BABAR / Super*B*

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1. Experiment goal

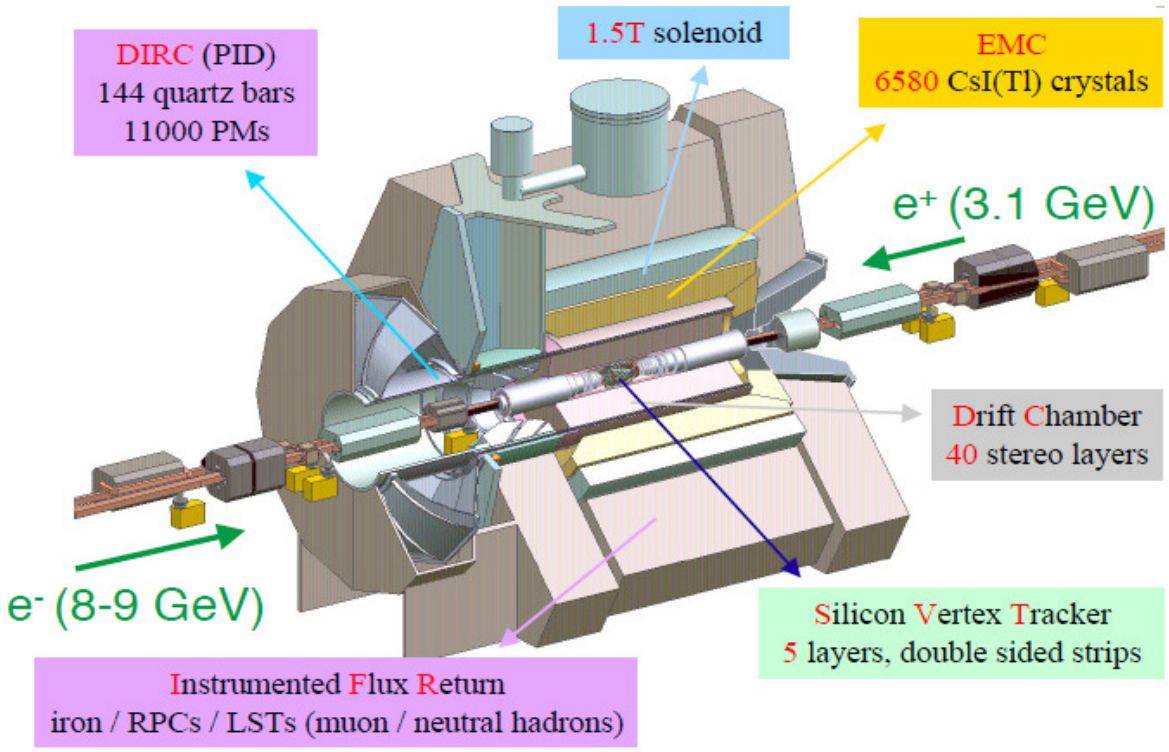
The primary goal of the *BABAR* experiment is to establish the violation of CP symmetry in B meson decays. Due to the very generic nature of the experiment, many other topics can be investigated, such as the existence of a light hidden sector from a few tens of MeV to ~10 GeV. A detailed list of possible measurements related to secluded sectors is discussed below.

Super*B* is a next generation flavor factory designed to distinguish between the different types of new physics scenario studying CP violation and rare processes. The objective of this experiment is to collect a luminosity about 100 times larger than that of actual flavor factories. Similarly to *BABAR*, light hidden sectors can be studied for the same range of energies. Super*B* is expected to start its operations in 2016.

2/3. Experimental setup and facilities

The *BABAR* experiment stopped taking data in 2010 and has been decommissioned. The experiment has entered a phase of intensive data analysis that should last several more years.

Super*B* will be located will be built on the campus of the University of Rome 'Tor Vergata'. The detector reuses most of the *BABAR* detector with some upgrades, while a new accelerator complex will be built. A new technology based on nano-size beams will provide a peak luminosity in excess of 10^{36} cm^{-2} s^{-1}, and Super*B* is expected to collect about 75 ab^{-1} of data after five years of running.



