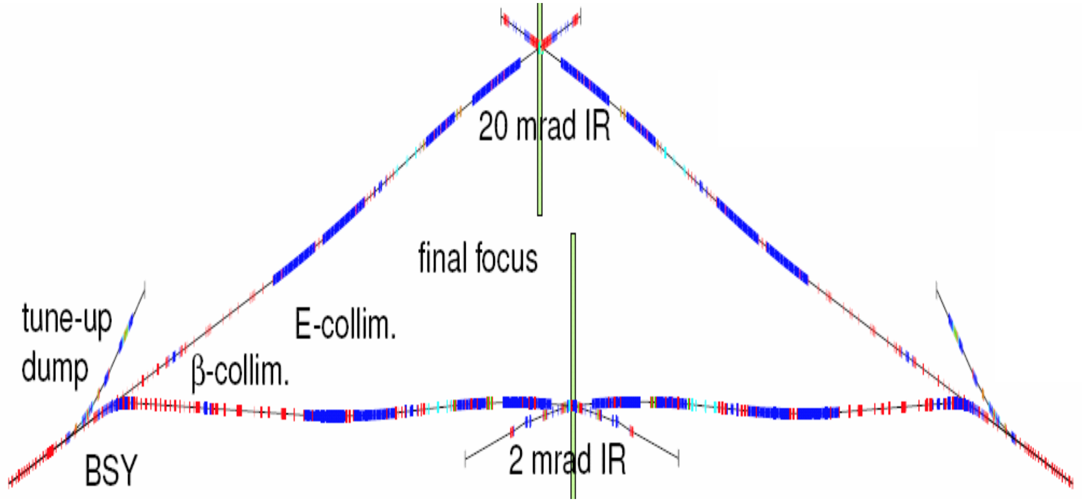
R & D Status of BDS

BDS Area leaders

Deepa Angal-Kalinin, Hitoshi Yamamoto, Andrei Seryi

BDS Baseline Configuration



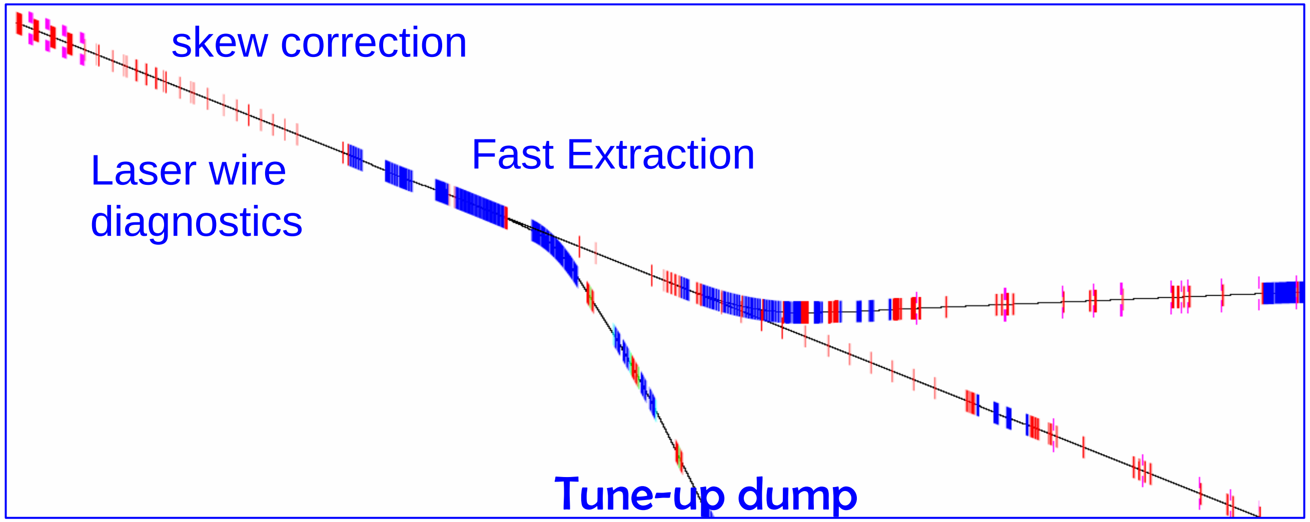
Design Optimisations
Parameter space

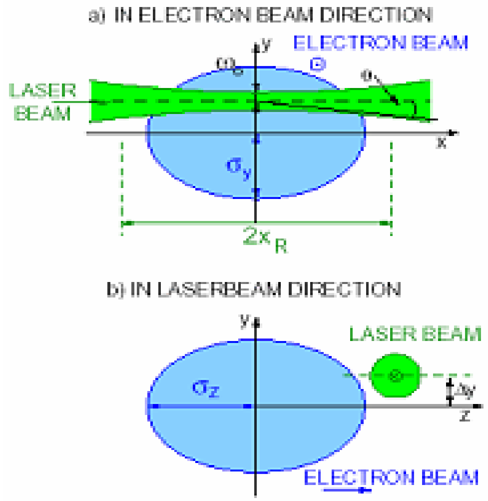
(Operation 48-500 GeV per beam)

↔

Magnets
Crab cavity system
Instrumentation
Collimation
Background
Vacuum
Beam Dumps
MPS/PPS
MDI
CF & S
Controls

Beam Characterisation

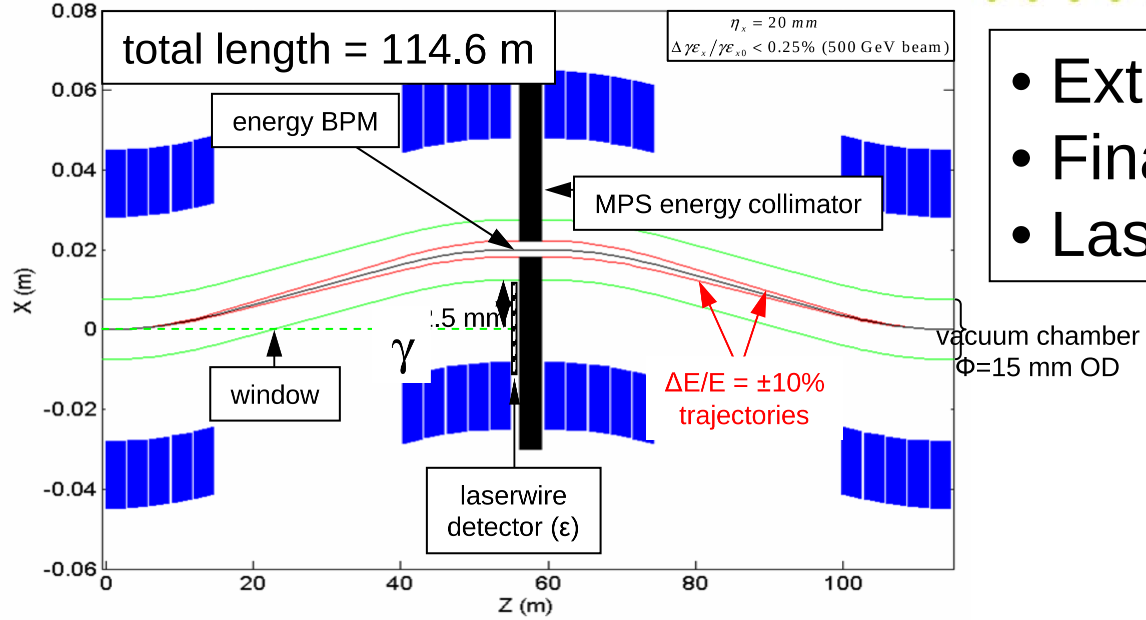




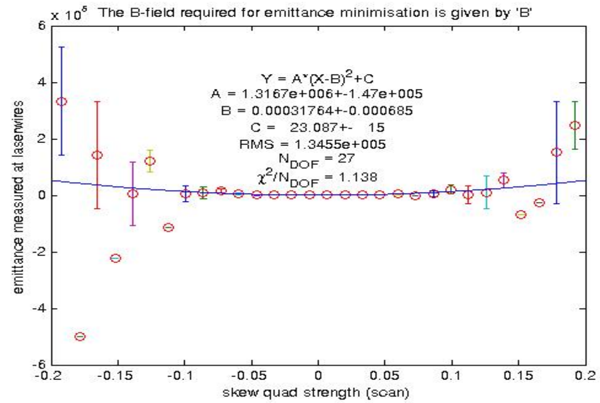
- Electron spot-sizes at laser wires ~1µm
  - laser waist should be smaller than this for emittance measurement
  - R&D programme on-going at ATF to address this
- 4 Vertical and Horizontal (2-D) LW stations required
  - R&D programme at PETRA to address this
- Other machine errors may dominate emittance measurement
  - beam jitter, residual dispersion, beta-function error, ….
- Intra-train scanning will require ultra-fast laser scanning techniques

LW collaboration

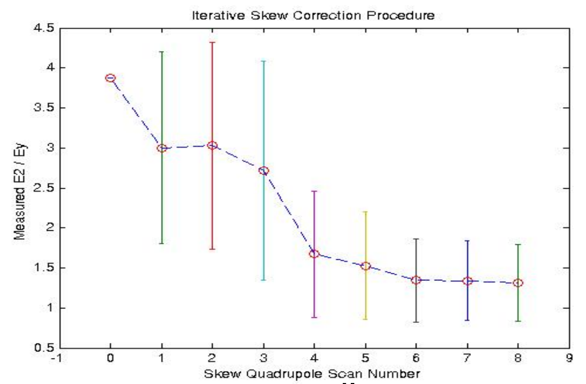
Beam Characterisation & Skew Correction



- Extraction of the LW signal
- Final focus optics at laser IP
- Laser transport details

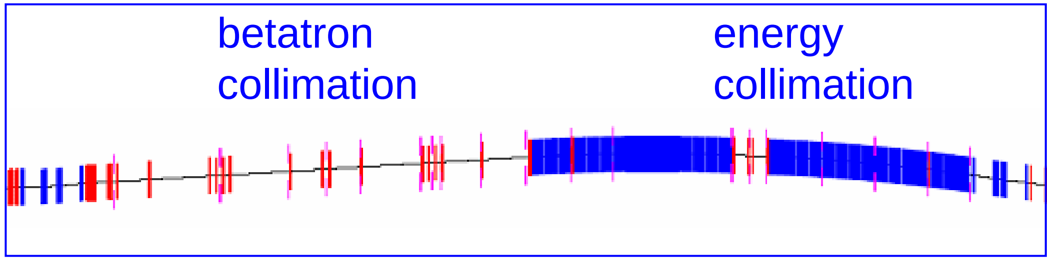


- Each skew quadrupole is scanned to minimise the beam spot sizes at the LWs
- Skew correction procedure needs few scans on skew quadrupoles



