NETZSCH

Laserflash-Analyse: Neue Modelle und Optionen

AKT, Selb, 3./4. April 2017, Dr. André Lindemann

Agenda

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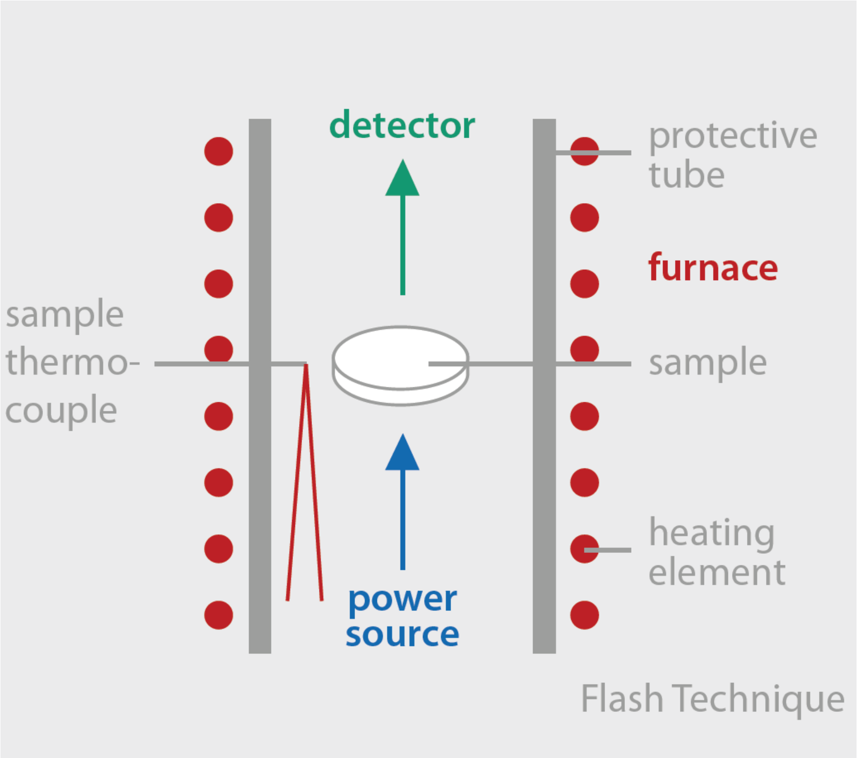
1. Introduction
2. Software Models
   a) Standard
   b) Special
3. Verification of new model
   a) HFM
   b) Special sample preparation
4. Improvement of 2D model

Flash Technique & HT LFA Systems

A short pulse leads to a temperature increase on backside

- Measurement principle introduced by Parker et al. in 1961
- The front surface of a plan-parallel sample is heated by a short light or laser pulse
- The temperature rise on the rear surface is measured versus time using an IR detector



Flash Technique & HT LFA Systems

Temperature increase is measured by IR detector

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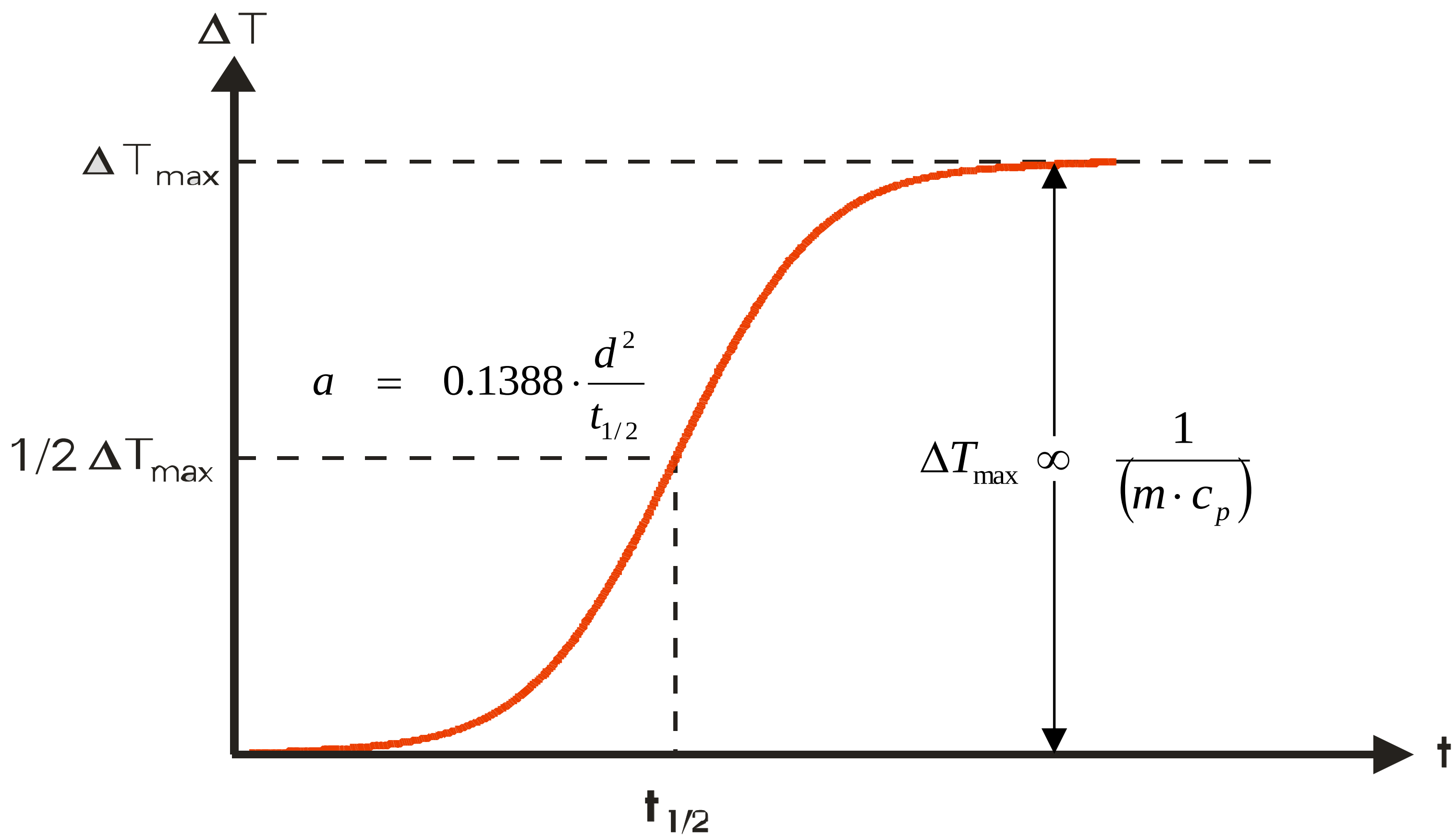

