# Background studies at ATF2 and the BDS/IR
## -focus on neutrons-

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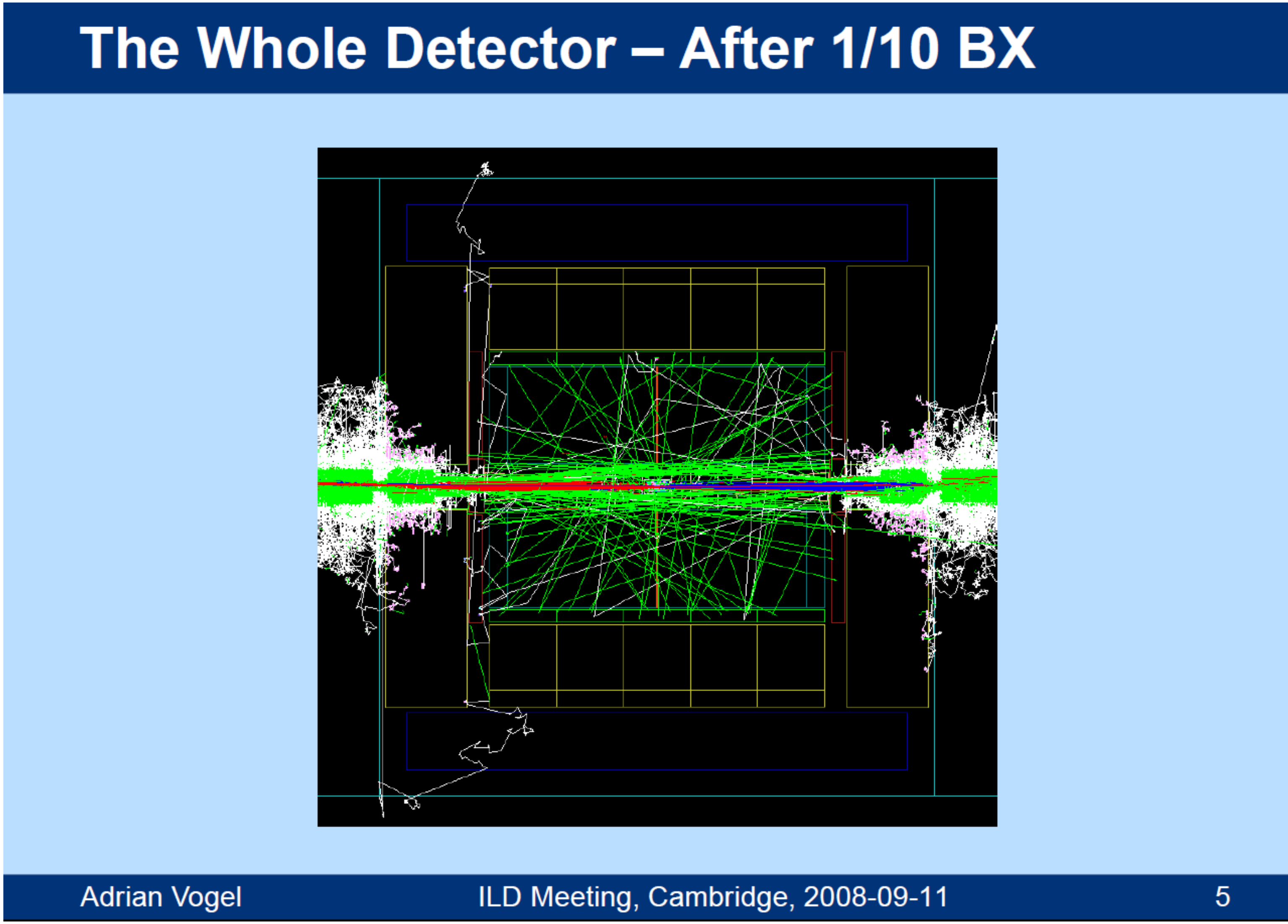
# Introduction [1/2]

- Background studies for ILC/CLIC are carried on with simulation tools
  - eg : Geant4, FLUKA, …
  - And detailed studies have already been conducted
    - See for example Adrian Vogel's thesis (with Geant4)
- Reliability of simulation is however questioned
  - Do MC and data differ by large factors ?
  - What is the case for the broadly used Geant4 software ?

