BDS report

BDS Area leaders

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VLCW06, Vancouver, July 19-22, 2006

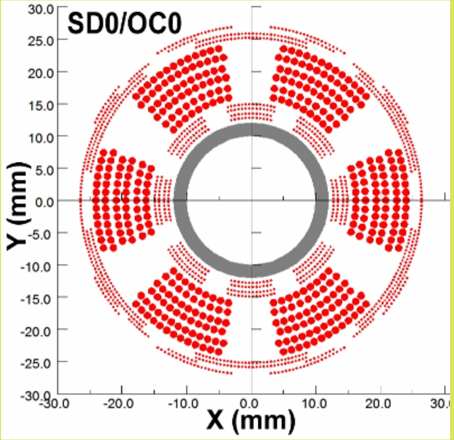
Contents

- Important design updates since Bangalore
- Cost of baseline and other configurations
- Plans

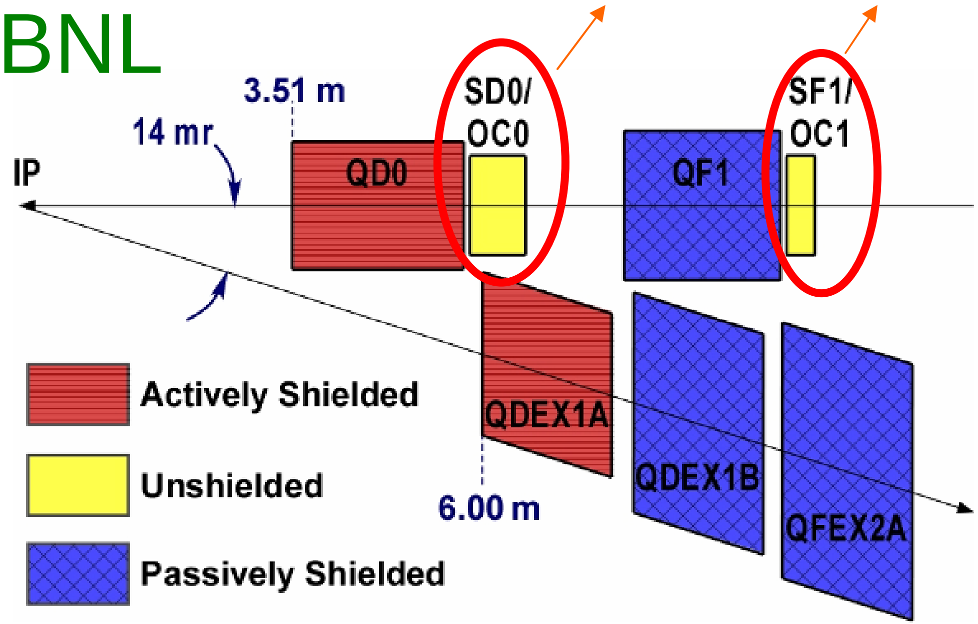
Design updates since Bangalore

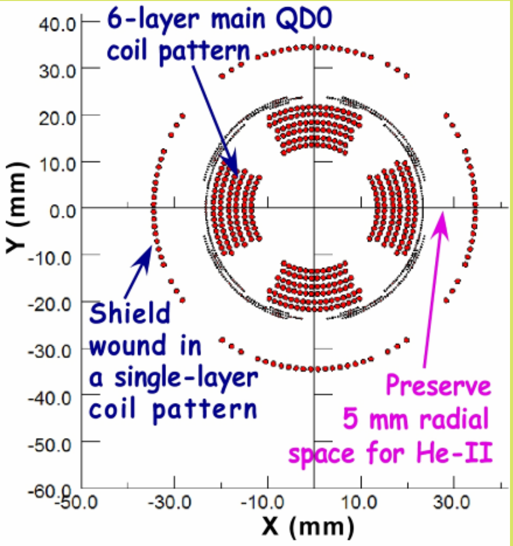
- Prototyping SC magnets for 14mr FD
- Evaluation of losses in extraction lines
- Detailed design of crab cavities
- Design of anti-solenoid & tail-folding octupoles
- Wakes in vacuum chamber
- Studies of SUSY reach
- SR backscattering in 2mrad extraction
- Evaluation of downstream diagnostics
- Work on 0mrad case
- 2mrad extraction magnet brainstorm
- More updates & more details in BDS R&D talk

FD14: SD0/OC0 prototype



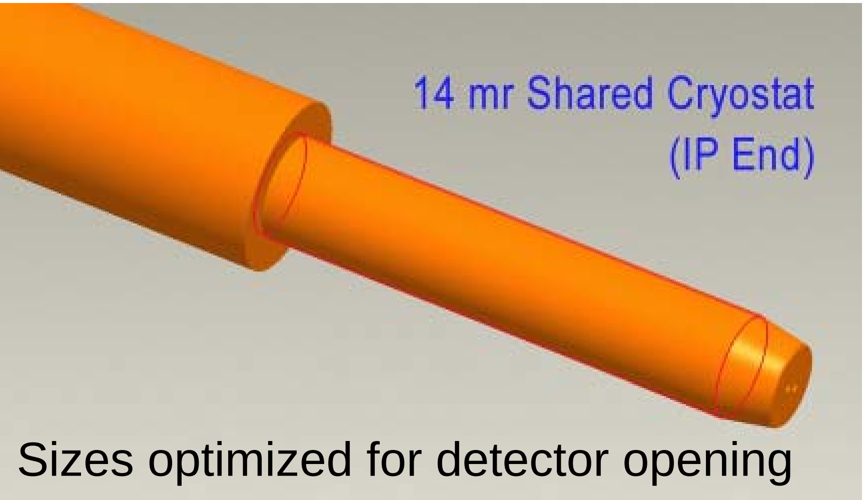
BNL





QD0 short model successfully tested earlier

FD14 design



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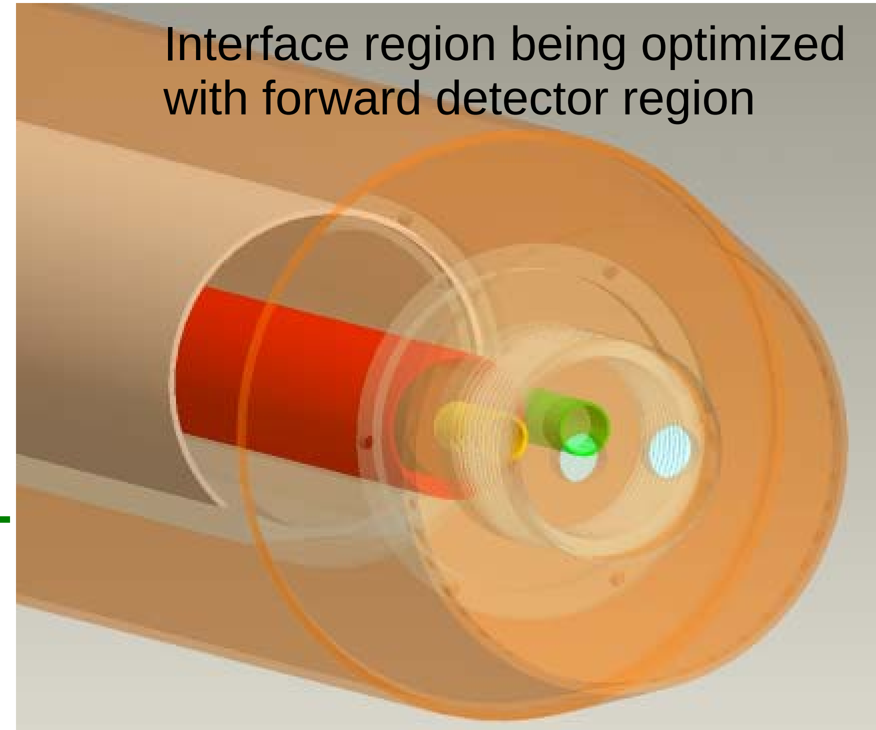
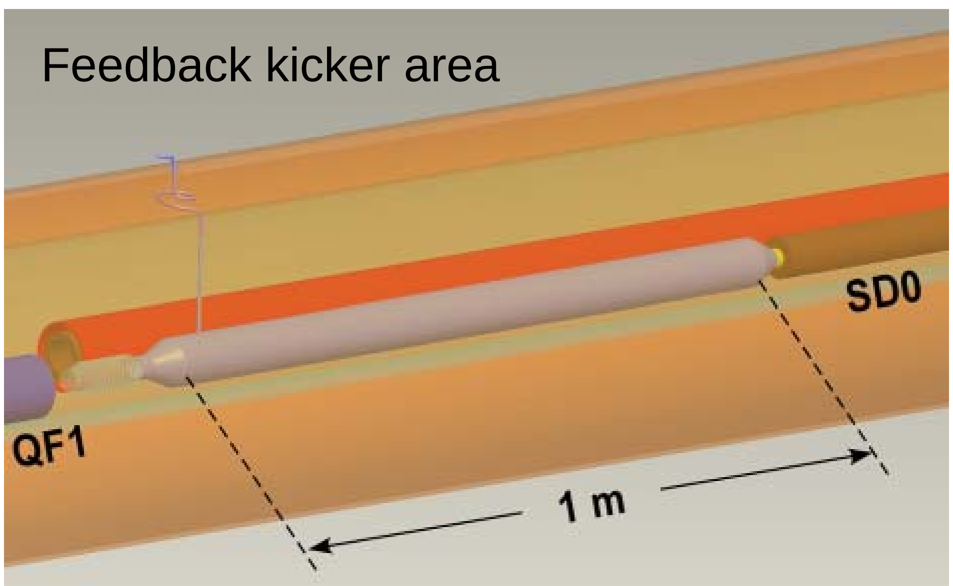




Focus on 14mr design to push technology

Size and interface of shared cryostat being optimized with detector

Feedback area being designed

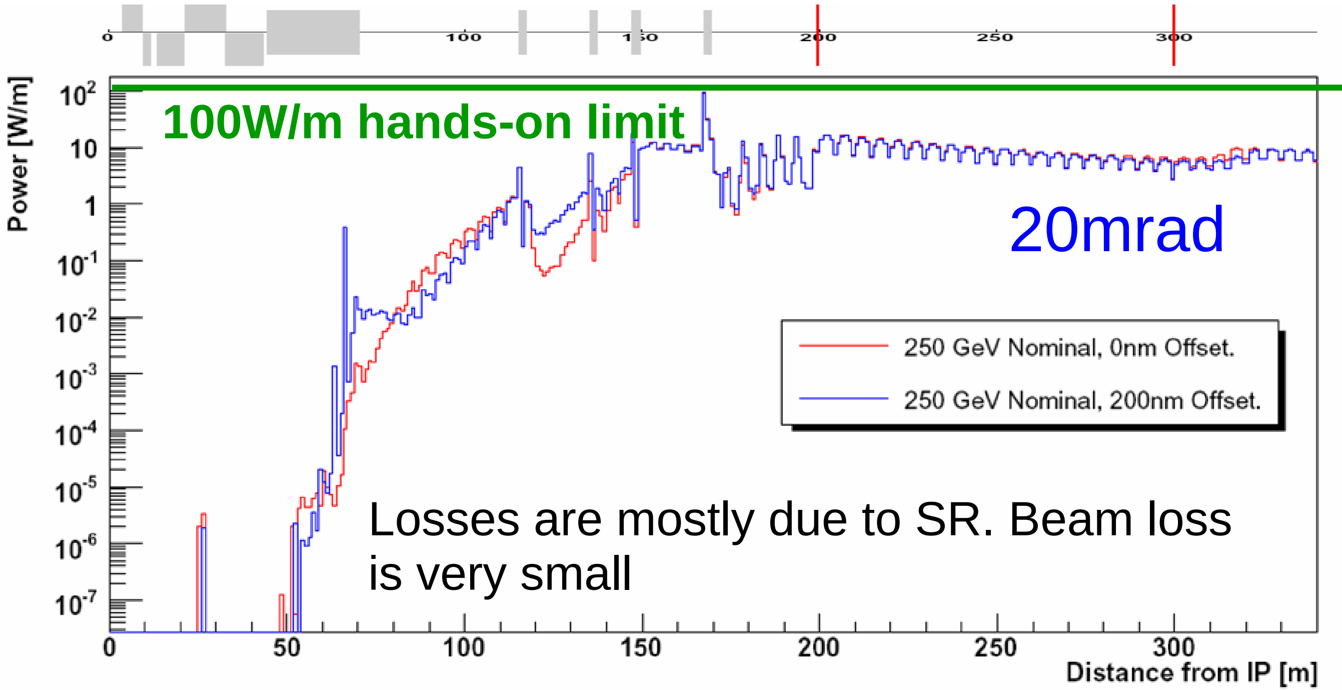
Losses in extraction line

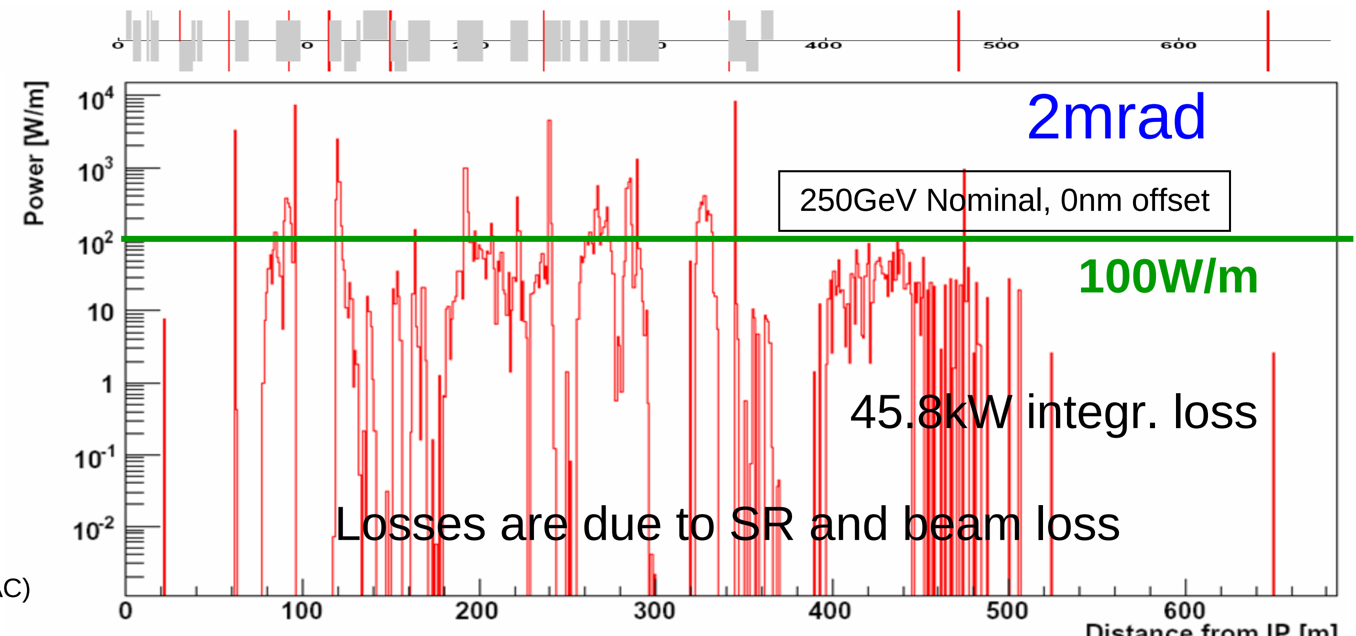
20mr: losses < 100W/m at 500GeV CM and 1TeV CM

