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Multi-neutron analysis with NeuLAND

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R³B

GSI

Recap ...

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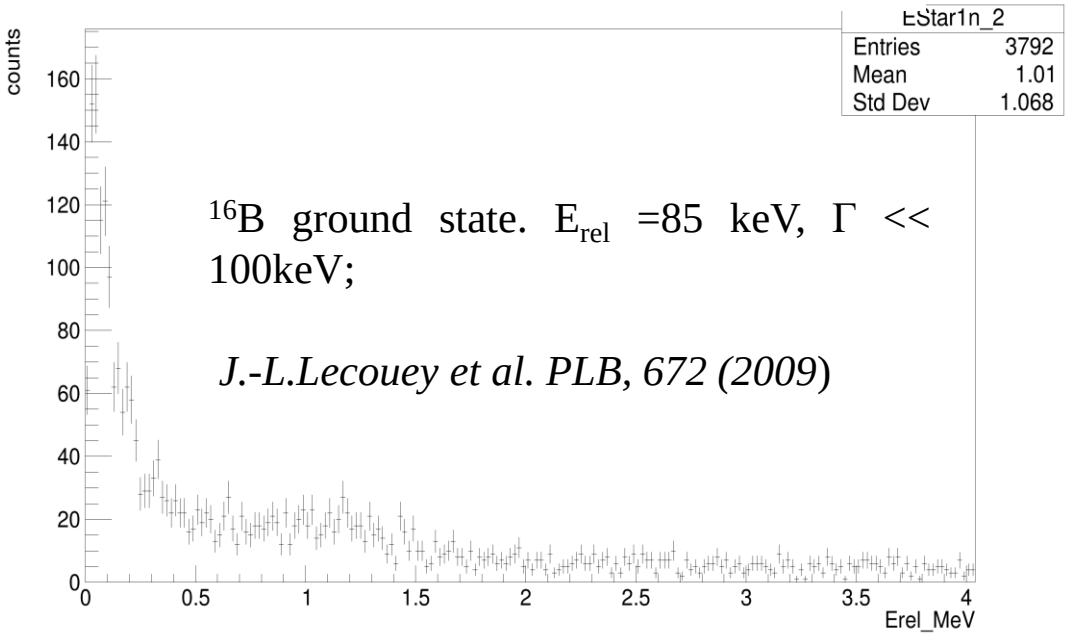
- 1n Reconstruction shown in Budapest,
  - Sorting and selecting *fastest hit in time*
  - Align Fragment velocity to neutron velocity
- To confirm with simulation if the approach is correct
- Extract efficiency
- 2n Relative energy reconstruction

Relative energy spectrum $^{17}C(-1p)^{15}B+1n$



<u>* Simulations shown based on QGSP_INCLXX physics list</u>

1 - Neutron simulations

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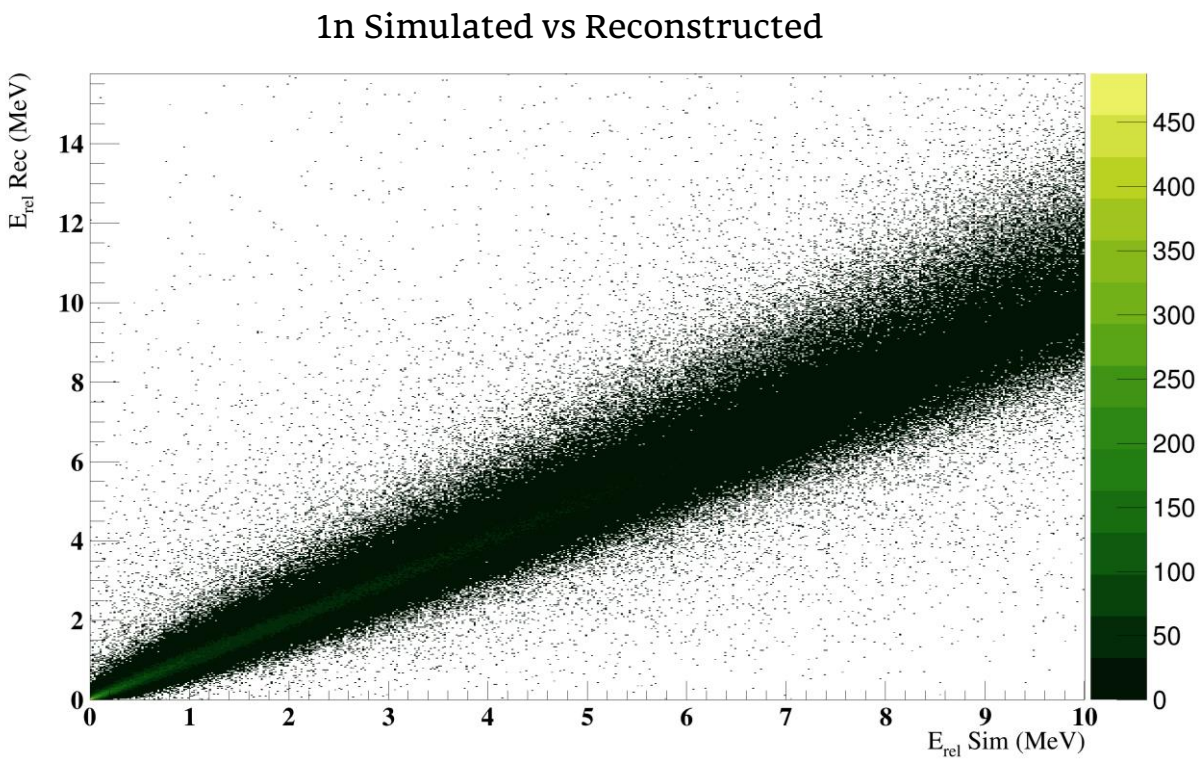
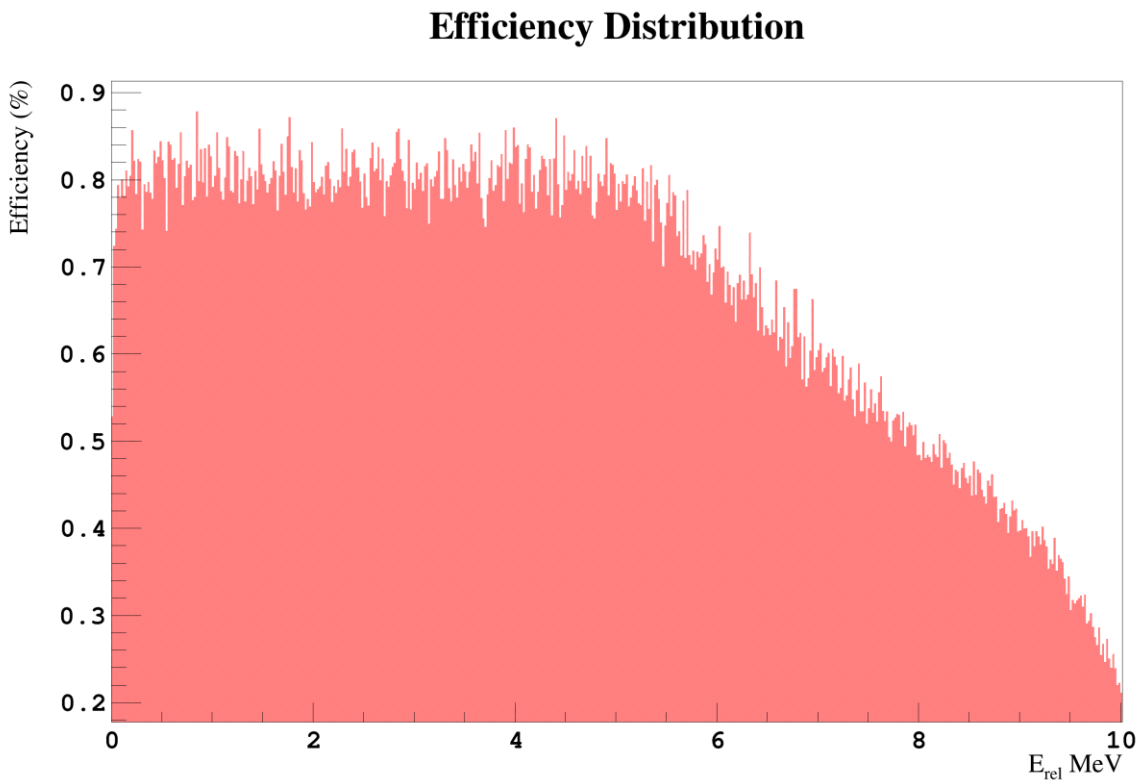
From uniform E_{rel} distribution 0-10 MeV simulation :





- Good correlation between simulation and reconstruction using *first hit in time* approach
- Efficiency with acceptance distribution

2 - Neutron reconstruction

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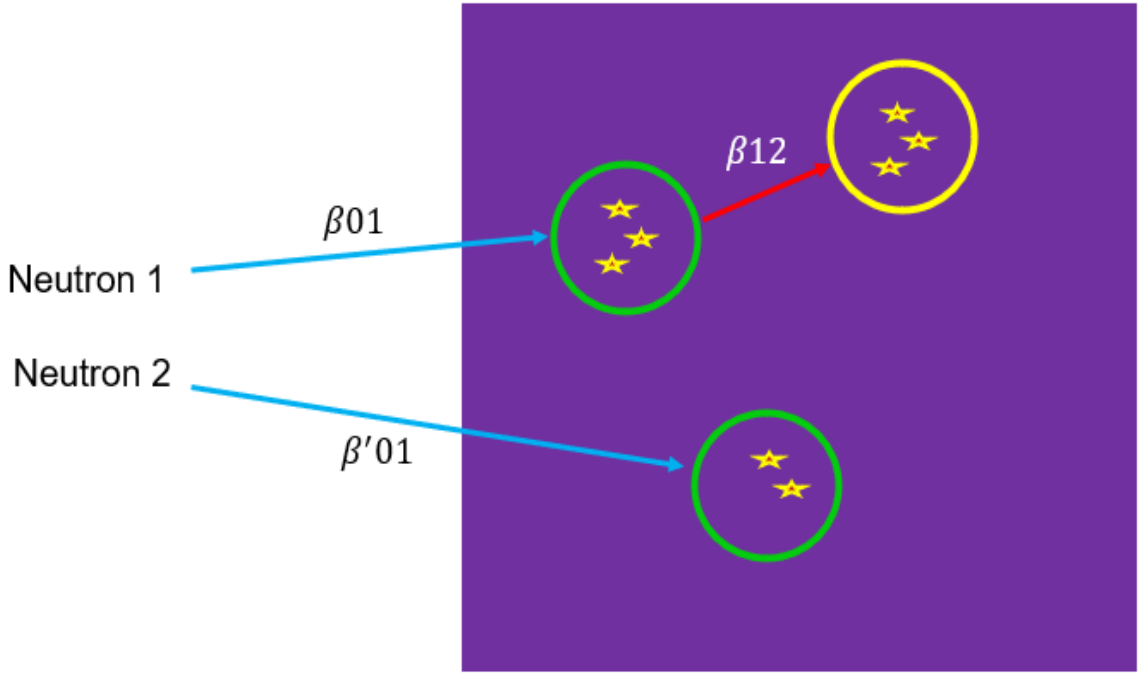
- Based on method adopted from *PhD thesis of Christopher Lehr* and *Kondo et al. NIM 463 (2020)*
- Method Based on **clustering** and **causality** condition
- First hints from 1-n reconstruction plots

