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ABSTRACT

Two main aims of the SHiP (Search for Hidden Particles) experiment are the observation of hidden particles and high-statistics study of tau neutrino events. These particles can be produced from the decay of charmed particles in the SHiP hybrid target which is composed of a totally 58-cm long series of TZM slabs followed by Tungsten slabs of the same total length. A major concern for the experimental design is the precise knowledge of the muon flux and the associated charm production cross section. To achieve the physics goals, we plan to carry out a test experiment with SHiP target replica using CERN SPS 400 GeV/c proton beam at H4 area in July 2018. In this test experiment, resistive plates chambers (RPCs) will be used for muon identification and their slope measurements. Recently, we constructed gas gaps and strip panels to build 5 trigger RPC modules. A RPC module is composed of a 2-mm gas gap and two orthogonal strips of a 10.625-mm pitch. In addition, we constructed a small prototype RPC of a size of 100 x 130 cm² with the same strip pitch to study the fundamental detector performance using cosmic rays. The current construction of the RPC modules is also as a pilot production for the future SHiP experiment in synergy with the present RPC production for the CMS experiment. In the presentation, we report the design of the RPCs for the test experiment and cosmic-ray test results for the prototype RPC.

HPL Trigger RPCs for SHiP

Resistive Plate Chambers for SHiP

- ✓ Gaseous detectors operating with an avalanche mode
- ✓ Fast time response of < 10 ns and a time resolution ~ 1 ns
- ✓ 2 orthogonal strip readouts for 2D trigger measurements (anode strips for x and cathode strips for y)

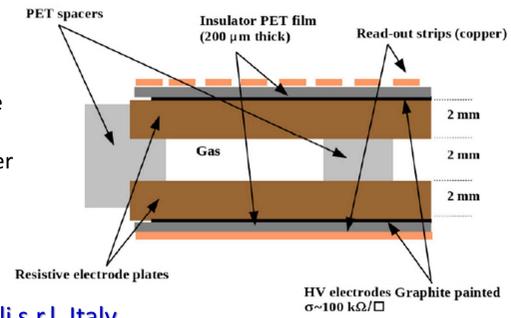
Expected position resolution of 3 ~ 4 mm in both directions

Bakelite electrode: produced at Puricelli s.r.l. Italy

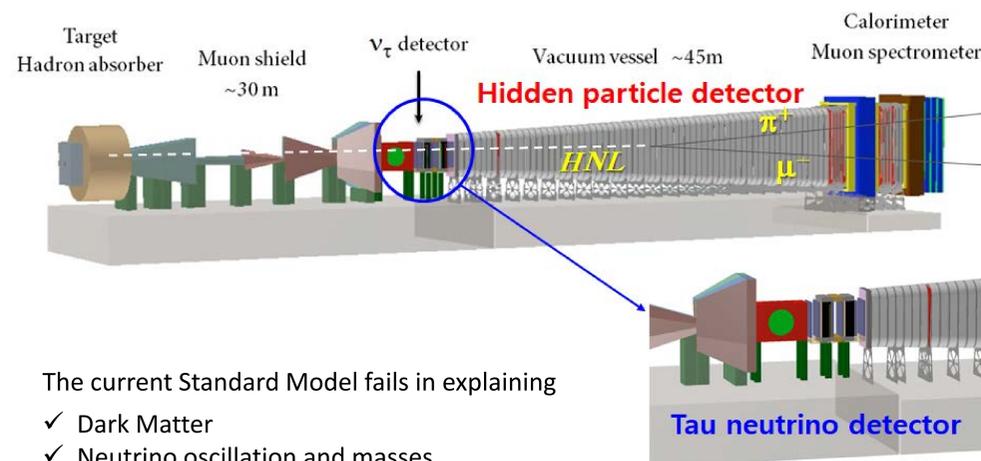
5 RPC modules prepared for the 2018 measurement at SPS/CERN

118 horizontal and 184 vertical strips (pitch = 10.625 mm) per RPC

Detector size = 2100 mm x 1350 mm / Active area = 1900 mm x 1200 mm



Motivation of SHiP



The current Standard Model fails in explaining

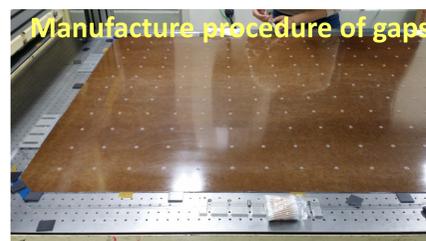
- ✓ Dark Matter
- ✓ Neutrino oscillation and masses
- ✓ Matter/antimatter asymmetry in the Universe

A Hidden Sector (HS) of weakly interacting BSM particles is for the explanation
Long-lived weakly interacting particles → requires high intensity beams

Collaboration of ~ 250 members from 52 institutes, 17 countries

Technical Proposal: [arXiv:1504.04956](https://arxiv.org/abs/1504.04956) (2015)

