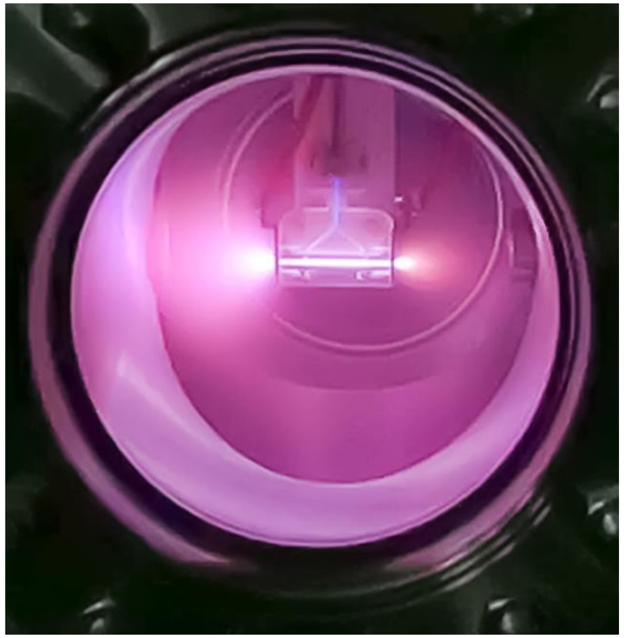
AQUA
The EuPRAXIA@SPARC_LAB water-window beamline

Francesco Stellato
University of Rome Tor Vergata & INFN
Fabio Villa
LNF-INFN

on behalf of the EuPRAXIA@SPARC_LAB

AQUA - Figures

Plasma / X-band RF driven FEL



A multi-purpose SASE FEL beamline

Parameter	Value
Wavelength	3-4 nm
Photons/pulse	10^{10} - 10^{11}
Pulse duration	10-50 fs
Repetition rate	10 Hz
Focal spot	~6 µm

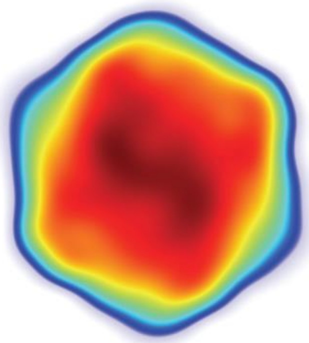
→ 100-400Hz new option is being explored

Ferrario *et al.* NIM 909 (2018)

