# Beam Steering

Whether in R&D or in product development, our disruptive 2D beam steering solutions offer completely new design and integration possibilities. They can be used in reflection mode (2D mirror) or in transmission mode (tunable prism).

Main features:
2D beam deflection with a single optical element
Large clear apertures and beam angles
Compact & lightweight
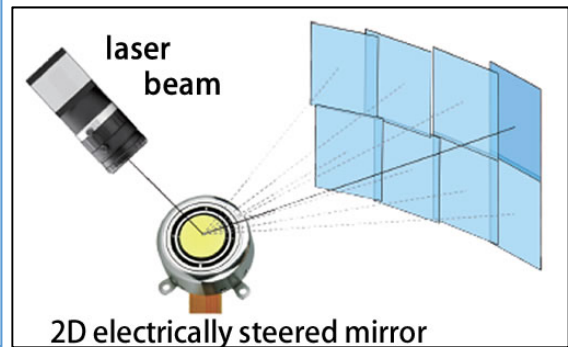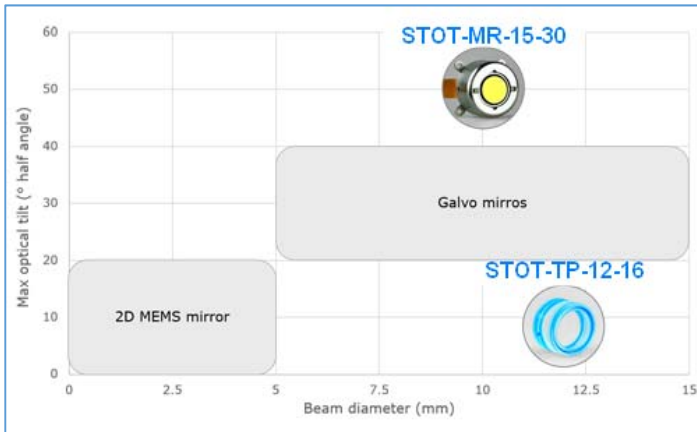
Dual axis vector scan mirror with position feedback
Our dual axis mirrors offer the benefit of large deflections and large mirror size in a compact package. The actuator is based on proven technologies. A built-in position feedback allows it to be accurately controlled with a standard PID controller. The virtual rotation point of our 2D mirrors is close to the mirror surface which makes 2D scanning straight forward. Applications range from automotive (LiDAR, dynamic headlights, ADAS) and vision (field-of-view expansion, zoom) to biometric (eye-tracking), diagnostics and 3D printing.

Tunable prism for laser alignment and image stabilization
Our tunable prism (TP) is suitable for optical alignment and beam-steering in transmission. The core element can be combined with your preferred actuation method and achieve a compact form factor. The low absorption makes it suitable for high-power applications. Thanks to the low dispersion liquid it can also be used for polychromatic applications.

3D beam steering
Combining a 2D mirror for x/y with an electrically focus tunable lens allows you to direct your laser beam spot precisely and fast at any point within the addressable volume. This can be of interest for dynamic headlights, diagnostic and spectroscopic devices and 3D printing.

1. Dual axis vector scan mirrors with position feedback
STOT-MR-15-30, STOT-MR-10-30

Compact, fast and precise beam steering

Our dual axis mirror series (called as voice-coil mirror, scan mirror or beam steering mirror) is the ideal choice for applications that require a large field of view combined with a compact form factor. With a package size of 30 x 14.5 mm it achieves up to ±25° mechanical tilt, corresponding to ± 50° optical deflection. The mirrors contain a position feedback system enabling accurate control of deflection angle within ±100 mrad using a standard PID controller.

In addition to the popular quasi-static version, two resonant versions are available: First, a single axis resonant mirror. Second, a linear axis combined with a perpendicular resonant axis. In contrast to galvo mirror heads, the rotation point is very close to the mirror surface. The mirrors are available for use with light in different wavelength ranges such as UV, VIS, and NIR.

