

The Perspective and Application of Extreme-UV FEL at Dalian



Weiqing Zhang

State Key Laboratory of Molecular Reaction Dynamics
Dalian Institute of Chemical Physics, CAS



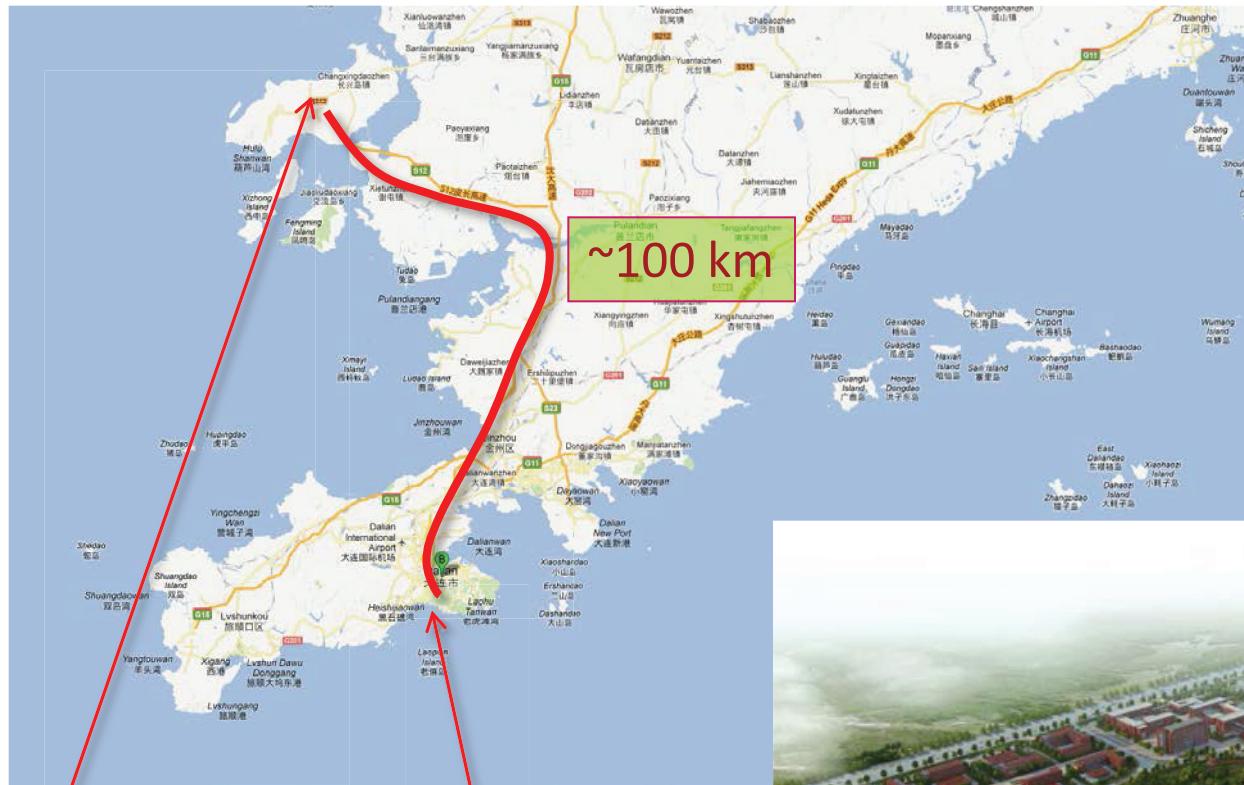
Dalian



Shanghai



Dalian Coherent Light Source Site



New DICP Campus

Main DICP Campus

EUV FEL

FEL13, 2013.08.29



Outline

**Proposed FEL Machine
(Dalian Coherent Light Source)**

Perspective and application of DCLS

Schedule

Major Technical Specifications of DCLS

- Targeted Wavelength Range:
50-150nm, completely tunable
- Pulse Energy: $\sim 100 \mu\text{J}$
- Repetition Rate: up to 50 Hz
- Pulse Width: 100 fs/1ps
- Two FEL Lines