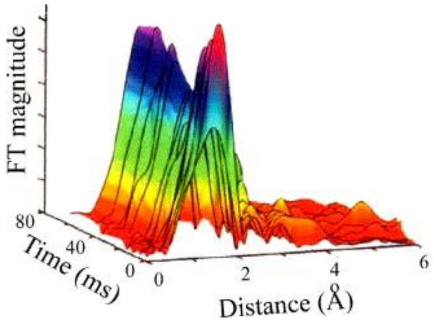
AQUA - Techniques & Samples @ 3-4 nm

Experimental techniques and typology of samples

Coherent imaging



X-ray absorption spectroscopy



Raman spectroscopy

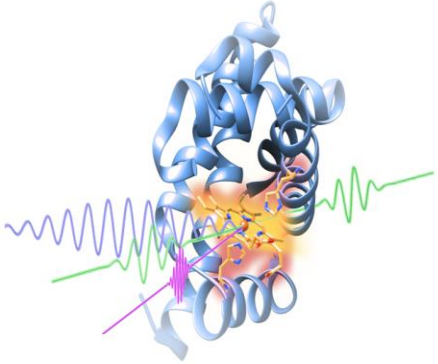
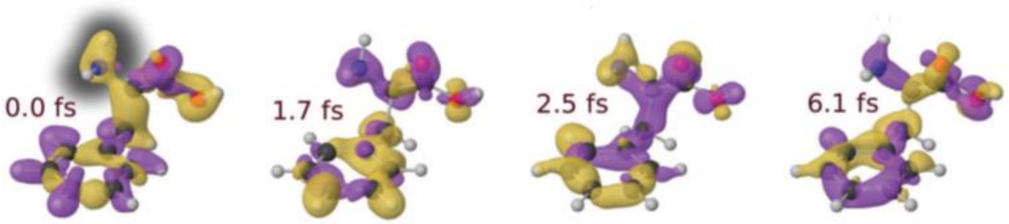
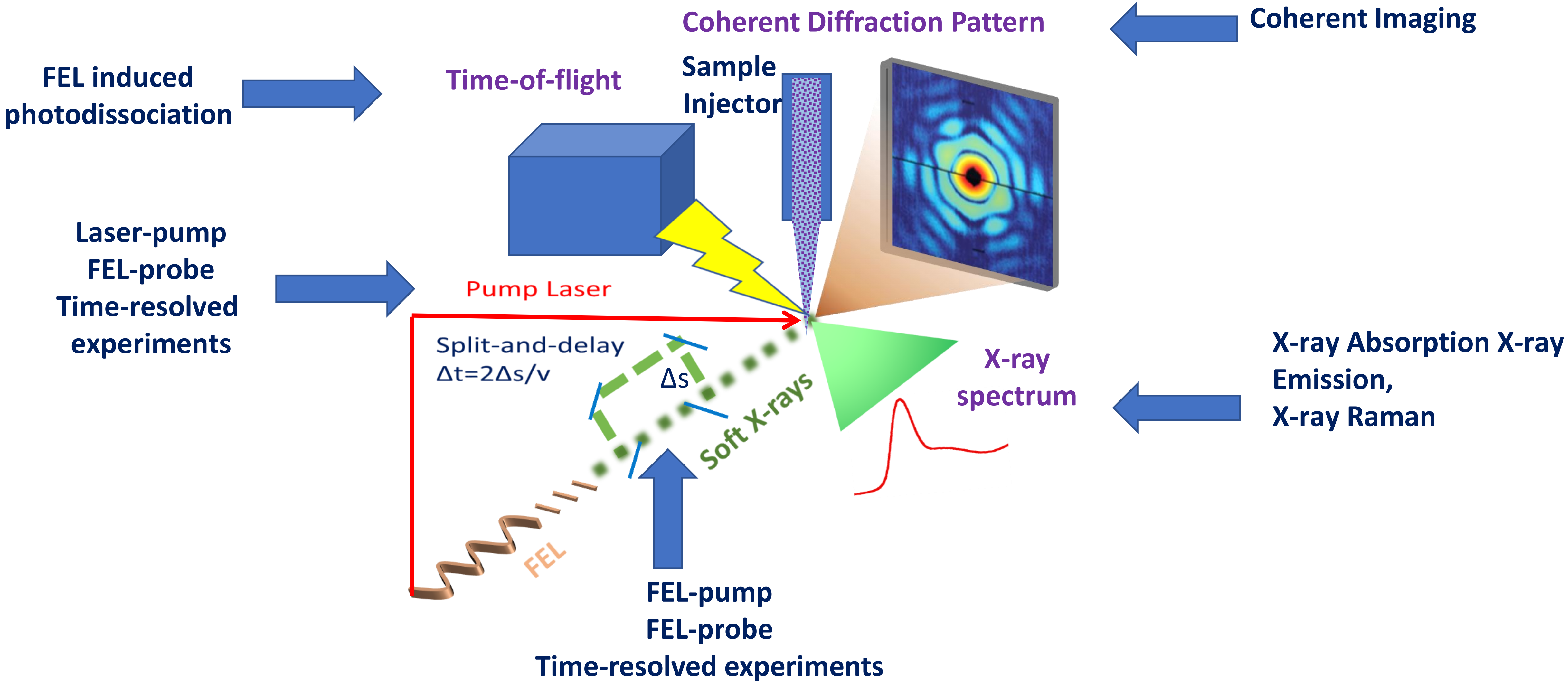


Photo-fragmentation of molecules



Proteins
Viruses
Bacteria
Cells
Metals
Semiconductors
Superconductors
Magnetic materials
Organic molecules

AQUA - Techniques & Samples @ 3-4 nm



AQUA – Coherent Imaging in the water-window

Energy region between
Oxygen and Carbon K-edge
2.34 nm – 4.4 nm (530 eV -280 eV)
Water is almost **transparent**
to radiation in this range while nitrogen and carbon are absorbing (and scattering)

