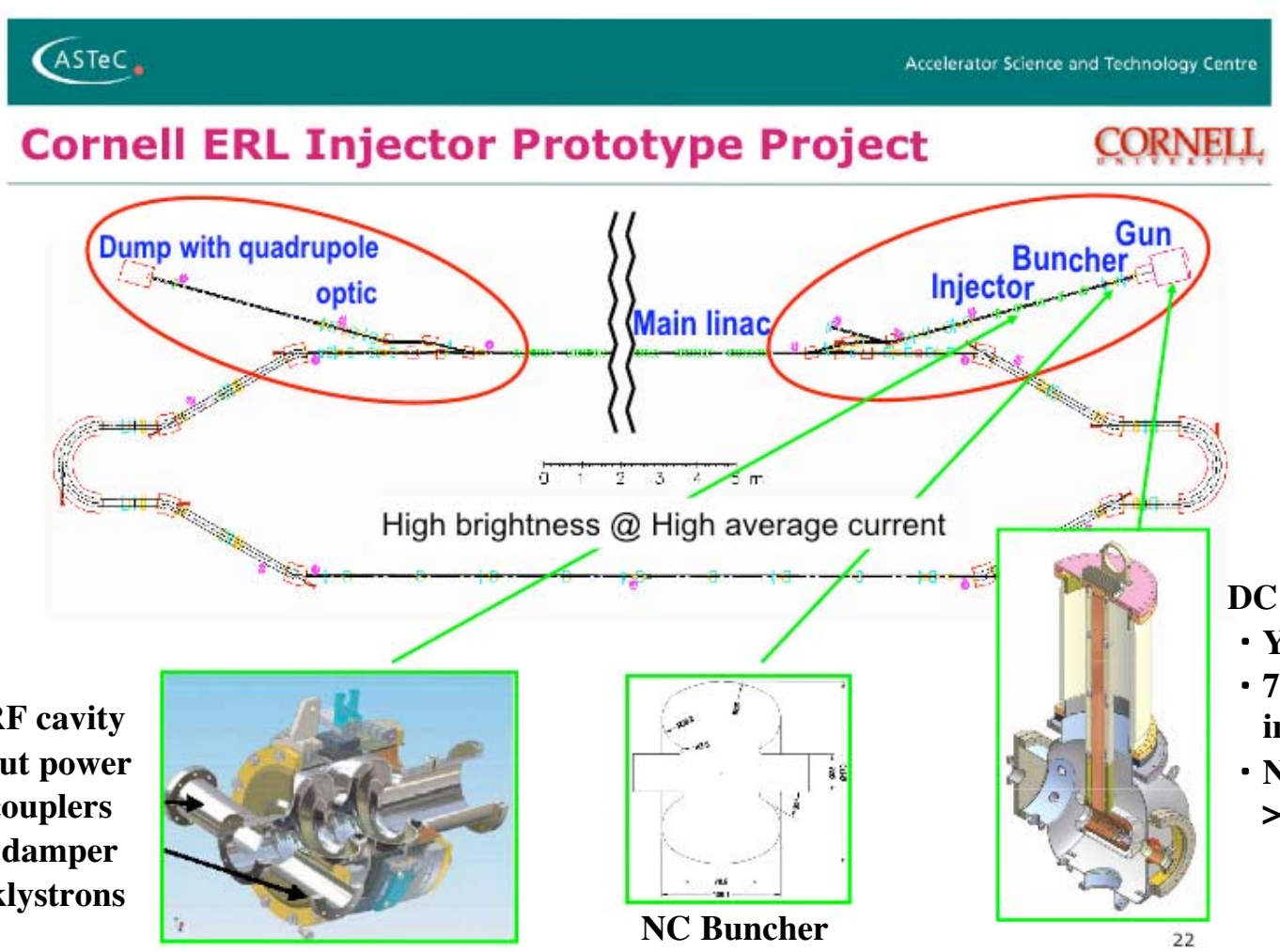
DARESBURY/EPAC06 報告

中村　典雄（東大物性研）
原田　健太郎（KEK-PF）
佐藤　政則（KEK加速器）

Overview of EPAC06

- **ERL**
  - Many presentations for ERLP by Daresbury Lab.
  - Invited talk by S. L. Smith
- **FEL**
  - FLASH: lasing at 13 nm, 25 fs radiation pulse at 32 nm
  - SCSS: lasing at 49 nm
- **Storage-ring based SR sources**
  - Diamond & Soleil: under commissioning
- **SCRF Cavity**
  - Many presentations!!
- **Femtosecond Timing System**
- **Femtosecond Bunch Profile Monitor**
- **ERL meeting at EPAC06 (28 June 2006)**
  - ERL2007 Workshop @ Daresbury (21-25 May 2007)

Cornell ERL Injector Prototype Project



Two-cell SCRF cavity
- **~50kW input power**
- **two input couplers**
- **80K HOM damper**
- **> 120 kW klystrons**

NC Buncher

DC Photoinjector Gun
- **Yb fiber laser**
- **750 keV 100mA supply in Autumn**
- **NEA GaAs/GaAsP >17% QE**

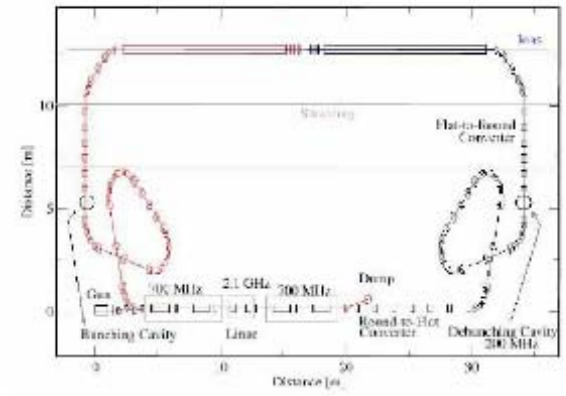
from S. L. Smith EPAC06

BNL Test Facility

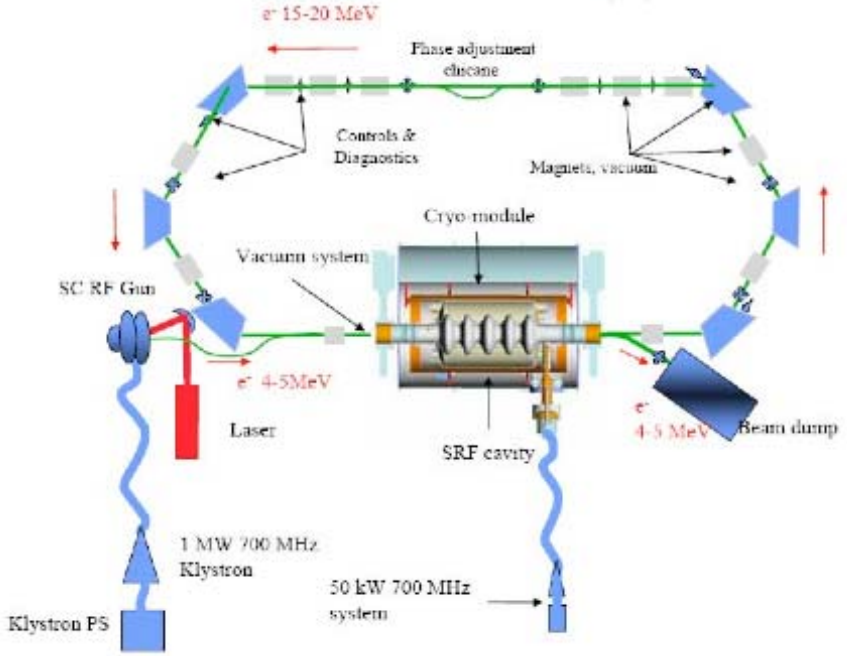
ASTeC — Accelerator Science and Technology Centre

BNL Test Facility

BROOKHAVEN NATIONAL LABORATORY



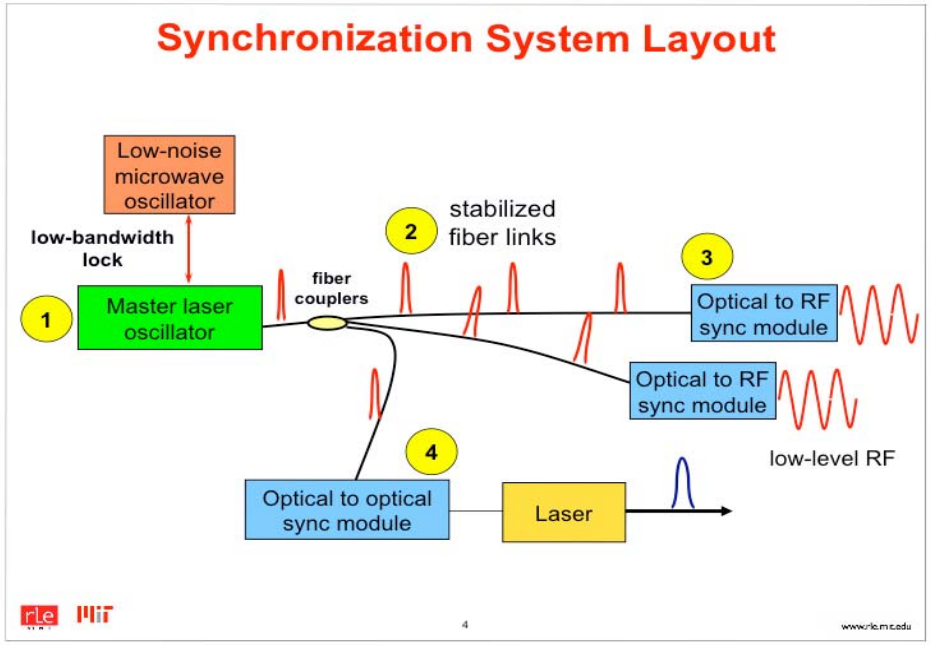
RHIC electron cooler is based on a 200 mA, 55 MeV ERL 20 nC per bunch, 9.4 MHz



