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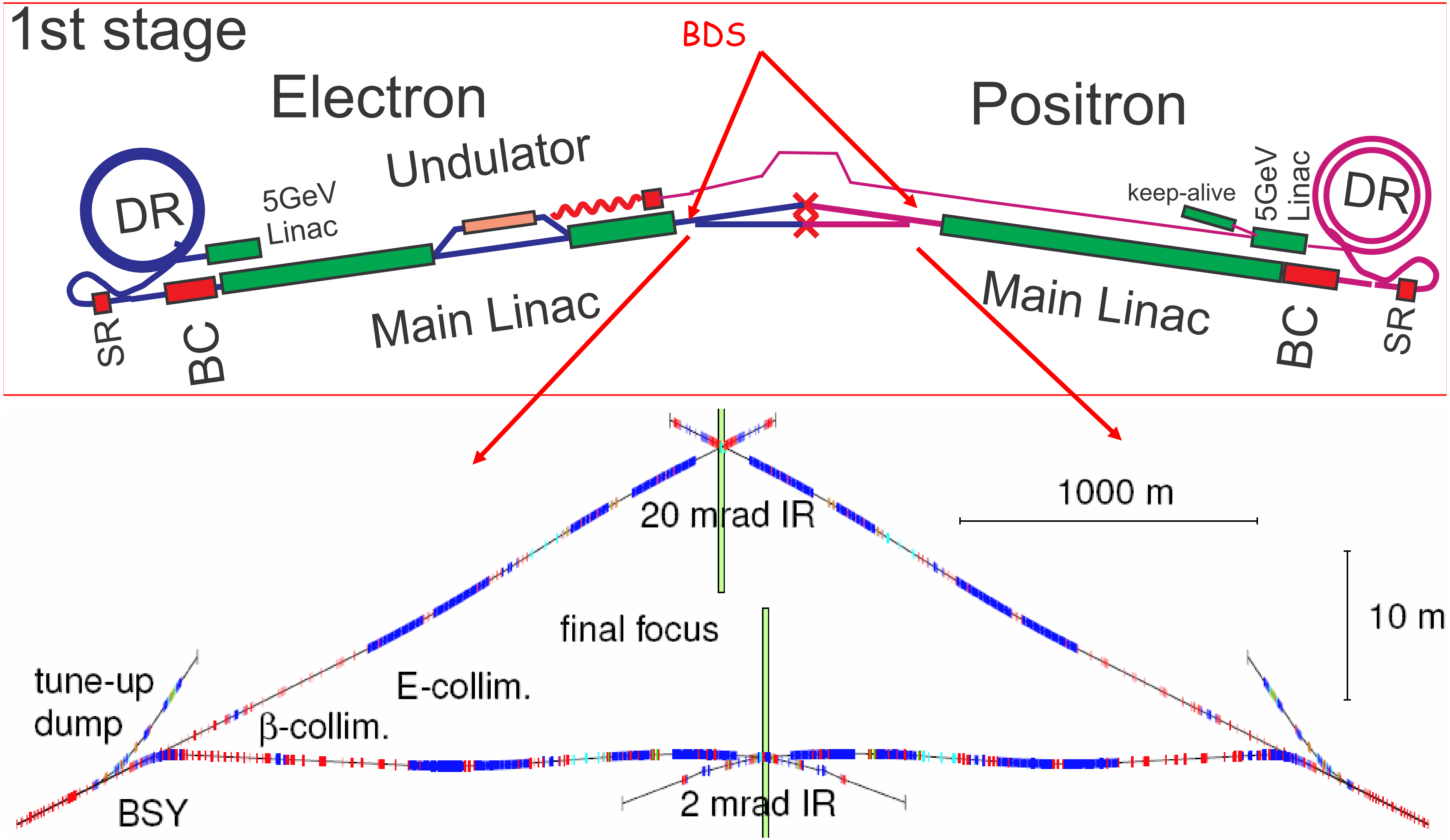
Beam Delivery System & ESA

Andrei Seryi
SLAC

Annual DOE HEP program review
5-8 June 2006, SLAC

BDS: from end of linac to IP, to dumps



GDE/RDR work in BDS area

linked from http://www.linearcollider.org/wiki/doku.php?id=rdr:rdr_as:rdr_as_home

ILC BDS Area. Materials for RDR (linked from Area System WIKI and BDS page at SLAC)

Layouts, apertures, tables of components, etc. (ILC2006b optics). (final for cost) UPDATED April 21, 2006
layout; boundaries for WBS; parts (excel and tape files) ; layout & t-space in 2mr extr;
Underground requirements, draft Posted April 27, 2006 Environmental requirements, draft Posted May 17

BDS Optics files (ILC2006b) (final for cost) UPDATED April 21, 2006

Technical specs for feasibility study and cost estimations
- 2mrad IR Final Doublet Posted Feb 22
- Crab cavity system Posted Feb 26
  - Specs for the crab cavity effect on the beam Posted April 20
- Muon walls Posted April 25
- Low field dipoles Posted May 2
- Beam Dump parameters (coordinates) DRAFT Posted May 3

to come:
- Collimators (spoilers, absorbers, PCs)
- 20/14mrad FD

Configuration Change Requests under considerations
- Upgrade path to gamma-gamma DRAFT Posted May 2. Submitted May 16
- Reducing the muon walls

BDS introductory description for Technical Systems (January 06)
- Magnets
- Vacuum
- RF, cryomodule, cavity package

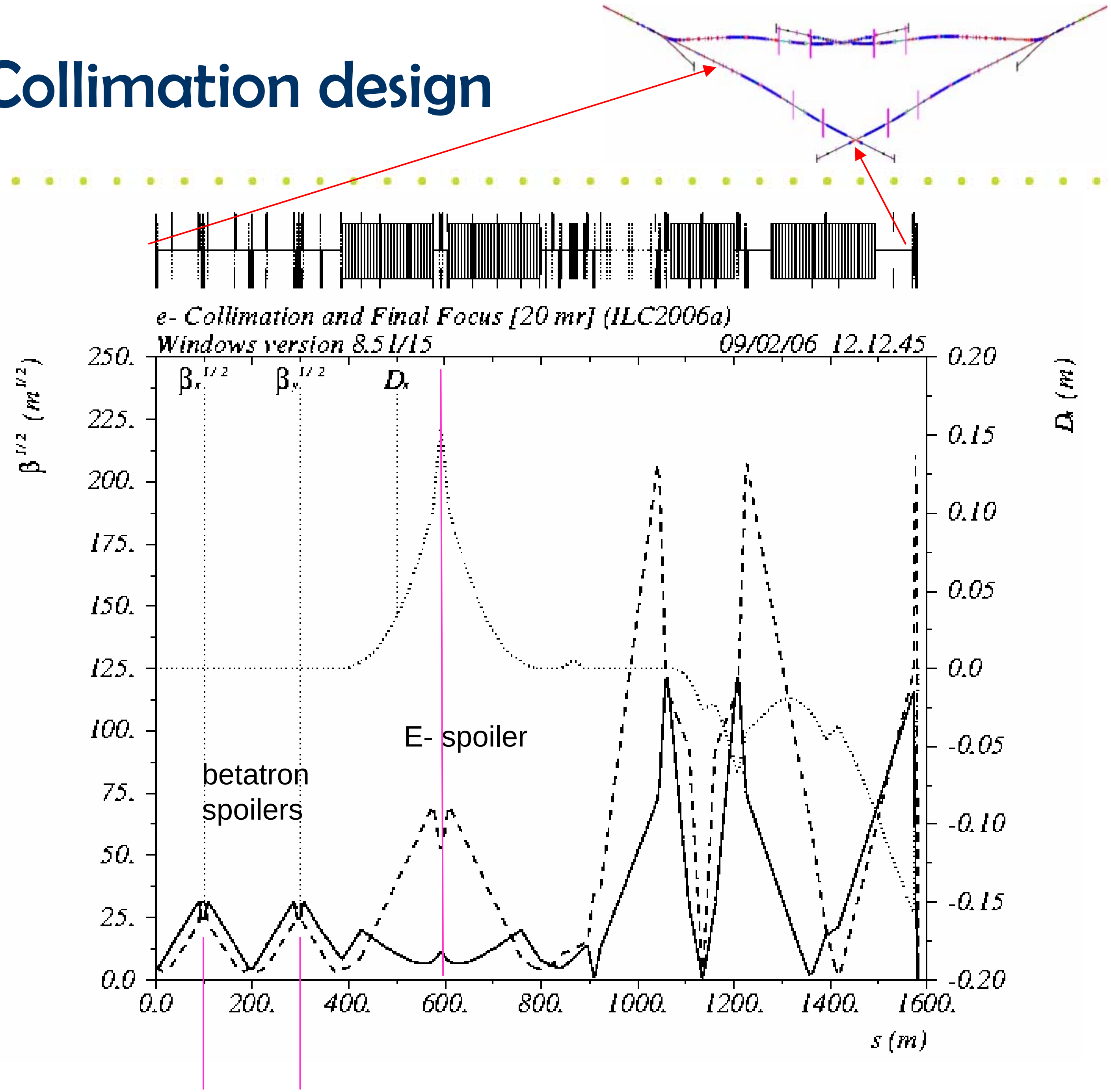
- Coordination of design, work with technical systems, in Americas and world

Beam Delivery System tasks

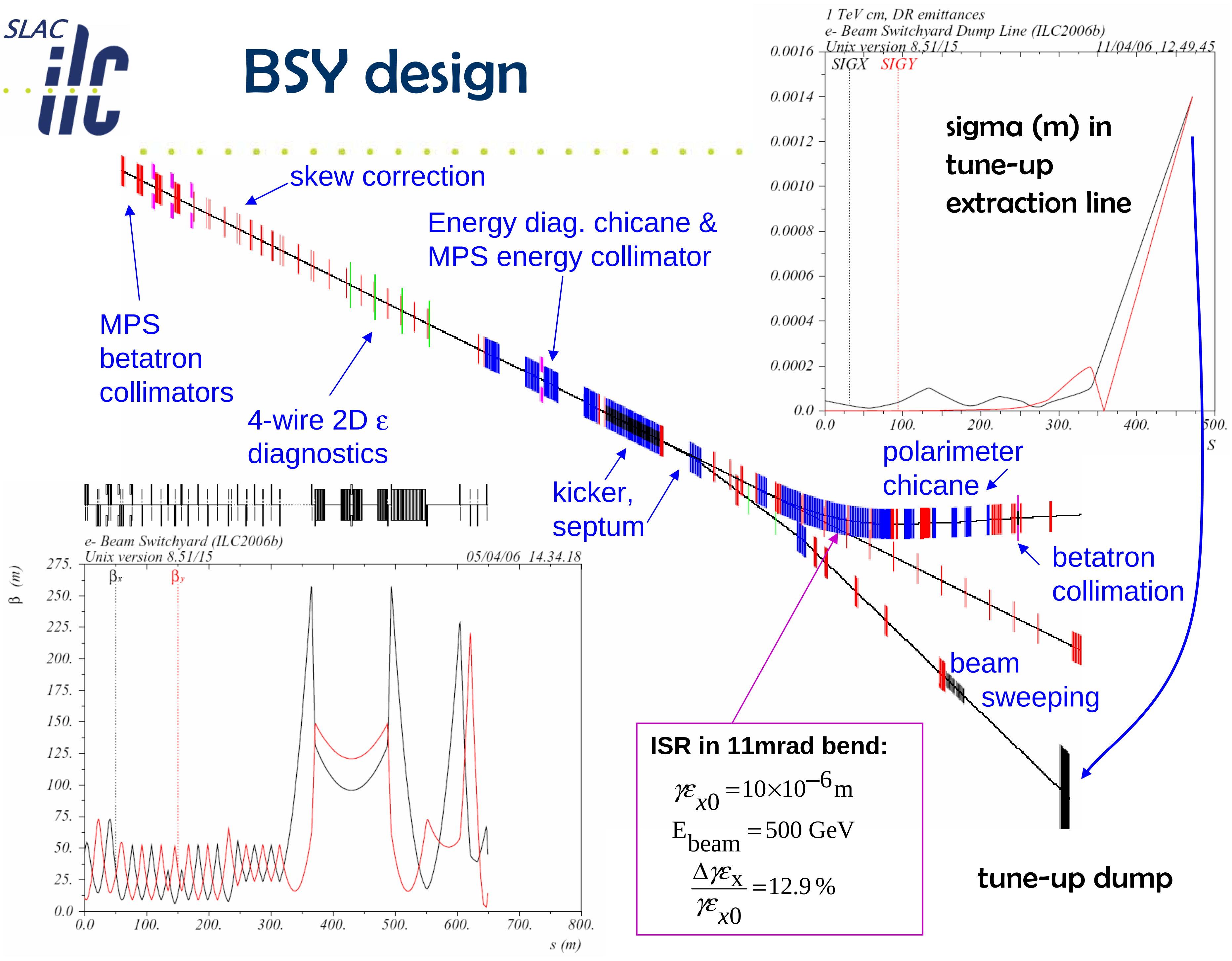
- Focus the beam to size of about 500 * 5 nm at IP
- Provide acceptable detector backgrounds
  - collimate beam halo
- Monitor the luminosity spectrum and polarization
  - diagnostics both upstream and downstream of IP is desired
- Measure incoming beam properties to allow tuning of the machine
- Keep the beams in collision & maintain small beam sizes
  - fast intra-train and slow inter-train feedback
- Protect detector and beamline components against errant beams
- Extract disrupted beams and safely transport to beam dumps
- Minimize cost & ensure Conventional Facilities constructability

FF & Collimation design

- FF with local chromatic correction
- Betatron spoilers survive up to two bunches
- E-spoiler survive several bunches



