For Forward Physics and Neutrinos at the LHC

Is this something ?

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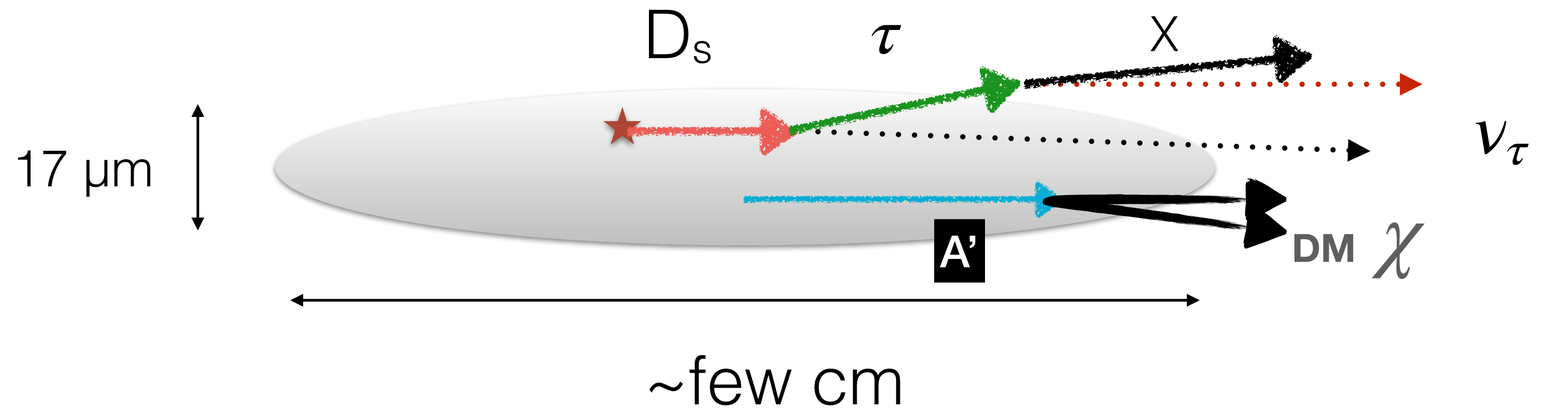
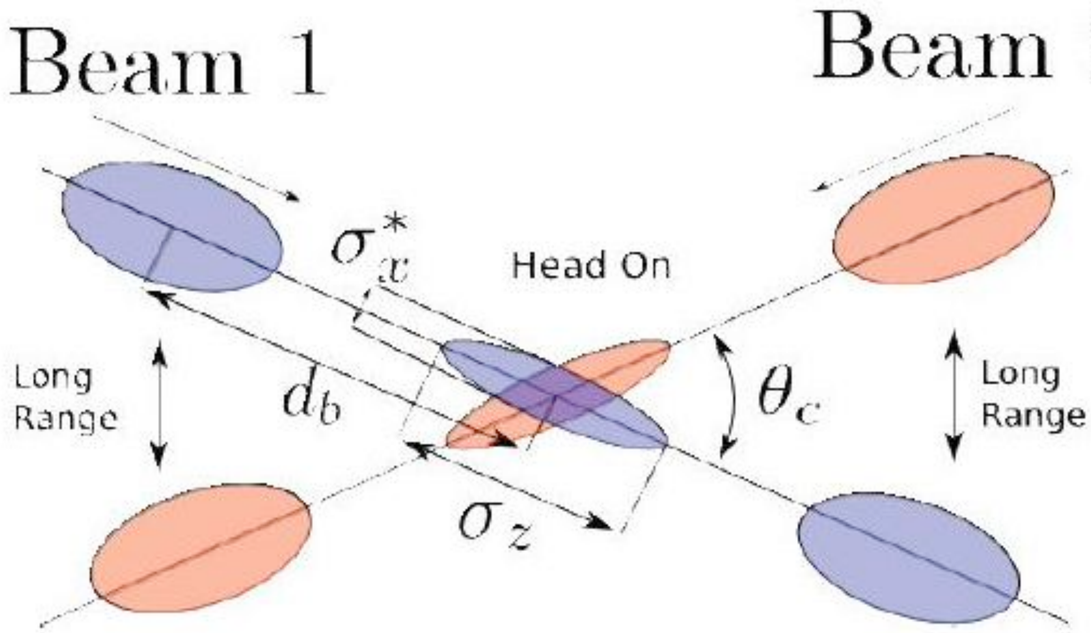
Production geometry for light DM and tau neutrinos

~4 GeV/14 TeV (momentum due to the crossing angle, ignored for the moment)



For γ~100, decay distances will be ~1-3 cm $\Longrightarrow$ size of the neutrino source for the LHC is ~10 cm. The LHC collision region is the most compact neutrino source ever made. The forward region of exploration is very forward y>6. The light weakly coupled A' could also decay in the detector in alternate scenarios.

