The main background sources for the SHiP experiment at CERN

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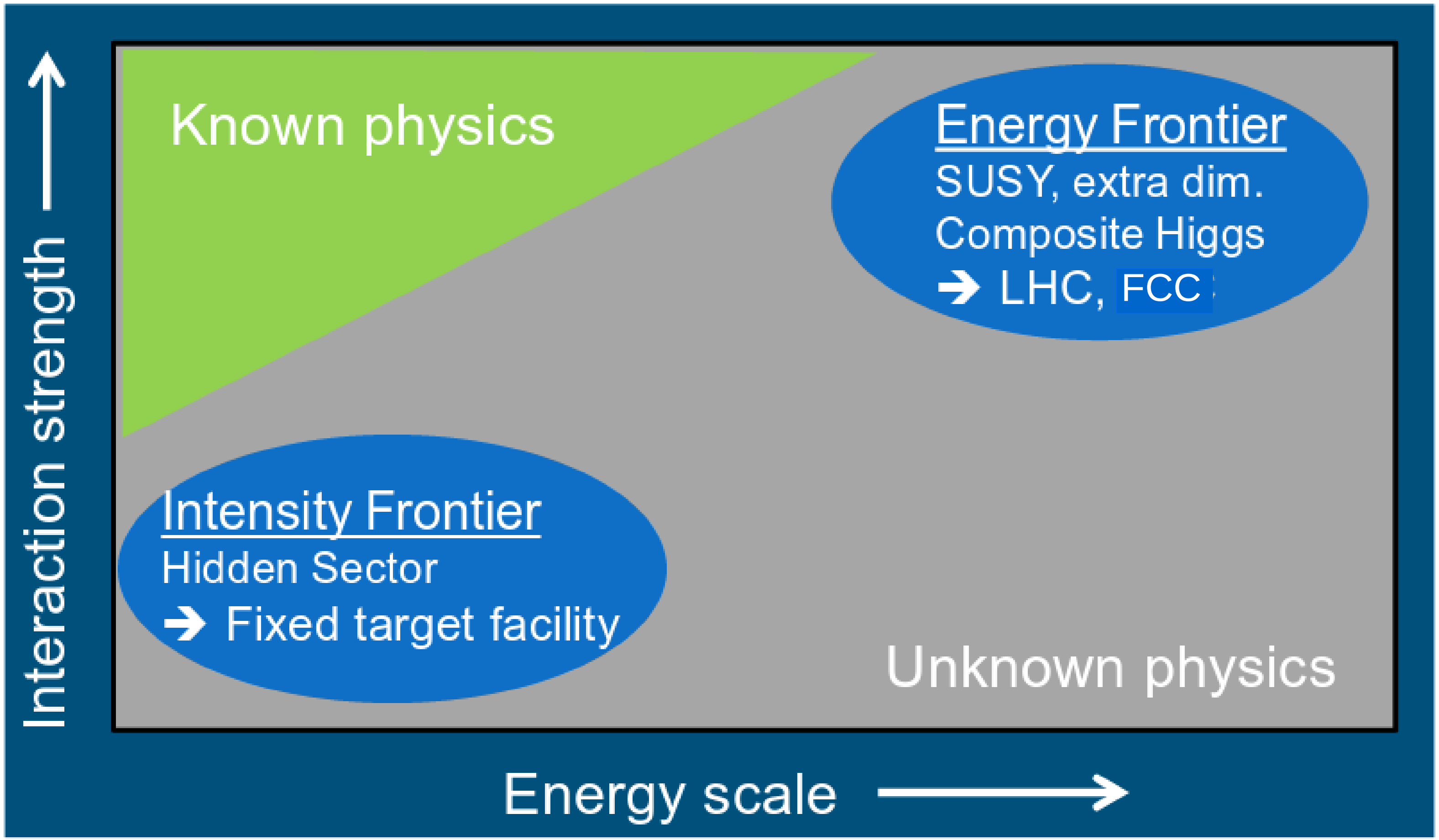
Where to find new physics

- **Experimental evidence for physics beyond the SM**

  → Neutrino Masses, Dark Matter , Baryon asymmetry

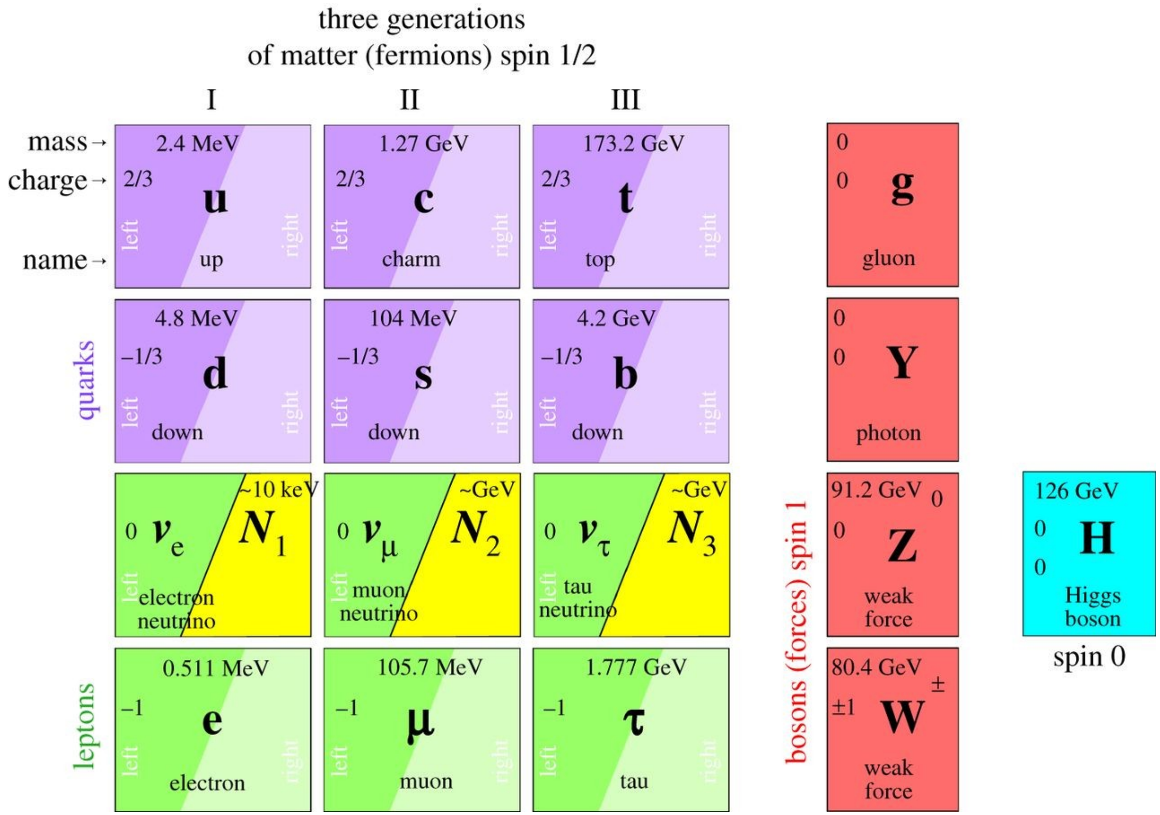
- **Possible ways to search for new physics**

