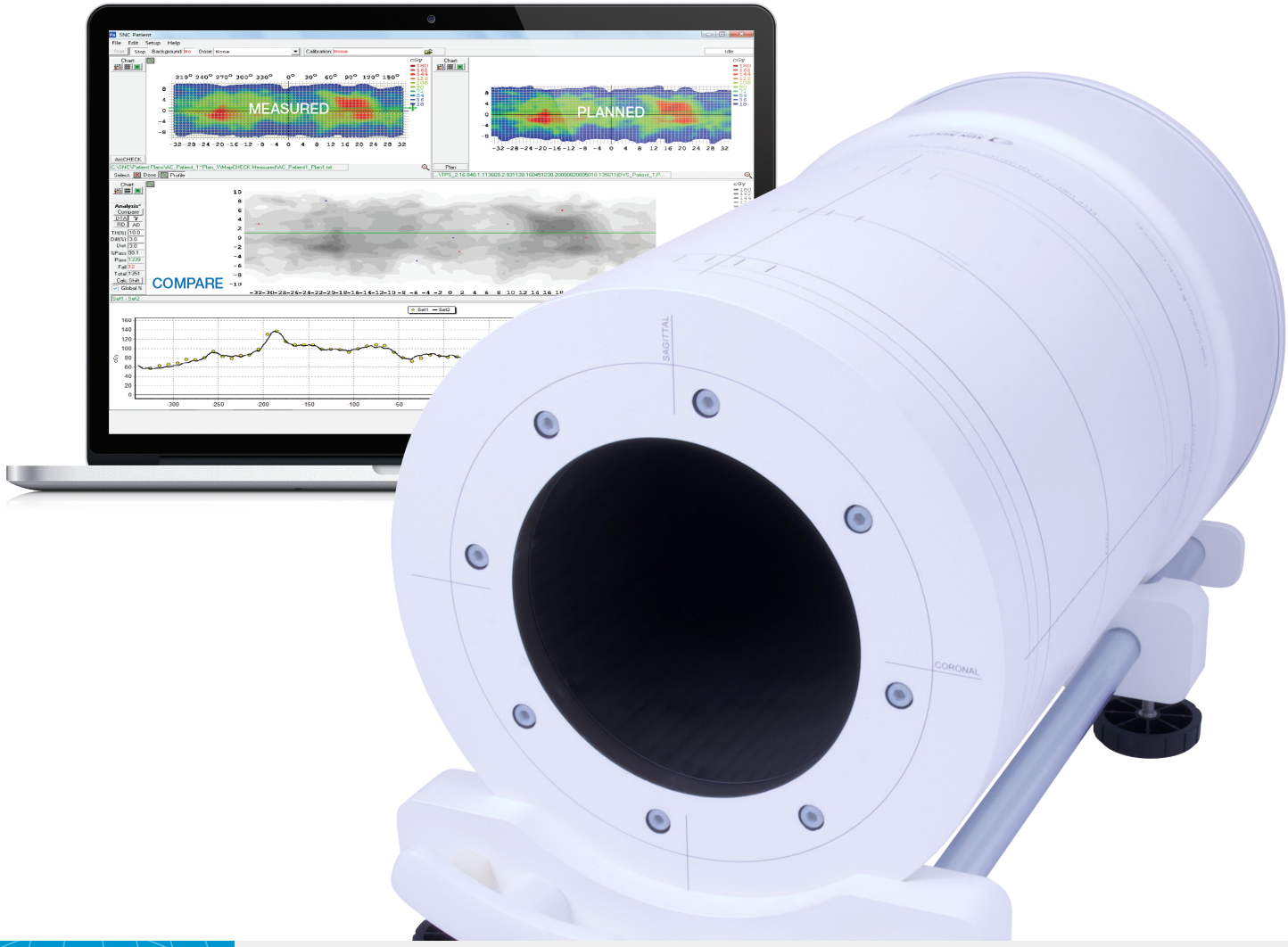


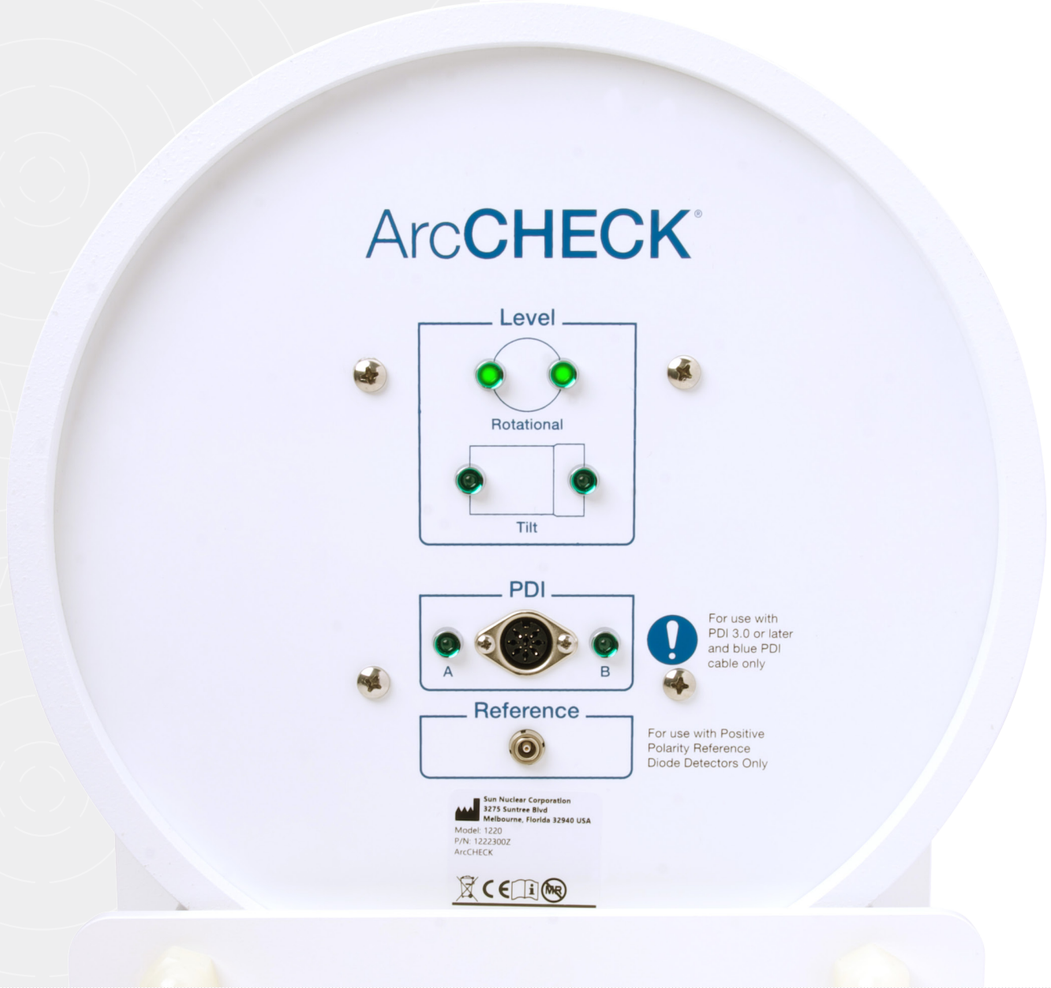

# ArcCHECK®

## The Benchmark for 3D Pre-Treatment QA

SUN NUCLEAR
A MIRION MEDICAL COMPANY

# The World's Most Selected 4D Array

ArcCHECK® is the only detector array specifically designed to identify errors in rotational delivery. It's the ideal solution for: 4D Patient Pre-Treatment QA for IMRT, VMAT, SBRT and MRgRT; including specialty systems such as Varian Medical Systems® Halcyon™ System and Ethos™ Therapy; and Accuray TomoTherapy® and Radixact™ Systems.




