UNIVERSITÄT DUISBURG ESSEN
Open-Minded

Interlaboratory study

DFG Priority Programme
“Materials for Additive Manufacturing”
(SPP 2122)

TECHNICAL CHEMISTRY I
BARCIKOWSKI GROUP

CENIDE
CENTER FOR NANOINTEGRATION DUISBURG-ESSEN

DFG

MAT frame
SPP 2122 Materials for Additive Manufacturing

Interlaboratory Study (ILS) – Aims and Scope

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Aim

- Address the scientific question “How does nano-additivation affect polymer & metal PBF-LB processability and final part properties?”
- Quantify the interlaboratory variability in: densification, dimensional accuracy, microstructural and mechanical properties as well as virgin & used powder properties
- Peer-reviewed publication (of both, the pilot run and final run), seed data for AM materials database

Background & Scope

- Basis: priority program SPP2122 “materials for additive manufacturing” (www.uni-due.de/matframe)
- Participants: International institutions that run PBF-LB (at least 10 for polymer, 10 for metal)
- Coordination: 1 coordinator per laboratory, protocol needs to be signed by the coordinator
- Materials: PA12 and AlSi10Mg alloy (3 batch jobs: pure/nano-1/nano-2)
- In-depth analyzed powders will be provided to all participants
- Central analysis of as-built parts

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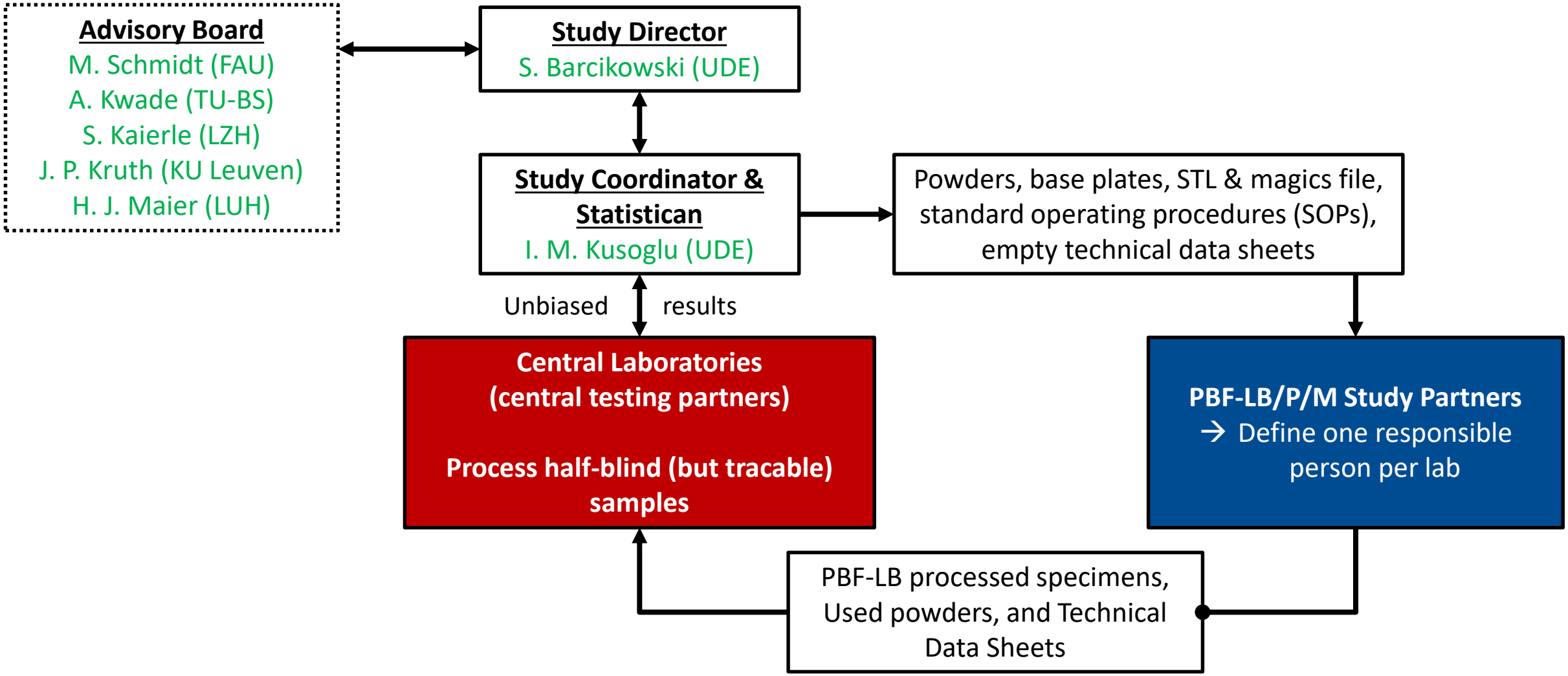
Nano-Additive Material Selection Criteria

