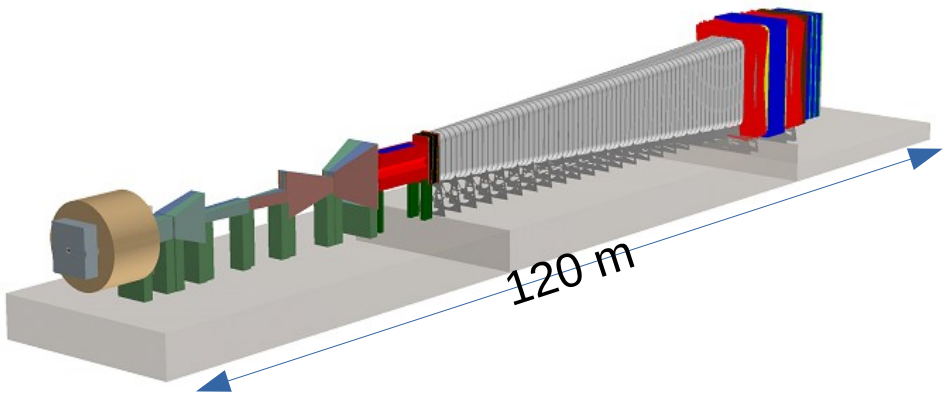
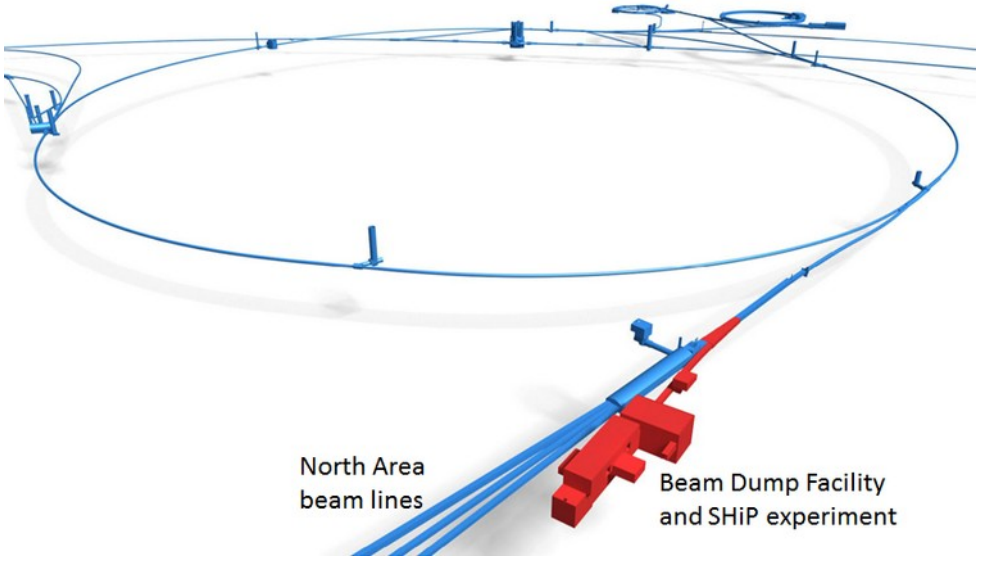
The Search for Hidden Particles (SHiP) detector and the Scatter Neutrino Detector SND@LHC

A. Blanco

SHIP => Search for Hidden Particles

General purpose experimental facility operating in **beam dump mode** at the CERN **SPS accelerator** to search for feebly interacting particles.



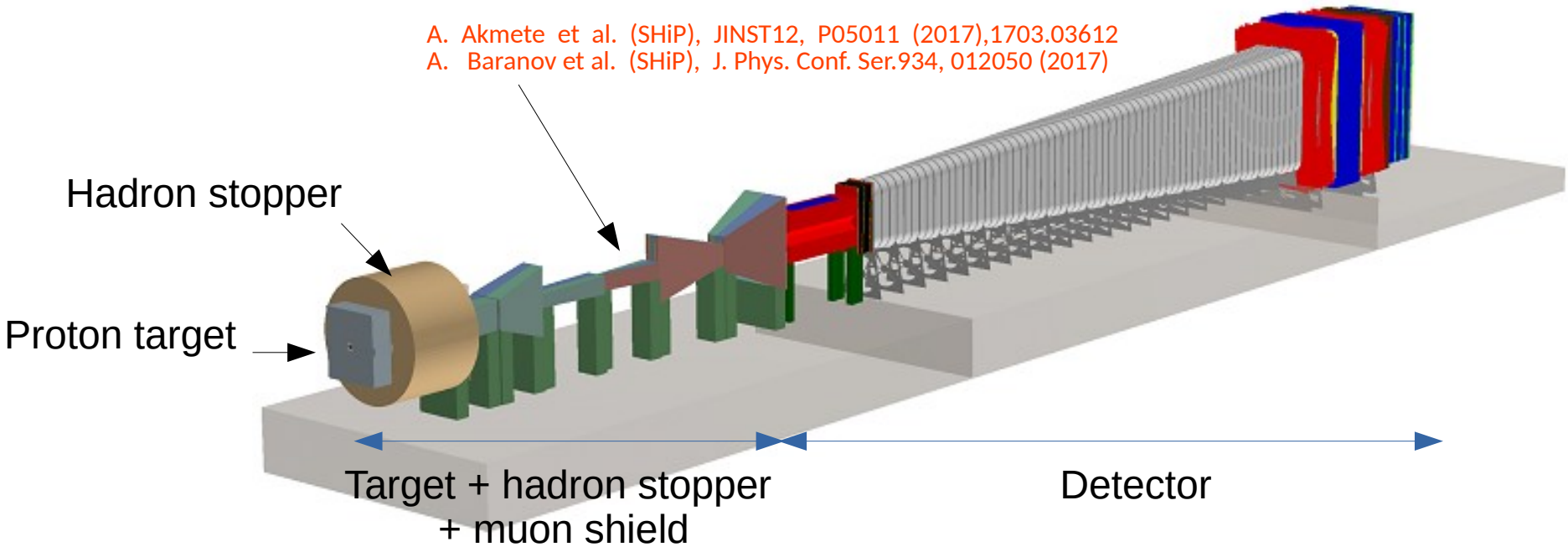


Using the **high-intensity beam of 400 GeV protons**, the experiment aims at profiting from the **4×10^{19} protons per year** that are currently unexploited, over a period of 5-10 years.

The setup consists of a **high-density proton target** located in the target bunker, followed by a hadron stopper and a muon shield.