BSY design



skew correction
Energy diag. chicane &
MPS energy collimator
MPS
betatron
collimators
4-wire 2D ε
diagnostics
kicker,
septum
polarimeter
chicane
betatron
collimation
beam
sweeping
tune-up dump
1 TeV cm, DR emittances
e- Beam Switchyard Dump Line (ILC2006b)
Unix version 8.51/15
11/04/06 12.49.45
SIGX SIGY
sigma (m) in
tune-up
extraction line
0.0016
0.0014
0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
0.0
0.0 100. 200. 300. 400. 500.
S
e- Beam Switchyard (ILC2006b)
Unix version 8.51/15
05/04/06 14.34.18
β (m)
βx βy
275. 250. 225. 200. 175. 150. 125. 100. 75. 50. 25. 0.0
0.0 100. 200. 300. 400. 500. 600. 700. 800.
s (m)
ISR in 11mrad bend:
$\gamma\varepsilon_{x0} = 10\times10^{-6}$m
$E_{beam} = 500$ GeV
$\frac{\Delta\gamma\varepsilon_x}{\gamma\varepsilon_{x0}} = 12.9\,\%$

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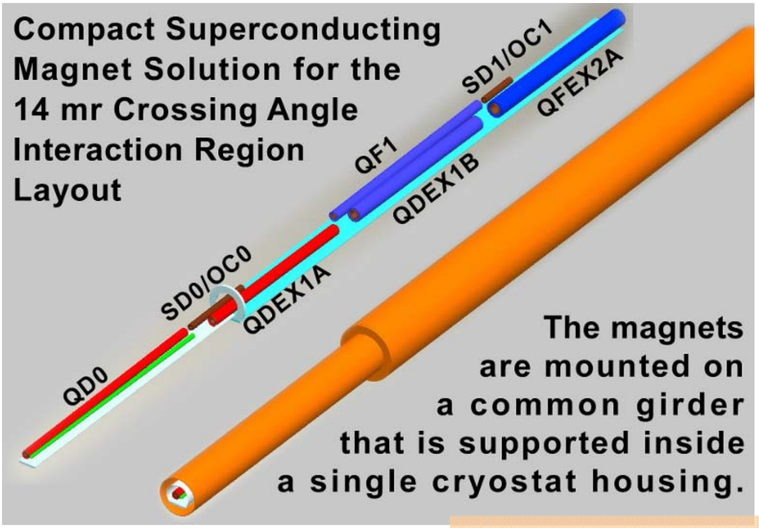
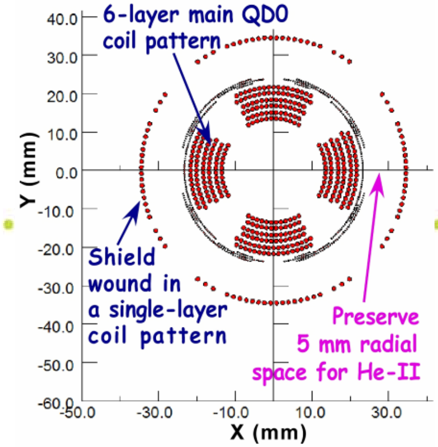
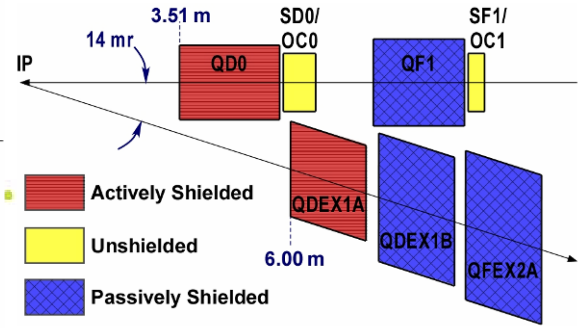
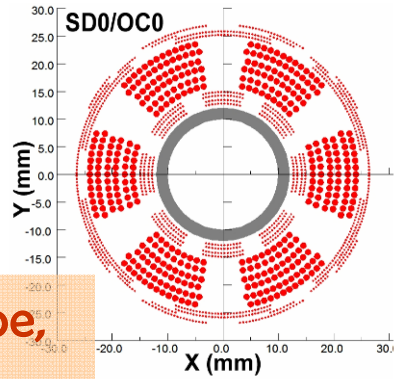
14(20)mrad IR

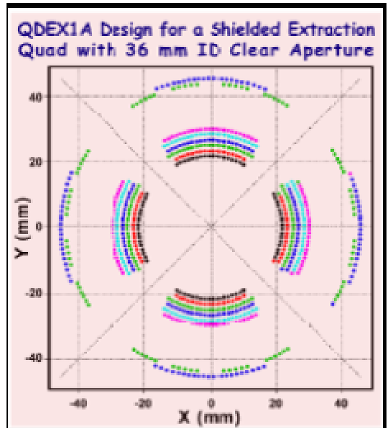
BNL design

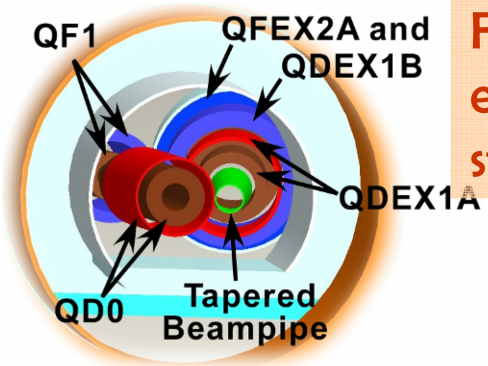




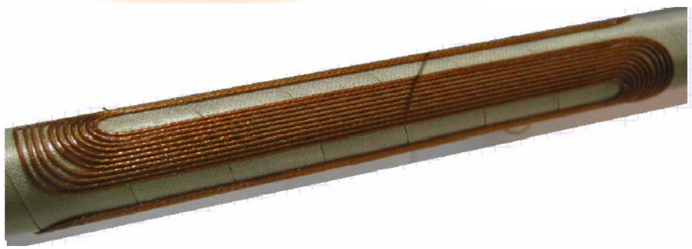


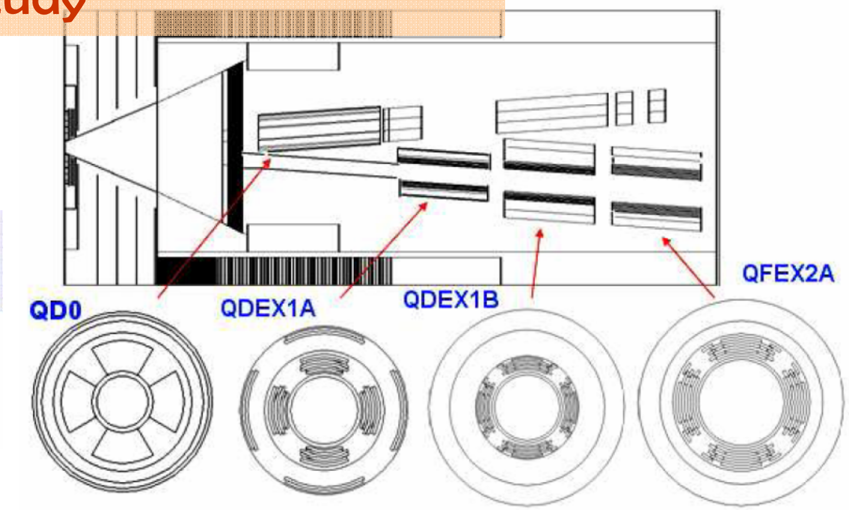


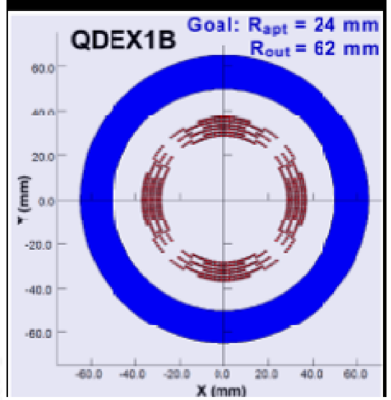




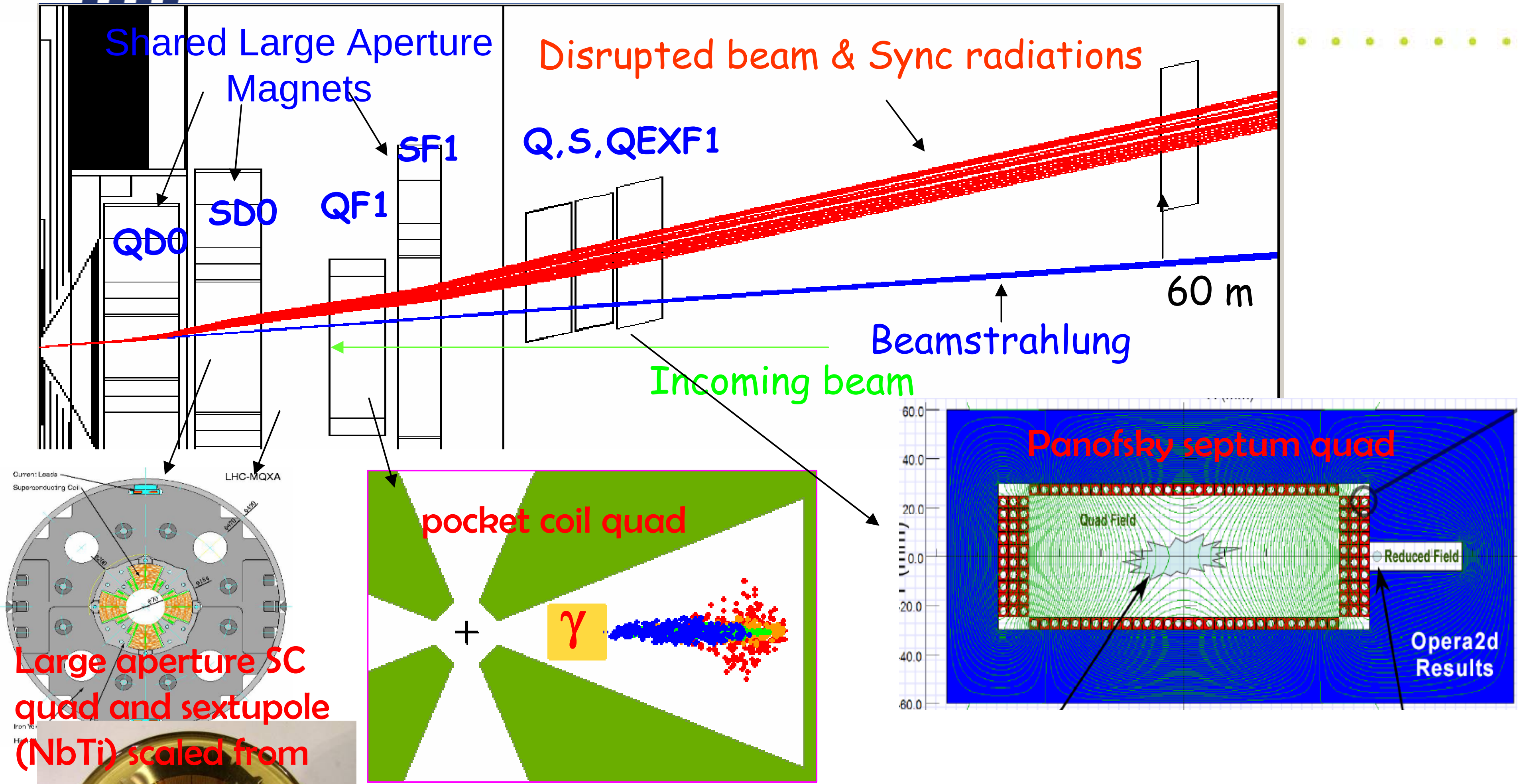
FY07: work on long prototype, engineering design, continue stability study







2mrad IR



- IR quads: evaluation for RDR by FNAL
- FY07: proposal by LBNL to evaluate Nb3Sn SC LARP technology for large aperture SC magnets in 2mrad IR

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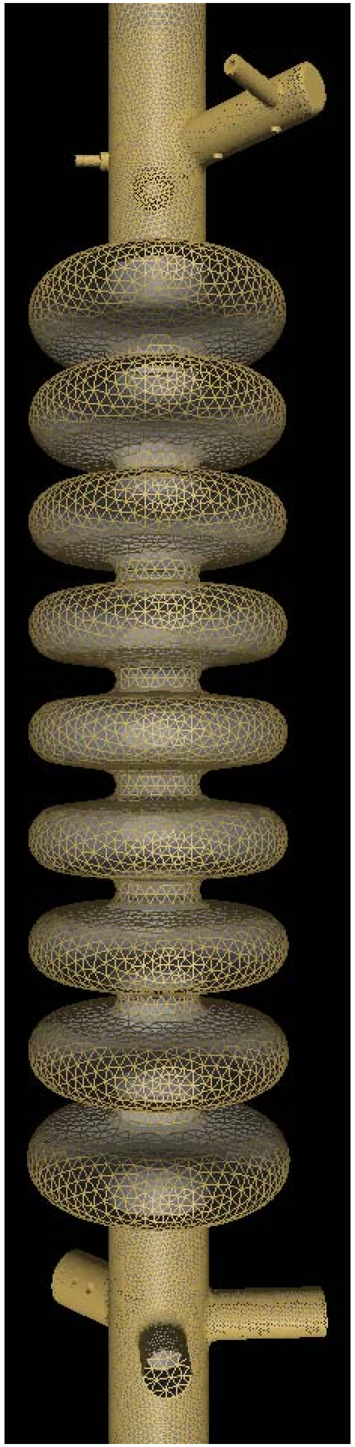
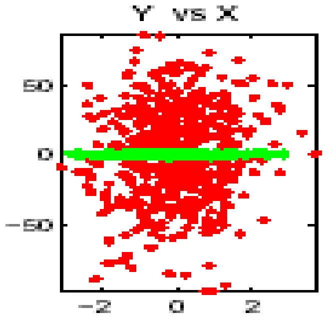
Crab cavity

Right: earlier prototype of 3.9GHz deflecting (crab) cavity designed and build by Fermilab. This cavity did not have all the needed high and low order mode couplers. Left: Cavity modeled in Omega3P, to optimize design of the LOM, HOM and input couplers.
FNAL T. Khabibouline et al., SLAC K.Ko et al.



