Advanced Accelerator Technologies

Advanced Accelerator Technologies AG (AAT)

A joint venture of international leading industries for collaborating with PSI and commercializing PSI know how

Jens Rehanek, CEO

Structure & Mission

Advanced Accelerator Technologies

AAT is a joint venture of leading global industrial suppliers for research and hightech enterprise equipment

AAT is commercialising and licensing partner to PSI

AAT-MISSION: **Commercialization of PSI-IP in accelerator technologies and applications**

Create value beyond the shareholders' individual expertise

- Accelerator component & system design, realization
- Proton Therapy instrumentation & services
- Compact accelerators such as Synchrotron Sources spanning various energies
- Neutron instrumentation
- Services and consulting

Management

Advanced Accelerator Technologies

Board of Directors (Verwaltungsrat):

- Josef Troxler (VR President; Ampegon Power Electronics & OCEM)
- Erwin Baumgartner (VR Vize-President; Heinz Baumgartner AG)
- Mark Plesko (Cosylab)
- Hans Priem (VDL ETG)
- Martin Jermann (Consultant, representing PSI)
- Daniel Kündig (Blauhut AG)

CEO:

- Jens Rehanek

Shareholders (companies):

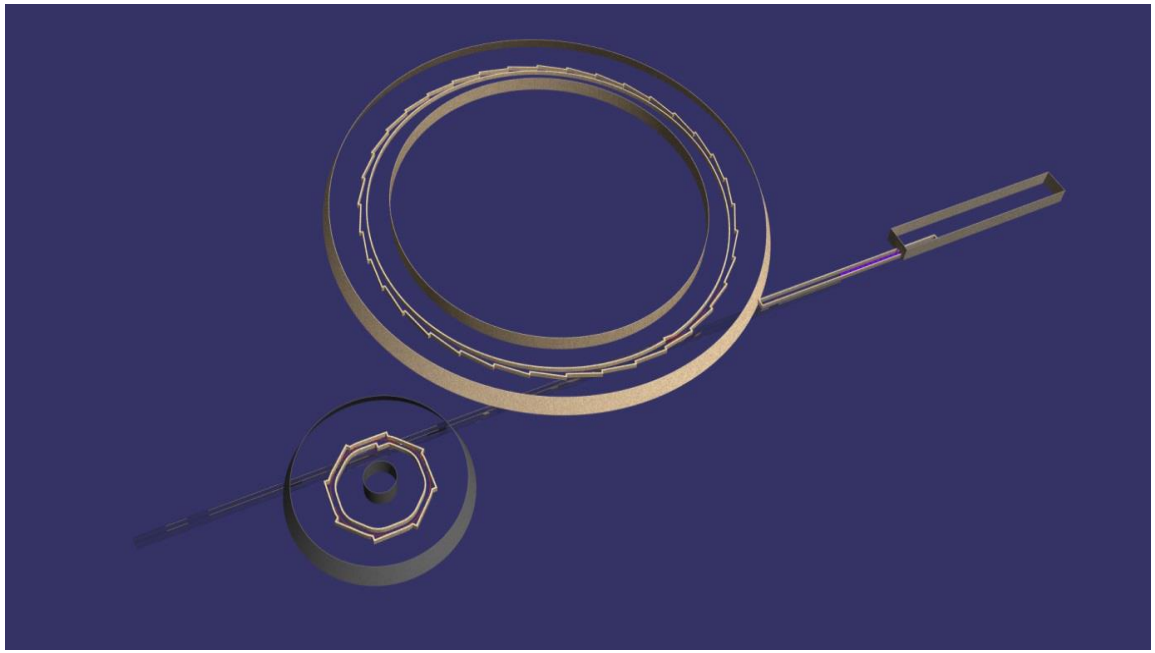
- Ampegon Power Electronics AG
- Cosylab Schweiz GmbH
- Heinz Baumgartner AG
- VDL ETG

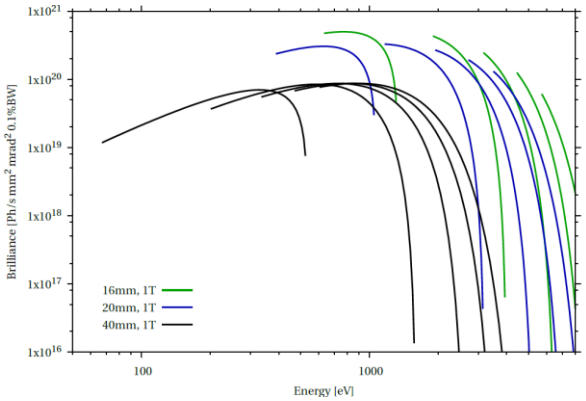
AAT
Fields of Business

Case Study for Photon Source Complex (1.5 GeV ring, 4 GeV ring, XFEL)

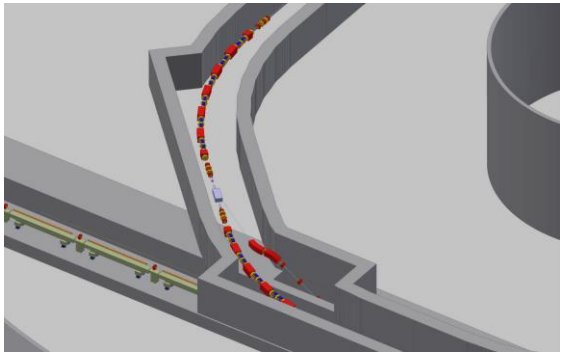
Advanced Accelerator Technologies

AAT has performed – together with PSI – a concept study for a large photon source complex, consisting
of a 1.5 GeV ring, a 4 GeV ring, and an X-ray free electron laser for a major University in China