Advantages
Large 2D scan angle
Compact
Precise

Applications
Automotive (LiDAR, dynamic headlights, ADAS)
Vision (field-of-view expansion, zoom)
Biometric (eye-tracking) , diagnostic equipment & 3D printing

Specifications	STOT-MR-15-30	STOT-MR-10-30
Scan direction	bi-axial	bi-axial
Mechanical tilt angle	±25° X axis; ±25° Y axis	±25° (slow) X axis; ±12.5° (fast) Y axis
Mirror diameter	15 mm	10 mm
Resolution (closed loop)	<5 mrad	<5 mrad
Repeatability RMS (typical)	30 - 100 mrad	30 - 100 mrad (slow) X axis
Full scale bandwidth	20 Hz	20 Hz (slow) X axis; 280 Hz (fast) Y axis
Mirror coating	gold, protected silver	gold, protected silver
Mirror reflectivity (gold coating)	avg >97% for NIR	avg >97% for NIR
Mirror flatness (P-V)	l/2	l/2

STOT-MR-15-30   STOT-MR-10-30 Laser Scanning for LiDAR
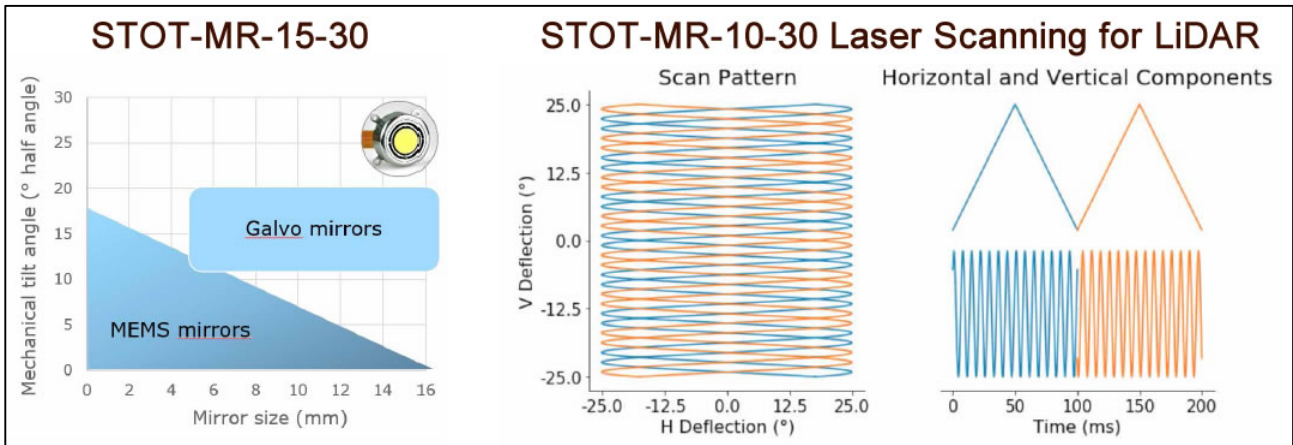
2. Tunable prism for laser alignment and image stabilization STOT-TP-12-16

The tunable prism is a tunable wedge that allows to tilt two optically flat and AR coated glass windows with respect to each other. The two glass windows are held together by a bellow structure that is filled with a low dispersion clear optical fluid. The core element can be integrated with a large variety of actuation principles such as mechanical or motorized lead screws, voice-coil and piezo actuators.

The following table outlines the specifications of our standard tunable prism core element for a particular fluid. Cover glass coatings and fluids can be adapted on demand.

Applications
Intuitive beam-steering in transmission configuration
Alignment between source and detector
Laser range finder
Image stabilization

Customization
Our tunable prism can be taylored to your specific requirements. Contact us with your requirements and we would be happy to assess the feasibility of your project.

