

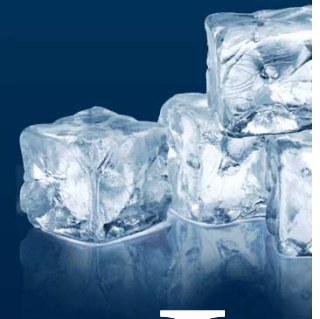
PROJECT SUDDEN:

SURFACE PHENOMENON AND DEFECTS ON MECHANICAL PROPERTIES IN ADDITIVE MANUFACTURING OF TI-6AL-4V

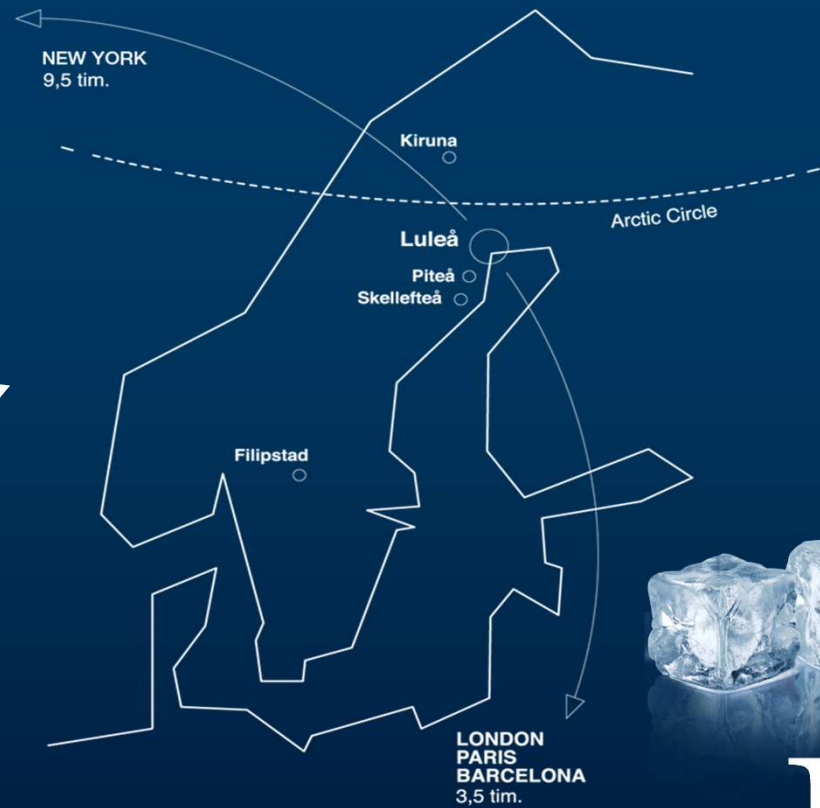
Viktor Sandell

Supervisors: Marta-Lena Antti, Pia Åkerfeldt, LTU

Thomas Hansson, GKN Aerospace



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OUTLINE

- Background
- Project overview
- Recent work:
 - Surfaces
 - Powders
 - Pre-study
- Future Work

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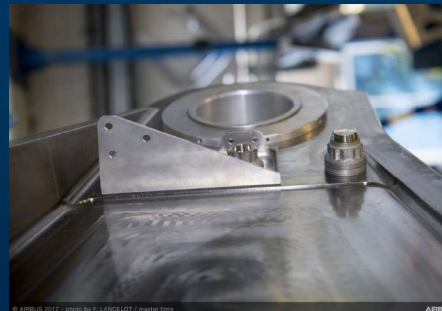
BACKGROUND

2015 – 2017

- Test flights with AM details
 - A350 XWB and A320neo
 - 737 Dreamliner
- First in-series assembly
 - 30% Weight Reduction.