# Example of background simulation



# Introduction [2/2]

- Activity at ATF2 to address some of the reliability questions of Geant4
  - The approach is to consider a real case situation
  - And “simply” measure, simulate, and compare
- What can be learned at ATF2, where $e^-$ beam energy is 1.3 GeV ?
  - At CLIC/ILC the maximum energy is O(TeV)
    - But in dense materials, this energy rapidly degrades to low energy EM particles
    - With high multiplicity
    - Neutron production through photo-nuclear effects is then dominated by this low energy regime
      - In the beam dump area
      - But also in dense materials close to the IP
    - ATF2 can say something about this neutron production regime
  - An other aspect is to learn and exercise in a real case methods and techniques needed for background simulation
    - As straightforward simulations are inefficient in getting workable statistics
    - This is needed for neutron background simulation
    - But (even if not presented today) should be useful for EM background modeling, in trying to correlate background level with beam parameters

# EXPERIMENTAL SETUP AND MEASUREMENT APPARATUS

# Experimental setup and apparatus

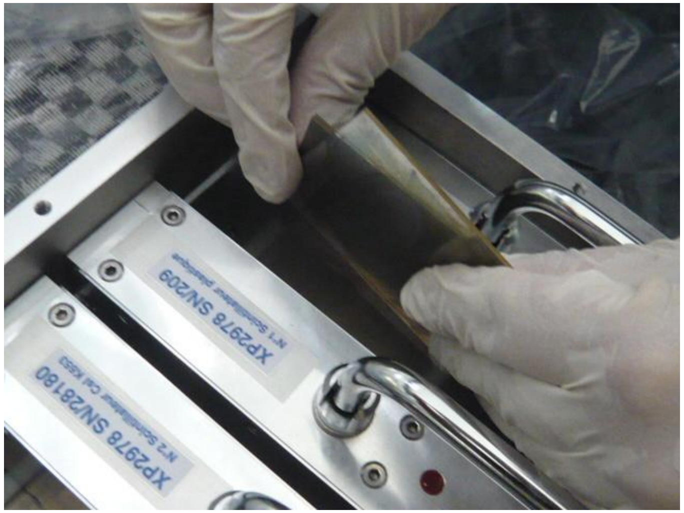
- Measure neutrons exiting from ATF2 beam-dump
  - Beam dump made of joint slabs iron made [~$(2m)^3$]
  - And has a small central part made of copper
- Measurement devices:
  - Plastic (BC-408) and pure CsI scintillators (both provided by Saint Gobain), read by photomultipliers
    - CsI crystal equiped with filter to cut the slow light component
    - Fast, and different response to neutron
      - Subject to different systematic effects => allow for cross-check
    - Plastic : for fast neutrons, CsI : intermediate
  - Record the time-dependent signal
    - Ie signal waveform, sampling at 1 G-sample/s
    - Absolute amplitude and time dependent signal shape tell about neutron production and transport in beam dump

