Design of the Beam Delivery System for the International Linear Collider

Andrei Seryi, SLAC

for BDS team

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Particle Accelerator Conference 07

22nd PAC Conference • June 25 - 29, 2007 • USA

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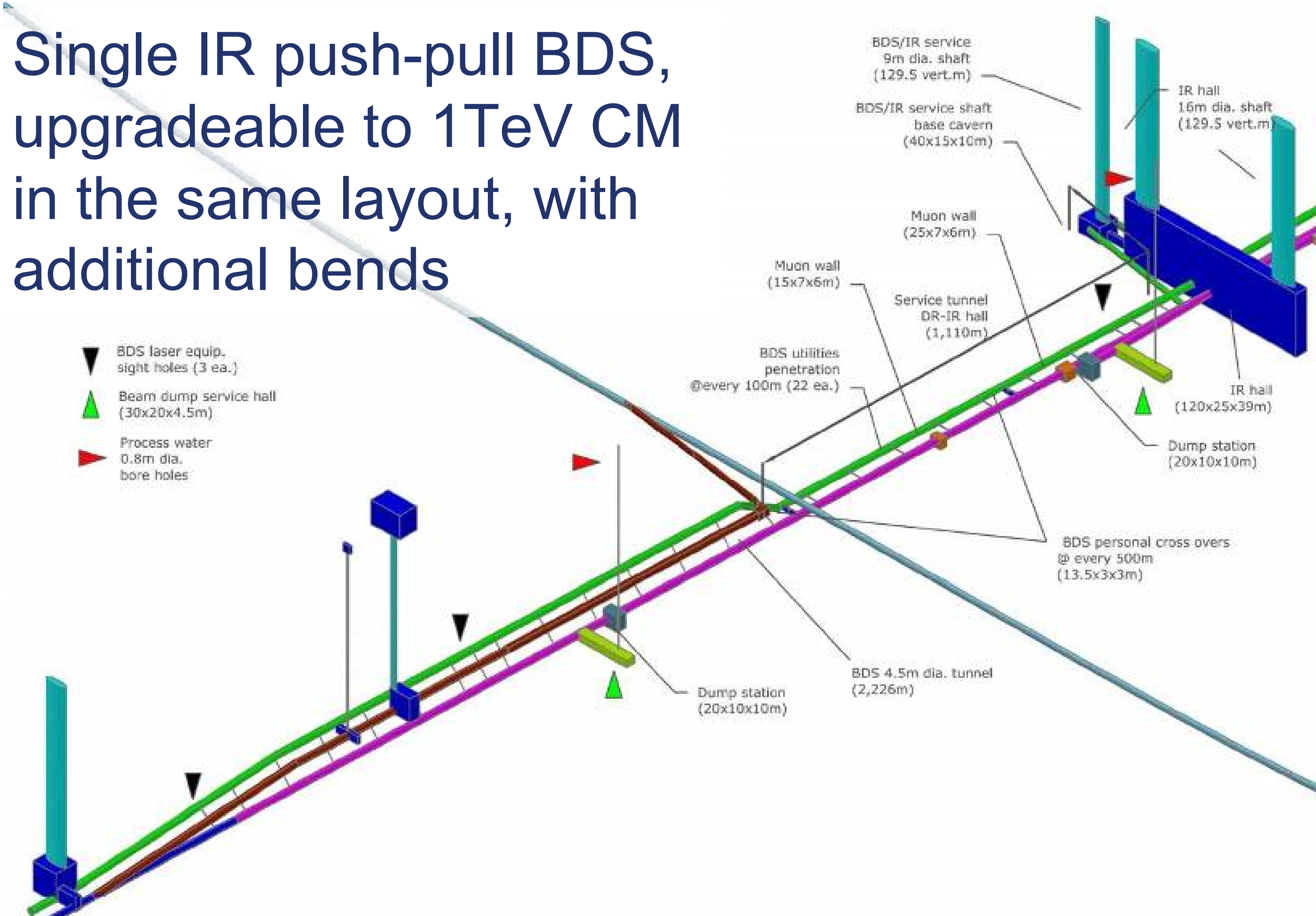
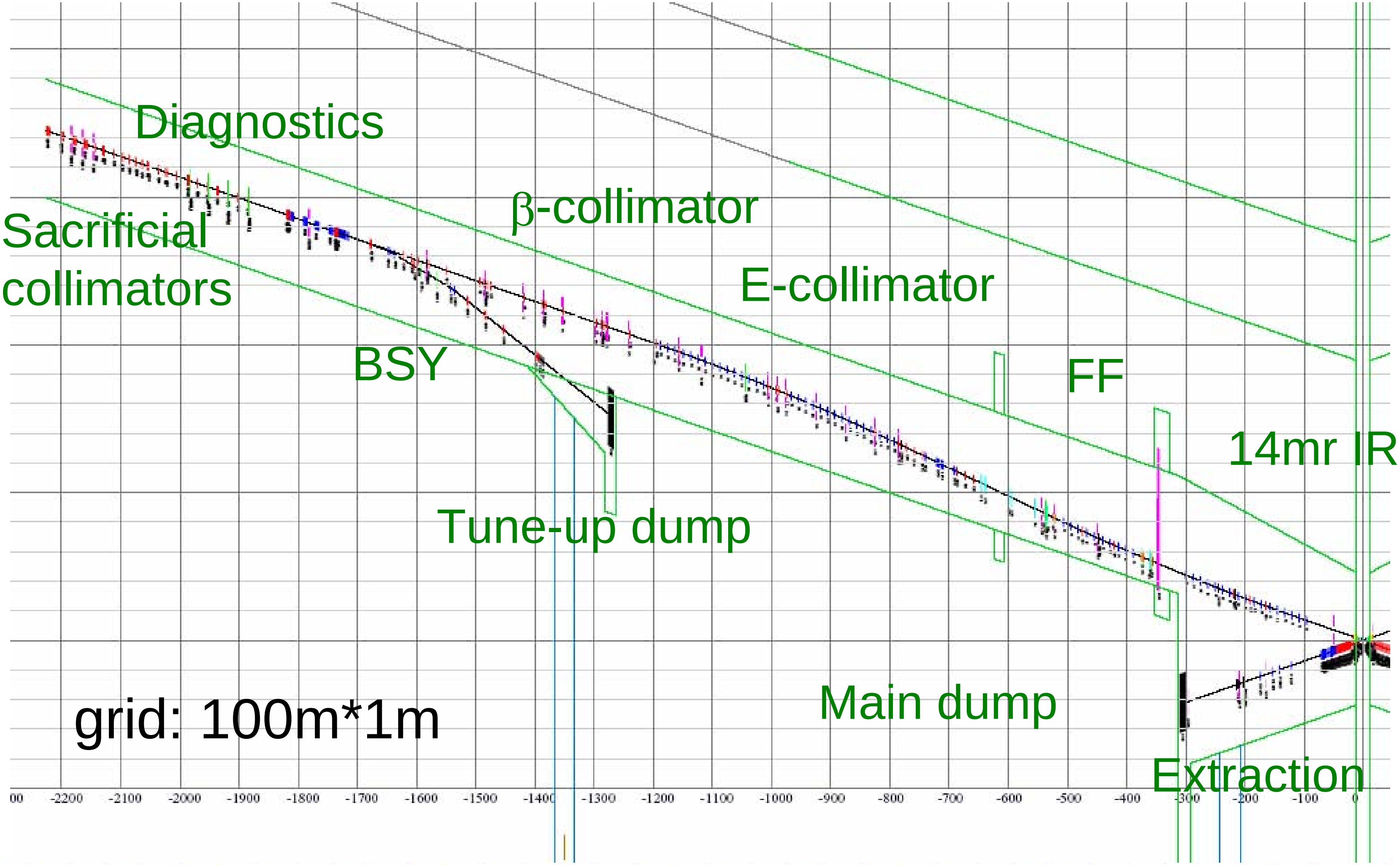
BDS layout

- Single IR push-pull BDS, upgradeable to 1TeV CM in the same layout, with additional bends

