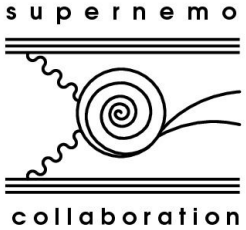
g_A sensitivity

Xalbat



Objectives

Measure the sensitivity of SuperNEMO to ξ_{31} in function of running time

Simulation for this study:

- G0 and G2 simulation with the correct source foil vertex
- Bkg, G0 and G2 simulation with the wrong source foil vertex

Same cut as Mathis

What's ξ_{31} and how to measure it

2v decay depends on phase space factor G:
-> G could be separated in different factors: $\mathbf{G_o}$, $\mathbf{G_2}$, G_{22}, G_4
-> Different kinematics for each (energy and angle)

$$\frac{NG_2}{NG_0} = \xi_{31}$$

With NG_2 and NG_0 the number of 2v events associated to each G_o, G_2 kinematics

Number of events for 1 year

2v activity on SuperNEMO: 0.011Bq (from Cupid-0 2v half-life)

➔ 346896 events/y

➔ $NG_2 + NG_0 = 346896$ events

Number of events for 1 year

2v activity on SuperNEMO: 0.011Bq (from Cupid-0 2v half-life)

➔ 346896 events/y

➔ $NG_2 + NG_0 = 346896$ events

$$\frac{NG_2}{NG_0} = \xi_{31} = 0.4$$

➔ $NG_0 = 247782$ events/y

➔ $NG_2 = 99113$ events/y

Expected number of reconstructed events for 1 year (ξ_{31} = 0.4)

Using the full dataset (200M):

- ➔ ε_{G0} = 8.8%
  - ➔ 21804 reconstructed events
- ➔ ε_{G2} = 6.1%
  - ➔6045 reconstructed events

Expected number of reconstructed events for 1 year (ξ_{31} = 0.4)

Using the full dataset (200M):

- ➔ ε_{G0} = 8.8%
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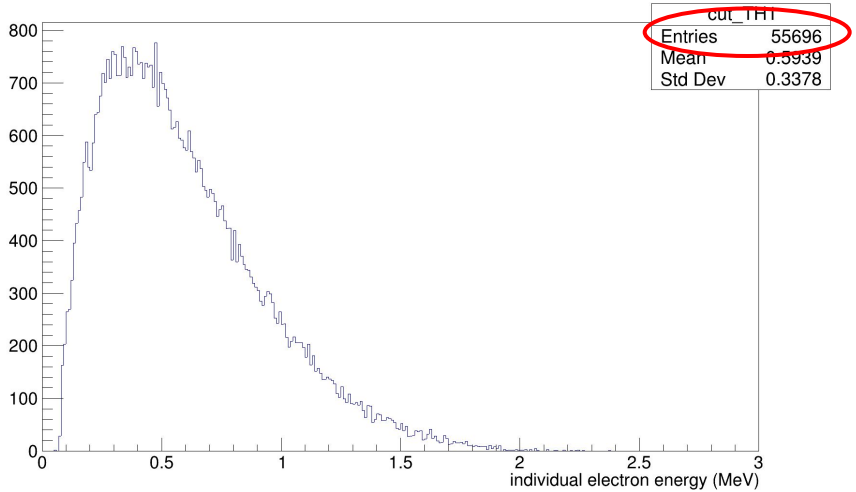

Background addition

Used simulation for the bkg:

- 40K source foil and PMT
- Tl208 source foil and PMT

(8” PMT missing due to time)

- Bi 214 source foil and PMT
- Rn foil surface and wire
- 234Pa source foil

Bad source foil vertices

Background addition

Used simulation for the bkg:

- 40K source foil and PMT
- Tl208 source foil and PM

(8” PMT missing due to time)

