

# Neutron background from the beam dump

## Systematic studies

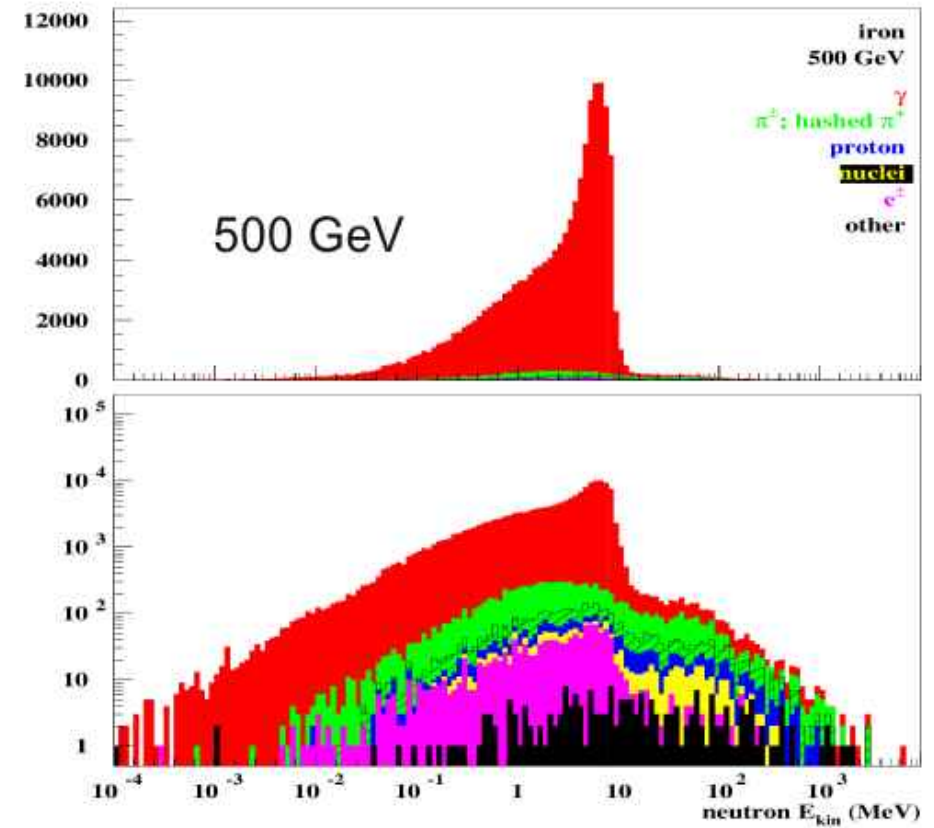
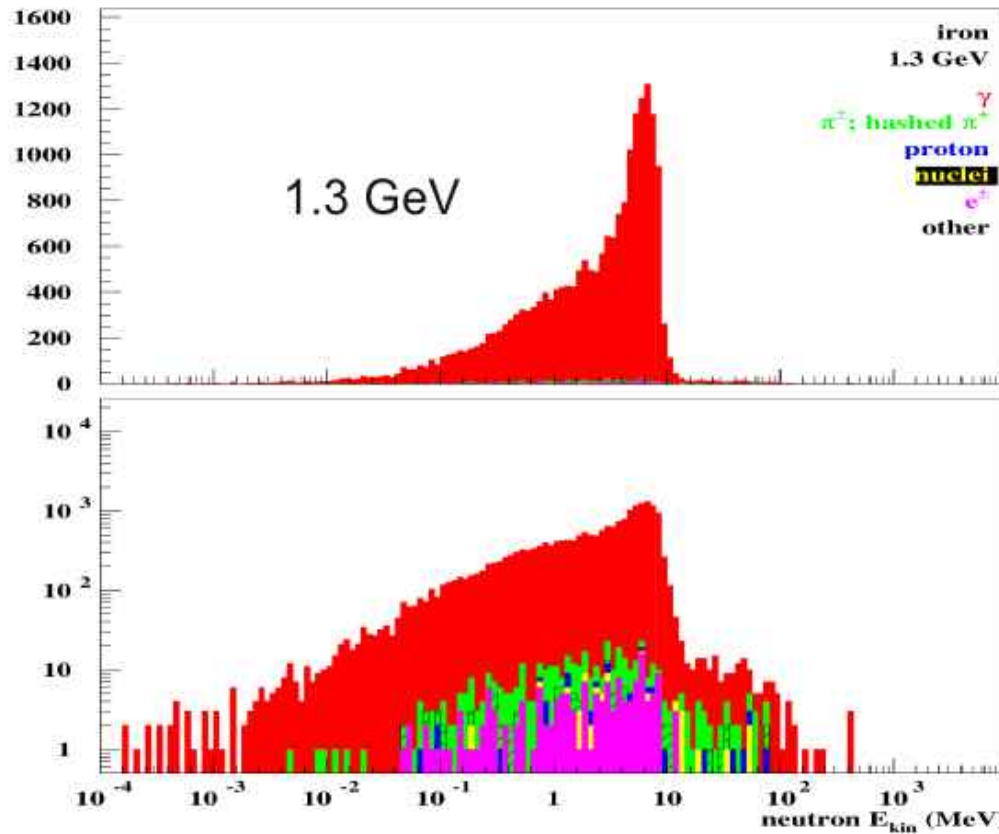
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LLR-Ecole Polytechnique

FJPPL-FKPPL workshop  
LAL, March 19-20, 2012

# Outline

- Neutron background measurements
- Access detector responses to neutrons (December 2011 measurements)
- Evaluate systematic effects sources
- Extract the measured neutron production
- Compare to GEANT4
- Conclusion

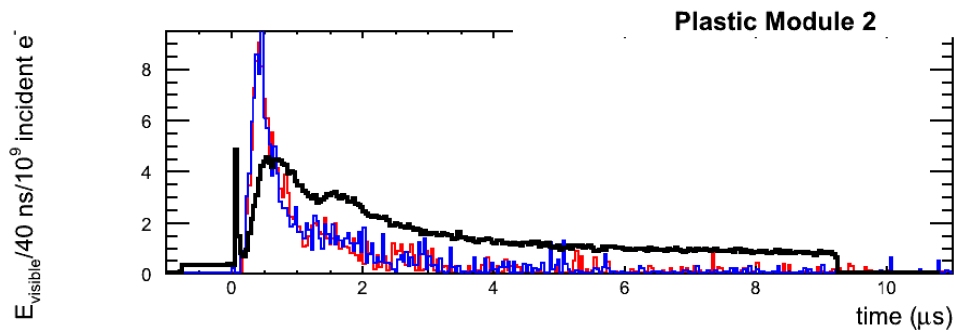
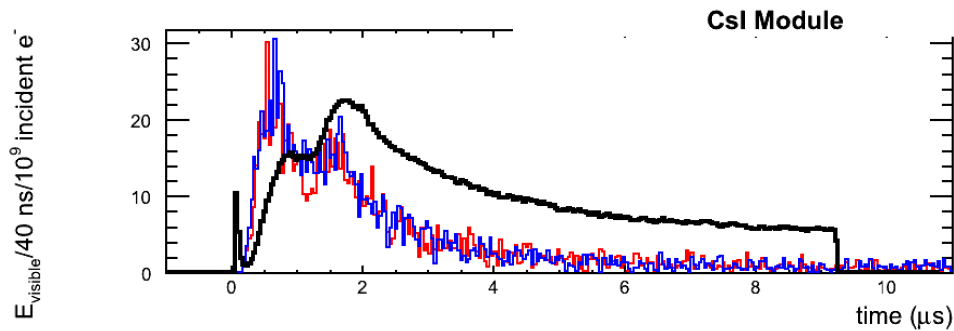
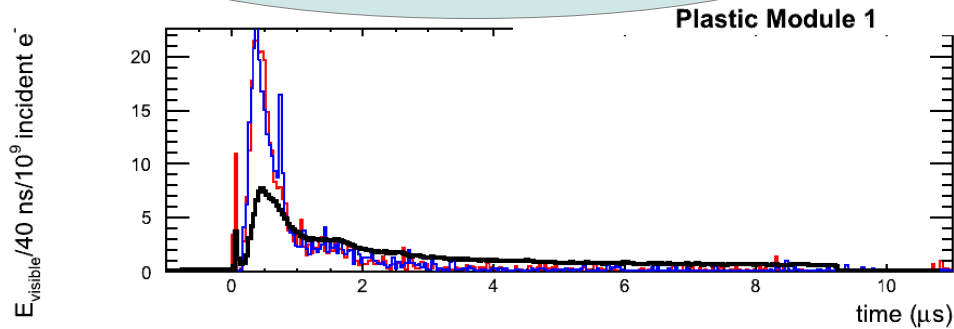
# Neutron production @ different e-incident energy on iron