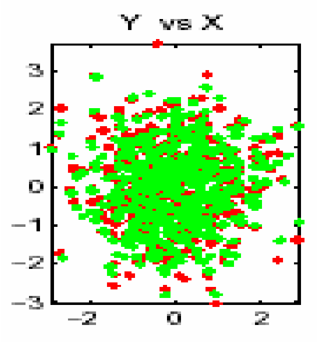
Submitted plans to design and build ILC compatible crab cavity in FY07

Anti-solenoid for IR



without compensation

$\sigma_y / \sigma_y(0) = 32$



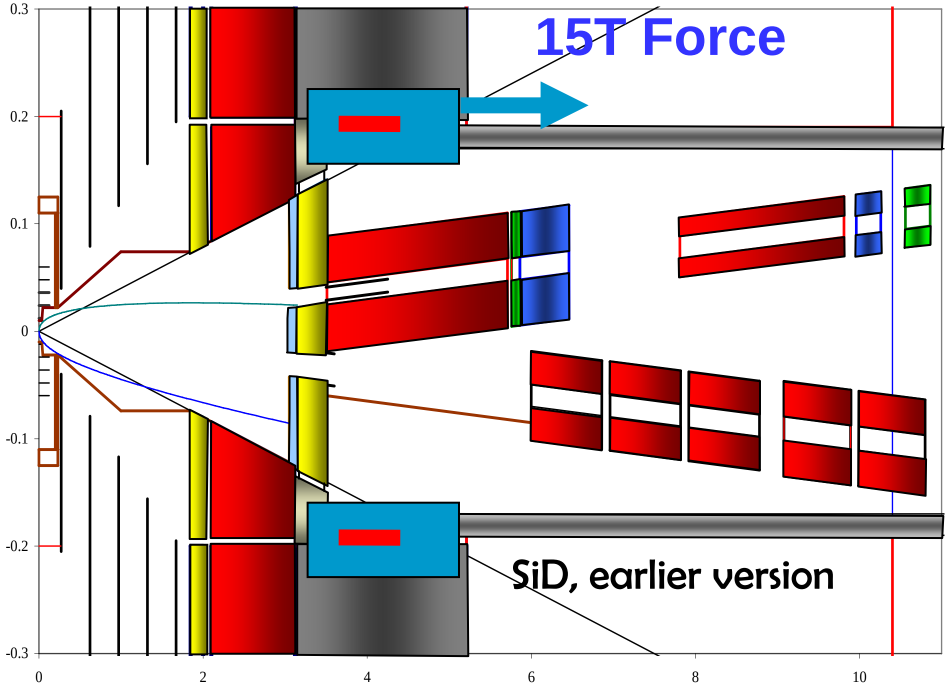
with compensation by antisolenoid

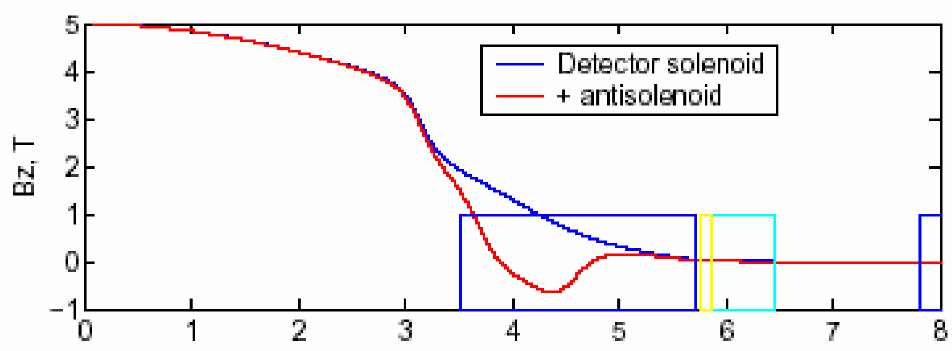
$\sigma_y / \sigma_y(0) < 1.01$

When solenoid overlaps QD0, anomalous coupling increases the IP beam size 30 – 190 times depending on solenoid field shape (green=no solenoid, red=solenoid)

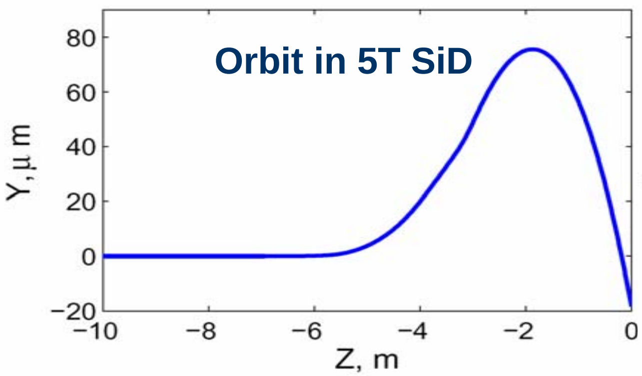
Even though traditional use of skew quads could reduce the effect, the LOCAL COMPENSATION of the fringe field (with a little skew tuning) is the best way to ensure excellent correction over wide range of beam energies

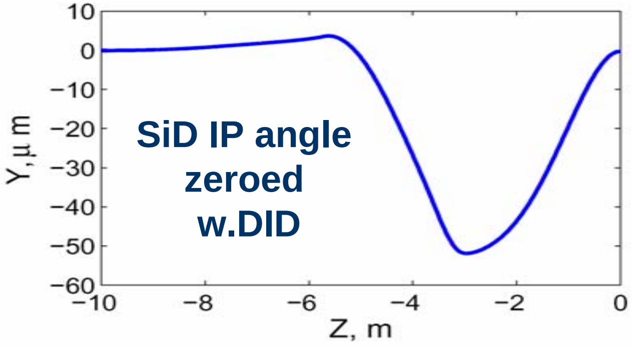
Local correction requires anti-solenoid with special shape. The antisolenoid is weak since its integrated strength is much smaller than that of detector solenoid



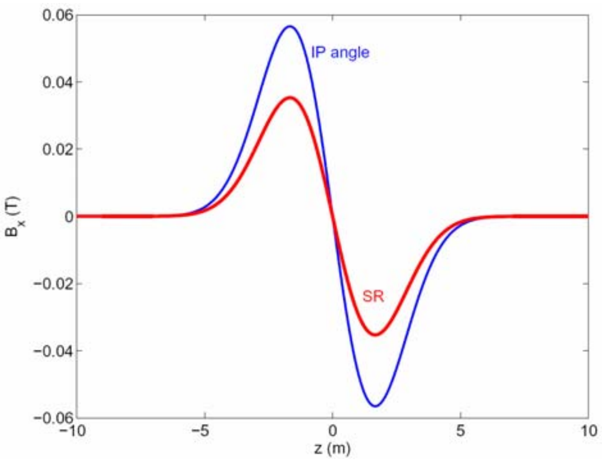


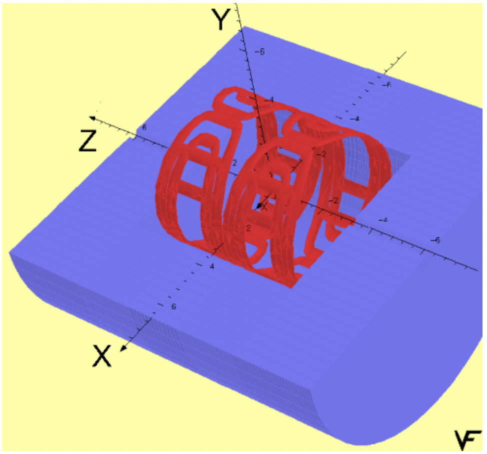
Design of DID





DID field shape and scheme

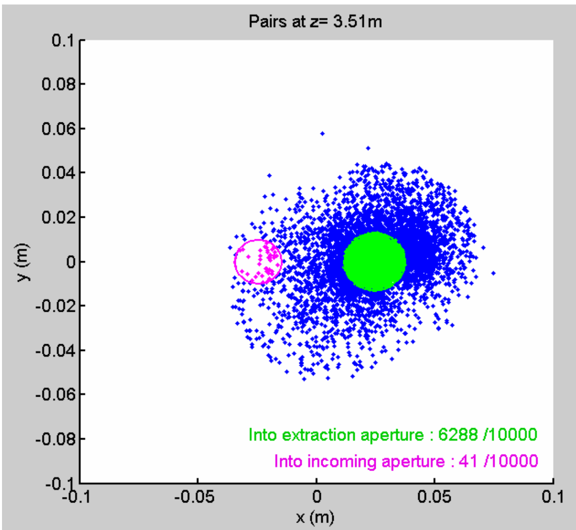


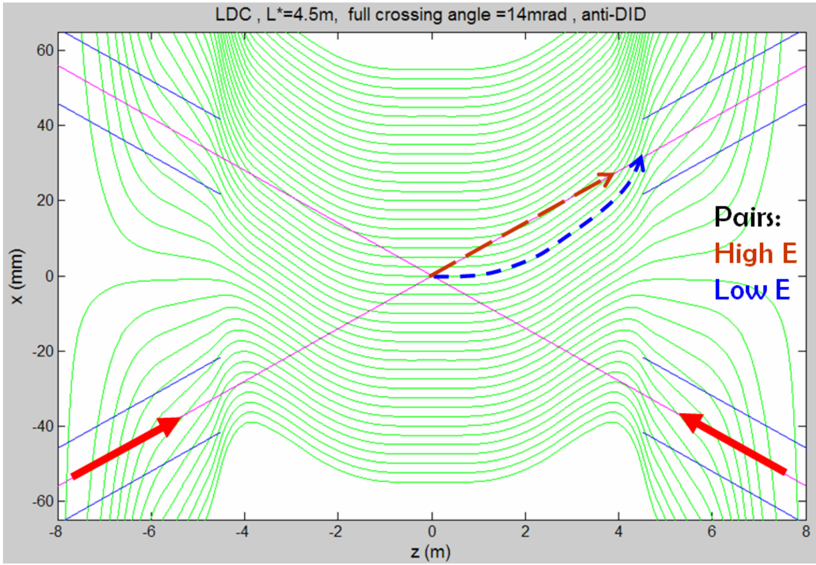


DID case

Detector Integrated Dipole allows to reduce y-orbit angle at IP or condense distribution of pairs on the beamcal

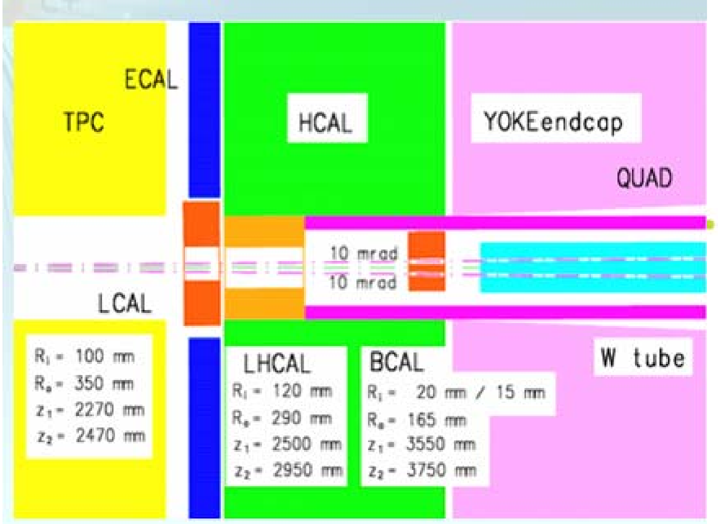
anti-DID case

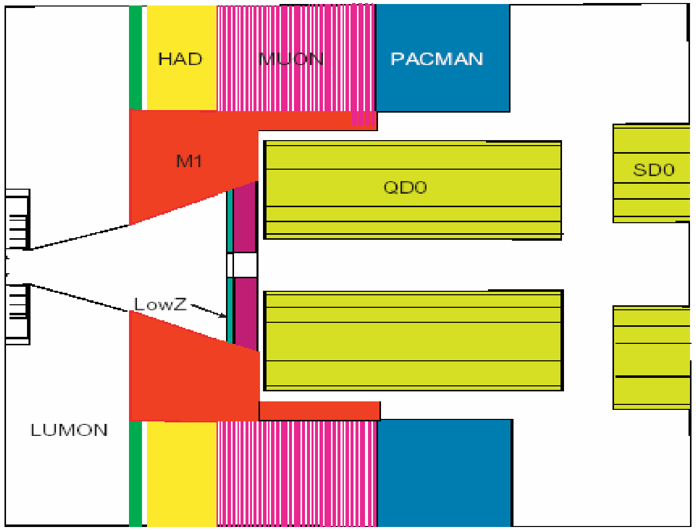




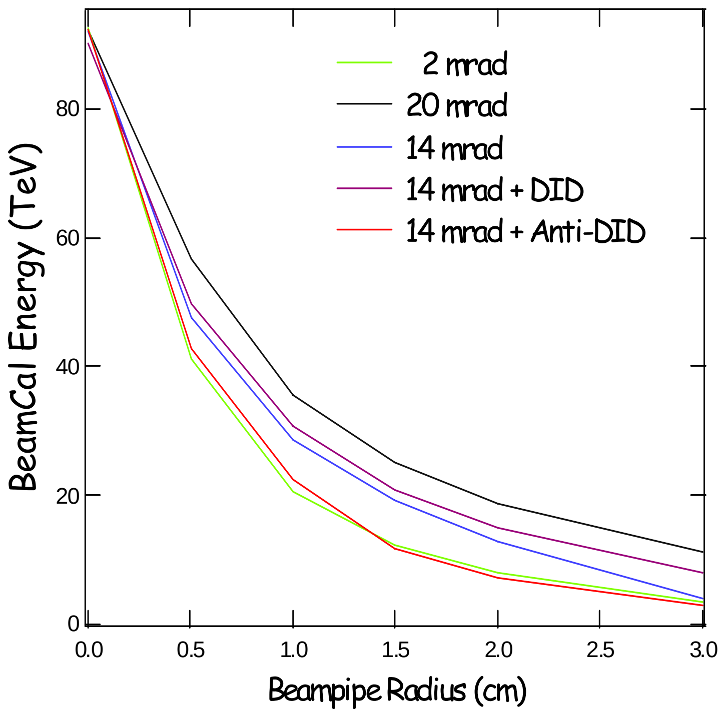
IR design

- Design of IR for both small and large crossing angles and to handle either DID or anti-DID
- Optimization of IR, masking, instrumentations, background evaluation
- Design of detector solenoid compensation





Shown the forward region considered by LDC for 20mrad (K.Busser) and an earlier version of 2mrad IR



T.Maruyama et al.