$$\lambda(T) = a(T) \cdot c_p(T) \cdot \rho(T)$$

Flash Technique – Introduction

Netzsch LFA Systems for almost all application ranges

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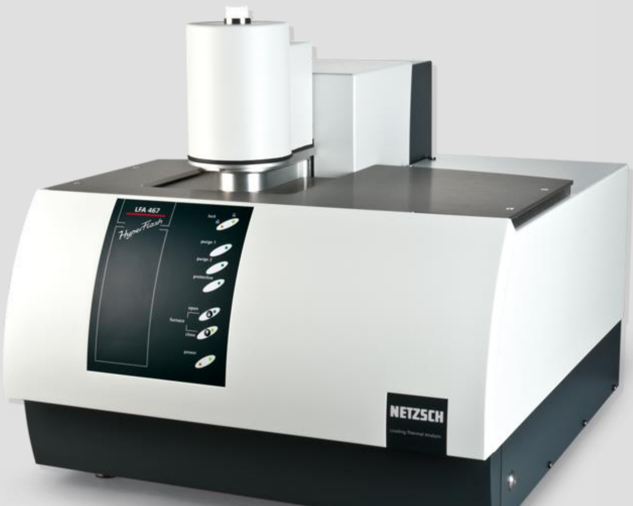

+ LFA 467 HT (1250°C)

LFA 467 *HyperFlash*

- -100°C to 500°C
- Sample changer for 16 samples
- *ZoomOptics* - IR detector
- Fastest data acquisition

LFA 457 *MicroFlash*®

- -125°C to 1100°C
- Sample changer for 3 samples

LFA 427

- -120°C to 2800°C

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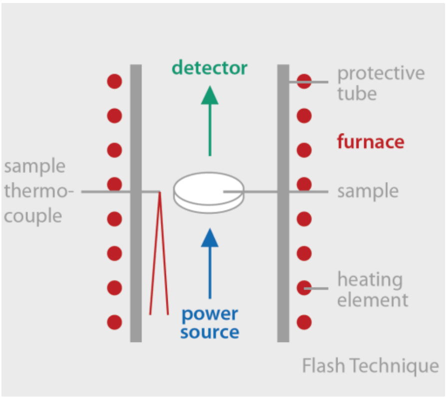
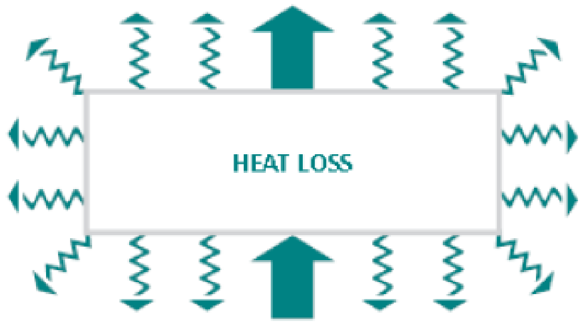
Software Models

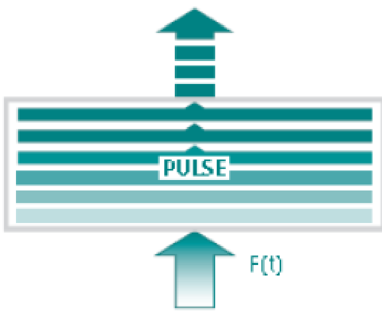
Standard Models Improved by Netzsch – Finite Pulse, BL corr…

- Standard Models

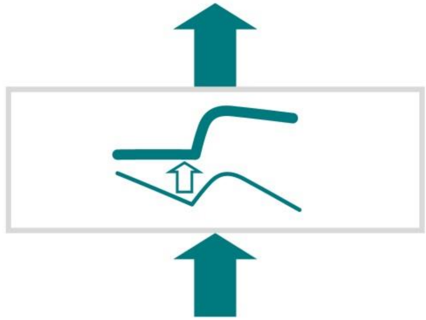




Improved Cape-Lehman (Blumm/Opfermann)
Cowan
Special Models

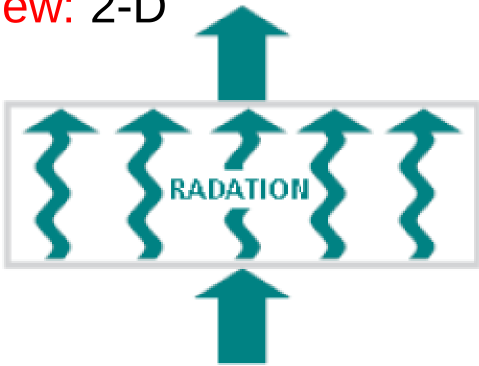


Finite Pulse Correction
Patented by Netzsch
Option for all Models



Baseline Correction
Option for all Models

Mehling (extended Cowan)
New: 2-D



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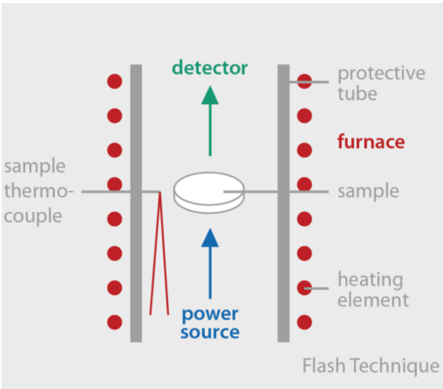
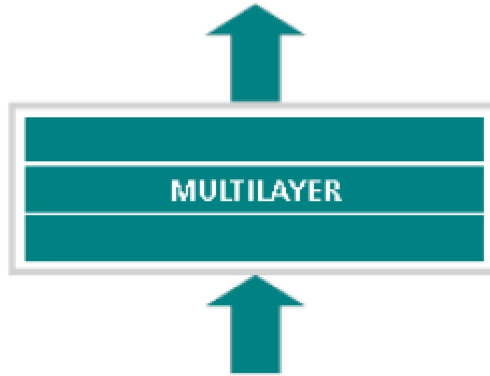
Software Models