Manufacture procedure of gaps at KODEL, Korea University



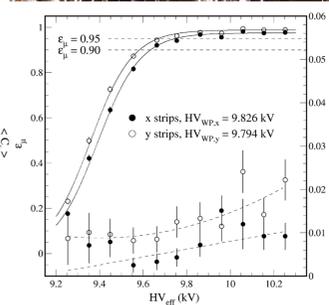
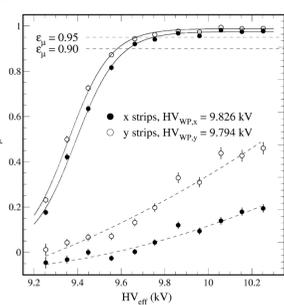
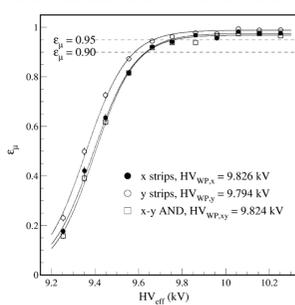
Test Results of a Prototype RPC

First prototype manufactured and tested with cosmic muons at Korea University

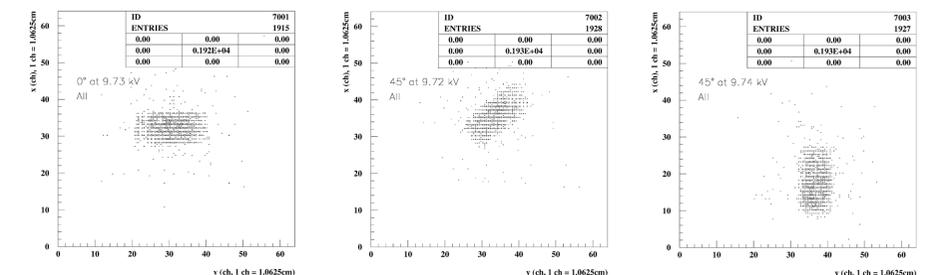
- 112 horizontal (x) and 80 vertical (y) strips (pitch = 10.625 mm)
- Detector size = 1300 mm x 1000 mm / Active area = 1200 mm x 800 mm
- Gas mixture = 95.2% C₂H₂F₄ + 4.5% iC₄H₁₀ + 0.3% SF₆



Digitization thresholds at Front-end-electronics
 Th = 0.8 mV for x (anode strip, negative)
 Th = 1.0 mV for y (cathode strips, positive)



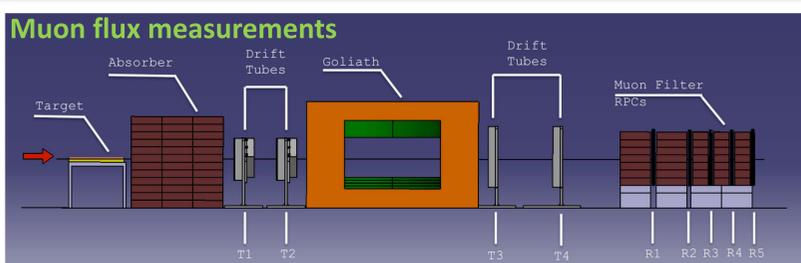
Reconstructed 2D images for cosmic muons (tagged by plastic scintillators)



- ✓ Working point (HV = 9.82 kV) efficiency requiring both x and y signals: 95 ~ 96%
- ✓ Mean cluster sizes at the WP: 1.5 for anode (x) and 2.1 for cathode (y) strips
- ✓ Probability of large pulses (defined by cluster size > 6) at the WP ~ 1%
- ✓ Noise rate at the WP in coincidence of x and y: ~ 650 Hz m⁻²

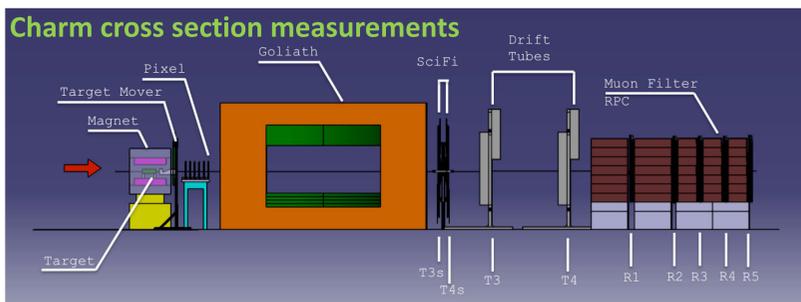
Measurements in 2018 at CERN SPS

Muon flux measurements



- ✓ SHiP target replica: TZM 58 cm-thick + Tungsten 58 cm-thick
- ✓ Spectrometer (Goliath+DTs) to measure momentum and charge of the muons
- ✓ Muon tagger (RPCs) to identify muons

Charm cross section measurements



Inclusive charm cross section measurements

- ✓ ECC (Emulsion Cloud Chamber) target: 12.5 x 10 cm² lead plates interleaved with emulsion films to detect both production and decay of the charmed hadrons
- ✓ Spectrometer (Goliath+DTs) to measure momentum & charge of charm daughters
- ✓ Muon tagger (RPCs) to identify muons

CONCLUSIONS

- The detector components, gaps and strips have been manufactured, tested by the **Korean SHiP group**, and delivered to CERN for the pilot experiment in July 2018.
- The detector characteristics of the prototype RPC are fairly satisfactory for reliable 2D trigger measurements for the future SHiP.
 - ✓ WP efficiency requiring both x & y signals exceeds 95%
 - ✓ Well reconstructed 2D images for cosmic muons → Adjuvant particle trackers as well as triggers for muons