# CLIC luminosity monitoring/re-tuning using beamstrahlung ?

1. Beamstrahlung etc. – from D. Schulte
2. Conceptual design of a CLIC post-collision beam-line ("spent beam") – from A. Ferrari
3. How could one measure beamstrahlung photons - ideas from E. Bravin
4. Possible layout, background, open questions

Courtesy of Konrad Elsener

# 1. Beamstrahlung etc. – from D. Schulte

## Luminosity and Background Values

| | | CLIC | CLIC | CLIC | ILC | NLC |
|---|---|---|---|---|---|---|
| $E_{cms}$ | $[TeV]$ | 0.5 | 1.0 | 3.0 | 0.5 | 0.5 |
| $f_{rep}$ | [Hz] | 100 | 75 | 50 | 5 | 120 |
| $N$ | $[10^9]$ | 4.0 | 4.0 | 4.0 | 20 | 7.5 |
| $\epsilon_y$ | $[nm]$ | 20 | 20 | 20 | 40 | 40 |
| $L$ | $10^{34}cm^{-2}s^{-1}$ | 2.14 | 2.7 | 7.0 | 2.0 | 2.0 |
| $L_1$ | $10^{34}cm^{-2}s^{-1}$ | 1.36 | 1.5 | 2.0 | 1.45 | 1.28 |
| $n_\gamma$ | | 1.10 | 1.20 | 2.4 | 1.30 | 1.26 |
| $\Delta E/E$ | | 0.07 | 0.11 | 0.31 | 0.024 | 0.046 |
| $N_{coh}$ | $10^5$ | 0.01 | 7.19 | $5.5 \times 10^3$ | — | — |
| $E_{coh}$ | $10^3 TeV$ | 0.15 | 216.28 | $3.9 \times 10^5$ | — | — |
| $n_{incoh}$ | $10^6$ | 0.05 | 0.09 | 0.44 | 0.1 | n.a. |
| $E_{incoh}$ | $[10^6 GeV]$ | 0.25 | 1.30 | 32.4 | 0.2 | n.a. |
| $n_t$ | | 11.5 | 17.1 | 66 | 28 | 12 |
| $n_{had}$ | | 0.10 | 0.29 | 3.2 | 0.12 | 0.1 |

- Target is to have about one beamstrahlung photon per beam particle
  - similar effect to initial state radiation

  ⇒ average energy loss is larger in CLIC than ILC
- Note: shorter bunches increase the photon energy but not the number

**luminosity tuning:**

performed in BDS, using laser wires etc.

... a tedious, long procedure ...

**luminosity monitoring and re-tuning:**

ILC uses incoherent pairs –
CLIC has problem: many coherent pairs

-> keep track of luminosity … "fast" signal needed
(there will be changes of beam position, angle, waist …)

… and correct for these changes

-> possible signal: beamstrahlung

CLIC

CERN-AB-2006-044

CLIC Note 669

**LUMINOSITY TUNING AT THE INTERACTION POINT**

P. Eliasson, M. Korostelev, D. Schulte, R. Tomás, F. Zimmermann

CERN, Geneva, Switzerland

**beamstrahlung photons:**

**energies:**
from <1 GeV to <1.5 TeV (max. at > 1 TeV)

**rate:**
2.4 photons per electron (positron) in beam,
i.e. 1E+10 photons per bunch
x 311 bunches
→ 3E+12 photons per 207 ns pulse
(repetition rate 50 Hz)

