Background study plan towards goal 1 in 2010-2011

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Outline

1. Realizations over the past year
    1. Hardware and acquisition
    2. Progress with simulation
2. Plans for 2010 – 2011
    1. Continuing with present activities
    2. New measurement ?

REALIZATIONS OVER THE PAST YEAR

Hardware and acquisition

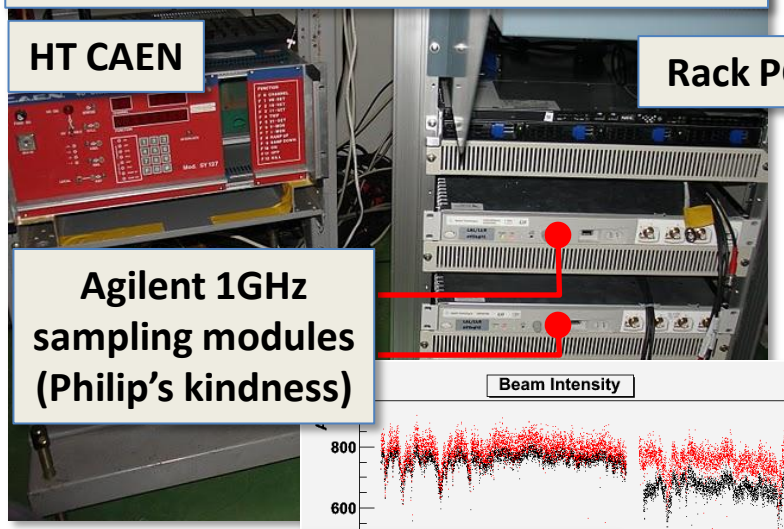
- Made a set of 8 simple detectors = {scintillator + photomultiplier}
  - That can be used alone
  - Or assembled in boxes to form « mini-calorimeters » with longitudinal segmentation (with W insertion if needed)
- Scintillator = plastic or pure CsI
  - Fast : allows TOF
    - Distinguish background sources
    - Separate (prompt) EM and (delayed) neutron backgrounds
  - Different response to neutrons:
    - Plastic sensitive to fast neutrons
    - Intermediate neutrons for CsI
- Tests done with cosmics, e^{+}'s (DESY), neutrons (Am/Be source CEA) in 2009
- Have been transported to KEK end of 2009

Detectors (example with using a box)

