Instrument: Medium-Resolution Echelle Spectrograph (MRES)
Status: In operation
Instrument scientist: Dr David Mrktichian (davidmkrt@narit.or.th)

Purpose and possible applications: MRES is a fibre-fed echelle spectrograph for observation of point-like sources with the visible magnitudes V < 14 in the wavelength region 367-1000 nm with an average resolving power R=λ/Δλ=15,000-20,000 depending on the selected mode. The list of possible applications includes studies of stellar and planetary atmospheres, binary and multiple stars, asteroseismology, and many others where the precise flux calibration and high resolution are not required.

General description: The Medium-Resolution Echelle Spectrograph of the Thai National Telescope consists of two units connected by a nearly 36-m-long fibre. The Nasmyth interface unit is stationary mounted at the instrument cube of the telescope and serves for the purposes of guiding and feeding the main unit through the fibre link with light from the target or from one of two calibration sources. The main unit is a spectrograph comprising one echelle grating, two prisms acting as a cross-dispersor, and a charge-coupled detector-based camera Andor iKon-M. The spectrograph is installed in the specialised room in the observatory building with the temperature-controlled environment, which provides high positional stability.

Guiding: The guiding can be performed in manual (standard, by the telescope operators) or automatic (experimental as of 2025) regime. The configuration of the guiding unit currently provides a circular, 5 arcmin in diameter field-of-view. Under the best observational conditions, the guiding is possible using the stars brighter than 17 magnitude.

The injection configuration of the optical fibre is optimised for image quality (seeing) better than 2 arcsec.

Calibration: Wavelength calibration and flat-fielding with MRES is performed usingh a hollow-cathode lamp of Th-Ar spectrum and a halogen source of the continuum spectrum, respectively. It is recommended to obtain the full set of calibration data (20 files of flat field spectrum and 3-5 files with ThAr) every night before or immediately after observation. In the exceptional cases, additional spectra of Th-Ar can be obtained during the night. The time required to switch the source from the telescope to calibration is normally less than 2 min.

Resolving power: Spectrograph MRES has three working modes with different resolving power (Tab. 1). Switching between the modes is performed manually through installation of a different slit by operators. It is recommended to avoid changing the slits within one night as this procedure requires obtaining a new set of calibrations.

Table 1. List of observational modes

Mode	Slit size (μ)	<R> (λ/Δλ)	Peak throughput (λ 525/750 nm)
1	0.3×0.3	15,000	2% / 3.2%
2	0.3×0.17	18,800	1.5% / 2.4%
3	0.17×0.17	19,000	<1%

Detector and working wavelengths: Starting from December 2024, MRES utilises a new Andor iKon-M detector with 1K×1K pixels format and 13μ pixel pitch. A single image taken

with MRES registers spectrum from 366 to 1000 nm in 61 orders without inter-order gaps before 858 nm. More details are given in Tab 2 and 3.

Table 2. Technical parameters of an Andor iKon-M camera used in MRES

Camera ID	Format (pixels)	Pixel size (μ)	Gain (e^-/ADU)	Readout noise (e^-)	Dark noise (e^-/pix/sec)
DU934P-BV	1024×1024	13.0	1.1	3.2	<0.0002

Table 3. Central wavelength (λ_c) and wavelength range of individual orders.

Order	Echelle order	λ_c (nm)	λ (nm)	Order	Echelle order	λ_c (nm)	λ (nm)
1	96	371.1	366.6 - 375.7	32	65	548.1	541.6 - 554.8
2	95	375.0	370.5 - 379.6	33	64	556.7	550.1 - 563.5
3	94	379.0	374.4 - 383.7	34	63	565.6	558.8 - 572.4
4	93	383.1	378.4 - 387.8	35	62	574.7	567.8 - 581.6
5	92	387.2	382.6 - 392.0	36	61	584.1	577.1 - 591.2
6	91	391.5	386.8 - 396.3	37	60	593.8	586.8 - 601.0
7	90	395.8	391.1 - 400.7	38	59	603.9	596.7 - 611.2
8	89	400.3	395.5 - 405.2	39	58	614.3	607.0 - 621.7
9	88	404.8	400.0 - 409.8	40	57	625.1	617.7 - 632.6
10	87	409.5	404.6 - 414.5	41	56	636.3	628.7 - 643.9
11	86	414.3	409.3 - 419.3	42	55	647.8	640.1 - 655.6
12	85	419.1	414.1 - 424.3	43	54	659.8	652.0 - 667.8
13	84	424.1	419.0 - 429.3	44	53	672.3	664.3 - 680.4
14	83	429.2	424.1 - 434.5	45	52	685.2	677.1 - 693.5
15	82	434.5	429.3 - 439.8	46	51	698.7	690.4 - 707.1
16	81	439.8	434.6 - 445.2	47	50	712.6	704.2 - 721.2
17	80	445.3	440.0 - 450.8	48	49	727.2	718.5 - 735.9
18	79	451.0	445.6 - 456.5	49	48	742.3	733.5 - 751.2
19	78	456.8	451.3 - 462.3	50	47	758.1	749.1 - 767.2
20	77	462.7	457.2 - 468.3	51	46	774.6	765.4 - 783.9
21	76	468.8	463.2 - 474.5	52	45	791.8	782.4 - 801.3
22	75	475.0	469.4 - 480.8	53	44	809.8	800.2 - 819.5
23	74	481.5	475.7 - 487.3	54	43	828.7	818.8 - 838.6
24	73	488.1	482.2 - 494.0	55	42	848.4	838.3 - 858.5
25	72	494.8	488.9 - 500.9	56	41	869.1	858.8 - 879.5
26	71	501.8	495.8 - 507.9	57	40	890.8	880.3 - 901.5
27	70	509.0	502.9 - 515.2	58	39	913.7	902.9 - 924.6
28	69	516.4	510.2 - 522.6	59	38	937.7	926.6 - 948.9
29	68	524.0	517.7 - 530.3	60	37	963.1	951.7 - 974.6
30	67	531.8	525.4 - 538.2	61	36	989.8	978.1 - 1001.6
31	66	539.8	533.4 - 546.4				

