

# **Dosimetry and LET spectrometry in He 150MeV/n (MONO) and C 290MeV/n (SOBP) ion beams - first results obtained by different detectors**

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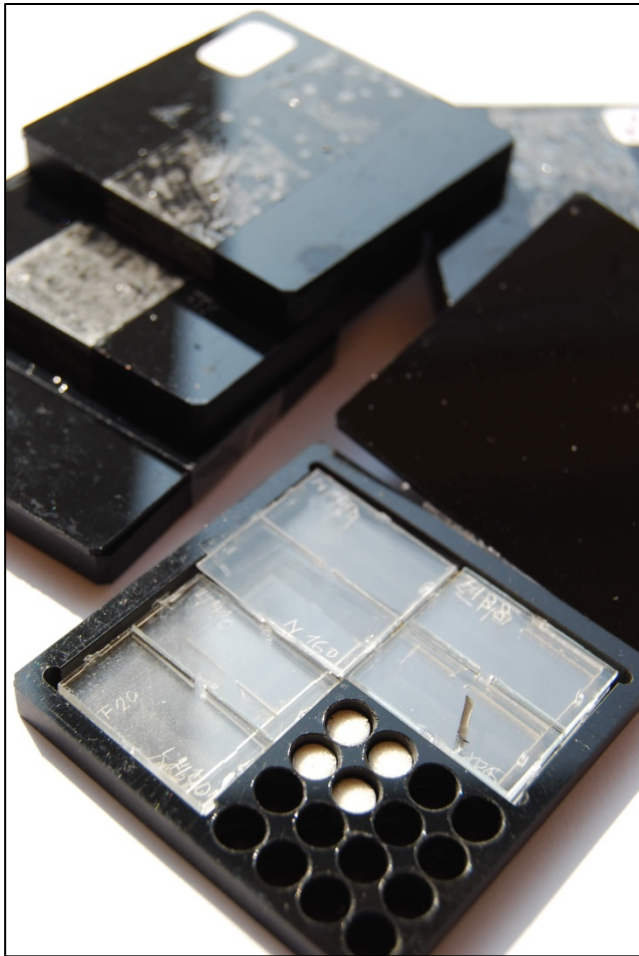
# Table of content

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- Irradiation performed during the 2<sup>nd</sup> run – January 2009:
  - He-ions 150 MeV/n MONO
  - C-ions 290 MeV/n SOBP
- Analysis of obtained results (preliminary)

# HIMAC program of NPI ASCR

- **Basic idea** – to start to build LET spectra library for radiobiology experiments in HIMAC ion beams – approved by HIMAC PAC – beginning 2008,
- **Methods used:**
  - ✓ **Experimental:**
    - ❖ LET spectrometers based on TED (CR-39) – above ~ 10 keV/ $\mu\text{m}$
    - ❖ Tissue equivalent proportional counter HAWK – all LET
    - ❖ MDU-Liulin energy deposition spectrometer – up to ~ 30 keV/ $\mu\text{m}$
    - ❖ Thermoluminescent detectors (TLDs) supplementary information for “low” LET region
  - ✓ **Calculation** – has partially started PHITS, MCNPX?

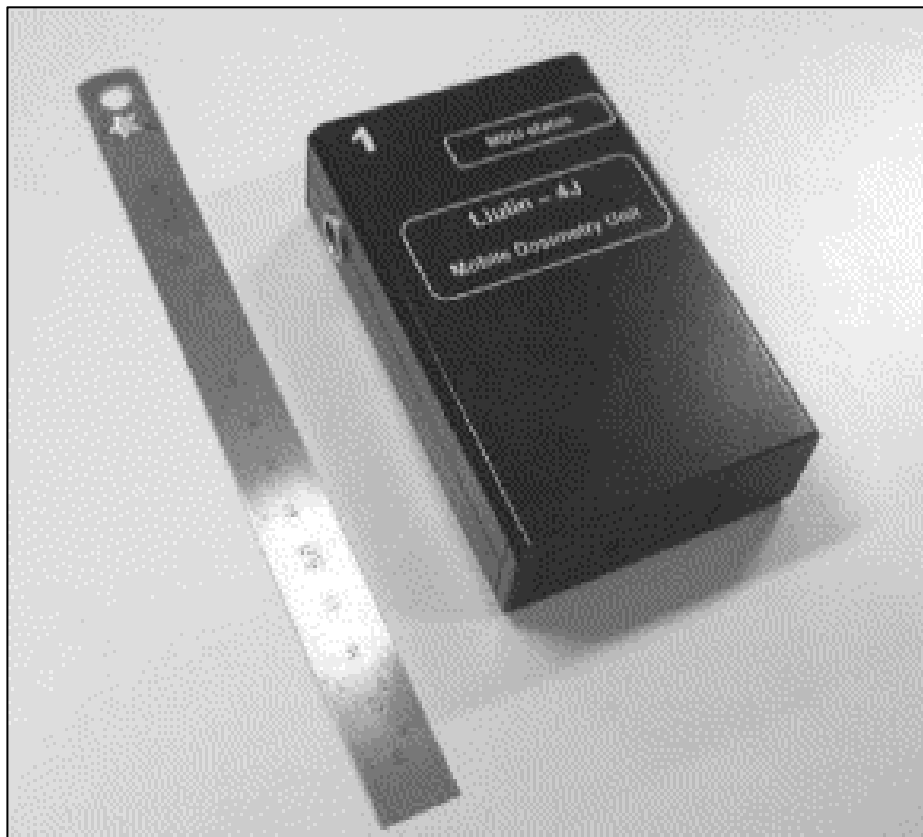
# Passive detectors holders



- TLD
  - $\text{CaSO}_4:\text{Dy}$  (4 in each holder)
  - $\text{Al}_2\text{O}_3:\text{C}$  (4 in each holder)
- TED – (selection will follow)
  - Page
  - HARZLAS TD-1
  - USF-4
  - Baryotrak
  - Tastrak 0.5 mm
  - (Tastrak 1 mm)