- Bi 214 source foil and PMT
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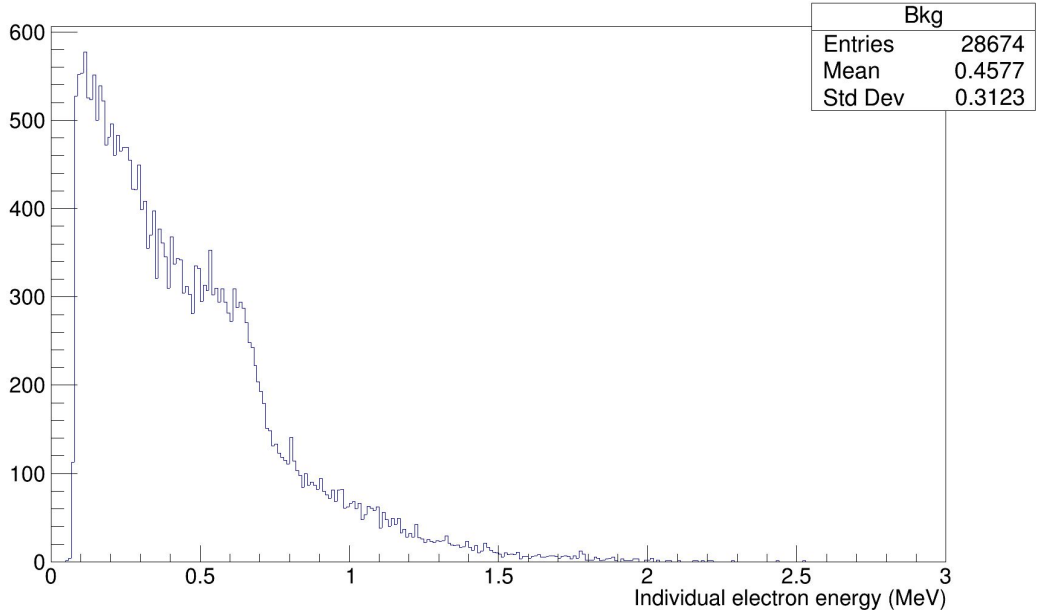
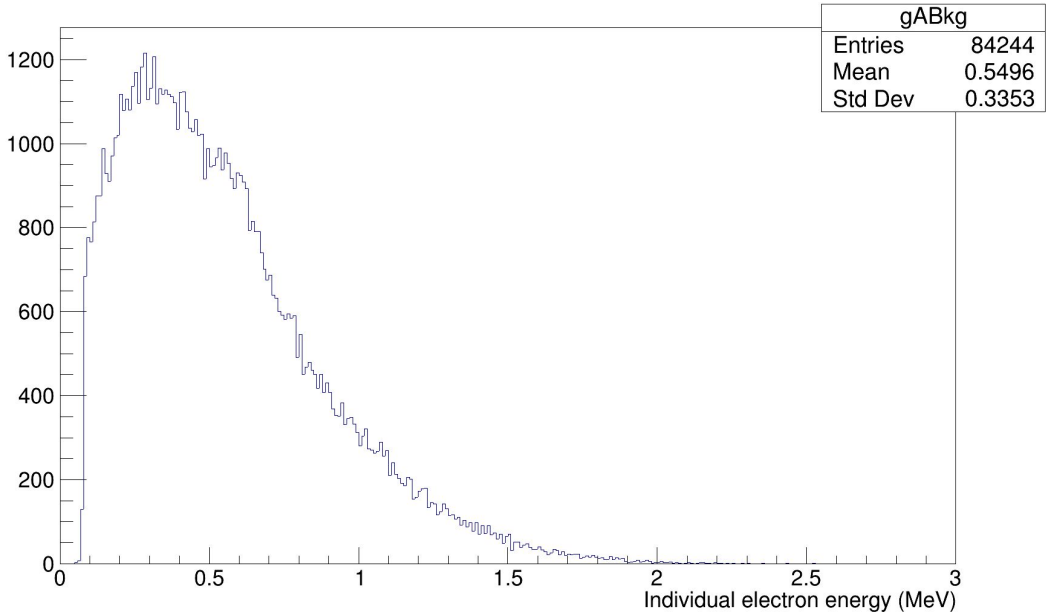
Bad source foil vertices



Mathis see 35 bkg events days in the data -> 12775 events/y
This plot show ~14300 events/y
Can do low and high Rn easily

Full spectra (ξ_{31} = 0.4)

Full spectra for 1y: G0 + G2 + Bkg events



Fitting

100 different samples created for 1,2 and 3 years and 11 values of ξ_{31} (0, 0.1, …, 1)
Total = 3300 samples (only 300 different one for the bkg)

Samples created by randomly choosing a number of events corresponding to Nyears of activity on the whole simulation

Issue for some simulations

For my analysis, I need 300y equivalent of bkg to create 100X3 year pseudo-data
How can I manage the lack of simulation for some bkg?

Bkg	Vertex	simulated events	Time equivalent (y)
^{208}Tl	source foil bulk	1X10^{7}	25 000
^{234m}Pa	source foil bulk	2X10^{8}	40
^{214}Tl_^{214}Po	source foil surface	1X10^{8}	~600
^{40}K	8” PMT	2X10^{10}	~1.5

Not enough simulation for some bkg
Not **realistic to produce enough simulation** for some of them: PMT could need 4X10^{12}
Could maybe be optimized, but not trivial and long process

Fitting

100 different samples created for 1,2 and 3 years and 11 values of ξ_{31} (0, 0.1, …, 1)
Total = 3300 samples

Samples created by randomly choosing a number of events corresponding to Nyears of activity on the whole simulation

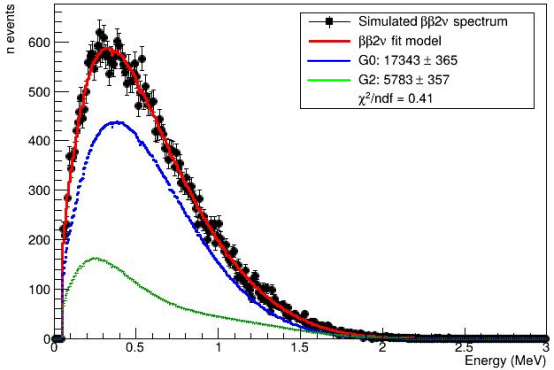
Fitting of these samples with 3 Probability Density Function (PDF):

- G0
- G2
- Bkg

Fitting without background

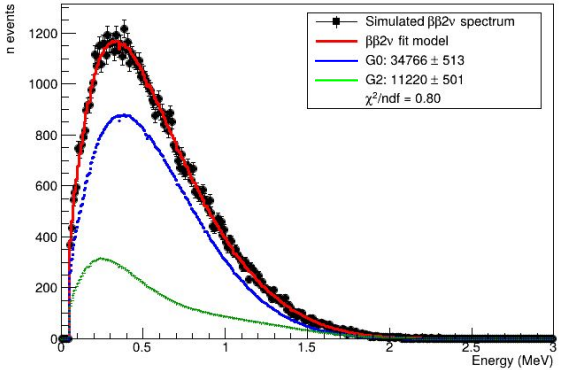
Fit done with Roofit, only 2 parameters NG_2 and NG_0
Effect of running time for $\xi_{31} = 0.5$