# Measurement devices

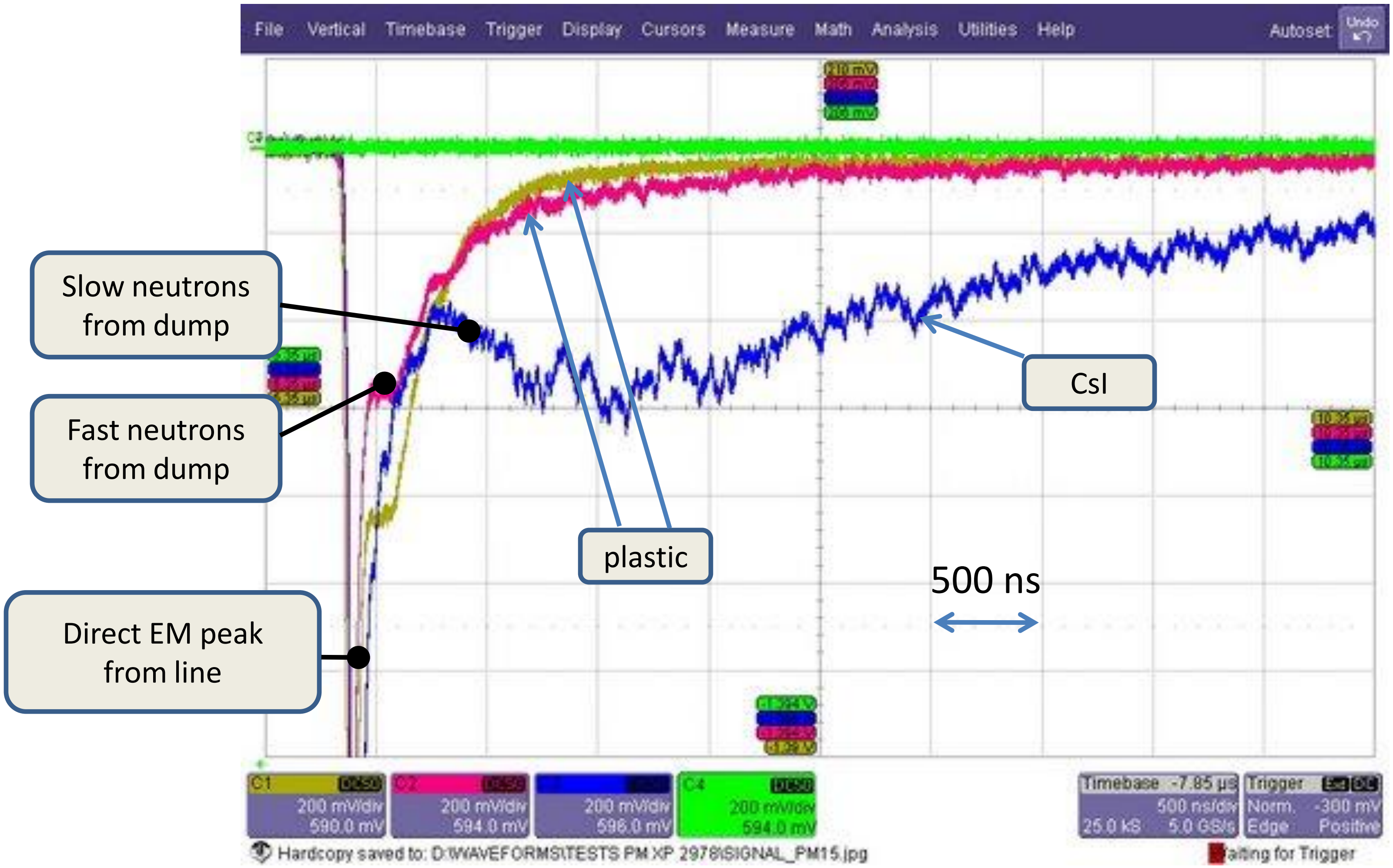
- Modules list:

| Module Number | Delivery Date | Module Name | Scintillator Type | Scintillator Dimensions (mm) | Photomultipler Type |
|---|---|---|---|---|---|
| 1 | March 2009 | mod-1-old-P | BC-408 | $60 \times 60 \times 38$ | XP2978/B |
| 2 | March 2009 | mod-2-old-CsI | CsI | $60 \times 60 \times 20$ | XP2978/B |
| 3 | March 2009 | mod-3-old-P | BC-408 | $60 \times 60 \times 38$ | XP2978/B |
| 9 | March 2009 | mod-ghost-old | (none) | / | XP2978/B |
| 4 | October 2009 | mod-1-new-P | BC-408 | $60 \times 60 \times 38$ | XP2920 |
| 5 | October 2009 | mod-2-new-P | BC-408 | $60 \times 60 \times 38$ | XP2920 |
| 6 | October 2009 | mod-3-new-P | BC-408 | $60 \times 60 \times 38$ | XP2920 |
| 7 | October 2009 | mod-4-new-CsI | CsI | $60 \times 60 \times 20$ | XP2920 |
| 8 | October 2009 | mod-5-new-CsI | CsI | $60 \times 60 \times 20$ | XP2920 |

- Installation example:



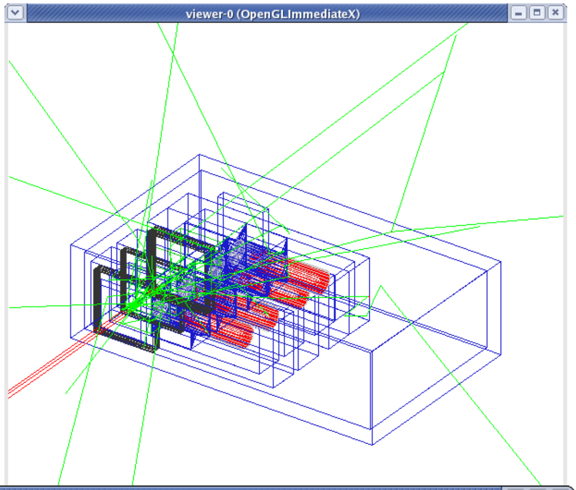
# Examples of observed signals near dump
(trigger = kicker)

