Update on low-energy electron reconstruction in CYGNUS

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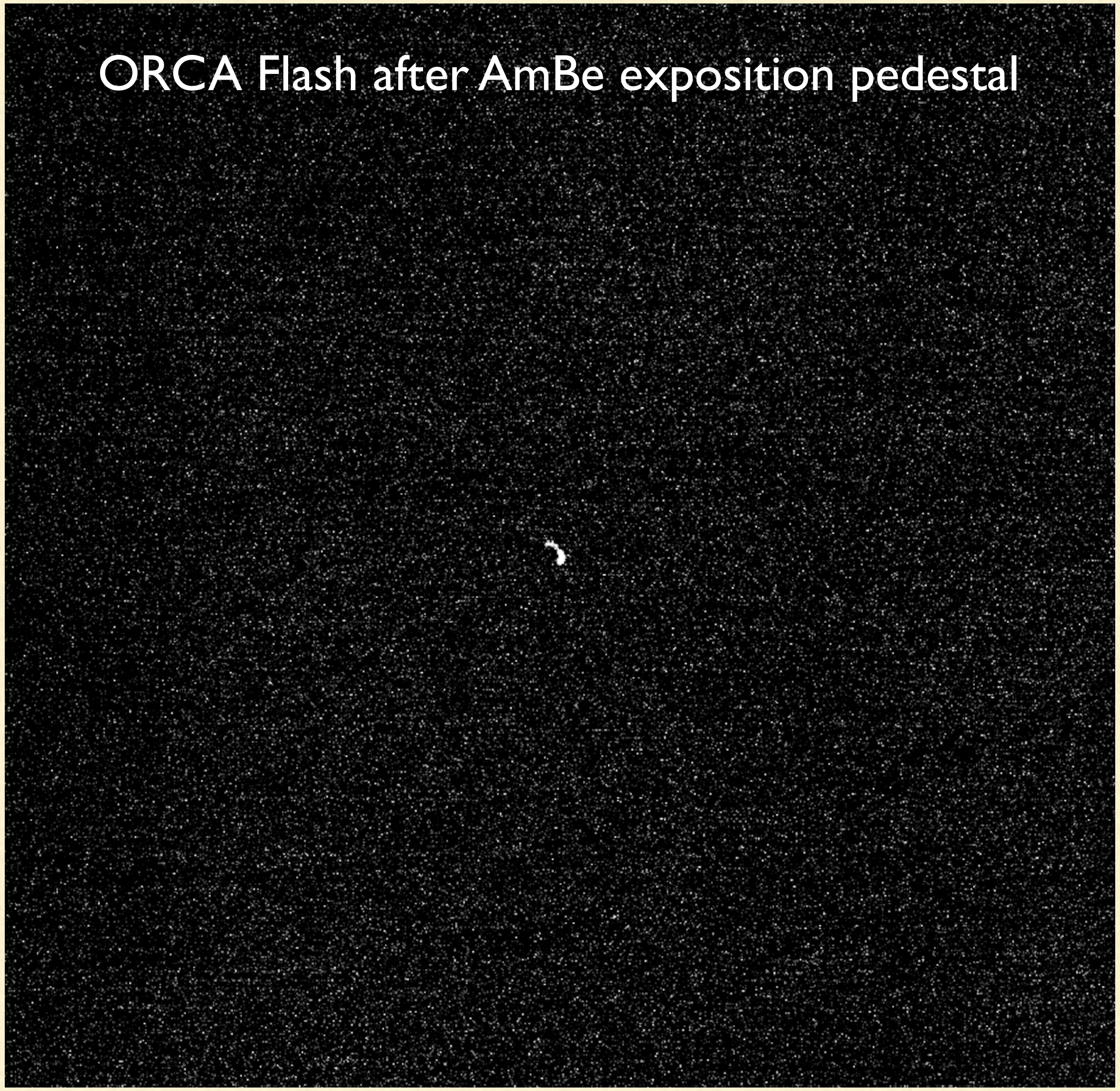
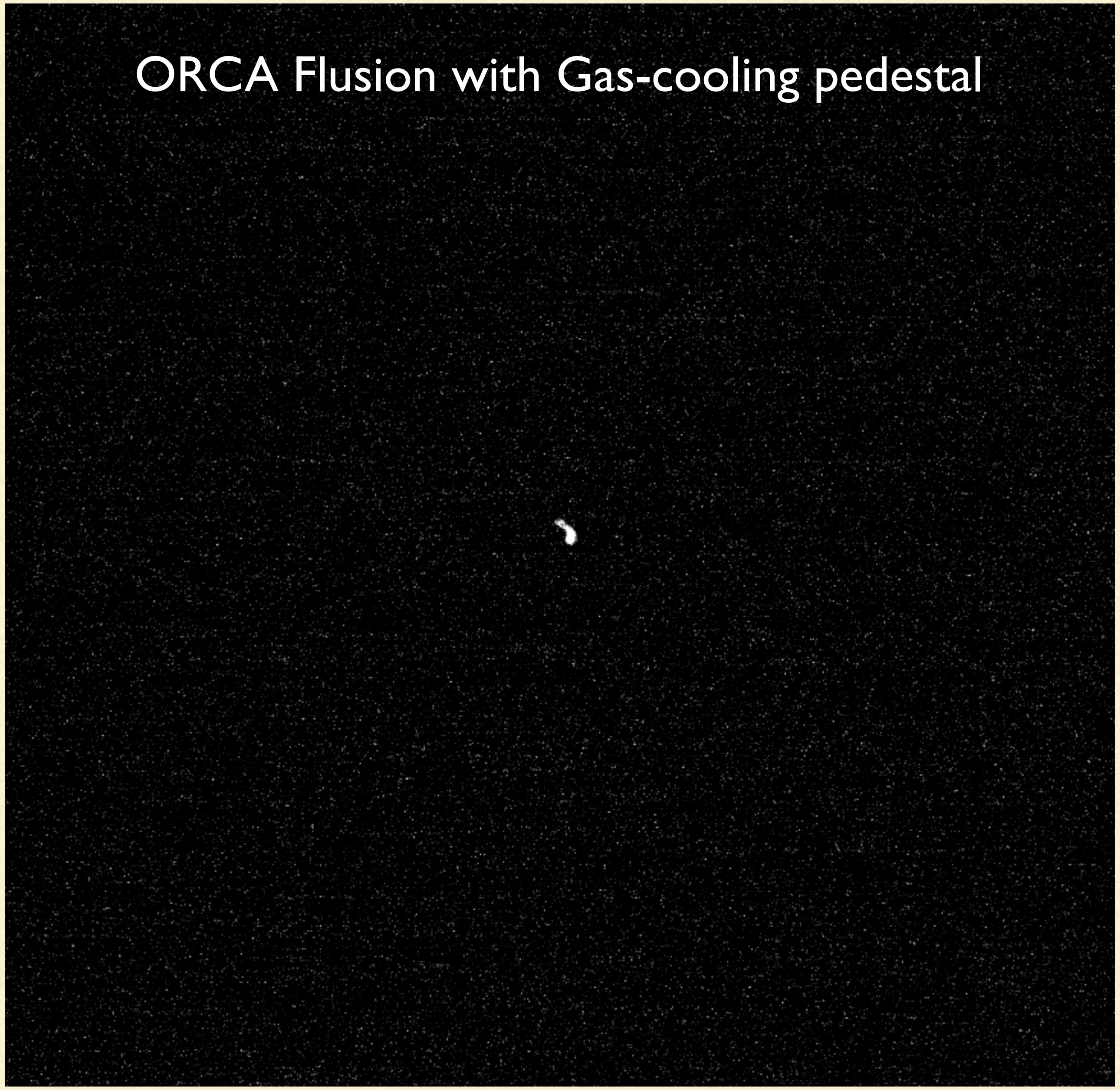
The 3944 and 3797 pedestals