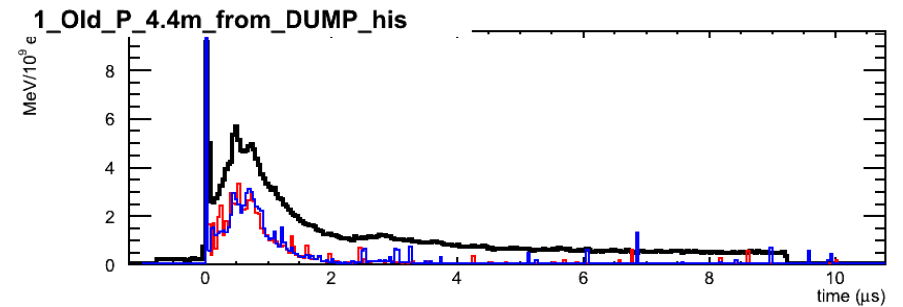
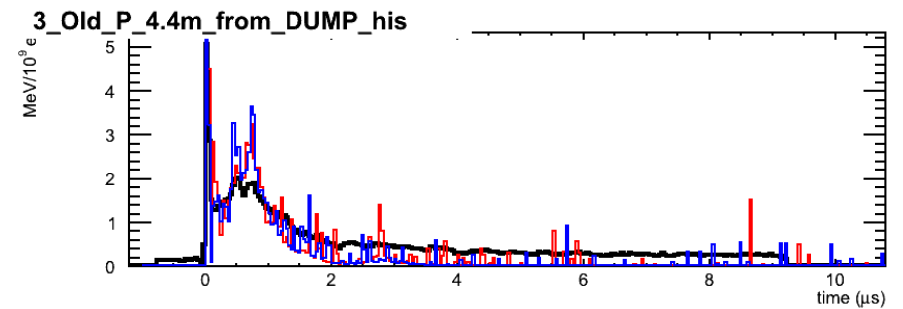
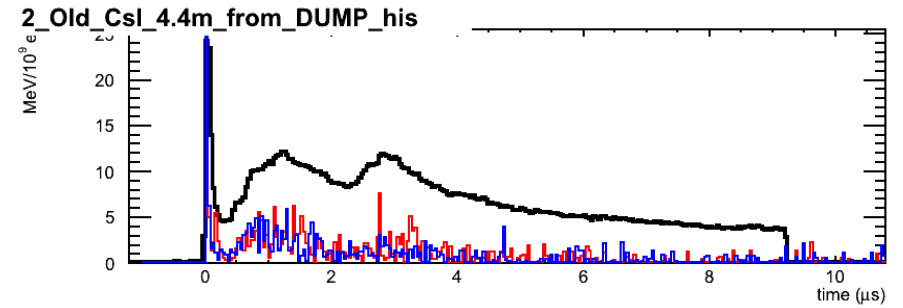
- Most of the neutrons are produced via photo-nuclear effect
- Produced neutron kinetic energy mainly  $< 10$  MeV
- ATF2 can produce the major part of the neutron spectrum accessible at 500 GeV

# Previous measurements

Mai 2010 Data : Dump right side



Nov 2010 Data : 4.4m / Dump

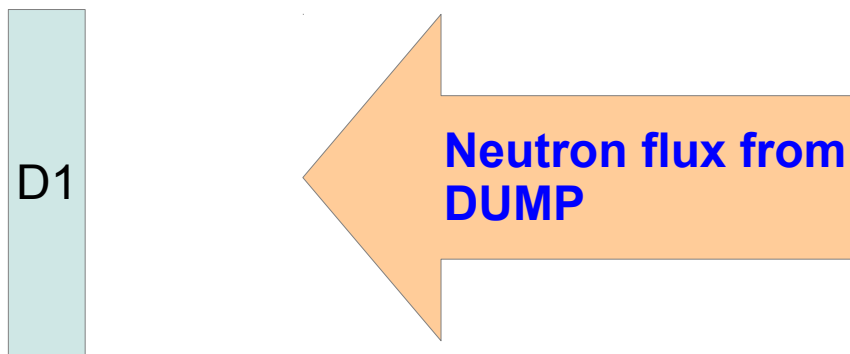


# Open questions concerning data/MC comparison

- Possible origins of the differences :
  - Neutron (**photo-**)production not well simulated ?
    - Could be tested by measuring the most energetic neutrons which are the one who had **the less interactions inside DUMP.**
    - Very difficult to measure (due to E.M background), need precise knowledge of the DUMP hole geometry, materials
  - Neutron transport inside the DUMP ?
    - Tested by comparing G4/Data but strongly depends on neutron production
  - Detector response to neutrons ?
    - **Purpose of Dec 2011 Measurements**

# Detector response measurement principle

## First measurement :

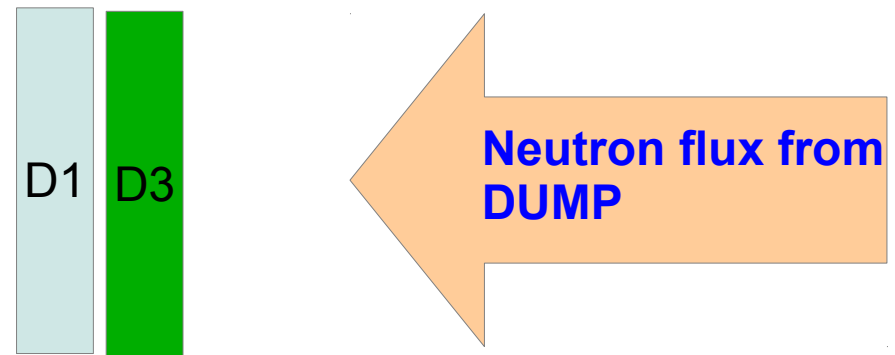


D1 signal :

$$S_1^I(t) = \phi(t)\varepsilon_1(t)$$

Neutron flux

D1 response



D1 signal :

$$S_1^{II}(t) = \phi(t)(1 - \varepsilon_3(t))\varepsilon_1(t)$$

Neutron flux

D1 response

D3 response

# Extract D3 response and neutron flux

$$\begin{aligned} R_1(t) &= \frac{S_1^I(t)}{S_1^{II}(t)} \quad \text{Ratio of D1 Responses} \\ &= \frac{\phi(t)(1 - \varepsilon_3(t))\varepsilon_1(t)}{\phi(t)\varepsilon_1(t)} \\ &= 1 - \varepsilon_3(t) \end{aligned}$$

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**Extract D3 response**

$$\begin{aligned} S_3(t) &= \phi(t)\varepsilon_3(t) \\ &= \phi(t)(1 - R_1(t)) \end{aligned}$$

