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Philips' EUV Lamp: Status and Roadmap

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EUV Symposium Antwerpen 2003

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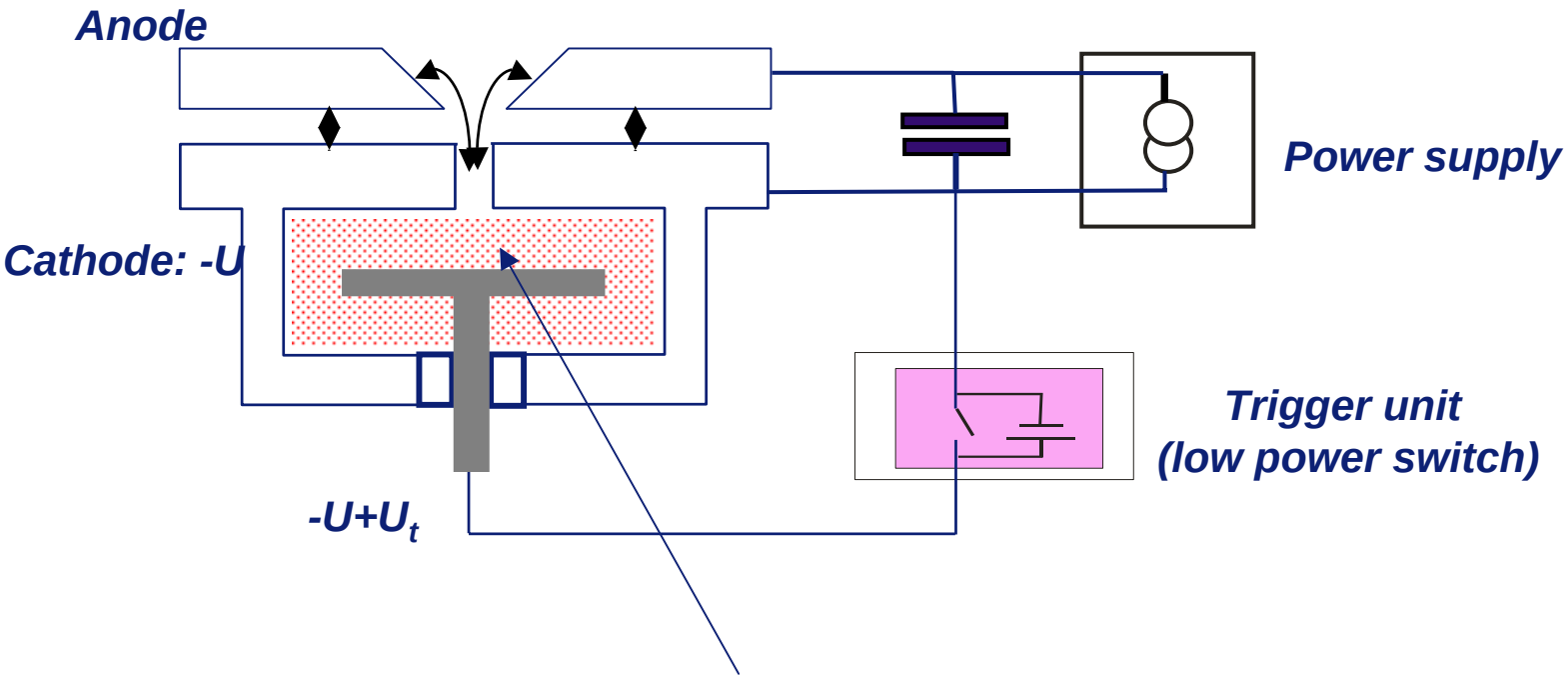
Philips Extreme UV: A joint venture between Philips and Fraunhofer

Outline

- Update on development of Xe source
  - power
  - lifetime
  - dose stability, integration
- Research on Sn source
- Roadmap power

Basic principle of the source:

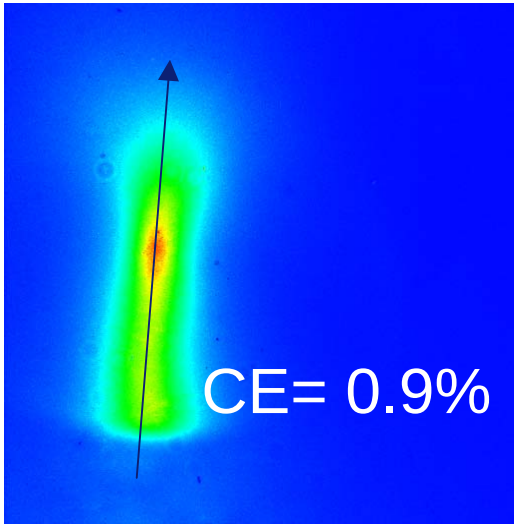


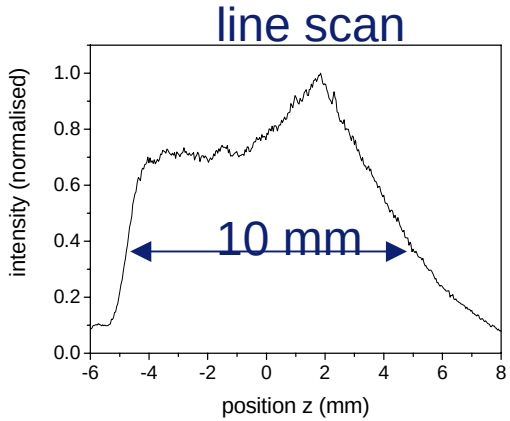
Hollow cathode plasma prior to breakdown

Areas of development Xe source for alpha-tool:

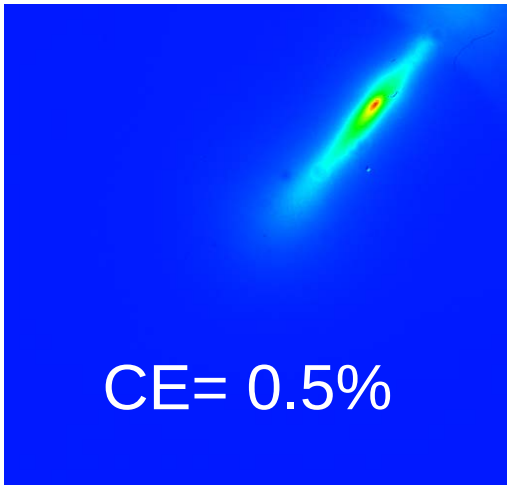
- large plasma-wall distance
- specific electrode forms
- different electrical circuits
- different electrode materials
- gas supply systems
- trigger systems
- modelling on ignition and pinching (2 papers on this conference)
- optical modelling
- debris generation and mitigation
- control of dose stability
- integration with collector module
- alignment and position control

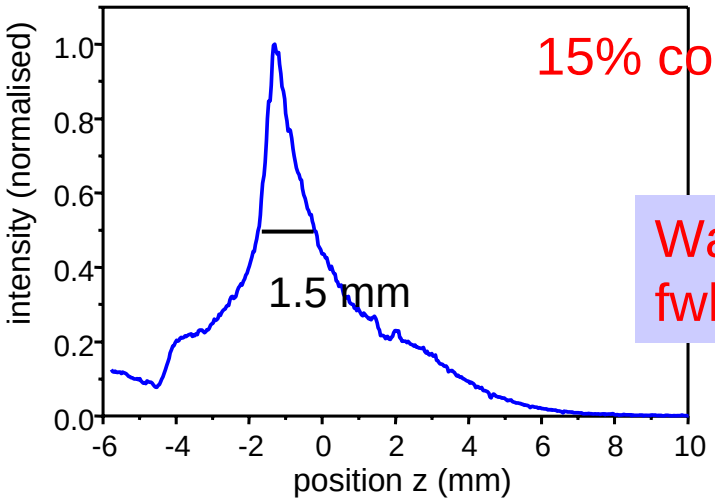
Conversion and collection efficiency:





<<5% collection efficiency

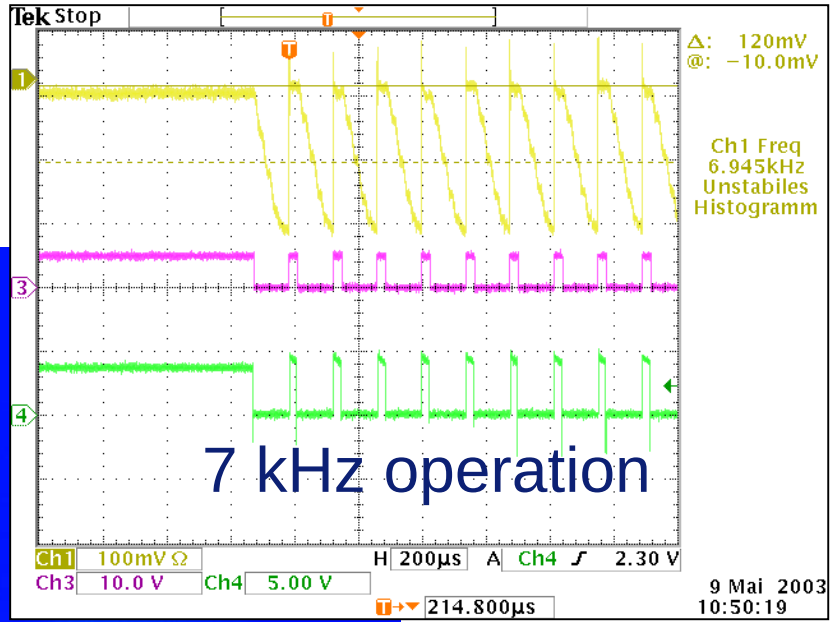


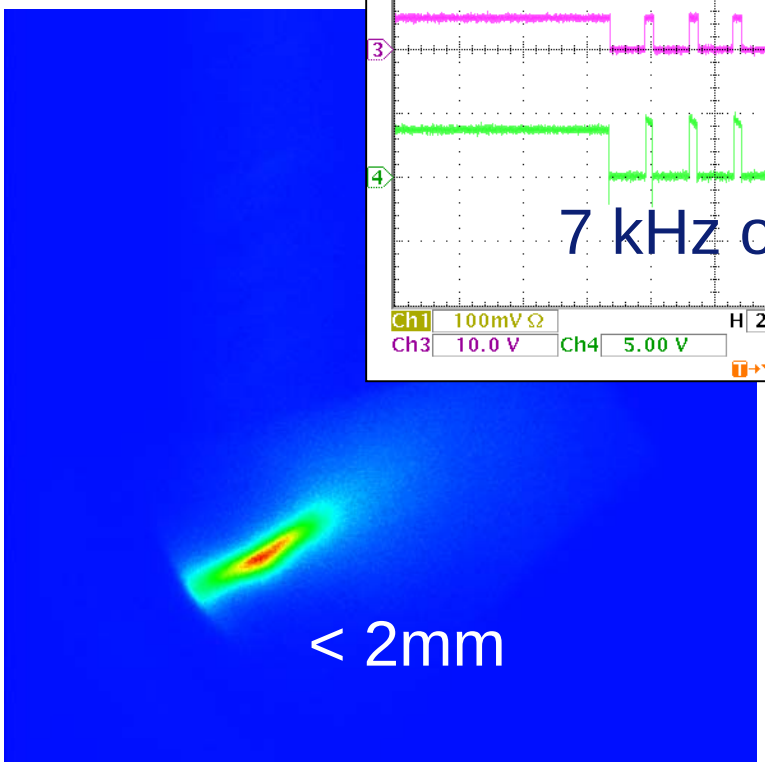


15% collection efficiency

Watch your background!
fwhm not a good measure

Power scaling Xe lamp: Frequency scaling

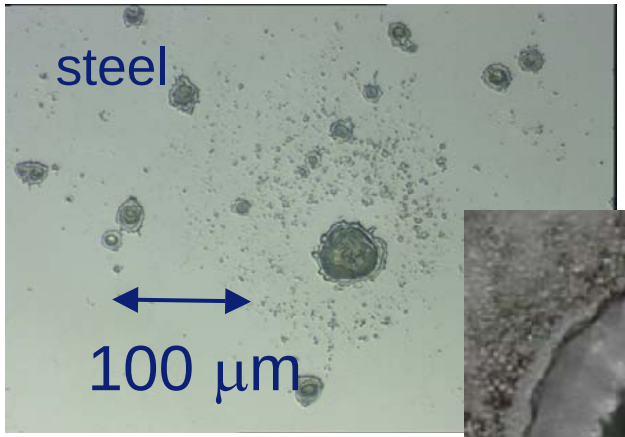




21 kW input power

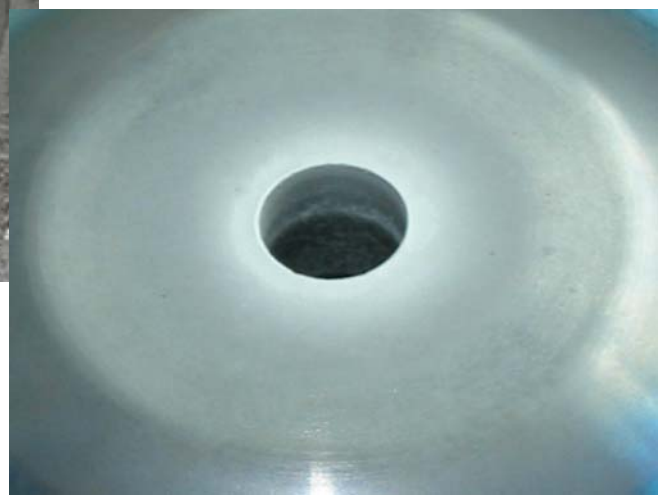
Corresponds to:
- 10 W in 2nd focus @ 1.8 sr collector
- assumption: no SPF

Electrode erosion: cathode spots associated with high currents



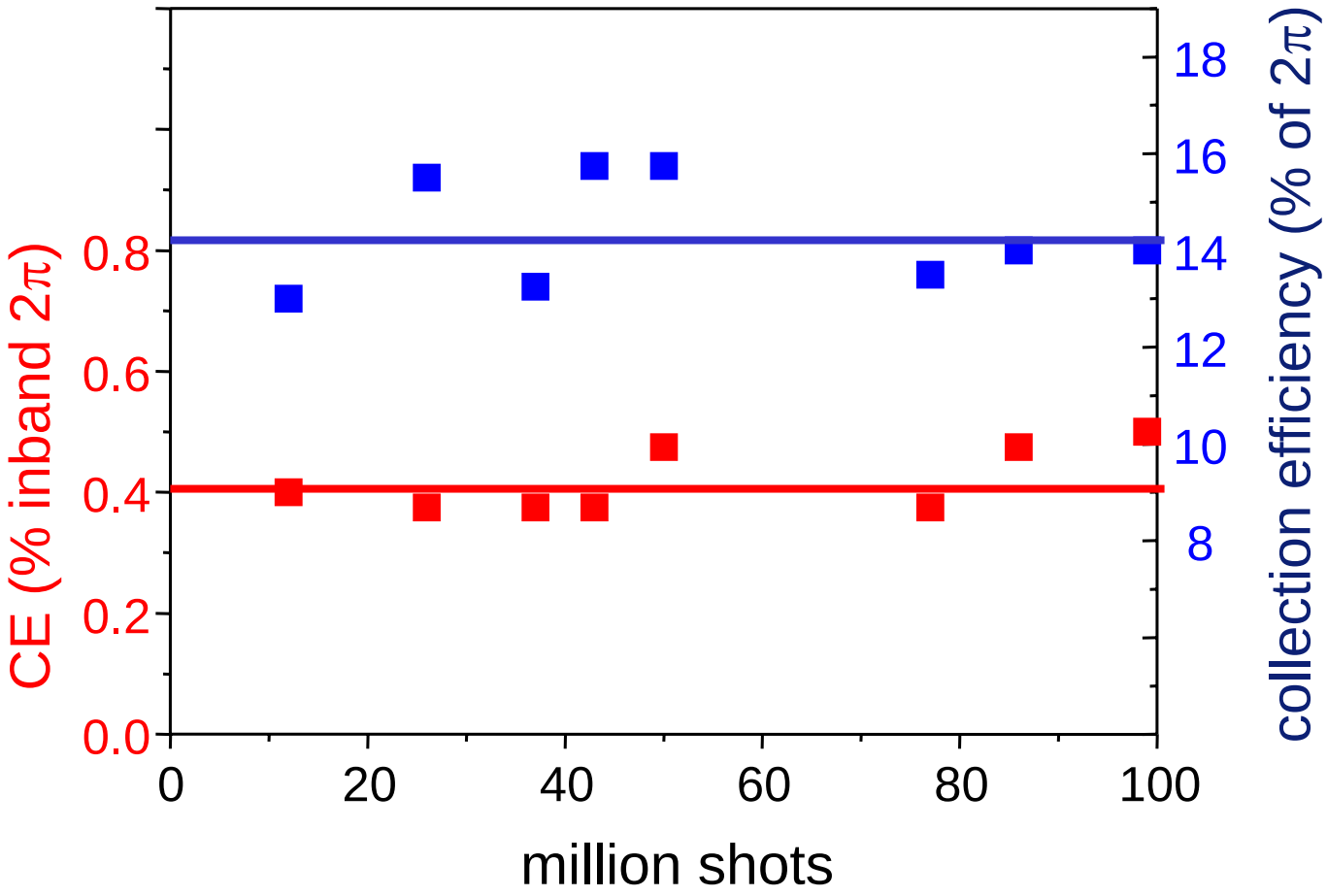
Cathode spots with >10^{-4} mm^3/C for W

