STATUS AND PLANS OF CORNELL UNDULATOR PROTOTYPING

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ILC meeting, November 6-10, Valencia, Spain

The main results obtained at Cornell reported at Vancouver

Tested 10 and 12 mm period undulators, ~40 cm each; 54 filament NbTi wire

Reached K=0.36 and K=0.72 respectively for the aperture available for beam 8 mm

Soon will be tested undulators with 56 filament wire, 6 layers and radial sectioning; expected gain ~25% for the same aperture 8 mm

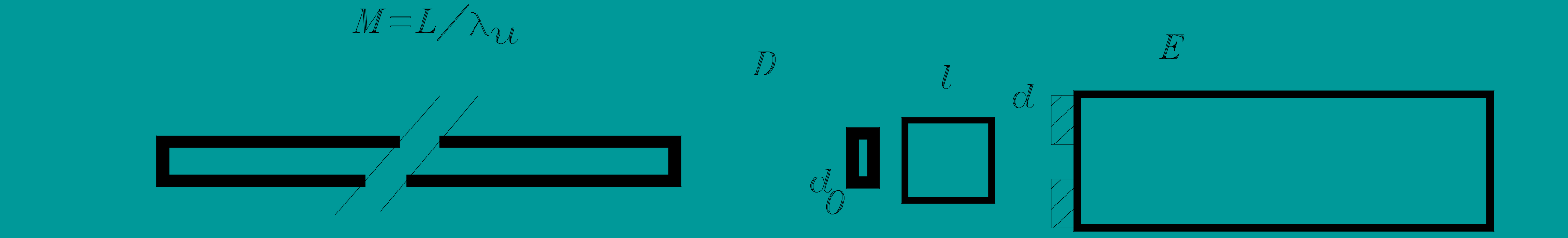
(NOW Reached K=0.42 for period 10 mm without radial sectioning)

6-m long Undulator module fabrication and its test is a priority job

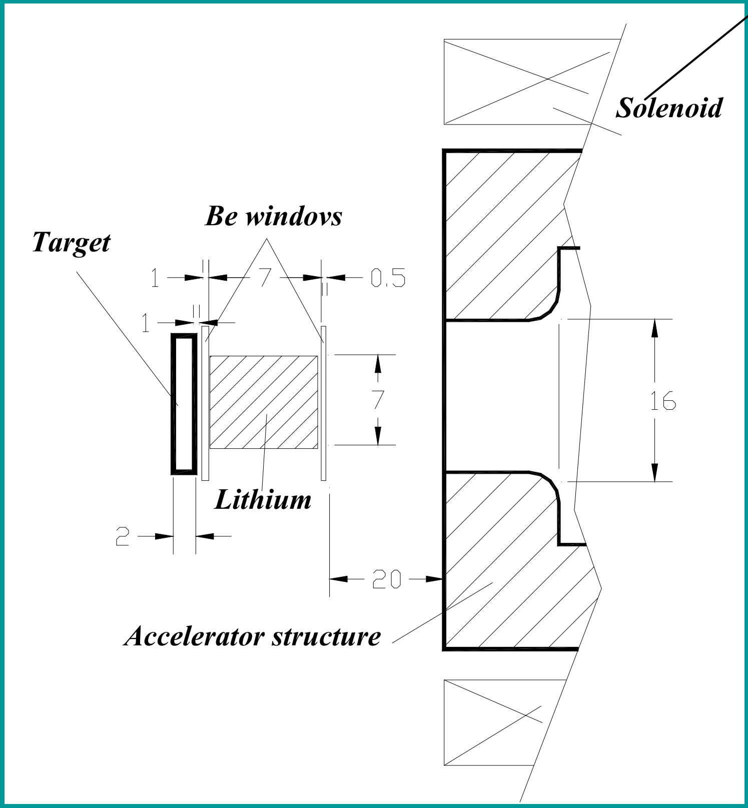
For all elements of positron production scheme we have original design, effective and compact

Target, collection optics and spin handling are in scope of our interest

START TO END SIMULATION OF CONVERSION (1986)



Length of undulator, beta-function, emittance, period, distance to the target, radius of target, parameters of Lithium lens, diameter of diaphragm, accelerating field



Beam energy …………….	150 GeV
Length of undulator…….	150 m
Period…………………….	7 mm
K^2 ……………………….	0.1
ge_x………………………..	3 10^{-5} m rad
$b_{undulator}$ …………………..	400 m
Distance to the target…..	180 m
Radius of target ………..	1mm
Positrons/Electron …….	1.5 (3)
Polarization …………….	70% (50% for yield 3)

These numbers can be considered as a base

Some latest improvements allow to relax these conditions~30% (higher K)

Multiple targets allow reduction of the undulator length in half

GENERAL CONCLUSIONS SINCE THAT TIMES:

- **150 GeV is optimal for the maximum yield**
- **K~0.35 is the best for polarization/yield ratio**
- **Engineering design of undulators is feasible**