2018 – 2019

- 80% growth in 2018
- Hurdles
 - Lack of standards
 - Lack of user experience



First in-series AM bracket –
A350 XWB Pylon (2017)



First FAA approved AM component –
GE90 engine sensor housing (2015)

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PROJECT OVERVIEW

(Production)

Feedstock Material

- Ti-6Al-4V Powder

Defects

- Surfaces
- Pores & Inclusions
- (Microstructure)

Post Production Treatment

- Surface Treatments
- Hot Isostatic Pressing

WP2

WP3

WP4

WP4

Fatigue Life

WP 2-5

- Testing
- Defect based modelling



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PROJECT OVERVIEW

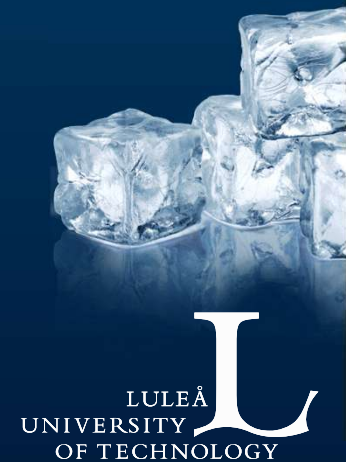
Global research areas [1]

- Closer evaluation of the physics of AM processes.
- **Failure mechanisms and the characteristic material anomalies.**
- Comprehensive material-process-structure-property relationships.
- Industry specifications database and AM materials and processes standards.
- AM component design guidelines and rulemaking.
- **Post processing methods and part quality enhancement.**
- **Monitoring and testing strategies for AM.**

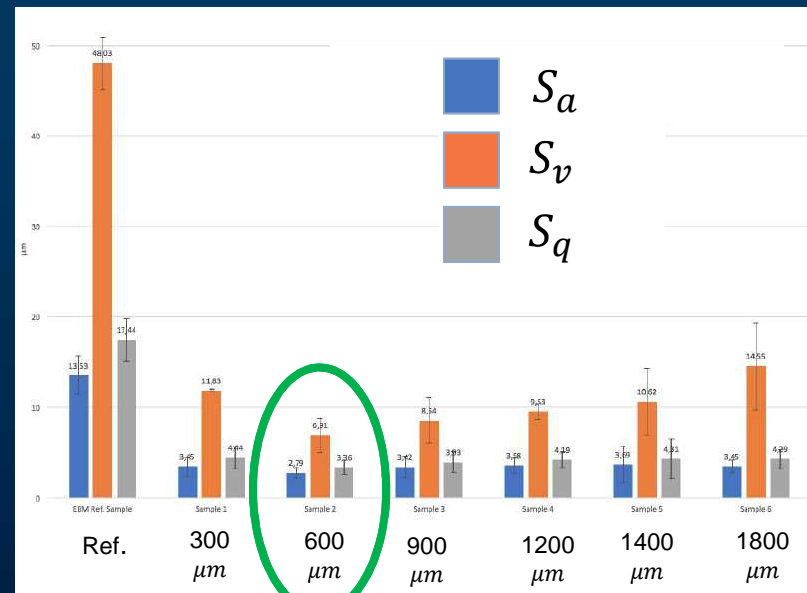
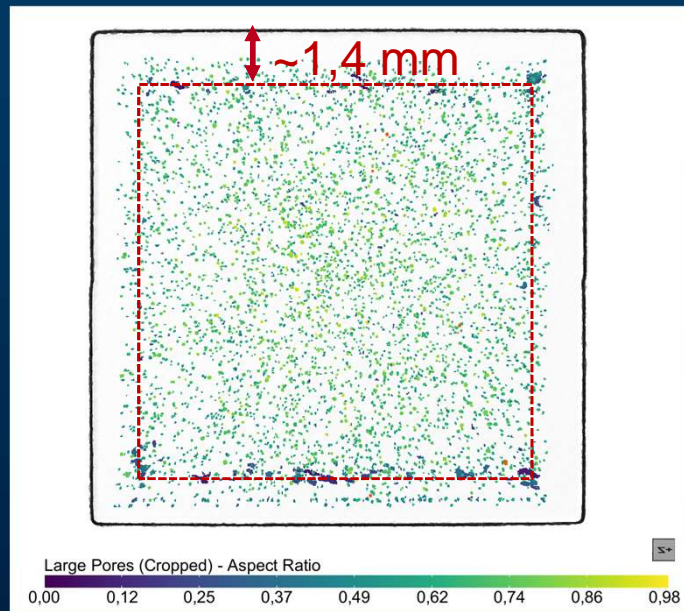
[1] S. Singamneni et. Al. *Additive Manufacturing for the Aircraft Industry: A Review*, J. Astrophys. Aerosp. Tech. 2019,8:1

