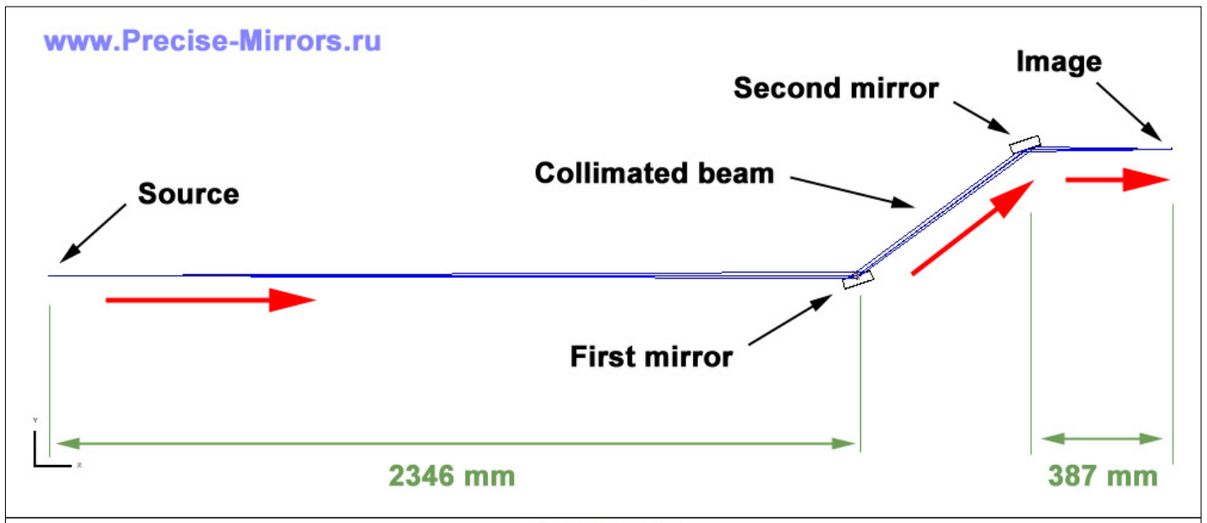
Typical request (for free form):

… we need two conjugated toroidal mirror (task: from a point source to a collimated beam and then vice versa to focus to a point).
Distance to source 2346 mm, distance between mirrors 573 mm, distance to image 387 mm, angle of incidence 71 degrees. Source diameter about 20-40 µ m,
source divergence about 10 mRadians. Desired image diameter (focal point) about 10 µm. Mirror sizes - lentgh no more than 150 mm, width - no more than 40 mm.

Illustrative explanatory drawing (not from customer)



Typical "world" answer (quote) from typical sales manager:

… two toroidal mirrors will cost YYYY Euro (USD...) and delivery terms will be FFFF weeks (days, monthes...). ***As for the image diameter You specified,***
a specialist is needed to determine it, who can simulate Your optical scheme design using specialized professional software.
We do not have such a specialist in the sales department, but when You place ***and pay for Your order*** *, such a specialist will definitely study Your wish...*

What will know this speciallist AFTER the order is paid? See below.

Our typical quotation (below, next pages)

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ii «Z I L T A»
Precision Optics Measuremnts

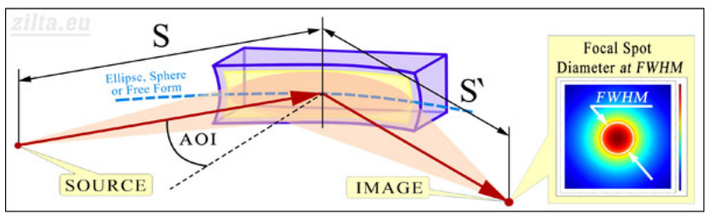
To: **"Name Surname"** <e-mail@-email.com> *dated:* 31 Feb 2023 Re: toroidal mirrors inquiry

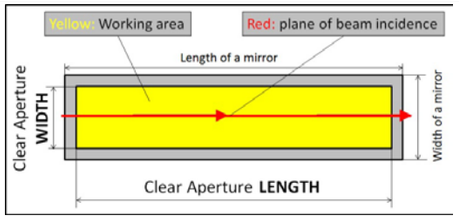
Offer No. 2023-0305-c01 (6 pages, with AQD and appendixes in file appendixes-fam-2023.pdf) **Base offer valid till 5 May 2023** **Special offer valid till 5 April 2023**