To understand and document the influence of nano-additives on …

Micropowder	Nano-additive
PA12	Ag, Carbon Black
AlSi10Mg	SiC, TiC

- … material properties of powder feedstock
- … melting-resolidification (crystallization) kinetics
- … processability
- … microstructure
- … mechanical properties
- … densification
- … chemical composition

Organizational Chart

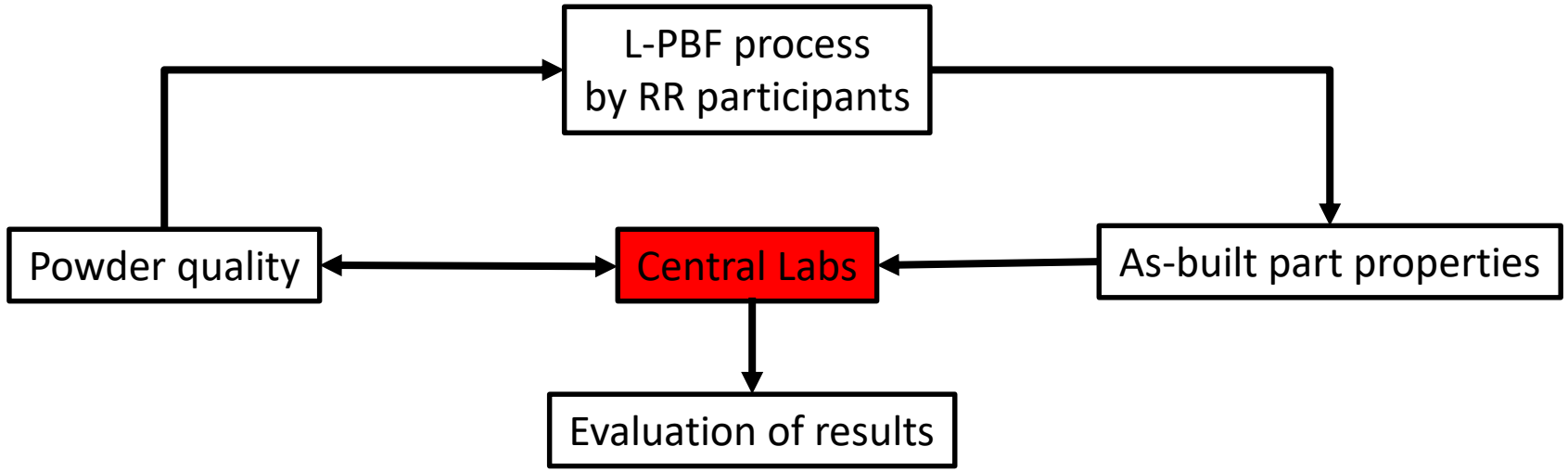


Questions to be answered within the ILS by evaluating the results of central laboratories

