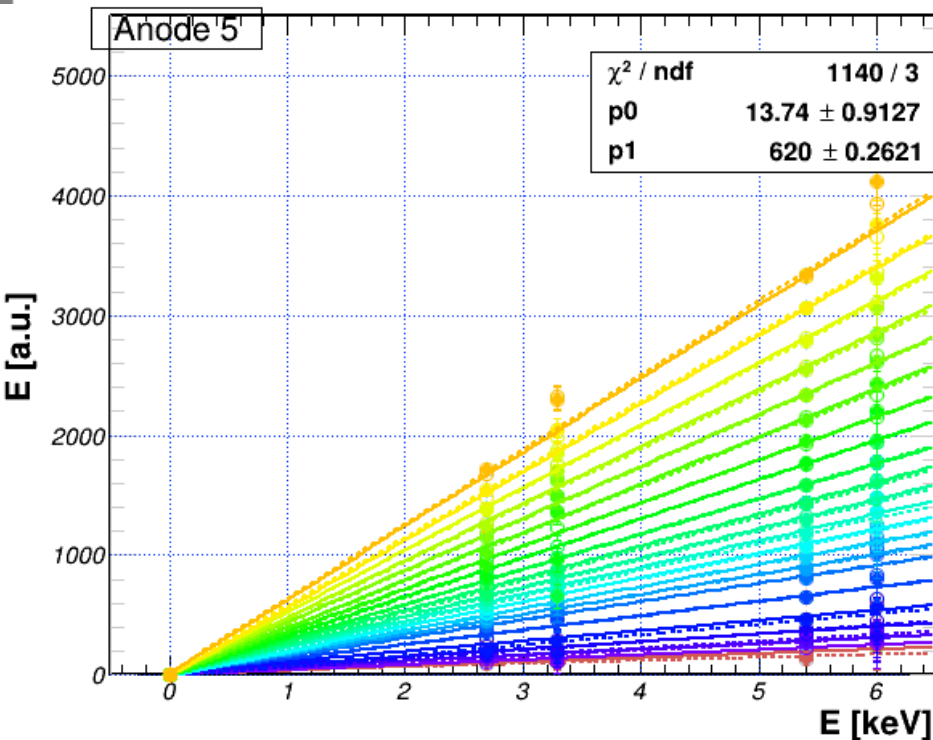
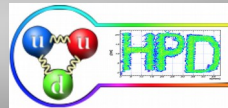
# ENERGY – <sup>55</sup>Fe Spectrum







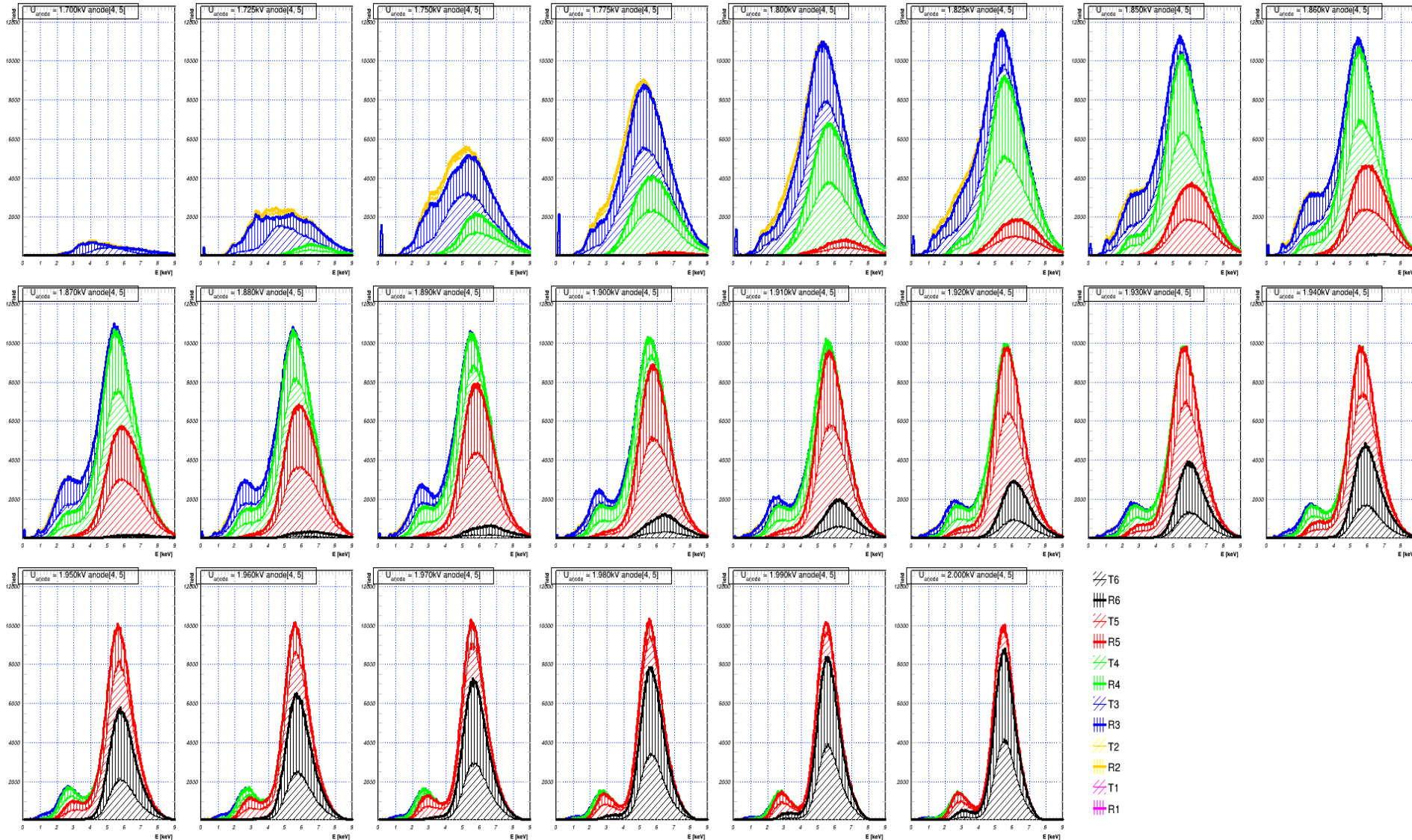
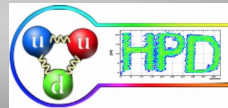
# ENERGY – Gain calibration



- Gain calibration using 4 identified peaks in  $^{55}\text{Fe}$  spectrum
  - Using 21  $U_{\text{anode}}$  [kV] values in the range [1.7, 2.0]
    - Anode-wise estimation for fine control of energy/cluster
    - Cluster type-wise selection



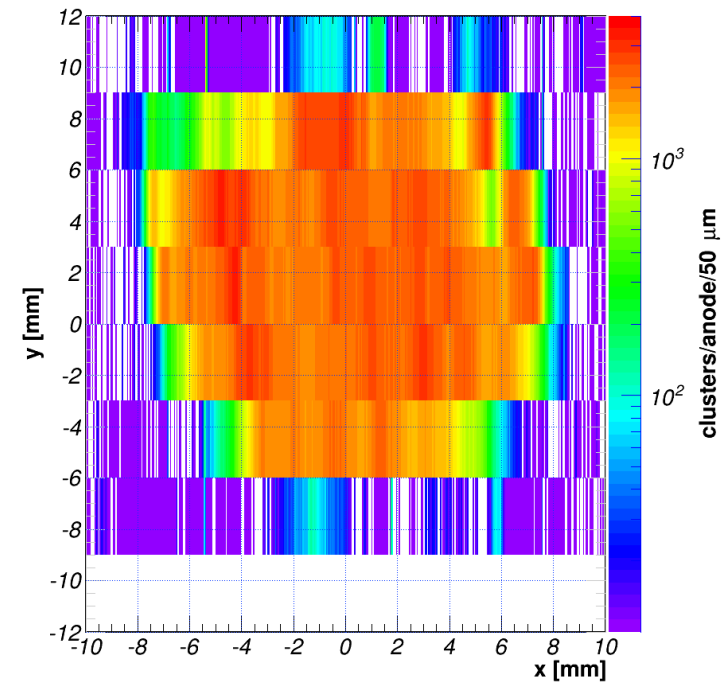
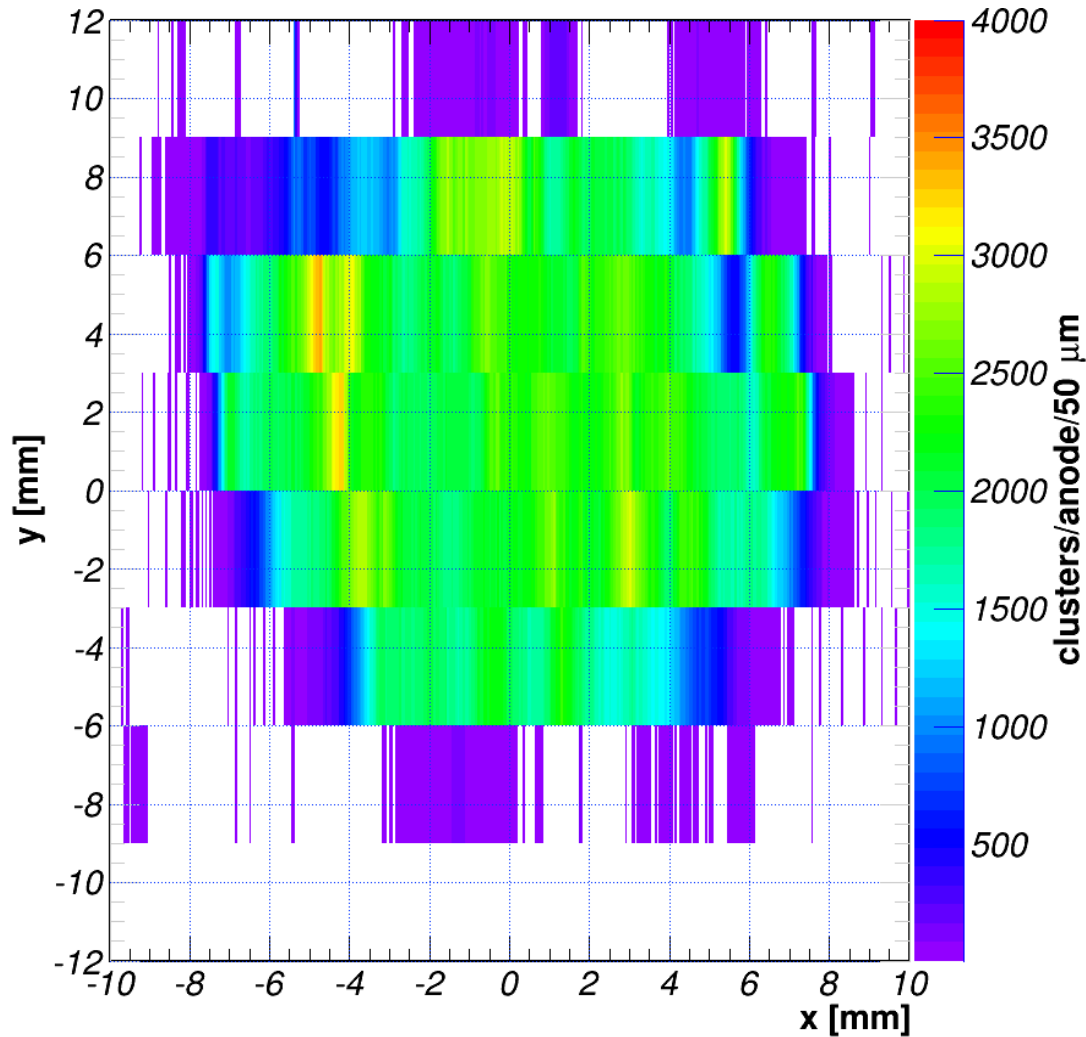
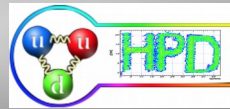
# ENERGY – 55Fe Spectrum with gas gain