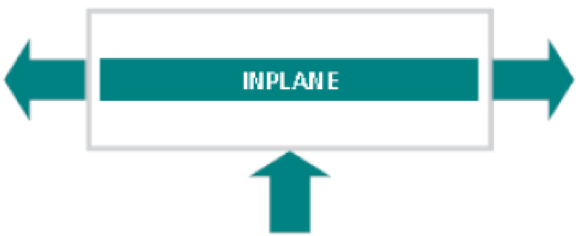
Models for nearly all Sample Structures

- Special Models

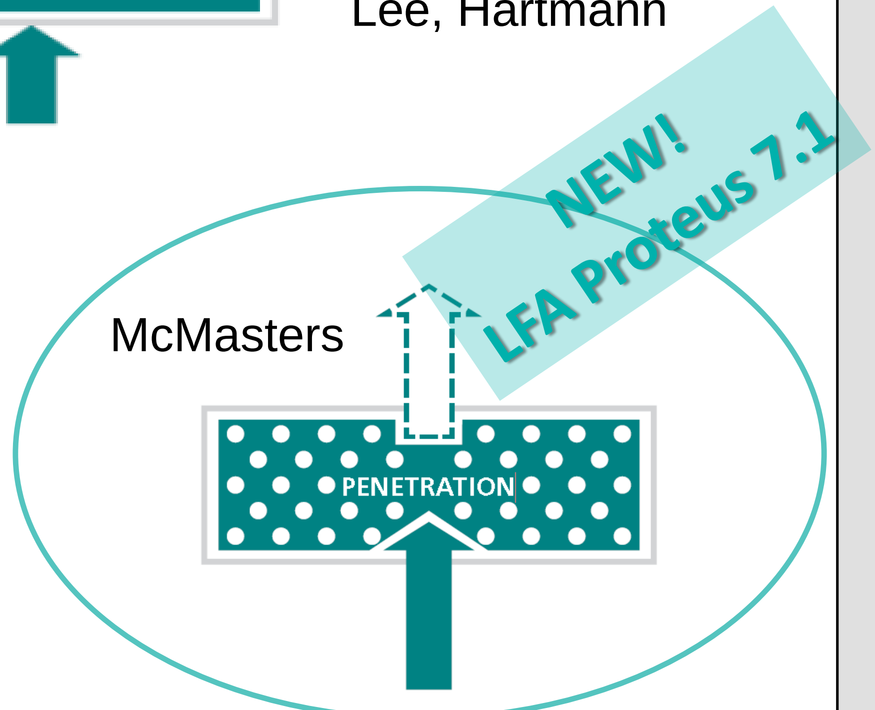




2-Layer
3-Layer
Contact resistance
Lee, Hartmann



Radial direction



Software Models

Background of New Beam Penetration Model

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Standard flash method:

- energy is totally absorbed on the front face
- a thermal wave will then travel through the specimen thickness before reaching the opposite face

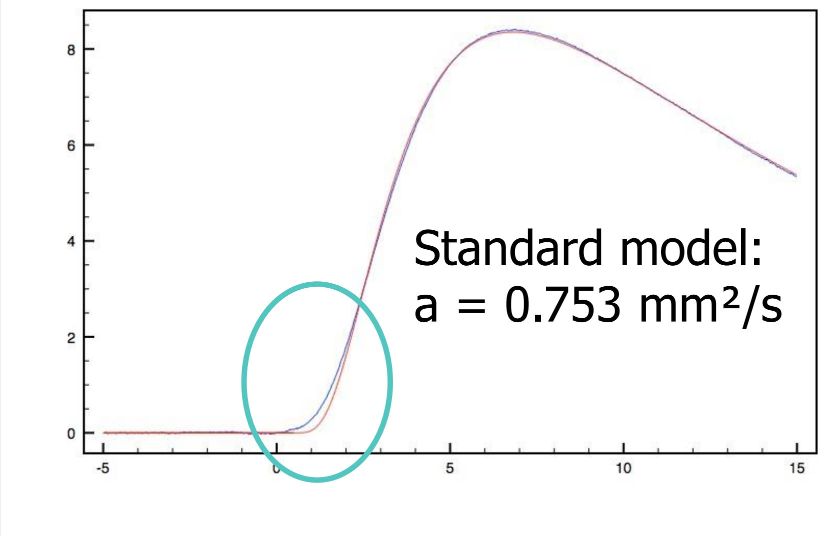
Porous materials:

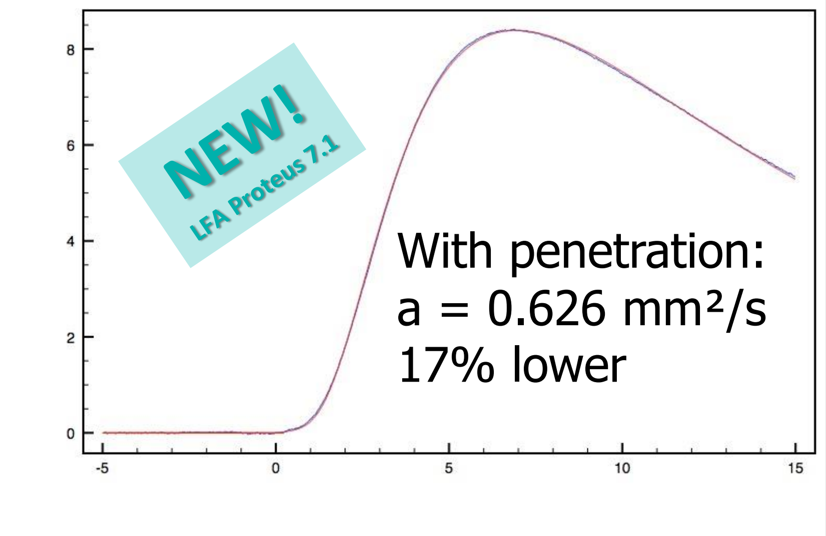
- absorption of the pulse energy is no longer limited to the front face
- absorption is extended over a thin layer into the specimen thickness
- the absorption layer can be handled as the mean free path of photon in the material
- this results in an exponentially decaying initial temperature distribution within the specimen

Software Models

Better Model Fit with New Penetration Model

- Graphite Felt Insulation
  - LFA 427
  - Different models





- Unsufficient model fit with standard model
- Results too high

- Excellent model fit with new penetration model
- Results more reliable

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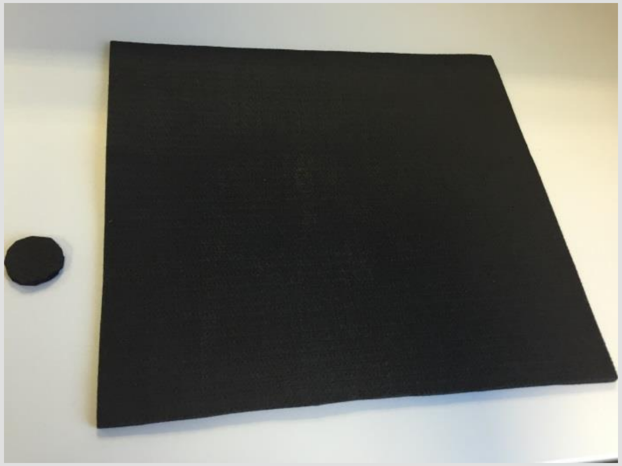
Software Models

