Edge effects and crosstalk evaluation for the BeamCal sensor

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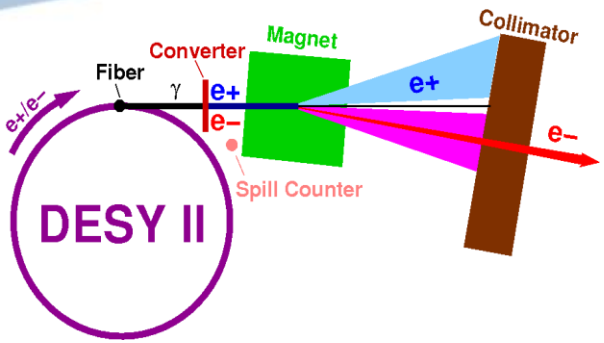
Outline

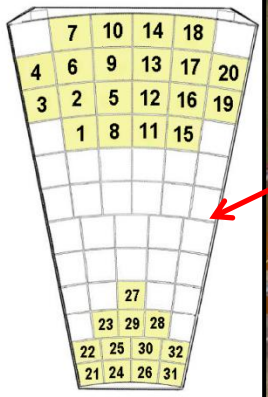
- ✓ Test Beam set-up
- ✓ Geometrical reconstruction - Methodology
- ✓ Signal analysis
- ✓ Induced effects on the neighboring pads
- ✓ Results
- ✓ Conclusions

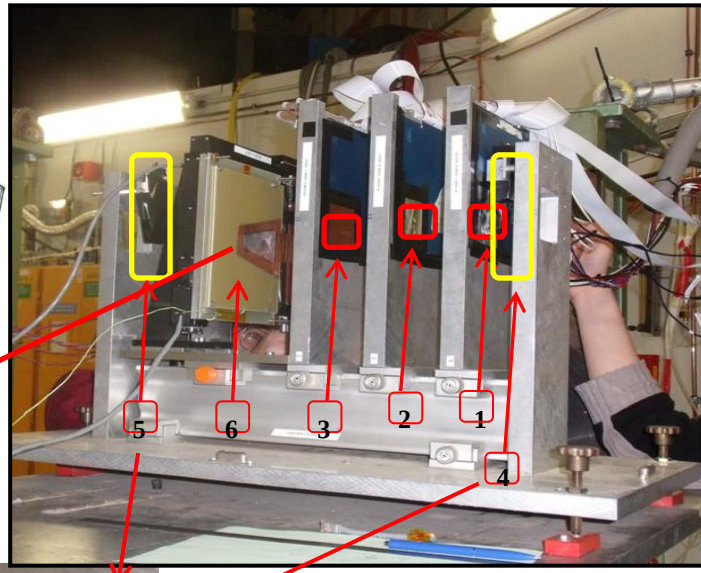
Test beam set-up

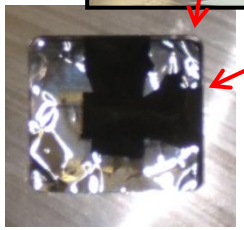


- DESY II Synchrotron provide electrons with up to 1000 particles per cm², energies from 1 to 6 GeV;
- Test Beam took place in beam line 22 of DESY II ring in Hamburg, from 4th to 22nd November 2011;
- Used 2 GeV electron beam;

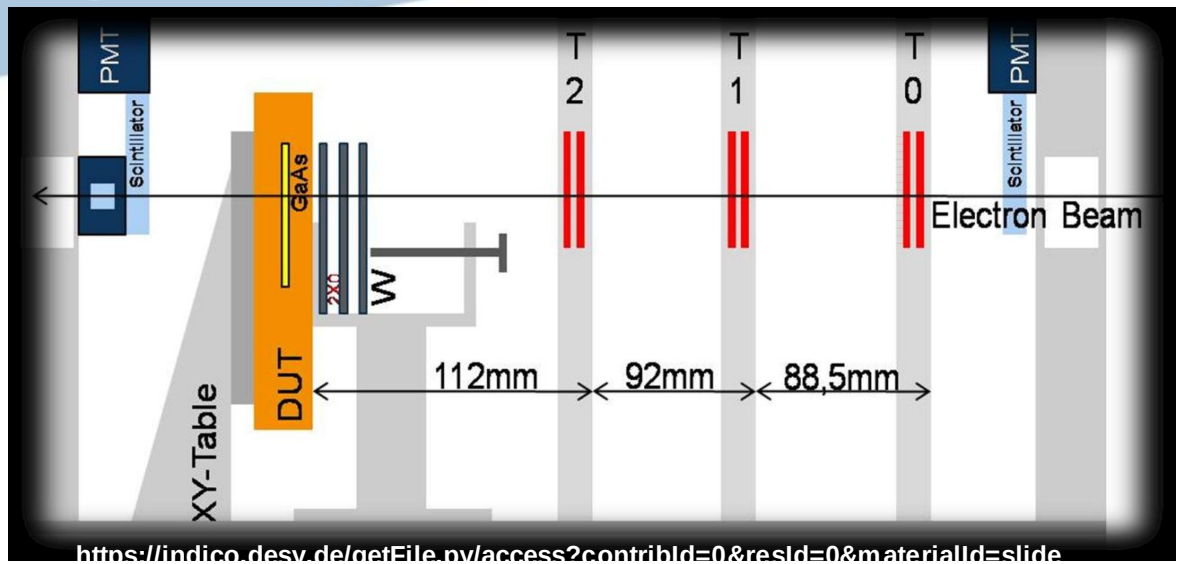
- **ZEUS telescope planes (1, 2, 3):**
  - Si planes: 300 μm thick
  - Active area: 32 x 32mm²
  - Double perpendicular layers,
  - 640 strip channels (50μm)
- **Trigger scintillators (4,5) :**
  - Trigger window: 7 x 7mm²
- **BeamCal Sensor (6)**
  - GaAs:Cr sensor







Set-up configuration



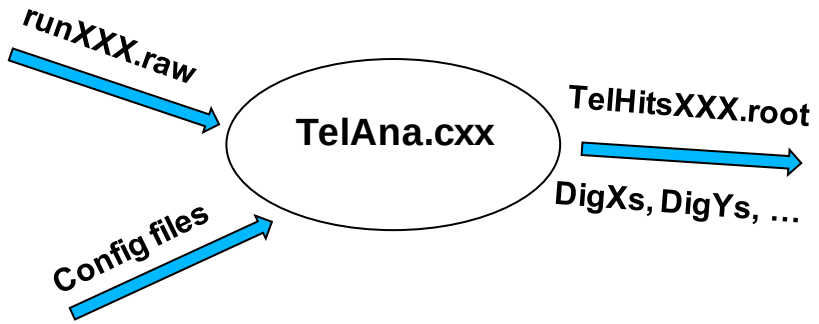
config files for DUT analysis for all runs

Energy = 2
[Telescope 0]
TELOffsetZ = 0.0

[Telescope 1]
TELOffsetZ = 88500.0

[Telescope 2]
TELOffsetZ = 180500.0

[DUT]
DUTOffsetZ = 292500
DUTThickness = 500.0



Track reconstruction method

- DigXs and DigYs coordinates have been taken from for all telescope planes;
- Hits number/plane = 1;

