international linear collider

Background measurement @ ATF2 (KEK)

What could be learned @ ATF2 that could be valid for ILC ?

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7th ATF2 Project Meeting

Outline

- Motivations : why do we want to measure the background @ ATF2
- Where and what we plan to measure the background
- Set of aparatus we are working on
- Conclusion : propositions for measurements

ILC background sources

- Machine produced background before IP
  - Beam tails (halo) from linac
  - Synchrotron radiation
  - Muons
  - Beam-gaz scattering
- Beam Beam background @ IP
  - Beamstrahlung
  - Coherent/incoherent pair prodution
  - Hadron prodcution
- Spent beam background
  - Backscattering of particles (specially neutrons)

D. Schulte, CERN, 2007

ILC vs ATF2 background sources

- Machine produced background before IP
  - Beam tails (halo)
  - Synchrotron radiation (small @ ATF2)
  - Muons
  - Beam-gaz scattering
- Beam Beam background @ IP
  - Beamstrahlung
  - Coherent/incoherent pair prodution
  - Hadron prodcution
- Spent beam background
  - Backscattering of particles (specially neutrons)

Tools common to ATF2 and ILC

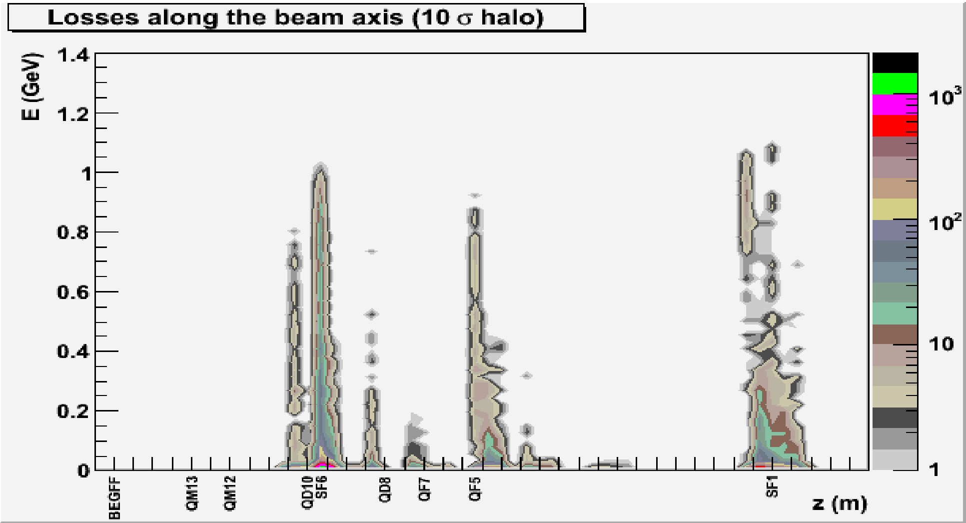
- BDSIM : Beamline Simulation toolkit based on GEANT4
  - Beam and halo transport
  - GEANT4 simulation of lost particles
- BDSIM is used for ILC studies
- Opportunity to test this tool @ ATF2 (in a particular conditions/context)

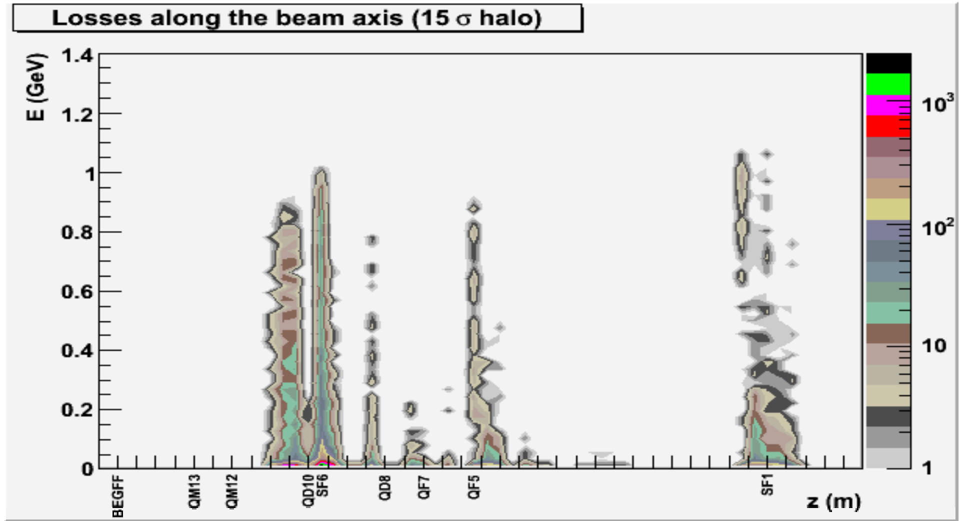
Background sources @ ATF2

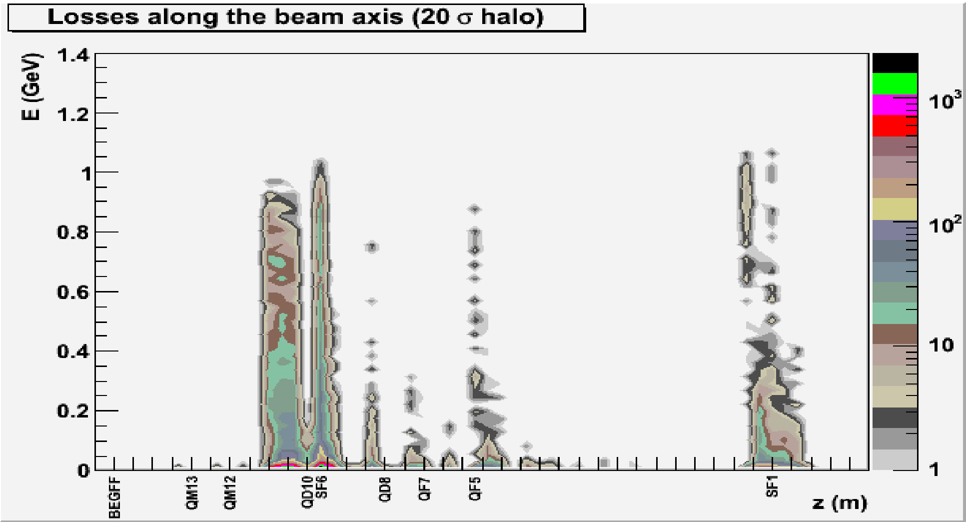
Beam halo && Beam gas scattering

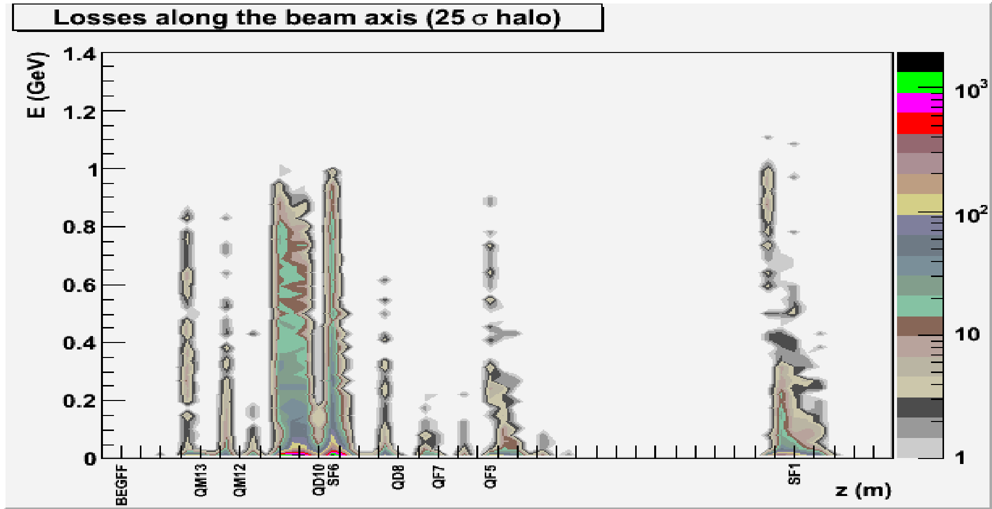
- From where the halo has been generated ?
- From which ”parameters” does it depends ?
  - Beam tube gas pressure
    - Beam-gas scattering
  - Othere particles processes
    - Touschek scattering, Intra-beam scattering, ...
  - Optics related effects (non scattering process)
  - Collective and equipment related (Wake-fields, ...)
- Possibilities @ ATF2 in HALO measurement
  - Measure the beam Halo @different positions
    - Test the beam halo transport

Example losses vs Z (BDSIM)









- Provide information on the beam halo distributions
- Provide a test of the ”use of” the BDSIM simulation
- **PLIC measurement desirable as well as all available detectors**

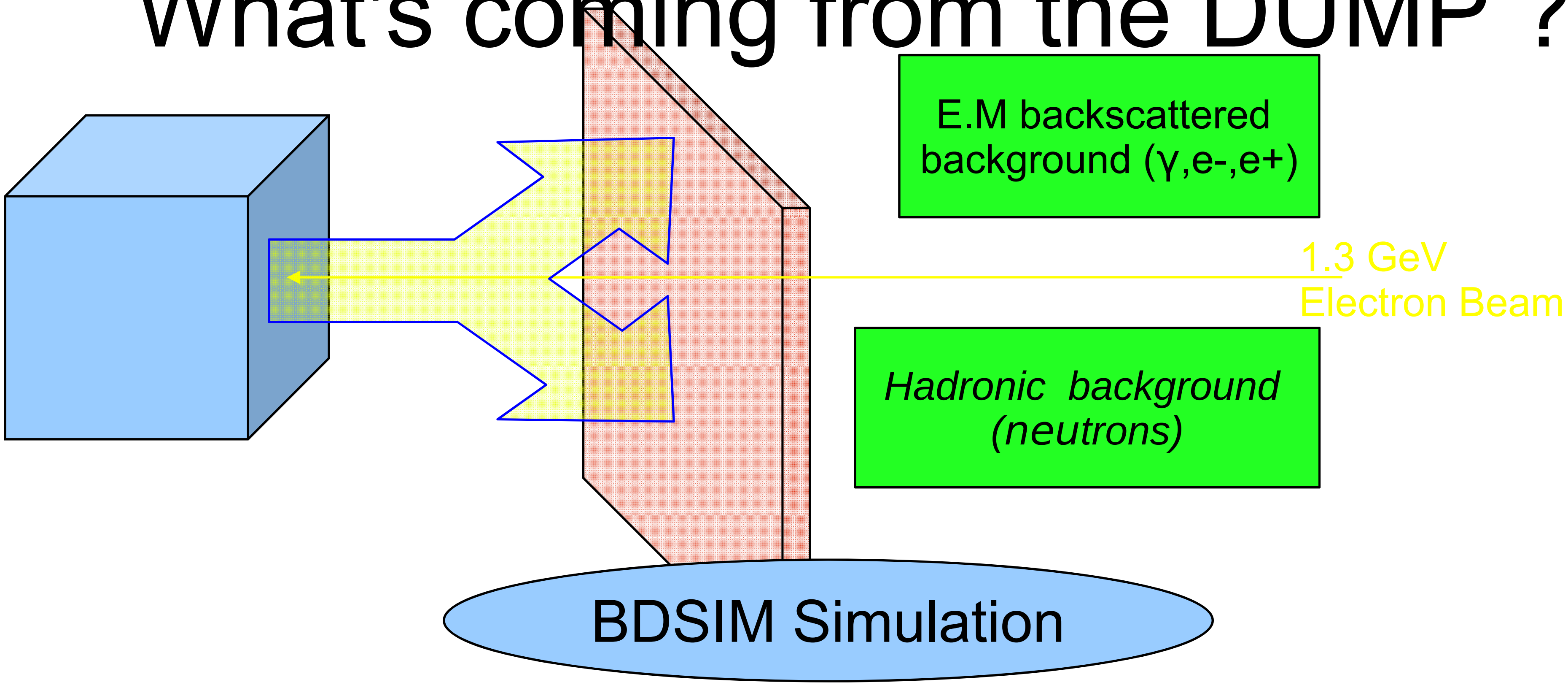
Beam gaz scattering

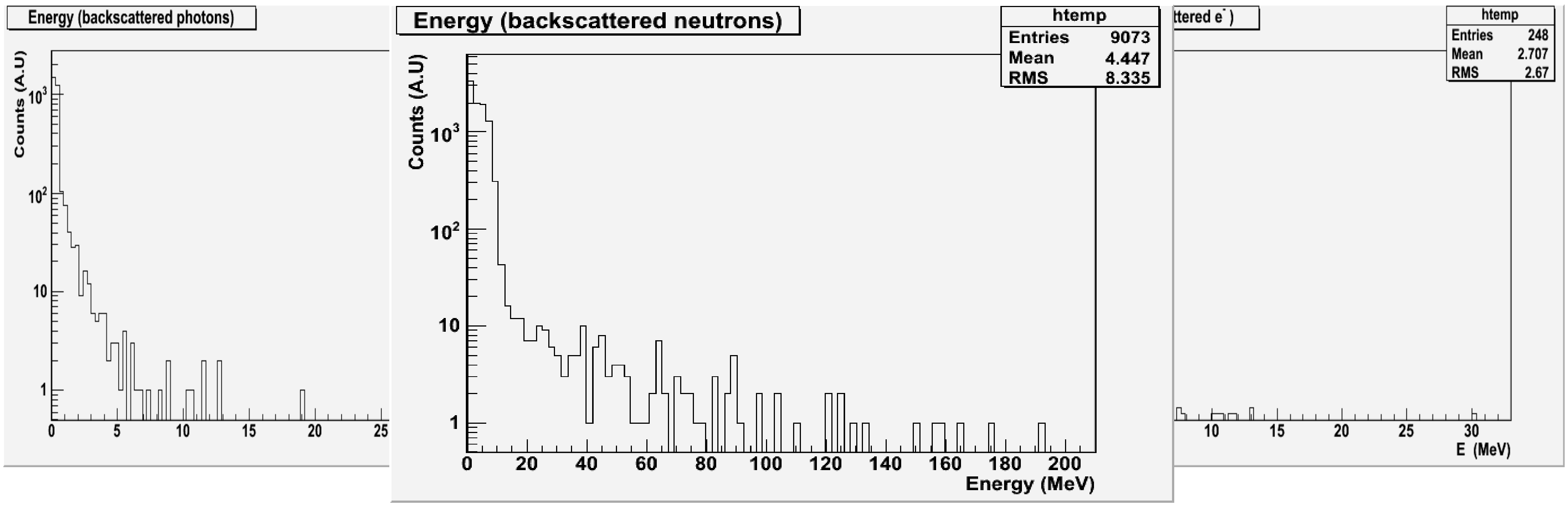
- Elastic scattering
  - Mott scattering : deflexion by the Coulomb potential of the particles in the residual gas
  - Elastic scattering changes the direction of the beam particles while the energy is not affected
  - Create Halo → Losses
- Inelastic scattering
  - Dominant process at high energy
  - Bremsstrahlung with the residual nucleon gas
- Can be tested @ ATF2 ?
  - Record the beam-pipe gas pressure
    - Possibilities to changes the beam-pipe gas pressure ?
  - Measure related impact on background
  - Related to beam halo measurement
  - Additionnal background ?