Specification (**TWO** concave mirrors)	**OPTION "A"** (**ultra precise toroids**)	**OPTION "B"** (**ultra precise Off Axis Parabolic**)	**OPTION "C"** (**ultra precise Off Axis Parabolic**)
Mirror sizes (LxWxH) // **Clear Aperture**, [mm], (**right** drawing **below**) tolerances: clear aperture +0.5 mm, L&W -0.5 mm, H ±0.5 mm	**100 X 30** x 25 // **75 x 25**	**100 X 30** x 25 // **75 x 25**	**100 X 30** x 25 // **75 x 25**
Minimal focal point ø ater TWO conjugated mirrors at work λ_{WORK}** (FWHM) for various soruce sizes, test measure in certificate at λ=633 nm – see below **AQD#1** and app.3	Source Ø 20 µm - **Ø500 µm*** Source Ø 40 µm - **Ø500 µm***	Source Ø 20 µm - **Ø12 µm*** Source Ø 40 µm - **Ø14 µm***	Source Ø 20 µm - **Ø7 µm*** Source Ø 40 µm - **Ø10 µm***
Max. power density (W/cm2) in focal plane, λ_{WORK}*, [%] see **AQD#1**	**< 1%** from reference 1	**65%** from reference 1	**REFERENCE 1**
Surface figure tolerance at AOI_{WORK}**, λ=633 nm, at size [mm] see.app.2	**λ/105 RMS** at 75x25 mm	**λ/105 RMS** at 75x25 mm	**λ/132 RMS** at 75x25 mm
Substrate roughness [nm], see app. 4	**0.3 nm, RMS**	**0.2 nm, RMS**	**0.2 nm, RMS**
Mirror **#1 distances: to source S_1 // to image S'_1**, [mm], (**left** drawing **below**)	**2346** ± 11.7 // **infinite**	**2346** ± 4.7 // **infinite**	**2346** ± 2.3 // **infinite**
Mirror **#2 distances: to source S_2 // to image S'_2**, [mm], (**left** drawing **below**)	**387** ± 1.9 // **infinite**	**387** ± 0.8 // **infinite**	**387** ± 0.4 // **infinite**
Angle **O**f **I**ncidence (**AOI**), [degrees], (**left** drawing **below**)	**71** ± 0.4	**71** ± 0.2	**71** ± 0.1
Mirror substrate material	By deafult: **AstroSitall®** (Zerodur analog, more details see in app. 6)		
Spectral range @ coating	Metall HR **20 - 50 nm** **Standard Au // Enhanced EUV** - see below **AQD#2** and in app. 7		
Oper. conditions: vacuum up to ~10^{-7} mbar, baking at 150 celcius.			
Individual certificate : Dimensions. Optical Distances & AOI. Shape tolerance: 3D topography map, focal spot and surface micro-roughness analyzes. Individually packed in membrane box.			
Uncoated **2 mirrors price** (Lithuania, Vilnius, EXW) and production time [CMU]	4'979 @ 12 weeks	5'725 @ 13 weeks	6'399 @ 14 weeks
Coating: Standard Au // Enhanced EUV, one RUN (**2 pcs**) [CMU]	'328 // '376 + 1 week		
Base offer 2 pcs price (Lithuania, Vilnius, EXW) and production time [CMU]	5'307 // 5'355 @ 13 weeks	6'053 // 6'101 @ 14 weeks	6'727 // 6'775 **@ 15 weeks**
Special offer 2 mirrors total price (discounted and faster) [CMU]	**4'723 // 4'766 @ 11 weeks**	**5'387 // 5'430 @ 12 weeks**	**5'987 // 6'030 @ 13 weeks**
Packing, insurance, delivery (**2 pcs**) **to Your Country, City** [CMU]	167 + 1 week	174 + 1 week	180 + 1 week

* - theoretical simulation for ideal adjustment and work condition; due to diffraction limits specified focal spot size may be available not for whole customer spectral work range.

** - λ_{WORK} = 35 nm AOI_{WORK}= 71.0 degrees





Standard: **CA** </=90% of mirror sizes
(yellow zone on left pictures) plus bevels 0.5x45°
CA >90% => add cost: Start price for best finish polishing on **bigger** substrate with CA<90%, only then add price of
the "***delicate* Cut** +final Certification" procedure

Payments: 80% advance, as for unique optic. Final payments: 30 days after delivery. Warranty: one Year (quoted); other – on request.