The Layout of DCLS

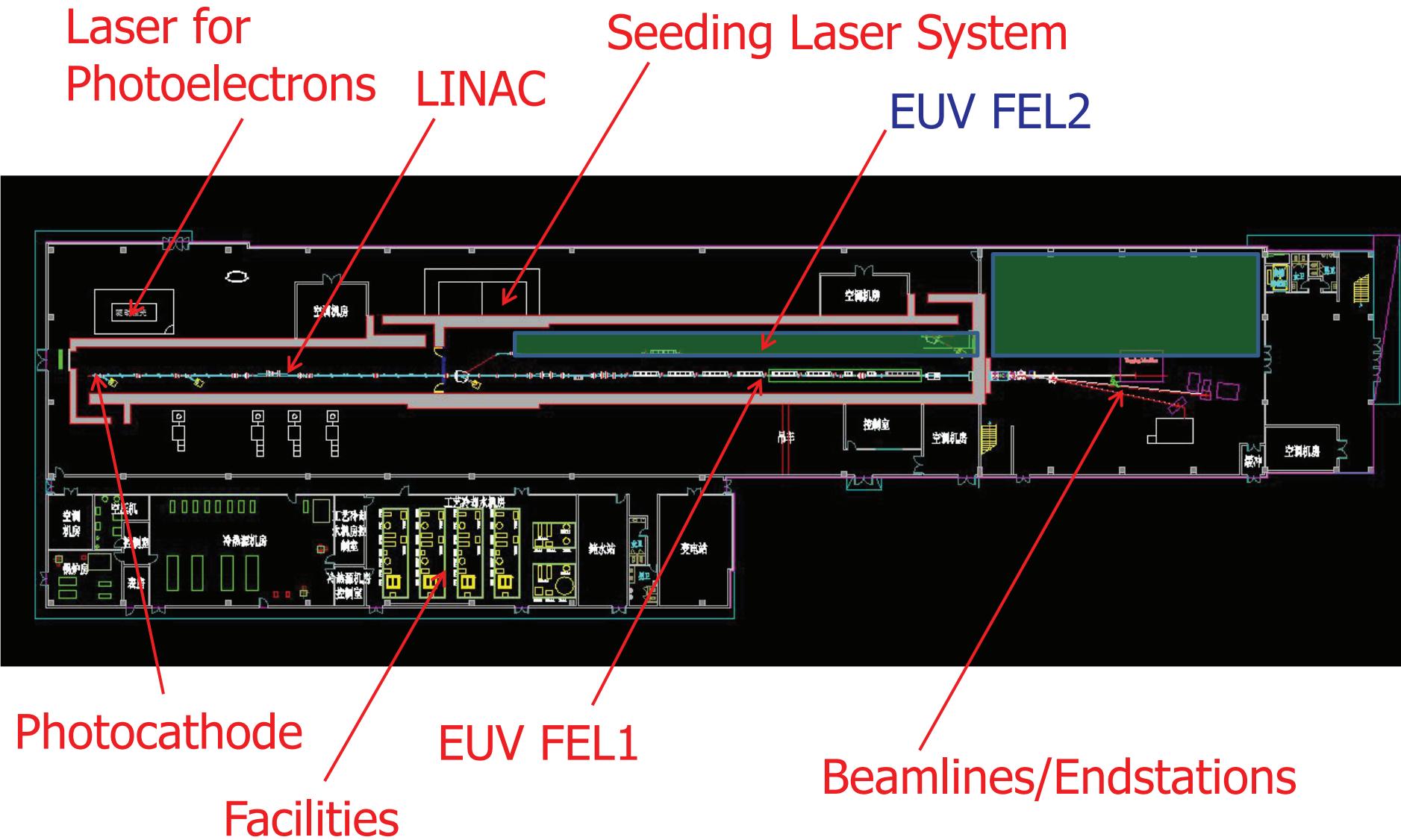
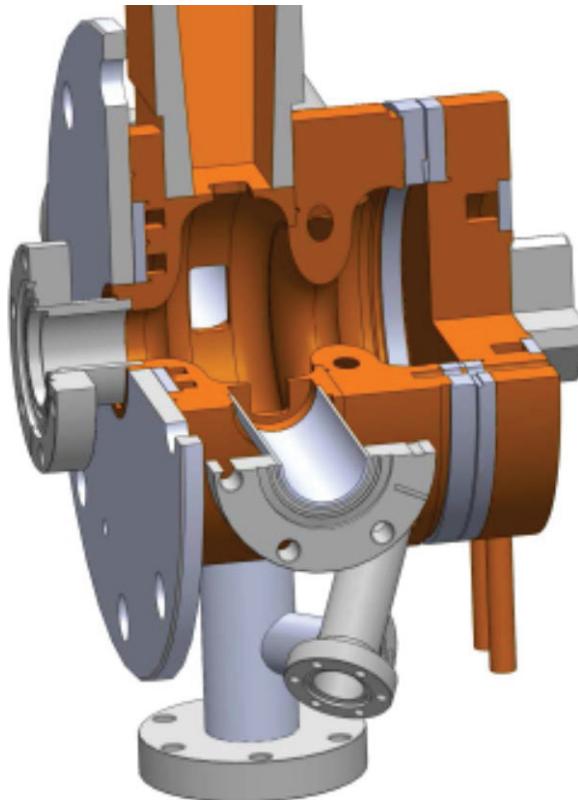
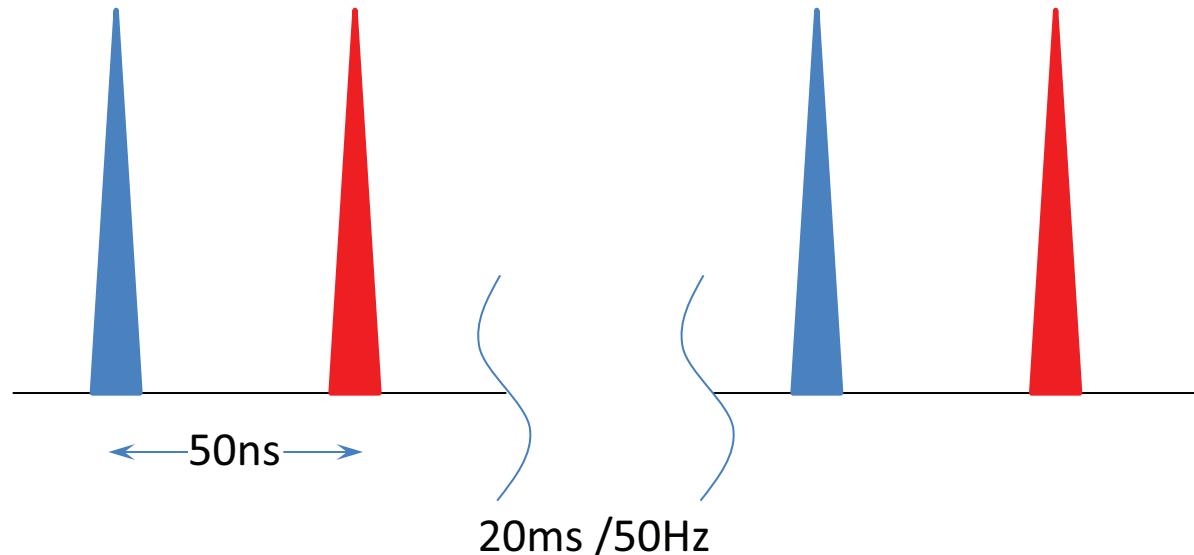