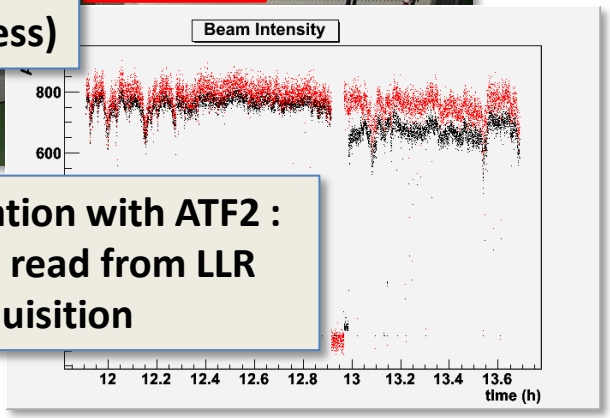
Acquisition

HT CAEN

Rack PC NEC

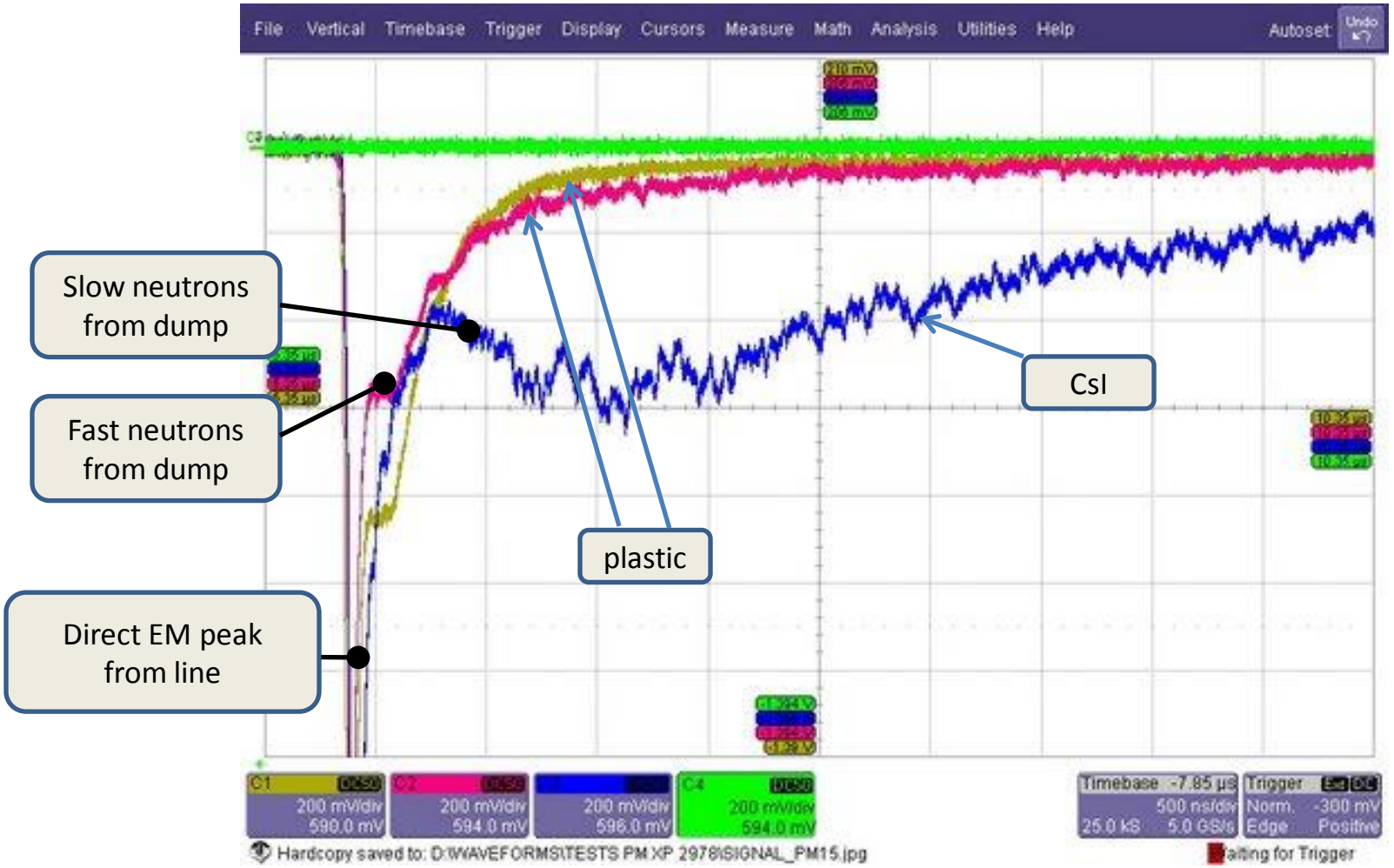


Agilent 1GHz sampling modules (Philip's kindness)



Synchronization with ATF2 : ATF2 data read from LLR acquisition

Examples of observed signals near dump
(trigger = kicker)

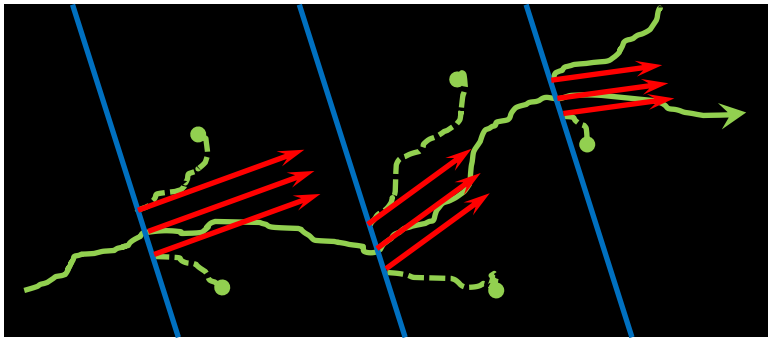


Rare Events Enhancement : Biasing Techniques

- Background is coming from ”rare events”
  - Even if “rare” is too often…
  - Rare in the sense that background particles depart (± strongly) from the typical behavior of the vast majority of other particles, eg:
    - Electrons scattering away from the nominal core-beam direction
    - Neutrons traversing the full dump and exiting it
- Background particles represent 10^{-3}… 10^{-6} or (much) less of the overall
  - This is making a “standard” simulation inefficient at producing workable statistics
  - Most of the time is “wasted” at producing typical events
- Biasing techniques are methods to enhance the occurrence of « rare events » in a simulation
  - They “distort” the simulation
  - With distortion reflected by a “weight”, w, attached to tracked particles
  - And that is used to compute final observable values : ie weighted means
- Rely on serious mathematical and statistical considerations
  - And receives much care, as in some fields, a “rare event” is a “catastrophic event”
  - eg:
    - Conjunction of conditions for an aircraft to crash
    - for a bank to go bankrupt
    - …