Coherent Imaging of biological samples living in their native state

Balerna *et al.* Cond. Matt. 2019

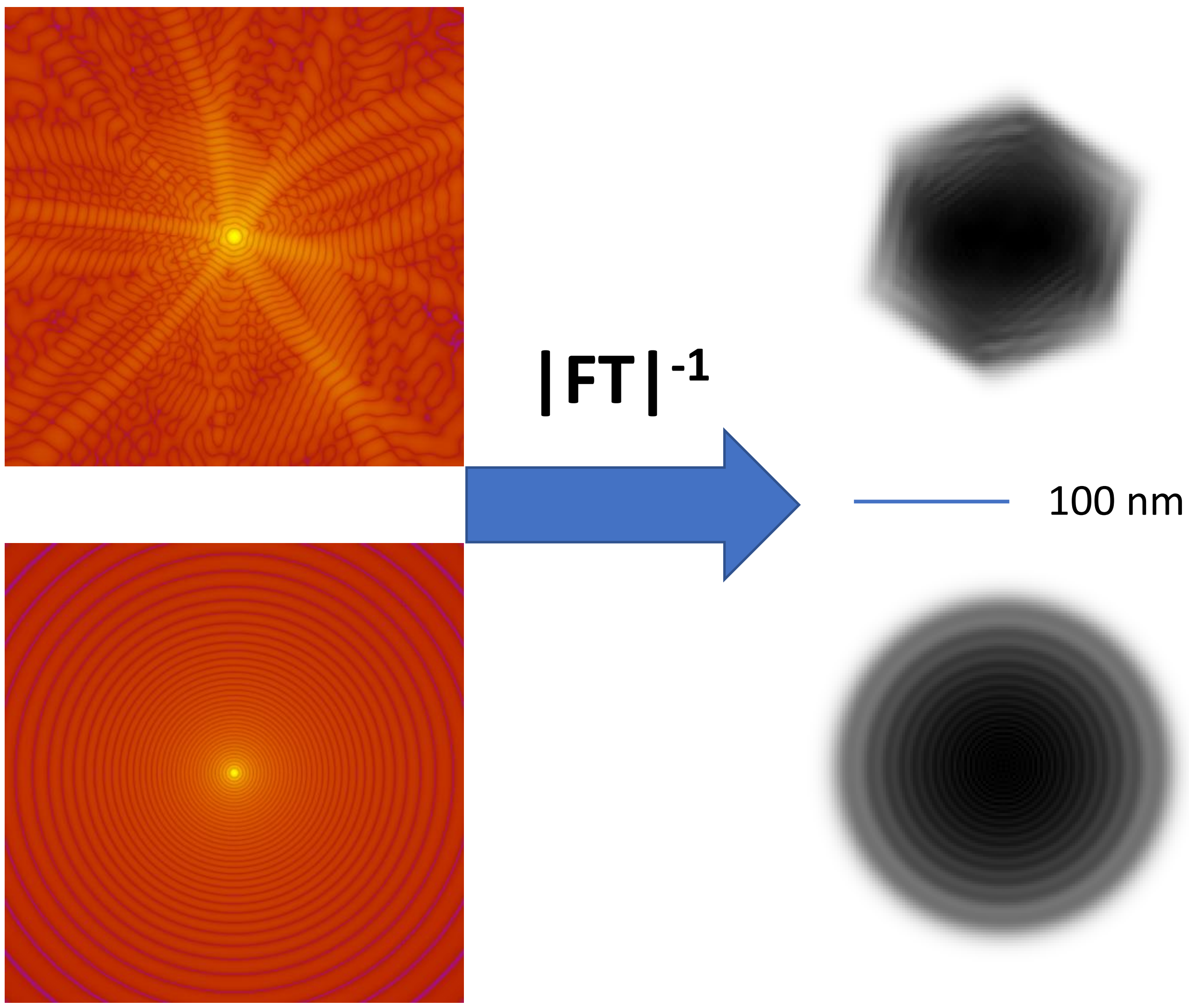
AQUA – Viruses in the water-window

Simulated diffraction patterns (**Condor** software) & electron density reconstructions for 100 nm diameter virions.