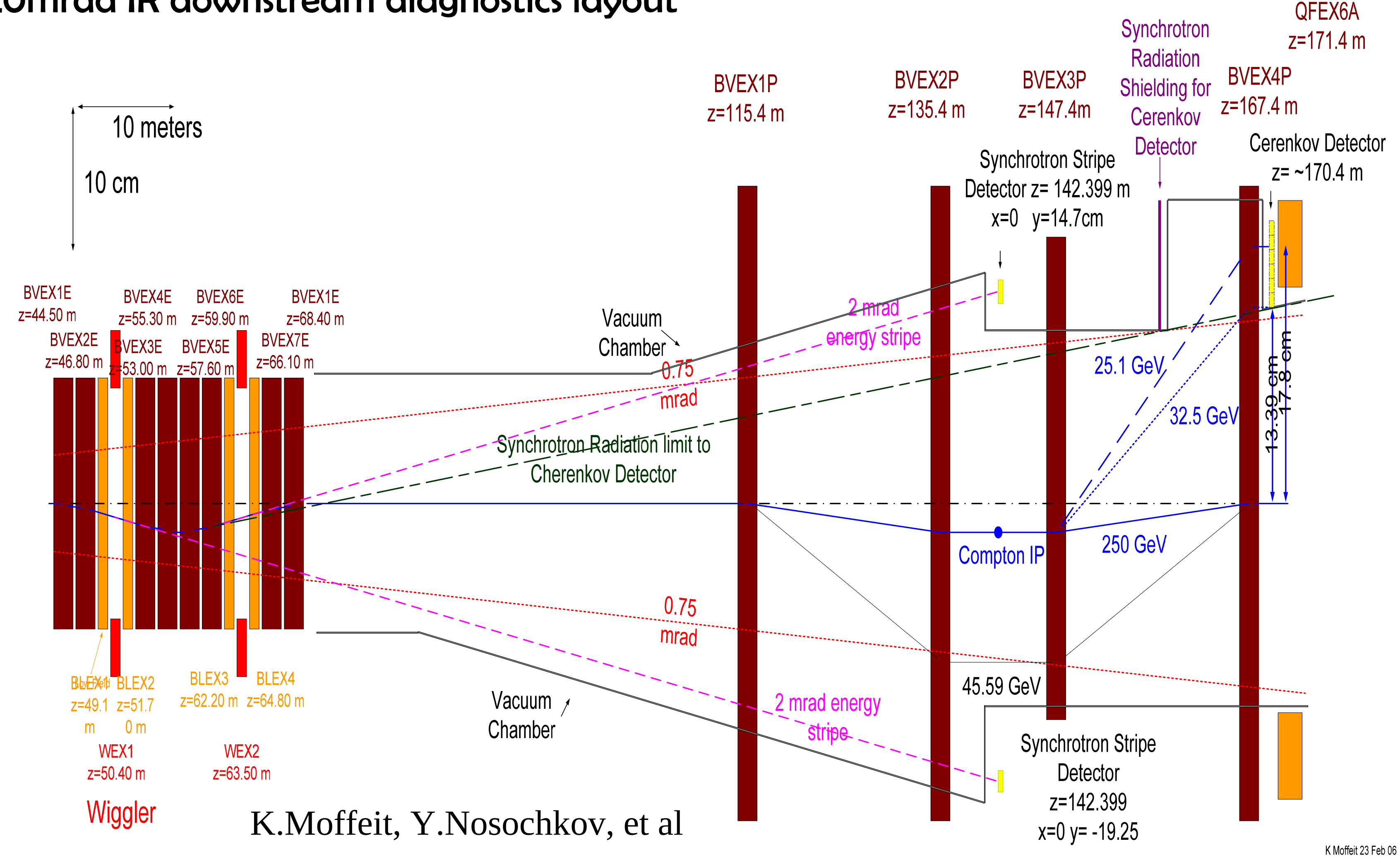
Downstream diagnostics

evaluation and optimization for both 20 and 2mrad IRs

Energy Chicane

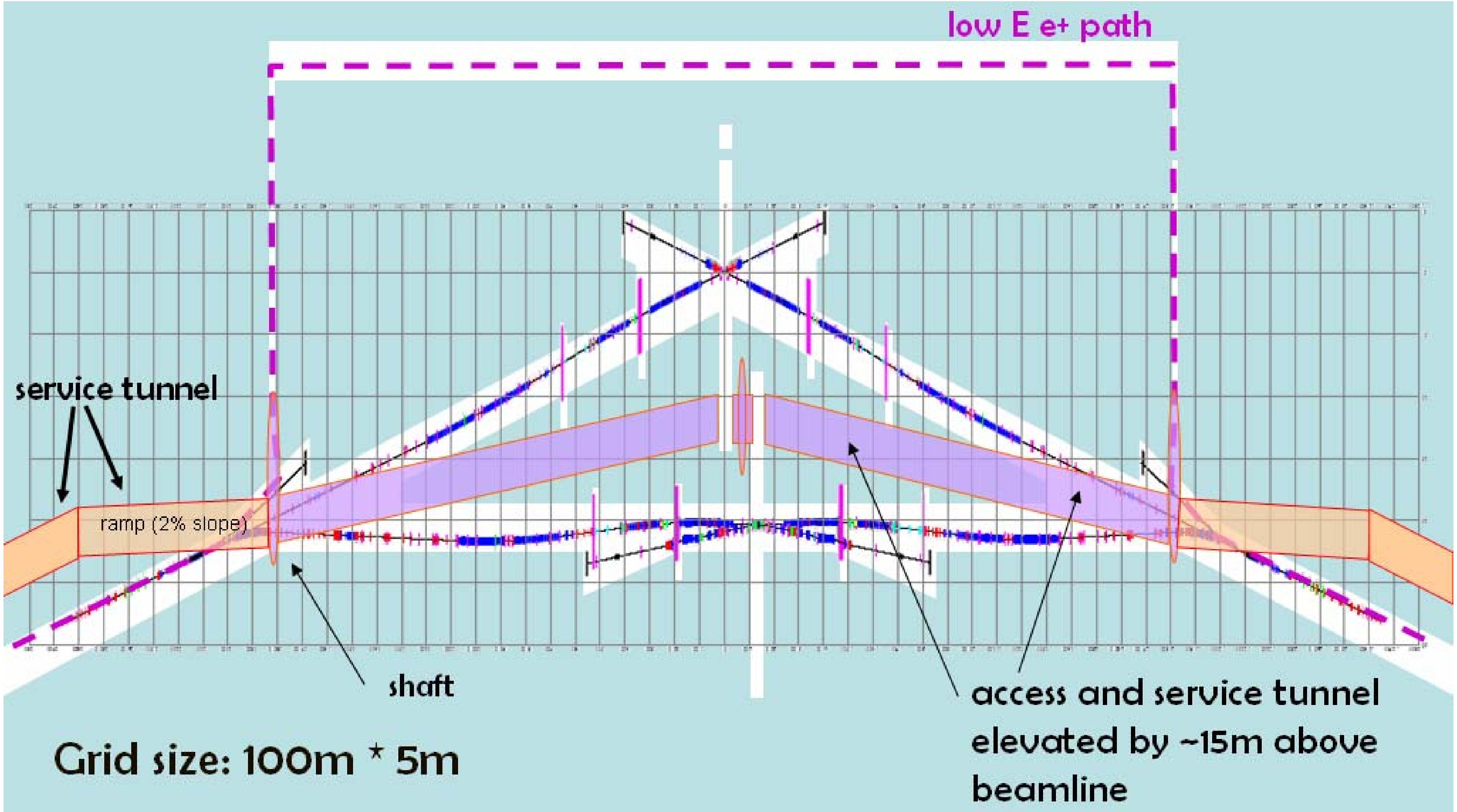
Polarimeter Chicane

20mrad IR downstream diagnostics layout

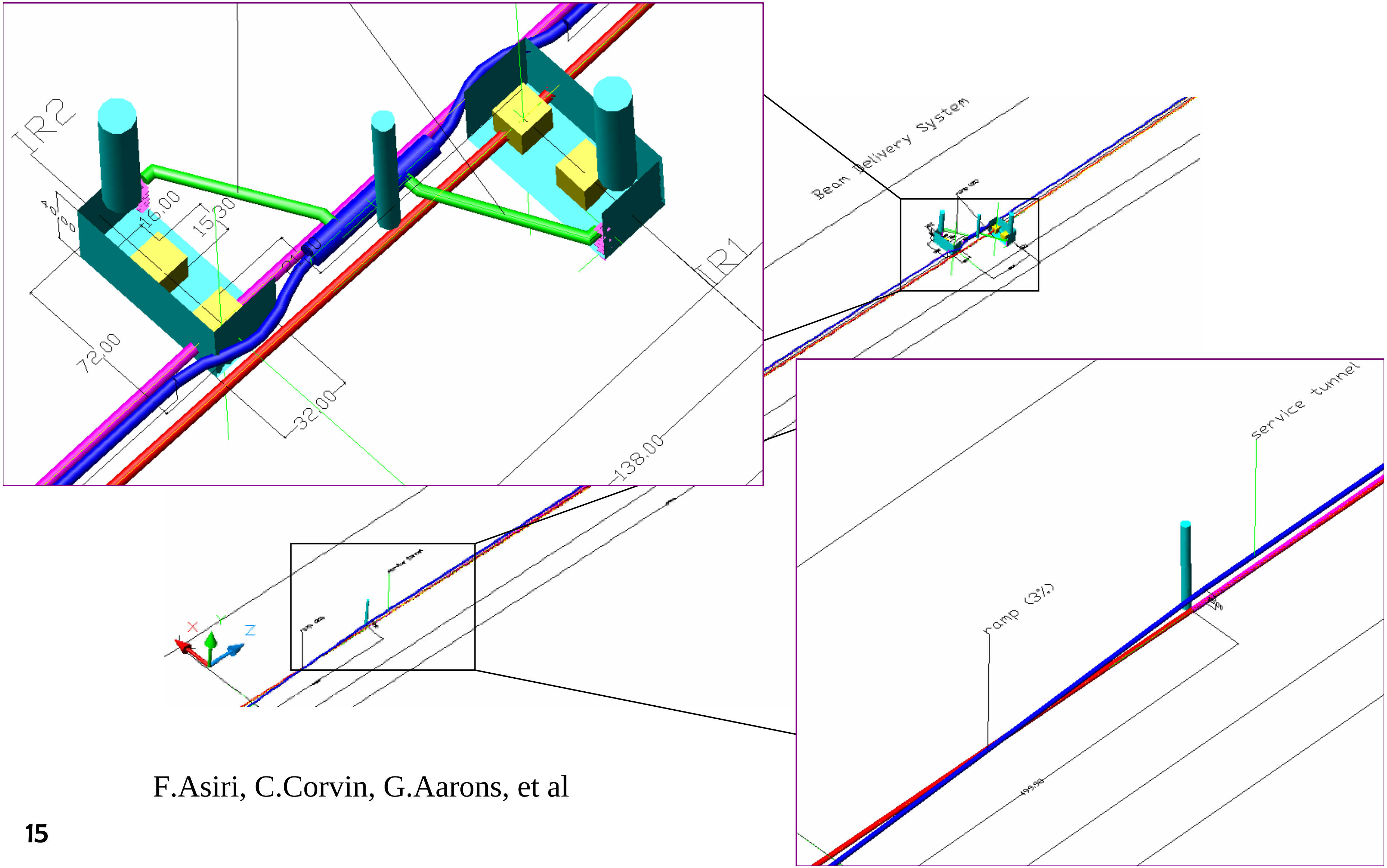


K.Moffeit, Y.Nosochkov, et al

Conceptual tunnel layout



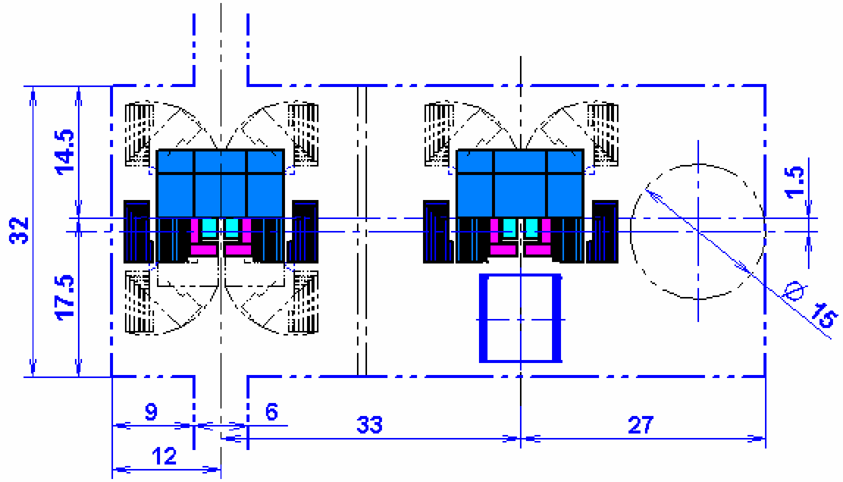
Detailed layout by Conventional Facilities & Siting and Installation groups

