Users Meting 2023

12 – 14 April 2023, Phoenix, US

ScandiNova

Phoenix, US, 12–14 April 2023

Welcome to ScandiNova's 13th Users Meeting

ScandiNova Users Meeting

A global journey

Participants from many application areas and countries

- 65 on-site participants
- 30 on-line participants

- Science
- Medtech
- Industry – Cargo Scanning, E-beam sterilization, Compact Light Source, Radar, System suppliers

- US, Canada, UK, Switzerland, Slovenia, Netherlands, Italy, Germany, France, Denmark, China, Japan, Korea, Australia, Sweden

The Users Meeting

Agenda – Overview

- **13 April**
- ScandiNova presentations
- Users presentations
- Visit Arizona State University
- Dinner Culinary Drop Out

- **14 April**
- Users presentations
- Workshop
- Training
- Visit and dinner Desert Botanical Garden

Some practical things

For questions

- Erik Sundström, erik.sundstrom@scandinovasystems.com, +46 70 395 33 95
- ScandiNova colleagues

Arizona State University Tour

Contact: Deanna Clark, Cell: 602-206-2435

Training 14 April

- Choose between K-series or M-series

Users Meeting Event app

- SMS from ScandiNova with link – save it on your mobile home screen

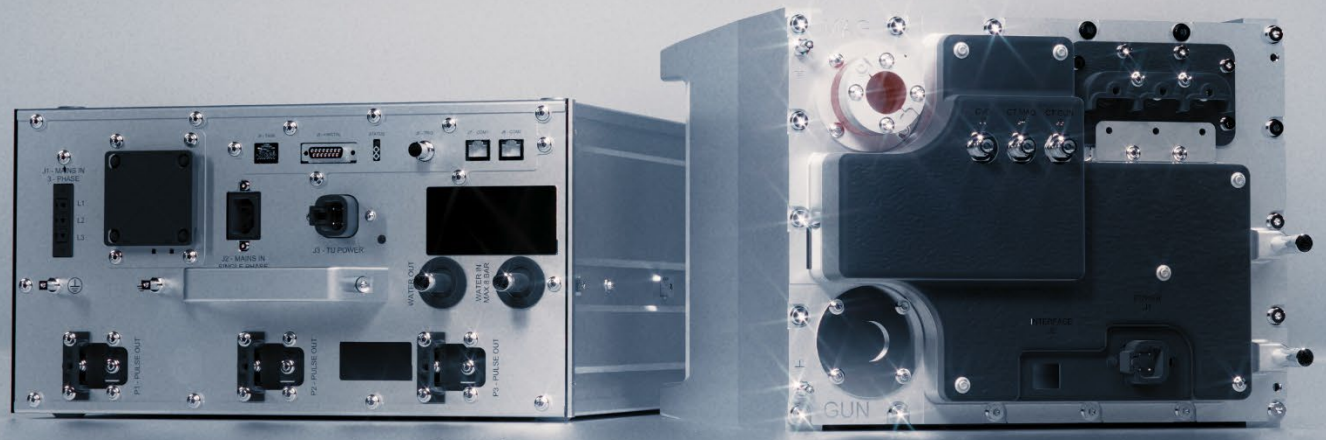
ScandiNova Updates

Niklas Edling, CEO

ScandiNova

ScandiNova today

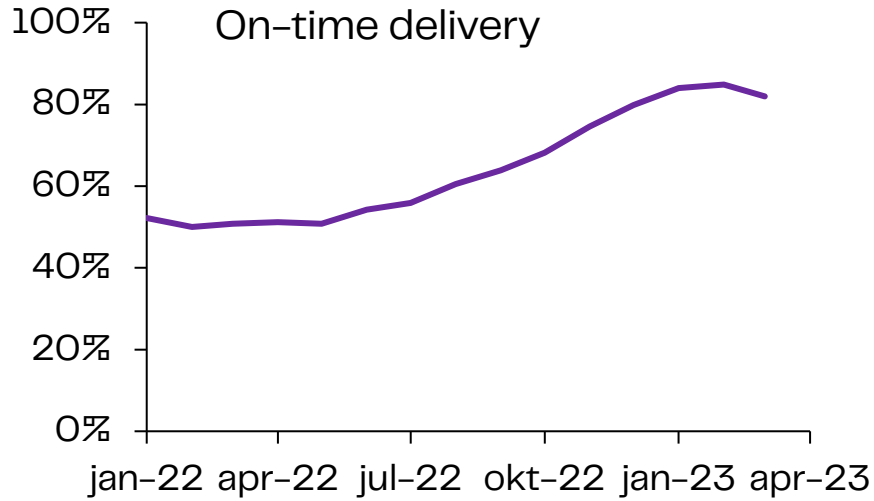
Pushing boundaries with high-end solutions for critical subsystems within MedTech, Science and Industry



ScandiNova

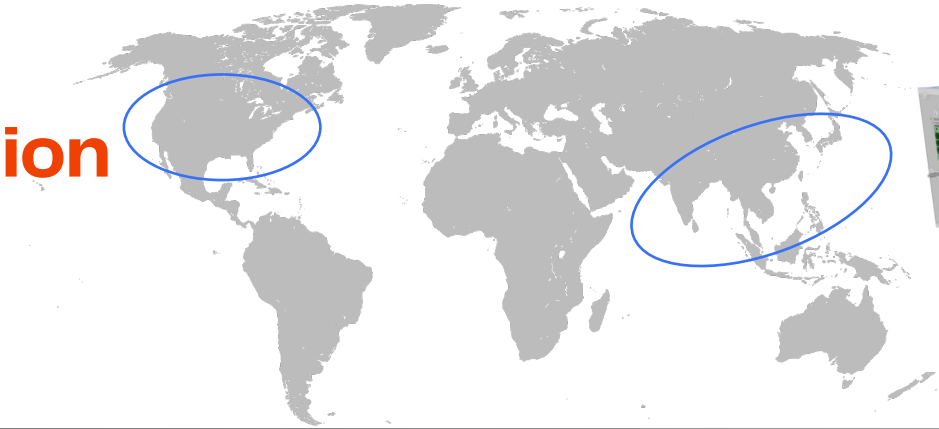
Excellence in pulsed power

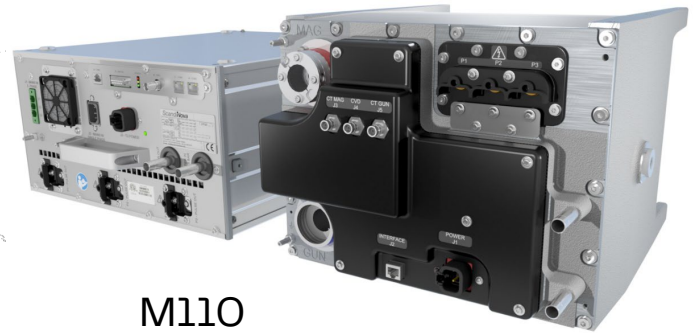
- **Robust and reliable**
- **Leading technology**
- **Customer collaboration**



M050

PG200





M110

This is ScandiNova

Excellence in pulsed power

Internal improvement

Implementation of a new ERP system

Sustainability

More evidence of energy savings using ScandiNova modulators

Growth

Further expansion in production capacity

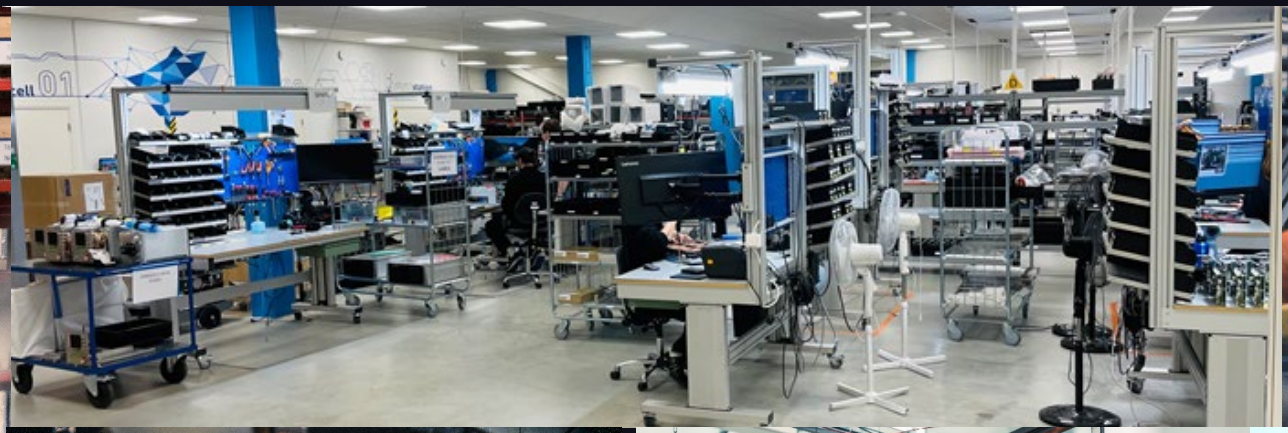
This is ScandiNova

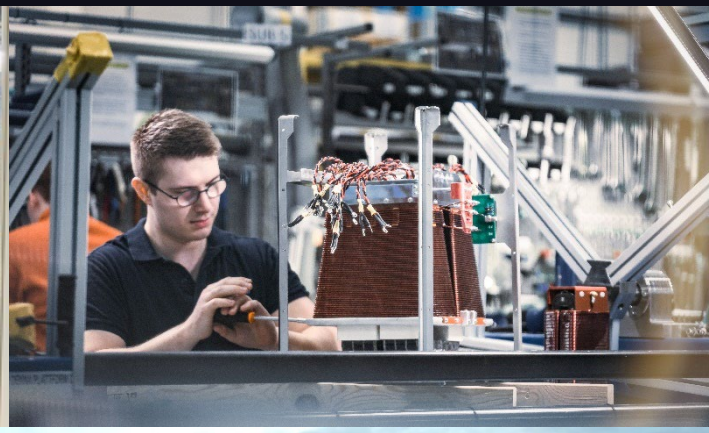
ScandiNova 2022

Revenue	+17% organic growth
Order intake	+41% organic growth

ScandiNova

- Supplier of modulators for
- MedTech, Science and Industry
- 125 employees

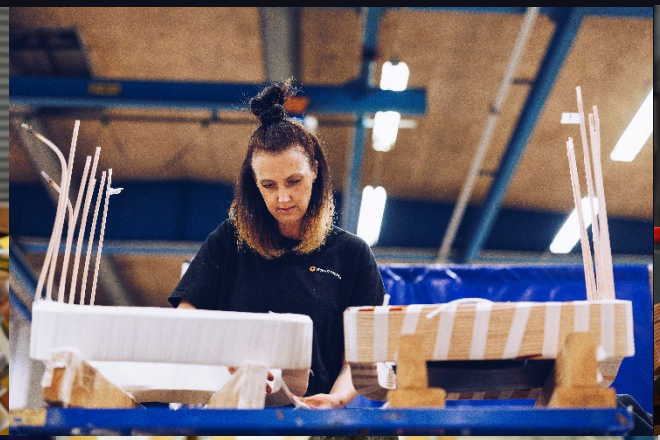




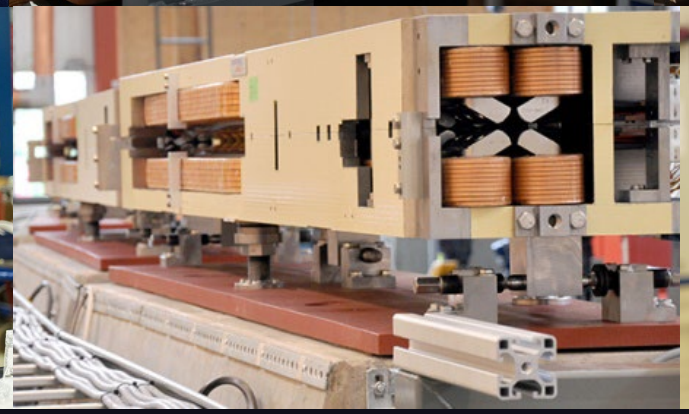
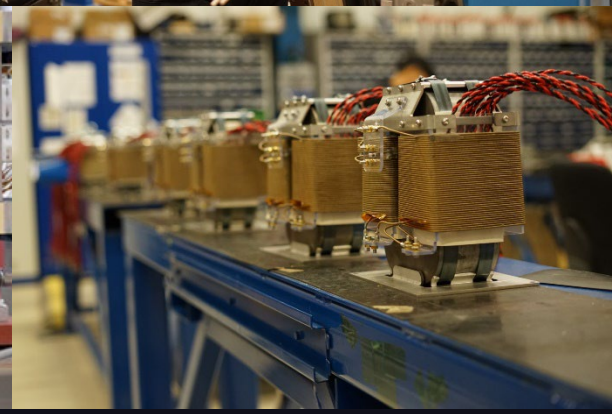
SCANDITRONIX

A ScandiNova Company

- Supplier of magnets, and coils for
- MedTech, Science and Industry
- 40 employees



IECO

A ScandiNova Company

- Supplier of power amplifiers and precision power supplies for
- MedTech, Science and Industry
- 35 employees

Together we are stronger

- Better equipped to meet tomorrows requirements
- Broader, complementing customer offering
- Strong common culture of high-end performance and reliability

ScandiNova

SCANDITRONIX
A ScandiNova Company

IECO
A ScandiNova Company

Product Overview and News

Klas Elmquist, Product Owner
Anders Larsson, BA Manager Medtech

ScandiNova


Klystron based
RF Units
K-SERIES

K-series applications

- Large scientific accelerators
- Sterilisation of foodstuff and medical material.
- Proton therapy
- Commercial synchrotrons

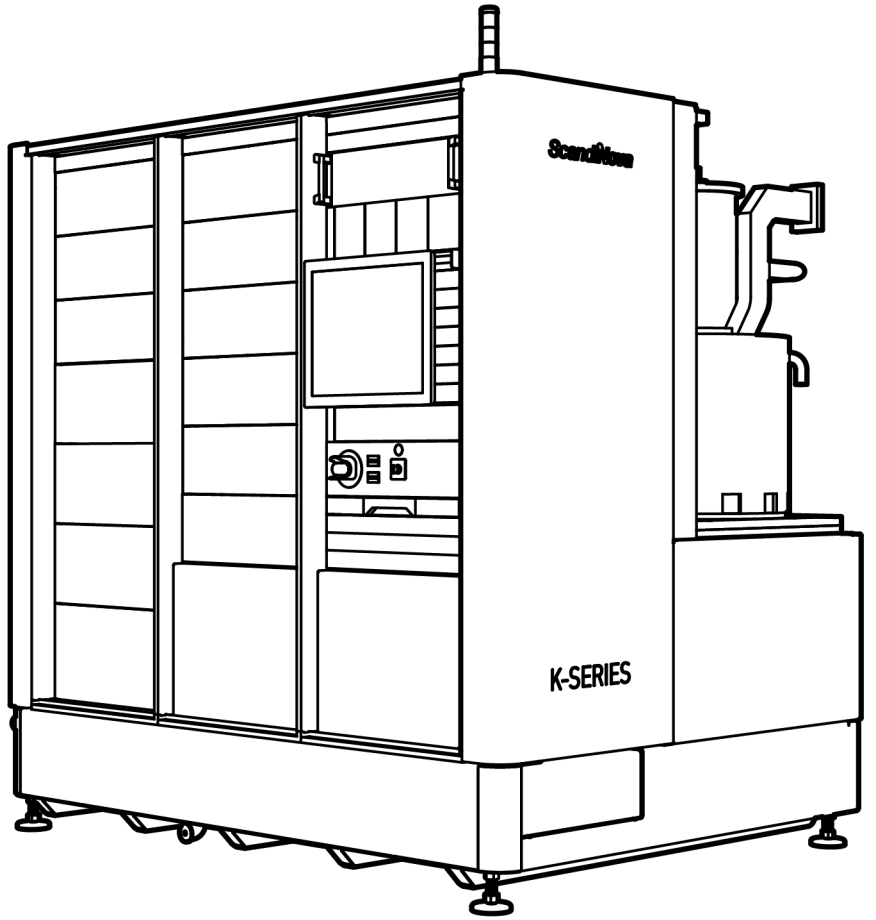
K-series

- RF Unit
- Reliable
  - Proven technology
- Klystron based
  - Solid state switches
- Modular
- Extreme pulse to pulse stability
  - Typical 50 ppm RMS
  - Has been measured to 13 ppm RMS
- Small footprint
  - Less than 1 m^2 for a K100
- Safe
  - IP2X even with covers off

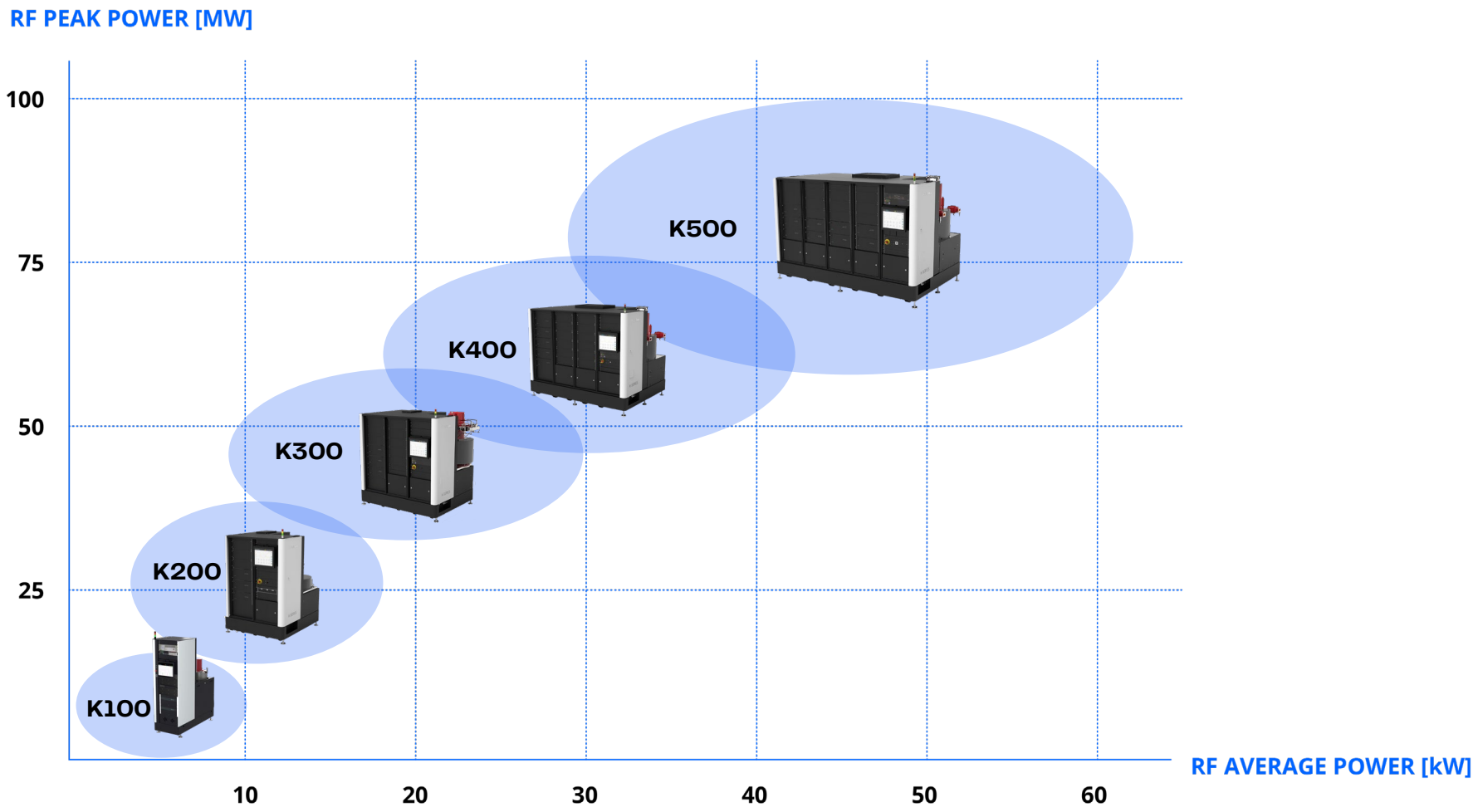
Subsystems

K-series RF Unit

- Modulator
  - Capacitive Charging Power Supply
  - Filament power supply
  - Switch Units
  - Pulse transformer
  - Control system
  - Cooling system
- Klystron
- Solenoid
- Solenoid Power Supply
- Ion Pump Power Supply
- Low level RF Amplifier
- RF diagnostics



K-series sizes




E-Gun
Modulators
E-SERIES

E-series applications

- Modulator for diode-type thermionic electron gun
- Used in medical and scanning applications

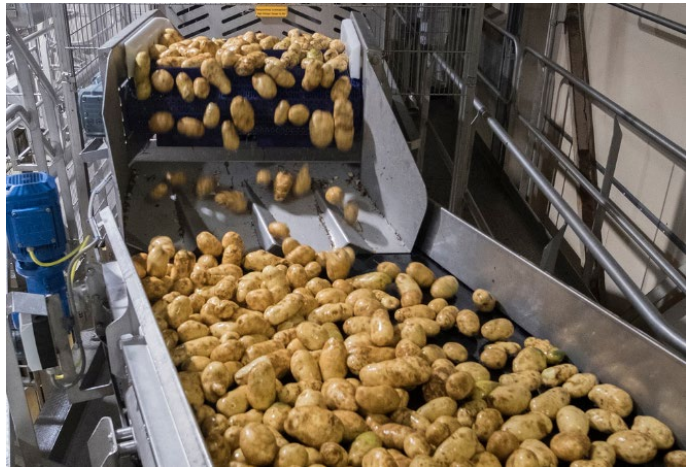
E110

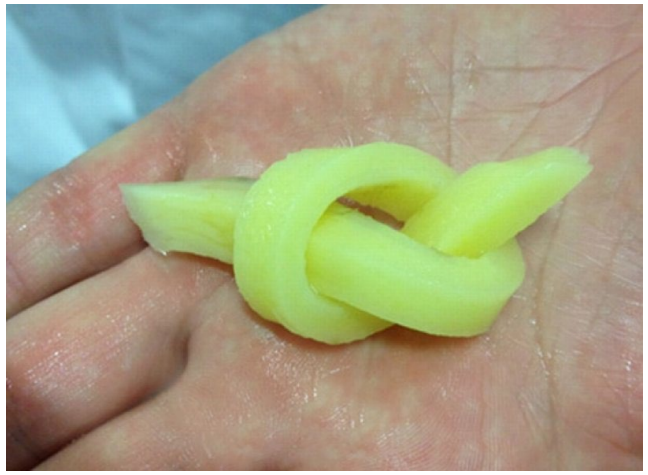
- Voltage up to 30 kV
- Filament PS included
- Built from the ground up to handle e-gun loads
- M-platform control system
- Dual energy capable
- On board digitizer (CT/CVD)
- Patented design


Pulse
Generators
PG-SERIES

PG-series applications

- Used for Pulsed Electric Field treatment of foodstuff.