Electrode #1 after 10^8 shots



Electrode #2 after 10^8 shots:
Improved current distribution

Long term stability (open loop operation)

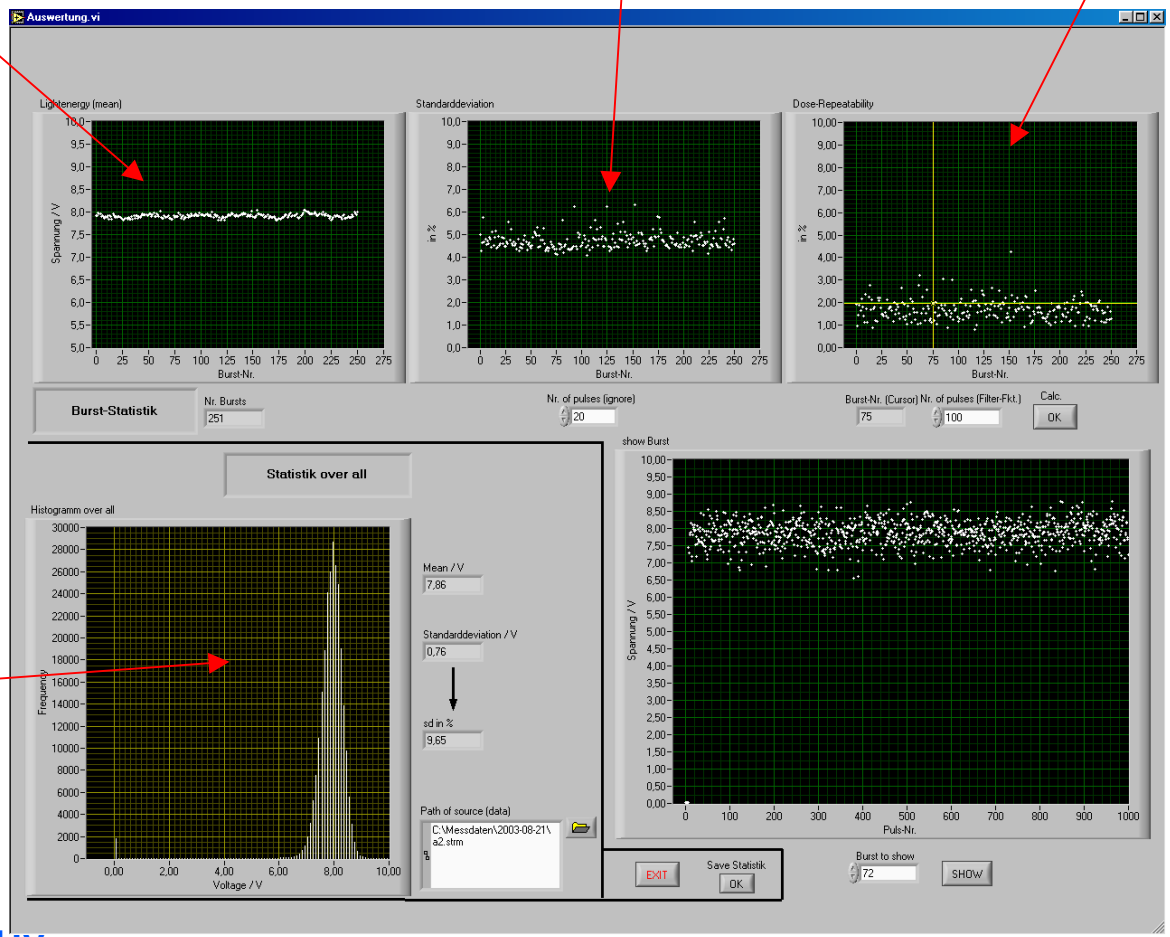


Single pulse statistics: *all* shots are recorded

Voltage

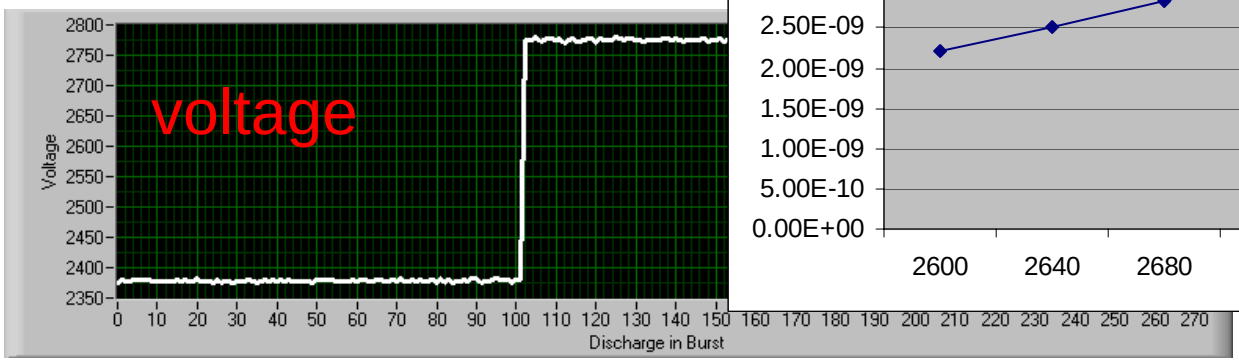
EUV signal

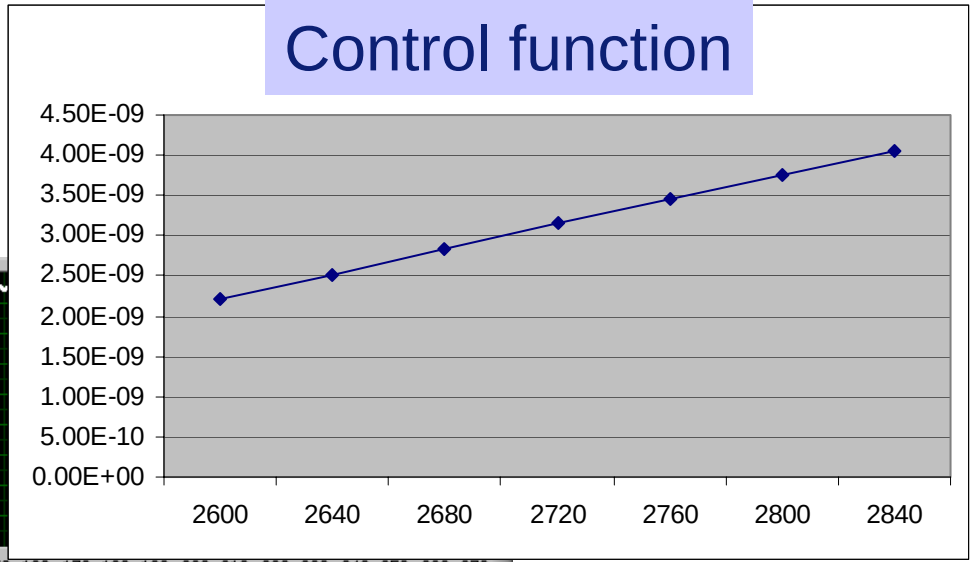
Dose stability

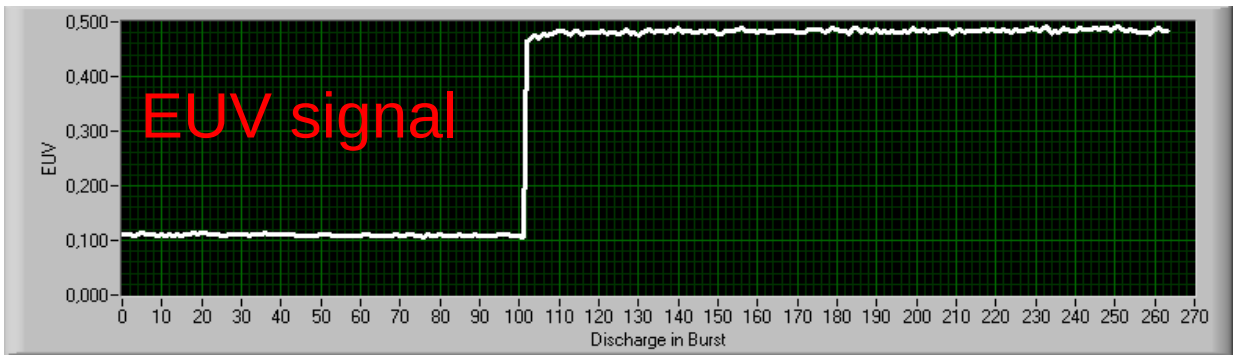


Statistics

Response on control parameter: Immediate response







