Sterile Neutrino Sensitivities

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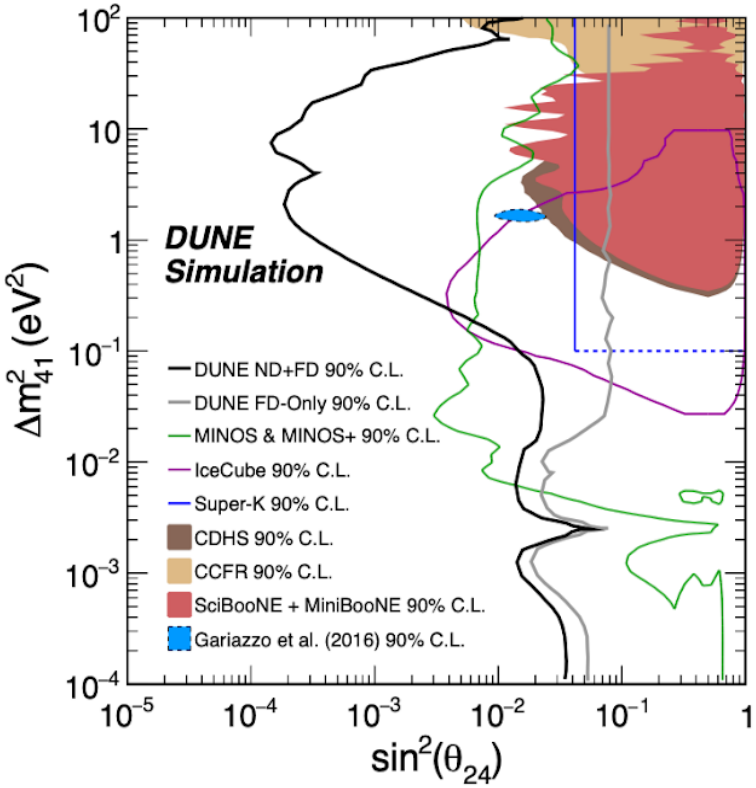
Aim this week

- To plot the chi^2 for the 3+1 parameter sensitivity for the Near Detector
- Combine with the far detector to find



Near Detector

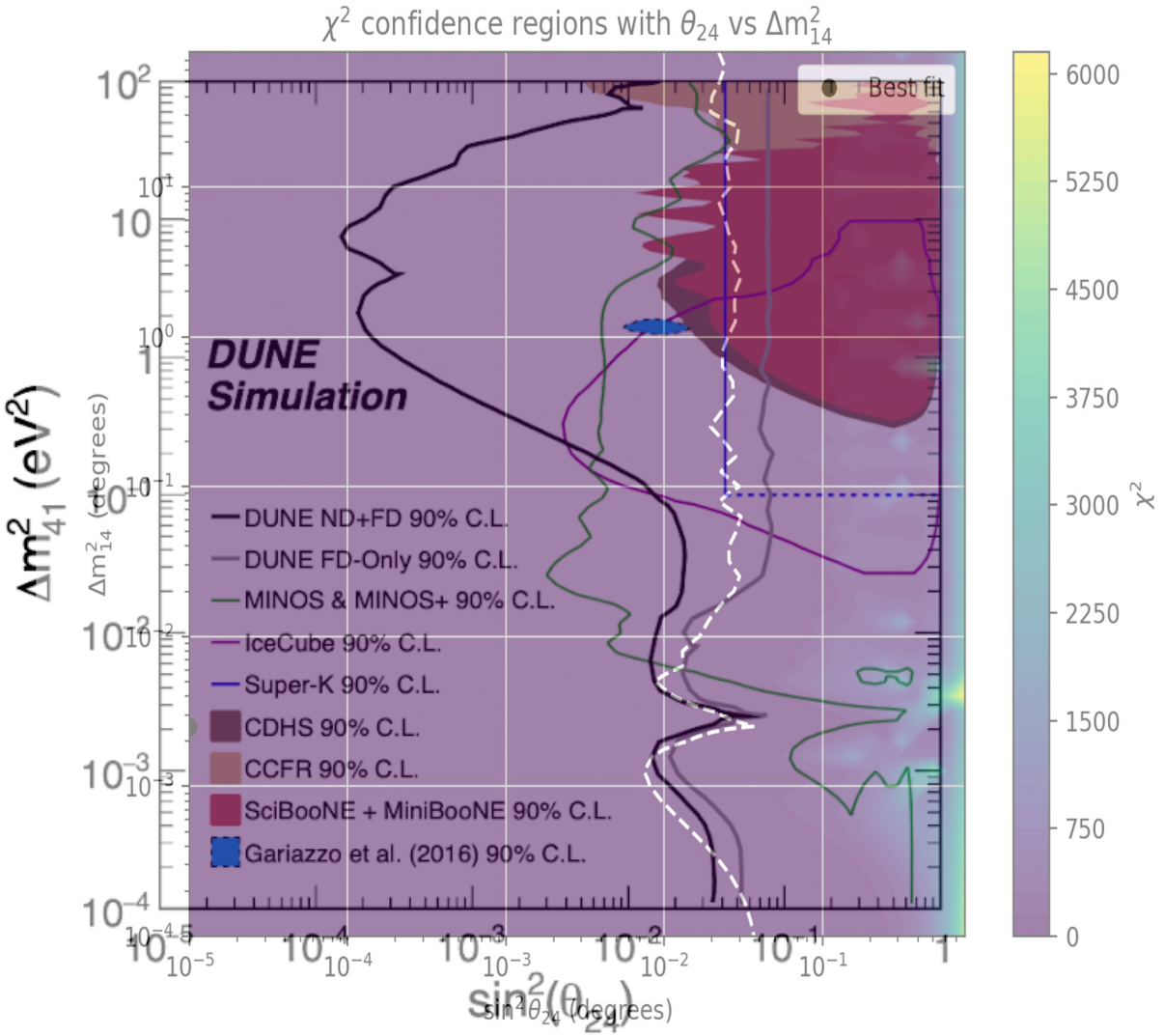
Greater sensitivity to the sterile neutrino mass squared difference term:

