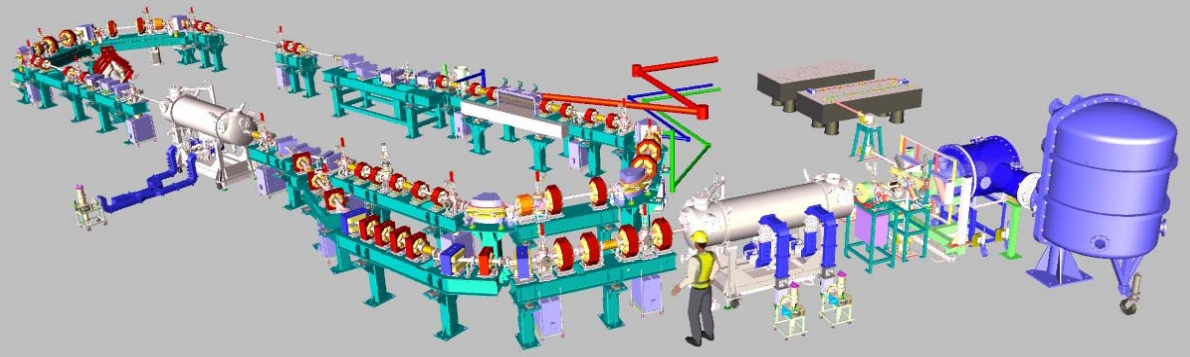
An Update On ALICE

Accelerators and Lasers In Combined Experiments

Alice
Accelerators and Lasers
In Combined Experiments

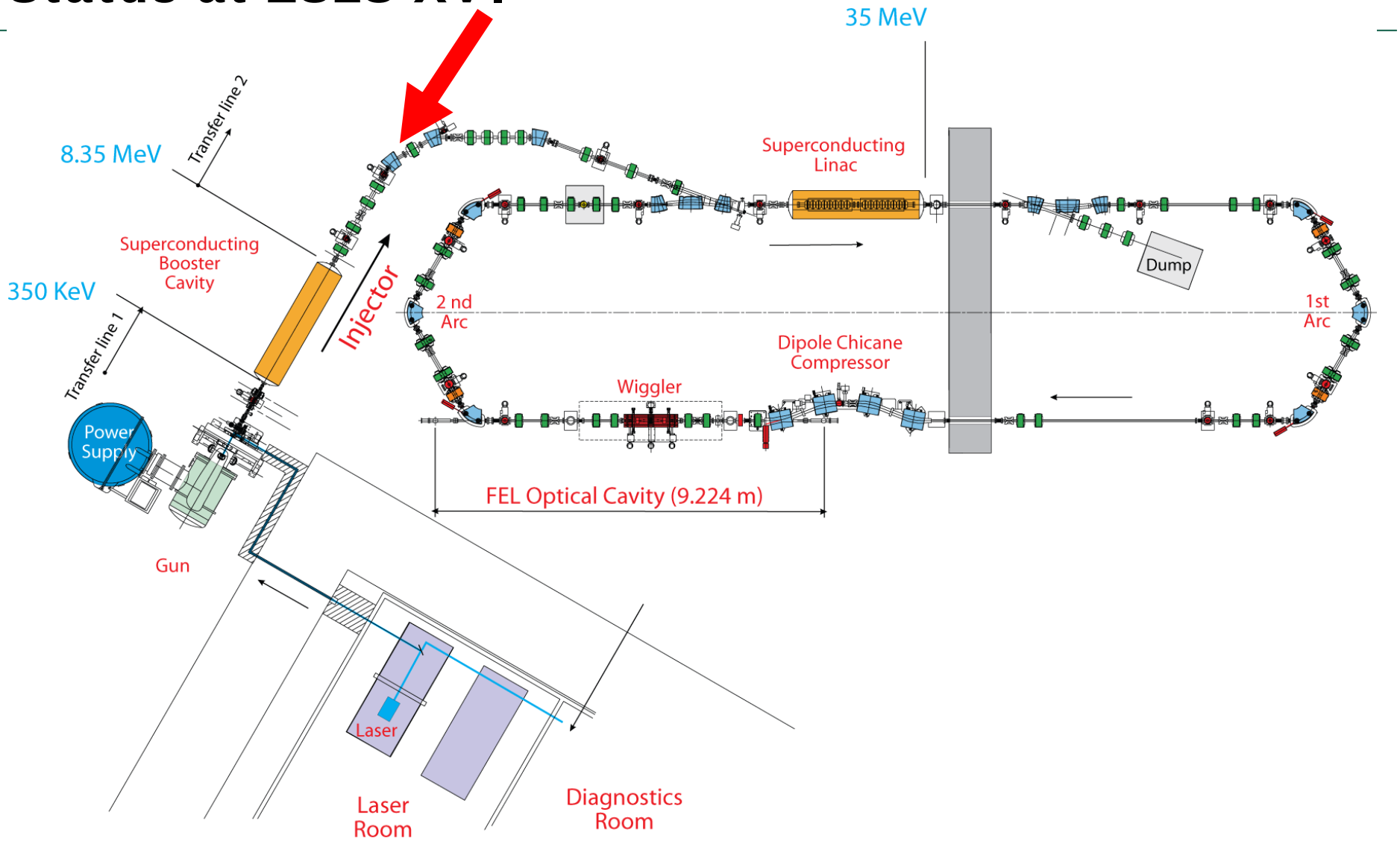


Susan Smith
Daresbury Laboratory

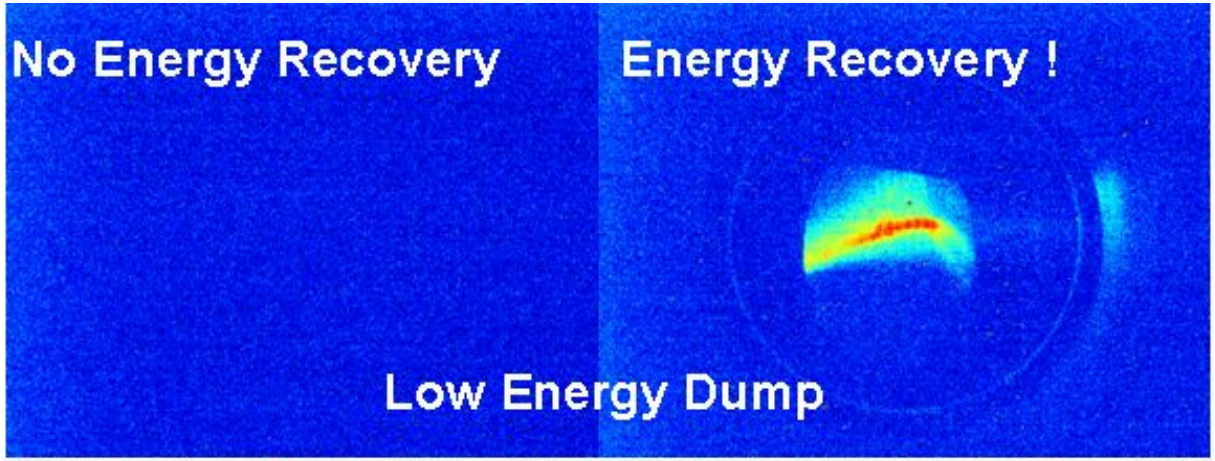
Content

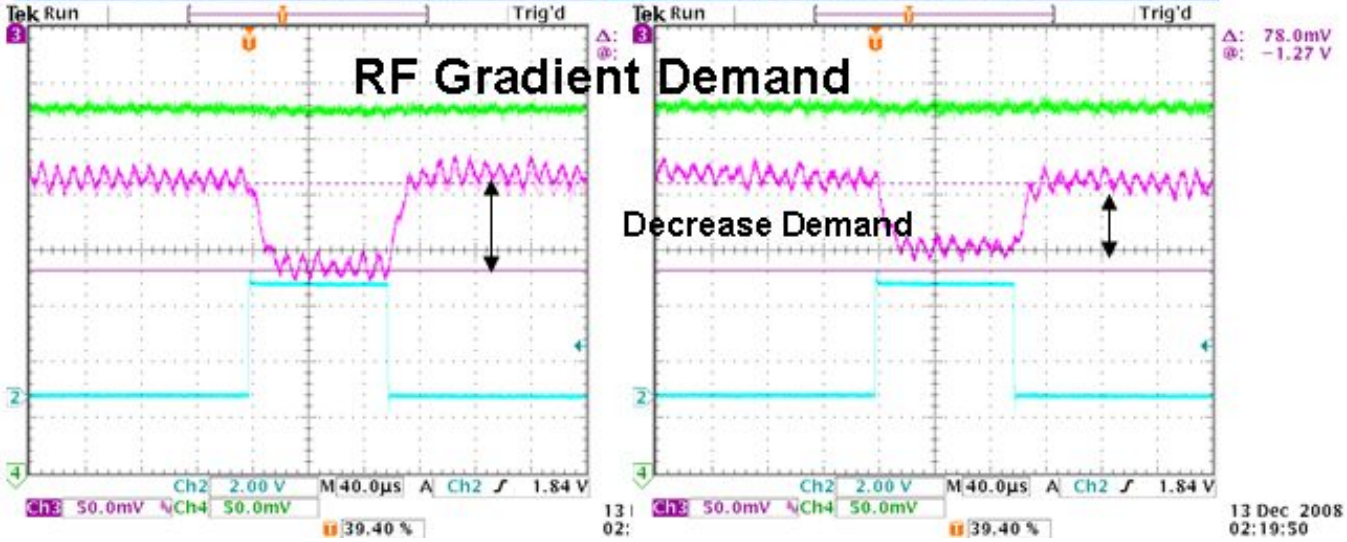
- Commissioning Progress
- Beyond energy recovery
- Future development
- Summary