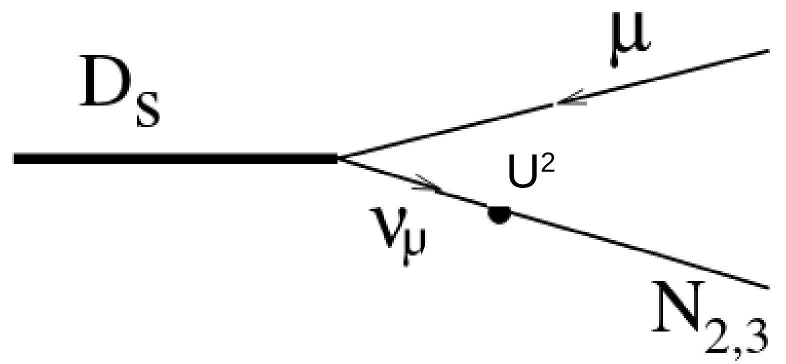


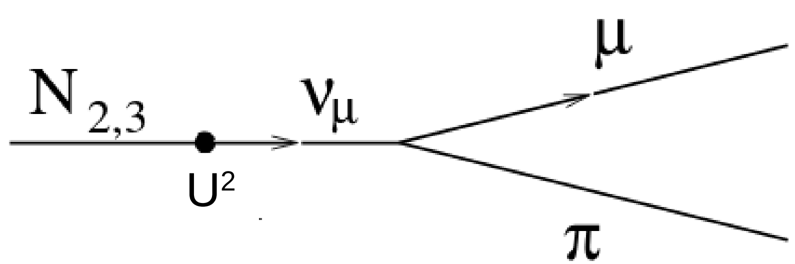
HNL of the νMSM (Neutrino Minimal Standard Model)

SHiP
Search for Hidden Particles

→**Light N$_1$** dark matter candidate , **Heavy Neural Lepton N$_{2,3}$**







Shaposhnikov
GorbunovarXiv05071729

Concept and design

Yields for 2×10^{20} pot (5 years):
$> 10^{18}\,D, \quad > 10^{16}\,\tau$

- **Surround Background Tagger (SBT):**

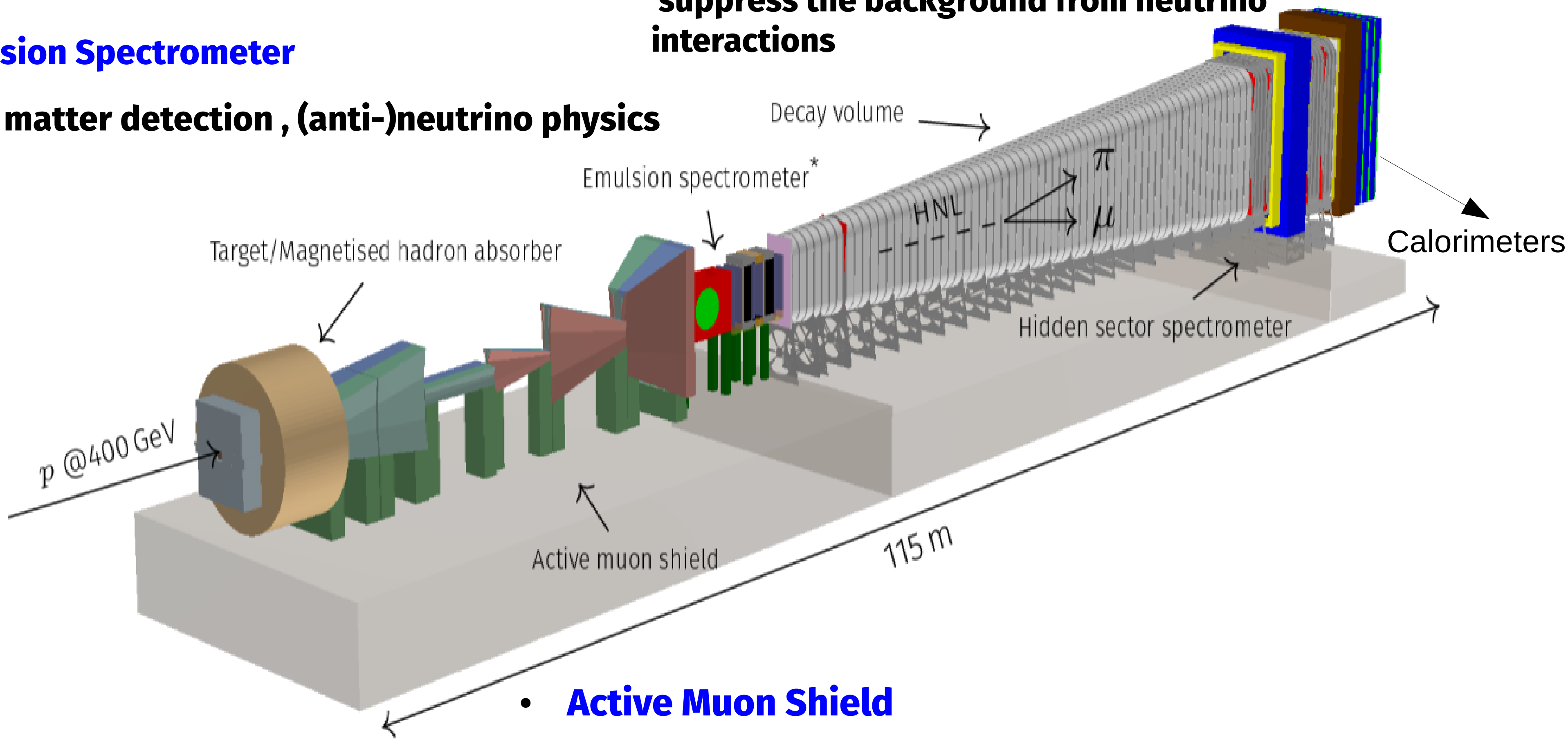
  Liquid Scintillator segments around the vessel