Most popular biasing techniques

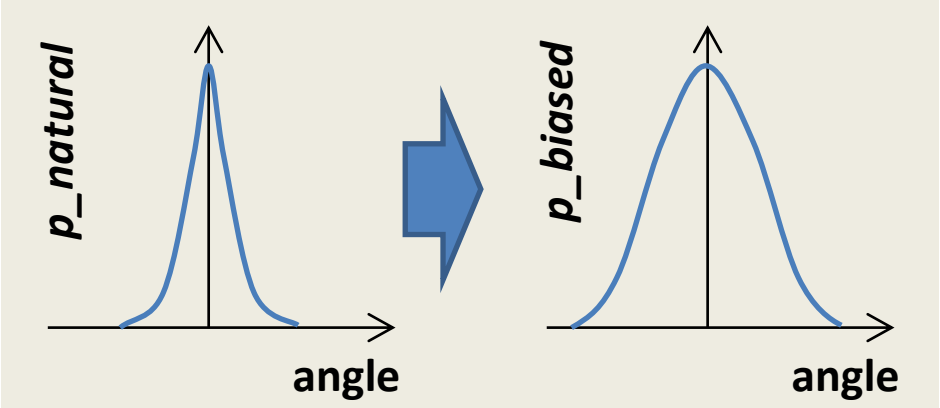
Splitting technique



- For particles moving in the "good direction"
  - Eg, toward outside dump
  - Artificially split (clone) particles at some points to basically compensate for the absorption
    - Here splitting by 3, ***w→w/3***
- For particles moving in the "wrong direction"
  - Eg inward dump
  - Kill with some probability
    - Here 1/3 (not shown), ***w→3*w***
- No modification of the underneath physics laws

Importance Sampling

- Modifies the underneath physics laws
- Replace the "natural" physics law for an interaction *p_natural*(*i→f*) by a biased one *p_biased*(*i→f*)
  - Choose *p_biased* to favor rare events
  - Eg : EM processes less forward peaked than typical $1/\gamma$, to have more often particles at large angles

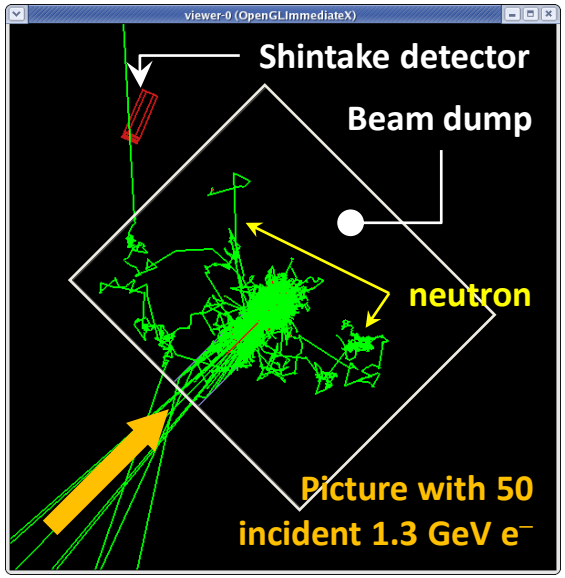


  - At each biased interaction :

