John Adams Institute for Accelerator Science

Imperial College London

Royal Holloway University of London

UNIVERSITY OF OXFORD

Topics of possible contribution to FCC study from John Adams Institute

Andrei A. Seryi

John Adams Institute for Accelerator Science

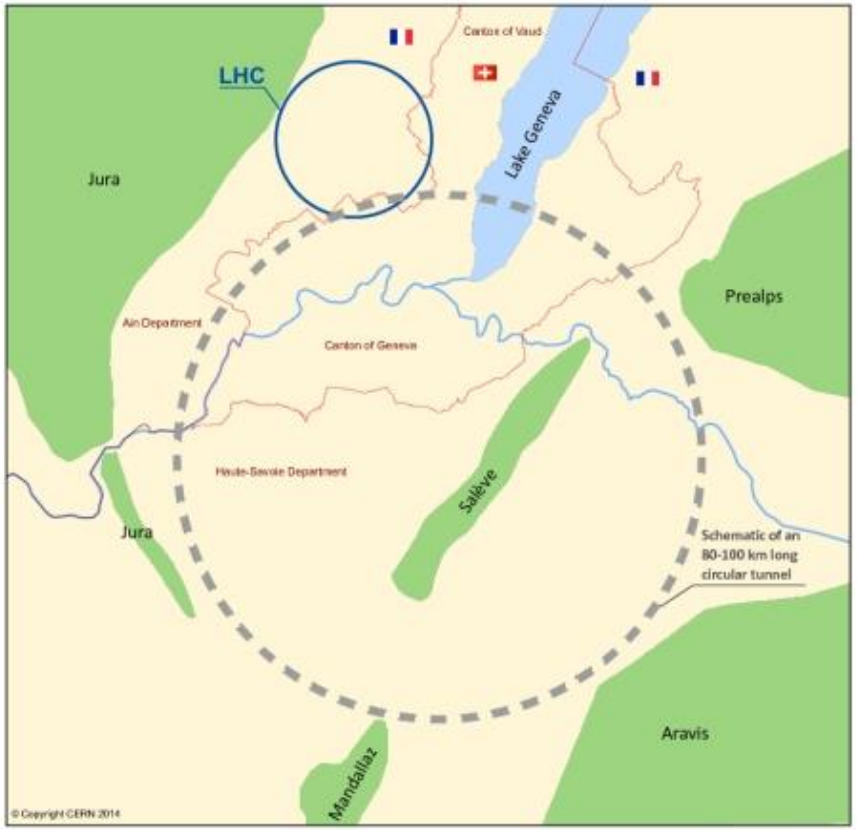
FCC meeting

14 February 2014

FCC

- **"…CERN is now initiating an exploratory study for a future long-term project centred on a new-generation circular collider with a circumference of 80 to 100 kilometres**
- **A worthy successor to the LHC, whose collision energies will reach 14 TeV, such an accelerator would allow particle physicists to push back the boundaries of knowledge even further**
- **The Future Circular Colliders (FCC) programme will focus especially on studies for a hadron collider, similar to the LHC, capable of reaching unprecedented energies in the region of 100 TeV"**

(from CERN Press release, 6 Feb 2014)



What is JAI

- **The John Adams Institute for Accelerator Science is a centre of excellence in the UK for advanced and novel accelerator technology, created in 2004 to foster accelerator R&D in the universities**

- **JAI is based on 3 universities: University of Oxford and RHUL initially, with Imperial College joining JAI in 2011**

- **JAI scale: ~30 academic professorial staff, ~20 research staff, ~10 affiliates, ~35 post-grad students, ~6-10 PhD/year in Acc. science**

Sir John Adams (24 May 1920 - 3 March 1984) was the 'father' of the giant particle accelerators which have made CERN the leader in the field of high energy physics. John Adams worked at the UK Atomic Energy Research establishment on design & construction of a 180 MeV synchro-cyclotron. He then came to CERN in 1953 & was appointed director of the PS division in 1954. In 1961-66 Adams worked as director of the UK Culham Fusion Lab. In 1971 he returned to CERN and served until 1975 as Director-General of then called Laboratory II, responsible for the design & construction of the SPS. From 1976-80 he was executive DG of CERN and instrumental in approval of LEP. John Adams was a foreign member of Russian Academy of Science. On the photo above Adams announcing that CERN just passed the Dubna's Synchrophasotron world record of 10GeV.

http://www.adams-institute.ac.uk

JAI research directions and FCC

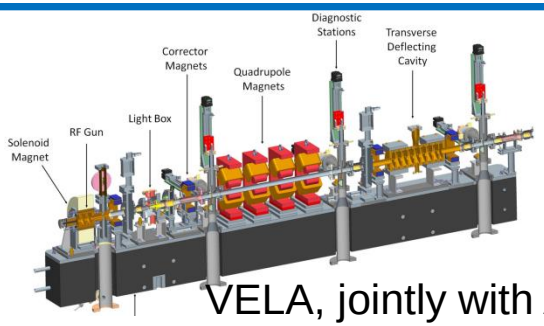
- **Plan of the talk:**

- **In the next slides:**
  - **Briefly describe 3 main research direction of JAI**
  - **Give examples of experience relevant for FCC**

- **Then, give a summary of anticipated areas of involvement in FCC**

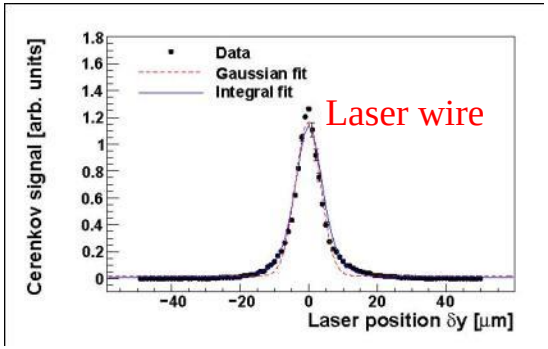
Direction 1: Advanced Beam Instrumentation

