INVESTIGATIONS ON A HYBRID POSITRON SOURCE WITH A GRANULAR CONVERTER

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INVESTIGATIONS ON A HYBRID POSITRON SOURCEWITH A GRANULAR CONVERTER

- **PLAN**
- *** Introduction**
- *** Positron sources using channeling: short recall**
- ***The hybrid source with a granular converter**
- *** Simulation results: yield, energy deposition density**
- ***Test foreseen on the KEKB linac**
- *** Preliminary conclusions**

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- **1- INTRODUCTION**
- **There is a strong need on intense positron sources for future colliders. The qualities of such sources are depending on the photon characteristics and on the converter in which these photons are materializing. Since 25 years, a proposition to use crystals as positron sources using the intense channeling radiation in axially oriented crystals brought very promising results as shown in CERN and KEK experiments. The main concern for all positron sources is not only the yield but also the energy deposition and the associated PEDD (Peak Energy Deposition Density). Recent investigations led to the concept of an hybrid source where the crystal-radiator and the amorphous converter were separated by some distance allowing to the charged particles emitted in the crystal to be swept off. Moreover, the replacement of the compact converter by a granular one, made of small spheres, seems very promising for the deposited power dissipation. We present this idea.**

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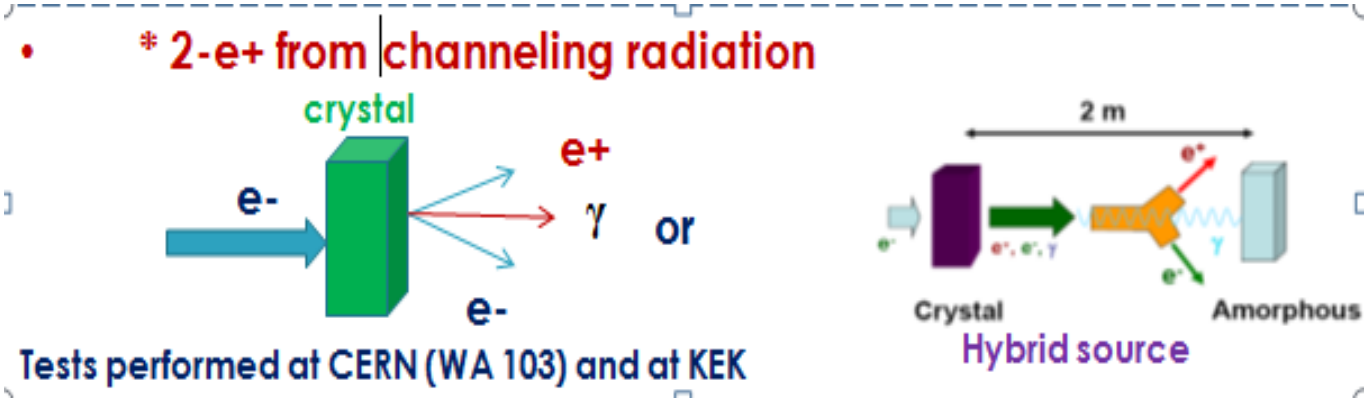
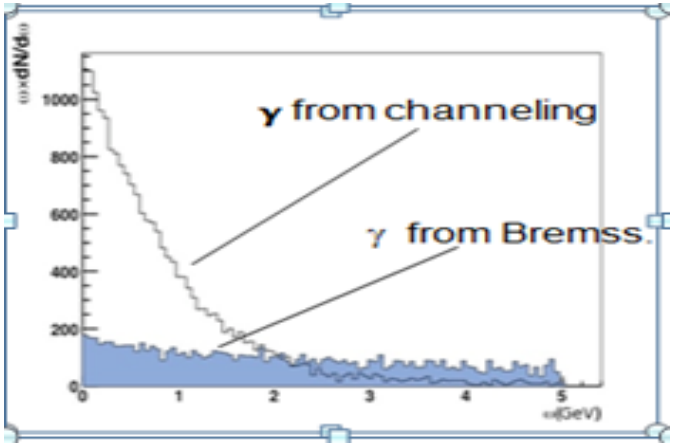
2- POSITRON SOURCES USING CHANNELING: SHORT RECALL



The main interest of the photons produced in channeling conditions is their soft spectrum particularly adapted for the positron source as the known matching devices put after the converter capture more efficiently soft positrons (typically from some MeV to 20-30 MeV)



