RPC2012

enapy CFNUL
Experimental Nuclear AstroPhysics Group

R3B

Simulations of an Innovative Time-of-Flight Detector for High-Energy Neutrons based on Iron-Less RPCs

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Outline

- GSI & FAIR
- Neutron Detector Design Parameters
- The RPC-based Detector
- The Iron-less Concept
- Physics Case
- Towards s406: Prototype Simulations

FAIR *(Facility for Antiprotons and Ions Research)*

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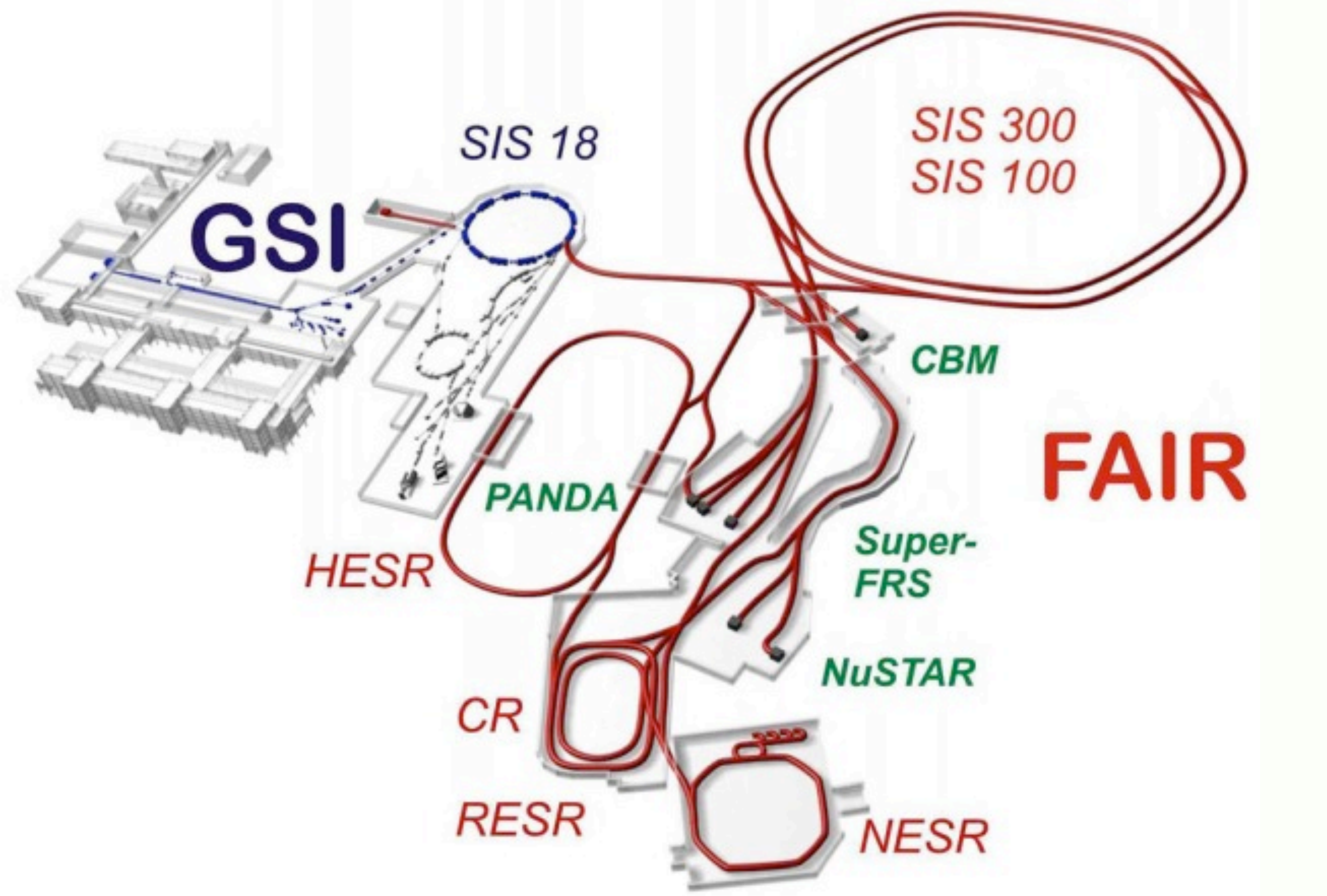
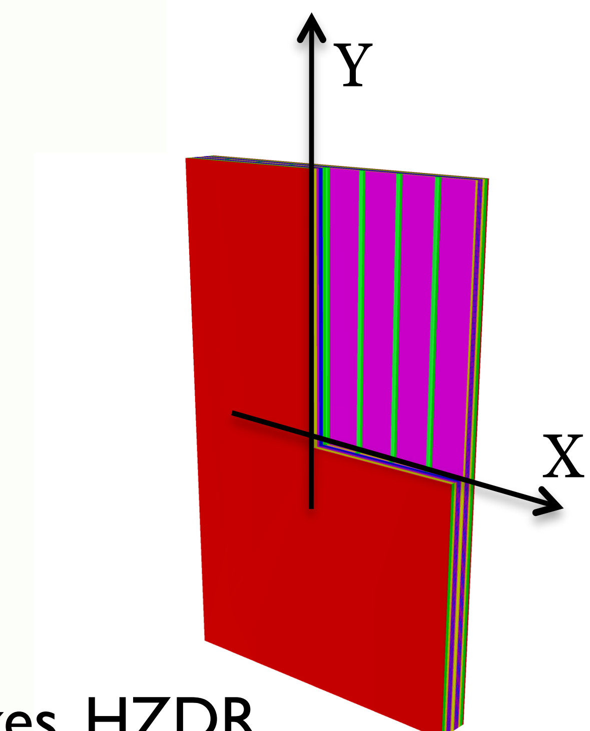


High-Energy Neutron Detector

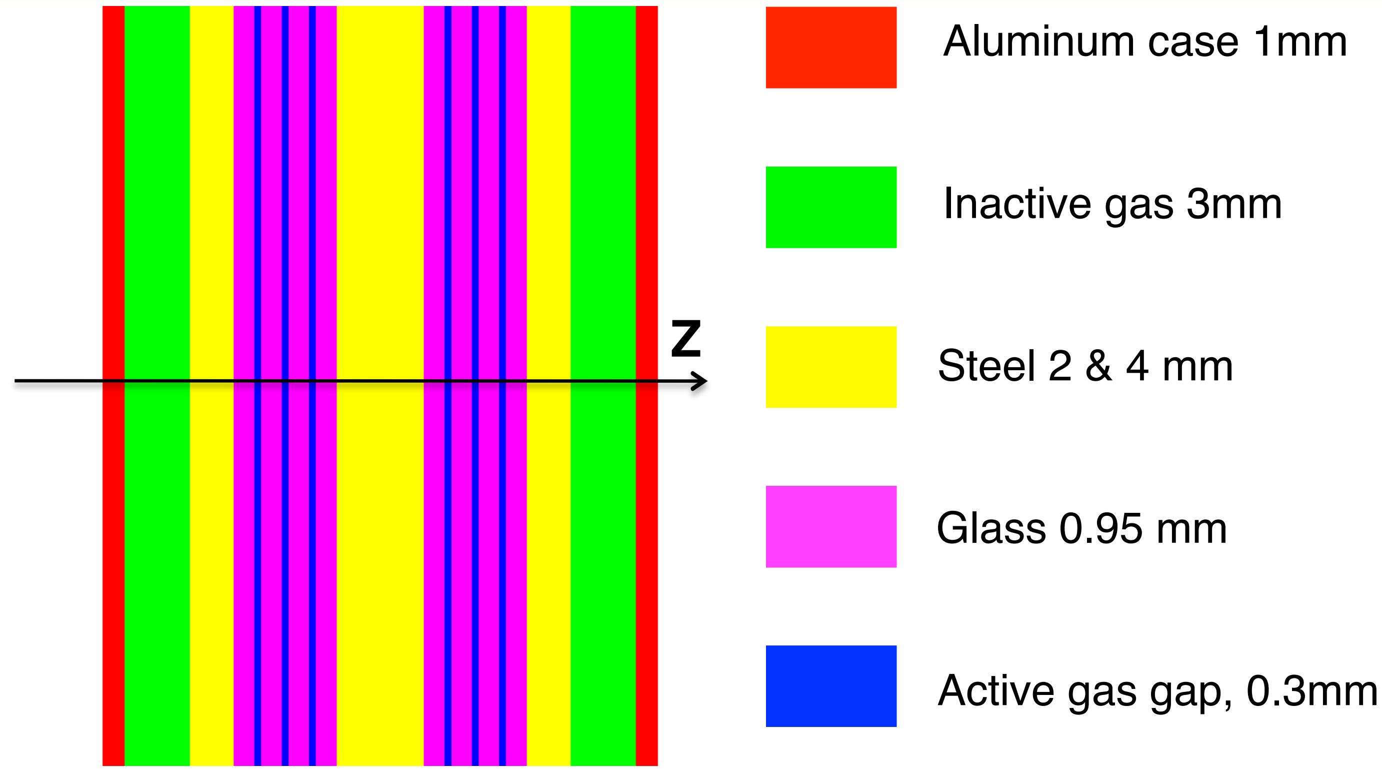
Design Goals

- One neutron detection efficiency > 90%
- $\sigma_t < 100$ ps
- $\sigma_{(x,y,z)} < 1$ cm
- Active area of 2×2 m^2
- Multi-hit capability up to 5 neutrons
- $\Delta p/p \approx 10^{-3}$
- Energy resolution of 20 keV for an excitation energy of 100 keV

