POSITRON SOURCES FOR LINEAR COLLIDERS
IHEP-IN2P3 COLLABORATION

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(Presentation of R.Chehab)

POSITRON SOURCES FOR LINEAR COLLIDERS

- **INTRODUCTION**
- **Research and development on polarized and unpolarized positron sources dedicated to the future linear colliders (ILC &CLIC) have been operated in many laboratories. The choice made by both groups belonging to IHEP and IN2P3 was to develop the Compton scheme for the polarized source and the so-called hybrid scheme for the unpolarized source. The latter uses an axially oriented monocrystal target to generate channeling radiation and an amorphous target to materialize the photons into electron-positron pairs. Collaboration of both groups with KEK (Tsukuba), BINP (Novosibirsk) and more recently with CERN has been running on. The main activities of the two groups, for these items, are presented hereafter.**

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- **PLAN**
- **1- THE POLARIZED POSITRON SOURCE (Compton Scheme)**
- *** Activity at IHEP**
- *** Activity at IN2P3 (LAL, IPNL with collaboration with V.M.Strakhovenko [BINP])**
- **2- THE UNPOLARIZED POSITRON SOURCE (Hybrid Scheme)**
- *** Activity at IN2P3 (LAL and IPNL) in straight collaboration with BINP (V.M.Strakhovenko)**
- *** Perspectives of collaboration between IN2P3 and IHEP with a PhD fellowship**

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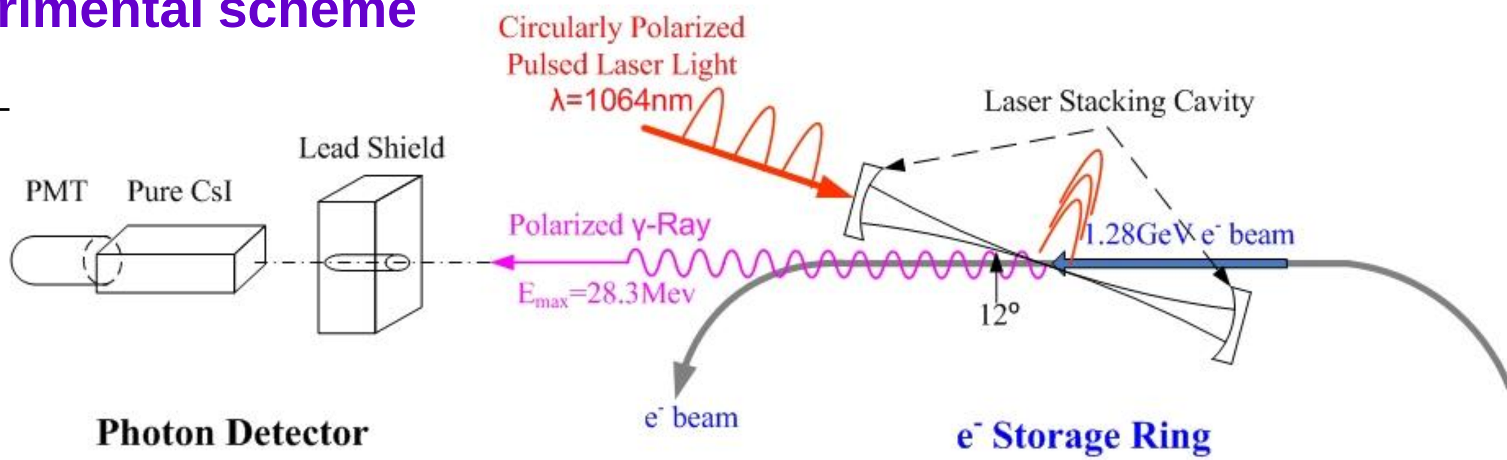
- **1- THE COMPTON SCHEME**
- **1-1 THE IHEP ACTIVITY IN COLLABORATION WITH KEK**
- **for the polarized γ rays generation**
- **Xiaoping LI participated at KEK to the activities on the optical stacking cavity on ATF**