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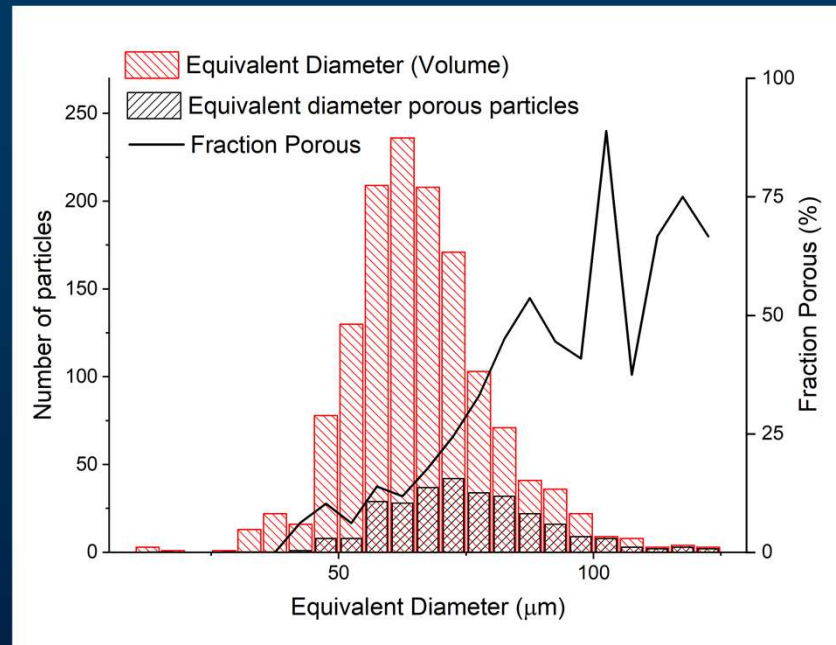
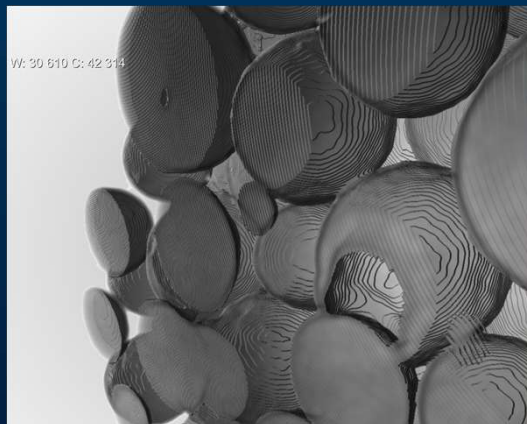
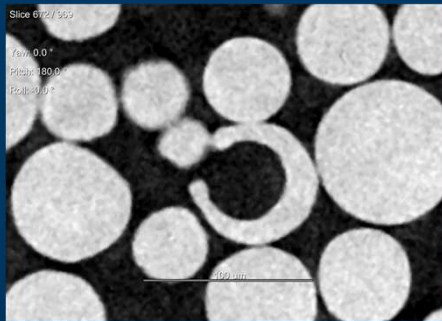
RECENT WORK: CHEMICAL MILLING



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RECENT WORK: POWDERS



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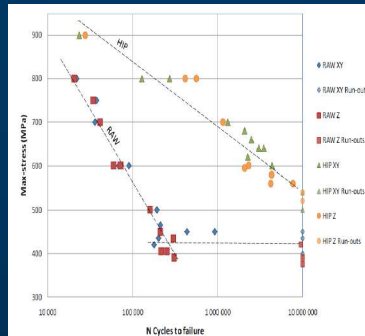
RECENT WORK: PRE-STUDY

- WP: 3-5
- Tools.
 - XCT
 - Pore analysis
 - Mechanical Testing.
 - Fracture analysis
 - Fracture modelling

