



BDS updates

Andrei Seryi, SLAC

for the Beam Delivery team

TILCo9

April 19, 2009

A horizontal dotted line in a light green color is located at the bottom of the slide, below the date.



Plan of the talk

- BDS status and deliverables for TDP
- Organization
- IR Integration – MDI-D
 - IR Interface document
 - Next: design optimization
 - SC FD & test at ATF2
- Beam dump design; Crab cavity
- Explorations of ideas & options
 - long L^* , Crystal collimation
- Low P parameters
- Staging & $\gamma\gamma$ study
- Plans for optics for new baseline & min machine



BDS RDR design

1TeV CM, single IR, two detectors, push-pull

grid: 100m*1m

Diagnostics

Beam
Switch
Yard

β -collimator

Sacrificial
collimators

Tune-up &
emergency
Extraction

Tune-up
dump

E-collimator

Final Focus

14mr IR

Muon wall
Main dump

Extraction

Final Doublet

Crab cavity

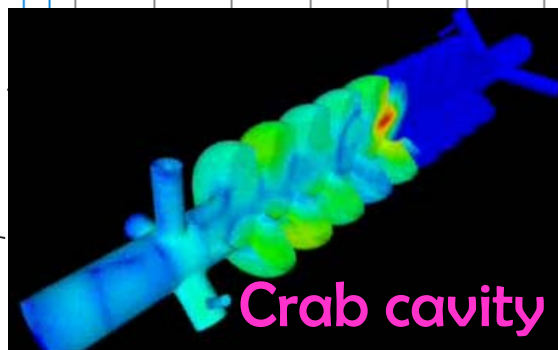
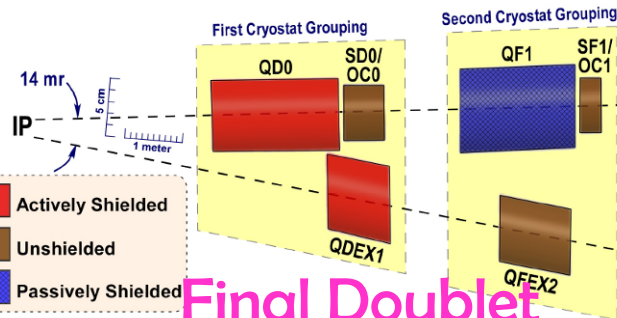
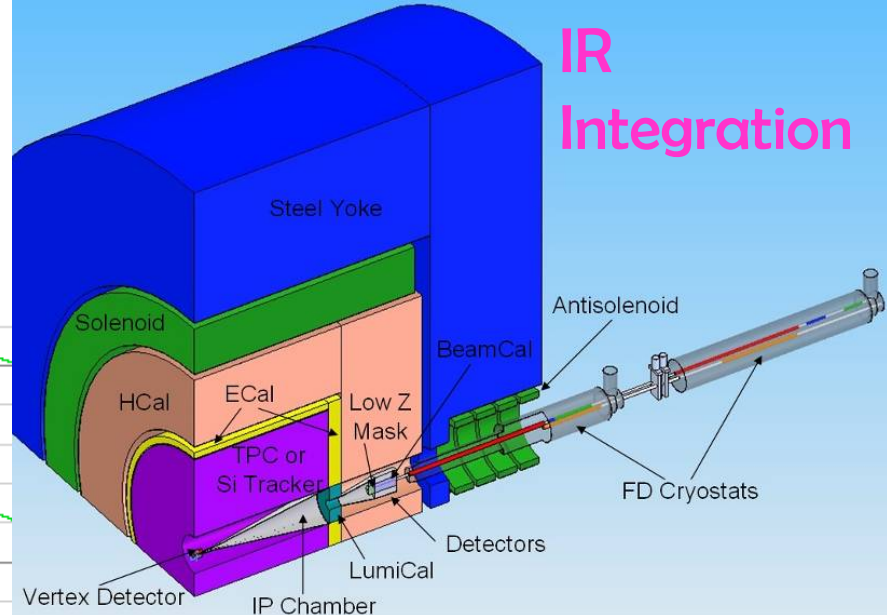




Table 3.4: TD Phase Beam Test Facilities Deliverables and Schedule.

Test Facility	Deliverable	Date
<i>Optics and stabilisation demonstrations:</i>		
ATF	Generation of 1 pm-rad low emittance beam	2009
ATF-2	Demonstration of compact Final Focus optics (design demagnification, resulting in a nominal 35 nm beam size at focal point).	2010
	Demonstration of prototype SC and PM final doublet magnets	2012
	Stabilisation of 35 nm beam over various time scales.	2012

3.3.5 Beam Delivery System

The main R&D focus for the BDS is the ATF-2 programme at KEK which will allow demonstrations of many of the key BDS components and design concepts, the Machine-Detector activity for optimization of the Interaction Region, and design for those BDS subsystems which are critical for system performance or which may expand the physics capabilities of the collider. Examples of R&D are:

- Development of instrumentation (e.g. laser-wires), algorithmic control software, beam-based feedback systems and emittance-preservation techniques to achieve the small beam-size goals (2010)
- Developing of IR Interface Document defining MDI specifications and responsibilities (2010) and design or optimised IR (2012)
- Development of the prototype of the Interaction Region SC Final Doublet (2012)
- Development of Interferometer system for FD stability monitoring (2012)
- Design of the beam dump system (2012)
- Tests of SC and PM Final doublet at second stage of ATF2 (2012)
- Design studies for the photon collider option (2012)
- Collimation and dump window damage tests at ATF2 (2010)
- Development and demonstration of the SCRF crab-cavity system (2010)

BDS in GDE Technical Design Phase plan

Plus, the min
machine study

may be delayed

may be limited in scope

Project managers

Detector liaison
S.Yamada, RD, (KEK)

BDS A.Seryi (SLAC)

deputy for cost & docs.

ATF2 construction, commissioning & operation
T.Tauchi (KEK)

Interaction Region and IR integration
B.Parker (BNL) chair, T.Markiewicz (SLAC) deputy

Detector concept liaison
ILD: K.Buesser, T.Tauchi
SiD: P.Burrows, M.Oriunno
4th : J.Hauptman, A.Mikhailichenko

Accelerator design & its integration
D.Angal-Kalinin (STFC)

Vacuum science, O.Malyshev (STFC)

Photon collider design, J.Gronberg (LLNL)

E-saving magnets & PS, C.Spencer, P.Bellomo (SLAC)

Crab cavity system
P.McIntosh (ASTeC)

BDS Beam Dump system
S.Pollepale (BARC) chair, R.Arnold (SLAC) deputy

BDS Collimation system
N.Watson (Birm.U.)

BDS instrumentation
P.Burrows (Oxford)

Laser wires, G.Blair (RHUL)

Alignment, D.Urner (Oxford)

BPM systems, S.Boogert (RHUL)

in some
cases TBC

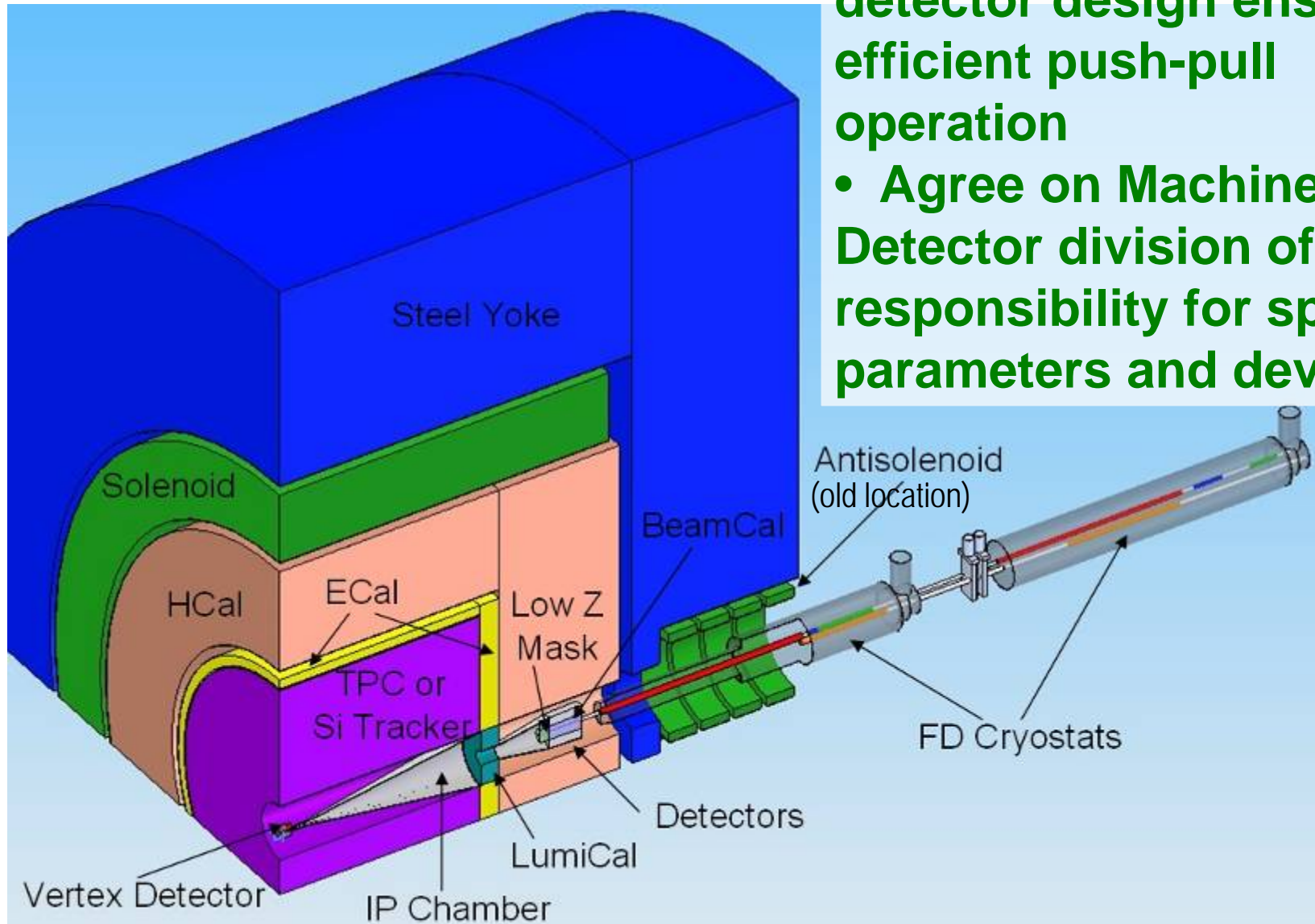
sub-WP shown are
examples and not a
complete list

**BSD TDP
structure
2008-12**

IR integration

Challenges:

- Optimize IR and detector design ensuring efficient push-pull operation
- Agree on Machine-Detector division of responsibility for space, parameters and devices



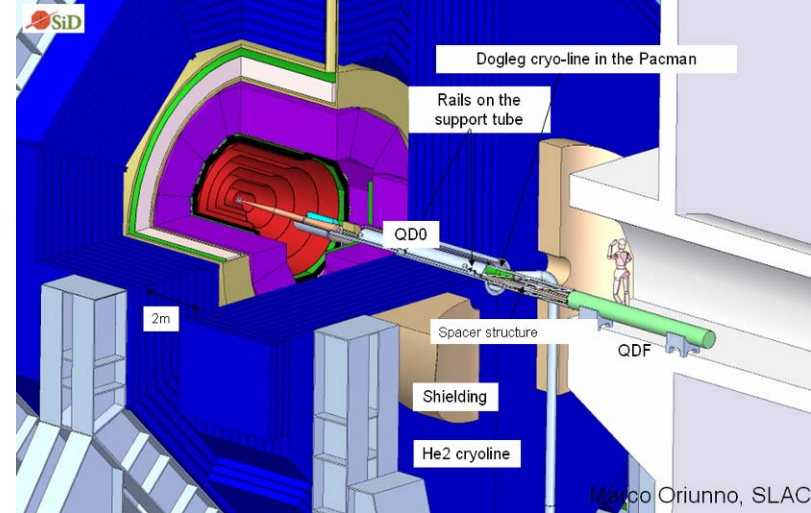
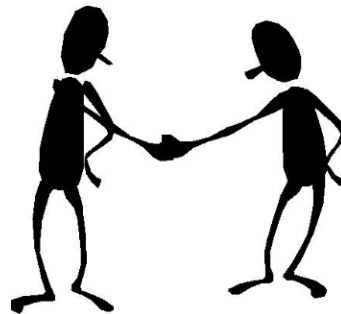
ILC IR integration