Photon Output of Medium Energy Ring with different ID‘s

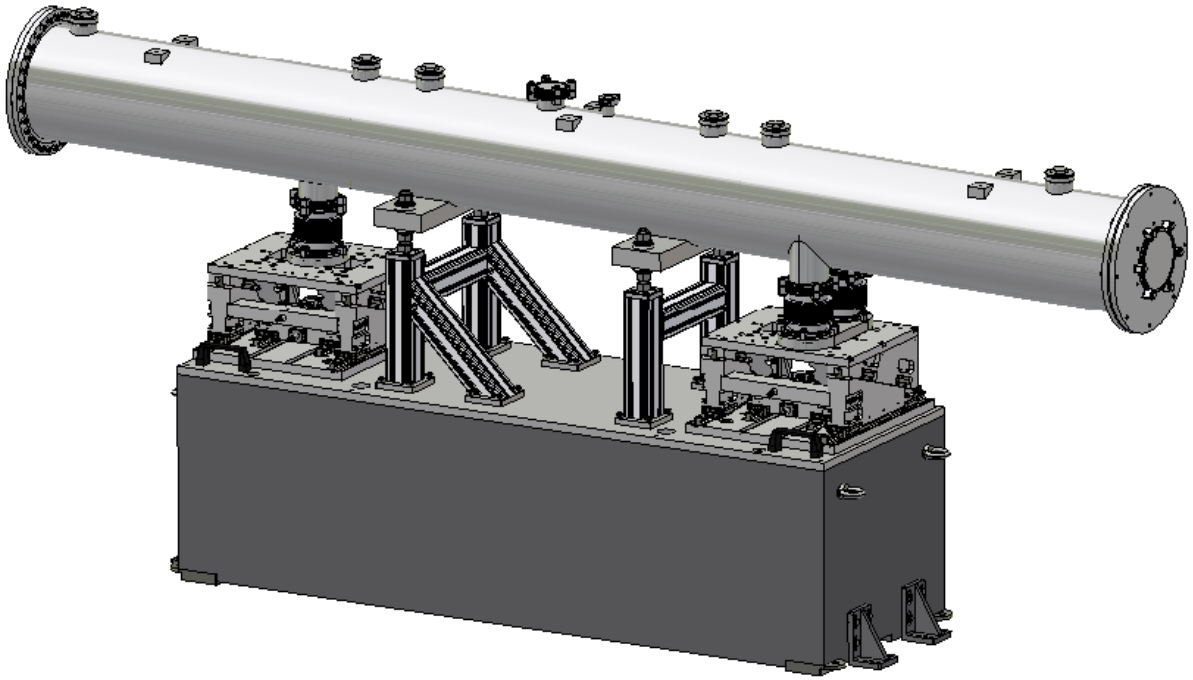


ESTIA Feeder Project (neutron source instrumentation)

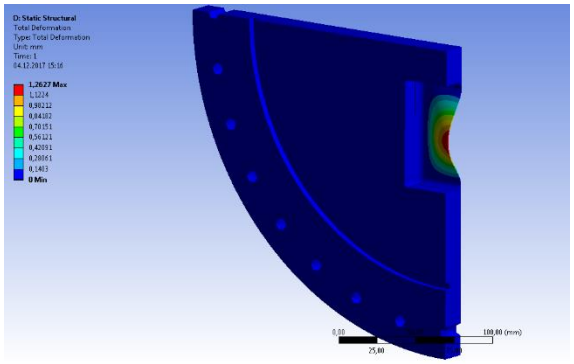
Advanced Accelerator Technologies

AAT has performed a design optimization (engineering) of a component for the European Spallation Source

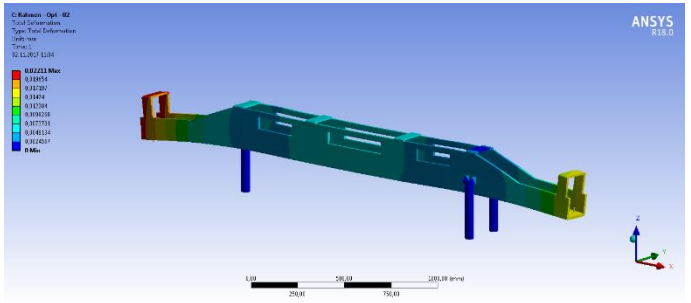
Manufacturing negotiations currently ongoing!



Gesamtaufbau



FEM Al Fenster



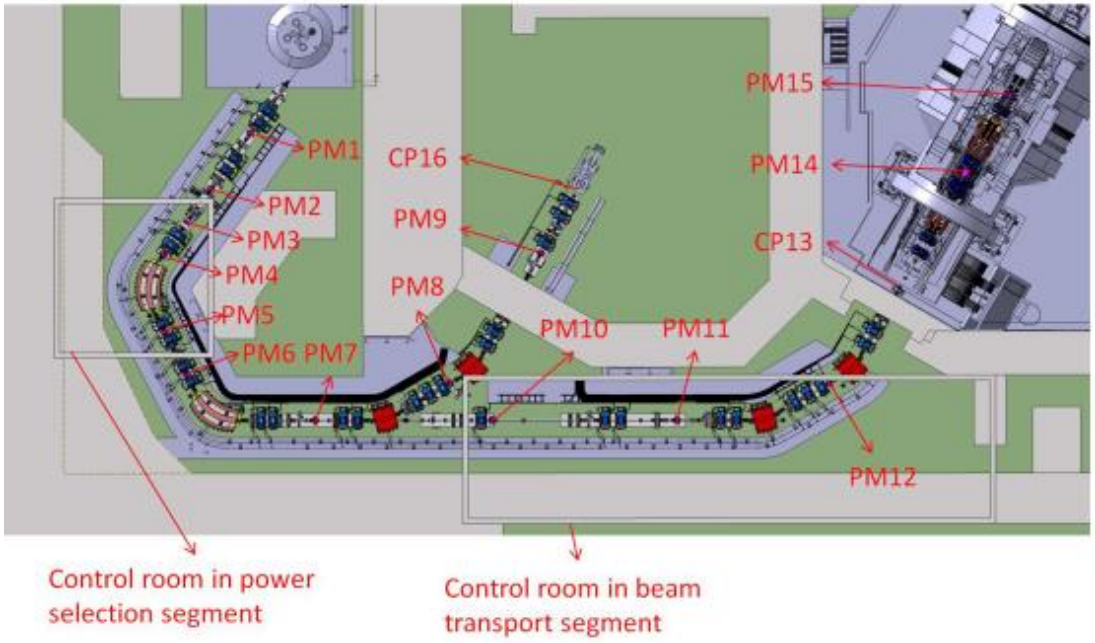
FEM Halterung Neutronen Guides

Diagnostics for proton therapy system

Advanced Accelerator Technologies

Layout, detailed engineering, built, delivery and test of the beam diagnostic system for a proton therapy installation inChina

AAT is offering subsystems, engineering and consulting in proton therapy technology to the worldwide increasing number of proton therapy projects, based on its license and cooperation agreement with PSI



