A CRYSTAL POSITRON SOURCE FOR CLIC

- R.CHEHAB
- IPNL-IN2P3/CNRS, UNIV. C.BERNARD I, LYON(FR)
- A.VARIOLA, A.VIVOLI
- LAL-IN2P3/CNRS, UNIV.PARIS-SUD, ORSAY(FR)
- V.M.STRAKHOVENKO
- BINP-NOVOSIBIRSK (RUS)

A CRYSTAL POSITRON SOURCE FOR CLIC

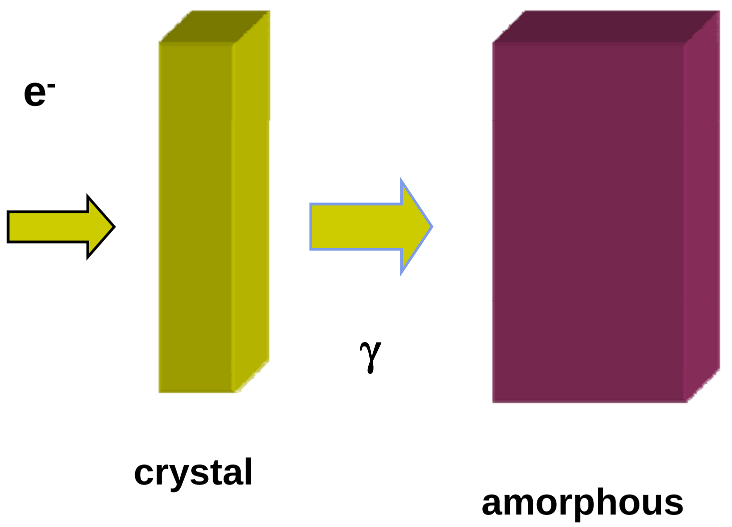
- **POSSIBILITY OF USING A CRYSTAL SOURCE FOR CLIC**
- The advantages linked to crystal targets (more soft photons produced than in amorphous targets due to channeling radiation) make them interesting :
- - to enhance the number of corresponding e+e- pairs
- - to lower the energy deposition in the target due to a somewhat different shower development

Experiments in CERN and KEK have shown very promising results

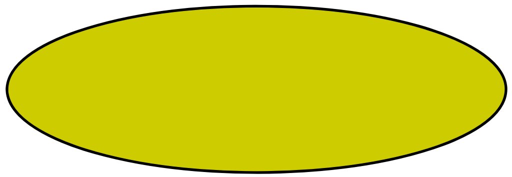
The solution chosen for CLIC is an hybrid one associating a crystal as a radiator and an amorphous disk as a converter. We present here some simulations with comparisons with purely crystal and amorphous targets.

A CRYSTAL POSITRON SOURCE FOR CLIC

- A crystal e+ source :
- - a 1.4 mm thick W crystal
- oriented along <111> axis
- - a 8 mm thick W amorphous disk
- A 5 GeV e- beam impinges on the crystal
- Charged particles are swept off after the crystal:only γ (> 2MeV) impinge on the amorphous target. The distance between the 2 targets is 3 meters.
- The simulations are made with V.S.'programme for the crystal and EGS4 for the amorphous target
- The e+ are captured by an AMD followed by a solenoid on an L-Band linac



A CRYSTAL POSITRON SOURCE FOR CLIC

- **ACCEPTANCE CONDITIONS FOR CLIC e+ SOURCE**
- **The accepted e+ are contained in the transverse phase space defined by the acceptance ellipse at the target:**
- **$[r/0.53]^2 + [p_T/11]^2 = 1$; r is in cm and p_T in MeV/c**
- 
- **The longitudinal momentum p_L is taken between 1.3 MeV/c (debunching) and 17.3 MeV/c (adiabatic condition)**
- **The longitudinal and transverse momenta satisfy the relation:**
- **$p_T < 0.1875$ MeV/c + $0.625\, p_L$; this relation corresponds to a maximum positron angle of emission of ~32 degrees which put a limit on the debunching (in an L-Band accelerator) with the focusing fields considered.**