## Volumetric Measurement QA for Patient Plan, Dose and Machine Testing

ArcCHECK is the only true 4D array specifically designed for QA of today's modern rotational deliveries and is recommended by AAPM Task Group 218 for 3D measurement requirements. Its 1,300+ SunPoint® Diode Detectors provide consistent and highly sensitive measurements for all gantry angles, with no additional hardware required. Independent absolute dose measurements enable the gold standard for stringent and efficient patient plan and machine QA testing.

### Patient Plan QA

Stringent, fully independent measurement QA of patient plan and delivery with SNC Patient™ software

### Dose and DVH QA

Full 3D Dose reconstruction for target and OAR DVH QA with 3DVH® software

### Machine QA

Dynamic machine QA testing routines are provided for a wide variety of tests with SNC Patient software

### Hardware

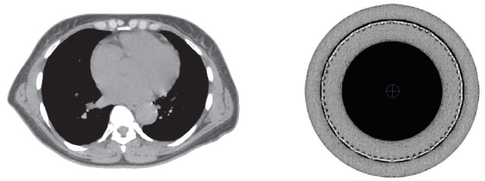
ArcCHECK embodies the spirit of independent Medical Physics measurement.

- 1,386 SunPoint Diode Detectors (0.019 $mm^3$)
- Consistent Beams Eye View (BEV) for all gantry angles measuring entrance and exit dose
- Real-time electrometer measures every pulse, as well as composite and sub-arcs
- Interior cavity allows for a wide range of detector and tissue equivalent inserts

# See the Entire Picture

## An Ideal Geometry

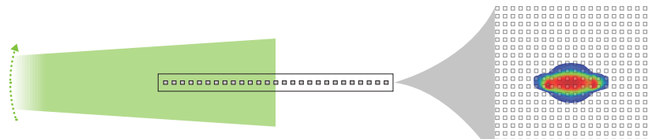
Phantoms are ideally shaped like a patient. The cylindrical design of ArcCHECK intentionally simulates patient geometry to better match reality.



Because ArcCHECK detectors always face the delivery beam regardless of gantry angle, detection of very small gantry angle errors are possible. In contrast, when a 2D array is irradiated obliquely, the geometry collapses to 1D. Even when there is no detector shadowing effect, significant information is lost on a 2D array, and errors up to 10° are missed 75% of the time.[1]

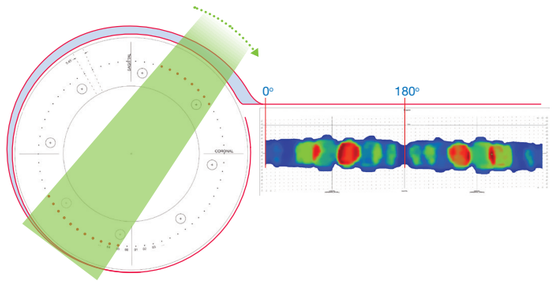
With ArcCHECK, gantry angle, leaf-end position, absolute dose, and time (4D) are measured and correlated to identify sources of error. Dose accuracy is improved and errors can be traced to the treatment planning system, the delivery system, or the imaging system.

### What You See with a 2D Array



**2D Array Measurement**
An inherent limitation of 2D arrays is an inability to capture all of the dose information for rotational deliveries.

### What You See with ArcCHECK




**ArcCHECK Measurement**
ArcCHECK displays BEV dose distribution throughout the entire arc delivery. More data is available to perform a more thorough QA analysis.

**"Significant information is lost on a 2D array, and errors up to 10° are missed 75% of the time."[1]**

1. Hauri, P et al., "Clinical evaluation of an anatomy-based patient specific quality assurance system," JACMP, 15, 2 (2014)





# Interior Measurements

Measuring completely around the isocenter in a uniform manner for each angle is a more stringent measurement than a simple composite dose at the isocenter. Errors visible in the isocenter are also visible in the surrounding dose measurements, but in more detail.

