Qeios

Beam Leakage: Does Polarization (of Positron) Optimize to 70%? More on Accelerators Too?

Hani W. Maalouf Physics Department, Lebanese University

Faculty of Science II, Fanar, Lebanon

Abstract: An instrumental trial based on the theory of gluons pre-quenching is proposed to resolve some of the beam deficiencies, especially the positron polarization. The idea can be used to maybe reduce the size of accelerators, as crucial in concordance after recounting such leaks or improvements.

Introduction:

The presence of lines in the accelerators' beams were discovered recently, [1].

Here, a theorist makes an effort to improve at least one instrumental effect, which can also be (on the side of) for experimental recycling and recollection of data to break the next new physics barriers.

Specifically, one may think in terms of the coherent mini-sub-beams spilled out of the main beam in the running energy ranges, well and up till around 100 GeV, and then passing the Electroweak scale into the BSM thresholds, represented by another Higgs-noted pseudo-scalar noted by indices 1 and 2, in the Appendix.

Also, more ruining may come out due to the non-elimination of the processes, especially the CP-violating ones, by the external magnetic field at very low diffusion angles as they diffuse almost along the beam axis and can escape also their reversion.

These sub-beams develop from the gluons which originate from the Higgs background, decaying into γ and Z, with the last re-decaying into gluons.

The gluons are known for making jets' quenching above a certain angle, leading to a spilling of frequencies ω_c at a smaller angle than θ_s.

https://doi.org/10.32388/IDE96Y

That should satisfy a longitudinal double-flux variation such that, after integration in the 2nd equation,

$$2\omega_s = sL^2 \Rightarrow 2\Delta N_x^D = \frac{sL^3}{3} \Rightarrow \Delta N^D = sL^3/2$$

Where the superscript D relates to double.

But a double of a single flux can be made from the turn of one side of a turn, so $\Delta N^D = 2\Delta N \Delta N$

$$\theta_s = \frac{1}{\Delta N} = \frac{1}{\sqrt{\frac{\Delta N^D}{2}}} = \frac{2}{\sqrt{sL^3}}$$

The length L is characteristic of nuclear matter.

While s is a collective screening due to a lattice of pure quark valence parameters just close to the inside of the nucleon, so then its range of interaction with the gluons' energy is the same as the Debye length. To deduce, up to a constant, that

$$s = \frac{q^2}{l}$$

Where q is the elementary charge of the nucleon, and l is the Debye Length, [2].

This integration allows a direct resolution as if there is a hidden transverse dimensional link that allowed the contact between the two fluxes.

In nuclear forces, this is a Yukawa-type force, which is exactly what gave the benchmark that links, as worked out in the Appendix, an internal mass order to the charge of the type

$q = \lambda m$

Where λ is of the order of a Yukawa coupling, being approximated by $\frac{Y'^{\text{1st gen}}_{\text{Yukawa}}}{(\lambda_{EW})^{\frac{1}{2}}}$, so an estimate of

$Y'^{\text{1st gen}}_{\text{Yukawa}} \approx 0.16 Y'^{\text{2nd gen}}_{\text{Yukawa}} \approx (0.16)^2 Y'^{\text{3rd gen}}_{\text{Yukawa}}$ while $Y'^{\text{3rd gen}}_{\text{Yukawa}} \approx \lambda' Y^{\text{3rd gen}}_{\text{Yukawa}}$

Where$Y^{\text{3rd gen}}_{\text{Yukawa}} \sim 1$ with $\lambda' \sim \lambda^2$ is the self-coupling in the extended Higgs.

Since the Debye occurs at the valence quark inside the nucleon and these constitute less than 1 per cent of the nucleon mass.

The order of the Yukawa is small, so it is expected to be of the order of 10^{-2} at best.

Then, too, the mass m has the order of a few hundredths of a nucleon, being associated with the link size reaching up to the restoration energy (here, the EW vacuum energy).

