Geant4 simulations of a Proton Recoil Telescope for the measurement of the n_TOF neutron flux between 100 MeV and 1 GeV

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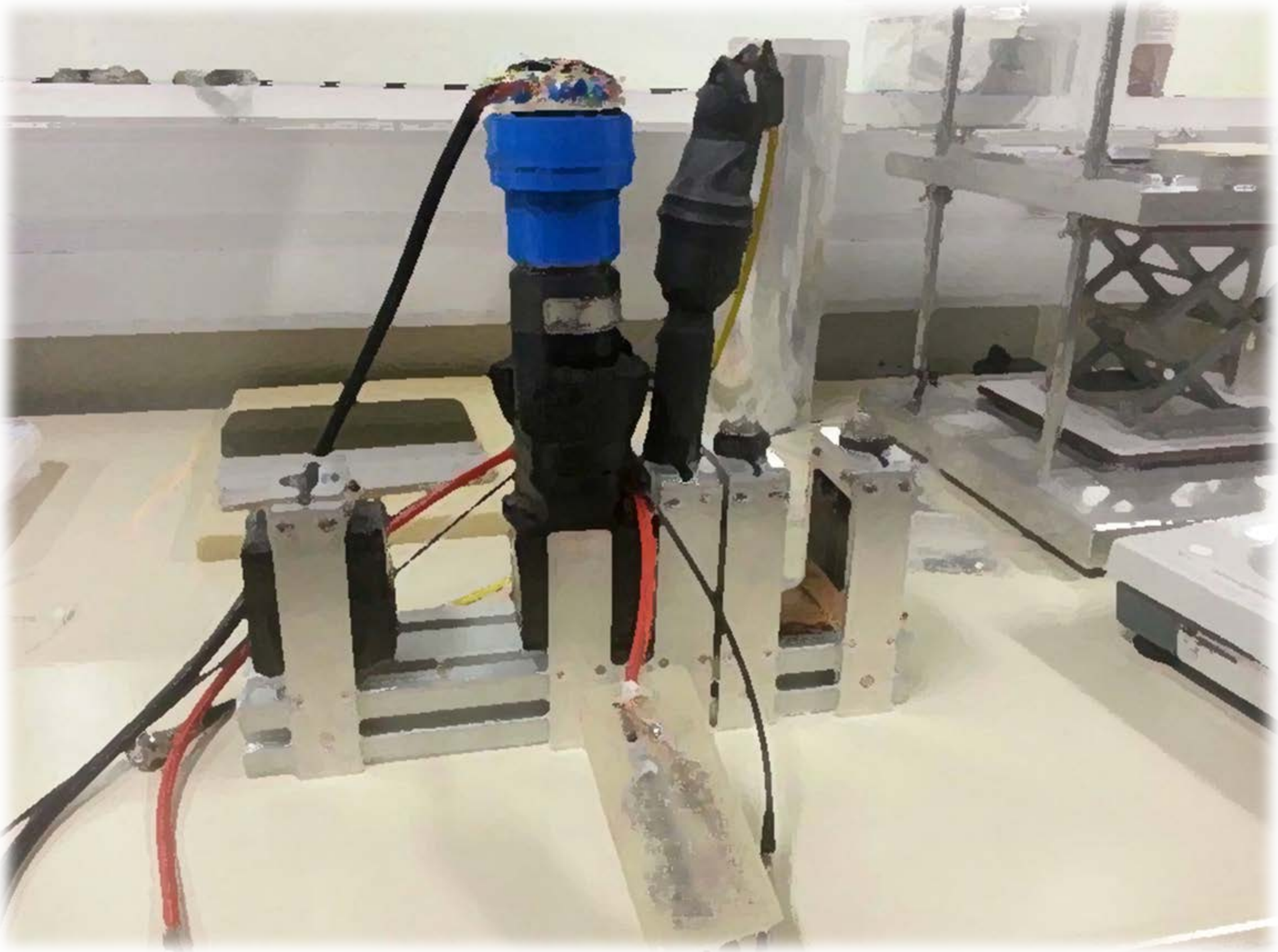
102° Congresso Nazionale - Società italiana di Fisica

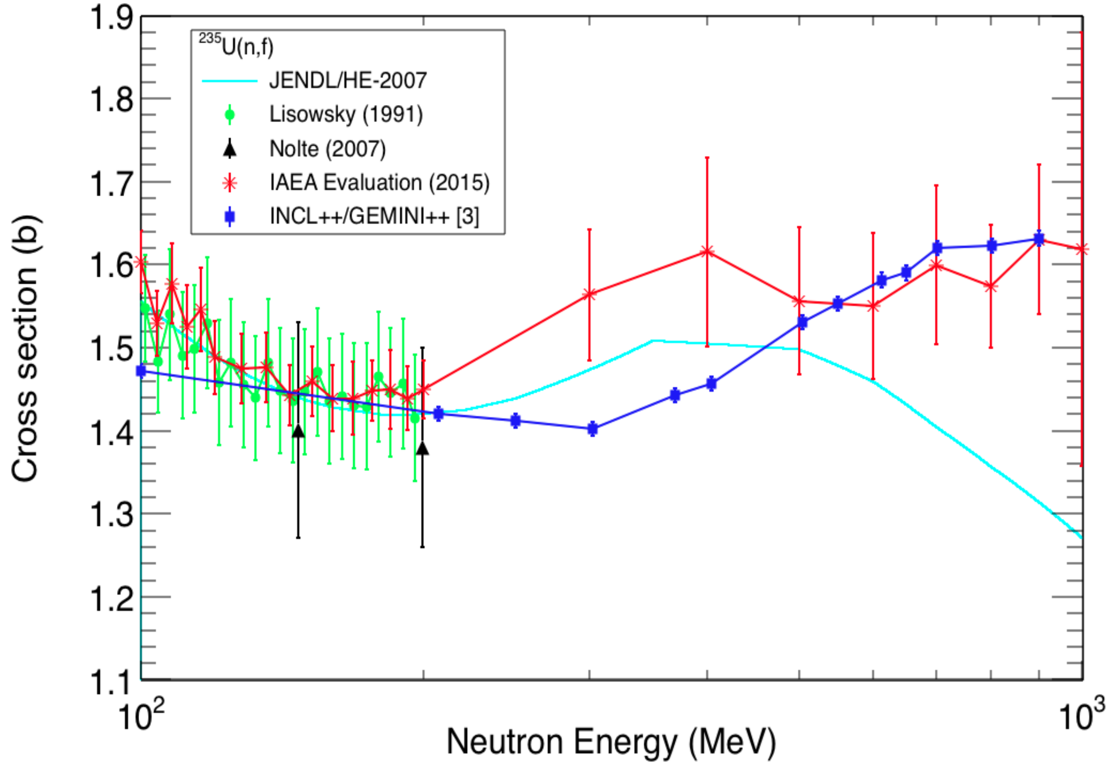
Outline

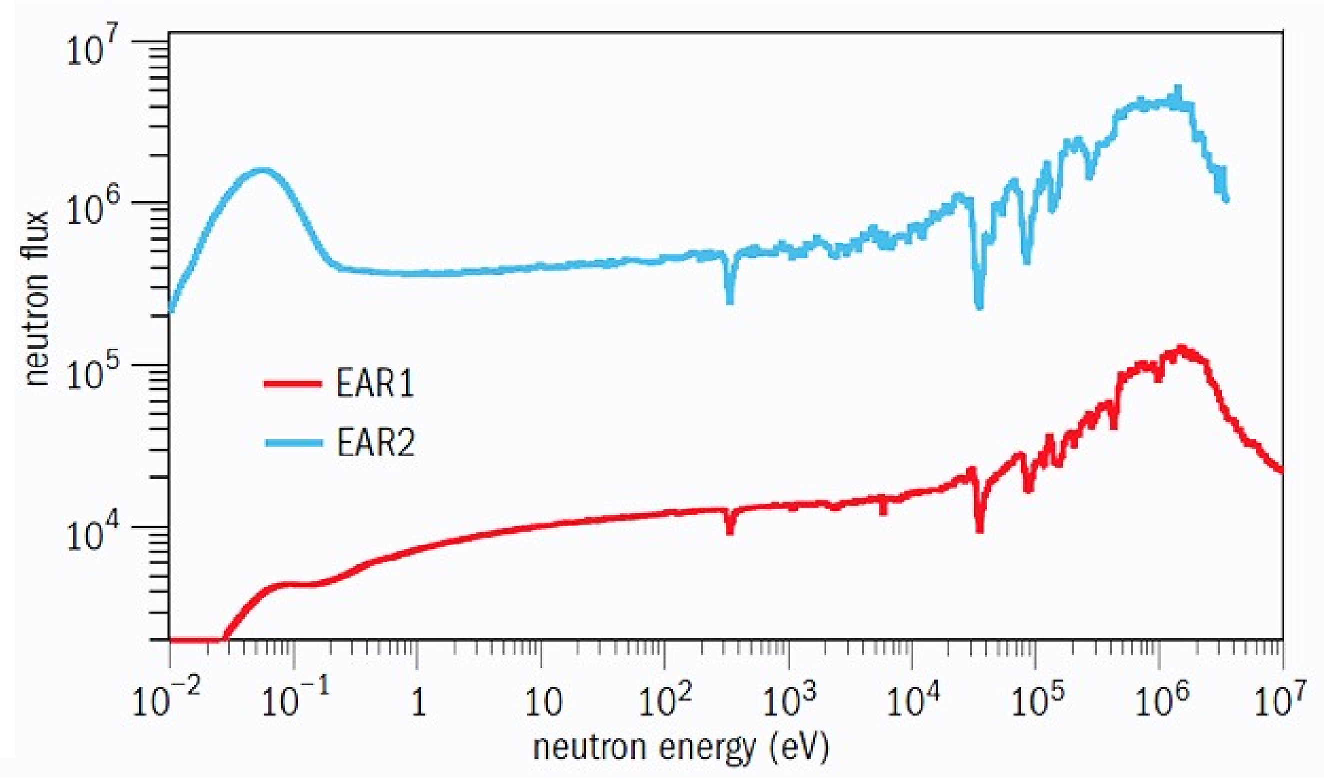
- Aims
- Procedure
- Geant4 Simulations
- Results
- Conclusions



Aims

- Measurement of the n_TOF neutron flux from 200 MeV up to 1 GeV
- Measurement of the $^{235}U(n,f)$ cross section above 200 MeV





Procedure

- **Measurement** of the ^{235}**U(n,f) cross section** above 200 MeV, relative to the **H(n,n)H** elastic scattering reaction.
- $\boldsymbol{\Delta E - E}$ **method** to identify **protons**