- **Evacuated the vessel**

  suppress the background from neutrino interactions

- **Emulsion Spectrometer**

  dark matter detection , (anti-)neutrino physics



- **Active Muon Shield**

  reduce the muon flux by at least six order Magnitude

Crucial challenge : Negligible Background

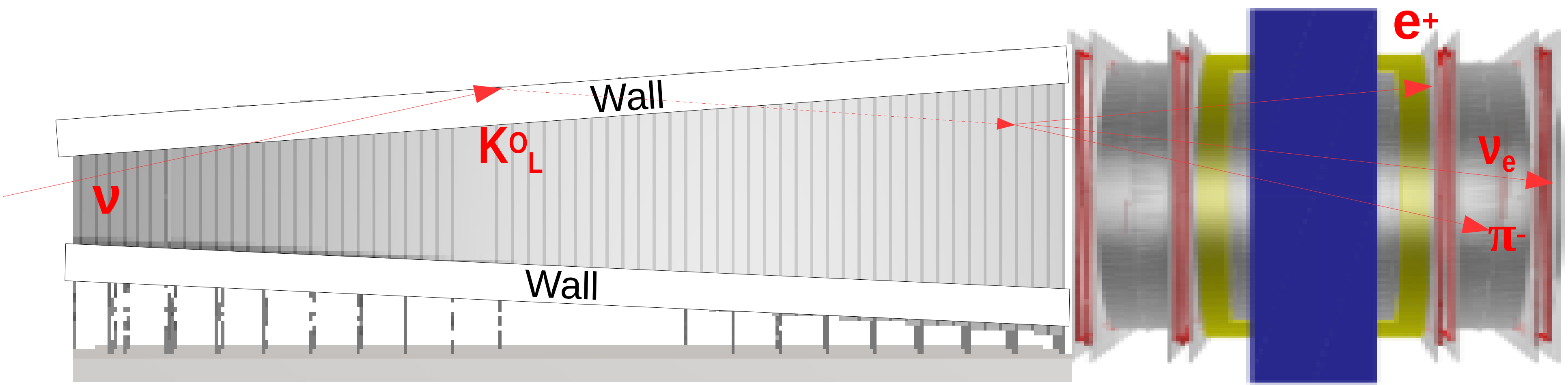
Possible signals and background sources

SHiP
Search for Hidden Particles

Models	Final states
Neutrino portal, SUSY neutralino	$\ell^\pm\pi^\mp, \ell^\pm K^\mp, \ell^\pm\rho^\mp, \quad \rho^\pm \to \pi^\pm\pi^0$
Vector, scalar, axion portals, SUSY sgoldstino	$\ell^+\ell^-$
Vector, scalar, axion portals, SUSY sgoldstino	$\pi^+\pi^-, K^+K^-$
Neutrino portal ,SUSY neutralino, axino	$\ell^+\ell^-\nu$
Axion portal, SUSY sgoldstino	$\gamma\gamma$
SUSY sgoldstino	$\pi^0\pi^0$

Background source	Decay modes
ν or μ + nucleon $\to X + K_L$	$K_L \to \pi e\nu, \pi\mu\nu, \pi^+\pi^-, \pi^+\pi^-\pi^0$
ν or μ + nucleon $\to X + K_S$	$K_S \to \pi^0\pi^0, \pi^+\pi^-$
ν or μ + nucleon $\to X + \Lambda$	$\Lambda \to p\pi^-$
n or p + nucleon $\to X + K_L$, etc	as above