Photo cathode (BNL type)



Key parameter	
Cathode material	Cu
Gun gradient (MV/m)	100
Laser power(uJ)	250
Laser longitudinal length (ps)	7
Emmittance (mm-mrad, rms)	1
Quantum efficiency	3×10^{-5}

Double pulse technique



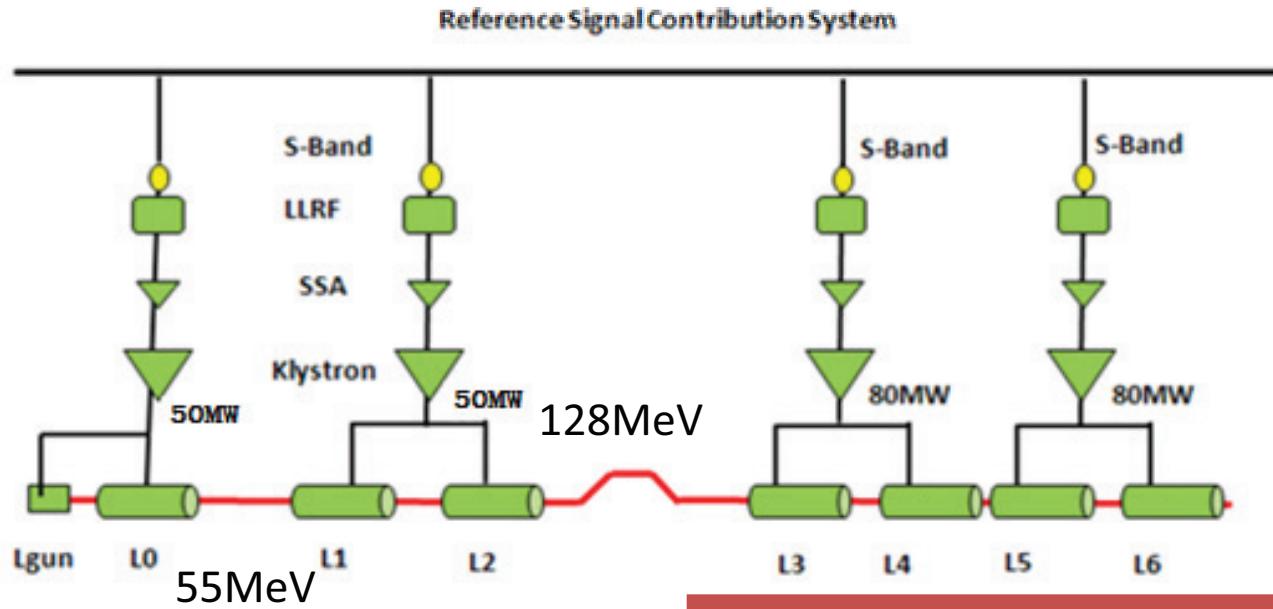
Double the flux of optical beam

From PSI SwissFEL CDR

Alternative of the second arm of undulator

Kicker of electron beam

SLAC type S-band linac structure

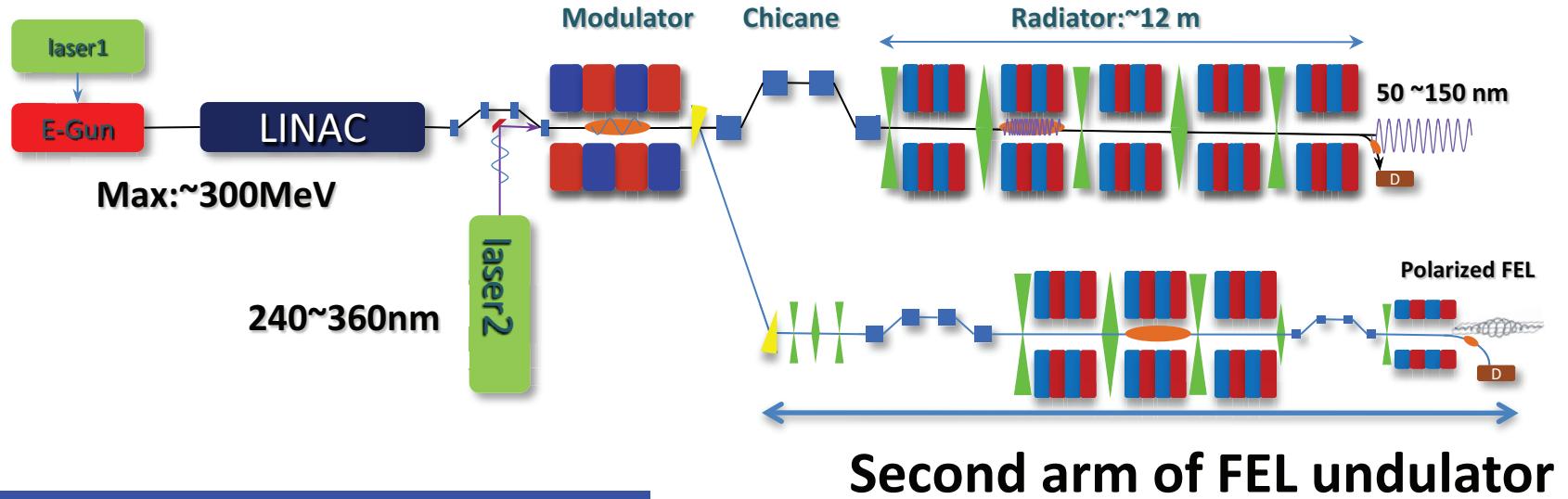


Key parameter

Maximum e beam energy (MeV)	300
Energy spread (rms)	<0.20%
Emmittance (mm-mrad, rms)	≤ 2.0
Bunch length (ps, FWHM)	≤ 1.0
Charge per bunch (nC)	0.5
Repetition rate (Hz)	50