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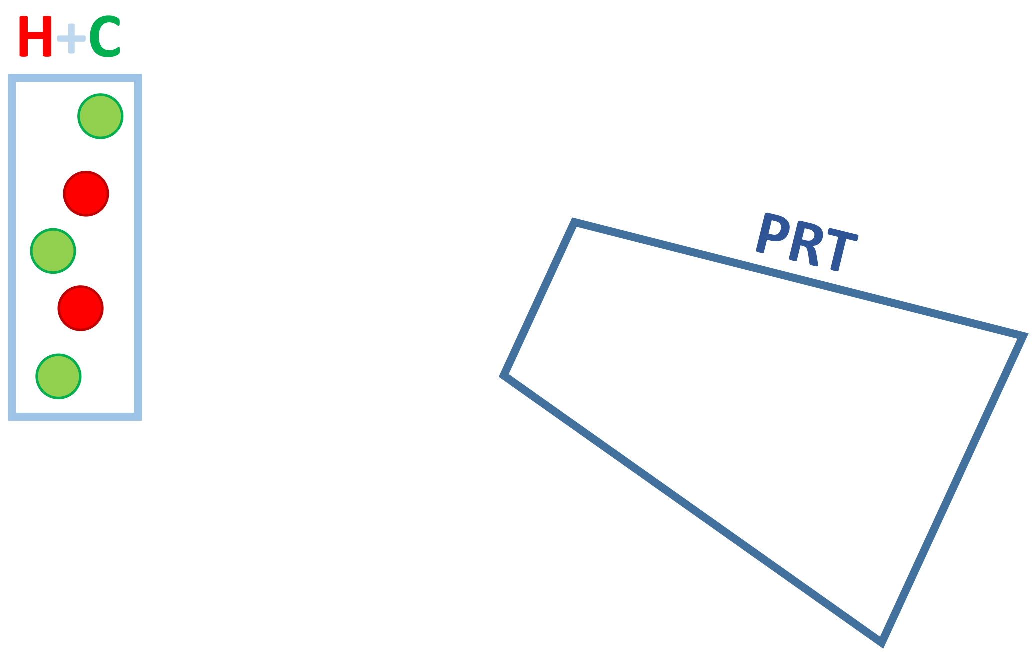

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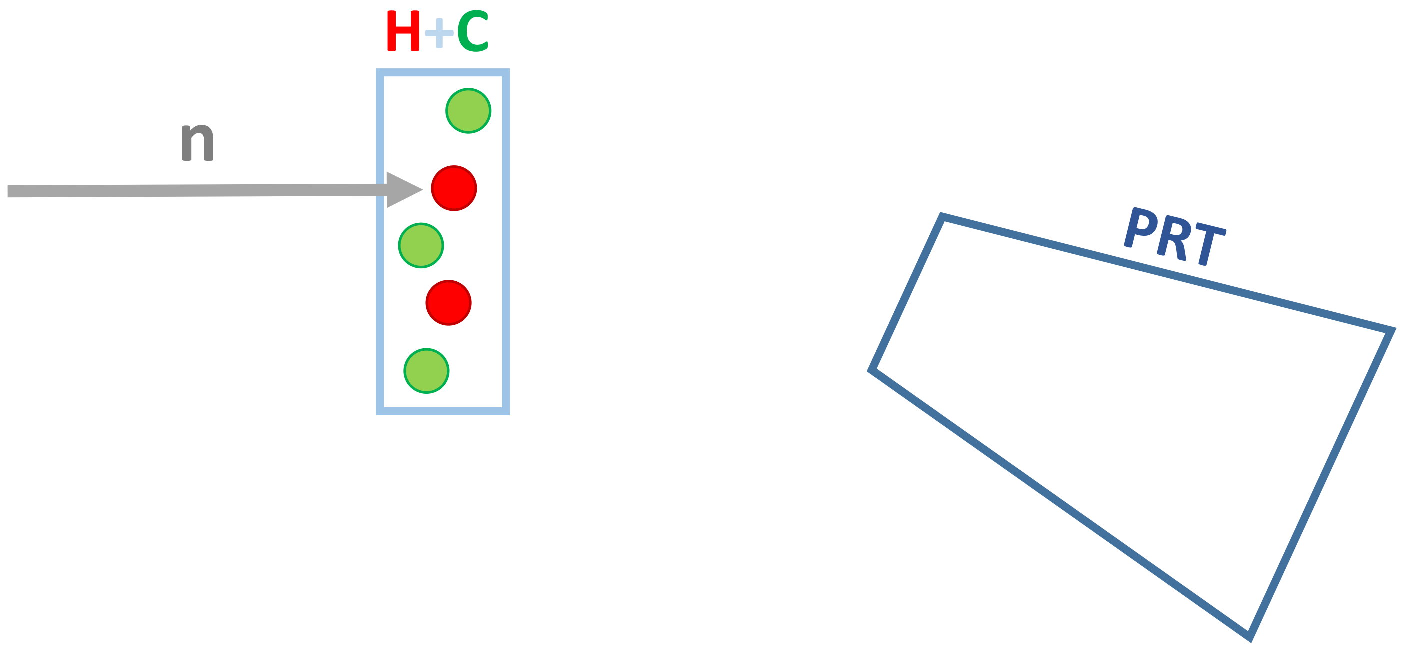

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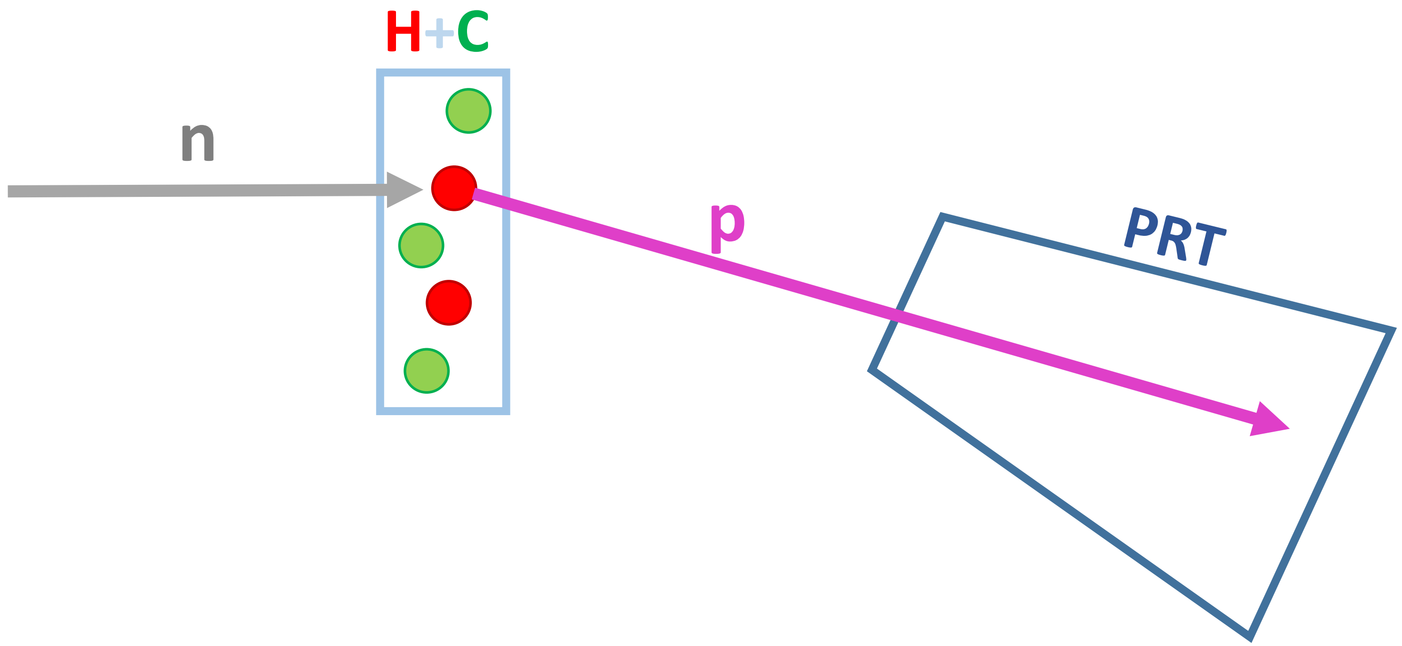

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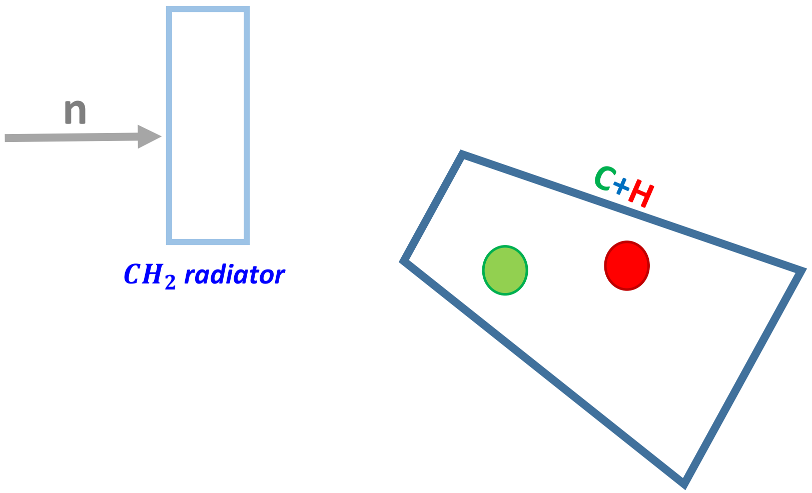

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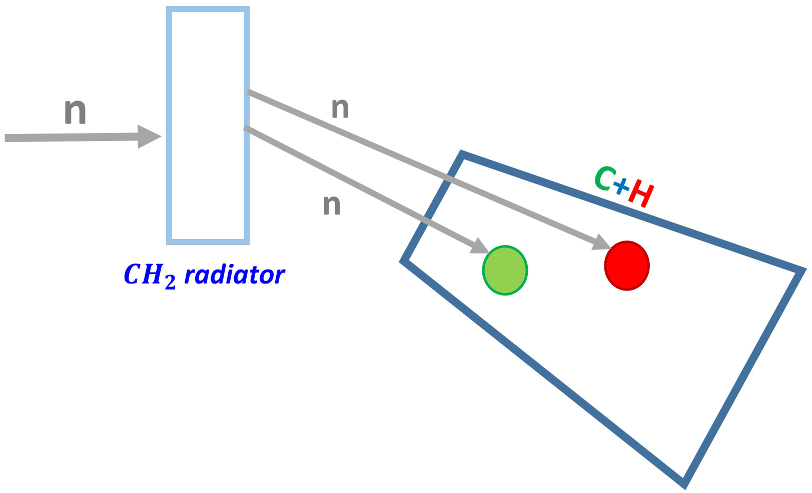