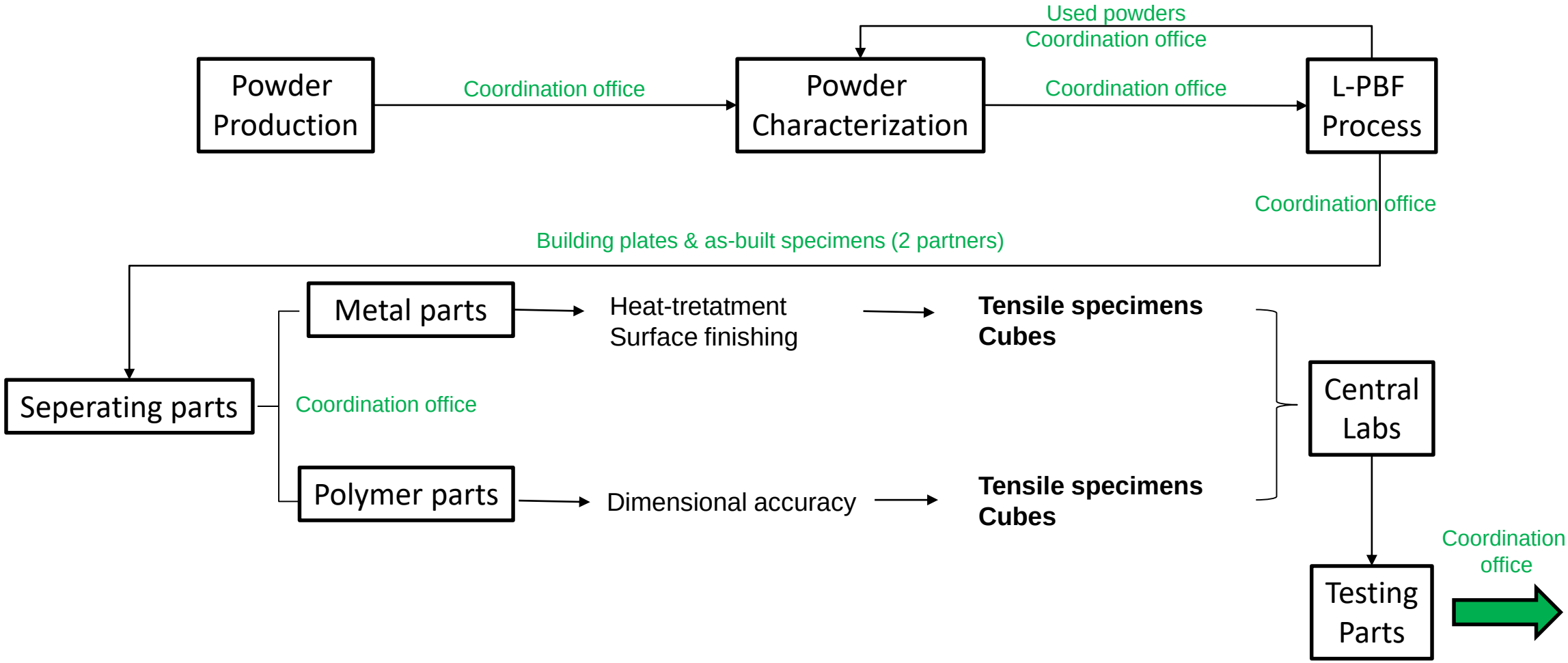
What is the effect of nanoparticles additivation on the powder properties of AlSi10Mg and PA12 powder feedstocks?

What is the effect of nanoparticles on chemical composition, relative density, volumetric pore size and distribution, microstructure, thermal properties, and mechanical properties of as-built parts?

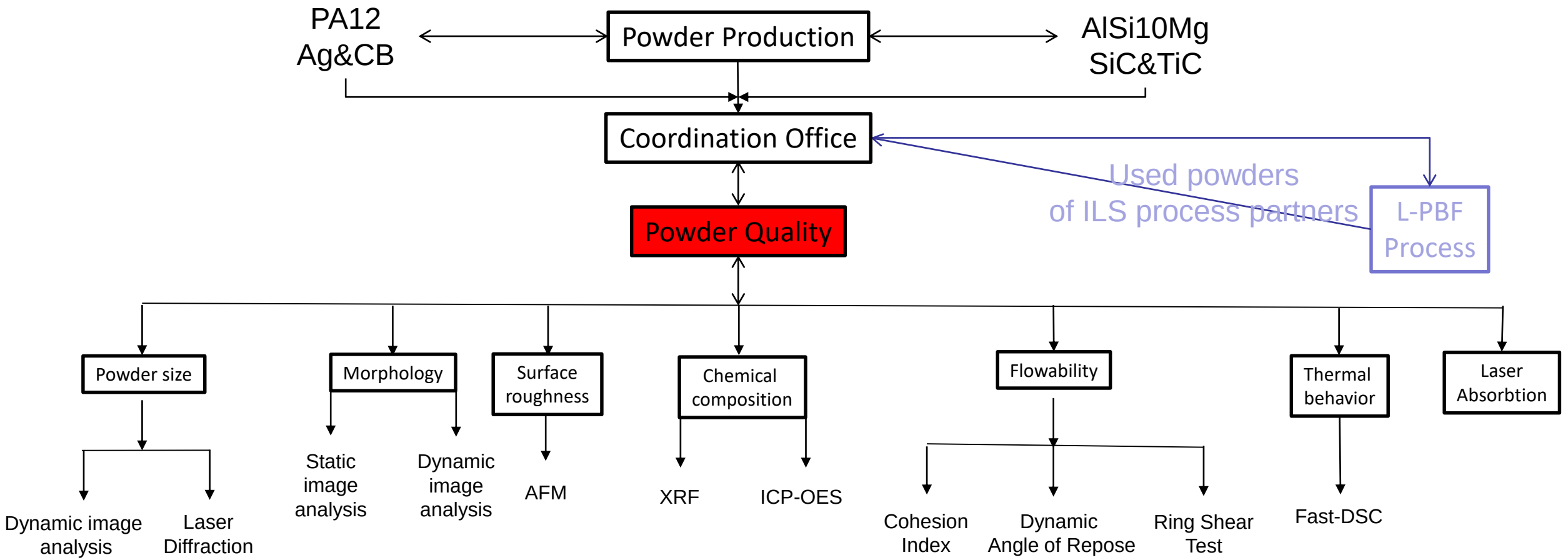
How is the statistical deviation of the results between the Interlaboratory Study participants?