**From D3 signal and  
D1 signal ratio**

$$\phi(t) = \frac{S_3(t)}{1 - R_1(t)}$$

**Extract neutron flux**

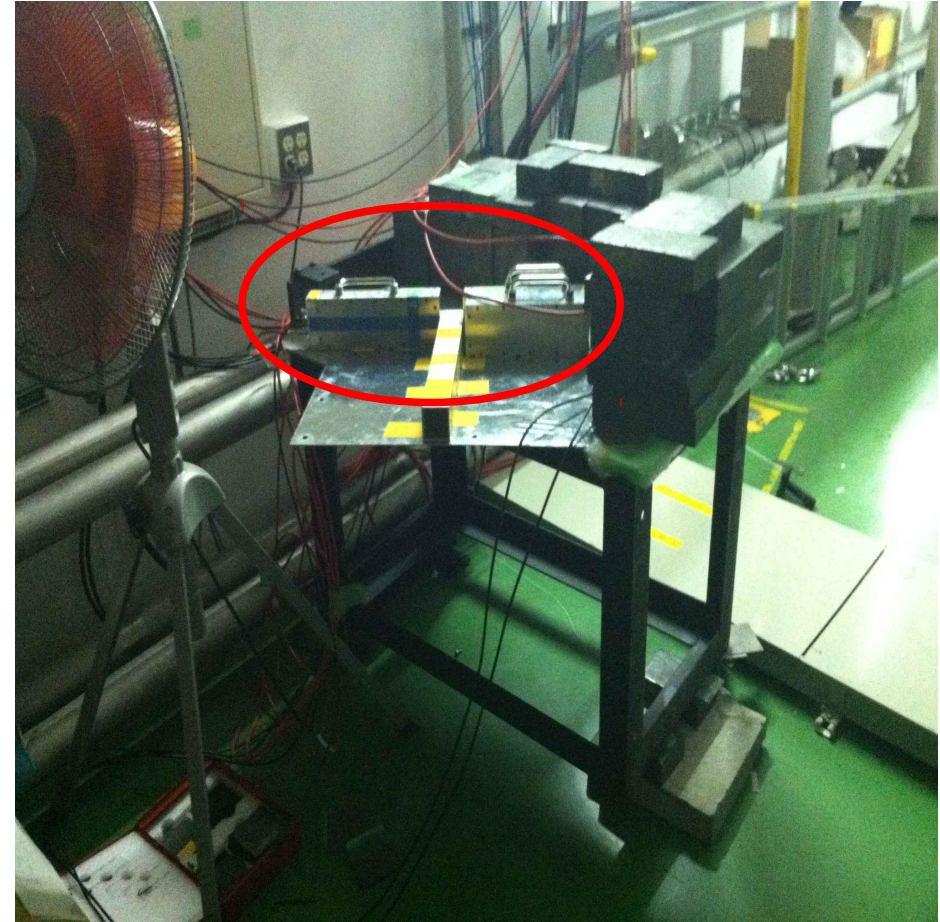


# December 2011 measurements

Dump right side



4.4m / Dump

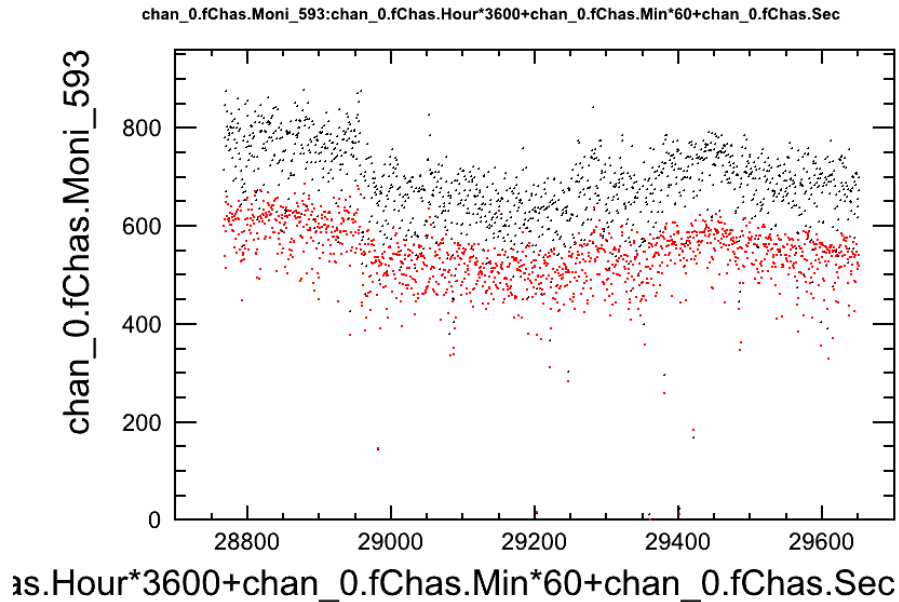




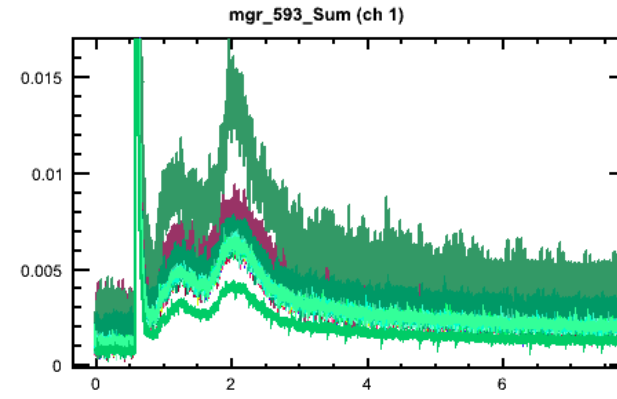
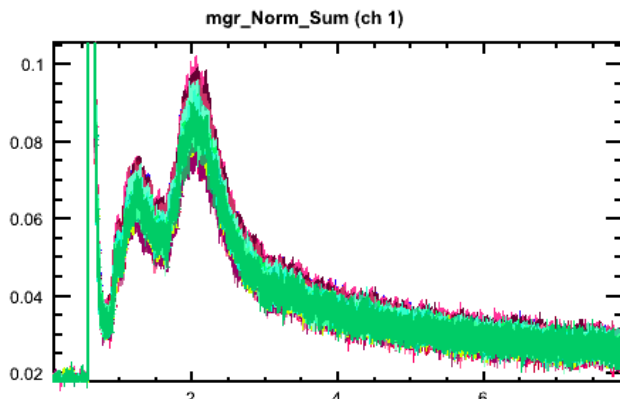
# Normalizations

- Different runs depending on the beam current entering the DUMP
  - Need to normalize using current entering DUMP
    - ICTDUMP
    - Taken from EPICS : `atf2_monitors[613]`
    - **Need error on that quantity**
  - Use modules sensitive to neutron signal :
    - When measuring from **right dump use modules @4m from dump to normalize**
    - **But only use neutron part of the WF signal.** E.M part of the signal might have different dependence.

# Beam current vs Deposited charge

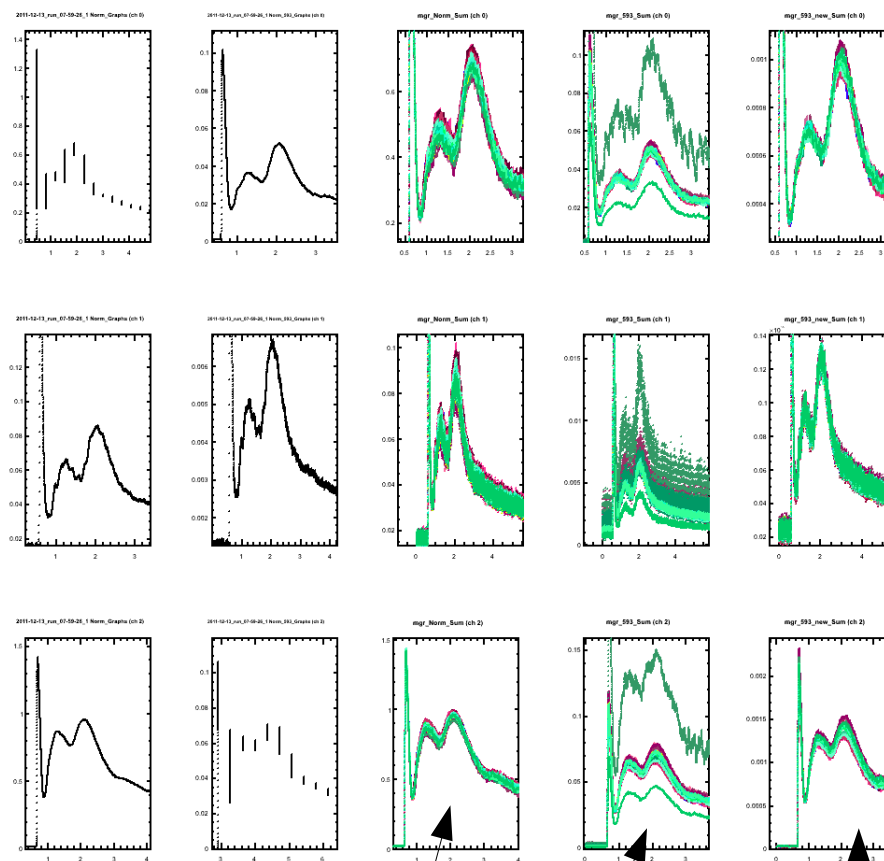
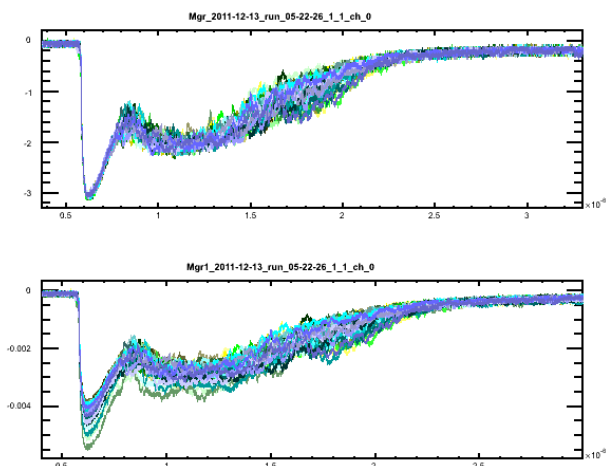