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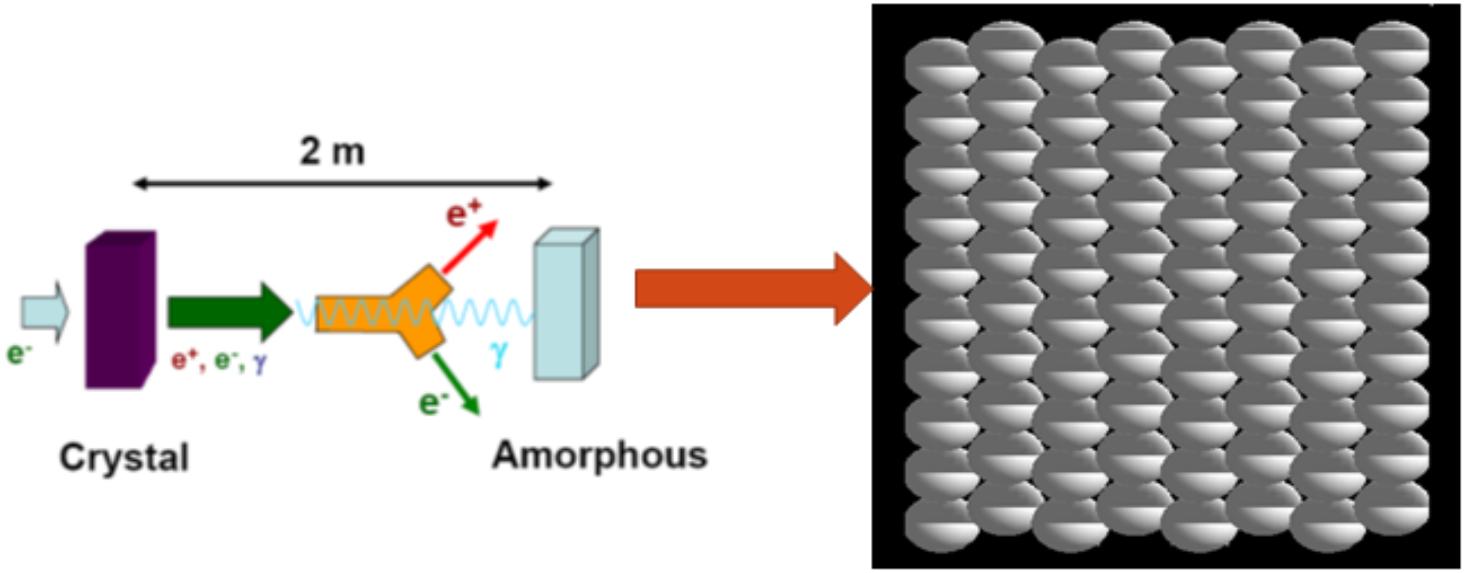
3- THE HYBRID SOURCE WITH GRANULAR CONVERTER

- **THE SCHEME**



The amorphous converter is made of a great number of small spheres with a radius of 1-2 mm. The spheres are put in a container with entrance/exit windows in Beryllium and up and bottom windows in titanium.

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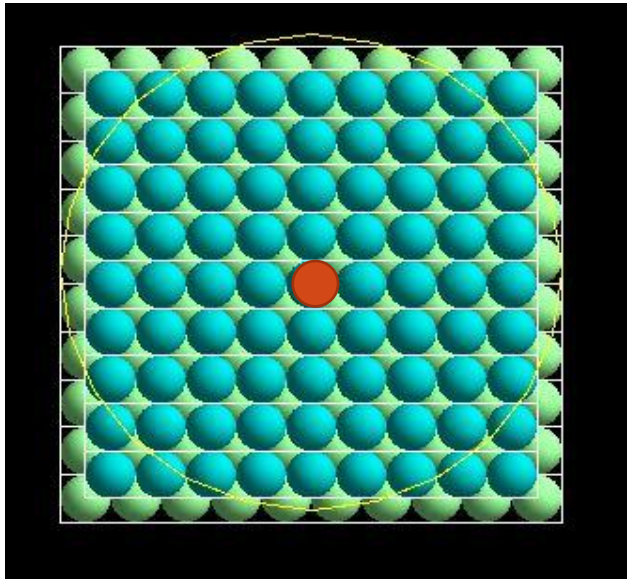
- **THE SIMULATIONS**
- **4 granular converters are studied and will be tested on KEK beam**
- *** One with 2 staggered layers (10x10**
- **and 9x9 spheres),**
- *** One with 4 staggered layers,**
- *** one with 6 staggered layers**
- *** one with 8 staggered layers**



- **The energy deposition is calculated in**
- **each sphere. The entrance face w.r.t.**
- **the photon beam has 10x10 spheres;**
- **the exit face has 9x9 spheres, presenting**
- **a central sphere on the axis (probable maximum heating). From the energy deposited in this central sphere we could derive the PEDD (approximation)**

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- **4- SIMULATION RESULTS (H.Guler)**
- **Simulations are carried out under the following hypotheses:**
- **- Incident electron energy on the crystal: 8 GeV**
  - **Crystal W thickness: 1 mm**
  - **Compact and granular W converters (with sphere radii of 1.1, 0.5, 0.2 and 0.1 mm)**
  - **Distance crystal-converter: 3 m**

Outputs: yield, Energy deposition/e-, Edep/cm3/e-

*** Evaluation of the thermal shocks (in preparation)**

The value of the energy deposited in the spheres allows the determination of the stresses due to the thermal shocks.

- **Some indications on the thermal stresses will be given.**
- **➔ Two working cases are considered for the incident electron beam:**
- *** the ILC beam size with 2.5 mm rms**
- *** the KEKB test beam with 1 mm rms**