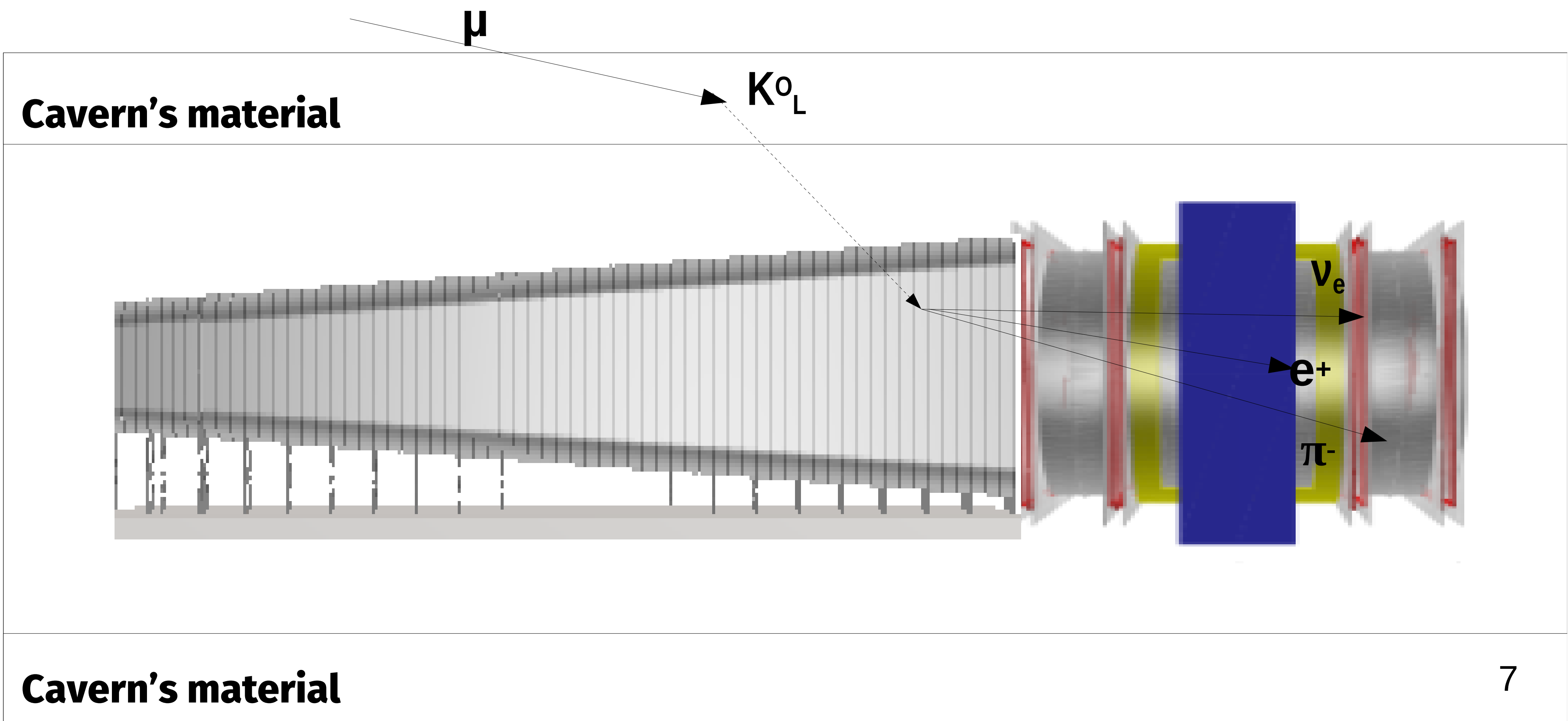
Neutrino background



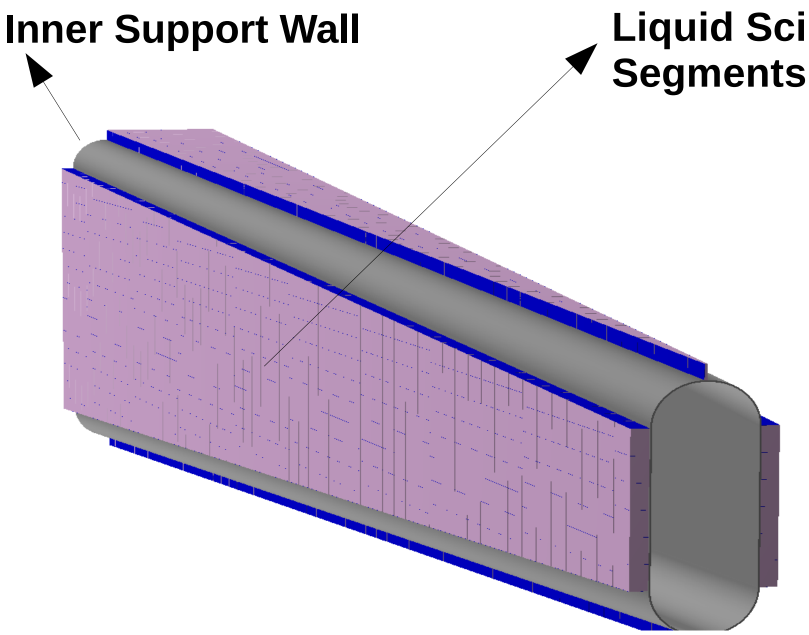
- 10^{11} ($7.3\ 10^{10}$) (anti-) neutrinos per spill (10^{13} pot) coming from the target
- 10^7 neutrino interactions expected for $N_{pot} = 2.10^{20}$ (5 years run) in the experimental set

Muon DIS (Deep Inelastic Scattering) background

- Two sources of muons :
  → Muons not sufficiently deflected by the Muon Shield
  → Cosmic muons
- Scattered by :
  → cavern walls
  → Vessel's walls



Surrounding Background Tagger (SBT)



Decay Vessel

- **Experimental Set-Up:**
  → **Liquid Scintillator segment:equipped with Wavelenght-shifting Optical Modules (WOMs) viewed by PMT or SiPMs**
- **Requirements:**
  → **high efficiency**
  → **good timing resolution**
- **Participating Institutes :**
  Berlin,Geneva, Kiev, Mainz

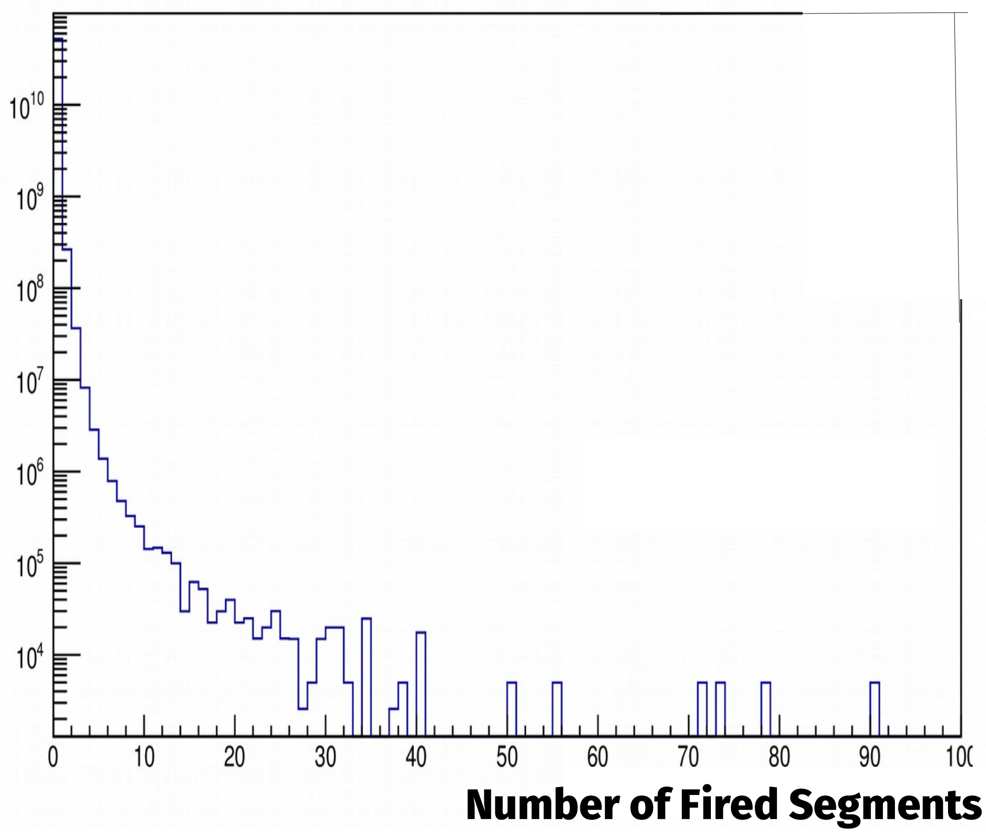
- **The SBT in the Software:**
  →**The size in Z ~ 80cm, 30 cm thickness**
  →**Mark the segment as fired if the Energy deposit> threshold=45MeV**
  →**Save the XYZ position of the segment , time information**

