PANalytical

EMPYREAN

Technical specifications

The Analytical X-ray Company

EMPYREAN

Cutting-edge technology in every aspect

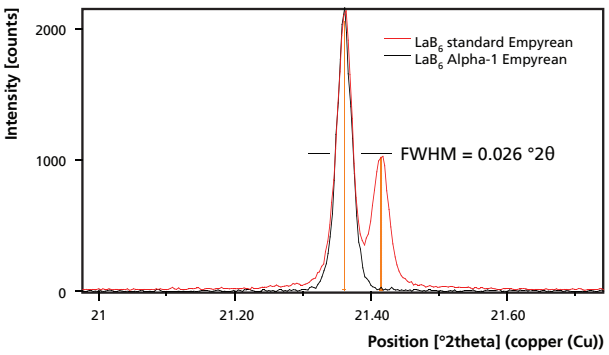
In order to make the ultimate X-ray diffractometer for powders, thin films, nanomaterials and 3D objects, all essential components have been newly developed by our experienced R&D team.

1 **Enclosure is on wheels** for easy installation and relocation.

2 PANalytical's Empyrean Tubes offer robust line/point focus exchange.

3 **The world's most accurate high-resolution goniometer**

Minimum step size 0.0001°, 2θ linearity ±0.01°



Empyrean sets the new bar for laboratory X-ray system resolution, with a FWHM of 0.026 degrees 2theta for the first reflection of NIST SRM660a LaB_6.

4 **The unique PIXcel^{3D} detector,** co-developed with CERN and other leading European scientific institutes - more on next pages

Enclosure

Specifications	
Exterior dimensions	1400 (w) × 1162 (d) × 1947 (h) mm. The instrument is on wheels. It can pass a 989 mm door opening, the absolute minimum door opening is 867 mm.
Accessibility of interior area	1360 (w) × 1100 (h), allowing access to the experimental area by at least four people simultaneously (ideal for teaching)
Weight	1050 kg (2310 lbs.)
X-ray safety	Less than 1 microSievert per hour, measured at 10 cm distance, determined with a Mo source @ 60 kV, 50 mA
Safety loops	XSAFE: two independent safety loops, monitoring the conditions under which the shutter can be opened. XSAFE is set up in such a way, that operation of the instrument with open doors and open shutters is not possible, even for maintenance engineers. MSAFE: Best-in-class protection of users against unexpectedly moving parts by a double mechatronic safety interlock system
Cooling water supply	4 - 6 liters/min, pressure up to 8 bar, temperature 15 to 35 °C > dew point
Compressed air supply	House line, compressor or air bottle; 2-5 bar (0.2 - 0.5 MPa)
Power supply	Single phase 180 - 253 V; 47 - 63 Hz
Maximum power consumption (without controllers for optional equipment)	4.6 kVA

X-ray generation

Specifications	
X-ray generator	4 kW (max 60kV, max 100 mA)
Tube voltage	15 – 60 kV
Tube current	5 - 60 mA
Available anode materials	Cu, Co, Cr, Fe, Mo, Mn, Ag
Focus size	0.4 mm × 12 mm (LFF), 2 mm × 12 mm (BF)
Line/point focus rotation	Standard feature

PIXcel^{3D}

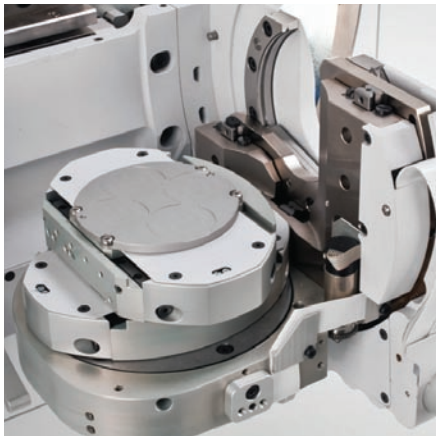
Specifications	
Detector size	256 × 256 pixels
Pixel size	55 µm by 55 µm
Point spread function	1 pixel
Count rate linearity	97% linear count rate per square mm: 13 million photons/(second mm^2)
Background noise	Less than 0.5 counts per second for the whole detector
Dynamical range	Up to 10^{10}
Energy discrimination	Two-level discriminator for rejection of sample fluorescence, higher harmonics and white radiation (user adjustable)
Calibrations needed by user	None
Exchange of detection medium needed	None: solid-state detection technology

Goniometer

Specifications	
Configurations	Vertical goniometer, theta-theta and alpha-1 geometry
Measuring circle diameter (radius)	480 mm (r 240 mm) (can be changed for specific applications)
Goniometer angular range (w/out accessories)	360 degrees
Maximum usable range (depending on accessories)	-111 < 2theta < 168 degrees
Angle positioning	DC motor drives with the next generation direct optical position sensing (DOPS2) using Heidenhain encoders and path tracking technology
Smallest addressable increment	0.0001 degree
2theta linearity over whole range	Equal or better than +/- 0.01 degree
Maximum angular speed	15 deg/sec

Cradles

5-axes cradle (chi, phi, X, Y, Z)



Holds samples up to 80 mm diameter and 16 mm height, maximum weight 0.5 kg.
With mapping range of 54 mm × 54 mm, or 2" wafers.
The cradle has a chi tilt range of 96 degrees and phi rotation range of 720 degrees.

