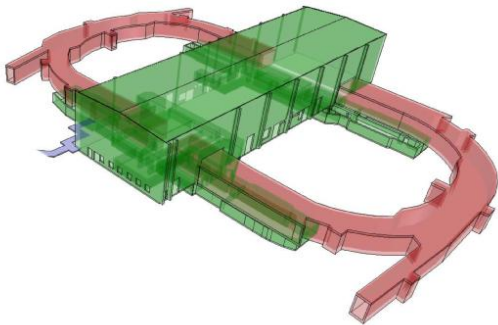


Short INnovative Bunches and Accelerators at DESY

# SINBAD

the accelerator R&D facility under  
construction at DESY

- Turn the facilities of the old DORIS storage ring plus associated halls into a dedicated multi-purpose accelerator R&D facility with several, independent experiments from ultra-fast science and high gradient accelerator modules.
- Based e.g. on the ongoing LAOLA activities, it is intended to provide a space for long-term dedicated accelerator R&D with multiple experiments using a common infrastructure.
  - e.g. one central high power laser used for several experiments.
- Project goals:
  - Production of ultra-short electron bunches for ultra-fast science.
  - Construction of a plasma accelerator module with usable beam quality for applications.
  - Setup of an attosecond radiation source with advanced technology (AXSIS collaboration).



- 290 m long, 5-9m wide RP-shielded tunnel in racetrack shape
  - 2 long straight sections of >70m length
- Central hall (650m<sup>2</sup>) + additional side rooms & cellars
- 1m thick shielding
- Multiple laser labs directly adjacent

# LOCATION ON THE DESY CAMPUS

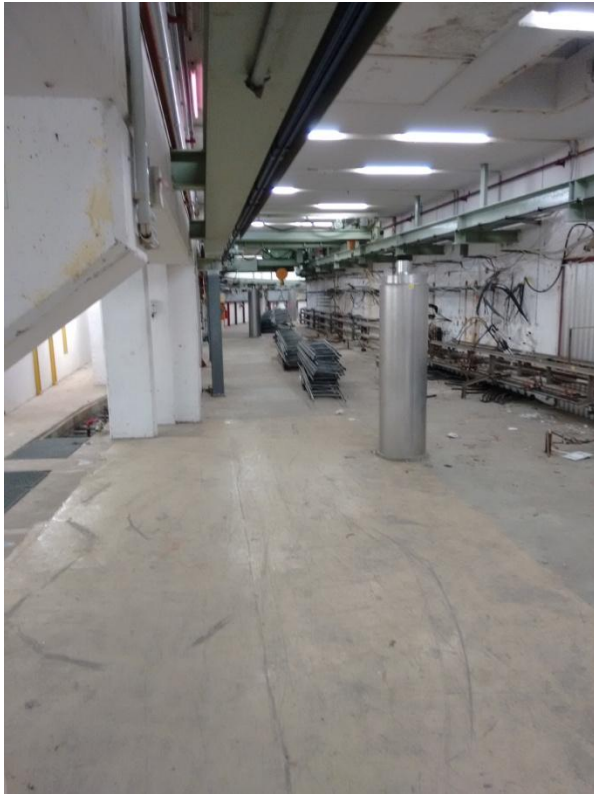


- In the old DORIS facilities
- Next to the central DESY control room
- Beam lines to DESY II



