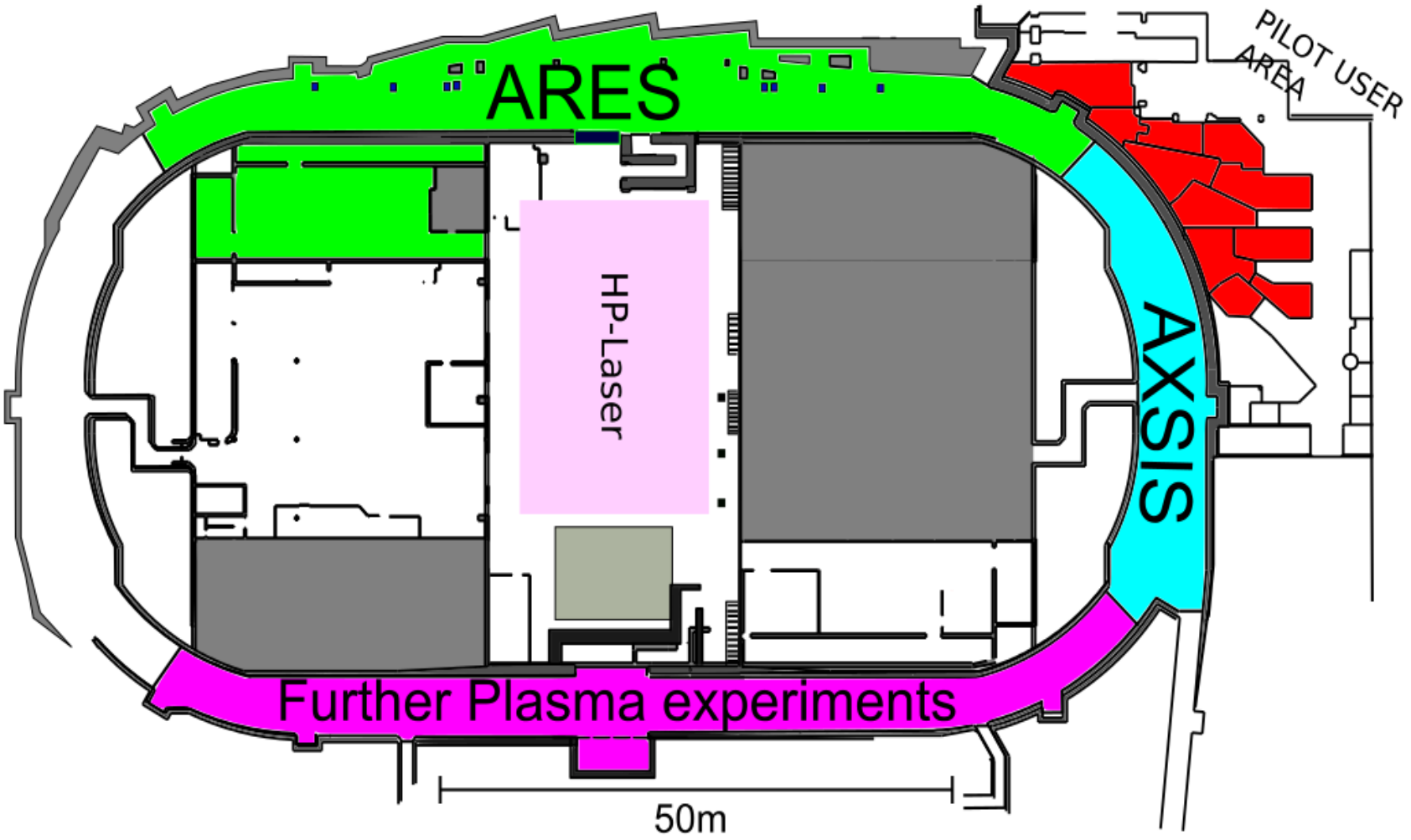
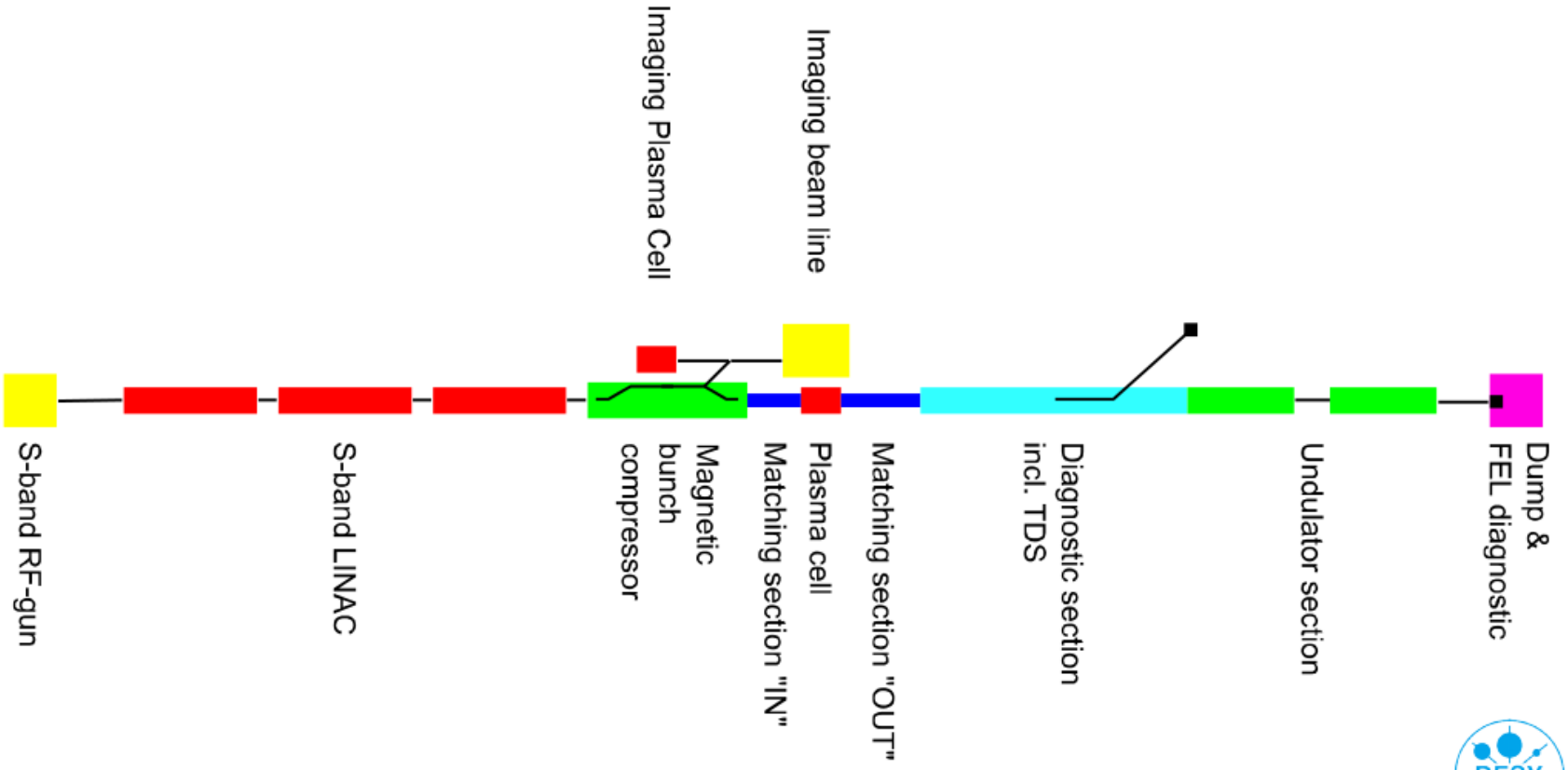
Accelerator Research and Development at DESY