The following table summarizes the main specifications of the STOT-TP-12-16:

	Clear aperture	Outer diameter	Max mech. tilt angle	Max. optical deflection
STOT-TP-12-16	12mm	16mm	+/- 20°	8.2°

Mechanical Specifications:
Clear aperture: 12mm
External diameter: 16mm
Thickness: 12 ± 0.5mm
Weight: 3.4g
Max. mechanical tilt angle (center pivot point)1: 20degree

Optical Specifications:
Max optical deflection @ 525nm: 8.2degree
Refractive index (25°C, @525nm): 1.38
Abbe number V (at 25°C): 63
Flatness of windows @525nm: 0.5 lambda
Refractive index vs temperature (dn/dT): -3.3e-4 1/°C
Transmission spectrum: 420-950 nm
Optical damage threshold @ 525nm: Depends on selected coating
Absorption: <0.1%
Polarization change: preserving
Storage temperature: [-40,+85] °C
Operating temperature: [-40,+85] °C

Beam deflection

The beam deflection of a ray passing through the wedge with an apex angle θw from left to right is etermined by
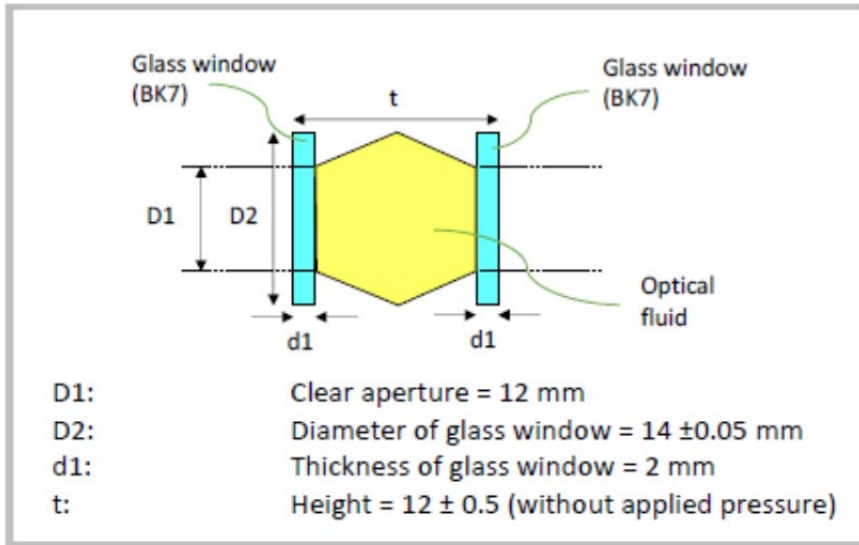
$$\theta_d = \sin^{-1}(n \cdot \sin \theta_w) - \theta_w$$