PLAN AS SHOWN IN EARLY 2008 (Sendai):

- Machine – Detector work on Interface issues and integration design is a critical area and a focus of efforts

- IR integration timescale

- EPAC08 & Warsaw-08
 - Interface document, draft
- LCWS 2008
 - Interface doc., updated draft
- LOI, April 2009
 - Interface document, completed
- Apr.2009 to ~May 2010
 - design according to Interface doc.
- ~May 2010: LHC & start of TDP-II
 - design according to Interf. doc and adjust to specific configuration of ILC



ILC-Note-2009-050
March 2009
Version 4, 2009-03-19

Functional Requirements on the Design of the Detectors and the Interaction Region of an e^+e^- Linear Collider with a Push-Pull Arrangement of Detectors

B.Parker (BNL), A.Mikhailichenko (Cornell Univ.), K.Buesser (DESY),
J.Hauptman (Iowa State Univ.), T.Tauchi (KEK), P.Burrows (Oxford Univ.),
T.Markiewicz, M.Oriunno, A.Seryi (SLAC)

Abstract

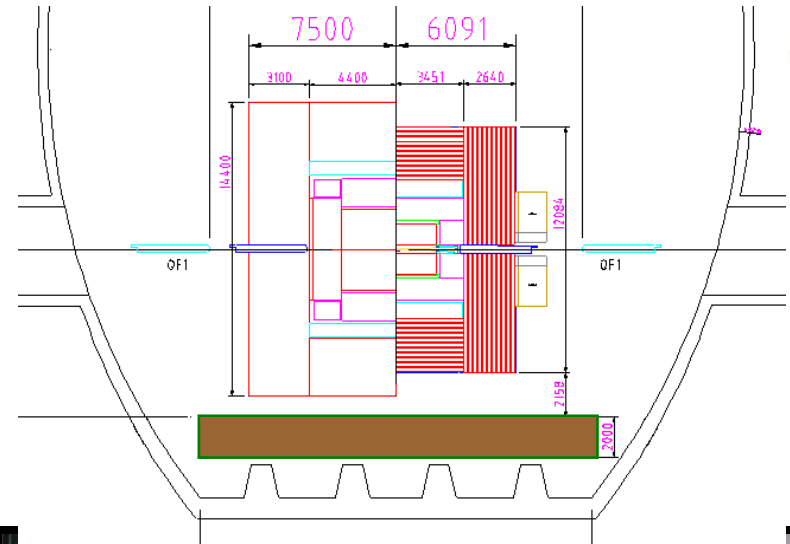
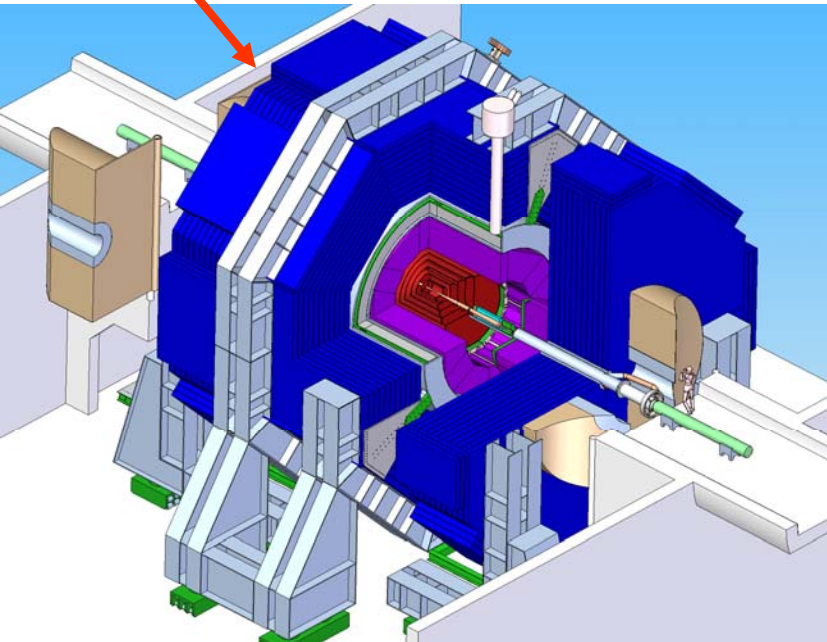
The Interaction Region of the International Linear Collider [1] is based on two experimental detectors working in a push-pull mode. A time efficient implementation of this model sets specific requirements and challenges for many detector and machine systems, in particular the IR magnets, the cryogenics and the alignment system, the beamline shielding, the detector design and the overall integration. This paper

<http://ilcdoc.linearcollider.org/record/21354?ln=en>

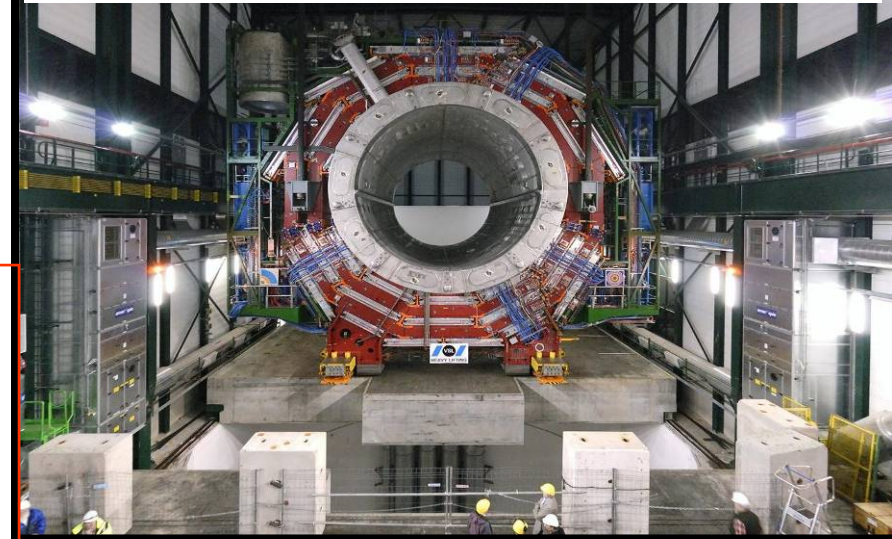


MDI issues to keep working on

Detector motion system with
or without an intermediate platform



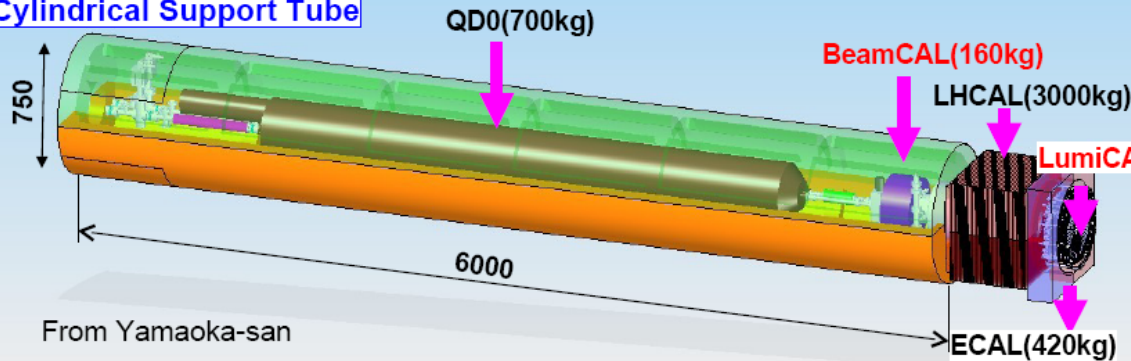
CMS platform – proof of principle for ILC



Planning for further design work
aiming to bring different push-pull
solutions to a compatible and cost
effective design

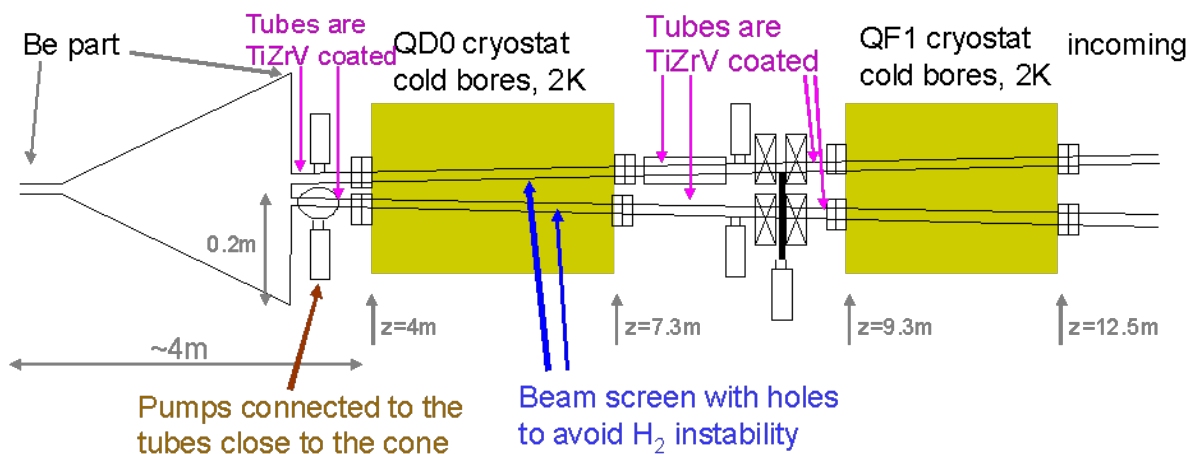
Important MDI issues, examples

Cylindrical Support Tube



- < 50nm for QDO stability
- compact movers for QDO
- support ~3t LHCAL mass such that it does not adversely affect the QDO dynamics

• Recently re-started Vacuum Science task force, led by Oleg Malyshev, STFC, focusing on IR vacuum system



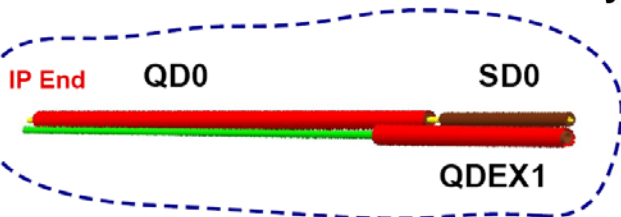
- May need pump close to IP
- Do not rely solely on QDO cold bore cryo-pumping
- High Order Modes
- Support and alignment of IR chamber and VX
- Assembly, flanges...



SC FD modified plans and ATF2 tests

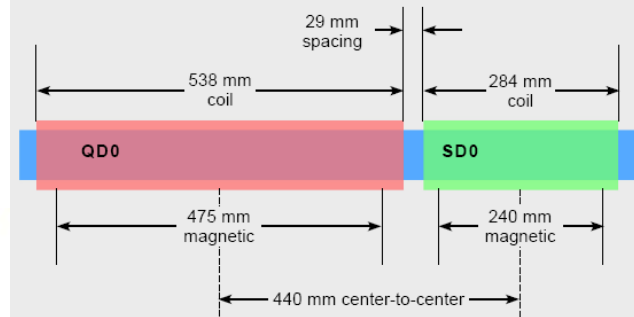


QD0 Cryostat Design for $L^* = 4.5$ m.