- **Far-Infrared Coherent Radiation**
  - CSR, CDR for beam diagnostics
  - Soft-X ray and microwave source based on Thomson scattering of CDR
- **Nano-resolution BPM**
  - C, S-band (~100nm resol.)
  - Special ~nm resolution
- **Coherent Smith-Purcell radiation**
  - Longitudinal diagnostics –extending to fs range
- **Laser – wire**
- **Ultra-fast nanosecond feedback**

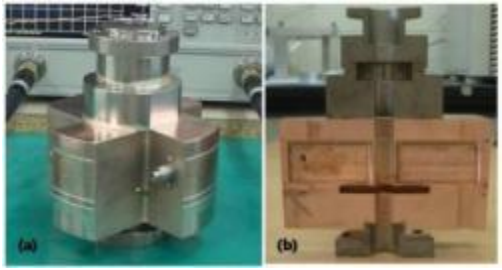


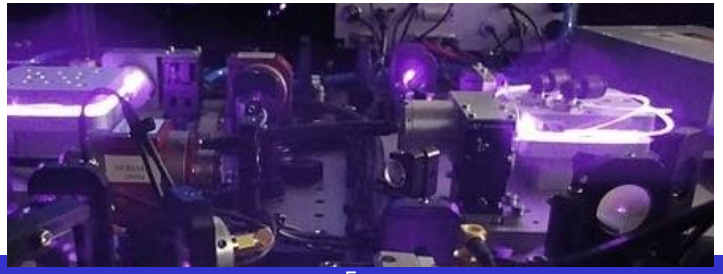
VELA, jointly with ASTEC

LUXC, jointly with KEK



Laser wire





Smith-Purcell diagnostics instrumentation

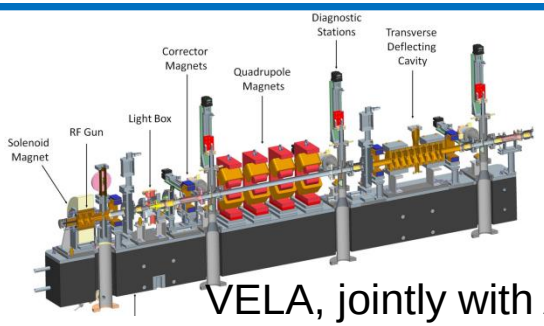
Direction 1: Advanced Beam Instrumentation

- Fa ation
  - CSR, CDR for beam diagnostics
  - on
- Na
  -
  -
- Coherent Smith-Purcell radiation
  - Longitudinal diagnostics –extending to fs range
- Laser – wire
- Ultra-fast nanosecond feedback

Applicable to FCC:

Diagnostics in general

Details what is needed for FCC are to be discussed



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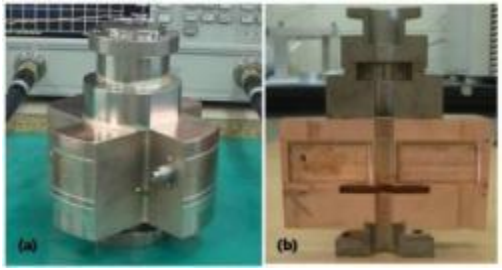
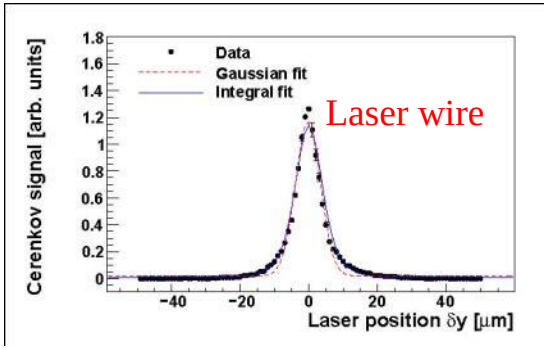
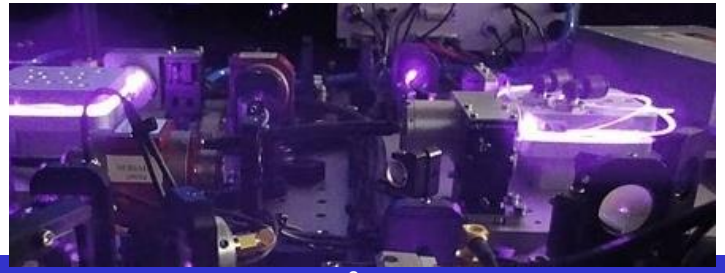


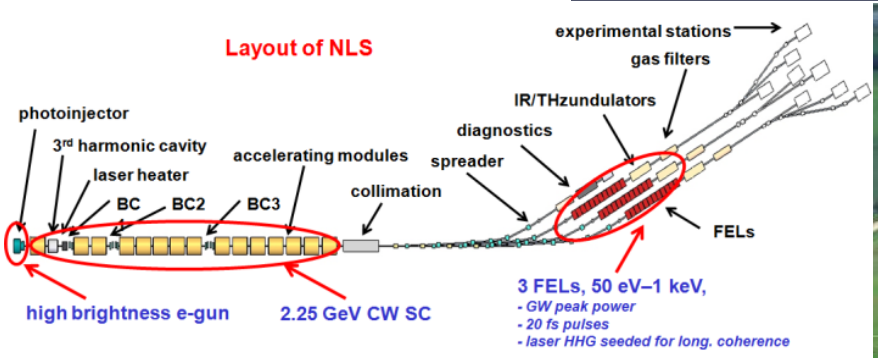
Smith-Purcell diagnostics instrumentation

