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Fraunhofer Institut Lasertechnik

The Philips Extreme UV Sn Source: Recent progress in power, lifetime and collector lifetime

Marc Corthout,
Rolf Apetz, Klaus Bergmann, Günther Derra,
Jeroen Jonkers, Joseph Pankert, Peter Zink

Overview

- Scalable power concept
- Integration with debris mitigation and collector
- Reliability and lifetime
- The Philips Extreme UV roadmap for HVM

Scalable power concept: rotating electrodes

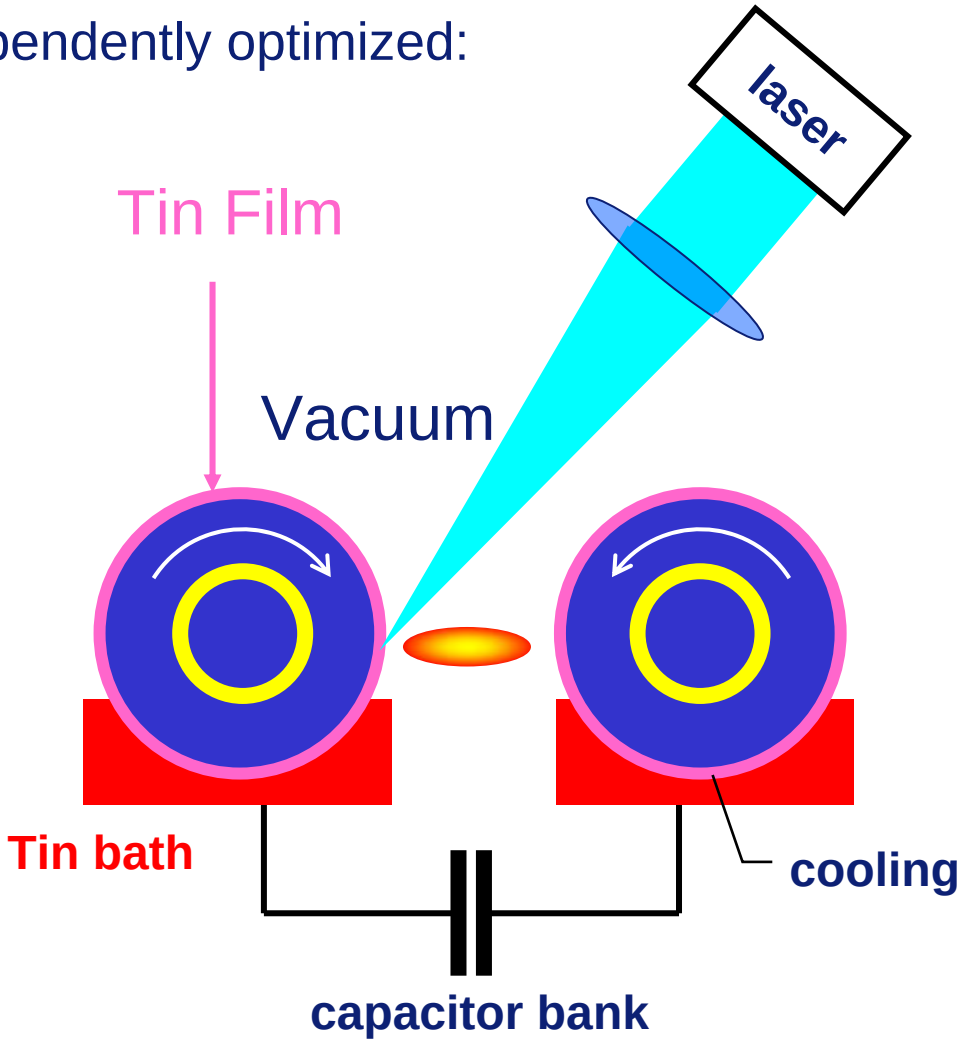
Three parameters that can be independently optimized:

- Conversion Efficiency
- Pulse energy
- Rep rate

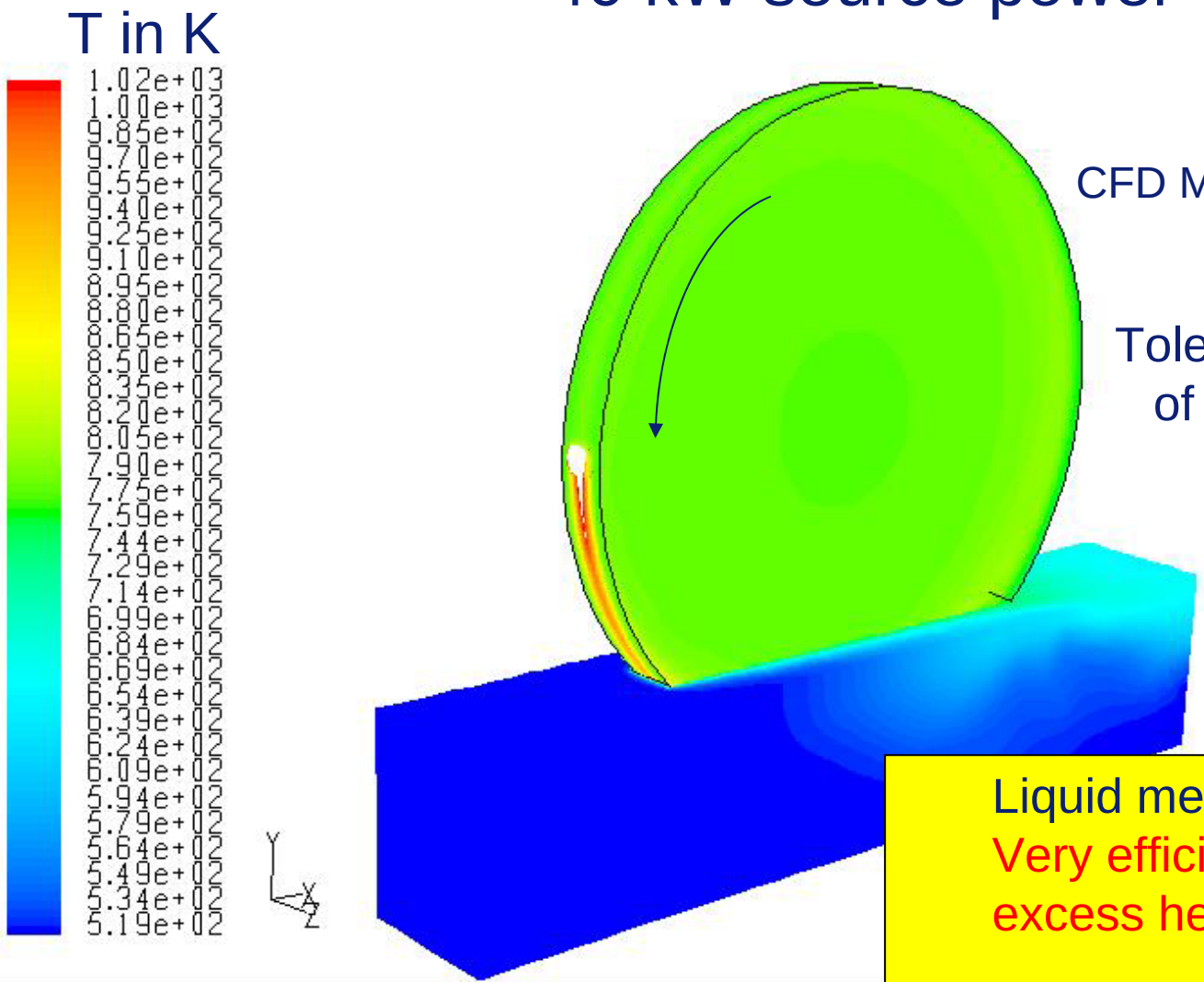
Keeping the source cool…

… and the scanner clean

are the bigger challenges



Wheel and Tin Bath Temperature profiles
40 kW source power

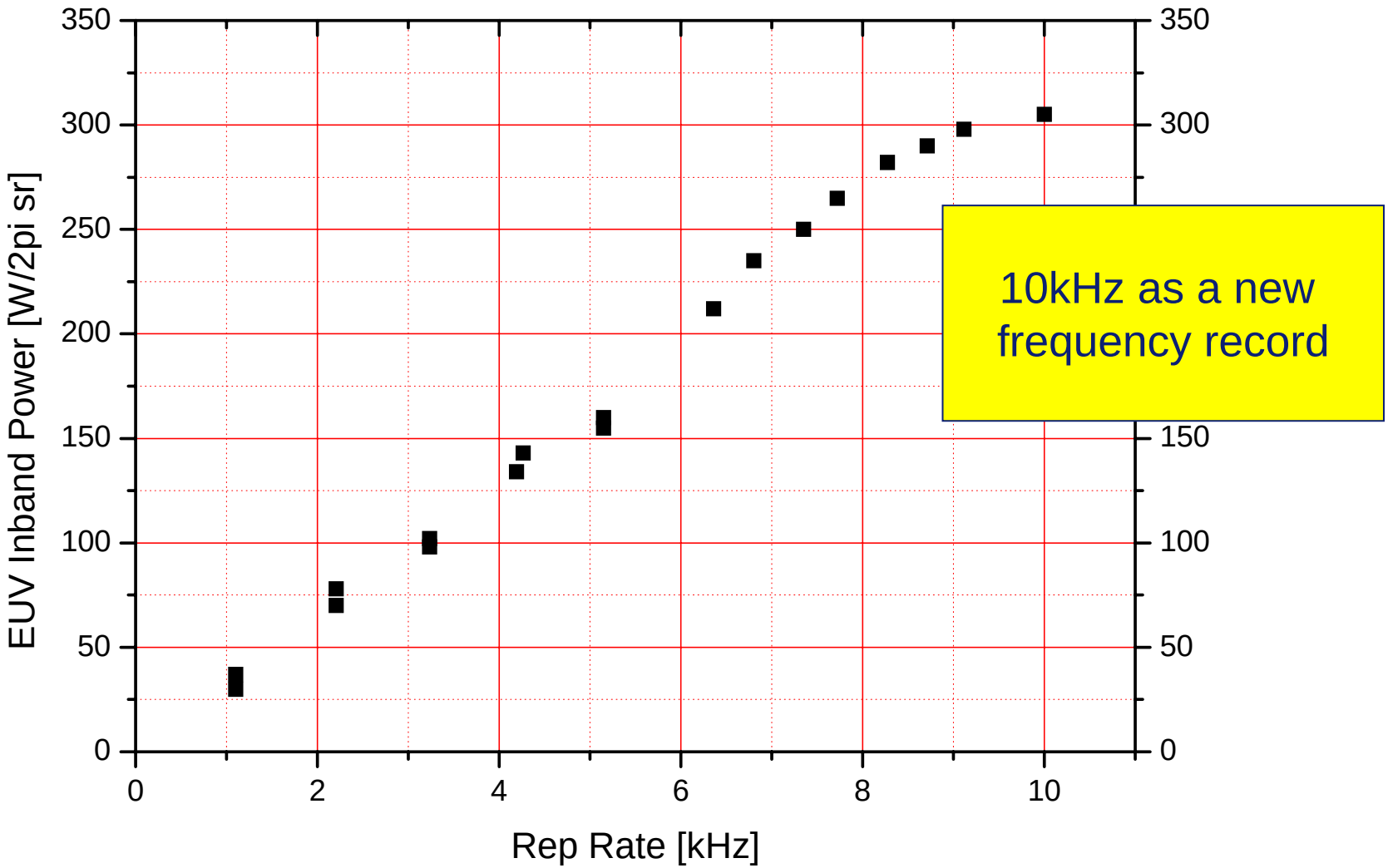


CFD Model with rotating wheel in liquid Tin bath

Tolerable Temperatures of wheel (~ 500º C) and bath !

