

Testing with Beams: WP11 report on TNA

5 Accelerator Test Facilities for ARIES Trans National Access

- WP11.1 KARA at KIT: Karlsruhe Research Accelerator,**
a synchrotron storage ring up to 2,5 GeV electron energy
- WP11.2 FLUTE at KIT: Ferninfrarot Linac- und Test-Experiment**
accelerates ultra-short e-bunches 5 to 50 MeV
- WP11.3 IPHI at CEA: Injector of Proton for High Intensity**
accelerates a 100 mA continuous p-beam up to 3 MeV
- WP11.4 ARES at DESY: Accelerator Research Experim. at SINBAD**
accelerates ultra-short e-bunches up to 155 MeV
- WP11.5 VELA at STFC: Versatile Electron Linear Accelerator**
ultra-high-performance injector up to 50 MeV, 250 pC

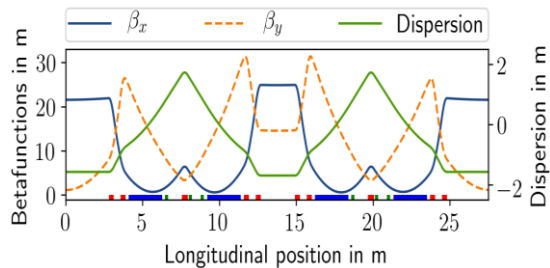
Robert Ruprecht, Florian Burkart, Anthony Gleeson, Michael Nasse,
Marcel Schuh, Jerome Schwindling et al.

WP11: electron and proton beam testing

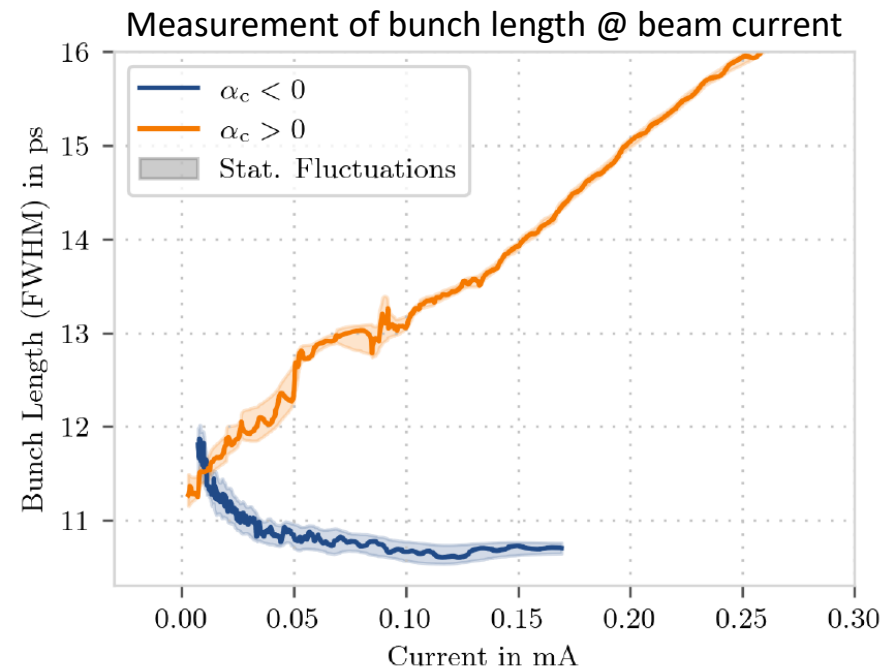
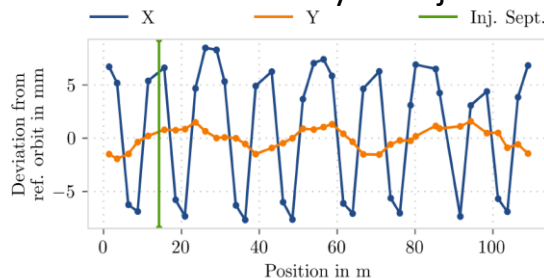
Contact: Robert.Ruprecht@kit.edu



- **Beam dynamics studies in the negative momentum compaction factor α_c regime in an e^- storage ring**
- Joint measurement campaign with SOLEIL and PSI
 - negative alpha optics at 500 MeV
 - Operation with different tunes, chromaticity and alpha