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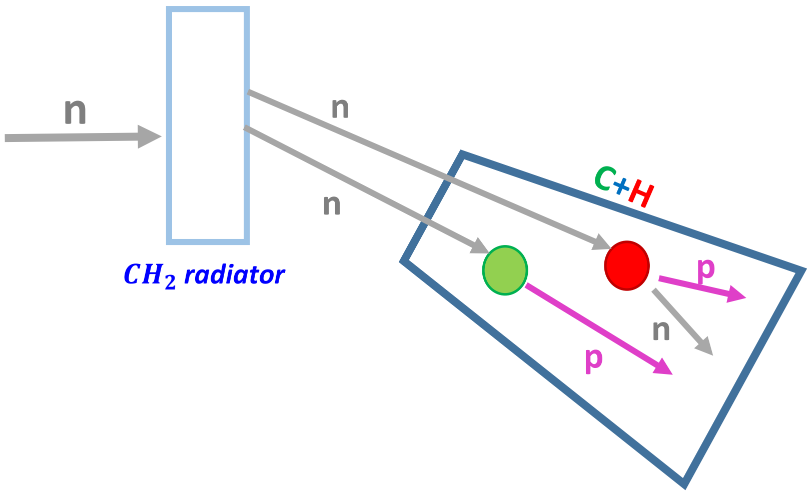

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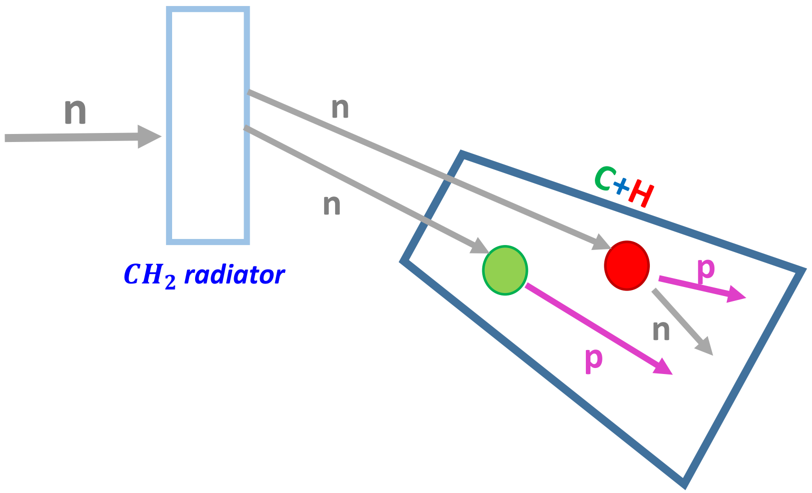

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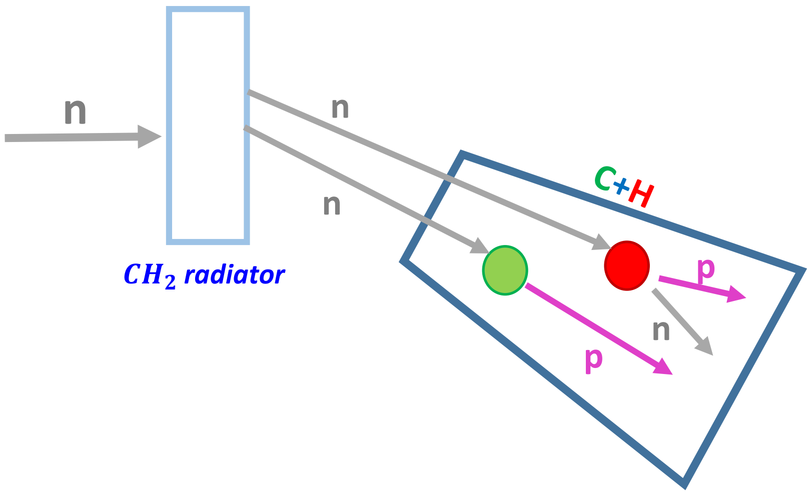

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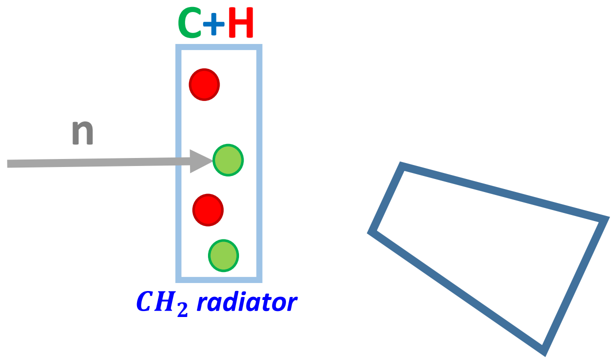

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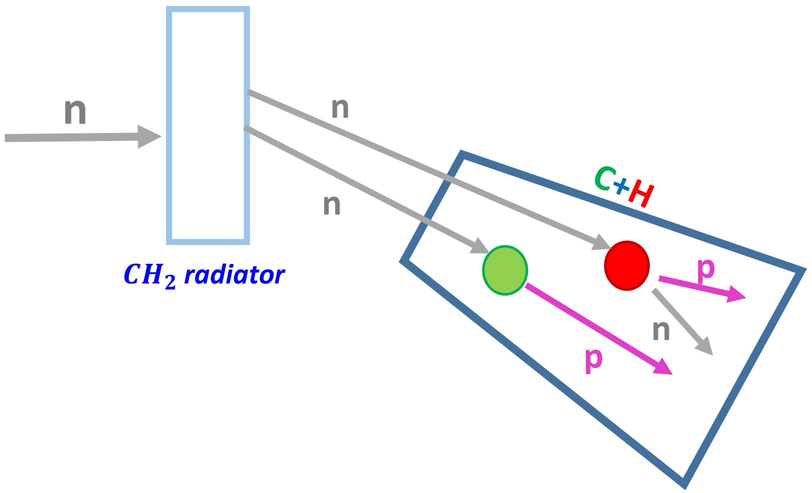

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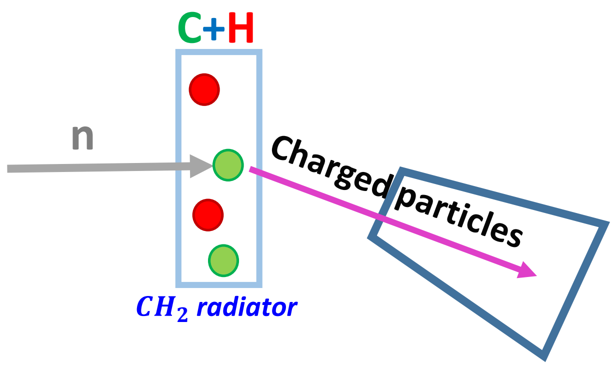
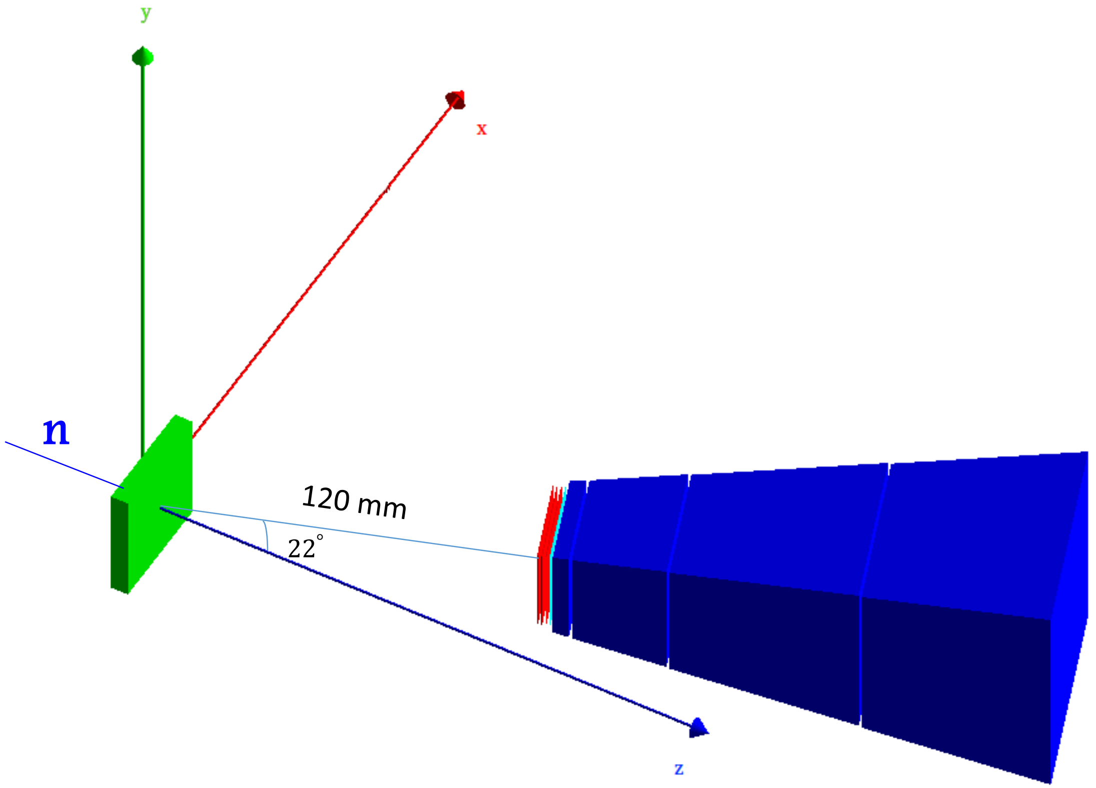


Simulations

Geant4 simulations



- Several telescope configurations simulated
- Trapezoidal geometry → **Defined solid angle**

Detector name	Position	Thickness	First Trapezium Face (mm^2)	Second Trapezium Face (mm^2)
Silicon1	1st	300 μm	30 x 30	30 x 30
Silicon2	2nd	300 μm	30 x 30	30 x 30
Silicon3	3rd	300 μm	30 x 30	30 x 30
Silicon4	4th	200 μm	30 x 30	30 x 30
Scintillator1	5th	5 mm	32.75 x 32.75	34 x 34
Scintillator2	6th	30 mm	34.25 x 34.25	41.75 x 41.75
Scintillator3	7th	60 mm	42 x 42	57 x 57
Scintillator4	8th	60 mm	57.25 x 57.25	72.25 x 72.25