- Seem ok : same tendency
- Normalize using beam current might be reasonable
- But :



Let's try to normalize using the average beam current @ each 50 triggers

# Beam current vs Deposited charge



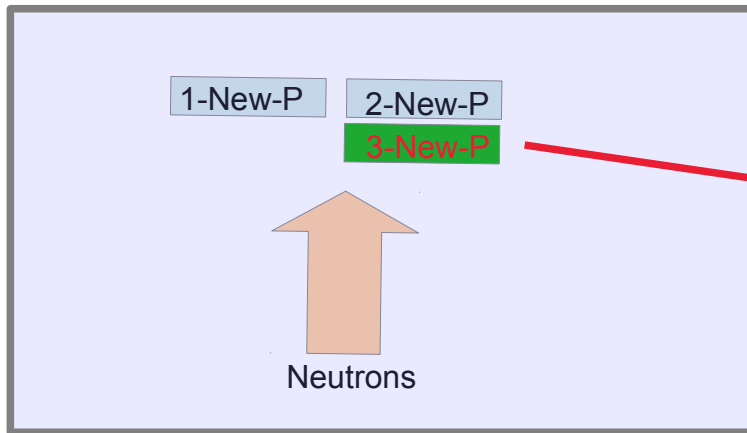
- Normalization seems to enhance the RMS artificially
- Could be the noise from DUMP current monitor
- Proposed solution :
  - Normalized using the mean beam current
  - For each 50 triggers

Non normalized  
(just by N trigger).

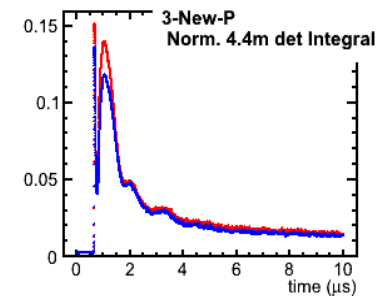
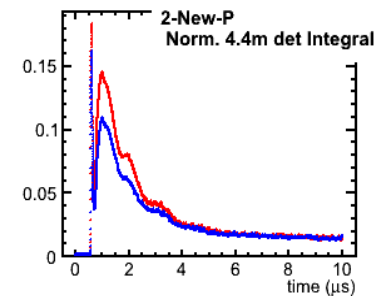
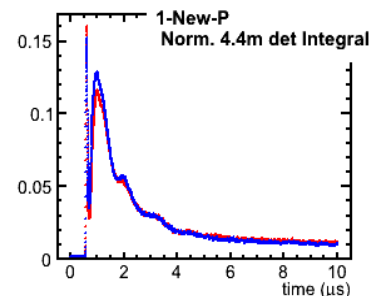
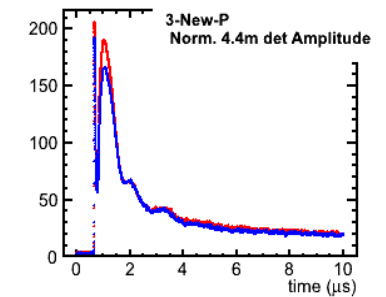
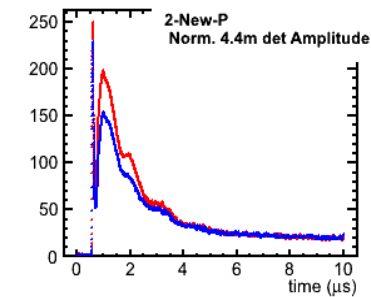
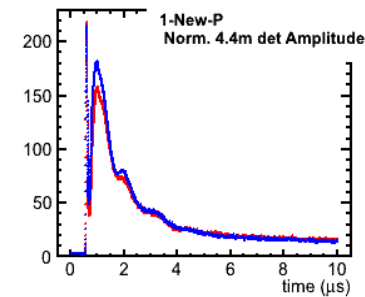
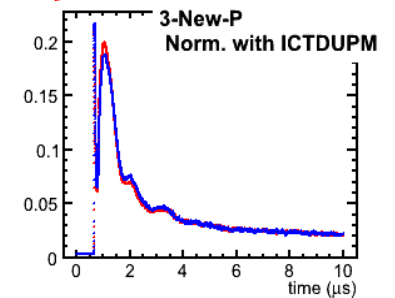
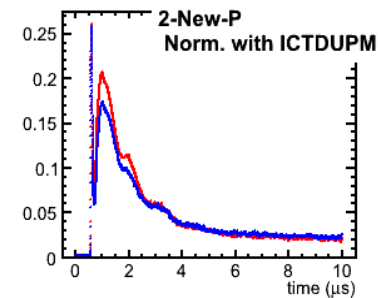
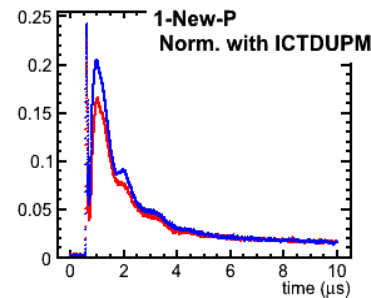
Normalized using  
beam current.

Normalized using averaged  
beam current 50 triggers.

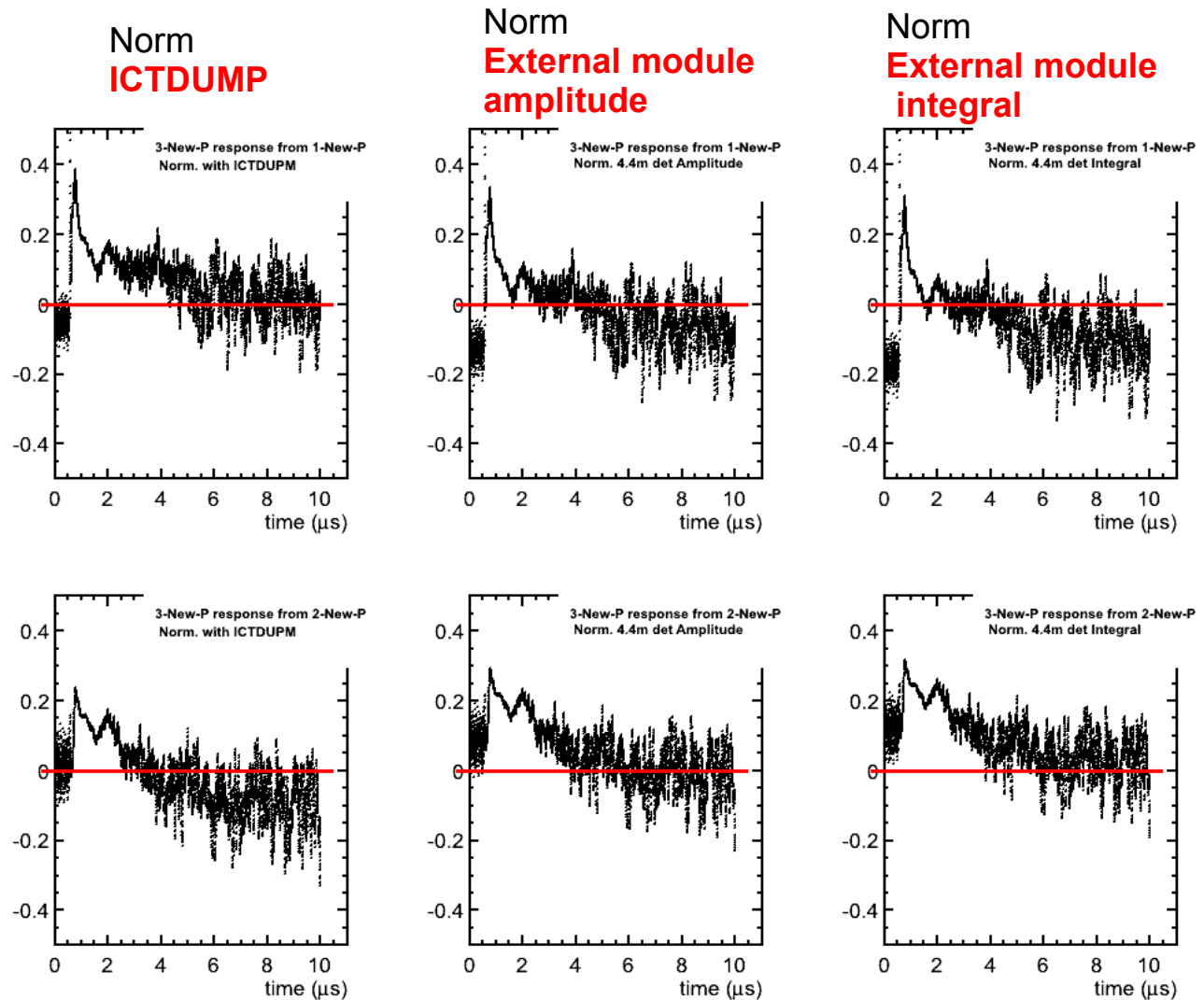
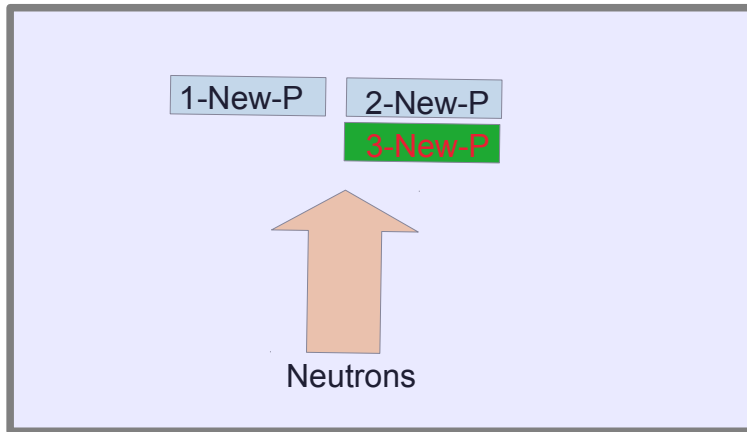
# Plastic response measurements



