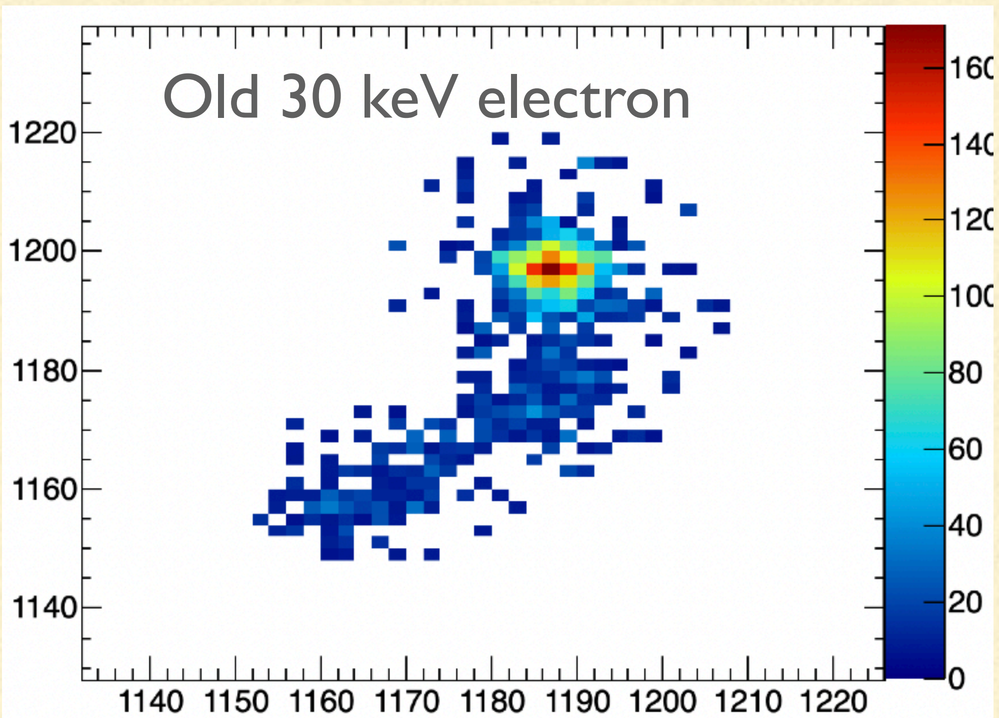
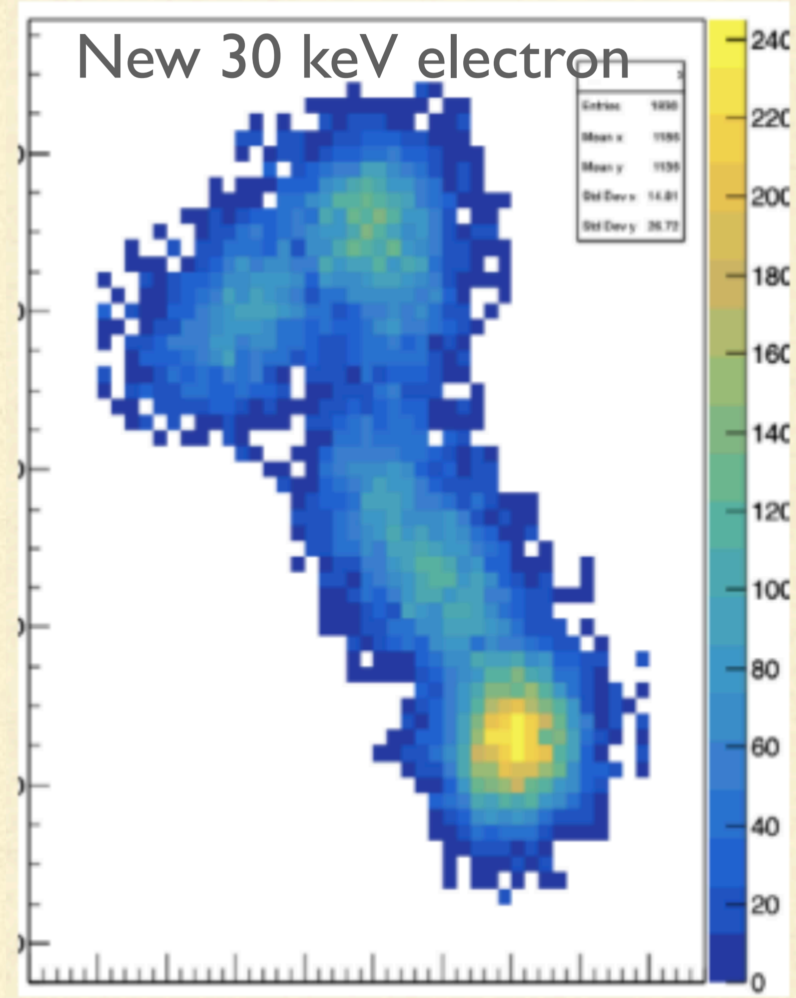
Back to Directionality of low energy electron recoil

S. Torelli - E. Baracchini

What changed from last time

- Summary of the changes: A lot





- Use of the new digitization code (prolem of a Factor ~5 light less)
- Optimization of the saturation parameters
- Optimization of the diffusion parameters
- Addition of vignetting
- Correct simulation of the fluctuaion

→ Agreement within data and MC in therms of Energy, resolution and topological variables

- Reconstruction with DBSCAN without GAC or Chan-Vese

Data sample

With the new digitization code optimized I produced samples of:

- 10.000 tracks per energy
- Isotropic direction
- Diffusion from 10 to 40 cm
- Random x-y position with vignetting included
- Energies of 16 18 20 22 24 28 32 36 40 50 60 70 keV

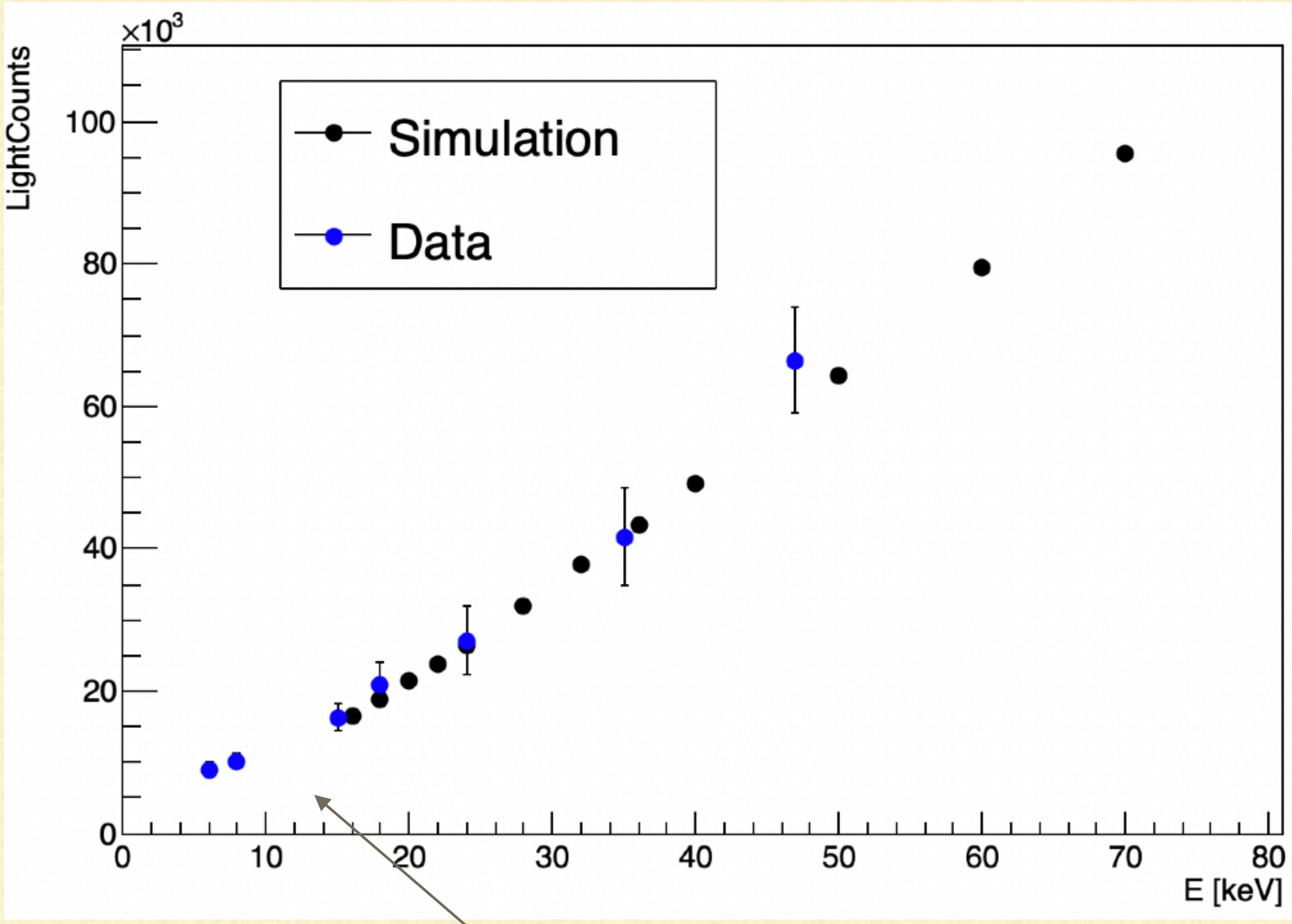
N.B. Some optimization of the parameters is needed to reconstruct 100 keV but it's duable

