Detector definition

Laura Segui, ESS Meeting 25/07/2016

Irfu - CEA Saclay
Institut de recherche sur les lois fondamentales de l'Univers

Detector definition – Parameters to define

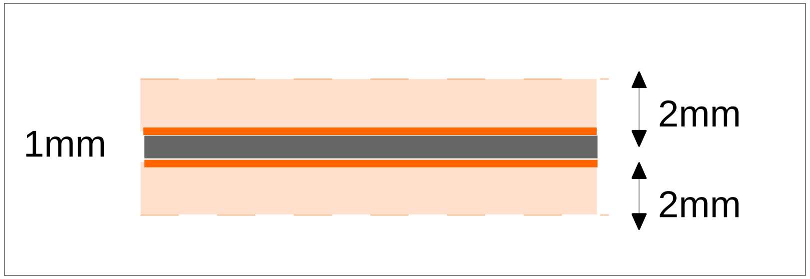
- Status
  - Results to proof of opeation from Georgios T.
    - Efficiency, time response, background discrimination
  - Cross-check of results with Geant4 for the slow detector
- New simulations in Geant4
  - Cross-check with Fluka results (G. Tsiledakis work)
  - More control over the process – more versatility
  - Low energy EM processes better defined
  - Reconstruct timing response
  - In FLUKA low energy neutron interactions in some materials (as polyethilene) not point-like treatment (of energy transfer).
    - Production of protons is a kerma approx. due to the groupwise treatment.
    - Better defined in Geant4 → point-like
  - Define both modules
- Optimization of the geometry parameters according

  to the input of the expected particle fluxes etc. to :
    - Improve efficiency
    - Reduce backgrounds
    - Define detector following safety and ESS regulations
    - Adjust costs

Detector definition – Parameters to define

- Micromegas detector
  - Bulk technology
    - Robustness, industrial
  - 2 back-to-back detectors with Al in the middle
  - Fragmented anode? Number of channels/detector
    - 1-5 channels /detector
    - Lower capacity
    - Imply to use more coaxial cables for the different signals

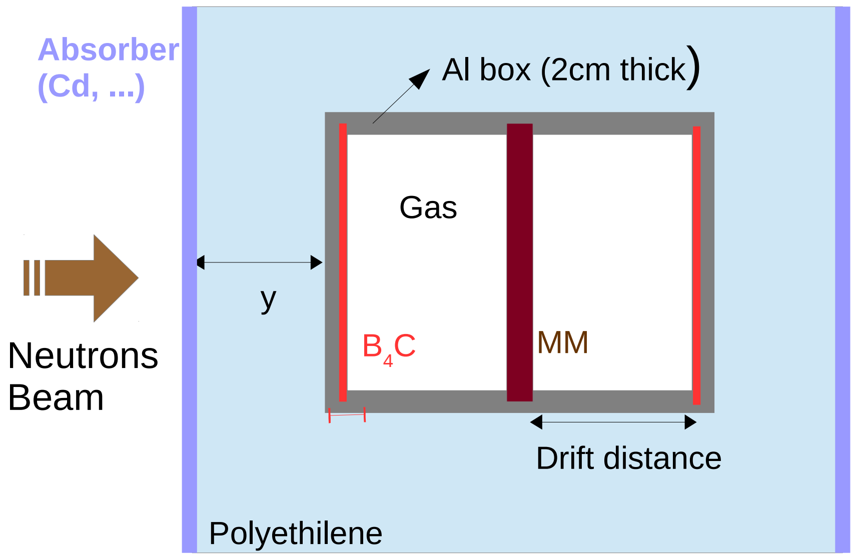
      → more expensive → find equilibrium
- Gas → see later
- Detector position
  - To try to find beam lost location
  - In collaboration with ESS



2 MMs, defined as a single Cu block of 2 mm with 1 mm of Al in the middle in the simulation

Simulations: Geometry and parameters to optimize

Type I detector: **Fast neutron flux monitoring with high sensitivity**



~ few $n \cdot cm^{-2} \cdot s^{-1}$
- Minimum E_n defined by the absorber
- 4π
- Adjustable neutron sensitivity, low γ sensitivity

Layers:

1. Cadmium (or other absorber) to eliminate incoming thermal neutrons
2. Polyethilene to thermalize fast beam neutrons
3. 2 layers of a B_4C convertor to capture them

