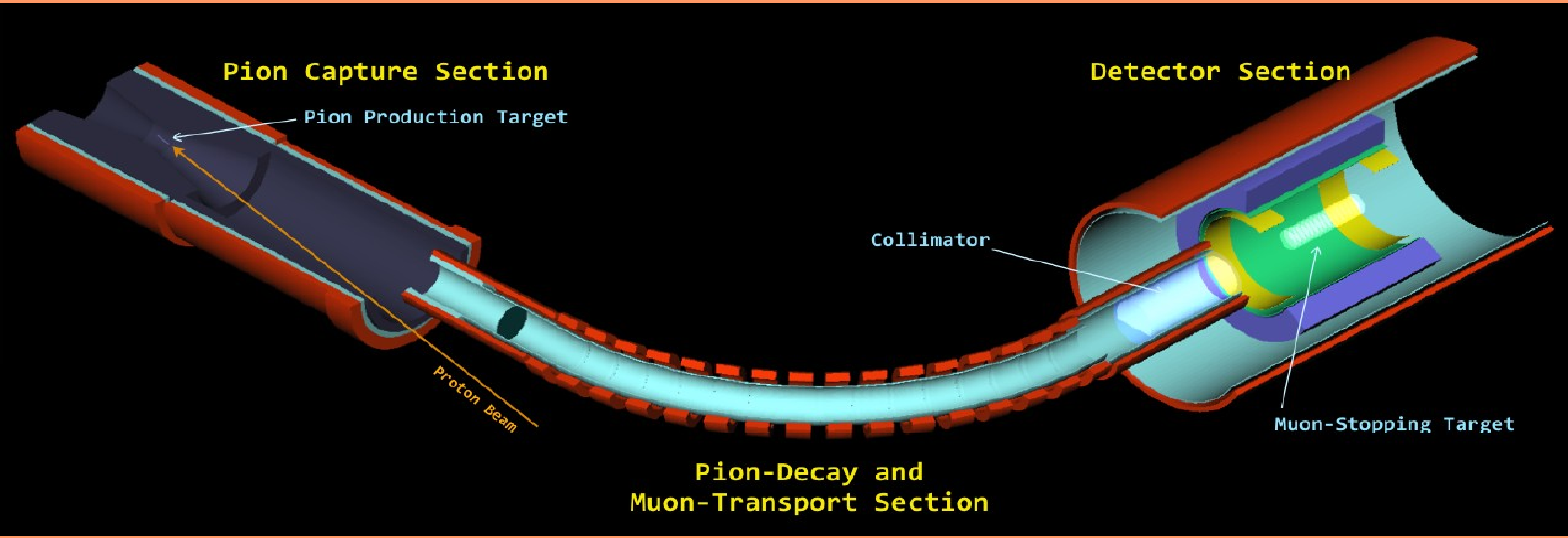
Simulations of the Cosmic-Veto System for the COMET Experiment



Charge Lepton Flavor Violating (CLFV)
neutrinoless μ → e conversion in nuclei

Oleg Markin, ITEP, MEPhI, Moscow

CLFV-searching experiments

$$\mu^- + N(A,Z) \rightarrow e^- + N(A,Z)$$

Expected single event sensitivity:

Mu2e @ FNAL: $5 \cdot 10^{-17}$

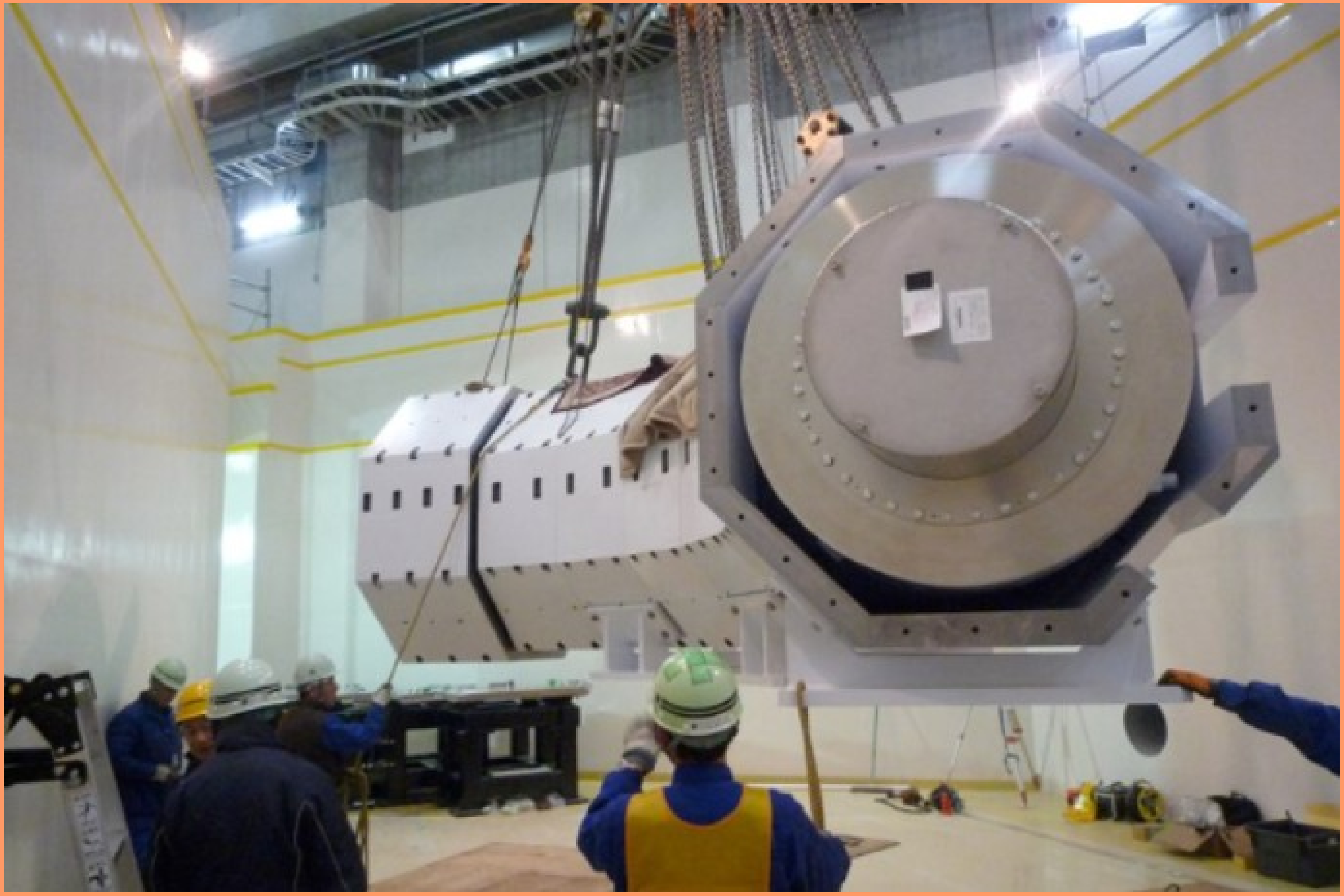
COMET Phase-II @ J-PARK: $2.6 \cdot 10^{-17}$
COMET Phase-I @ J-PARK: $3.1 \cdot 10^{-15}$

Current limits:

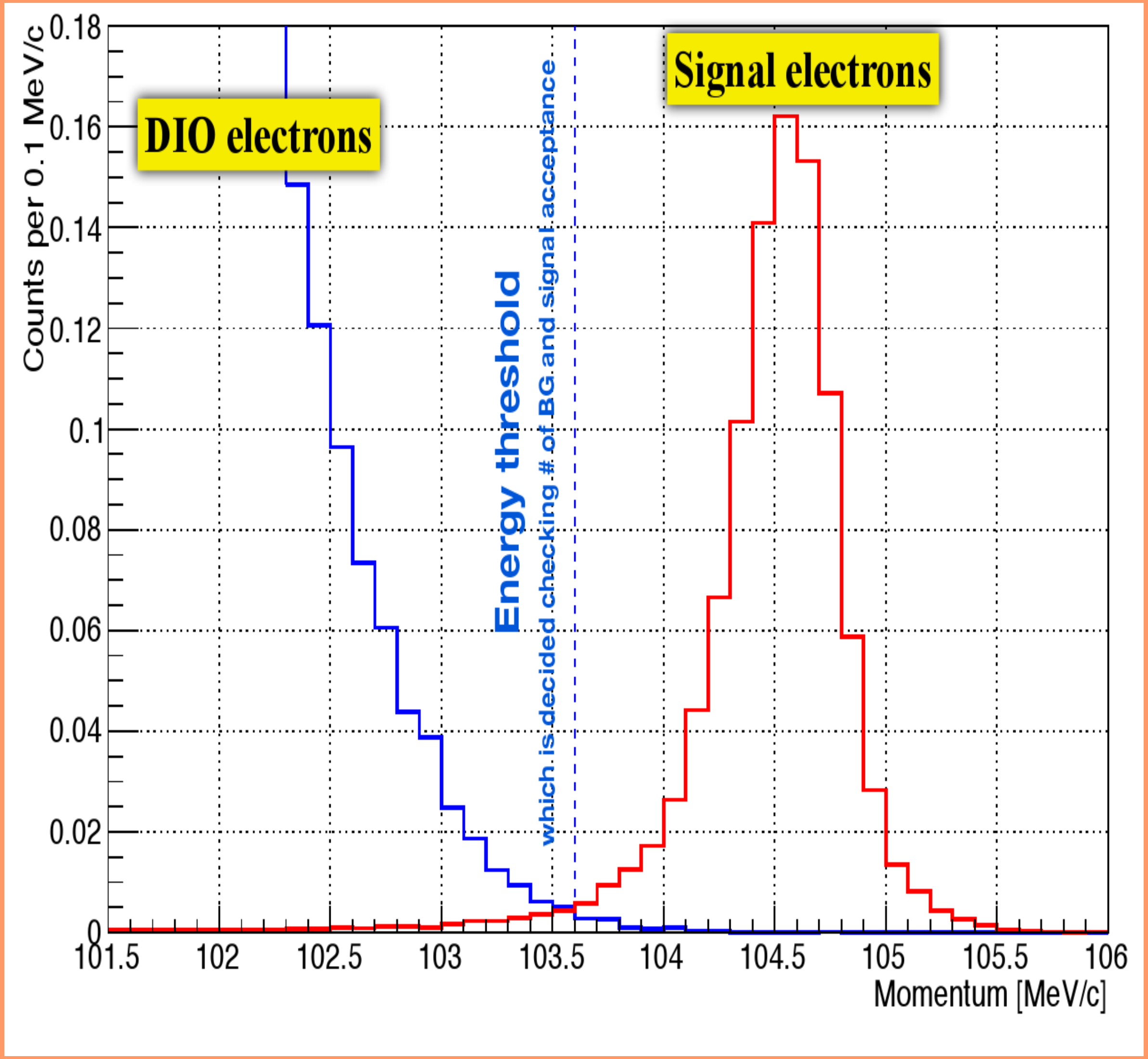
MEG @ PSI: BR($\mu^+ \rightarrow e^+ + \gamma$) < $5.7 \cdot 10^{-13}$

SINDRUM-II @ PSI: BR($\mu^- + \mathrm{Au} \rightarrow e^- + \mathrm{Au}$) < $7 \cdot 10^{-13}$

Construction of the COMET Phase-I

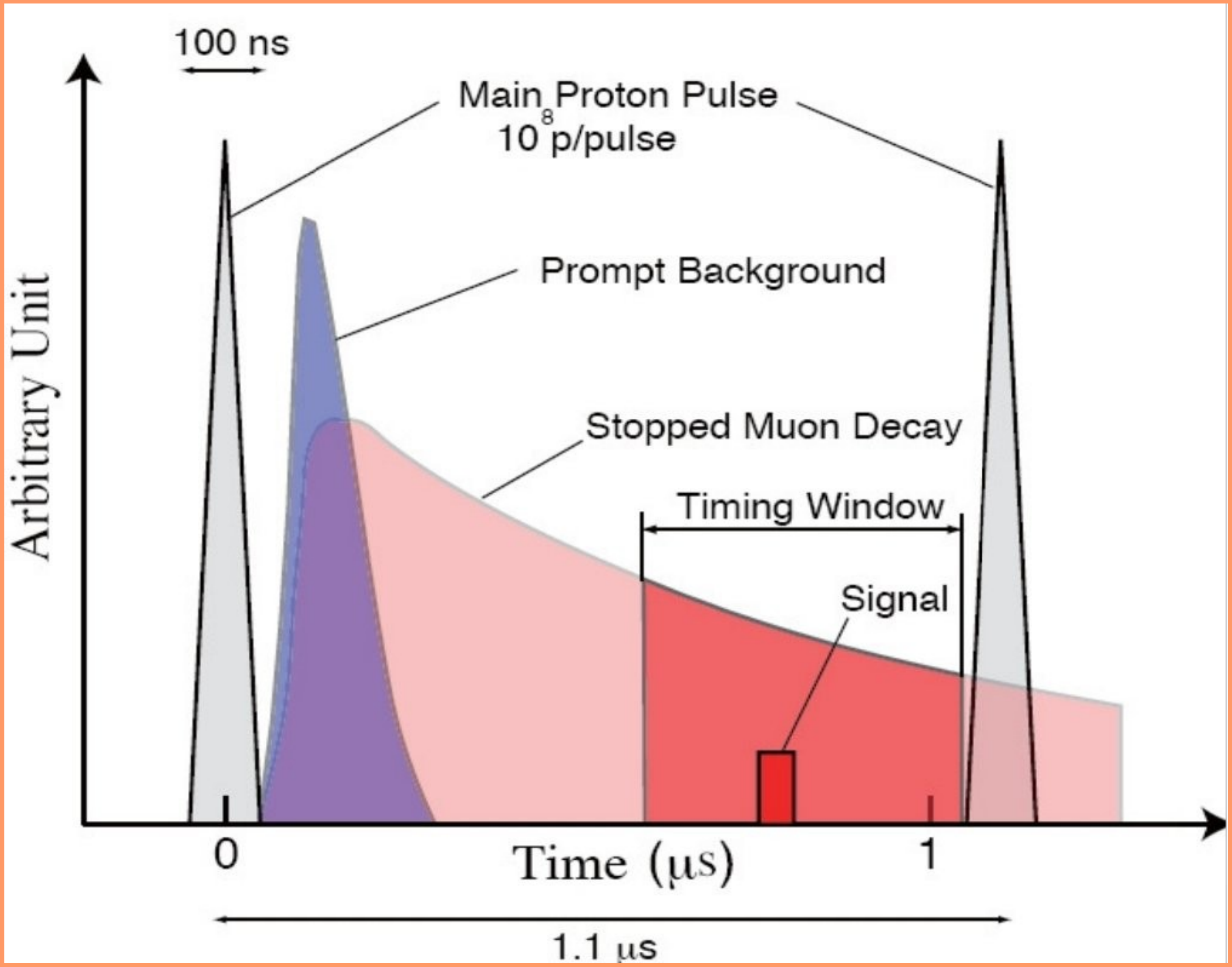


Cylindrical Drift Chamber



Wire stringing of the Belle-II CDC at FUJI exp hall

Beam-related backgrounds



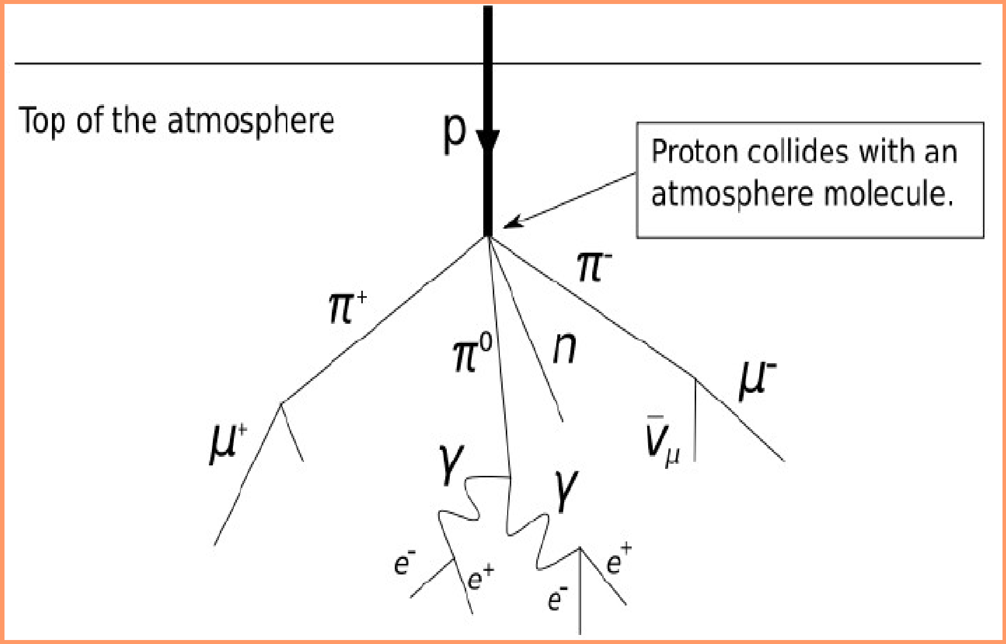
To cope with background-induced electrons in the detector:

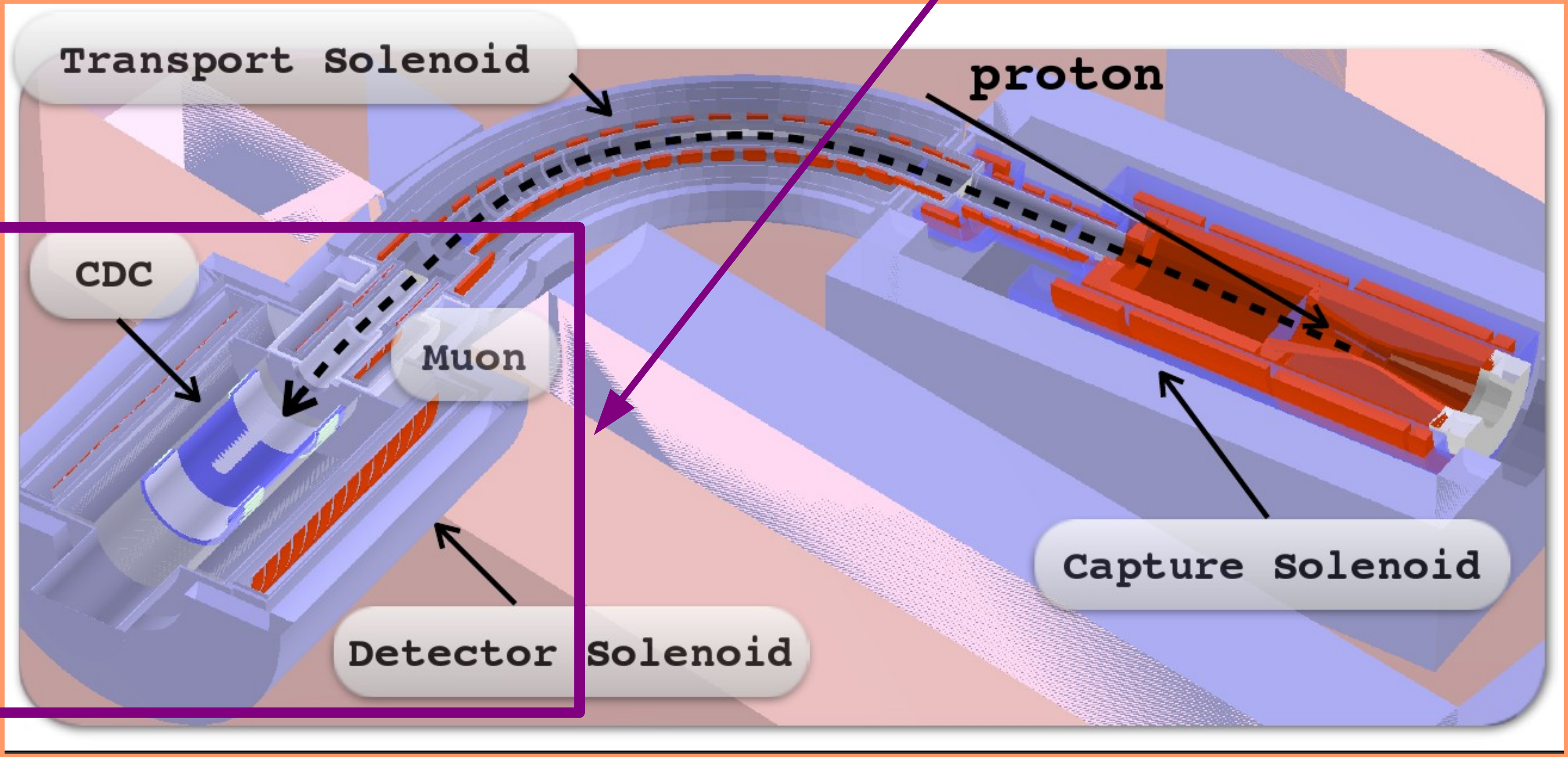
- a pulsed proton beam
- a curved muon-transport solenoid

