HORIZON 2020

# *Accelerator Performance and Concepts* report from WP6

http://aries.web.cern.ch/content/wp6

Giuliano Franchetti and Frank Zimmermann,

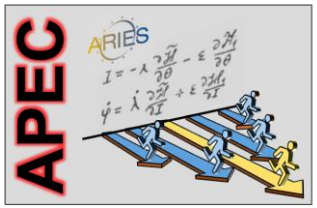
with input from Alessandro Drago, Johannes Gutleber, Florian Hug, Mauro Migliorati, Arto Niemi, and Marco Zanetti

1st Annual Meeting of ARIES

Riga Technical University, 23 May 2018

This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under Grant Agreement No 730871.

# APEC structure




**Task 6.1 Coordination and communication**
Coordinated by Frank Zimmermann (CERN), Giuliano Franchetti (GSI)

**Task 6.2 Beam Quality Control in Hadron Storage Rings and Synchrotrons**
Coord. by Giuliano Franchetti (GSI), Frank Zimmermann (CERN)

**Task 6.3 Reliability and Availability of Particle Accelerators**
Coord. by Johannes Gutleber (CERN), Klaus Hoeppner (HIT),
represented by Arto Niemi (CERN)

**Task 6.4 Improved Beam Stabilization**
Coord. by Mauro Migliorati (U. Roma Sapienza), Alessandro Drago (INFN-LNF)

**Task 6.5 Beam Quality Control in Linacs and Energy Recovery Linacs**
Coord. by Florian Hug (JGU Mainz)

**Task 6.6 Far Future Concepts & Feasibility**
Coord. by Marco Zanetti (INFN & U. Padova), Frank Zimmermann (CERN)

# WP6 APEC outreach - examples

- **articles in Accelerating News**

  "Accelerator reliability training help for experts" (APEC 6.3), by Panos Charitos, Accelerating News no. 22

  "Workshop shines Light on Photon-Beam Interactions" (APEC 6.6), M. Zanetti and F. Zimmermann, Accelerating News no. 23

- **invited presentation "*Accelerators in the 21st Century*",** 6th International Conference on New Frontiers in Physics (**ICNFP 2017**), Kolymbari, 28 August 2017

- **invited presentation "*Accelerators for Particle Physics – Big and Small*", EAAC'17**, La Biodola, 25 September 2017


- **SEMINAR "Horizon 2020 – Work Programme 2018-2020," Tokyo, Cooperation opportunities for researchers in Japan, Europa House**, Minami Azabu, Tokyo, 24 November 2017, Talk on *Future Circular Colliders and EU-Japan collaboration*

- **Europa Open Science House** at **Science Agora Tokyo**, and its Inauguration, Telecom Center, Odaiba, Tokyo, 25 November 2017, Talk on *Future Circular Colliders and EU-Japan collaboration*

**Task 6.2 "Beam Quality Control in Hadron Storage Rings and Synchrotrons":**

1. **Space Charge 2017** workshop, Darmstadt, 4-6 Oct. 2017 (https://indico.gsi.de/event/5600
2. **Slow Extraction** workshop, CERN, 9-11 Nov. 2017 (https://indico.cern.ch/event/639766/).
3. **Pulsed Power for Kicker Systems** (PULPOKS) Workshop, CERN, 12-14 March 2018 (https://indico.cern.ch/event/682148/).
4. **2nd CERN Space Charge Collaboration** meeting, CERN, 12-14 March 2018 (https://indico.cern.ch/event/688897/).
5. **FCC Week 2018**, Amsterdam, 9-13 April 2018 (https://indico.cern.ch/event/656491/).

**Task 6.3 "Reliability and Availability of Particle Accelerators":**

1. **Mini-workshop on Reliability and Availability**, CERN, 18–21 September 2017 (https://indico.cern.ch/event/651934/).
2. **Accelerator Reliability Workshop 2017** (ARW2017), Versailles, France, 15-20 October 2017 (https://indico.cern.ch/event/558933/).

**Task 6.4 "Improved Beam Stabilization":**

1. Mini-Workshop on **Impedances and Beam Instabilities in Particle Accelerators** 2017, Benevento, Italy, 18-22 September 2017 (http://pcwww.unisannio.it/workshopwakefields2017/ ).

**Task 6.5 "Beam Quality Control in Linacs and Energy Recovery Linacs":**

1. **LHeC/FCC-eh** Workshop, CERN, 11-13 Sep. 2017 (https://indico.cern.ch/event/639067/).
2. ARIES APEC Topical Workshop on **Ion Sources and Low Energy Beam Transport into RF Linacs,** February 28 - March 2, 2018 (https://indico.cern.ch/event/709057 ).

**Task 6.6 "Far Future Concepts & Feasibility":**

1. **Photon Beams** workshop, Padova, 27-28 Nov. 2017 (https://indico.cern.ch/event/668097).

in total 11 WP6 workshops during the first year of ARIES, 1046 participants

# Space Charge 2017, Darmstadt

→ highlight talk “Advances in space charge modelling and mitigations”, Giuliano Franchetti, Friday

**themes:**

- integrable optics, IOTA , PIP-3 project
- scalable experiments like Paul trap
- measuring full 6D beam distribution at SNS


# Slow Extraction, CERN

**themes:**

- spill performance, theoretical limitations
- input from clients, future requirements
- potential mitigation measures and new technologies
- synergy between laboratories
- pan-European and international collaborations
- retaining knowledge


**themes:**

improving lines of communication; sharing knowledge, experience and development approaches; sharing information about ongoing projects; discussion of future requirements

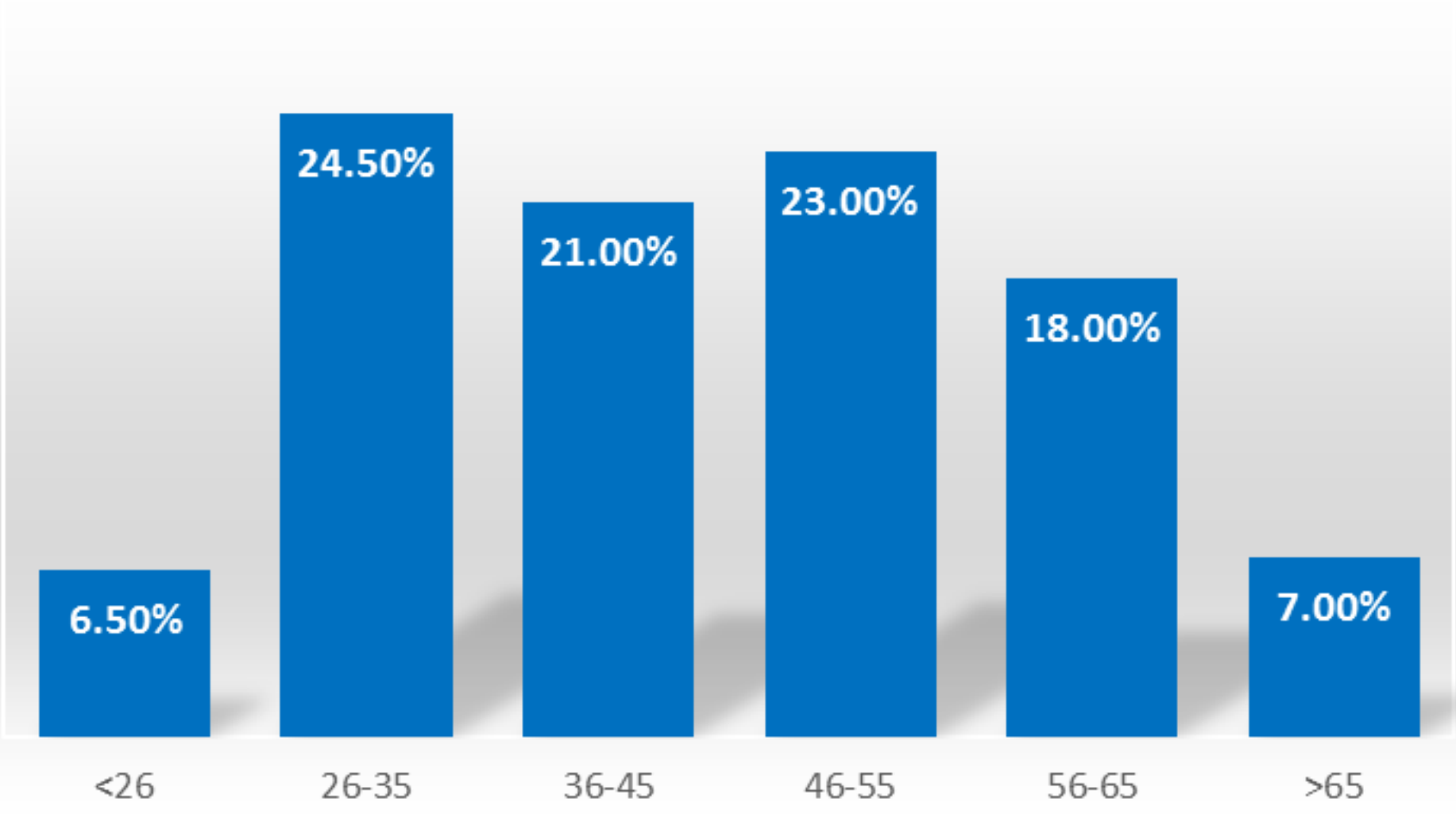
# Space Charge Collaboration Meeting, CERN