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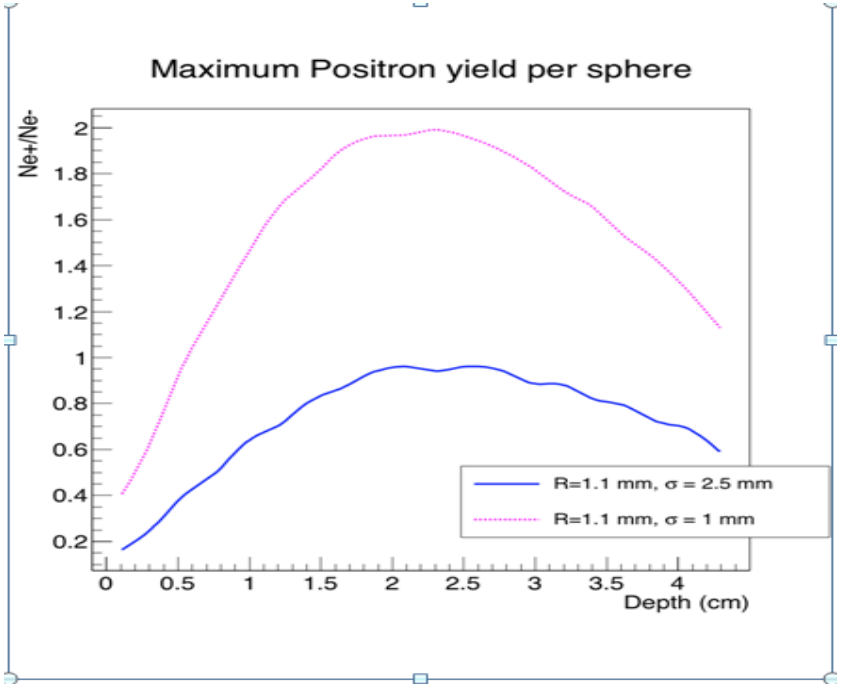
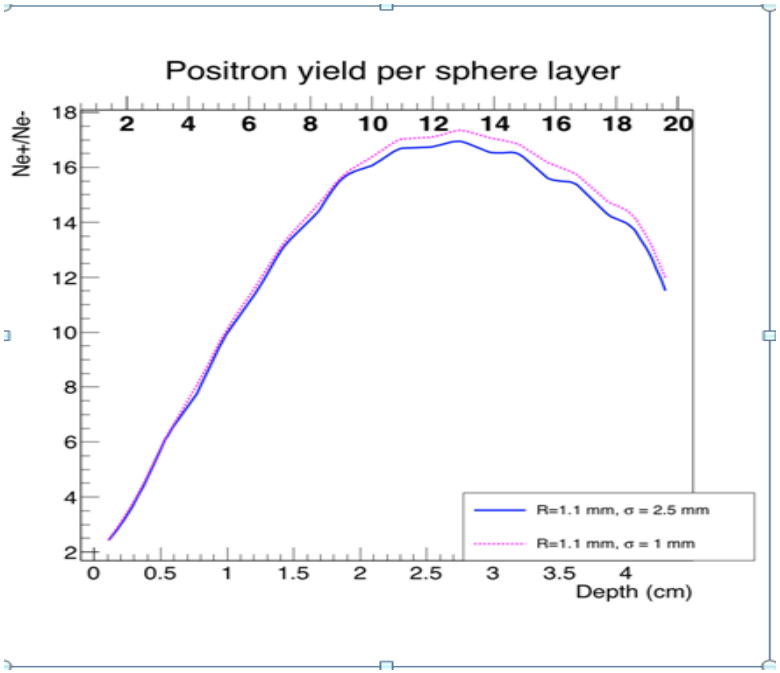
POSITRON YIELD

The positron yields per central sphere and per layer (slice on figures) of spheres are represented. The largest yield/sphere is for the smallest beam as expected. The total yield is practically the same regardless to the beam size (for enough large transverse dimensions; here, 2.4x2.4 cm2). The incident electron energy for the hybrid source is 8 GeV.





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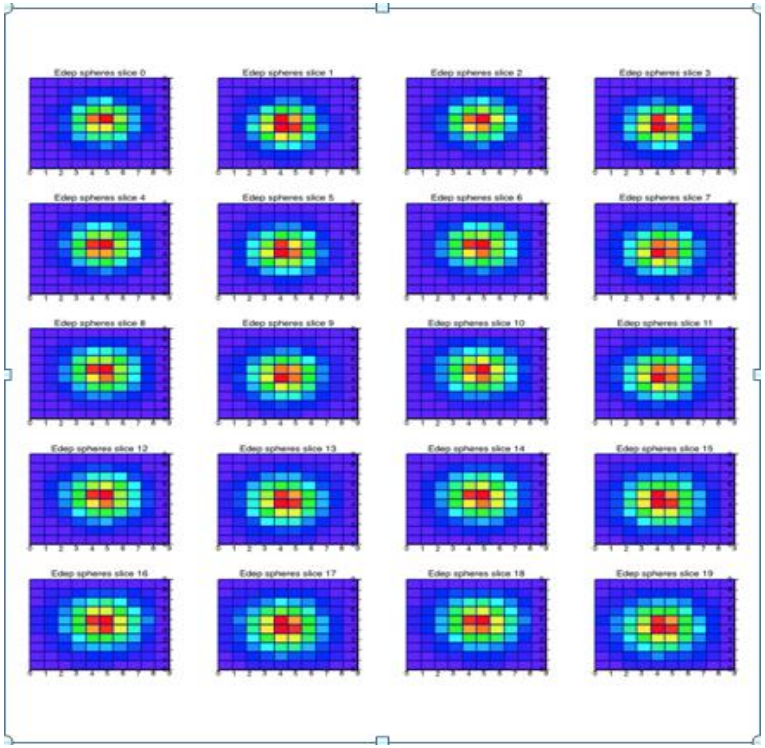
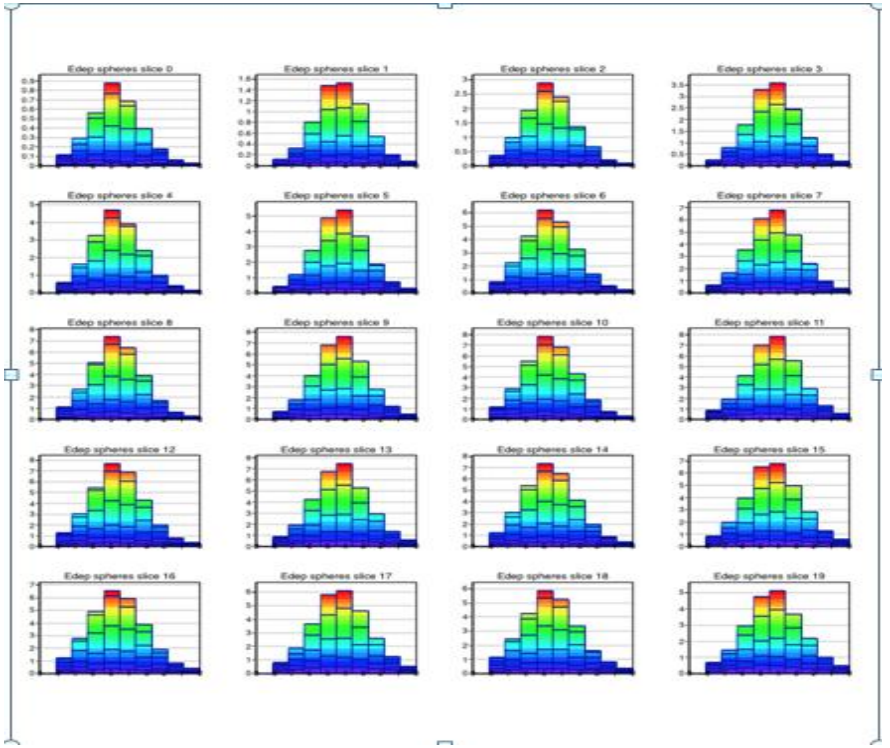
ENERGY DEPOSITED IN THE SUCCESSIVE LAYERS OF W SPHERES