Main Projects for PhD thesis

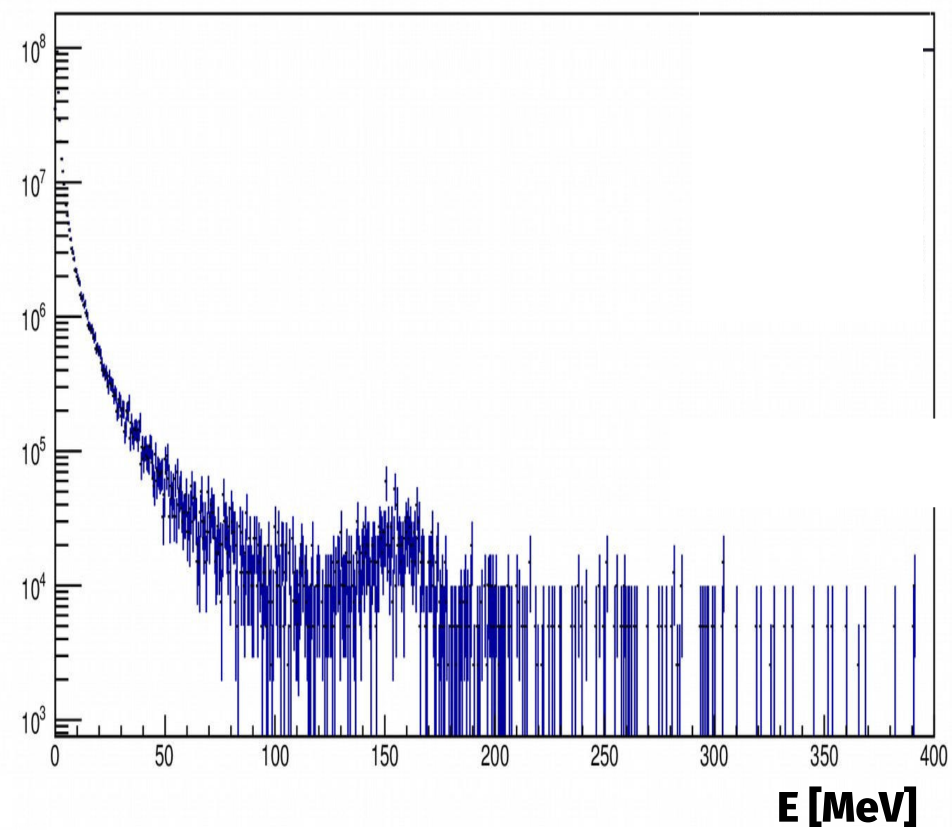
- Study the Hit rate in the SBT for muons from the target
- Study different background sources and the role/performance of the SBT in the suppression of these backgrounds

Study the Background event Rate from muons from the target in the SBT

Number of Fired segments per event (without threshold)



Sum of Deposited Energy loss per segment without threshold



Origin of the peak: MIP

Study the Rates from muons from the target

Background events rate for different thresholds in the SBT :

0 MeV	5 MeV	25 MeV	45 MeV	65 MeV
267 MHz	54MHz	13MHz	7.5MHz	6.7MHz

Background events rate for different thresholds per segment:

0MeV	5MeV	25MeV	45MeV	65MeV
242kHz	49kHz	23kHz	12kHz	6kHz

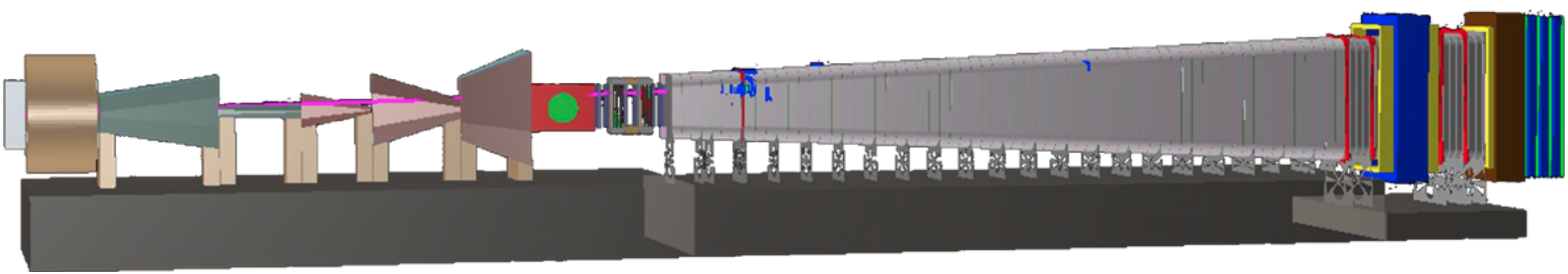
Perform the same studies for neutrino and muon DIS background