2mr: losses are at 100W/m level for 500GeV CM and exceed this level at 1TeV

Radiation conditions and shielding to be studied

J. Carter, I. Agapov, G.A. Blair, L. Deacon (JAI/RHUL), A.I. Drozhdin, N.V. Mokhov (Fermilab), Y.M. Nosochkov, A.A. Seryi (SLAC)





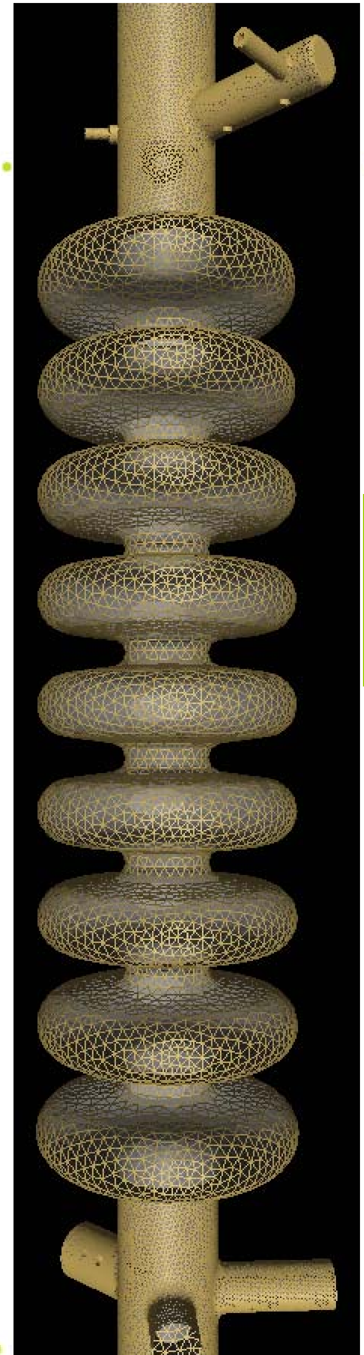
Crab cavity

Right: earlier prototype of 3.9GHz deflecting (crab) cavity designed and build by Fermilab.

Left: Cavity modeled in Omega3P, to optimize design of the LOM, HOM and input couplers.

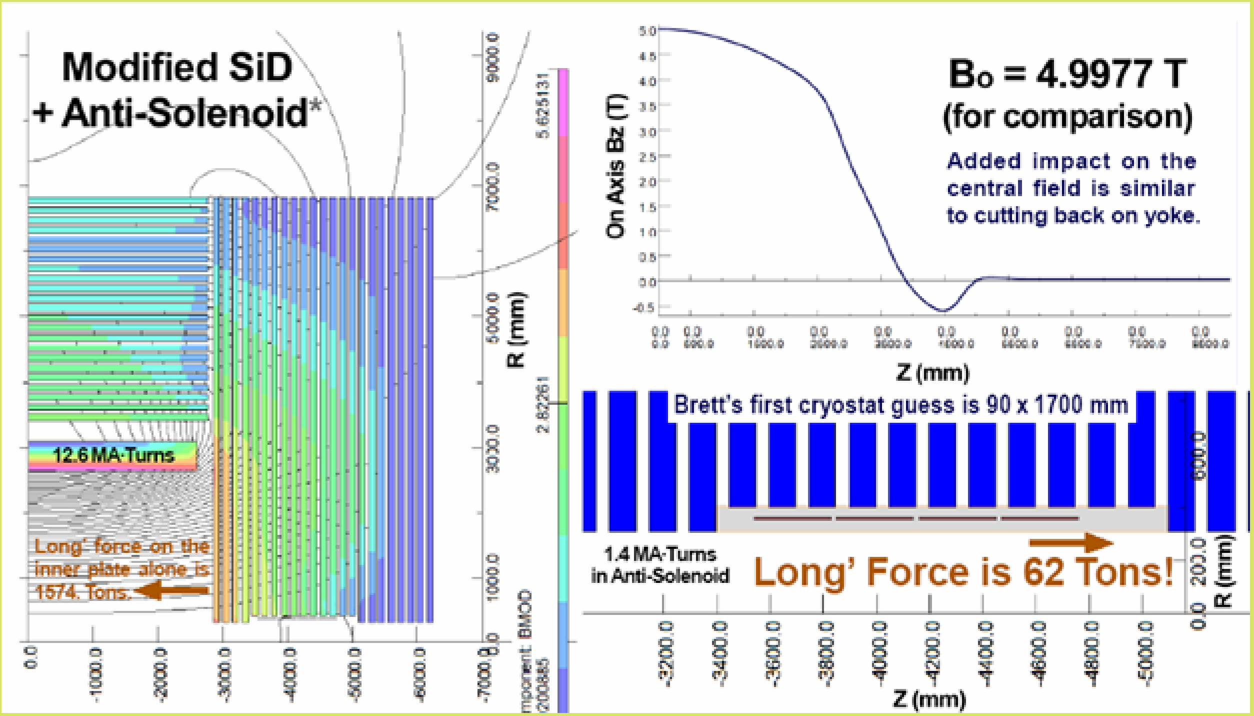
FNAL T. Khabibouline, L.Bellantoni, et al., SLAC K.Ko et al., Daresbury P. McIntosh, G.Burt, et al.

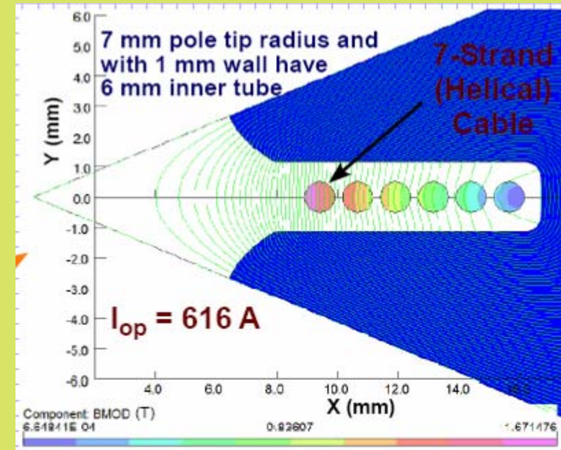
Collaboration of FNAL, SLAC and UK labs is working on the design.



Submitted coordinated UK & US plans to design and build ILC compatible crab cavity & develop phase stabilization

Tail folding octupoles & antisolenoids





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

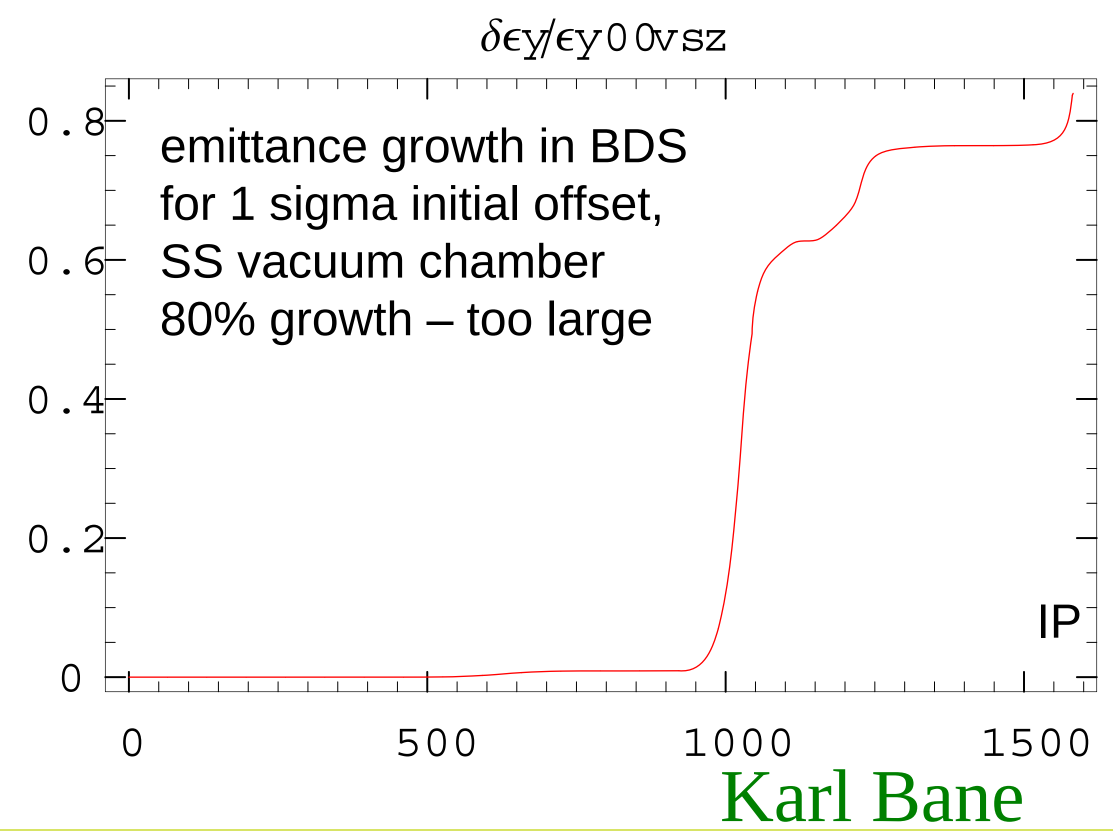
BNL; P.Parker et al.

Wakes in vacuum chamber

Emittance growth for SS vacuum chamber is unacceptably large

Partial change to Cu or Al chamber and optimization of aperture reduces the growth to ~5% for 1σ initial offset

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



Benchmarks for evaluation of ILC detectors

Reaction which cares most about crossing angle is

$$ee \to \tilde{\tau}_1^+\tilde{\tau}_1^-,\ \tilde{\chi}_1^+\tilde{\chi}_1^-\ \text{(Point 3)}$$

Detection is challenged by copious

$$ee \to \tau\tau ee$$

which require low angle tagging.