  SC and pulsed undulators were tested
- **The spin handling is guaranteed**

We are working on re-checking of these results

ILC Beam parameters

$g e_x$=8 10^{-6} m rad -high edge
$g e_y$=8 10^{-8} m rad –high edge
b_x ~200 m

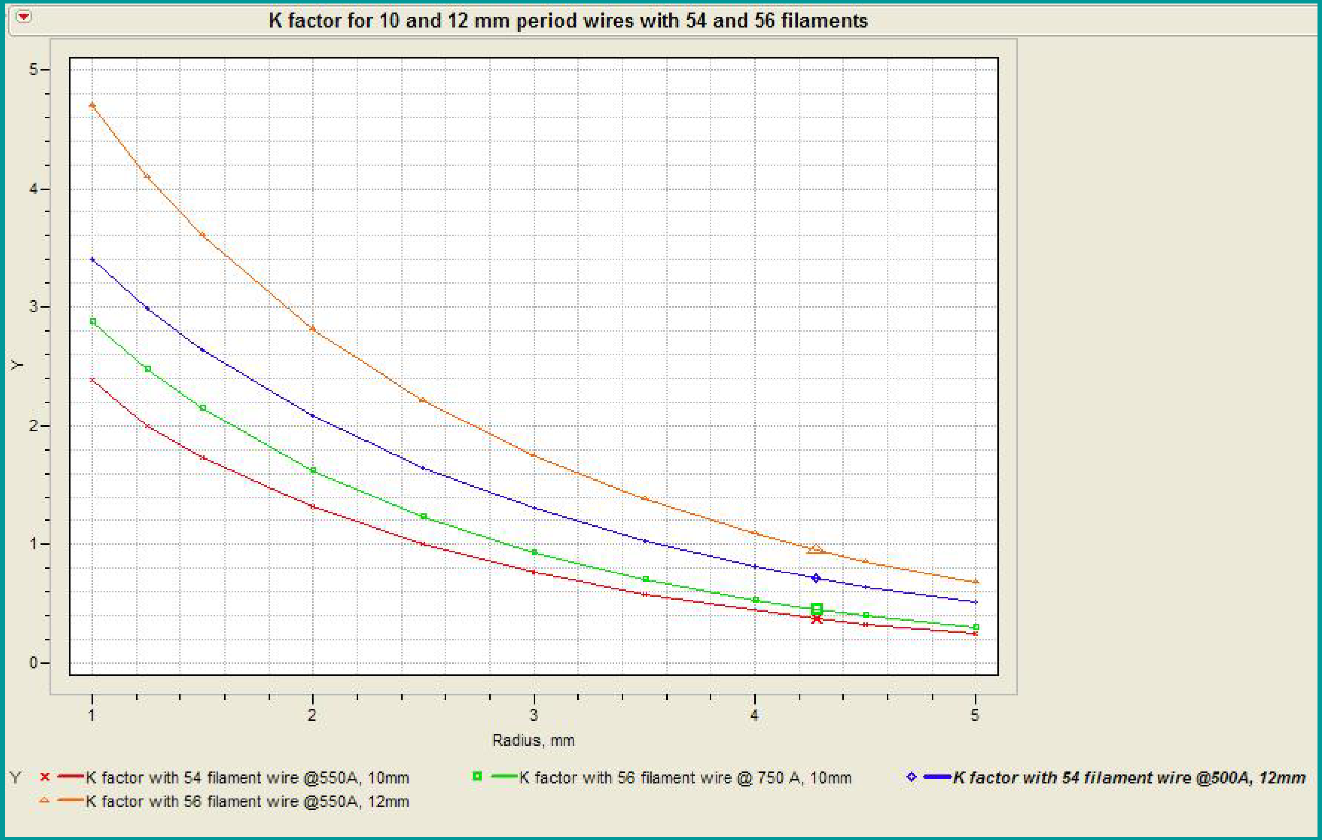
Angular spread in radiation	$\alpha \sim \sqrt{1+K^2} / \gamma$	$3 \cdot 10^{-6}$ $(K=1)$
Angular spread in beam, vert.	$y' \cong \pm\sqrt{\gamma\varepsilon_z / \beta\gamma}$	$3.5 \cdot 10^{-8}$
Angular spread in beam, rad.	$y' \cong \pm\sqrt{\gamma\varepsilon_z / \beta\gamma}$	$3.5 \cdot 10^{-7}$
Radius of helix	$a \cong \lambda\!\!\!^{-}_u K / \gamma$	$5 \cdot 10^{-7} cm$ $(K=1)$
Beam size, vertical	$\sqrt{\langle y^2 \rangle} \cong 2 \times \sqrt{\gamma\varepsilon_y \beta / \gamma}$	$1.4 \cdot 10^{-3} cm$
Beam size, radial	$\sqrt{\langle x^2 \rangle} \cong 2 \times \sqrt{\gamma\varepsilon_x \beta / \gamma}$	$1.4 \cdot 10^{-2} cm$

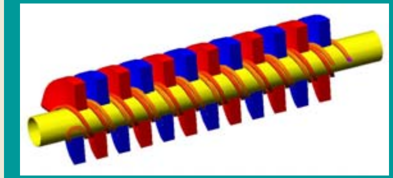
50 sigma ~7 mm ; At the beginning of operation one can expect emittance degradation

That is why we have chosen as big aperture as possible -- Ø8 mm clear.