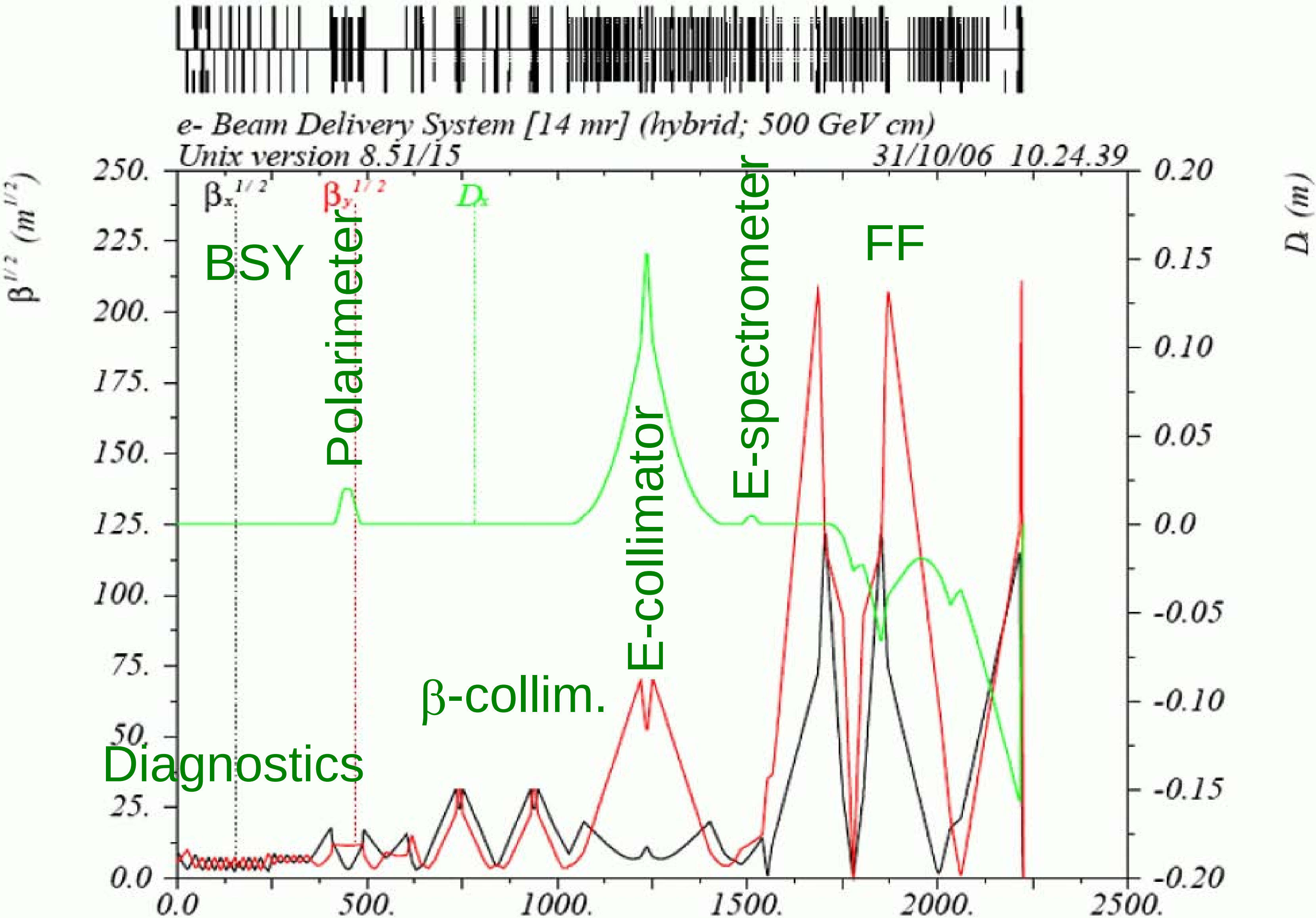


Parameter	Units	Value
Length (linac exit to IP distance)/side	m	2226
Length of main (tune-up) extraction line	m	300 (467)
Max Energy/beam (with more magnets)	GeV	250 (500)
Distance from IP to first quad, L*	m	3.5-(4.5)
Crossing angle at the IP	mrad	14
Nominal beam size at IP, σ^*, x/y	nm	639/5.7
Nominal beam divergence at IP, θ^*, x/y	μrad	32/14
Nominal beta-function at IP, β^*, x/y	mm	20/0.4
Nominal bunch length, σ_z	μm	300
Nominal disruption parameters, x/y		0.17/19.4
Nominal bunch population, N		2×10^{10}
Beam power in each beam	MW	10.8
Preferred entrance train to train jitter	σ_y	< 0.5
Preferred entrance bunch to bunch jitter	σ_y	< 0.1
Typical nominal collimation aperture, x/y		8–10/60
Vacuum pressure level, near/far from IP	nTorr	1/50

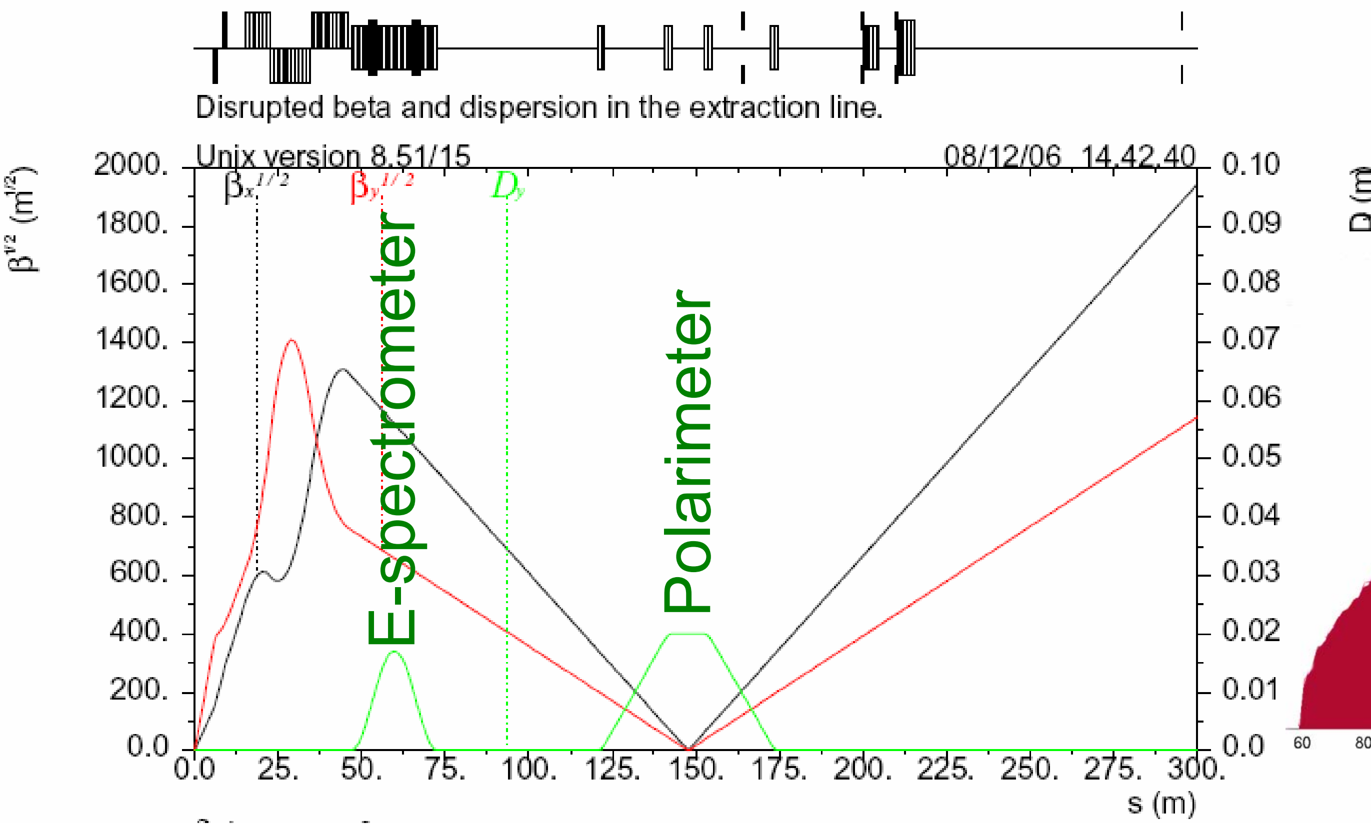
BDS beamline

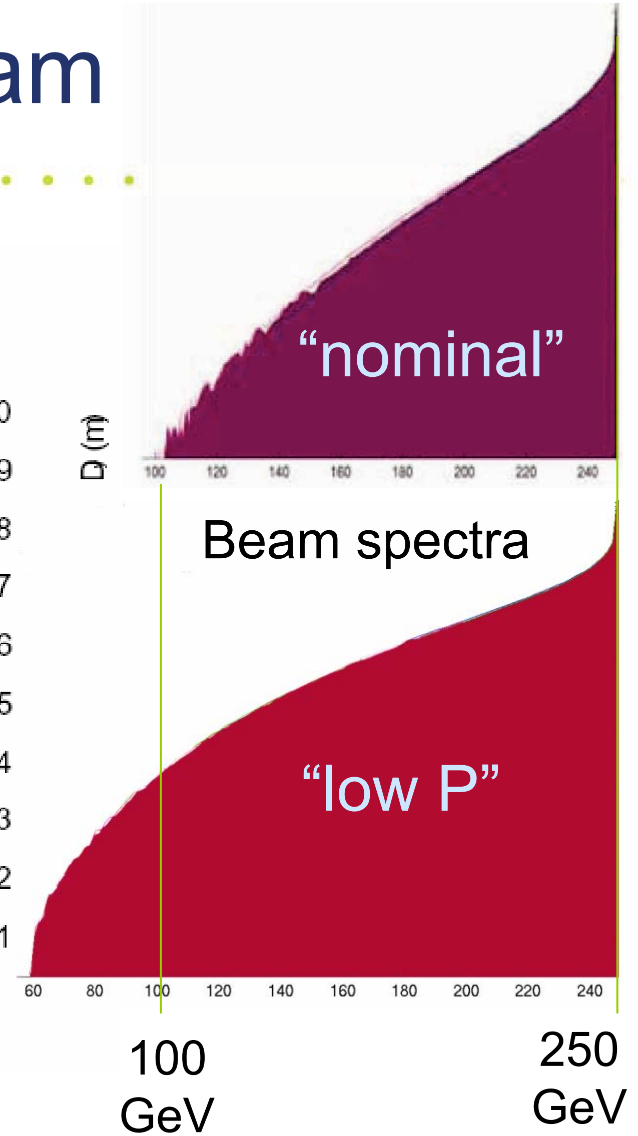


BDS optics for incoming beam



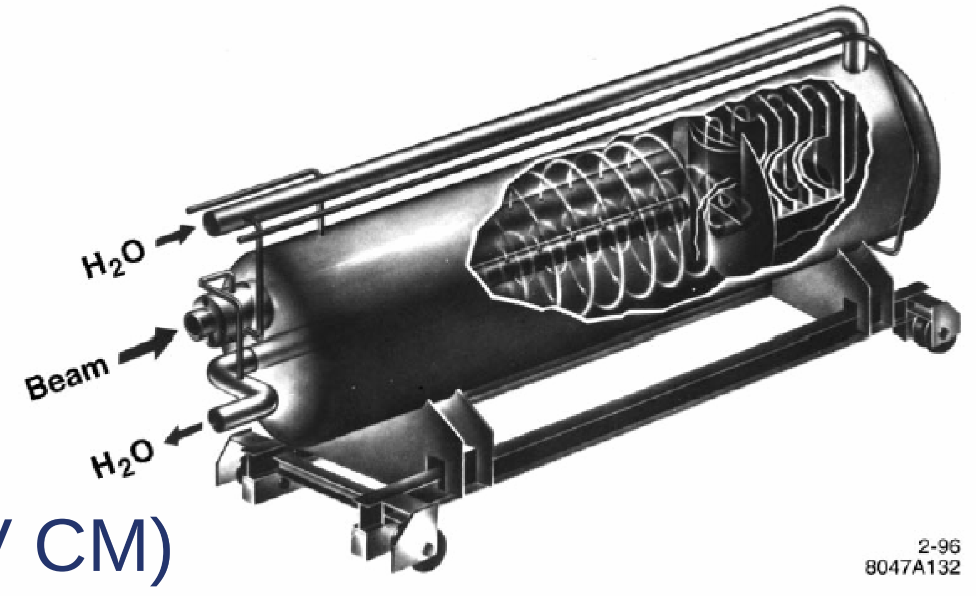
Optics for outgoing beam





Extraction optics can handle the beam with ~60% energy spread, and provides energy and polarization diagnostics