Definitions:

Crosstalk : Multiple hits coming from same neutron but identified as hits coming from different neutrons

Causality : Hits originating in a second point from the same neutron after an initial scattering from a different point



NeuLAND

2 - Neutron reconstruction

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Some initial processing:

- Sort hits based on time
- Align fragment velocity similar to 1n case
- Select only hits > 6 MeVee
- Perform clustering to remove proton crosstalk
  - multiple approaches available in current work a square cut was used in space time: Δ X = 25cm , Δ Y = 25cm, Δ Z = 25cm, Δ T = 3ns

Look at 1-neutron case first

Hints from 1 – Neutron simulations

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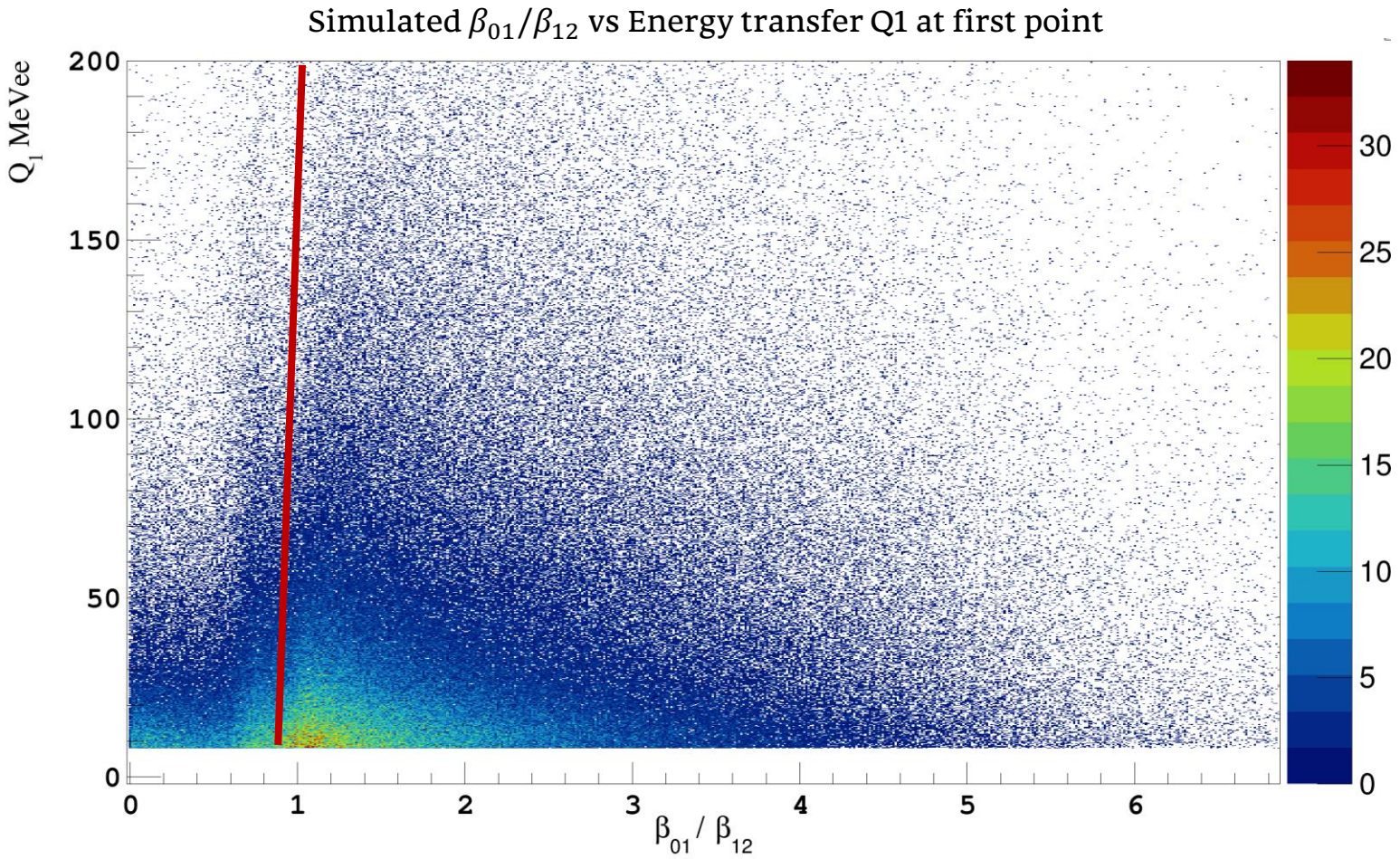
- Causality cut for $\beta_{12} < \beta_{01}$
- Allowance for time resolution of NeuLAND



Hints from 1 – Neutron simulations

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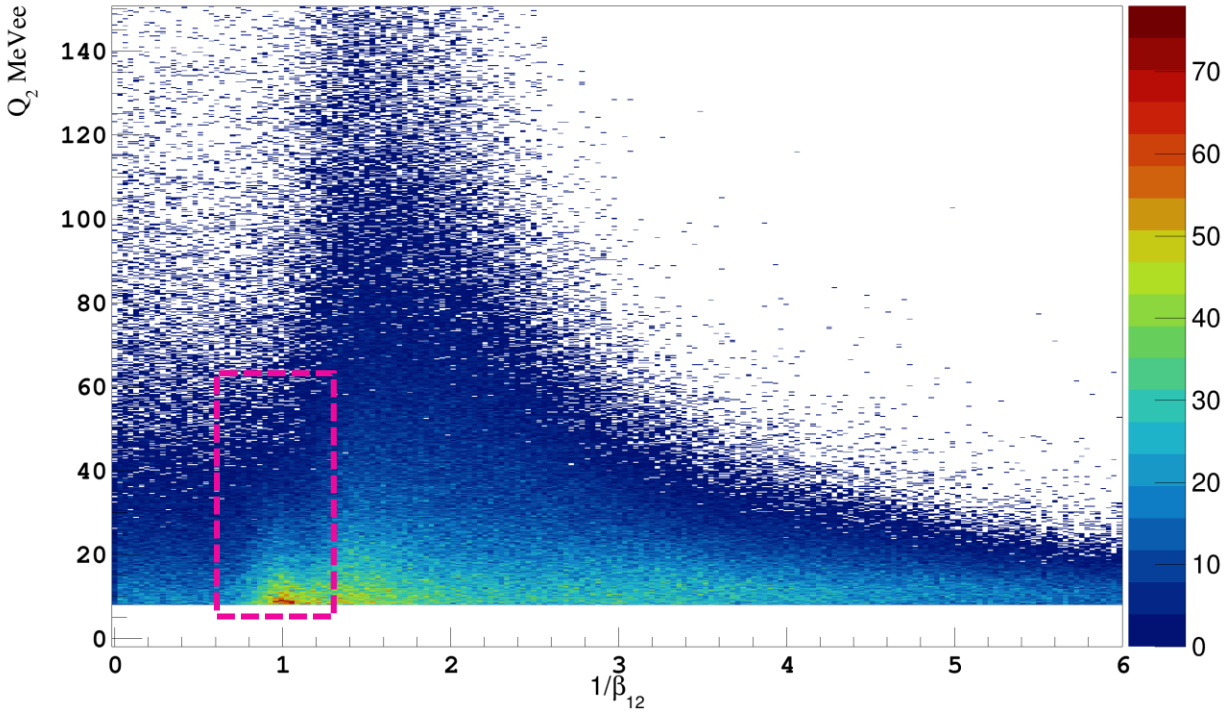
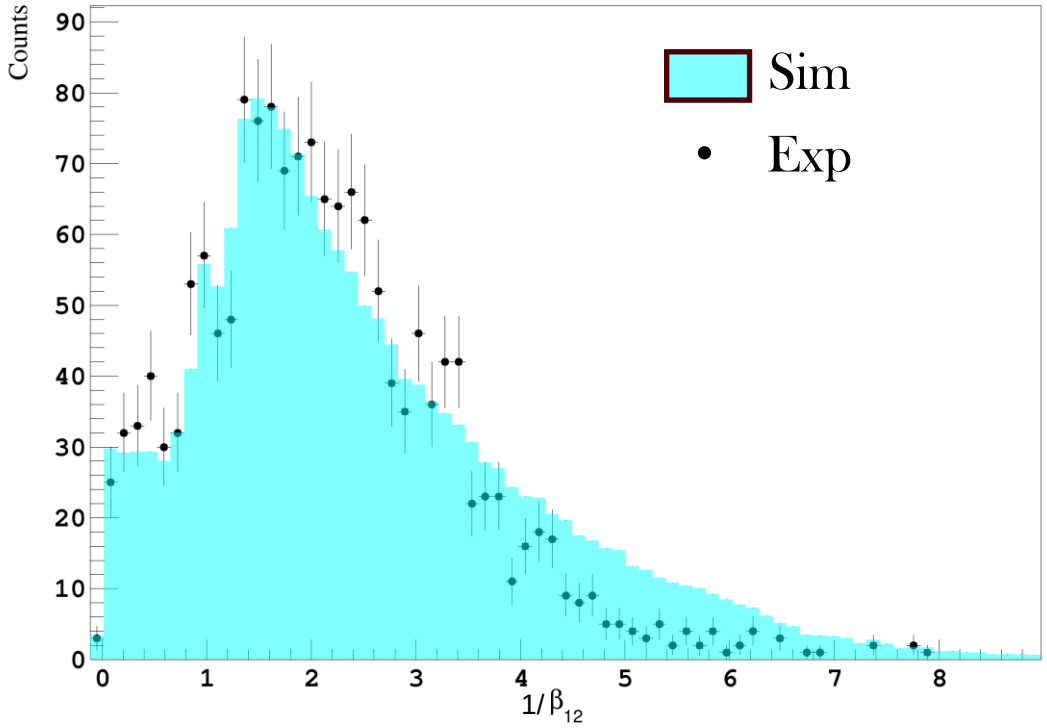
Simulated $1/\beta_{12}$ vs Energy transfer Q2 at second point