Backscattered production

- Iron made beam DUMP
  - 1.3 GeV e- hitting the DUMP
  - Shielding around the beam-DUMP interaction region
- Electromagnetic background
  - Low energetic photons (mainly X rays)
  - Backscattered electrons
- Hadronic background (neutrons)
  - Mainly produced by photo-production
  - Slower component : nucleon-nucleon effects
  - Delayed from EM background
    - Use TOF to separate from EM background

What's coming from the DUMP ?

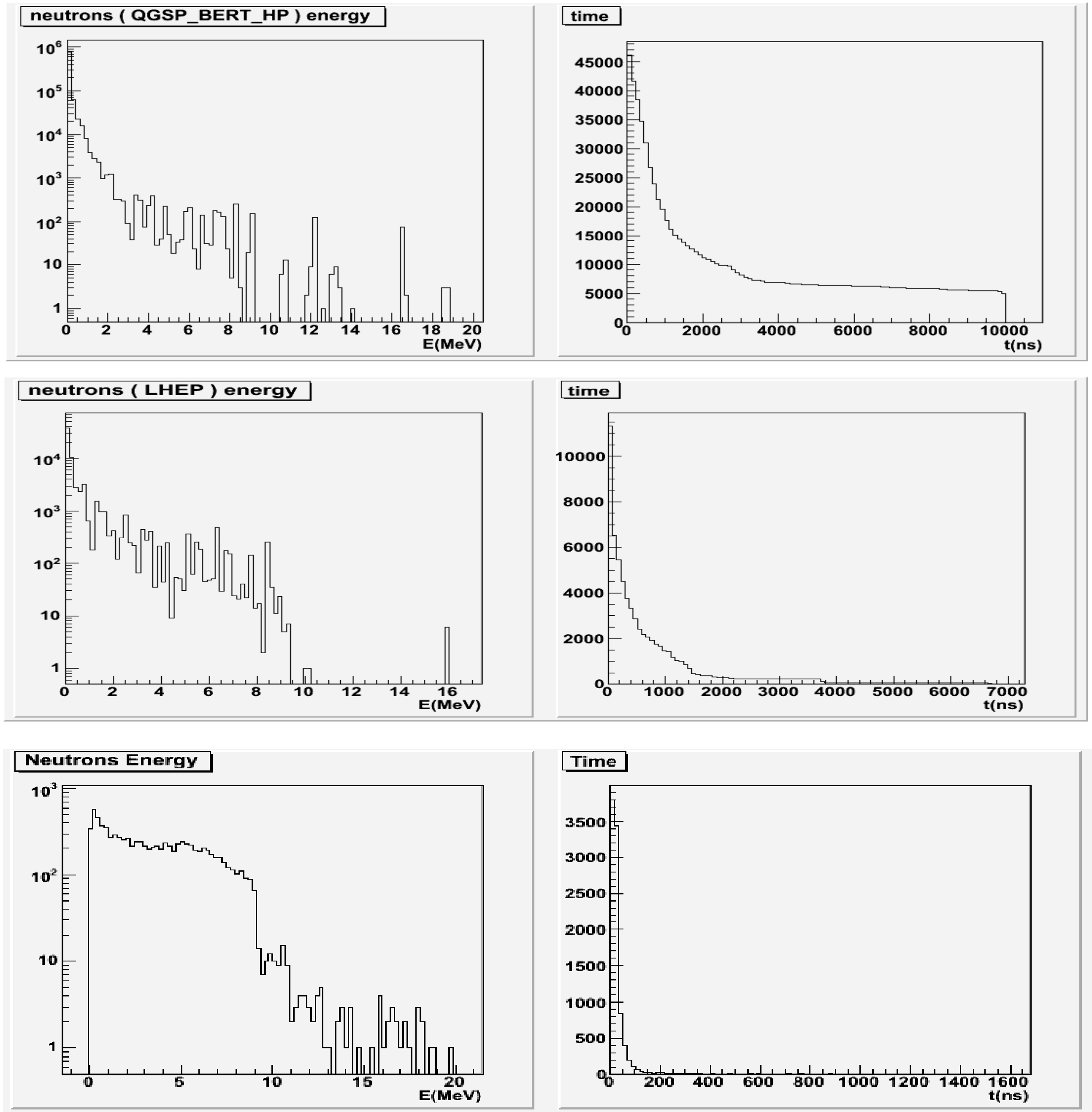




Test neutron production models @ ATF2

- Many models (physics lists) describe neutron production in GEANT4
  - 1 process -> many possible models -> many cross sections
    - A process
      - uses cross sections to decide when and where an interaction will occur
      - uses an interaction model to generate the final state
    - For each process – default cross sections
      - some contain only a few numbers to parameterize cross section
      - some represent large databases
- Simulation : Use the ATF2 (1.3 GeV e-) beam hitting the iron DUMP
- Compare different physics lists

Neutron production for 3 ”models”



QGSP

- Quark-Gluon string with precompound
- Precompound call nuclear desexitation routine
- 12 GeV → 50 TeV

BERT

- BERTini cascade
- Unique evaporation model to de-excite the remnant nucleus
- Up to 10 GeV

HP

- High precision neutron
- Allow precise transportation of neutrons

LHEP

- Low and high energy parametrized
- Fast parametrized model based on GHEISHA
- Average energy and momentum are well described

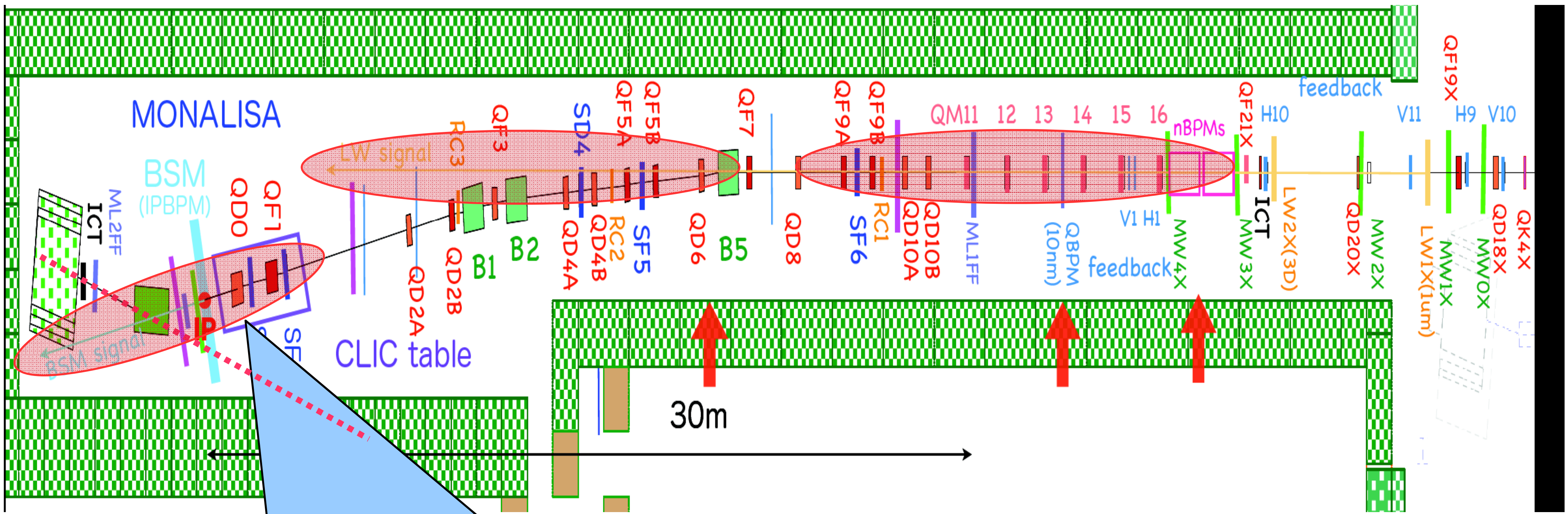
BDSIM user defined Hadronic Physics list

Where ?

Proposal for dedicated measurements

(in addition to those provided by PLIC, Shintake, …)

HALO : Background measurement

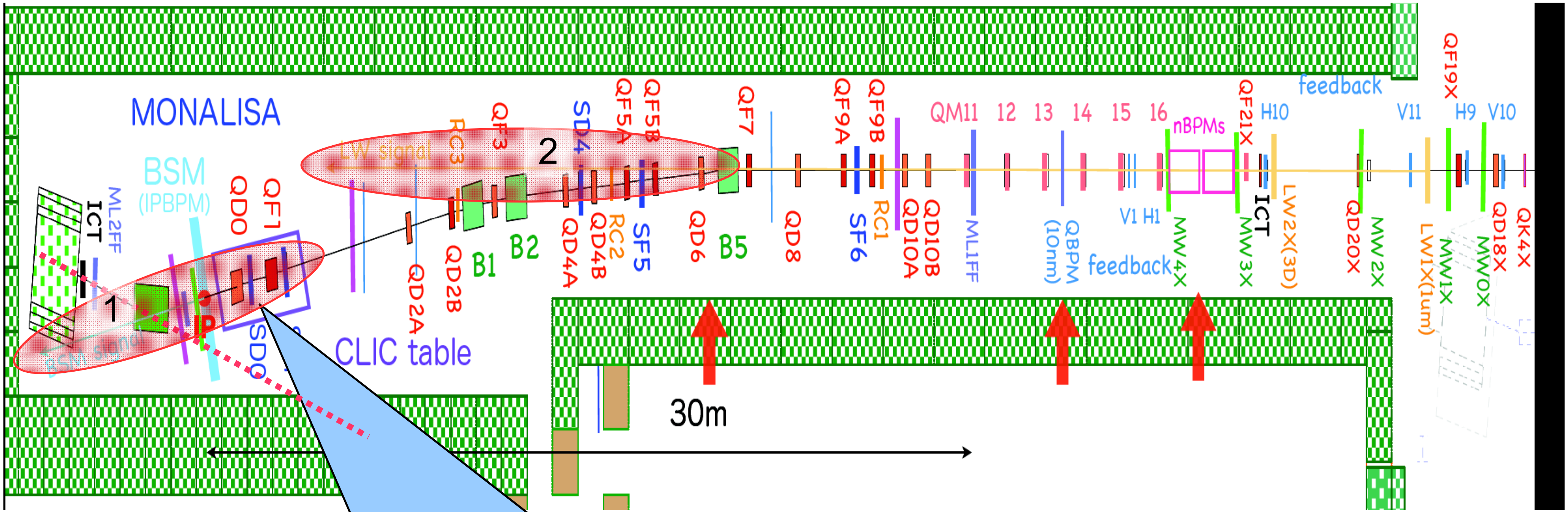


➢Beam HALO studies through:

➢Background (Bremsstrahlung photons) measurement

- ➢Around LW signal area
- ➢Around Shintake Detector Area

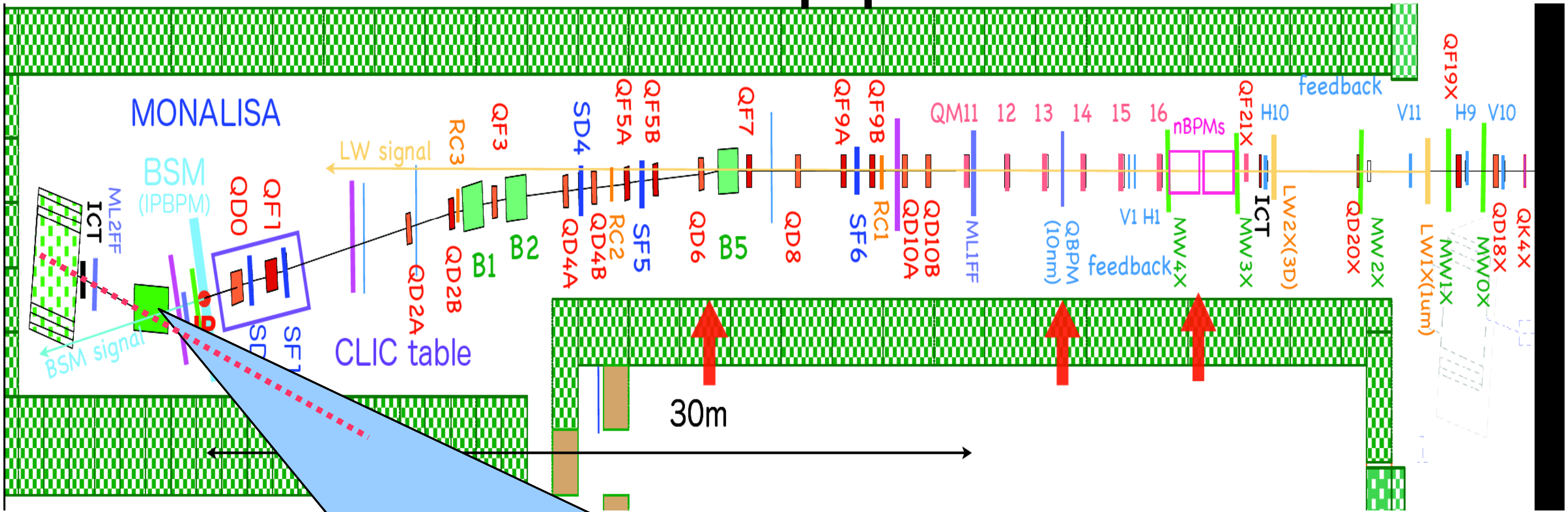
Wire Scanner generated background measurement



➢Wire Scanner generated background

- ➢From (All) different Wire scanners
  - ➢Study angular distributions
  - ➢measurement around area 1 and 2

Backscattered γ/X and neutrons inside beampipe



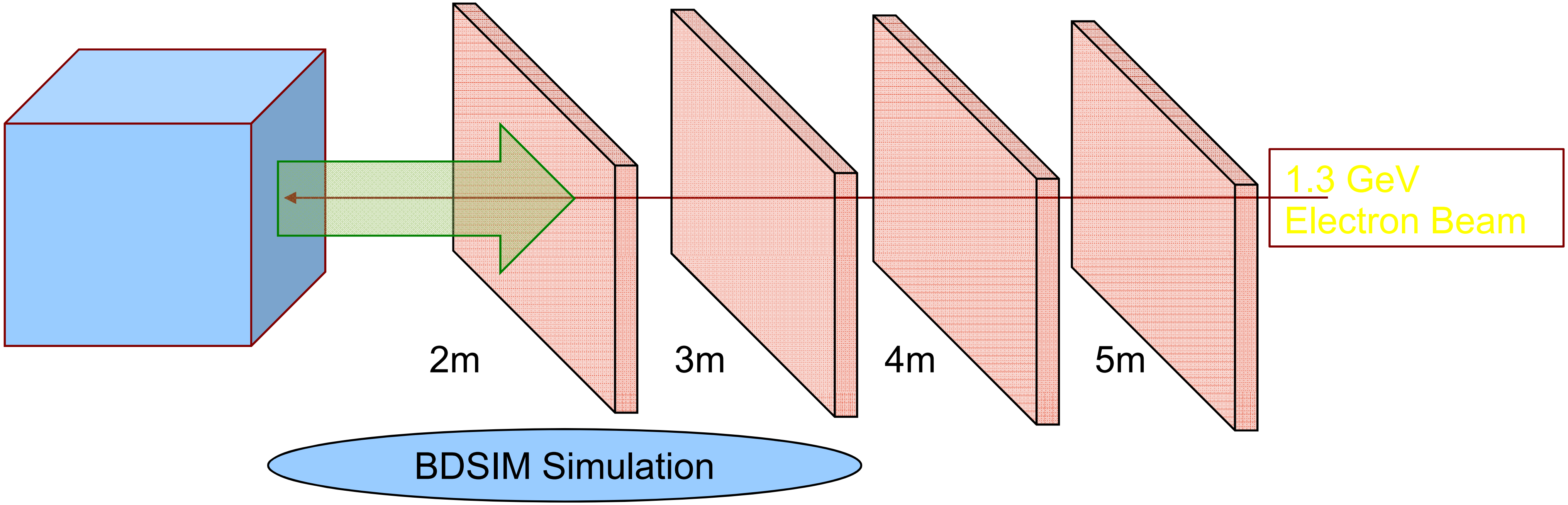
➢Backscattered γ/X and neutrons:

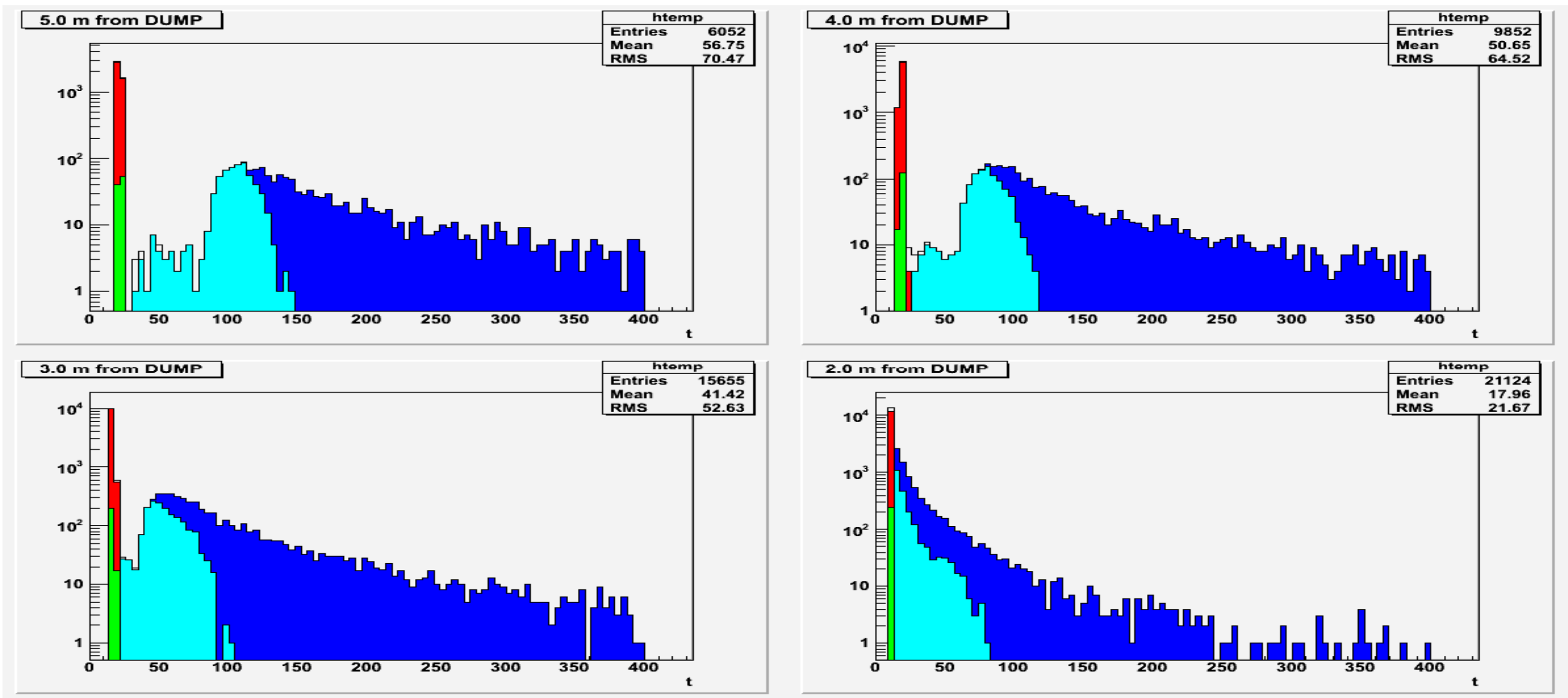
➢Use TOF to separate forward brem, backscattered photons, backscattered neutrons

➢Possibility to measure neutrons, and be sensitive (?) to rebounds in the beam pipe

➢**Enough space to measure ?**

Backscattered Background @ different distances from beam DUMP





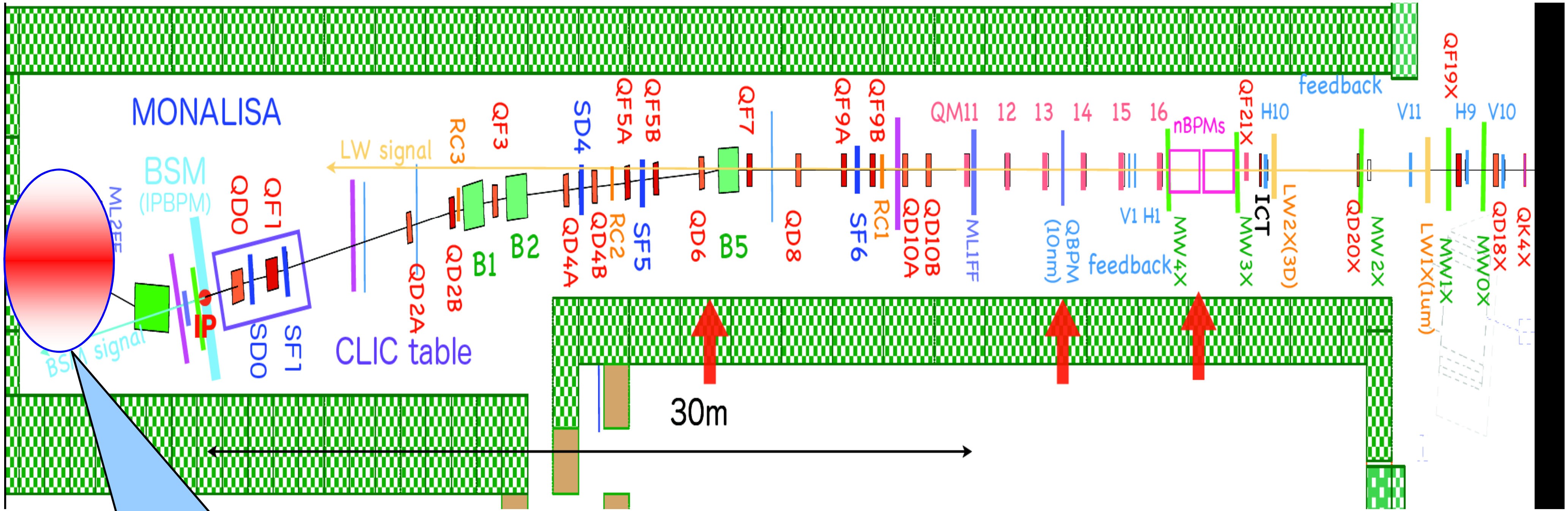
Gammas

e-

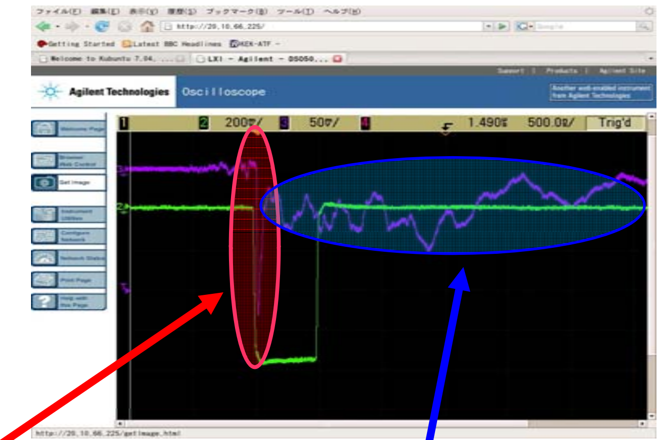
Fast neutrons (E>5 MeV)

Neutrons

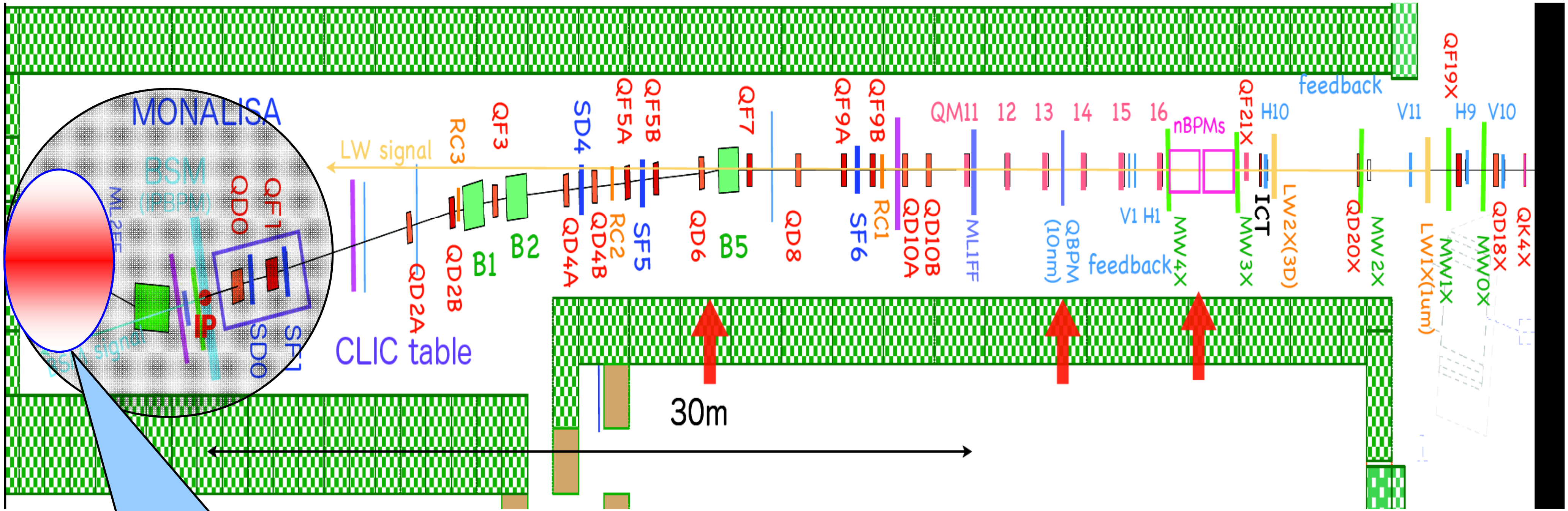
Backscattered neutrons from DUMP



➢Neutrons detection :
- Time of Flight (TOF) based measurements
- Angular distribution around the DUMP



