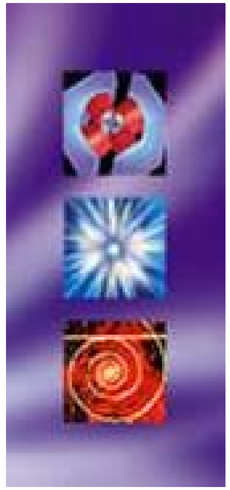
Small crossing angle designs for the ILC

Deepa Angal-Kalinin
Daresbury Laboratory, UK



Task Groups

2mrad : recent contributors

R.Appleby, D.Angal-Kalinin, F.Jackson, D.Toprek (CI)

P.Bambade, S.Cavalier, O.Dadoun, M.Lacroix, F.Touze, G.Le Meur (LAL)

Y. Iwashita (Kyoto)

Head-on

O. Napoly, O. Delferrière, M. Durante, J. Payet, C. Rippon, D. Uriot (CEA)

B. Balhan, J. Borburgh, B. Goddard (CERN)

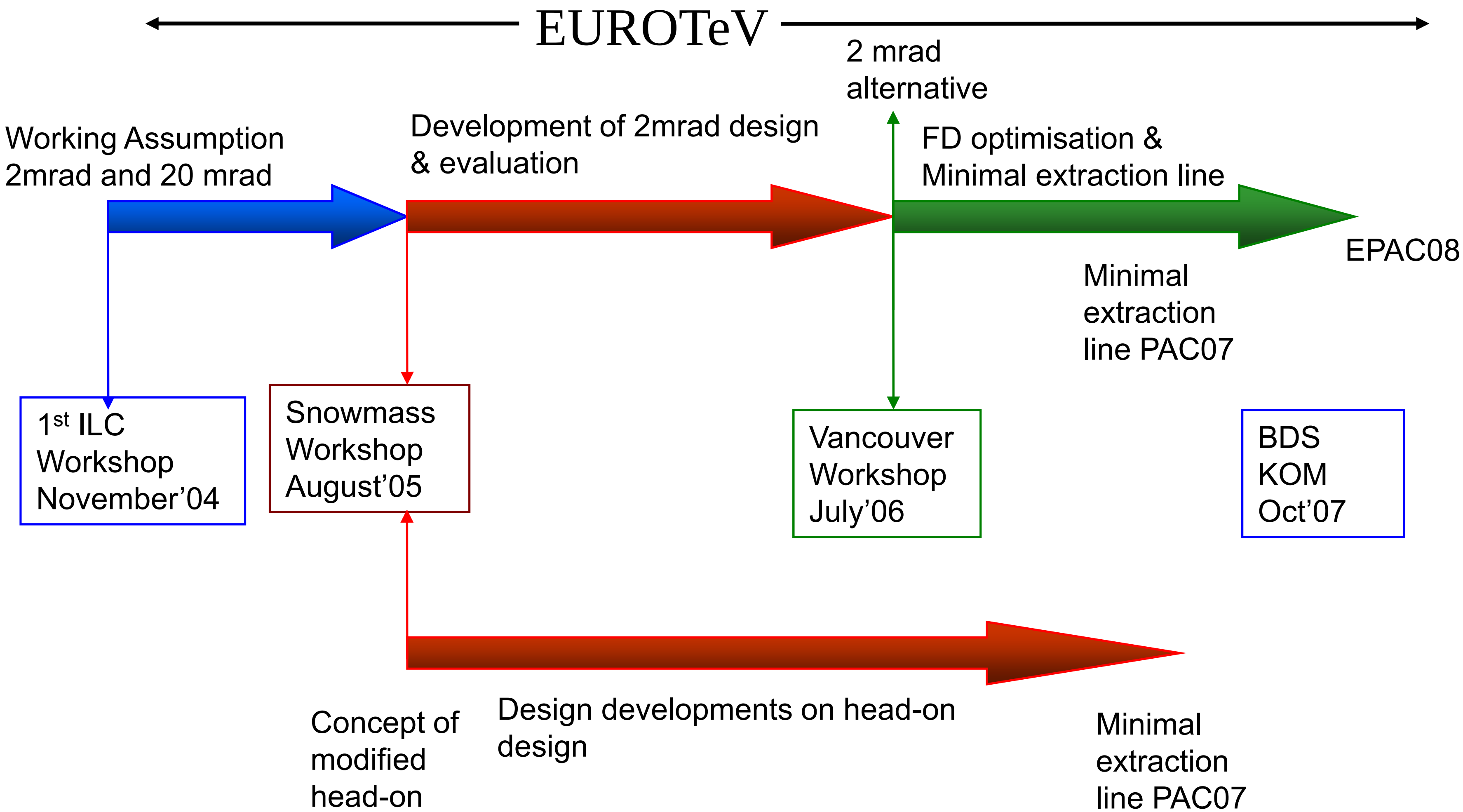
P. Bambade, J. Brossard, O. Dadoun (LAL)

L. Keller (SLAC), G. Sabbi (LBNL)

D. Angal-Kalinin, F. Jackson, R. Appleby (CI)

S. Kuroda (KEK), Y. Iwashita (Kyoto)

Recap


EUROTeV
2 mrad alternative
Working Assumption 2mrad and 20 mrad
Development of 2mrad design & evaluation
FD optimisation & Minimal extraction line
EPAC08
Minimal extraction line PAC07
1st ILC Workshop November'04
Snowmass Workshop August'05
Vancouver Workshop July'06
BDS KOM Oct'07
Concept of modified head-on
Design developments on head-on design
Minimal extraction line PAC07

Motivation for small/zero crossing angle configurations

Focusing and colliding easier

No pre-IP constraints

- Crab-cavity control & tuning
- Non-axial solenoid + DID / anti-DID ➔ pre / post-IP trajectory bumps

