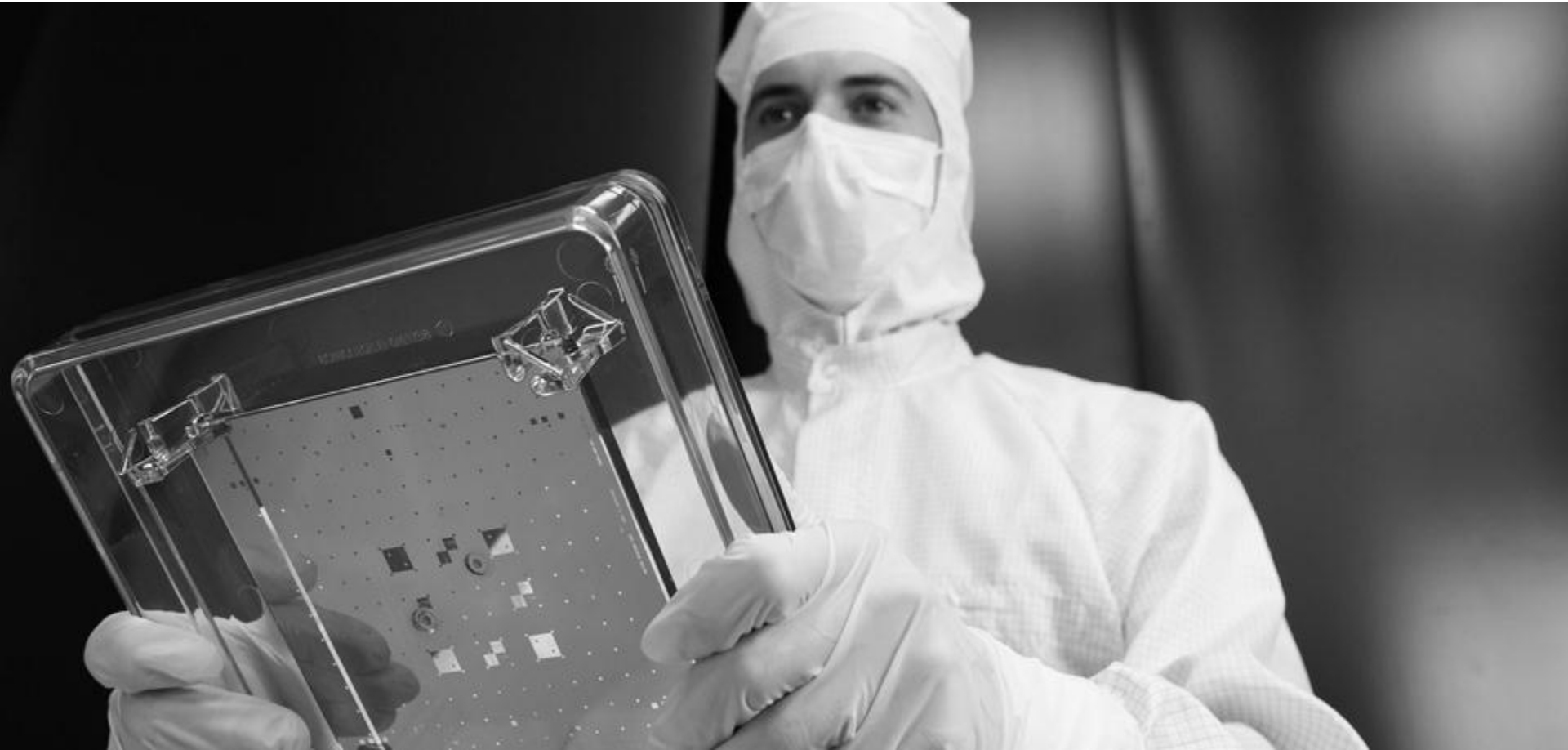


# Light Sources for EUV Mask Metrology



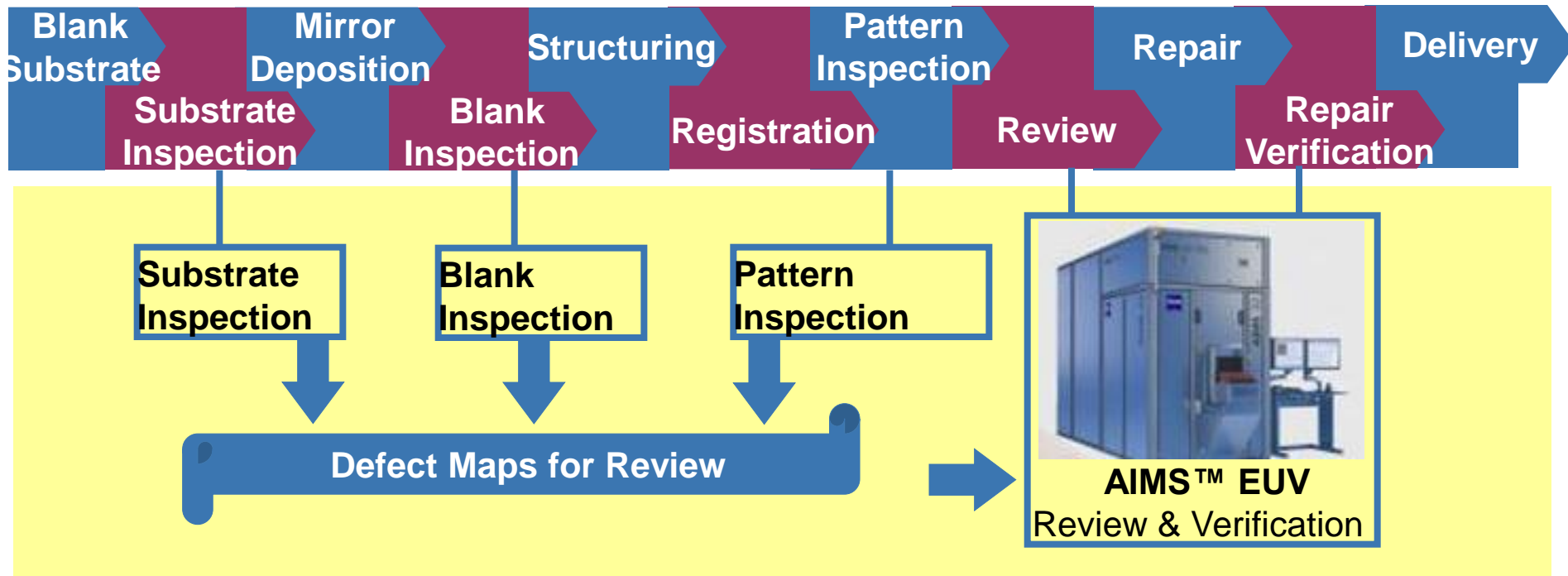
**Heiko Feldmann, Ulrich Müller**

Dublin, October 9, 2012

- 1 Actinic Metrology in Mask Making
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- 3 Metrology Performance Drivers and their Relation to the Source