The location - How we intend to use it



ARES (Accelerator Experiment at SINBAD)

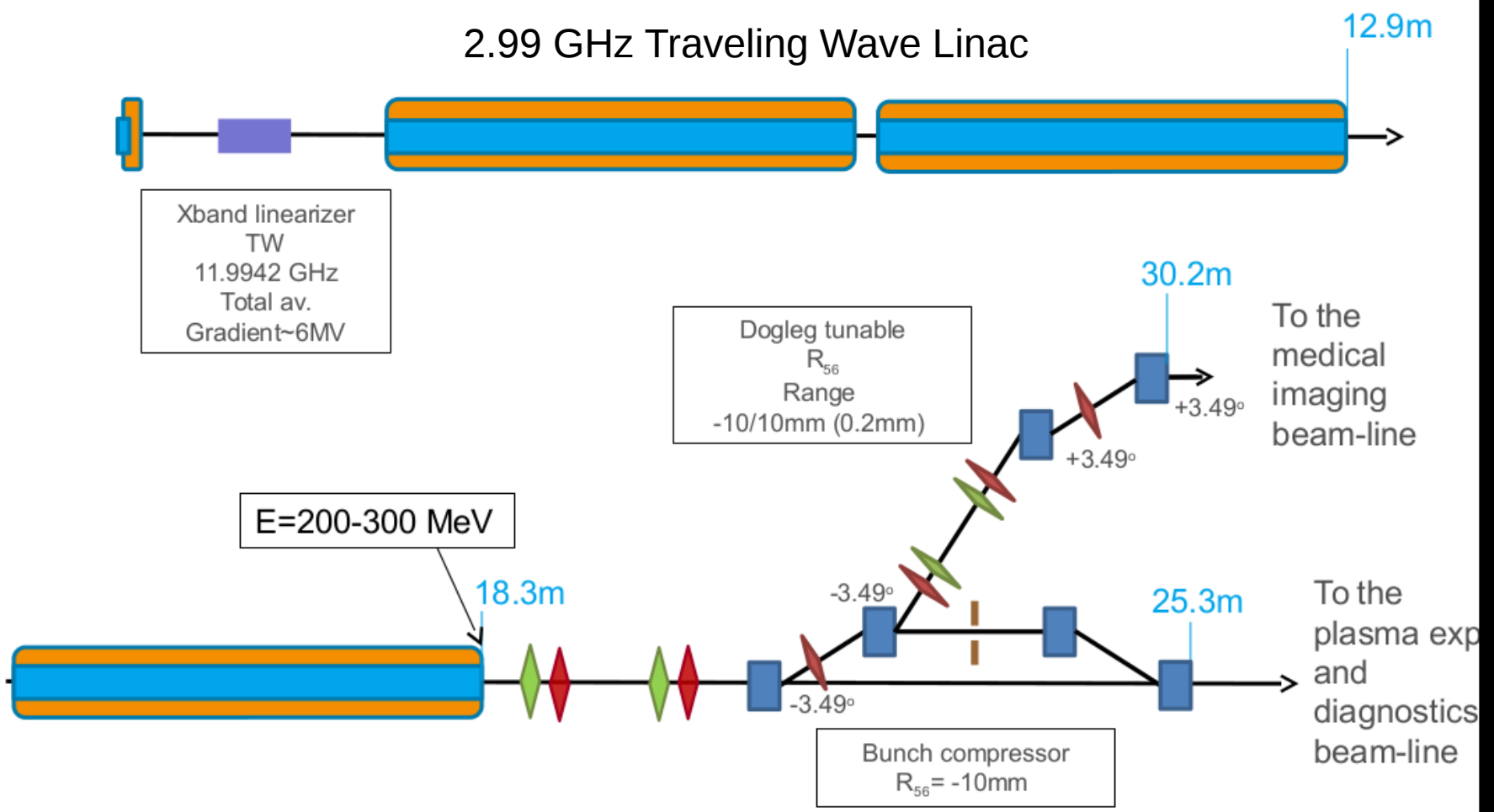
- Staged approach:
  - S-band linac for ultra-short electron bunches (100 MeV, fs)
  - Plasma acceleration for energy doubling at low plasma densities
  - Increase plasma-energy to reach FEL - capabilities



