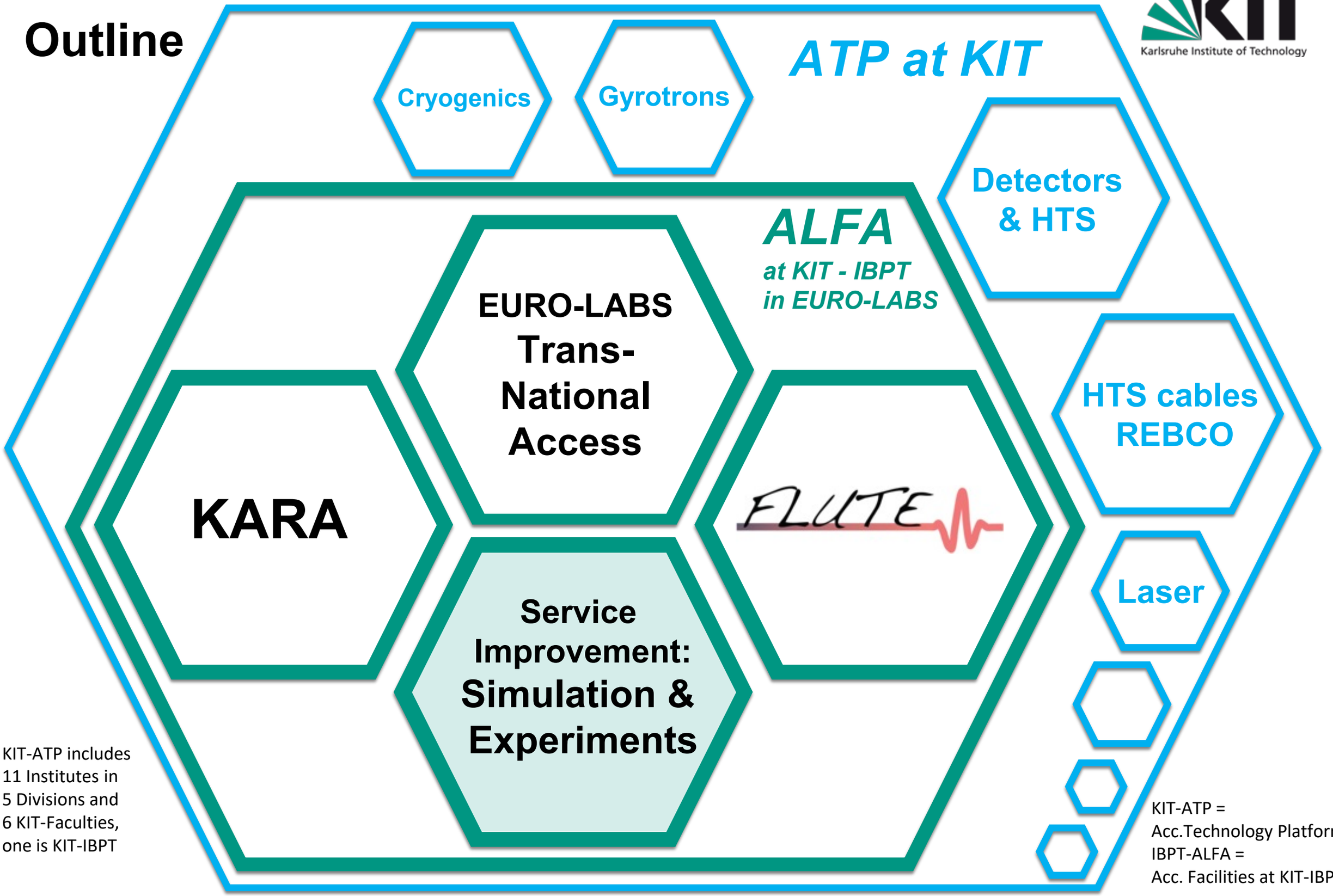
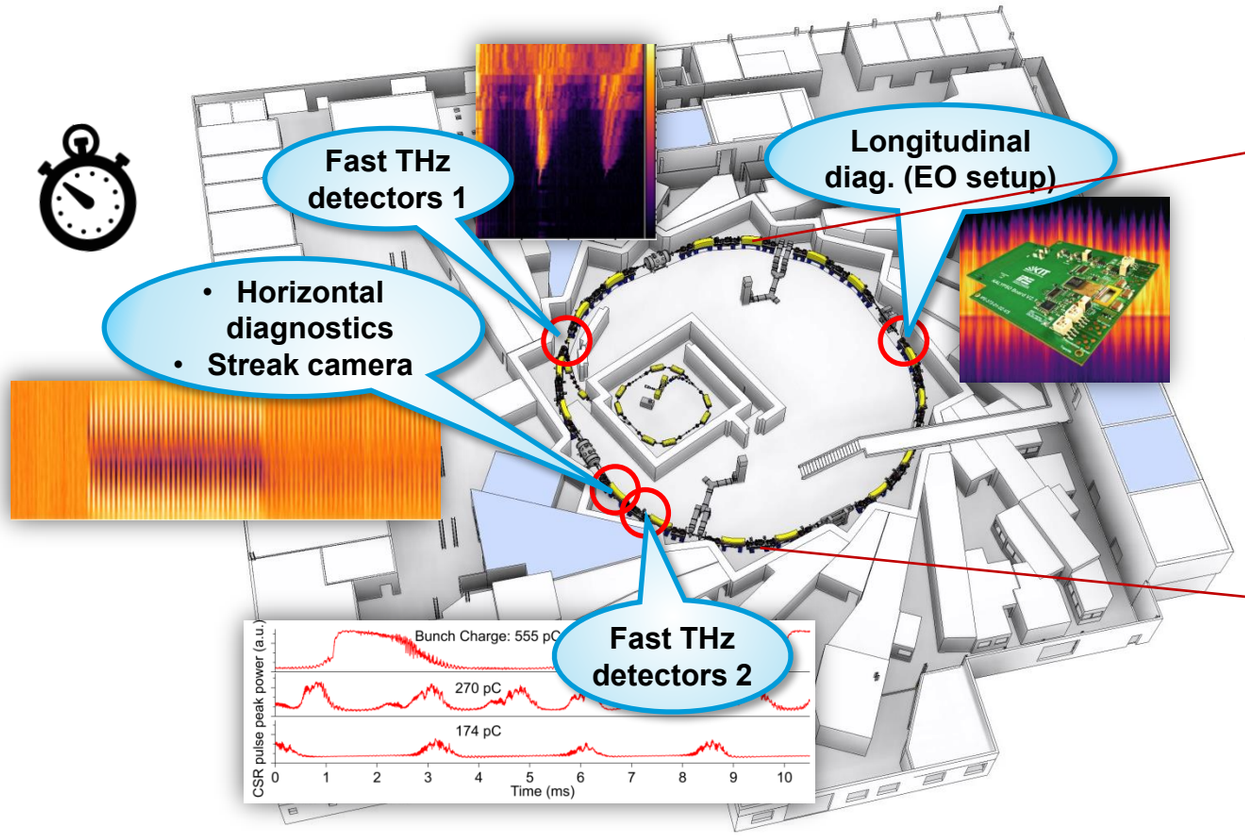
# Outline