DCLS: 50-150nm tunable

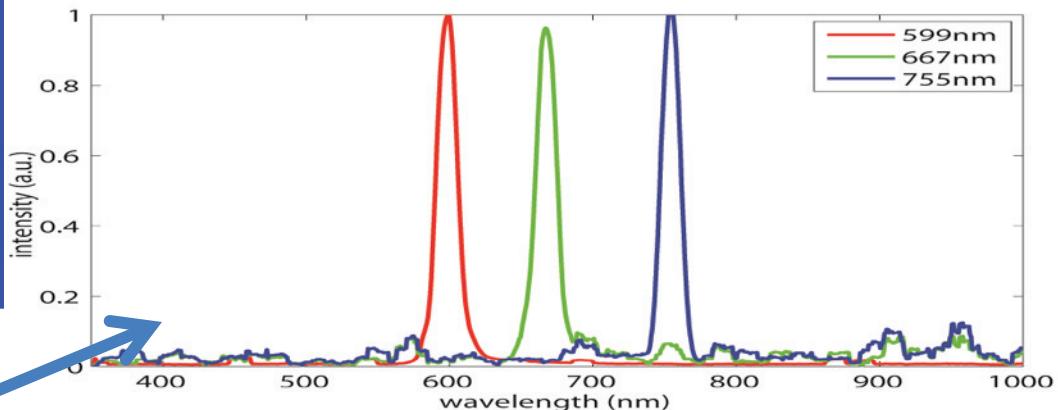
HGHG



Second arm of FEL undulator

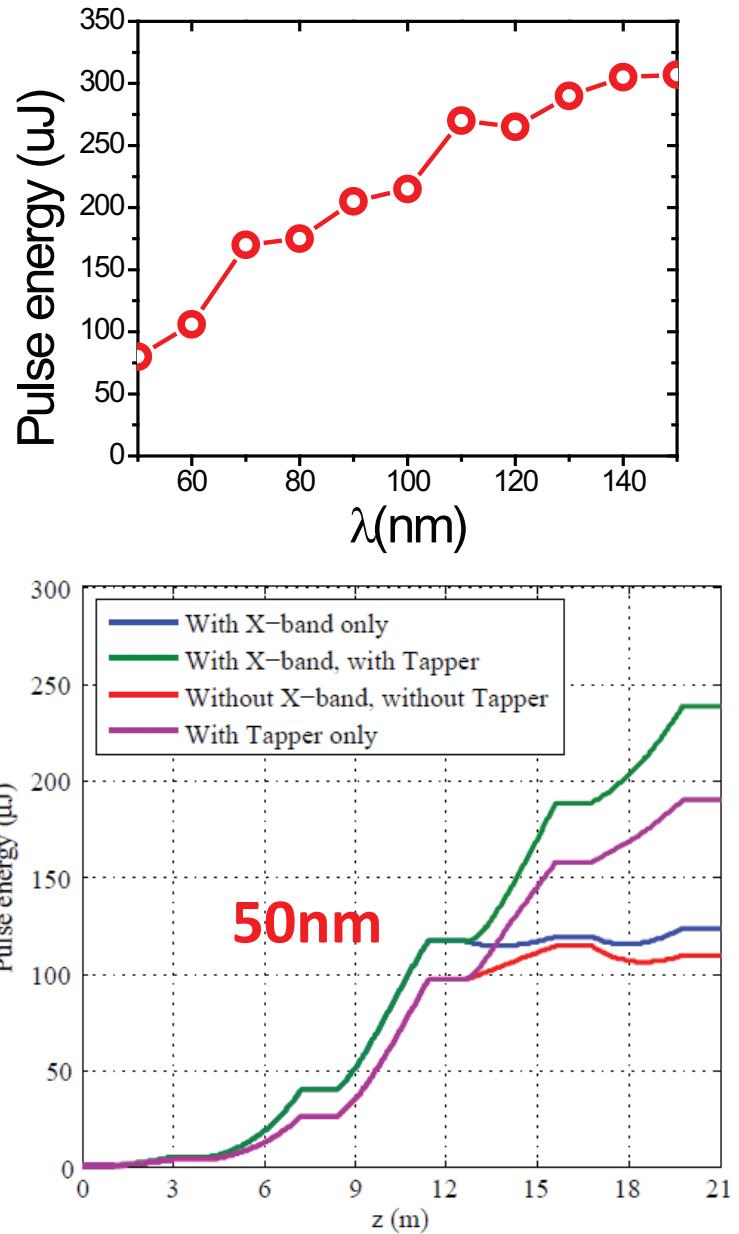
Adjustment:
Wavelength of seed laser
Gap of modulator
Gap of radiator