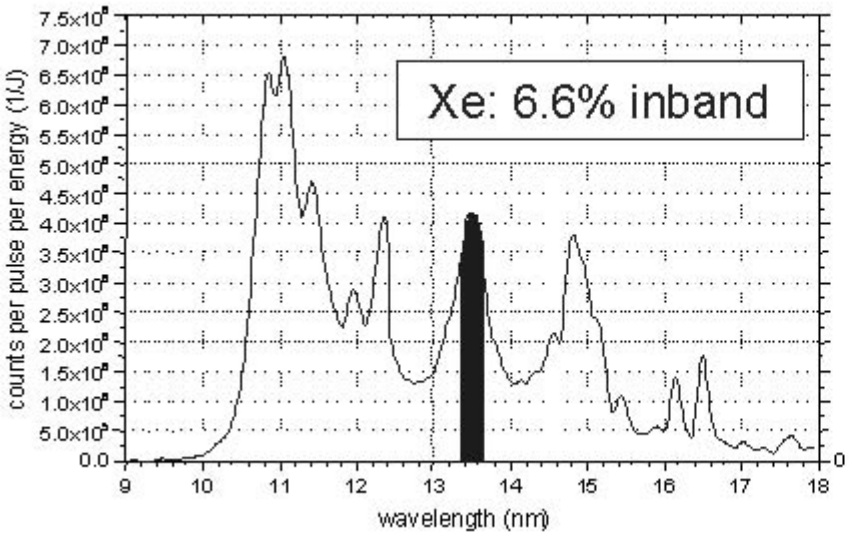
Dose control of lamp on single shot basis possible

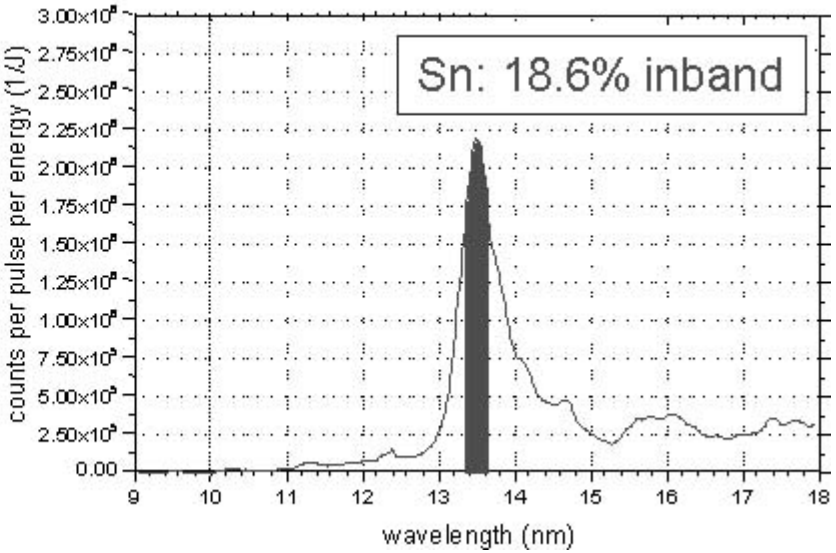
Summary on Xe

- 10 W 2nd focus demonstrated (7kHz)
- Trade-off between CE and collection efficiency (at large plasma wall distance)
  - often some background intensity
- Electrode erosion manageable by current distribution
- Lamp shows behaviour allowing active dose control
- We still think we need higher CE for final specification