Status at ESLS XVI



First Circulation 13th December 2009

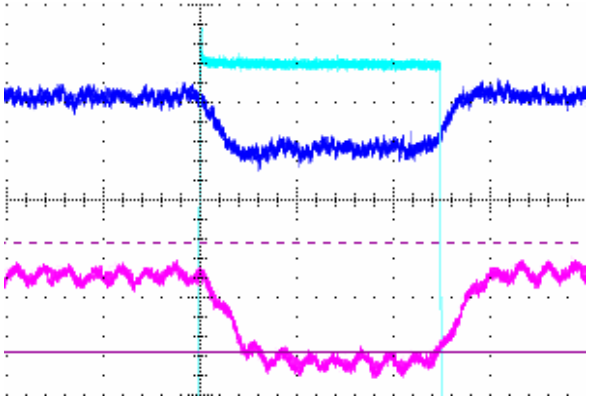




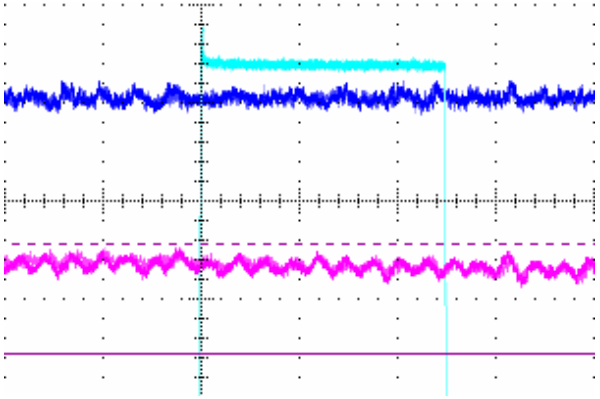
11 MeV operation

Full Energy Recovery

- Full energy recovery (21st December 2008)



Without Energy Recovery



With Energy Recovery

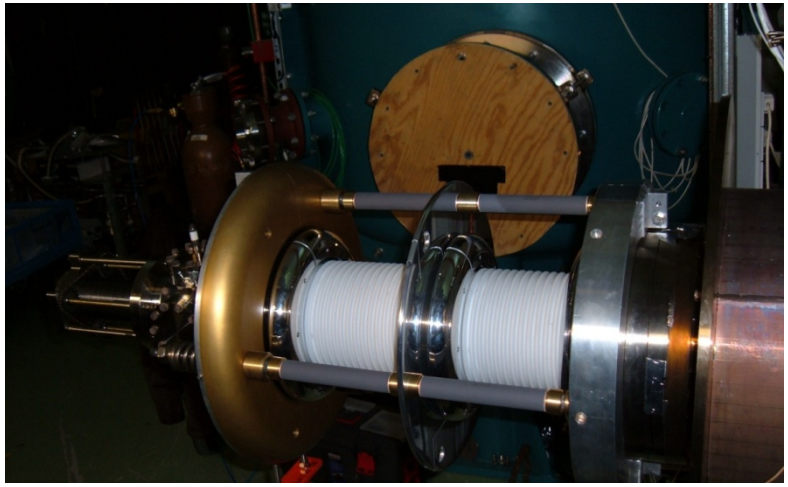
LLRF (power demand) signals without (left) and with (right) energy recovery

Full energy recovery has been established at 21MeV beam energy and several bunch charges up to 20pC.

Higher bunch charges were not attempted because of the beam loading effects in the injector SC booster cavities

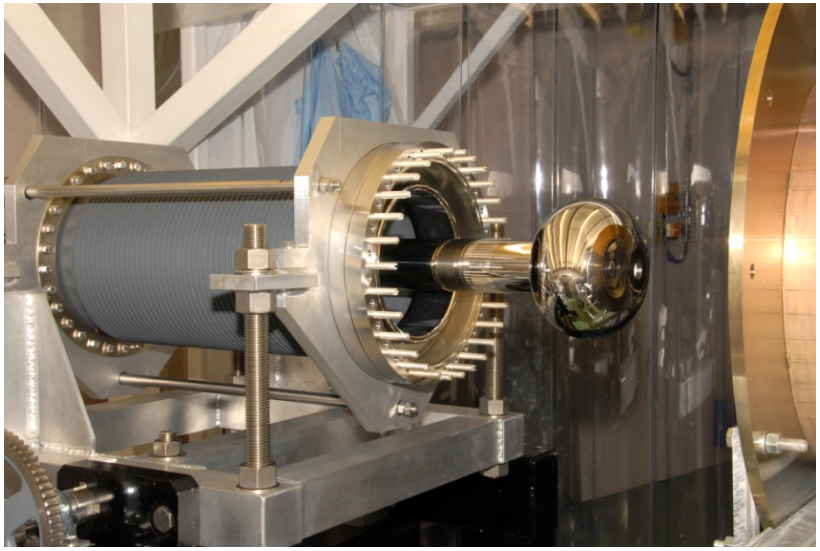
Gun voltage (~230kV)

- Lower than nominal (230kV instead of 350kV) is due to
  - Stanford ceramic
  - Field emitter on the cathode
- Both do not help emittance and injector set up



Stanford

original



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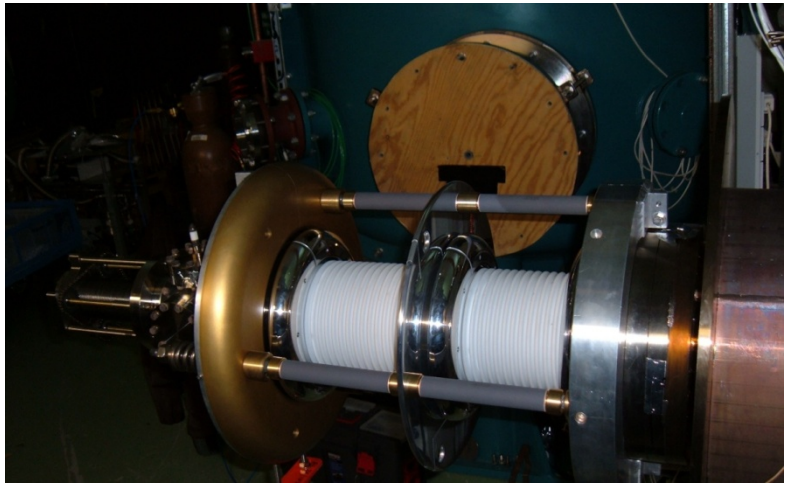
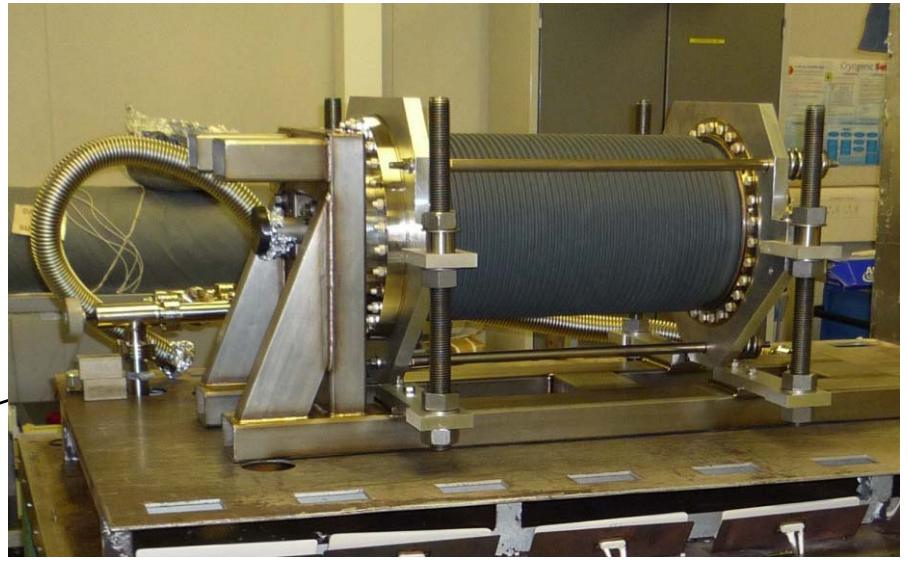


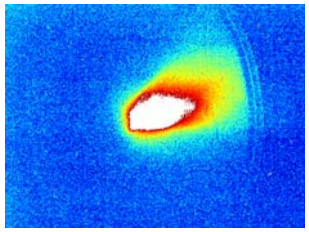
Stanford



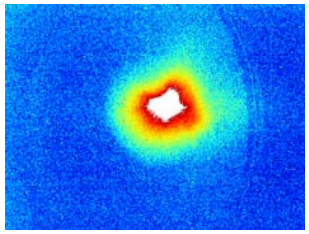
CPI ceramic tests

Field emission from the cathode

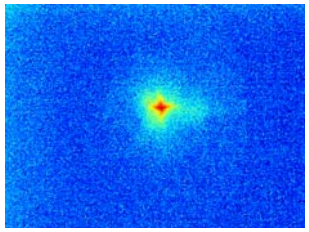
- Solution:
  - disperse most of FE within the gun beamline, increasing SOL-01 field, reduce gun voltage to ~230kV
- Increased SOL-01 settings:
  - Not good for lower (<80pC) bunch charges due to transverse cross-over. Approximately optimal for Q ~ 80pC



SOL-01=2.6A

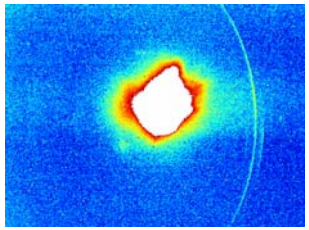


SOL-01=2.9A

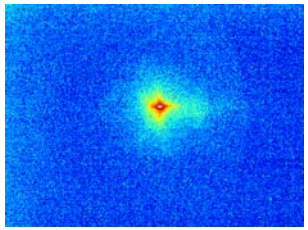


SOL-01 = 3.3A

FE electron after acceleration booster at various SOL-01 (YAG-02)