Woodley, Jenner

Collimator design

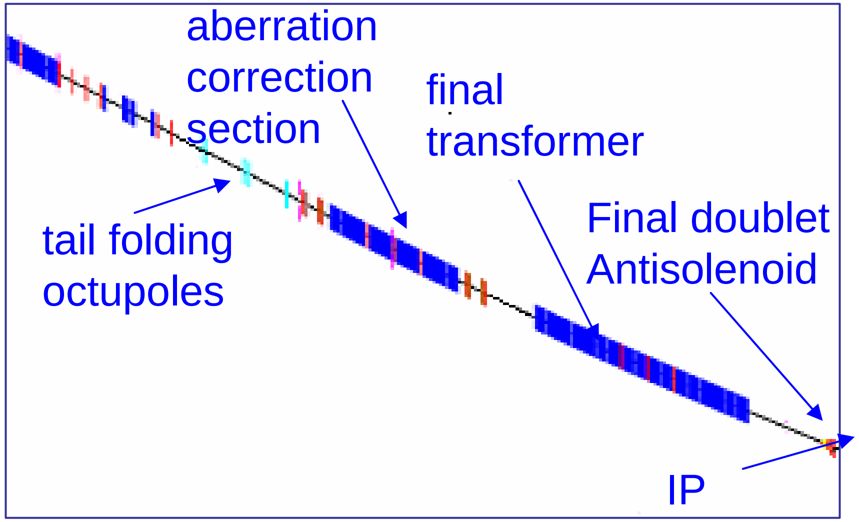


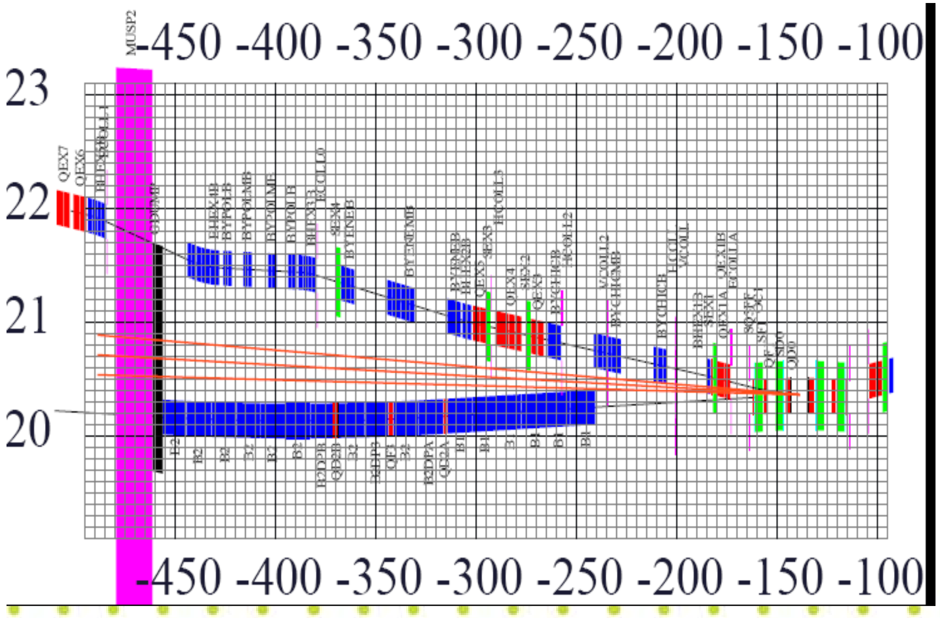
- Spoiler gaps : < 1mm
- Engineering design :
  - **adjustable jaw spoilers**
  - **Absorbers**
  - **protection collimators**
  - **stoppers**
  - **masks**
- Monitoring of damage to materials of the collimator jaws
- Alignment of spoilers

ESA Test beam for T-480 (UK,SLAC)

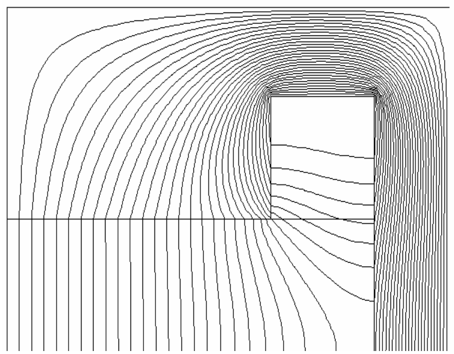
Wakefield & material response simulations require experimental tests to ensure the predictions. ESA, (FLASH), (CERN)

Final Focus

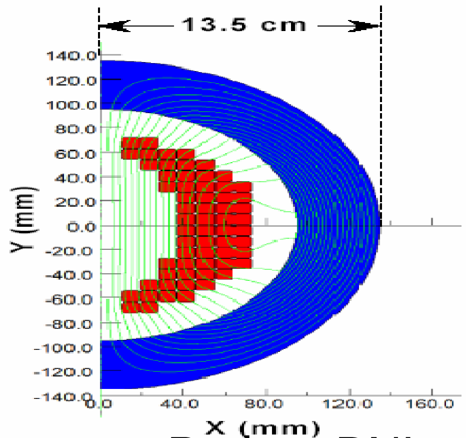




- The low field bends ~ 6 cm pole gap
- Operation at 48 GeV, the fields <20 Gauss
- 2 mrad : The photon cone should be able to pass near or through these bends to the photon dump
- Prototypes required



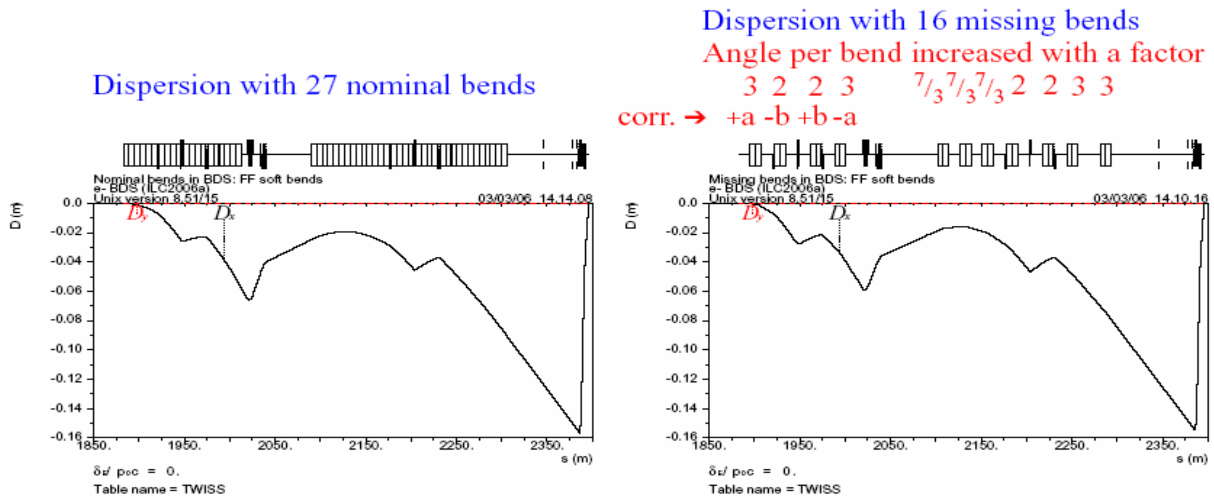
Spencer, SLAC



Parker, BNL

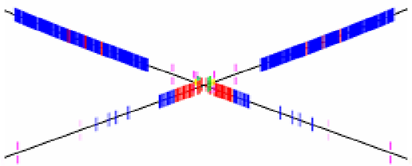
Missing bend strategy at 500GeV CM

- Install less number of bends at 500GeV CM
- Bends can be split and arranged in strings so that decreasing the energy much below the nominal 500GeV CM will be done by switching off the strings.
- Details of this scheme need to be worked out.

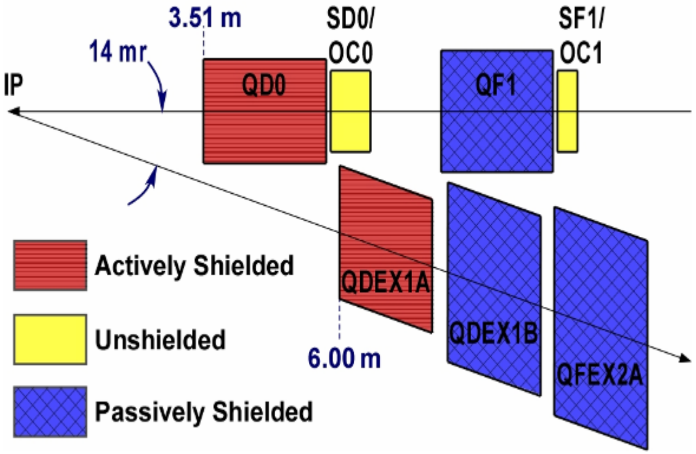


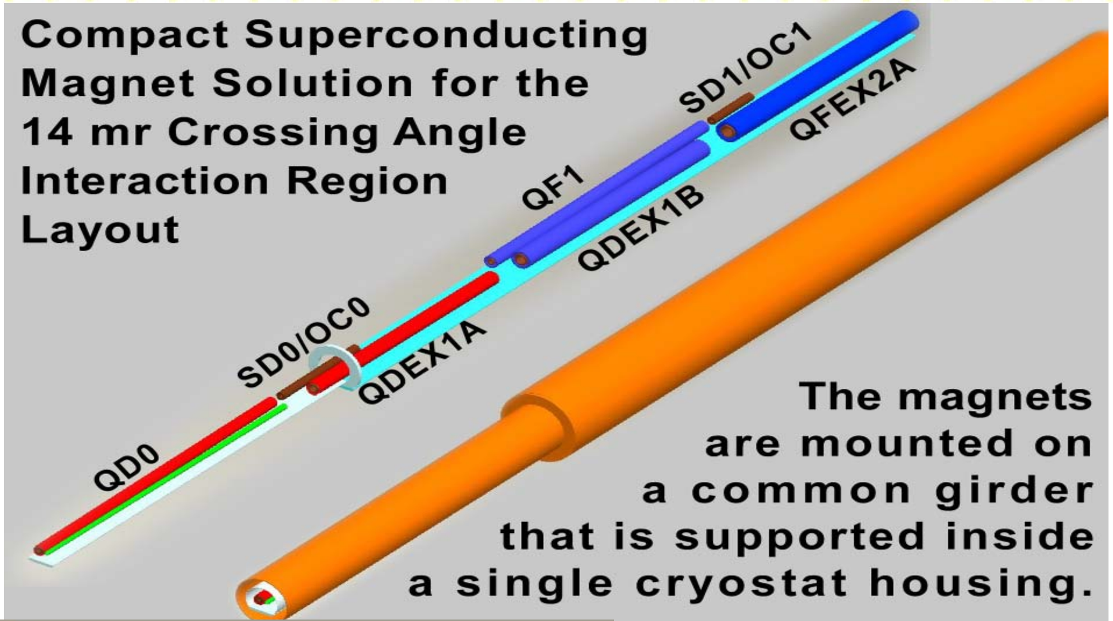
- Additional corrections to the B5 bend angles, a = 4.01% and b = 14.26%, cancel the residual IP dispersion $\eta_x^* = 78\ \mu m$ (caused by missing bends) and maintain the X-position of IP.