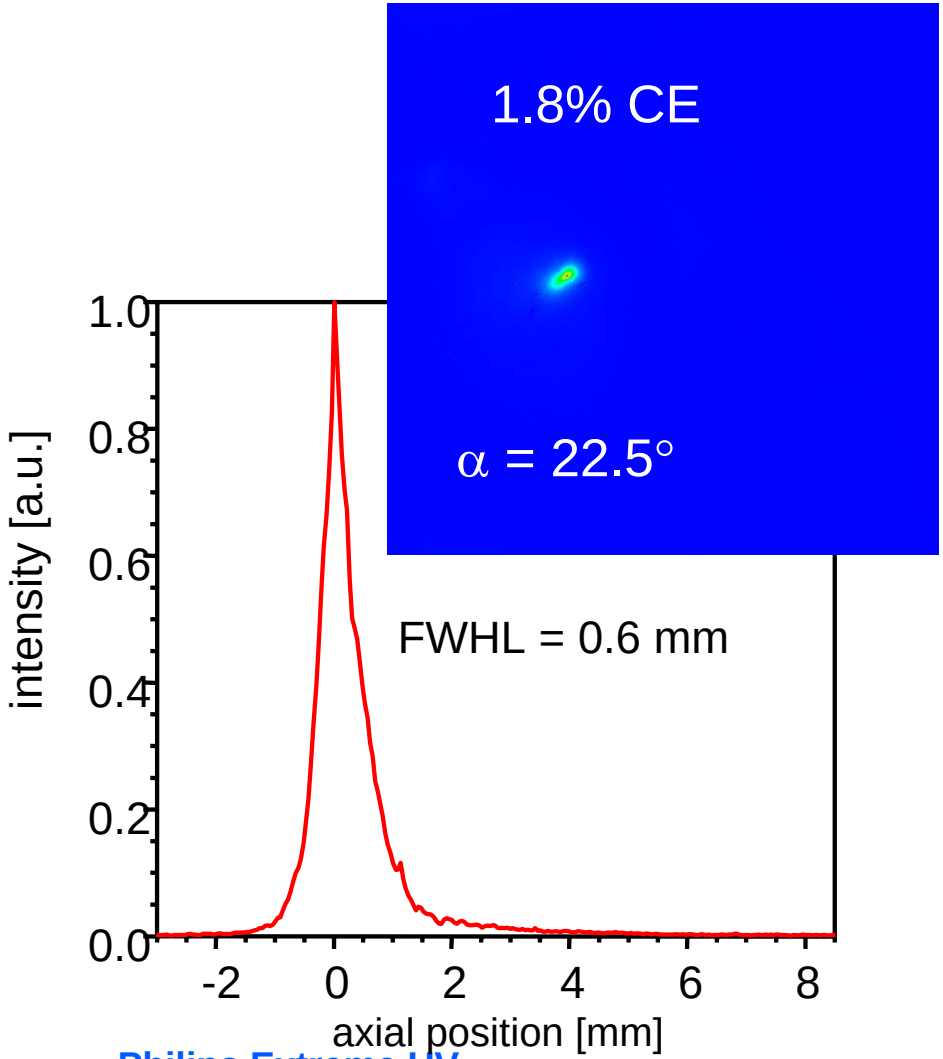
Research on Sn discharge:

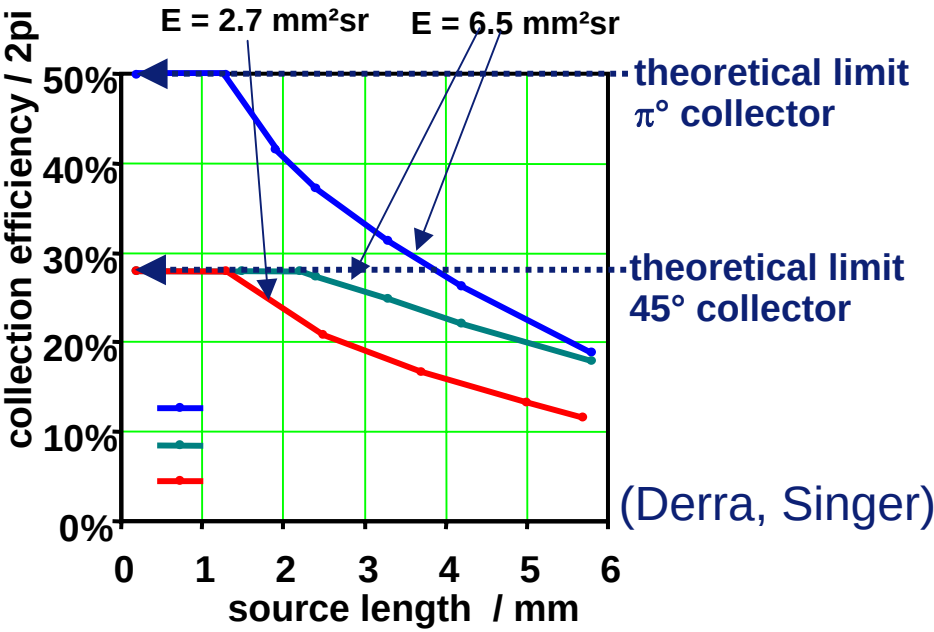
- Sn necessary for scaling to 100 W
- Issues:
  - Sn delivery (vapour pressure control)
  - pinching (comparable to Xe)
  - removal of excess of Sn





