Super*B*: *Other experiments session*

LHCb/LHCb upgrade
(see LHCb web site/search Google)

& NA62

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Caveats:

(i) this is based on the LHCb upgrade letter of intent that was recently submitted to CERN and on the NA62 CDR and subsequent discussions with the collaboration.

(ii) I am extrapolating from that – Guy Wilkinson (LHCb) will be visiting Elba to talk about the project, so I hope he will be able to fill in gaps and correct any mis-understandings I may have.

(iii) Expect a speaker from NA62 to attend Elba meeting to talk in more detail about their physics programme and what they expect to have done by the time we start data taking.

LHCb: Target luminosities / timescales

- LHCb:
  - Original target luminosity was $2fb^{-1}$ per year for 10 years.
  - Target is now: $5fb^{-1}$ by 2017 to account for LHC start-up.
  - LHCb defines state of the art for us (SuperB's starting point)

- LHCb upgrade
  - Target: $50fb^{-1}$, accumulating $5fb^{-1}$ per year.
  - Timescale (my estimate is based on LOI and known LHC timescale)
    - Start 2018 (stated in LOI)
    - Shutdown in 2021/2022 for ATLAS/CMS upgrades for SLHC.
    - End of data taking ~2030 with the target data sample.

- SuperB defines state of the art for the upgrade to follow on from. Final results from LHCb upgrade ~9 years after SuperB.

LHCb expectations

- LHCb data taking will stop in our first year of nominal data taking (2017).
- By the time we understand our detector, most of the core LHCb measurements will have been published.
  - There could be some discovery of NP in the B_s sector that could open up new avenues of investigation for SuperB.

Table 1.1: LHCb quark flavour physics goals, illustrated with selected examples for the current and upgraded detector.

	Exploration	Precision studies
Current LHCb	Search for $B_s \to \mu^+\mu^-$ down to SM value Search for mixing induced CP violation in B_s system $(2\beta_s)$ down to SM value Look for non-SM behaviour in forward-backward asymmetry of $B^0 \to K^*\mu^+\mu^-$ Look for evidence of non-SM photon polarisation in exclusive $b \to s\gamma^{(*)}$	Measure unitarity triangle angle γ to $\sim 4°$ to permit meaningful CKM tests Search for CPV in charm

Table extract from LHCb Upgrade LOI

Some possible scenarios

- NP in $B_s \rightarrow \mu\mu$:
  - Many enhancements in this mode from non-trivial SUSY [not MSSM].
  - Means we can probe charged Higgs sector in $B \rightarrow l\nu$, τ decays etc.
  - SM measurement doesn't rule out NP for us.

- NP in $K^*\mu\mu$:
  - SuperB can't compete with exclusive measurement of muon mode: LHCb can tell us about NP there.
  - But SuperB can do inclusive measurements and (ee), so we can do something useful that is unique: need both to measure full set of observables.
  - Planning a session dedicated to uncertainties and phenomenology on this mode at Elba to explore theory issues in this area.

- NP in B_s mixing / β_s:
  - Increases the need for precise CKM over-constraint from SuperB (both angles and sides).
  - SuperB has unique potential to measure all angles and sides precisely.
  - What about charm/B_d mixing?