PG-series

- Modular design
- Few subsystems
- Up to 50 kV
- Rugged encapsulation

PG050

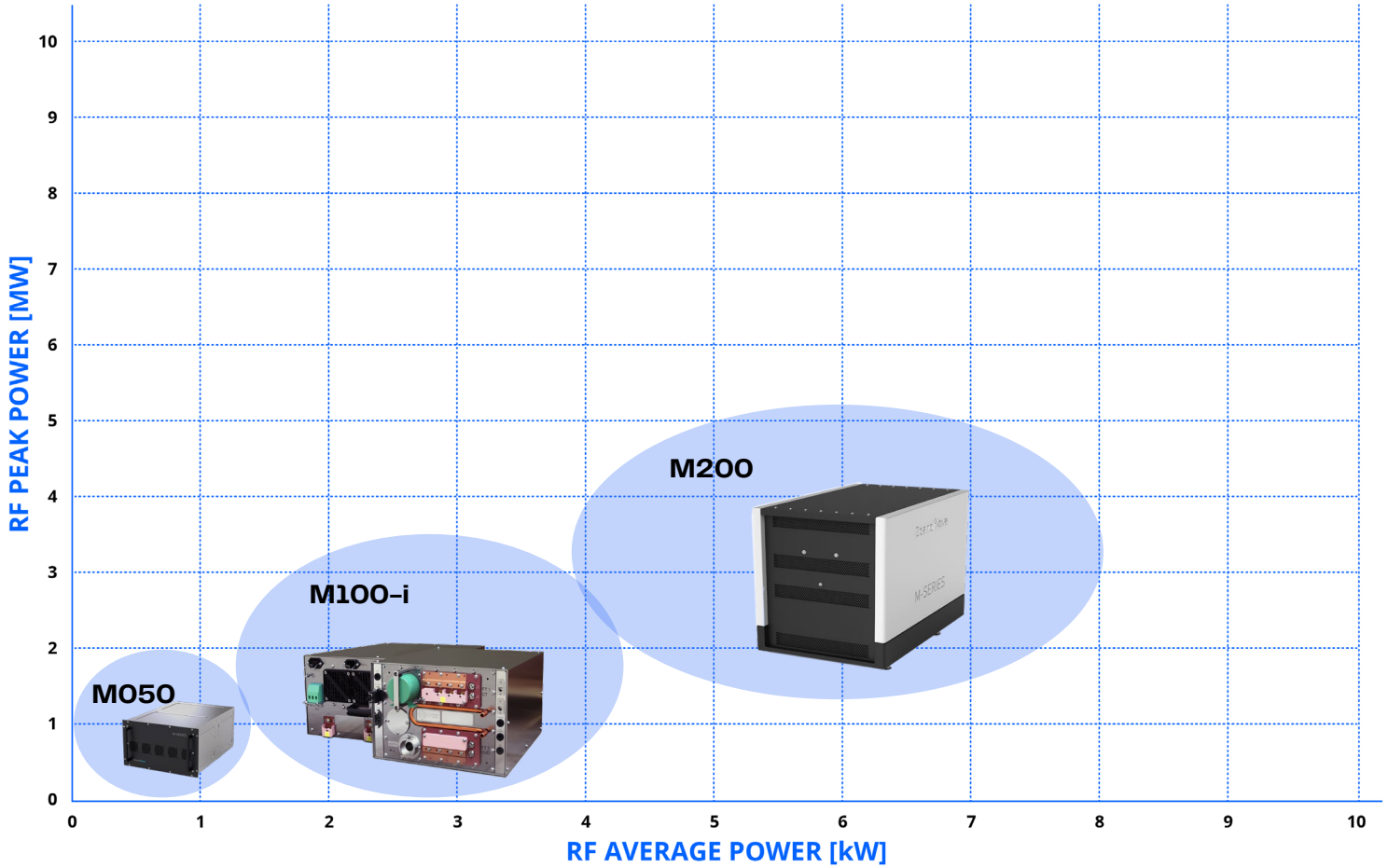
PG200


M-SERIES
Magnetron
Modulators
M-SERIES

M-series applications

- Radiation Therapy
- Cargo Scanning/NDT
- Radar
- RF Test Stands

M-series sizes

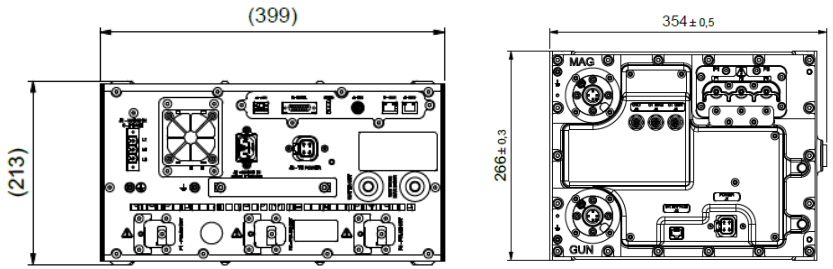


- Compatible with magnetrons from all major suppliers.
- FPGA-based control system
- Communication via Modbus
- Main components:
  - CCPS
  - Switch Unit
  - Tank Unit

New magnetron modulator – M110

- 20% smaller and lighter
- Improved diagnostics
- Power factor correction
- Active pulse shaping

- Ready for delivery in 2023



Improved diagnostics

- M110 is part of a larger system
- Data is captured throughout the system
- Data from M110 can be merged with other information and stored locally or by the OEM supplier.
- ScandiNova can add additional data from internal sources to complete the picture and provide suppport and recommendations.

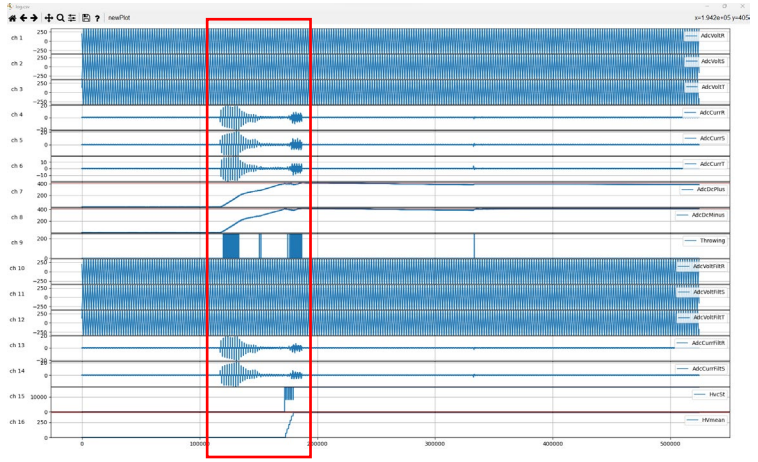
- Capabilities:
- Pulse diagnostics
  - Magnetron current
  - Magnetron voltage
  - Gun Current
  - IGBT-currents
- Temperatures
- Fan and pump speed
- Arcing / moding detection and protection
- Continous logging of FGPA parameters with trigger criteria

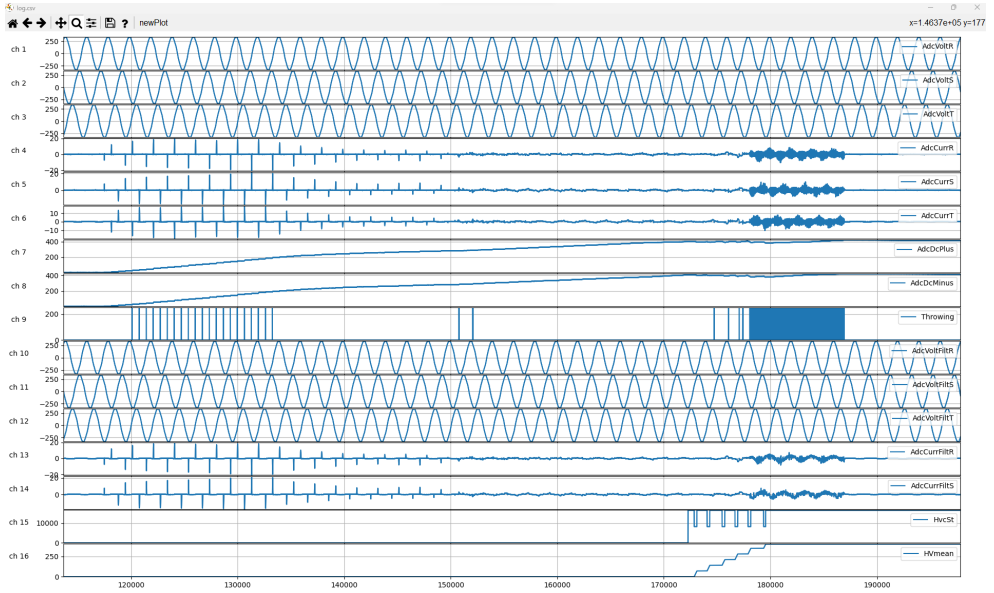
Improved diagnostics – Vision

- System is operating
- An unexpected event somewhere in the system.
- The host can:

  Download the pulse shapes for the last couple of pulses, time resolution 20ns.

  Download the log file for the last few seconds of operation, time resolution 10µs.
- This shows the series of events in great detail and can provide essential system information for the customer.





The Future of RF Performance Klystron Systems

Kévin Pepitone, RF application specialist

ScandiNova

Introduction

Kévin Pepitone

- RF Application Specialist at ScandiNova since February 1, 2023

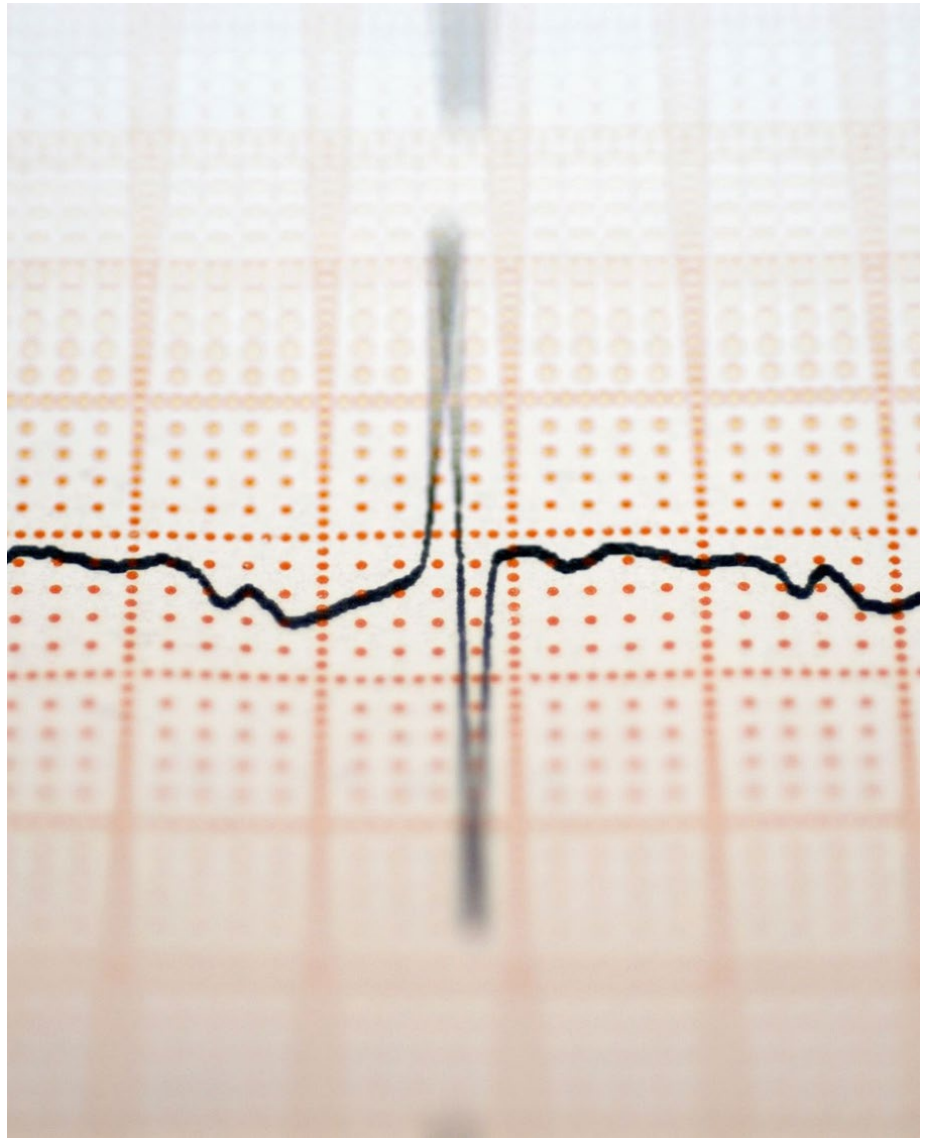
- 5 years at Uppsala University, Sweden
  - Superconducting magnets
  - Research project for CERN – AWAKE
  - Beam dynamics simulations
- 4 years at CERN, Switzerland
  - CLIC
  - AWAKE
- 4 years at CEA, France
  - Homogeneity of high-current and high-energy electron beam

- kevin.pepitone@scandinovasystems.com

Introduction

Table of contents

- ScandiNova RF unit
- Beam stability – Pulse to pulse stability – Phase stability
- What are the limiting factors
  - Definitions
  - Measurements
- Stability of the RF unit
- Conclusions and future developments



ScandiNova RF unit

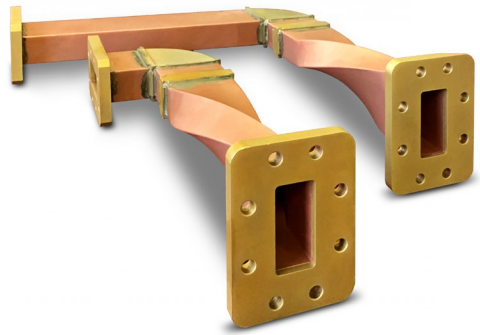
ScandiNova

ScandiNova RF unit

Turnkey-RF unit

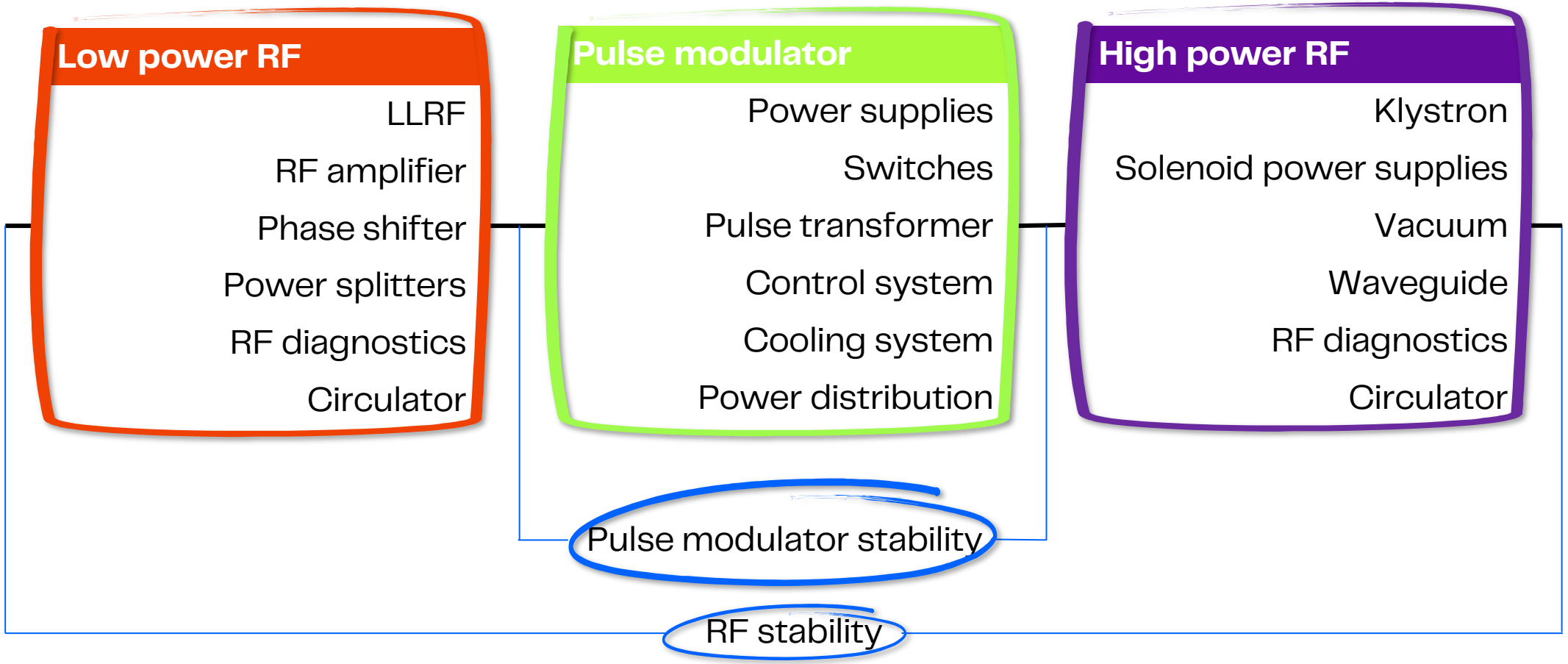
	FULL RF UNIT	BASE CONFIGURATION	MY NEEDS
Charging PS	•	•	
Switches	•	•	
Pulse Transformer	•	•	
Control System	•	•	
Cooling System	•	•	
Filament PS	•	•	
Power Distribution	•	•	
Klystron	•		
Solenoid PS	•		
Vacuum PS	•		
Low-level RF Amplifier	•		
RF Diagnostics	•		
Circulator	•		

Further components can be added on request.



ScandiNova RF unit

Pulse modulator stability and RF stability

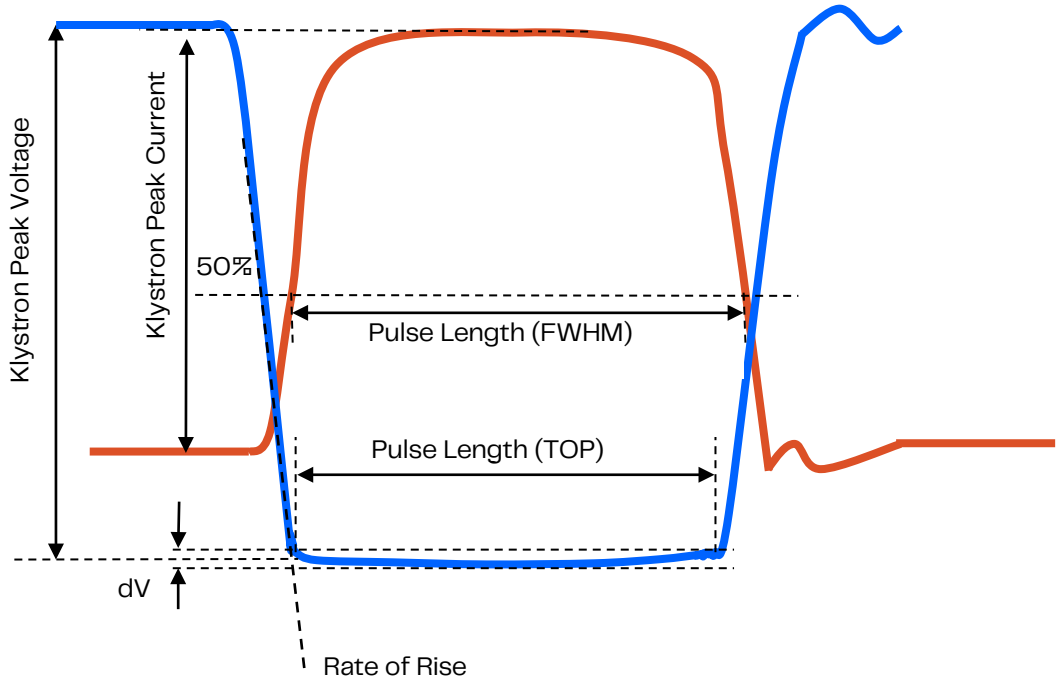


Phase stability of the pulse modulator

ScandiNova

Phase stability of the pulse modulator

Beam – Pulse to pulse – Phase stability



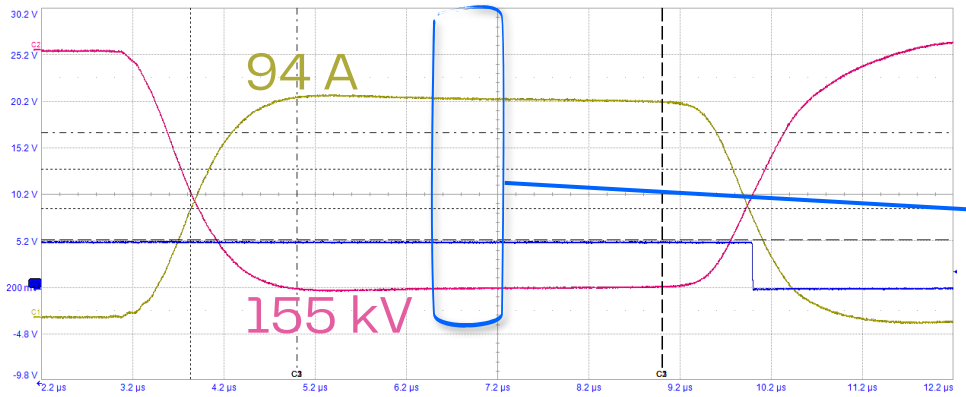
Beam Stability: The ability of a particle beam to stay the same size, shape, and position over time. It's important for precise applications like particle accelerators.

Pulse to Pulse Stability: Consistency of energy or particle pulses from one pulse to the next. Important in radar systems and pulsed lasers for accurate results.

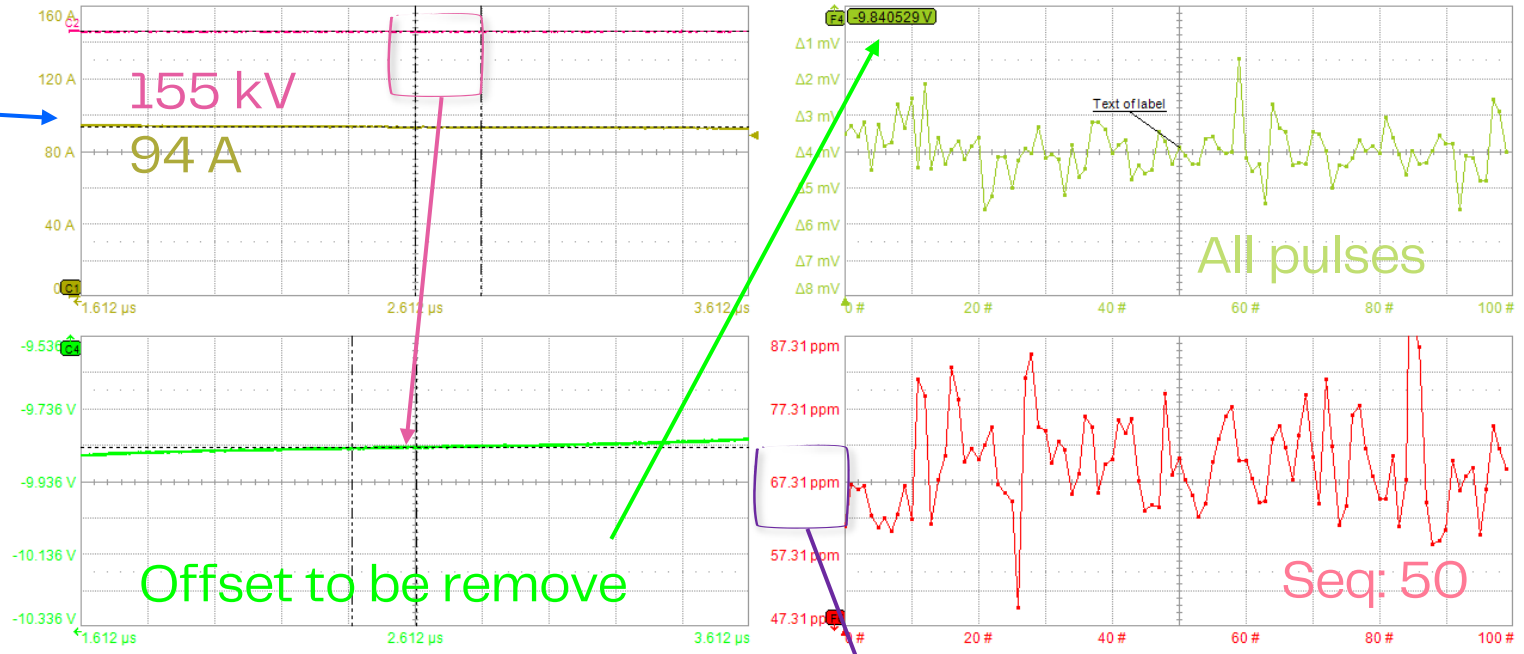
Phase Stability: Keeping a constant phase relationship between two signals or two acquisitions signals. Crucial for precise results in radio communication and signal processing.