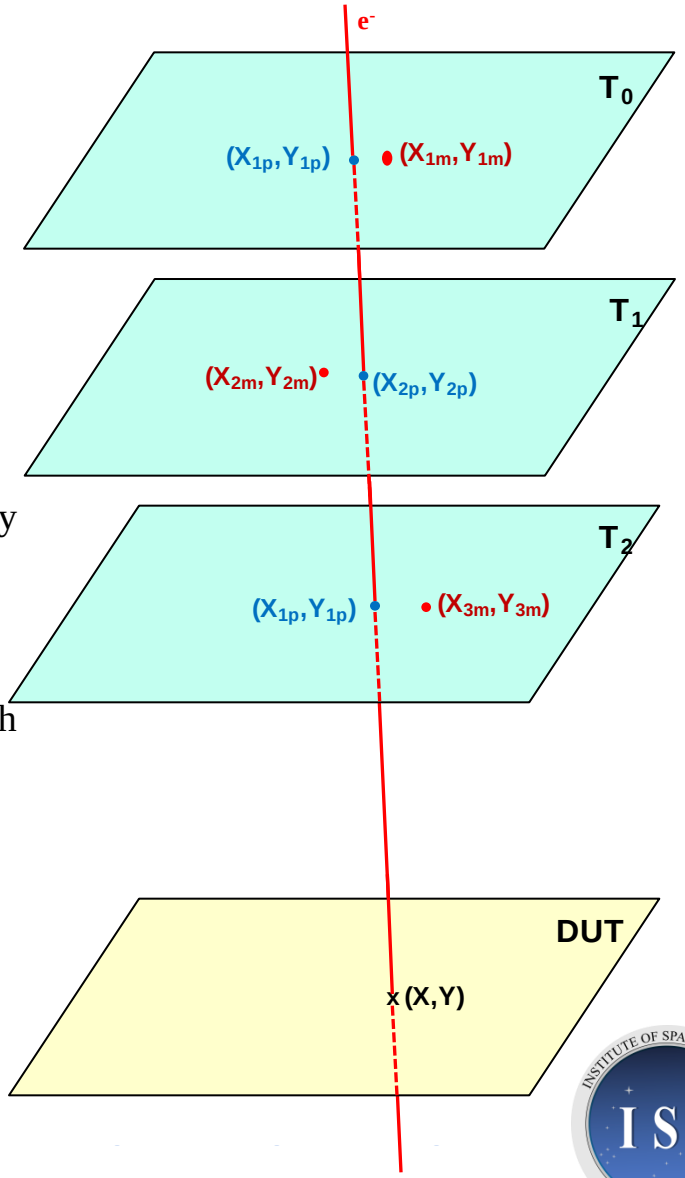
where:

•(X_{im}, Y_{im}) = measured coordinates or given coordinates by TelAna, $i \in [1, 3]$;

•(X_{im}, Y_{im}) = (DigXs, DigYs);

•(X_{ip}, Y_{ip}) = predicted coordinates given by line intersection with each telescope plane

$$Min\ (d^2) = Min\left(\sum_{i=1}^{3}\left(\left(x_{ip} - x_{im}\right)^2 + \left(y_{ip} - y_{im}\right)^2\right)\right)$$

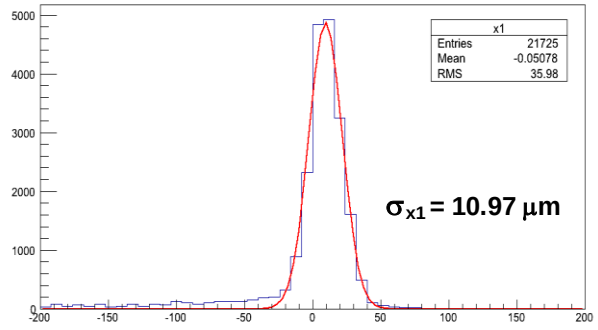


Track reconstruction method

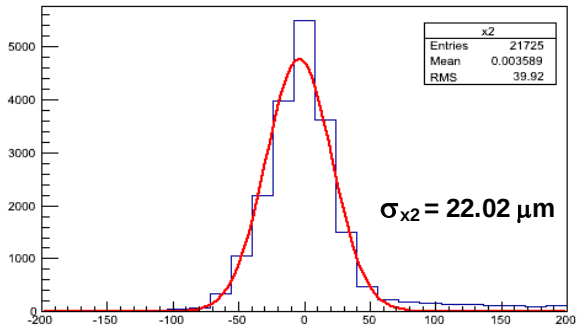
Tracking:

- Sigma from fits are smaller than about 30μm
- The Si chamber alignment was make with a maximum 100 μm shift

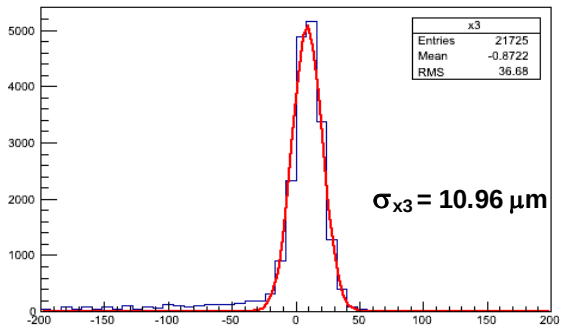
ΔX_1



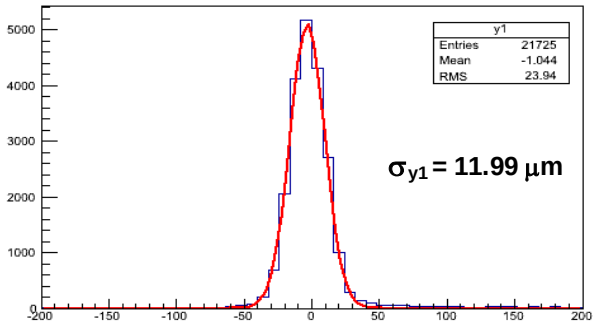
ΔX_2



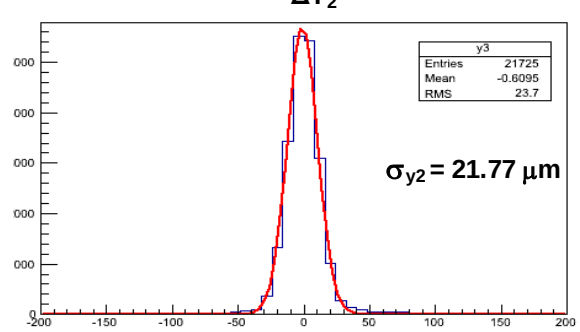
ΔX_3



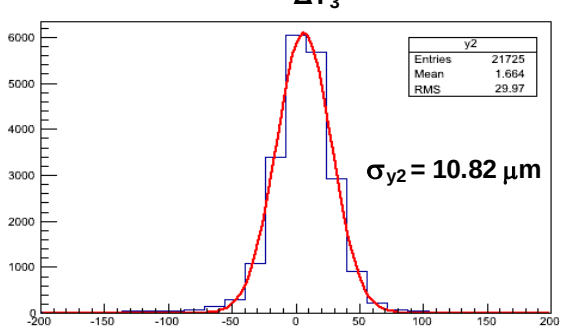
ΔY_1



ΔY_2



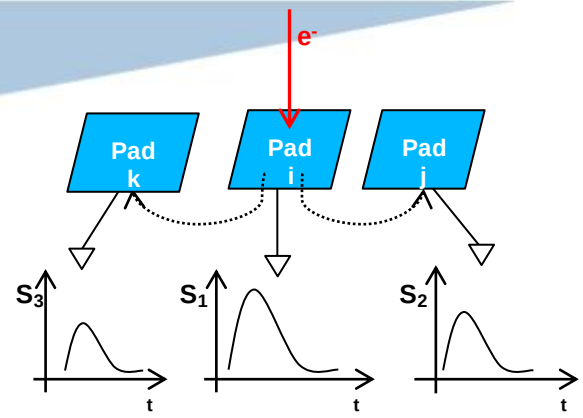
ΔY_3

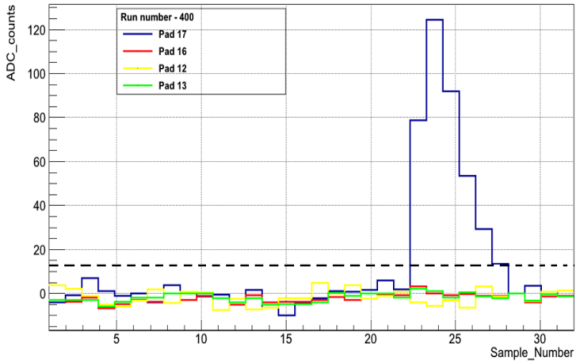


Signal management

Signal:

MAXC(pad_nr)>Eped (pad_nr) + coef*RMS(pad_nr), where coef = 3



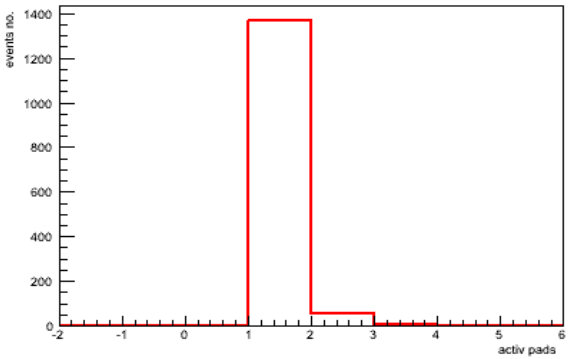


Active pads in a trigger for one track/event:

PadNo.	#ch1	#ch2	#ch3	…	#chi
SignalValue	S_1	S_2	S_3		S_i

ContainerSignalSize Є [1, 32]

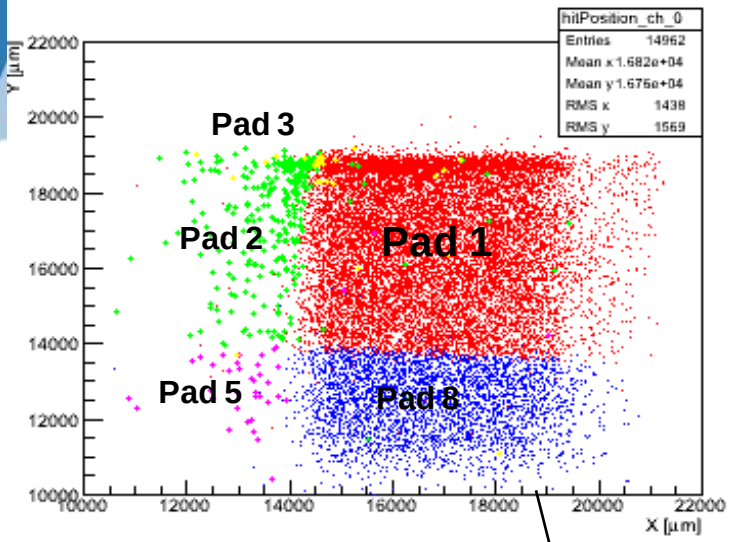
$S_1 \geq S_2 >= S_3$...,

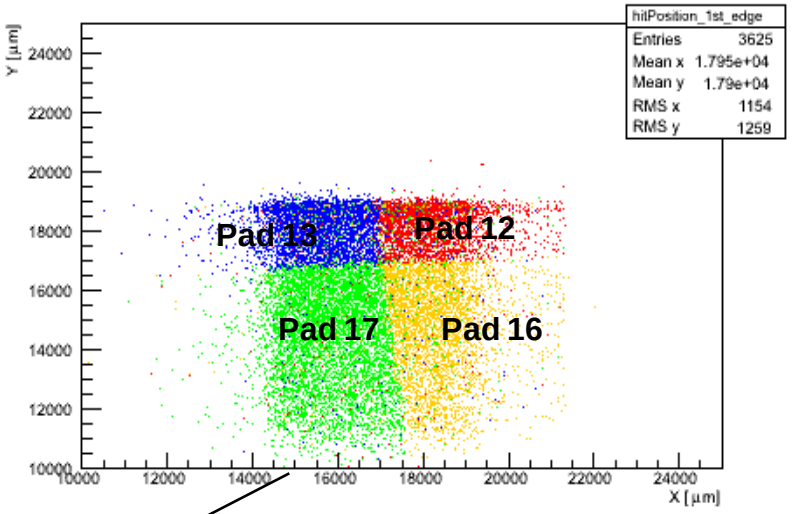


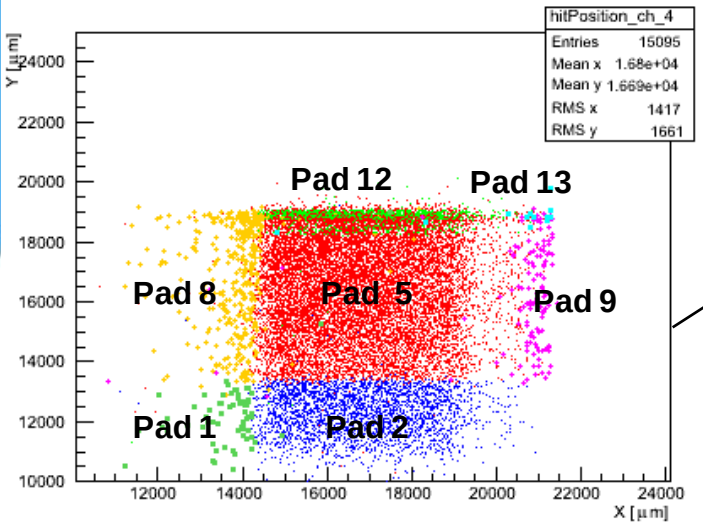
where:

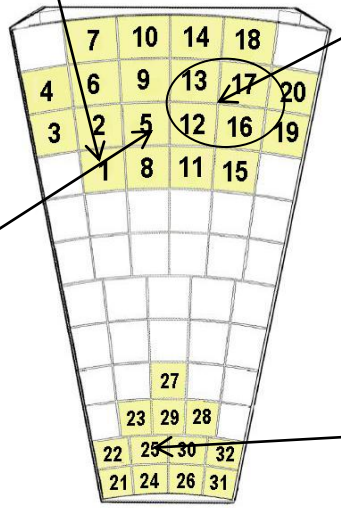
- S_1 is the signal for the hit pad
- S_2, S_3… are the induced signals

