H8 crystal data analysis

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H8 Crystal test Beam

The UA9 collaboration is studying techniques to steer ultra-relativistic beams with bent crystals to improve the collimation of proton and heavy ion beams at the LHC.

Measurements of key crystals properties (bending angle, channeling efficiency, etc..) are performed on the SPS extraction line (H8) with 400 GeV/c protons before testing crystals with circulating beams.

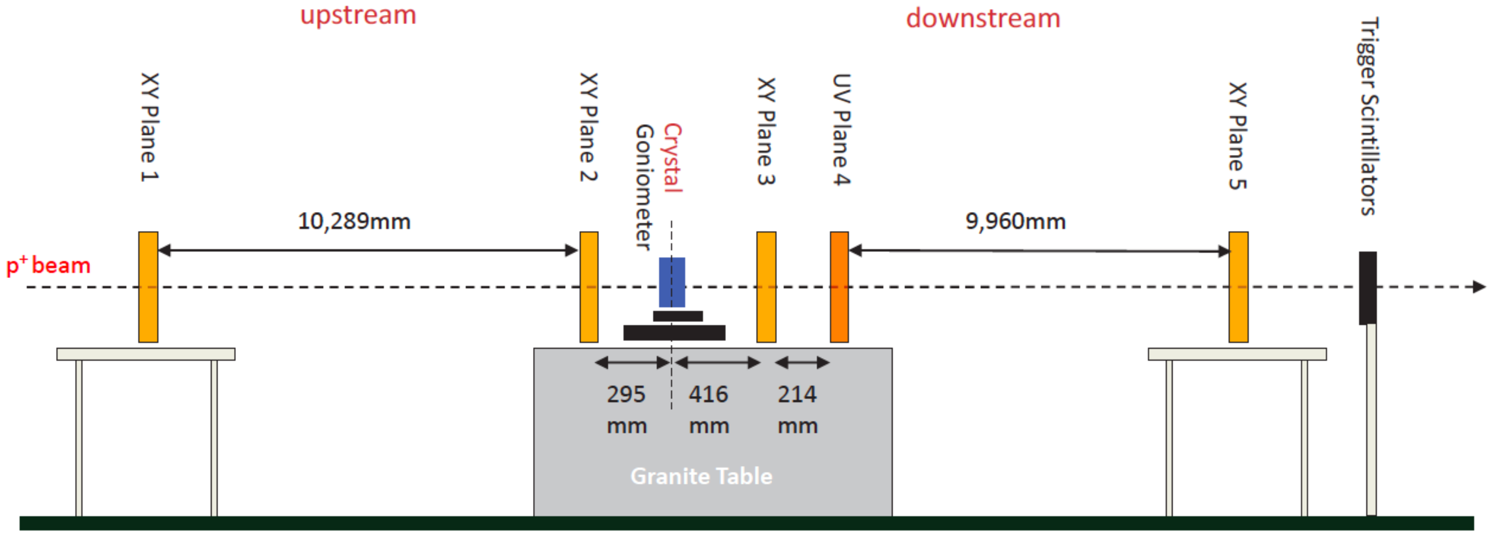
Scope of my master thesis work:
Consistently analyze all the crystals tested in H8 (total of 15 between 2009-2012).

- Compile a comprehensive statistical treatment of different crystals
- Identify "fine" systematic effects (e.g., transitions)
- provide inputs to crystal code developers

Immediate goal: compile list of experimental data for an upcoming workshop on crystal simulations.

H8 experimental Layout

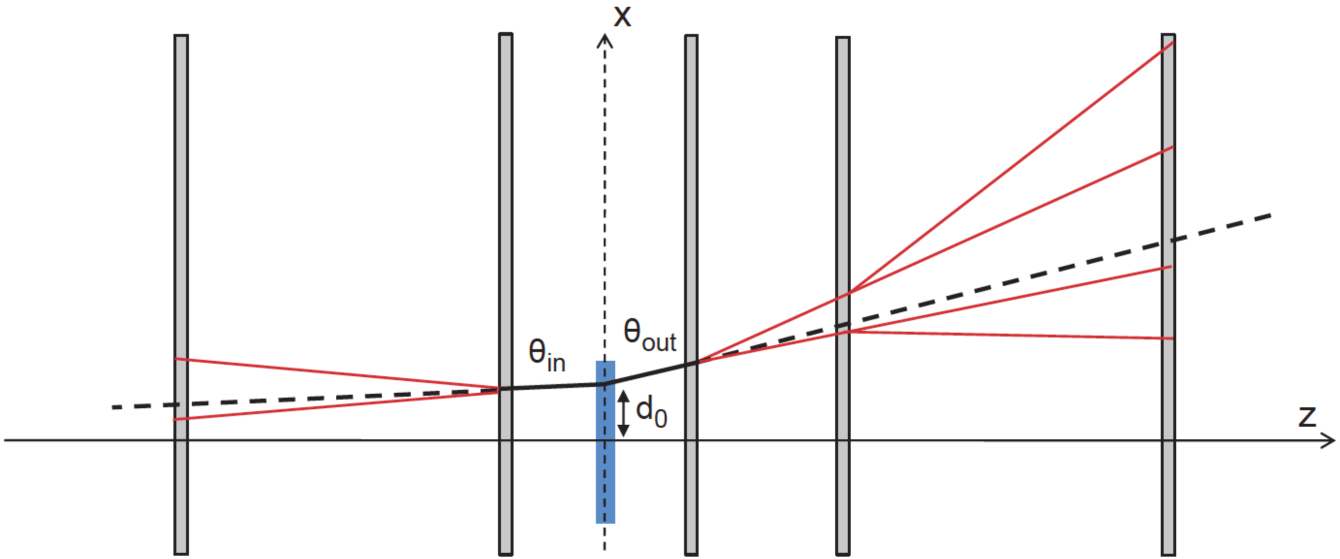
- Five silicon micro-strip sensors (active area 3.8x3.8 cm^2 in the x-y plane) are used to track the particles in the plane orthogonal to the beam direction before and after passing through the crystal.



[1] M. Pesaresi et al., *Design and performance of a high rate, high angular resolution beam telescope used for crystal channeling studies*,2011 JINST 6 P040006

Track reconstruction

- Only one track per event is reconstructed.
- The event reconstruction uses the first two and the last two detectors to measure the incoming and the outgoing angle of the tracks, respectively.
- The impact point at the crystal position is given by the interpolation of the incoming and the outgoing tracks.



Experimental data structure

A complete experimental characterization of a crystal consists of different acquisition runs

- "Alignment" run: used to validate the telescope performance without crystals on the beam line
- Transverse position scan: used to find the crystal, when it crosses the beam
- Crystal angular scan: used to identify the interesting angular regions - amorphous, channeling and volume reflection orientations.
- High statistic acquisitions: performed in the region where we want fully analyze a given effect. Typically, done in the optimum channeling orientation.

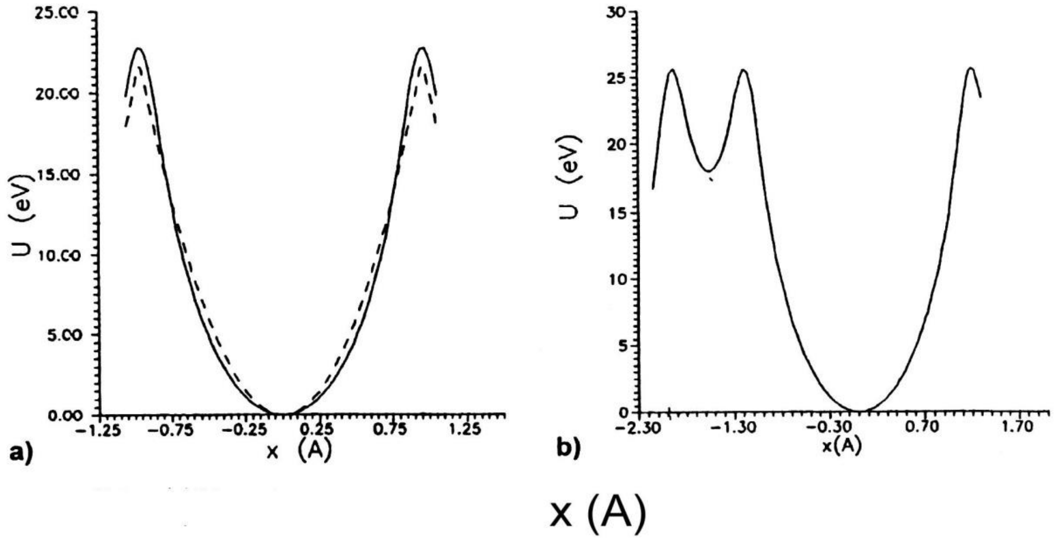
UA9 Crystals

Two kind of crystals were test in H8

- Strip crystal : the anticlastic bending is induced on the planes (110)
- Quasi-mosaic crystal : the anticlastic bending is induced on the planes (111)

The main difference is that the strip channels have all the same width, while the QM have a main channel and a smaller secondary (1/3).

A total of 15 crystals were analyzed, 10 strip and 5 quasi-mosaic



Run Analysis

We developed analysis tools in Root to get from the raw data (details in next slides):

- Alignment run ->
  - check of beam parameters (e.g. input distributions on crystal)
  - telescope resolution
- Hi stat CH ->
  - Geometrical cut (different strategy between ST and QM)
  - Torsion correction
  - Crystal channeling efficiency
  - Dechanneling length
  - First look to transition region
- Angular scan run ->
  - Volume capture features

The analysis for the STF45 crystal is shown in the following slides as a case study

Alignment Run Analysis

– With the crystal removed from the line is possible to measure the key parameters :

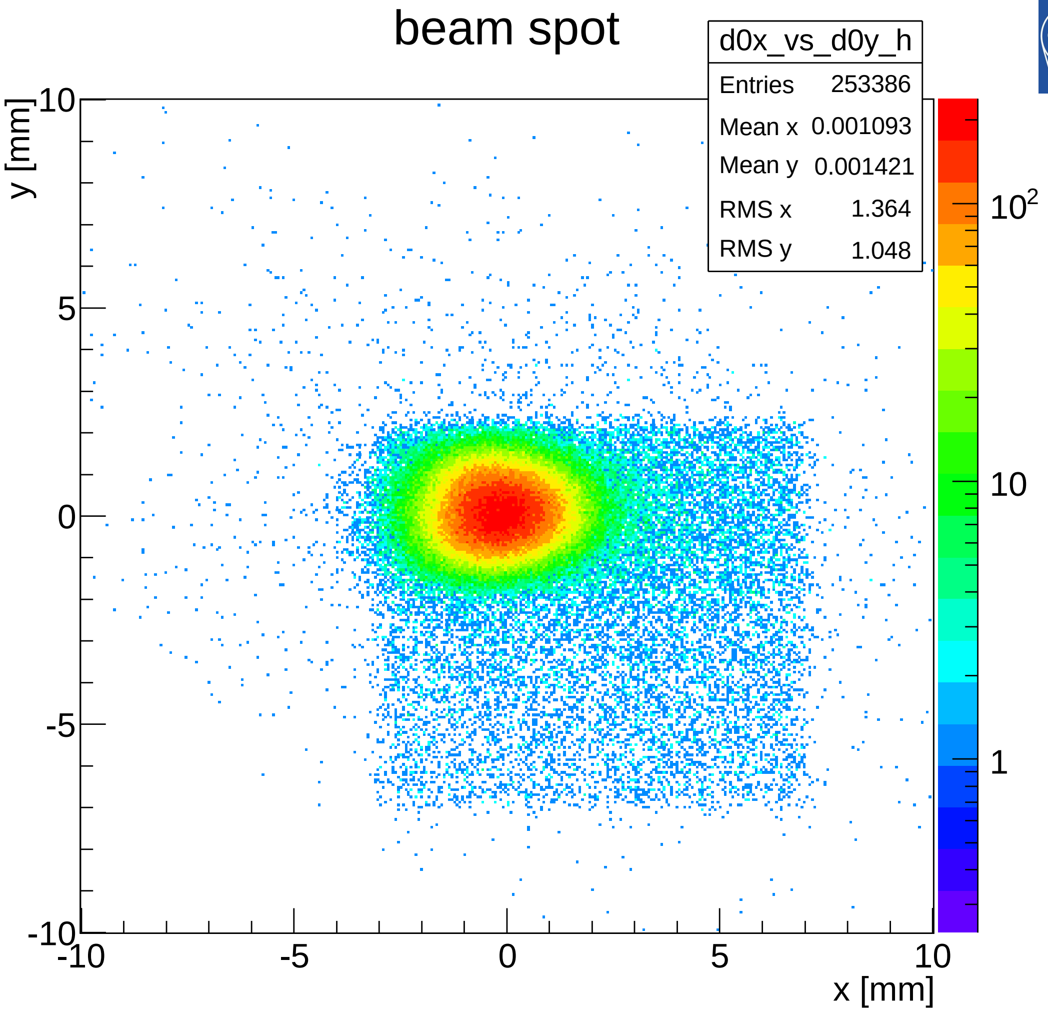
- Beam divergence
- Beam distribution
- Telescope resolution

Alignment Run Analysis

The incoming beam spot can be well approximated by a double Gaussian (see next slide).

The surrounding background (square area in light blue) is given by the interaction of the beam particle with the micro collimators placed at the beginning of the line;

When the micro collimators are moved the shape of the background change.

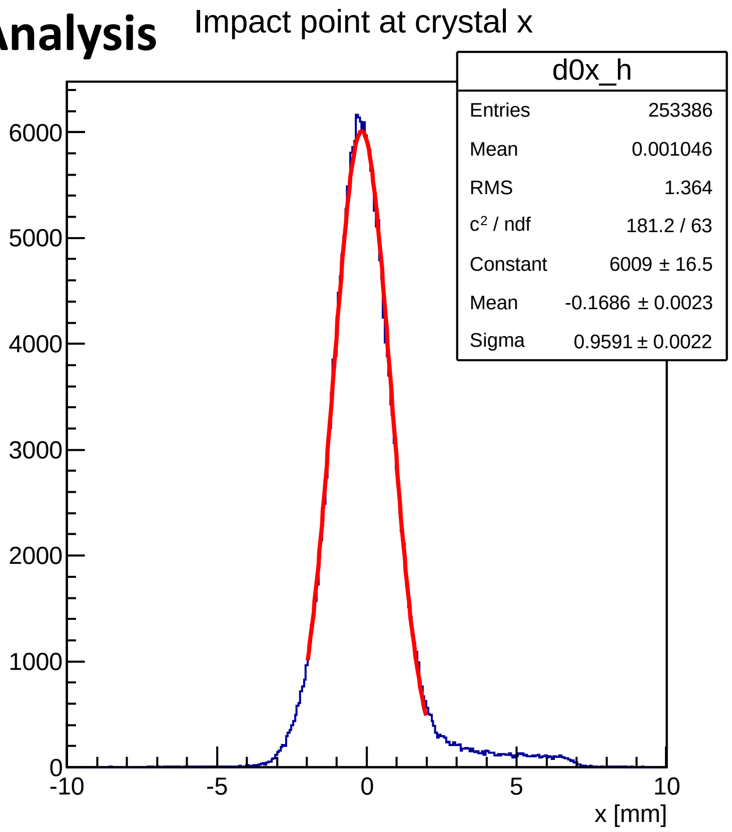


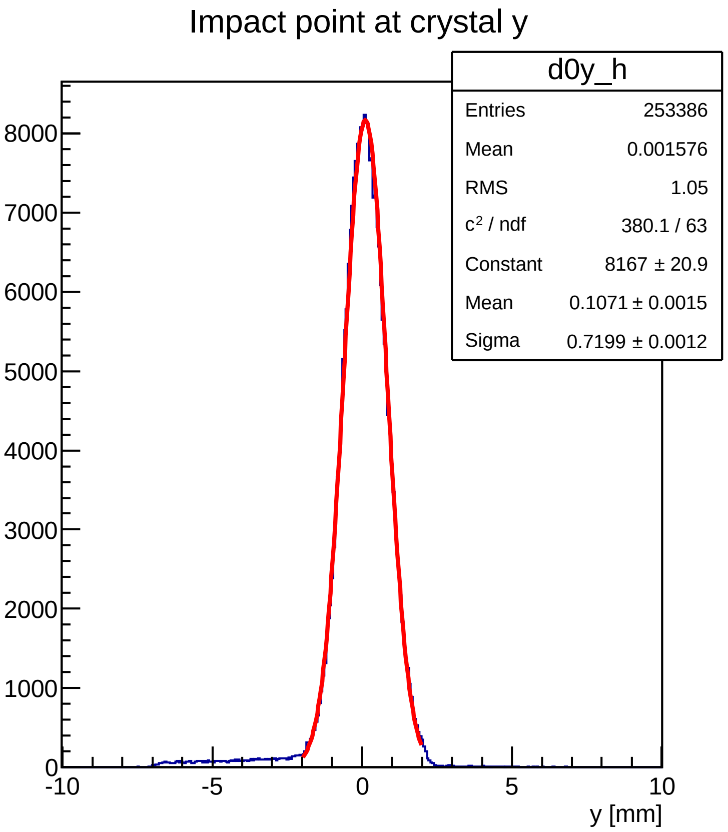
Alignment Run Analysis

Here we can see the beam profile in the orthogonal plane.

The plots show the double Gaussian shape of the beam core with a sigma of 0.96 mm and 0.72 mm in x and y respectively.

The asymmetric tail are not fitted, because are the background due to the micro collimators.