ATP at KIT
Cryogenics
Gyrotrons
Detectors & HTS
ALFA
at KIT - IBPT
in EURO-LABS
EURO-LABS
Trans-
National
Access
KARA
FLUTE
HTS cables
REBCO
Laser
Service
Improvement:
Simulation &
Experiments
KIT-ATP includes
11 Institutes in
5 Divisions and
6 KIT-Faculties,
one is KIT-IBPT
KIT-ATP =
Acc.Technology Platform
IBPT-ALFA =
Acc. Facilities at KIT-IBPT

# Synchrotron KARA (KArlsruhe Research Accelerator)

KIT Light Source for User Applications & Accelerator Test Facility

with distributed synchronized sensor network: emitted CSR, energy spread, bunch profile, phase space tomography in MBI,
in parallel: simulation of MBI by OCELOT, INOVESA



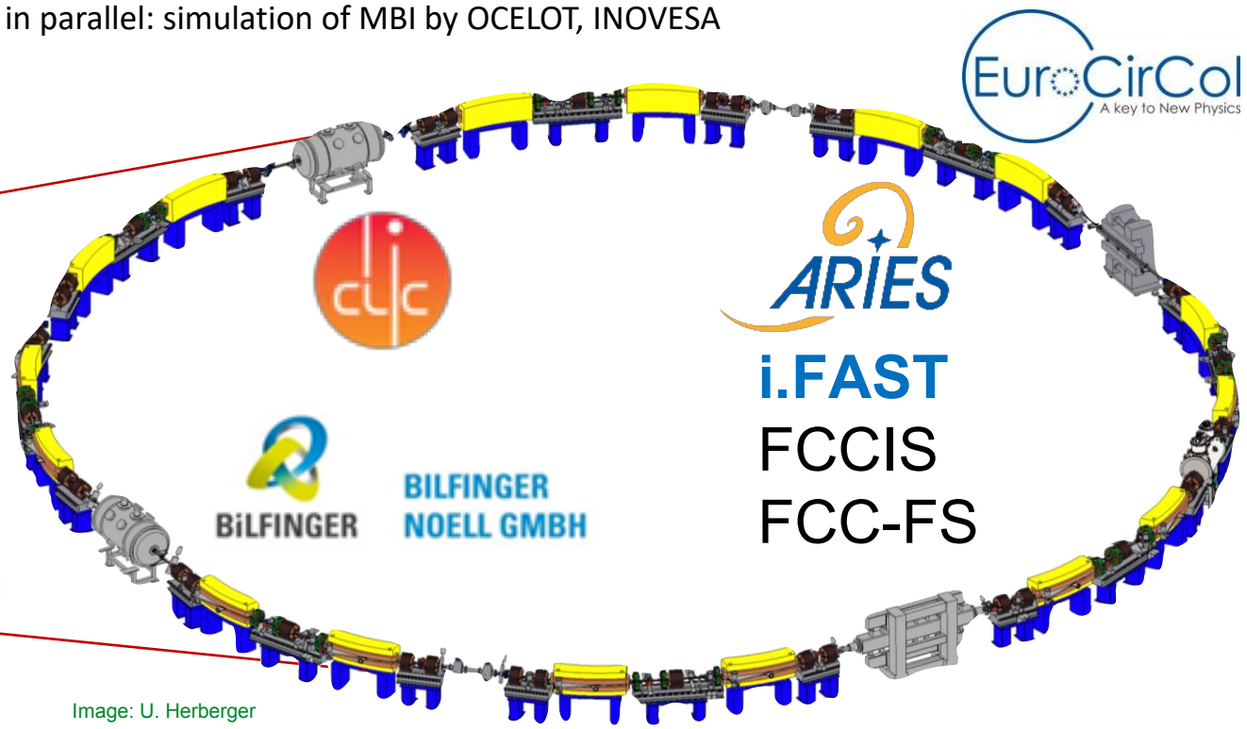




Image: U. Herberger

www.ibpt.kit.edu/kara

- Circumference: 110.4 m
- Energy range: 0.5 - 2.5 GeV
- RF frequency: 500 MHz
- Revolution frequency: 2.71 MHz
- Operation (22-)23h/5d/30w/y
- Single or multi-bunch mode

Short bunch mode

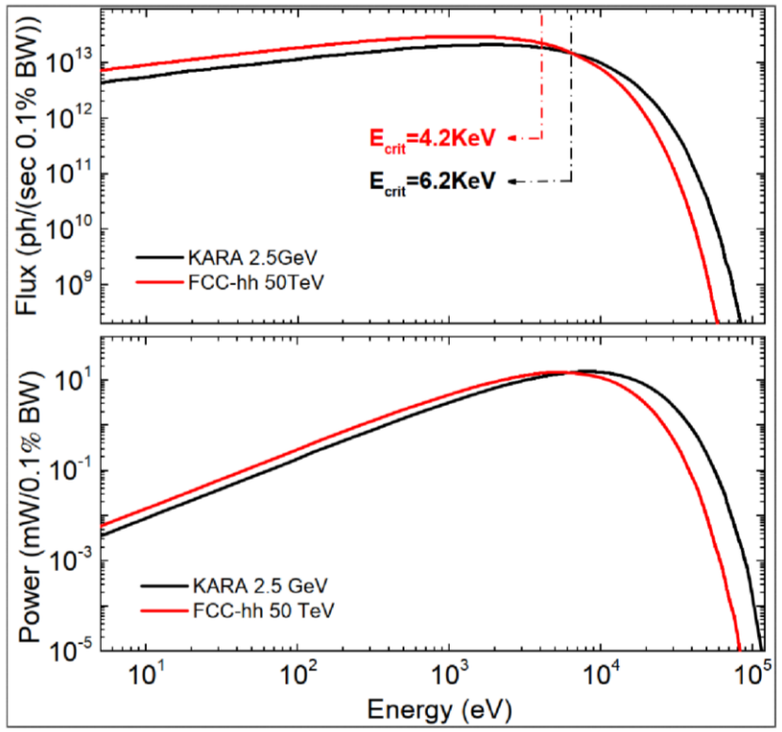
- Lower momentum compaction factor
  → Bunch length: 45 ps ↘ few ps
- Coherent synchrotron radiation (CSR) in THz range

