Beam delivery and ATF2

Andrei Seryi

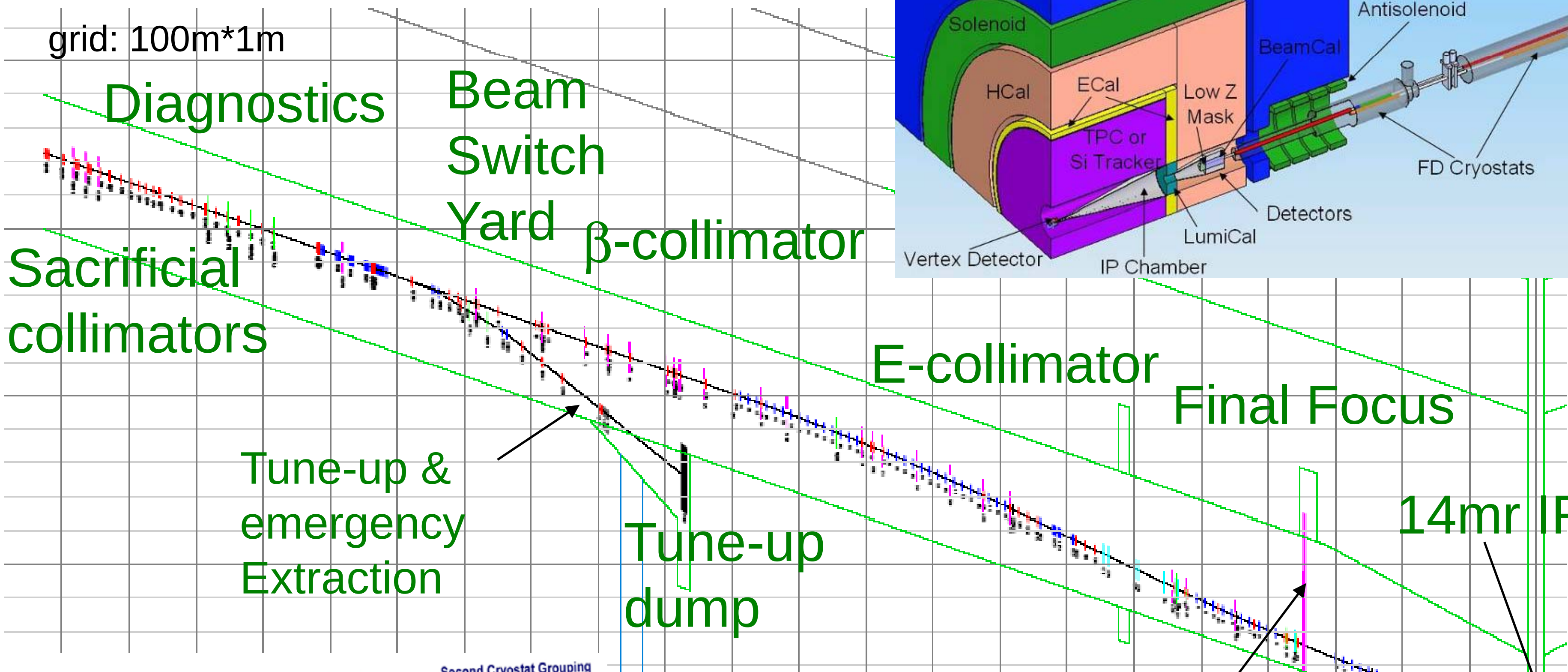
SLAC

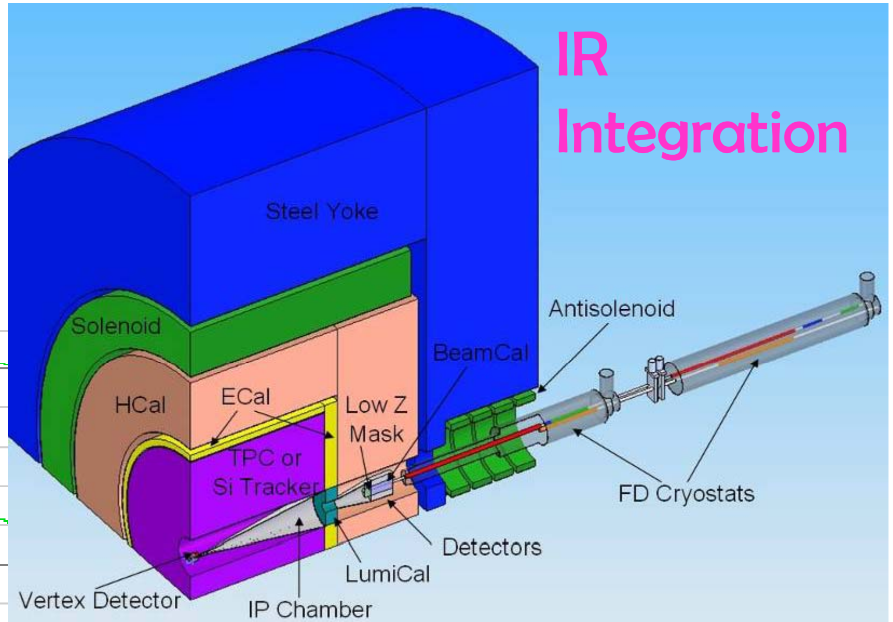
October 1, 2008

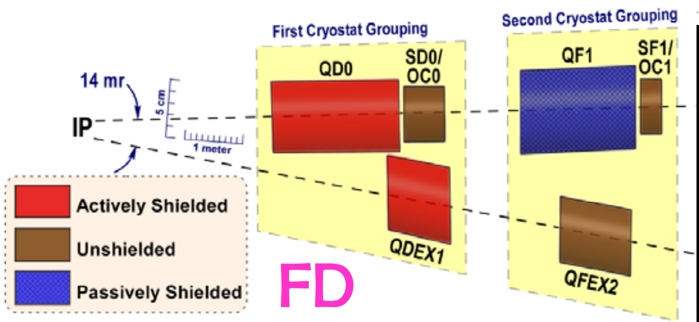
Plan of a brief talk to initiate discussion

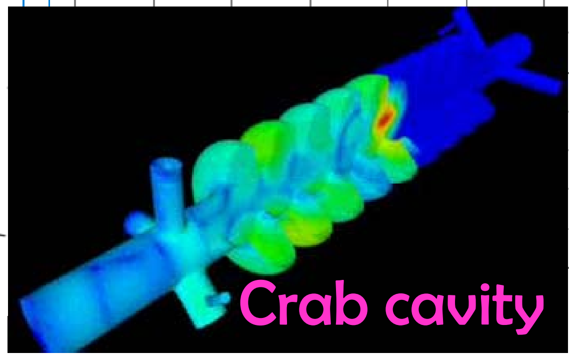
- BDS design status
- BDS R&D in technical design phase
  - effect of the 2007 crisis and criteria for new directions
- ATF2 mission
- BDS organization and work-packages
- New developments in ILC design
  - Lower cost, better performance, enhanced physics reach
- Can ATF2 make additional studies to enable better ILC?
  - examples: longer L*, lower beta*, gg, travelling focus for new low P…
- What ATF2 lessons can be applied to ILC BDS?

BDS RDR design









BDS strategy

In TDP I & II plan, the scope of work changed, and the focus is shifted

Earlier planned detailed design & engineering will not be performed

→

- Focus on a few critical directions. Selection criteria:
  - –Critical impact on performance versus cost;
  - –Advanced ideas promising breakthrough in performance;
  - –Broad impact and synergy with other worldwide projects