This 8 mm diameter allows K~0.4

K factor as function of radius of undulator chamber

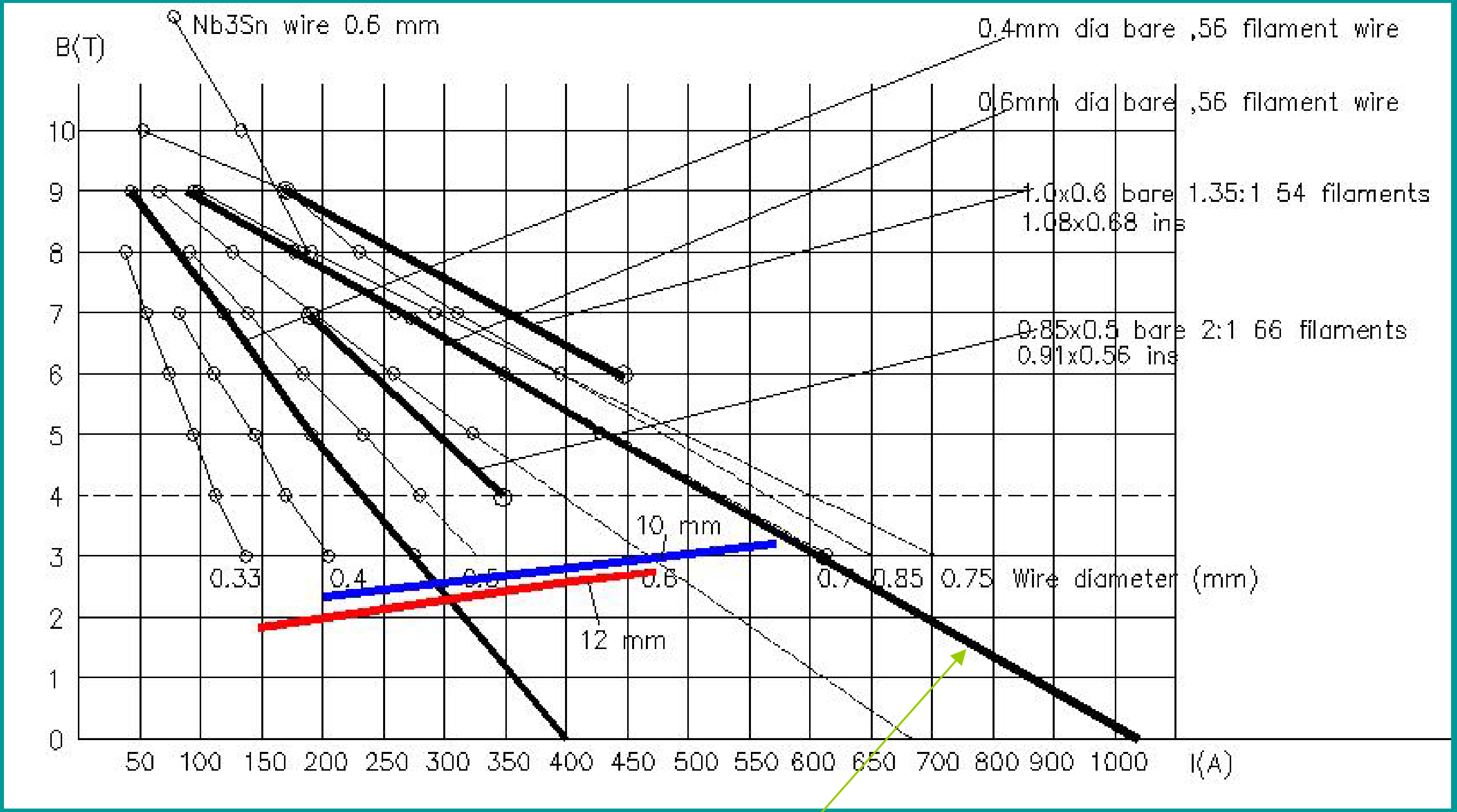




NbTi wire 56 filaments demonstrate best properties

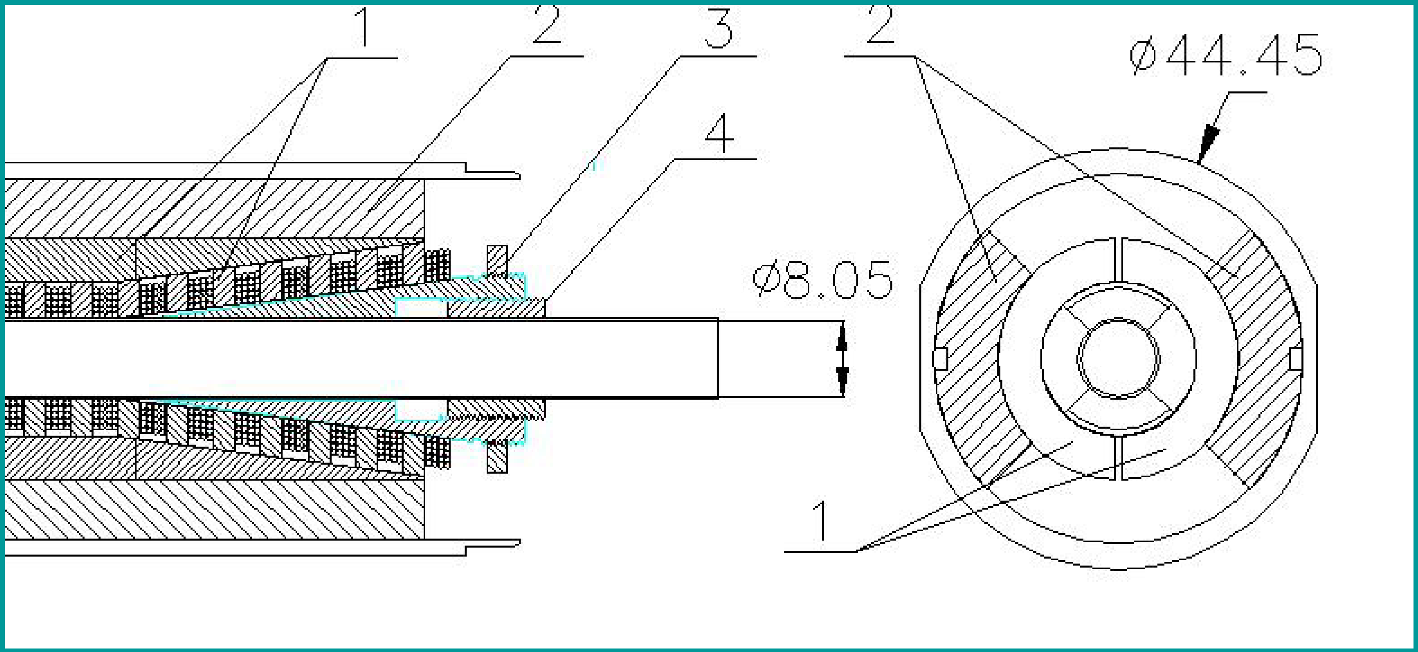
Sectioning coil in radial direction allows further enhancement

Wires for undulator



Nb3Sn wire investigated-baked and prepared;
All undulators so far made with wire Ø0.6 mm bare (54 and 56 filaments);
56 filament NbTi found the best;