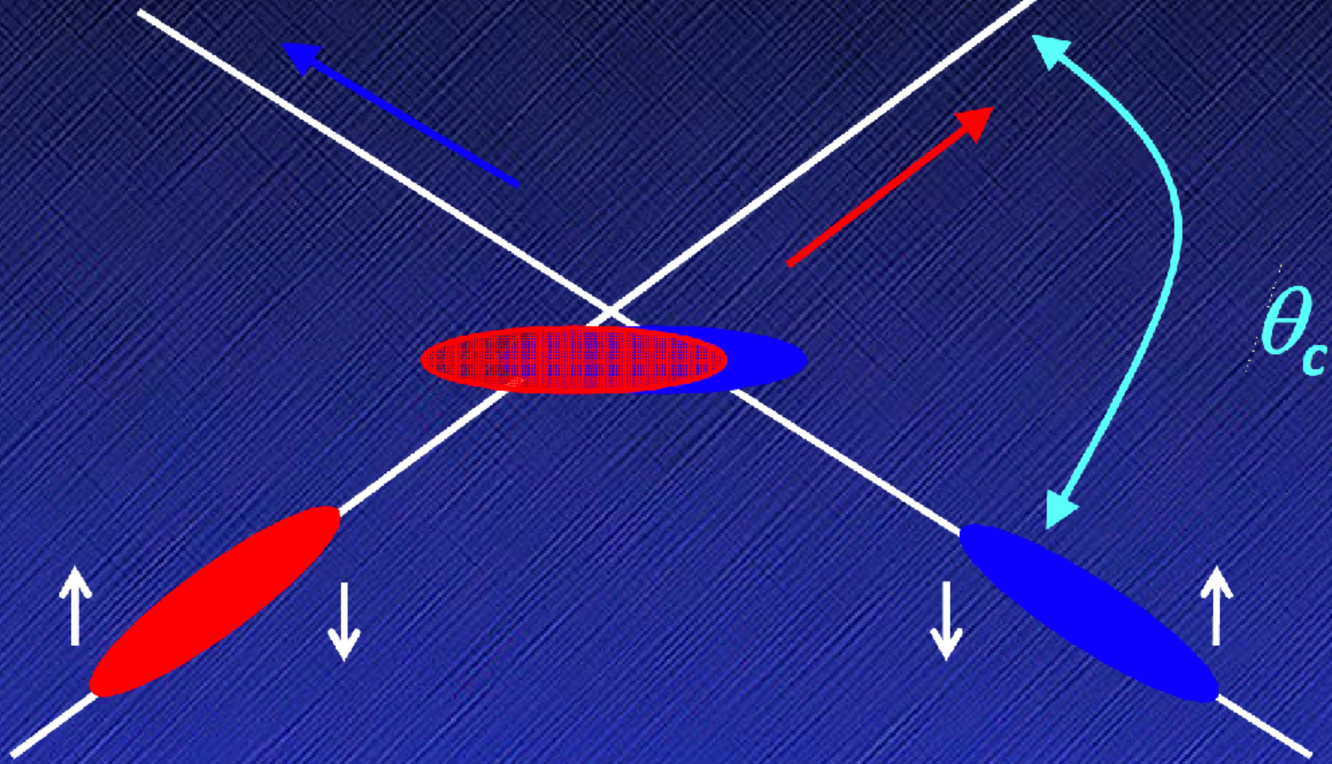
LHC interaction region



The larger is the crossing angle, θc~285microrad , the smaller is the area of overlap and therefore smaller is the possibility of collision. It is worth noting that while σz is constant over the machine (~7.5 cm), σx varies and assumes its minimum in the Interaction Points.

We have ignored the crossing angle in our calculation, but will need to include it in detailed simulation.

crab crossing restores bunch overlap



- RF crab cavity deflects head and tail in opposite direction so that collision is effectively “head on” for luminosity and tune shift
- bunch centroids still cross at an angle (easy separation)
- 1st proposed in 1988, in operation at KEKB since 2007

When does this happen at the LHC ?

Physics

Light dark matter, Neutrino physics, Forward hadrons.

1) Light dark matter with a dark photon mediator. This is a new region of interest for DM detection. The mass region is 10 — 1000 GeV. There are several experimental ideas in play. We would need to examine them carefully as part of our effort.

2) Neutrino measurements with focus on utilizing the large tau neutrino flux. There is value in doing this detection, but more exploration is necessary. Experimental data is needed to really understand the flux.

3) Cross section measurements on very high energy neutrinos. These would be important for the high energy astrophysical neutrino community.

4) Hadronic physics measurements using neutrinos. Such measurements are sensitive to forward heavy quark production, thus quite in line with our interests.