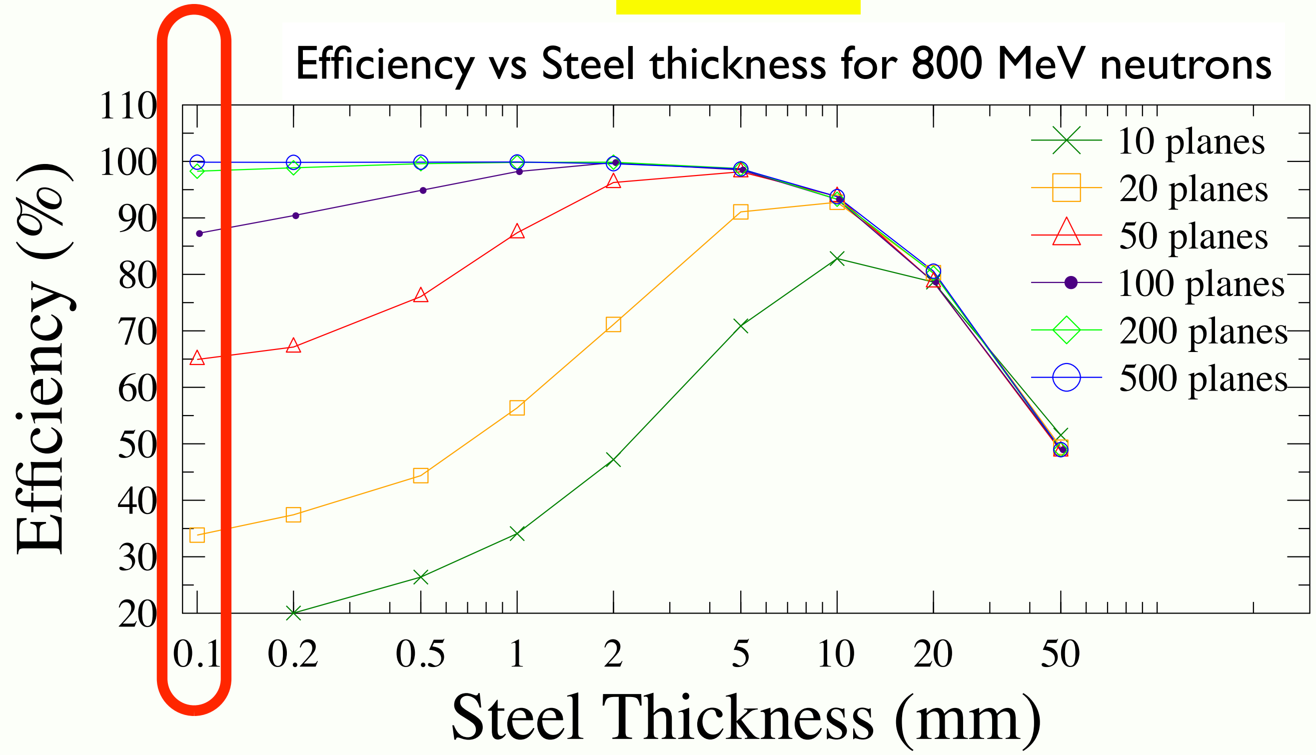
Starting point



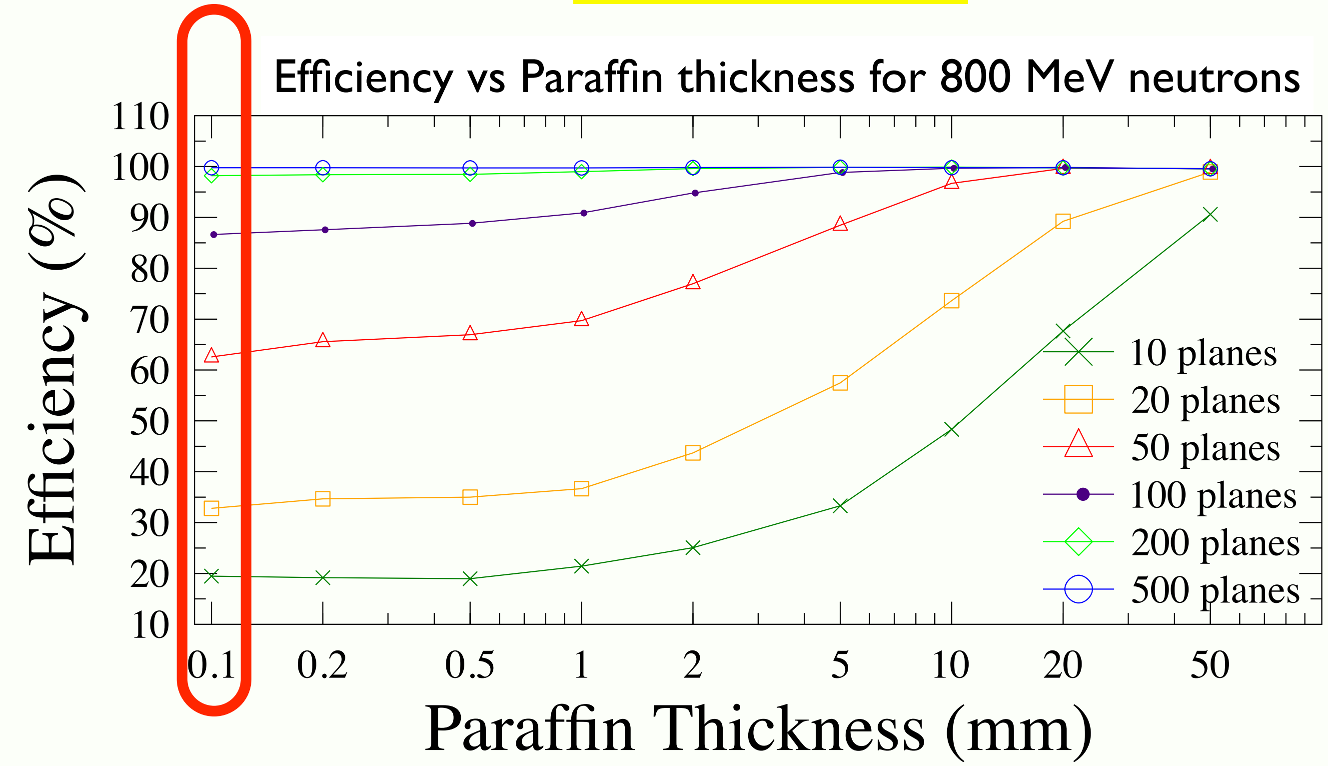
Z. Elekes, HZDR



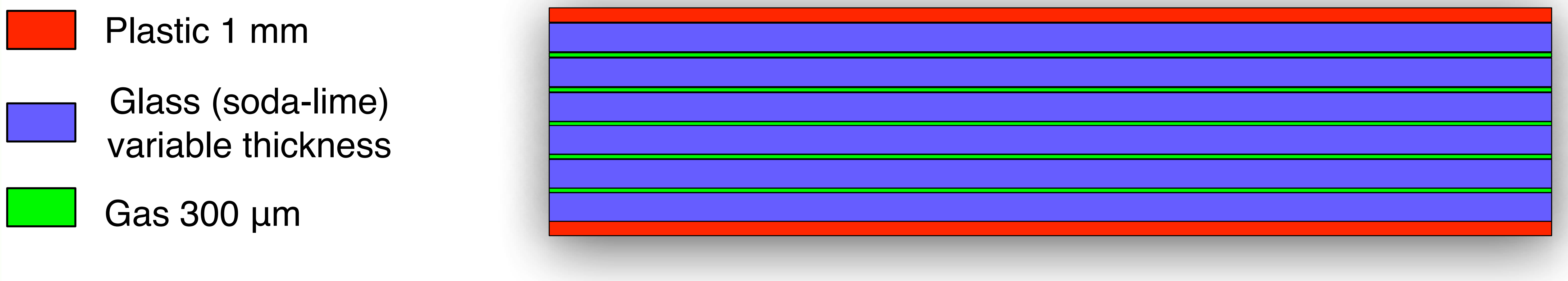
Steel



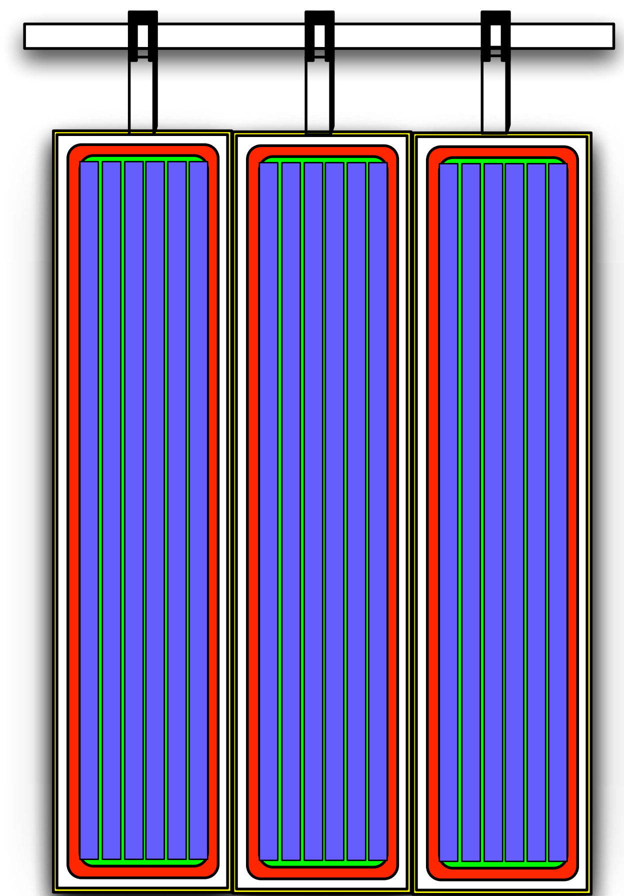
Paraffin



