POLARIZED POSITRON PRODUCTION FROM POLARIZED ELECTRONS IN COMPARISON WITH LASER SCHEME

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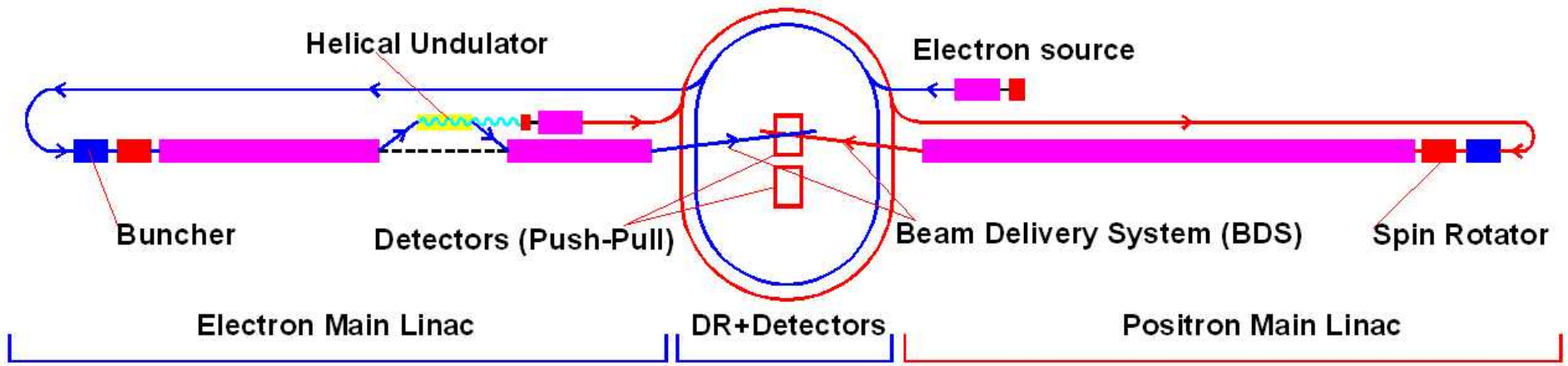
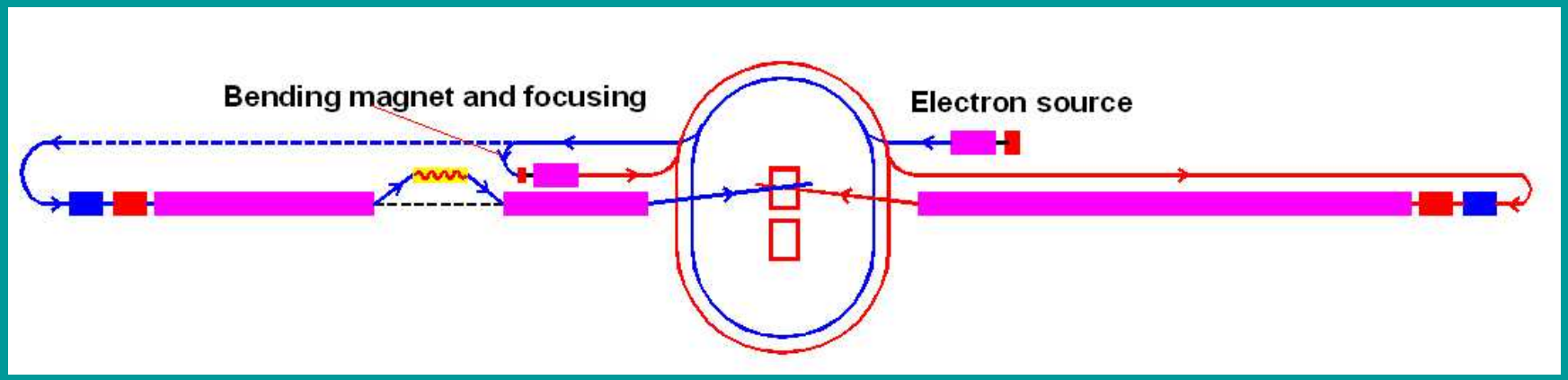
POSITRON SOURCE FOR ILC



Main advantage of this scheme is that it allows **POLARIZED** positron production

