

# Development of Real-Time VHEE Dosimetry at UHDR Using Beam Instrumentation



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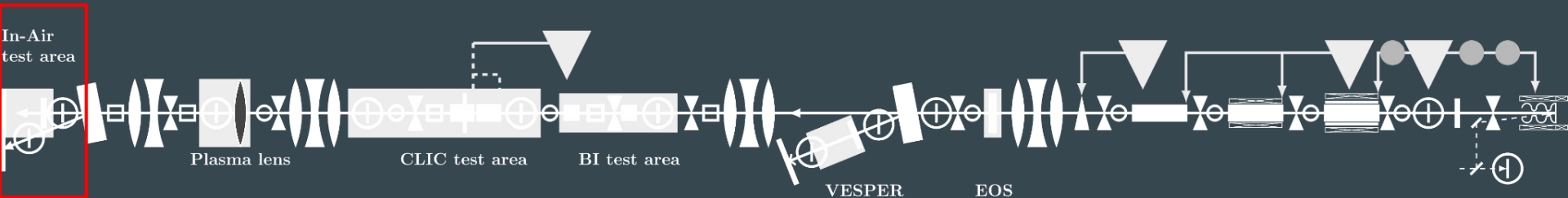
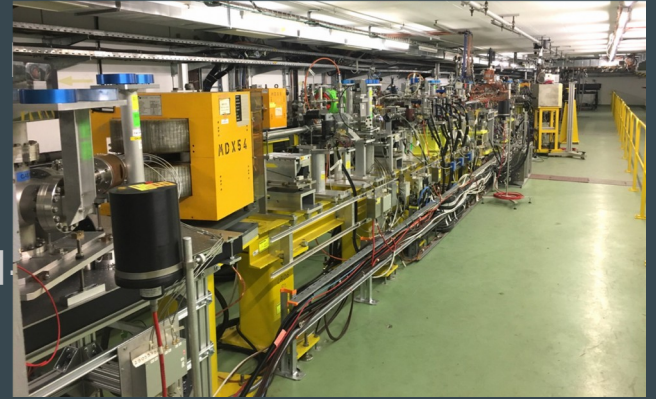
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# CLEAR: CERN Linear Electron Accelerator for Research

- User facility detached from
- 60-200 MeV electrons
- 10 pC – 70 nC / train
- 0.833 Hz or 10 Hz rep. freq
- Train length 1 ps – 50 ns

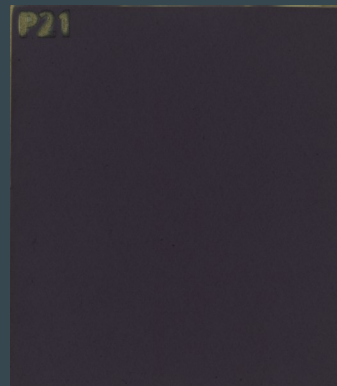


# How are we working with dosimetry at CLEAR?

- Challenge: real-time dosimetry for UHDR VHEE and FLASH RT
  - Ionization chamber saturation at high dose per pulse
  - Requirements: High time-resolution and a wide dynamic range
- Two separate but complementary approaches
  - Optical and scintillating fibers (Joseph John Bateman, Oxford/CERN)
  - Beam instrumentation for real-time information about transverse beam distribution and charge
- Films as main tool for correlation
  - Assumed to be energy and dose-rate independent
  - High spatial resolution -> information about beam size and transverse dose distribution
  - A big effort in establishing a well adapted and reliable film dosimetry protocol at CLEAR