The considered **3 nm FEL** beam has the **EuPRAXIA** design parameters

Icosahedral

Spherical



Hantke *et al.* J. Appl. Cryst. 2016

AQUA – Conceptual Design Report Scientific case

A scientific case
@ 3 nm
«AQUA»
has been assembled and published.

Contributions from~15 different institutions

Participants from ~30 different institutions @ ESUW21

Article

MDPI

The potential of EuPRAXIA@SPARC_LAB for radiation based techniques

Antonella Balerna[1], Samanta Bartocci[2], Giovanni Batignani[3], Alessandro Cianchi[4,5], Enrica Chiadroni[1], Marcello Coreno[1,6], Antonio Cricenti[6], Sultan Dabagov[1,7,8], Andrea Di Cicco[9], Massimo Faiferri [2], Carino Ferrante[3,10], Massimo Ferrario[1], Giuseppe Fumero[3,11], Luca Giannessi[12,13], Roberto Gunnella[9], Juan José Leani[14], Stefano Lupi[3,15], Salvatore Macis[4,5], Rosa Manca[2], Augusto Marcelli[1,6], Claudio Masciovecchio[12], Marco Minicucci[9], Silvia Morante[4,5], Enrico Perfetto[4,16], Massimo Petrarca[3,15], Fabrizio Pusceddu[2], Javad Rezvani[1], José Ignacio Robledo[14] , Giancarlo Rossi[4,5,17], Héctor Jorge Sánchez[14,18], Tullio Scopigno[3,10], Gianluca Stefanucci[4,5], Francesco Stellato[5], Angela Trapananti[9], and Fabio Villa[1]

Balerna *et al.* Condensed Matter 4, 30 (2019)

AQUA @ ESUW21

Flavio Capotondi - Elettra
Development on coherent diffraction based imaging techniques at FERMI seeded-FEL

Emiliano De Santis – Uppsala University
Controlling protein orientation using strong electric fields: perspectives for single particle imaging

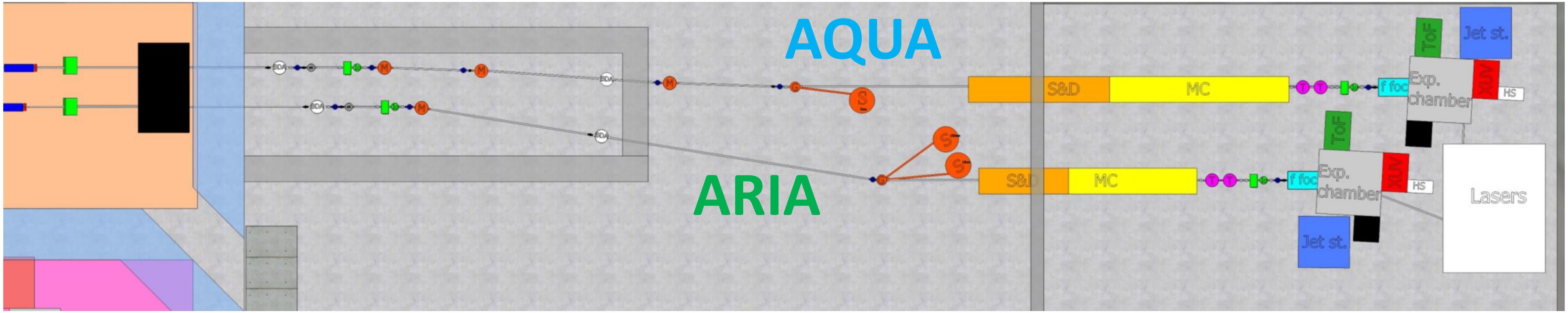
Markus Guehr – Potsdam University
Investigations of molecular photoenergy conversion using ultrashort x-ray pulses

Javid Rezvani – Camerino University
Soft x-ray absorption and pump-probe experiments of transient states using FEL sources

Majed Chergui – EPFL
Ultrafast dynamics of molecular systems with ultrashort optical and X-ray pulses

Matteo Mitrano – Harvard University
Dynamical control of electronic interactions in quantum materials