This offer valid as contract. References at Precise-Mirrors.ru Other at Zilta.eu

"SIGNED"

Синявский Максим Николаевич

Sinyavsky Maxim

CMU in prices - **C**onditional **M**onetary **U**nits only for EXAMPLE OF THIS TYPICAL quotation

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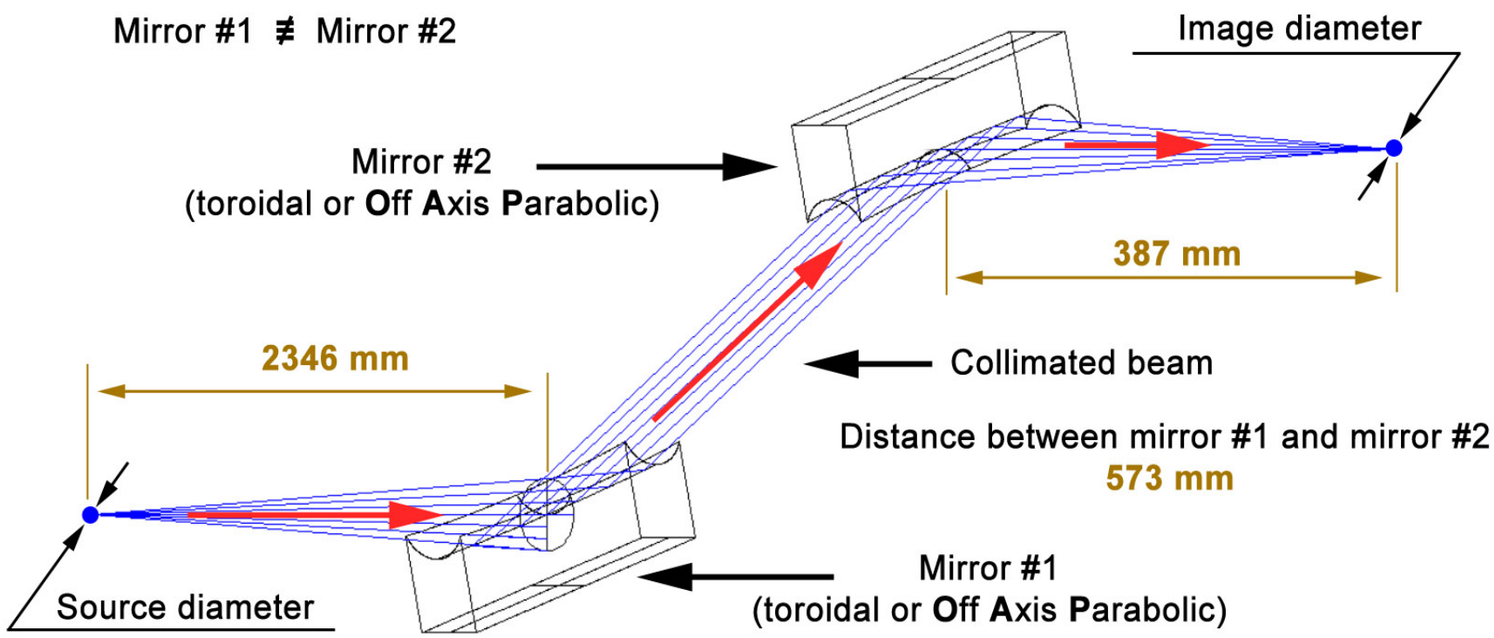
Add **Q**uotation **D**ata (**AQD**) **#1**. Optical scheme used for this quotation: two NOT identical conjugated concave mirrors.



Important notes.

1). The total stochastic distortion Es, which will be in the optical scheme, is calculated by the formula: $E_{sum}=(E_1^2+E_2^2+E_3^2+...)^{0.5}$, where E_1, E_2, E_3 are stochastic distortions on the first, second, third, etc., respectively mirrors.
In our case, this means that if both of our mirrors have an accuracy of, for example, $\lambda/125$ (RMS), then the total accuracy of our optical design (see above) will be $((\lambda/125)^2+(\lambda/125)^2)^{0.5} \approx \lambda/100$ (RMS). Similarly, You can calculate the total distortion for other values of the shape accuracy of each of the mirrors separately (both values are indicated in the quotation table).