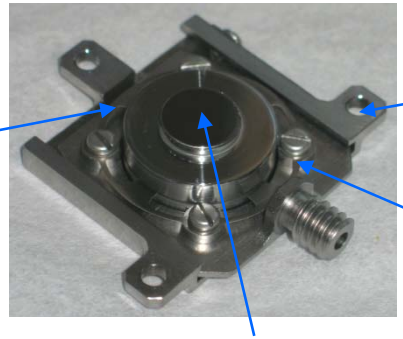
INJ-2 : Beam+FE

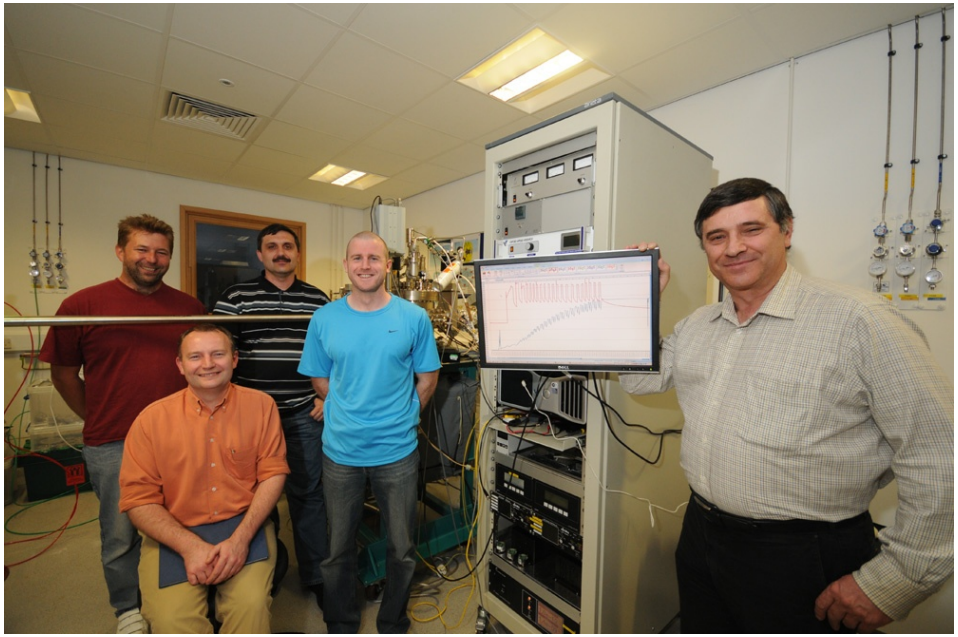


INJ-2: FE only

FE electrons do not appear to be a factor after acceleration in the main linac

Photocathode Preparation Facility:- First results





Commissioned in April 2009

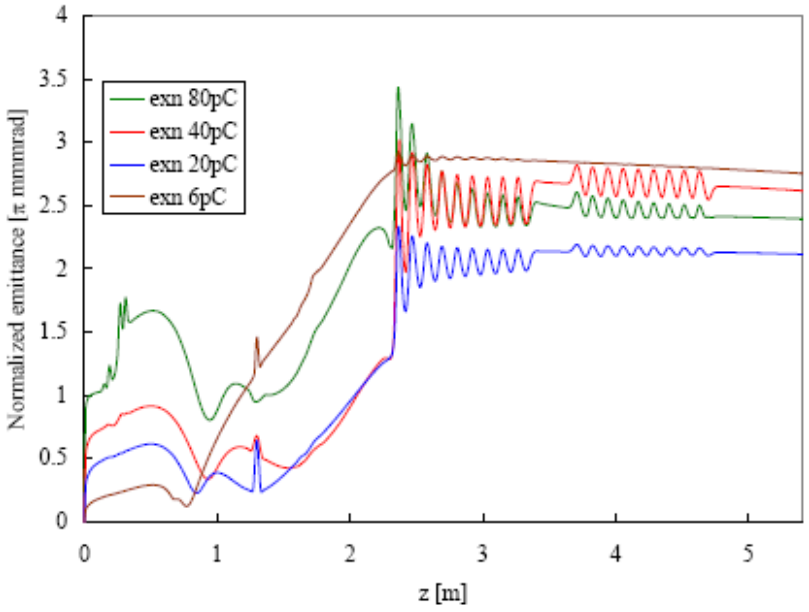
A GaAs photocathode loaded from atmosphere without chemical etching and cleaned with atomic hydrogen

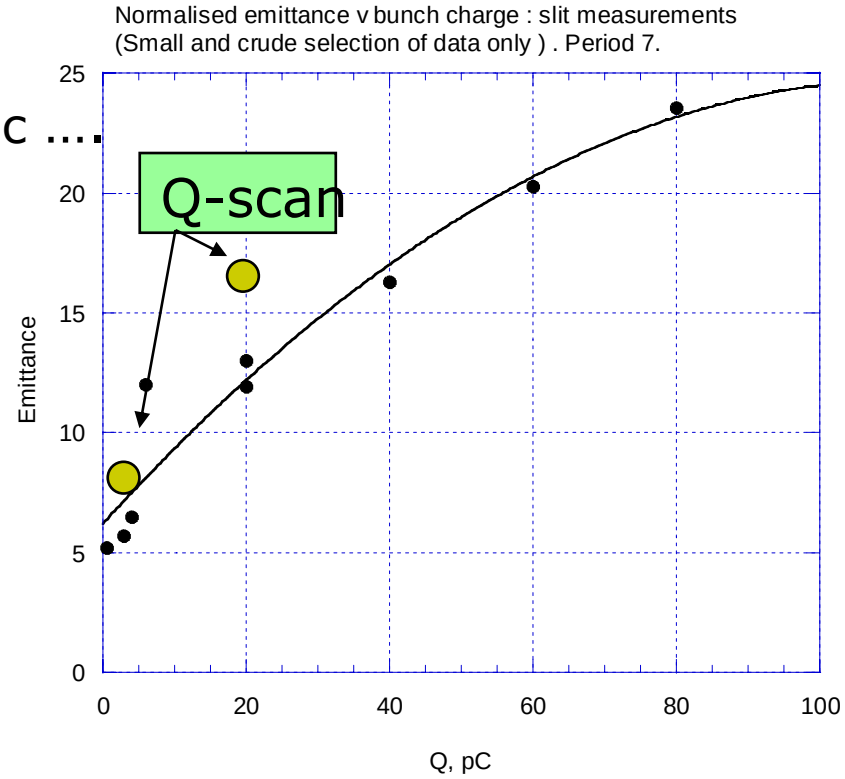
Activated with Cs-O "Yo-Yo" procedure

Qe=15% at λ=635 nm

Emittance

- Beam characterisation was not a priority
- Very crude measurements made so far (slit & Q-scan)
- Both indicate emittance much larger than expected from the model
- No optimisation was attempted yet …
  - SOL-01 > 280G (not good for Q~10-30pC)
  - laser beam offset ?
  - INJ optimisation
  - ~10mm.mrad ? : cautiously optimistic ….





Field Emission in SC linac

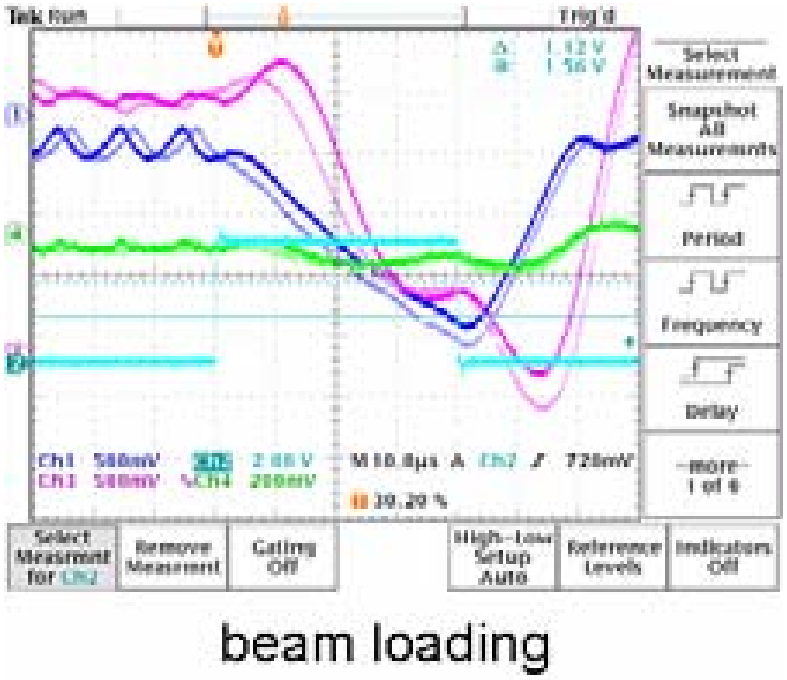
- Major problem is the field emission in the main linac
  - Limited to ~23 MeV acceleration total
  - Have to reduce the energy gain in the booster accordingly (set by beam energy ratio in injection and extraction chicanes)

- February 2009
  - Gun : 230keV
  - after Booster: 4.8 MeV
  - after Main linac : 20.8 MeV