Phase stability of the pulse modulator

Pulse to pulse stability



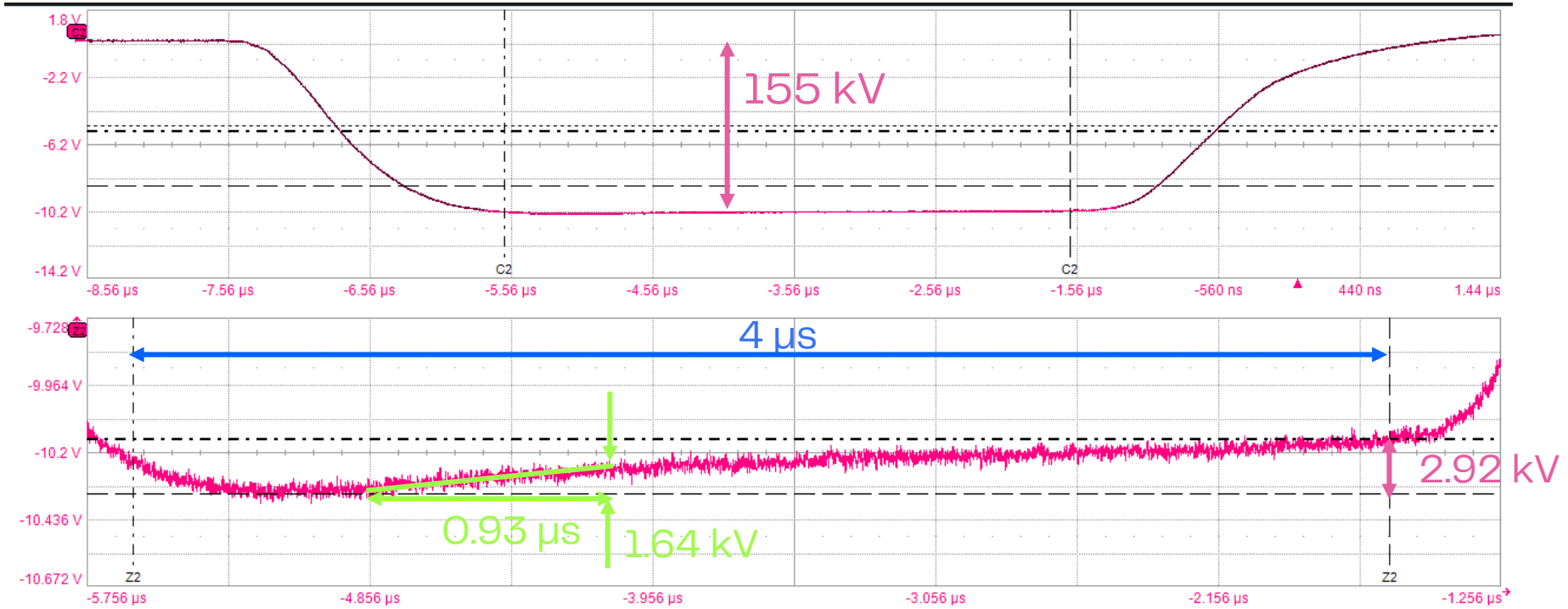
6.4 µs pulse width, 370 Hz, 15.1 MW peak power on the modulator



The measured pulse to pulse stability is 67 ppm

Phase stability of the pulse modulator

Signal analysis



The flatness is $\frac{2.92\ kV}{155\ kV} = \pm 0.9\ \%$

Effect of the jitter on the trigger

The voltage slope is $\frac{1{,}64\ kV}{0{,}93\ \mu s} = 1.77\ kV/\mu s$

Let's consider a **jitter 5–10 ns**

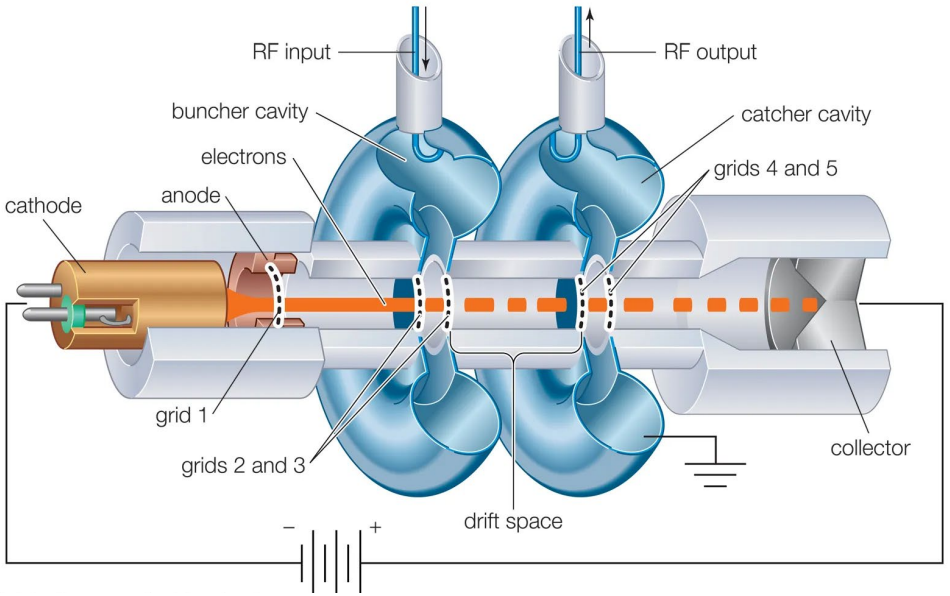
The voltage shift is $jitter * voltage\ slope$

We obtain a voltage shift 8.8 – 17.7 V

Which corresponds to 5.7 – 11.4 ppm

Phase stability of the pulse modulator

Definition of a klystron



A klystron is an electron source in which electron are produced, accelerated and dumped in a very short distance

The modulator produces the electric field to accelerate the electrons between the anode and the cathode

The klystron consists of a cylindrical vacuum chamber containing a series of electrodes that accelerate and decelerate the electron beam, creating oscillations at a desired frequency

Phase stability of the pulse modulator

Theory

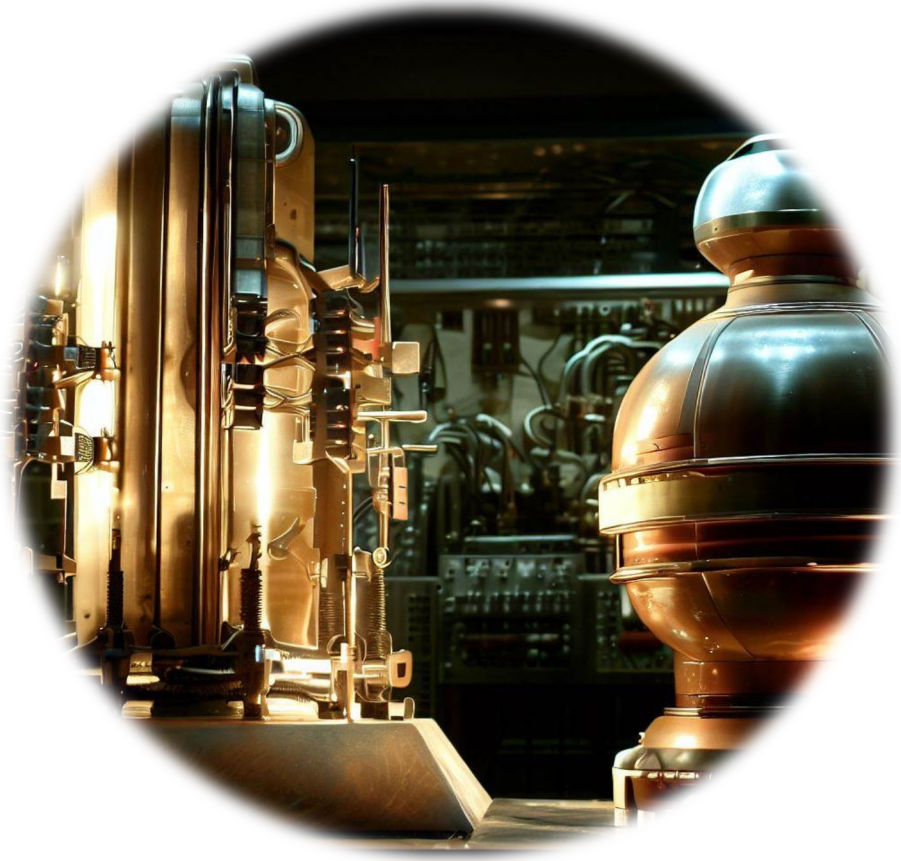
$E_{tot} = qV + m_0c^2$ where V is the accelerating voltage, q is the electron charge and m_0c^2 is the rest energy

$E_{tot} = \gamma m_0 c^2$ where γ is the Lorentz factor which is $\frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$

We obtain that the electron velocity $v = c\sqrt{1-\left(\frac{m_0c^2}{qV+m_0c^2}\right)^2}$ and finally the traveling time of the electrons on the tube which is $t = \frac{L}{v}$

The phase depends on the traveling time by $\varphi = 360° \times f \times t$

A small variation the accelerating voltage V will imply a small variation on the traveling time t which implies a small variation on the phase φ



Phase stability of the pulse modulator

From Pulse to pulse to Phase stability

Let's consider a driving voltage V = 155 kV, which has a traveling tube of L = 0.5 m and operates at a constant temperature and at f = 3 GHz

- By computing the previous equations, we obtain that
  The traveling time is t = 2.60057 ns
- Now let's consider variation of the driving voltage

Pulse to pulse stability (ppm)	Voltage difference (V)	Traveling time (ns)	Traveling time difference (ps)	Phase stability (°)
1000	155.00	2.59971	0.8655	0.9348
500	77.50	2.60014	0.4330	0.4676
200	31.00	2.60040	0.1732	0.1871
100	**15.50**	**2.60049**	**0.0866**	**0.0936**
70	**10.85**	**2.60051**	**0.0606**	**0.0655**
10	**1.55**	**2.60056**	**0.0087**	**0.0094**
8	**1.24**	**2.60057**	**0.0069**	**0.0075**

Phase stability of the pulse modulator

Comparison of 3 klystrons

K400
RF peak power: 30 – 60 MW
Pulse voltage: 280 – 450 kV
Pulse current: 230 – 450 A
Modulator peak: 160 MW
Modulator avg.: 125 kW

TH2100

50 MW
S-band
2998 MHZ

307 kV
0,51 m tube

$t = 2.18283$ ns

E37202

50 MW
C-band
5712 MHZ

360 kV
0,45 m tube

$t = 1.85355$ ns

VKX8311A

50 MW
X-band
11994 MHZ

410 kV
0,795 m tube

$t = 3.18744$ ns

Klystron	Pulse to pulse stability (ppm)	Voltage difference (V)	Traveling time (ns)	Traveling time difference (ps)	Phase stability (°)
TH2100	50	15.35	2.18281	0.0262	0.028
E37202	50	18.00	1.85353	0.0201	0.041
VKX8311A	50	20.50	3.18741	0.0316	0.136

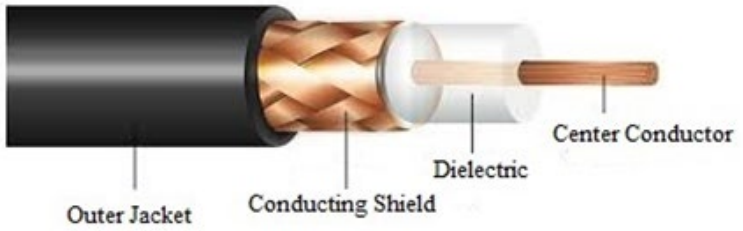
Phase stability RF units

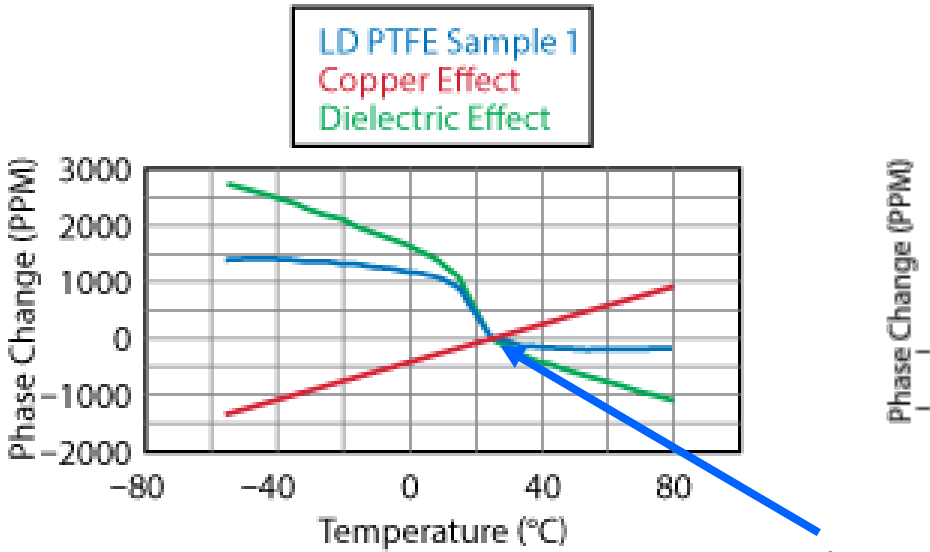
ScandiNova

Phase stability of the RF units

RF cables

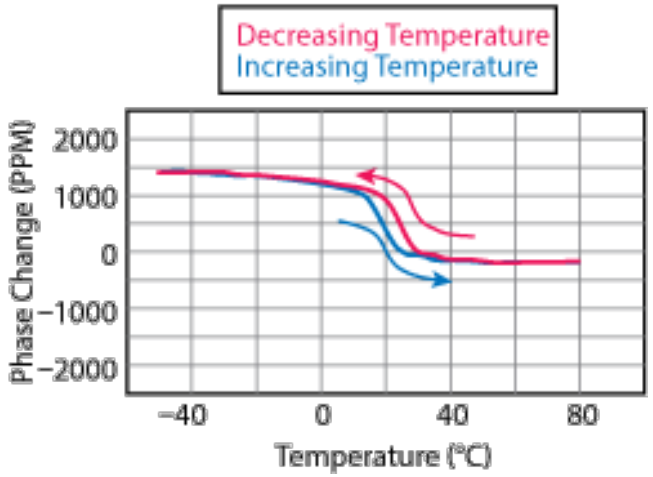
An ideal microwave cable assembly has no loss, no reflected energy, and no electrical length variation under any environmental conditions that system components may experience.





PTFE knee

Copper 17 ppm/°C
Dielectric -23 ppm /°C



Phase transition between
18 °C and 20 °C

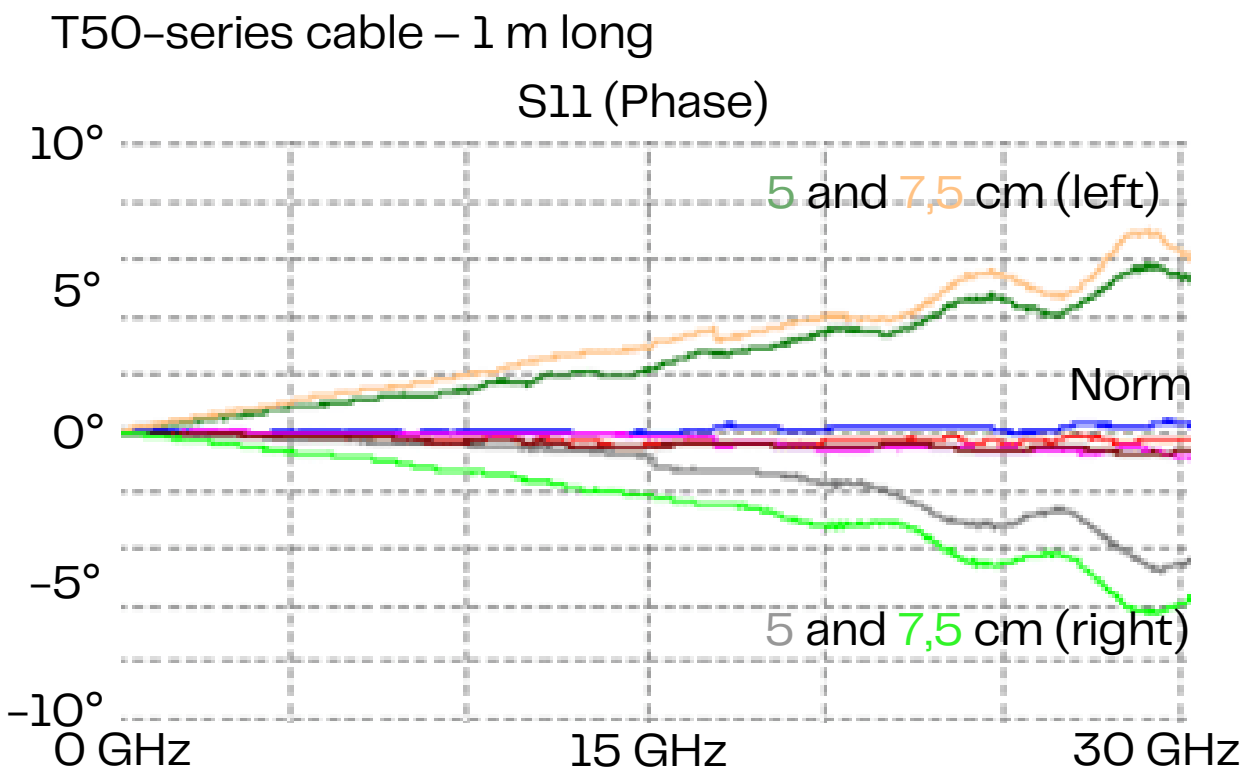
Phase differs on the temperature of assembly

Phase repeatability is also to be considered

Phase stability of the RF units

Cable curvature and vibrations

		SUCOFLEX 126	SUCOFLEX 126E
Max. operating frequency	GHz	26.5	26.5
Application		dynamic	dynamic
Velocity of propagation	%	77	77
Weight	g/m	70	66
Min. bending radius static	mm	16	16
Min. bending radius repeated	mm	25	25
Phase stability vs. flexure (360°, diameter 55 mm)	°el/GHz	< 0.9	< 0.9
Phase stability vs. temperature (−40 to +85 °C)	ppm	< 1500	< 1500
Assembly phase matching tolerances	°el/GHz	± 0.5	± 0.5
Cable attenuation at 25 °C	dB/m	see graph	see graph
Insertion loss stability vs. bending	dB	± 0.2	± 0.2
Insertion loss stability vs. temperature	%/°C	< 0.2	< 0.2
Insertion loss stability vs. shaking	dB	± 0.1	± 0.1
Power handling	watt	see graph	see graph



Phase stability of the RF units

Cable calculations

The electrical length of a cable is $\ell_e = \frac{360°}{c} \times f \times L \times \sqrt{\varepsilon_r}$

Let's consider a $L = 3$ m long cable, frequency of $f = 3$ GHz and a dielectric constant $\varepsilon_r = 2.0$

The electrical length is $\ell_e = 15.27E^{3°}$

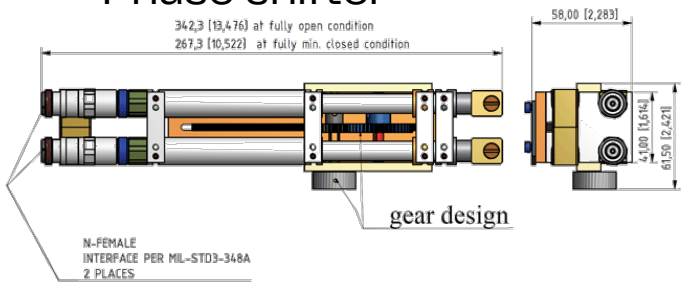
A variation on temperature will correspond to a phase shift i.e. 1.527° for 100 ppm

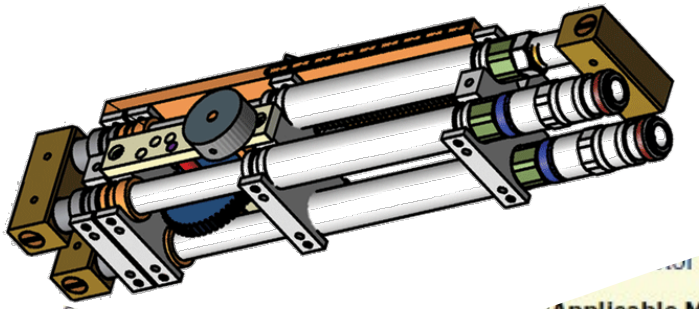
A loop of 360° with a diameter of 55 mm will correspond to a phase change of 0.8–0.9°/GHz

Phase stability of the RF units

RF components

Phase shifter



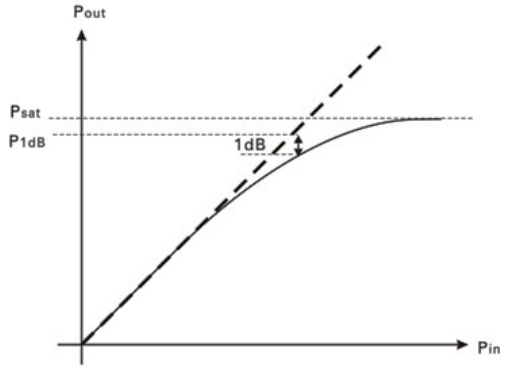


Settable: To better than 1.0 deg due to multi-turn shaft and linear control. One rotation at 1.0GHz is approx. 3.5°	Applicable Mil-Specs General: Product Specific:
Temperature Stability: 0.025°/DC°/GHz	

RF amplifier, attenuators, LPF, Power splitters

Specifications for 19" Rack-Mount

- Centre Frequency : 2.85Ghz & 2.998GHz
- Peak Output Power : 350W @ 5% duty
- Full Power Bandwidth: 40MHz min
- 3dB Power Bandwidth : 200Mhz typ
- Input Power for Rated Output : 0dBm nom
- Absolute max input Power : +15dBm (CW)
- Duty Cycle : 5% max
- Input Signal Characteristic : Pulsed
- Input Pulse Width : 200uS max
- Pulse Repetition Frequency : 5KHz max
- RF Output Stability in Pulse :0.2dB/10uS max, 0.8dB/200uS max @ peak O/P
- RF Output Phase Stability in Pulse : 1 degree max

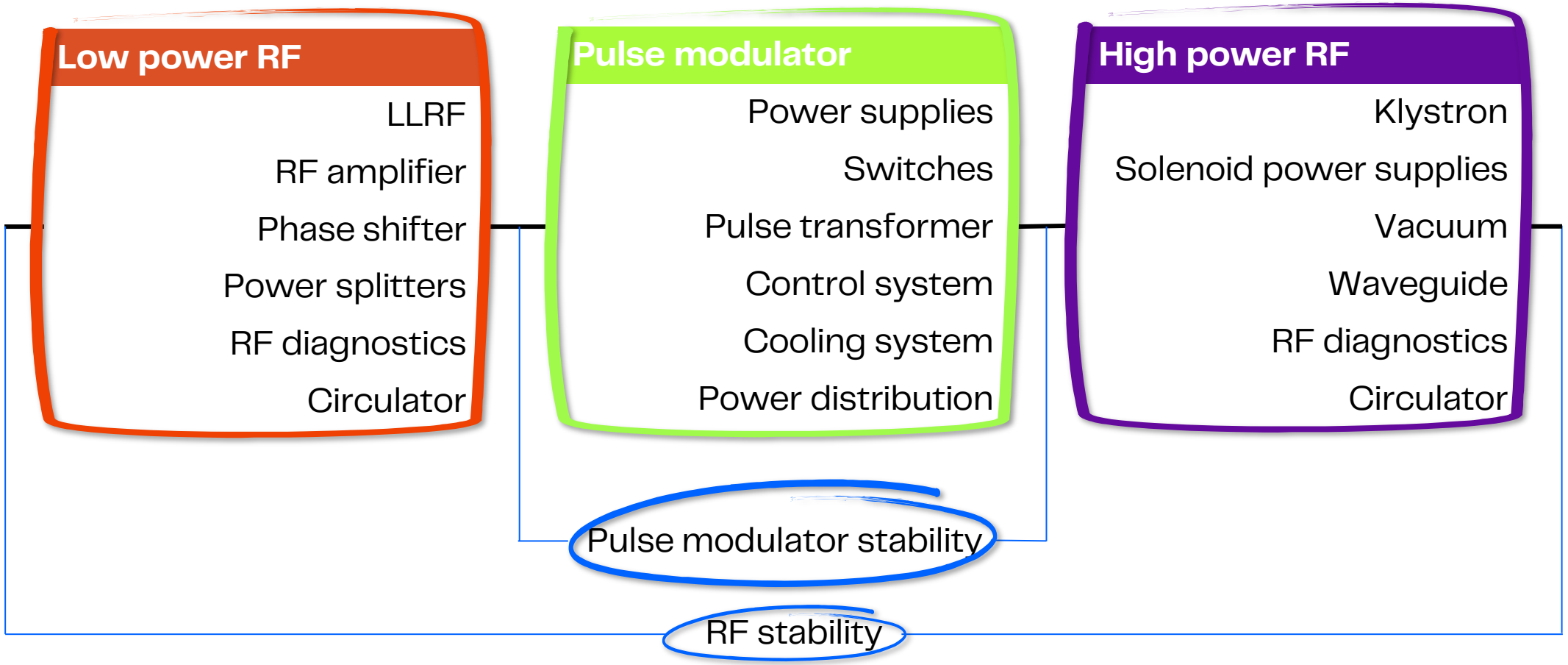


Use of measurement devices

ScandiNova

Use of measurement devices

How to measure the stabilities

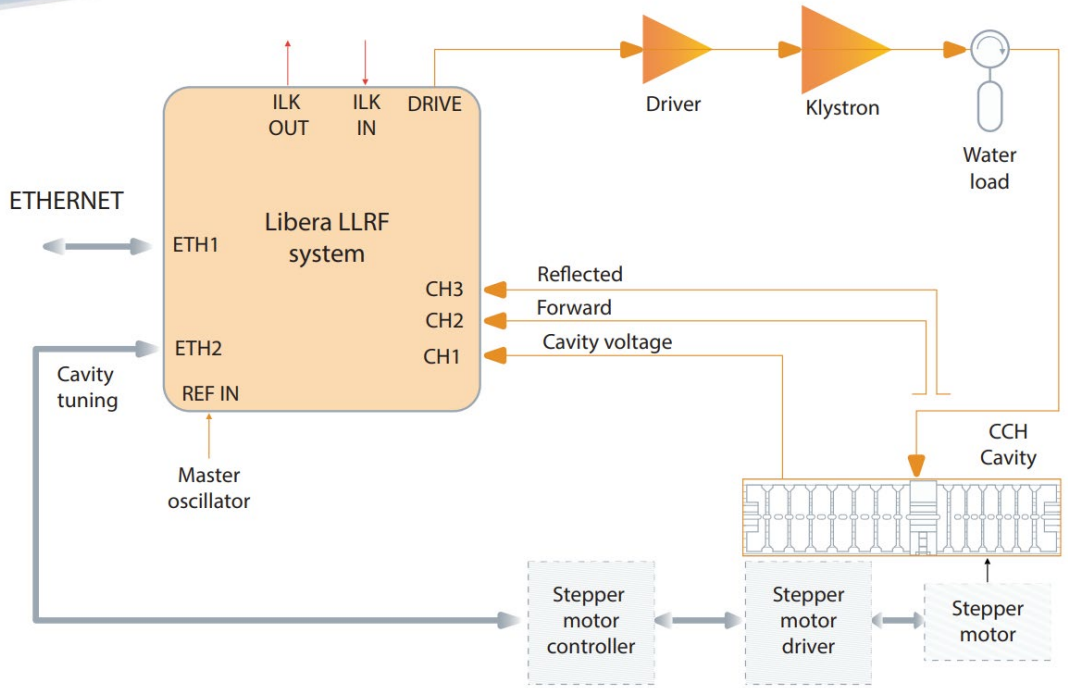


Use of measurement devices

Libera

mTCA based LLRF system

- Customized amplitude and phase pulse shape
- High-resolution amplifier and diagnostics
- Precise temperature stabilization



LIBERA LLRF PERFORMANCE

Amplitude stability	< 0.01% RMS
Phase stability	< 0.01° RMS
Latency (Input -> Drive output)	Down to 250 ns
Long-term temperature stability with temperature stabilized RF front-end	< 100 fs RMS / 72 hours

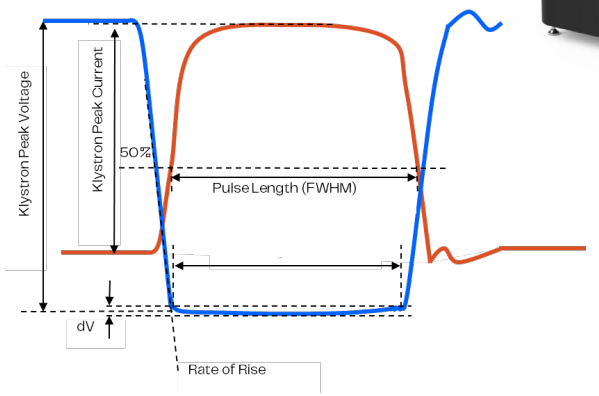
Conclusions and future developments

ScandiNova

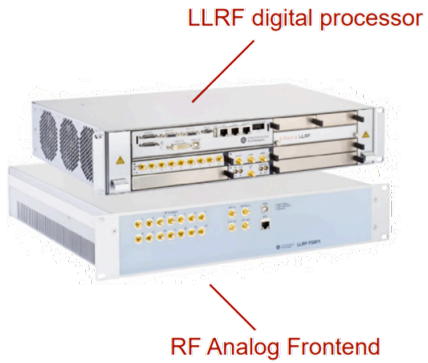
Conclusions

- The pulse modulator offers a pulse to pulse stability of about 20-50 ppm
- It can be improved by adding more power supply in parallel

- The flatness is understood and is in the % range

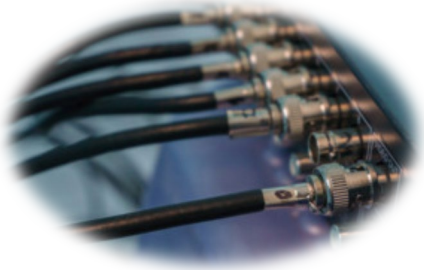


- We want to provide the best performances for the RF-unit by making accurate RF measurements (amplitude and phase, I & Q) and integration of the RF devices



Conclusions and future developments

Future possible development



- Thermalization of all the LLRF system
- Integration of the RF cables to limit the curvature and vibrations by using cable trays between the klystron and the control rack

- Study and qualify RF to optical transition

- Understand if active loops systems to compensate fast variations (phase noise, vibrations on the cables) and slow variations (temperature, humidity, klystron's usage) are good solutions
- Fast-feedback loop (intra-pulse feedback, beam loading compensation, klystron non-linearities compensations)

- Integrate the improvements on all our products

2500 Installations – Takeaways!

Mikael Lindholm, Founder, VP Sales & Marketing

ScandiNova

Introduction

The first 2500 units

- When?
- Where?
- What?
- Usage?