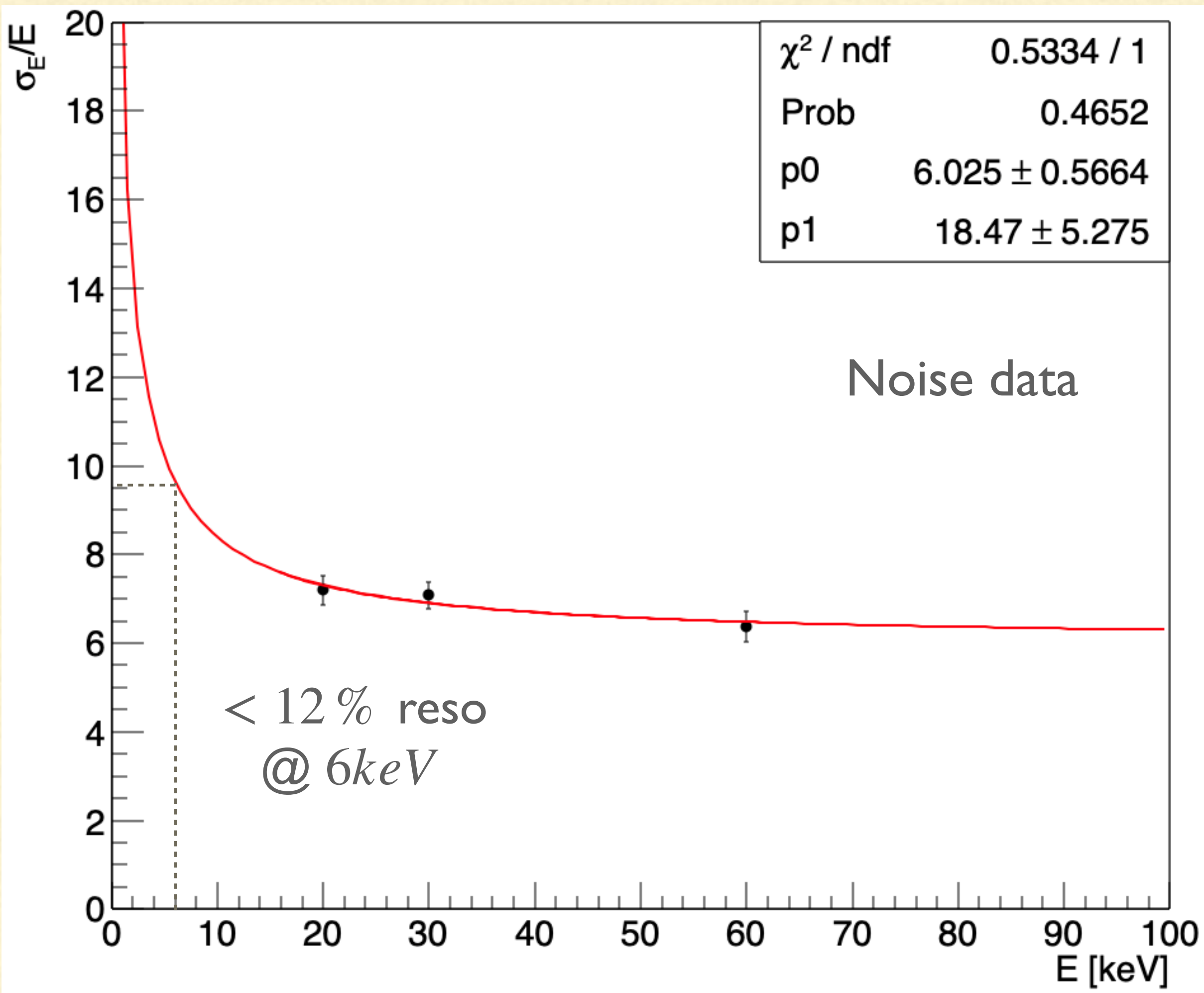


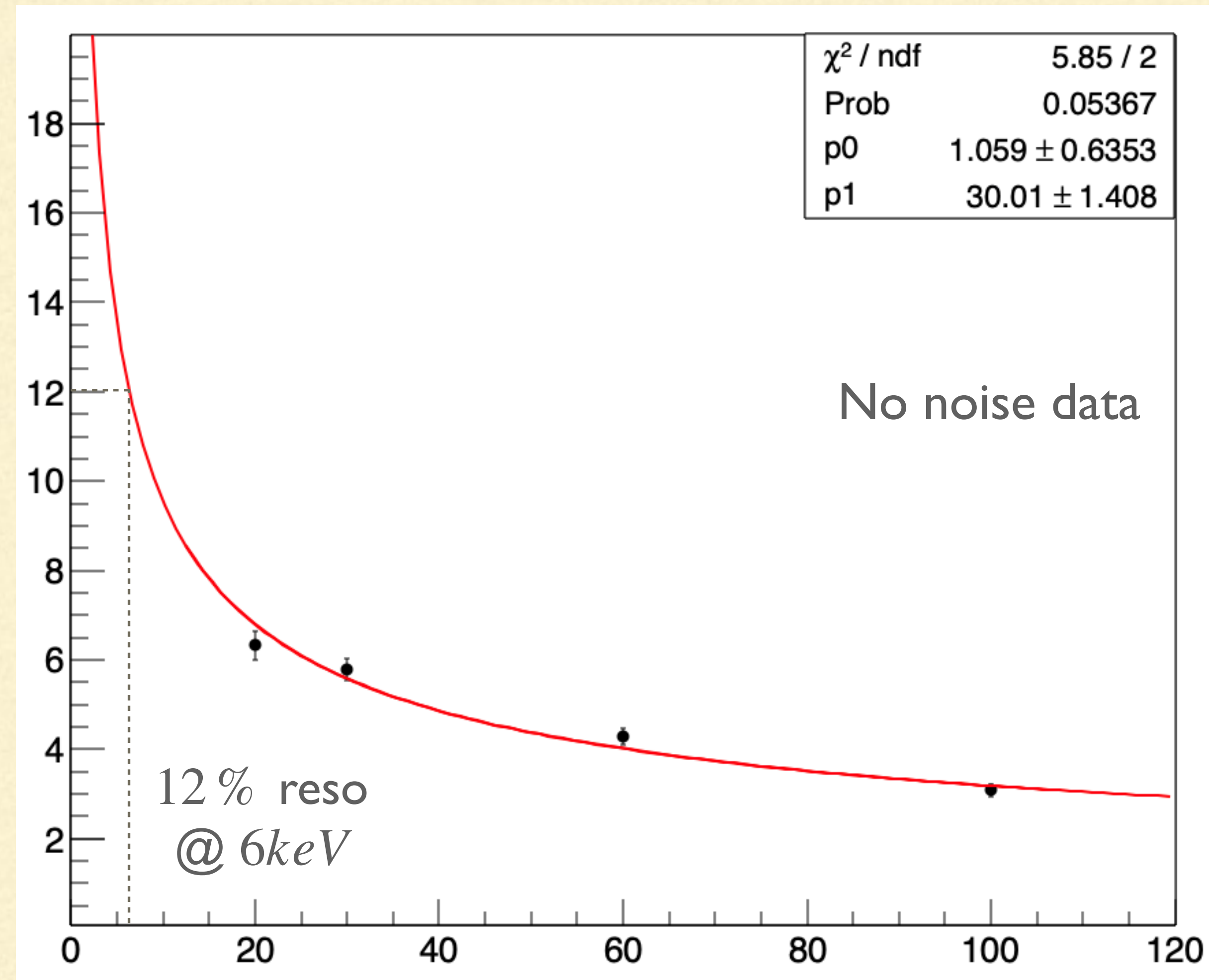
- Redigitization and reconstruction of all dataset used for this study with new pedestal

Data used for the digitization

```
'diff_coeff_B'          : 0.0196,       #diffusion parameter [mm/sqrt(cm)]^2
'diff_const_sigma0'     : 0.0784,       # diffusion constant [mm]^2
'z_dim'                 : 350,          #first dimension of the detector
'y_dim'                 : 350,          #second dimension of the detector
'z_pix'                 : 2304,         #number of pixels in the first dimension
'y_pix'                 : 2304,         #number of pixels in the second dimension
'x_gem'                 : 510,          #coordinate of the cam in the simulation (x the is drift direction in geant4 sim) [mm]

'tag'                   : 'Data',
'noiserun'              : 3944,
'Conversion_Factor'     : 3000./6,      #Number of photoelectrons emitted per keV (iron calibration) [LIME has 60% light wrt LEMON]

'ion_pot'               : 0.0462,       #ionization potential for He/CF4 60/40 [keV]
'GEM_gain'              : 123,          #gain in a single GEM foil, value chosen to reproduce the measured light yield in LEMON
'photons_per_el'        : 0.07,         #number of photons per electron produced in the avalanche
'sensor_size'           : 14.976,        #sensor dimension [mm]
'camera_aperture'       : 0.95,

'bckg'                 : True,          #if 'True' background is added
'rootfiles'             : True,         #choose input type: True for G4 root iput, False for SRIM txt files
'events'                : 500,          #number of events to be processed, -1 = all
#'donotremove'            : True,           # Remove or not the file from the tmp folder
}
```