→

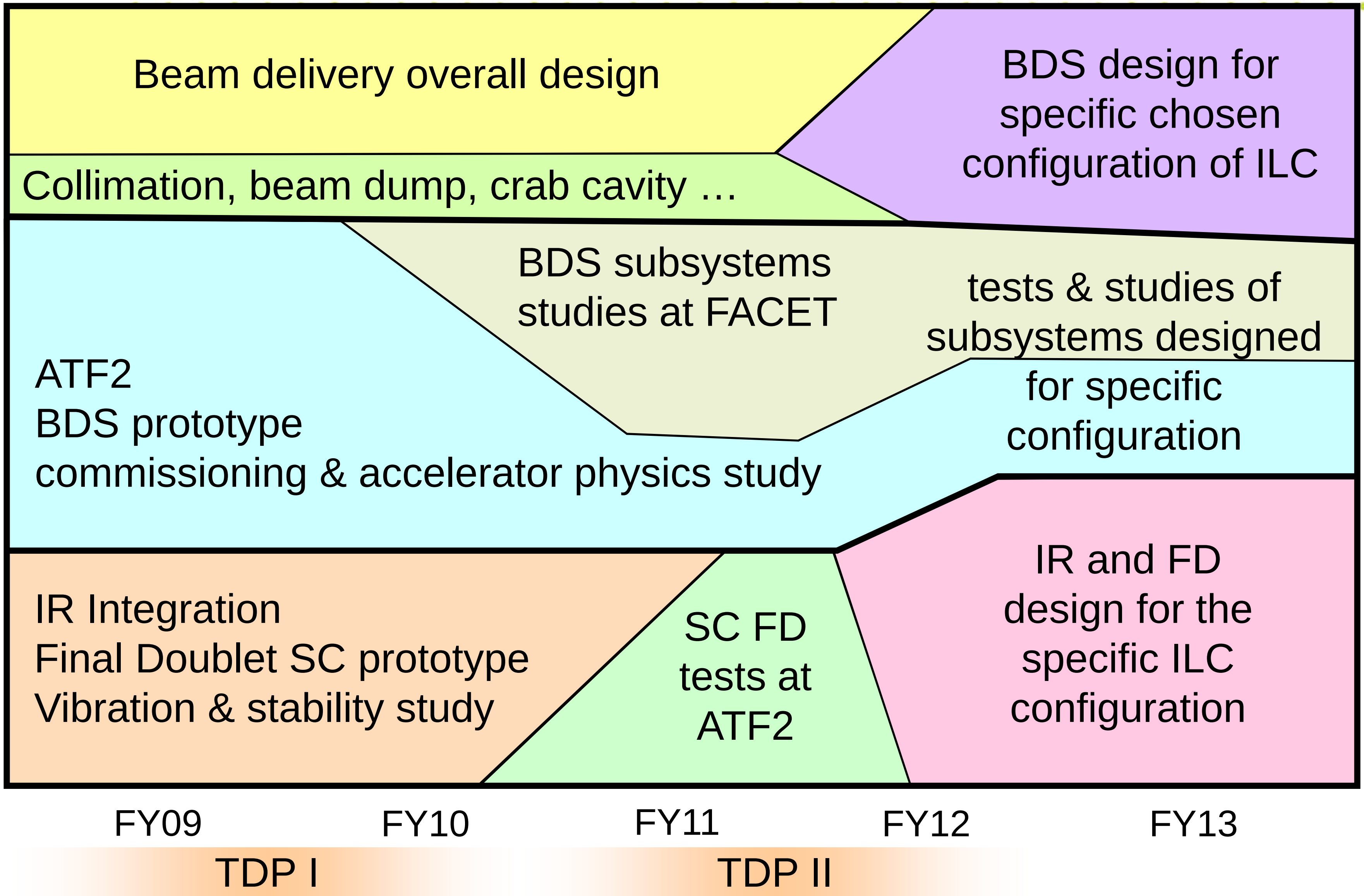
- Three critical directions:
  - –General BDS design
  - –Test facilities, ATF2
  - –Interaction Region optimization

General BDS design:
beam dump
photon collider
crystal collimation
crab cavity
MDI diagnostics …

Test facilities, ATF2:
ATF2 commissioning & operation
Develop methods to achieve small beam size
Diagnostics, Laser Wires, Feedbacks …

Interaction Region optimization:
IR interface document & design
SC FD prototyping and vibration test
ILC-like FD for ATF2 …

BDS plans


Beam delivery overall design
BDS design for specific chosen configuration of ILC
Collimation, beam dump, crab cavity …
BDS subsystems studies at FACET
tests & studies of subsystems designed for specific configuration
ATF2
BDS prototype
commissioning & accelerator physics study
IR Integration
Final Doublet SC prototype
Vibration & stability study
SC FD tests at ATF2
IR and FD design for the specific ILC configuration
FY09
FY10
FY11
FY12
FY13
TDP I
TDP II