Rank of layers (slices); from left to right and up to bottom





The deposited energy is maximum on the central spheres. The vertical scale on the figure on the right is in MeV/e-. The deposited energy in each layer is increasing with the rank, as for the transition curve, crossing a maximum.

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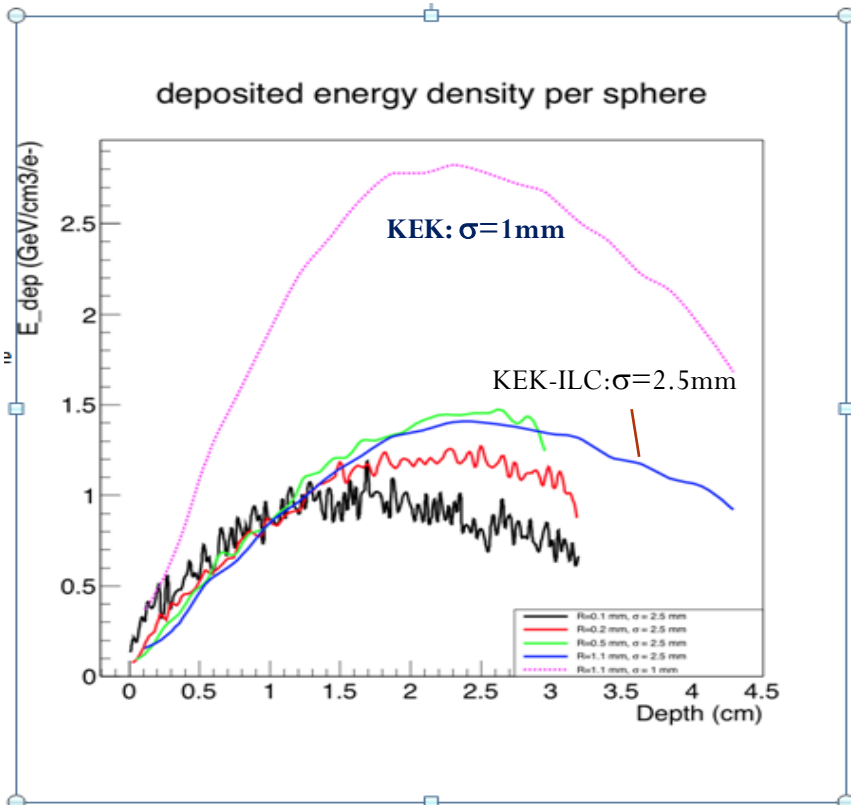
ENERGY DEPOSITION DENSITY

The energy deposition density in the central sphere (even rank of slice) has been calculated for the 2 cases:

- KEKB beam with σ=1 mm (R=1.1 mm)
- ILC beam case with σ=2.5 mm and R=1.1, 0.5, 0.2 and 0.1 mm

It can be seen that up to a thickness of 1.5 cm, the granular converter does not show significant differences concerning the radius dimensions. That means that up to this thickness the deposited energy density calculated with spheres of 1.1 mm radius represents a rather good approximation for the PEDD.



