Hadron & Nuclei Spectroscopy

Spaceborn Satellite

Particle Accelerator

Dark Matter

Cosmic Particles

Standard Model Validation

Neutrino

Ground Detectors

# Beyond imagination

Pushing the boundaries of science,
from **imagination into reality**

Deep Underground & Underwater Detector

HAMAMATSU

PHOTON IS OUR BUSINESS

# From imagination into reality

From the observation of shimmering stars to the collision of galaxies far away, Hamamatsu Photonics has been driven to support and collaborate with the most groundbreaking scientific experiments worldwide. Fascinated by the power of light and how it can help us understand the meaning of our universe, we pursue our passion for discovering the unknown. To do this, we specialize in helping customers visualize, measure, and analyze crucial information through the wonders of photonics technology.

## From a dream to a worldwide corporation

From its humble beginnings as a small research laboratory in Hamamatsu City, Japan, the company has grown into a world-renowned provider of sophisticated detectors, sources, and imaging products ranging from components to full-blown systems.

### Our company

**70 years +** experience

**90%** PMT market share

**1.6 billion euros** in sales turnover

**10 research & manufacturing facilities**

**IEEE Milestone Certification** for 20-inch PMT

### CERN collaboration

**9 Contracts** signed with CERN for ATLAS and CMS HL-LHC upgrades

**2008** | European Organization for Nuclear Research Recognition for involvement in CERN

### Nobel Prize contributions

**2002 | 2015**
**Masatoshi Koshiba & Takaaki Kajita**
World's first successful observation of neutrinos using our PMTs

**2013**
**Francois Englert & Peter W. Higgs**
Detection of Higgs bosons thanks to our SSD, APD and PMTs

**2015**
**Takaaki Kajita**
Discovery of neutrino oscillations that indicate a neutrino has a mass

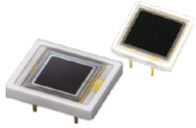
Please note that these figures have been taken in 2023 and may be subject to change.

## A Selection of Key Products for High Energy Physics Applications

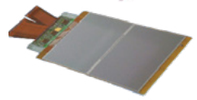
To view a wider selection, please visit:
hep.hamamatsu.com

**PMTs, Assemblies, Modules**

**MPPC®s, Arrays & Modules**



**Large Area APDs & Arrays**



**Silicon Strip Detectors**

## From impossible to possible

You can count on us to offer:

**Highest-quality products**

**Manufacturing capabilities**

**Customization**

**Collaboration**

From the first meeting to delivery, we pride ourselves on our successful long-term relationships with our customers. We collaborate with research institutes from all over the world, working with them to find the right technology for their specific experiment. This means being able to advise, often adapt existing technologies, and manufacture these bespoke products while maintaining the highest quality.

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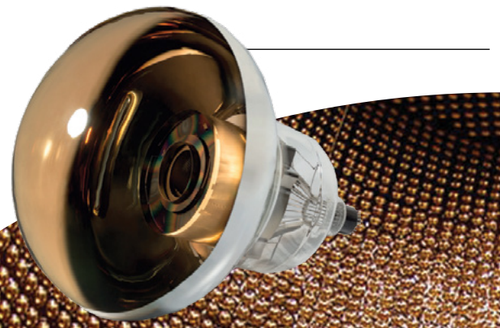
# Highest-quality products

Hamamatsu Photonics' products are known for their high quality in terms of reliability, robustness, and performance. Our technological know-how has been guided by our participation in numerous scientific experiments, which have pushed our performance beyond expectations.

We have mastered the techniques of photocathode fabrication by both handcrafting the glasswork and automating the mass production of glass. This combination of skills and capabilities makes our products not only refined but also able to respond to experimental needs.

Famous for our photomultipliers, our product line has dramatically increased since its inception in 1959. From the smallest 3/8-inch diameter photomultiplier tubes (R1635) to the world's largest 20-inch hemispherical tubes (R12860), our customers are able to rely on a variety of features including shape, size, and spectral response range as well as our ability to adapt to their needs.

For this reason, we own 90% of the world market share.



The world's largest 20-inch hemispherical tube, R12860, will be used for the Hyper-Kamiokande, a neutrino observatory and experiment under construction in Japan (based on the highly successful Super-Kamiokande experiment).