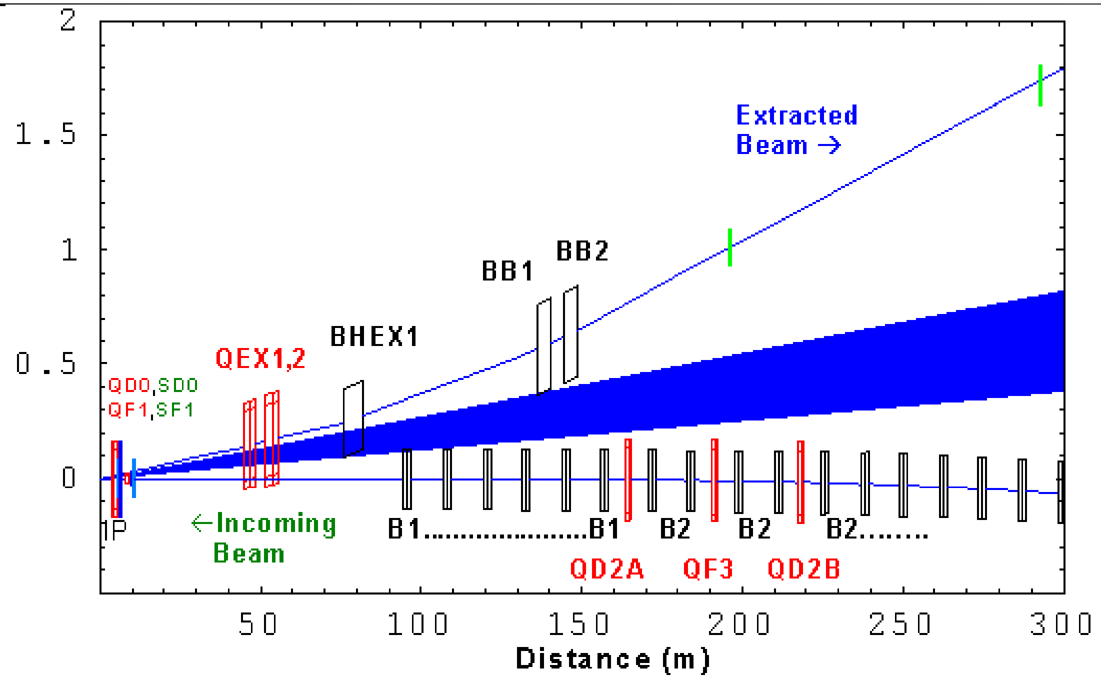
Physics & detector advantaged

- Simpler forward geometries
- Better hermeticity
- No DID / anti-DID

Extraction more difficult

- Dispersion of the low energy tails
- Challenging beam usage and transport to the dump

Latest status : 2 mrad design



EUROTeV Reports : 2006-022, 2008-034

EUROTeV Memos :2007-001, 2007-004, 2007-005

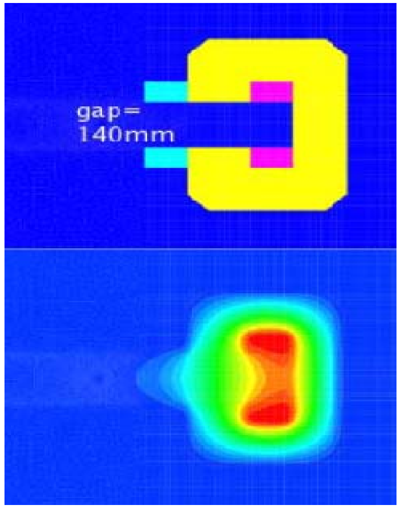
BDS KOM meeting
http://ilcagenda.linearcollider.org/materialDisplay.py?contribId=24&sessionId=8&materialId=slides&confId=1860

Sendai GDE meeting
http://ilcagenda.linearcollider.org/contributionDisplay.py?contribId=109&sessionId=9&confId=2432

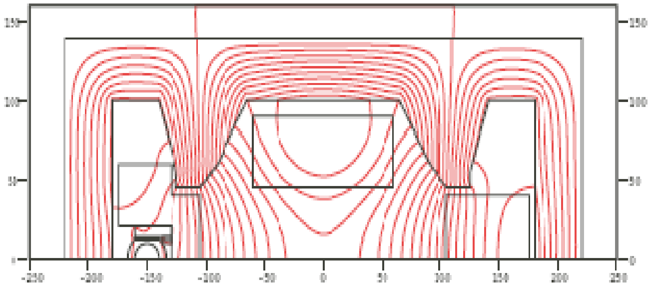
- Minimum extraction line with optimised final doublet, reasonable extraction magnet parameters and acceptable losses on dedicated collimators, for all parameter sets.
- Can be adjusted depending on best choice of dump arrangement
- Designs available for extraction line magnets (SD0 to be checked)
- Optimised final focus design including the fields from extraction magnets
- Downstream polarimetry and energy measurements are not included
- Exploring other diagnostics tools for monitoring the disrupted beam