**angular distribution:** ± 50 μrad (full width) (2005 parameters)

**NB.**
**all numbers for nominal collision parameters !**

CLIC

CLIC Note 704

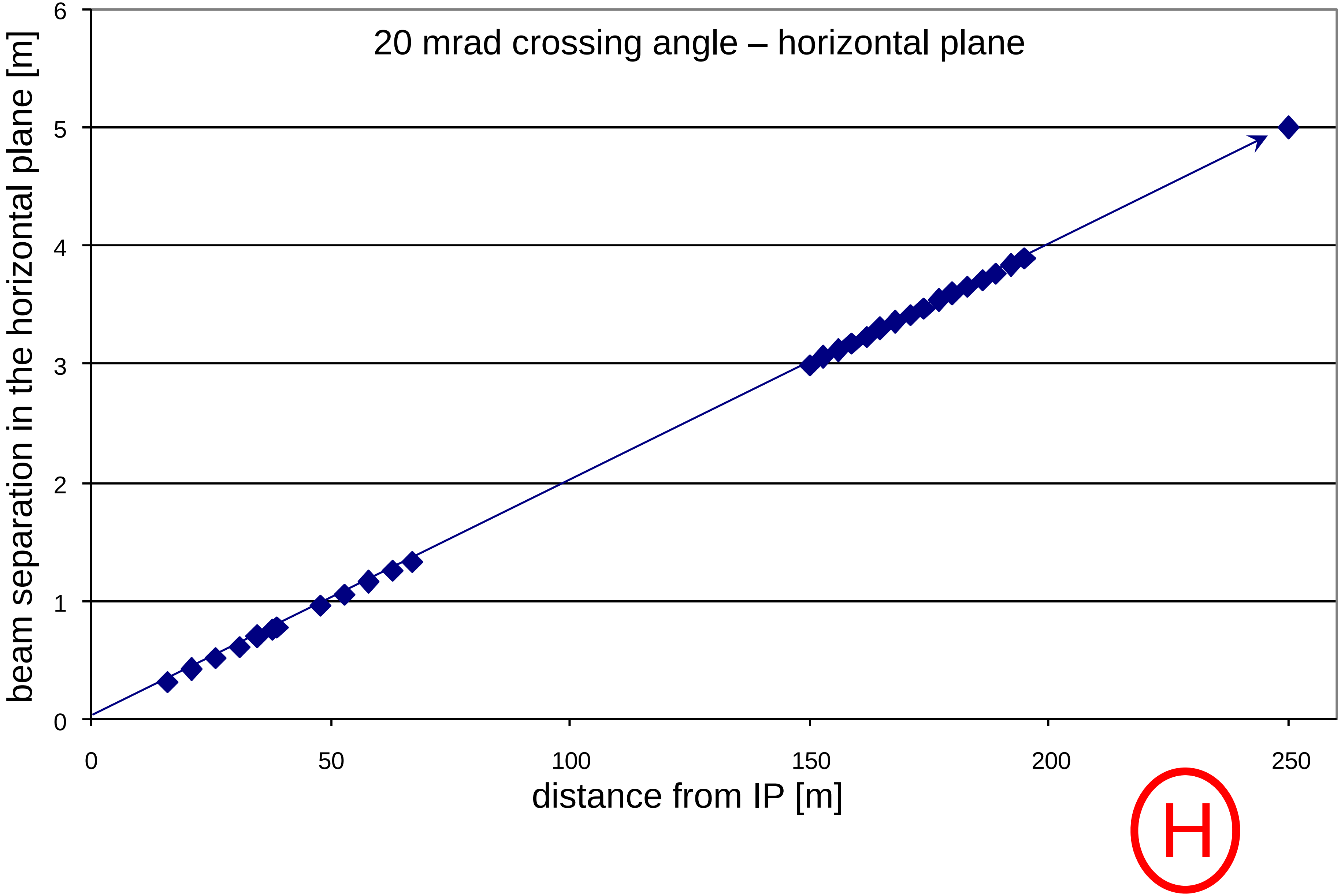
EUROTeV

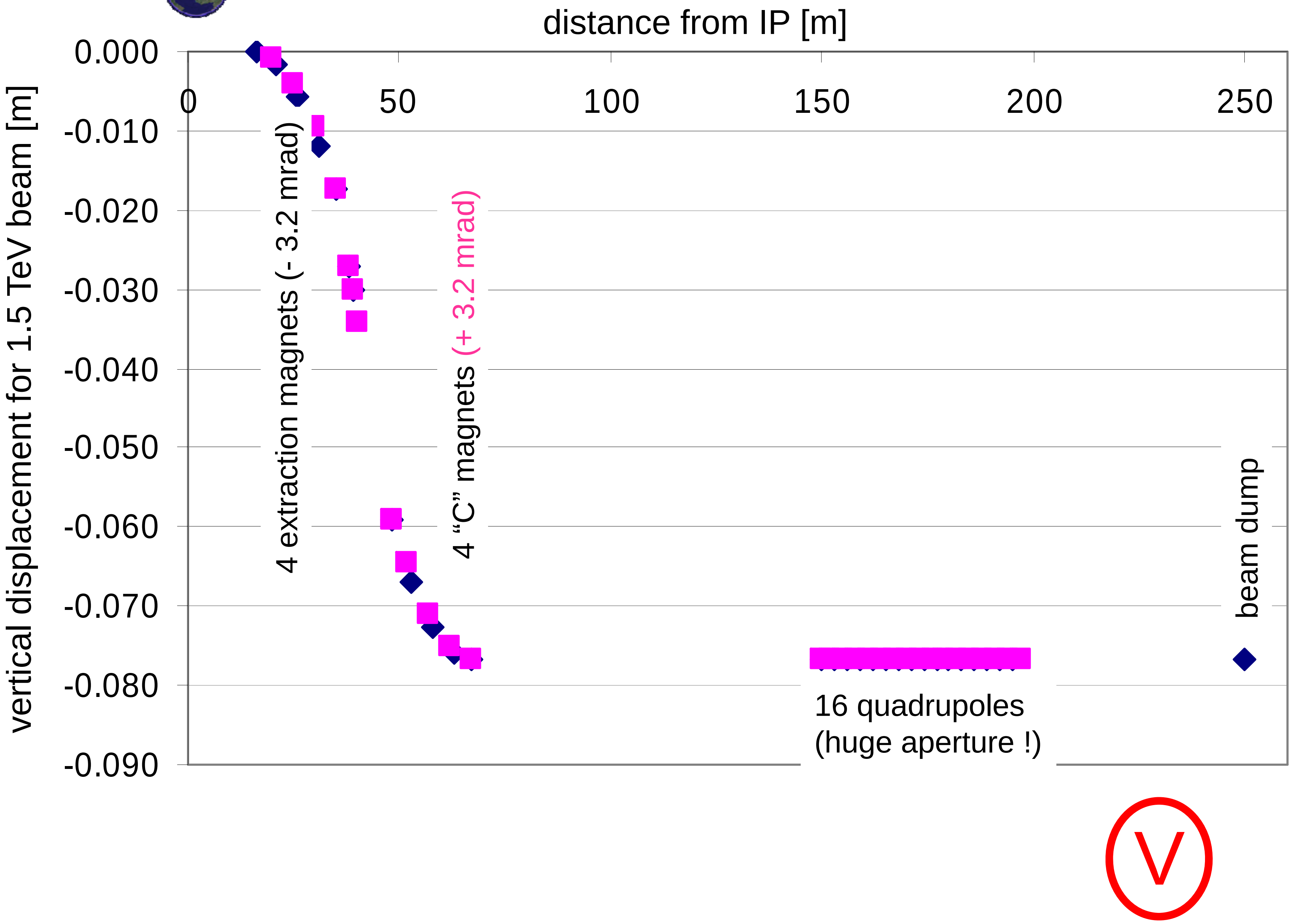