Large orbit deviations necessary for injection



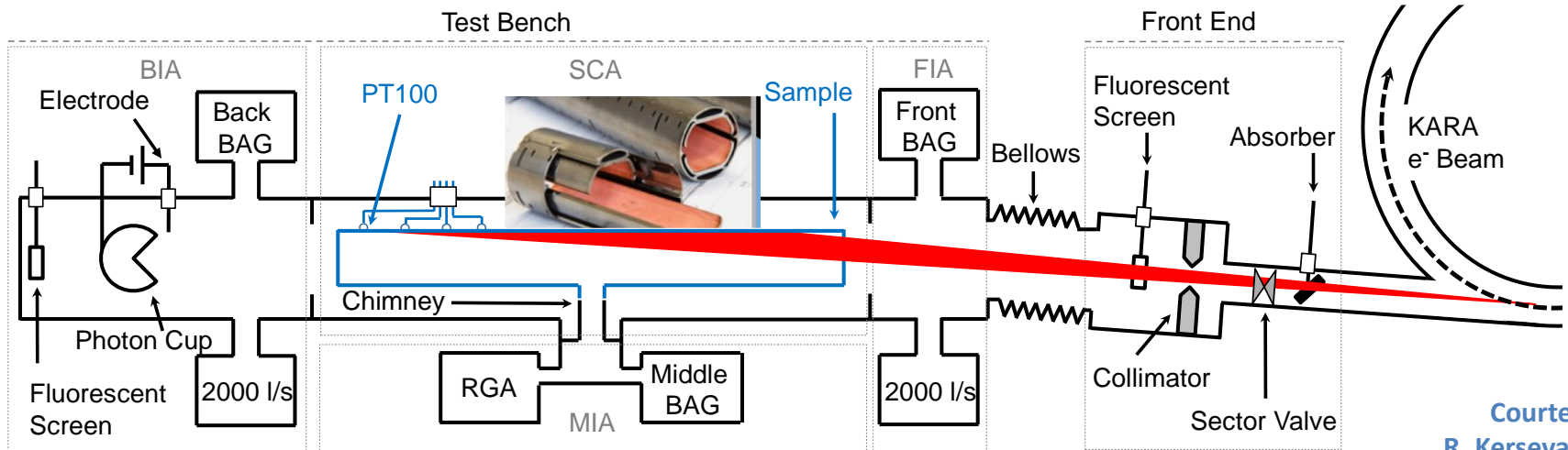
- **Collaboration with ARIES - WP7**

P. Schreiber et al, DOI:10.23732/CYRCP-2020-009.297



Courtesy:
P. Schreiber, M. Brosi,
A. Papash et al.

- **BESTEX at KARA**
 - **FCC-hh Beam Screen prototypes** including the baseline design tested at CERN's BESTEX beamline at KARA
 - test under cryogenic conditions (liquid Nitrogen cooling)