# MDU-LIULIN

Si-energy deposition  
spectrometer



# HAWK

Tissue equivalent  
proportional counter



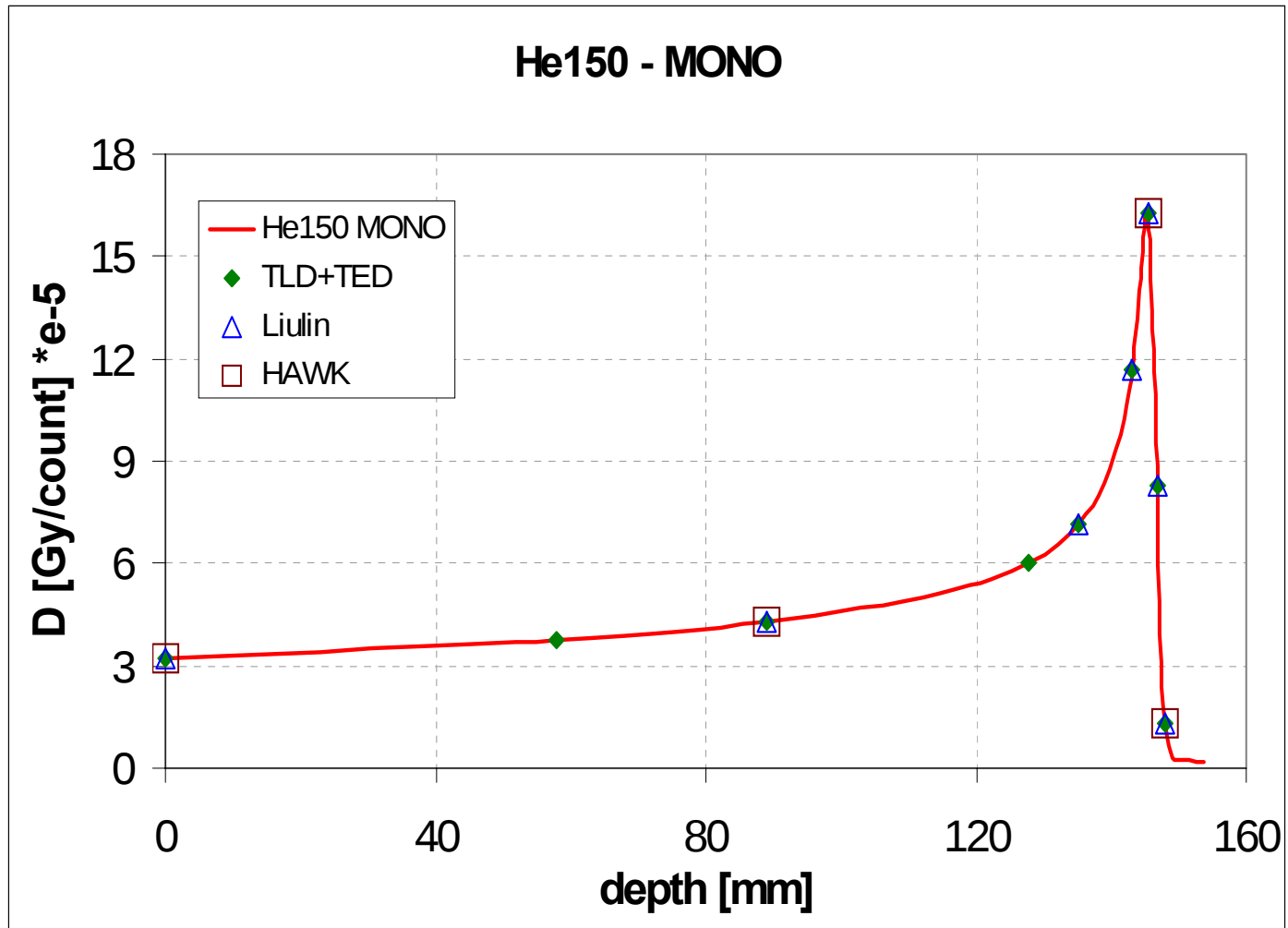
# He 150 MONO

## Irradiation conditions - overview

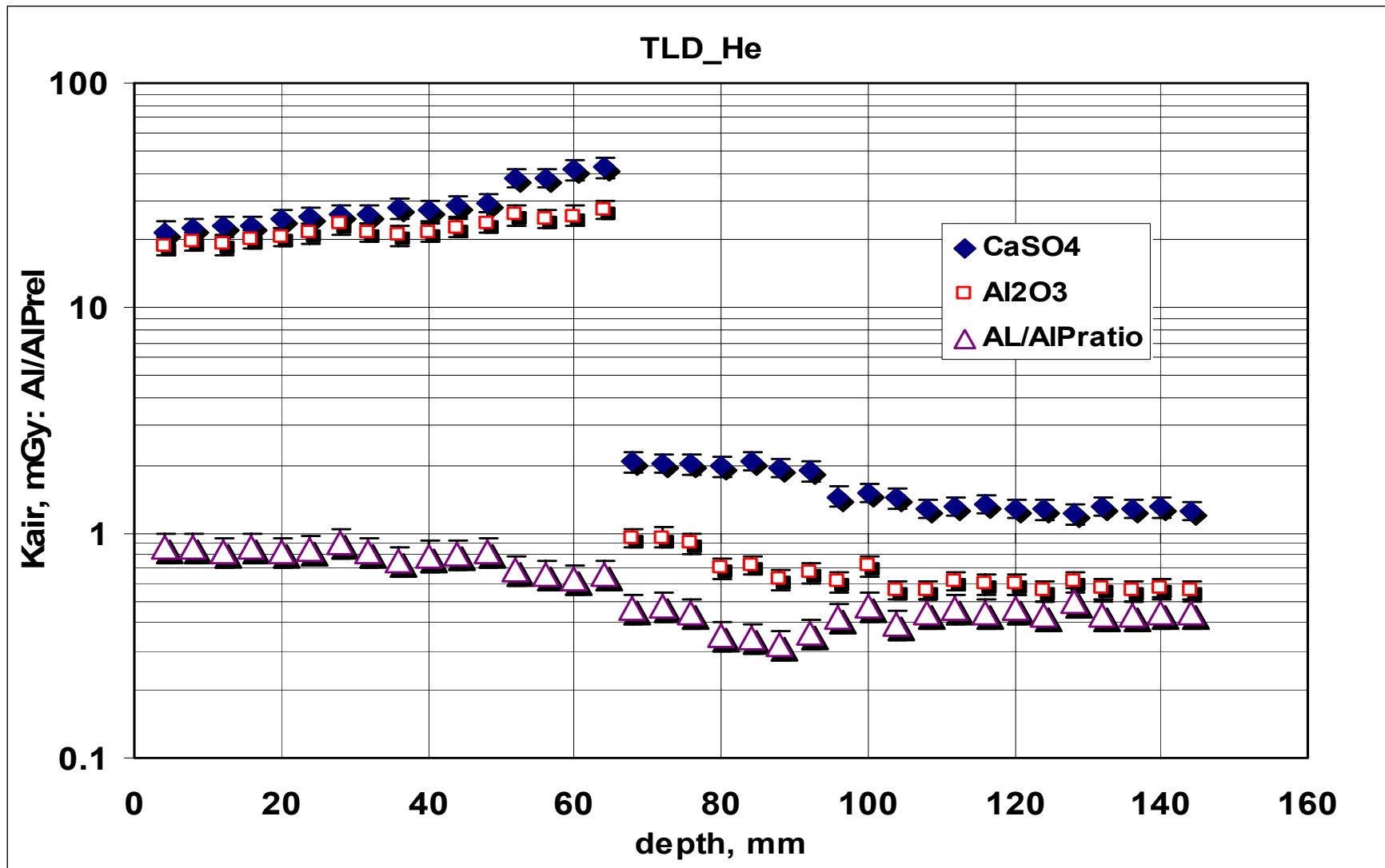
| BF | Depth,<br>mm | TLD+TED           | Liulin, intensity,<br>full time | TEPC, intensity,<br>full time |
|----|--------------|-------------------|---------------------------------|-------------------------------|
| 1  | 0            | $5 \cdot 10^6$    | 130 p/cm <sup>2</sup> , 10 min  | 50 p/cm <sup>2</sup> , 10 min |
| 2  | 57.87        | $4.96 \cdot 10^6$ | 130 p/cm <sup>2</sup> , 10 min  | 50 p/cm <sup>2</sup> , 10 min |
| 3  | 88.91        | $5 \cdot 10^6$    |                                 |                               |
| 5  | 127.68       | $4.93 \cdot 10^6$ |                                 |                               |
| 6  | 135.20       | $10^5$            | 130 p/cm <sup>2</sup> , 10 min  | 50 p/cm <sup>2</sup> , 10 min |
| 9  | 143.16       | $10^5$            | 130 p/cm <sup>2</sup> , 10 min  |                               |
| 12 | 145.61       | $10^5$            | 130 p/cm <sup>2</sup> , 10 min  |                               |
| 14 | 146.78       | $10^5$            | 130 p/cm <sup>2</sup> , 10 min  |                               |
| 16 | 147.92       | $10^5$            | 130 p/cm <sup>2</sup> , 10 min  |                               |