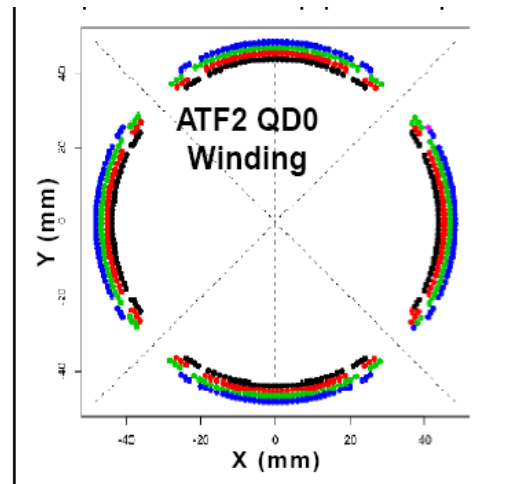


Earlier plan was to prototype ILC-like QD0 magnet with cryostat & study its stability

- In TDP, plans for SC FD prototype at BNL were adjusted
 - delay efforts on ILC-like FD prototype; for near-term only make long cold mass and perform its field tests (cryostat later)
 - enhance efforts on ILC-technology-like SC Final Doublet for ATF2 upgrade

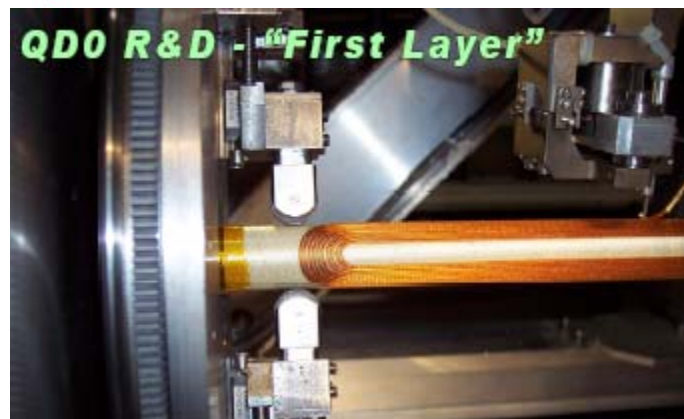
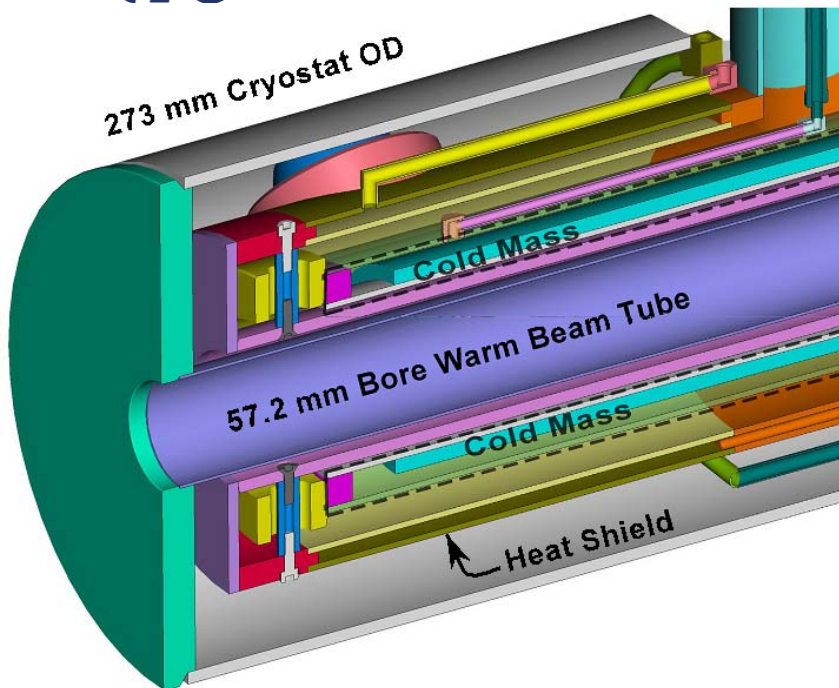


Brett Parket, at al, BNL



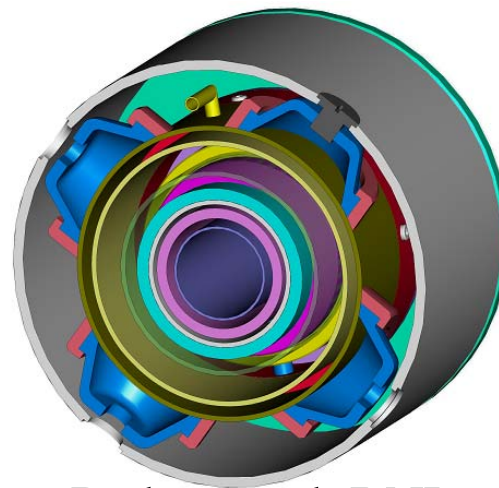
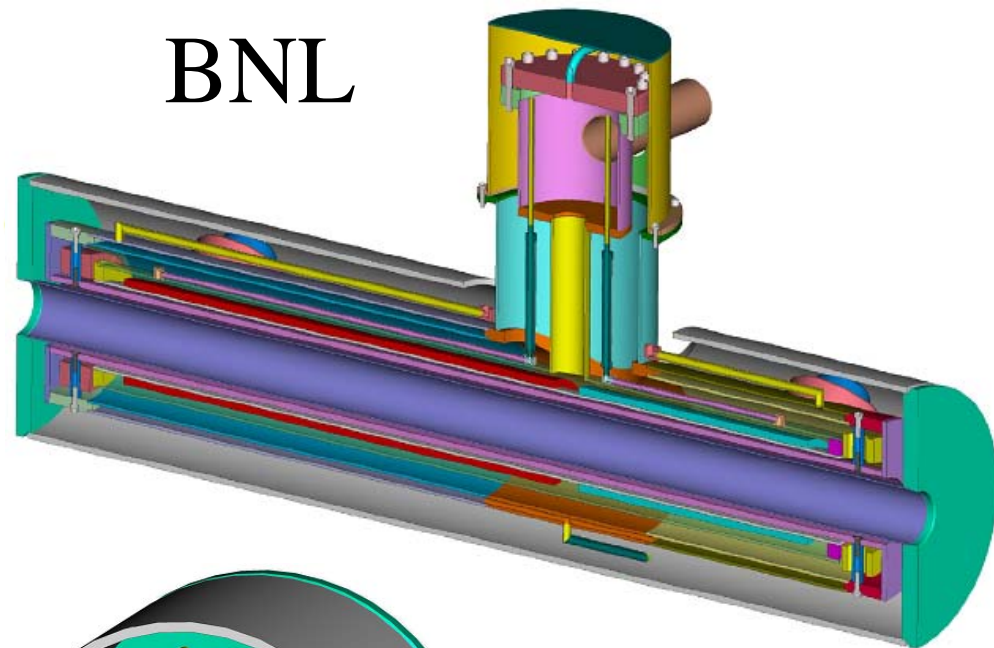
- Only produce one quadrupole/sextupole magnet combination (in common cryostat).
- No self-shielding or anti-solenoid (simple).
- KEK Cryogenic system (major challenge).
- 50 mm aperture but with a warm bore (i.e. optimize to limit cold mass heat leak).
- Minimum degrees of freedom (correctors).
- Found it easy to match corrector coils and main coil magnetic lengths.

SC FD for ATF2

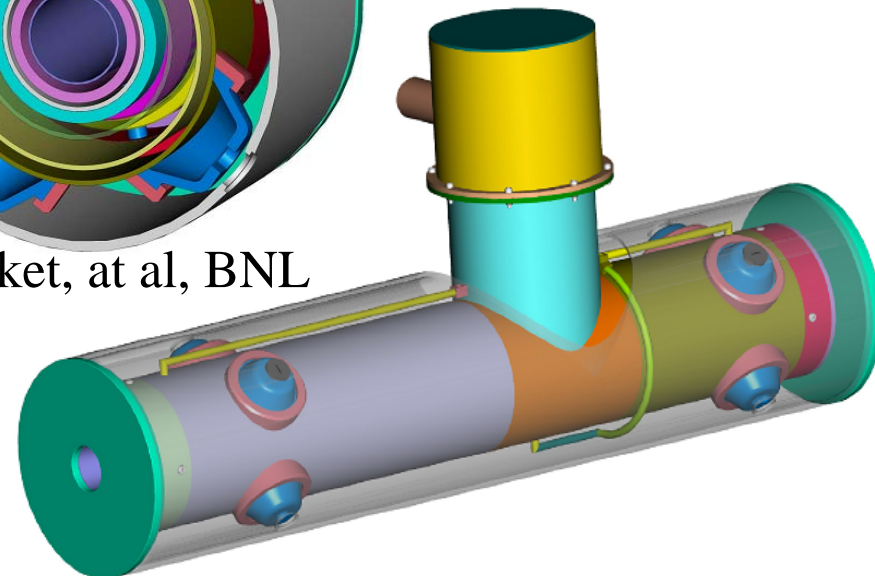


Long coil winding

BNL



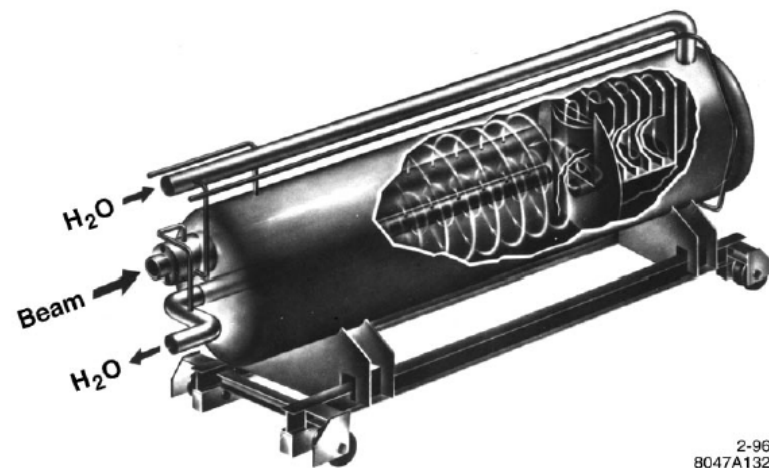
Brett Parket, et al, BNL



Cross Section View at Support Location

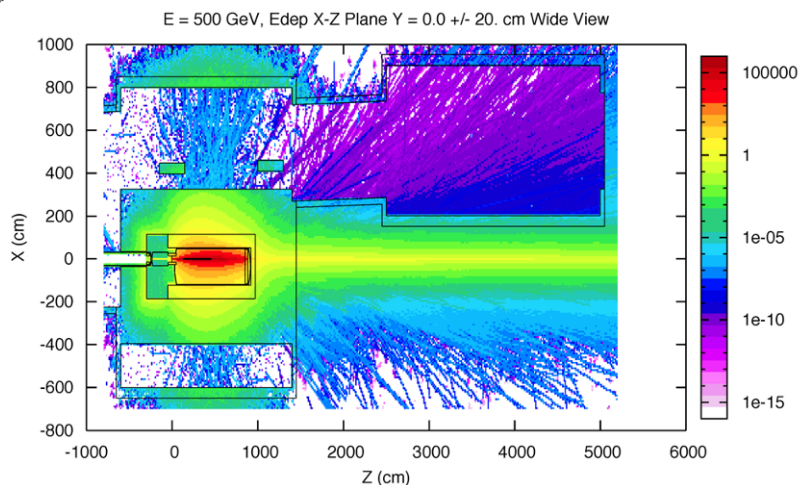
18MW Beam dump

BARC, India, & SLAC, collaboration



Beam dump with double header
(Satyamurthy Polepalle et al,
BARC-SLAC)

Maximum Temperature – 147°C
Maximum delta T – 28°C

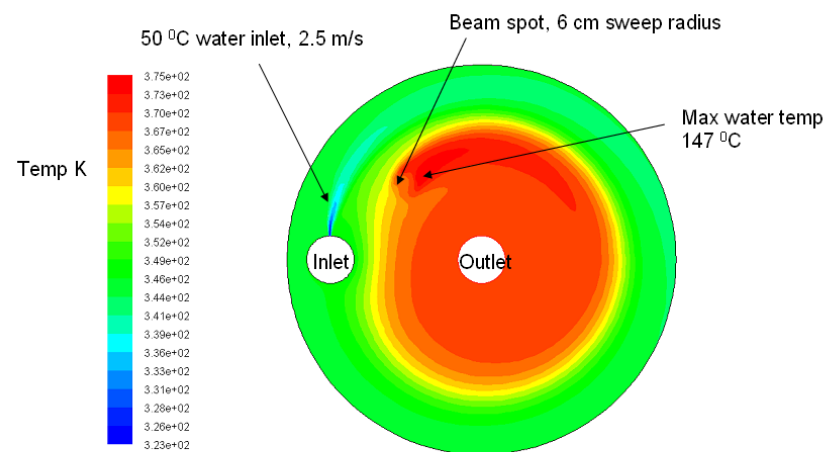


Dieter Walz, Ray Arnold, **Satyamurthy Polepalle (BARC, India)**, John Amann, at SLAC beam dump area (February 2008)

Planning for the next working meeting of the task force at SLAC in ~May 2009, to continue the work on beam dump design

Space Distribution of Steady State Water Temperature

Use 2-D FLUENT models to study water velocity, header size, beam spot location, sweep radius.



