Hybrid Source Studies

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- Introduction
- Simulation
- Results
- Conclusion

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Positron sources using channeling

- Baseline for CLIC :
  1. Un-polarized : hybrid source
  2. Polarized : Compton scheme*

for both we want to evaluate : positron yield, energy deposition, *polarization (…) with respect to incident beam energy, target thickness, #cavities , #lasers …

1. Un-polarized : hybrid source

- At energies of some GeV the electron motion in the axial fields of an aligned crystal ~ helical undulator (without the polarization)

gamma + ~~charged particles~~

- Only the photons are impinging on the converter:

limits the energy deposition in the amorphous target

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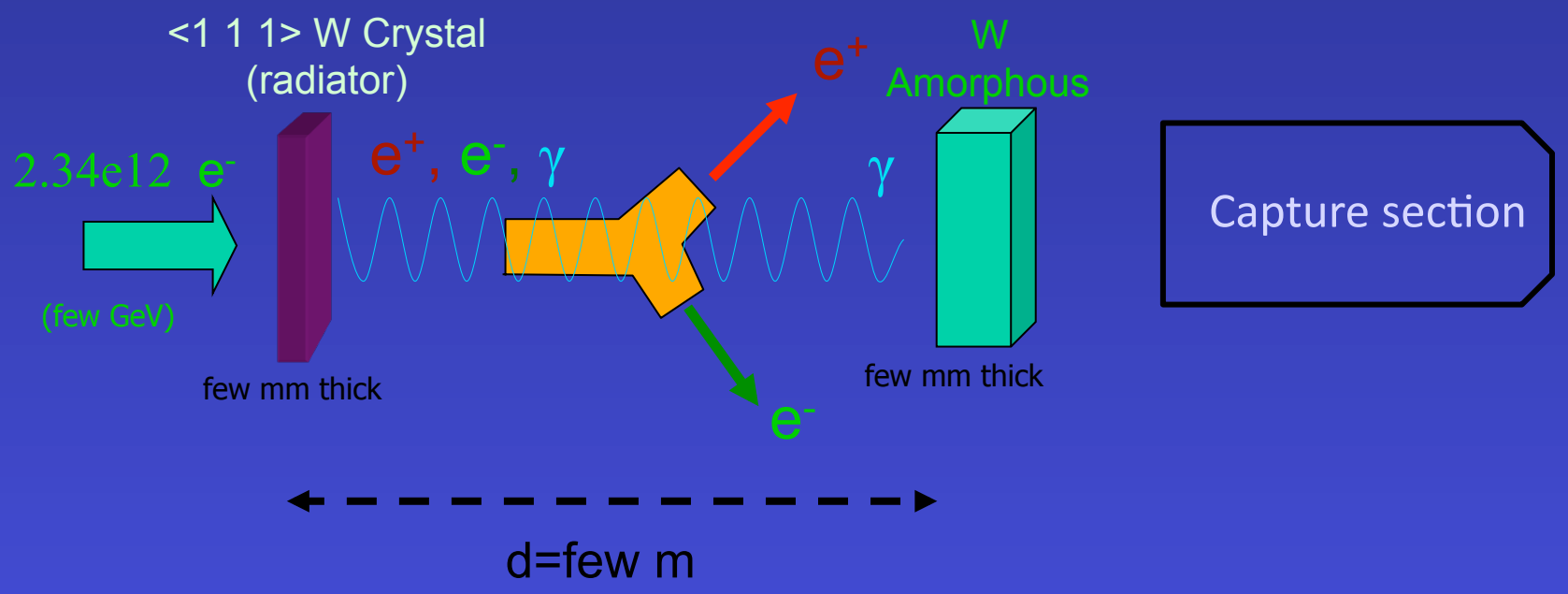


Positron sources for CLIC

1. Un-polarized : hybrid source

One of our study is the impact of the:

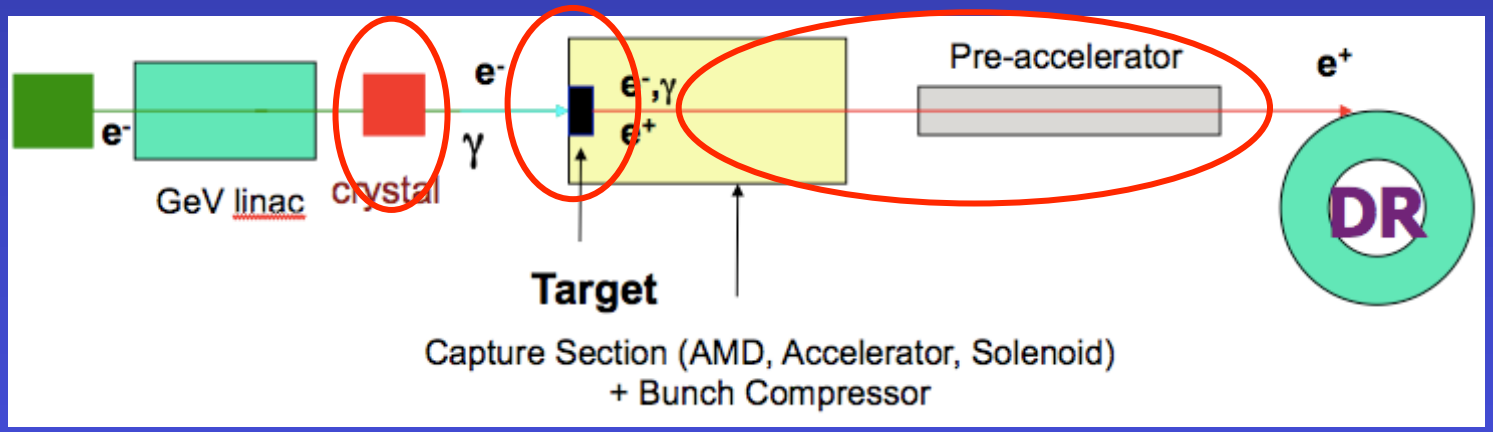
- Amorphous thickness
- Distance between the crystal and the amorphous
- Different incident electron beam energy