Comparison: HFM vs. LFA to check Penetration Model

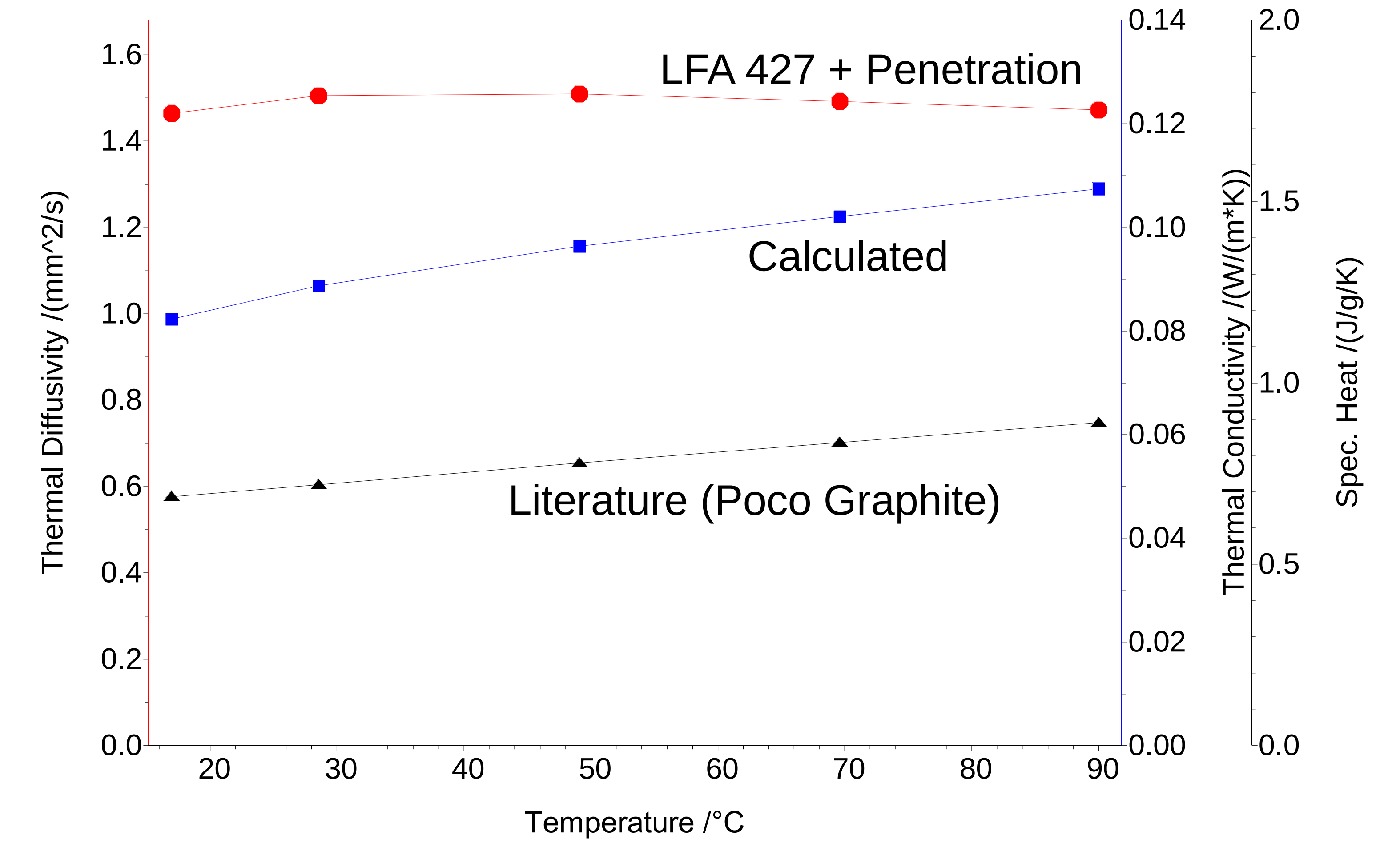
- Sample
  - Graphite Felt Insulation
- Measurements
  - Thermal Diffusivity
  - Thermal Conductivity
- Temperature Range
  - RT – 90°C
- Goal
  - ✓ Accuracy Check of Penetration Model