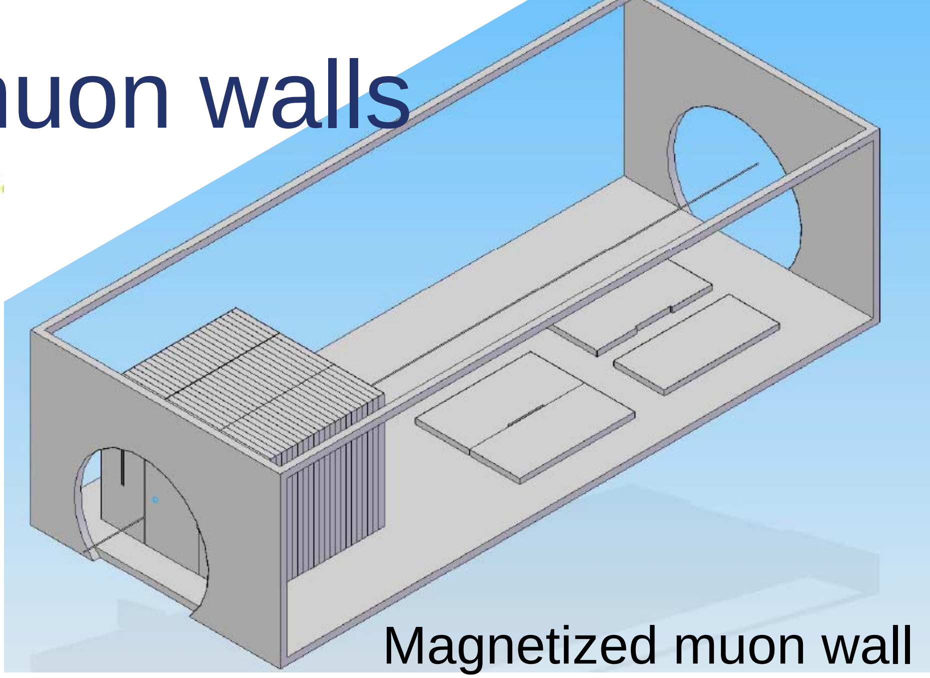
Beam dump

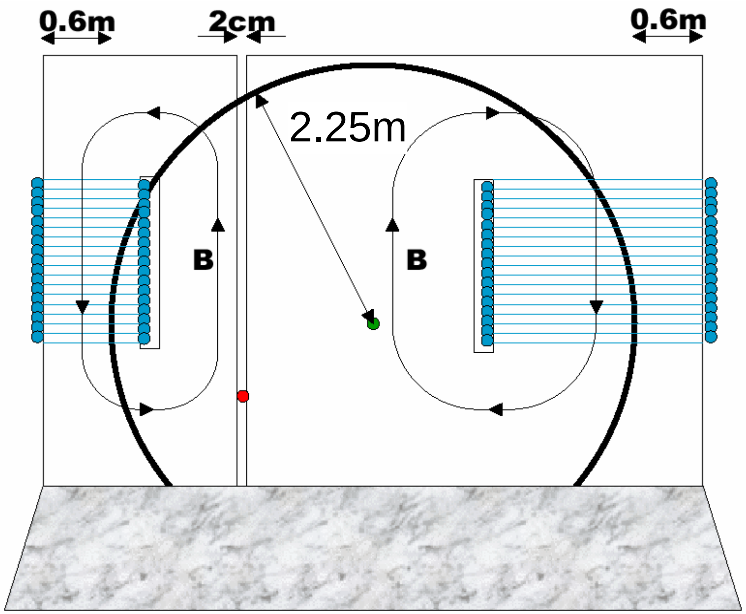


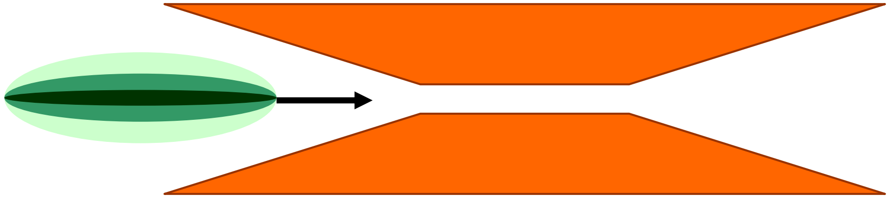
- 17MW power (for 1TeV CM)
- Rastering of the beam on 30cm double window
- 6.5m water vessel; ~1m/s flow
- 10atm pressure to prevent boiling
- Three loop water system
- Catalytic H_2-O_2 recombiner
- Filters for 7Be
- Shielding 0.5m Fe & 1.5m concrete

Collimators & muon walls

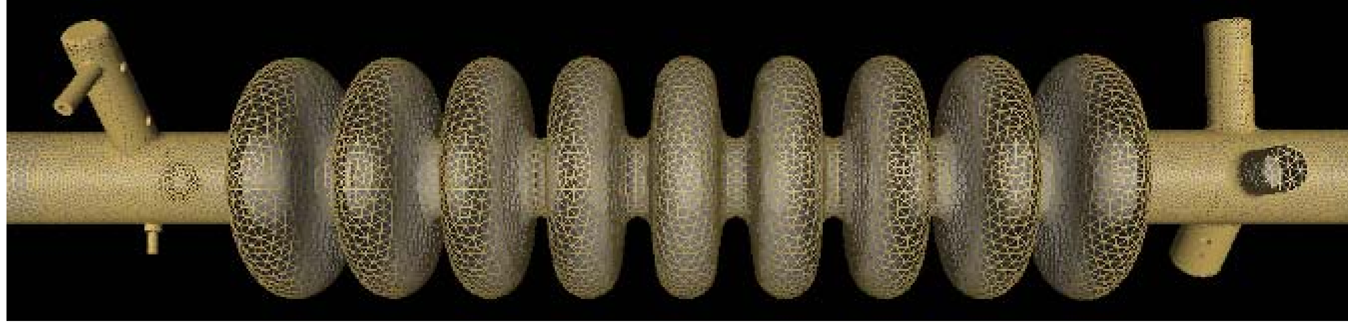
- Collimators: spoiler-absorber pairs
- In Final Doublet & IP phase
- Spoilers can survive direct hit of two bunches
- Can collimate 0.1% of the beam
- Muons are produced during collimation
- Muon walls reduce muon background in the detectors


Magnetized muon wall





Crab cavity design



FNAL 3.9GHz 9-cell cavity in Opega3p. *K.Ko, et al*

old / new
HOM coupler

WEPMS050
L. Xiao, et al
WEPMN079
G. Burt, et al

3.9GHz cavity achieved 7.5 MV/m (FNAL)