Exp vs Sim $1/\beta_{12}$



- Cut for $1/\beta_{12}$= 1 for secondary gamma
- Allowance for time resolution

Hints from 1 – Neutron simulations

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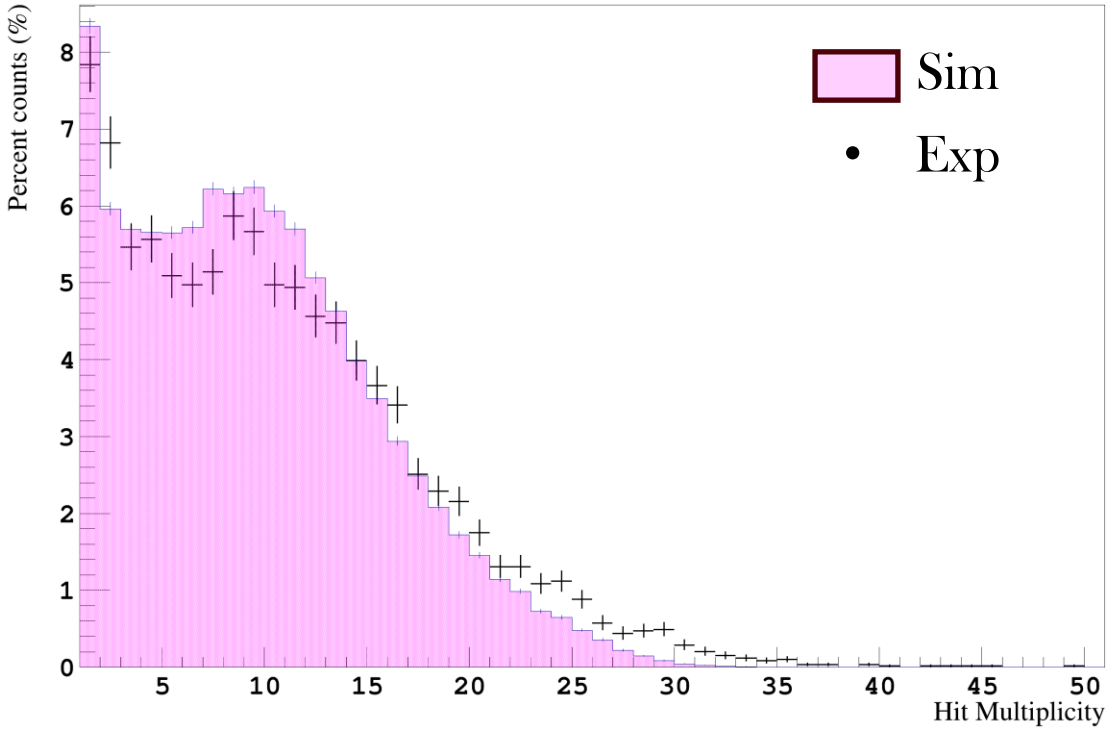
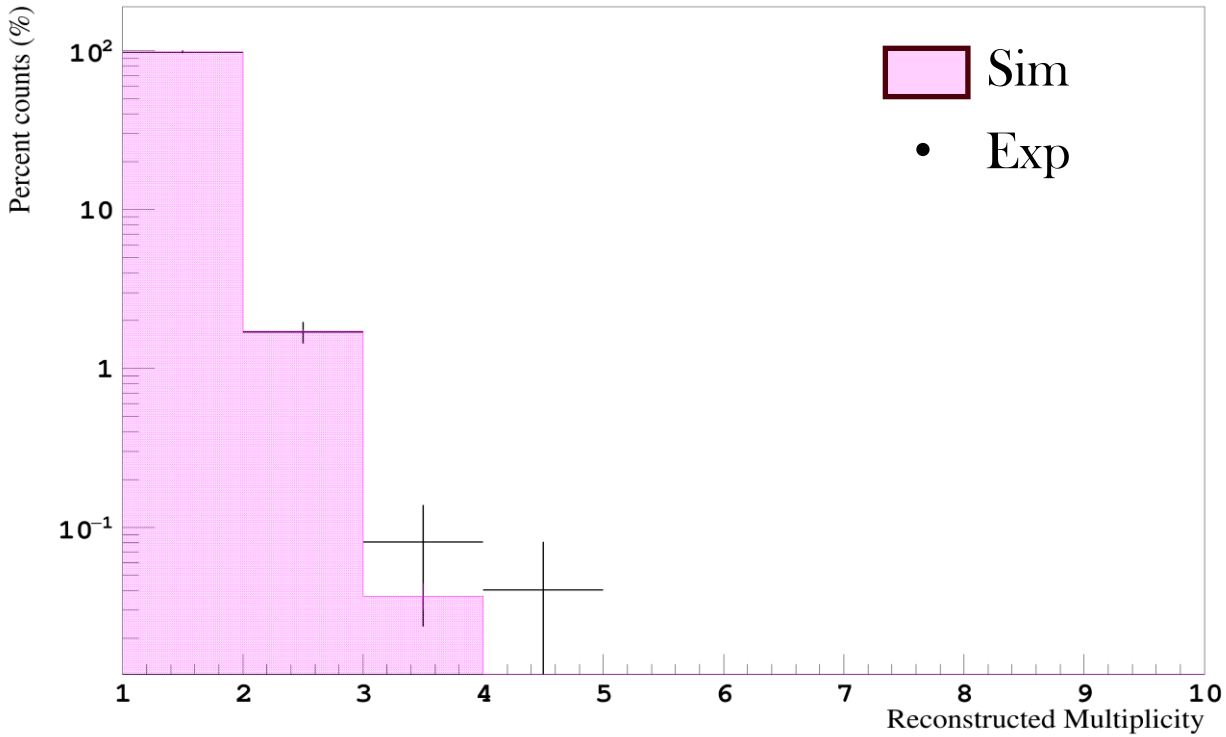
Sim vs Exp hit multiplicity (before reconstruction)



Sim vs Exp multiplicity after reconstruction



2 – Neutron simulations

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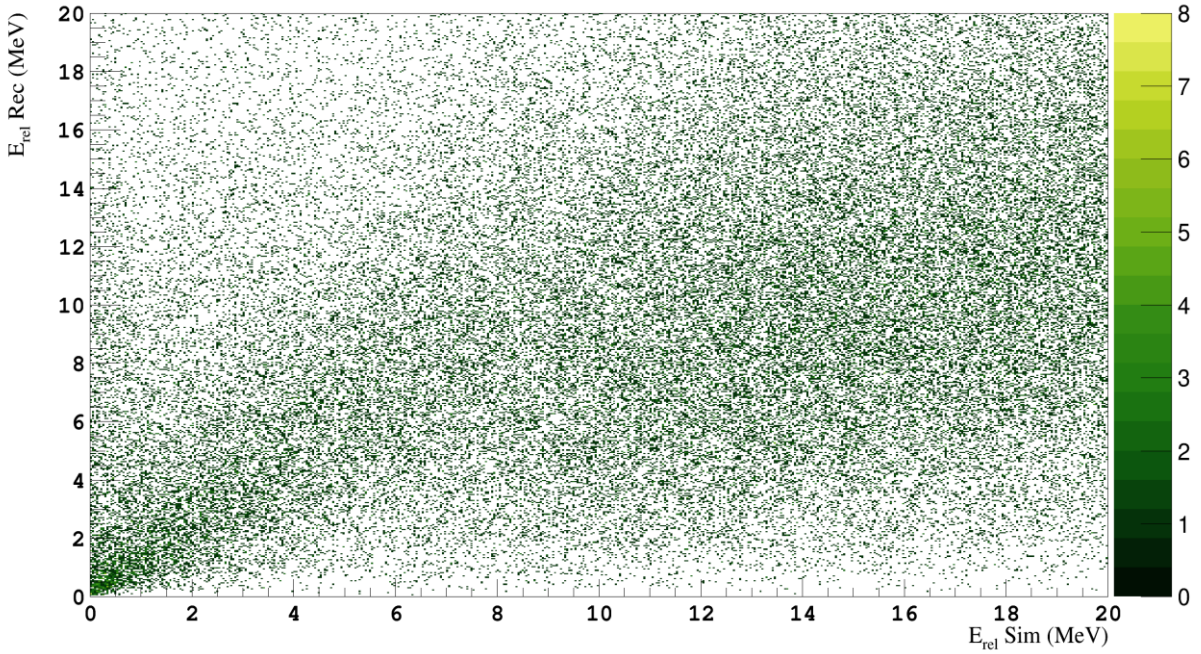
What does crosstalk look like in terms of relative energy?

2 – Neutron simulations

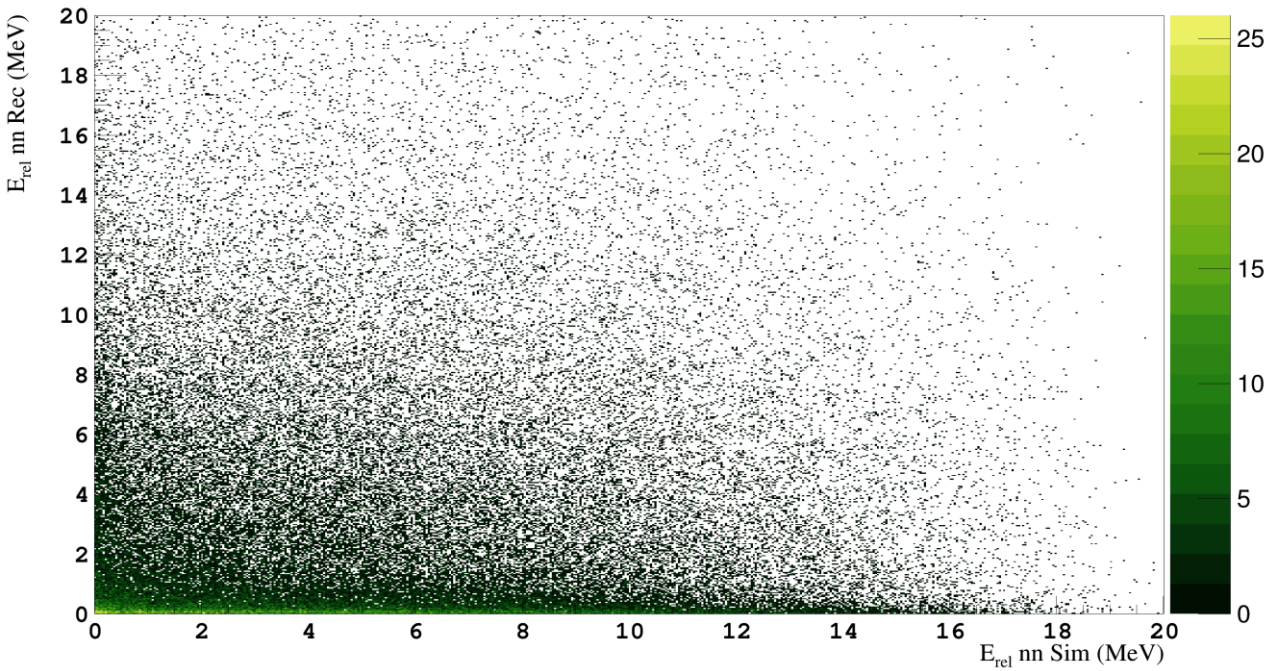
What does crosstalk actually look like in relative energy terms?