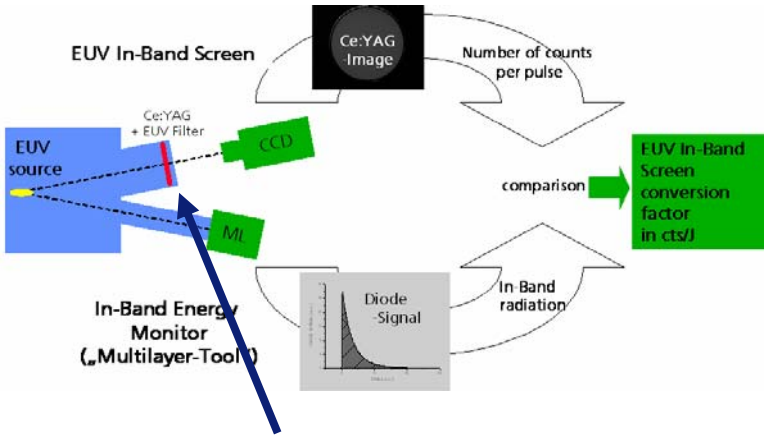
Liquid metal cooling
Very efficient to remove excess heat of more than 40kW!

Turning the rep rate scalability “button”

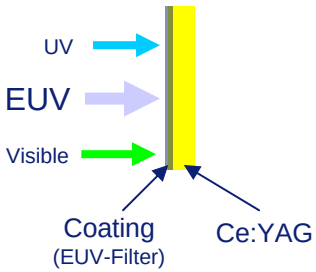


Collector qualification: Metrology

Calibration strategy



Converter Screen



Reliable measurement methodology, matching calculated results (see Poster session 08-ME-04 by Klaus Bergmann)

Results

Measured and calculated collector transmission :

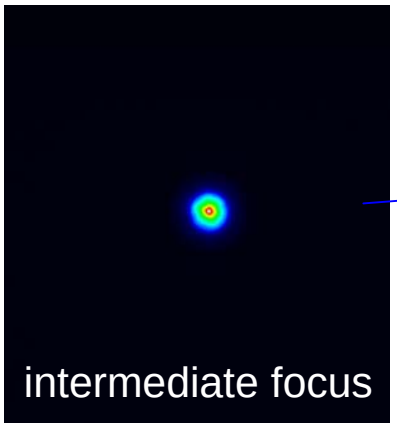
Au - single shell : **38,2**% ± 1,4% (calc. **38,3**% ± 1,5%)

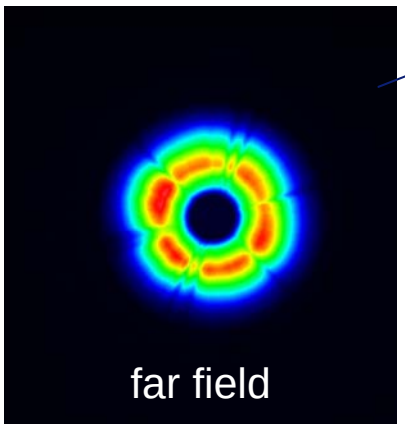
Ru - single shell : **53,8**% ± 1,9% (calc. **53,4**% ± 2,1%)*

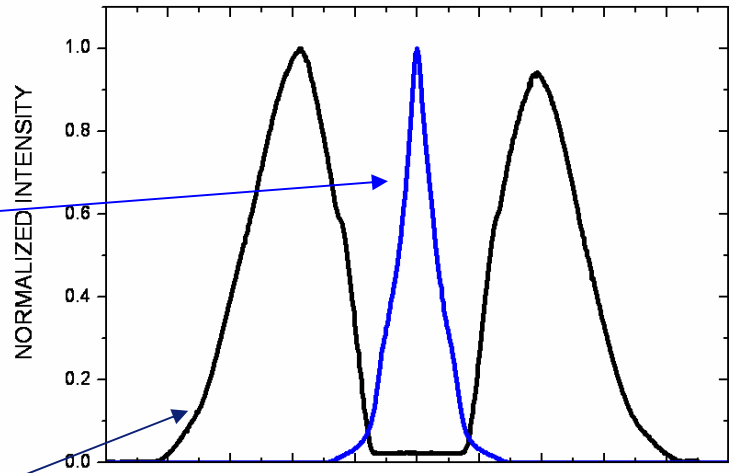
Ru - double shell : **50.7**% ± 1,8% (calc. **52,3**% ± 2,1%)*

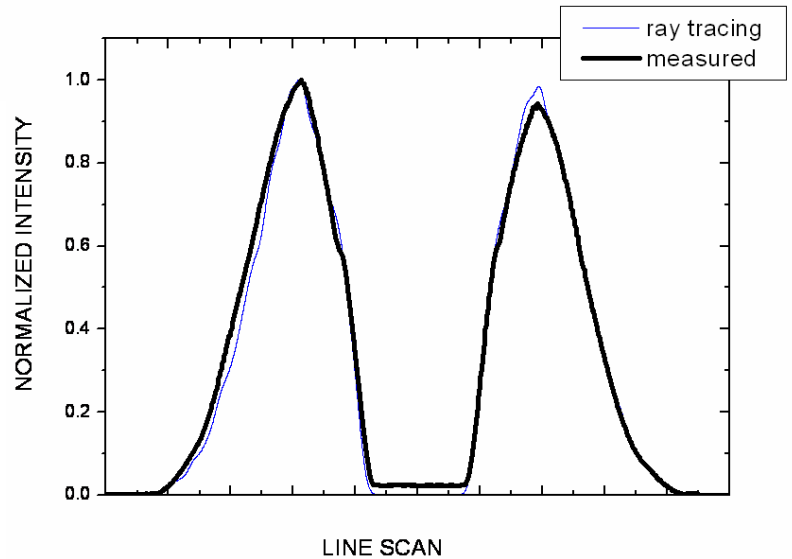
*Collector with galvanic Ru-coating. Present PVD Ru coating improves transmission of about 20%