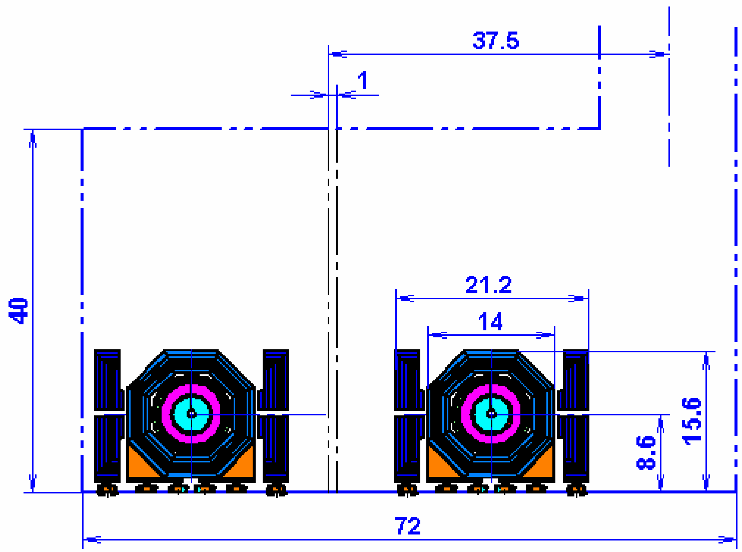


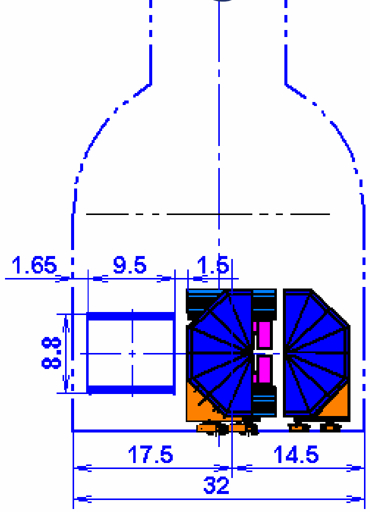
F.Asiri, C.Corvin, G.Aarons, et al

Collider hall

- Generic collider hall assumed, to house any considered detector
- Must have independent commissioning of BDS and detector operation => IR hall configuration



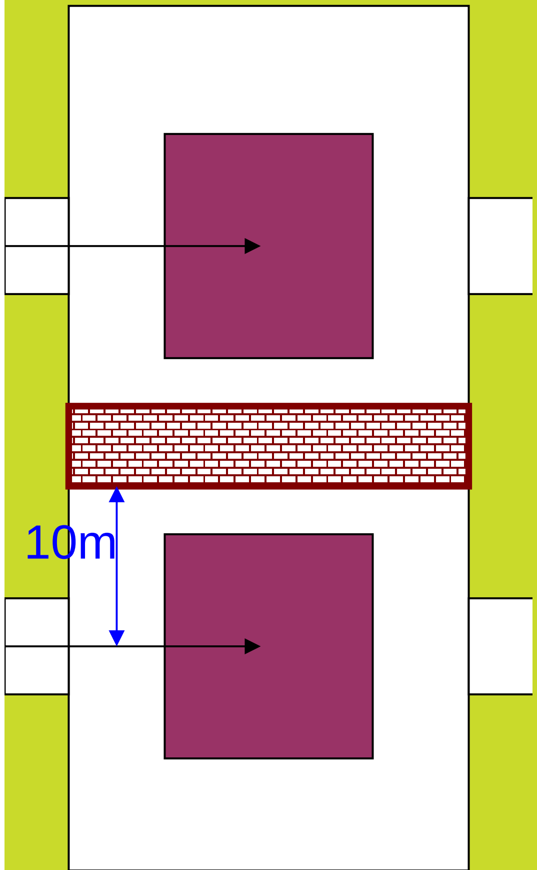


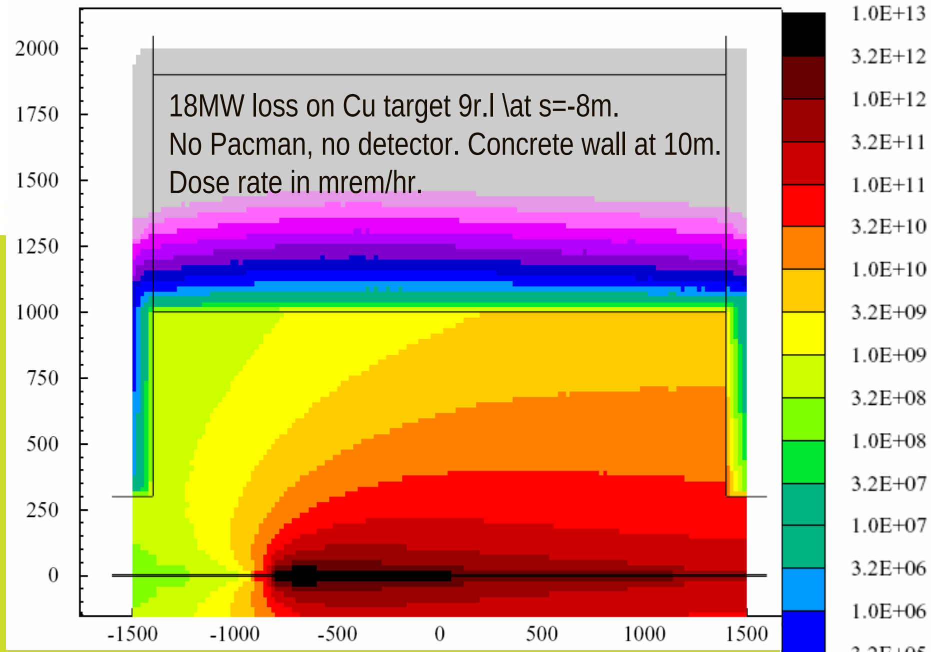


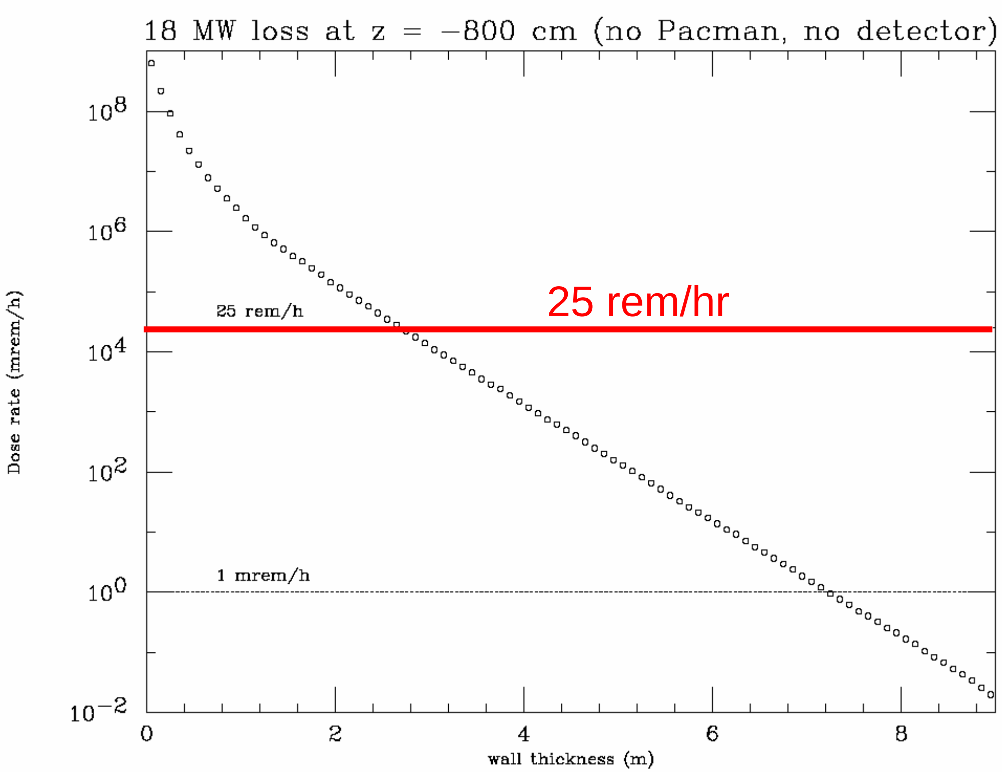
Shown example for GLD detector

IR & rad. safety

- For 36MW MCI, the concrete wall at 10m from beamline should be ~3.1m



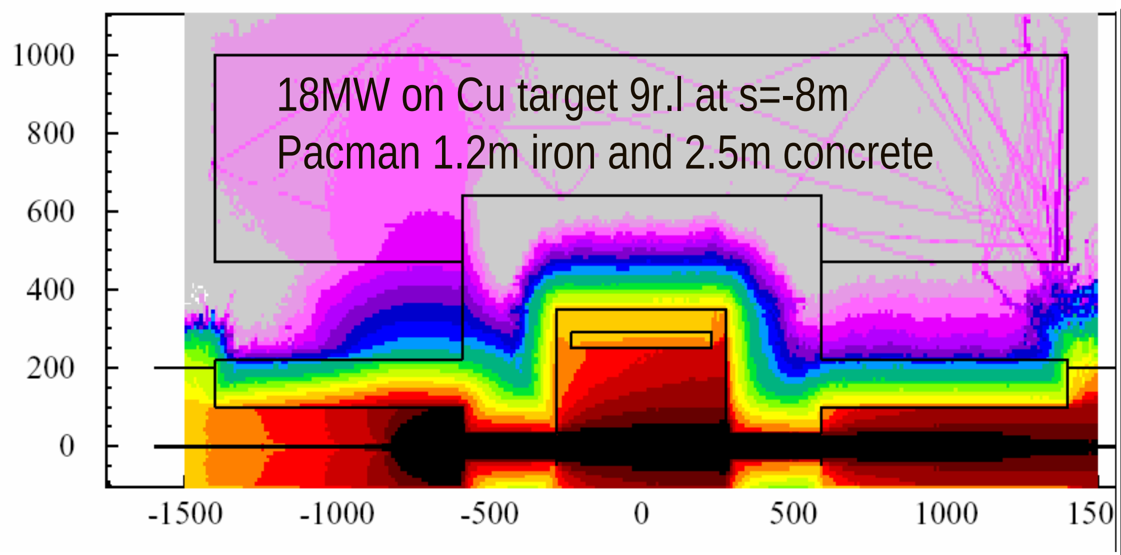


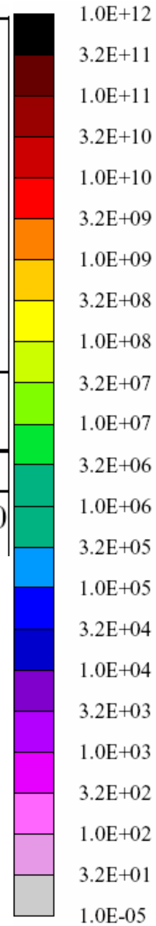


Self-shielding detector

Detector itself is well shielded except for incoming beamlines

A proper “pacman” can shield the incoming beamlines and remove the need for shielding wall





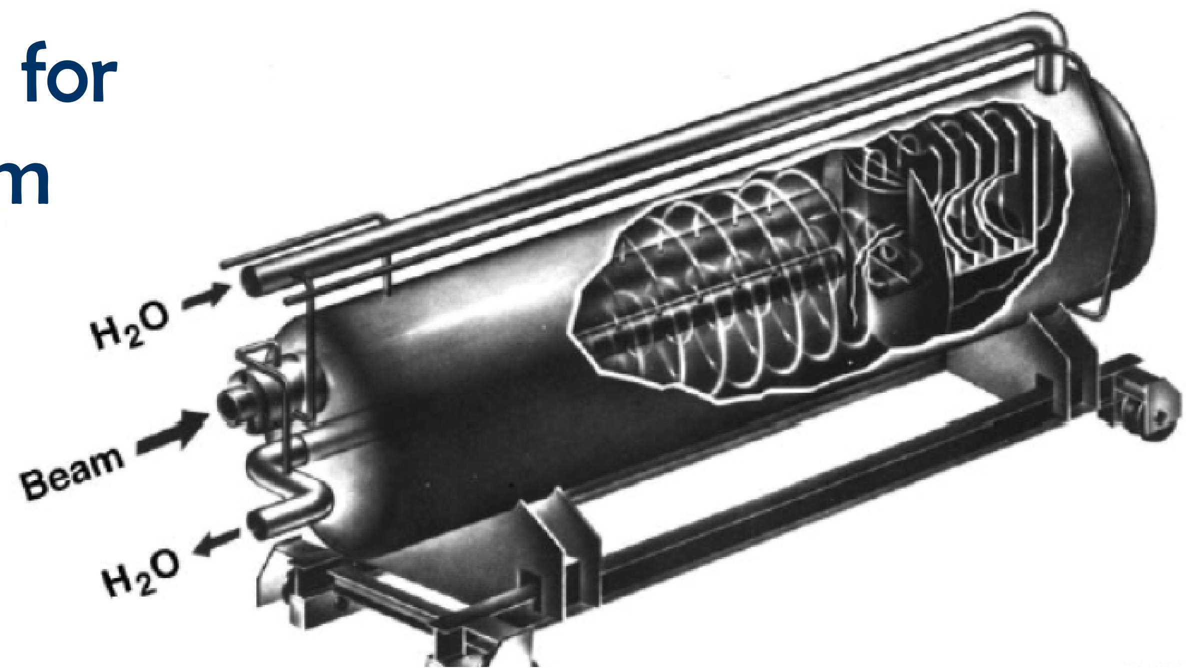
18MW lost at s=-8m.
Packman has Fe: 1.2m, Concrete: 2.5m

dose at pacman external wall
0.65rem/hr (r=4.7m)