ArcCHECK measures entry and exit dose for every angle. For each beam angle, ArcCHECK measures high dose regions at the entrance and low dose regions at the exit, detecting potential delivery and TPS modeling errors for both high and low dose levels. For those who would like to measure the dose at isocenter or elsewhere within the cavity, Sun Nuclear offers the versatile MultiPlug™ and CavityPlug™ with detector insert capabilities.

## CavityPlug™

- Precision fitted to ArcCHECK cavity
- Measure dose in cavity center
- Precision milled holders available for a wide range of detectors.
  - Custom holders can be created for any detector not currently available
- Solid insert included to achieve solid cavity



## MultiPlug™

- Hounsfield Unit (HU) conversion testing
- Tissue equivalent inserts, available as options:
  - Brain
  - Bone
  - Breast
  - Liver
  - Lung
  - Muscle
  - Apidose
  - Titanium
  - Water/Air
- Dose in up to 25 locations
- Film cassette insert
- Bezel angle indicator for rotation within cavity
- Precision milled detector holder included
  - Solid insert included to achieve solid cavity

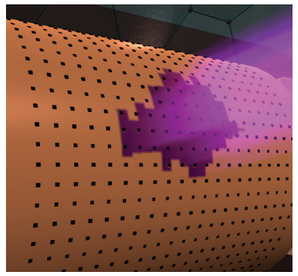


# Helical Detector Grid

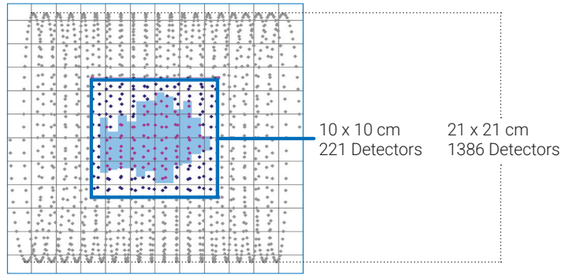
Detectors are arranged on a HeliGrid™ which increases the sampling rate and reduces BEV detector overlap and shadowing.

- An ArcCHECK 10 x 10 cm$^2$ area contains 221 detectors
- Entrance and exit dose are measured, effectively doubling the detector density in the measurement field

### Beam Delivery



### ArcCHECK Detector BEV




# Virtual Inclinometer™

ArcCHECK calculates gantry angle independently using entrance and exit dose.

- Virtual Inclinometer is accurate to ±1°[2]
- System design eliminates the need for additional inclinometer cables and mounting to the delivery system.

# Larger Fields

Two ArcCHECK measurements can be combined in SNC Patient software for larger field sizes.

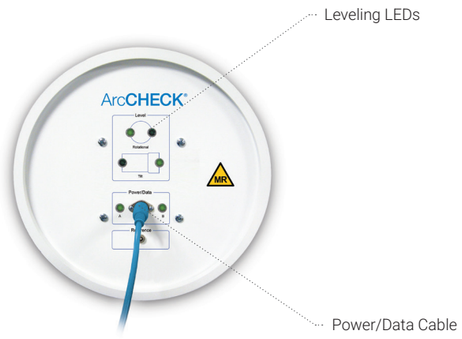
# Smaller Fields

Merge feature provides 442 detectors within a 10x10 cm$^2$ field.

# Easy Setup

ArcCHECK contains a sophisticated yet easy to use leveling system that ensures quick and accurate setup.