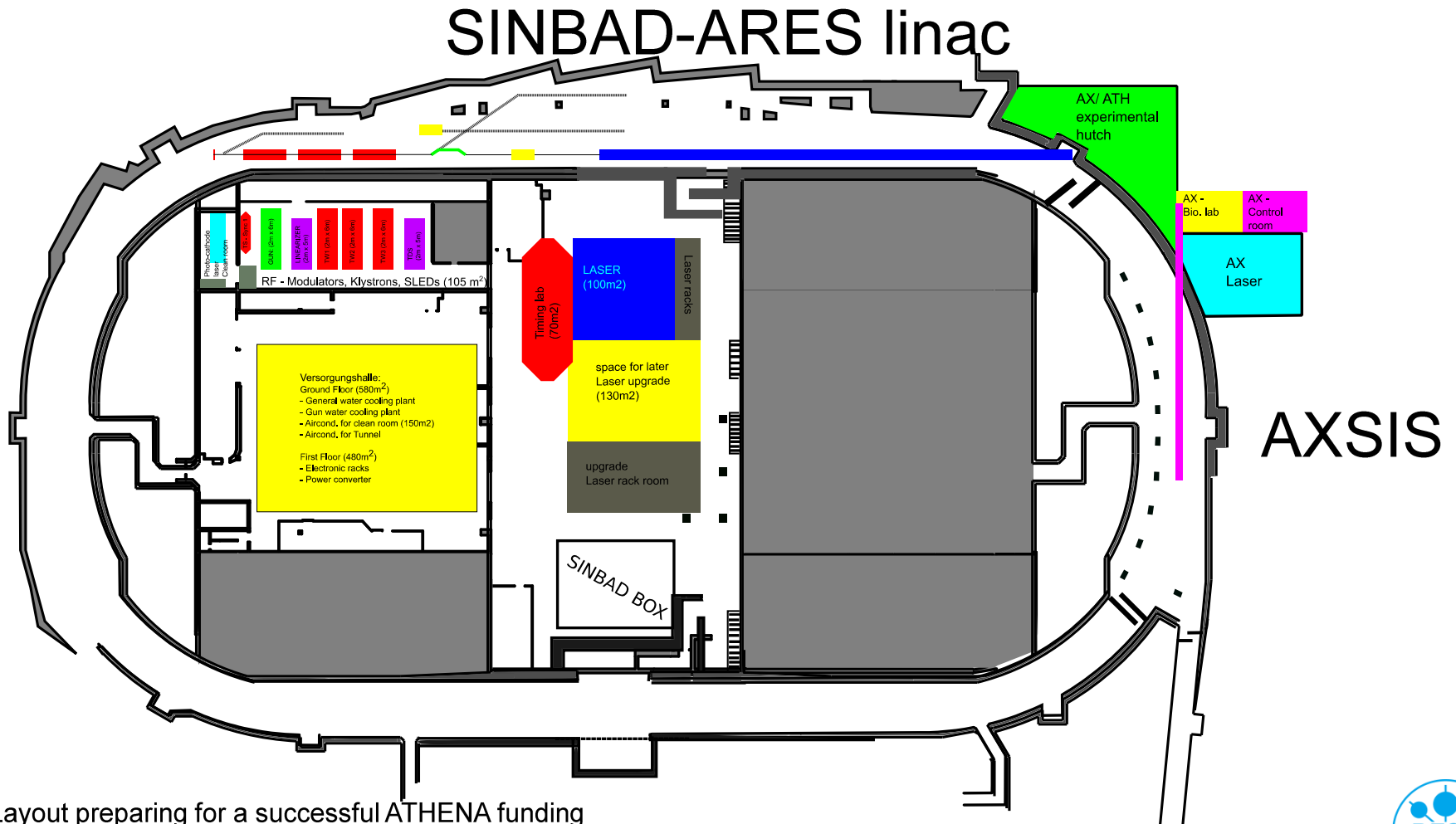
# CURRENT CLEAN-UP STATUS

- Removal of old DORIS beam line completed
- Removing of cabling & piping in final stages
- Structural refurbishment (floor, walls, ....) about to start
- Installation of technical infrastructure planned for spring/summer 2016



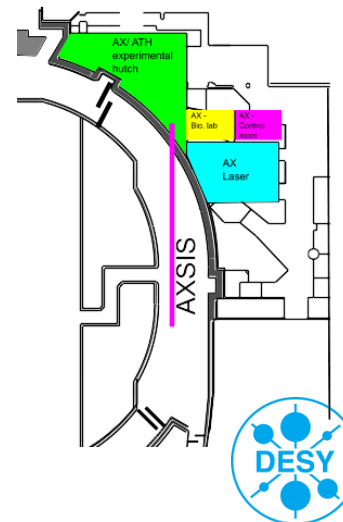
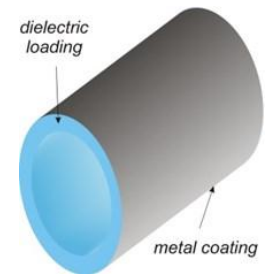
# OVERALL FORESEEN FACILITY LAYOUT

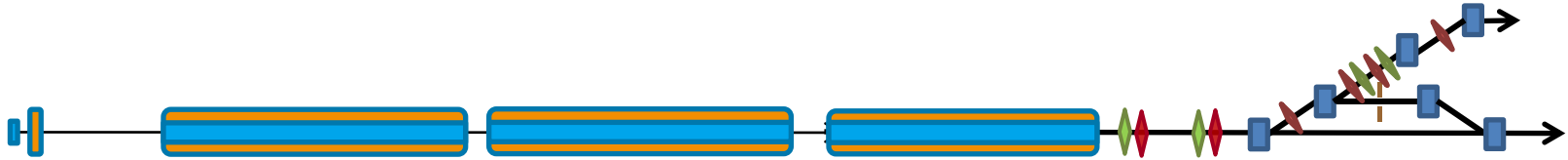
- SINBAD will initially host 2 experiments
  - SINBAD-ARES linac
  - AXISIS