EUROTeV-Report-2007-001

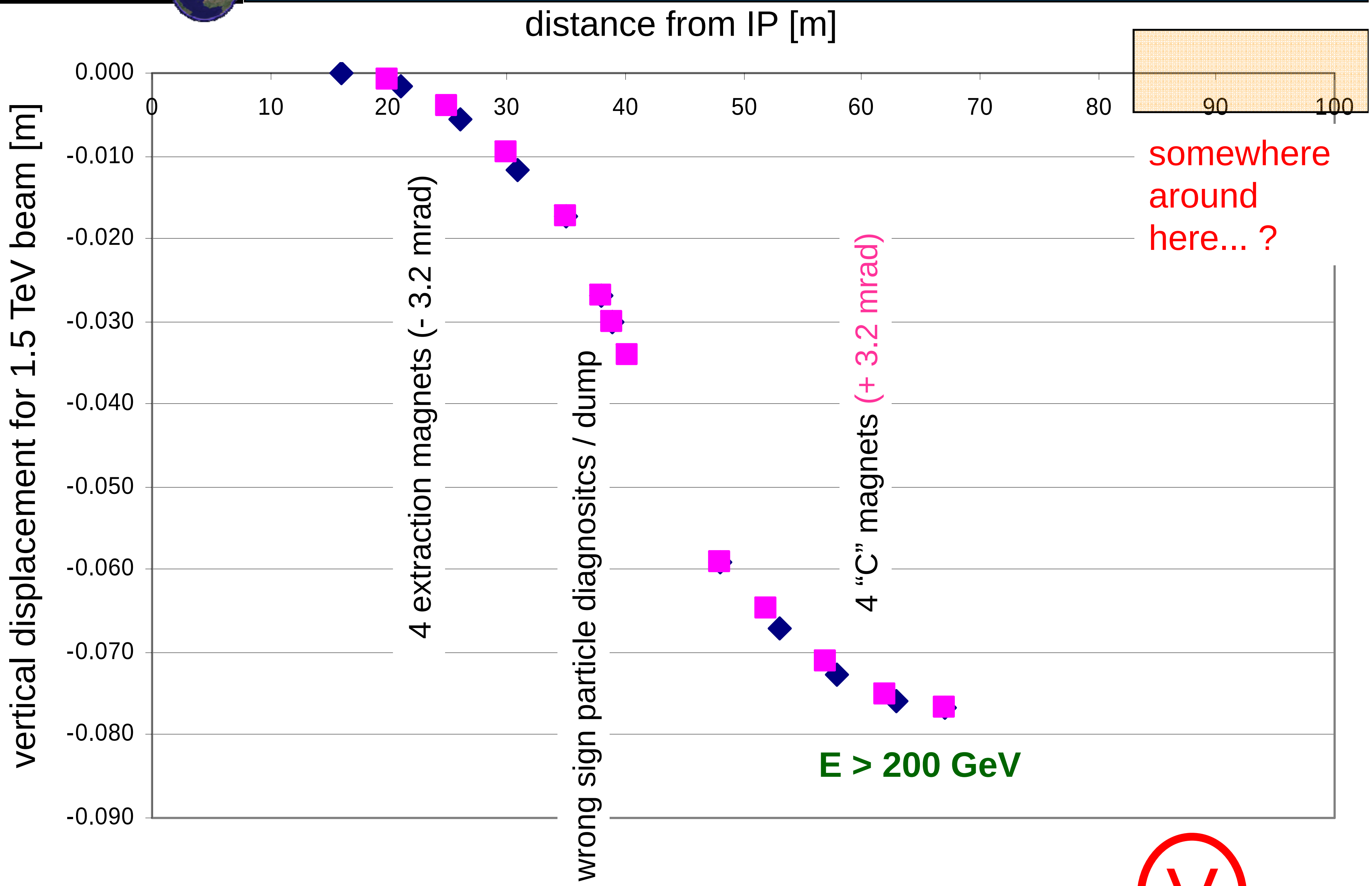
CERN-OPEN-2007-005
06/02/2007

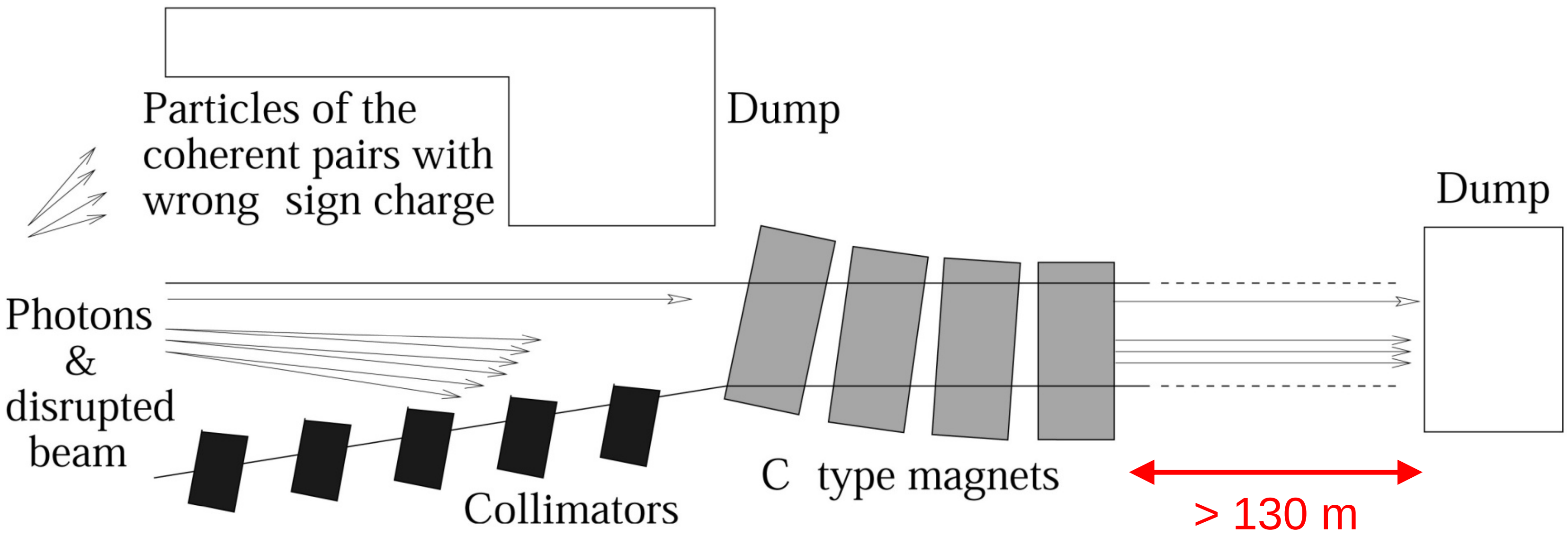
# 3. Conceptual design of a post-collision transport line for CLIC at 3 TeV