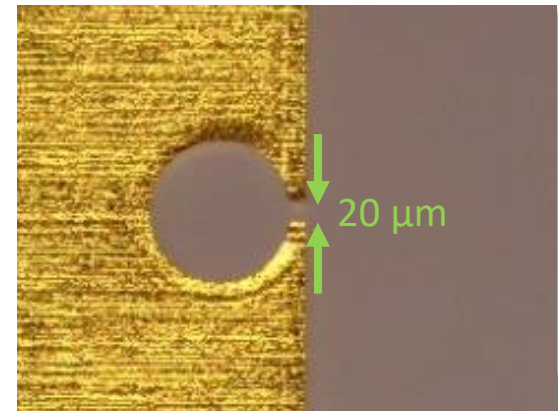
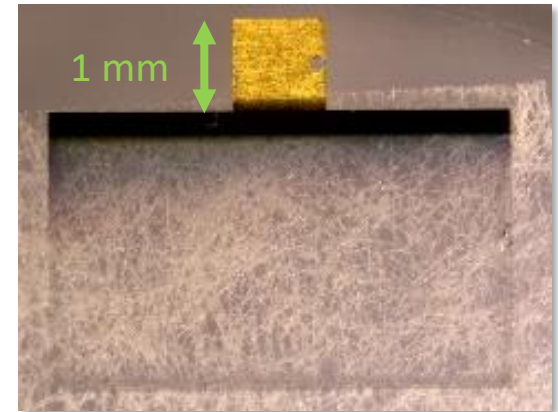
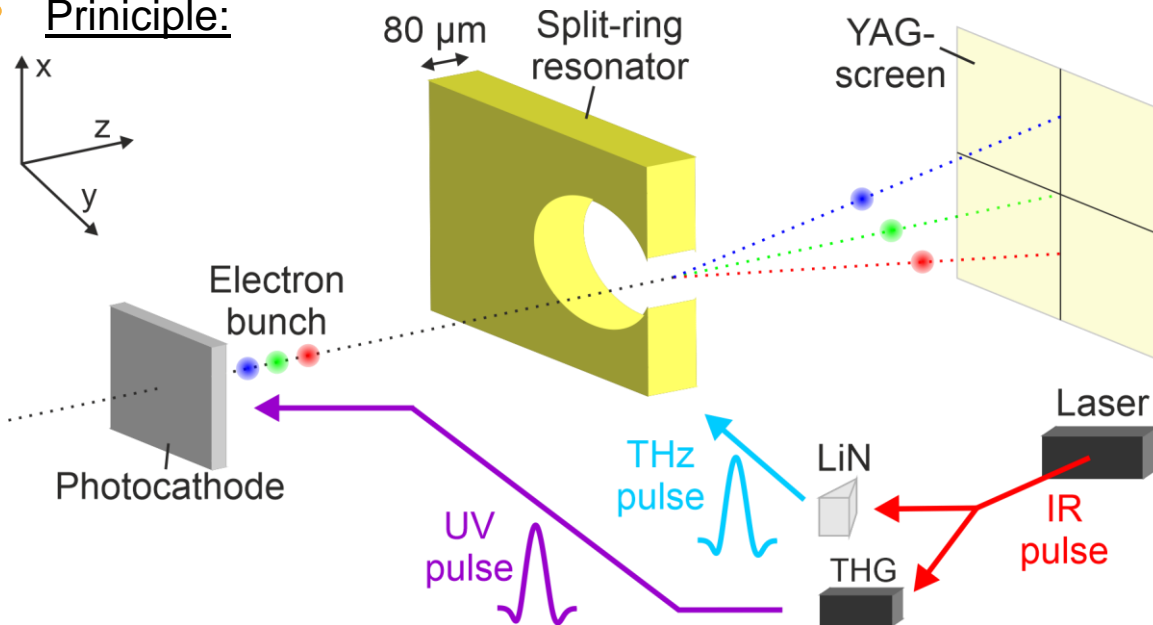


Courtesy:
R. Kersevan et al.

TNA [h]	P3	overall
KARA	558	2746

Split Ring Resonator (SRR) experiment

- Goal: single shot longitudinal diagnostics based on THz-driven streaking using a SRR amplifier
- International collaboration with the University of Bern and PSI
- Principle:



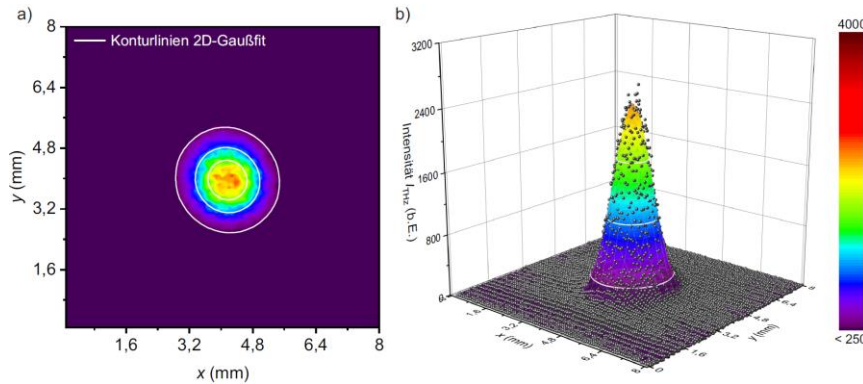
Courtesy M. Nabinger

Photos M.J. Nasse

TNA [h]	P3	overall
FLUTE	320	456

Status of SRR experiment

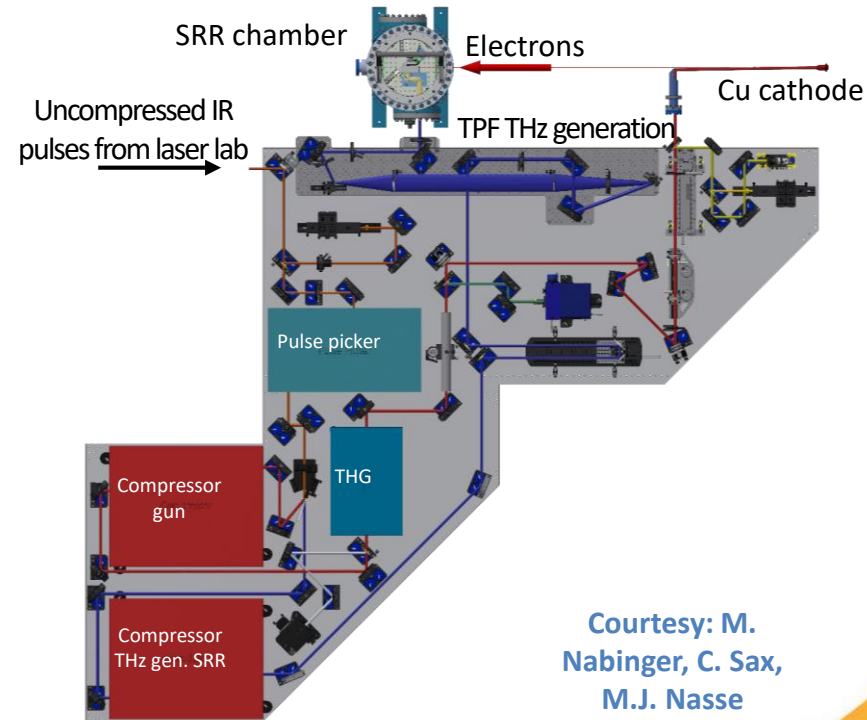
- THz generation adjusted in photoinjector optical setup in experimental hall reaching a conversion efficiency of 0.027% [5]



Done: control transversal and longitudinal laser beam shape with spatial light modulators [6]



- Many experiment done, no streaking observed yet



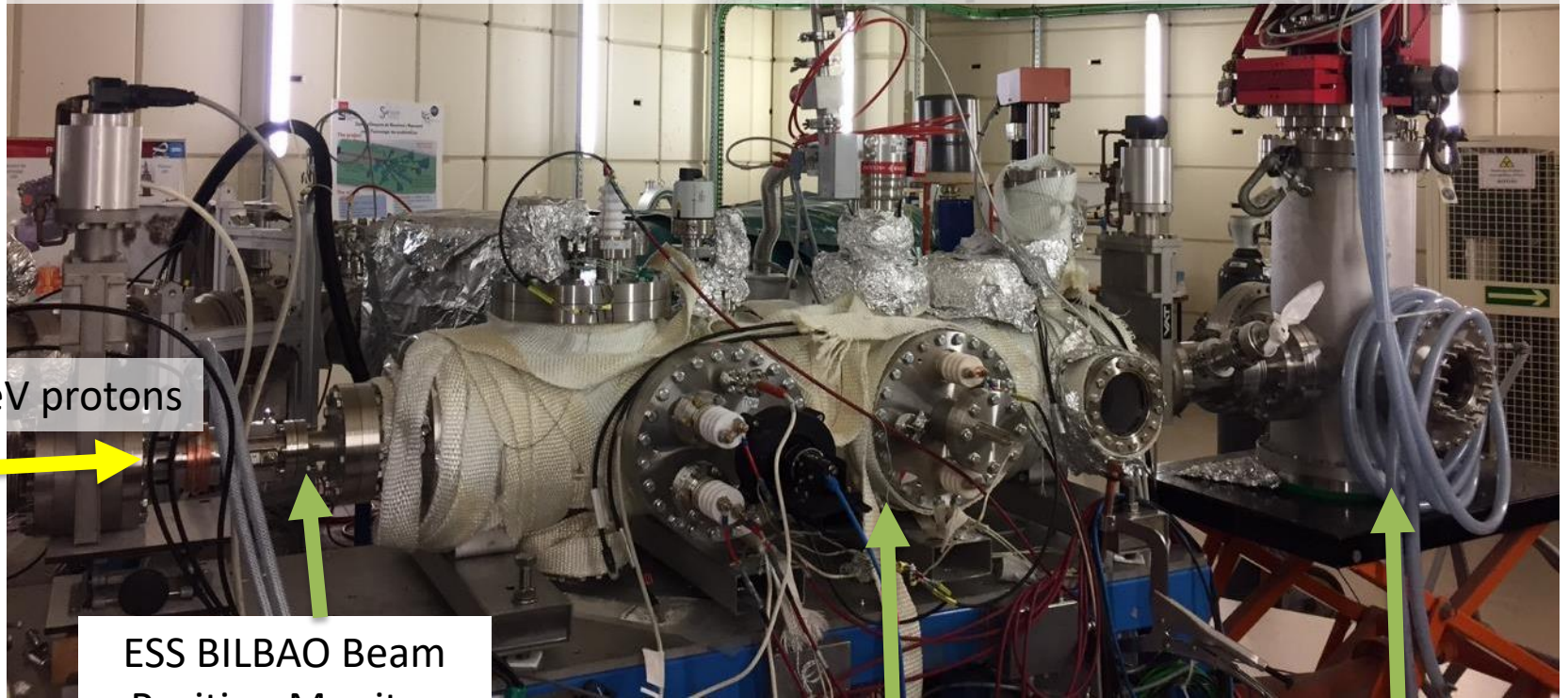
Courtesy: M. Nabinger, C. Sax, M.J. Nasse