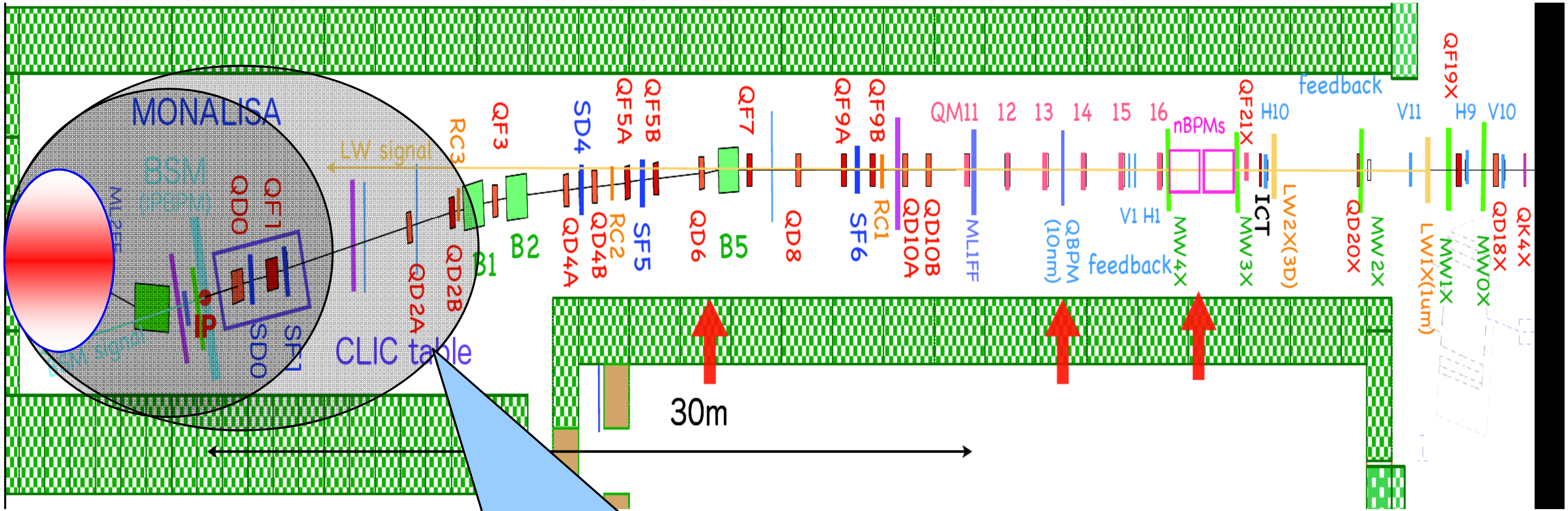
Backscattered neutrons from DUMP



➤ <u>Neutrons detection :</u>

- Time of Flight (TOF) based measurements
- Angular distribution around the DUMP

Backscattered neutrons from DUMP



➤ <u>TOF Neutrons @ different distances from DUMP:</u>
- ➤ Fast/thermal neutrons discrimination
- ➤ Fast neutrons/EM background discrimination

Can use **Paraffin** to moderate fast neutron to separate fast neutrons from thermal neutrons

How ?

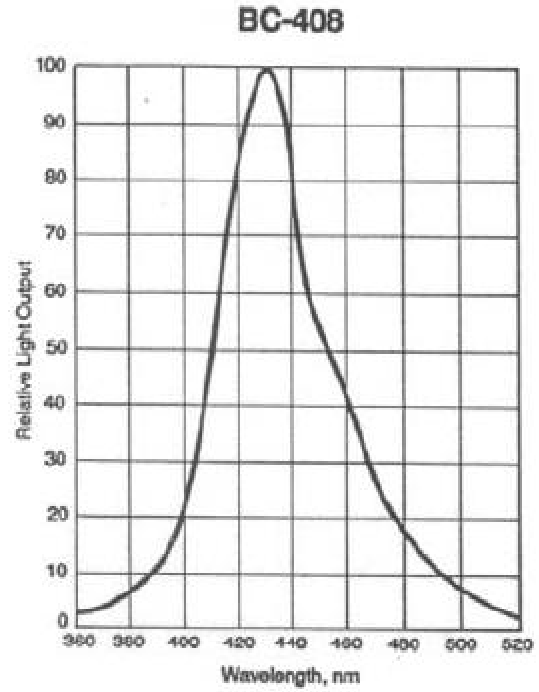
Set of apparatus we are working on

Detector Concept

- Constraints :
  - (small amount of) money to build the detector
  - Places @ ATF2 to measure background
- Need a flexible (**evolutive**) detector
- Need a **mobile** detector
- Need an hybrid detector
  - To detect e.m background
    - X rays, gammas, electrons
  - Neutrons
    - Fast and slow component

Our detectors – so far

- **3 pure CsI detectors**
  - 60mm*60mm*20mm
  - UV filter (keep UV)
- **5 Plastic scintillators (BC-408)**
  - 60mm*60mm*38mm
- **Readout :**
  - Photomultiplier
  - Oscilloscope



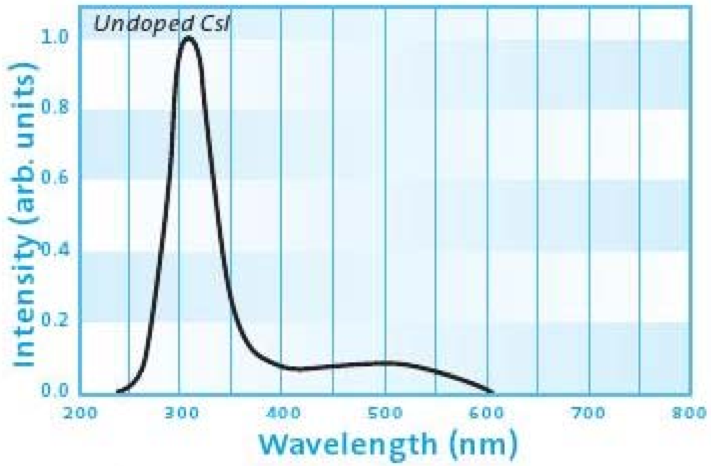
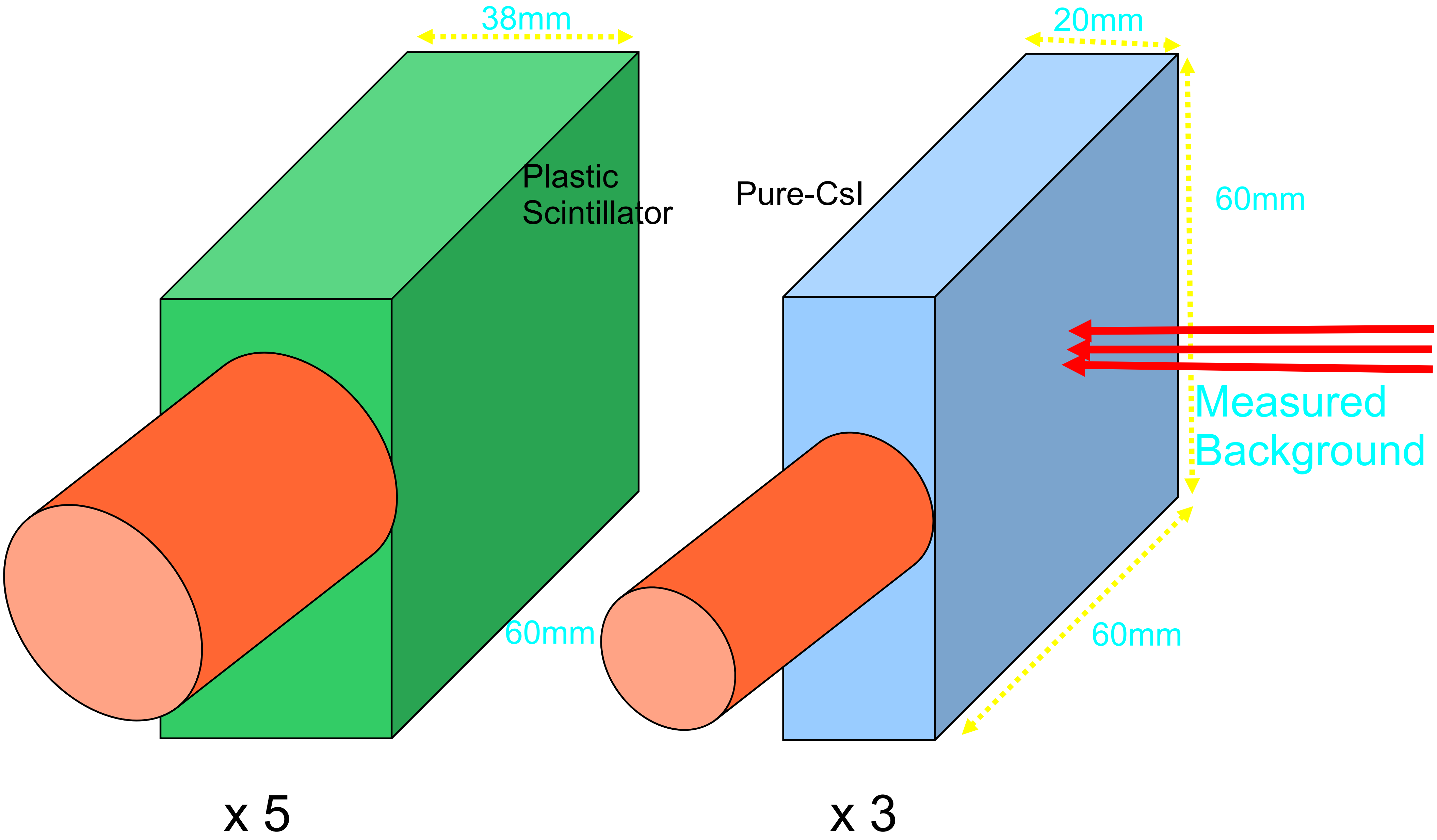
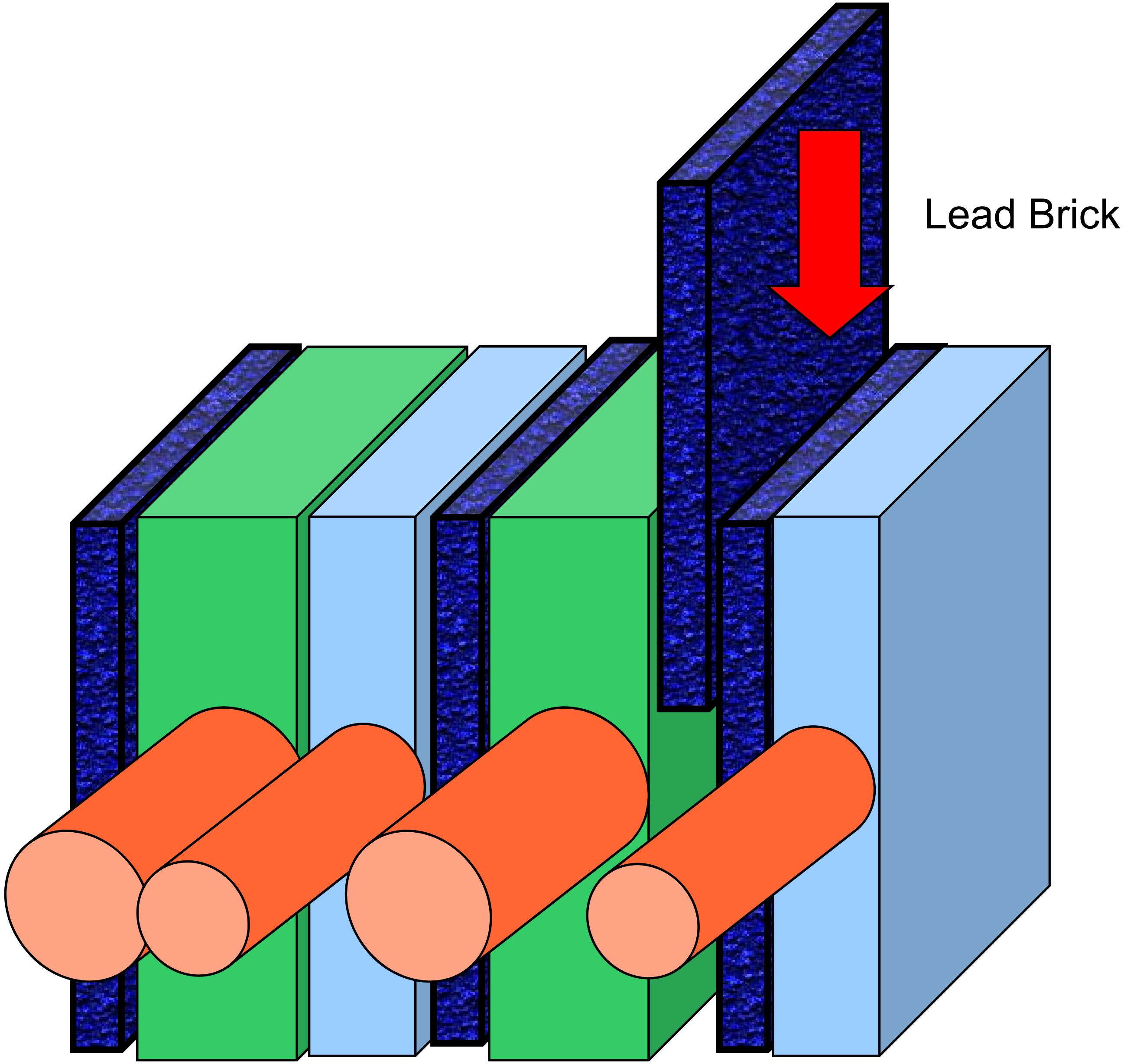