**Themes:**

1. SC effects in CERN accelerator chain (PSB, LEIR, PS, SPS).
2. SC effects in SIS100
3. Emittance growth
4. Direct/indirect and incoherent/coherent space-charge approaches
5. Space-charge simulations and modelling
6. SC code benchmarking
7. Noise issues both in PIC simulations and in adaptive frozen space-charge models
8. Special diagnostics tools (quadrupole pickups etc.)
9. Space-charge compensation
10. Interplay with field errors, and power-converter ripple
11. Indirect space-charge effects
12. Hardt description of quadrupole modes
13. Time reversibility criterion

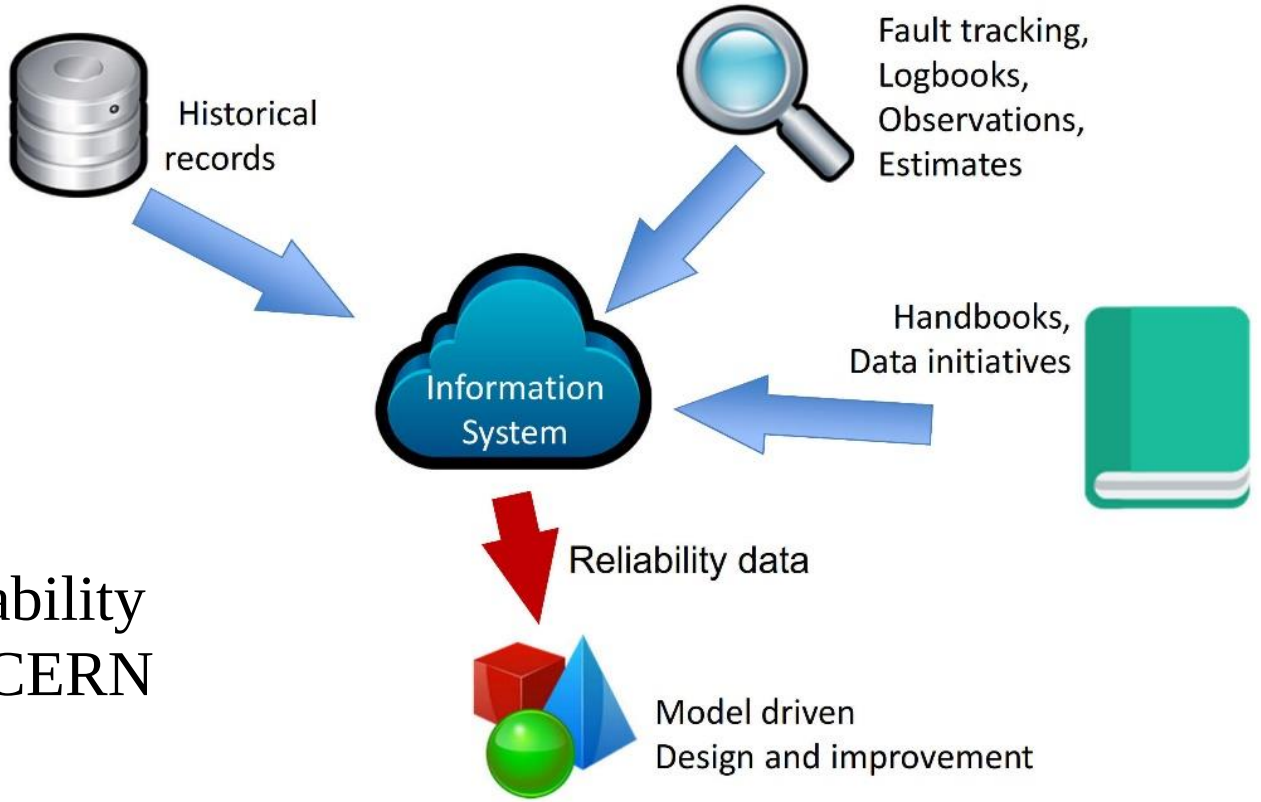
# FCC Week 2018


Sijbrand de Jong, the President of the CERN Council, opening the FCC Week 2018 in Amsterdam (credit: FCC Study Office | Hucopix)




Age distribution of the FCC Week 2018

# mini-workshop on Reliability and Availability, CERN




**theme:**
state-of-art of reliability data collection at CERN

Schematic high-level architecture where inputs from different sources are stored in a database to provide reliability data for end users (A. Preinerstorfer, H. Humer, T. Gruber, and P. Böhm / AIT).

# ARW2017, Versailles

# ARW2017, Versailles cont'd


platform for accelerator experts from around the world to meet and share their experiences on operating reliable facilities; the workshop fostered information exchange on technical issues and equipment reliability

# WP6.3 accelerator reliability training no. 1, 15-18 May 2018,

https://indico.cern.ch/event/701737/registrations/40519/

21 participants, 7 students, 1 woman

Jussi-Pekka Penttinen (Ramentor/ Tampere Uni. Tech.) instructing use of ELMAS fault tree software

Frank Mueller (Stuttgart Uni.) teaching reliability engineering

Participants from DESY following training

# WP6.3 accelerator reliability training no. 2, 9-12 October 2018, *registration open!* https://indico.cern.ch/event/723678/

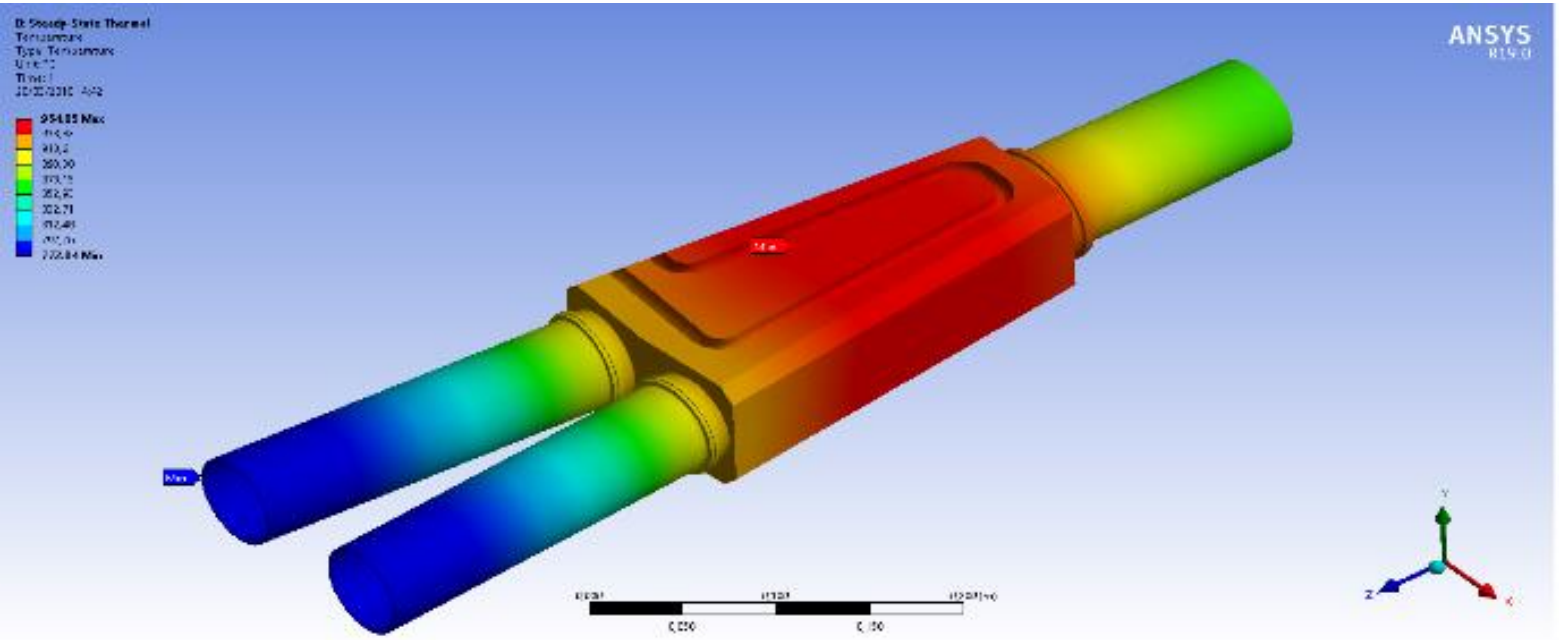
# Mini-Workshop on Impedances and Beam Instabilities in Particle Accelerators 2017, Benevento


no violent instabilities occurred through the interaction of participants, despite heated debates