1 year



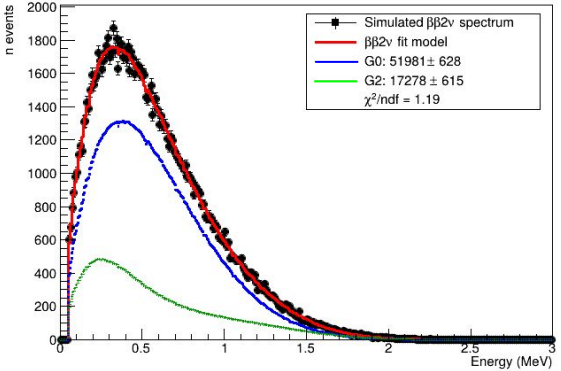
$\xi_{31} = 0.532 \pm 0.032$

2 year



$\xi_{31} = 0.500 \pm 0.023$

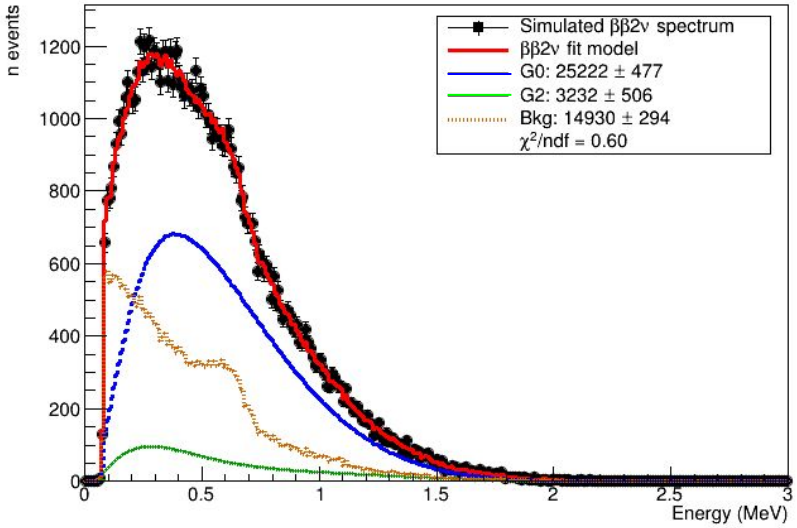
3 year



$\xi_{31} = 0.501 \pm 0.018$

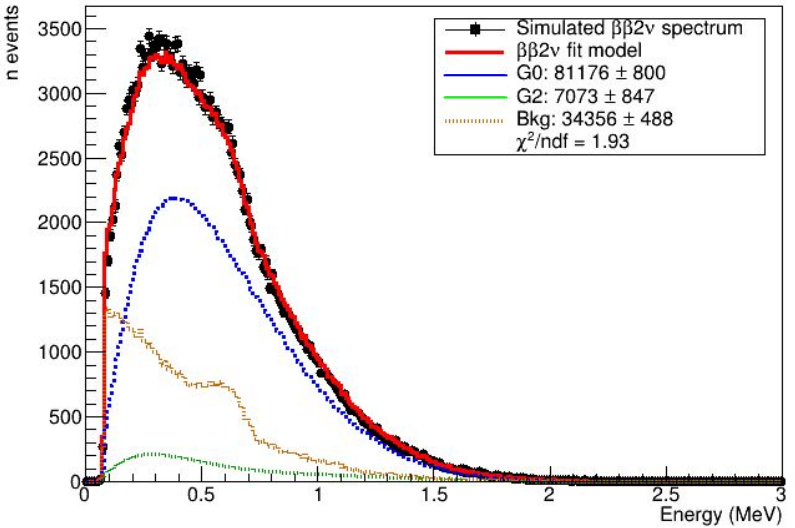
Issue with the decrease of the fit quality with background and longer run time