- 4 Overview: Top Level Criteria for the Next Generation AIMS EUV Source

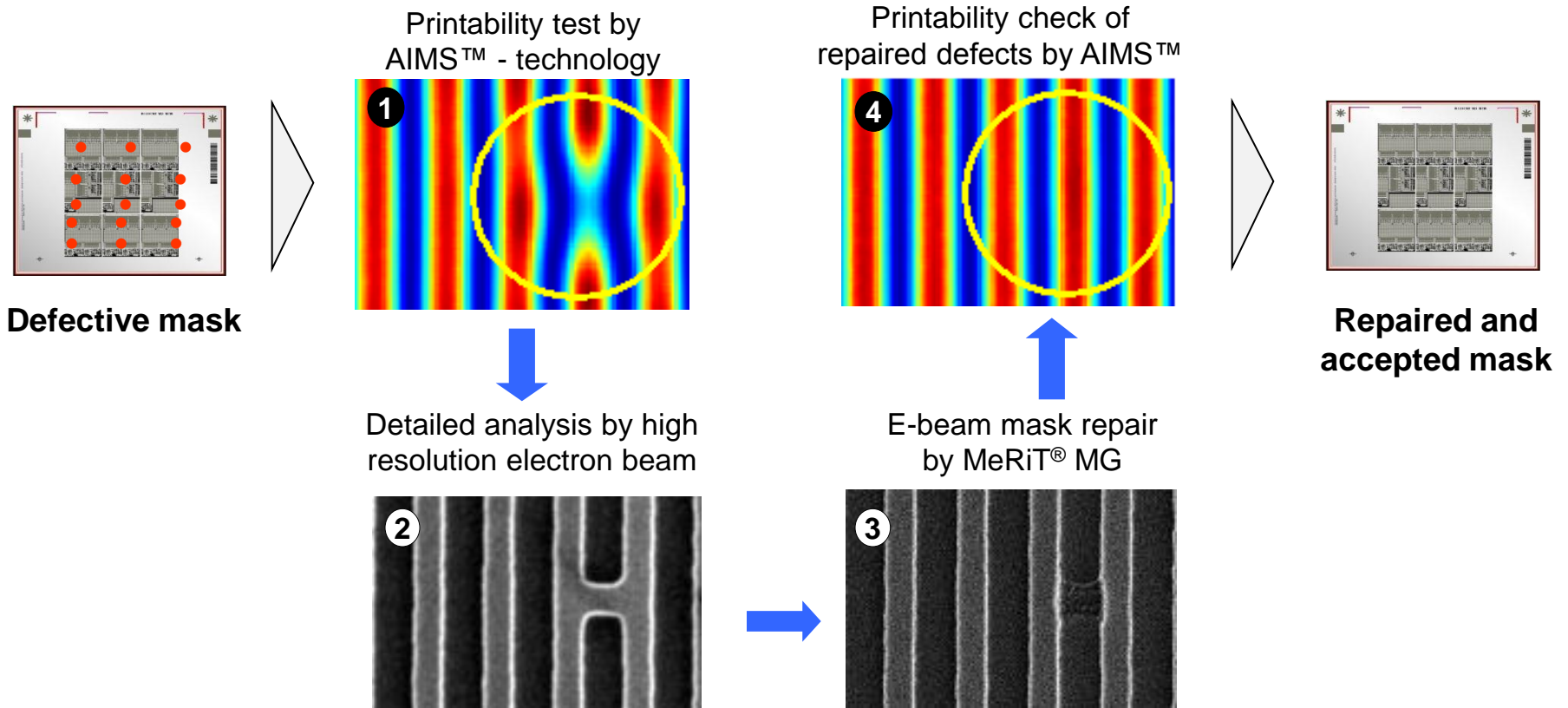
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# Metrology for EUV Mask Manufacturing

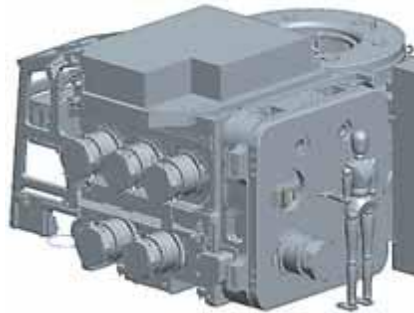
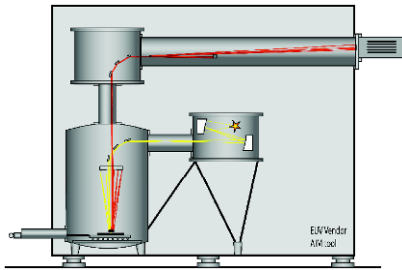