Software Models

Promesing Results with Penetration Model

- Graphite Felt Insulation



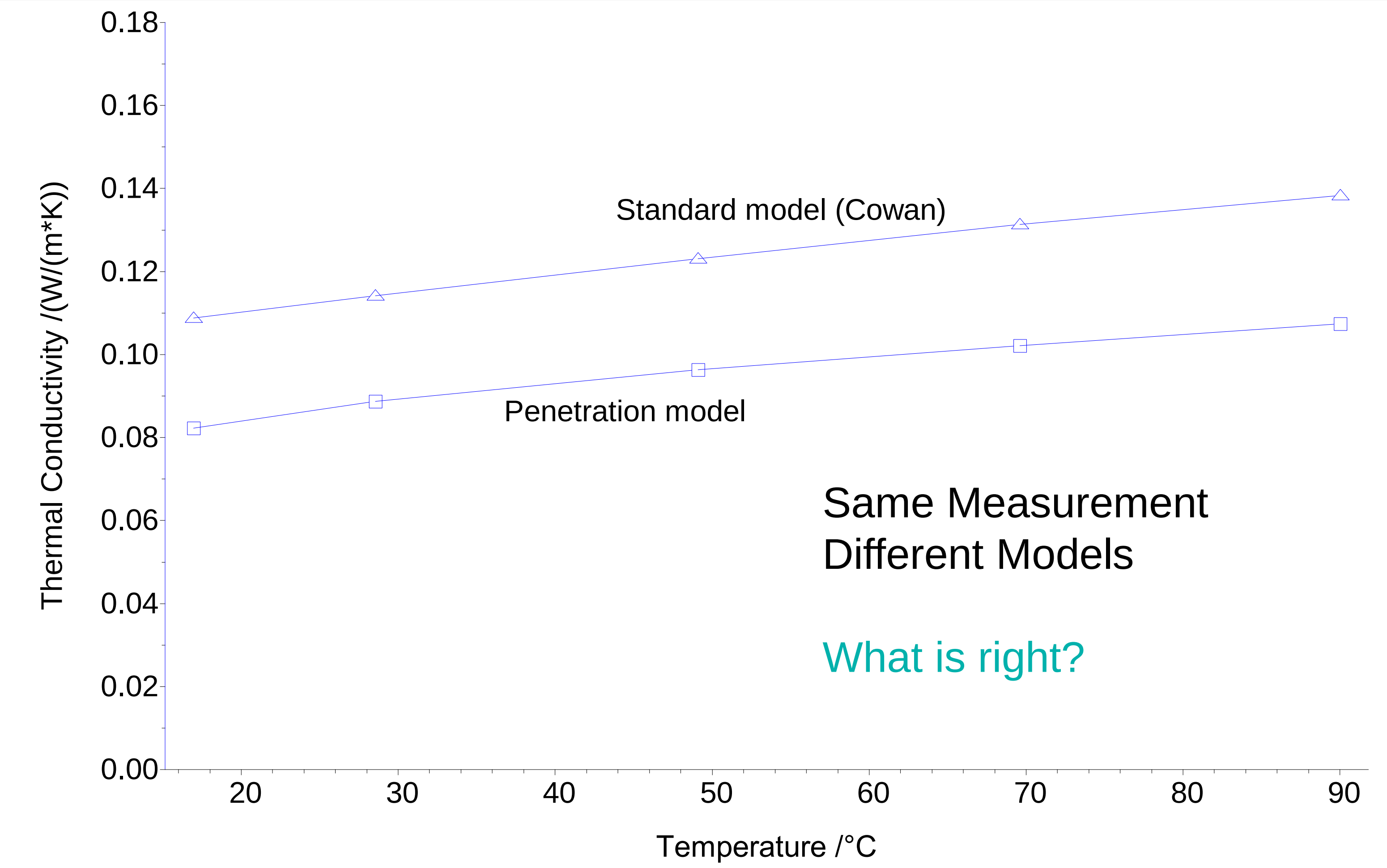
Identity : x		**Material :**	Grafitfilz	**Coating :**	---	**Operator :**	x
Date/Time : 2015-05-27 14:53:54		**Thickness/Diameter :**	5,4500 mm / 20,000 mm	**Atmosphere :**	Air	**Customer :**	x
Sample : Grafitfilz		**Density (20,0 °C) :**	0,082 g/cm^3	**Laboratory :**	x	**Approximation :**	None
Instrument : LFA 427	**Remark :** ---					**Calc. code :**	undefined/l/1-0-1

Created with NETZSCH Proteus software

Software Models

Comparison: Significant Differences between Models

- Graphite Felt Insulation – Comparison of Models



	Identity	Sample	Thickness /mm	Density	Material	Atmosphere	Date/Time	Calc. code
■	x	Grafitfilz	5,4500	(20,0 °C) 0,082 g/cm^3	Grafitfilz	Air	2015-05-27 14:53:54	undefined/l/1-0-1
▲	x #02	Grafitfilz	5,4500	(20,0 °C) 0,082 g/cm^3	Grafitfilz	Air	2015-05-27 14:53:54	C+p/l/1-0-1

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Software Models

Same results for HFM and LFA with new Beam Penetration Model

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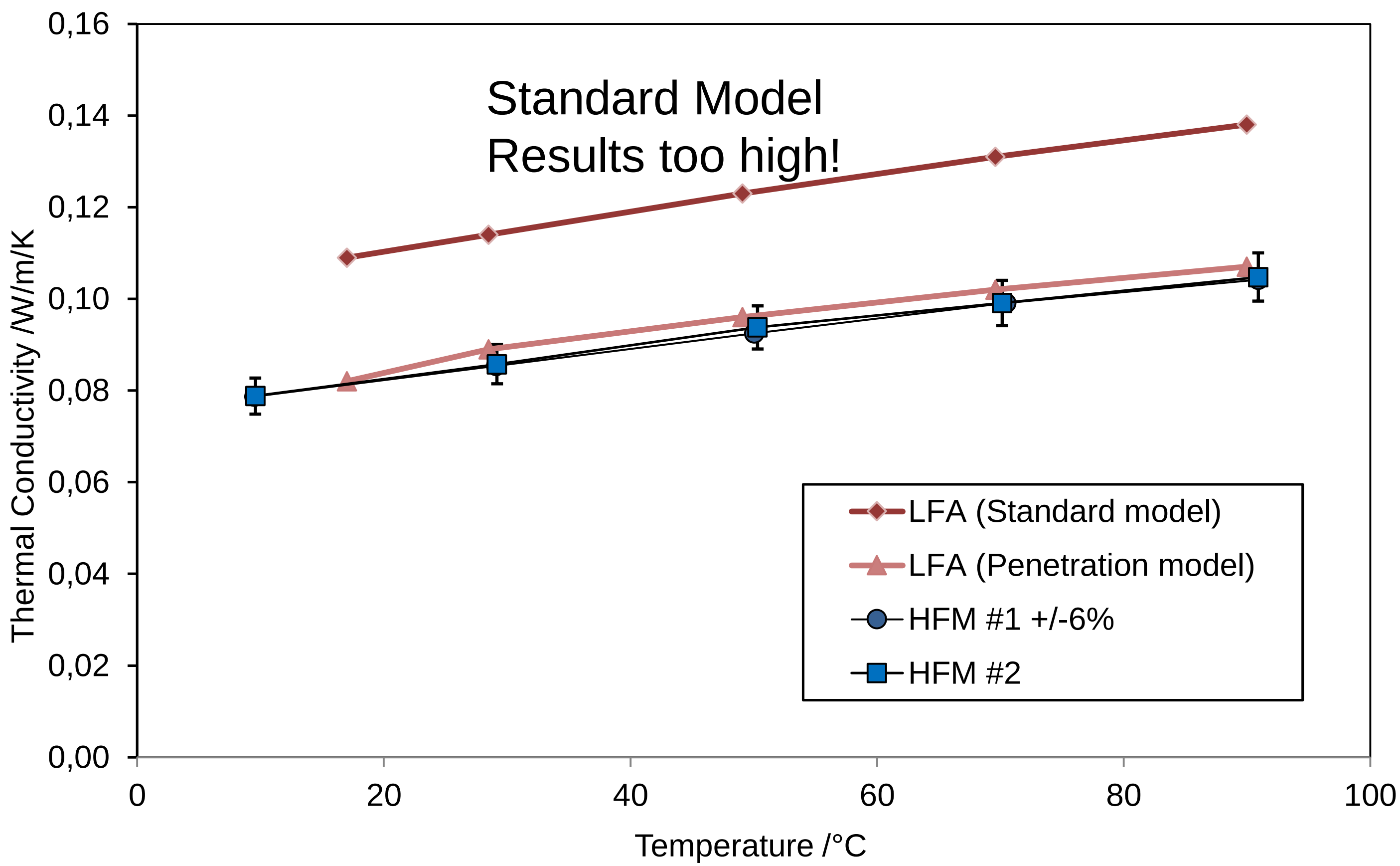
- Graphite Felt Insulation – LFA vs. HFM



