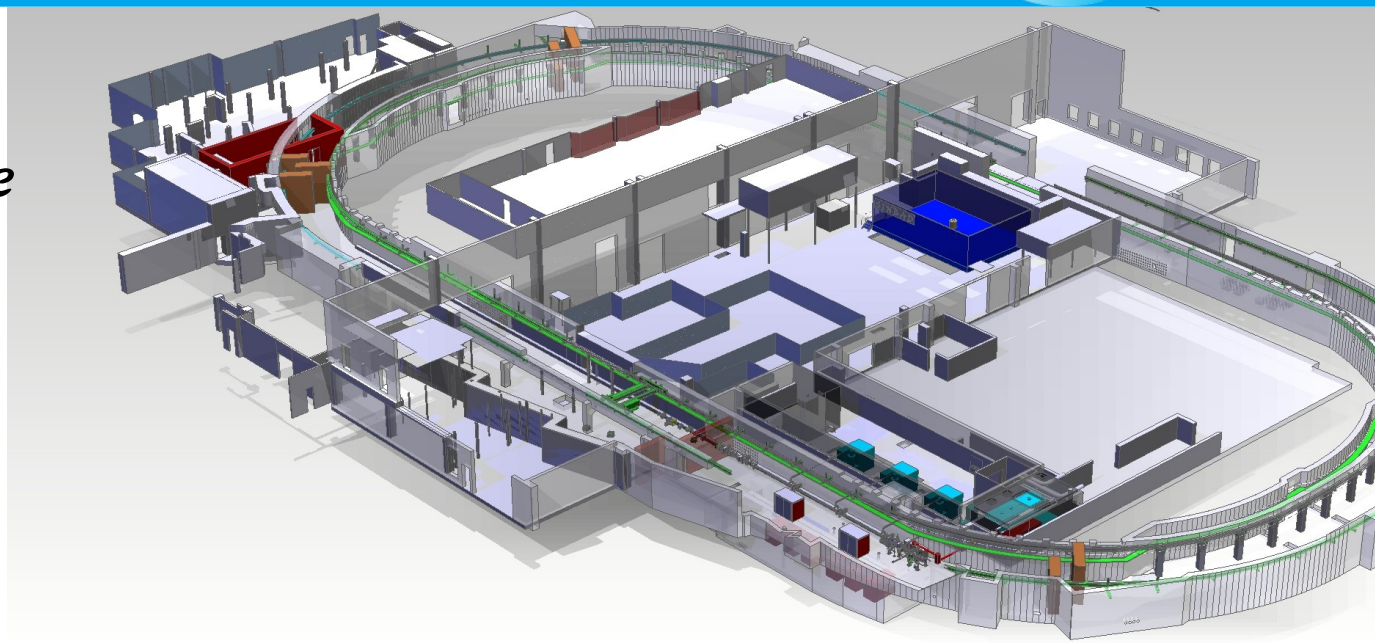
SINBAD



Status and objectives of the dedicated accelerator R&D facility SINBAD at DESY

U. Dorda

EAAC'17 workshop

25.09.2017

HELMHOLTZ ASSOCIATION

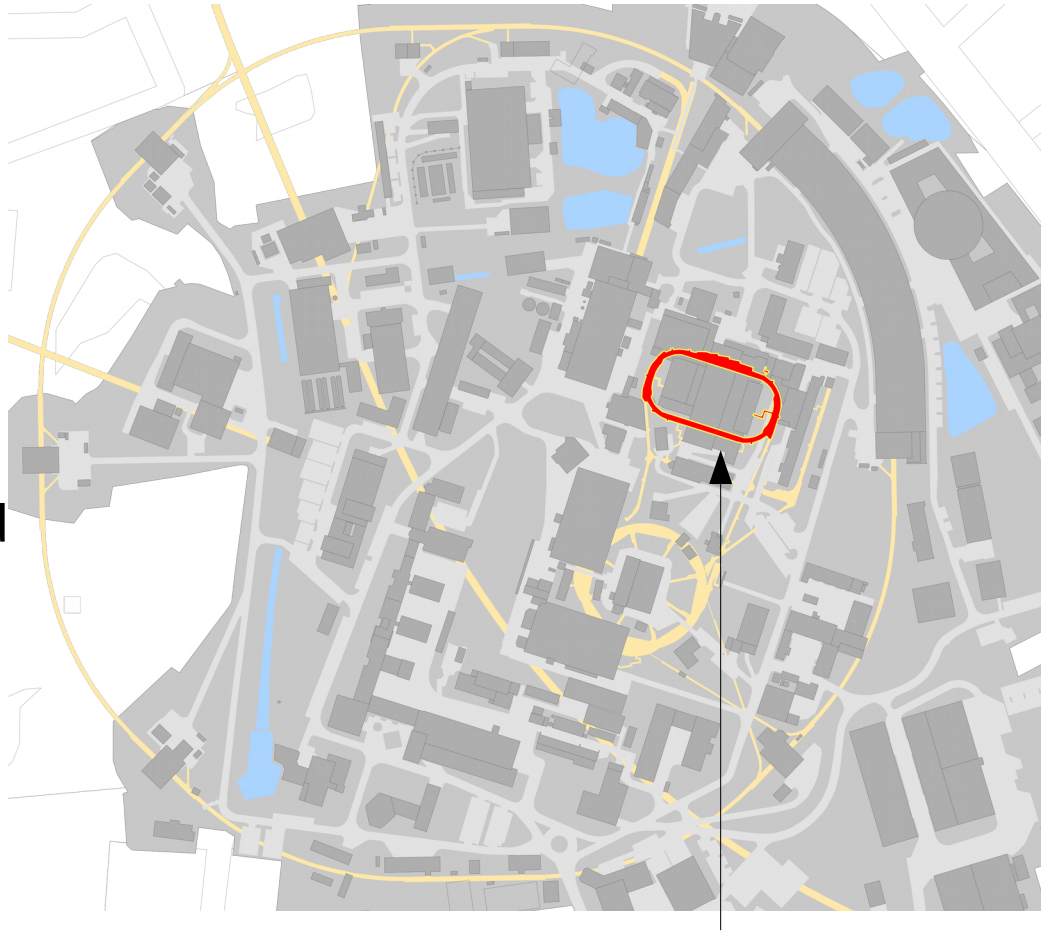
SINBAD

DESY

Introduction

SINBAD Overview & Objectives

- Set up a dedicated multi-purpose accelerator R&D facility with several, independent experiments from ultra-fast science and high gradient accelerator modules.
- SINBAD is the framework for all accelerator R&D activities in the old DORIS facilities
- SINBAD is currently still in the contruction phase



SINBADs two initial experiments

ARES

> 100 MeV S-band electron linac for ultra-short bunches

- Target: operational beginning of 2019

> Upgrade with magnetic compressor & compare various compression techniques

> Use beam to inject into AACs, e.g.