2). It's possible to use **or** two conjugated toroidal mirrors, **or** two conjugated Off Axis Parabolic (OAP) mirrors. In some cases (identical mirrors) looks like that both of these options gives a similar result. However, there is a fundamental difference between these options: the stability of the optical system. The second toroidal mirror must compensate the spherical aberrations of the first toroidal mirror, therefore, an optical system of two such mirrors is very sensitive both to the slightest displacement and to the accuracy of manufacturing the surfaces of these mirrors. Below is an example of modeling the stability of an optical system for two cases - toroid-toroid or OAP-OAP.

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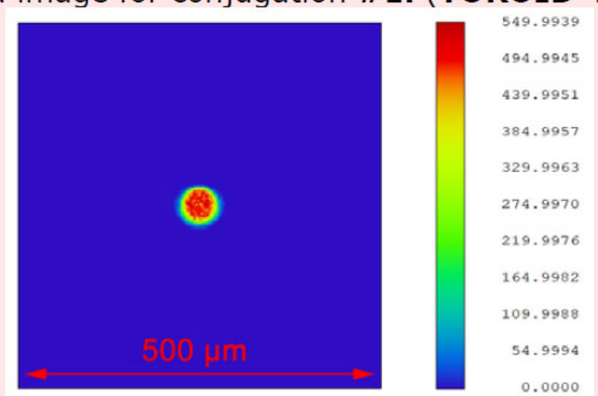
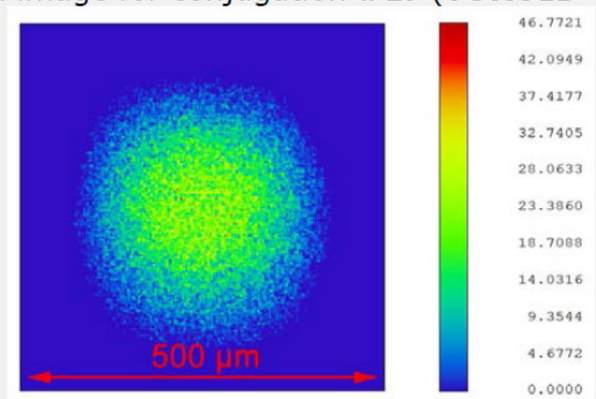
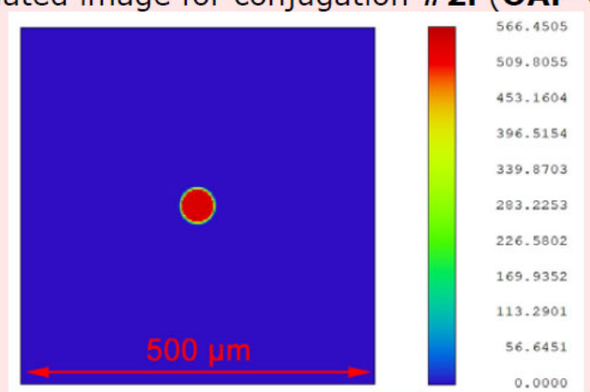
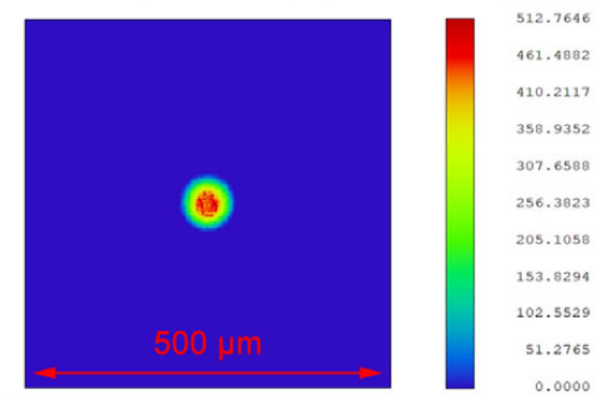
Zemax image simulations. Optical scheme - **EXAMPLE (!) -** «typical optical scheme: source - 800 mm – Mirror#1 - collimated beam – Mirror#2 - 800 mm - Image», uniform light source Ø50 µm, full clear aperture (10x100 mm) usage, shift – parallel in sagittal plane, λ_{cert}=633 nm, simulation wavelength **30 nm**)