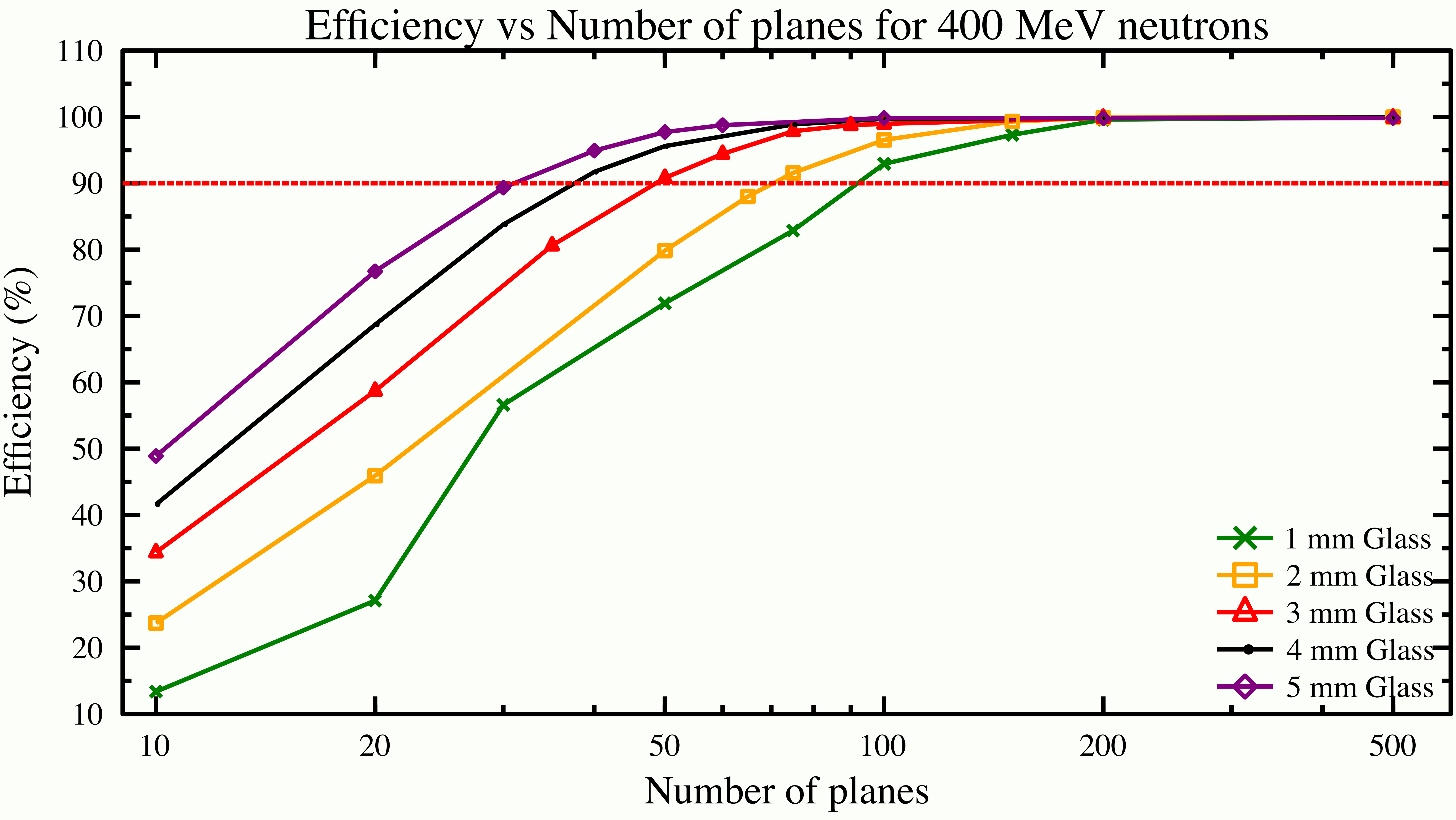
The Iron-less concept



- A geometry of a RPC with 2 × 2 m^2
- 5 gaps of gas (84% of Freon, 10% of SF_6 and of 6% Isobutane)
- 6 glass plates (73% of SiO_2, 14% of Na_2O, 9% of CaO and 4% of MgO)
- Plastic case