Polarized gamma-rays generation experiment on KEK-ATF

Experimental scheme



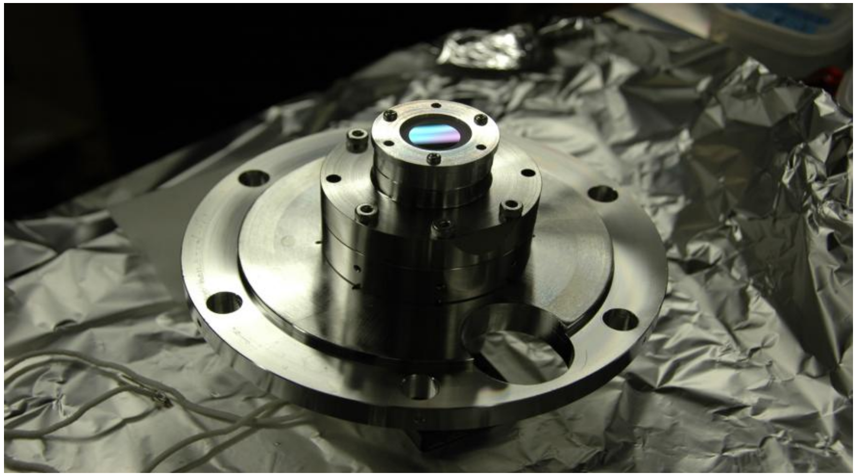
Parameters of laser, electron beam and optical stacking cavity

Laser Light		Electron Beam		Optical Stacking Cavity	
Type	YAG(1064nm)	Energy	1.28GeV	Cavity Length	420mm
Frequency	357MHz	Bunch Size	σ_x=78μm	Mirror Curvature	210.5mm
Power	10W(28nJ/pulse)		σ_y=6μm	Mirror Reflectivity	99.6%
Pulse Width	7ps(FWHM)	Emittance	$\varepsilon_x=1.0\times10^{-9}$ m rad	Design Finesse	780
Polarization	500:1		$\varepsilon_y=0.5\times10^{-11}$m rad	Waist Size	30μm

Polarized gamma-rays generation experiment on KEK-ATF

Laser optical stacking cavity

Quarter-wave-stack dielectric mirror



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- **1-2 ACTIVITY IN IN2P3 ON COMPTON SCHEME**
- **This activity is developed in collaboration with Prof. Strakhovenko from BINP.**
- **Simulations have been operated with the following hypotheses:**
- **- Interaction between a 1.8 GeV electron beam provided by an ERL**
- **(Energy Recovery Linac) and a Nd:YaG laser beam in 5 Fabry-**
- **Perot cavities.**
- **- The photons resulting from Compton interaction impinge on a thin**
- **W target (0.4 Xo)**
- **- The positrons generated are captured in an Adiabatic Matching**
- **Device (AMD) providing a large momentum acceptance**
- **- The positrons are accelerated up to 5 GeV before injection in DR**