SDUV



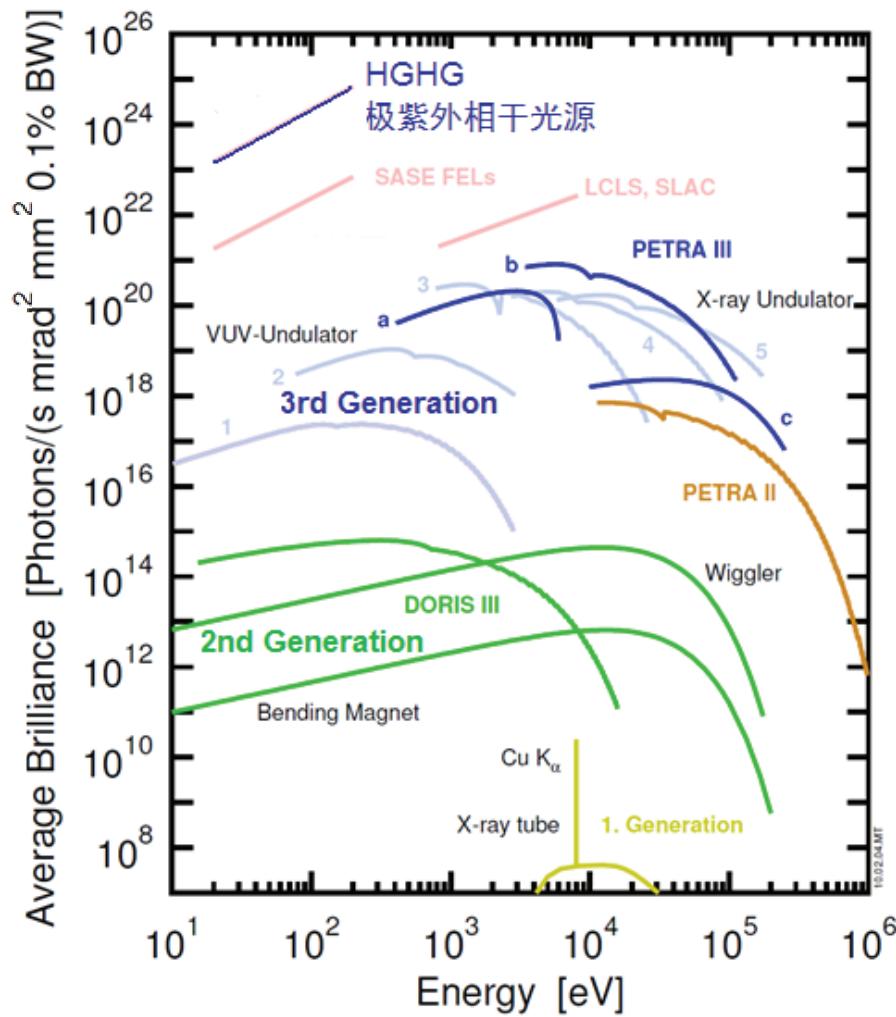
Hybrid undulator

Modulator parameter	
Period (mm)	50
Gap (mm)	10-60
Total length(m)	0.5
Radiator parameter	
Period (mm)	30
Gap (mm)	9-40
Total length(m)	12+6
Seed laser parameter	
Wavelength (nm)	240-360
Pulse length (fs/ps)	100/1
Power (uJ)	10/100



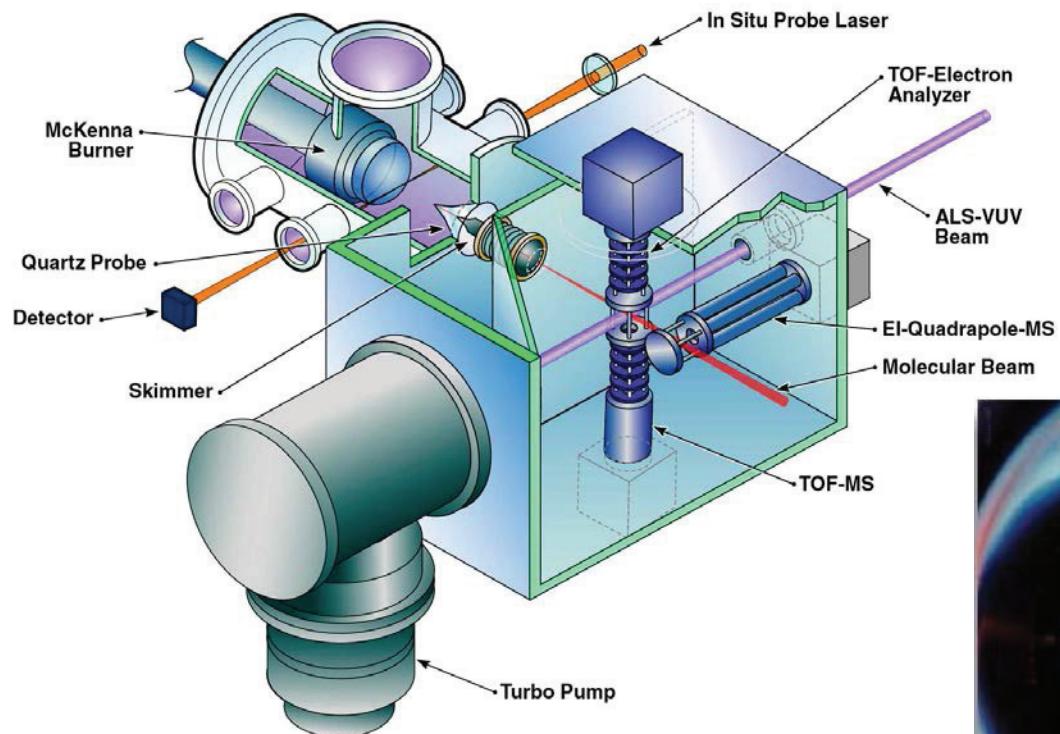
Major Opportunities in Research

- **High Brightness**
 - Sensitive Detections of Atomic and Molecular Species
- **Ultrafast Character (ps,fs)**
 - Probing ultrafast processes of molecules in gas phase and at surfaces

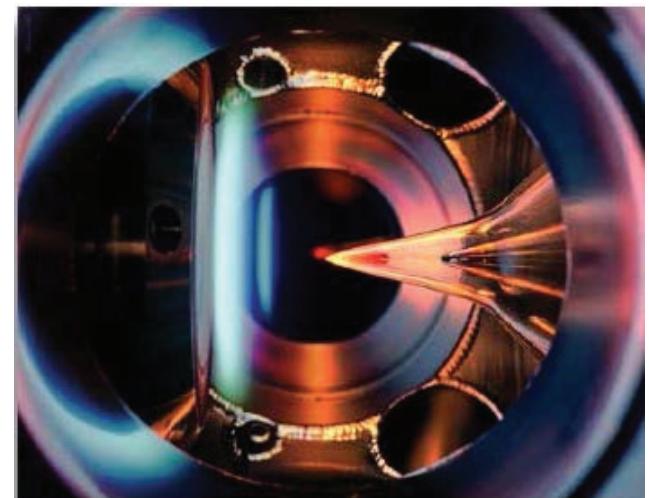


Perspective and application of DCLS

Case I: Combustion



Science 308, 1887-1889 (2005)



(Direct EUV Ionization)

Molecular Ionization Energies

Molecular ionization is very important for detection of atomic and molecular systems, while EUV is the most efficient tool for this.