Magnet designs : 2 mrad

BHEX1

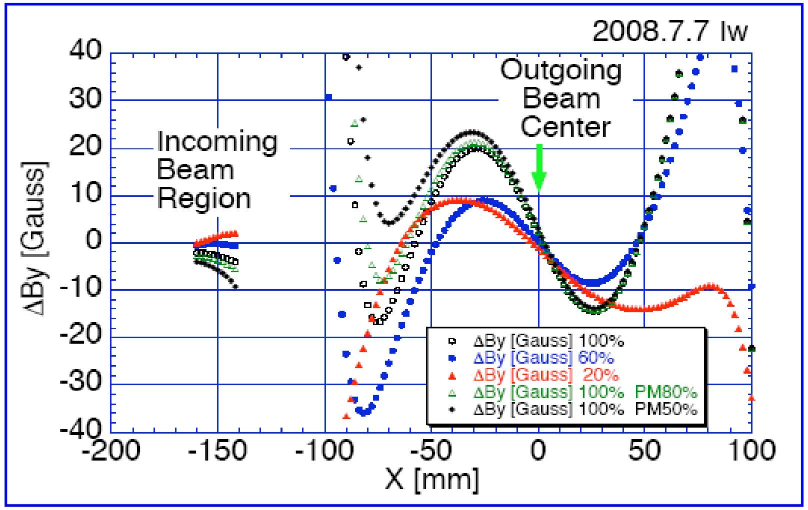


QEX1



Width = 200mm, h=85mm,
G>7.5T/m

QEX1



- C-shaped dipole : l=6m, h=70mm, B=0.278T
- Separation from the incoming beam centre : 27 cm
- Sufficient gap for beamstrahlung photons
- Strong quadrupole component seen by the incoming beam – need to absorb in the final focus optics (or shield magnetically)

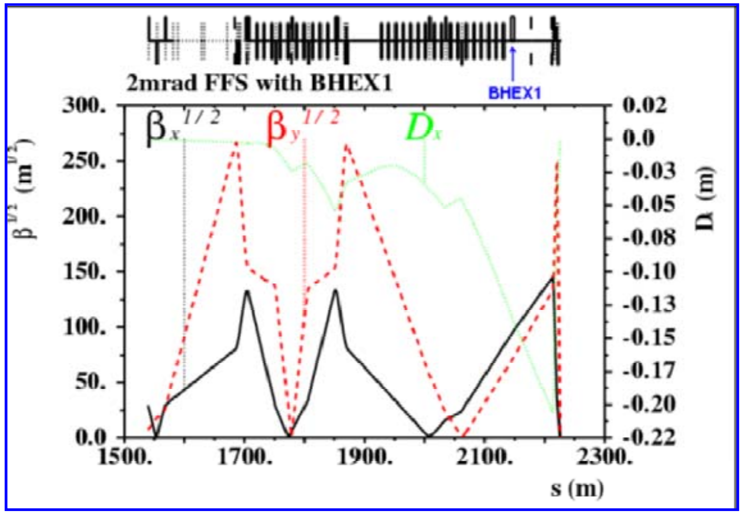
- Field at incoming beam location (-150 mm) should be less than 10G
- Demagnetization of the PMs?
- 50% demagnetization (PM50%) – incoming beam centre <6G
- need the radiation doze on the magnets for evaluation of the demagnetization.

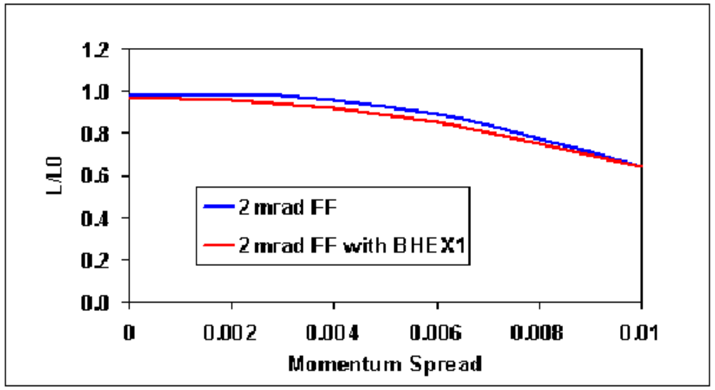
S. Cavalier, F. Touze, G. Le Meur

Y. Iwashita

Final focus optimisation

- The final focus has been re-optimised for 2mrad FD parameters and to absorb the BHEX1 quadrupole component by:
  - adjusting the final doublet to obtain beam waists at the interaction point
  - adjusting QD2B and QF3 to obtain pseudo '– I' transform between the sextupoles SD4 and SD0
  - adjusting the soft dipoles in the final focus to obtain dispersion matching
- Cancellation of chromatic and geometric aberrations by optimising the sextupoles

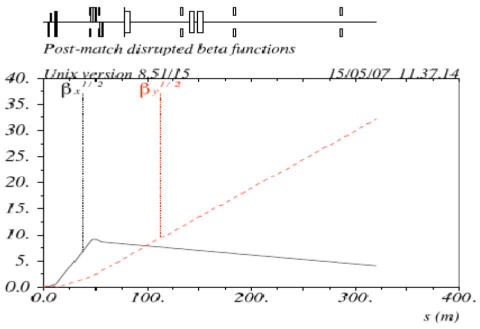


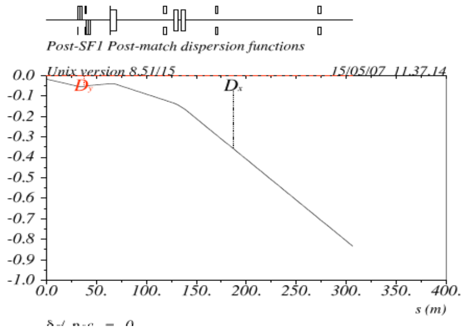


Spent beam diagnostics

Spent beam disruption and beamstrahlung low-energy tail varies strongly with IP beam offsets & sizes → allows useful diagnostic by measuring the beam loss profile at high-β / high-η points in the extraction line (e.g. at QEX1 protection collimator…)

- σ_x reduction → low-energy tail ↗
- Δ_x offset → low-energy tail ↘ & creates horizontal asymmetry
- σ_y reduction → vertical disruption angle ↗ symmetrically
- Δ_y offset → low-energy tail ↗ & creates vertical asymmetry





