Low Emittance Rings Workshop, February, 2024

Mike Seidel, PSI/EPFL

Community Activities on Sustainability

2014-17: EUCARD-2, WP Energy Efficient Accelerator Technologies

https://www.psi.ch/enefficient

2017–21: ARIES, Work Package Efficient Energy Management

https://www.psi.ch/aries-eem

2021–25: I.FAST, Work Package Sustainable Concepts

https://www.psi.ch/scat

EuCARD² Enhanced European Coordination for Accelerator Research & Development

ARIES ACCELERATOR RESEARCH AND INNOVATION FOR EUROPEAN SCIENCE AND SOCIETY

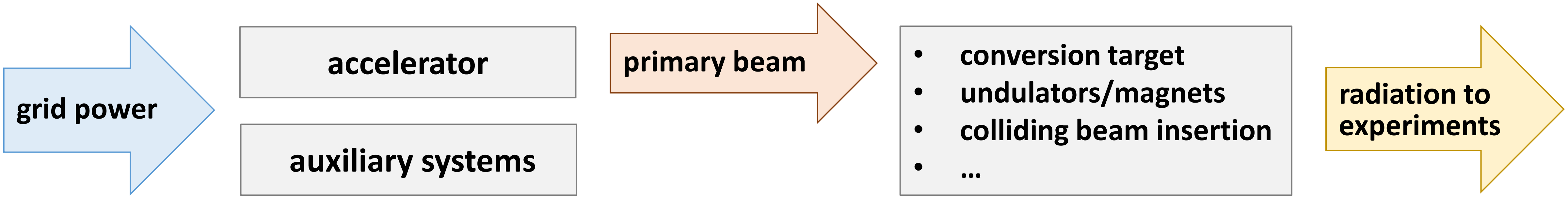
iFAST Innovation Fostering in Accelerator Science and Technology

→ consult websites for link collection to workshops and documentation

ICFA

- ICFA panel on sustainable accelerators, chair: Thomas Roser (BNL)
- https://icfa.hep.net/icfa-panel-on-sustainable-accelerators-and-colliders/

Power-Flow in Accelerator driven Research Infrastructures (RI)



primary beam production

- electrons
- protons
- ions

conversion to specific secondary radiation

- X-rays
- neutrons, muons, neutrinos
- exotic particles

high level goal:

Science output per grid power, per operating/investment cost.

WP11 Overview

task 1: Sustainable Concepts for RIs: networking, workshops on selected topics
deliverable: report

1) System Efficiency of Accelerator Concepts (N.Catalan Lasheras, CERN)
2) Key Technologies and Components for High Efficiency (A.Sunesson [C.Martins], ESS)
3) Cross Linking Accelerator R&D with Industrial Approaches (P.Spiller, GSI)
4) Ecological Concepts (D. Voelker, DESY)

task 2: **High Efficiency Klystron** (O.Brunner CERN, THALES, ULANC)

- deliverable: industrial prototype
- replacing klystrons in LHC

task 3: **Permanent Combined Function Magnets for Light Sources** (B.Shepherd, UKRI, DLS, KYMA, DESY)

- deliverable: magnet prototype, applicable for Diamond upgrade
- several advantages of permanent magnets, not just power consumption

Energy for Sustainable Science, Grenoble 2022

6th workshop
101 particpants, 2-day program, 32 presentations, few remote
chair: Jean-Luc Revol (ESRF)

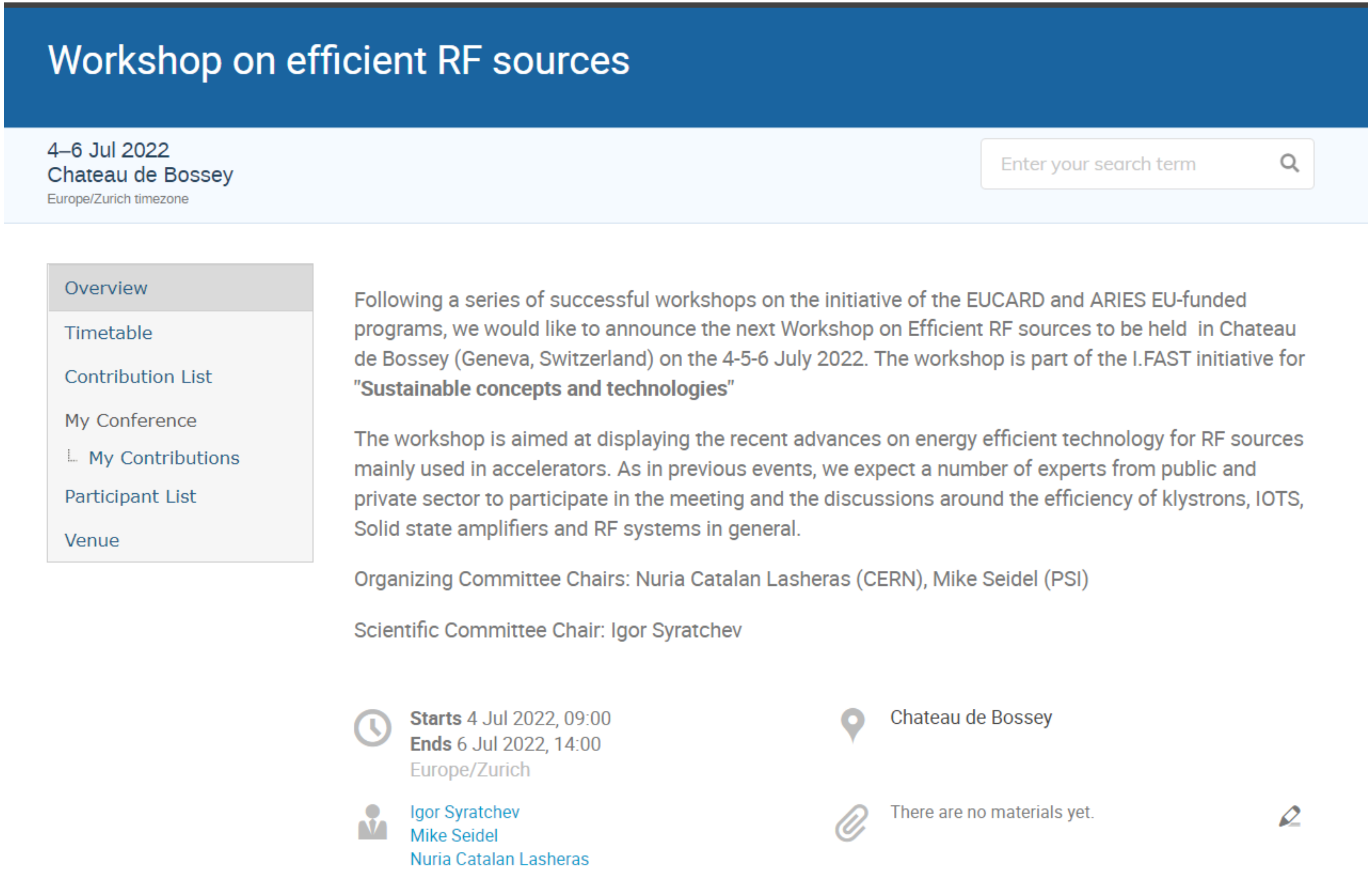
ESSRI 2024: CIEMAT Madrid, Sep 25-27
https://agenda.ciemat.es/event/4431/
chairmanship & organization: J.Perez et al.