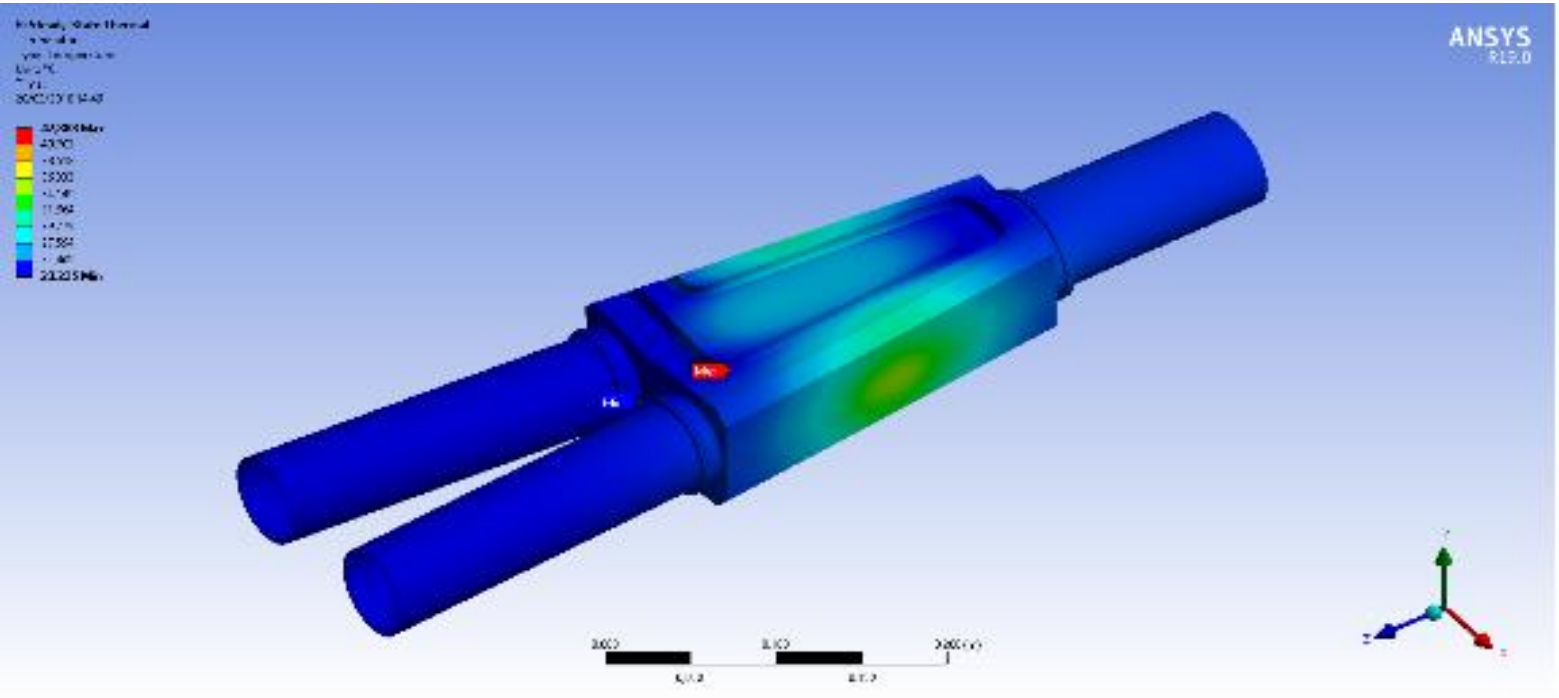
theme: approaches for potentially extending the performance reach:

- modifying machine optics
- Landau damping incl. radio frequency quadrupoles or electron lenses
- feedback systems to damp coherent instabilities.