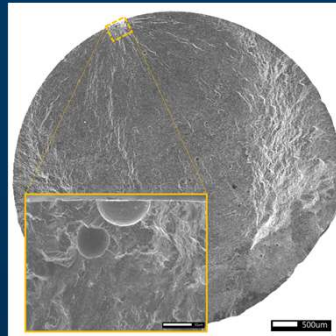
RECENT WORK: PRE-STUDY



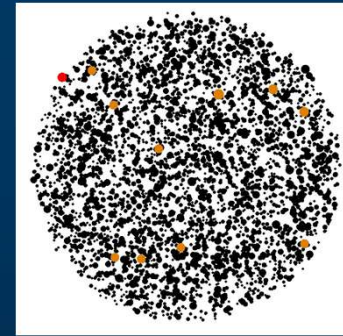
XCT-Analysis



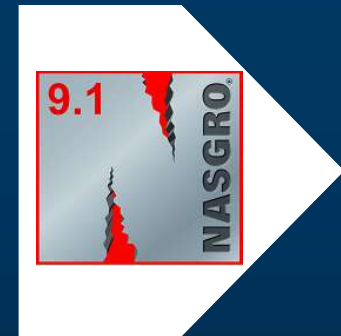
Fatigue testing



Fractography



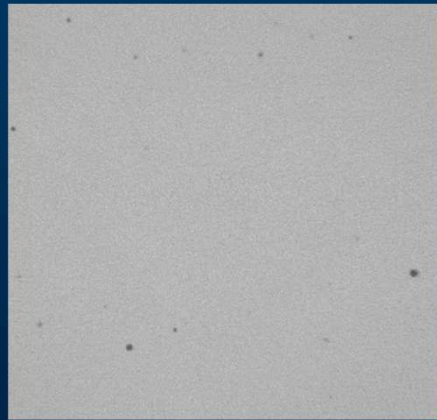
Correlation



Modelling

RECENT WORK: PRE STUDY

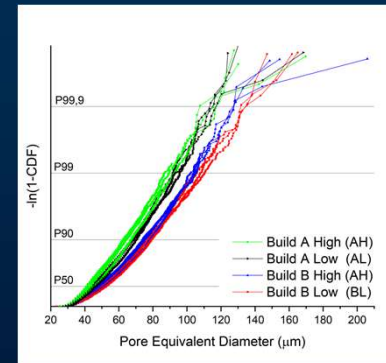
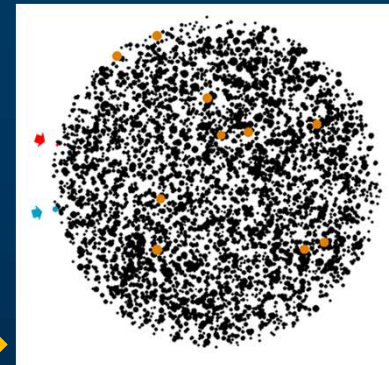
XCT Work Flow