A. Ferrari,
Uppsala University, Sweden


20 mrad crossing angle – horizontal plane
beam separation in the horizontal plane [m]
distance from IP [m]
0
1
2
3
4
5
6
0
50
100
150
200
250
H


distance from IP [m]
vertical displacement for 1.5 TeV beam [m]
0.000
-0.010
-0.020
-0.030
-0.040
-0.050
-0.060
-0.070
-0.080
-0.090
0
50
100
150
200
250
4 extraction magnets (- 3.2 mrad)
4 “C” magnets (+ 3.2 mrad)
beam dump
16 quadrupoles
(huge aperture !)
V


distance from IP [m]
0.000
-0.010
-0.020
-0.030
-0.040
-0.050
-0.060
-0.070
-0.080
-0.090
0
10
20
30
40
50
60
70
80
90
100
vertical displacement for 1.5 TeV beam [m]
4 extraction magnets (- 3.2 mrad)
wrong sign particle diagnositcs / dump
4 "C" magnets (+ 3.2 mrad)
somewhere around here... ?
E > 200 GeV




A. Ferrari, CLIC note 704

## 3. How could one measure beamstrahlung photons - ideas from E. Bravin (18 July 2007 meeting)

3E+12 photons in 207 ns, E up to 1.5 TeV

→ better use a “thin” detector – “fast”

(get information on the number of photons, can not get information on their energy)

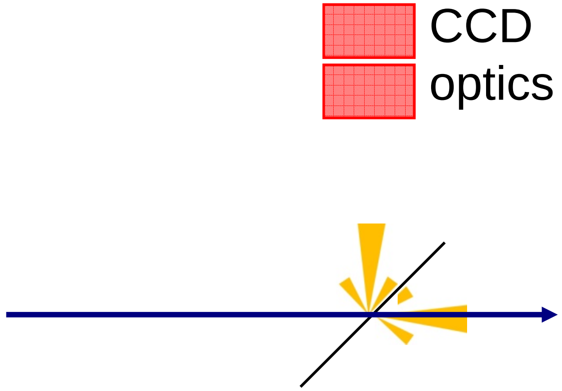
basic principle: converter + OTR monitor

$\gamma$ -> e+e- (optical transition radiation)

question: layout, backgrounds, etc. etc.

typical OTR monitor arrangements:

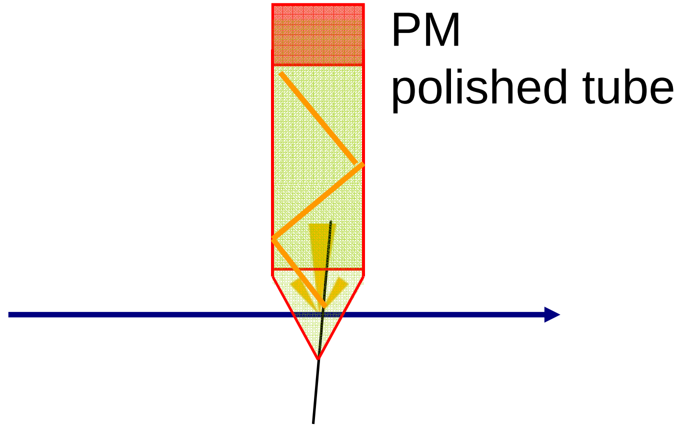
e.g. “intensity” and profile




works at >10E+11 part.
good pos. resolution
(+ size of beam)