- DLA → ACHIP
- ATHENAe upgrade option: External injection into plasma

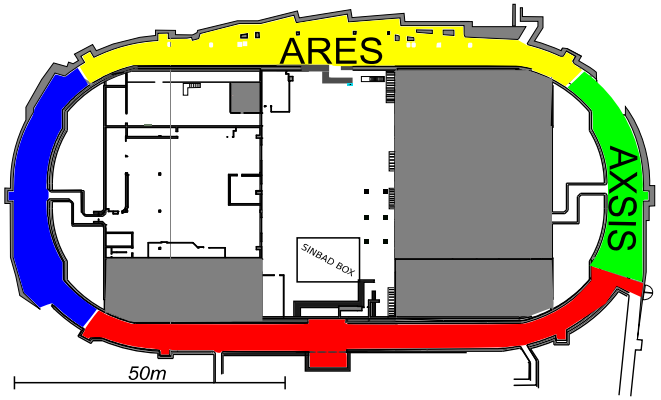
AXSIS

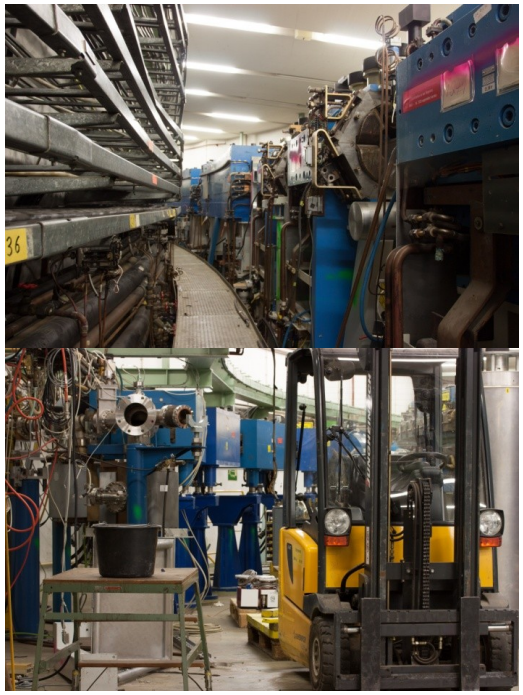
> ERC funded collaboration for acceleration in THz driven, dielectric loaded waveguides

> See plenary talk by N. Matlis

Overall facility status

- DORIS is completely removed and the building rennovated
- Technical infrastructure (water, air…) in the ARES area installed with the associated stations in the neightbouring halls being currently refurbished.