«Ideal world»: ideal positioning and ideal mathematical reflective surfaces	**«Real world»:** Micro shift 5 µm and ultra precise (λ_{cert}/100 RMS) reflective surfaces
Simulated image for conjugation **#1i** (**TOROID-TOROID**)  Max. power density [W/cm2] ~ **97 %** from reference	Simulated image for conjugation **#1r** (**TOROID-TOROID**)  Max. power density [W/cm2] ~ **8 %** from reference
Simulated image for conjugation **#2i** (**OAP-OAP**)  Max. power density [W/cm2] - – **REFEFENCE**	Simulated image for conjugation **#2r** (**OAP-OAP**)  Max. power density [W/cm2] ~ **90 %** from reference

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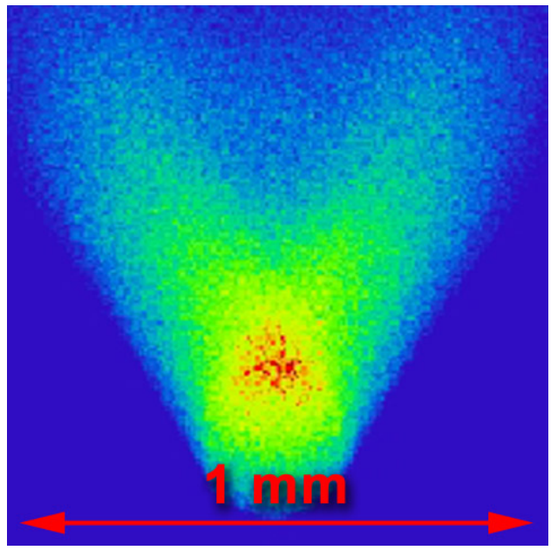
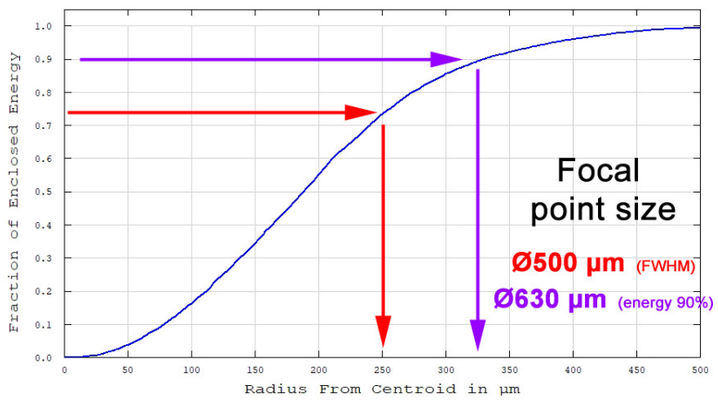
ZEMAX theoretical image analyze for two conjugated mirrors (see scheme at page 2 above)
(beam size on the mirrors – ~Ø25 mm ("light print"), **source Ø40 µm** homogeneous isotropic, simulation wavelength 35 nm)

AFTER TWO CONJUGATED MIRRORS,
OPTION "A" (ultra precise toroids)

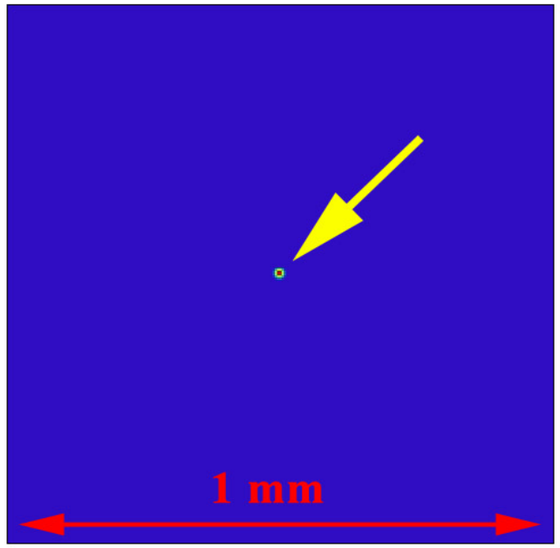


Max. power density [W/cm2] < 0.1% from reference 1

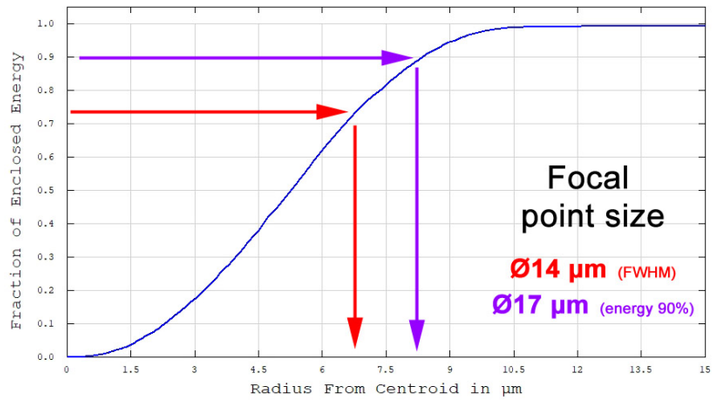


Encircled energy (with diffraction limitations)
(NOT meets customer requirements)