Muon DIS Background

- **Muons from the target :**

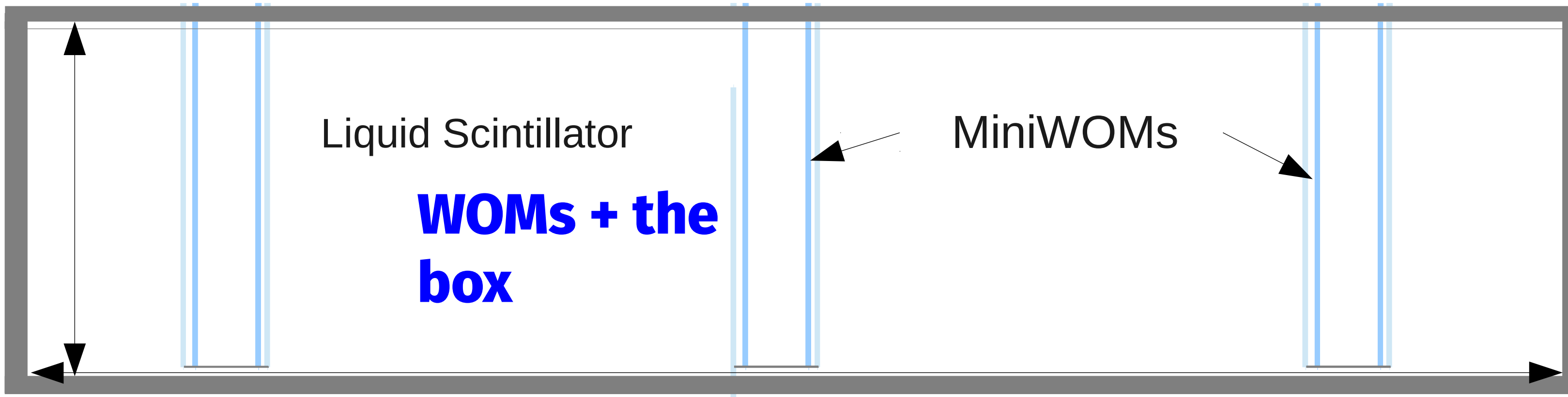
  → from 18 M (corresponding to 1/1000 of one spill) 18 hits start of the Decay Vessel

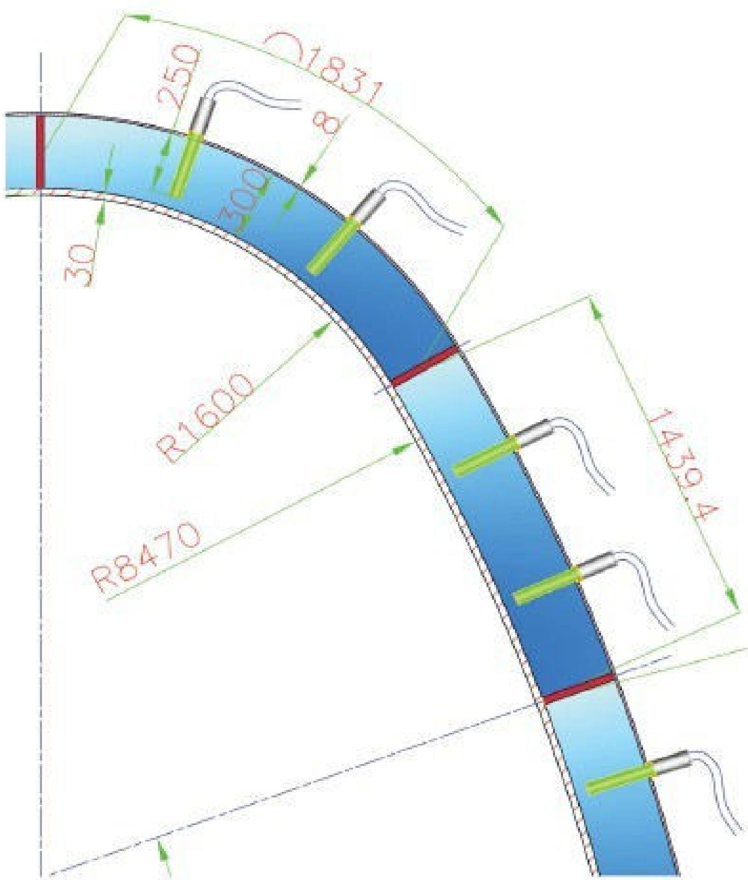
- **Possible ways to increase the statistics ?**



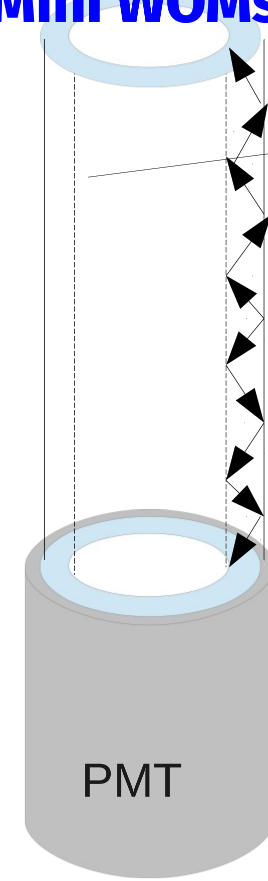
1. **Generate DIS event (Pythia)**
2. **Propagate them with Geant4**
3. **Look for possible HNL candidates , passing the offline selection cuts**