in terms of positrons Yield and energy deposited

Channeling simulation Vladimir's code (Xavier)

Geant4
EGS or Fluka

Parmela (Astra, …) Poirier&Vivoli



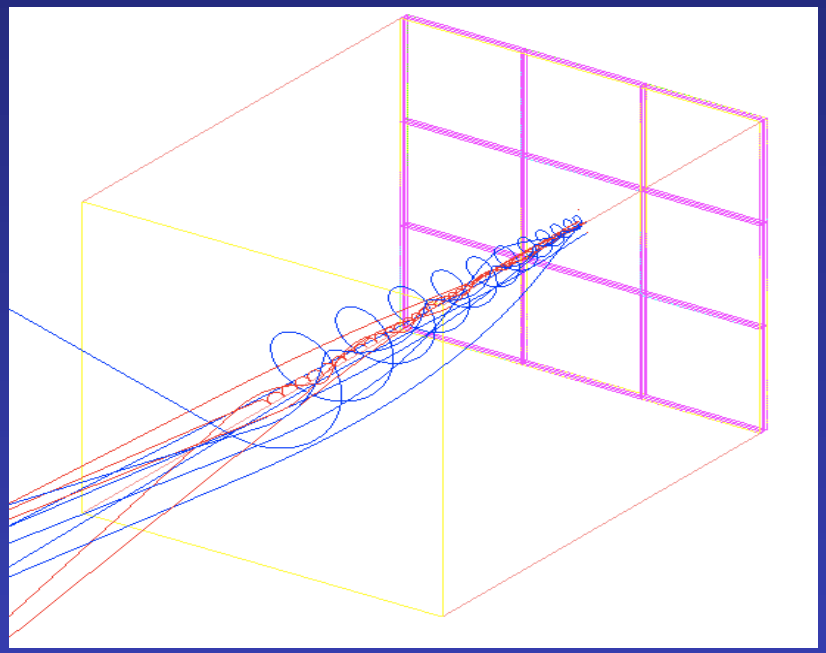
Target simulation

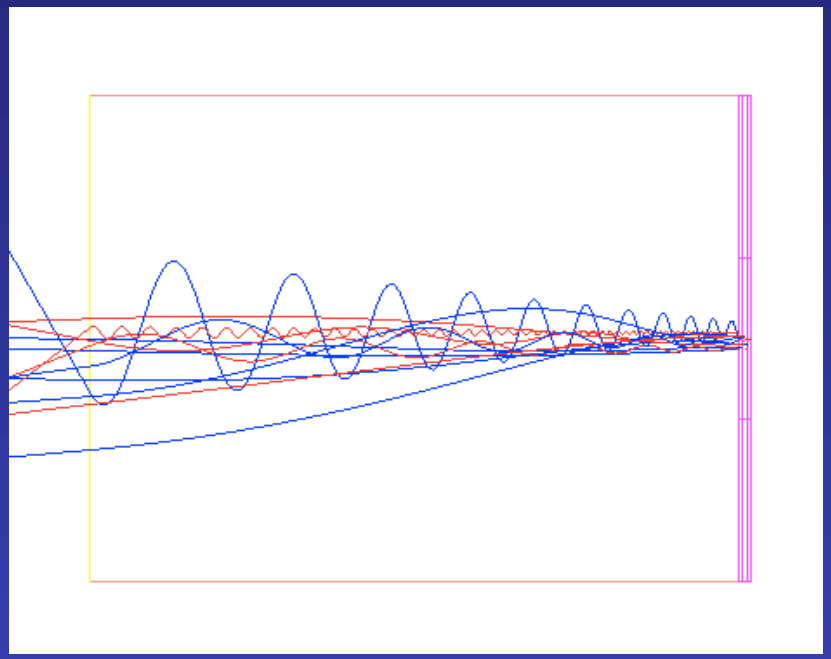
- Simulate the interaction between a primary beam (photon from crystal, polarized photon from Compton…) and an amorphous target
  - Peak Power Energy density (PEDD)
    - Segmented target (Mesh)
  - Simulate the first element of the capture section
    - Adiabatic Matching Device (AMD) …
  - Store the phase space parameters of the particles after the AMD (just after target)
    - To simulate the capture and acceleration of the positron (Parmela)
  - Hadronic processes
  - Possibility to study the positron polarization
- Simulation geant4 based
- Positron Production Simulation

  (PPSim by analogy with BDSim Geant4 acceleration toolkit)
- PPSim and not PPS-Sim

  Sorry to the DESY Zeuthen positron group: the name is very closed to PPS-SIM see the A. Schaelicke's tomorrow