Segmentation

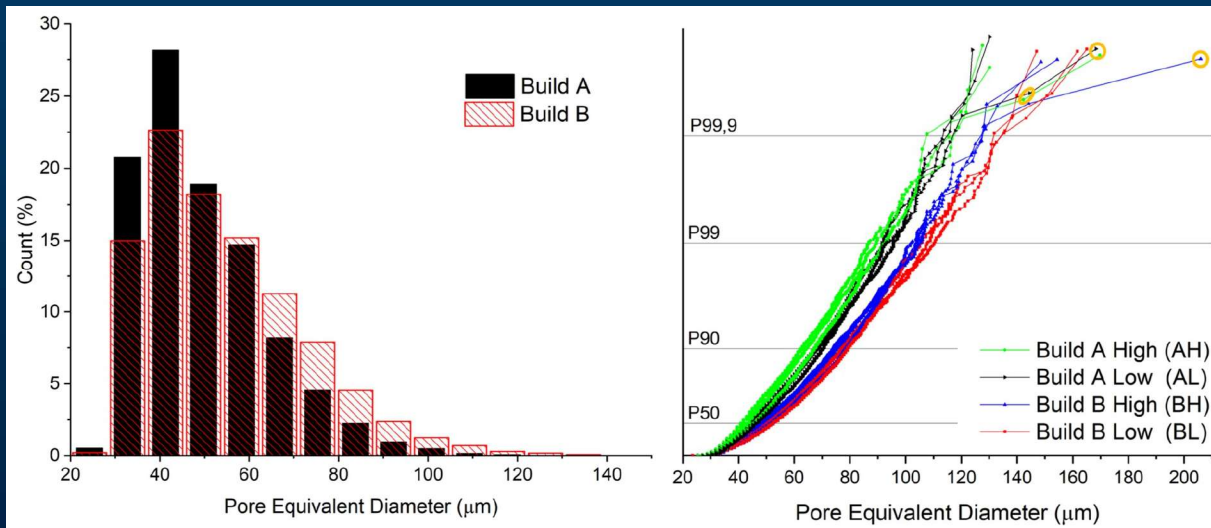


Analysis

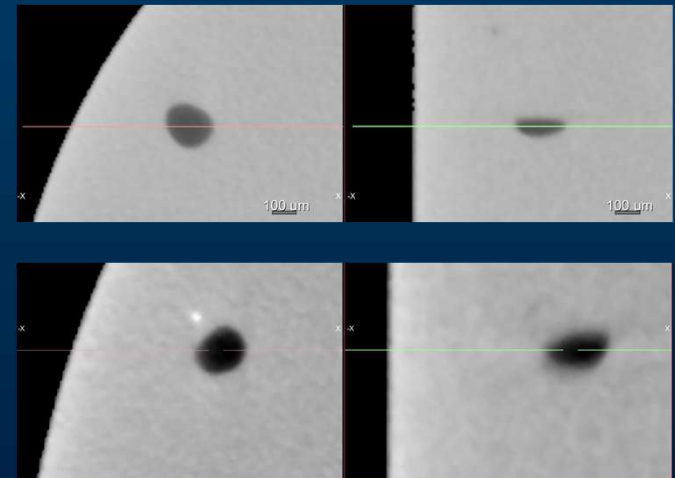


RECENT WORK: PRE-STUDY

Pore Distributions: Build & Position

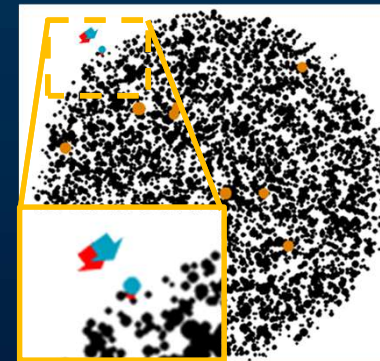
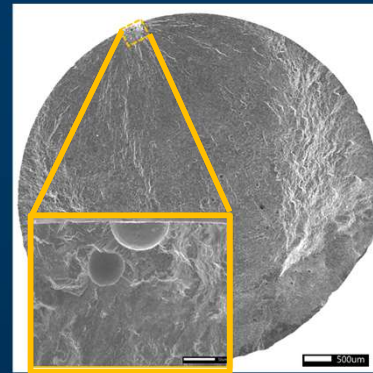
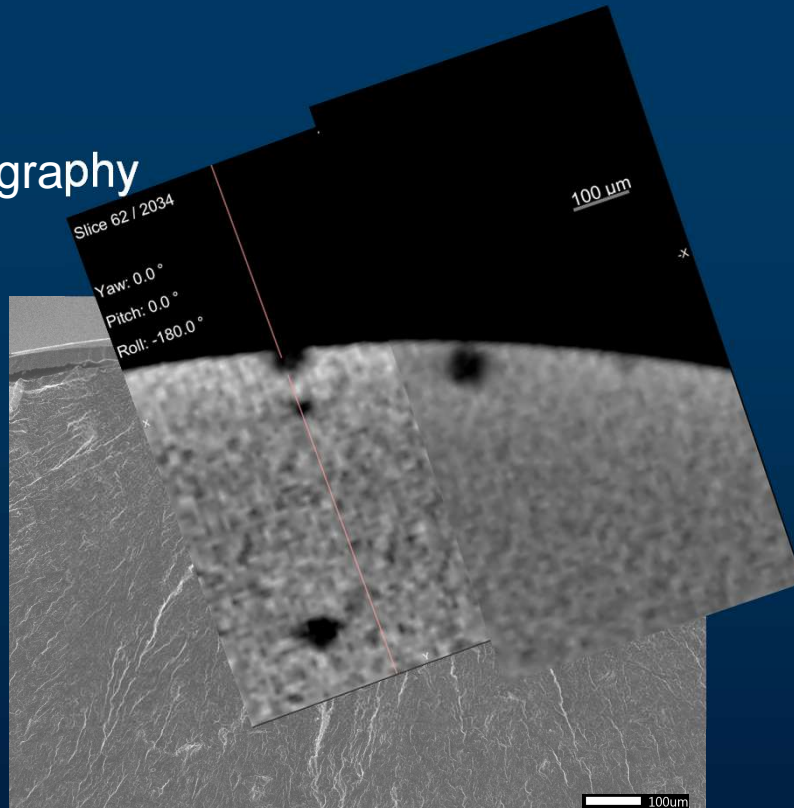