ARES-Linac

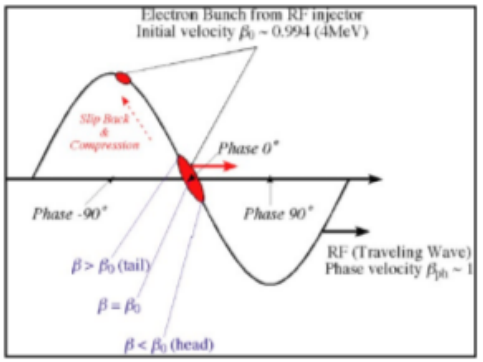
- Initial stand-alone goal: acceleration of ultra-short bunches in a conventional compact linac.
  - Reaching the sub-fs domain **(FWHM bunch length ≤ 1 fs)**
  - E-bunch energy **100 MeV** (later upgrade to 200 MeV)
  - Nominal Charge for ultra-short bunches with RF compression: **0.2-20 pC**
  - Maximal Charge that can be extracted from the cathode: 1nC
  - Energy spread: **0.1 - 0.4 %**
  - Transverse emittance **< 0.5 mm mrad**
- Second stage: ARES as injector into plasma
  - External injection into plasma cell + FEL
    - Arrival time jitter (RMS) **≤ 10 fs**
    - Transverse position jitter **≤ few µm**
  - Imaging set-up (Thomson scattering)

