INVESTIGATION OF DIAMOND SAMPLES UNDER HIGH DOSES OF ELECTROMAGNETIC IRRADIATION (at S-DALINAC)

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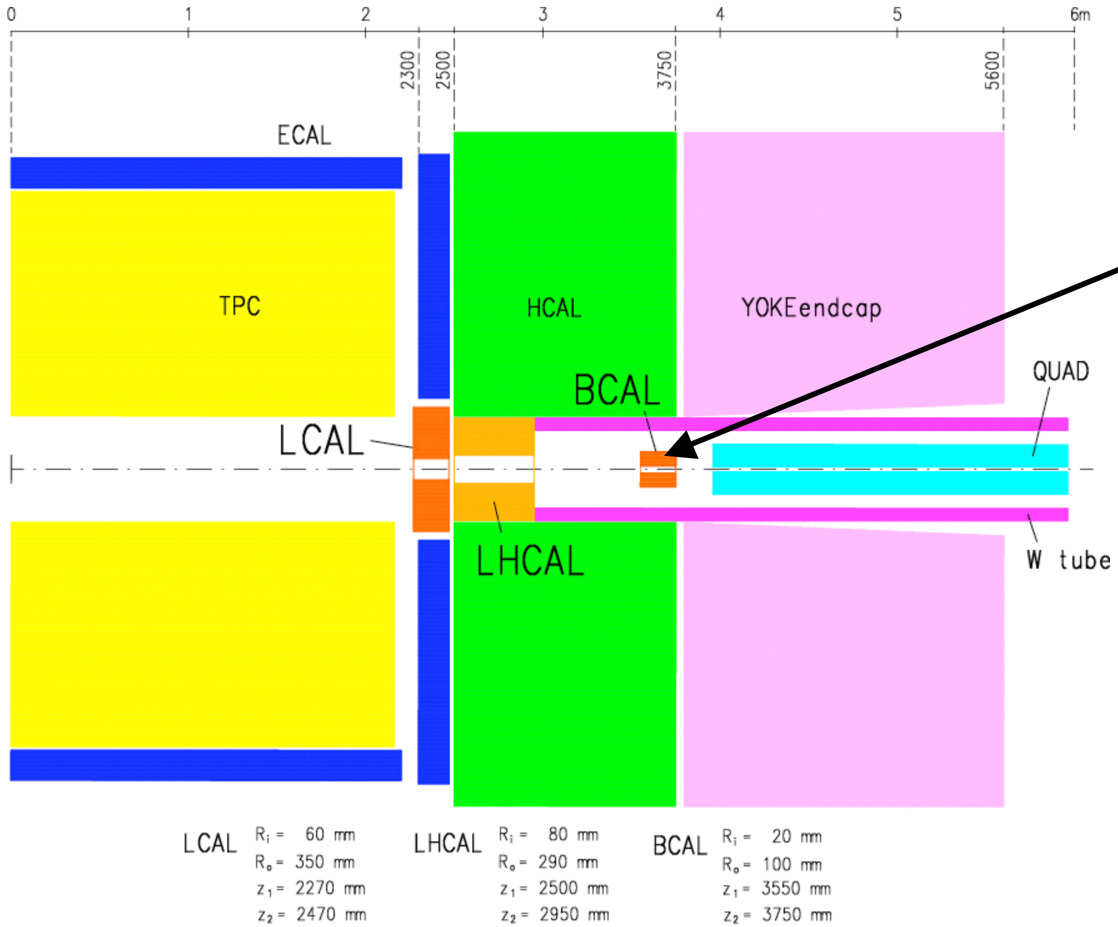
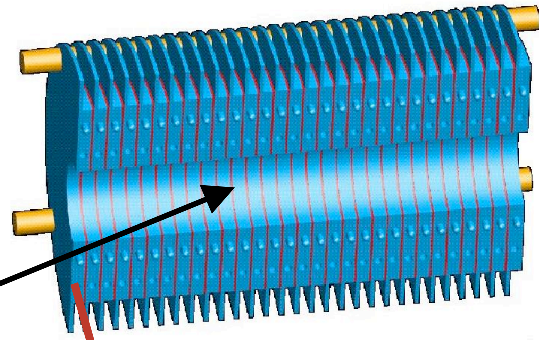
OUTLINE OF THIS TALK

1. Motivation
2. Test Beam @ S-DALINAC
3. Measurements
    1. Layout and method
    2. Simulations, geometry
    3. Samples
    4. Analysis
4. Results (preliminary)
5. Conclusions

MOTIVATION FOR RADHARD SENSORS



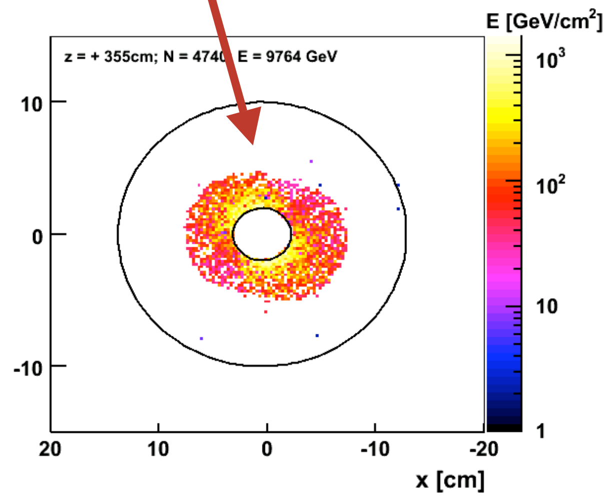


BeamCal

30 layers of
W / CVD diamond (?)
5 < ***ANGLE*** < 28 mrad

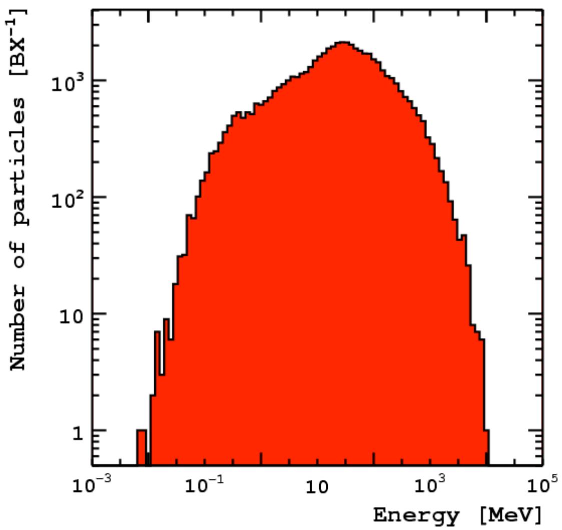
Energy deposition from beamstrahlung pairs in BeamCal:

Dose of up to 10 MGy/a



MOTIVATION - ENERGIES AND DOSES

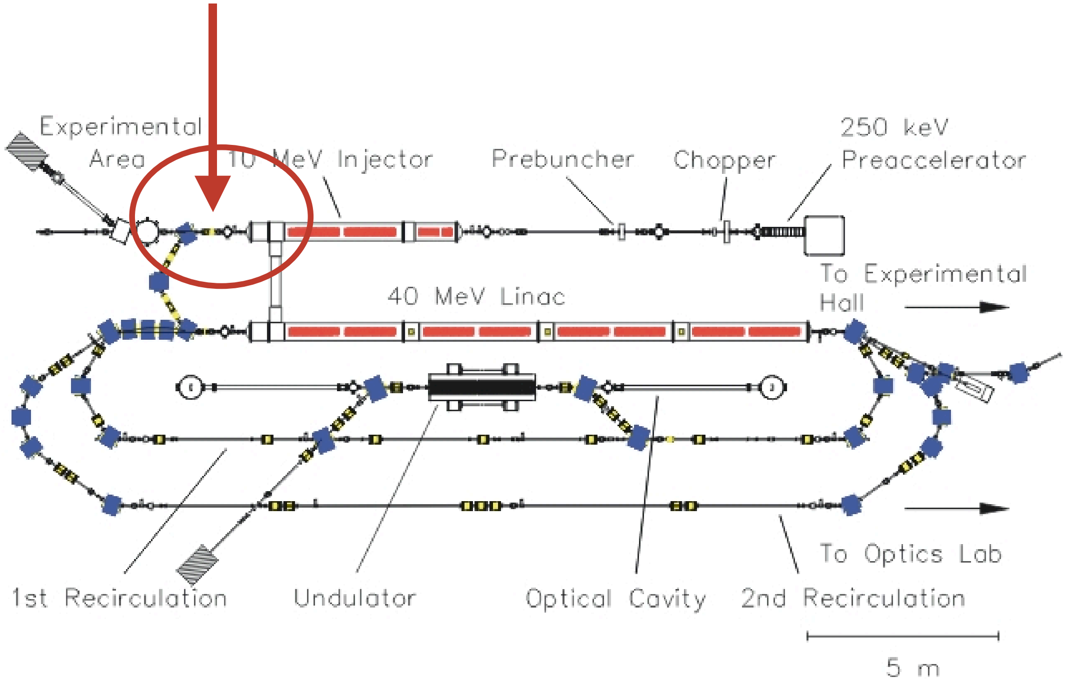
Simulated situation in BeamCal:
Energy spectrum of particles depositing energy in the sensors

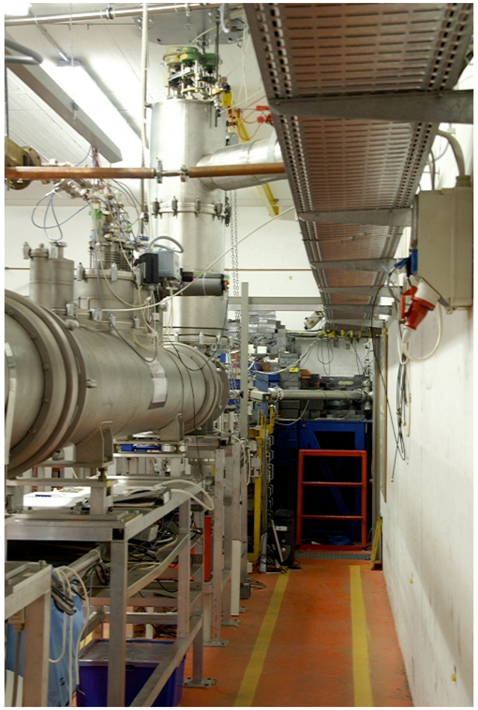


Spectrum given for $2X_0$:
- similar for all planes
- peaks @ 10 MeV

---> use 10 MeV electrons (secondaries…)
---> doses of > 1 MGy

TEST BEAM @ S-DALINAC





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Using the injector line of the S-DALINAC:

10 ± 0.015 MeV and possible beam currents from ***1nA to 50µA***

LAYOUT AND METHOD (1)

Irradiation … spectroscopic measurement …

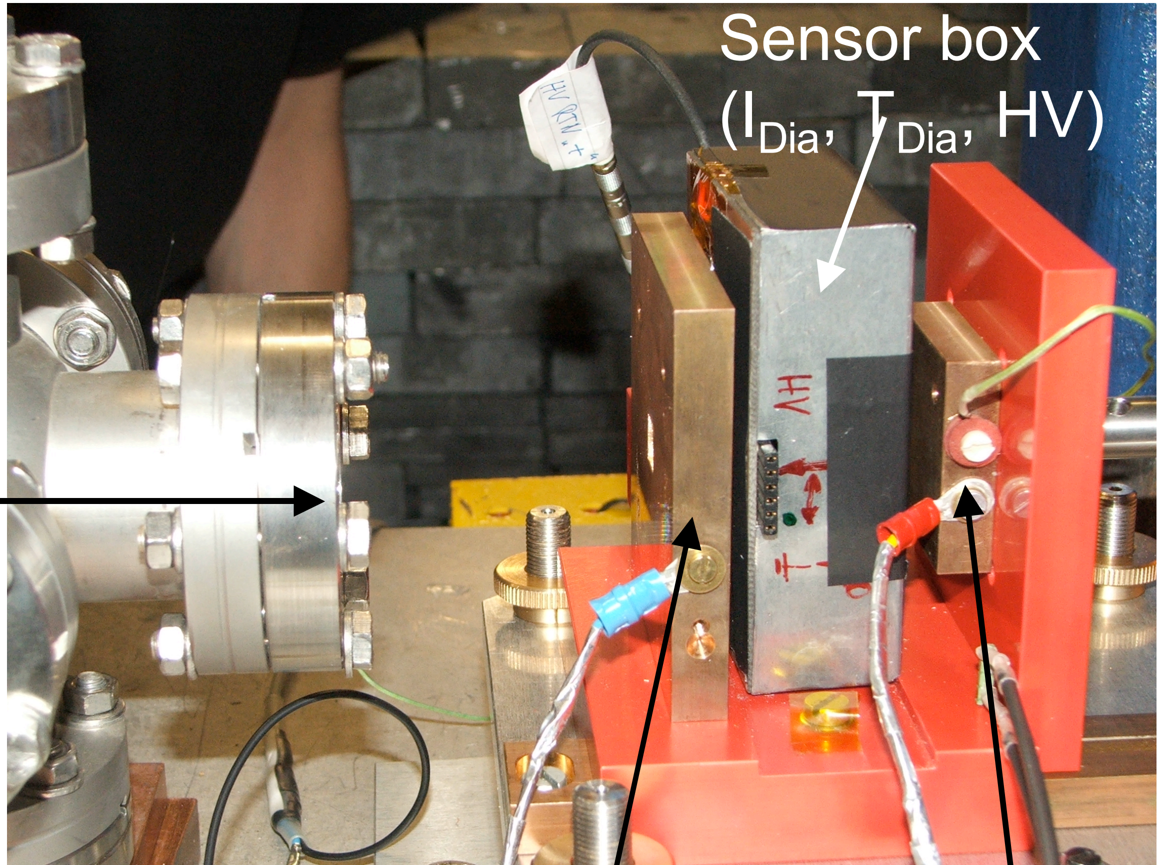
-> use of 2 setups:

a) beam area

b) “CCD measurement”