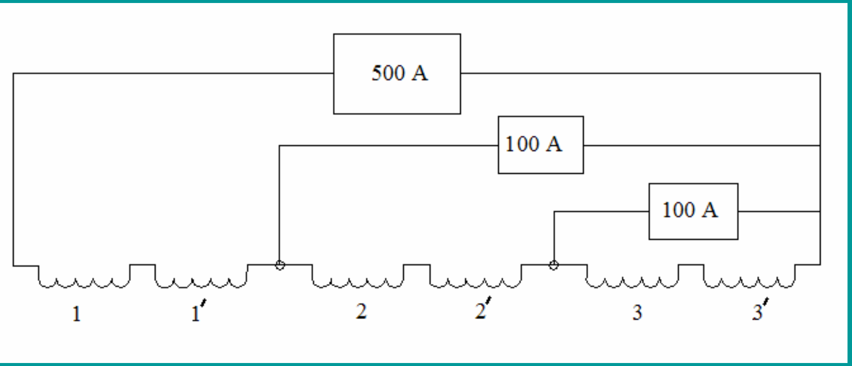
Cornell Undulator design

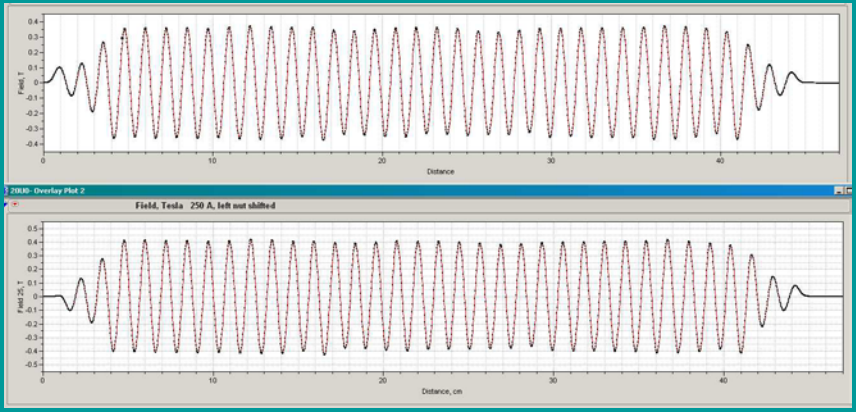


Details of design. 1–Iron yoke, 2–Copper collar, 3, 4–trimming Iron nuts. Inner diameter of **Copper** vacuum chamber is 8mm clear.

Period kept even

10 and 12 mm period undulators will have sectioned coils





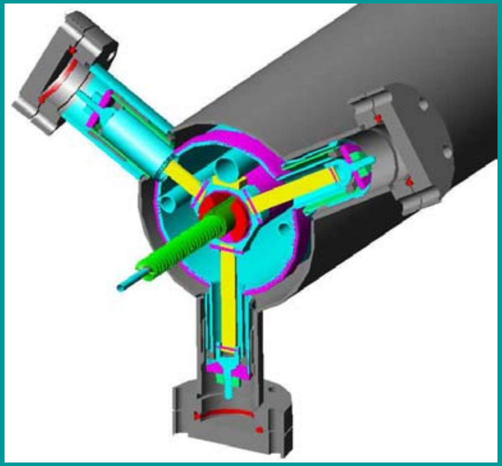
10 mm undulator operated with 500+50 A. 4x6 wires

For the moment 12 mm undulator feed with one PS; 5x6 wires, have room 6x6 wires (done 6x5)

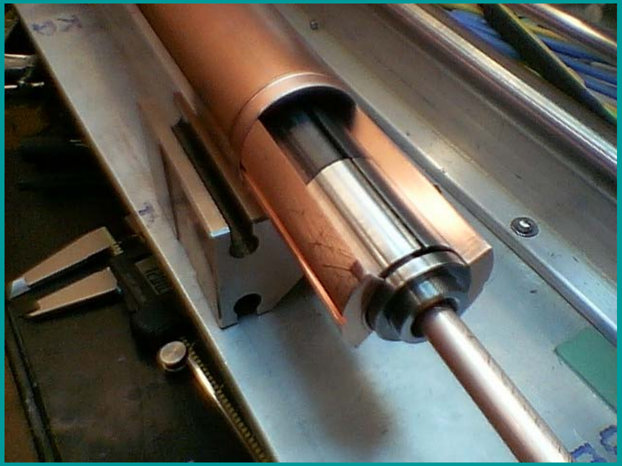
In a future there will be 3 PS for coils sectioned in radial direction (now-- two)

Undulator magnets with10 mm period, 8 mm clear aperture ready for insertion in cold mass case

Cold mass case has diameter 1.5”