Options:
- dial gauge
- automatic height optimization
- microscope
- sample holder 80 mm (w or w/o levelling option)
- in-plane sample holder
- clamping device for PW18xx circular sample holders
- holder for 4×32 mm samples
- beam knife for line detector
- beam knife for reflectometry

3-axes cradle (chi, phi, Z)

Holds samples up to 140 mm diameter and 64 mm height, maximum weight 2 kg.
Can handle non-ambient chambers like the DHS1100.
The cradle has a chi tilt range of 96 degrees and phi rotation range of 720 degrees.

Options:
- sample holder 140 mm (w or w/o levelling option)
- transmission capabilities up to 40 degrees 2theta
- dial gauge
- automatic height optimization
- microscope
- clamping device for PW18xx circular sample holders
- beam knife for line detector
- beam knife for reflectometry

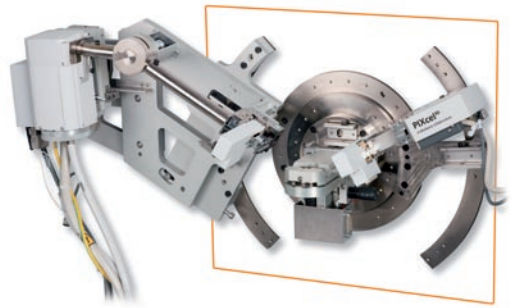
PreFIX optics

PreFIX (**pre**-aligned, **f**ast **i**nterchangeable **X**-ray) is PANalytical's established method for robust, alignment-free component exchange. It allows for best performance, for every sample and application.

Incident beam optics, line focus

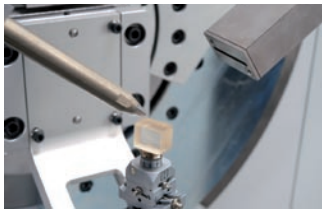
- Programmable divergence slit module
- Fixed divergence slit module
- Parabolic mirror (Cu, Co, others upon request)
- Focusing mirror (Cu, Co, Mo, Ag, others upon request)
- Hybrid monochromator 2×Ge(220) for Cu, Co
- Hybrid monochromator 4×Ge(220) for Cu, Co
- 4×Ge(220) monochromator line focus asym. for Cu*
- 4×Ge(220) monochromator line focus sym. for Cu*
- 4×Ge(440) monochromator line focus sym. for Cu*
- Symmetric incident beam Johansson monochromator for Cu or Co

* *Can also be used for point focus applications*



Incident beam optics, point focus

- Monocapillary (available exit diameters from 50 µm to 1000 µm)
- Crossed slits collimator
- Double crossed slits collimator
- X-ray polycapillary lens
- 4×Ge(220) monochromator line focus asym. for Cu
- 4×Ge(220) monochromator line focus sym. for Cu
- 4×Ge(440) monochromator line focus sym. for Cu

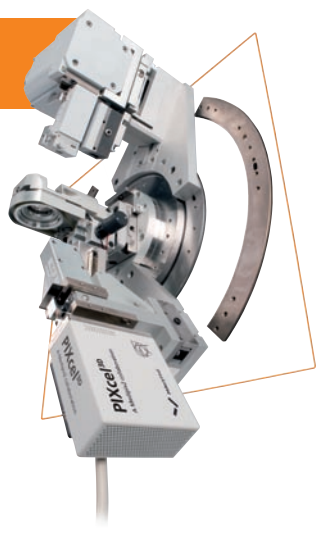


Diffracted beam optics

- Set of fixed receiving slits
- Set of fixed anti-scatter slits
- Programmable receiving slit
- Programmable anti-scatter slit with two independent motors, also for X'Celerator and PIXcel^{3D}
- Parallel plate collimators (0.09, 0.18, 0.27 degree)
- PreFIX 3-bounce sym. analyzer for Cu
- PreFIX 2-bounce asym. analyzer for Cu
- Rocking curve optics
- Diffracted beam parabolic mirror (Cu, Co)
- Diffracted beam monochromators for all detectors, including X'Celerator and PIXcel^{3D}
- 2nd diffracted beam path for automatic exchange between combinations of two diffracted beam optical modules
- Radius reduction interfaces 85 mm and 185 mm

Detectors

	0D	1D	2D	3D
Xe proportional detector (optional monochromator)	✓			
Scintillation detector (optional monochromator)	✓			
X'Celerator (optional monochromator)	✓	✓		
PIXcel^{3D} (optional monochromator)	✓	✓	✓	✓



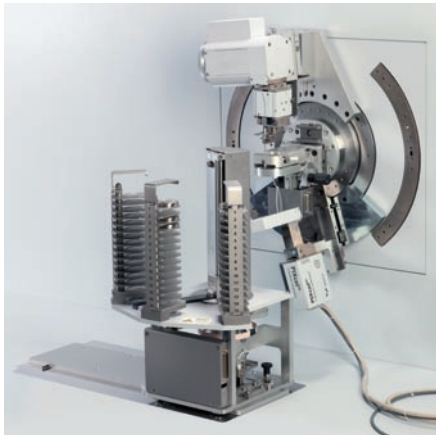
PreFIX sample stages

PreFIX sample stages can be easily removed from the goniometer and exchanged without realignment.