## Photomultiplier Tubes (PMTs)

### Key features

- High gain
- Low noise
- Wide range of spectral responses
- Variety of photosensitive areas
- Bare tubes, assemblies, and modules

To view a wider selection, please visit:
hep.hamamatsu.com

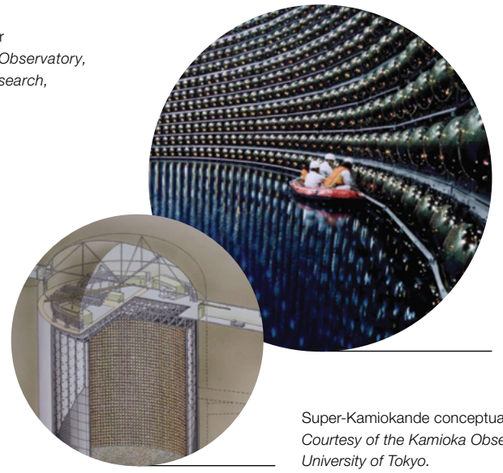
**Case study**

## Kamiokande

Kamioka Nucleon Decay Experiment

Over 11,000 of our PMTs are lined up in the world's largest underground neutrino detector, the Super-Kamiokande. Buried deep within the earth of Japan, this golden observatory seeks to study how matter was created in the early universe. Originally known as Kamiokande, our PMTs contributed to the world's first successful observation of neutrinos. They exceeded in performance and demonstrated resilience to the harsh underwater environment for years.

Super-Kamiokande detector
*Courtesy of the Kamioka Observatory, Institute for Cosmic Ray Research, University of Tokyo.*



Checking PMTs
*Courtesy of the Kamioka Observatory, Institute for Cosmic Ray Research, University of Tokyo.*

Super-Kamiokande conceptual diagram
*Courtesy of the Kamioka Observatory, Institute for Cosmic Ray Research, University of Tokyo.*

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# Manufacturing capabilities

Hamamatsu Photonics boasts 7 factories in Japan as well as 1 in China, the USA, and South Korea. Each of our factories focuses on specific technologies, business operational efficiency, information sharing, and customer response speed.

We are one of very few that manufactures both photodetectors and light sources. This gives us the advantage of being able to propose an optimum set of photodetectors and light sources that are specifically designed, developed, and manufactured to match each application.

In addition, we have been able to adapt certain manufacturing capabilities*. To meet the high-tech needs of the European Laboratory for Particle Physics' (CERN) CMS experimental apparatus in the High Luminosity Large Hadron Collider (HL-LHC) experiments, we designed and developed a unique 8-inch pixel array detector. It is the world's largest photodiode (PD) with high radiation resistance among PD detectors used in high-energy physics. To accommodate this, a mass-production system was created for this detector.

*Please note that this capability depends entirely on the request. However, our philosophy is always to try!

Hamamatsu's APDs helped confirm the existence of the Higgs boson unraveling the mysteries of the birth of the universe. Other products included SSDs.





## Large-area Photodiodes, APDs, and Arrays

### Key features

- Large photosensitive area options (>100mm²)
- Photodiodes designed for direct detection of high-energy particles and X-rays
- Variety of package types
- Array options for spatial resolution

To view a wider selection, please visit:
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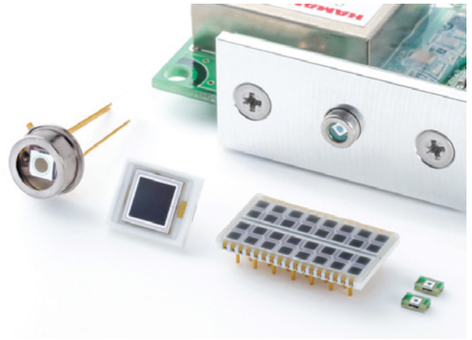


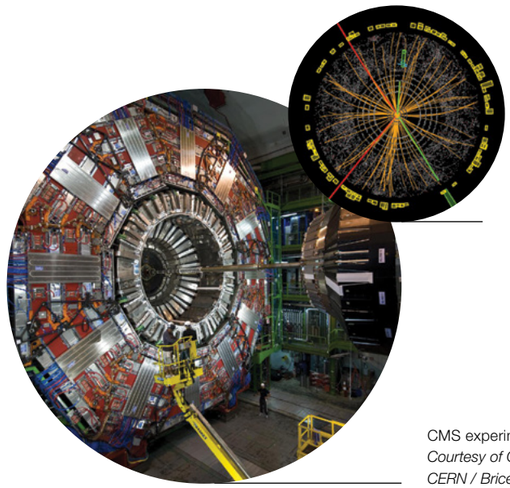
### Case study

## CERN

European Laboratory for Particle Physics

Physicists and engineers are replacing the heart of the CMS experiment - the pixel detector. *Courtesy of CERN, Conditions of Use © 2017 CERN / Brice, Maximilien*