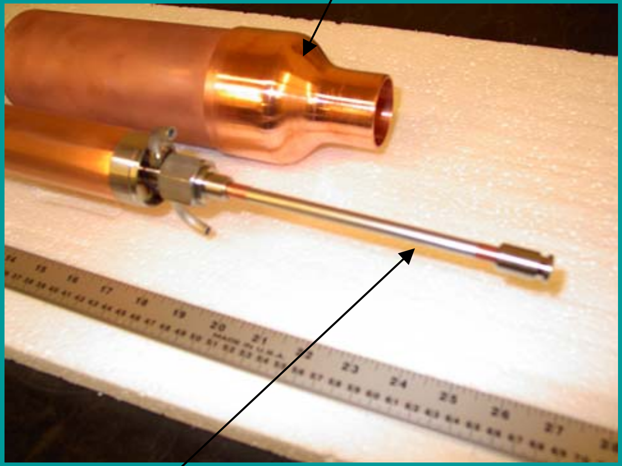


Cold mass support



End windings

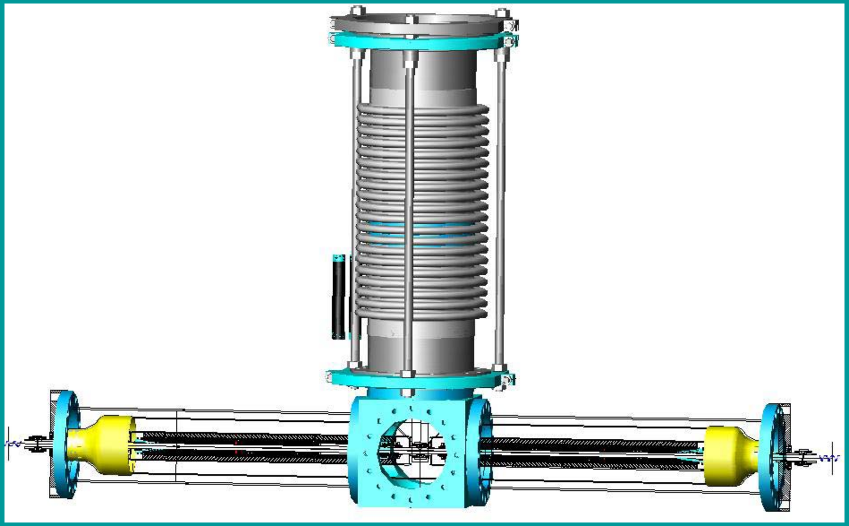
70K shield elements



StSteel tube to room temperature

FY2008 Project Activities and Deliverables

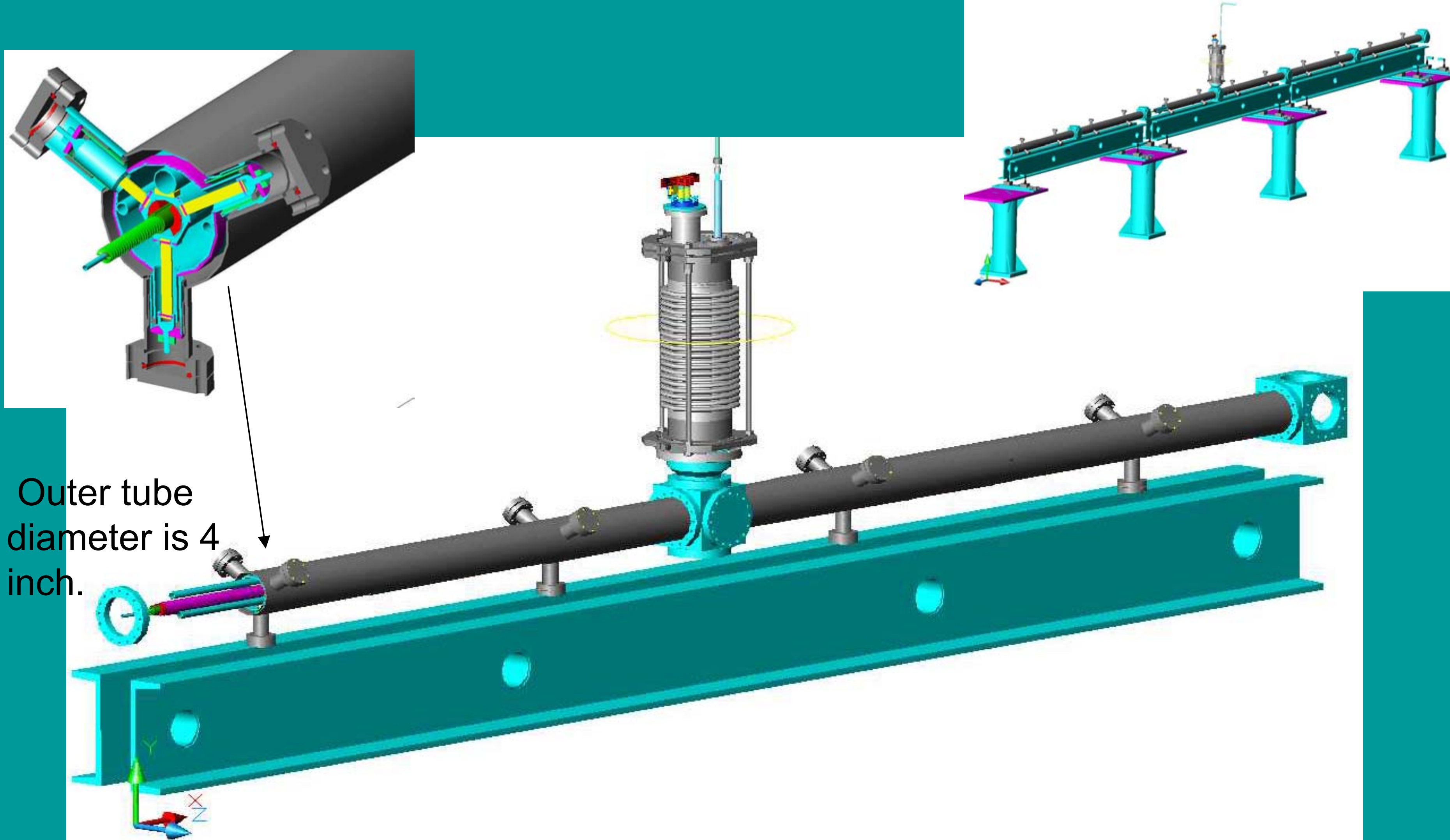
Optimization of prototype(s) having 8 mm aperture and 10 mm period. Calculations of emittance and alignment perturbations in the undulator will be completed in this year. Materials and equipment required for fabrication and test of 2x30 cm long models will be obtained and used for prototype shown in Figure below



Sketch of the Prototype what will be fabricated. Walls and some elements of LHe input are not shown. Undulator cold masses have been fabricated. This model will have all elements similar to the in fully equipped 6-m long section except the length of cold mass.

FY2009 Project Activities and Deliverables

Fabrication and assembling the 4-6-m long section will be accomplished in this year.
Design of Hall probe system for the field measurements in 6-m long module will be accomplished.
Note that the field measurements must be done in vacuum at cryogenic temperature.