From uniform E_{rel}F + 2n distribution 0-20 MeV simulation :

Simulated vs Reconstructed F+2n E_{rel}



Simulated vs Reconstructed nn E_{rel}



2 – Neutron simulations

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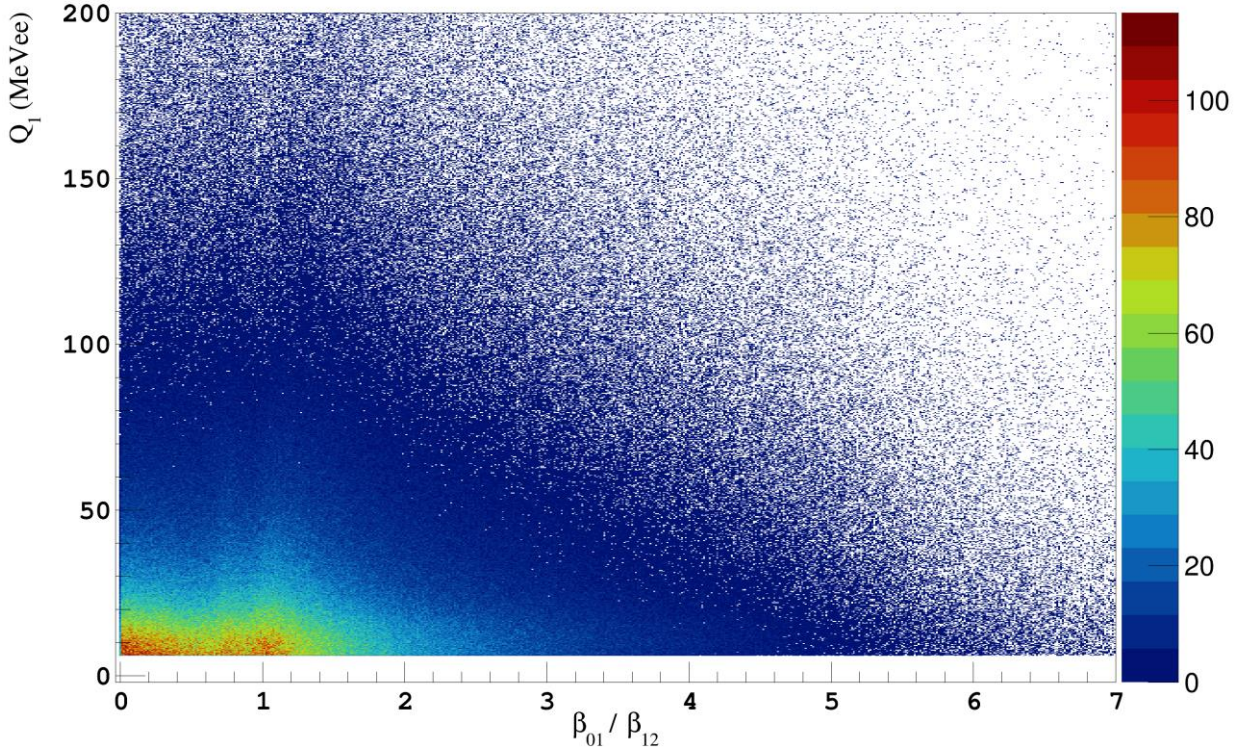
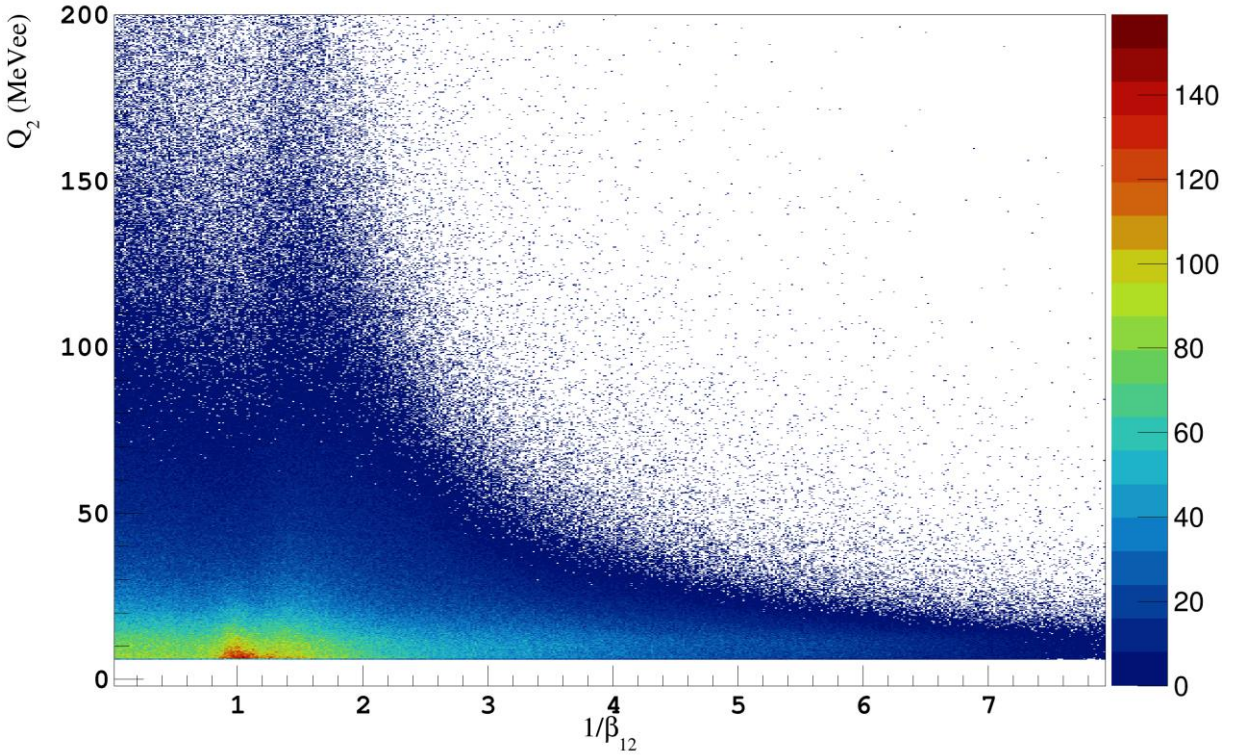
Velocity distribution plots

Simulated β_{01}/β_{12} vs Energy transfer Q1 at first point



Simulated $1/\beta_{12}$ vs Energy transfer Q2 at second point



2 – Neutron simulations

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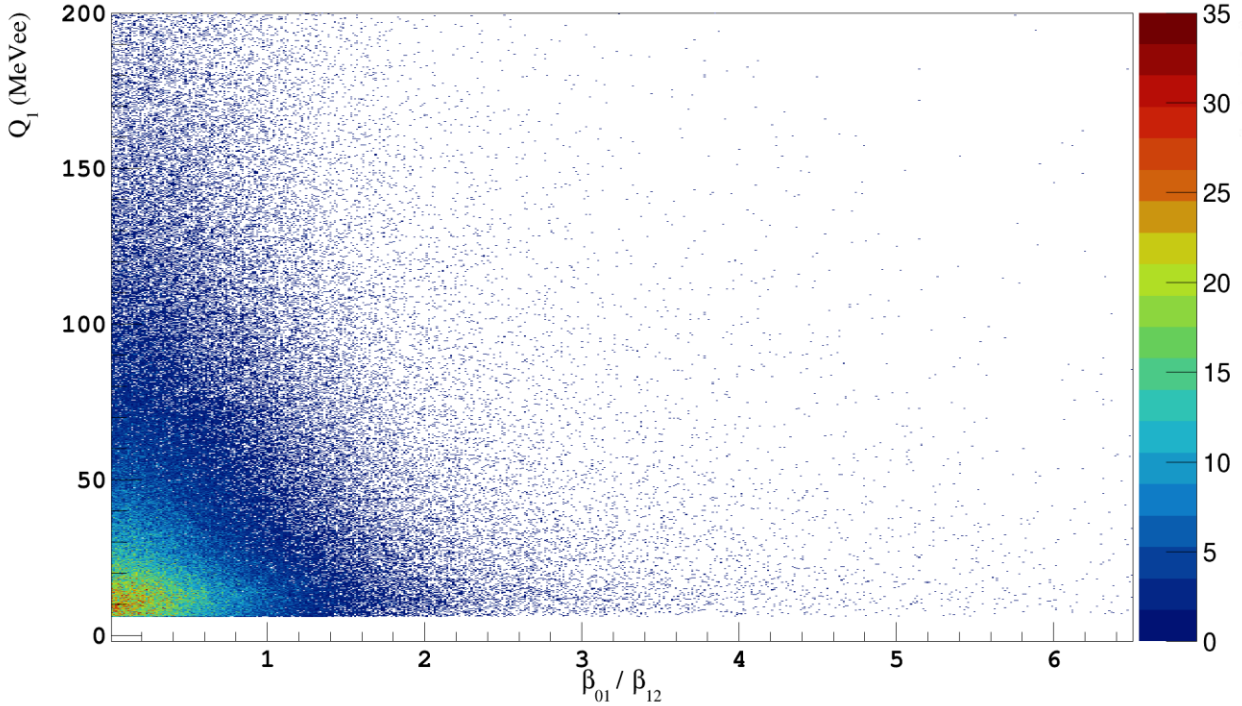
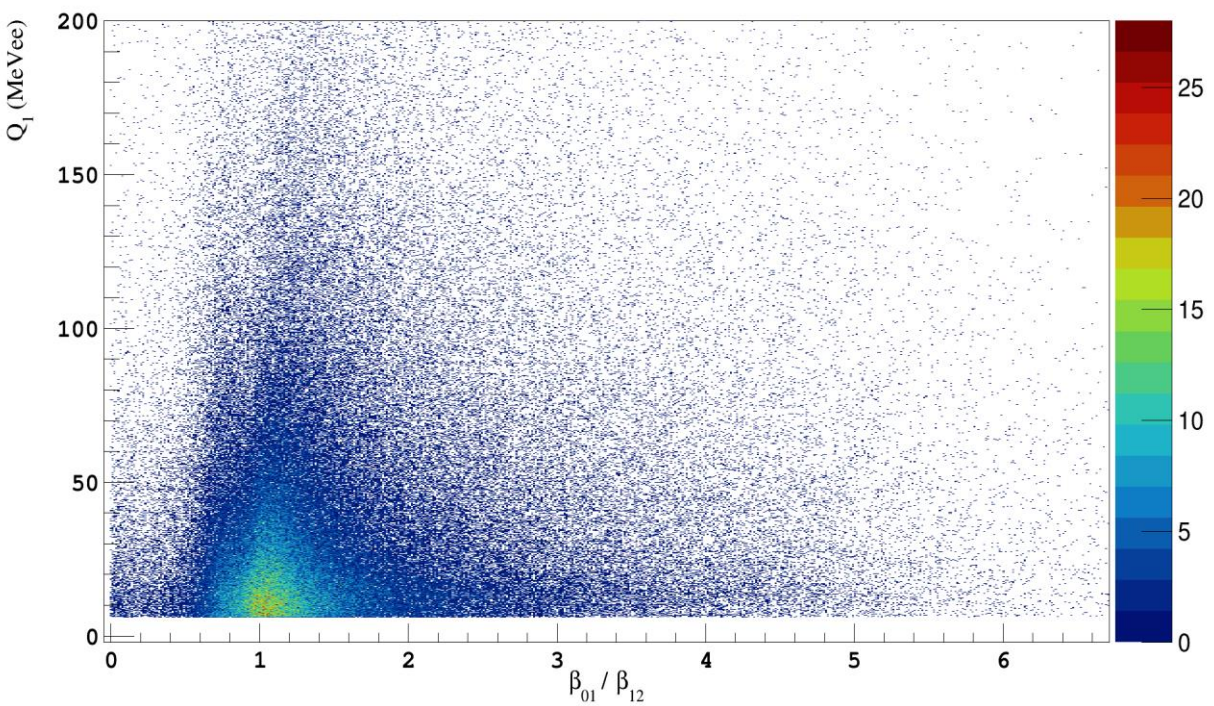
Velocity distribution plots