# Depth dose dependence

## H 150 MONO beam

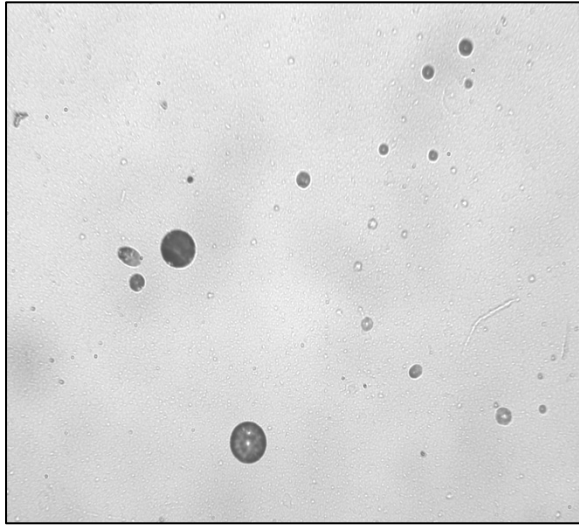


# TLD depth dependence – He 150 MONO

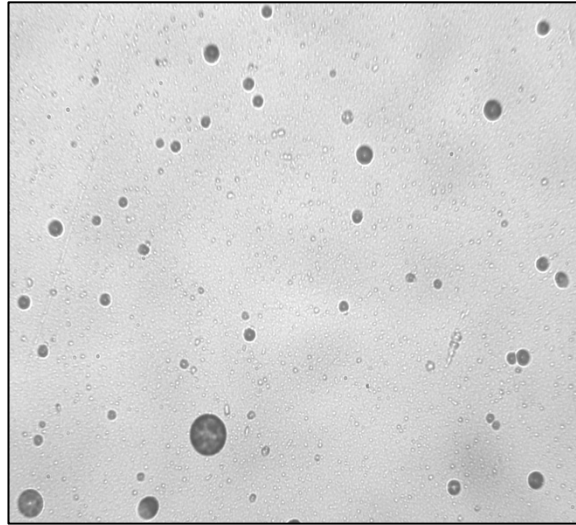


**Remarks:** TLD: BF 1-1 to 5 -5E 06; after – 5E 5;

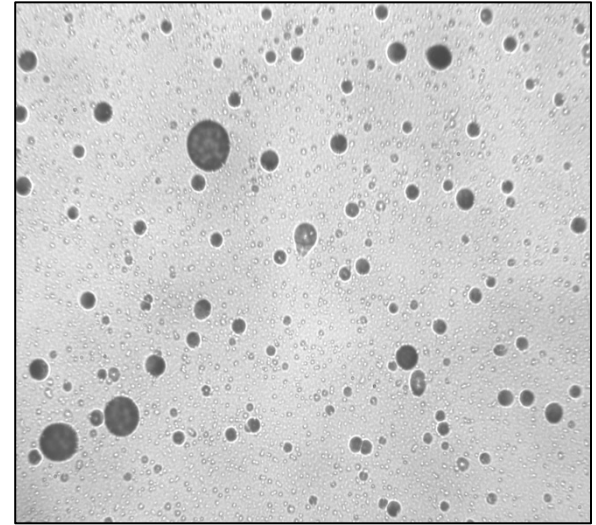
# He 150 MeV MONO – tracks from secondaries to primaries



