Neutron background from the beam dump : update

Hayg Guler, Marc Verderi

LLR-Ecole Polytechnique

13th ATF2 Project meeting Jan /11-13, 2012

outline

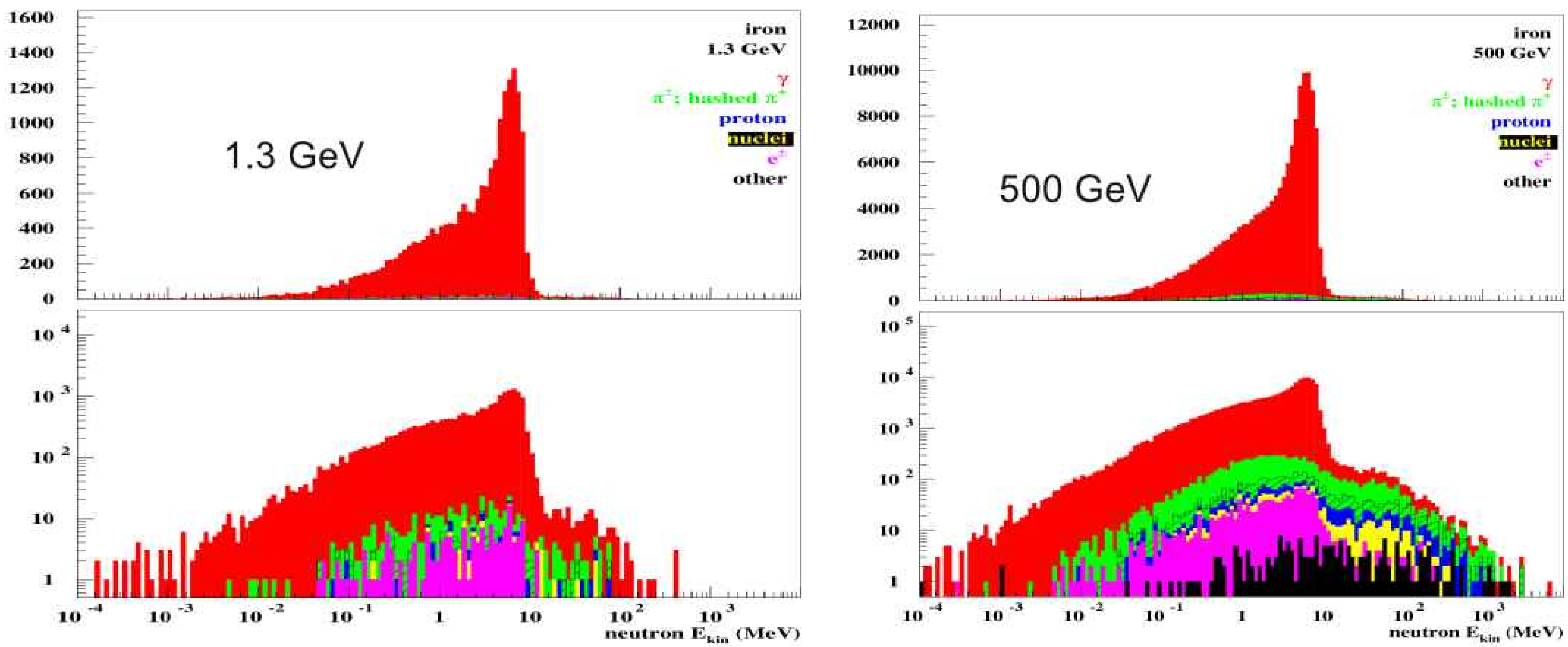
- Why measuring neutrons @ ATF2 is useful for next e- linear collider(s) ?
- Measurements so far and comparison to Geant4
- What is missing in G4 to draw a conclusion
- New systematic studies
- Conclusion

outline

- Why measuring neutrons @ ATF2 is useful for next e- linear collider(s) ?
- Measurements so far and comparison to Geant4
- What is missing in G4 to draw a conclusion
- New systematic studies
- Conclusion