1997

Installations:

2

Countries:

1

Operation Hours:

445

1998

Installations:

2

Countries:

1

Operation Hours:

1.122

1999

Installations:

4

Countries:

2

Operation Hours:

2.041

2000

Installations:

6

Countries:

2

Operation Hours:

3.167

2001

Installations:

9

Countries:

3

Operation Hours:

4.628

2002

Installations:

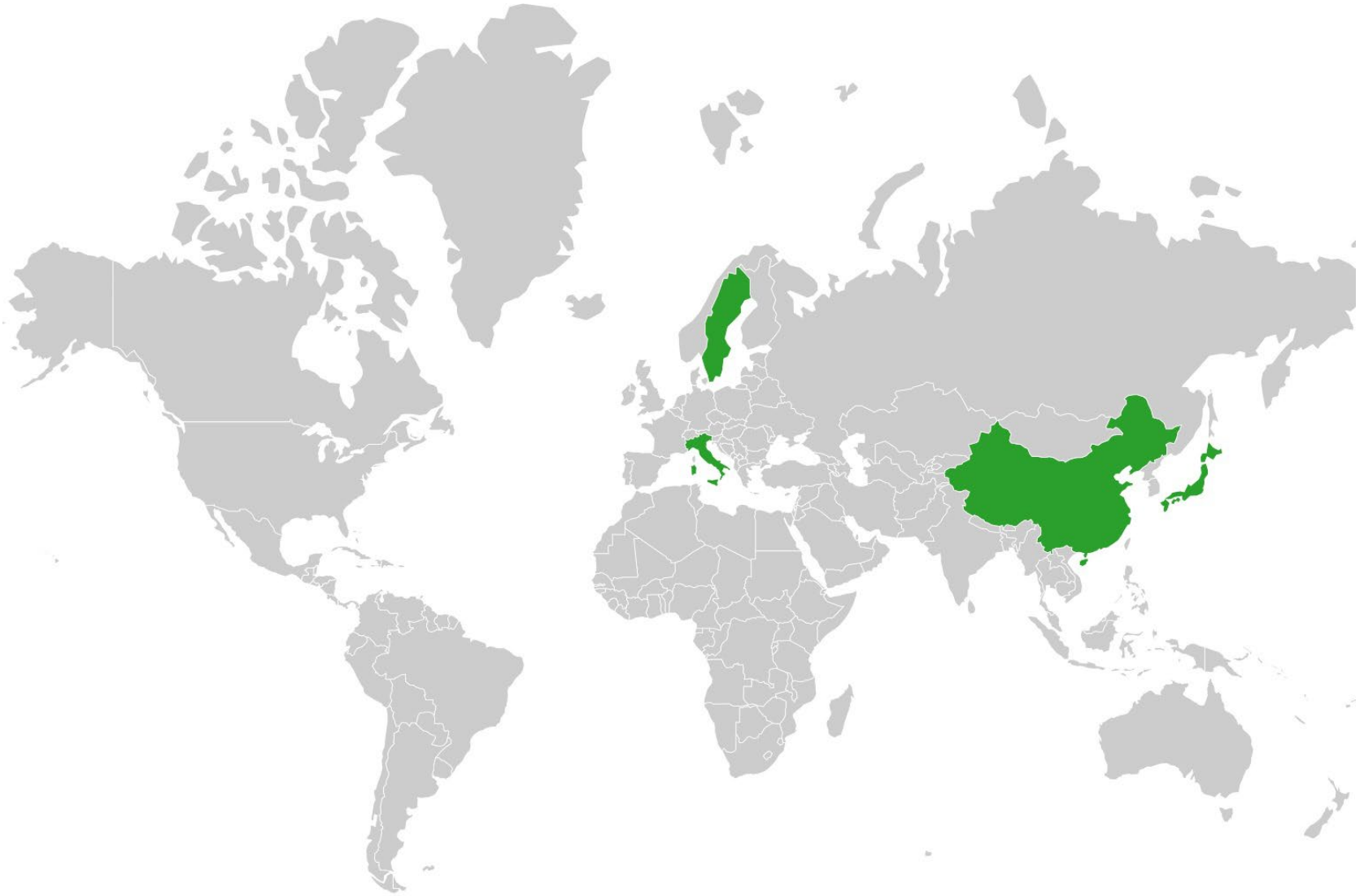
10

Countries:

3

Operation Hours:

7.438



2003

Installations:

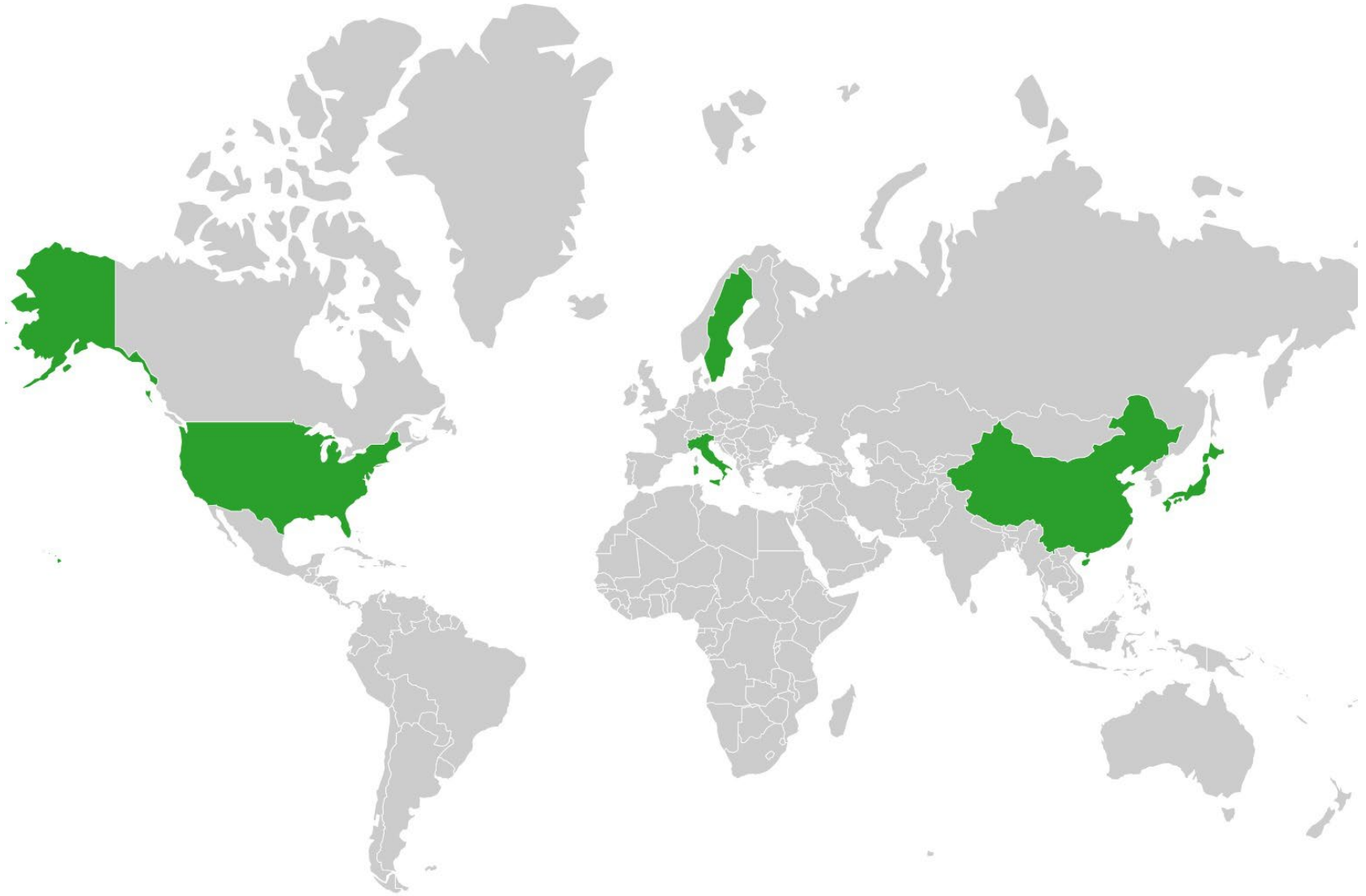
12

Countries:

4

Operation Hours:

11.266



2004

Installations:

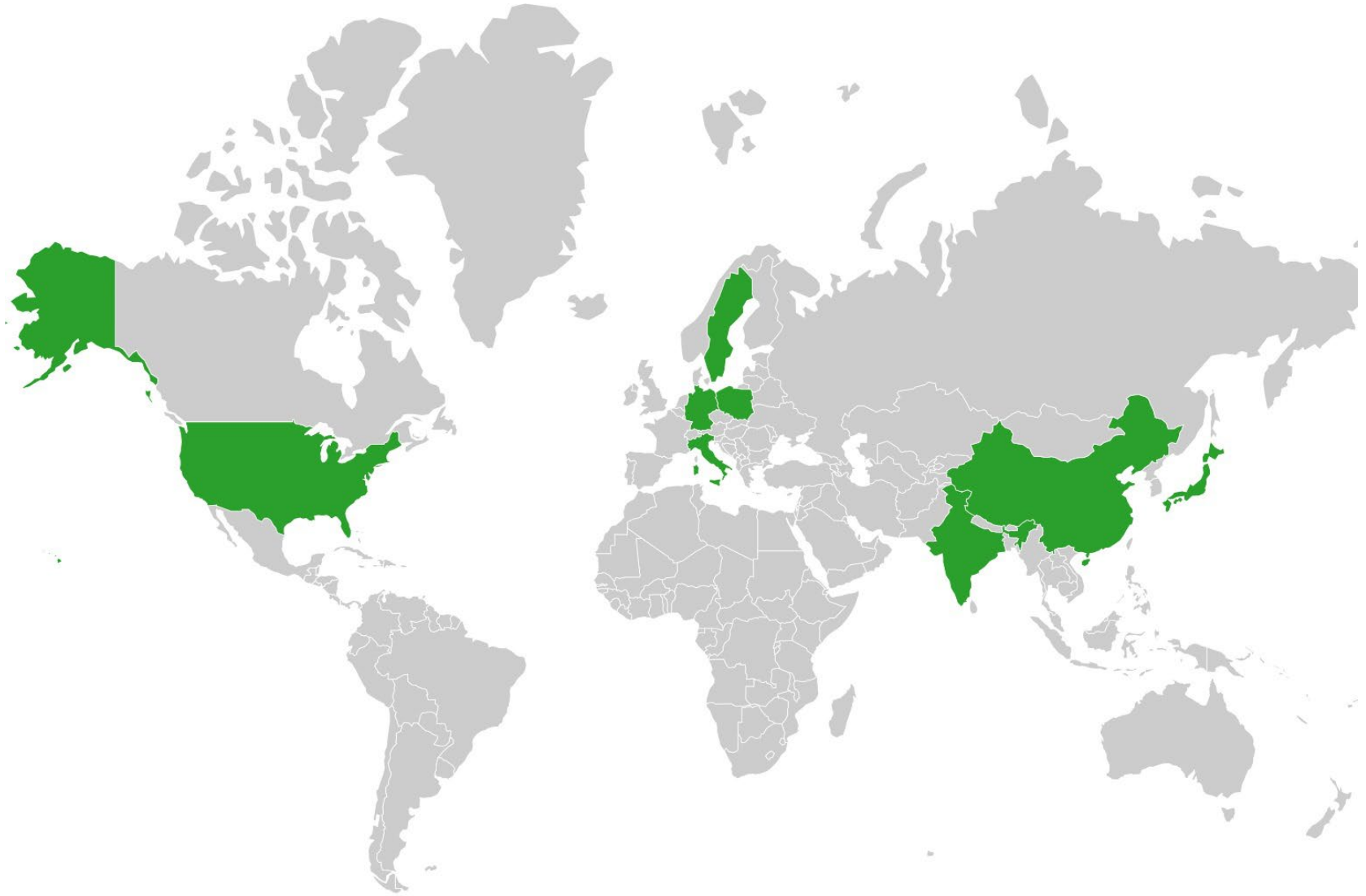
14

Countries:

5

Operation Hours:

16.081



2005

Installations:

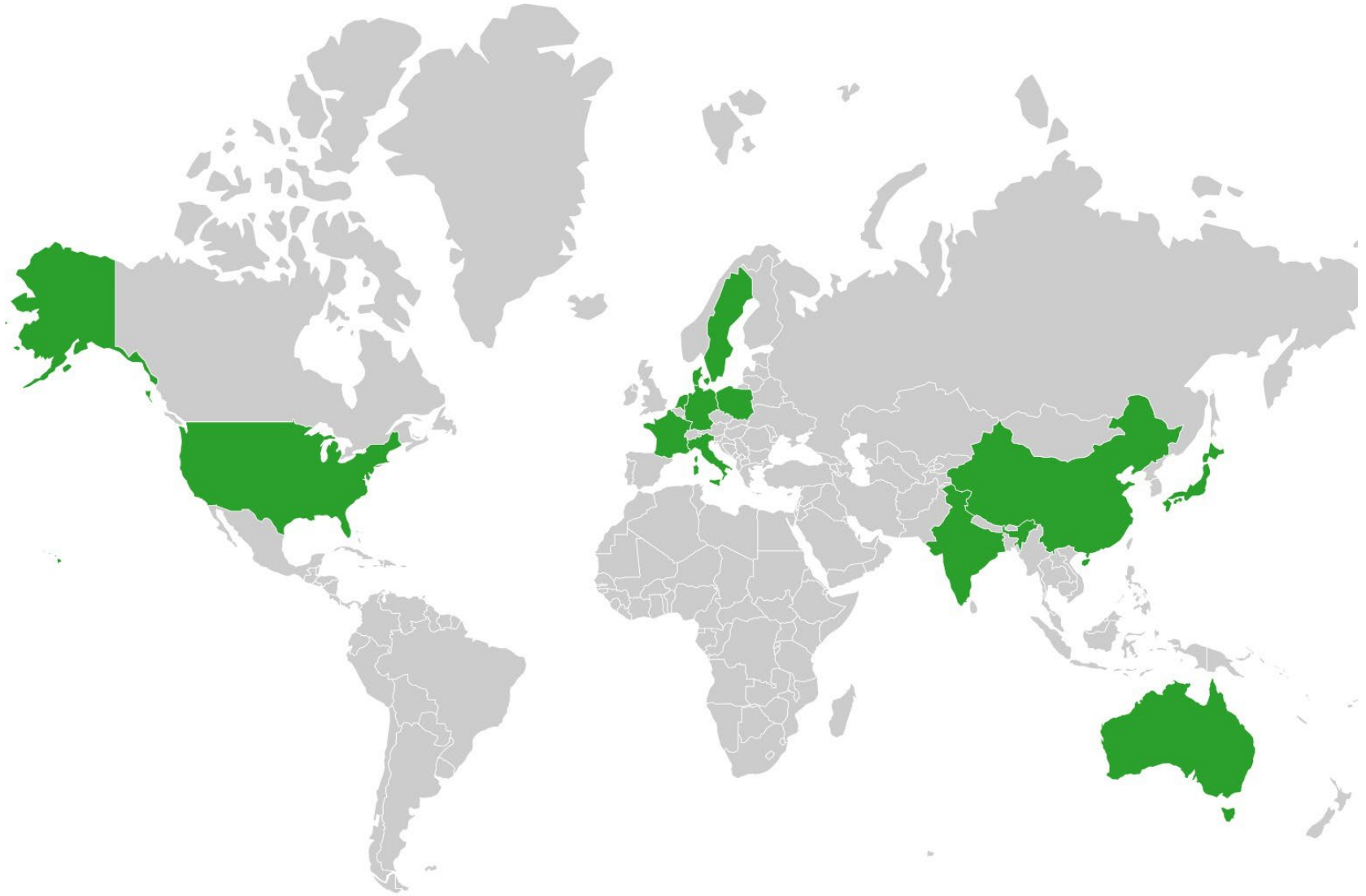
19

Countries:

8

Operation Hours:

23.165



2006

Installations:

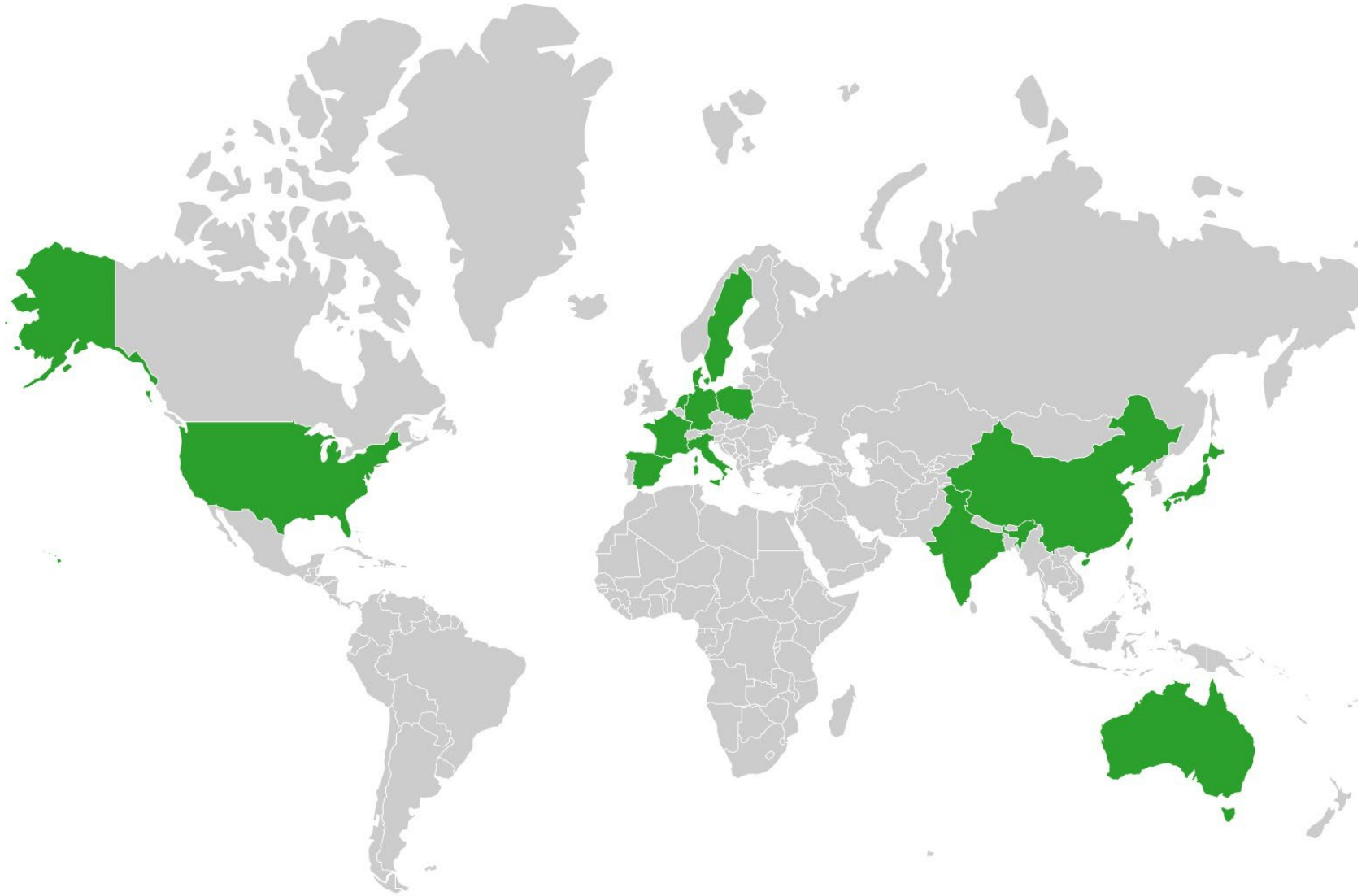
31

Countries:

12

Operation Hours:

35.116



2007

Installations:

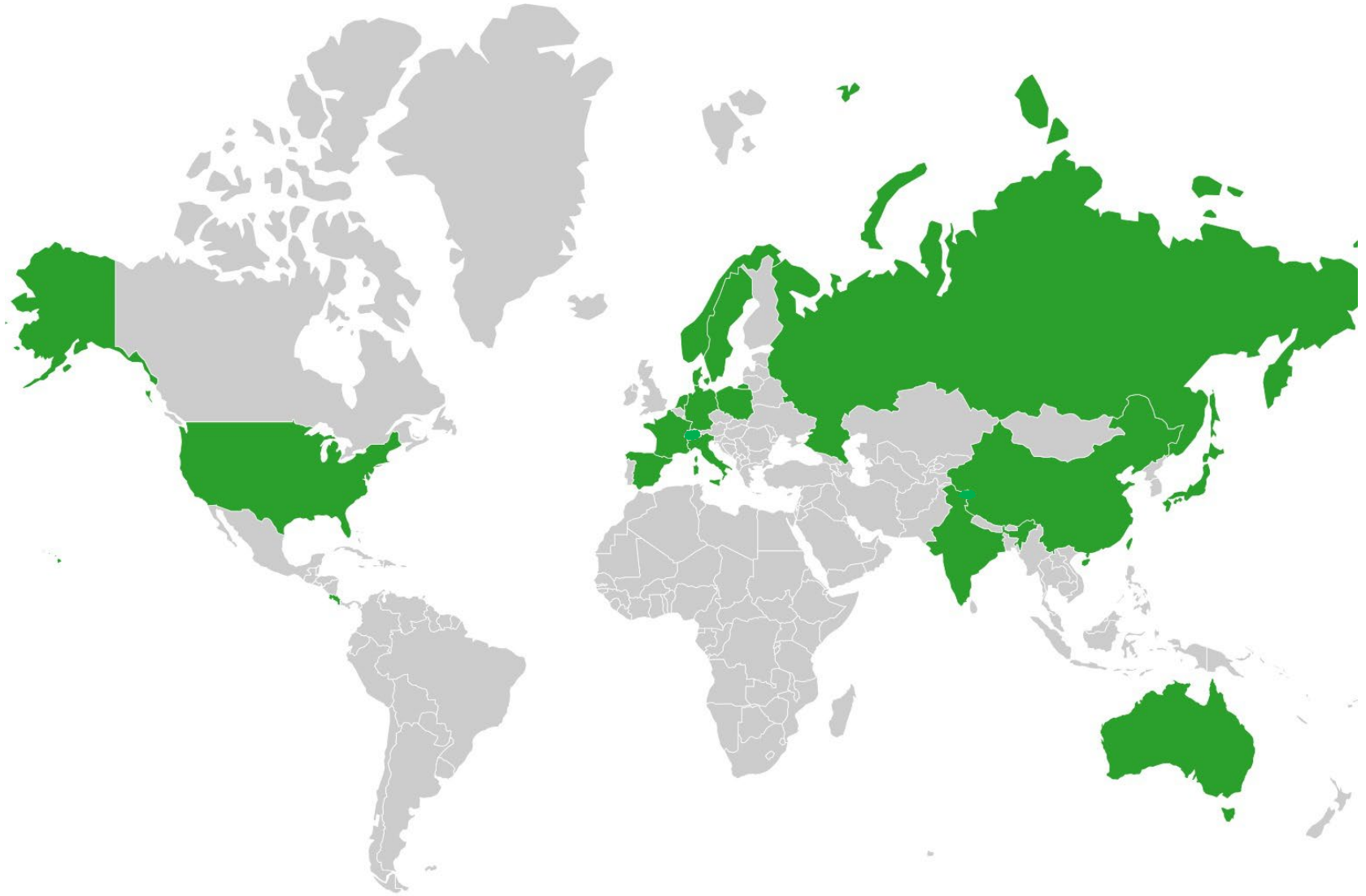
38

Countries:

14

Operation Hours:

50.021



2008

Installations:

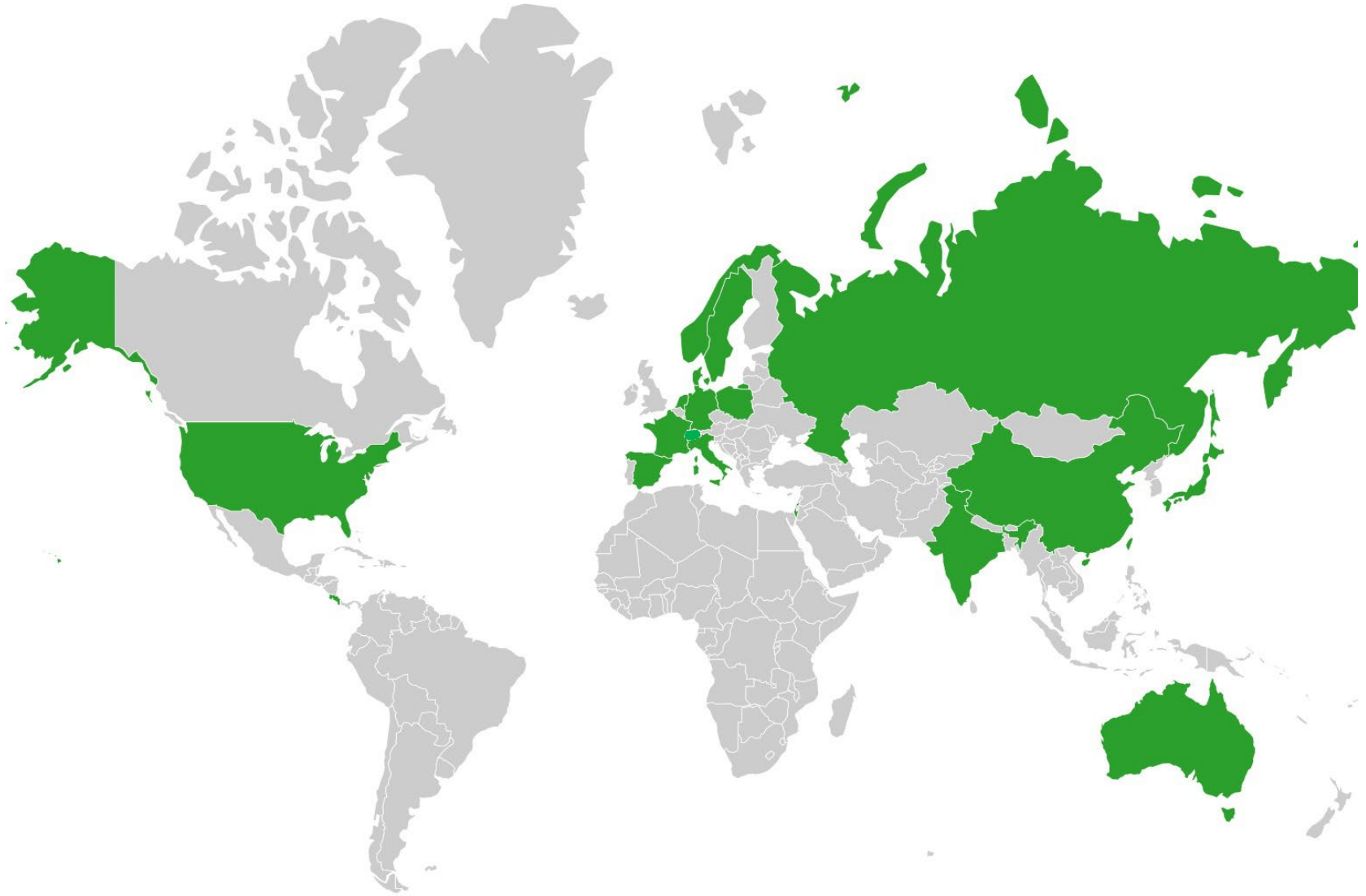
52

Countries:

17

Operation Hours:

71.984



2009

Installations:

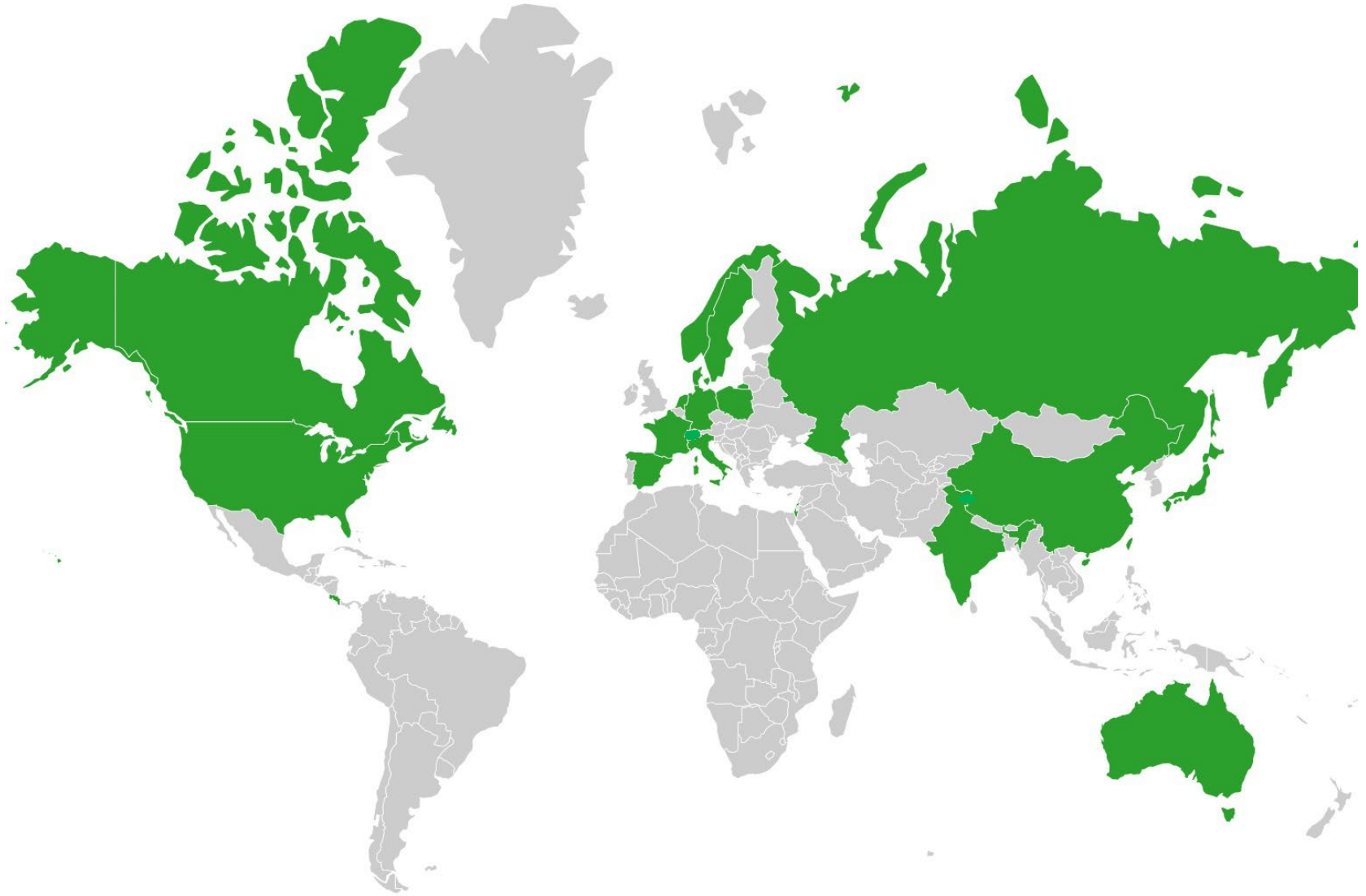
71

Countries:

18

Operation Hours:

102.514



2010

Installations:

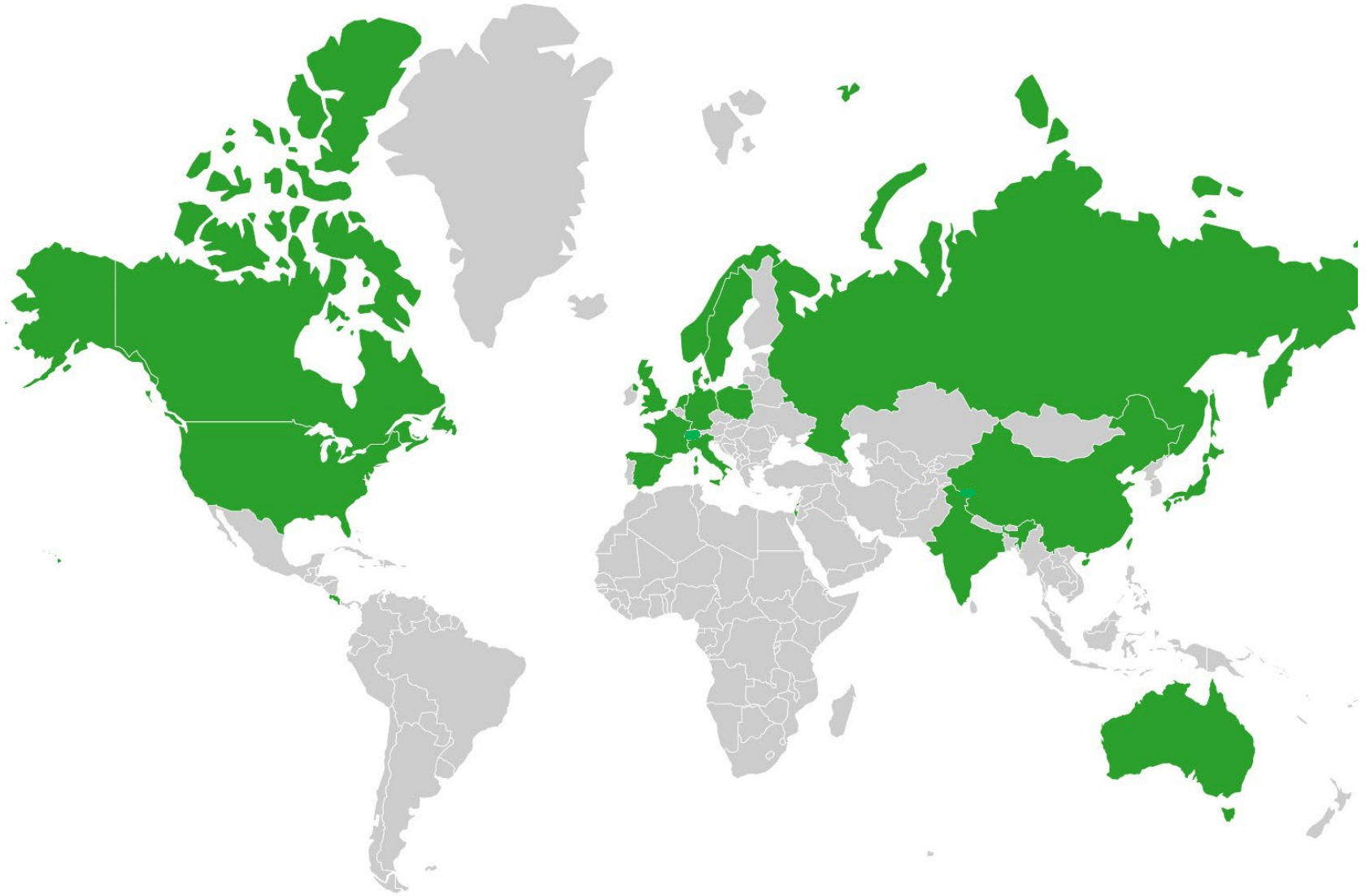
99

Countries:

20

Operation Hours:

146.861



2011

Installations:

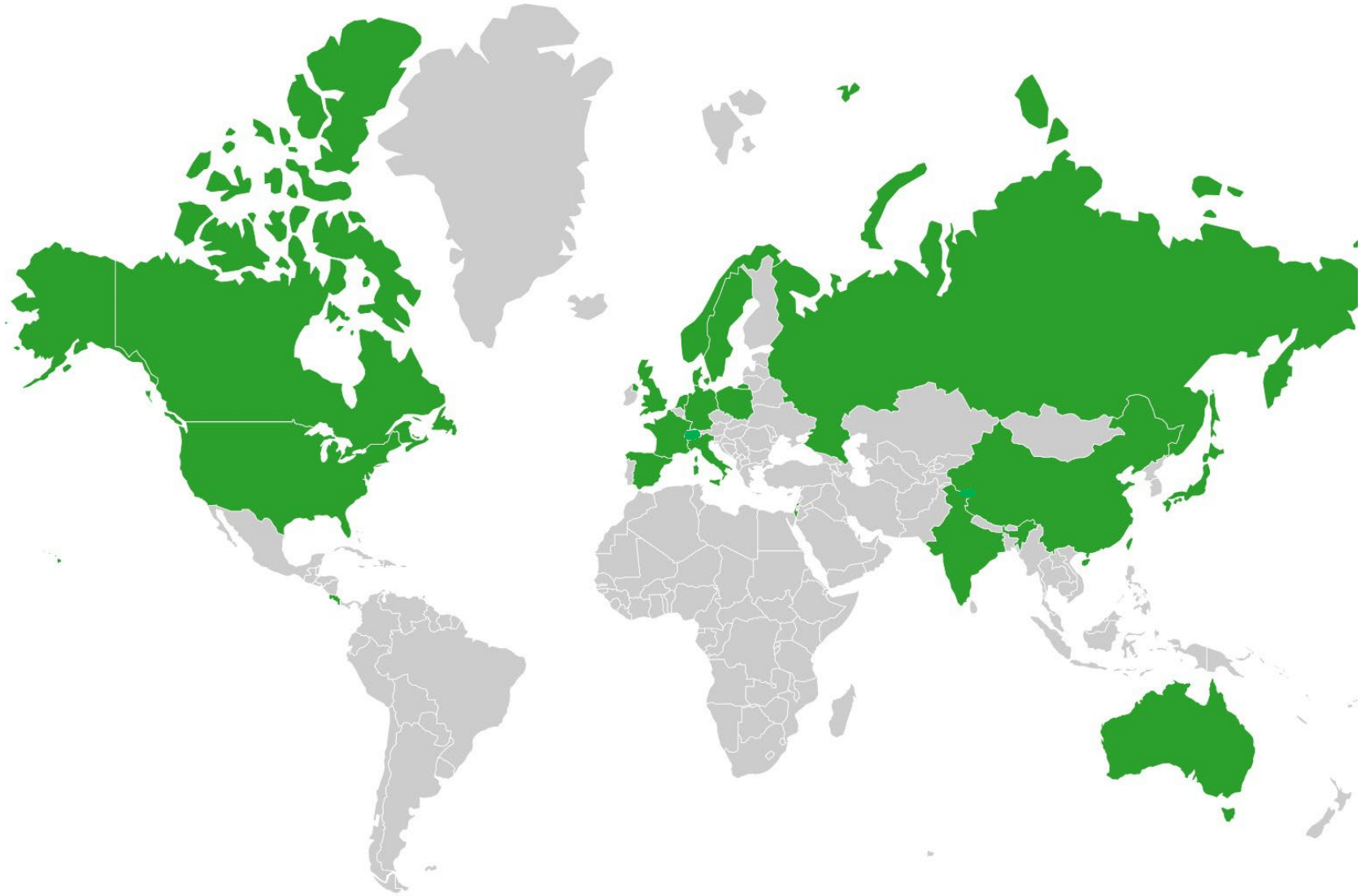
131

Countries:

22

Operation Hours:

204.388



2012

Installations:

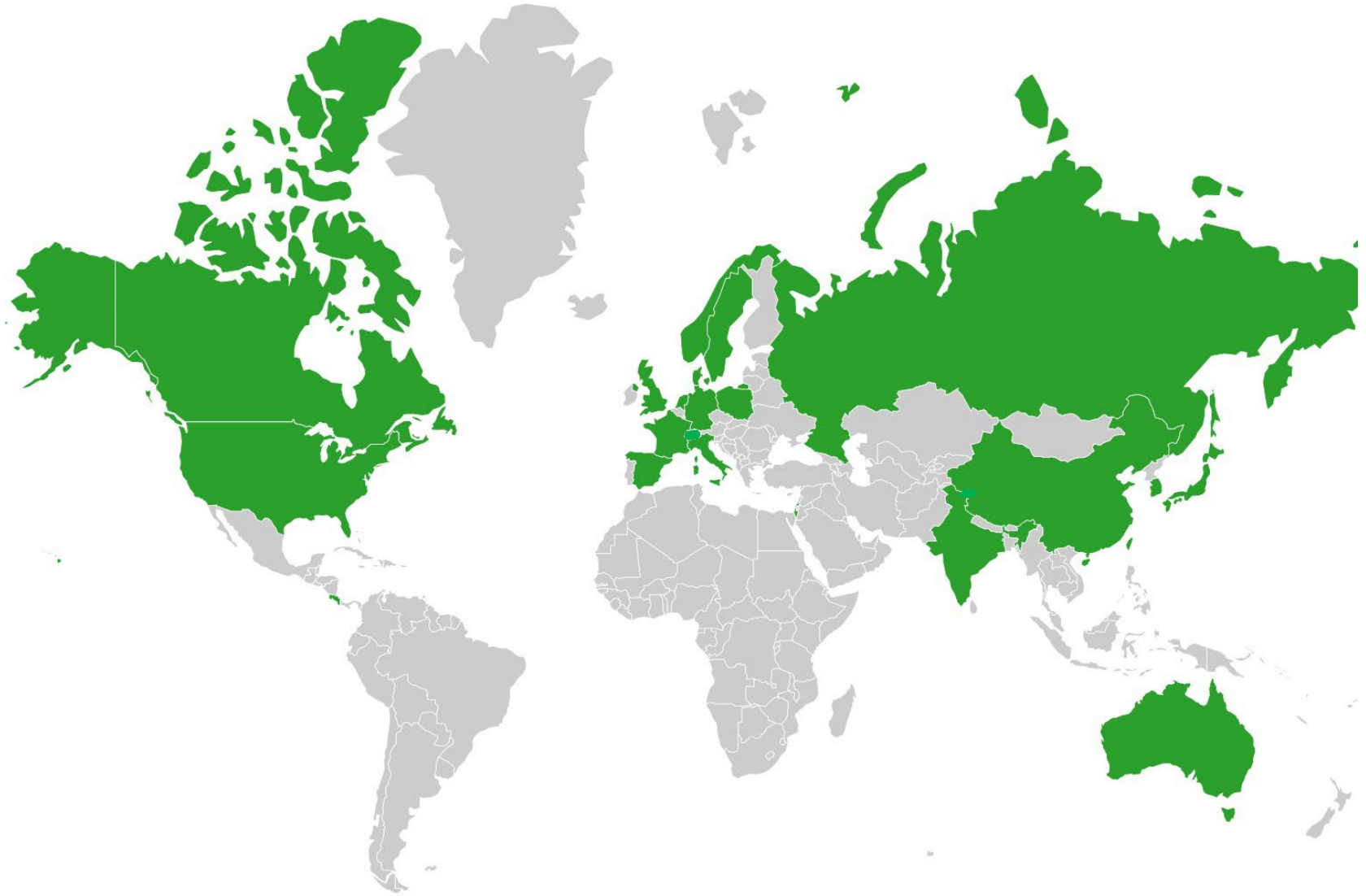
175

Countries:

23

Operation Hours:

287.532



2013

Installations:

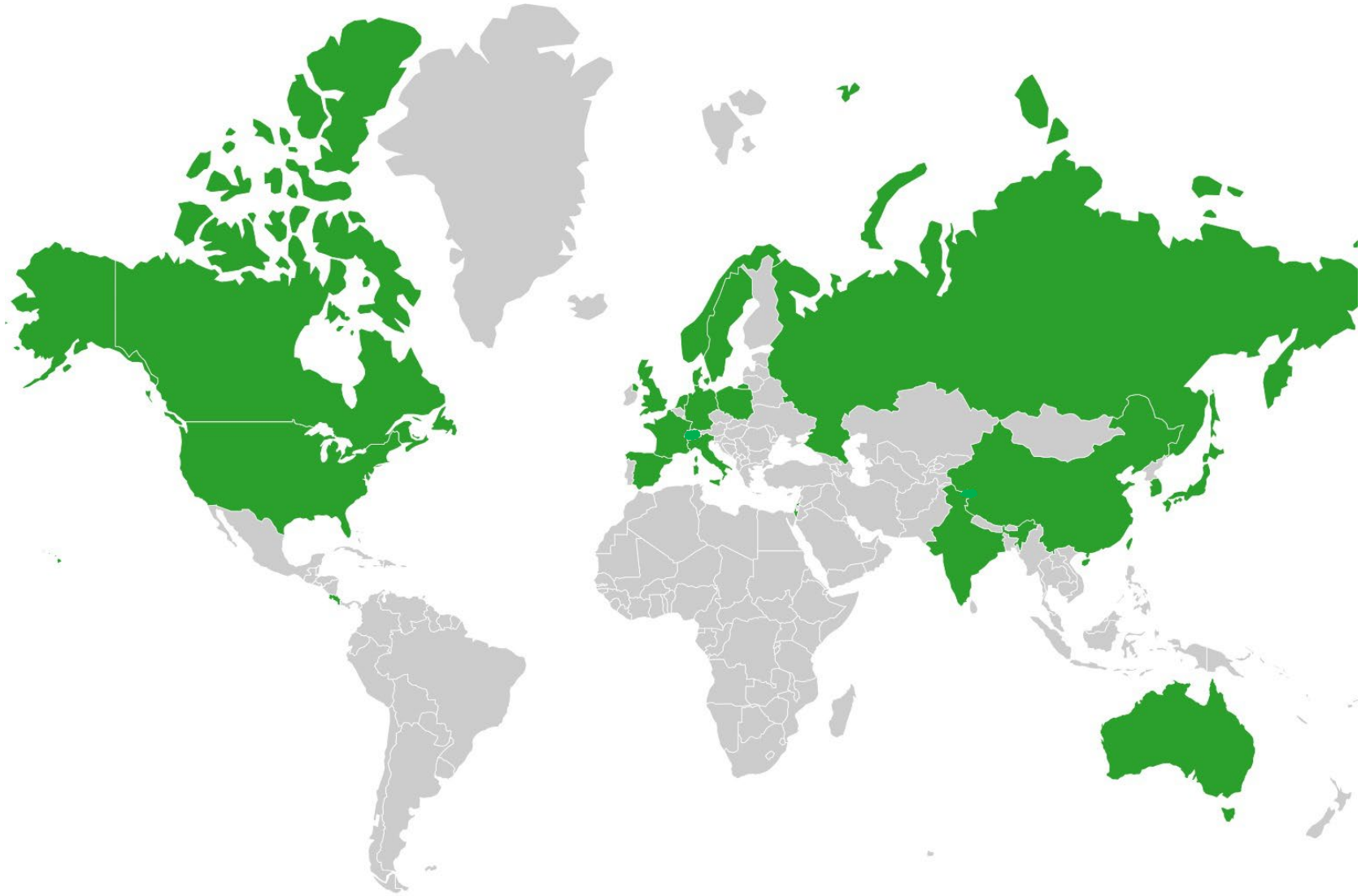
213

Countries:

25

Operation Hours:

394.914



2014

Installations:

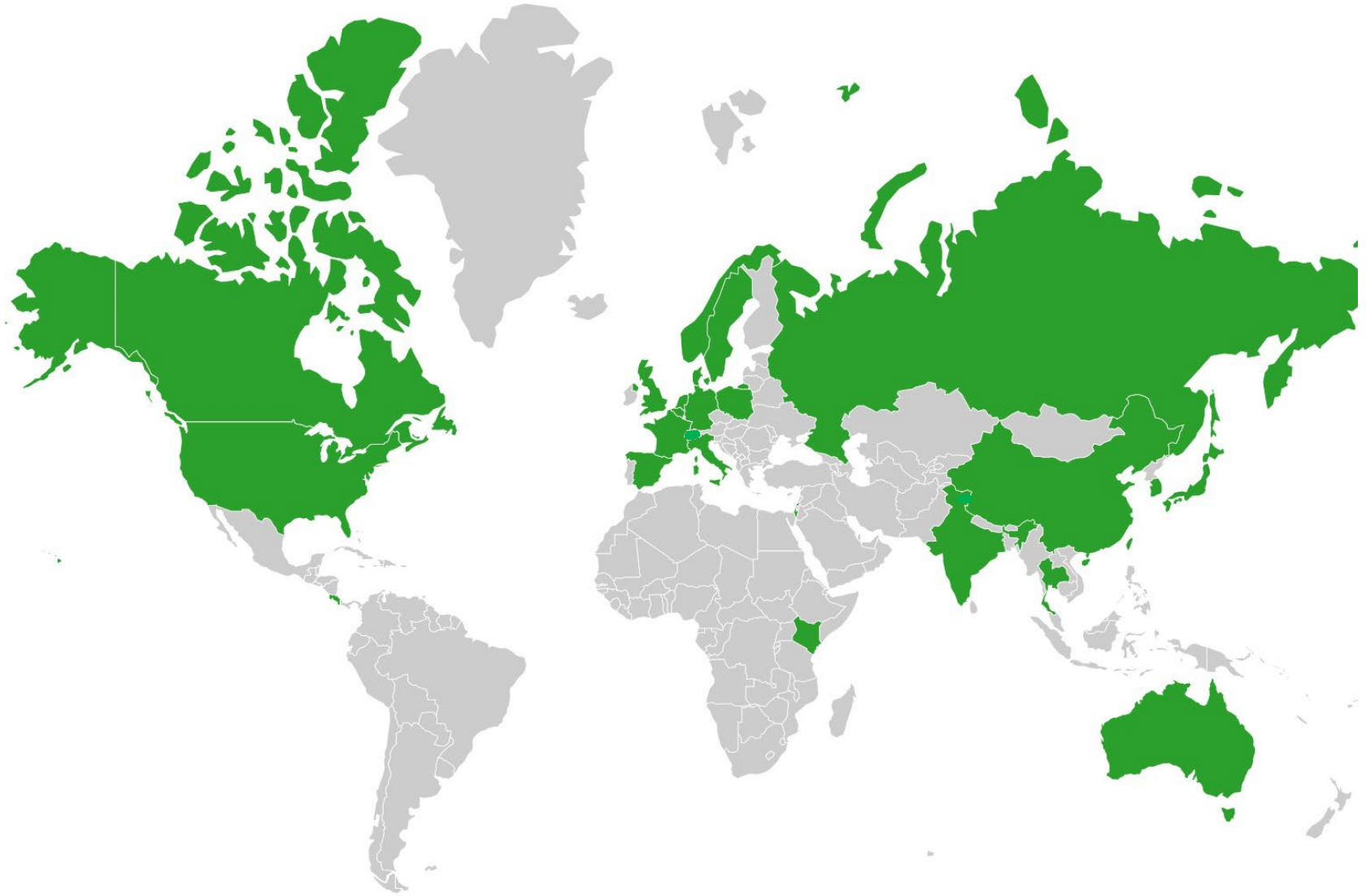
250

Countries:

27

Operation Hours:

511.808



2015

Installations:

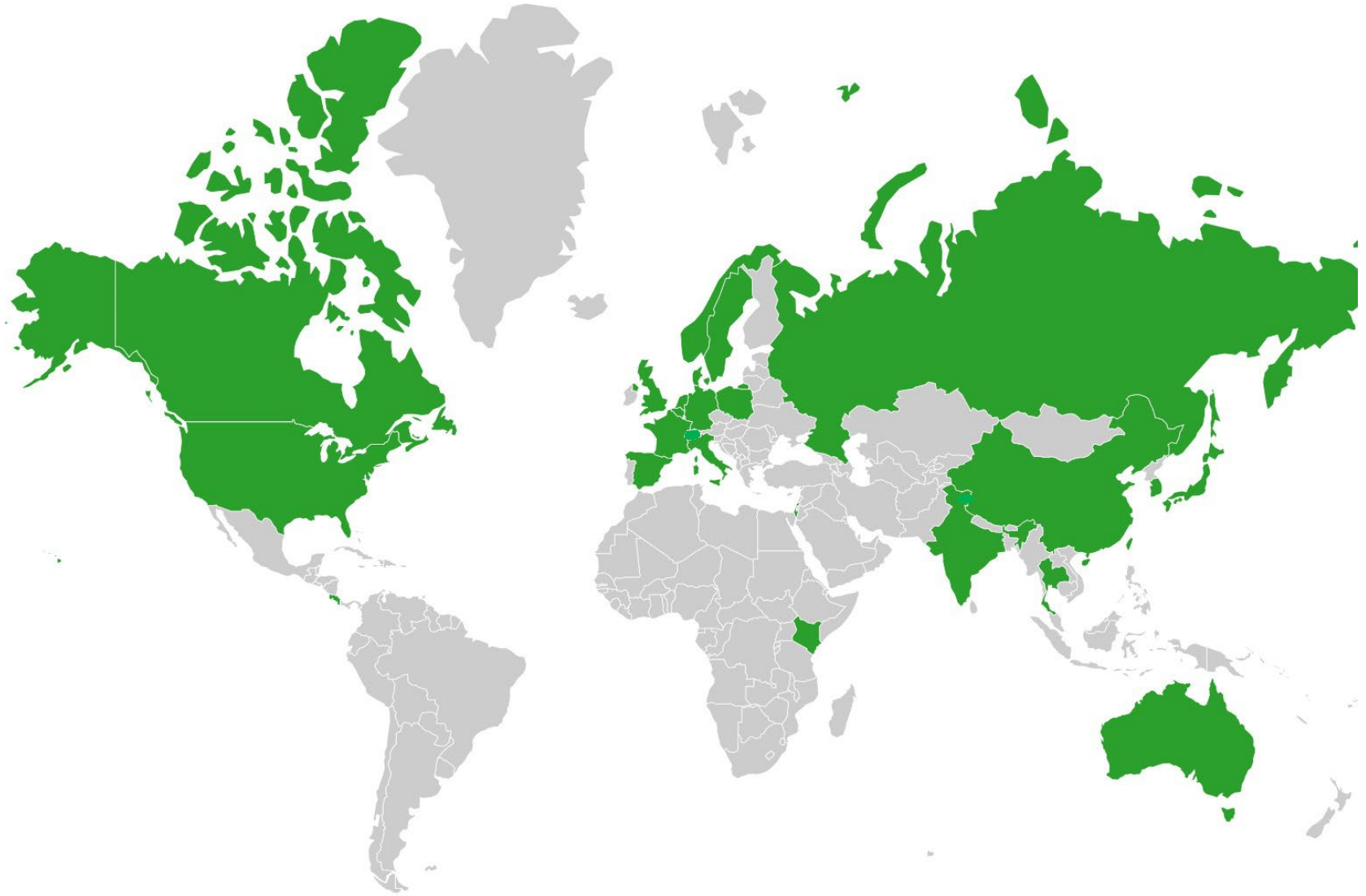
345

Countries:

30

Operation Hours:

657.696



2016

Installations:

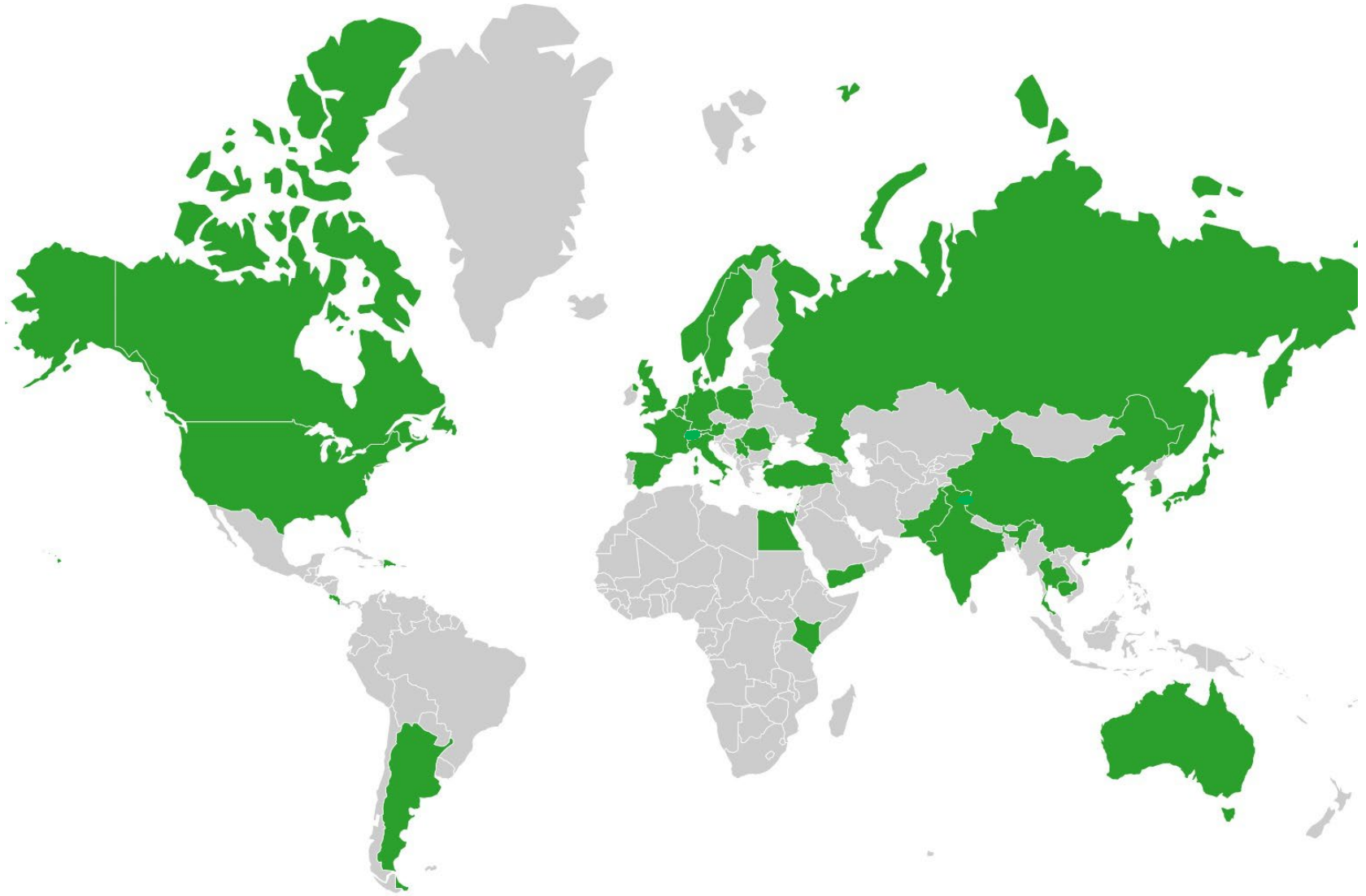
409

Countries:

32

Operation Hours:

809.056



2017

Installations:

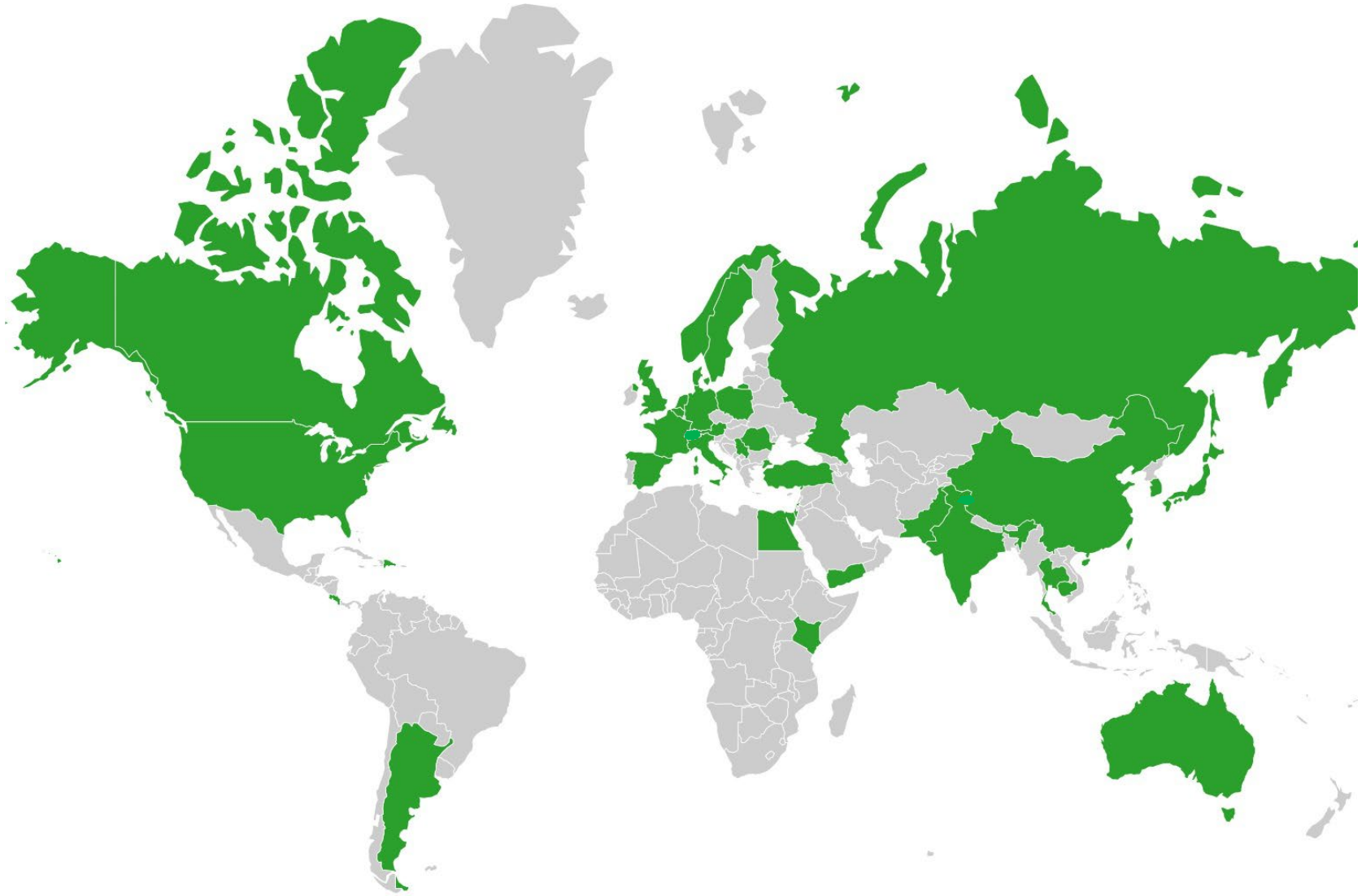
547

Countries:

41

Operation Hours:

960.575



2018

Installations:

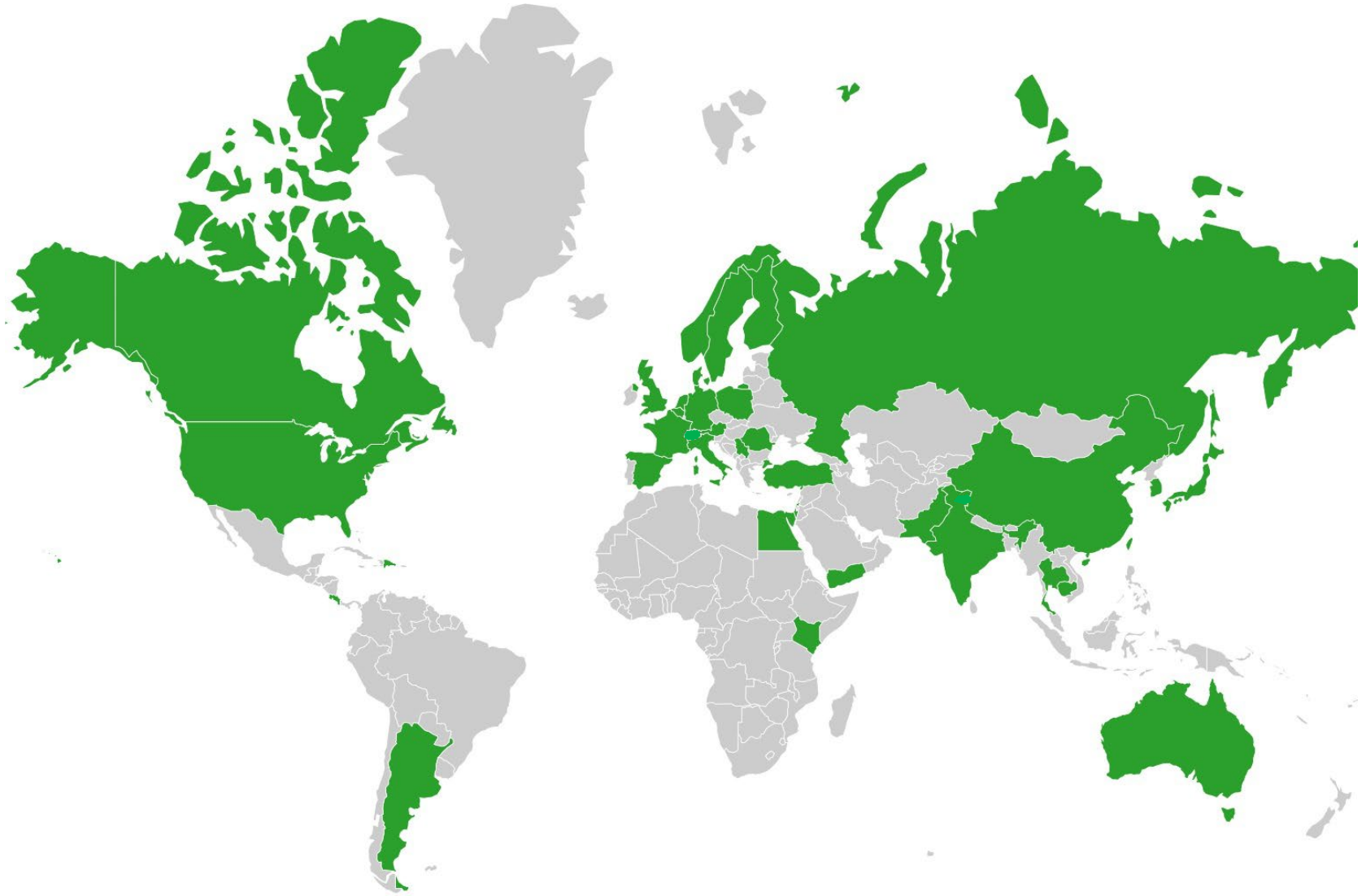
708

Countries:

43

Operation Hours:

1.139.586



2019

Installations:

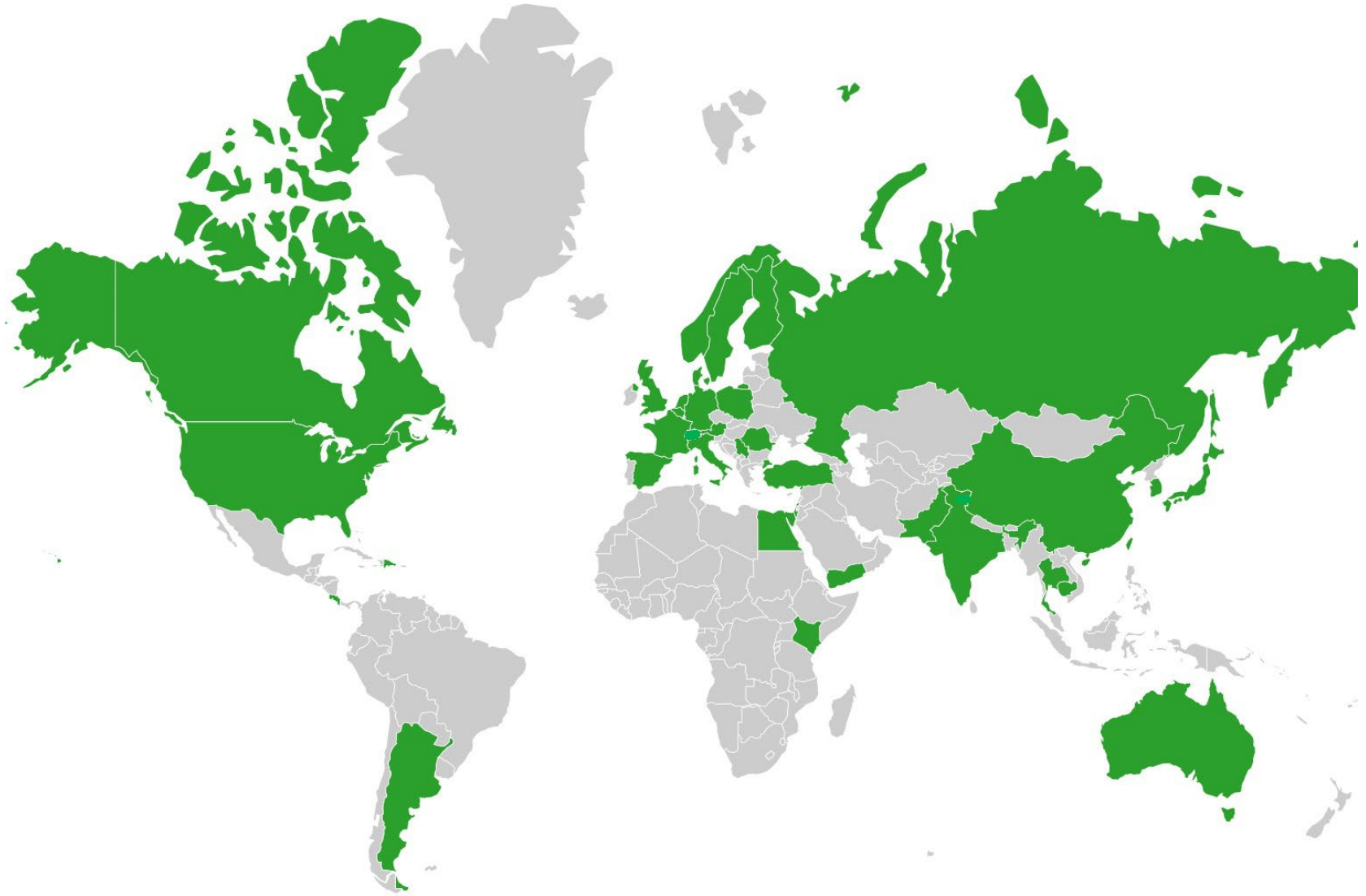
1011

Countries:

45

Operation Hours:

1.375.873



2020

Installations:

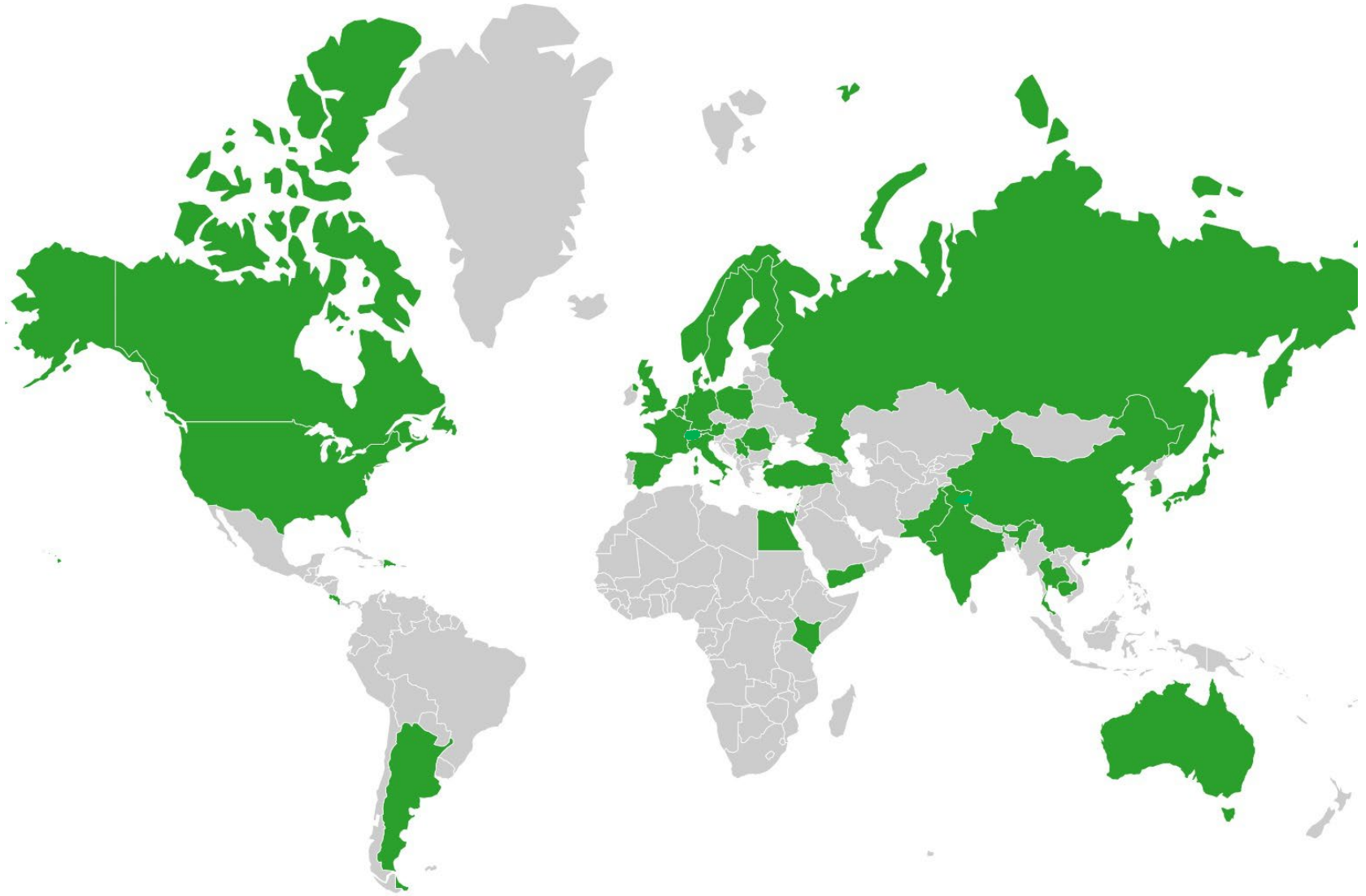
1278

Countries:

45

Operation Hours:

1.672.273



2021

Installations:

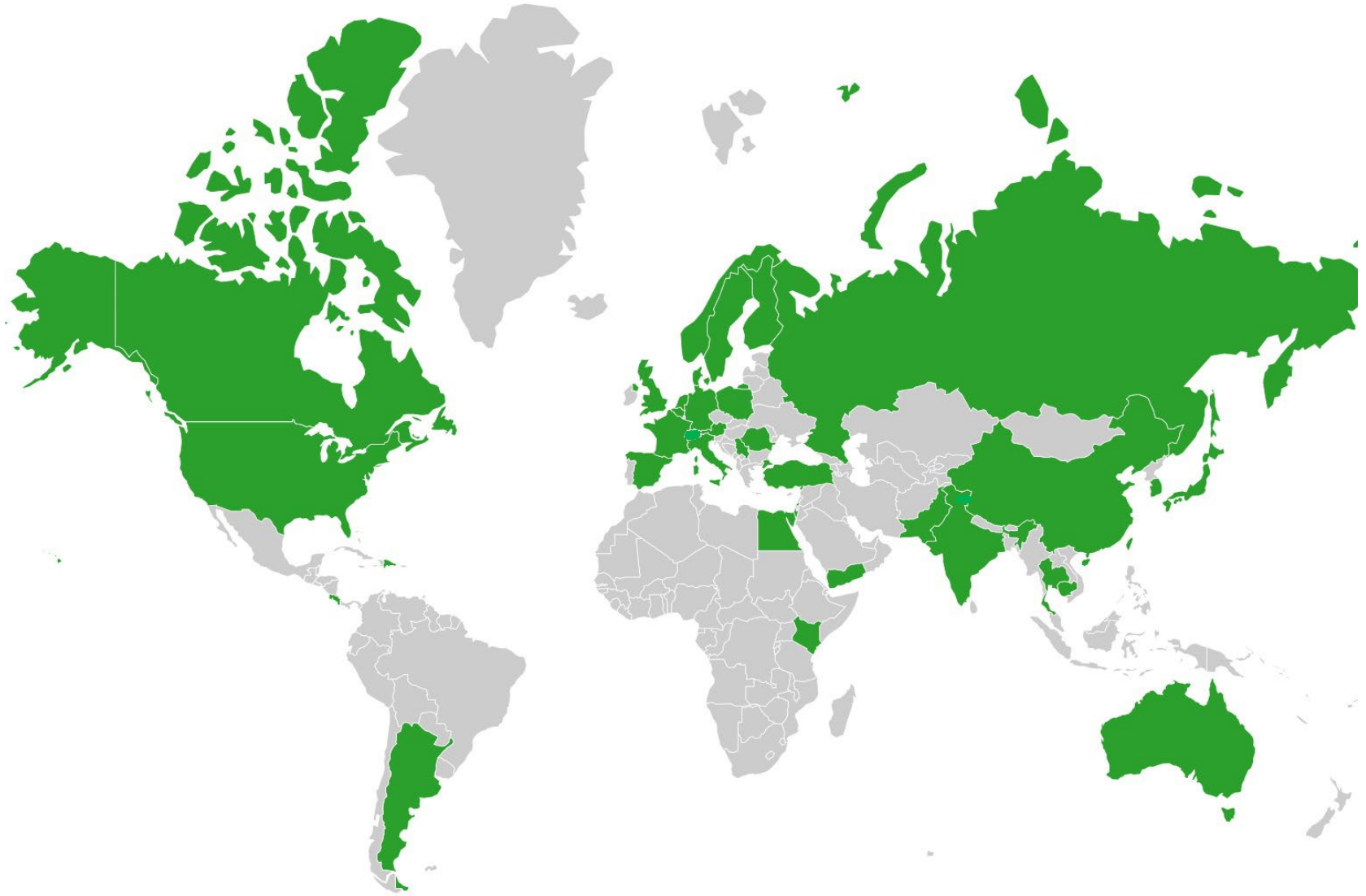
1793

Countries:

46

Operation Hours:

2.085.212



2022

Installations:

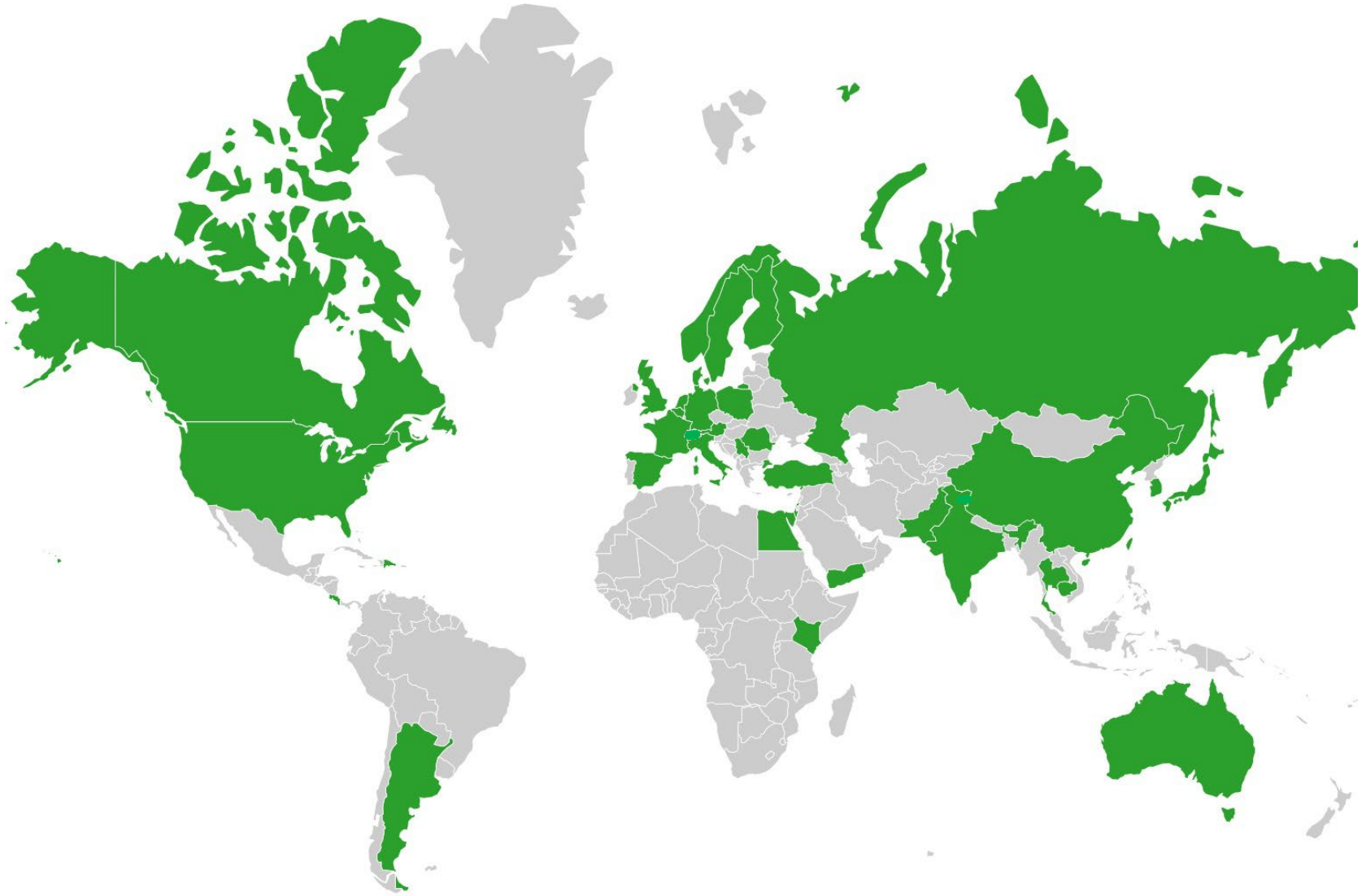
2410

Countries:

47

Operation Hours:

2.640.073



2023
Feb 25

Installations:
2500

Countries:
47

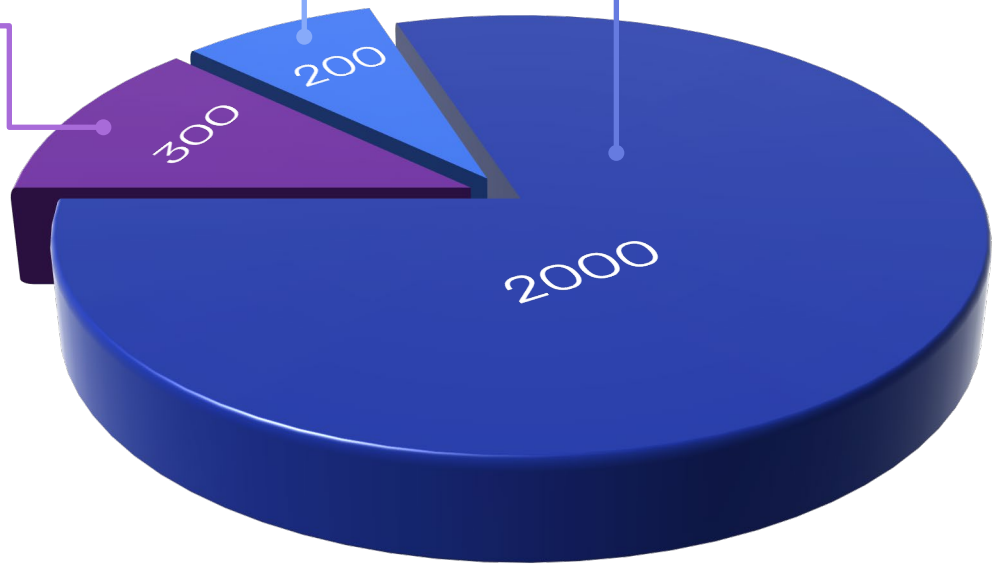
Operation Hours:
2.738.906

What has been delivered

Types of products

E & PG-series

K-series



M-series

Where the products are used

Typical applications

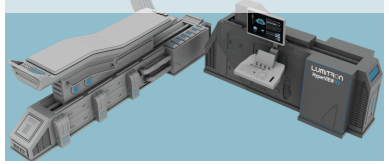
MEDTECH

Intraoperative RT (e^-)

Radiotherapy (γ)

Protontherapy (p^+)

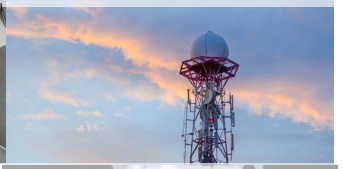
Medical Imaging



INDUSTRY

Food processing

RADAR



Cargo Scanning

Industrial Imaging

E-beam sterilization

Klystron test stand

Suceptibility Testing

Magnetron test stand

SCIENCE

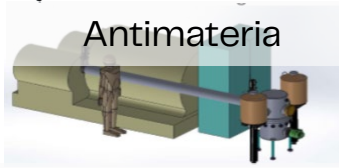
Synchrotron

Free Electron Laser

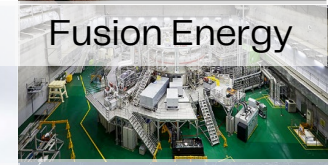
Gamma Source

Isotope Research

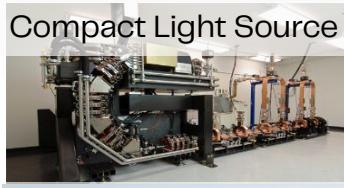
Antimateria



Fusion Energy



Compact Light Source



Hadron collider

Lepton collider

Trends & Achievements 1997 – 2023

ScandiNova

Continuous improvements

Product evolution

1997

KMOD
- 1st concept
- HV pulser
- Single Sw. Unit

1999

KMOD
- 2nd concept
- HV pulser
- Single Sw. Unit

2005

K1
- 3rd concept
- HV pulser
- Single Sw. Unit

2006

K1-C
- 4th concept
- HV pulser
- 6x Sw. Unit

2011

K1
- 5th concept
- RF integration
- 6x Sw. Unit

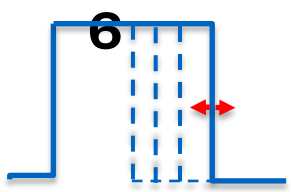
2016

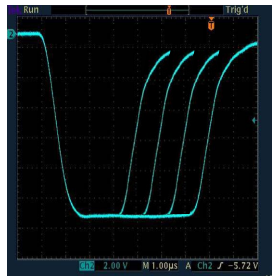
K100
- 6th concept
- RF Unit
- 6x Sw. Unit
- ScandiCat

Meeting customer demands

New features

1996

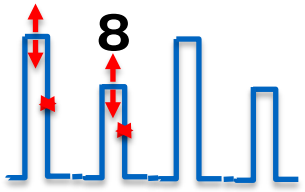


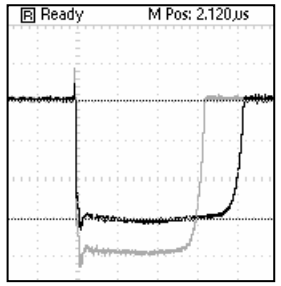


Adjustable Pulse width

- Set by user
- 10 ns resolution

2008

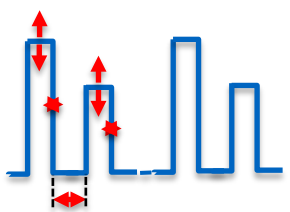


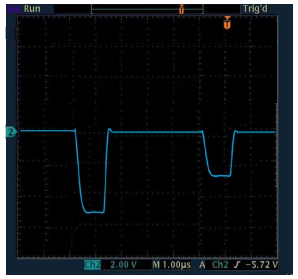


Dual Energy

– Set different Amplitude
–Set different pulse width

2011

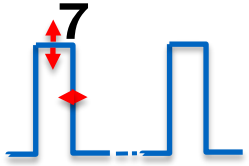


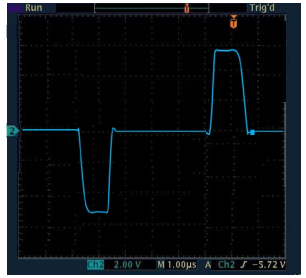


Dual Pulse

–2x consecutive pulses
–Set different amplitude
–Set different pulse width
– Set time between pulses