# WP6.4 simulated heating of new DAFNE vacuum chamber for Siddartha



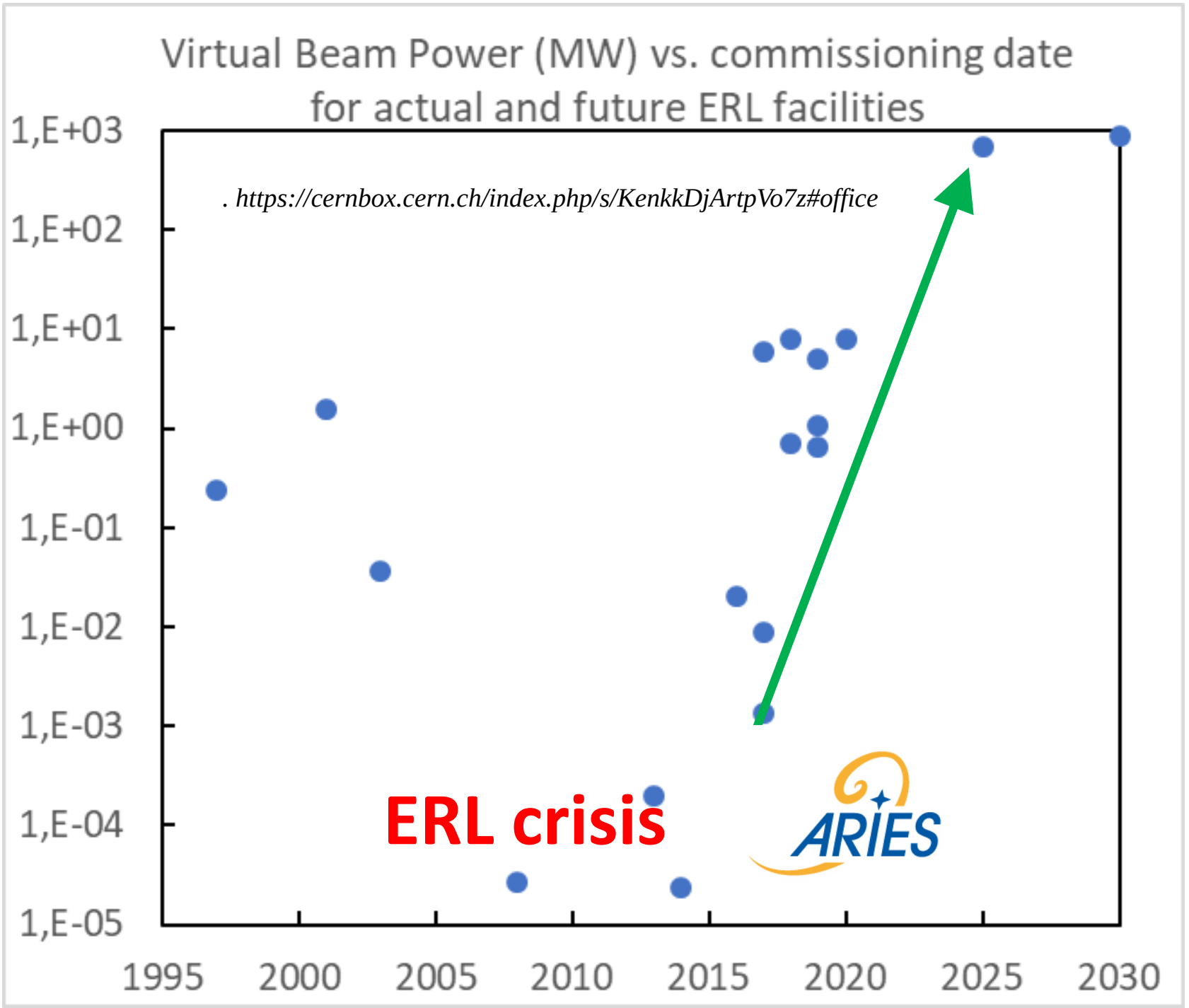

w/o cooling




with cooling

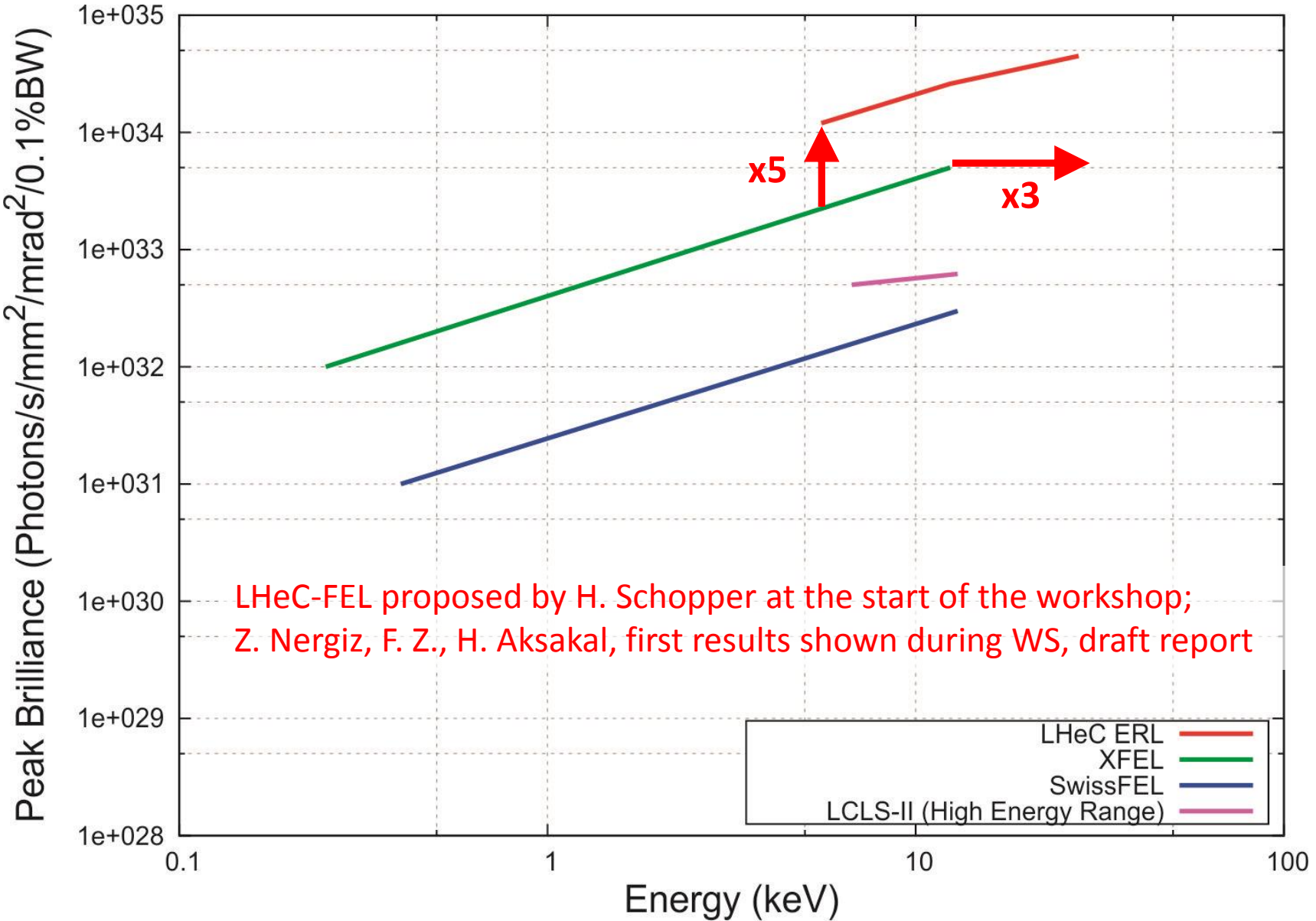
# LHeC/FCC-eh 2017, CERN

**themes:** physics cases, accelerator layout, detector development, and design of test facility


Virtual Beam Power (MW) vs. commissioning date
for actual and future ERL facilities
. https://cernbox.cern.ch/index.php/s/KenkkDjArtpVo7z#office
1,E+03
1,E+02
1,E+01
1,E+00
1,E-01
1,E-02
1,E-03
1,E-04
1,E-05
1995
2000
2005
2010
2015
2020
2025
2030
ERL crisis
ARIES

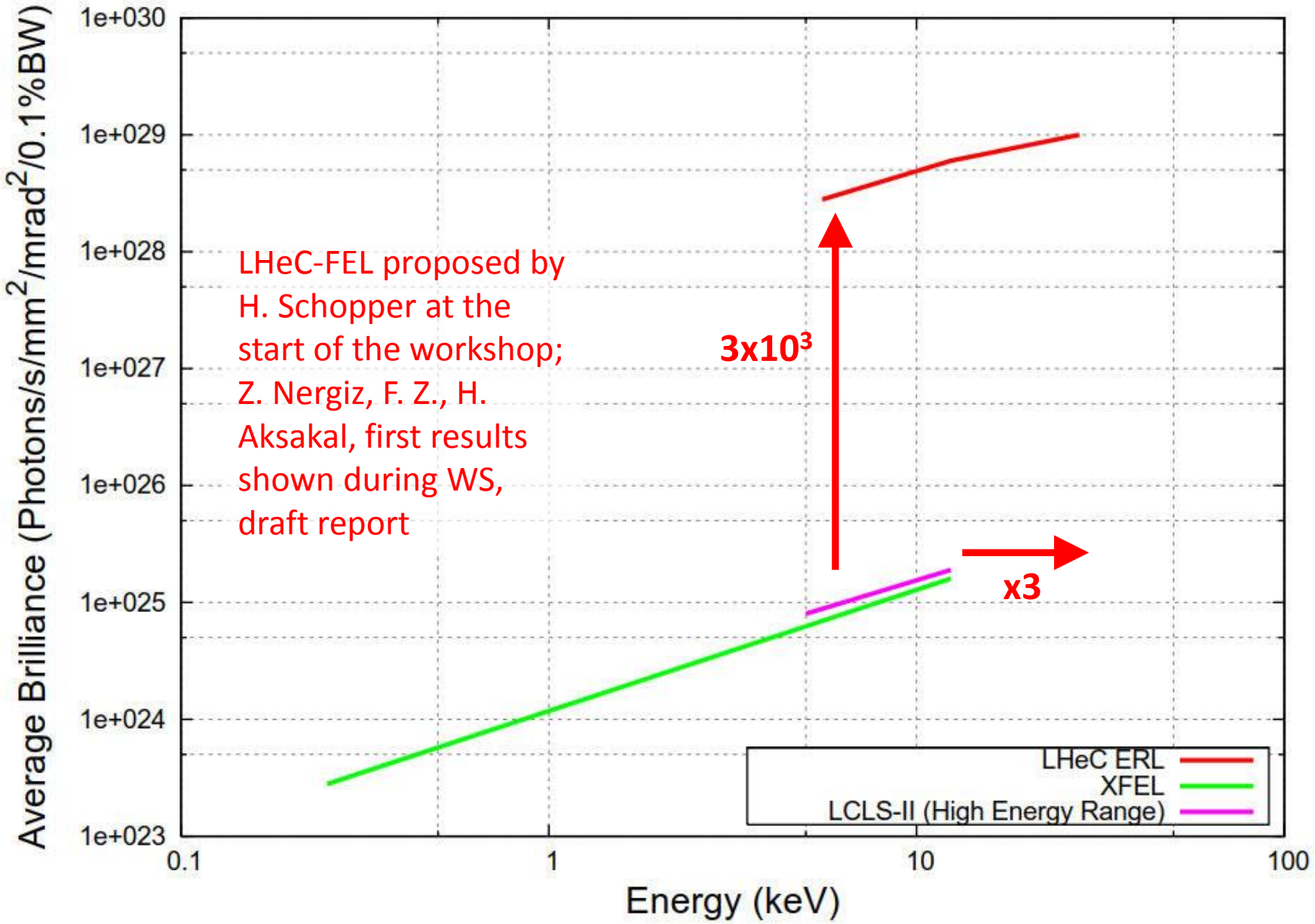
# highlight ARIES WP6.5 workshop *LHeC/FCC-eh*