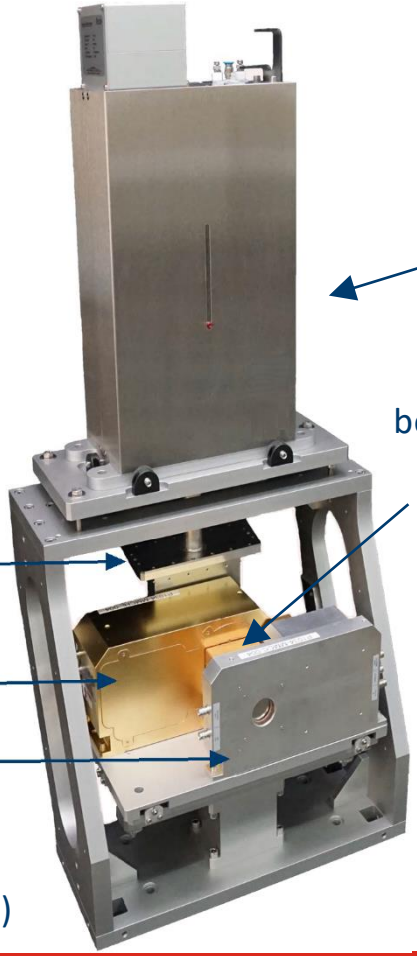
Diagnostics for proton therapy system

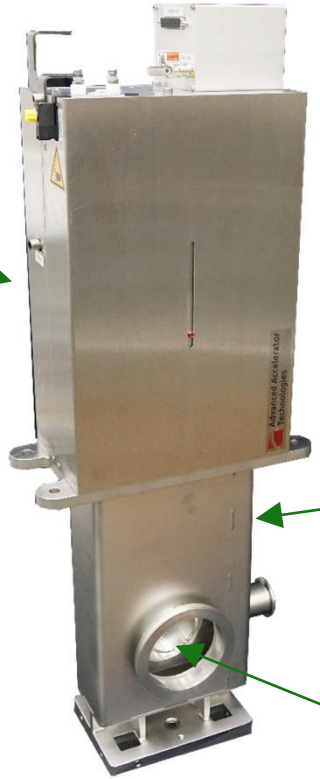
Advanced Accelerator Technologies

Beam diagnostic elements have been designed by PSI and successfully operated since the commissioning of the PROSCAN proton therapy facility in 2005 [1]. The Swiss company AAT developed commercially available products based on some of the PSI detectors [2]. 14 profile monitors were delivered to a proton therapy installation in China, as well as 4 control point stations measuring the beam quality at the entrance of the treatment areas.

control point station in air

PAUL SCHERRER INSTITUT PSI





[1] R. Dölling et al., AccApp'07 p. 152, BIW'06 p. 271, BIW'04 p. 244, DIPAC 2007 WEPC23
[2] M. Grossmann et al., PTCOG58 (2019)

Conclusions

- The work and projects of AAT are based on experience of PSI, as well as each of the industry partners in their respective fields
- In the developments in the field of Proton-Therapy, PSI is world-leading – since start of operation treatment of 7000 patients with eye-tumors, with a success rate of 98%

  → **AAT is commercializing parts of these developed technologies for the worldwide market**
- As a Synchrotron source, PSI has the Swiss Light source running – since it was built, it runs more than 99% reliable scheduled operation time within all the years -> based on this,

  → **AAT is offering dedicated Engineering Services and Compact Synchrotrons for diverse applications (e.g. semiconductor industry)**
- We have fully developed:
  - **Design-chain**
  - **Supply-chain**
  - **Network**

AAT
Industry Partners

AMPEGON
POWER ELECTRONICS

Ampegon Power Electronics AG, based in Baden (Switzerland), is a new company founded in Juli 2019 by the Italian industrial Network Aretè & Cocchi Technology, which has taken over all strategic assets of Ampegon AG.

Ampegon Power Electronics serves the global Science, MedTech, Industry and Broadcast markets with an extensive product range tailored to customer needs in these strategic fields.

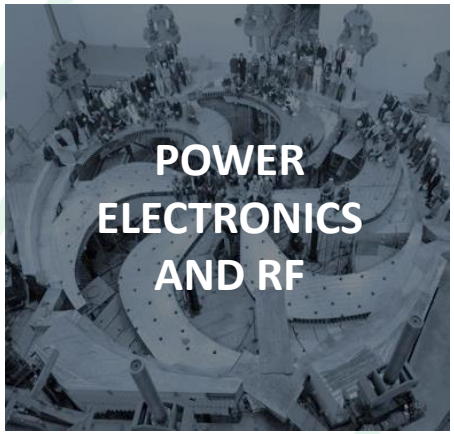
OCEM
POWER ELECTRONICS

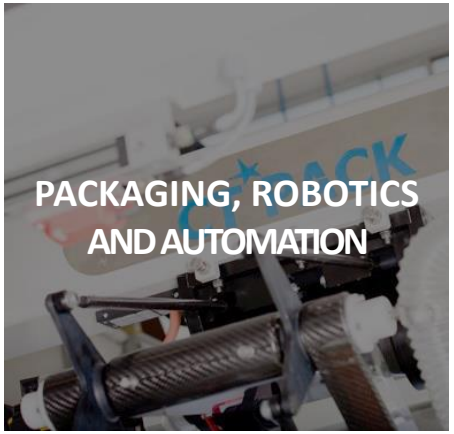
OCEM Power Electronics, based in Bologna (Italy) and founded in 1943, develops complex power electronics systems for advanced industries and Big Science research facilities.

Power converters supplied to more than 50 research facilities in more than 20 countries, including four Nobel-Prize winning labs.

AMPEGON

Ampegon / OCEM: part of Aretè & Cocchi Technology Network





AMPEGON POWER ELECTRONICS

OCEM POWER ELECTRONICS

CT PACK

CORTI AUTOMAZIONI

Industry Technology Suzhou

FPE

OCEM AirfieldTechnology

MULTIELECTRIC OCEMAIRFIELD

ALGOTEX

AUGIER energy

PRIATHERM

ARETÈ & COCCHI TECHNOLOGY

500	90+	150
Total workforce	Sales countries	Million € sales

- Industrial group dedicated to Innovation, Technology & Growth
- Established in 2010 by Gino Cocchi
- Consists of eleven business units
- Manufacturing facilities in Italy, France, USA, China, Switzerland
- Commercial and technical centers in more than 15 countries
- By 2020, €150M of Sales

AMPEGON

OCEM POWER ELECTRONICS

Key Technology Areas of Ampegon & OCEM

Magnet Power supplies:

- High current applications
  - ➢ various voltage and accuracy levels (ppm)