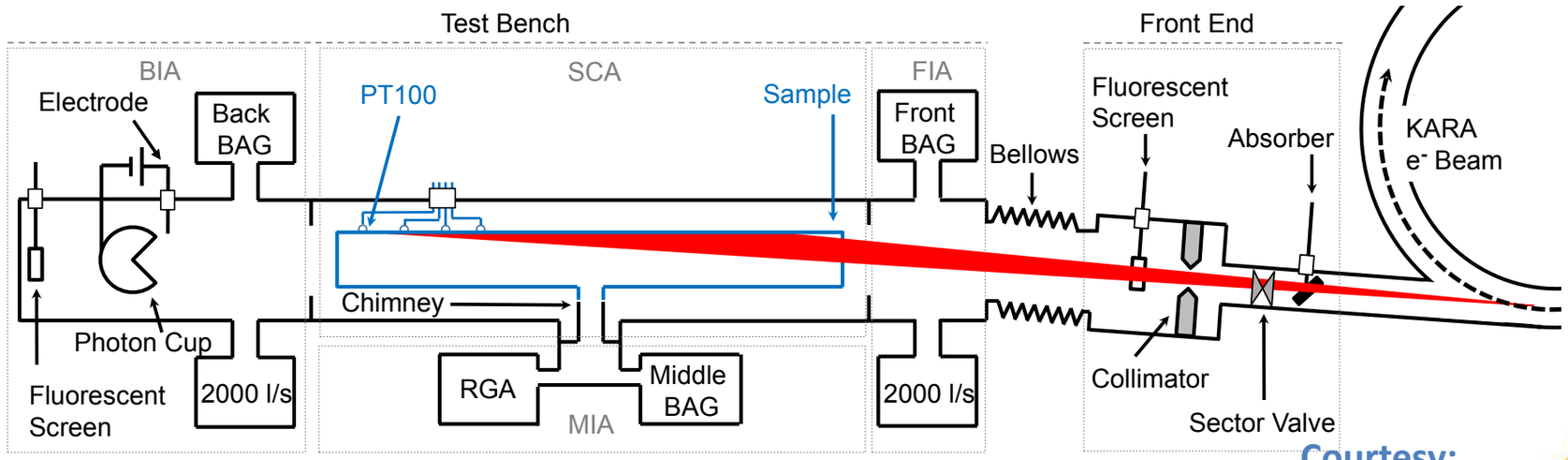
Negative momentum compaction factor

Contact: Marcel.Schuh@kit.edu

# ARIES-TNA-WP11.1 KARA, KIT

- BESTEX beamline at KARA
  - The FCC-hh's photon spectrum and linear power are reasonably reproduced in KARA, even at nominal beam energy.
  - Photo-desorption studies on **FCC-hh Beam Screen prototypes** including the baseline design tested at CERN's BESTEX beamline
  - test under cryogenic conditions (liquid Nitrogen cooling)




| TNA [h] | | overall |
|---|---|---|
| KARA | | 2647 |

Courtesy:
R. Kersevan et al.


L. A. González et al. DOI: 10.1103/Phys.Rev.Accel.Beams 22, 083201
L. A. González et al. (2021) Phys.Rev.Accel.Beams 24, 113201





Contact: Robert.Ruprecht@kit.edu

# FLUTE – Accelerator Test Facility at KIT

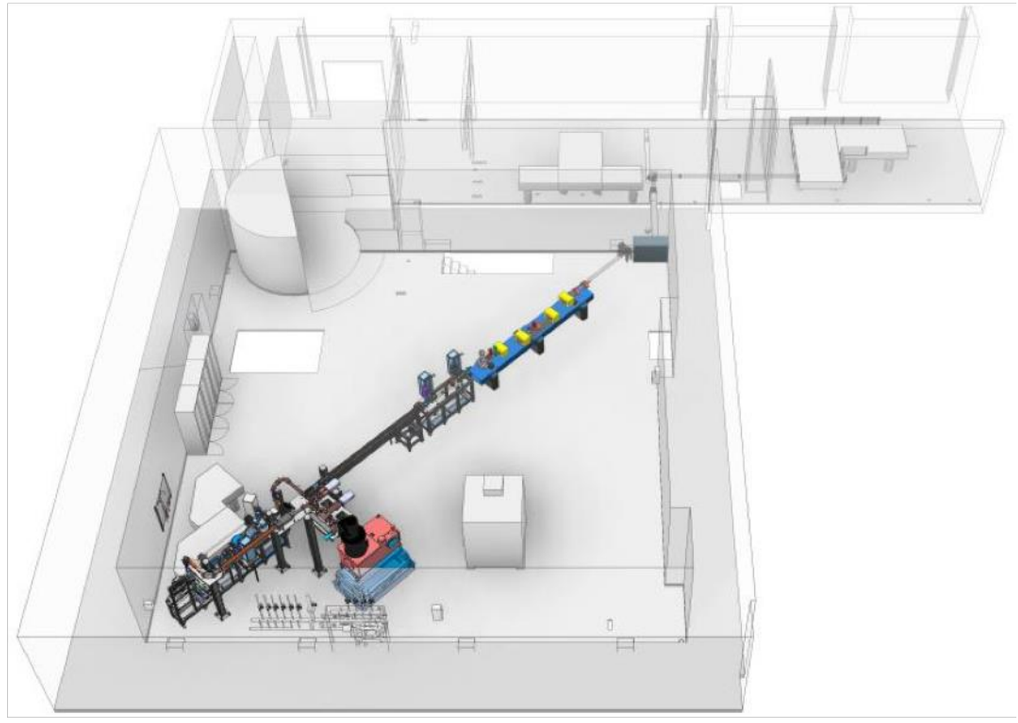
Karlsruhe Institute of Technology

PAUL SCHERRER INSTITUT PSI DESY.