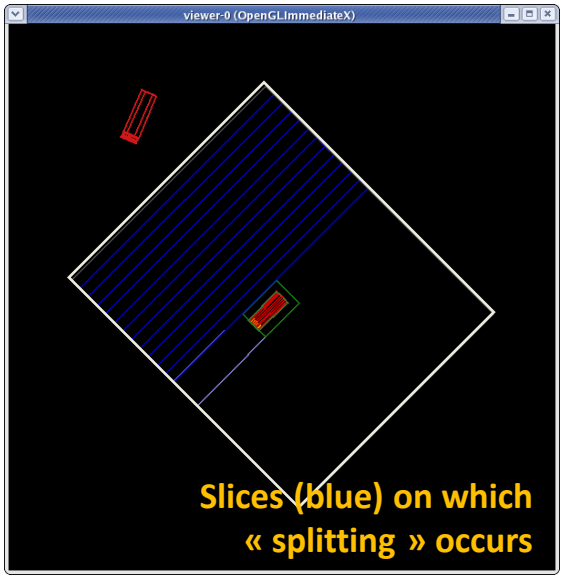
    w → w * p_natural/p_biased

Example of simulation results with splitting

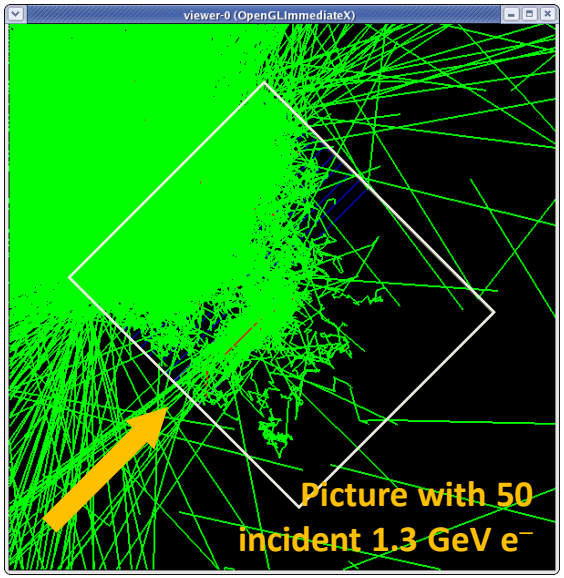
“natural” simulation



“biasing” geometry setup

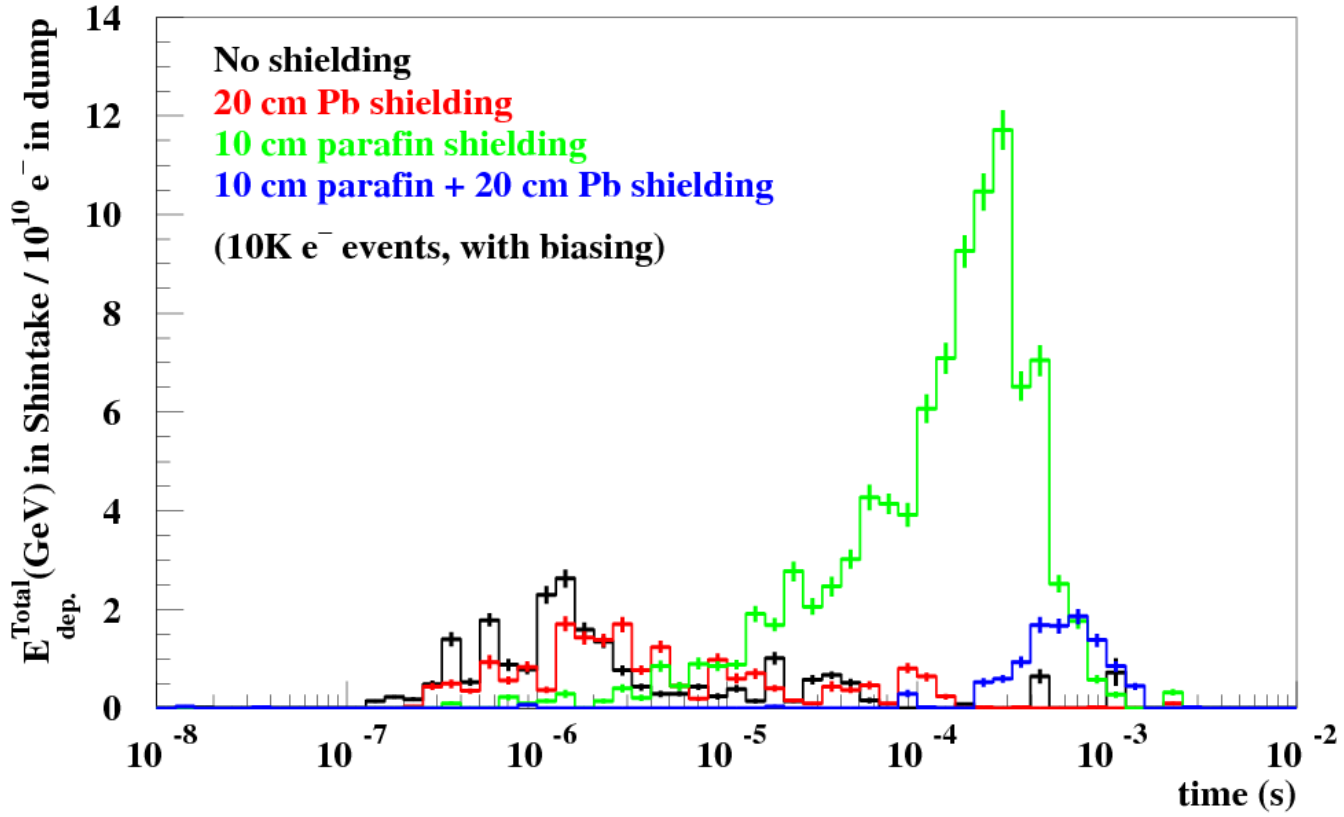


“biased” simulation



- Setup for simulation of neutron background inside Shintake photon detector