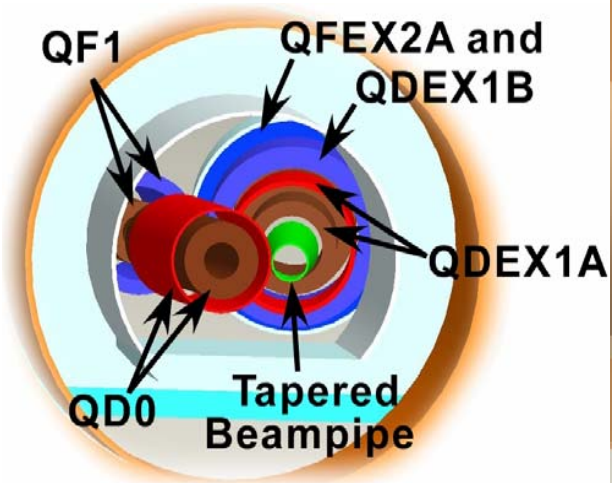
One of the possible configuration in the FF part (Nosochkov, SLAC)

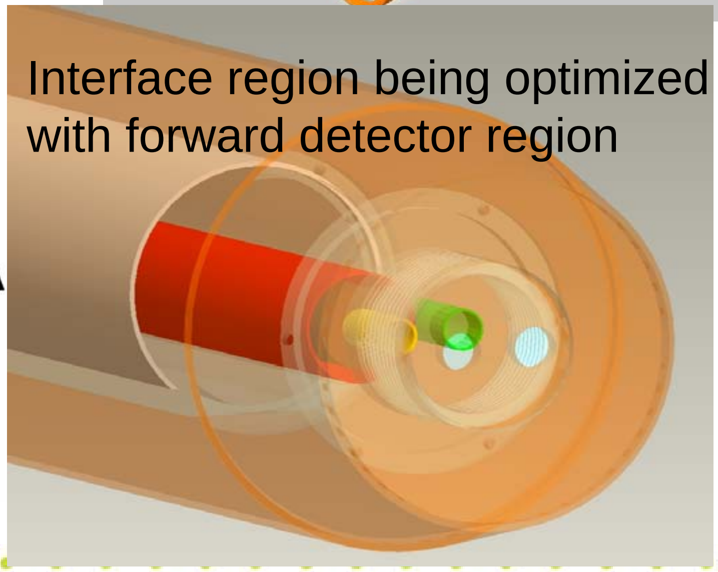


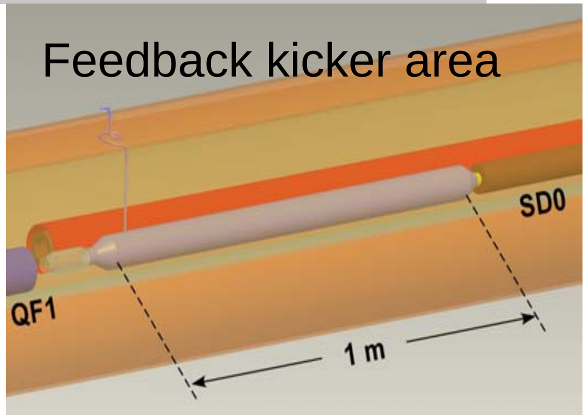
20/14 mrad IR

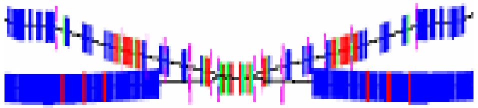

3.51 m
14 mr
IP
SD0/
OC0
SF1/
OC1
QD0
QF1
QDEX1A
QDEX1B
QFEX2A
6.00 m
Actively Shielded
Unshielded
Passively Shielded


Compact Superconducting
Magnet Solution for the
14 mr Crossing Angle
Interaction Region
Layout
SD1/OC1
QFEX2A
QF1
QDEX1B
SD0/OC0
QDEX1A
QD0
The magnets
are mounted on
a common girder
that is supported inside
a single cryostat housing.


QF1
QFEX2A and
QDEX1B
QDEX1A
QD0
Tapered
Beampipe

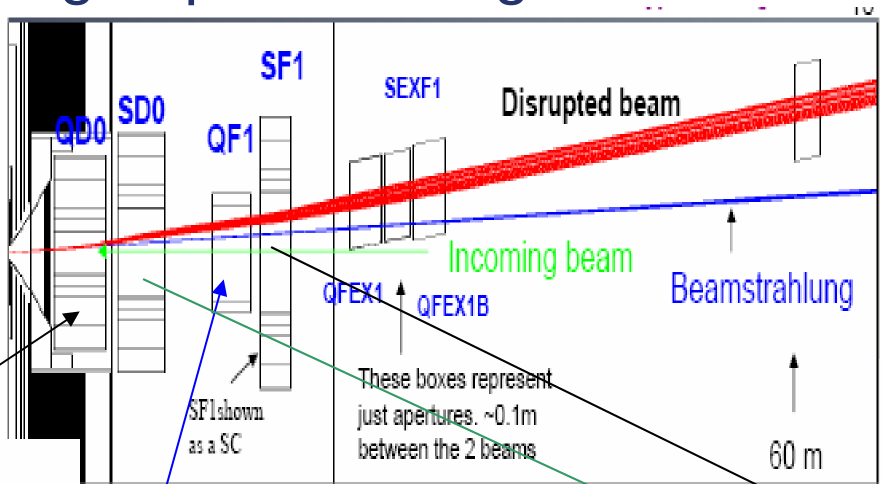

Interface region being optimized
with forward detector region

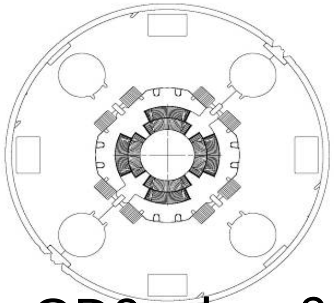

Feedback kicker area
SD0
QF1
1 m



2 mrad IR

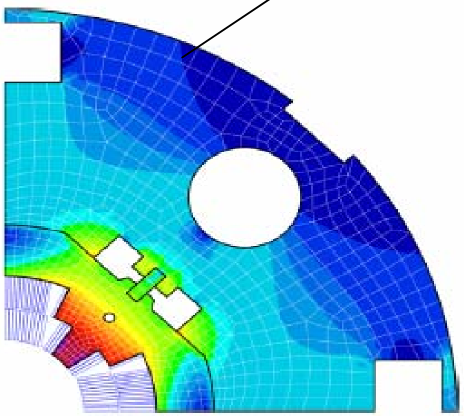
- To extract the disrupted spent beam+ beamstrahlung requires large aperture magnets





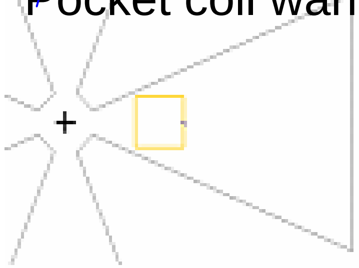
QD0 ~ low-β LHC quad

Large aperture, R= 88 mm (SD0), 112 mm(SF1) sextupole design

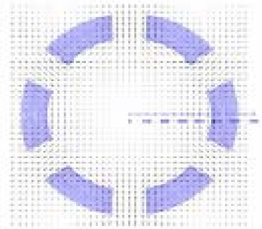


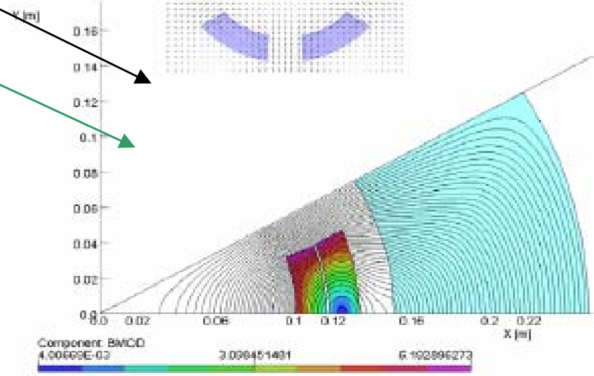
Kashikhin, FNAL

Pocket coil warm QF1



Spencer, SLAC





Kashikhin, FNAL

2 mrad IR magnets

Open Issues for NbTi Approach

- More detailed calculations of magnetic center motion (SC magnetization, Lorentz forces, mechanics, iron saturation, hysterisis etc)
- Present estimate is 1-5 μ magnetic centre stability
- Need to develop correctors, optimise magnet movers for larger magnet weight/size

Alternative approach using Nb_3Sn

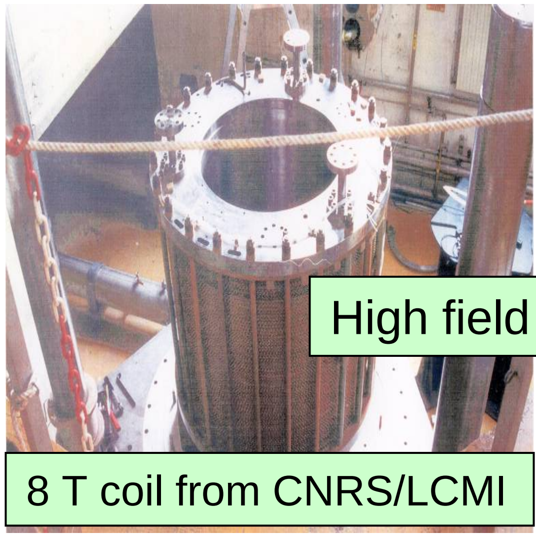
- LARP - Technology Quadrupole should provide higher gradients (250T/m) in 90 mm aperture
- R&D goal : 300T/m in 90 mm aperture for high gradient quadrupole by 2009
- Higher field with Nb_3Sn at 4.2K than with NbTi at 1.8K

Kashikhin, Sabbi

2 mrad IR – QD0

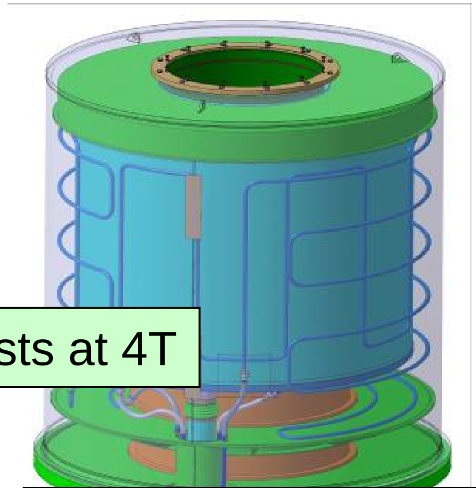
- The construction of 1m long, 56mm aperture Nb_3Sn quadrupole with no magnetic yoke - prototype at Saclay
- Quadrupole collaring – October 2006
- To test the high gradient performance and mechanical stability of an Nb_3Sn SC large aperture quadrupole in an external solenoid field