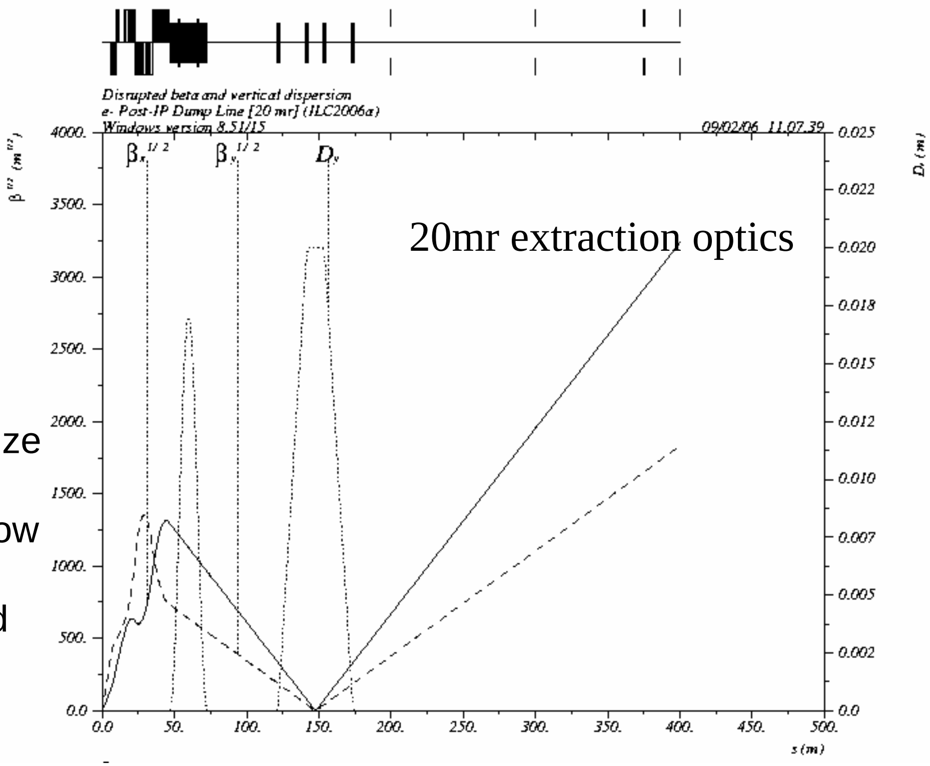
dose at r=7m
0.23rem/hr

Beam dump for 18MW beam

- Water vortex
- Window, 1mm thin, ~30cm diameter hemisphere
- Raster beam with dipole coils to avoid water boiling
- Deal with H, O, catalytic recombination
- etc.
- Had a mtg at SLAC in May to determine specs for 18 MW ILC dump
- Submitted plans for R&D study in FY07



undisrupted or disrupted beam size does not destroy beam dump window without rastering. Rastering to avoid boiling of water



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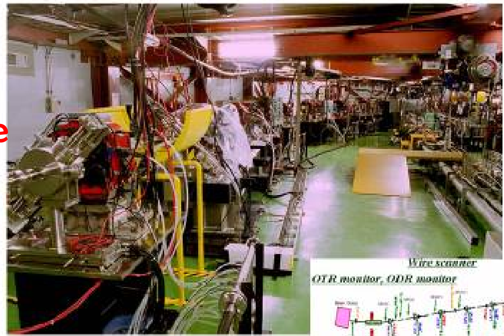
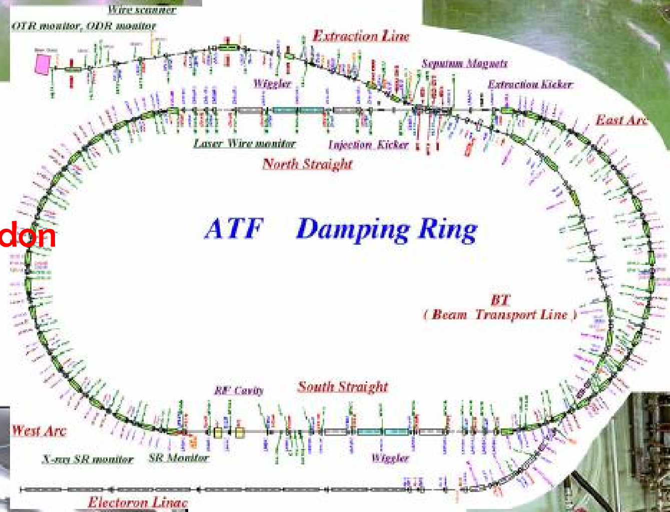
BDS facilities: ATF/ATF2 and ESA

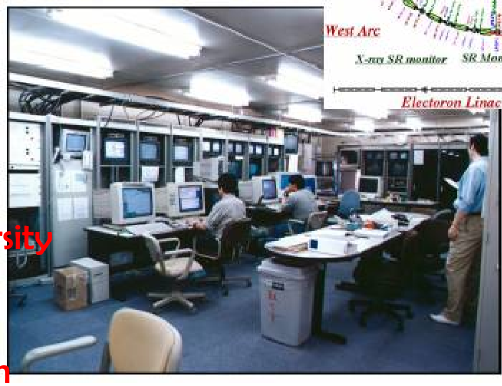
ATF/ATF2 collaborators:

BINP SB RAS, Novosibirsk
CCLRC/DL/ASTeC,Daresbury
CEA/DSM/DAPNIA, Gif-sur-Yvette
CERN, Geneva
The Cockcroft Institute, Daresbury
DESY, Hamburg
Fermilab, Batavia
Hiroshima University
IHEP, Beijing
John Adams Institute at Oxford University
John Adams Institute at Royal Holloway, Univ. of London
KEK, Ibaraki
Kyoto ICR
LAL, Orsay
LAPP, Annecy
LBL, Berkeley
LLNL, Livermore
University College London
NIRS, Chiba-shi
North Carolina A&T State University
University of Oregon
Pohang Accelerator Laboratory
Queen Mary University of London
SLAC, Stanford
University of Tokyo


Extraction Line


Damping Ring

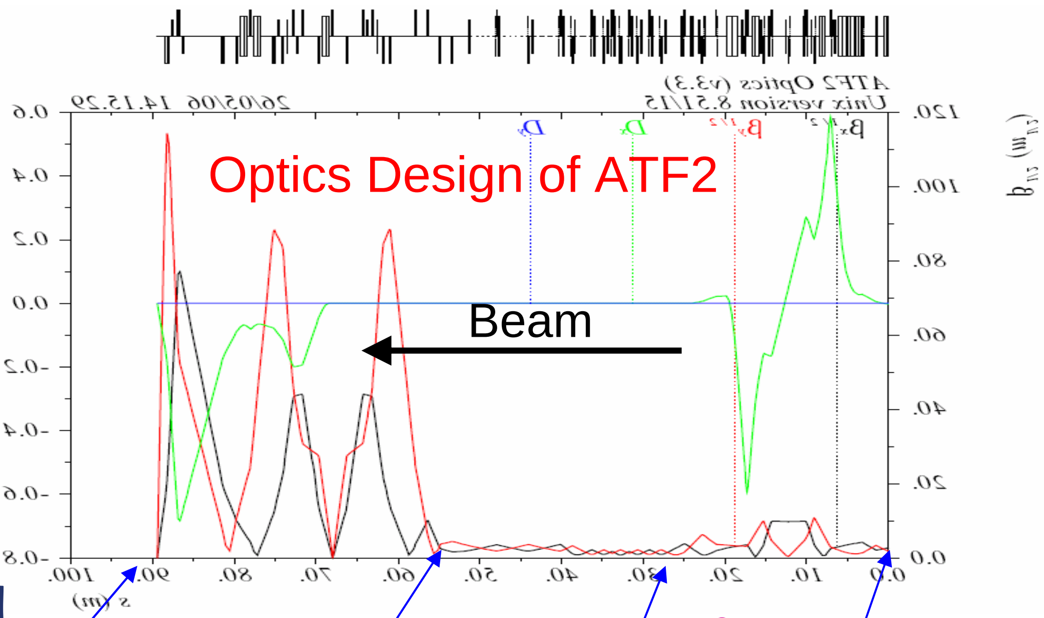


Control Room


Linac


at SLAC

ATF2
model of ILC FF



(A) Small beam size

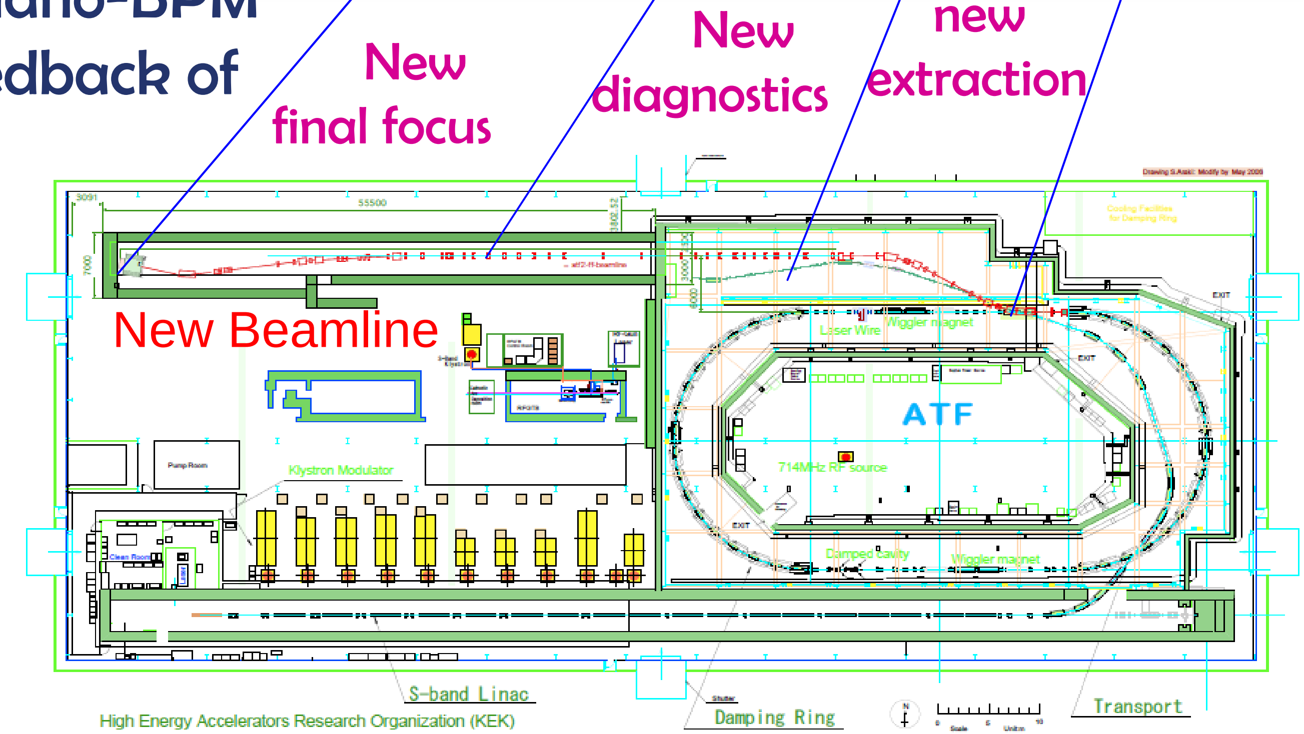
Obtain σ_y ~ 35nm

Maintain for long time

(B) Stabilization of beam center

Down to < 2nm by nano-BPM

Bunch-to-bunch feedback of ILC-like train

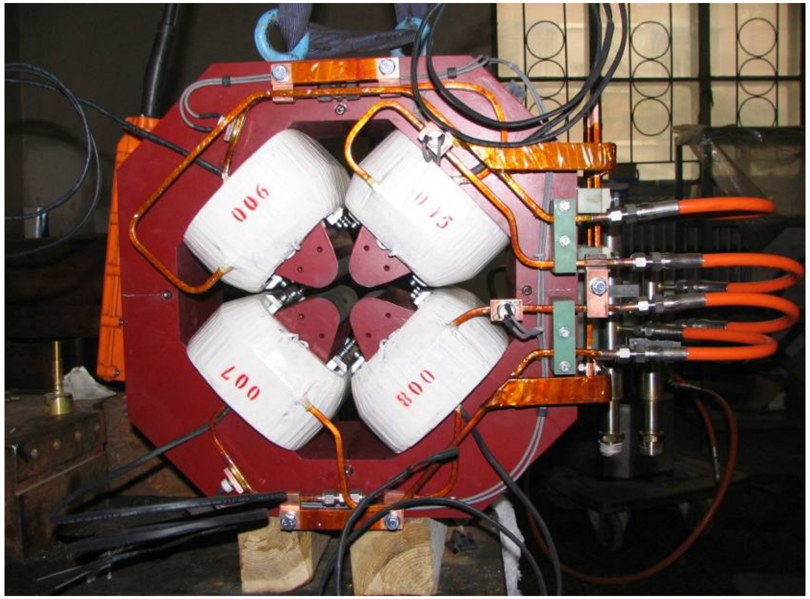


Designed and constructed in international manner, with contributions from all three regions

Magnets for ATF2: SLAC participation

IHEP team, C.Spencer (SLAC)