Current estimates on observable sensitivity

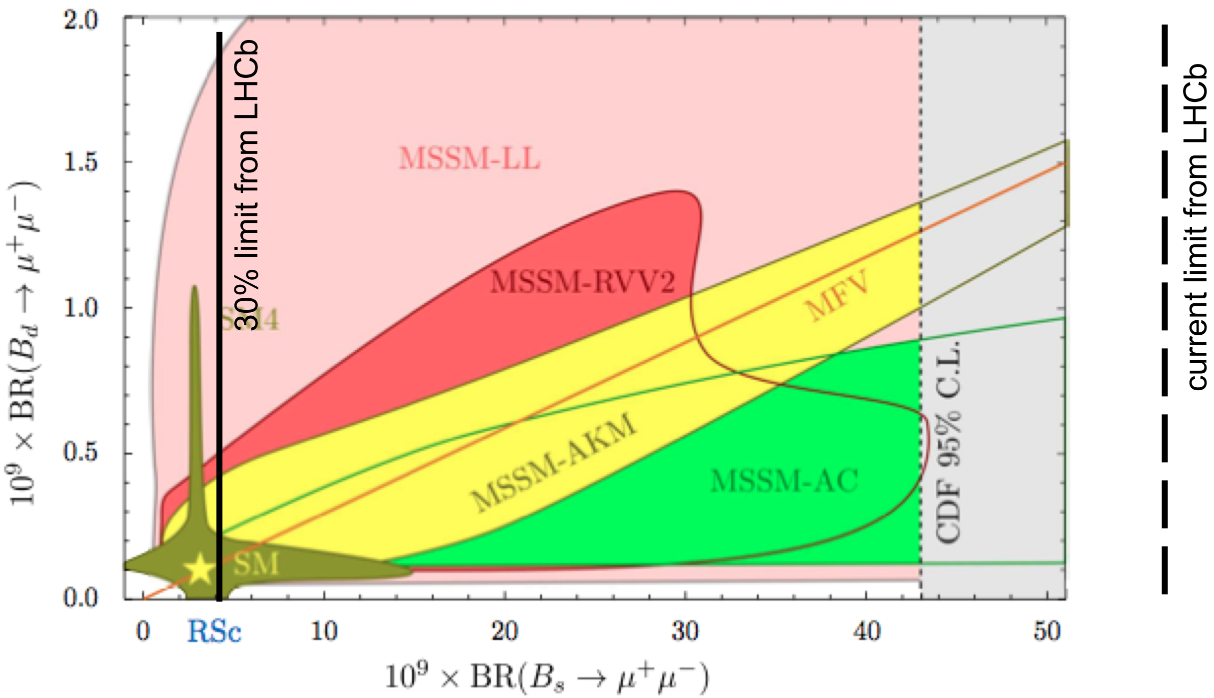
- Table 2.1: Sensitivities of the LHCb upgrade to key observables. For each observable the current sensitivity is compared to that expected after LHCb has accumulated 5 fb^{-1} and that which will be achieved with 50 fb^{-1} by the upgraded experiment, all assuming $\sqrt{s} = 14$ TeV. (Note that at the upgraded experiment the yield/fb^{-1} in hadronic B and D decays will be higher on account of the software trigger.)

Type	Observable	Current precision	LHCb (5 fb^{-1})	Upgrade (50 fb^{-1})	Theory uncertainty
Gluonic penguin	$S(B_s \to \phi\phi)$	-	0.08	0.02	0.02
	$S(B_s \to K^{*0}\bar{K}^{*0})$	-	0.07	0.02	< 0.02
	$S(B^0 \to \phi K_S^0)$	0.17	0.15	0.03	0.02
B_s mixing	$2\beta_s\ (B_s \to J/\psi\phi)$	0.35	0.019	0.006	~ 0.003
Right-handed currents	$S(B_s \to \phi\gamma)$	-	0.07	0.02	< 0.01
	$\mathcal{A}^{\Delta\Gamma_s}(B_s \to \phi\gamma)$	-	0.14	0.03	0.02
E/W penguin	$A_T^{(2)}(B^0 \to K^{*0}\mu^+\mu^-)$	-	0.14	0.04	0.05
	$s_0\, A_{\mathrm{FB}}(B^0 \to K^{*0}\mu^+\mu^-)$	-	4%	1%	7%
Higgs penguin	$\mathcal{B}(B_s \to \mu^+\mu^-)$	-	30%	8%	$< 10\%$
	$\frac{\mathcal{B}(B^0 \to \mu^+\mu^-)}{\mathcal{B}(B_s \to \mu^+\mu^-)}$	-	-	$\sim 35\%$	$\sim 5\%$
Unitarity triangle angles	$\gamma\ (B \to D^{(*)}K^{(*)})$	$\sim 20^\circ$	$\sim 4^\circ$	0.9°	negligible
	$\gamma\ (B_s \to D_s K)$	-	$\sim 7^\circ$	1.5°	negligible
	$\beta\ (B^0 \to J/\psi\, K^0)$	1°	0.5°	0.2°	negligible
Charm CPV	A_Γ	2.5×10^{-3}	2×10^{-4}	4×10^{-5}	-
	$A_{CP}^{dir}(KK) - A_{CP}^{dir}(\pi\pi)$	4.3×10^{-3}	4×10^{-4}	8×10^{-5}	-

Table extract from LHCb Upgrade LOI

Constraining NP

- Remember the context: what can we add to elucidate NP, using the starting point of the constraints expected from LHCb.