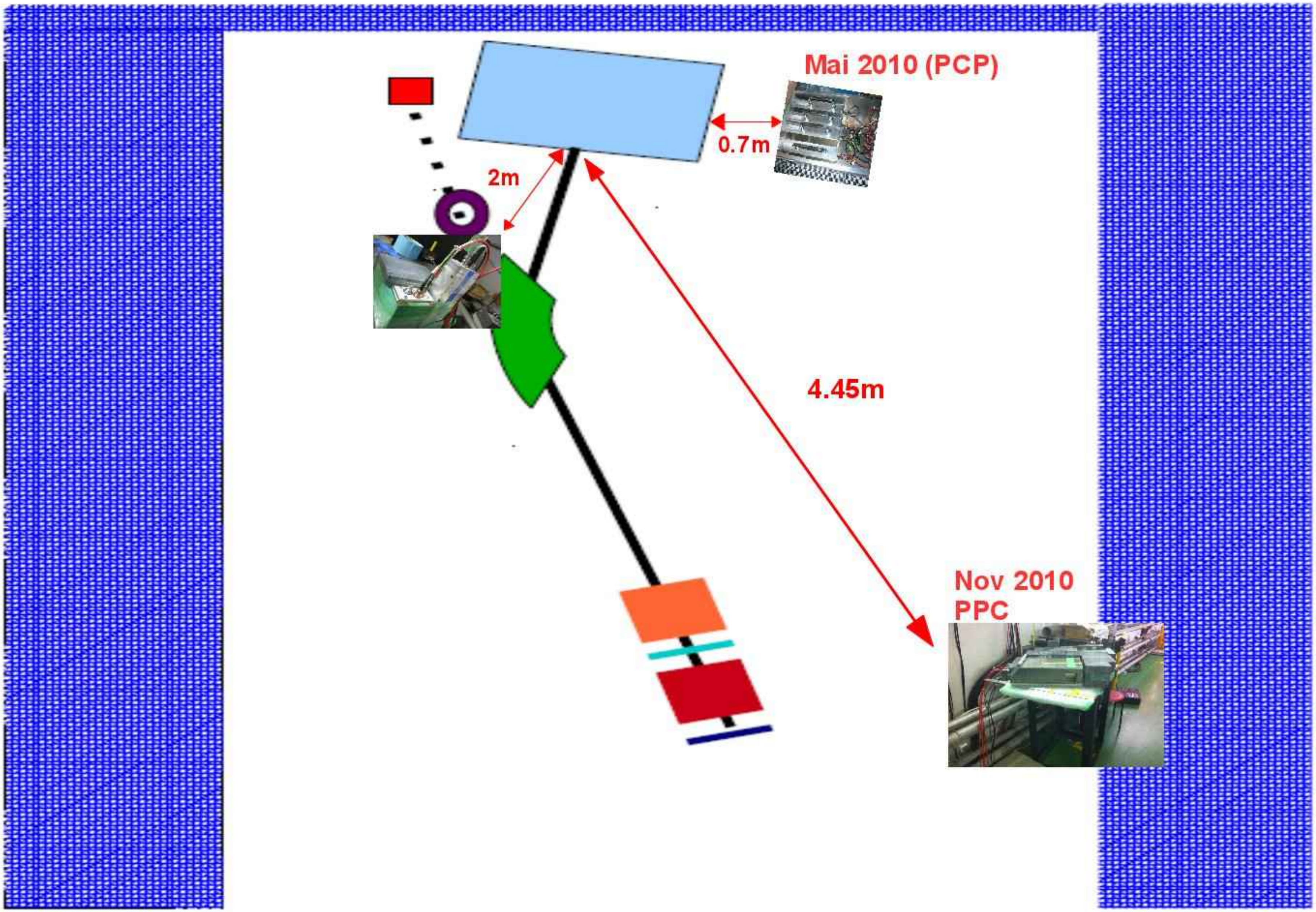
Motivations

Neutron production @ different e- incident energy on iron



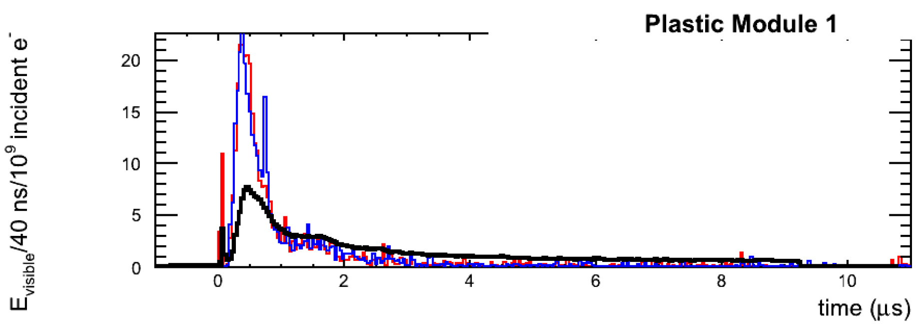
- Most of the neutrons are produced via photo-nuclear effect
- Produced neutron kinetic energy mainly < 10 MeV
- ATF2 can produce the major part of the neutron spectrum accessible at 500 GeV