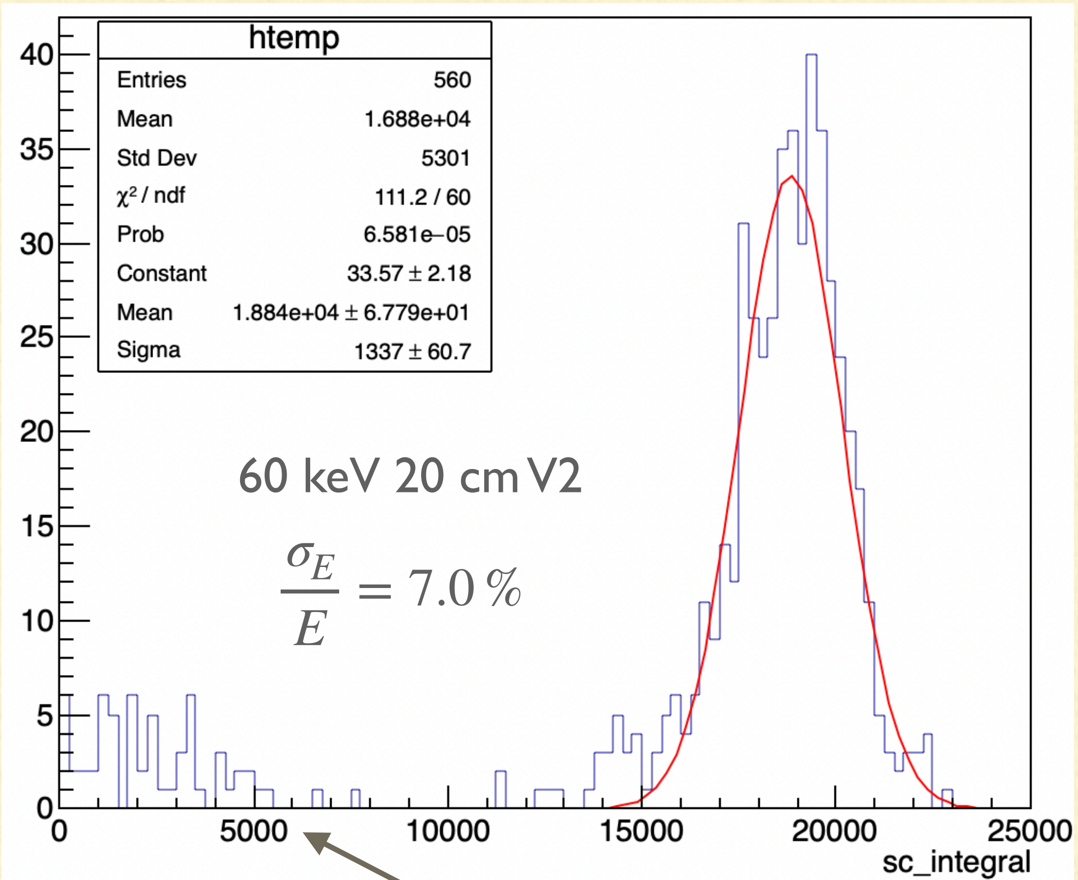
Energy resolution of simulated data

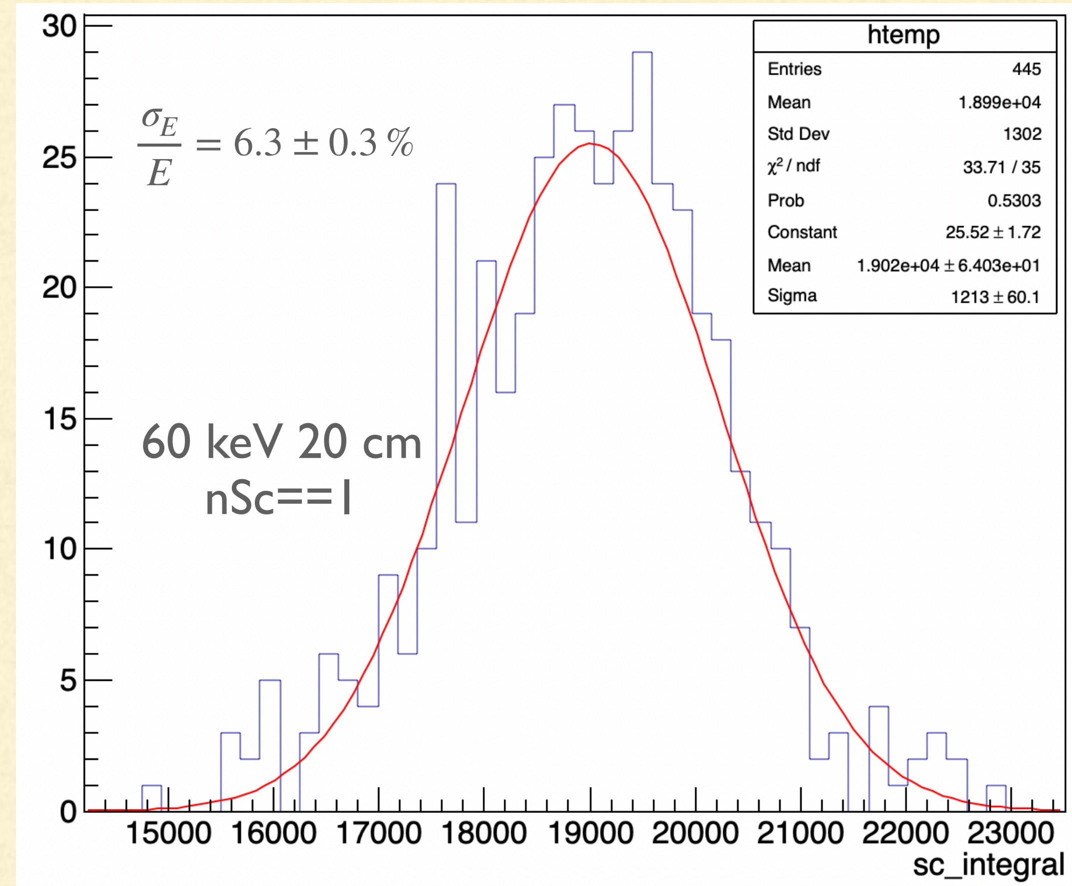




Flat @30 keV as a function of the distance

The 60 keV case





Another step to improve the resolution

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1) Interaction region identification

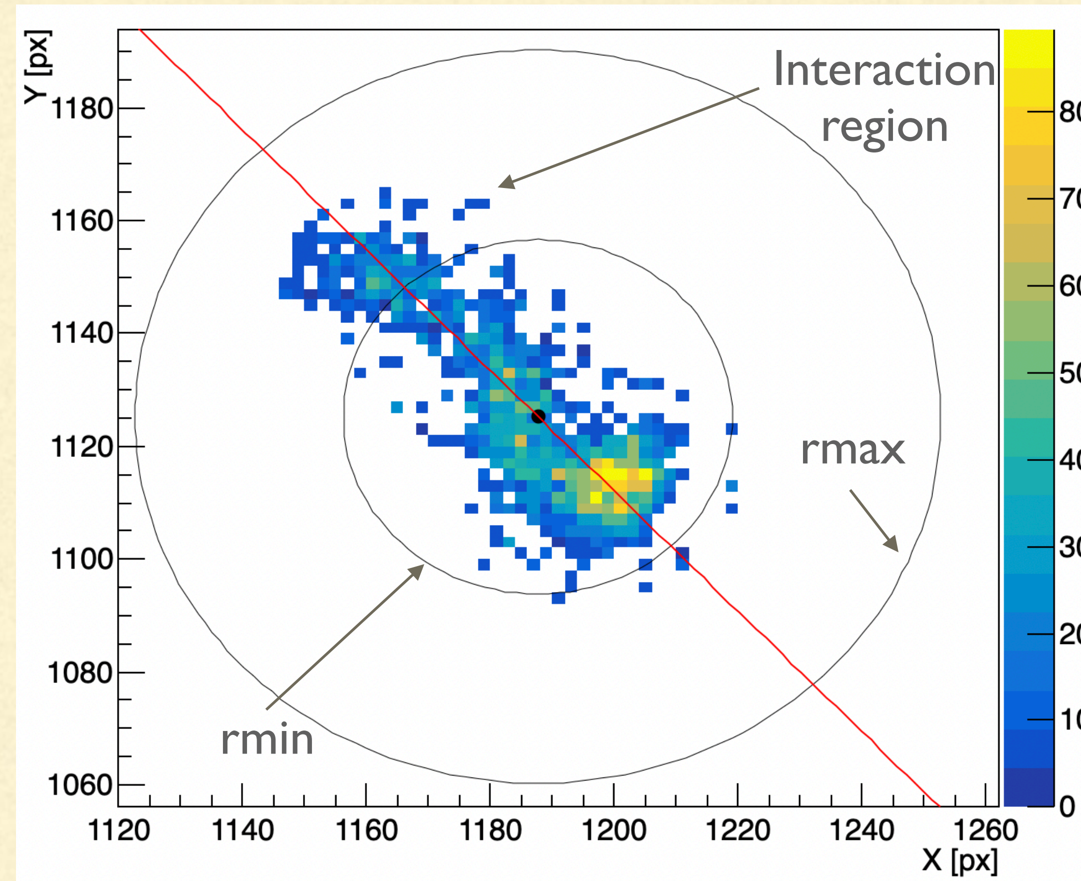
2) First IP calculation (as barycenter)