Outliers



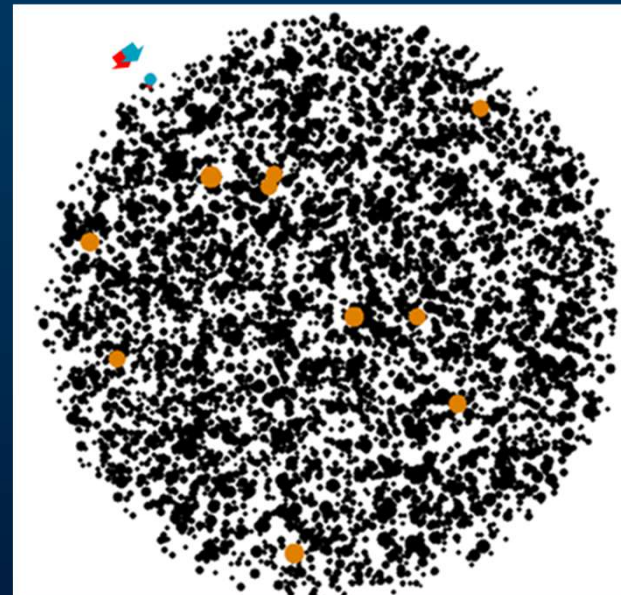
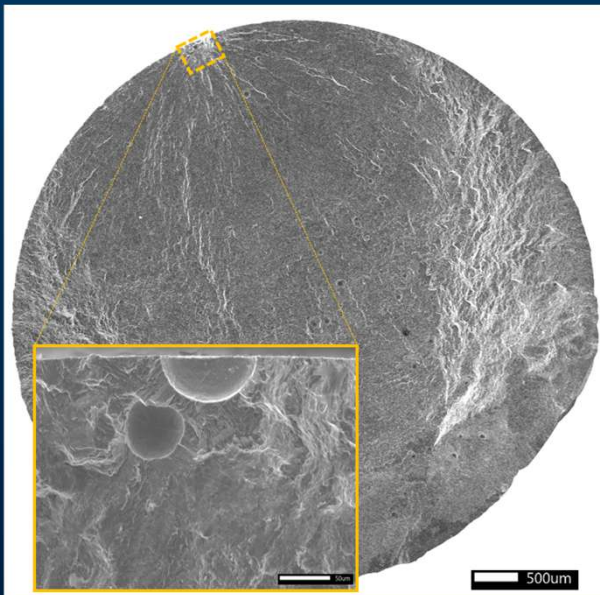
RECENT WORK: PRE-STUDY