Incident electron energy is 8 GeV for all curves

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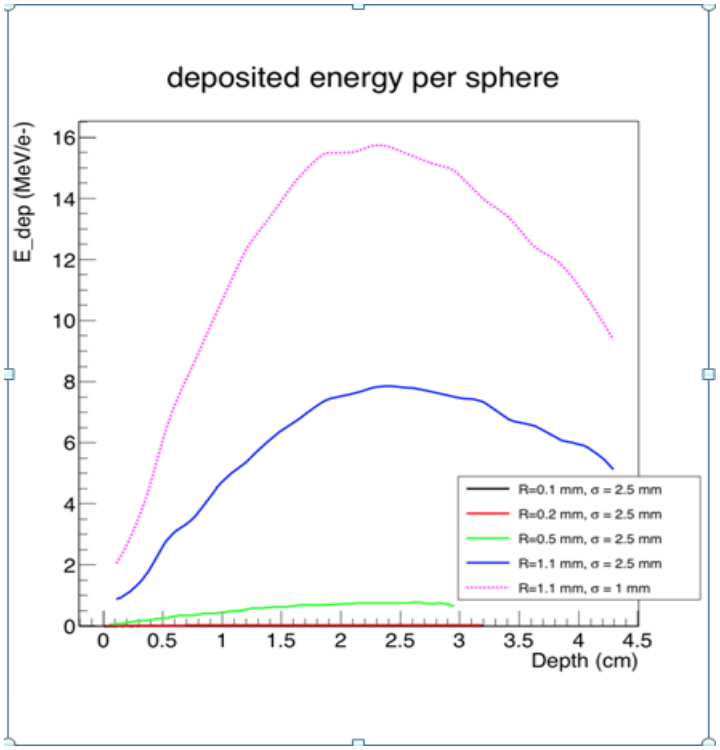
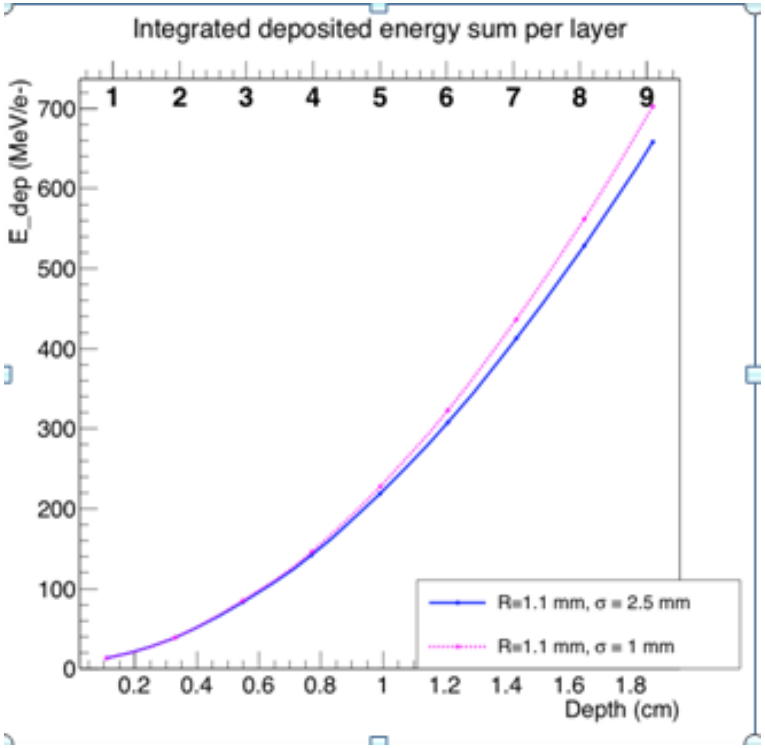
DEPOSITED ENERGY: in the central sphere (left) and integrated on the number of layers (right). 6 layers corresponds to rank N=6 .





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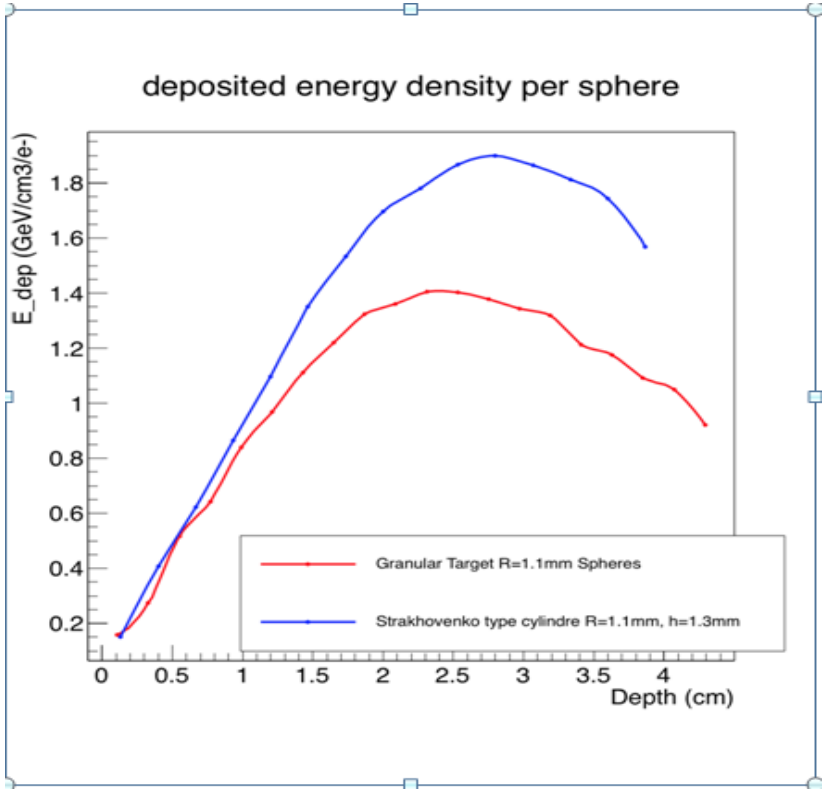
COMPARISON BETWEEN A GRANULAR AND A COMPACT CONVERTER

The Energy Deposition Density (EDD) is compared for the 2 cases: granular (red) and compact (blue). The elementary volumes are of the same values for the granular as for the compact (1.1 mm radius spheres and 1.1 mm radius cylinder with 1.5 mm height).
It is seen that for moderate thicknesses (up to 1.5 cm) the energy deposition density is slightly lower for the granular converter. At larger thicknesses, the advantage of the granular target is obvious.