RF Amplifiers

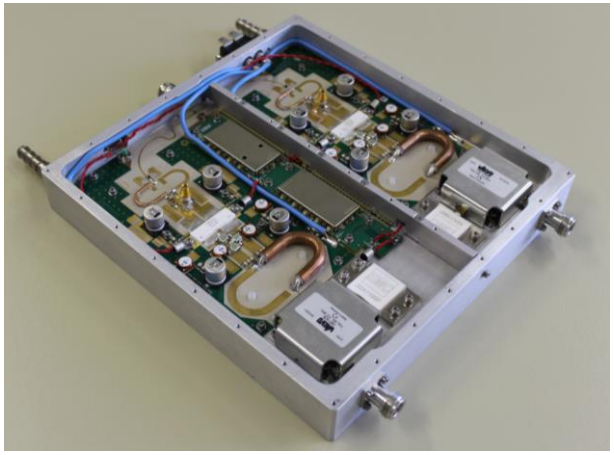
- Tube based amplifiers (high power, pulsed applications)
- Solid-state amplifiers at various frequencies (3-30MHz, 216MHz, 500MHz)
  - ➢ Highest efficiencies, narrow band applications, modular approach

Power supplies / Modulators

- High voltage power supplies (HVPS)
  - ➢ High Energy CW output up to 10MW continuous.
  - ➢ Pulsed applications - Long (ms) and short (us) pulses

Control Systems

RF Amplifiers: DLS Diamond, UK; BNL (NSLS-II), USA

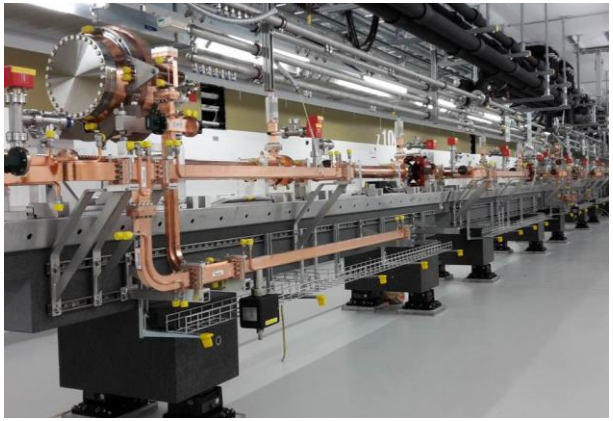


- Fully solid-state RF amplifier for electron synchrotron rings:
  - Frequency: 500MHz
  - RF power: 75kW (CW)
  - Efficiency
    - Total: >60%
    - DC to RF: >64%
  - Spurious: <-75dBc
- Modular system allows multiple outputs to be combined using waveguide combiner. 320kW systems quoted
- DC power supplies are hot-pluggable, RF modules are not. (Opens resonant combiner, common water cooling, etc.)
- Features redundant modules

Power Supplies: DESY, Germany (European X-FEL)

- Development and delivery of one Prototype Klystron Modulator System, 2008
  - 12 kV, 2000 A
  - 1.7 ms pulse duration at 10 Hz repetition frequency
  - 24 switching modules, each providing min. voltage of 545 V
  - Full system configuration tests of prototype at DESY site including cable, pulse transformer and klystron: 2009/2010
- 22 Modulators delivered within 2012/2013
- 7 Modulators delivered 2013/2014

Modulators: PSI, Switzerland (SwissFEL)



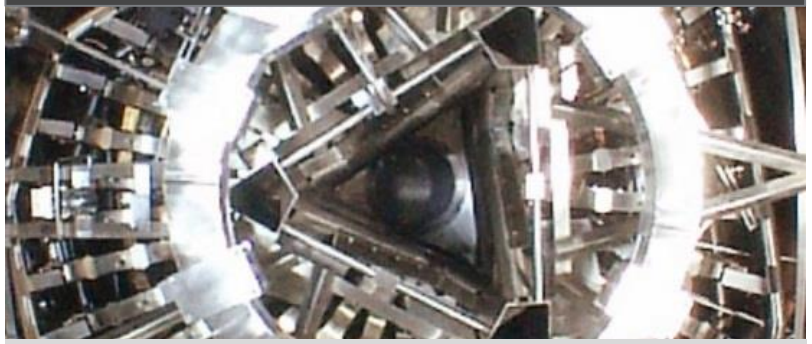
- Development and delivery of a prototype solid state short pulse modulator system in 2013 based on a novel, highly efficient concept.
  - 370kV / 340A
  - 6 us pulse duration and 100Hz repetition rate
  - Active PFC: cos(phi) >92%
  - 12 pulse power modules equipped with press pack IGBTs
  - Matrix pulse transformer
  - Very high pulse efficiency: 0.8us rise time, 1.4us fall time
  - Extremely high pulse to pulse stability of <10 ppm
- Long term test and prototype qualification with klystron load at PSI in 2015
- 13 Modulators delivered between 2016/2018

Customer References in Science

Accelerator-based Research

PSI
diamond
SSRF
ALBA
PAL 포항가속기연구소 Pohang Accelerator Laboratory
Canadian Light Source Centre canadien de rayonnement synchrotron
LAL Laboratoire de l'Accélérateur Linéaire
DESY
CLRC
DANFYSIK
國家同步輻射研究中心 National Synchrotron Radiation Research Center
BROOKHAVEN NATIONAL LABORATORY
TRIUMF
research instruments

Fusion Research & Plasma Physics

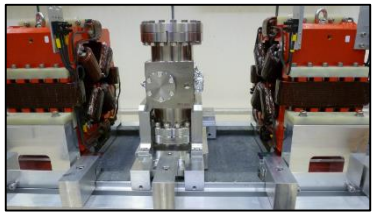


FUSION FOR ENERGY
TRI ALPHA ENERGY THE POWER OF INGENUITY
KIT Karlsruher Institut für Technologie
IHEP
EPFL ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE
ANU THE AUSTRALIAN NATIONAL UNIVERSITY
ITER-India
MIT
iter
IPP Max-Planck-Institut für Plasmaphysik

- Founded in 1962
- SME with 50 employees
- 100`000 man hours
- ISO 9001:2008 / ISO 3834-2

Treatment	Working surface	Especially
Milling	3000mmx2000x2000mm	3-axis / 5-axis
Turning	2000mm diameter 4000mm length	Shaft and robot loading
Water and abrasive waterjet cutting system	2000mmx4000m	Chamfers and 3-D cuts without angle errors and with tight tolerances