Almost 50 years after first being proposed, the Higgs boson's existence was finally confirmed by CERN's Large Hadron Collider (LHC), the world's largest accelerator stretching in a 27km ring in Switzerland. Our SSDs (Silicon Strip Detectors) contributed to this great discovery. They detected the tracks along which the particles pass to a resolution within a few dozen micrometers.



Higgs boson experiment
*Courtesy of CERN, Conditions of use © 2012 CERN*

CMS experiment
*Courtesy of CERN, Conditions of Use © 2017 CERN / Brice, Maximilien*

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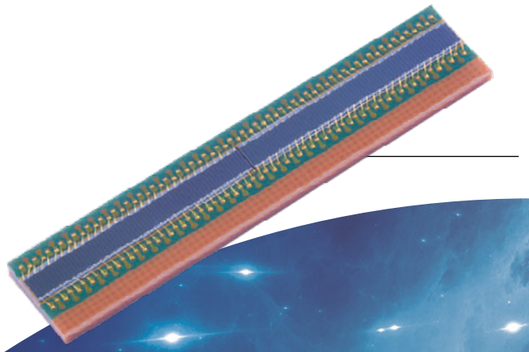
# Customization



Since every scientific experiment is unique, we have developed the know-how to propose unique solutions. As most of our products are made in-house, we can customize the shape, size, and electromagnetic spectrum to achieve various applicational needs.

Many years ago, we developed the house brand Multi-Pixel Photon Counter or MPPC® (Silicon photomultiplier) which has proven to be of great interest since it offers high sensitivity, compared to APDs for example, yet is also robust and compact.

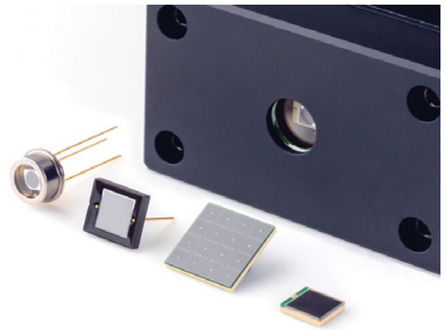
For the Cherenkov Telescope Array, the shape, dimensions, and microcell size of the MPPC©s were evaluated from a fully customized hexagonal structure to a more typical square with 75 x 75 µm cells. Another example is the S13552, a one-dimensional 128-element MPPC array used by the scintillating fiber tracker in LHCb (Large Hadron Collider beauty experiment), LHC of CERN. Often, the technology required does not exist, yet scientists collaborating with our researchers have worked together to find the optimal solution.



One of our many MPPC®s. This one-dimensional 128-ch array is a custom-made device originally developed for the SciFi Tracker at LHCb experiment at CERN. It was the first of this size when commissioned.

CTAO Telescopes in Southern Hemisphere
*Courtesy of Credit: Gabriel Pérez Diaz (IAC)/Marc-André Besel (CTAO)/ESO/ N. Risinger (skysurvey.org)*

## Multi-Pixel Photon Counters (MPPC®s) / Silicon Photomultipliers (SiPMs)



### Key features

- High gain and photon detection efficiency
- Range of photosensitive areas
- Immunity to magnetic fields
- Resistance to excess light
- Module and array options

To view a wider selection, please visit:
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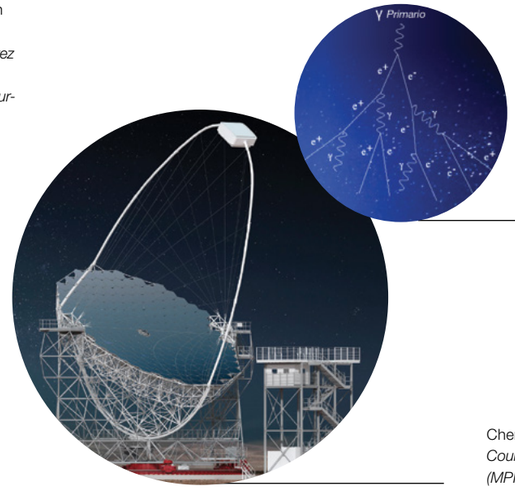
### Case study

## CTA

Cherenkov Telescope Array

The next generation of telescopes, CTA, was born from the idea of creating unprecedented technology. Hundreds of thousands of our PMTs and MPPC®s are helping achieve this by capturing ultra-high energy gamma rays with the hope of addressing some of the most perplexing questions in astrophysics.