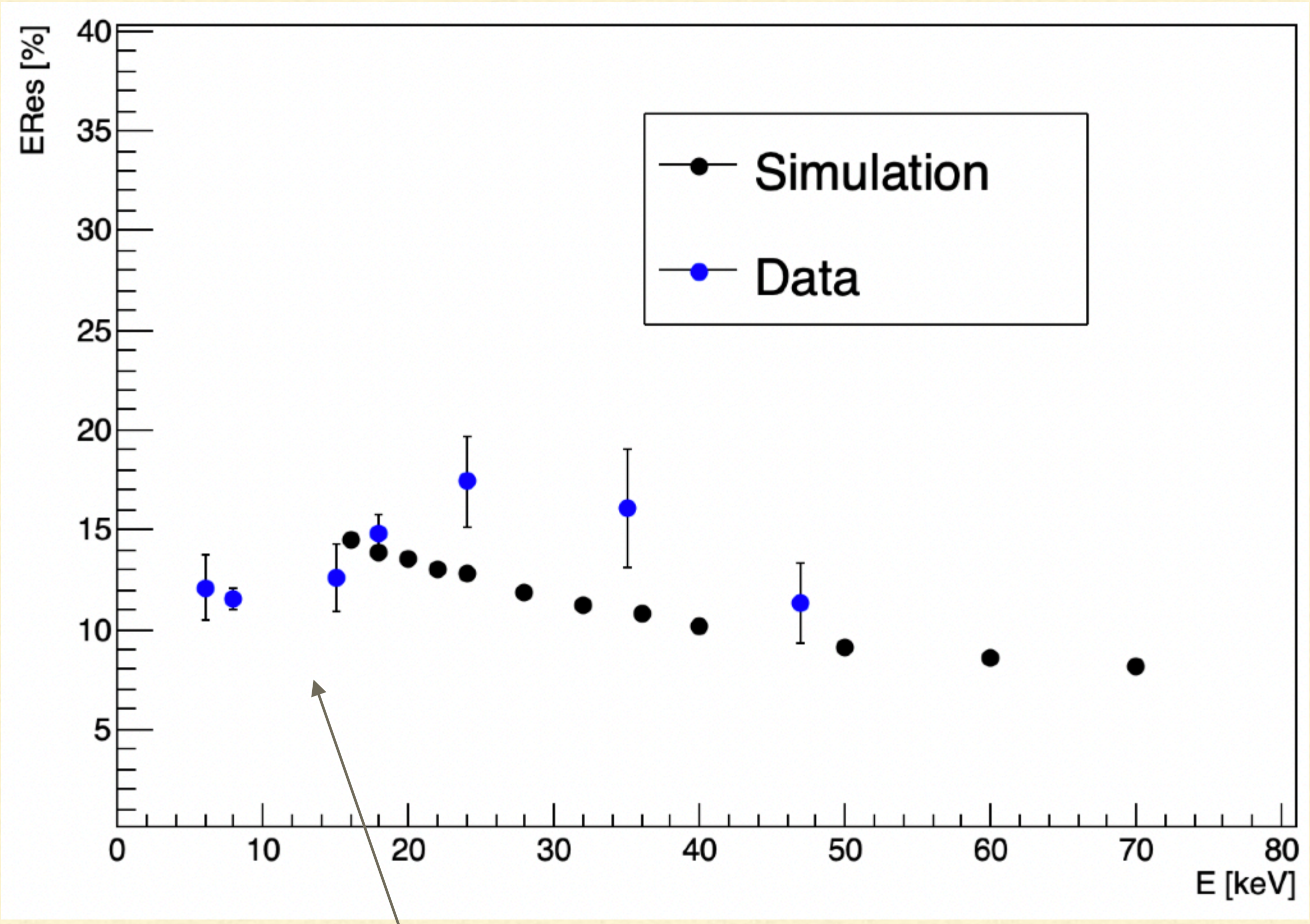
- Possibility of retrive the original impact point since the GEANT xyz are saved

- Images @ : /nfs/cygno2/users/torellis/digitization/OutDigi/LIME_${E}keV_Sat_10_40_cm_3944bkg__Vign_BeforSensorFLu

- Reconstructed tracks @ : /nfs/cygno2/users/torellis/reconstruction/LIME_HighStat_5790bkg_Iso_Vign_FluBeforeSensor

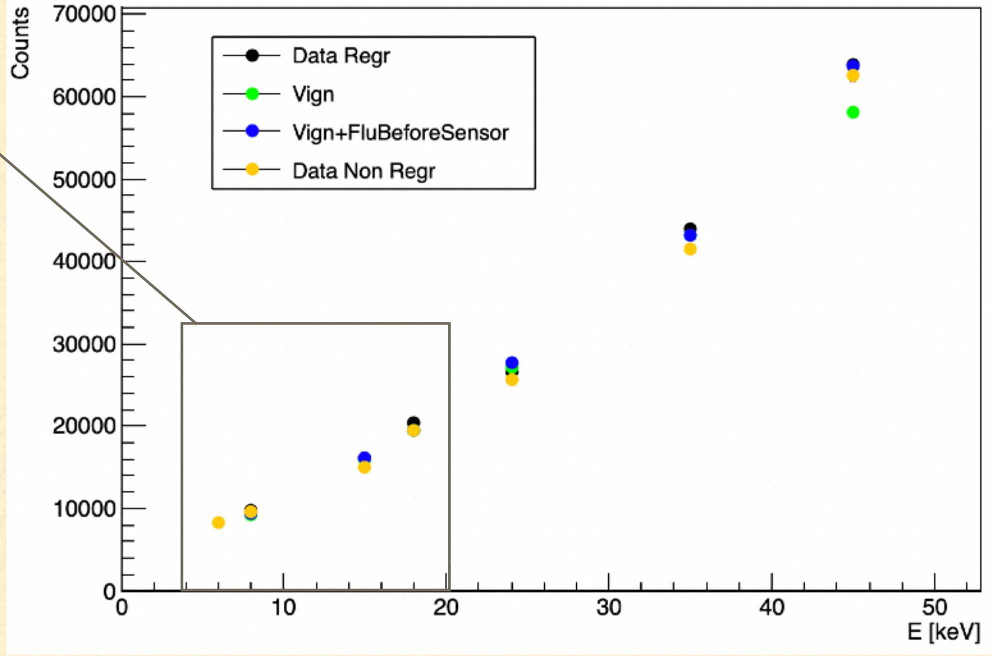
Linearity and EReso

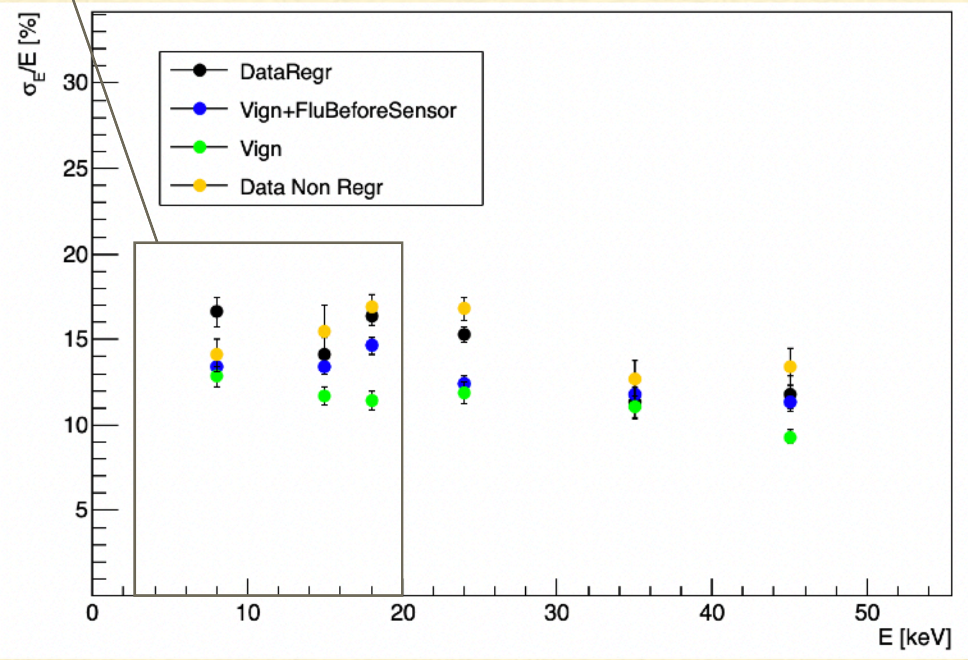




From previous results simulation points expected to follow the trend of data at lower energies (0-20keV)