- Layout preparing for a successful ATHENA funding
- HP-laser "ANGUS" currently in use at LUX & managed by A. Maier's group

- THz- laser acceleration in dielectric-loaded waveguide & ICS
- Collaboration between F. Kaertner, H. Chapman, R. Assmann & P. Fromme funded by an ERC synergy grant
- Location:
  - Accelerator & ICS in ARC-1
  - “Users” & Laser labs in former Hasylab user areas
- Targeted beam parameters
  - E: 15 / 25 MeV (4 & 12 keV photons)
  - Q: 0.1 pC, kHz rep rate
  - T: aiming for sub-fs bunch length





- Layout comprises:
  - REGAE-type RF electron gun (S-band)
  - 2 (upgrade 3) linac-II type S-band RF-structures
  - Magnetic compressor with slit
- Design studies focus on short bunch length & low timing jitter
  - while keeping flexibility for “user” requirements sufficient for radiation production (higher charge in longer bunches)
  - RF-compression, magnetic compression with slit, hybrid compression
- Main design parameters
  - Particle type: electrons
  - Energy: **100MeV** (with upgrade option to 250MeV)
  - RMS bunch length: **few fs**, aiming for sub-1fs
  - Charge: **0.2-20 pC** (depending on bunch length)
  - Normalized transverse emittance < 0.5 mm mrad (20pC case)
  - Arrival time jitter (RMS)  $\leq 10$  fs



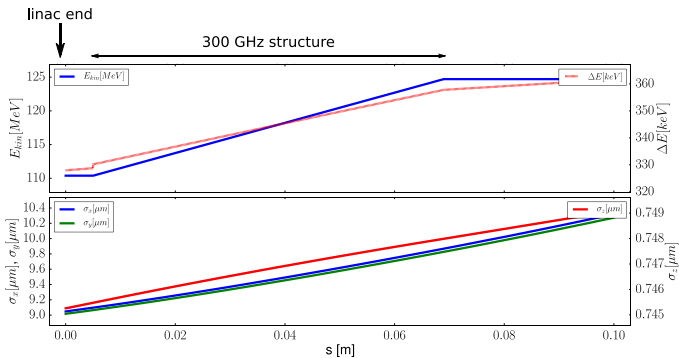
- On the long run, we aim for multiple (3) research beam lines downstream
  - Keeping option to add a beam line into the hall in the far future
- Envisaged topics:
  - Laser plasma wake field acceleration with external injection and demo-FEL
    - Extent depending on approval of the ATHENA proposal
  - Laser driven dielectric structures
    - Laser labs of I. Hartl and F. Kaertner adjacent
  - Imaging beam line (ICS)
    - Comparing conventional beams to LPWA
  - Beam diagnostic test stand
- Relying/ planning on strong collaborations
  - Current: LAOLA, AXSIS, future test-site for “accelerator on a chip”
  - Hope for: ATHENA, EuCARD-3 TNA





# LINAC WORKING POINTS FOR INJECTION INTO ADVANCED ACCELERATION SCHEMES

	WP3 (vb)	WP2 (vb)	WP (BC)	WP (VB+BC)
Q final [pC]	0.5	0.5	0.7	<b>2.8</b>
Q initial [pC]	0.5	0.5	20	10
tRMS [fs]	2.486	2.321	<b>0.21</b>	0.66
tFWHM [fs]	4.1	2.777	<b>0.22</b>	1.54
E [MeV]	110.9	110.9	100.2	101.6
$\Delta E/E$	0.3%	<b>0.09%</b>	0.2%	0.2%
xRMS [mm]	<b>0.009</b>	0.152	0.059	0.087
yRMS [mm]	<b>0.009</b>	0.152	0.057	0.090
nEx [ $\mu\text{m}$ ]	<b>0.054</b>	0.072	0.076	0.22
nEy [ $\mu\text{m}$ ]	<b>0.054</b>	0.073	0.066	0.21
Peak current [A]*	57	62	950	<b>1200</b>
Local peak current [A]**	85	111	<b>1730</b>	1490
B [A/m <sup>2</sup> ]***	$1.97 \cdot 10^{16}$	$1.16 \cdot 10^{16}$	<b><math>1.89 \cdot 10^{17}</math></b>	$2.60 \cdot 10^{16}$