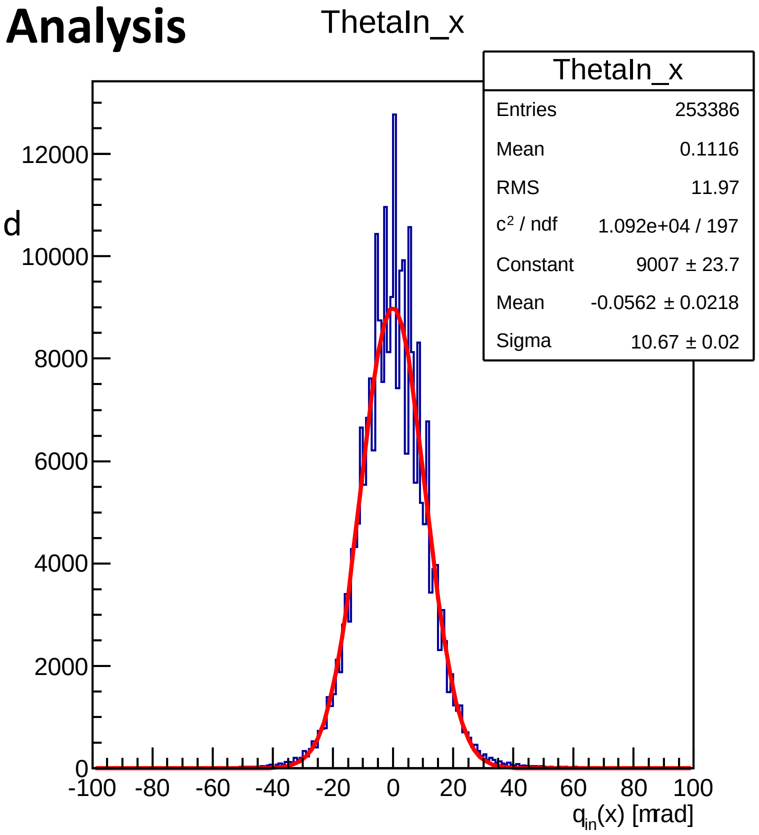


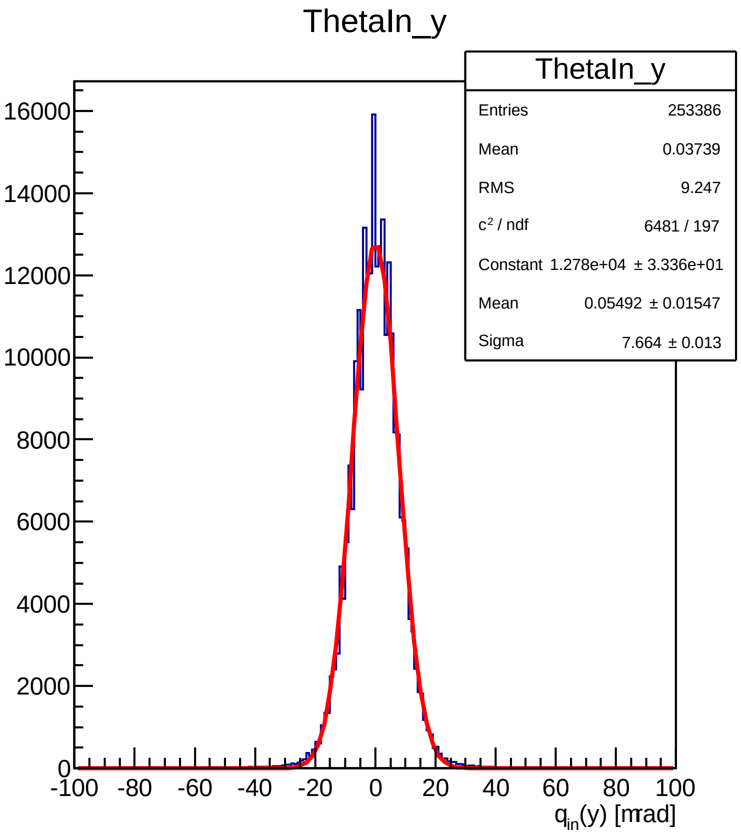
Alignment Run Analysis

The beam divergence is found to be 10.67 μrad in x and 7.66 μrad in y.

This beam characteristics are crucial for the key measurements.

Because the input angular distributions are bigger than $\theta_{c,}$ we need to apply a selection to analyze the different effects.



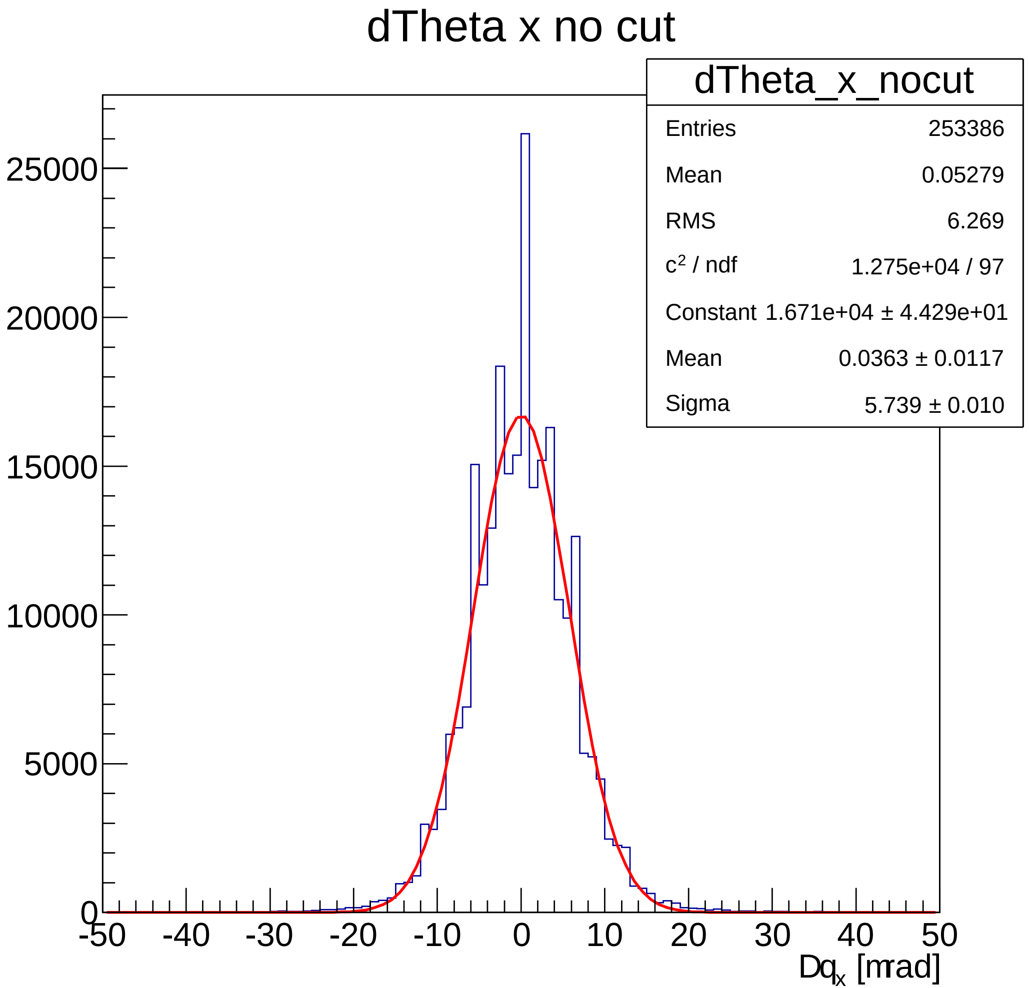


Alignment Run Analysis

This plot shows the difference between the outgoing and the incoming angle of the tracks without any object on the beam line.

The sigma of this distribution gives us the telescope resolution taking into account a variety of systematic effects, including scattering in air.

The resolution of the telescope is 5.7 μrad in good agreement with the resolution estimated in [1].



[1] M. Pesaresi et al., *Design and performance of a high rate, high angular resolution beam telescope used for crystal channeling studies*,2011 JINST 6 P040006

Alignment Run Recap

Xtal code	Year	Beam				
		Profile x [mm]	Profile y [mm]	diivergence x [µrad]	Divergence y [µrad]	resolution [µrad]
STF38A	2010	-0,13270	0,13030	0,07468	0,00352	-0,01429
		1,01400	0,72100	10,67000	7,65800	5,61900
STF40A	2010	-0,24180	0,14220	0,15240	0,02425	-0,00123
		1,01700	0,72410	10,68000	7,69700	5,75600
STF45A	2010	-0,16020	0,10370	0,01150	0,02443	0,08381
		1,00100	0,72470	10,65000	7,68400	5,76200
STF47	2011	-0,00370	0,01531	-0,26940	0,03901	0,11090
		1,06300	0,94890	11,73000	8,96400	5,28300
STF48	2011	-0,00205	0,01041	-0,07798	-0,07146	0,01915
		1,05500	0,96020	11,88000	8,98200	5,30200
STF49	2011	0,06175	0,02809	1,66700	-0,07302	0,08502
		1,07500	0,97870	12,17000	8,97300	5,25900
STF50	2012	-0,19090	-0,00974	-0,91380	0,36410	0,08330
		1,29400	0,86090	10,90000	8,04900	5,49400
STF51	2012	-0,16570	-0,01585	0,89920	0,37180	0,03139
		1,29000	0,82470	10,88000	8,02200	5,49600
STF70	2012	-0,05129	0,00606	-2,10500	0,65960	-0,02615
		1,23900	0,82740	9,21600	5,74800	5,28400
STF71	2012	-0,04791	0,01497	-1,95900	0,60250	-0,02782
		1,21500	0,82460	9,11100	5,73100	5,31100

Xtal code	Year	Beam				
		profile x [mm]	profile y [mm]	divergence x [µrad]	divergence y [µrad]	resolution [µrad]
QMP26	2012	0,00601	0,00718	-0,93280	0,32510	-0,07774
		1,26900	0,82050	9,13400	5,77400	5,42100
QMP27	2010	-0,24180	0,14220	0,15240	0,02425	-0,04542
		1,01700	0,72410	10,68000	7,69700	5,73100
QMP28	2012	-0,35030	0,10311	-1,95100	0,62960	-0,06831
		1,28700	0,82170	9,15300	5,77000	5,40800
QMP29	2012	-0,05129	0,00606	-2,10500	0,65960	-0,02615
		1,23900	0,82740	9,21600	5,74800	5,28400
QMP32	2011	-0,00084	0,01506	-0,31540	-0,04166	0,09989
		1,05900	0,94390	11,83000	8,94900	5,28600

Each crystal has a good alignment run

If a run is missing, the closer one is used.

Hi Stat @ Channeling

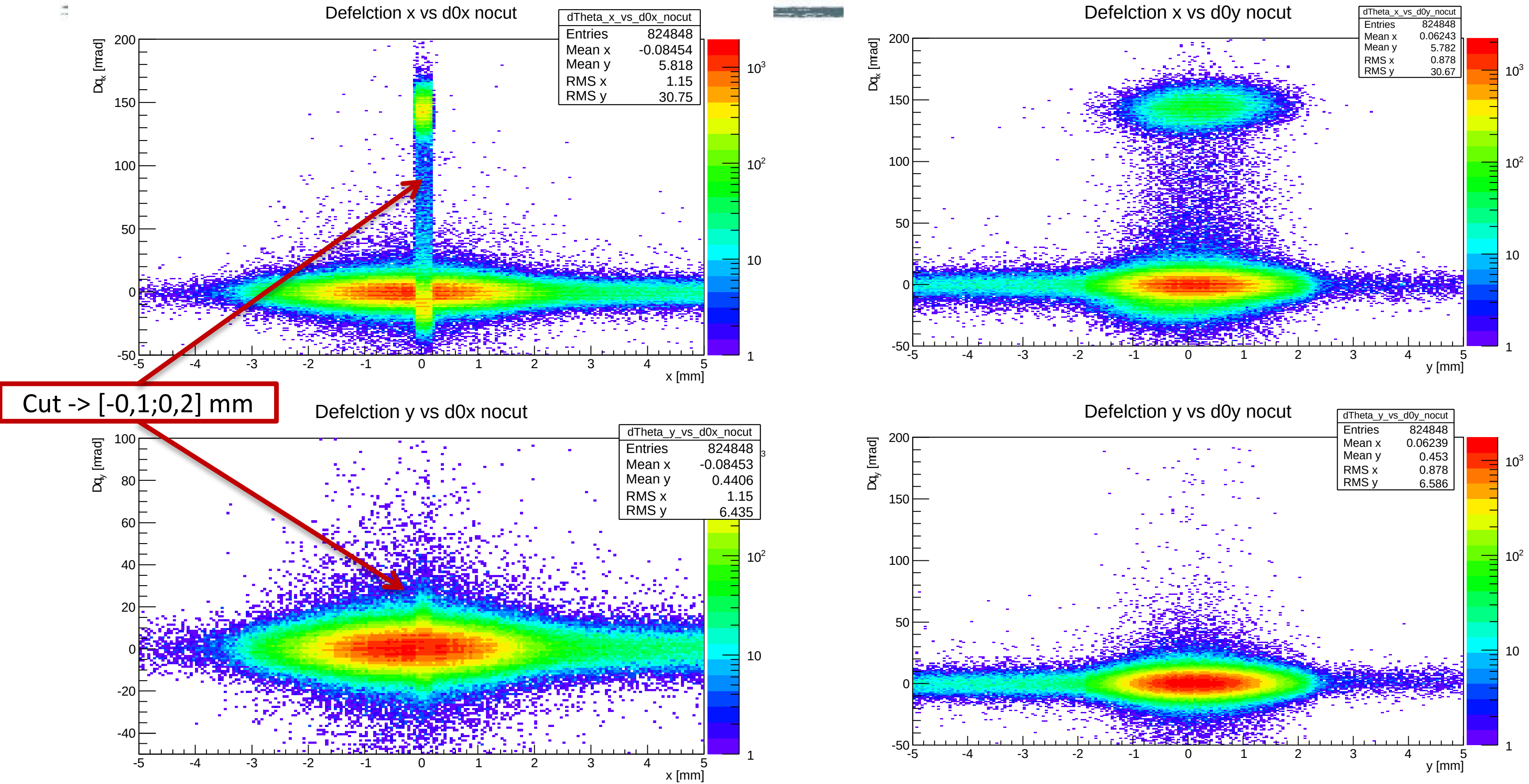
Two kinds of cuts are performed on the initial distributions:

- Geometrical cut
- Angular cut

The geometrical cuts are used to select particle impinging on the crystals and can be established by looking at the spread given by the multiple coulomb scattering.

The angular cuts are performed to study the coherent interactions in crystals.

Geometrical cut



Cut recap

Xtla code	Year	Cut		
		x [mm]	y [mm]	Initial gonio angle [µrad]
STF38A	2010	-1,0500	-2,0327	4712400
		-0,0500	2,2933	
STF40A	2010			
STF45A	2010	-0,1000	-2,0704	4714800
		0,2000	2,2778	
STF47	2011	-0,9000	-2,8314	
		1,1000	2,8620	
STF48	2011	-0,7000	-2,8702	4712947
		0,3000	2,8910	
STF49	2011	-0,1500	-2,9080	4714776
		0,4000	2,9642	
STF50	2012	-0,7000	-2,5924	3143940
		0,3000	2,5730	
STF51	2012	-1,1000	-2,4900	3146760
		0,9000	2,4583	
STF70	2012	-0,5250	-2,4761	4744150
		0,4250	2,4883	
STF71	2012	-0,4000	-2,4588	4746650
		0,6000	2,4888	

Xtla code	Year	Cut		
		x [mm]	y [mm]	Initial gonio angle [µrad]
QMP26	2012	--0,2500	-0,8500	4750397
		0,4500	0,0000	
QMP27	2010	-0,4000	-1,5000	
		0,0000	1,5000	
QMP28	2012			
QMP29	2012	-1,5000	-1,5000	4749570
		0,5000	1,5000	
QMP32	2011			4710993

The table summarize the geometrical cuts made

Torsion Analysis

For particles with the same impact angle, the torque applied to the crystals causes different relative angles with respect to the crystal planes. The difference if proportional to the y impact location.

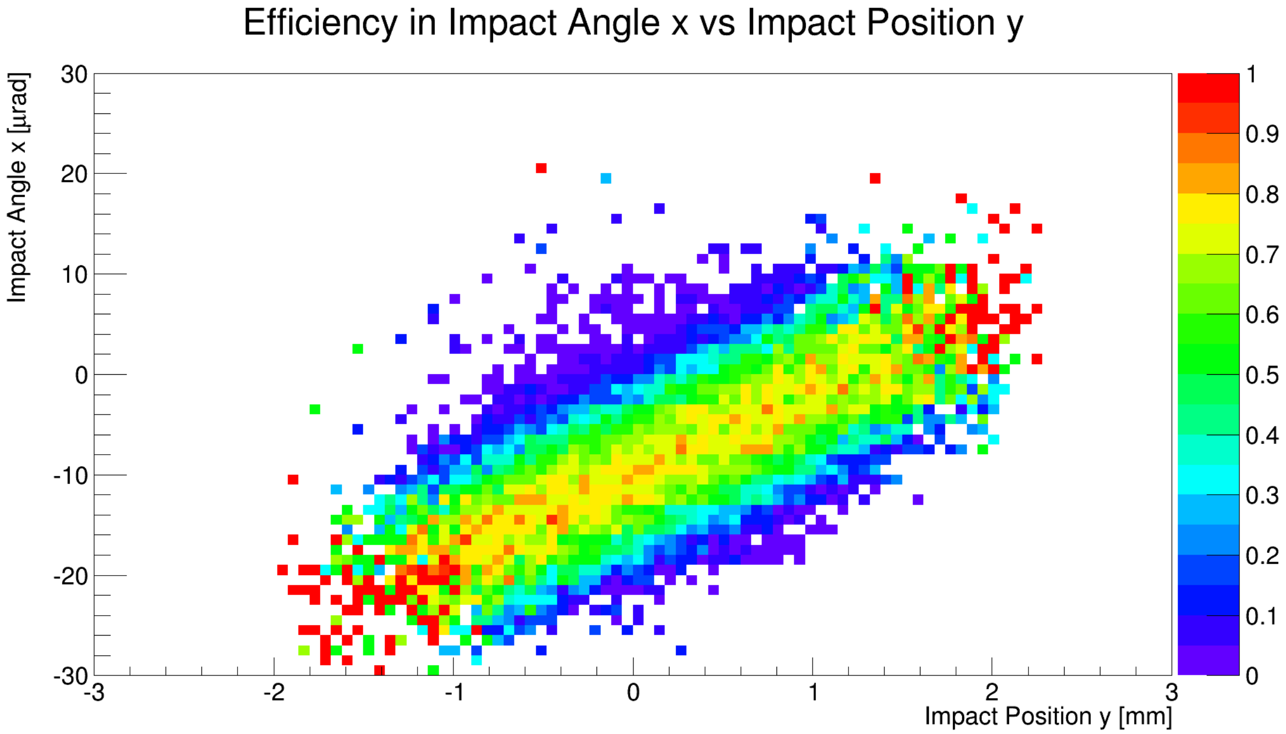
This effect is defined as torsion. As a result, the channeling efficiency varies with both the horizontal impact angle and the vertical impact position.