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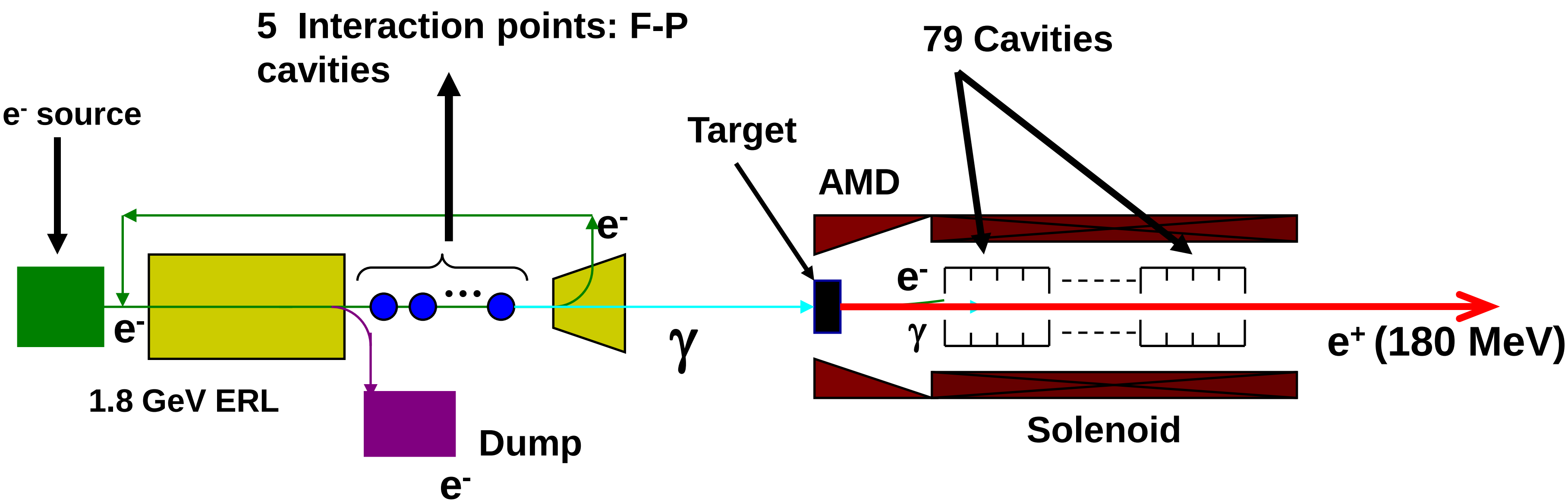
Scheme of the Capture Section (up to 180 MeV)



A. Vivoli, Capture and Transport Simulation of Positrons...
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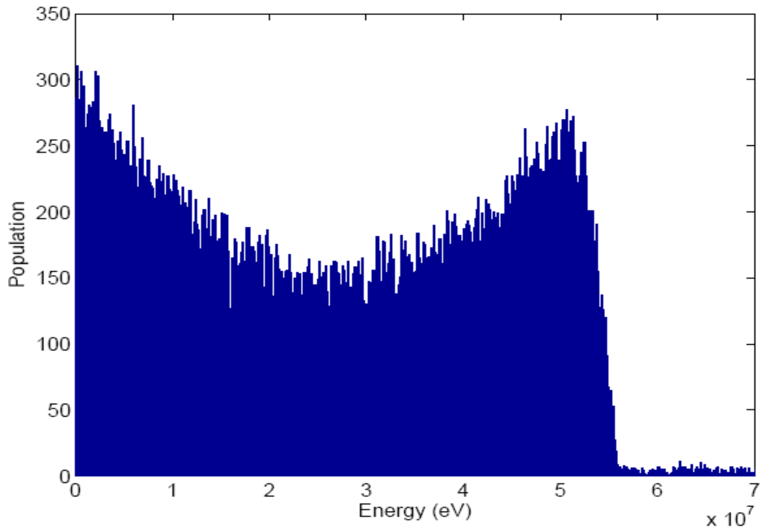
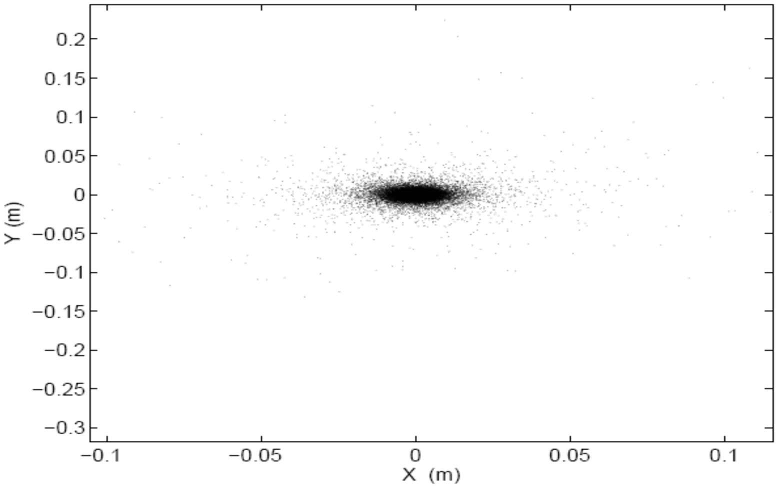
Simulation (CAIN)