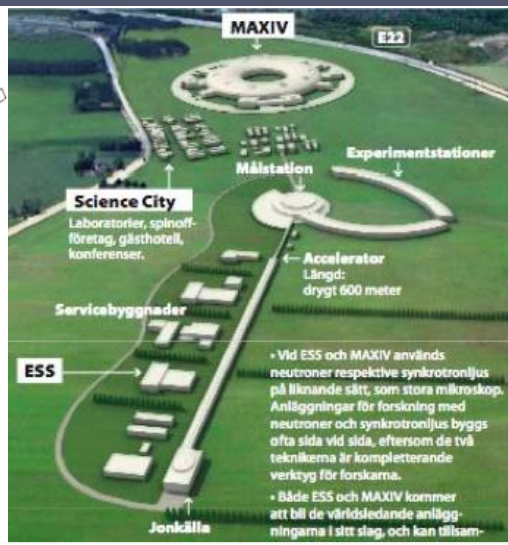


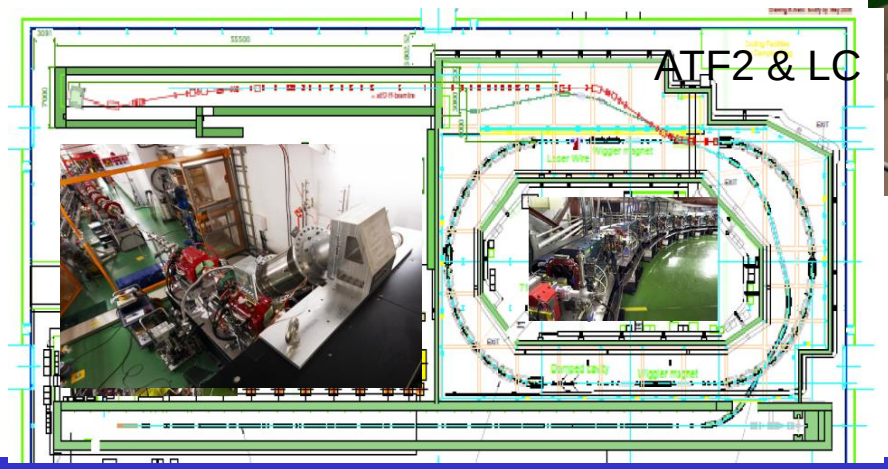


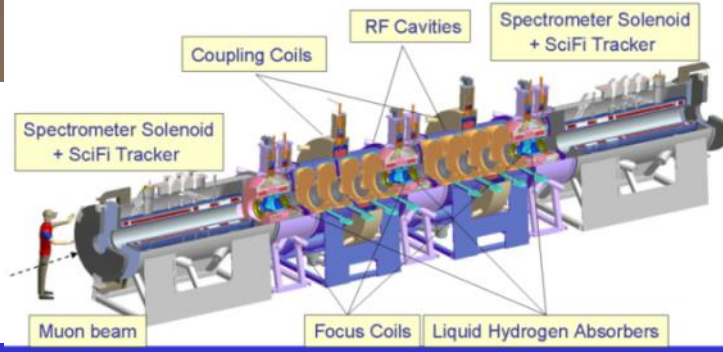
Direction 2: Enabling Acc. Techniques

- 3rd Gen Light Sources
- Future 4th Gen Light Source design
- ISIS & ESS neutron sources
- Neutrino Factory / μ-cooling
- Proton therapy
- Ion sources
- Linear Colliders
- LHC upgrade
- FCC









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Applicable to FCC:

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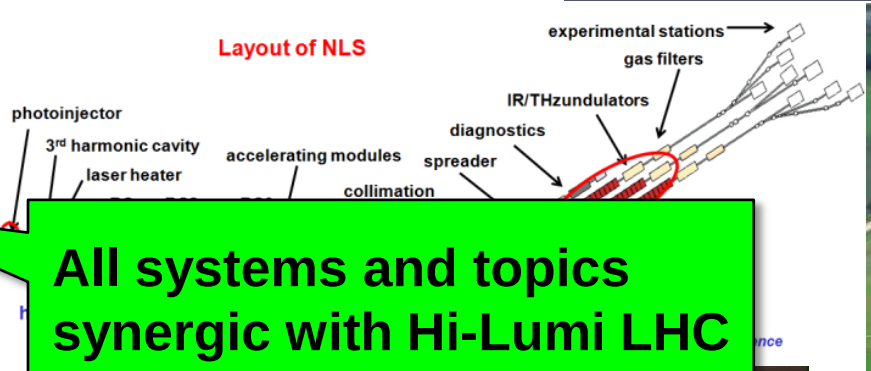
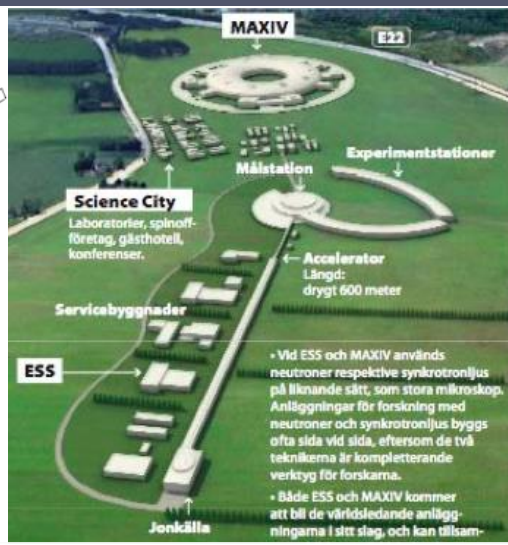
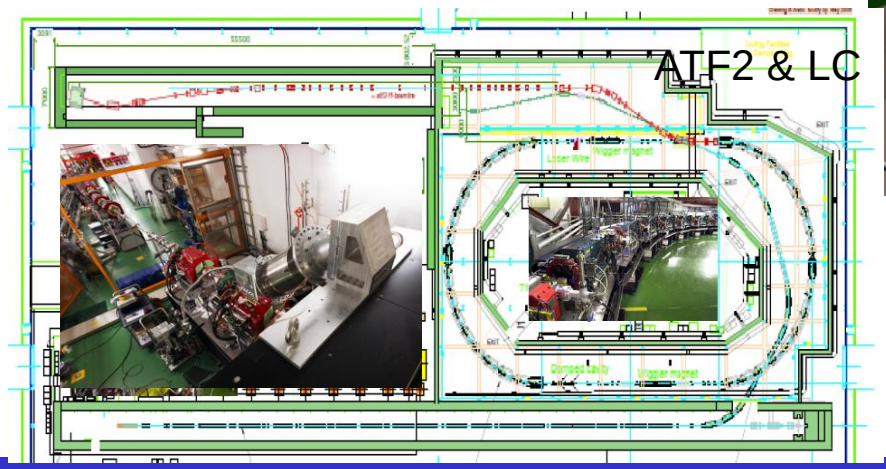
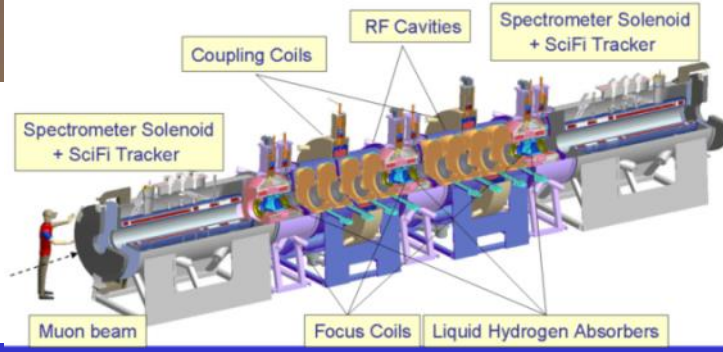


All systems and topics synergic with Hi-Lumi LHC





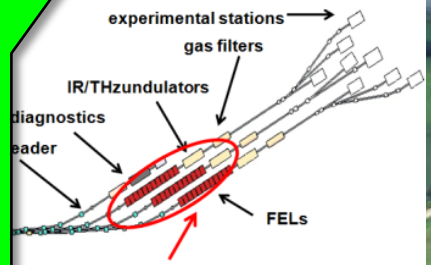


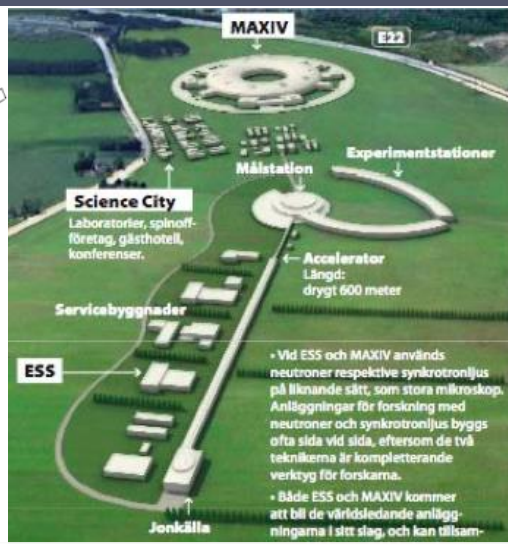
Direction 2: Enabling Acc. Techniques

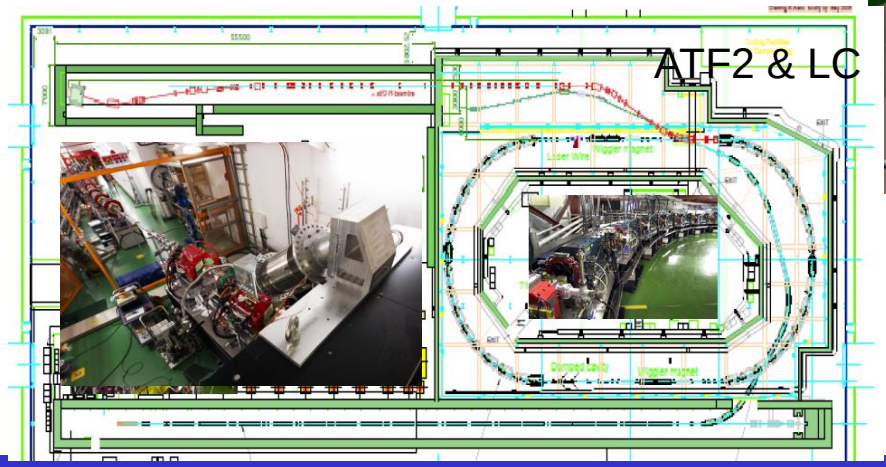
- 3rd
- Future 4th Gen Light Source design
- ISI
- Ne
- Pr
- Ion
- Lin
- LH
- FC