Blue and black points

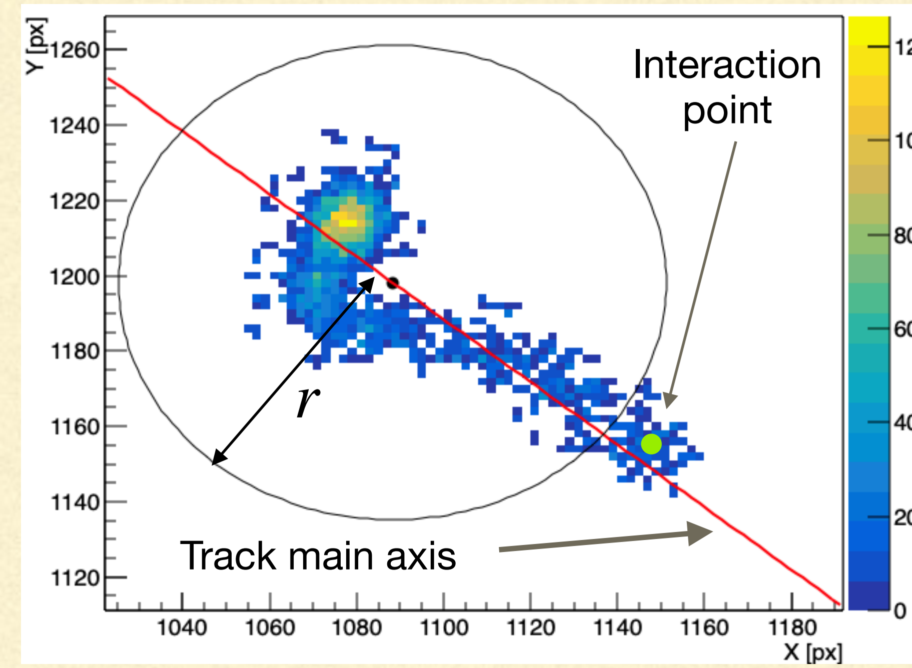




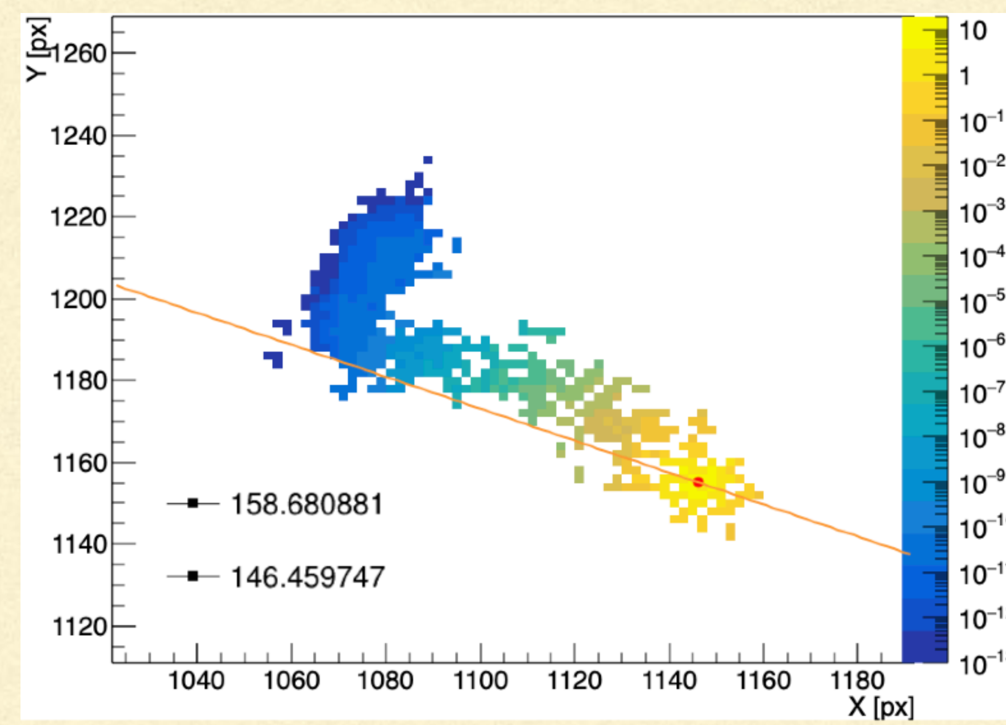
The directionality algorithm in a nutshell

- Algorithm adapted from X-ray polarimetry:

"Measurement of the position resolution of the Gas Pixel Detector"
Nuclear Instruments and Methods in Physics Research Section A, Volume 700, 1 February 2013, Pages 99-105



- First part of the algorithm: searching for the beginning of the track with:
  - Skewness
  - Distance of pixels from barycenter (farthest pixels)
  - Selection of a region with fixed number of points N_{pt}

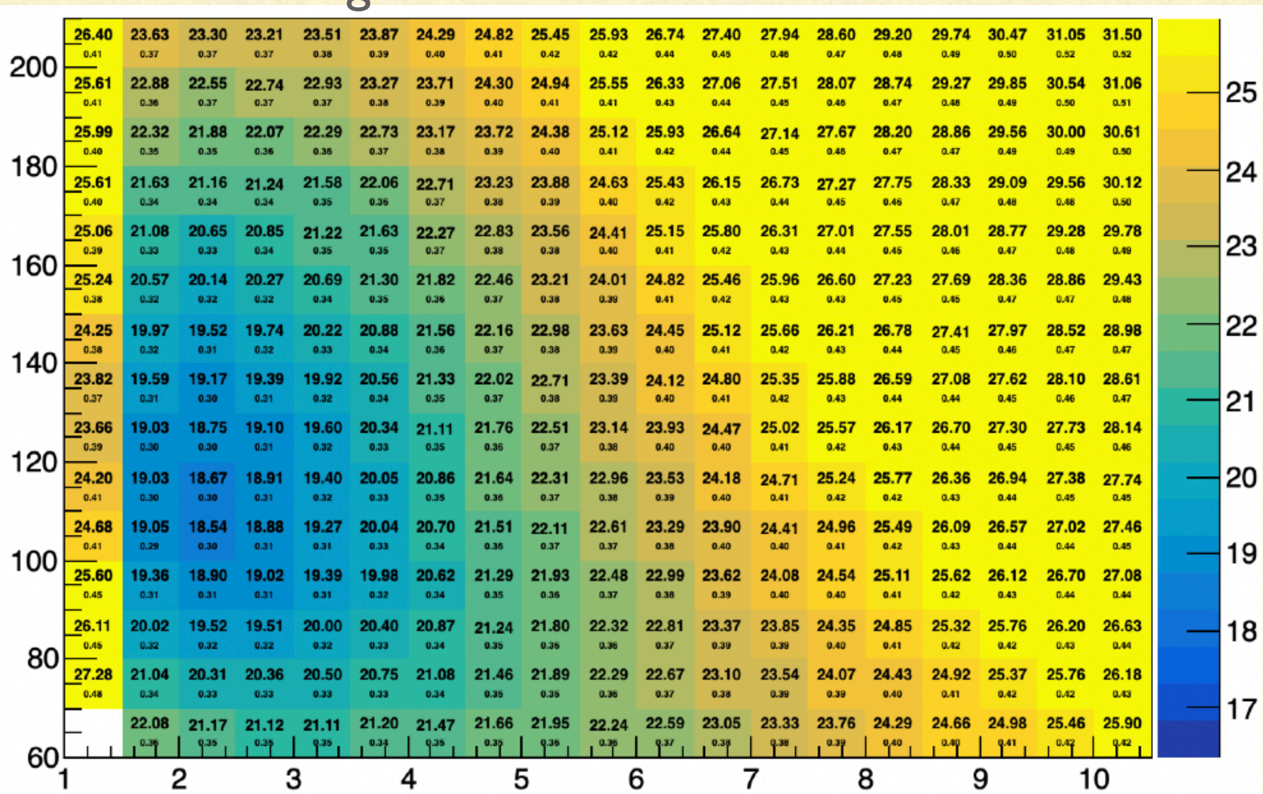


- Second part of the algorithm aims to find the direction:
  - Track point intensity rescaled with the distance from the interaction point: $W(d_{ip}) = exp(-d_{ip}/w)$
  - Direction taken as the main axis of the rescaled track passing from the interaction Point
  - Orientation given following the light in the Pixels