Tagging is challenged by background from pairs and presence of exit hole

TABLE II: Benchmark reactions for the evaluation of ILC detectors

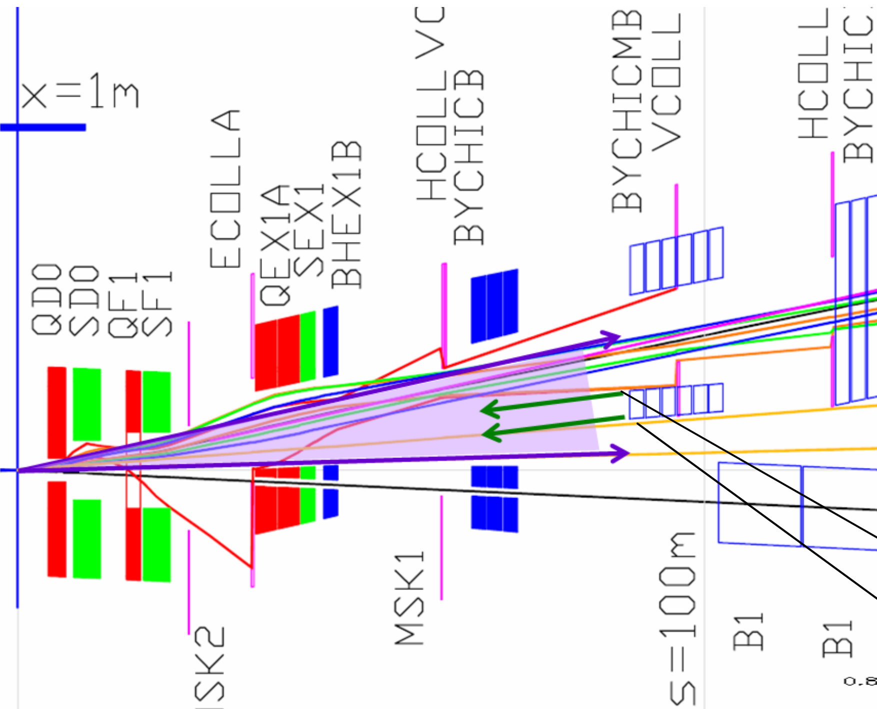
	Process and Final states	Energy (TeV)	Observables	Target Accuracy	Detector Challenge	Notes
Higgs	$ee \to Z^0h^0 \to \ell^+\ell^- X$	0.35	M_{recoil}, σ_{Zh}, BR_{bb}	$\delta\sigma_{Zh} = 2.5\%$, $\delta BR_{bb} = 1\%$	T	{1}
	$ee \to Z^0h^0$, $h^0 \to b\bar{b}/c\bar{c}/\tau\tau$	0.35	Jet flavour , jet $(E, \vec{p})$	δM_h=40 MeV, $\delta(\sigma_{Zh} \times BR)$=1%/7%/5%	V	{2}
	$ee \to Z^0h^0, h^0 \to WW^*$	0.35	M_Z, M_W, σ_{qqWW^*}	$\delta(\sigma_{Zh} \times BR_{WW^*})$=5%	C	{3}
	$ee \to Z^0h^0/h^0\nu\bar{\nu}$, $h^0 \to \gamma\gamma$	1.0	$M_{\gamma\gamma}$	$\delta(\sigma_{Zh} \times BR_{\gamma\gamma})$=5%	C	{4}
	$ee \to Z^0h^0/h^0\nu\bar{\nu}$, $h^0 \to \mu^+\mu^-$	1.0	$M_{\mu\mu}$	5σ Evidence for $M_h = 120$ GeV	T	{5}
	$ee \to Z^0h^0, h^0 \to invisible$	0.35	σ_{qqE}	5σ Evidence for $BR_{invisible}$=2.5%	C	{6}
	$ee \to h^0\nu\bar{\nu}$	0.5	$\sigma_{bb\nu\nu}$, M_{bb}	$\delta(\sigma_{\nu\nu h} \times BR_{bb}) = 1\%$	C	{7}
	$ee \to t\bar{t}h^0$	1.0	σ_{tth}	δg_{tth}=5%	C	{8}
	$ee \to Z^0h^0h^0$, $h^0h^0\nu\bar{\nu}$	0.5/1.0	σ_{Zhh}, $\sigma_{\nu\nu hh}$, M_{hh}	δg_{hhh}=20/10%	C	{9}
SSB	$ee \to W^+W^-$	0.5		$\Delta\kappa_\gamma, \lambda_\gamma = 2 \cdot 10^{-4}$	V	{10}
	$ee \to W^+W^-\nu\bar{\nu}/Z^0Z^0\nu\bar{\nu}$	1.0	σ	$\Lambda_{*4}, \Lambda_{*5} = 3$ TeV	C	{11}
SUSY	$ee \to \tilde{e}_R^+\tilde{e}_R^-$ (Point 1)	0.5	E_e	$\delta M_{\tilde{\chi}_1^0}$=50 MeV	T	{12}
	$ee \to \tilde{\tau}_1^+\tilde{\tau}_1^-$, $\tilde{\chi}_1^+\tilde{\chi}_1^-$ (Point 1)	0.5	E_π, $E_{2\pi}$, $E_{3\pi}$	$\delta(M_{\tilde{\tau}_1} - M_{\tilde{\chi}_1^0})$=200 MeV	T	{13}
	$ee \to \tilde{t}_1\tilde{t}_1$ (Point 1)	1.0		$\delta M_{\tilde{t}_1}$=2 GeV		{14}
-CDM	$ee \to \tilde{\tau}_1^+\tilde{\tau}_1^-$, $\tilde{\chi}_1^+\tilde{\chi}_1^-$ (Point 3)	0.5		$\delta M_{\tilde{\tau}_1}$=1 GeV, $\delta M_{\tilde{\chi}_1^0}$=500 MeV,	F	{15}
	$ee \to \tilde{\chi}_2^0\tilde{\chi}_3^0$, $\tilde{\chi}_1^+\tilde{\chi}_1^-$ (Point 2)	0.5	M_{jj} in $jj\not{E}$, $M_{\ell\ell}$ in $jj\ell\ell\not{E}$	$\delta\sigma_{\tilde{\chi}_2\tilde{\chi}_3} = 4\%$, $\delta(M_{\tilde{\chi}_2^0} - M_{\tilde{\chi}_1^0})$= 500 MeV	C	{16}
	$ee \to \tilde{\chi}_1^+\tilde{\chi}_1^-/\tilde{\chi}_i^0\tilde{\chi}_j^0$ (Point 5)	0.5/1.0	$ZZ\not{E}$, $WW\not{E}$	$\delta\sigma_{\tilde{\chi}\tilde{\chi}}$=10%, $\delta(M_{\tilde{\chi}_3^0} - M_{\tilde{\chi}_1^0})$ =2 GeV	C	{17}
	$ee \to H^0A^0 \to b\bar{b}b\bar{b}$ (Point 4)	1.0	Mass constrained M_{bb}	δM_A=1 GeV	C	{18}
-alternative	$ee \to \tilde{\tau}_1^+\tilde{\tau}_1^-$ (Point 6)	0.5	Heavy stable particle	$\delta M_{\tilde{\tau}_1}$	T	{19}
SUSY	$\tilde{\chi}_1^0 \to \gamma + \not{E}$ (Point 7)	0.5	Non-pointing γ	$\delta c\tau$=10%	C	{20}
breaking	$\tilde{\chi}_1^\pm \to \tilde{\chi}_1^0 + \pi_{soft}^\pm$ (Point 8)	0.5	Soft $\pi^\pm$ above $\gamma\gamma$ bkgd	5σ Evidence for $\Delta\tilde{m}$=0.2-2 GeV	F	{21}
Precision SM	$ee \to t\bar{t} \to 6$ *jets*	1.0		5σ Sensitivity for $(g-2)_t/2 \le 10^{-3}$	V	{22}
	$ee \to f\bar{f}$ $(f = e, \mu, \tau; b, c)$	1.0	σ_{ff}, A_{FB}, A_{LR}	5σ Sensitivity to $M_{Z_{LR}} = 7$ TeV	V	{23}
New Physics	$ee \to \gamma G$ (ADD)	1.0	$\sigma(\gamma + \not{E})$	5σ Sensitivity	C	{24}
	$ee \to KK \to f\bar{f}$ (RS)	1.0			T	{25}
Energy/Lumi	$ee \to ee_{fwd}$	0.3/1.0		δM_{top}=50 MeV	T	{26}
Meas.	$ee \to Z^0\gamma$	0.5/1.0			T	{27}

Physics Benchmarks for the ILC Detectors, hep-ex/0603010,
M. Battaglia, T. Barklow, M. E. Peskin, Y. Okada, S. Yamashita, P. Zerwas

Study of SUSY reach

- SUSY reach is challenged for the large crossing angle when Δm (slepton-neutralino) is small
- Studies presented at Bangalore (V.Drugakov) show that for 20mrad+DID (effectively ~40mrad for outgoing pairs), due to larger pairs background, one cannot detect SUSY dark matter if Δm=5GeV
- The cases of 20 or 14mrad with anti-DID have same pairs background as 2mrad. Presence of exit hole affects detection efficiency slightly. The SUSY discovery reach may be very similar in these configurations
- Several groups are studying the SUSY reach, results may be available after Vancouver

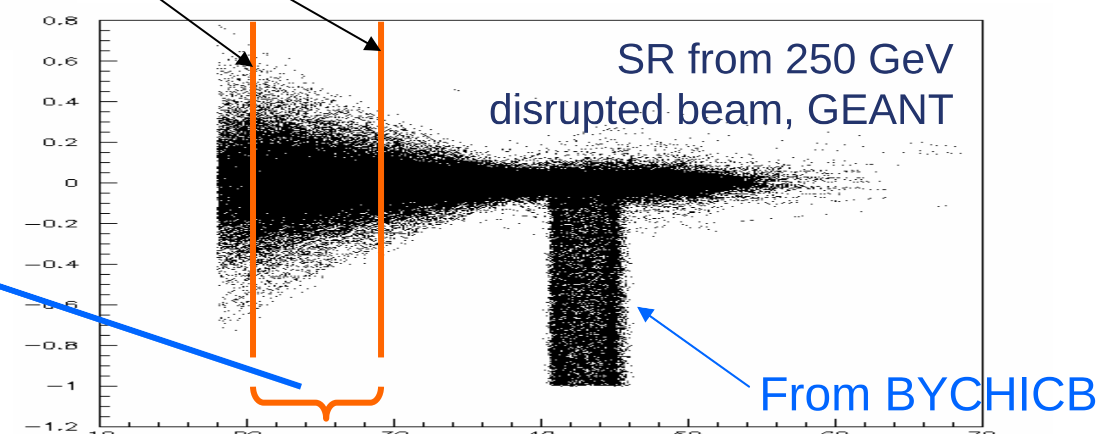
Backscattering of SR



Photon flux within 2 cm BeamCal aperture:

	Rate	#γs at IP/BX	#γs in SiTracker from pairs
250 GeV	$1.1x10^{-8}$	2200	700
500 GeV	$2.9x10^{-8}$	11700	1900

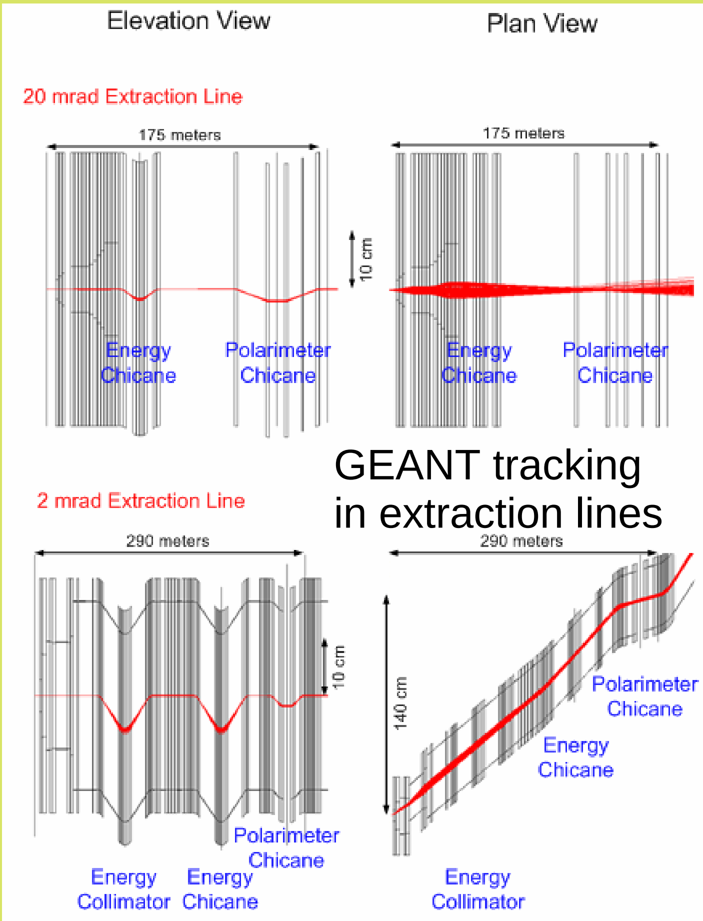
Flux is 3-6 times larger than from pairs.
More studies & optimization needed



FD produce SR and part will hit BYCHICMB surface
Total Power = 2.5 kW
<Eγ>=11MeV (for 250GeV/beam)

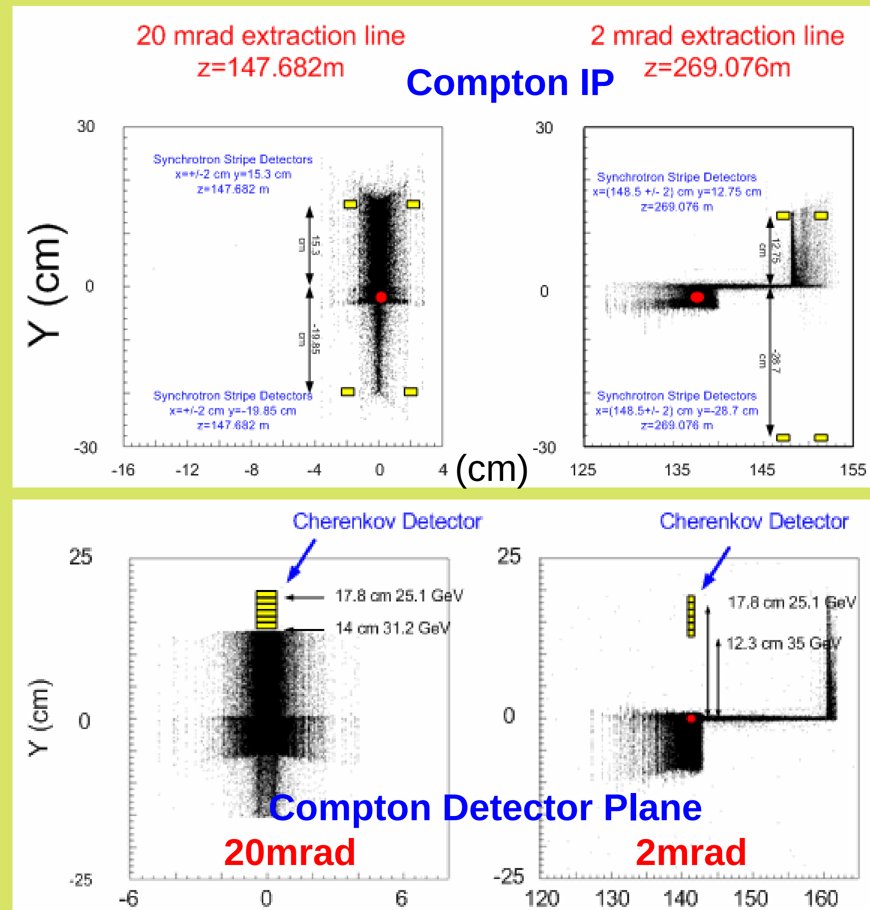
Takashi Maruyama

Downstream diagnostics evaluation (1)



GEANT tracking in extraction lines

Study achievable precision of polarization and energy measurements, background & signal/noise, requirements for laser, etc.