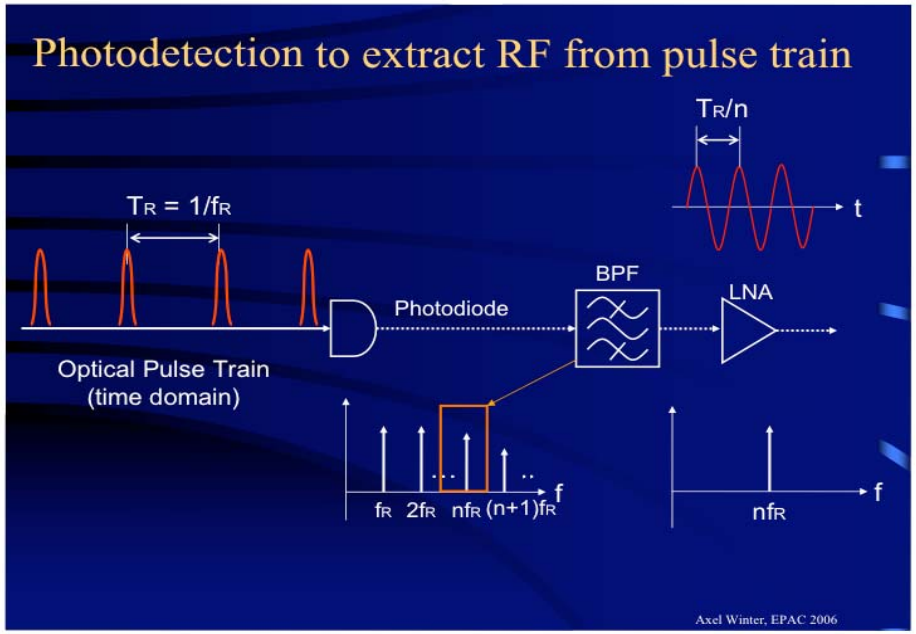
The prototype ERL (20-25 MeV) is still under construction with plan for commissioning in 2008 (linac tests later this year).

from S. L. Smith EPAC06

Femtosecond Timing System



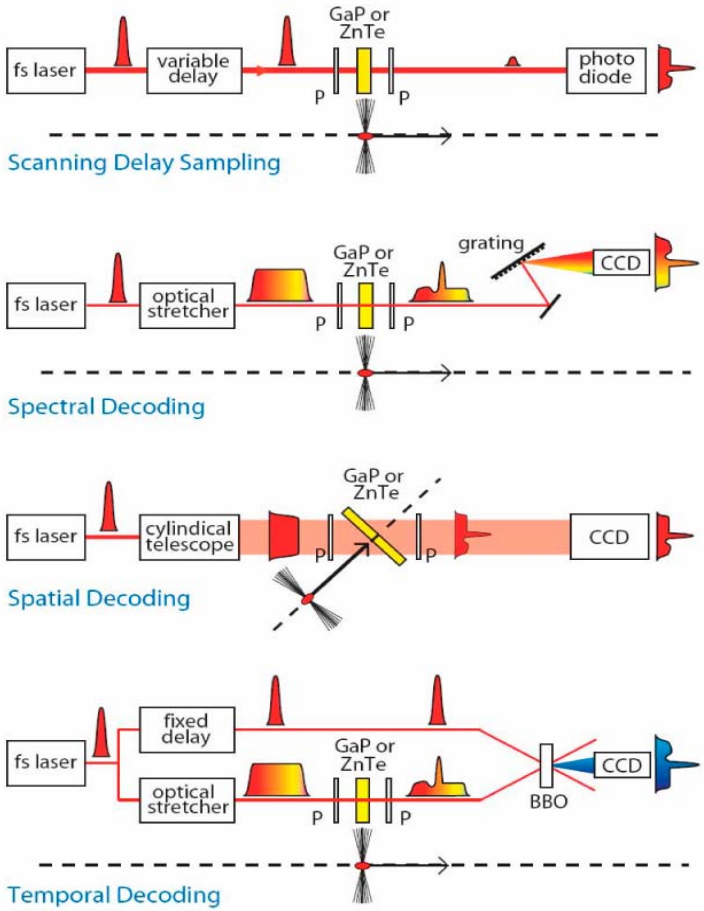
J. Kim et al. EPAC06



A. Winter et al. EPAC06

① Optical master oscillator(mode-locked fiber laser) ~10 fs (--> 1 fs in future)
② Timing-stabilized fiber links ~10 fs (--> < 1 fs in future)
③ Optical-to-RF synchronizatioon ~3 fs (--> < 1 fs in future)
④ Optical-to-optical synchronization < 1 fs

Femtosecond bunch profile monitor



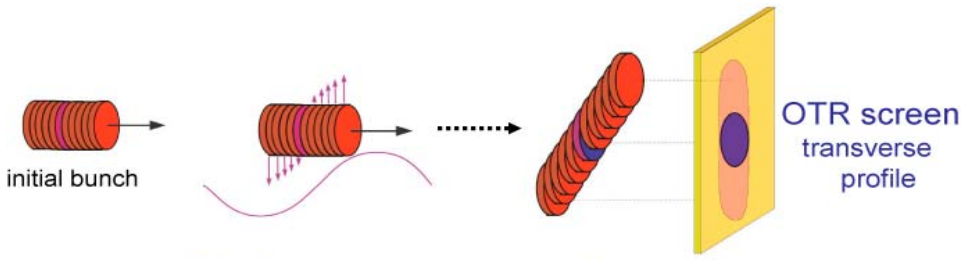
FELIX, DESY
SLS
BNL
...

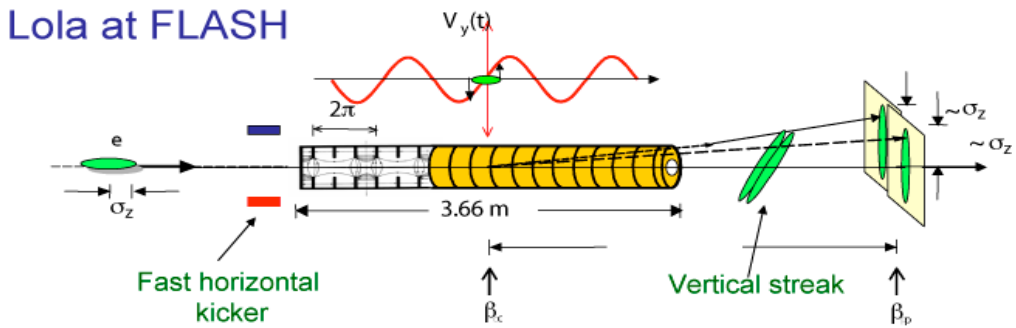
FELIX
DESY
BNL
...