- **3-New-P response measured**
- As seen from plastic modules **1-New-P** and **2-New-P**
- Used 3 types of normalizations :
  - ICTDUMP
  - Modules from Group2 (@ 4.4m from dump) :
    - Neutron signal waveform Maximum Amplitude
    - Neutron signal waveform Integral

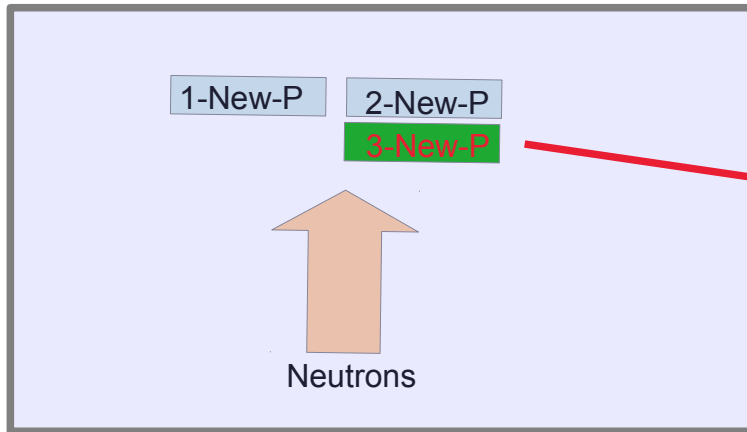


# Plastic response measurements

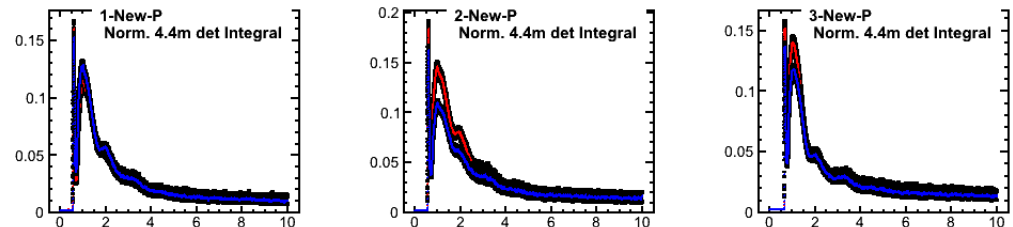
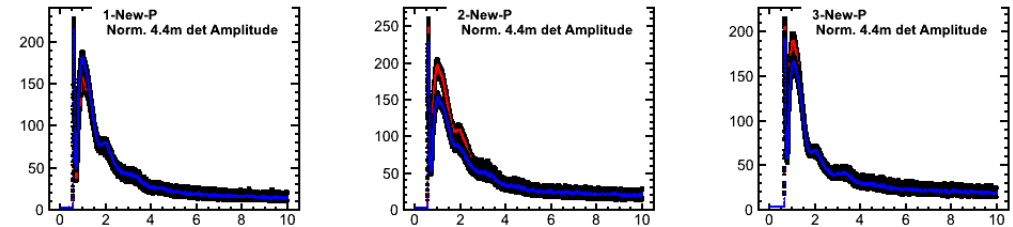
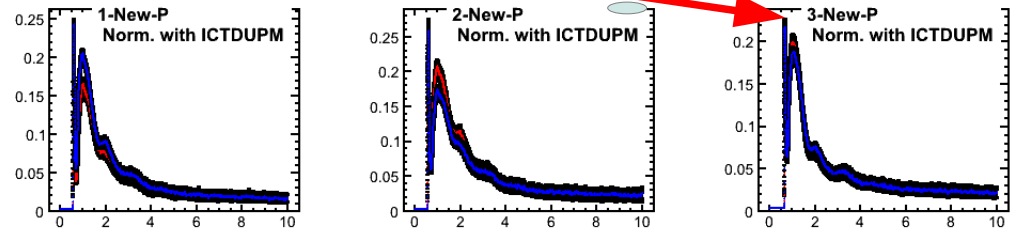


- **3-New-P response measured**
- Module Response :
  - Positive means absorption
  - negative means emission.
  - Y axis label \* 100 = absorption value in %