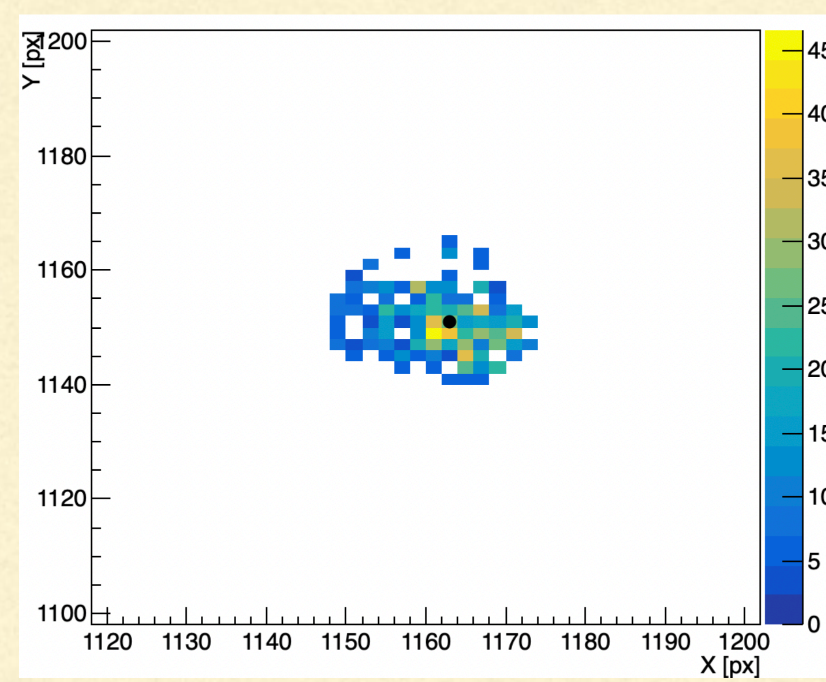
3) Cyrcular Selection ($r = 12\ px$, optimized on 30 keV)

4) IP recalculation (as barycenter of previus selection)

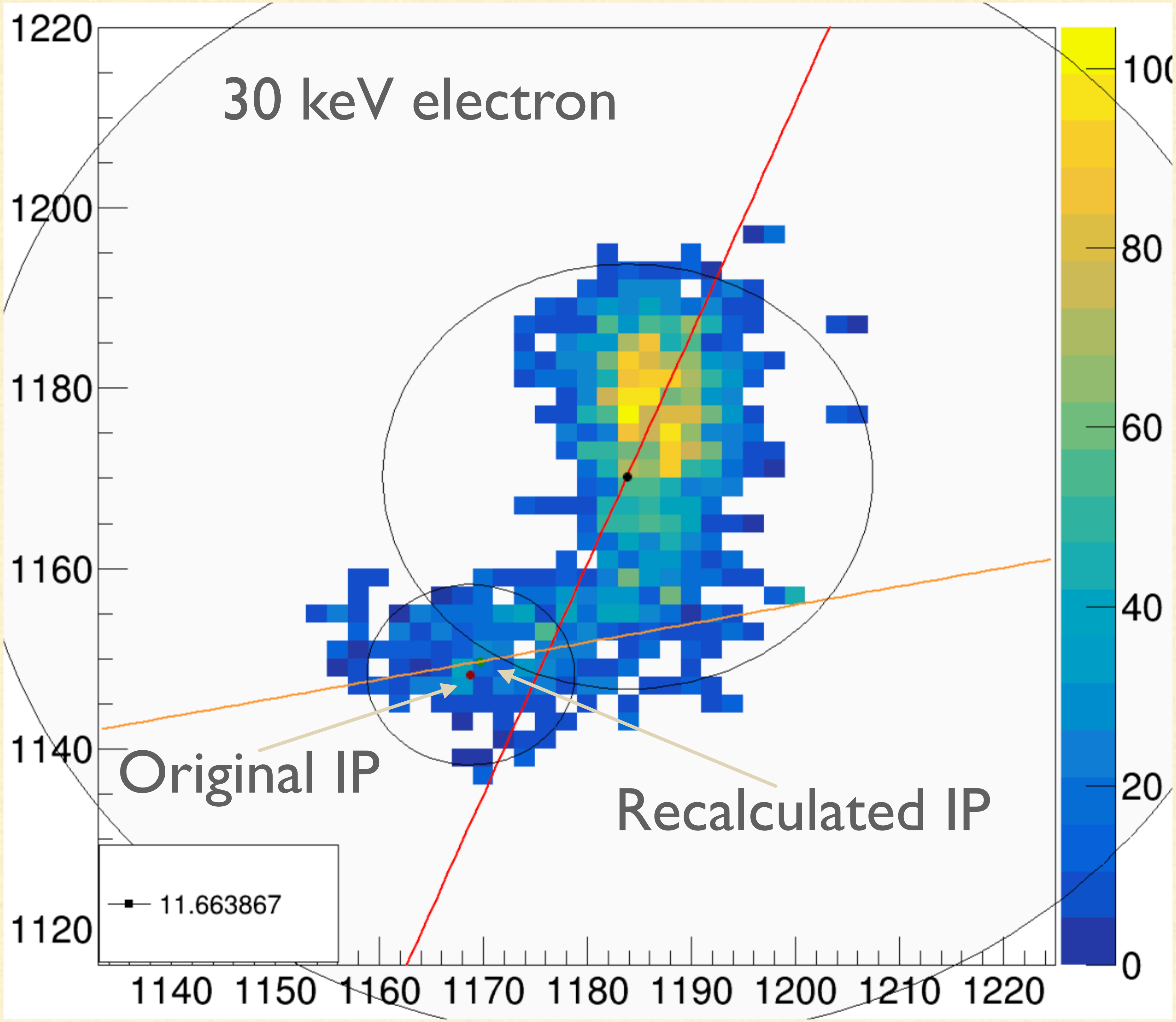
5)Cyrcular Selection around this last IP

...





Example



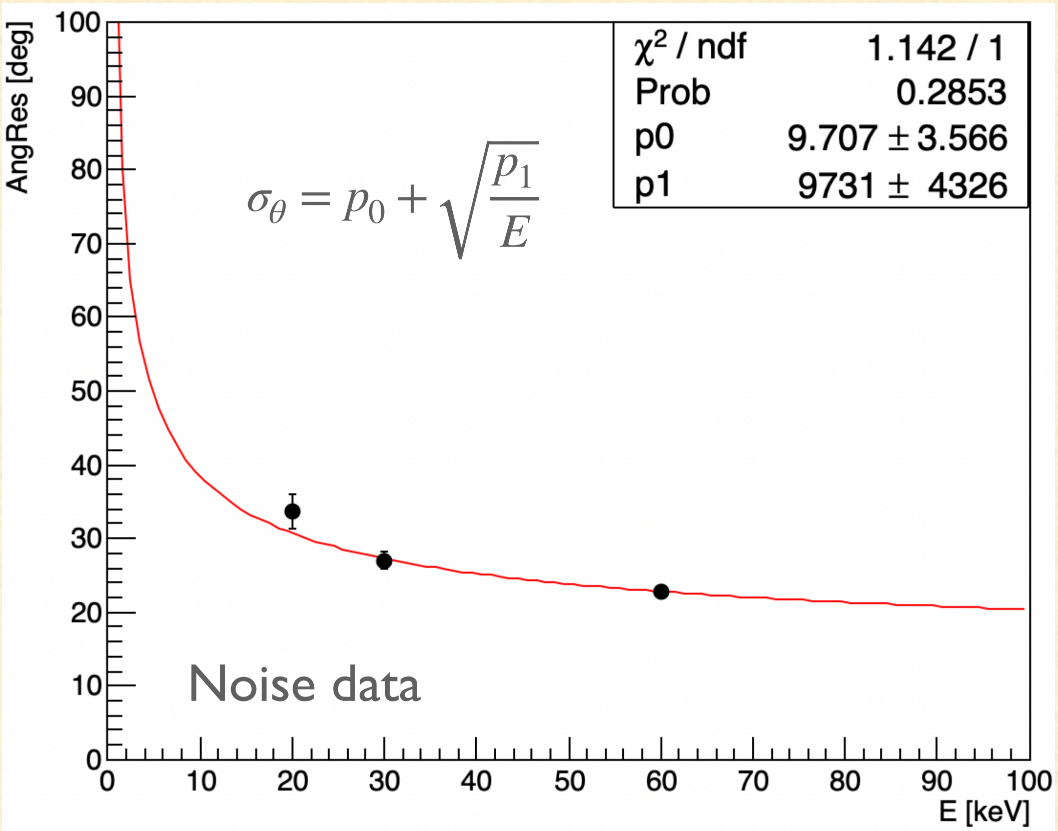
30 keV electron
Original IP
Recalculated IP
11.663867
1220
1200
1180
1160
1140
1120
1140 1150 1160 1170 1180 1190 1200 1210 1220
0
20
40
60
80
100