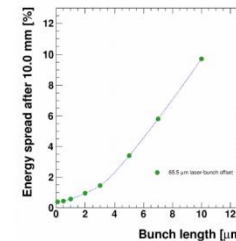


Simulated injection into a 300GHz dielectric structure

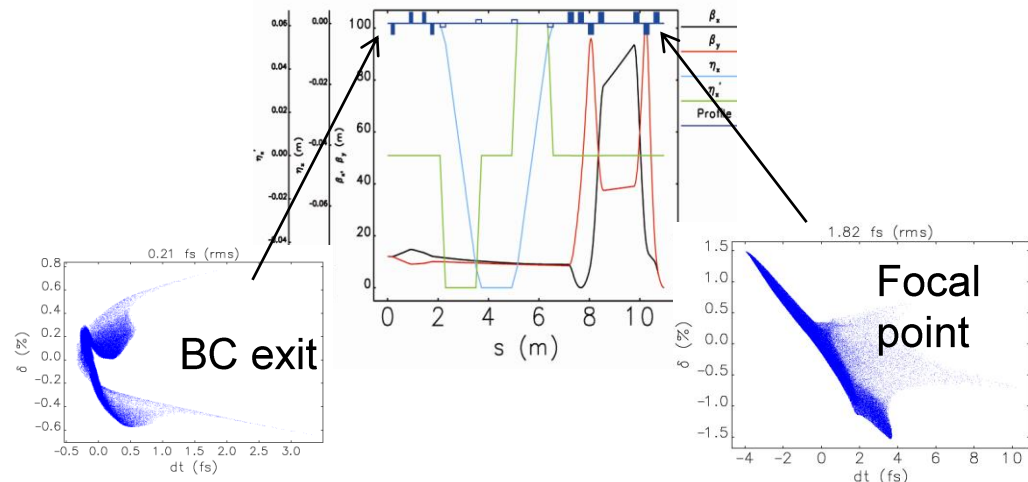
## Plasma application

- Velocity bunching (vb) for external injection in to LPWA: matched  $\beta$  functions range from cm to mm ( $n \sim 10^{14}$  to  $n \sim 10^{17}$ )
- Bunch length < 5 fs (small final energy spread)

Example: Simulations at  $n = 10^{17}$

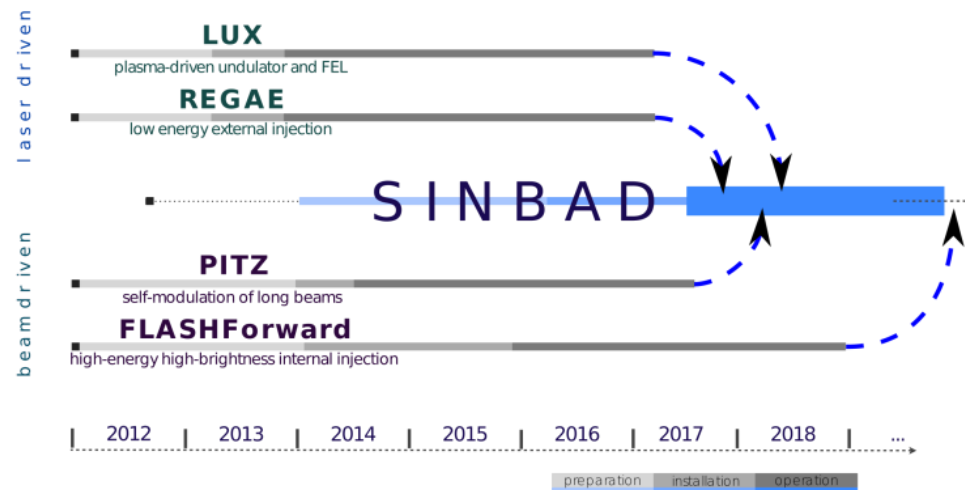


- While for VB, the focusing is done along the linac, in case of a bunch compressor (BC), a focusing optics is needed



# PLASMA ACCELERATION AND SINBAD IN THE LAOLA CONTEXT

- Based on the experience of the ongoing LAOLA experiments
- LAOLA = Collaboration UHH and DESY on plasma wake field acceleration currently installing operating:
  - REGAE – e.g. B. Zeitler, WG4, Thu 18:20
  - LUX – e.g. talk by A. Walker, WG7, Wed 17:10
  - FlashForward – e.g. PS 1 by V. Libov
  - PITZ – e.g. talk by M. Gross; WG1; Tue 15:50
- Removal of the ANGUS laser to the SINBAD-hall center
  - Allow for external injection into LPWA
  - In parallel, internal injection LPWA in second long straight section, e.g. LUX-follow-up and ATHENAe for KIT

