
SMART
PAF
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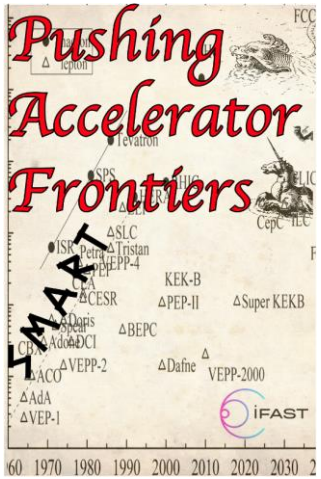
Pushing
Accelerator
Frontiers
SMART
FCC
Tevatron
SPS
SLC
Tristan
PEP-4
KEK-B
CESR
PEP-II
Super KEKB
BEPC
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ACO
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iFAST
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Task 5.2 Pushing Accelerator Frontiers (PAF)

- **Main tools:** **topical workshops and dedicated prospective studies**
- **Overriding goal:** survey **accelerator frontiers and develop long-term strategies** for boosting the performance of **future facilities** and for **overcoming limitations;** develop a **coherent landscape for future accelerators and issue targeted R&D recommendations**

- **Thrust 1:** networking on **novel intense positron sources**, providing a **"condensation point" for the worldwide positron-source community** (**CNRS – Iryna Chaikovska**)

  - different methods of e^+ production, both classical techniques & especially novel/exotic ones

- **Thrust 2:** **survey extreme beams and ultimate limits**, and examine **approaches to overcome the present limits on beam brightness** (**CERN – Frank Zimmermann, GSI – Giuliano Franchetti**)

  - **space-charge compensation or cooling, crystalline beams,..** - ultimate limits on **high-gradient acceleration, high-field bending, beam size, beam density, and luminosity**

- **Thrust 3:** **artificial intelligence for accelerators,** applications of **machine learning, deep learning, advanced optimization algorithms and neural networks**, for accelerator control & design (**PSI – Rasmus Ischebeck**)

- **Thrust 4:** **accelerators for "dark sector" & precis. physics** (**CERN – Christian Carli, GSI – Bernd Lorentz**)

  - accelerator/beam requirements for dark-sector searches in fixed-target experiments; investigating current precision frontier accelerator developments, such as EDM ring designs

- **Thrust 5**: **green accelerators, sustainable accelerator concepts, e.g. energy recovery, energy efficiency, and possibly particle (e.g. positron) recycling** (**CERN, GSI, CNRS, PSI, + JGU – Florian Hug**)

Summary of WP5.2 (PAF) activities so far

- *iFAST **Extreme Storage Rings** workshop, zoom, 31 Jan- 8 Feb 2022 https://indico.cern.ch/event/1096767/ ; summary report: https://doi.org/10.5281/zenodo.6481111*

  150 expert participants from around the world, including CERN (13), GSI (23), PSI (5) , CNRS (4)., JGU/HI Mainz (1), DESY (8), etc.

- *ARIES & iFAST SMART joint **Brainstorming & Strategy** WS, Valencia, 29 Mar – 1 Apr 2022 https://indico.cern.ch/event/1133593/ ; summary report: https://doi.org/10.5281/zenodo.7071937 ;* 14 participants: CERN (6), GSI (1), PSI (1) , CNRS (1)., DESY (2), LANL (1) , FNAL (2), LPNHE (1)

- *Co-sponsored Electron-Cloud Workshop 2022 (ECLOUD'22), La Biodola, Italy, 25-28 Sept. 2022 ; https://agenda.infn.it/event/28336/*

- *Topical iFAST workshop on **Accelerators for the Dark Sector**, CERN, 31 Oct 2022*
  https://indico.cern.ch/event/1217033/ ; summary: https://doi.org/10.5281/zenodo.7299802 ; 7 participants: CERN (4), PSI (2), CNRS (1)

- *Co-sponsored FCC-ee Injector Studies Mini-Workshop, IJCLab, 24-25 Nov 2022 , https://indico.ijclab.in2p3.fr/event/8920/*