~35% measurement of B_d mode with upgrade.

NB Initial results from LHCb shown already at Moriond.

Figure 2.1: Correlations between $\mathcal{B}(B_s \to \mu^+\mu^-)$ and $\mathcal{B}(B^0 \to \mu^+\mu^-)$ in models respecting the MFV hypothesis (straight line) and in a range of alternative models. From Ref. [23], which gives a full definition of the various models. The vertical dashed line represents the experimental limit. The allowed values in the SM are restricted to the region of the yellow star.

Searching for ~1GeV Majorana ν

- Another scenario for the list of exotics searches in di-lepton and invisible decays of neutral mesons for the TDR.

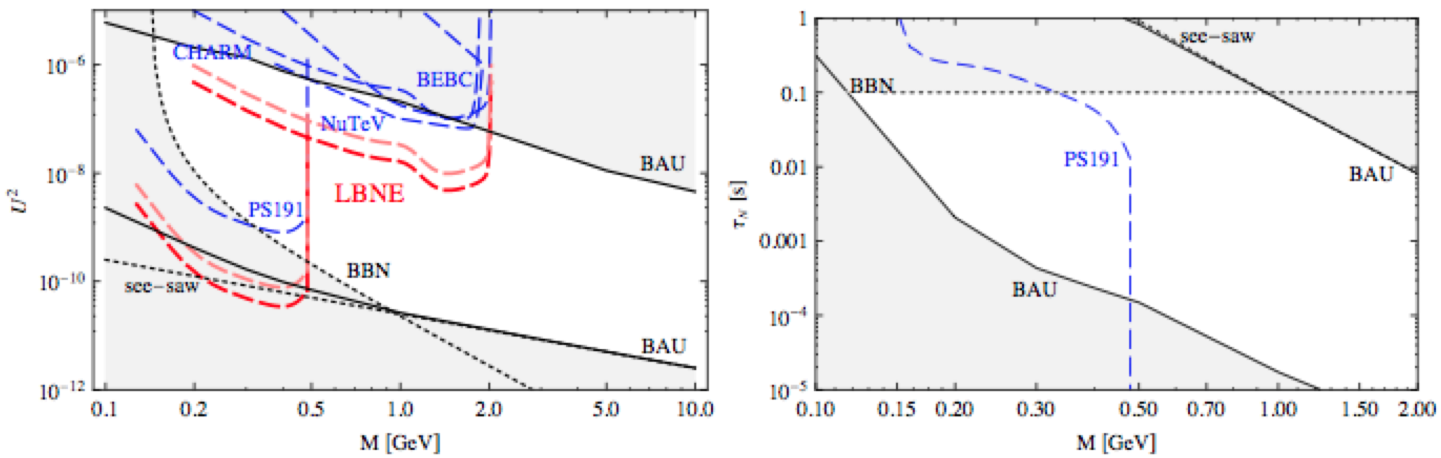


Figure 2.16: Constraints on the sterile-to-active neutrino mixing angle squared, U^2, and on the sterile neutrino lifetime, τ_N. These come from the baryon asymmetry of the Universe (solid lines); from the see-saw formula (dotted line); and from requiring Big Bang nucleosynthesis (dotted line). These constraints are shown for the case of an inverted hierarchy in the active neutrino sector. The regions excluded by direct experimental searches are indicated by the blue dashed lines [96, 97]. The pink and red curves indicate the expected sensitivity of the proposed LBNE detector at FNAL in two possible configurations.