Exploratory study under way → will be reported as part of ILPS/PCDL deliverable

Ideas exist to instrument protection collimators

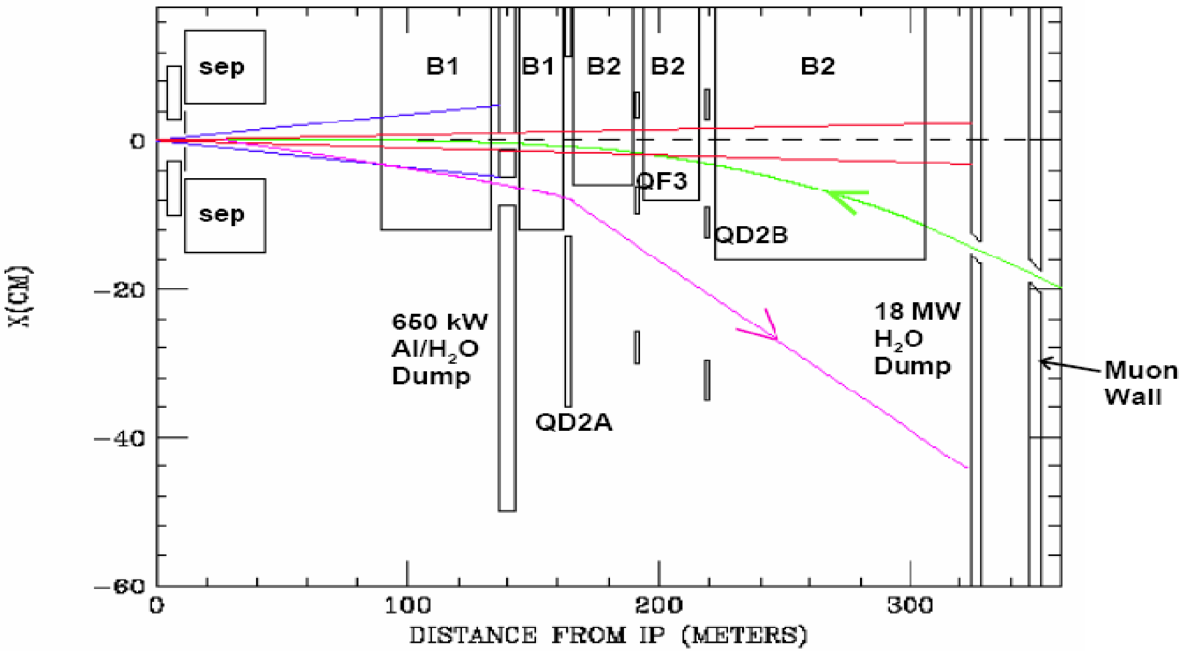
1) Compton beam loss monitor
J. Steijger, NIKHEF 2000-037

2) Secondary emission monitor
M. Bernard et al., EPAC96

Counts (Compton…) shower particles at distant absorber

SEM current from W wire or Ti strips collected directly or behind on biased multi-grid

Modified head-on scheme



EUROTeV Reports : 2006-083, 2007-043, 2007-052

BDS KOM meeting
http://ilcagenda.linearcollider.org/materialDisplay.py?contribId=23&sessionId=8&materialId=slides&confId=1860

- Feasibility of beamline elements:
- Large aperture SC quadrupole and sextupole doublets
- Electrostatic separators
- High power collimators
- Extraction quadrupoles
- Final focus : L*= 4 - 6m
- Parasitic crossing
- Intermediate beam dump

Separator specifications

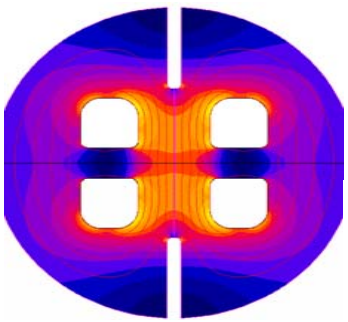
Beam-beam instability from parasitic crossings is under control when :

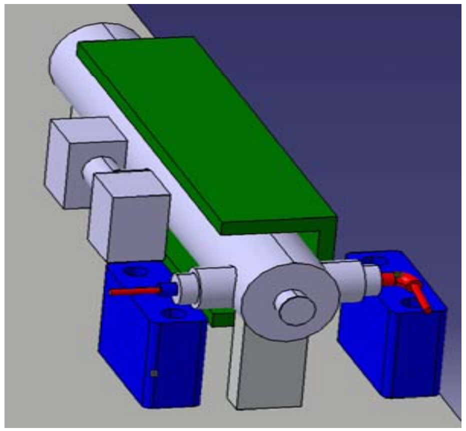
- Horizontal transverse separation is larger than 11 mm, and
- R34(IP → 1st PIP) < β*1/2 x 100 m1/2

The total deflection provided by separator of 252 µrad is :

•12mm separation at 55 m from IP & 70 mm at QD2A

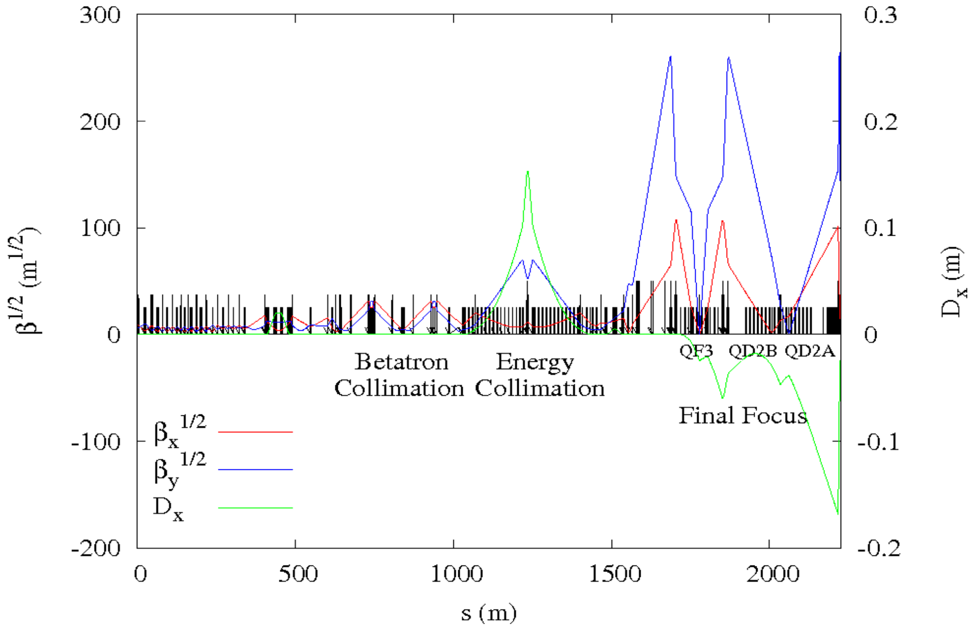
(1st separator electrode starts at 11.314 m from IP)