AQUA & ARIA Beamlines



EuPRAXIA@SPARC_LAB experimental hall can fit two beamlines

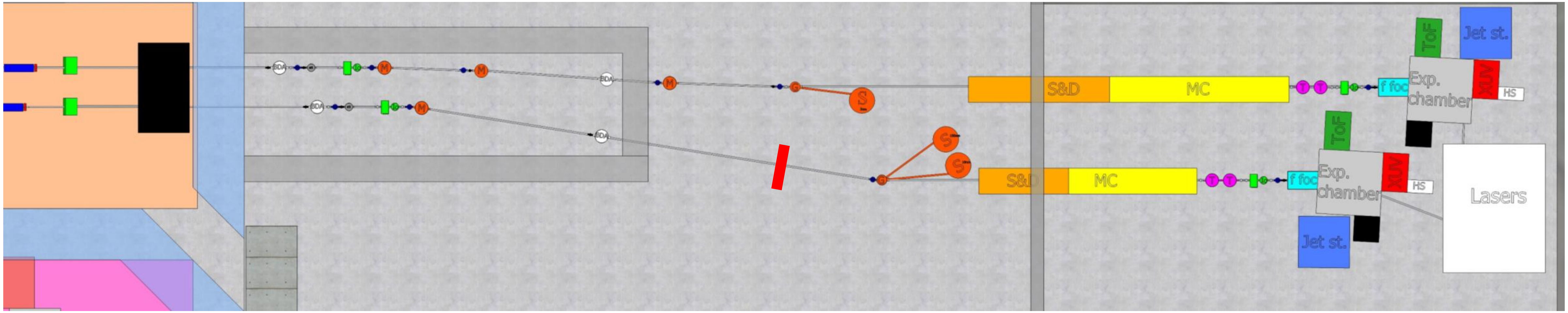
Beam characterization

online single-shot measurements

- Photon number/pulse: gas intensity monitors
- Longitudinal dimension & arrival time: THz/IR ionization streaking
- Spectrum: grating spectrometer
- Beam position: plate BPMs
- Polarization: gas ionization ToF array

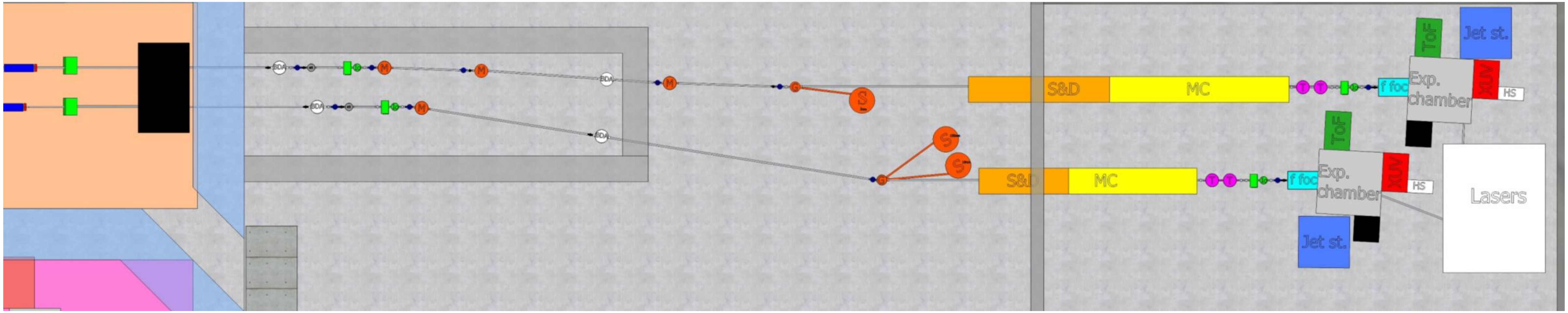
offline characterization of the beam

- Transverse dimensions: scintillating screens
- Coherence: interferometric measurements
- Wavefront: Hartmann sensor



Beam manipulation

- Position: Mirrors @ grazing incidence (Ni@3-4 nm, Al?@200-50 nm)
- Dimensions: K-B mirrors
- Time shape: split & delay line
- Spectrum: Grating monochromator (with close dispersion)
- Energy: film attenuators
- Beam definition apertures (for machine protection)