First day ...

09:00	Welcome	*Francesco Sette*	*Auditorium, ESRF, Grenoble*	09:00 - 09:10
	Workshop Introduction	*Frederick Bordry*	*Auditorium, ESRF, Grenoble*	09:10 - 09:20
	Practical Information	*Jean-Luc Revol*	*Auditorium, ESRF, Grenoble*	09:20 - 09:30
	Climate change is accelerating. We need to move much faster	*Michel Jarraud*	*Auditorium, ESRF, Grenoble*	09:30 - 10:00
10:00	Energy Transition: towards a complex cyber-physical system of systems	*Lucas Saludjian*	*Auditorium, ESRF, Grenoble*	10:00 - 10:30
	Coffee break & Photo		*Entrance Hall, ESRF Central Building*	10:30 - 11:15
11:00	Electrical Flexibility Market	*Bernadette Remenyi et al.*	*Auditorium, ESRF, Grenoble*	11:15 - 11:45
	Energy management at Stanford University	*Lincoln Bleveans*	*Auditorium, ESRF, Grenoble*	11:45 - 12:15
12:00	ERLs and Sustainability	*Andrew Hutton*	*Auditorium, ESRF, Grenoble*	12:15 - 12:45
	Lunch		*Site Restaurant*	12:45 - 14:00
13:00				
14:00	Challenges of a megawatt CW class solid state power am.	*Eric Montesinos*		
	An overview of the status of energy sustainability at the .	*Mamad Eshraqı*		
	Progress with permanent magnets and return on experien	*Joel Chavanne*		
	Energy optimisations implemented at accelerators and ir	*David Reinhard*		
15:00	Free Air Cooling solution for the Data Centers	*Laurent Roy*		
	Energy management at High Magnetic Field Facilities	*François Debray*		
	Energy management University Darmstadt	*Christopher Ripp*		
	ESRF EBS energy management	*Christian Nevo*	*Auditorium, ESRF*	15:15 - 15:40
	Coffee break			
	Coffee break			

WP11, 1.1: N.Catalan-Lasheras

- RF efficiency in operational and planned accelerators
- High efficiency klystrons
- Industrial partners contribution
- Magnetrons, IOTs, tetrodes
- Solid State Amplifiers



Workshop on efficient RF sources

4–6 Jul 2022
Chateau de Bossey
Europe/Zurich timezone

Enter your search term

- Overview
- Timetable
- Contribution List
- My Conference
  - My Contributions
- Participant List
- Venue

Following a series of successful workshops on the initiative of the EUCARD and ARIES EU-funded programs, we would like to announce the next Workshop on Efficient RF sources to be held in Chateau de Bossey (Geneva, Switzerland) on the 4-5-6 July 2022. The workshop is part of the I.FAST initiative for "**Sustainable concepts and technologies**"

The workshop is aimed at displaying the recent advances on energy efficient technology for RF sources mainly used in accelerators. As in previous events, we expect a number of experts from public and private sector to participate in the meeting and the discussions around the efficiency of klystrons, IOTS, Solid state amplifiers and RF systems in general.

Organizing Committee Chairs: Nuria Catalan Lasheras (CERN), Mike Seidel (PSI)

Scientific Committee Chair: Igor Syratchev

Starts 4 Jul 2022, 09:00
Ends 6 Jul 2022, 14:00
Europe/Zurich

Chateau de Bossey

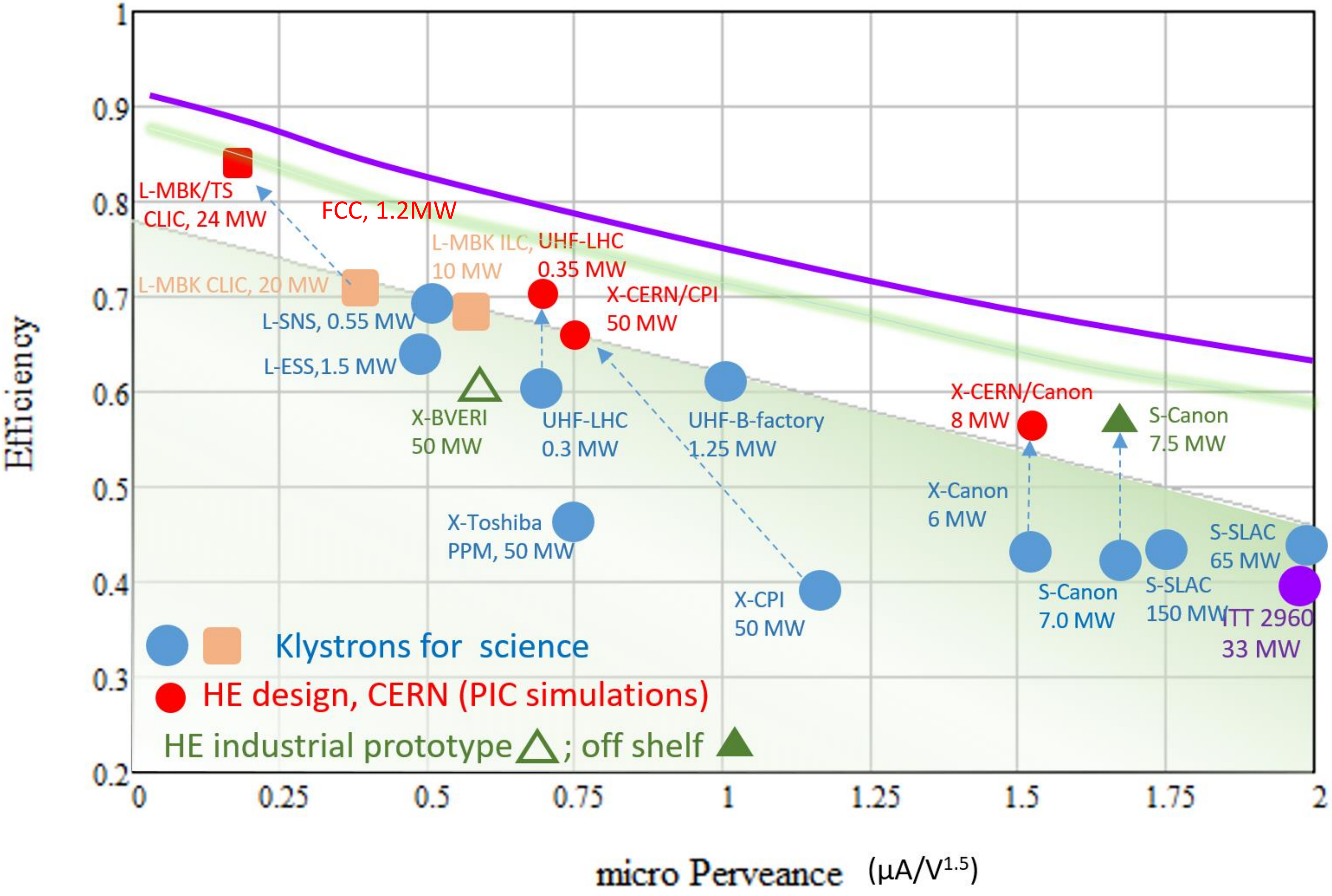
Igor Syratchev
Mike Seidel
Nuria Catalan Lasheras

