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Search for muonic dark force at Belle II

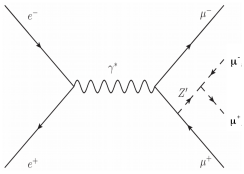
Rajesh Kumar Maiti[1], Giacomo De Pietro[2], Enrico Graziani[2], Gianluca Inguglia[1], and Martina Laurenza[2]

[1] *HEPHY Vienna,* [2] *INFN and University of Roma Tre*

HEPHY INSTITUT FÜR HOCHENERGIEPHYSIK
FWF P31361 Der Wissenschaftsfonds.

Introduction and Motivations

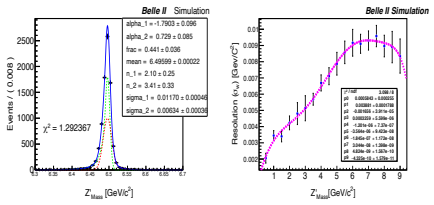
- A U(1)′ extra gauge boson Z′, which couples to L_μ - L_τ [1] current via a new coupling g' [2].
- The interaction Lagrangian is $\sum_l \theta g' \bar{l}\gamma^\mu Z'_\mu l$.
- In $e^+ e^-$ collision Z′ could be produced alongside with two muons and further decaying into another pair of muons, resulting in a four muon final state ($e^+e^- \to \mu^+\mu^- Z'(\to \mu^+\mu^-)$ (muonic dark force)).



- The existence of the Z′ could reveal insights about $(g\text{-}2)_\mu$ anomaly, dark matter issues and some flavour anomalies.
- BaBar search on 514 fb^{-1} data indicates no significant signal [3].
- We aim at 100 fb^{-1} of data set and expect to be competitive with BaBar analysis due to an aggressive background suppression strategy.

Signal selection and fitting

- Different mass hypotheses (500 MeV - 10 GeV in 500 MeV steps) are generated via Madgraph.
- Some signal preselections are:
  1. Impact parameters consistent with tracks coming from the interaction point.
  2. No of tracks = 4 in the events.
  3. Kinematical fit.
  4. Particle ID.
- Mass distributions are modeled by double crystal ball functions and resolutions are given by a weighted average of the component crystal ball widths.



- Resolution for a generic mass point given by interpolation of the crystal ball parameters.
- Resolution varies from 2 MeV to 10 MeV depending on the Z′ mass.

References

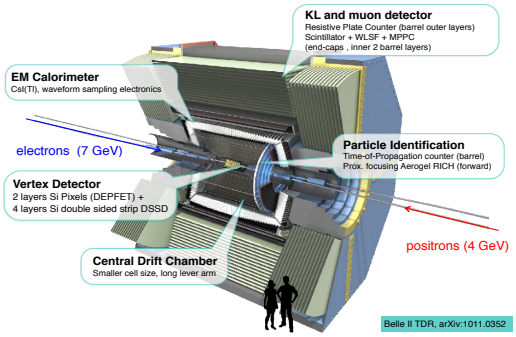
[1] Altmannshofer *et al.* "Explaining dark matter and B decay anomalies with an L_μ-L_τ model", JHEP **1612** 106 (2016).

[2] B.Shuve and I.Yavin *et al.* "Dark matter progenitor: Light vector boson decay into sterile neutrinos", Phys. Rev. D. **89**, 113004 (2014).

[3] Babar collaboration, "Search for a muonic dark force at BABAR", Phys. Rev. D **94**, 011102(R) (2016).

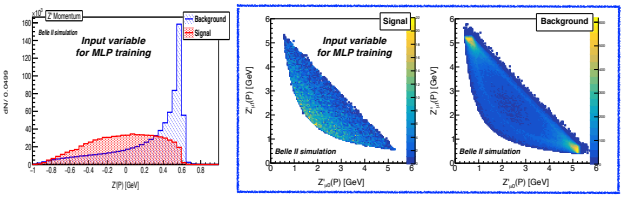
RajeshKumar.Maiti@oeaw.ac.at

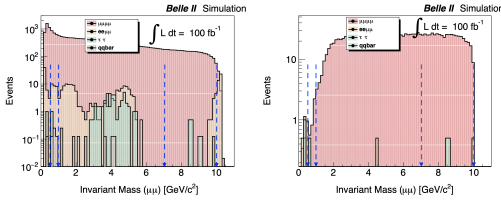
Belle II at SuperKEKB



- Asymmetric e^+ e^- collider located at KEK in Tsukuba, Japan.
- Centre of mass energy of 10.58 GeV (B-factory).
- Rich physics program including B, D, τ physics and dark sector.
- Nano-beam scheme allows an instantaneous luminosity of 6×10^{35} cm $^{-2}$ s^{-1}.
- Aim to collect 50 ab^{-1} of data.

Background suppression



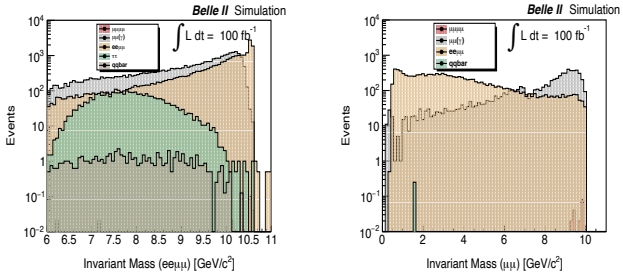


Before MLP | After MLP

- Expected Standard Model backgrounds are $\mu\mu\mu\mu$, double photon conversion, ISR photon conversion and combinatorials.
- Artificial Neural Network (MLP, MultiLayer Perceptron) used for background suppression.
- 15 discriminating variables in 4 different mass ranges.

Blue dashed line shows different mass ranges

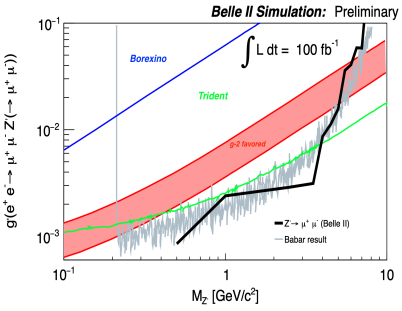
Control sample study



- We plan to use $ee\mu\mu$ events as a control sample to validate our selections.
- Test the performance of background suppressing MLP.
- Also use it for trigger and systematic studies.
- Some data-MC disagreement expected, mostly due to the absence of the ISR process in AAFH $ee\mu\mu$ generator.
- A great amount of work is in progress.

Preliminary results

- We used a fitting technique to estimate the sensitivity (90% CL upper limits).
- No trigger condition and systematics are taken into account yet.



Conclusions and future studies

- Fit based approach used for sensitivity estimation.
- Profile likelihood method used for upper limit estimation.
- Test and validate the full analysis chain on control samples.
- Finalize our trigger selection and compute all systematics.
- Some study also ongoing on possible displaced vertex signatures (model independently).