- *Co-sponsored FCC-ee Pre-Injector meeting, INFN-LNF, 20-21 April 2023, https://agenda.infn.it/event/34369/*

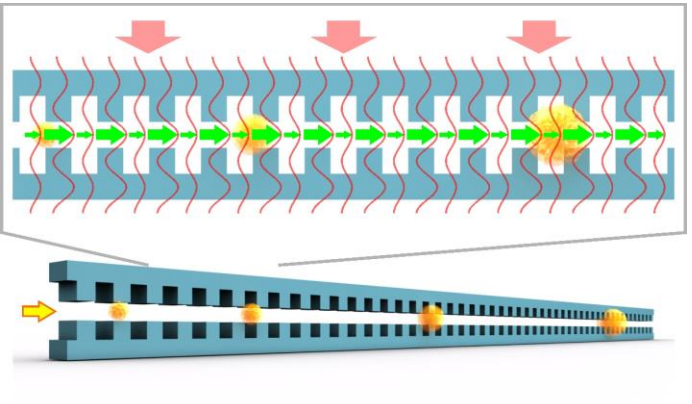
- *Co-sponsored Channeling 2023, Riccione, 4-9 Jun 2023;* https://agenda.infn.it/event/21811 ; 3x postponed!, more than 90 participants (13 or 14 countries), from which about 30 well known experts in the field (13-15 key researchers !), 93 presentations of which 12 were invited

- *Topical iFAST workshop on **Gigahertz Rate and Rapid Muon Acceleration** (GR2M), Bern, 10-13 Dec 2023, https://indico.psi.ch/event/14790 ;* 22 registered participants:: CERN (3), EPFL (3), PSI (3), ETHZ (1), Bern (1), TU Darmstadt (1), HU Duesseldorf (1), FAU Erlangen (1), LST Lisboa (1), Sorbonne (1), FNAL (1),...

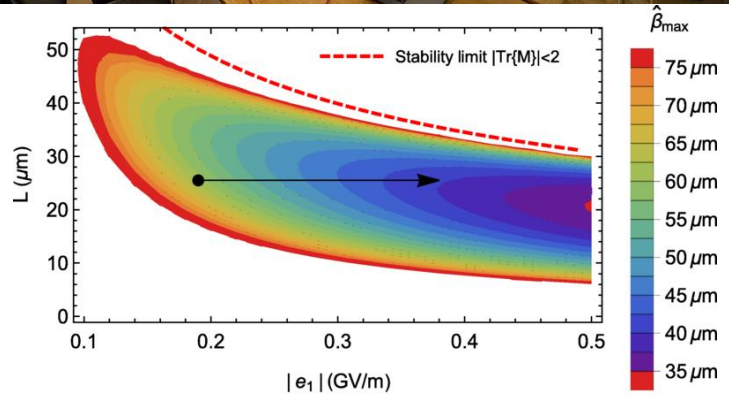
Themes: (1) Dielectric laser acceleration (DLA) for single electrons – & muons too; (2) plasma wakefield acceleration for muons and pions

GR2M highlights

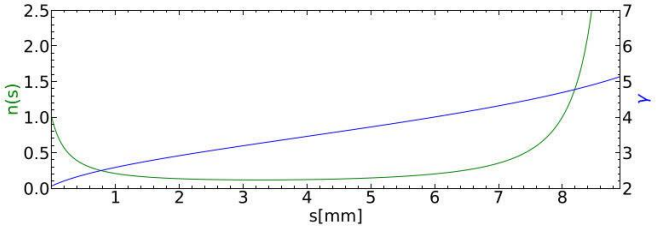
3 reports: WS summary (https://zenodo.org/records/10615611)
CERN Courier article, IPAC'24 paper