Photons

Mean Energy : 27,7 MeV Number of photons simulated : 75177 10^5





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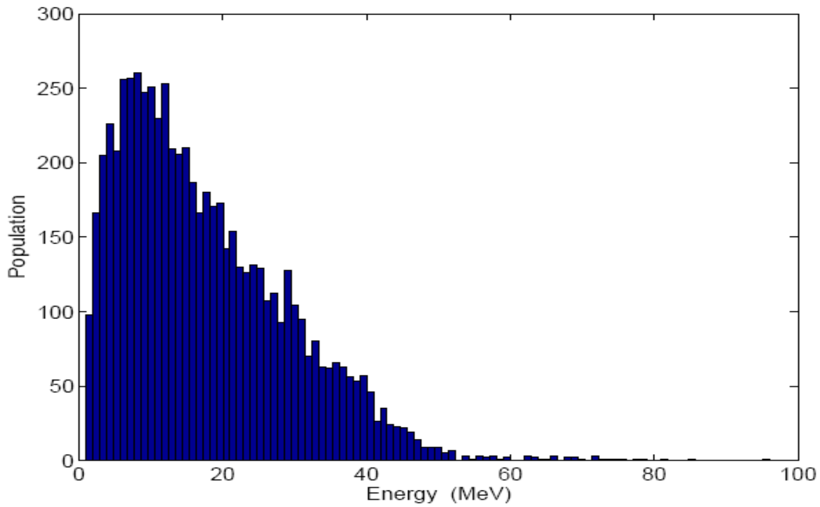
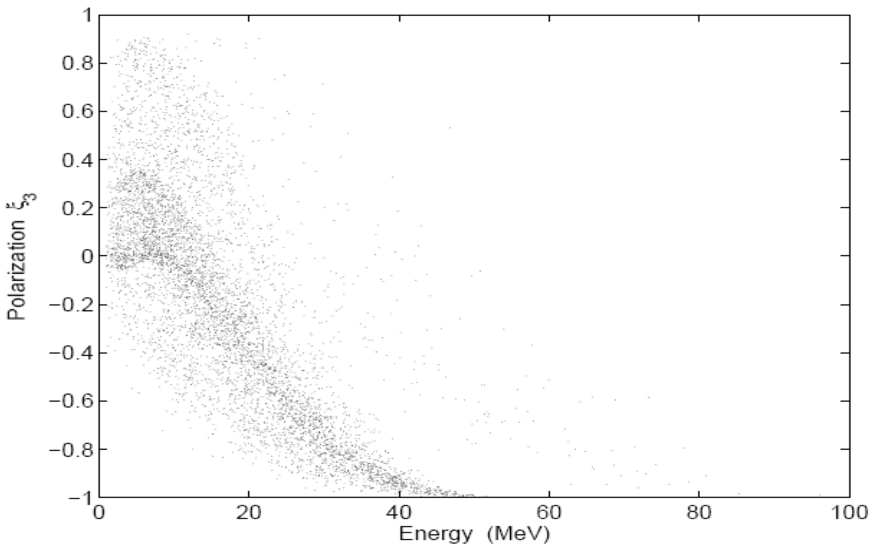
Positron Production (EGS)

- Number of e^{+}: 6470 10^5
- Mean energy : 17.627 MeV
- Polarization : 21%





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Beam parameters

Parameters of the positron beam at the exit of the target (z = 0 cm) and at the exit of the AMD (z = 50 cm)

	N. e^+ 10^5	ε_x (rms) p mm mrad	ε_y (rms) p mm mrad	<E> MeV	σ_E MeV	σ_z (rms) mm
Z = 0	5499	1807(*)	2444(*)	19.35	11.69	0.31
Z = 50	2866	434 (**)	433(**)	20.15	11.08	7.9