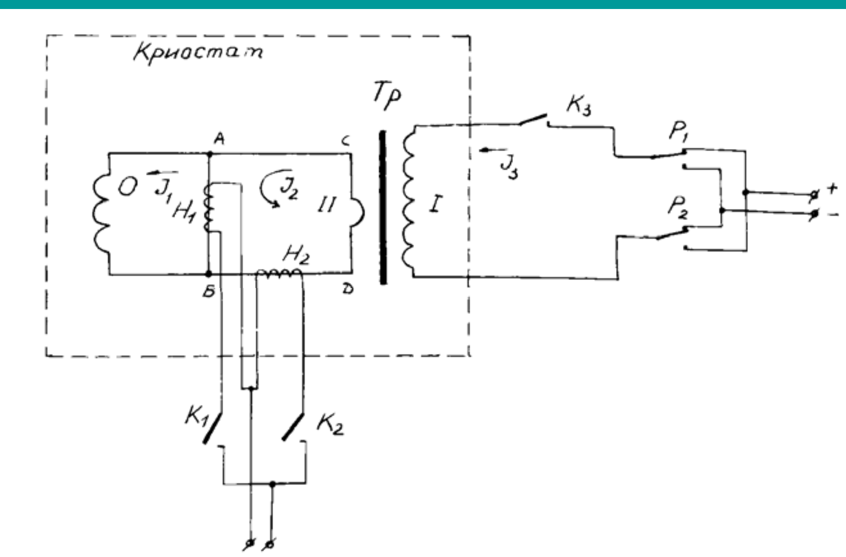
Cryomodule, 4-6 m—long. Cryostat contains two 2-3 m–long identical sections having opposite polarity. This delivers zero first integral along this module.

$$I^1_{x,y} = \int_{-\infty}^{+\infty} H_{x,y}(s)ds = 0$$

Assembling the short prototype with existing cold masses shown earlier

Plan is to test SC transformer scheme

This scheme used in 1986 to feed SC undulator



Scheme allows to work with captured flux

Two-year Budget, in then-year K$

Item	9/07-8/08	9/08-8/09	Total
Other Professionals	31.0	32.55	63.55
Graduate Students	21.8	23.762	45.562
Undergraduate Students	5.0	5.250	10.25
Total salaries and Wages	57.8	61.562	119.362
Fringe Benefits	10.23	10.742	20.972
Total Salaries, Wages and Fringe Benefits	68.03	72.304	140.334
Equipment	25	49	74
Travel and transportation	7.5	7.5	15
Materials and Supplies	30	45	75
Other direct costs	19.528	21.286	40.814
Subcontract	0	0	0
Total direct costs	153.33	195.089	345.147
Indirect costs	62.263	73.634	135.897
Total direct and indirect costs	212.321	268.723	481.044

Aperture available for the beam is 8 mm in Ø clear

Wire – Ø0.6 **mm bare**

Coil not sectioned

OFC vacuum chamber, RF smooth

SC wire	54 filaments	56 filaments	
# layers	5 layers	6 layers	6 layers+sectioning
λ=10 mm	K=0.36(tested/calculated)	K=0.42(tested/calculated)	K≈0.5 (calculated)
λ=12 mm	K=0.72(tested/calculated)	K≈0.9(calculated)	K≈1.1 (calculated)

For aperture diameter 5mm we expect period 8mm and K=0.4

CONCLUSIONS

Tested 10 and 12 mm period undulators, aperture 8 mm, ~40 cm each;

Reached K=0.42 and field longitudinal profile measured with 56 filament wire for 10 mm period;

K=0.72 (54 filaments) reached and measured for 12 mm period undulator
Radial sectioning will be implemented in the following models

According to our calculations these parameters satisfy requirements of ILC; Change of ILC parameter list required

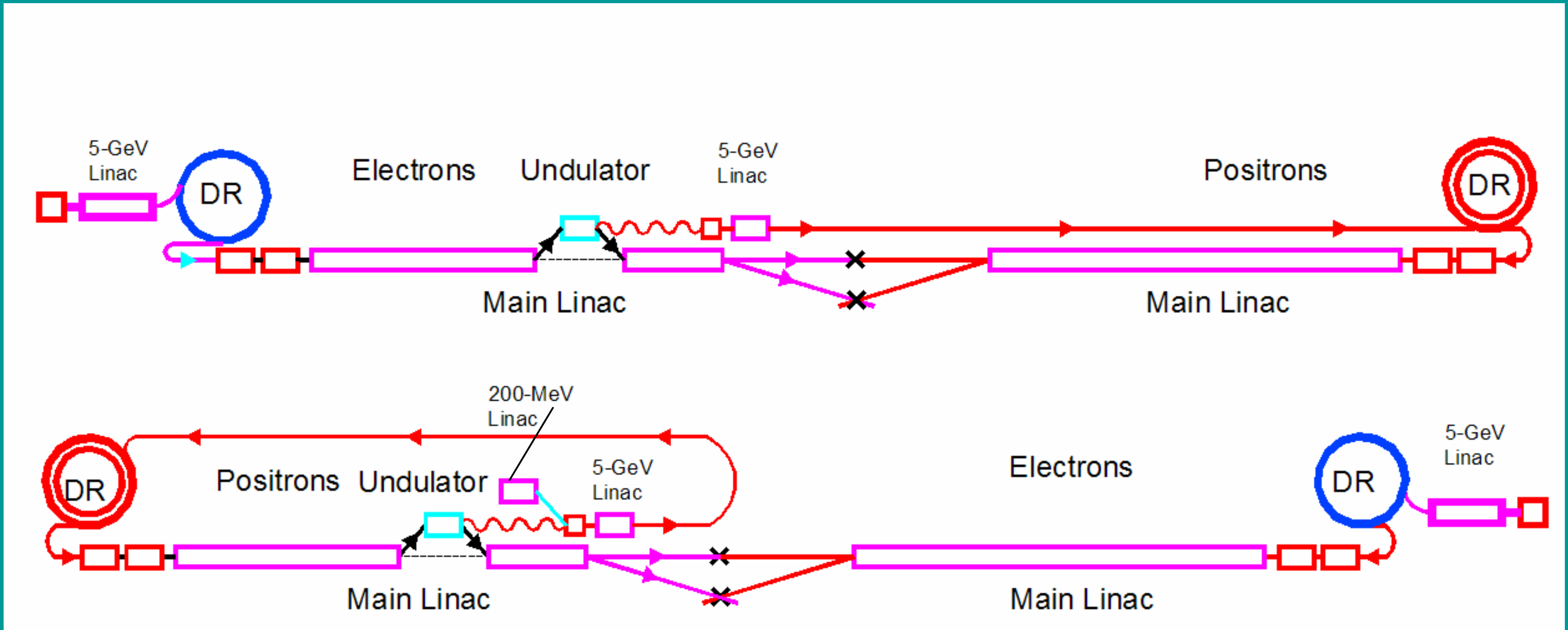
4-6-m long Undulator module fabrication and its test is a priority job;
Funding requires to accomplish this stage