The channeling efficiency is defined as the number of channeled particles normalized to the total number of particles

$$efficiency = \frac{Channeled\ Event}{Total\ Event}$$

Channeled events are calculated from the deflection profile

Efficiency vs. Impact angle x vs. Impact y

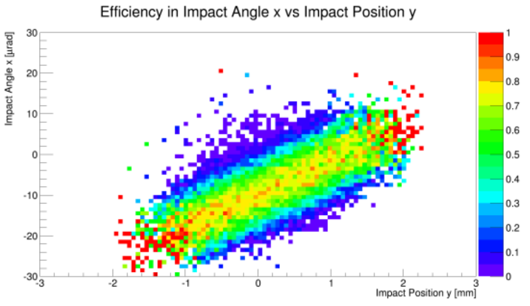


2-dimensional efficiency plot as a function of impact x angle and impact y points is obtained.

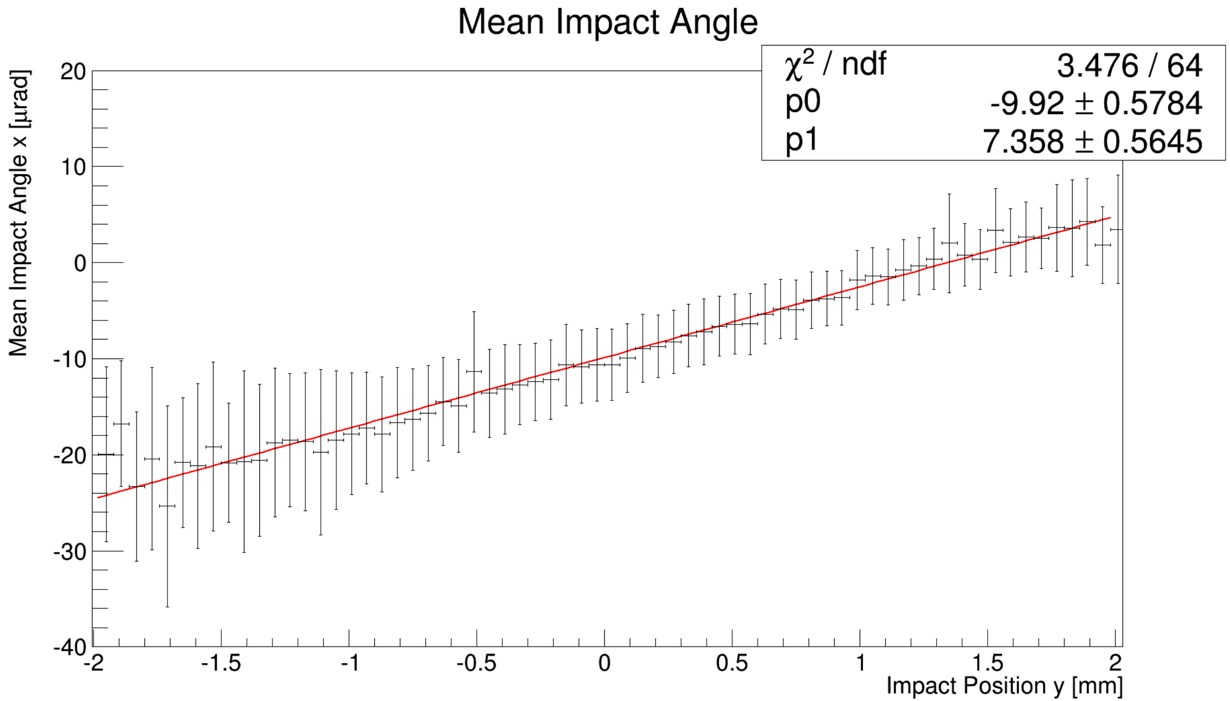
The center of gravity of each stripes on the impact y point axis gives the mean impact x angle as a function of vertical impact position

Efficiency vs. Impact angle x vs. Impact y

STF48



The linear regression gives the torsion value and the initial impact angle offset



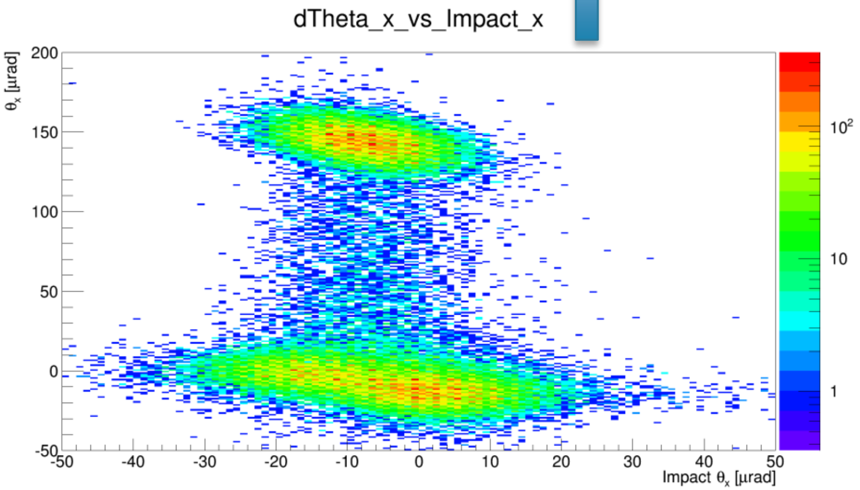
Torsion correction

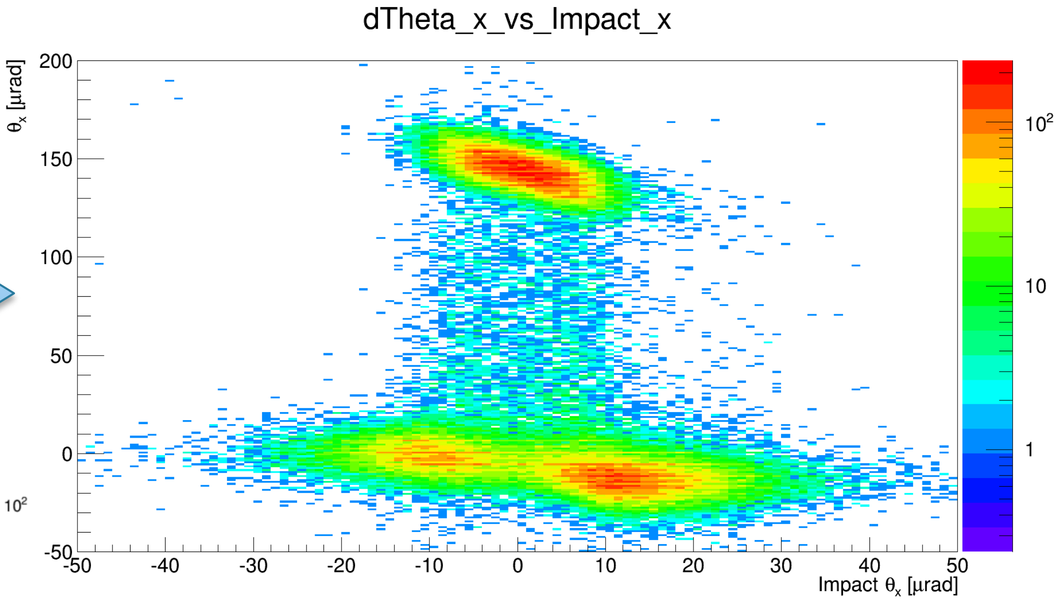
If we define the impact x angle as

$$\theta_{corr}(x) = g.Pos\,(x) + \theta_{in}(x) - g.Pos_{init}(x)$$

The torsion correction made is

$$\theta_{corr}(x) - \left(torsion * Impact(y) + g.Pos_{offset}(x)\right)$$





The plots show the x deflection as a function of the impact x angle before and after the torsion correction

Torsion Recap

Xtla code	Year	Torsion		
		Initial gonio angle [μrad]	torsion [μrad/mm]	angle offset [μrad]
STF38A	2010	4712484	-5,032	-5,515
STF45A	2010	4714900	7,358	-9,920
STF47	2011	4707125	-2,521	1,753
STF48	2011	4712893	6,942	7,285
STF49	2011	4714841	5,310	5,285
STF50	2012	4822985	4,998	-4,654
STF51	2012	4822990	-1,075	-2,193

Xtla code	Year	Torsion		
		Initial gonio angle [μrad]	torsion [μrad/mm]	angle offset [μrad]
QMP26	2012	4750437	6,888	2,217
QMP27	2010	4822988	1,381	-0,351
QMP29	2012	4749647	-0,343	-0,873
QMP32	2011	4822992	-0,634	-2,424

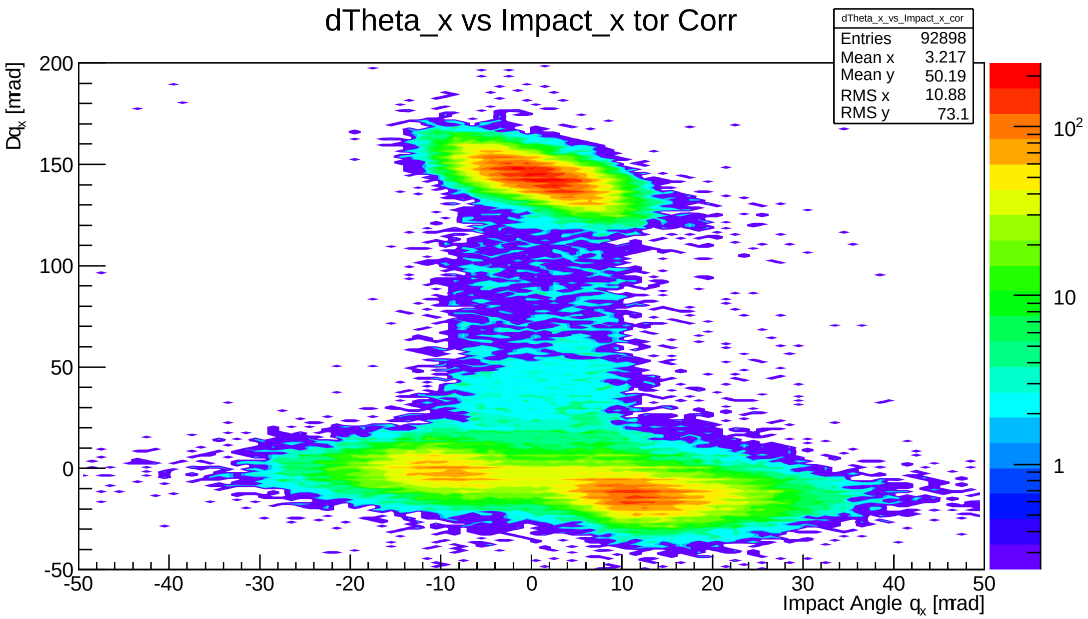
The calculated torsions are summerized in this table

Hi Stat @ Channeling Analysis

<u>The optimum channeling condition is the one studies in more detail.</u>

All the analysis are performed by studying the deflection x angle as a function of the impact x angle. We can then distinguish three regions with respect to the x deflection

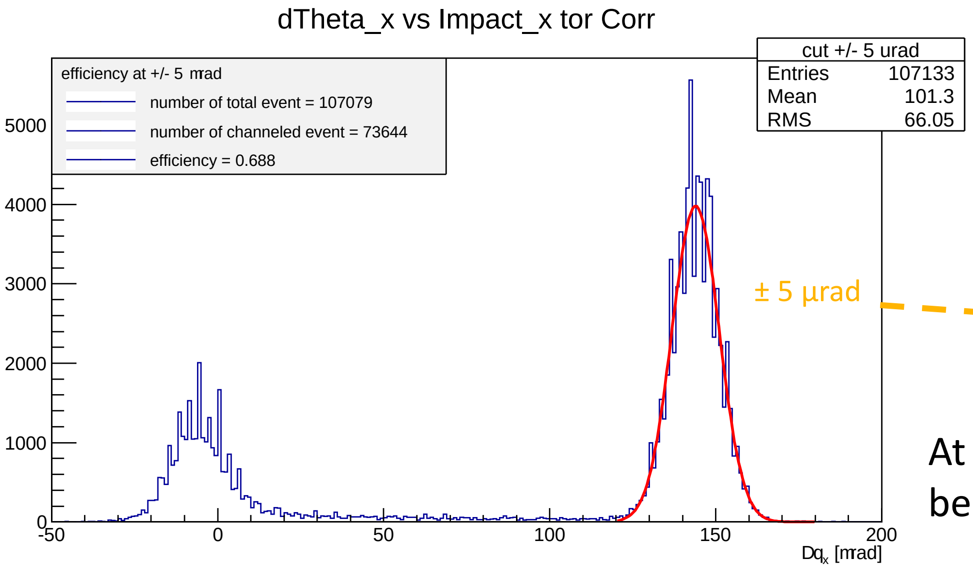
- Channeling, the spot around 150 µrad
- Transition region between the amorphous and the volume reflection zone
- Dechanneling, the region between the first two

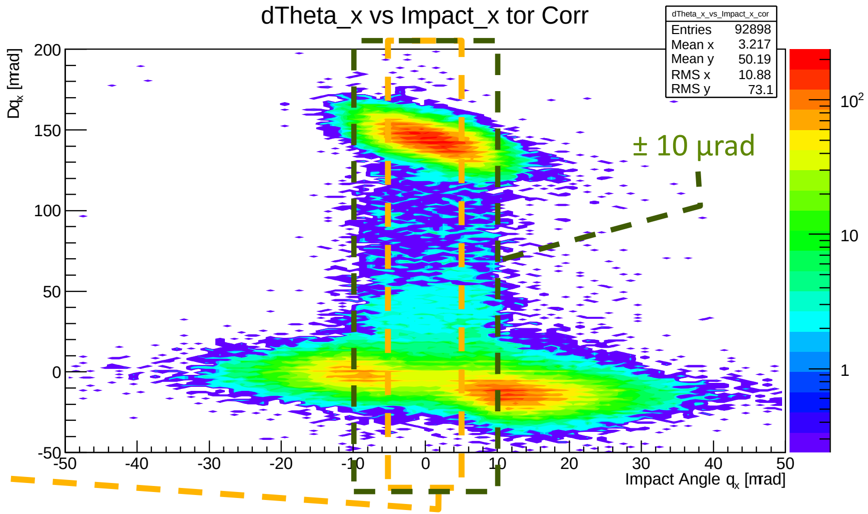


Channeling Efficiency

The channeling efficiency is evaluated at two different angular cuts ± 5 e ± 10 µrad, that for 400 GeV/c protons represent the critical angle for channeling and two times the critical error, respectively.

Projecting on the y axis the kick, with the cut described, are obtained.





At ± 5 µrad the channeling efficiency is measured to be 0,69.