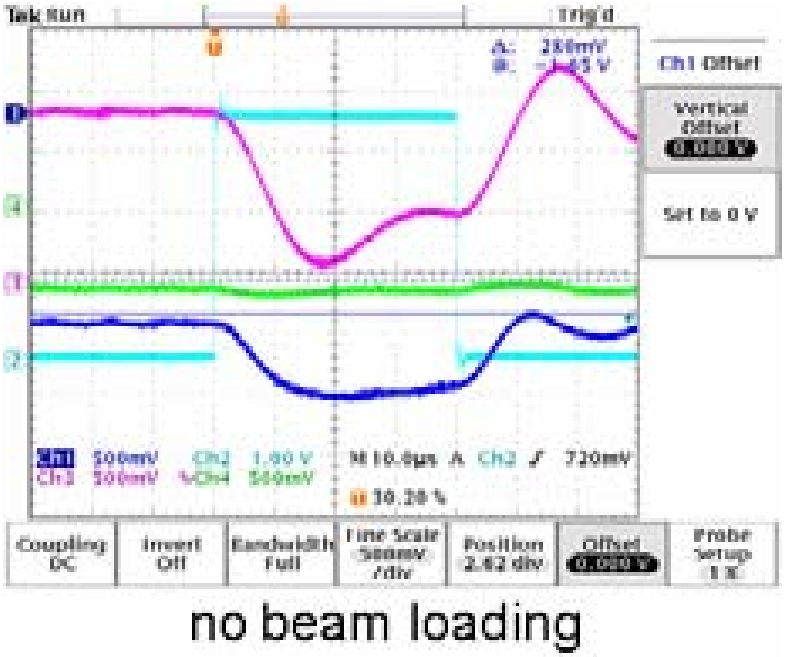
- July 2009 Further conditioning and short pulse 3 ms RF operation
  - Gun : 230keV
  - after Booster: 7 MeV
  - after Main linac : 29.8 MeV

- Propose to carryout helium processing of SRF cavities in 2010 before module change

Optimisation of RF System



a) Beam loading evident

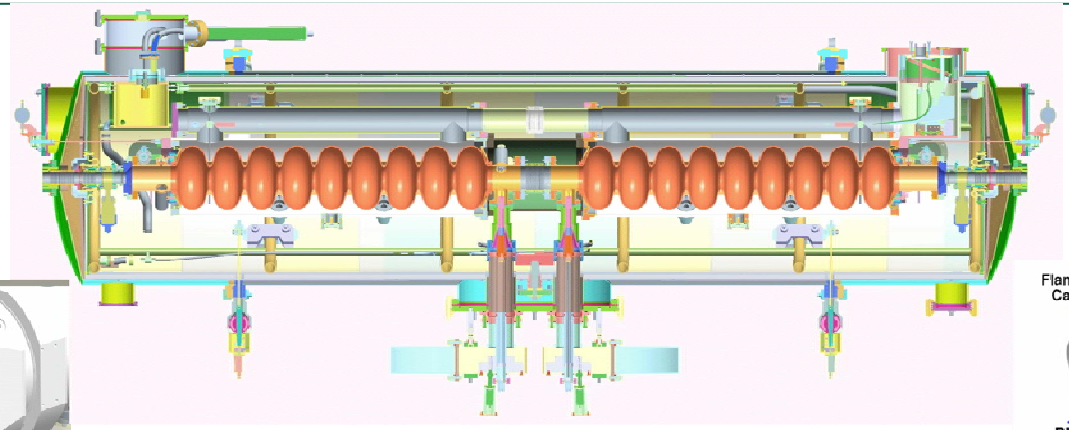


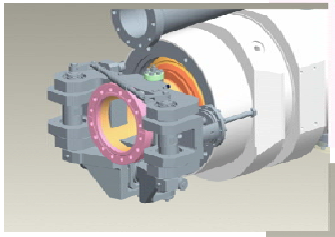
b) After optimisation to to keep beam energy (green) stable

Optimisation of the LLRF system response & external quality factors of the booster

extended operation of the machine to~40 pC bunch charge and up to 100 μs train lengths in an energy recovery regime

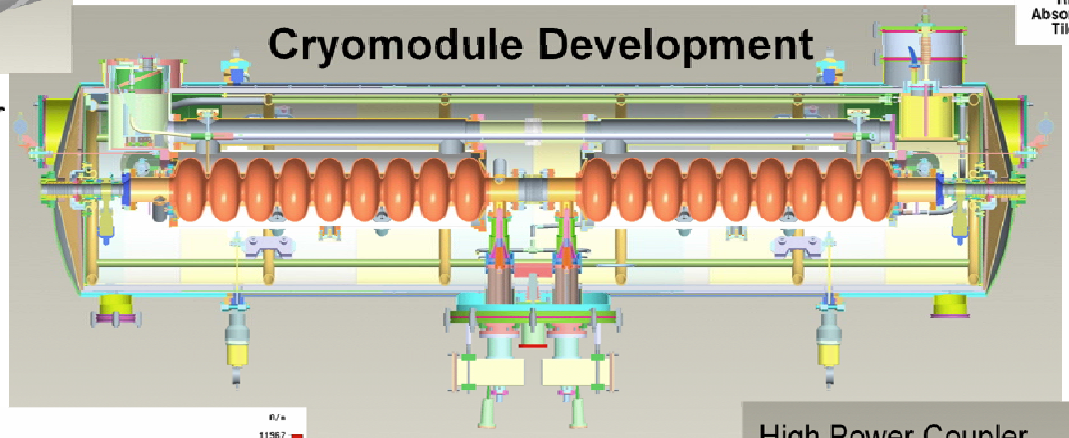
International Module Collaboration

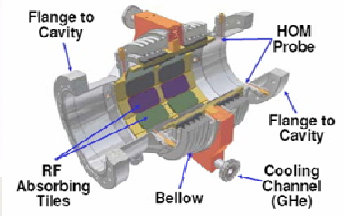




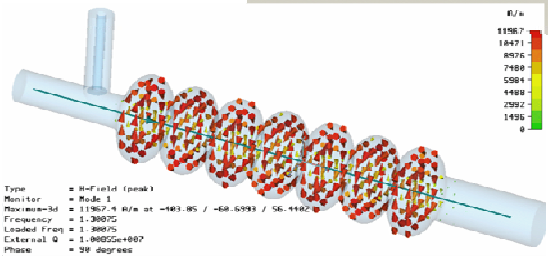
Frequency Tuner with fast control

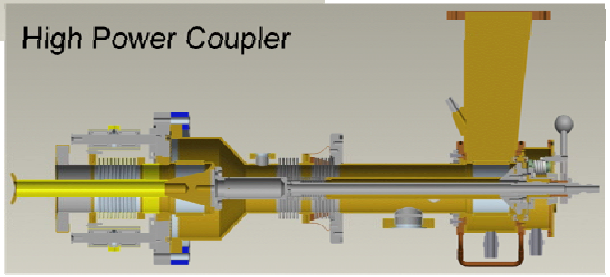
Cryomodule Development





Higher Order Mode Absorbers





Gun Parameters

	Nominal Parameters	Current parameters
Gun DC Voltage	350kV	350kV with nominal HV ceramic; currently **gun operates at 230kV**
Nominal bunch charge	80pC	80pC (~200pC potentially be delivered)
Laser Nd:YVO4 (2nd harmonic)	532nm	532nm
Laser spot	4.1mm FWHM	Variable
Laser pulse length	28ps FWHM	28ps with laser pulse stacker
Quantum Efficiency	1-3%	~4% (~15% in the lab conditions)

ALICE parameters

Injector Energy	8.35MeV	**Currently 7 MeV**
Total beam energy	35MeV	**Currently 29.8MeV**
RF frequency	1.3GHz	1.3GHZ
Bunch repetition frequency	81.25MHz	81.25MHz
Train Length	0-100μs	Up to 100μs at lower bunch charges
Train repetition frequency	1-20Hz	1-20Hz
Compressed bunch length	<1ps @80pC	To be measured
Peak current in compressed bunch	150A	To be measured
Maximum Average Current	13 μA	
Max. current within the train	6.5mA	>6.5mA but at shorter train lengths

ALICE : Status and projections

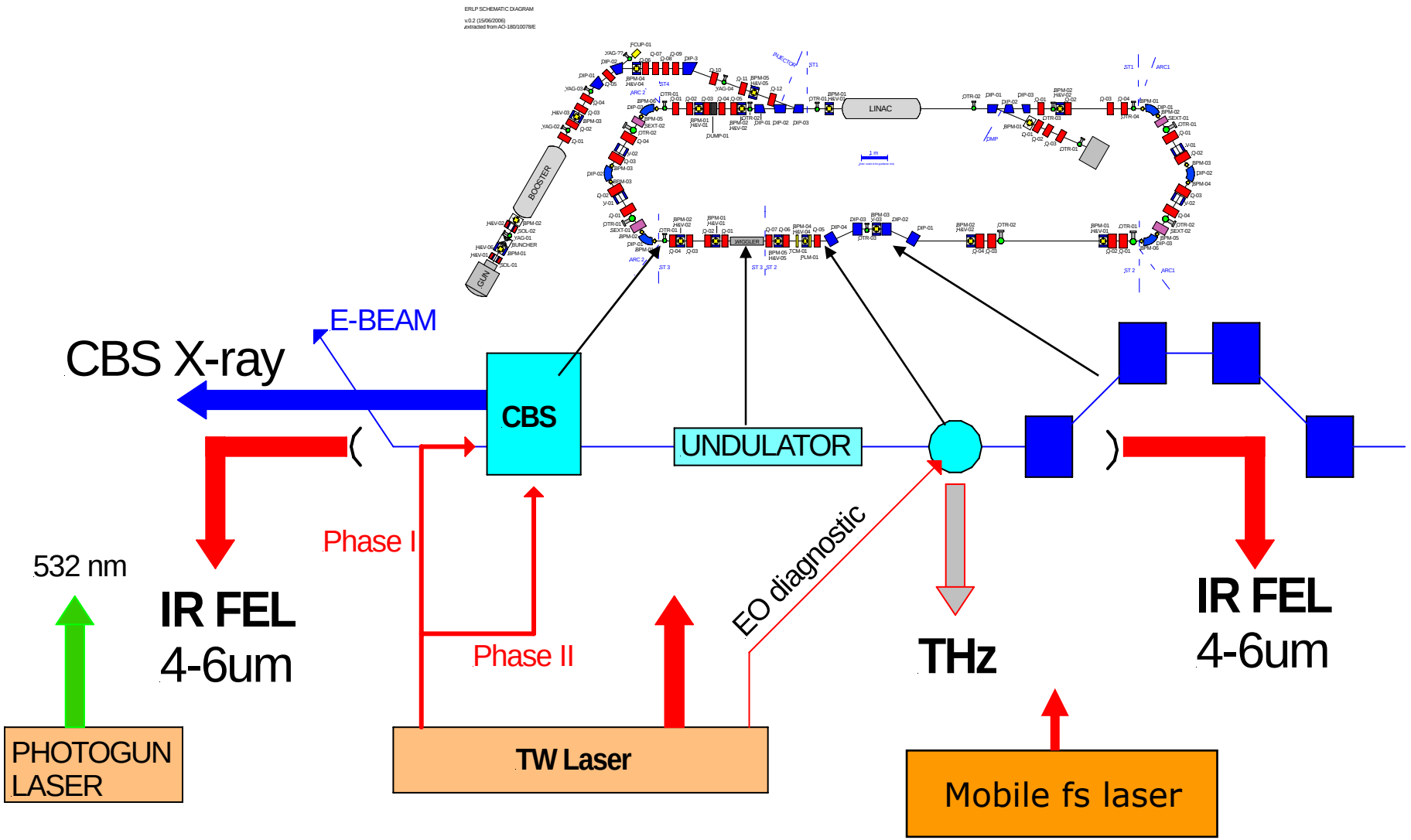
- ALICE is now operational in full energy recovery mode routinely at 40 pC and 29.8 MeV
- Beam loading is still an issue and requires careful optimisation for 40 pC. Improvement expected with feed-forward system.