Overall performance: Under the typical observational condition at Doi Inthanon, the overall peak performance of MRES is about 2% at 525 nm and exceeds 3% at 750 nm with a slit of

0.3×0.3 μ (Fig. 1). In case of using the rectangular 0.17×0.3 μ slit, MRES loses about 30% of its efficiency, though in reality the losses can be even higher depending primary on the guiding.

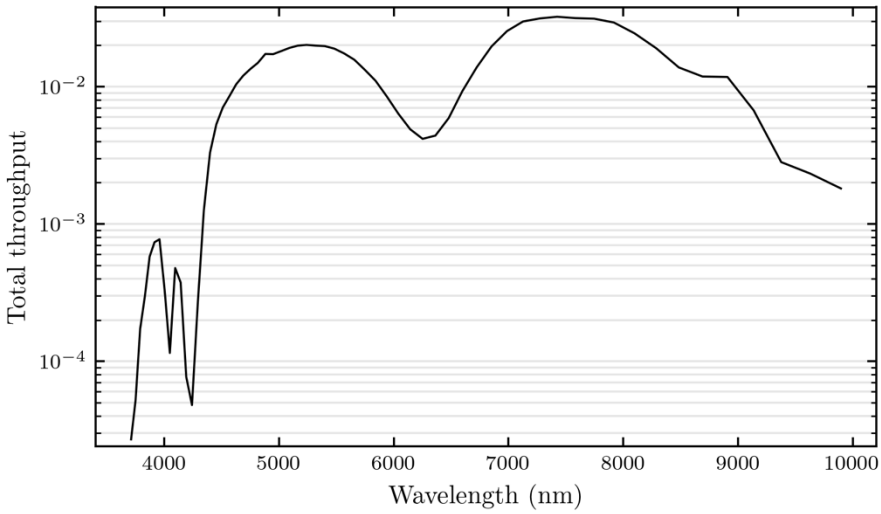

Figure 1. Total throughput of MRES, including atmosphere and telescope optics, measured using a standard star HR 3454 on 13 February 2025 under the standard observational conditions (clear sky, full Moon, no wind, seeing 2-3 arcsec, airmass=1).

To calculate the expected signal-to-noise ratio (SNR), one can use a theoretical curve in Fig. 2 showing the dependence of SNR from brightness for a typical A0 star observed on the bright night at the zenith distance z=45° under the typical observational conditions at Doi Inthanon, and evaluated at λ=525 nm. Accuracy of this estimate is ±20%.

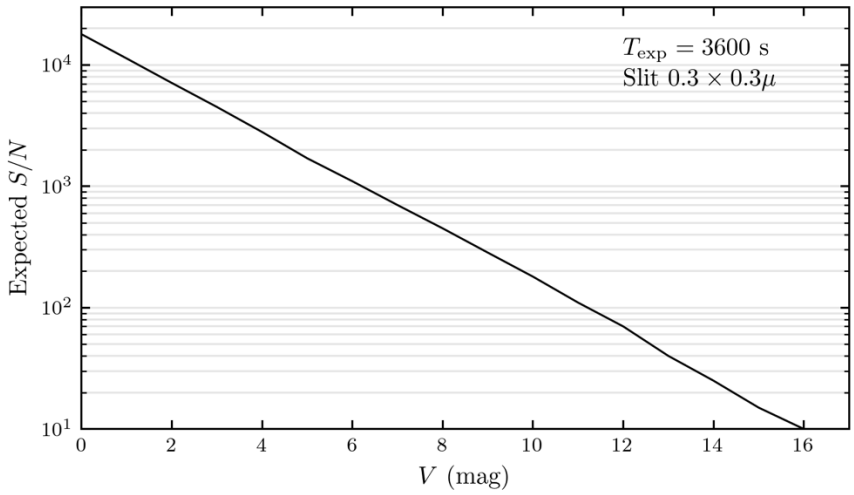

Figure 2. Theoretically achieved SNR measured at 525 nm for a typical A0 star observed with MRES using the slit 0.3×0.3 μ in 1-hour exposure under typical observational conditions.

Data archiving and handling: All spectra obtained with MRES are stored normally in the observational archive of NARIT. Access to the data is regulated by the corresponding institute policies. The raw data can be processed by the end users using their preferred tools or with a python-based pipeline PyYAP, developed exclusively for MRES. The pipeline's code is available on https://github.com/ich-heisse-eugene/PyYAP.