www.ibpt.kit.edu/flute

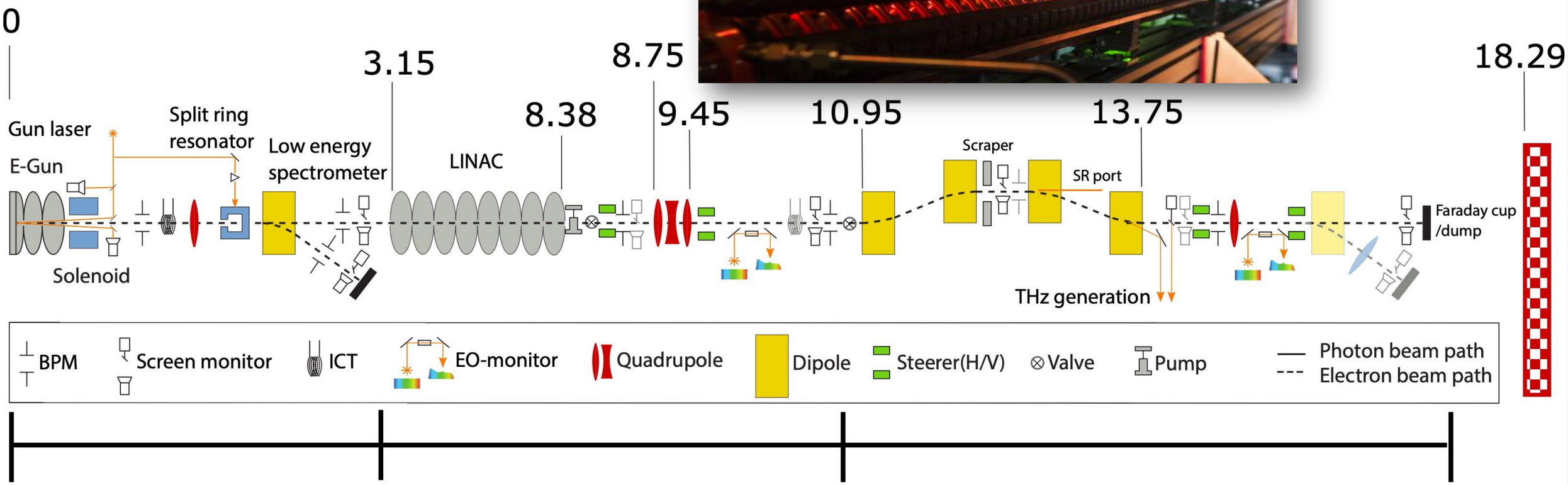
- FLUTE (Ferninfrarot Linac- Und Test-Experiment)
  - Compact test facility for **accelerator physics within ARD**
  - **Experiments** with $e^-$ & THz radiation, e.g. experiments for FLASH therapy
- R&D topics
  - Systematic bunch compression and THz generation studies
  - Serve as a test bench for new beam diagnostic methods and tools
  - Develop single shot fs diagnostics
  - Synchronization on a femtosecond level

| | | |
|---|---|---|
| Final electron energy | 5 to 50 (41) | MeV |
| Electron bunch charge | 0.001 - 1 (3) | nC |
| Electron bunch length | 1 - 300 | fs |
| Pulse repetition rate | up to 10 | Hz |
| THz E-Field strength | up to 1.2 | GV/m |