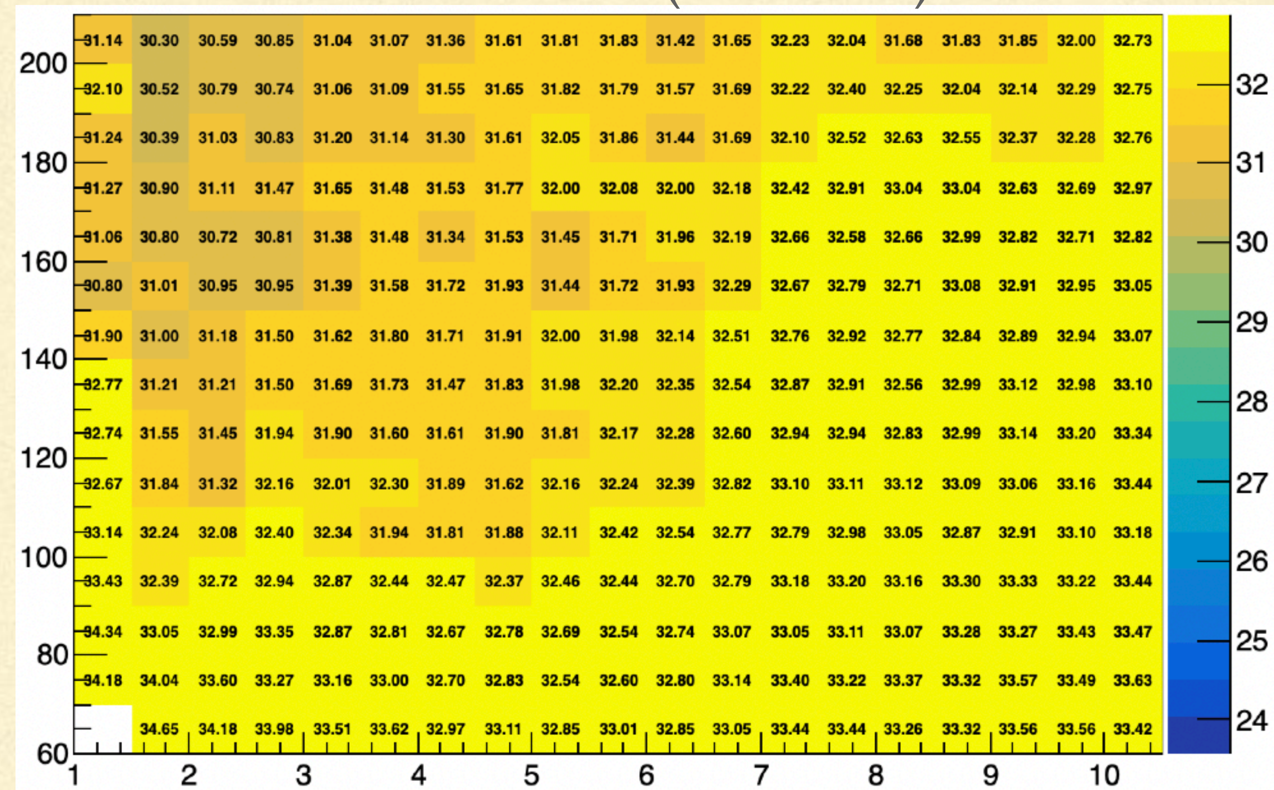
- Two parameters of the algorithm: N_{pt} and w

Parameters optimization

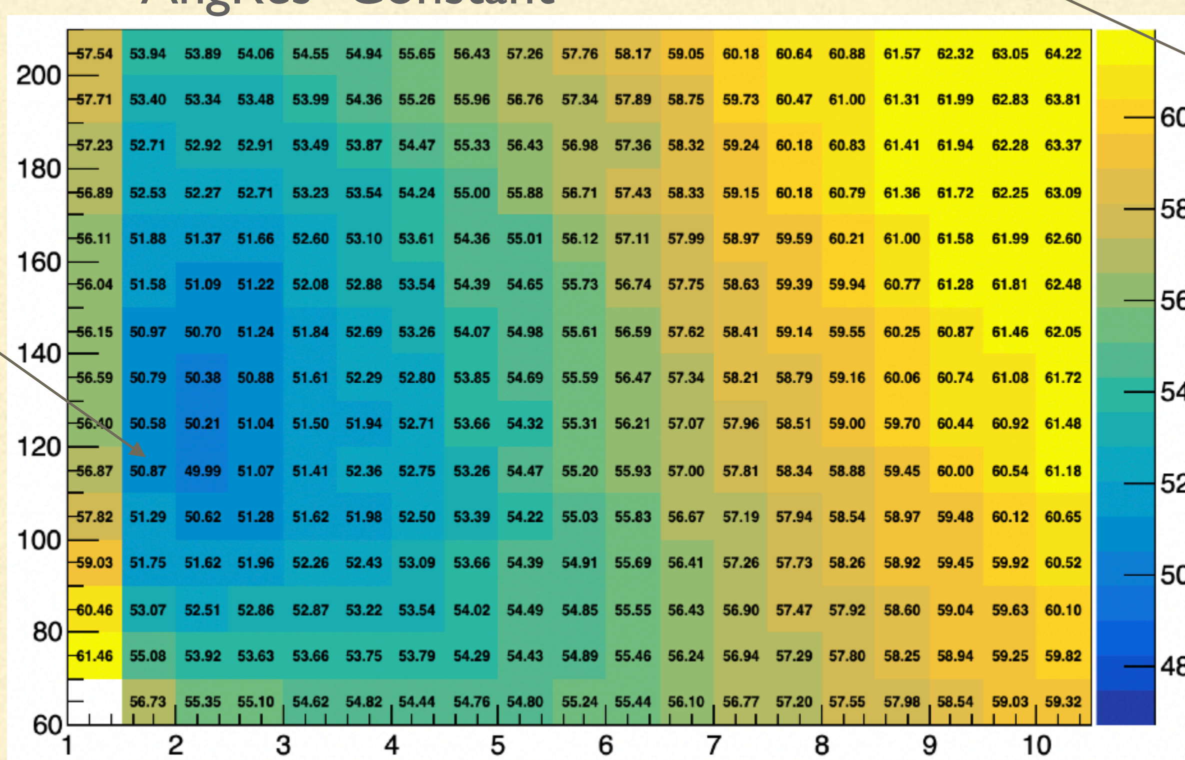
AngRes Vs NPIP and w



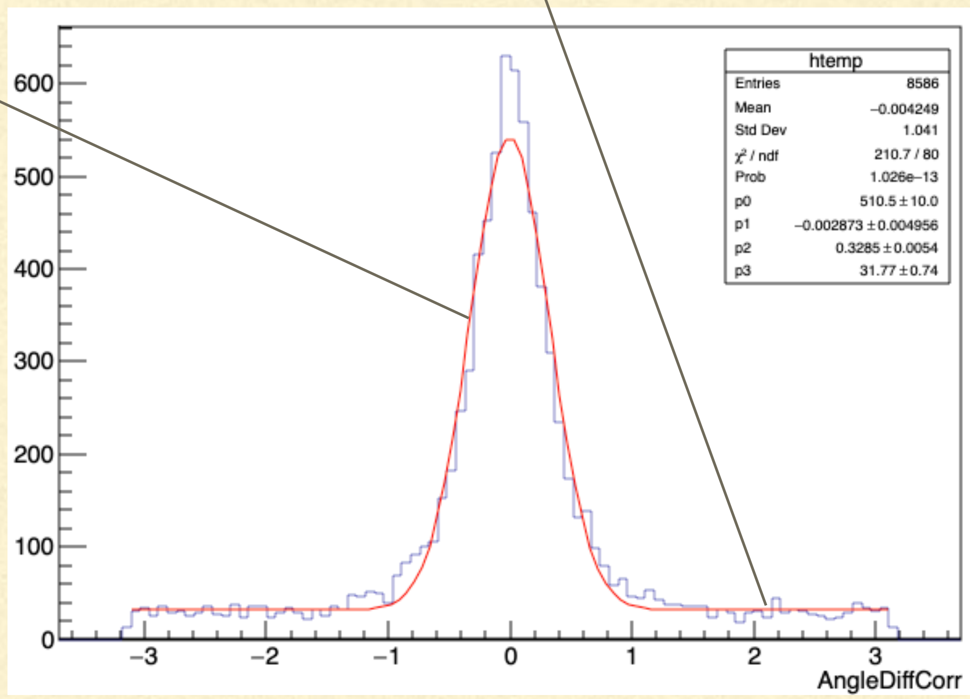
Constant term (lack of 3D)