- Removing limitations (changing gun ceramic, cathode) is a risky business

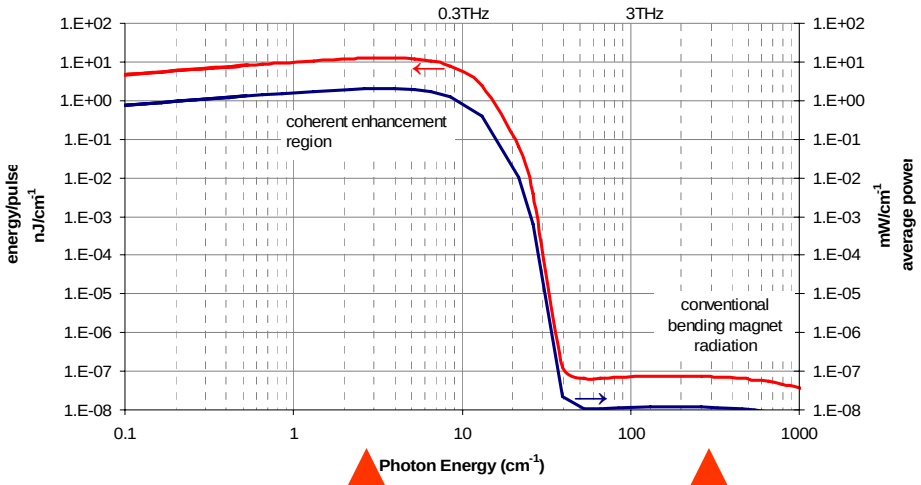
- FE limitations cannot be removed until 2010 (main linac)

- These limitations will (almost certainly) stay "as is" until the next long shutdown in mid 2010

ALICE – not just Energy Recovery Linac …



ALICE THz Source



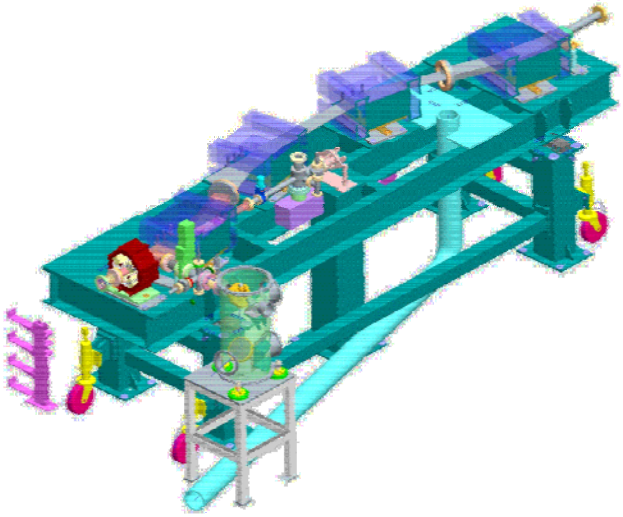
Synchrotron light spectrum
Electron bunch length ~0.6ps

Coherently Enhanced Synchrotron Light

$I \propto N^2$

Conventional Synchrotron Light

$I \propto N$

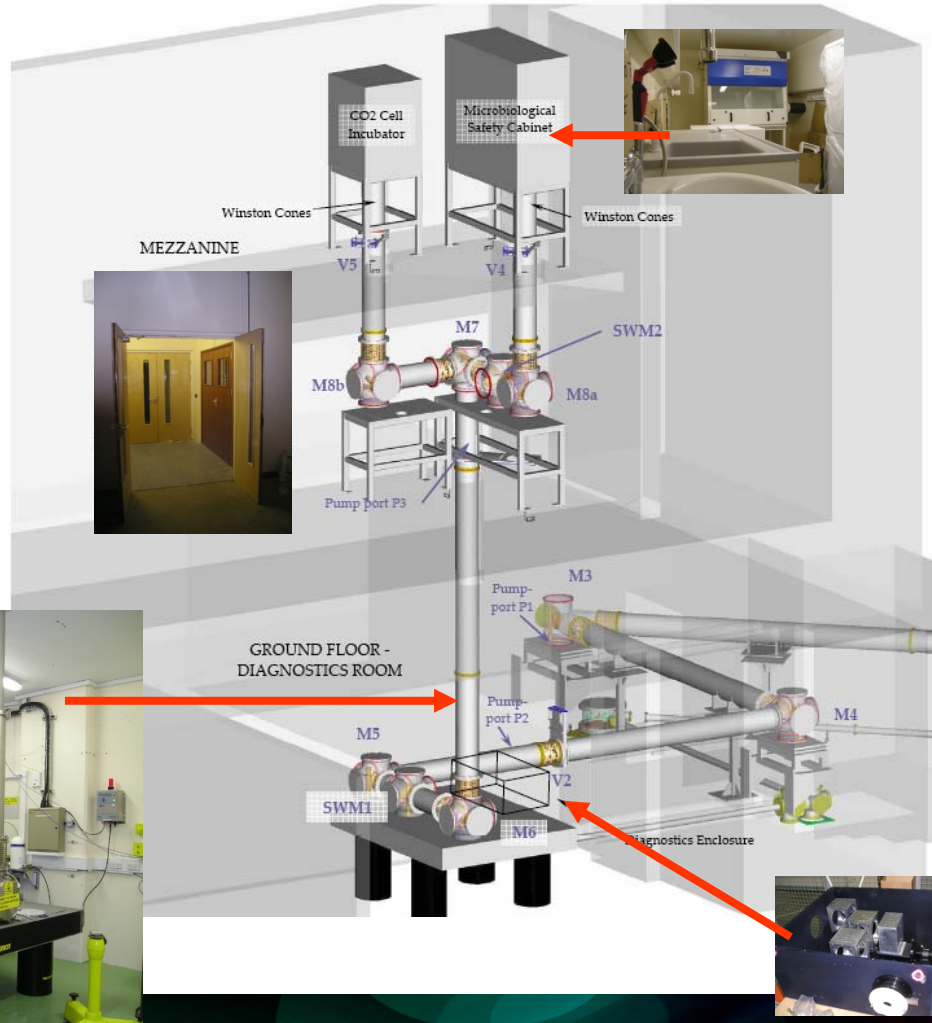


THz Programme & Tissue Culture Facility on ALICE

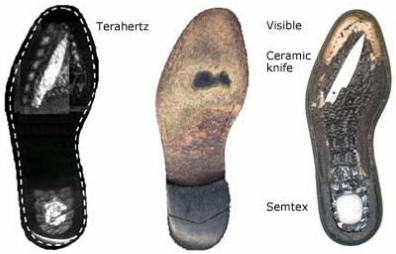
A world-unique facility allowing the effect of high peak power / high rep rate THz on living cells to be investigated.