SLAC
DESY

FELIX
DESY

Electro-optical Techniques



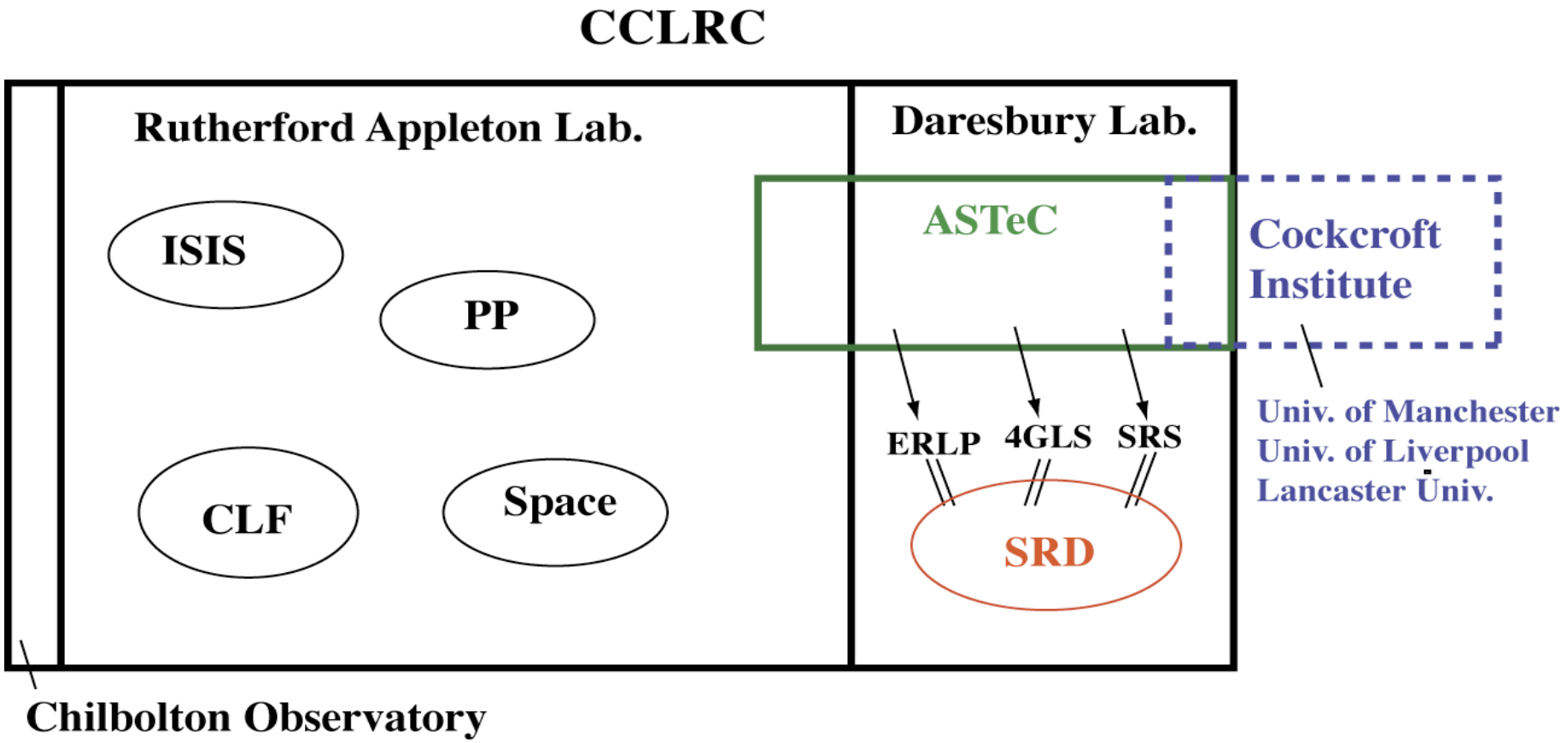


Transverse Deflecting Cavity

S. P. Jamison et al. EPAC06

Daresbury Laboratory

Organization



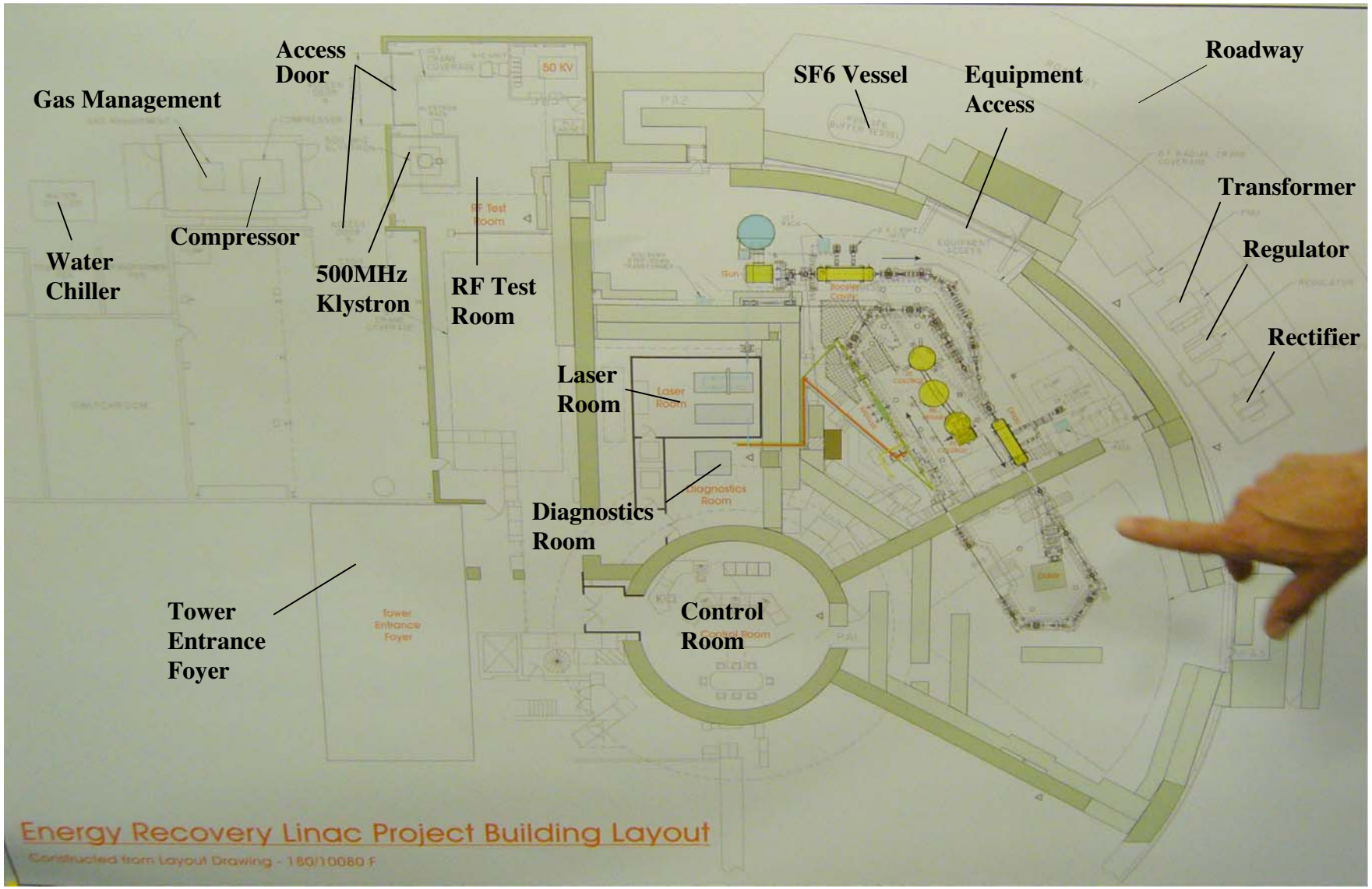
- CCLRC: Council for the Center Laboratory of the Research Councils
- ASTeC: Accelerator Science and Technology Center
- SRD: Synchrotron Radiation Department
- CLF: Central Laser Facility
- PP: Particle Physics Department

ERLP Building & Control room

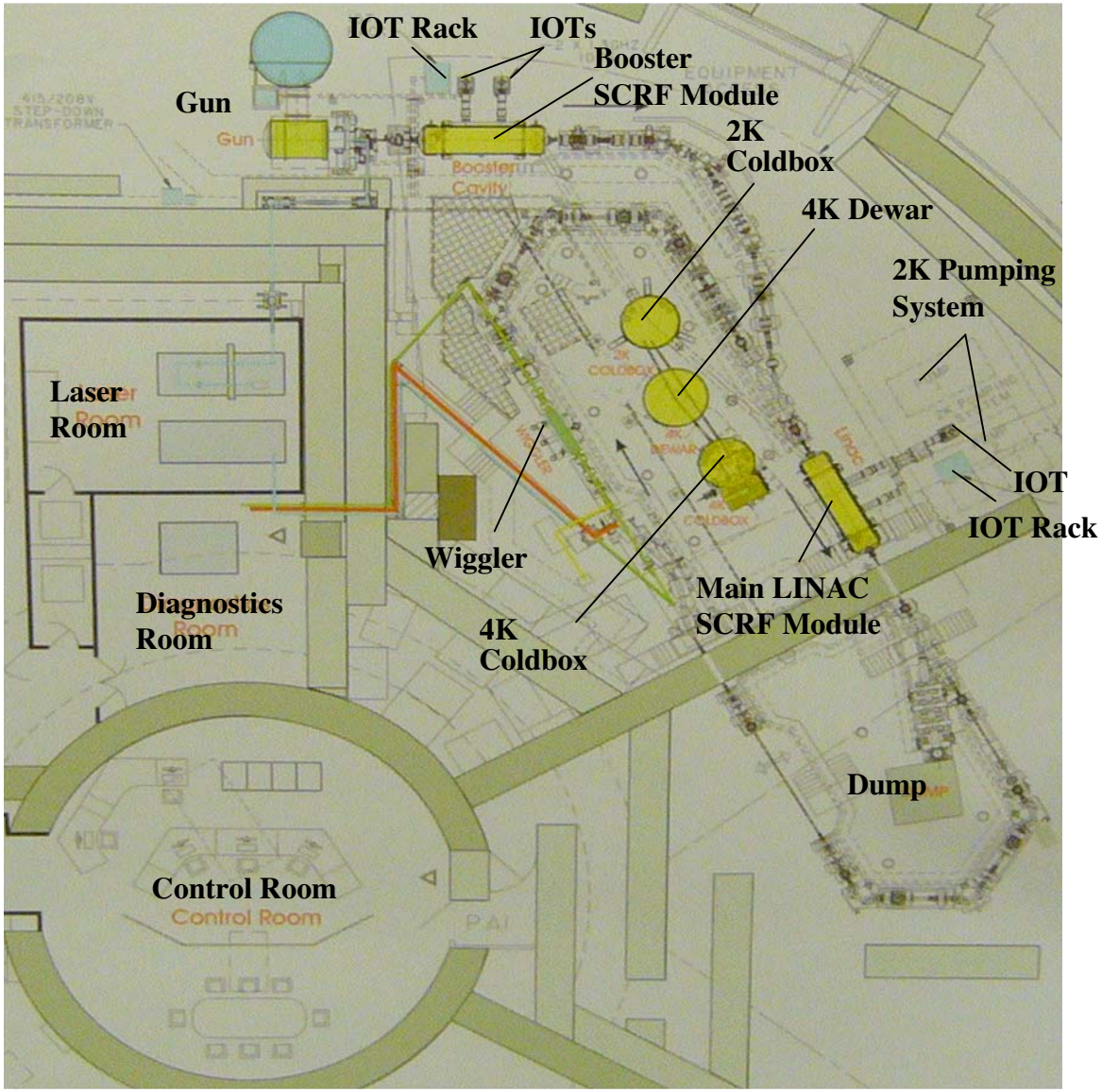
ERLP building

Control room

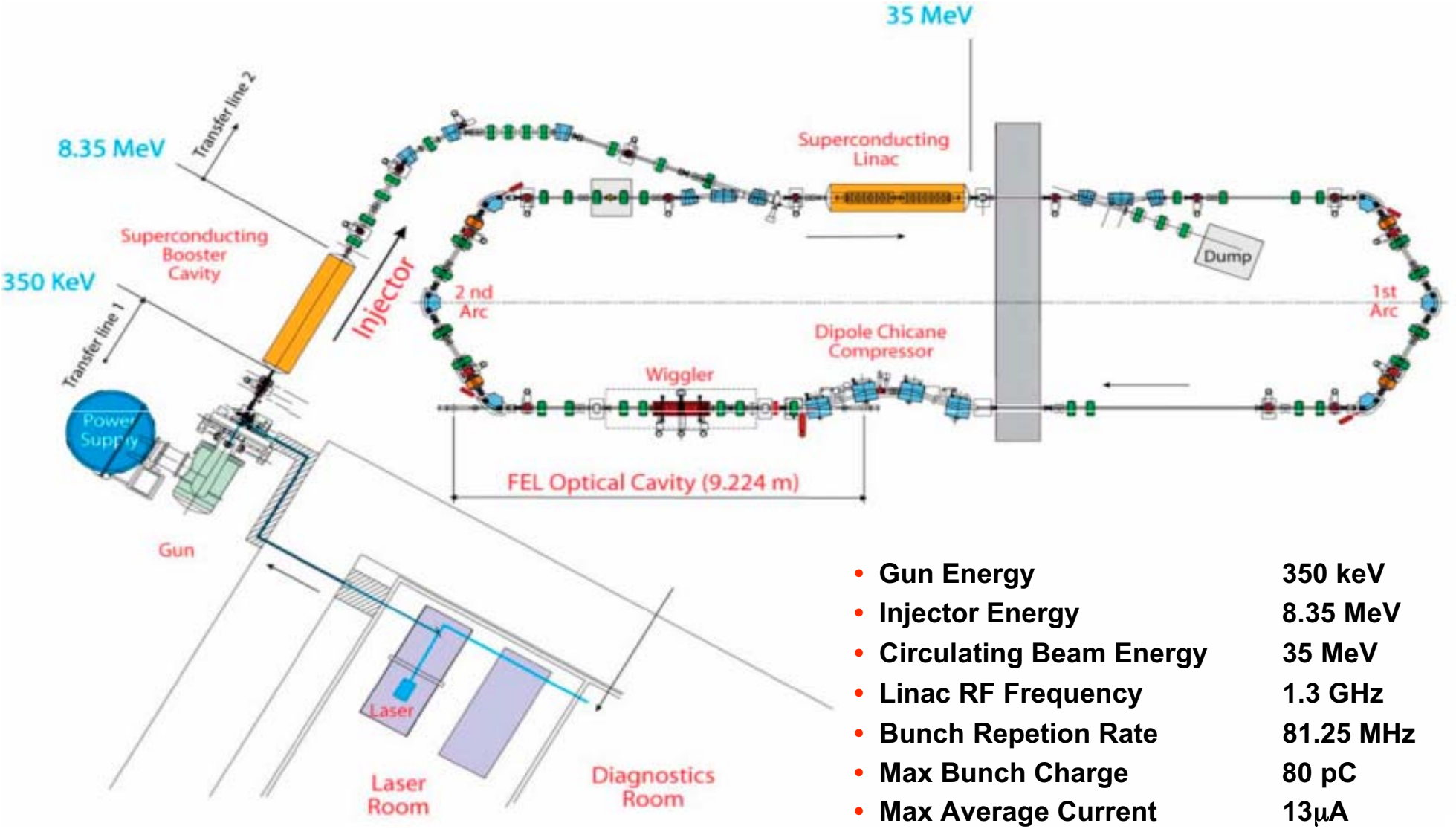
ERLP Building Layout (1)