Ken Moffeit, Takashi Maruyama, Yuri Nosochkov, Andrei Seryi, Mike Woods (SLAC), William P. Oliver (Tufts University), Eric Torrence (Univ. of Oregon)

Downstream diagnostics evaluation (2)

Comparisons for 250GeV/beam	20mr	2mr
Beam overlap with 100mm laser spot at Compton IP	48%	15%
Polarization projection at Compton IP	99.85%	99.85%
Beam loss form IP to Compton IP	<1E-7	>2.6E-4
Beam SR energy loss from IP to middle of energy chicane	119MeV	854MeV
Variation of SR energy loss due to 200nm X offset at IP	< 5MeV (< 20 ppm)	25.7MeV (~100 ppm)
The need for SR collimator at the Cherenkov detector	yes	No

comparable with the goal for E precision measurements

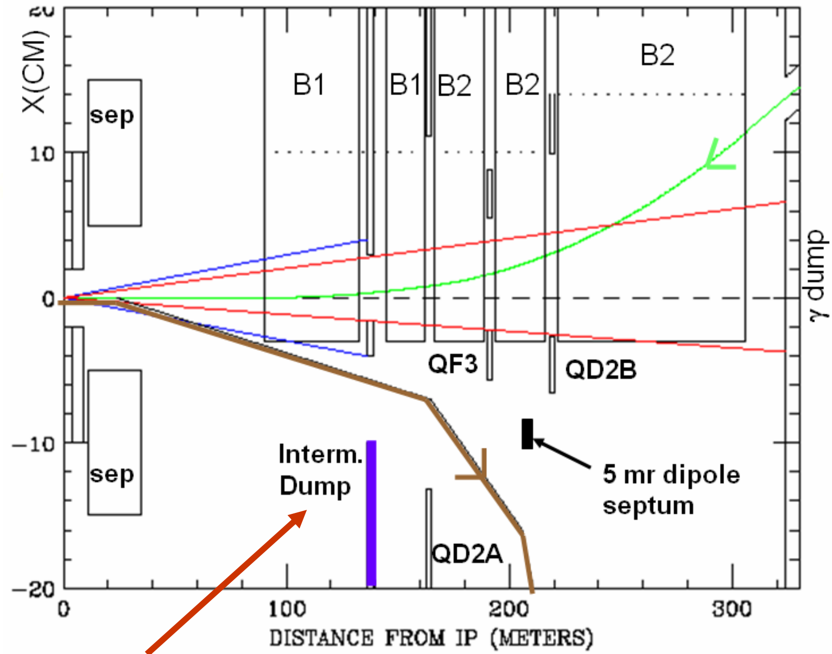
Recent work on 0mr

Put together a full optics with downstream diagnostics (FF is optimized for this case)

Design only for 500GeV CM, and bunch separation 307ns or more

A lot more design work is needed before it could be fully evaluated

Design for 1TeV to be studied

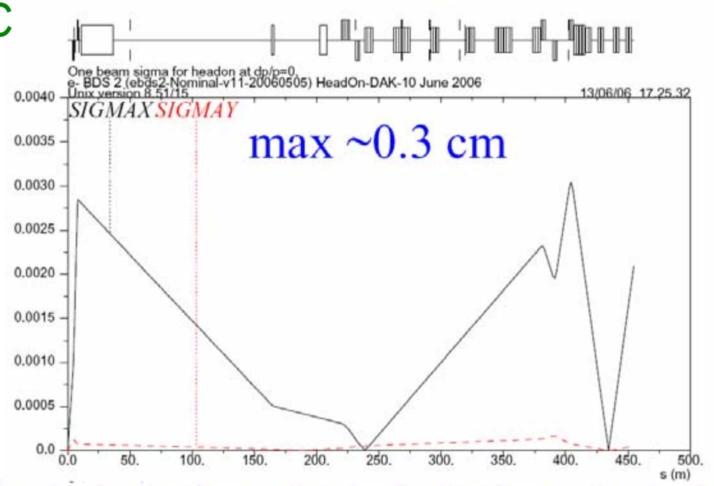


Intermediate dump need to collimate tail up to ΔE=-10%

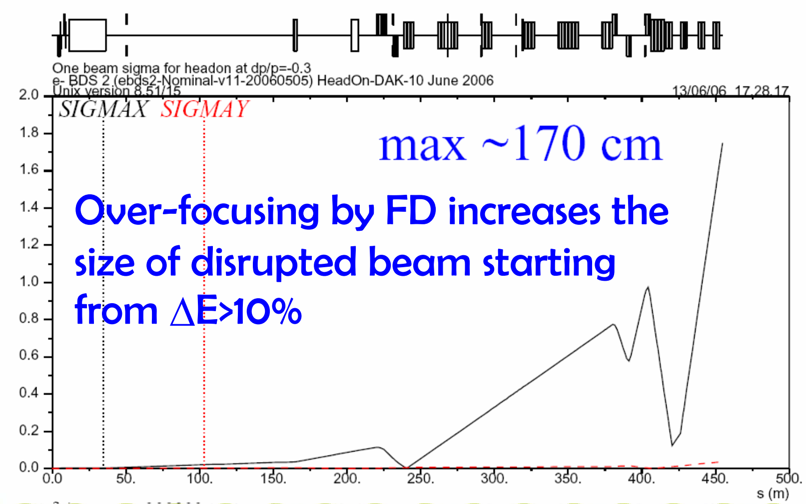
UK-France-SLAC task force

J.Payet, O.Napoly, C.Rippon, D.Uriot, D.Angal-Kalinin, F.Jackson, M.Alabau-Pons, P.Bambade, J.Brossard, O.Dadoun, C.Rimbault, L.Keller, Y.Nosochkov, A.Seryi, R.Appleby

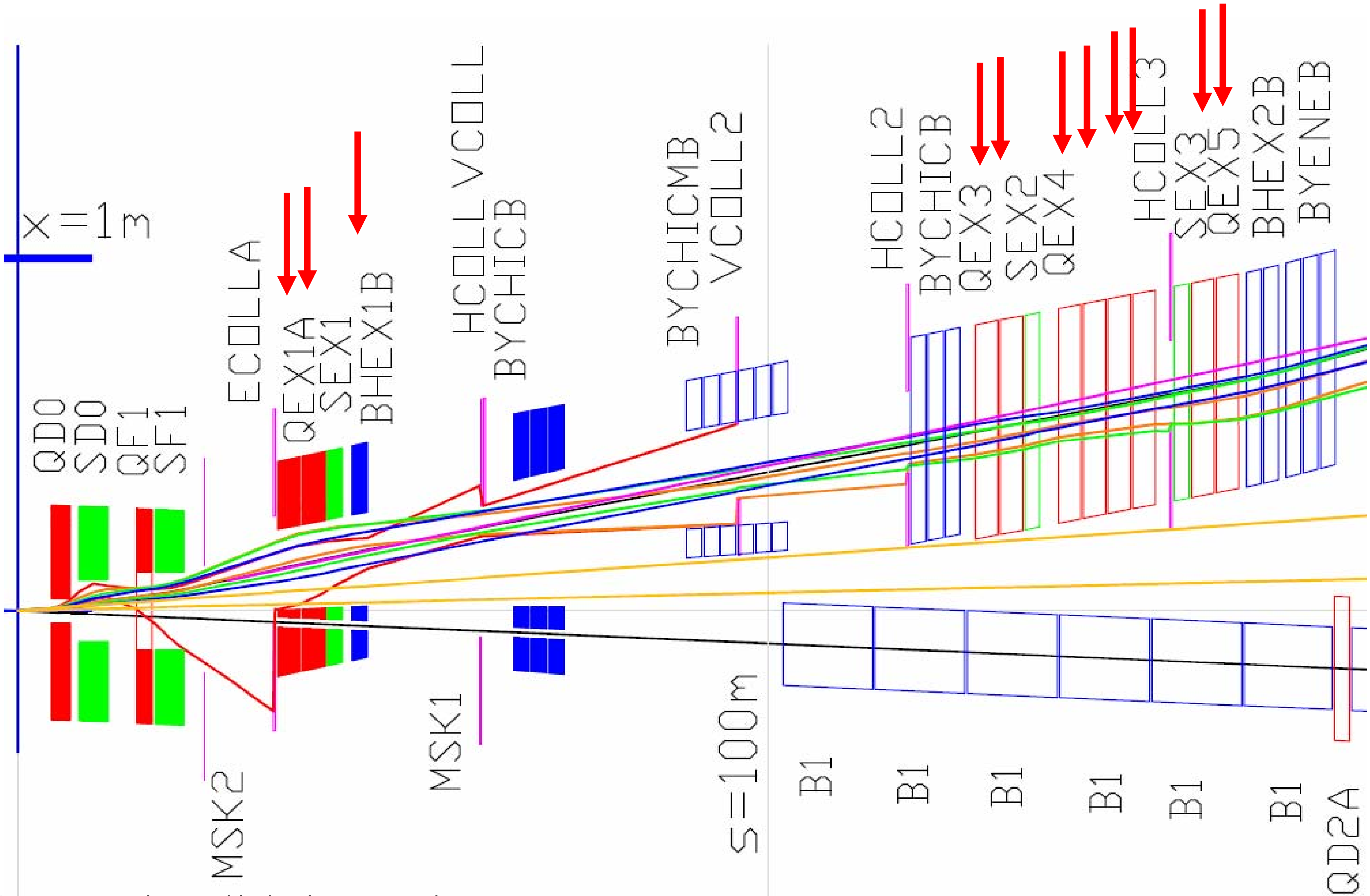
0 mrad disrupted $\sqrt{\beta\varepsilon}$ at 250 GeV



0 mrad $\sqrt{\beta\varepsilon}$ at Δp/p = -30%



Brainstorm to design magnets in 2mrad extraction

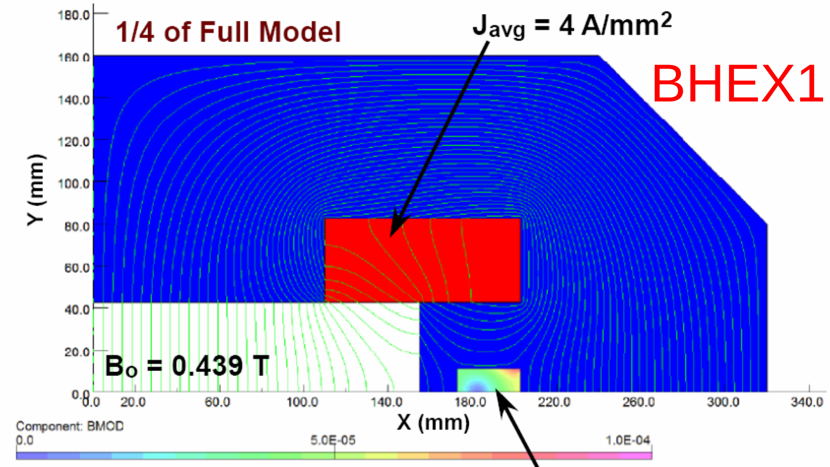


Some magnet sizes on this drawing are tentative

Brainstorm for 2mrad magnets

Recent suggestions

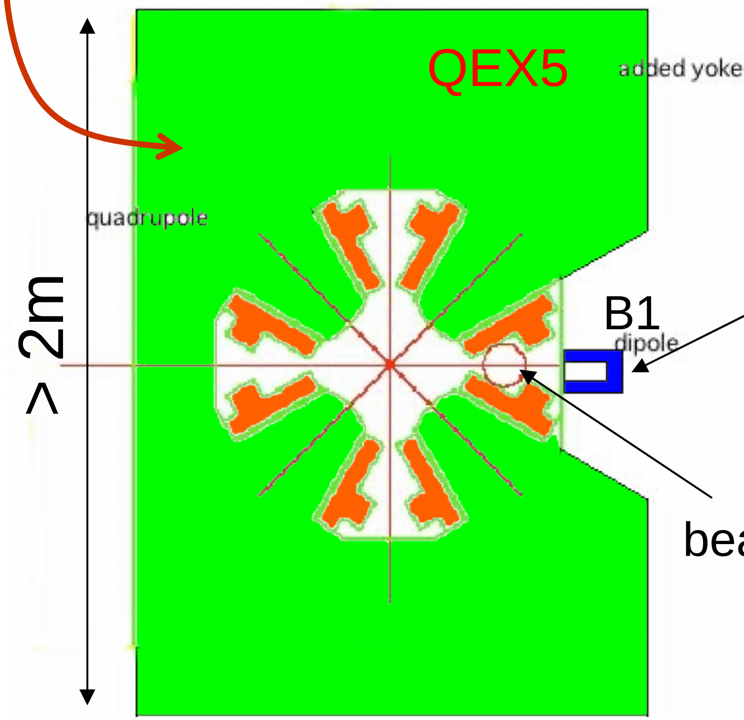
Clear aperture is 305 x 80 mm for a 2.5 mm wall thickness



|B| is about 1 gauss inside cutout region

Make simple racetrack coils that go around poles and insert right/left cutouts with beam pipes during final assembly.