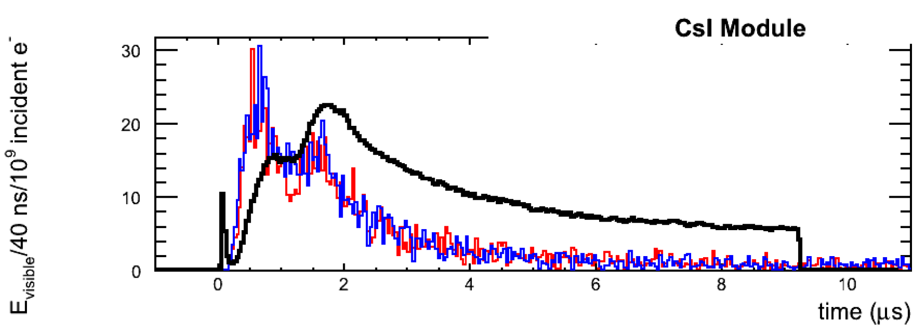
Previsous measurement places

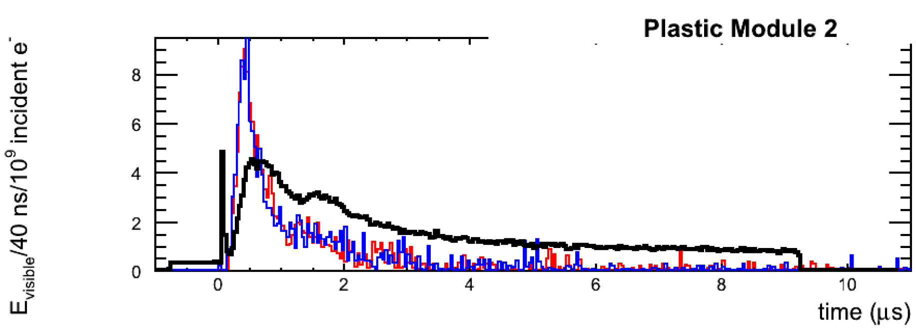


Data vs Geant4

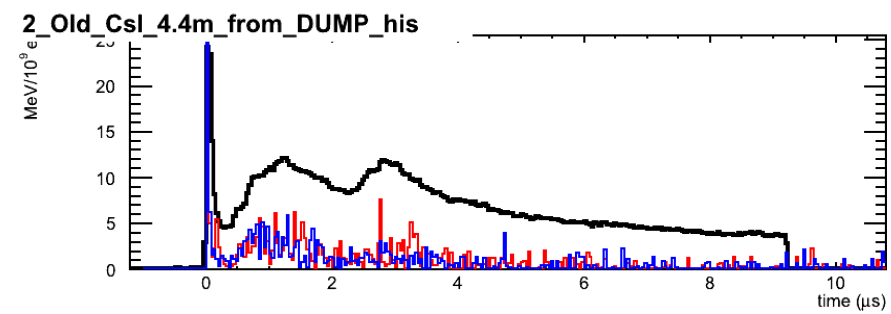
Mai 2010 Data : Dump right side

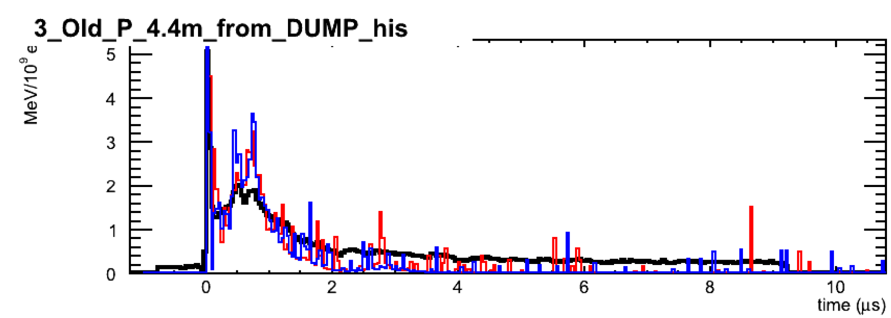


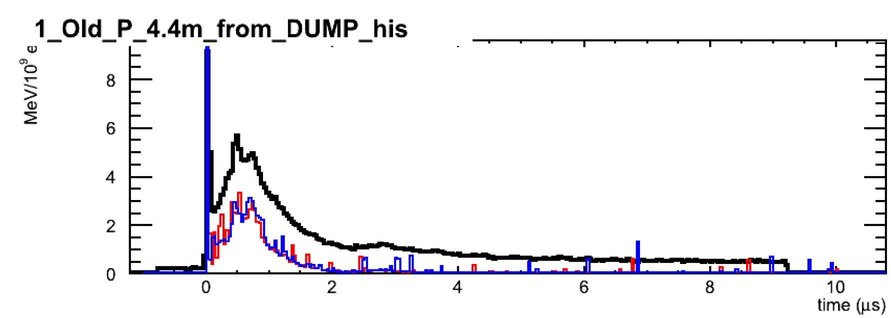




Nov 2010 Data : 4.4m / Dump







Summary

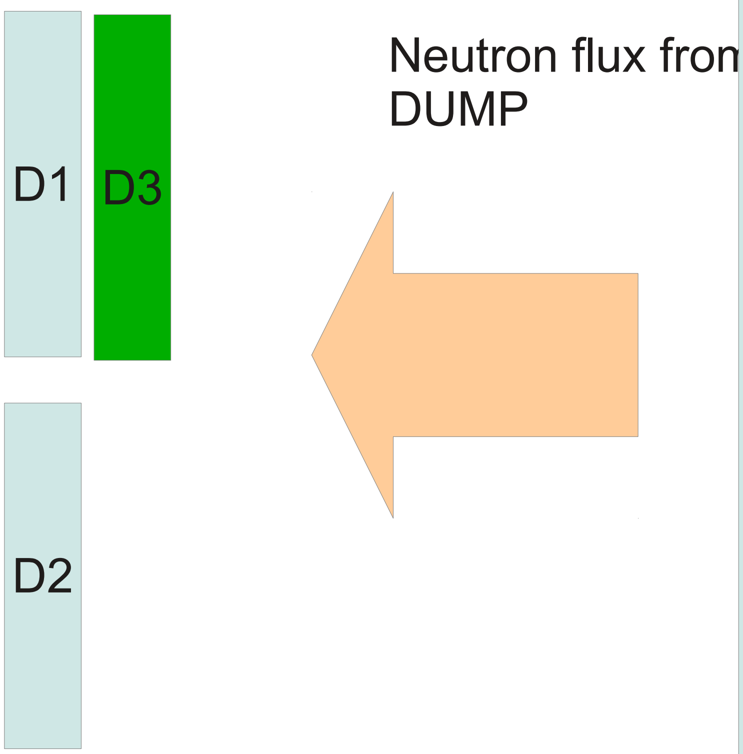
TIPP 2011

- Studies are on going at ATF2 to evaluate how well Geant4 can predict the neutron production and transport.
  - Difficulties with the measurements around the ATF2 DUMP because we are sensitive to both.
  - Parallel measurements using AmBe source can be complementary (known spectrum but need to trigger on signal itself).
- Measurements around the DUMP :
  - Simulation cannot reproduce the Data (factor 2 to ~5)
  - Gross feature (bump time positions) are reproduced by simulation
  - Two physics lists (most adapted to the neutron energy regime) are used
- First answers concerning the reliability of Geant4 to predict neutron background levels for MDI for the next linear colliders.