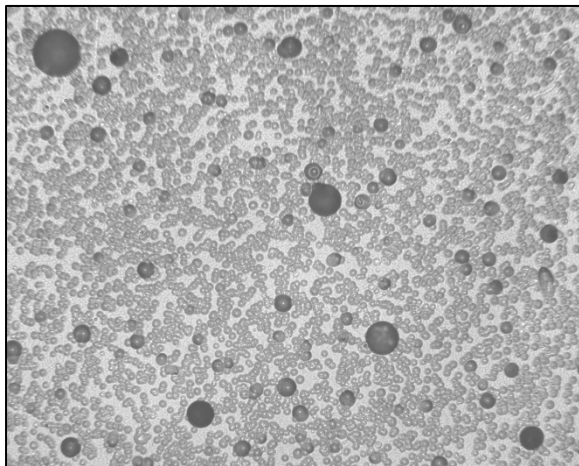
BF 0 mm



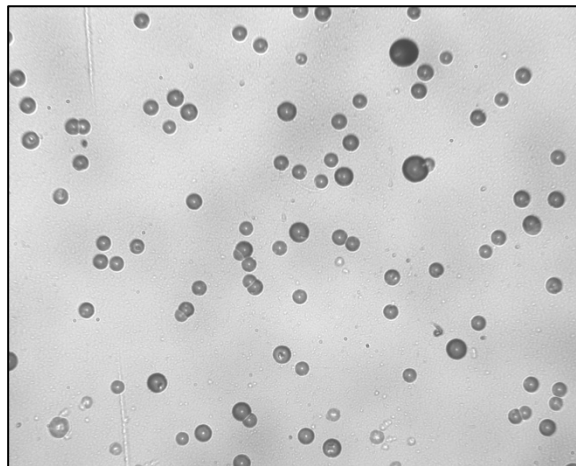
BF 57.87 mm



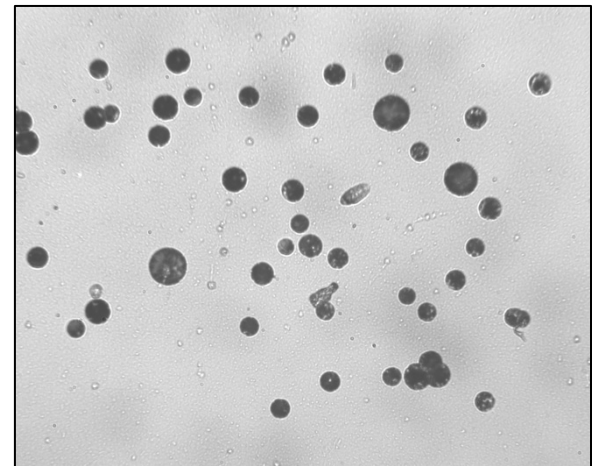
BF 88.91 mm



BF 127.68 mm



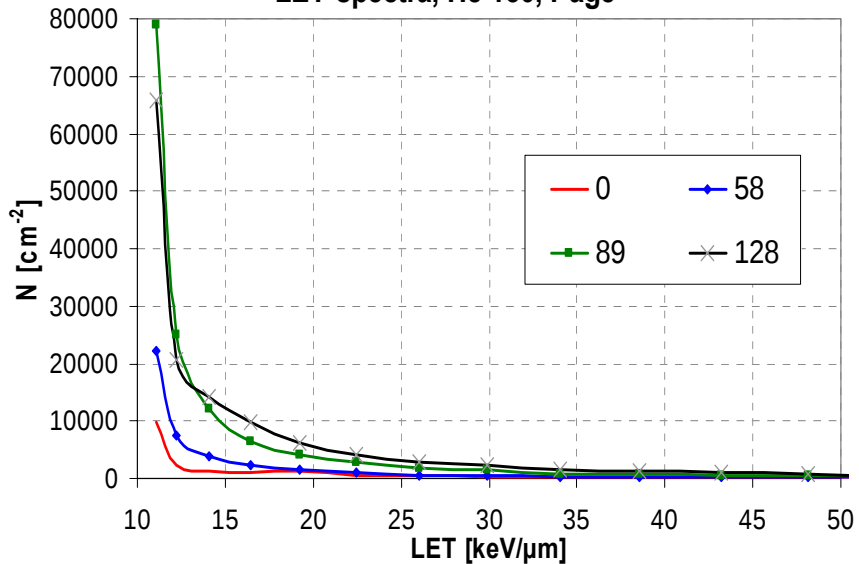
BF 143.16 mm



BF 145.61 mm

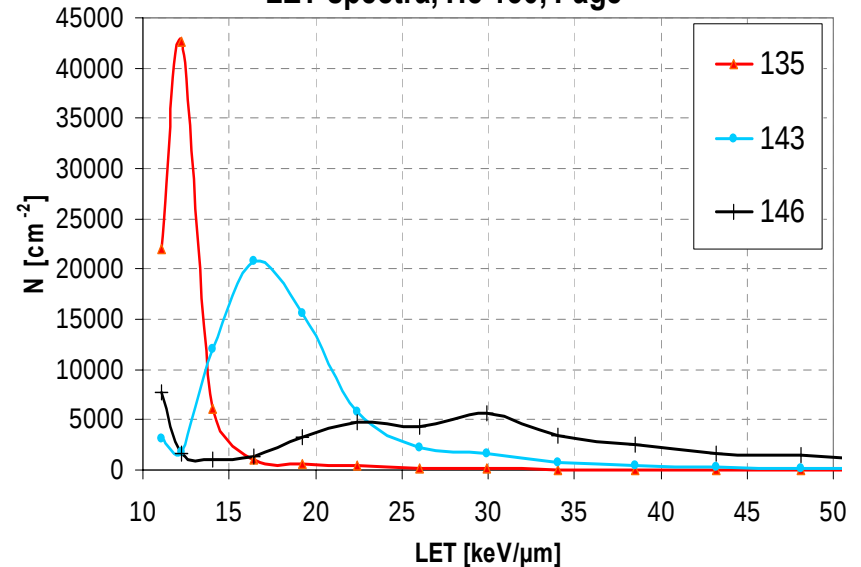
# LET spectra (Page) - He 150 MONO

LET spectra, He 150, Page



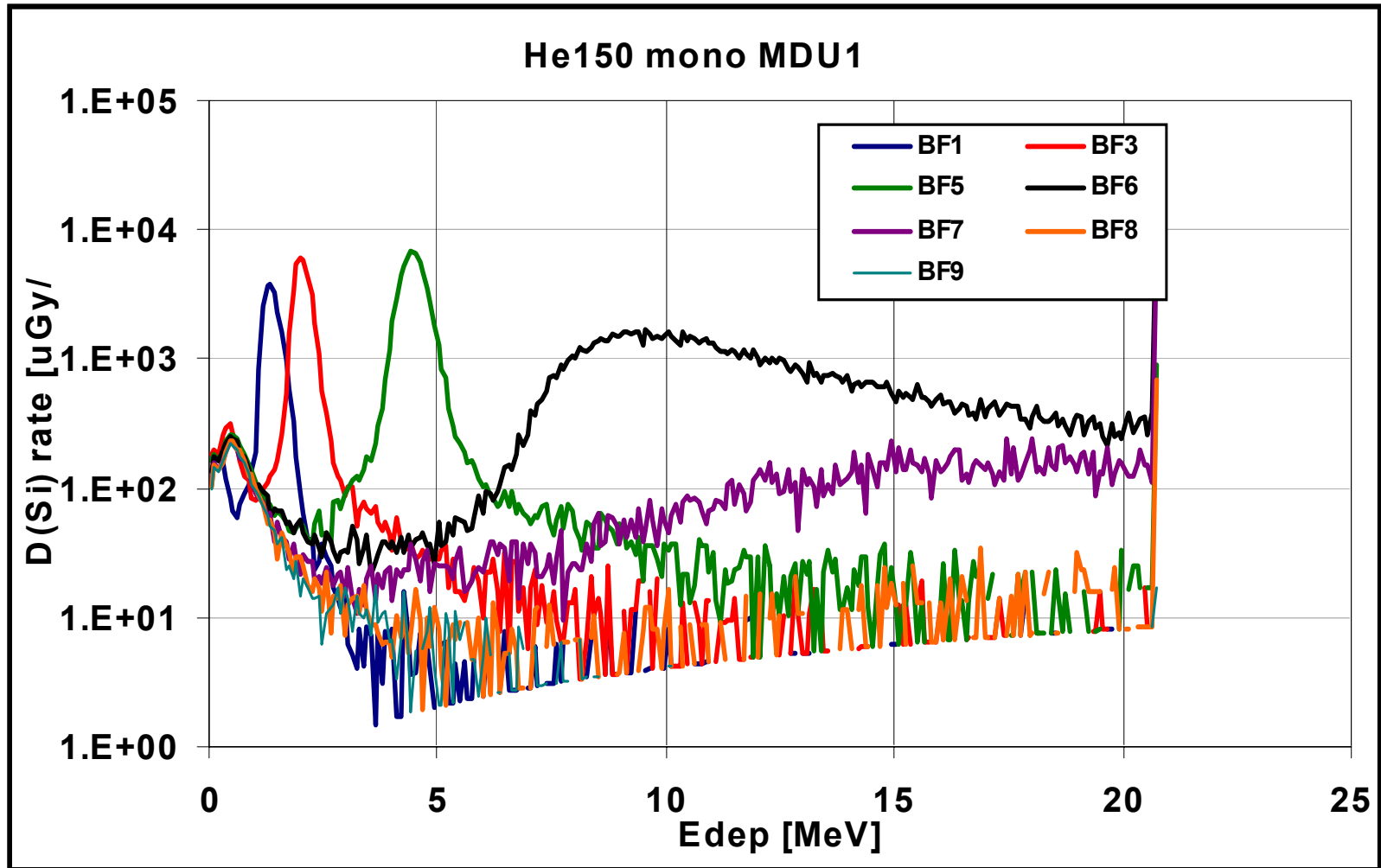
