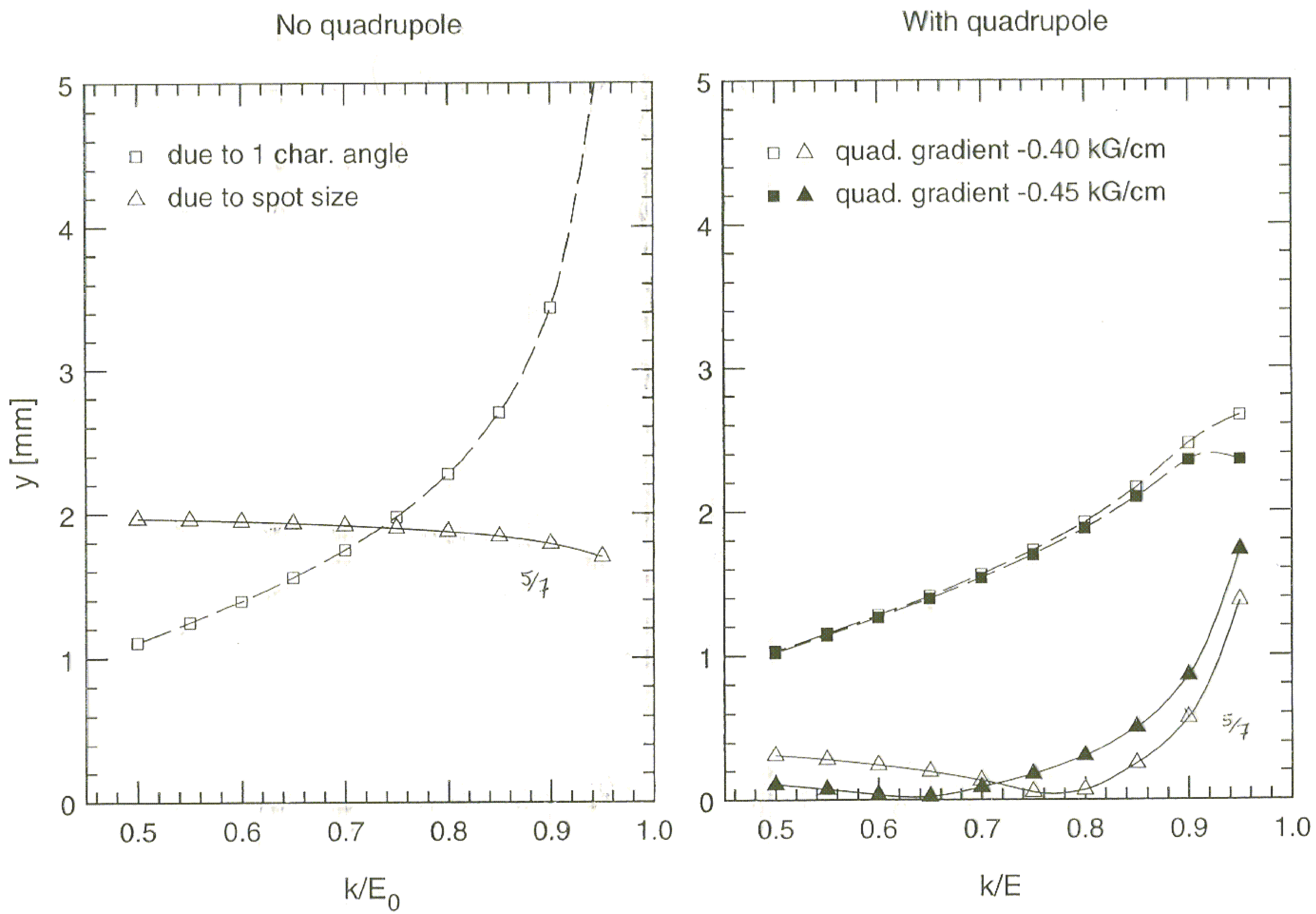
Hall D Beamline
working group update

Richard Jones
Jim Kellie
Ken Livingston
Dan Sober
Hall Crannel
Jay Benesch

- crystals
- electron beam optics
- tagger magnet
- focal plane instrumentation

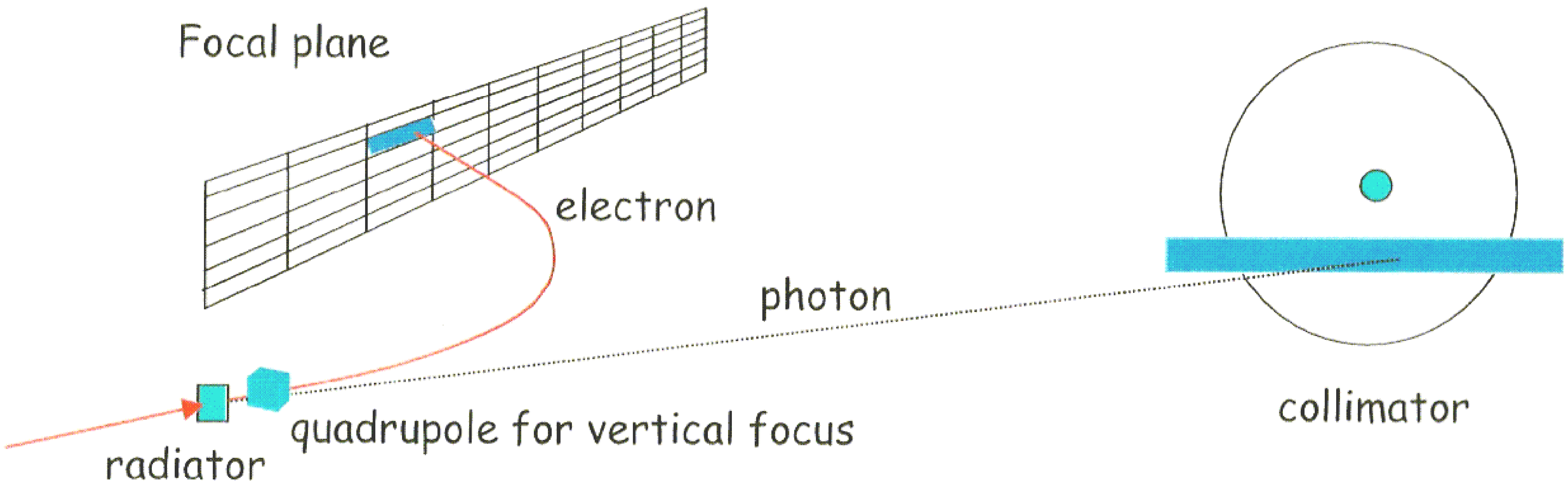
Tagger focal plane instrumentation

- Advantages of *2D focal-plane readout*
  - ✔ increased polarization
  - ✔ increased tagging efficiency
- Possible designs
  - ❑ silicon microstrips
  - ❑ thin scintillator tiles
- For design report
  - ✔ present as an option being studied
  - ✔ show what could be obtained in terms of polarization and tag. eff.


No quadrupole
With quadrupole
due to 1 char. angle
due to spot size
quad. gradient -0.40 kG/cm
quad. gradient -0.45 kG/cm
y [mm]
k/E0
k/E
5/7
5/7

Tagger focal plane instrumentation

* Novel design for the microscope: *2D focal-plane readout*



* Vertical coordinate determines whether photon can possibly pass the collimator or not

Tagger focal plane instrumentation

- Solution now under consideration
  - microscope of fast silicon strips or thin scintillation counters arranged in a movable box that gets mounted in front of...
  - A fixed array of 100 scintillator paddle detectors that covers the entire focal plane and can provide:
    - **feedback for crystal alignment**
    - **continuous monitoring of CB spectrum (at reduced voltage)**
    - **incoherent tagging up near the endpoint (charm studies)**
    - **a reference for finding the energy scale of the microscope**

- Cost scale:
  - $100K material costs for fixed array, incl. analog electronics
  - microscope needs R&D: estimates $100K - $200K

Tagger focal plane instrumentation

* Instrumenting the entire focal plane at full segmentation required at the coherent peak is
  - expensive
  - unnecessary