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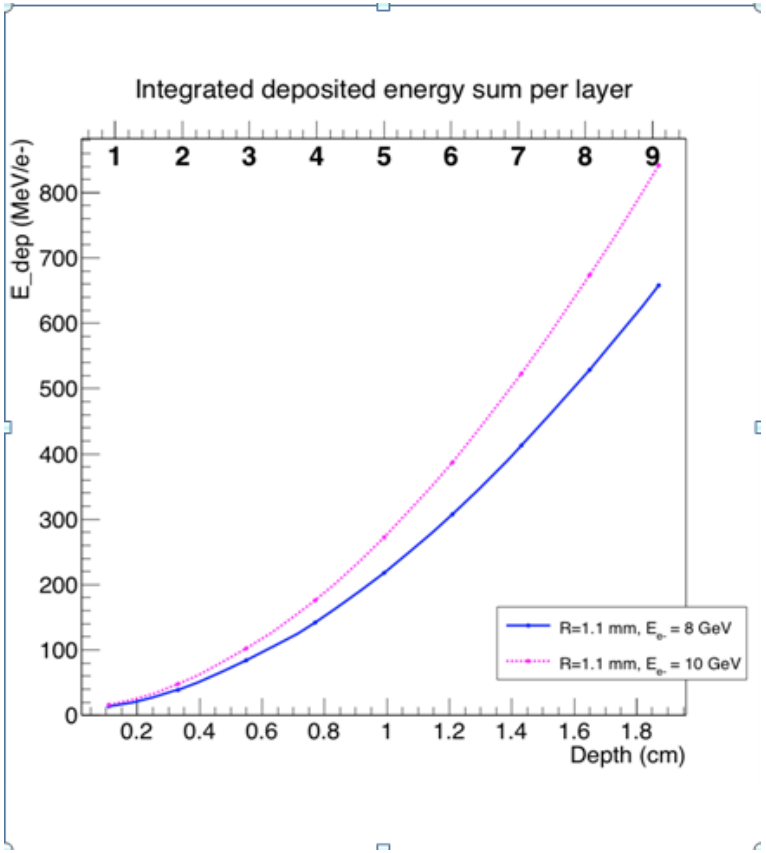
COMPARISON OF DEPOSITED ENERGIES FOR INCIDENT BEAMS OF 8 AND 10 GeV

A comparison is operated concerning the integrated deposited energies in the ganular converter for 8 and 10 GeV incident energies. For example, for a 6 layer converter (giving interesting yield for ILC) the deposited energy is about 400 MeV/e- at 10 GeV (ILC scheme) and about 300 MeV/e- for the KEKB test at 8 GeV incident energy.



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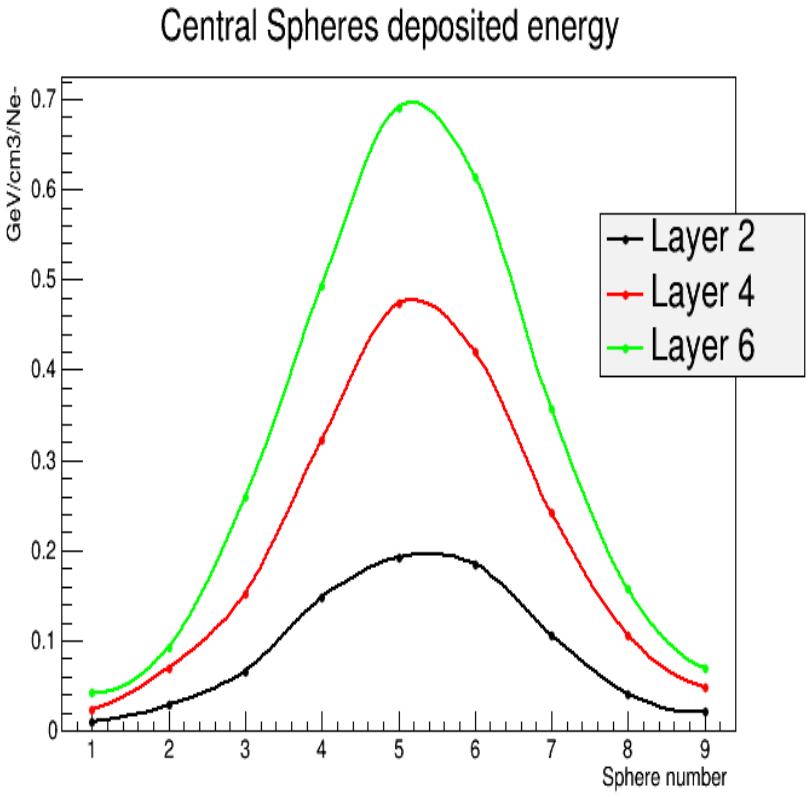
LATERAL DISTRIBUTION OF THE ENERGY DENSITY

The lateral density distribution along a central axis has been determined. The density is calculated on adjacent spheres at the exit of the converter. Here, converters with 2, 4 and 6 layers have been considered. These layers are made with 9x9 spheres, henceforth, with a central sphere. The thermocouples can be put on adjacent spheres to get the actual energy deposition distribution.