PPSim screenshoot





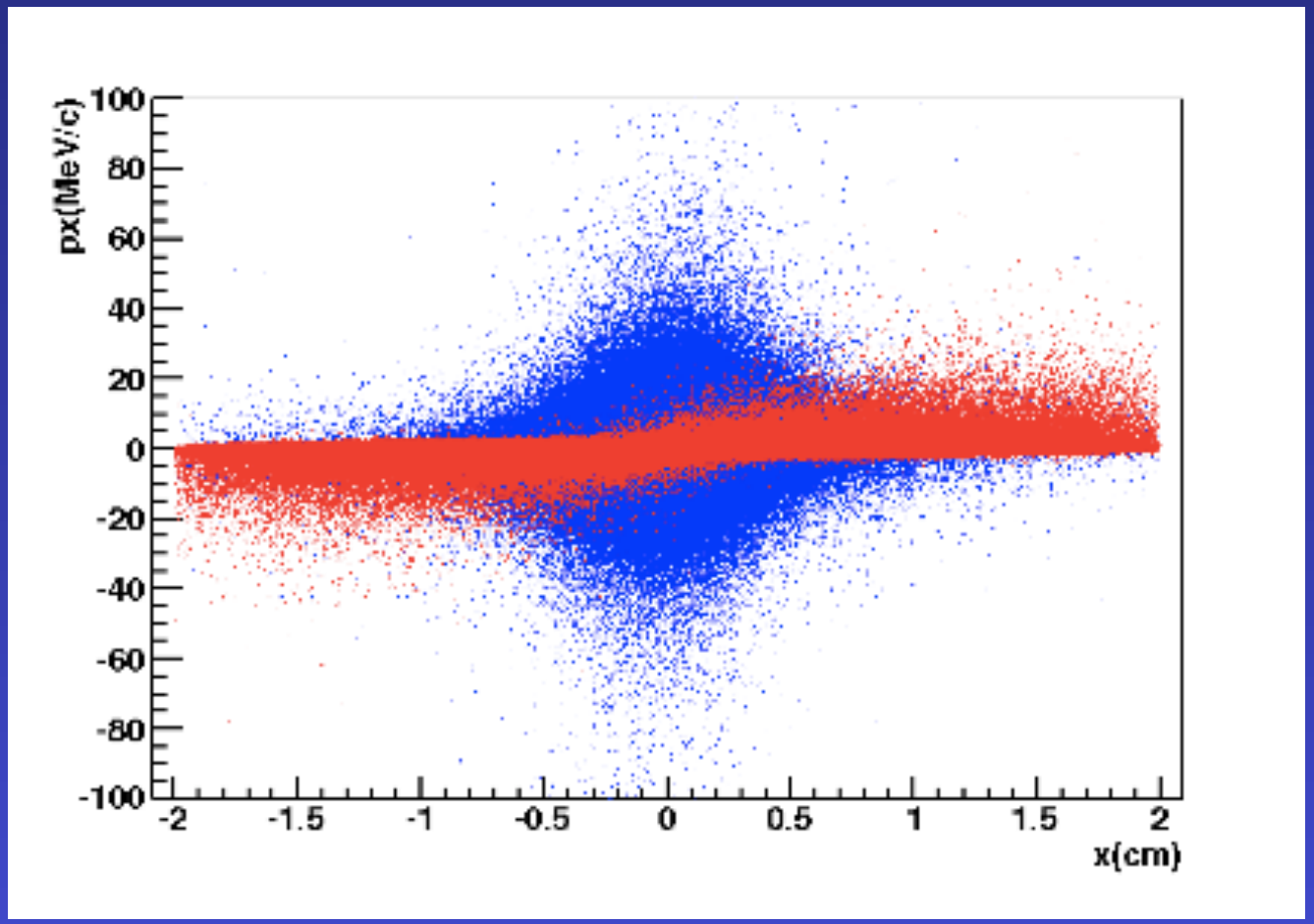
- AMD (B0=6 T, L=50cm, α=22m^{-1})

$$B = \frac{B_0}{1 + \alpha z}$$

- Target segmented here 1×3×3 (for display reason)

AMD effect

- Positron emittance: before (blue) and after the AMD (red)