AFTER TWO CONJUGATED MIRRORS,
OPTION "B" (ultra precise Off Axis Parabolic)

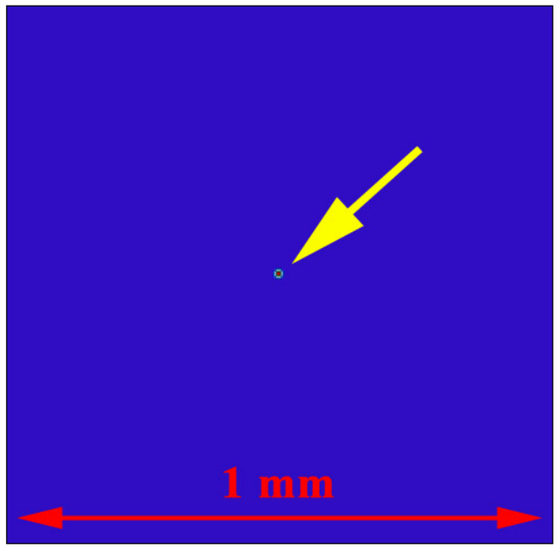


Max. power density [W/cm2] 65% from reference 1

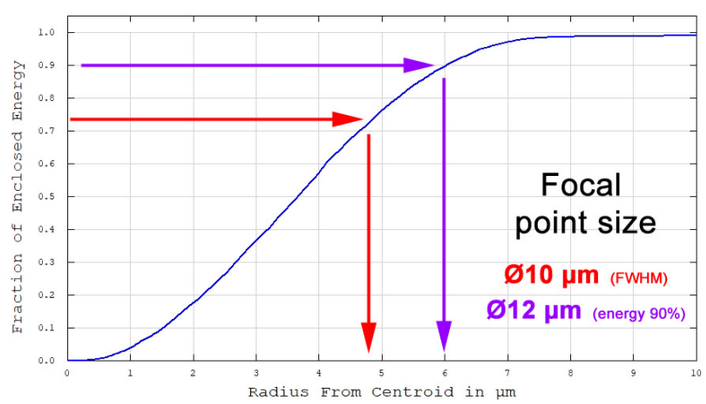


Encircled energy (with diffraction limitations)
(nearly meets customer requirements)

AFTER TWO CONJUGATED MIRRORS,
OPTION "C" (ultra precise Off Axis Parabolic)



REFERENCE 1



Encircled energy (with diffraction limitations)
(nearly meets customer requirements)

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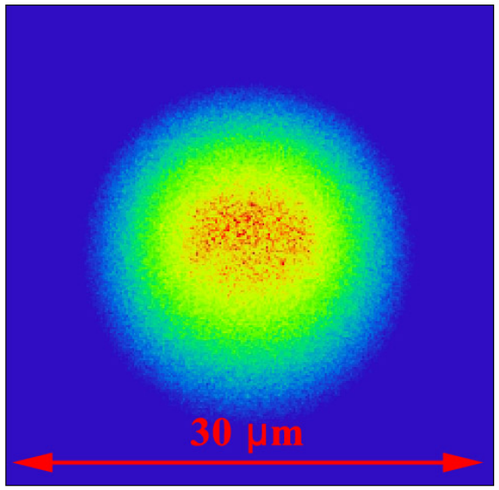
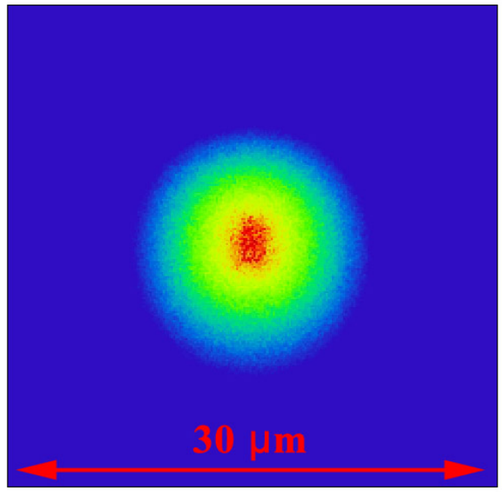
ZEMAX theoretical image analyze for two conjugated **OAP** mirrors (see scheme at page 2 above)
(beam size on the mirrors – ~Ø25 mm ("light print"), **source Ø20 ÷ Ø40 µm** homogeneous isotropic, simulation wavelength 35 nm)