Capture percentage : 52,12 %

(*) emitted; (**) accepted

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- **2- THE UNPOLARIZED POSITRON SOURCE**
- **THE HYBRID SCHEME (IN2P3 with BINP)**
- **The scheme is based on the generation of a high yield of photons by channeled electrons along a crystal (W) axis. The photons are, then, directed to an amorphous W target where a large number of e+e- pairs are created. The positrons are, like in the Compton scheme, captured by a matching lens (AMD) and, then, accelerated up to 5 GeV [or 2.4 GeV for CLIC]**
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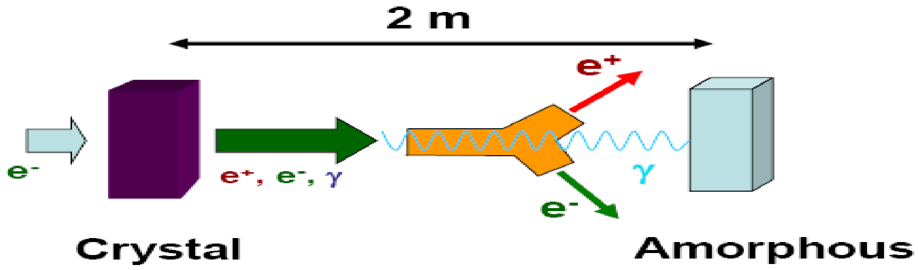

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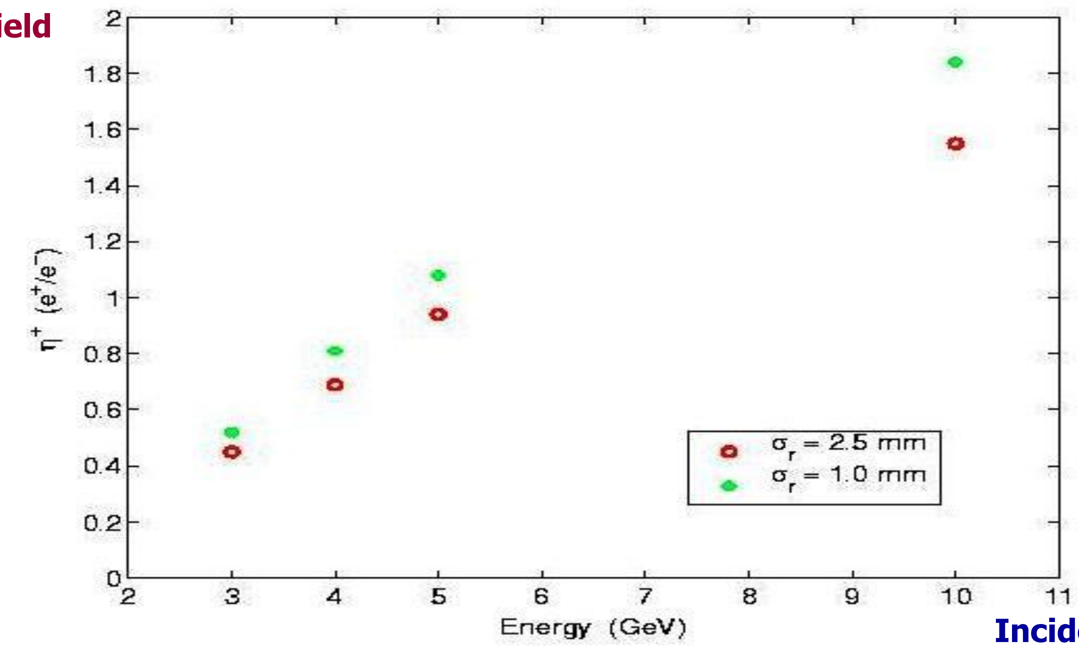
- **POSITRON YIELD FOR DIFFERENT INCIDENT ENERGIES**
- **Two rms radius values for the incident e- beam: 1 and 2.5 mm**

Accepted yield



Incident energy

The yield values are associated to hybrid sources defined above:10 GeV/1mm crystal & 8mm am. 3, 4, 5 GeV/ 1.4 mm crystal & 10mm am.