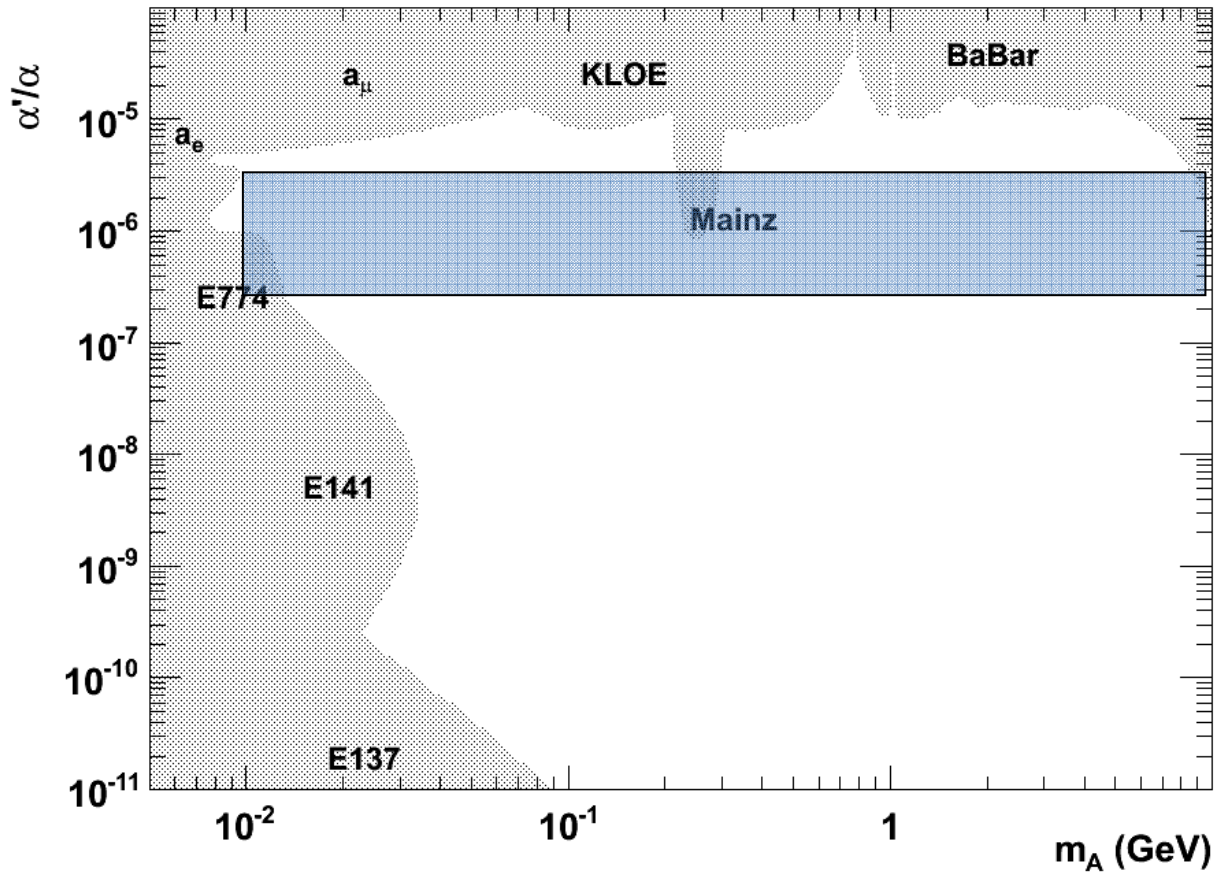
Overview of the BABAR detector

4. Physics reach

In this section, I discuss on-going and planned studies of dark sector performed with the *BABAR* detector. Projections for Super*B* are given at the end of each section.

4.1 Search for dark photon in $e^+e^- \to \gamma A'$, $A' \to e^+e^-, \mu^+\mu^-, \pi^+\pi^-$ (on-going)

Search for dark photon in two leptons or two pions final states. The photon is required to be detected to ensure good trigger efficiency and reduce the background level. We expect limits on the mixing parameter, ε^2, in the range $O(10^{-7})$ – $O(10^{-6})$ for $0.01 < m_A < 10$ GeV. An improvement by a factor ~10 is expected for Super*B*.