Where n is the refractive index of the optical fluid inside the wedge.
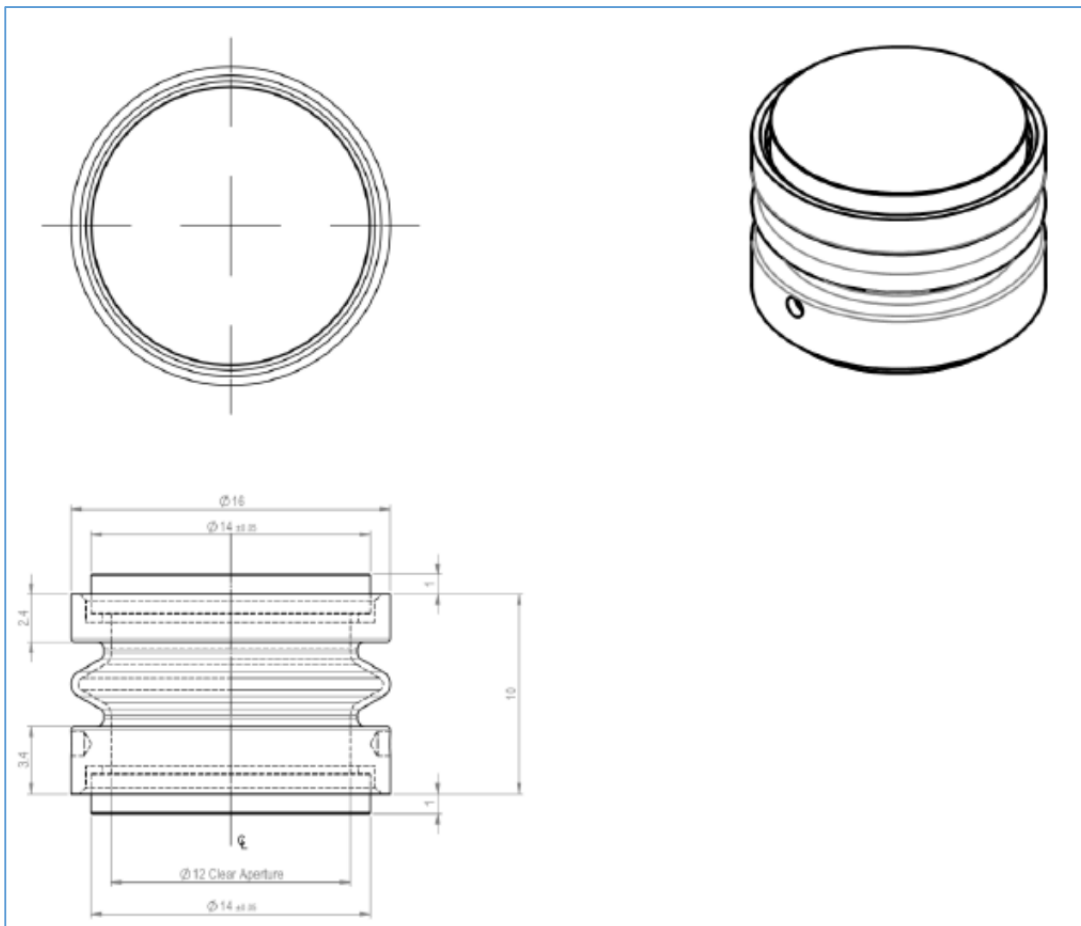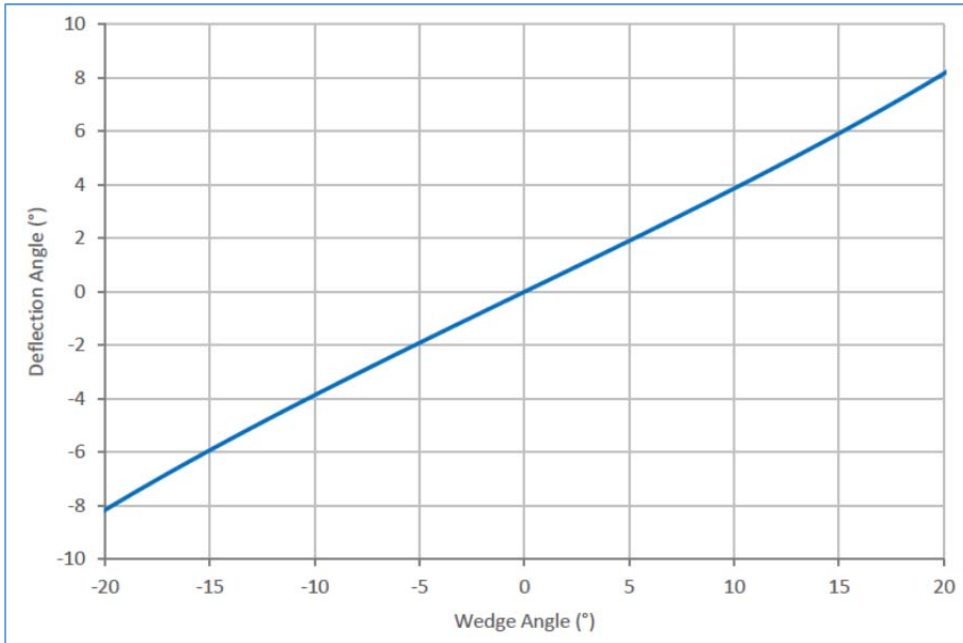
Optical layout

The following figure contains the information needed to model the STOT-TP-12-16 for simulations.