There are no materials yet.

https://indico.cern.ch/event/1138197/

I.Syratchev, High efficiency klystron technologies

Efficiency performance of the selected commercial klystrons and the new HE klystrons.

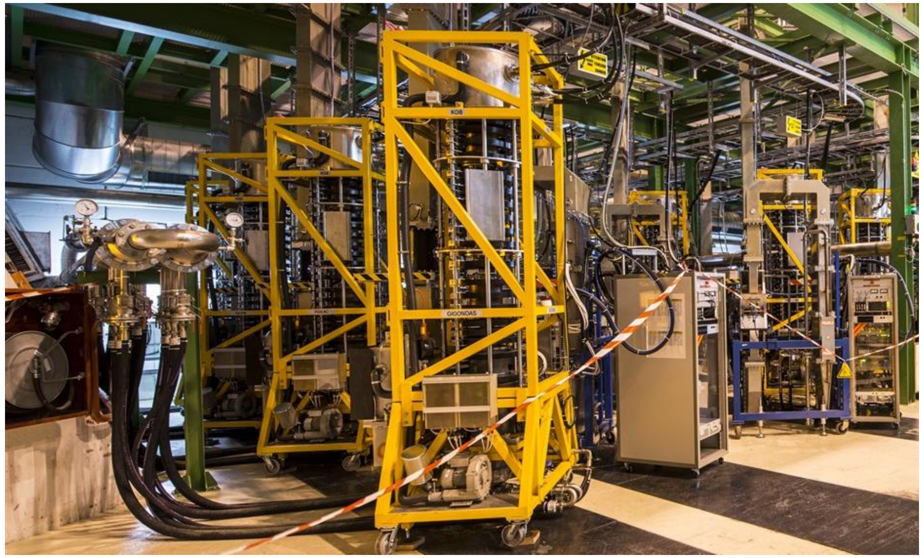


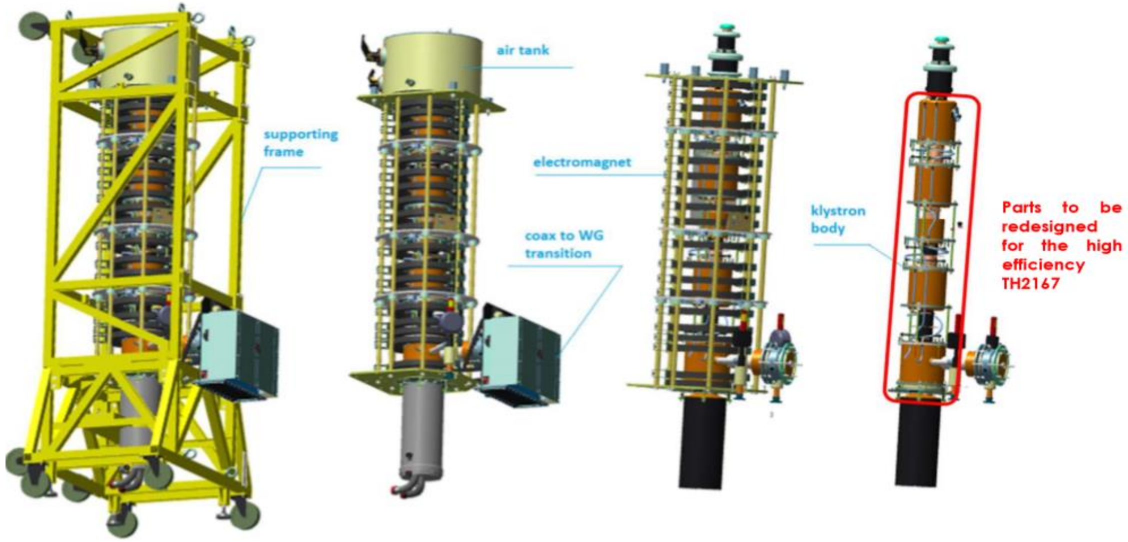
klystron talks, Tu

09:00	**HE klystrons technologies** *Chateau de Bossey*
	Review of computer codes for the klystrons design *Chateau de Bossey*
10:00	**FCC HE TS klystron development** *Chateau de Bossey*
	Coffee Break *Chateau de Bossey*
11:00	**CSM HE LHC klystron. THALES** *Chateau de Bossey*
	50 MW Xband HE klystron program. CPI *Chateau de Bossey*
12:00	**CEPC high efficiency klystron status** *Chateau de Bossey*
	X-band HE klystron development. Canon Electron Tubes & Devices *Chateau de Bossey*