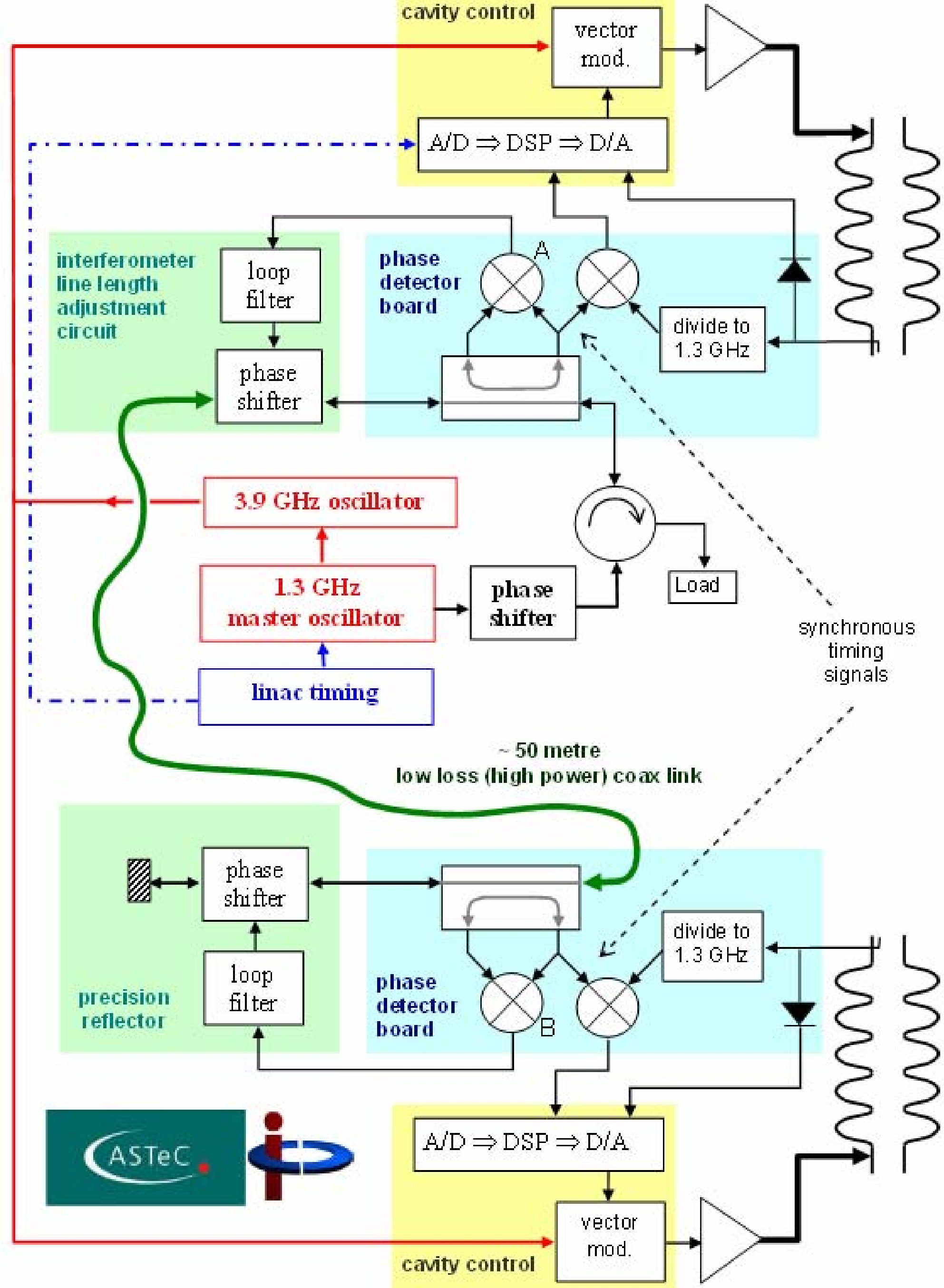
- Based on FNAL design of 3.9GHz CKM deflecting cavity
- Initial design been optimized now to match ILC requirements on damping of parasitic modes, and to improve manufacturability
- Design & prototypes been done by UK-FNAL-SLAC collaboration

Crab cavity LLRF

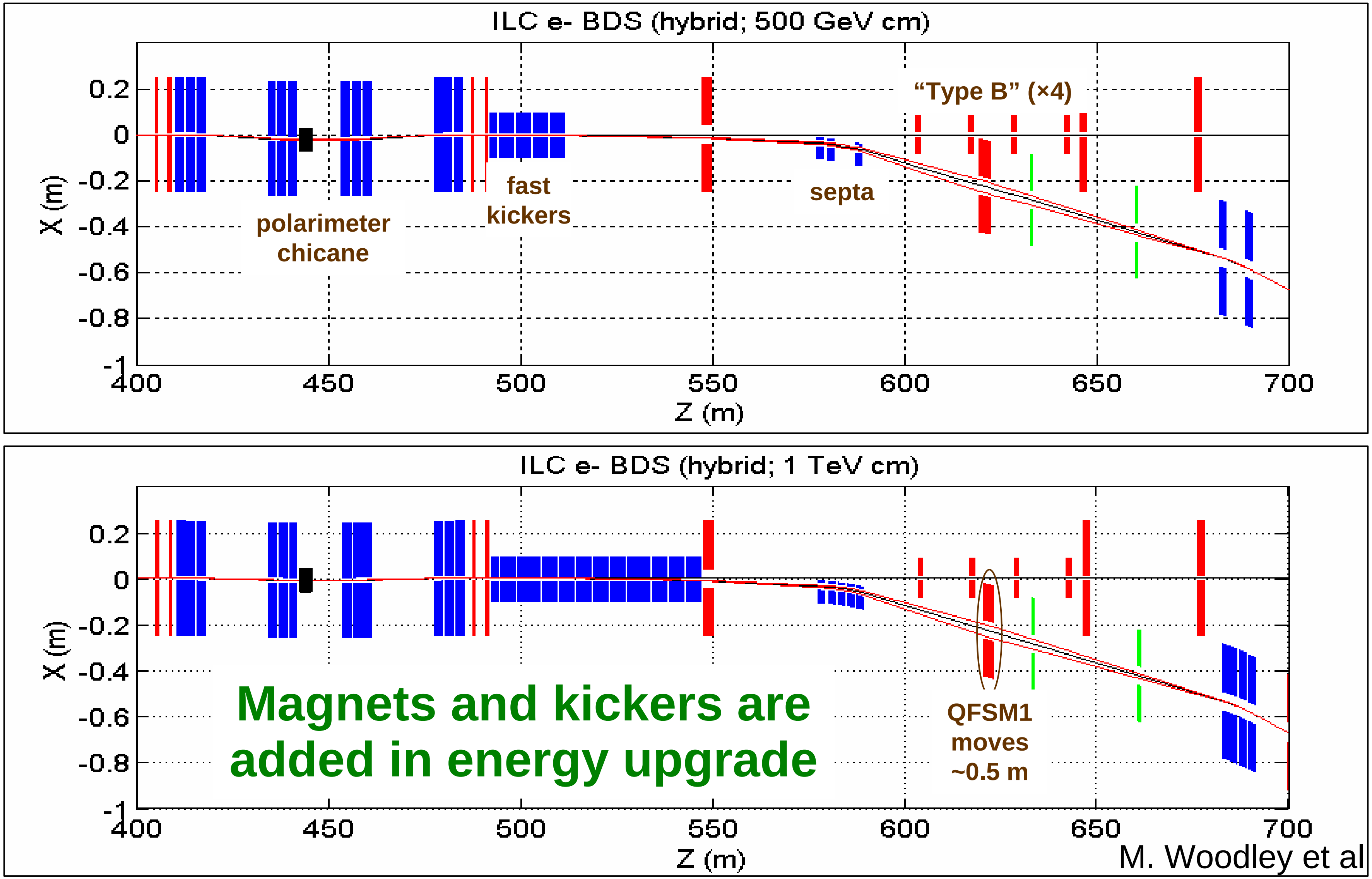
- LLRF phase and synchronization stability
- Required: ~67fsec or 0.094º for <2% luminosity loss
(7 cell 1.5GHz cavity at JLab achieved 37fsec)

- Design features: digital phase detector, RF interferometer
- Simulations predict that specs can be met