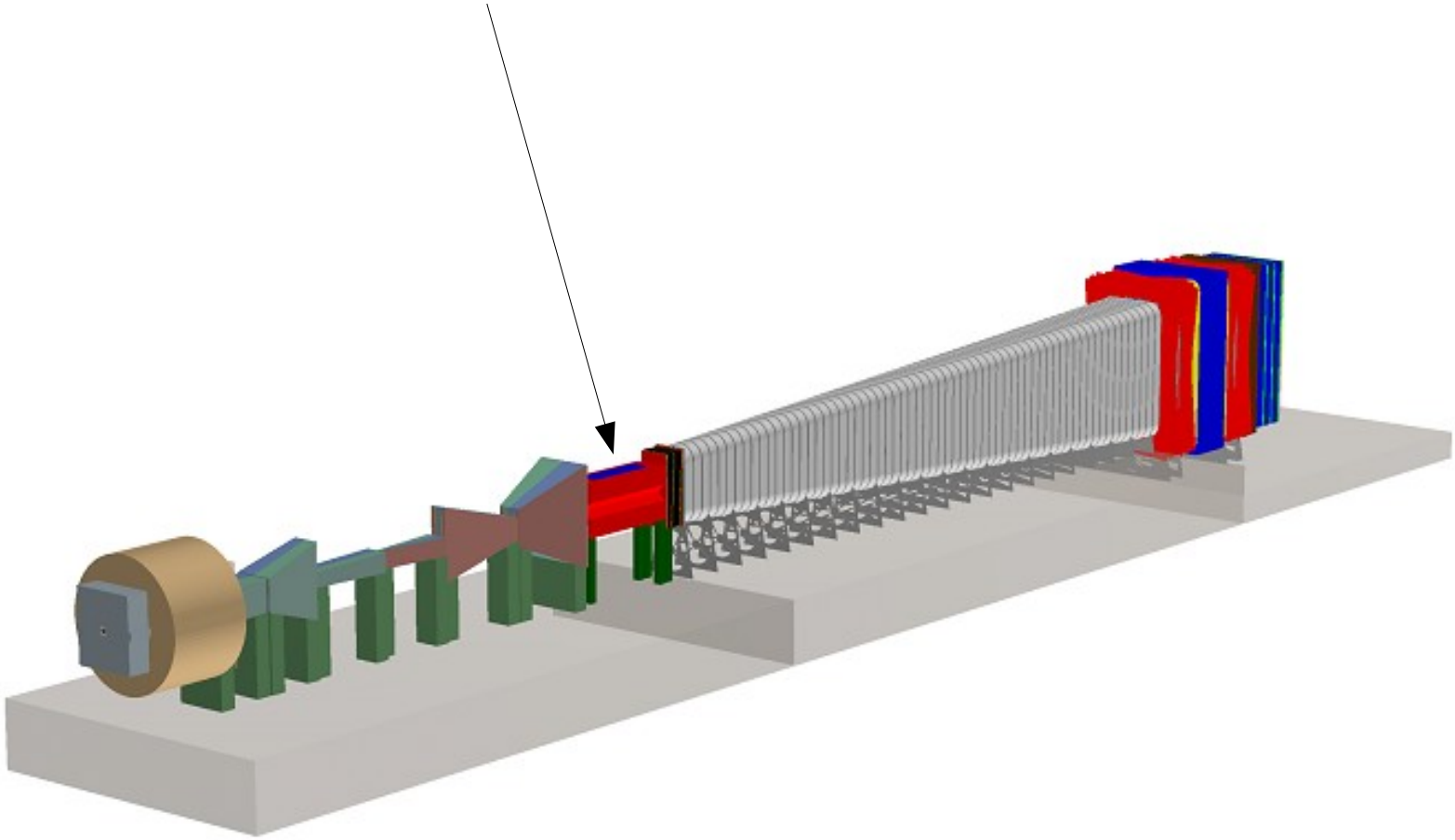
Muon shield based on magnetic deflection reduces flux from 10^{11} down to 10^{5}

A. Akmete et al. (SHiP), JINST12, P05011 (2017),1703.03612
A. Baranov et al. (SHiP), J. Phys. Conf. Ser.934, 012050 (2017)



Incorporates **two complementary detectors**

Upstream detector Scattering and Neutrino Detector (SND) designed for recoil **signatures of light dark matter scattering** and **for tau neutrino** physics.



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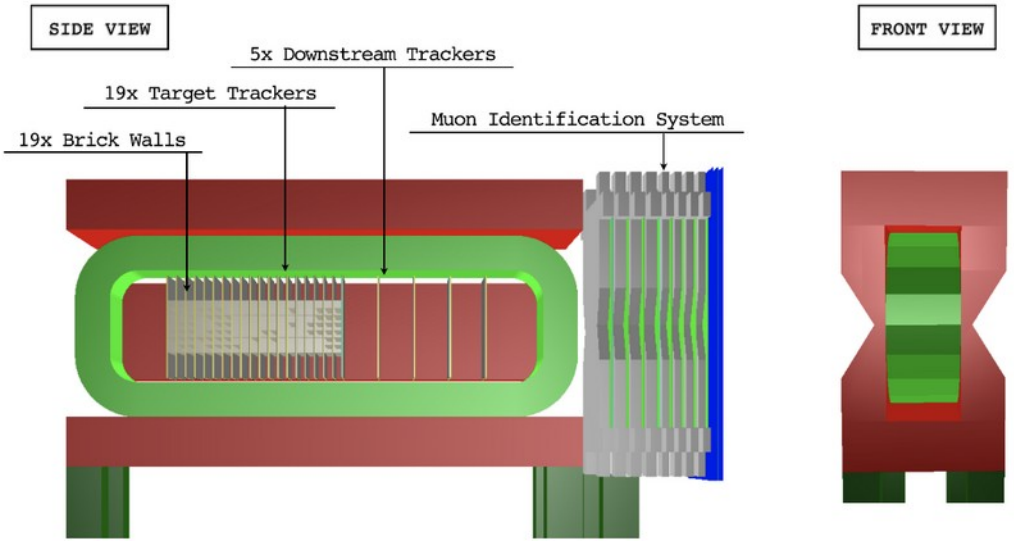

It consists of a spectrometer magnet housing a **layered detector system with high-density target plates, emulsion film technology and electronic high precision tracking to determine the charge and momentum** plus **a muon identification system.**

High precision tracking

Nuclear emulsion film

C. Fukushima, et al.,Nucl. Instrum. Meth.A592, 56 (2008)

80x80 cm², 1.5 um σ

Scanning time 6 months.

Scintillating fiber tracker (SciFi)

https://indico.desy.de/indico/event/18050/session/9/contribution/18

100x100 cm², 50 um and 400 ps σ

Muon identification system

C. Ahdida et al. (SHiP), Eur. Phys. J. C80, 284 (2020)

Resistive Plate Chambers (Bakelite)

4300x2900 cm², 1 cm strips

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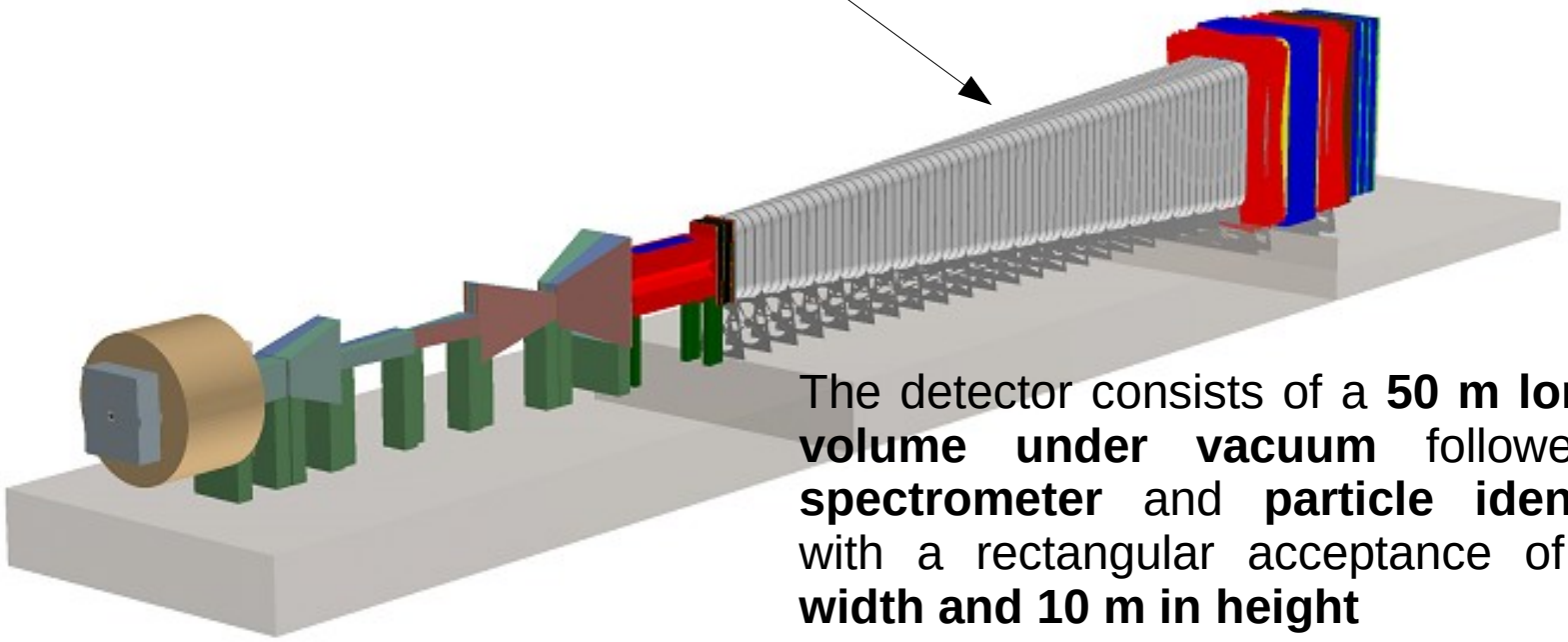
Downstream detector system Hidden Sector Decay Spectrometer (HSDS) aims at **measuring visible decays of hidden sector particles** to both fully reconstruct final states and to partially reconstruct final states with neutrinos, in a nearly background free environment.