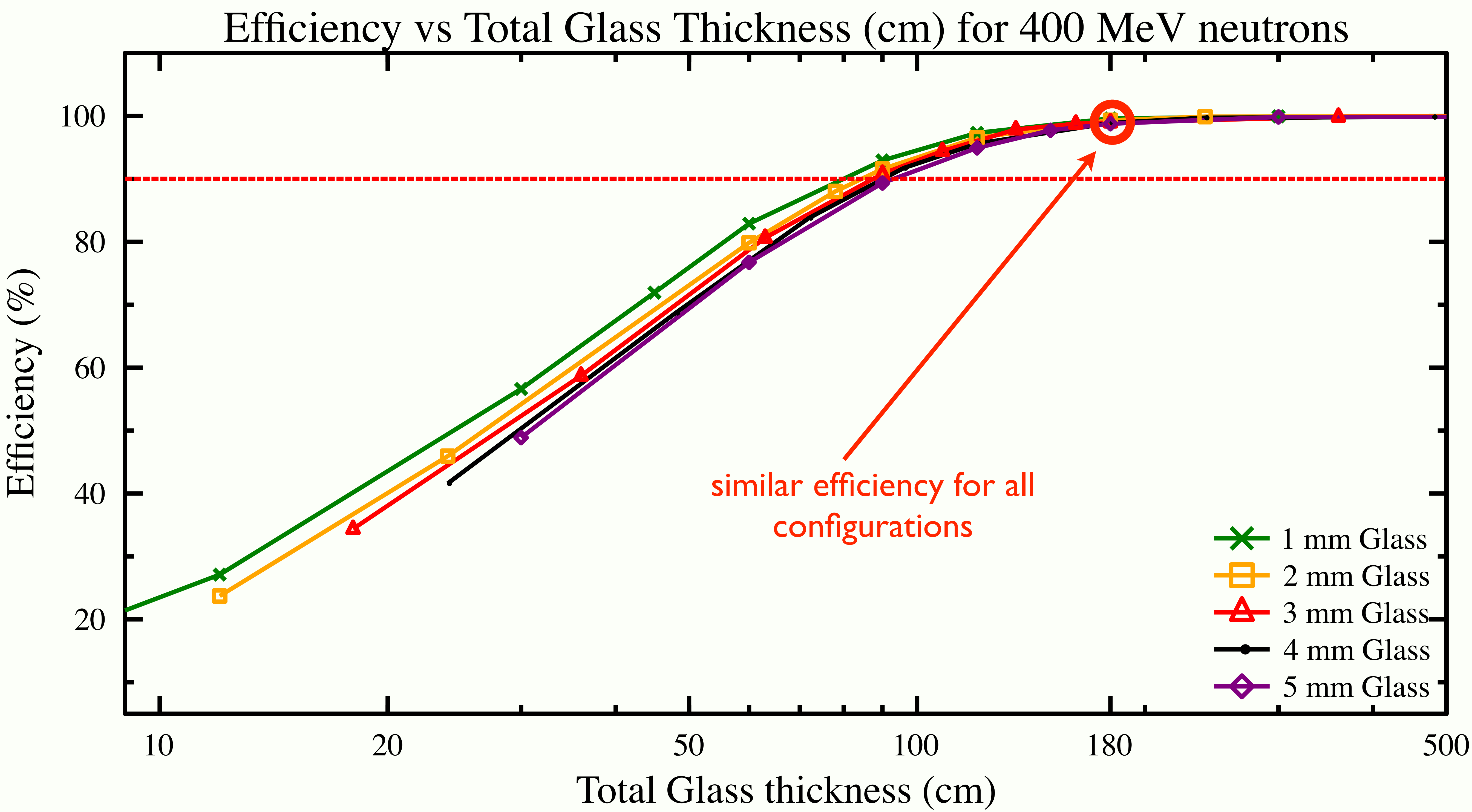


The Iron-less concept



The Iron-less concept

Select Geometries:

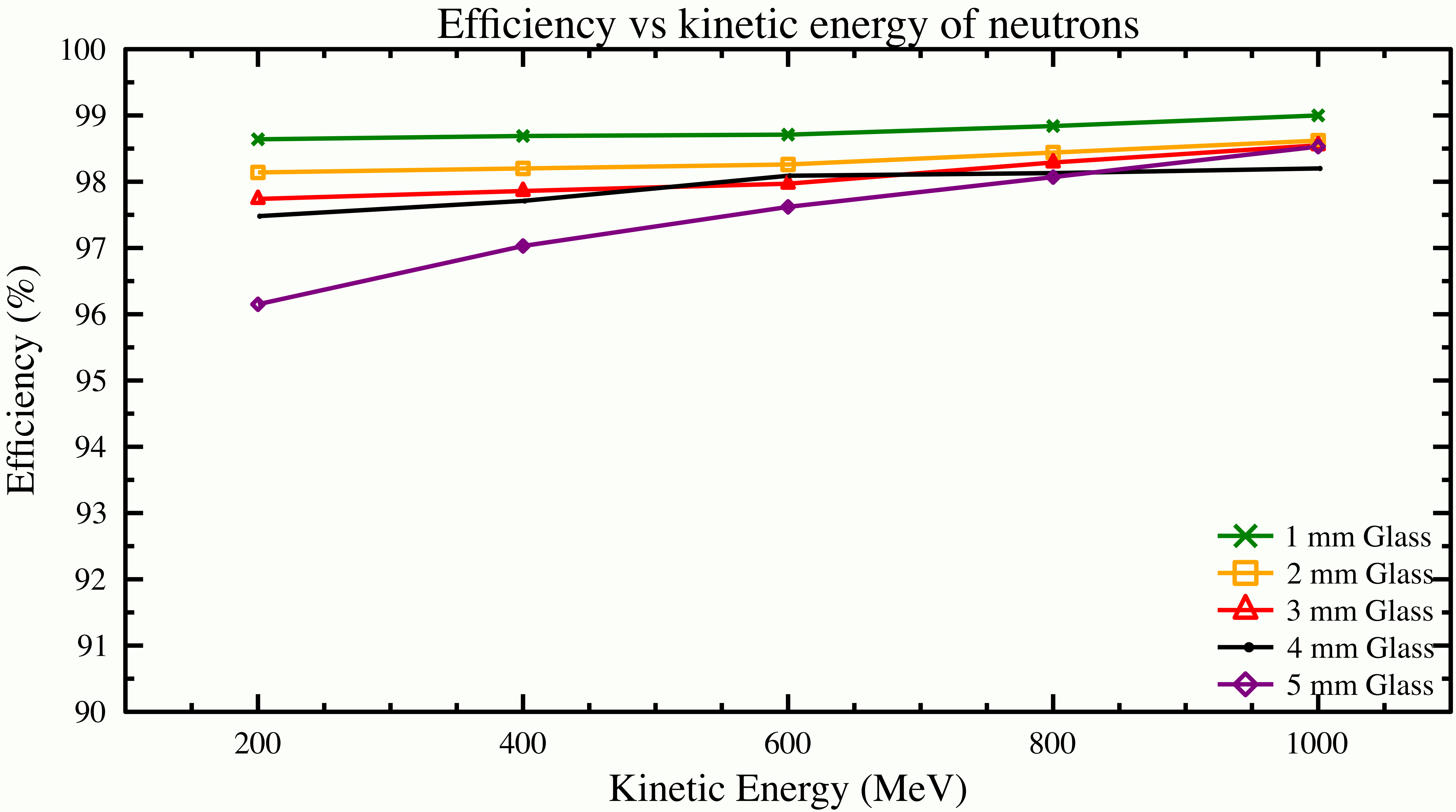


The Iron-less concept

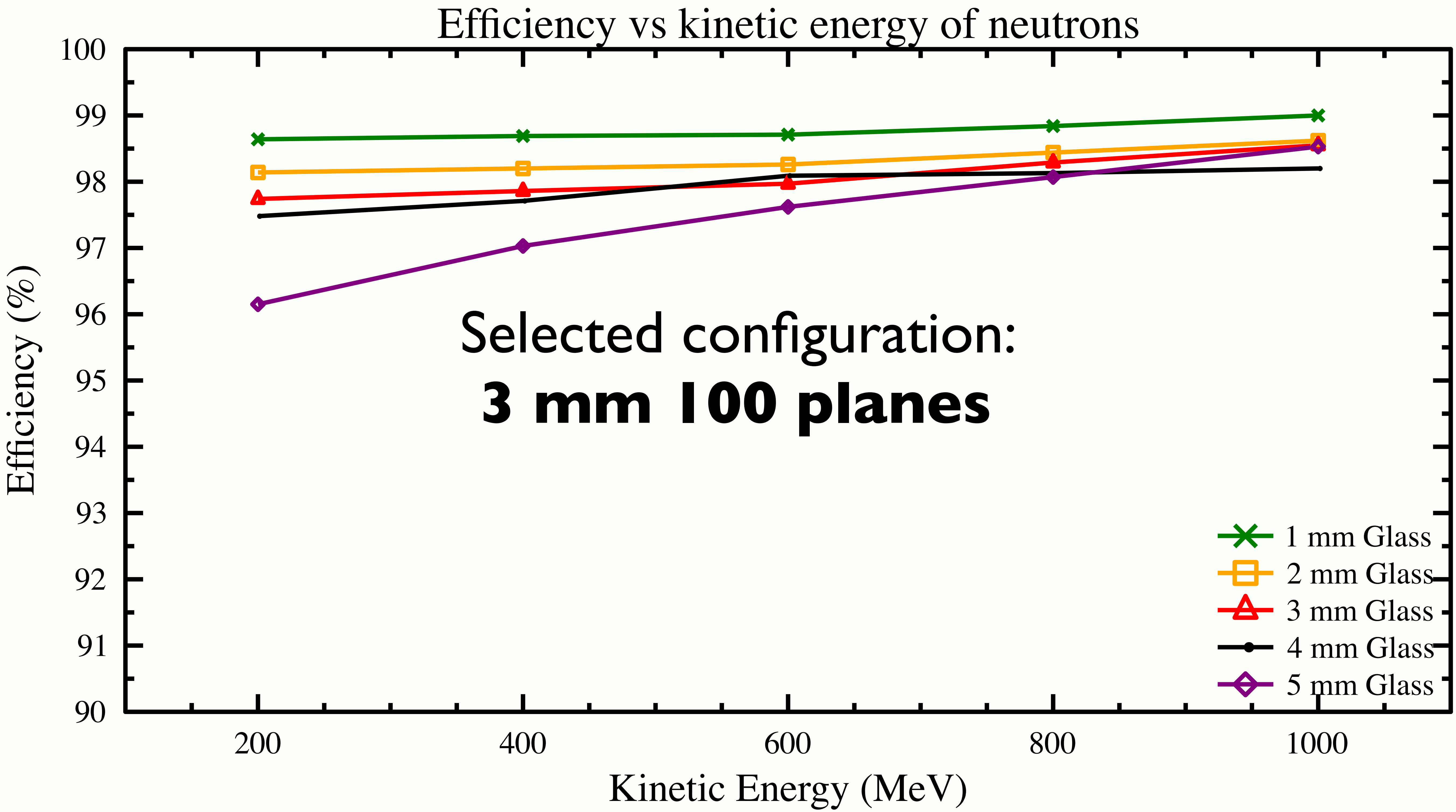
Selected Geometries:

Detector configuration	One neutron detection efficiency
1 mm / 300 planes	99.60%
2 mm / 150 planes	99.31%
3 mm / 100 planes	98.96%
4 mm / 75 planes	98.87%
5 mm / 60 planes	98.76%

The Iron-less concept



The Iron-less concept

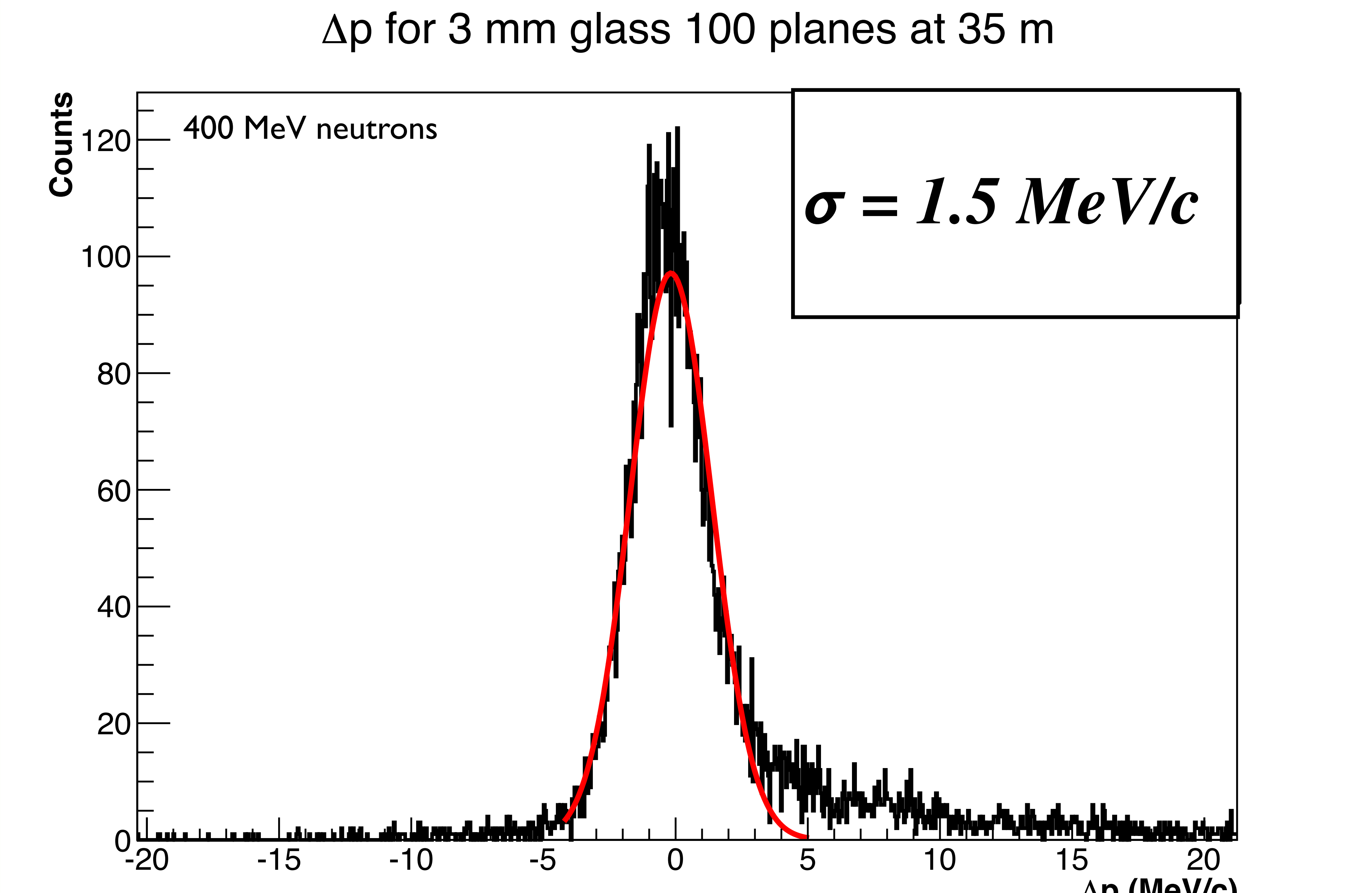


Selected configuration:
3 mm 100 planes

Reconstruction of the neutron momentum

Folded Uncertainties

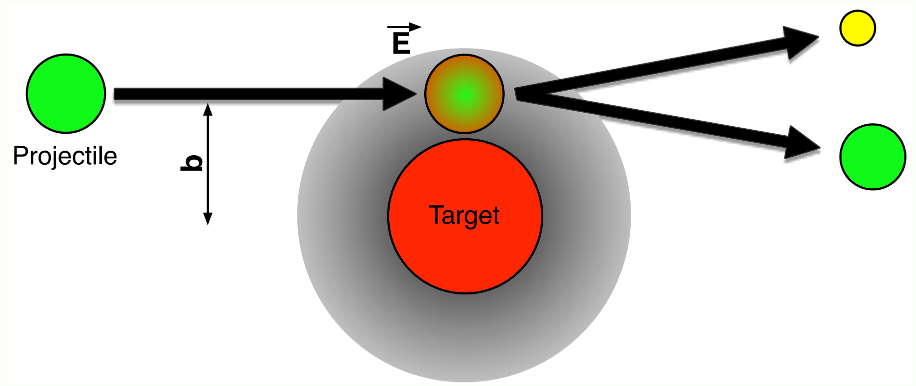
- σ_t = 80 ps
- Δx = 3 cm (width of the readout strip)
- σ_y = 1 cm
- Δz = 2.25 cm (length of total plane thickness)

