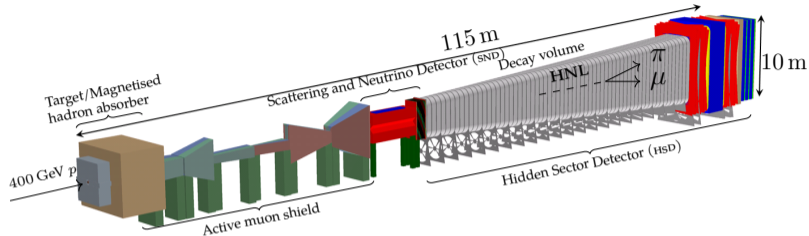


The SHiP experiment

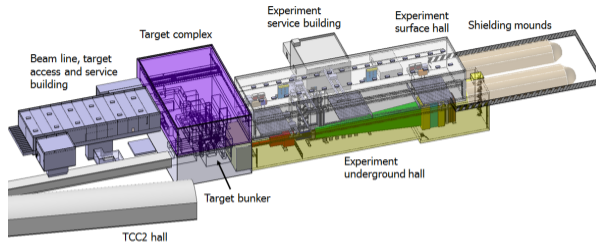
Oliver Lantwin *on behalf of the SHiP collaboration*

2023-06-21

[oliver.lantwin@cern.ch]



- › General purpose beam dump experiment at SPS with 400 GeV and 4×10^{19} PoT per year
- › Annually, 2×10^{17} charmed hadrons, 1.4×10^{13} beauty hadrons, 2×10^{15} tau leptons and $\mathcal{O}(10^{20})$ photons above 100 MeV, as well as unprecedented sample of ν_τ



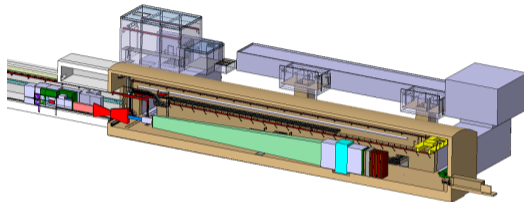
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Originally designed for dedicated new beamline with a new experimental cavern (“ECN4”)...

See [[CERN-SPSC-2019-049](#)] as well as tens of earlier reports, tens of PhD theses &c.



...now fully reoptimised for the existing ECN3 cavern!



- › New location at existing beamline with improved muon shield → same (or even better) physics at much lower cost
- › Currently preparing for possible approval as part of the ECN3 decision process at CERN

LoI submitted to SPSC end of last year just after [Massi's report at LLP12](#)



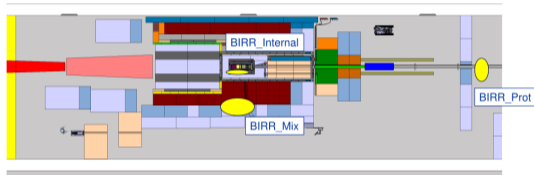
- › Optimisation of muon shield allowed further shrinking of detector size ($4 \times 6 \text{ m}^2$) while maintaining or even improving acceptance across benchmark models
- › With robust warm baseline, focus of further optimisation on hybrid warm/super-conducting magnet option which can provide further improvements in acceptance
- › SND re-optimised for neutrino physics and light dark matter
- › For consistency between ECN3 scenarios, planning for 15 years of running

Stay tuned for our proposal document for ECN3 to the SPSC for all the details!



Several groups outside of SHiP have started evaluation concurrent uses of the BDF facility, which provides a unique spectrum of particles at very high intensity!

- › Irradiation facility for



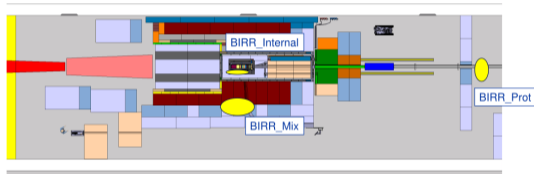
M. Calviani

Plenty of space for new (LLP?) ideas!



Several groups outside of SHiP have started evaluation concurrent uses of the BDF facility, which provides a unique spectrum of particles at very high intensity!