[1] J. Fabiańska et. al., *Sci. Rep.* 4, 5645 (2014)
 [3] M. Yan et al, *IPAC 2018, WEPAL029* (2018)
 [5] M. Nabinger, master thesis KIT (2021)

[2] V. Schlott et al, *IBIC 2017, TUPCC16* (2017)
 [4] M.J.Nasse et al., *IPAC2019, MOPTS018* (2019)
 [6] C. Sax, master thesis KIT (2021)

ARIES-WP11.3 IHPI, CEA

- The accelerator IPHI was running during 4 weeks in September – October 2018 to accommodate experiments including tests of the **BPM + electronics from Bilbao + ESS (TNA)**



3 MeV protons

ESS BILBAO Beam
Position Monitor

Profile monitors for
ESS

Emittance meter for
MYRTE / MYRRHA



- Since then, most time devoted to tests of neutron production using Beryllium targets in view of the French compact neutron source project SONATE
- 1st version of the target operated during ~ 100 hours at ~ 3.5 kW (500 W/cm²)
- A 50 kW version has been developed and tested in 2021
- Because of this program and lack of TNA users, IPHI was **not** involved in TNA extension



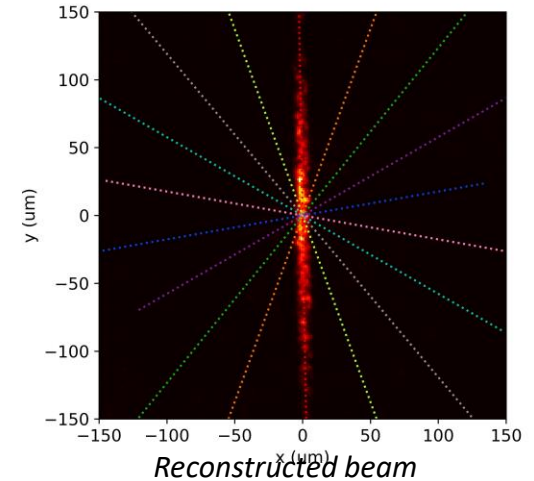
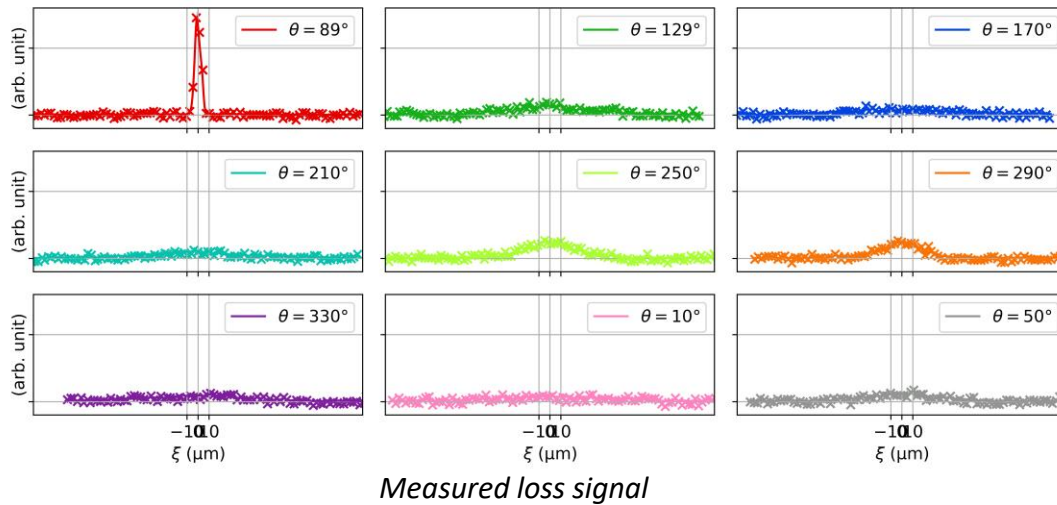
Beryllium target + cooling inside
½ moderator + shielding