400MHz/GeV * 8GeV / 5MHz = 640 channels

most of these are unpolarized

* What is needed for Hall D?
  - A tagging "microscope"

    Finely segmented (20MeV) high-rate counters with timing resolution < 1ns over a small range in photon energy (< 1GeV)
  - Coverage for the rest of the focal plane

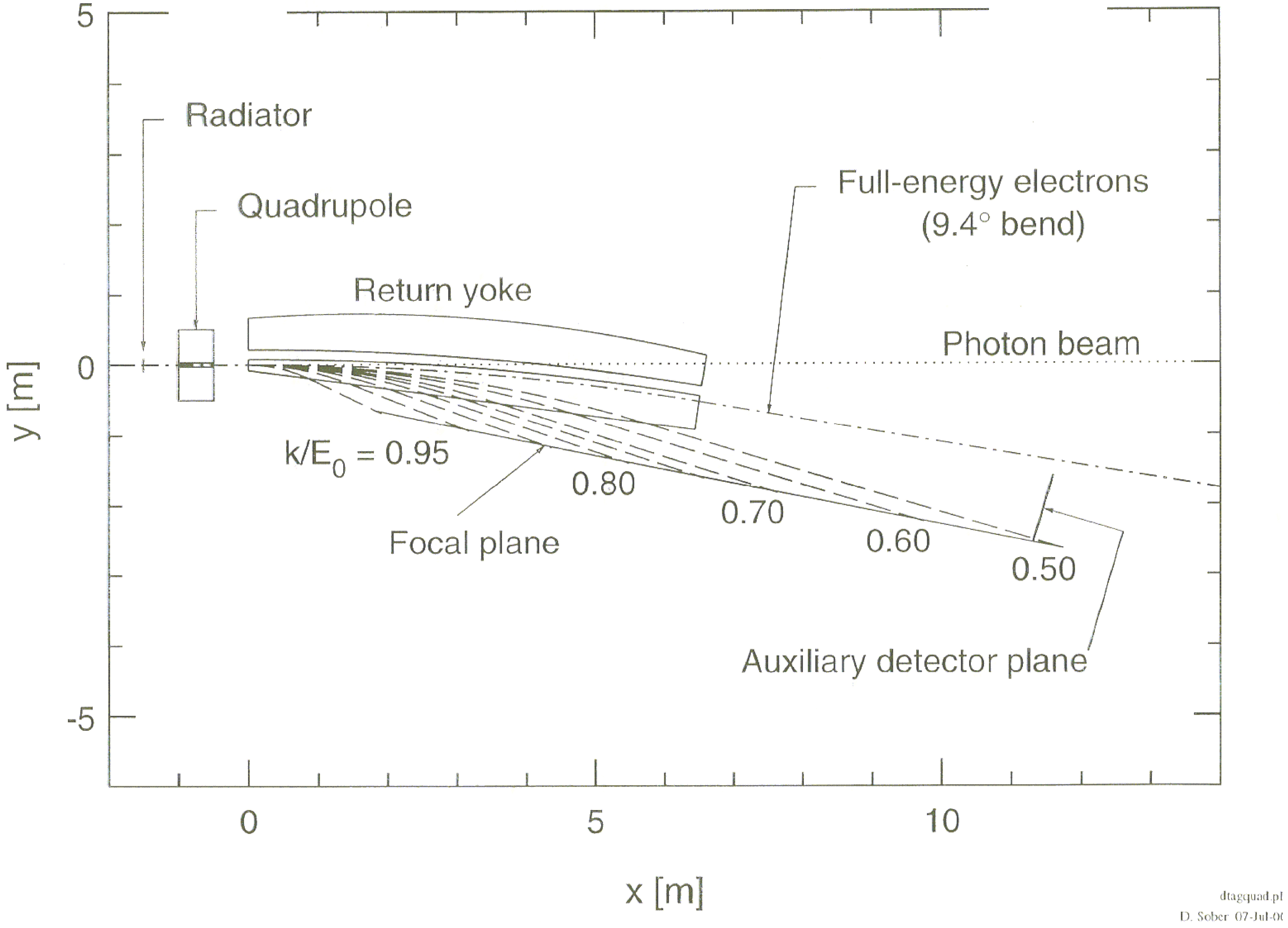
    Another set of detectors with coarser segmentation (100MeV) but do not need to count at high rates or have fast timing