Writing the quenching parameter in the new link parameters

$$\theta_s^2 = \frac{4}{sL^3} = \frac{4}{\left(s\left(\frac{2\omega_s}{s}\right)^{\frac{3}{2}}\right)} \Rightarrow \theta_s^4 = \frac{4^2 s}{(2\omega_s)^3} = \frac{2\lambda^2 m^2}{l\omega_s^3}$$

$$\Rightarrow \theta_s \cong 1.2\lambda^{\left(\frac{1}{2}\right)}\left(\frac{L_s^3}{L_m^2 l}\right)^{\frac{1}{4}}$$

In values $L_s = 1$ Gev, $l \sim 0.1$ MeV and $L_m = 150$ GeV

$$\theta_s \cong 1.2\lambda^{\frac{1}{2}}\left(1 \times \frac{1\times10^4}{(1.2)^2\times10^4}\right)^{-\frac{1}{4}} \approx 1.3\lambda^{\frac{1}{2}} = 1.3 \times \left[(0.16)^2(0.1)^{2-\frac{1}{2}}\right]^{\frac{1}{2}}$$

$$= 1.4 \times 0.16 \times 0.18 \cong 0.028 \sim \frac{\theta_{spilling}}{2} \approx \frac{0.05}{2} = 0.025$$

Where $\theta_{leak} \cong 5\%$ is the cited value for the ruining beam leak, [1].

As a centering of an angle θ_s with respect to the cylindrical axis would simply lead to its doubling, making it a value that easily compares to leaking.

In terms of the parameters, since L_s and L_m are fixed, what is left is

$$\theta_s \propto \frac{\lambda^{\frac{1}{2}}}{l^{\frac{1}{4}}}$$

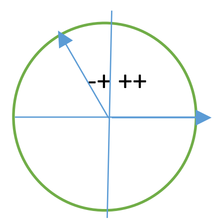
So, decreasing the Debye energy by a factor of 20 would lead to a decrease of the angle by a factor of 2.5; however, such a decrease in scattering would correspond to a significant lowering of the energy of the system. So, if its Yukawa's are also expected to be heightened by almost 10, the same outcome is on the side of low energy.

For the high energy, the Yukawa, since dealing with the low quarks, are stabilized, while if the Debye will increase by a factor of 2 up to 10, then the increase of the spilling beam angle is by a factor of 1.2 up to 1.8.

Therefore, a direct improvement is not much feasible in the regions where there is a clear separation between the gluons' Debye and the Yukawa of the quarks.

Impact of the Boundary Conditions: Gaining the Polarization of the Positron

Under isotropic beams' conditions, the beam surface is supposed to be the gauge matching region. If one assumes that the beam surfaces are roughly circular, then since leakage is partial on the circumference and the fusion-disintegration plays a role between various spillings, a matching in-between is the concluded boundary condition.



Since three directions are free to spill, then an isotropic angle is 120°.

However, forgetting about the longitudinal beam leakage matching since it goes along the beam itself.

Its matching is then between k_x and k_y such that their signatures go along or not, (as due to the Poincaré circle available gauge that is here the Möbius one, [3], however restricted to the line of the circumference with turns one with equal signs and another with different signs).

And since the signs of k_x and k_y are distributed along the different circular quadrants, one fixes the equal signs at the 1st quadrant and at the end should multiply by 4, being the 1st turn.

A 2nd turn is at the 2nd quadrant, and plus signs are not specified in the transverse directions.

Therefore, the 2nd quadrant is re-divided into 4 possible alternances of signs, to deduce that the coherence (or Polarization ratio p_{e^+}) is proportional to

$$p_{e^+} = 4\left[\frac{1}{3}\frac{1}{4} + \left(\frac{1}{3}\frac{1}{4}\right)^2 + \cdots\right] = \frac{1}{3}\frac{1}{1-1/12} = \frac{4}{11} = 0.36$$

If the k_z is also randomly collected, like e.g., if from Bremsstrahlung production, this polarization would double, so

$$p_{e^+}^{Brems} = 8\frac{\frac{1}{12}}{1-\frac{1}{12}} = 0.72$$

That would be the case [4] if the source jets were restricted to be less than $\theta_s \approx 0.03$.

That number is at least better than the state-of-the-art number, 30%, [5].

Appendix:

Consider the decay of a generic Higgs H going to Z and Gamma, with a coupling noted by g.