Actinic Metrology is required to predict printing behaviour of hot spots in the mask pattern

# The AIMS™ in the mask manufacturing process: It is required for producing defect free masks



# Schedule to EUV mask defect printability review established: AIMS™ EUV development program started



Ideas and concepts

Detailed design

Delivery



AIMS™ EUV  
C&F study

39 months of main development project

SEMATECH TWG:  
AIMS™ EUV ultimately  
needed for high  
volume EUVL

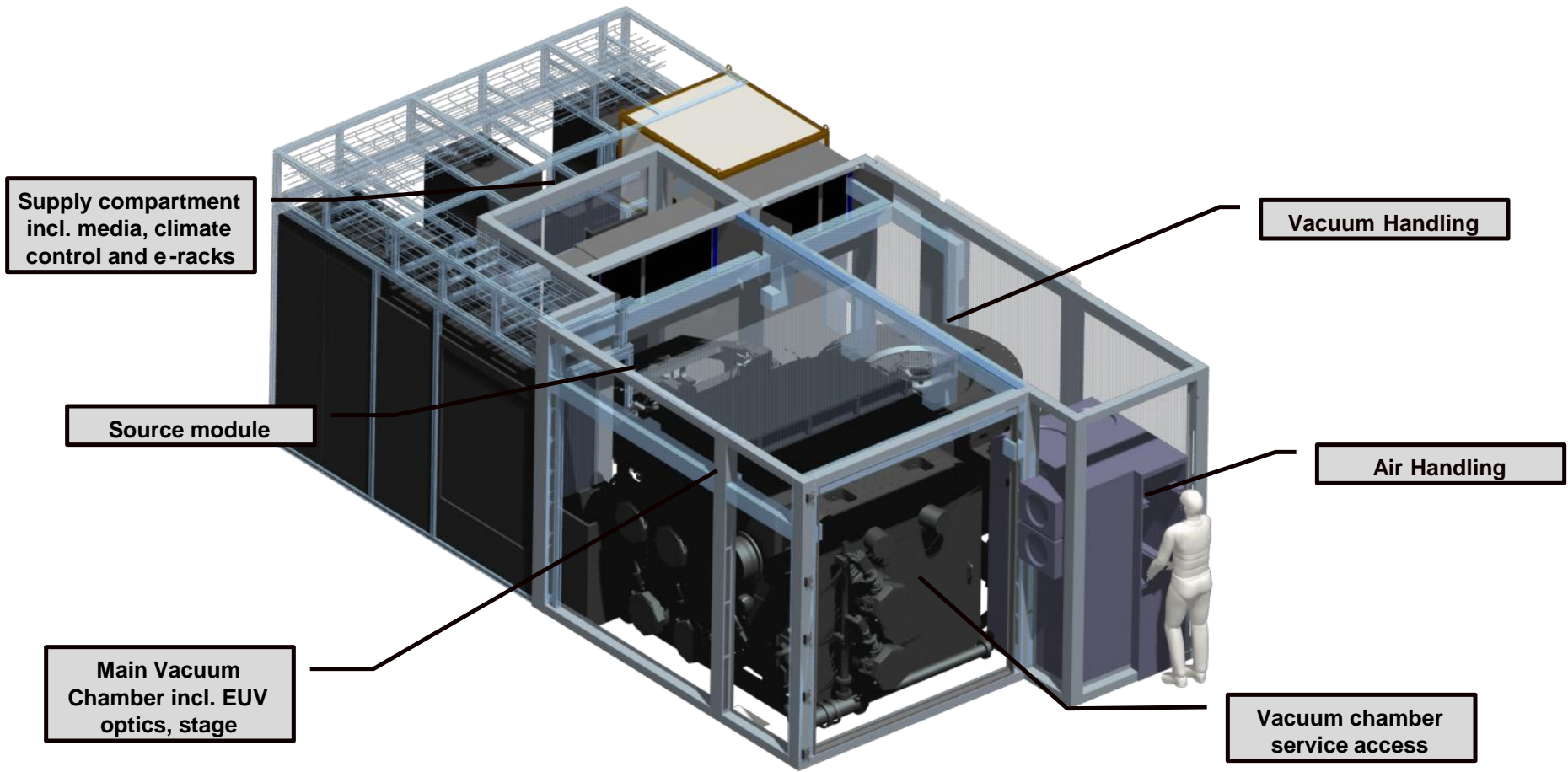
AIMS™ EUV  
Development Start

First AIMS™ EUV  
Delivery

Carl Zeiss SMT is currently building a first generation AIMS tool supporting the 16nm node. For the 11nm node, an extension will be required.