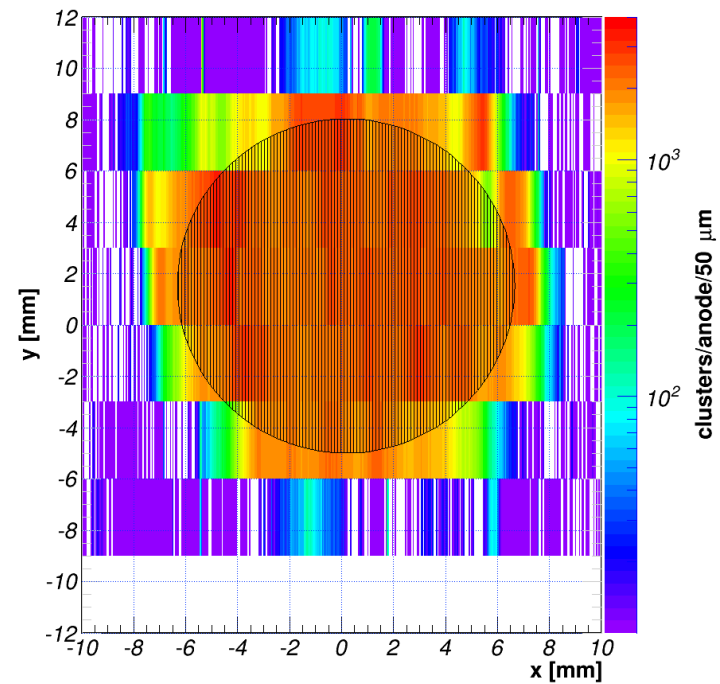
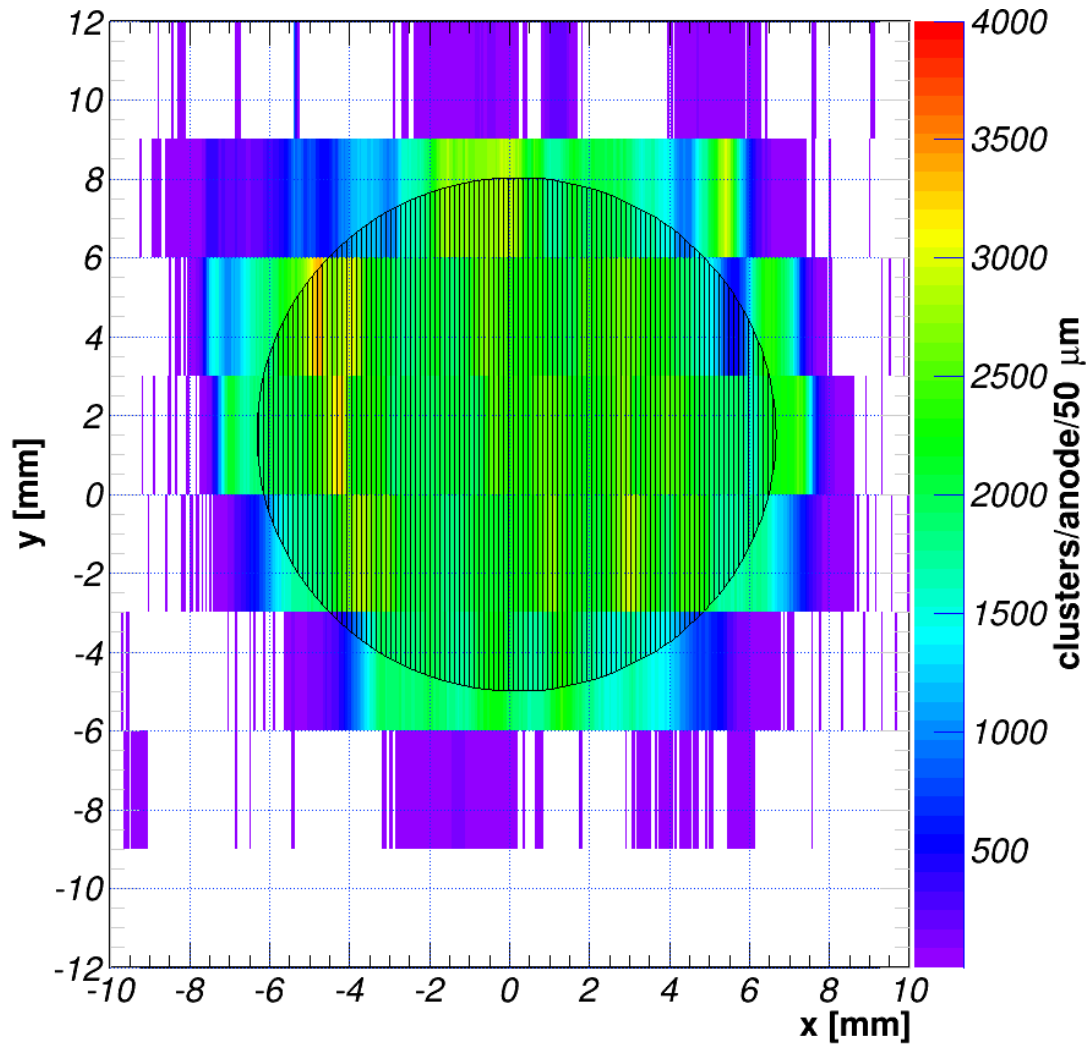
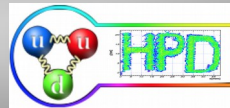
# POSITION



The reconstructed image of a 13 mm circular opening seen with X-rays from  $^{55}\text{Fe}$