Channeling efficiency recap

That is the recap of the channeling efficiency for the analyzed crystals

Xtla code	Year	CH Efficiency	
		± 5 µrad	± 10 µrad
STF45A	2010	0,699468	0,543188
STF47	2011	0,558797	0,481339
STF48	2011	0,553509	0,428917
STF49	2011	0,465897	0,348585
STF50	2012	0,562371	0,458784
STF51	2012	0,519111	0,47025

Xtla code	Year	CH Efficiency	
		± 5 µrad	± 10 µrad
QMP27	2010	0,585585	0,500364
QMP29	2012	0,662400	0,562291
QMP32	2011	0,505	0,405

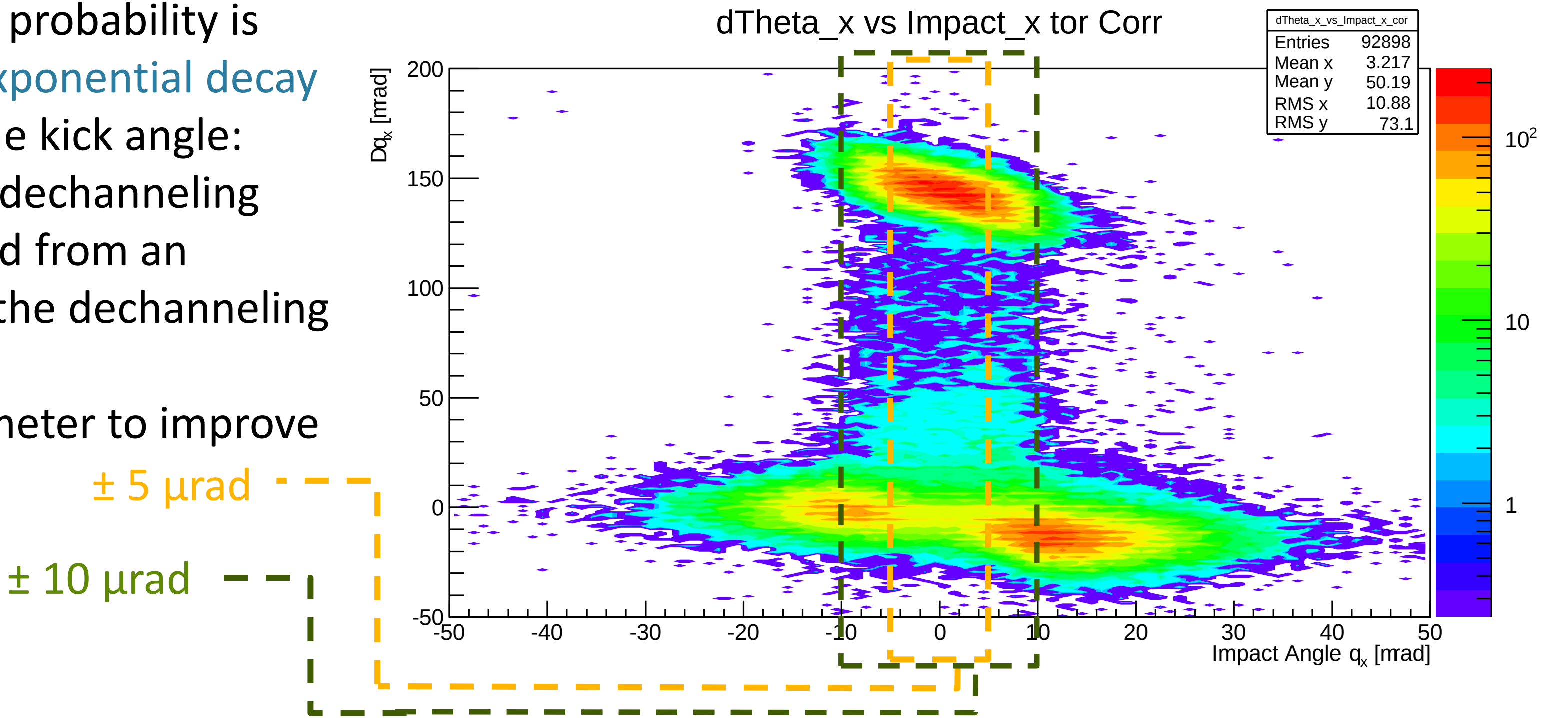
Dechanneling length

On the same histogram the dechanneling length analysis is also performed

A channeled particle can escape from the channel due with the interaction with the crystal plane, this particles are defined as dechanneled particles.

The dechanneling probability is described as an exponential decay as a function of the kick angle: the characteristic dechanneling length is calculated from an exponential fit in the dechanneling region.

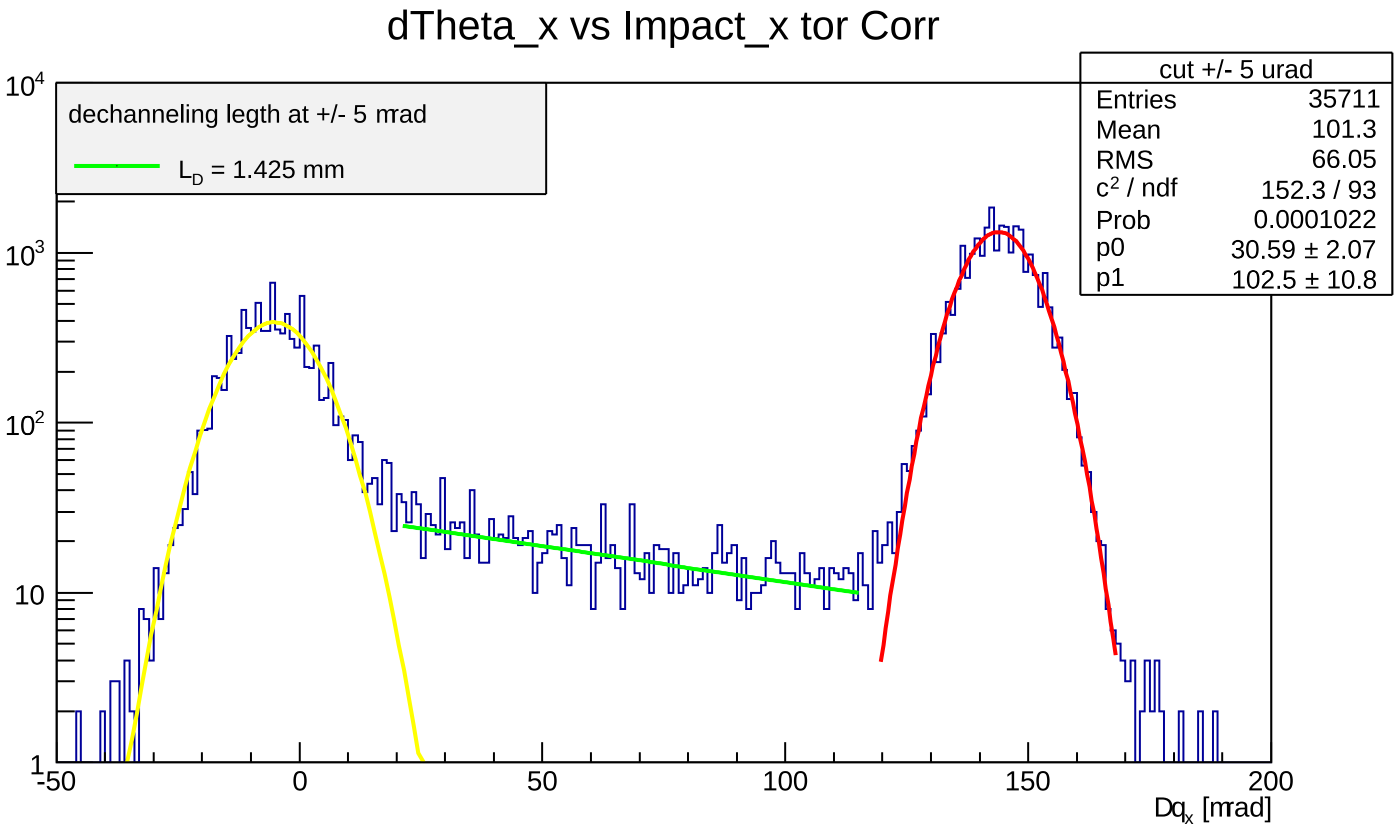
This is a key parameter to improve simulations.



Dechanneling Length

± 5 μrad

The exponential fit gives the dechanneling angle. To get the dechanneling length we have to multiply the parameter by the bending radius of the crystal.
Variation on the fit range don't show significant changes of the dech length, that is estimated to be ~ 1,4 mm



Dechanneling length recap

Xtla code	Year	Dechanneling Length	
		± 5 µrad	± 10 µrad
STF45A	2010	1,425	1,250
STF48	2011	1,525	1,414
STF49	2011	0,186	0,177
STF50	2012	1,523	1,369

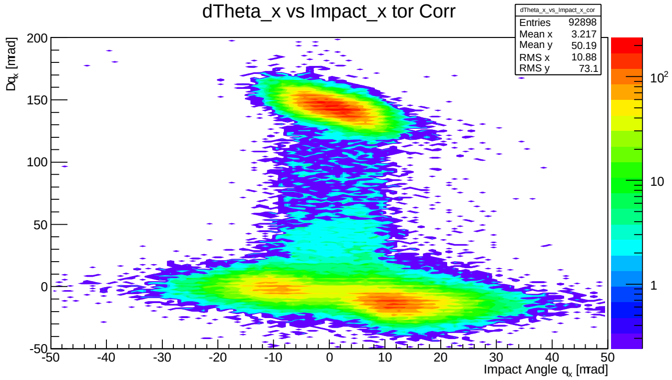
That is the recap of the dechanneling length

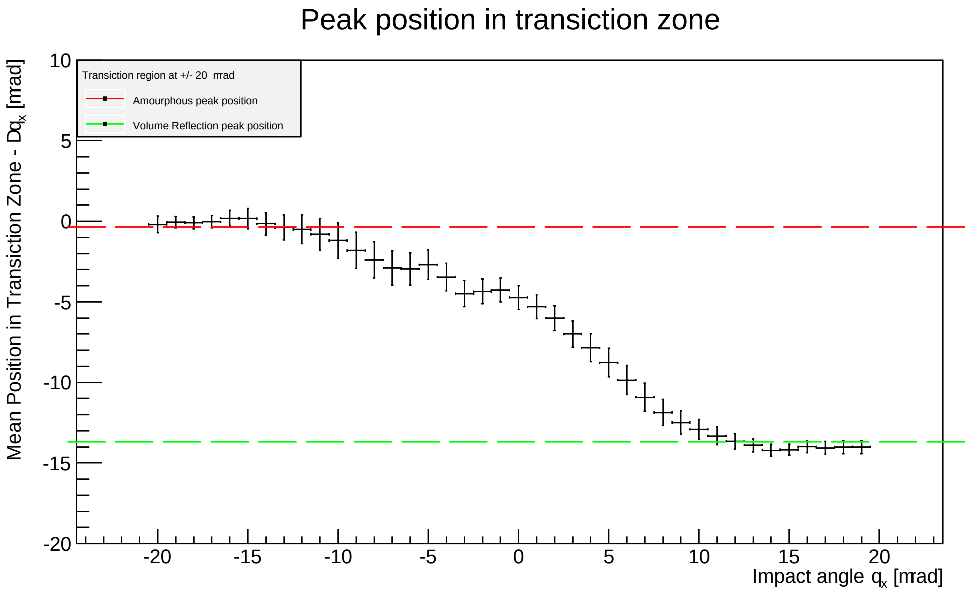
Xtla code	Year	Dechanneling Length	
		± 5 µrad	± 10 µrad
QMP27	2010	1,146	1,352
QMP32	2011	0,417	0,370

Transition zone

The transition zone describes how the amorphous region is transformed to the volume reflection region after the channeling region

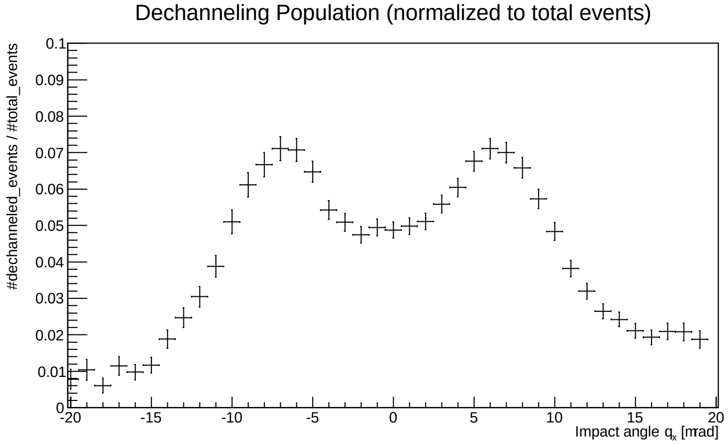
The trend plotted would be useful for a confrontation with the crystal simulation routines.

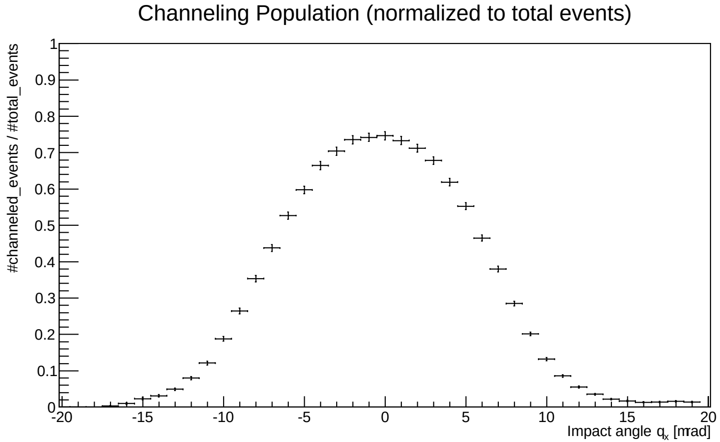


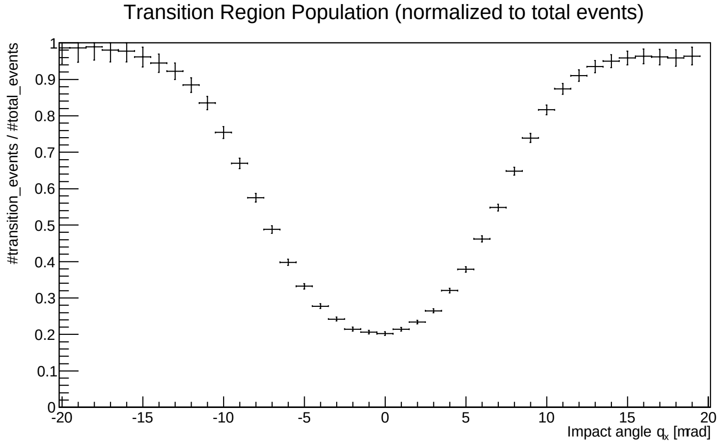


Population

The Population of the three different region are evaluated as a function of the impact incoming angle.





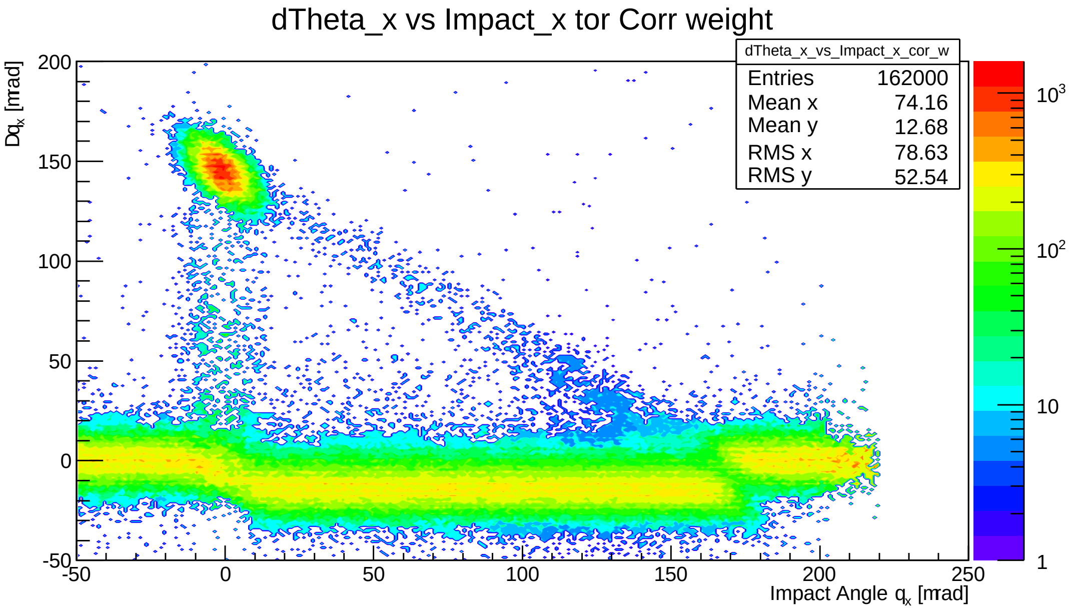


Angular Scan Analysis

The angular scan has the same geometrical cuts and torsion correction.

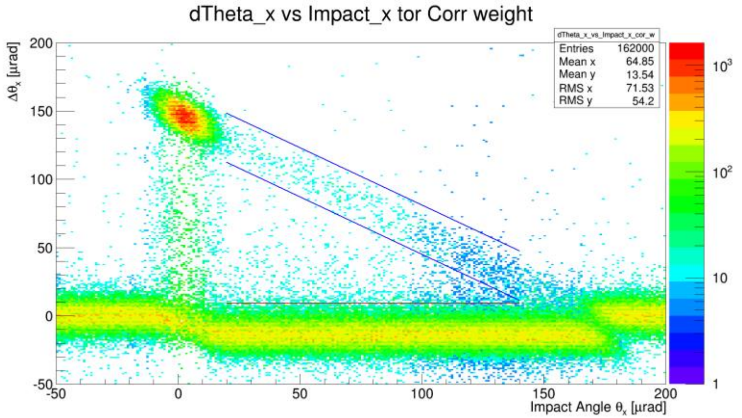
The deflection x as a function of the impact x angle is shown

In this case we can see all the volume reflection region, and the halo that have the same trend of the channeling spot is the volume capture region.
Non-channeled particles can be channeled due to the interaction with the crystal plane. This particles are defined as captured.

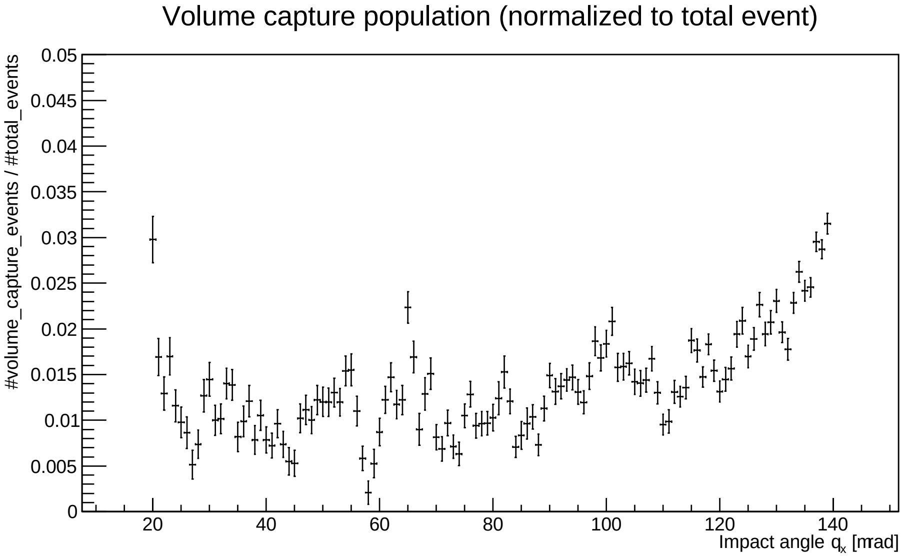


Volume capture analysis

We define the region of captured particle as the area within 3 σ of the trend of the channeled spot



The captured population is plotted as a function of the impact x angle. The rise in the end of reflection region is a well-known behavior.