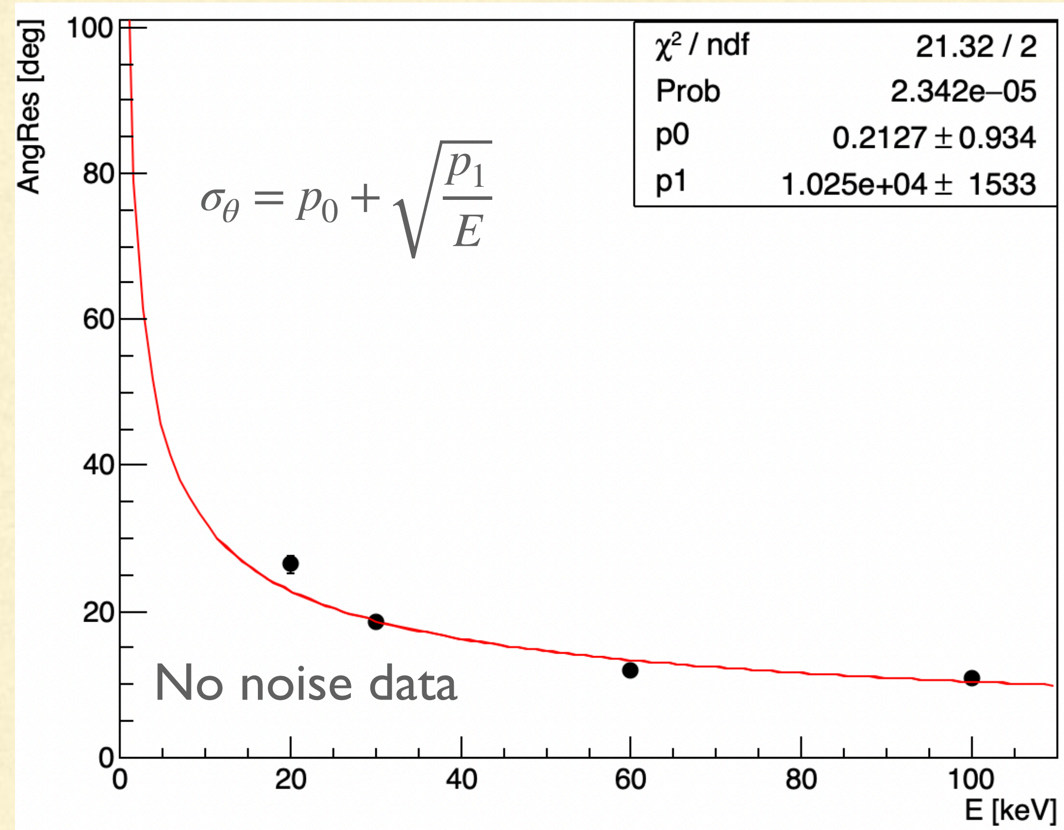
IP resolution with IP recalculation

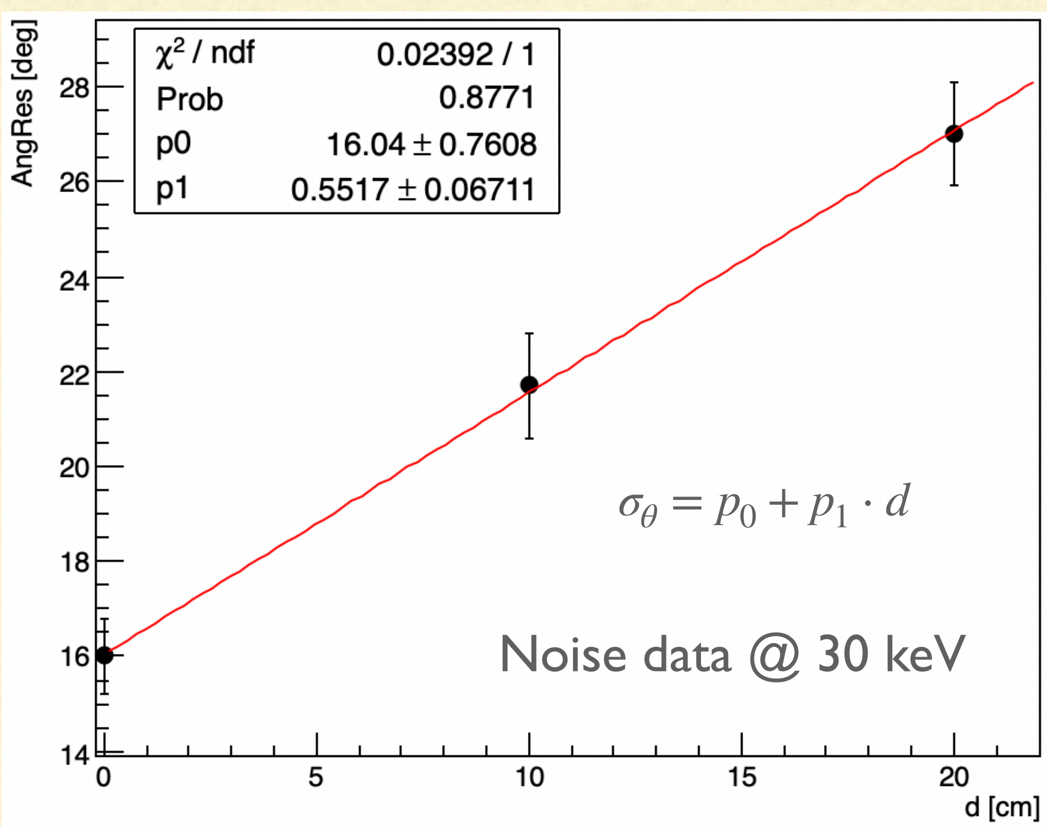
	Noise data		No noise data	
20 keV	$\sigma_\theta = 33.7 \pm 2.4°$	HT=75.2%	$\sigma_\theta = 26.4 \pm 1.3°$	HT=89.6%
30 keV	$\sigma_\theta = 27.0 \pm 1.1°$	HT=84.6%	$\sigma_\theta = 18.5 \pm 0.8°$	HT=88.8%
60 keV	$\sigma_\theta = 22.7 \pm 1.0°$	HT=83.1%	$\sigma_\theta = 12.0 \pm 0.4°$	HT=91.5%
100 keV			$\sigma_\theta = 10.9 \pm 0.3°$	HT=88.2%
0 cm	$\sigma_\theta = 16.0 \pm 0.8°$	HT=88.4%	$\sigma_\theta = 11.9 \pm 0.4°$	HT=91.2%
10 cm	$\sigma_\theta = 21.7 \pm 1.1°$	HT=88.4%	$\sigma_\theta = 15.9 \pm 0.6°$	HT=90.2%
20 cm	$\sigma_\theta = 27.0 \pm 1.1°$	HT=84.6%	$\sigma_\theta = 18.5 \pm 0.8°$	HT=88.8%

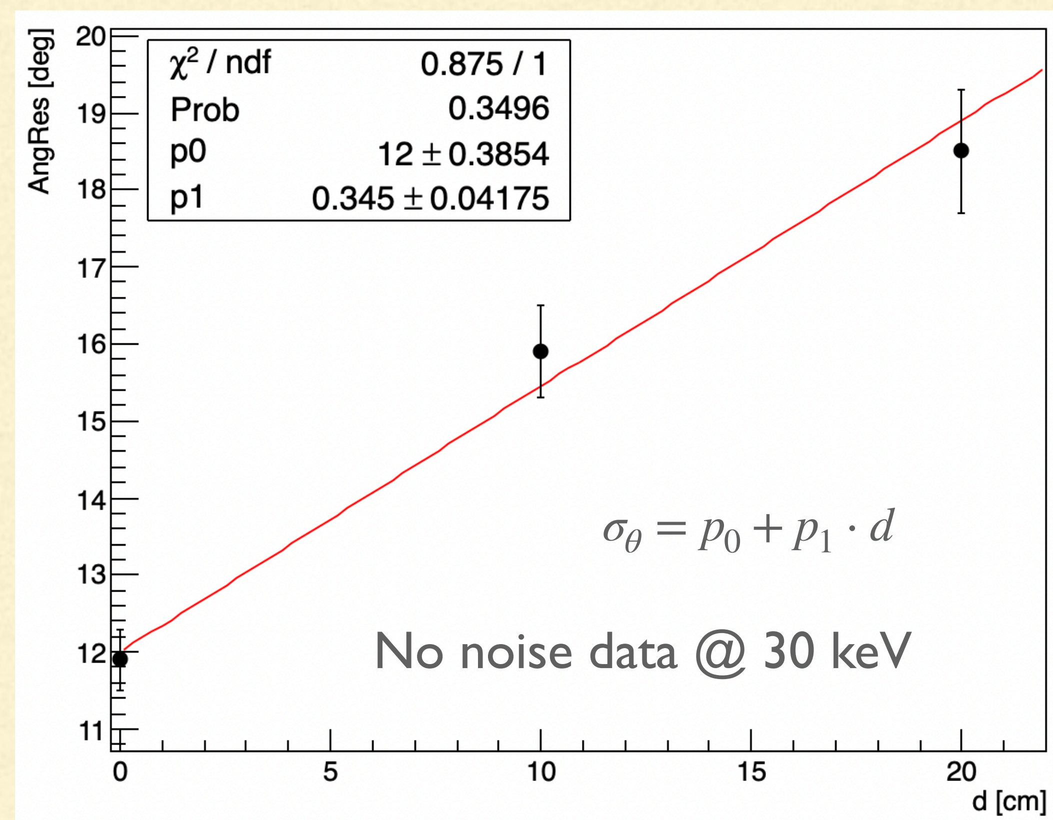
Improvement at higher energies, optimization needed at lower energies