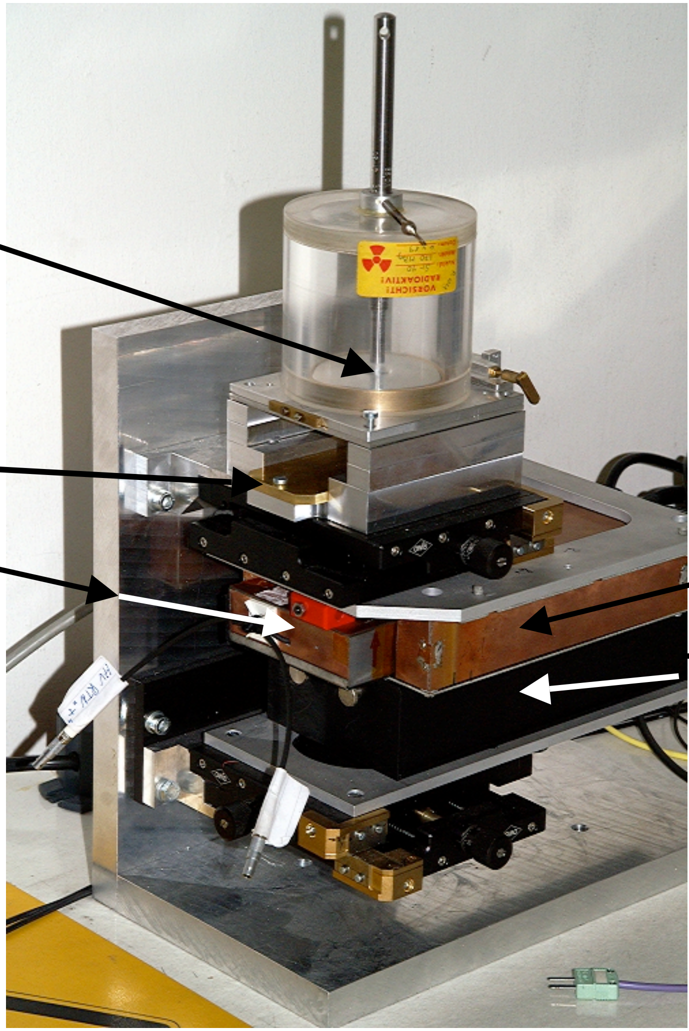
LAYOUT AND METHOD (2)

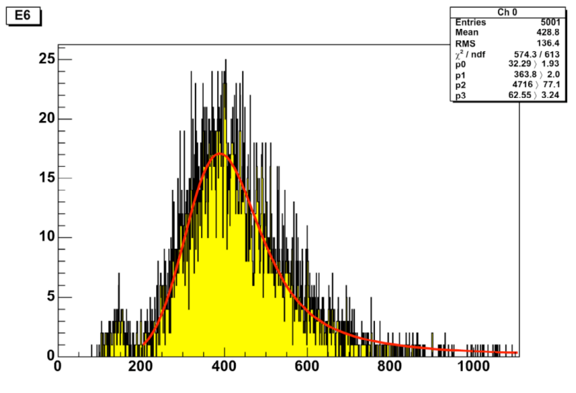
Beam area:



LAYOUT AND METHOD (3)

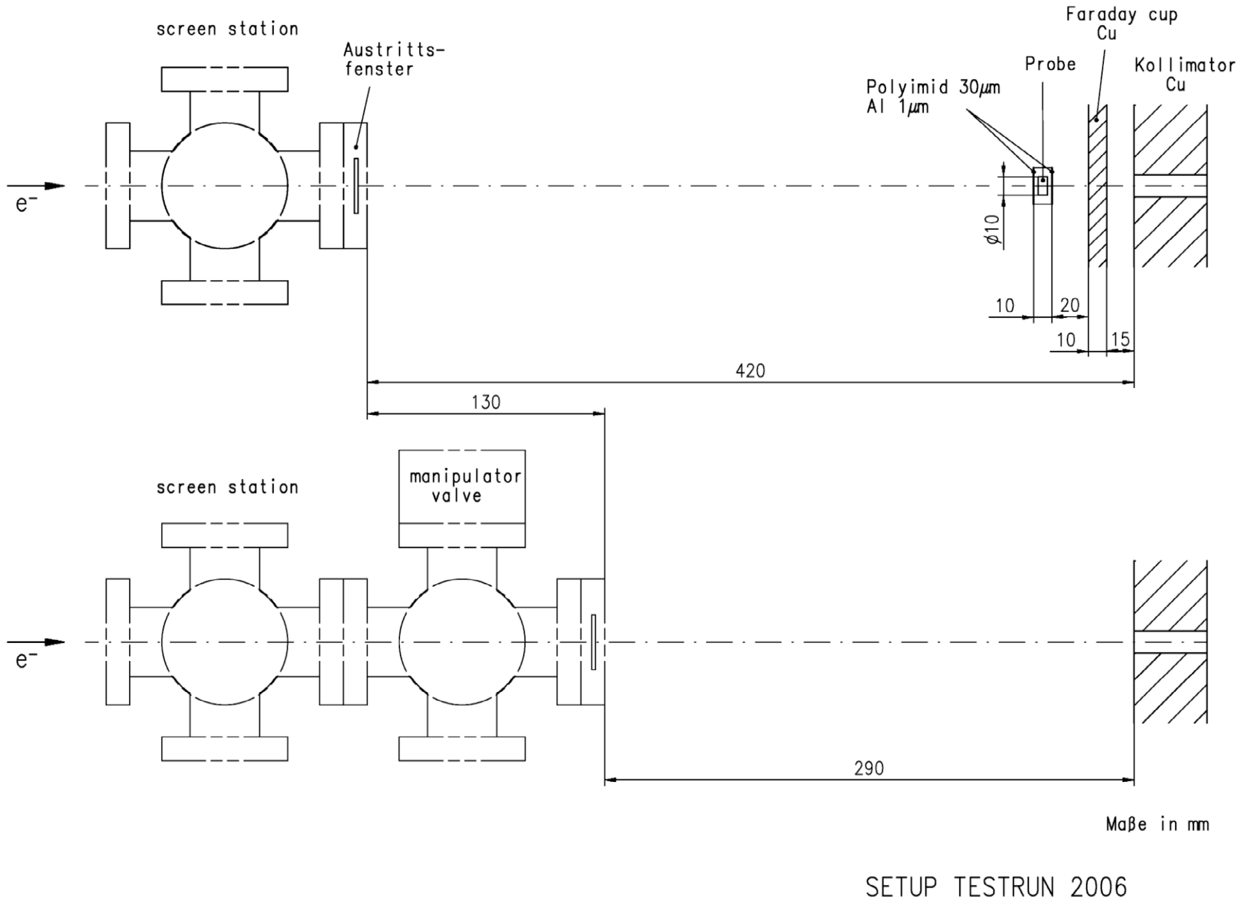
CCD measurement:



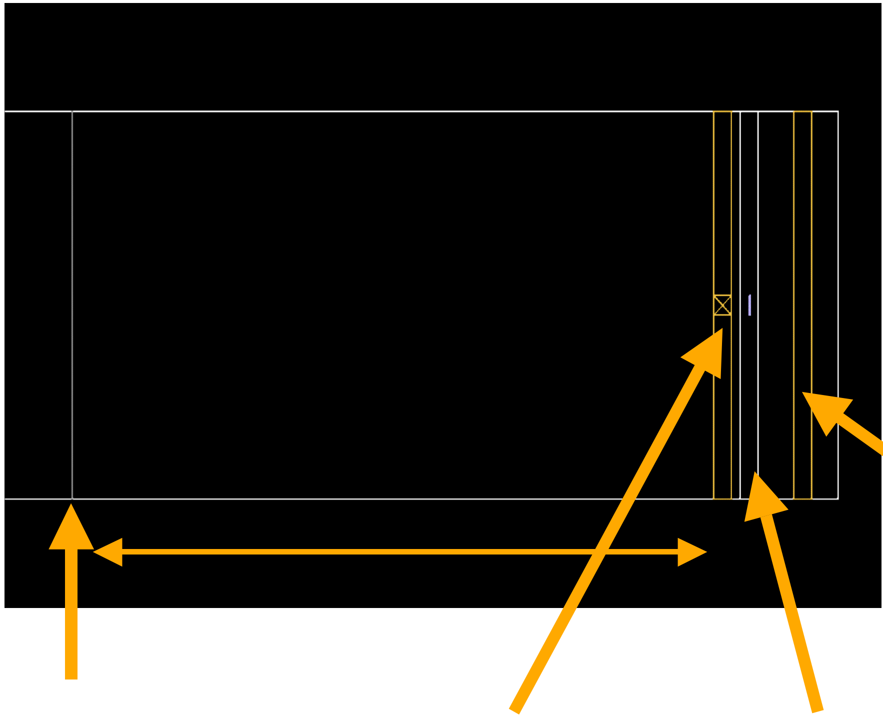


SIMULATION AND GEOMETRY (1)

Given:



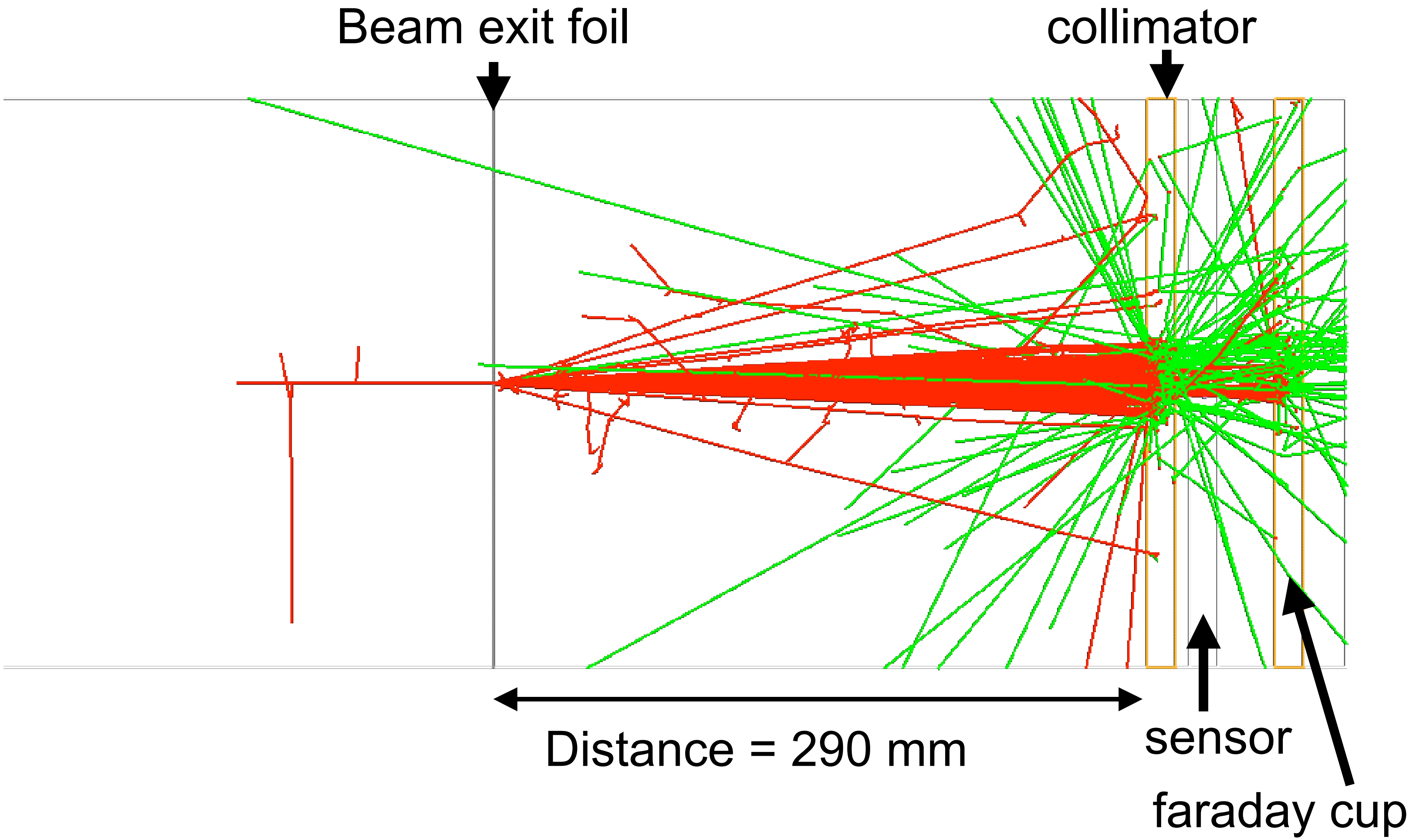
SIMULATION AND GEOMETRY (2)