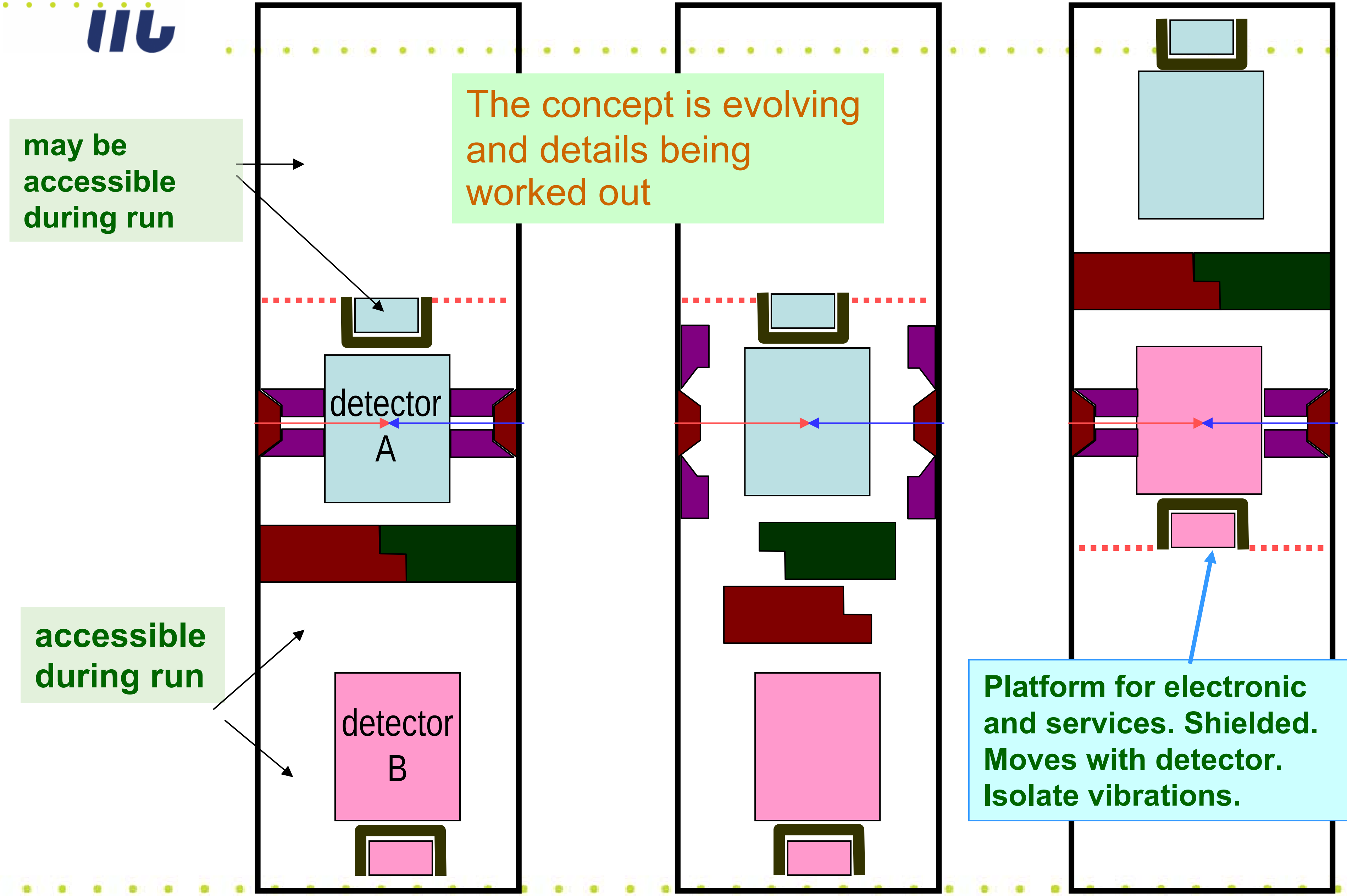
WEPMN080
G. Burt, et al



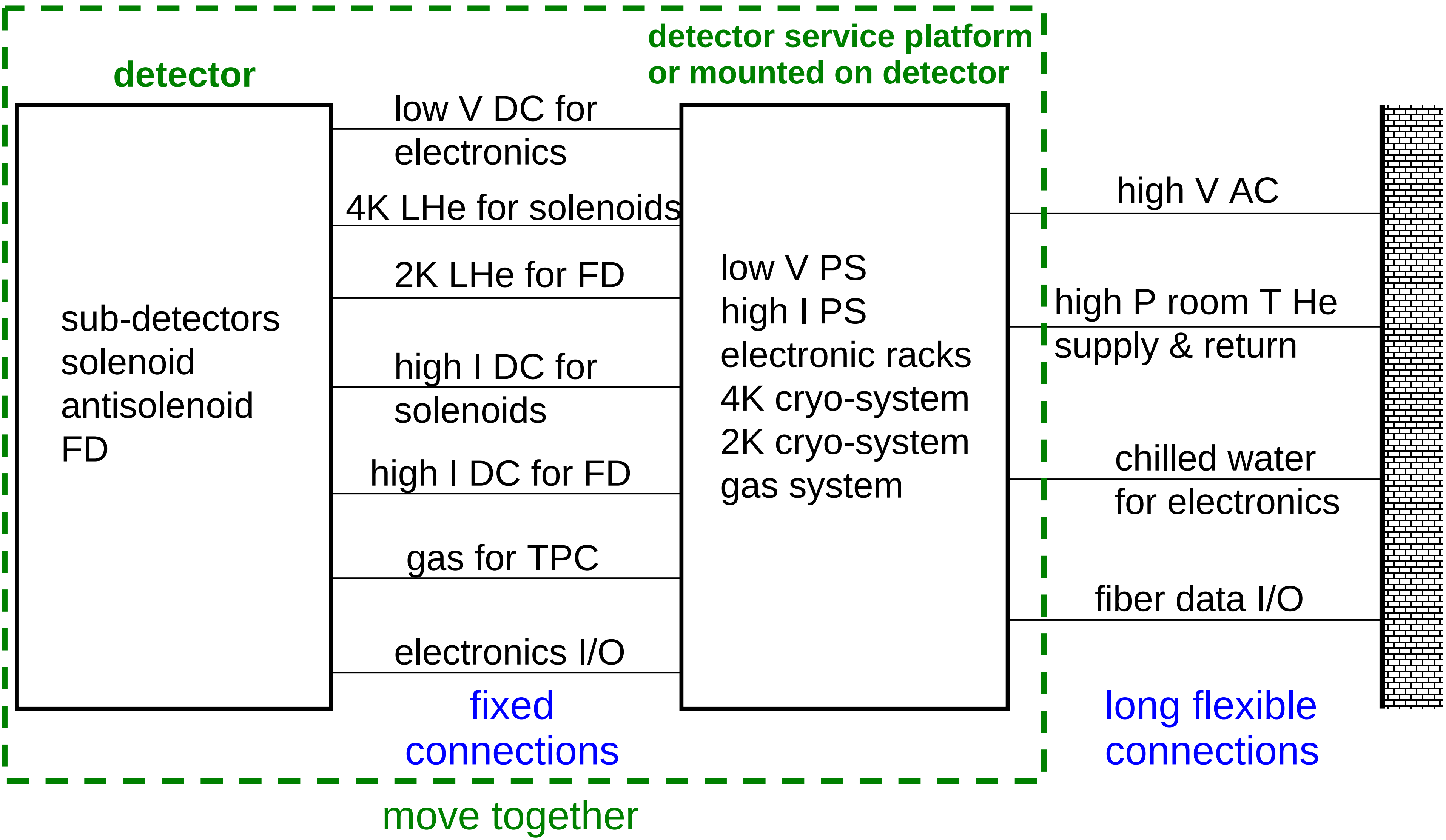
500GeV => 1TeV CM upgrade
example for BSY



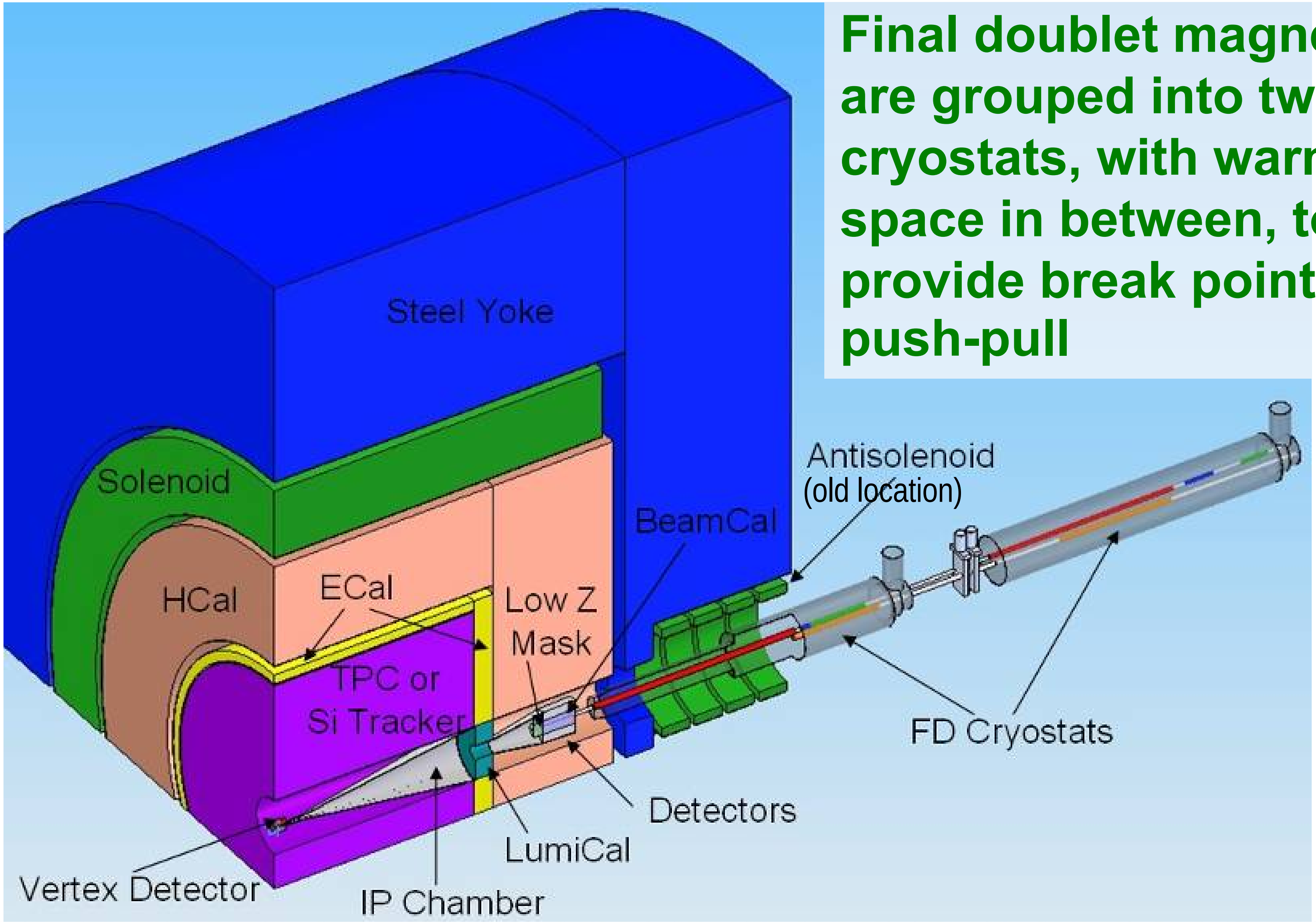
Concept of single IR with two detectors



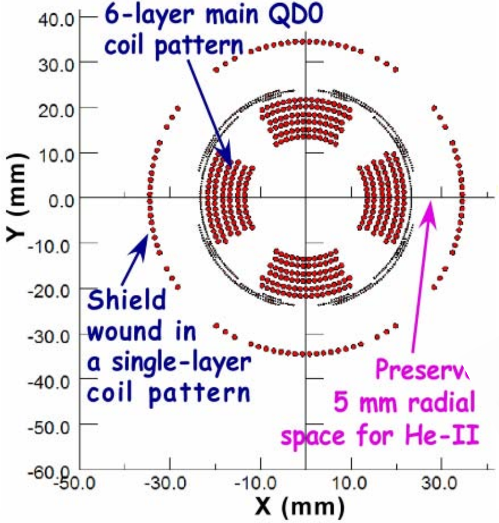
Concept of detector systems connections



IR integration

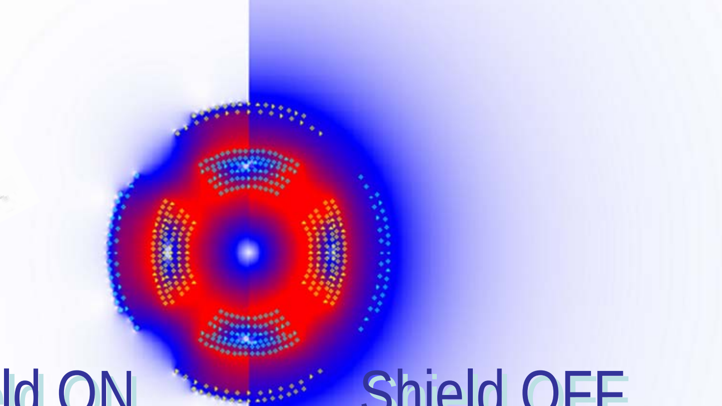


Final doublet magnets are grouped into two cryostats, with warm space in between, to provide break point for push-pull