Angular resolution with IP recal









IP resolution on new data

	Data with noise	Data without noise
$20\ keV$	$\sigma_x = (0.784 \pm 0.043)mm$ $\sigma_y = (0.751 \pm 0.030)mm$	$\sigma_x = (0.487 \pm 0.017)mm$ $\sigma_y = (0.93 \pm 0.03)mm$
$30\ keV$	$\sigma_x = (0.99 \pm 0.05)mm$ $\sigma_y = (0.612 \pm 0.04)mm$	$\sigma_x = (0.509 \pm 0.018)mm$ $\sigma_y = (0.399 \pm 0.021)mm$
$60\ keV$	$\sigma_x = (1.71 \pm 0.13)mm$ $\sigma_y = (0.763 \pm 0.04)mm$	$\sigma_x = (0.580 \pm 0.028)mm$ $\sigma_y = (0.328 \pm 0.018)mm$
$100\ keV$		$\sigma_x = (0.686 \pm 0.03)mm$ $\sigma_y = (0.428 \pm 0.028)mm$

$0\ cm$	$\sigma_x = (0.464 \pm 0.018)mm$ $\sigma_y = (0.27 \pm 0.03)mm$	$\sigma_x = (0.349 \pm 0.014)mm$ $\sigma_y = (0.268 \pm 0.010)mm$
$10\ cm$	$\sigma_x = (0.67 \pm 0.04)mm$ $\sigma_y = (0.47 \pm 0.03)mm$	$\sigma_x = (0.425 \pm 0.016)mm$ $\sigma_y = (0.355 \pm 0.015)mm$
$20\ cm$	$\sigma_x = (0.99 \pm 0.05)mm$ $\sigma_y = (0.612 \pm 0.04)mm$	$\sigma_x = (0.509 \pm 0.018)mm$ $\sigma_y = (0.399 \pm 0.021)mm$

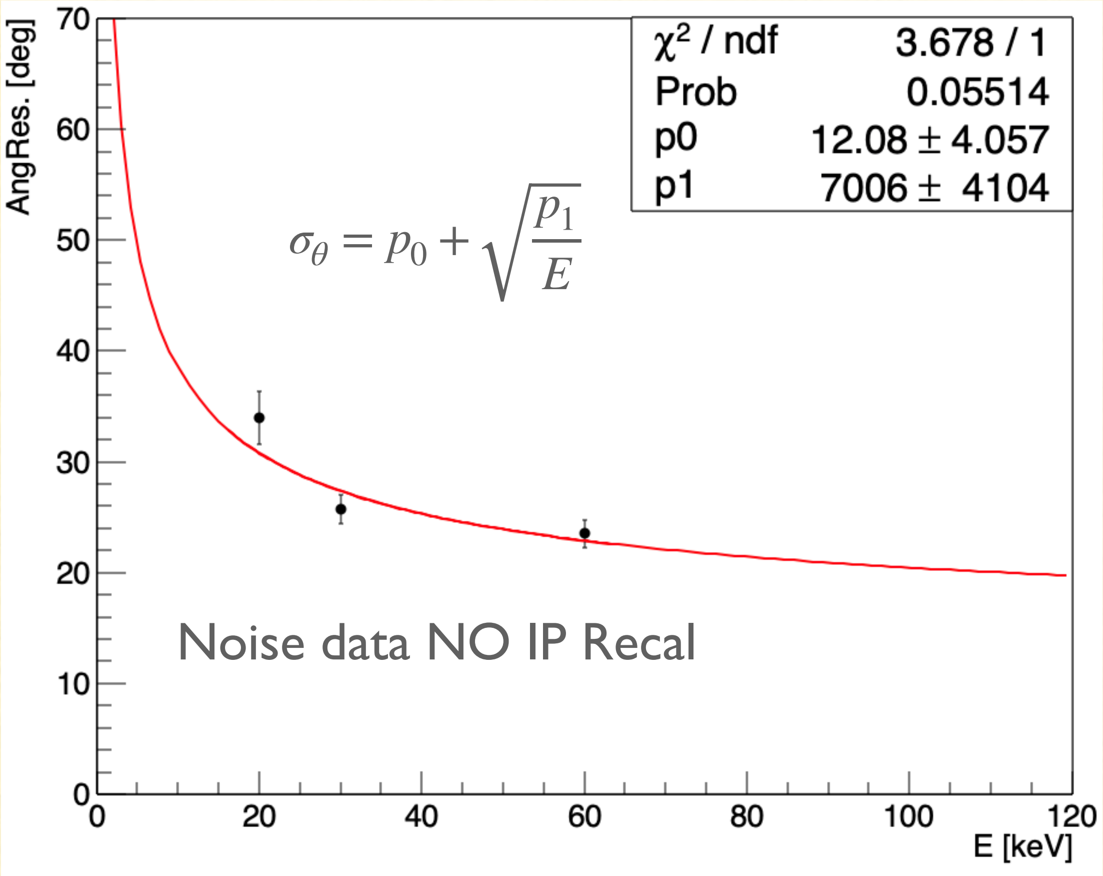
Best IP doesn't coincide with best Ang Res