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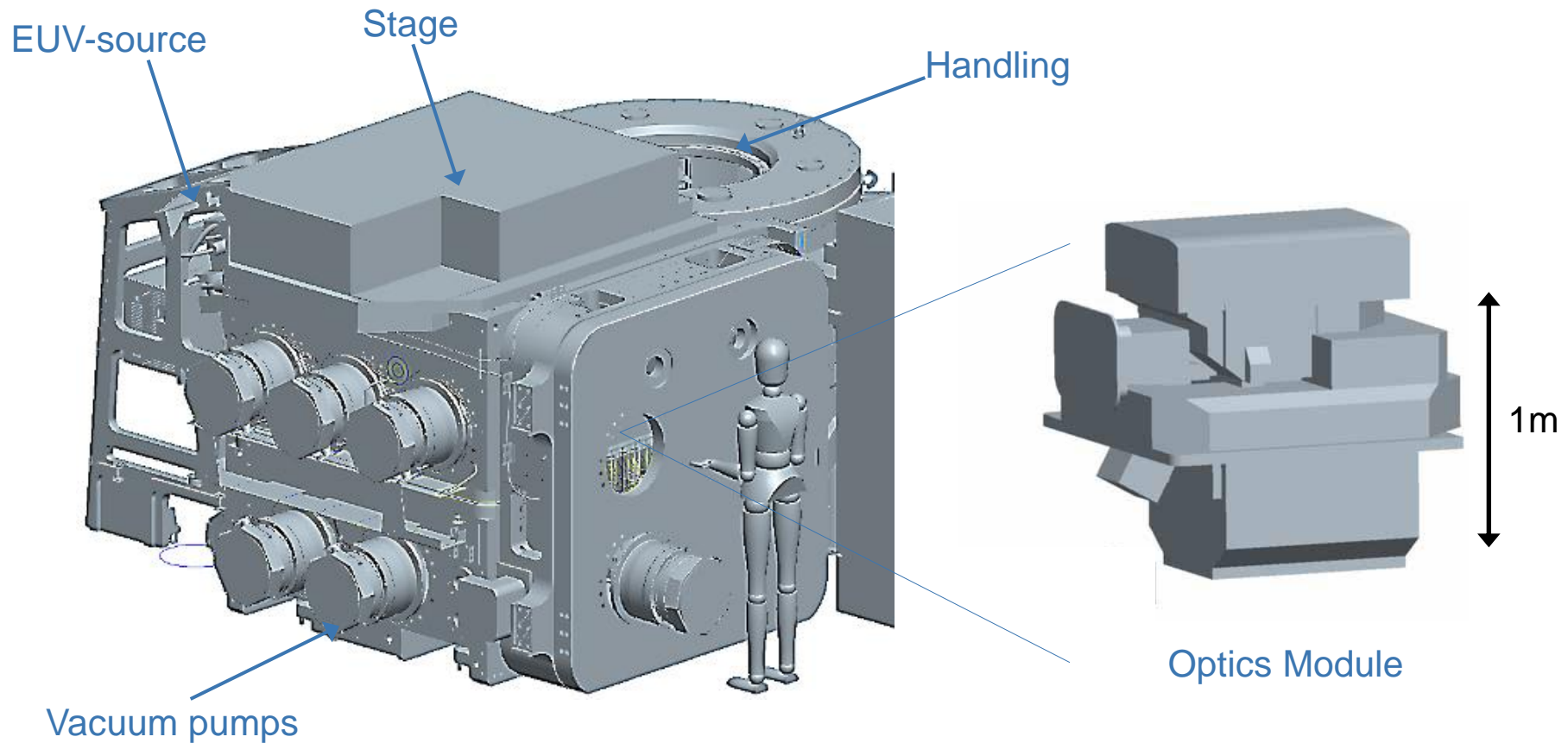
# Preliminary layout of the AIMS™ EUV