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- **INCIDENT BEAM:** an incident electron beam of 10 GeV
- **TARGETS:**
- **CRYSTAL:** a 1 mm thick W crystal <111> orientation
- **AMORPHOUS:** a 8 mm thick amorphous target
- **CAPTURE SYSTEM:** AMD with decreasing field from 6 to 0.5 Tesla on 50 cms
  Accelerating field is 18 MeV/m, peak [SW]
- **RESULTS:** accepted yield: 1.8 e+/e- (σ^-=1mm)
- 1.5 e+/e- (σ^-= 2.5 mm)
- **PEDD:** assuming an incident e- bunch of 2. 10^{10} e-

	crystal		amorphous	
	PEDD/e-	PEDD/bunch	PEDD/e-	PEDD/bunch
σ^-=1mm	2 GeV/cm3	0.33 J/g/bunch	7.5 GeV/cm3	1.25 J/g/bunch
σ^-=2.5mm	0.35 GeV/cm3	0.058 J/g/bunch	2 GeV/cm3	0.33 J/g/bunch

- **It is quite clear that the hybrid target cannot sustain the 2820 bunches and that distributed targets system must be considered.**

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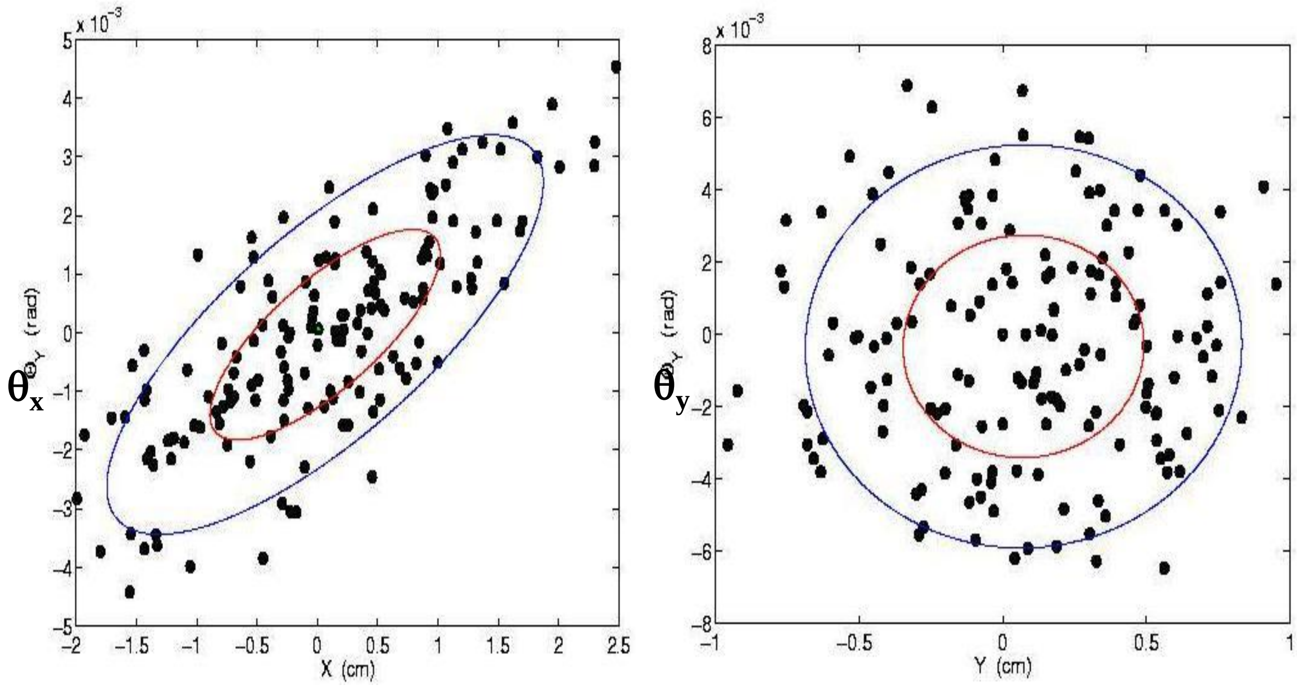
- **TRANSVERSE EMITTANCES AT ILC PREACCELERATOR @ 270 MeV**
- **(σ^{-}=2.5 mm)**