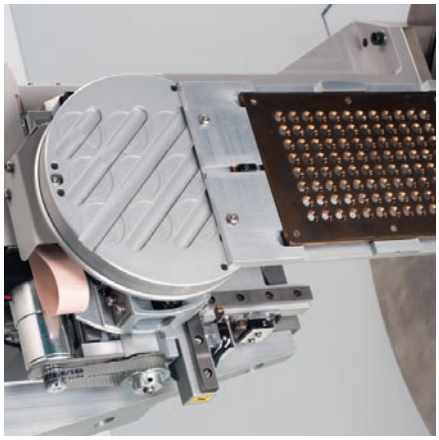
Non-spinning stages
- Programmable XYZ stage
- High-throughput stage
- Multi-purpose sample stage (MPSS)
- Pre-aligned capillary holder stage
- Flow cell for in situ crystallization research

Spinning stages
- Reflection transmission spinner stage
- Capillary spinner
- Microdiffraction spinner
- Computed tomography rotating stage

Stages with tilt capability
Empyrean's tilting stages are hot-swappable: they can be PreFIX exchanged and stored elsewhere without power interruption
- 3-axes cradle (chi, phi, Z)
- 5-axes cradle (chi, phi, X, Y, Z)



Sample stages for high temperature
All non-ambient chambers with Z-axis feature computer-controlled sample height optimization and automatic compensation for temperature-induced displacements of the sample
- HTK1200N rigid with Z-axis
- HTK1200N spinner with Z-axis
- HTK16N with Z-axis
- HTK2000N with Z-axis
- HTK2000N W with Z-axis
- Domed Hot Stage DHS1100



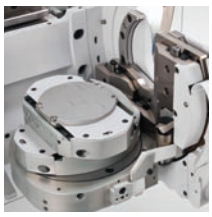
Sample stages for low and medium temperatures
All non-ambient chambers with Z-axis feature computer-controlled sample height optimization and automatic compensation for temperature-induced displacements of the sample
- TTK450 with Z-axis
- Oxford PheniX cryostat with Z-axis
- Cryo & Humidity Chamber (CHC Plus) with Z-axis

Transmission non-ambient stages
- VGI 2000M controlled temperature and humidity cell
- Cryostream Plus for cooling and heating of samples in glass capillaries

Reaction and high pressure stages
All non-ambient chambers with Z-axis feature computer-controlled sample height optimization and automatic compensation for temperature-induced displacements of the sample
- Reaction chamber XRK900 rigid with Z-axis
- Reaction chamber XRK900 spinner with Z-axis
- High Pressure Chamber HPC 900 with Z-axis

Sample changer for reflection transmission spinner stage
- 15 sample positions, upgradeable to 45 sample positions

5 **New, unique PreFIX sample stages**

6 **Universal PreFIX**
The Empyrean system is equipped with universal PreFIX optics, stages and accessories, PANalytical's proven proprietary kinematic mounting concept for pre-aligned fast interchangeable X-ray modules.

7 **Wide opening cabinet** gives easy access to the experimental area.


8 **Comprehensive software suite** for data collection and analysis.

9 **Meets all relevant worldwide regulations,** for X-ray, electrical and mechanical safety.

10 **19 inch rack mounts** offering easy access to non-ambient controllers and integrated vacuum system

PANalytical

Global and near

PANalytical
PANalytical is the world's leading supplier of analytical instrumentation and software for X-ray diffraction (XRD) and X-ray fluorescence spectrometry (XRF), with more than half a century of experience. The materials characterization equipment is used for scientific research and development, for industrial process control applications and for semiconductor metrology.
PANalytical, founded in 1948 as part of Philips, employs around 900 people worldwide. Its headquarters are in Almelo, the Netherlands. Fully equipped application laboratories are established in Japan, China, the USA, and the Netherlands. PANalytical's research activities are based in Almelo (NL) and on the campus of the University of Sussex in Brighton (UK). Supply and competence centers are located on two sites in the Netherlands: Almelo (development and production of X-ray instruments) and Eindhoven (development and production of X-ray tubes). A sales and service network in more than 60 countries ensures unrivalled levels of customer support.
The company is certified in accordance with ISO 9001:2000 and ISO 14001.

The product portfolio includes a broad range of XRD and XRF systems and software widely used for the analysis and materials characterization of products such as cement, metals and steel, nanomaterials, plastics, polymers and petrochemicals, industrial minerals, glass, catalysts, semiconductors, thin films and advanced materials, pharmaceutical solids, recycled materials and environmental samples.

Visit our website at www.panalytical.com for more information about our activities.

PANalytical is part of Spectris plc, the precision instrumentation and controls company.

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