Cosmic-ray veto

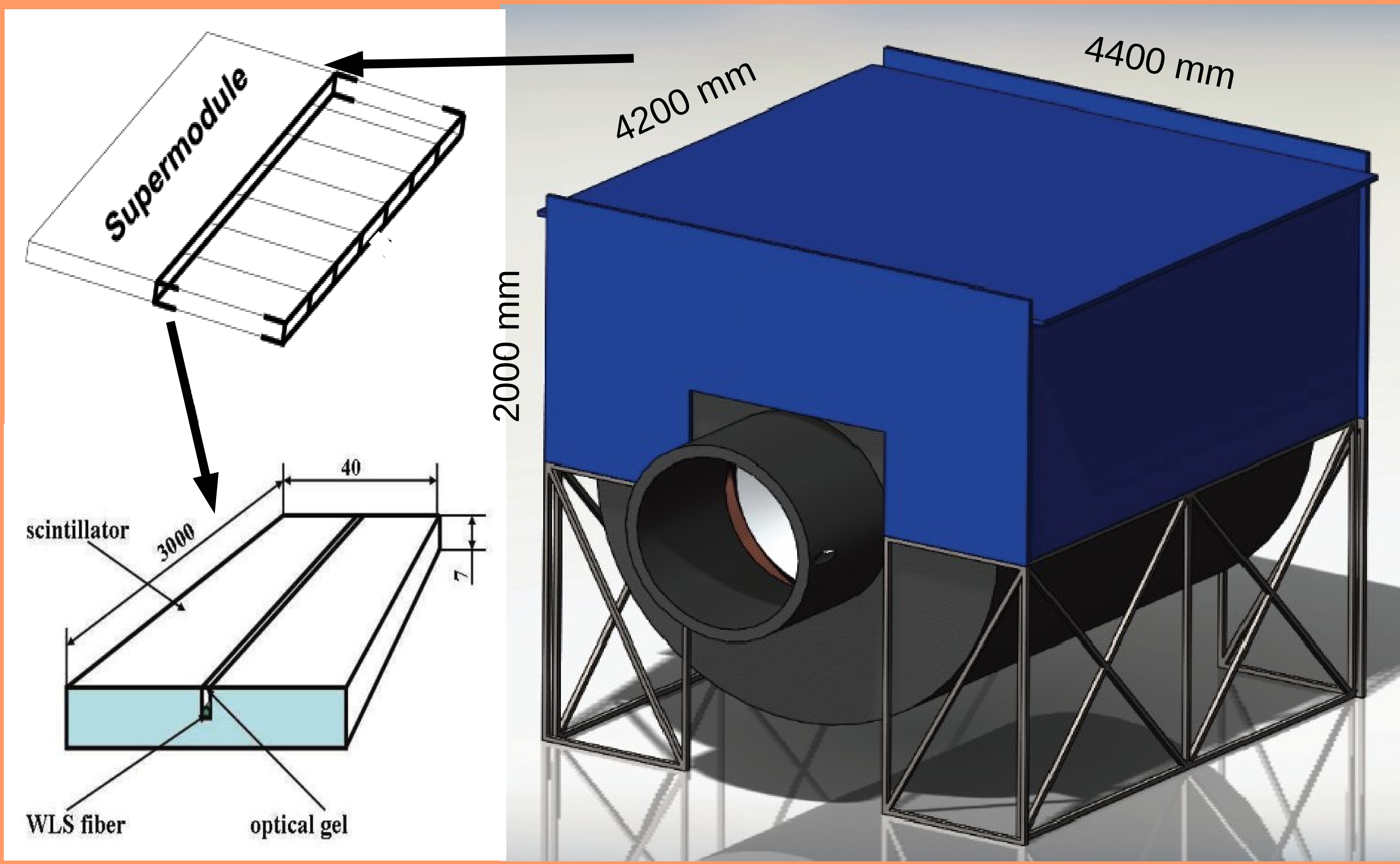
1. Passive shielding
2. Veto counters

Efficiency goal is 0.9999

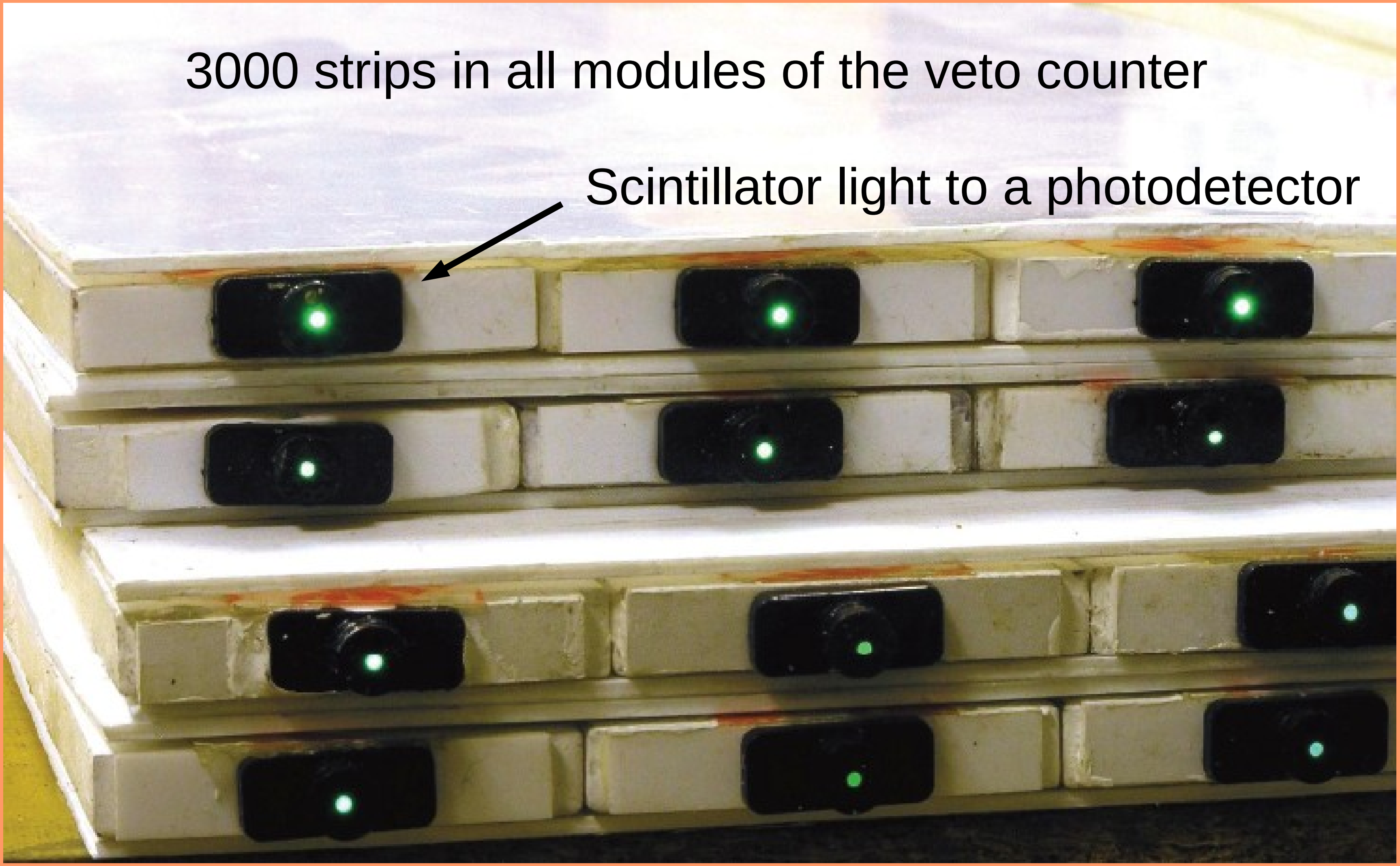




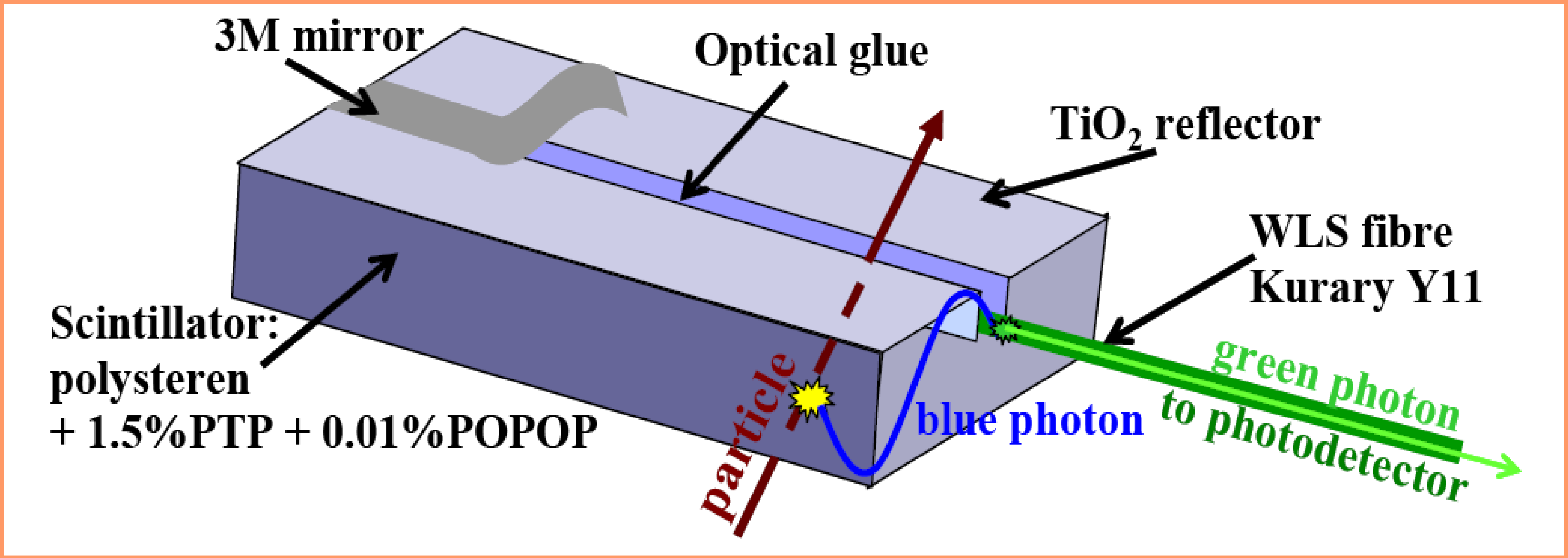
Design of cosmic-veto counters



15 scintillator strips per module
4 layers of modules with offsets

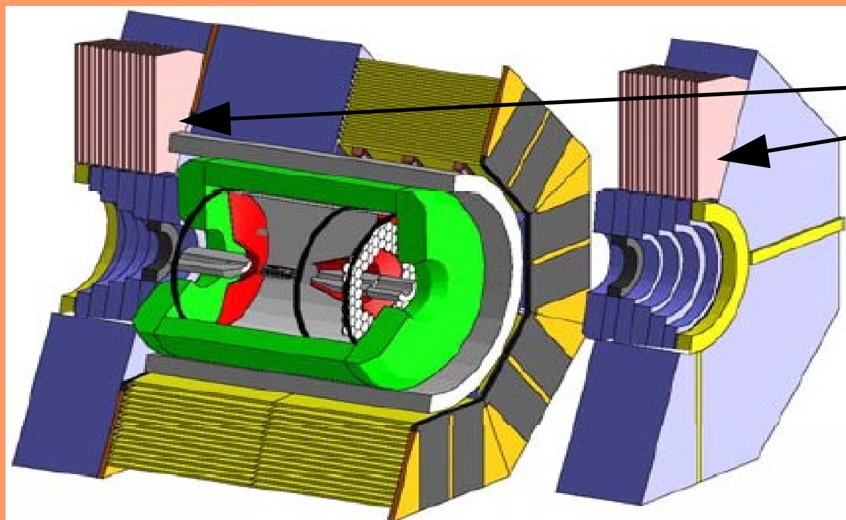


Scintillator strips read by MPPCs



~ 40 photons, ~ 50 photons and ~ 70 photons per MIP
at 2000 mm, 1000 mm, and 100 mm
from the photo-detector respectively