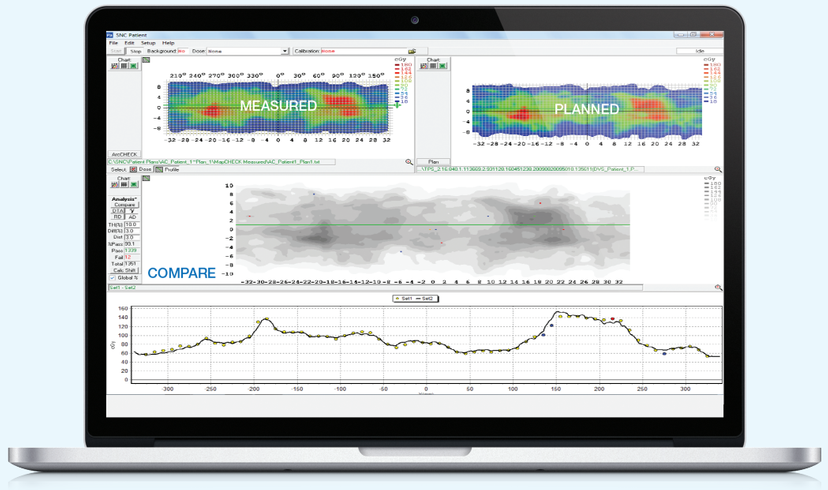
- With integrated rotation and tilt inclinometers, the leveling LEDs relay setup status in real-time.




2. *Kozelka, J. et al., "Optimizing the accuracy of a helical diode array dosimeter," Med. Phys., 38, 9 (2011)*

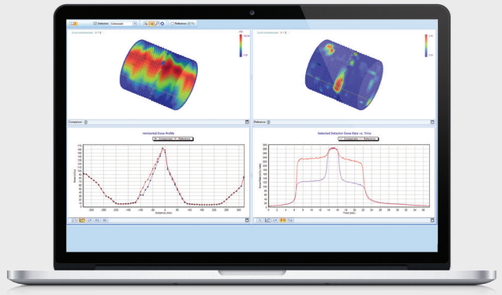






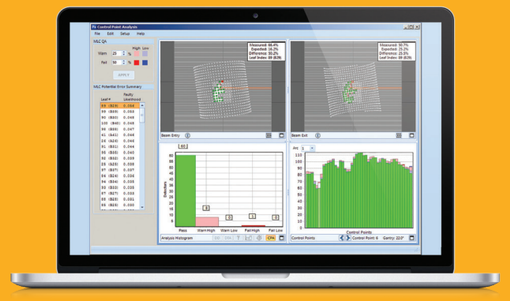

### 3D Dose Analysis

With a single mouse click, SNC Patient software compares measured ArcCHECK dose points to planned dose points. Compare normalized data or absolute dose data using Distance to Agreement (DTA), Gamma (γ), and Gradient Compensation.



### 4D Beam Reproducibility Analysis

Speed up TG-53 checks and monthly VMAT tests with 4D QA of your month-to-month machine performance. Users can analyze when, where, and in what magnitude discrepancies are occurring.



### Dynamic MLC Analysis

Evaluate the difference between the planned and delivered MLC pattern, and identify leaves that may indicate required service. Additional machine QA tests are also included.