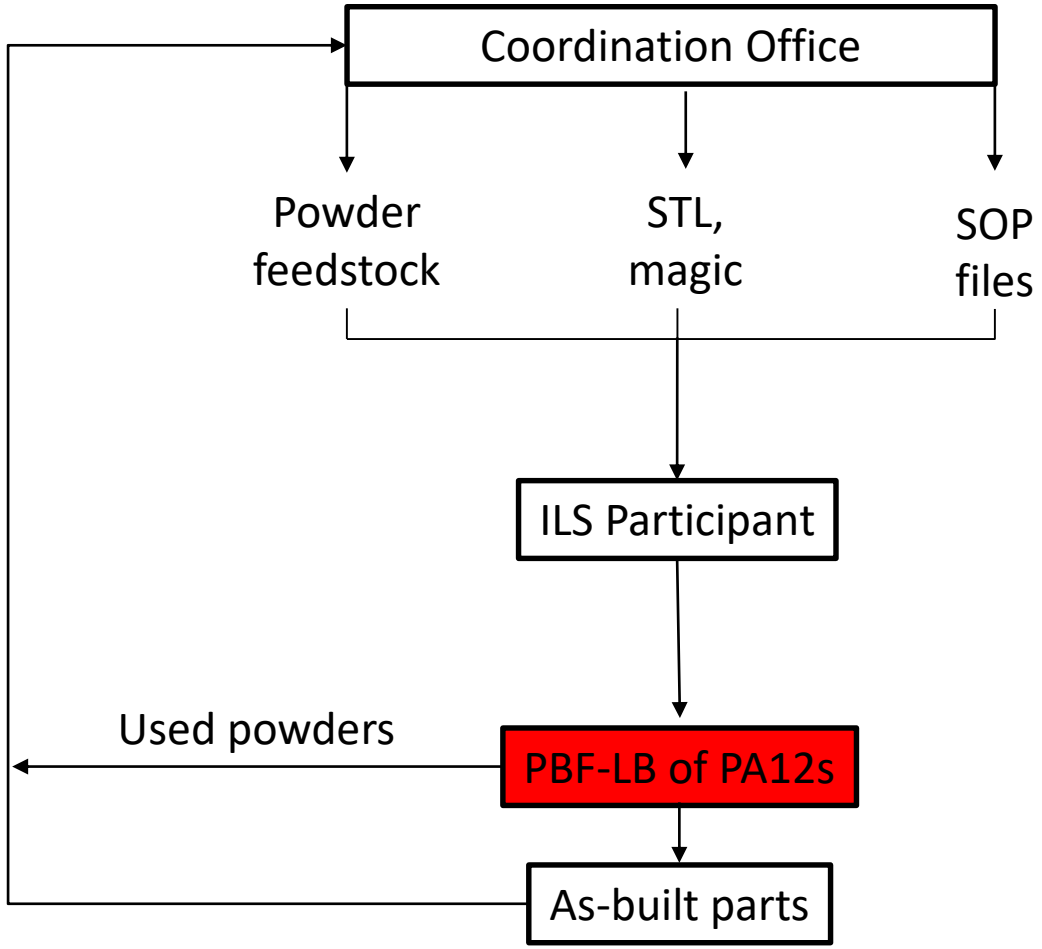
Workflow of ILS



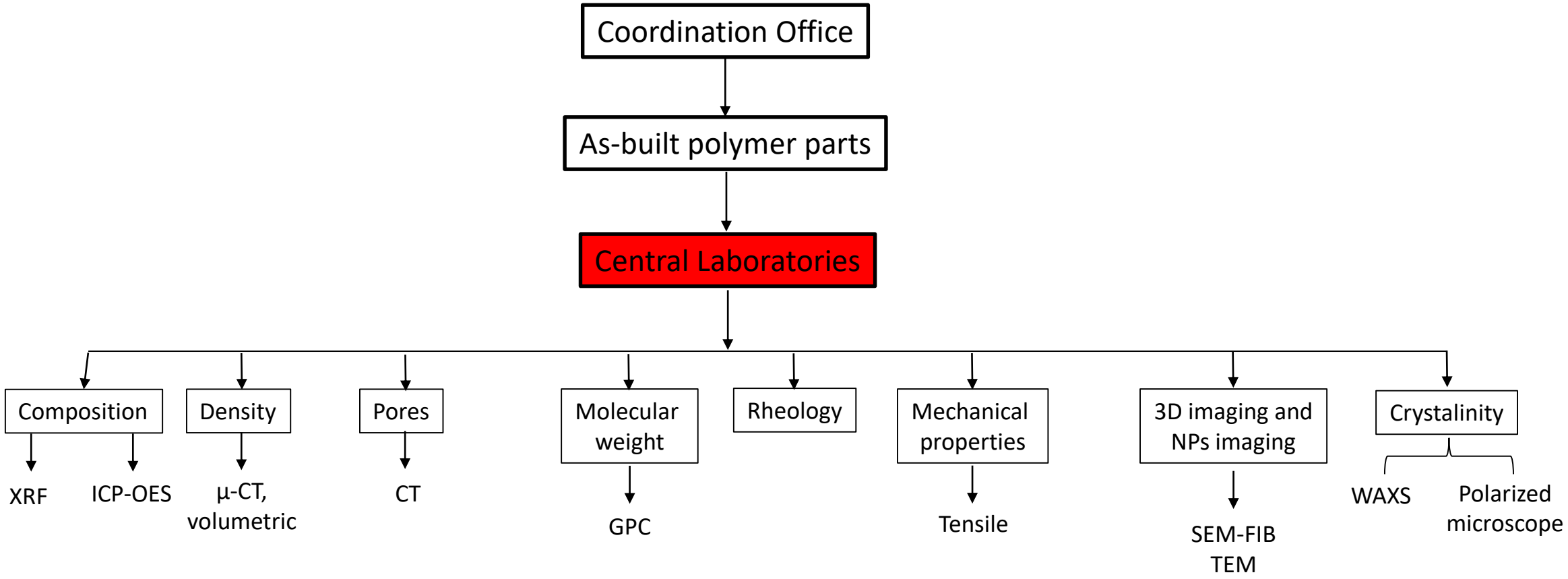
Workflow for powder production & characterization in ILS