Temperature contours for CASE 5b (At location of Z=1.82 m for 2.50 m/s nozzle velocity without blocking outlet)

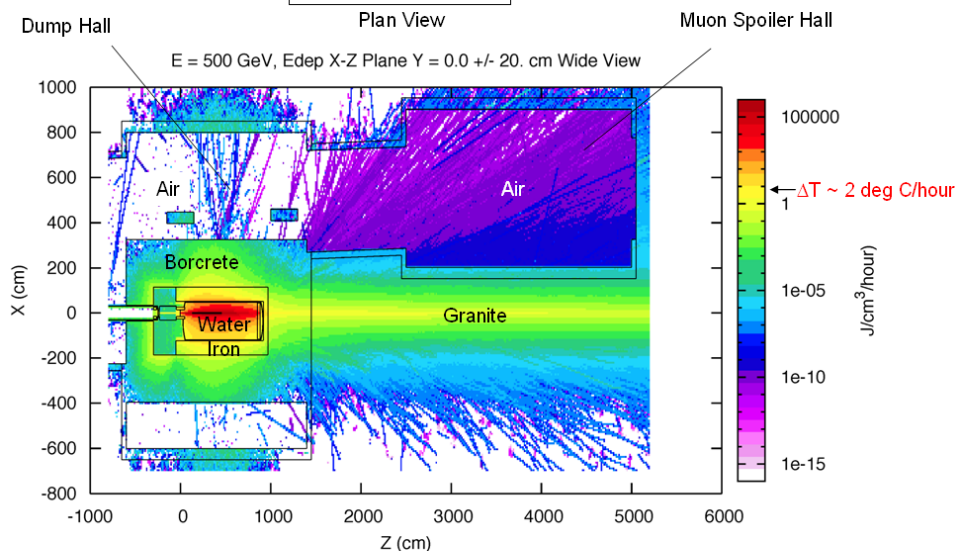
R. Arnold

Dumps - LCWS08, 19 Nov 2008

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Prompt Energy Deposition - J/cm³/hour - Geometry V2

Even the rocks get hot!

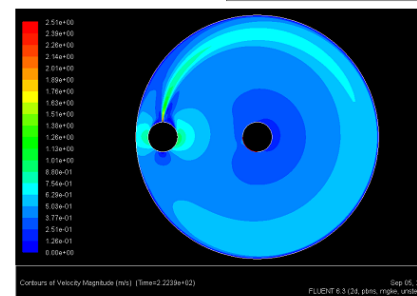
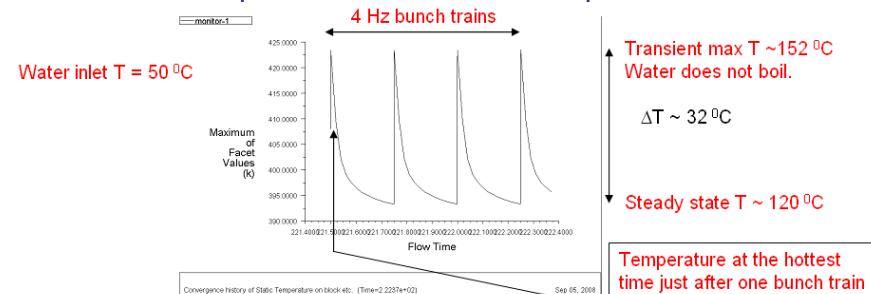


R. Arnold

Dumps - LCWS08, 19 Nov 2008

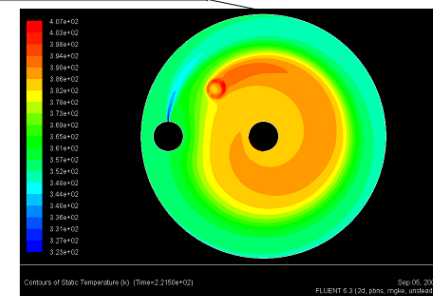
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Time Dependence of Water Temperature



Velocity distribution at 222.3 seconds

R. Arnold

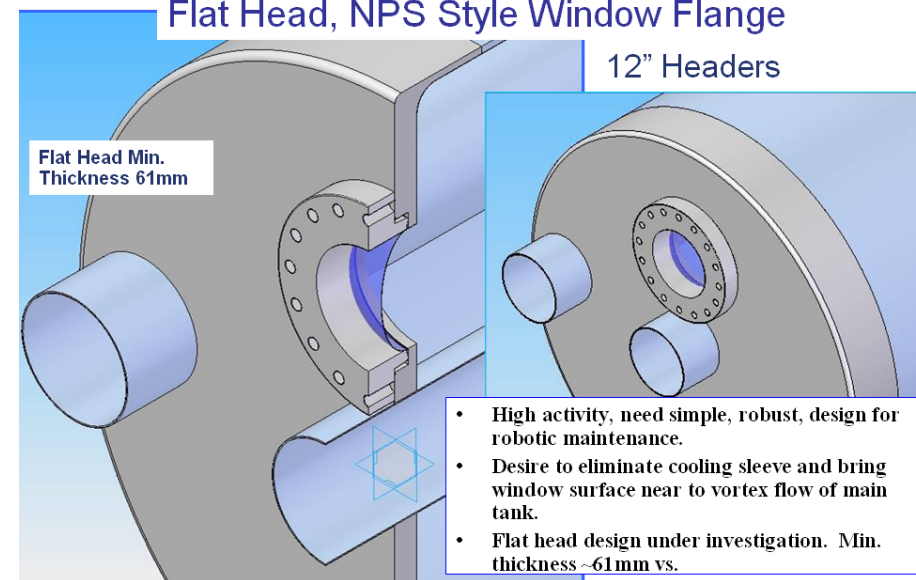


Temperature Distribution at 221.5 seconds

Dumps - LCWS08, 19 Nov 2008

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Variation of Baseline Design Flat Head, NPS Style Window Flange



R. Arnold

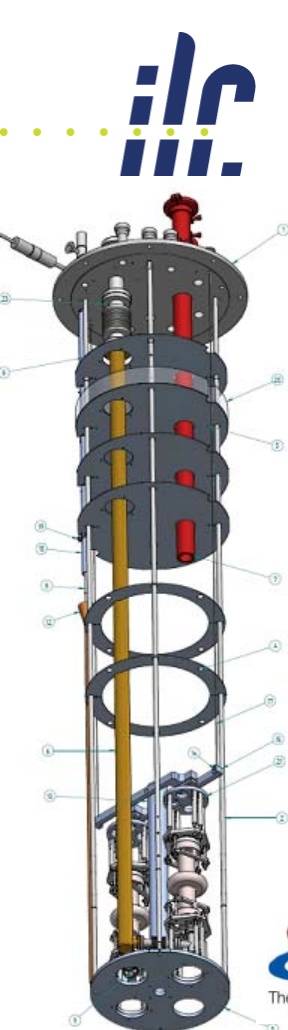
Dumps - LCWS08, 19 Nov 2008

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BDS updates, continued

- Re-started work with Rad. physics group (KEK & SLAC colleagues) for shielding calculations
- The power saving magnet group is proceeding with their work
- Collimation – prepare for beam damage tests at ATF2
- Crab cavity work proceeding at STFC, looking for improvement of stability results
 - very promising results (illustration on next page)
 - no clear path after this year (funding)
 - very tentative discussion of CC test at ATF2 (to create trav. focus) – (issues: cryostat & cryo integration)



Cavities limited in gradient to 1 MV/m (~40kV/cell) – shielding implications.

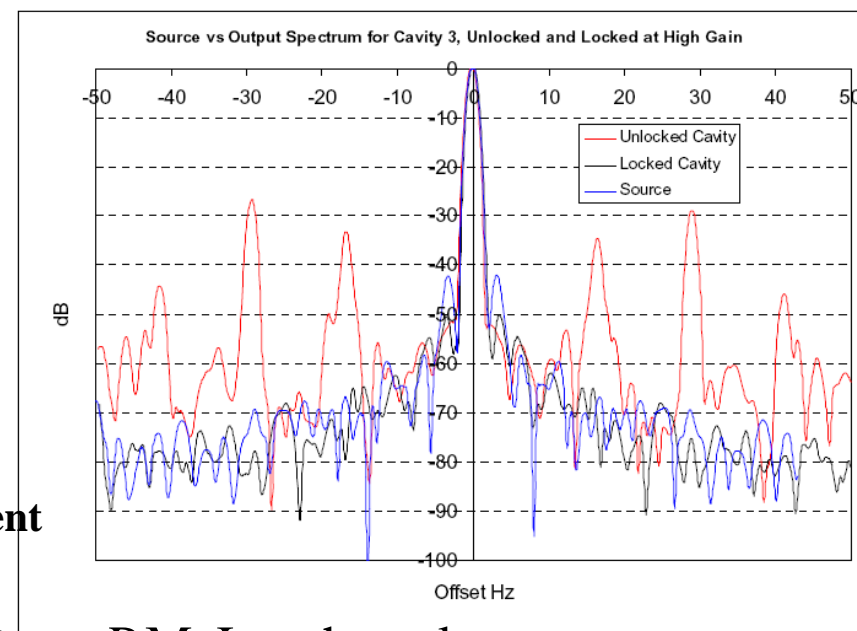
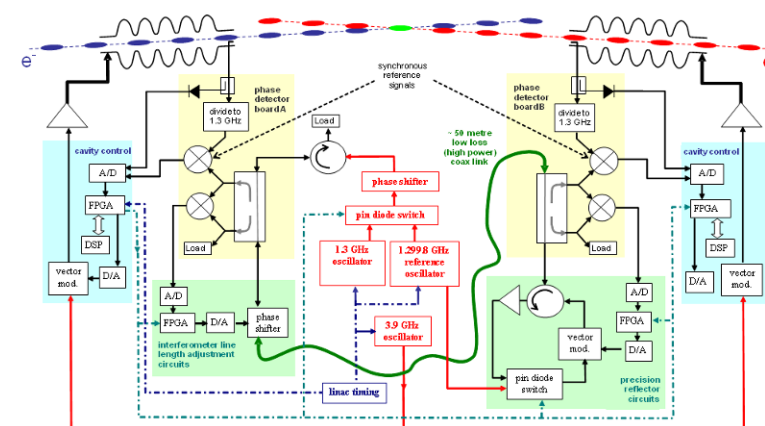
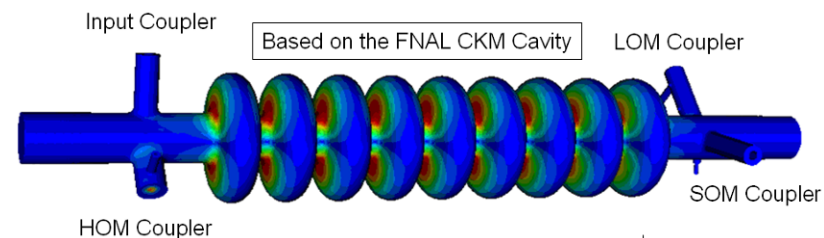