➢ New penetration model improves measurements on felt/fibre samples

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Software Models

Comparison: Modified Sample to check Penetration Model

- Samples
  - ➢ Filled Polymer (Disc)
  - ➢ Same Sample with Holes

- Measurements
  - ➢ Thermal Diffusivity at RT
  - ➢ LFA 467

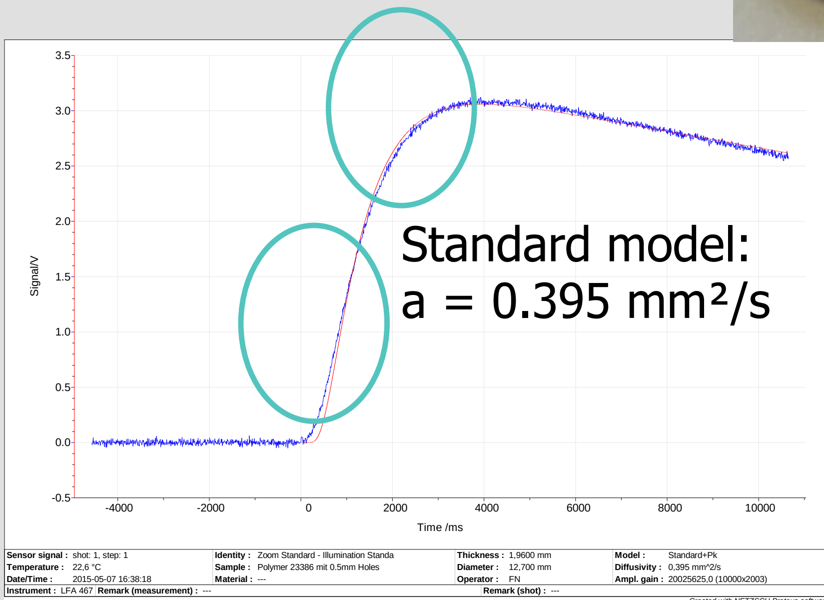
LFA 467

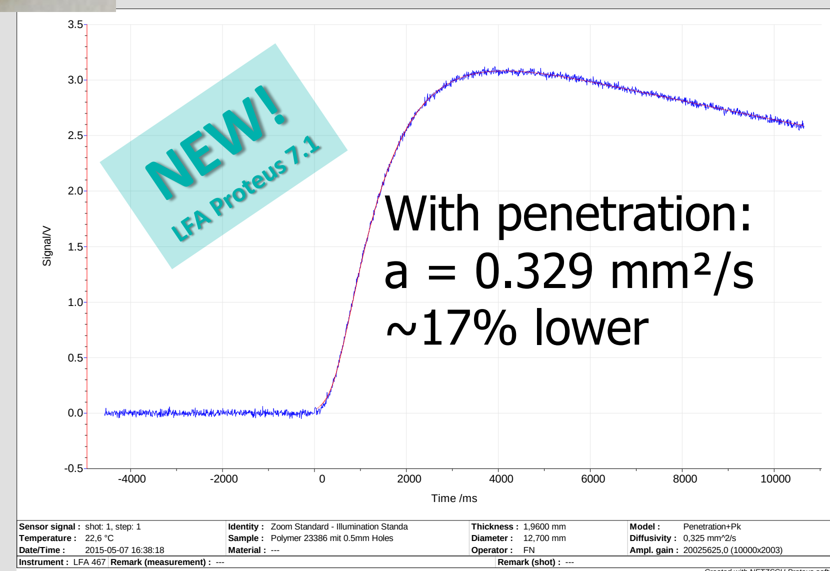
- Goal
  - ✓ Check if Penetration Model can also be used at Porous Samples

Software Models

The Model Fit at Penetration Model looks better

- Polymer Sample with Holes





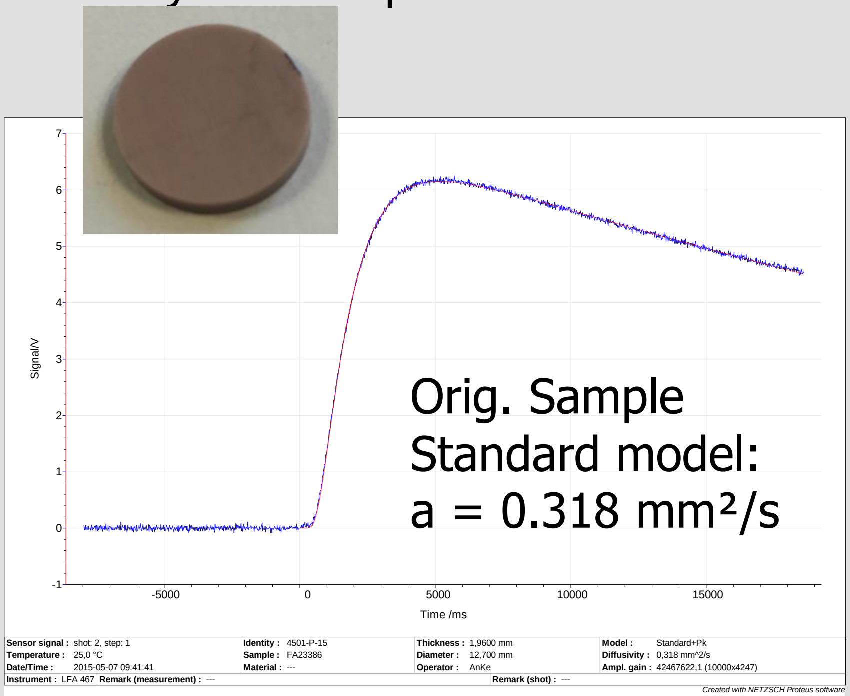
- Unsufficient model fit with standard model
- Results seems to be too high