Collector qualification: In-Band Screen Images (with aperture @ IF) at Xe source

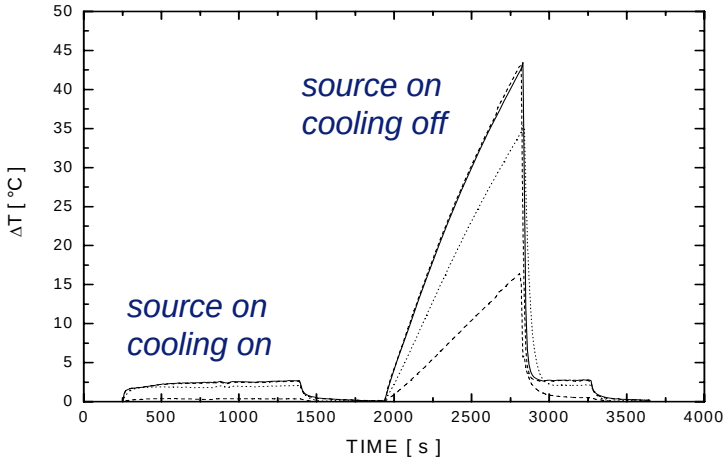








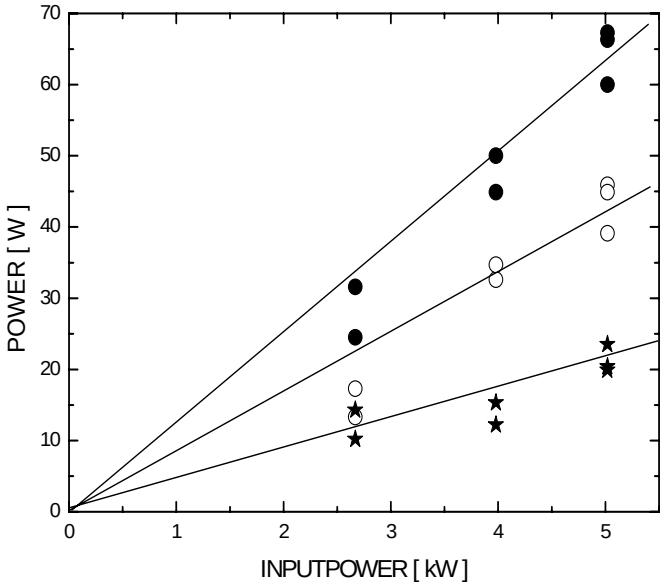
Collector qualification: Thermal tests at Xe source



Maximum temperature increase of 5°C for input power of 5 kW with real plasma source

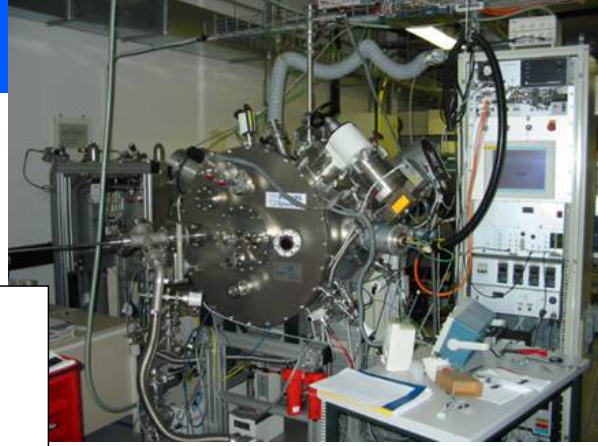
(see Poster 04-OP-83 by Klaus Bergmann)