Input ξ_{31} = 0.2 for 1y



ξ_{31} = 0.19 +- 0.03

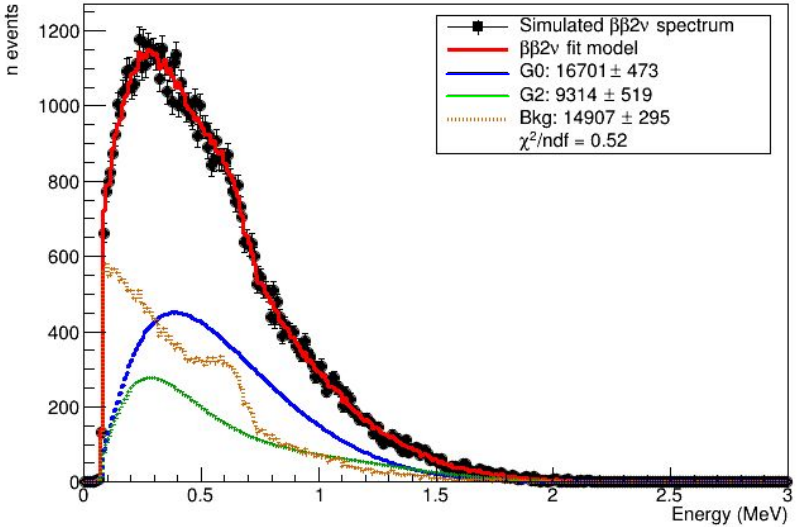
Input ξ_{31} = 0.2 for 3y



ξ_{31} = 0.13 +- 0.01

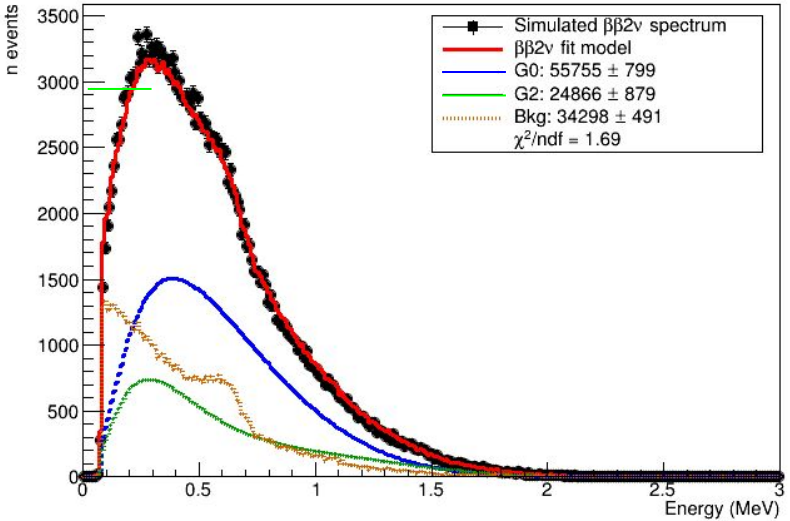
Issue with the decrease of the fit quality with background and longer run time

Input ξ_{31} = 0.8 , 1y



ξ_{31} = 0.81 +- 0.05

Input ξ_{31} = 0.8 , 3y

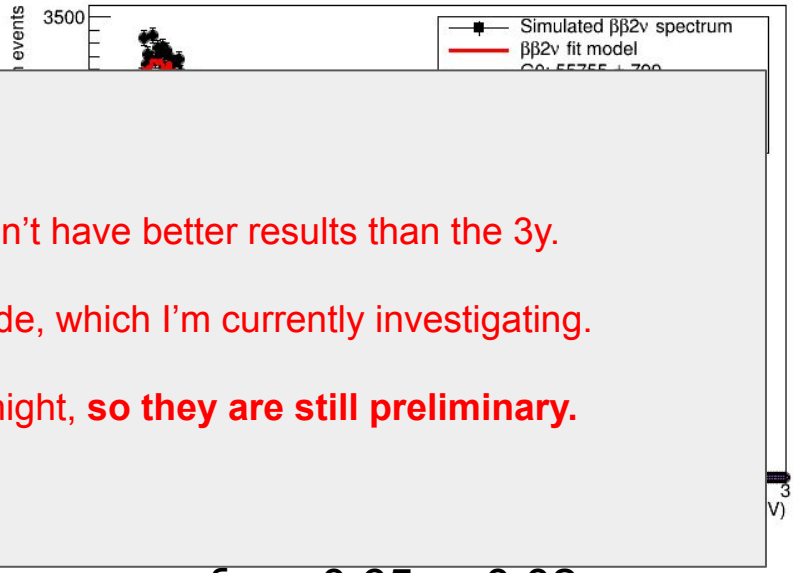


ξ_{31} = 0.65 +- 0.02

Issue with the decrease of the fit quality with background and longer run time

Input ξ_{31} = 0.8 , 1y

Input ξ_{31} = 0.8 , 3y



No reason for this error, the 1y shouldn't have better results than the 3y.

Certainly an issue somewhere in my code, which I'm currently investigating.

These results were obtained only last night, **so they are still preliminary.**

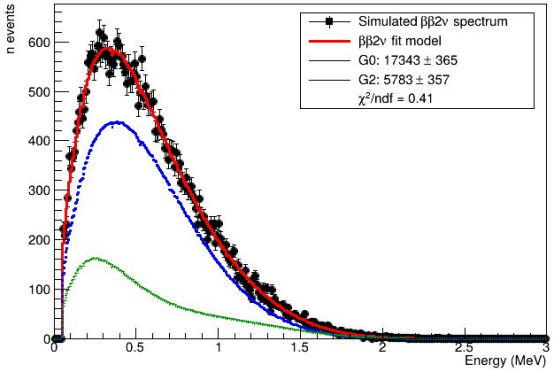
ξ_{31} = 0.81 +- 0.05

ξ_{31} = 0.65 +- 0.02

Fitting without background for the rest of the presentation

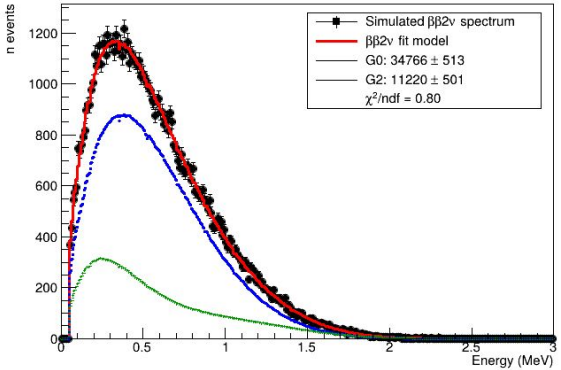
Fit done with Roofit, only 2 parameters NG_2 and NG_0
Effect of running time for $\xi_{31} = 0.5$