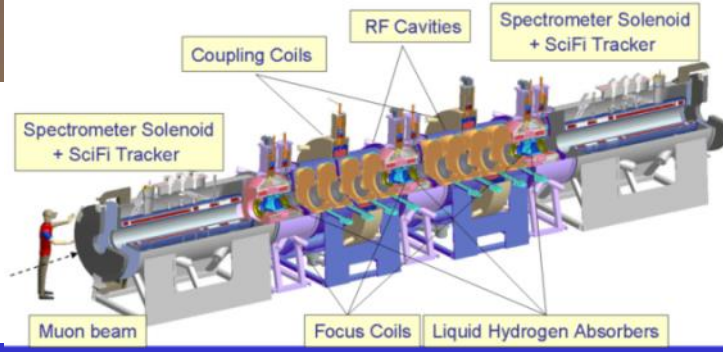
Applicable to FCC:

Synchrotron radiation
Impedances
Beam stability
Dynamic aperture & lifetime
Vacuum chamber design
Optics
etc







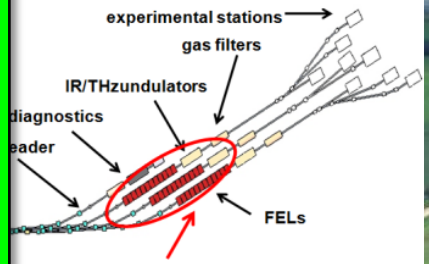


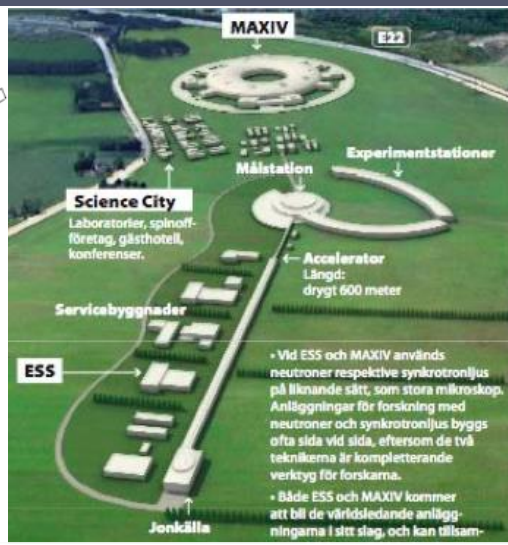
Direction 2: Enabling Acc. Techniques

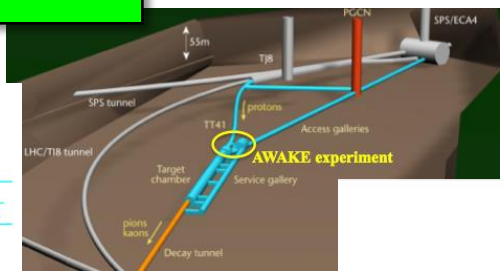
- 3rd
- Future 4th Gen Light Source design
- ISI
- Ne
- Pr
- Ion
- Lin
- LH
- FC

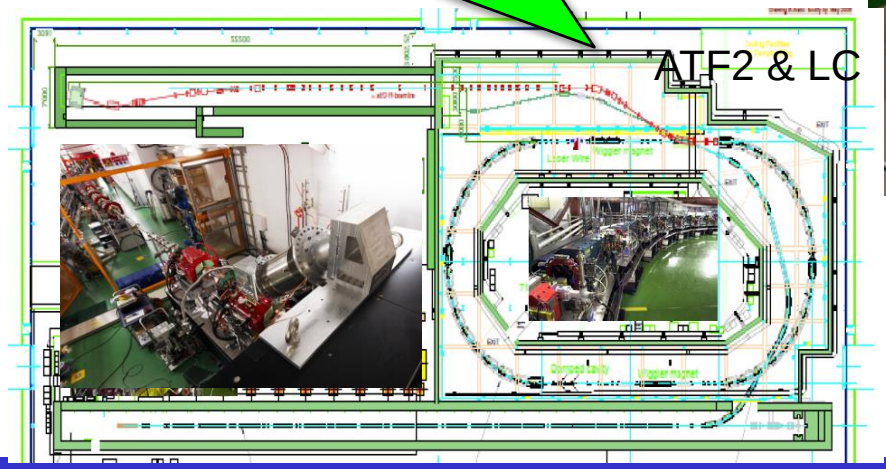
Applicable to FCC:

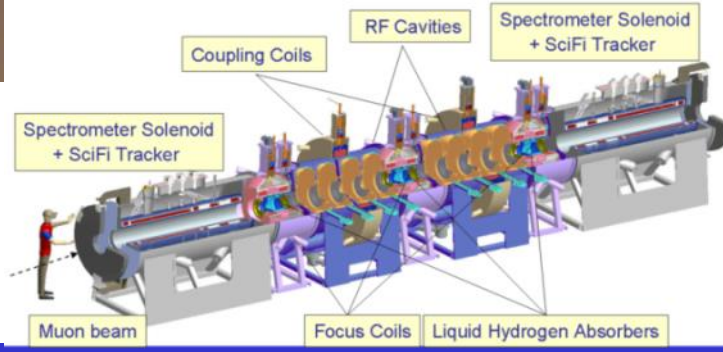
Final focus design
Local chrom correction
Lowest beta*
Feedback on ns time scale (for transv stability and lumi leveling)
Machine-Detector Interface
Collimation & backgrounds
etc