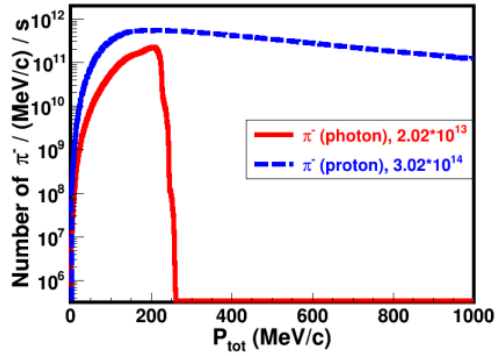
DLA principle: The DLA structure is illuminated by laser light from the top. Green arrows indicate the positive force of the laser's electric field that can accelerate electrons [T. Latychevskaia]



Contours of β_{max} in the $(|e_1|, L)$ plane, where L is the length of a **periodic APF cell**, and e_1 the accelerating electric field]; the black arrow indicates the laser amplitude dependent tuning range, from maximal admissible beam size to the structure damage threshold [U. Niedermayer]



Simulated **phase-locked plasma acceleration of μ's**, γ versus s (blue), with subluminal driver at group vel. 0.96c, & tailored plasma density (green) [C. Badiali].



π^- prod. rates for 8 GeV p- and **300 MeV γ-driven** schemes, with 1 MW beams hitting a 20-cm graphite target [W. Krasny]

GR2M press echo

ACCELERATORS | MEETING REPORT

Pushing accelerator frontiers in Bern

12 April 2024

Future concepts The AWAKE facility could conceivably be used to test the plasma-wakefield acceleration of muons. Credit: CERN-PHOTO-202307-176-29

Novel accelerator concepts will play an important role in future accelerators for high-energy physics. Two relevant scenarios being explored in the framework of the European Union I.FAST project are the generation of relativistic single electrons with gigahertz repetition rate for dark-matter searches, and the rapid acceleration of muons with GV/m accelerating fields for experiments at the energy frontier. The topical workshop "Gigahertz Rate and Rapid Muon Acceleration", held in Bern from 10 to 13 December 2023, addressed the latest developments in these and related topics. ...

CERNCOURIER | Reporting on international high-energy physics

Physics | Technology | Community | In focus | Magazine

FLAVOUR PHYSICS | MEETING REPORT

Tango for two: LHCb and theory

The 13th Implications of LHCb measurements and future prospects workshop showcased mutual enthusiasm between the experimental and theoretical communities

ACCELERATORS | MEETING REPORT

Pushing accelerator frontiers in Bern

The topical workshop "Gigahertz Rate and Rapid Muon Acceleration" showed how advanced accelerator concepts can jump-start dark-sector searches.

PEOPLE | NEWS

Physics community pays tribute to Peter Higgs

An iconic figure in modern science, Higgs in 1964 postulated the existence of the eponymous Higgs boson.

WP5.2 coordination meeting, Paris 16 April 2024

upcoming WP5.2 events

- **“iFAST Brainstorm in Frankfurt (iBiF)” – Developing the Roadmap for Future Accelerators –** GU Frankfurt, 2-3 September 2024 https://indico.gsi.de/event/19422/
- **“Channeling 2024” (co-sponsored) – Riccione, 8-13 September 2024** https://www.lnf.infn.it/conference/channeling2024
- **“SC2024” (co-sponsored) – Dong Guan, 11-13 September 2024** https://indico.ihep.ac.cn/event/21466/
- **“AHIPS” – Advances in High-Intensity Positron Source Physics and Technologies, Paris**, 23-25 October 2024, topics: High-Energy Positron Sources, Low-Energy Positron Sources and Physics Applications, High-Power Target Technologies, Polarized Positron Sources and Applications , Novel Approaches, Positrons in a Plasma Wakefield Accelerator, PWA-based Applications, Advanced optimization and Machine Learning Applications for Accelerators
- **SRGWmb2024 – Storage Rings & Gravitational Waves – mini brainstorm**, CERN, end ’24 or start ’25