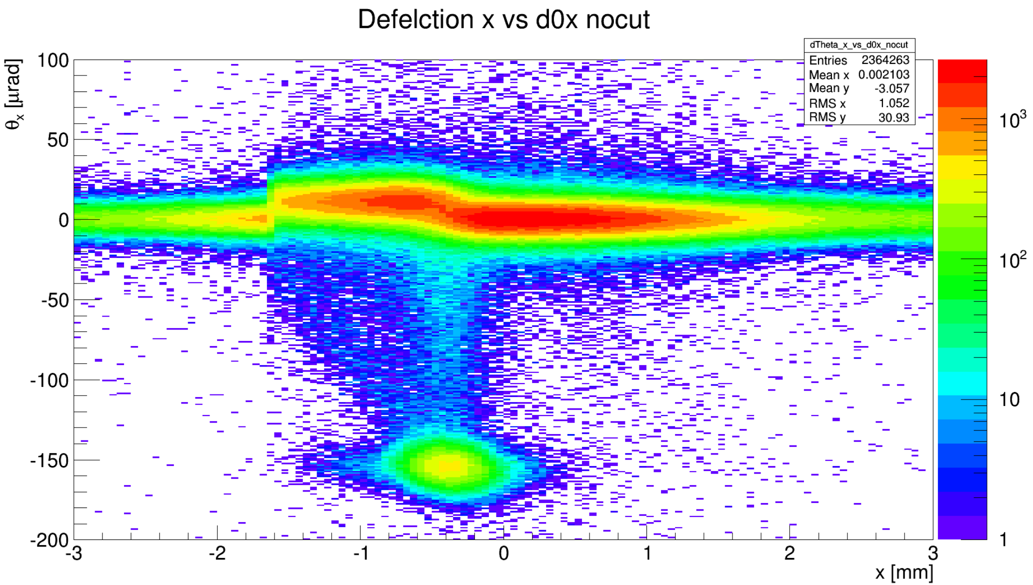


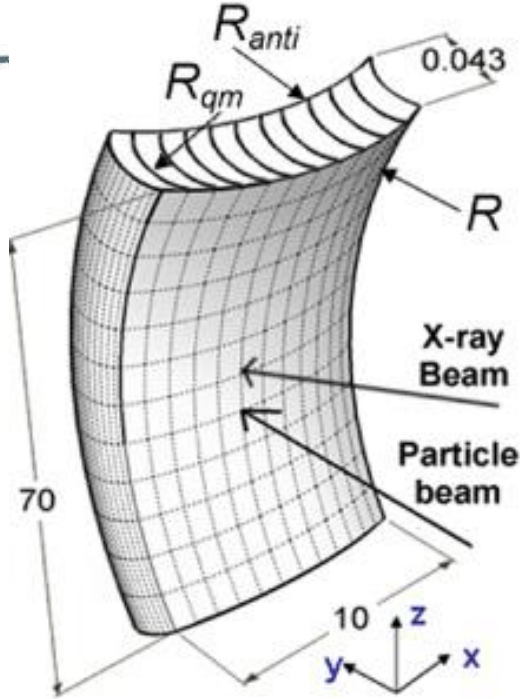
This analysis is performed for the first time, we are looking for a model that describes the trends observed.

Example of QM

The crystal face xy is not flat, because of a characteristic additional bending on the QM crystal

- the kick as a function of the impact position (on a fixed crystal) shows a behavior similar to an angular scan.





We have to find a region where this curvature is negligible.

Conclusion

Achieved goals :

- ✓ A complete analysis of the crystal tested in the H8 line has been done.
- ✓ The results of the present analysis fit the results in literature.
- ✓ Many fine systematic effect were analyzed.
- ✓ A complete list of experimental data and inputs are ready for crystal code developers.

Future goals :

- ❑ understanding and development of an analytical model of the various "fine" effects observed.
- ❑ implementation of the analytical models to improve the crystal simulation routines.

BACKUP

recoData caratteristic

dfs/Experiment/UA9/Data-Test_beams

- 2010 data [/2010_09_16,_H8_re-recodata]
  - reconstruction problem
    - » Each variable is in the array “thetaIn_x”, inside the “tracks” branch
  - The data was reprocessed because of a bug, but some interesting run is still missing
- 2011 data [/2011_09_07_recodata4]
  - Optimization problem
    - » Each variable in some branch is aa array (100 place), of which only the first spot (0) is the real data (should be reprocessed from CMS)
- 2012 data [/2012_10_12_H8_protons/Data1] [/2012_10_12_H8_protons/Data2][/TB_22_06_2012_recodata]
  - Tree optimized and “performant”
    - » But run collected in different folder
  - data in [/TB_22_06_2012_recodata] is in a tree 2011 like

- Issue : several run is missing, so some crystals are unanalyzable

Xtla code	Year	Nominal Propiety							Analyzed run		
		x [mm]	y [mm]	z [mm]	bending [µrad]	curvature [m]	torsion [µrad/mm]	miscut [µrad]	Alignment	HiStat CH	Angular scan
STF38A	2010	1	55	1,89	100		8,67	<10	545	546	546
STF40A	2010	0,475	55	1	150	6,67		70	347	383	384 386
STF45A	2010	0,3	55	2	150	13,33	3,3	70	406	410	408
STF47	2011	2	55	3,1	45	68,89	0,5	150	616	608	
STF48	2011	1	55	2	~170		0,5	140	628	630	629
STF49	2011	0,5	55	0,8	~270		TBD	<170	643	649	646
STF50	2012	1		2	170	11,76	TBD	70 ± 30	894	889	888
STF51	2012	2		3	45	66,67	TBD		904	899	897
STF70	2012	1	55	3	55		1		1192	1240	1238
STF71	2012	1	55	3	55		1		1174	1191	1188

Missing re-recoData 2010

Missing angular scan

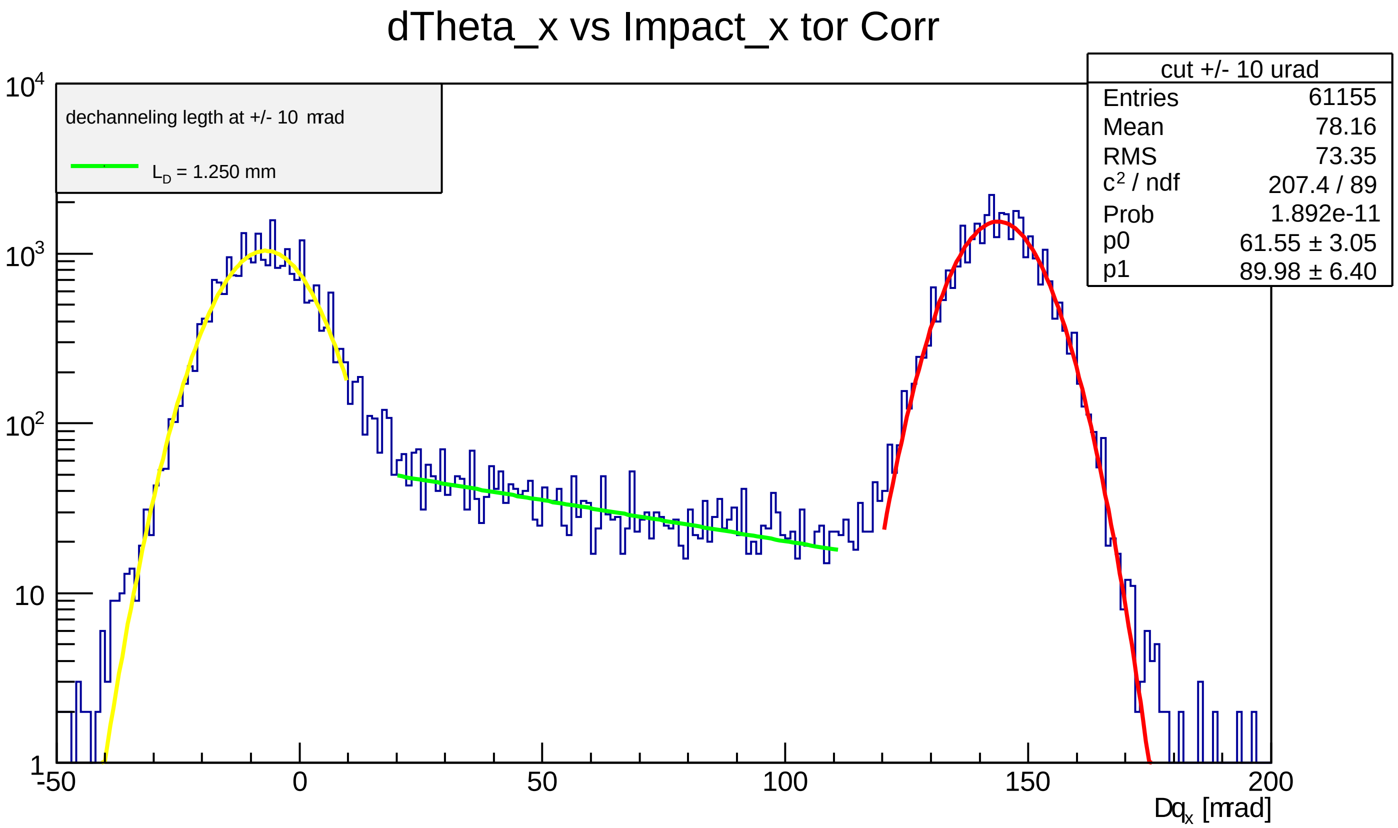
Missing Hi stat ch

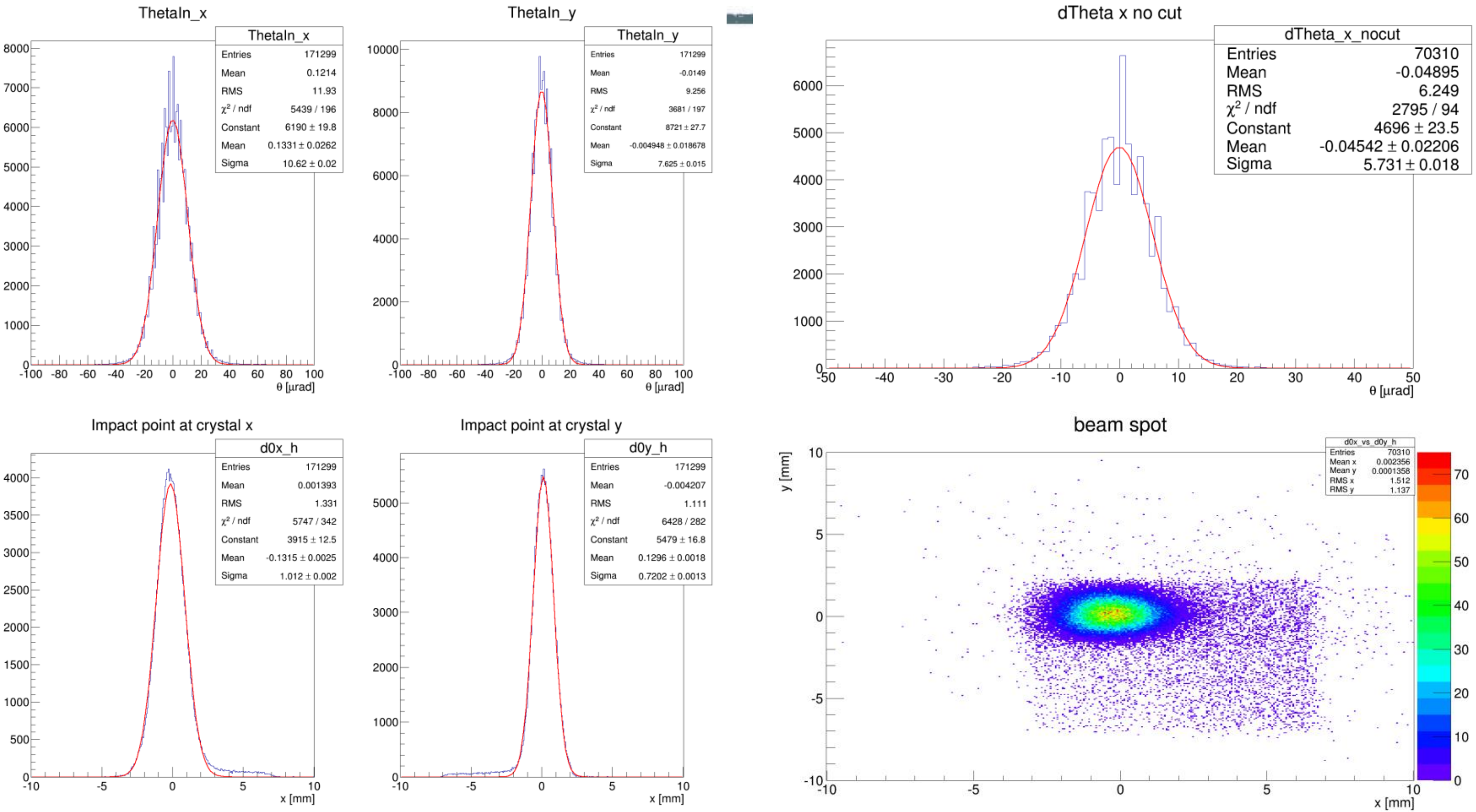
Xtla code	Year	Nominal Propiety							Analyzed run		
		x [mm]	y [mm]	z [mm]	bending [µrad]	curvature [m]	torsion [µrad/mm]	miscut [µrad]	Alignment	HiStat CH	Angular scan
QMP26	2012	18	13	1,973	50			<100	1000	1012	1011
QMP27	2010			1,77	116	15,26			347	348	321
QMP28	2012			6	~50				1024		1028
QMP29	2012			6	~50				1192	1197	1196
QMP32	2011			0,96	~175				569	572	570

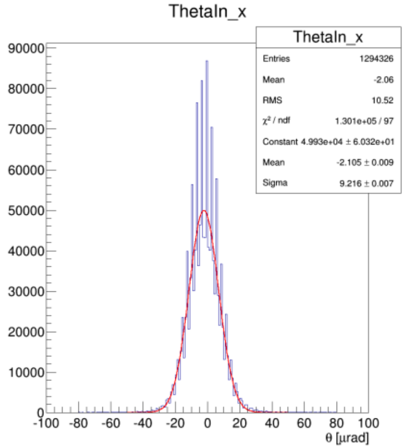
Bad Angular Scan Moving backward

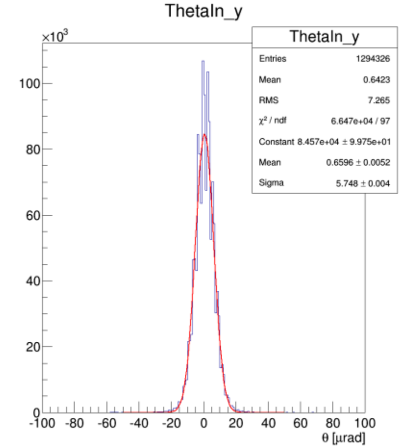
Dechanneling Lengt

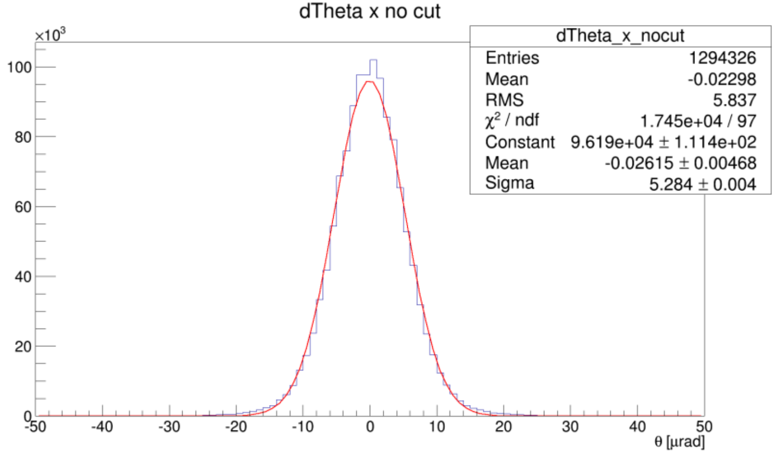
± 10 μrad

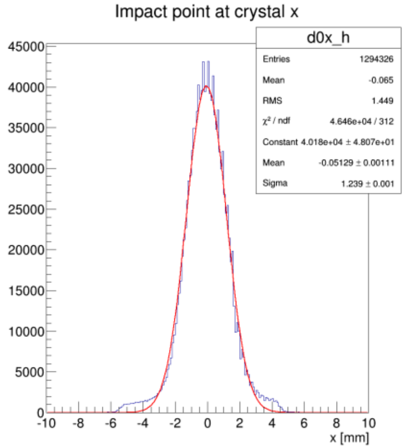


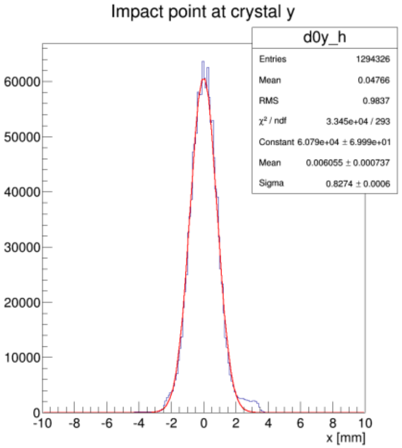

ThetaIn_x
ThetaIn_x
Entries 171299
Mean 0.1214
RMS 11.93
χ² / ndf 5439 / 196
Constant 6190 ± 19.8
Mean 0.1331 ± 0.0262
Sigma 10.62 ± 0.02
θ [μrad]
ThetaIn_y
ThetaIn_y
Entries 171299
Mean -0.0149
RMS 9.256
χ² / ndf 3681 / 197
Constant 8721 ± 27.7
Mean -0.004948 ± 0.018678
Sigma 7.625 ± 0.015
θ [μrad]
dTheta x no cut
dTheta_x_nocut
Entries 70310
Mean -0.04895
RMS 6.249
χ² / ndf 2795 / 94
Constant 4696 ± 23.5
Mean -0.04542 ± 0.02206
Sigma 5.731 ± 0.018
θ [μrad]
Impact point at crystal x
d0x_h
Entries 171299
Mean 0.001393
RMS 1.331
χ² / ndf 5747 / 342
Constant 3915 ± 12.5
Mean -0.1315 ± 0.0025
Sigma 1.012 ± 0.002
x [mm]
Impact point at crystal y
d0y_h
Entries 171299
Mean -0.004207
RMS 1.111
χ² / ndf 6428 / 282
Constant 5479 ± 16.8
Mean 0.1296 ± 0.0018
Sigma 0.7202 ± 0.0013
x [mm]
beam spot
d0x_vs_d0y_h
Entries 70310
Mean x 0.002356
Mean y 0.0001358
RMS x 1.512
RMS y 1.137
y [mm]
x [mm]