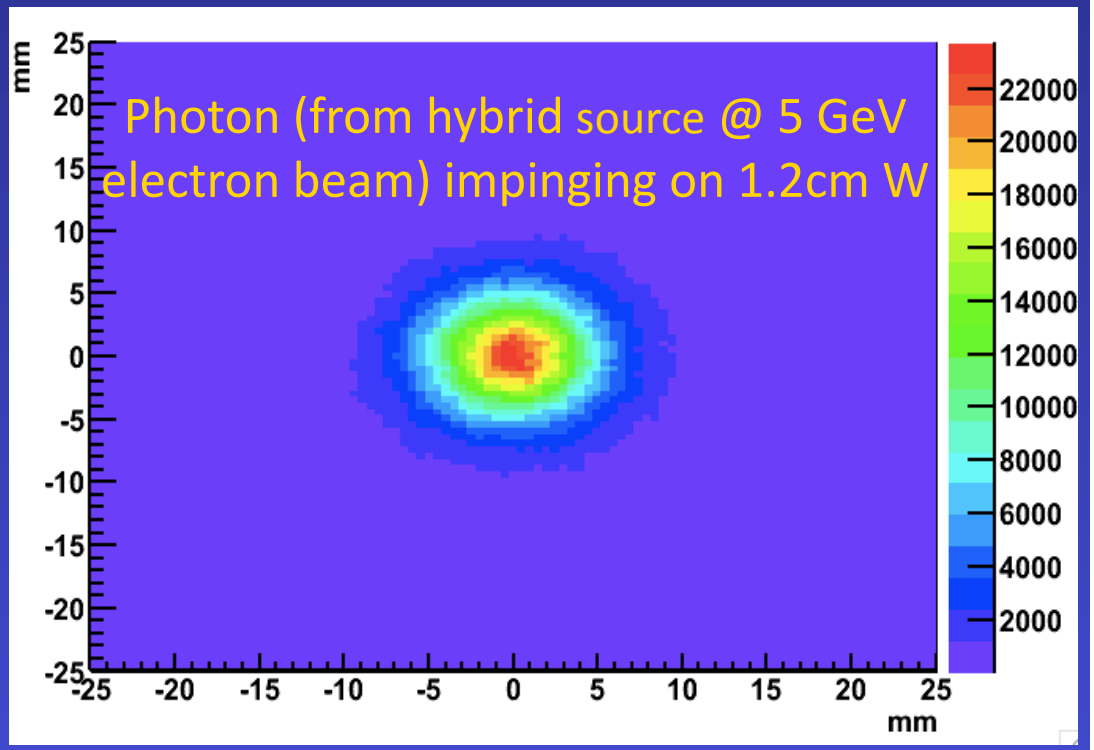
The AMD transform the phase space into larger dimensions and smaller momentum which will be easier to transport

Root output file

ROOT header

```
TFile*                    ppsim.root
OBJ: TNtuple              ntuple ntuple : 0 at: 0x2f00000
OBJ: TH3F  histo_pedd     histo 3D Pedd : 0 at: 0x1857400
KEY: TTree  Sampler1;1  Sampler output
KEY: TTree  Sampler2;1  Sampler output
KEY: TH3F  histo_pedd;1                histo 3D Pedd
KEY: TH1F  ElossHisto;1 Energy Loss
KEY: TObjString
##########################################
#  Particles Types                  : 22
#  Particles Number                 : 60000
#  Particles Mean Energy : 163.814815 MeV
#  Material: G4_W   size(x,y,z)=(50.0,50.0,12.0) mm
#  Number of slices(nx,ny,nz)=(101,101,10)
##########################################
```

Sampler sensible volume to store phase space particle before and after AMD. Can added more and move the sampler where we want (from BDSIM concept).



Target is a sensible volume:

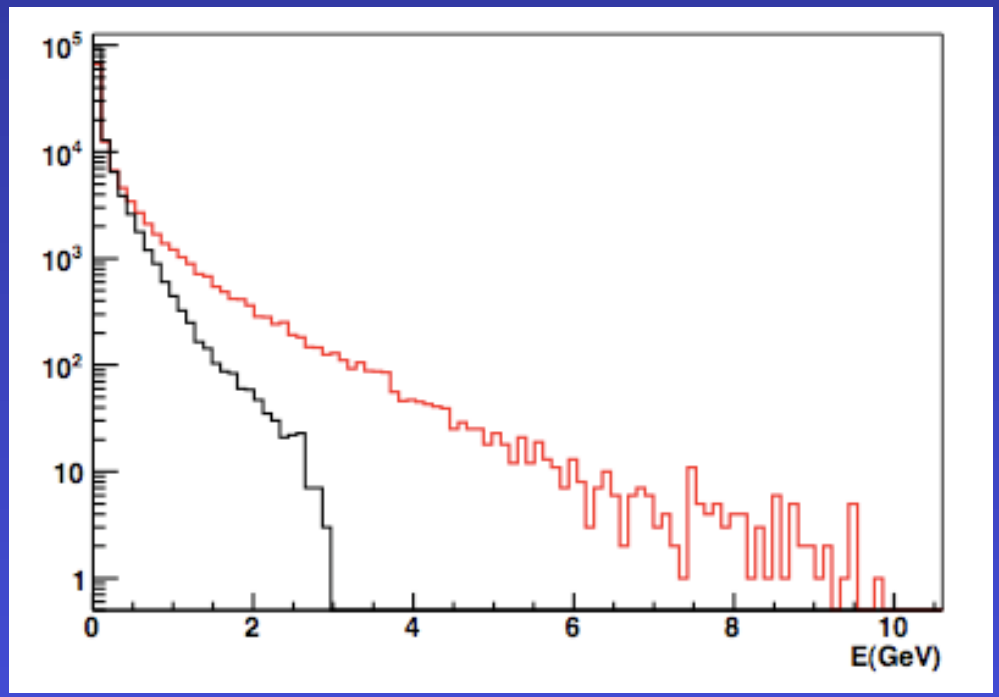
PPSTargetCaloSD::ProcessHits(G4Step*aStep,G4TouchableHistory*)

depESum[NrZ][NrY][NrX] += aStep➔GetTotalEnergyDeposit()

Crystal simulation

- Vladimir's simulation
- Energies electrons beam : 3, 4, 5 and 10 GeV (thickness 1., 1.4, 1.5 and 1.6 mm)
- gamma selection from those files
- X,Y : Gaus(0,2.5 mm)