Design of the 8 T solenoid cryostat

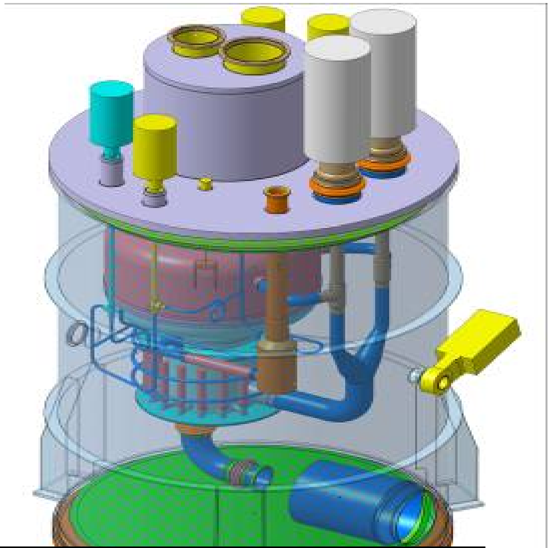


High field tests at 4T

8 T coil from CNRS/LCMI



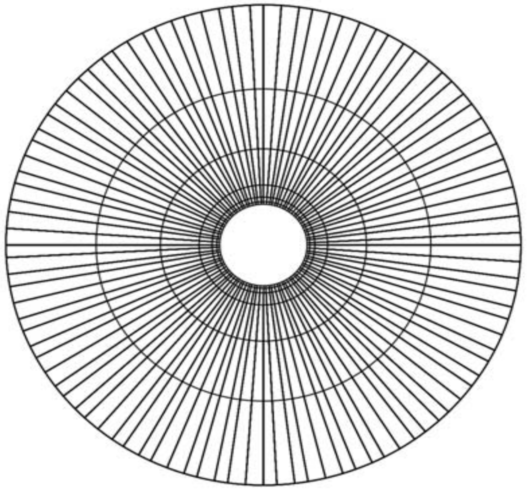
Cryostat with 600 mm warm aperture



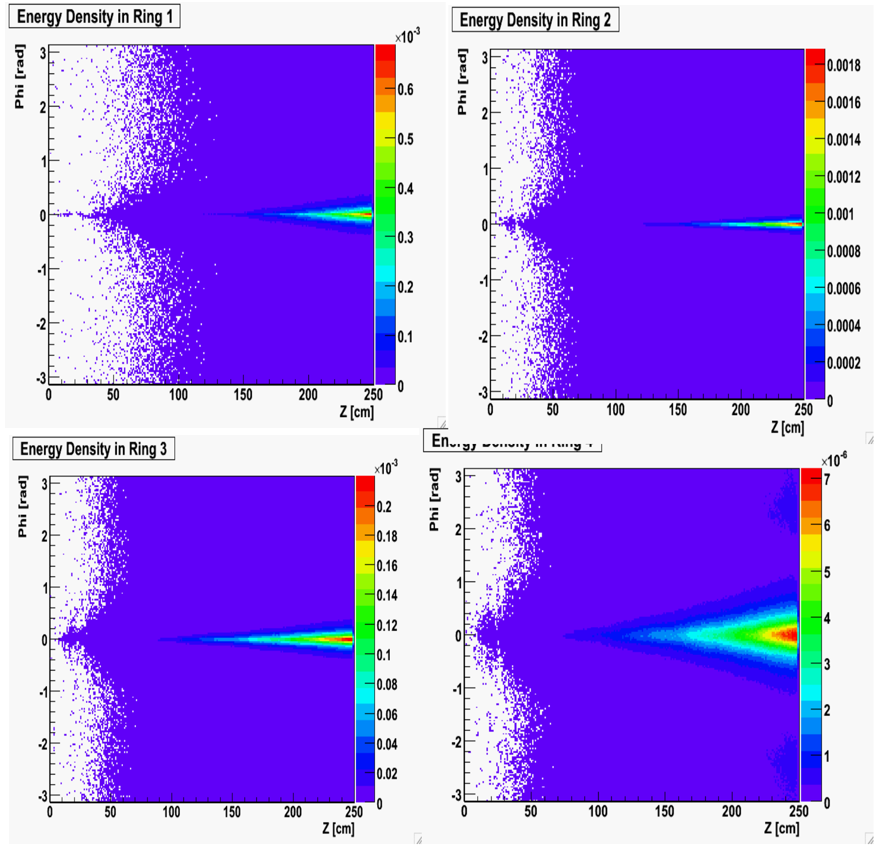
Pressurized 1.8 K He satellite

CEA, Saclay

2mrad Losses - QD0 Power Density Maps



(QD0 Scored into 300000 volumes)

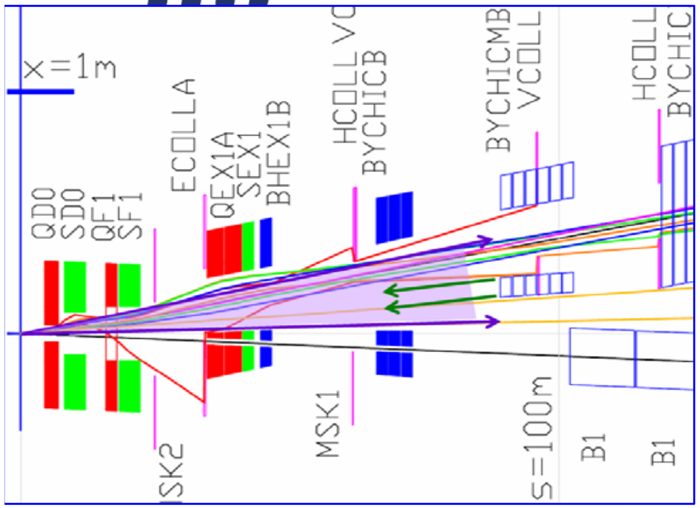


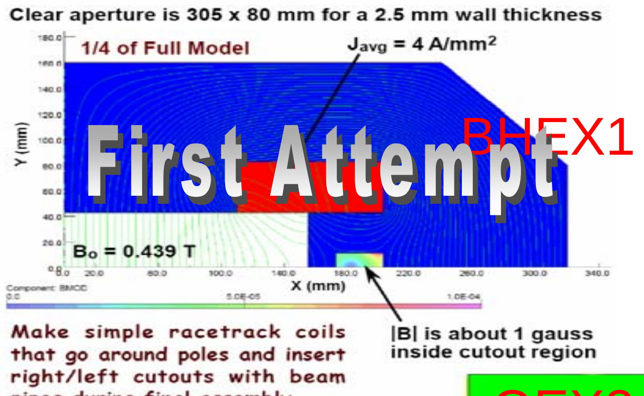
- Detailed studies of the localised power deposition in the SC magnets
- Tracking in BDSIM with shower development to give energy deposition
- The localised power deposition in QD0 can be controlled using Tungsten liners

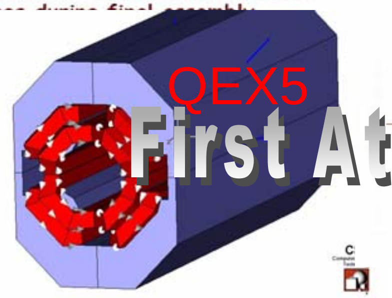
- Power density maps for the first 4 rings (All density units in W/g)

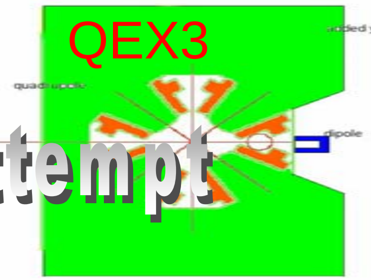
Carter, RHUL

2 mrad extraction line magnets





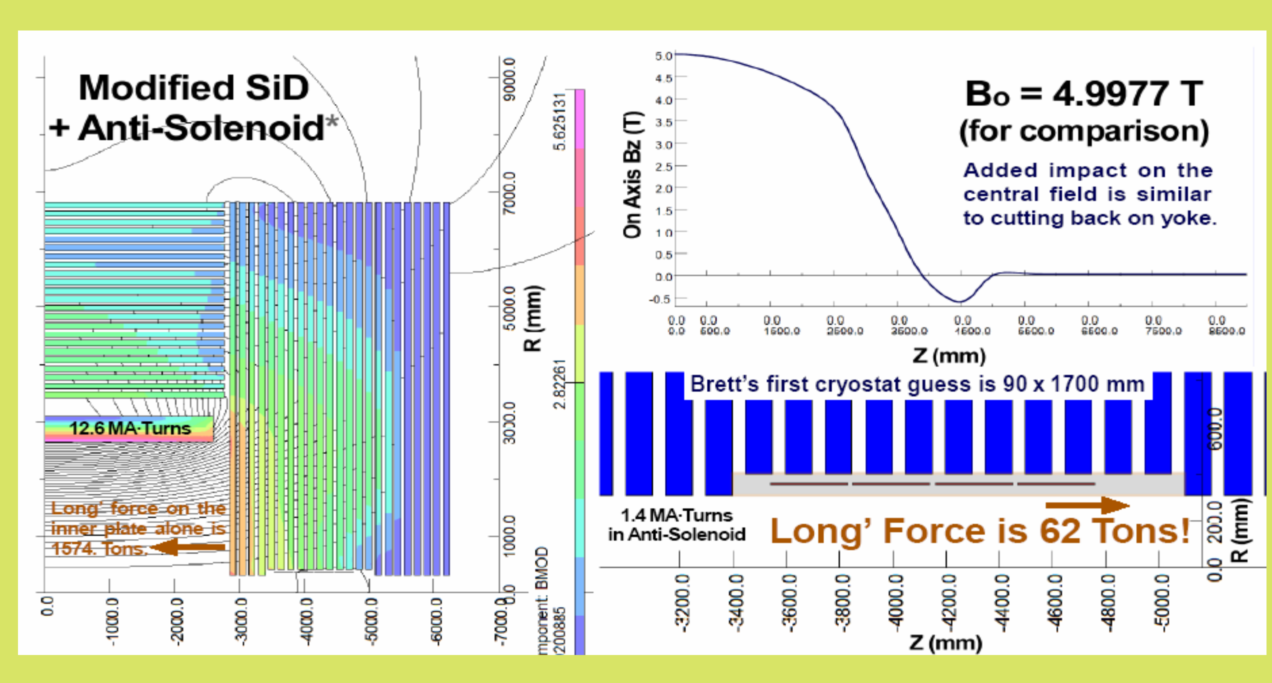




- Large apertures, high fields, beamstrahlung photons passing nearby, SR photons makes these magnets very challenging
- Power at 1TeV CM ~MW/magnet.
- Use of HTS? Pulsed magnets?
- There is interest from 3 regions - investigating the possibilities
- Further feasibility study and design optimizations are needed
- Ongoing 2 mrad lattice optimisations at 500GeV CM will reduce the apertures for these magnets