Weightman et al
University of Liverpool
University of Nottingham

Northwest
REGIONAL DEVELOPMENT AGENCY



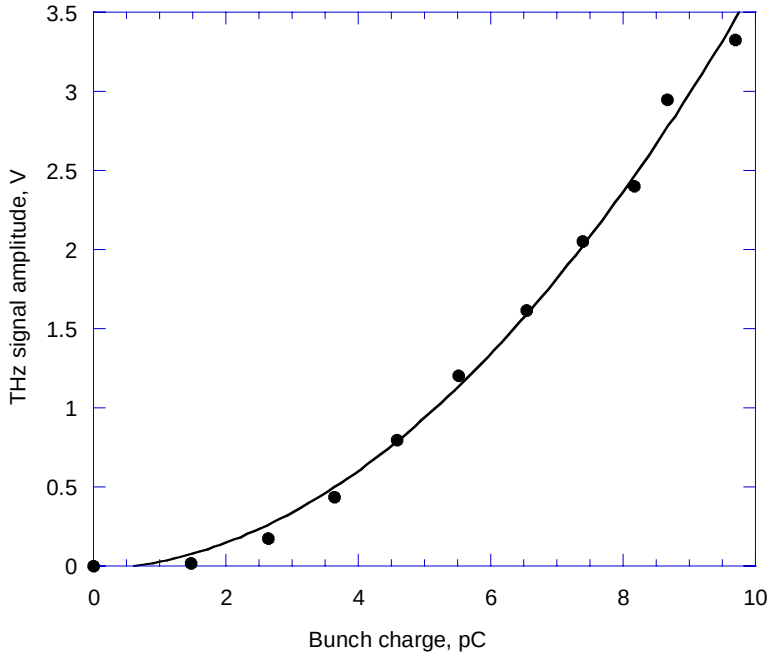
THz has important role in security screening



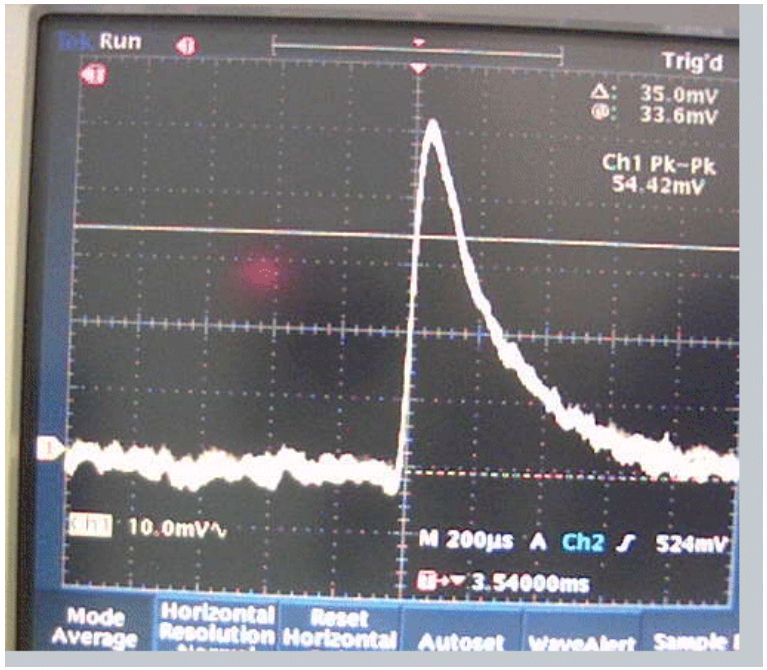
TeraView

THz Detected In the Diagnostics Room

- THz coherently enhanced radiation (February 2009)



Quadratic dependence of the THz signal amplitude on the bunch charge.



Typical signal from THz detector (bolometer)

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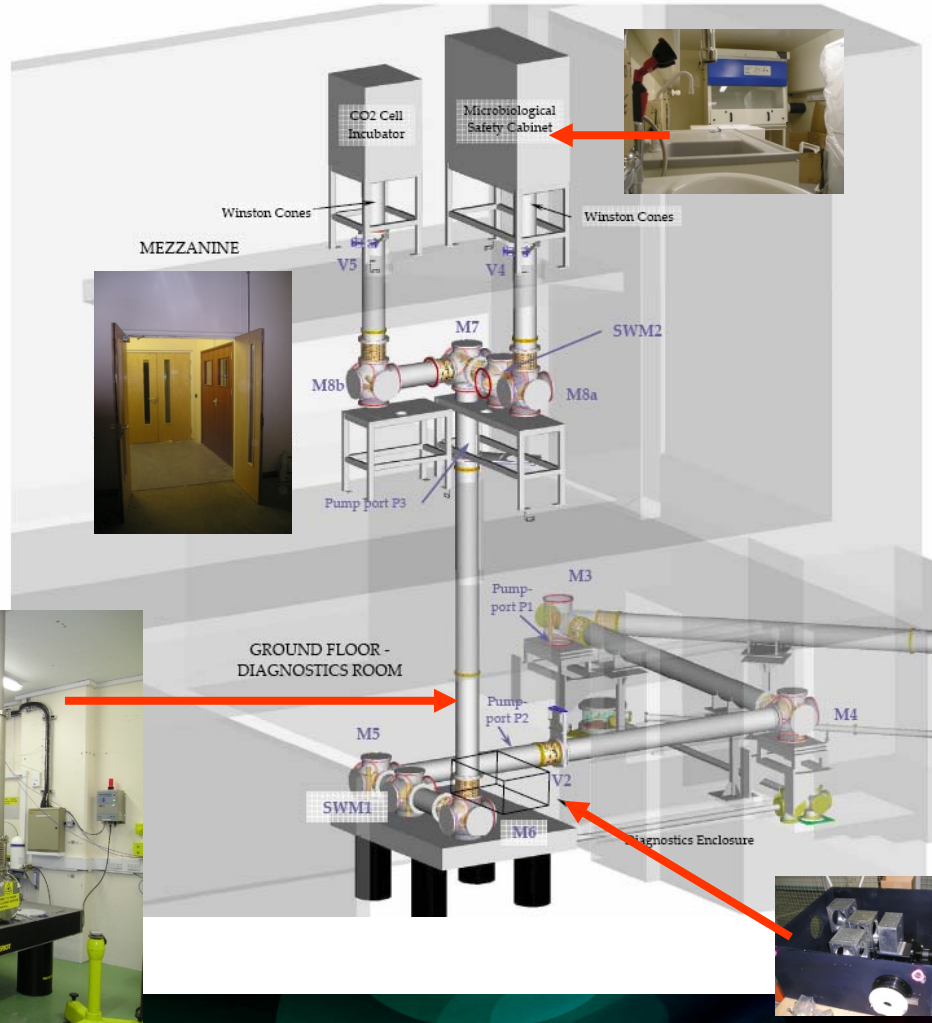

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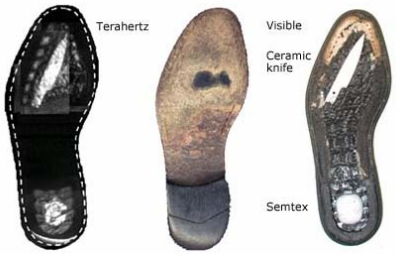
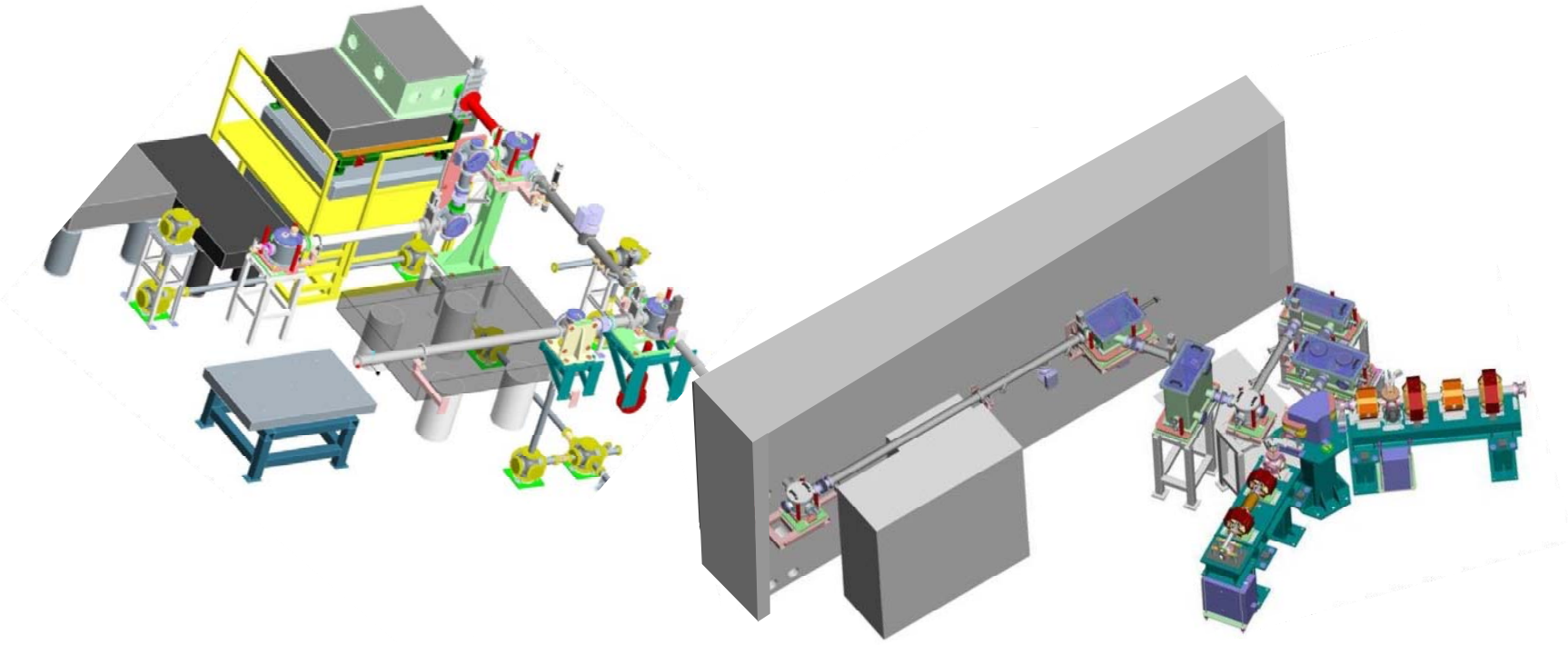
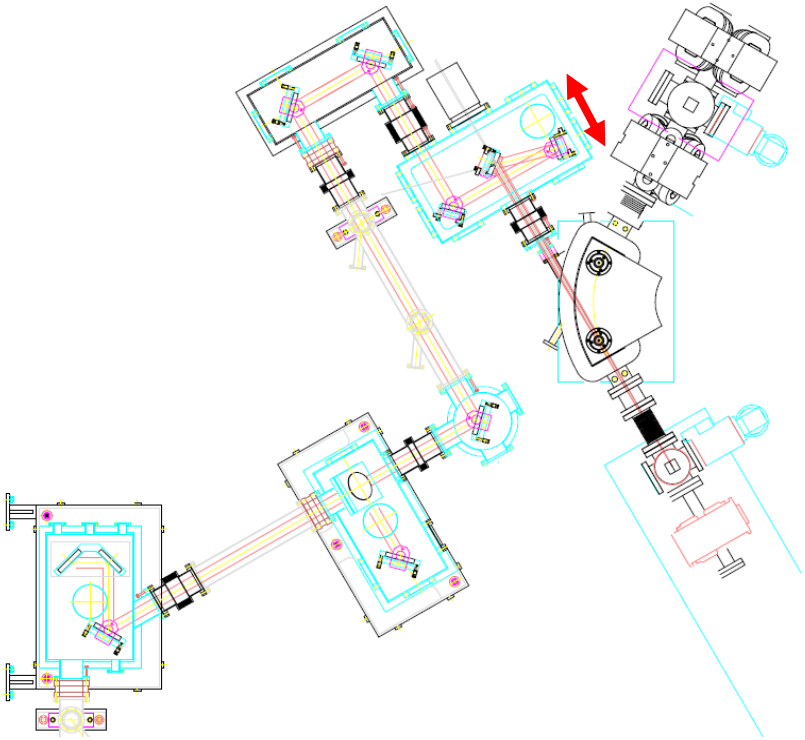