Work financed by a grant from
the Ile – de – France region

TNA [h]	2020	Overall
IPHI	0	72

ARIES-TNA-WP11.4 ARES, DESY

- First successful external user experiments at SINBAD/ARES: S band linac
- **PSI wirescanner tests to characterize electron bunches with micron precision**



“Successful test of the wirescanner at ARES and successful characterization of the electron bunch for both a 2D and 4D scan with extremely high resolution.”



Wirescanner with 1 micron thick gold wires. Installed in the ARES UHV experimental chamber

TNA [h]	2021	overall
ARES	77	210

Courtesy:
F. Burkart

ARIES-TNA-WP11.4 ARES, DESY

- 2nd TNA at ARES: normal conducting S-band electron linac
- **High energy & high dose irradiation of diamond samples**

**beam irradiation finished,
analysis ongoing**

EPFL

3 mm x 3 mm x 0.3 mm
thick diamond plate



Project Leader:
Prof. Dr. Christophe Galland, Dr. Elena Losero

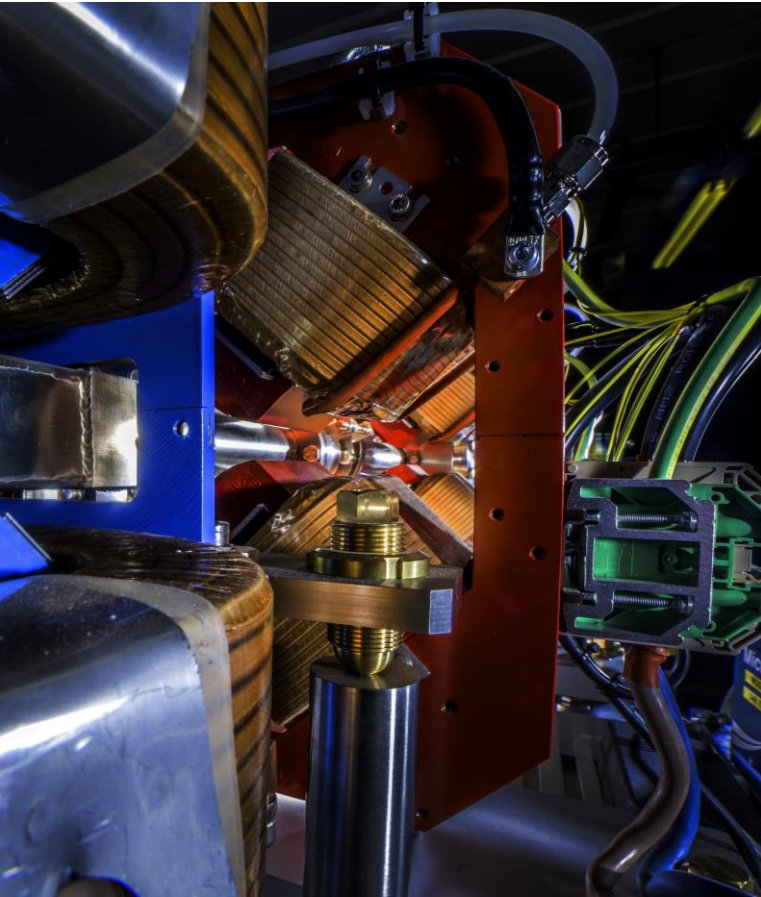
Exploring the physics of high energy electron irradiation of diamond for increasing the yield of nitrogen vacancy (NV) center creation, with potential benefits for quantum sensing.