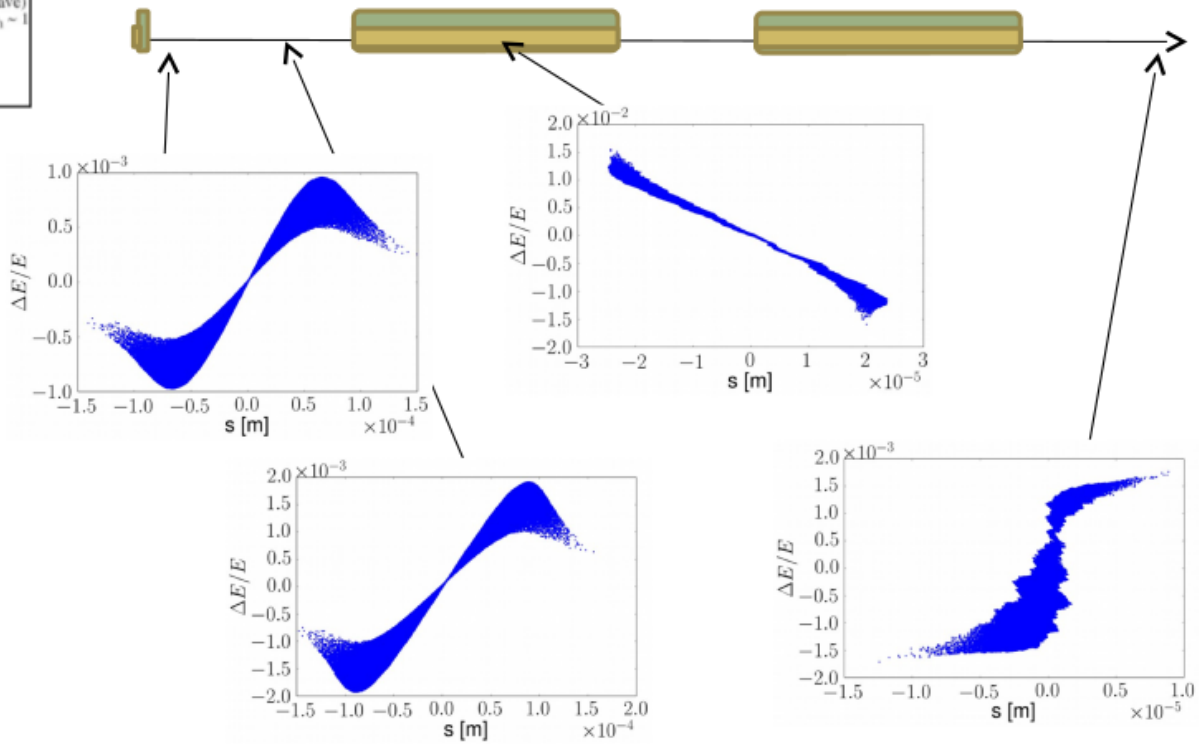
ARES – upgraded layout



RF compression concept

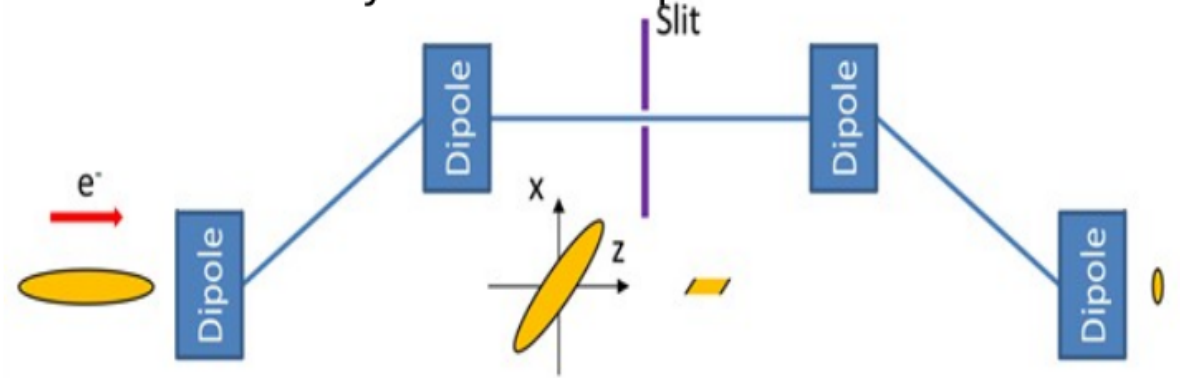
- The first TWS is not used for acceleration but for bunch compression



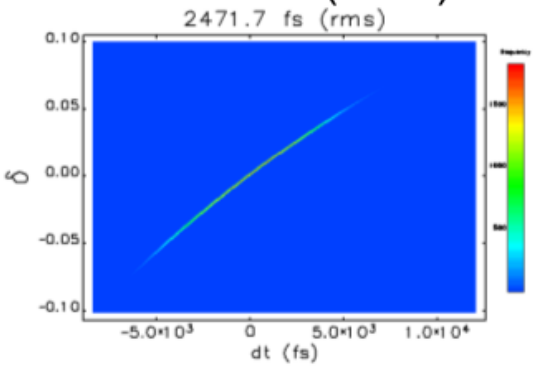


Chicane/Slit Method

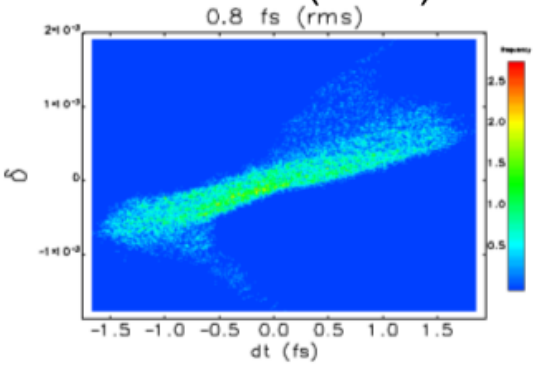
- Add an energy-chirp during acceleration
- Add a 4-dipole chicane with $\Delta s = R56 \frac{\Delta p}{p}$
- At center, electrons are aligned according to their energy $\Delta x = D_x \frac{\Delta p}{p}$
- Add a slit to cut out only the central part



Before:
20pC
2500fs (RMS)



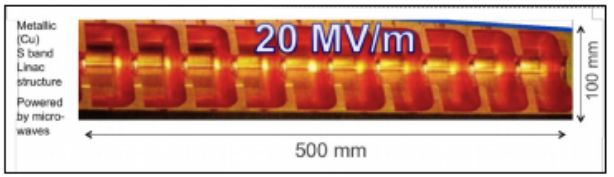
After:
0.37pC
0.8fs (RMS)



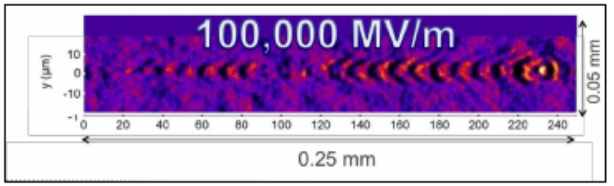
Chicane parameters:
- Chirp: -35/m
- Slit width: 0.3mm
- R56: 28.7 m
- D_x: 20 mm

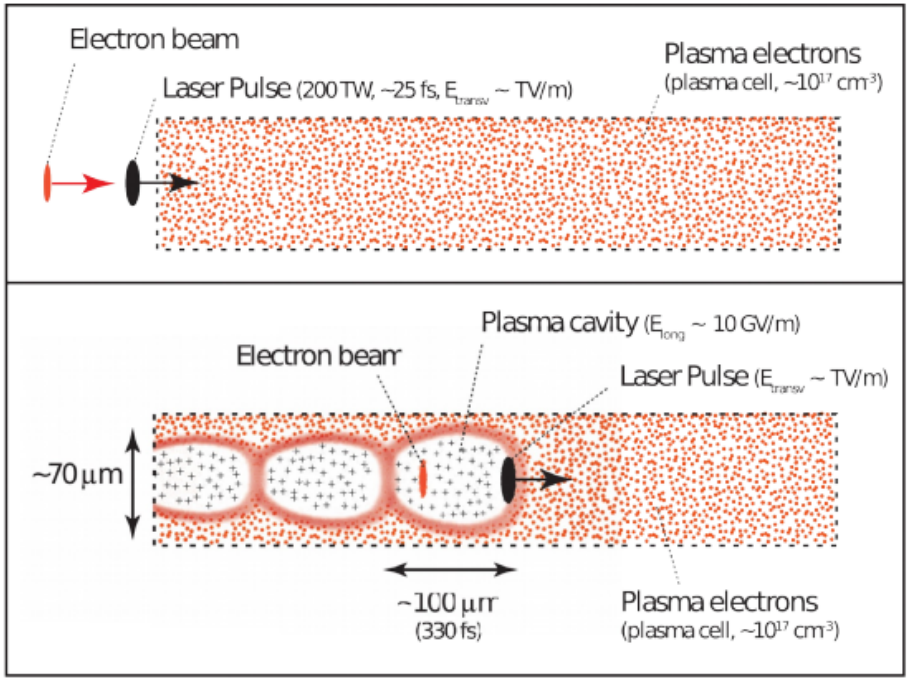
Plasma acceleration basics

RF: Direct transfer of electromagnetic energy of the waves in vacuum to kinetic energy of particles