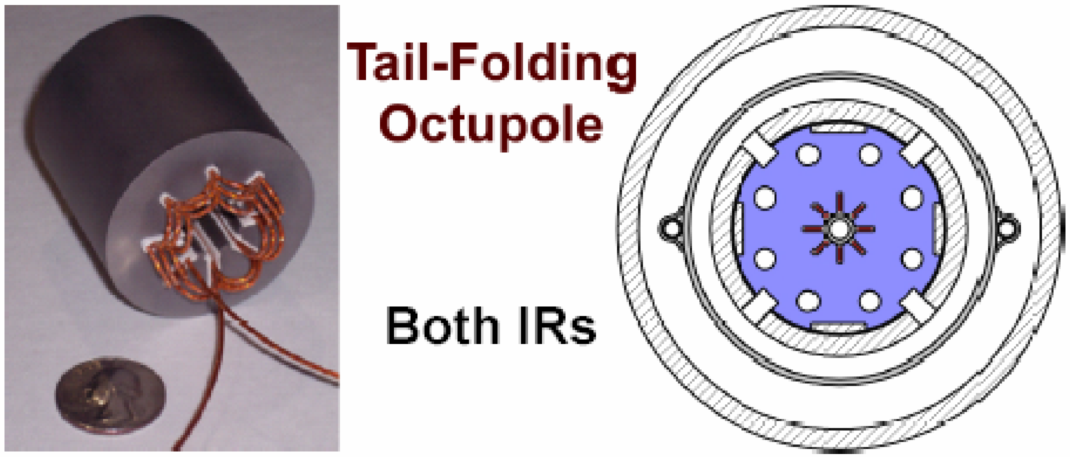
Kashikhin, Parker, Tompkins, Spencer, Kumada, Takano, Iwashita, Bondarchuk, Sugahara

Antisolenoids and Tail folding octupoles for both IRs



Antisolenoids (needed for both IRs to compensate solenoid coupling locally) with High Temperature Superconductor coils

Superferric TFOs (for beam halo handling) with modified serpentine pattern can achieve 3T equivalent at r=10mm



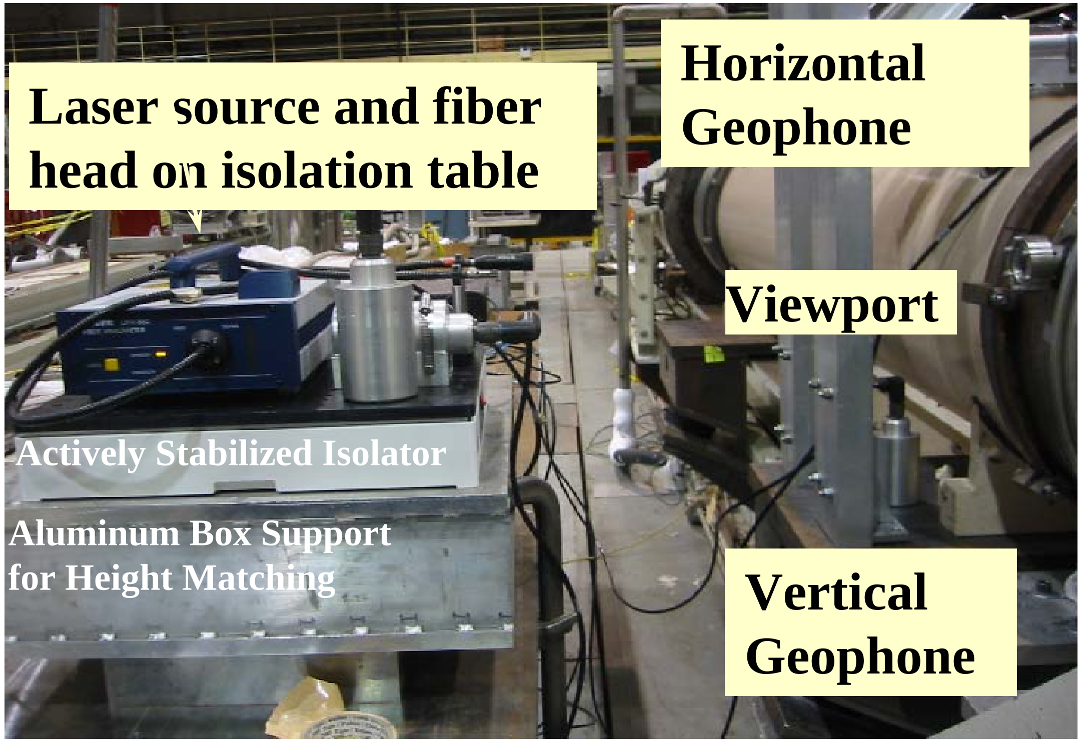
Vibration Work at BNL

- Development of vibration measurements in a SC quadrupole **in cold state**. (Using existing RHIC arc quadrupole spare)

- Primary focus on:

– Developing ability to make measurements on a cold mass surrounded by a cryostat.

– Amount of *additional* vibrations, if any, caused by cryogenic system.

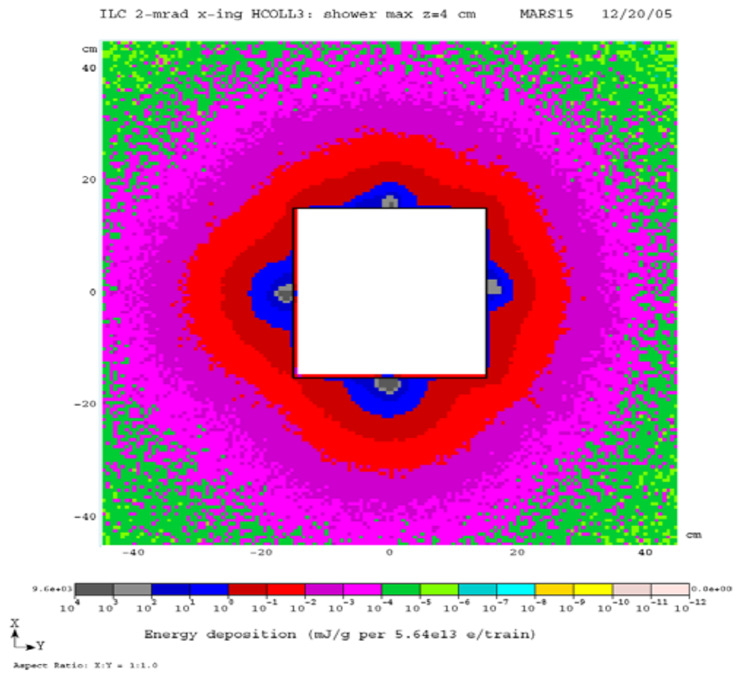


Plans

- Develop a probe to measure quadrupole field center directly.
- Carry out preliminary vibration measurements using the laser system in an ILC-like mock up model (room temperature only)

Beam Loss and Radiation Loads in IP and Extraction Lines

- Detailed STRUCT modeling of beam loss and design of protection masks.
- MARS calculations of radiation loads, heating, quench stability of SC magnets, radiation damage, radioactivation, shielding and impact on environment in detector, final doublet, extraction and incoming beamlines.



- Dynamic heat loads up to 500 W/m
- Power density above quench limit
- Peak dose in coils up to 270 MGy/yr
- 2-mrad x-ing: 0.76 MW synch rad loss

Mokhov, Drozhdin,FNAL

Vacuum Issues

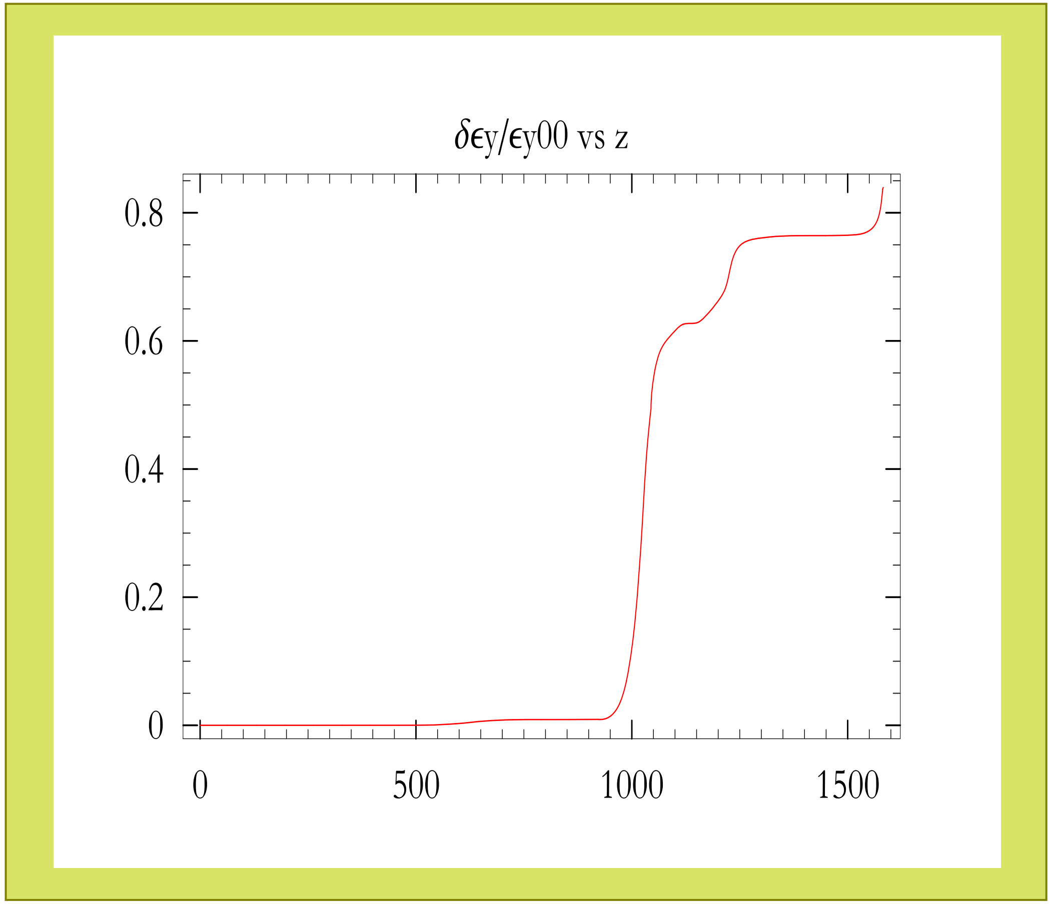
- Vacuum design
- Requirement of < 10 nTorr in last ~500m from IP
- Choice of material : SR, beam losses, resistive wall
- Instrumentation with optical windows
- Baking : BPMs tuning
- NEG coating?
- Photodesorption – High critical energy of photons – no experimental data
- Electron desorption – no data exists for such high energy electrons
- Pumping ports and bellows : RF shielding – heating and wake fields.
- Long chambers, misalignments of chambers – wake fields

Wakes in vacuum chamber

Emittance growth for 1sigma entrance beam offset and SS vacuum chamber unacceptably large.