- Biased simulation more efficient than natural simulation by a factor better than 1000.
  - Setup was even not really optimized
- Used to illustrate the effect of various shielding configurations between dump and detector

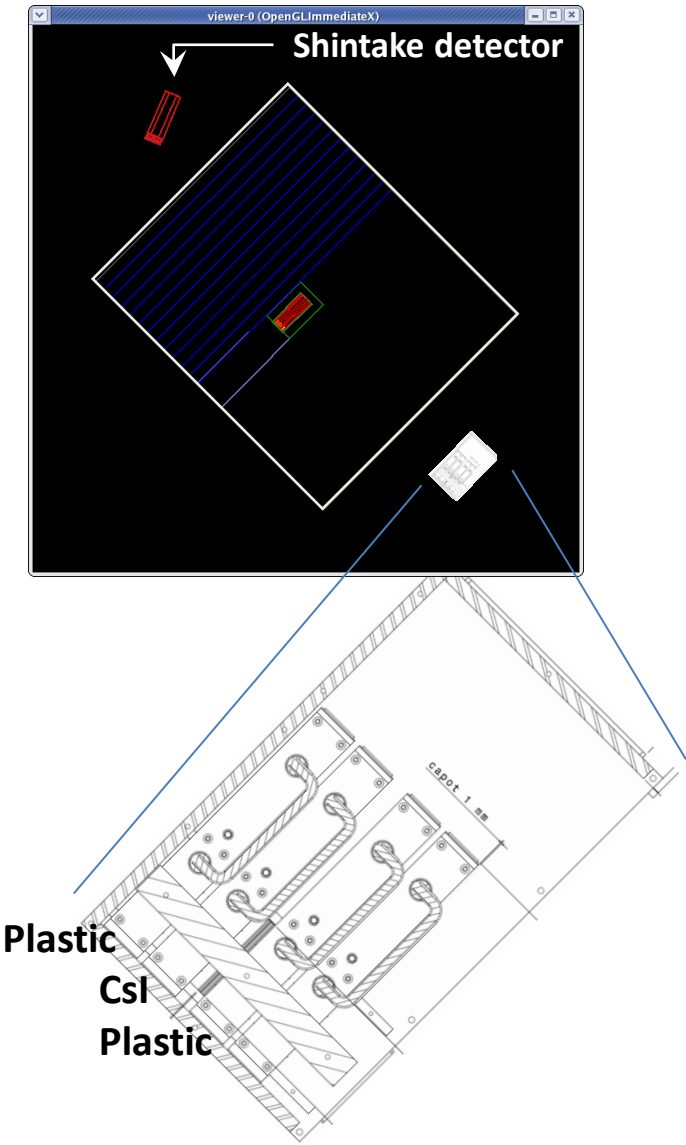
Effect of shielding on Shintake neutron background level