Objective of I.FAST WP 11.2

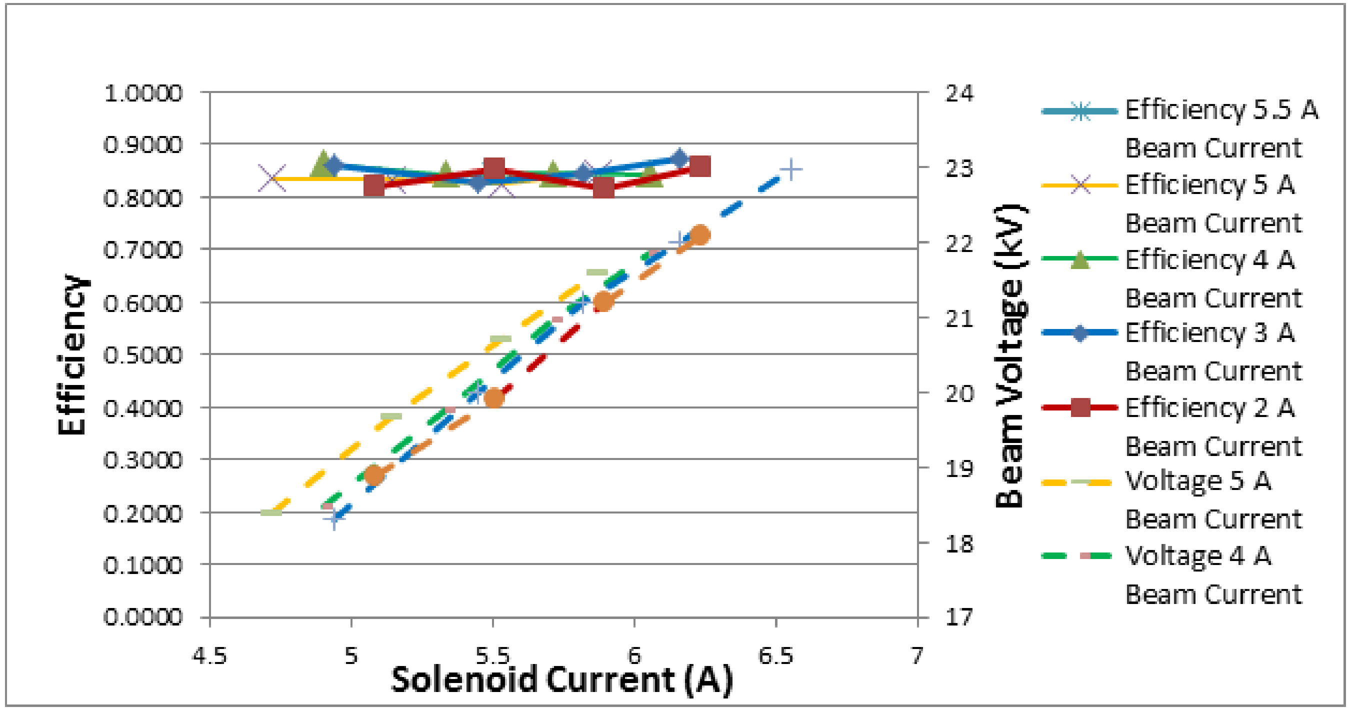
- Design and build an industrial prototype of the LHC klystron reaching 70% efficiency, in collaboration with THALES.
- In order to control the costs, the choice was made to retrofit the existing LHC klystrons, TH2167, with the aim of reusing some components (e.g. solenoid).
- Kick off meeting on Sept 2021





Lawrence Ives, Calabazas Creek Research, High Efficiency RF Source Development

Efficiency varied between 81% and 87%, depending on parameters



A 100 kW 1300 MHz **magnetron** with 10% duty

collaboration with Fermilab

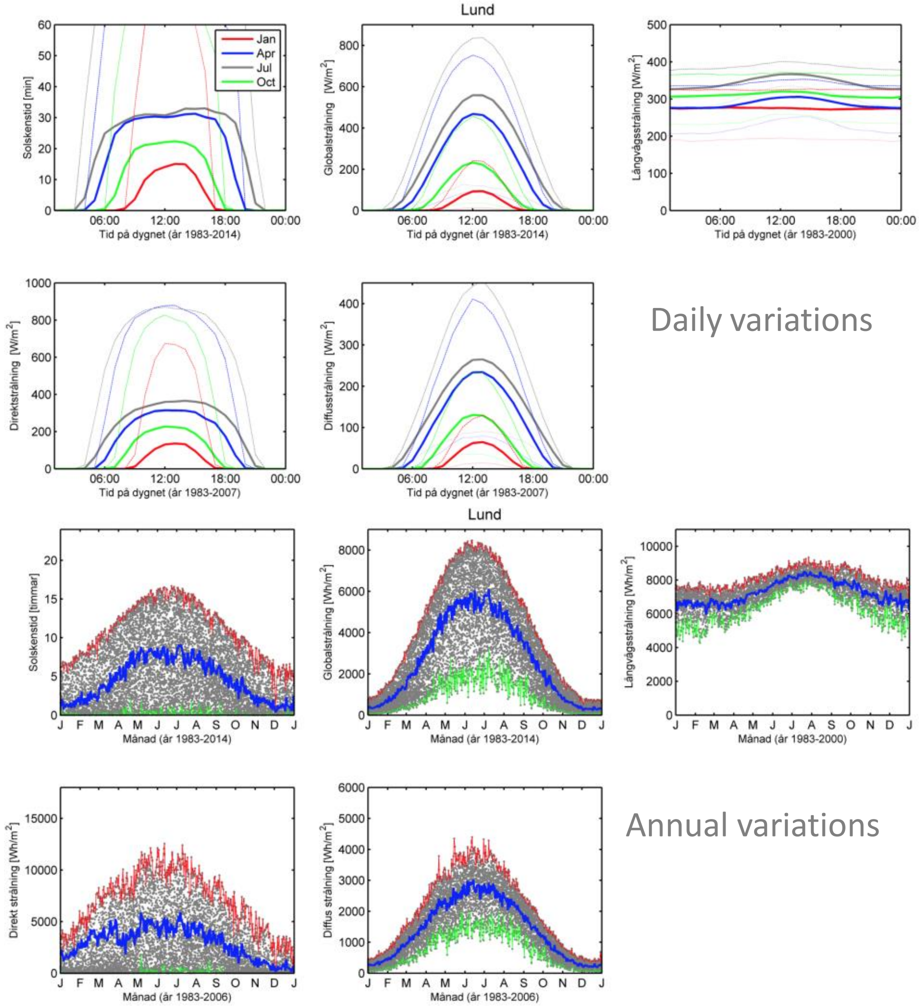
[related: I.FAST Innovation Funds project: D.Dancilos, Crossed Field Amplifier, presented on Fri]