1

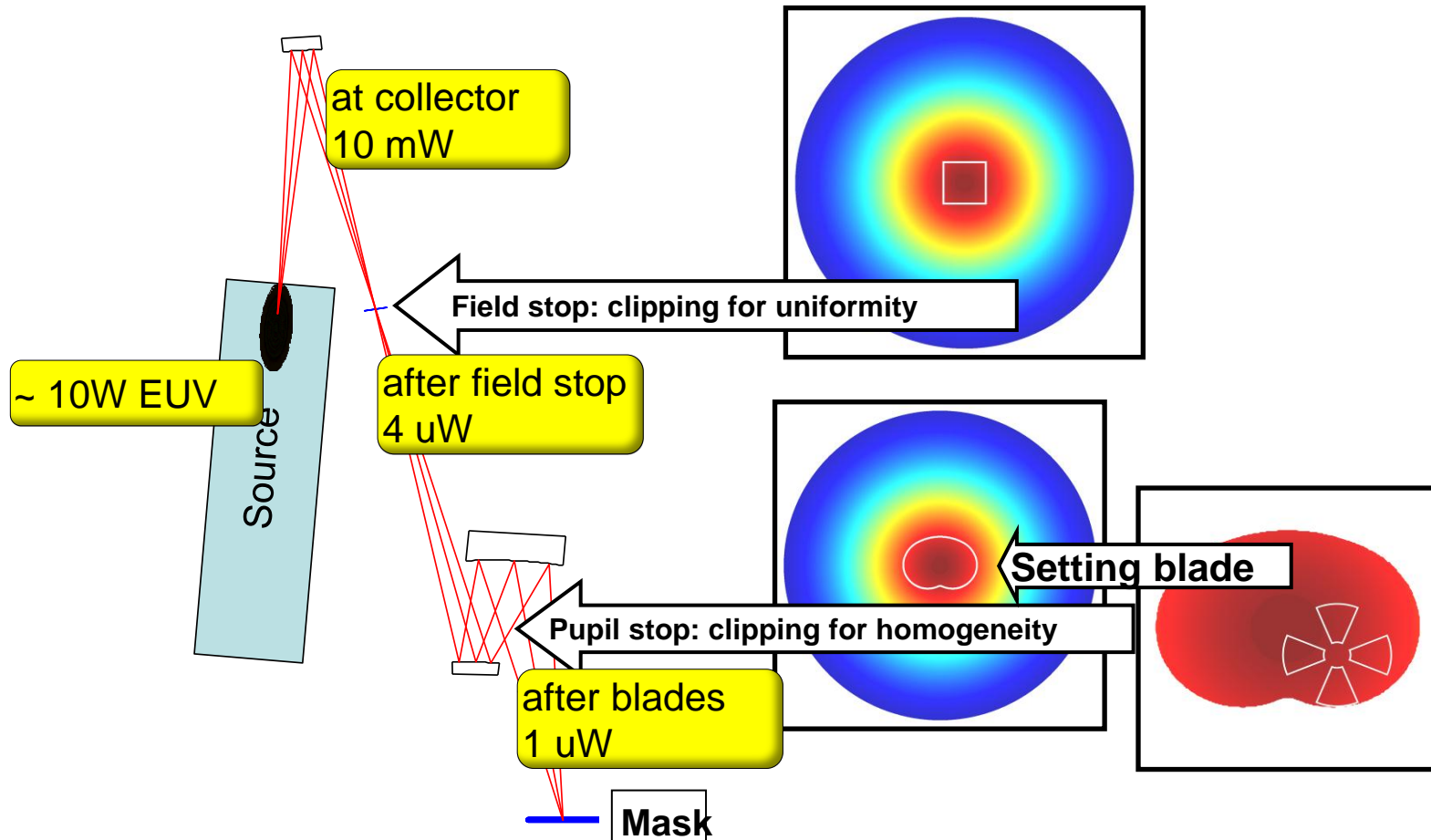


# AIMS™ EUV design phase ongoing: Preliminary layout Metrology Core



# The Illumination Concept

## Source Brightness is important



Most of the EUV radiation is lost due to geometrical clipping.  
To maximize the photon count within the limited etendue,  
Brightness is more important than source power!

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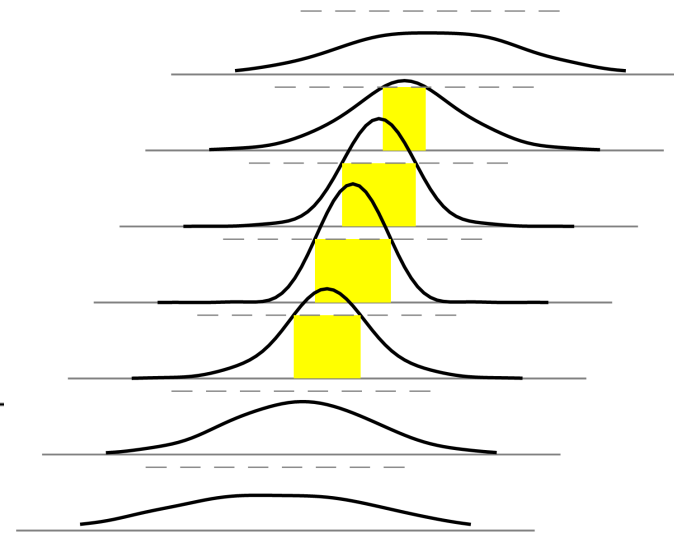
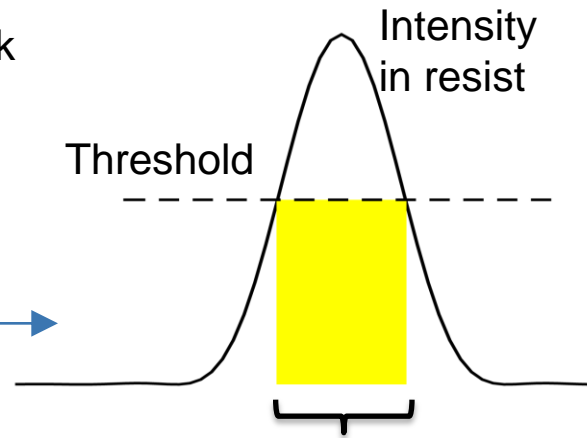
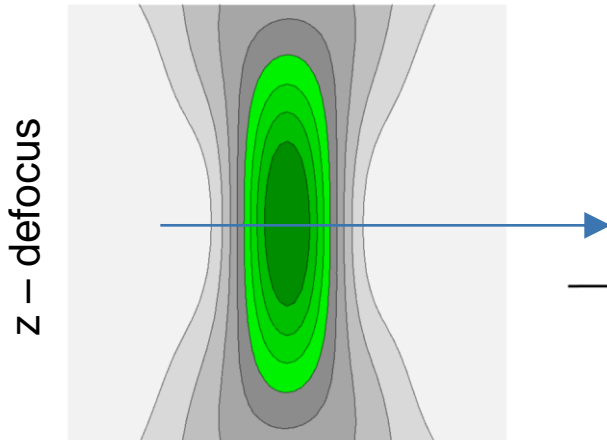
# AIMS

## Aerial Image Metrology System



### Aerial image

3D intensity distribution  
as generated by the mask



x,y - across the wafer

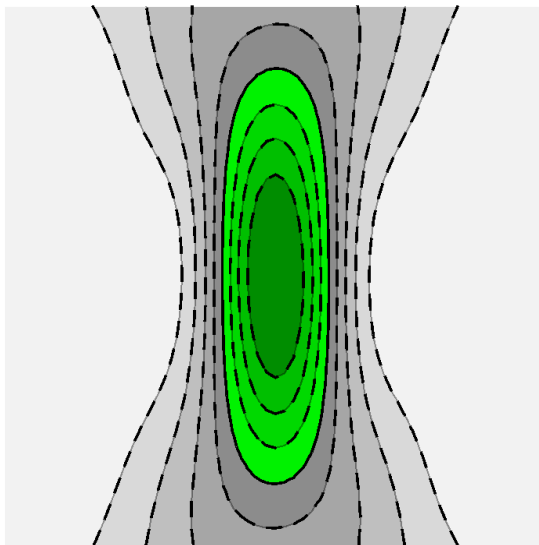
CD - critical dimension  
10-20nm

Measurement  
through focus

The 3D aerial image measured by AIMS is influenced by

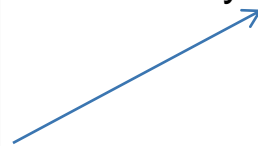
- Illumination distribution
- Mask structures (and possible defects)
- NA of the projection optics