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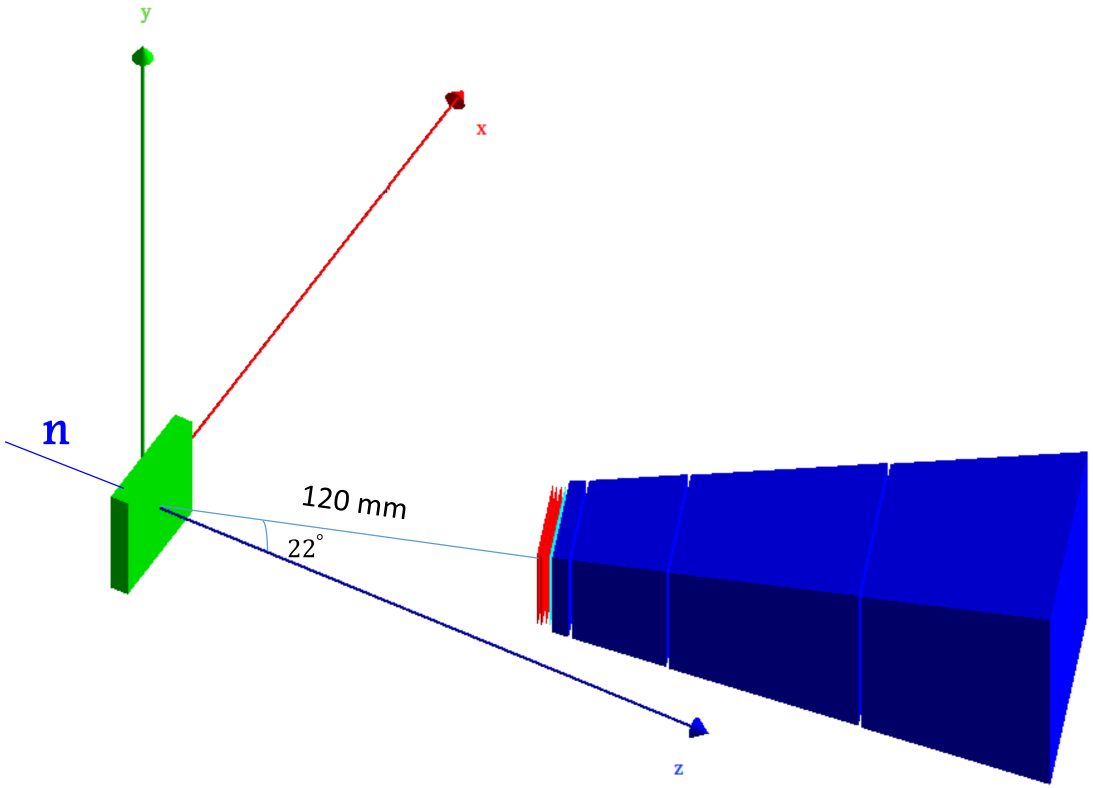
Geant4 simulations



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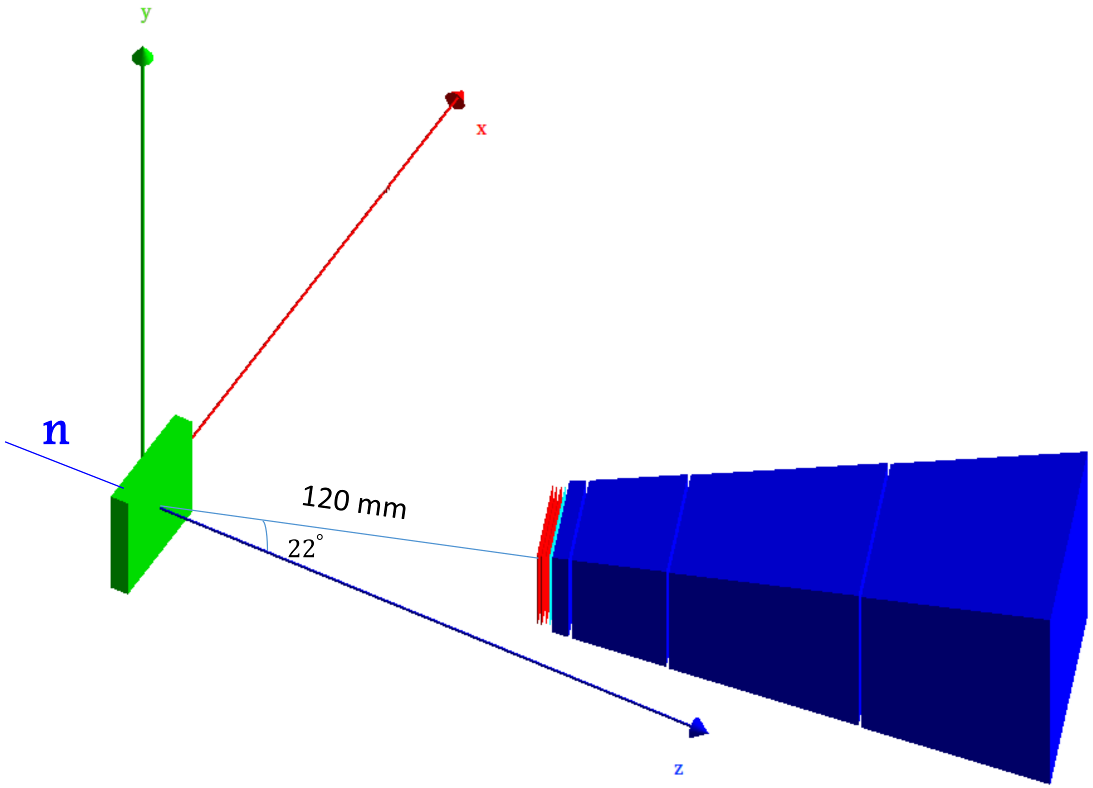

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↓

p stopped up to 250 MeV: no way to stop higher energy *p*

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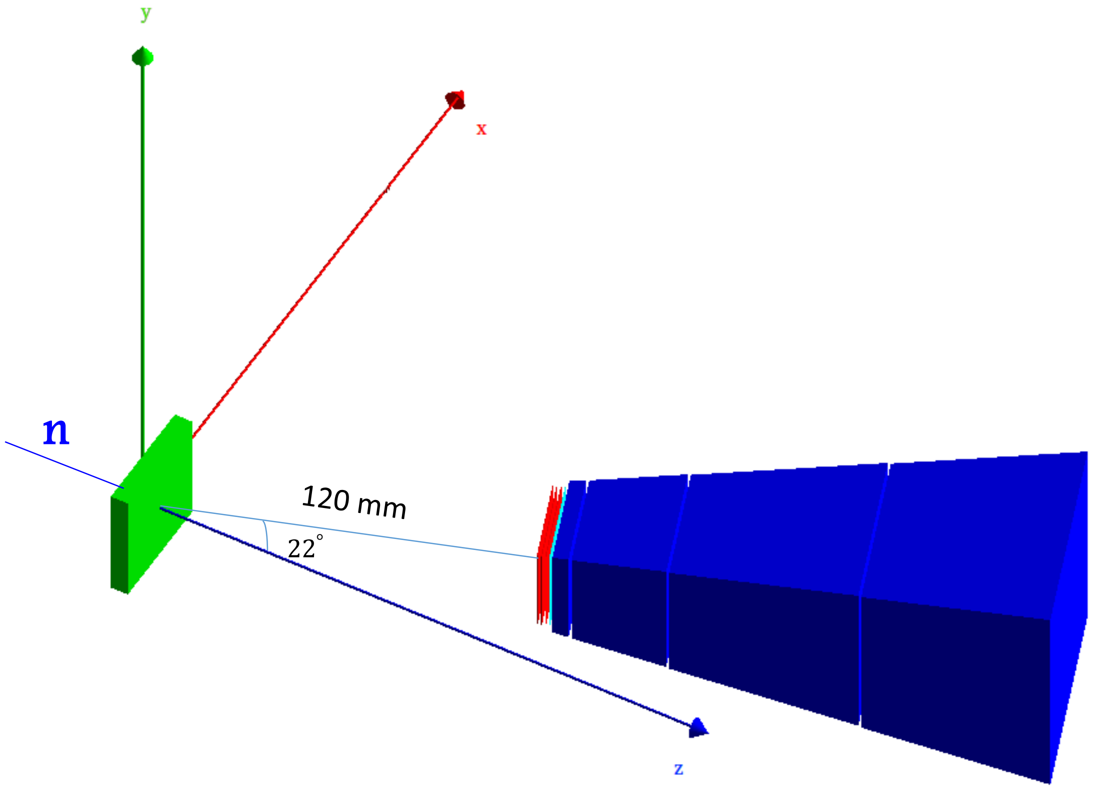

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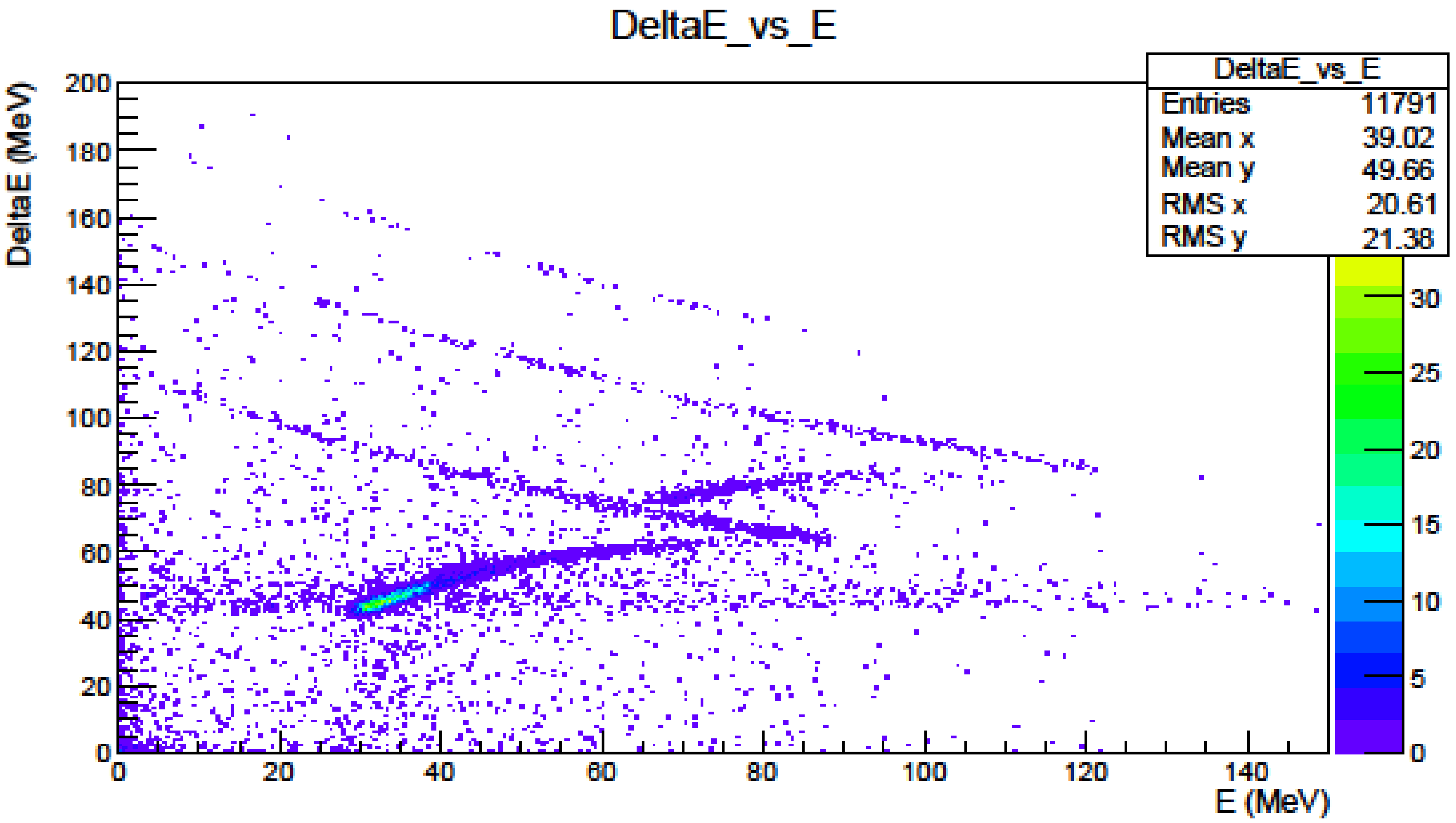
  p stopped up to 250 MeV: no way to stop higher energy *p*

- Choise → **plastic scintillators**: *p* stopped up to 150 MeV but they are **faster**.