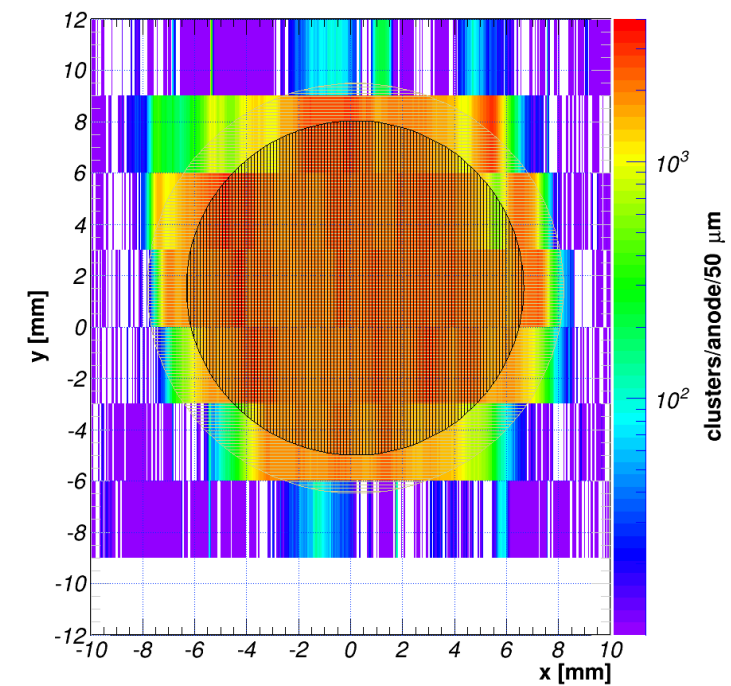
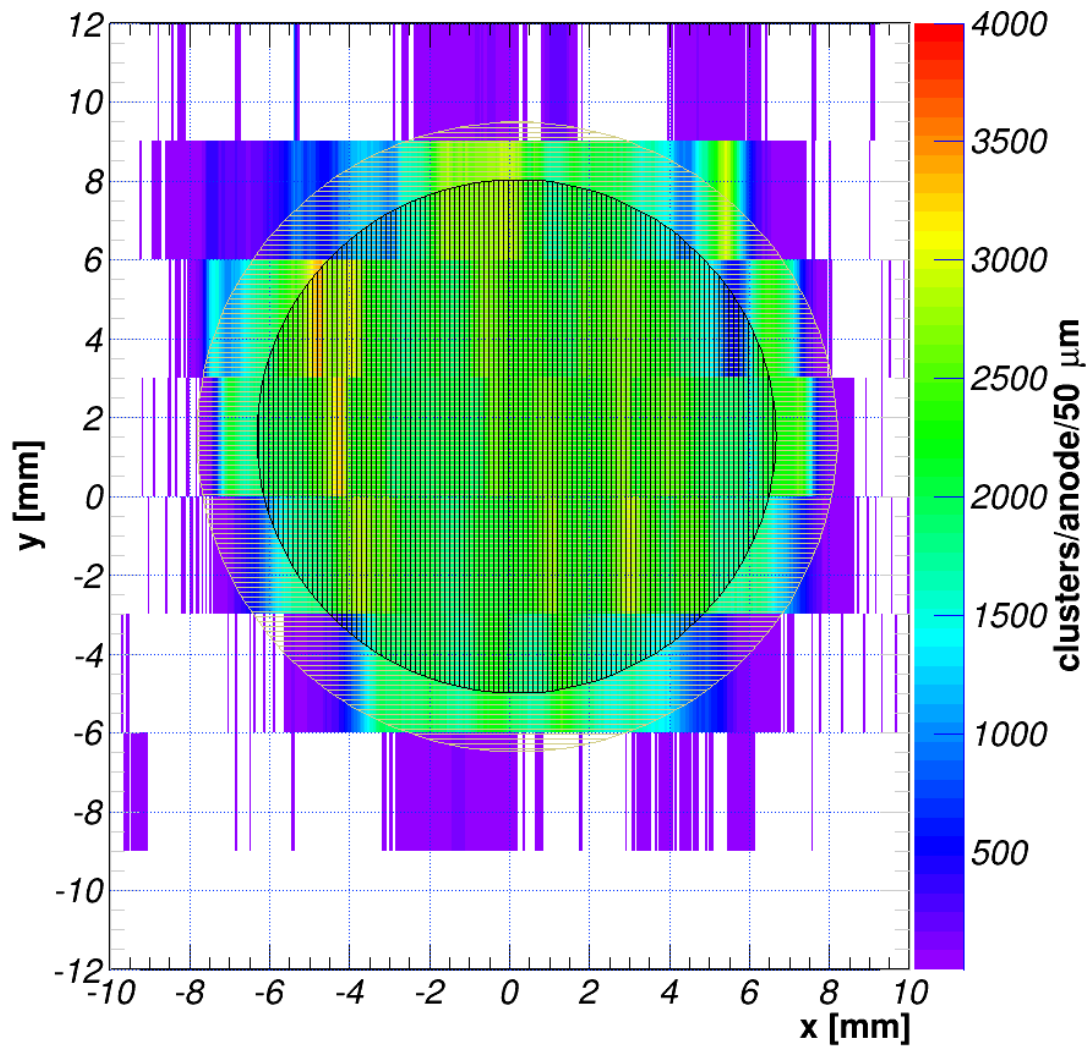
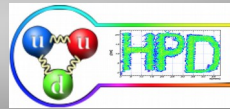
# POSITION



The 13 mm circular opening centered on the measurements



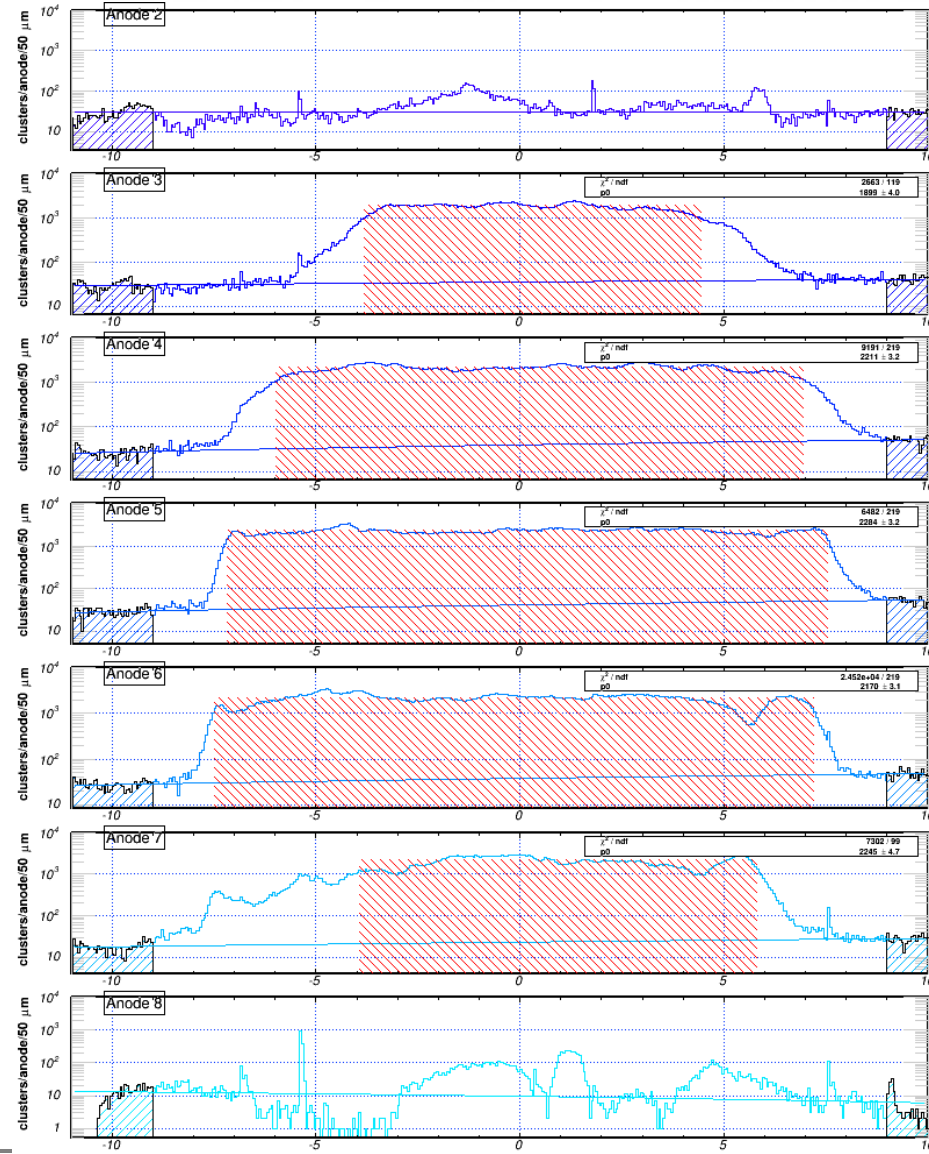
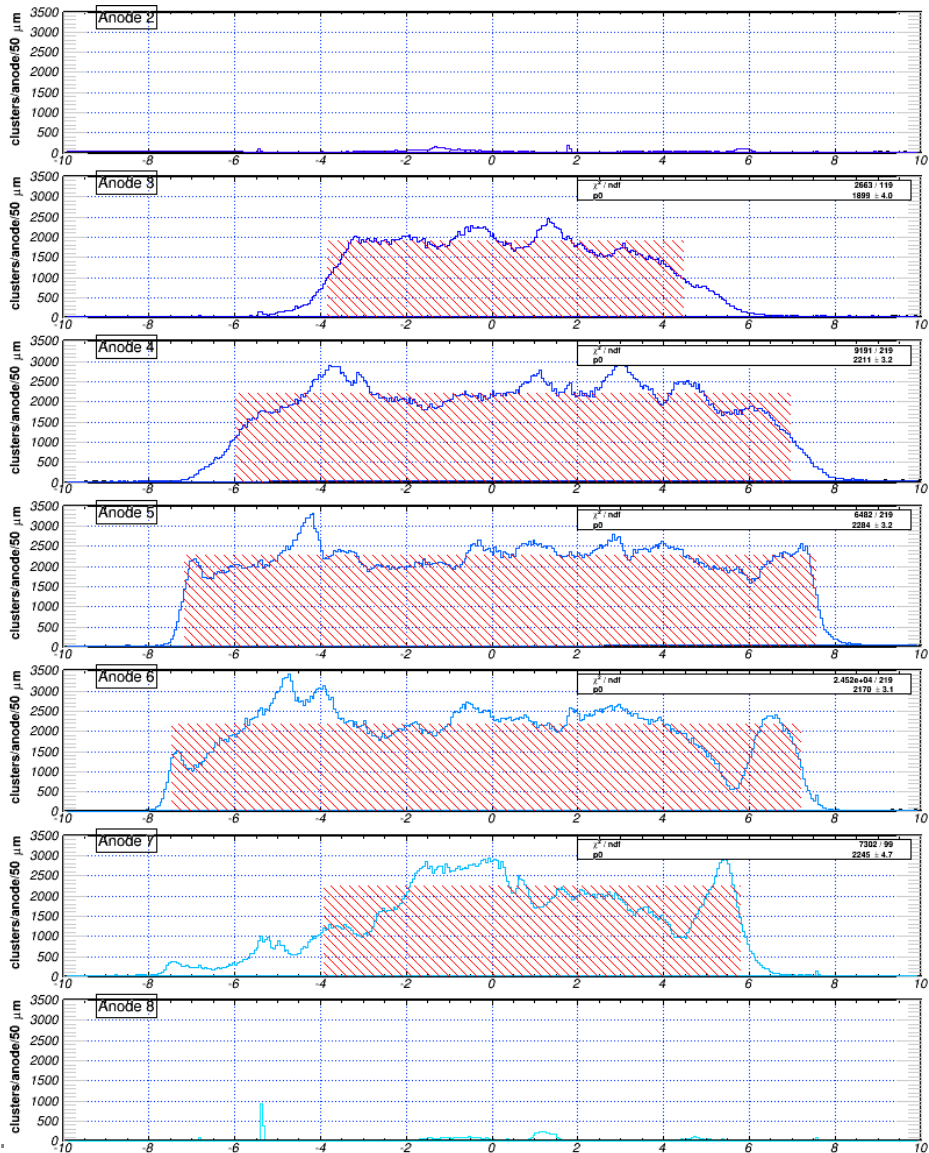
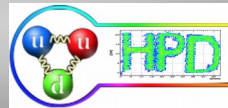
# POSITION