# Measurement Accuracy Drivers: Image Stability

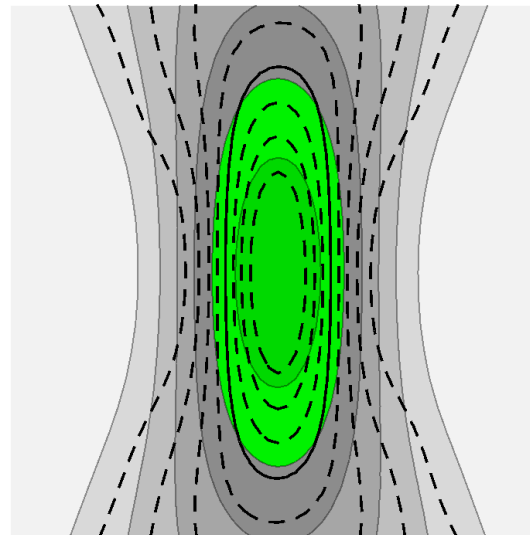
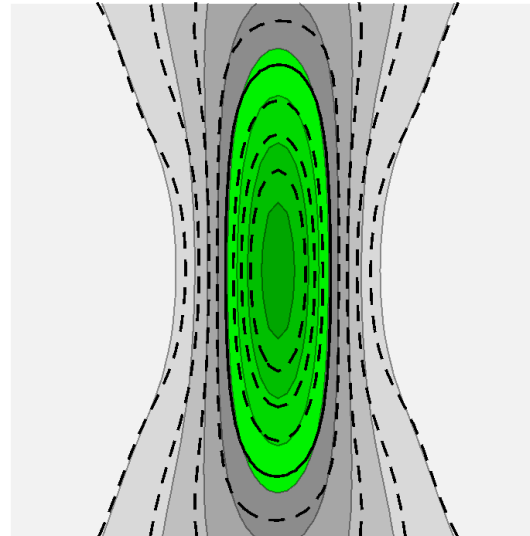
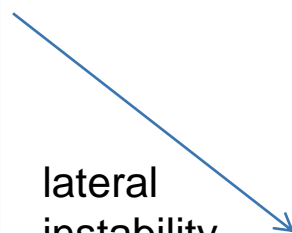


unaberrated image

focus  
instability



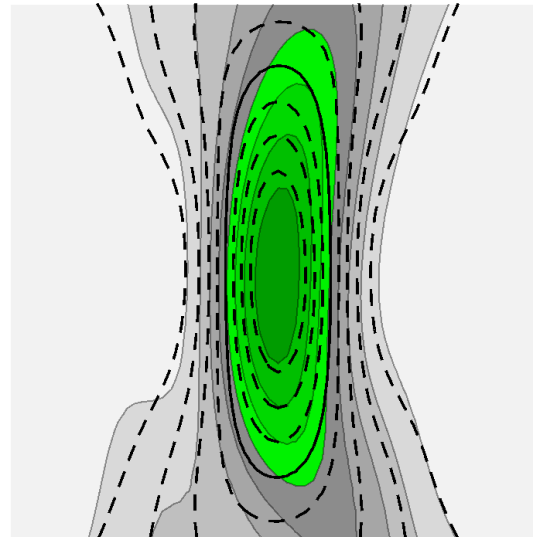
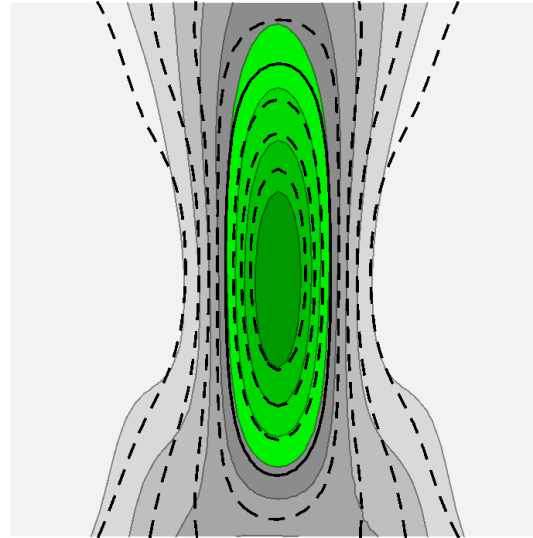
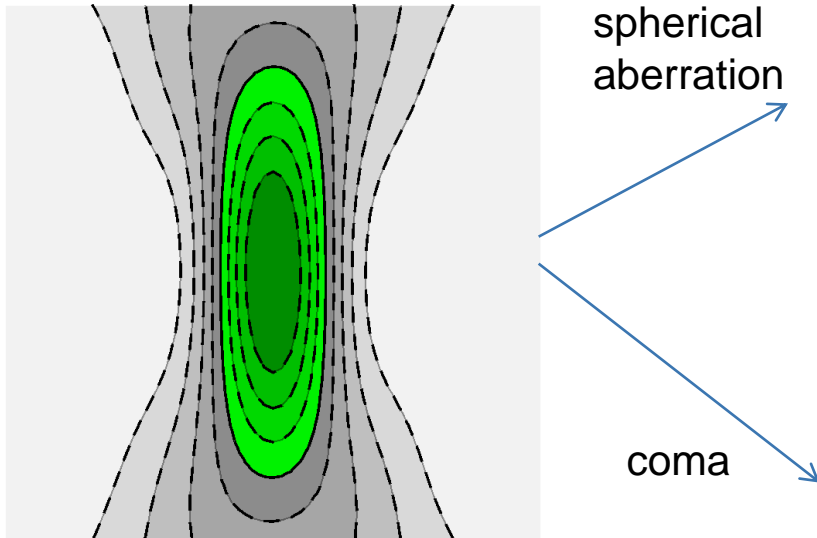
lateral  
instability



The aerial image  
and the mask  
must be stabilized  
in the nm range.