Change to Cu or Al chamber and optimization of aperture reduces the growth to ~5% for 1 sigma initial offset

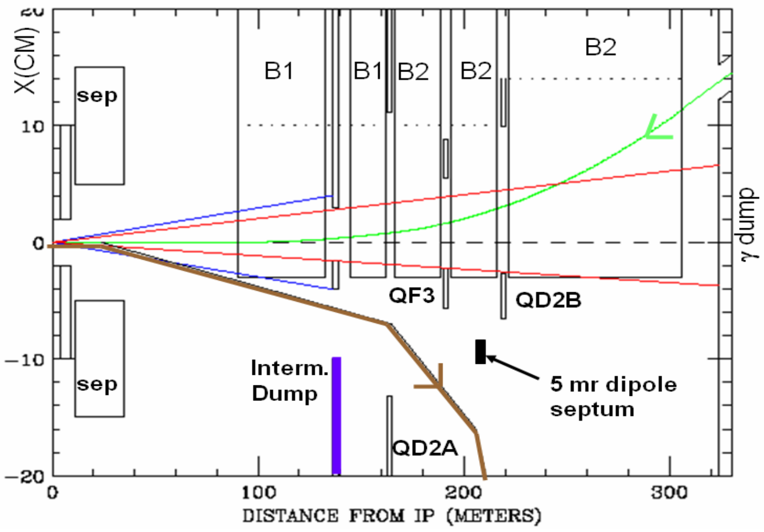
Misalignments of vacuum chamber can cause emittance growth – require further R&D



Bane, SLAC

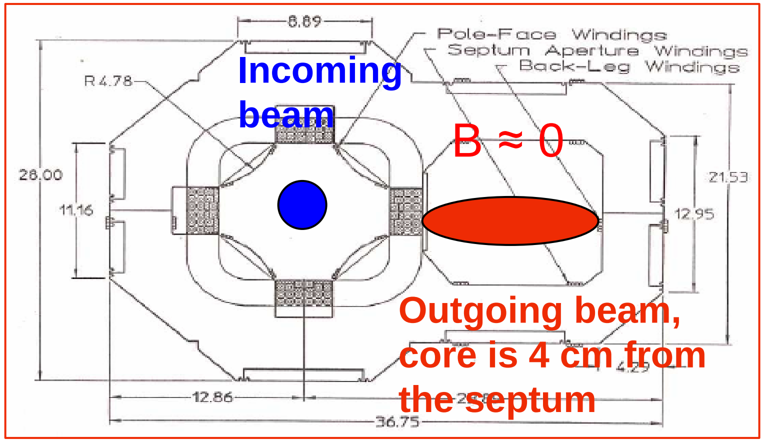
Modified head-on extraction scheme

TESLA 'Head-on' scheme revisited :
Based on LEP electrostatic separators at 25 kV/cm and QD2A off-axis quadrupole *(L.Keller)*



- Final focus optimised to bring the ES closer. Extraction line optics includes beam diagnostics similar to 2 mrad
- Overfocussing of low energy tail particles need careful collimation design
- Design at 500 GeV CM, bunch spacing >300 nsec
- Need feasibility studies at 1 TeV parameters

QF3 modeled after PEPII/Babar IR Septum quad



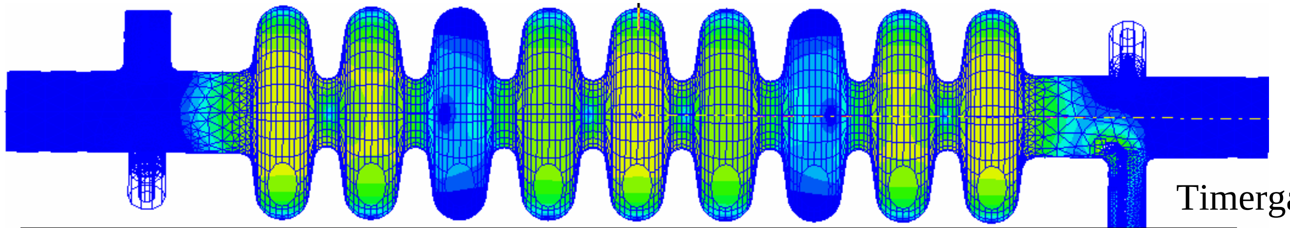
UK-France-SLAC task force

Head-on extraction scheme : R&D

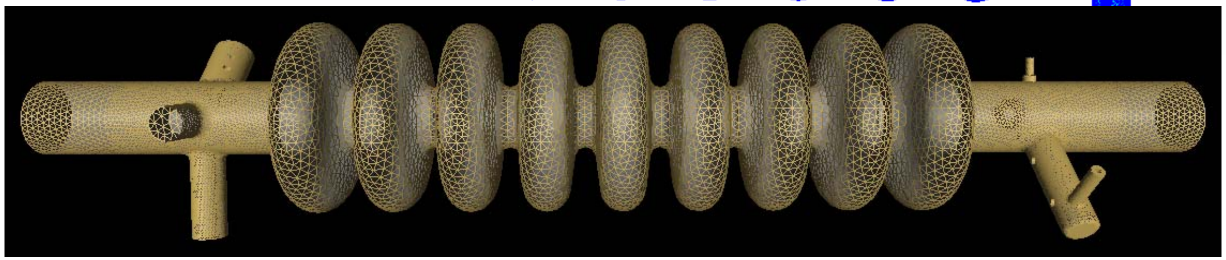
- Include fringe fields of incoming large aperture dipoles
- Detailed tracking studies to assess the beam losses,SR, back scattering, collimation etc
- Elucidate whether NbTi technology (~9T max on the conductor) can survive the external field from the solenoid, by a magnetic 3D calculation. (Nb_3Sn Mandatory?)
- Integration of the FD (including correctors, skew quad, feedback kickers & BPMs) in the detector cryostat
- R&D on electrostatic separators for 1 TeV operation.
- Put LEP separators into an electron beam and hit the plates with the same amount of power as estimated from the power loss simulations as a function of electric field.

Crab cavities : Ongoing R&D (1)

- High reliance on crab system to recover the luminosity loss for large crossing angle IR needs the guarantee of the performance in the presence of realistic beam.
- Suitability of 3.9GHz CKM deflecting mode cavity developed at FNAL as a crab cavity – by FNAL, UK, SLAC
- Long range and short range wake fields are being investigated. Input and mode couplers need different designs.



Timergali Khabiboullin, FNAL

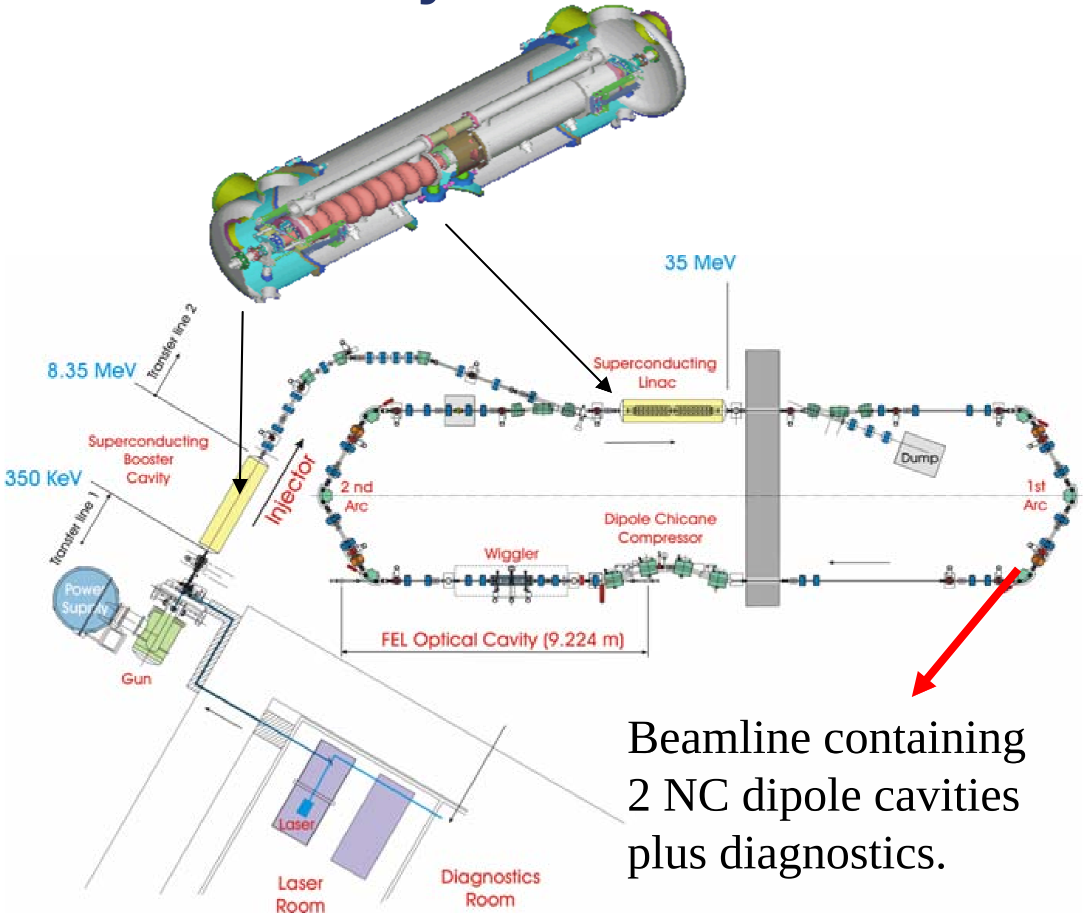


Omega3P Mesh

Zenghai Li , SLAC

Crab cavities : Ongoing R&D (2)

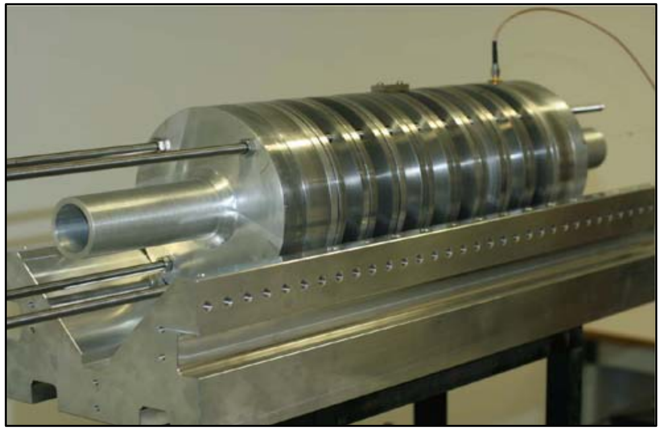
Phase Control Beam Tests on Daresbury ERLP in 2007



Beamline containing 2 NC dipole cavities plus diagnostics.