Simulated β_{01}/β_{12} vs Energy transfer Q1 at first point for two well identified neutrons



Simulated β_{01}/β_{12} vs Energy transfer Q1 at first point for cross talk



2 – Neutron simulations

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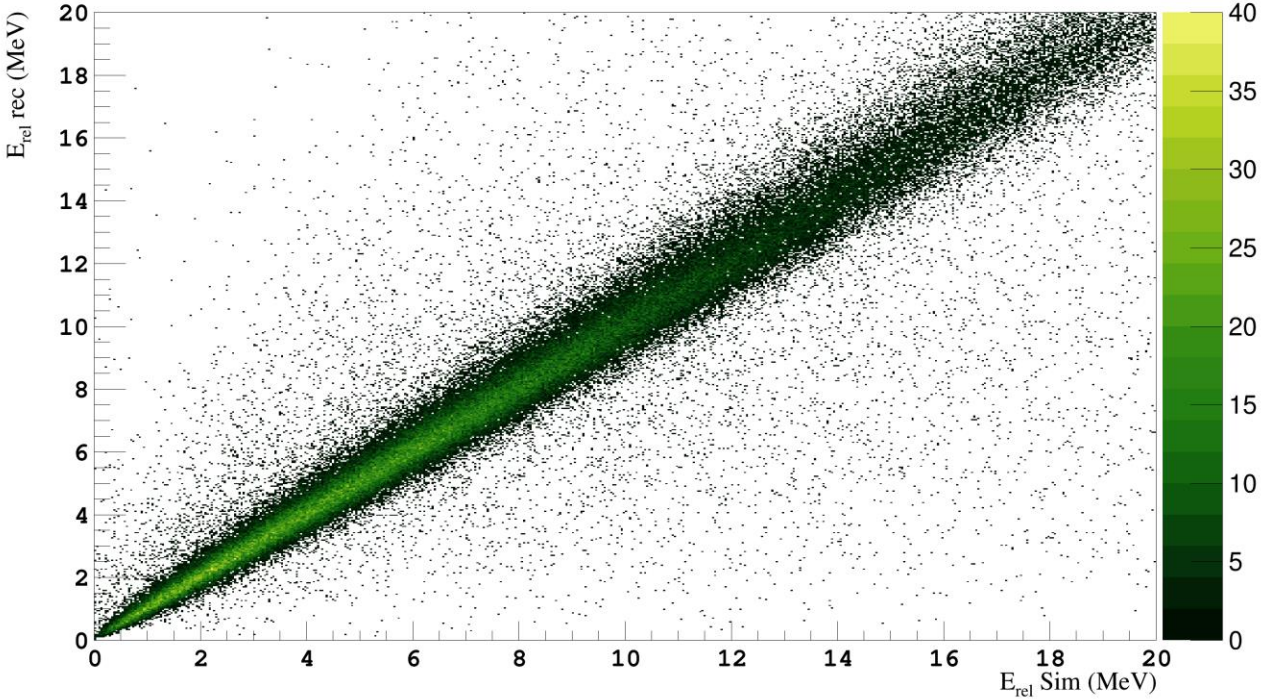
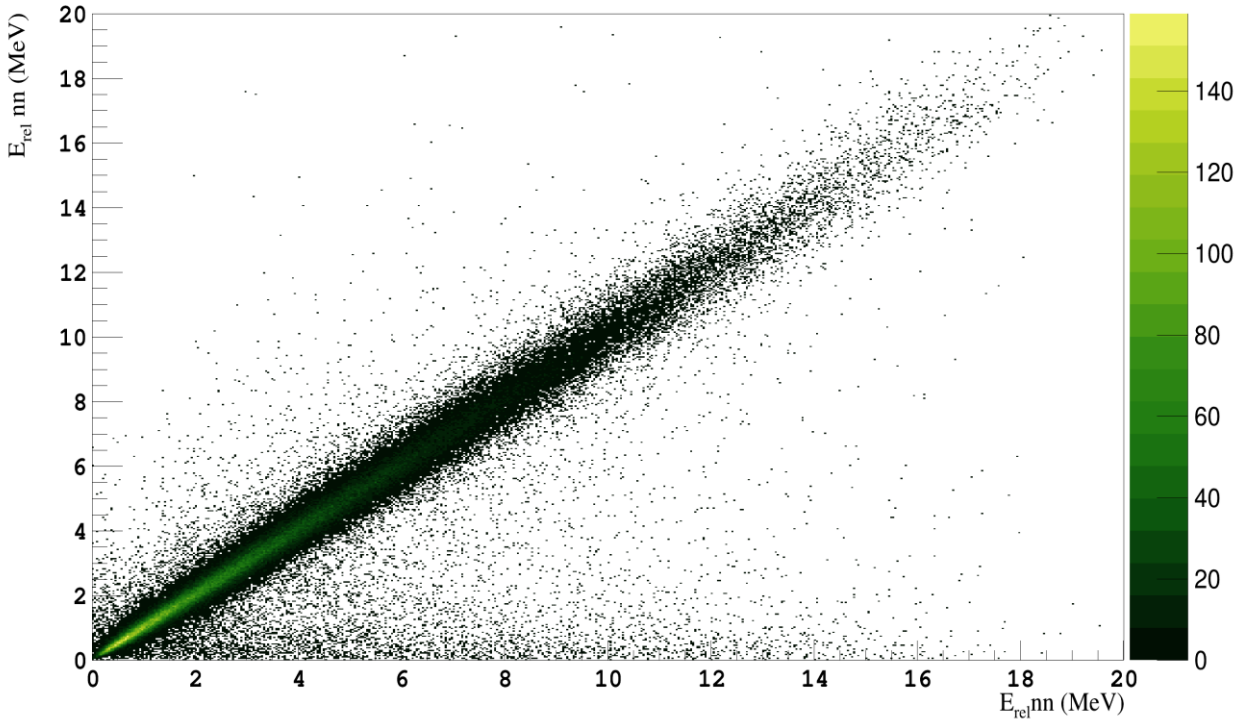
After reconstruction…

Simulated vs Reconstructed F+2n E_{rel}



Simulated vs Reconstructed nn E_{rel}

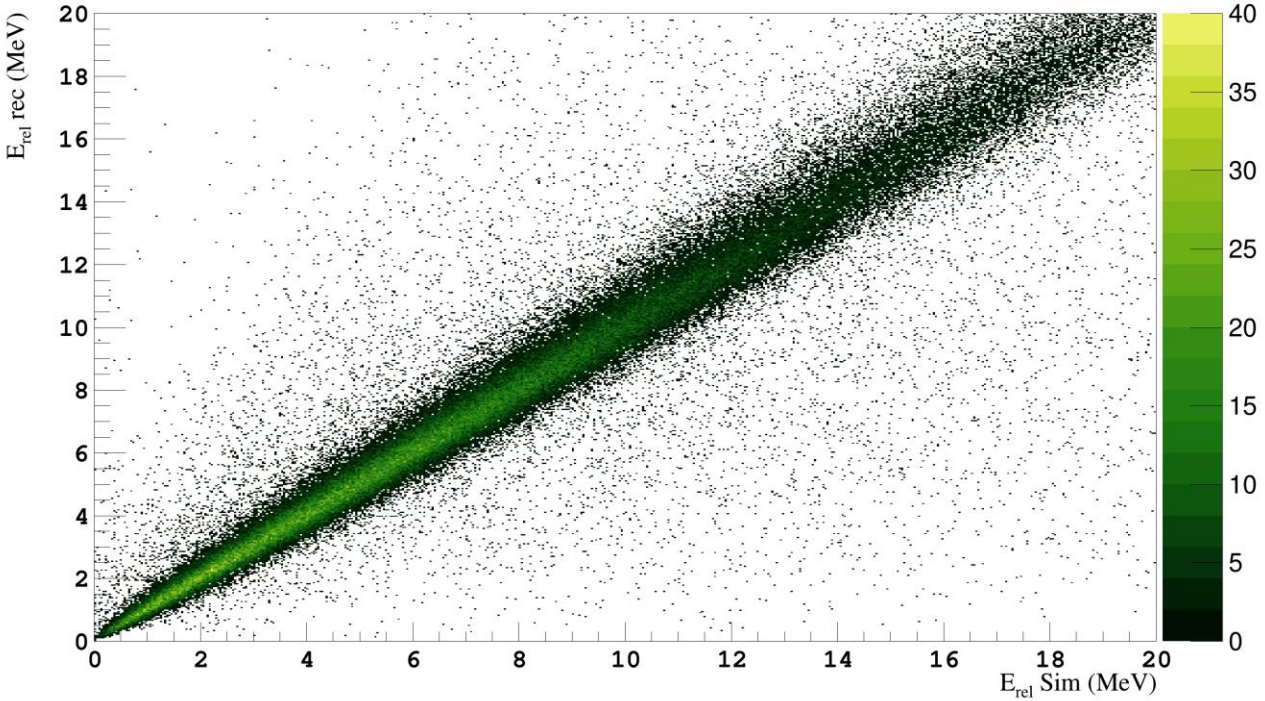


- Good correlation between simulation and reconstruction for both F+2n and nn E_{rel}
- Small amount of crosstalk remain ~ 4%