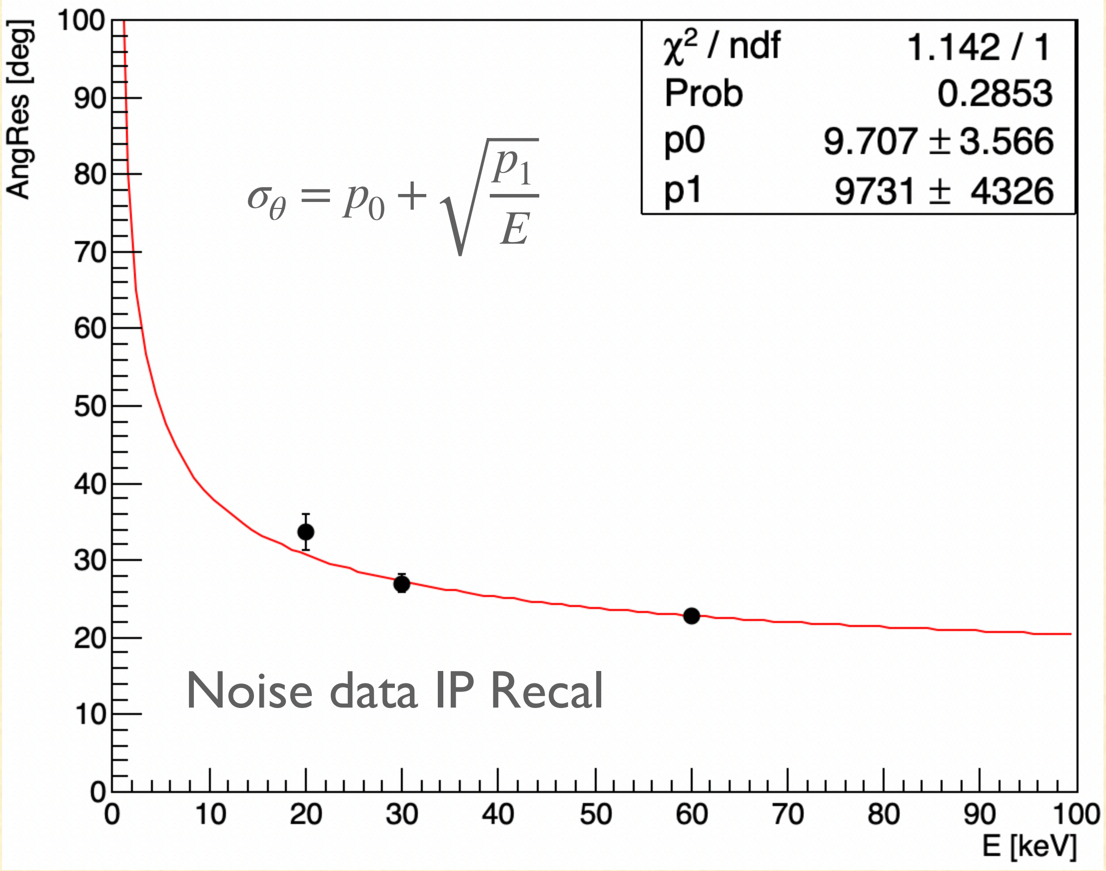
Conclusions

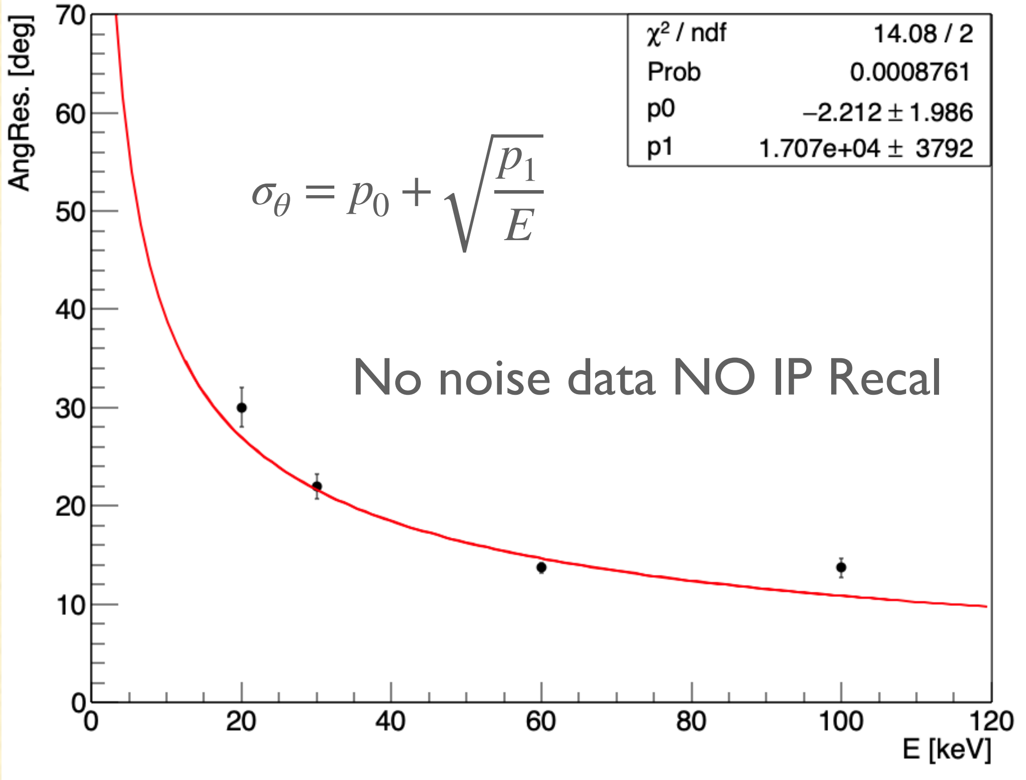
- Tracks has been successfully digitized and reconstructed
- The energy resolution scaling is consistent and compatible with energy resolution @ $6\ keV$
- Energy resolution on new tracks scales consistently with expectations
- Worse performances in general due to tracks lower granularity
- The IP recalculation improves the directionality at higher energies, should be optimized at lower energies

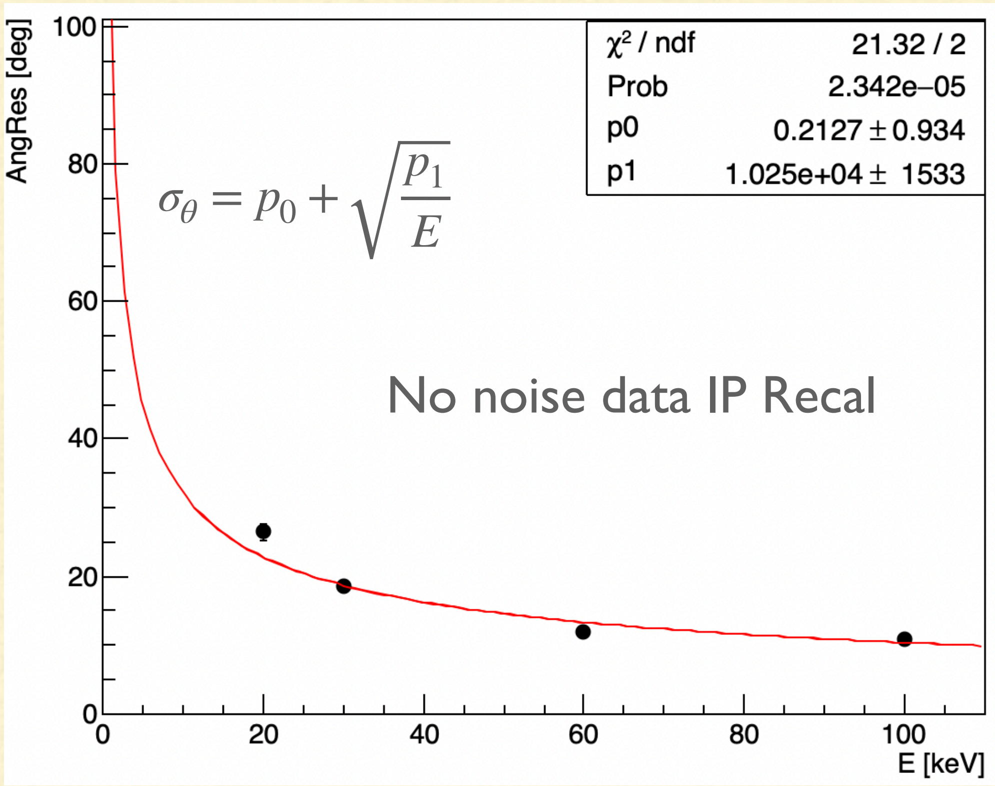
Backup

Comparison

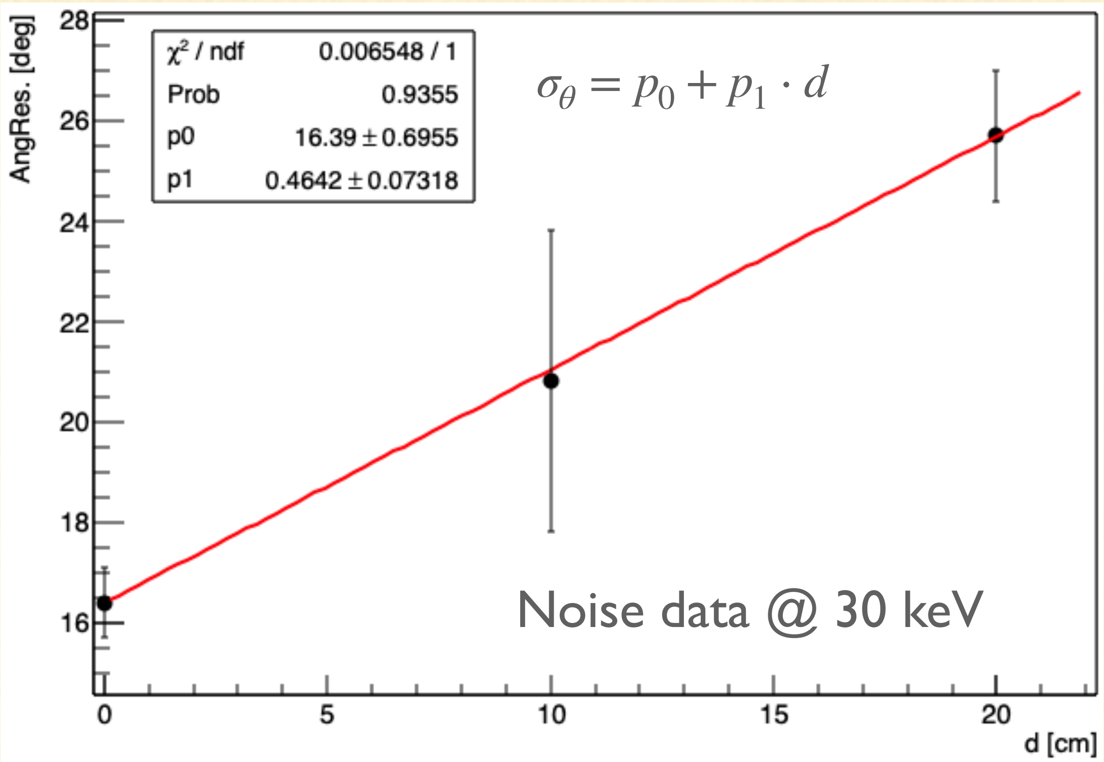

AngRes. [deg]
E [keV]
χ^2 / ndf 3.678 / 1
Prob 0.05514
p0 12.08 ± 4.057
p1 7006 ± 4104
$\sigma_\theta = p_0 + \sqrt{\frac{p_1}{E}}$
Noise data NO IP Recal