AngRes+Constant



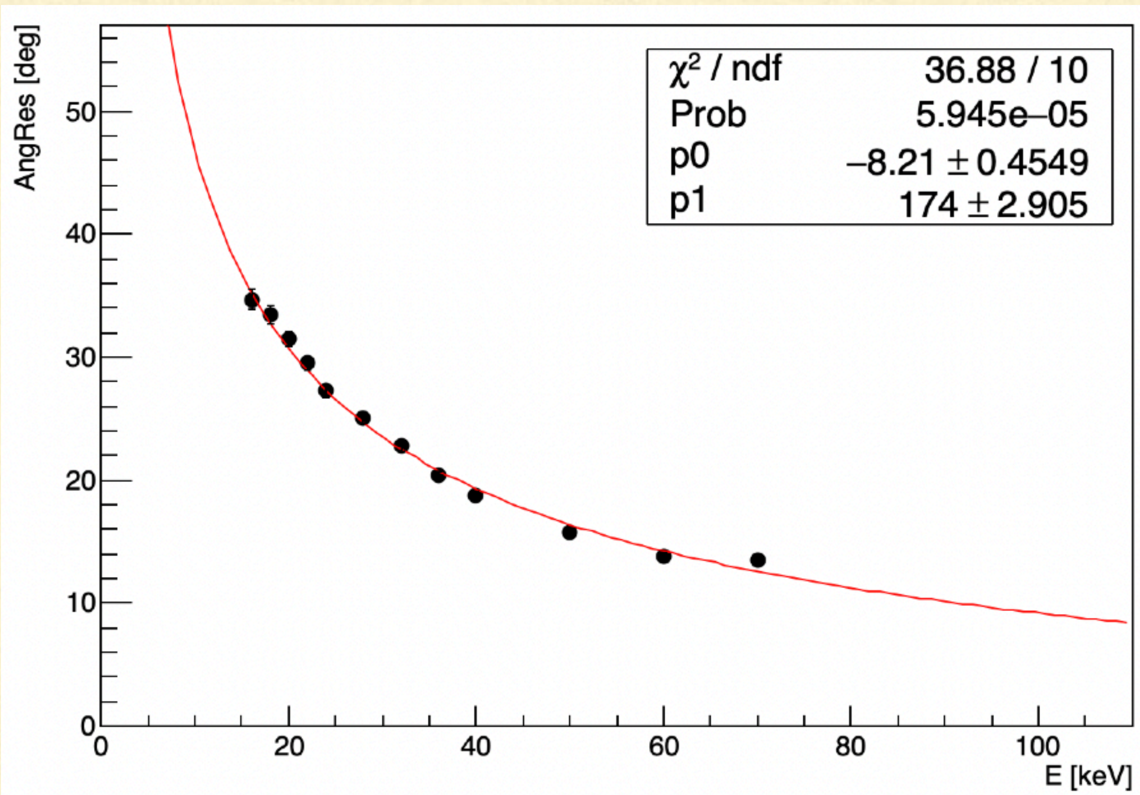
Best compromise always in this region

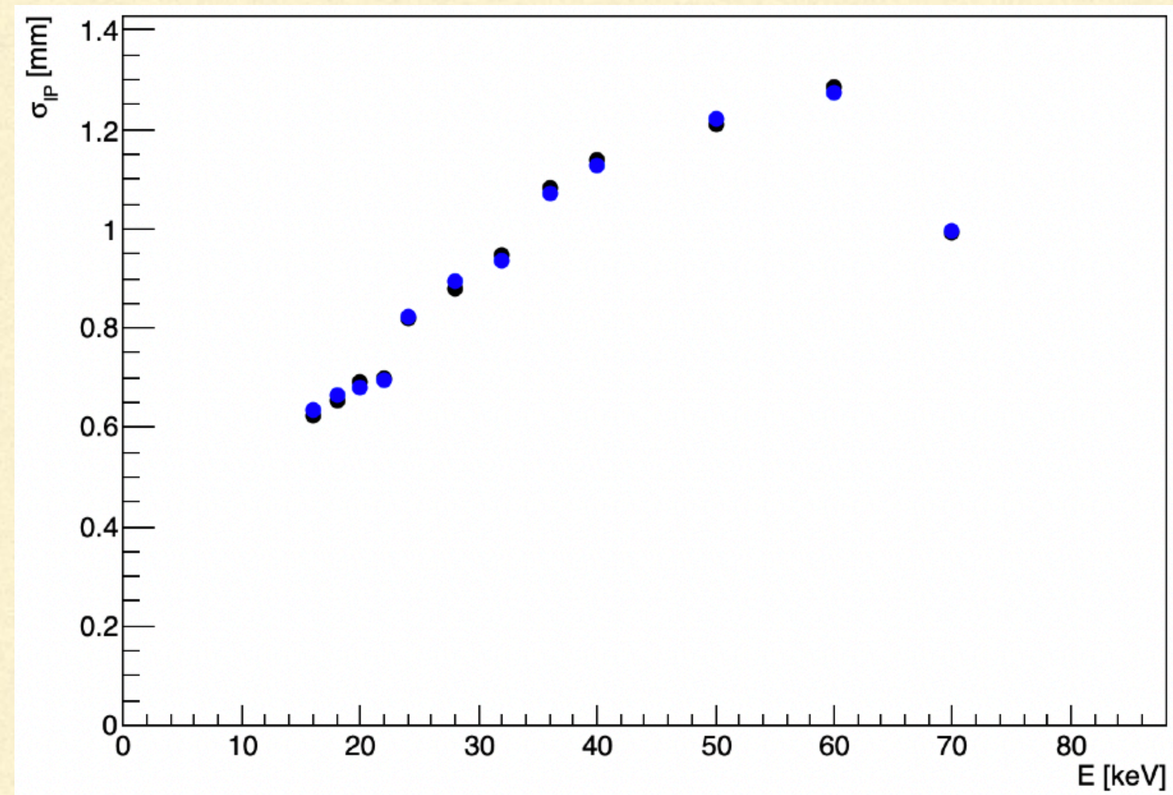


Results on angular resolution and IP resolution

After the optimization of the parameters:

N_{pt}	100	100	100	100	110	110	110	120	120	120	120	90
w	1.5	1.5	1.5	1.5	1.5	1.5	2	2	2	2.5	2.5	2