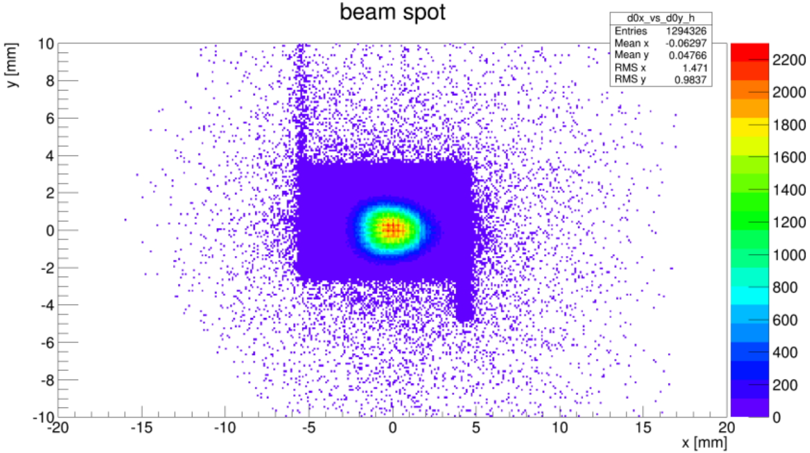

ThetaIn_x
ThetaIn_x
Entries 1294326
Mean -2.06
RMS 10.52
χ² / ndf 1.301e+05 / 97
Constant 4.993e+04 ± 6.032e+01
Mean -2.105 ± 0.009
Sigma 9.216 ± 0.007
θ [μrad]


ThetaIn_y
ThetaIn_y
Entries 1294326
Mean 0.6423
RMS 7.265
χ² / ndf 6.647e+04 / 97
Constant 8.457e+04 ± 9.975e+01
Mean 0.6596 ± 0.0052
Sigma 5.748 ± 0.004
×10³
θ [μrad]


dTheta x no cut
dTheta_x_nocut
Entries 1294326
Mean -0.02298
RMS 5.837
χ² / ndf 1.745e+04 / 97
Constant 9.619e+04 ± 1.114e+02
Mean -0.02615 ± 0.00468
Sigma 5.284 ± 0.004
×10³
θ [μrad]


Impact point at crystal x
d0x_h
Entries 1294326
Mean -0.065
RMS 1.449
χ² / ndf 4.646e+04 / 312
Constant 4.018e+04 ± 4.807e+01
Mean -0.05129 ± 0.00111
Sigma 1.239 ± 0.001
x [mm]

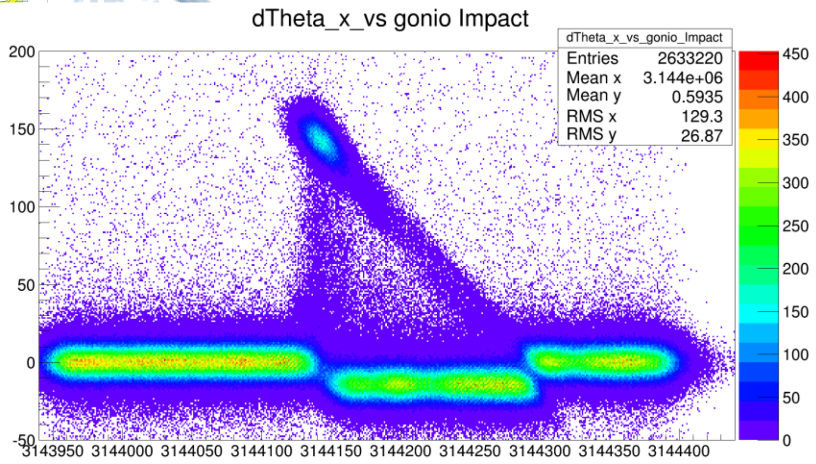

Impact point at crystal y
d0y_h
Entries 1294326
Mean 0.04766
RMS 0.9837
χ² / ndf 3.345e+04 / 293
Constant 6.079e+04 ± 6.999e+01
Mean 0.006055 ± 0.000737
Sigma 0.8274 ± 0.0006
x [mm]


beam spot
d0x_vs_d0y_h
Entries 1294326
Mean x -0.06297
Mean y 0.04766
RMS x 1.471
RMS y 0.9837
y [mm]
x [mm]

Angle Scan Run Analysis

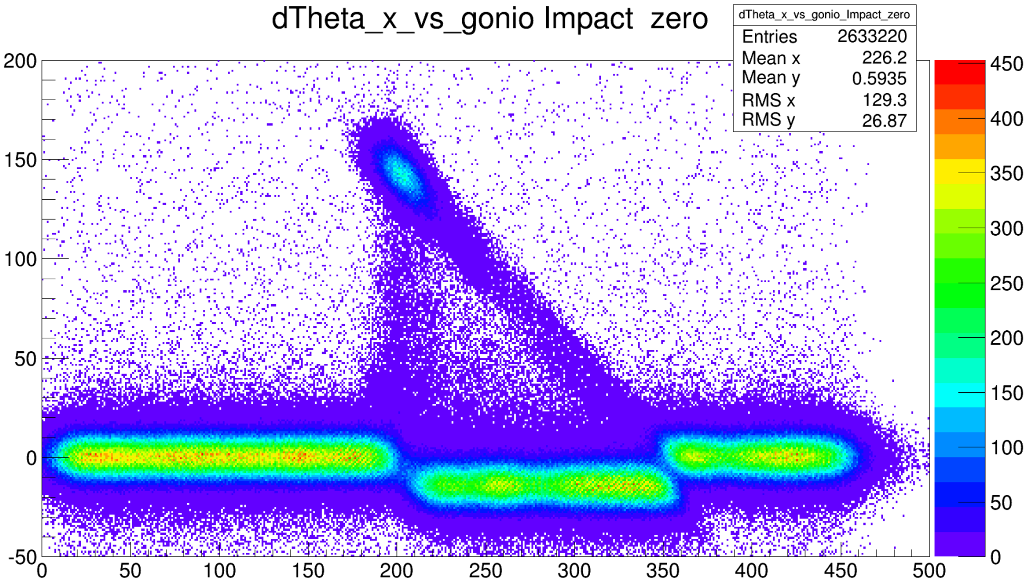
- Angular scan of the crystal, moving the goniometer on the horizontal plane respect to the beam
- We obtain both the scan of the angular kick with respect to the impact x angle and the goniometer position

  - From the second one we get three stripes in which each effect is quite evident, and we analyze the peak of AM, CH and VR
    - NB : That's only a check, befor torsion correction, so we don't know jet what is the impact angle respect the crystallographic plane. So for each stripes all the beam divergence is accepted.

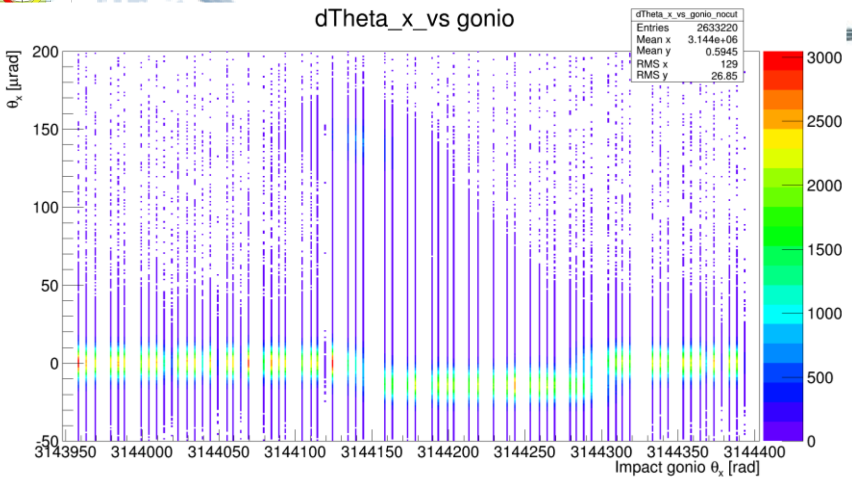


x deflection vs. impact angle x

Down here is subtracted the initial angle scan of the goniometer



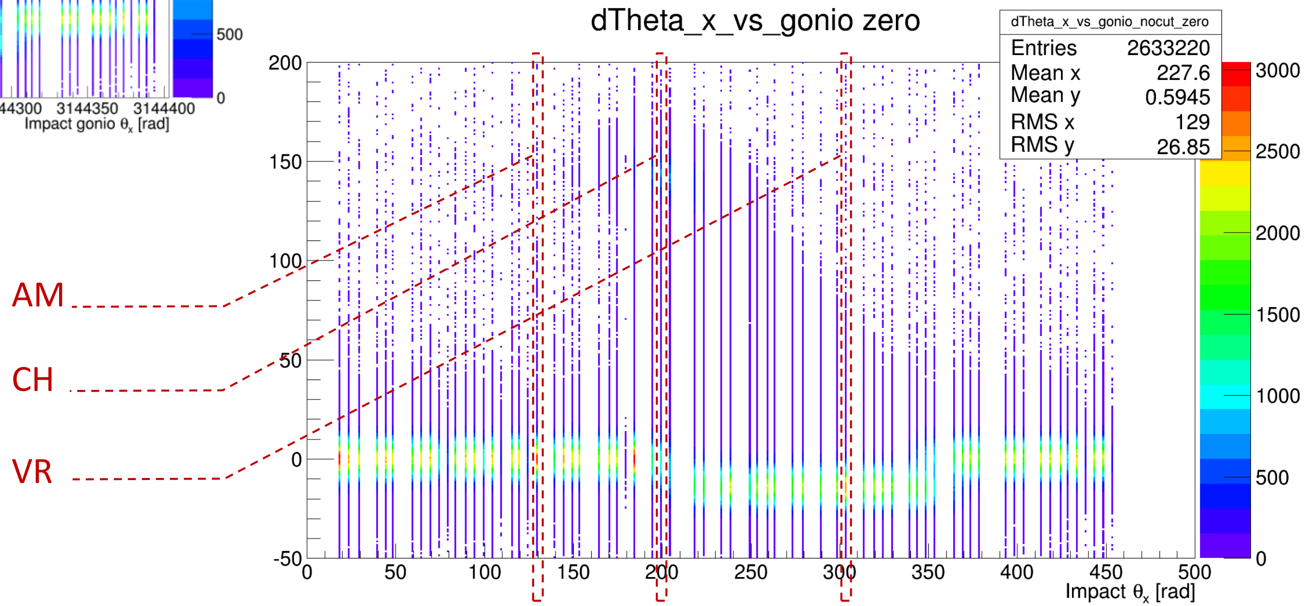
STF50



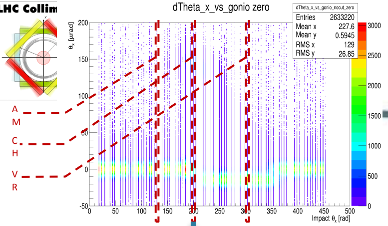
x deflection vs. the goniometer position on the horizontal plane.

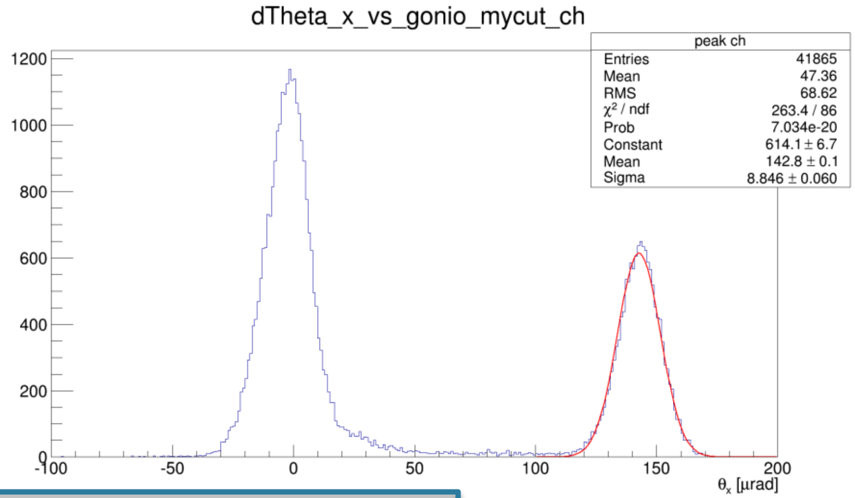
Down here is subtracted the initial angle scan of the goniometer

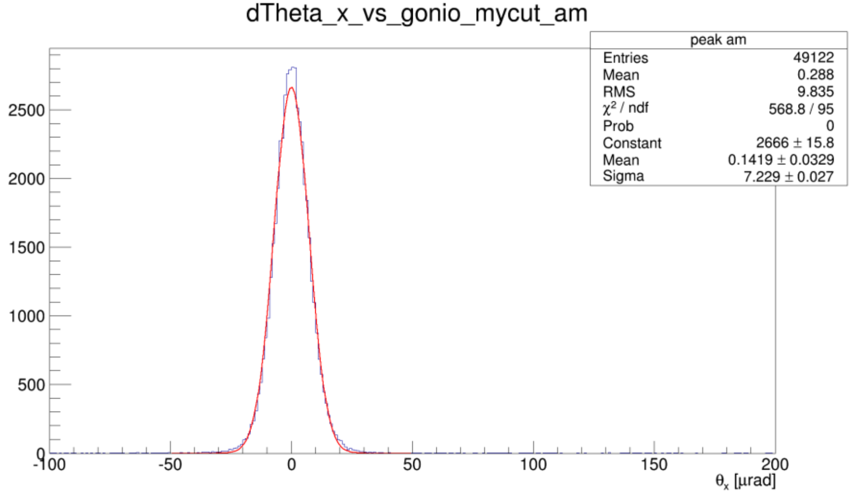
Slice selected for the analysis

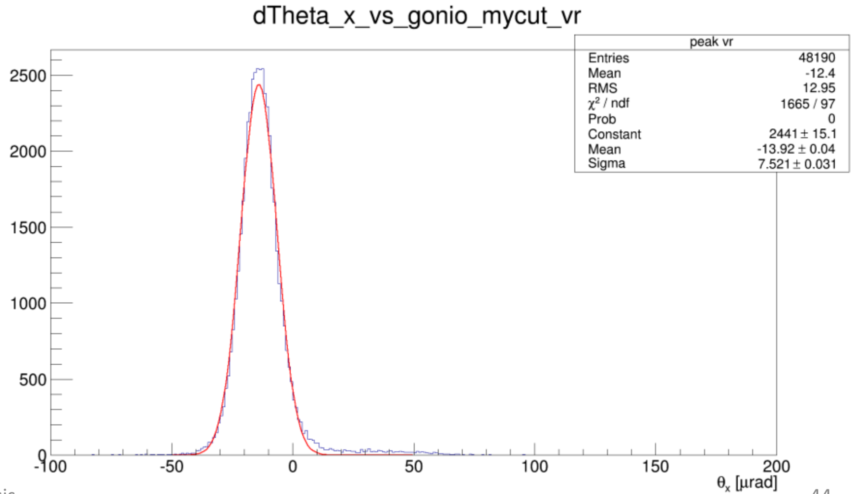


Peak


dTheta_x_vs_gonio zero
Entries 2633220
Mean x 227.6
Mean y 0.5945
RMS x 129
RMS y 26.85
A
M
C
H
V
R
Impact θx [rad]


dTheta_x_vs_gonio_mycut_ch
peak ch
Entries 41865
Mean 47.36
RMS 68.62
χ2 / ndf 263.4 / 86
Prob 7.034e-20
Constant 614.1 ± 6.7
Mean 142.8 ± 0.1
Sigma 8.846 ± 0.060
θx [μrad]


dTheta_x_vs_gonio_mycut_am
peak am
Entries 49122
Mean 0.288
RMS 9.835
χ2 / ndf 568.8 / 95
Prob 0
Constant 2666 ± 15.8
Mean 0.1419 ± 0.0329
Sigma 7.229 ± 0.027
θx [μrad]


dTheta_x_vs_gonio_mycut_vr
peak vr
Entries 48190
Mean -12.4
RMS 12.95
χ2 / ndf 1665 / 97
Prob 0
Constant 2441 ± 15.1
Mean -13.92 ± 0.04
Sigma 7.521 ± 0.031
θx [μrad]

Agnle Scan Analysis Recap

Xtla code	Year	Measurements		
		ch peak [μrad]	vr peak [μrad]	am peak [μrad]
STF38A	2010	*220,600*	*-13,380*	*-0,952*
		9,781	*7,873*	*7,377*
STF40A	2010			
STF45A	2010	*144,500*	*-13,380*	*-0,184*
		8,403	*7,855*	*7,800*
STF47	2011	*32,140*		
		9,074		
STF48	2011	*141,300*	*-13,340*	*0,000*
		9,792	*7,680*	*6,900*
STF49	2011	*244,900*	*-8,185*	*0,206*
		7,630	*7,871*	*6,008*
STF50	2012	*142,800*	*-13,920*	*0,142*
		8,864	*7,521*	*7,229*
STF51	2012	*30,280*	*-13,000*	*0,466*
		11,330	*9,105*	*8,158*
STF70	2012	*55,020*	*-13,450*	*0,785*
		9,543	*8,120*	*7,074*
STF71	2012	*61,590*	*-14,550*	*0,396*
		11,320	*7,883*	*7,653*

From HiStat CH

To do

Xtla code	Year	Measurements		
		ch peak [μrad]	vr peak [μrad]	am peak [μrad]
QMP26	2012	*42,980*	*-13,190*	*-0,736*
		15,750	*8,164*	*7,738*
QMP27	2010	*~110*		
QMP28	2012			
QMP29	2012	*31,600*	*-13,840*	*-0,164*
		8,937	*9,594*	*9,343*
QMP32	2011	*-155,000*		*0,281*
		7,506		*6,052*

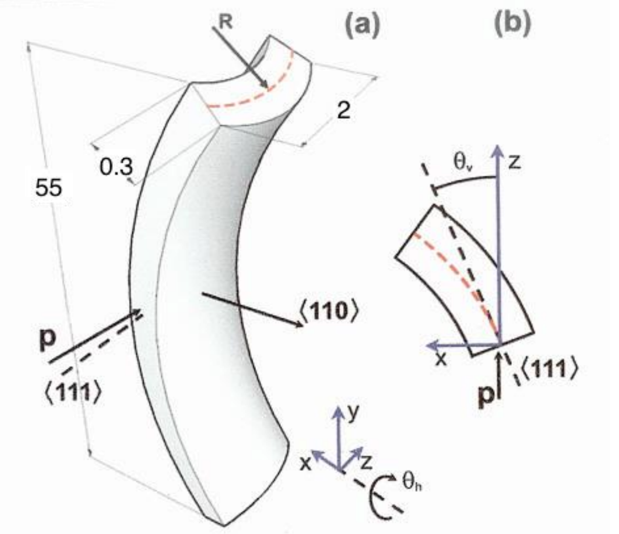
Note – VR sigma should be 1,387 μrad, which have to be added to the AM spread.