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THERMAL STRESSES

THERMAL LOAD IN THE CONVERTER MATERIAL INDUCES STRESSES AND DESTRUCTIVE SHOCK WAVES AS OBSERVED ON THE SLC TARGET. TWO WAYS ARE USED TO LOWER THE THERMAL LOAD: MULTI-TARGETS AND TIME STRUCTURE MODIFICATION

Considering an application to ILC, we are proposing after T.Omori to modify the beam time structure before the target, (see figure) recuperating the nominal one after the DR. In that case, macropulses with a duration < 1 μs are impinging on the W spheres. Considering the small spheres dimensions, there is a stress relaxation during the temperature rise due to a shock wave propagation shorter than the heating time (~1 μs) . As an example, for the ILC conditions, the radial stress due to a μs pulse is about 10 times lower than for a Dirac pulse. P. Sievers (CERN) is analyzing such effects (see POSIPOL series)

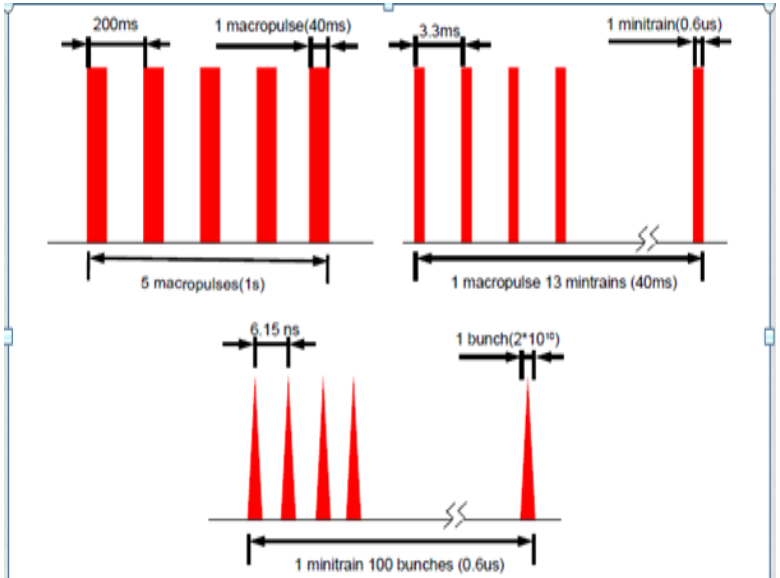

Figure 4.1: ILC beam structure. KEK scheme[42]

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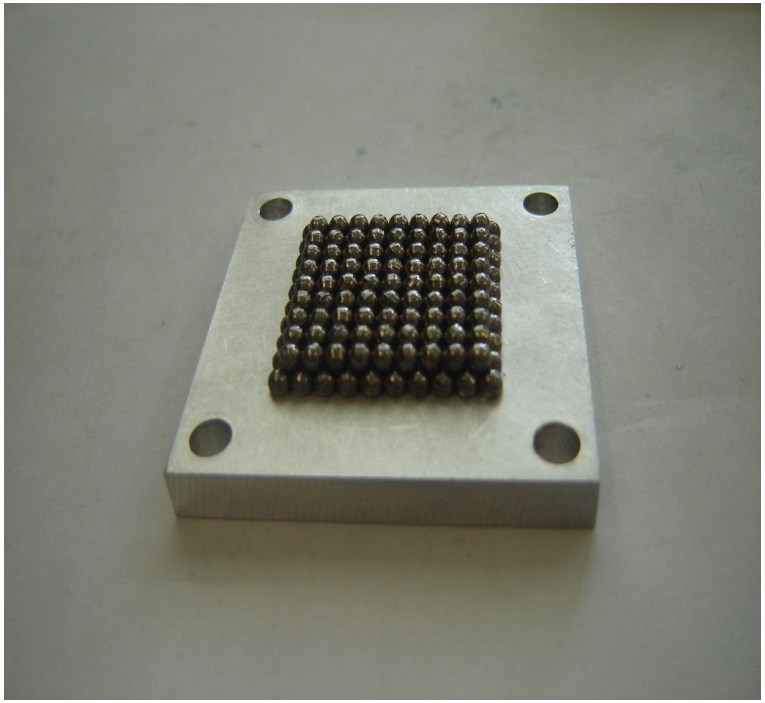
- **5- TEST FORESEEN AT THE KEKB LINAC**
- *** THE GRANULAR CONVERTER**
- **Made with staggered layers; the photon**
- **beam is crossing successively layers of**
- **10x10, 9x9, 10x10, 9x9,…The W spheres**
- **have 2.2 mm diameter.. They have been**
- **realized by a French company. The**
- **relative density of a granular target w.r.t.**
- **a compact one is ~ 0.75. Henceforth,**
- **its geometrical thickness is slightly**
- **larger w.r.t. a compact one giving the**
- **same yield.**



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THE GRANULAR TARGETS

We represent, here, 3 from the 4 granular targets built at LAL-Orsay. The entrance and exit windows (grids with 1.8 mm holes) are in Al. and have as many holes as the number of spheres of the layer. This mounting allows the positionning of thermocouples on the exit face of the converter.