Plasma acceleration: Transfer of electromagnetic energy of laser pulse or a beam to kinetic energy of particles via a medium: plasma

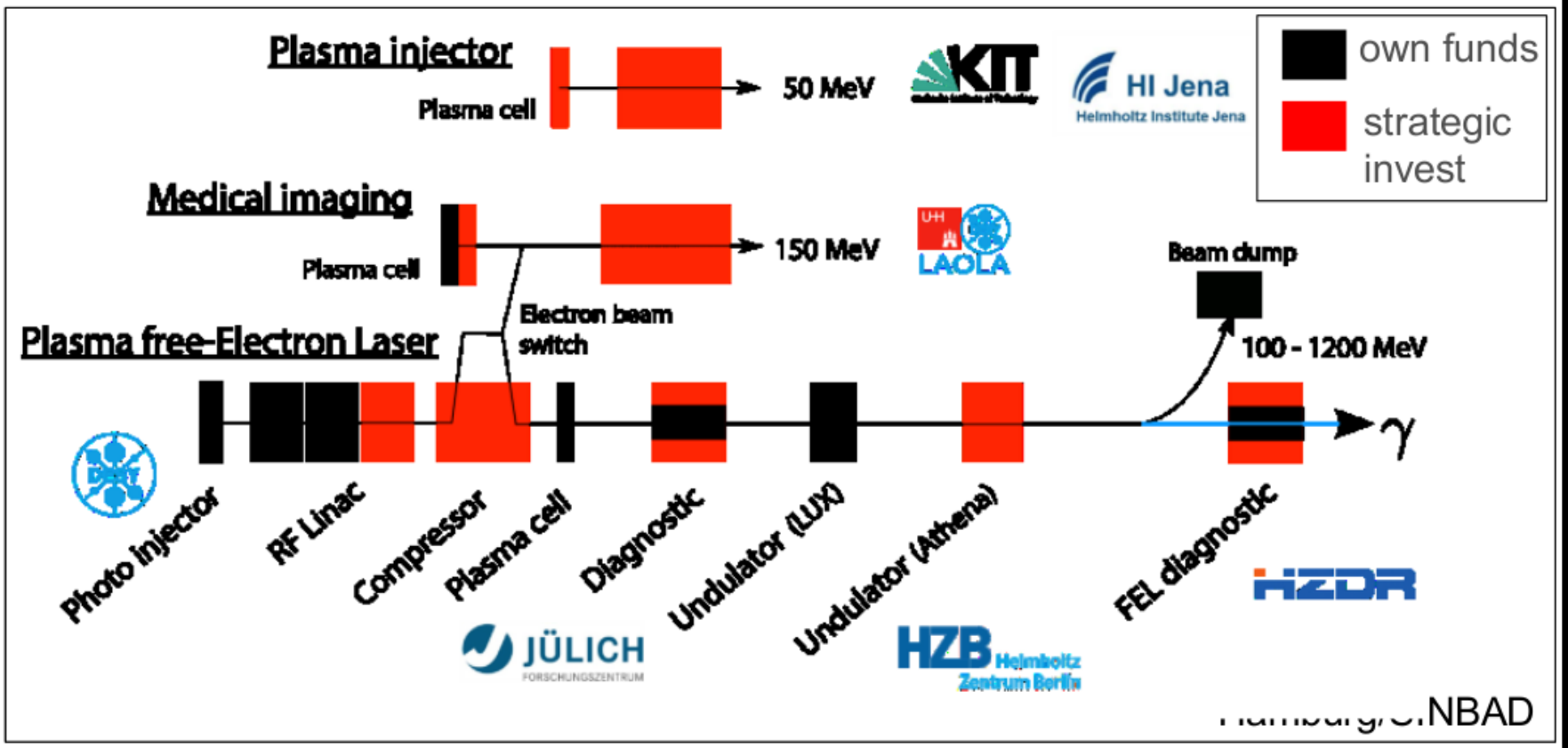




A ultra-short laser pulse or intense beam is focused on a plasma

The pondermotive force of the laser/ Space charge force of the drive beam creates plasma wakes creating ultra-high accelerating gradients and transverse (de-) focusing fields

ATHENA$_e$ (plasma-based e- FEL and injector)