“rad. hard” cameras exist...
very slow

e.g. “intensity” only



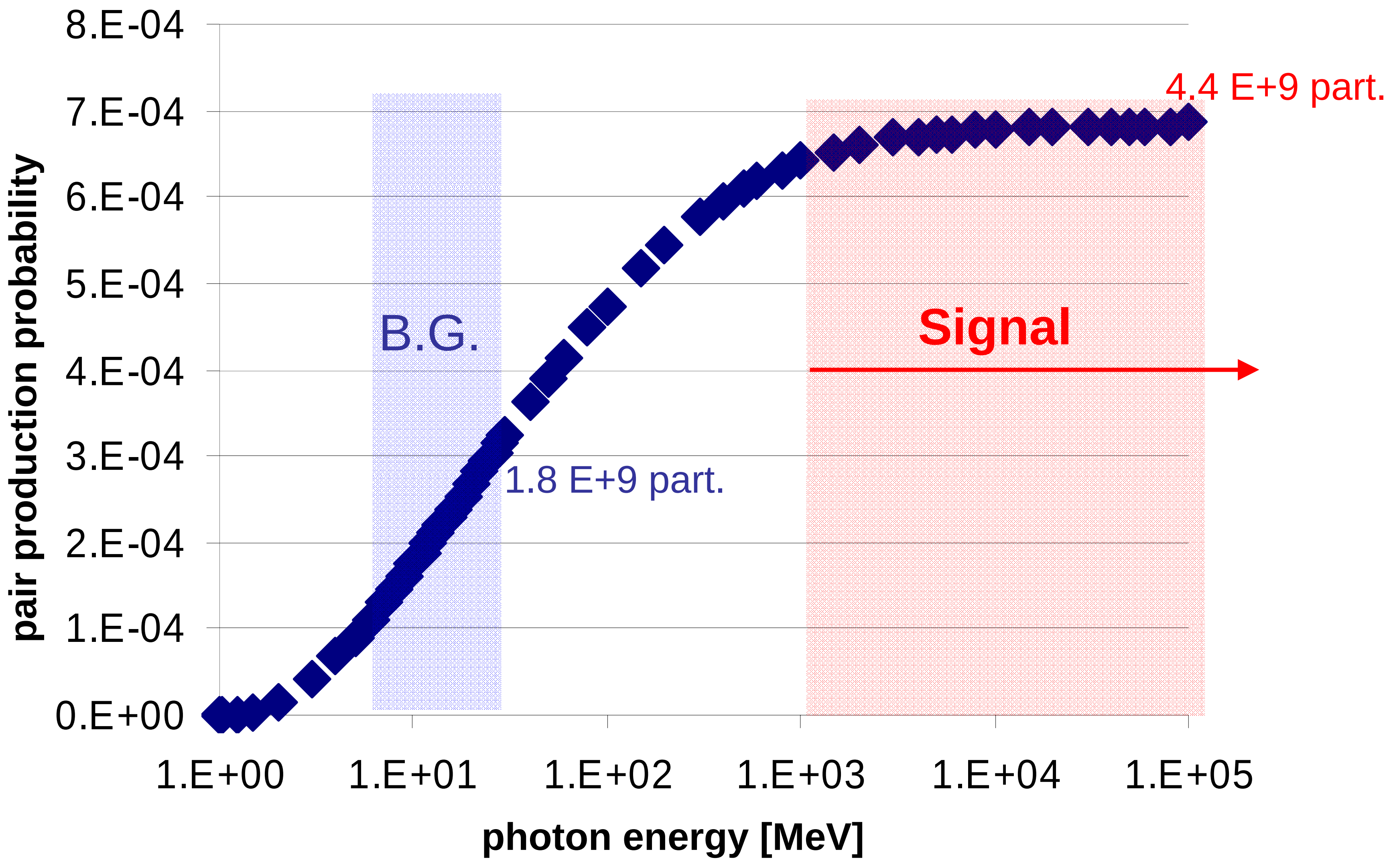

almost “single counting”;
very fast (< 1 ns)

“radiation hard”

sensitive to “direct hits”