Results CE and collection efficiency:

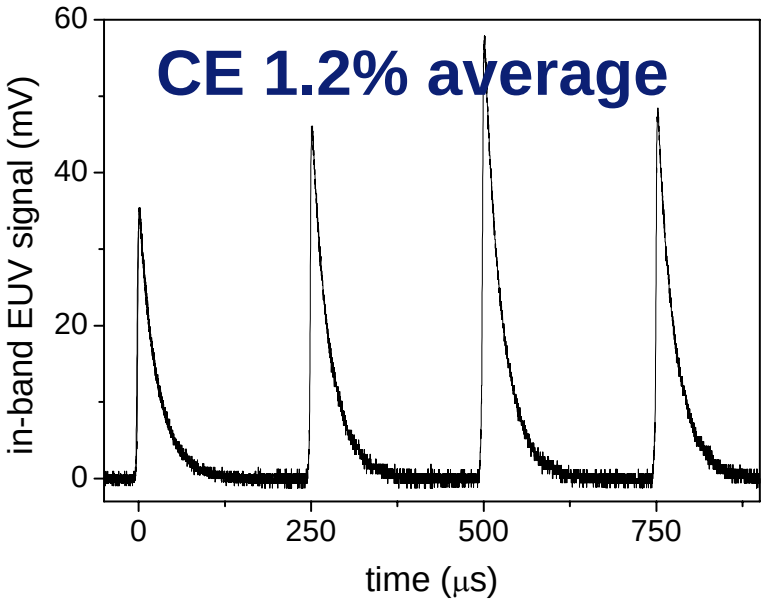


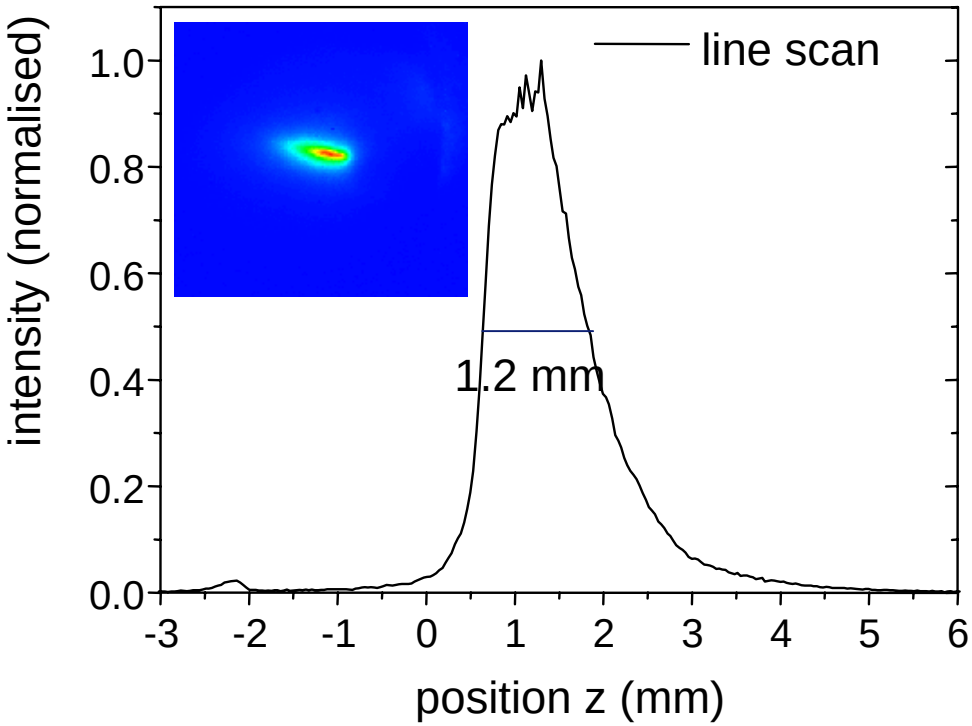


(Derra, Singer)

- Excellent collection efficiency
- Power @ 2nd focus compared to Xe more than factor of 5

Power scaling Sn-source: High frequency operation at 4 kHz, 2.2 J





Power scaling Sn-source: High frequency operation

8800 W input

↓

106 W inband 2π

↓

53 W in π collector

↓

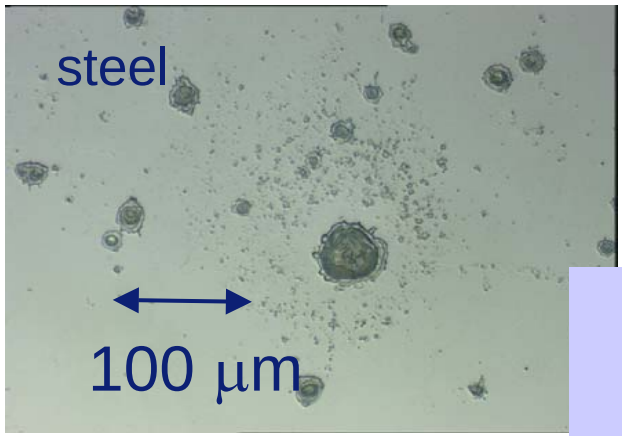
40% transmission
2nd focus

↓

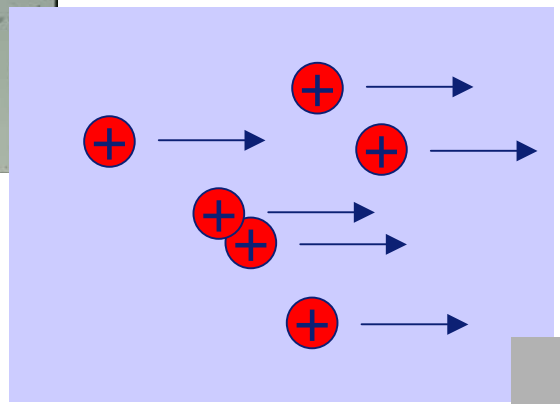
21 W @ 2nd focus

30 kW input and 2% CE seem possible on the long run!