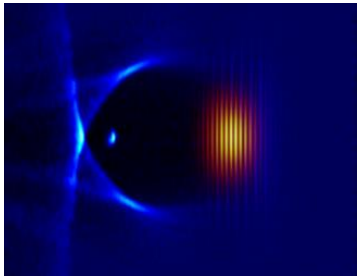






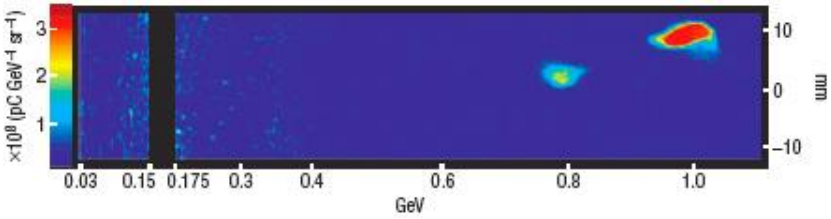
Direction 3: Laser-Plasma Acceleration

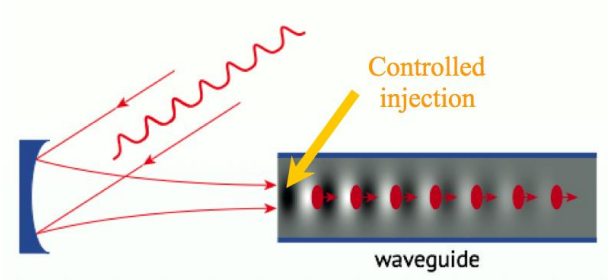
- **Analytical & simulations studies**
- **Pioneering experiments:**
  - **acceleration to GeV and above**
- **Application develiopments:**
  - **First use of laser-plasma generated γ-s for bio & medical applications**
- **System-wide approach:**
  - **Development of high-rep-rate and high wall-plug-efficient laser-plasma based light sources**



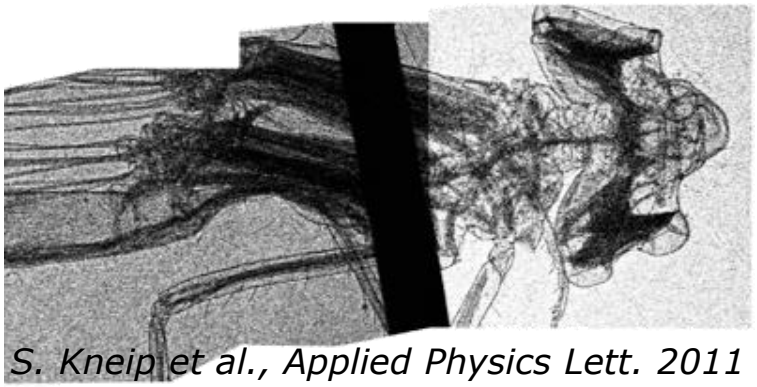
Simulation of laser-plasma acc.

1 GeV acc. in 3cm of plasma
W. Leemans, et al., ***Nature Physics*** 2006



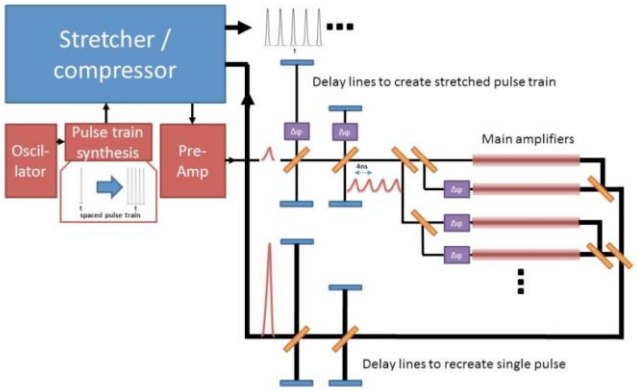


Towards light sources - small source size of laser-plasma acc. beam ideal for phase contrast imaging:



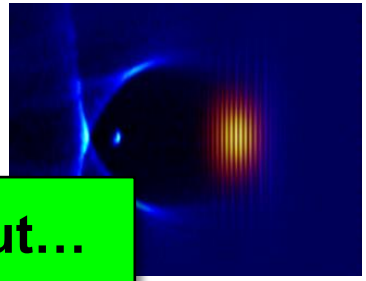
S. Kneip et al., Applied Physics Lett. 2011

Multi-Pulse Laser Wakefield Acceleration: A New Route to Efficient, High-Repetition-Rate Plasma Accelerators and High Flux Radiation Sources, S. M. Hooker, R. Bartolini, S. P. D. Mangles, A. Tunnermann, L. Corner, J. Limpert, A. Seryi, and R. Walczak, Jan 2014, http://arxiv.org/abs/1401.7874v1



Direction 3: Laser-Plasma Acceleration

- Ana **Applicable to FCC:** es
- **Pioneering experiments:**



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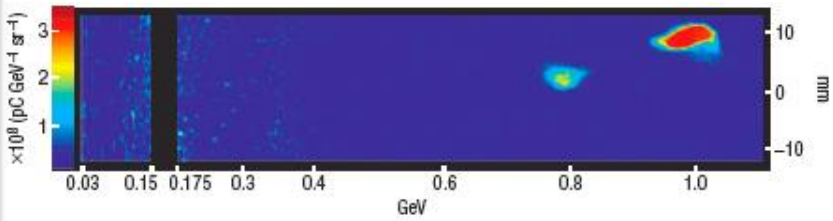

Perhaps not any concrete topic, but…

The general approach – open mind for novel ideas, combined with the aim for near-term practical application and with system-wide optimization down to details such as overall wall-plug efficiency