1 year



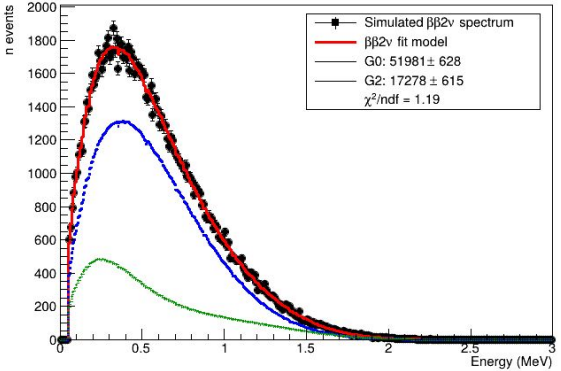
$\xi_{31} = 0.532 \pm 0.032$

2 year



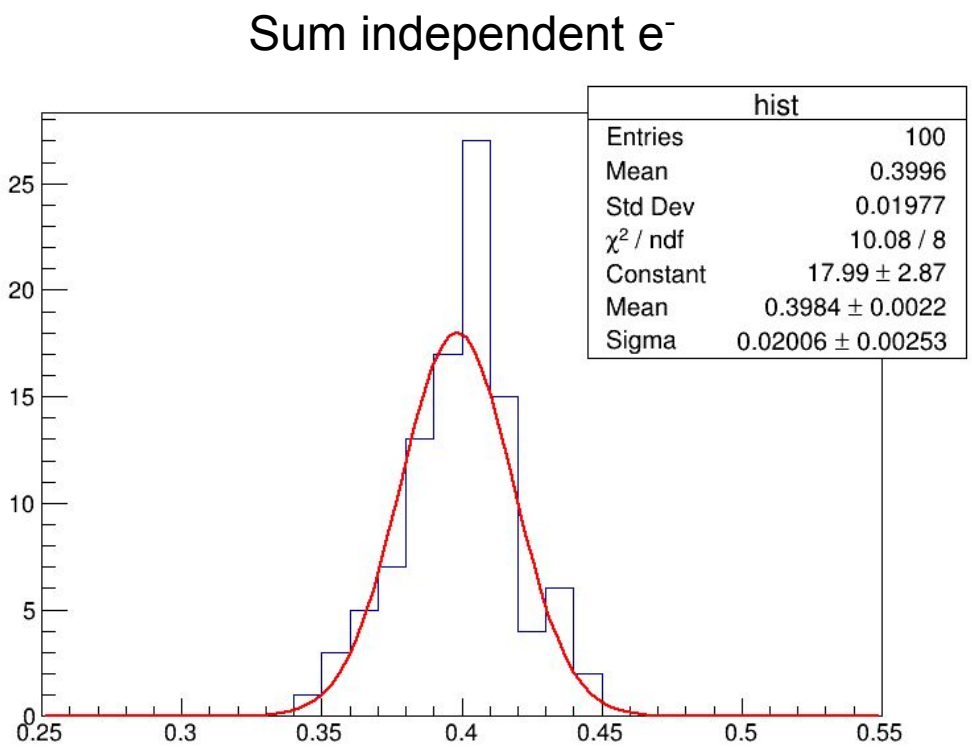
$\xi_{31} = 0.500 \pm 0.023$

3 year



$\xi_{31} = 0.501 \pm 0.018$

Distribution of the measured ξ_{31} (3 years, ξ_{31} = 0.4)