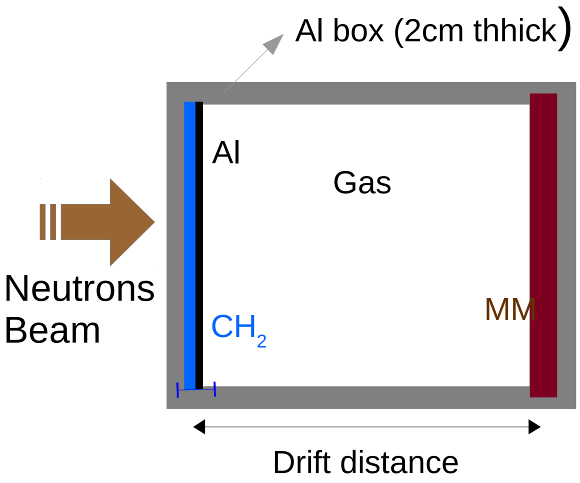
Optimize

- Drift distance
  - Betw. 1-10 mm (start 5mm)
  - n/γ discrimination
- B_4C thickness
  - Betw. 0.1-2 μm (start 1.5μm) → n efficiency
  - Thinner → clearer energy peaks
    → better discimination but lower efficiency
  - Number of layers → improve efficiency?

- **Polyethilene shielding (*y*)**
  - Betw. 1-10 cm (start with 4cm as Giorgios)
  - Depends on n energies (input from ESS)
- **Cd (or other absorber)** thickness
  - Start with 1mm
  - Will depend on the $E_{th.}$ for thermal n's
- Different gases?
- Also can define different dimensions for different locations depending on the n energy expected

Simulations: Geometry and parameters to optimize

Type II detector : **high flux high energy neutrons**



- Directional
- Insensitive to gammas
- High particle fluxes

Layers :

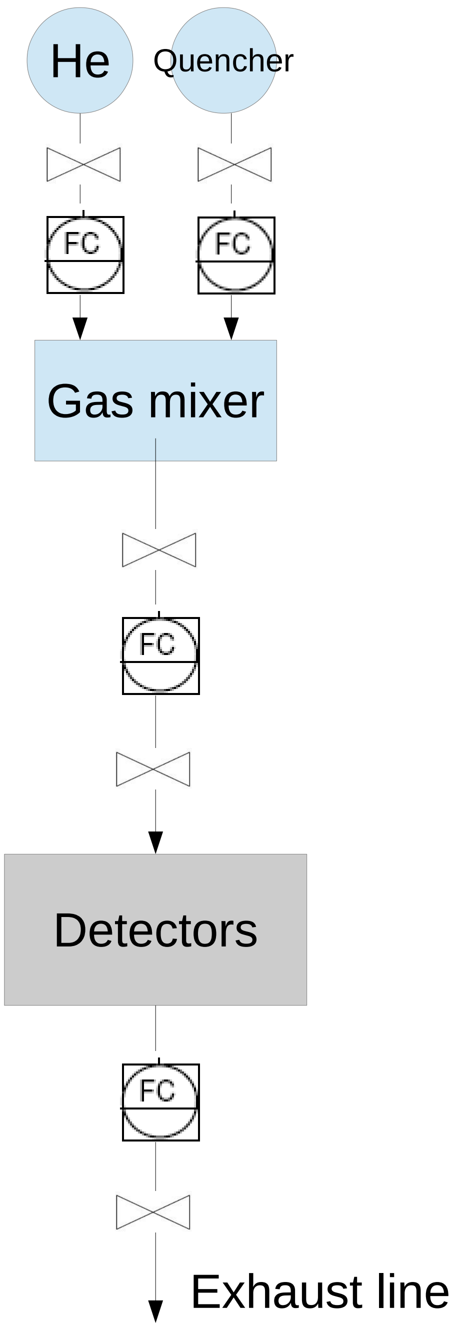
1. Aluminum plate (10-50 mm) for the detector body
2. 2 mm of Polyethilene/CH2 for "neutron conversion" to proton recoils
3. 50 nm aluminum foil or deposition on the polyethylene → for voltage

Optimize

- Drift distance
  - Btw. 1-10 mm (start with 5mm)
  - n/γ discrimination
- CH_2 thickness
  - Btw. 0.1-2 μm (start with 1.5μm)
  - n efficiency
- **Aluminium** thickness
  - Btw. 10-50mm (start with 20mm)
  - At some point will stop losing protons
  - Depends on n spectrum
- *Alternative:* U-238 fission >1MeV
- Different gases?