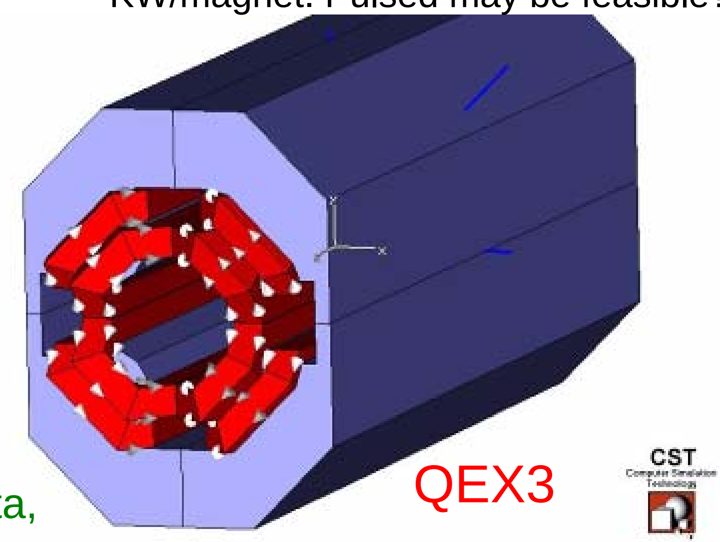
Power @ 1TeV CM is 1MW/magnet. Temperature rise is very high. Use of HTS? Pulsed? Further feasibility study and design optimization are needed



should have 6-60GS field!

beamstrahlung

Power @ 1TeV CM is 635-952 KW/magnet. Pulsed may be feasible?



Vladimir Kashikhin , Brett Parker, John Tompkins, Cherrill Spencer, Masayuki Kumada, Koji Takano, Yoshihisa Iwashita, Eduard Bondarchuk, Ryuhei Sugahara

2 mrad extraction magnet status

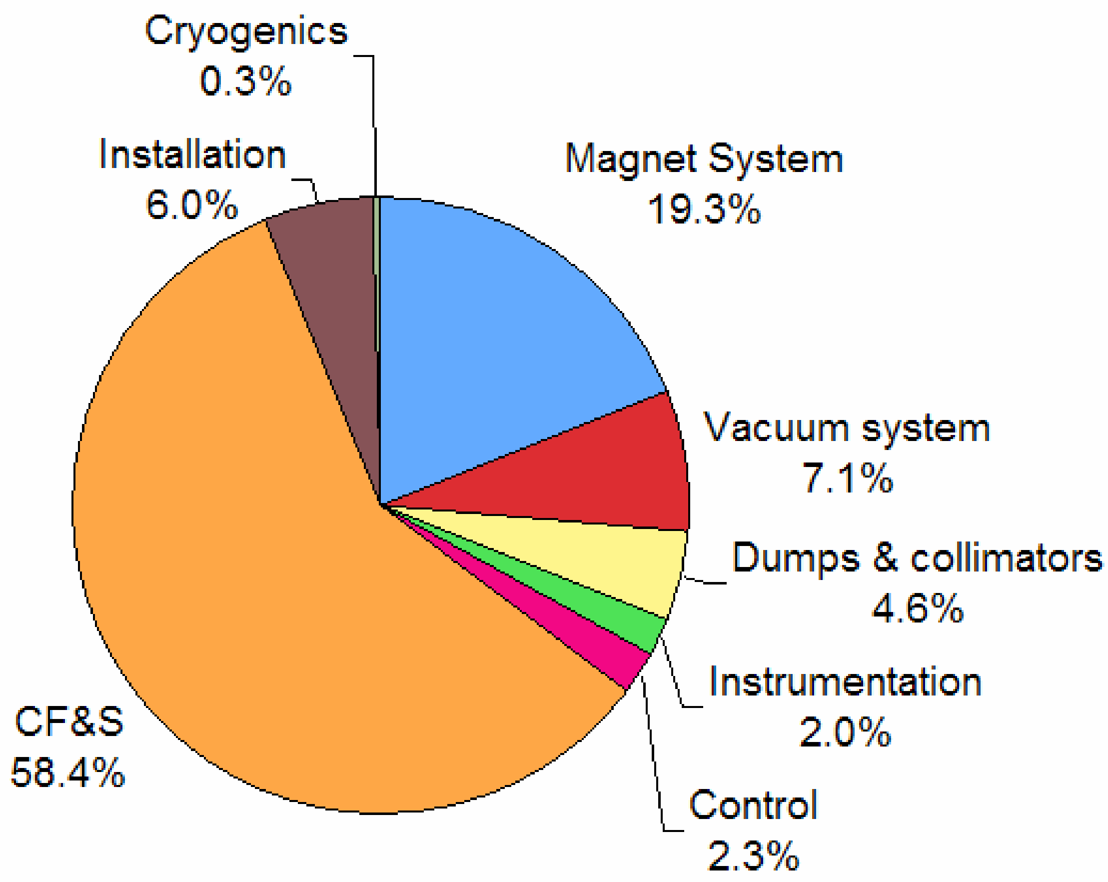
- There were a lot of recent work and ideas
- Some of recent suggested designs did not take all constraints into account
- It appears that there is a chance that a working design would be found, if not DC then pulsed magnets
- There is a lot of work and R&D to be done to come to a reasonable design
- Implications for operation and MPS to be studied, mitigations to be found
- For the cost, assigned same as QEX6 for these magnets

BDS cost status

- So far haven't received:
  - **cost of kickers & septa**
  - **cost of anti-solenoids**
  - **some CF&S costs not available, e.g. beam dump enclosures**
  - **use estimated placeholder for these costs**
- Some items may be missing, like part of support for FD, cost of concrete neutron wall, etc.
- Overall > 90% complete
- **The design and cost is for 1TeV CM**

Overall cost: BDS 20/2 baseline

- Cost drivers
  - **CF&S**
  - **Magnet system**
  - **Vacuum system**
  - **Installation**
  - **Dumps & Colls.**
- They are analyzed below



Cost of different configuration

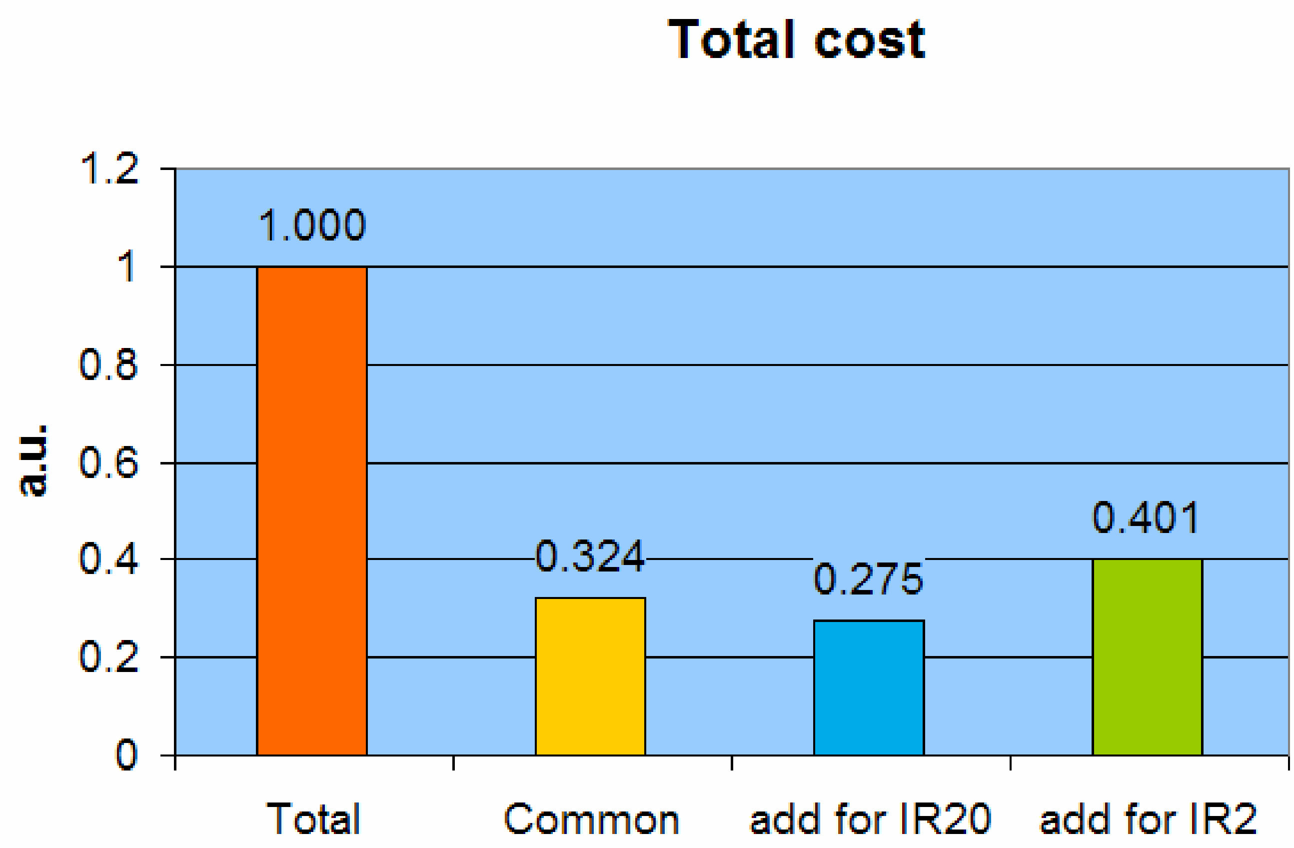
- The WBS includes counts, lengths, or cost fractions from different subsystems of BDS:

Example

							comm			spec			large			small	total	IR20	IR2
WBS	Description			BSY1	BSY2	BSYD		IRT1	IRT2		FF1	DL1		FF2	DL2				
1.6	BDS																		
		1.6.1.1	D166L1000	0	0	0	0	0	0	0	0	12	12	0	0	0	12	12	0
		1.6.1.2	D166L2000	0	0	0	0	0	0	0	0	16	16	0	0	0	16	16	0
		1.6.1.3	D20L12000	0	0	0	0	0	0	0	60	0	60	60	0	60	120	60	60

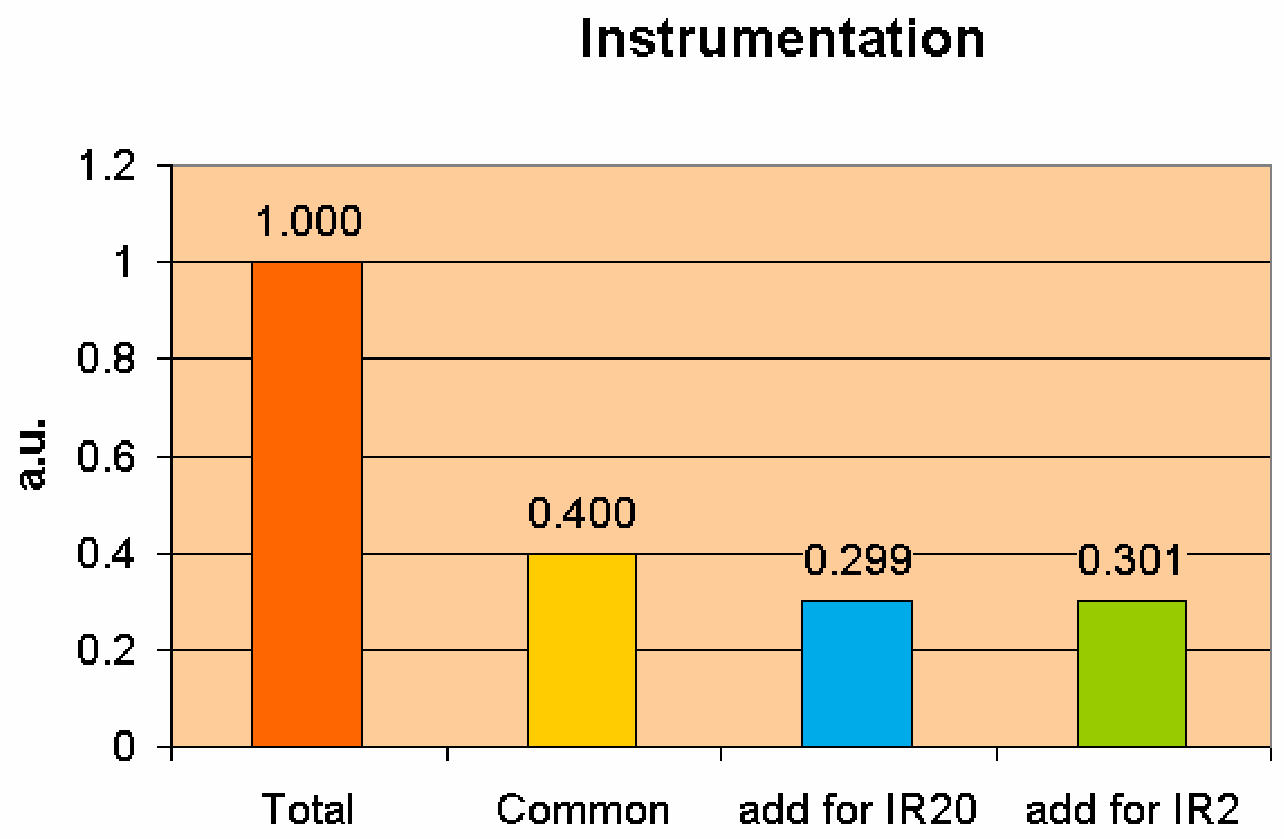
- WBS has ~240 input lines * 39columns not including the sub-WBSs
- This allows calculating the total cost and also the common cost, additional cost for 20mrad IR and additional cost for 2mrad IR

