ПИЯФ @SHiP

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Сессия Ученого Совета

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Search for Hidden Particles

Поиск частиц, из которых может состоять Темная материя

52 института из 17 стран

SHiP Technical Proposal 2015
SHiP Physics Paper 2015

“Sensitivity of the SHiP experiment to Heavy Neutral Leptons”
SHiP Coll., subm. JHEP Nov. 2018

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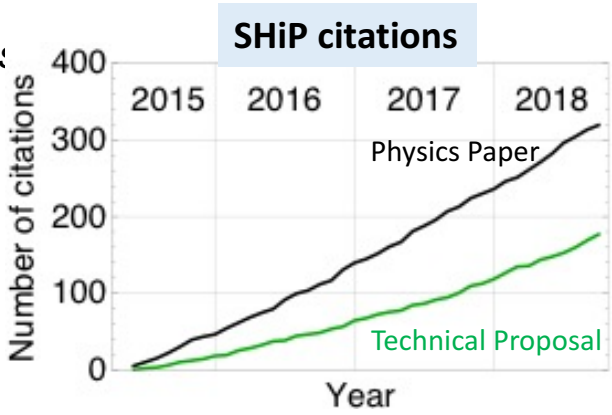
1.1 Physics Landscape in 2015

- *Discovery of Higgs makes Standard Model complete in terms of its constituents*
- *Experimental evidences of BSM makes us certain that the SM is not complete*

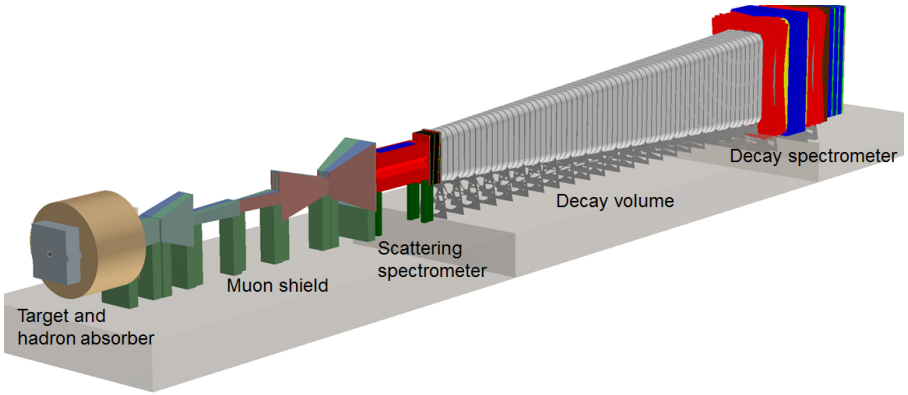


1.2 Physics Landscape in 2018

The Landscape of 2015 has not changed after completion of the LHC Run 2 and other world-wide experiments !

- *Intriguing LHCb hints of LFV, if confirmed, will not determine the scale of NP Possible explanations may involve particles with O(keV), O(100 MeV) or well beyond the reach of LHC*
- *Significant advances in neutrino physics but no new knowledge on the scale of NP that drives neutrino oscillations*
- ***SHiP received significant amount of attention in the last 3 years***

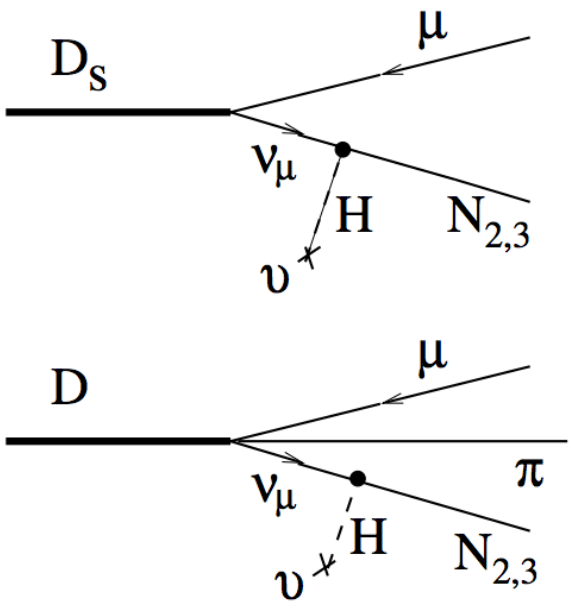
1.3 Overview of the SHiP developments and advances since the TP