The detector consists of a **50 m long decay volume under vacuum** followed by a **spectrometer** and **particle identification** with a rectangular acceptance of **5 m in width and 10 m in height**

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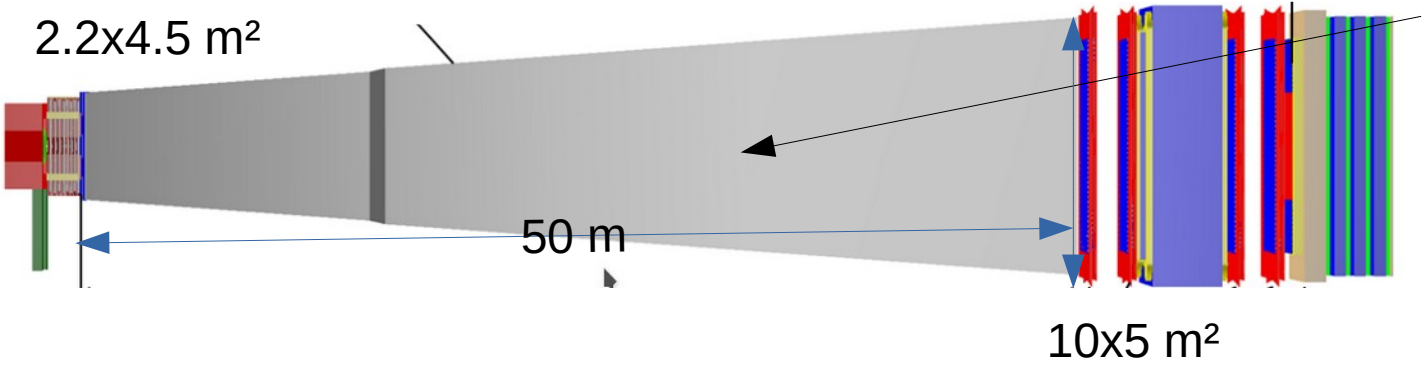

Vacuum vessel 50 m long to suppress the background from neutrinos in the fiducial volume.

A. Salzano, (SHIP), IOP Conf. Ser. Mater. Sci. Eng.1044, 012009 (2021)

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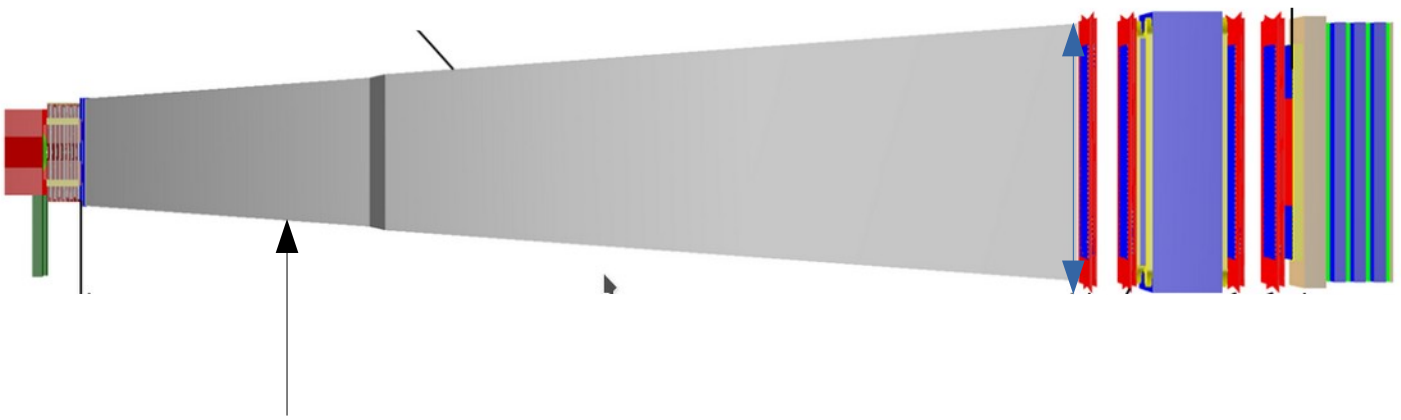

To ensure signal candidates, the decay volume is completely covered by a high efficiency **background tagger system based on liquid scintillator technology readout by wavelength--shifting and SiPM,** providing 99.9 % detection efficiency.

M. Ehlert, et al., JINST14, P03021 (2019),1812.06460

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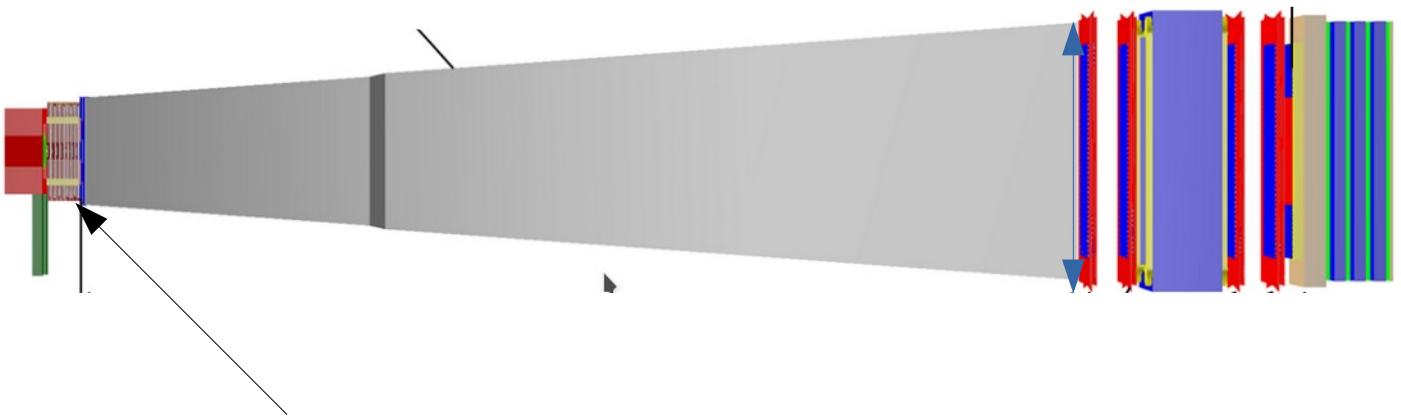

Upstream Veto Tagger with the purpose to veto events induced by neutrinos or muons in the vicinity of the entrance of the decay vessel is based in the **MRPC technology.**