How to separate neutron production to detector response ?

- Measurement chain for simulation :
  - Electron beam initiates E.M. Shower inside the DUMP (hitted material are copper, iron ...)
  - First neutrons are produced via photo-production
  - Neutrons transportation inside DUMP
    - Secondary neutrons productions
    - Neutrons energy decrease until thermalizing
  - Neutrons exit the dump, hit crystals and deposited energy

Access detector response



- Measure neutron signal on D1, D2, D3
- Hypothesis :
  - Without D3, signal on D1 = D2
    - Same background environment
  - To correct from D1 and D2 different response :
    - Measurement1 : D3 front of D1
    - Measurement2 : D3 front of D2
- Compare D1 to D2 (meas 1 && 2)
  - **Access D3** response independently on beam background flux
  - If measure D3, from D3 response, could also **access the neutron flux**

Detector responses

1 With D3 in front of D1

- $S2(t) = \phi(t)\varepsilon_2(t)$
- $S3(t) = \phi(t)\varepsilon_3(t)$
- $S1(t) = \phi(t)(1 - \varepsilon_3(t))\varepsilon_1(t)$
- $R1(t) = \frac{S1(t)}{S2(t)} = \frac{\varepsilon_1(t)(1-\varepsilon_3(t))}{\varepsilon_2(t)}$

2 with D3 in front of D2

- $S1(t) = \phi(t)\varepsilon_1(t)$
- $S3(t) = \phi(t)\varepsilon_3(t)$
- $S2(t) = \phi(t)(1 - \varepsilon_3(t))\varepsilon_2(t)$
- $R2(t) = \frac{S1(t)}{S2(t)} = \frac{\varepsilon_1(t)}{\varepsilon_2(t)(1-\varepsilon_3(t))}$

3 Extract D3 response :

$$R(t) = \frac{R1(t)}{R2(t)} = (1 - \varepsilon_3(t))^2$$
$$\varepsilon_3(t) = 1 - \sqrt{R(t)}$$

No need S3 signal to extract S3 Response. Can use lead brik, tungstene, etc

4 Extract the neutron flux :

- $S3(t) = \phi(t)\varepsilon_3(t)$
- $S3(t) = \phi(t)(1 - \sqrt{R(t)})$
- $\phi(t) = \frac{S3(t)}{1-\sqrt{R(t)}}$