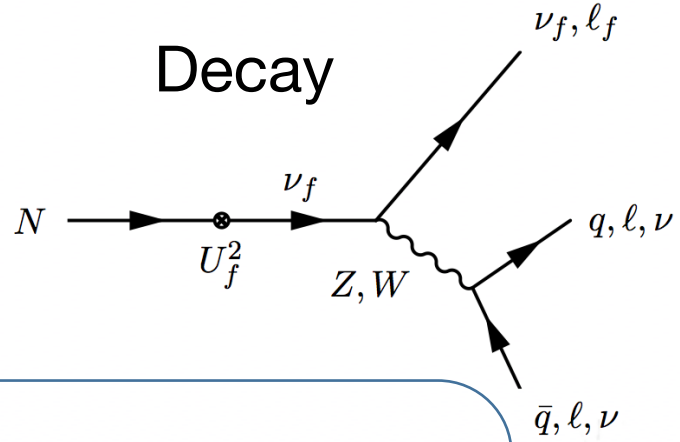
SHiP remains a unique dedicated experiment capable of reconstructing the decays vertex of hidden particle, measuring its invariant mass and providing PID of the decay products in zero background environment

SHiP: HNL

Production



Decay



$N \to H^0\nu$, with $H^0 = \pi^0, \rho^0, \eta, \eta'$

$N \to H^\pm \ell^\mp$, with $H = \pi, \rho$

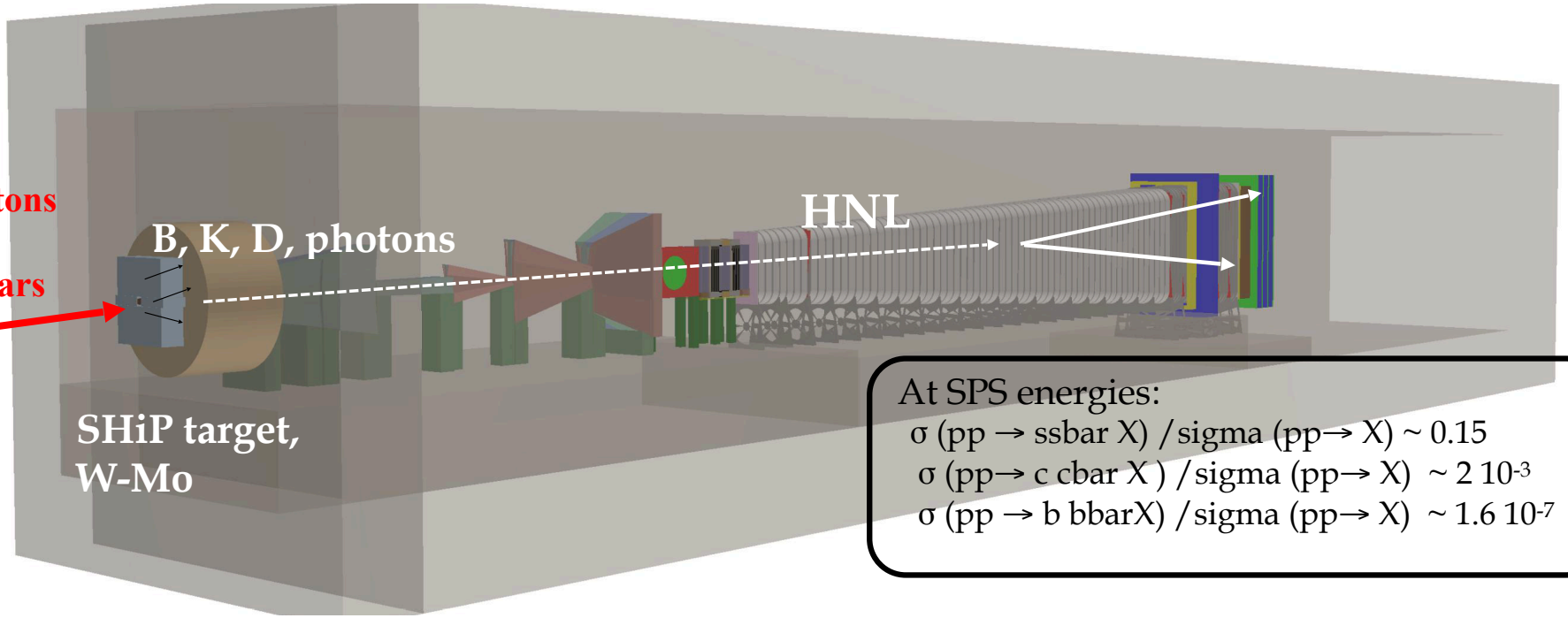