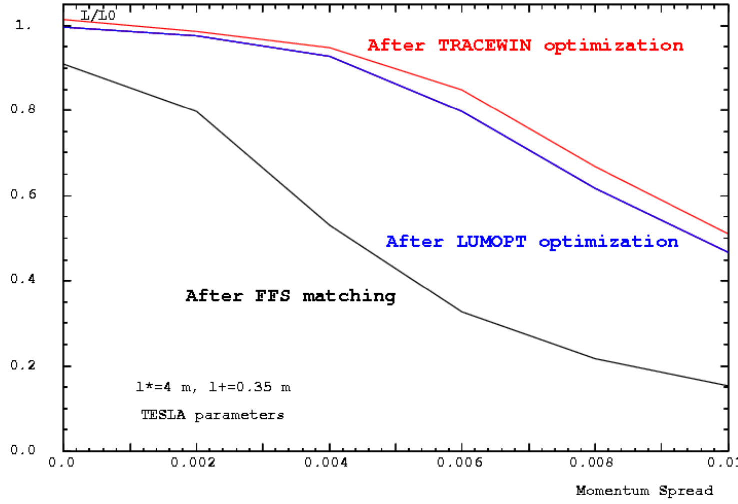


Separator parameters for	250 GeV	500 GeV	
Active length	28		m
Number of tanks	7		
Electrode length per tank	4		m
Electrode spacing	0.65		m
total installation length	32.55		m
Electrode material	titanium		
Total deflection required	252		µrad
E_0 (at separator center)	**2.25**	**4.50**	MV/m
Split size in electrodes	50	50	mm
Gap width	100 (70-140)		mm
electrodes	**2.62**	**5.23**	MV/m
Applied Voltage	131	262	kV
Spark rate / tank	< 0.04		#/hr
Field homogeneity	1.0E-02		
in area	22 x 12		mm
Quadrupole component	0.E+00		
Sextupole component	1.60E-03		
Octupole component	0.E+00		
Decapole component	1.14E-04		
Required HV generator	300		kV
generator	2/2/2/1		