from DORIS
to SINBAD

AXSIS

THz laser driven dielectrics

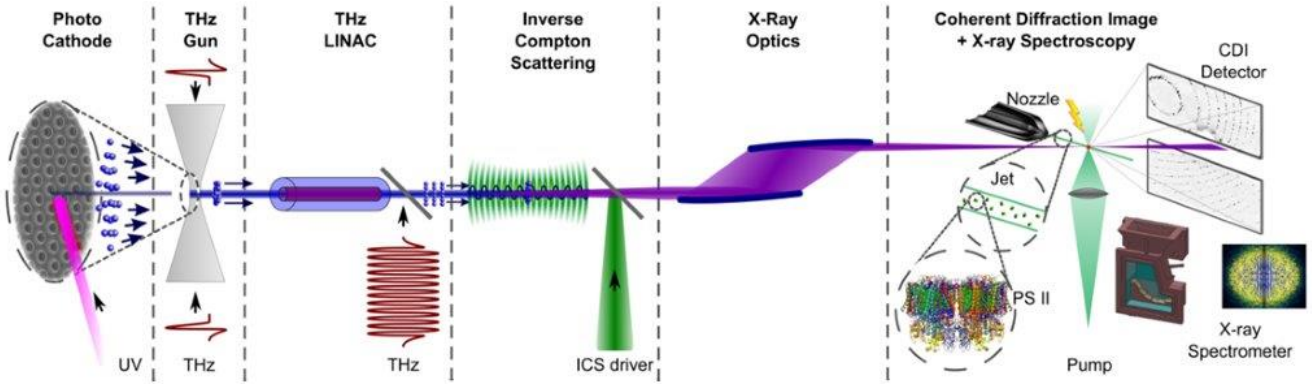
Introduction to AXSIS

> Collaboration of 4 Pis:
  - H. Chapman, R. Assmann, F. Kaertner, P. Fromme

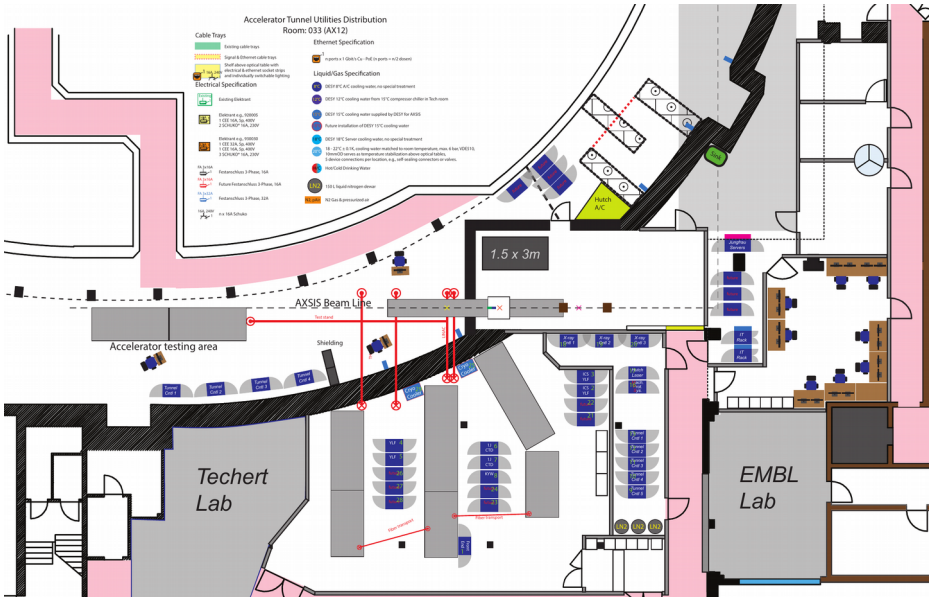
> Goal develop an X-ray source based on THZ-laser acceleration in dielectric loaded waveguides
  - Few MeV electron bunches with sub/single pC charge
  - Photocathode gun driven by THz

> See plenary talk by N. Matlis

> Hosted in one arc of SINBAD + neighbouring former user-areas.



AXSIS -2



- Planned facility layout
- Construction work in tunnel completed, outside starting up right now
- Infrastructure installation etc. until summer 2018

THz gun test stand

> Setup at DESY-CFEL

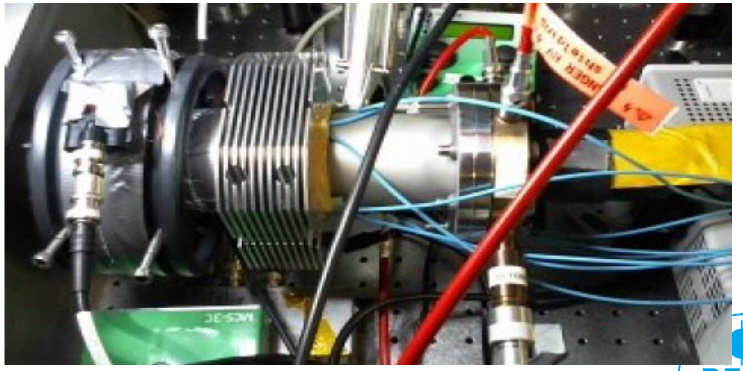
> Test THZ gun concepts in paralell to facility construction and laser development

> See talk by G. Vashchenko

> f=300HZ, few uJ power

> Extracted keV-level electrons

> Important lessons learned in production, handling, etc.



ARES

Linac

DESY

ARES - linac - Overview

Characteristics

> Normal conducting S-band electron linac up to 100 MeV
  - upgrade option 200 MeV

> Two 4.2m S-band travelling wave structures with individual klystrons

> Single pulse with 50Hz

> Low charge: 0.5 - 30pC

> Aiming for ultra short bunches, single/sub- fs

> Design, layout, ... optimized for stability
  - short cable lengths, grounding, …

Target time plan

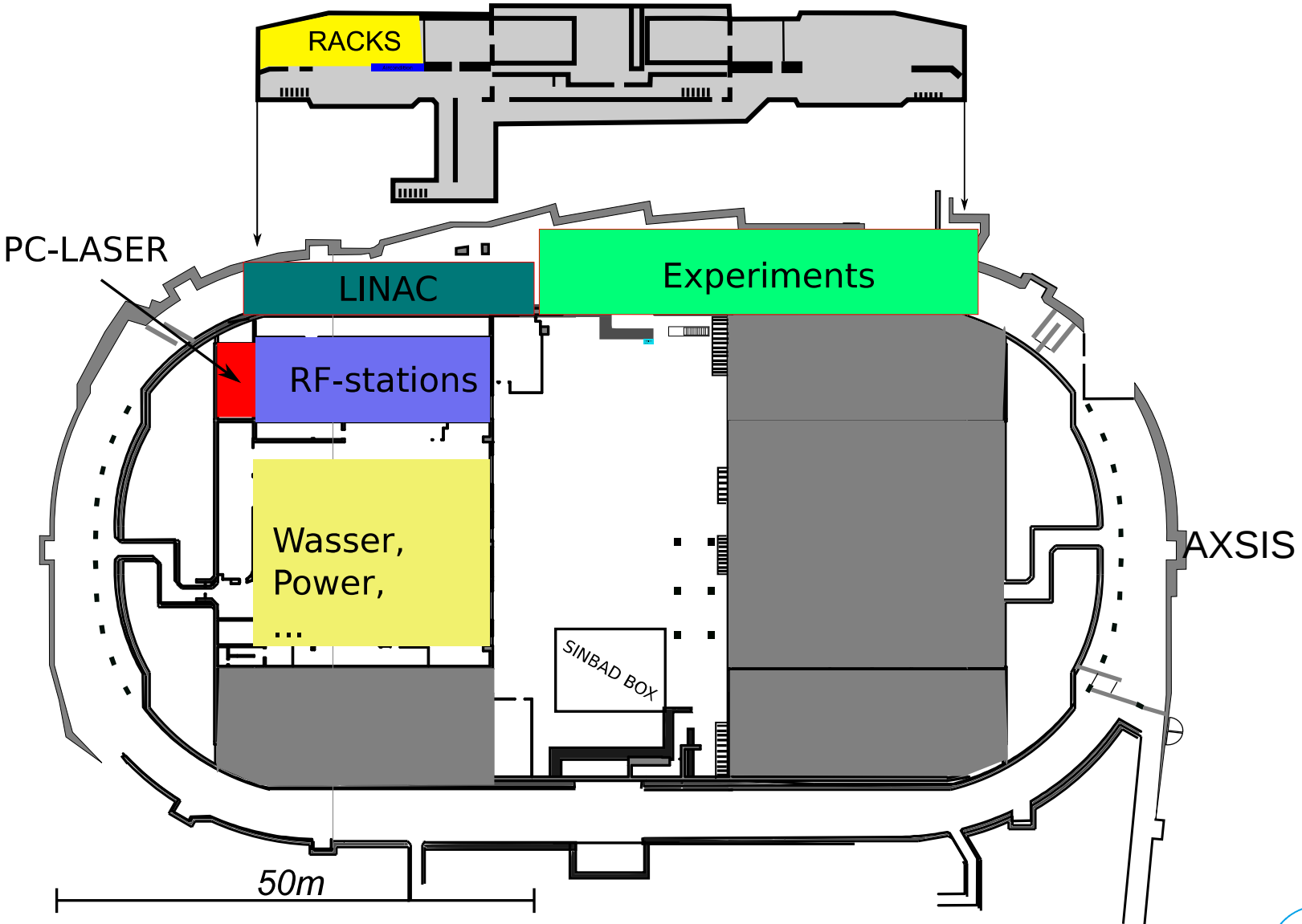
> Tech infrastructure installation finished by End 2017.