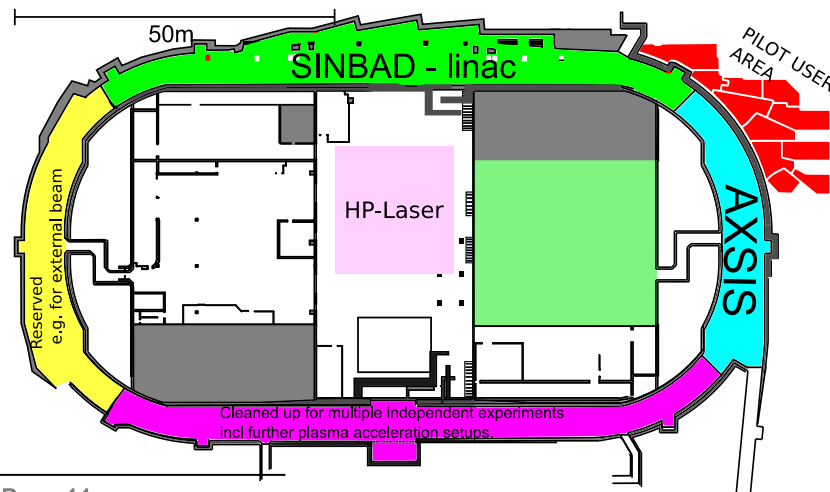


- Timeline

- 2015: Removal of old DORIS and building renovation
- 2016: Installation of technical infrastructure
  - ATHENA decision
- 2017: First beam from RF-gun
- 2018: First beam from linac, start research line operation

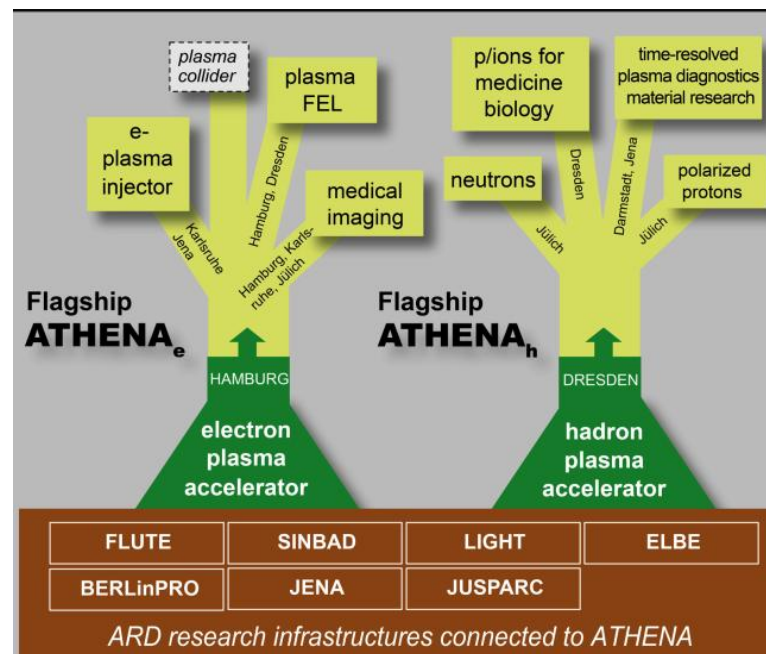
- Additional longer term ideas

- Energy upgrade to 250 MeV and X-band TDS (via CERN collaboration)
- Internal injection LPWA in second long straight section
- External beam option (electrons & positrons up to 6 GeV from linac II/ DESY II)





- Joint **request** of 7 Helmholtz centers for Helmholtz strategic investment funds
- “ATHENA provides the infrastructure required for **bringing compact and cost-effective plasma accelerators to user readiness**. Flagship projects will be set up in Hamburg (electrons) and Dresden (hadrons). Applications for science, medicine and industry will be developed in all centers.”*
- ATHENA<sup>e</sup> flagship would be hosted at **SINBAD**.
- Submission done in June 2015, Decision: Spring 2016
- Would allow upgrading with e.g. X-band RF systems, add undulators, upgrade synchronization, add undulators, ...



- All DESY groups involved in the facility clean up and planning of future experiments!
- All collaboration partners!, especially LAOLA & AXSIS!
- R. Assmann, B. Marchetti, J. Zhu,