Courtesy:
F. Burkart

TNA [h]	P3	overall
ARES	242	242

ARIES-TNA-Experiments within WP11.5

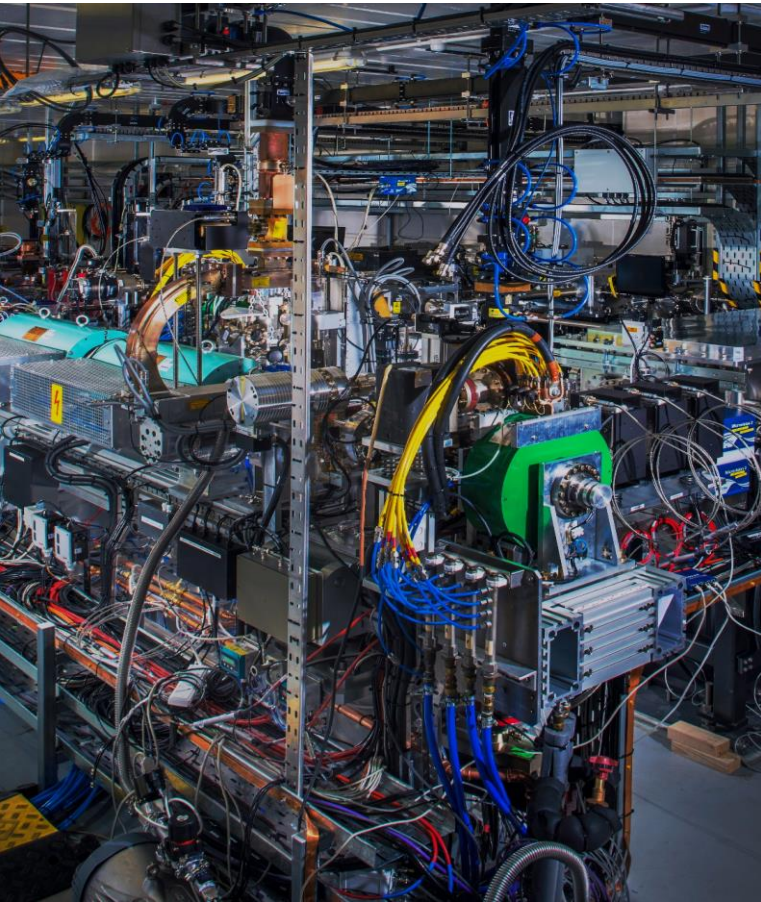
VELA: Status



- TNA units delivered in this period: 104
- The final period saw successful delivery of TNA for DESY (Knetsch *et al*) following-up on their previous work on plasma afterglow metrology and for PSI (Frojdth *et al*) evaluating the Jungfrau hybrid pixel detector for electron diffraction at MeV energies.
- A VELA/CLARA user meeting will be held on 5th July 2022 at Daresbury Laboratory to celebrate completion of the latest exploitation run (including TNA) and provide information on forthcoming machine updates and schedules.

ARIES-TNA-Experiments within WP11.5

VELA: Status



- The VELA/CLARA facility will now undergo further developments to complete CLARA Phase 2, including commissioning of the 250 MeV Full Energy Beam for Exploitation (FEBE) facility
- The next round of beam exploitation is anticipated in 2024, with the intention to offer TNA access to VELA/CLARA under the Horizon Europe EURO-LABS project.






TNA [h]	P3	overall
VELA	104	184

ARIES-TNA-Experiments within WP11

Overview, Boundary Conditions, and Outlook:

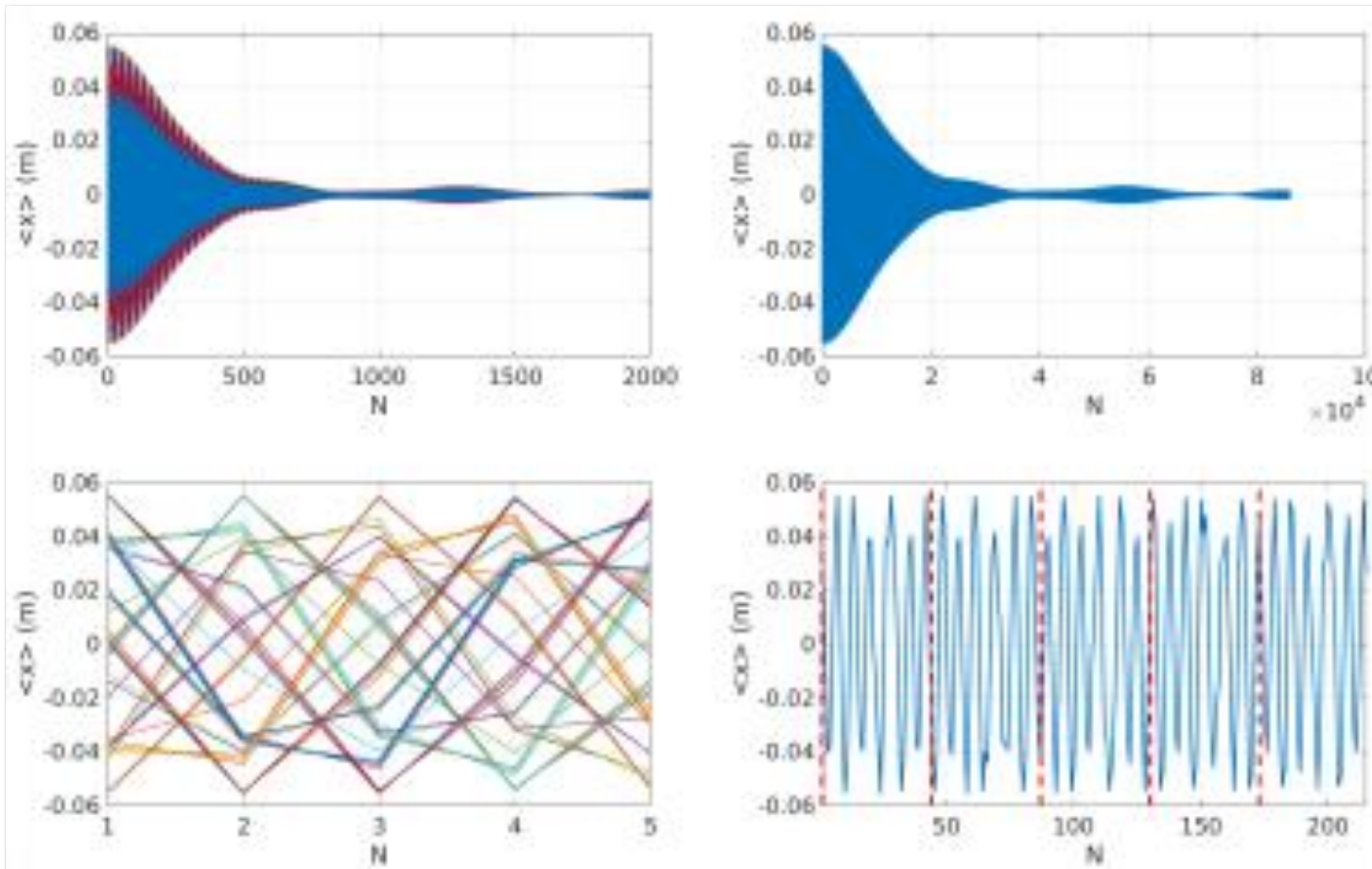
Corona Virus Covid 19: lock-downs, no travelling in EU, worldwide

- Only remote users in 2020 to 2022
- KARA and FLUTE delivered more TNA as planned in Annex 1
- SINBAD operation in P3, two proposals in 2021/22
- VELA with technical delay, start-up in Q3-2021
- IPHI closed ARIES-TNA after 4 years

	ARIES-TNA WP 11	TA in P3 for remote [h]	TA for users in 5 years, all [h]
	KARA (ANKA)	558	2746
	FLUTE	320	456
	IPHI	-	72
	ARES (SINBAD)	242	242
	VELA	104	184

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- Optics characterisation at KARA including the **high wiggler field**



- Tune and chromaticity measurements based on turn by turn orbit data using NAFF
- Presented at the 1st ARIES Annual Meeting by P. Zisopoulos

NAFF = Numerical Analysis of Fundamental Frequencies allows a fast convergence to the tunes in the order of $1/N^4$

P. Zisopoulos et al., https://indico.cern.ch/event/699219/contributions/2929063/attachments/1654466/2647866/ARIES18_Zisopoulos.pdf