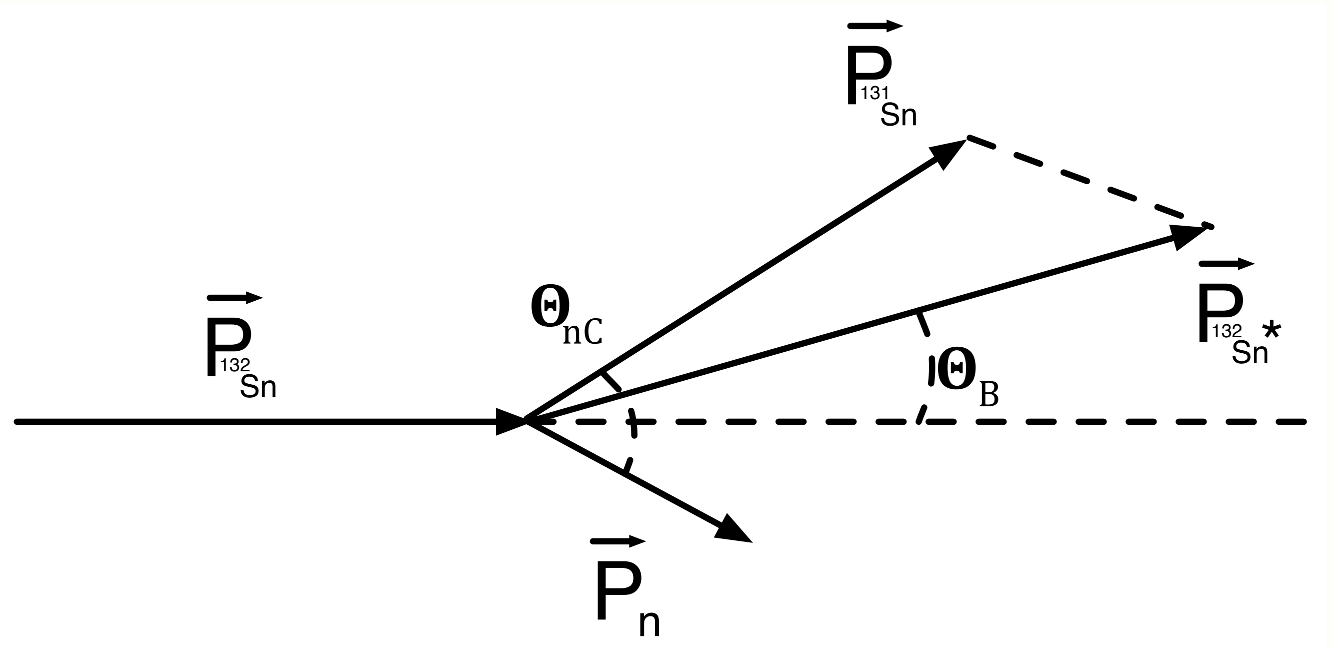


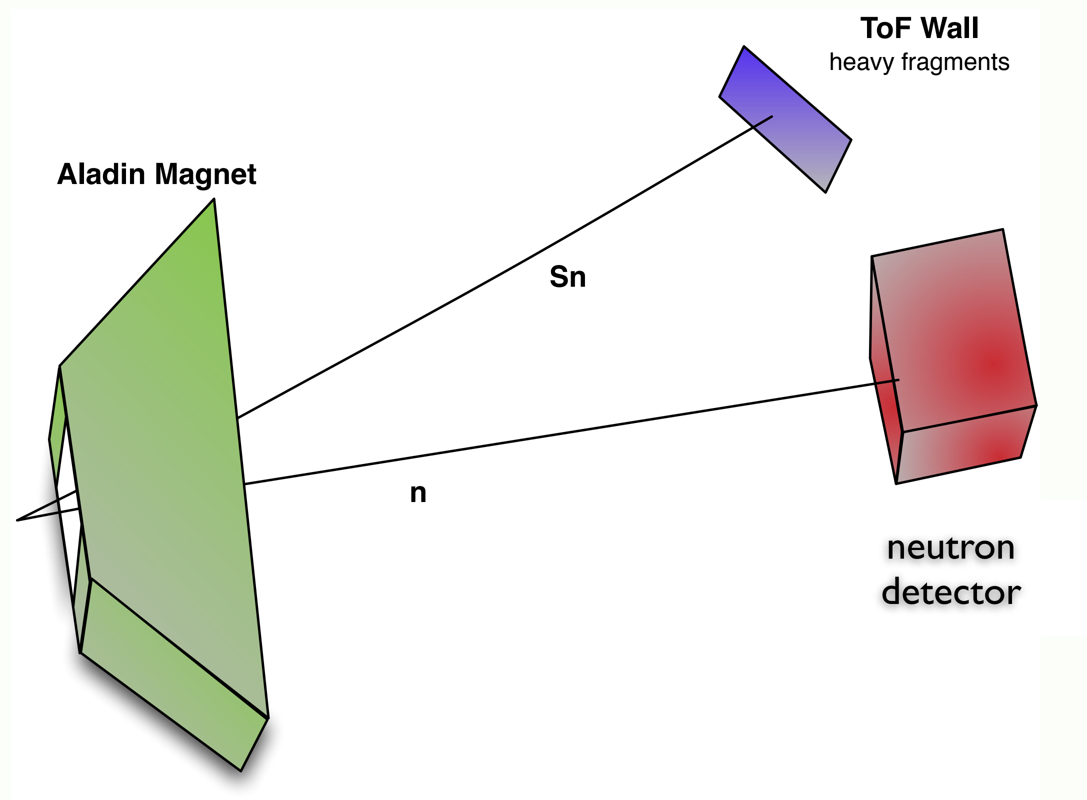
Physics Case

The $^{132}Sn(\gamma,n)$ ^{131}Sn Coulomb Dissociation reaction simulated

- Detector placed at 12.5 m and 35 m from target
- E_{rel} = 100 keV
- Energies of 200 AMeV, 600 AMeV and 1000 AMeV

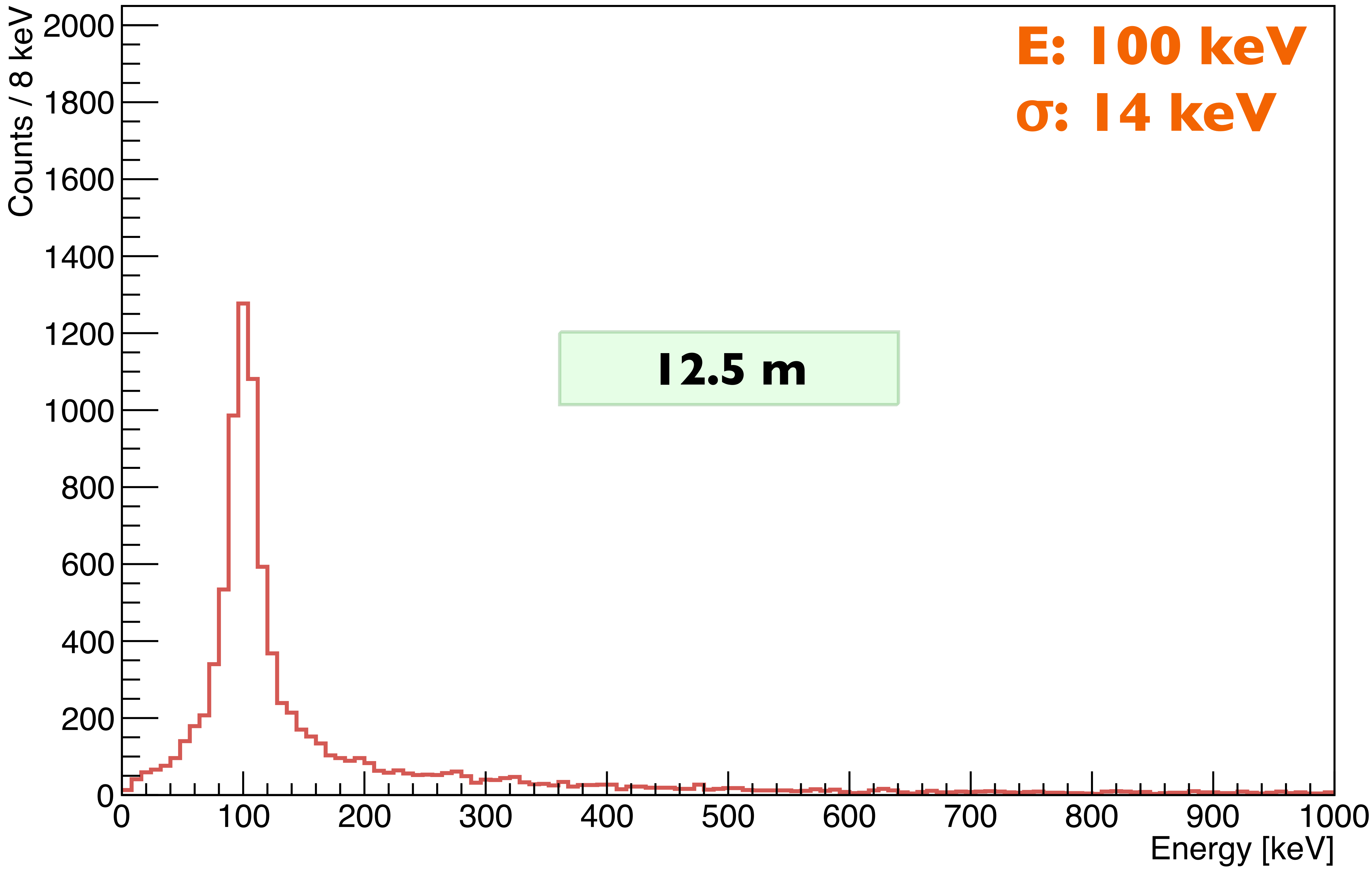






Physics Case

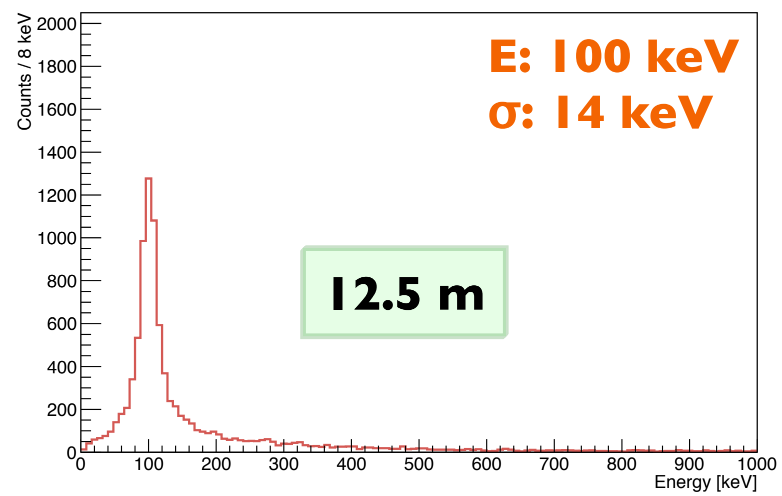
E_{rel} spectrum for $^{132}Sn(\gamma,n)^{131}Sn$ @ 200 MeV