Gas and gas system

- Baseline : $He+CO_2$ → **not flammable!**
  - He : good to reduce gammas and X-Rays
  - CO_2 : fast
  - Could also add small percentage of H → methane, ethane,...
    - Flamability limits?
  - Can further investigate also $Ar+CO_2$
- P = 1 atm
- Flux <1 l/h
- No need purification
- Gas system :
  - Define P&ID, define number of controllers, flowmeters, valves, ...
  - Exhaust line
  - Intallation responsability? Where to install it?
  - Following ESS standards → need to know them
- Monitoring of possible leakage of gas
  - In principle detectors leak-tight to <<10^{-4} mbar/l/h
  - Define monitoring system
  - One possible solution :
    - Flowmeter at IN & OUT of the detectors line → alarm if flux different
    - 4 detectors / line for example
    - Want to monitor each one independtly?
  - Define system with ESS



Conclusions and outlook

- New set of simulations being defined
  - Geometry defined by mid August
  - Finalize analysis definition along September
- In september also start scheduling tests for next year at:
  LICORNE (fast neutrons)
  COCASE (high activity Cobalt source)
  ORPHEE (high thermal neutron flux / aging)
  Synergium with cavity standard tests with real electric field @ Saclay

SEDI laboratory (long term stability)

Input needed from ESS to complete simulations/design

✔ Energy spectrum of neutrons
✔ Energy spectrum of gammas/xrays
✔ Flux maps
  ✔ Text file with (x,y,z), E, momentum, direction
  ✔ Expected rate for backgrounds (radiation hardness)
✔ Energy threshold for thermal/fast neutrons
✔ Is it possible to have X-rays «bursts»?
✔ Materials that we can use (discuss along today)
  - Gas, plastics, metals, etc..
✔ ESS standards

Define responsabilities for

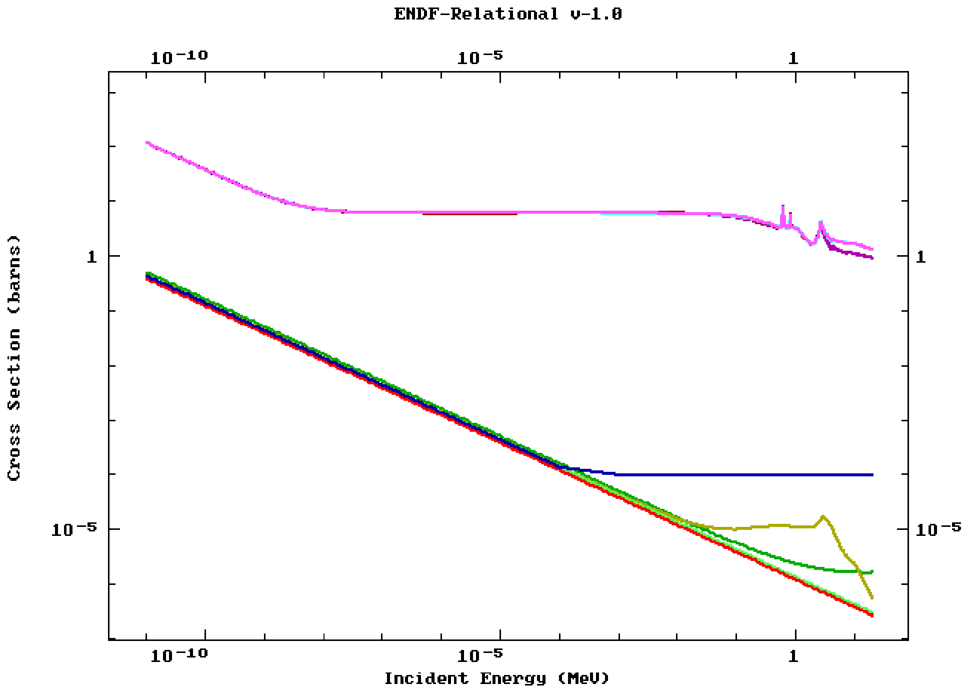
✔ Gas system
  ✔ Design → Saclay with the regulations of ESS
  ✔ Installation
  ✔ Monitoring system

Simulations

↕

Design

Thank you!



Cd cross-sections

B cross-sections