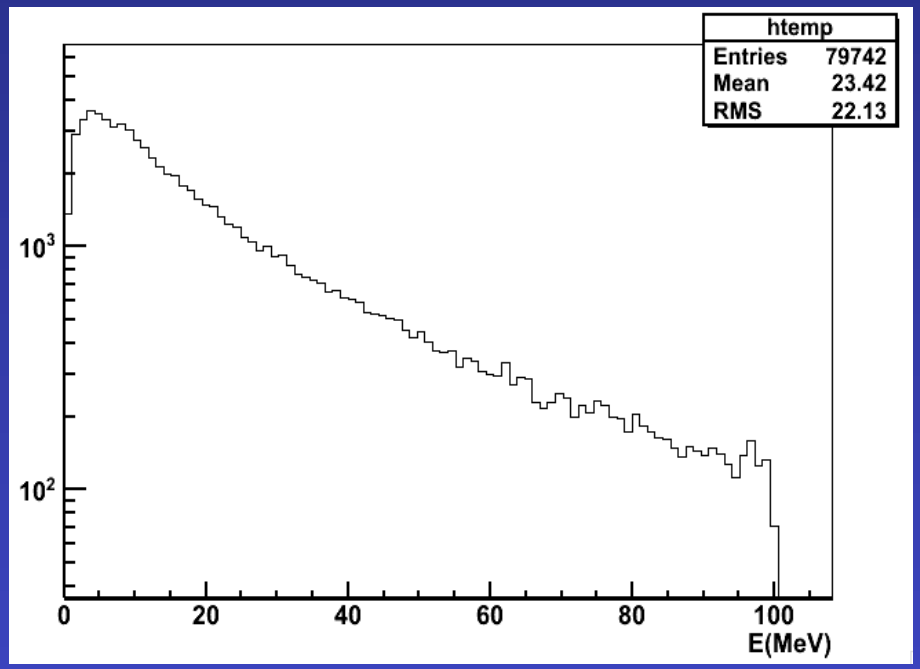
Incident E_{e^-}(GeV)	Incident P_{e^-}(kW)	P_γ(kW)
3	54	32
4	72	45
5	90	58
10	190	130

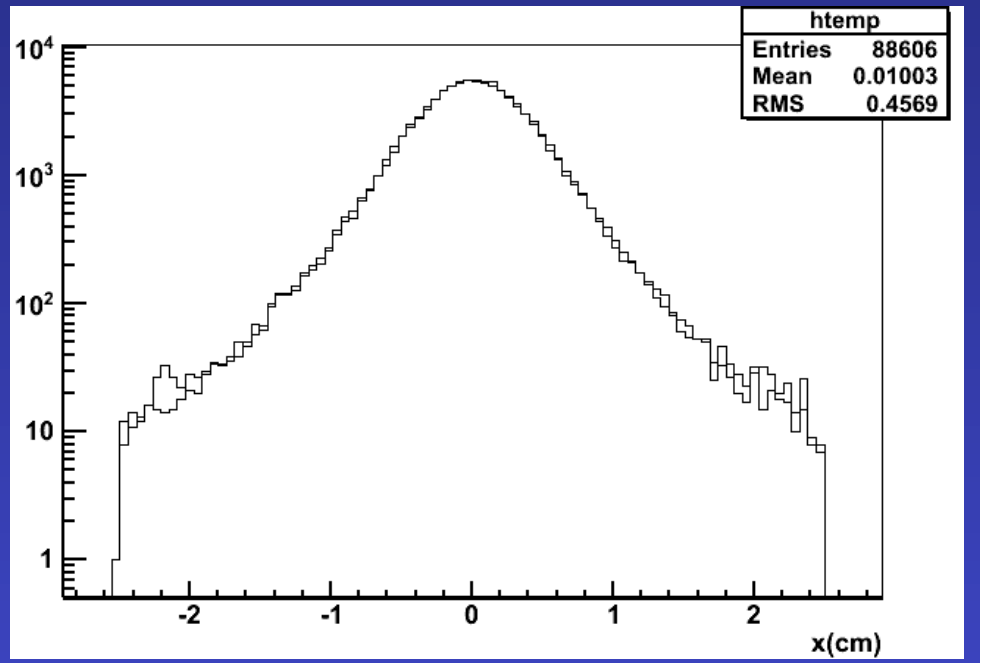


E_{e^-}(GeV)	N_{e^-}	N_γ	$\overline{E}_\gamma$(MeV)
10	5×10^3	112098	304
5	6×10^3	119813	160
4	6.5×10^3	118312	136
3	8×10^3	125810	115

Positrons phase space

- Incident electron beam 5 GeV (target=12mm, d=2m)