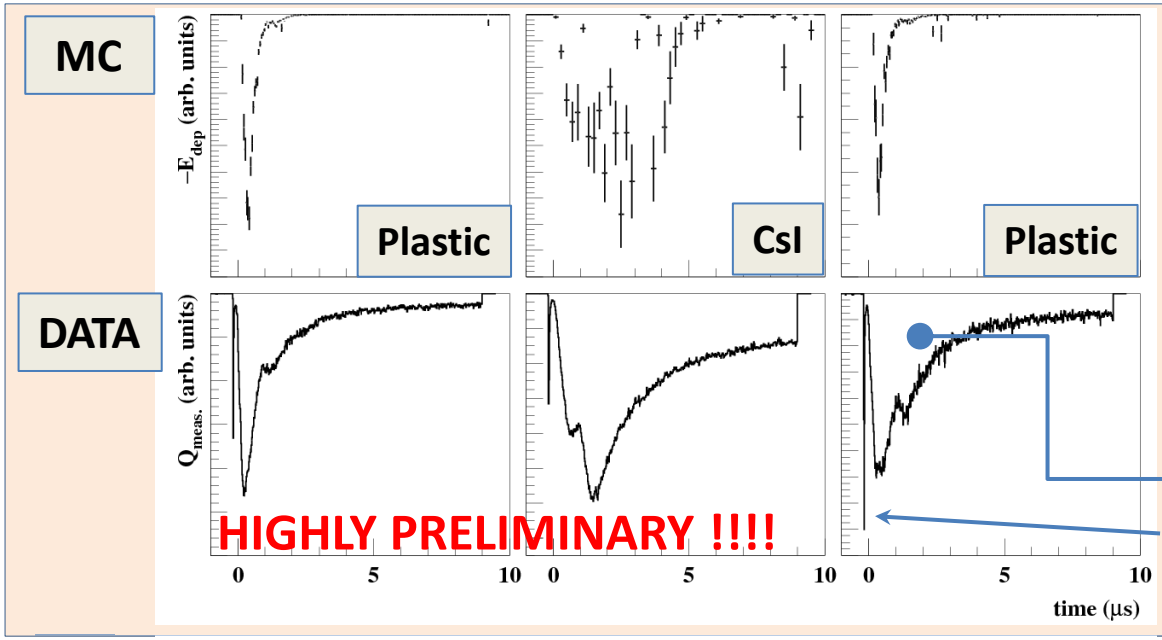
⇒ Splitting biasing technique actually provides a solution to tackle the statistics issue in case of neutron production and transport studies

A measurement under analysis

- Previous simulation result was not checked against Shintake measurement
  - To be done
- We made additional measurements related to Shintake background issue
  - To check how well (or not) these backgrounds are reproduced by the simulation
- We considered a position symmetric to that of the Shintake detector
  - And use a setup with Plastic –CsI– Plastic modules



First DATA/MC « comparison »



(-) Energy deposit as function of time in « **Plastic - CsI - Plastic** » scintillators near beam dump. 100K incident e^- in beam dump

Average of 100 photomultiplier signals for « **Plastic - CsI - Plastic** » scintillators near beam dump.

Neutron delayed signal

EM prompt peak

- Still many work to do…
  - Even if some gross features are there
- At least above plot demonstrates that hardware and software have both reached a ***workable state***.
- ***First more quantitative results to come in the next weeks !***

PLANS FOR 2010-2011

Continuing with present activities

- Continuing with present activities and measurements, ie:
- Neutron background studies
  - Push forward analysis to reach physics goal of assess correctness / limitation of the Geant4 simulation
  - Might require some more data in 2010
    - And possibly no new measurements in 2011
  - We do not anticipate to attack new issues regarding neutrons at the moment
- Electromagnetic background study around the IP area
  - We collected background data before and after IP
    - And collected related beam conditions
    - So we have “on tape” data of interest to (help to) understand background behavior with beam parameters variations
  - But have not gone through serious analysis of them yet, and we need to push forward this analysis
  - Anticipated, is the need for an implementation of an “importance sampling” based biasing for the simulation
    - Problem understood at the principle level
    - Where and how modify Geant4 EM processes identified as well
    - “only” have to do it, but this will be a significant new feature

New measurement ?

- We consider making new EM background related measurements around the IP area
  - ***Preliminary idea at this stage***
  - With no assessment done at this point
- Idea is to measure EM backgrounds, still with TOF based techniques, but being “away” from the beam line
  - Using TOF, and several detectors at a time, it might be possible to do “triangulation” to locate the background source(s)
    - Note that a 1 ns resolution, should allow in principle to locate sources with a 30 cm resolution in position
  - And -with probably a delicate analysis- estimate related source intensities
- A measurement than we should correlate with the PLIC measurement, for cross-checking, and more information extraction
- About the tools:
  - For the hardware, we can reuse our current detectors, they are fast enough
  - For the software, the modeling in the simulation would rely on the “importance sampling” biasing technique, still to get statistics far away from the beam line
- Beyond principles, a first assessment with simulation should be done.

Conclusion

- Over the past year, key components have reached a workable state:
  - Detectors, acquisition and simulation
- Neutron background analysis is the focus at the moment
- EM background analysis has to follow next
  - With already potentially interesting data “on tape”
- A new EM background measurement technique for 2011 is proposed
  - still at the preliminary stage
  - but may be interesting if naïve expectations could be achieved