Figure 1. Scintillation emission spectrum of CsI(pure)

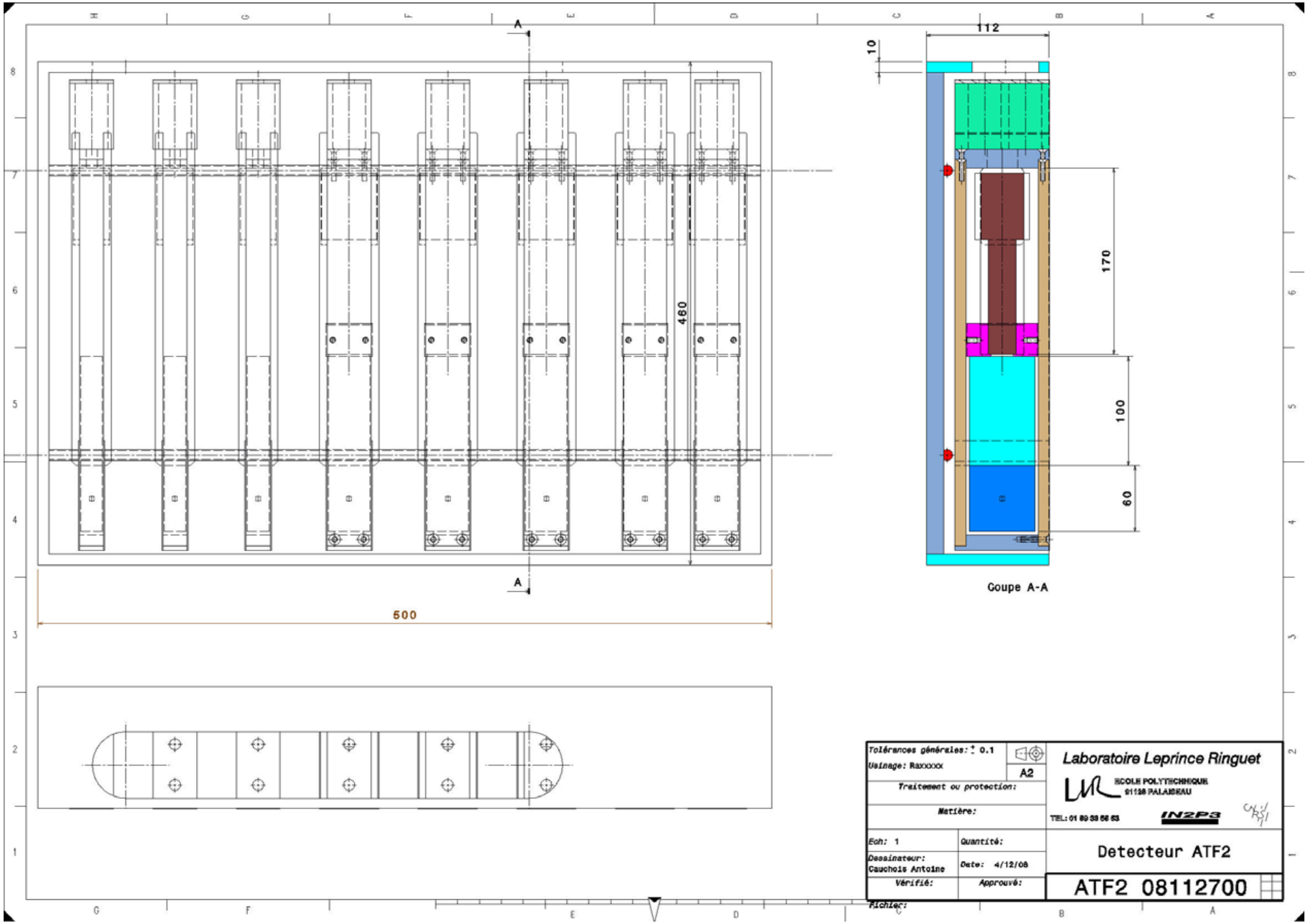
Detection devices



Adaptable configuration, eg:



Mecanical drawing



What do we need on site

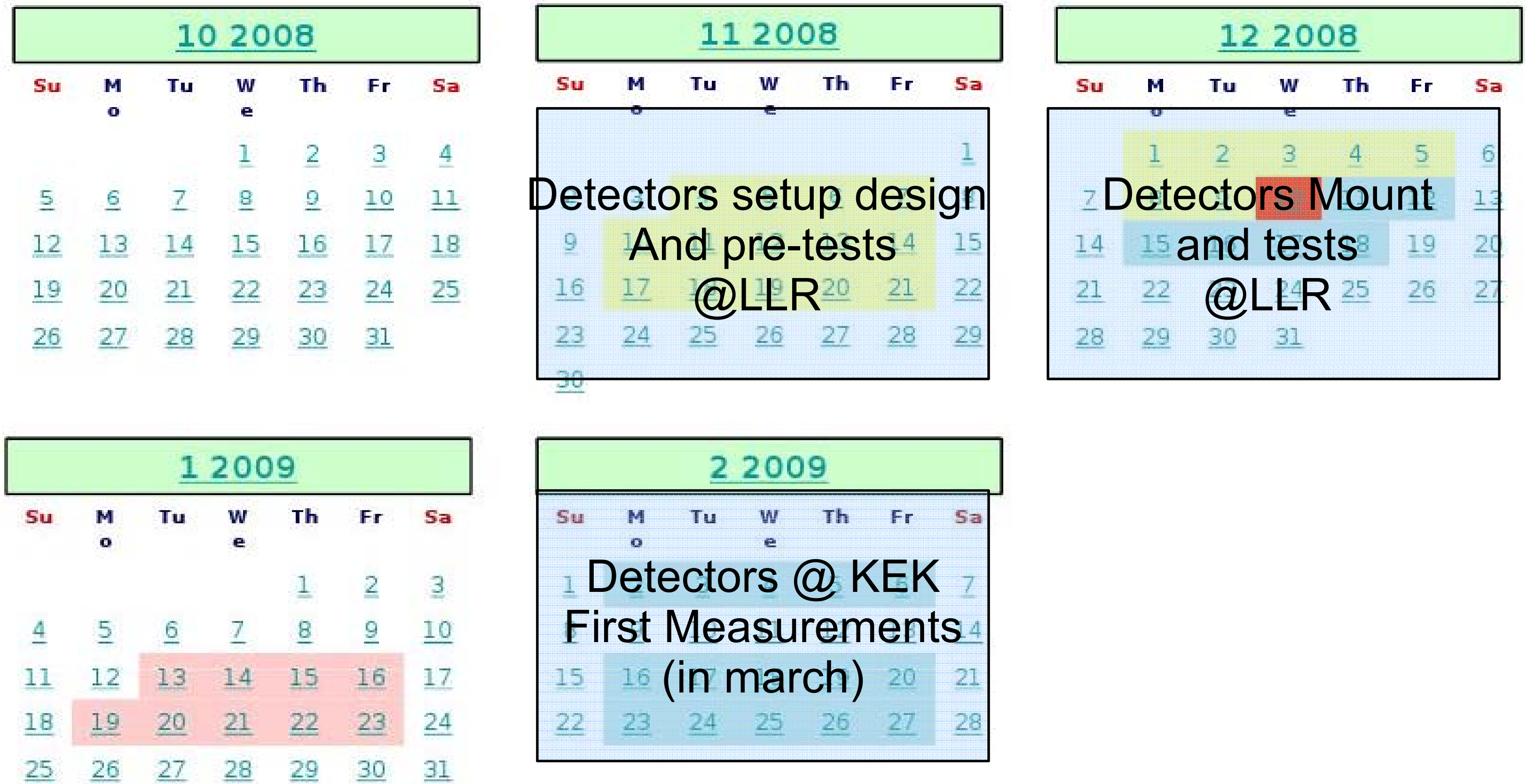
- We would need to measure background @ any place along the ATF2 beamline
- No definite place has been define
  - Need to send our signals from everywhere
  - Need to know our detector position with a good precision
- One need to keep the flexibility the change the detector position as often as needed.
  - Oscilloscope will be used from the beginning
  - Other solution would come later on
    - Dedicated electronic

Time Schedule & Calibration

- November-December 2008 :
  - Receive all crystals from Saint-Gobain
  - Build the detectors
- December-January :
  - E.M calibration :
    - Use radioactive sources @ LLR
    - Use DESY e- beam (1 to 6 GeV) ?
    - Any possibility @ KEK ?
  - Calibration to neutron signal :
    - Need to calibrate neutron response :
      - Neutron beam @ saclay (France) ?
      - @KEK ? Others ?

Time Schedule

Plan of New ATF Beam Schedules



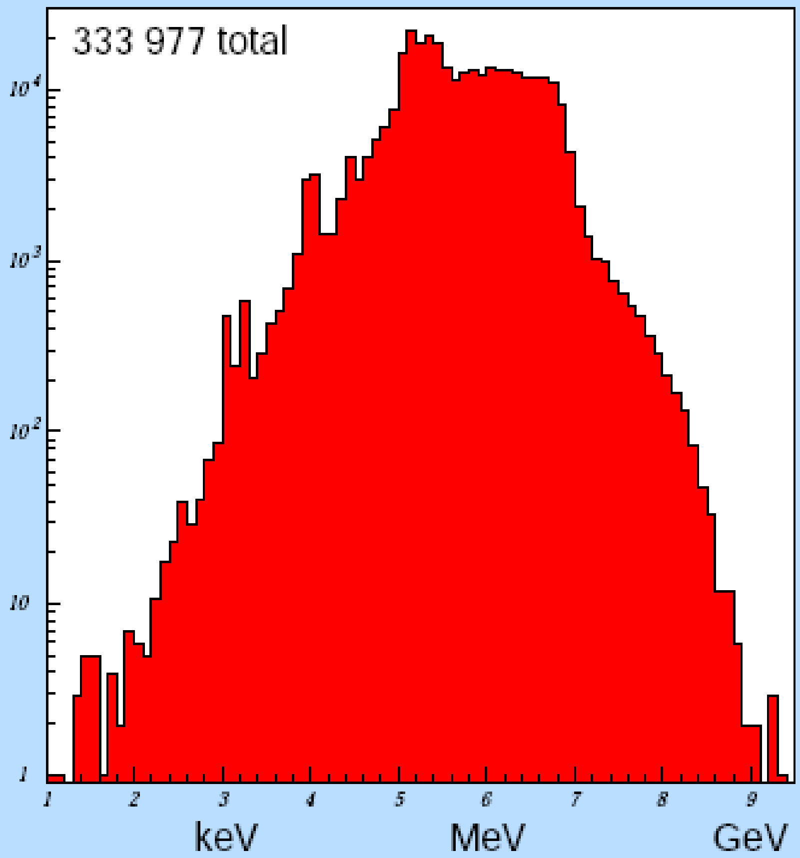
- preparation of radiation inspection
- radiation inspection
- fast kicker study (cannot extract the beam)

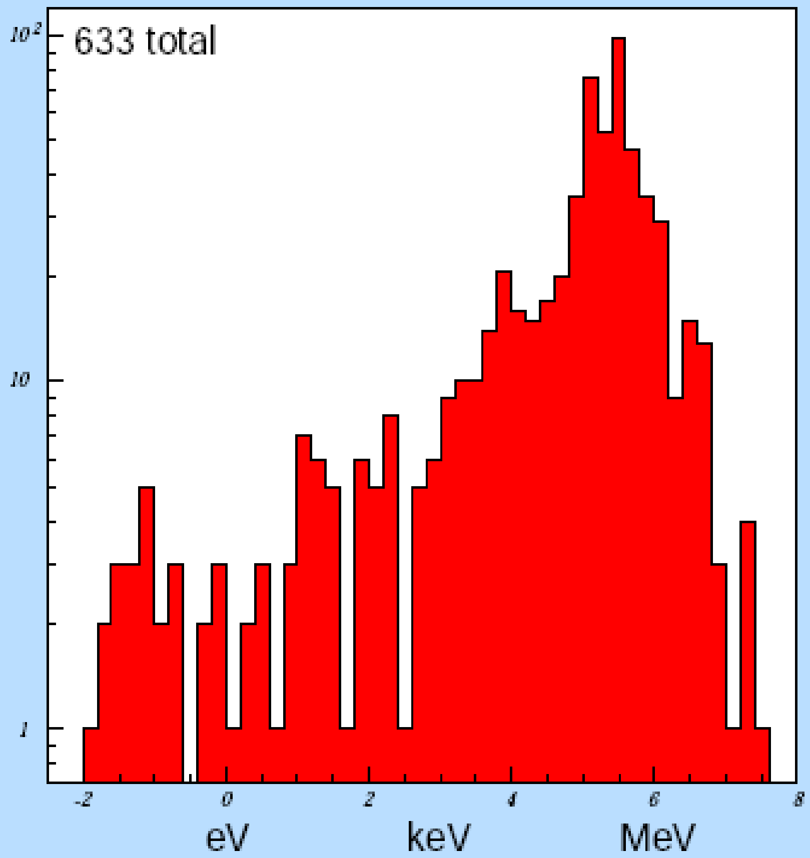
To measure list (preliminary)