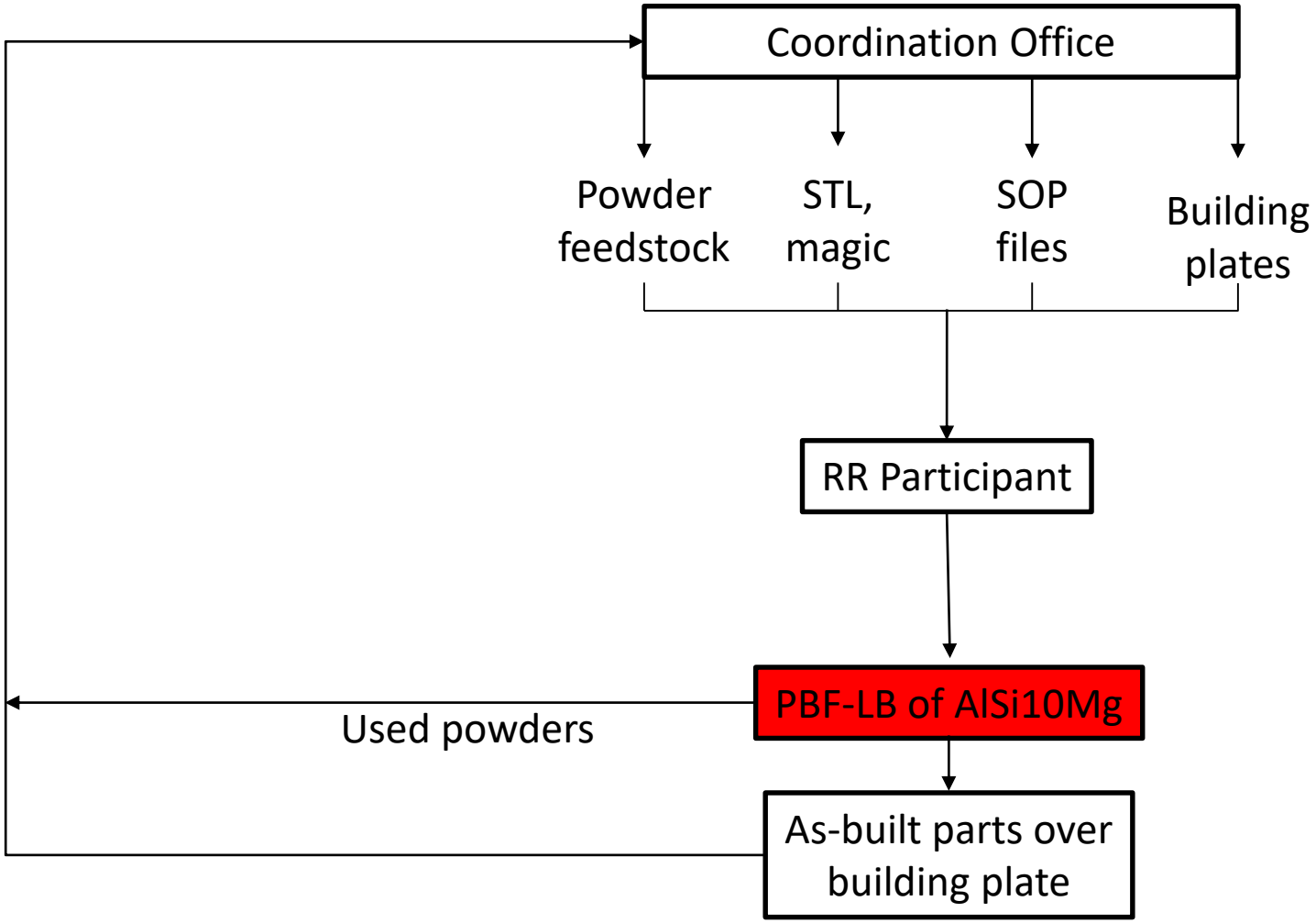
Workflow for L-PBF processing of PA12, Ag/PA12, and CB/PA12 powder