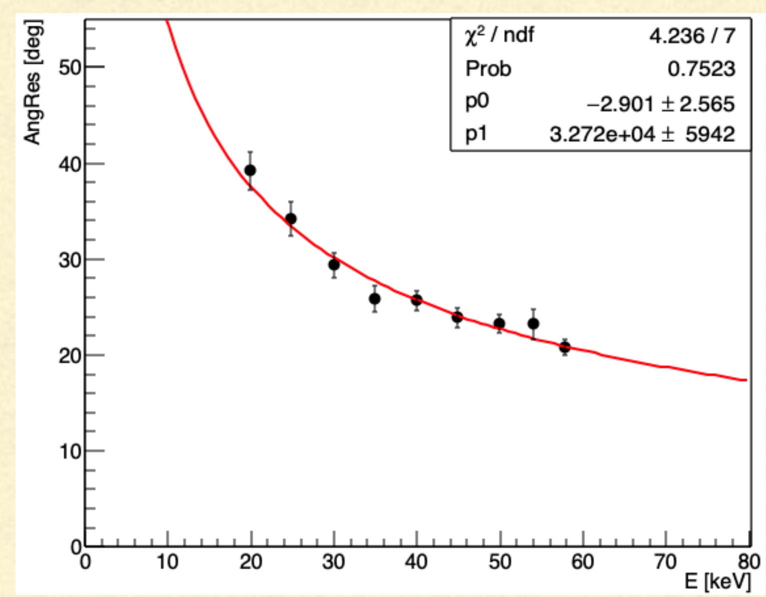


Parameters varying in a more smooth way

Much better Ang Res than previous case with
37° @ 20 keV and 26° @ 40 keV

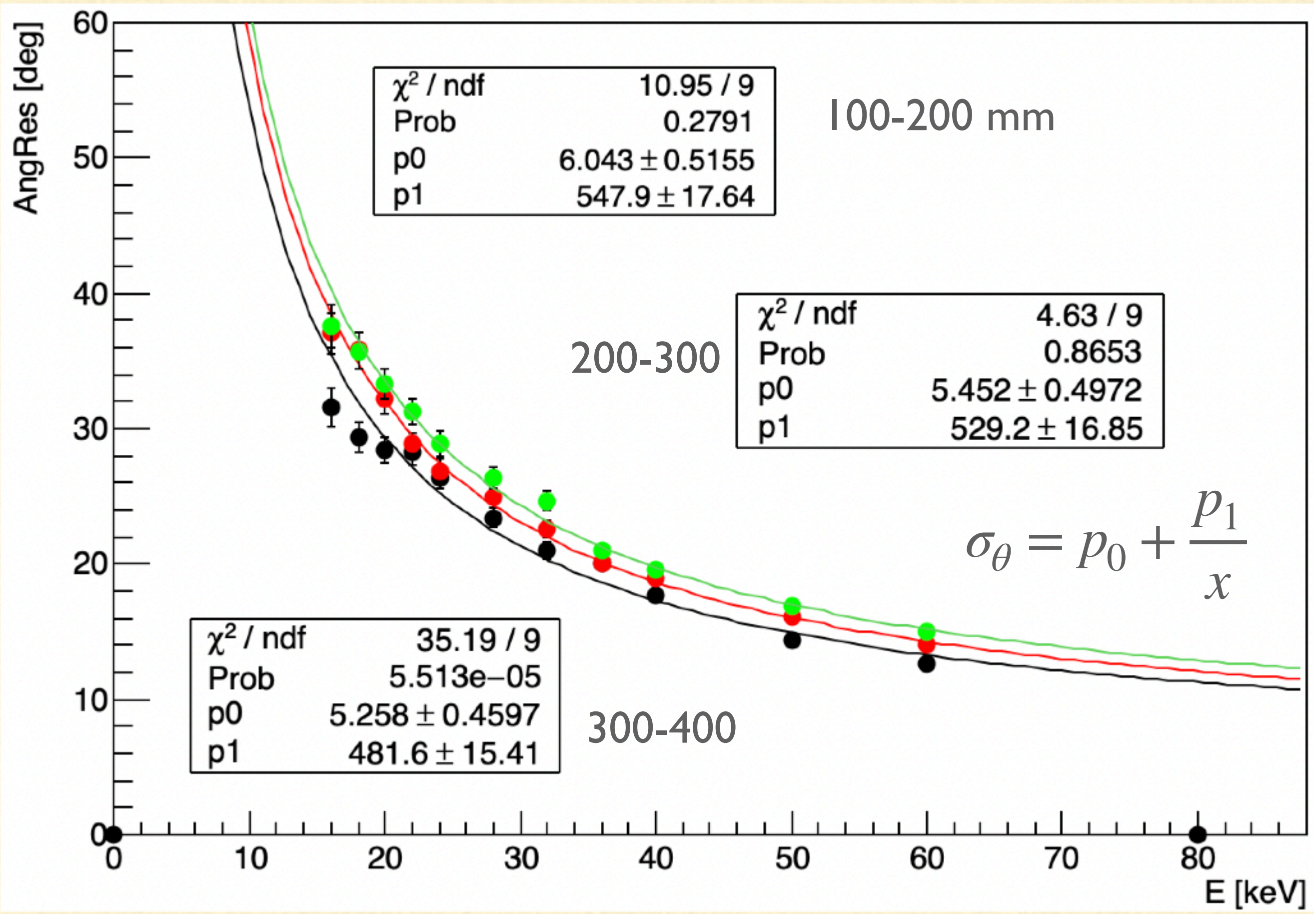
Much better IP Res than previous case with
1 mm @ 20 keV and 1.5 mm @ 40 keV

Algorithm didn't change, only light that means better signal to noise ratio and easier reconstruction

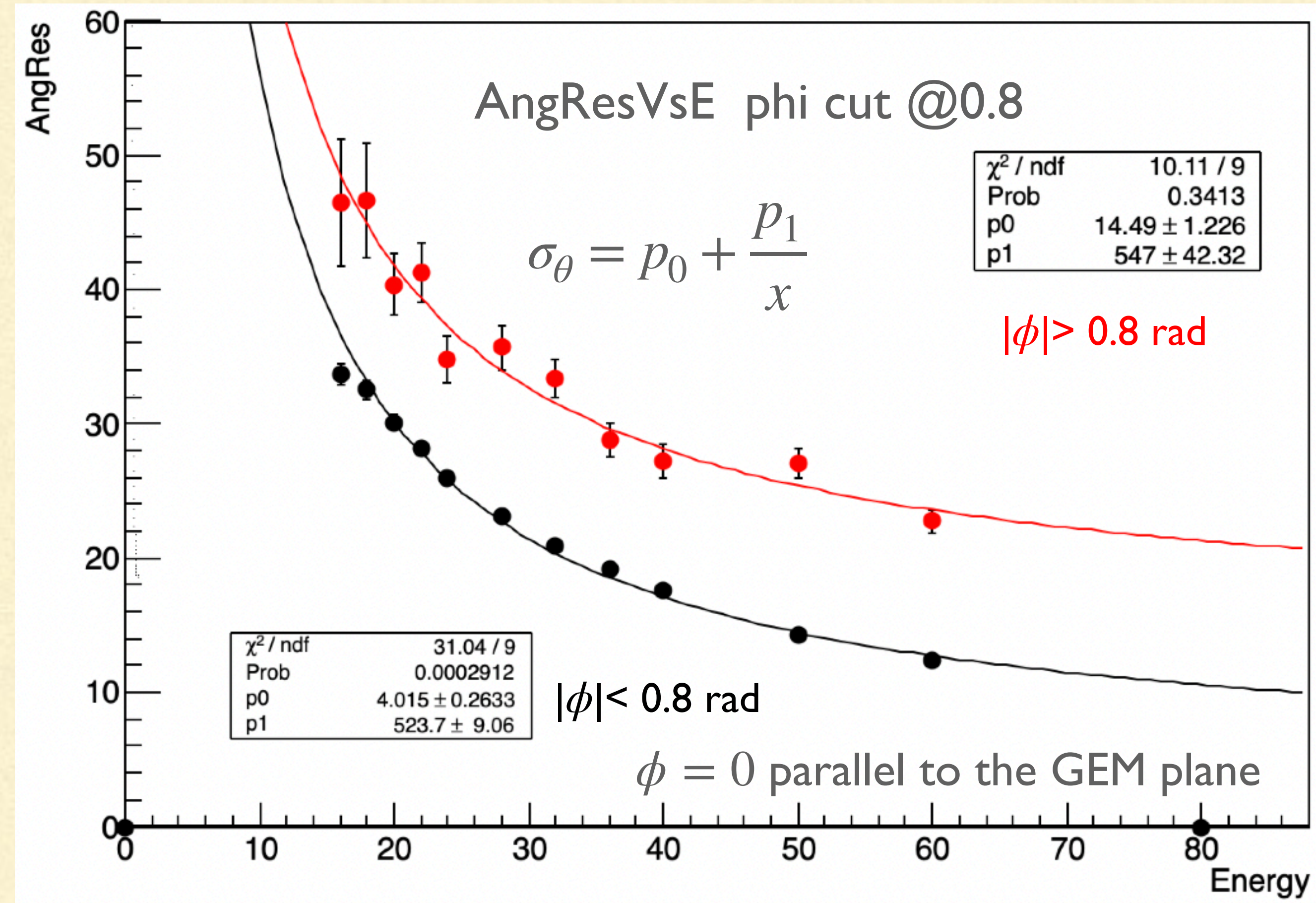


Other considerations

Effect of the diffusion on ang res



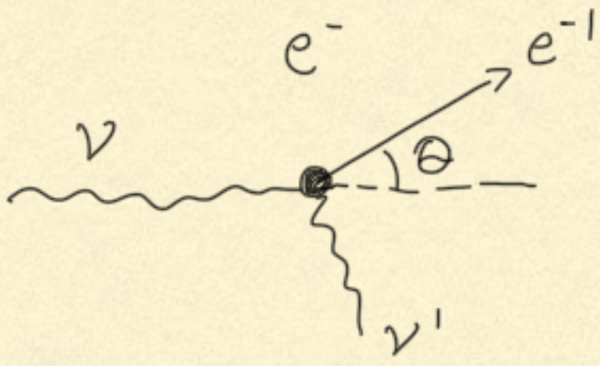
Effect of the lack of 3D on ang res



- Diffusion weights less on higher energies
- Angular resolution converges at higher energies for different distances

