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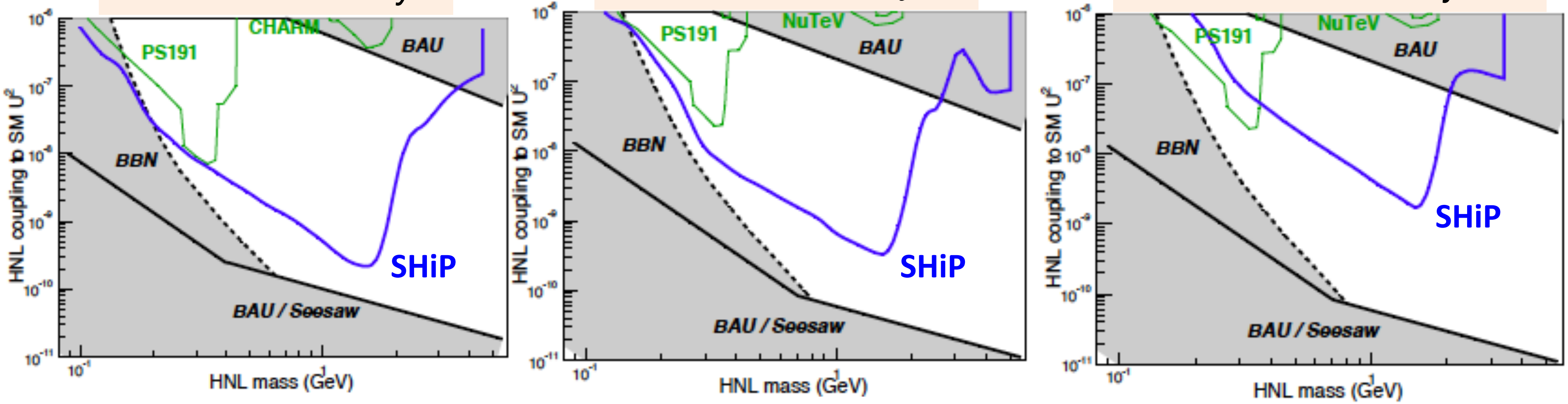
New phase of SHiP optimization

SHiP sensitivity reach for HNL

(as in TP)

- ✓ *BAU constraint is model-dependent (shown below for νMSM)*
- ✓ *Seesaw limit is not.* ***It is a "bottom-line"***

$U^2_e : U^2_\mu : U^2_\tau \sim 52:1:1$ *Inverted hierarchy*	*$U^2_e : U^2_\mu : U^2_\tau \sim 1:16:3.8$* *Normal hierarchy*	*$U^2_e : U^2_\mu : U^2_\tau \sim 0.061:1:4.3$* *Normal hierarchy*



Can one further improve SHiP sensitivity

(under condition that background stays at ~zero level) ?

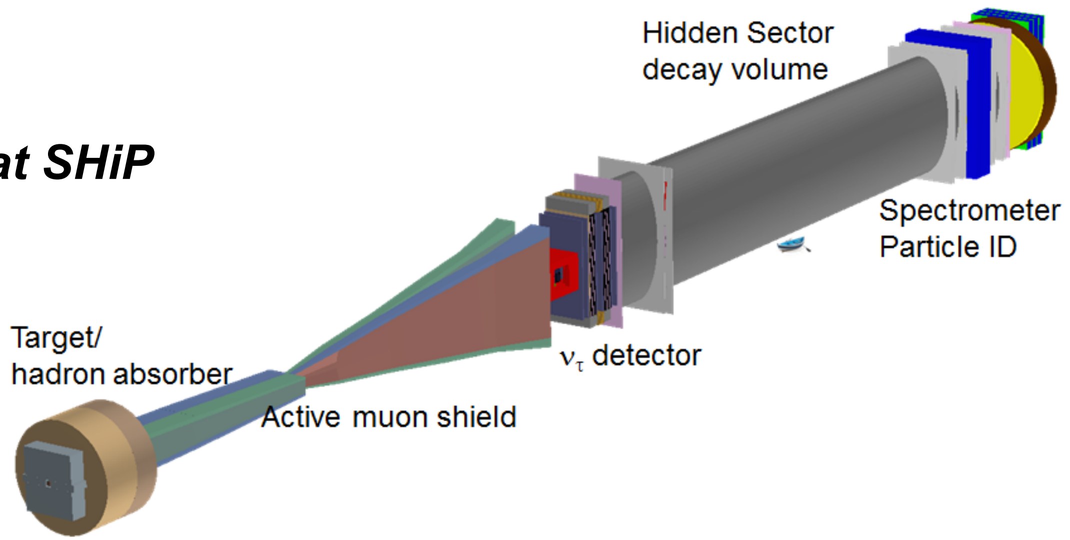
Signal yield

✓ ***In reserve (at the generator level):***

- *Include cascade production of charm in the simulation*
  Tune PYTHIA to reproduce correctly the production of charm in pp and πp collisions (see talk of Hans on Friday)

✓ ***Non-trivial factors***

- ***Increase total number of p.o.t. at SHiP***
  - *Number of protons per extraction*
  - *SHiP share of the SPS protons*
  - *Running time*



- ***Maximization of the SHiP acceptance***
  - *Length of the muon shield*
  - *Can one shorten the length of the muon shield using a superconducting magnet for the first section*
  - *Length and conical shape of the decay volume (see talk of Hans)*

Optimization of sub-detectors

Assume shortened distance (compared to TP) between the target and the decay volume, and the conical shape of the decay volume

✓ *The dimensions of all upstream sub-detectors have to be re-optimized*
- *Tau neutrino detector*
- *Upstream Veto Tagger*
- *Straw Veto Tagger*
- *Surround Background Tagger*