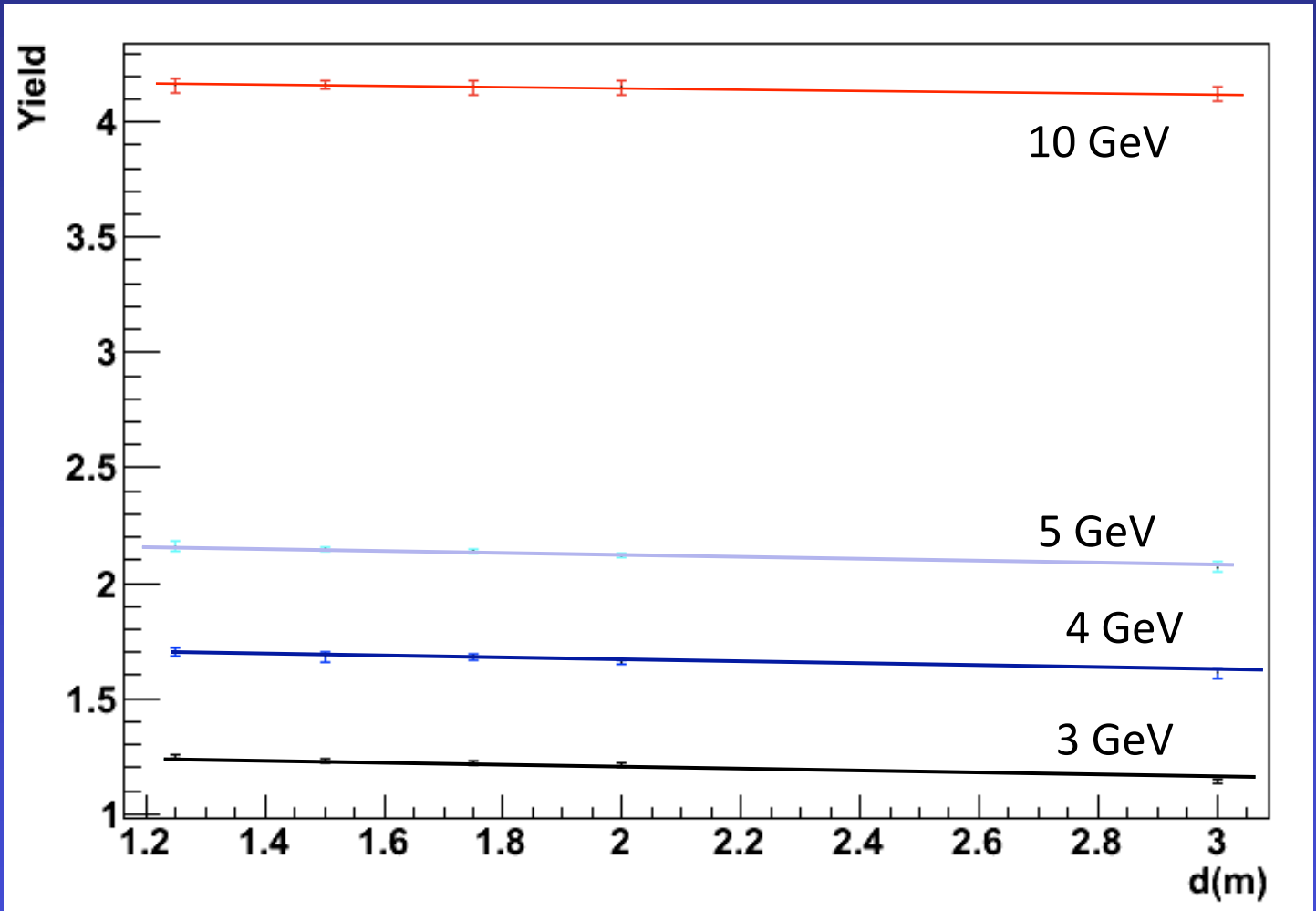


<E> ~ 23.5 MeV

$\sigma_{x,y}$ ~ 4.5 mm

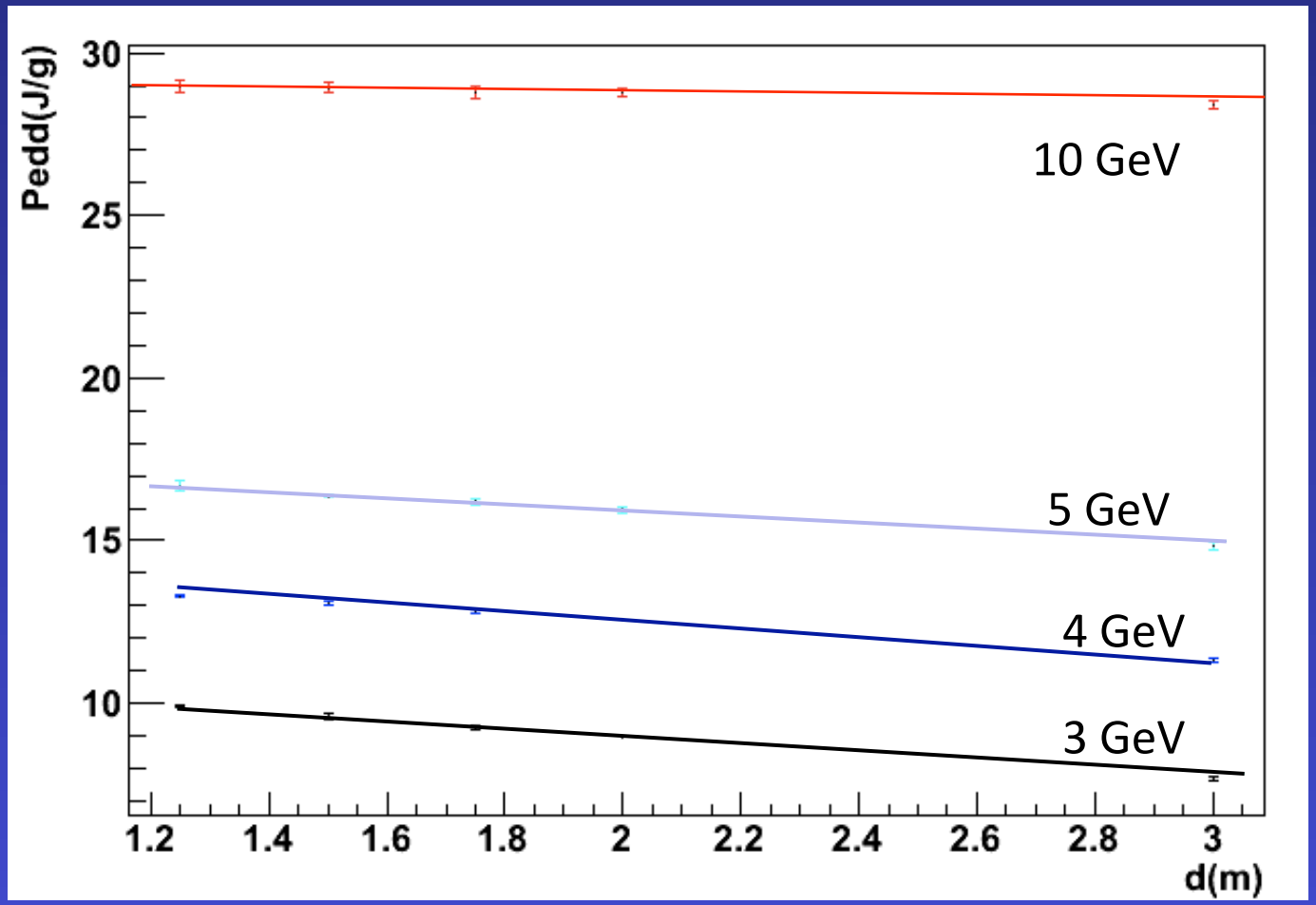
Results: Positron Yield(distance crystal-amorphous)