## peak brilliance, LHeC-FEL compared with state-of-the-art

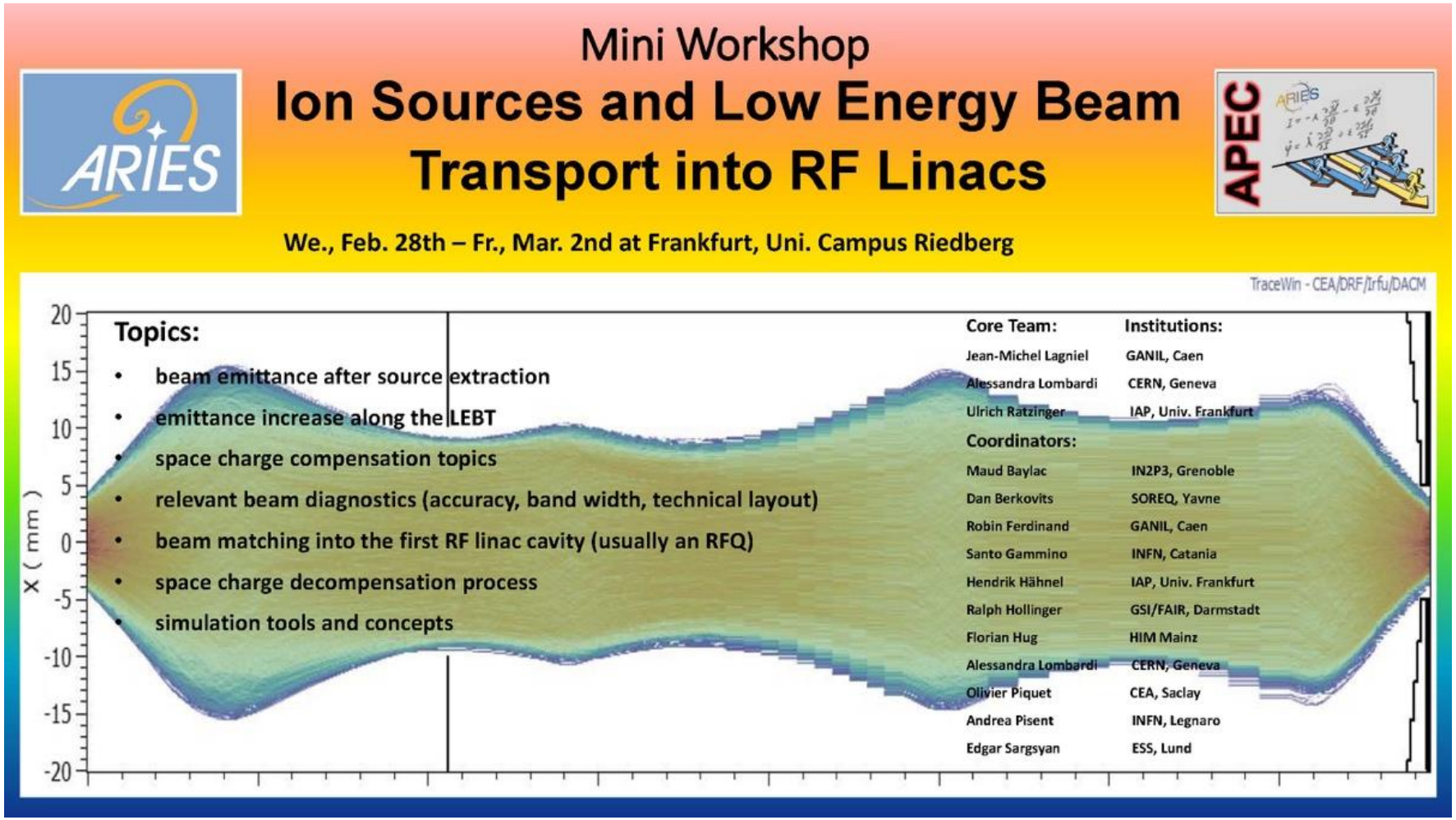


# highlight ARIES WP6.5 workshop *LHeC/FCC-eh*

## average brilliance, LHeC-FEL compared with state-of-the-art



# mini-workshop on Ion Sources, LEBT & RFQ, Frankfurt a.M.



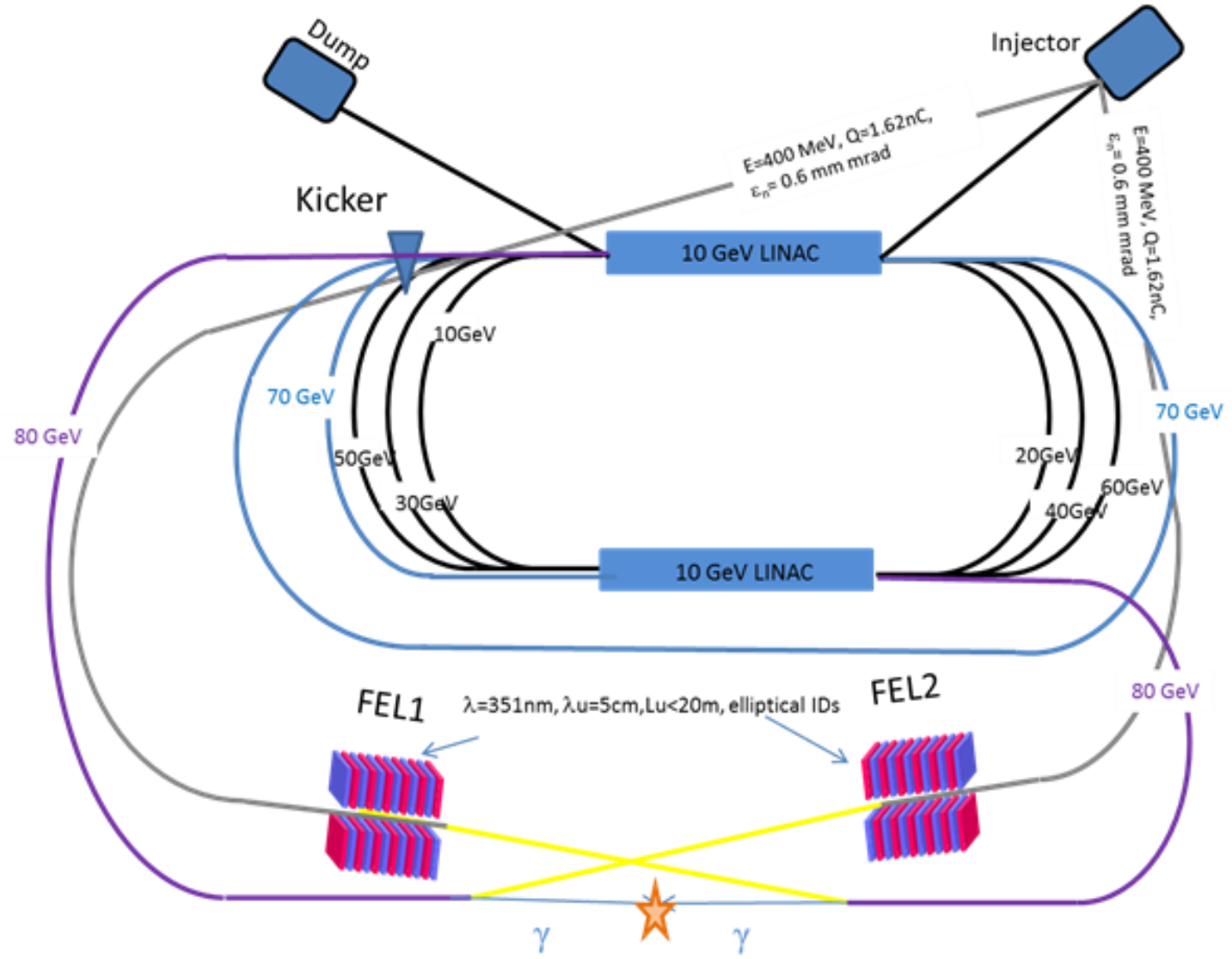

**themes:** diagnostics, chopping, collimation, charge state separation, multiple charge state beam transport + acceleration (MSU-RIA)