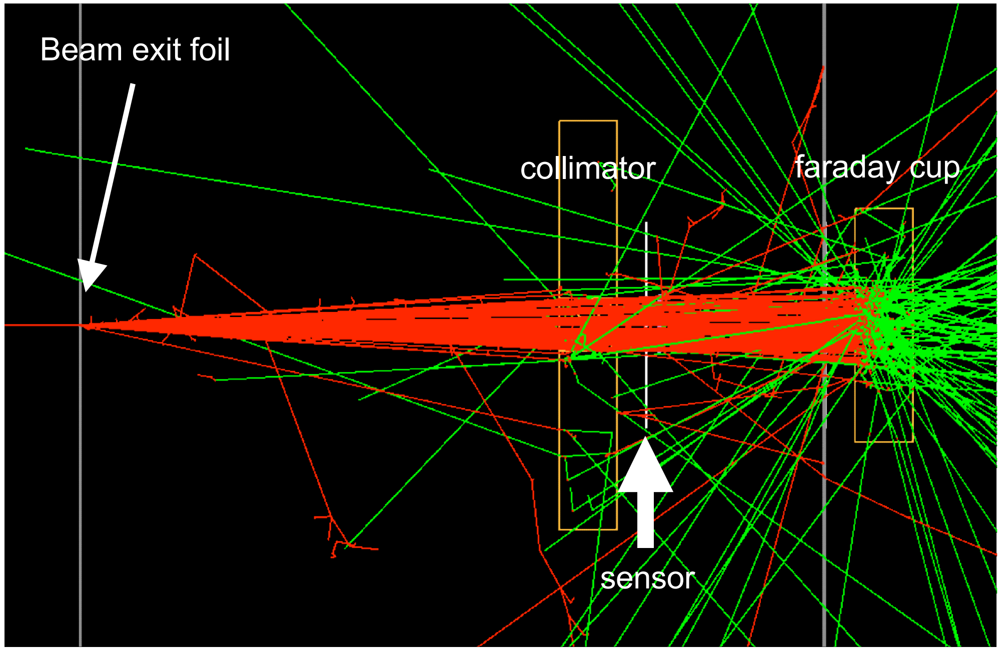
Optimizing of
- Distances
- dimensions

Beam exit -> collimator -> sensor -> faraday cup

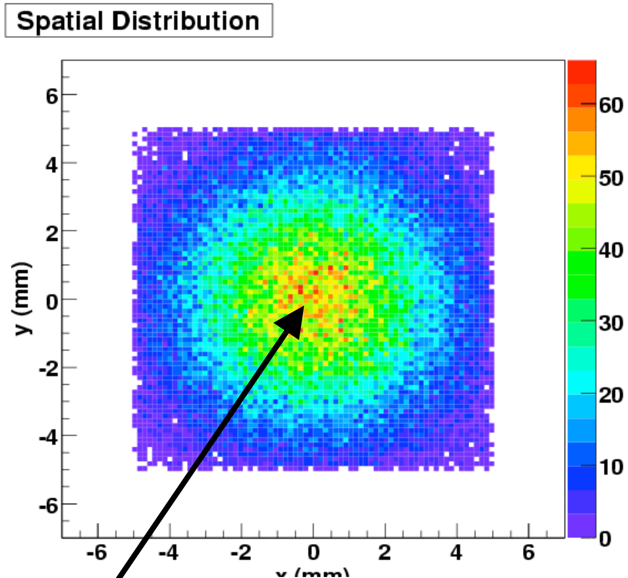
SIMULATION AND GEOMETRY (3)



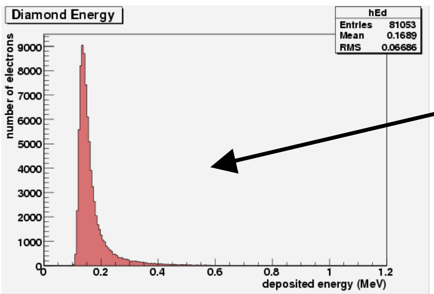
SIMULATION AND GEOMETRY (4)



Optimized:
- Distance
- collimator, ratio R

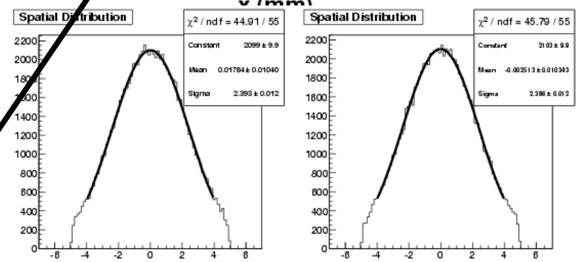


Statistics (extract $R = (N_{FC}/N_{Sensor}) = 0.98$)



Energy deposition

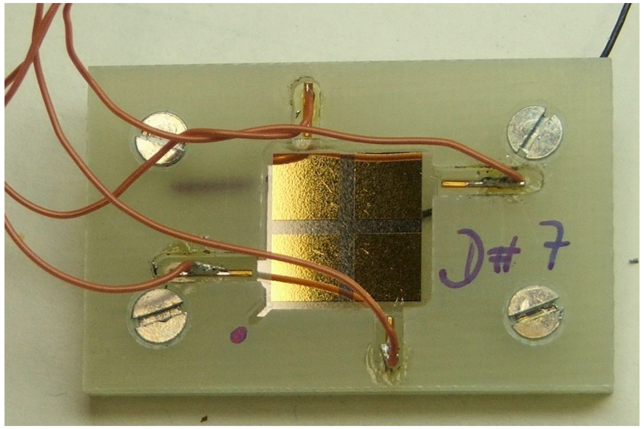
Spatial distribution

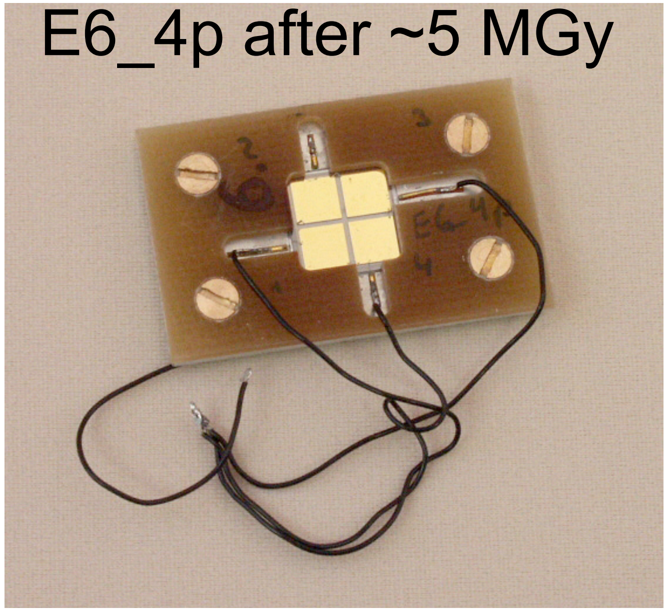


SENSOR SAMPLES

Investigate:

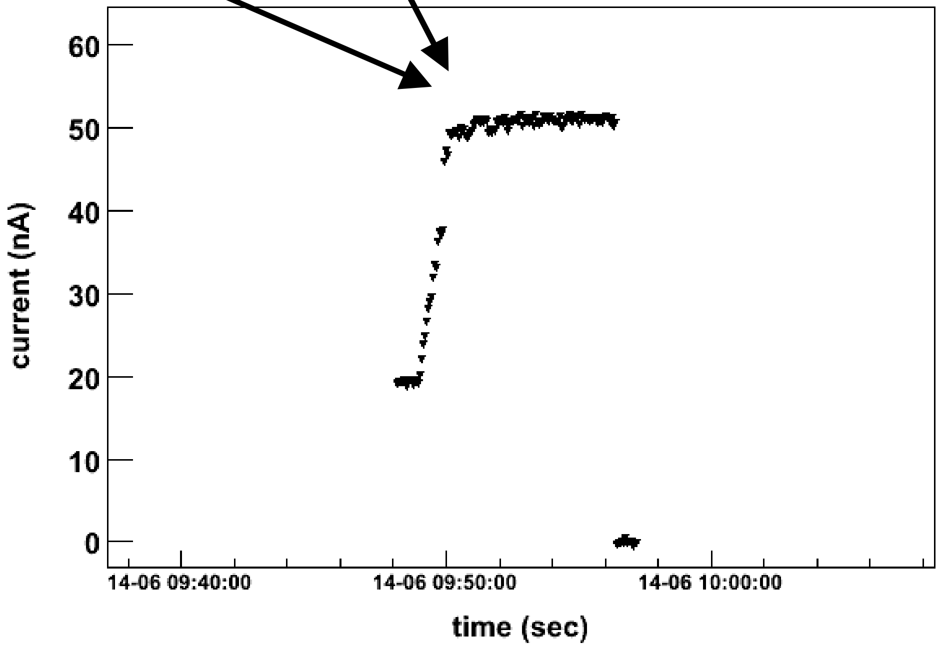
- 2 samples from E6 (pCVD)
  - 1 MGy
  - 5 MGy
- 2 samples from IAF Freiburg
  - 1 MGy (pCVD)
  - 5 MGy
- 2 Si samples (Micron Ltd. UK)
  - both drew high currents after ~50 kGy.



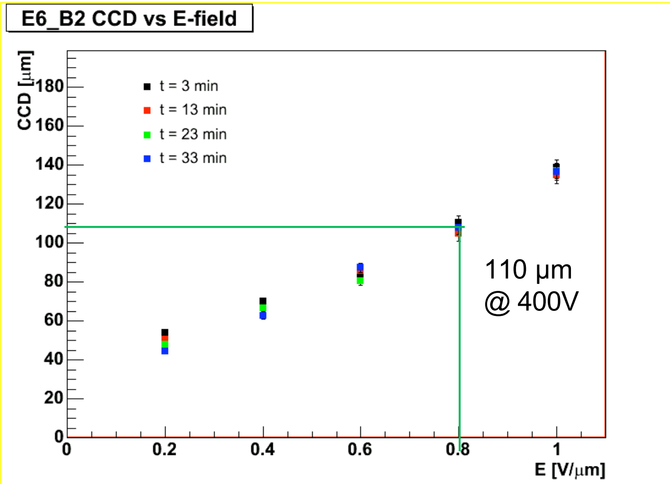


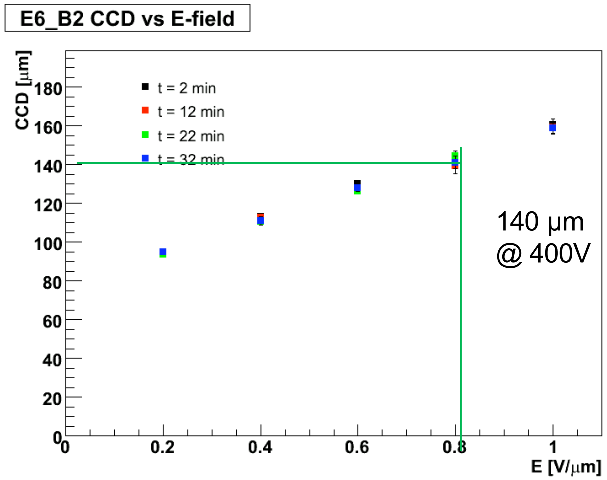
MEASUREMENTS IN TESTBEAM (1)

- Tuned the beam to currents in the Faraday cup of:
  - 10, 20, 50 and 100 nA
- This corresponds to dose rates of:
  - 59, 118, 295 and 590 kGy/h
- Dose controlled by beam current
- Error assumed ~ 10%

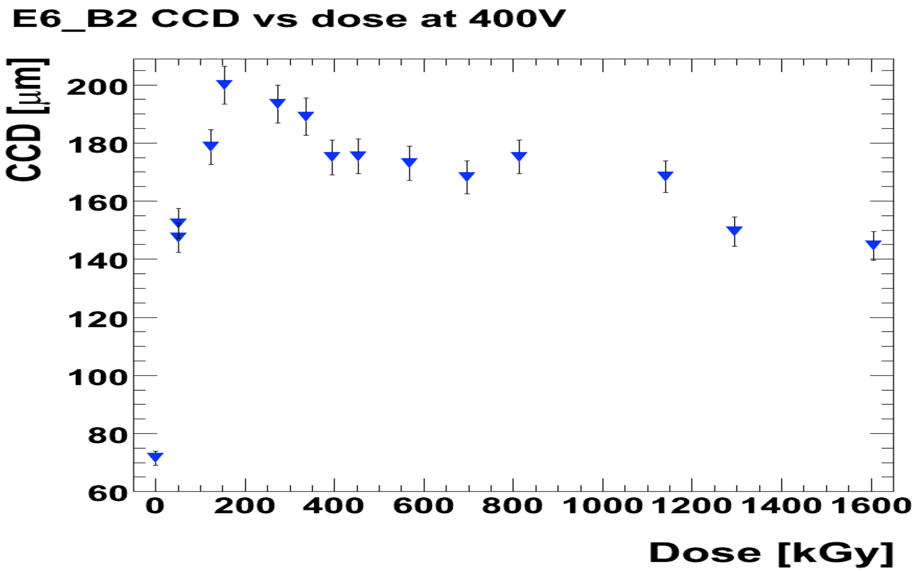


MEASUREMENTS IN TESTBEAM (2)