LIP contribution, see later

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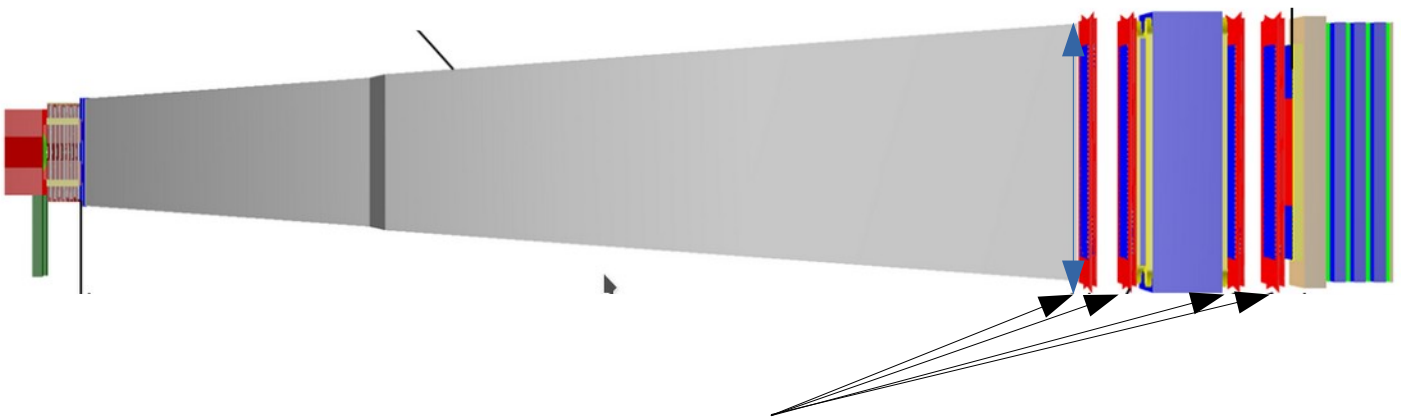

Spectrometer Tracker, designed to accurately reconstruct the decay vertex, the mass, and the impact parameter of the hidden particle trajectory at the proton target, includes four tracker stations, two stations upstream and two downstream of the magnet. The baseline technology are **straw drift tubes** 2 mm long, providing 120 um σ.

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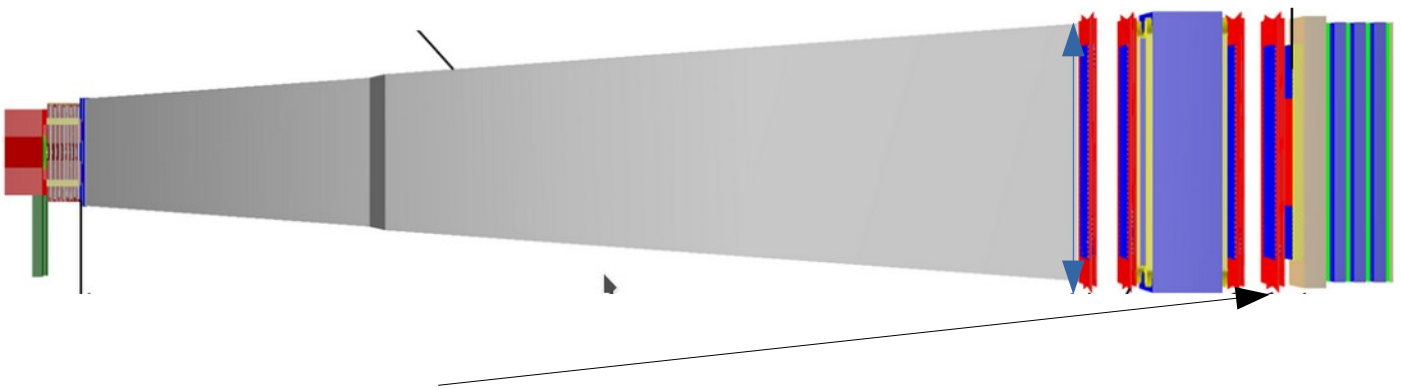

Timing detector to provide information on the coincidence of the charged particles originating from a decay candidate to disentangle from combinatorial background. Two technologies are proposed, plastic scintillators providing 80 ps σ.

C. Betancourt, (SHiP), Nucl. Instrum. Meth. A979, 164398 (2020)

and MRPC => LIP contribution, see later

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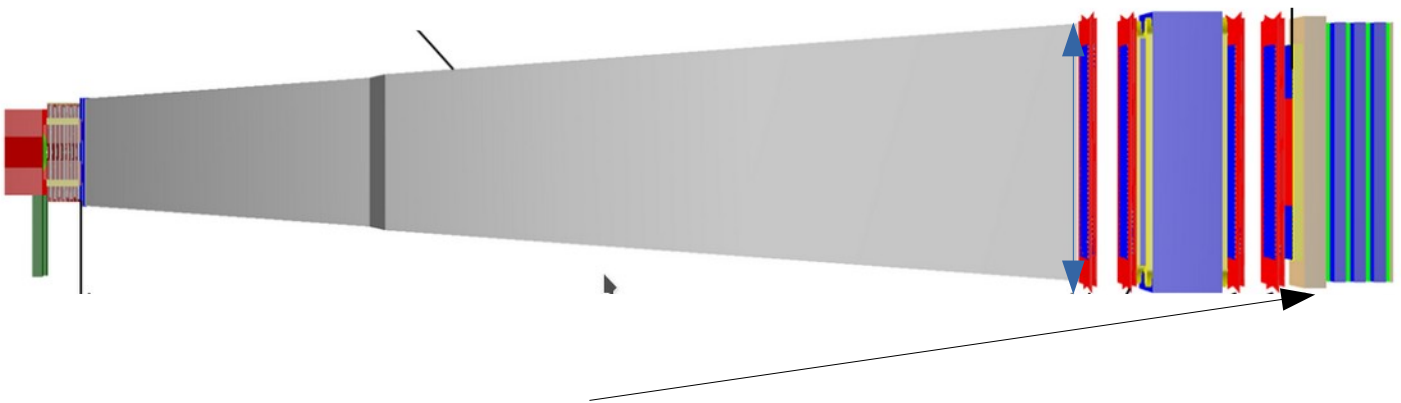

Electromagnetic calorimeter providing electron and photon identification and discrimination against hadrons and muons, as well as measuring the shower angle. It is based on a **segmented lead sampling calorimeter equipped with scintillating plastic bars** read-out by WLS fibers with course spatial resolution and high resolution planes based on **micro-megas.**

W.M. Bonivento (SHiP), JINST13, C02041 (2018)