This requirement  
drives a large  
effort in mechatronics  
layout of the  
metrology core.

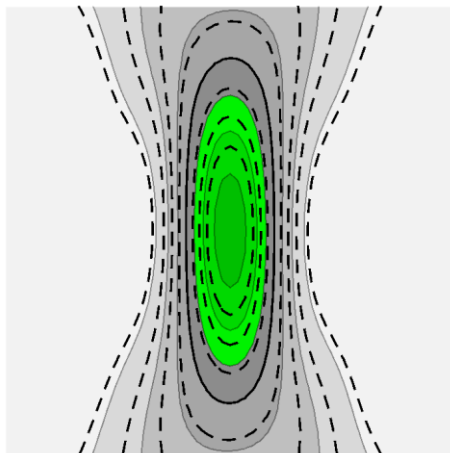
# Measurement Accuracy Drivers: Aberrations



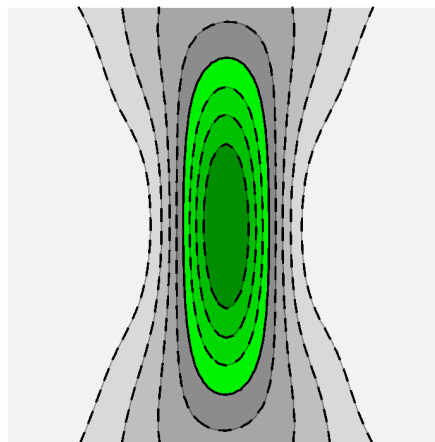
Aberrations must be at the same sub-nm level as for lithography scanner optics.

This drives efforts in optics design and manufacturing.

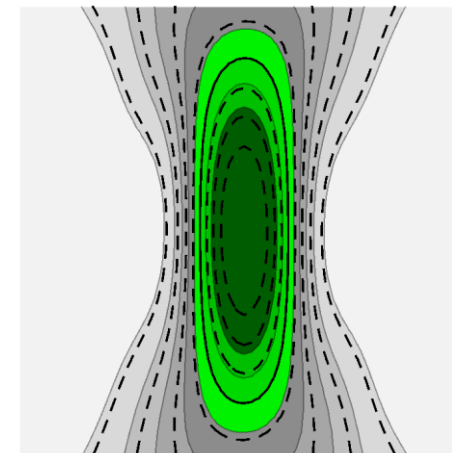
# Measurement Accuracy Drivers: Dose Control



low dose



target dose



high dose

Dose is a critical parameter for CD measurement.  
Defocussed measurements are much more critical than at the best focus positions.

Dose control drives most of the source requirements:

- Power stability
- Homogeneity
- Position and shape stability (see following slide)

# AIMS™ EUV Design: Metrology Source stability



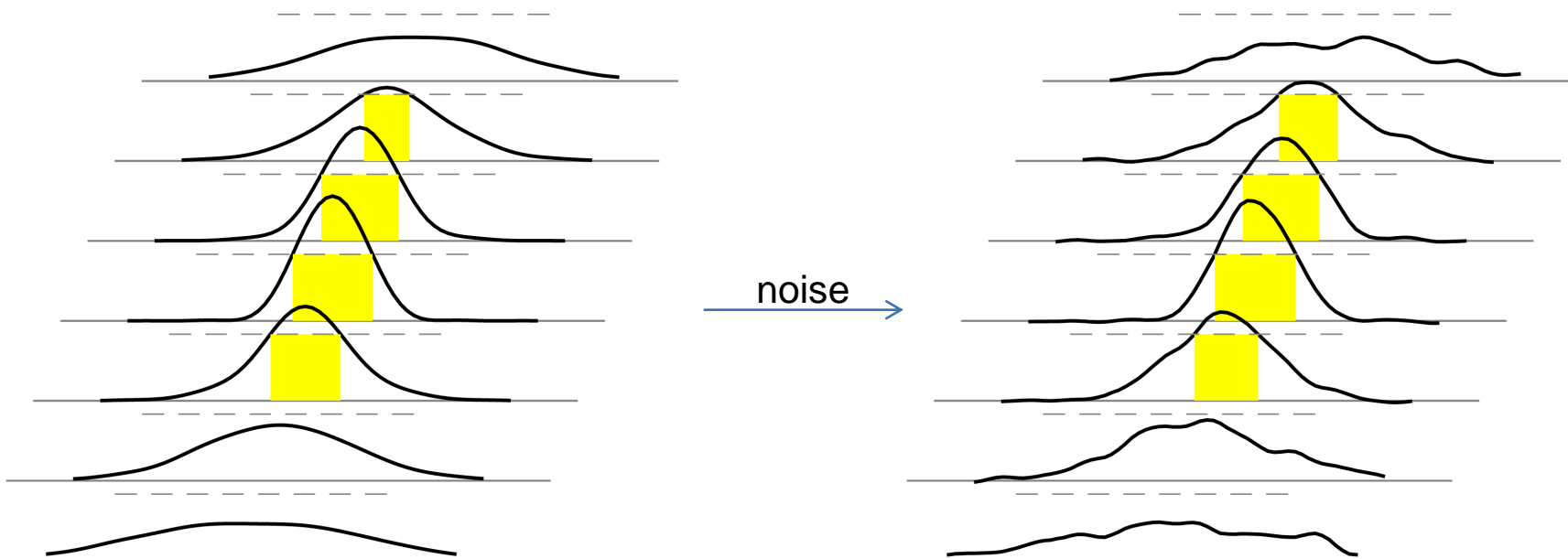
current baseline source ← next generation source