# Plastic response measurements



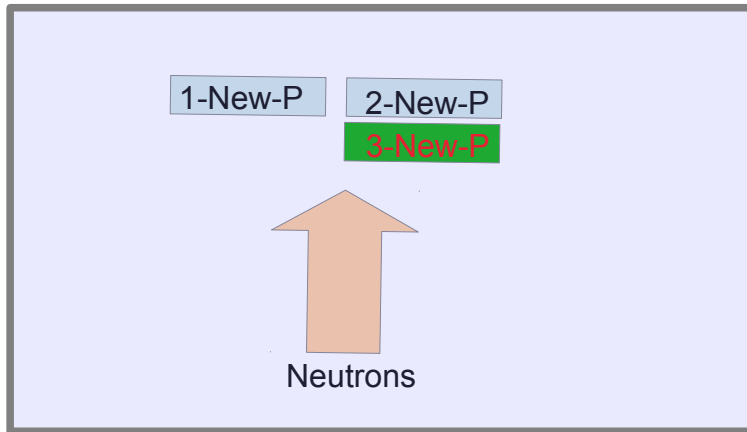
Same with errors



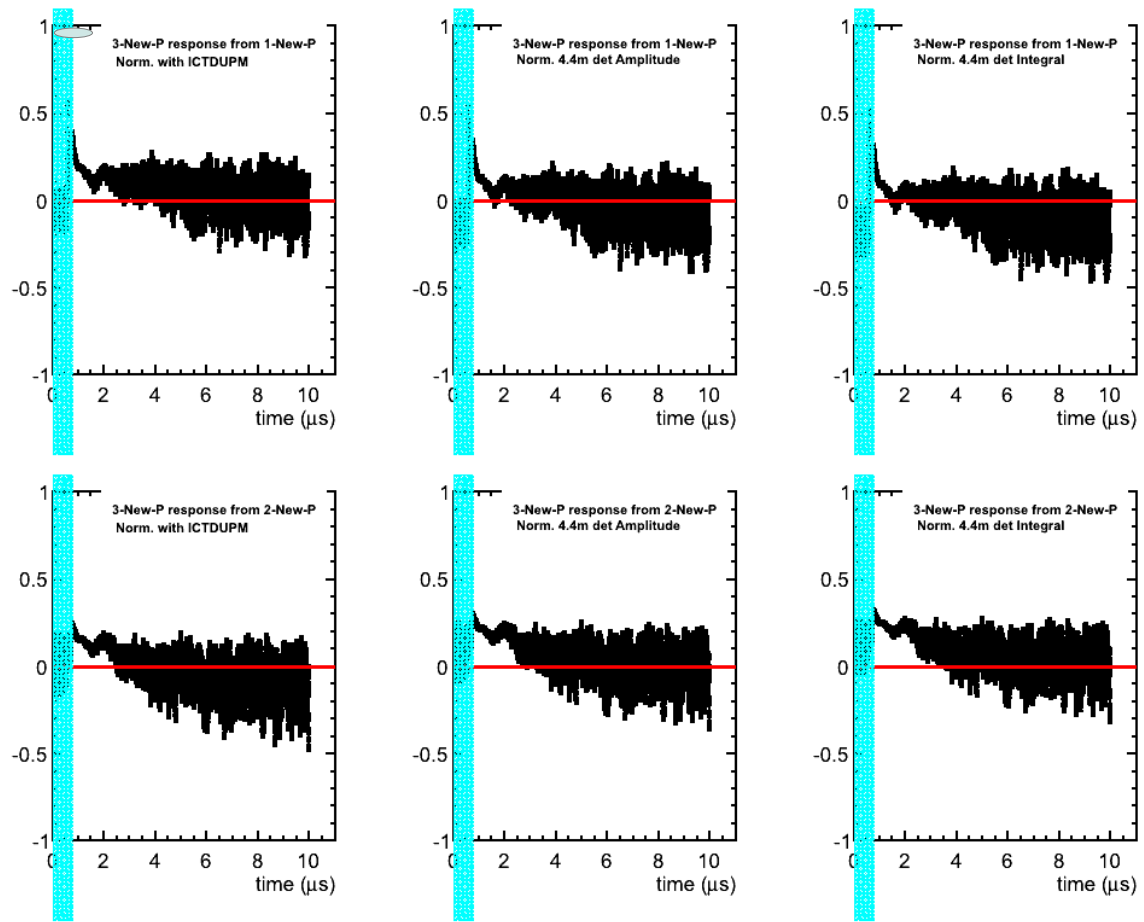
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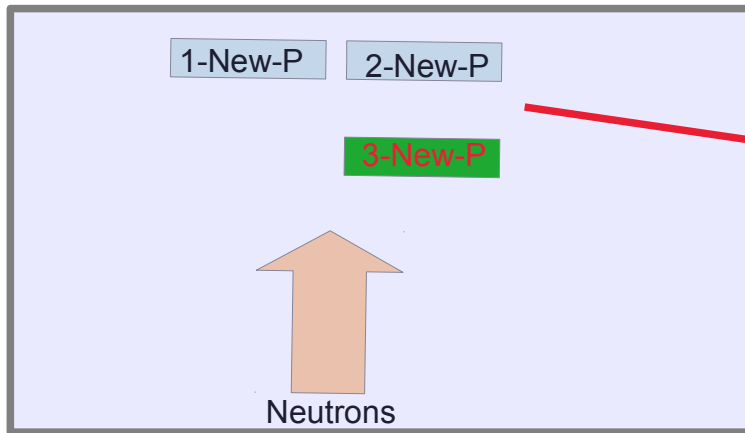


Cyan band covers E.M. part

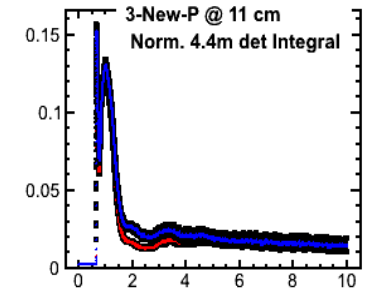
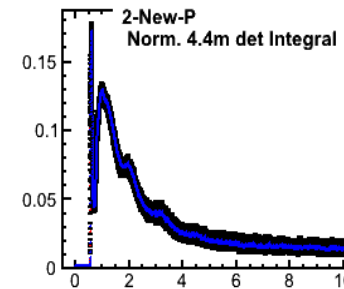
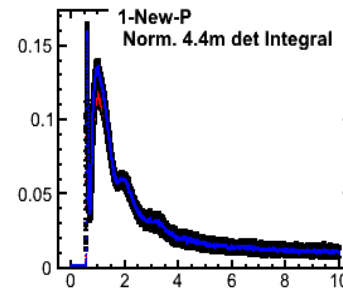
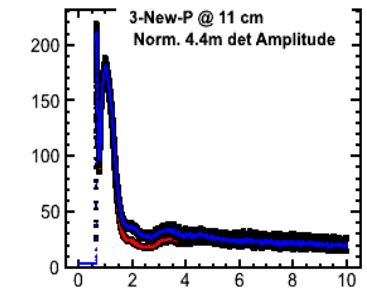
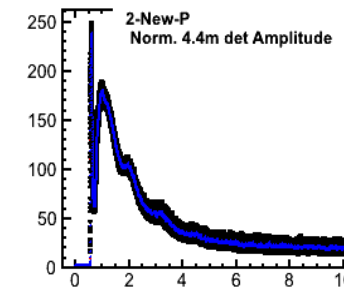
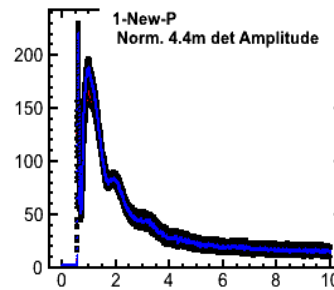
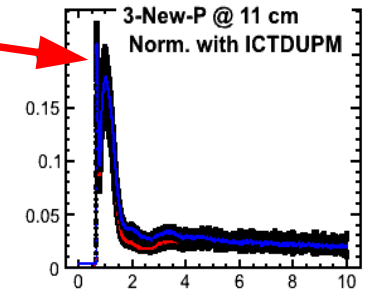
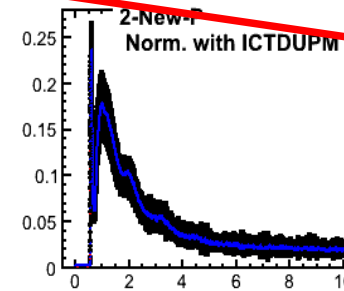
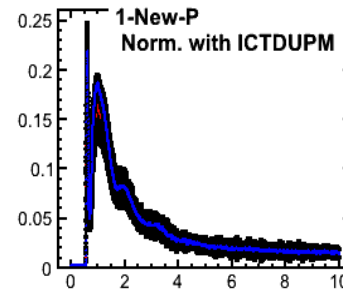


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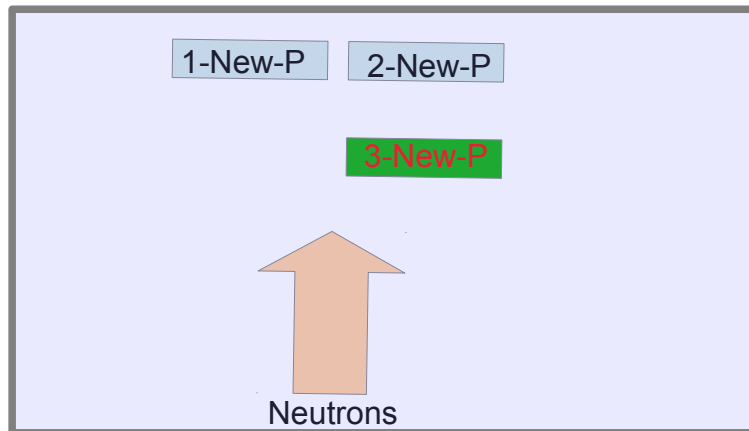
# Plastic @ 11cm response measurement