- Positron yield after the AMD r < 2.0 cm (e=10mm of amorphous)
  - Constraint only geometry not on Pt and Pz
- Positron yield not so affected by the distance



Results: PEDD (distance crystal-amorphous)

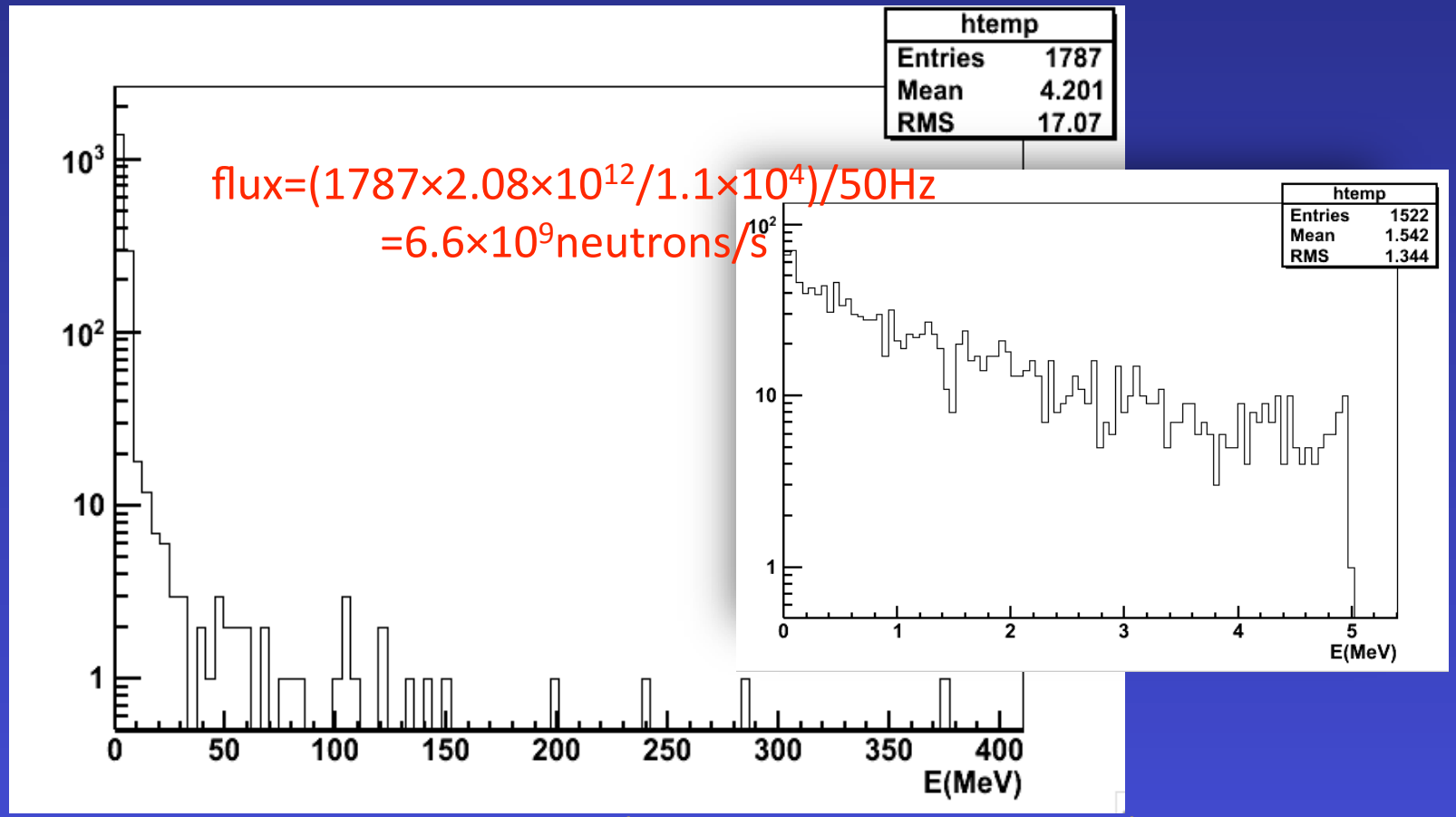
- PEDD for 10mm of amorphous (elementary volume few mm^3)
- PEDD decrease as the distance "d" increases