The only leading CP-violating factors are $Z_\mu H A^\mu$ and $Z_\mu H^3 A^\mu$.

Write the 1st $Z_\mu H A^\mu$ Ward identity for v_1, then for v_2,

$$\int_0^\Lambda d^4k' \frac{\epsilon_\mu(k)}{(k+k')^2}\frac{1}{k'^2}\frac{\epsilon^\mu(q_Z)}{(q_Z-k')^2+M_Z^2}$$

$$= \int_0^\Lambda \int_0^\Lambda d^4q_Z' d^4k' \frac{1}{(q_Z'+q_Z)^2+M_Z^2}\frac{\epsilon_\mu(k)}{k'^2}\frac{\epsilon^\mu(q_Z)}{(q_Z-k')^2+M_Z^2}$$

$$- \int_0^\Lambda \int_0^k d^4k'' d^4k' \frac{1}{(k''+k')^2}\frac{\epsilon_\mu(k)}{(k''+k')^2}\frac{\epsilon^\mu(q_Z)}{k'^2}$$

For, $Z_\mu H^3 A^\mu$ one uses the external-internal separation, i.e., that of $H^3 = H^{(ext)} H^{2^{(int)}}$.

With the Goldstone breaking applied to the internal, one simply gets the previous tree diagram plus the tree diagram with a blob on it.

These equations are true only for a single Higgs, which is not true for our case since there are, neglecting in the lower energy domain, the Heavy Higgs Pseudo-scalars, H_1 and H_2, which have a certain mixing plus different vacuum decay values.

H_1, H_2

$H_1H_1H_1, H_1H_2H_1 + 2 \leftrightarrow 1, H_1H_2H_2$

$H_2H_1H_1, H_2H_2H_1 + 2 \leftrightarrow 1, H_2H_2H_2$

Giving the values, defining $g_i \equiv g_i^{HZA}$

g_1, g_2

$\lambda_{111} \times v_1^2, 2\lambda_{121} \times v_1 \times v_2,\ \lambda_{122} \times v_2^2$

$\lambda_{211} \times v_1^2, 2\lambda_{221} \times v_1 \times v_2,\ \lambda_{222} \times v_2^2$

Adding it all together,

$$g_1 + g_2 + (\lambda_{111} + \lambda_{211})v_1^2 + 2(\lambda_{121} + \lambda_{221})v_1 \times v_2 + (\lambda_{122} + \lambda_{222})v_2^2$$

As there is a mostly true approximation, $\frac{g_2}{g_1} \cong \frac{\lambda_2}{\lambda_1}$, for various λ's, so

$$g_1 \times (1 + a) + \lambda_{111} \times (1 + a)v_1^2 + 2\,\lambda_{121} \times (1 + a)v_1 \times v_2 + \lambda_{122} \times (1 + a)v_2^2$$

These formulas apply, being submitted to the spontaneously breaking, to the RHS case.

Which brings their equations to the following form

$$g_1 \int_{m_{s_0}}^{\Lambda(0)} d^4k' \frac{\epsilon_\mu(k)}{(k+k')^2}\frac{1}{k'^2}\frac{\epsilon^\mu(q_Z)}{(q_Z-k')^2+M_Z^2} + g_2 \int_{m_s}^{\Lambda(m_s)} d^4k' \frac{\epsilon_\mu(k)}{(k+k')^2}\frac{1}{k'^2}\frac{\epsilon^\mu(q_Z)}{(q_Z-k')^2+M_Z^2}$$

$$+(\lambda_{111} + \lambda_{211})v_1^2 \int_{m_{s_0}}^{\Lambda(0)} d^4k' \frac{\epsilon_\mu(k)}{(k+k')^2}\frac{1}{k'^2}\frac{\epsilon^\mu(q_Z)}{(q_Z-k')^2+M_Z^2}$$

$$+2(\lambda_{121} + \lambda_{221})v_1 \times v_2 \int_{m_s}^{\Lambda(m_s)} d^4k' \frac{\epsilon_\mu(k)}{(k+k')^2}\frac{1}{k'^2}\frac{\epsilon^\mu(q_Z)}{(q_Z-k')^2+M_Z^2}$$

$$+ (\lambda_{122} + \lambda_{222})v_2^2 \int_{2m_s}^{\Lambda(2m_s)} d^4k' \frac{\epsilon_\mu(k)}{(k+k')^2}\frac{1}{k'^2}\frac{\epsilon^\mu(q_Z)}{(q_Z-k')^2+M_Z^2}$$