Results



- Neutron beam **E=250** MeV
- Although this configuration does not stop the *p* above 150 MeV the signal is well separated from the background

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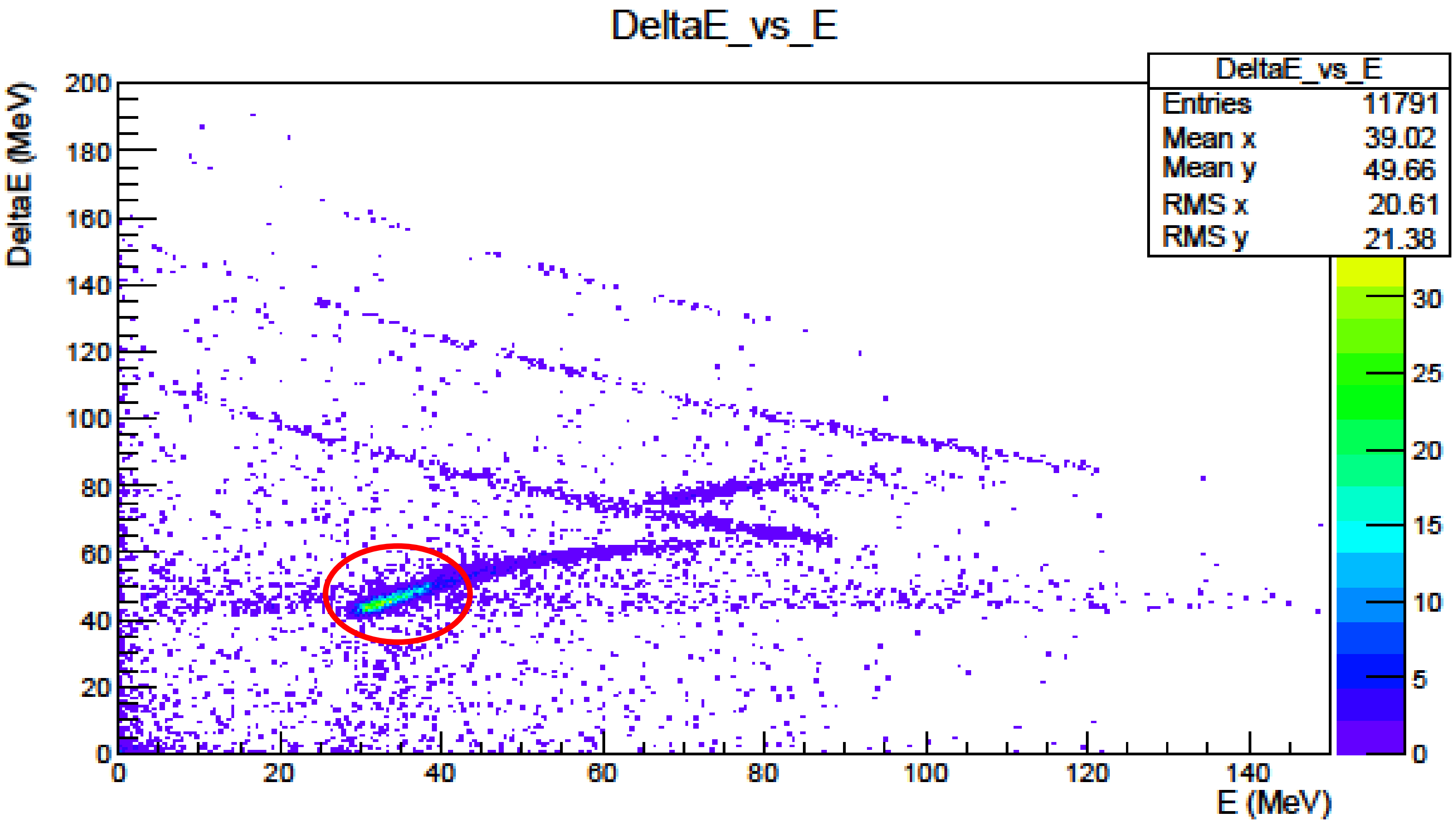

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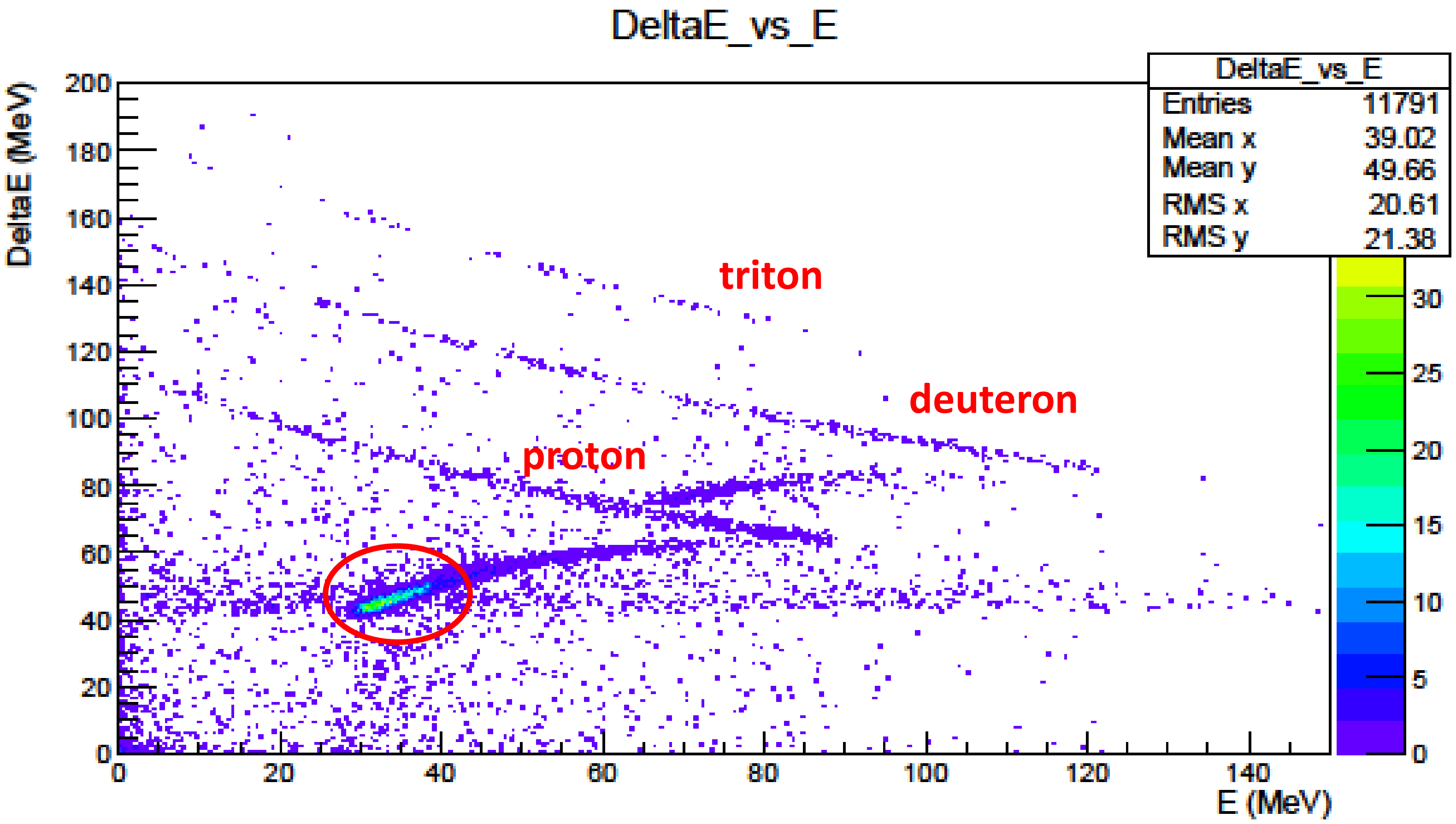