ATTENTION: No absolute calibration for the intensity !!

## Pair Production (nuclear field) in 1 mm graphite (0.005 $X_o$)



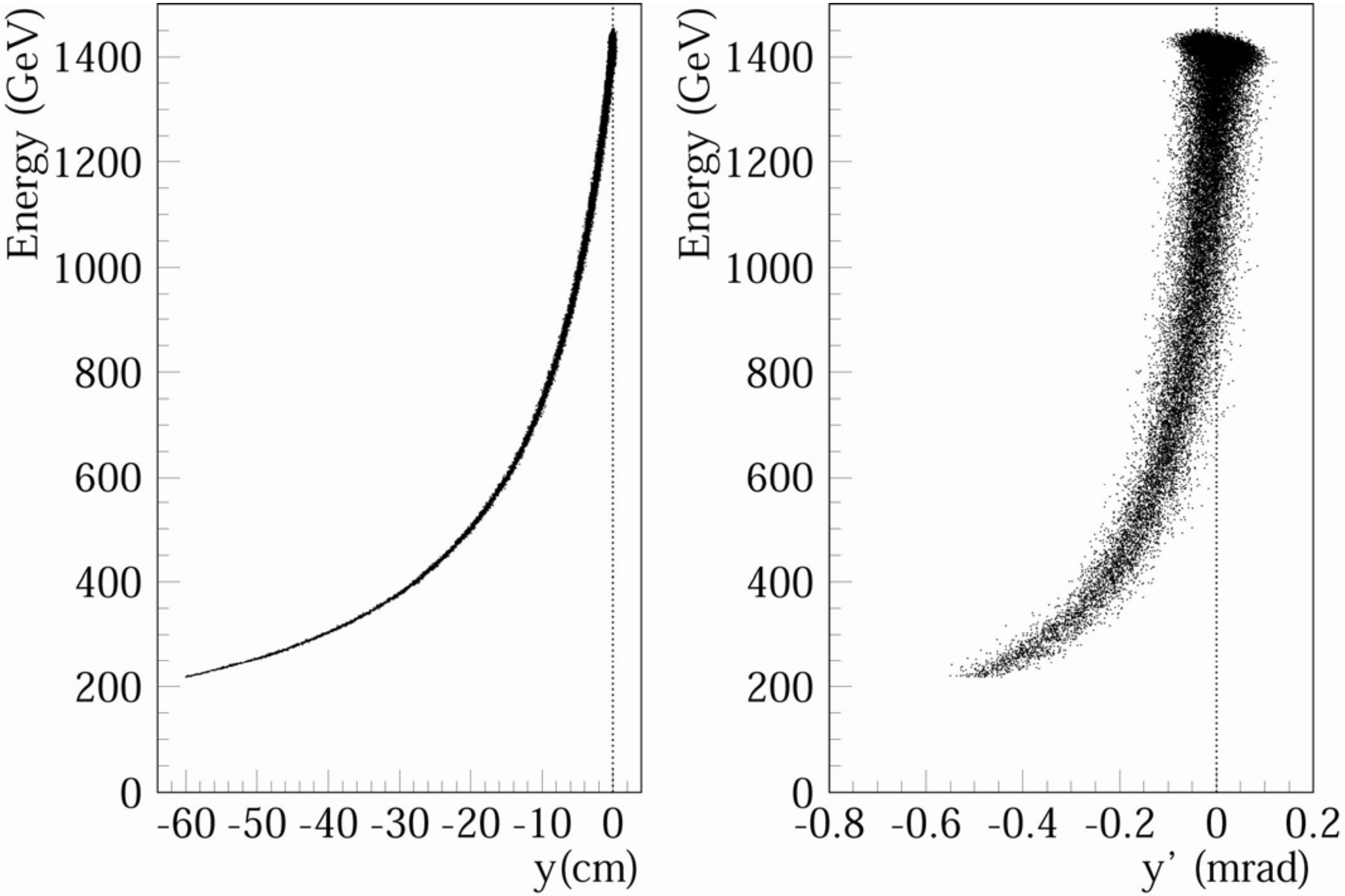
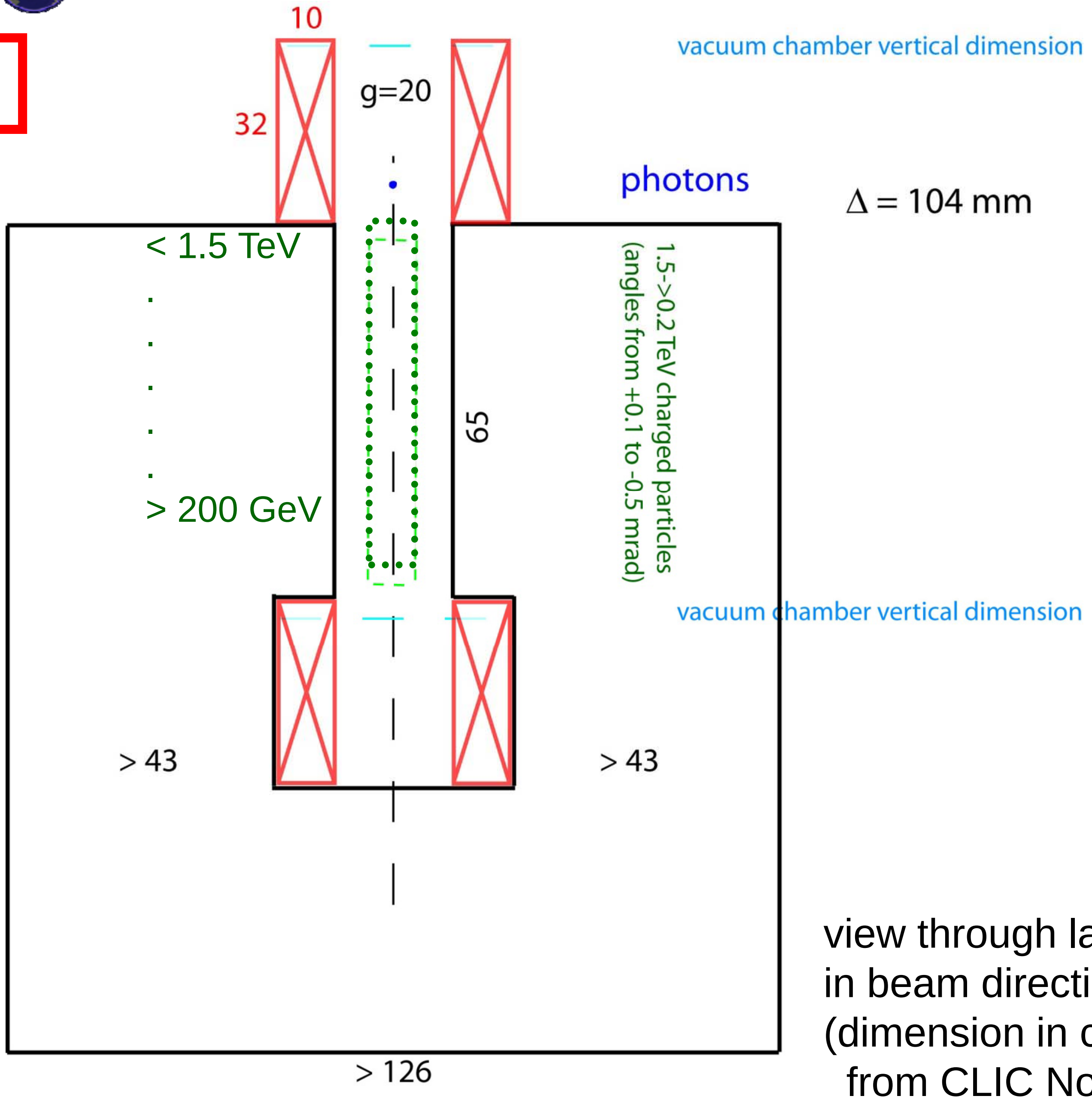