Backup slides : MiniWOMs





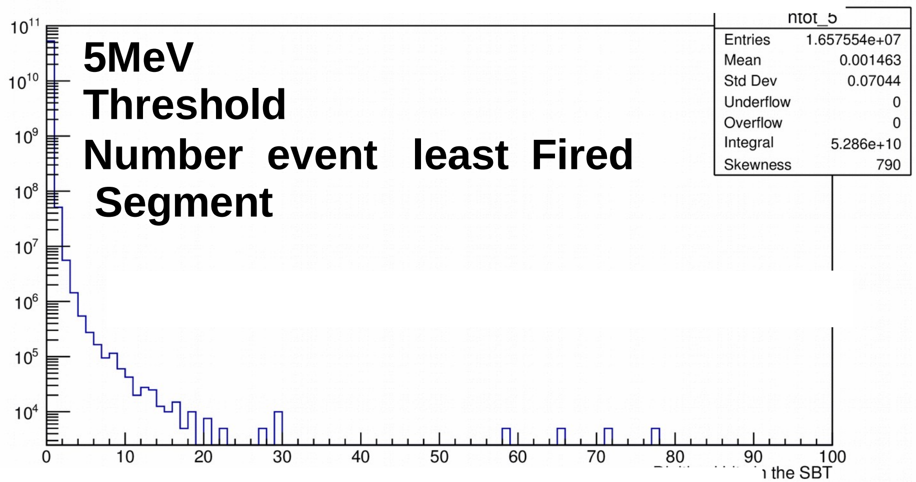
Mini WOMs

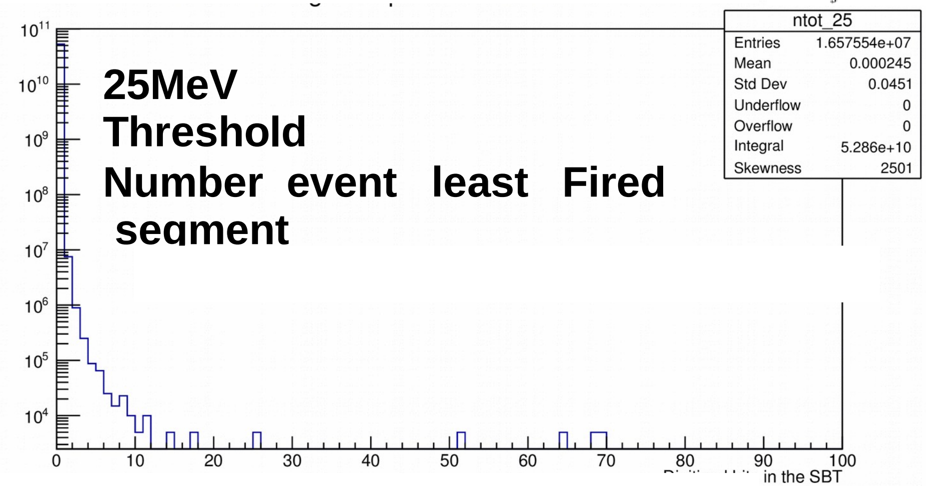


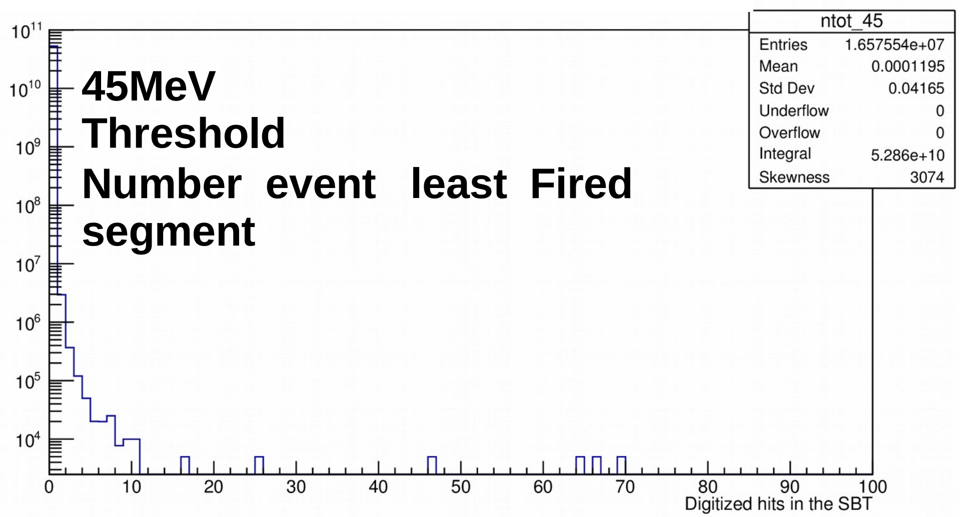
Outer tube

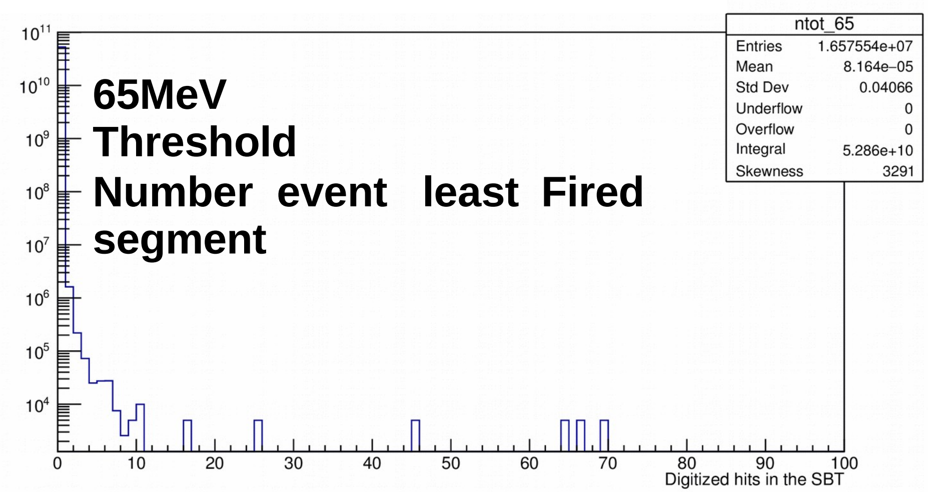
Inner tube : painted with wavelength - shifter paint