# Photon Beams, Padua


→ WP6 highlight talk "The γ factory" by Witek Krasny, Friday

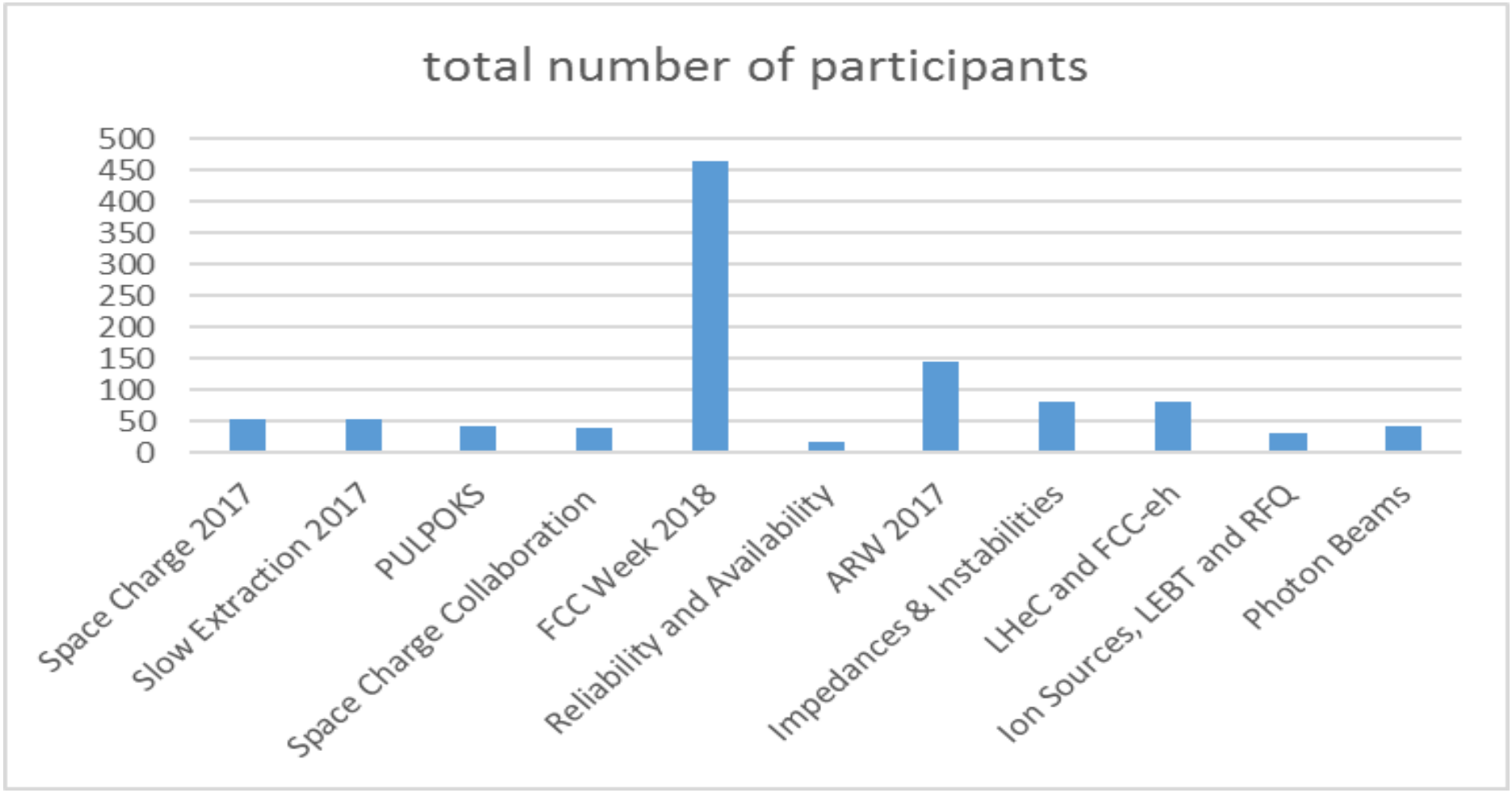
state-of-the-art in γγ colliders, Compton sources, γ factories

# highlight ARIES WP6.6 workshop *Photon Beams 2017*



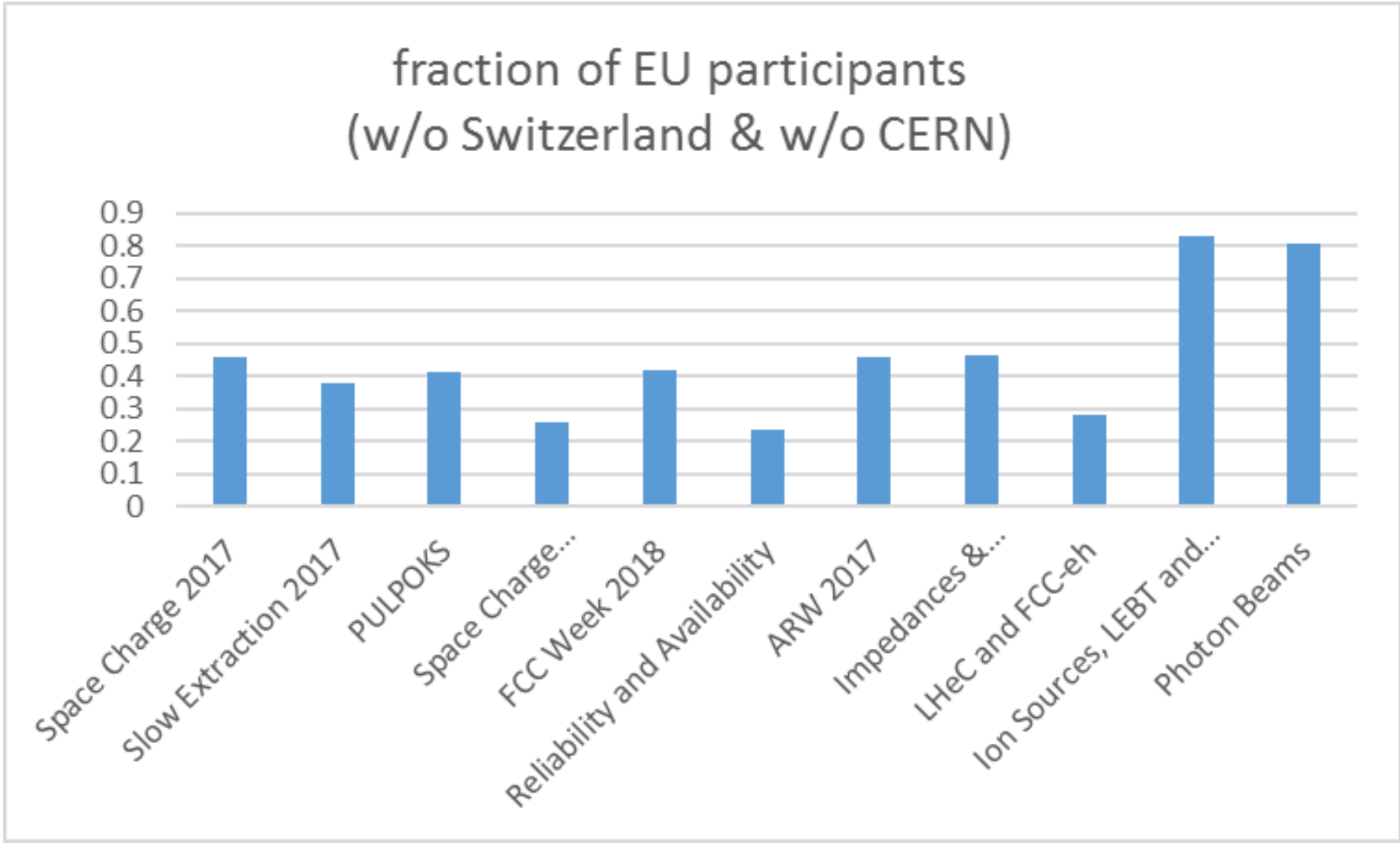

*Generic recirculator-based $\gamma\gamma$ Higgs factory with two FELs (A. Meseck).*