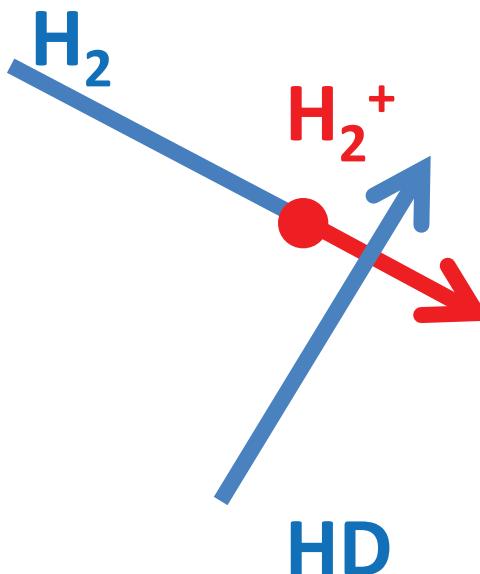
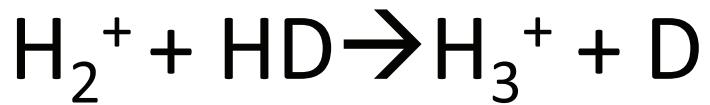
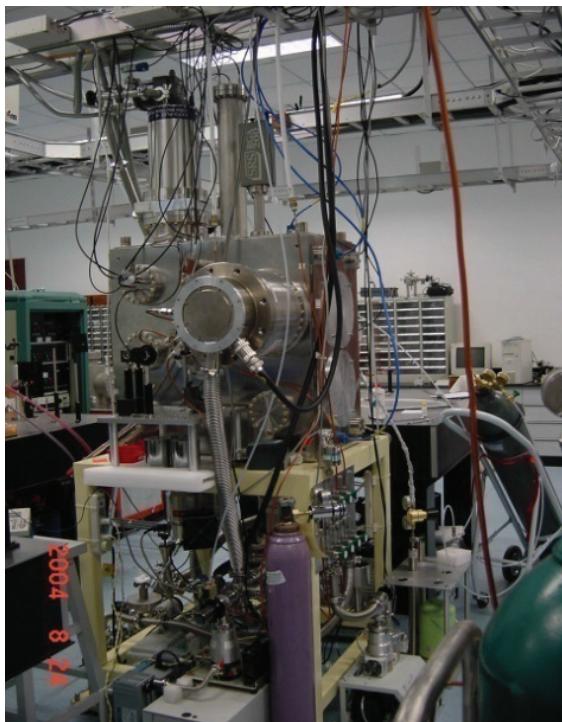
Electron impact ionization can produce fragmentation, and has no species selectivity

Molecule	IE (ev)
CH ₄	12.61
CH ₃	9.84
CO	14.01
NO	9.26
H ₂	15.43
OH	13.0
H	13.6
CH	10.64
CH ₃ F	12.5
CH ₃ O	10.88
CH ₃ Cl	11.26