Blue: 80%
Red: rms

ε_x=11π mmmrad
ε_y= 12 πmmmrad

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- **THE PROBLEM OF PEDD**

- **The local and almost instantaneous energy deposition in a target (for instance during a pulse duration) may be very critical for the target survival. Indeed, due to inhomogeneous energy deposition in the target, thermal gradients causing mechanical stresses lead to target destruction as by shock waves. After the SLC target destruction, analyses showed that a maximum value of 35 J/g (in tungsten) must not be exceeded. So, an accurate simulation of the energy deposited in the target has to be worked out dividing the target in elementary domains (typically, annular disks with radius increments of tenths of mm and thickness of tenths of Xo). The energy deposited in each domain is calculated and comparisons made with the maximum allowed value. The PEDD is strongly depending on the incident beam intensity and energy and on its transverse dimensions; it depends also on the thickness of the target.**

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- **SOME PEDD VALUES**
- **We give here some values of the PEDD corresponding to one electron in GeV/cm³ and will precise later the actual values for precise applications (ILC and CLIC).**
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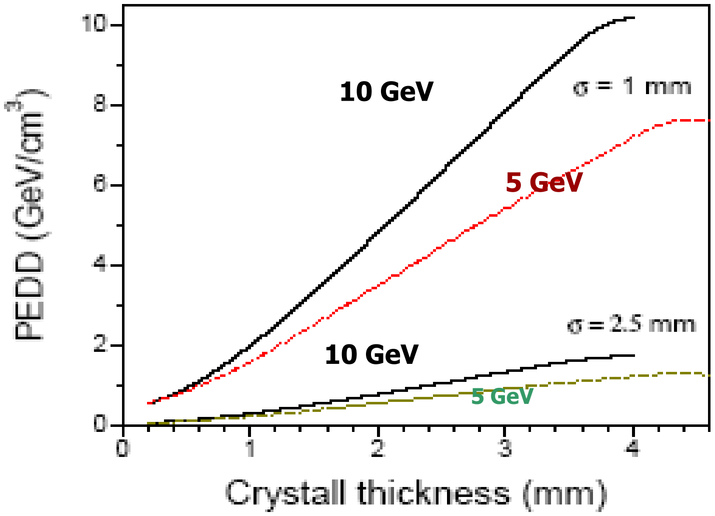

From X.Artru et al: Polarized and unpolarized positron sources… (NIMB,2008)

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Collaboration IHEP- LAL/IPNL on channeling effect in crystals

A PhD student Chenghai Xu from Graduate University of Chinese Academy of Sciences will go, hopefully, to LAL in near future as a collaborative student. His main subject will focus on intense source of positrons using channeling effect in crystals. And his research will involve:

1. ***Intensive simulations on the crystal target***
2. ***The control of the transverse emittance***
3. ***The determination and control of the longitudinal emittance***
4. ***The minimization of the energy deposition in the target***
5. ***The study of the Coulomb scattering of the incident electrons on the crystal nuclei***

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- **SUMMARY AND DISCUSSION**
- **The R&D carried out in IHEP and IN2P3 (LAL/IPNL) shows a common interest on the polarized positron source based on Compton interaction between a GeV electron beam and a circularly polarized laser. Both institutes are narrowly collaborating with KEK for this purpose.**
- **The choice for the unpolarized positron source for ILC is based for both institutes on the hybrid scheme associating a crystal oriented on one of its main axes- providing a large number of photons due mainly to channeling- and an amorphous converter where the photons, only, contribute to pair production. Such scheme minimizes the energy deposition in the targets which is of big concern for all the positron sources. A PhD thesis, foreseen for this activity, will improve the collaboration between our institutes.**

POSIPOL 2009 Workshop
Lyon, France 23-26 june
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