The Cockcroft Institute
of Accelerator Science and Technology



Independent phase lock achieved for both cavities:

- **Unlocked** => 10° r.m.s.
- **Locked** => 0.135° r.m.s.
- Performance limited by:
 - **Source noise (dominant); ADC noise; Measurement noise;**
 - **Cavity frequency drift; Microphonics**
- Improvements being made; new tests being prepared



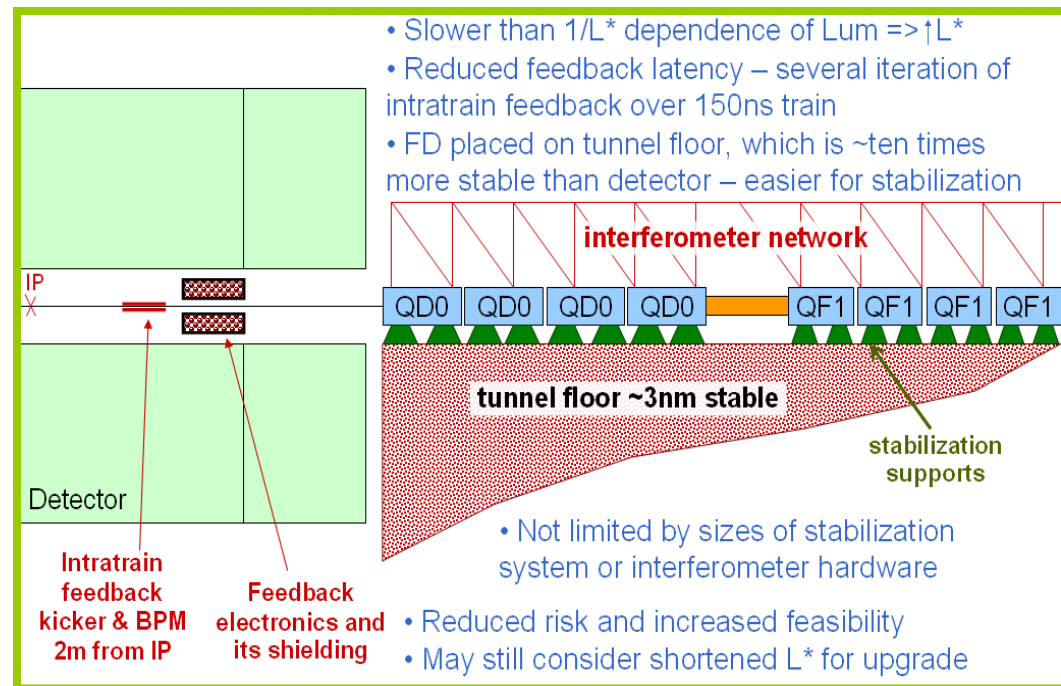
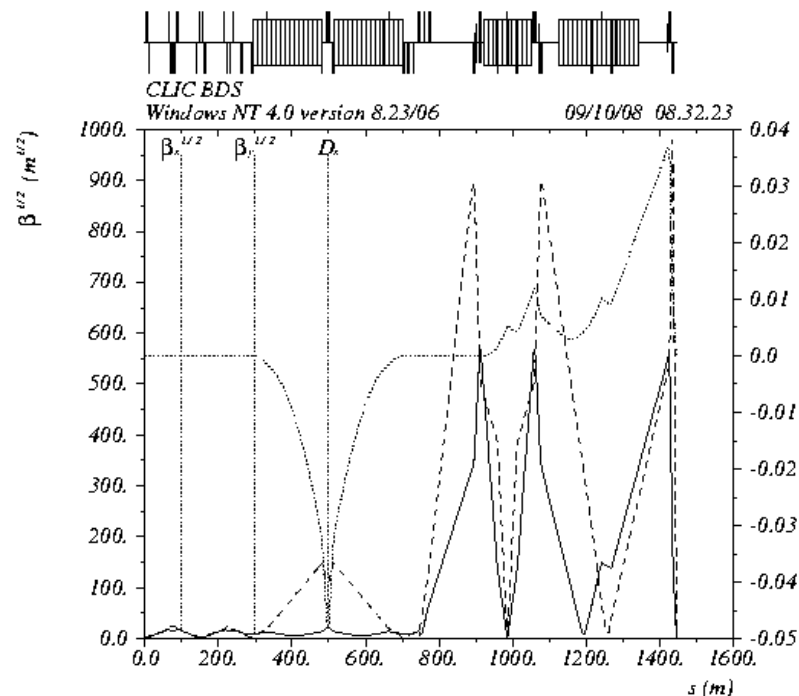
P.McIntosh at al



Exploration of ideas & tests for more performing machine

- Longer L^* or smaller β^*
 - Minimal machine may require tighter focusing at IP
 - CERN/CLIC colleagues suggested to study squeezed y - β^* at ATF2 (0.025 mm instead of 0.1 mm nominal)
 - Squeezed β^* study at ATF2 is one of example of strong synergy and mutual benefits of ILC-CLIC collaboration
 - Such study may support
 - Test of high chromaticity FF, as in CLIC FF design
 - Smaller β^* for “New Low P” parameters of ILC
 - Lengthening L^* for easier MDI
- Crystal collimation
 - Exploring Volume Reflection radiation in bent crystals as a phenomena to improve the collimation system of linear collider

Longer L^* or smaller β^*

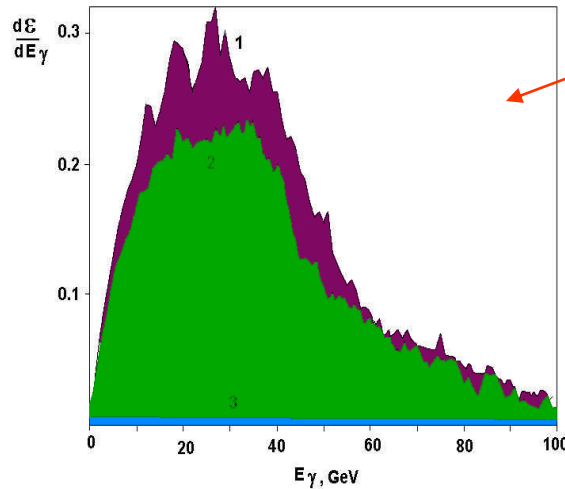
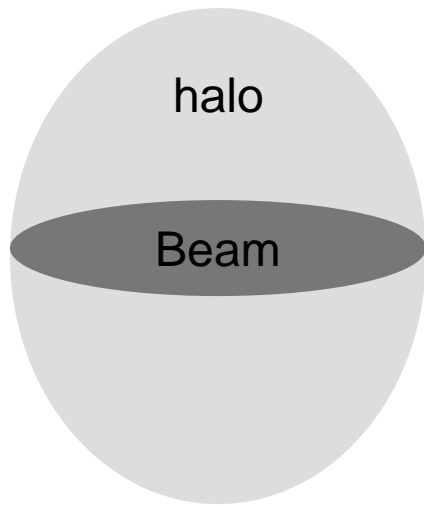


“Doubled L^* design”, $L^*=8m$, 3TeV CMS CLIC

- Study prompted by the CLIC FD stability challenge ($< 0.2nm$)
- Double the L^* and place FD on a stable floor
- Initial study show that $L^*=8m$ optics is possible (CLIC08 workshop)
 - Presently CLIC colleagues are studying impact on field and alignment tolerances

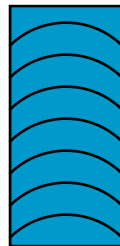


LC Collimation concept based on Volume Reflection radiation



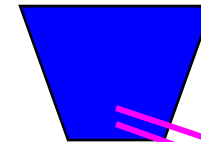
Volume reflection radiation
spectrum of 200GeV e+ or e- on
0.6mm Si crystal ($R_{\text{bend}}=10\text{m}$)
Yu. Chesnokov et al, IHEP 2007-16

Crystal
with Volume
Reflection



VR halo particles
with $dE/E \sim 20\%$
loss due to VR
radiation

Bends

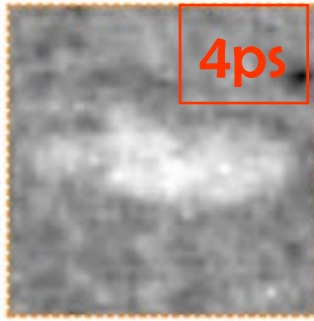
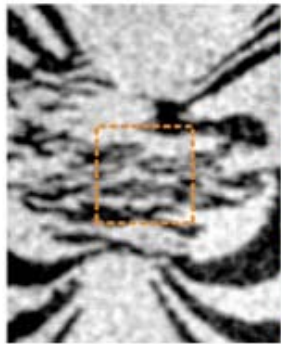


photons of VR
radiation (to be
absorbed in
dedicated places)

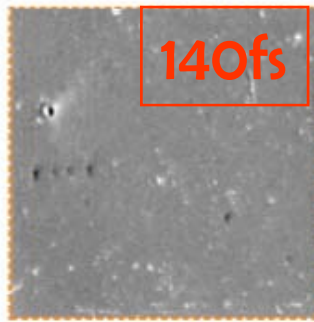
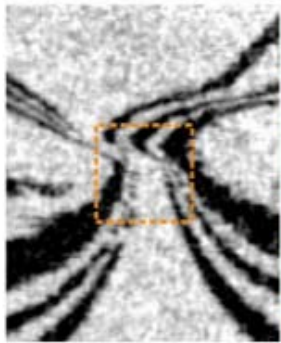


Absorb
off-Energy
particles

Crystal (or spoiler) survivability

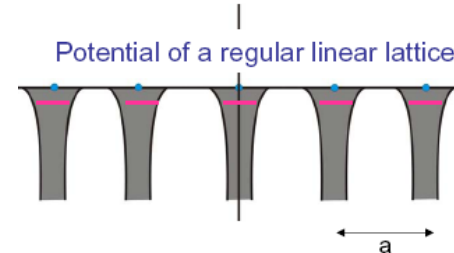
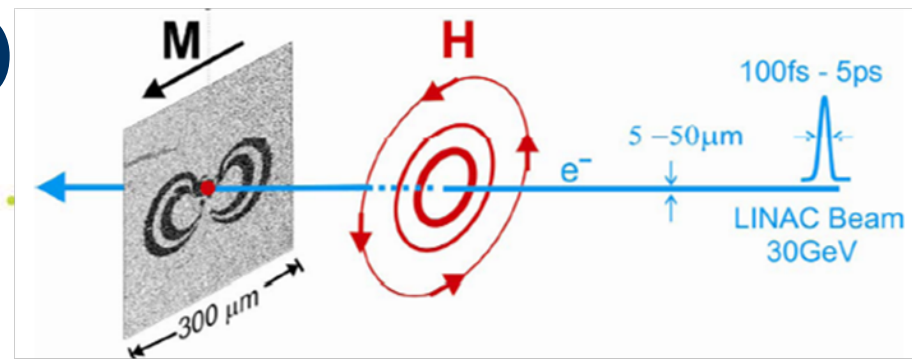


4ps



140fs

*New effect observed:
while there was damage of a sample observed for 4ps beam, this damage disappeared for a shorter 140fs beam.