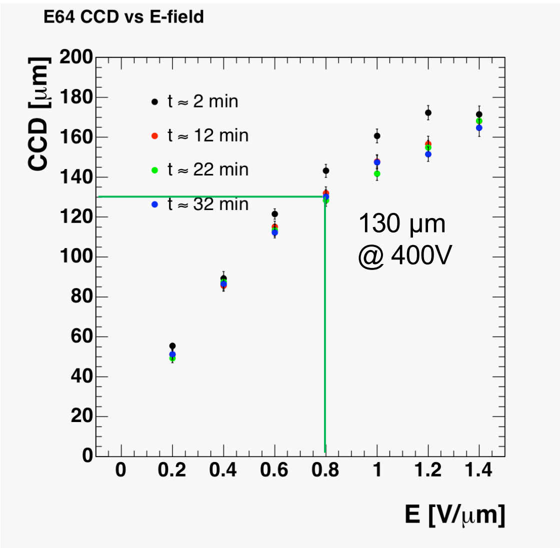


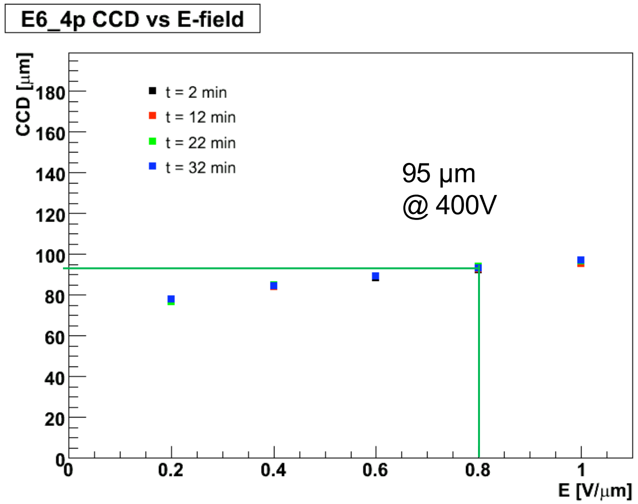
Before
Irradiation
(pumping?)



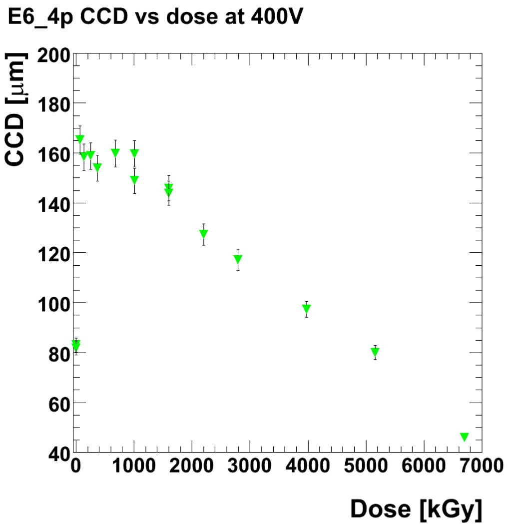
after
irradiation

MEASUREMENTS IN TESTBEAM (3)



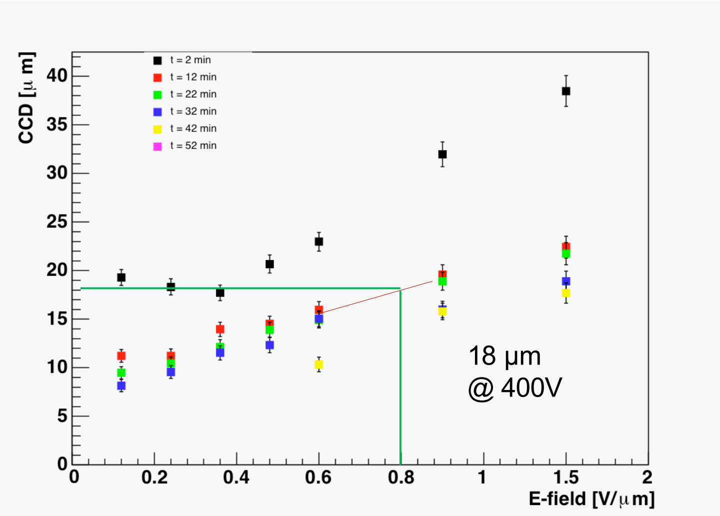


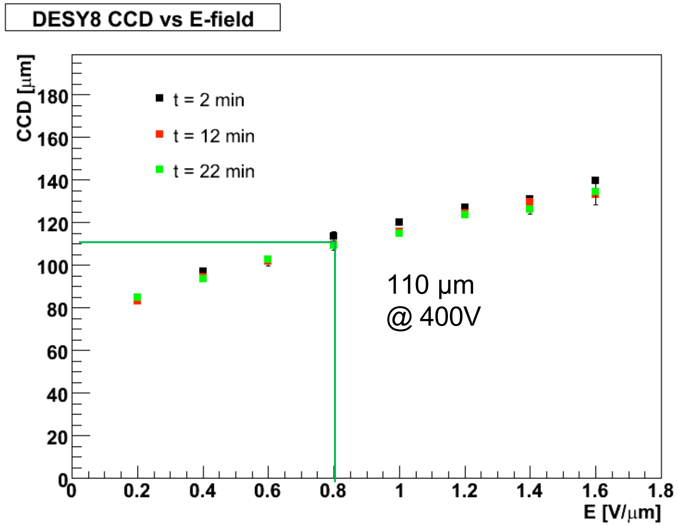
Before Irradiation



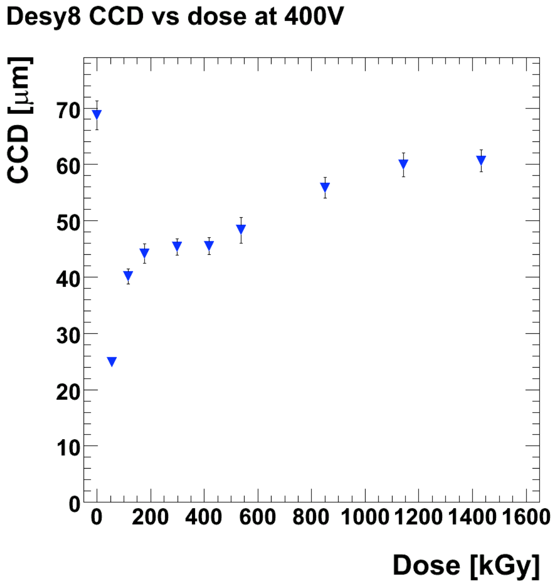
after irradiation

MEASUREMENTS IN TESTBEAM (4)