$N \to 3\nu$

$N \to \ell_i^\pm \ell_j^\mp \nu_j$

$N \to \nu_i \ell_j^\pm \ell_j^\mp$

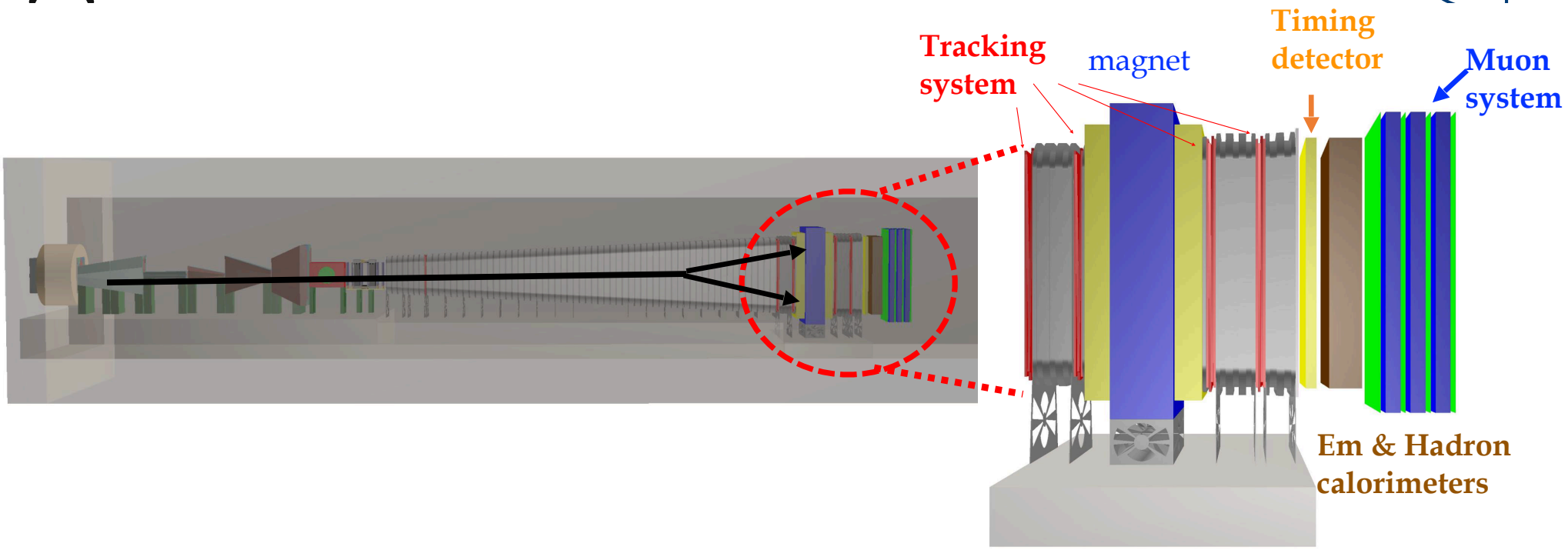
SHiP: HNL signal

Beam:
400 GeV/c protons
4×10^{13} pot/spill
2×10^{20} pot/5 years



At SPS energies:
$\sigma(pp \to s\bar{s}X) / \sigma(pp \to X) \sim 0.15$
$\sigma(pp \to c\bar{c}X) / \sigma(pp \to X) \sim 2\ 10^{-3}$
$\sigma(pp \to b\bar{b}X) / \sigma(pp \to X) \sim 1.6\ 10^{-7}$