# WP6 workshop statistics – # participants



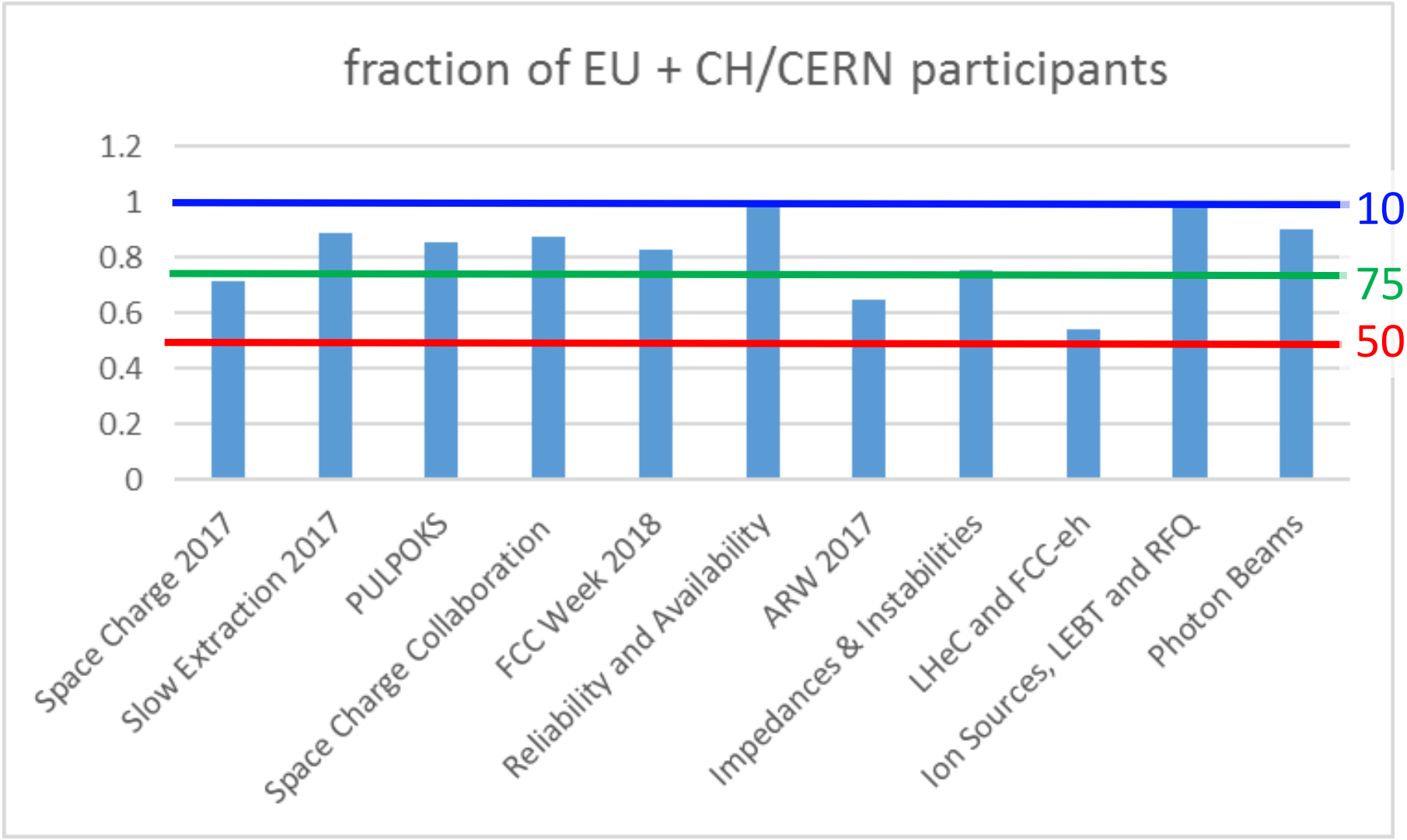

Total number of participants in each of the WP6 workshops.

# WP6 workshop statistics – “EU” participants



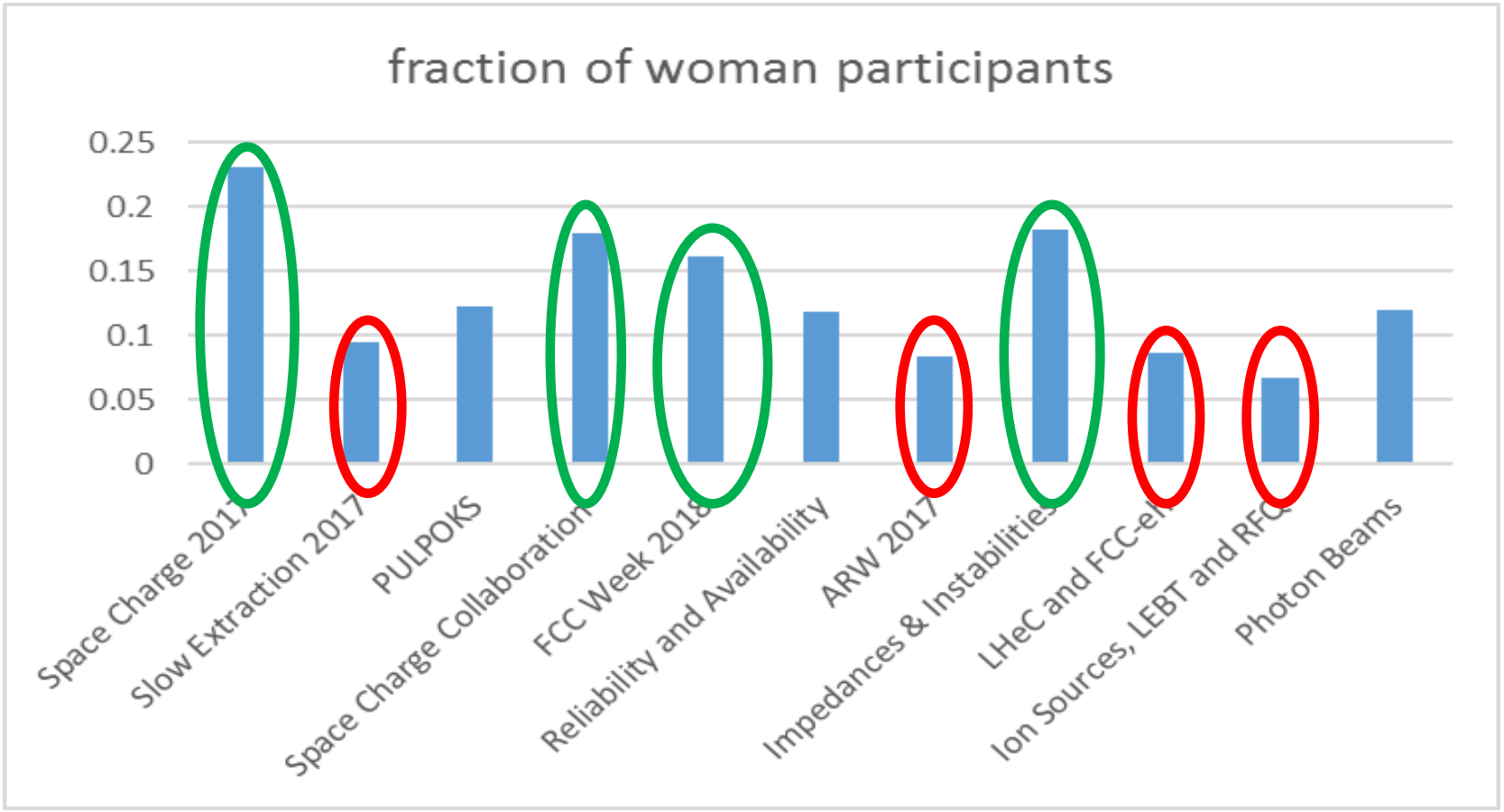

Fraction of workshop participants coming from institutes in EU member states.

# WP6 WS statistics – “EU + Swiss” participants




Fraction of workshop participants coming from institutes in EU + CH

# WP6 workshop statistics – woman participants




Fraction of woman participants in each of the WP6 workshops.