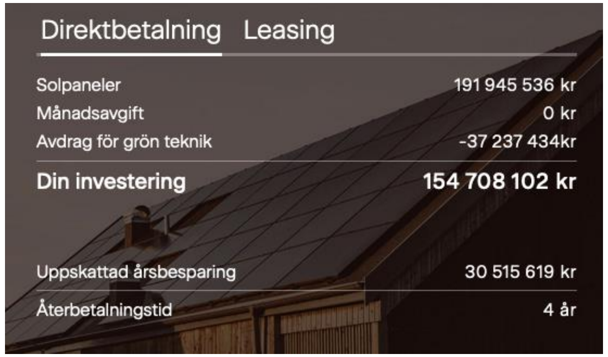
ESS Topics, Anders Sunesson (Carlos Martins)

- Sustainability in accelerator operation:
  - PV installation to supplement the grid – considerable savings possible
  - More efficient DC/DC converter to directly power equipment (in fact, most electronics is powered by DC!), for example to 1.1 kV voltage, which would allow direct powering of HV modulators with higher efficiency
- Improved power converters in general using active frontends – less need for compensation for flicker etc
- Workshop 2023 moved to 2024. Focus Efficient Power converters
- ESS co-applicant to HORIZON 2023 program FlexRICAN geared towards sustainability and flexibility in how you power facilities

SOLAR CELLS POWERING THE NEUTRON SOURCE

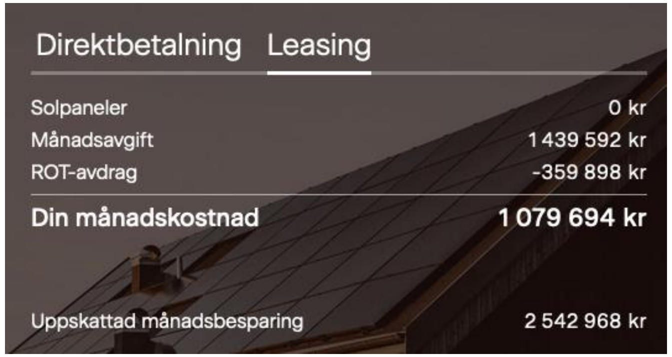
- Panels are 1.1 x 1.75 m, each rated at 410 W
  - With ~34k panels the installed capacity is ~14 MW, total cost (incl VAT): 154 MSEK





Direktbetalning | Leasing

Solpaneler	191 945 536 kr
Månadsavgift	0 kr
Avdrag för grön teknik	-37 237 434kr
Din investering	**154 708 102 kr**
Uppskattad årsbesparing	30 515 619 kr
Återbetalningstid	4 år



Direktbetalning | Leasing

Solpaneler	0 kr
Månadsavgift	1 439 592 kr
ROT-avdrag	-359 898 kr
Din månadskostnad	**1 079 694 kr**
Uppskattad månadsbesparing	2 542 968 kr

https://www.smhi.se/kunskapsbanken/meteorologi/stralning/solstralning-i-sverige-1.89984

iFAST

6.–8. Feb. 2023
Hamburg
Europe/Berlin Zeitzone

Critical Materials and Life Cycle Management: The Example of Rare Earths – curse or blessing?

DESY Hamburg, Denise Völker, Andrea Klumpp et al

- Übersicht
- Zeitplan
- Anmeldung
- Information
- Participant list
- Impressions of the work shop

Orga
denise.voelker@desy.de
andrea.klumpp@desy.de

Life Cycle Assessments get more and more in the focus in industry and also in science. iFAST presents a platform for discussing and finding solutions in these topics.
In our workshop we want to focus on the Life Cycle Management using the example of Rare Earths Elements (REE), the key material in permanent magnets used in a variety of fields like accelerator, turbines, hard drives and many more.

On the workshop we will discuss the following points:

- Life cycle management
  Consider entire life cycle of technical component using critical materials:
  construction – operation – deconstruction
- Mining and processing of REE
  a socio-ecological approach – energy savings versus destructive mining and processing
- Using permanent magnets
  Examples of the use of permanent magnets and its Pro and Con
- Certification for mining and processing of REE
  How to force more sustainable thinking in the production of REE
- Recycling of permanent magnets
  New processes for the re-use and recycling of permanent magnets
- Alternatives for permanent magnets with REE
  New magnetic materials as well as improved electromagnets

Science, industry, politics and NGO in cooperation can forces to tackle the problem – we can develop solutions together.

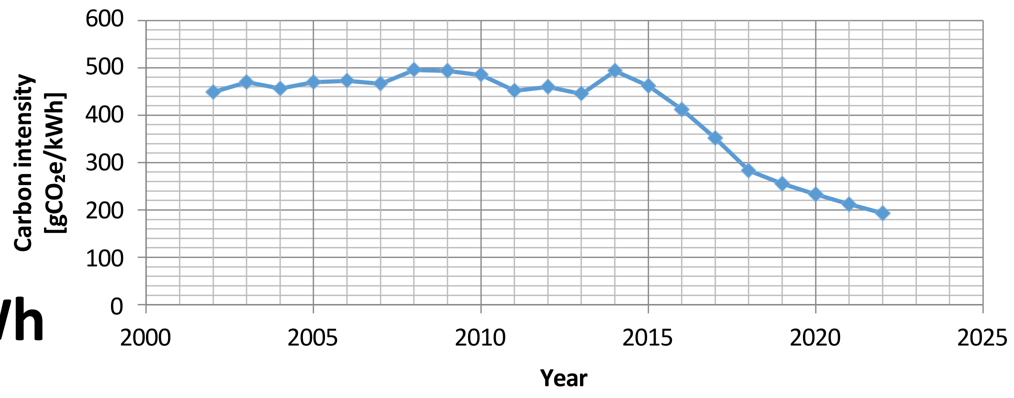
SUSTAINABLE DESY

Topics:

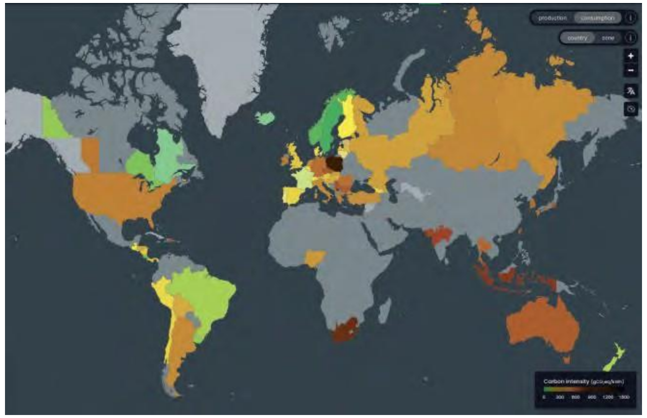
- rare earths: benefits and issues
- assessing carbon footprint, env. impact, societal impact …
- supply chains and certification
- recycling

https://indico.desy.de/event/35655/

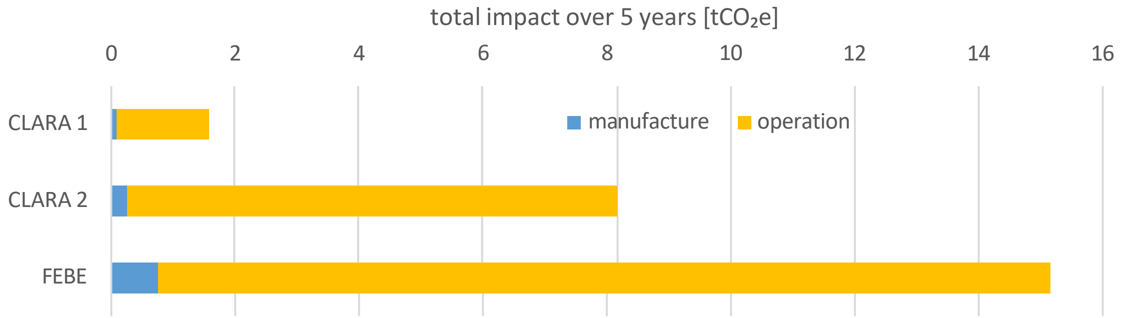
B.Shepherd (STFC): Three quadr. type electro- vs. permanent magnet comparison



- Power usage at nominal operating point
  - CLARA 1: **385 W**
  - CLARA 2: **2.01 kW**
  - FEBE: **3.72 kW**
- UK electricity carbon intensity 2022: **193 gCO_2e / kWh** (and improving every year!)
  - Highly dependent on fuel mix:
    Sweden 21g; France 102g; USA 432g; Germany 481g; Switzerland 153g (source: Electricity Maps)

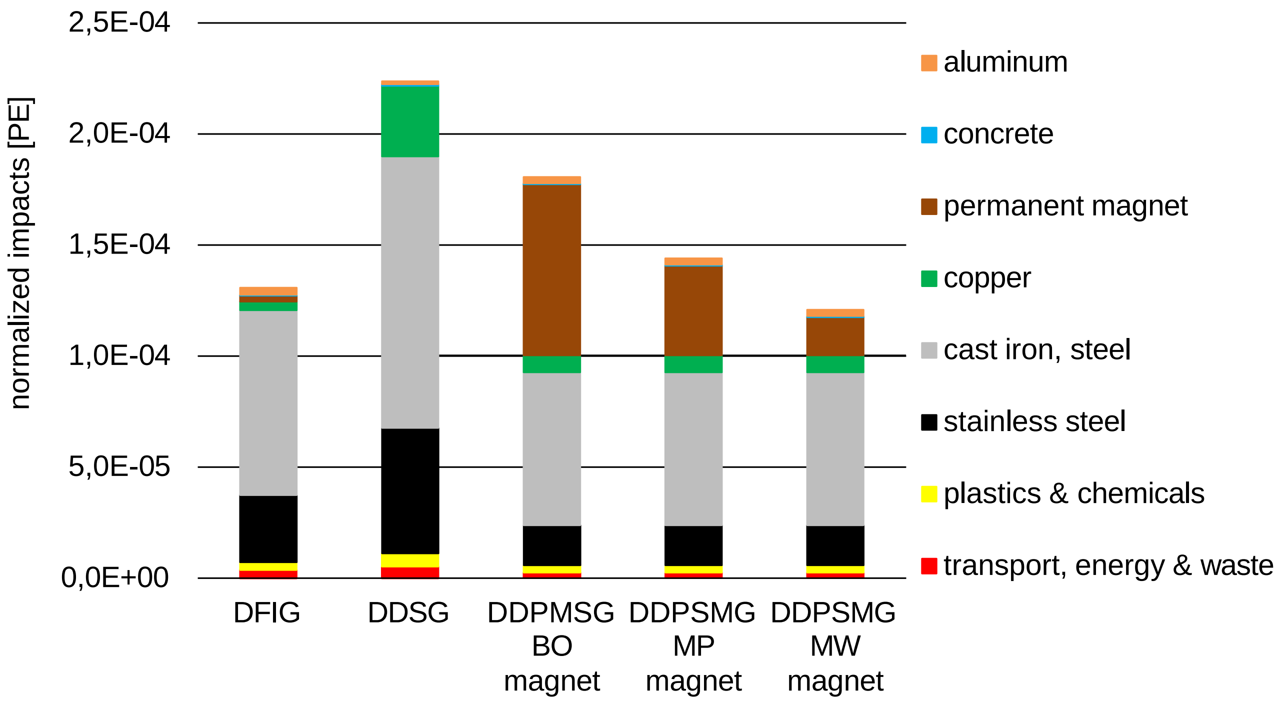


- Assume operated for 5 years, 250 days per year, 16 hours per day
- Total impact of operation *(note: cooling not included)*
  - CLARA 1: **1.49 tCO_2e**
  - CLARA 2: **7.76 tCO_2e**
  - FEBE: **14.4 tCO_2e**
- Much greater than manufacture impact



Petra Zapp (IEK-STE), excerpt: Comparison of Wind Generator Types

Influence of RE origin (ore type, mining location, specific site conditions) on environmental impacts per 1 kWh electricity generated by 3 MW wind power plant



DFIG: doubly-fed induction generator
DDSG: direct driven synchronous generator

DDPMSG: electrically excited and direct drive permanent magnet synchronous generator