Proposed CTAO Telescopes
*Courtesy of Gabriel Pérez Diaz, IAC*

Cherenkov Effect
*Courtesy of R. White (MPIK) / K. Bernlohr (MPIK) / DESY*

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# Collaboration

Finally, we are proud to claim over 50 years of experience in collaborating with the most prestigious research facilities around the world. Since we started expanding our sales territories across the globe, we have been able to support researchers internationally.

It was through collaboration that Hamamatsu managed to advance its technology. The company transformed its technology to fit the exact requirements for the XENONnT experiment by engaging in high levels of communication with its researchers. From researchers across Europe to engineers in Japan, together, they built and tested the ideal PMT from one end of the world to another.

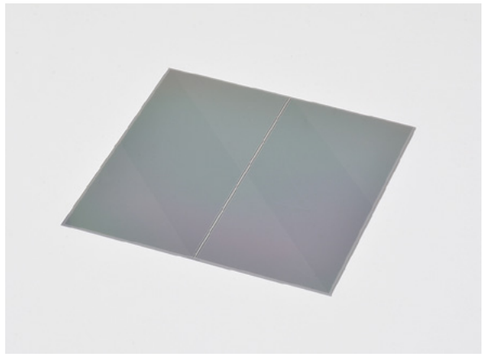
We are also thrilled about the work done with FERMI, a gamma-ray space telescope developed in collaboration with the U.S. Department of Energy, along with important contributions from academic institutions and partners across Europe and our headquarters in Japan. The collaboration ended in success in part because FERMI was able to deliver on budget, on time and launch the largest silicon instrument ever in space to this day.

One of our many Strip detectors. This single-sided SSD was developed for J-PARC muon g-2/EDM experiment and can detect incident positions of high-energy particles with high accuracy.

## Silicon Strip Detectors (SSDs)

### Key features

- Large area coverage
- Accurate position sensitivity (micron level)
- Designed for direct detection of high energy particles



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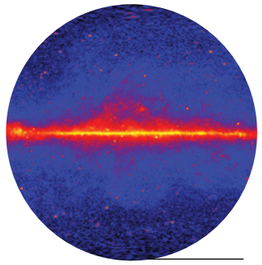
### Case study

## FERMI

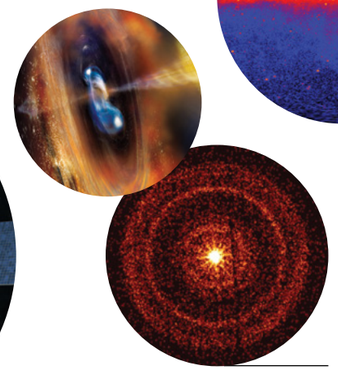
Gamma-ray Space Telescope

NASA's Fermi Gamma-ray Space Telescope, illustrated here, scans the entire sky every three hours as it orbits Earth.
*Courtesy of NASA's Goddard Space Flight Center/Chris Smith (USRA/GESTAR)*

Placed into a circular orbit around Earth with an altitude of about 560 km, it circles the planet every 90 minutes. Known as the Fermi Gamma-ray Space Telescope, it observes our cosmos using the highest-energy form of light. It is a testament to Hamamatsu's strip detectors which have proven to be the most reliable and robust over the last 15 years.



Fermi's 12-year View of the Gamma-ray Sky
*Courtesy of NASA/DOE/Fermi LAT Collaboration*



NASA's Fermi, Swift Capture Revolutionary Gamma-Ray Burst
*Courtesy of A. Simonnet (Sonoma State Univ.) and NASA's Goddard Space Flight Center Courtesy of NASA/Swift/A. Beardmore (University of Leicester)*

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contact@hamamatsu.eu

# From us to you

Contact one of our many sales offices across the world, our sales engineers will be able to assist you with your questions.

**BEYOND IMAGINATION**
Photonics Solutions for High Energy Physics
FEBRUARY 2024
Created by Hamamatsu Photonics Europe