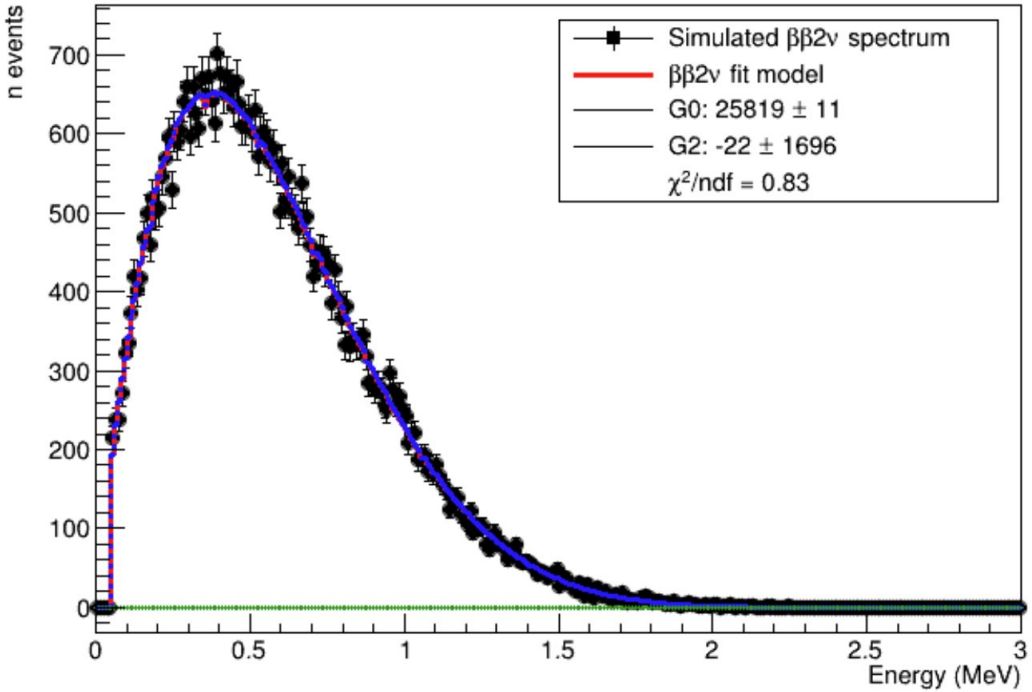


100 samples to have a Gaussian distribution

➔ Sensible Gaussian fit

Easier for the analysis than the previously used 30 samples

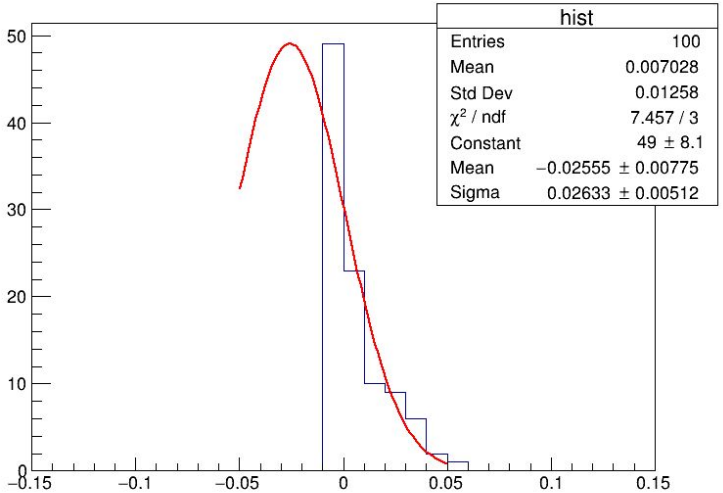
Edge case of $\xi_{31} = 0$



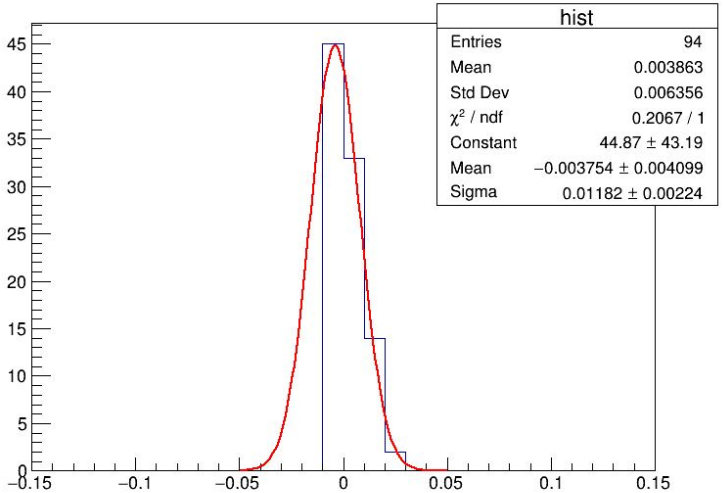
Possible to have negative contribution from G2

Edge case of $\xi_{31} = 0$

1 year



3 year



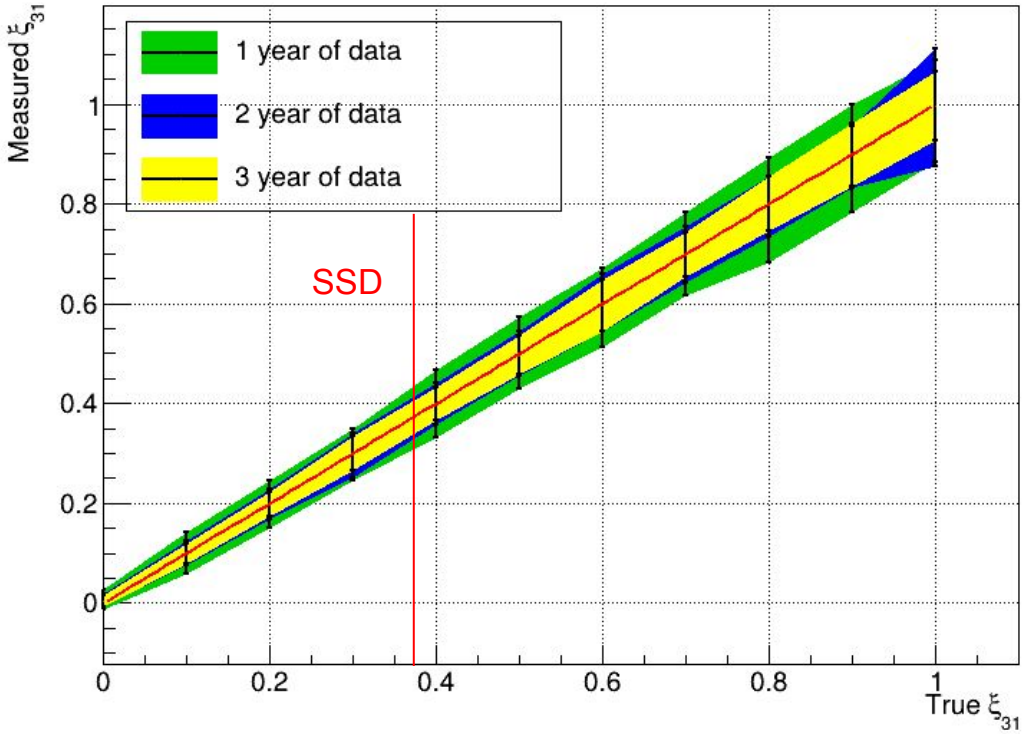
Distribution not really a Gaussian.
Fit not that good, so I took the mean and standard deviation

Distribution of the measured ξ_{31}

New sensitivity plot!

- ➔ Sensitivity band at 90% confidence level
- ➔ Big difference between 1–2 years, less for 2–3 years
- ➔ Widening uncertainties
- ➔ Need to add more points to have straighter sensitivity band