Contact: Robert.Ruprecht@kit.edu

# FLUTE – Overview




## 1st stage

*(in refurbishment)*

- E- gun
- Solenoid
- 1st diagnostics section
  with 5 years in operation

## 2nd stage

*(new RF in FAT)*

- Linac
- 2nd diagnostics section
- Quadrupole triplet

## 3rd stage

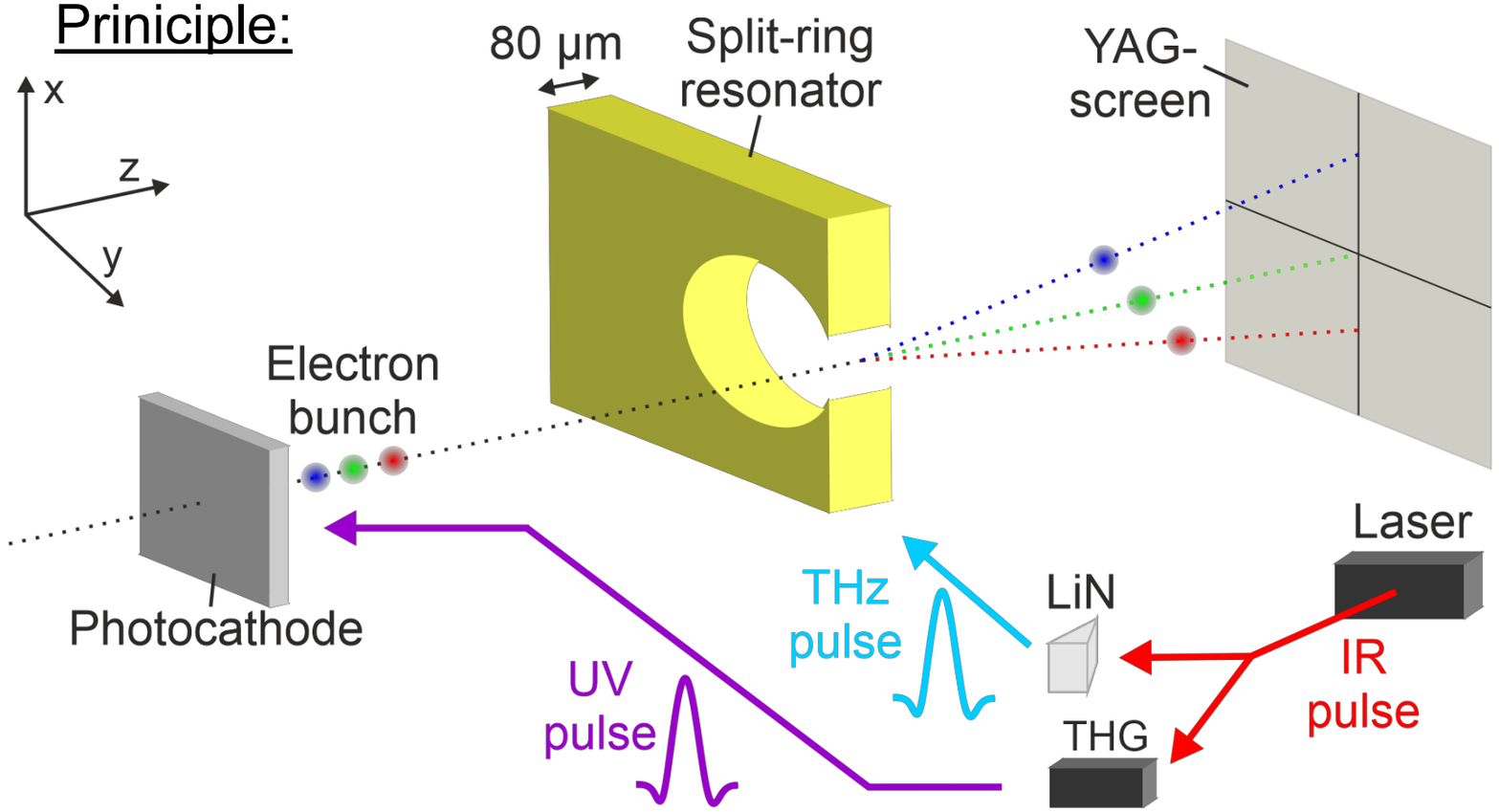
*(assembly components)*

- Bunch compressor
- $e^-$ diagnostcs
- THz diagnostics

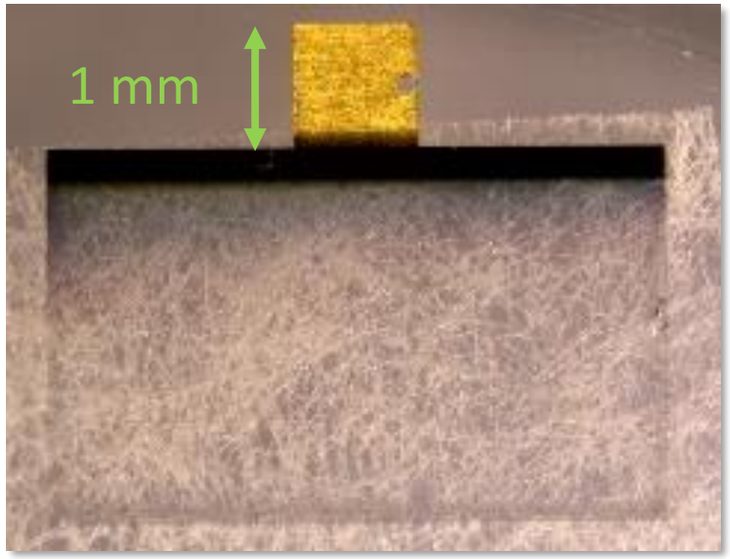
Contact: Robert.Ruprecht@kit.edu

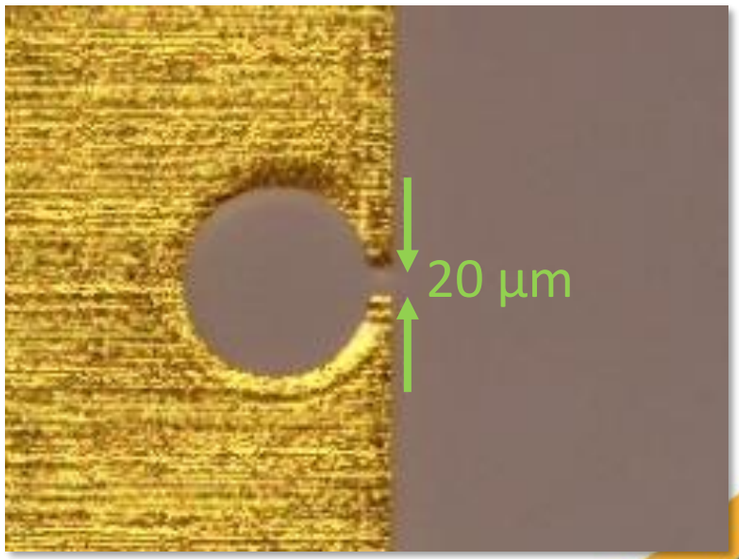
# Split Ring Resonator (SRR) experiment

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




Courtesy M. Nabinger




Photos M.J. Nasse

| TNA [h] | | overall |
|---|---|---|
| FLUTE | | 456 |



Contact: Michael.Nasse@kit.edu

# Acknowledgements

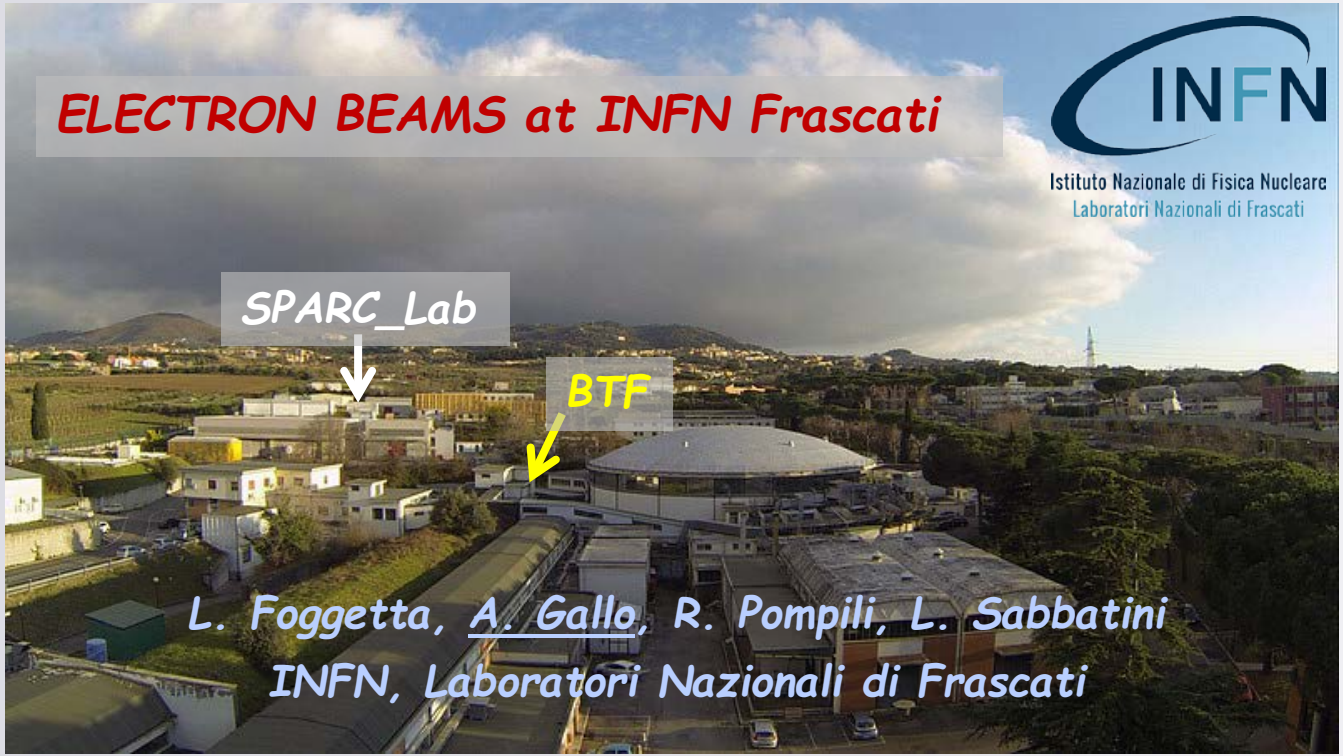

- The accelerator team:
  Axel Bernhard, Edmund Blomley, Tobias Boltz, Miriam Brosi, Erik Bründermann, Sara Casalbuoni, Hyuk Jin Cha, Kantaphon Damminsek, Samira Fatehi, Stefan Funkner, Julian Gethmann, Andreas Grau, Bastian Haerer, Dima El Khechen, Michael Hagelstein, Erhard Huttel, Igor Kriznar, Benjamin Kehrer, Sebastian Maier, Anton Malygin, Sebastian Marsching, Yves-Laurent Mathis, Wolfgang Mexner, Akira Mochihashi, David Moss, Matthias Nabinger, Michael J. Nasse, Marvin Noll, Yuancun Nie, Gudrun Niehues, Meghana Patil, Alexander Papash, Mischa Reissig, Robert Ruprecht, David Saez de Jauregui, Andrea Santamaria Garcia, Jens Schäfer, Thiemo Schmelzer, Patrick Schreiber, Marcel Schuh, Nigel J. Smale, Johannes L. Steinmann, Pawel Wesolowski, Christina Widmann, Andreas Will, Tonia Windbichler, Chenran Xu, and Anke-Susanne Müller
- KIT Institutes (ETP, IHM, IMS, IPE, IPS, LAS)
- Collaboration partners examples:

EC Funded program to promote Transnational Access to Research Infrastructures for Nuclear and Particle Physics (Accelerators & Detector) R&D

HORIZON-INFRA-2021-SERV-01-07 - Research Infrastructures Services Advancing Frontier Knowledge

Grant Agreement 101057511 – EURO-LABS

# WP 3
# TASK 3.3



# EUROLABS Task 3.3 - ELECTRON BEAMS at INFN Frascati - PREMISES

- INFN Frascati Labs have a long-established tradition in production and operation of $e^+/e^-$ beams;
- Presently there are two major accelerator complexes:
  - ✓ The DAFNE $e^+/e^-$ collider (including a $e^+/e^-$ Linac, a two-lines **BTF**, a Damping ring + Transfer Lines)
  - ✓ The $e^-$ multi-disciplinary test facility **SPARC_Lab** (including a high brightness photo-injector, the high power laser system FLAME + various lines for FEL, THz radiation, beam diagnostics, …)
- Within the EURO-LABS project the beams of two facilities are offered to transnational users, namely:

**Beam Test Facility** (lines #1 and #2, $e^+/e^-$ )


**SPARC_Lab** (high brightness $e^-$)

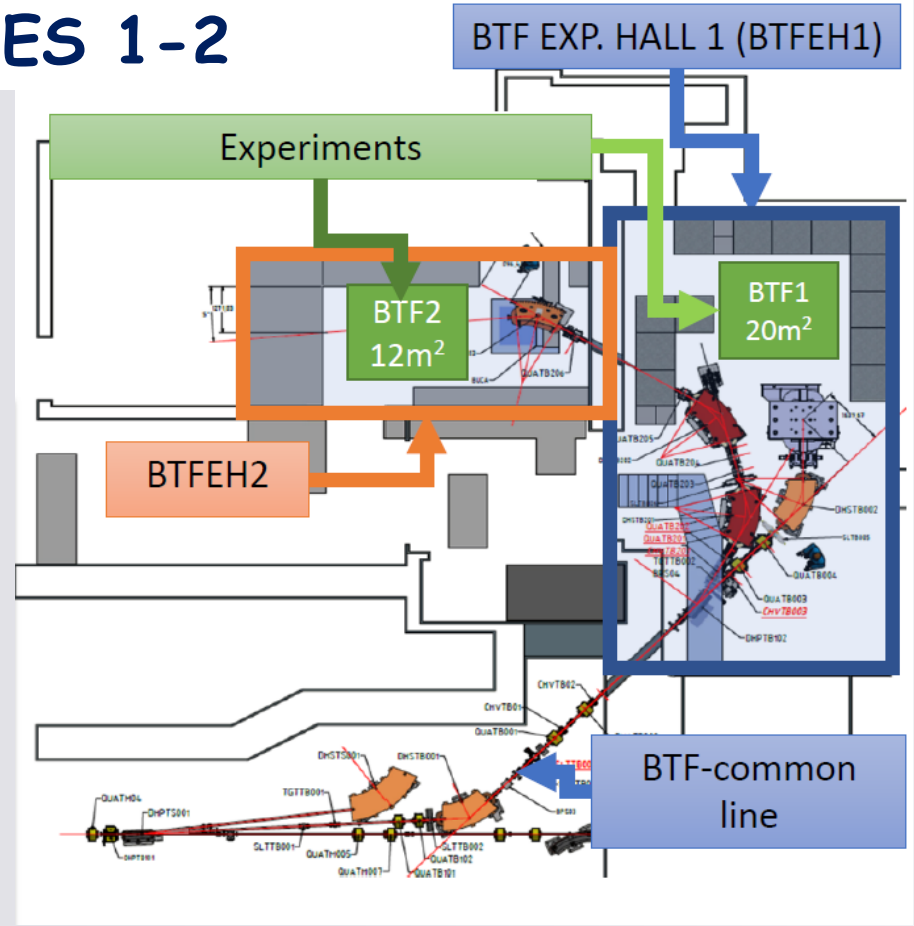
# BEAM TEST FACILITY – LINES 1-2

**The Beam Test Facility (BTF) is part of the DAΦNE accelerator complex in LNF (Frascati, Italy):**

- **it can extract and manipulate the high intensity LINAC e+/e- beam usually injected in DAΦNE main rings**

**BTF** is a facility:

- with a **pulsed** electrons (or positrons) beam, in a definite range of parameters
- optimized for detector **calibration, long time experiment and weekly test beams**
- with the possibility of **device e+/e- irradiation**
- with services at the user disposable
  - DAQ data,
  - SLOW DCS data,
  - Gas pipelines (for BTFEH1)
  - HV
  - Networking
  - Detectors and payload logistics
  - Dedicated Staff