What	Where	Detector	Additional device	Additional detector	Remarks	Shifts needed (hours)
Backscattered neutrons	Around the beam dump	Complete detector	Lead brick and paraffin		TOF	1*8h + parasite
Neutrons in beam pipe	Around the Shintake detector area	Complete detector	Lead brick and paraffin		TOF	1*8h + parasite
Beam HALO	Around the Shintake and LW area	Complete detector	Lead brick and paraffin	Shintake detector + LW detector + PLIC + WS	Measure the halo @ different places	1 * 12h + parasite
Beam-Gas scattering	Around the Shintake and LW area	Complete detector	Lead brick and paraffin	Shintake detector + LW detector + PLIC + WS	Change the beam gas pressure	2 * 8h
Wire-scanner background	Around the Shintake and LW area	Complete detector	Lead brick and paraffin	Shintake detector + LW detector + PLIC + WS	Measure the background angular distribution	2 * 8h
Losses	Along the beam line	Complete detector	Lead brick and paraffin	Shintake detector + LW detector + PLIC	Measure background + losses @any z and any time	1 * 8h + parasite

Some slides concerning ILC simulations concerning neutrons

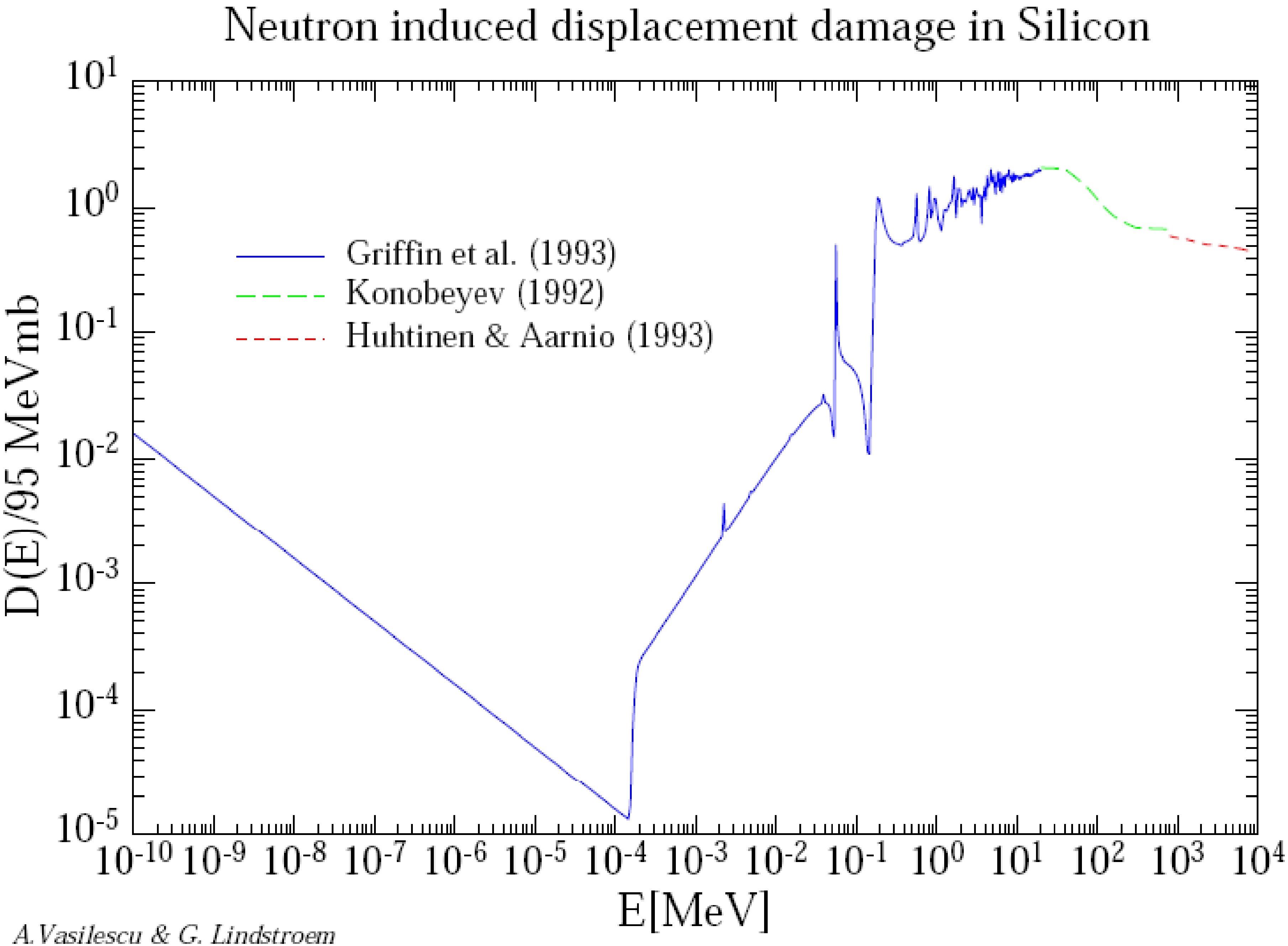
Neutron Production – Energies



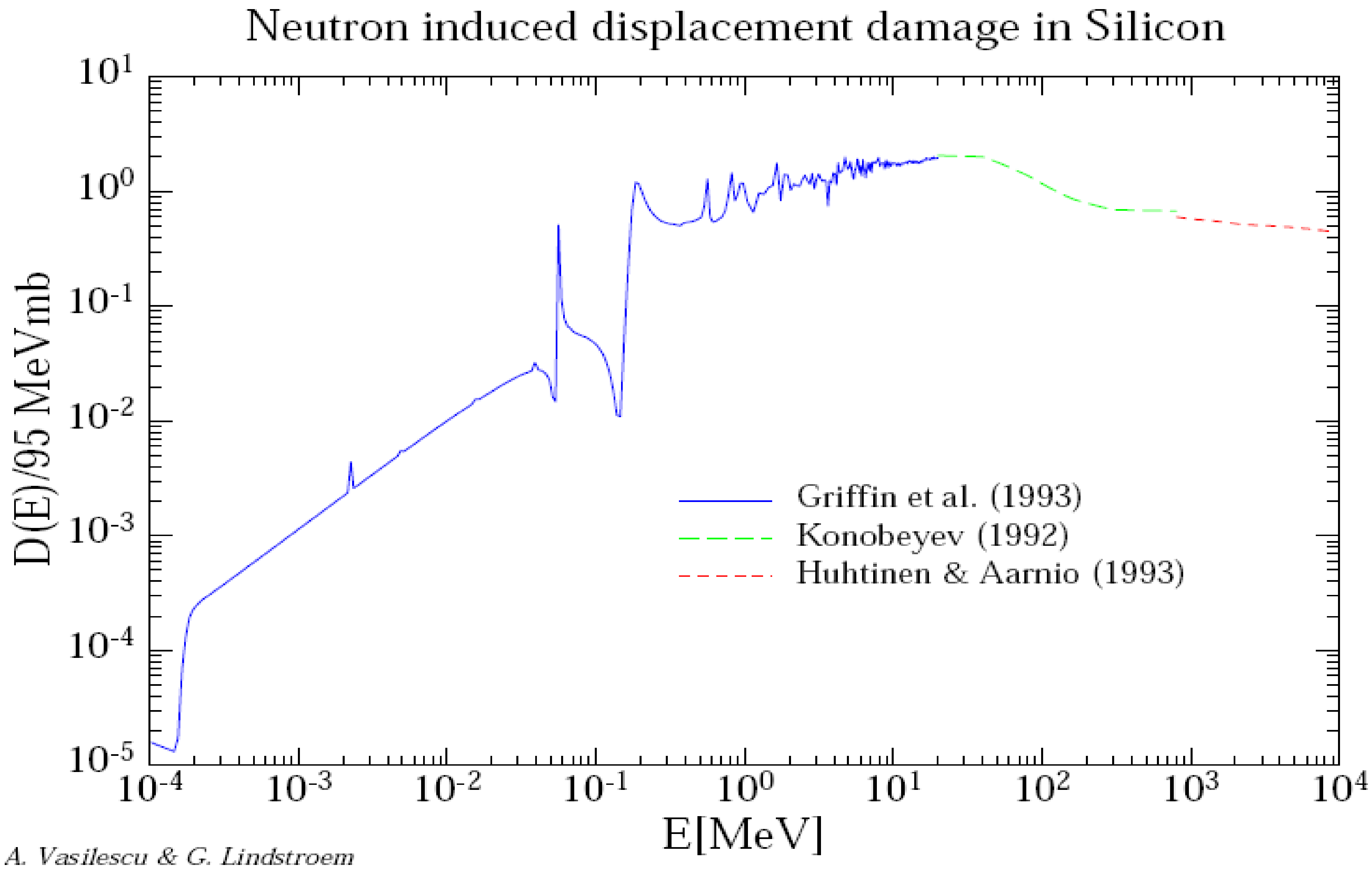


Energies of neutrons. . .

. . . when entering the TPC (some more than once)



A.Vasilescu & G. Lindstroem


Neutron induced displacement damage in Silicon
D(E)/95 MeVmb
10^1
10^0
10^-1
10^-2
10^-3
10^-4
10^-5
10^-4
10^-3
10^-2
10^-1
10^0
10^1
10^2
10^3
10^4
E[MeV]
Griffin et al. (1993)
Konobeyev (1992)
Huhtinen & Aarnio (1993)
A. Vasilescu & G. Lindstroem

Thanks !

CsI crystals

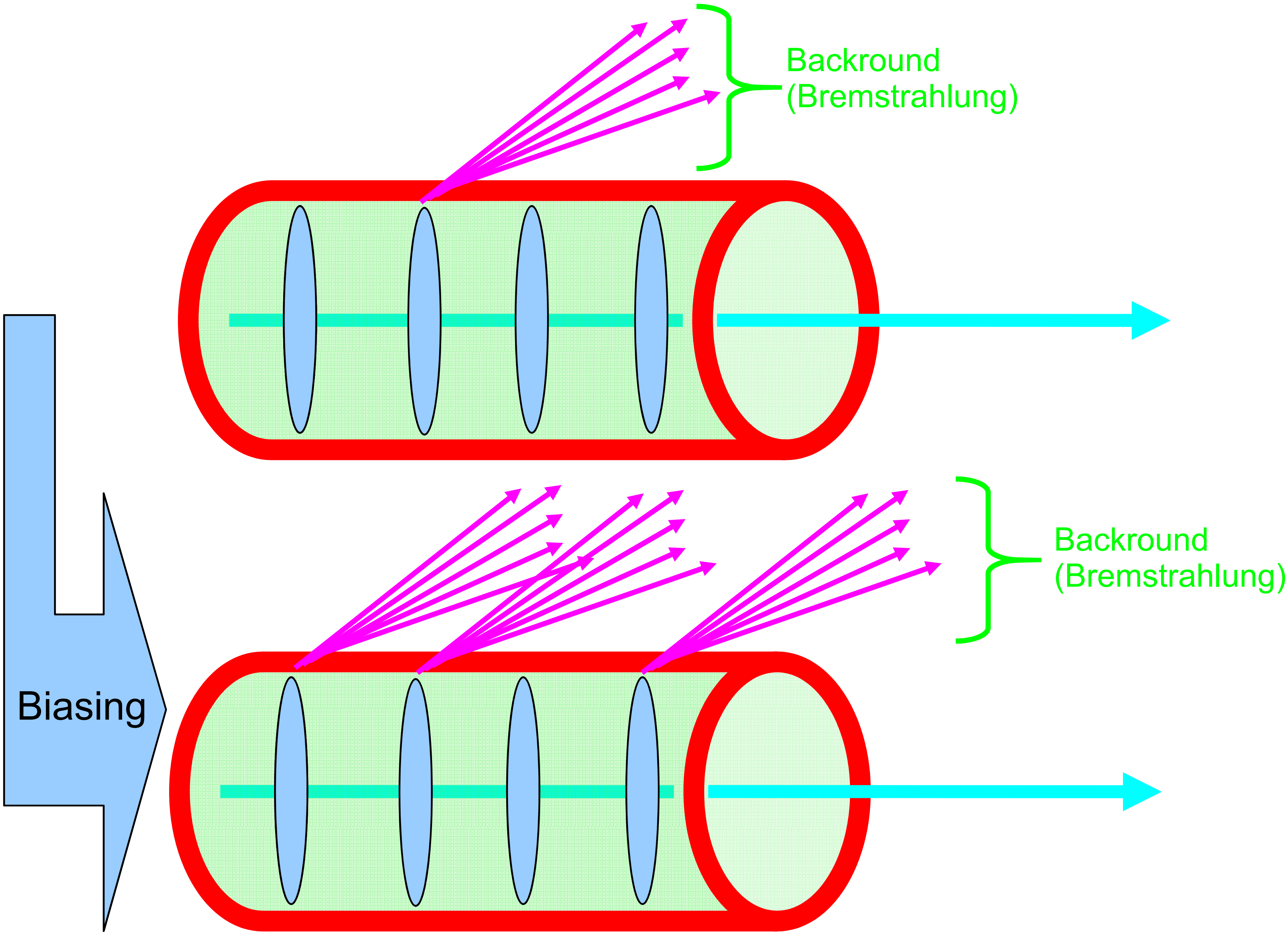
Scintillator	Light yield (photons/keV)	Light ouput (%) of NaI(Tl) bialkali pmt	Temperature coefficient of light output (%/C) 25°C to 50°C	1/e Decay time (ns)	Wavelength of maximum emission λm (nm)	Refractive index at λm	Thickness to stop 50% of 662 keV photons (cm)	Thermal expansion (/C) x 10^{-6}	Cleavage plane	Hardness (Mho)	Density g/cm^3	Hygroscopic	Comments
NaI(Tl)	38	100	-0.3	250	415	1.85	2.5	47.4	<100>	2	3.67	yes	General purpose; excellent energy resolution
Polyscin® NaI(Tl)									none				Polycrystalline NaI(Tl); for extra strength;
CsI(Tl)	54	45	0.01	1000	550	1.79	2	54	none	2	4.51	slightly	High Z; rugged; good match to photodiodes and red pmt
CsI(Na)	41	85	-0.05	630	420	1.84	2	54	none	2	4.51	yes	High Z; rugged; good match to bialkali pmt
CsI(pure)	2	4-6	-0.3	16	315	1.95	2	54	none	2	4.51	slightly	High Z; Fast emission