Goudket , Kalinin, Ma, Daresbuty

Test Model Cavity Verifications



- Model will be used to evaluate:
  - Mode frequencies
  - Cavity coupling
  - HOM, LOM and SOM Qe and R/Q
- Flexible modular design

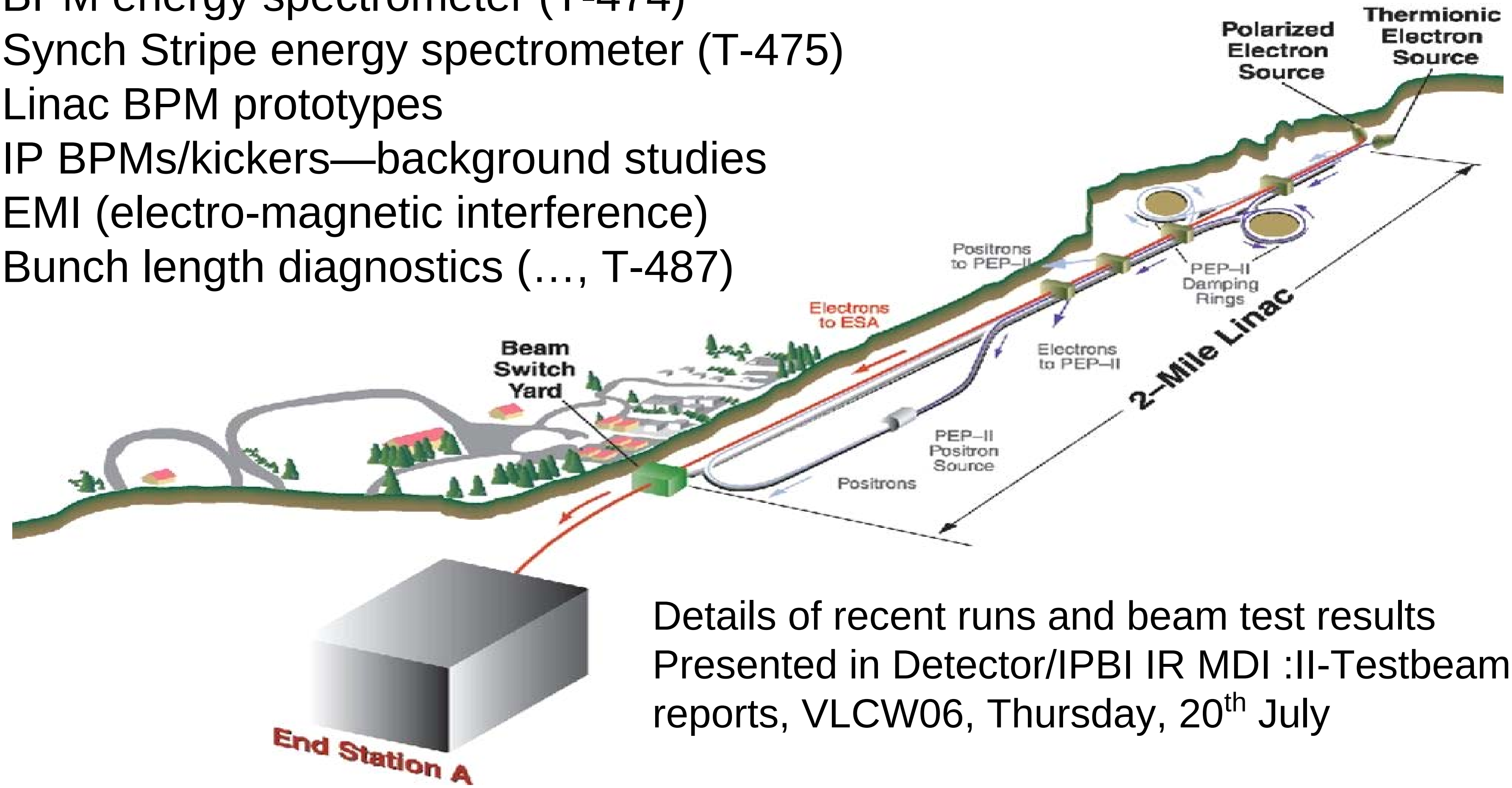
Beam dump

- Base line has 6 full power (11/18MW) beam dumps - pressurised water dump
- Window prototypes and beam tests
- Remote handling
- Photon dump
- Alternative : Nobel gas based dump
  - 1 km of Ar with a cooled Fe jacket acts as a scattering target and blows up beam
  - Issues include heating of the gas, activation and ionisation effects
  - Needs R&D to prove feasibility
- Or, the hybrid dump

Test Facilities : End Station A, SLAC

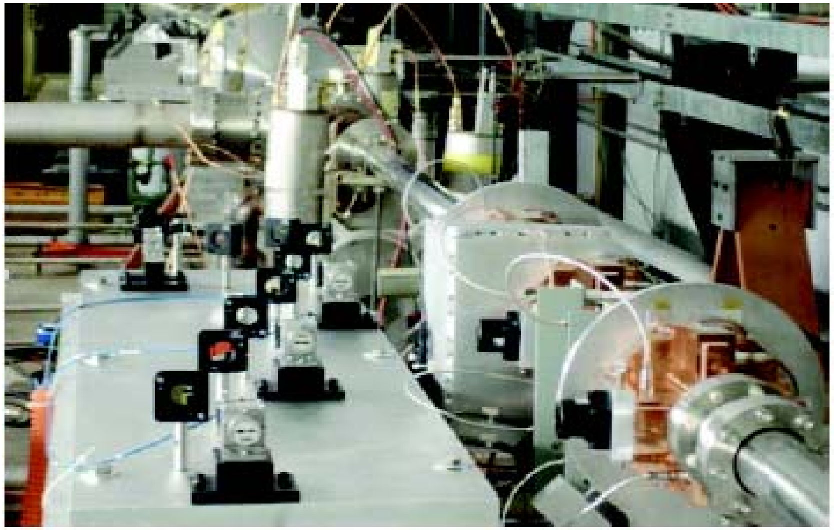
Collimator design, wakefields (T-480)
BPM energy spectrometer (T-474)
Synch Stripe energy spectrometer (T-475)
Linac BPM prototypes
IP BPMs/kickers—background studies
EMI (electro-magnetic interference)
Bunch length diagnostics (…, T-487)

40 participating institutes
Participation from all the 3 regions

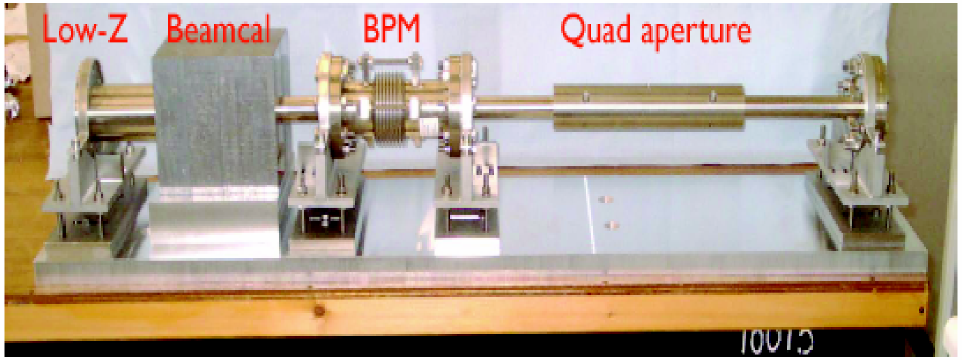


Details of recent runs and beam test results
Presented in Detector/IPBI IR MDI :II-Testbeam reports, VLCW06, Thursday, 20th July

Test Facilities : End Station A, SLAC

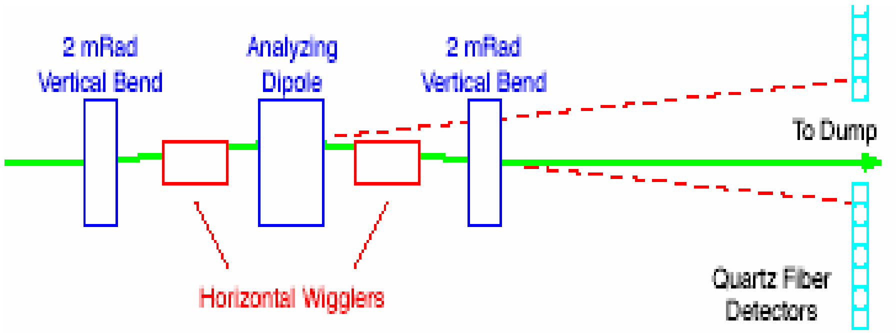


Emulate extraction line in ESA, look for effects on BPM with backgrounds

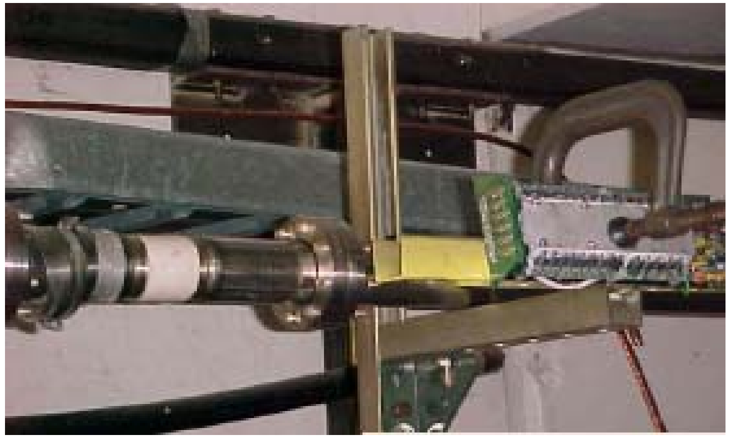


Electromagnetic background in FONT

BPM Spectrometer : 3 SLAC style and 3 ILC style BPMs



Extraction line Spectrometer



EMI Pick : Ceramic gap +SLD/VXD3 readout → Reproduce original failure mode

ESA test beam program overview

- Strong collaborations for important ILC beam tests, addressing ILC luminosity and ILC precision