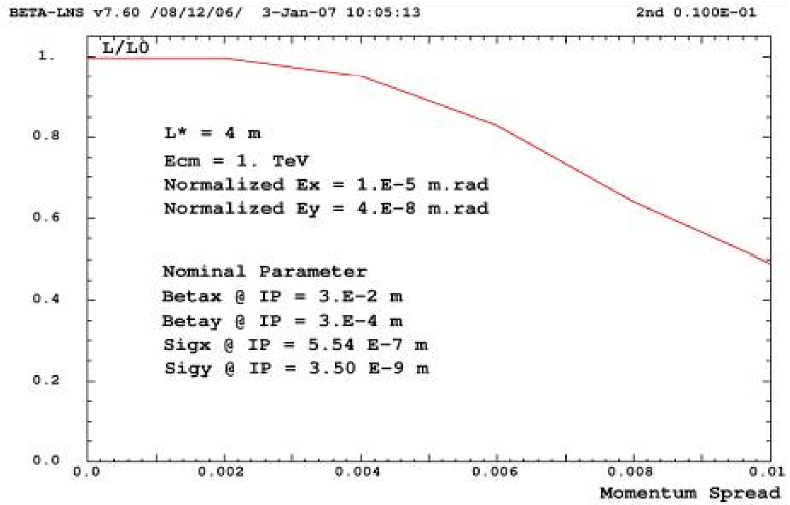
Final focus system



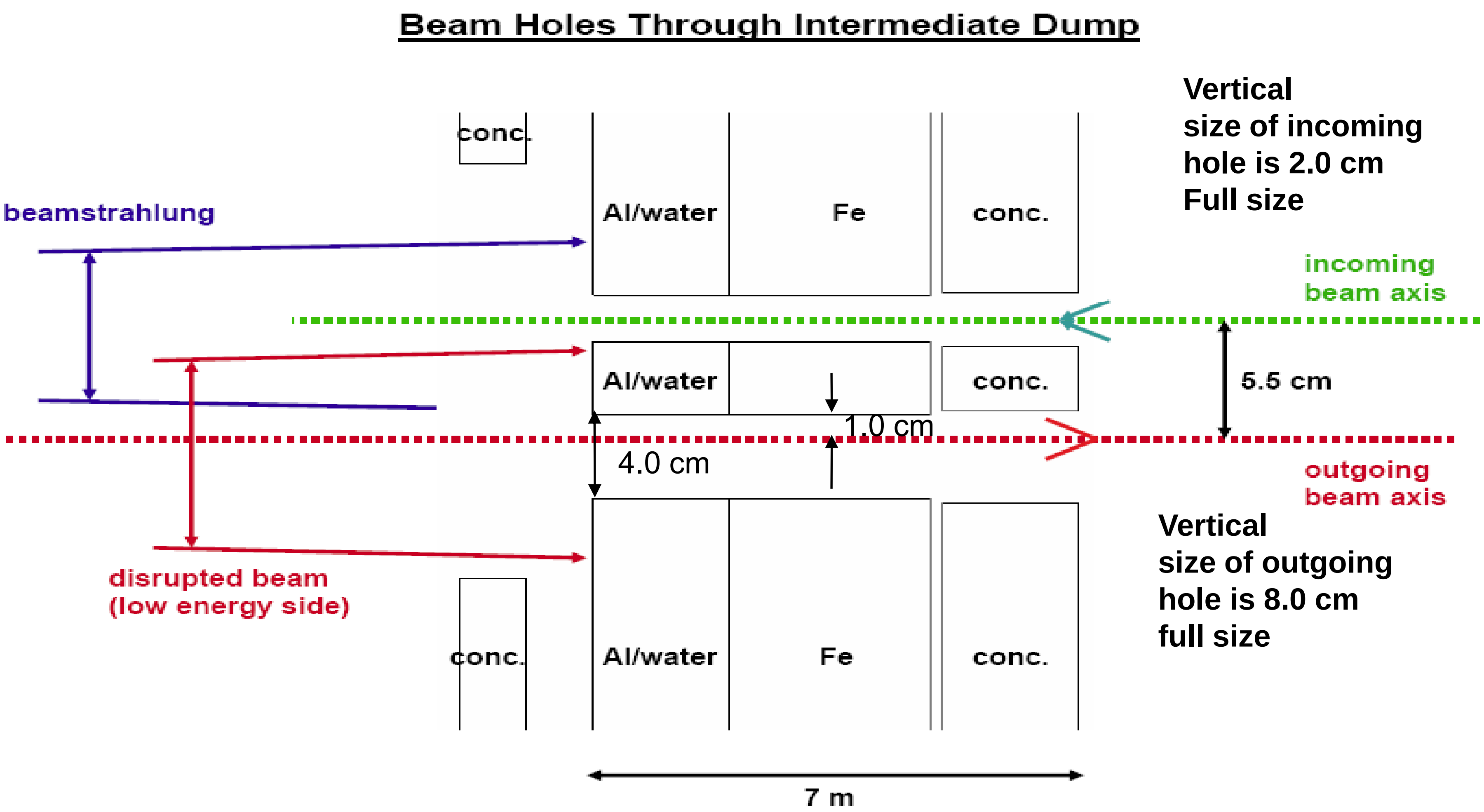
J. Payet et al PAC2007



Automatic FFS tuning



Intermediate Beam Dump



Vertical size of incoming hole is 2.0 cm Full size

Vertical size of outgoing hole is 8.0 cm full size

Summary

- 2mrad design
  - Minimum extraction line design with feasible magnets
  - Plan to complete the design by end of this year
  - Post-IP polarimetry & spectrometry excluded → alternative methods without second focus maybe feasible but need dedicated project for development
  - Few ideas for diagnostic tools to monitor the disrupted beam will be explored and reported as part of EUROTeV deliverable
  - Such ideas can be explored and studied in details if efforts available
- Modified head-on design
  - Minimum extraction line with feasible magnets
  - Details of electrostatic separators and configuration worked out
  - Parasitic crossing under control for nominal parameters
  - R&D required for electrostatic separators
  - Intermediate dump concept needs to be developed in details

EUROTeV deliverable for BDSLD

"Fully documented optimized BDS lattice, including component (magnet) specifications"

- There is no single report describing this for the ILC
  - RDR web page
  - 2mrad and head-on decks at separate places
- Website exists for CLIC with all the decks
  - http://clicr.web.cern.ch/CLICr/MainBeam/BDS/
- Document this information in a EUROTeV deliverable report

Extra Slides

2mrad FD magnets

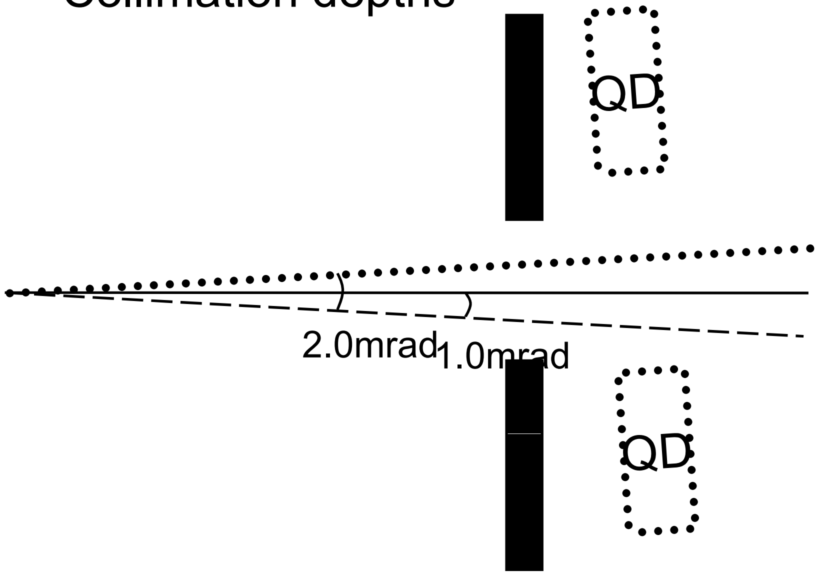
- QD0 : r=28mm, LHC like quadrupole
- SD0 : r=60mm, scale down from FNAL design presented at