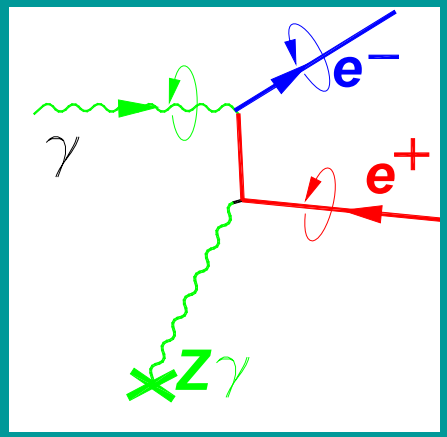
In principle, positrons could be generated by positrons, so the linacs become independent

Filling positron ring from electron source



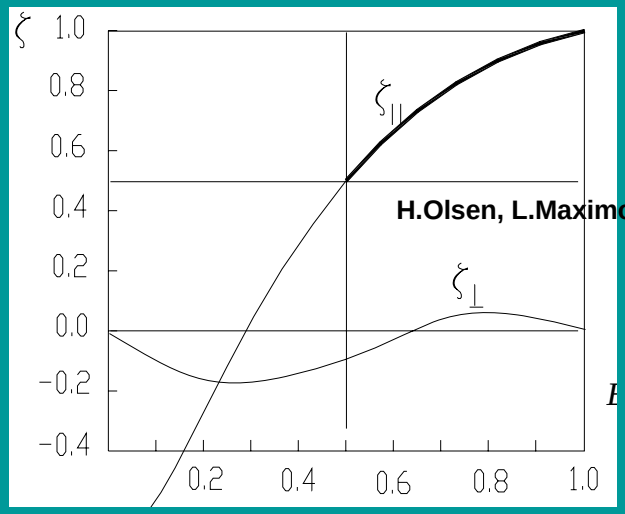
No special keep alive source required

(POLARIZED) POSITRON PRODUCTION



+cross diagram

Only gamma quanta can create positron (with electron)



Longitudinal polarization as function of particle's fractional energy $E^+/(E_\gamma - 2mc^2)$

Photon polarization

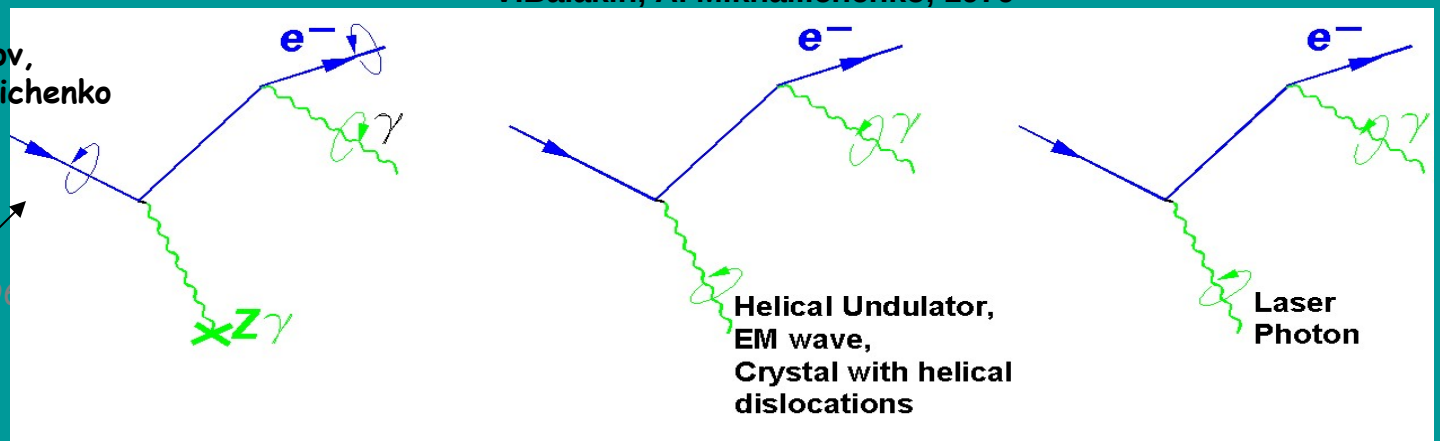
$$\vec{\varsigma} = \xi_2 \cdot \left[f(E_+, E_-) \cdot \vec{n}_\parallel + g(E_+, E_-) \cdot \vec{n}_\perp \right] = \vec{\varsigma}_\parallel + \vec{\varsigma}_\perp$$

Polarization is a result of selection positrons by theirs energy

The ways to create circularly polarized photons in practical amounts

V.Balakin, A. Mikhailichenko, 1979

E.Bessonov, A.Mikhailichenko 1996



E.Bessonov 1992

Polarized electron

Fragment from the V.E.Balakin, A.A.Mikhailichenko, "The conversion System for Obtaining Highly Polarized Electrons and Positrons", BINP 79-85, Sept. 13 1979.

energy interval of collected particles and limited efficiency of conversion gammas into pairs.