- Energy spectrometer R&D and beam tests are necessary to test capability for 100ppm accuracy; significant impact on machine design; new BPMs being designed and built in theUK

- 4 test beam experiments have been approved; additional ones in preparation or under study

- Successful 5-day commissioning run in January 2006, 2-week Run 1 in April/May and Run 2 in July

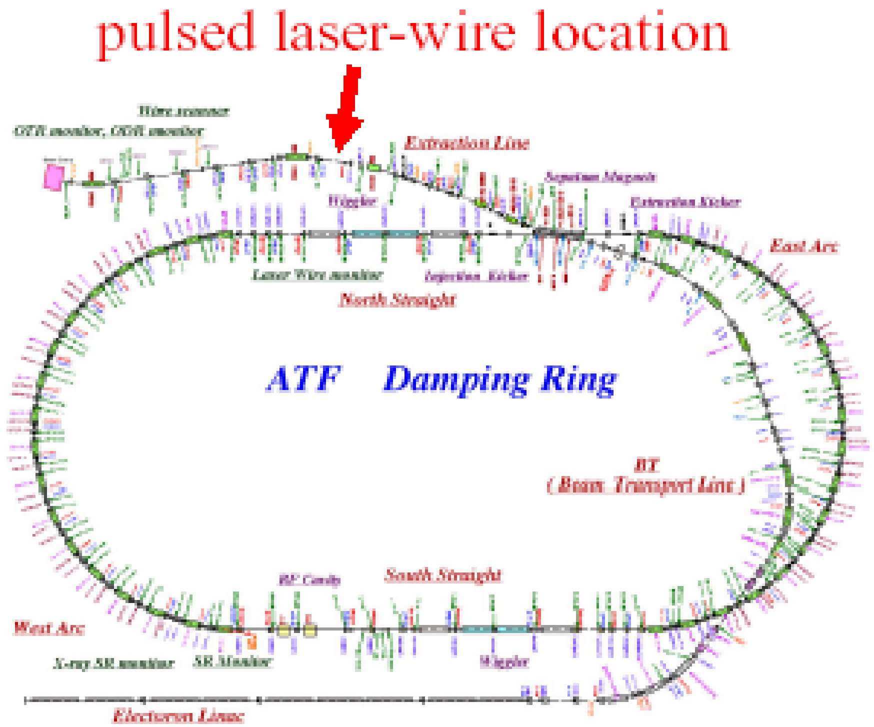
- Plans to continue into FY07 andFY08, parasitic with PEP-II operation. Studying possibilities to continue into LCLS era.

Woods, Boogert

ATF, KEK

J. Urakawa

- ATF Laserwire– Currently limited by laser profile at 18μ
- NanoBPM – Try to reduce 17 nm to 5 nm
- FONT4 – Digital Feedback – processing with latency <150 nsec
- Shintake monitor – Improve from 70 nm (FFTB) to 35 nm (ATF2)
- Profile monitor with optical cavity

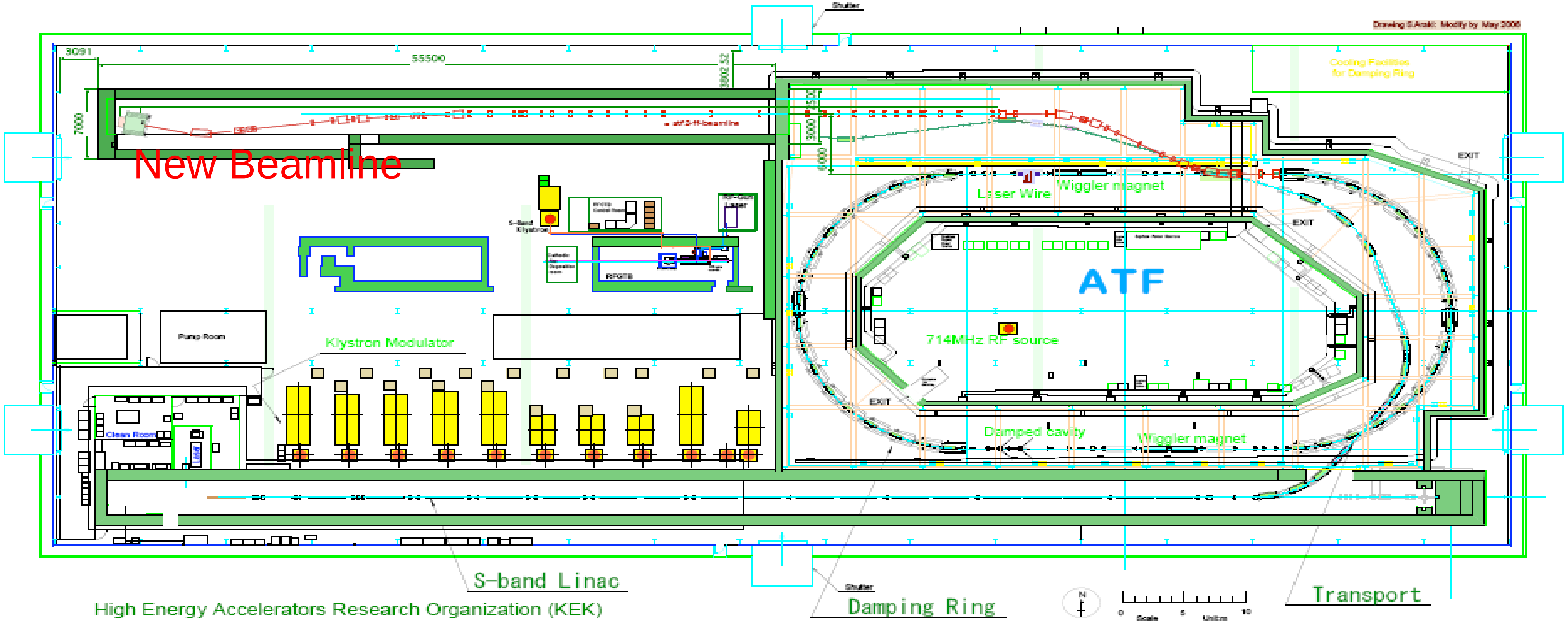


ATF – Participation from all the 3 regions.

ATF2, KEK

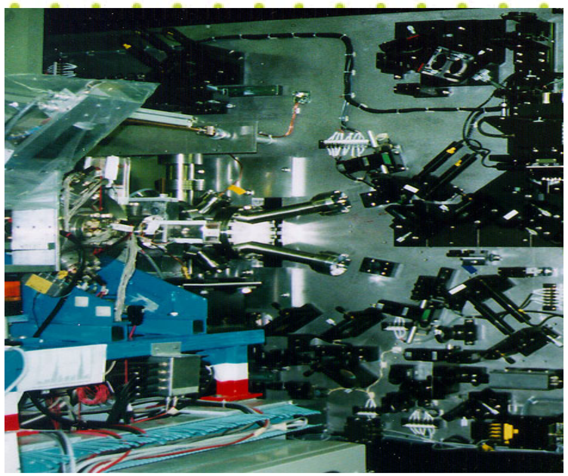
(A) Small beam size
Obtain $\sigma_y \sim 35nm$
Maintain for long time

(B) Stabilization of beam center
Down to < 2nm by nano-BPM
Bunch-to-bunch feedback of ILC-like train

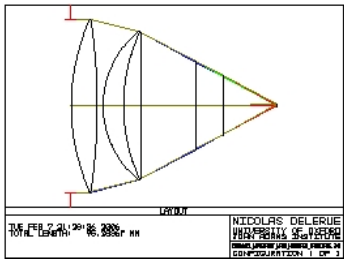


Advanced beam instrumentation at ATF2

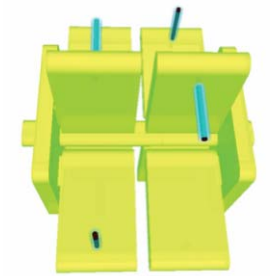
- BSM to confirm 35nm beam size
- nano-BPM at IP to see the nm stability
- Laser-wire to tune the beam
- Cavity BPMs to measure the orbit
- Movers, active stabilization, alignment system
- Intratrain feedback, kickers to produce ILC-like train



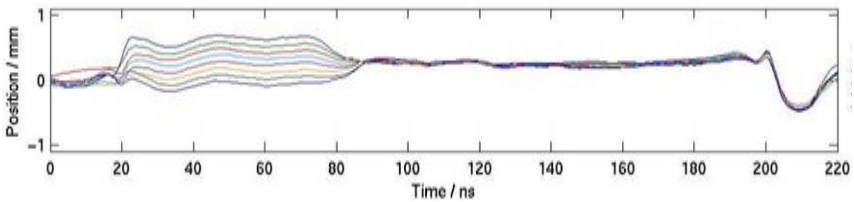
IP Beam-size monitor (BSM)
(Tokyo U./KEK, SLAC, UK)



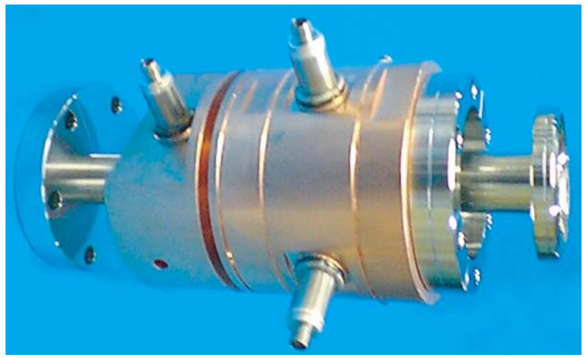
Laser-wire beam-size
Monitor (UK group),
low-f optics



Cavity BPMs with
2nm resolution,
for use at the IP
(KEK)



FONT – UK group



Cavity BPMs, for use with Q
magnets with 100nm
resolution (PAL, SLAC, KEK)

Moving into TDR Phase

- Integration of FD, feedback, correctors inside the detector, cryostat : For both the interaction regions : 2/20, 0/14 mrad
- Integration of the beam lines
- MPS, failure scenarios and PPS
- Stability measurements for critical elements
- Feasibility and optimisation of extraction line magnets (2 mrad)
- Wake fields : with all the details
- Details of water dump and R&D for gas dump feasibility
- Prototypes for large aperture SC magnets, effects of external solenoid field, stability studies
- Crab cavity prototypes and demonstration of phase stability
- Clear path to g-g, e-e- updates

Moving into TDR Phase

- Limited resources : Clear path to define the TDR work and R&D for baseline and alternatives.
- Coordinated R&D plans with more engineering resources are submitted for next three years in UK and for the next year in US. Uncertainty in the final approval may need distribution of resources.
- Need to organise the design and engineering efforts.
- Plan to make a detailed R&D plan with priorities for the area soon.