Overall cost split: BDS 20/2



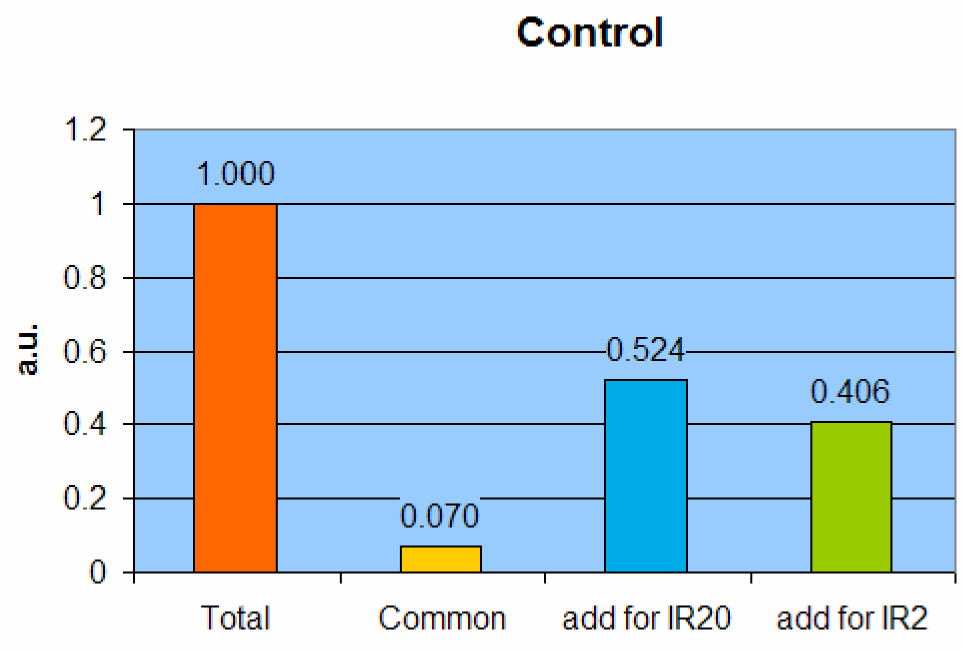
- Additional costs for IR20 and IR2 are different
- They are explained below

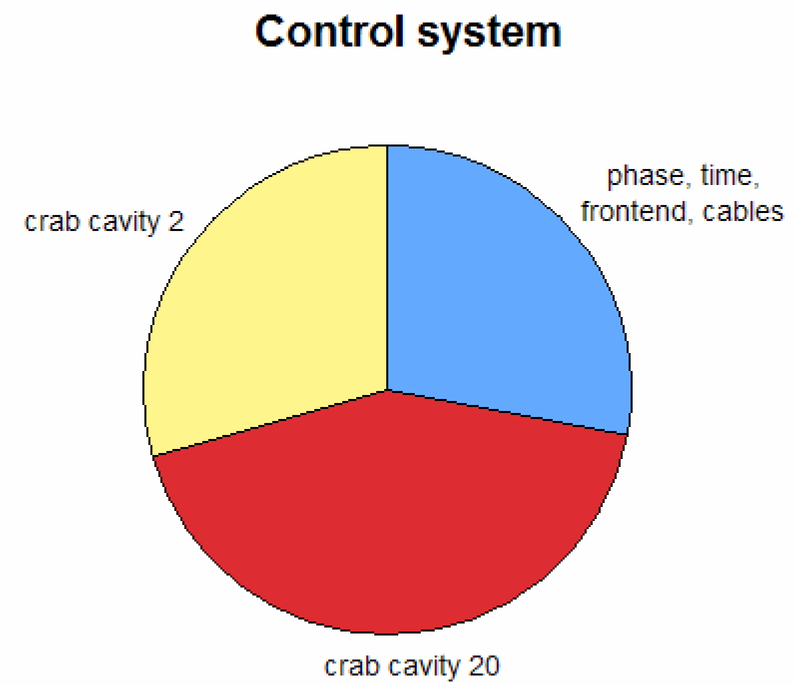
Instrumentation: BDS 20/2



Instrumentation cost splits rather evenly. Difference of the length of extraction line is responsible for cost difference of add_IR20 and add_IR2. Large common fraction is due to shared lasers

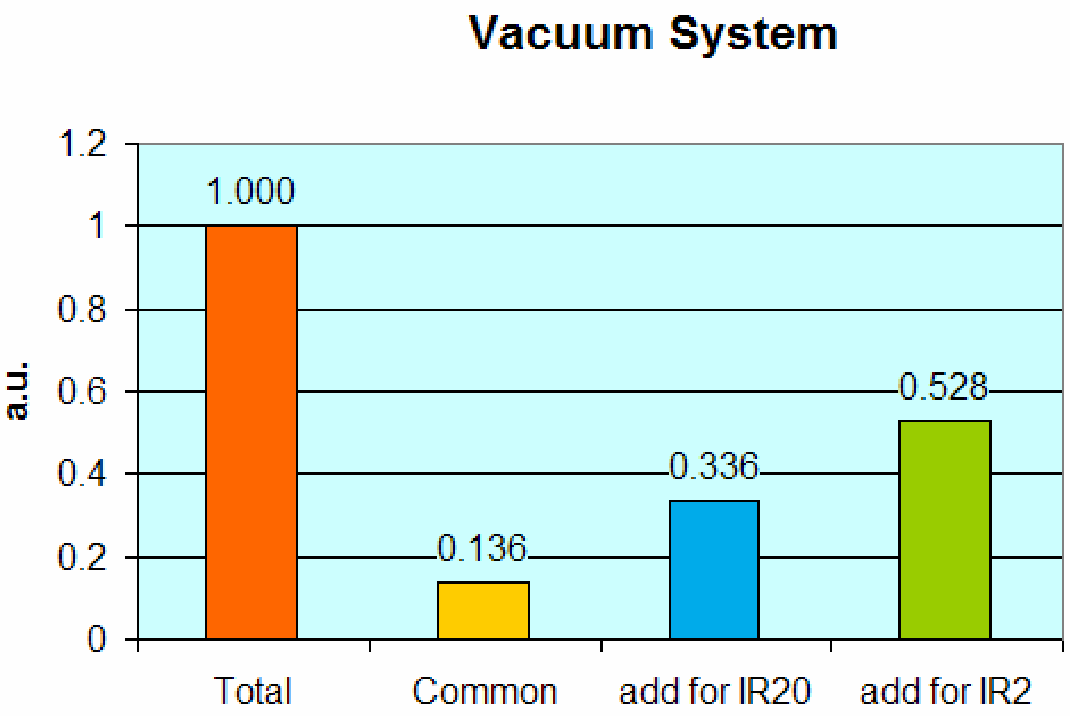
Control system: BDS 20/2





Control cost dominated by the cost of crab cavity which costs somewhat more for IR_20. This explains the difference and the smaller common cost.

Vacuum system: BDS 20/2 alt



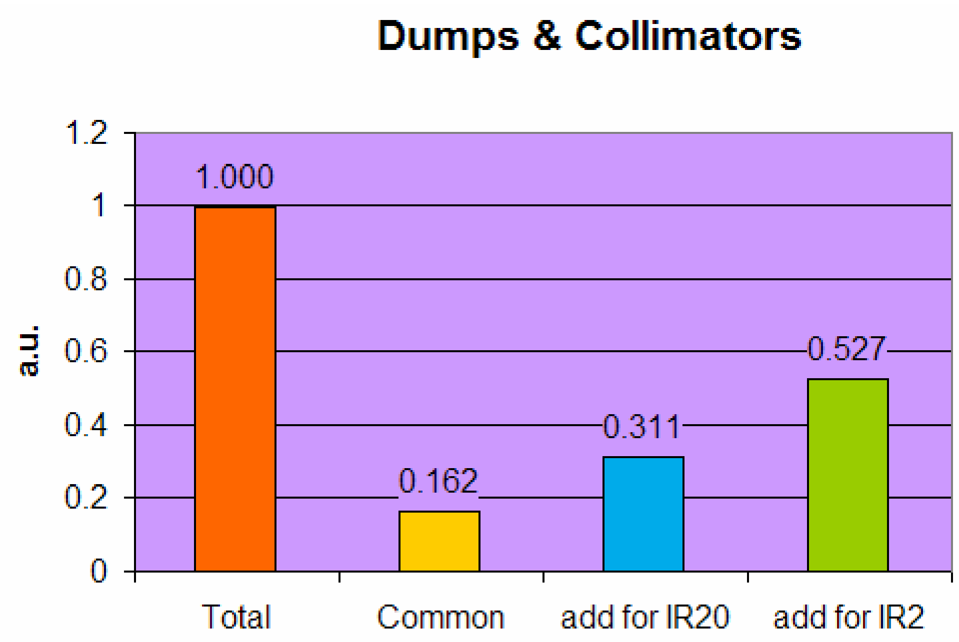
Long large aperture extraction line and additional vacuum chamber for beamstrahlung photons cause the cost difference

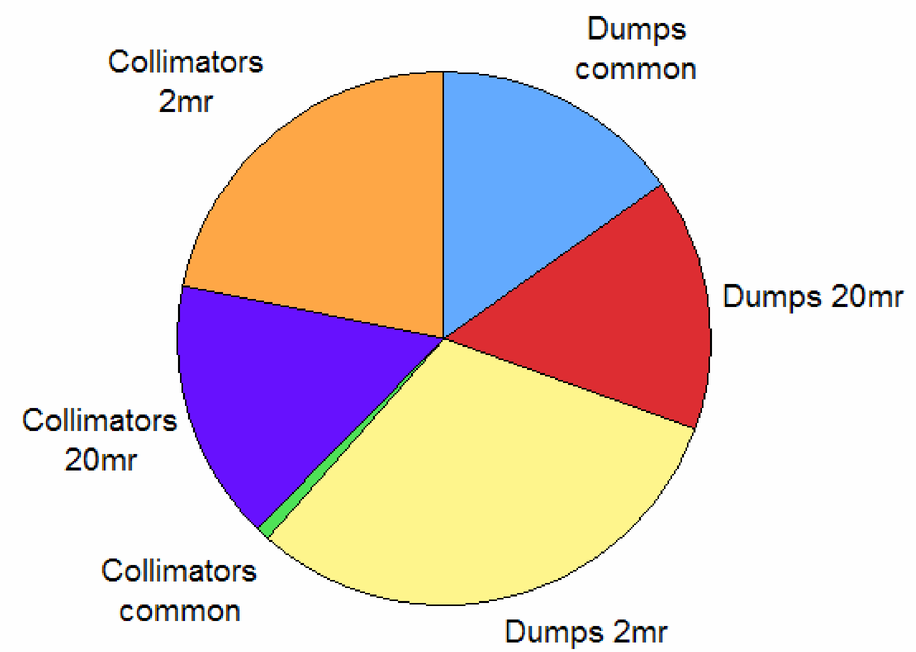
Have two versions of estimation, with different materials

This version uses Al in main beamlines, and Cu where larger losses may be expected. The SS chamber used in γ extraction line

Other version is SS+Cu coated in regions contributing most to the wakes (slightly more expensive)

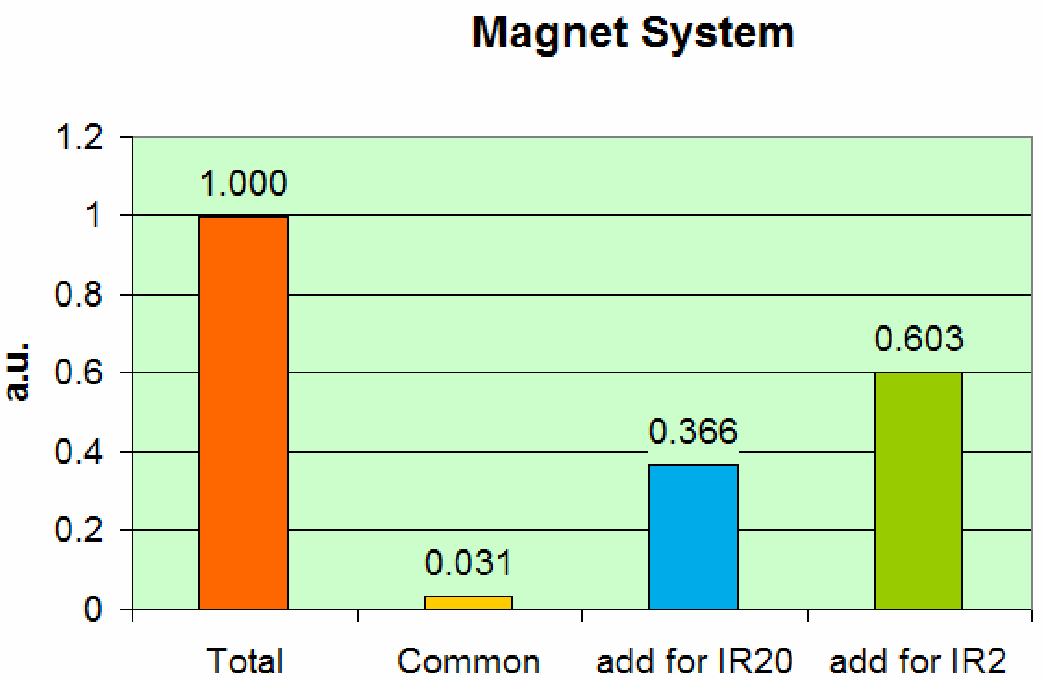
Dumps & collimators: BDS 20/2

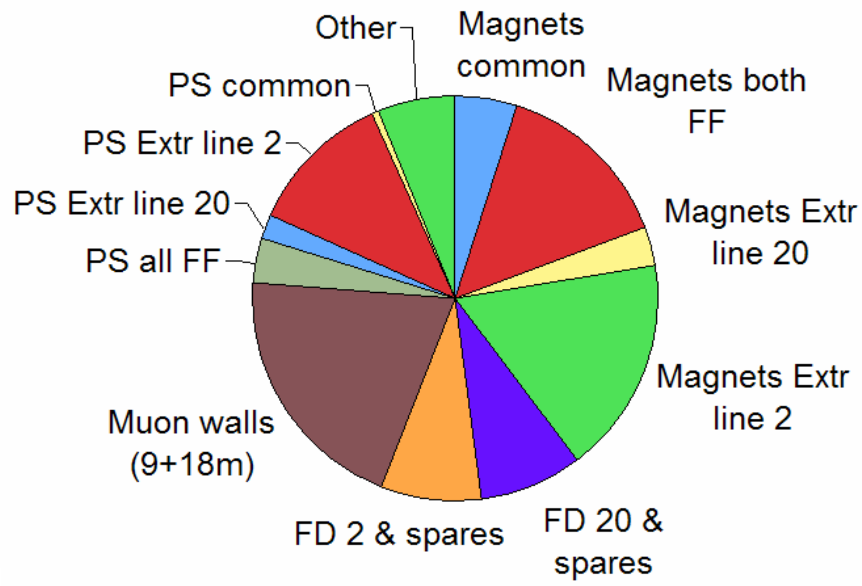




Larger number of collimators in 2mrad extraction line and additional photon dump cause the difference