Integrations with $\int_{m_{s_0}}^{\Lambda(0)} \square$ eliminate, while noting $dk'D = d^4k' \frac{\epsilon_\mu(k)}{(k+k')^2}\frac{1}{k'^2}\frac{\epsilon^\mu(q_Z)}{(q_Z-k')^2+M_Z^2}$, so

$$[g_2 + 2(\lambda_{121} + \lambda_{221})v_1v_2]\left[\int_{m_s}^{\Lambda(m_s)} dkD - \int_{m_{s_0}}^{\Lambda(0)} dkD\right]$$

$$+ (\lambda_{122} + \lambda_{222})v_2^2\left[\int_{2m_s}^{\Lambda(2m_s)} dkD - \int_{m_{s_0}}^{\Lambda(0)} dkD\right]$$

View $\int_{m_{s_0}}^{\Lambda(0)} D = \int_{m_{s_0}}^{m_s} D + \int_{m_s}^{\Lambda(m_s)} D - \int_{\Lambda(0)}^{\Lambda(m_s)} D \Rightarrow \int_{m_s}^{\Lambda(m_s)} D - \int_{m_{s_0}}^{\Lambda(0)} D = -\int_{m_{s_0}}^{m_s} D + \int_{\Lambda(0)}^{\Lambda(m_s)} D$, which can be written due to the large values of Λ compared to the integration parameters as

$$-\int_{m_{s_0}}^{m_s} D(k) + [\Lambda(m_s) - \Lambda(0)] \times D\big(\Lambda(0)\big) = -\int_{m_{s_0}}^{m_s} D(k) + m_s\Lambda'(m_s) \times D(\Lambda(0))$$

Since, $m_s \geq m_{s_0}$ is not zero in value and can reach up to being close to m_Z, one can work the integrations exactly, and after a trivial collection of terms by adding the missing integration domains, all the RHS eliminates, while from the LHS there remains

$$(g_2 + 2(\lambda_{121} + \lambda_{221})v_1) \int_0^{m_s} d^4k' \frac{\epsilon_\mu(k)}{(k+k')^2} \frac{1}{k'^2} \frac{\epsilon^\mu(q_Z)}{(q_Z-k')^2+M_Z^2} =$$

$$-(\lambda_{122} + \lambda_{222})v_2 \int_0^{2m_s} d^4k' \frac{\epsilon_\mu(k)}{(k+k')^2} \frac{1}{k'^2} \frac{\epsilon^\mu(q_Z)}{(q_Z-k')^2+M_Z^2}$$

So defining $\int_a^\Lambda d^4k' \frac{\epsilon_\mu(k)}{(k+k')^2} \frac{1}{k'^2} \frac{\epsilon^\mu(q_Z)}{(q_Z-k')^2+M_Z^2} = F(a)$, the equation can be written as

$$(g_2 + 2(\lambda_{121} + \lambda_{221})v_1) = -2(\lambda_{122} + \lambda_{222})v_2$$

As v_2 relates to v_1 and the lambdas relate to the Yukawas, it can be deduced that the above form is used.

References:

1- G. Franchetti, H. Bartosik and F. Schmidt, Experimental observation of fixed lines in a Particle Accelerator Research Square DOI: 10.21203/rs.3.rs-2371173/v1

2- J. Casalderry-Slana and E. Iancu hep-ph/1105.1760

3- I. Ovinnikov 1901.01427 [cs.LG]

4- A. Bessonov and A. Mikhailichenko A Method of Polarized Positron Beam production Conf. Proc.C. 960610 (1996) 1516-1518

5- J. Beyer and J. List Isolating Systematic effects with Beam Polarization at e^+e^- Colliders hep-exp/2105.09691