Source shape	Instability type	Pupil plane	Image plane	Compensation efficiency
Spherical Source	Position drifts			
Elliptical Source	Position drifts			
Elliptical Source	Shape / Size Drifts			
Local In-homogeneities	Position drifts			
Local In-homogeneities	In-homogeneity Drifts			

- Compensational strategies for source instabilities established
- Next generation source needs to be on a comparable stability level as the current baseline source



# Measurement Accuracy Drivers: Noise from CCD and shot noise

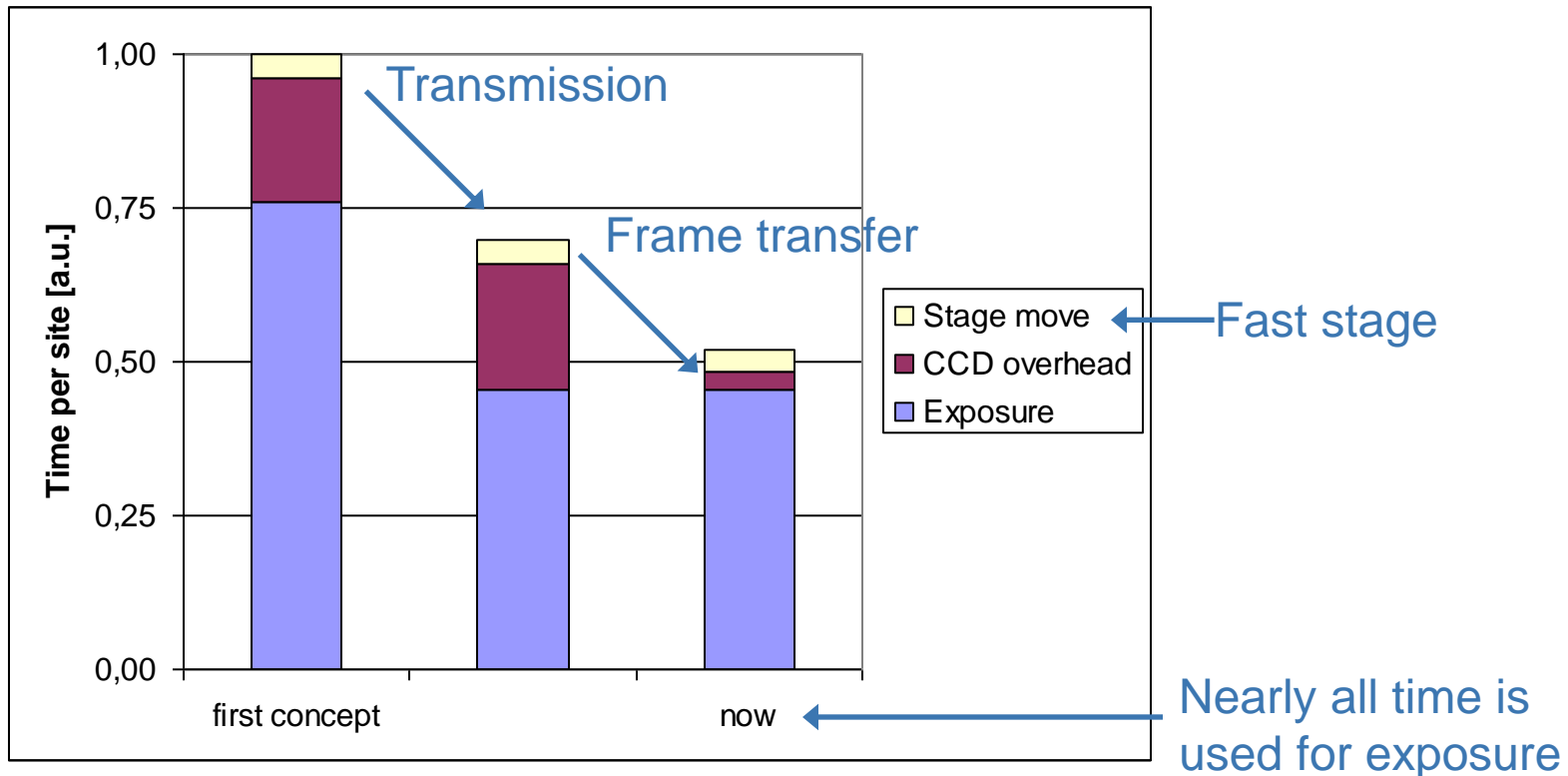


- The suppression of shot noise drives the exposure dose and thus
- requires high transmission optics and high quantum efficiency
  - requires a high brightness source to limit the exposure time

# Optimization for photon efficiency has improved the run rate



Run rate improvement:



**Photon efficiency = Optimization of application performance**

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## We are looking for a next generation source for AIMS EUV based on the key parameters\*

- Stability
  - Plasma position <3% of FWHM
  - Energy stability <3.5% ( $3\sigma$ ) pulse-to-pulse
- Brightness
  - > 30W/mm<sup>2</sup>/sr (minimum)
  - >100 W/mm<sup>2</sup>/sr (target)
- Cleanliness 100%
- Availability / Reliability

\*These are our key guiding parameters for the search and early selection. They will be modified and extended for different source concepts individually. For detailed information, please contact Heiko Feldmann



We make it visible.

Dirk Hellweg et. al.

„Closing the Infrastructure Gap – Status of the AIMS™ EUV Project”  
Proc. SPIE 8322

Dirk Hellweg et. al.

„AIMS™ EUV - the actinic aerial image review platform for EUV masks ”  
Proc. SPIE 7969

Anthony Garetto et. al.

“Status of the AIMS™ EUV Project”, BACUS 2012, to be published

Heiko Feldmann et. al.

“Actinic Review of EUV Masks”  
Proc. SPIE 7636