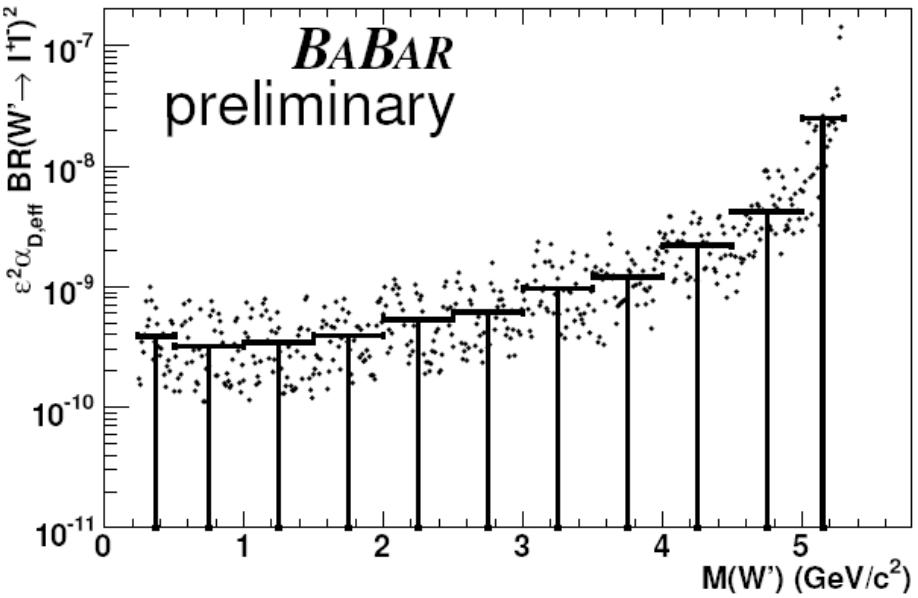
Range of expected limits on $\varepsilon^2 = \alpha'/\alpha$ using the full BABAR dataset (blue box) compared to constraints from other experiments(shaded area).

4.2 Search for dark boson in $e^+e^- \rightarrow A^{*\prime}$, $A^{*\prime} \rightarrow W'\,W'$, $W' \rightarrow l^+l^-$ (arXiv:0908.282)

Search for a pair of dark bosons in four lepton final states, assuming the production of two identical bosons. The measurement is sensitive to the product $\alpha_D\,\varepsilon^2$, where $\alpha_D = g_D^2/4\pi$ and g_D is the dark sector coupling constant. No signal is observed and limits on the product $\alpha_D\,\varepsilon^2$ at the level of $O(10^{-10})$ – $O(10^{-8})$ are set.

A similar measurement with a radiative photon, $e^+e^- \rightarrow A'\gamma$, $A' \rightarrow W'\,W'$, $W' \rightarrow l^+l^-$, could improve the limits by a factor ~5. The assumption of two identical bosons could also be relaxed, looking for the production of two different bosons, but limits are expected to be in the same range than that of identical bosons.

An improvement by a factor ~10 is expected for Super*B*.



Upper limits (90% CL) on the product $\alpha_D\ \varepsilon^2$ BF(W'→l^+l^-)^2 as a function of the dark boson mass. The points denote individual limits and the line average limits.

4.3 Search for dark Higgs in e^+e^- → A*', A*' → h' A', h' →A'A' (on-going)

Search for dark Higgs production in the regime of prompt Higgs decay (i.e. $m_h > 2\ m_A$). This measurement is sensitive to the product $\alpha_D\ \varepsilon^2$. In the Abelian case, there is a single dark photon, providing a powerful constrain to reject the background, If no signal is observed, limits on the product $\alpha_D\ \varepsilon^2$ at the level of O(10^{-10}) – O(10^{-8}) could be set. Weaker limits are expected in the non-Abelian case (many dark photons), as the background is much larger.

Depending on the mass hierarchy, the dark Higgs can also produce displaced vertices or escape undetected. The displaced vertices case covers only a small fraction of the parameter space and is considered to be a low priority measurement. The trigger efficiency for invisible decays is limited and can only provide weak constraints, if any.

An improvement by a factor 10-100 is expected at Super*B* for dark Higgs searches in the Abelian case, depending on the level of background.

4.4 Search for dark hadrons in many lepton final states (on-going)

Search for dark hadrons decaying to leptons and pions in QCD-like events. These events are expected to produce final states containing many leptons and hadrons. Progress in the simulation of such events (showering algorithms) is however needed to set proper limits.