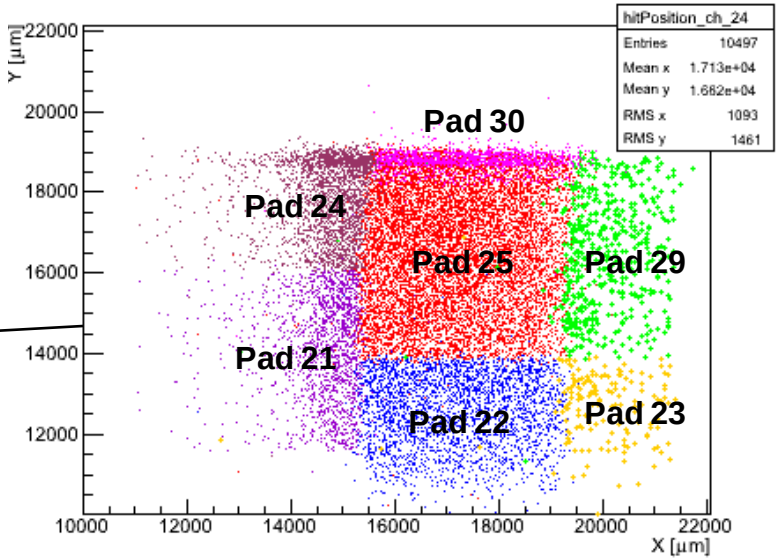
Hits map on the sensor





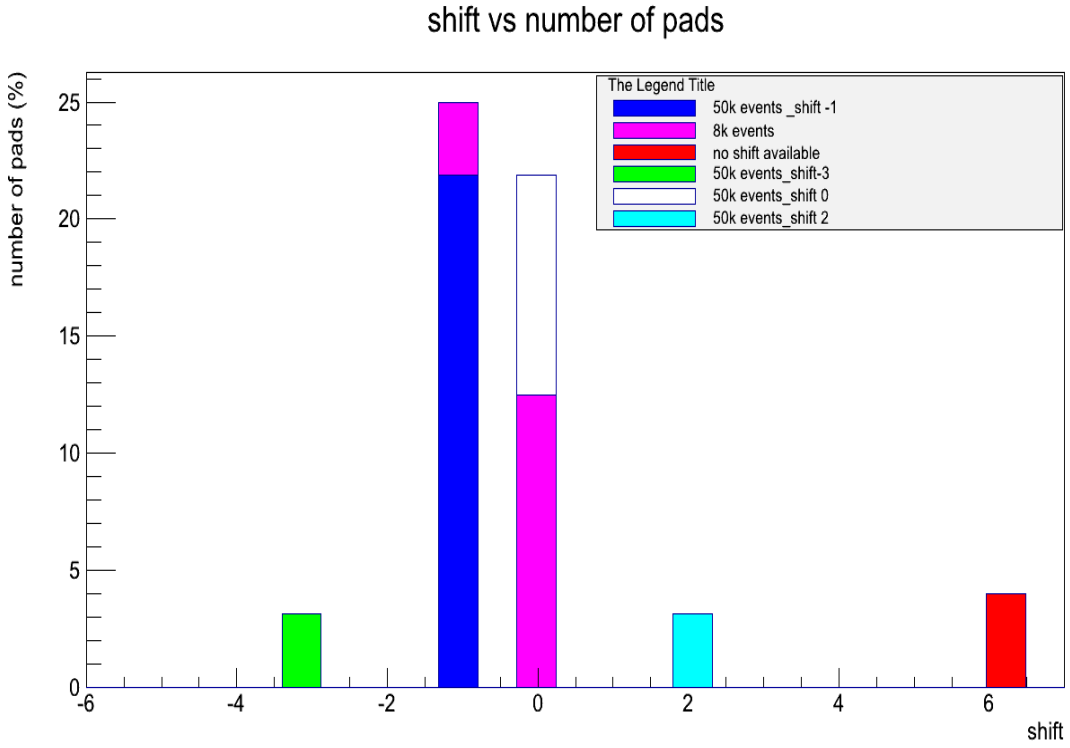


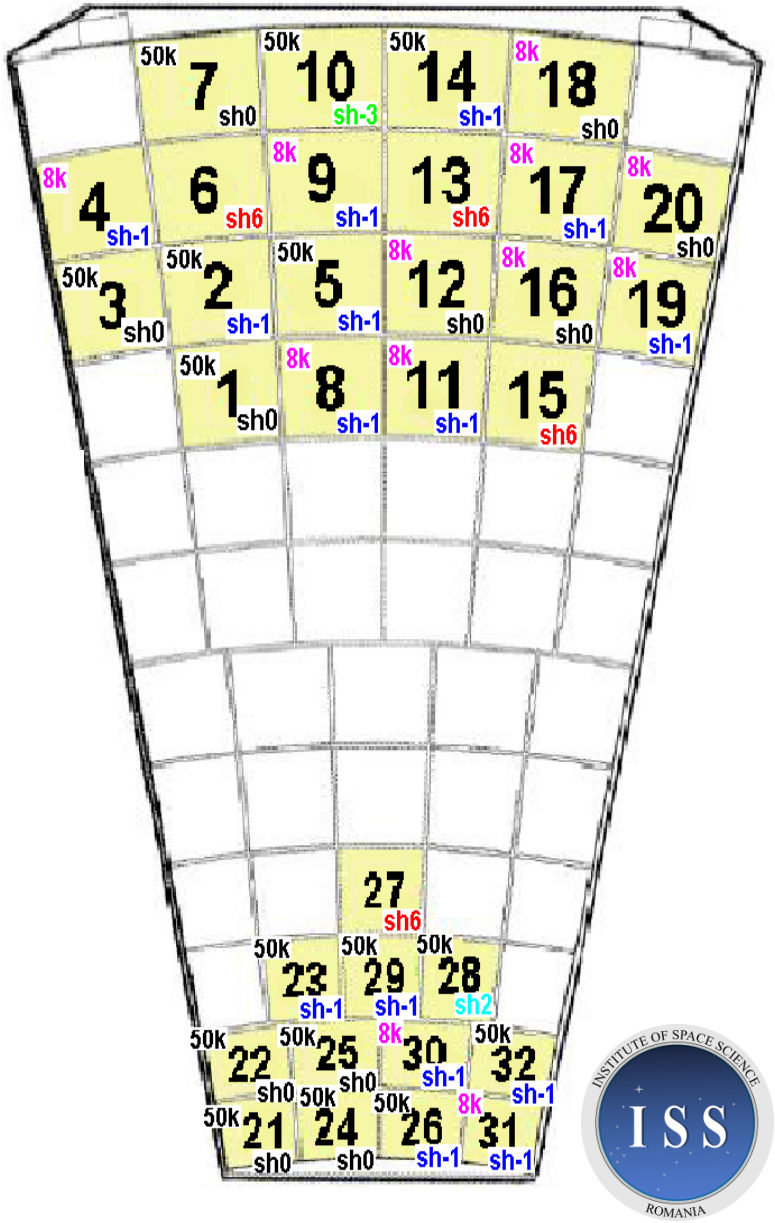




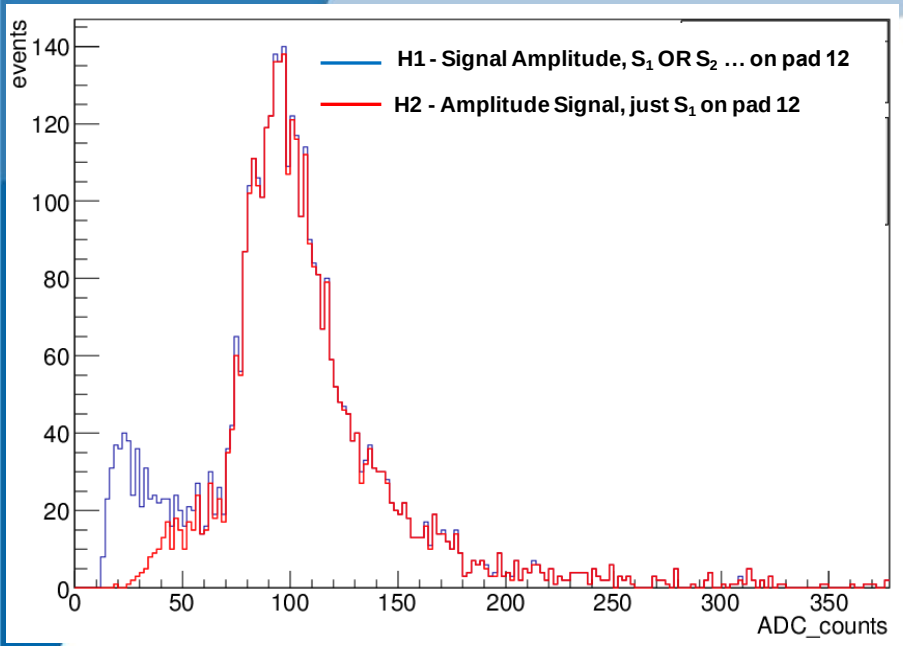
Shifts between FCAL and TelAna triggers

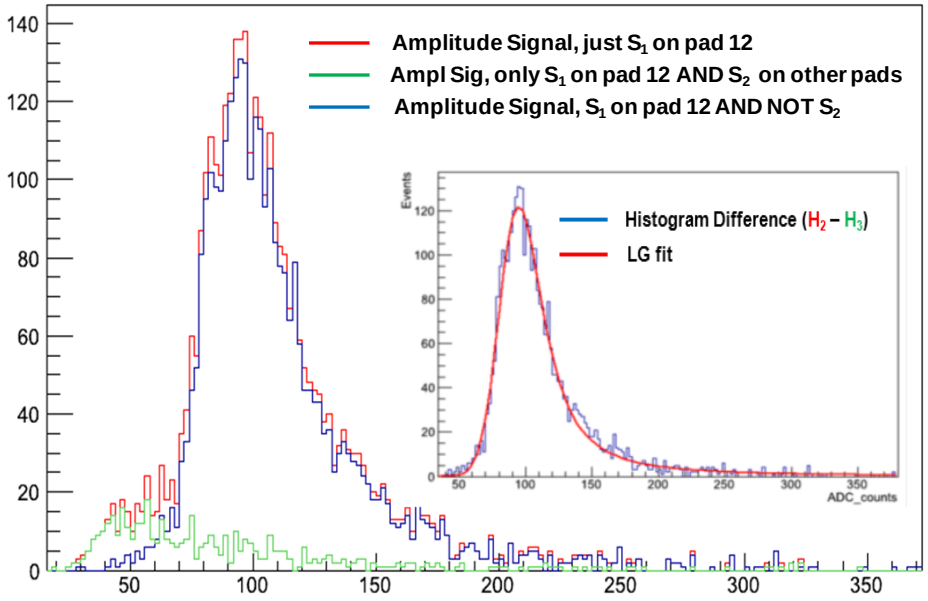
- 11 shifts, [-5, -4, ...0 … 4, 5], between TelAna and FCAL triggers according with Szymon method;
- The shifts effect has been studied for all runs
- Some runs work only for the first 8k events **(???)**