> Start gun-stage beam commissioning: spring 2018

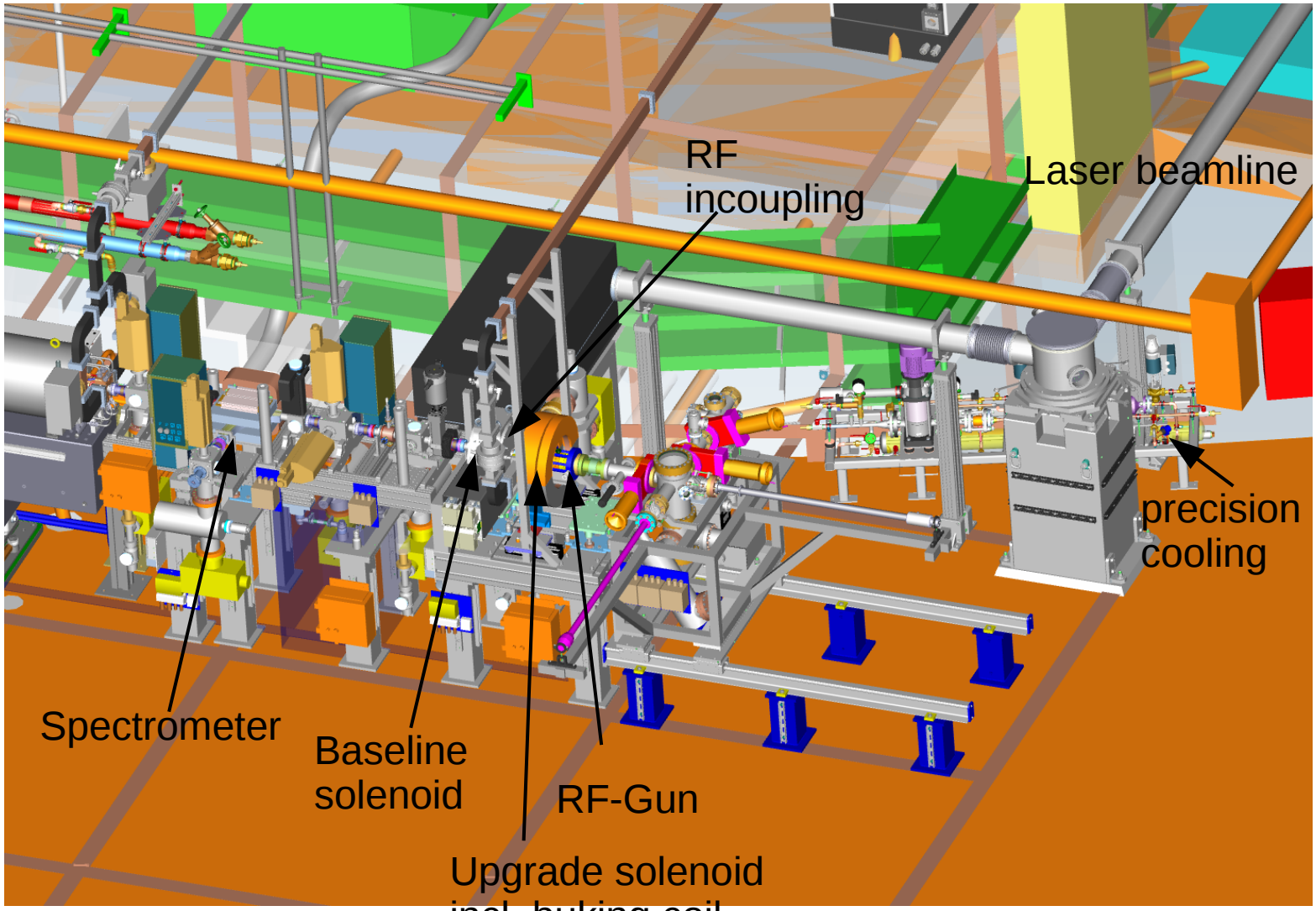
> Linac installation: Summer 2018

> First experiments using linac beam: spring 2019

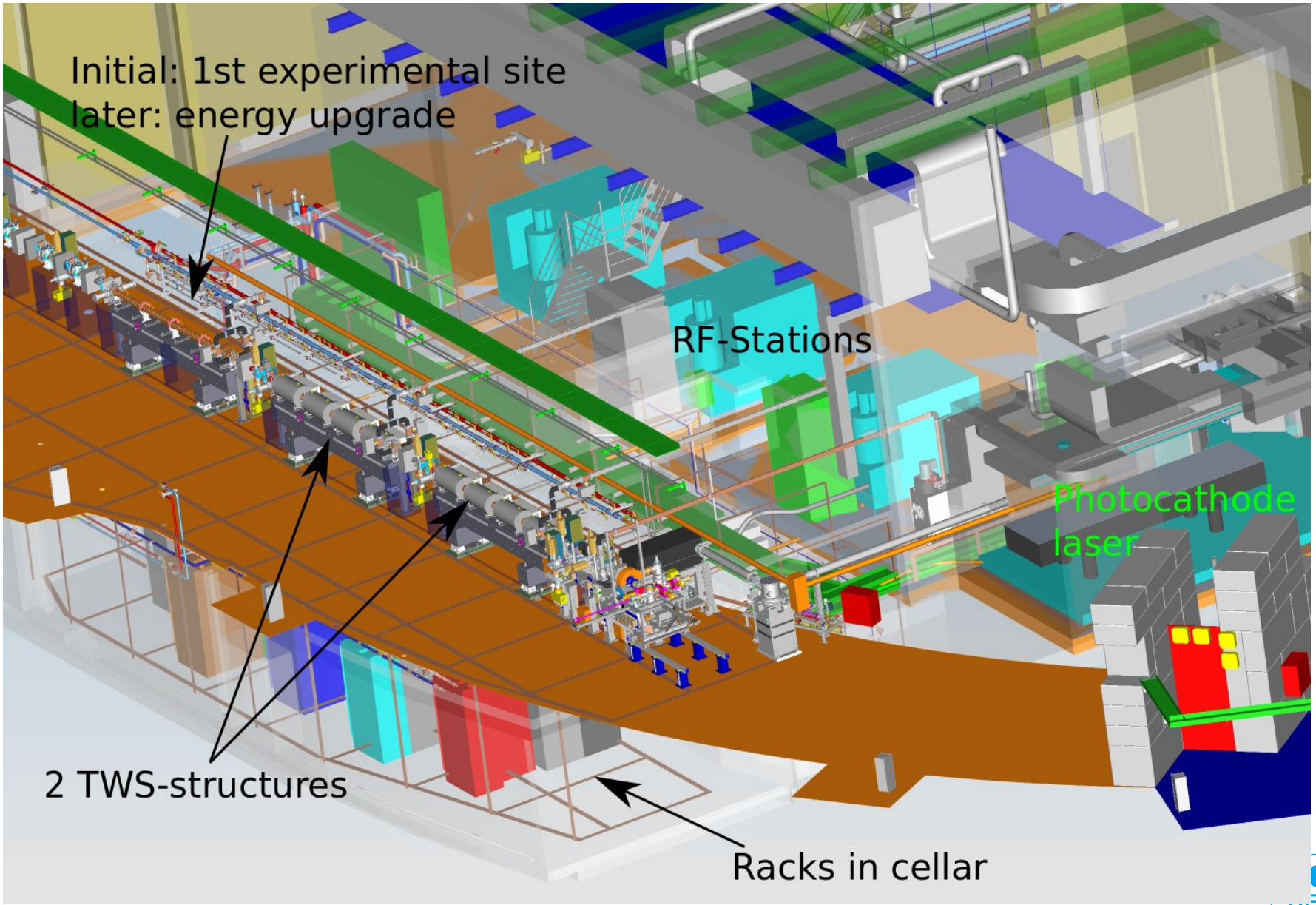
SINBAD-ARES-linac



ARES - linac: Gun region



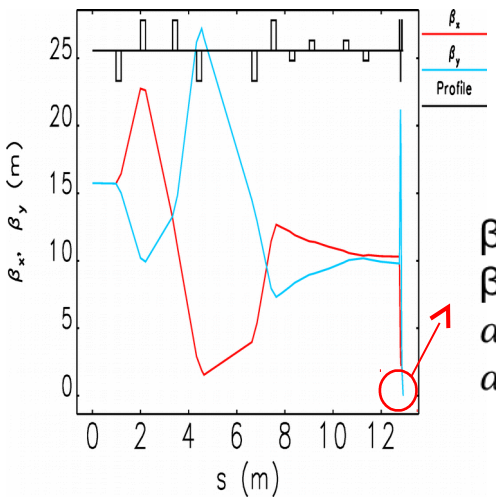
Layout


Initial: 1st experimental site
later: energy upgrade
RF-Stations
Photocathode laser
2 TWS-structures
Racks in cellar

Different compression schemes

Simulations by J. Zhu & B. Marchetti

	ARES
E (MeV)	~ 100
Q (pC)	0.5 ~ 30