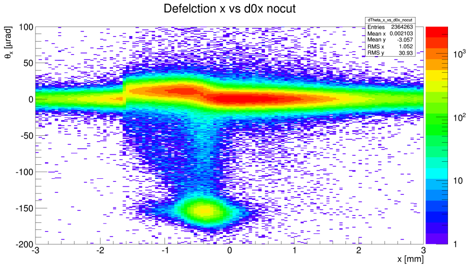
Hi Stat CH analysis

Strip geometrical cut

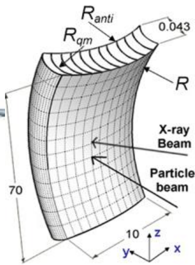
Angular kick as function of x and y impact point is measured

- The x cut is performed where a deflection appear in x deflection and where a spread due to multiple scattering appear in the y deflection plot.
- Most of the case the y height of the crystal contains the y dimension of the beam
  - y cut : ± 3 σ from the mean of the y beam profile





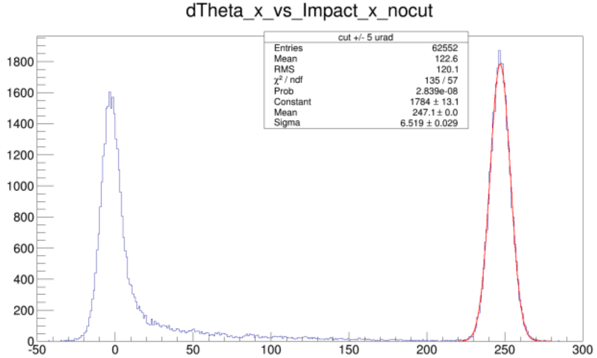
QM cut

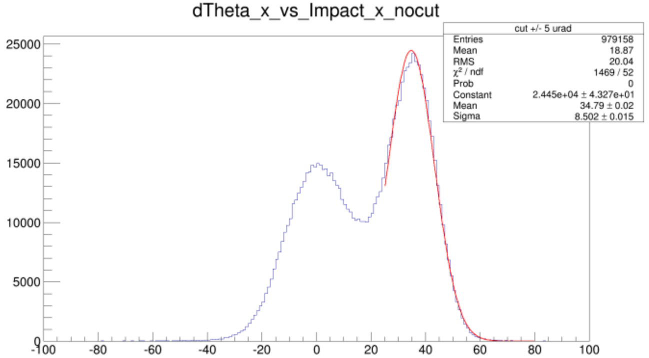


We measure the channeling efficiency (#ch/#tot) versus the impact point on the plane xy

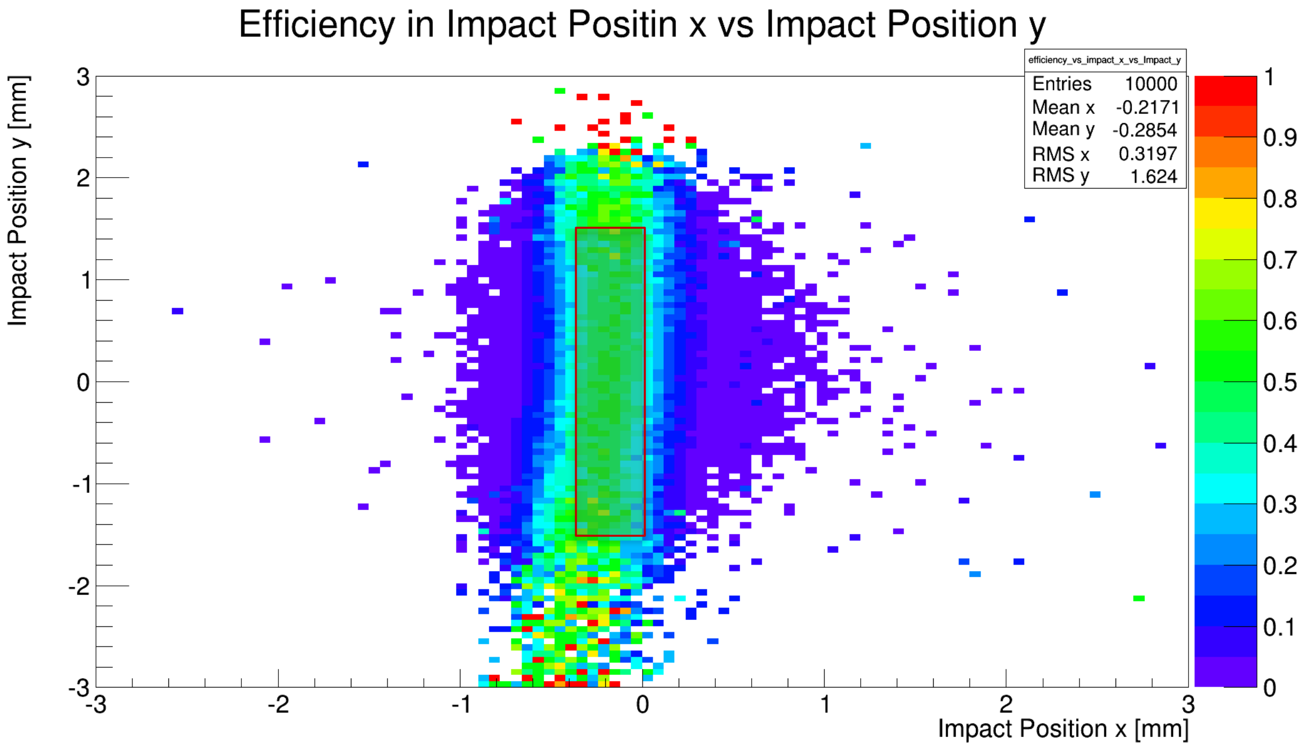
note :

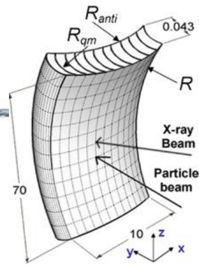
- We get a pixeled map of the xy plane. Each pixel have as dimension the spatial tracker resolution (50/60 µm)
- For each pixel we analize the 1dim histogram of the angular kick inferred to each particle. A gaussian fit is performed around the CH peak
- The channeling event are measured in two different way, depending on the crystal bending
  - Bending > 90 µrad : event counted inside the 3 σ from the mean of the fit
  - Bending ~ 50 µrad : gaussian fit integral (because of the overlapped events in the tail)





QM cut





We get a map of the channeling efficiency in each pixel. Then we chose a zone where the efficiency is higher then 0.5 and with a minimal fluctuation

QMP27

x = [-0,4 ; 0,0]

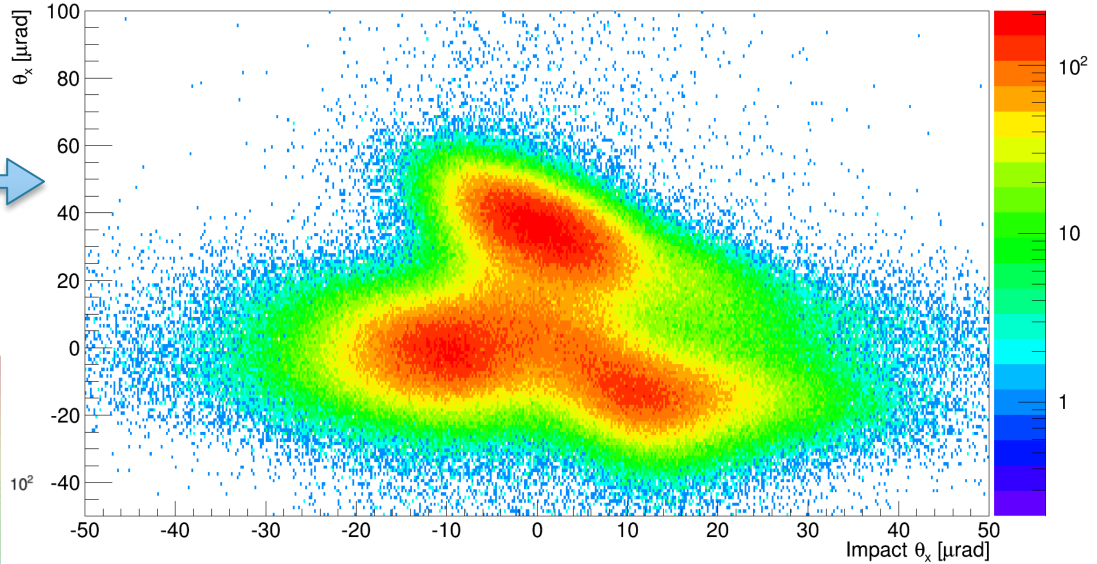
y = [-1,5 ; 1,5]

Torsion correction

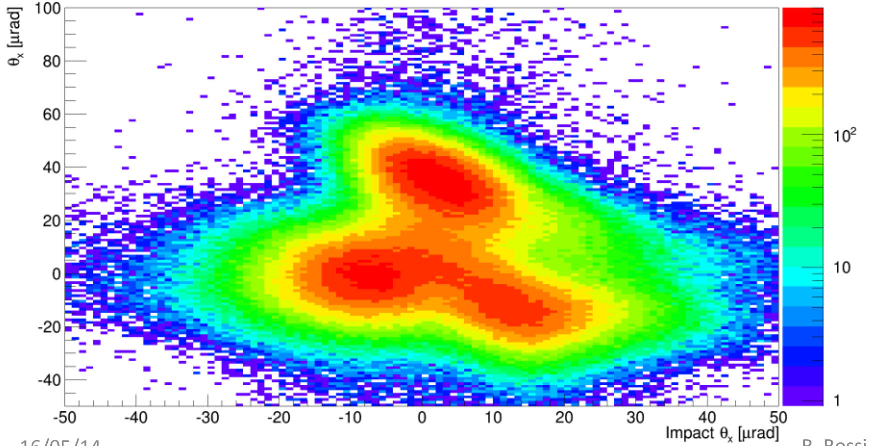
STF47

$$\theta_{corr}(x) = g.Pos\,(x) + \theta_{in}(x) - g.Pos_{init}(x) - (torsion * Impact(y) + g.Pos_{offset}(x))$$