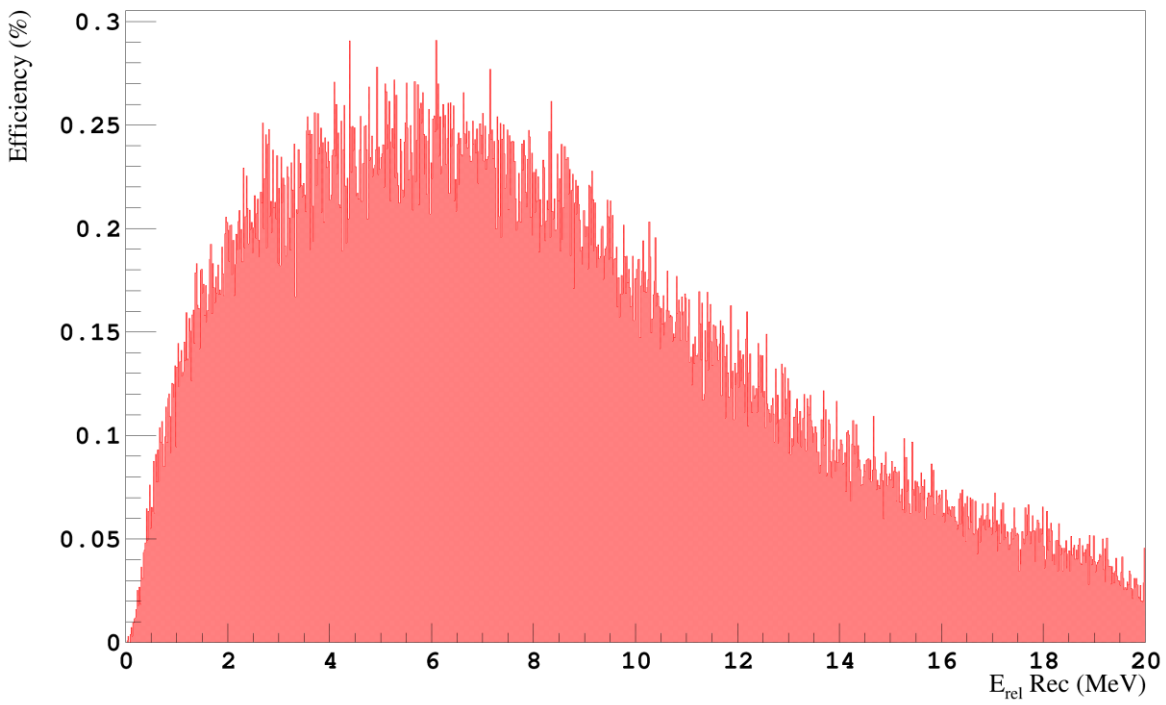
2 – Neutron simulations

After reconstruction…

Simulated vs Reconstructed F+2n E_{rel}



Efficiency Distribution



- Good correlation between simulation and reconstruction for both F+2n and nn E_{rel}
- Small amount of crosstalk remain ~ 4%
- Efficiency distribution

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So what about Experiment?

So what about Experiment?

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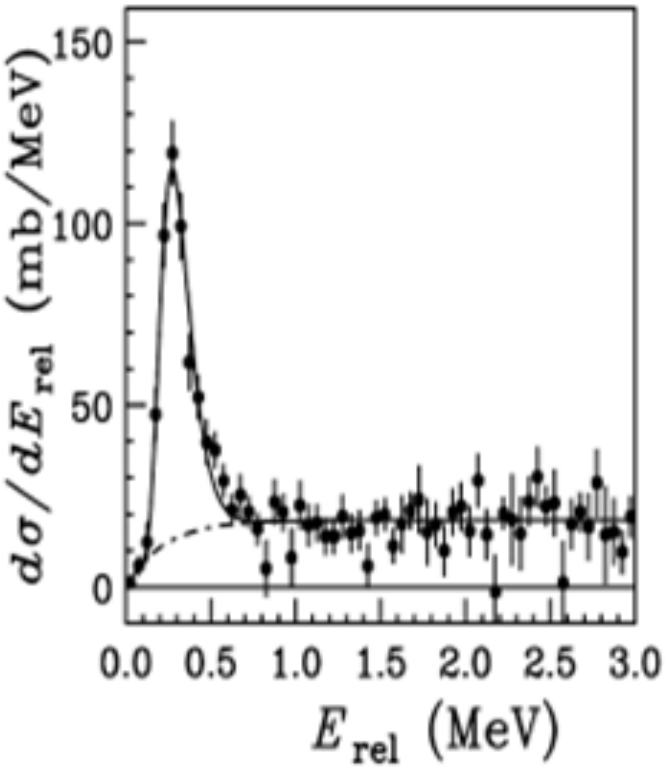
- We take the case for ^{15}B (-1p) ^{12}Be + 2n
- Narrow resonance at ~ 280 keV below 1n threshold
- Previously only published with inelastic scattering



T. Sugimoto et al. PLB 654, 160 (2007)

2 – Neutron reconstruction

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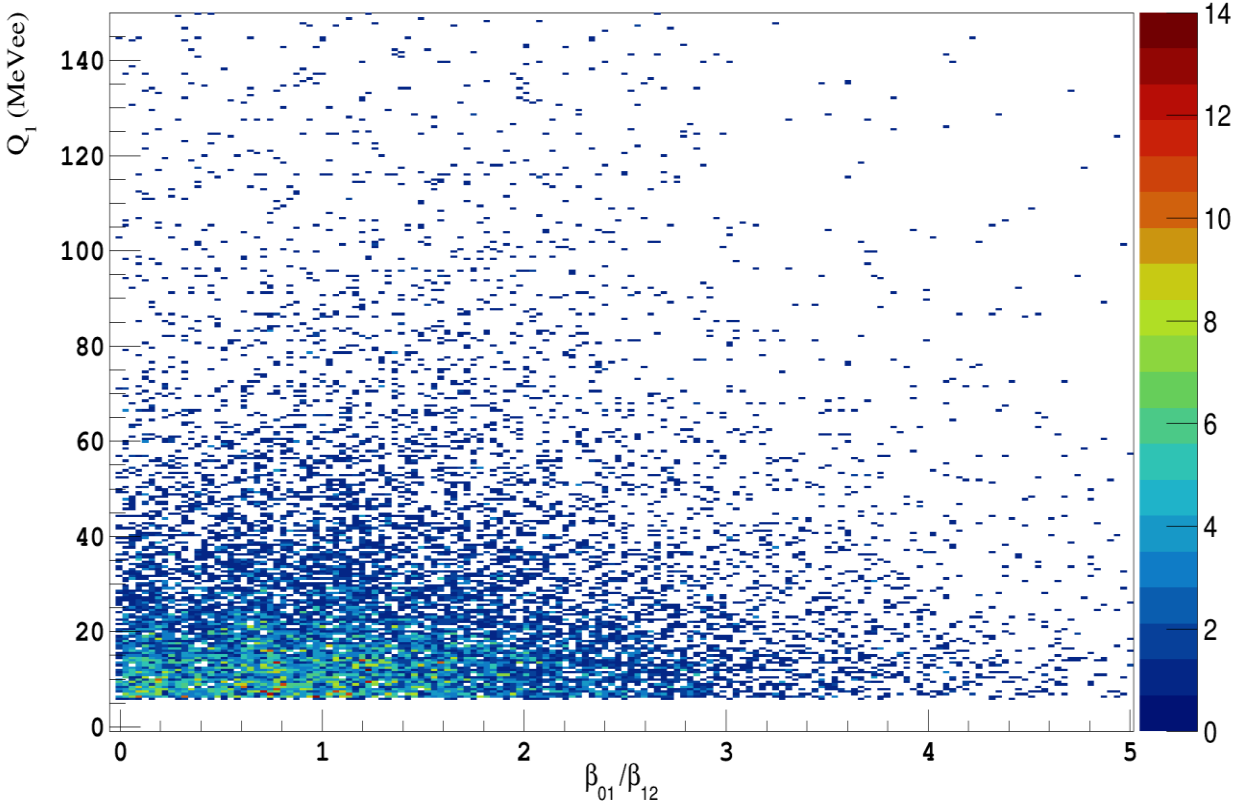
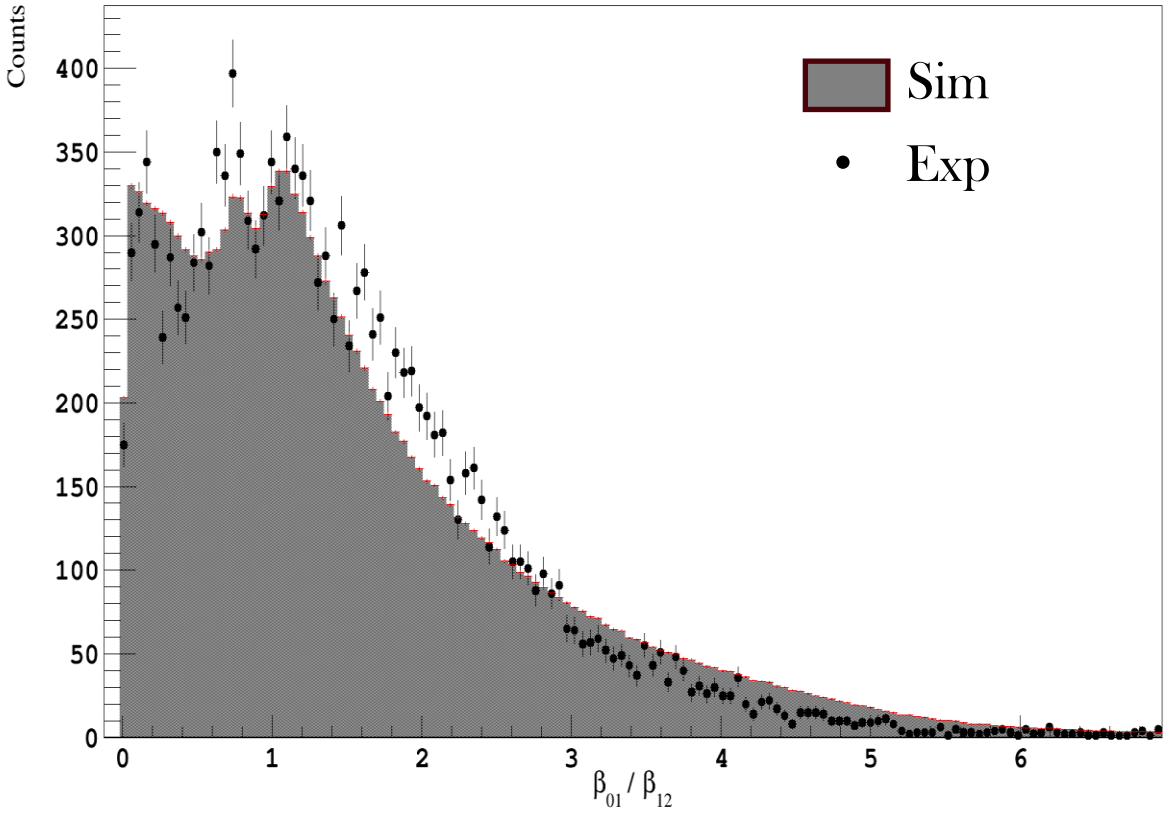
Velocity distribution plots