- › Irradiation facility for
 - › development of radiation hard electronics



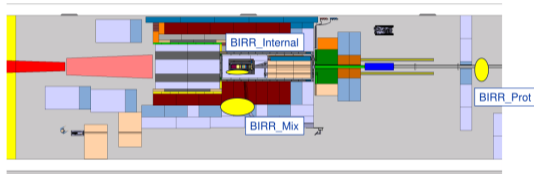
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 - › nuclear physics



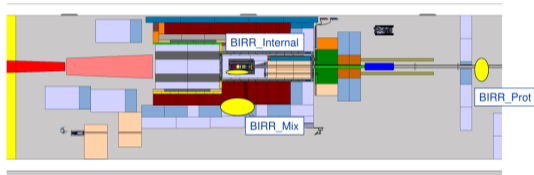
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- › Irradiation facility for
 - › development of radiation hard electronics
 - › nuclear physics
 - › astrophysics



M. Calviani

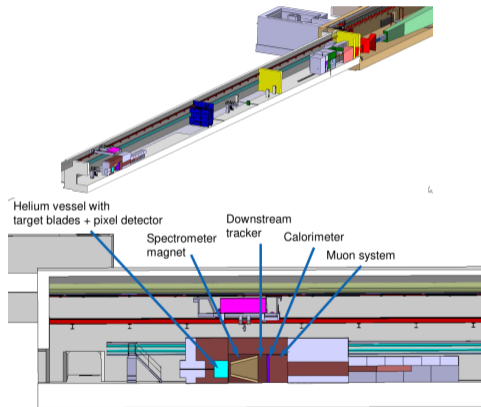
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Several groups outside of SHiP have started evaluation concurrent uses of the BDF facility, which provides a unique spectrum of particles at very high intensity!

- › Irradiation facility for
 - › development of radiation hard electronics
 - › nuclear physics
 - › astrophysics
- › TauFV upstream of BDF

Plenty of space for new (LLP?) ideas!

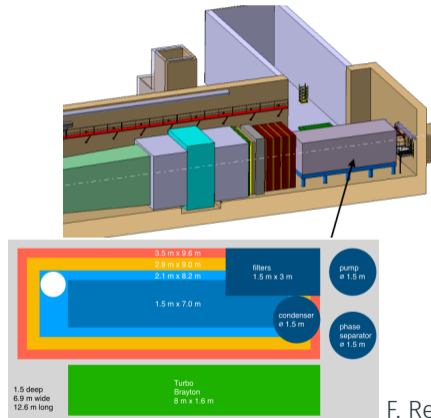




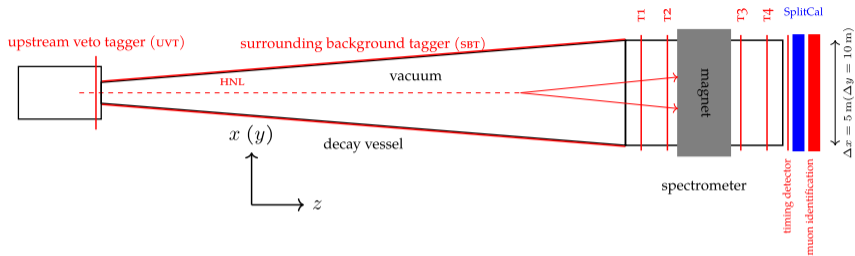
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- › Irradiation facility for
 - › development of radiation hard electronics
 - › nuclear physics
 - › astrophysics
- › TauFV upstream of BDF
- › LAr TPC for long lived particles, light dark matter and neutrinos

Plenty of space for new (LLP?) ideas!



F. Resnati

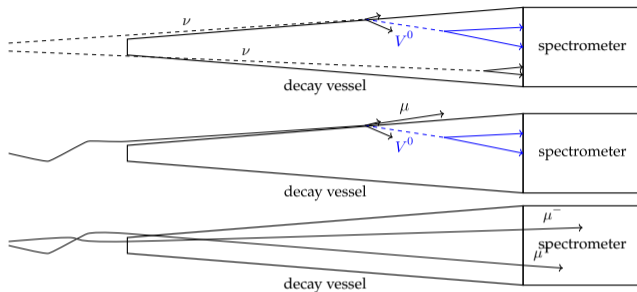


- › Full spectrometer allows measurement of
 - › invariant mass, impact parameter, decay vertex of signal candidate
 - › distinguish between signal models using PID of decay products
- › If LLPs are discovered, detector can perform precision measurements of LLPs
- › Background taggers and timing detector allow powerful background rejection

...and a second detector for scattering signatures!