- Worsening with tracks parallel to the GEM plane
- Difference constant even at higher energies
- 100 and 150 keV needed to constrain p_0

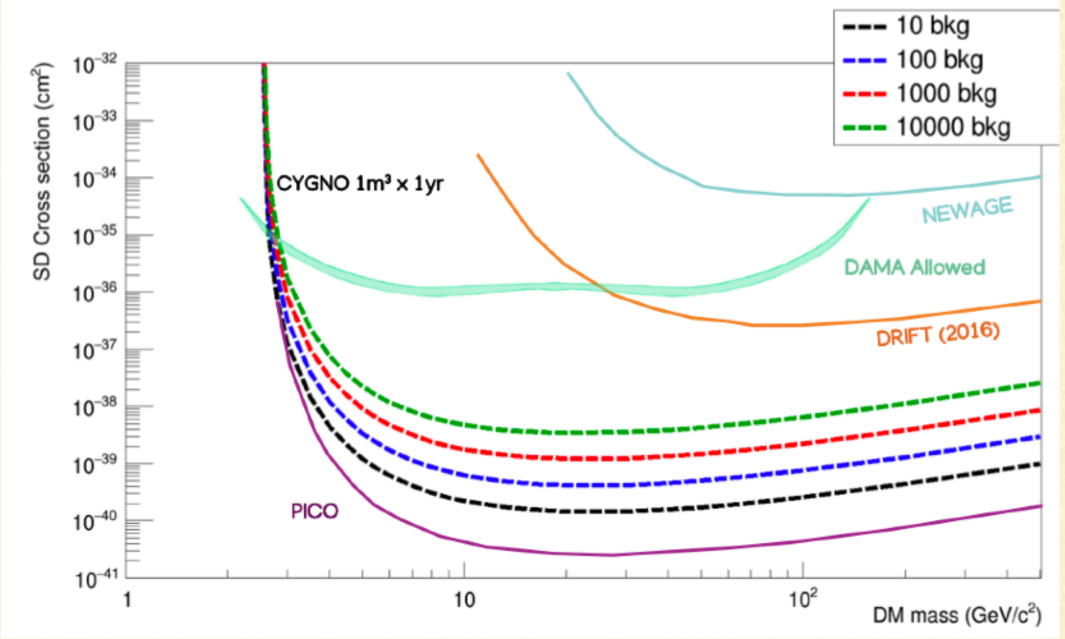
pp Solar neutrino physics case



Given an hypothesis of background, how much exposure we need to measure neutrino from the pp cycle?

Already Giorgio and Stefano developed and tested the framework for DM sensitivity with the bayesian approach

$$\mathcal{L}_{b+s} = (\mu_s+\mu_b)^{N_{evt}} e^{-(\mu_b+\mu_s)} \times \prod_{i=1}^{N_{bins}} \left[\left(\frac{\mu_s}{\mu_s+\mu_b} \left(\sum_{j=He}^{El} \left(\sum_{k=i}^{N_{adjacent}} P_{s,j,k} P_{k,i} \right) P_j \right) + \frac{\mu_b}{\mu_s+\mu_b} P_{b,i} \right)^{n_i} \frac{1}{n_i!} \right]$$



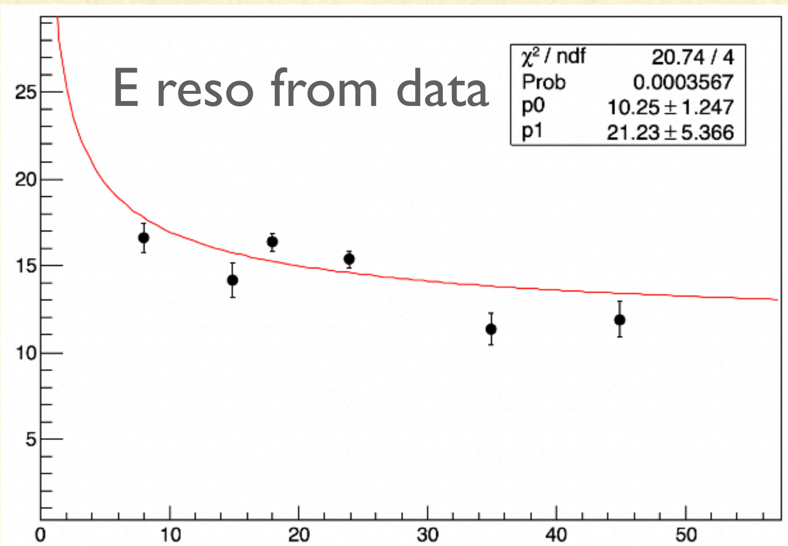
By apporting some changes to the model and to likelihood function:

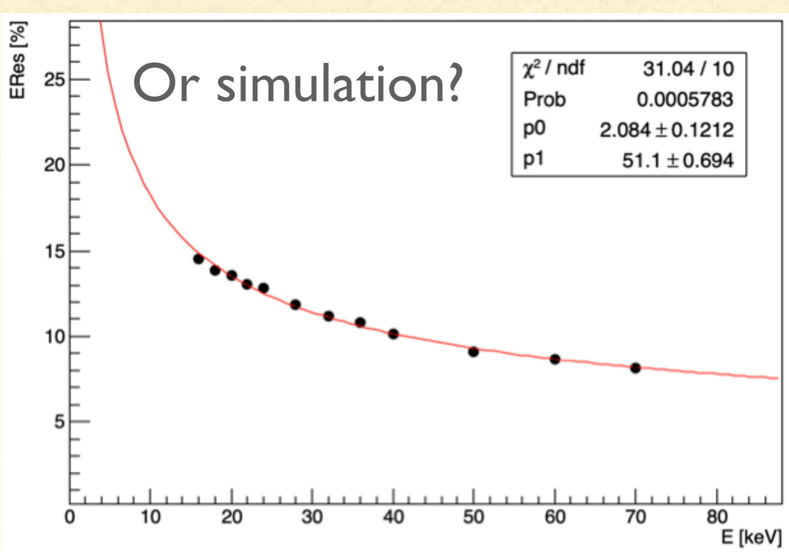
- Not considering different element of the gas for the interaction
- Considering different angular resolution for different energies