- Neutron beam **E=250** MeV
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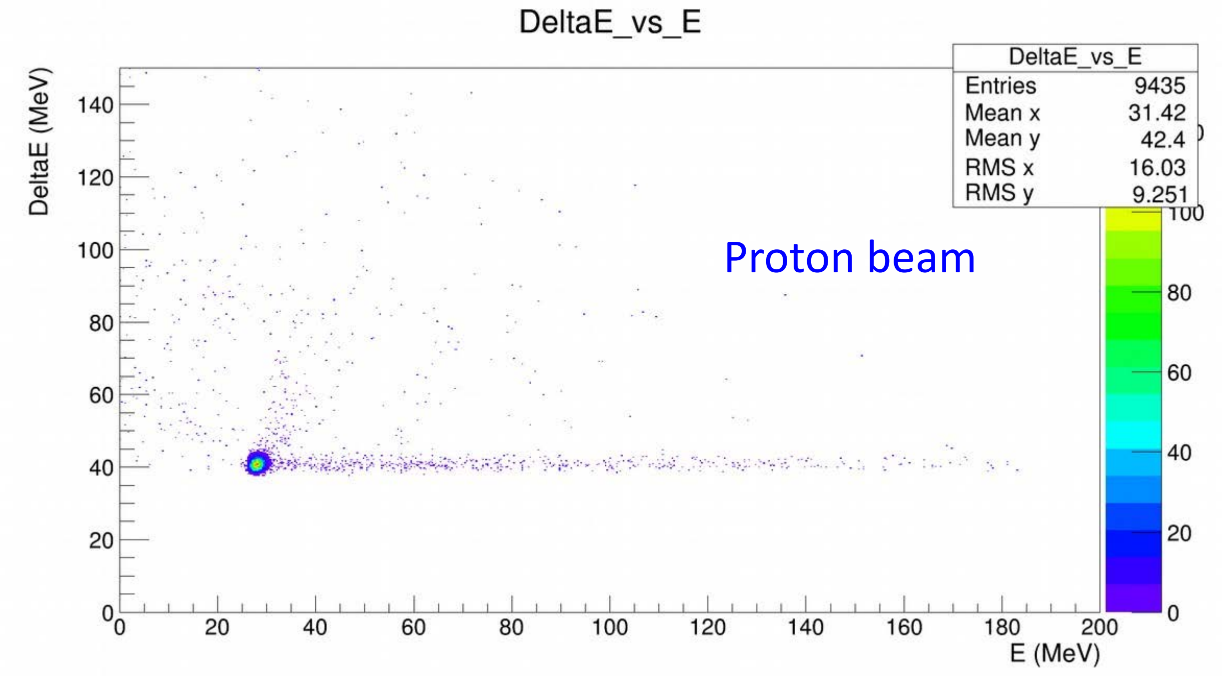
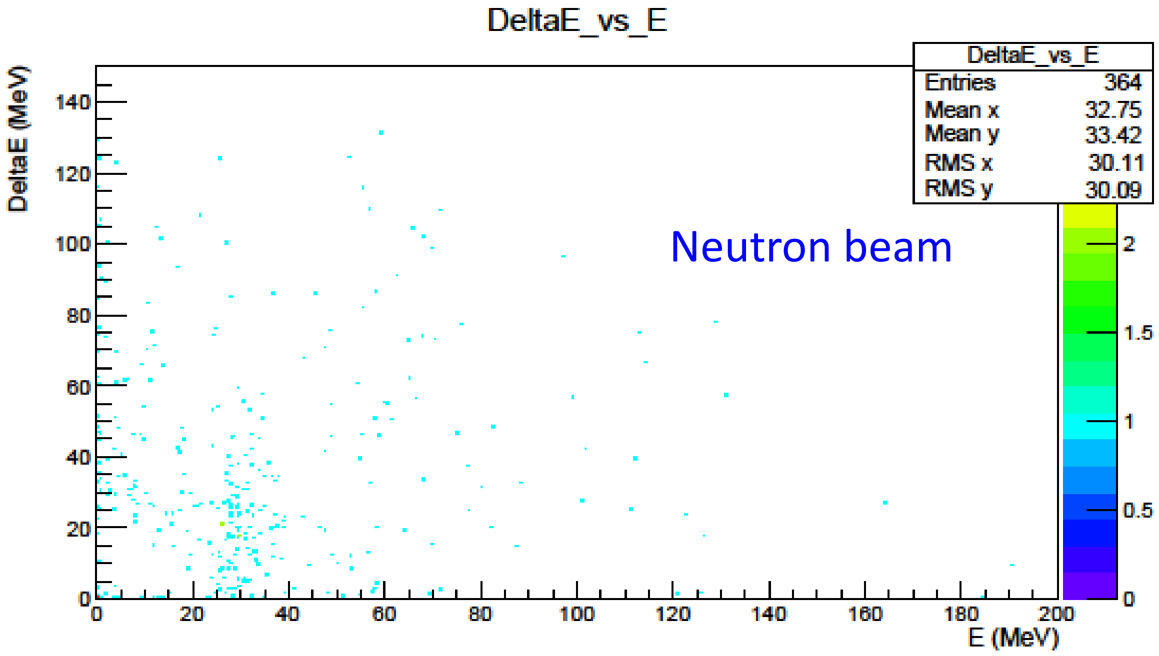
Results

n+p → n → interaction with the Carbon in the detectors

- **Neutron beam** and **proton beam** of 250 MeV impinging directly on the PRT





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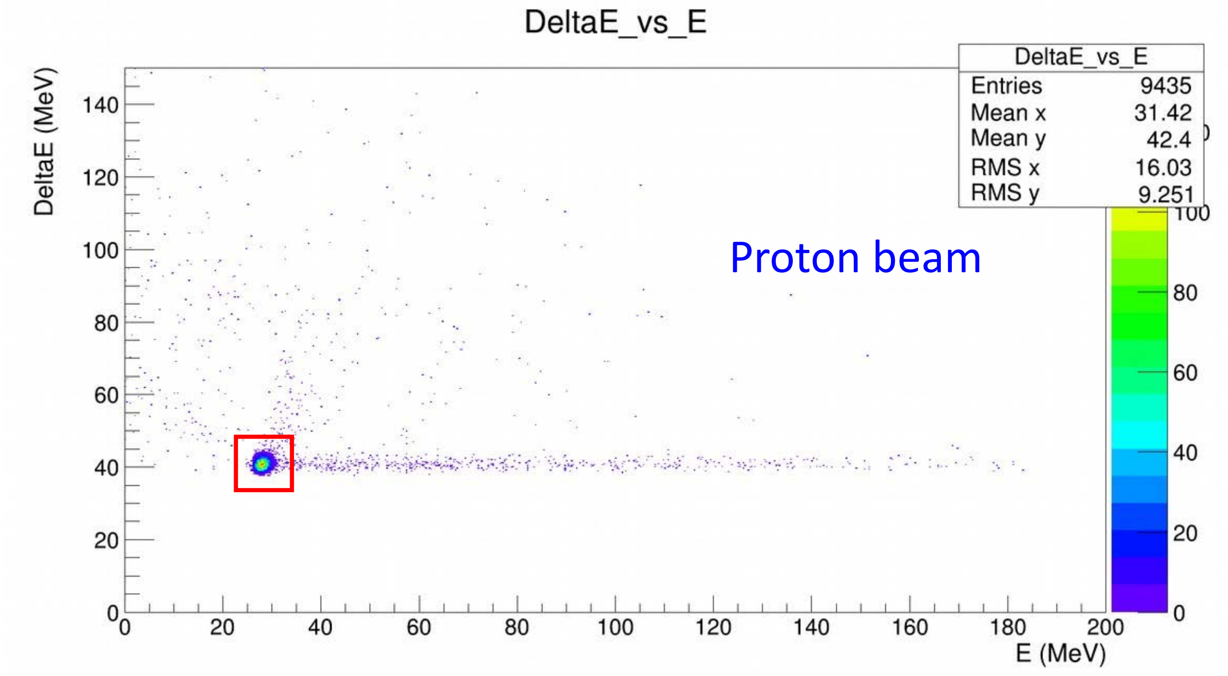
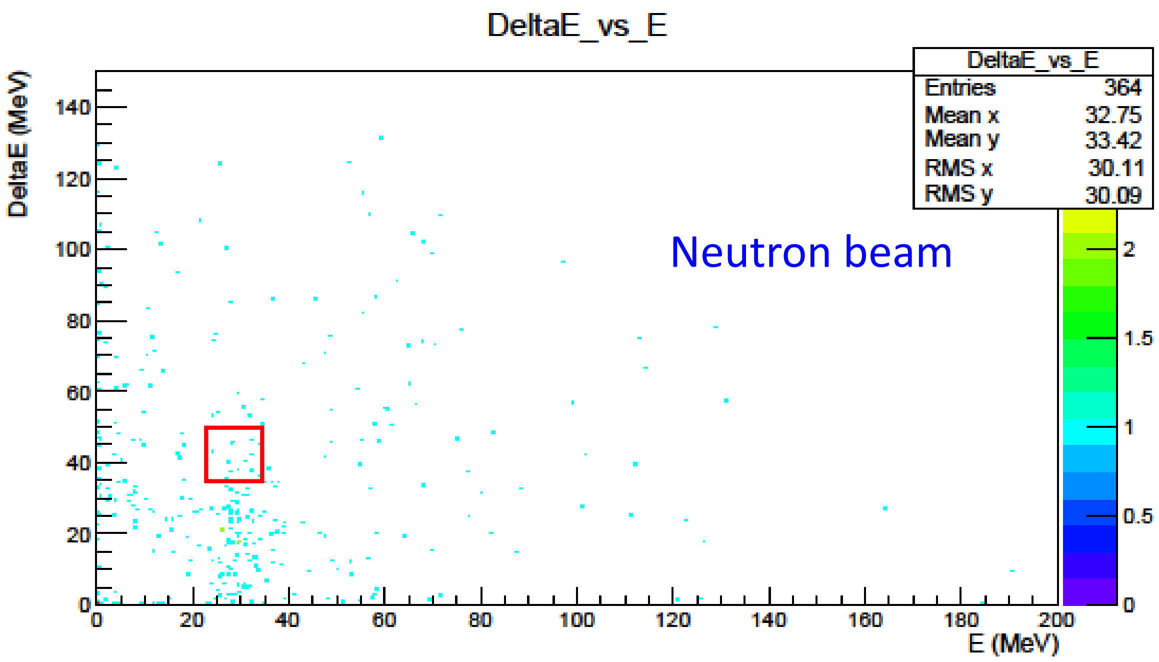
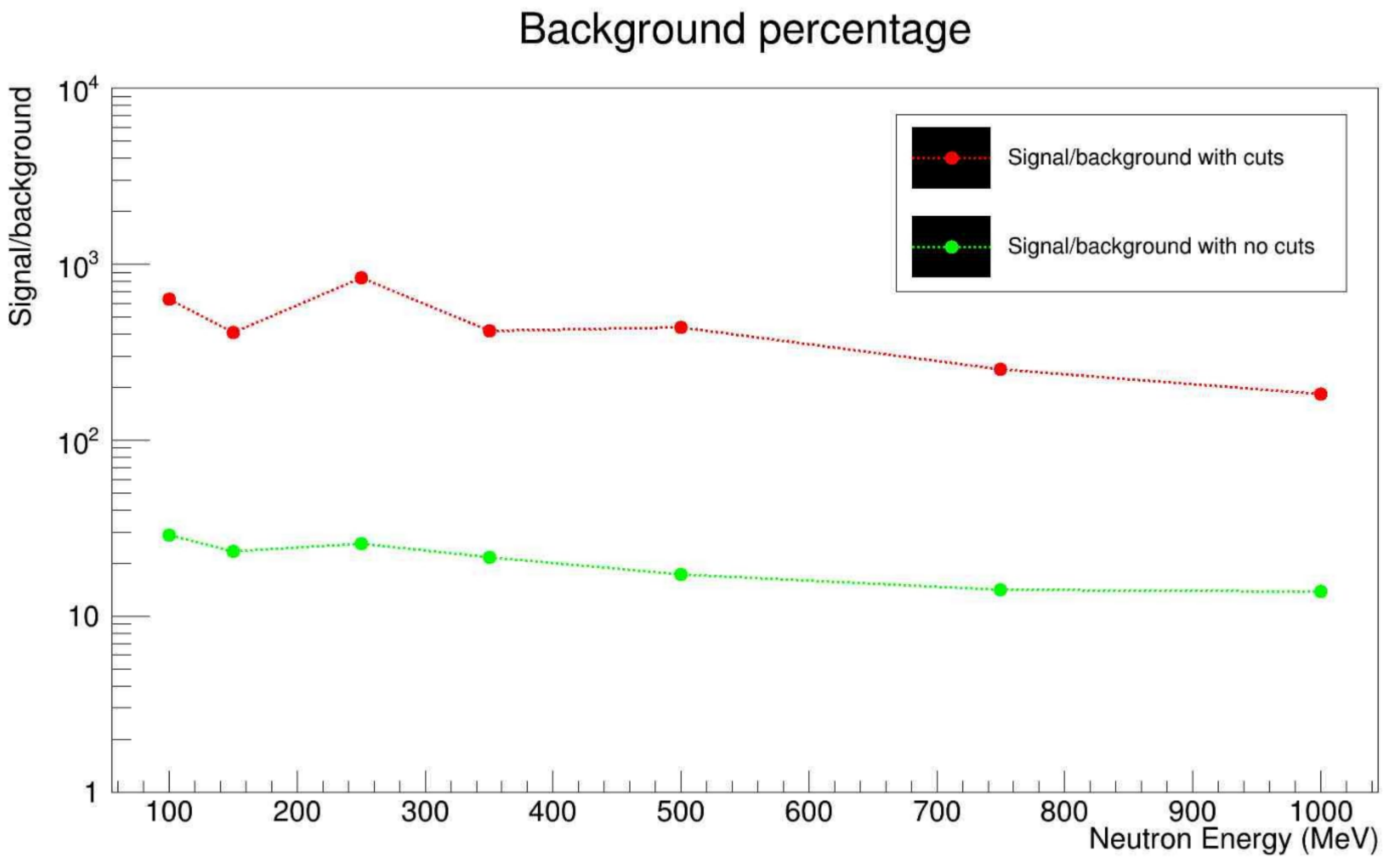