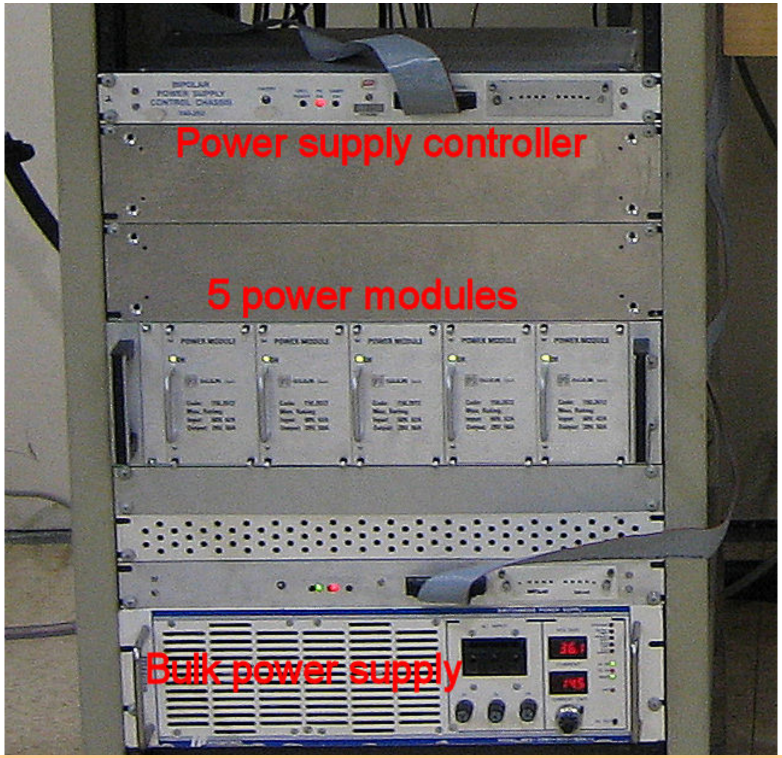
Cherrill Spencer (SLAC) visiting IHEP



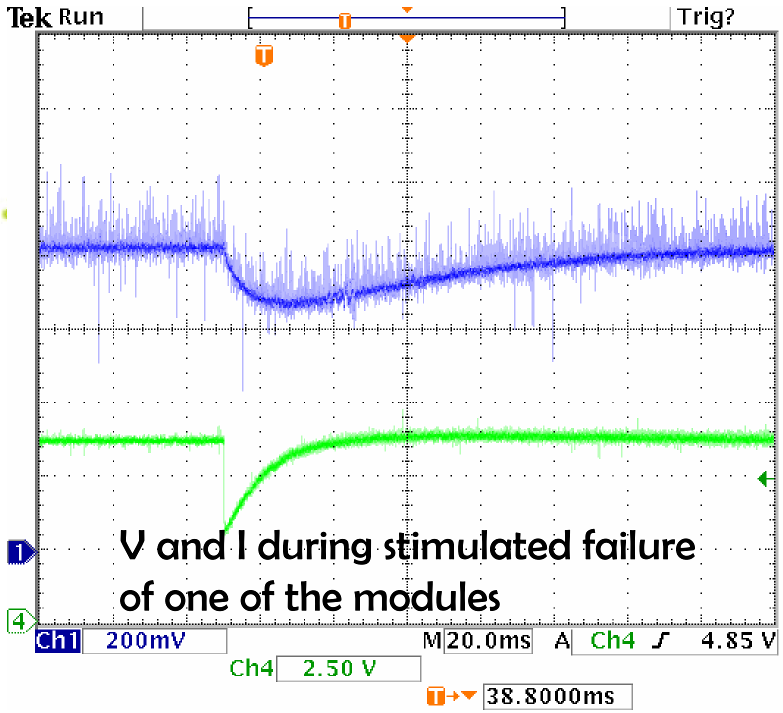
- Design and measurements of beamline quads
- Design & production of FD and bends

HA PS for ATF2

- High Availability power supply developed by SLAC was selected for the ATF2 project to power more than 40 magnets



- PS work in "4 out of 5" mode to ensure redundancy and high availability
- SLAC controller ensure stability of 0.5ppm/deg.C over 24hrd

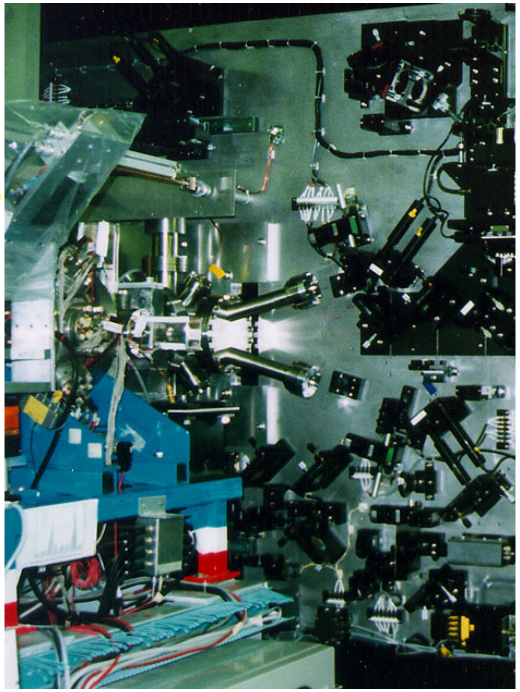


V and I during stimulated failure of one of the modules

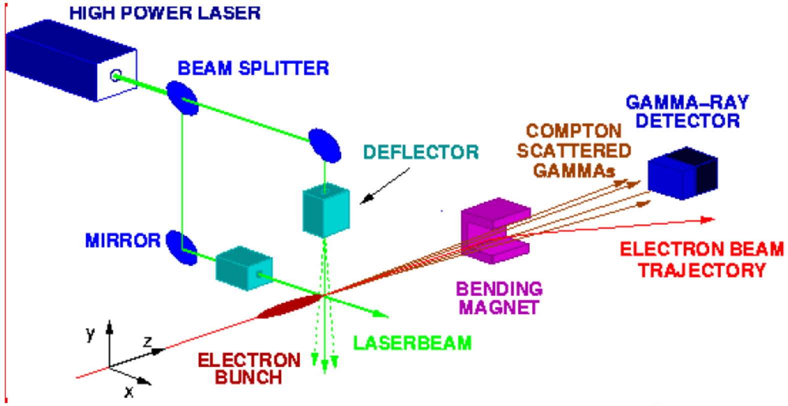
Visit of KEK colleagues for PS review

Advanced beam instrumentation at ATF2

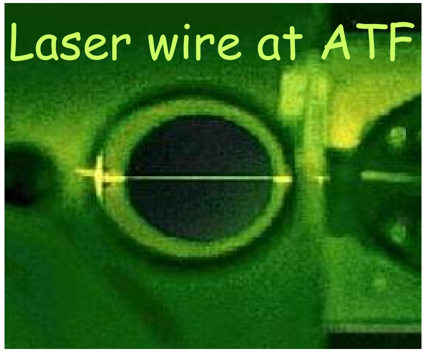
- BSM to confirm 35nm beam size
- nano-BPM at IP to see the nm stability
- Laser-wire to tune the beam
- Cavity BPMs to measure the orbit
- Movers, active stabilization, alignment system
- Intratrain feedback, Kickers to produce ILC-like train

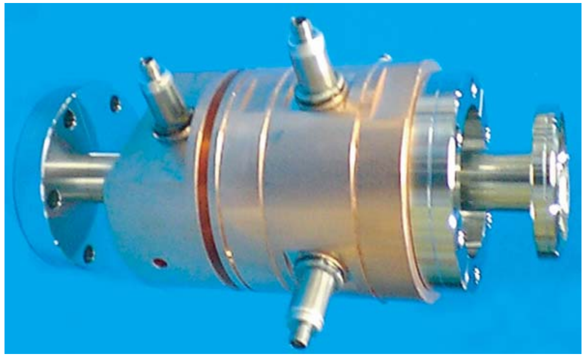


IP Beam-size monitor (BSM) (Tokyo U./KEK, SLAC, UK)



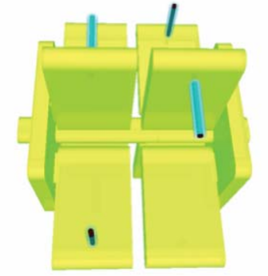
Laser-wire beam-size Monitor (UK group)





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

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



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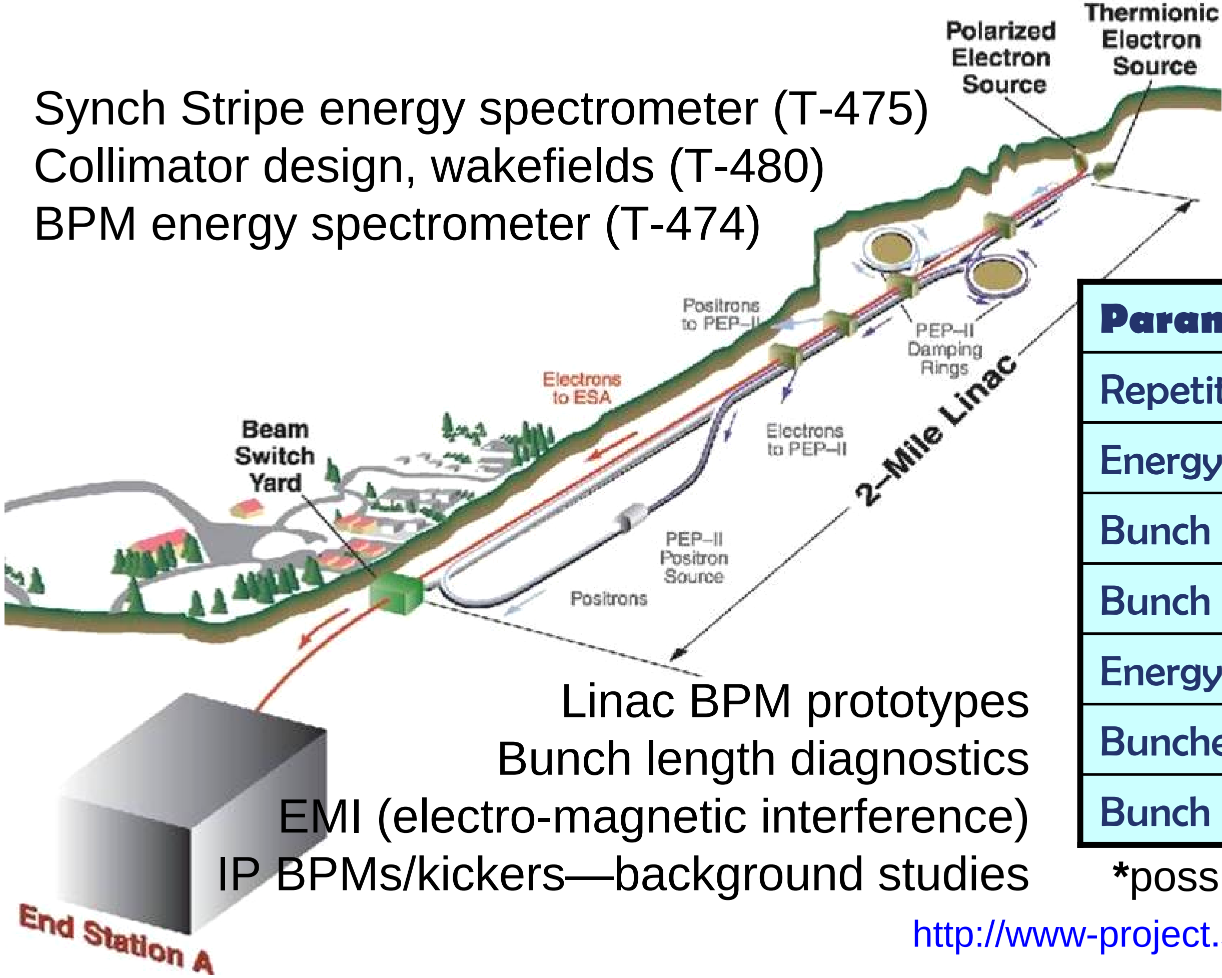
ILC Beam Tests in End Station A

Synch Stripe energy spectrometer (T-475)
Collimator design, wakefields (T-480)
BPM energy spectrometer (T-474)



Linac BPM prototypes
Bunch length diagnostics
EMI (electro-magnetic interference)
IP BPMs/kickers—background studies

Mike Woods, Ray Arnold in "SLAC Today" news

Parameter	SLAC ESA	ILC-500
Repetition Rate	10 Hz	5 Hz
Energy	28.5 GeV	250 GeV
Bunch Charge	2.0×10^{10}	2.0×10^{10}
Bunch Length	300 µm	300 µm
Energy Spread	0.2%	0.1%
Bunches / train	1 (2*)	2820
Bunch spacing	- (20-400ns*)	337 ns

*possible, using undamped beam

http://www-project.slac.stanford.edu/ilc/testfac/ESA/esa.html

CCLRC	LLNL	QMUL	U. of Bristol	UMass Amherst
CERN	Lancaster U.	SLAC	UC Berkeley	U. of Oregon
DESY	Manchester U.	TEMF TU Darmstadt	U. of Cambridge	Oxford U.
KEK	Notre Dame U.	U. of Birmingham	UCL	

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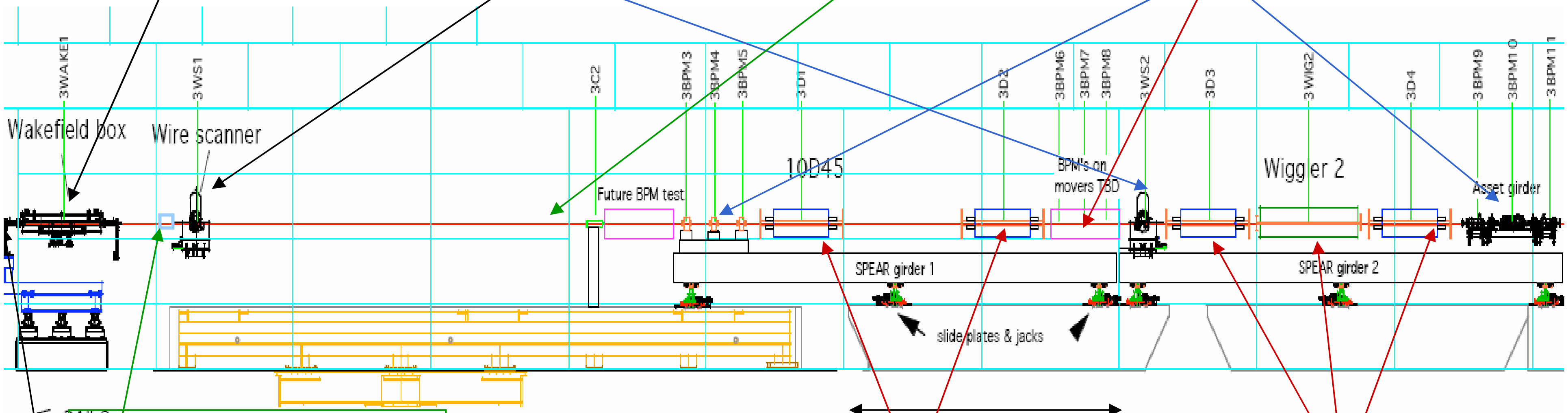
ESA Equipment Layout