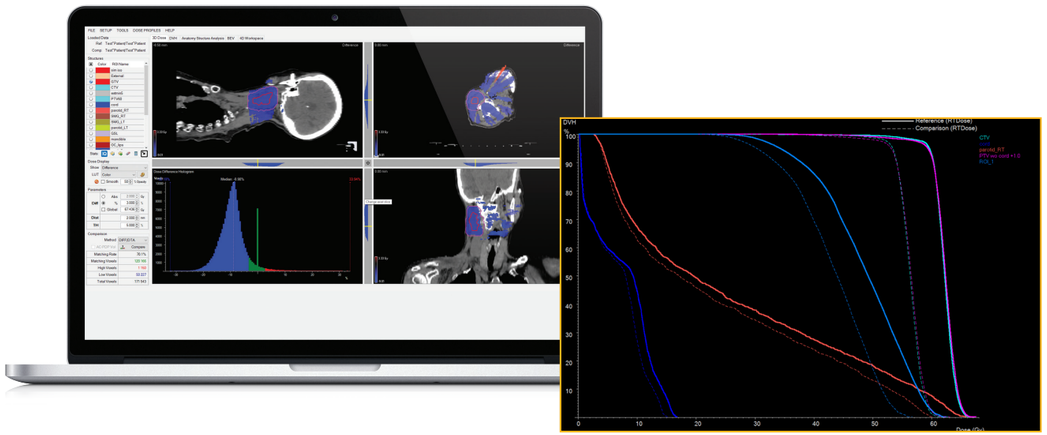
## 3DVH®

3DVH uses ArcCHECK QA measurements to estimate 3D dose to the patient geometry.

- Perform 3D dose and DVH QA analysis on patient – not phantom – geometry
- Identify TPS and beam delivery errors
- Supports coplanar and non-coplanar beams reduces BEV detector overlap and shadowing.



**Phantom Evolution**
3%/3mm criteria showing 99.2% passing rate, a good test of deliverability and machine performance.



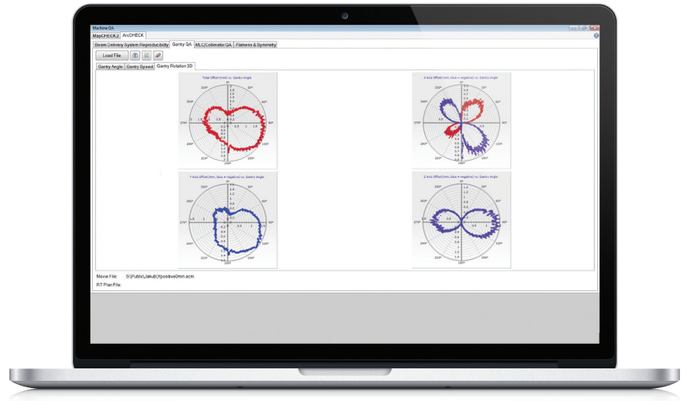

**Clinical Evaluation**
Evaluating the same plan, 3DVH shows substantial target underdose, indicating that although the plan was properly delivered, the clinical impact was below expectations.

U.S. Patent No. 7,945,022

## Machine QA Analysis

Use ArcCHECK for a wide variety of machine QA tests in dynamic and rotational mode.

- Dynamic Gantry Rotation QA*
- Dynamic Gantry Angle QA*
- Dynamic Gantry Speed QA
- Dynamic Symmetry and Flatness*
- MLC QA
- Treatment Reproducibility QA





*Also available with static angles

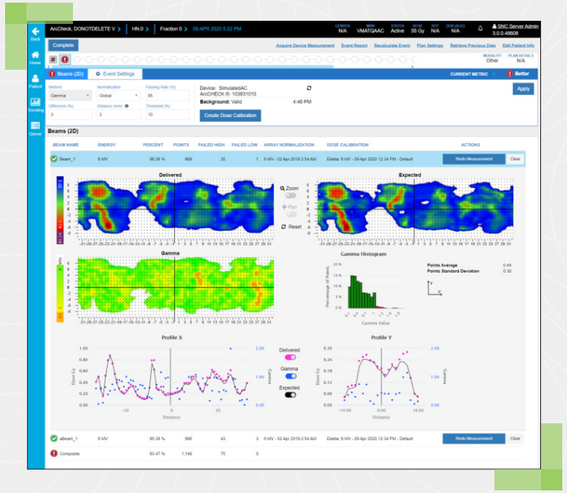
## INTEGRATION

### Integration with the SunCHECK® Platform

Together, ArcCHECK and SunCHECK® Patient provide unmatched flexibility for pre-treatment QA, improved root cause analysis, and efficient audit QA

**Simplified Workflow**
Easily transition between ArcCHECK Patient QA records and SunCHECK Patient QA records, all in one Platform, saving ~30 minutes per patient otherwise spent searching for data.