The 13 mm circular opening projected on the detection plane



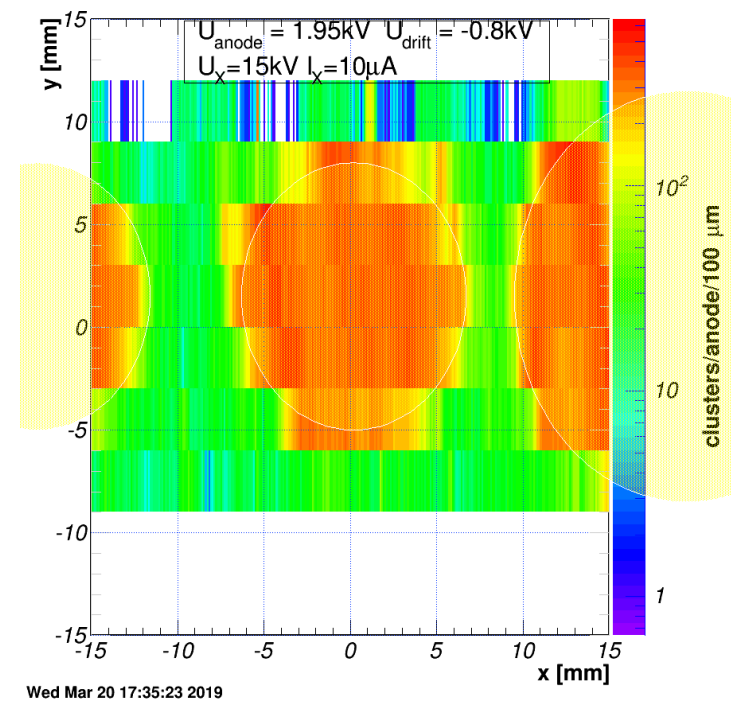
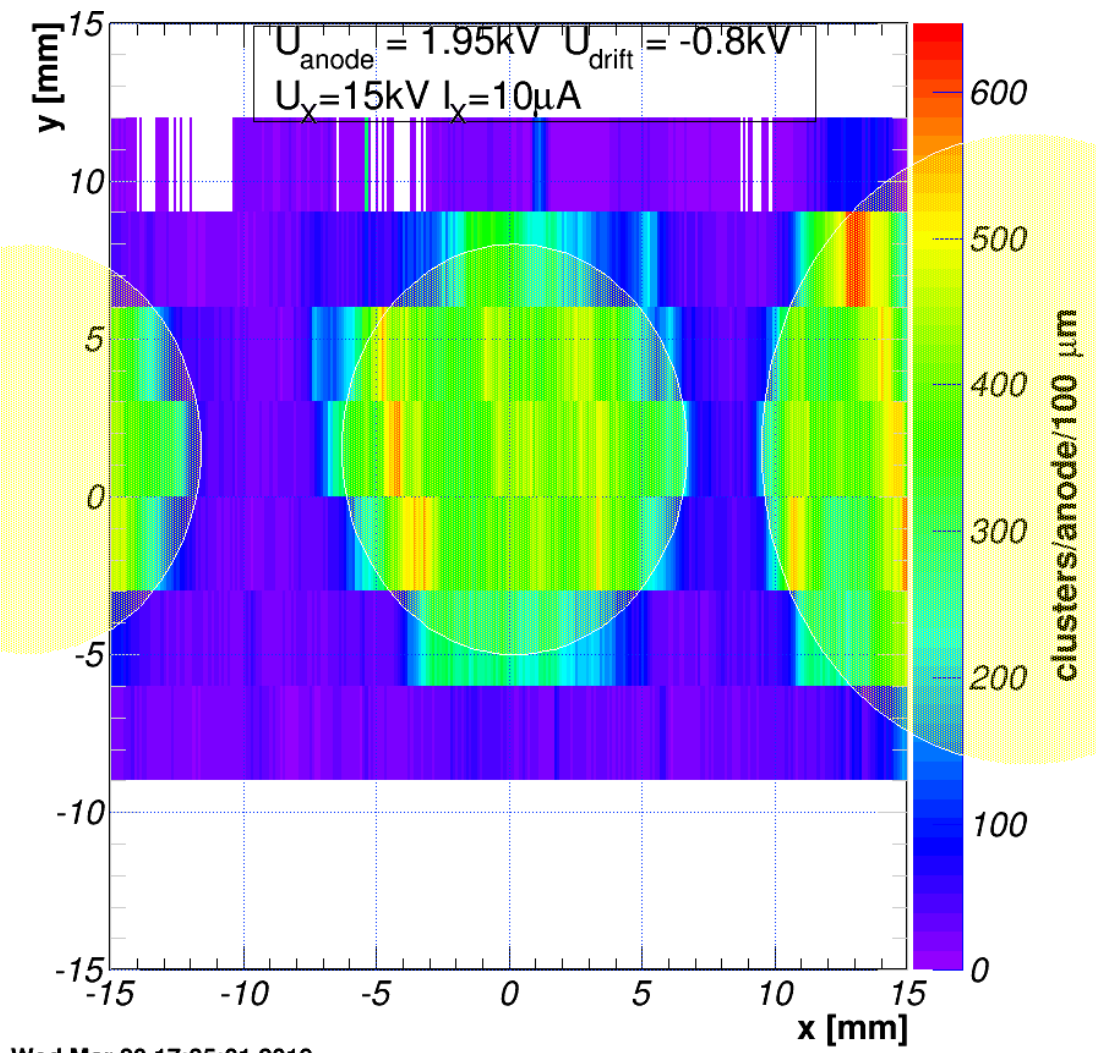
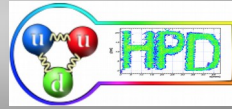
# POSITION







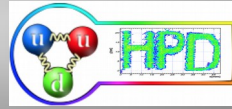
# POSITION → X-rays tube @ 150 from detector



The reconstructed image of a set of circular openings (see shaded area) seen with X-rays from tube