Wakefield box

Wire Scanners

FONT-ESA

rf BPMs



18 feet

Ceramic gap BLMs

+ ceramic gap (downstream of 3BPM11, not shown) for EMI studies

Dipoles + Wiggler

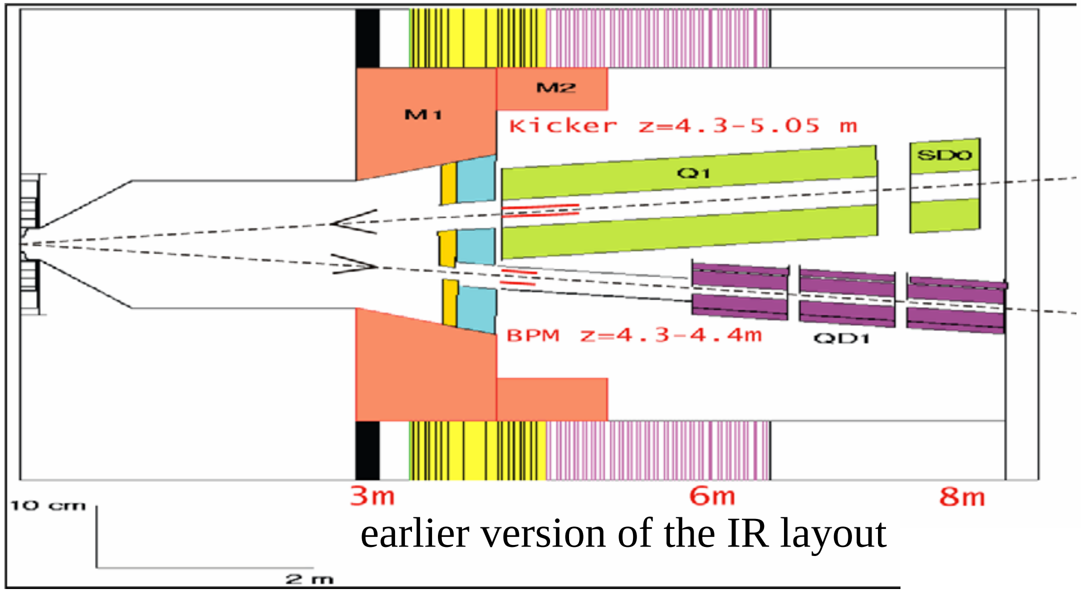
Upstream

4 rf BPMs for incoming trajectory
1st Ceramic gap w/ 4 diodes (16GHz, 23GHz, 2 @ 100GHz)

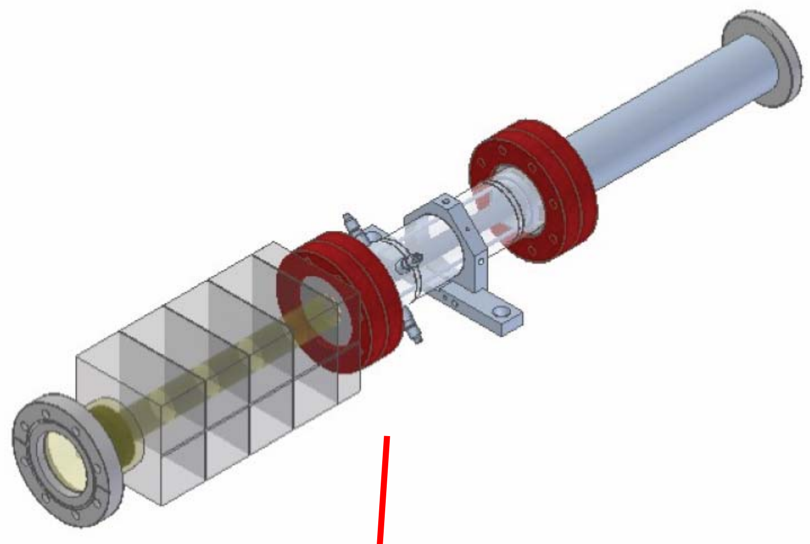
blue=April '06
green=July '06
red=FY07

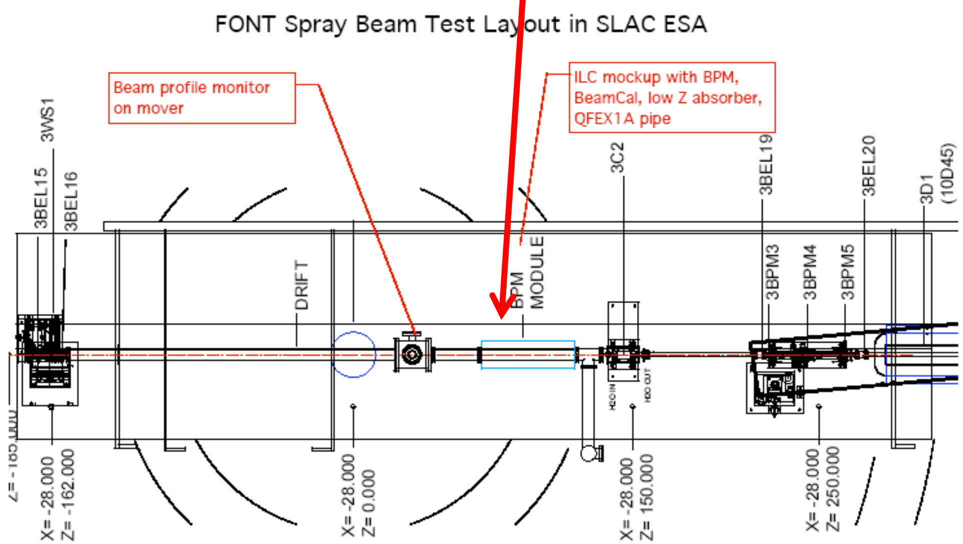
+ T-487 for longitudinal bunch profile (location tbd) using pyroelectric detectors for Smith-Purcell radiation

EM Background Environment for FB BPM



earlier version of the IR layout





- To be studied in July 2006

ILC-ESA Beam Tests. April 24 – May 8, 2006

~40 participants from 15 institutions in the UK, U.S., Germany and Japan: Birmingham, Cambridge, Daresbury, DESY, Fermilab, KEK, Lancaster, LLNL, Notre Dame, Oxford, Royal Holloway, SLAC, UC Berkeley, UC London, U. of Oregon

1. **Energy spectrometer prototypes**
   - T-474 BPM spectrometer: M. Hildreth (Notre Dame), S. Boogert (Royal Holloway and KEK) are co-PIs
   - T-475 Synch Stripe spect.: Eric Torrence (U. Oregon) is PI
2. **Collimator wakefield studies**
   - T-480: S. Molloy (SLAC), N. Watson (Birmingham U.) co-PIs
3. **Linac BPM prototype**
   - BPM triplet – C. Adolphsen, G. Bowden, Z. Li
4. **Bunch Length diagnostics for ESA and LCLS**
   - S. Walston (LLNL) and J. Frisch, D. McCormick, M. Ross (SLAC)
5. **EMI Studies**
   - G. Bower (SLAC) + US-Japan collaboration with Y. Sugimoto (KEK)

2006 Running schedule:

i. January 5-9 commissioning run
ii. April 24 – May 8, Run 1
iii. July 7-19, Run 2

T-474, T-475 T-480, EMI and Bunch Length msmts in Run 1 and Run2. FONT-ESA (IP BPM background studies) in July

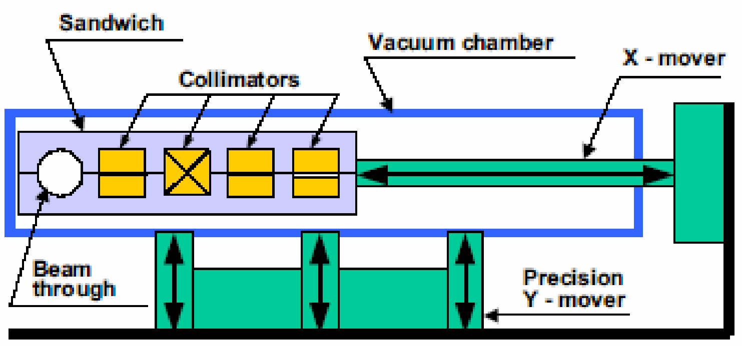
Plan for two 2-week runs in each of FY07 and FY08

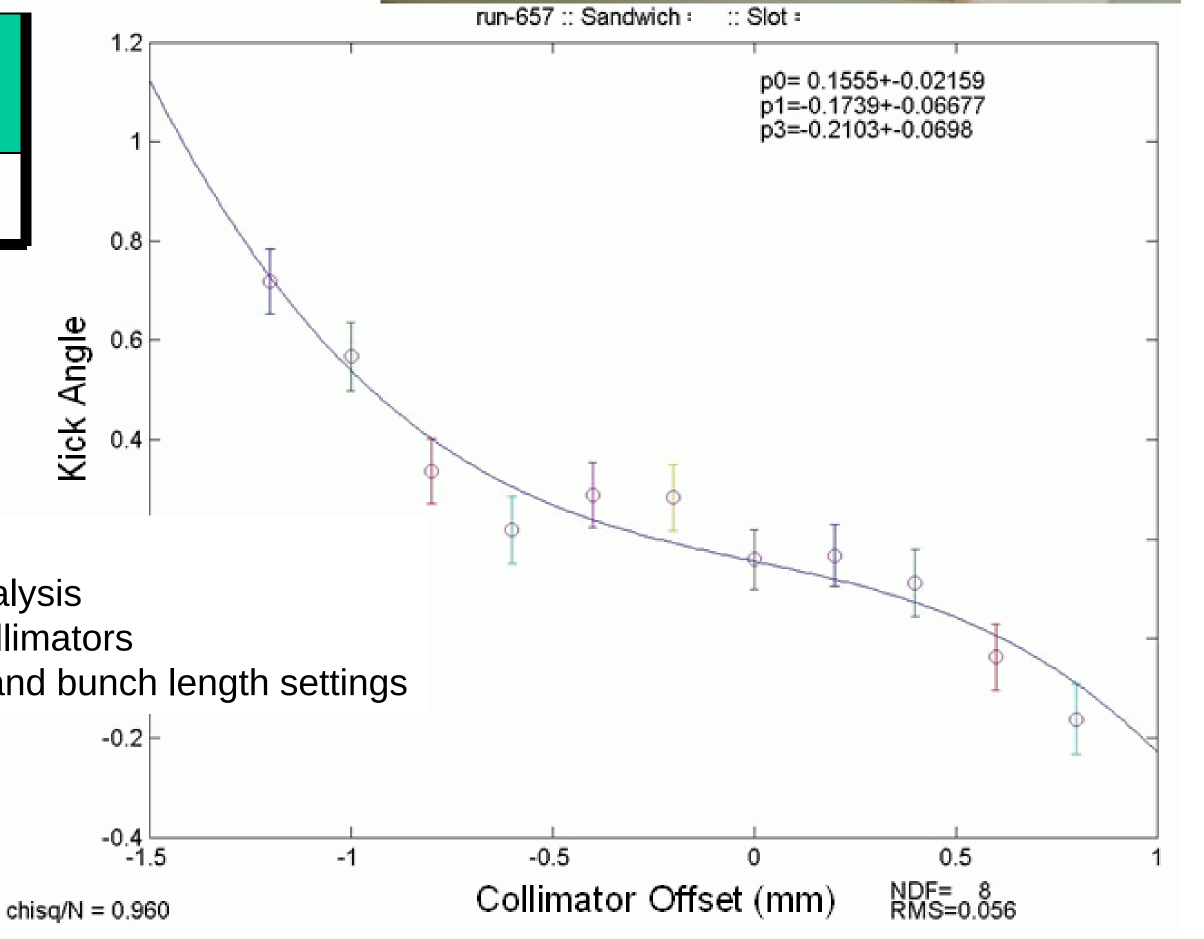
New hardware installed since January Commissioning Run was successfully commissioned:

1. 8 sets of collimators to test in collimator wakefield box (2 sets of 4)
2. 2 bpm triplets downstream of wakefield box + bpm processors
3. 2nd wire scanner downstream of wakefield box
4. 2nd 100-GHz diode bunch length detector
5. 2 EMI antennas (broadband up to 7GHz; use with 2.5GHz bandwidth scope)

ESA wakefield study

<u>First results on Collimator Wakefield Kicks</u> (Run 1 Data)





- Online results during Run 1
- Error bars will come down w/ offline analysis
- Have measurements on all 8 sets of collimators
- Took data with different bunch charge and bunch length settings

Conclusion

- BDS group at SLAC in close collaboration with Americas and worldwide efforts are proceeding with design of BDS system
- R&D of critical hardware is ongoing or planned in FY07
- Experimental facilities for critical components
  - ESA: commissioned and first tests started
  - ATF2: hardware being designed and constructed, start of operation is planned for beginning of 2008