ERLP Building Layout (2)



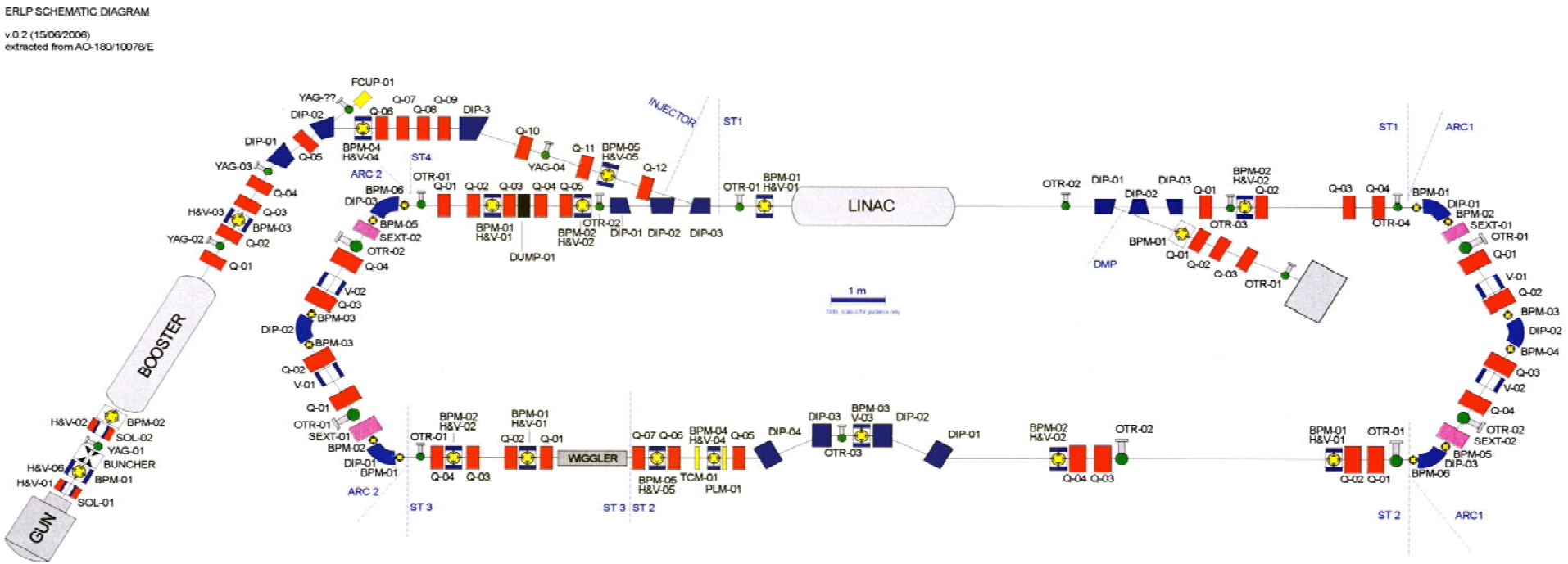
ERL Prototype



- Gun Energy 350 keV
- Injector Energy 8.35 MeV
- Circulating Beam Energy 35 MeV
- Linac RF Frequency 1.3 GHz
- Bunch Repetion Rate 81.25 MHz
- Max Bunch Charge 80 pC
- Max Average Current 13μA

D. J. Holder, EPAC06

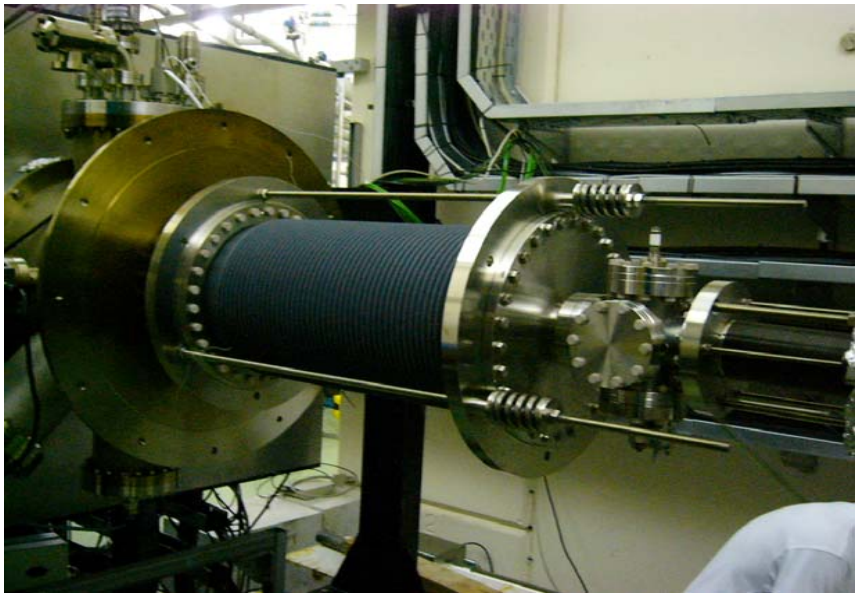
ERLP Component Layout



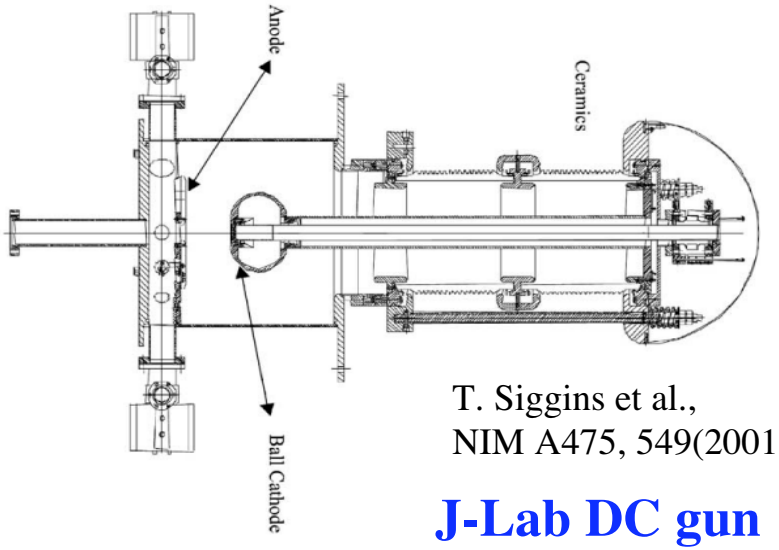
DC Photocathode Gun (1)

- **Photoinjector Laser**
  - **Nd:YVO_4 mode locked laser, Wavelength 532 nm**
  - **Pulse length ~10 ps, Pulse repetition rate 81.25MHz**
  - **Pulse energy at cathode 80 nJ, Pulse width ϕ2-6 mm**
- **DC Gun**
  - **Negative affinity GaAs cathode (ϕ25.4 mm)**
  - **High voltage 350 kV (by 500 kV power supply)**
- **Operation modes**
  - **Single bunch, Short (20 μs) and Long trains (100 μs)**
  - **Repetition rate 1 - 20 Hz**
  - **Bunch charge 80 pC (max), Bunch length ~20 ps**
  - **Max average current 13 μA (6.5 mA in pluse train)**
  - **Max duty cycle 0.2 %**

DC Photocathode Gun (2)