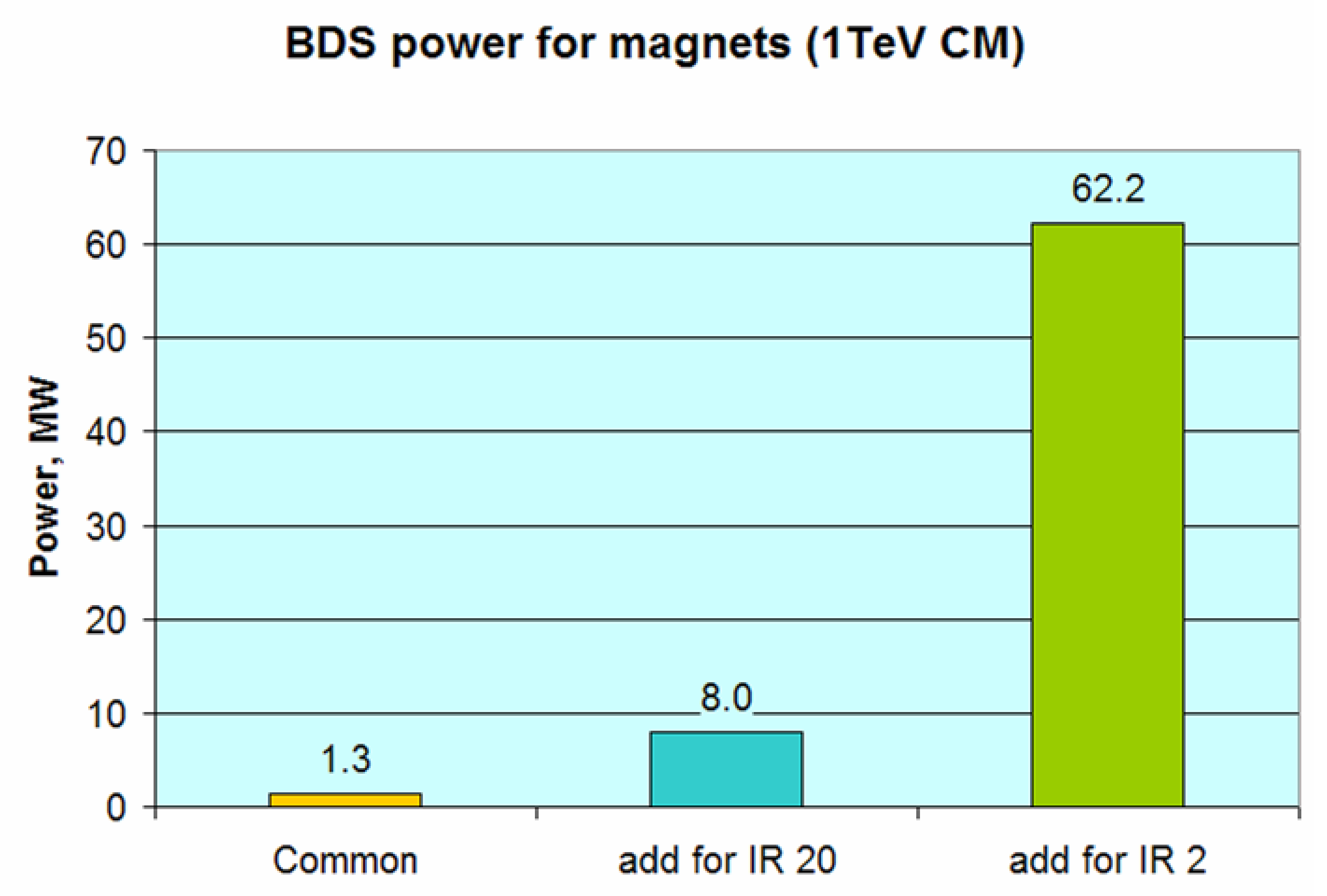
Magnet system: BDS 20/2



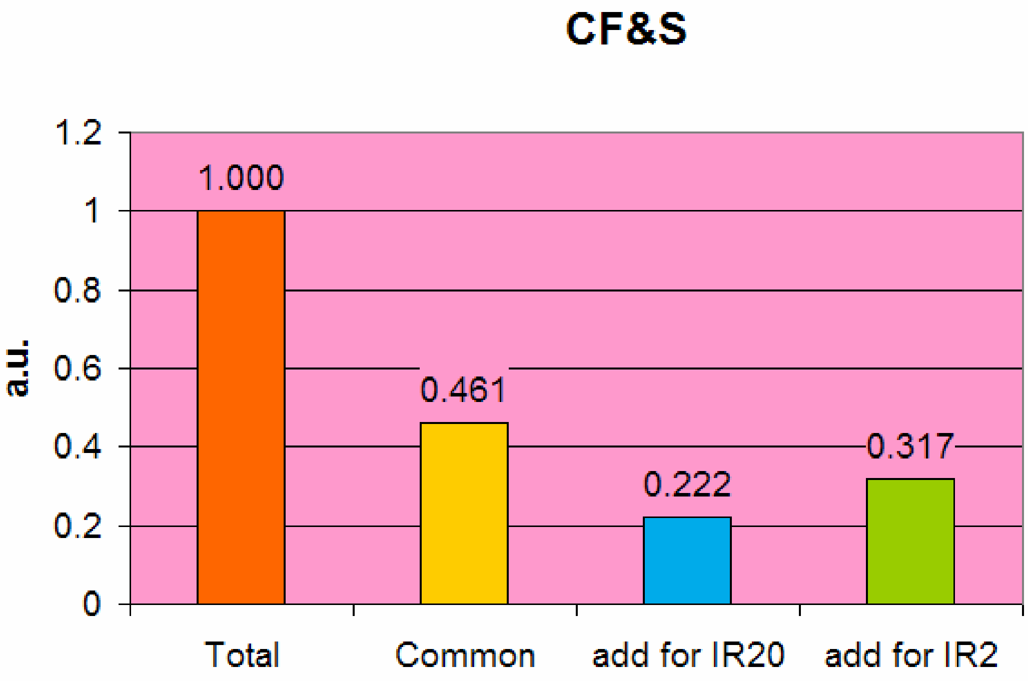


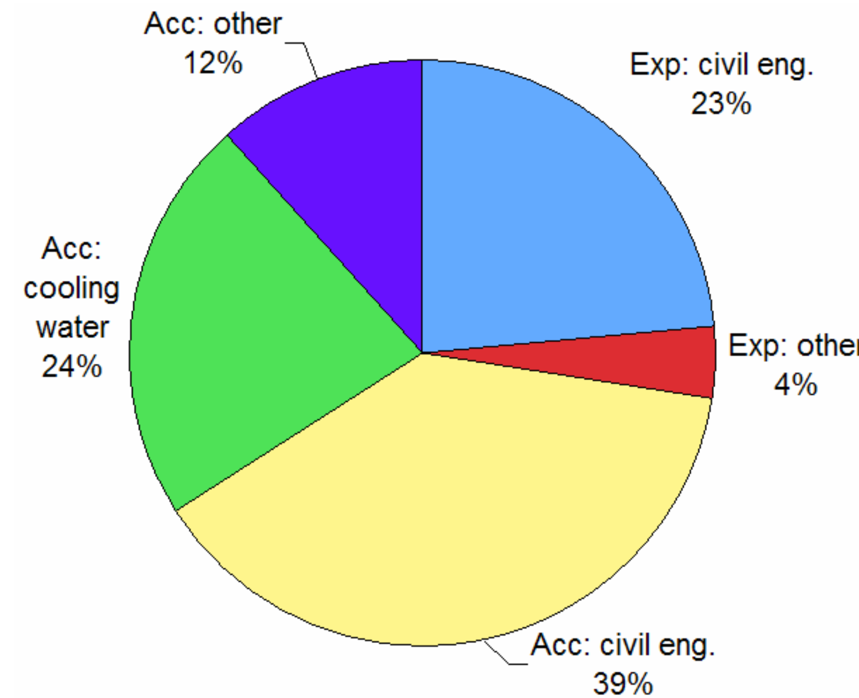
Larger number of huge extraction line magnets, and its power supplies (PS) cause the cost difference