$$P(\nu_\alpha \rightarrow \nu_\beta) \propto \sin^2(\frac{\Delta m^2 L}{4E})$$

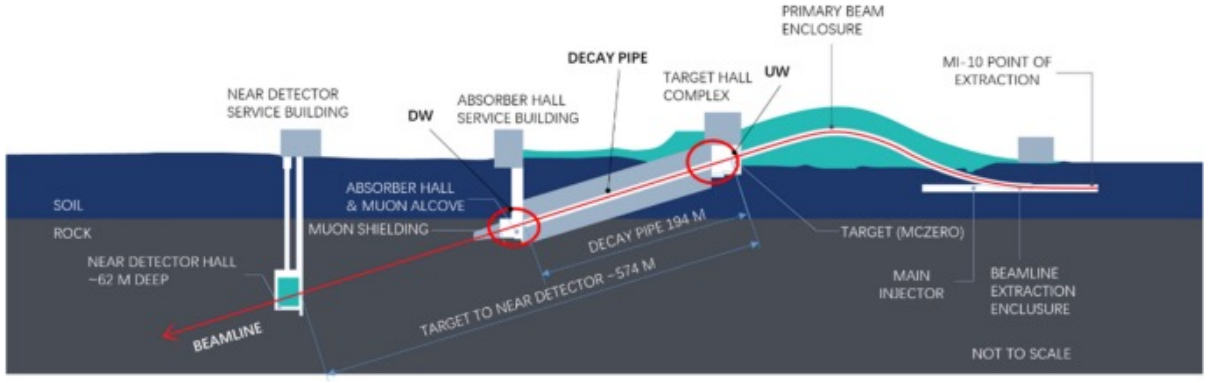
$$L \approx 0.574\ km$$

$$\Delta m^2_{41} \approx 1\ eV$$

The decay pipe is 194m long



Decay pipe



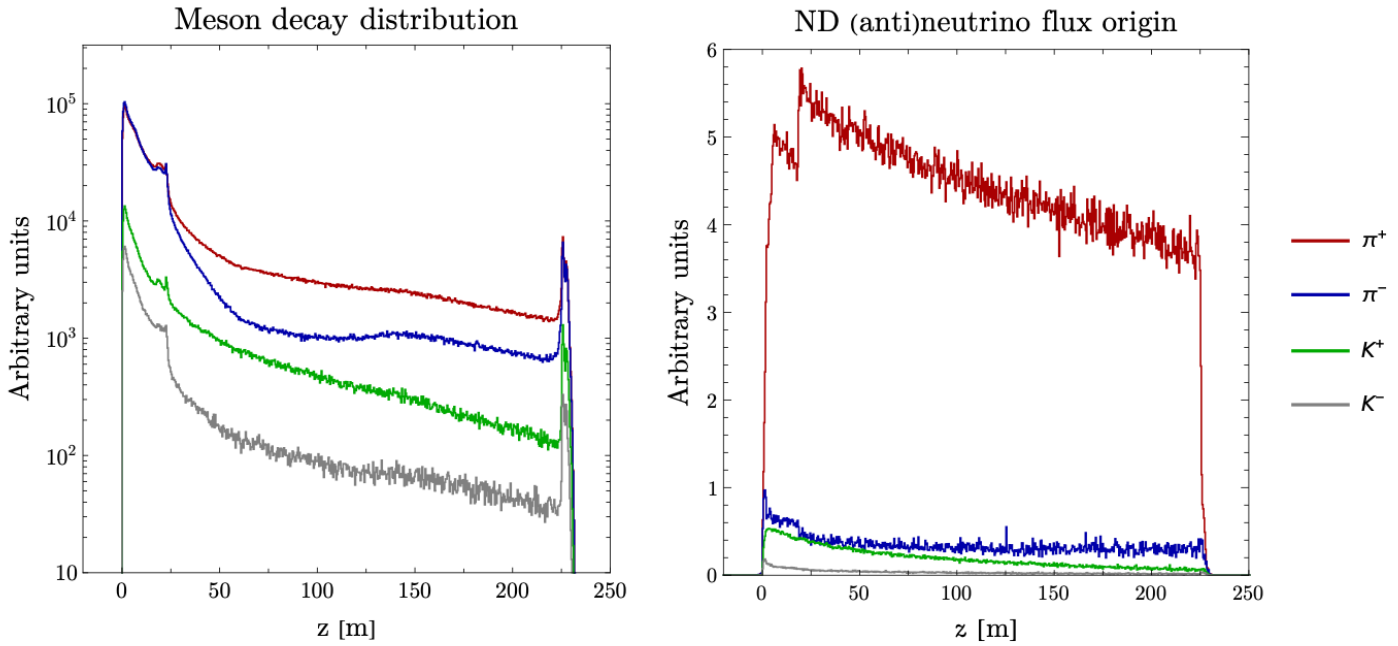


Figure 2: Left panel: the meson decay distribution in FHC mode as a function of distance from the target (cf. fig. 1). Right panel: the origin of the corresponding neutrinos and antineutrinos reaching the ND.

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Changes to the simulation

- Baseline & Density

```
/* Baseline */
$profiletype = 3
$densitytab = {2.6}
$lengthtab = {0.574}
```

- Detector mass

```
LAMASS = 0.05 // 40kt
```

- Flux files (from 2020 TDR ancillary files

```
include "./flux/BeamND.inc"
```

- Two slice model not required
- Energy resolution (Smear matrices) – have not yet found ND files therefore introduces a systematic error
- As goes for relevant efficiencies

Changes to the simulation

- Channels remain unchanged
- Rules:

```
rule(#nue_app)<
        @signal = 1.0@#FHC_app_osc_nue : 1.0@#FHC_app_osc_nuebar
        @background =  1.0@#FHC_app_bkg_nue : 1.0@#FHC_app_bkg_nuebar : 1.0@#FH

        @sys_off_function = "chiNoSysSpectrum"
        @sys_off_errors   = {}