OPTION "B", SOURCE **Ø40 µm**,
focal point image simulation



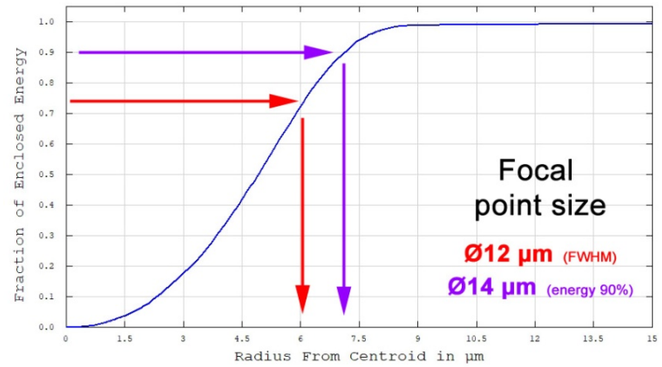
Max. power density [W/cm2] 31% from reference 2

OPTION "C", SOURCE **Ø40 µm**,
focal point image simulation



Max. power density [W/cm2] 66% from reference 2

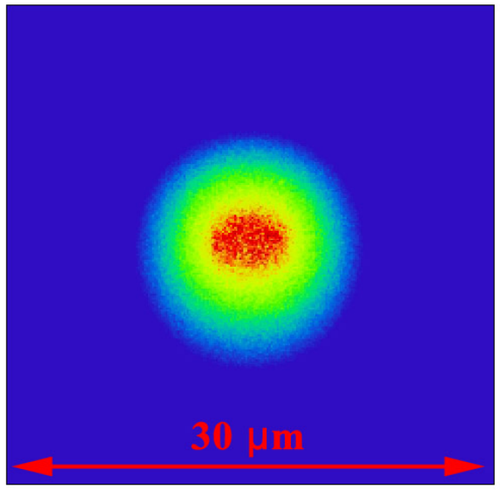
OPTION "B", SOURCE **Ø20 µm**,
energy distribution in focal point



Encircled energy (with diffraction limitations)
(nearly meets customer requirements)

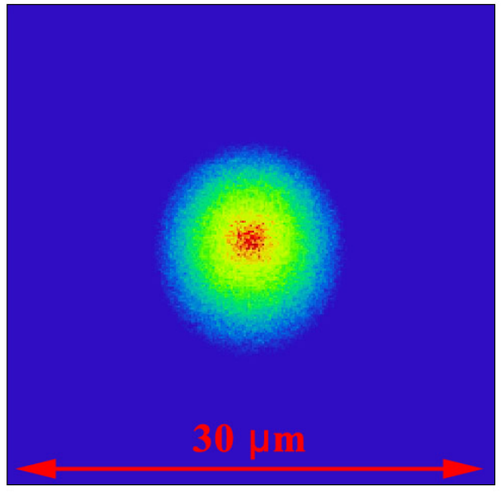
Encircled energy for OPTION "B" and source Ø40 µm at page 4 above

OPTION "B", SOURCE **Ø20 µm**,
focal point image simulation



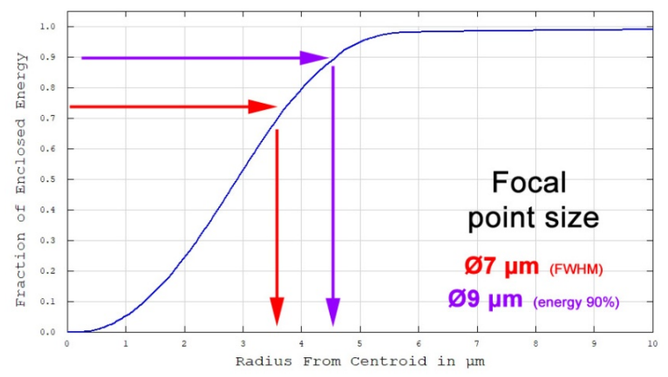
Max. power density [W/cm2] 59% from reference 2