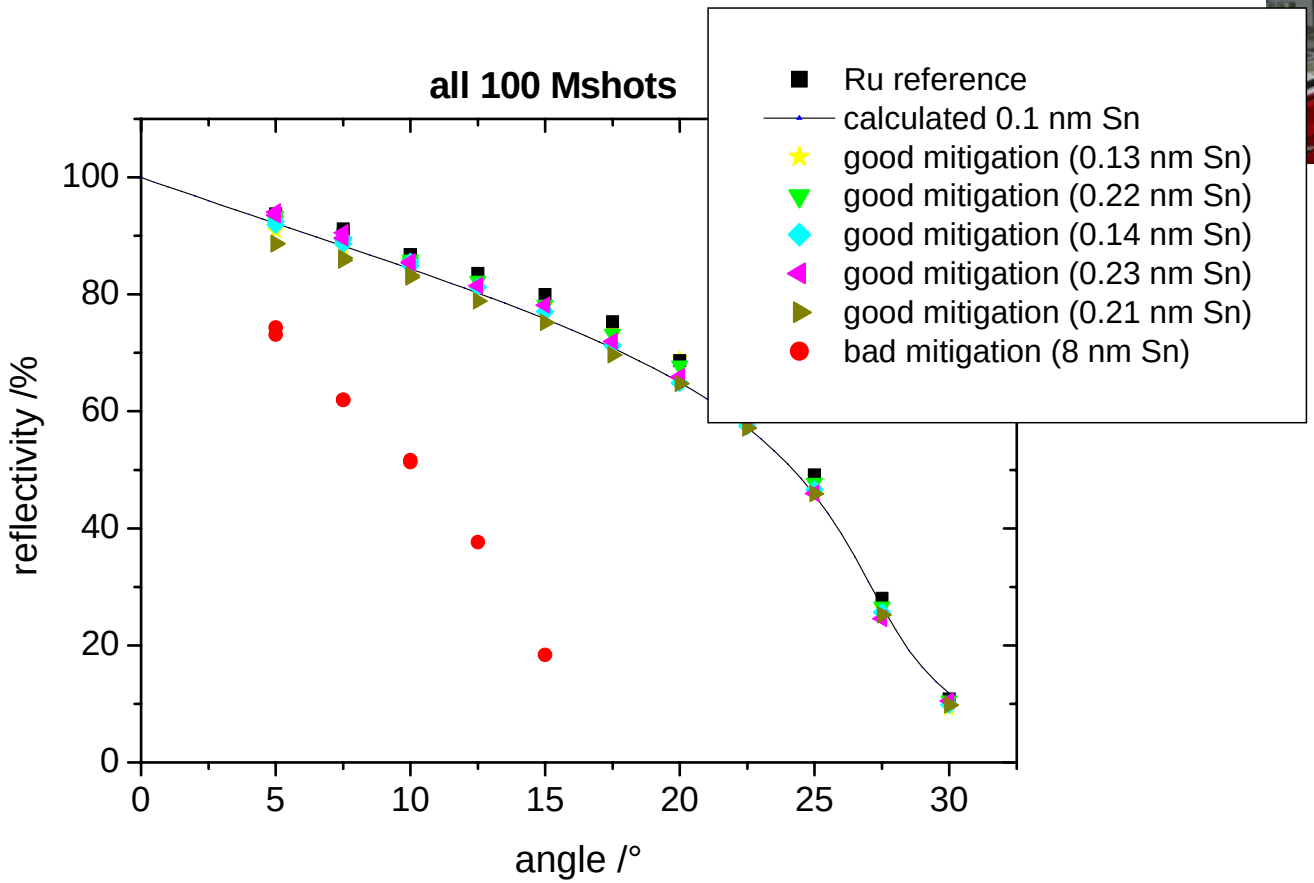
Power Distribution



- cooling power for 2 shell collector (total and distribution to each shell)
- power distribution in agreement with solid angles of shells

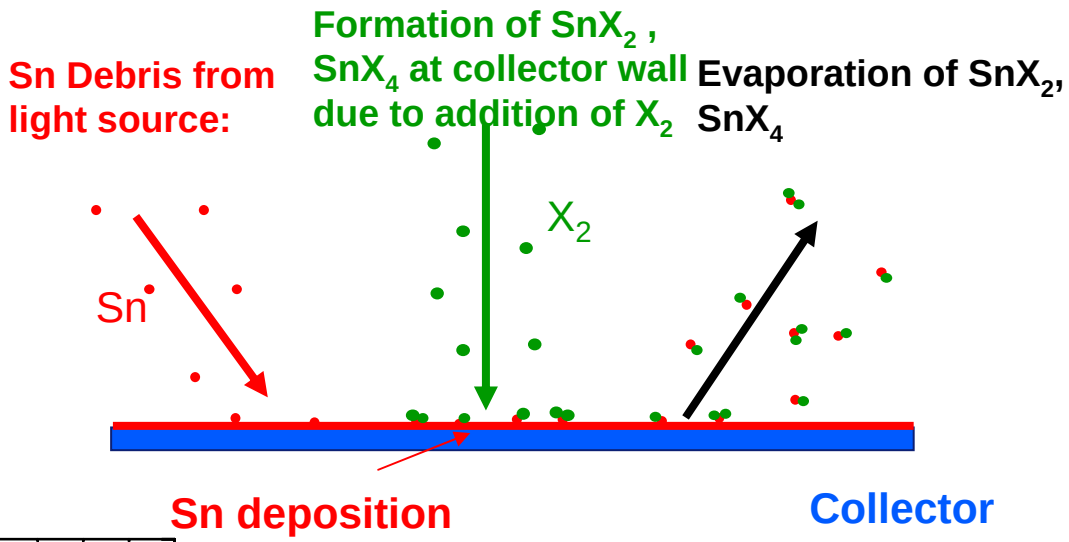
Sn Debris mitigation at test stand: study of process window

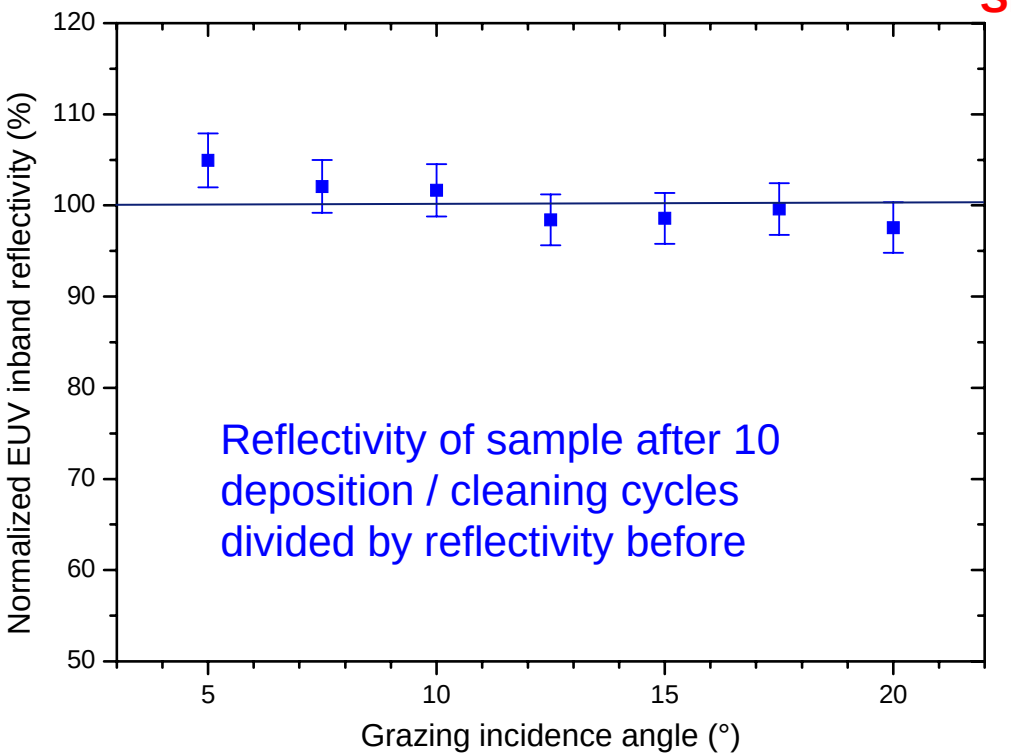




No significant reflectivity loss with good mitigation after 100M shots
→ >1Gshot lifetime before cleaning