Tagger magnet

- Suggested change: 1.5 Tesla field, 14º bend
- Reasons for choice:
  - focal plane contains much larger bite [25% , 92%]
  - no additional cost for the magnet
  - offers access to full range desired for crystal alignment without the need for two beam dumps -- which do *not* come without cost

- Disadvantages:
  - useable only up to $E_0 < 16$ GeV
  - space per GeV on focal plane is reduced by factor ~2

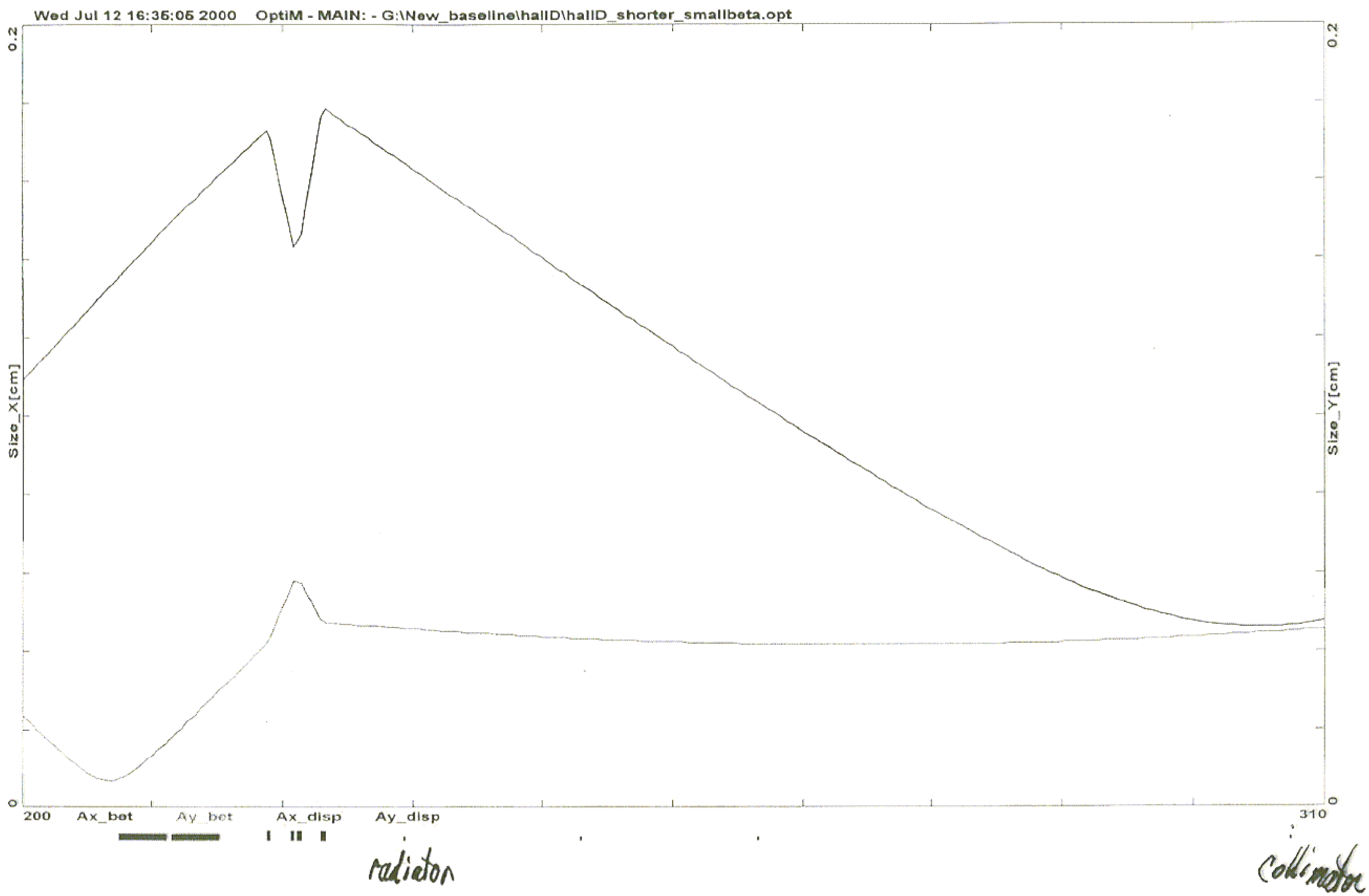
10MeV : 18mm → 10MeV : 10mm


Radiator
Quadrupole
Return yoke
Full-energy electrons
(9.4° bend)
Photon beam
k/E0 = 0.95
0.80
0.70
0.60
0.50
Focal plane
Auxiliary detector plane
5
0
-5
y [m]
0
5
10
x [m]
dtagquad.pl
D. Sober 07-Jul-00

Tagger magnet

* Present design: 1 Tesla field, 9.4° bend
* Reasons for choice:
  - good resolution over required tagging range **[50% , 95%]**
  - still works for future upgrade to $E_0 < 24$GeV

* Disadvantages:
  - access to the tagger range below 50% is desirable for crystal alignment and perhaps some physics measurements
  - to detect electrons in this range in the present design is possible, but with reduced energy resolution and space


Wed Jul 12 16:35:05 2000 OptiM - MAIN: - G:\New_baseline\hallD\hallD_shorter_smallbeta.opt
Size_X[cm]
Size_Y[cm]
0.2
0.2
0
0
200
310
Ax_bet
Ay_bet
Ax_disp
Ay_disp
radiator
collimator

Electron beam optics

* Realistic optics design carried out by **Jay Benesch**
* Meets or exceeds all Hall D design parameters
* Extra space has been allocated in the region between tagger building and Hall D for the collimator enclosure to allow for:
  - secondary collimator
  - primary and secondary sweeping magnets
  - 5m shielding for muons and neutrons