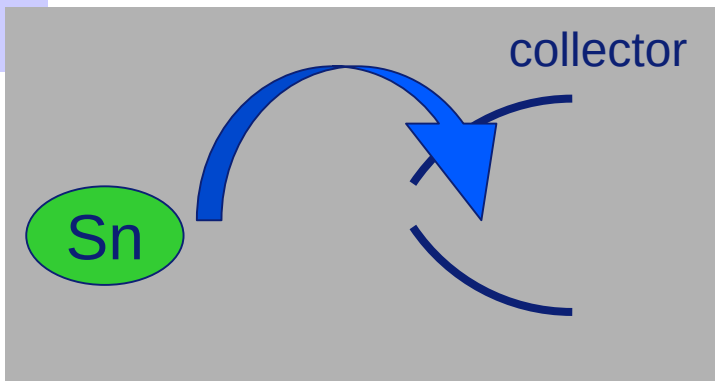
Debris: Comparison Xe and Sn at same EUV output (i.e. 5 times higher input for Xe)



Cathode erosion (proportional to current)



Fast ions (proportional to total EUV)



Sn deposition on collector

Example of debris mitigation:

No noticeable deposition

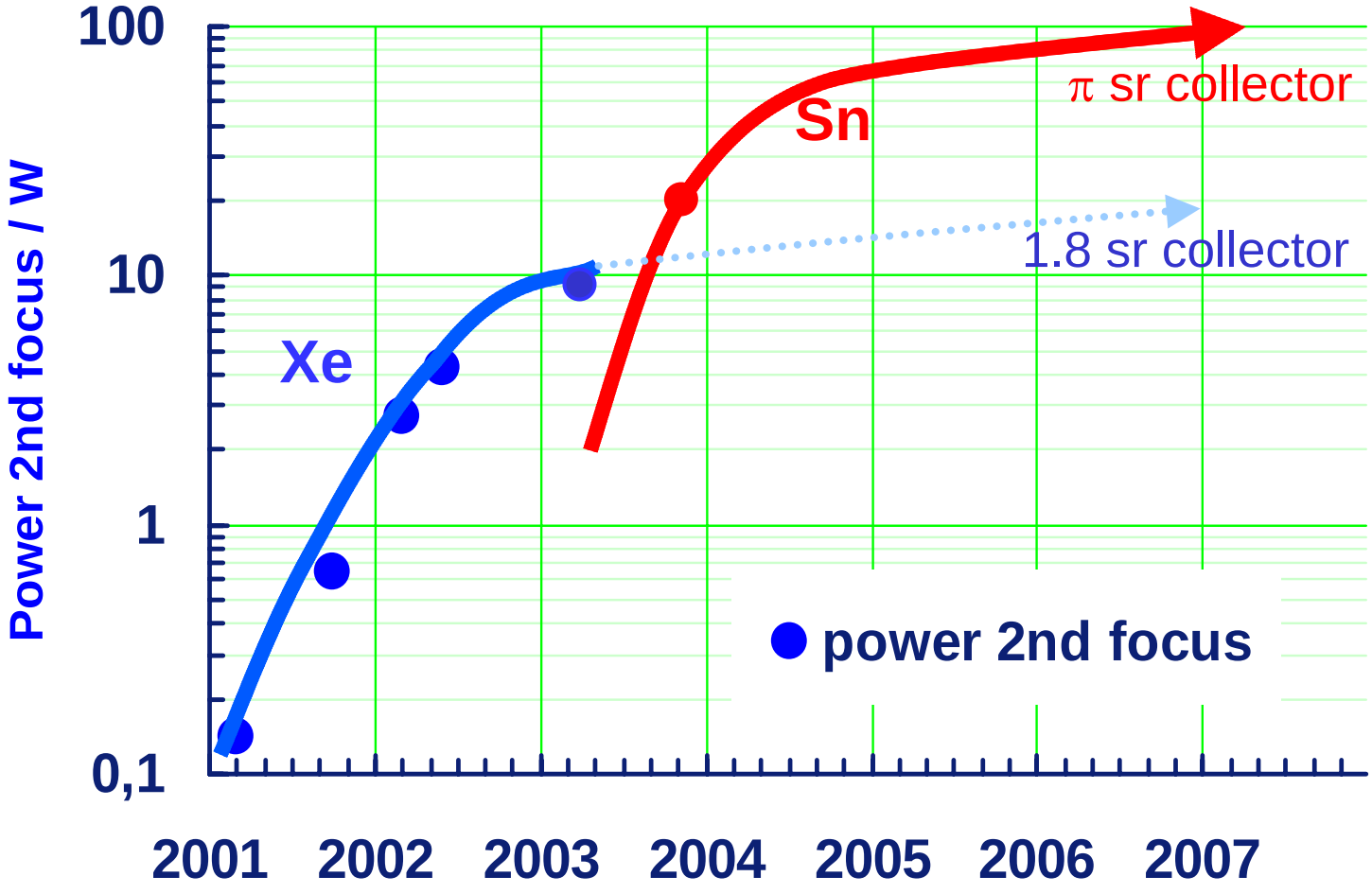
Without mitigation: 80 nm

Power scaling alpha/gamma tool:

	Xe	Sn
conversion efficiency (% of 2Pi)	0.5	2
pinch size (mm)	2	<1
collector opening (sr)	1.8	3
collection efficiency (% of 2 Pi)	20	45
collector + mitigation efficiency (%)	50	40
limit of power input (kW)	30	30
inband power limit 2nd focus (W)	15	108

We estimate that Xe is limited to about 15W on a 1.8 sr collector
γ-tool specifications only achievable with Sn source!

Power Roadmap Philips EUV:



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