SHiP: HS spectrometer

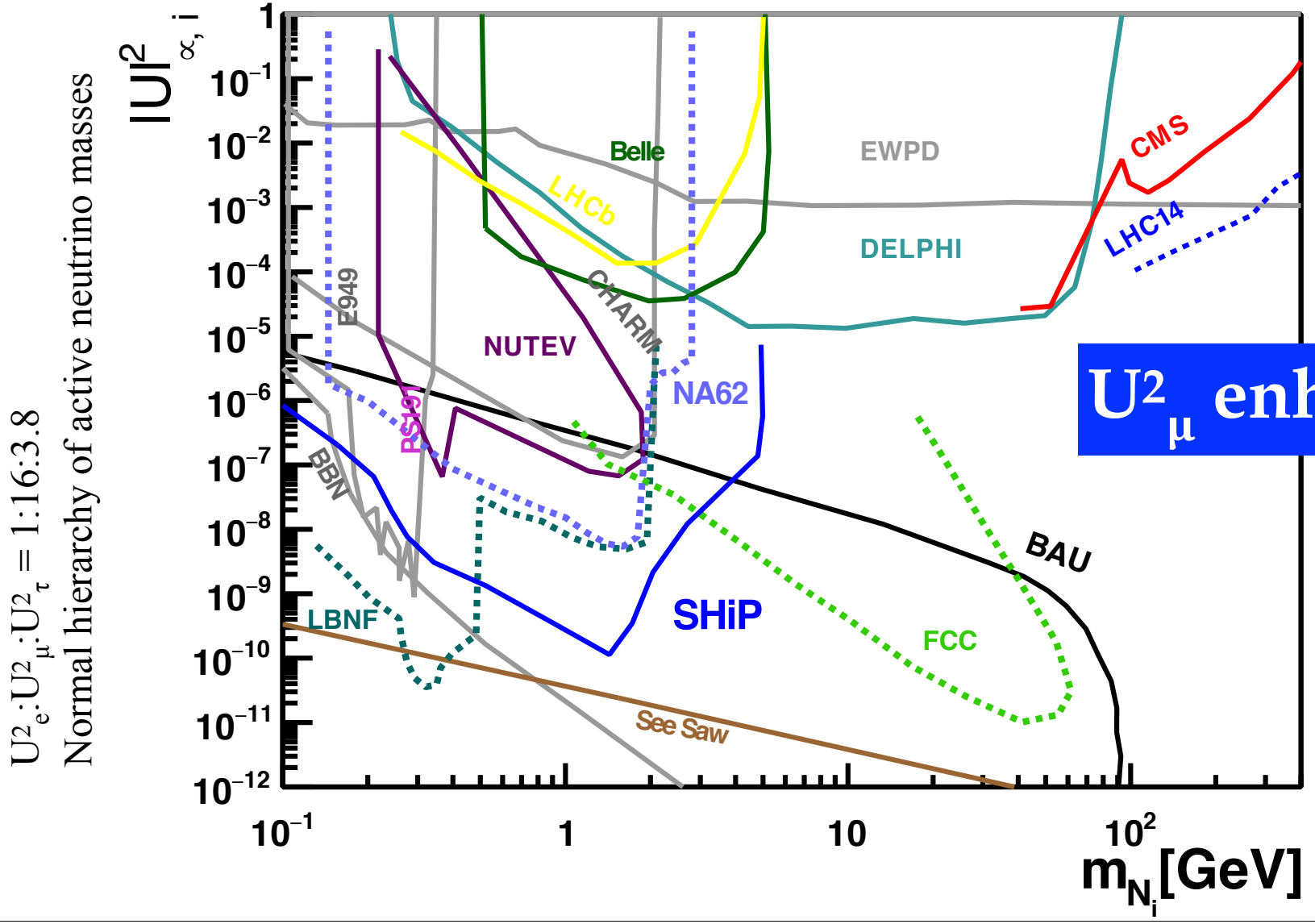


1) Fully reconstructed signal: at least two charged particles (+ π^0 , γ) e.g. N—>$\mu^+\pi^-$ or N—>$\rho^+\mu^-$