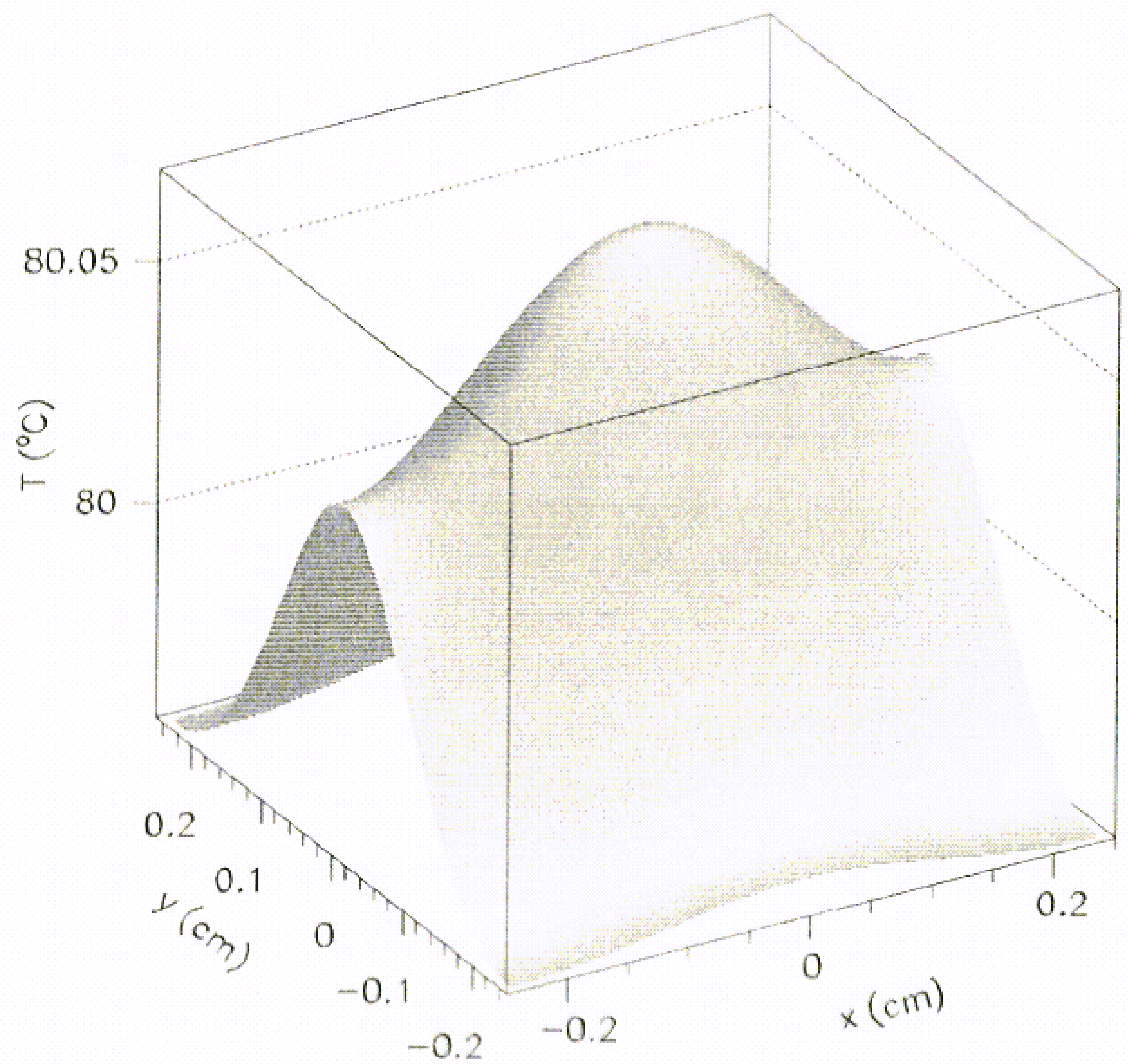
Crystals

Heat damage: are we in trouble at 3μA?

- Diamond has a very high melting point: 4027 °C
- ***but*** at low pressure it transforms itself into graphite starting at 707 °C

- Calculate using diffusion equation
  - heating by beam ionization
  - cooling through radiation
  - no heat sink through mount

- 5mm x 5mm x 15μm crystal
- 12 GeV beam at 3μA



Crystals

Radiation damage: are we in trouble at 3μA?