Actively shielded QD0

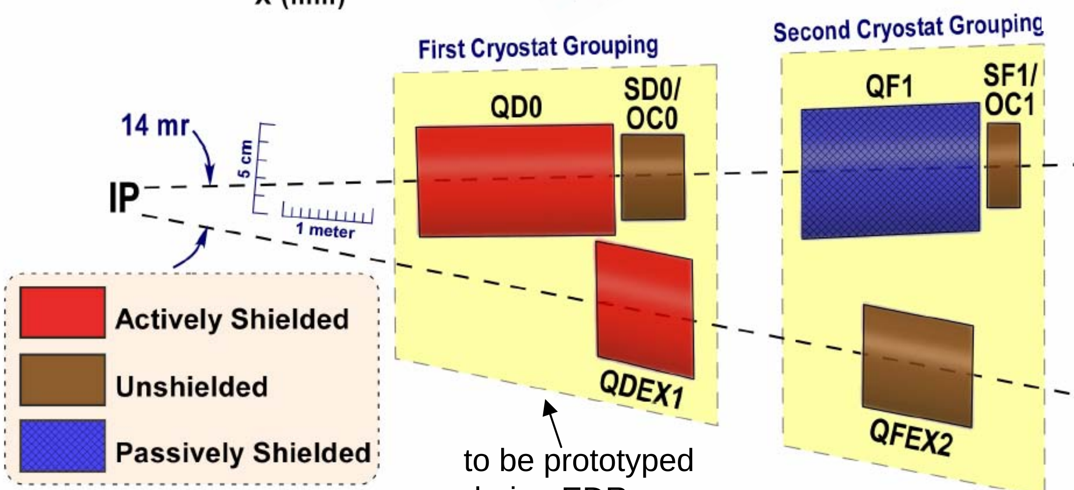
BNL



Shield ON

Shield OFF

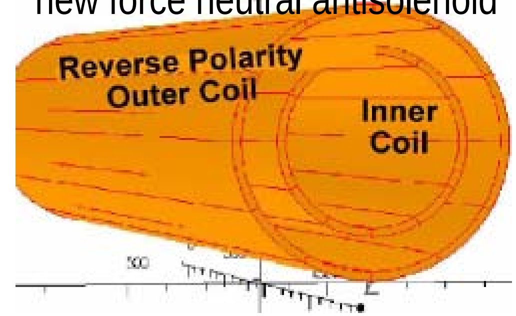
Intensity of color represents value of magnetic field



to be prototyped during EDR

Two Coils; Different Radii

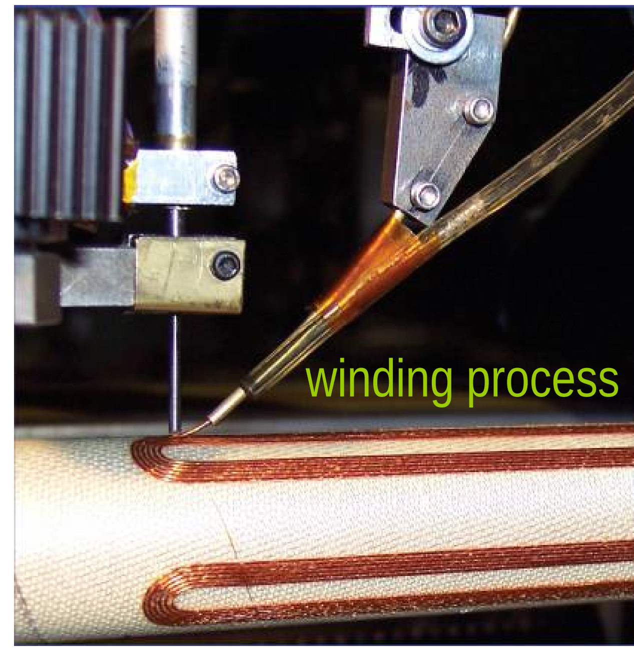
new force neutral antisolenoid

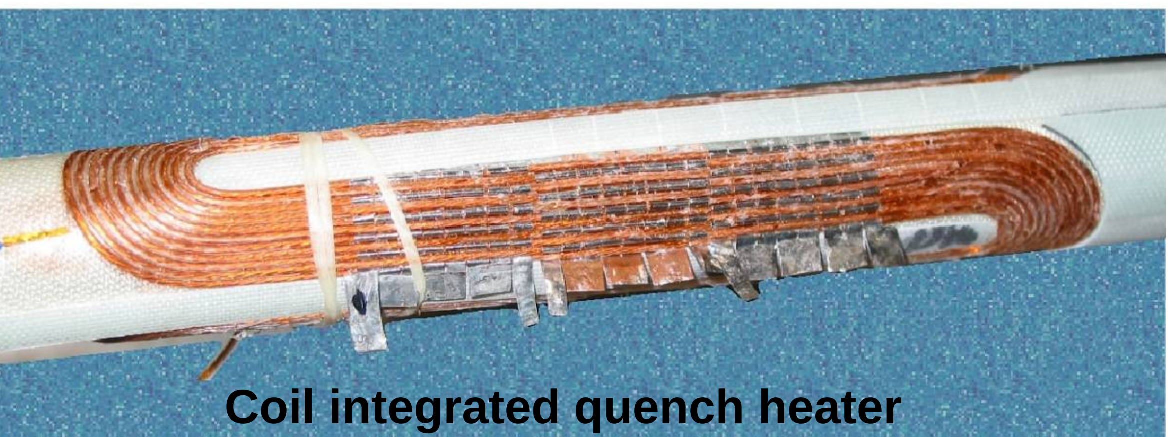


- **Interaction region uses compact self-shielding SC magnets**
- **Independent adjustment of in- & out-going beamlines**
- **Force-neutral anti-solenoid for local coupling correction**