Target, collection optics and spin handling are in scope of our interest

For all elements of positron production scheme we have original design, effective and compact

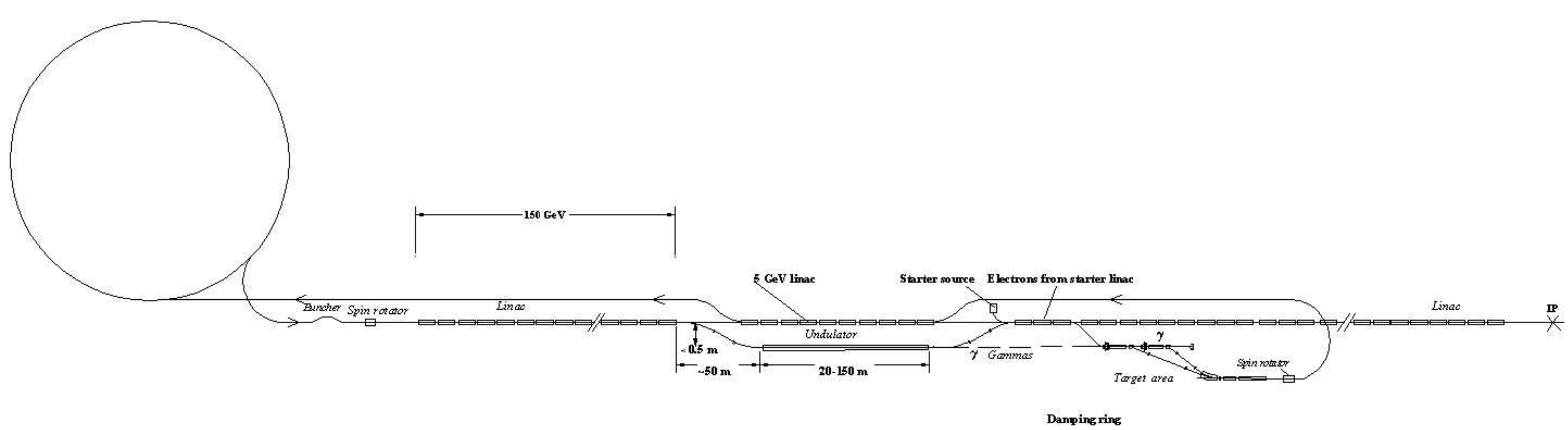
Back-up slides

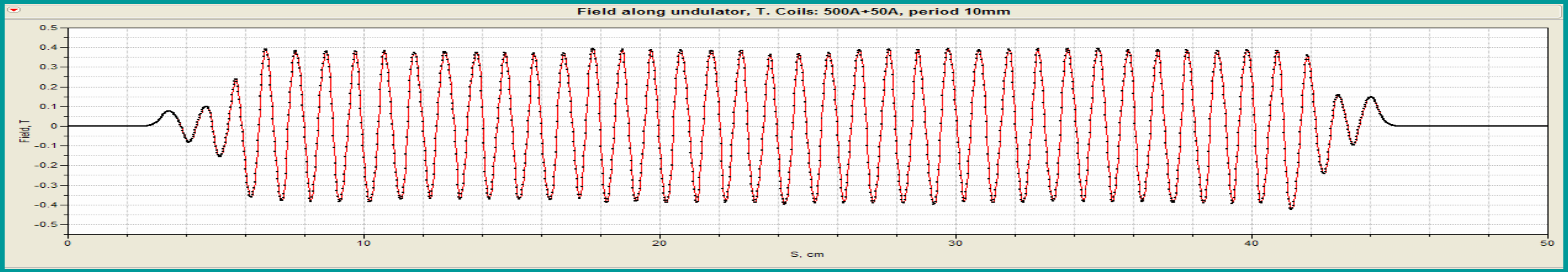
Independent positron/electron operation



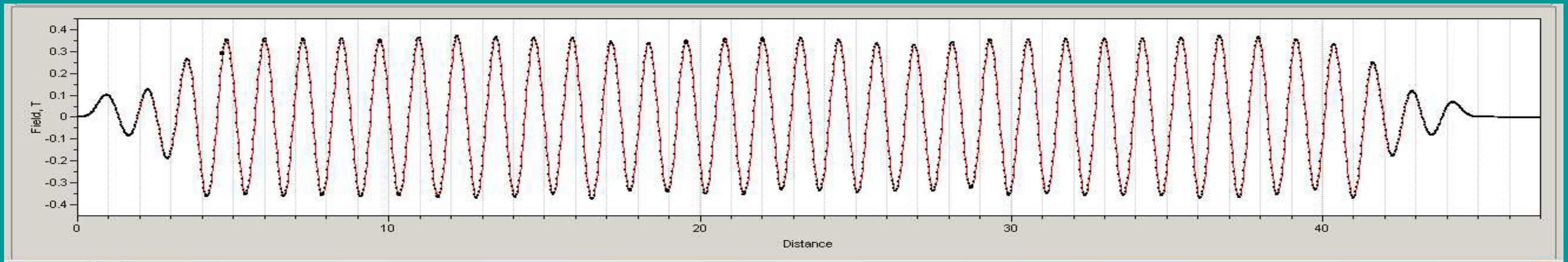
Positron wing of collider can operate independently from electron one, thanks to the presence of **fast feedback and starter source**.