The influence of edge effects on the Signal Amplitude





Blue histogram (H1):

1.1 ContainerSignalSize >= 1

1.2 Pad 12 has a signal:

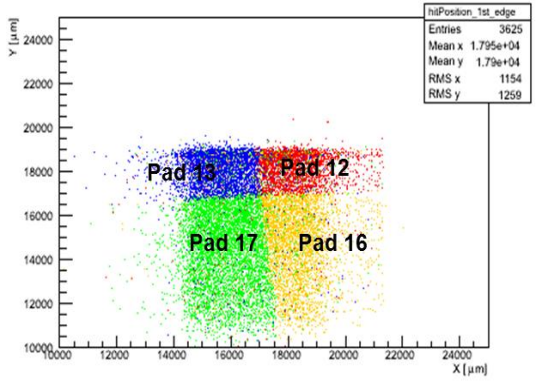
- pad 12 is fired (S_1) OR
- Signal on Pad 12 (S_2) is induced

Red histogram (H2):

2.1 ContainerSignalSize >= 1

2.2 Pad 12 has a signal:

- pad 12 (S_1) is fired



Green histogram (H3):

1.1 ContainerSignalSize > 1

1.2 Pad 12 has a signal:

- pad 12 is fired (S_1) AND
- Induced signal on neighboring pads

Blue histogram (Diff):

1.1 Container SignalSize =1

1.2 Pad 12 is fired

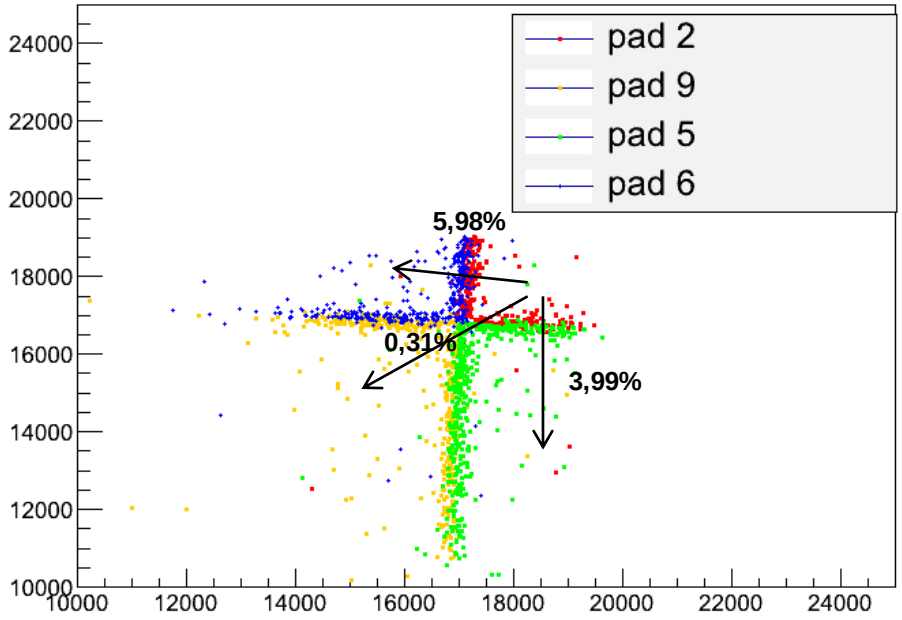
Edge effects evaluation for $S_2>0$

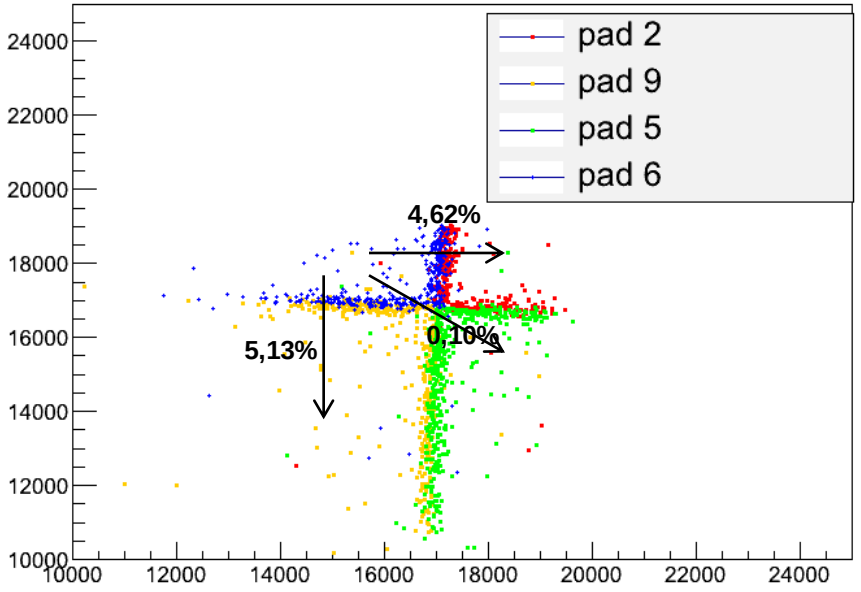
Channel number	1			5			8			4			
	N_{ij}	N_{ij}/N_i	$\sigma(N_{ij}/N_i)$	N_{ij}	N_{ij}/N_i	$\sigma(N_{ij}/N_i)$	N_{ij}	N_{ij}/N_i	$\sigma(N_{ij}/N_i)$	N_{ij}	N_{ij}/N_i	$\sigma(N_{ij}/N_i)$	N_i
1	0	-	0,000	153	5,98%	0,005	8	0,31%	0,001	102	3,99%	0,004	2558
5	183	4,62%	0,003	0	0,00%	0	203	5,13%	0,004	4	0,10%	0,000	3960
8	10	0,15%	0,000	198	3,04%	0,002	0	0,00%	0,000	229	3,52%	0,002	6505
4	134	3,19%	0,003	4	0,10%	0,000	304	7,24%	0,004	0	0,00%	0,00	4198