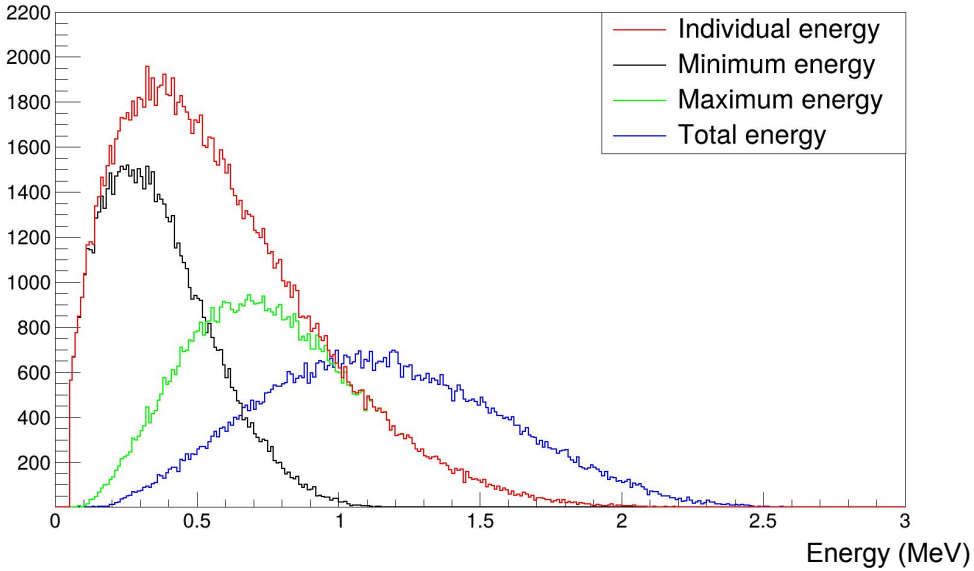
Red line is a x=y line



Different variables to study

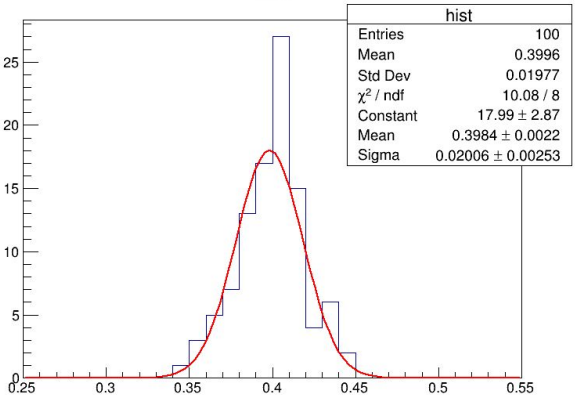
ξ_{31} sensibility is different in function of the studied variables:

- Total energy
- Sum of the individual energy
- Less energetic electron
- Most energetic electron

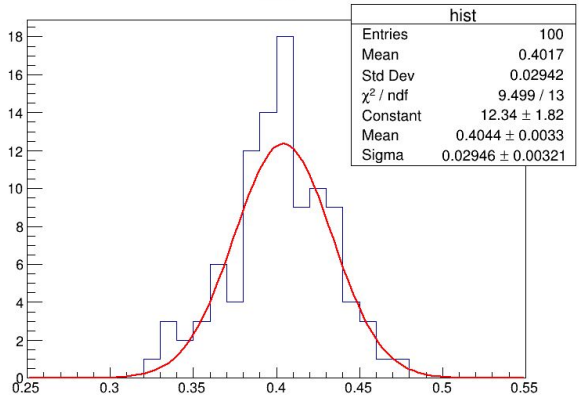


Difference with different variables (3 years, ξ_{31} = 0.4)

