# Beyond Standard Model Physics at RHIC

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## Abstract

One of the most vital tasks of an experiment using a polarized hadron collider in a new energy region must be a study of physics beyond the standard model. In the last few years, several theoretical articles have been devoted to the study of (1) quark compositeness and a contact interaction, (2) new gauge bosons $W'^{\pm}$ and $Z'$, and (3) CP-violation. In the theoretical work [1, 2, 3], it is shown that RHIC can reach a similar sensitivity for the TEVATRON, due to its polarized beam.

The purpose of the present study is to explore the discovery potential for physics beyond standard model, from the experimental perspective. In order to study a physics sensitivity and to determine a search window, event generator based simulation studies are indispensable. A lot of non-standard model scenarios can be examined using PYTHIA. A contact interaction, phenomenologically introduced as a "residual interaction" which originates in interactions between quark- and lepton-subconstituents, is included in it. However, as same as for all other sub-processes, PYTHIA includes only helicity averaged cross sections for the contact interaction.

The author developed a plug-in program "POLBEYOND" for PYTHIA by which helicity-dependent matrix elements and spin asymmetries for Drell-Yan and quark scattering process can be examined.

Fig.1 shows the expected single spin asymmetries

$$A_L = \{\sigma(-) - \sigma(+)\}/\{\sigma(-) + \sigma(+)\} \tag{1}$$

at RHIC ($\sqrt{s} = 500$GeV) in $\mu^+\mu^-$ pair production assuming full acceptance and detection efficiency. The results were obtained for various $\Lambda$, which is a model-independent scale parameter of the contact interaction, defined as $F(Q^2) = (1 + Q^2/\Lambda^2)^{-1}$, where $F(Q^2)$ is a "form factor" of the quark or lepton. Helicity-dependent matrix elements including contact interaction terms were obtained by crossing the electron quark scattering formula shown in [4], from s-channel to t-channel. Final hadronic spin asymmetries were estimated using a weighting method. The weight factor consists of partonic-level helicity-dependent cross sections, polarized and unpolarized parton distribution-functions. The event generation was controlled by the unpolarized sub-processes, which are already included in PYTHIA for fermion pair creation via $\gamma^*/Z$ production including contact interaction effects. The present result shows that we can expect to observe an anomalous parity violation if $\Lambda \sim 1$ TeV, however, at least the realisic acceptance for a detector should be considered in order to predict more accurate search limit. Furthermore, a full detector simulation is also possible using PYTHIA+POLBEYOND.

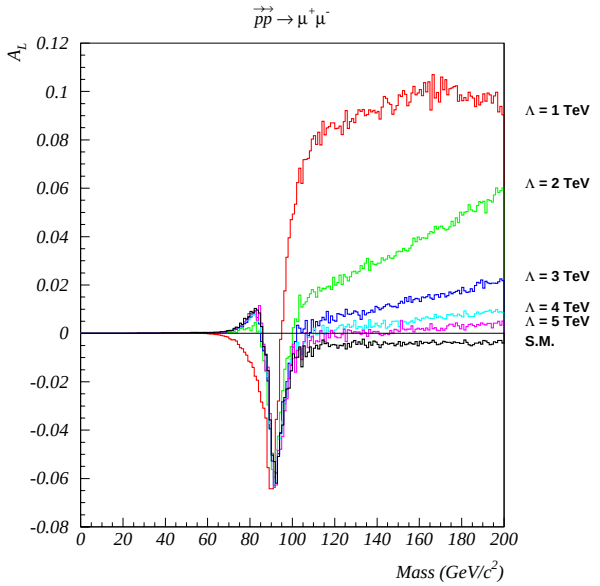


Figure 1: Single spin asymmetries $A_L$ are plotted as functions of Drell-Yan Mass with selections of $\Lambda = 1, 2, 3, 4, 5$ TeV and for the case of the Standard Model ($\Lambda \to \infty$) obtained by PYTHIA+POLBEYOND. Present results are for the reaction of $pp \to \mu^+\mu^-$ at $\sqrt{s} = 500$ GeV, with a constructive interference between the Standard Model and left-handed contact interaction. GS-95 NLO-A is used as a polarized parton distribution function.

Although Drell-Yan is a clean process, other processes which have larger cross section must be studied. It is because the present limit is considered as $\Lambda \geq 3$ TeV from TEVATRON, atomic parity violation experiments, etc. For this reason, parity violation in jet production is also studied, as shown in Fig.2. From this jet study, it is shown that we can reach above 3 TeV sensitivity, which is higher than the current limit of 2.7 TeV, within original $\sqrt{s}$=500GeV with $800pb^{-1}$ plan. Here we can also see that by the energy and liminosity upgrade plan which is now under discussion, the sensitivity must be improved in order of magnitude. Indeed, it is also shown that the sensitivity limit can be above 6 TeV by the RHIC upgrade. We note that the observation of an anomalous parity viloation would directry indicate the presense of new physics.

# References


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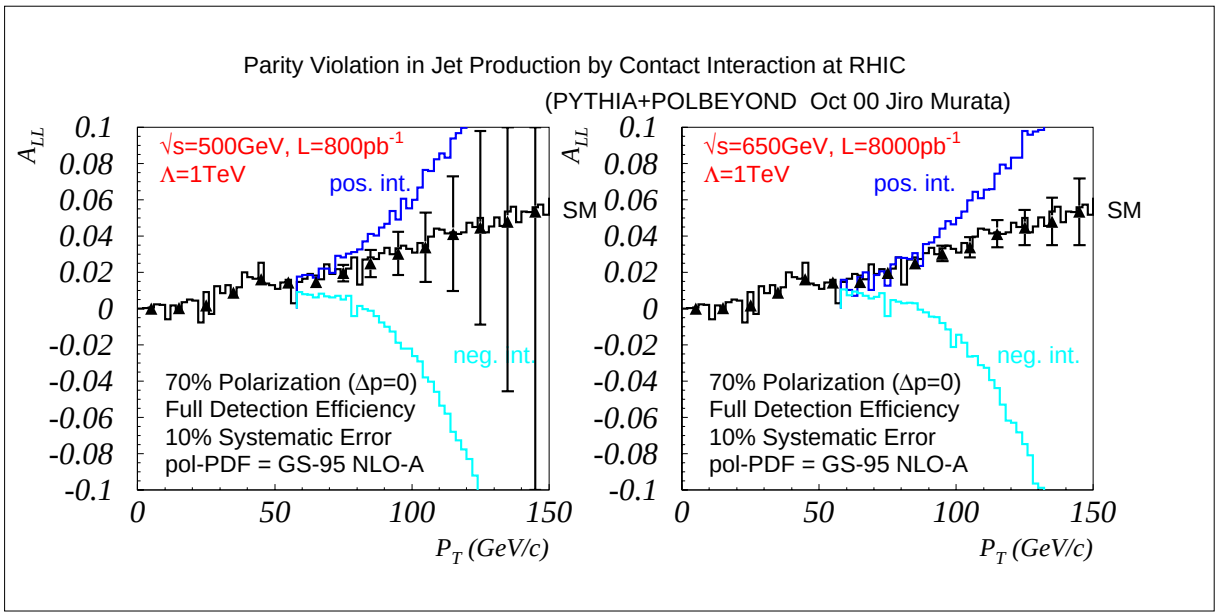


Figure 2: Parity violating double spin asymmetries $A_{LL}^{PV}$ are plotted as functions of Jet $P_t$, for $\sqrt{s} = 500$ GeV with $800pb^{-1}$ and $\sqrt{s} = 650$ GeV with $8000pb^{-1}$.