A CRYSTAL POSITRON SOURCE FOR CLIC: RESULTS

Incident e- beam with σ =1 mm

Total number of e+: 8.2 e+/e-

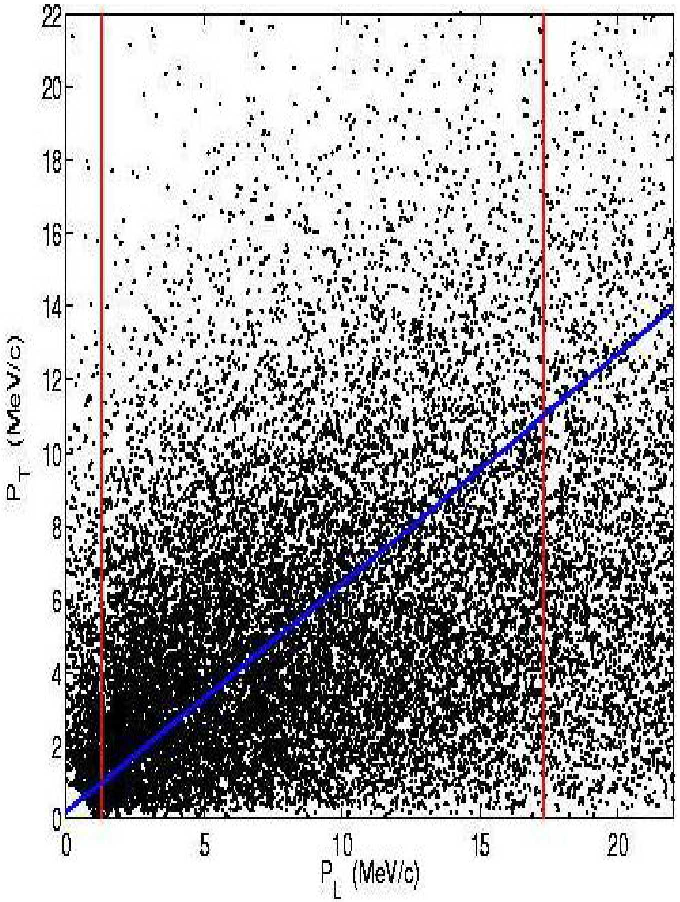
Acceptance in (p_L,p_T) space

The acceptance limits described before are related to an AMD device with a magnetic field tapering from 7 Tesla to 0.5 Tesla on 21 cms. A long solenoid with 0.5 Tesla put on the accelerating sections, follows.

These limits are illustrated on the figure; the accepted e+ lie between the p_L axis, the limits on p_L (red lines) and the line defined by eq.:

$$p_T = 0.1875 + 0.625\, p_L \quad \text{(blue line)}$$

Only the e+ comprised in these limits are accepted : 1.12 e+/e-



A CRYSTAL POSITRON SOURCE FOR CLIC

- **COMPARISON WITH PURELY AMORPHOUS AND CRYSTAL TARGETS GIVING THE SAME YIELD (at E- = 5 GeV)**
- **If we consider an amorphous target giving almost the same total positron yield $\eta+$ [~8 e+/e-], the target thickness is: 9 mm**
- **A purely crystal source giving the same total e+ yield is 4 mm thick**
- **Comparison of the 3 kinds of e+ sources for CLIC conditions [$3.4x10^{12}$e-/pulse]: we compare for same total $\eta+$:**

	Total Dep. En.(%)	PEDD (Gev/cm3)	PEDD (J/g)
Purely amorp.	4.5%	7	200
Purely crystal	2.4%	7.2	204
Hybrid	6%	1.5	42

- **We recall that these results correspond to an incident e- beam with σ= 1mm**
- **We can see the interesting advantage of the hybrid source on the others for the PEDD. If we consider the maximum limit of 35 J/g for W, we are led to multiple targetting: 6 for the to first cases and 1-2 for the third. (see discussion later). Comparisons related to accepted yields instead of total yields lead to analog conclusions.**

A CRYSTAL POSITRON SOURCE FOR CLIC

- **Comparisons between targets giving close accepted yields**
- **A more practical consideration leads to look at equivalent e+ sources concerning accepted e+. For that, we compare the three schemes for accepted yields 1.1 < η< 1.5 e+/e-. That fully satisfies CLIC expected yield:0.6 to 0.8 e+/e- at 200 MeV, with a margin for additional losses in the accelerator channel due to debunching, though the limits considered for the acceptance took already in account the limits on bunch lengthening. The schemes presented above provide such accepted yields (for σ=1mm).**
- **If we increase the incident beam dimensions from 1 to 2.5 mm, the hybrid scheme provides an accepted yield of 0.9 instead of 1.1 being still in the acceptable yields for CLIC, at 200 MeV.**

A CRYSTAL POSITRON SOURCE FOR CLIC

- **SOME PARAMETERS SCALINGS**
- **1) <u>Incident transverse beam dimension σ</u> : the PEDD being of major concern, better results can be obtained with σ = 2 mm. For instance, the PEDD (peak energy density deposited in elementary volume) is decreased by ~4 when doubling size. The accepted yield is slightly decreased (see above for 2.5 mm) ; the large geometrical acceptance of the AMD prevents from important losses.**
- **In that case only one hybrid target is needed. The other schemes require two targets at least.**
- **2) <u>Incident beam energy:</u> 5 GeV as incident energy is preferable to 2 GeV; the crystal processes are more efficient (for W, the radiated energy due to channeling becomes higher than bremsstrahlung for ~1 GeV). An additional advantage of the higher incident energy is a lower energy deposition ratio.**
- **3) <u>Target thickness:</u> the energy deposited in the whole target as the PEDD increase with target thickness. Working at a higher incident energy, the target thickness (for the same yield) is decreased. The PEDD for the nominal CLIC conventional target [2Gev/4Xo] is of 87 J/g whereas it is of ~50 J/g for a thinner conventional target [5GeV/2.5 Xo] both for an incident beam with σ= 2mm.**

A CRYSTAL POSITRON SOURCE FOR CLIC

- **SUMMARY & CONCLUSIONS**
- **The simulations results presented here show;**
- **- that a positron source using an hybrid scheme with a W crystal oriented along its <111> axis followed by an amorphous target 8 mm thick, where only the γ are impinging, provides a total yield of ~8 e+/e- and an accepted yield of ~0.9 with a 5 GeV incident electron beam having 2.5 mm rms transverse size. The PEDD associated with such scheme is < 35 J/g and allows use of a unique target**
- **- In any case, the choice of a higher incident energy (5 GeV instead of 2 GeV) with a correspondingly thinner target provides a more comfortable situation for the PEDD.**