secondary particles

LET spectra, He 150, Page



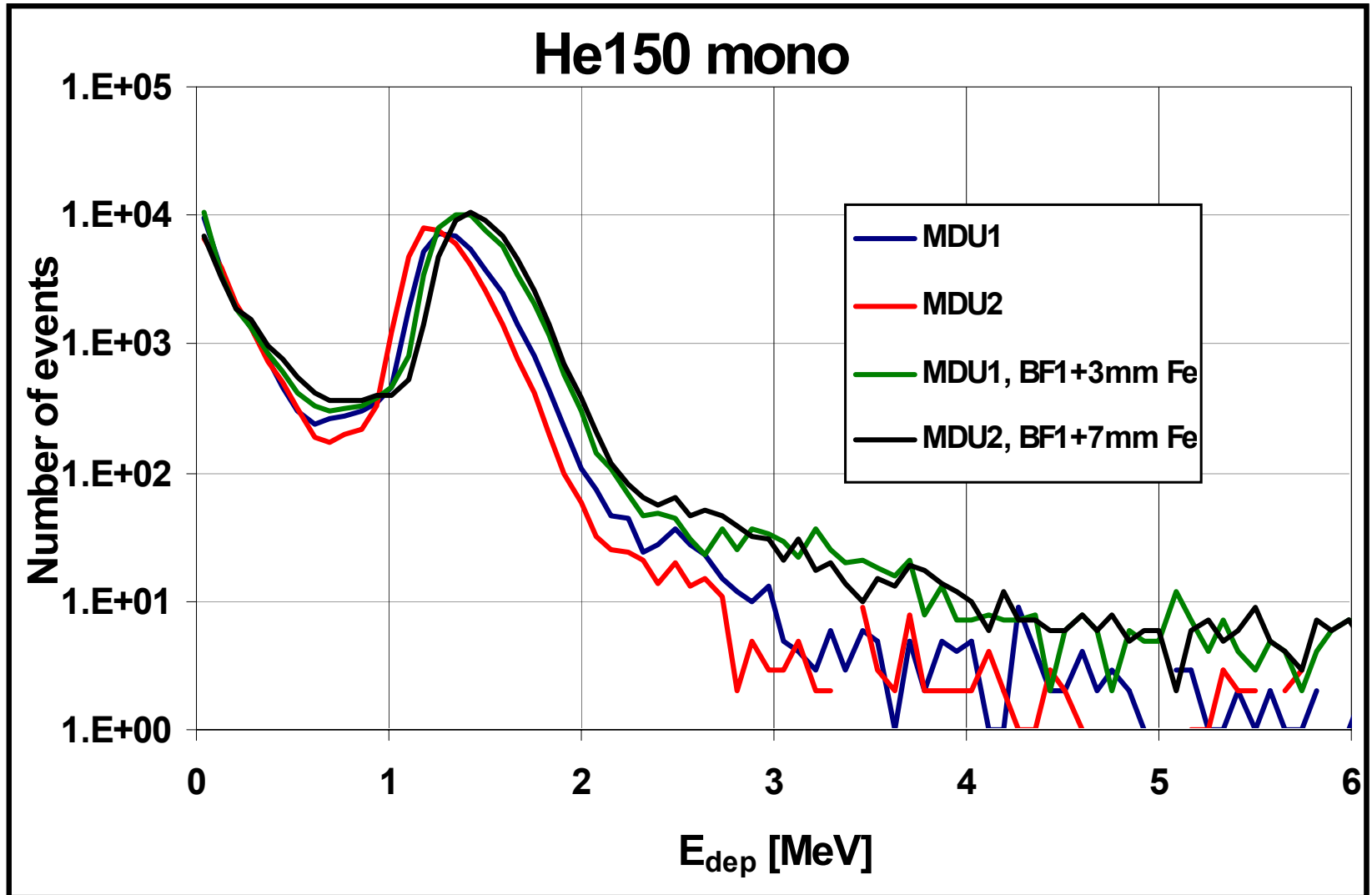
mostly primary He ions

# Liulin $E_{\text{dep}}$ spectra - He 150 MONO

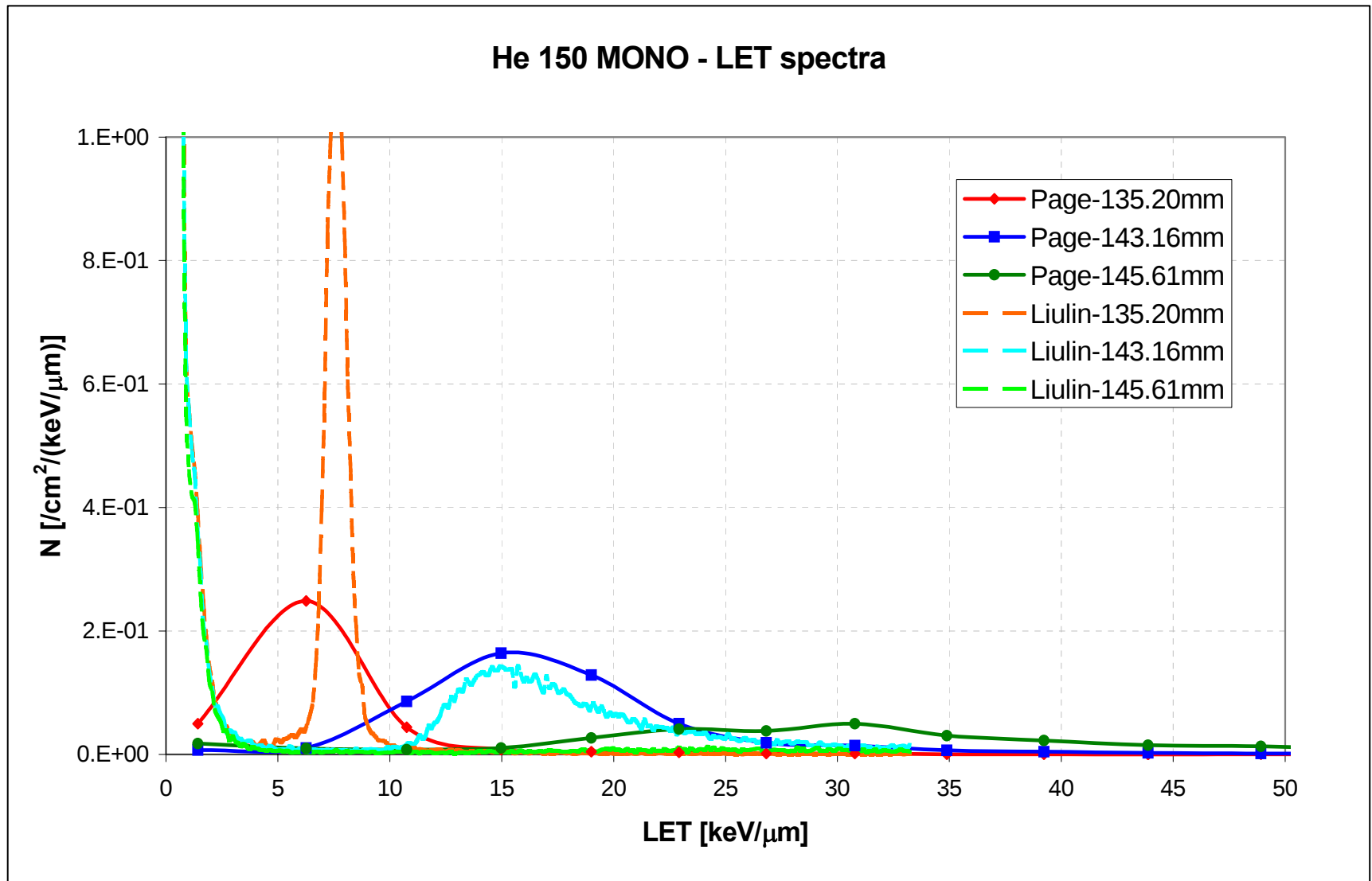


**Remarks:** BF1 –  $2.2\text{keV}/\mu\text{m}$ ; BF3 –  $3.6\text{keV}/\mu\text{m}$ ; BF5 -  $4.9\text{keV}/\mu\text{m}$

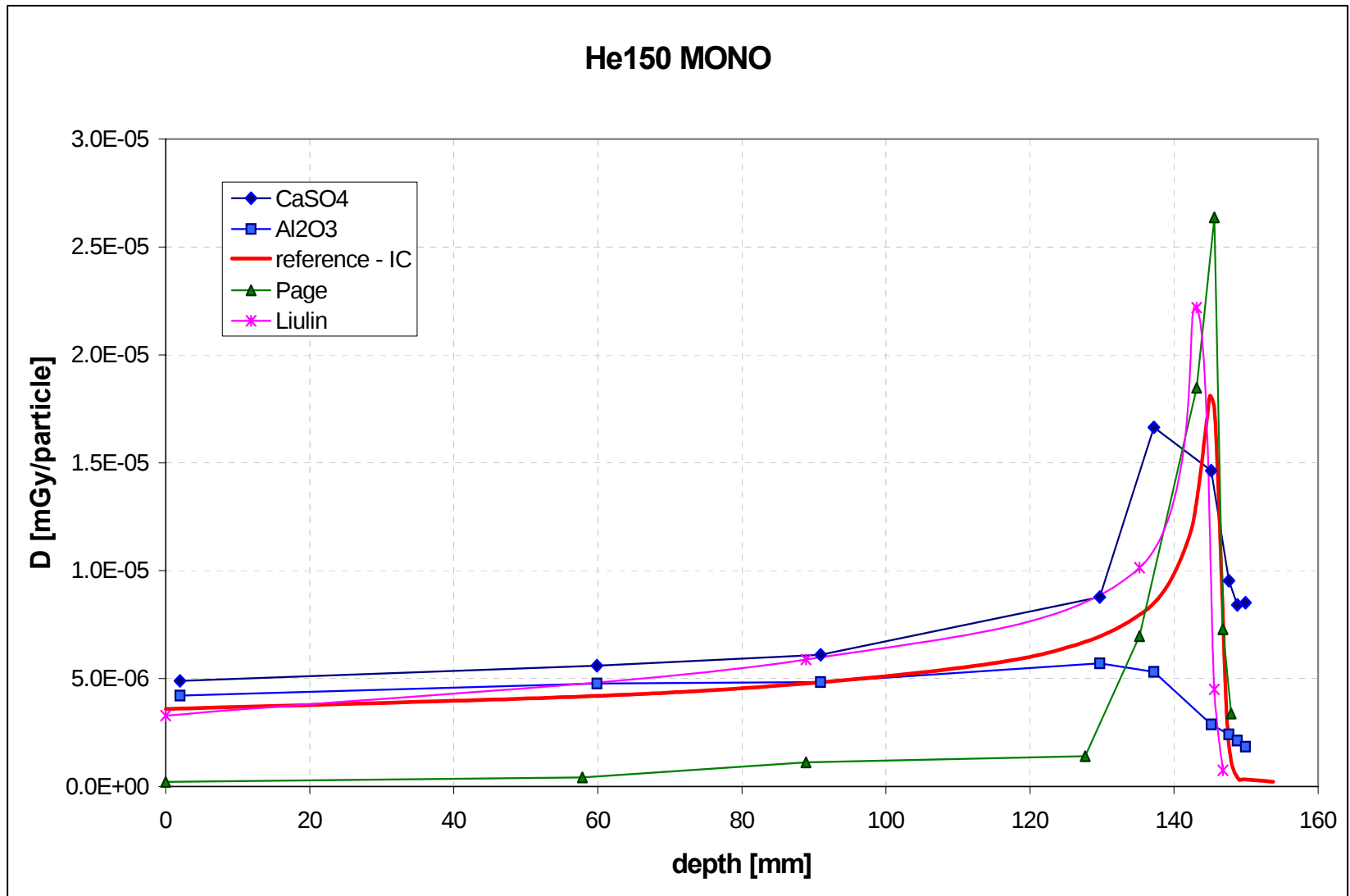
# Liulin's comparison He 150 MONO(1)