TeraView

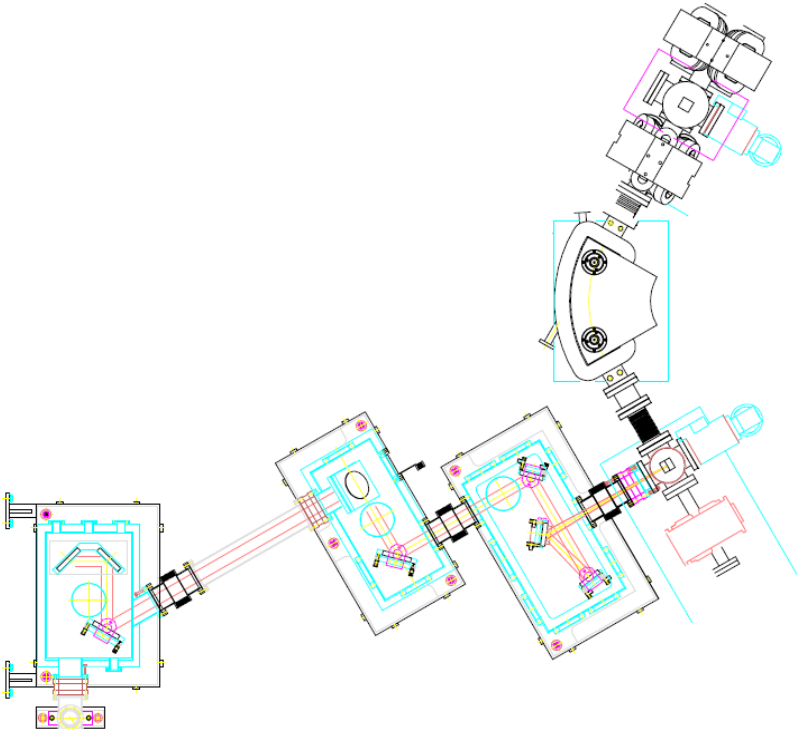
Compton Backscattering Experiment



Compton Backscattering Experiment



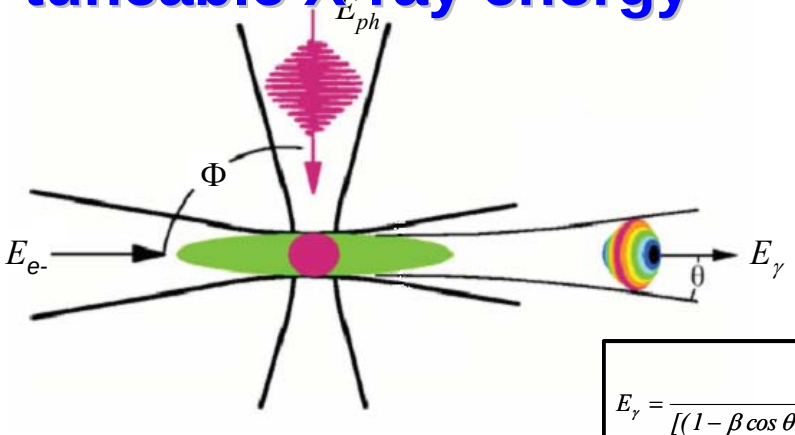
head on configuration



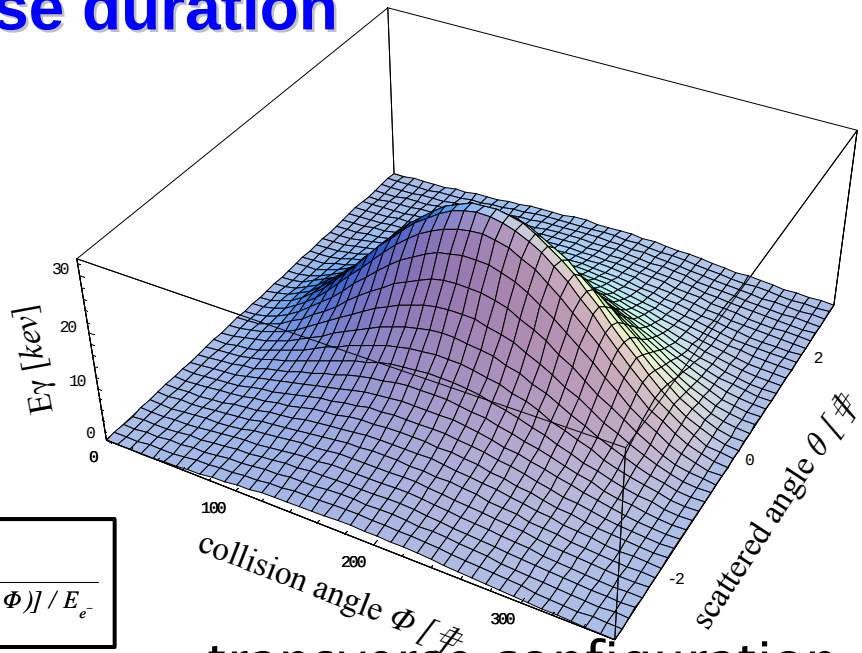
90° configuration

Compton Backscattering Experiment

10^7 X-ray per shot
sub ps down to 100 fs X-ray pulse duration
polarised X-rays
tuneable X-ray energy



$$E_\gamma = \frac{E_{ph}(1-\beta\cos\Phi)}{[(1-\beta\cos\theta)+E_{ph}(1-\cos(\theta-\Phi)]/E_{e^-}}$$