Selection of proton signal

Results

n+p → n → interaction with the Carbon in the detectors



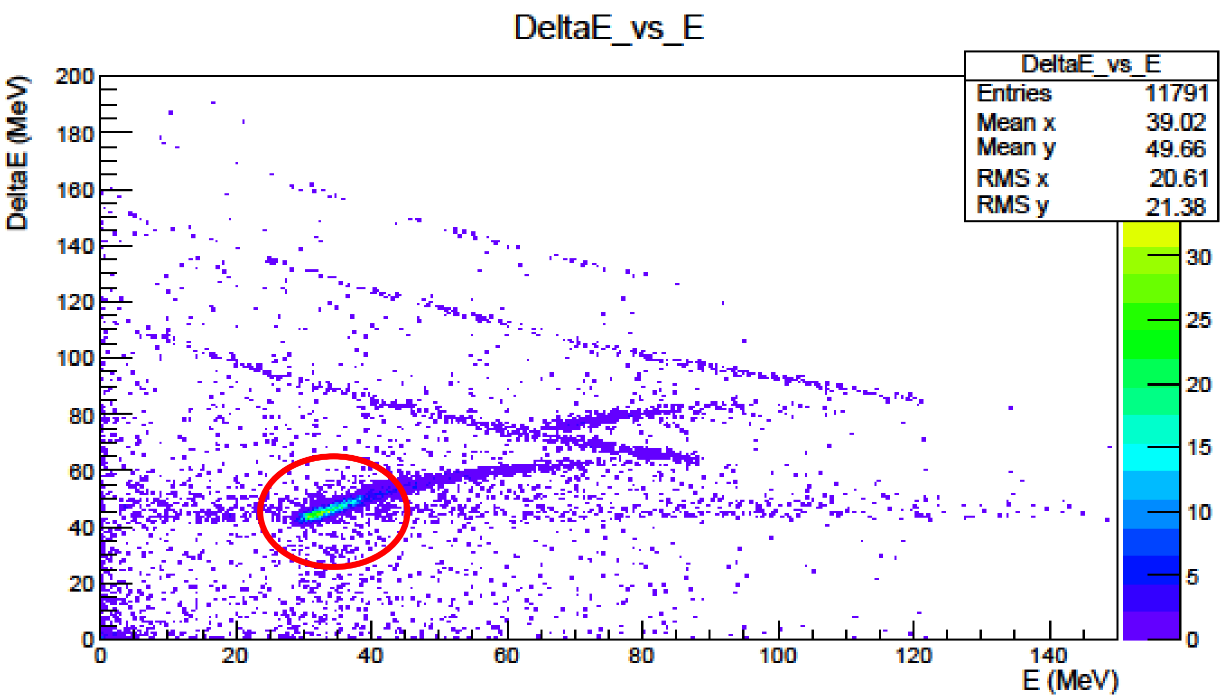
Comparison between the two methods

Neutron Energy	Signal/backgr with no p selection	Signal/backgr with p selection
100	28.79	690
150	23.46	410
250	25.92	834
350	21.54	419.85
500	17.29	436.89
750	14.13	254.34
1000	13.84	182.24

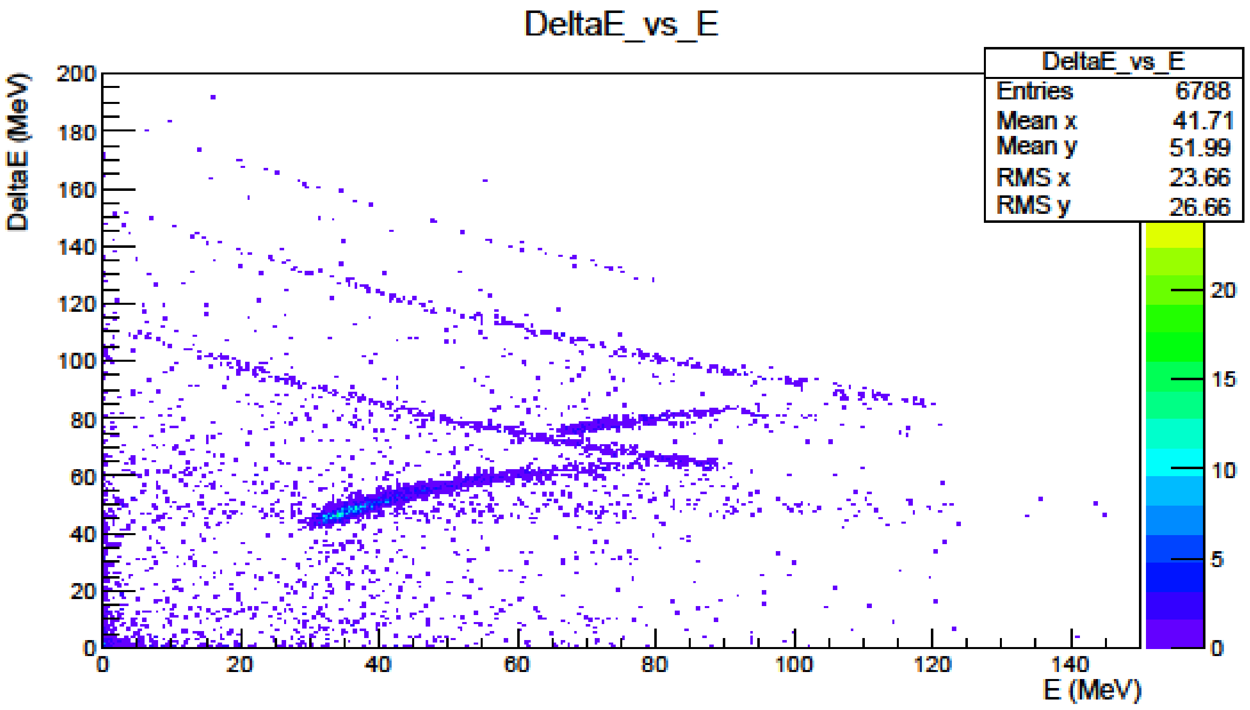
Results

CH_2 radiator → n+C → p

Neutron beam of 250 MeV impinging on a CH_2 radiator



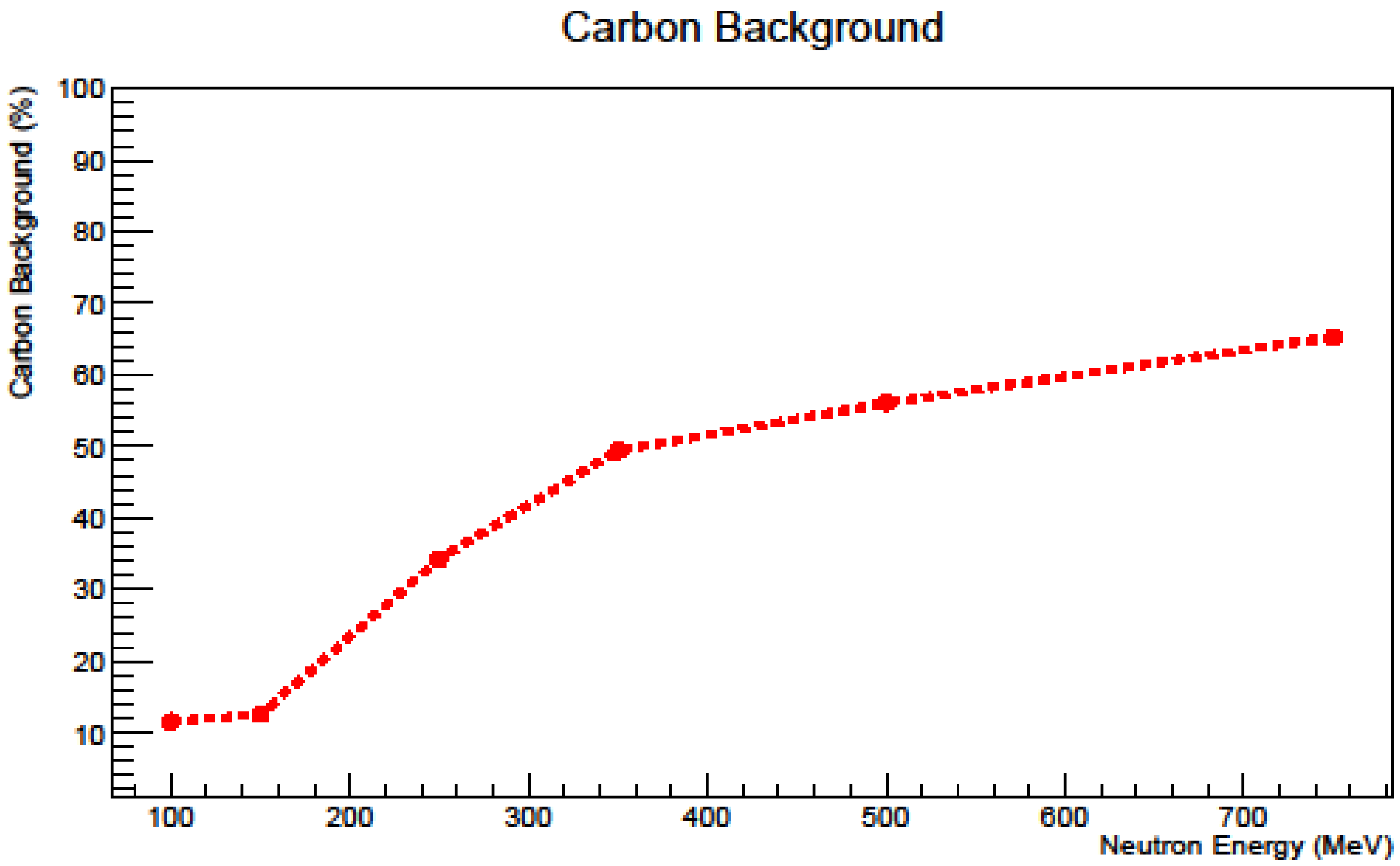
Neutron beam of 250 MeV impinging on a **C** radiator