Backup slides: Number of Fired segments for different thresholds

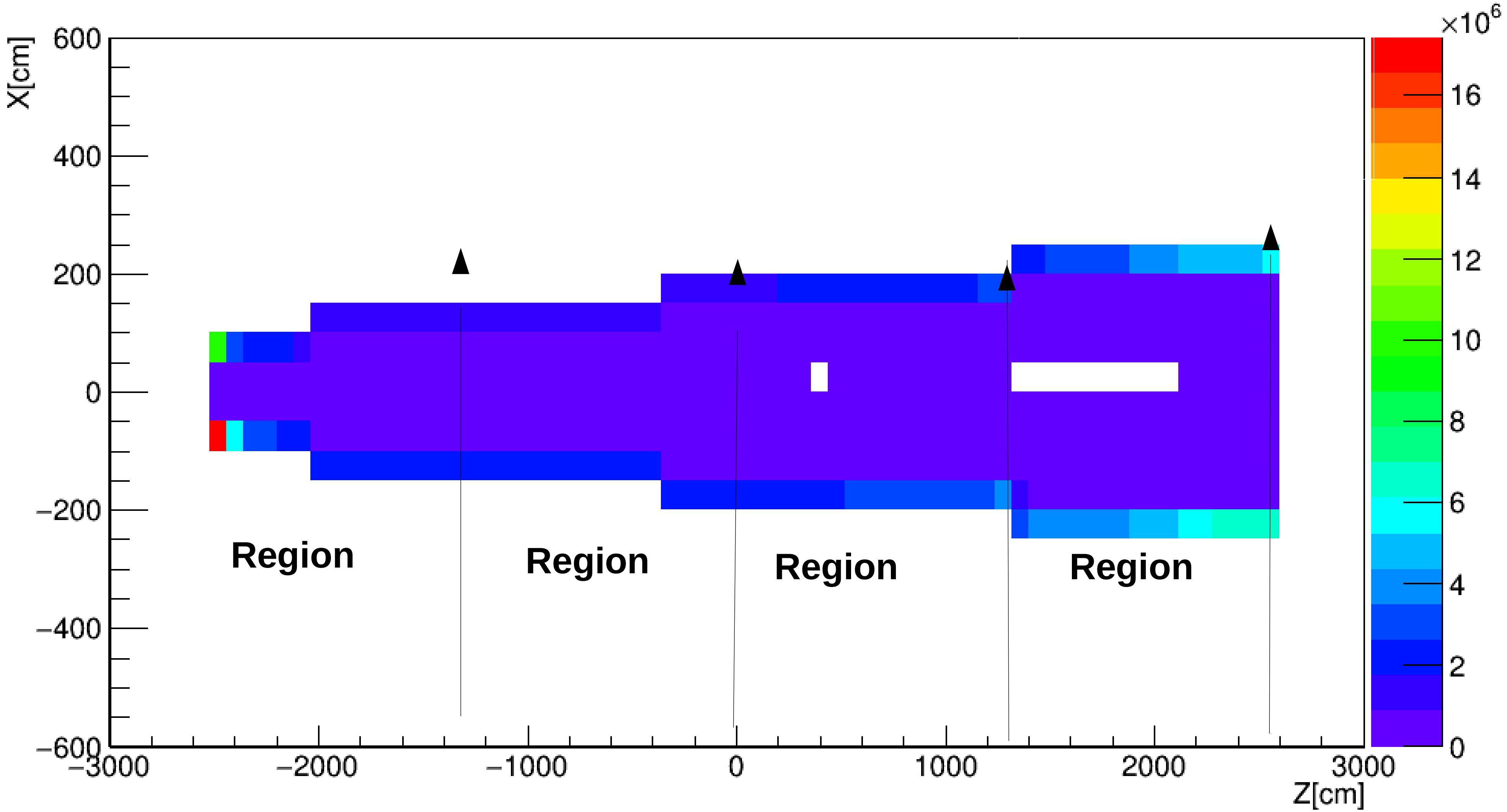






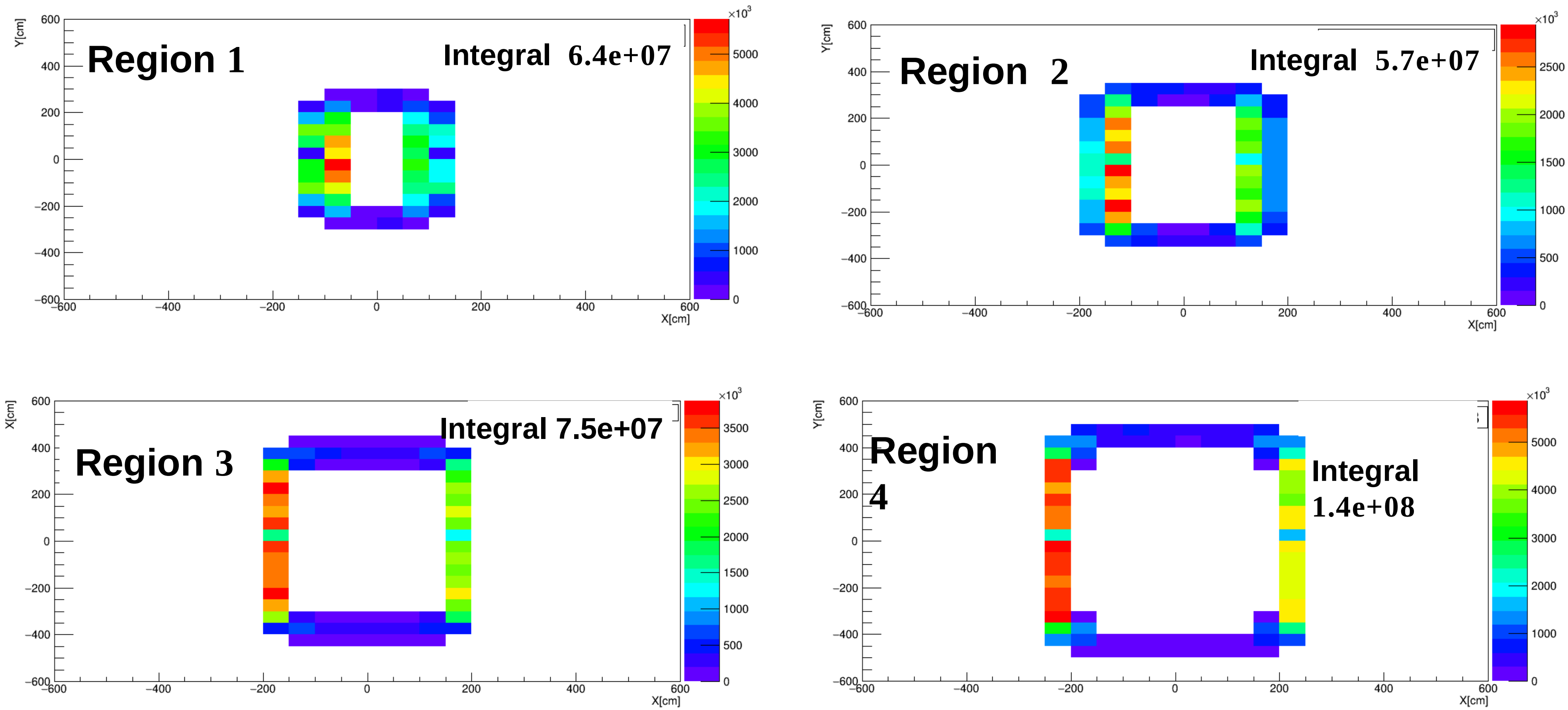


Backup slides: The position of the fired segments without thresholds



→ 2 hot spots in Z direction

Backup slides: The position of the fired segments without thresholds



→ hot spots in region1: 50 cm in Y and in 50 cm in X