- › Very minimal selection common to all signal channels
- › Background tagging being optimised right now to improve signal efficiency while mainting background rejection



	ν DIS	μ DIS	μ Comb
Expected events	< 0.3	$< 10^{-2}$	2.1×10^{-3}

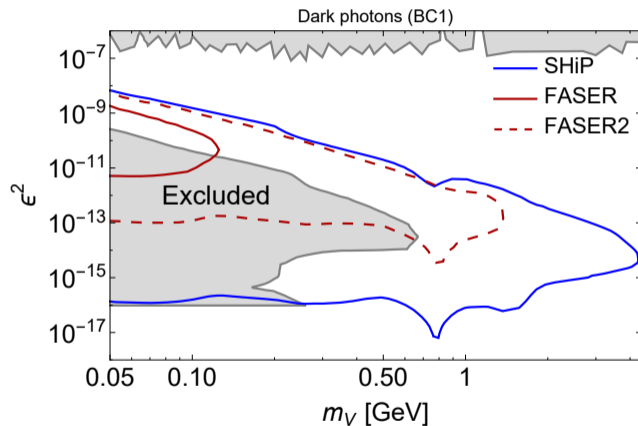
See Lol and upcoming proposal for more details



- › Tool for the semi-analytic calculation of experimental sensitivities to many FIP models
- › Very useful during SHiP reoptimisation to complement slower full sensitivity studies and for models not yet implemented fully
- › Aims to be useable for any experiment, with many experiments (at SPS, **LHC**, **FCC**, FNAL) already implemented and where possible validated against official sensitivities
 - › Possible road to a consensus tool verified by the community?

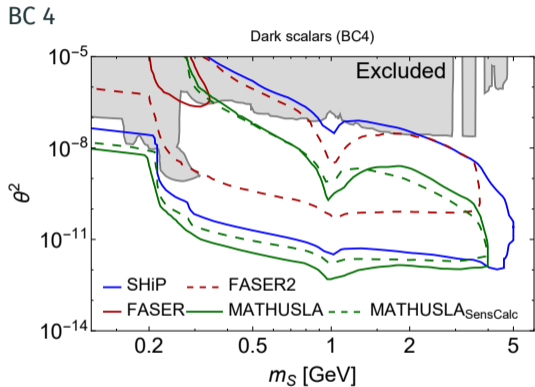


- › For the ECN3 proposal, we now consider sensitivities over 15 years
- › SHiP has full simulation for HNL with arbitrary coupling, dark photons and RPV SUSY, in excellent agreement with **SensCalc**
- › Common, minimal selection for all channels
- › Showing PBC benchmarks here for easy of comparison: SHiP is designed to be as model-independent as possible for
 - › Fully reconstructed decays to charged particles or photons
 - › Partially reconstructed decays where e.g. a neutrino escapes detection
 - › Diphoton vertexing possible
- › Lines from other experiments taken from the [FIPs 2022 summary plots](#)