Incorporates **two complementary detectors**

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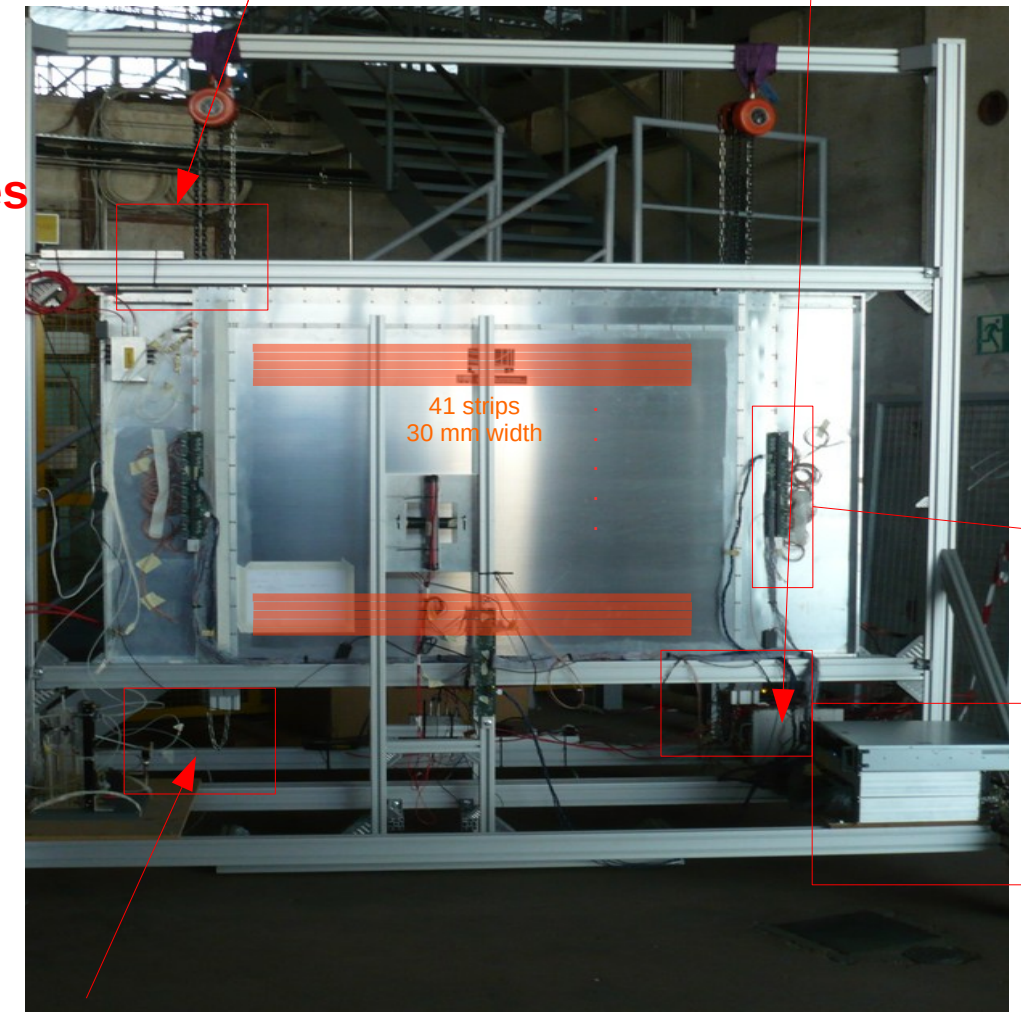
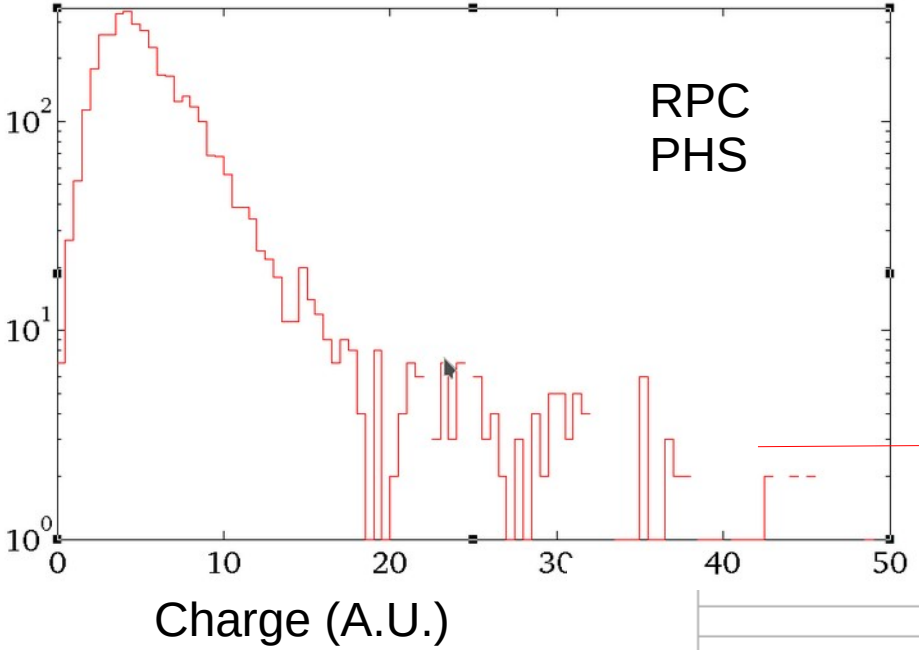
Muon system for the identification of muons comprise four stations of active layers, based on **scintillating tiles with direct SiPM readout**, interleaved by the three muon filters providing an efficiency detection >95 %.

LIP contribution for
Upstream Veto Tagger and
Timing Detector

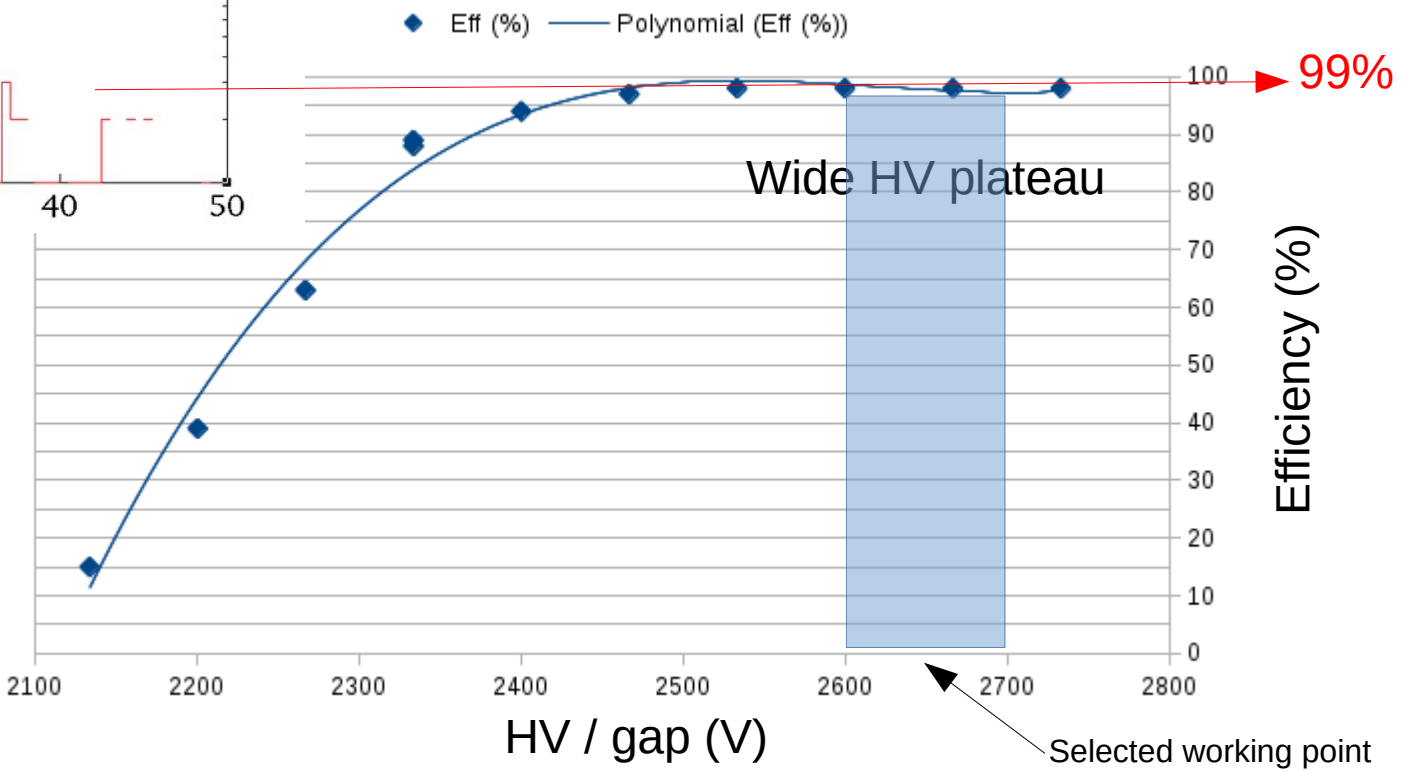
both are very similar technologies



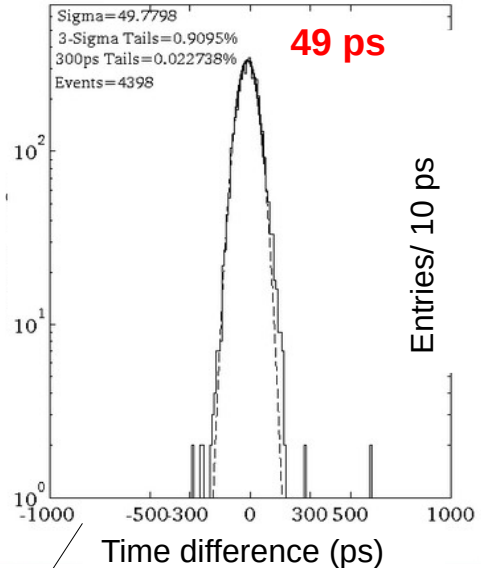
Gas system, 97.5% $C_2H_2F_4$ + 2,5% SF_6 @ 50 cc/min