# BEAM TEST FACILITY – LINES 1-2

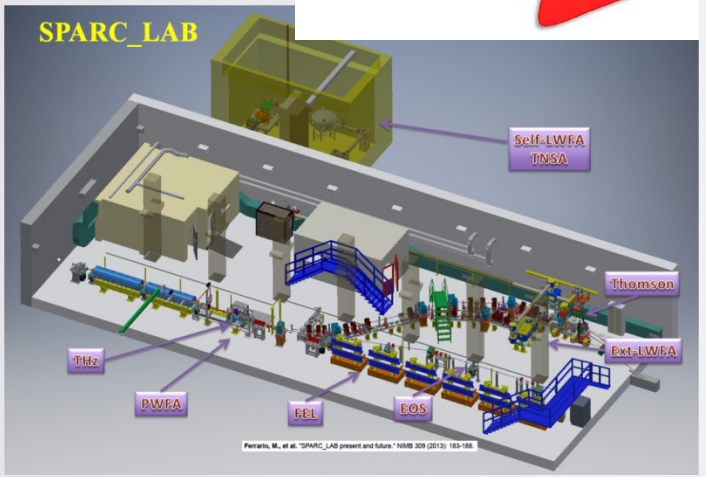
| Parameters | BTF1 Time sharing | | BTF1 Dedicated | | BTF2 Time sharing | BTF2 Dedicated |
|---|---|---|---|---|---|---|
| | With Cu target | Without Cu target | With Cu target | Without Cu target | With Cu target | With Cu target |
| Particle | $e^+$ / $e^-$ (User) | $e^+$ / $e^-$ (DAΦNE status) | $e^+$ / $e^-$ (User) | | $e^+$ / $e^-$ (User) | |
| Energy (MeV) | 25–500 | 510 | 25–700 ($e^-$/$e^+$) | 167–700 ($e^-$)<br>250–550 ($e^+$) | 25–500 | 25–700 |
| Best Energy Resolution at the experiment | 0.5% at 500 MeV | 0.5%/1% | 0.5% | Energy dependent | 1% at 500 MeV | |
| Repetition rate (Hz) | Variable from 1 to 49 (DAΦNE status) | | 1–49 (User) | | Variable from 1 to 49 (DAΦNE status) | 1–49 (User) |
| Pulse length (ns) | 10 | | 1.5–320 (User) | | 10 | Expected 10-100 |
| Intensity (particle/bunch) | $1–10^5$ (Energy dependent) | 1 to $10^7$ / $1.5x10^{10}$ | $1–10^5$ (Energy dependent) | 1 to $3x10^{10}$ | Expected $1–10^4$ (Energy dependent) | |
| Max int flux | $3.125x10^{10}$ part./s | | | | $1x10^6$ part./s | |
| Beam waist size(mm) | 0.5–55 X / 0.35–25 Y (vacuum window dependent) | | | | 1x1 | |
| Divergence (mrad) | Down to 0.5 | | | | Down to 0.5 | |

- Pulsed **electron** and **positron** beams (up to 49 pulses/second)
- Wide range: from 10^10 down to single particle per bunch, continuous energy selection
- Different ranges of parameters in the **two running modes**:
  - Dedicated: only when DAΦNE collider shutdown, exclusive BTF users
  - Time sharing: DAΦNE spare pulse injections mode via pulsed magnet
    - Beam top parameters defined by DAΦNE injections

- Now BTFEH1 and BTF1 line are set up for dark matter searches PADME experiment, no external user
- **BTFEH2 and BTF2 line are recently equipped**
  - **under commissioning both safety and beam**
  - **beam parameters under study**

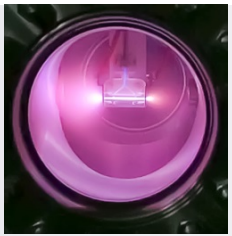
# SPARC_LAB facility

**SPARC_LAB** is a **multidisciplinary test facility** of the INFN Frascati Labs based on 2 pillars: a conventional **high brightness RF photo-injector (SPARC)** and a **multi-hundred TW laser system** (FLAME). Several experiments have been performed and many others are in preparation using the photo-injector and the laser either independently or jointly. The experimental activities cover various fields such as FEL, THz radiation production, Thomson scattering, beam dynamics and beam diagnostics studies.
In the last years plasma acceleration research, in the self-injection and external injection (both particle and laser driven) modalities, has become a relevant part of the SPARC_LAB scientific program.




C-Band accelerating structure and PWFA chamber


**Capillary Discharge**



# Available beams

**Beam properties**

- 10-500 pC electron bunches
- 20 fs – 5 ps duration (rms)
- 80-140 MeV energy
- 20 um-2mm spot sizes

**Diagnostics**

- Spot size, energy, duration, emittance

**Advanced features**

Plasma acceleration stage (1-10 cm, up to 300 MV/m now, then 1 GV/m)

THz diagnostics

Electro-Optical Sampling (EOS) diagnostics

Final focus system based on permanent magnet quadrupoles (PMQ)

# Possible users

**Historically, major users at SPARC_LAB were involved in:**

- FEL users for radiation characterization
- Development of advanced beam diagnostics (THz, Smith-Purcell, Cherenkov)
- Materials study with THz radiation

**Considering also recent activities, possible user activities can be extended to:**

- Plasma acceleration studies (different plasma shaping, beam characterization, etc.). This can be partially done offline @ PLASMA_LAB
- Machine Learning (ML) studies for plasma, FEL and other activities
- Laser-beam interaction (Thomson scattering)
- Photo-cathode laser studies (different wavelengths, longitudinal shaping)
- Cathode studies (also offline at Cathodes LAB)

# WP 3 - Task 3 - Electron beam Facilities
# LPA-UHI100: a laser-driven electron source

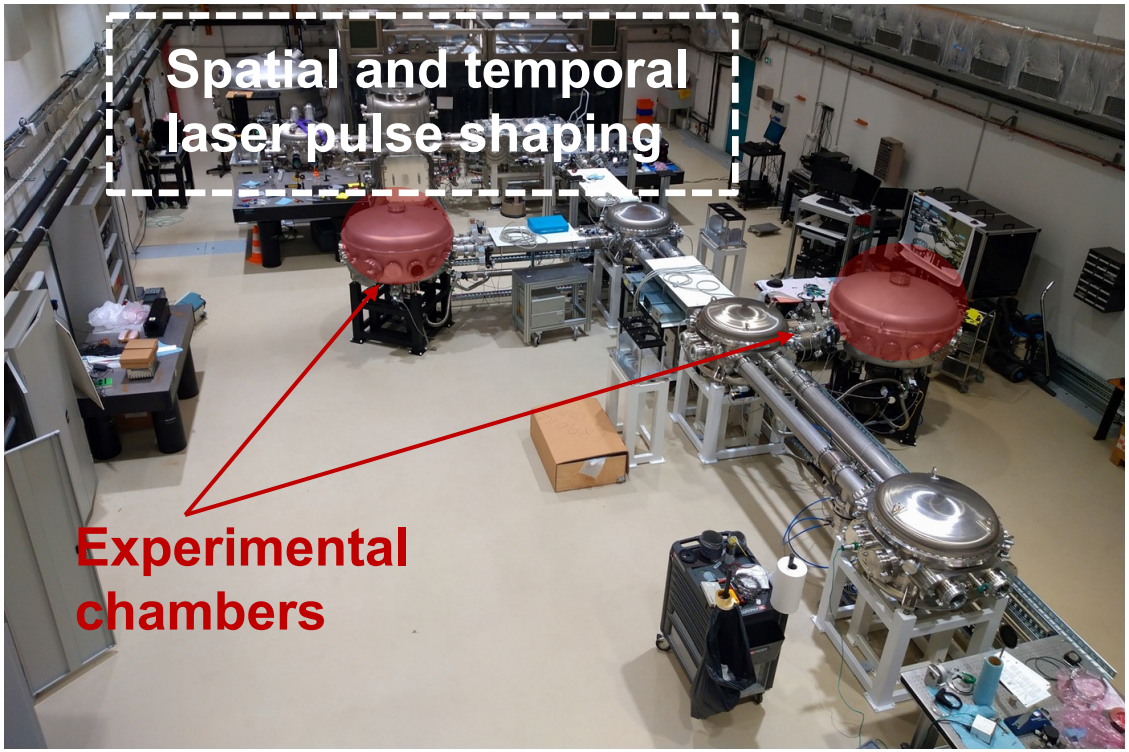
Contact : S. Dobosz Dufrénoy ( CEA-Paris Saclay)