- Pure CsI used @ATF/KEK: Fast (**16ns decay time)** but low light signal (**2 γ/keV**)
- Sensitive to full E.M + Nuclear background ☺
- Can use PMT to ”collect” signal photons
- Don't need pre-Shower system
- **Use TOF** to separate neutrons from E.M background☺

BC-408 plastic scintillators

- Useful to have a second detector which reacts in different way than pure-CsI
  - Different response to neutron detection
  - Can separate e- from gamma (use lead pre-shower or not)
- Very large light output ☺
- Rise time : 0.9 ns
- Decay time : 2.1 ns
- Capability to separate neutrons from E.M background ?
  - Use TOF to discriminate neutrons from E.M background

Event Biasing in BDSIM → How ?



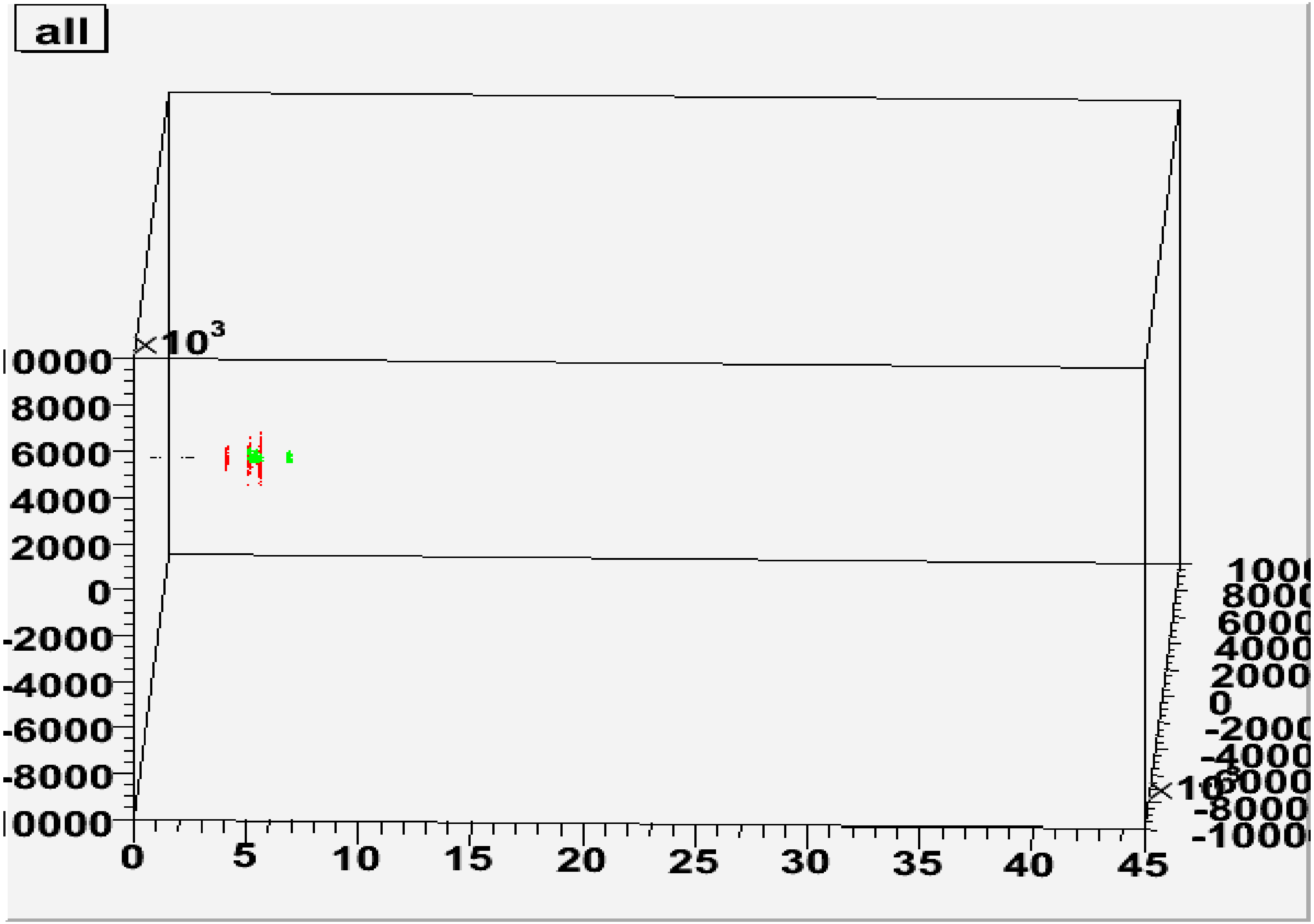
Geometry Based Biasing

- Importance Sampling
  - Geometry splitting with Russian roulette
- Weight Windows
- Weight cutoff
  - Also known as weight roulette

Jane Tinslay - Geant4

- Above biasing methods implemented within a common framework in Geant4
  - Process based approach - biasing is applied through a G4VProcess
  - Apply in mass or parallel geometries divided up into cells
    - A cell is a physical volume, specified by replica number if applicable
    - Cannot use parallel geometry in simulations involving fields

Movie BDSIM


all
×10³
10000
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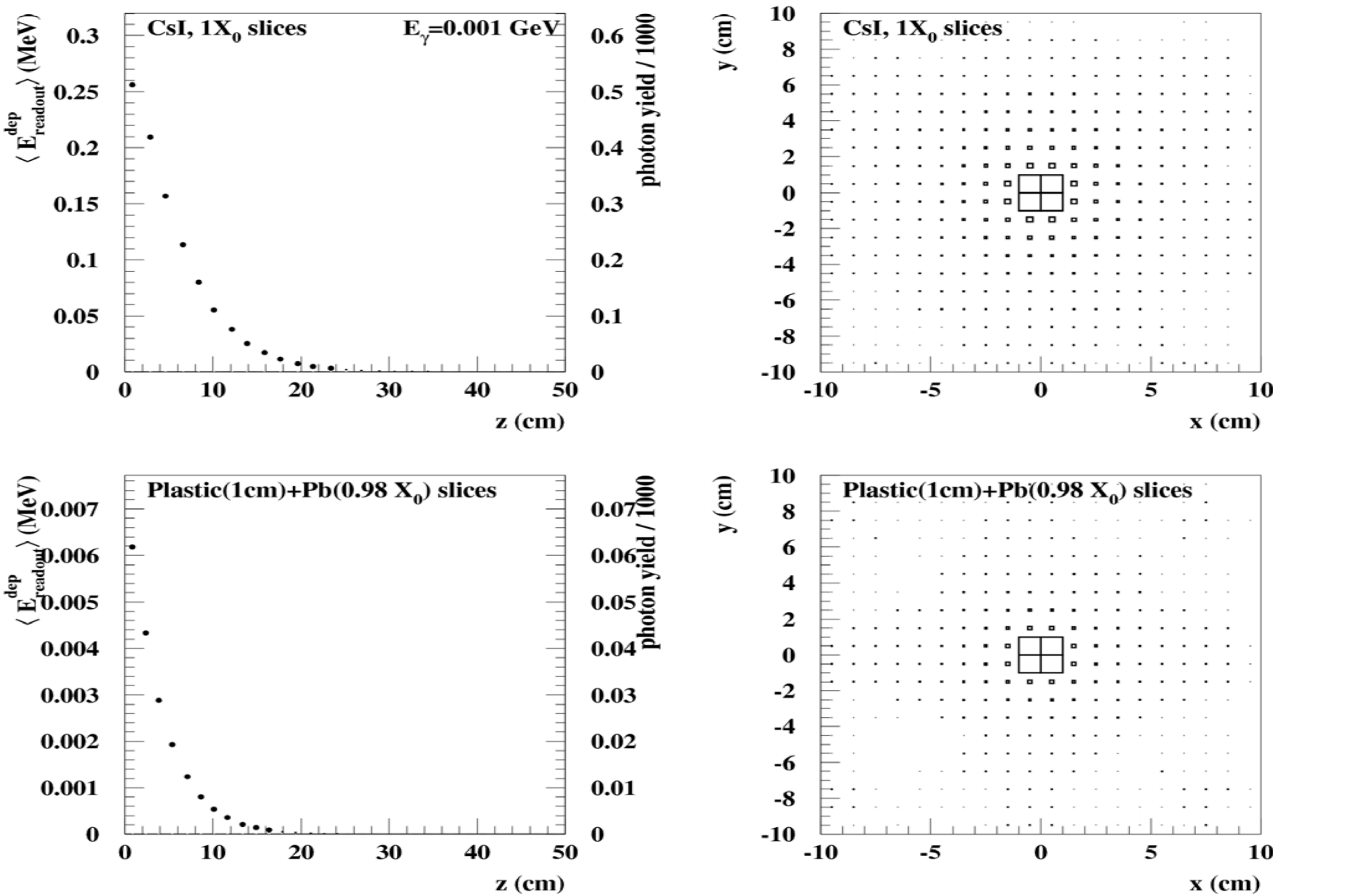
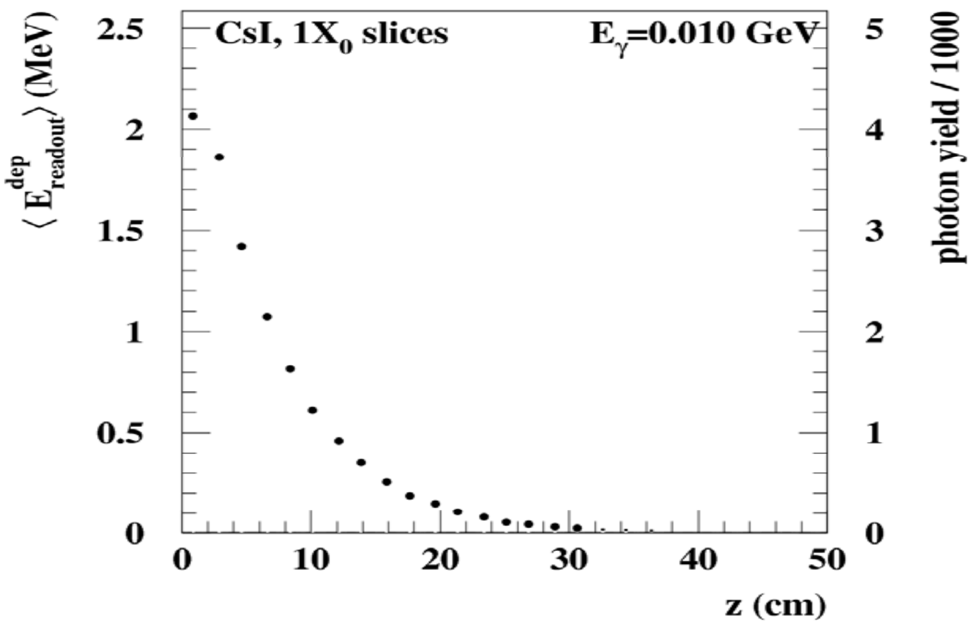
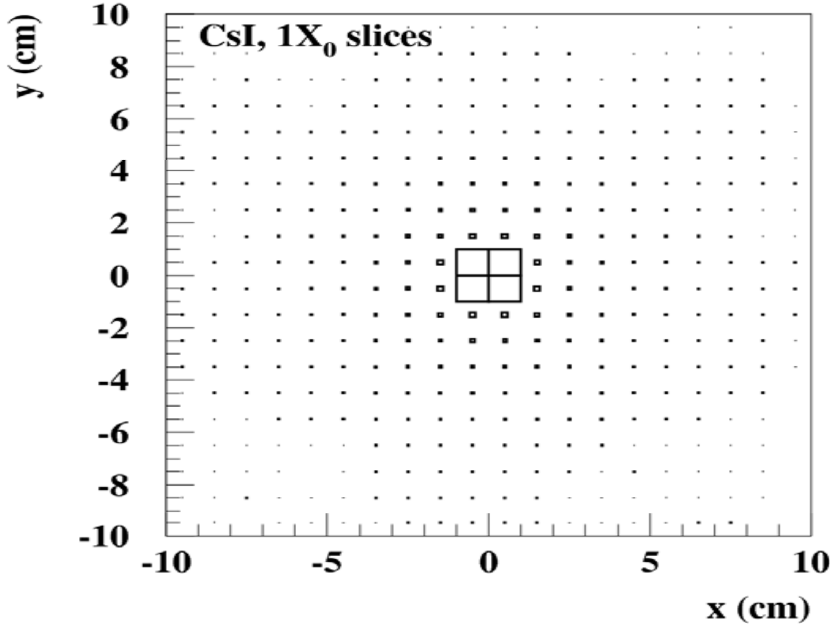
40
45