✓ *The dimensions of the Main spectrometer, Timing detector, Calorimeter and Muon system will not change compared to TP*
- *Require proper optimization on the basis of the cost-to-performance ratio*
  - *New PID detectors may be needed*
    - *To secure background at zero level at increased sensitivity*
    - *To enhance photon reconstruction for new signal channels, e.g. ALP → $\gamma\gamma$ (see talk of Walter)*

Evacuation of the decay vessel

The pressure inside the decay vessel has been assumed in TP to be 10^{-6} bar
At this pressure the background from the interaction of the ordinary neutrinos with the remaining air is totally negligible

✓ *Can one relax the requirement to vacuum using extra suppression by*
- surrounding veto tagger (optimize its granularity)
- pointing requirement …

✓ *Can one replace the vacuum vessel with the He bag*
(see talk of Geoff)

It has to be tested 10 times that background due to neutrino interactions with He, and worsened momentum and invariant mass resolution due to multiple interactions, can be tolerated !

→ *much simplified engineering design of the decay volume*
→ *possible replacement of Liquid scintillator with plastic scintillator*

For the time being both the vacuum and Helium options have to be pursued

Milestones for the SHiP optimization

- ✓ *Agree on the length, and the design of the muon shield (magnetization of the hadron absorber, SC magnet vs conventional magnet for the 1st section, geometry of the wings for the 2nd section, etc…)*

- ✓ *Construction of the decay volume: vacuum vs Helium option*

  - *Decay vessel for the He option requires relatively modest engineering effort*
    - *Can be made of "any" shape*
    - *Thickness of the He bag is negligible*
    - *Design of the surrounding structure, understanding of the corresponding material budget*

  - *Decay vessel for the vacuum option requires big engineering effort.* ***VERY URGENT task !***
    - *Can it be of conical or trapezoidal shape ?*
    - *Can it made of concrete, or other "technological" material ?*
    - *Material budget ?*
    - *Actual cost of the structure*

Milestones for the SHiP optimization

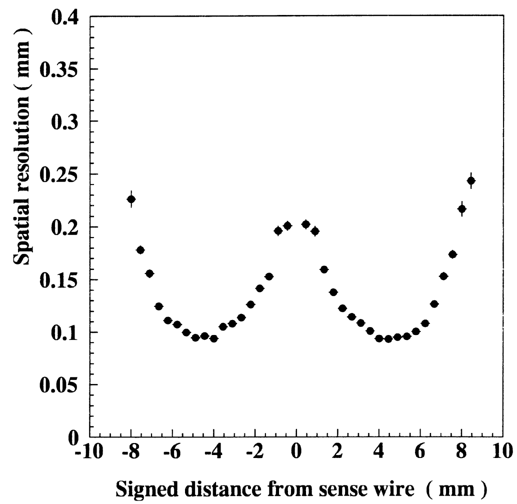
✓ *If Helium option:*

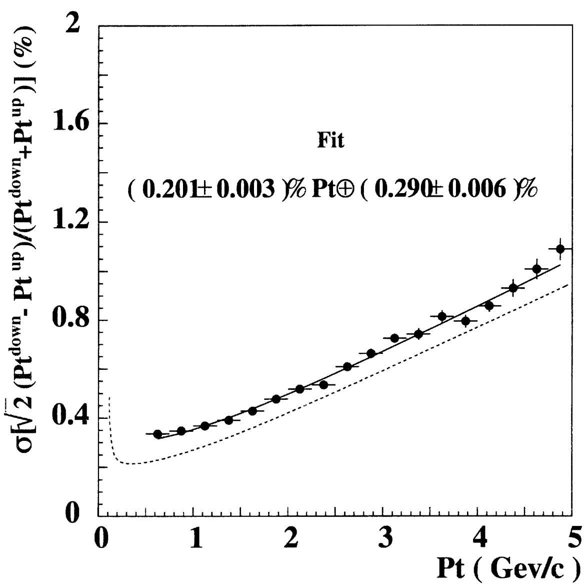
- *Optimize the granularity of the SBT made of plastic scintillator (or mixture of plastic and liquid scintillator)*
  The cell size is determined by backgrounds from em-showers, cosmics, …

- *Possible replacement of the straw tubes with the planes of multiwire drift chambers, or even a use of the He vessel as a gigantic TPC ?*

BELLE Central Drift Chamber with minimal material budget

- *The wire length is 2400 mm*
- *The sense wire is 30 μm diameter gold-plated W, the field wires are 125 μm diameter unplated Al*
- *The working gas is 50/50 mixture of He/C_2H_6, which has ~650 m radiation length. The large ethane component also provides good dE/dx resolution*
- *1.5 T Magnetic field*





Critical R&D topics for sub-detectors

(see talk of Richard)

- ✓ *We expect a quick summary from the sub-detector conveners*

- ✓ *A few examples:*
  - *Tau neutrino detector:*
    - *choice of technology for the Target Tracker*
    - *Optimization of the geometry and materials for the neutrino target*

    …
  - *Upstream Veto Tagger*
    - *Understanding of the minimal Scint. Thickness to produce sufficient Light Yield Is it really needed ? It should be optimized together with the Straw Veto Tagger and V0 decay volume in between*
  - *Surround background tagger*
    - *What prototypes are needed for both Liquid and Plastic scint. options*
  - *Calorimeter*
    - *Are we sure that the "shashlik" technology provides the most effective solution If not, what prototypes are needed?*
    - *R&D on the pre-shower module that can provide 1 mm spatial resolution*

Conclusion

SHiP optimization campaign should be taken with highest priority !

Please can we count on your active participation in the SHiP optimization, starting from discussions at this meeting !