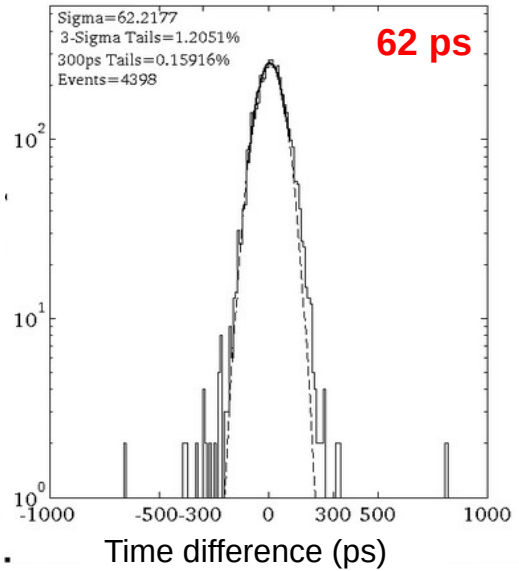
Arbitrary point,
but quite homogeneous on the entire area



Tsc1 - Tsc2

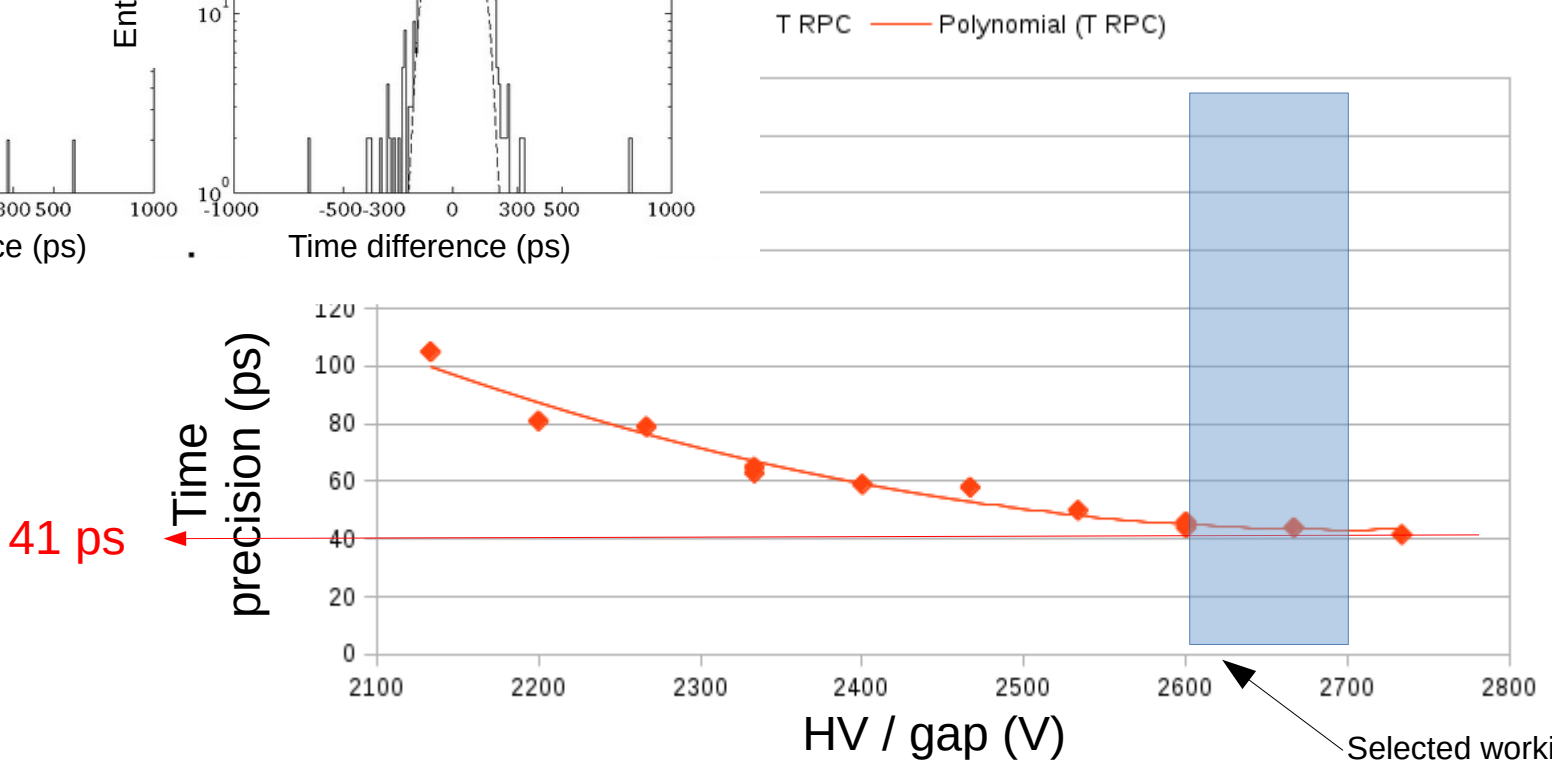


Tsc1-Trpc

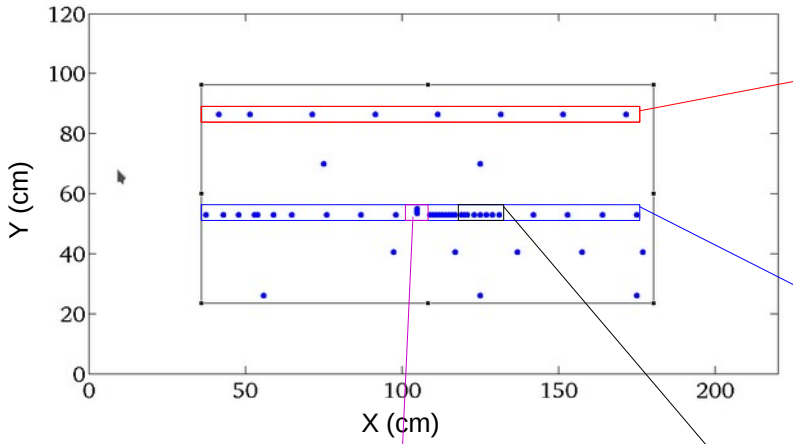


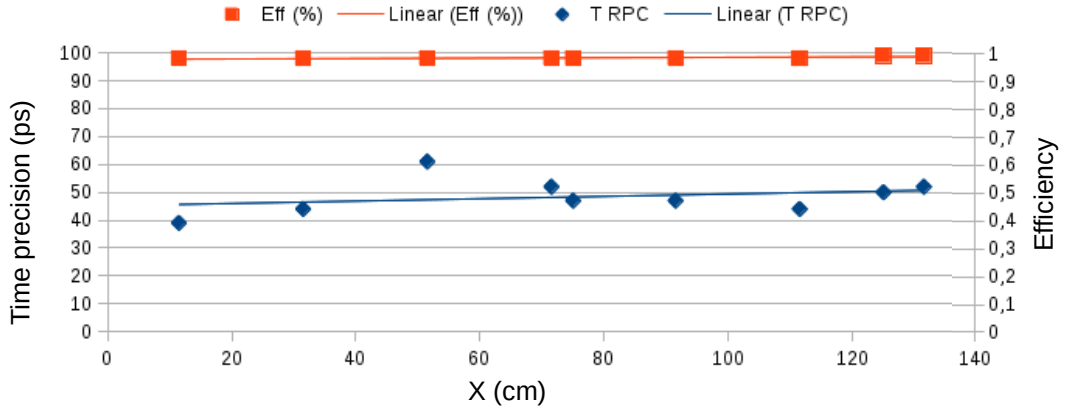
Arbitrary point,
but quite homogeneous on the entire area