Fractography



RECENT WORK: PRE-STUDY

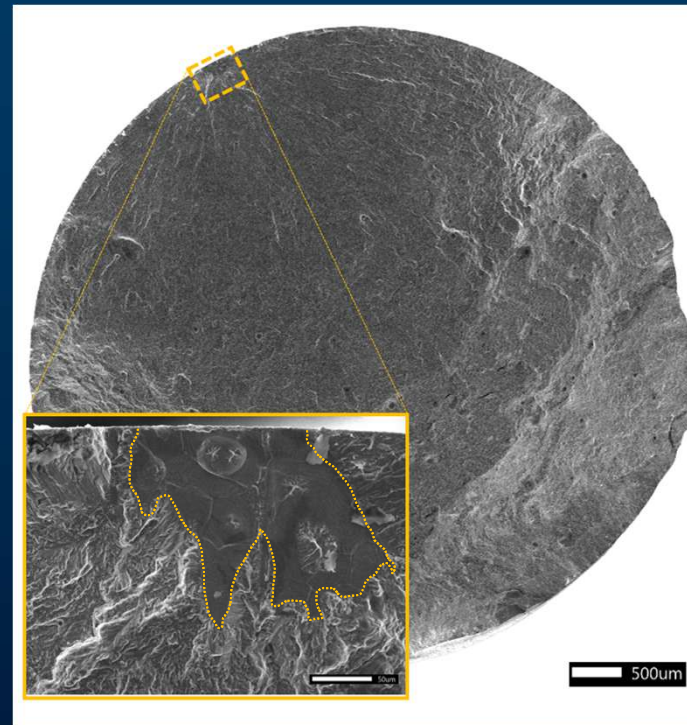
Fractography



RECENT WORK: PRE-STUDY

Fatigue testing

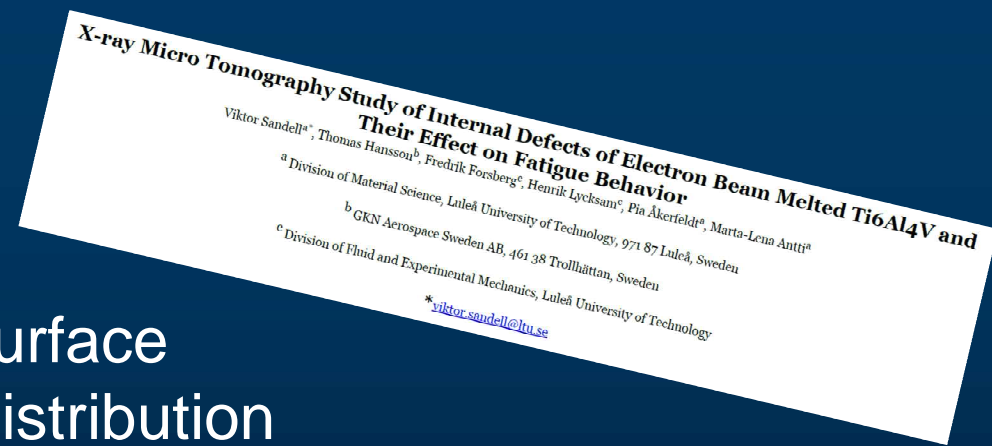
Specimen ID. No.	# Cycles
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A3BK35-2	15514
A3BK36-1	18672
A3BK36-2	16022
A3BK46-1	15642
A3BK46-2	16527
A3K35-1	18340
A3K35-2	12334
A3K36-1	18975
A3K36-2	20763
A3K46-1	18712
A3K46-2	19396



RECENT WORK: PRE-STUDY

Conclusions:

- Closeness to the surface
- Random in plane distribution
- Larger pores = Shorter life (on average, in this study)
- Statistical analysis
- XCT reliability?



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FUTURE WORK

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Defects

- Surfaces
- Pores & Inclusions
- (Microstructure)

Post Production Treatment

- Surface Treatments 1.
- Hot Isostatic Pressing 2.