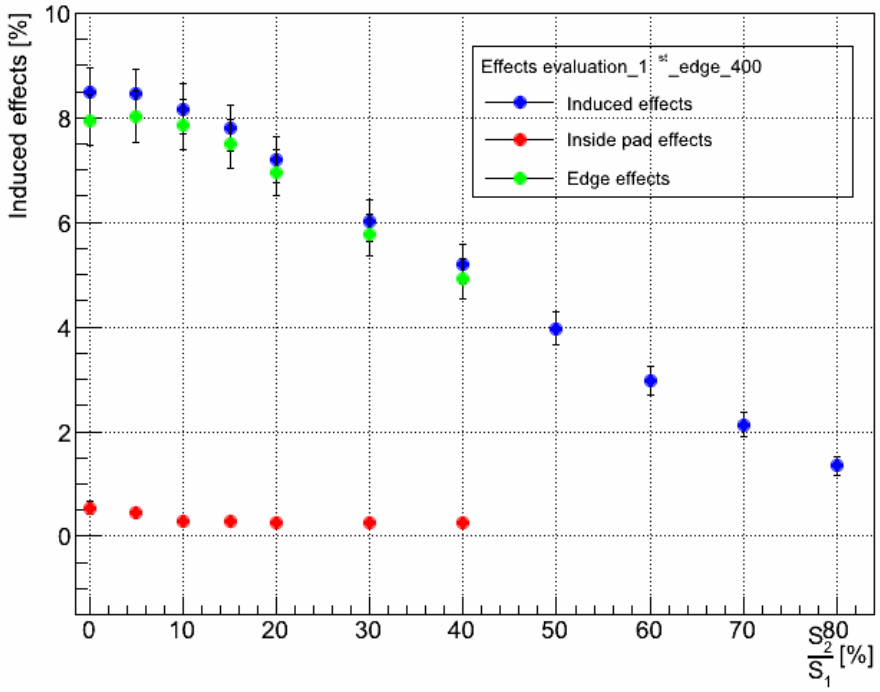
where: **N_{ij} – triggers number for electron interaction with pad *i* which induce signal on pad *j*;**

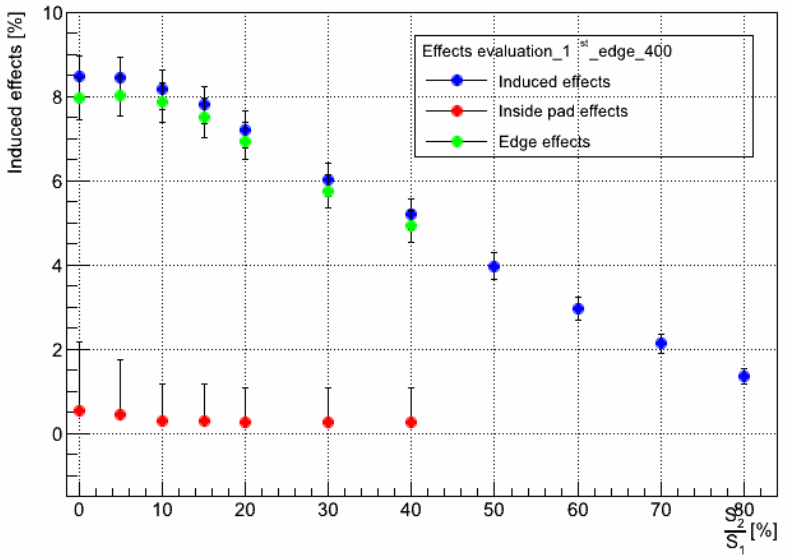
N_i – total triggers number which produce signal on pad *i* ;

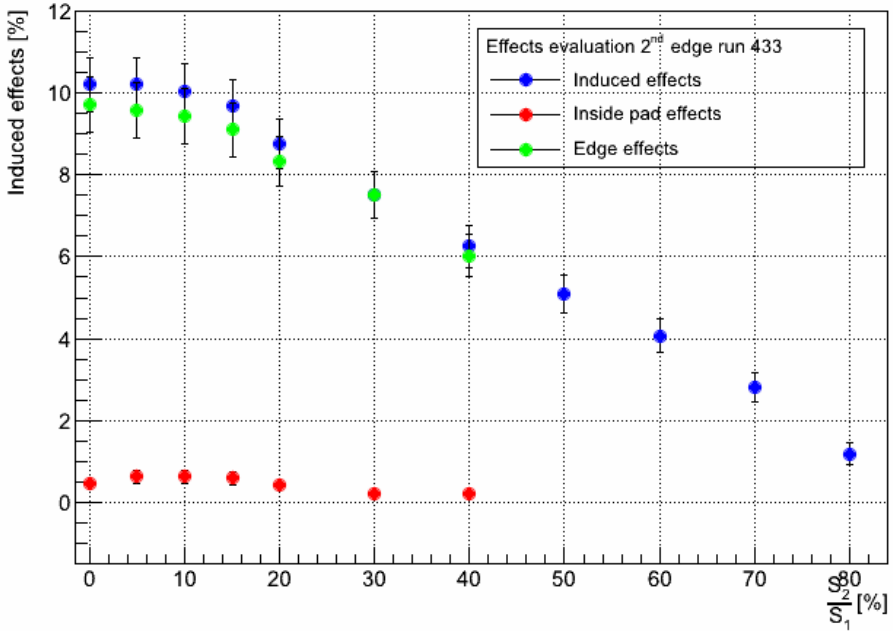
Edge effects = N_{ij}/N_i

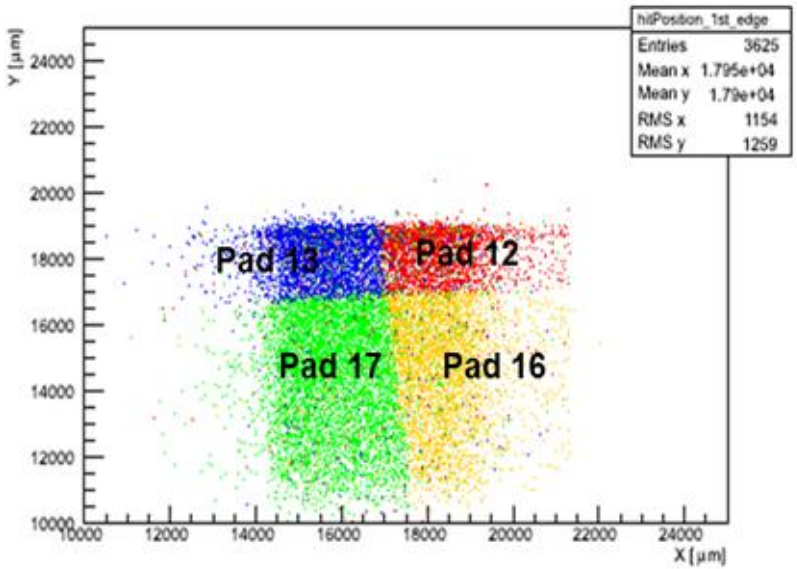


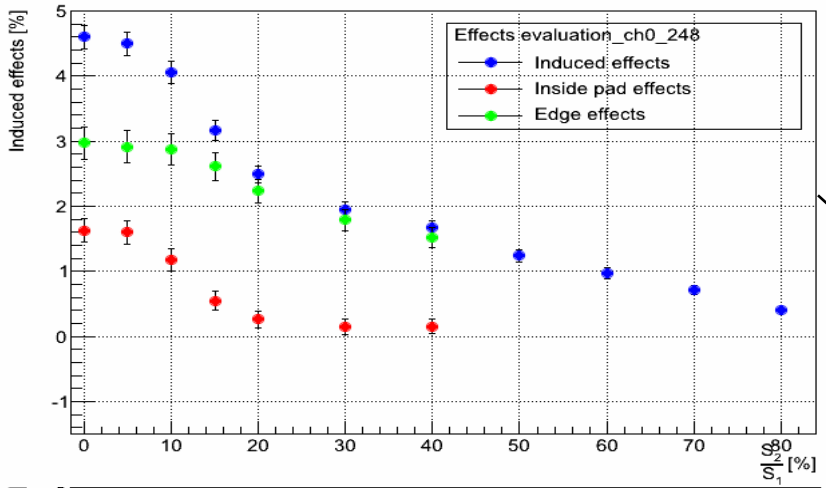


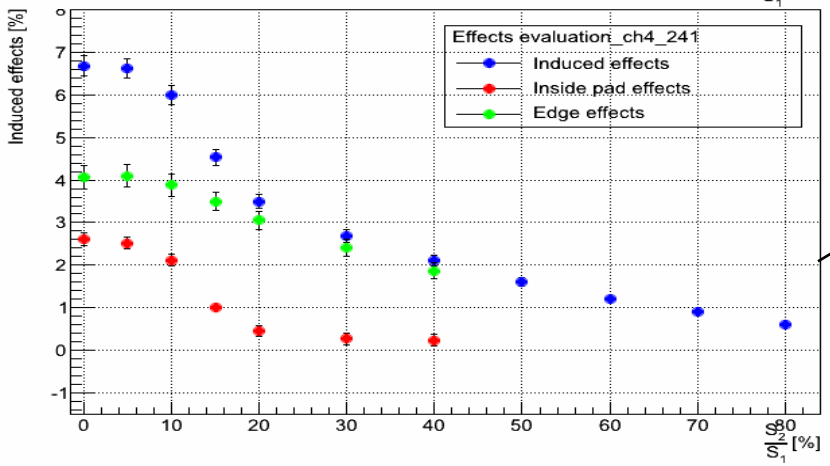

Induced effects [%]
Effects evaluation_1st_edge_400
Induced effects
Inside pad effects
Edge effects
S2/S1 [%]