- Electricity generation by DDPMSG with permanent magnet produced from Chinese RE (Bayan Obo) has higher normalized environmental impacts compared to
  - U.S. Mountain Pass (→ 20%)
  - Mt. Weld (Aus) (→ 33%)
- Electricity generation by Australian DDPMSG is 8% better than by DFIG

A. Schreiber, J. Marx and P. Zapp: **Comparative life cycle assessment of electricity generation by different wind turbine types;** Journal of Cleaner Production ***2019*** Vol. 233 Pages 561-572

GSI: Energy Efficiency – Topics

P.Spiller, J.Stadlmann et al

1. Energy Saving HTS Magnet
2. KI based Power Grid Monitoring
3. Sensor Based Power Monitoring
4. Watchdog for Accelerator Devices
5. Development of a HTS Nuclotron Cable
6. FAIR Energy Consumption Forecast
7. Cooling Water Flow Control
8. Energy Efficient Design of SIS100 Cooling System
9. Energy Efficient beam Transport by High Current Pulsed Magnets

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EU IFAST Workshop - Accelerator meets Industry

P.Spiller, J.Stadlmann
et al, GSI

„Superconductivity for Sustainable Energy Systems and Particle Accelerators“
@ GSI, Darmstadt, Germany; October 19th-20th, 2023

Scope: Energy efficient superconducting accelerator components and energy systems. Application/dual use of s.c. accelerator technologies in energy systems. Collaboration of research and industry. New superconductor technologies and applications. Minimization of AC loss and heat load. Higher coolant temperatures.

CONECTUS

CONECTUS

CONsortium of European Companies determined To Use Superconductivity

BiLFINGER Bilfinger Noell GmbH

Bock SuperConductors Consulting GmbH

BRUKER

can superconductors

evico

Leybold

LUVATA

MW MARK & WEDELL

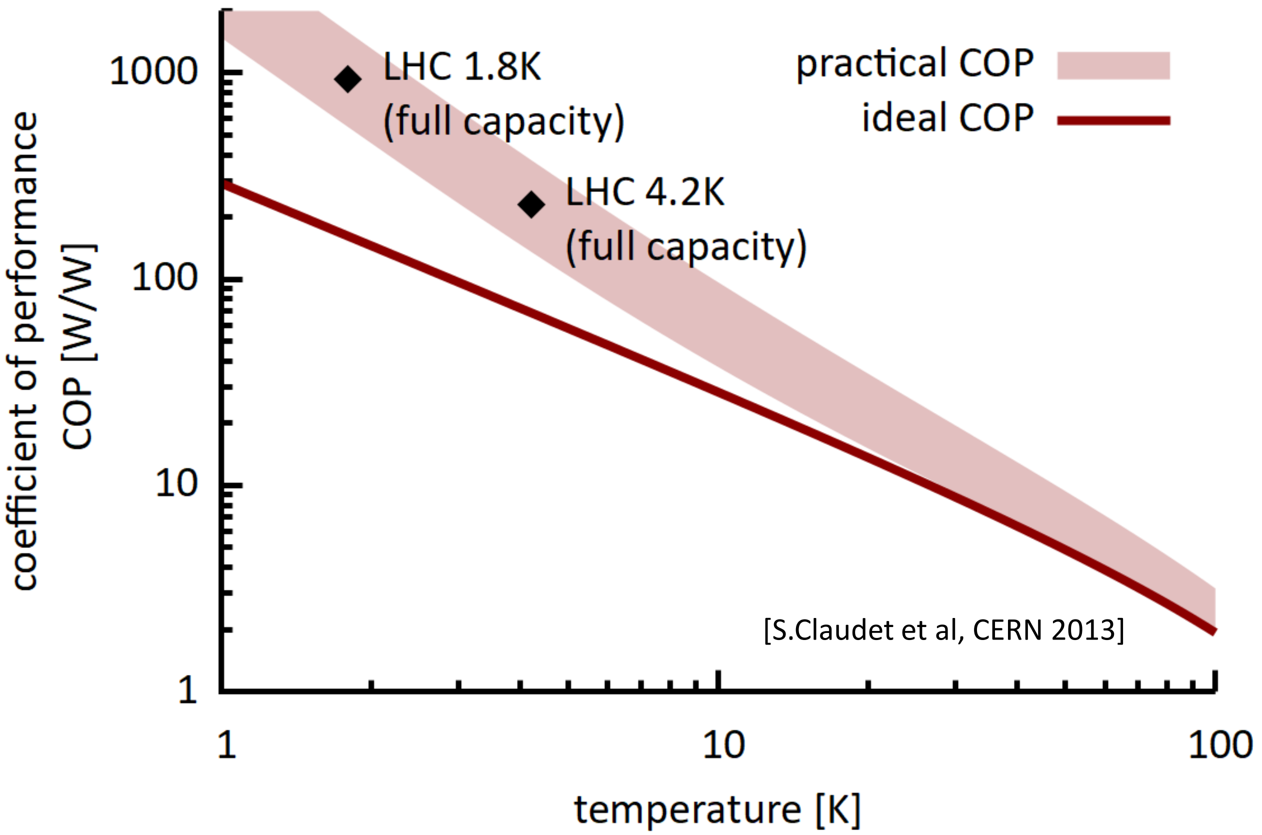
SIEMENS

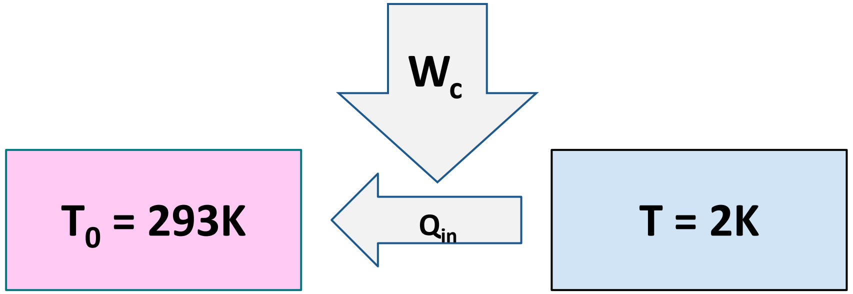
SHI Cryogenics Group

THEVA

Department of Inorganic Chemistry
UCT PRAGUE

Cryogenic Efficiency – Motivation for HTS Magnets & RF





best possible coefficient of performance (COP):

$$\mathrm{COP} = \left(\frac{W_c}{Q_\mathrm{in}}\right)_\mathrm{Carnot} = \frac{T_0 - T}{T}, \quad T_0 = 293\,\mathrm{K}$$