- Cubic and rotational machining
- Precise manufacturing of Single Cube parts material (AISI 316 LN ESR)
- highest surface requirements
- Assembly of workpieces in the UHV range
- Engineering



PSI SwissFEL

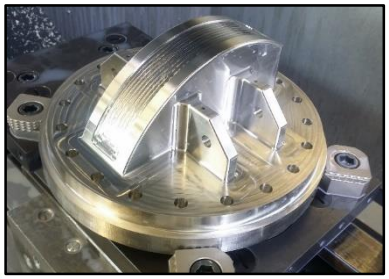
Photon Single-Shot Spektrometer

Heinz Baumgartner AG
Innovation in Mechanics

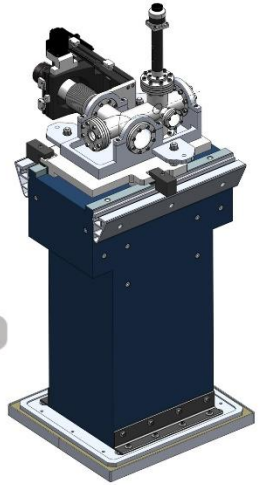
The Photon Single-Shot Spectrometer is a crucial component for commissioning and operation of the Swiss Free Electron Laser (SwissFEL) at PSI. Additionally, it is delivering online-information on the FEL-beam properties during experiments, a vital information for evaluating recorded data reasonably.

HBAG contributed/supported by:

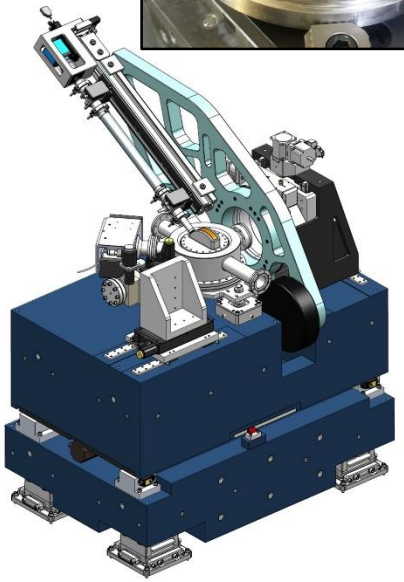
- Design and manufacturing
- Project Lead
- Full Assembly and FAT



PAUL SCHERRER INSTITUT
PSI



Grating Einheit



Spektrometer Einheit

PSI SwissFEL

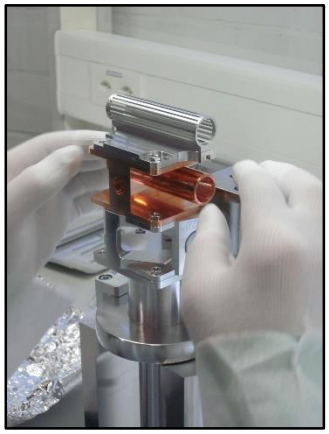
Electron Transverse Profile Imager

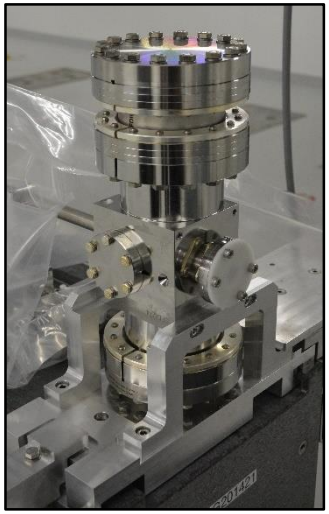
Heinz Baumgartner AG
Innovation in Mechanics

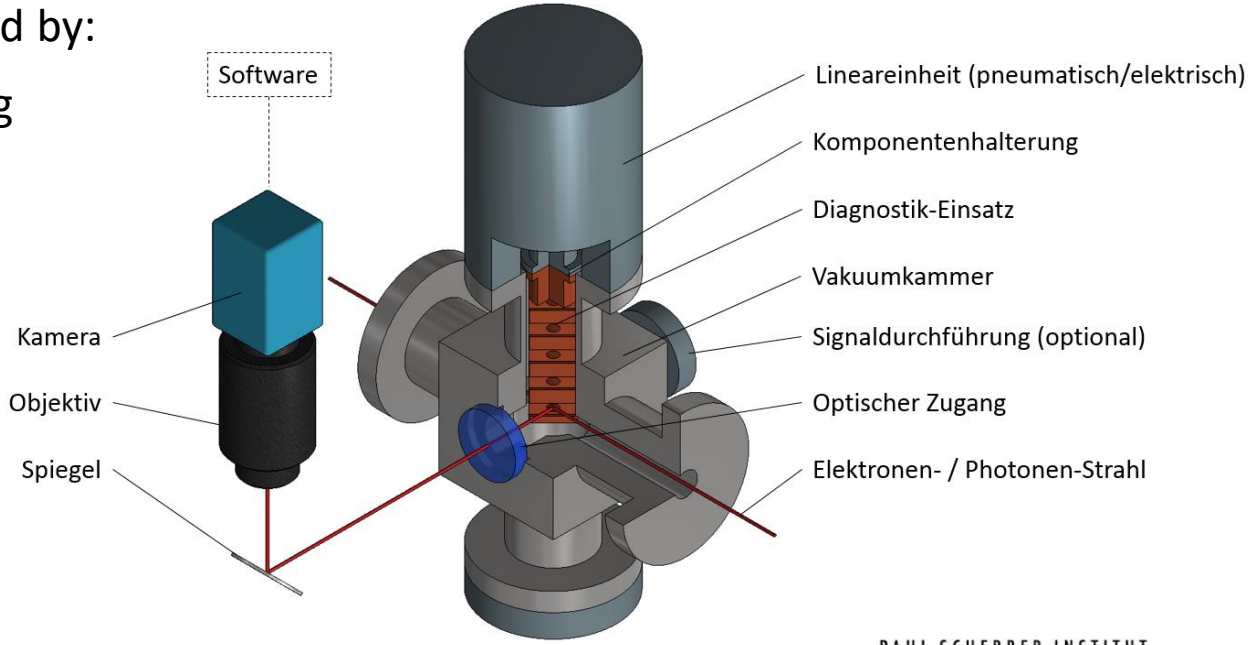
The Transverse Profile Imager is an important component for commissioning and operation of the Swiss Free Electron Laser (SwissFEL) at PSI. It delivers information on the FEL-beam properties profile and intensity, a vital information for running SwissFEL stable.