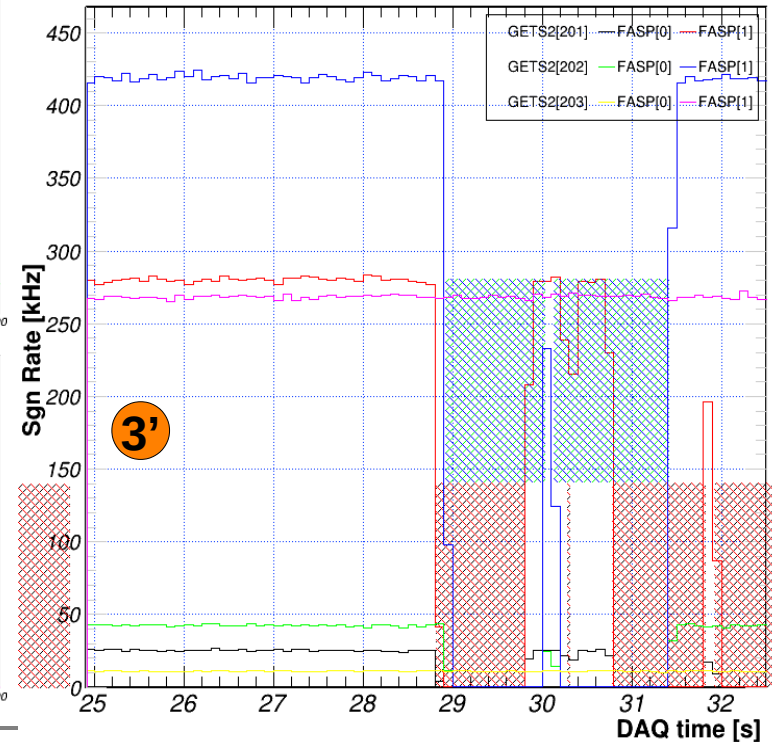
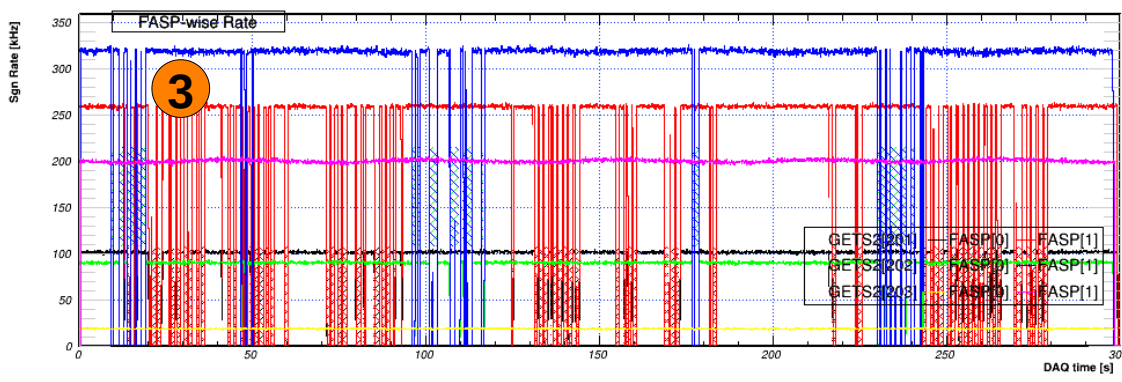
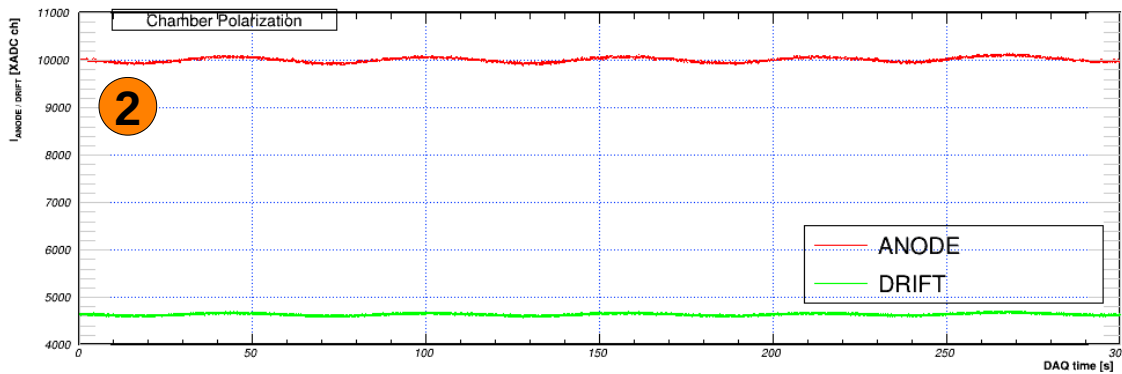
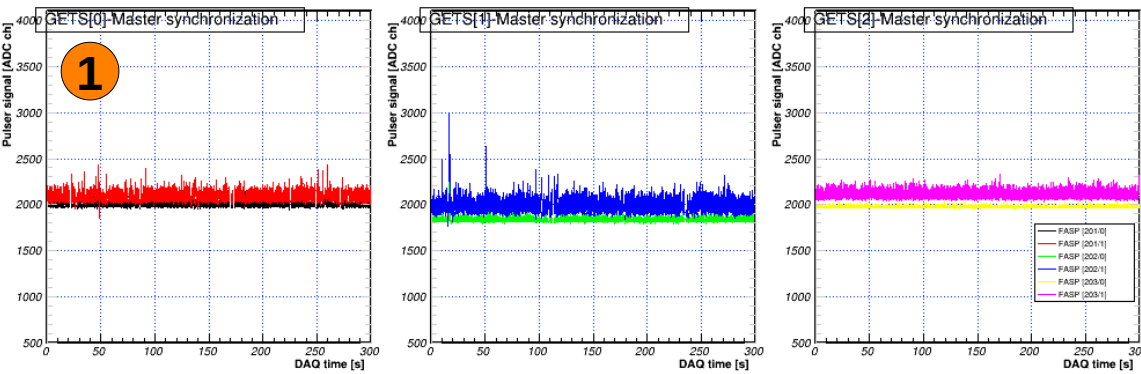
# RATE → DAQ



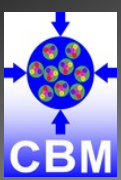
1. DAQ time synchronization

2. HV monitoring

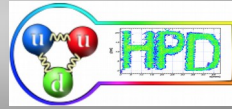
3. DAQ Data transfer monitor



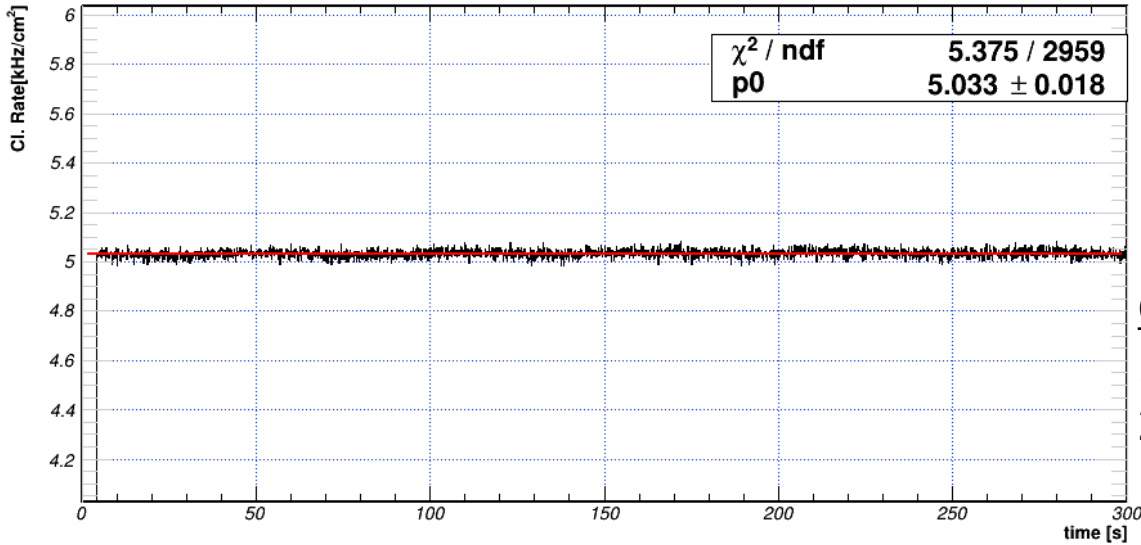




# RATE → clusters

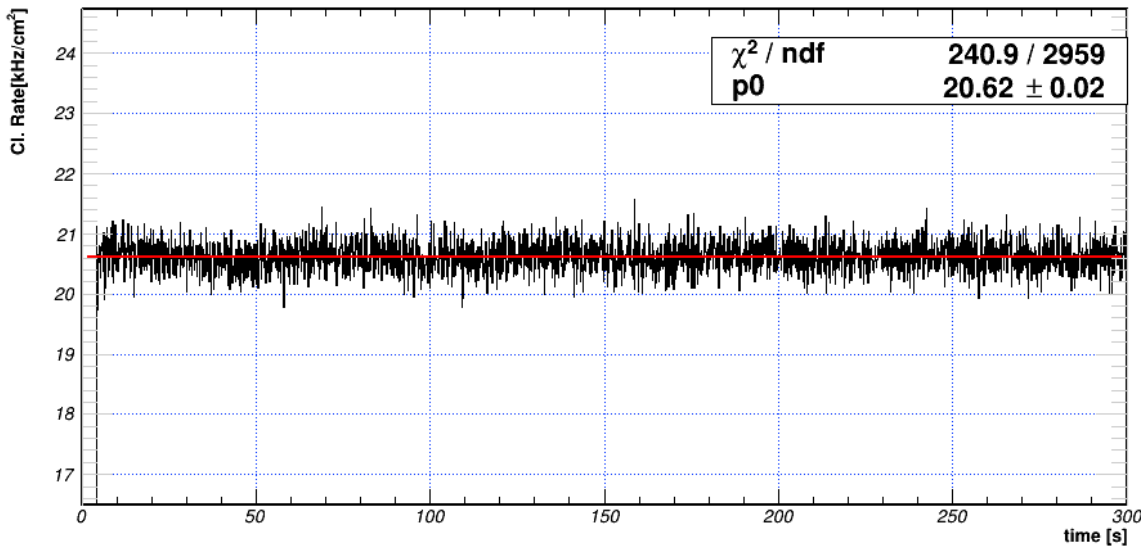


... for the X-ray tube @ 60cm away from the detector



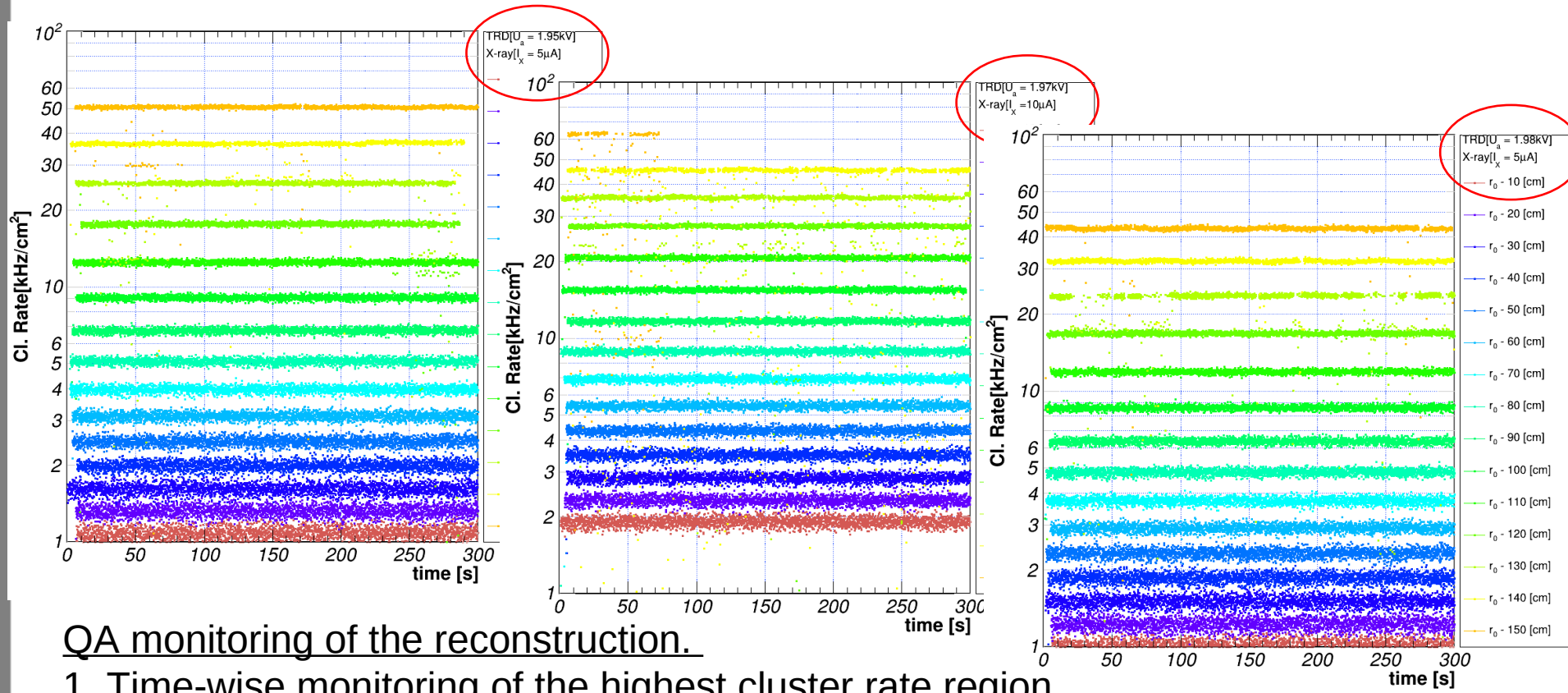
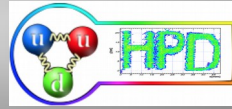
QA monitoring of the reconstruction.