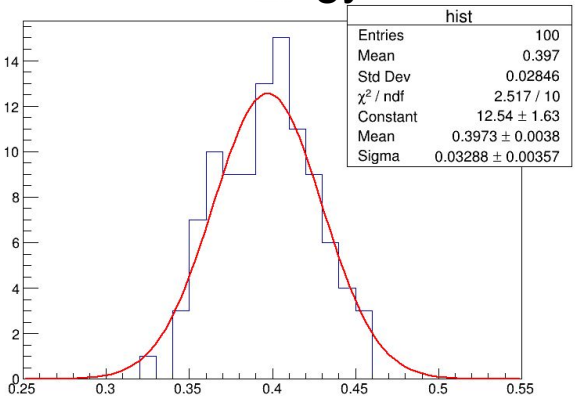
Sum independent e⁻



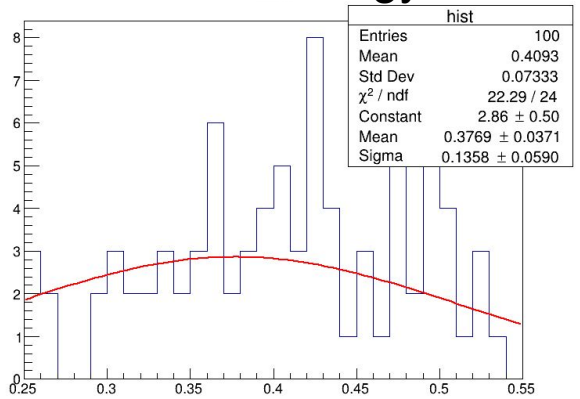
Max energy e⁻



Min energy e⁻

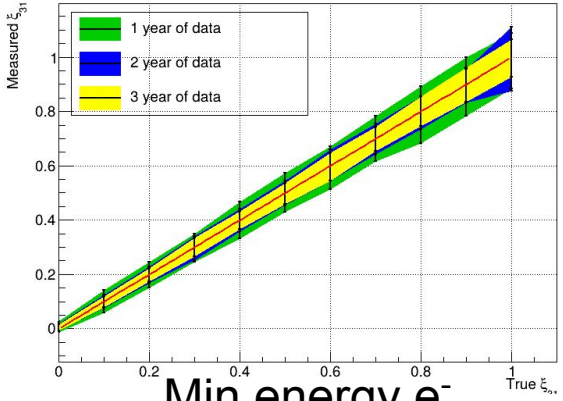


Total energy

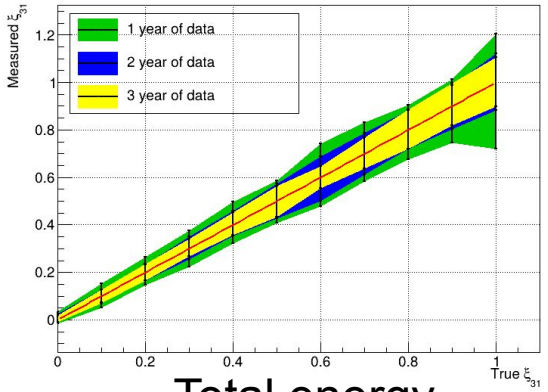


Difference with different variables

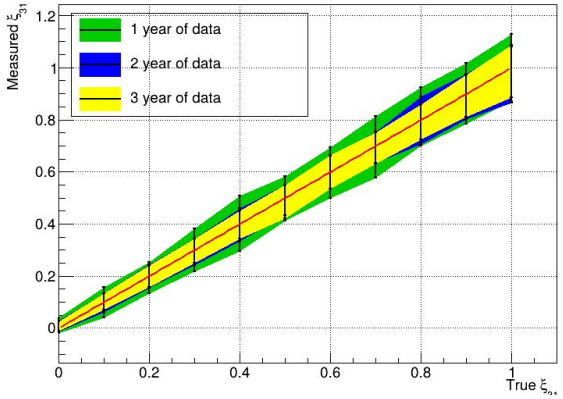
Sum independent e-



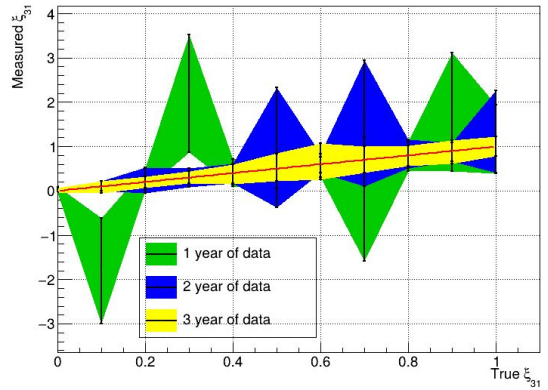
Max energy e-



Min energy e-

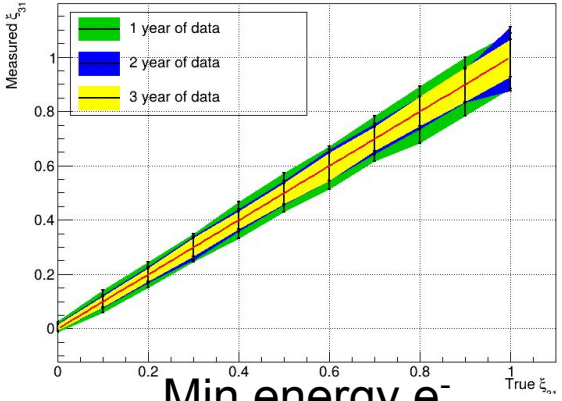


Total energy

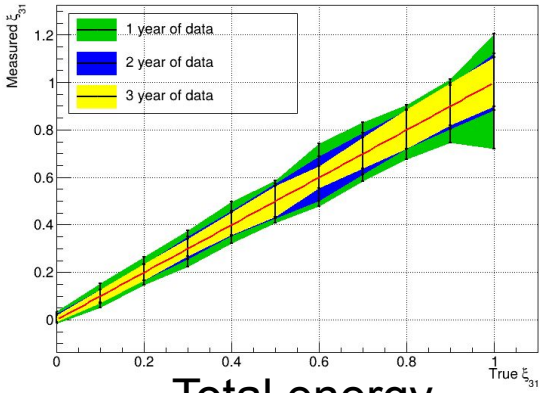


Difference with different variables

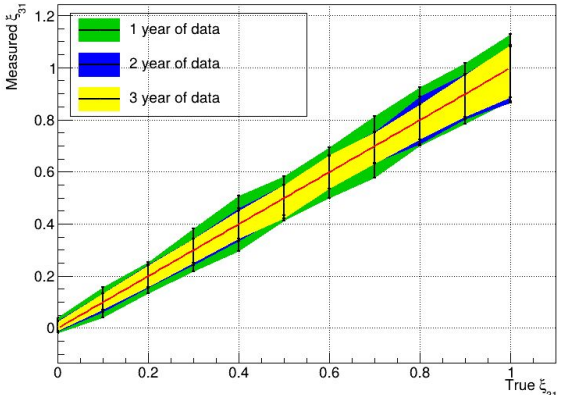
Sum independent e⁻



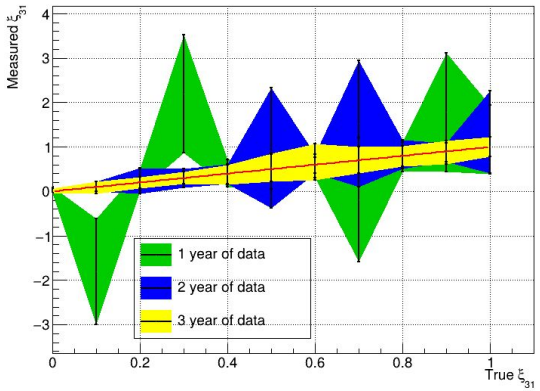
Max energy e⁻



Min energy e⁻



Total energy



The summed spectrum is the best, but a **combined fit** with max and min energy could be interesting

The total energy spectra need far more time to be linear than the other

➔ **Big advantage of SuperNEMO**

Conclusion

Longer data taking means better precision, especially between 1 and 2 years without bkg

Bkg addition add strange effect, and I suspect there's a bug in my code
The results shown for no bkg will be similar with background, but a sensitivity a little worsened (from 1y results)

Proof that individual energy is best, combined fit could be interesting

Conclusion

Next Steps:

- Understand the bkg issue
- Add a model to fit the error bar
- Do a combined fit
- Add more ksi31 values?
- Go to negative value?