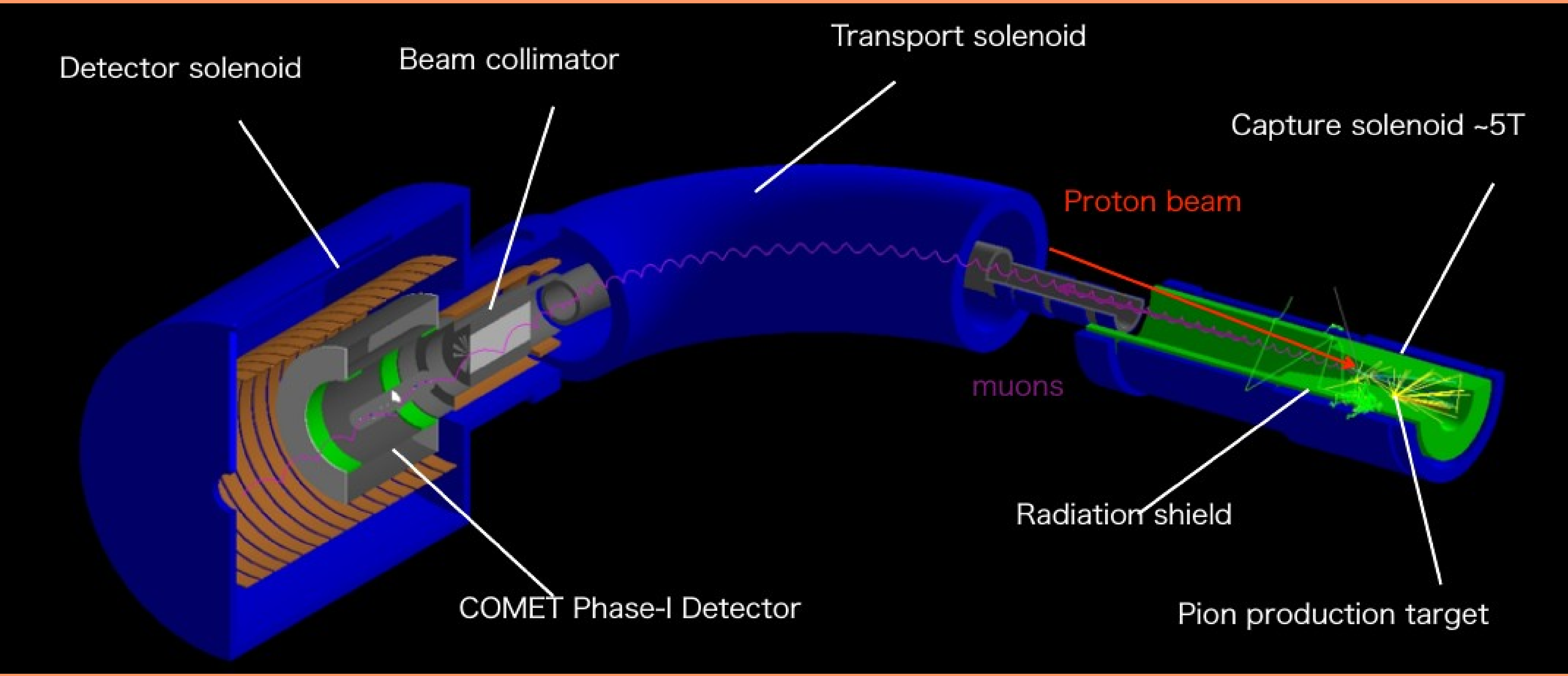
Production experience



16800 strips produced for
Belle II KLM detector endcaps

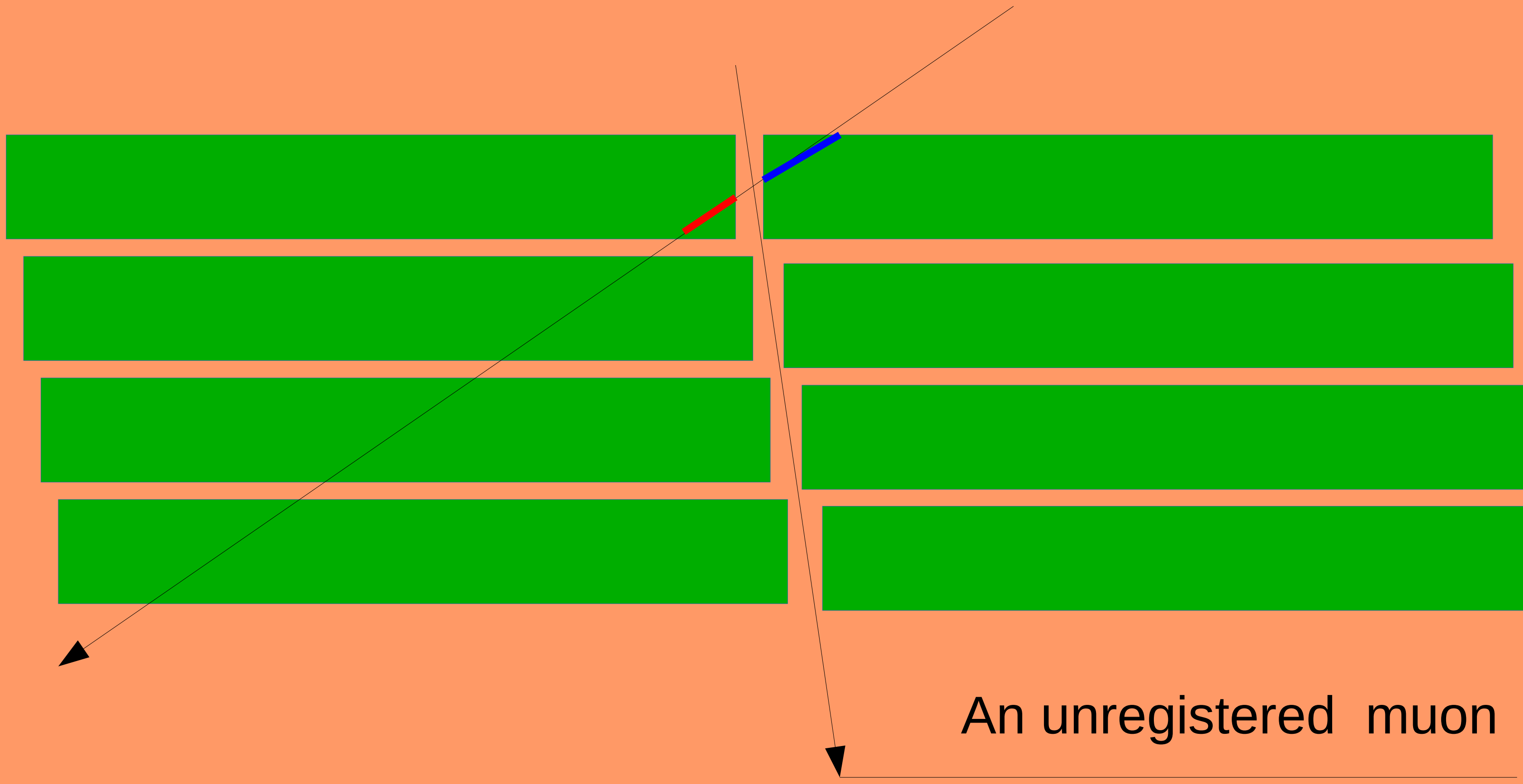
The longest strip 2.8 m
The shortest strip 0.6 m