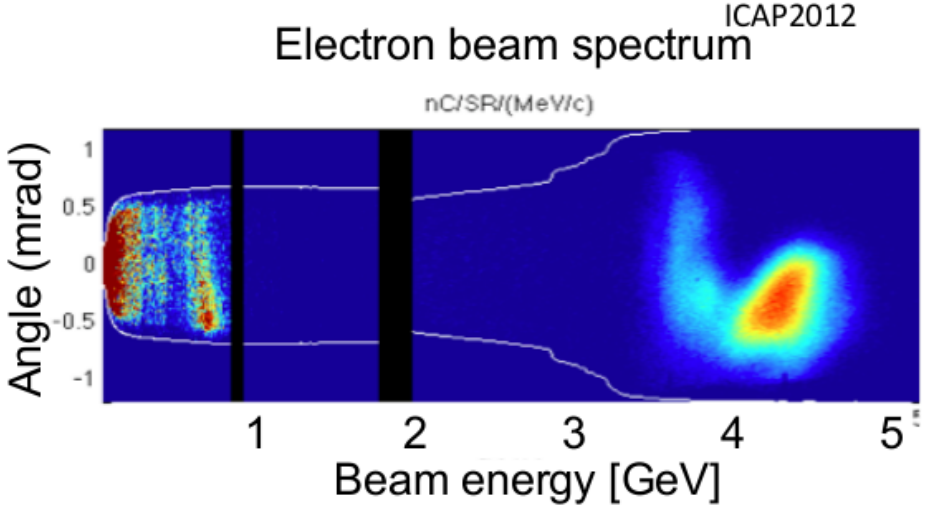
Helmholtz centers and institutes contribute to more than one area/topic! Here only indication for one important contribution! Indicates also UHH/LAOLA contribution!