WP2

WP3

WP4

WP4

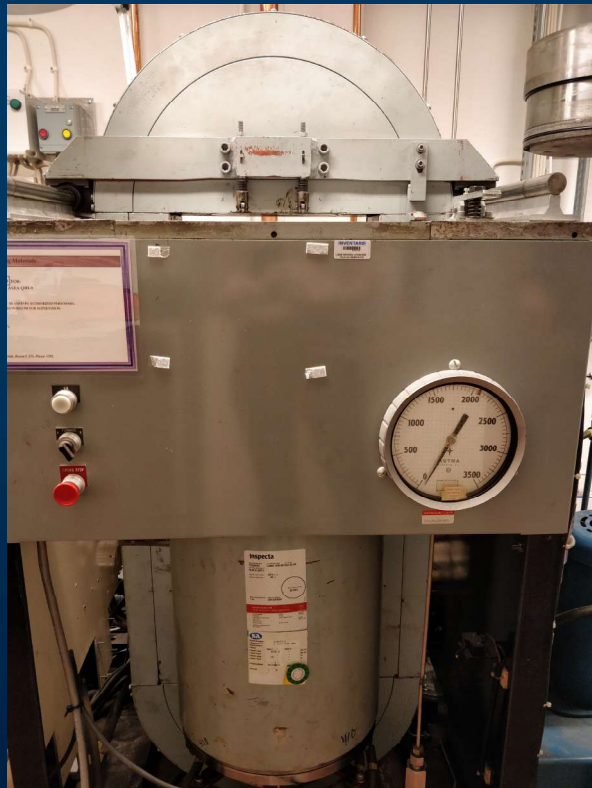
Fatigue Life

- Testing
- Defect based modelling

3.

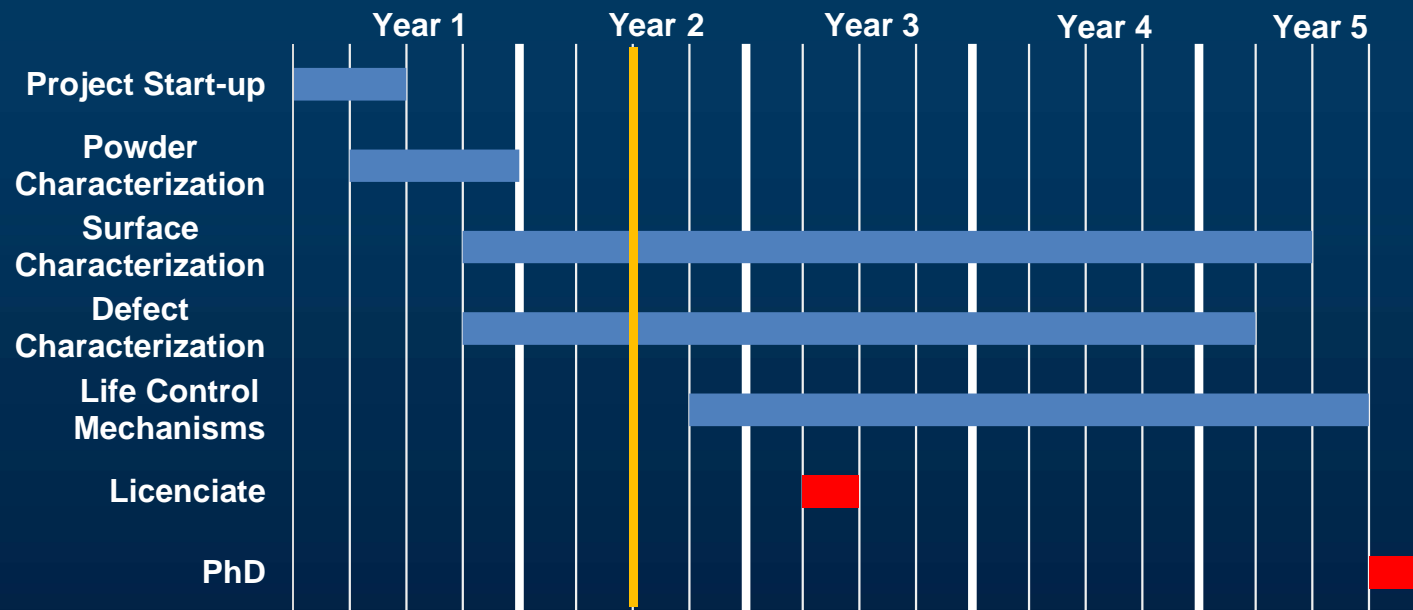
WP 2-5

FUTURE WORK: HIP & BENDING



PROJECT SUDDEN

Project Timeline



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