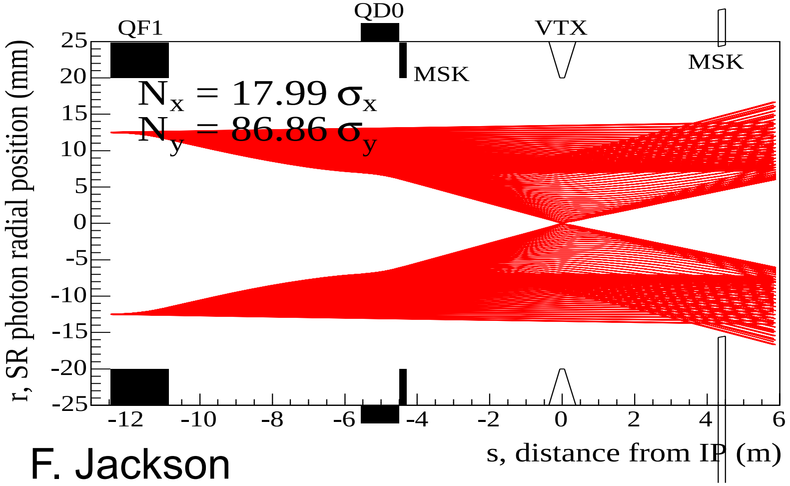
http://www-project.slac.stanford.edu/lc/bdir/Meetings/beamdelivery/2005-04-19/index.htm

- QF1 : r=15mm with pocket field : C. Spencer → F. Touze & G. Meur, LAL
- SF1 : r= 30mm with pocket field : F. Touze & G. Meur, LAL → underway at this moment

Collimation depths and backscattering

Collimation depths



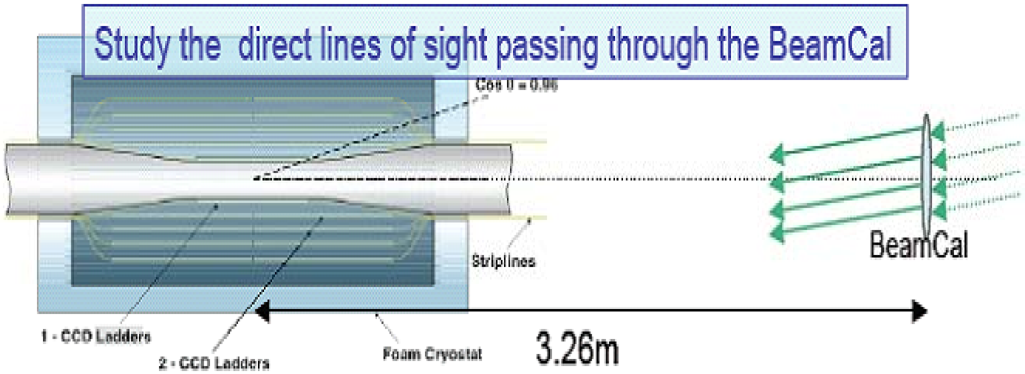


F. Jackson

EUROTeV-Report-2008-023

Backscattering studies

Mokka simulations and BDSIM simulations

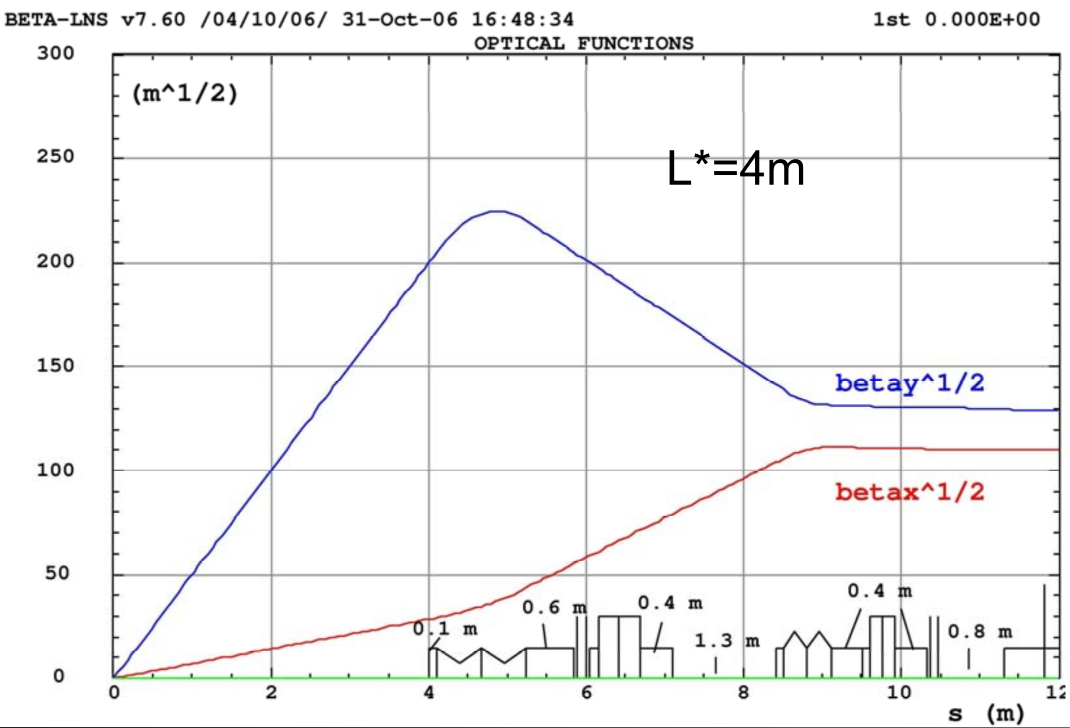


	D [m]	X [cm]	P [kW]	#γ's/bx	VD hits / BX
QEX1COLL	45	20	0.2	1.3	0.02
QE2COLL	53	-	0	0	0
BHEX1COLL	76	41	0.1	0.2	0.004
COLL1	131	85	52.3	40	0.8
COLL2	183	115	207.5	82	1.8
COLL3	286	-	0	0	0