SNS IMP IFAST ICFA HFHF Helmholtz Forschungsakademie Hessen für FAIR

第六届 空間電荷效應 國際研討會

6th Workshop on Space Charge

Chairs:
Sheng Wang (Workshop Chair)
Giuliano Franchetti (Program Committee Chair)

Richard Abram Baartman, TRIUMF
Hannes Bartosik, CERN
Oliver Boine-Frankenheim, GSI
Alexey Burov, FNAL
Yuan He, IMP
Dong-O Jeon, IBS
Shinji Machida, ISIS
Kazuhito Ohmi, KEK
Ji Qiang, LBNL
Jiancheng Yang, IMP
Yaoshuo Yuan, IHEP
Frank Zimmermann, CERN

Dong Guan, China, 10–13 Sep.2024
Coordinator: Yaoshuo Yuan ysyuan@ihep.ac.cn
https://indico.ihep.ac.cn/event/21466/

Hosted by IHEP and IMP, CAS

iFAST

HFHF Helmholtz Forschungsakademie Hessen für FAIR

BrainStorm@GoetheUniversity
Roadmap for Future Accelerators
2nd-3rd September 2024
Campus Riedberg, Frankfurt a.M.
https://indico.gsi.de/event/19422/

Ralph Aßmann	GSI
Christian Carli	CERN
Iryna Chaikovska	IJCLab
Bernd Lorentz	GSI
Giuliano Franchetti	GSI/IAP/HFHF
Florian Hug	J. Gutenberg Uni
Rasmus Ischebeck	PSI
Anke-Susanne Müller	KIT
Holger Podlech	Goethe Uni/HFHF
Frank Zimmermann	CERN

latest & future milestones & deliverables

Month 24/25 – milestone MS18

Task 5.2 Milestone MS18:
Present and future AI accelerator applications
Delivered 31/05/2023

I.FAST
Innovation Fostering in Accel
Horizon 2020 Res

accelerator
ications

MILESTONE: MS18

Document identifier:	IFAST-MS18
Due date of deliverable:	End of Month 24 (30 April 2023)
Report release date:	31/05/2023
Work package:	WP5: R&D Strategies
Lead beneficiary:	PSI
Document status:	Final

ABSTRACT

Based on presentations and discussions at two iFAST workshops, we review and classify present-day applications of artificial intelligence and machine learning in the field of particle accelerators, illustrating the various types of deployment and their demonstrated merits by way of example. Extrapolating ongoing trends and sketching possible future developments, we formulate a few open questions, and issue R&D recommendations. In particular, we suggest the construction of a testbed for self-controlling complex accelerators.

Upcoming

Month 42 (Oct '24) – deliverable 5.2

D5.2: Roadmap for future accelerators

Strategy for intense positron sources; R&D plan towards ultimate beams; State of the art and possible directions for crystalline beams; Strategy and requirements for EDM ring or other precision experiments; Roadmap for accelerator AI; State of the art and future roadmap for green accelerators

addressed by iBiF, Channeling2024, AHIPS

Upcoming

Month 48 (Apr '25) – milestone MS19

Ultimate hadron-beam brightness

addressed by SC2024

2023 SAC Feedback on WP5.2

C: Very impressive and outstanding activities to organize many forward-looking workshops.

Response: Thank you ! - We will do a few more

C: The SAC encourages the brainstorming activities to seek for novel ideas for future advanced accelerators.

Response:
Several new ideas emerged at the GR2M workshop

Relevance of WP5.2 (PAF) objectives & impact

- *Machine learning, dark sector searches, and sustainable accelerators (ERLs, GF, …) are attracting ever larger interest in the community; SMART-PAF is developing roadmaps and guidance*
- *Efficient e^+ production is important for future e^+e^- Higgs factory of any flavour*
- *We further explore intriguing far-future possibilities, such as quantum computing, gravitational wave detection, and energy production using storage rings*

WP5.2 PAF Publications

• 5 journal articles
• 8 proceedings papers
• 1 CERN Courier article

Frank Zimmermann, ***Accelerator Technology and Beam Physics of Future Colliders***, Front. Phys. 23 May 2022, Sec. Radiation Detectors and Imaging, Volume 10 - 2022 | https://doi.org/10.3389/fphy.2022.888395