Simulations of the CVS:
1. Efficiency of cosmic-muon registration



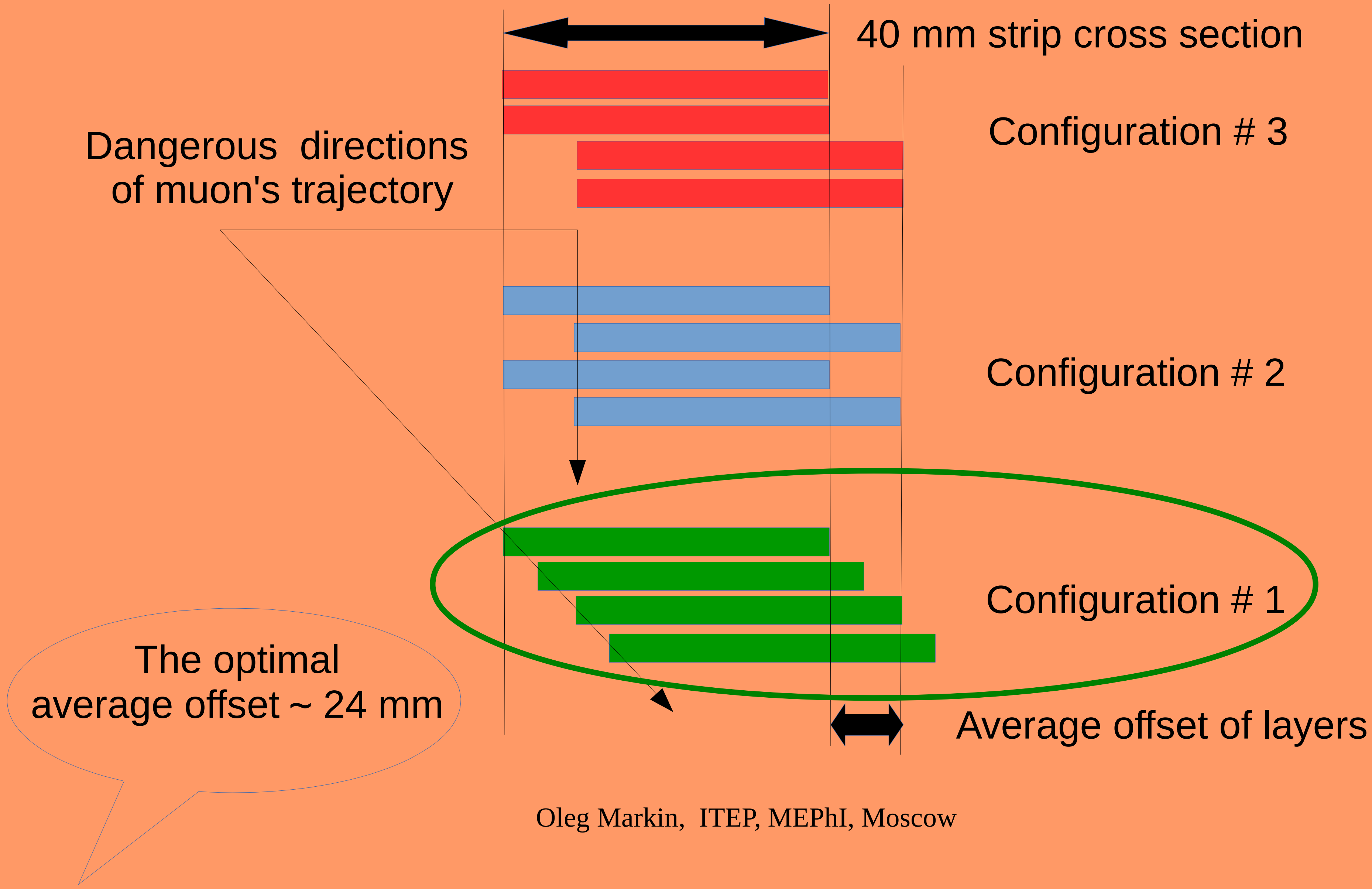
Effect of inactive zones has been simulated to optimize strip layout