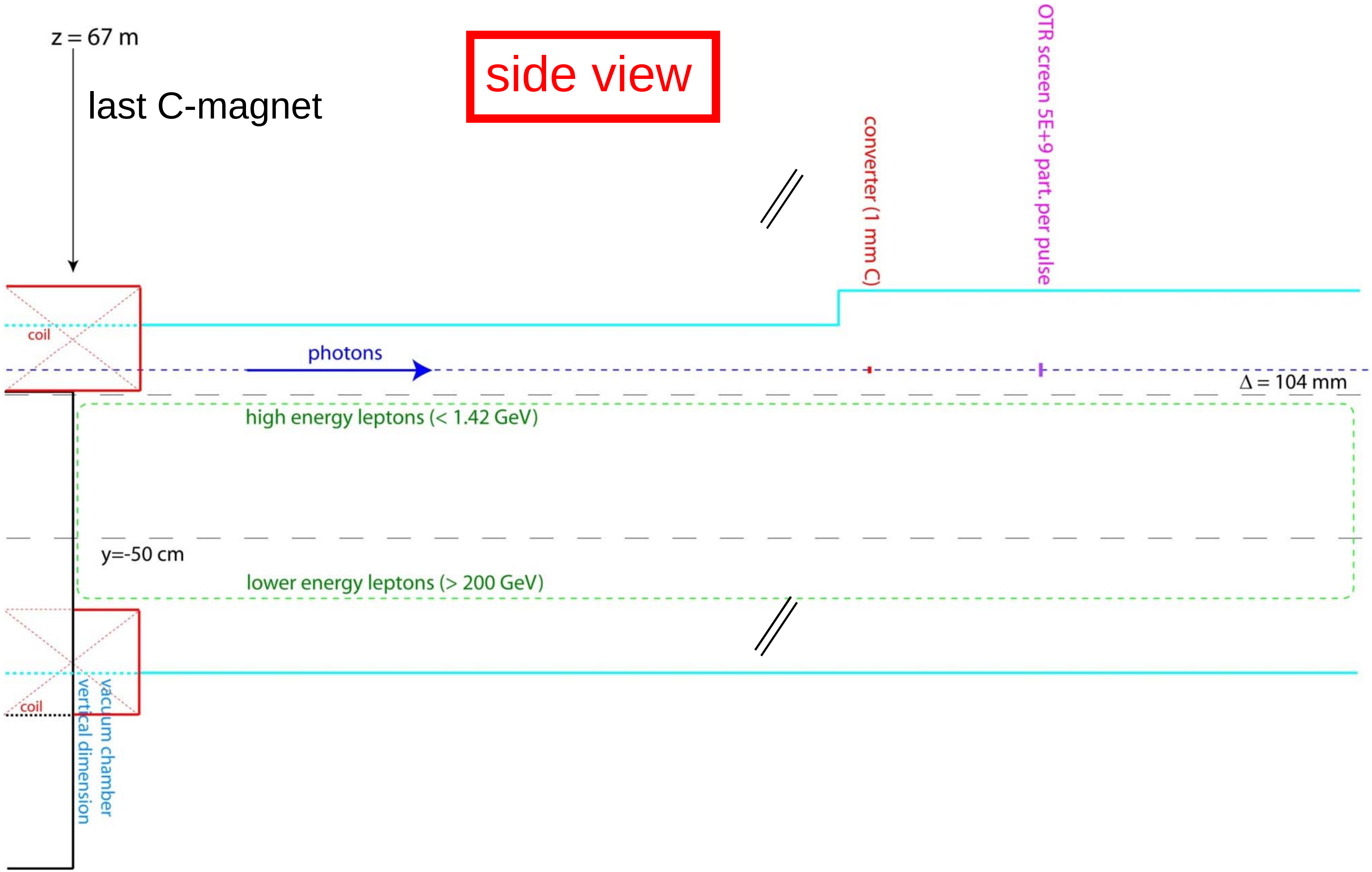

Figure 15: y and y distributions as a function of the energy for the disrupted beam, as obtained at the exit of the post-collision chicane.

A. Ferrari, CLIC note 704

top view




view through last C-magnet in beam direction (dimension in cm, from CLIC Note 704)


side view
z = 67 m
last C-magnet
converter (1 mm C)
OTR screen 5E+9 part. per pulse
coil
photons
Δ = 104 mm
high energy leptons (< 1.42 GeV)
y=-50 cm
lower energy leptons (> 200 GeV)
coil
vacuum chamber
vertical dimension

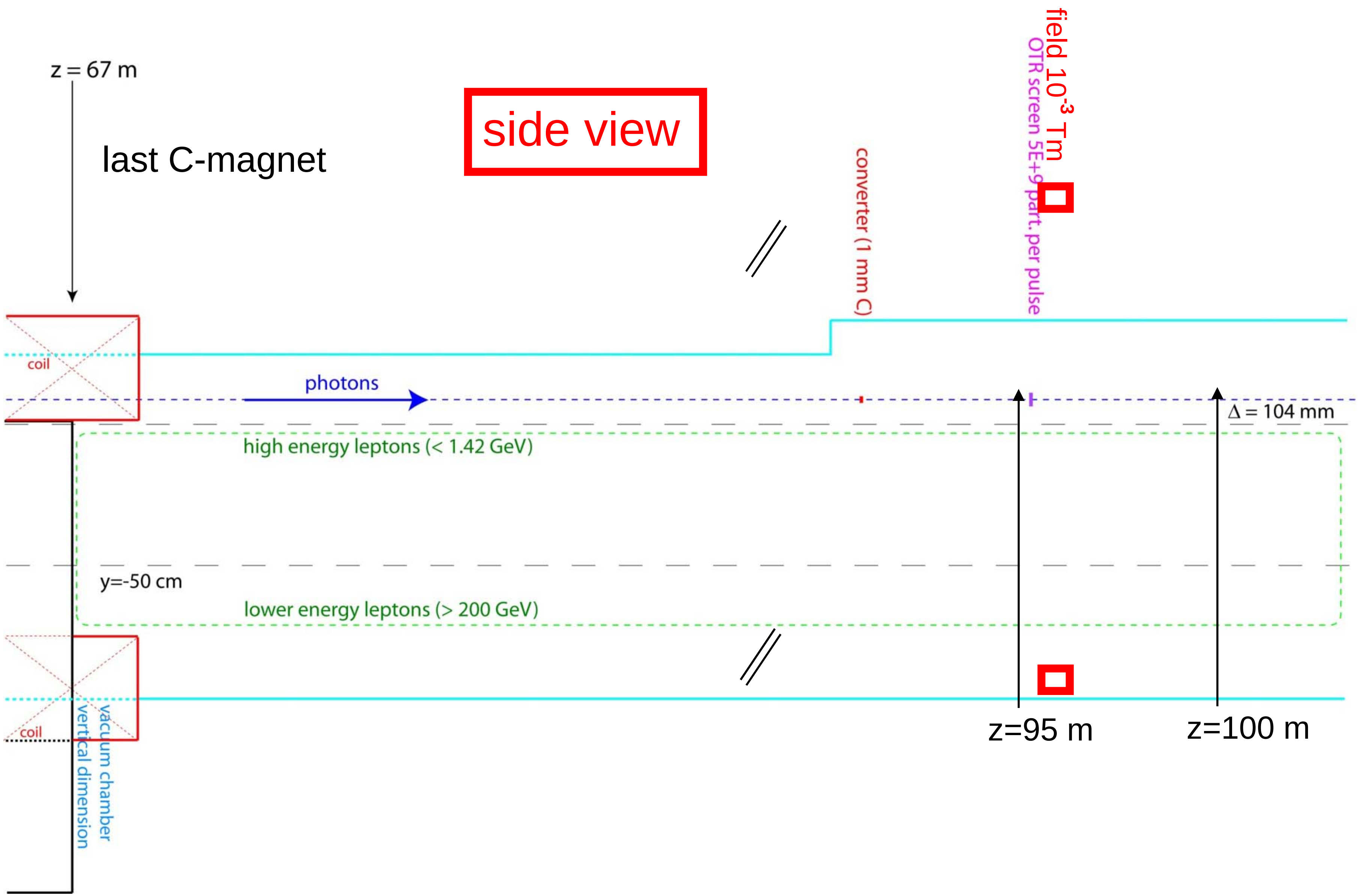
background No. 1: synchrotron radiation photons
pair production -> < 50 MeV particles

solution (?): $10^{-3}$ Tm magnetic field (-> 15 mrad at 20 MeV)
(if possible, sweep l.e. particles in H-plane,
observe OTR light in V-plane)

use “small” OTR screen at 5 m from converter
(e.g. diameter 30 mm OTR screen)

background No. 2: scattered electrons/positrons of all kinds
-> to be studied

background No. 3: neutrons
(stay far away from IP and from dumps) -> to be studied


z = 67 m
last C-magnet
side view
converter (1 mm C)
field 10$^{-3}$ Tm
OTR screen 5E+9 part. per pulse
coil
photons
Δ = 104 mm
high energy leptons (< 1.42 GeV)
y=-50 cm
lower energy leptons (> 200 GeV)
coil
vacuum chamber
vertical dimension
z=95 m
z=100 m

# open questions:

-> strength of C-magnets
(separation beamstrahlung from particles > 100 mm (?))