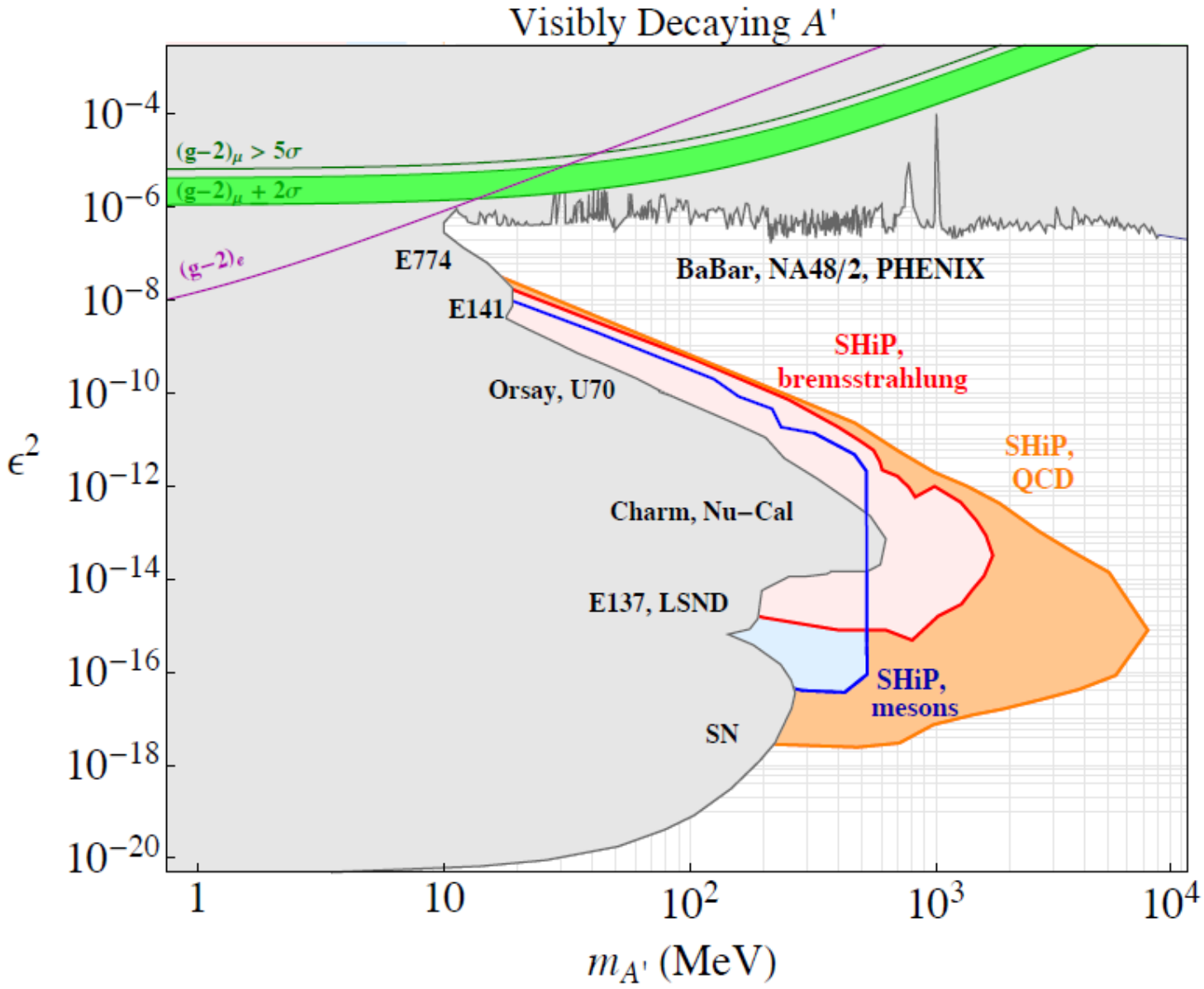
2) Partially reconstructed signal (neutirnos in the final state) e.g. N—>$\mu^+\nu\nu$