Algorithm: in which strip the muon signal is higher



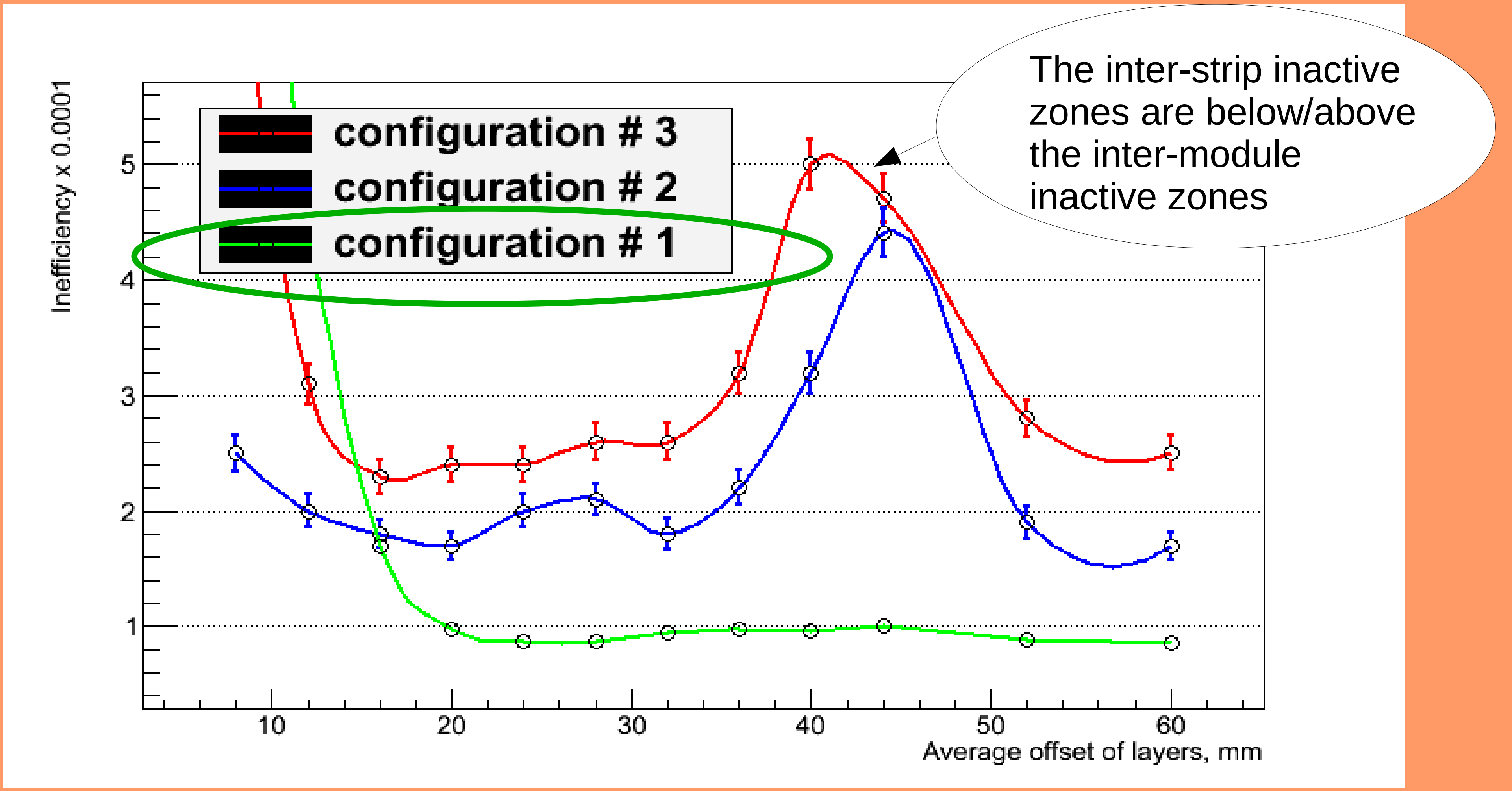
An unregistered muon

Optimization of strip layout: configuration #1 performs better

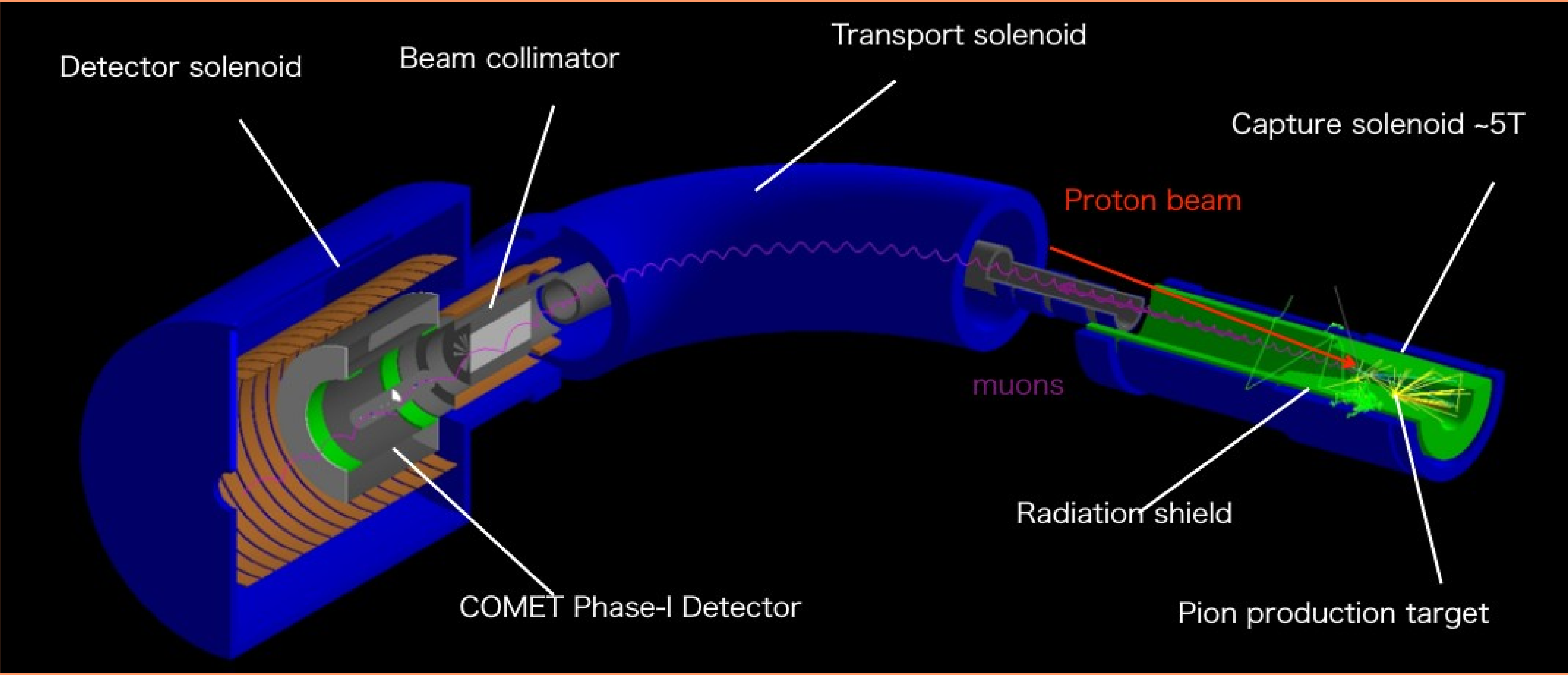


Inefficiency versus strip offset for three strip layouts

Inter-strip gaps = 0.3 mm, inter-module gaps = 5 mm and no gaps between layers

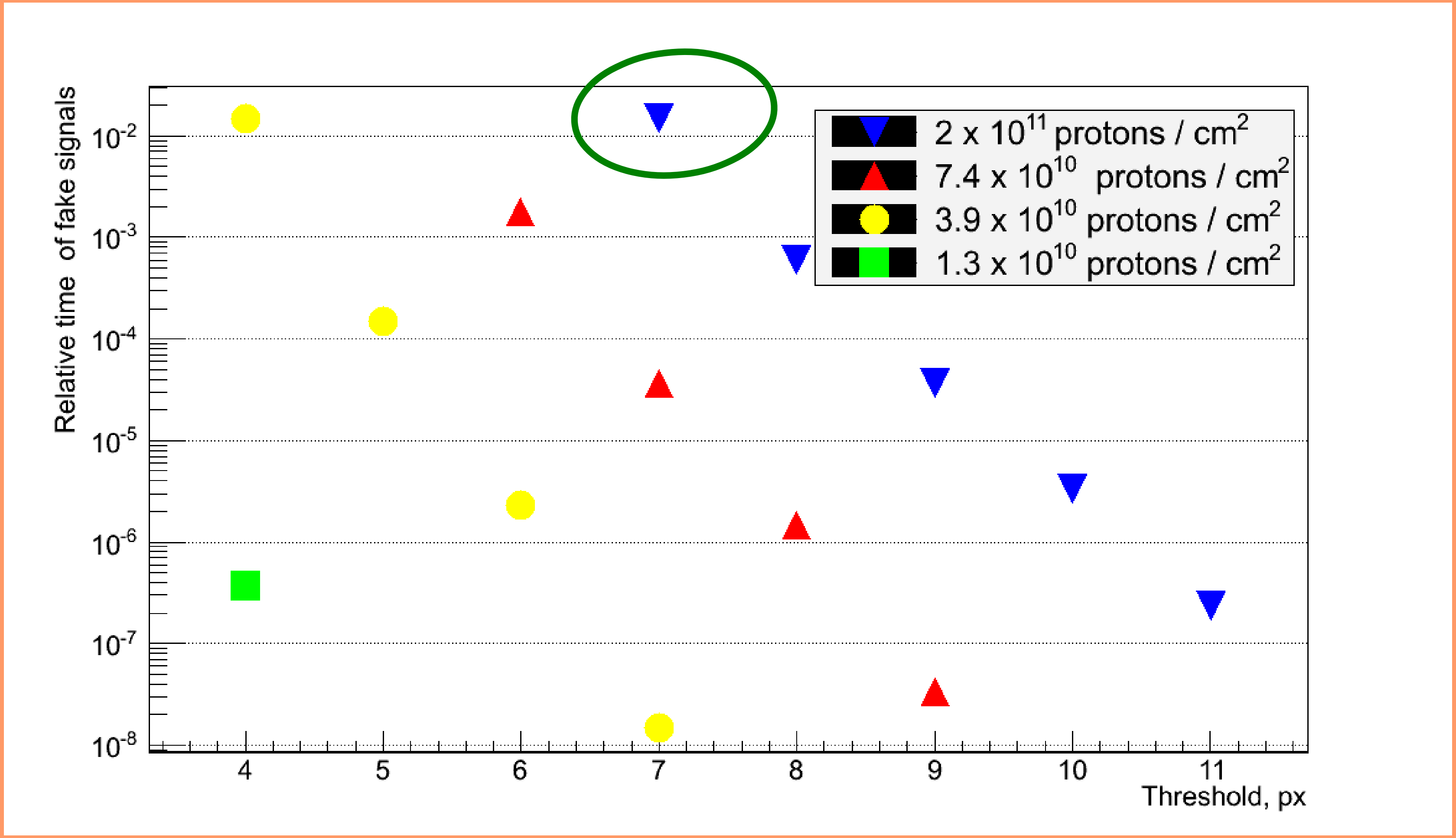


Simulations of the CVS:
2. Photo-detector noise & background neutrons' fake veto signals