1. total detector area and
2. centered on X-rays tube beam





# RATE → clusters



## QA monitoring of the reconstruction.

1. Time-wise monitoring of the highest cluster rate region

2. Data sets used

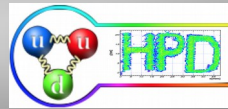
a) U<sub>a</sub>=1.95kV/I<sub>x</sub>=5μA

b) U<sub>a</sub>=1.97kV/I<sub>x</sub>=10μA

c) U<sub>a</sub>=1.98kV/I<sub>x</sub>=5μA



# RATE → The method

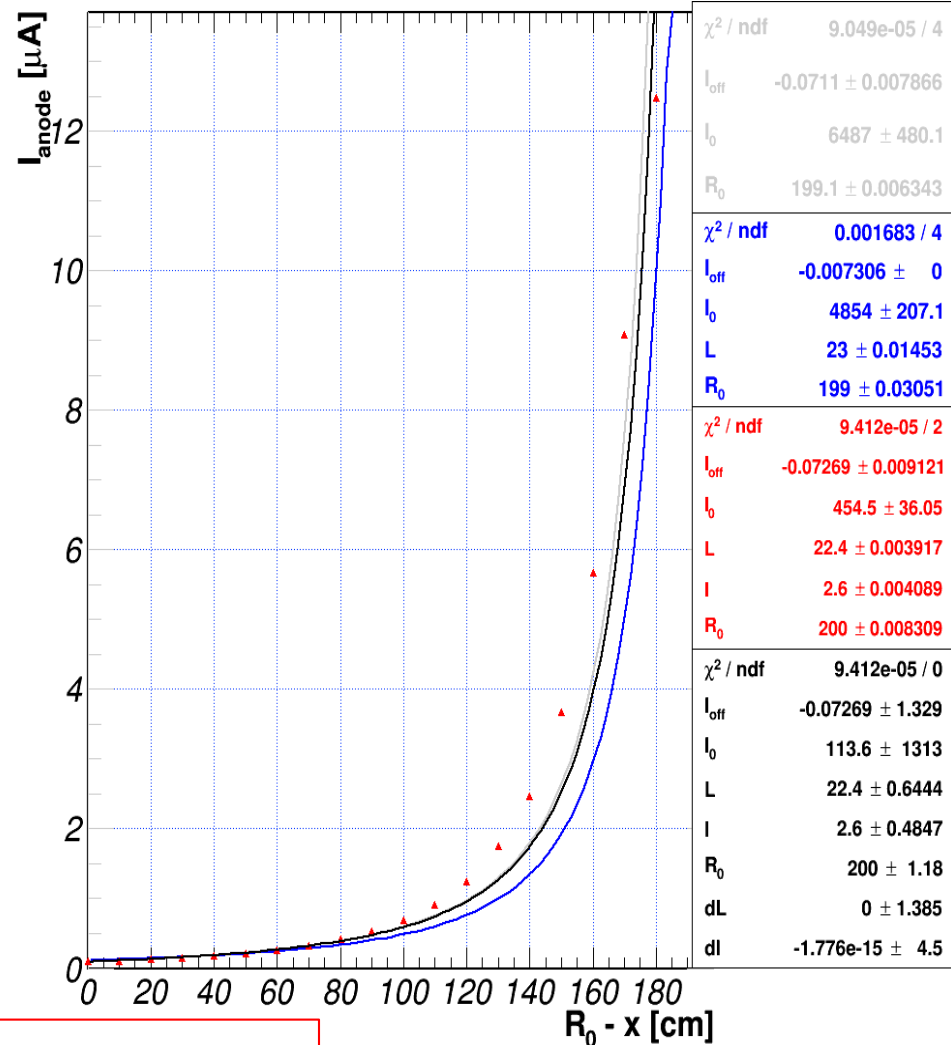


$$R(r) = f(r)$$

- **R** : rate related observable
  - e.g.  $N_{\text{clusters}}$ ,  $I_{\text{anode}}$ , etc.
- **r** : reference observable
  - e.g.  $I_X$ ,  $I_{\text{GIF}}$ ,  $X_{\text{TUBE-TRD}}$
- **f(r)** : known (?!) dependence
  - Good systematic control !!

## E.g. Geometrical models $R \# I_A(r \# x)$

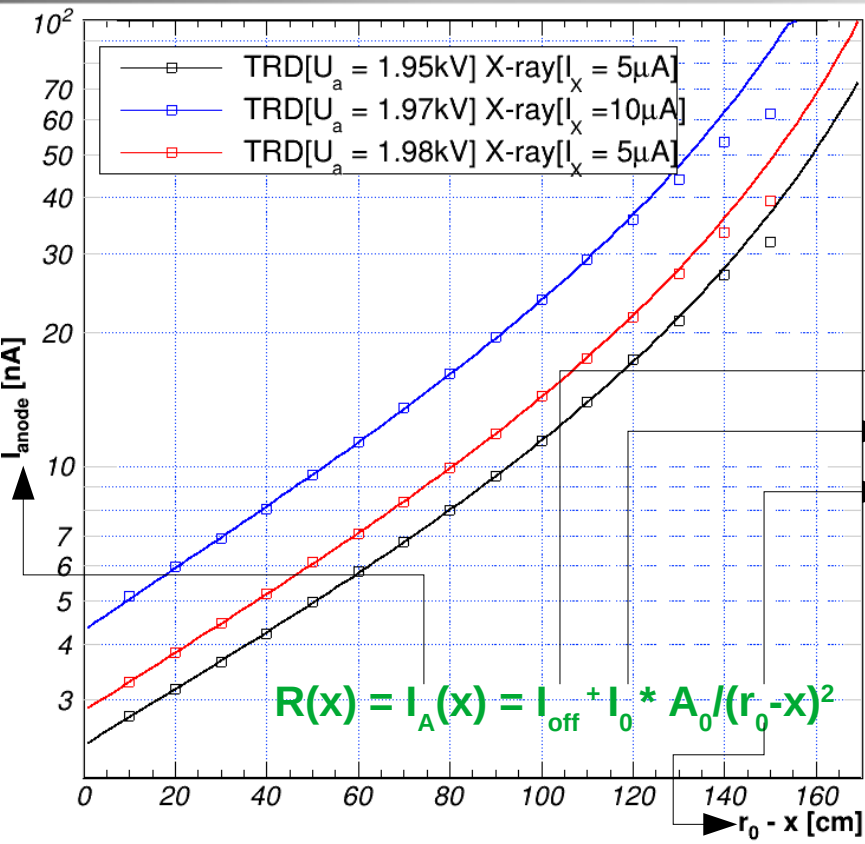
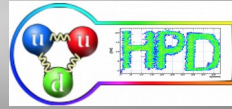
- $R(x) = I_A(x) = I_{\text{off}} + I_0 * A_0 / (r_0 - x)^2$
- $R(x) = I_A(x) = I_{\text{off}} + I_0 * A_0 / [(r_0 - x)^2 + L^2]$
- $R(x) = I_A(x) = I_{\text{off}} + I_0 * A(L, l) / (r_0 - x)^2$
- $R(x) = I_A(x) = I_{\text{off}} + I_0 * A(L, l, dL, dl) / (r_0 - x)^2$



Thu Mar 15 11:36:43 2018



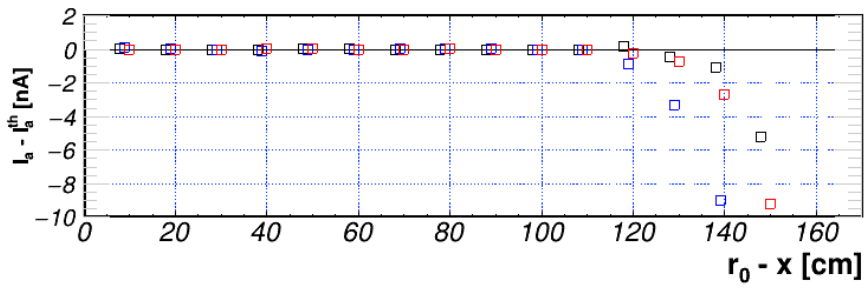
RATE  $\rightarrow I_{\text{anode}}(x)$



$\chi^2 / \text{ndf}$	0.003394 / 7
$I_{\text{off}}$	$-1.785 \pm 0.08465$
$I_0$	$2.136\text{e}+05 \pm 5752$
$r_0$	$215.1 \pm 1.717$