W_c = amount of work required to remove heat Q_{in} at cold temperature T

$$P_\mathrm{cryo} = \mathrm{COP} \cdot P_\mathrm{dissip}$$

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Sustainability for RI’s - Balancing

practical benefits
- energy efficiency → energy consumption
- optimized lifecycle management, carbon footprint

acceptance/outreach
- support through the public and funding agencies
- model role of science; positive outreach

to be balanced with green house gas footprint:
- key goals: research reach (quality), performance (quantity)
- manpower effort, cost, overall feasibility
- conceptual and/or technology measures

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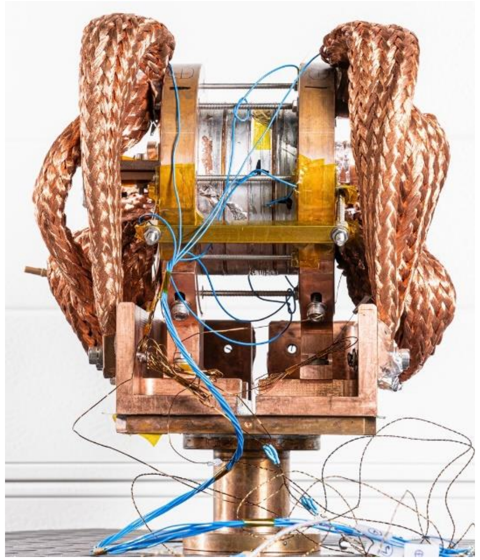
I.FAST WP11 Outlook

WP11 Plans:

- co-organising Energy for Sustainable Science workshop Madrid, Sep.
- efficient (and complient) power converters, ESS, April
- efficient RF Systems, Toledo, September
- delivery report (best practices etc.)

thoughts on future topics:

- high temperature superconductors for magnets and RF
- lifecycle management of accelerator components → design to ease recycling, repairs, minimisation of waste



5cm bore solenoid 18.2 Tesla @ 12 K (!) ReBCO, non-insulated coil program: CHART @ PSI

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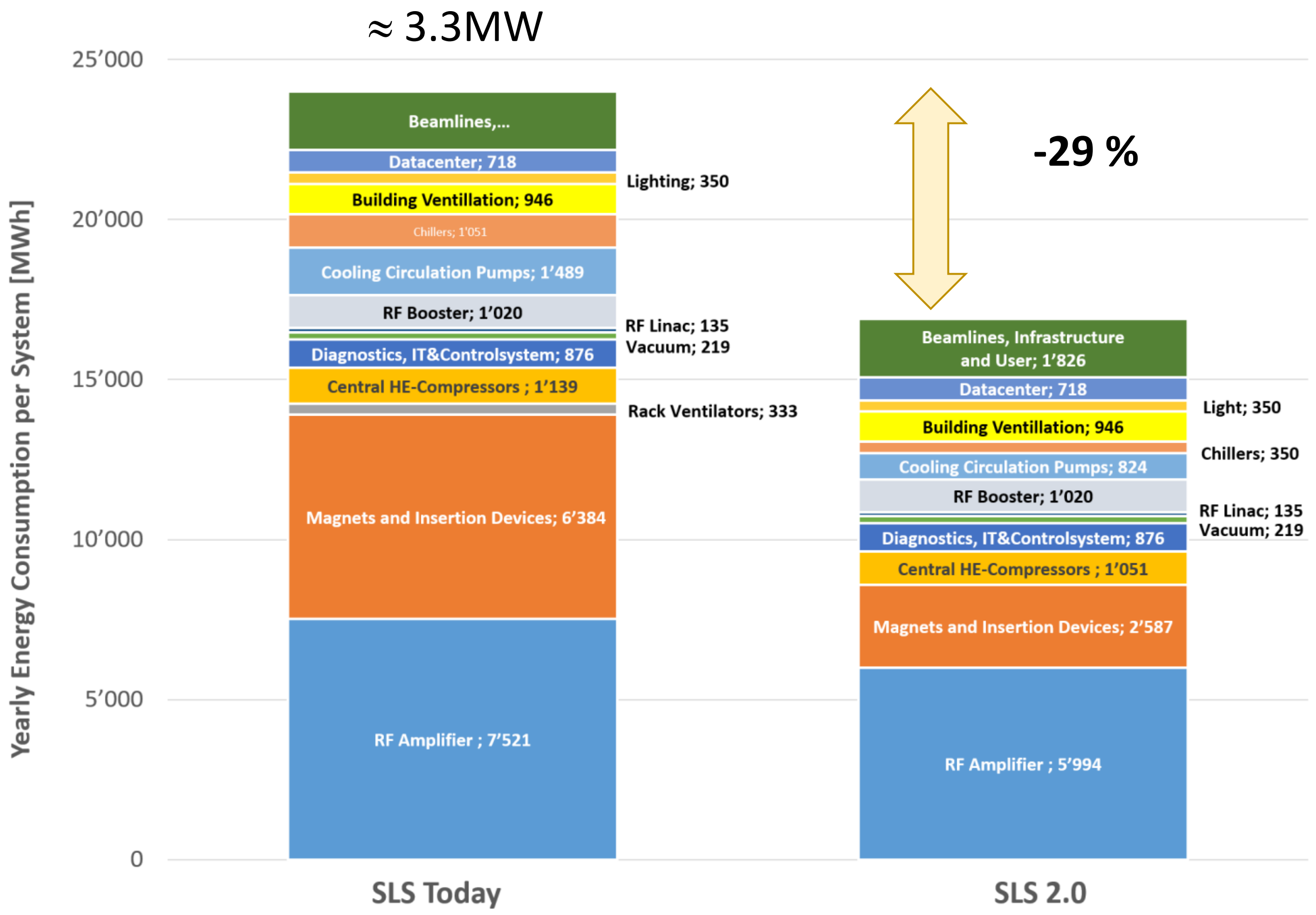
Appendix Example: Swiss Light Source SLS and its Upgrade



More radiated X-ray power for users
Less electricity consumption

Key savings:

Electromagnets → Permanent magnets
Klystrons → Solid state amplifiers (63%)
standard pumps → modern pumps for cooling

SLS2.0

P_{tot} = 2.4MW
P_{RF} = 0.82MW
$P_{\gamma \text{ (undulators)}}$ = 91kW