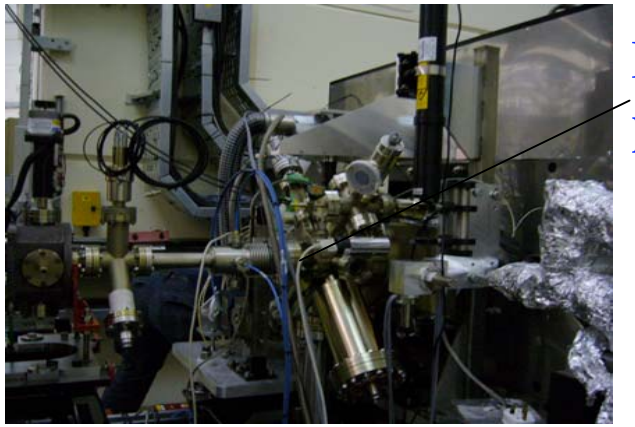


ERLP DC gun



T. Siggins et al.,
NIM A475, 549(2001)

J-Lab DC gun

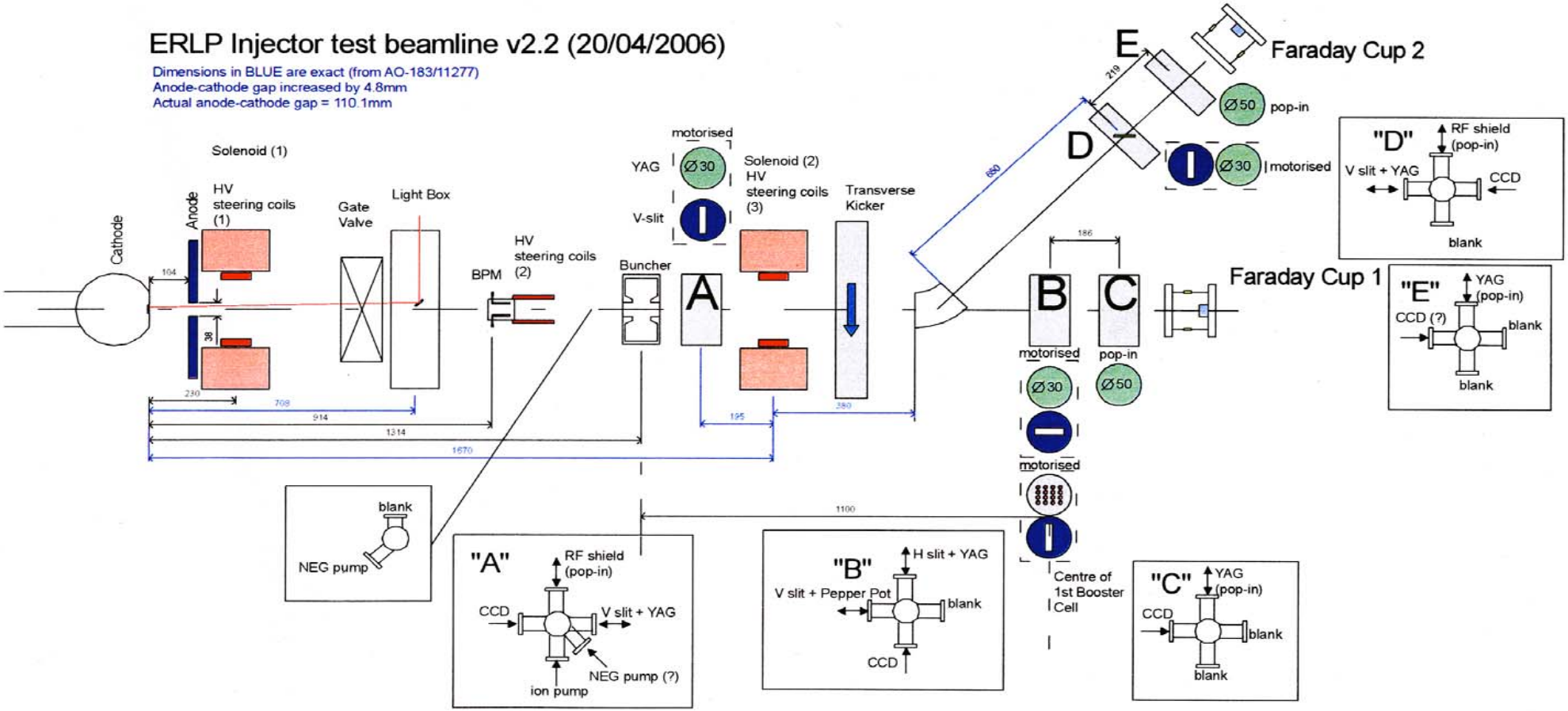


Lightbox for
photoinjector laser

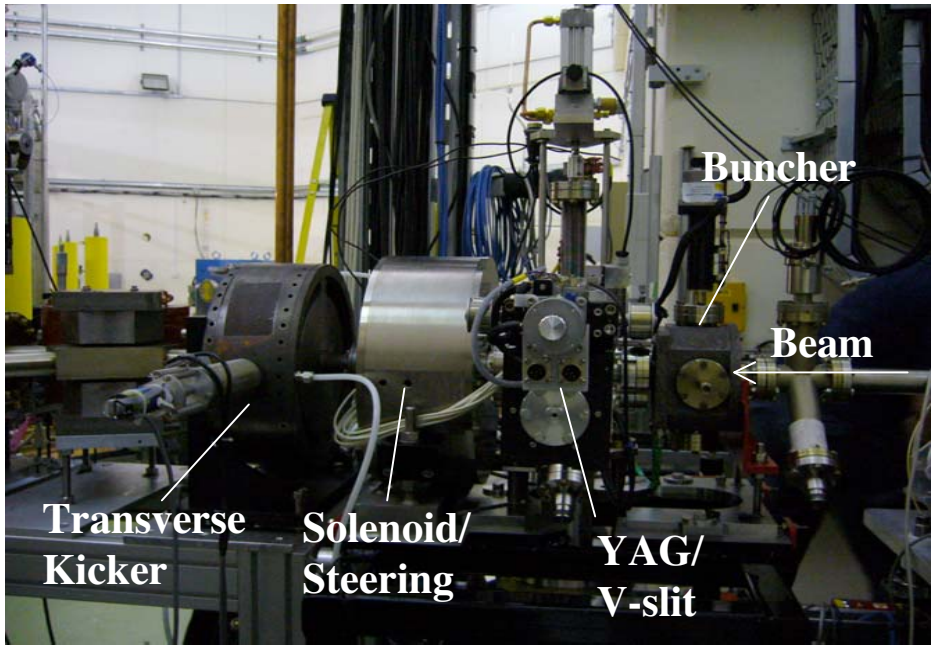
500kV
Power Supply

Gun Commissioning Scheme

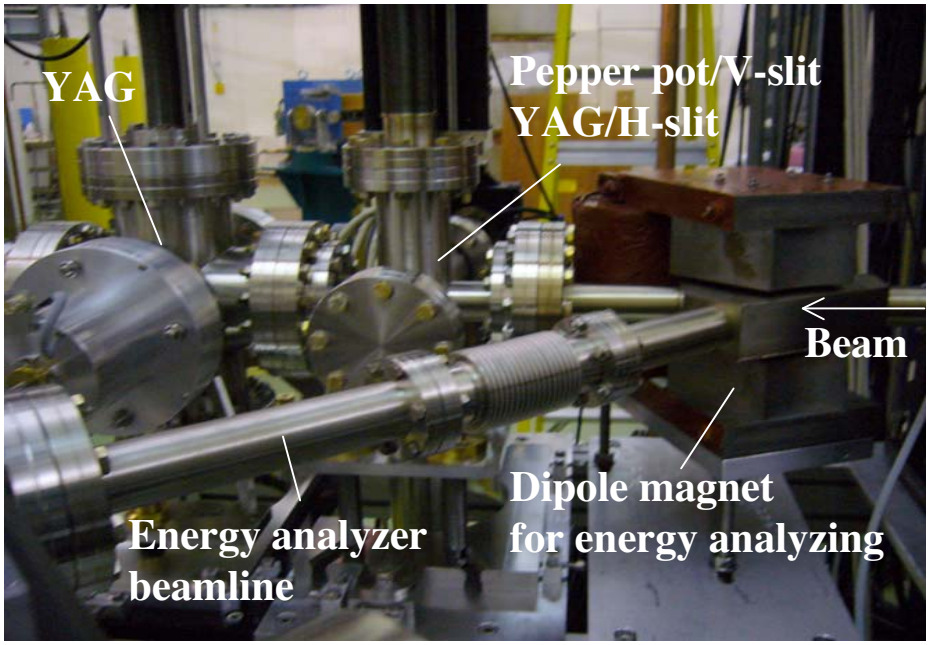
ERLP gun commissioning doc v.3.3



Gun Diagnostic Beamline



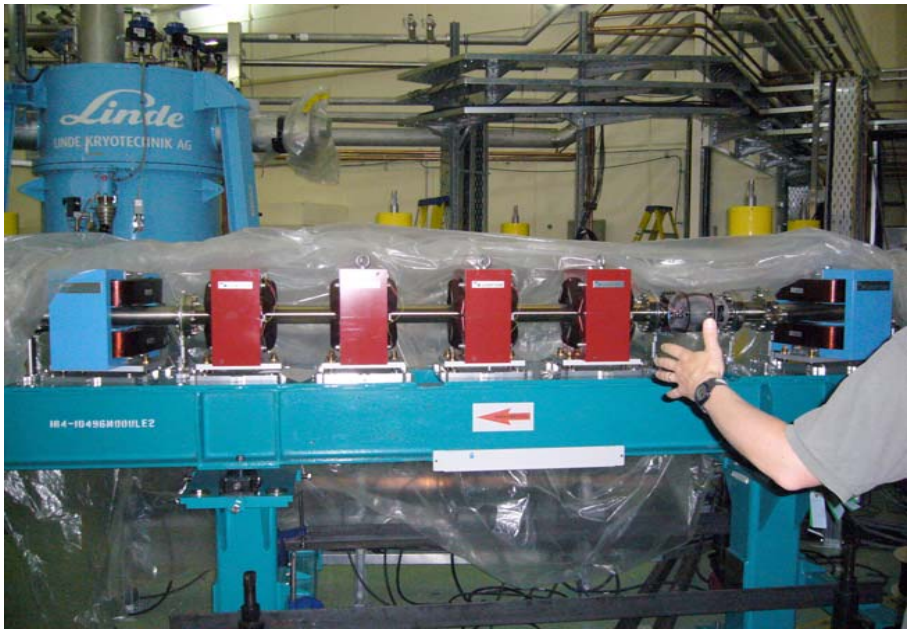
Gun diagnostic components (1)

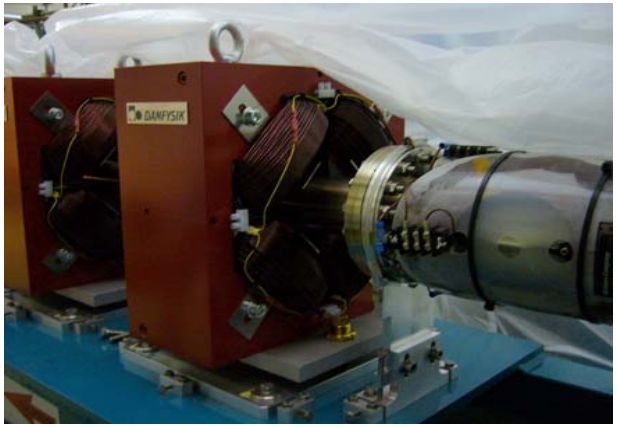


Gun diagnostic components (2)

- Bunch profile measurement by transverse kicker (TM110 cavity)
- Energy analysis by dipole magnet and YAG screen with V-slit
- Emittance measurement by pepper pot and YAG screen
- Current(charge) measurement by Faraday cups

Injector Beamline



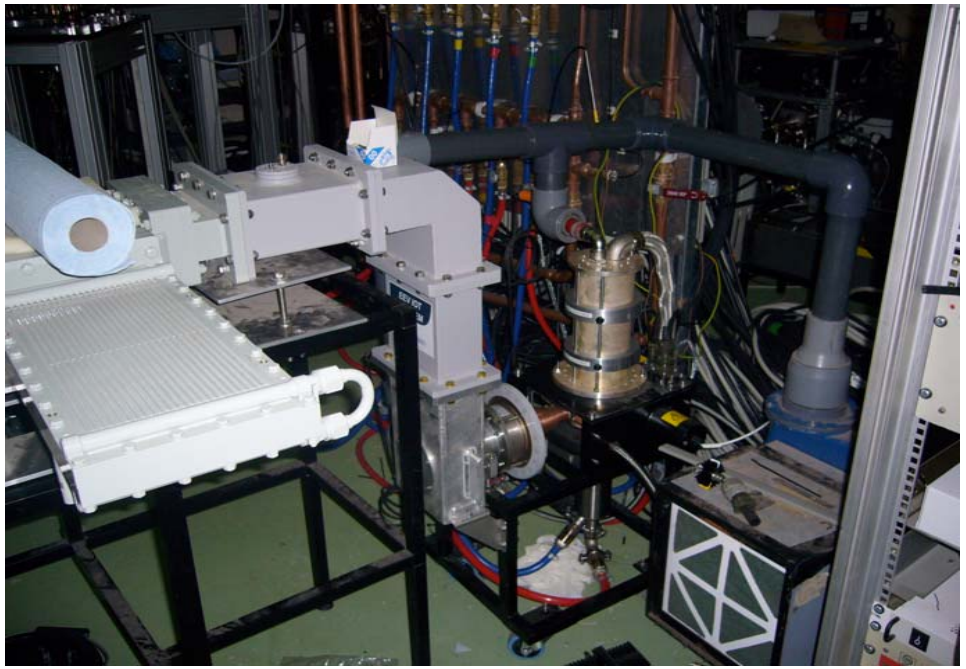


Superconducting RF Cavity System (1)