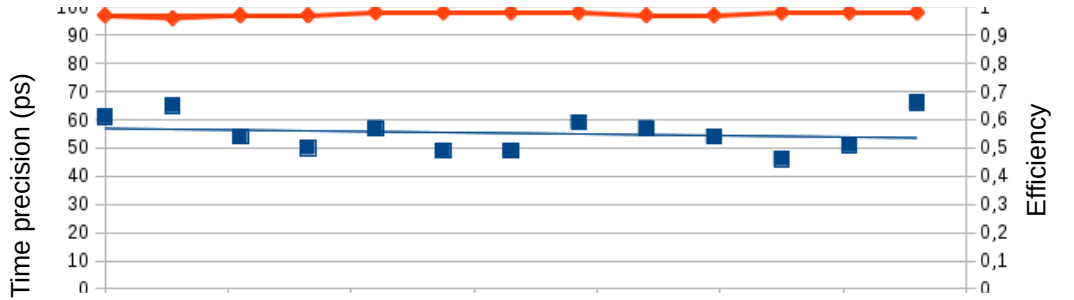
Limited by
FEE and DAQ

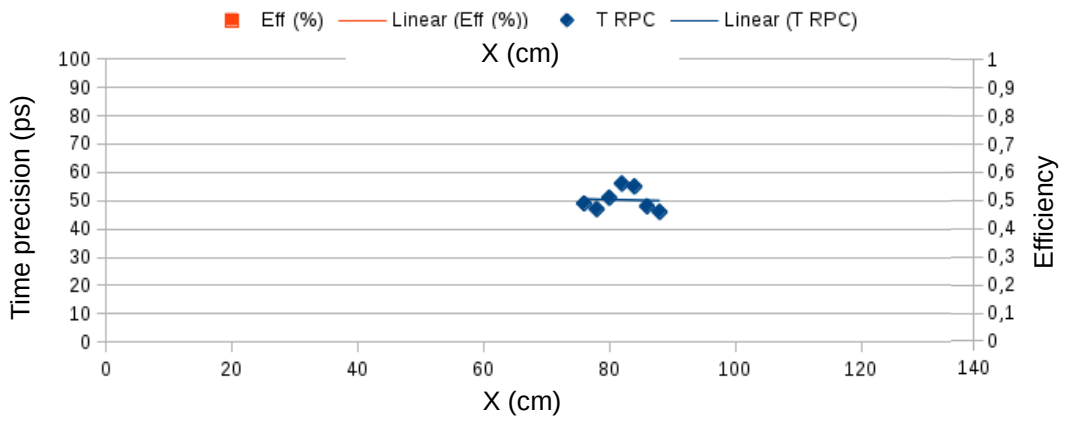


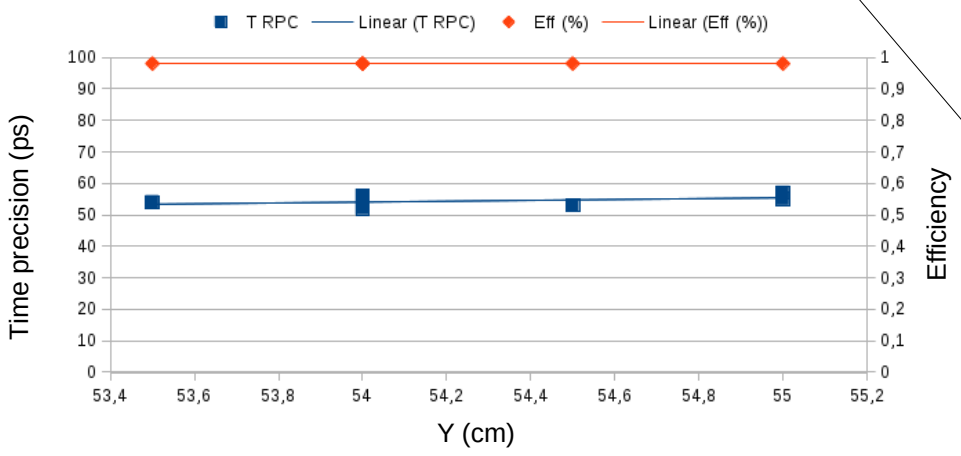
No noticeable dependence with position



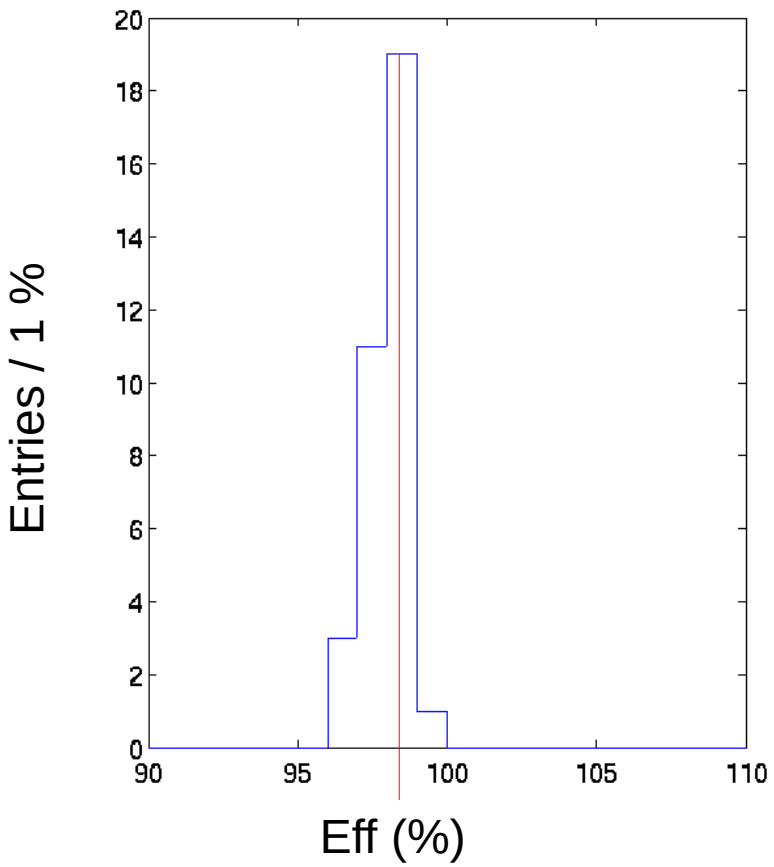


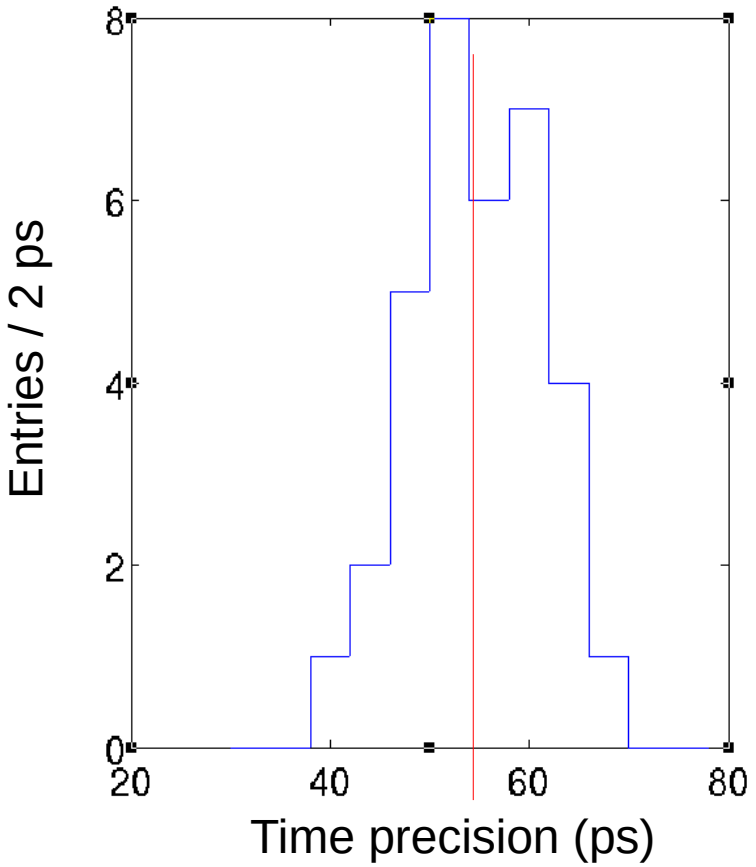






All positions



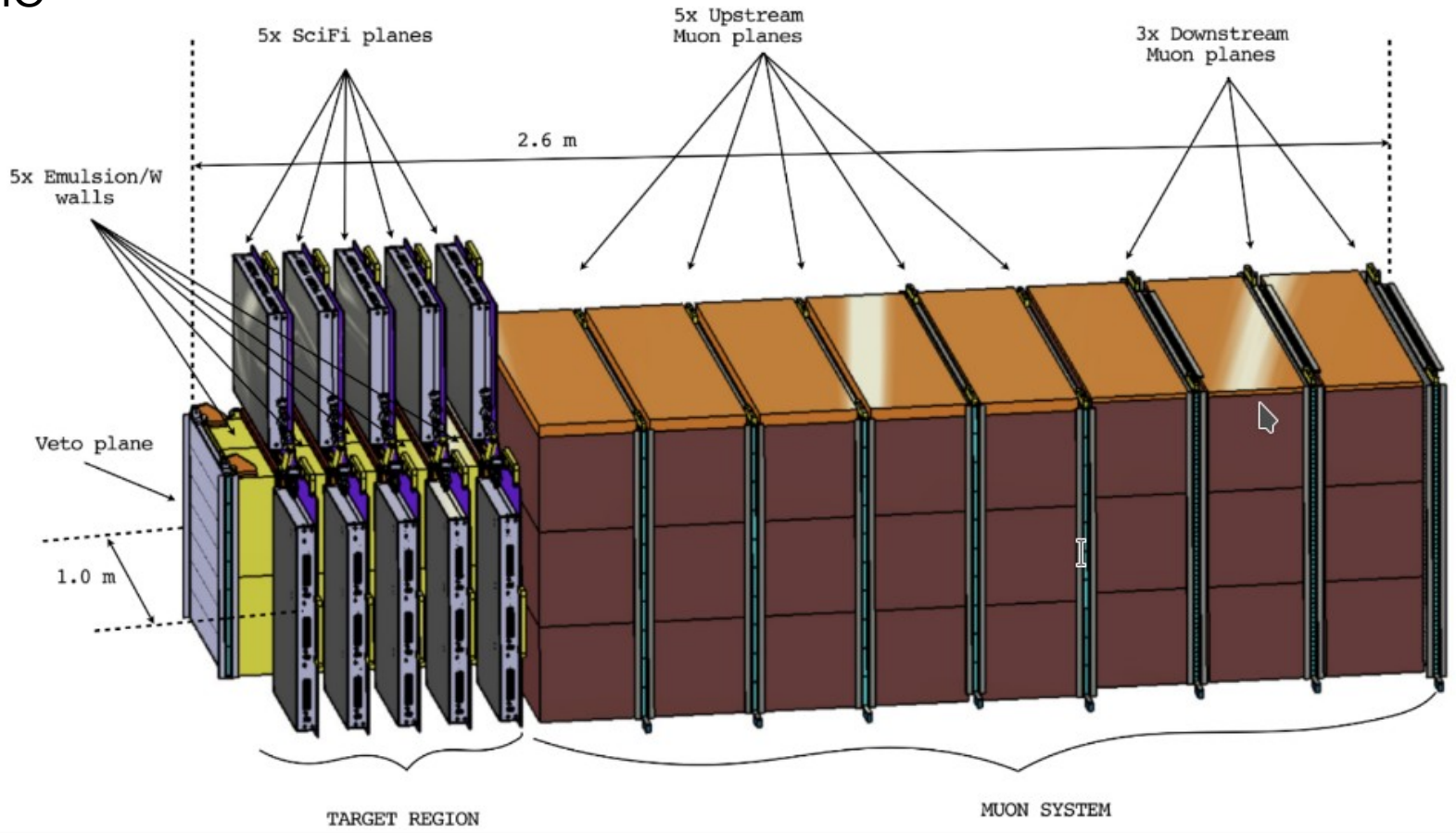


<98 %>

<54 ps>

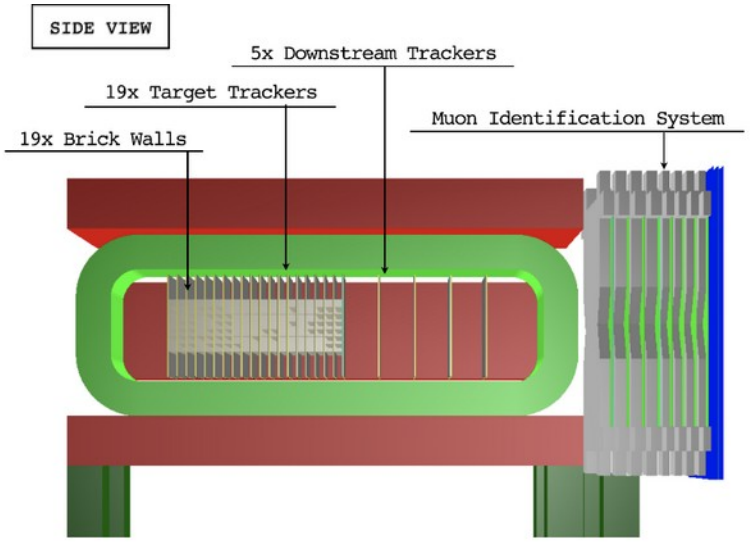
Multi-hit capability of the detector could be an issue, more R&D needed
=> thesis opportunity

SND@LHC