2017

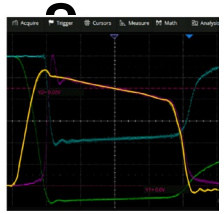


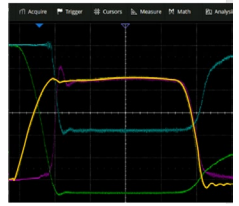


Dual Polarity

–Used for PEF treatment
- Set amplitude
- Set Pulse width

2020

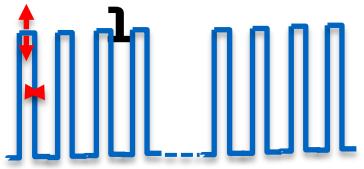


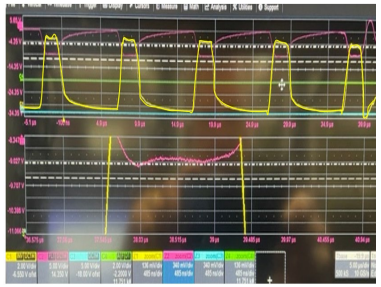


DMPS

– Digitally Modulated Pulse Shaping
– Correct for pulse droop

2021



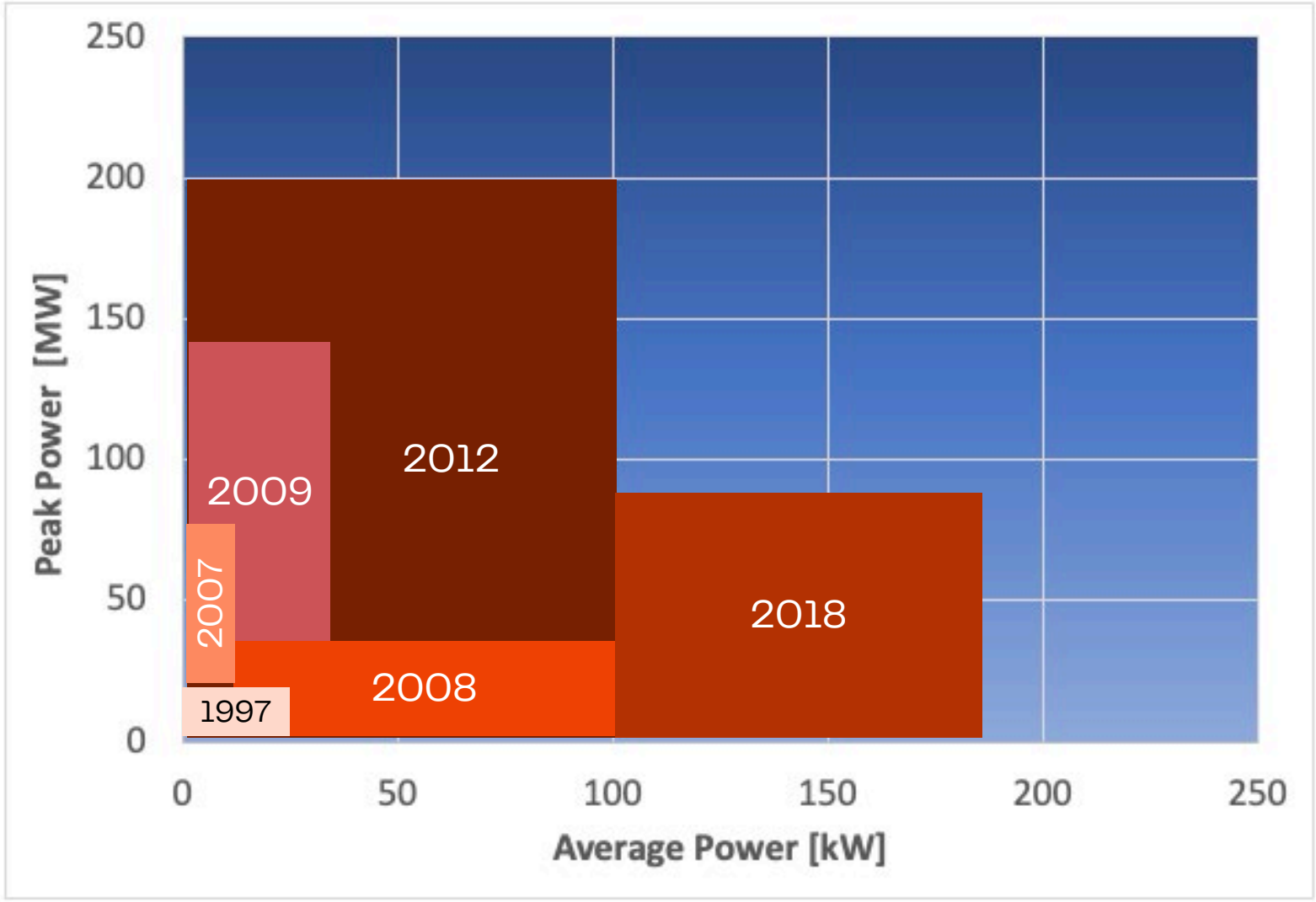


Burst Mode

– Several consecutive pulses
– Suitable for FLASH therapy

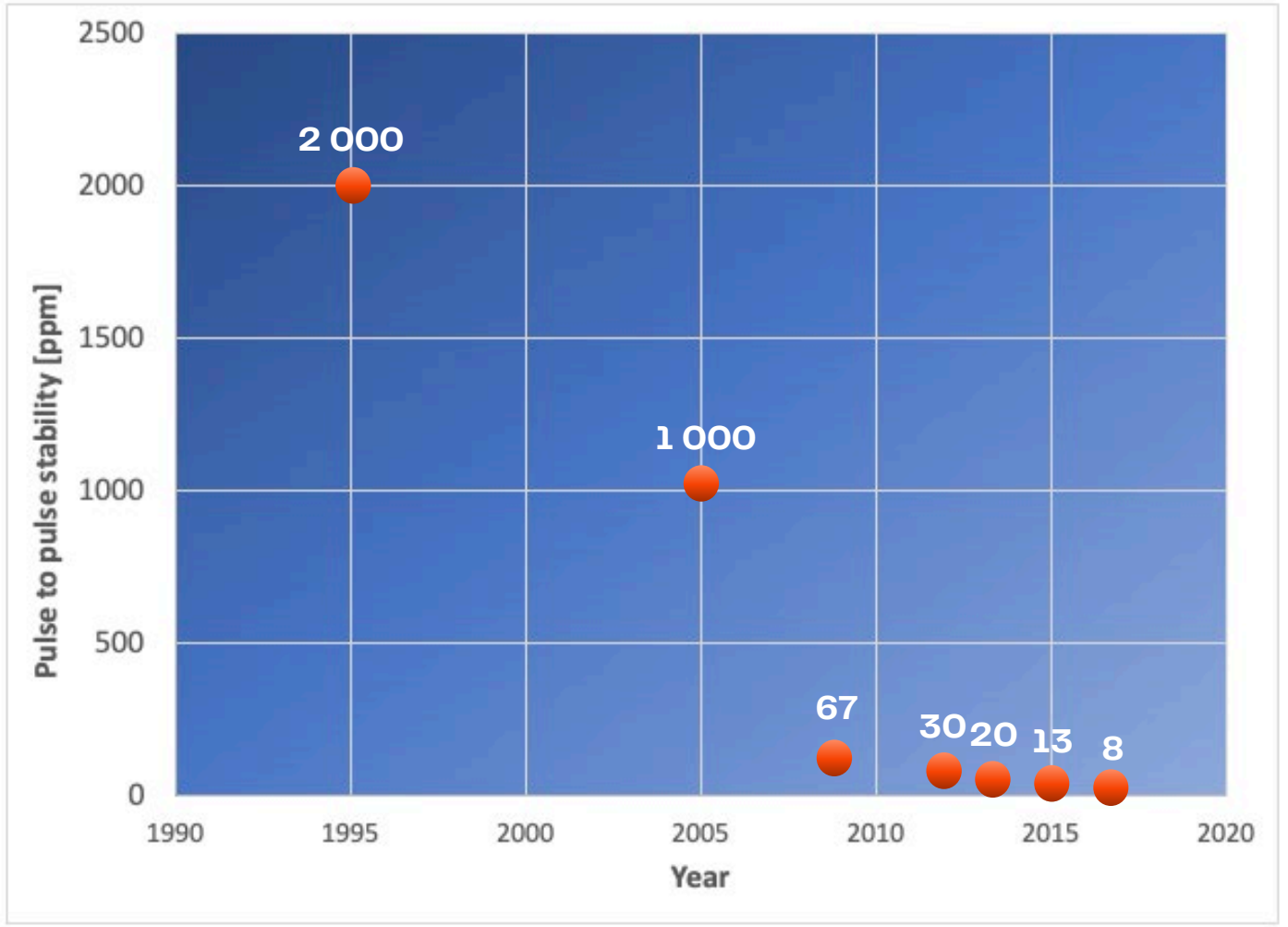
Stretching the performance

Expanding the boundaries



Stretching the performance

Reducing the RF phase shift



Stretching the performance

Environmental demands

PRESSURE

High altitude 3.000 m

TEMPERATURE

High temperature +45 °C

Low temperature -40 °C

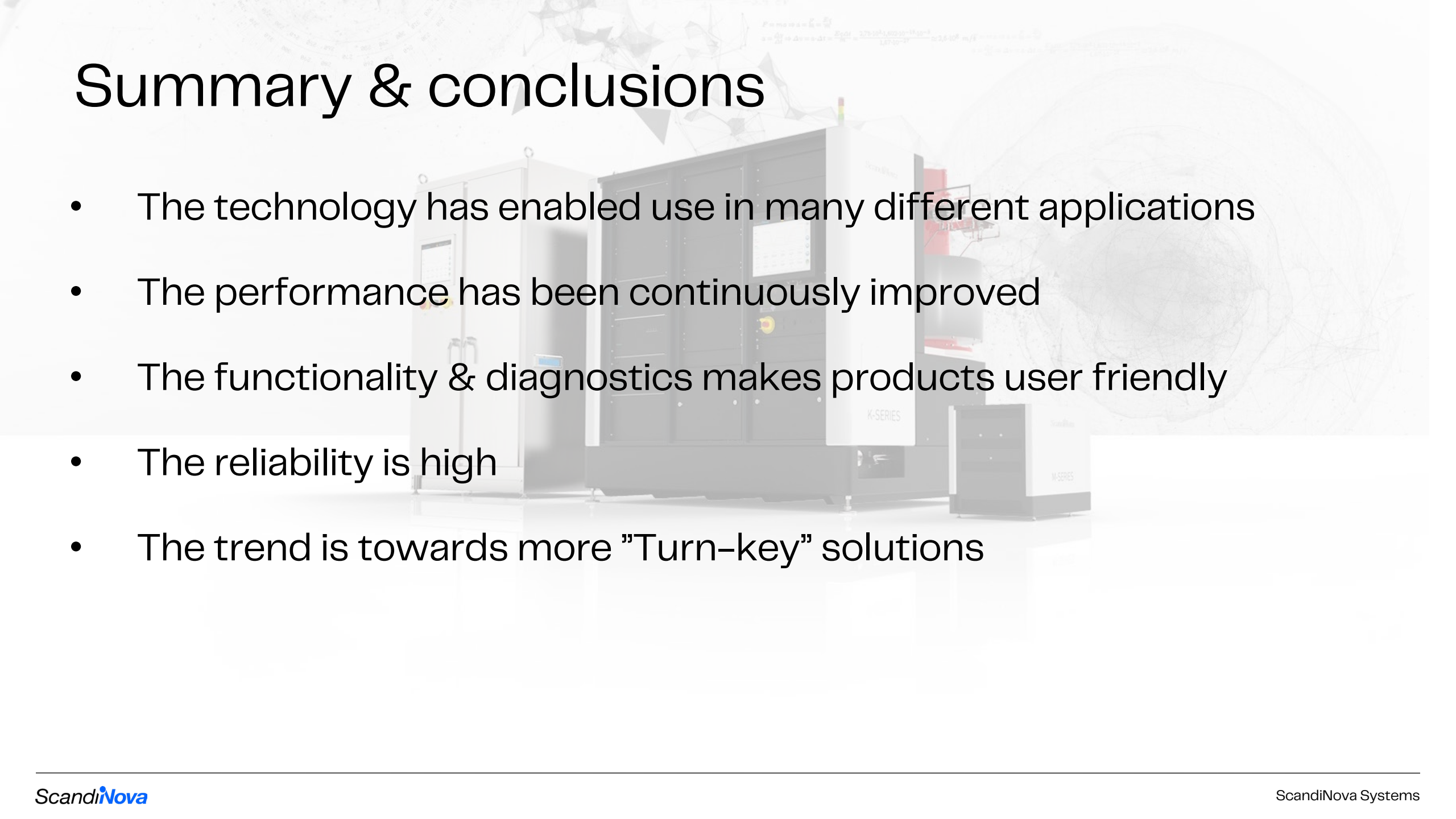
HUMIDITY

High humidity 95 %

SHOCK & VIBRATION

Strong G-forces 3G

Summary & conclusions



- The technology has enabled use in many different applications
- The performance has been continuously improved
- The functionality & diagnostics makes products user friendly
- The reliability is high
- The trend is towards more ”Turn-key” solutions


THANK YOU!
CERN
PAUL SCHERRER INSTITUT
PSI
PAL
POHANG ACCELERATOR LABORATORY
SLAC
NATIONAL ACCELERATOR LABORATORY
KAERI
Korea Atomic Energy Research Institute
Siam Photon
Australian Synchrotron
synchrotron.vic.gov.au
MTC
Metal Technology Co. Ltd.
eli
extreme light infrastructure
VAREX IMAGING
ELEKTA
HITEC Poland
SCANTRONIC systems
lyncean TECHNOLOGIES, INC.
Technische Universität Berlin
AS&E
NUCTECH
TII
Technology Innovation Institute
IUAC
Institute for Plasma Research
AARHUS UNIVERSITY
HEAT AND CONTROL
MAARUD
Estrella
Kraft
CRIC
VARIAN
medical systems
Nisshinbo Micro Devices Inc.
sec
e-beam pioneer
PMB
ALCEN
UNIVERSITY OF COPENHAGEN
ADAM
BERKELEY LAB
Lawrence Berkeley National Laboratory
cnrs
KIT
Karlsruhe Institute of Technology
MAX-PLANCK-GESELLSCHAFT
Fritz-Haber-Institute
NIU
cea
SACLAY
GL
LinearBeam
PROTONS FOR LIFE
INFN
Istituto Nazionale di Fisica Nucleare
KERI
Energy Advanced Systems, Inc.
Los Alamos
NATIONAL LABORATORY
清華大學
Tsinghua University
Lawrence Livermore National Laboratory
MIT
Massachusetts Institute of Technology
BROOKHAVEN
NATIONAL LABORATORY
COBHAM
GETINGE
INVAP
Argonne
NATIONAL LABORATORY
DAPHNE TECHNOLOGY
CPI
Communications & Power Industries
BESSY
BRIDGE 12
korens RTX
saligus
L&W Research Inc.
Best Theratronics
ADVANCED ONCOTHERAPY
research instruments
Sterigenics
Sik
INSTITUTET FÖR LIVSMEDEL OCH BIOTEKNIK
ZAP
H6
Systems Inc
동남보건대학교
DONGNAM HEALTH UNIVERSITY
AcceleRAD Technologies
BARC
INFN
LECCE
DESY
KEK
高エネルギー加速器研究機構
BOKU
DANFYSIK
e2v
INTRAOP
STOPPING CANCER IN ITS TRACKS
POSITHÔT
Rensselaer
radiabeam
TECHNOLOGIES
Canadian Centre canadien Light de rayonnement Source synchrotron
ASU
Arizona State University
SAMEER
EEC
TU Delft
Technische Universiteit Delft
Stanford University
PIEAS
ite
SCANTECHNOLOGY
SESAME
UPC
ENEA
NRC·CNRC
JAGIELLONIAN UNIVERSITY IN KRAKOW
LUMITRON TECHNOLOGIES
SPC ELECTRONICS
XSS SOLUTIONS
NSRRC
National Synchrotron Radiation Research Center
HZB Helmholtz Zentrum Berlin
三菱重工
UNIVERSITÀ DEGLI STUDI DI UDINE
METAS
Federal Office
Science & Technology Facilities Council
ScanTech
MAX IV
TU/e
Technische Universiteit Eindhoven University of Technology
MTT AERO C&RT
COMMUNICATION AND RADAR TECHNOLOGY
UCLA
Canon
ETM
ELECTROMATIC INCORPORATED

ScandiNova in the Western Hemisphere and After Sales

Douglas Eaton, Sales Manager
Ola Boden, After Sales Manager

ScandiNova

Industrial Business
Cargo Scanning

Varex Imaginging

Currently procuring M100Di modulators and E110Di modulators

New opportunity developing utilizing M50 modulators

New opportunity using M110i modulators

AS&E / Rapiscan opportunities

Industrial Business

Surveillance Radar

Surveillance Radar Retrofit

Two existing customers developing refurbishment packages for twystron based long range surveillance Radars

Low volumes to date but potential market of 300 to 500 systems worldwide.

Spin-off opportunities with succesful deployment of these systems

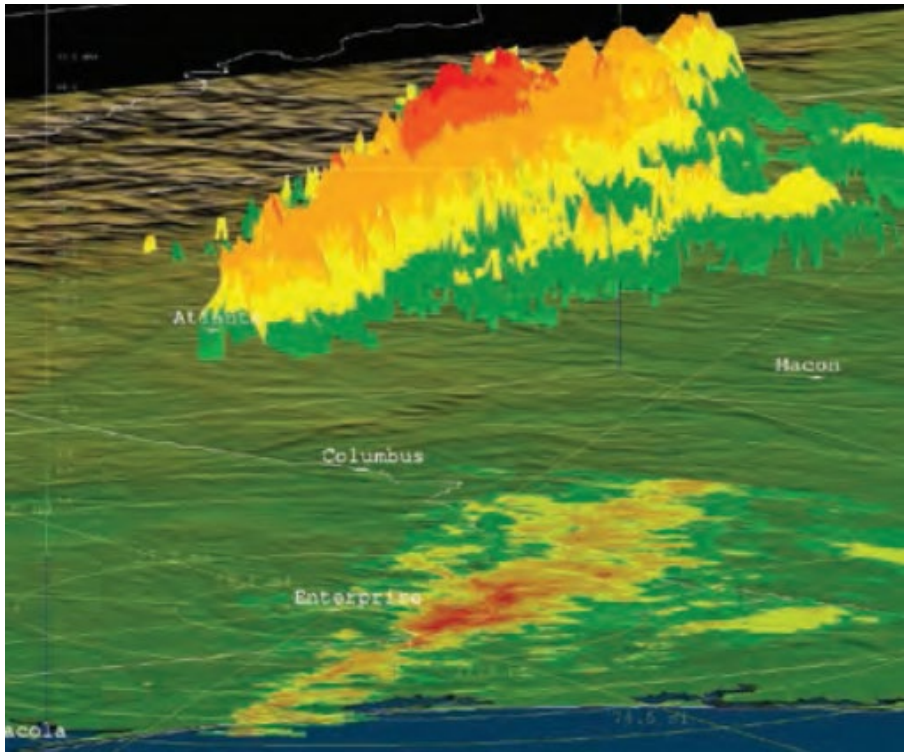
Industrial Business

Weather Radar

Enterprise Electronics Corporation (EEC) is now an OEM customer

Current volume of over 30 M50 units per year

Current volume of over 10 M100i units per year



Industrial Business

PEF / Sterilization / Electronic Cold Pasteurization

Approximately 10 systems per year for various applications for Heat & Control

Potential large growth in the Electronic Cold Pasteurization market in the coming years. Estimate multiple K300 systems during 2023 for Reveam (Scantech Sciences)

Pending business with Mevex for K400 units for new systems and retrofits

Industrial Business

Other Business

Accelerad – Industrial Sterilization

Bridge 12 – Industrial Sterilization

Lumitron – Industrial / Medical Imaging

RadiaBeam – Industrial Imaging

ScanTech Sciences – M100i systems for cargo scanning

CPI – K400 Test Stand

CPI – K500 Test Stand

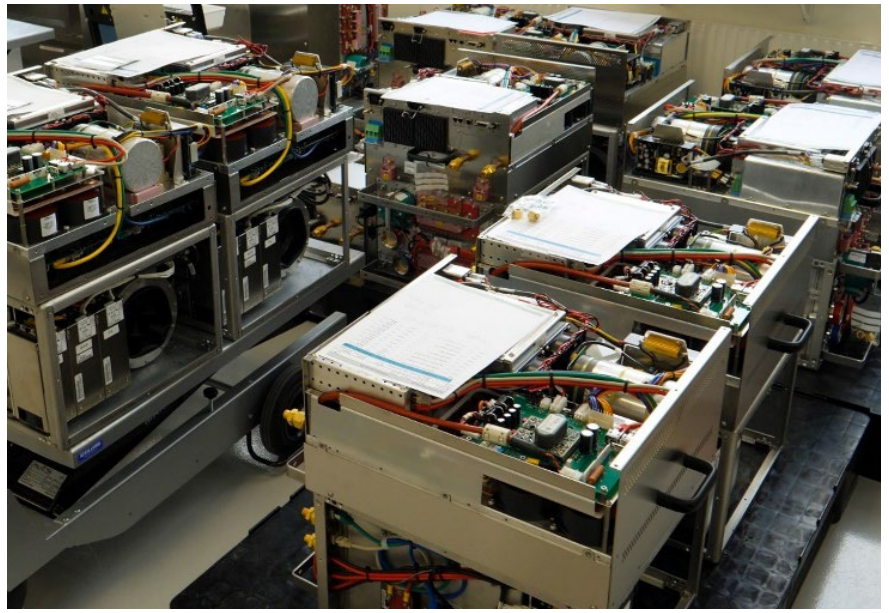
Med-Tech Business

Largest segment for the western hemisphere market, dominated by OEM sales to radiotherapy suppliers.

2023 deliveries of M100i modulators will be approximately 400 units

2023 deliveries of M50 modulators will be approximately 25 units

All US Radiotherapy companies are engaged with ScandiNova



Med-Tech Business

New suppliers are entering the market, some with interesting technologies that are creating new treatment markets rather than displacing sales by existing companies.

Existing OEM customers

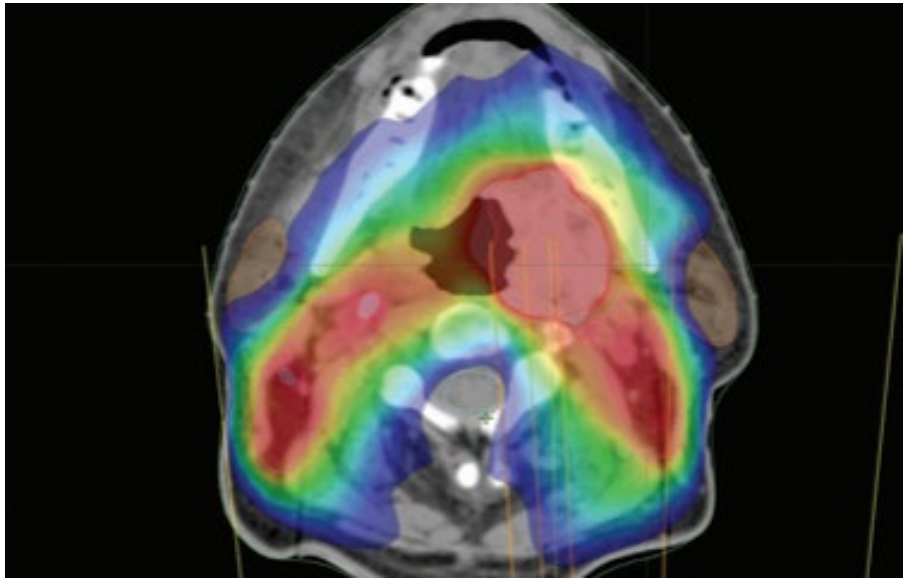
Varian Medical – Palo Alto, CA / Beijing China

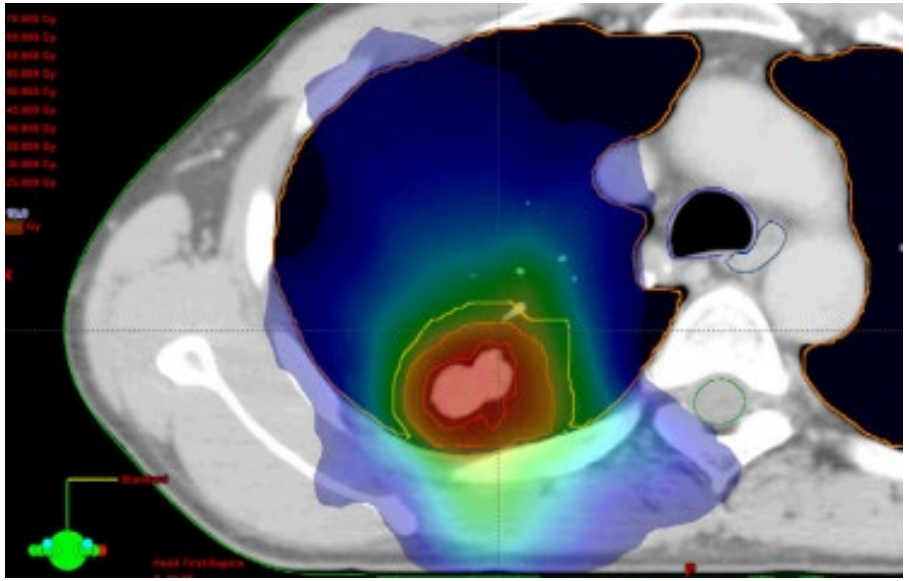
IntraOp Medical – Sunnyvale, CA

Accuray – Sunnyvale, CA / Madison, WI

ZAP Surgical – San Carlos, CA

RefleXion Medical – Hayward, CA





Scientific Business

Current Projects

Rensselaer Polytech – 5 K400 modulators being installed and commisioned

Stanford Medical – Flash Oncology

Argonne NL – APS Qualification, 2 units delivered, more on the way

SLAC – K100 for diagnostics

Los Alamos – K300 C-band Test Stand – 2nd unit recently purchased

Future Projects

Arizona State Univ – two K200 systems upcoming

Duke University – one K400 RF Unit potential

SLAC – Special Project

Western Hemisphere Growth

Service Center

Planning opening of US service center – location is still being determined

US Service Person

Plan for addition of one full time service person in US before the end of 2023

Plan for additional service person in 2024

Introduction

Ola Bodén

- ScandiNova since June 2021

- More than 25 years experience of Service and After Sales
  - ScandiNova
  - Siemens Industry
  - Mycronic AB, Mycronic Japan KK
  - DuPont Scandinavia

Global Service

ScandiNova

Global Service

News!

>2 500 installations world wide

News:

New Service Centers in USA and Japan to be opened 2023 - 2024

Reopening of Beijing Service Center 2023

ScandiNova Services

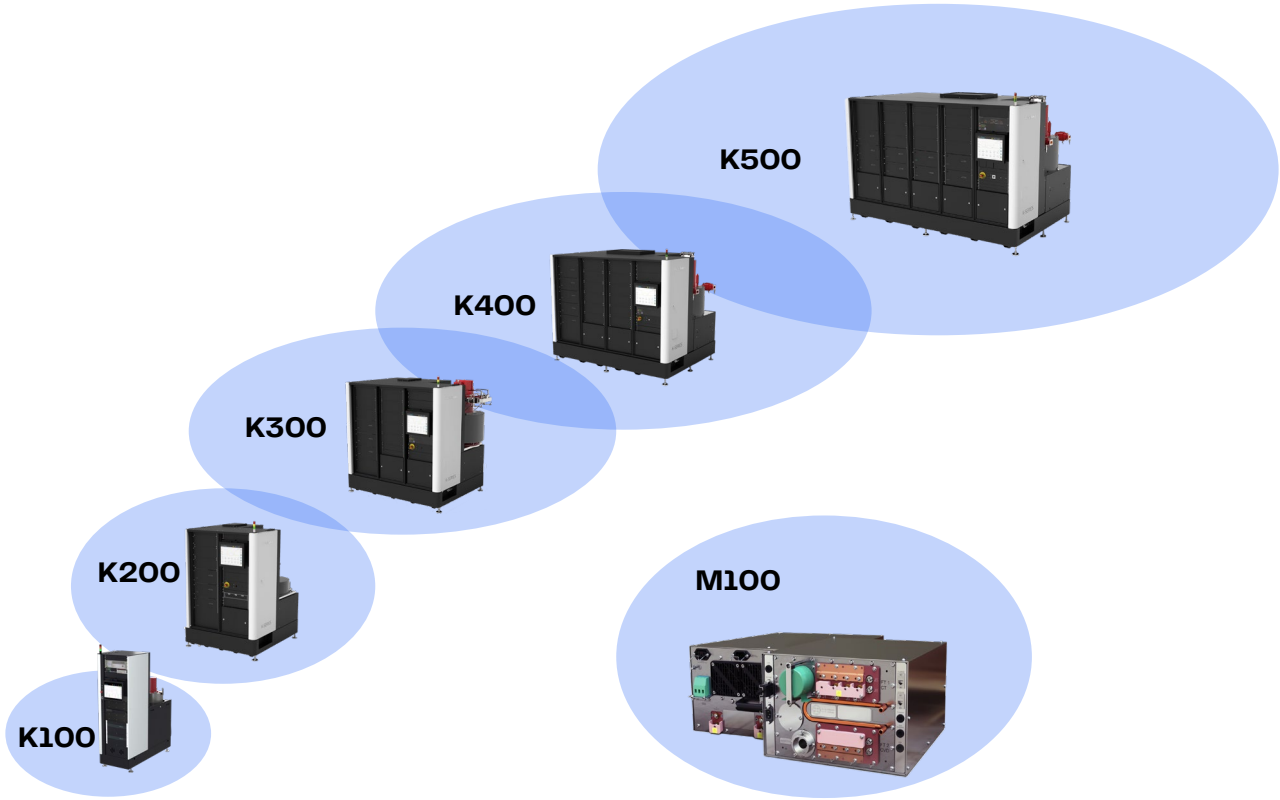
ScandiNova

	Nova Premium	Nova Plus	Nova	Repair agreement	No Agreement
Repairs included	Yes	Yes	No	Repairs included	No
On-Call 24/7	Yes	Yes	Yes	NA	No (8-5 CET)
Response time	2 h	4 h	8 h	NA	Best effort
Remote support (unlimited hours)	Yes	Yes	Yes (limited hours)	NA	Best effort
Emergency visits included	Yes	Yes	No	NA	No
Start travel (emergency visit)	24 h	48 h	5 WD	NA	Best effort
Preventive Maintenance included	Yes, 2 / year Training incl. 2 / year	Yes, 1 / year Training incl. 1 / year	No	NA	No (quoted on request)
Consumables included	Yes	Yes	No	NA	No (on order)
Spare parts	Spare part kit at customer site	Delivery from stock: -10%	On order: -5%	On order: -5%	On order, no discount

Repair Agreement

Secure your OPEX

- Fixed price per year
- All repairs included
- Priority in repair



Repair Agreement

All repairs included

All repairs included

- M100
- K-Series

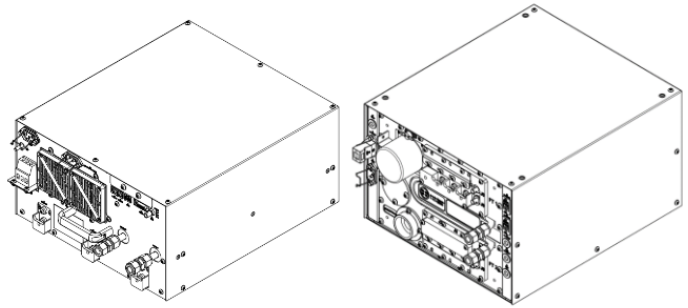
Available

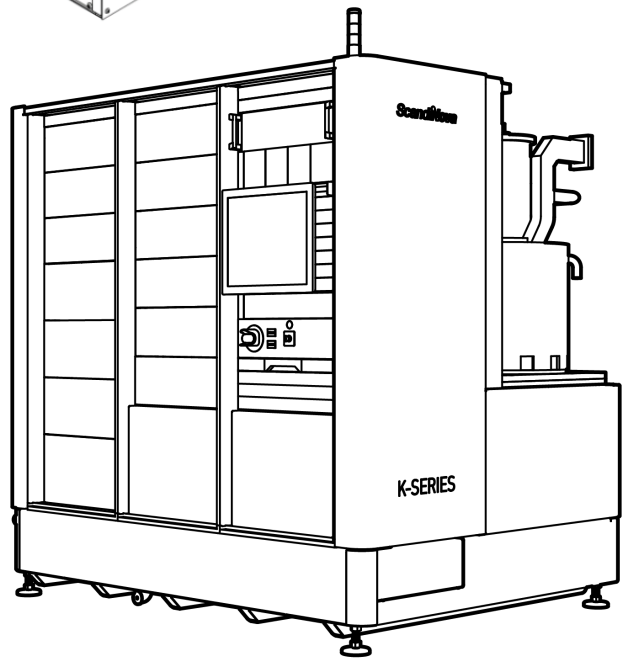
M100

- Pulse Unit
- Tank Unit

K-Series, Subunits

- Switch Unit (SU)
- CCPS
- FiliBias
- Digitizer
- RF Digitizer
- Trig and Interlock Unit
- Hard Wire Interlock Unit
- Bleeder Unit
- RF Switch Unit





Workshop and Training

ScandiNova

Workshop 14 April

Questions to discuss

- New features or functions
- Improvement areas; performance, reliability, other
- Digital services
- Documentation
- Other

30 minutes discussion

2 minutes presentation

- Group 1: Mikael Lindholm/Per Bendixen
- Group 2: Douglas Eaton/Kévin Pepitone
- Group 3: Klas Elmquist/Ola Boden
- Group 4: Anders Larsson/Erik Sundström

Training

M-series

Anders Larsson, BA Manager Medtech

Break-out room

K-series

Per Bendixen, Technical Account Manager

Klas Elmquist, Product Owner

Big conference room

Thank you!

ScandiNova