The larger the distance is, the larger the incident photon spot size impinging on the amorphous: <u>the smaller is the PEDD</u>

Results: neutron flux

- For 5 GeV incident e- beam
- Giant resonance maximum E [10;20] MeV
- Most of the flux is below 10 MeV



Seems to be very huge number (someone can comment ?)

Results CLIC note in preparation (abacus)

e(cm)	d(m)	Yield	Energy max. (10^9GeV/mm^3)	Pedd (J/g)
0.6	1.25	1.90 ± 0.02	1.35	11.23 ± 0.10
	1.5	1.90 ± 0.02	1.34	11.08 ± 0.11
	1.75	1.89 ± 0.02	1.32	10.91 ± 0.08
	2	1.88 ± 0.01	1.30	10.78 ± 0.09
	3	1.82 ± 0.02	1.21	10.00 ± 0.08
0.8	1.25	2.10 ± 0.02	1.72	14.26 ± 0.09
	1.5	2.10 ± 0.02	1.70	14.06 ± 0.09
	1.75	2.03 ± 0.01	1.66	13.74 ± 0.65
	2	2.04 ± 0.01	1.65	13.70 ± 0.10
	3	2.00 ± 0.02	1.54	12.76 ± 0.09
1	1.25	2.16 ± 0.02	2.01	16.69 ± 0.16
	1.5	2.15 ± 0.01	1.98	16.38 ± 0.010
	1.75	2.14 ± 0.01	1.95	16.20 ± 0.09
	2	2.12 ± 0.01	1.92	15.96 ± 0.09
	3	2.07 ± 0.02	1.80	14.86 ± 0.12
1.2	1.25	2.16 ± 0.02	2.20	18.164 ± 0.11
	1.5	2.17 ± 0.02	2.17	18.00 ± 0.13
	1.75	2.15 ± 0.02	2.14	17.72 ± 0.12
	2	2.13 ± 0.02	2.11	[illegible]
	3	2.08 ± 0.02	1.97	16.30 ± 0.11

Table 4: 5GeV

e(cm)	d(m)	Yield	Energy max. (10^9GeV/mm^3)	Pedd (J/g)
0.6	1.25	3.36 ± 0.03	2.08	17.24 ± 0.18
	1.5	[illegible]	2.07	17.18 ± 0.09
	1.75	[illegible]	2.06	17.09 ± 0.09
	2	[illegible]	2.06	17.12 ± 0.13
	3	[illegible]	2.03	16.82 ± 0.11
0.8	1.25	[illegible]	2.84	23.51 ± 0.18
	1.5	[illegible]	2.81	23.33 ± 0.13
	1.75	[illegible]	2.81	23.35 ± 0.17
	2	[illegible]	2.80	23.24 ± 0.15
	3	[illegible]	2.76	22.89 ± 0.14
1	1.25	[illegible]	3.50	28.98 ± 0.19
	1.5	[illegible]	3.50	28.94 ± 0.18
	1.75	[illegible]	3.48	28.85 ± 0.20
	2	[illegible]	3.47	28.76 ± 0.13
	3	[illegible]	3.43	28.40 ± 0.12
1.2	1.25	[illegible]	4.03	33.44 ± 0.20
	1.5	[illegible]	4.01	33.27 ± 0.22
	1.75	[illegible]	4.02	33.32 ± 0.16
	2	[illegible]	4.00	33.21 ± 0.23
	3	[illegible]	3.95	32.78 ± 0.24

Pessimistic:
I took a wrong sigma for
my calculation (factor sqrt(2) less)
Need to redo the simulation

RMS presented in the following done with 20 different experiences (20 seed)

Conclusion & prospects

- In term of PEDD :
  - no problem for 3, 4, 5 GeV (PEDD<35J/g)
  - Preferable at 3m
- At 10 GeV must use a 0.8 cm target thickness
- Heating simulation (in progress)
- Need to study the contribution of charged particles
  - use charged particles coming from the radiator (e+, e-) with energy larger than $E_{treshold}$ to increase the yield e+/e-
- For PEDD, the Mesh characteristics is critical value
  - Need to have a good criteria

Conclusion & prospects

- My simulation can not handle the polarization when positron cross the AMD
- Geant4 can not track the polarization with the AMD
  - People from DESY Zeuthen gave me the classes to be implemented (need to fix this in Geant4?)
  - BDSIM simulation for the propagation of the positron after the target
- Check my code with PPS-Sim (Iryna)
- Discussion : upgrade the existing channeling code(s) in OO (perspective of Geant4 classes ?)