ε (μm)	< 1
σ_t (fs)	0.5 ~ 30
I (kA)	~ 1.5
σ_{BTJ} (fs)	< 10
β_x/β_y (mm)	~ 1



β_x = 1 mm
β_y = 1 mm
α_x = 0
α_y = 0

MC: pure magnetic compression
VB: pure velocity bunching
HB: hybrid compression

Plasma entrance

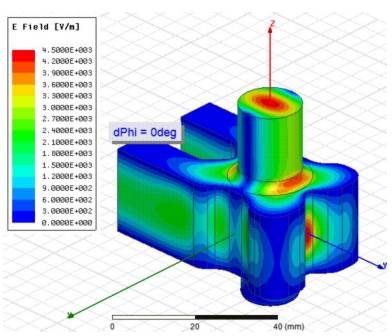
	WP1	WP2	WP3	WP4
Q (pC)	0.8	5.7	30	17.3
σ_t (fs)	0.5	2.0	29.6	12.2
I (kA)	0.6	1.1	1.6	1.5
$\varepsilon_x/\varepsilon_y$ (μm)	0.10 / 0.10	0.52 / 0.43	0.84 / 0.84	0.52 / 0.94
β_x/β_y (mm)	1.8 / 3.1	5.2 / 1.5	\	4.5 / 0.9
Compression method	MC	MC	VB	HB

Linac exit (without final focus)