- **Superconducting RF(SCRF) linac module**
  - **Two SCRF modules for booster and main linac (L=3.26 m)**
  - **Two 9-cell TESLA structure cavities in each module**
  - **RF frequency 1.3 GHz, Operating temperature 2K**
  - **Designed by FZR Rossendorf and manufactured by ACCEL**
  - **4 MV/m for booster, 15 MV/m for main linac**
- **RF Power Source**
  - **Three 16kW IOTs (two for booster, one for main linac)**
  - **Conventional high-voltage power supply from SRS**
- **Cryogenic System**
  - **Total loss ~150 W at 15 MV/m, Liq. He requirement of 250 L/hour**
  - **Compressor + 4K coldbox + 4K dewar + 2K coldbox with 2 pumps + …**
- **Collaborative R&D**
  - **Superconducting RF cavities for high current (~ 100 mA)**
  - **7-cell TESLA structure with three HOM dampers**

Superconducting RF Cavity System (2)

SCRF module



IOT system

- SCRF module for booster delivered in April 2006
- SCRF module for main linac scheduled to arrive in July 2006
- IOT system under test on site

Superconducting RF Cavity System (3)

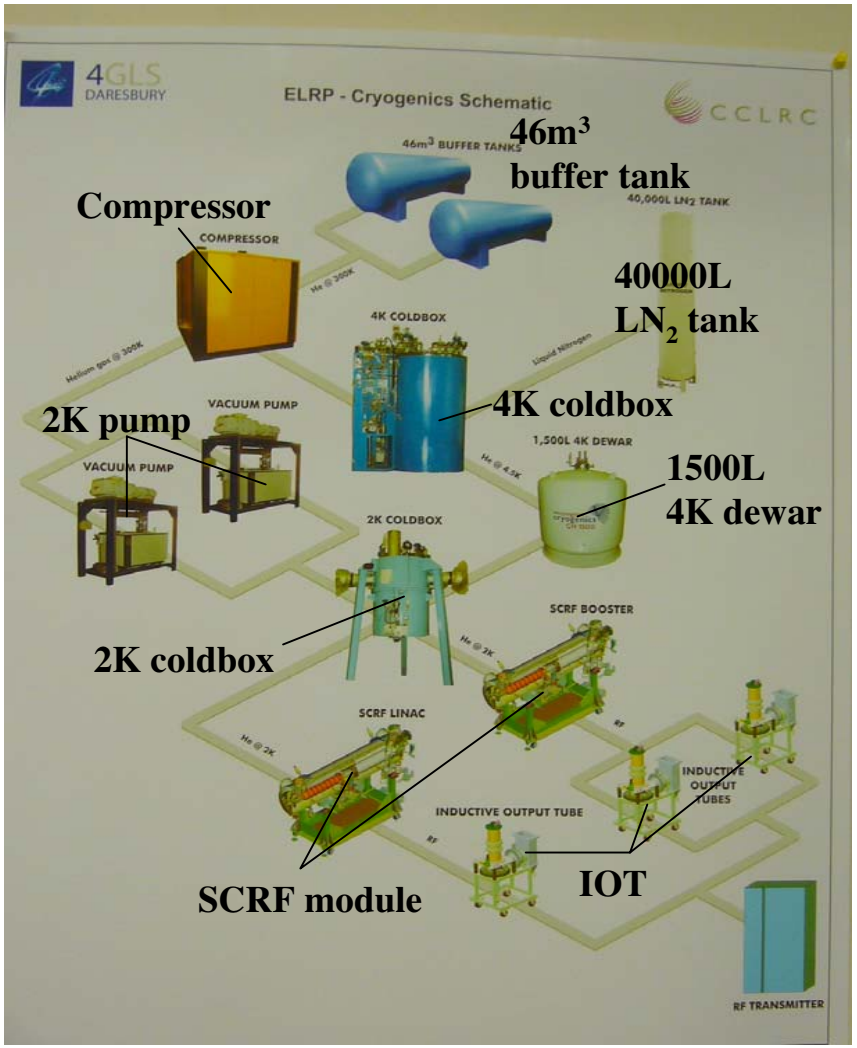
Cryogenic System

2K Coldbox

2K Pump
（中２階）

4K Dewar

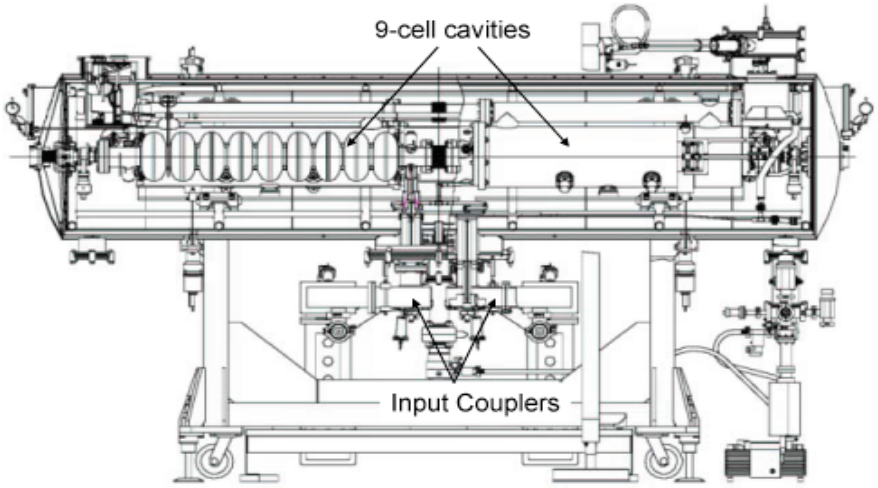
4K Coldbox



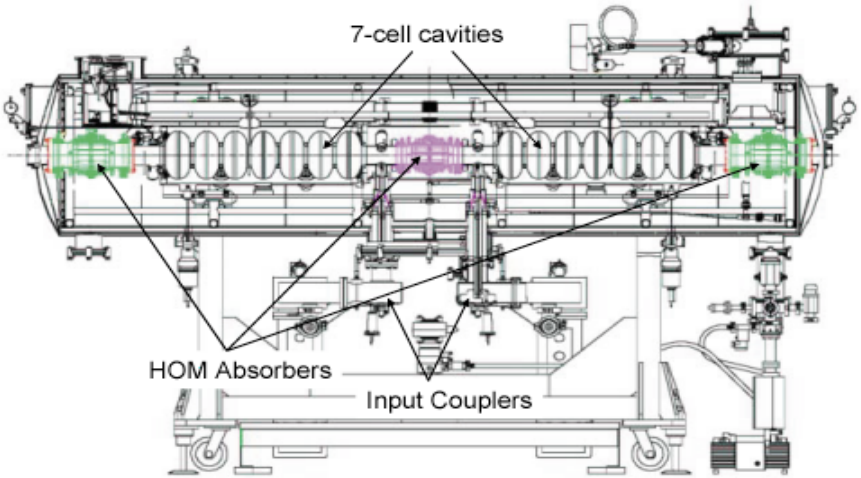
ERLP Cryogenics Schematic

Superconducting RF Cavity System (4)

Superconducting Cavity R&D
Collaboration with Cornell, LBNL, FZR Rossendorf

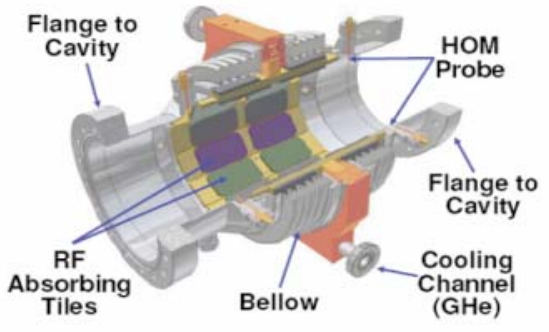


Present 9-cell cavity



Modified 7-cell cavity (2008)

80K
HOM absorber



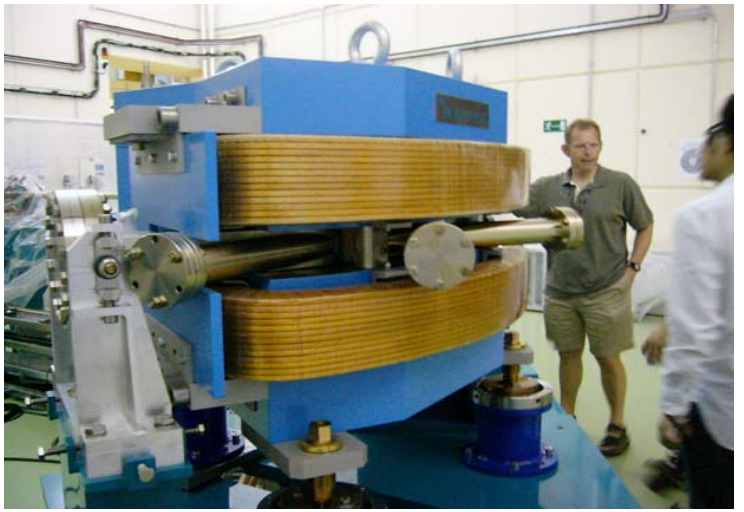
P. A. McIntosh et al., Proc. of EPAC06

Magnet System (1)

- **Dipole**
  - **19 Dipoles: 6(TBA), 3(Injector), 3(Merger), 3(Dump), 4(Chicane)**
  - **Full Gap: 73mm(Injector), 52mm (TBA),**
  - **Magnetic field: B=0.27 T(TBA), B=0.08 T(Injector)**
- **Qudrupole**
  - **43 Qudrupoles: 12(Injector), 8(TBA arcs), 20(Straight), 3(Dump)**
  - **Bore Radius: 45mm (TBA), 102.5mm (Dump), 45/33mm (Injector)**
  - **Magnetic field: B'=1.82 T/m(TBA)**
- **Sextupole**
  - **4 Sextupoles: TBA arcs only, Bore Radius: 45mm**
  - **Magnetic field: B"=40 T/m^2**
- **Corrector & Solenoid**
  - **19 Correctors: 4(Injector, H/V), 11(Straight, H/V), 4(TBA arc, V)**
  - **2 Solenoids: injector only**
- **Air cooling except for 6 TBA dipoles**
- **One TBA arc can slide up to 70 mm for optimum RF phase**