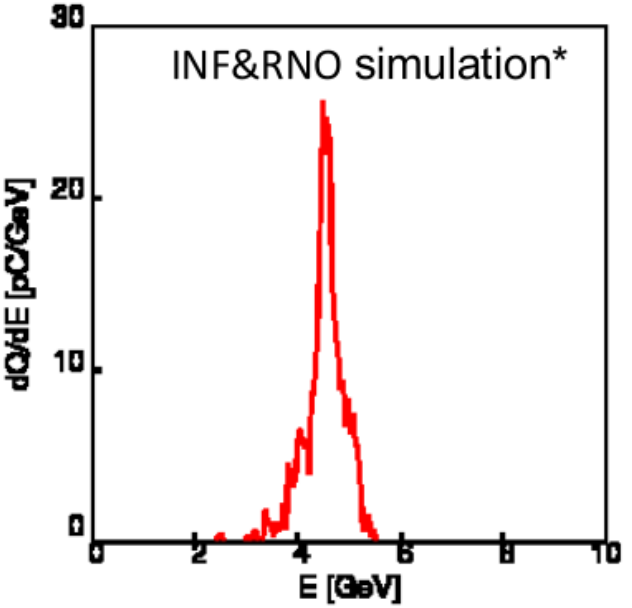
ARD

HELMHOLTZ GEMEINSCHAFT

4.25 GeV beams have been obtained from 9 cm plasma channel powered by 310 TW laser pulses **(15 J)**

*C. Benedetti et al., proceedings of AAC2010, proceedings of ICAP2012





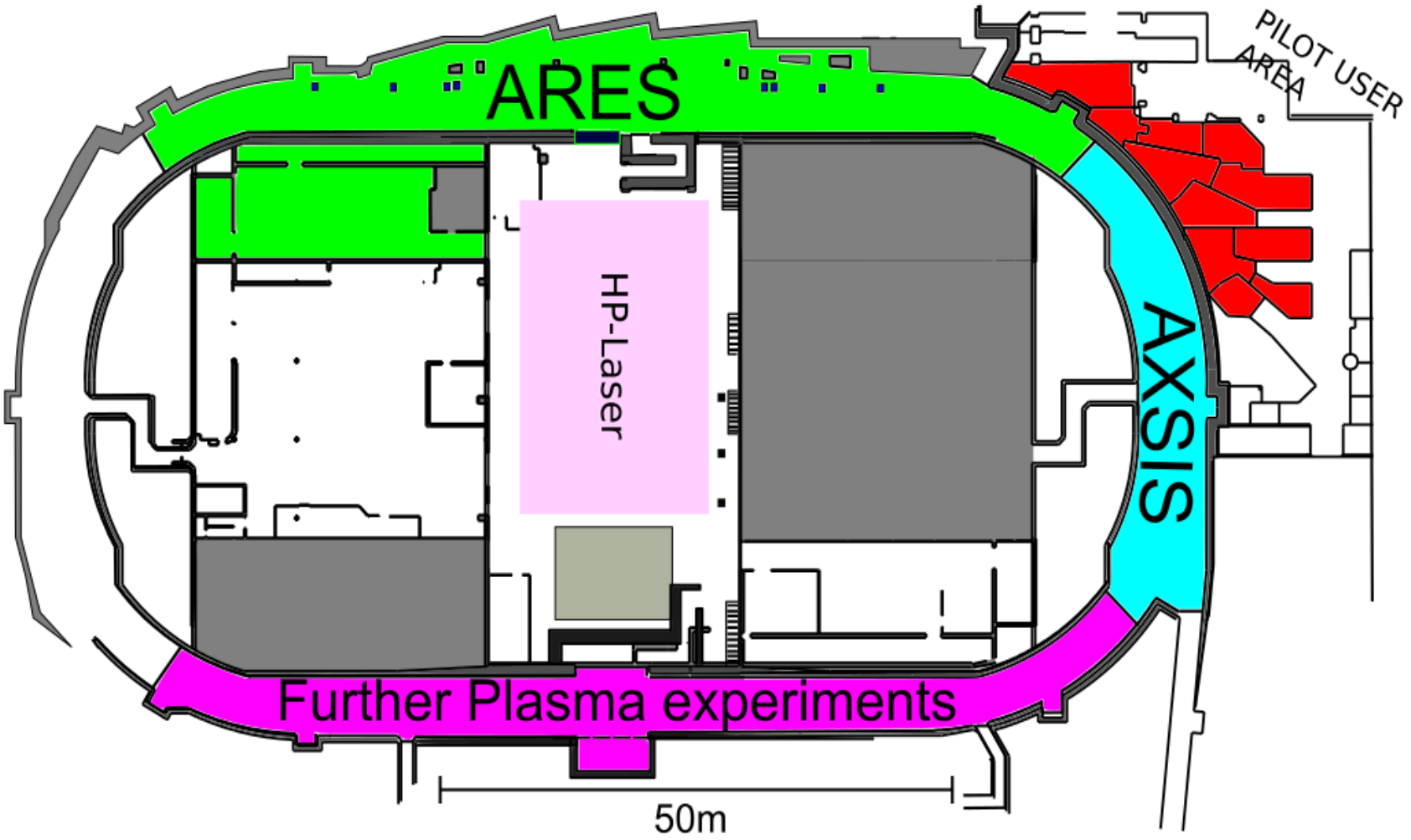
Slide: W. Leemans

- **Laser** (E=15 J):
  - Measured longitudinal profile (T_0= 40 fs)
  - Measured far field mode (w_0=53 μm)
- **Plasma:** parabolic plasma channel (length 9 cm, n_0~6x10^{17} cm^{-3})

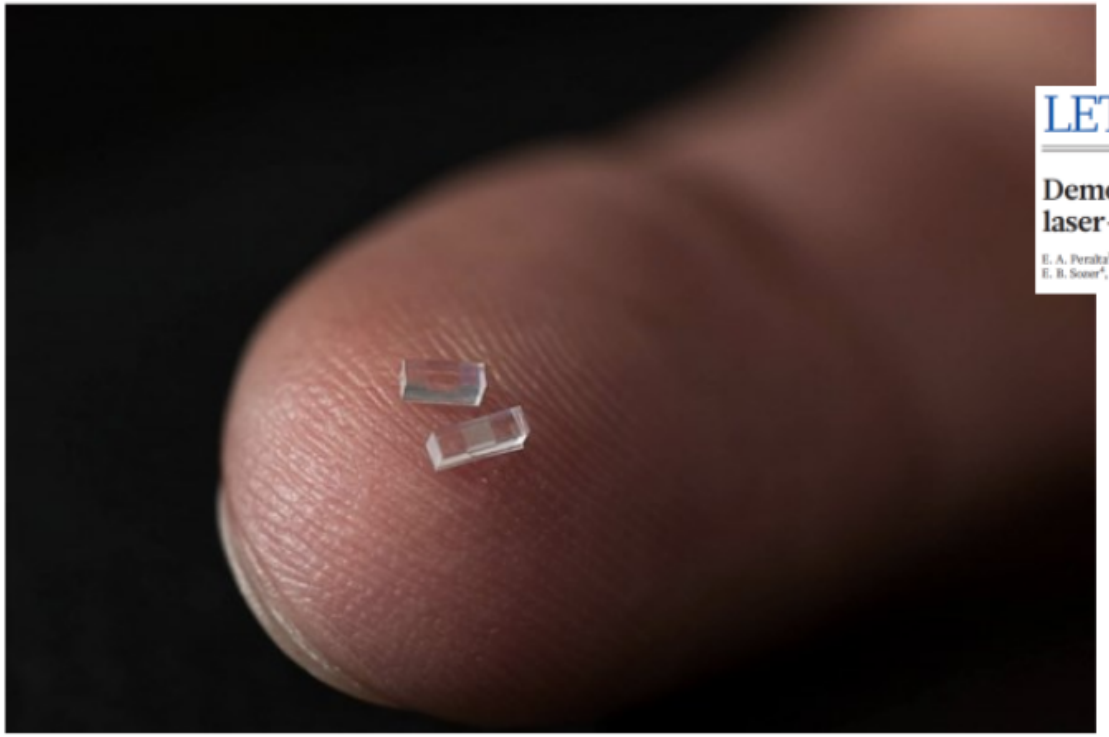
	Exp.	Sim.
Energy	4.25 GeV	4.5 GeV
ΔE/E	5%	3.2%
Charge	~20 pC	23 pC
Divergence	0.3 mrad	0.6 mrad

W.P. Leemans et al.,PRL 2014, in print

The location - How we intend to use it



Methode 1: Dielektrische Strukturen



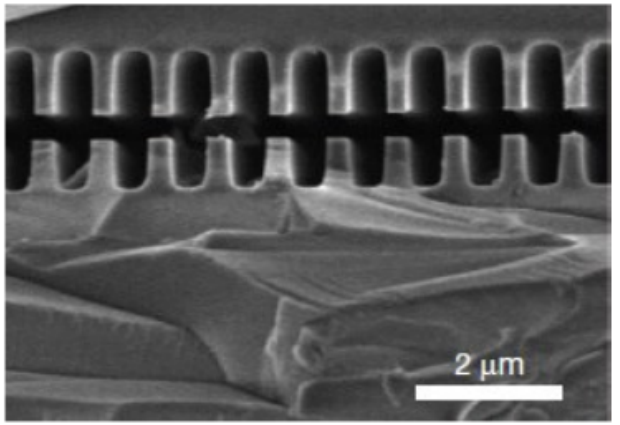
Beschleuniger auf einem Chip

LETTER

doi:10.1038/nature12664

Demonstration of electron acceleration in a laser-driven dielectric microstructure

E. A. Peralta[1], K. Soong[1], R. J. England[2], E. R. Colby[2], Z. Wu[2], B. Montazeri[3], C. McGuinness[3], J. McNeur[4], K. J. Leedle[3], D. Walz[2], E. B. Sozer[4], B. Cowan[5], B. Schwartz[5], G. Travish[4] & R. L. Byer[1]



AXSIS: Grössere Apertur (etwa 1mm) mit THz Laser alsTreiber! Franz Kärtner als Weltspezialist für THz Laser.