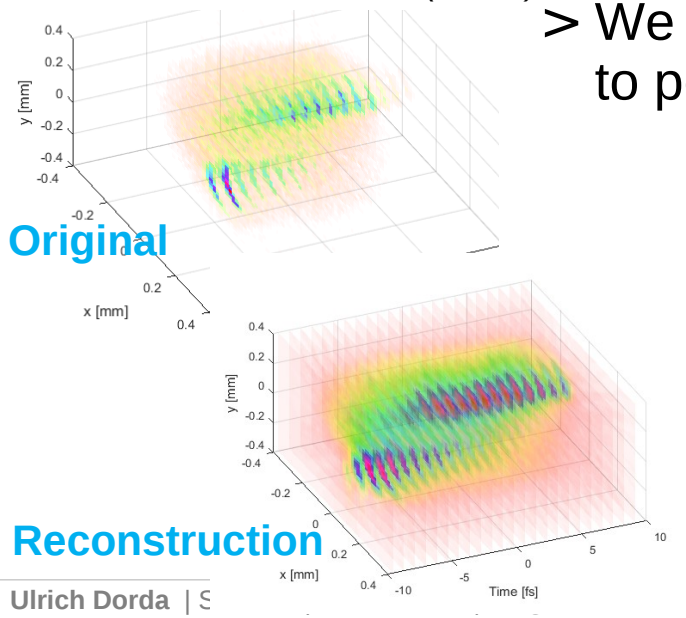
SINBAD –

ARES – experiments

X-band TDS collaboration with CERN & PSI



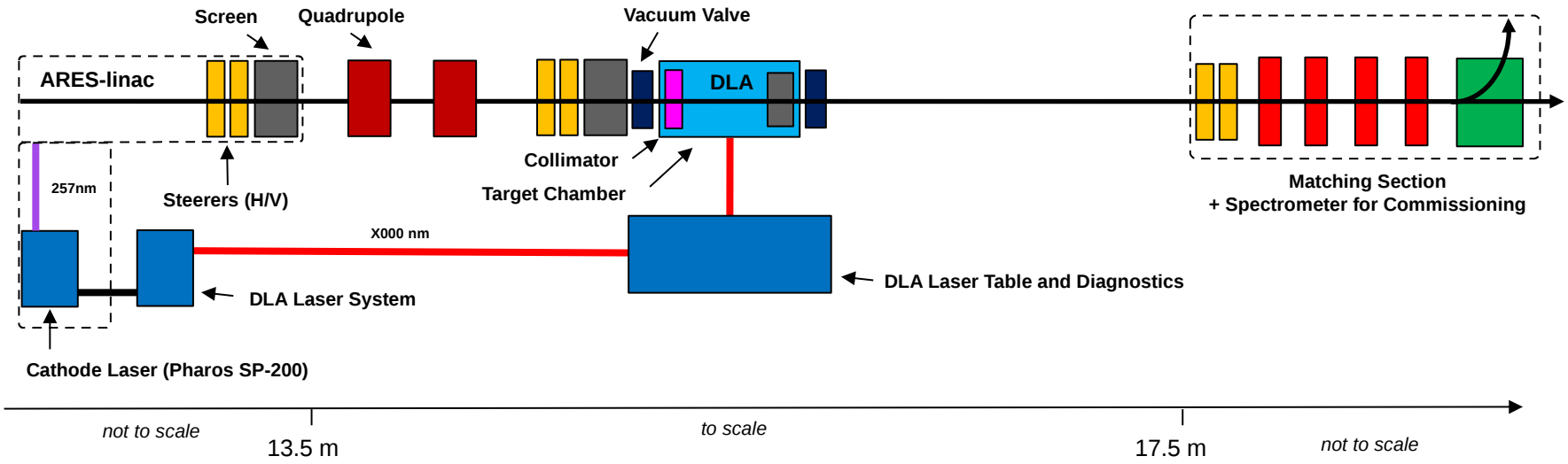
Variable Polarization Circular TE11 Mode Launcher, *A. Grudiev (CERN)*



> Part of the X-band TDS-collaboration with CERN & PSI.
  - See “X-Band TDS Project”, MOPAB044, Proc. IPAC 2017
  - Flash2, FlashForward and SINBAD are involved at DESY
> The TDS will feature a variable polarization
  - A. Grudiev, CLIC-note-1067 (2016)
  - Allows changing of the streaking direction
> Efforts on the beam line layout, integration issues and procurement at ARES are currently advancing.
> We aim for fs-resolution of the bunch length
> We investigate the option to use the polarisation feature to perform tomography
  - Streak beam at different angles
  - Identify longitudinal slices for each direction
  - Combine 1D transverse slice profiles to for a 2D transverse slice profile
  - Stack slices to for 3D charge profile
  - Talk by D. Marx in WG5

DLA @ SINBAD - General

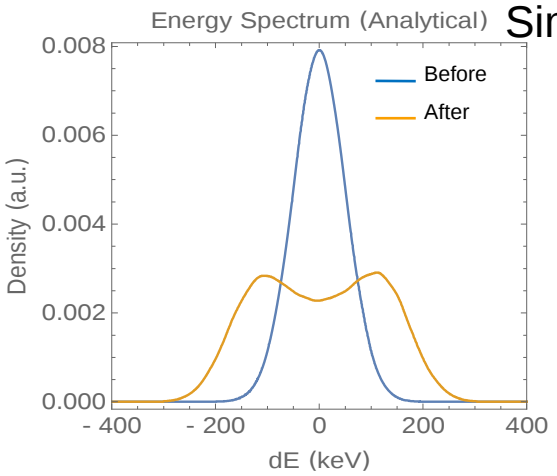
- We are part of the ACHIP collaboration
- Multiple experiments planned to be conducted at ARES
- ARES is very well suited for DLA experiments
  - Dedicated R&D facility → High availability
  - Broad range of beam parameters reaching single digit fs bunch lengths, up to 100 MeV
- Experimental Area (*final positions not yet fixed*):



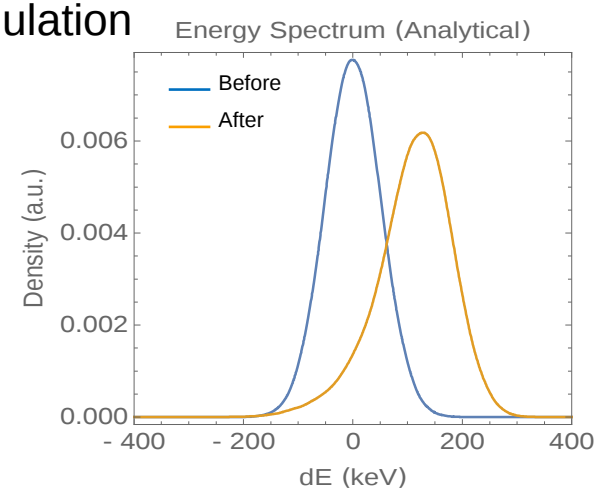
ACHIP @ SINBAD - Experiments

- **Three experiments have been internally proposed so far**
- External injection of pre-accelerated ultra-short single bunches into a grating-type DLA
  - **Goal**: Show net-acceleration with low energy spread growth instead of modulation
  - **Challenge**: DLA structures with periodicity of 2 um require ultra-short bunches
  - Ideally: $\sigma_\phi < \pi/4$
  - Possible ARES working points have been identified using ASTRA, almost reaching that goal using velocity bunching @ 500 fC