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D1:	Clear aperture = 12 mm
D2:	Diameter of glass window = 14 ±0.05 mm
d1:	Thickness of glass window = 2 mm
t:	Height = 12 ± 0.5 (without applied pressure)

Transmission range

The optical fluid and the two glass windows are highly transparent and hardly absorbing in the range of 250 – 2500nm. The figures below show the transmission spectrum for the standard extended VIS coating (420-950 nm) assuming normal incidence. By request cover glasses can be coated as desired.
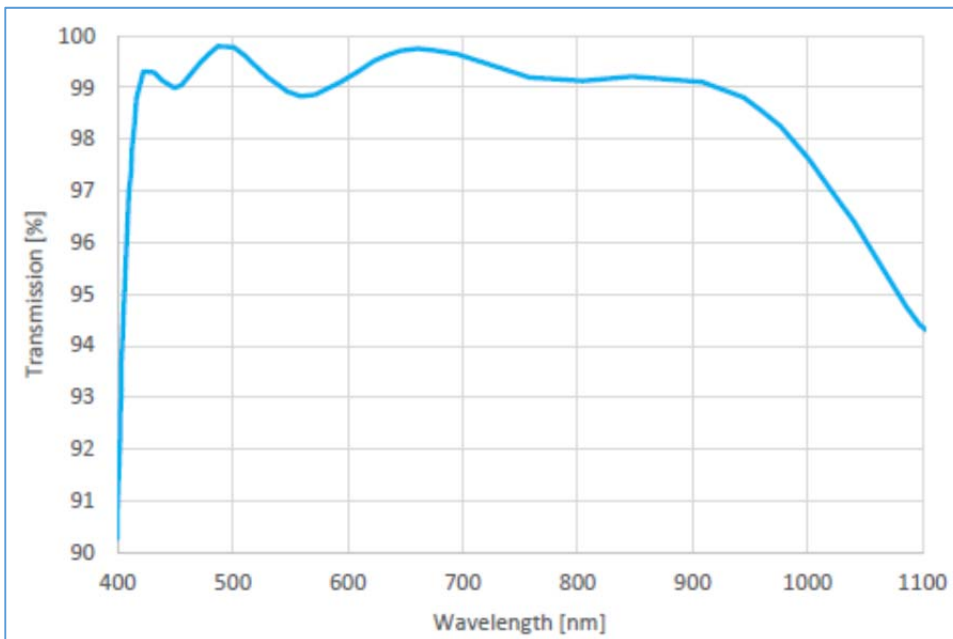
Mounting possibilities

There are various mounting possibilities for the STOT-TP-12-16. A simple mechanical gimbal mount based on off-theshelf components is shown as follows:
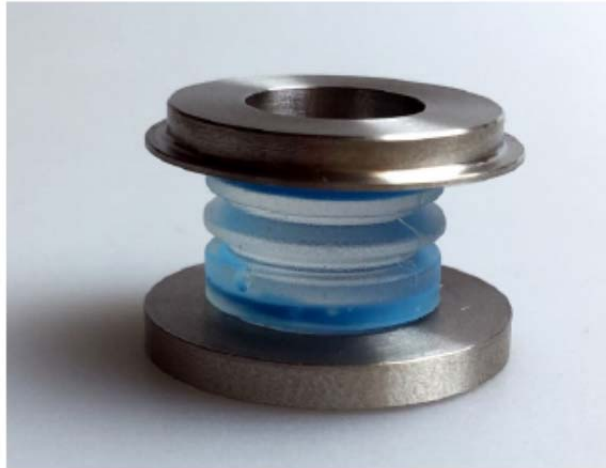
3. Mirror Driver STOT-MR-E-2

The STOT-MR-E-2 driver is an ideal solution for driving the MR-series 2D beam steering mirrors. It consists of a base unit containing control electronics and an integrated head unit with mirror and driving electronics. The driver in the standard version with housings can be used for testing and proof of concept work. The boards without housing are available as OEM version for integration with system electronics.

The driver is compatible only with our mirrors and allows various operation modes. The driver can be controlled from a host PC via our user interface. In addition, the driver offers the following communication interfaces:

USB, UART
SPI (I2C available as customization)
Analog input (± 5 V)
Software SDKs for Python and C# are available. The driver is RoHS, REACH and CE certified.