**Separate Error Sources**
More easily identify sources of error. DoseCHECK™ software identifies algorithm errors. ArcCHECK identifies delivery errors.



# Selected Publications

## ArcCHECK® Accuracy Studies

**Commissioning Monte Carlo algorithm for robotic radiosurgery using cylindrical 3D-array with variable density inserts**
Dechambre et al., Liege University Hospital, Belgium, European Journal of Med Physics, **33** (152-158) (2017)

**Filmless methods for quality assurance of Tomotherapy using ArcCHECK**
Yang et al., Hong Kong, Med. Phys., **44** (7-8) (Jan 2017)

**A comparison of the gamma index analysis in various commercial IMRT/VMAT QA systems**
M. Husseina et al., Radiotherapy and Oncology **109** (3), (2013)

**Optimizing the accuracy of a helical diode array dosimeter: A comprehensive calibration methodology coupled with a novel virtual inclinometer**
J. Kozelka et al., Med. Phys. 38 (9), (2011)

- Validates ArcCHECK: Field size dependence, angular dependence, dose rate dependence, and intrinsic relative sensitivity (array calibration) factors, along with Virtual Inclinometer.

**Robotic radiosurgery system patient-specific QA for extracranial treatments using the planar ion chamber array and the cylindrical diode array**
M. Lin et al., JACMP. 16 (4), 2015

- Compares Angular Dependence, Detector Accuracy, and Sensitivity to various errors
- Confirms diode accuracy for small-field measurements

## ArcCHECK-MR® Studies

**Performance of a cylindrical diode array for use in a 1.5 T MR-linac**
Houweling A. et al., Physics in Medicine and Biology, **61** (3) (2014)

**Patient-specific quality assurance for the delivery of (60)Co intensity modulated radiation therapy subject to a 0.35-T lateral magnetic field.**
Li HH. et al., Int J Radiat Oncol Biol Phys, **91** (1):65-72 (2015)

## 3DVH® Studies

**Automated Planning and Delivery of Hippocampal Avoidance Whole-Brain Radiotherapy for Brain Metastases Using HyperArc Technology,**
I Rusu, et al. Loyola Univ Medical Center, Maywood, IL, WE-C1000-GePD-F7-5, AAPM 2019

- ArcCHECK successfully used to perform PSQA on HyperArc plans

**Clinical Evaluation of Lung SBRT for the Halcyon Platform and Dosimetric Comparison with the Truebeam STx and Millennium MLC Systems**
C Kennedy, et al. University of Pennsylvania, Philadelphia, PA, SU-F-SAN4-8, AAPM 2019

- ArcCHECK used to perform PSQA on Lung SBRT plans from Halcyon v1.0 and v2.0

**VMAT QA: Measurement-guided 4D dose reconstruction on a patient**
B. Nelms et al., Med. Phys. **39** (7), (2013)

**Using a Novel Dose QA Tool to Quantify the Impact of Systematic Errors Otherwise Undetected by Conventional QA Methods: Clinical Head and Neck Case Studies**
M. Chan et al., Technology in Cancer Research & Treatment **13** (1), (2014)

- Discovered both systematic and patient specific errors using 3DVH that were missed by Gamma QA. Used both EPI Dose and film t o verify all 3DVH discovered errors were true

**Evaluating IMRT and VMAT dose accuracy: Practical examples of failure to detect systematic errors when applying a commonly used metric and action levels**
B. Nelms et al., Med. Phys. 40 (11), (2013)

- Four separate hospitals submitted an article on errors they discovered using 3DVH but were missed by conventional planar Gamma analysis.