HBAG contributed/supported by:

- Design and manufacturing
- Project Lead
- Full Assembly and FAT







PAUL SCHERRER INSTITUT
PSI

COSYLAB

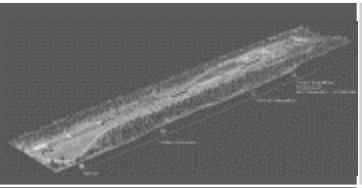
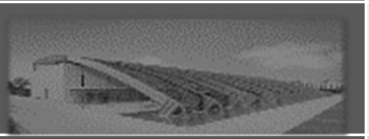
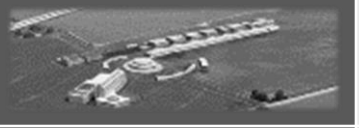
Advanced Accelerator Technologies

- World leading Systems Integrator for Particle Accelerator Control Systems
- Engineering and Integration Services for Proton Therapy Systems

- Founded in 2001, >20% CAGR
- 100+ employees worldwide, local branches in USA, Japan, China, Switzerland, Sweden
- ISO9001, ISO13485, ISO14971, IEC62304

- Largest international Big Physics projects as customers (ITER, ESS, FAIR, SwissFEL, SLAC, …) as well as over 10 PT projects, such as MedAustron, HIMM (China), etc.

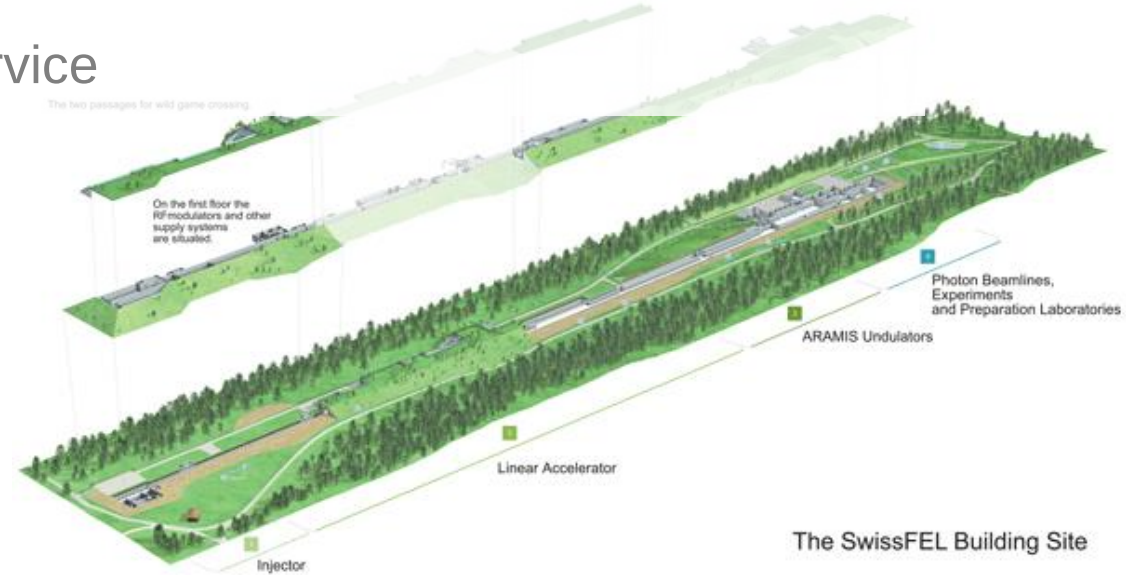
Cosylab Key Project References

Reference	Description	Contract/Invoiced
PSI SwissFEL & Swiss Light Source 	SwissFEL –Free electron laser SLS – Synchrotron radiation light source	-
ELI-NP 	Laser and gamma beam facility	-
SLAC LCLS/LCLS-II 	Free electron laser	-
European Spallation Source (ESS) 	Neutron source based on high-power proton linac	- Open contract
iBNCT (Tokai, Japan) 	Boron Neutron Cancer Therapy (8 MeV p-linac)	- Open contract
HIMM (Lanzhou, China) 	cyclotron+synchrotron for cancer therapy (Carbon)	-
MedAustron 	Proton/Carbon synchrotron for cancer therapy	- Open contract

PSI Villigen, Switzerland : SwissFEL & SLS

COSYLAB

- On-site expert support for SLS and SwissFEL
- Timing test stand
  - MRF VME-EVG-230 event generator, VME-EVR-230RF event receiver
  - Driver, FPGA coding
  - 100 Hz event sequence loading
- Low level SW developments
  - Linux kernel module for ioXos IFC1210 SBC
- High level SCADA:
  - EPICS v4 Snapshot service



The SwissFEL Building Site

ELI-NP (750MeV electron linac)