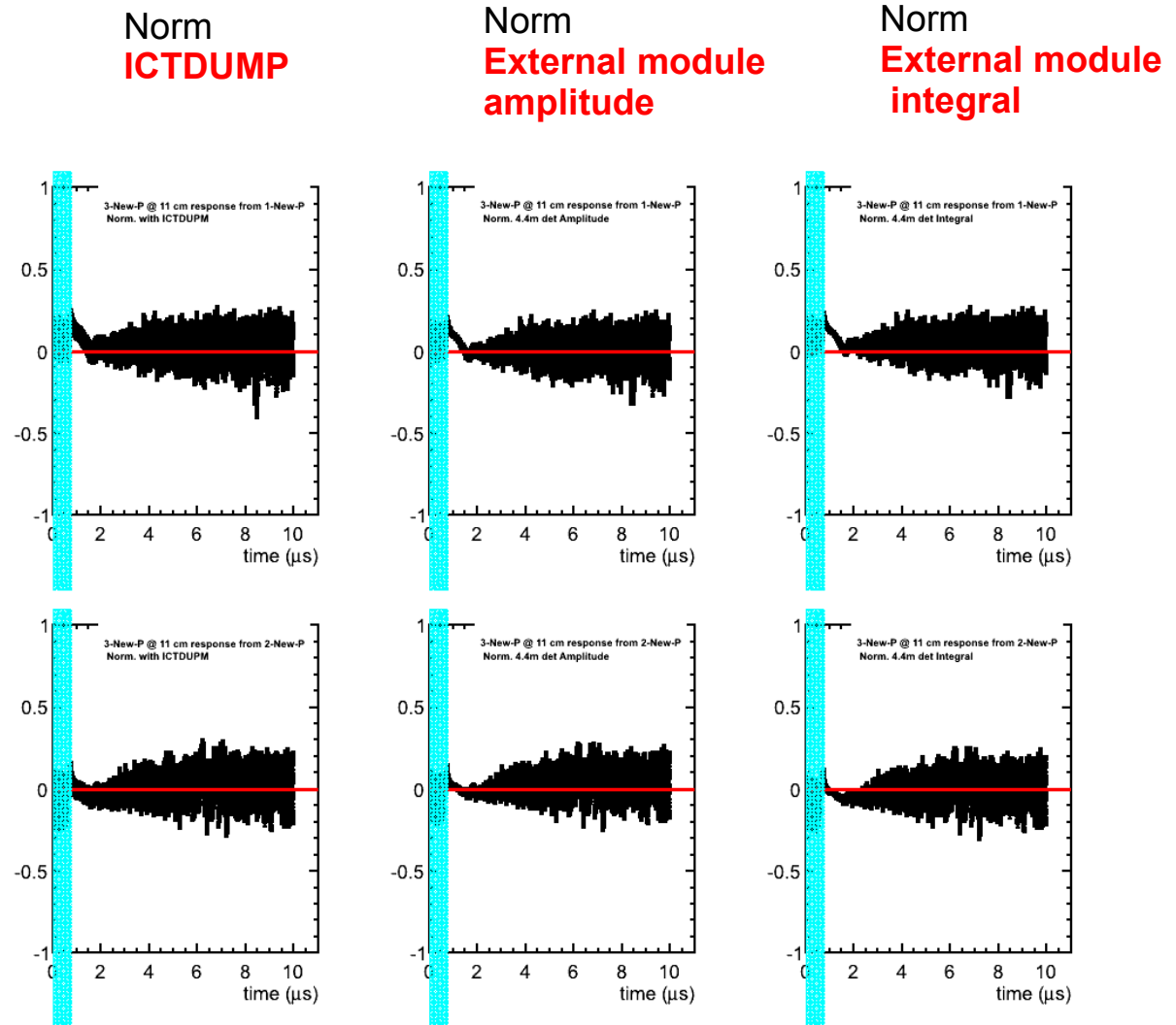
- **3-New-P response measured**
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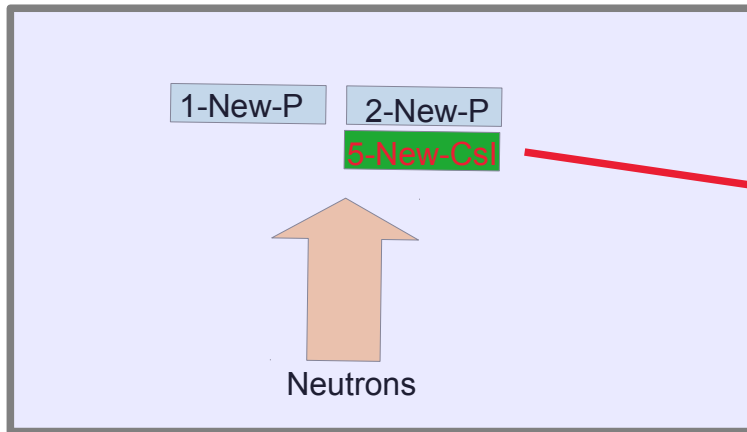
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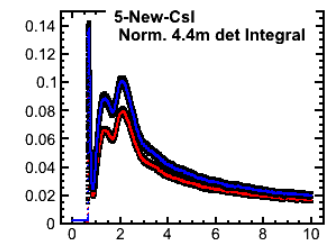
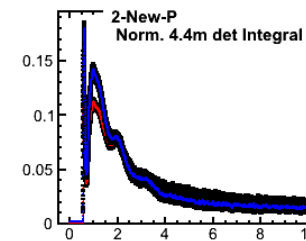
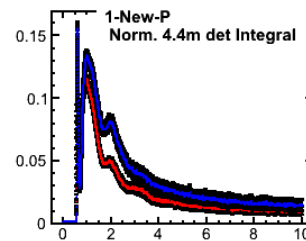
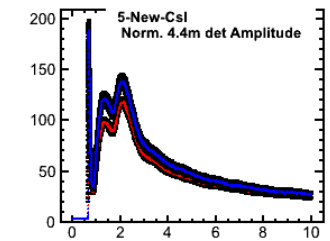
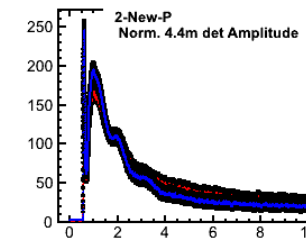
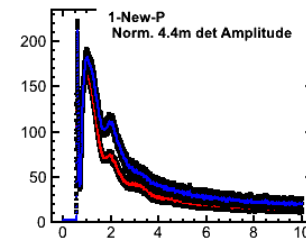
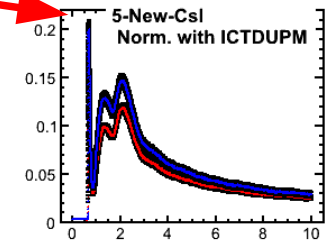
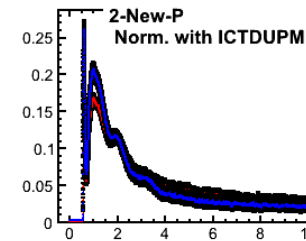
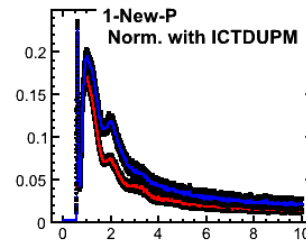
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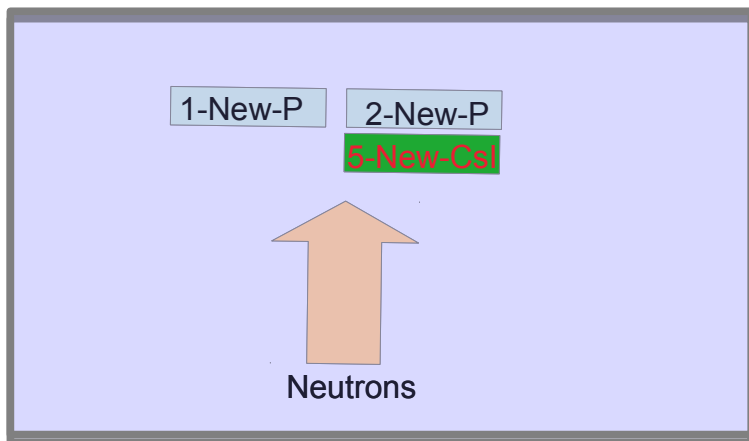
# Csl response measurements