Experimental β_{01}/β_{12} vs Energy transfer Q1 at first point



Exp vs Sim β_{01}/β_{12}



2 – Neutron reconstruction

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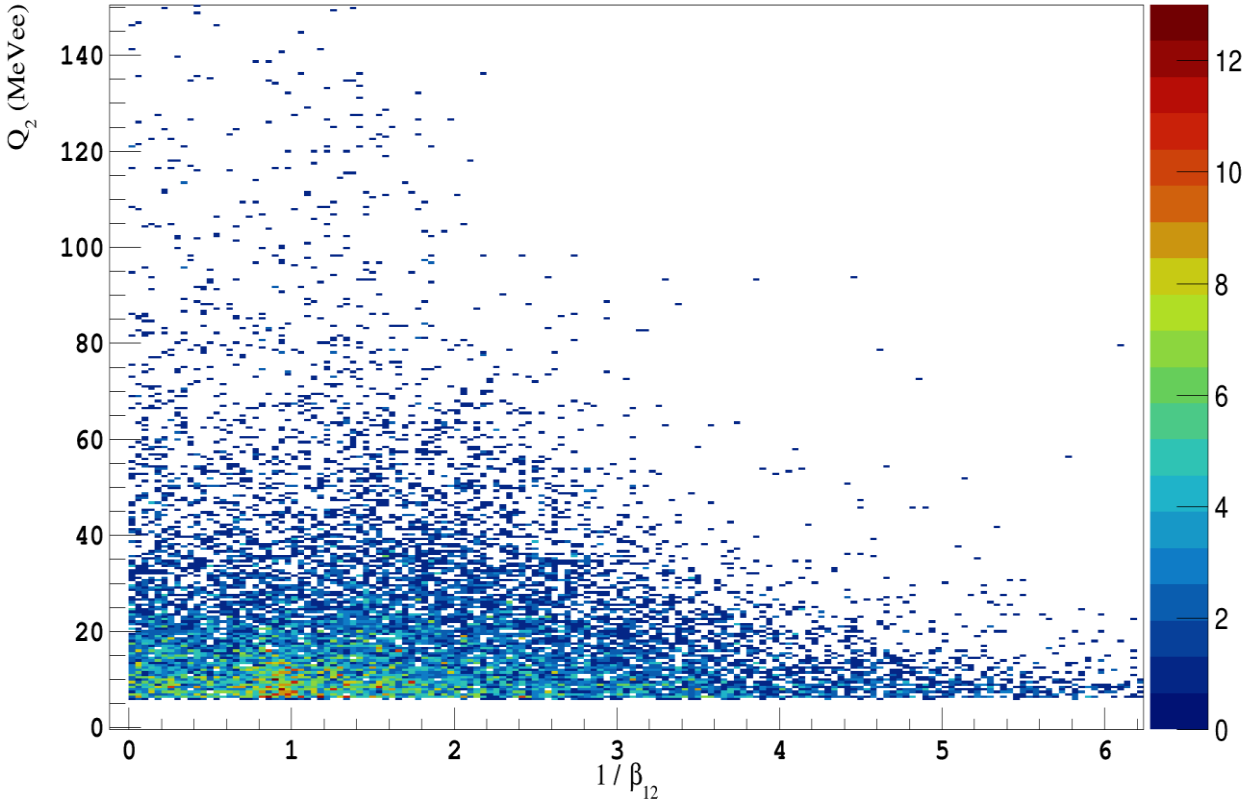
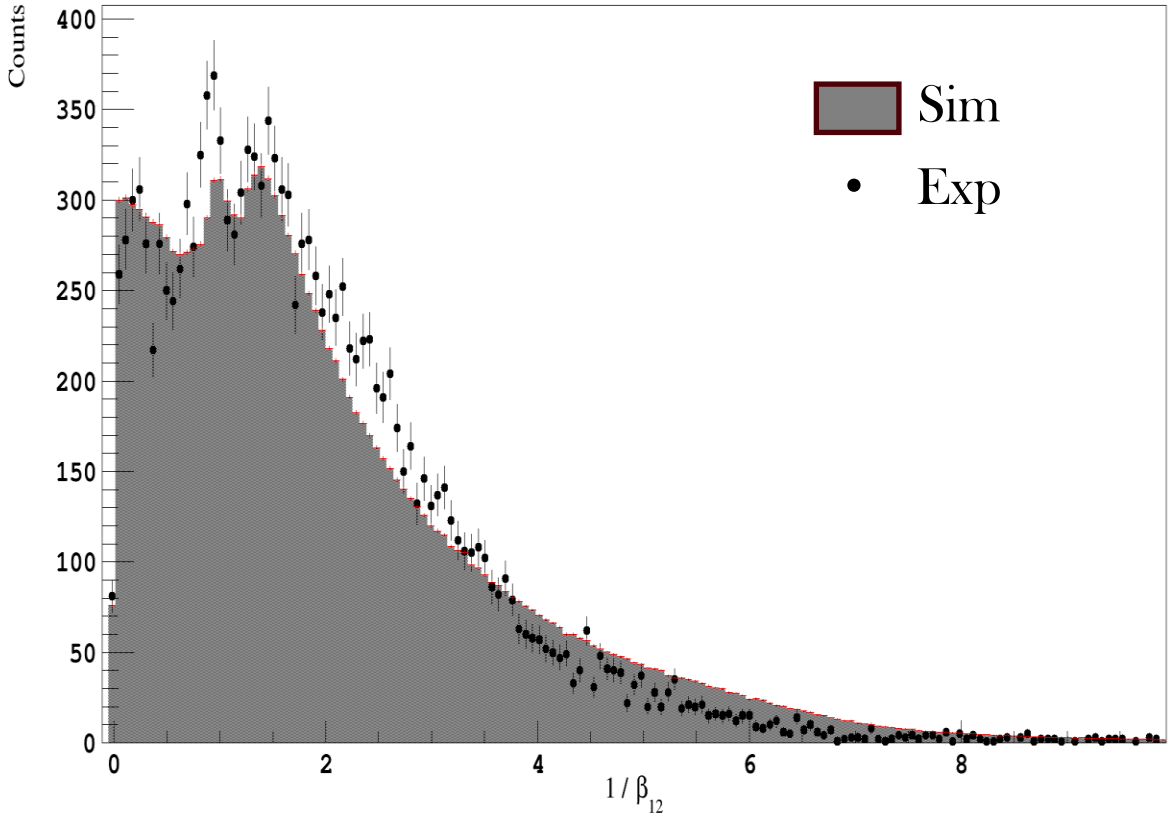
Velocity distribution plots

Experimental $1/\beta_{12}$ vs Energy transfer Q1 at first point



Exp vs Sim $1/\beta_{12}$



^{15}B (-1p) ^{12}Be + 2n

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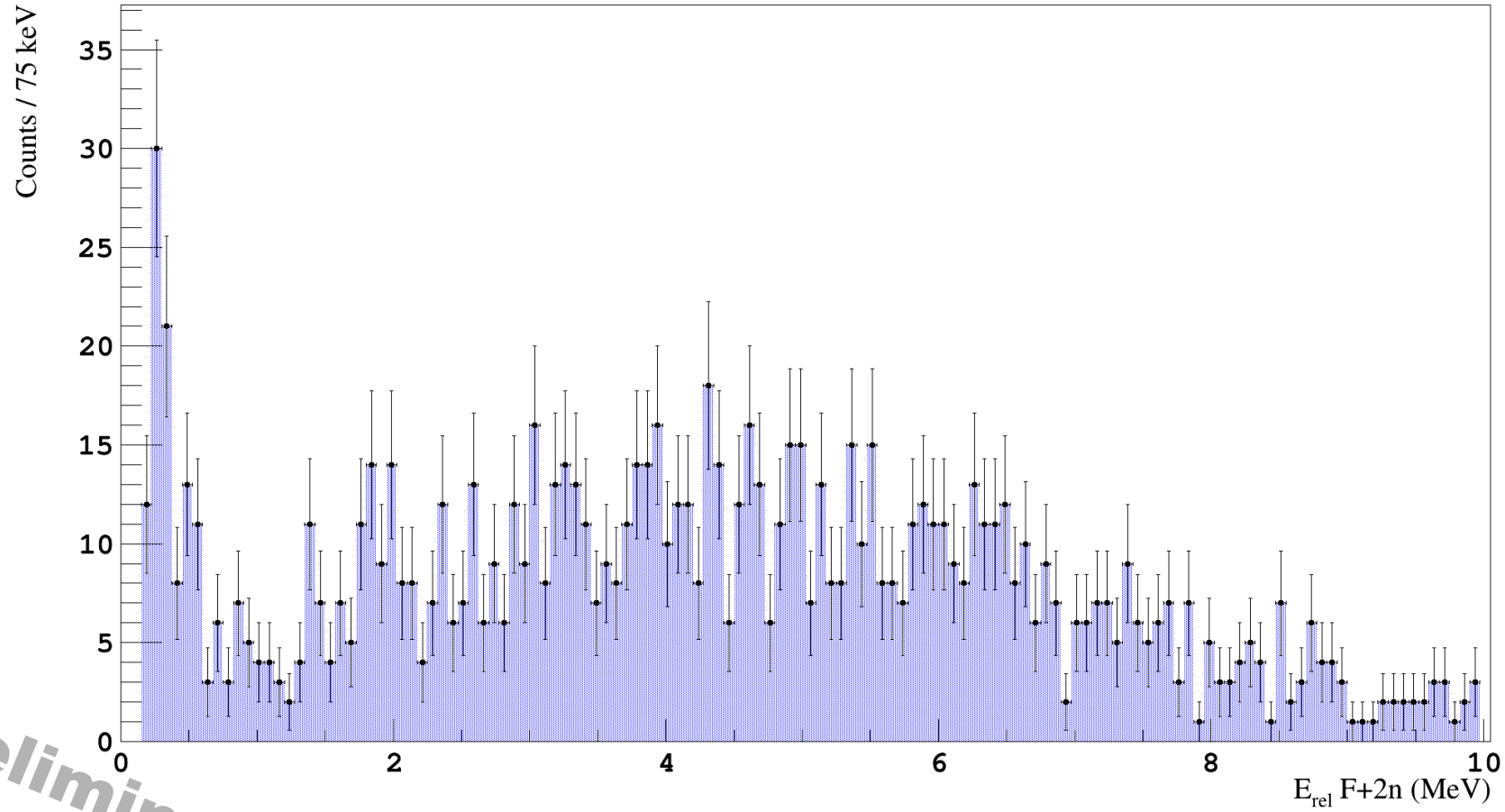
Reconstructed Frag + 2n E_{rel} distribution



Preliminary!!!