4) Fully neutral channels e.g. A—> $\gamma\ \gamma$

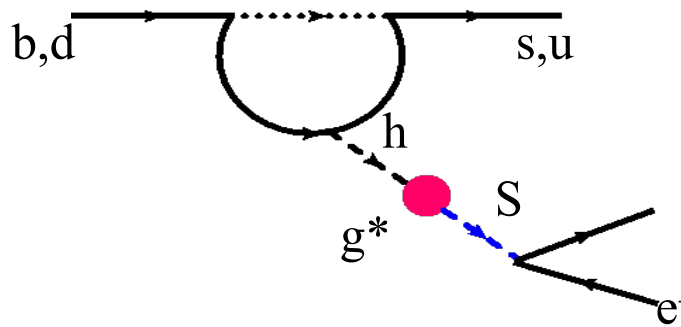
SHiP: HNL


$U^2_e : U^2_\mu : U^2_\tau = 1 : 16 : 3.8$
Normal hierarchy of active neutrino masses
$|U|^2_{\alpha,i}$
m_{N_i}[GeV]
Belle
LHCb
EWPD
CMS
LHC14
DELPHI
CHARM
E949
NUTEV
NA62
RS191
BBN
BAU
SHiP
FCC
LBNF
See Saw
U^2_μ enhanced

SHiP: Dark Photon

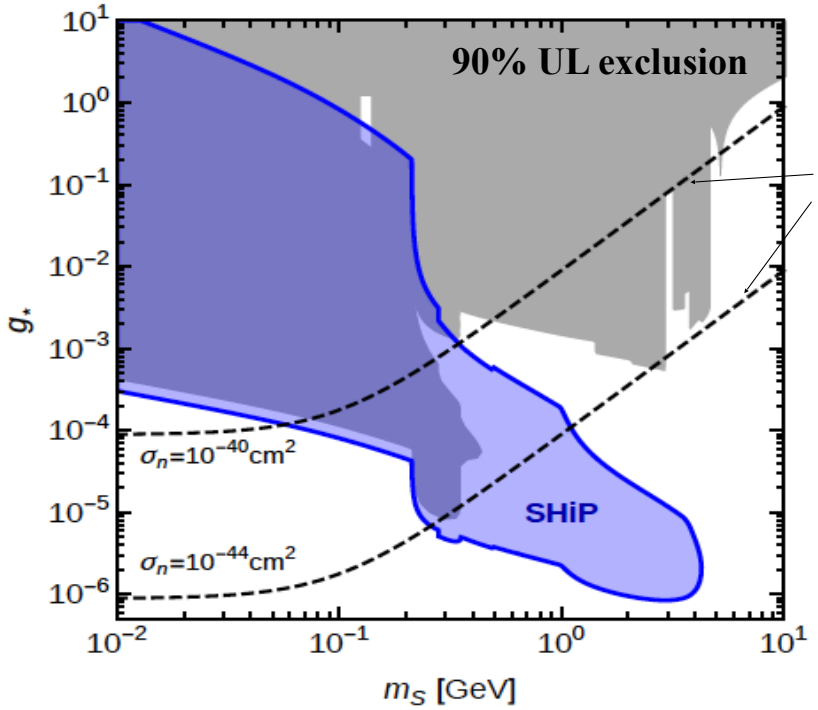


SHiP: Dark Scalar



$$\rightarrow \Gamma(K \to \pi\phi) \sim (m_t^2 |V_{ts}^* V_{td}|)^2 \propto m_t^4 \lambda^5$$
$$\Gamma(D \to \pi\phi) \sim (m_b^2 |V_{cb}^* V_{ub}|)^2 \propto m_b^4 \lambda^5$$
$$\rightarrow \Gamma(B \to K\phi) \sim (m_t^2 |V_{ts}^* V_{tb}|)^2 \propto m_t^4 \lambda^2$$

e^+e^-, $\pi^+\pi^-$, K^+K^-, $\mu^+\mu^-$, …
detected in the downstream spectrometer



Contours of constant DM nucleon cross section, where we assumed that S acts as the mediator between DM and nucleons:

⟶ current limits from LUX experiment assuming m_χ ~ 5-10 GeV and k = 0.1

$$\sigma_n \simeq 10^{-40}\mathrm{cm}^2 \left(\frac{\kappa}{0.1}\right)^2 \left(\frac{g_\star}{0.01}\right)^2 \left(\frac{\mathrm{GeV}}{m_S}\right)^4$$