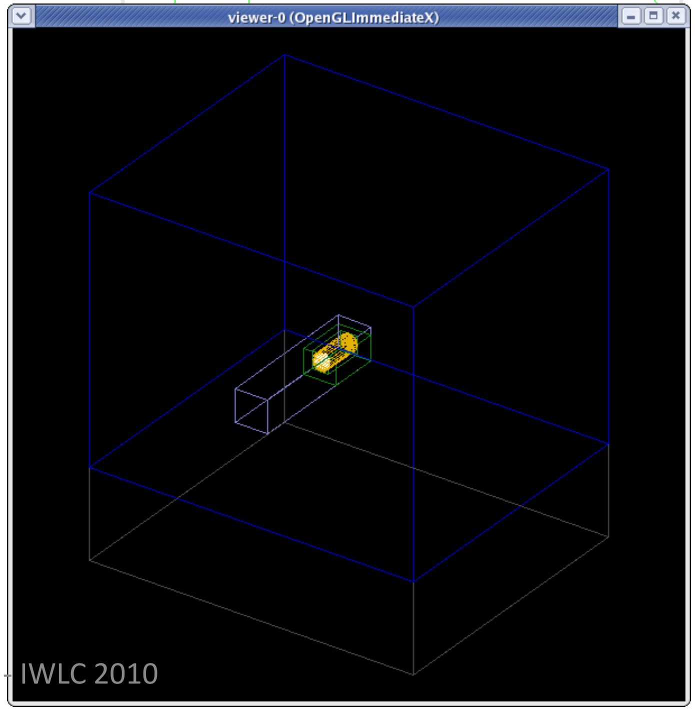


# SIMULATION SETUP AND PRACTICE

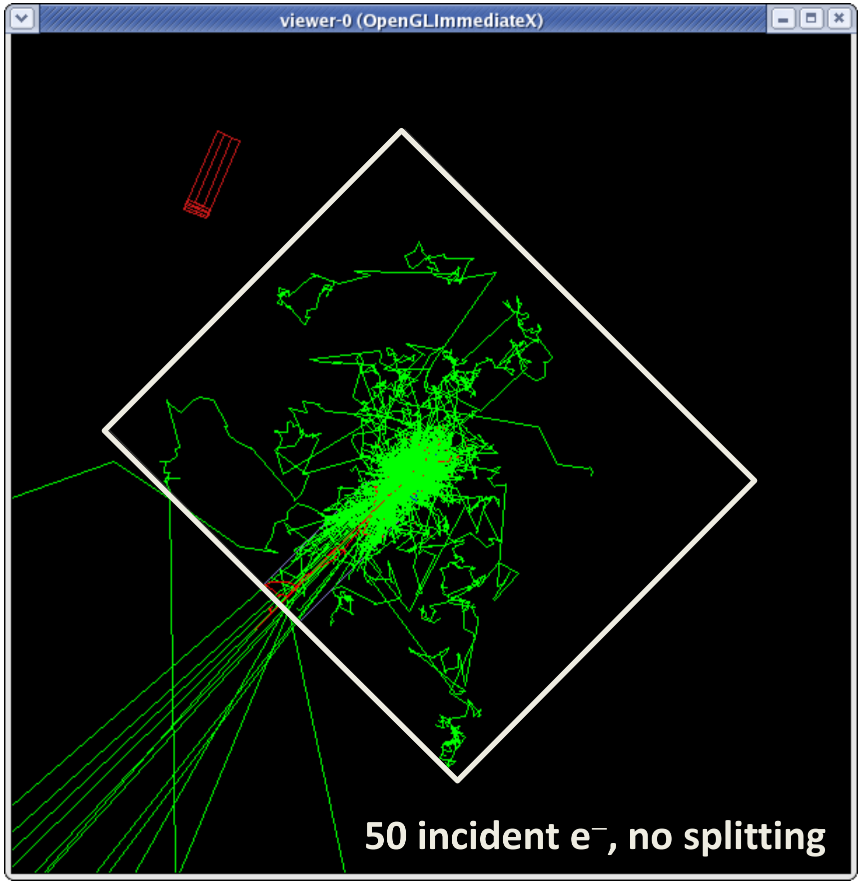
# Simulation setup

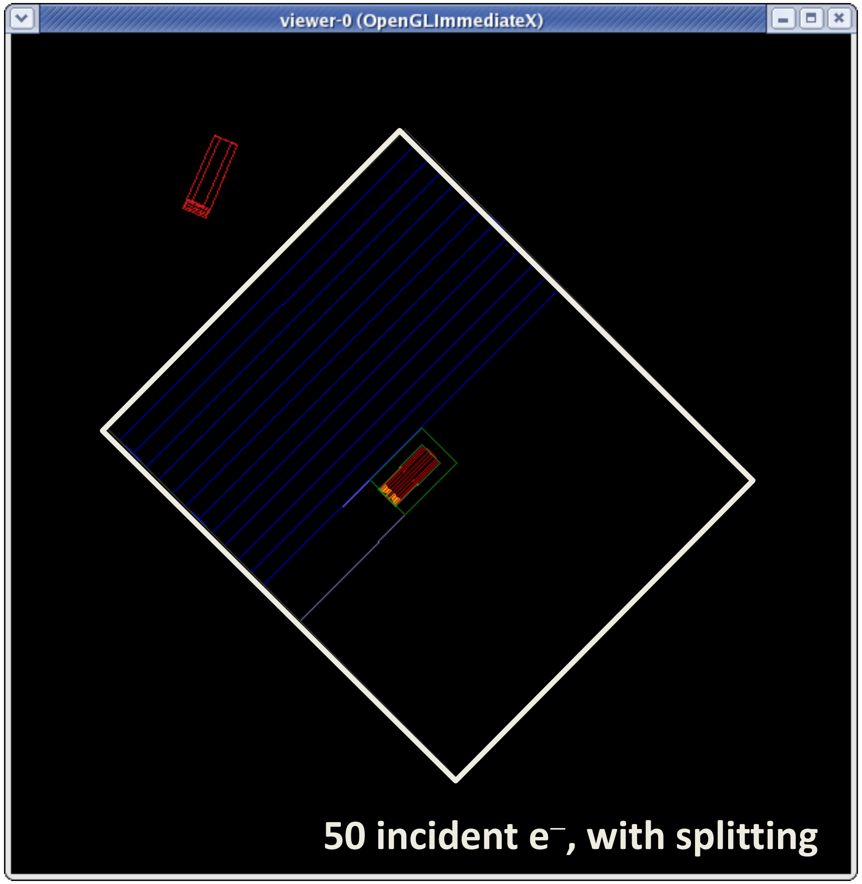
- Geant4 version and physics:
  - Use Geant4, v9.3 – ref 06
  - Physics list considered :
    - QGSP_BERT_HP, to start with
    - There are other ones a priori suitable
- Implement detailed description of measurement modules, and realistic description of beam dump
- Use "splitting" technique, also called "geometrical biasing"
  - To get workable statistics