OPTION "c", SOURCE **Ø20 µm**,
focal point image simulation



REFERENCE 2

OPTION "C", SOURCE **Ø20 µm**,
energy distribution in focal point



Encircled energy (with diffraction limitations)
(meets customer requirements)

Encircled energy for OPTION "C" and source Ø40 µm at page 4 above

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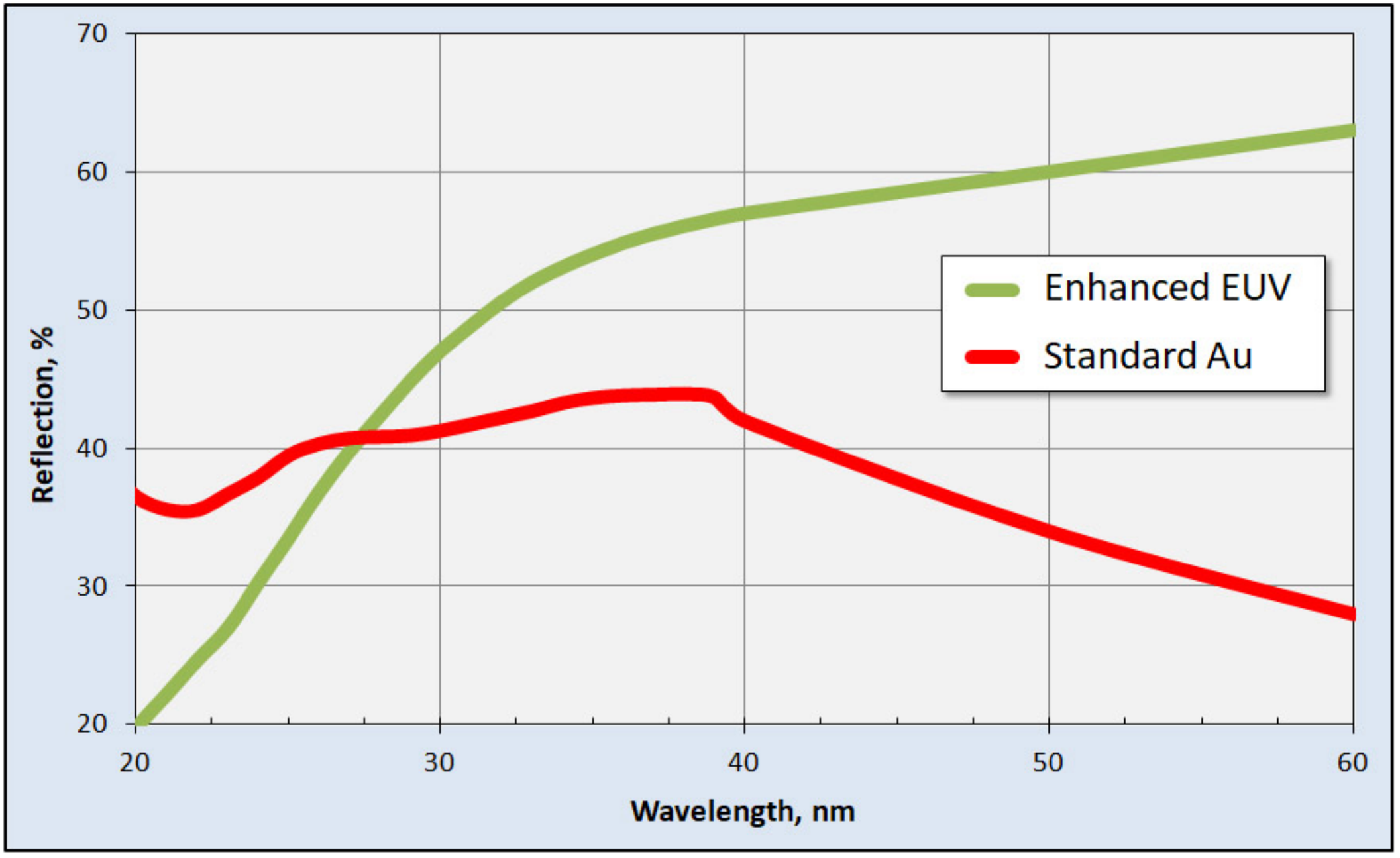
Add **Q**uotation **D**ata (**AQD**) **#2**. Typical reflectance (unpolarized) for
Standard Au and **Enhanced EUV** **at 20 - 60 nm** spectral range **at AOI=71.0 deg**



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