To ser
size of laser-plasma acc. beam ide eleration:
phase contrast imaging: ew Route to
cient, High-
Repetition-Rate Plasma
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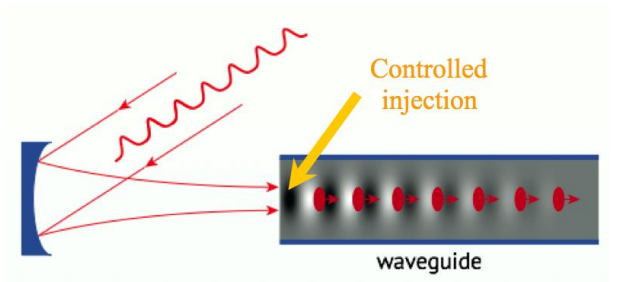

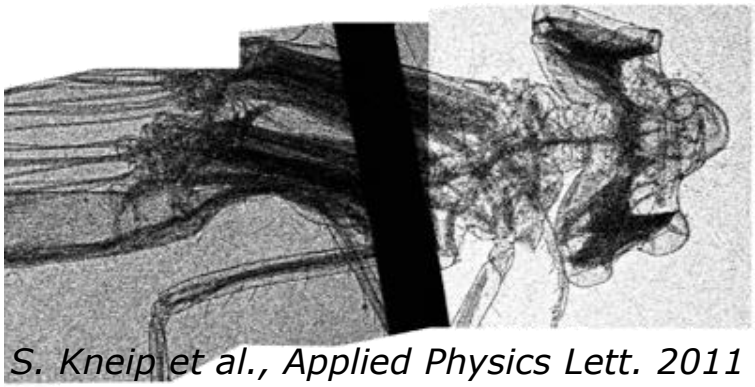

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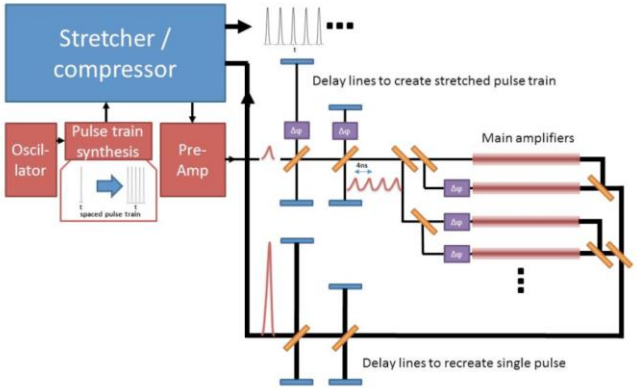


Initial areas of JAI FCC involvement

- **Synchrotron radiation, impedances, optics, vacuum chamber, beam stability**
- **Final Focus optics, MDI, collimation, backgrounds**
- **Ultra-fast beam manipulation for transverse stability or lumi leveling**
- **Diagnostics**
- **etc.**

Extra slides – JAI in a bit more details

JAI Faculty


Simon Hooker


Pavel Karataev


Peter Norreys


Riccardo Bartolini


Stewart Boogert


Phil Burrows


John Cobb


Bucker Dangor


George Doucas


Brian Foster


Laura Corner


Glenn Christian


Ken Peach


Chris Prior


Armin Reichold


Andrei Seryi


Roman Walczak


Stephen Gibson

Research Facilitator


Michele Warren


Ted Wilson


Emmanuel Tsesmelis

CERN


Mike Partridge


Bleddyn Jones

GRAY INSTITUTE FOR RADIATION ONCOLOGY & BIOLOGY

PTCRi


Stuart Mangles


Steve Rose

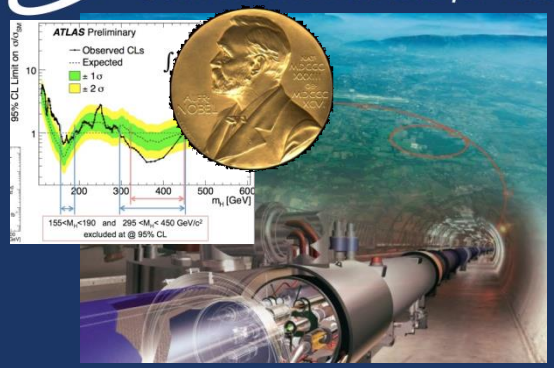

Zulfikar Najmudin

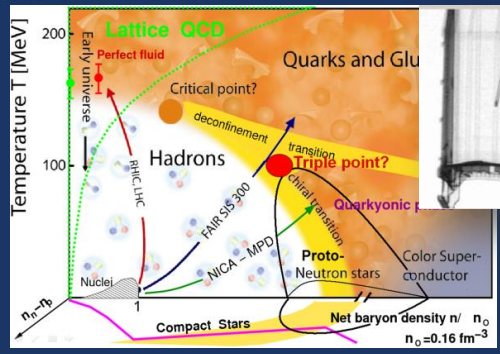

Ken Long

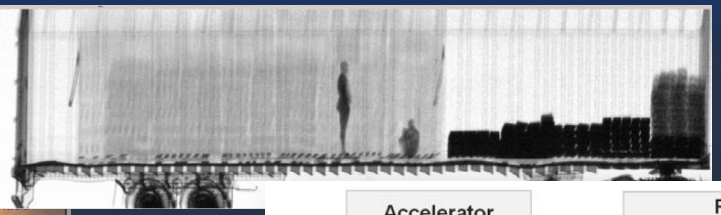

Ivan Konoplev

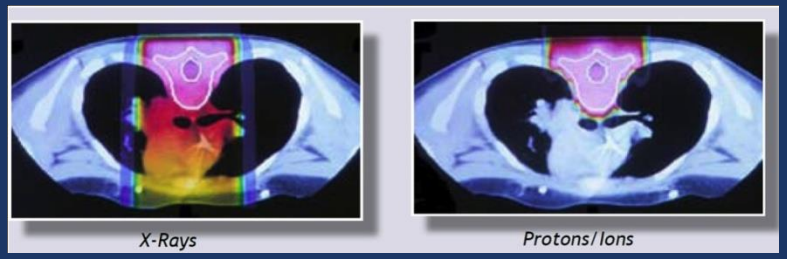
Also : JAI Academic and Industrial Affiliates (not shown)