# Illustration of the « splitting » technique



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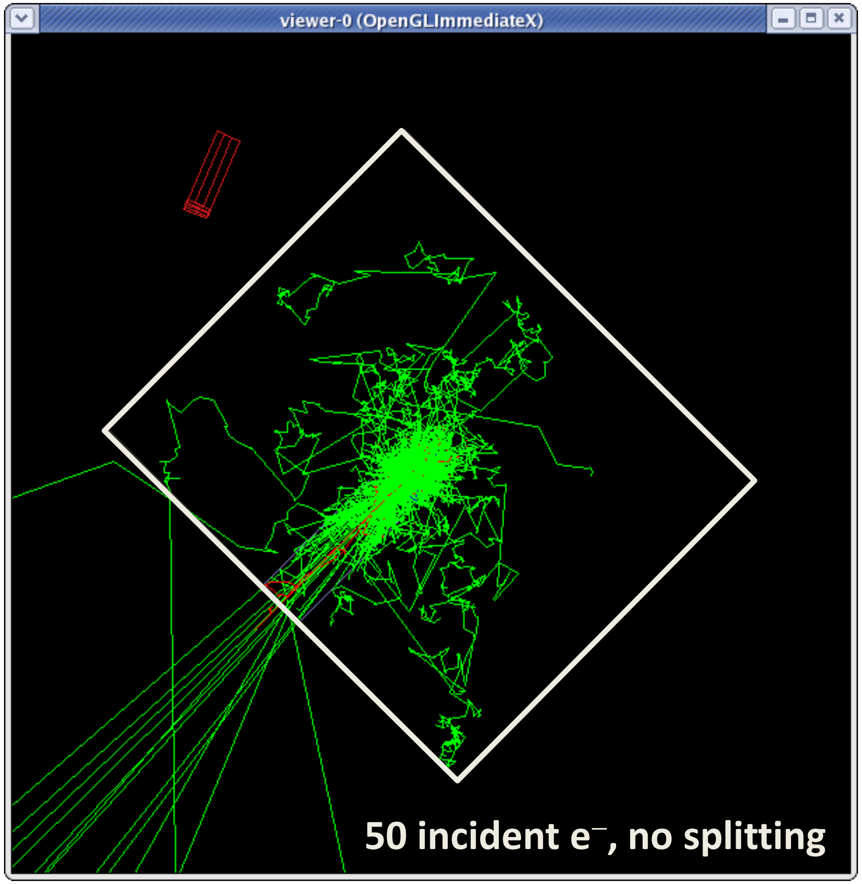
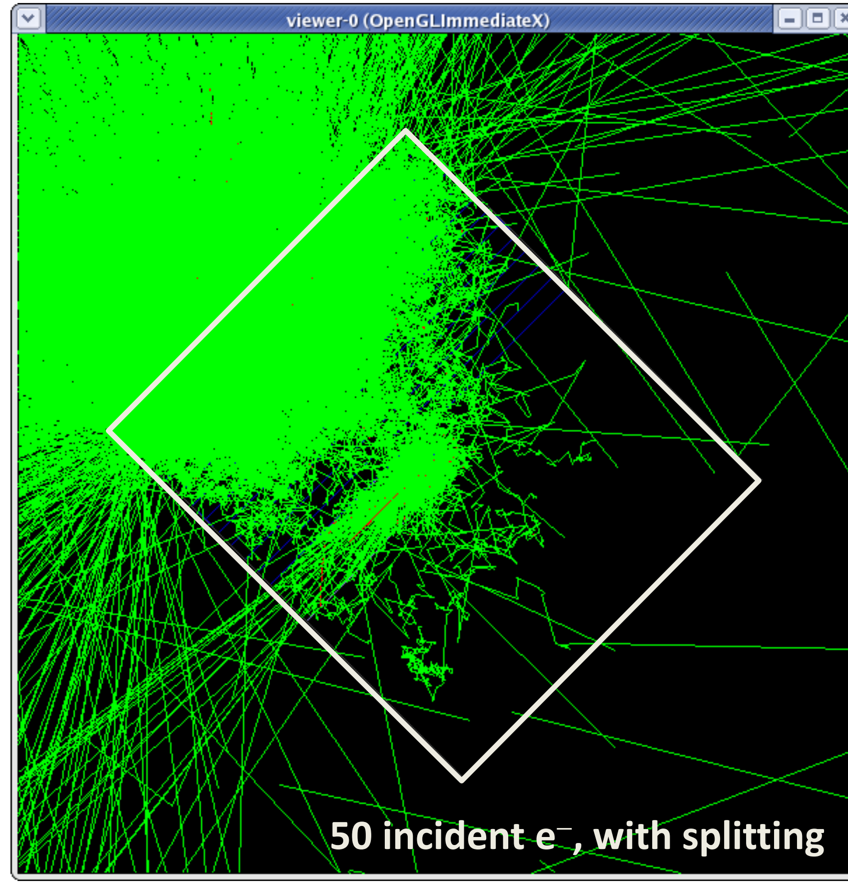



In this case, biased simulation is about 3 order of magnitudes more Efficient than the « straightforward » simulation.