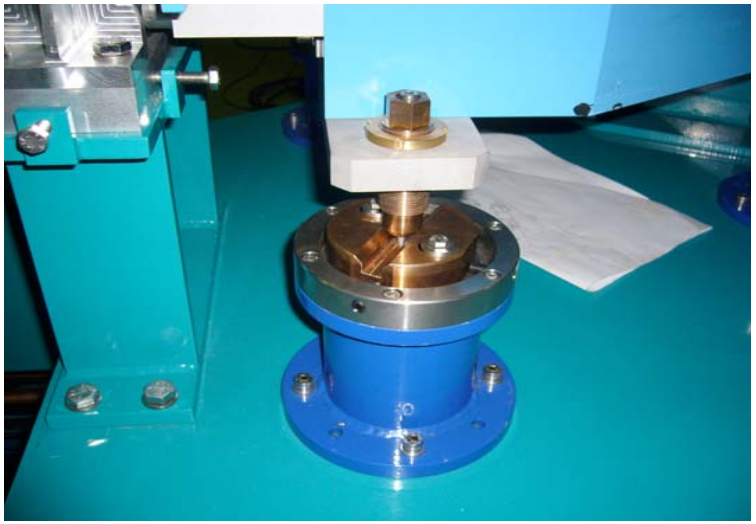
Magnet System (2)

3 dipole magnets for TBA arc



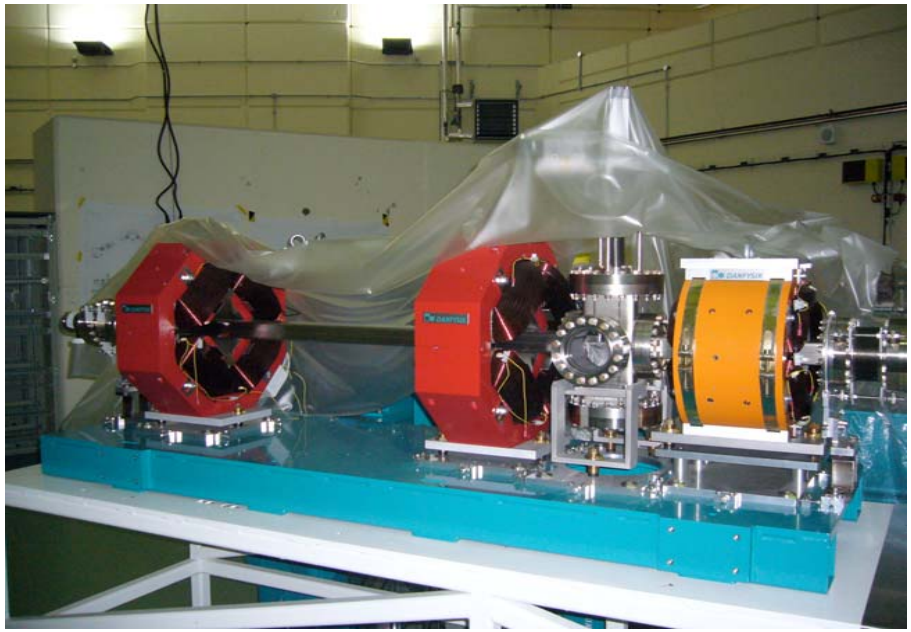
Dipole magnet with SR & alignment ports

Girder with a slide mechanism

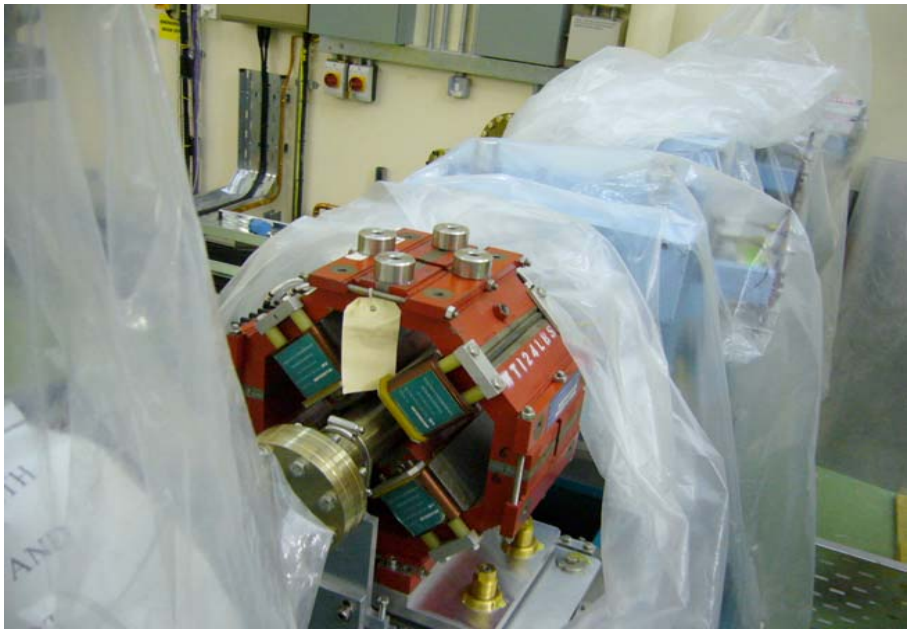


Dipole magnet alignment system

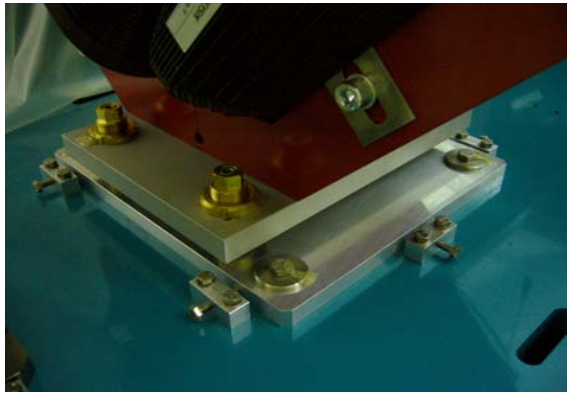
Magnet System (3)

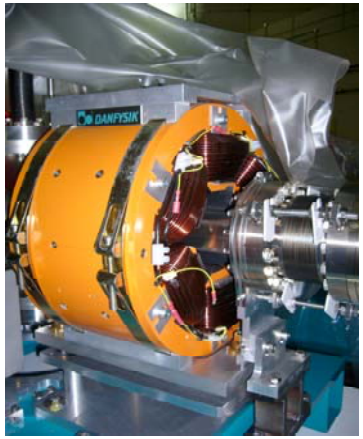


New multipole magnets for TBA arcs



J-Lab Magnets for straight section



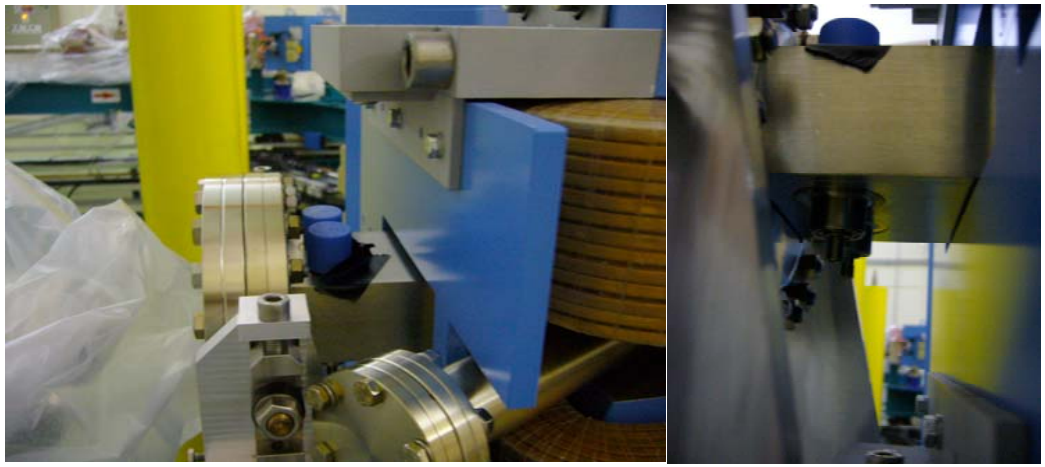


H/V Corrector

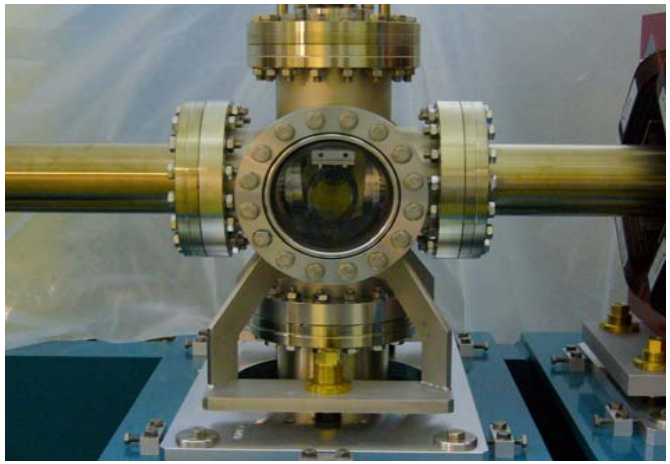
Other Subsystems

- **Monitor system**
  - 24 BPMs: 5(Injector), 11(Straight), 12(TBA) , 1(Dump)
  - 4 YAG screen monitors: injector only
  - 15 OTR monitors: 10(Straight), 4(TBA), 1(Dump)
  - Two kind of loss monitor systems
  - Bunch profile monitor by electro-optic detection (200-fs resolution)
- **Vacuum system**
  - 5×10^{-8} mbar (beam transport) ~ 10^{-11} mbar (Gun, SCRF cavity)
  - Ion pumps at OTRs, Chamber material: Stainless steel (316LN?)
- **IR-FEL**
  - Planar wiggler with 40 periods of 27 mm (loaned from J-Lab)
  - Optical cavity length 9.22m
- **Alignment & Utilities**
  - Laser Tracker & Monuments for alignment
  - Two radial 6-ton cranes
  - Cables & Pipes (cooling water, He, N_2 etc)