# LET spectra – He 150 MONO comparison TED and Liulin



# Depth dose comparison – He 150 MONO



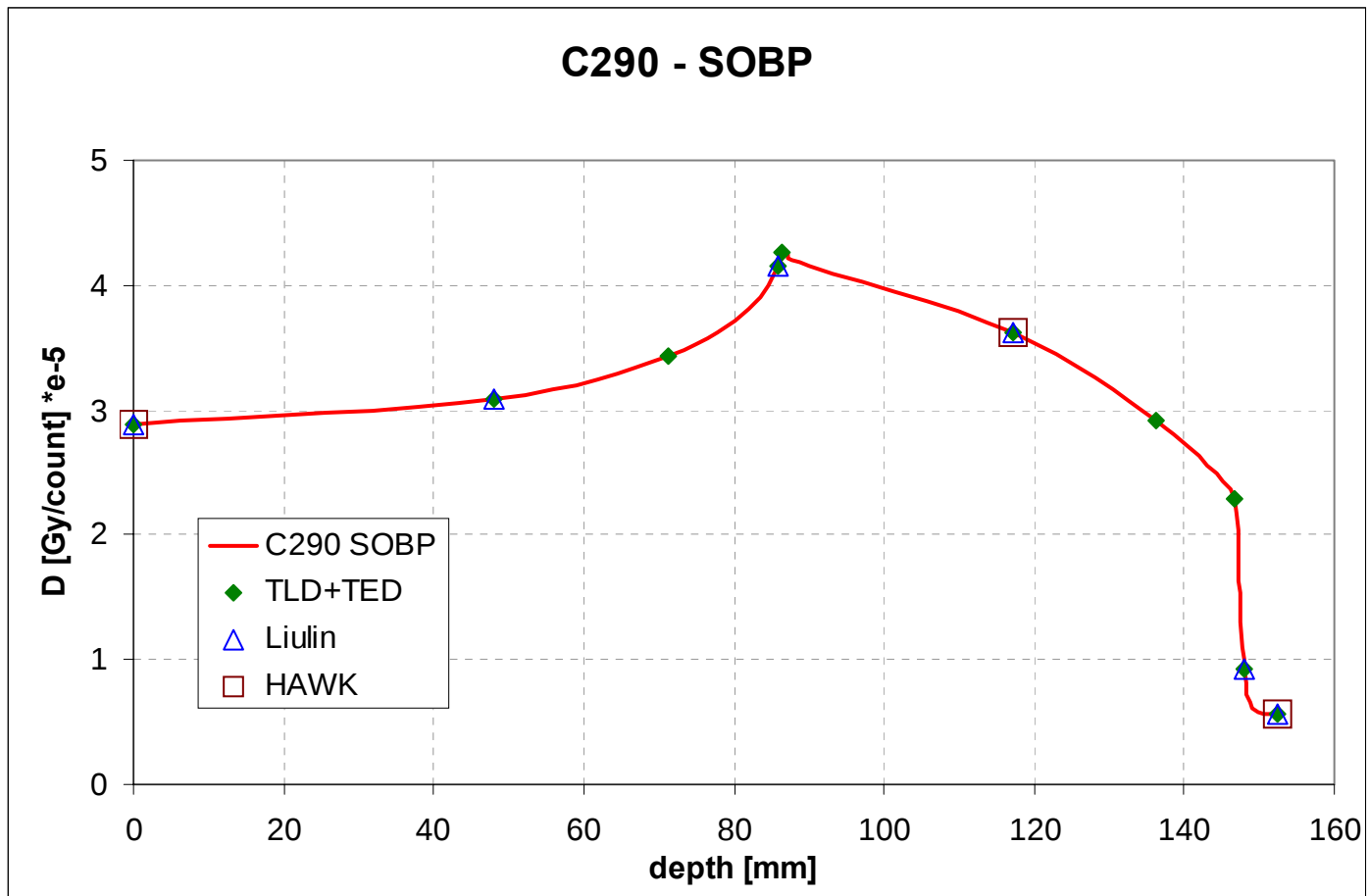
**TLD – average from all 4 detectors**

# C 290 SOBP

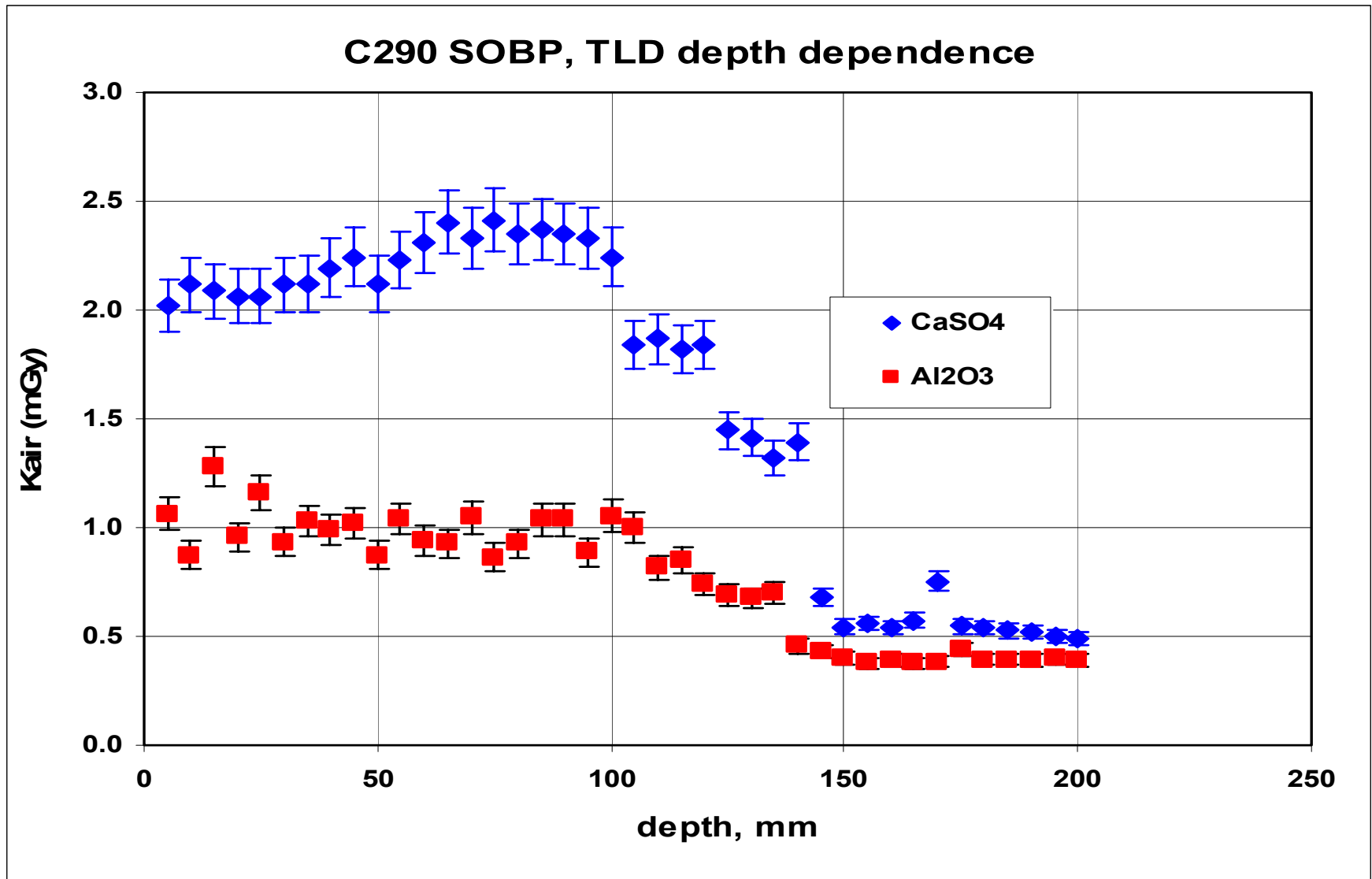
## Irradiation conditions - overview

| BF | BF depth,mm | TLD+TED,cm <sup>-2</sup> | Liulin                         | TEPC                             |
|----|-------------|--------------------------|--------------------------------|----------------------------------|
| 1  | 0           | 10 <sup>5</sup> (97500)* | 130 p/cm <sup>2</sup> , 10 min | 50 p/cm <sup>2</sup> ,<br>10 min |
| 2  | 48.13       | 10 <sup>5</sup> (97500)  | 130 p/cm <sup>2</sup> , 10 min | 50 p/cm <sup>2</sup> ,<br>10 min |
| 3  | 71.36       | 10 <sup>5</sup> (97500)  |                                |                                  |
| 5  | 85.83       | 10 <sup>5</sup> (97500)  | 130 p/cm <sup>2</sup> , 10 min |                                  |
| 7  | 86.97       | 10 <sup>5</sup> (97500)  |                                |                                  |
| 9  | 117.24      | 10 <sup>5</sup> (97500)  | 130 p/cm <sup>2</sup> , 10 min | 50 p/cm <sup>2</sup> ,<br>10 min |
| 10 | 136.34      | 10 <sup>5</sup> (97500)  |                                |                                  |
| 12 | 146.78      | 10 <sup>5</sup> (97500)  |                                |                                  |
| 14 | 147.92      | 10 <sup>5</sup> (97500)  | 130 p/cm <sup>2</sup> , 10 min | 50 p/cm <sup>2</sup> ,<br>10 min |
| 16 | 152.46      | 10 <sup>5</sup> (97500)  | 130 p/cm <sup>2</sup> , 10 min |                                  |