Co bandwidth $\sim 3\text{eV}$

Potential along E field direction



$$E \sim 10^{10} \text{ V/m}$$

$$a = 0.25 \text{ nm}$$



$$\Delta V = e E a \sim 2.5 \text{ eV}$$

For short bunches the field gradient exceeds 2.5V over distance between atoms.
Potential wells around each atom shift, and conduction zones do not overlap any more.
=> breakup of conduction path, no current, no heat transfer and no damage.
Energy still goes into the material, but is probably dissipated via emission of terahertz photons

J. Stohr (SLAC), et al, "Exploring Ultrafast Excitations in Solids with Pulsed e-Beams", presented on Feb 19, 2008 at SLAC FACET review,
<http://www-group.slac.stanford.edu/ppa/Reviews/facet-review-2008/Agenda.asp>

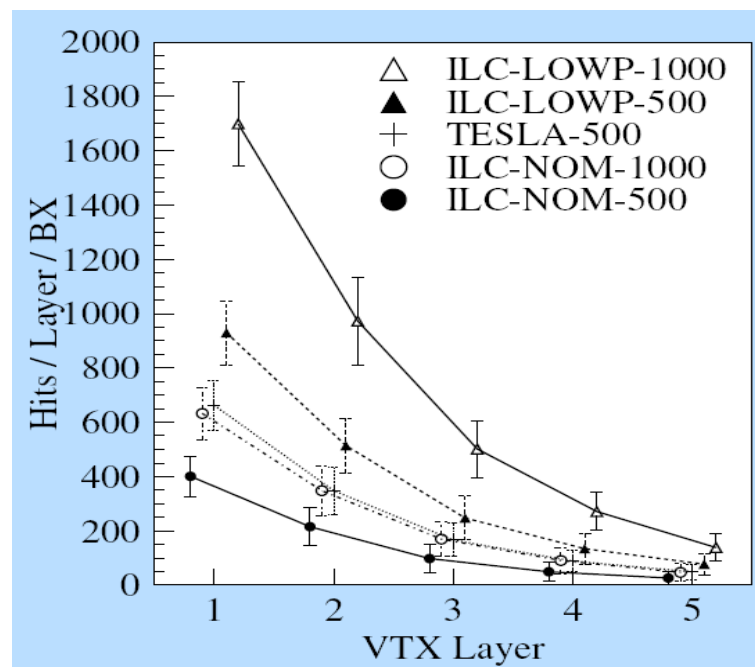
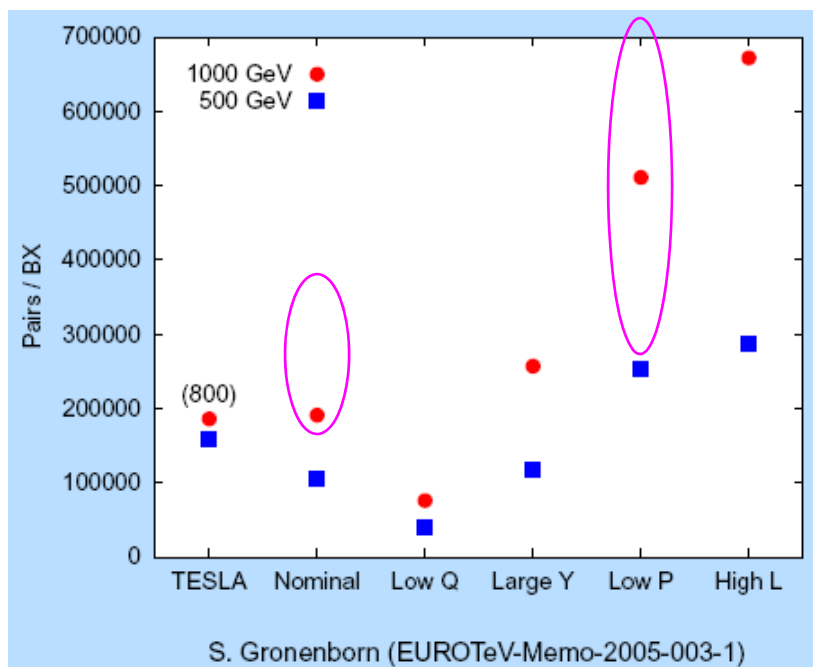
A.Seryi, Apr/19/09

This may show that approach to collimation design has been conservative

Low Power option



- Motivation: reduction of beam power => potential cost reduction; reduced cryo system; smaller diameter damping rings, etc.
- The RDR “low power” option may be a **machine** “cost saving” set but it is not a favorite set for detectors:



- Improved Low P may require tighter IP focusing, and use of “travelling focus” [V.Balakin, 1990]



New Low P parameter set

	Nom. RDR	Low P RDR	new Low P
Case ID	1	2	3
E CM (GeV)	500	500	500
N	2.0E+10	2.0E+10	2.0E+10
n_b	2625	1320	1320
F (Hz)	5	5	5
P_b (MW)	10.5	5.3	5.3
$\gamma\epsilon_x$ (m)	1.0E-05	1.0E-05	1.0E-05
$\gamma\epsilon_y$ (m)	4.0E-08	3.6E-08	3.6E-08
β_x (m)	2.0E-02	1.1E-02	1.1E-02
β_y (m)	4.0E-04	2.0E-04	2.0E-04
Travelling focus	No	No	Yes
Z-distribution *	Gauss	Gauss	Gauss
σ_x (m)	6.39E-07	4.74E-07	4.74E-07
σ_y (m)	5.7E-09	3.8E-09	3.8E-09
σ_z (m)	3.0E-04	2.0E-04	3.0E-04
Guinea-Pig $\delta E/E$	0.023	0.045	0.036
Guinea-Pig L ($\text{cm}^{-2}\text{s}^{-1}$)	2.02E+34	1.86E+34	1.92E+34
Guinea-Pig Lumi in 1%	1.50E+34	1.09E+34	1.18E+34

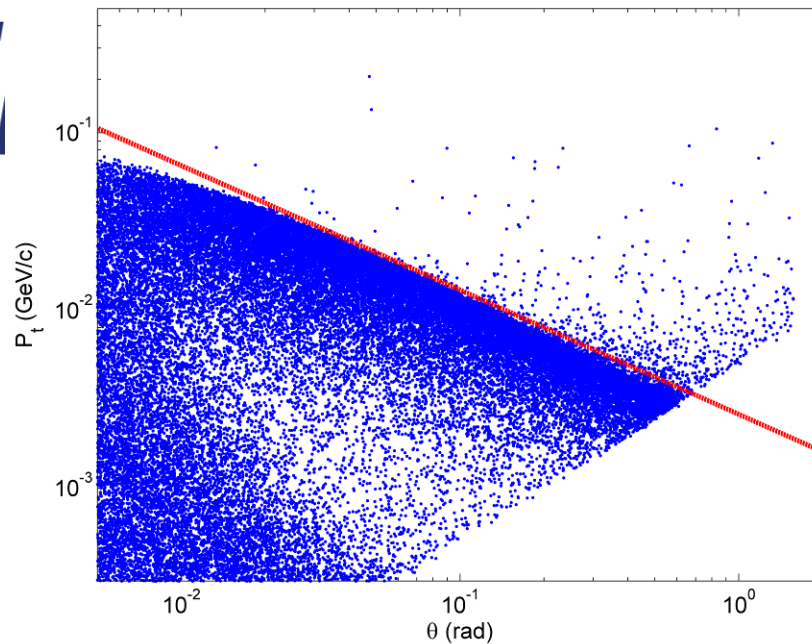
Travelling focus allows to lengthen the bunch

Thus, beamstrahlung energy spread is reduced

Focusing during collision is aided by focusing of the opposite bunch

Focal point during collision moves to coincide with the head of the opposite bunch

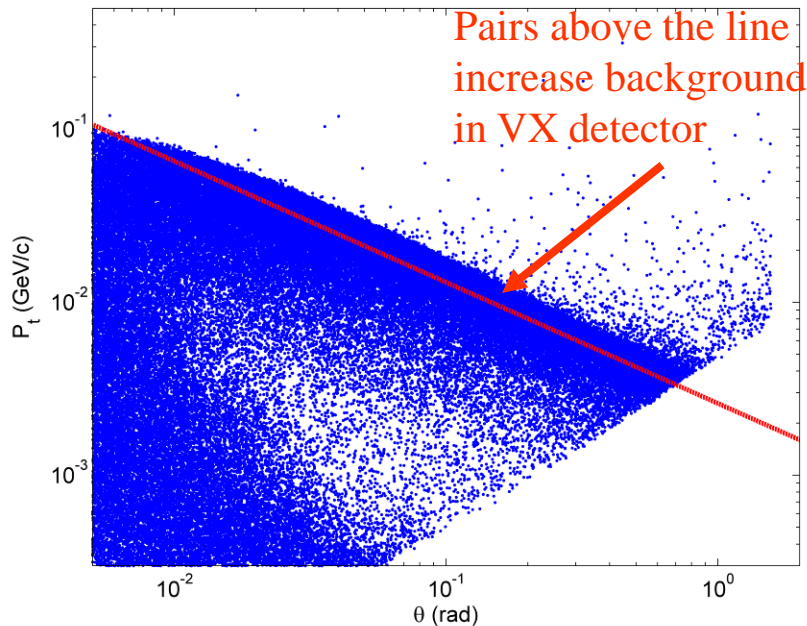
*for flat z distribution the full bunch length is $\sigma_z * 2 * 3^{1/2}$



e⁺e⁻ pairs

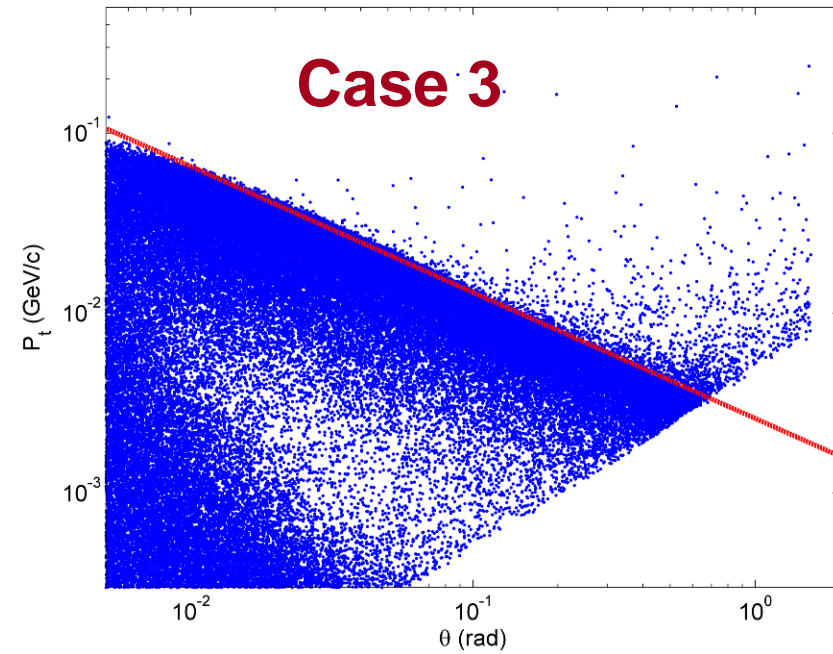
- Edge of pairs distribution in θ - P_t important for VX background
- RDR Low P: edge higher \Rightarrow unfavorable for background
- New Low P: edge location similar as RDR Nominal

RDR Low Power



New Low Power (Travelling focus)