Magurele, Romania

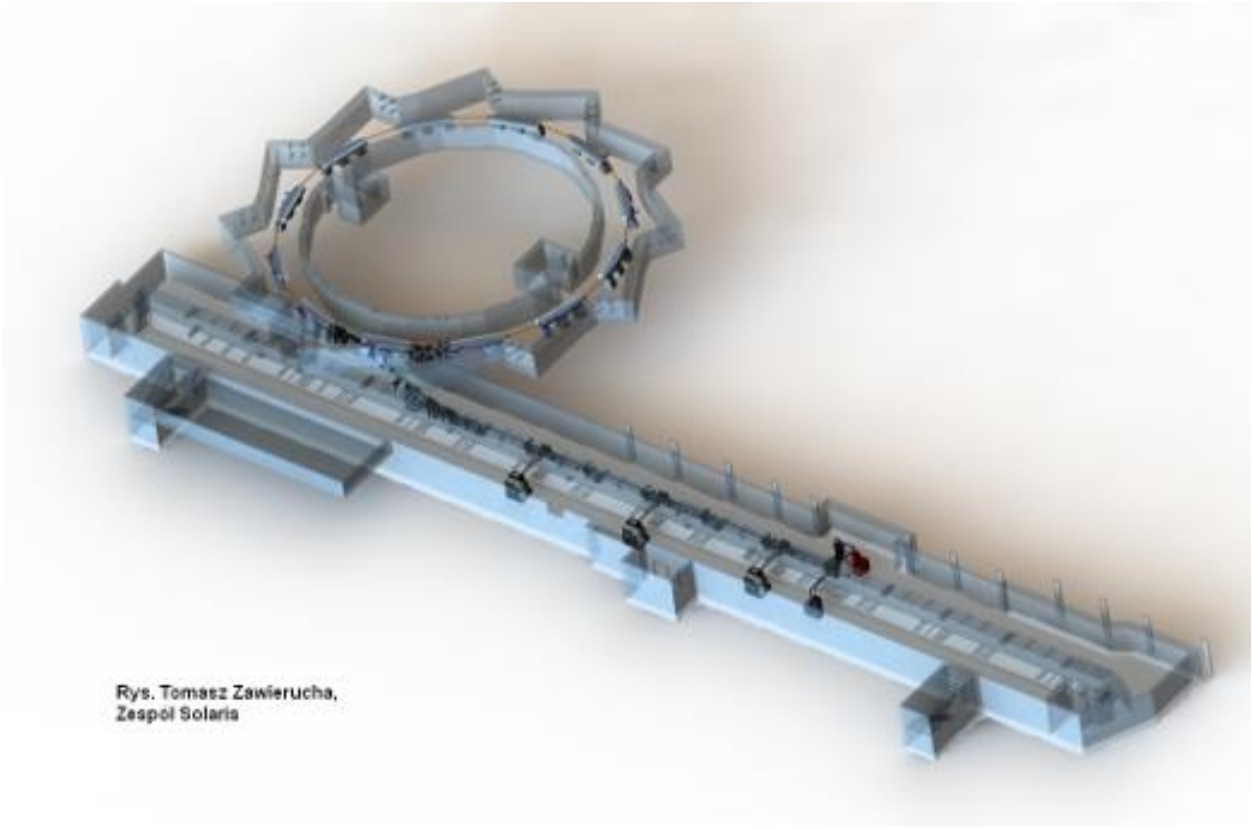
COSYLAB

- Customer: INFN Frascati
- Provide all major aspects of the control system
- EPICS SW and HW
- Reuse of Software
- **Turnkey Control System**
  - **Lower costs and development time**

SOLARIS Krakow, Poland

COSYLAB

- 1.5 GeV storage ring
- Complete (turnkey) control system
- TANGO
- Specific HW



PAL:
PLS II and PAL XFEL, Korea

COSYLAB

PLS II

- FOFB
  - Beam stabilization measures
  - Utilizing exising HW

PAL XFEL – 10 GeV FEL

- Complete central control system

SLAC, Stanford, California :
LCLS I and II (a complex FEL)
SPEAR3 (asymetric ring)

- Mainly on-site work
- Motion control
  - Configuration, systems integration
  - Safety features (E-Stop, safety analysis …)
- Beam Profile Monitors
  - GigE cameras, camera servers, IOCs
  - Testing image acquisition, storage, network capabilities for data storage
- I/O controller maintenance
- and many more...

Many other lightsources

COSYLAB

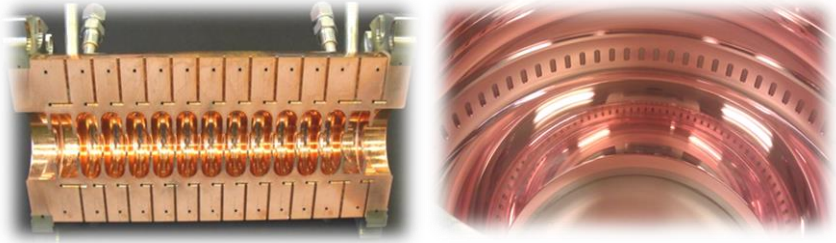
- Starting from ANKA (years ago)

Control subsystems, hardware, specific interventions:

- NSLS II
- APS
- MAX IV
- SPring-8

VDL Group

- ✓ Headquarter in NL
- ✓ Established in 19 countries
- ✓ > 16,000 employees
- ✓ privately owned
- ✓ *VDL ETG:* high-end contract manufacturing

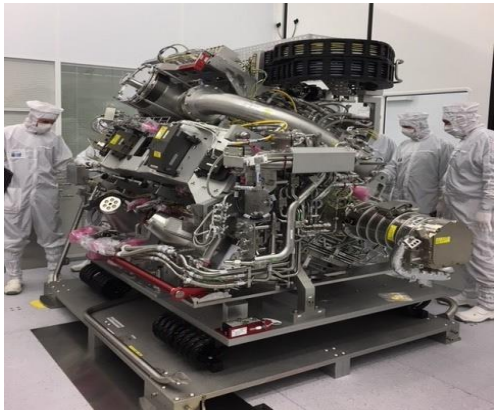


SwissFEL: rf-structures, couplers and buncher units

- High Precision Machining (HPT)
- Ultra High Precision Machining (UPT)
- Metrology
- Welding/Vacuum Brazing
- Vacuum Technology
- Clean room assembly
- Magnet technology
- Functional frames
- Complex Assemblies
- Cleaning
- Functional qualification
- Industrialization & Redesign

Wafer handling systems

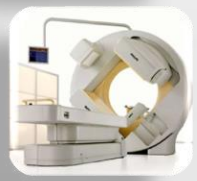
EUV Vessel



VDL ETG: main market segments

Semiconductor Capital Equipment

Analytical Equipment



Medical Equipment

Science & Technology

- Accelerators & FELs
- Instruments for astronomy
- Satellites (communication, earth observation)

Suppliers, Research, Competitors, Engineering, and Customers

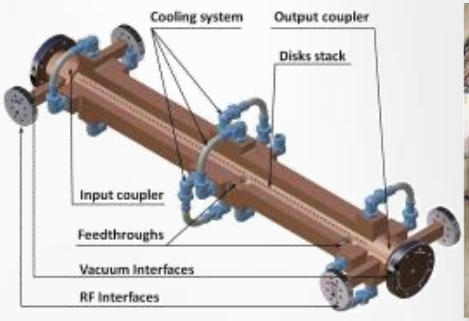
Ecosystem VDL ETG

VDL's partnership with SwissFEL

PAUL SCHERRER INSTITUT PSI

All high power RF parts manufactured @ VDL

- 4 x X-band structures
- 112 x C-band structures (12,096 parts)
- 112 x J-couplers (672 parts)
- 1 x BOC Pulse compressor
- 2 x RF-Gun (6 parts)



Accelerator spin-offs - applications

Accelerators

Electron

Low energy application *(large market)*

Material treatment *(existing / growing market)*

E-beam Welding *(growing market)*

SEM/ TEM *(existing market)*

Fundamental research *(niche market)*

Generating radiation

Collision with target to generate X-Ray *(existing and large market)*

- **X-ray imaging** *(large market)*
- **Tumor treatment** *(large market)*
- **Sterilization** *(existing / growing market)*
- **Security** *(proof of concept)*