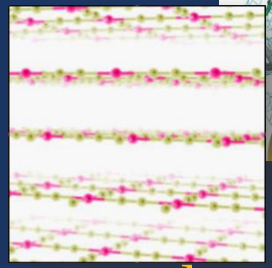
Accelerators for science and society

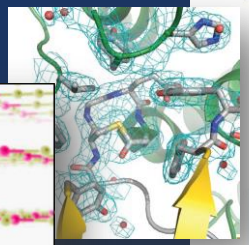


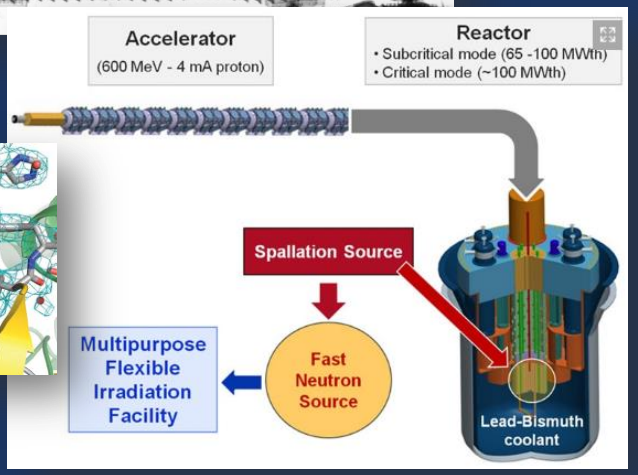












Accelerators: high energy physics, nuclear physics, healthcare, security, energy, life science, novel materials, industry, …

Tens of millions of patients receive accelerator-based diagnoses and treatment each year in hospitals and clinics around the world

All products that are processed, treated, or inspected by particle beams have a collective annual value of more than $500B

The fraction of the Nobel prizes in Physics directly connected to accelerators is about 30%

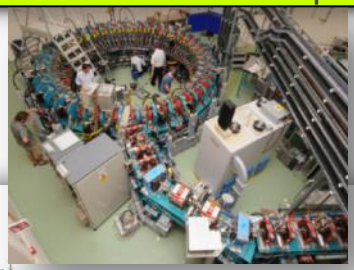
within the UK SciTech ecosystem


Diamond Light Source


Central Laser Facility


Daresbury Science & Innovation Campus, CI


ISIS neutron source




Accelerator Science &Technology Centre


Rutherford Lab & Harwell-Oxford Innovation campus

JAI is part of the world's most highly-regarded university fostered innovation ecosystem

RAL CLF ISIS Diamond

Research & Enterprise

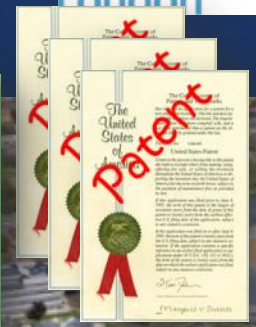
DL ASTeC CI

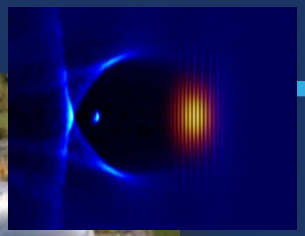
John Adams ... lerator Science

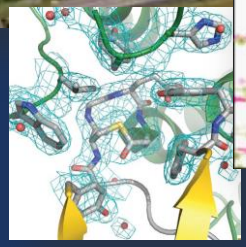
Imperial College London

Royal Holloway University of London

UNIVERSITY OF OXFORD





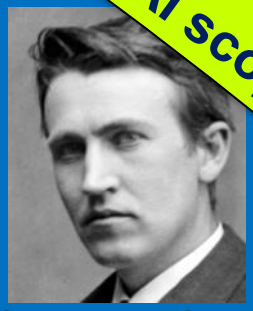


Fundamental knowledge

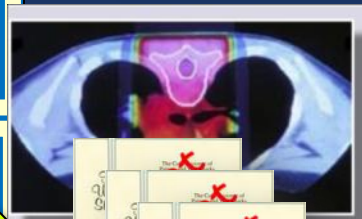
Niels Bohr

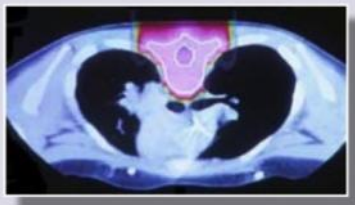
Louis Pasteur

Accelerator Science and Technologies – JAI scope

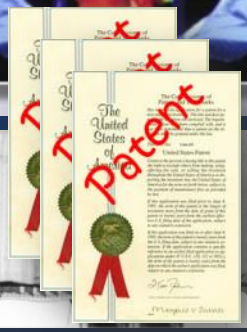


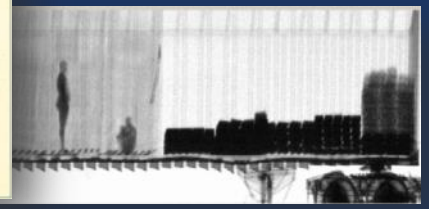
Thomas Edison





Protons/Ions





Consideration of use