BDS in GDE Technical Design Phase plan

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

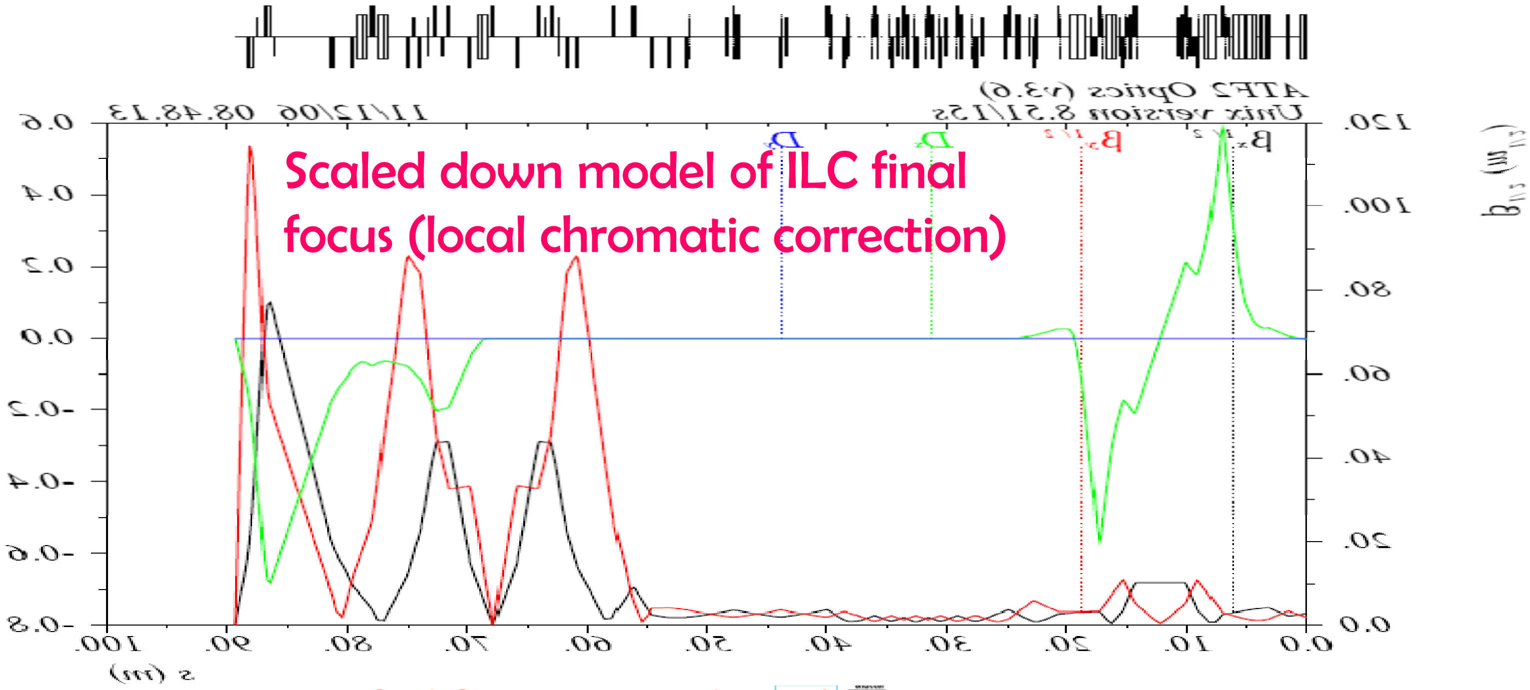
Test Facility	Deliverable	Date
Optics and stabilisation demonstrations:		
ATF	Generation of 1 pm-rad low emittance beam	2009
ATF-2	Demonstration of compact Final Focus optics (design demagnification, resulting in a nominal 35 nm beam size at focal point).	2010
	Demonstration of prototype SC and PM final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