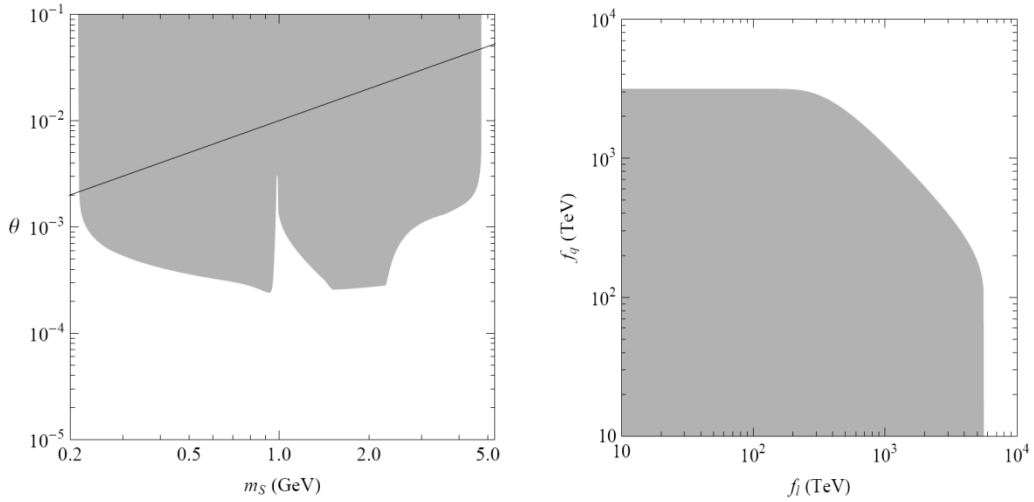
4.5 Search for dark scalar and pseudo-scalar particle in B decays (on-going)

Search for dark scalar (s) and pseudo-scalar (a) particles in $B \rightarrow K(*)l^+l^-$ decays. Expected limits on the scalar mixing angle and pseudo-scalar couplings have been derived by Battell *et al.* (PRD 83 054005) and Freitsys *et al.* (PRD 81 034001) assuming limits on the branching fraction $B \rightarrow Ks$ and $B \rightarrow Ka$ at the order of $O(10^{-8}) – O(10^{-7})$. Limits at the level of $10^{-4} – 10^{-3}$ are derived for the scalar mixing angle, and at the level of 10^3 TeV for the pseudo-scalar couplings.

We also search for a dark scalar in $B \rightarrow ss \rightarrow 2(l^+l^-)$ decays, which is sensitive to the product λ_H $Br(s \rightarrow l^+l^-)$. If no signal is observed, we anticipate limits on the branching fraction $B \rightarrow 2(l^+l^-)$ at the level of $10^{-8} – 10^{-7}$.

Additional searches for the decays $B \rightarrow K\ 2(l^+l^-)$ and $B \rightarrow 4(l^+l^-)$ are also planned.

Depending on the level of background, an improvement by a factor 10-100 is expected at Super*B* for these searches.



*Expected sensitivity on the scalar mixing angle θ (left) and pseudo-scalar couplings f_l vs f_q (right) from Batell et al. (*PRD 83 054005*).*

4.6 Search for long lived dark matter in $e^+e^- \rightarrow \gamma$ + invisible (PRL 107 021804)

Search for dark sector states decaying outside the detector, looking for a peak in the photon energy spectrum. The measurement of invisible Y(1S) can be readily reinterpreted in this framework. Extension to the full dataset depends on the trigger performances and available manpower.

4.7 Search for dark photon in π^0 decays

Search for a dark photon in π^0 decays. Preliminary studies showed that KLOE has already set better limits in this mass range.

4.8 Search for displaced vertices

Search for generic new physics in displaced vertices, applicable to several channels discussed above.

5. Status and Schedule

BABAR has completed its data taking phase and has entered the intensive analysis phase.

The Super*B* experiment has been proposed and accepted by the Italian government in may 2011. It will be located at the campus of the University of Rome 'Tor Vergata' and is expected to start taking data in 2016. Super*B* is expected to collect 75 ab^{-1} of data after five years of operations.

6. Future plans

No future plans are foreseen for *BABAR*, and Super*B* must be first build and operational before considering upgrades.

7. Collaborating Institutions and Collaborators

This information can vary on monthly basis. I would kindly request you contact the spokesperson of these collaborations to obtain the relevant lists and their appropriate formatting.

8. Written materials

The *BABAR* experiment is described in this paper

B. Aubert et al. (BABAR Collab.), Nucl. Instrum. Meth. A 479, 1 (2002).

The SuperB Conceptual Design report is available at

http://superb.infn.it/liferay-portal/cdr

More details on these experiments are available at

http://web.infn.it/superb/

http://www.slac.stanford.edu/BFROOT/