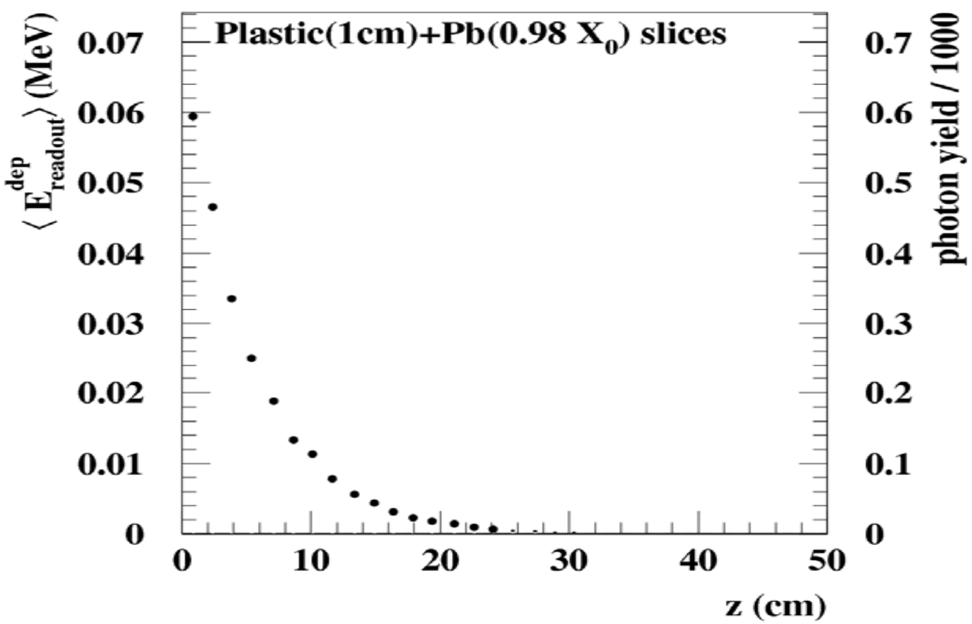
CsI vs Plastic scintillator (1 MeV)

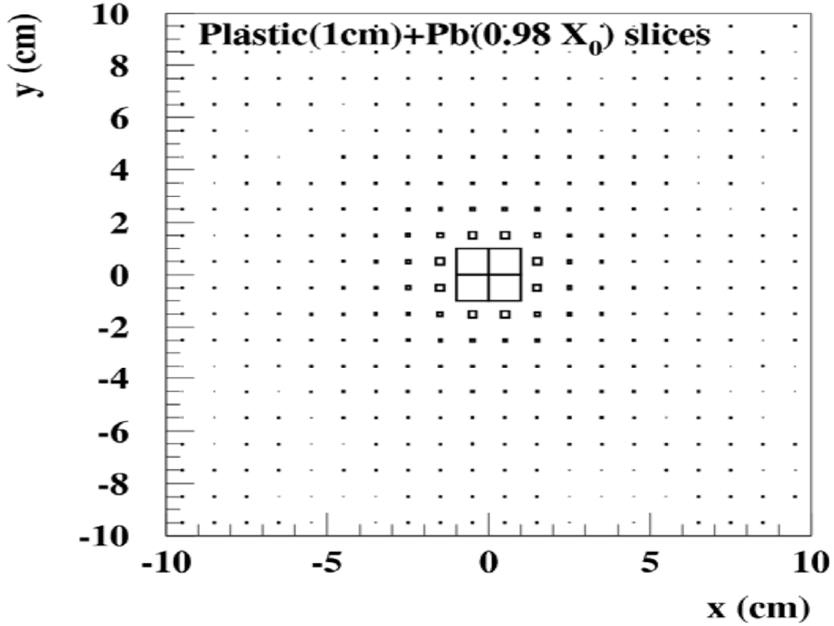


CsI vs Plastic scintillator (10 MeV)

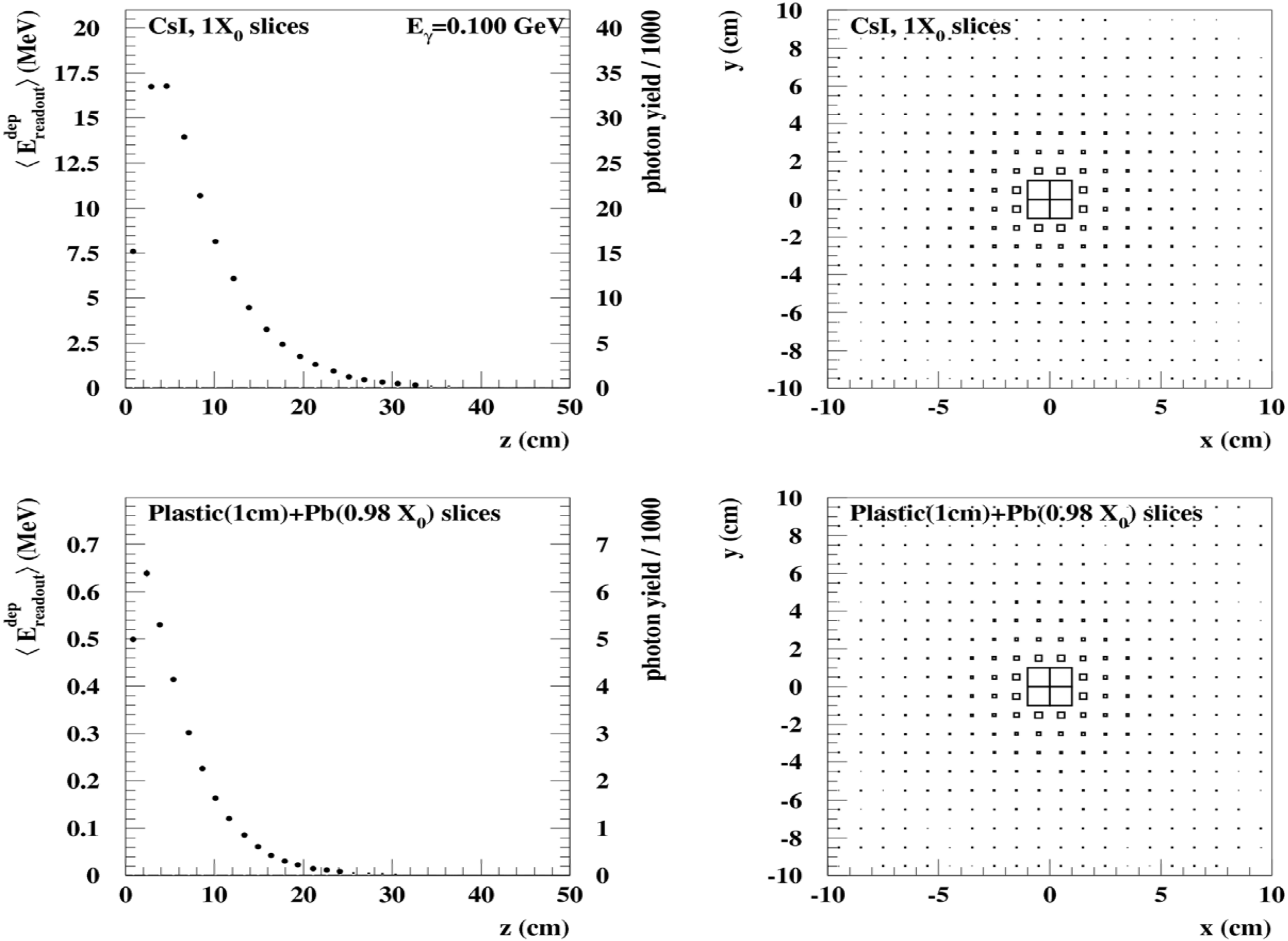




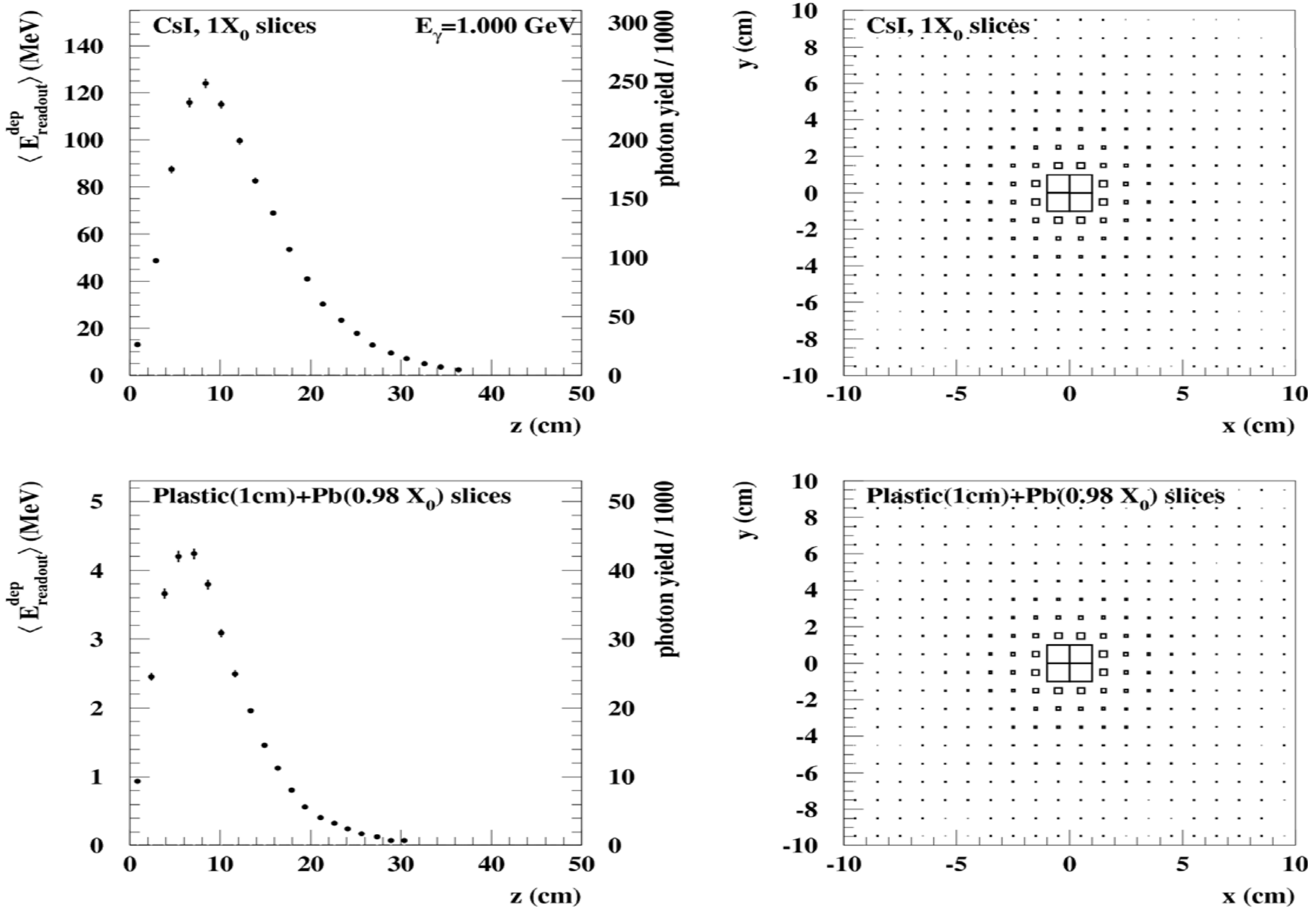




CsI vs Plastic scintillator (100 MeV)



CsI vs Plastic scintillator (1 GeV)



Hybrid

- The background @ ATF/ATF2 has an electromagnetic component generated by the electron beam HALO hitting the beampipe (and other accelerator components). In addition the electron beam hitting the beam dump generate backscattered electromagnetic background.
- The Hadronic component is mainly coming from the beam dump, mainly composed by backscattered thermal neutrons.
- The calorimeter "final aim" is to measure and characterize the background. One possible solution is to use different crystals sensitive to each background component (photons, electrons, thermal neutrons, fast neutrons, ...).

Use additionnal information

Goal :
Have a detailled time dependent picture of the losses and background @ any place around the ATF2 area beamline

- Use WS information → Know beam Size
- Use LW information → Measure background = f(time)
- Use Shintake photon detector information
  - Measure background = f(time)
- Use PLIC information : measure beam losses = f(time)

Our plans in background measurement

- Forward background
  - Measure the beam HALO and transport
  - Measure the beam losses and compare to simulation (BDSIM)
  - Evaluate the beam-gaz scattering
  - Measure the backscattered electromagnetic background
- Characterize the hadronic background
  - Measure the backscattered neutron background from the beam DUMP (separate it from the E.M background)
  - Measure neutrons background @ any place
  - Test the neutron transport in BDSIM