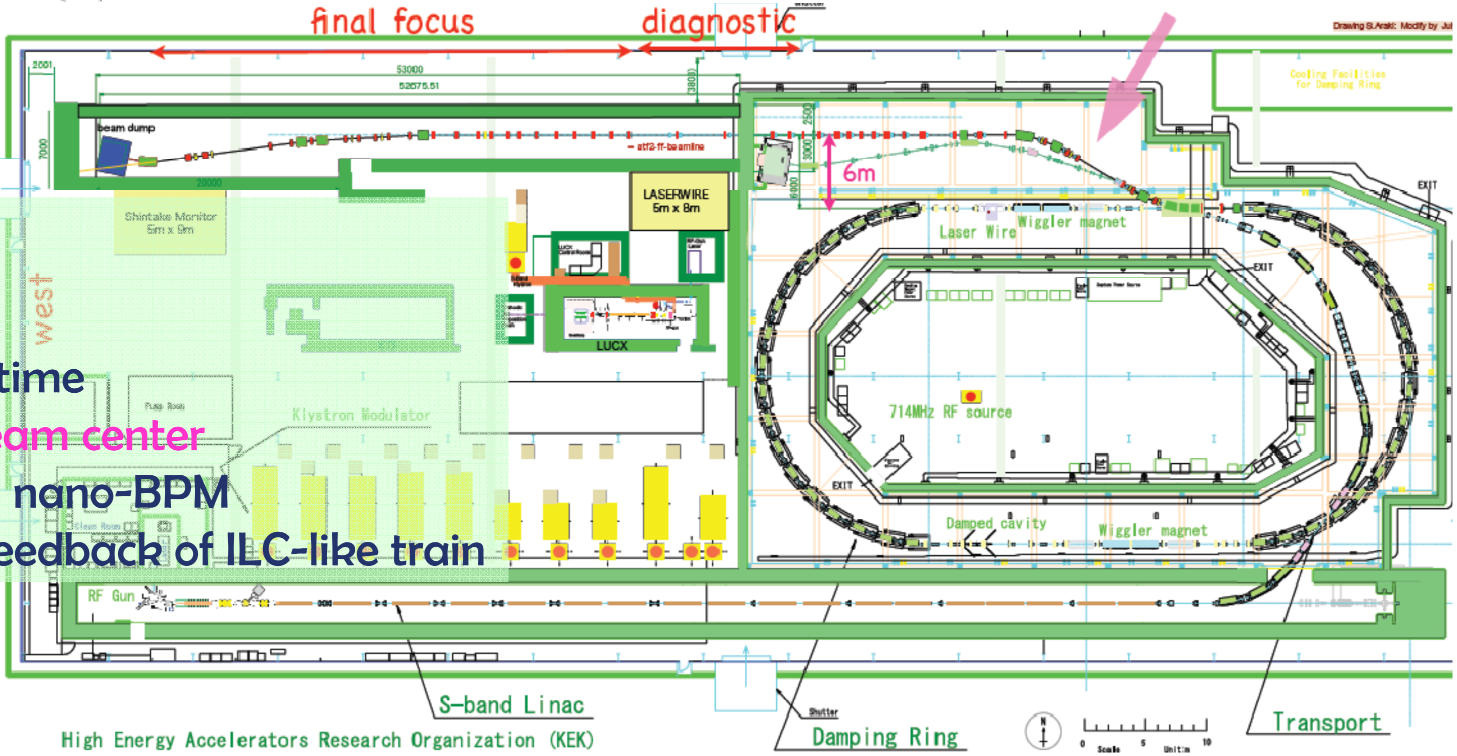
3.3.5 Beam Delivery System

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)

ATF2 – model of ILC BDS





ATF2 goals

(A) Small beam size
- Obtain $\sigma_y \sim 35$nm
- Maintain for long time

(B) Stabilization of beam center
- Down to < 2nm by nano-BPM
- Bunch-to-bunch feedback of ILC-like train

A.Seryi, Oct 1, 2008

ATF International Collaboration

ATF International organization is defined by MOU signed by 20 institutions:

CERN
DESY
LAL, Orsay
Tomsk Polytechnic Univ.
INFN, Frascati
University College London
Oxford Univ.
Royal Holloway Univ.