# Film Dosimetry

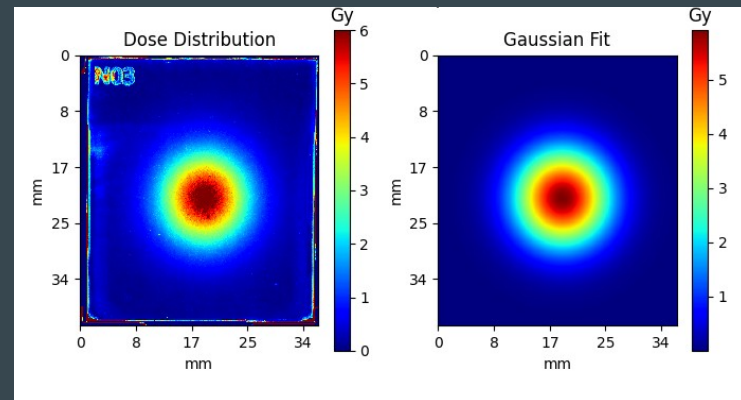
- Film batches calibrated at eRT6 (CHUV)
  - 5.5 MeV electrons
  - 1 cm solid water and uniform dose-distribution
  - Referenced against Advanced Markus chamber
- Cut and engraved using a laser cutter
  - Size standardization for irradiation and processing
  - Limits layer detachment
- Scanned using a flatbed photo scanner
  - Well-defined standard scanning position and orientation
  - Five “warm-up” scans then single scan per film
- Custom scripts developed for film analysis
  - Single channel (green or red) used for dose evaluation
  - Conversion from pixel value to optical density
  - Background subtraction (unexposed film)
  - Gaussian fitting algorithms for beam size evaluation



Calibration

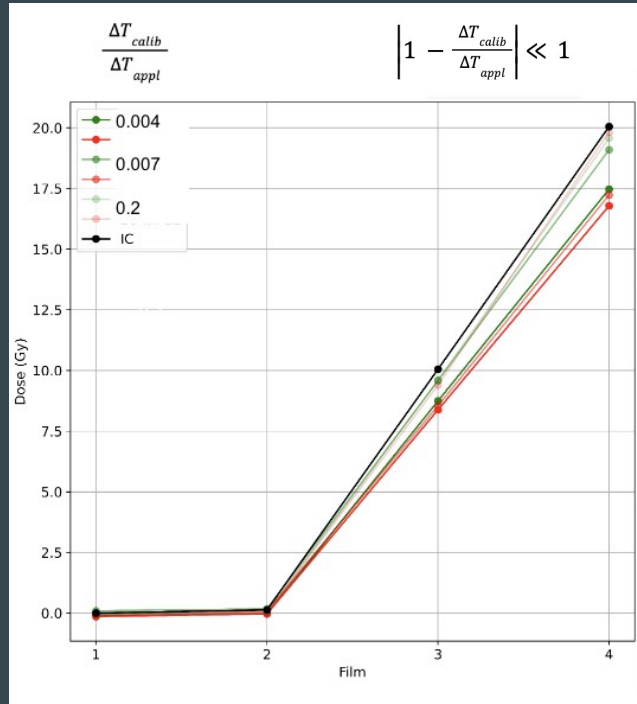


Application



V. Rieker et al. Development of Reliable VHEE/FLASH Passive Dosimetry Methods and Procedures at CLEAR, IPAC23

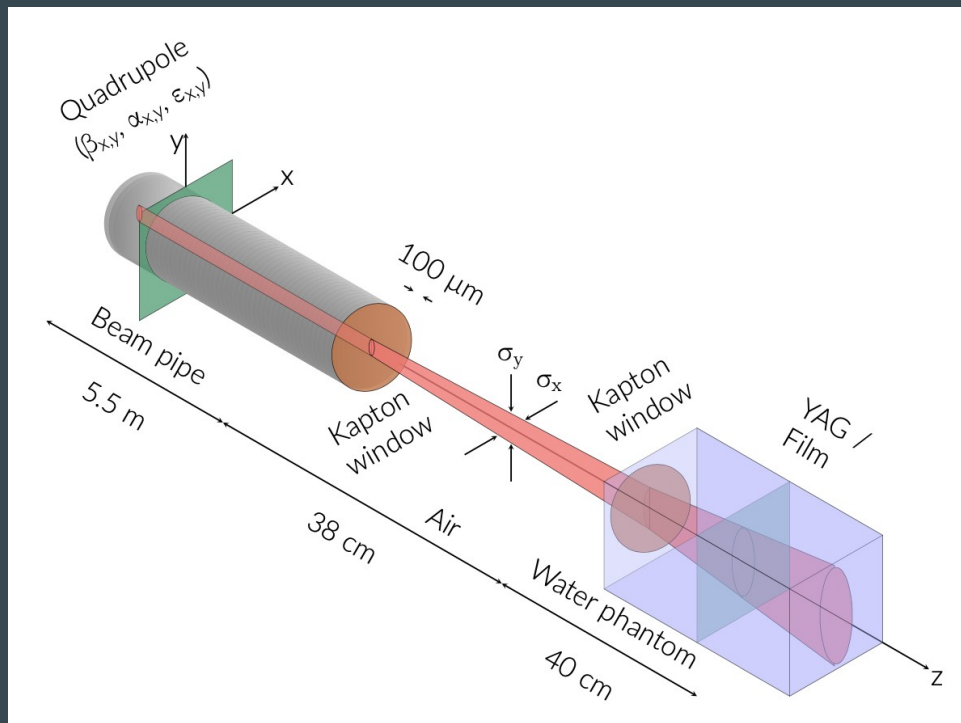
# Lessons learned...