dTheta_x_vs_Impact_x_nocut



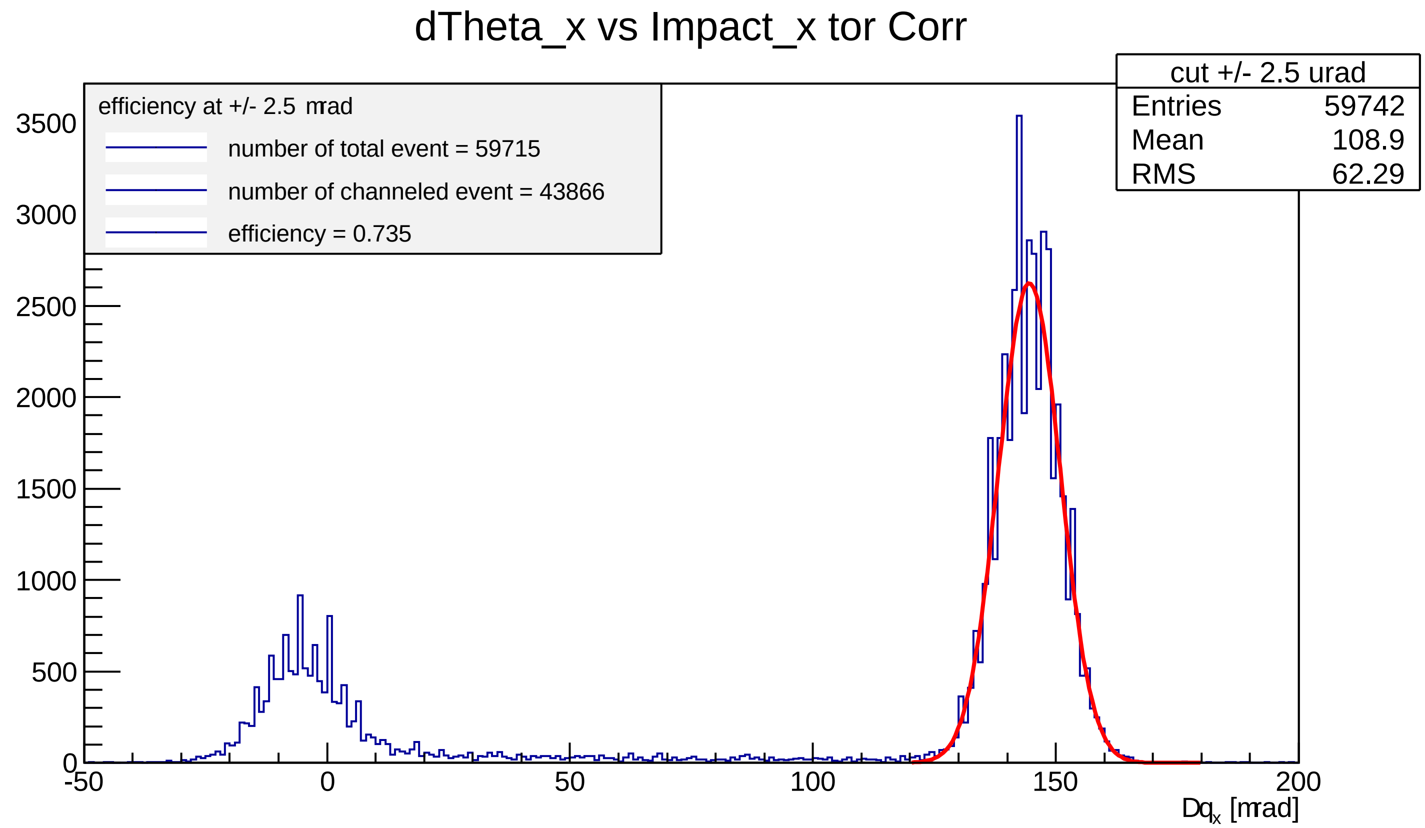
dTheta_x_vs_Impact_x



Channeling Efficier

± 2.5 μrad

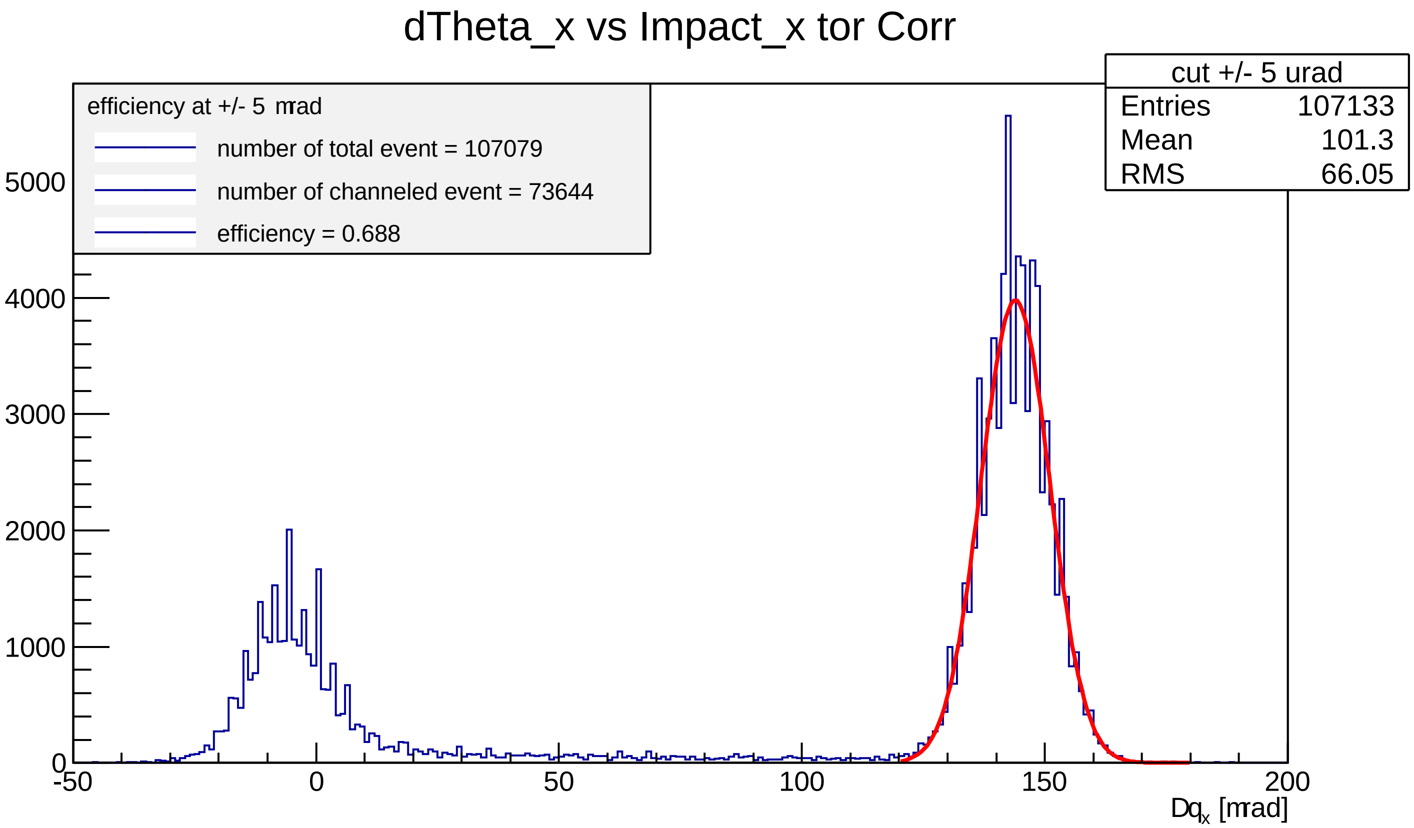
Efficiency = 0,74



Channeling Efficiency

± 5 µrad

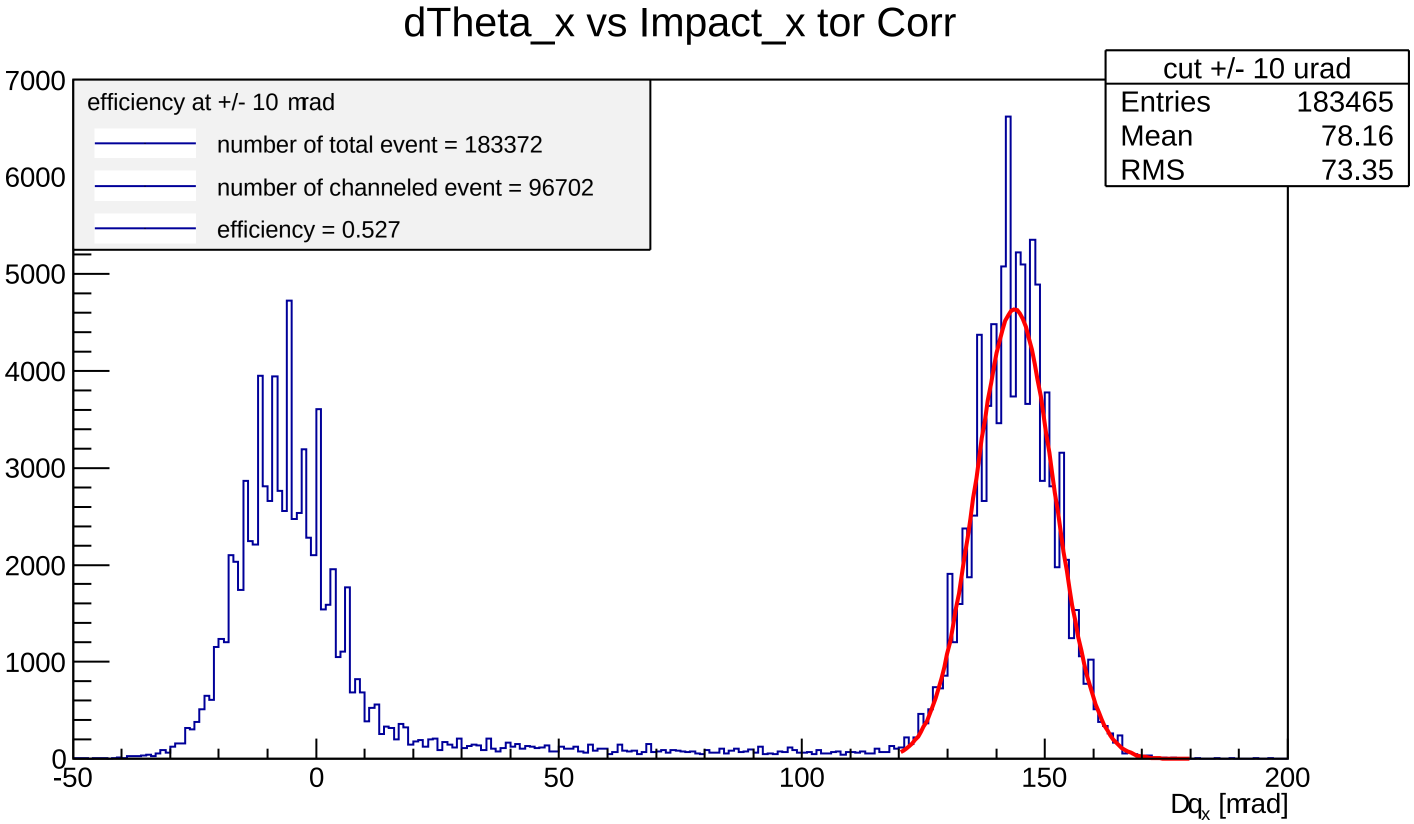
Efficiency = 0,69



Channeling Efficier

± 10 µrad

Efficiency = 0,53



Hi Stat CH Analysis

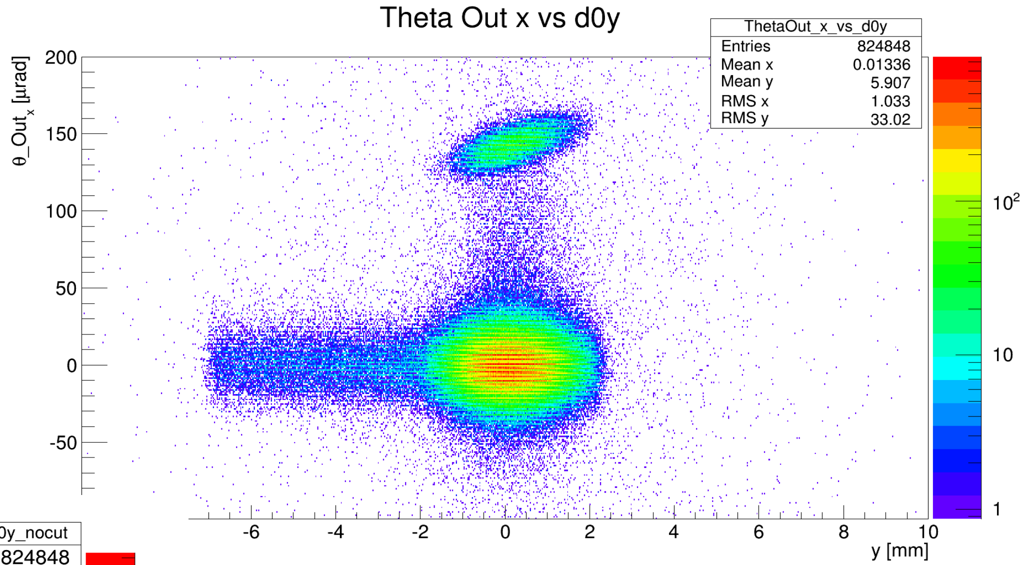
torsion

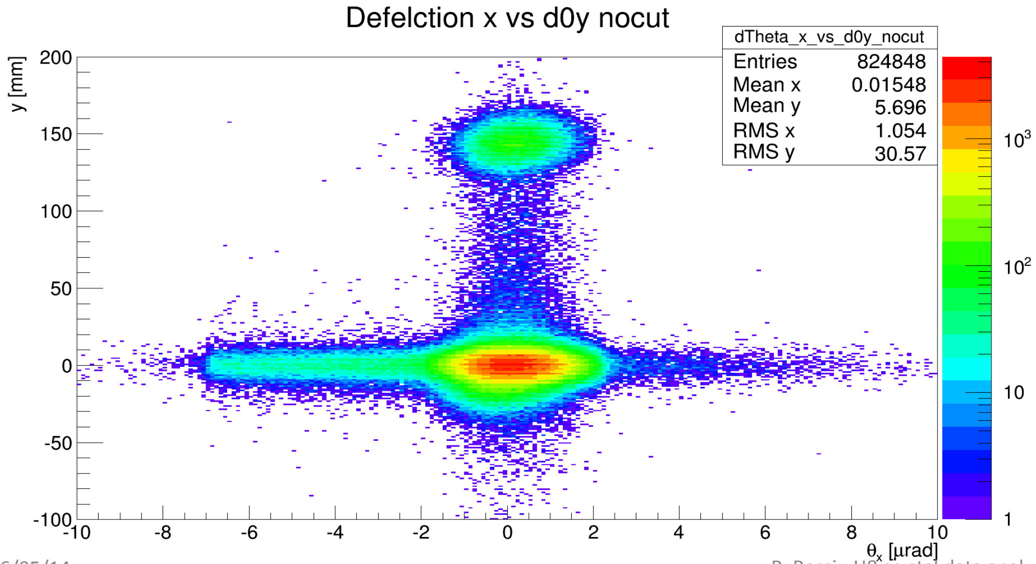
- x kick vs. impact y position is analyzed to measure the bending variation as a function of the vertical impact position

- The outgoing x angle vs. impact y position is also analyzed to measure directly the torsion as the variation of the outgoing angle as a function of vertical impact position

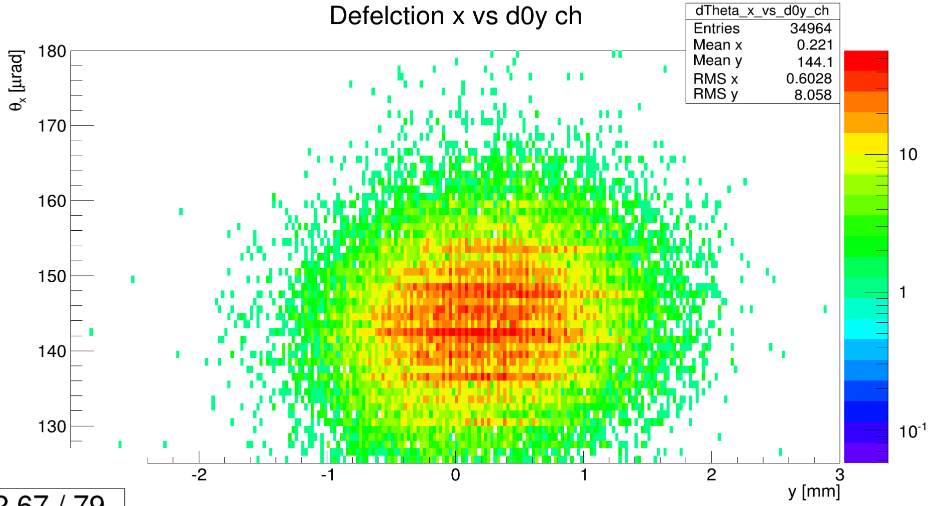
Geometrical cut is used for both the analysis

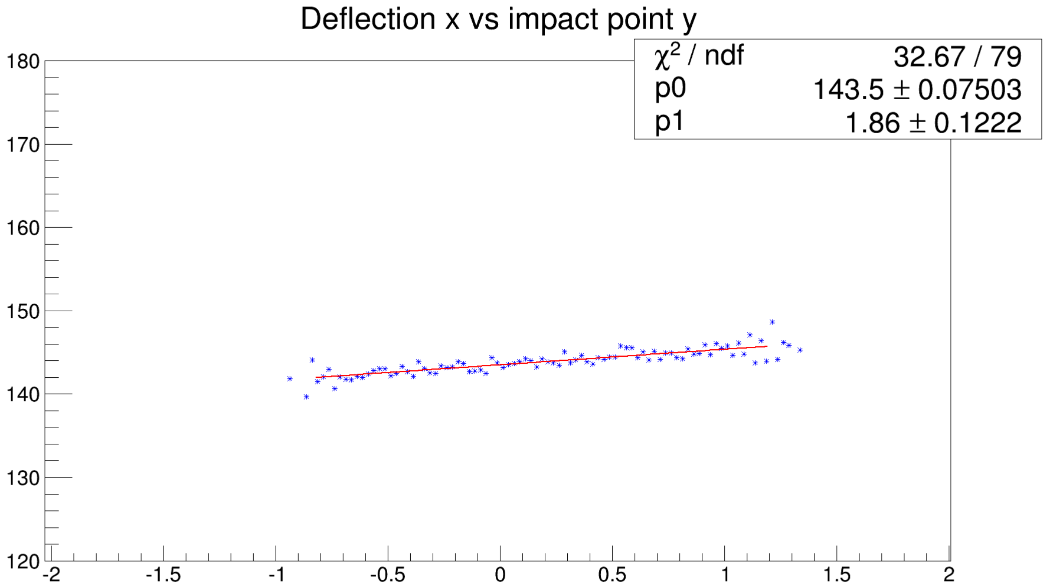
STF45


Theta Out x vs d0y
ThetaOut_x_vs_d0y
Entries 824848
Mean x 0.01336
Mean y 5.907
RMS x 1.033
RMS y 33.02
θ_Out_x [µrad]
y [mm]

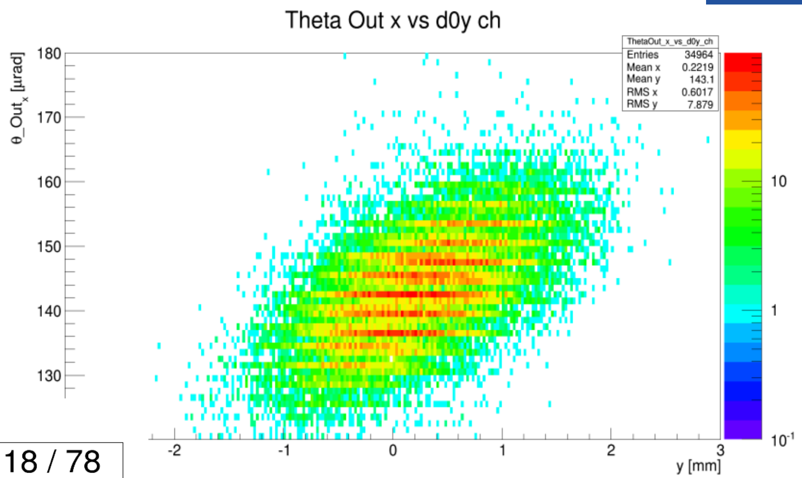

Defelction x vs d0y nocut
dTheta_x_vs_d0y_nocut
Entries 824848
Mean x 0.01548
Mean y 5.696
RMS x 1.054
RMS y 30.57
y [mm]
θx [µrad]

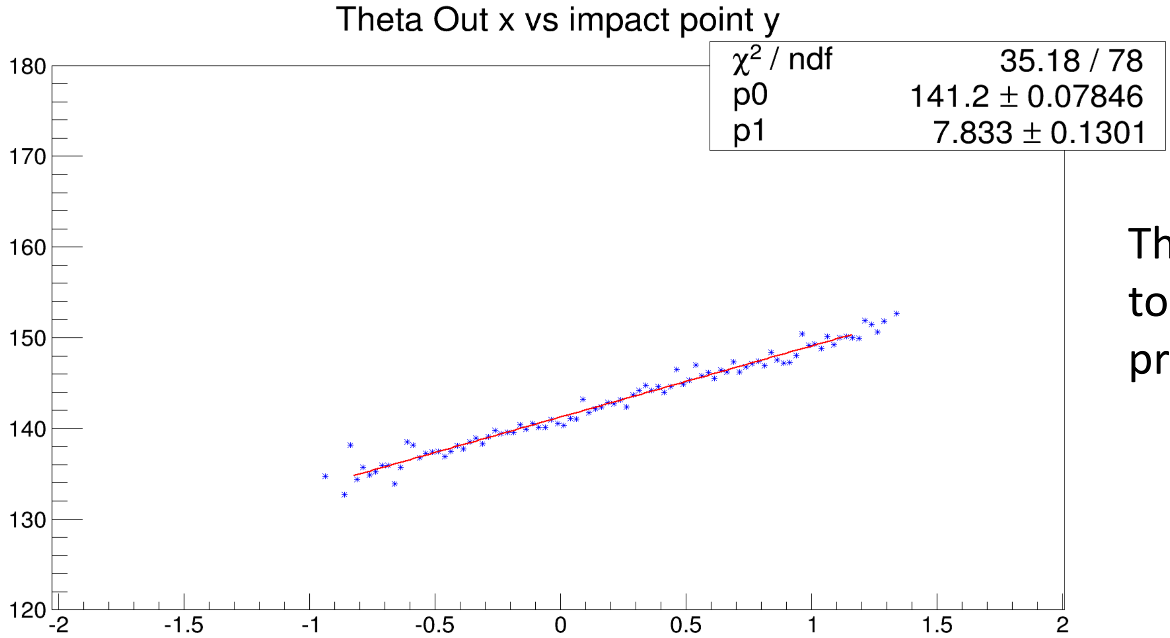
STF45





As we can see, a very slight variation of bending is present in this crystal





This torsion value is comparable to the one obtained with the previous method