PRODUCTION OF CIRCULAR POLARIZED PHOTONS

The properties of non-coherent ondulator radiation are considered in detail in /4/. Circularly polarized photons are produced in helical fields of minimal period. Much more interesting is to obtain such fields with the help of the usual helical static fields and the electromagnetic waves. It may well be that the method of gamma production in helical crystals can be useful in future.

The main parameters for production of ondulator radiation are:

$$\beta_\perp = \frac{e H_\perp \lambda_0}{2\pi m c^2 \gamma}, \quad \Omega = \frac{2\pi c}{\lambda_0}, \quad K, \quad L$$

Fragment from the E.Bessonov's paper published in the Proc. 15 Int. Conf. on High Energy Accelerators HEACC'92 (1992) and Int. J. Mod. Phys (Proc. Suppl.) 2A .

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4. THE TYPES OF THE UNDULATORS

Below we should like to pay attention to some other types of the undulators [7-10].

1.The helical trajectories of particles are forming by the dynamic undulators - circular polarized electromagnetic waves. That is why we can use such waves emitted by the powerful lasers, free-electron lasers, klystrons and so on instead of the helical undulators.

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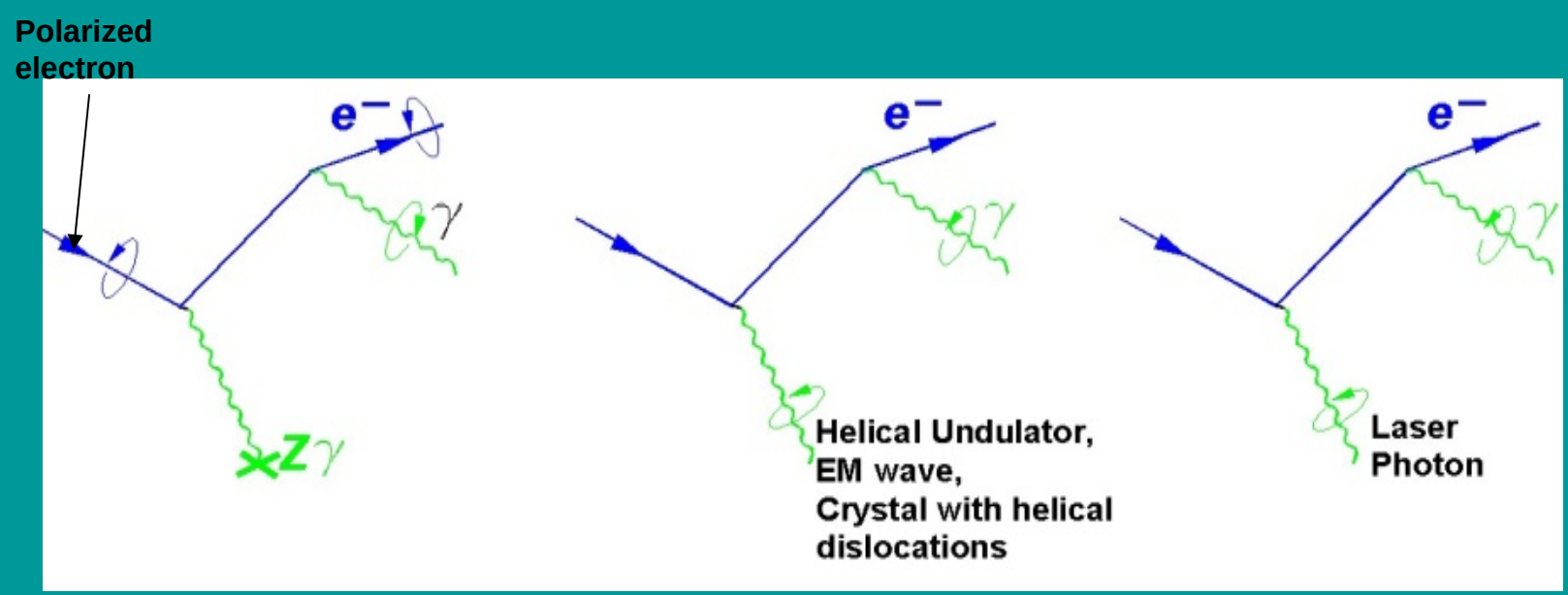
One can see that there was clear understanding that there is nothing special about laser radiation in comparison with EM waves