References

- ***Detecting and studying high energy collider neutrinos with FASER… 1908.02310***
- ***CMS note: 1903.06564***
- ***FASER proposal: 1708.09389, 1812.09139, 1901.04468,***
- ***FASER-nu: 1908.06564***
- ***LHCb data: 1510.01707***
- ***Our paper: Far forward neutrinos from the Large Hadron Collider. arXiv.org:2002.03012 JHEP 06 (2020) 032***

- Further studies on the physics potential of an experiment using LHC neutrinos
  N. Beni et al., e-Print: 2004.07828 [hep-ex]

- ***Far forward workshop: Nov 9-10 https://indico.cern.ch/event/955956/***
- ***Recent Nu at LHC workshop: Jan 15, 2021: https://indico.cern.ch/event/977827/***

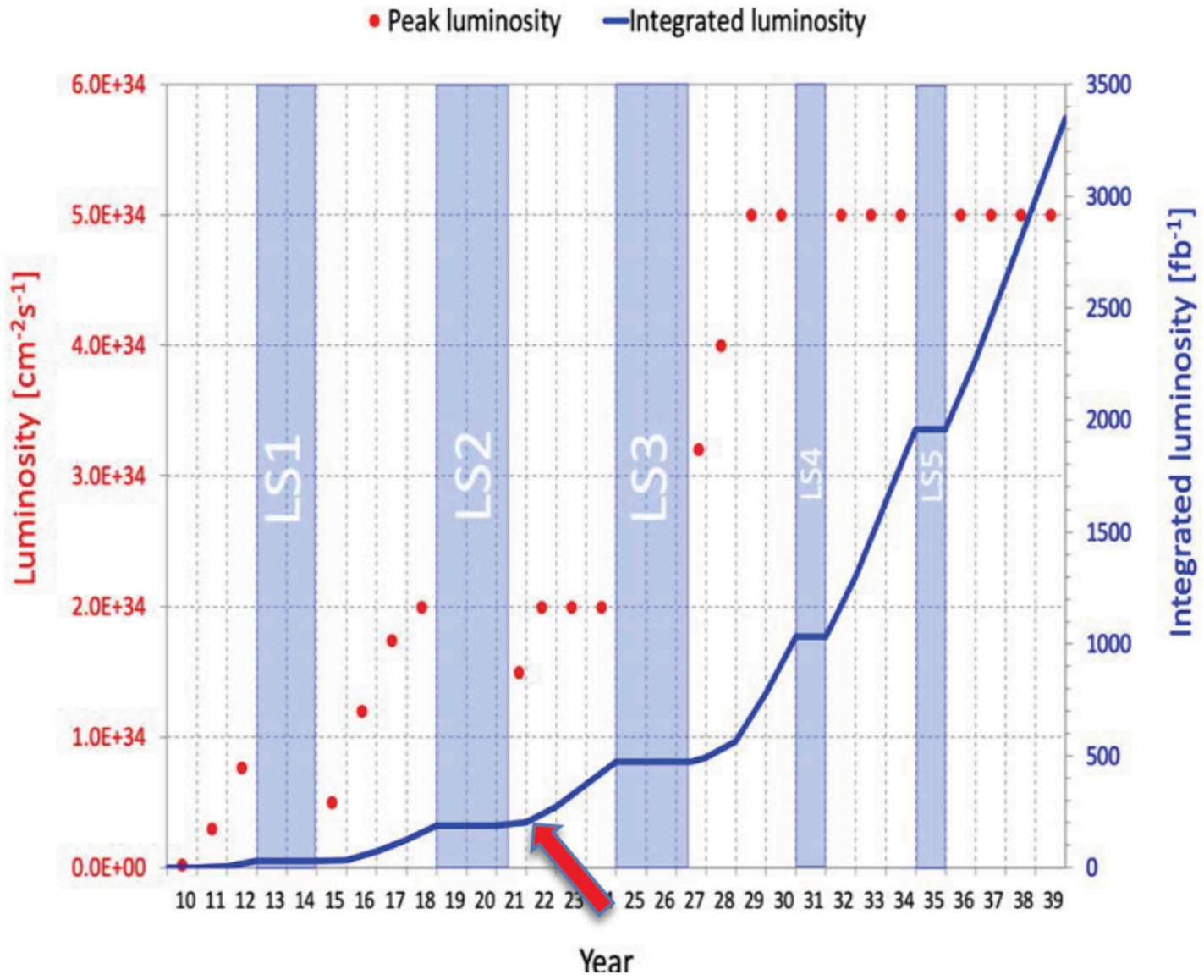
First workshop

https://indico.cern.ch/event/955956/timetable/#20201109.detailed

We also plan to discuss the status of a first manuscript collecting material of relevance for the Forward Physics Facility, which we have started to prepare on the basis of the results of the various discussions during the Kickoff Meeting and for which your contribution will indeed be welcome.

If you are interested in participating and presenting a contribution, please register through the meeting webpage

https://indico.cern.ch/event/1022352/



If facility is to be built, then the ideal time is LS3 2025-2027

Questions to answer

- Are these the only modes of search for dark matter ?
- Is the sensitivity reasonable given experimental constraints.
- What is the physics menu for the neutrino beam ?
- What detector(s) ?
  - Emulsion
  - Tracking counters
  - Liquid argon ?
- Can we have precise event timing in the detector design ?
- Is there physics by having multiple detectors with different capabilities.
- What physics do we gain by integrating the readout with the collider detectors ?