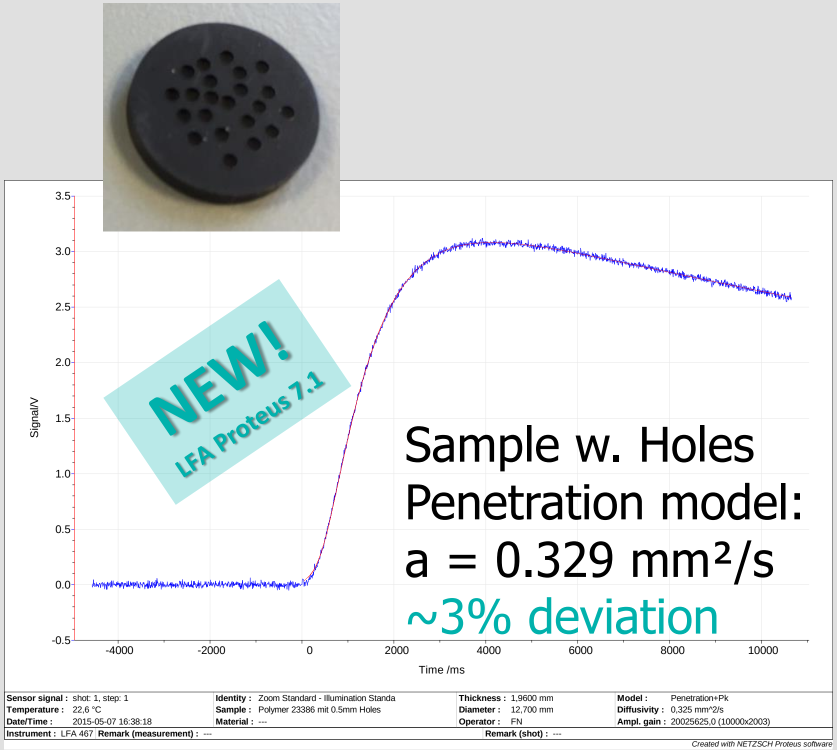
- Excellent model fit with new penetration model
- Results more reliable ???
- ➢ compare with results on original sample

Software Models

Nearly Same Results with Original Sample

- Polymer Sample with and w/o Holes





- ➢ Correct fit with standard model
- ➢ Correct results

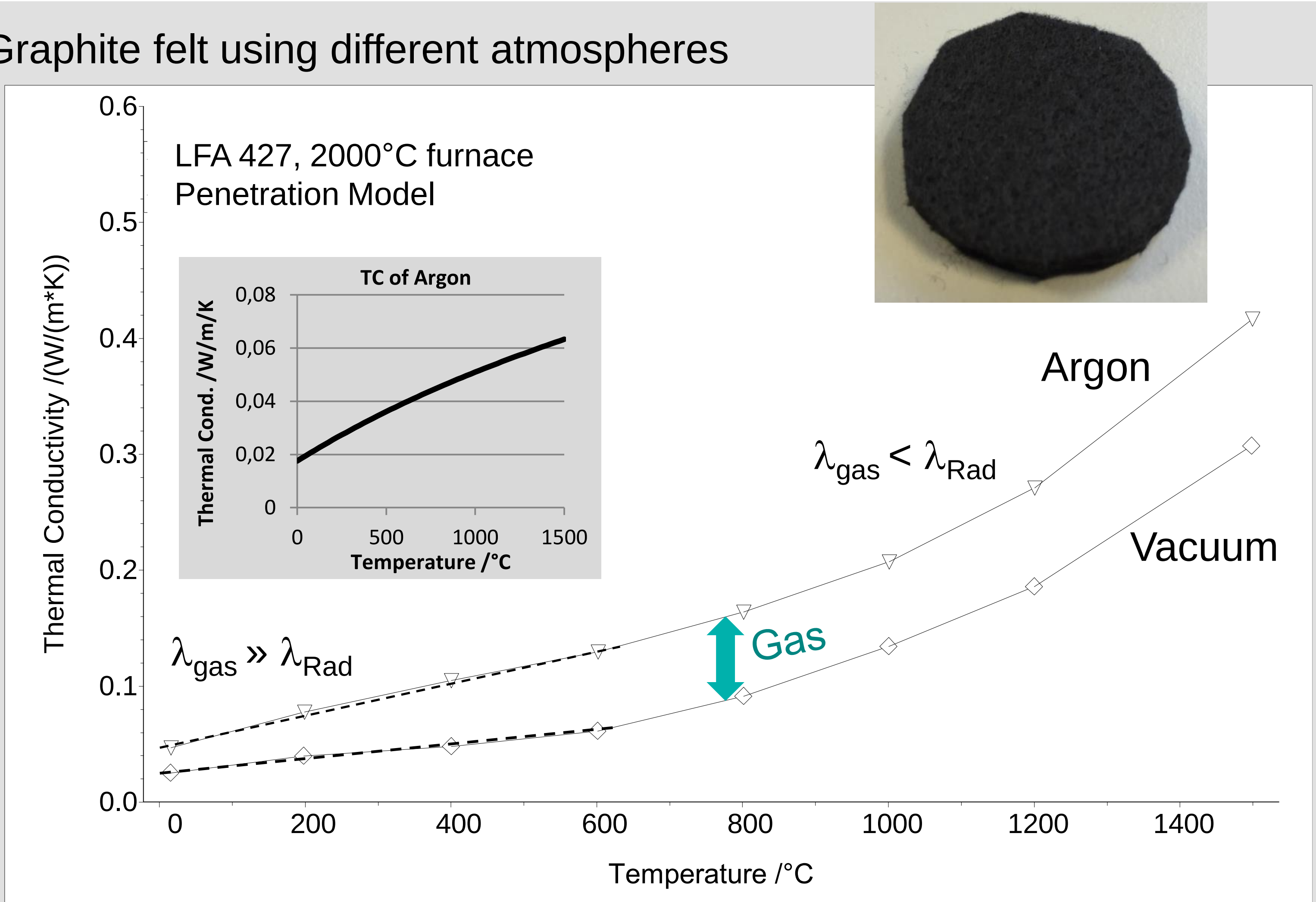
- ➢ Excellent model fit with new penetration model
- ➢ Nearly same results compared to original sample

- ➢ New penetration model improves also measurements on porous samples

Applications – Carbon Fibre Insulation

Significant Influence of Heat Transfer Through Gas Phase

- Graphite felt using different atmospheres



	Identity	Sample	Thickness /mm	Density	Material	Atmosphere	Date/Time	Calc. code
◆	2201-U-11	graphite felt vacuum	2,8000	(20,0 °C) 0,084 g/cm^3	graphite felt	Ar	2012-04-17 08:59:31	undefined/I/1-0-1
▼	2201-U-11	graphite felt argon	2,8000	(20,0 °C) 0,084 g/cm^3	graphite felt	Ar	2012-04-16 16:25:23	undefined/I/1-0-1