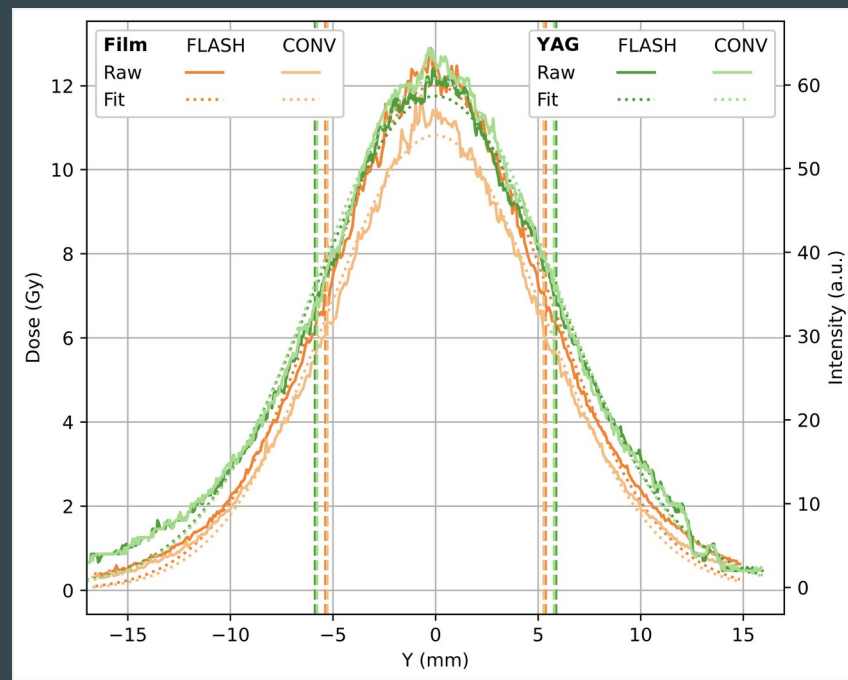
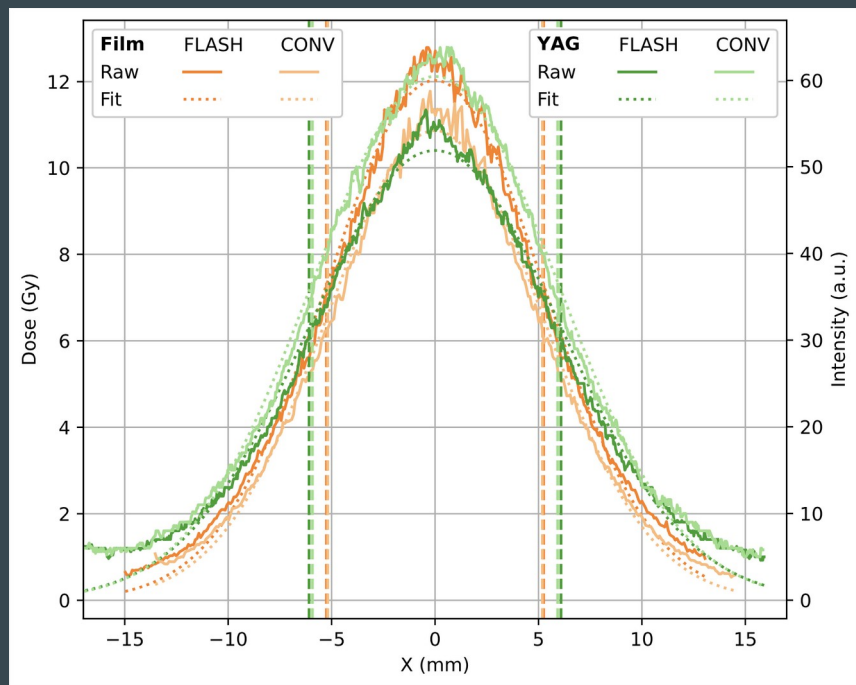
Key take aways:

1. There is no full standard protocol which is feasible for every application: tradeoff between accuracy and time
2. Ensure the processing steps are identical for your calibration and application films and you'll most likely be fine.