SND@LHC is a modified version of SHiP SND, which allow to test in advance part of the technology and do some physics !!!

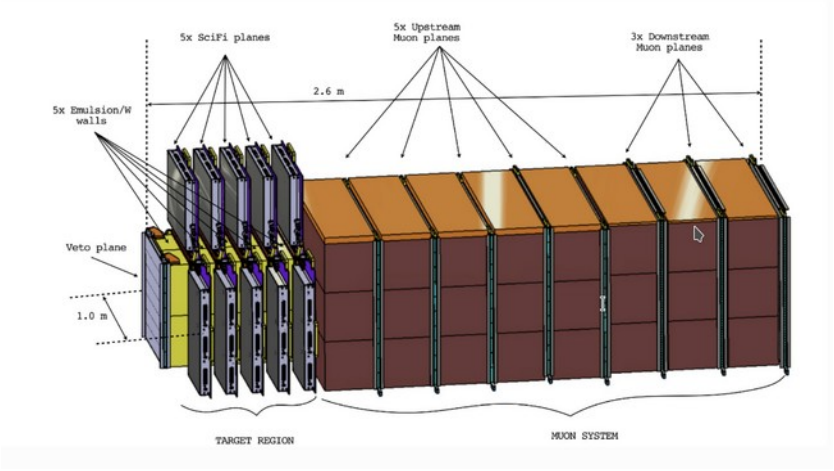
SHiP



Both detectors are very similar.

The high precision tracking (**Nuclear emulsion film and Scintillating fiber tracker (SciFi)**) are present in SHiP and SND.

SND



The muon detector has been replaced by scintillating technology and a veto plane added US.

Lot of opportunities in detector construction, commissioning, data taking, calibration, DAQ, monitoring and DCS……and physics