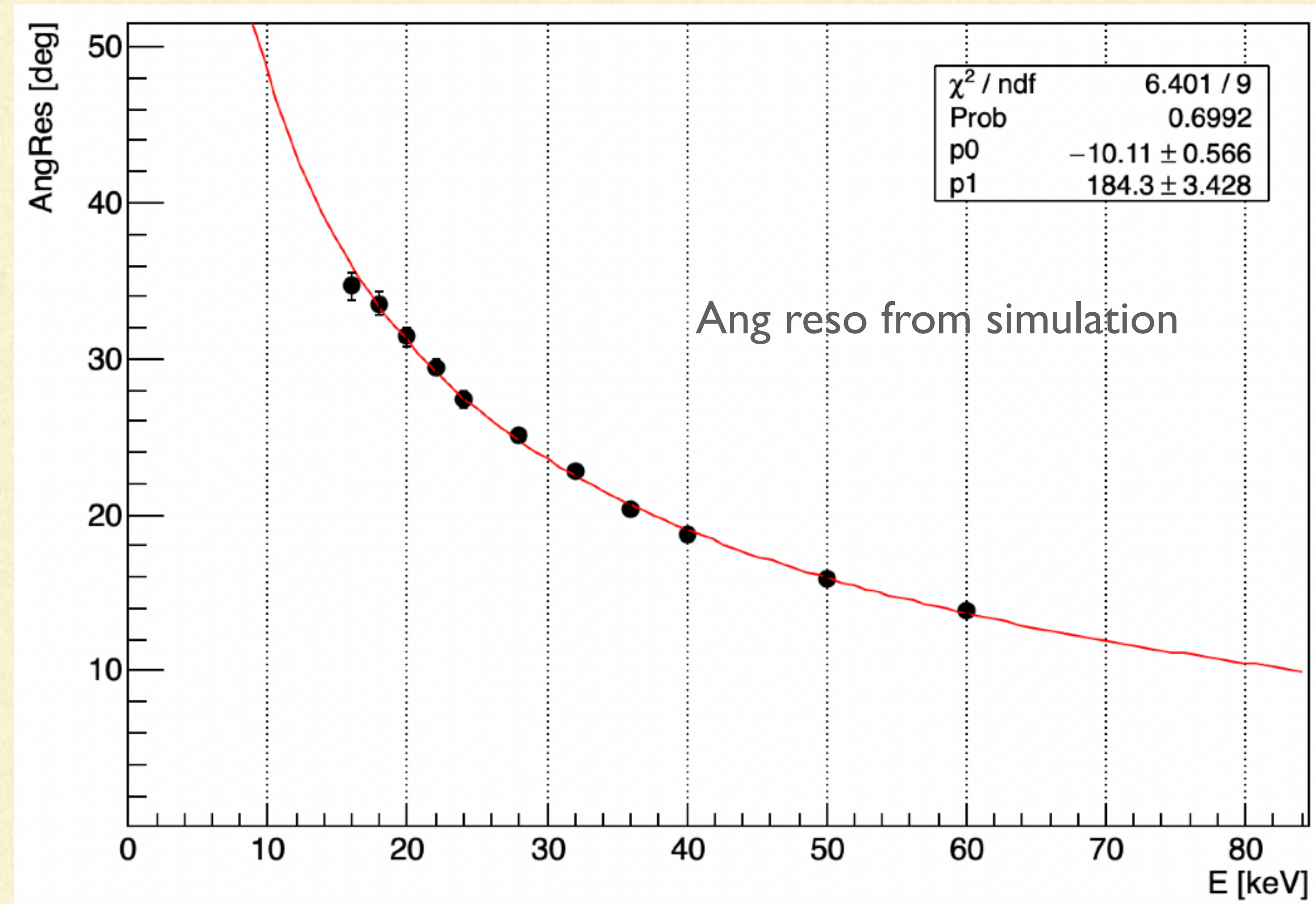
The same framework can be applied to neutrino

Resolutions for pp solar neutrino physics case

The idea is to make and estimation with the bayesian approach using the current resolutions





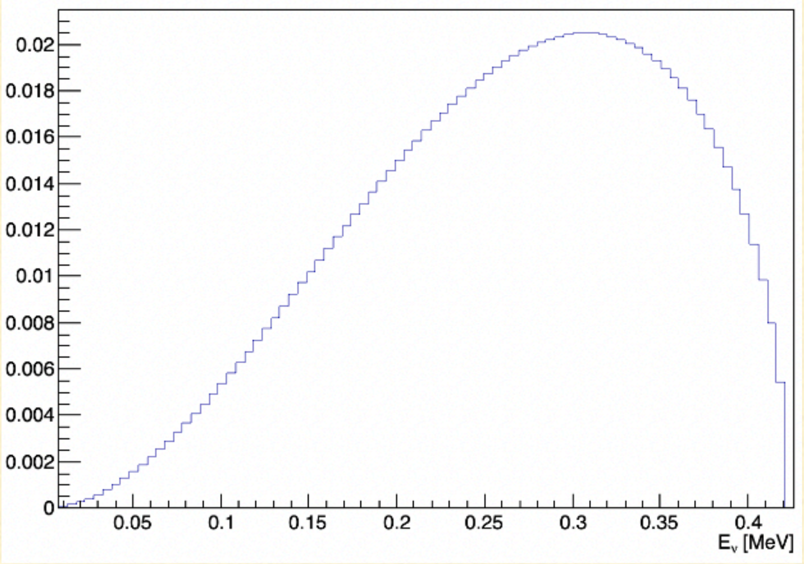


E reso from data is the most sure thing but from simulation is more consistent

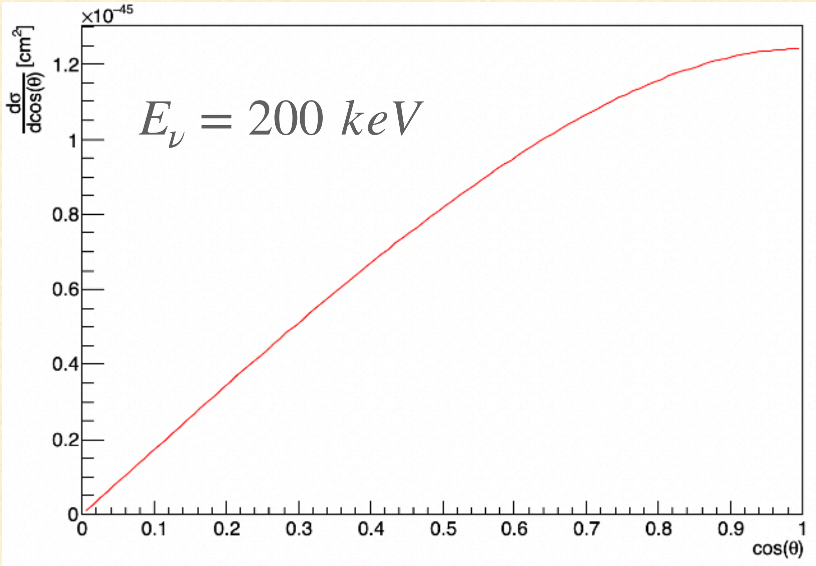
Threshold at 10 keV for the moment (since we have less than 1 rad of AngRes) but can be optimized

Template production

1. Extraction of a random neutrino energy according to the flux

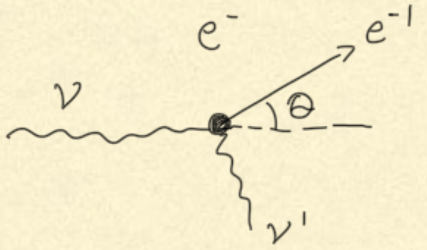


2. Extraction of a random $\cos\theta$ value according to the differential cross section for extracted neutrino energy



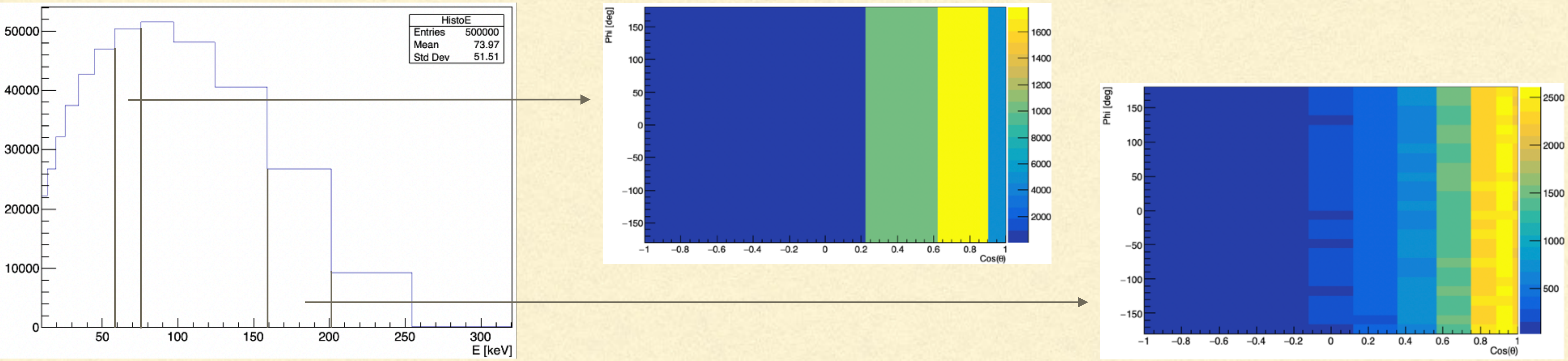
3. Calculation of the e^- kinetic energy given E_ν and $\cos(\theta)$

$$T_e'(\theta) = \frac{2E_\nu^2 m_e cos^2(\theta)}{(E_\nu + m_e)^2 - E_\nu^2 cos^2(\theta)}$$



4. Smearing of energy and angle according to the resolutions

5. Filling the histograms built according to the resolution



Conclusions and future

- After the optimization of the MC the simulated tracks show a good agreement with data
- The angular resolution as a function the algorithm parameters is more consistent than in the previous case
- The results on angular resolution and IP resolutions improved a lot as expected
- I'm starting to study the feasibility of the neutrino physics case
- I would need now the shape of a bkg spectra to generate the template distributions of the bkg. Any idea?
- Plan to produce the template and the data sample for signal and bkg and use the code of Stefano for the sensitivity limits
- Eventually improve the directionality algorithm
- Test the directionality algorithm with MANGO using a source of polarized gammas