feedstocks



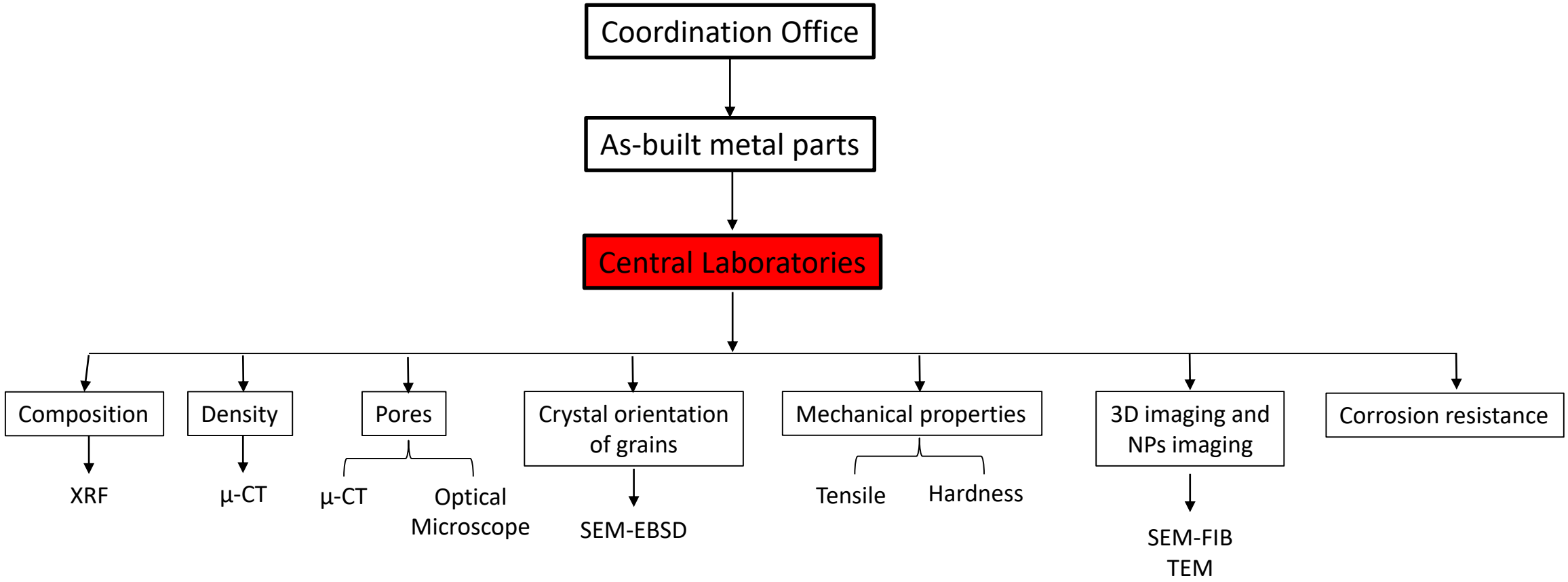
Workflow for testing as-built polymer parts