F. Zimmermann, Y. Papaphilippou, A. Poyet, ***Impact of Longitudinal Gradient Dipoles on Storage Ring Performance***, **Proc. IPAC'22**, p. 30

G. Franchetti, F. Zimmermann, ***Trapping of Neutral Molecules by the Electromagnetic Beam Field***, **Proc. IPAC'22**, p. 1649

F. Zimmermann, A. Latina, M. Antonelli, M. Boscolo, A.P. Blondel, R. Farmer, ***Muon Collider Based on Gamma Factory, FCC-ee and Plasma Target***, **Proc. IPAC'22**, p. 1691

James Beacham and Frank Zimmermann, ***A very high energy hadron collider on the Moon***, **New J. Phys**. 24 023029, DOI 10.1088/1367-2630/ac4921

I. Chaikovska et al., ***Positron sources: from conventional to advanced accelerator concepts-based colliders***, JINST 17 P05015, 2022

L. Bandiera et al., ***Crystal-based pair production for a lepton collider positron source***, EPJ C vol. 82, 699 (2022)

F. Zimmermann, ***Beam Physics Frontier Problems***, Proc. eeFACT'22 ICFA workshop, p.42, https://accelconf.web.cern.ch/eefact2022/papers/tuyat0101.pdf

F. Zimmermann et al., ***Dark Sector Searches Based on Dielectric Laser Acceleration***, IPAC'23, p. 702, https://accelconf.web.cern.ch/ipac2023/pdf/MOPL068.pdf

G. Franchetti & F. Zimmermann, ***Impact of the Neutral Molecule Trapping on Beam Lifetime and Beam Profile***, IPAC'23, p. 2697, https://accelconf.web.cern.ch/ipac2023/pdf/WEPA023.pdf

I. Chaikovska et al., ***Update on the FCC-ee positron source design studies***, Proc. IPAC'23, Venice, Italy, paper MOPL095 https://doi.org/10.18429/JACoW-IPAC2023-MOPL095

R. Chehab et al., ***Advantages of hybrid positron sources with granular converters***, Nucl. Instrum. Methods A, 1060, 2024, 168994, https://doi.org/10.1016/j.nima.2023.168994

F. Zimmermann et al., ***Advanced Accelerator Concepts for Dark Sector Searches and Fast Muon Acceleration***, submitted to IPAC'24

G. Franchetti GSI, R. Ischebeck PSI, F. Zimmermann CERN, ***Pushing accelerator frontiers in Bern***, CERN Courier, 12 April 2024, https://cerncourier.com/a/pushing-accelerator-frontiers-in-bern/

in addition to the various workshop summary & milestone reports on zenodo

iFAST

Thank you for your attention!

This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under GA No 101004730.

spare slides

WP5 milestones

MS15	International workshop on muon source design		5.1	M18
MS17	**Beam requirements for dark-sector searches**	✓	**5.2**	**M18**
MS18	**Present and future AI accelerator applications**	✓	**5.2**	**M24**
MS20	Engineering design of improved power supply current measurement and RF-amplifier layout		5.3	M24
MS16	International workshop to define R&D plans		5.1	M36
MS19	**Ultimate hadron-beam brightness**		**5.2**	**M48**

WP5 deliverables

D5.1: International collaboration plans towards a multi-TeV muon collider Report on established collaboration and results disseminated by the action [MUST]	M46
D5.2: Roadmap for future accelerators **Strategy for intense positron sources; R&D plan towards ultimate beams; State of the art and possible directions for crystalline beams; Strategy and requirements for EDM ring or other precision experiments; Roadmap for accelerator AI; State of the art and future roadmap for green accelerators [PAF]**	**M42**
D5.3: Ripple mitigation for slow extraction beam quality improvement Simulation results for improvements including their experimental	M46