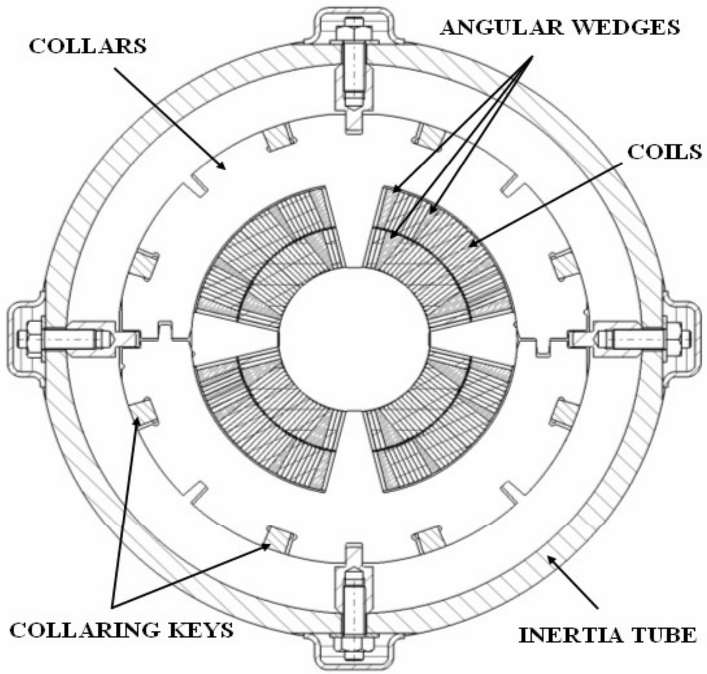
LAL/RT-07-07 & EUROTeV-Report-2007-047

P. Bambade, O. Dadoun

Head-on - Final Doublet for 500 GeV cm Energy



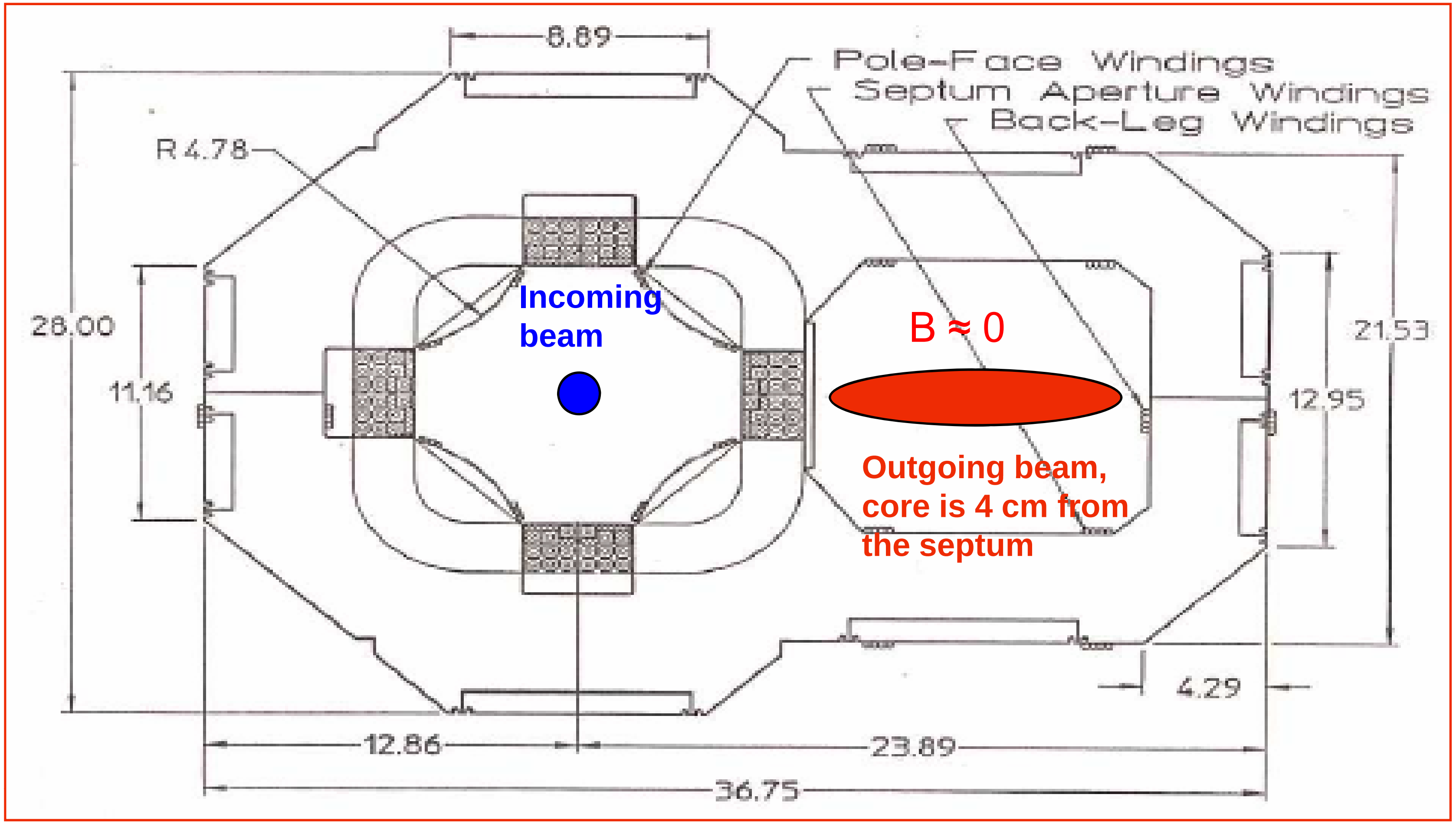
Final doublet design assumes engineered LHC arc superconducting Quadrupoles and Sextupoles with 56 mm bore diameter



	QD0	QF1	SD0	SF1
Length [m]	1.146	0.593	0.548	0.314
Gradient	250 T/m	250 T/m	3880 T/m2	3662 T/m2
Field @ bore	7 T	7 T	3 T	2.9 T

Head-on - Beam Extraction Scheme

QF3 modeled after PEPII/BaBar IR Septum Quad design



(units cm)

Head-on Electrostatic Separator Failures