$\chi^2 / \text{ndf}$	0.03606 / 7
$I_{\text{off}}$	$-3.108 \pm 0.2577$
$I_0$	$3.288\text{e}+05 \pm 1.647\text{e}+04$
$r_0$	$210.9 \pm 2.171$

$\chi^2 / \text{ndf}$	0.005121 / 7
$I_{\text{off}}$	$-1.402 \pm 0.1085$
$I_0$	$1.801\text{e}+05 \pm 7720$
$r_0$	$218.4 \pm 2.265$

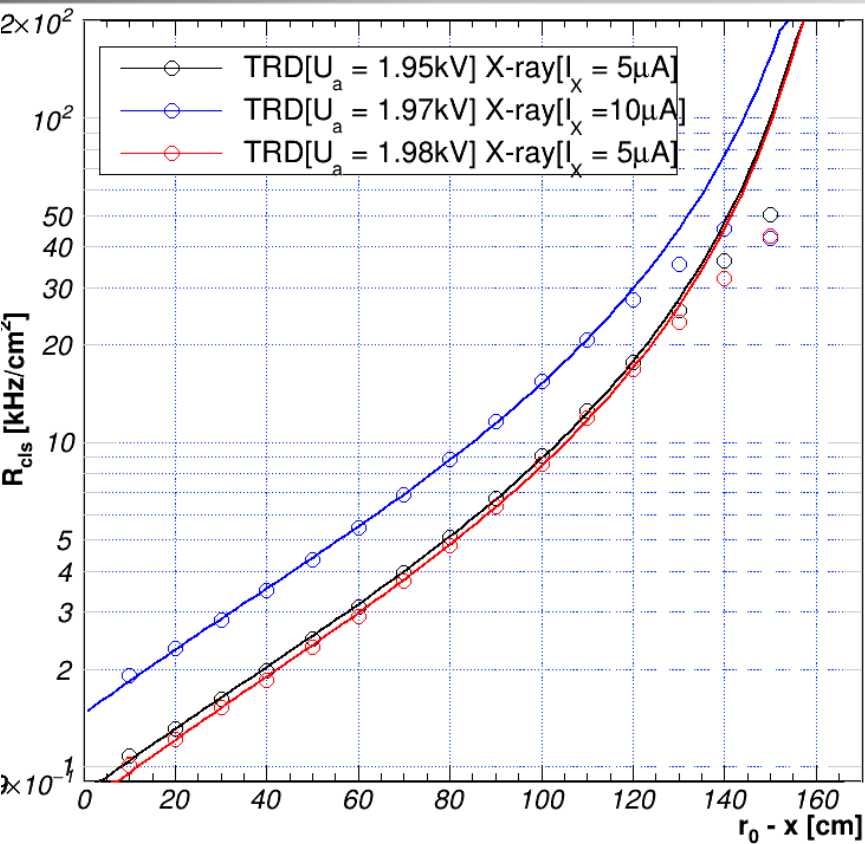
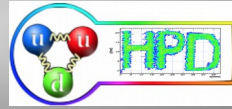


### Observations

- >  $r_0$  systematically larger than real value (172 cm)
- >  $I_{\text{off}}$  different for each set
- >  $I_0(1.97\text{kV}) < 2 * I_0(1.95\text{kV})$
- > Departure from model @ high rates !



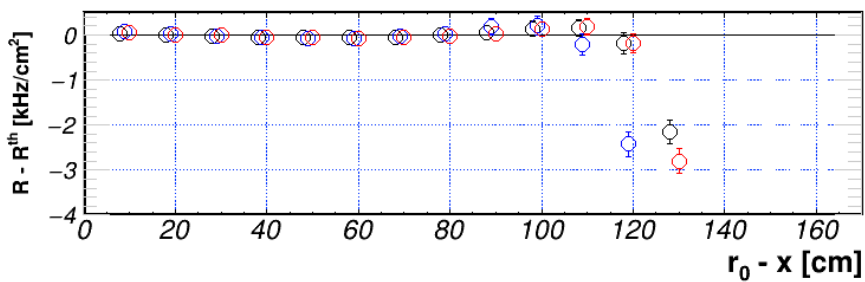
# RATE $\rightarrow$ clusters



$\chi^2 / \text{ndf}$	4.688 / 9
$I_{\text{off}}$	$-0.9048 \pm 0.09069$
$I_0$	$4.925\text{e}+04 \pm 2665$
$r_0$	$172.5 \pm 1.48$

$\chi^2 / \text{ndf}$	5.311 / 8
$I_{\text{off}}$	$-1.606 \pm 0.1757$
$I_0$	$9.316\text{e}+04 \pm 5973$
$r_0$	$174.4 \pm 2.017$

$\chi^2 / \text{ndf}$	4.464 / 9
$I_{\text{off}}$	$-0.9174 \pm 0.0864$
$I_0$	$5.196\text{e}+04 \pm 2642$
$r_0$	$172.7 \pm 1.412$

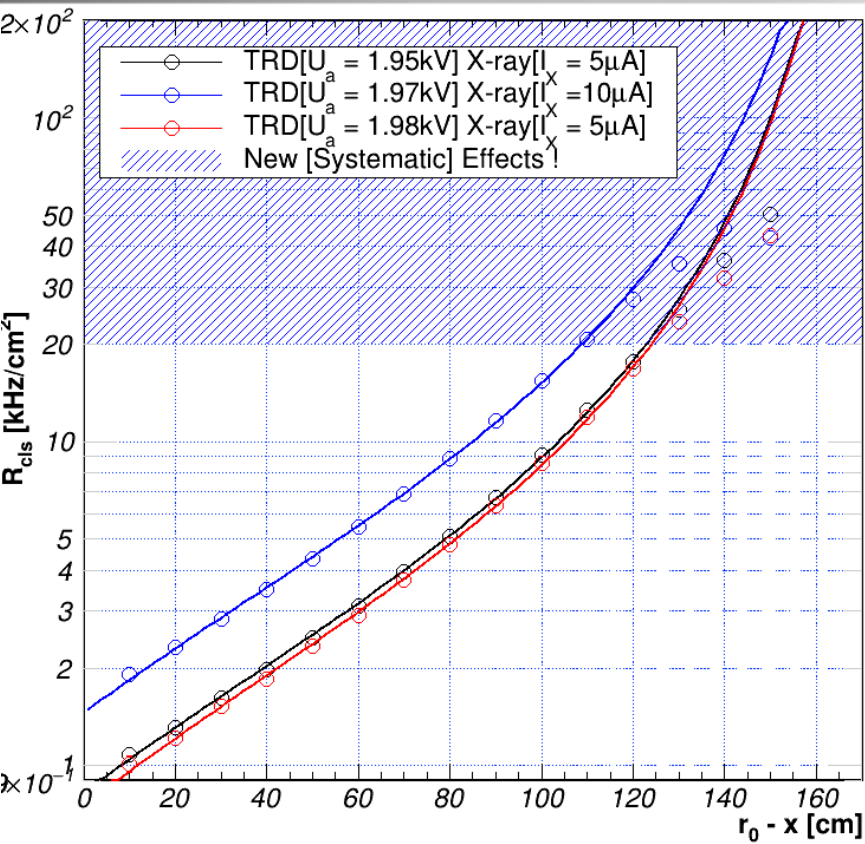
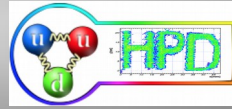


## Observations

- >  $r_0$  approx measured value (172 cm)
- >  $I_{\text{off}}$  similar for each set
- >  $I_0(1.97\text{kV}) < 2 * I_0(1.95\text{kV})$
- > Departure from model @ high rates !



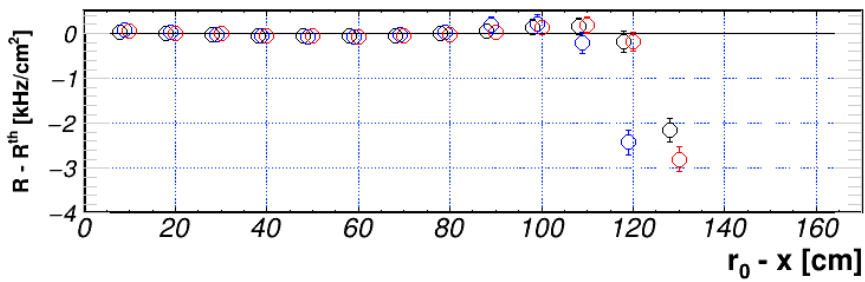
# RATE → clusters



$\chi^2 / \text{ndf}$	4.688 / 9
$I_{\text{off}}$	$-0.9048 \pm 0.09069$
$I_0$	$4.925\text{e}+04 \pm 2665$
$r_0$	$172.5 \pm 1.48$