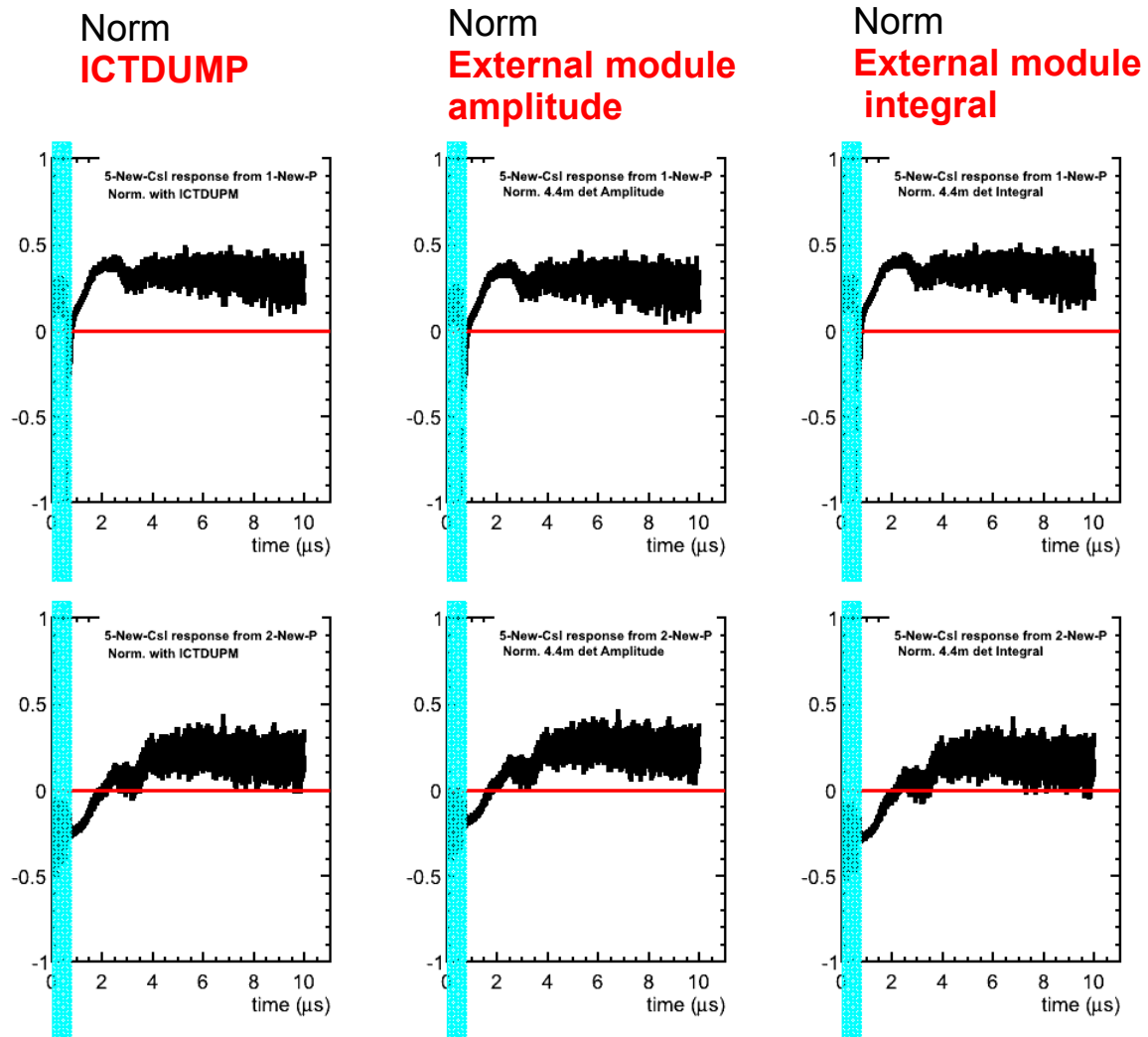
- **5-New-Csl** response measured
- As seen from plastic modules **1-New-P** and **2-New-P**
- Used 3 types of normalizations :
  - ICTDUMP
  - Modules from Group2 (@ 4.4m from dump) :
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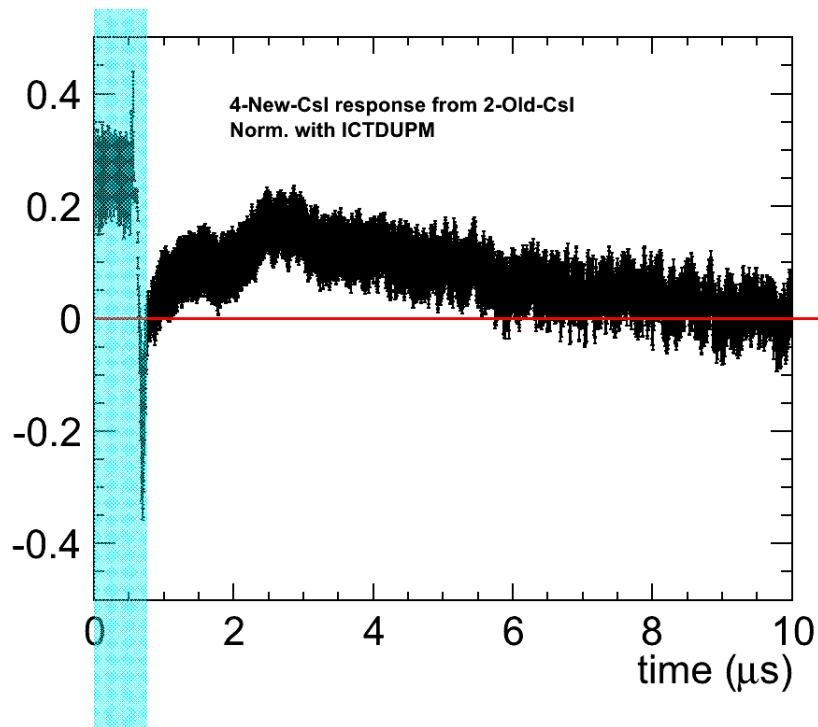
# Csl response measurements



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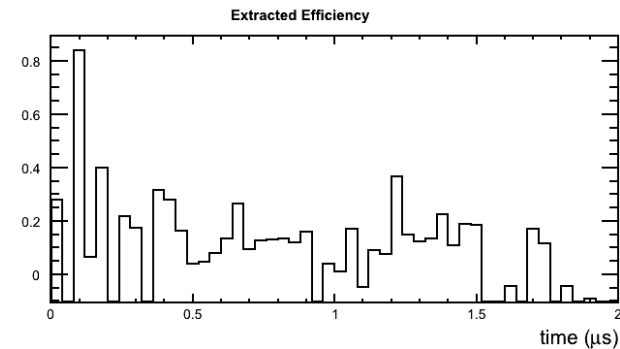
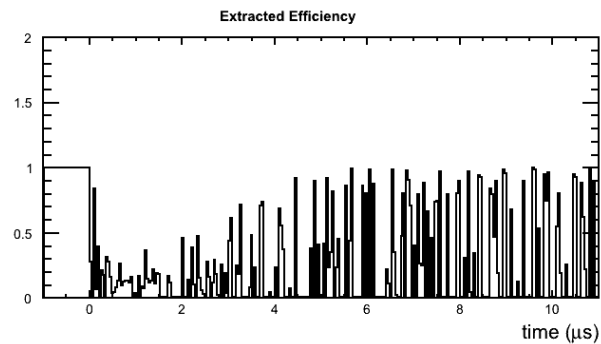
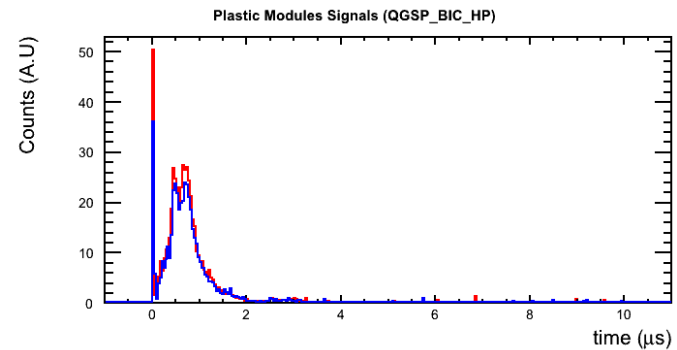
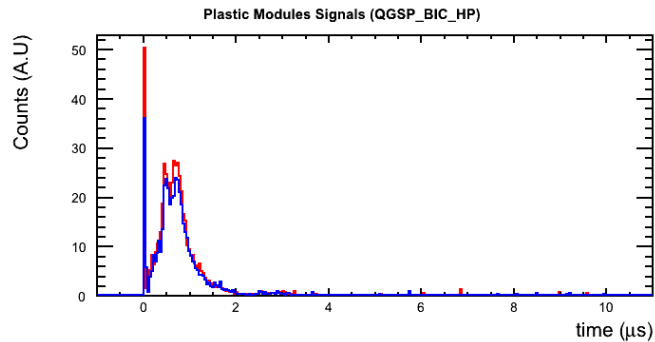
# 4-new-CsI response from 2-Old-CsI



- CsI efficiency extracted from CsI detector
- Efficiency measured to be at  $\sim 15\%$  at its maximum value around  $3 \mu\text{s}$
- Error only includes WF jitter and some additional systematic error might be added



# Geant4 predictions



- G4(QGSP\_BIC\_HP) predicts <20% efficiency
- Still limited statistic to draw a definite conclusion but it seems that the disagreement G4/data is not so pessimistic.

# Conclusion

- Detector responses have been evaluated
- Systematic error are not totally under control
  - Need to understand the **angular variation of neutron background**
  - Need to put a **systematic error on normalization**
- First hints concerning GEANT4 capacity to simulate detectors efficiency.
- Still need some studies to understand where GEANT4 failes to describe neutron production signal exiting the DUMP