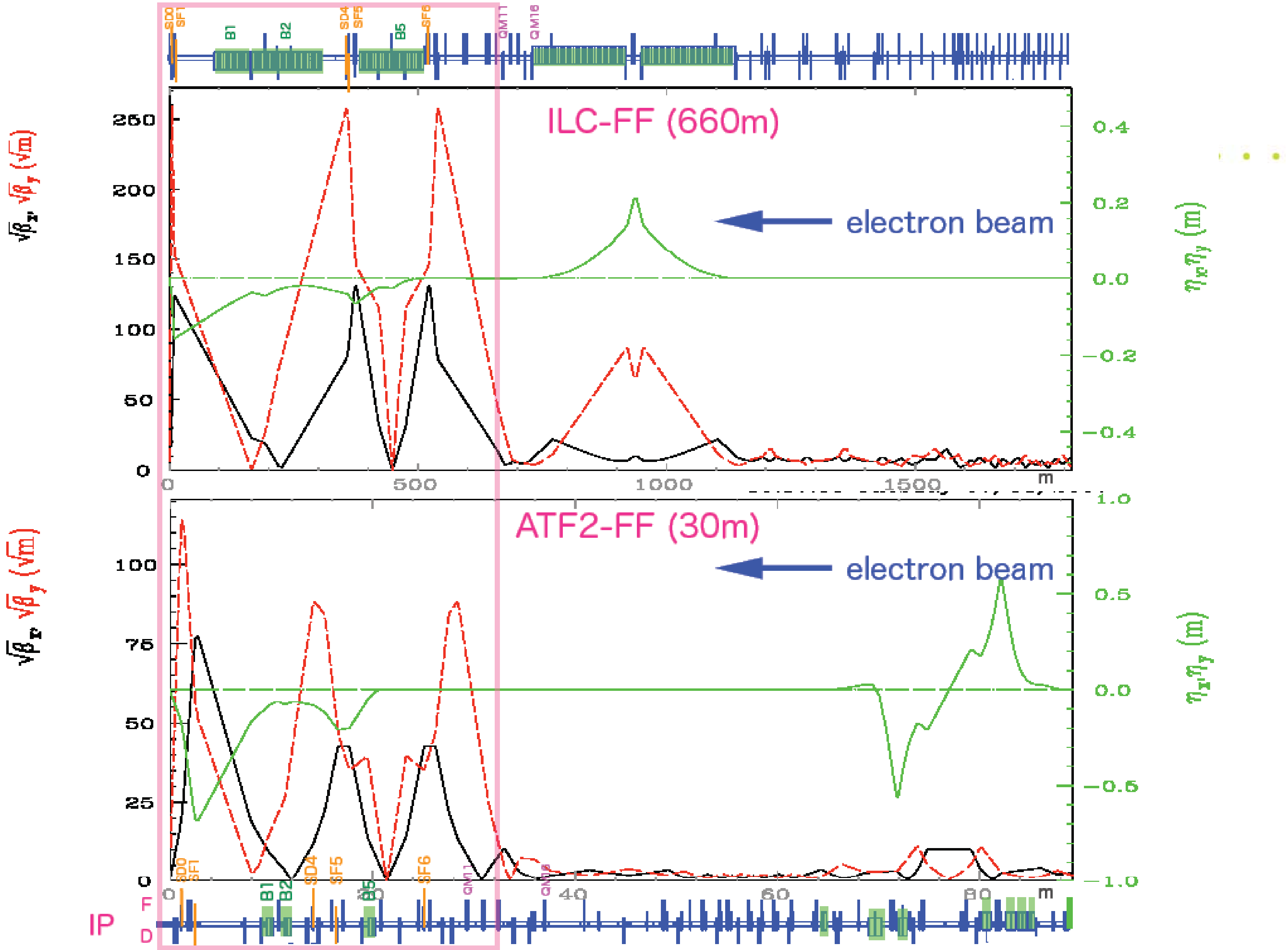
KEK
Waseda Univ.
Nagoya Univ.
Tokyo Univ.
Kyoto Univ.
Hiroshima Univ.
PAL (Korea)
IHEP (China)

SLAC
LBNL
FNAL
Cornell Univ.