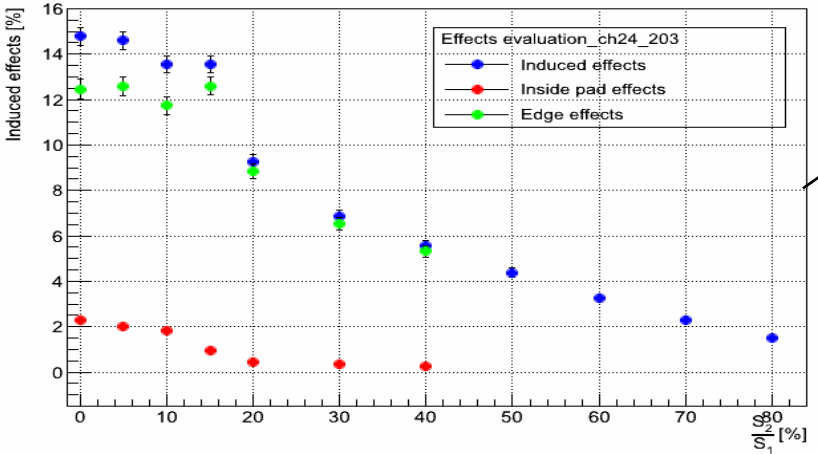

Induced effects [%]
Effects evaluation_1st_edge_400
Induced effects
Inside pad effects
Edge effects
S2/S1 [%]

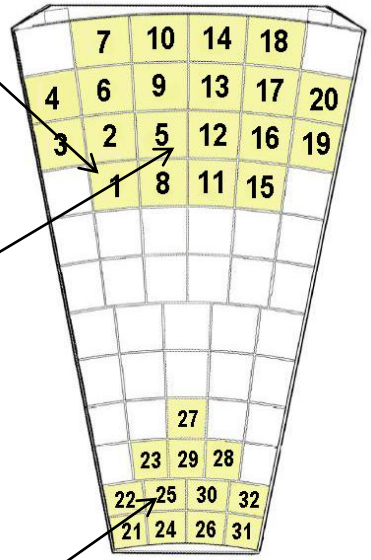

Induced effects [%]
Effects evaluation 2nd edge run 433
Induced effects
Inside pad effects
Edge effects
S2/S1 [%]

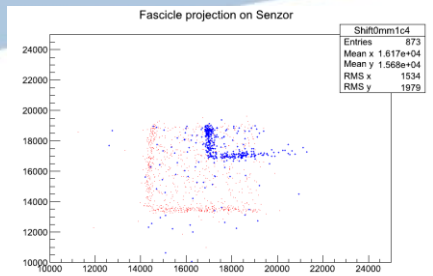

hitPosition_1st_edge
Entries 3625
Mean x 1.795e+04
Mean y 1.79e+04
RMS x 1154
RMS y 1259
Y [µm]
X [µm]
Pad 13
Pad 12
Pad 17
Pad 16

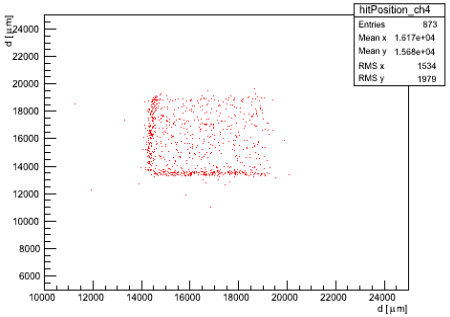

Effects evaluation_ch0_248
Induced effects
Inside pad effects
Edge effects
Induced effects [%]
$\frac{S_2}{S_1}$ [%]

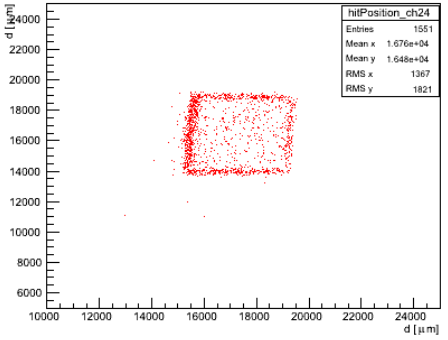

Effects evaluation_ch4_241
Induced effects
Inside pad effects
Edge effects
Induced effects [%]
$\frac{S_2}{S_1}$ [%]

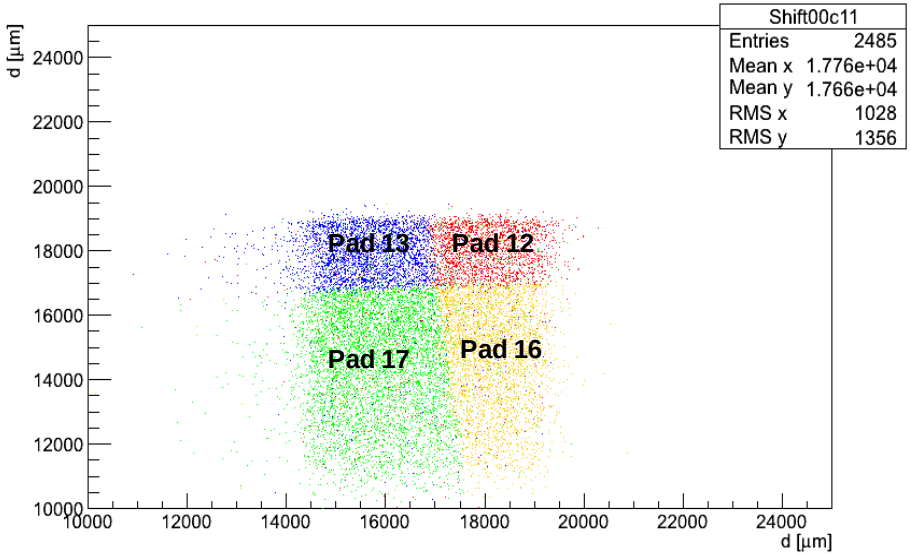

Effects evaluation_ch24_203
Induced effects
Inside pad effects
Edge effects
Induced effects [%]
$\frac{S_2}{S_1}$ [%]


7 10 14 18
4 6 9 13 17 20
3 2 5 12 16 19
1 8 11 15
27
23 29 28
22 25 30 32
21 24 26 31