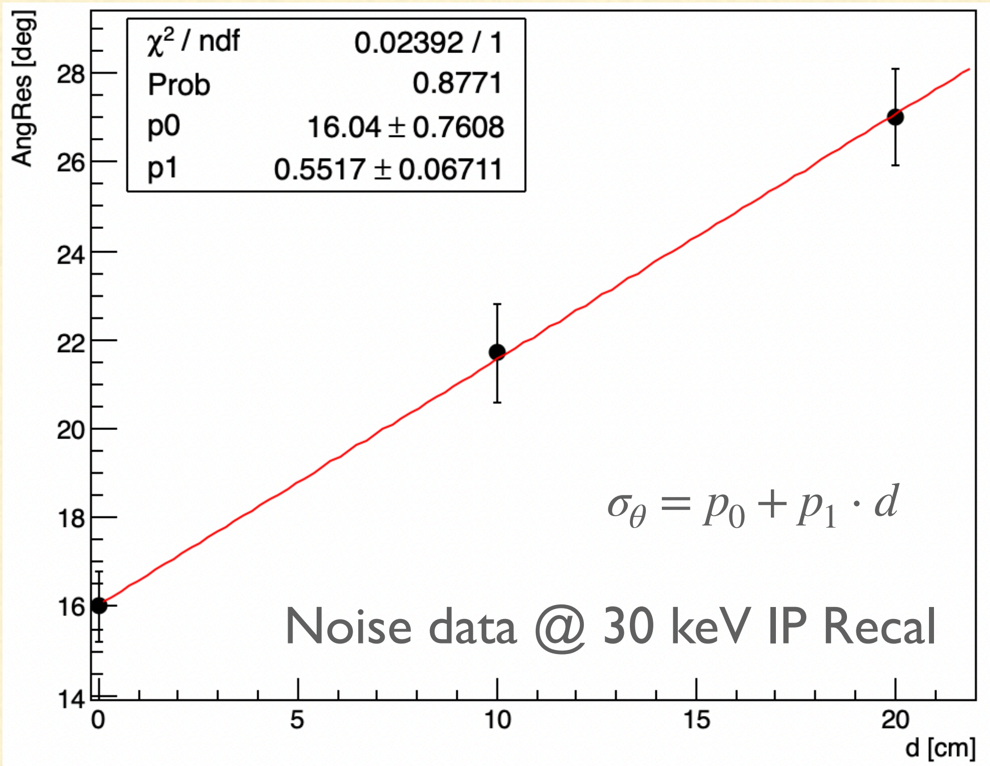

AngRes [deg]
E [keV]
χ^2 / ndf 1.142 / 1
Prob 0.2853
p0 9.707 ± 3.566
p1 9731 ± 4326
$\sigma_\theta = p_0 + \sqrt{\frac{p_1}{E}}$
Noise data IP Recal

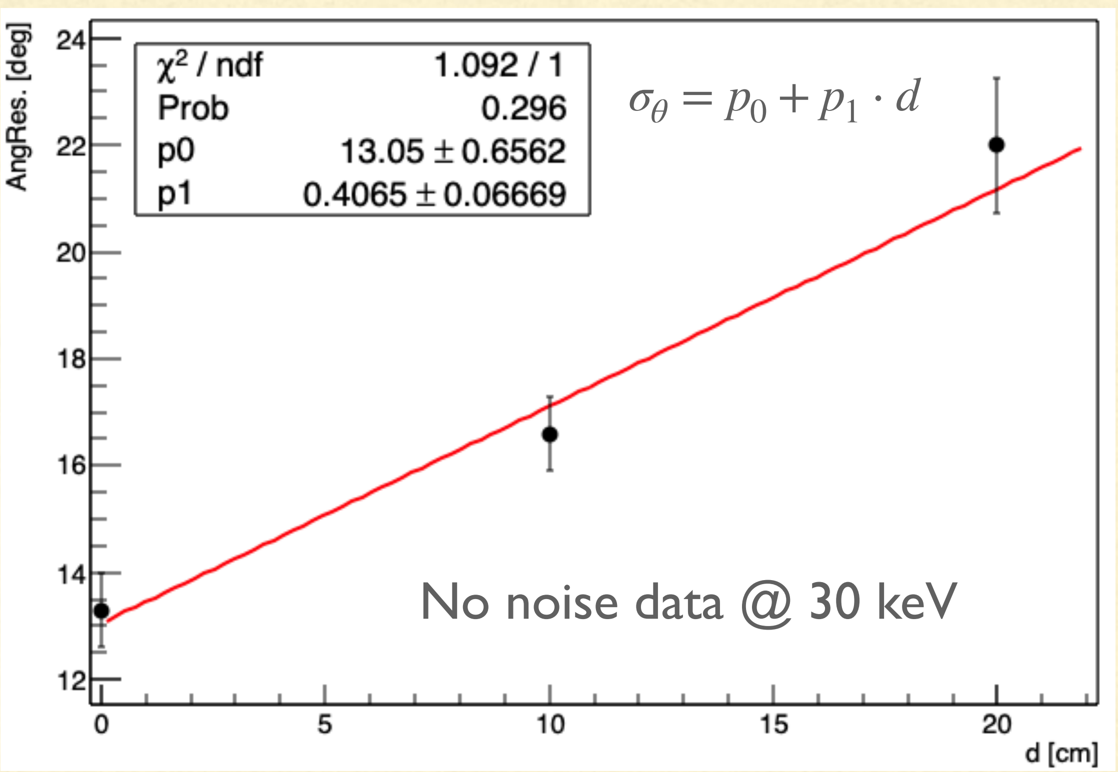

AngRes. [deg]
E [keV]
χ^2 / ndf 14.08 / 2
Prob 0.0008761
p0 −2.212 ± 1.986
p1 1.707e+04 ± 3792
$\sigma_\theta = p_0 + \sqrt{\frac{p_1}{E}}$
No noise data NO IP Recal

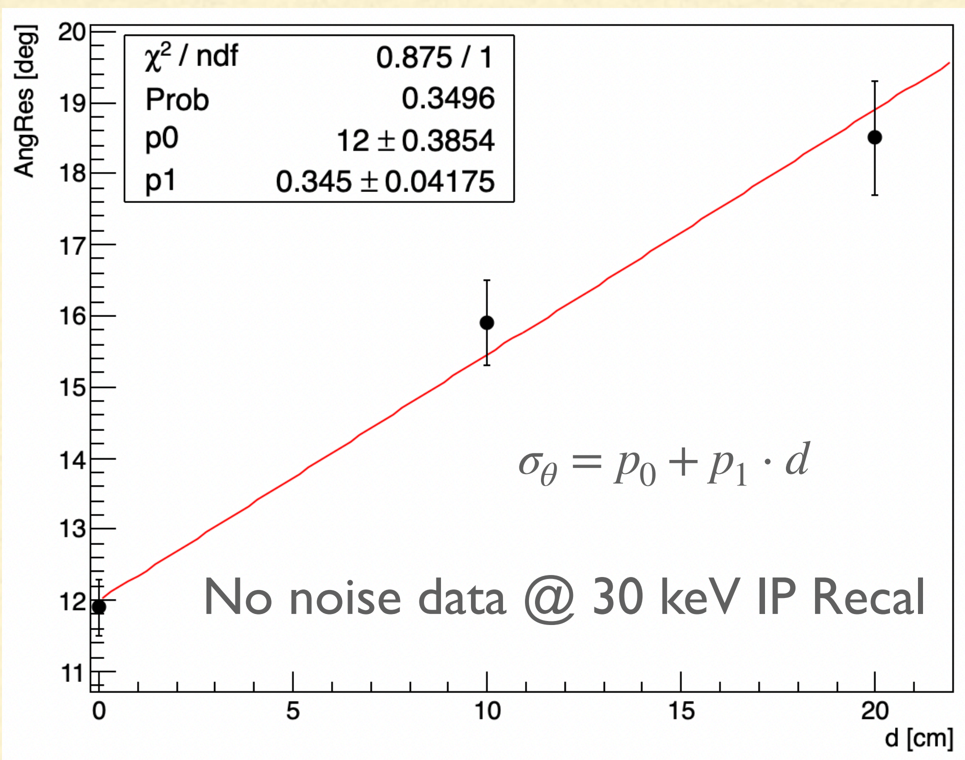

AngRes [deg]
E [keV]
χ^2 / ndf 21.32 / 2
Prob 2.342e−05
p0 0.2127 ± 0.934
p1 1.025e+04 ± 1533
$\sigma_\theta = p_0 + \sqrt{\frac{p_1}{E}}$
No noise data IP Recal

Comparison


AngRes. [deg]
d [cm]
χ² / ndf 0.006548 / 1
Prob 0.9355
p0 16.39 ± 0.6955
p1 0.4642 ± 0.07318
$\sigma_\theta = p_0 + p_1 \cdot d$
Noise data @ 30 keV


AngRes [deg]
d [cm]
χ² / ndf 0.02392 / 1
Prob 0.8771
p0 16.04 ± 0.7608
p1 0.5517 ± 0.06711
$\sigma_\theta = p_0 + p_1 \cdot d$
Noise data @ 30 keV IP Recal


AngRes. [deg]
d [cm]
χ² / ndf 1.092 / 1
Prob 0.296
p0 13.05 ± 0.6562
p1 0.4065 ± 0.06669
$\sigma_\theta = p_0 + p_1 \cdot d$
No noise data @ 30 keV


AngRes [deg]
d [cm]
χ² / ndf 0.875 / 1
Prob 0.3496
p0 12 ± 0.3854
p1 0.345 ± 0.04175
$\sigma_\theta = p_0 + p_1 \cdot d$
No noise data @ 30 keV IP Recal