<10% : reliability, ion sources, LEBT, LHeC, slow extraction

>15% : space charge, FCC, impedances and instabilities

# milestone

**MS26 Report on 1st Annual workshops of all APEC tasks (APEC 6.1) - M12)**

Status: submitted for approval

…

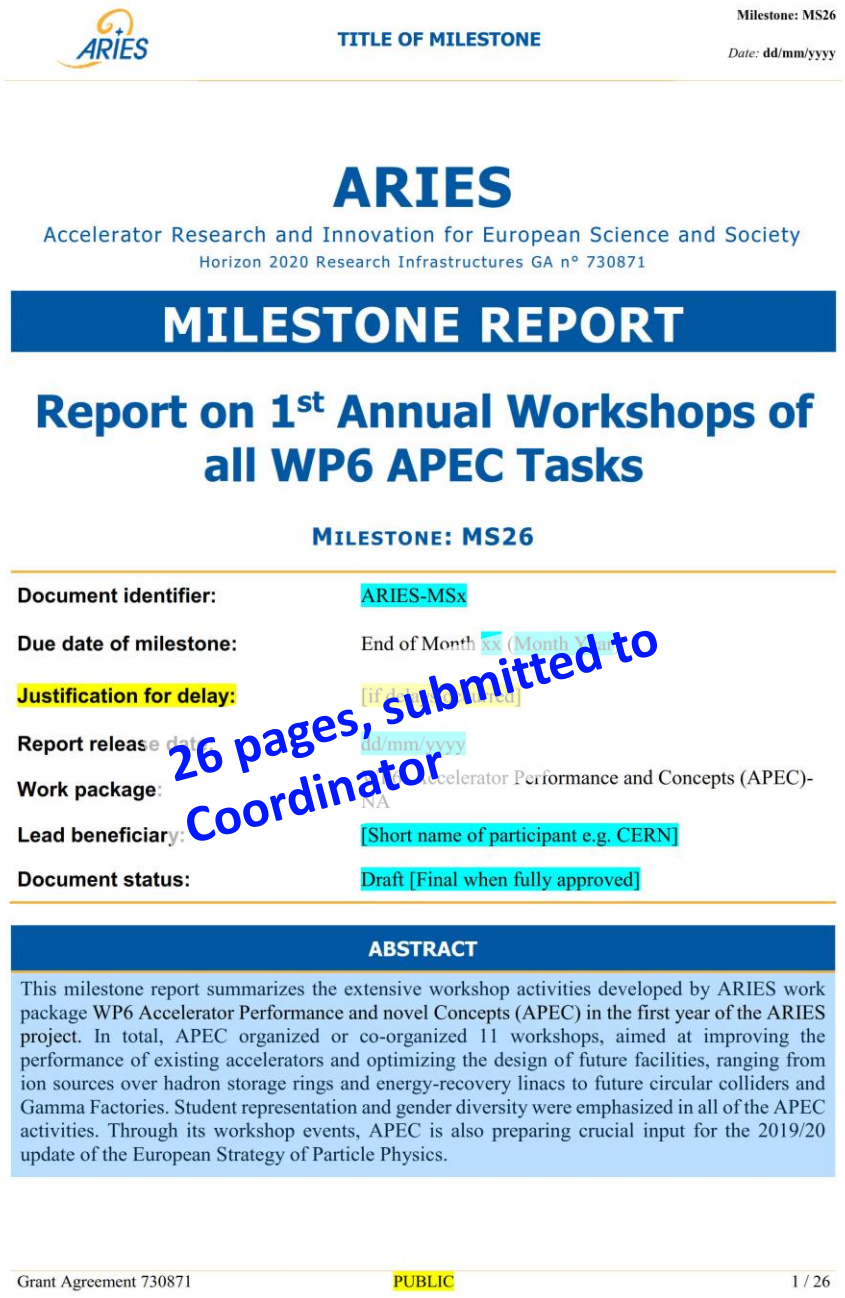
# deliverables

**D6.1 Ranking of performance degrading mechanisms for hadron storage rings and synchrotrons (APEC 6.2) - M28**

**D6.2 Report on optimal RAMS characteristics for particle accelerators (APEC 6.3) - M36**

**D6.3 Summary of novel methods to reduce accelerator impedance (APEC 6.4) - M36**

…



ARIES | TITLE OF MILESTONE | Milestone: MS26 | Date: dd/mm/yyyy

ARIES

Accelerator Research and Innovation for European Science and Society

Horizon 2020 Research Infrastructures GA n° 730871

MILESTONE REPORT

Report on 1st Annual Workshops of all WP6 APEC Tasks

MILESTONE: MS26

| | |
|---|---|
| Document identifier: | ARIES-MSx |
| Due date of milestone: | End of Month xx (Month Year) |
| Justification for delay: | [if delayed] |
| Report release date: | dd/mm/yyyy |
| Work package: | Accelerator Performance and Concepts (APEC)-NA |
| Lead beneficiary: | [Short name of participant e.g. CERN] |
| Document status: | Draft [Final when fully approved] |

26 pages, submitted to Coordinator

ABSTRACT

This milestone report summarizes the extensive workshop activities developed by ARIES work package WP6 Accelerator Performance and novel Concepts (APEC) in the first year of the ARIES project. In total, APEC organized or co-organized 11 workshops, aimed at improving the performance of existing accelerators and optimizing the design of future facilities, ranging from ion sources over hadron storage rings and energy-recovery linacs to future circular colliders and Gamma Factories. Student representation and gender diversity were emphasized in all of the APEC activities. Through its workshop events, APEC is also preparing crucial input for the 2019/20 update of the European Strategy of Particle Physics.

# recruitment

**Task 6.3:** HIT will recruit an early stage researcher; other work is contracted to AIT

**Task 6.4:** INFN/Frascati/Rome will recruit a postdoc second half of 2018

**Task 6.6:** **INFN/Padua *post-doc started on 1 May 2018, one year contract initially***

# WP6 scientific publications

**JOURNAL ARTICLES**

1. K. Ohmi, N. Kuroo, K. Oide, D. Zhou, and F. Zimmermann, *Coherent beam-beam instability in collisions with a large crossing angle*, **Phys. Rev. Lett. 119, 134801** (2017)
2. G. Guillermo, D. Sagan, and F. Zimmermann, *Examining mitigation schemes for synchrotron radiation in high-energy hadron colliders*, **Phys. Rev. Accel. Beams 21**, 021001 (2018)
3. M. Migliorati, E. Belli, M. Zobov, *Impact of the resistive wall impedance on beam dynamics in the Future Circular e+e− Collider*, **Phys. Rev. Accel. Beams 21**, 041001 (2018)
4. F. Zimmermann, Future Colliders for Particle Physics – "Big and Small", Proc. EAAC'17, La Biodola, 24-30 September 2017, **Nucl. Instr. Methods A** https://doi.org/10.1016/j.nima.2018.01.034 (2017)
5. M. Benedikt and F. Zimmermann, Proton Colliders at the Energy Frontier, invited article for Special Kai Siegbahn Issue of **Nucl. Instr. Methods A** (2018)

**CONFERENCE PAPERS**

1. F. Zimmermann, Accelerators in the 21st Century, Proc. ICNFP2017, Kolymbari, 17-29 August 2017, **EPJ Web of Conferences** (2018)
2. F. Zimmermann, *Possible Limits of Plasma Linear Colliders*, Proc. IPAC'17 Copenhagen, **IOP Conf. Series: Journal of Physics: Conf. Series 874** (2017) 012030
3. F. Hug, *Application of Non-Isochronous Beam Dynamics in ERLs for Improving Energy Spread and Stability*, **Proc. IPAC'17** Copenhagen
4. M.A. Valdivia, F. Zimmermann, *Optimized Monochromatization for Direct Higgs Production in Future Circular e+e- Colliders*, **Proc. IPAC'17** Copenhagen
5. G. Guillermo, M. Ady, R. Kersevan, F. Zimmermann, D.C. Sagan, R. Cimino, E. La Francesca, *Comparing Behaviour of Simulated Proton Synchrotron Radiation in the Arcs of the LHC with Measurements*, **Proc. IPAC'17** Copenhagen

**REPORTS**

1. S. Fartoukh, M. Giovannozzi, D. Missiaen, E. Todesco, F. Zimmermann, *Considerations on a Partial Energy Upgrade of the LHC*, **ARIES-2017-001**; CERN-ACC-2017-096 (2017)

# upcoming WP6 workshops

- **ECLOUD'18**, La Biodola, Italy, June (6.2, 6.4)
- **LHeC, FCC-eh, and PERLE Workshop**, LAL Orsay, France, 27-29 June, 2018 (6.5)
- **Muon Collider workshop**, Padova, 2-3 July 2018 (6.6)

→ highlight talk "the muon collider", Manuela Boscolo, Friday

- **Channeling Conference 2018**, Ischia, 23-28 September 2018 (6.6)
- **eeFACT2018**, Hong Kong 24-29 September 2018 (6.4)
- **ARIES ERL collaboration**, Mainz, September 2018 (6.5)
- **First topical workshop on Beam Quality Control, Impedances and Reliability in Hadron Storage Rings and Synchrotrons**, Goethe University Frankfurt, December 2018 (6.2/6.3/6.4)
- **Gamma Factory mini-workshop**, CERN, December 2018 (6.6)
- **Accelerator applications of crystals and nanotubes**, jointly with ARIES WP17 (?), 2019 (6.6)
- **Gravitational waves and accelerators**, 2020 (6.6)

*spare slides*

# Status of WP6 – *Accelerator Performance & Concepts*

**Progress**: in year 1, organized 11 workshops (T6.2: 5, T6.3: 2, T6.4: 1, T6.5: 2, T6.6:1);
total number of participants: 1046;
7 refereed journal publications: 7 (PRL: 1, PRAB: 2, NIM A: 2, EPJ: 1, IOP: 1);
another 5 workshops already scheduled (T6.2: 1, T6.2/T6.3/6.4(joint): 1, T6.5: 1, T6.6: 2) ;
in addition outreach articles (e.g. Accelerating News: 2), seminars, and public events;
recruitments of postdocs/ESR underway (T6.3, T6.4, T6.6); other T6.3 work contracted (AIT);
focus on students and gender diversity;
well on track for meeting the ARIES WP6 ambition ("identification and ranking of performance degrading mechanisms for hadron storage rings and synchrotrons, and novel methods to reduce accelerator impedance; definition of optimal design and operational RAMS characteristics for particle accelerators to improve availability beyond 90%")

**Status of contractual obligations** (Milestones, Deliverables):
MS26: Report on 1st annual workshops of all tasks completed in mid May (2 weeks late)

**Open issues, difficulties** *(if any)* : None