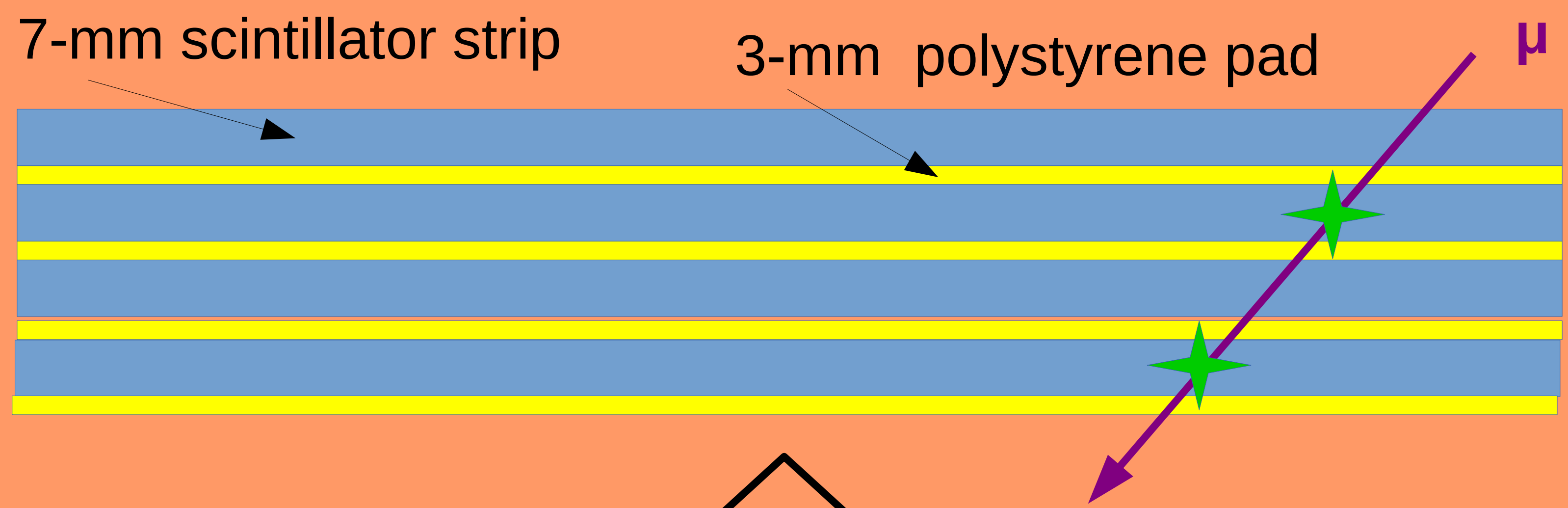


Time lost due noise signals of MPPC, depending on irradiation

Suppose the veto time window = 100 ns and the resolution time = 20 ns



Shielding of veto counters against neutrons from the muon-stopping target



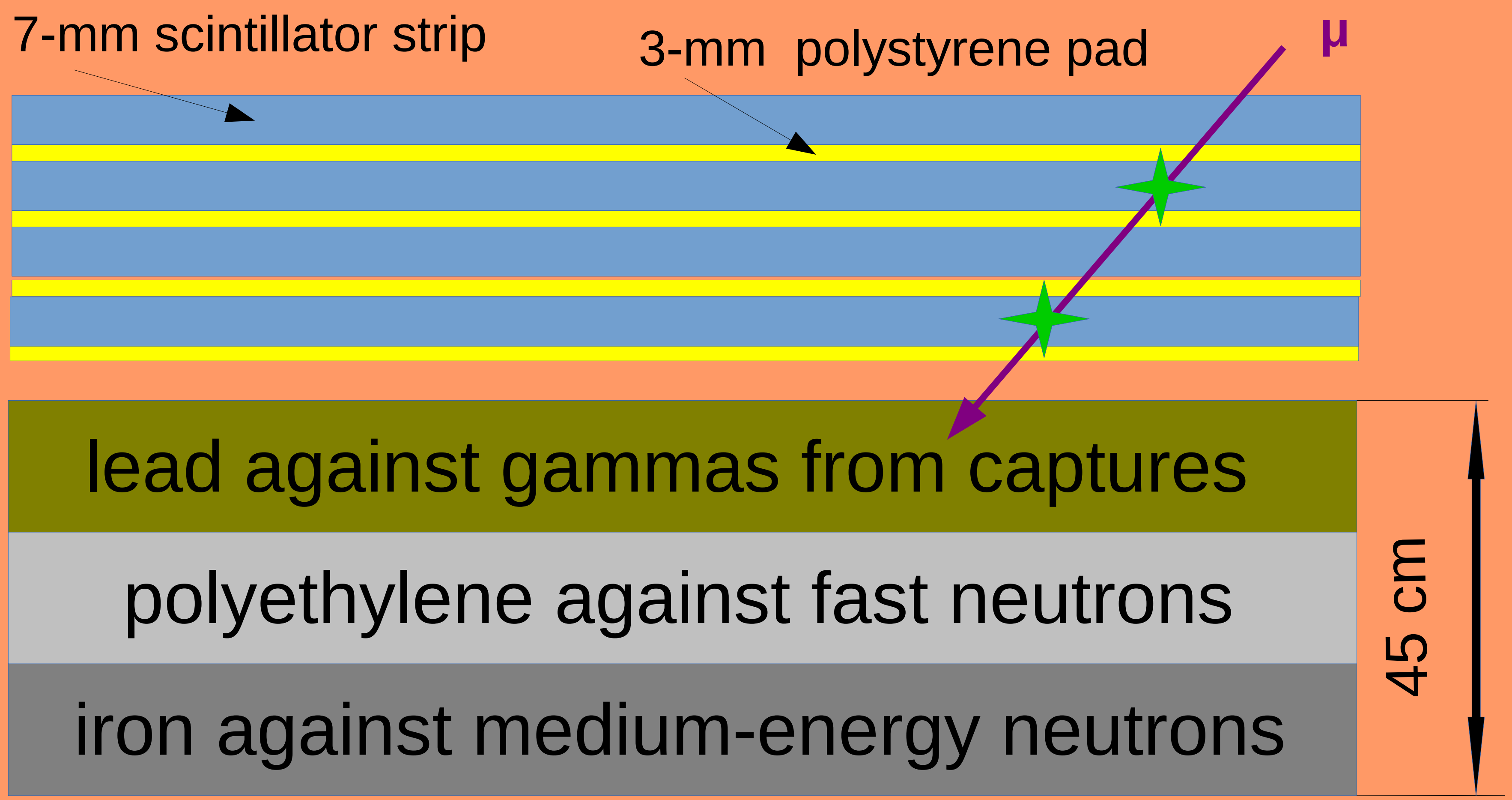
10^9 neutrons per second up to 100 MeV

$$N(Z)+\mu^- = N(Z-1)+\nu_\mu+n$$

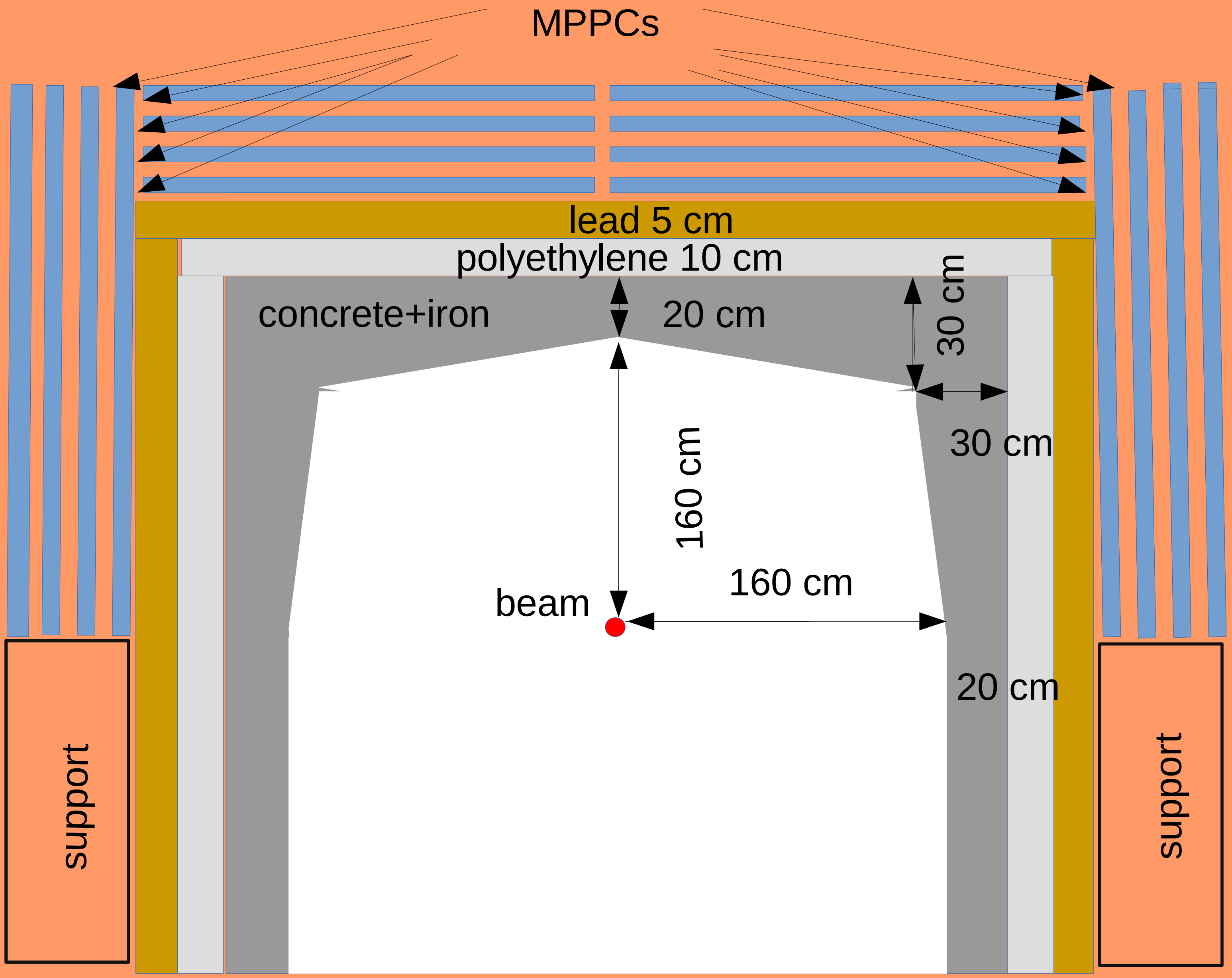
Fake muon veto signals

Loss of the data-taking time

Shielding of veto counters against neutrons from the muon-stopping target



Conceptual design of the CVS



Summary

- A well-established scintillator-strip technology can be used for the COMET cosmic-veto counters.

- The 'ladder' strip layout is preferable. At the 11 px threshold, its inefficiency is about 0.0001 and even less in the central region of detector and decreases by an order of magnitude if the threshold is reduced by 2 px.

- The time loss caused by the MPPC noise is tolerable throughout the full time of data taking.

- A 45 cm thick shield comprised of reinforced concrete, polystyrene and lead allows the time loss caused by neutrons to be less than 1% even at the 5-pixel threshold of photo-detectors.

- Inner shielding reduces the irradiation of MPPCs to an acceptable level.