$\chi^2 / \text{ndf}$	5.311 / 8
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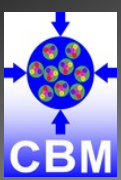
$\chi^2 / \text{ndf}$	4.464 / 9
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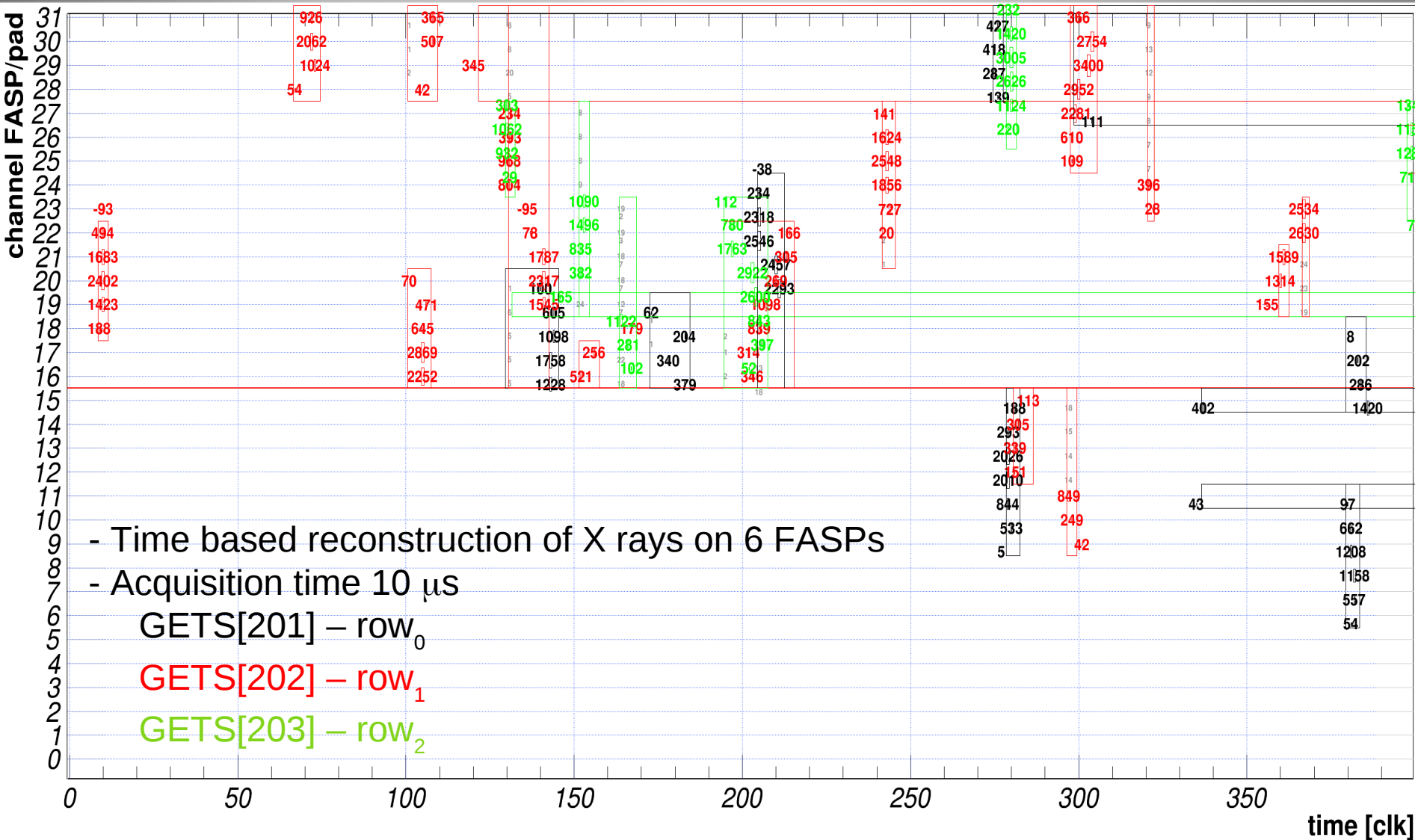
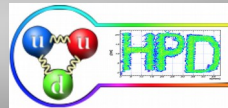
## Observations

- >  $r_0$  approx measured value (172 cm)
- >  $I_{\text{off}}$  similar for each set
- >  $I_0(1.97\text{kV}) < 2 * I_0(1.95\text{kV})$
- > Departure from model @ high rates !





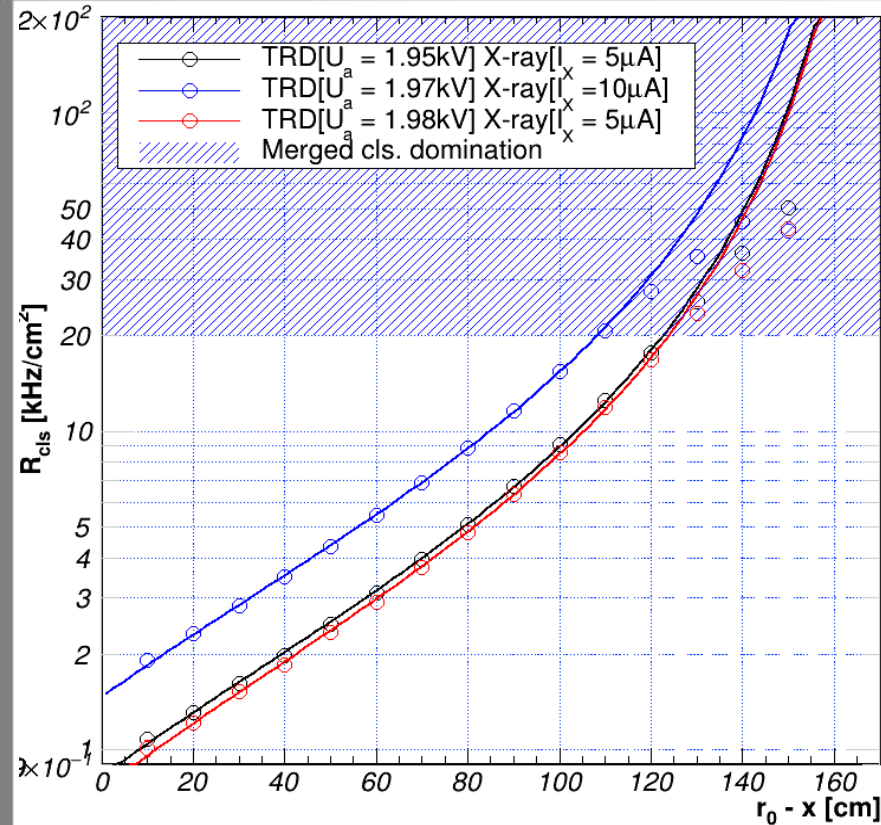
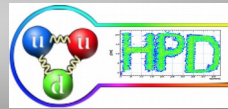
# RATE → real life signals @ 100 kHz/cm<sup>2</sup>



- Time based reconstruction of X rays on 6 FASPs  
 - Acquisition time 10 μs



# RATE → clusters' systematic



$\chi^2 / \text{ndf}$	2.655 / 8
$I_{\text{off}}$	$-0.8921 \pm 0.0501$
$I_0$	$4.861\text{e}+04 \pm 726$
$r_0$	$172 \pm 0$

$\chi^2 / \text{ndf}$	2.017 / 8
$I_{\text{off}}$	$-1.491 \pm 0.07298$
$I_0$	$8.762\text{e}+04 \pm 1004$
$r_0$	$172 \pm 0$

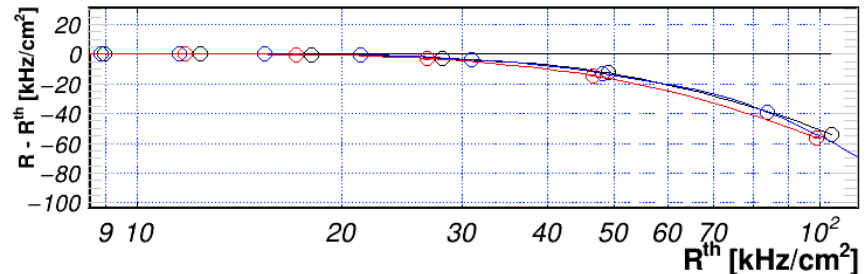
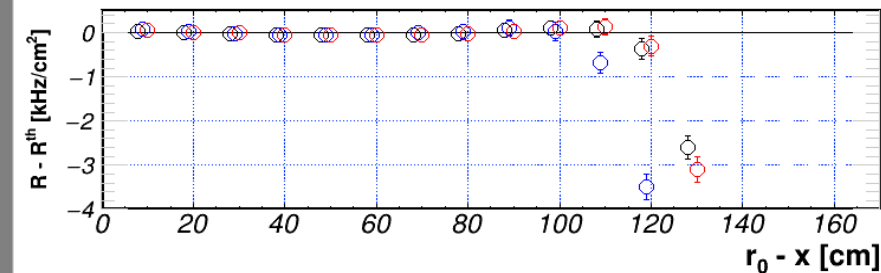
$\chi^2 / \text{ndf}$	2.554 / 8
$I_{\text{off}}$	$-0.9002 \pm 0.04813$
$I_0$	$5.108\text{e}+04 \pm 724.4$
$r_0$	$172 \pm 0$

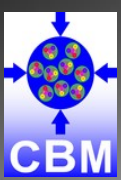
## Observations

### for all 3 data sets

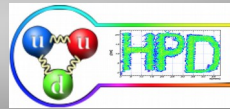
- Sudden departure from the power law
- Similar trend against theoretical rate

- Systematic effect of particle pile-up
- Need cluster deconvolution (to be done)





# Conclusions



Close to production versions (mCBM and beyond) for:

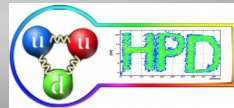
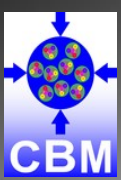
- ◆ FASP (v03)
- ◆ GETS
- ◆ Time-Based RECO

... were tested for basic performance observables of the TRD system

- ENERGY – Full description of FEE and detector features provide detailed and precise gain and spectrum estimations
  - ◆ Reconstruction of overflow signals (large Edep) still an issue
- X-Y POSITION
  - ◆ “Independently” measured with perforated masks
  - ◆ x-y reconstruction works
  - ◆ Systematic effects of cluster [a]symmetry under scrutiny
- RATE
  - ◆ FEE-DAQ systematic under control
  - ◆ No time dependent effects observed for rates close to the target 100kHz/cm<sup>2</sup>
  - ◆ Particle pile-up above 20kHz/cm<sup>2</sup> still need to be addressed

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BACKUP