**LPA-UHI100** (**L**aser **P**lasma **A**ccelerator on **UHI100** laser facility) = a platform providing **electron beam line and experimental area** dedicated to **laser-driven electron acceleration studies in plasma media, and applications**.(FLASH Radiotherapy, secondary particles generation, diagnostic developments ….)

UHI100 facility: 2,5J @λ=800nm/ 25fs/5Hz

Amplitude

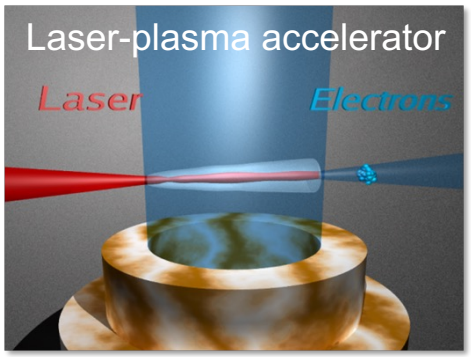
Experimental area




**Fully radioprotected area**

# Electron beam line key parameters

Laser propagation in plasma




- Up to **150MeV** over few mm length
- **10's pC up to 100's pC/ shot** depending on the acceleration mechanism
- **fs** range duration
- **few mrad** divergence

Facility fully equipped **with control and diagnostics of the laser beam** (crucial to control the e- beam properties)

Electron diagnostics: **Magnetic spectrometers** (dipole+ Lanex screen or YAG screen), ICT

Technical support: 2 technicians, 2 engineers, 1 local co-investigator in charge of the access in the experimental room. A workshop accessible during the campaigns

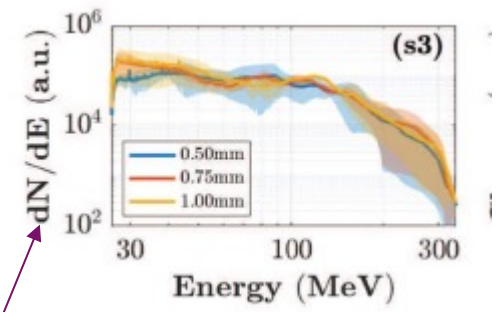
Service improvements:

**Differential pumping system** to increase the repetition rate of the electron source from **0,03Hz to 1Hz**

# One example of ACCESS through ARIES:

## « Non-invasive characterization of laser-driven positron source »

G. Sarri and coll (Queen's Univ, Belfast)



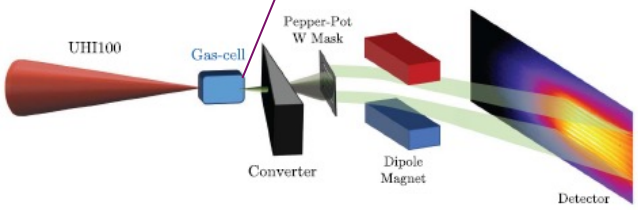
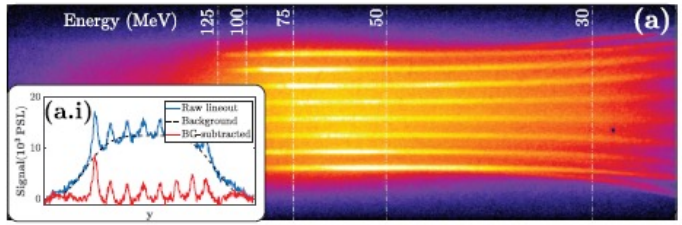
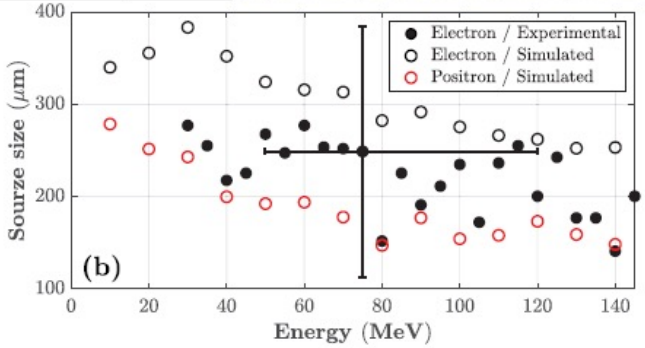
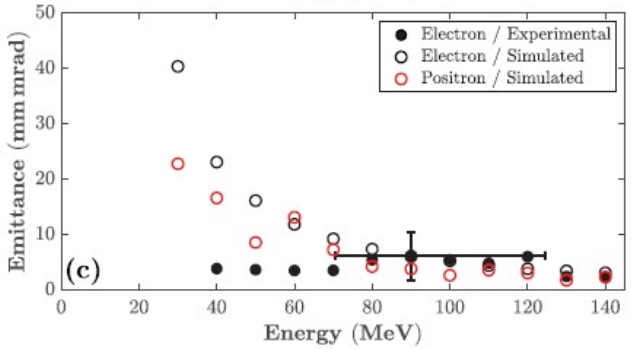




**Figure 2. Experimental setup.** Cartoon depicting the experimental setup. The UHI100 laser was focussed using an F/13 OAP onto a gas cell of variable length. The electron beam driven by the laser was the impinged into a secondary Pb converter of variable thickness. The electron-positron beam was then propagated through a pepper-pot mask before entering a magnetic spectrometer.



# Expected target users and beam time allocation

For each run:

- **3 users** with physical access to the facility (others possible for simulation support to experiments or experiment preparation)
- **4 weeks duration** (160UC)
  - Experimental set up for 3 days
  - 17 days of beam time (full laser energy for laser-plasma accelerator)

⇒ **Over the whole duration of the project: 4 runs** (640 UC)