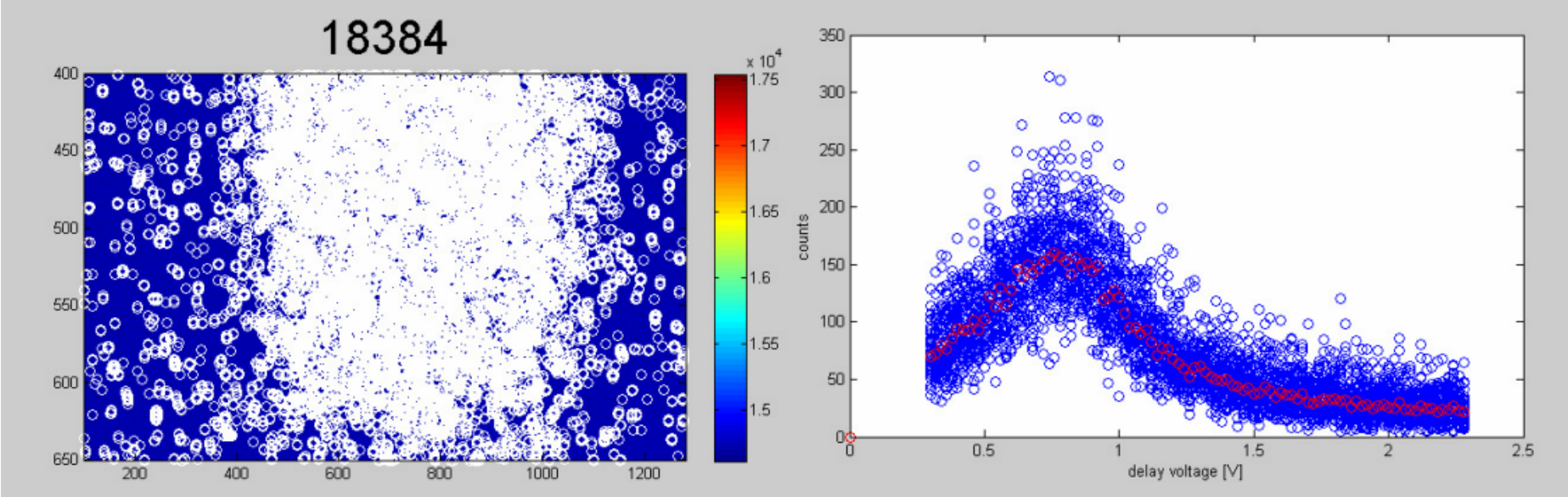
head on configuration

$$E_\gamma^\pi \approx 4\gamma^2 E_L \approx 30 \text{ keV}$$

transverse configuration

$$E_\gamma^{\frac{\pi}{2}} \approx \frac{E_\gamma^\pi}{2} = 15 \text{ keV}$$

1st Compton X-rays 15th Nov 2009

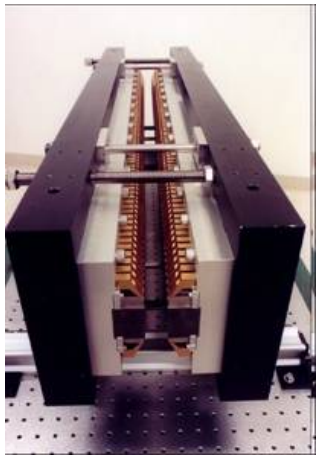


X-rays from electron beam-TW laser scattering

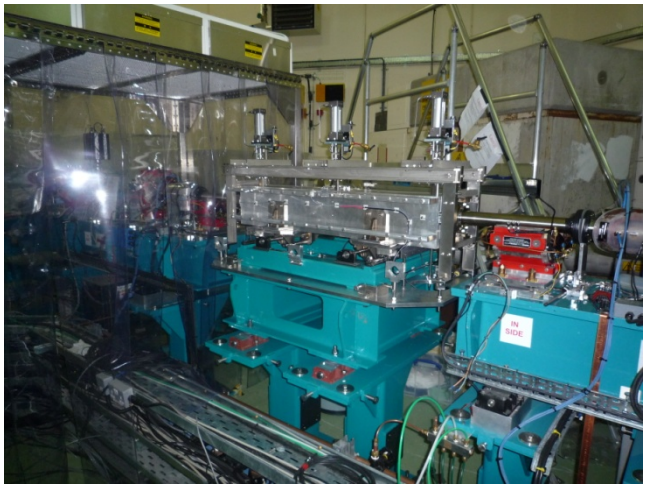
Scan through the electron beam using laser timing

Physicists at Daresbury, working on ALICE are celebrating after successfully colliding electrons and a powerful laser beam to produce short-pulsed X-rays.

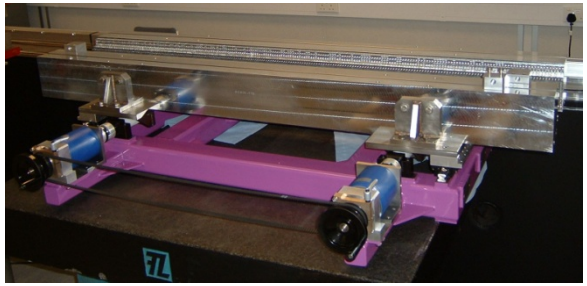
FEL Commissioning 2010



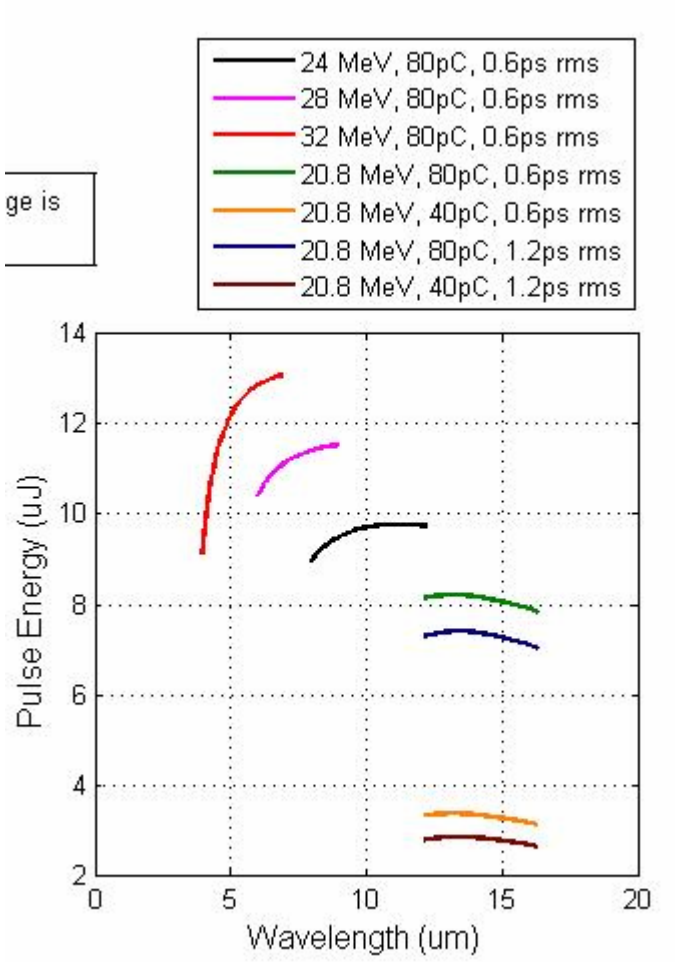
Fixed gap
JLAB wiggler



Installed 18th Nov 2009



Variable gap carriage

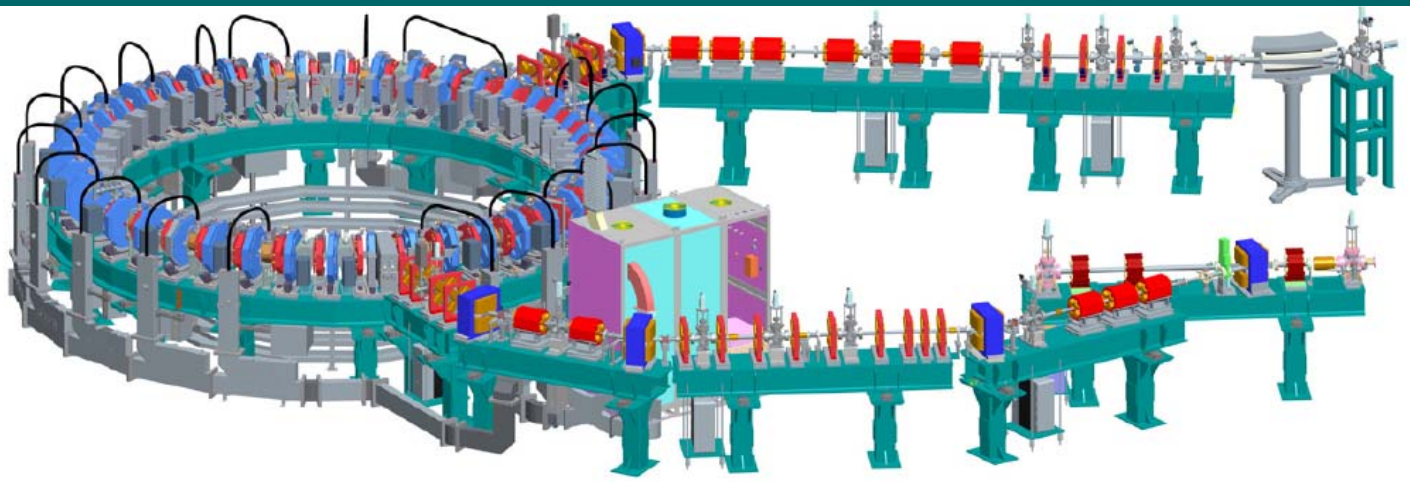


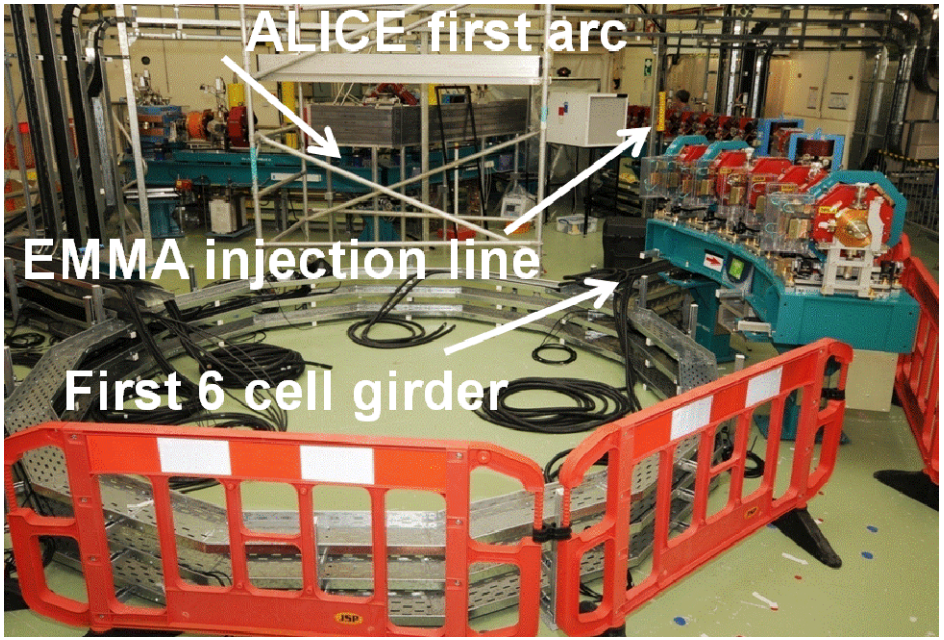
Future developments

ALICE: Future R & D

- RF feed-forward system, injector optimisation and characterisation
- IR FEL commissioning
- Electro-optic diagnostic commissioning
- THz development
  - THz transport beamline optimisation, THz spectra
  - Tissue Culture Facility (TCF) experiments (human tissue exp)
- Laser-THz synchronisation/pump-probe experiments
  - (for novel solar cells research; collaboration-Manchester Uni.)
- Helium processing of LINAC cavities
- EMMA commissioning & research
  - World's first non-scaling FFAG
- Installation of a new improved SC RF cryomodule
- Installation of large ceramic1kHz operation
- Other smaller scale projects
  - in parallel with EMMA and photo-science R&D
- Installation of the gun load lock system & diagnostics line

EMMA





World's First Non scaling-FFAG

Summary

- Commissioning
  - Energy recovery
  - Achieved 1st THz in Diagnostics Room
  - Initial characterisation of beam
  - RF conditioning & optimisation

- Future experiments
  - Accelerator science R&D
  - Photon science R&D
  - Technology developments