Workflow for L-PBF processing of AlSi10Mg, SiC/AlSi10Mg, and TiC/AlSi10Mg powder feedstocks



Workflow for testing as-built metal parts

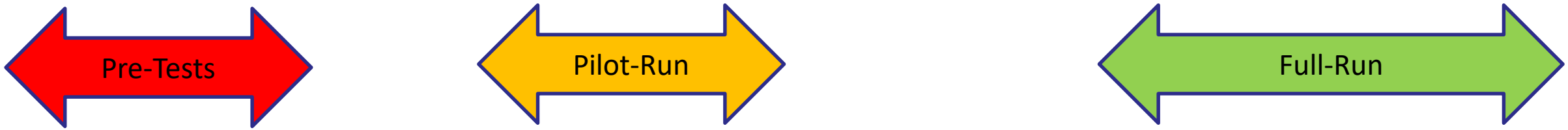


Time planning for Interlaboratory Study

First funding period of SPP2122

Second funding period of SPP2122

2020							2021											2022										
June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec



- ✓ Developing new powder feestocks for L-PBF
- ✓ Producing high amounts of NPs modified powder feedstocks for L-PBF
- ✓ Determine the quality of produced powders
- ✓ Define standard process parameters for interlaboratory Study
- ✓ SOPs for higher reproducibility and repeatability of the interlaboratory study

- ✓ Check workflow and sampleflow of interlaboratory Study chain
- ✓ Check central laboratories for testing as-built specimens
- ✓ Check processability of powders in different L-PBF machines
- ✓ Check SOPs for processing and testing parts
- ✓ Peer-reviewed publication from the results

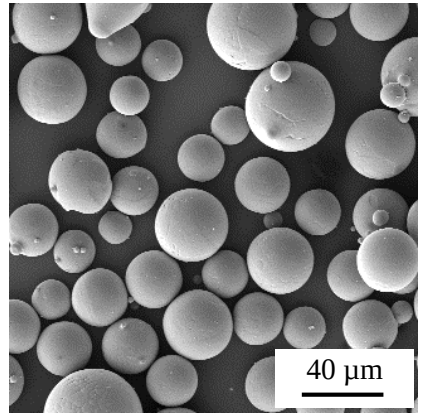
- ✓ Produce 100 kg of NPs additivated powder feedstocks for Interlaboratory Study
- ✓ At least 10 participants for L-PBF of metal powders
- ✓ At least 10 participants for L-PBF of polymer powders
- ✓ Quantify the inter-laboratory variability in: densification, geometric tolerance,
- ✓ microstructure and mechanical properties as well as virgin & used powder properties
- ✓ Peer-reviewed publication, seed data for AM materials database

Final team of the Full-Run ILS will be determined from participants of the second funding period

Powder Quality Assurance

Detailed powder properties:

- Particle shape distribution (size dependent aspect ratio)
- Particle size distribution (Q_x, d10, d50, d90)
- Hausner Ratio
- Avalanche Angle
- Ring shear test and/or Freeman Powder Rehometer
- Chemical Composition incl. Oxygen, Humidity



→ Two samples per powder material: Used (powder bed) and virgin (stored) powder; aliquots of every laboratory

→ Standard operating procedure (SOP) for handling, sampling, and storage provided