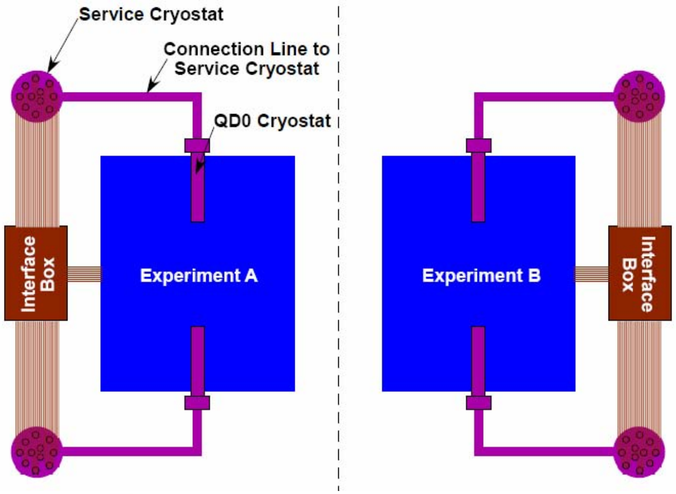
THPMS091 *Brett Parker, et al*

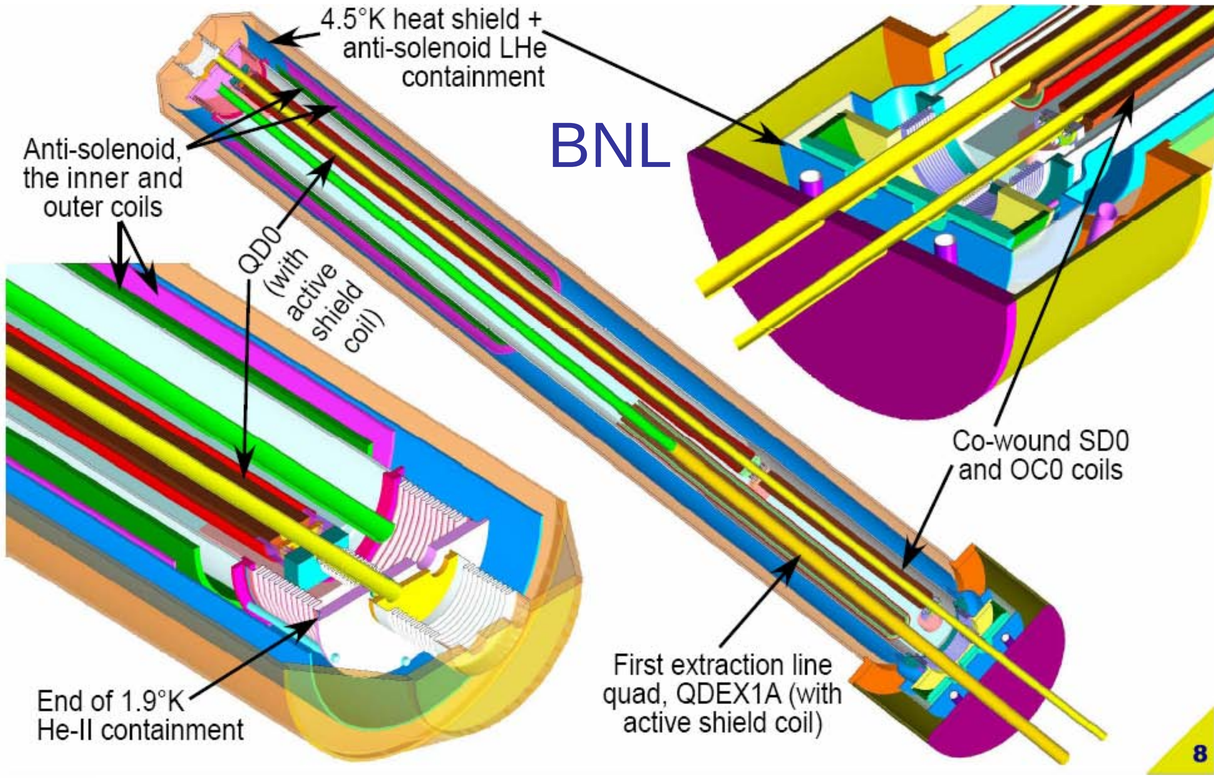
IR magnets prototypes at BNL

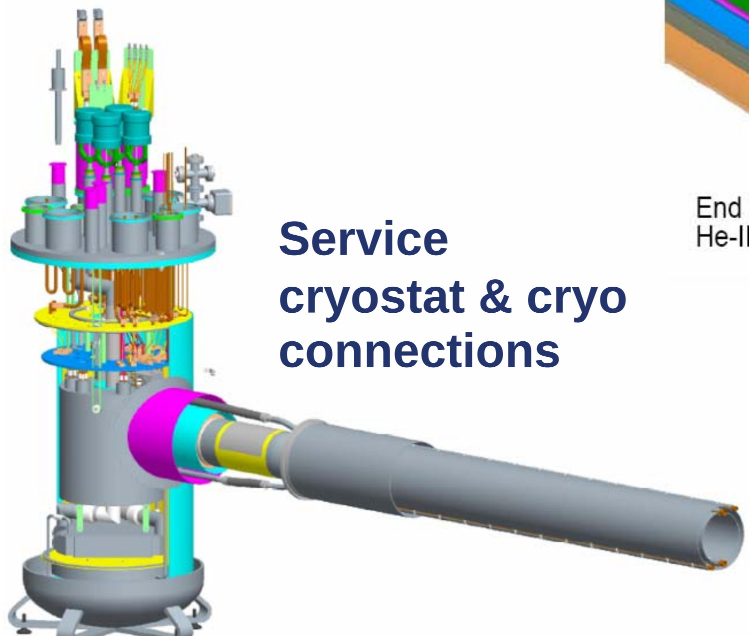




IR integration



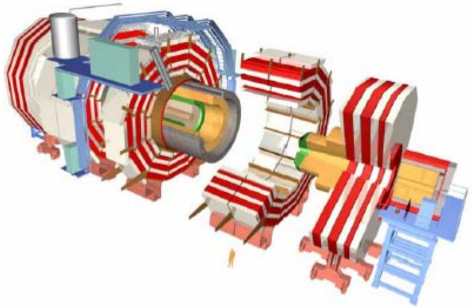


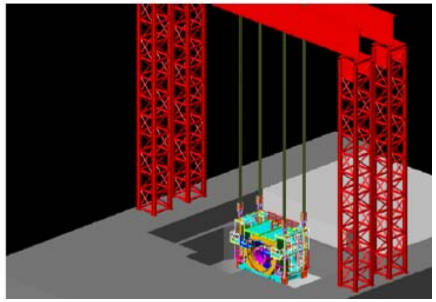


Service cryostat & cryo connections

- Detailed engineering design of IR magnets and their integration has started

Detector assembly





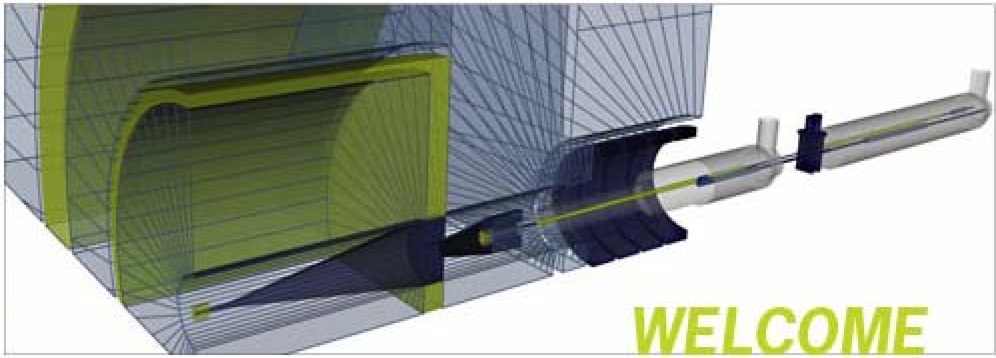
- CMS detector assembled on surface in parallel with underground work, lowered down with rented crane
- Adopted this method for ILC, to save 2-2.5 years that allows to fit into 7 years of construction

photos courtesy CERN colleagues

IRENG07 Workshop

ILC INTERACTION REGION ENGINEERING DESIGN WORKSHOP — SLAC

- Home
- Goals
- Registration
- Payment Information
- Agenda
- Organizing Committees
- The Charge to the IPAC
- Accommodations
- Travel and Directions
- Visa Information
- Social Events
- Contact



ILC Interaction Region Engineering Design Workshop

September 17-21, 2007

Stanford Linear Accelerator Center

Menlo Park, California

Please join us to review and advance the design of the subsystem of the Interaction Region of ILC, focusing in particular on their integration, engineering design and arrangements for push-pull operation.

RECENT NEWS

- **Agenda has been updated.**

REGISTRATION

Registration is necessary to participate in the workshop.
Registration fee is $30 and reception fee is $20.

→ **Register**

ACCOMMODATIONS

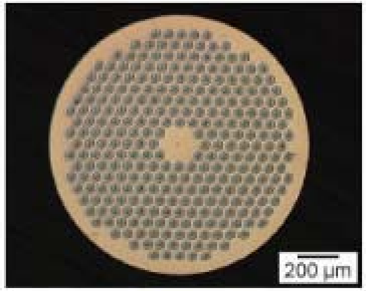
A block of 40 rooms is reserved until July 15, 2007 at the **Stanford Guest House**. Please reserve your room early and mention that you are attending this workshop.

→ **More Information**

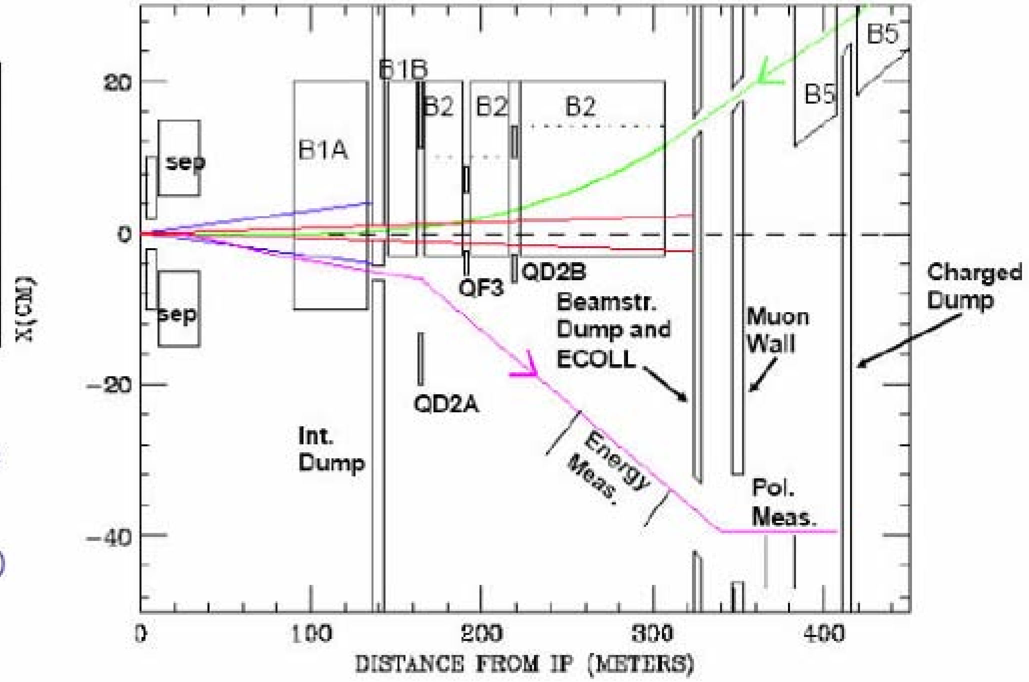
http://www-conf.slac.stanford.edu/ireng07/

IR alternatives, 0mrad

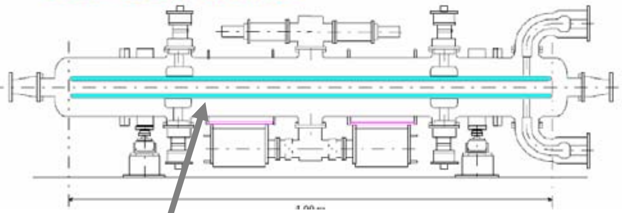
CESR separator

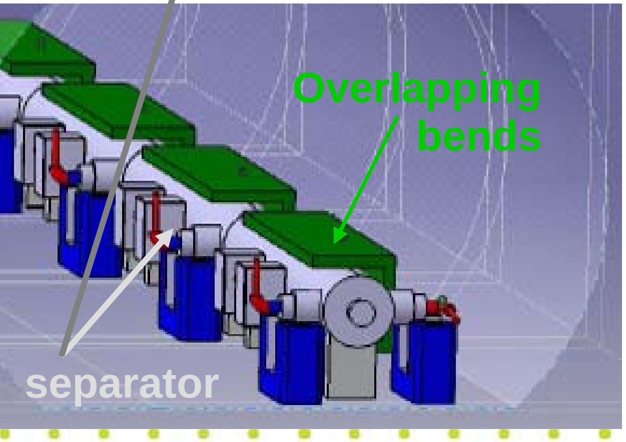


SMI/NED
(step II iteration)
1.26 mm ; 288 x 50 μm tube
1400 A (~2500 A/mm²)
@4.2 K & 12T
(measured at TEU & INFN-Mi)