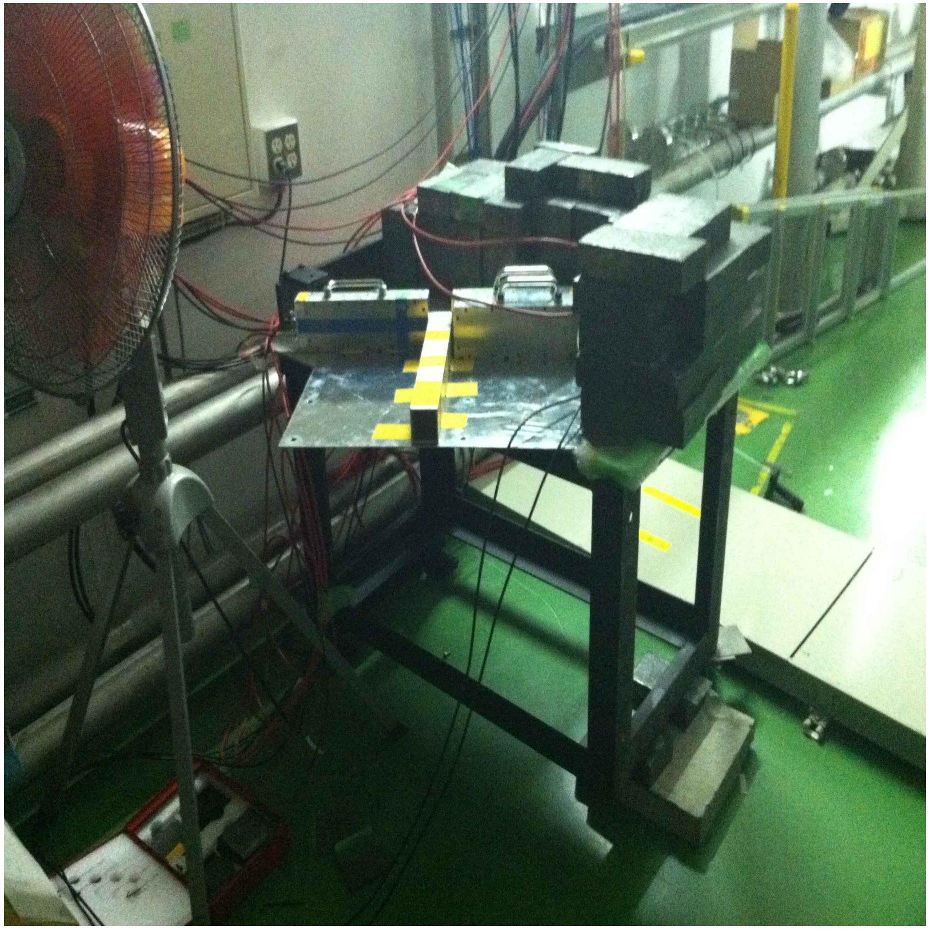
In practice

- We had one dedicated shift in december
  
  - Needed lot of access in order to change detector positions
  - To measure detector response for our CsI and Plastic modules
  - But too short to make all needed measurements
- Thanks to other groups we managed to get more access
- Position at 4.4m from dump too noisy …
  
  - Probably background from new bend collimator
  - Only data from position right dump are usable.