→ Powders in sufficient quantity provided

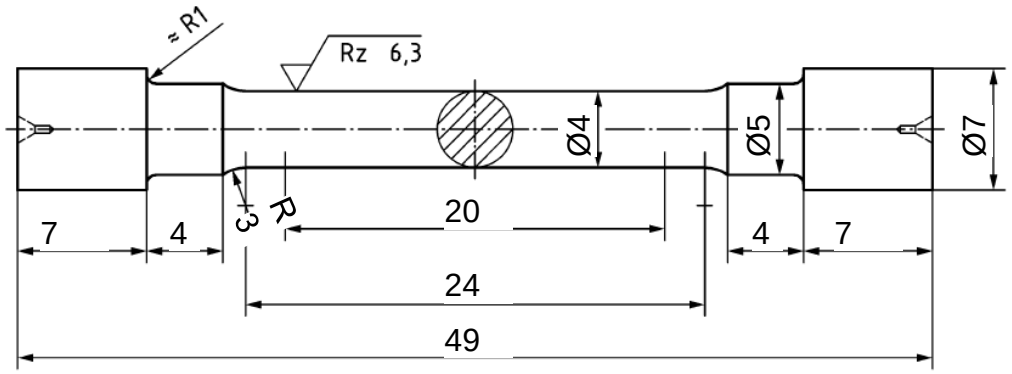
Build jobs

- **Each partner defines one responsible contact person**
- **Magics-files (.stl respectively) provide by Coordinator / LPT**
- **One buildjob per powder material; tensile bars (3 orientations) and cubes**
  - Required powder bed dimension PBF-LB/M: min 200 x 200 x 73 mm³
  - Required powder bed dimension PBF-LB/P: min 200 x 75 x 62 mm³
- **Each participant will follow SPP2122-provided standard operating procedures (SOP)**
- **3 materials (blend, 2 types nanocomp.) for each metal & polymer feedstocks**

Build job for PBF-LB of Polymer parts

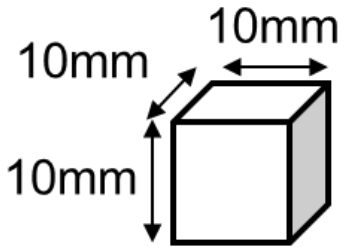
Each build job yields:

10 tensile specimens (0°)
10 tensile specimens (45°)
10 tensile specimens (90°)
7 cubes
3 cylinders
3 disks



Tensile specimen, DIN 50125:2016-12 Form C

Minimum build area : 200 mm x 75 mm
Total height of build volume: 62 mm
(49 mm height of tensile bars, 10 mm base and 3 mm top powder layer)



Cubes

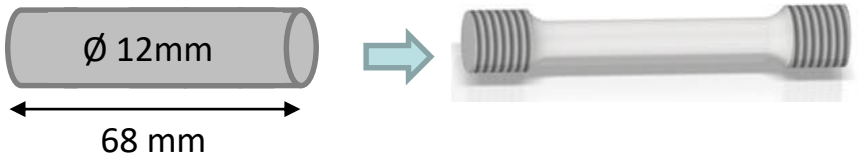
Build job for PBF-LB of Metal Parts

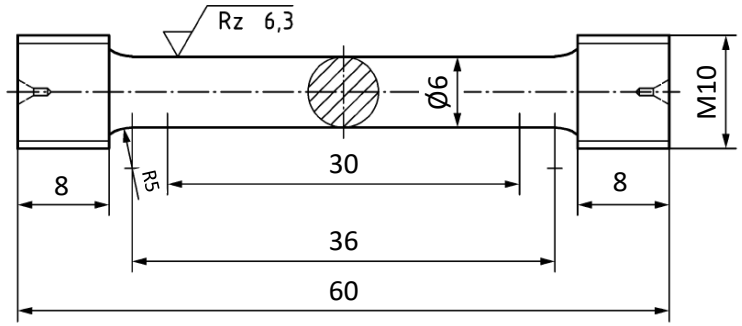
Each build job yields:

9 bars (0°)
9 bars (45°)
9 bars (90°)
12 cubes
3 cylinders

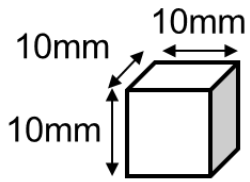
Minimum build area : 200 mm x 200 mm
Total height of build volume: 73 mm
68 mm height of tensile specimen
5 mm support structures

As-built bars will be machined to tensile specimens





Tensile specimen, DIN 50125:2016-12 Form B



Cubes

Thank you for your interest on ILS of SPP2122

For further information please read white paper of the ILS concept
Materials 2021, 14(17), 4892; https://doi.org/10.3390/ma14174892

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