Simulation



$\sigma_\phi = 1.0 \cdot \pi$
Previous experiments



$\sigma_\phi = 0.25 \cdot \pi$
Advantage with ARES linac

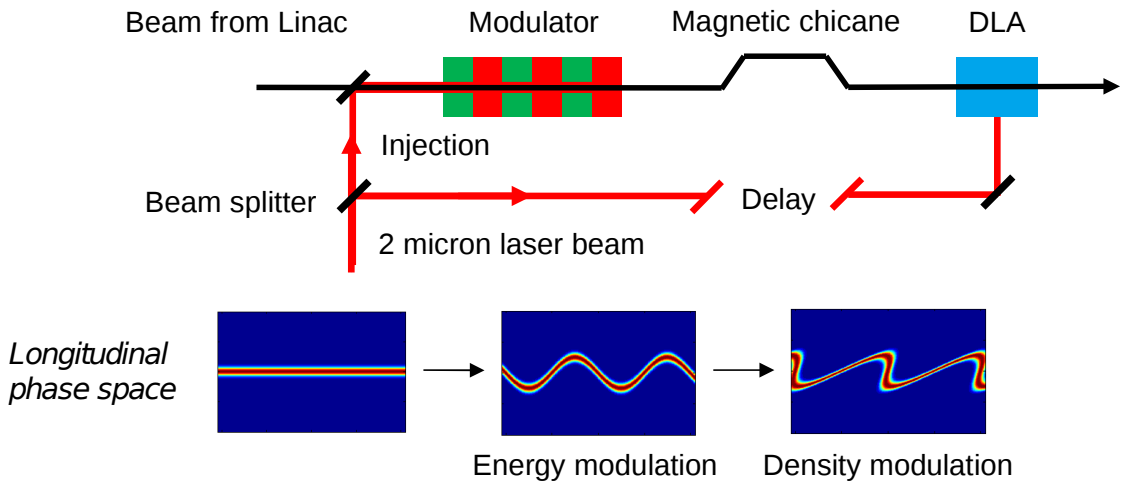
Parameter @ IP (15.5 m)	Value (WP 2)
Charge [pC]	0.5
Bunch Length [fs,fwhm]	2.1 (0.3 * λ_L)
E [MeV]	99.1
ΔE/E [%]	0.12
$\sigma_{x,y}$ [µm]	7.8
$\varepsilon_{n,x,y}$ [nm]	105

- Longitudinal bunch diagnostics using a DLA-based TDS (structure design ongoing)

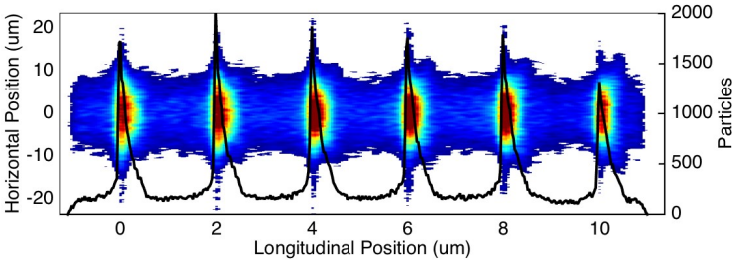
ACHIP @ SINBAD – Experiments

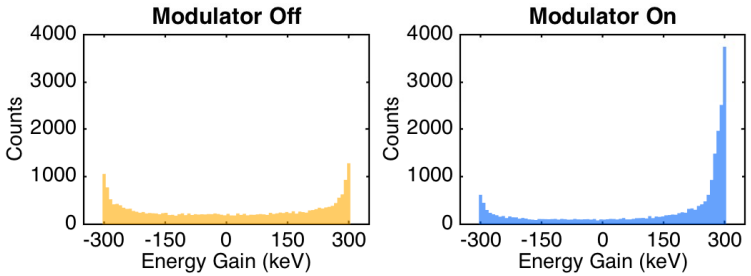
> External injection of phase-synchronous micro-bunch trains into a grating-type DLA

- **Goal**: Increase efficiency and stability of the acceleration by phase-locking a train of sub-fs micro-bunches to the acc. buckets of the DLA
- **Scheme**: Drive both the conditioning of a long beam and the DLA interaction with the same laser



Simulations using ASTRA + GENESIS + VSim





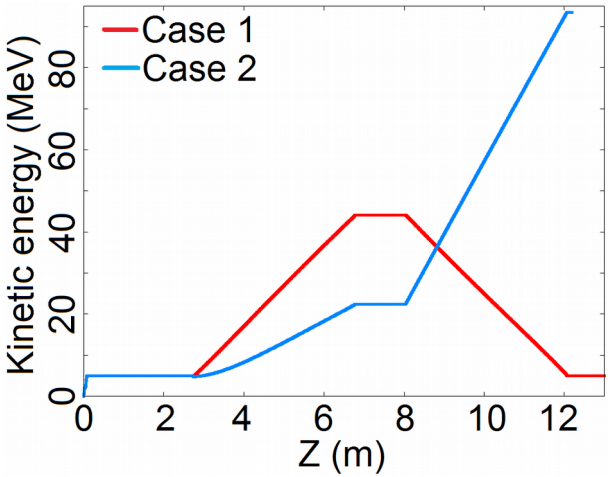
Microbunch length: (699 ± 88) as, FWHM, Microbunch spacing: (2.00 ± 0.01) µm