10 eV ~ 120 nm

Case II: Ion molecule reaction

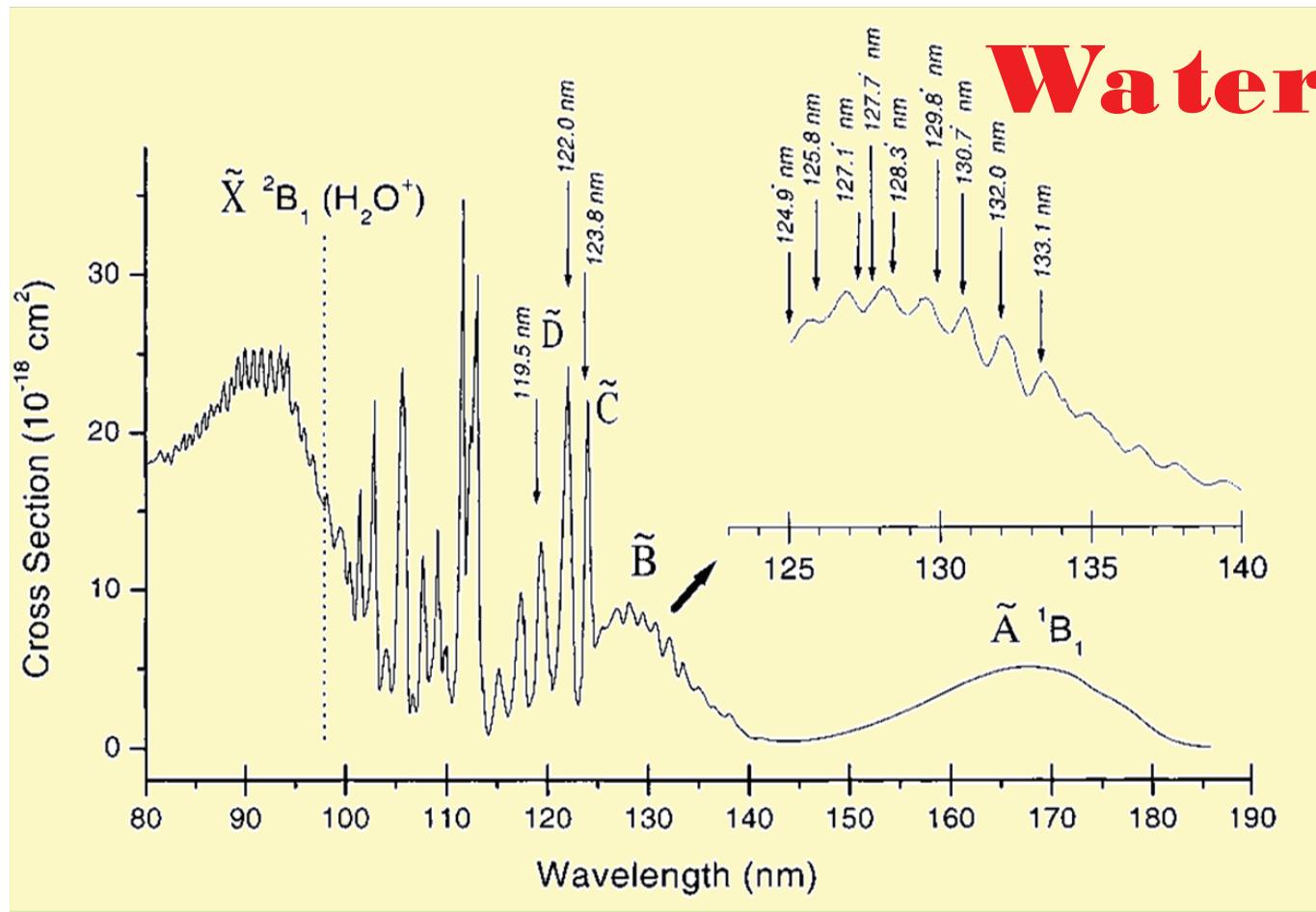
H/D atom Rydberg tagging technique



$\text{H}_2 \rightarrow \text{H}_2^+$ cross section: $\sim 1.0 \times 10^{-17} \text{ cm}^2$ @ 76nm

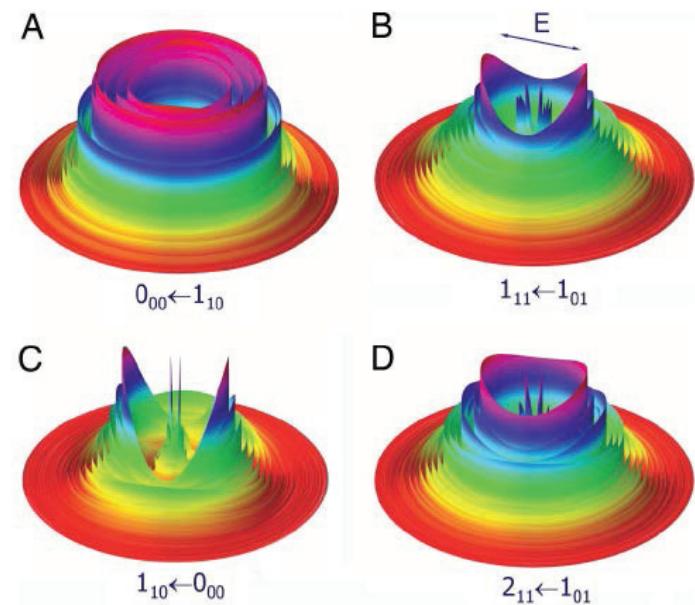
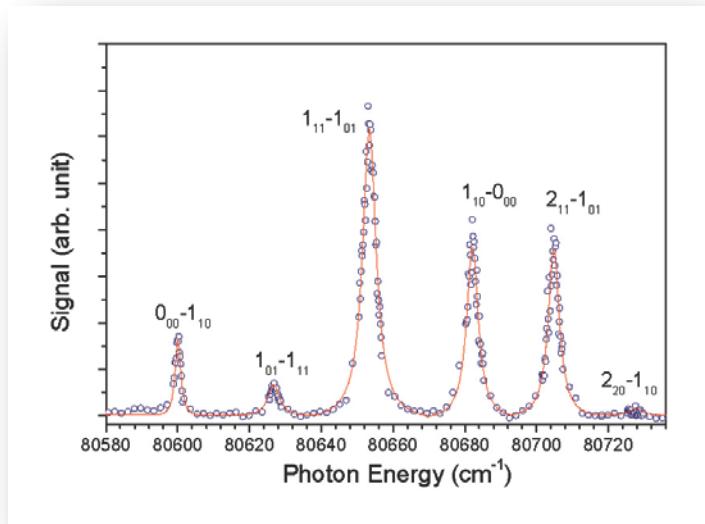
J. Chem. Phys. **126**, 094306 (2007)