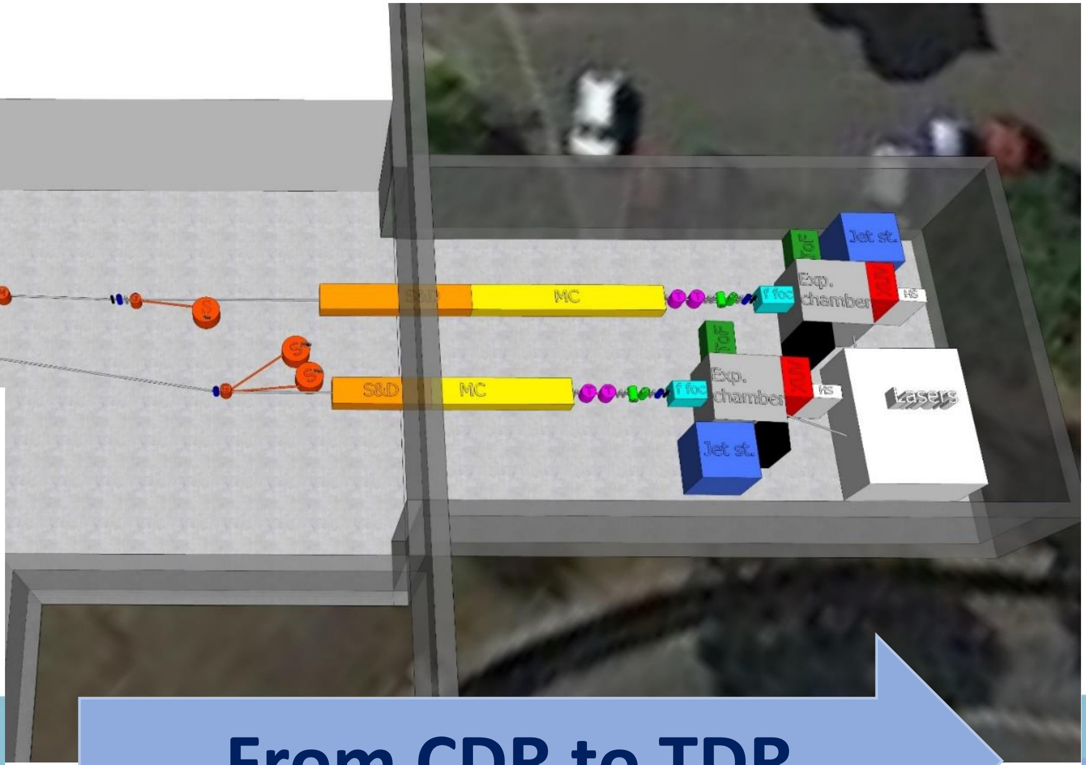


External Radiation Sources with FEL pulses

Time-resolved pump-probe experiments require coupling to an **external radiation sources** (besides FEL split&delay):

1. **IR/vis lasers**: Two options are being explored for the TDR:
   - Tunable laser source for the experiments requiring intensity < TW (with Ti:sapphire harmonics and OPO source)
   - High-power Ti:sapphire laser at 800 nm (more than ∼100 mJ/35fs pulses require a large increase in costs, encumber and complexity due to laser compression, transport synchronization and safety)
2. **THz** setup will also be detailed in the TDR

Users' inputs are timely due
Bringing this picture from CDR to TDR level

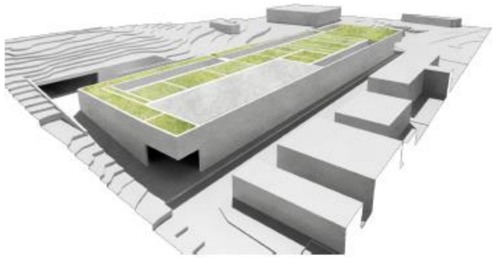


INFN
Istituto Nazionale di Fisica Nucleare

LNF–18/03
May 7, 2018

EuPRAXIA@SPARC_LAB

Conceptual Design Report



From CDR to TDR

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Technical Design Report