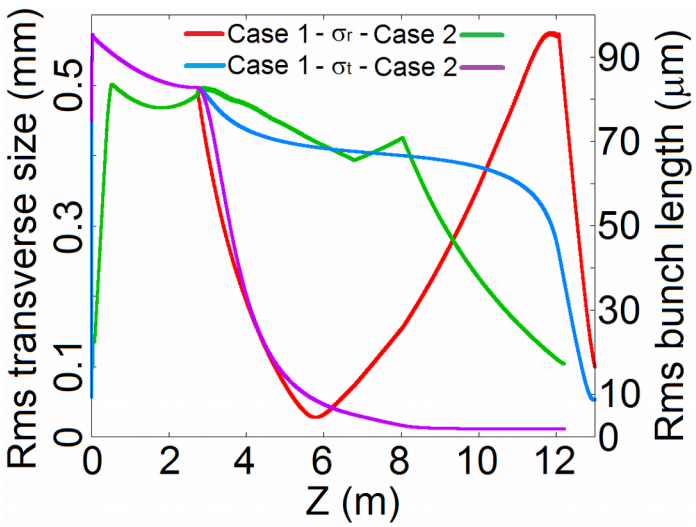
Possible experiments with DLW on ARES

- Transmission experiment: Charge transmission through a DLW can be affected by many parameters (focusing, transverse misalignment, angle between DLW axis and bunch trajectory, bunch properties, DLW dimensions, etc.) → Mastering all these aspects requires experiments.

- Acceleration experiment: ARES → wide-range of energy (5-100 MeV), while still keeping a bunch length compatible with injection in THz-driven DLW (< 10 µm rms) and sufficient transverse focusing provided by the intended magnets.

- Bunch length measurement: THz-driven DLW → femtosecond bunch length measurement with the 3-phase method or longitudinal phase-space tomography.

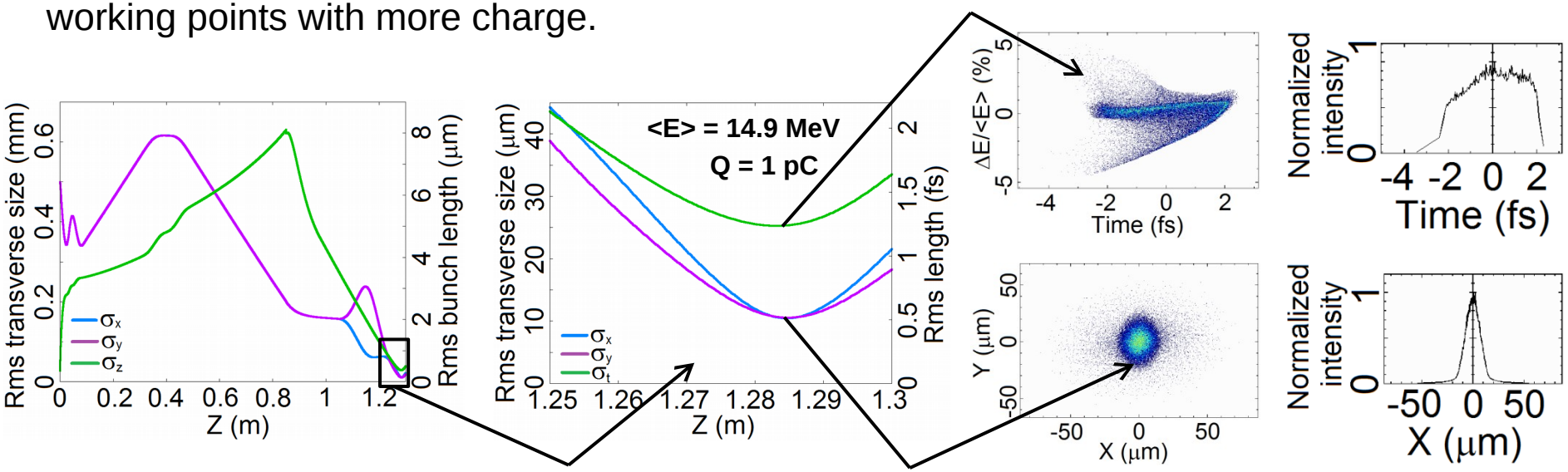




More on T. Vinatier poster: ***Possible experiments using dielectric-loaded waveguides on the ARES linac***

Combination of S-band gun with THz-driven DLW linac

- Objective: Study the possibility to inject the bunch coming from an ARES-like RF-gun in a THz-driven DLW and obtain by simultaneous acceleration and compression, and by transverse focusing after the DLW, a bunch with charge ≥ 1 pC, energy of 10-20 MeV, length ≤ 1 fs rms, transverse size ≈ 10 µm rms with a compact (< 2 m) beam line. Possible application: Production of (sub)-fs X-ray pulses by Inverse Compton Scattering.
- Current status: First possible working point simulated (ASTRA). Investigations ongoing for solving limitations on energy spread and transverse emittance, and find other possible working points with more charge.



More in T. Vinatier presentation: ***Simulations of an hybrid and compact attosecond X-ray source based on RF and THz technologies***

External access via ARIES TNA

> We are part of several collaborations via which access to ARES is possible.

> In addition, access to SINBAD will be possible with the ARIES transnational program

- https://aries.web.cern.ch/content/transnational-access
- User travel support included

> Starting from spring 2019 onwards

> (Almost) No restrictions on topics

- e.g. beam diagnostic tests etc..

> Still several slots available.

- Pl. contact me here at the workshop or per mail/tel to discuss ideas!

ATHENA for LWFA

- > 7 Helmholz centeres for the ATHENA collaboration on plasma acceleration.
- > SINBAD will host the electron site.
- > Adding a high power laser (move ANGUS laser) in the central hall and perform LWFA studies
- > Internal & external injection
- > Install setup in second long straight section

Summary

> SINBAD is still in the construction phase with first electrons coming soon!

> AXSIS → see N. Matlis talk, starting coming summer

> ARES → ultra short bunches, linac installation coming summer

> First experiments e.g. ACHIP are forming

> Further upgrades including LWFA are looking good

> External access possible via ARIES-TNA

Thanks to the collaborators

> DESY technical groups

> AXSIS

> LAOLA

> ACHIP

> X-band collaboration with CERN & PSI

And the funding agencies: Helmoltz, ERC, Moore foundation, ARIES