Standard products	Mirror type included	Components included
STOT-MR-E-2 Base unit	N/A	STOT-MR-E-2 Base unit controller box, power supply, USB cable
STOT-MR-E-2 Mirror head gold	STOT-MR-15-30-G-25x25D	Mirror head (incl. mirror and cable) protection cap, heatsink
STOT-MR-E-2 Mirror head silver	STOT-MR-15-30-PS-25x25D	Mirror head (incl. mirror and cable), protection cap, heatsink
STOT-MR-E-2 Mirror head custom	STOT-MR-C-15-30 (custom mirror), or resonant mirror	Mirror head (incl. mirror and cable), protection cap, heatsink

	STOT-MR-10-30-G/MR-10-30-PS	
STOT-MR-E-2 OEM version	N/A	Carrier board (without housing), CPU board (without housing), proxy board (without mirror head), connection cable

4. Comparison of Scanning Technologies

Tilt vs Mirror Size-competing technologies
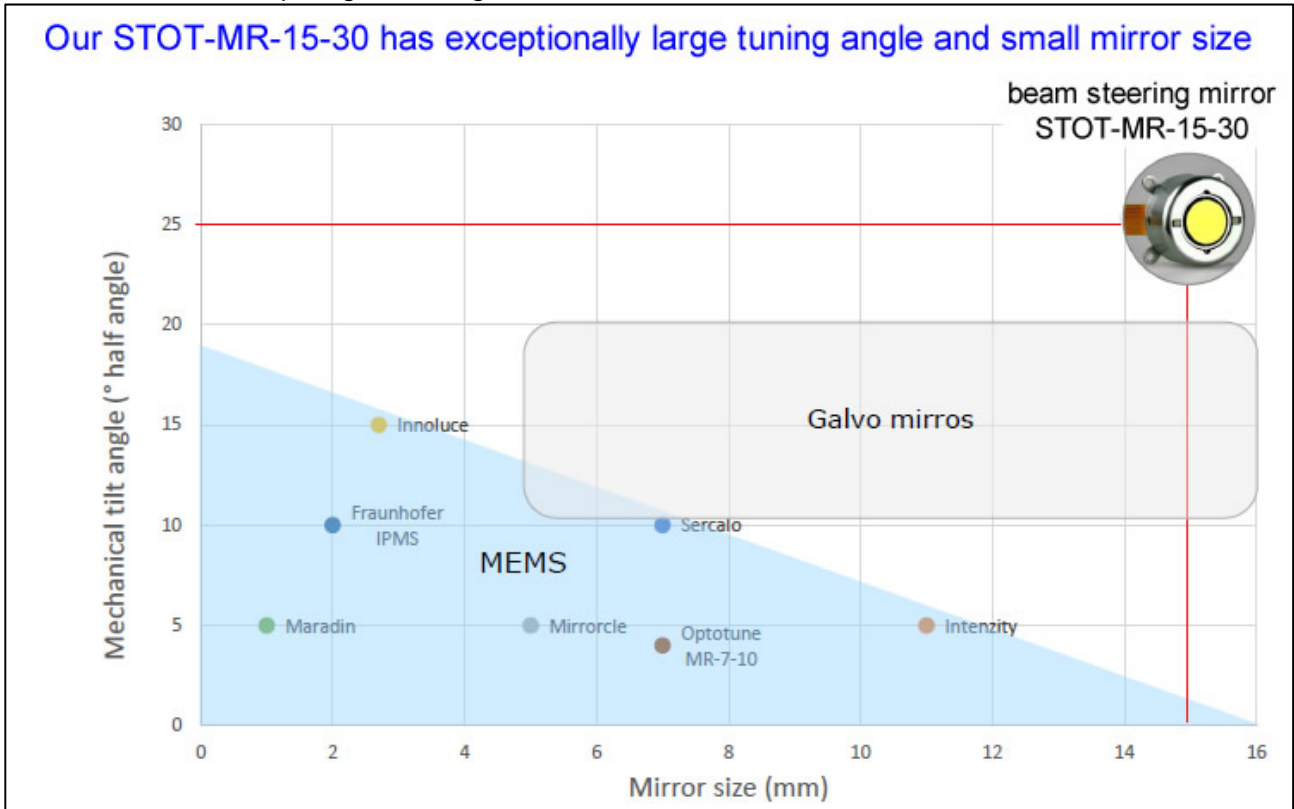
Voice-coil Mirror (VCM, beam steering mirror) in Comparison to MEMS and Galvo