        @sys_on_function  = "chiZero" //chiMultiExp
        @sys_on_errors    = {}
        //@energy_window = 0.5 : 1.8
```

A simplified statistical model

Chi^2 Output

- All 0s

```
# sin^2(theta_24)   Delta_m^2_41   chi^2
1e-05 0.0001 0
1e-05 0.000125893 0
1e-05 0.000158489 0
1e-05 0.000199526 0
1e-05 0.000251189 0
1e-05 0.000316228 0
1e-05 0.000398107 0
1e-05 0.000501187 0
1e-05 0.000630957 0
1e-05 0.000794328 0
1e-05 0.001 0
1e-05 0.00125893 0
1e-05 0.00158489 0
1e-05 0.00199526 0
1e-05 0.00251189 0
1e-05 0.00316228 0
1e-05 0.00398107 0
1e-05 0.00501187 0
1e-05 0.00630957 0
1e-05 0.00794328 0
1e-05 0.01 0
```

Multiple Experiments

- Neutrinos produced along whole length of decay pipe
- GLoBES models neutrinos from a point source
- Make 30 segments of the decay pipe, run an experiment for each then combine results to get a more realistic picture of the ND

Multiple Experiments

```c
int main(int argc, char *argv[])
{

  glbInit(argv[0]); // Initialize GLoBES library (libglobes), multi experiment smeared-source
    for (int i = 1; i < 2; i++) {
      char glb_filename[128];
      sprintf(glb_filename, "nd_globes/ND%d.glb", i);
      if (glbInitExperiment(glb_filename, NULL, NULL) != 0) {
        fprintf(stderr, "Error initializing experiment: %s\n", glb_filename);
        return -1;
      }
  }
```