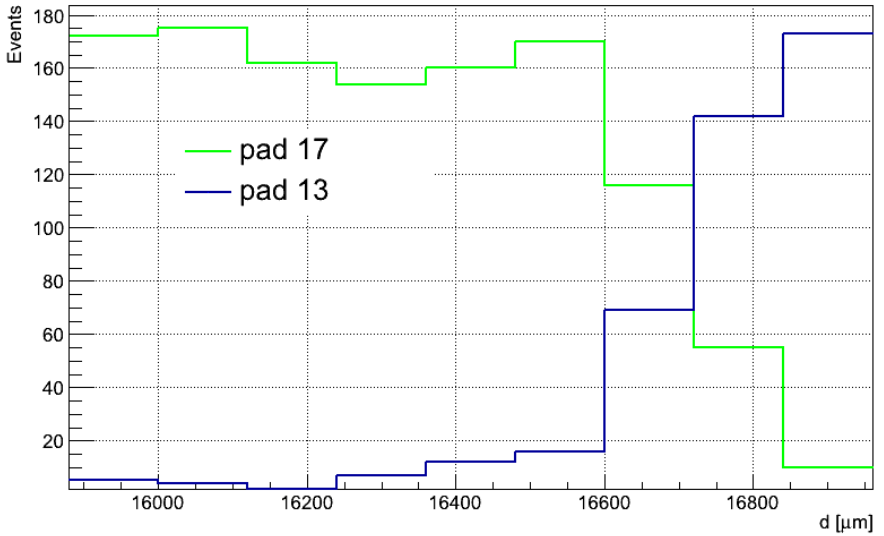

Fascicle projection on Senzor
Shift0mm1c4
Entries 873
Mean x 1.617e+04
Mean y 1.568e+04
RMS x 1534
RMS y 1979


hitPosition_ch4
Entries 873
Mean x 1.617e+04
Mean y 1.568e+04
RMS x 1534
RMS y 1979
d [µm]

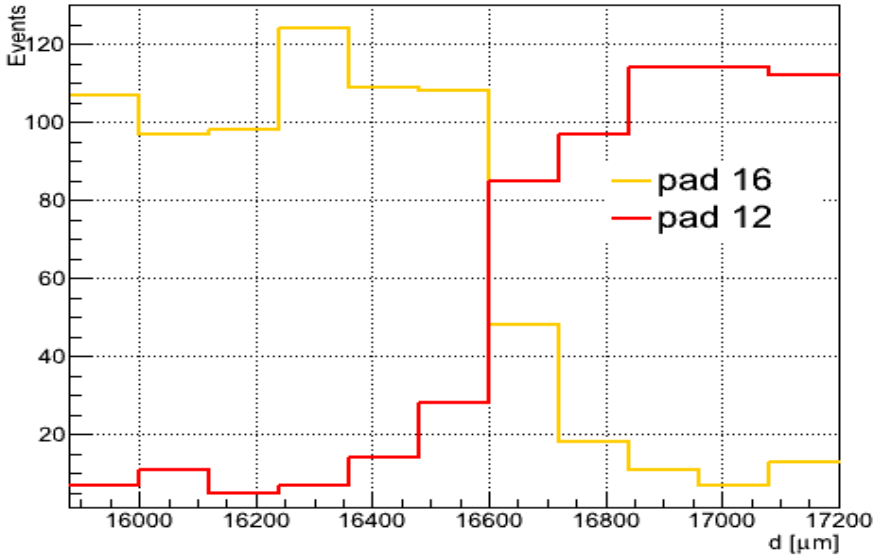

hitPosition_ch24
Entries 1551
Mean x 1.676e+04
Mean y 1.648e+04
RMS x 1367
RMS y 1821
d [µm]



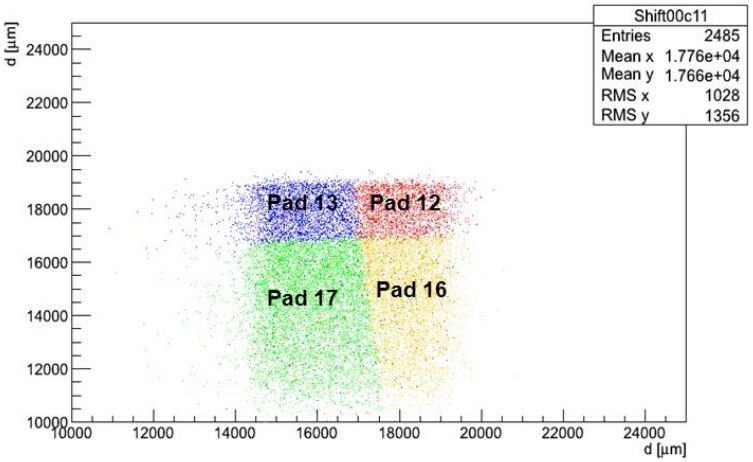
Events distribution on distance to border



Events distribution on distance to border

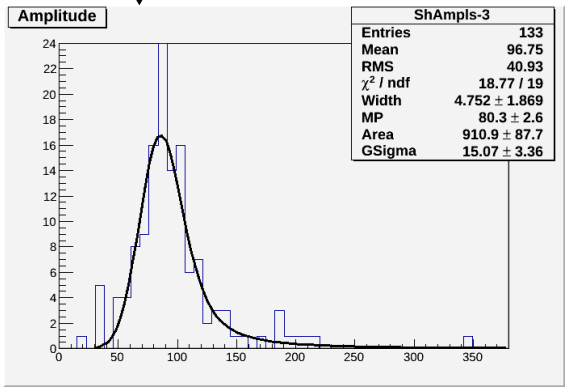


Signal Amplitude dependence on the interaction point



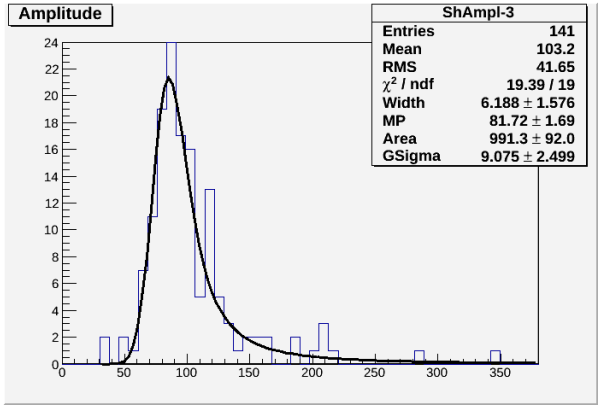
$f_d(S_1)$ = amplitude distribution function

↓ Pad13, d = - 300µm,

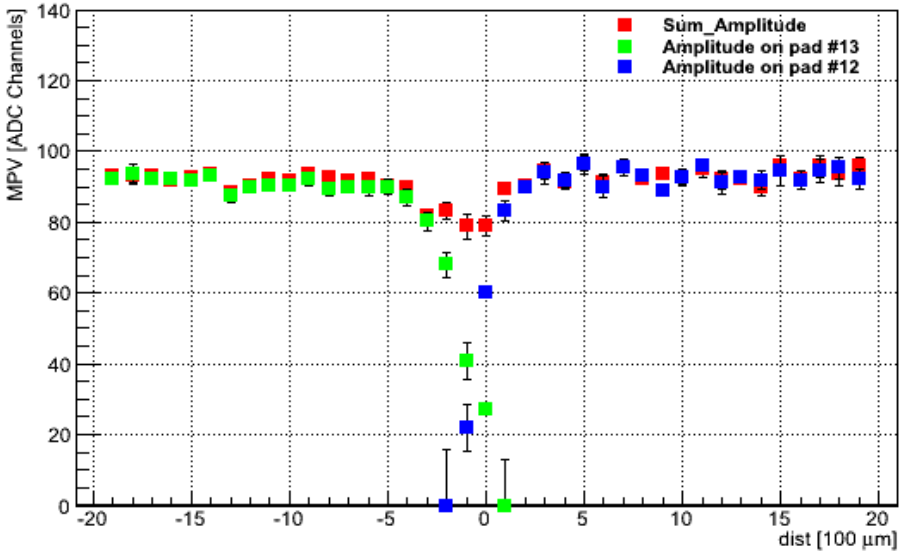


$f_d(S_1 + S_2)$ = amplitude distribution function

↓ Pad13 + Pad 12, d = - 300µm,



$X < d_{hit} < X + 100\mu m$



Conclusion

- ✓ Edge effects are smaller than 10% for GaAs pads in the 2011 fascicle beam;
- ✓ MPVs drop on a distance of about 400μm at the edge border;
- ✓ MPVs are constant along the pad (Signal uniformity);
- ✓ MPVs of the sum distributions drop for about 17% at the border between 2 pads;
- ✓ The signal from inside pads will be studied in the future.

THANK YOU FOR ATTENTION!