Modules position

Dump right side

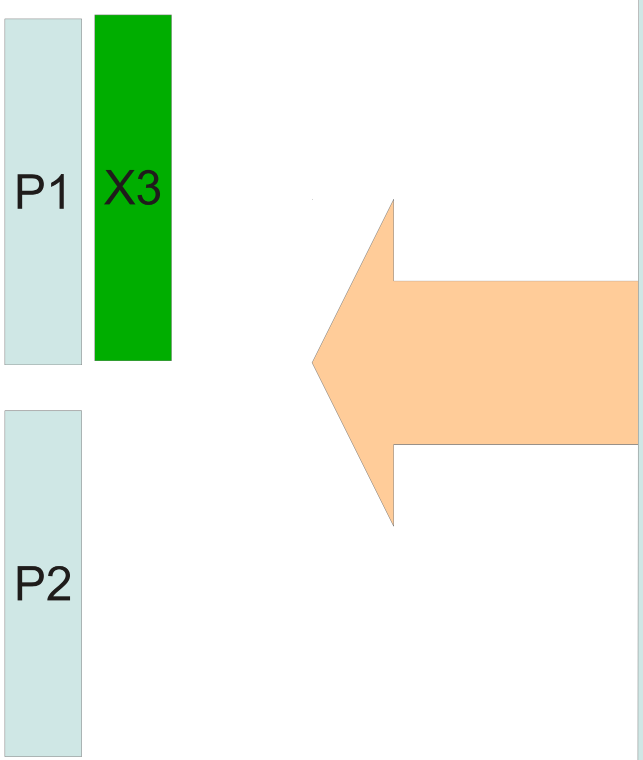
4.4m / Dump



Possible consistency cross check

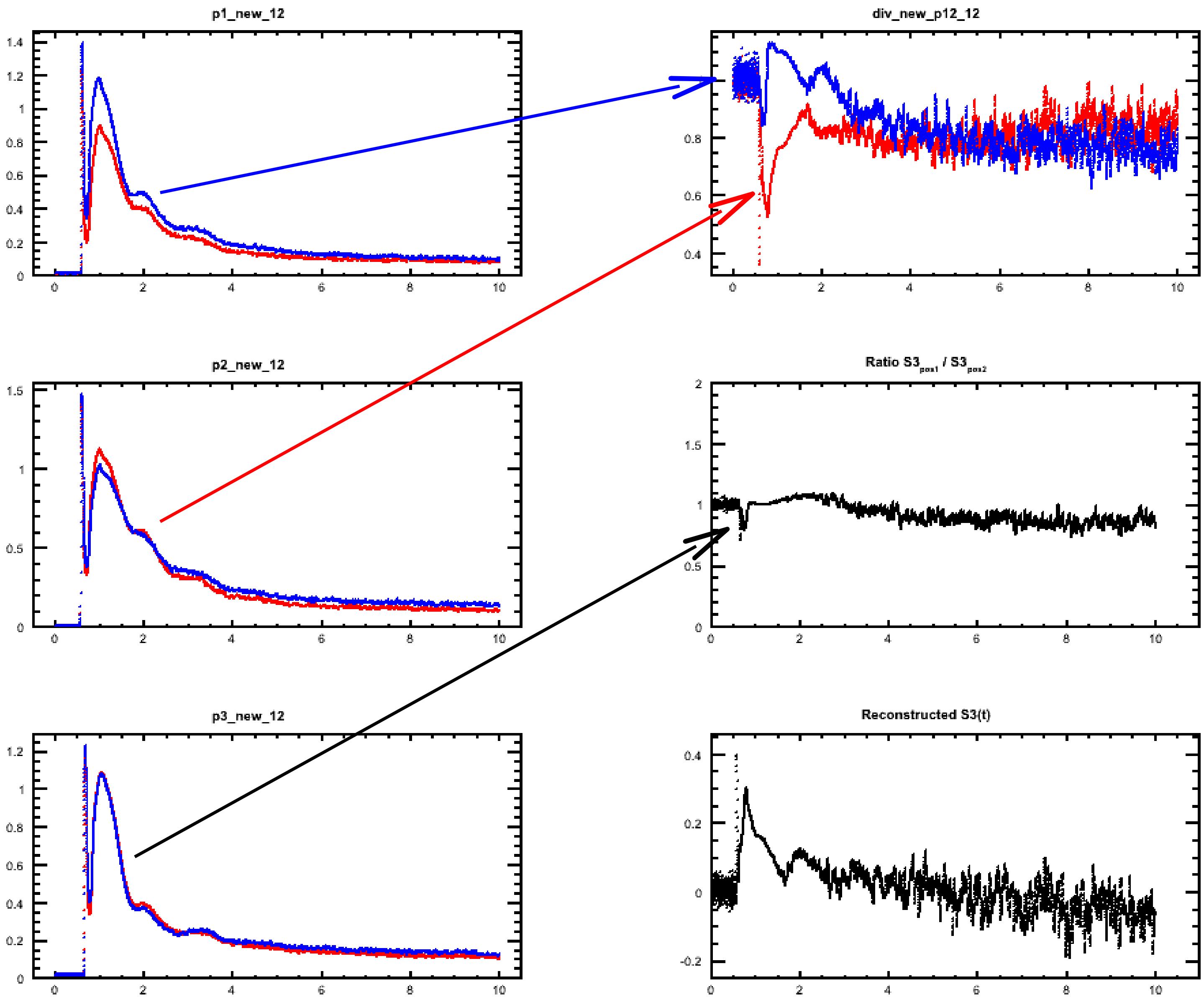
- Detector response should enter inside geant4 as a function of incident neutron energy which is related to its TOF.
- But, one can check the consistency of the data :
  - Neutron flux extracted on plastic scintillators should be the same than extracted on CsI crystals.
  - Detector response should not depend on their position
    - Unfortunately 4.4 m data are not available
    - But could compare ground data to 1m high data (Right Dump)

Plastic Data (Right Dump)