# Depth dose dependence C290 SOBP beam

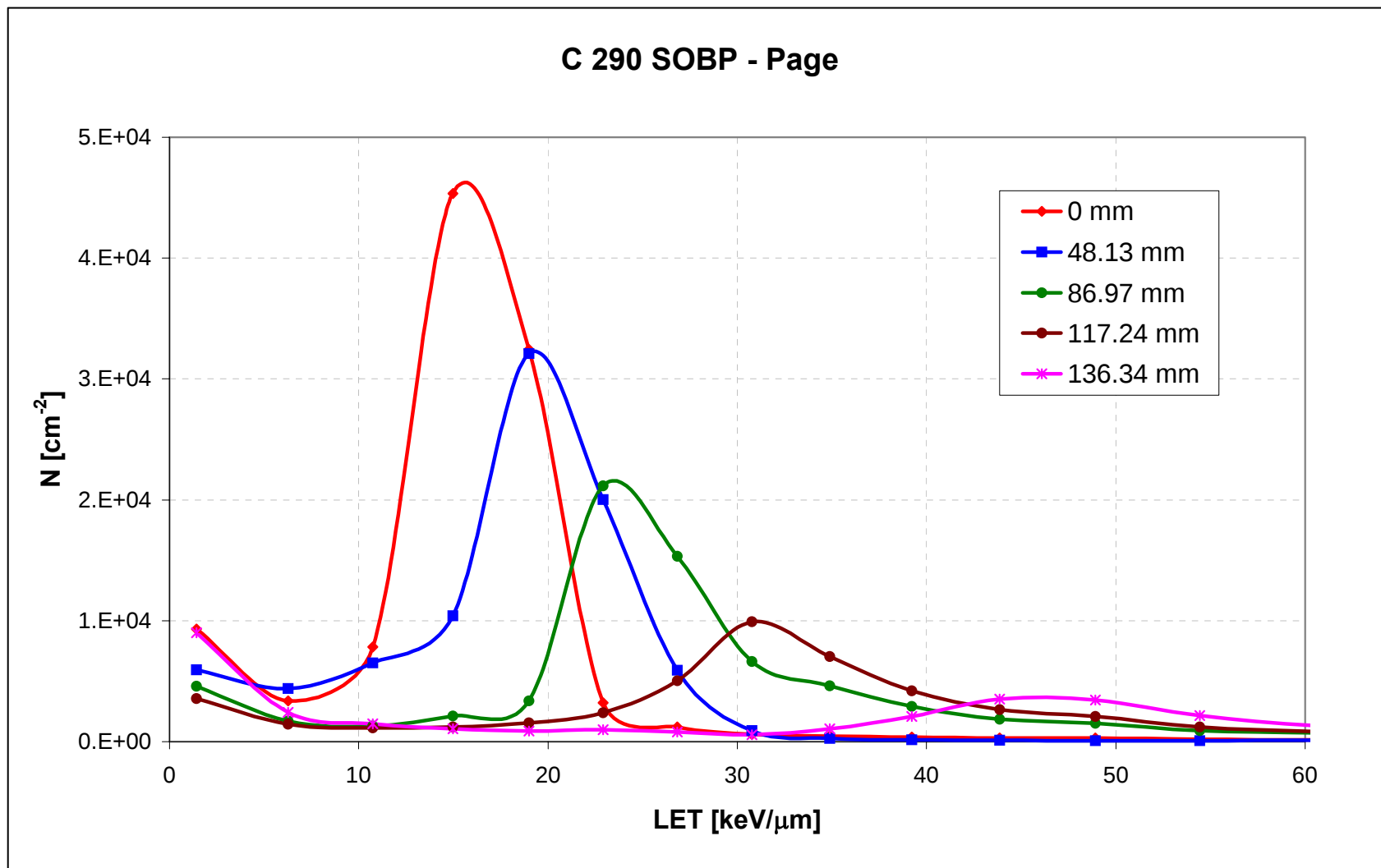


# TLD depth dependence – C 290 SOBP

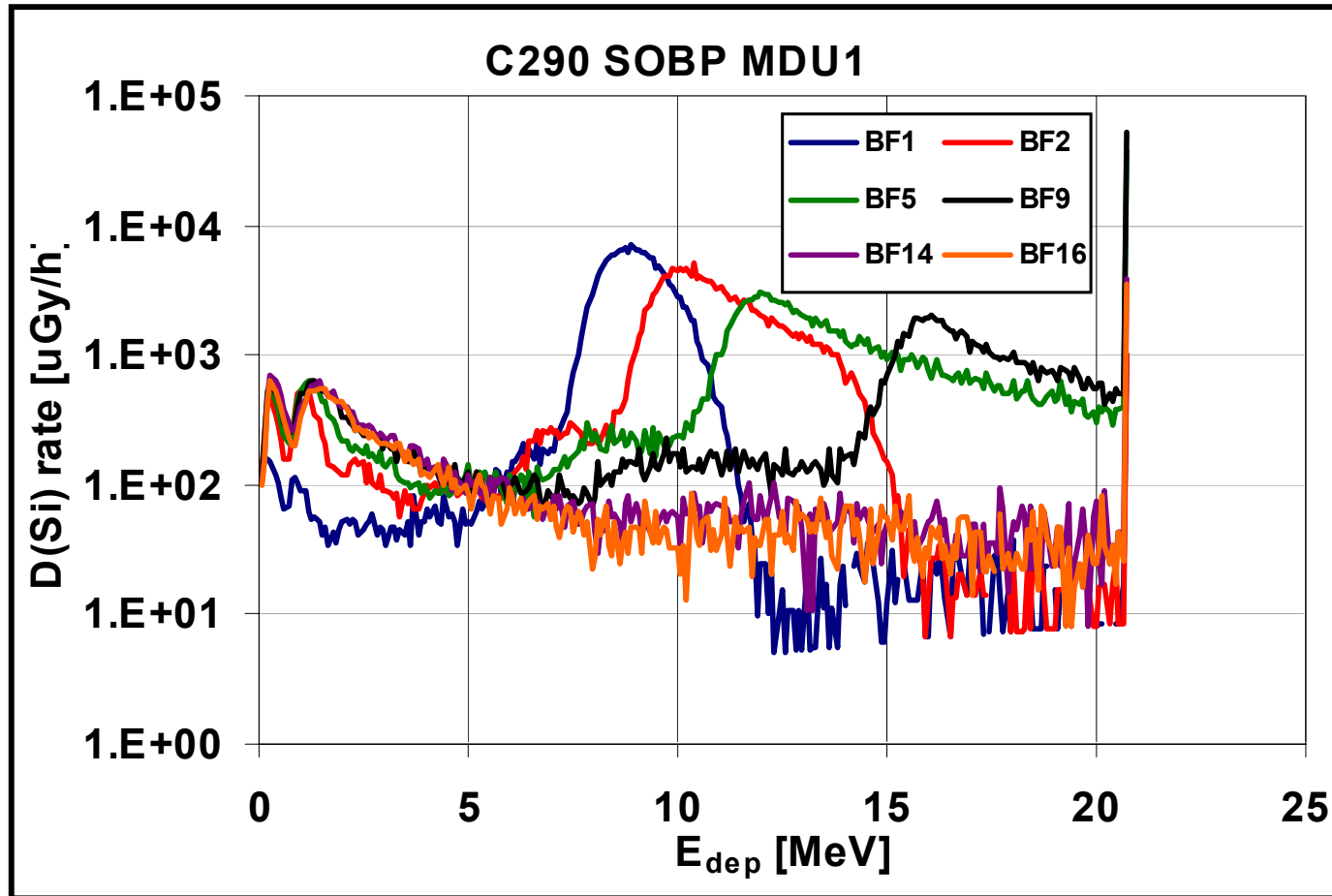


**Remarks:** TLD: all BF  $\sim 1 \text{E } 06 \text{cm}^{-2}$

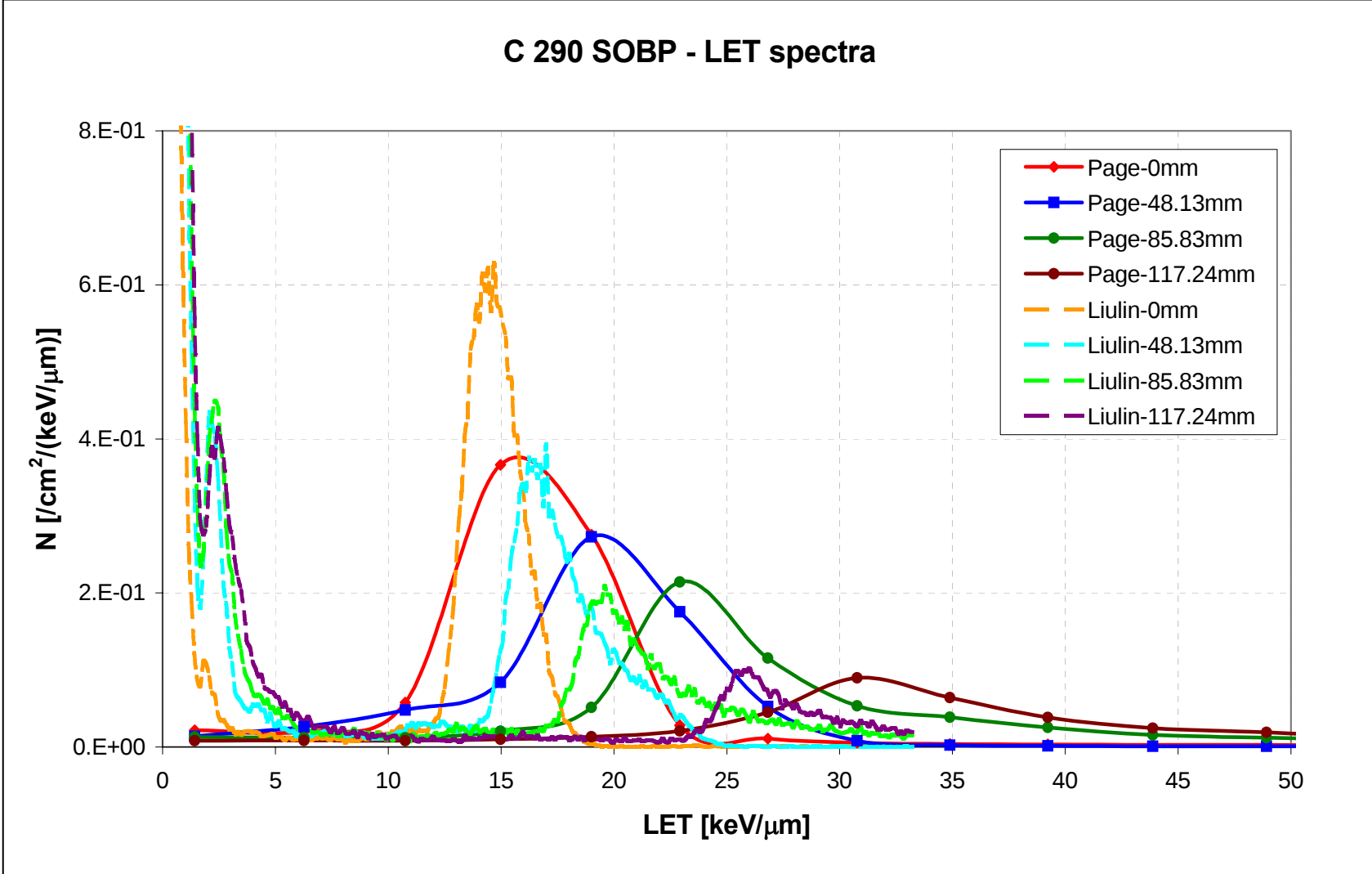
# LET spectra (Page) - C 290 SOBP



# Liulin Edep spectra - C 290 SOBP

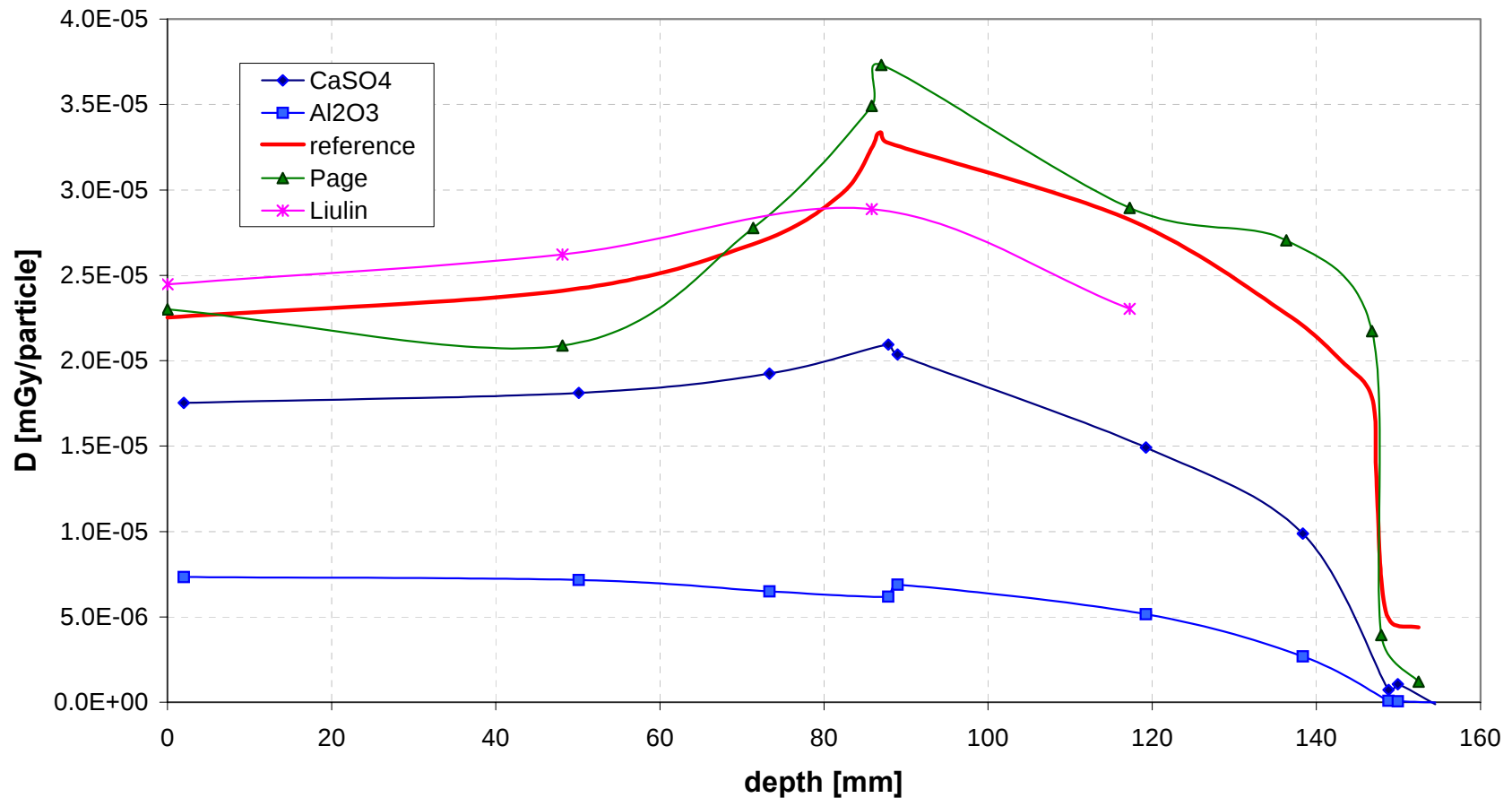


# LET spectra – C 290 SOBP comparison TED and Liulin



# Depth dose comparison – C 290 SOBP

C290 SOBP



TLD – average from all 4 detectors

# Further expected studies

## **1. May 2009(done):**

- Ne 400 MeV/amu SOBP;
- Fe 500 MeV/amu MONO;
- TED and TLD's – depths all as in previous studies (holders modified);
- Liulin – 3 exposures – 30.5; 59.64; 113.65 mm of PMMA;
- HAWK – 5 exposures – 30.5; 59.64; 68.91; 71.6; 73.1 mm of PMMA;

## **• 2. Next run (beginning of 2010):**

- He 150 MeV/n SOBP;
- C 135 MeV/n SOBP

# Acknowledgements

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- MDU-Liuln equipment was manufactured at STIL BAS Sofia in the team of Ts. Dachev. We are grateful to them for continuous support during the test and use of equipment.
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