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Improvement of 2D model

Consideration of Illuminated Area

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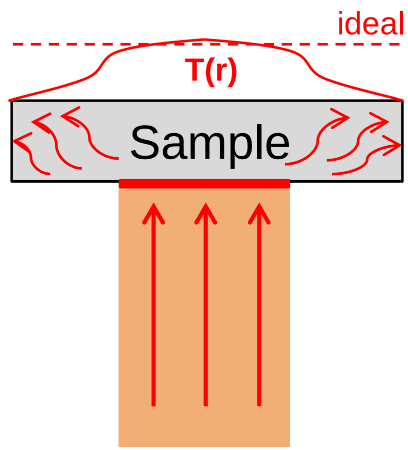
- Since LFA Proteus 7.1

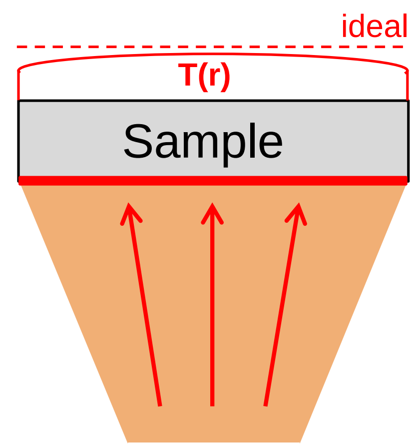
Calculate Diffusivity

Use	View	Model	Heat Loss			Correction		Illuminated Area /%	Spot Ratio
			Front	Back	Side	Baseline	Pulse		
☑	☑	Standard	☑	☑	☑	None	Numerical	95	0,71
☐	☐	Transparent	☑	☑	☐	Linear	Numerical	100	0.0
☐	☐	Penetration	☑	☑	☐	Linear	Numerical	100	0.0

- Illuminated Area 50%



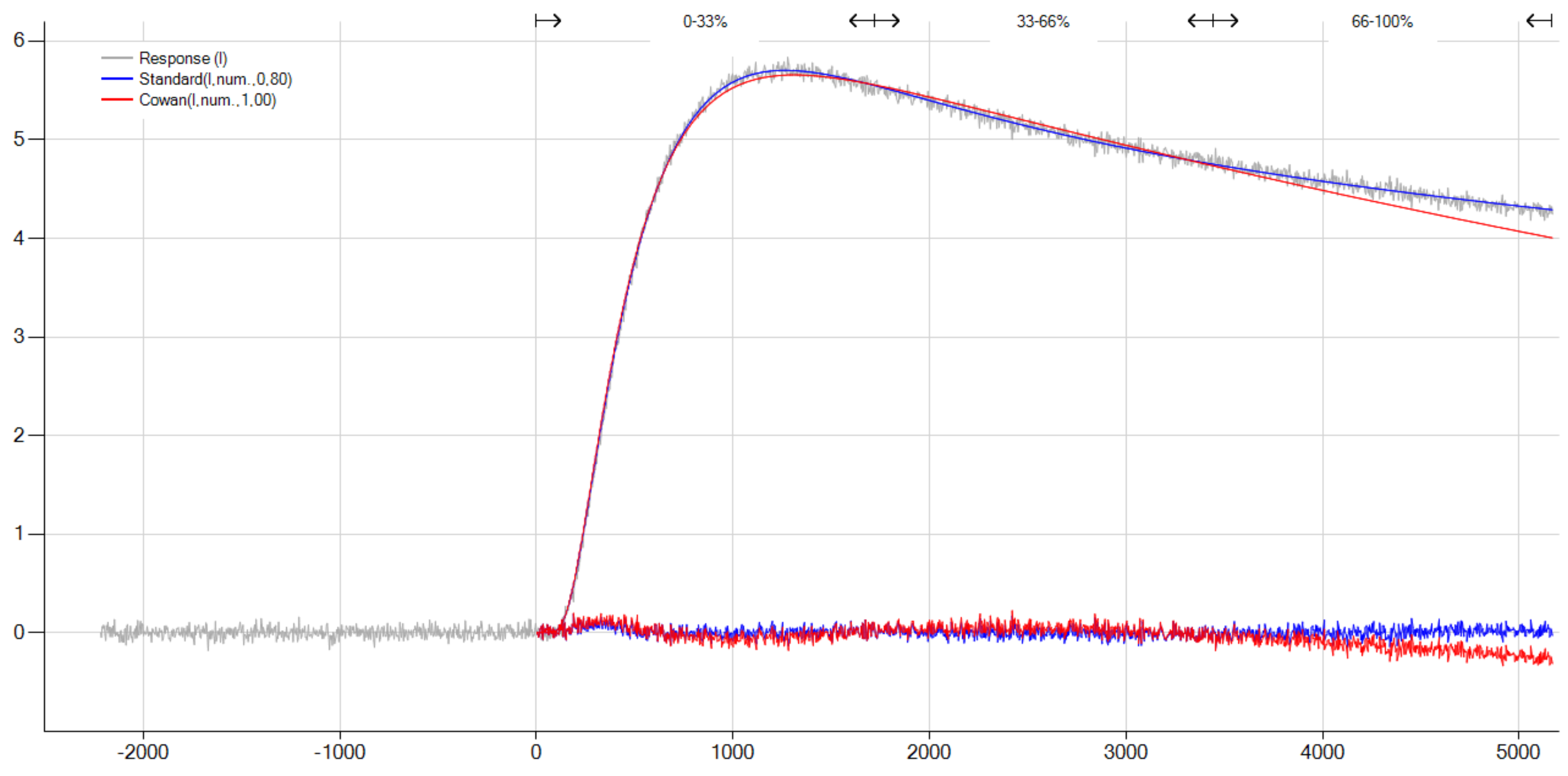
- Illuminated Area 100%



Improvement of 2D model

Consideration of Illuminated Area

- Comparison 1D vs. 2D with Illuminated Area



Conclusion

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- New penetration improves accuracy at fibres/felts and porous materials

  - Good agreement with HFM results
  - Measurements on samples with bore-holes show that penetration model can also be used at porous samples or samples with higher roughness

- Further improvement of 2D model

  - Consideration of real illuminated area by laser / flash lamp
  - Improvement of model fit and higher accuracy
  - Advantage at small sample diameters and/or thick samples

- Thank you for your Attention!