Power for magnets



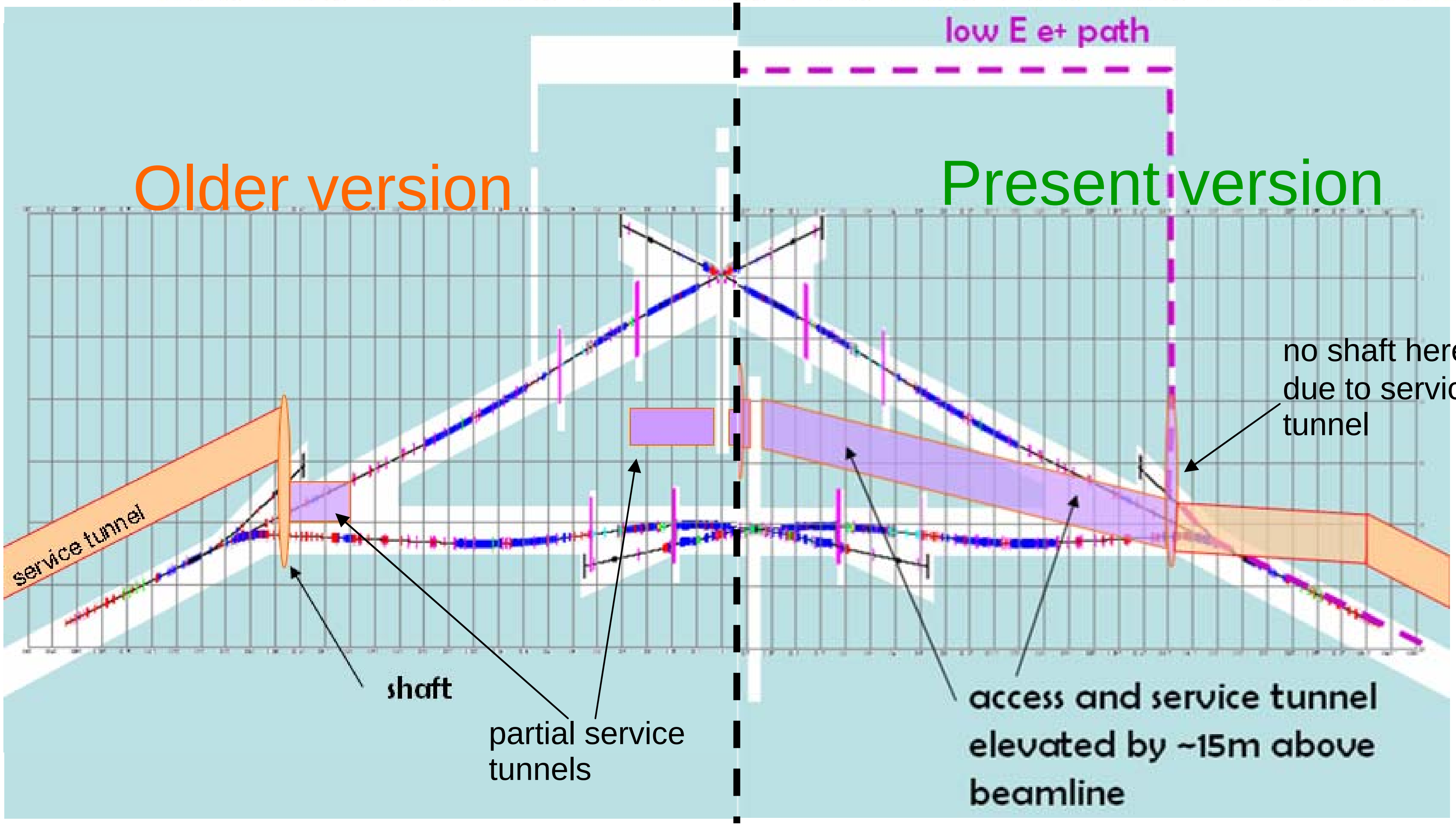
CF&S: BDS 20/2





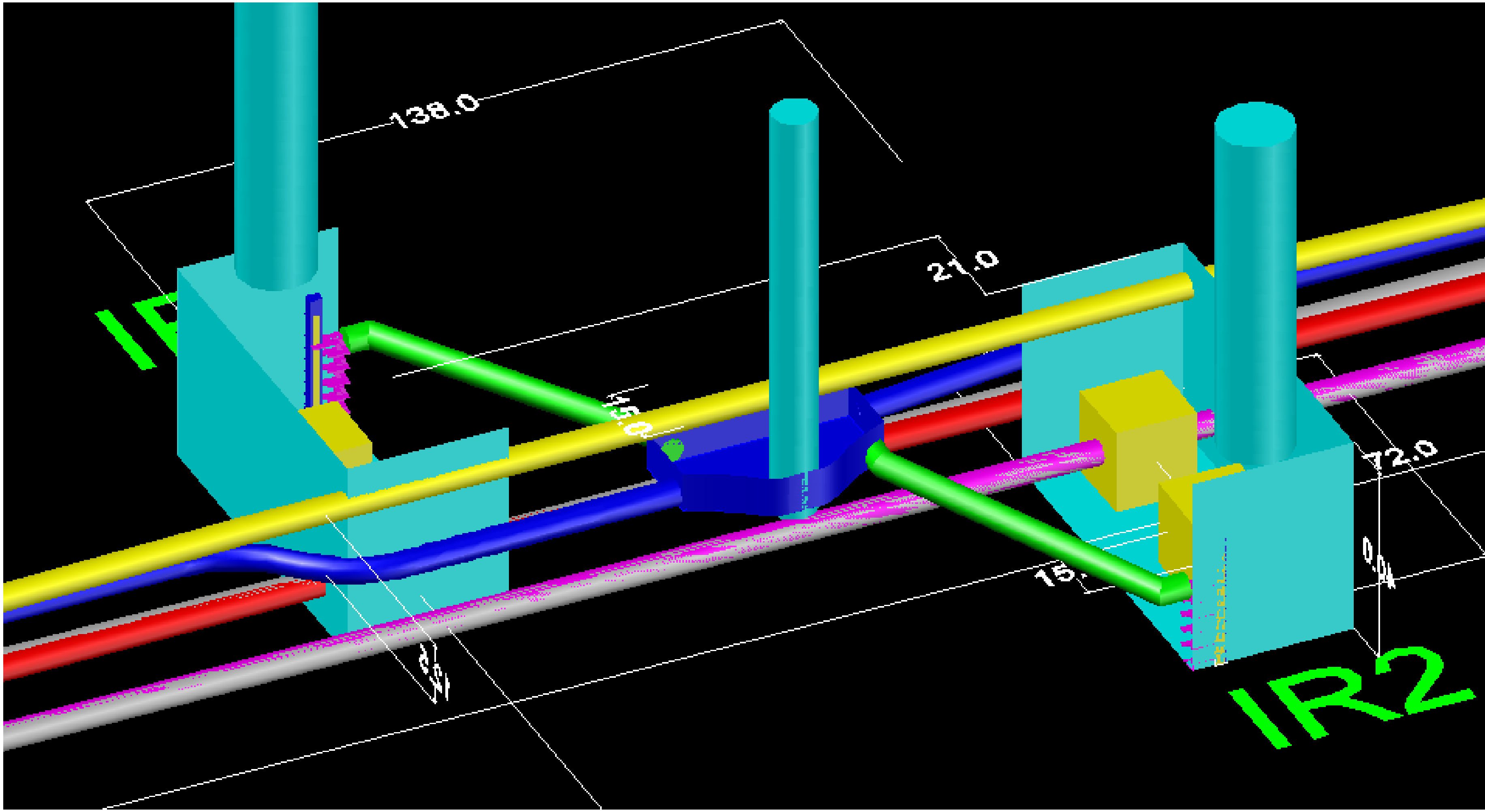
The common fraction is quite large. The difference come from beam dump halls and mostly from cooling water

CF&S conceptual layout



Full length service tunnel in BDS solves issues of access, egress, T stability, places for PS, access to laser rooms, etc. **This solution saves ~percent of BDS cost (could be site dependent).**

CF&S conceptual layout



Example of CF&S layouts for the regions of the IR halls

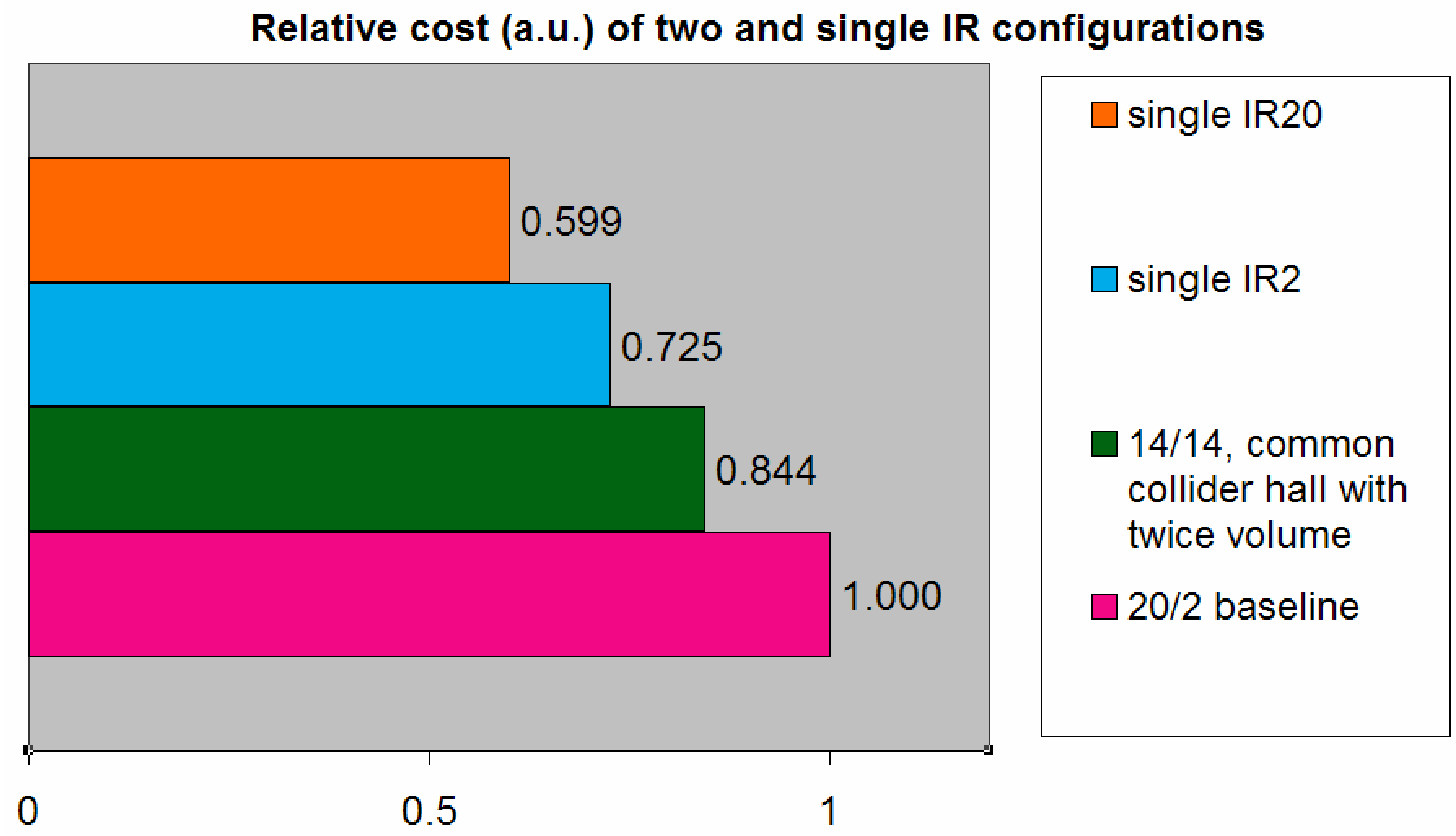
Compared configurations

- Compare the relative cost of
  - **20/2 baseline = normalized to 1.000**
  - **single IR case, 20mrad**
  - **single IR case, 2mrad**
    - » The single IR cases have all the common elements, in particular they have tapered tunnel in BSY, which allow to construct second IR in the future
  - **14/14 two IR case with common collider hall**
    - » the common collider hall with same total volume (2*72*32*42m)

Cost adjustments for 14/14

- Adjustments included for 14/14mrad cost
  - **removed stretches in optics**
  - **shorter (~11/14) tapered tunnels**
  - **remove one surface building**
  - **savings due to common hall (but volume still twice the single volume)**
  - **add cost of 42% more gradient bends (for 14mrad bend), their PS, BPMs, movers, etc**

Cost of different BDS configurations



Savings and very rough effects

Savings may be not possible, not additive, and require more studies

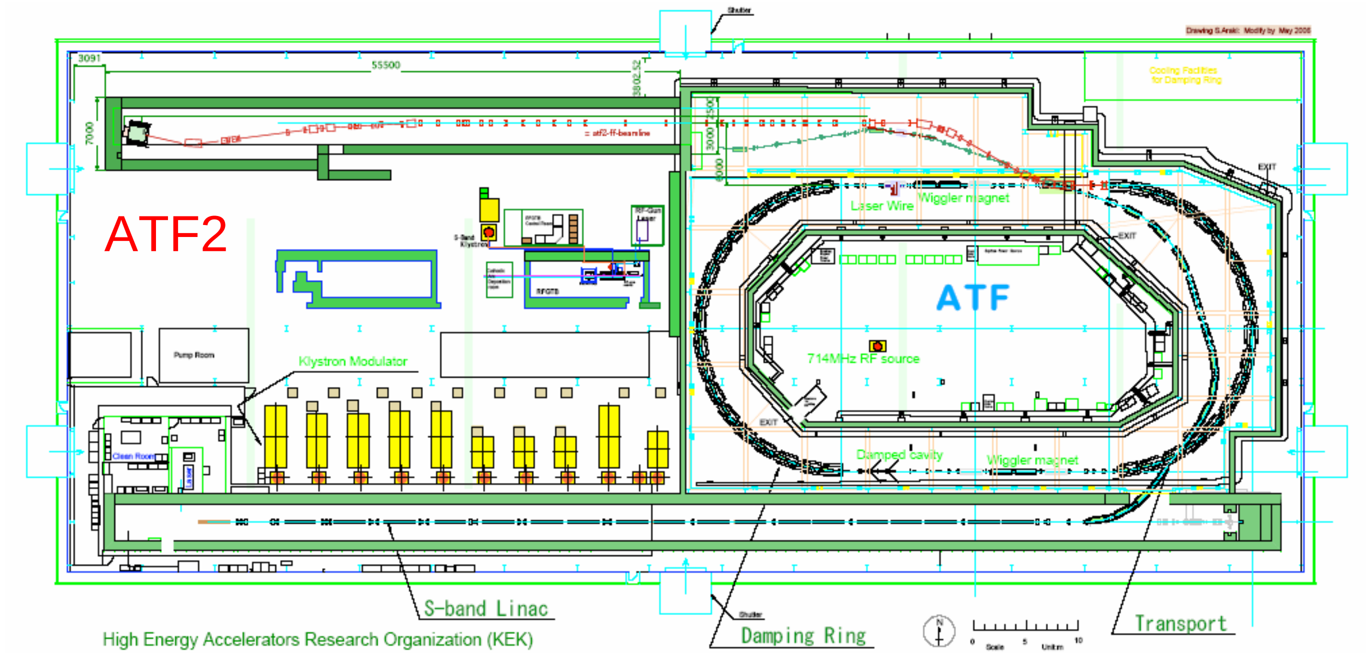
Action	Effect,%	Consequence, risk or issue
use single 5m wall instead of two 9&18m walls	-(2.5-3)	can not collimate 1e-3 , limited to 2e-5
remove cost of spare FDs	-(0.5-1)	spare FDs not available if needed
decrease size of collider hall from 32*72*40m to ~32*54*35m & surface detector assembly	-(3-4)	cannot simultaneously assemble detector underground and commission the BDS
do not install PS for 1TeV at the start	-(1-2)	harder 1TeV upgrade
do not install full cooling capacity for 1TeV	-(2-4)	harder 1TeV upgrade
Reduce number of bends	-(0.3-0.5)	E upgrade more difficult
Decrease vacuum chamber aperture	-(0.2-0.4)	more losses and background
Reduce number of movers	-(<0.1)	more complex tuning
Shorten extraction lines, rely on sweeping	-(0.2-0.5)	MPS issues in beam dumps
Shorten the separate low E e+ tunnel	-(0.3-0.6)	cannot access part of beamlines of IR which is off
Combine two IR halls (14/14 case), on surface detector assembly, decrease hall size to ~98*32*35m	-(3-4)	for simultaneous commissioning of beamline & undergrnd detector assembly, may have to make final assembly at other IP, then move detector
Shorten the fraction of the tapered tunnel	-(0.5-1)	Difficult access around beamlines in BSY region
Full power tune-up dump => low power	-(1-2)	MPS and operation
Combine tune-up dump with main dump	+(1-2)	MPS & operation, accessibility of collider hall
Remove service tunnel	+(0.5-1)	Access, egress, T stability, cabling, laser rooms,

Plans and Goals

- This workshop
  - **discuss design, costs and cost savings with technical groups and MDI panel**
- between this and the Valencia workshop
  - **study and if found possible, implement agreed upon cost savings**

Towards the TDR

- Coordinated activity in all three regions
- Coordinated R&D plans are being submitted for next three years in UK and for the next year in US
- For the test facilities, international collaborations for ESA and ATF2 – the ILC FF model:



Summary

- The status of BDS design and cost estimation was presented