- Mainz crystal shows severe damage after only a few Coulombs

  10^{20} electrons, 100μm spot size ⇨ 500 Coulombs/mm^2

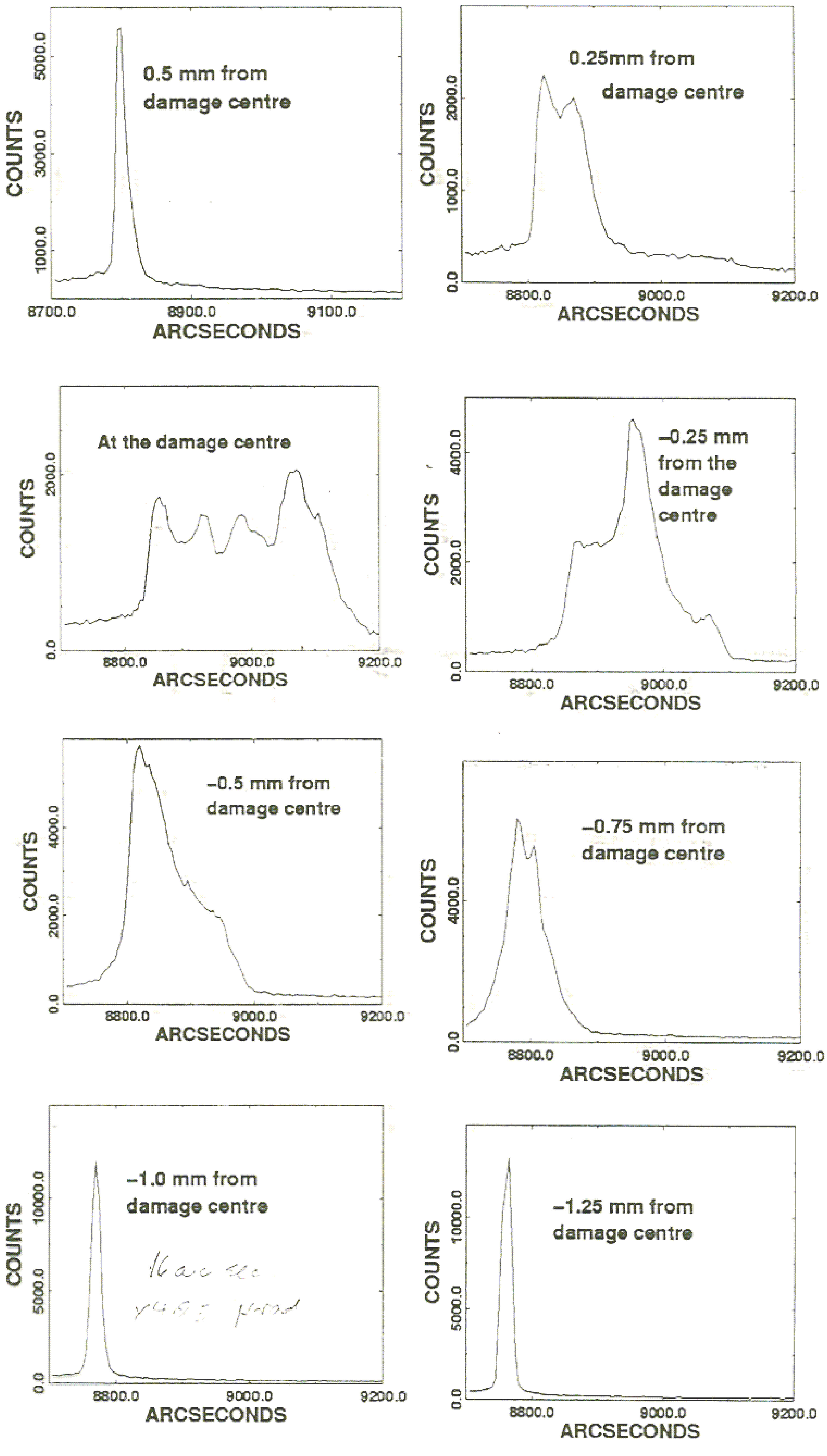
- Hall D has a larger spot size

  2.7mm^2 spot size, 500 Coulombs/mm^2 ⇨ 125,000 hours @ 3μA

- C. Sinclair: Rule of thumb from SLAC experience
  - degradation visible after one-to-few Coulombs/mm^2
  - some performance recovery by annealing the damaged crystal

✔ up to 5 spot moves per crystal

✔ several weeks before change of crystal required


0.5 mm from
damage centre
COUNTS
5000.0
3000.0
1000.0
8700.0
8900.0
9100.0
ARCSECONDS
0.25mm from
damage centre
COUNTS
2000.0
1000.0
0.0
8800.0
9000.0
9200.0
ARCSECONDS
At the damage centre
COUNTS
2000.0
0.0
8800.0
9000.0
9200.0
ARCSECONDS
–0.25 mm
from the
damage
centre
COUNTS
4000.0
2000.0
0.0
8800.0
9000.0
9200.0
ARCSECONDS
–0.5 mm from
damage centre
COUNTS
4000.0
2000.0
0.0
8800.0
9000.0
9200.0
ARCSECONDS
–0.75 mm from
damage centre
COUNTS
4000.0
0.0
8800.0
9000.0
9200.0
ARCSECONDS
–1.0 mm from
damage centre
COUNTS
10000.0
5000.0
0.0
8800.0
9000.0
9200.0
ARCSECONDS
–1.25 mm from
damage centre
COUNTS
10000.0
5000.0
0.0
8800.0
9000.0
9200.0
ARCSECONDS

Crystals

- New section by Jim Kellie on synthetic diamonds
  - selection
  - characterization
  - thinning
- New section by Ken Livingston on crystal alignment
- New figure on radiation damage of crystals
  - damage looks very severe
  - exposure is very high for Mainz crystal

10^{20} electrons, 100μm spot size ⇨ 500 Coulombs/mm^2