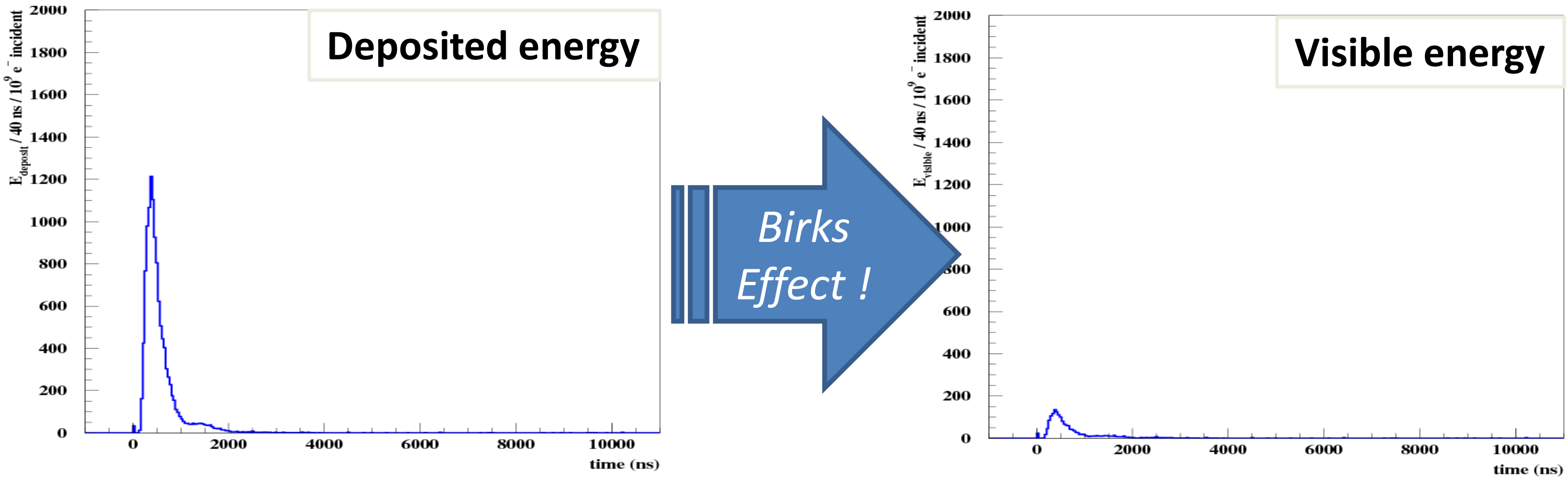
# EXPERIMENTAL EFFECTS AND MEASUREMENTS

# Experimental effects

- Experimental effects can be large
  - And are still under work at present
- Effects under study:
  - Calibration
    - Calibration done with cosmic rays
  - Attenuation by cables
    - Up to 50 meters long at present ☹
    - But fortunately rather small effect for slow signal like average of neutron signals
  - Scintillation saturation (Birks' effect) in plastic scintillators
    - Large effect for neutrons !
    - Fast neutrons detected as n → p, with high dE/dx for p

# Size of Birks saturation effect

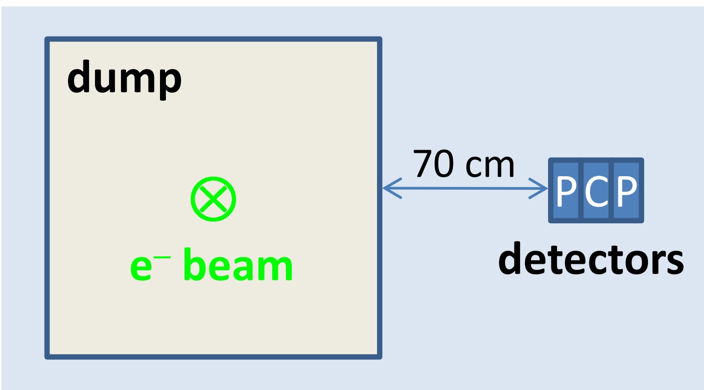
- Birks saturation : $dE_{vis}/dx \sim dE_{dep}/dx \,/\, (1+k_B\, dE_{dep}/dx)$
- Simulated waveform in plastic scintillator
  - Birks constant $k_B = 1.15 \cdot 10^{-2}$ g/cm$^2$/MeV
    - value in BC-408 plastic, as measured in Chinese Physics C (HEP & NP), 2010, **34**(7) 988-992