NA62

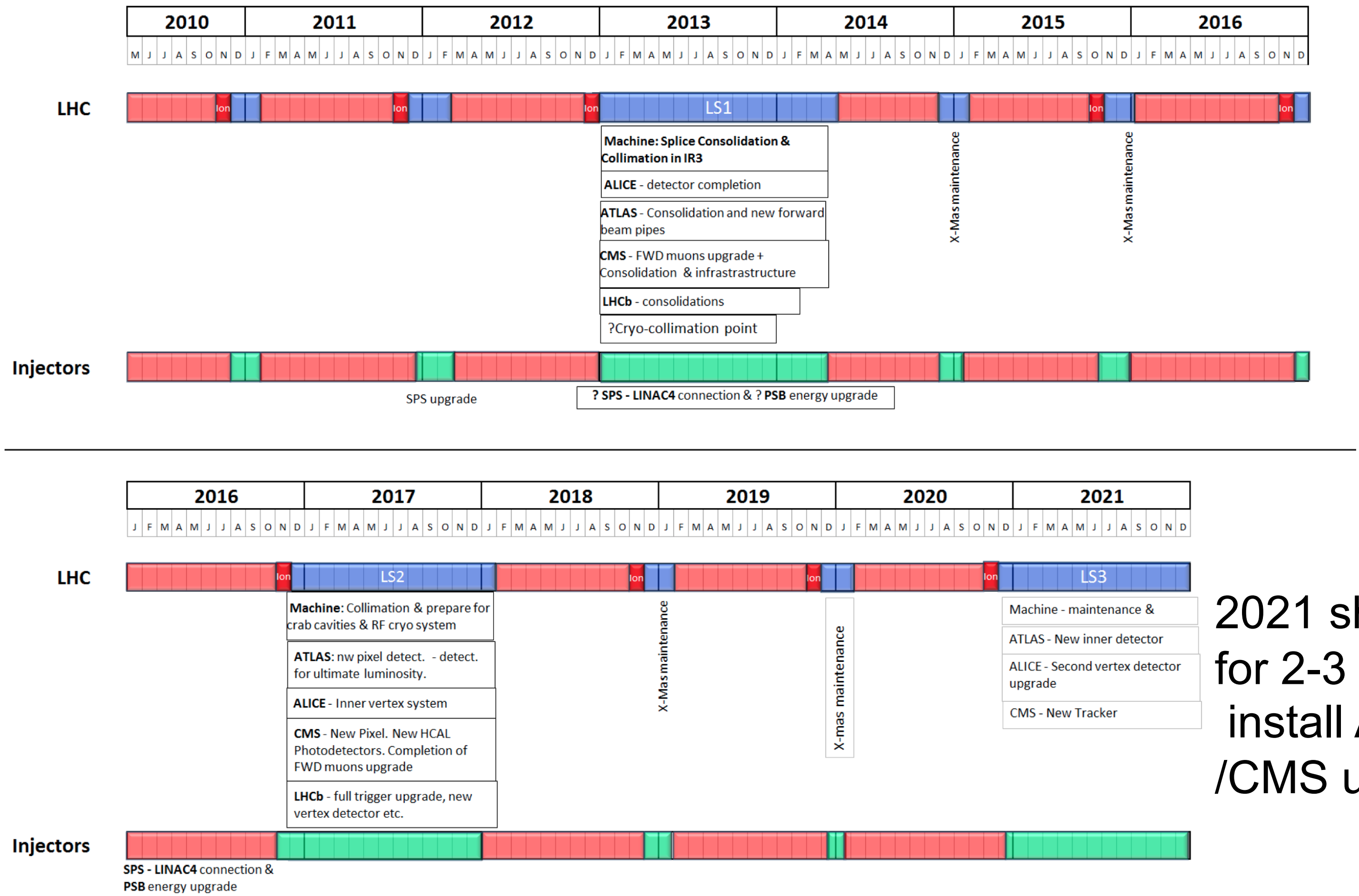
- Aim to measure $K^+ \to \pi^+ \nu\overline{\nu}$ with 100 signal events (~10% precision).
  - Clean constraint on the height of the UT.
  - Will be done before the start of SuperB, so kaons will give two constraints on the apex of the triangle: ε_K and $\Gamma_{\pi\nu\nu}$.
  - Will not be as precise as existing constraints from B decays (but is a nice cross check from kaon decays).

- Open question: NA62 expect they need 100 days to record 100 events.
  - Will they decide to run longer to improve this constraint to a more significant level?

LHC / injector operation plan

From L. Rossi

New Rough Draft 10 year plan



2021 shutdown for 2-3 years to install ATLAS /CMS upgrades

SuperB: commission in 2016 full run in 2017

Summary

- The flavour landscape will change in the next 6 years.
- Complementarity with other experiments is a great strength.
  - We (SuperB) should adapt and respond to new opportunities to constrain new physics.
    - Remember that the direct search machines will also make significant constraints that we should fold into our programme.
- Ideas from other flavour experiments may be of interest to us, and we need to keep watching (even though we don't have data ourselves).
- This talk is based on non-expert opinion wrt capabilities of CERN experiments (any mistake is mine!).
- We expect to have experts at the Elba meeting who will be able to correct any mis-understandings.