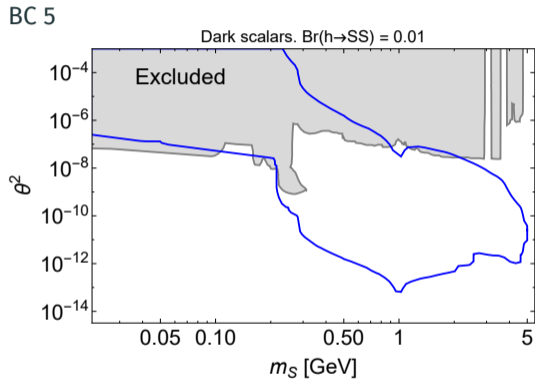


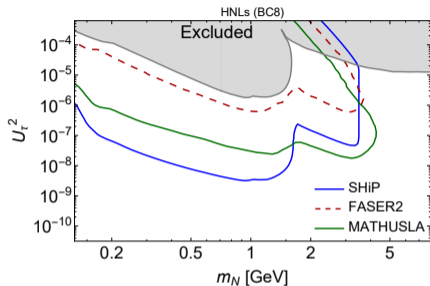
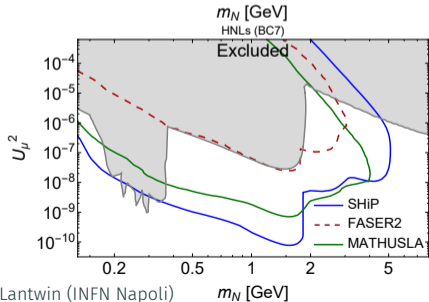
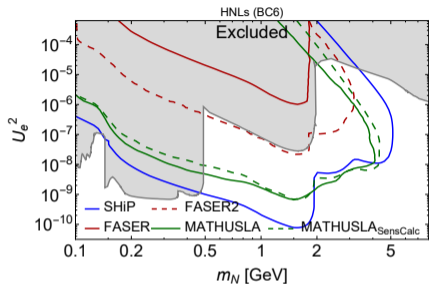
- › Implemented in full simulation
- › Production taken into account via:
 - › Bremsstrahlung
 - › Meson decay
 - › QCD

Detailed study for ECN4: [Eur.Phys.J.C 81 \(2021\) 5, 451](#)



› Implementation in full simulation in progress

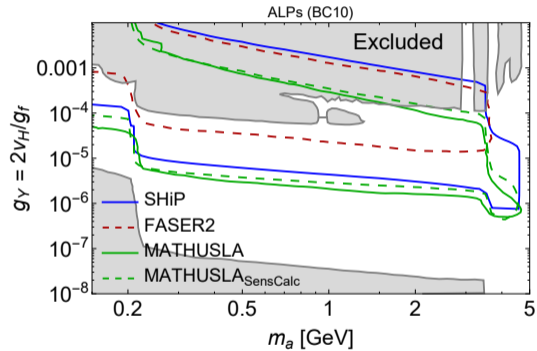
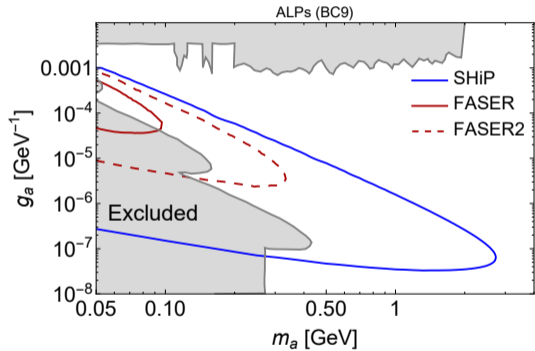




- › Arbitrary coupling ratios implemented in full simulation
- › Production from charm and beauty hadrons considered
- › Could measure HNL oscillations in large regions of currently unexplored parameter space, see [JHEP 04 \(2020\) 005](#)

Detailed study for ECN4: [JHEP 04 \(2019\) 077](#)

2023-06-21





SND has been reoptimised for ECN3

Neutrino physics

- › Thousands of neutrinos of all flavours
- › Very powerful detector with possibility to differentiate neutrinos from anti-neutrinos

Light Dark Matter

- › Detailed study for ECN4: [JHEP 04 \(2021\) 199](#)
- › Preliminary results indicate at least as good as ECN3!



- › Many test beams and two dedicated experiments run to prototype and validate all parts of SHiP's design
- › SND@LHC has been successfully taking data since 2022, observing the first LHC neutrinos together with FASERv demonstrating the technology of SHiP's SND





- › SHiP has been re-optimised for ECN3, with better performance than ever
- › Currently very busy finalising our proposal for ECN3 to the SPSC by mid-august

...and after the ECN3 decision the real work starts!

Plenty of room to get involved in for new groups and individuals (physics (ex and ph), hardware, software, ML...)