-> investigate beamstrahlung distribution
for various non-perfect conditions (e.g. Fig. 20 in CLIC note 704)

-> introduce "realistic" monitor into simulations (?) and test the "tuning knobs"

\+ everything overlooked or forgotten !

## 5. Summary

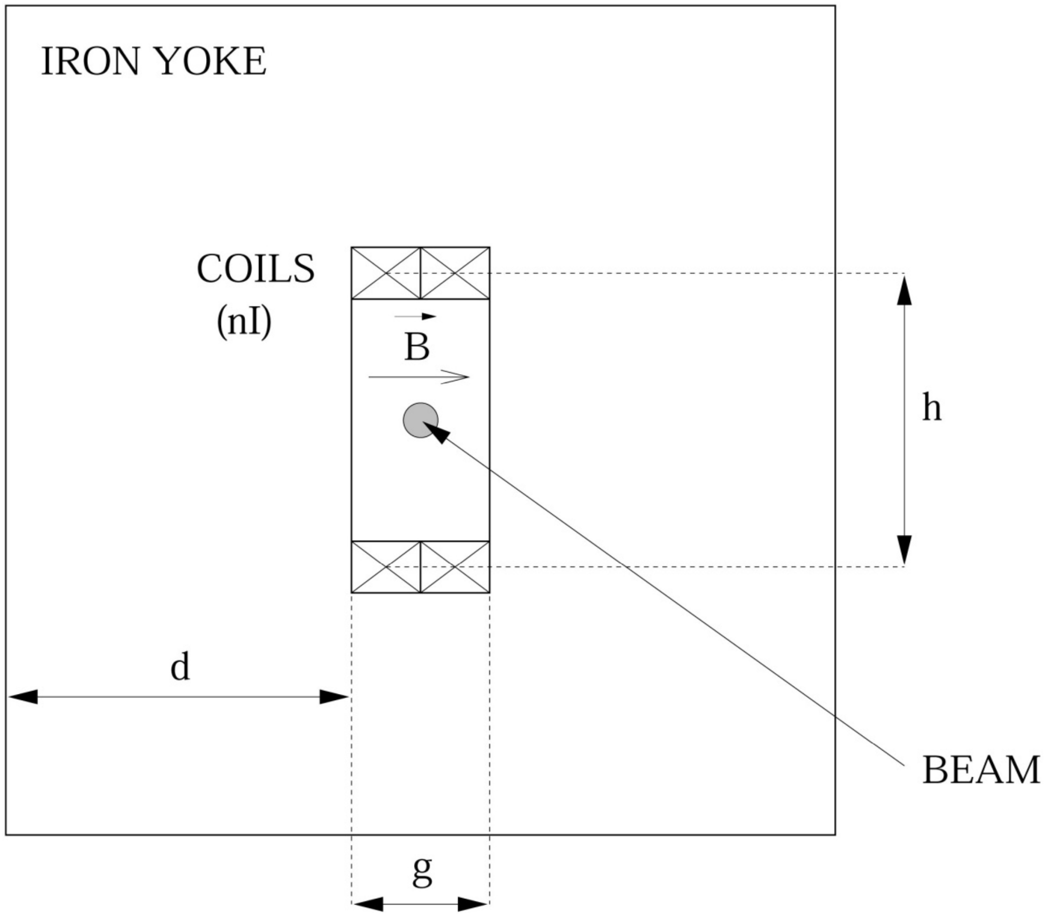
The option of using beamstrahlung photons for “fast” feedback and luminosity tuning at CLIC appears still valid.

The technique using a converter plus OTR has several interesting features (e.g. change converter thickness for lower intensity running, different options for OTR detection, etc. etc.).

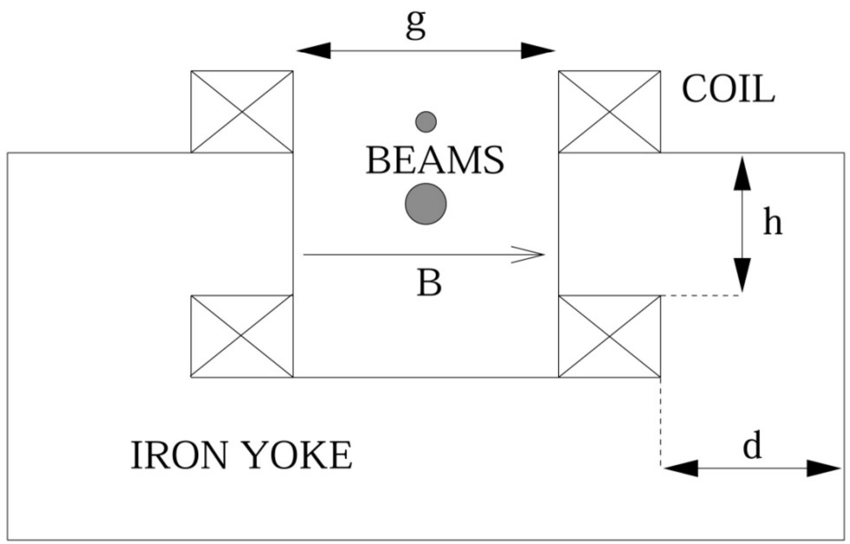
Assuming that CLIC-Note 704 is the reference design for the post-collision beamlines, the location at about 100 m from the interaction point could be reasonable.

“... affaire à suivre ...”

extraction magnet
(“window-frame”)




C - magnet




A. Ferrari, CLIC note 704