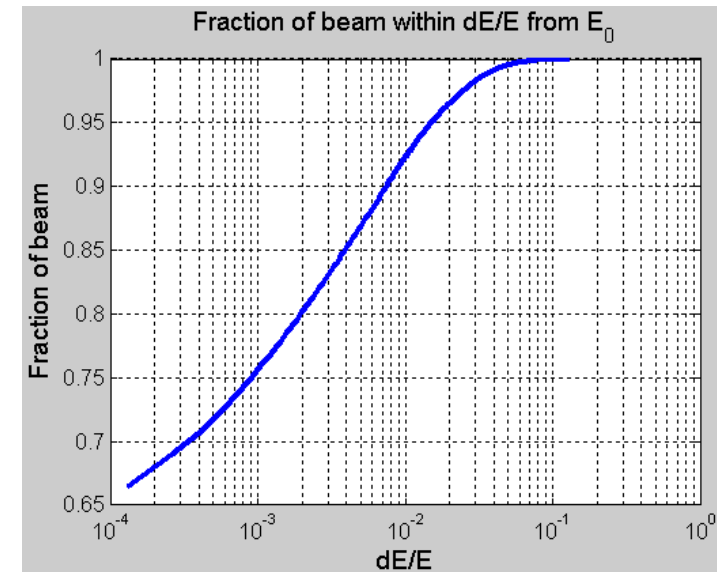
Case 3



Independently confirmed by Takashi Maruyama

	Nominal RDR	E-Recycle trav. foc.
E CM (GeV)	500	500
N	2.0E+10	5.0E+09
n_b	2625	11000
Tsep (ns)	369.2	90.0
Iave in train (A)	0.0087	0.0089
f_{rep} (Hz)	5	5
P_b (MW)	10.5	11.0
$\gamma\epsilon_x$ (m)	1.0E-05	4.0E-06
$\gamma\epsilon_y$ (m)	4.0E-08	2.0E-08
$\beta_{x/y}$ (mm)	20 / 0.4	20 / 0.4
$\sigma_{x/y}$ (nm)	639 / 5.7	404 / 4.0
σ_z (mm)	0.3	0.6
Dy	19.0	21.2
Uave	0.047	0.009
δ_B	0.023	0.002
P_Beamstrahlung (MW)	0.24	0.024
ngamma	1.29	0.53
Hd	1.70	1.53
Geom Lumi (cm⁻² s⁻¹)	1.14E+34	6.69E+33
Luminosity (cm⁻² s⁻¹)	1.95E+34	1.02E+34

- Spin-off of the study:
- a curiosity
- Parameter sets with very low beamstrahlung

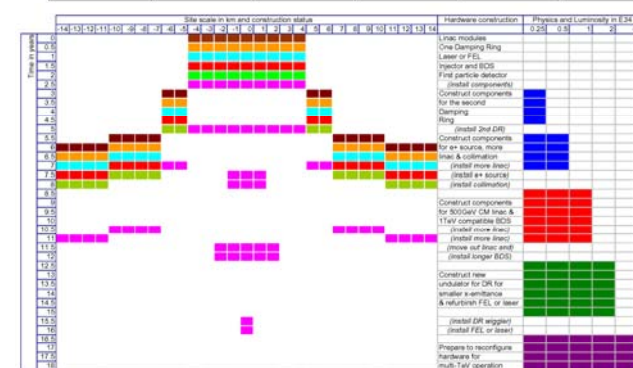
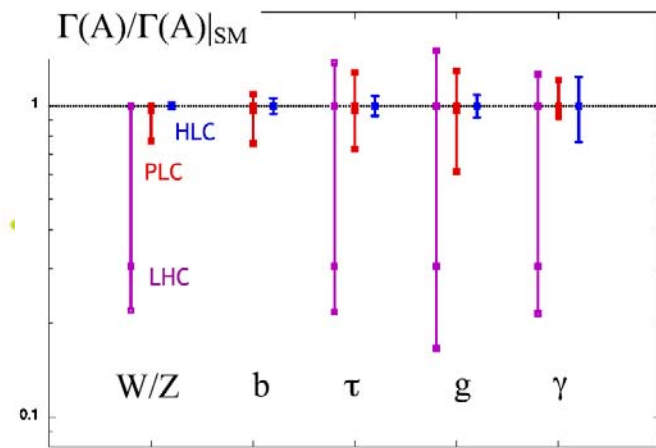


- About 92% of outgoing beam have $dE/E < 1\%$

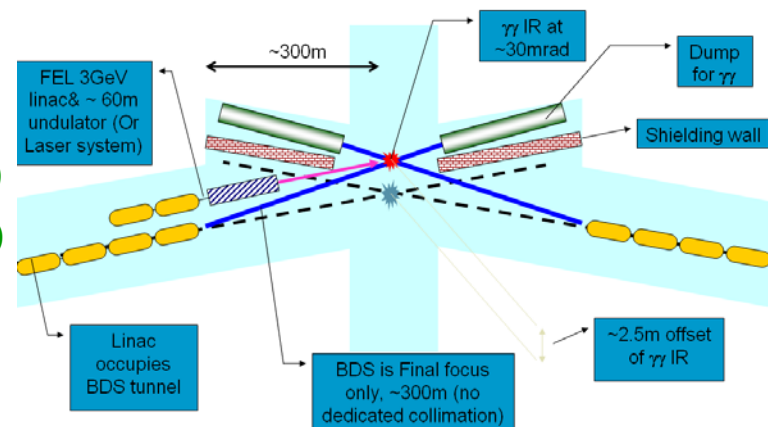


Contribution to the report on staging

Stage	E CM (GeV)	Mode	E reach (GeV)	BDS (km per side)	Total site (km)	Lumi E34	Physics program (yrs)	Features
1st	180	$\gamma\gamma$	128	0.3	8.8	0.25	2	Single DR
2nd	180	$\gamma\gamma$	128	0.3	8.8	0.5	2	Faster kicker or second DR
3rd								
4th	230	e^+e^-	230	0.8	12.1	0.9	3	Add e^+ source Lengthen BDS Add dedicated collimation
5th	500	e^+e^-	500	2.2	27.2	2	5	Lengthen BDS to 1 TeV layout
6th	500	$\gamma\gamma$	400	2.2	27.1	4.5	2	Lower DR x-emittance



180GeV CM $\gamma\gamma$ initial configuration



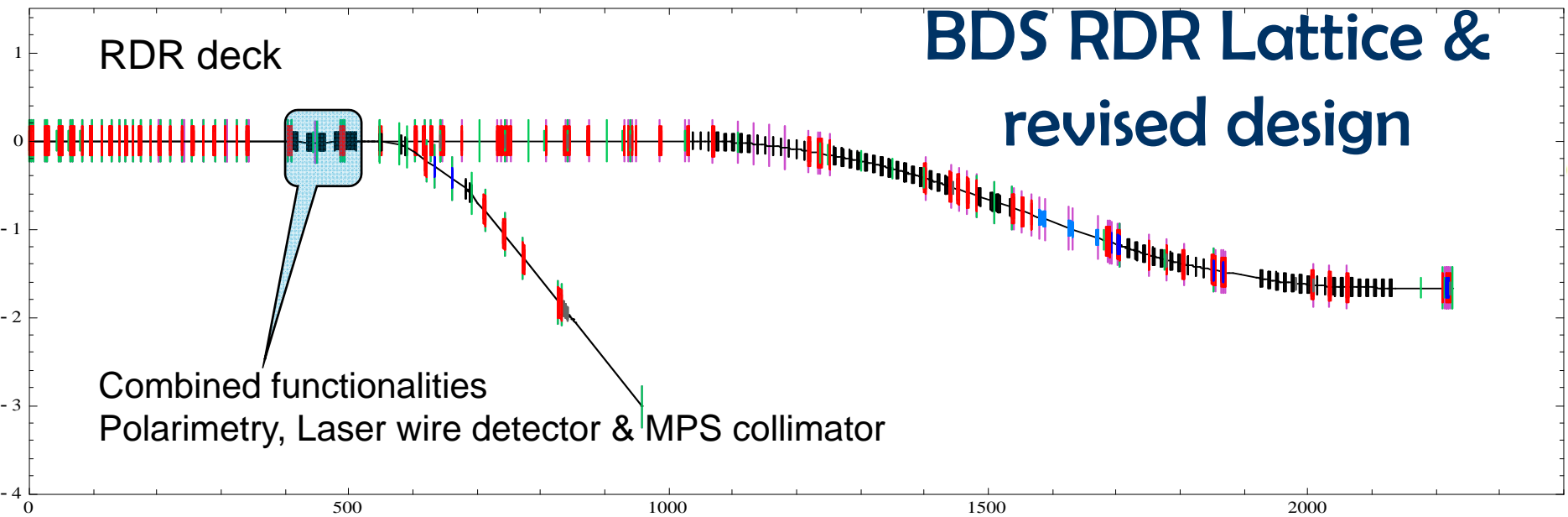
- GDE panel evaluated $\gamma\gamma$ as 1st stage – a report edited by M.Peskin, T.Barklow, J.Gronberg and A.S.
 - Physics case, machine configuration, IP parameters, laser or FEL photon driver, tentative cost
- Cost comparison (P.Garbincius)
 - 180 GEV CM photon collider PLC (costs 52% of ILC RDR)
 - 230 GeV CM e^+e^- collider HLC (costs 67% of ILC RDR)
- Path for further cost reduction of 1st stages outlined
- Enabling technologies described



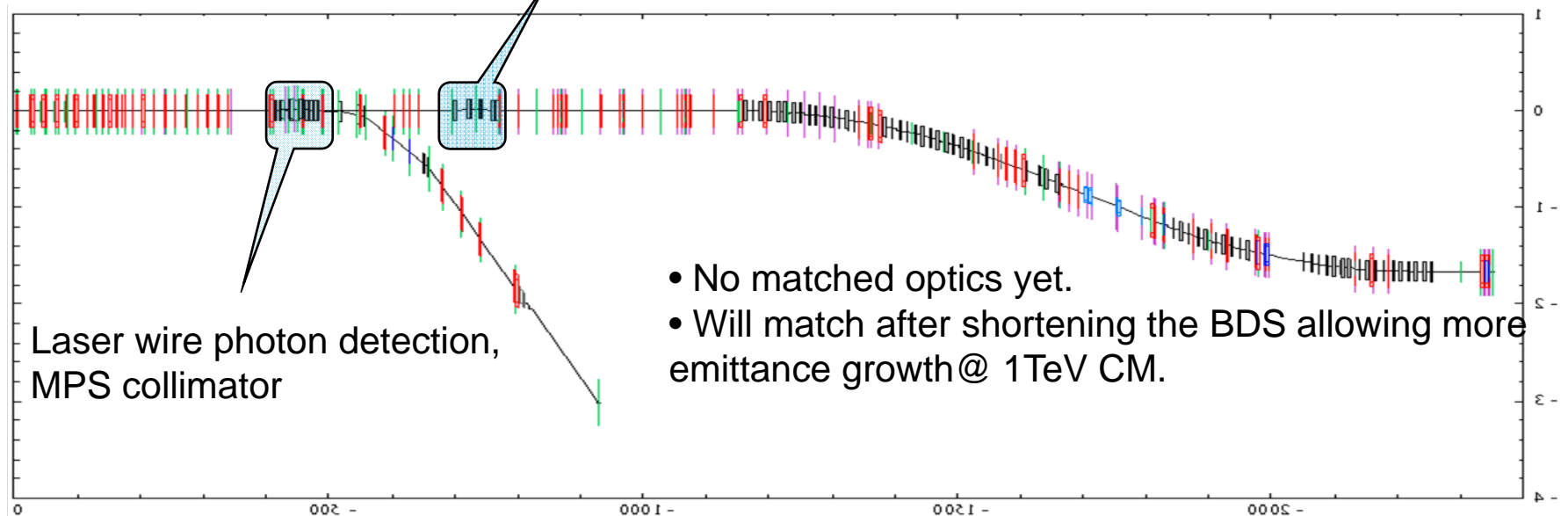
BDS Lattice for revised design

- BDS Lattice design plans:
 - next steps of modifying the RDR deck to separate combined functionalities of upstream polarisation measurements + laser wire detection + MPS
 - Reduction in BDS length to allow more emittance growth @1TeV CM.
 - Changes for minimum machine with central integration region
- The layouts presented here are based on the discussion and actions from the BDS optics meeting of 29/01/09, attended by
 - D.Angal-Kalinin, F. Jackson, J. Jones, Y. Nosochkov, A. Seryi, M.Woodley
 - <http://ilcagenda.linearcollider.org/getFile.py/access?contribId=1&resId=0&materialId=minutes&confId=3344>

BDS RDR Lattice & revised design



Include additional chicane for polarimetry:

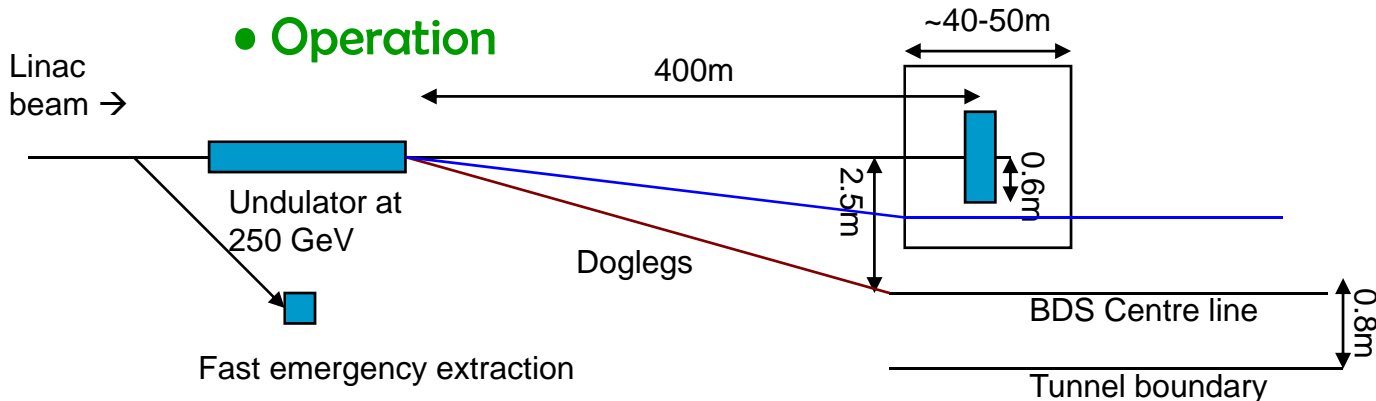
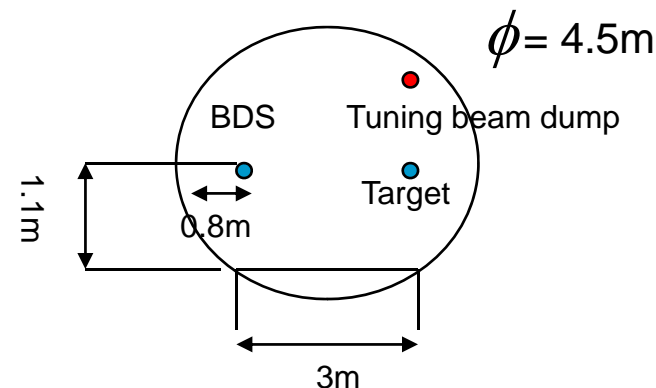




Central region integration : Minimum Machine, BDS

Integration studies needed:

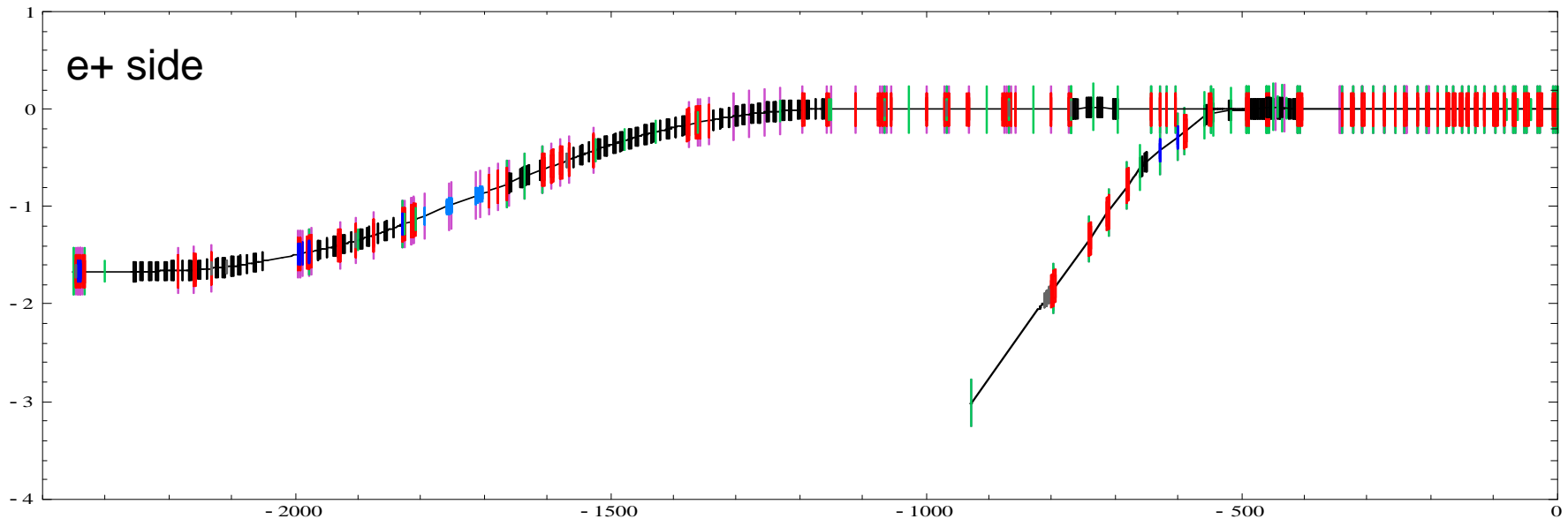
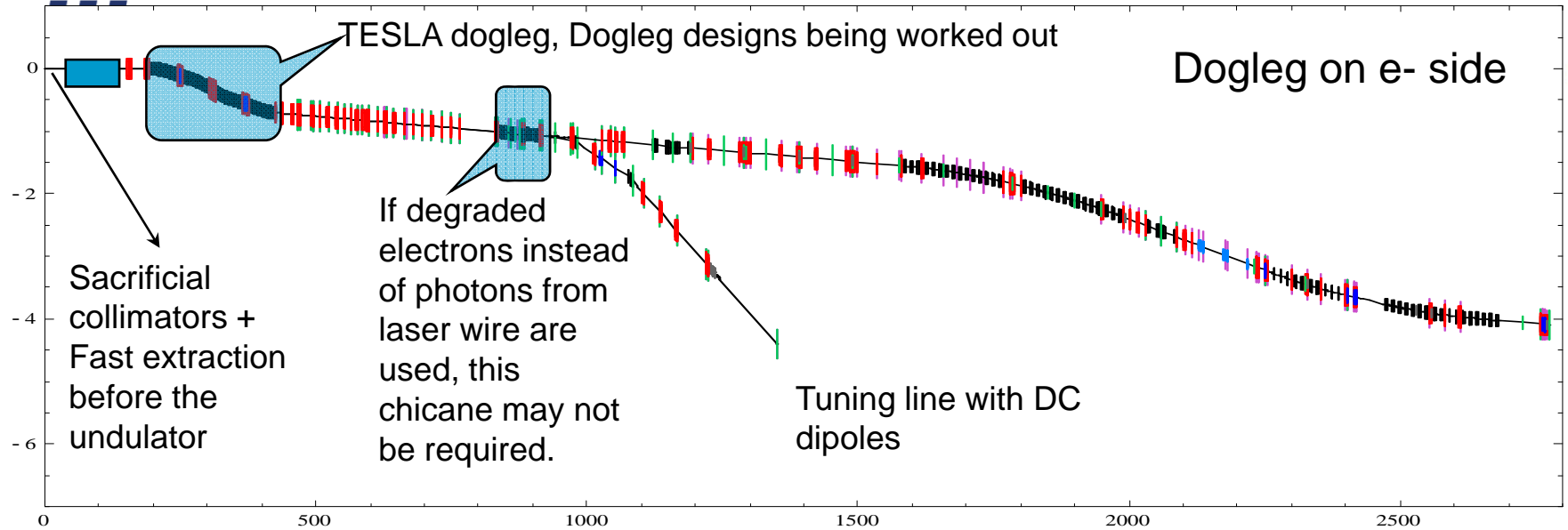
- Radiation
- Optics
- Engineering
- Installation
- Commissioning
- Operation



- 2.5m can be reduced to up to 1.5m if beam passes through a drift space for ~40-50m without any components through the remote shielding block of the target.
- If 2.5 m, not enough space for tuning beam line. Take the beam vertically to beam dump?



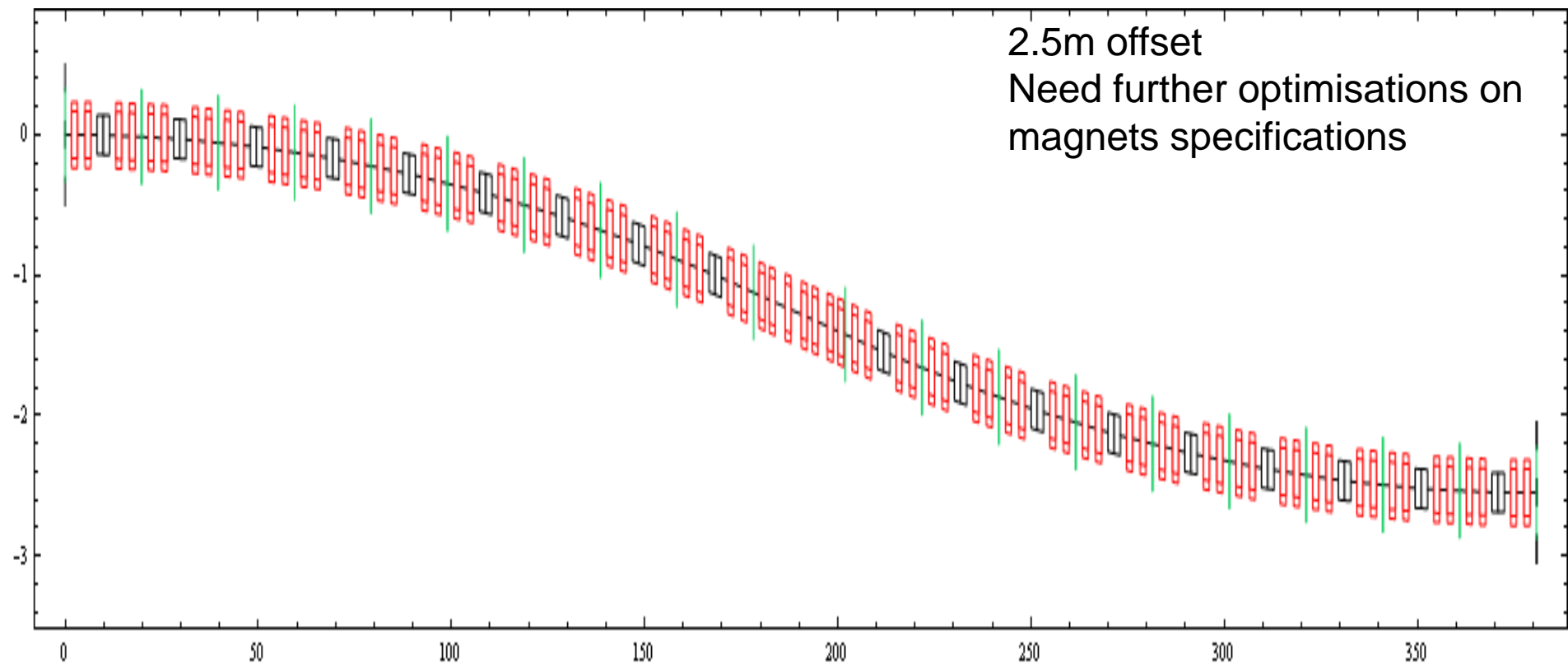
Minimum Machine





Dogleg Chicane Designs

- Studying TME (Theoretical Minimum Emittance) lattices for dogleg with different offsets and missing magnet schemes for smaller offsets.



J. Jones



Plans for optics design

- Revised RDR lattice with
 - Shortened RDR allowing higher emittance growth at 1TeV CM
 - Separate chicane for upstream polarimetry
- Minimum machine with dogleg chicane
 - With different offsets
- Plan to have revised lattices ready by October'09.



Conclusion

- The BDS group, in TDP phase, is focusing on several key areas that may make significant contribution to reduction of cost, risk and increase of machine performance