^{15}B (-1p) ^{12}Be + 2n

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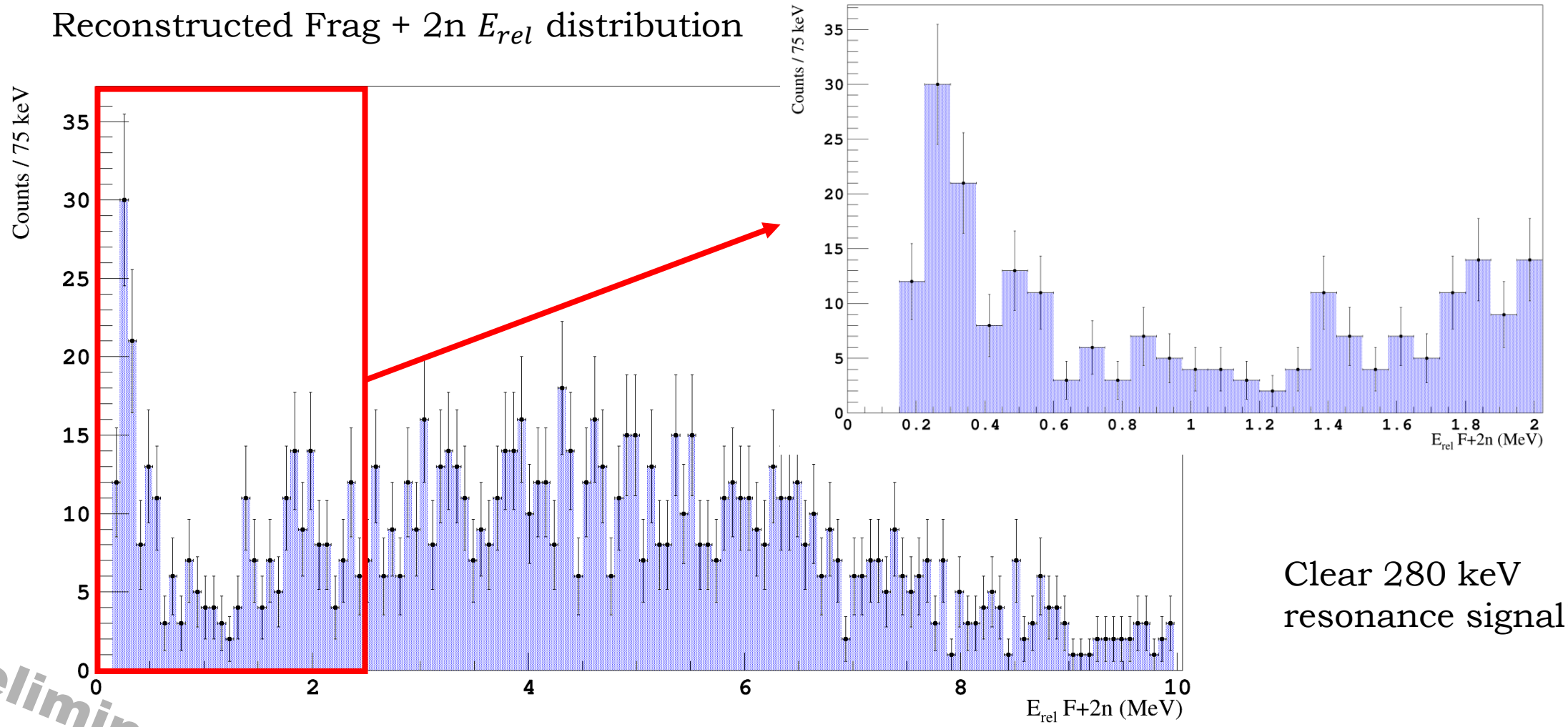
Reconstructed Frag + 2n E_{rel} distribution



Clear 280 keV resonance signal!!

Preliminary!!!

^{15}B (-1p) ^{12}Be + 2n

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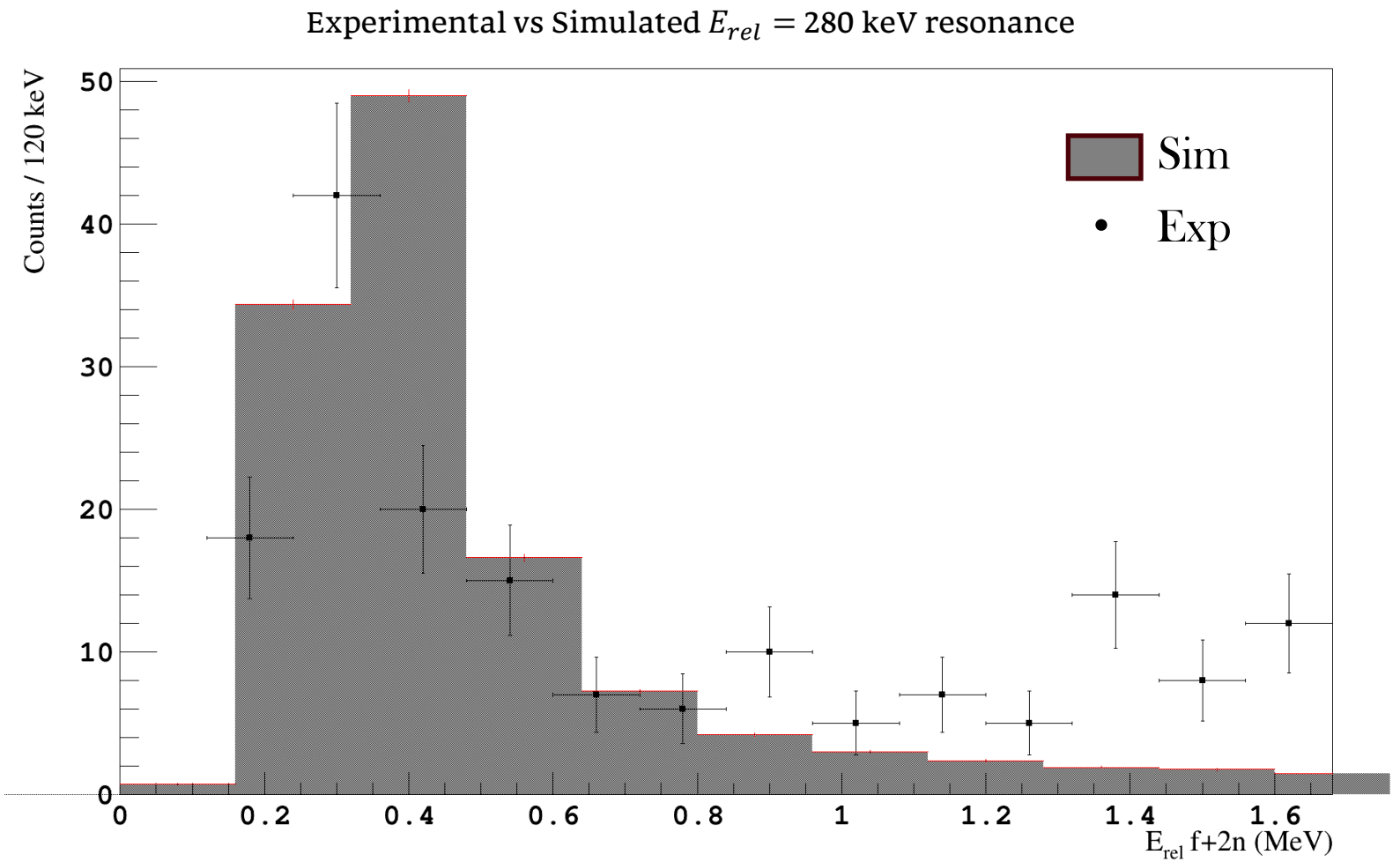
1st test comparison of simulated and experimental data



Preliminary!!!

OutLook

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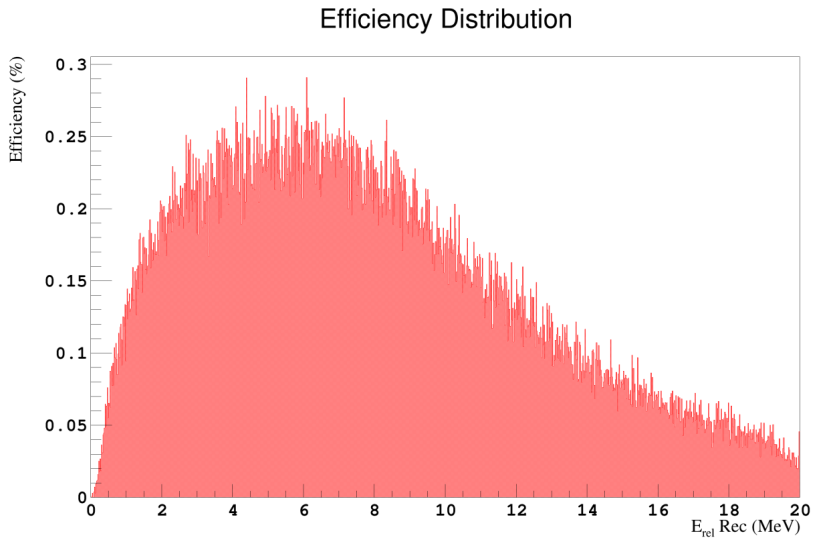
- First Frag + 2n Erel reconstruction
- Need to further refine method
- Use proper simulation parameters, time/energy resolution etc.
- Problems
  - Discrepancy in energy distribution between simulation and experiment
  - Low efficiency and large crosstalk at low relative energies
- Test alternative methods: TDR?



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Thank you