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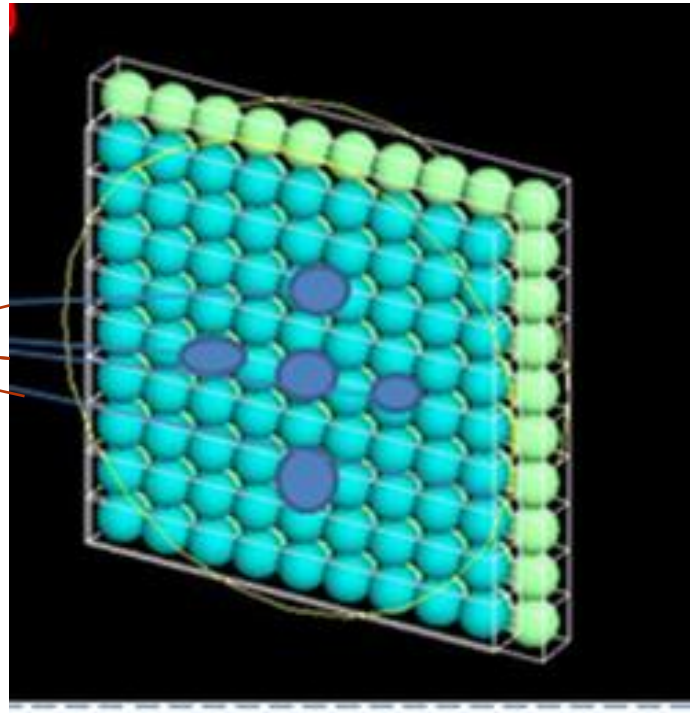
TESTS FORESEEN AT KEK: YIELD AND TEMPERATURE MEASUREMENTS

*** Yield : for different positron energies (between 5 and 30 MeV)**

*** Temperature : on chosen W spheres on the exit face of the converter**

The expected measurements are concerning the temperature rise in the spheres using thermocouples. In a future stage use of infrared cameras should give complementary informations. The thermocouples having a small section (< 1mm2) will be glued to the spheres (with Ag. paste)



The distribution of the thermocouples (>5) can provide a view of the temperature distribution in the transverse plane of the exit face.

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THE EXPERIMENTAL LAY-OUT: the beam test will be done at KEK injector linac, 3d SY. The crystal is mounted on a 2-axis goniometer. Analysing magnet, collimators and detectors are in vacuum conditions (10^{-3} Torr). Geometrical acceptance of the detector is small (0.22msr)

Scheme of the installation

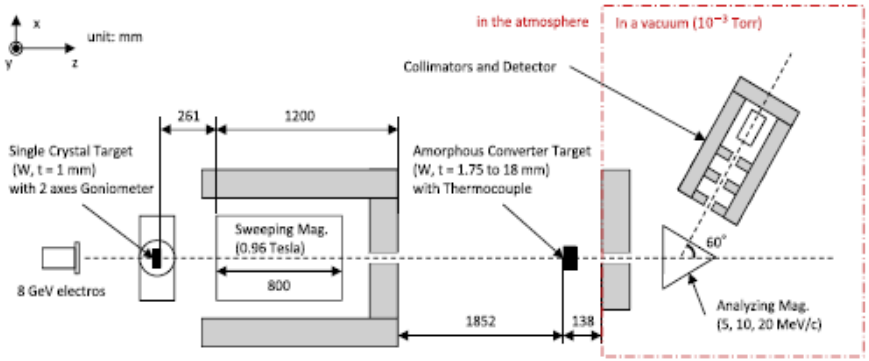
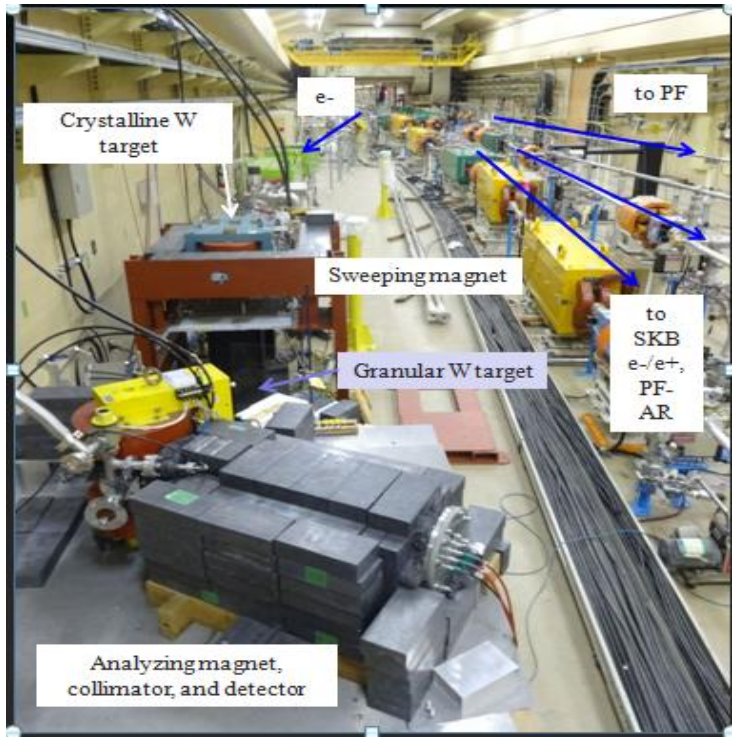


Fig. 4. Layout of the hybrid target and the positron detector system in the experiment in top view.



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- **6-SUMMARY AND PRELIMINARY CONCLUSIONS**
- 1-The simulation results for a hybrid positron source with a granular converter show:
- - a total positron yield of about 10 e+/e- for E-=8 GeV
- - a deposited power of ~310 MeV/e- for E-=8 GeV
- - an energy deposition density of about 1 GeV/cm3/e- for 6 slices; this
- value is close to that of a compact converter.The thicknesses giving the
- same e+ yield (for E-=8 GeV) being 8mm for the compact and 12 mm
- for the granular converters.
- 2- Use of a granular converter in a hybrid positron source presents interesting advantages:
- - moderate deposited energies and energy density deposition.
- - lower stresses due to the small sphere volume value and hence the lower shock
- wave propagation time w.r.t. the beam duration.
- - better heat dissipation due to interesting ratio [surface/volume] of
- the spheres.
-