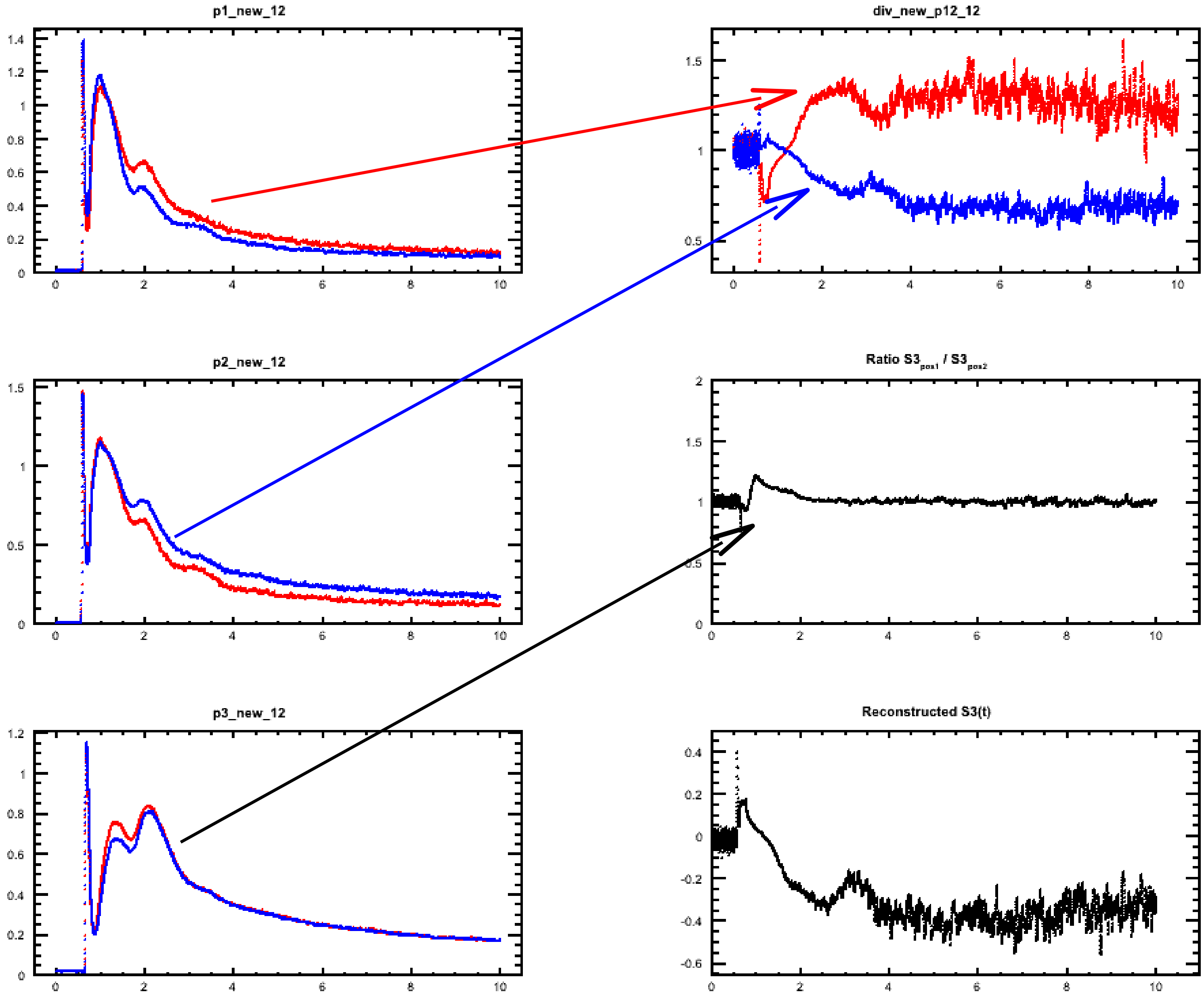


- X = Plastic
  - Should reduce high energy neutrons
- X = CsI
  - Should reduce equally fast and slow neutrons

Plastic Data (Plastic in front)



Plastic Data (CsI in front)



Work still in progress

- Normalize by beam current (even stable during data taking)
- Estimate validity of S1 = S2
  - Neutron flux spacial variation
- Need to answer the question from where comes the difference between data and G4 :
  - From Detector response ? (neutron deposit energy on CsI or Plastic scintillator)
  - From the neutron flux :
    - more difficult to understand
    - Neutron photo-production or neutron transport ?

Conclusion

- December data were indispensable to disantangle the various sources of experimental effets which enter into the background neutron detection
- The analysis in still in progress but :
  - CsI or Plastic shielding (front modules) is well understood
  - 4.4 m data from dump is unfortunately missing :
    - Less spacial effects at 4.4m than 1m
    - Also access fast neutrons to understand production
- Modules are now placed to measure FF background
- Thanks again for help for KEK members !