Results

CH_2 radiator → n+C → p

After the selection of proton signal …

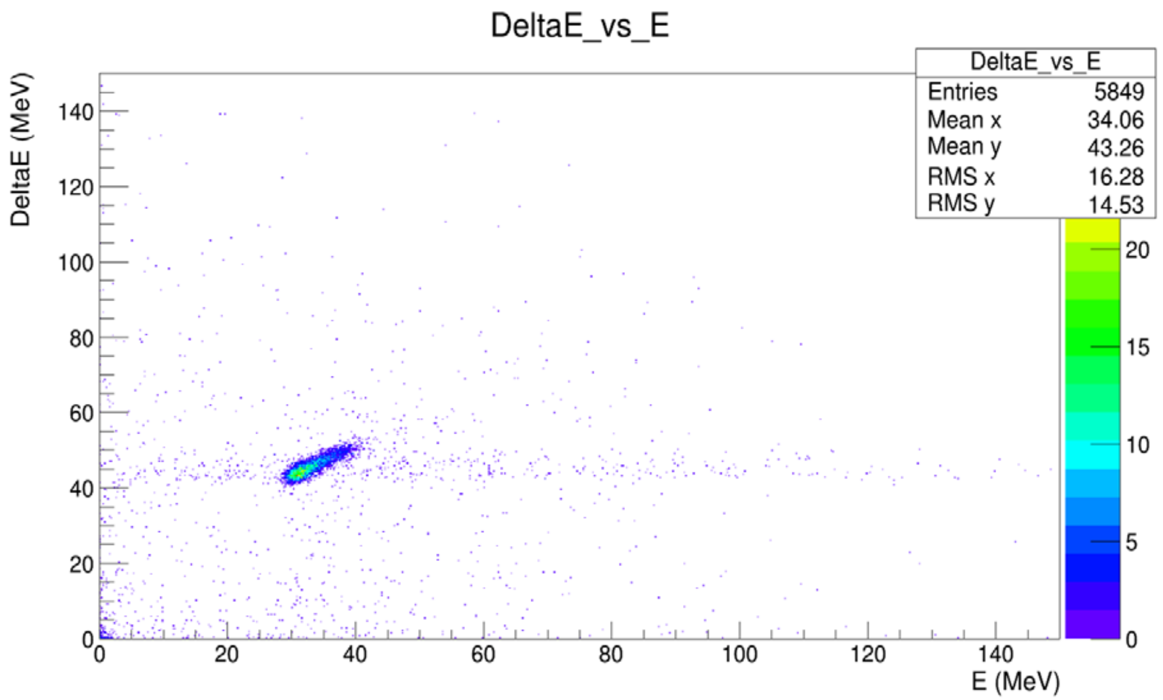


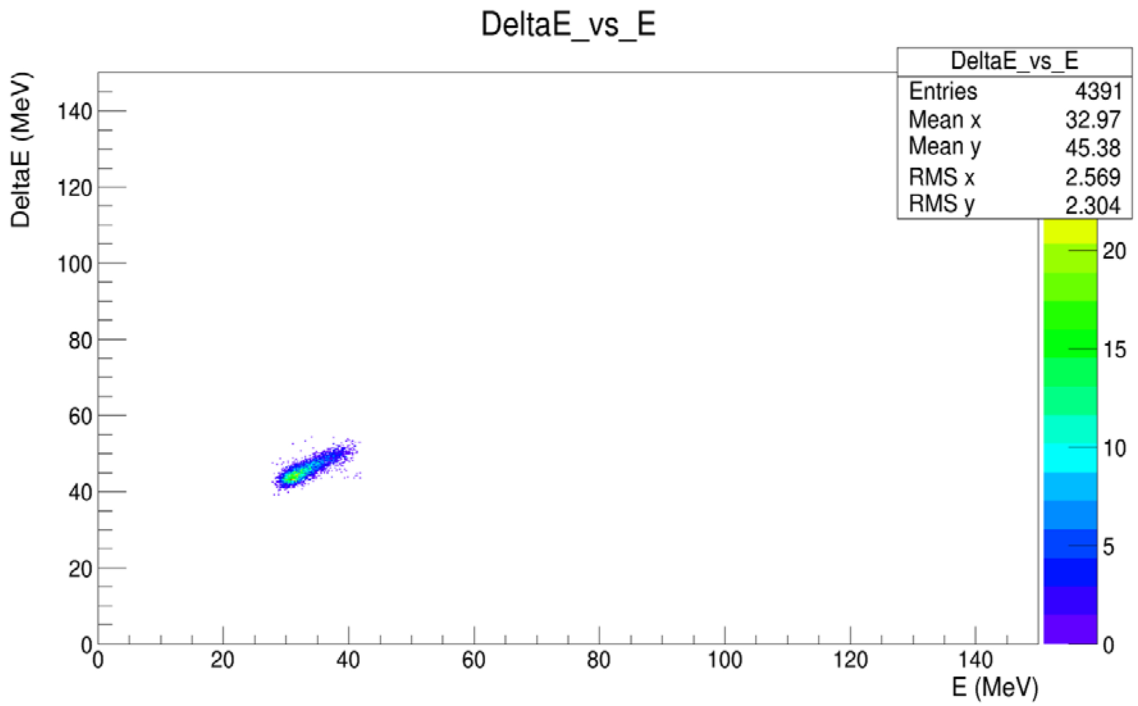
Neutron Energy	Carbon Background (%)
100	11.55
150	12.53
250	34.27
350	49.36
500	56.07
750	65.31
1000	72.20

Results

Multiple scattering of protons in the detectors → additional background and change in the efficiency

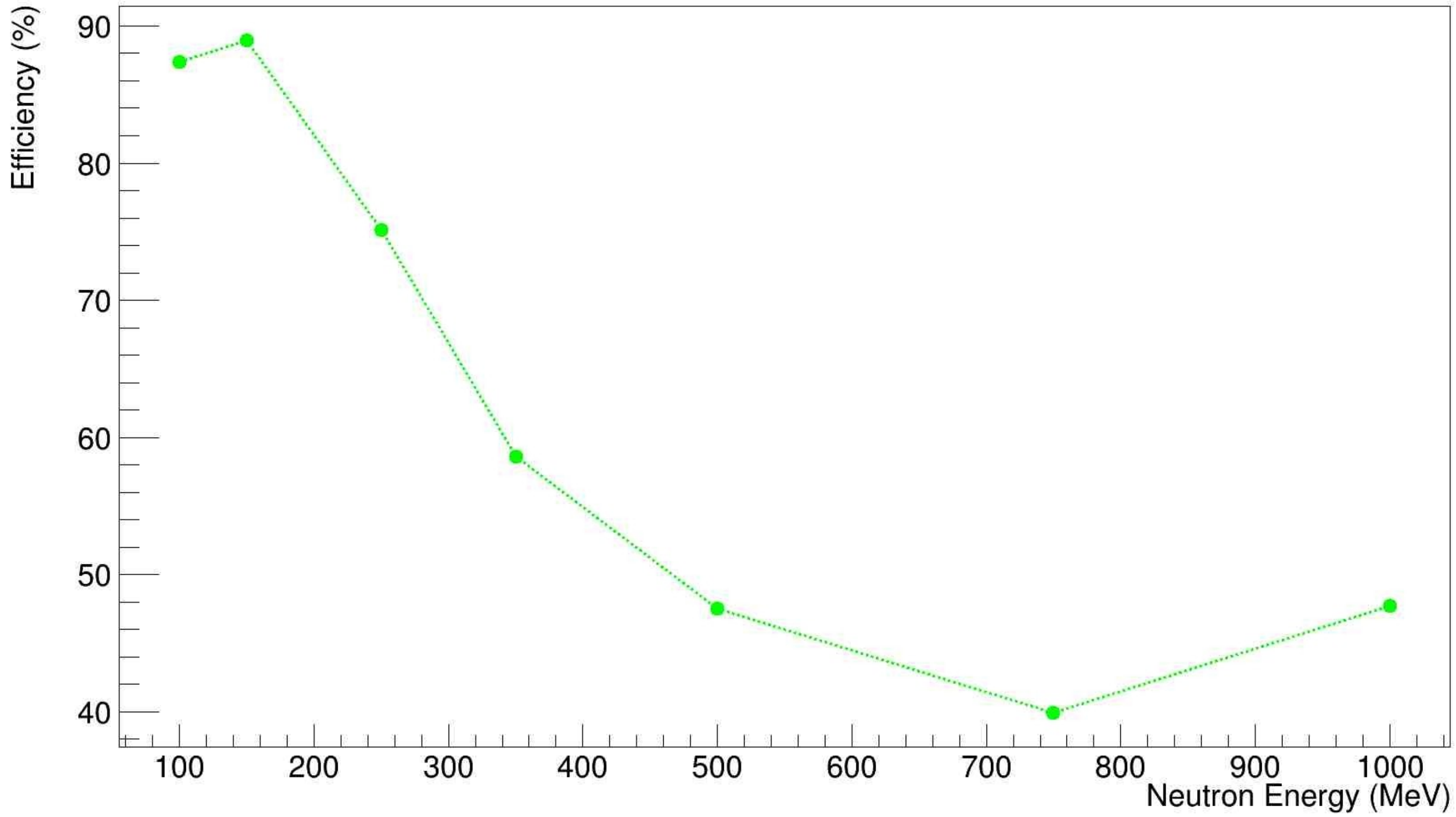
Neutron beam of 250 MeV impinging on a H_2 radiator





Efficiency: ratio between the protons in the peak and total incident protons on the PRT

Efficiency



Neutron Energy	Efficiency (%)
100	87.4
150	88.96
250	75.07
350	58.58
500	47.52
750	39.91
1000	47.72

Conclusions

- The measurement is **difficult** (especially close to 1 GeV) but **feasible**
- PRT configuration simulated also with the whole n_TOF energy spectra
  →**the conclusions are the same**.
- Simulations indicate that there are **background problems at high energies** due to interactions of neutrons with the carbon in the radiator.
  Future GOAL: refine the analysis and especially measure the background with a pure carbon target!
- **Next step**: TEST under the beam to verify the simulations

Thank you for your kind attention