Free Electron Laser wide range of wavelengths *(growing market)*

- **Materials and biological research** *(growing market)*
- **Light source lithography** *(ideas)*
- **Defense (USA)** *(ideas)*
- **Fundamental research** *(niche market)*

Proton

Tumor treatment *(small but growing market)*

Materials Research *(small market)*

Proton beam lithography *(ideas)*

Fundamental research (niche market)

Other elements

Tumor treatment *(proof-of-concept)*

Material treatment *(growing market)*

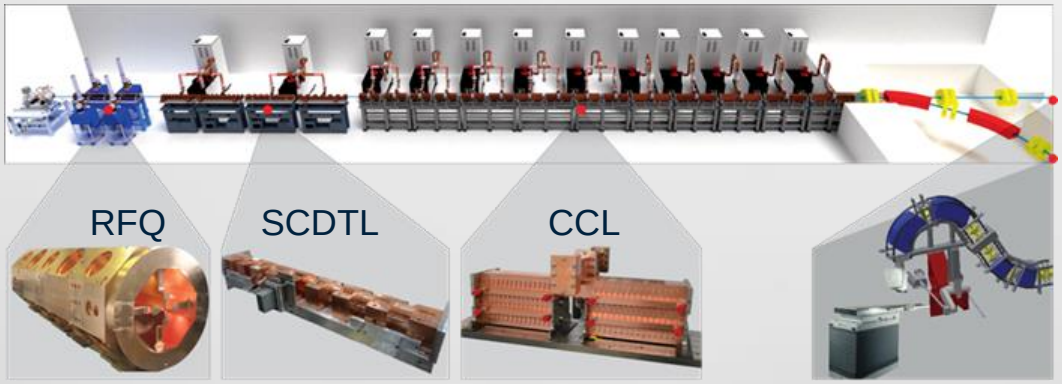
Fundamental research *(niche market)*

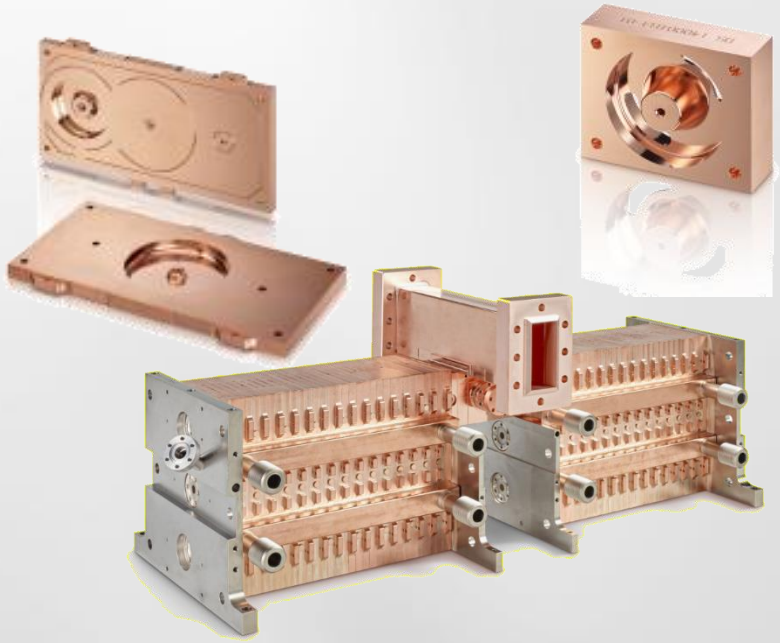
Normal Conducting X-band

VDL Science & Technology 2020

Applications : Proton therapy

- LIGHT (Linac for Image Guided Hadron Therapy) developed by ADAM
- VDL ETG is partner to manufacture, build and test the CCL accelerating modules
- First modules delivered for high power test (Low power RF and bead pull test done @ VDL)



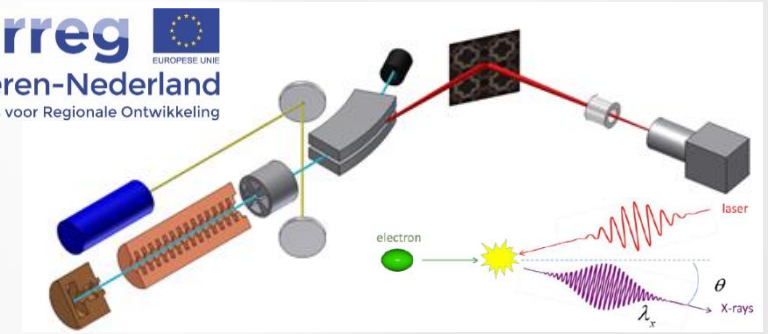


VDL Science & Technology 2020

ICS Source

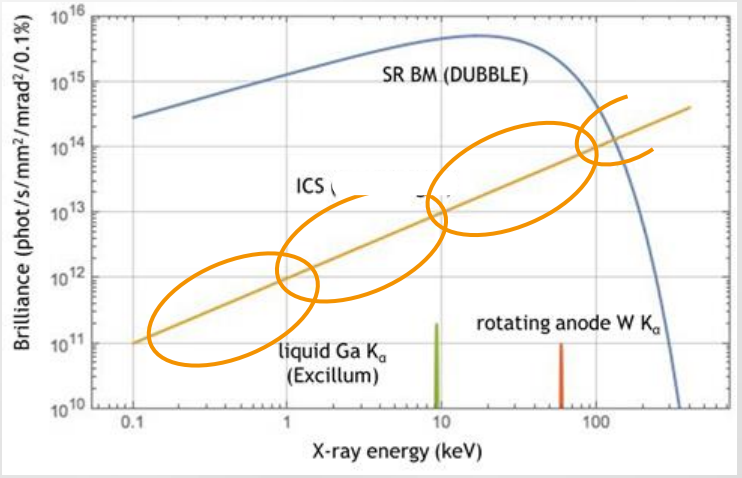
Smart Light

Interreg Vlaanderen-Nederland
Europees Fonds voor Regionale Ontwikkeling



- Smart*Light is a compact, high brilliance, monochromatic X-ray source, outperforming currently available tools
  - “it is the PC version of the mainframe synchrotron”

- Compared to machines currently under development, ICS source is
  - Compact
  - Configurable and tunable (machine modular)
  - Energy switching securing high throughput / fast imaging
  - Field upgradeable



VDL ETG GROUP 2019

Facts and figures