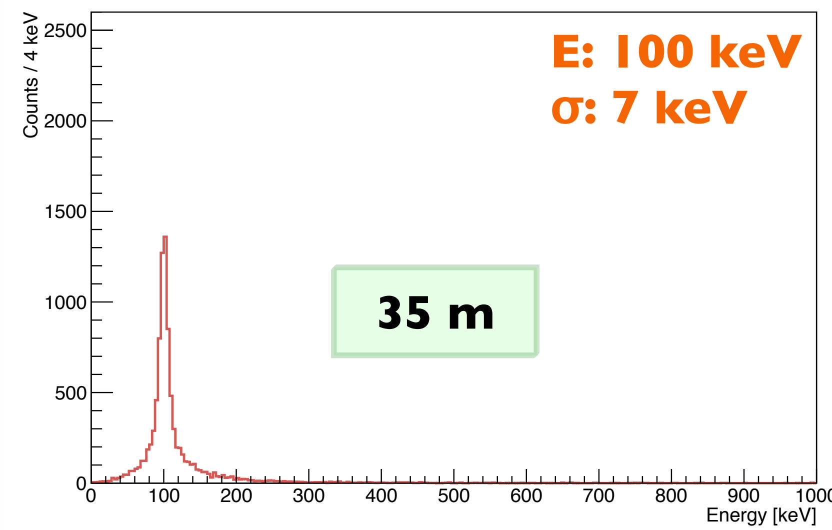


Physics Case

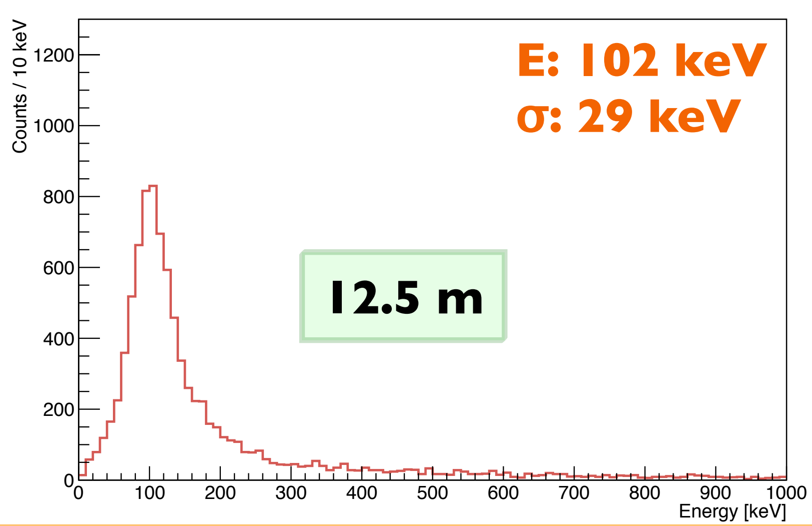
E_{rel} spectra for $^{132}Sn(\gamma,n)^{131}Sn$

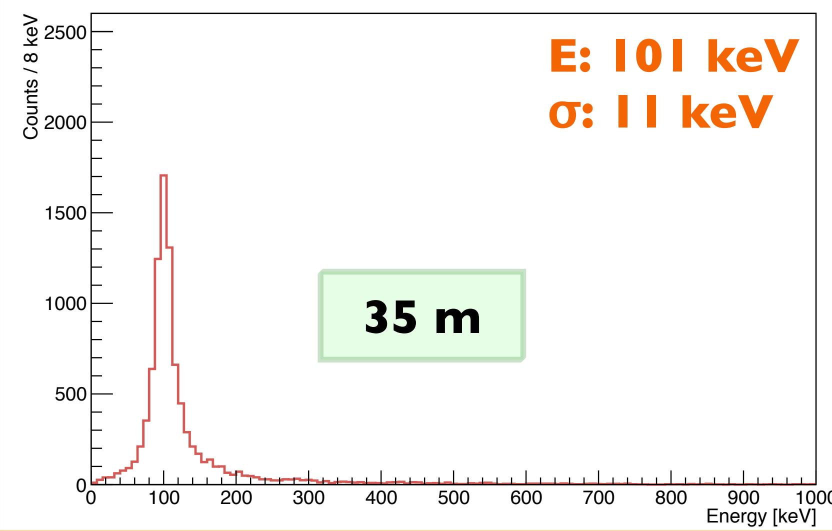
200 MeV



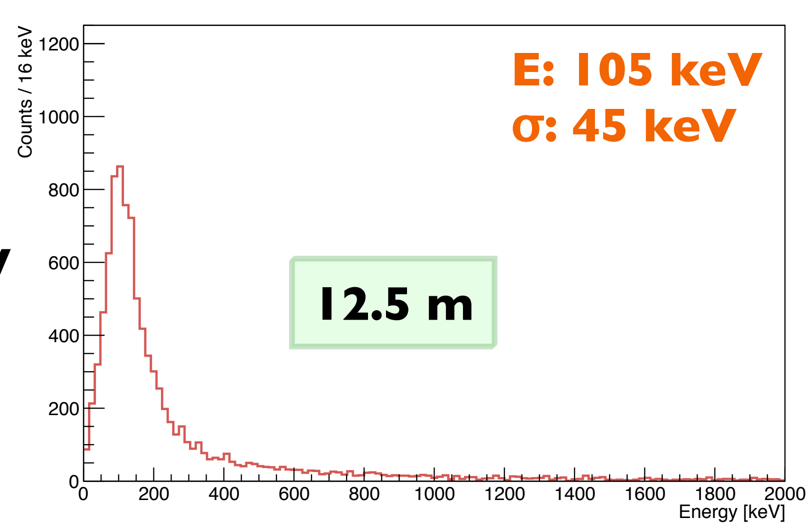


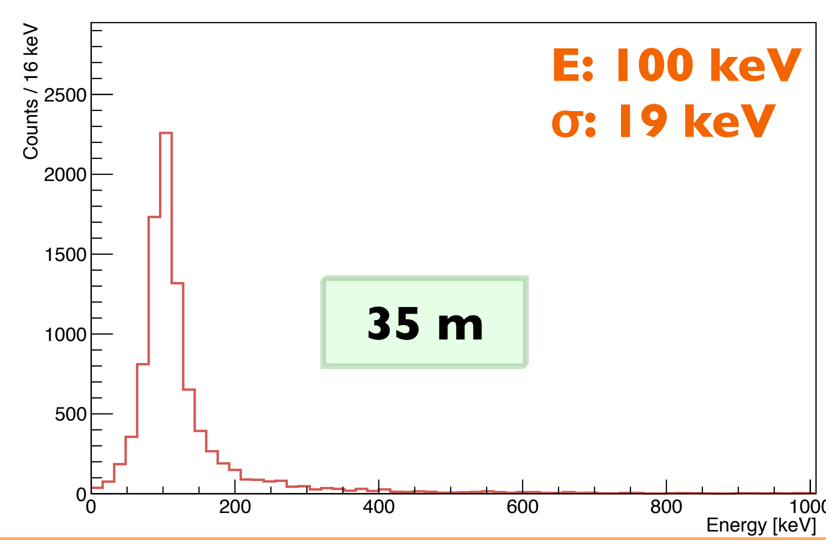
600 MeV





1000 MeV





Prototype test

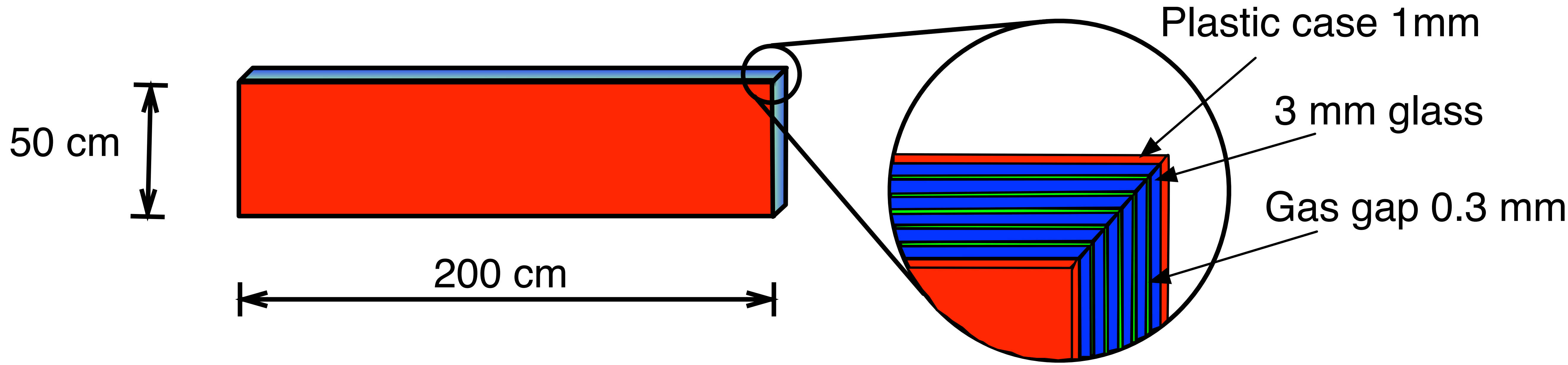
Experiment s406

- Deuteron-breakup reaction experiment at GSI with "monoenergetic" neutrons

- Quasi-free scattering reaction of a deuteron beam on protons using a CH_2 target