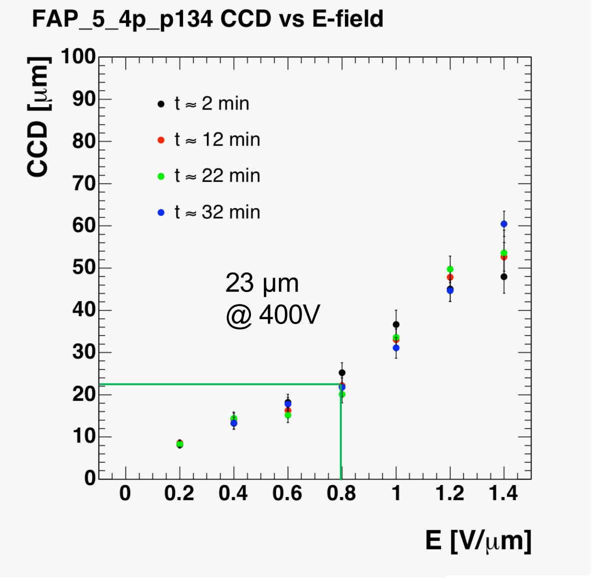


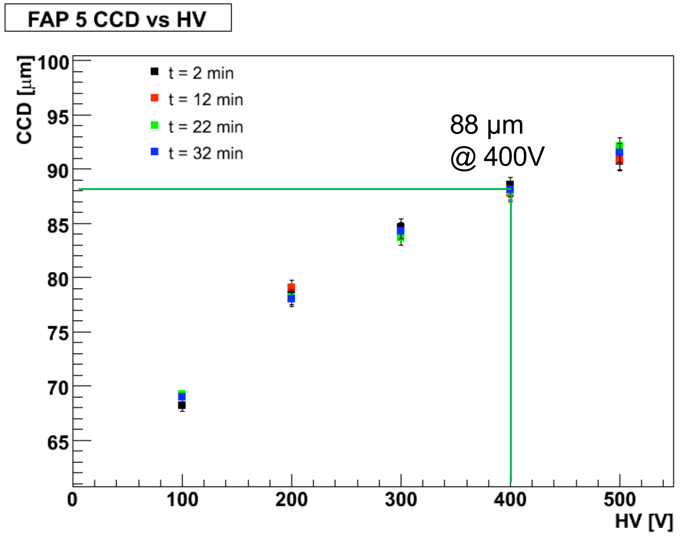
Before Irradiation



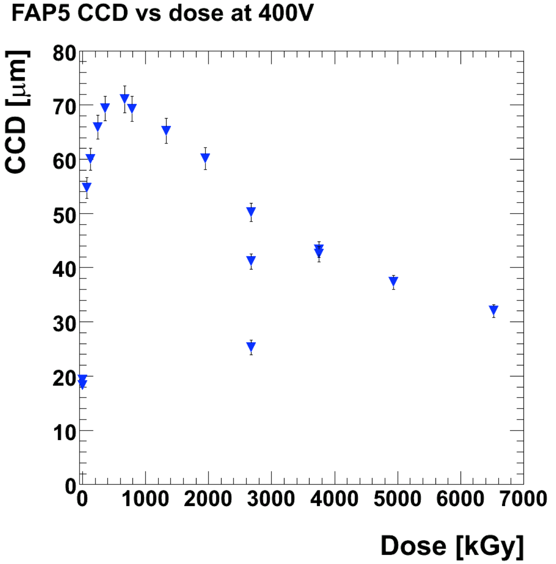
after irradiation

MEASUREMENTS IN TESTBEAM (5)



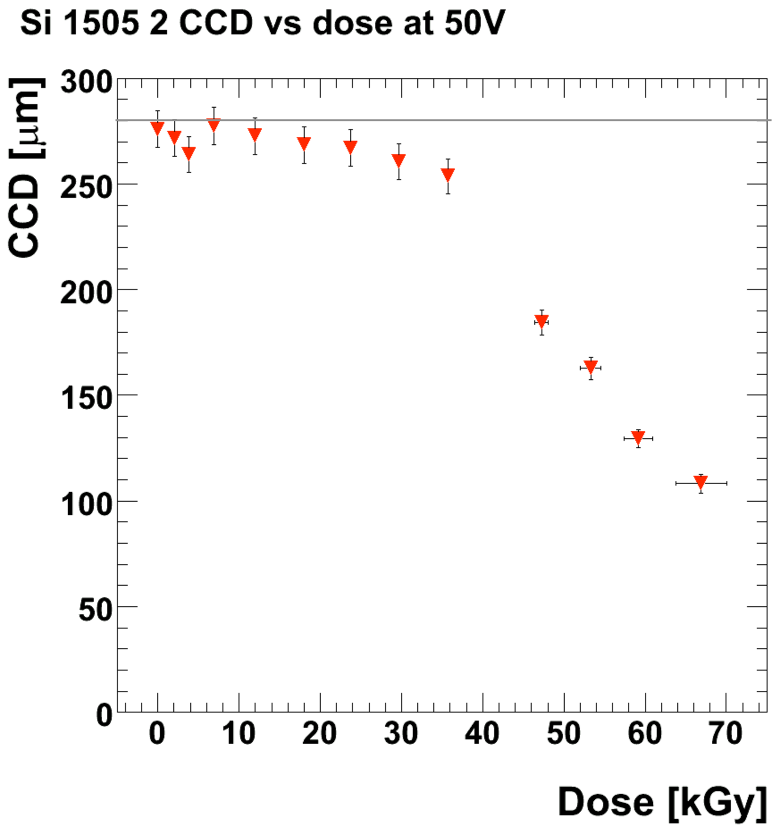


Before
Irradiation



after
irradiation

MEASUREMENTS IN TESTBEAM (6)



Thickness = 280 µm
Initial CCD = 280 µm
(100% collection efficiency)

CONCLUSIONS

- S-DALINAC is well suitable facility up to 10 MeV:
  - wide range of intensities possible (1 nA to 50 μA)
  - good experimental support, helpful crew
- More measurements planned
- Completely different behaviour of different samples:
  - nearly stable vs. dose, recovers behaviour (E6_B2)
  - degrading vs. (much higher: ~ 4*) dose, recovers with lower CCD (E6_4p)
  - improves CCD vs. dose, stays with larger CCD (DESY-8, FAP-5, both Fraunhofer)
- Further investigations needed
- Standard silicon stable only until ~ 50 kGy, damage after irradiation permanent