Cleaning of collectors: additional to suppression



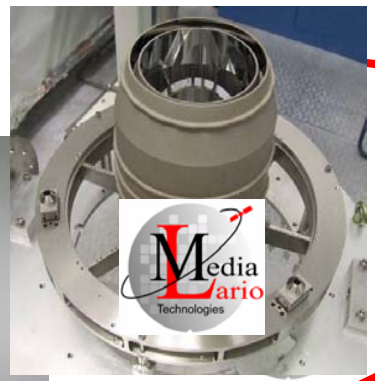


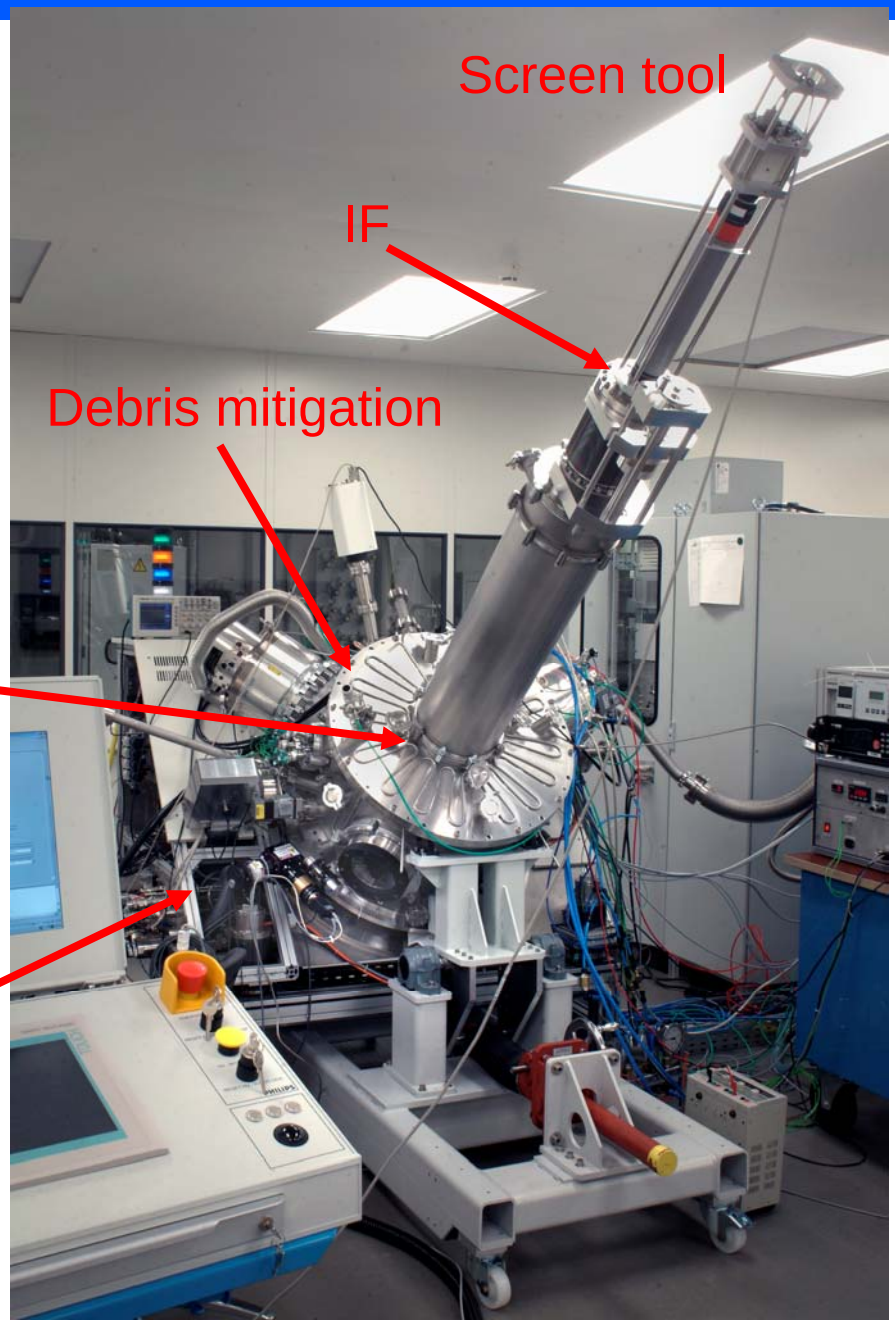
Enables >> 10^{10} Shots collector lifetime

ASML

Putting our Sn SoCoMo prototype together:

- EUV source
- 2-shell collector
- mitigation and
- IF and far field analysis

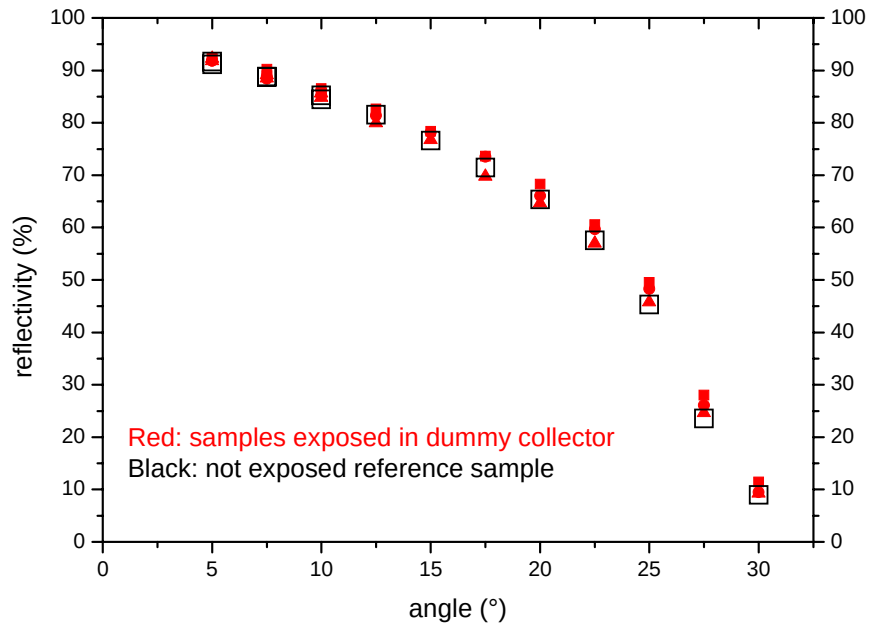




Collector integration at Sn based EUV source:

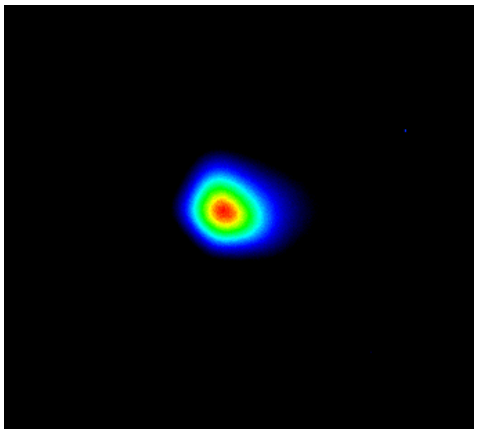
Mitigation pre-tests with dummy collector containing mirror samples

After 42 Mshots for all the 48 samples:
-Sn deposition < 0.1 nm
-No detectable sputtering
-No reflectivity loss

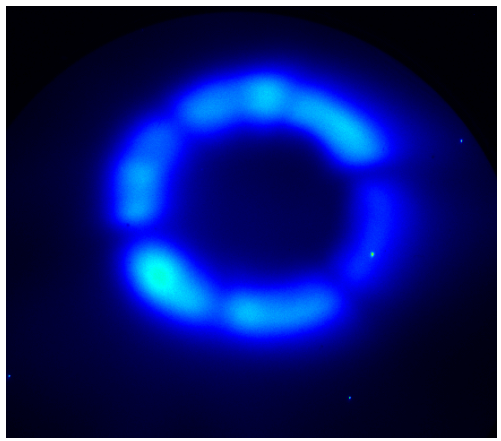


Collector integration at Sn based EUV source:

IF and far field pictures for double shell grazing incidence collector from Media Lario Technologies