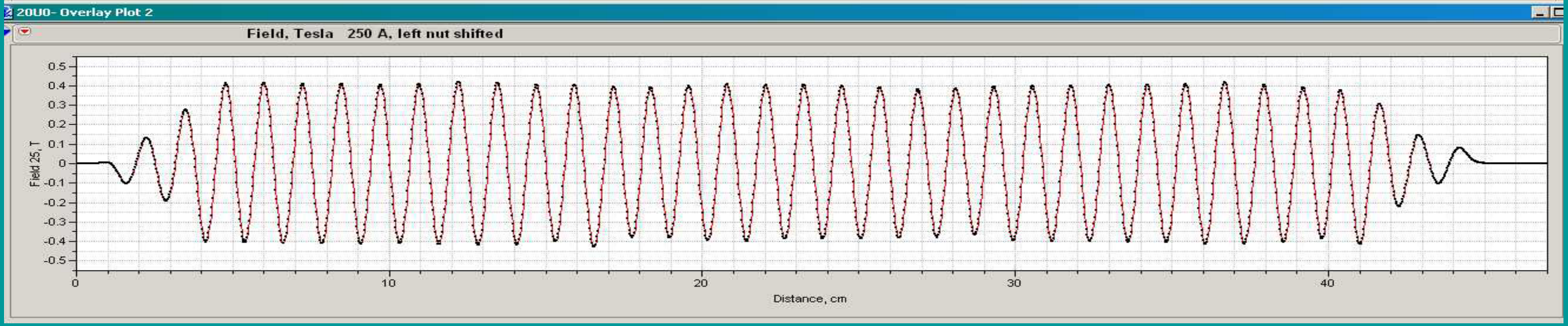
Detailed scheme for independent operation of electrons/positrons at ILC





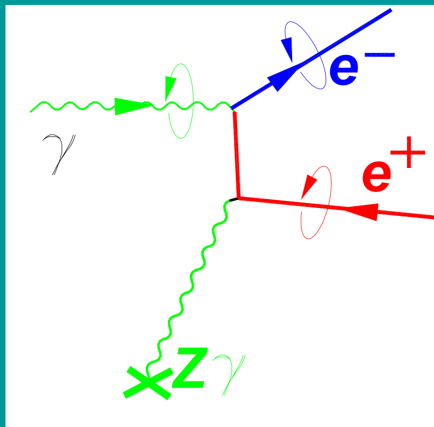
Longitudinal field profile for 10-mm period undulator measured with Hall probe. Current in main PS 500A, K=0.36



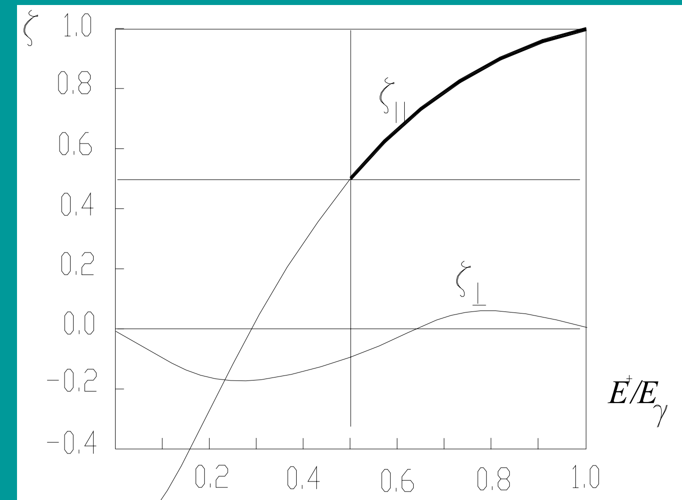


Longitudinal field profile for 12 mm period; left nut is in different position. Current in PS 250A, (maximal -530A)

Polarized e± production



The way to create circularly polarized positron, left. Cross-diagram is not shown. At the right–the graph of – longitudinal polarization – as function of particle's fractional energy

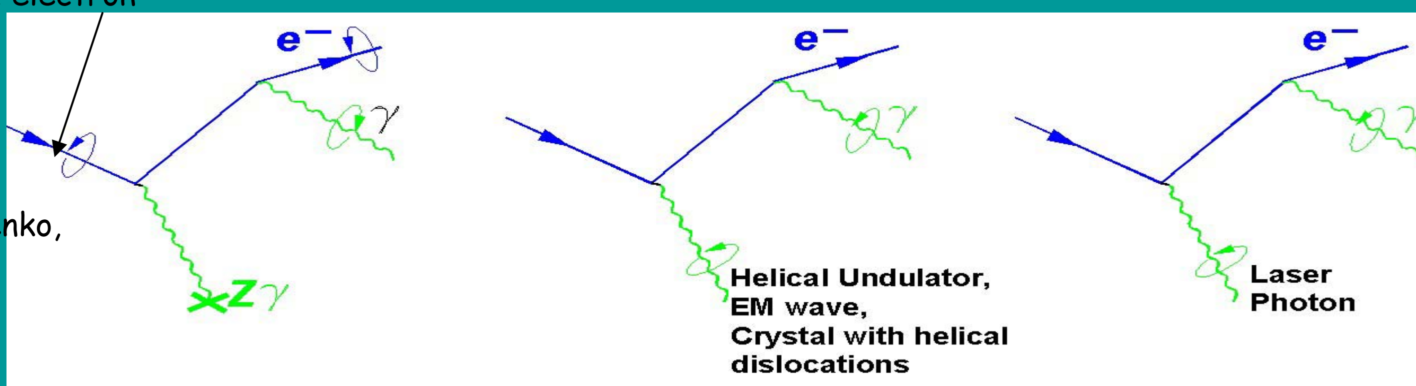


The way to create circularly polarized photon

V.Balakin, A. Mikhailichenko, 1979

Polarized electron

E.Bessonov, A.Mikhailichenko, 1996



E.Bessonov 1992

Polarization of positrons is a result of positron selection by energy

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