Practical application of a diagram with polarized electron

If stacking in DR is allowed, then one additional way becomes open for polarized positrons production



Efficiencies of these processes in comparison

$$N_\gamma \cong n_e \sigma_{e\gamma} L \cong \alpha r_0^2 Z^2 N_A \tau \approx 1$$

$$N_A = 6\ 10^{23}$$

$$N_\gamma \cong n_\gamma \sigma_{e\gamma} L \cong \alpha r_0^2 n_\gamma \sigma_z$$

$$n_\gamma \cong Q / \sigma_x / \sigma_y / \sigma_z / \eta\omega$$

Calculations show that efficiency ~3% is possible for the first process with positron polarization ~75%

No powerful lasers !

Calculations (B-M, EPAC96)

Number of photons radiated by electron having energy $mc^2\gamma$

$$\frac{dN_\gamma}{dE_\gamma do} \cong \frac{3\gamma^2}{2\pi}\frac{1+(\gamma\vartheta)^4}{\left(1+(\gamma\vartheta)^2\right)^4}\frac{dN_\gamma}{dE_\gamma}$$

Energy spectrum

$$\frac{dN_\gamma}{dE_\gamma} \cong \frac{\tau}{E_\gamma}$$

τ-thickness in X_0 units (~0.5 up to1)

Let η describes the geometrical efficiency of capture, then for η=0.3

$$N_+ / N_\gamma \approx \frac{7}{9}\cdot\tau\cdot\eta = \frac{7}{9}\cdot 0.5\cdot 0.3 \approx 0.11(11\%)$$

This factor 11%must be reduced by 1/3 –cross section difference from 7/9 , coming to 3%

For the number of positrons

$$N_+ \cong \frac{\tau^2}{2\ln(183Z^{1/2})}\begin{cases}\frac{19}{15}(1-\eta)^{5/2}, 0.89<\varsigma<1\\ 0.015+\frac{31}{40}(0.89-\varsigma), 0.11\le\varsigma\le 0.89\end{cases}$$