LEP ZL module

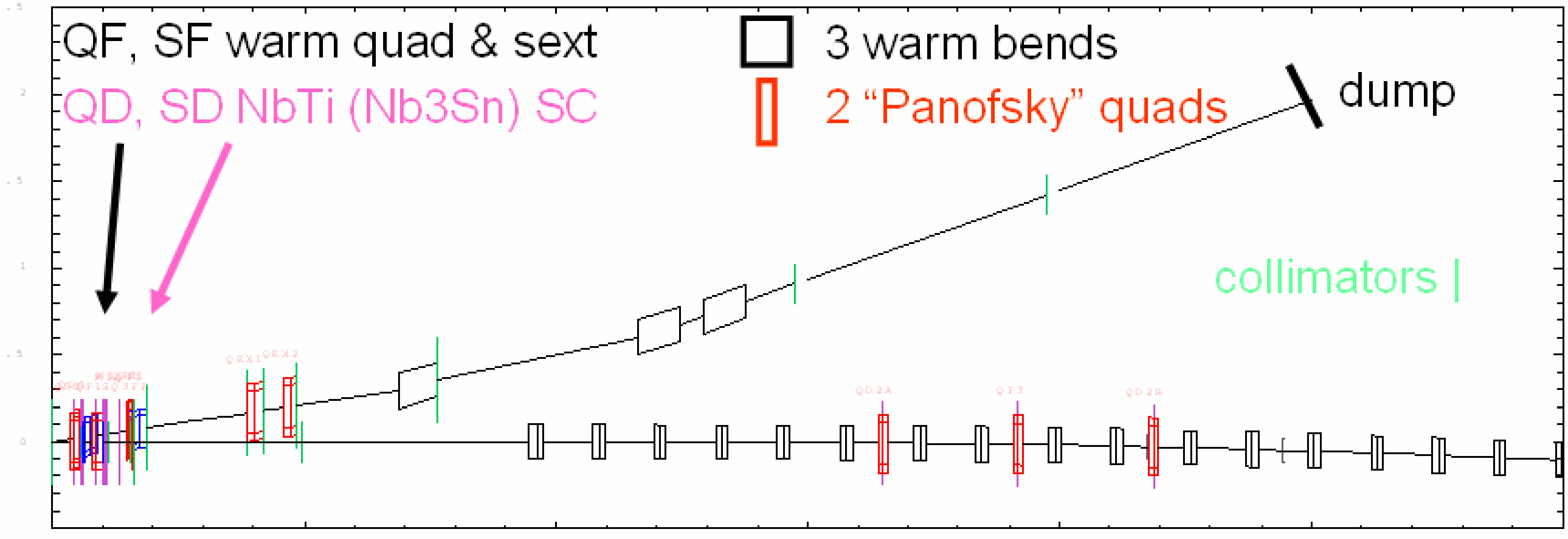




- FD: NbTi @ 500GeV CM (250T/m, 7T/bore); Nb_3Sn @ 1TeV CM (~370T/m, 10.5T/bore)
- Separator: Δ=12mm at 55m from IP (to control parasitic crossing beam-beam instability) => 2.6MV/m (±130kV over 100mm gap) & *2 at 1TeV CM), split gap, overlapped with dipole field; low spark rate is essential
- Challenges: intermediate ~1MW dump, possible back shine to detector; design of downstream diagnostics

THPMN005 *Olivier Napoly, et al*

IR alternatives, 2mrad



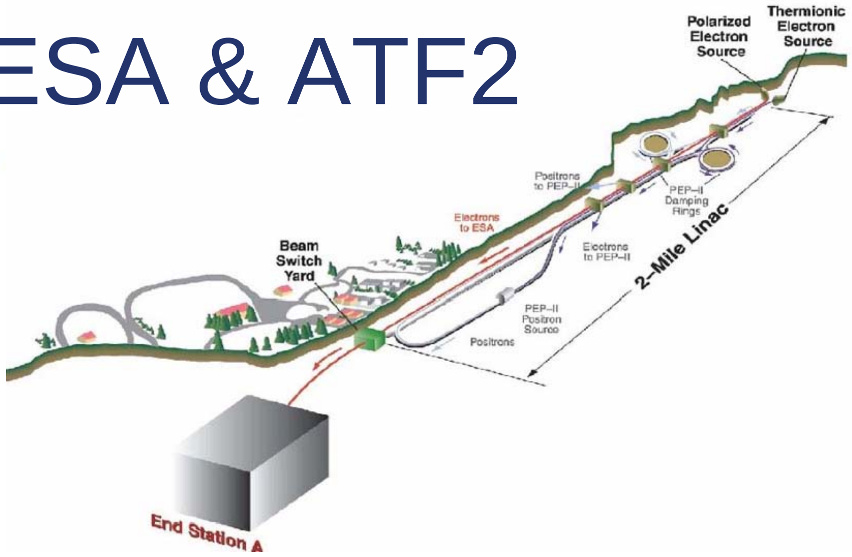
- Focus of latest optics work: trying to design minimal system, shortest, most economical, without downstream diagnostics (added later if new ideas found)
- FD reoptimized with new ILC parameters: SC QD0/SD0 &warm QF1/SF1
- FD is NbTi at 500GeV CM (225T/m, 6.3T/bore) and Nb_3Sn at 1 TeV CM (350T/m, 8.8T/bore)
- Beamline downstream of FD to be designed & studied. Study feasibility of downstream diagnostics, study beam & SR losses and evaluate backscattered background

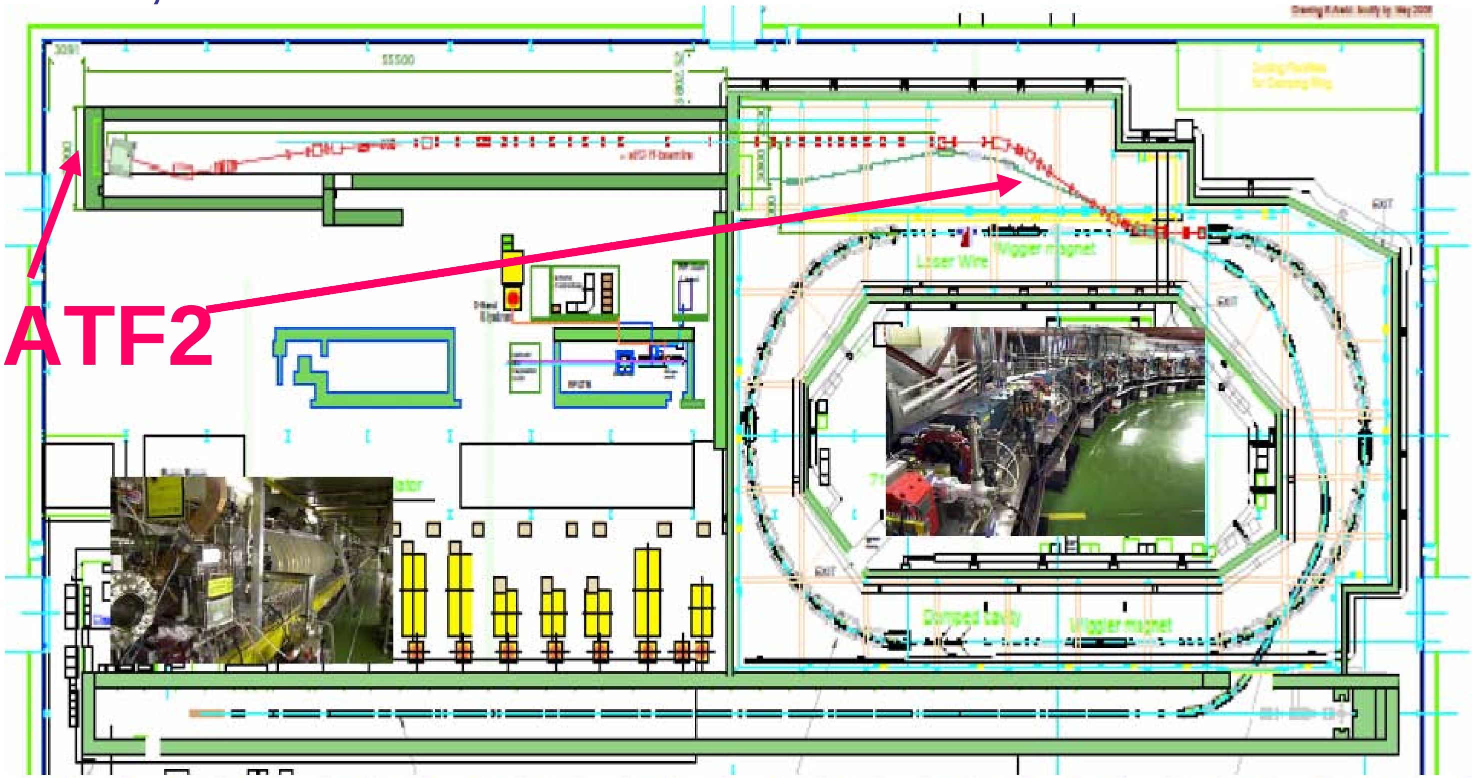
THPMN077 *Robert Appleby, et al*

Test facilities: ESA & ATF2

ESA: machine-detector tests; energy spectrometer; collimator wake-fields, etc.

ATF2: prototype FF, develop tuning, diagnostics, etc.





Summary

- Beam delivery system for ILC has been designed
- R&D and prototyping for critical subsystems is ongoing
- Detailed engineering design of BDS subsystems is starting