Case III: Photochemistry

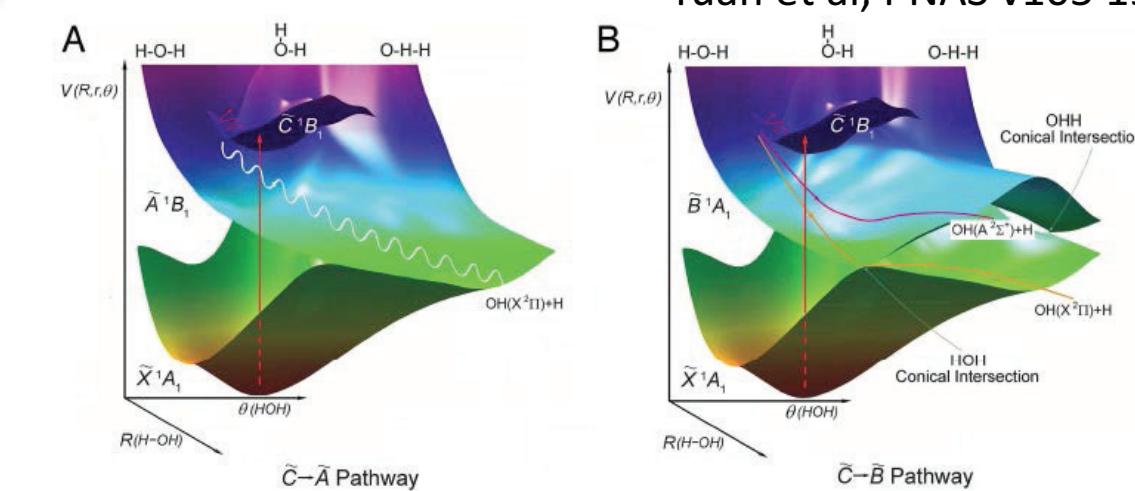


Absorption Spectrum of the Water Molecule

Case III: Photochemistry

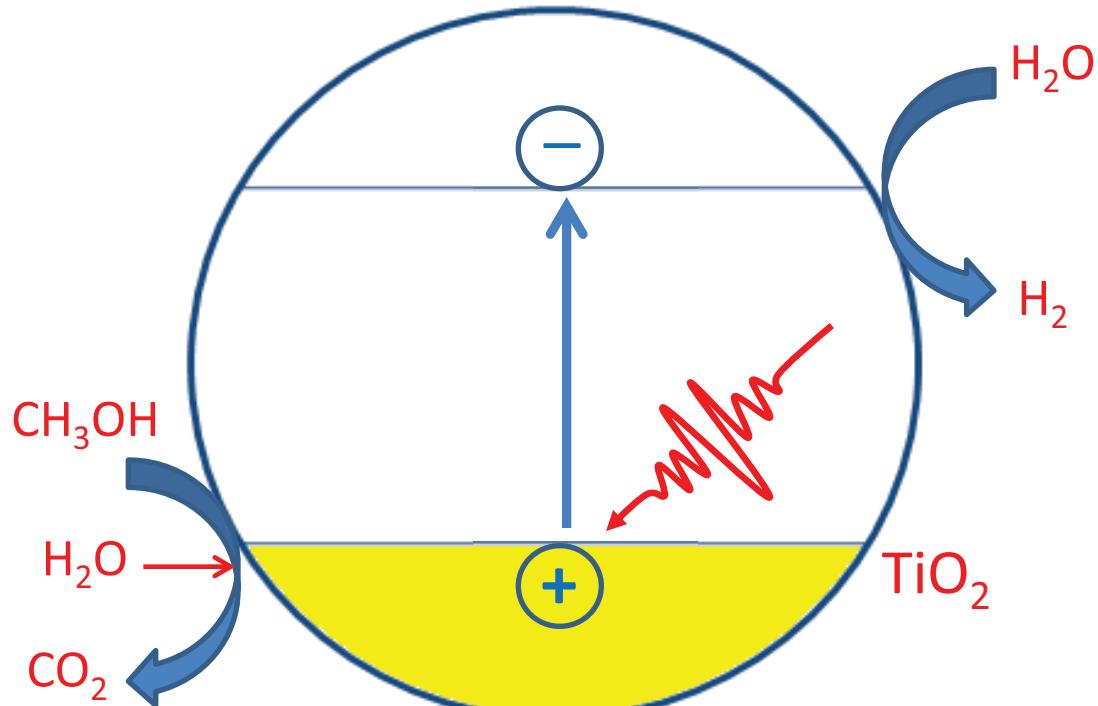


Yuan et al, PNAS v105 19148 (2008)



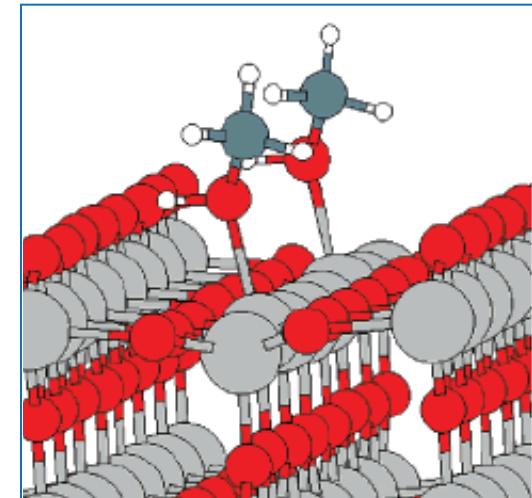
Case IV: Ultrafast Dynamics at Surfaces

Time Resolved UPS Probe (Pump-Probe)



Chem. Rev. 95, 735 (1995)

Photo catalysis
Electron dynamics in
Solar Cells
Electron Transport
Processes



Dynamics of Photo catalysis on Surfaces

Welcome more
innovational proposals

Schedule

2012.03 Starting of DCLS

Formal collaboration with SINAP

2012.04 First version of CDR and discussion

2012.11 Second version of CDR

Technical design of DCLS construction

2013.06 Technical design report

2013.08 Review of TDR at Dalian

2013.09 China-Germany Workshop

“EUV FELs in Molecular, Cluster and Surface Science at DCLS”

2013.10 Construction Starts

Completion of technical design

2014.11 Installation and commissioning.

2015 First lasing, first User experiment on DCLS

Acknowledgement

DICP:

Prof. Xueming Yang
Prof. Dongxu Dai
Dr. Guorong Wu
Dr. Jianyang Zhang
Dr. Chunlei Xiao
Dr. Qing Guo

.....

SINAP:

Prof. Zhentang Zhao
Prof. Dong Wang
Prof. Lixin Yin
Prof. Qiang Gu
Prof. Ming Gu
Prof. Yongbin Leng
Prof. Bo Liu
Dr. Haixiao Deng
Dr. Jianhui Chen

.....

Major Funding: NSFC / CAS

Thank you for attention

Welcome to Dalian