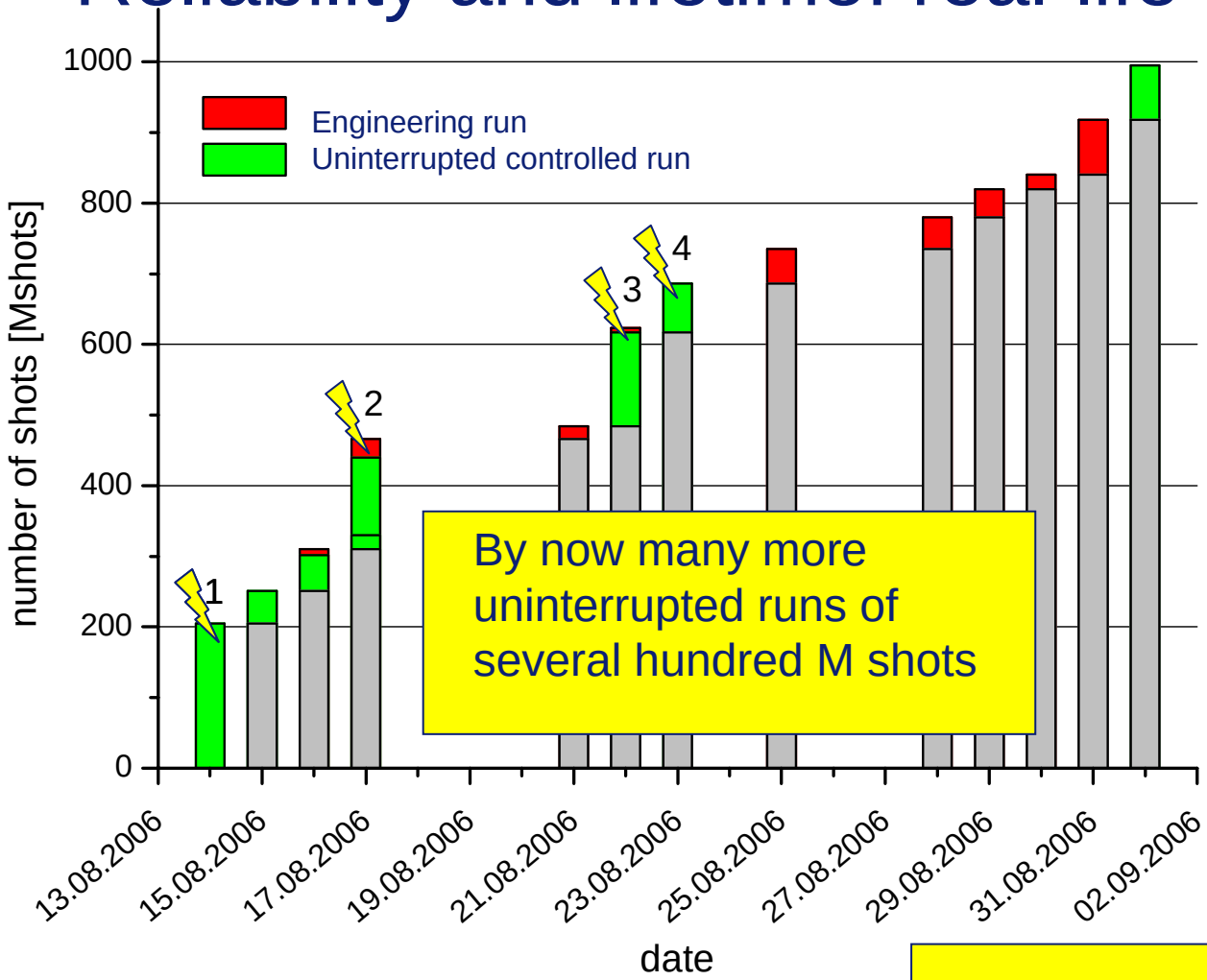


Inband radiation near IF



Inband radiation far field

Reliability and lifetime: real-life data



By now many more uninterrupted runs of several hundred M shots

Failures:

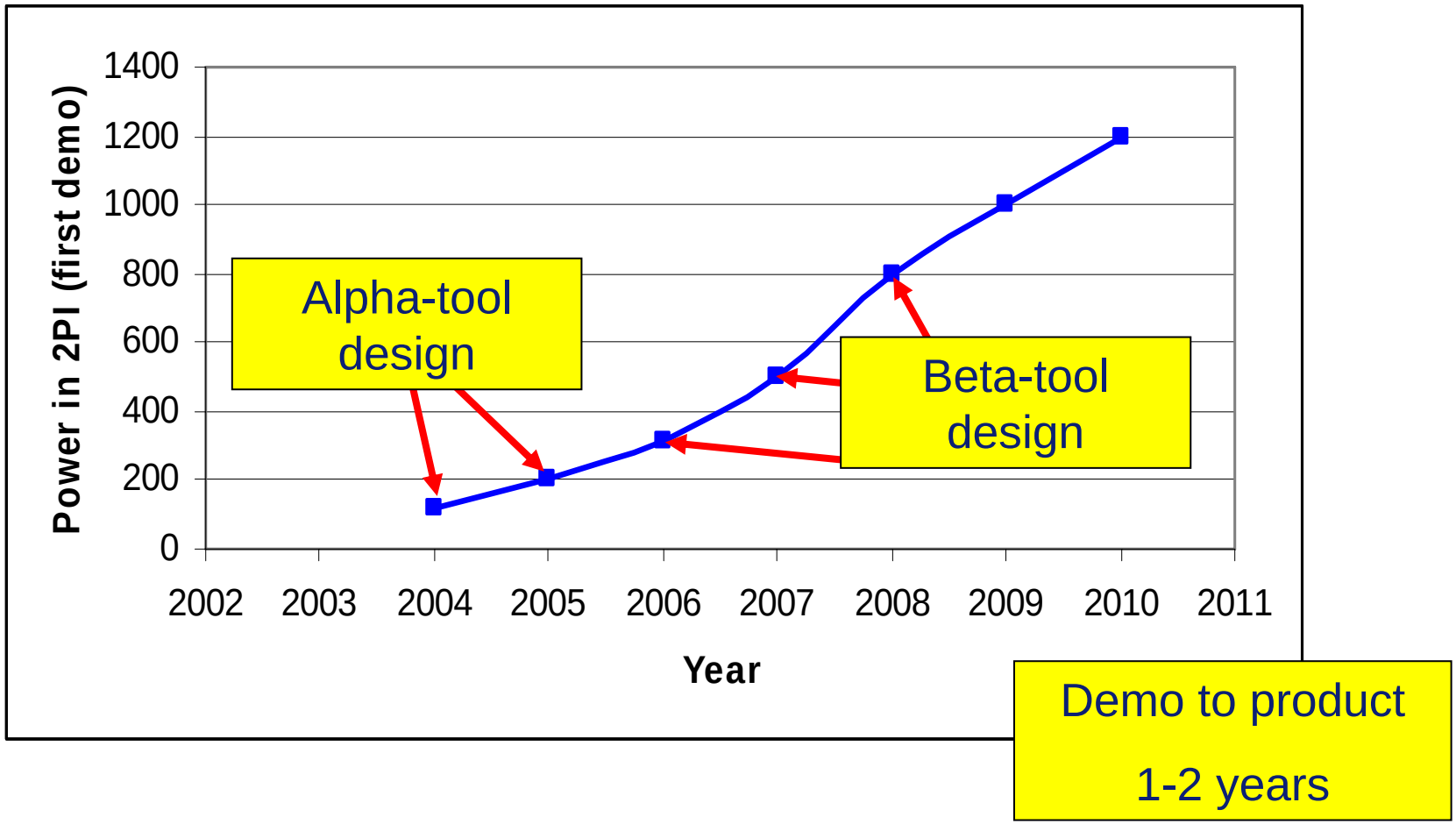
1. failure in control electronics
2. failure in tin handling
3. failure in tin handling
4. failure in control electronics

Rotating electrodes remained intact

2 failures in tin handling
2 failures in control electronics
4 failures in 1 Gshots **MTBF = 250 Mshots**

Continuous step-by-step improvement
Expected to increase alpha-tool MTBF
By more than an order of magnitude!

Philips Extreme UV roadmap for HVM



Conclusions

- Power can be scaled to the right levels based on the patented rotating electrodes concept
- Reliability is the next challenge for HVM, but continuous learning from the alpha-sources will lead us there
- GI collector successfully coupled to Tin source with debris mitigation

- The race to make reliable HVM sources timely is on!

Acknowledgements

Our Philips Extreme UV team

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- Media Lario
- Zeiss

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