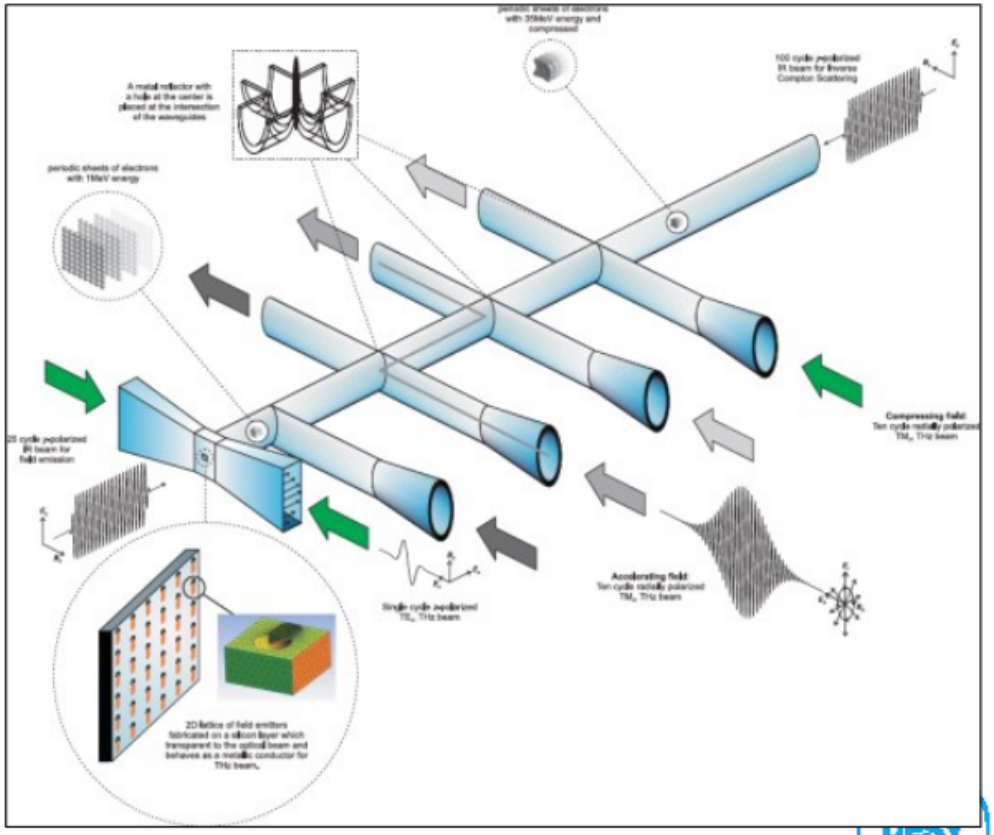
Koppelung des transversalen Laserfeldes in longitudinale Richtung. Plus advanced Photokathoden.

ERC Synergie Grant (EU finanziert; 13.9 M€)

European Research Council
Established by the European Commission

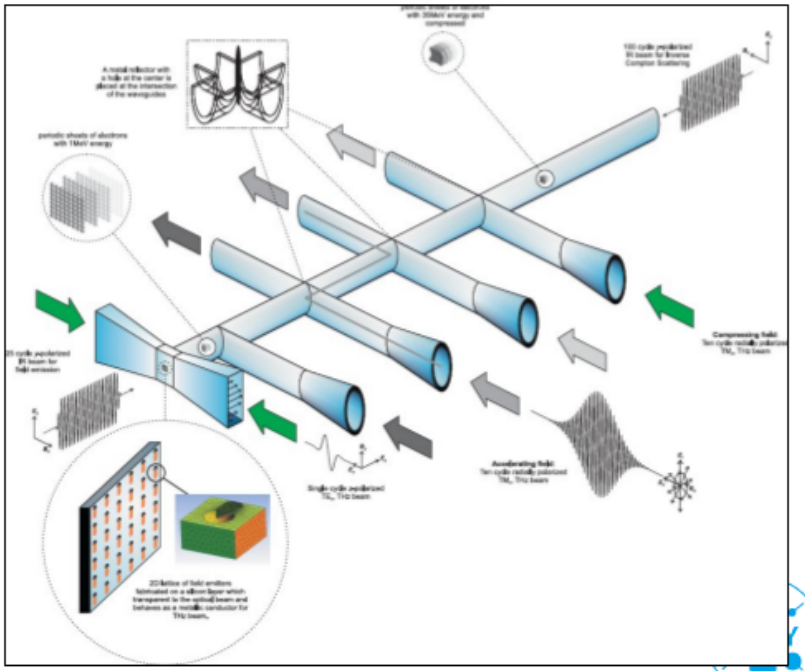
- **Kompakte atto-Sekunden Lichtquelle**, basierend auf neuer, lasergetriebenen Beschleunigertechnologie (kein Plasma). Forschung am Photosystem.

- **Interdisziplinäres Team:**
  - Laserwissenschaft (F. Kärtner, DESY/Uni HH)
  - Spektroskopie (H. Chapman, DESY/Uni HH)
  - Biologie (P. Fromme, Uni Arizona)
  - Beschleunigerwissenschaft (R. Aßmann, DESY)



AXSIS building blocks

- THz photo-cathode gun (future upgrade: nano-structured photo-cathode)
- THz laser acceleration to 15MeV in dielectric loaded waveguides
- RF compression by THz module
- Charge: few pC
- Repetition rate: kHz
- ICS process: 1J laser at 1 μm wavelength (10 μm spot size)
- X-ray beam line design chosen
- Discussions on BD-line ongoing



Beam in 2020!