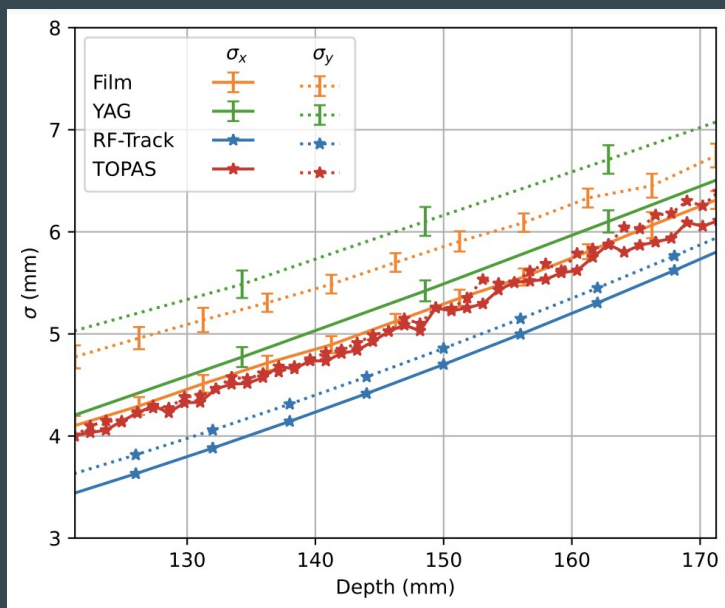
# Experimental Setup



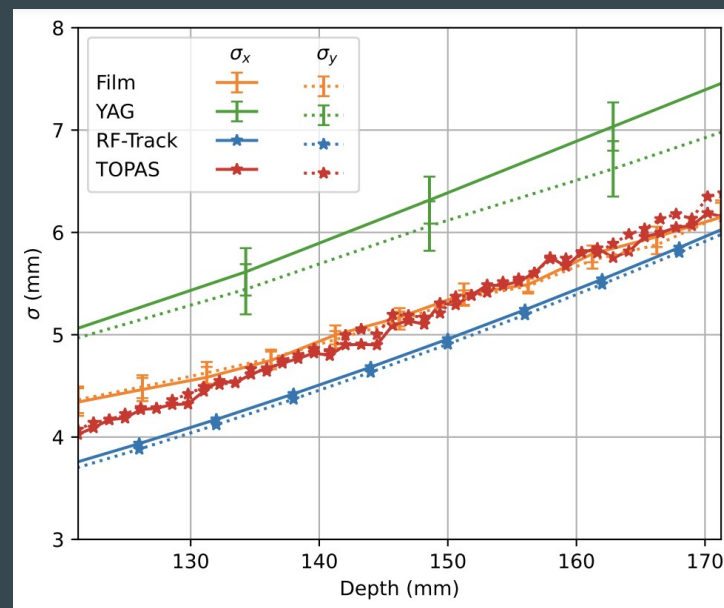
# Beam Size Evaluation



# Beam Size Evaluation



10 nC CONV



10 nC FLASH



# There is still stuff to do...

- Bridging the gap between the beam size on the YAG and on the films
  - YAG saturation?
    - Screen thickness
    - YAG VS OTR
  - Sensitivity to secondaries
  - Cherenkov radiation in water
- Statistics on a large and diverse set of film-data correlated with beam parameters
- Possible energy and dose-rate dependence of films?
  - Little data exist in the VHEE UHDR regime
  - Correlations with RPL dosimeters, alanine pellets and TLDs
- $\Delta T$  dependent film calibration for increased accuracy and flexibility

# Acknowledgements

- Supervisors: Roberto Corsini, Steinar Stapnes, Erik Adli
- CLEAR operation team
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