**Sensitivity of volumetric modulated arc therapy patient specific QA results to multileaf collimator errors and correlation to dose volume histogram based metrics**
L. Coleman et al., Med. Phys. 40 (11), (2013)

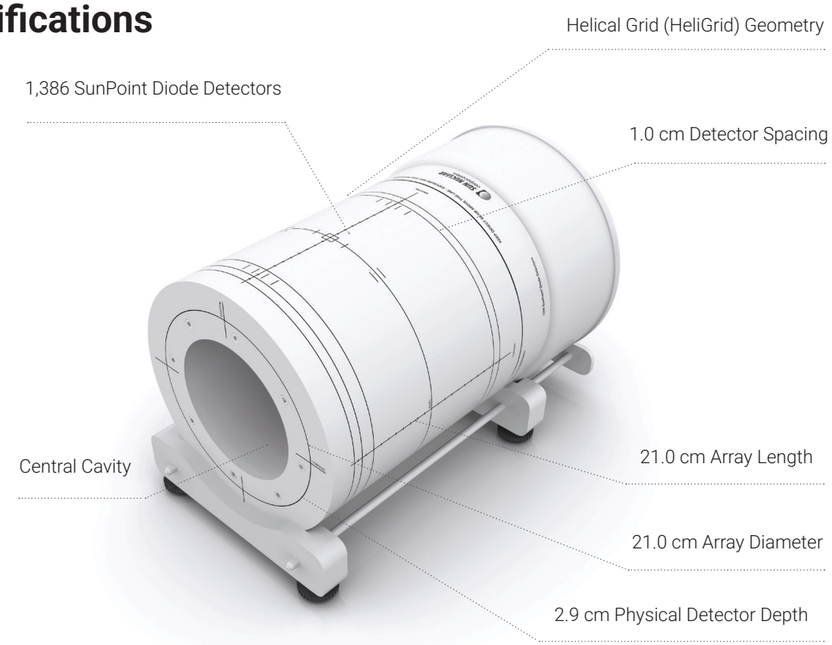
- Concludes that 5% DVH errors are missed with Gamma only analysis and that volumetric analysis is recommended for VMAT QA.

## Learn more at sunnuclear.com/publications





# Specifications




| | |
|---|---|
| Detector Type: | SunPoint® Diode Detectors |
| Detector Quantity: | 1,386 |
| Detector Spacing (cm): | 1.0 |
| Array Diameter (cm): | 21.0 |
| Array Length (cm): | 21.0 |
| Cavity Diameter (cm): | 15.0 |
| Inherent Buildup (g/cm²): | 3.3 |
| Inherent Backscatter (g/cm²): | 3.3 |
| Detector Physical Depth (cm): | 2.9 |
| Array Geometry: | Helical Grid (HeliGrid) 1 cm offset |
| Phantom Material: | PMMA (Acrylic) |
| Active Detector Area (mm²): | 0.64 |
| Detector Sensitivity (nC/Gy): | 32.0 |
| Max Dose/Pulse (Gy): | 0.002 |
| Detector Volume (mm³): | 0.019 |
| Detector Stability: | 0.5% / kGy at 6 MV |
| Dose Rate Dependence: | ±1% over the range 150 MU/min to 1400 MU/min |
| Update Frequency (ms): | 50 |
| Number of Connection Cables: | Single power/data cable |
| Dimensions (Total Length)(cm): | 44.29 |
| Weight (kg): | 15.4 |

## Recommended System Specifications (SNC Patient, 3DVH)

| | |
|---|---|
| Operating System: | Windows 10 Pro 64-bit |
| CPU: | Recommended 2.3 GHz or better, multi-core (2 or more cores) |
| RAM: | Recommended 8 GB or more |
| Hard Drive Space: | Recommended 5 GB or more |

## Compatibility

| | |
|---|---|
| FFF: | Yes |
| MR: | Yes (ArcCHECK-MR®) |
| Varian and Elekta C-arm linacs, Varian Medical Systems® Halcyon™ System , Ethos™ Therapy and Accuray's TomoTherapy® and Radixact™ Systems: | Yes |
| SunCHECK: | Direct device connectivity within SunCHECK Patient |

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