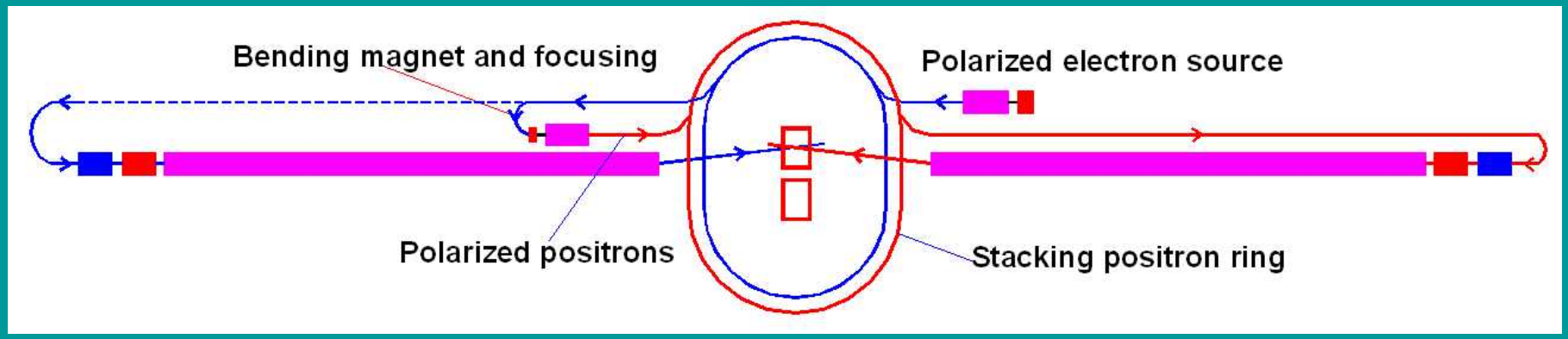
$$\varsigma = E_+ / E_{+\max}$$

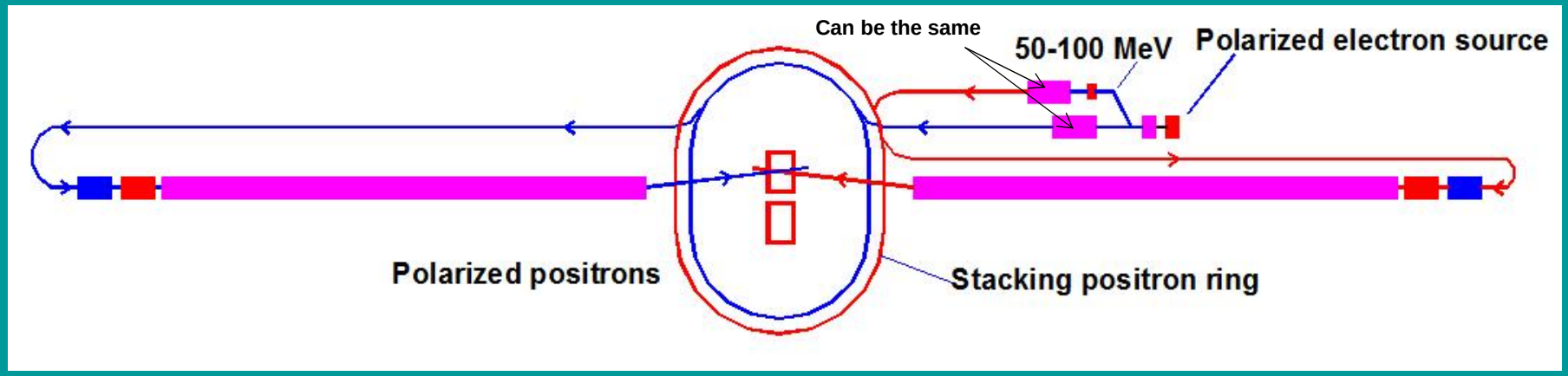
Finally $N_+ / N_e \approx 3\%$ (max)

So the number of electrons per positron required ~30 for each positron at the exit

1.5% guarantied with very modest parameters (1.5% is about maximum for Compton scheme)

POLARIZED POSITRON PRODUCTION WITH STACKING IN DR

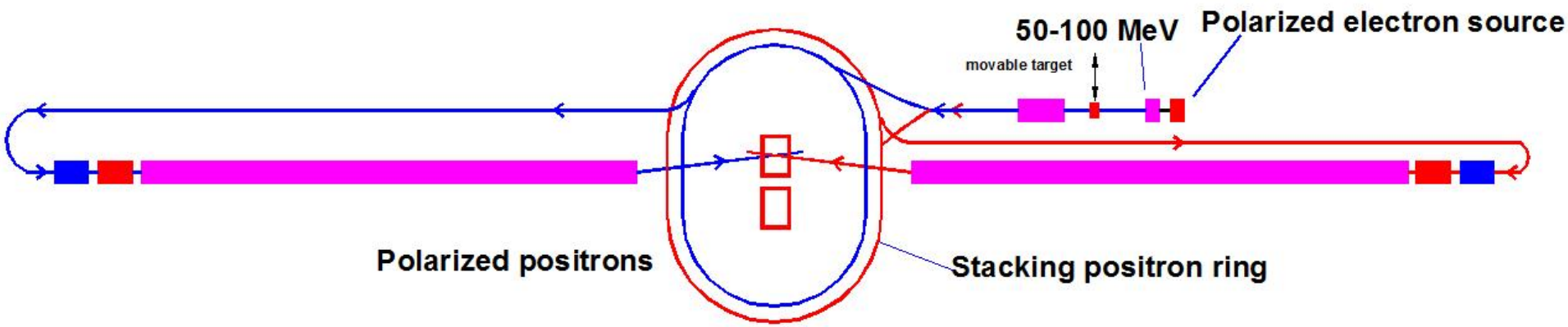




Power in a beam $P \cong 100MeV \times 2820 \times 5 \times 2 \cdot 10^{10} \times 30 \times 1.6 \cdot 10^{-19} \cong 130kW$

Power in a target $P \cong 2MeV \times 7 \times 2820 \times 5 \times 2 \cdot 10^{10} \times 30 \times 1.6 \cdot 10^{-19} \cong 7kW$

Finally, Scheme for polarized positron generation



Basically this is a ***conventional*** scheme with stacking

However, the Undulator-based scheme remains more advantageous

E.A.Bessonov, A.A.Mikhailichenko: THP071, EPAC 1996, Barcelona, June 9-14.

Potylitsin send his paper in NIM later, than it was published in EPAC 96 proceedings:

A.P.Potylitsin, NI&M A 398(1997) 395-398, Received 18 December 1996; in revised form 27 May 1997.

Conclusions

Direct polarized positron production from polarized electrons can be foreseen as a showstopper for so-called Compton scheme:

efficiency is the same (even better), but no powerful lasers required at all;

can start at low energy (≥50MeV)

Undulator based scheme of photon production more practical for the purposes of (polarized) positron generation:

This conclusion remains the same since the time of EM wave undulator considered in comparison with the static field one