SHiP: Physics Signals

Signature	Physics	Backgrounds
$\pi^-\mu^+, K^-\mu^+$	HNL,NEU	RDM, $K_L^0 \to \pi^-\mu^+\nu_\mu$
$\pi^-\pi^0\mu^+$	HNL($\to \rho^-\mu^+$)	$K_L^0 \to \pi^-\mu^+\nu_\mu(+\pi^0)$, $K_L^0 \to \pi^-\pi^+\pi^0$
π^-e^+, K^-e^+	HNL, NEU	$K_L^0 \to \pi^-e^+\nu_e$
$\pi^-\pi^0e^+$	HNL($\to \rho^-e^+$)	$K_L^0 \to \pi^-e^+\nu_e$, $K_L^0 \to \pi^-\pi^+\pi^0$
$\mu^-e^+ + p^{miss}$	HNL,Higgs Portal (HP)($\to \tau\tau$)	$K_L^0 \to \pi^-\mu^+\nu_\mu$, $K_L^0 \to \pi^-e^+\nu_e$
$\mu^-\mu^+ + p^{miss}$	HNL,HP($\to \tau\tau$)	RDM, $K_L^0 \to \pi^-\mu^+\nu_\mu$
$\mu^-\mu^+$	DP,PNGB,HP	RDM, $K_L^0 \to \pi^-\mu^+\nu_\mu$
$\mu^-\mu^+\gamma$	Chern-Simons	$K_L^0 \to \pi^-\pi^+\pi^0$, $K_L^0 \to \pi^-\mu^+\nu_\mu(+\pi^0)$
$e^-e^+ + p^{miss}$	HNL,HP	$K_L^0 \to \pi^-e^+\nu_e$
e^-e^+	DP,PNGB,HP	$K_L^0 \to \pi^-e^+\nu_e$
$\pi^-\pi^+$	DP,PNGB,HP	$K_L^0 \to \pi^-\mu^+\nu_\mu$, $K_L^0 \to \pi^-e^+\nu_e$, $K_L^0 \to \pi^-\pi^+\pi^0$,$K_L^0 \to \pi^-\pi^+$
$\pi^-\pi^+ + p^{miss}$	DP,PNGB, HP($\to \tau\tau$), HSU,HNL($\to \rho^0\nu$)	$K_L^0 \to \pi^-\mu^+\nu_\mu$, $K_L^0 \to \pi^-e^+\nu_e$, $K_L^0 \to \pi^-\pi^+\pi^0$, $K_L^0 \to \pi^-\pi^+$,$K_S^0 \to \pi^-\pi^+$,$\Lambda \to p\pi$
K^+K^-	DP,PNGB, HP	$K_L^0 \to \pi^-\mu^+\nu_\mu$, $K_L^0 \to \pi^-e^+\nu_e K_L^0 \to \pi^-\pi^+\pi^0$, $K_L^0 \to \pi^-\pi^+$,$K_S^0 \to \pi^-\pi^+$,$\Lambda \to p\pi$
$\pi^+\pi^-\pi^0$	DP,PNGB,HP, HNL($\eta\nu$)	$K_L^0 \to \pi^-\pi^+\pi^0$
$\pi^+\pi^-\pi^0\pi^0$	DP,PNGB,HP	$K_L^0 \to \pi^-\pi^+\pi^0(+\pi^0)$
$\pi^+\pi^-\pi^0\pi^0\pi^0$	PNGB($\to \pi\pi\eta$)	–
$\pi^+\pi^-\gamma\gamma$	PNGB($\to \pi\pi\eta$)	$K_L^0 \to \pi^-\pi^+\pi^0$
$\pi^+\pi^-\pi^+\pi^-$	DP,PNGB,HP	–
$\pi^+\pi^-\mu^+\mu^-$	Hidden Susy (HSU)	–
$\pi^+\pi^-e^+e^-$	Hidden Susy	–
$\mu^+\mu^-\mu^+\mu^-$	Hidden Susy	–
$\mu^+\mu^-e^+e^-$	Hidden Susy	–

HNL=Heavy Neutral Lepton, NEU=neutralino

DP=Dark Photon, PNGB=Pseudo-Nambu Goldston Boson

Background: RDM=random di-muons from the target

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Straw Tracker R&D

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Заключение

SHiP Straw Tracker:

- **production technology**
- **event reconstruction**
- **physics performance**
- **digital read-out: conception**
- **test beam stand and data analysis**

SST Meeting, PNPI NRC – SPbPU, May 23-25, 2018

Status: R&D Midterm Preparation

2019-2020 European Strategy
2020 can be approved


Сказочного
Нового Года!