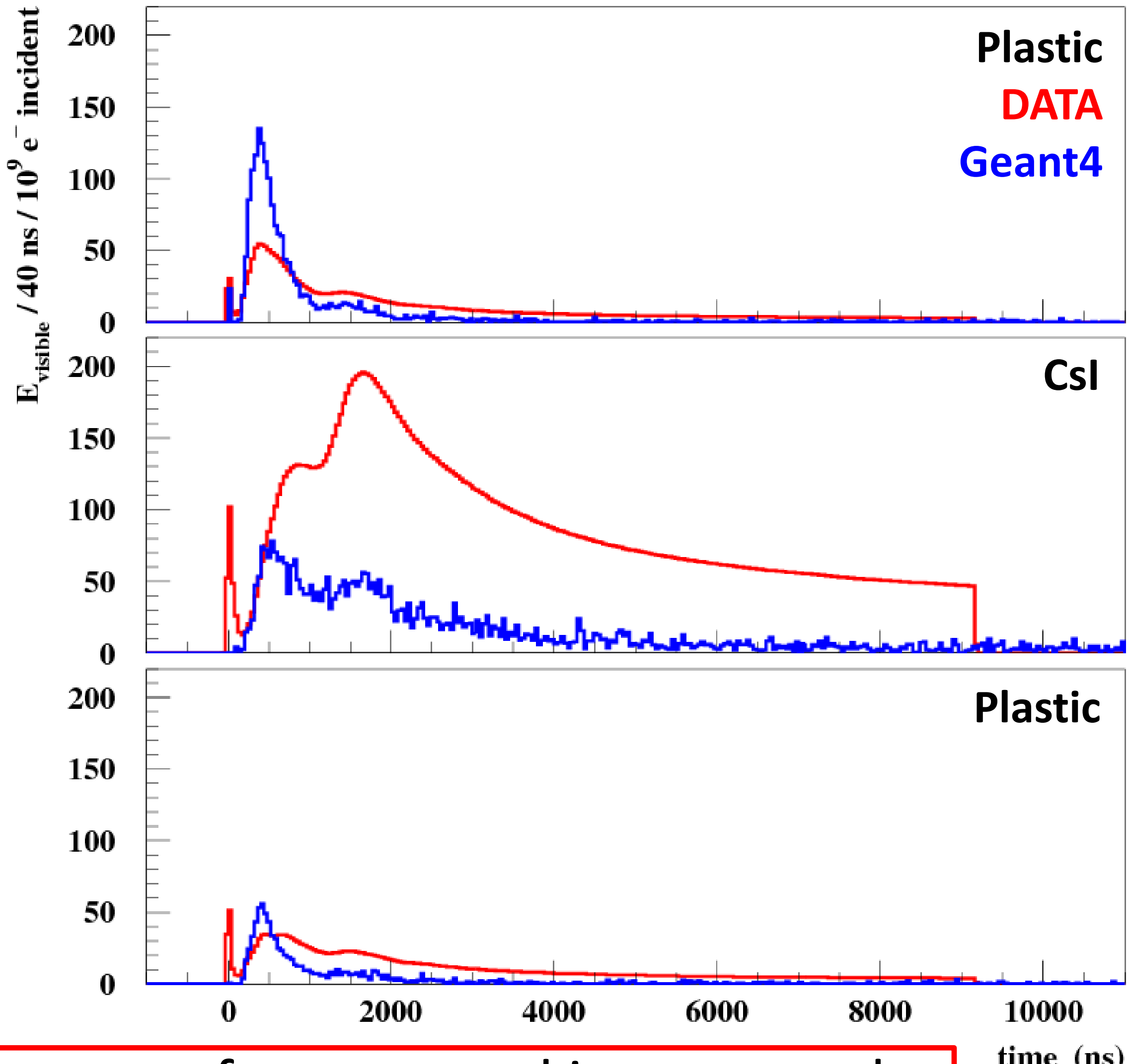



- Very large effect !
- Size of systematic effect on this reduction to be estimated.

# Preliminary Geant4/data comparison

- Experimental setup:
  - Plastic, CsI, plastic
  - 70 cm to dump on lateral side (opposite to Shintake photon detector)




- Plots normalized to $10^9$ incident 1.3 GeV $e^-$.
- Significant differences
- But Geant4 reproduces the gross features, and is not away by order of magnitudes.

# Conclusion

- A study is ongoing at ATF2 to evaluate the physics reliability of Geant4 about neutron production and transport in a context of background modeling
- Comparison between Geant4 (QGSP_BERT_HP physics list) and data are still preliminary at this stage
  - More work needed to have systematic effects on measurements under control
  - More Geant4 physics lists to be tested
- Simulation and data differ
- But gross-features are reproduced by the simulation
  - Simulation and data are not apart from order of magnitudes
  - They are typically within a factor 2 to 5
- This is, we hope, a start of the response for the MDI needs