- Four different energies (200, 300, 500 and 800 MeV)

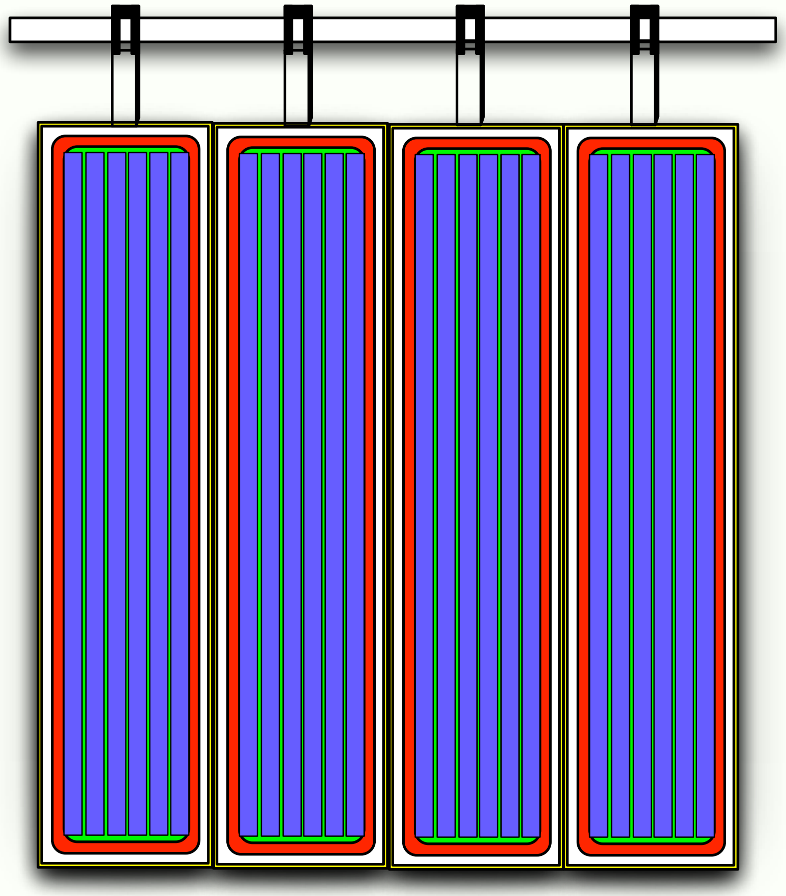
- June 2012



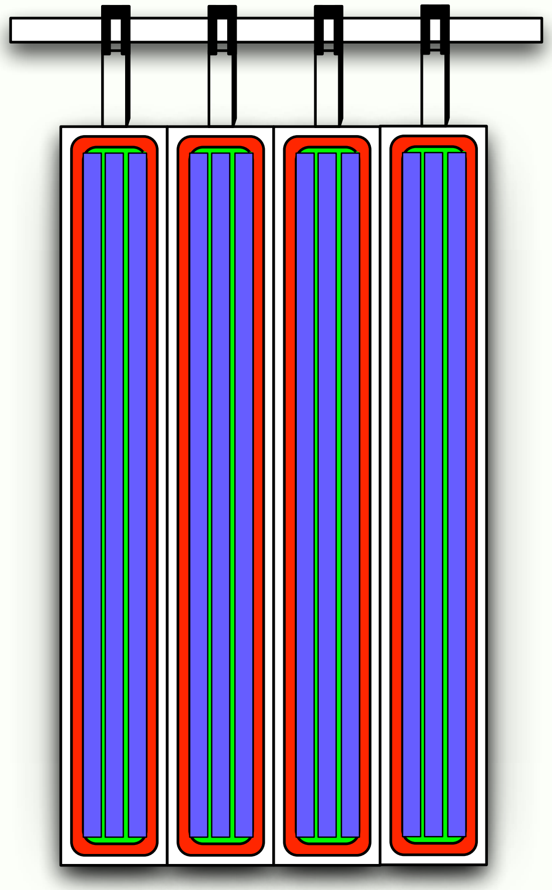
Prototype Design

Detection efficiency

Construction by LIP-Coimbra



4 modules of 5 gaps

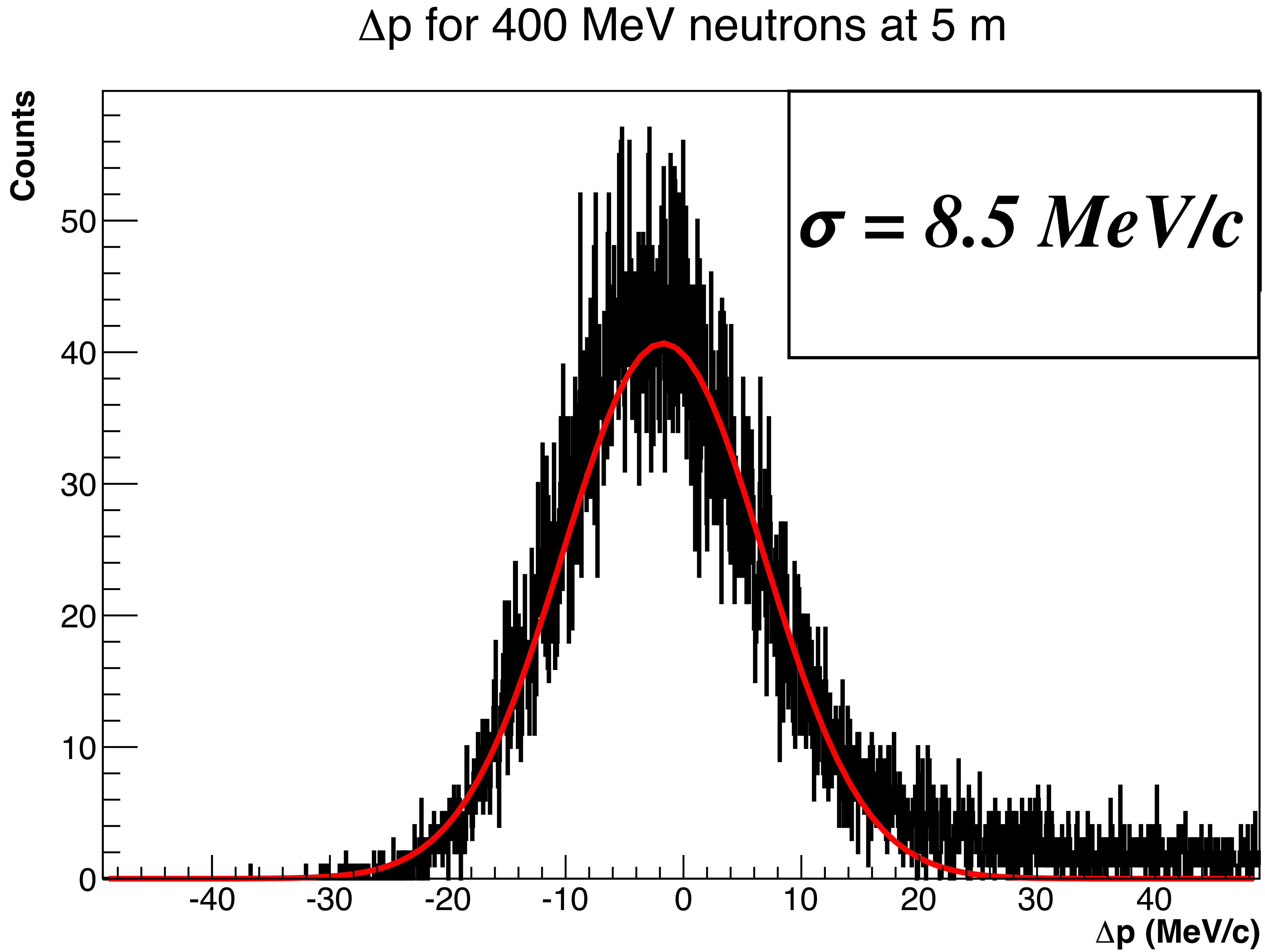


4 modules of 2 gaps

One neutron detection efficiency: **14%**

Prototype simulations

Momentum reconstruction



Final considerations and future work

• The simulations have shown a **high efficiency and very good momentum resolution in the detection of one neutron** events for a wide energy range (between 200 MeV and 1 GeV).

• The **prototype** will consist of **8 planes** (with 2 different configurations) **to reach an efficiency of about 14%** for the range of energies considered.

• Based on simulations, the necessary **tools to analyze the data** from the **prototype test** will be developed.

Thank you!