Electron Beam Monitors

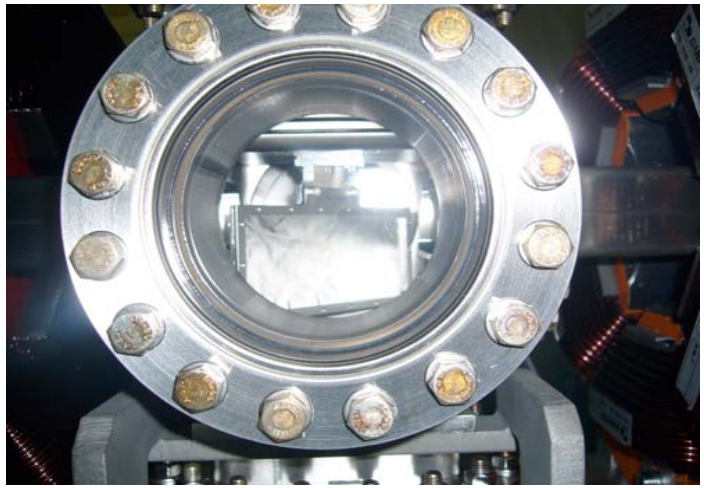


Button-type BPM for TBA arcs



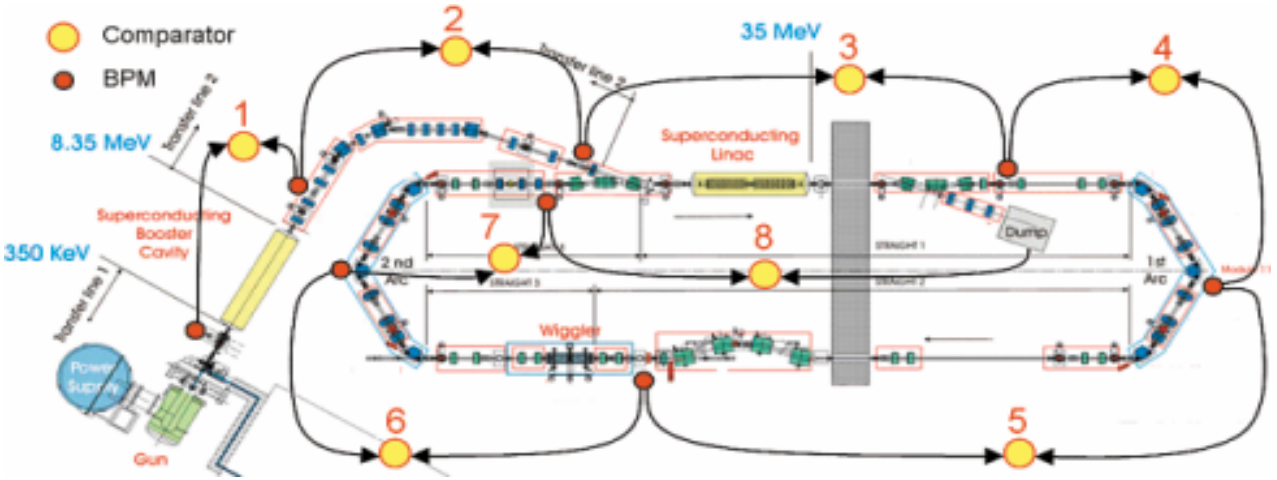
YAG screen for injector

Stripline BPM with steering coils
for injector/straight section

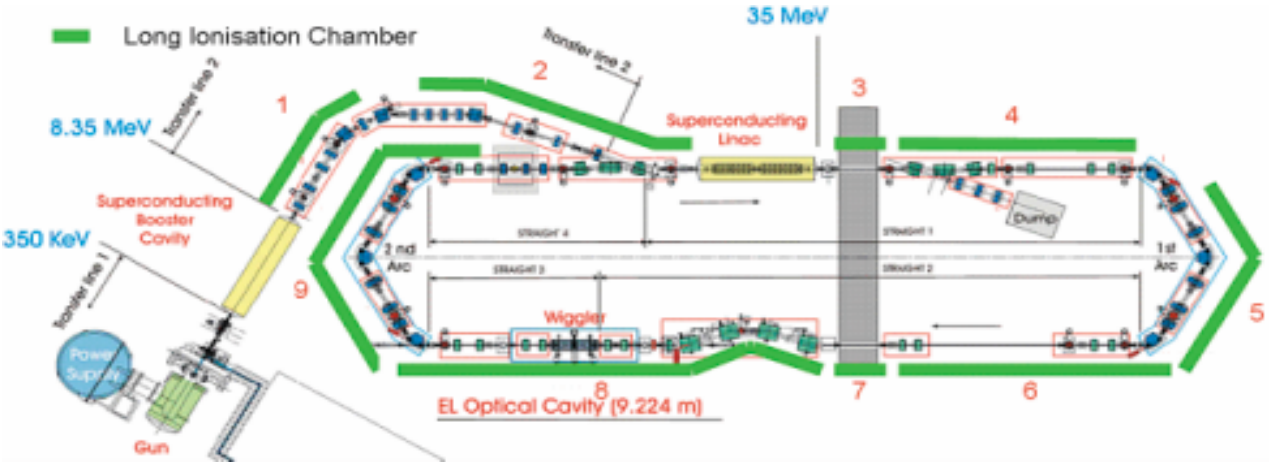


OTR monitor
for TBA/straight sections

Loss Monitor Systems



Current Difference Monitor Implementation



Long Ionization Chamber Layout

S. A. Buckley and R. J. Smith, Proc. of EPAC06

Alignment tools & Utilities

Monuments for alignment

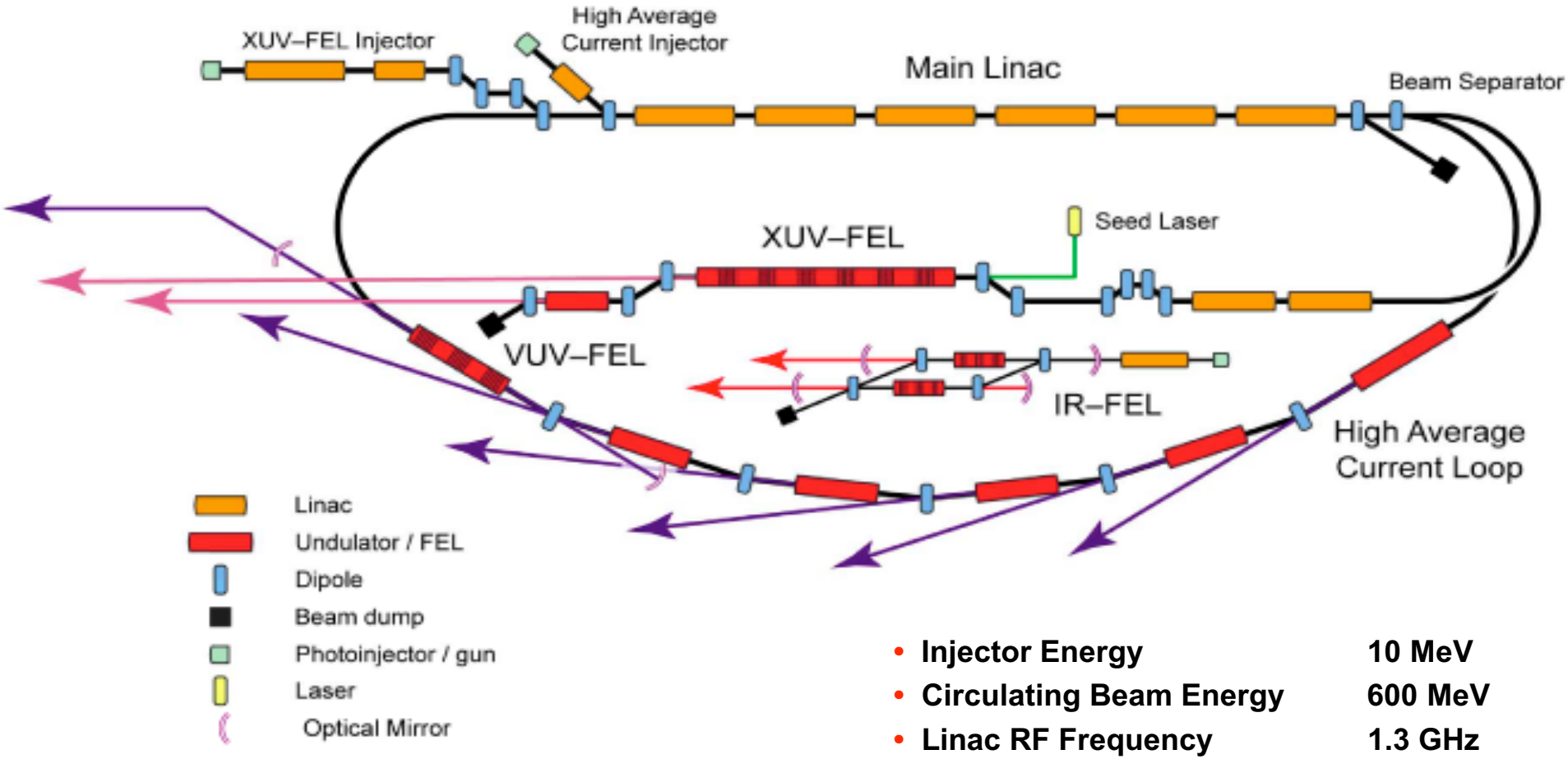
He & N_2 pipes

Laser tracker

Radial 6-ton crane

Cabling & Cooling water pipes

4GLS Conceptual Layout



S. L. Smith, Proc. of EPAC06

• Injector Energy	10 MeV
• Circulating Beam Energy	600 MeV
• Linac RF Frequency	1.3 GHz
• Normalized emittance	2 mm mrad
• Bunch Length at IDs	100-900 fs
• Bunch Charge	77 pC
• Average Current	100mA

Status & Schedule

ERLP

- Laser system ready, IOTs under test
- SCRF modules arrive April/July 2006 (~7 months late)
- 4K/2K commissioning May/November 2006
- Gun commissioning August-October 2006 (~1 year late)

  (First beam from photoinjector detected 16 August 2006 !!)
- Complete machine ready December 2006
- Energy Recovery Spring 2007
- Exploitation 2007 …

4GLS

- Conceptual Design Report(CDR) April 2006
- Technical design phase 2007-8
- Prototyping(SCRF, Photoinjector)
- Bid for funding 2007/2008
- Construction 2008 - 2012/13

Thanks

Dr. S. L. Smith, Dr. D. J. Holder, Dr. Y. Saveliev, Dr. R. Smith,
Dr. B. Muratori, Ms. S. Waller, Prof. M. W. Poole, …