http://atf.kek.jp/

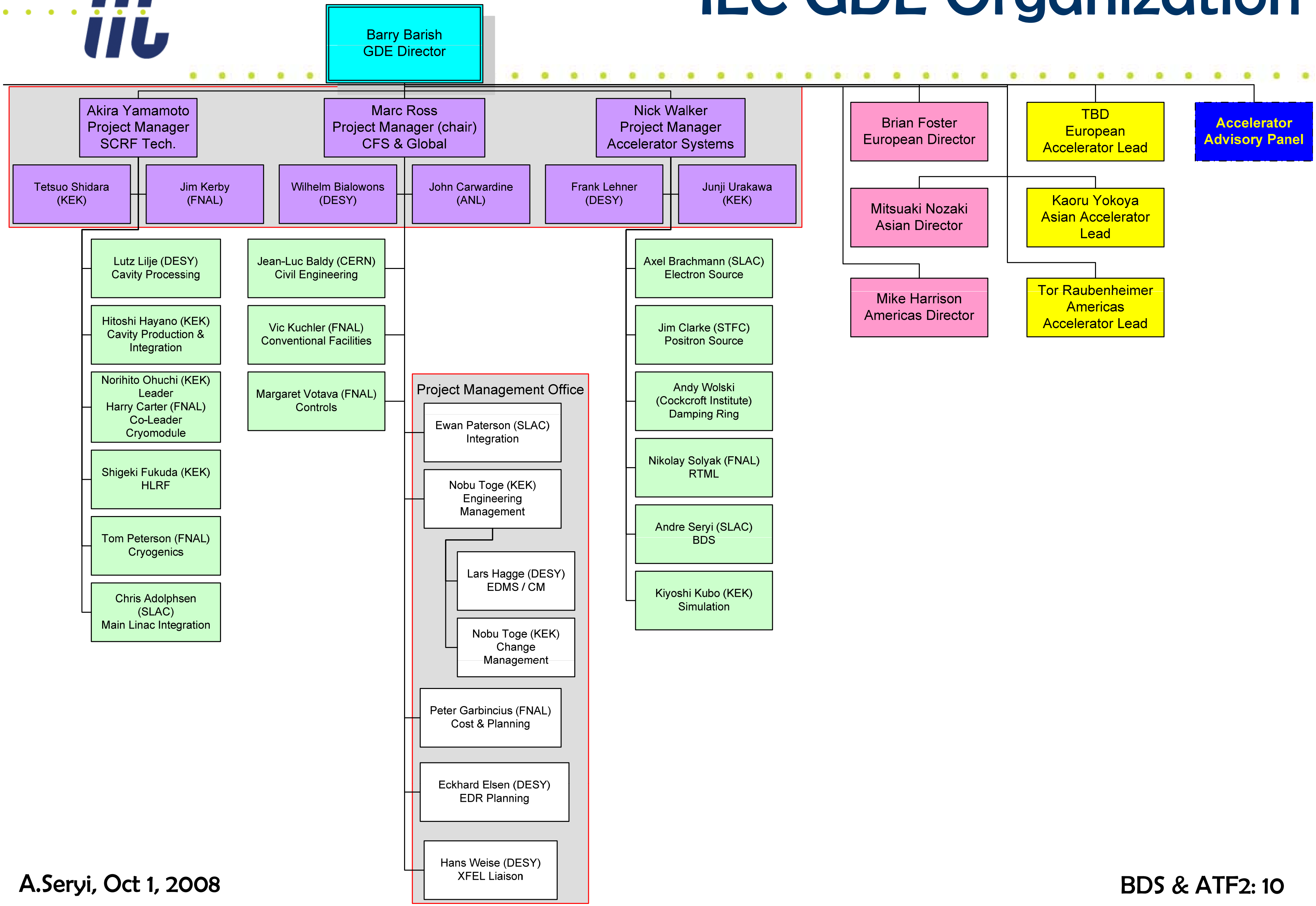
MOU: Mission of ATF/ATF2 is three-fold:

- ATF, to establish the technologies associated with producing the electron beams with the quality required for ILC and provide such beams to ATF2 in a stable and reliable manner.
- ATF2, to use the beams extracted from ATF at a test final focus beamline which is similar to what is envisaged at ILC. The goal is to demonstrate the beam focusing technologies that are consistent with ILC requirements. For this purpose, ATF2 aims to focus the beam down to a few tens of nm (rms) with a beam centroid stability within a few nm for a prolonged period of time.
- Both the ATF and ATF2, to serve the mission of providing the young scientists and engineers with training opportunities of participating in R&D programs for advanced accelerator technologies.

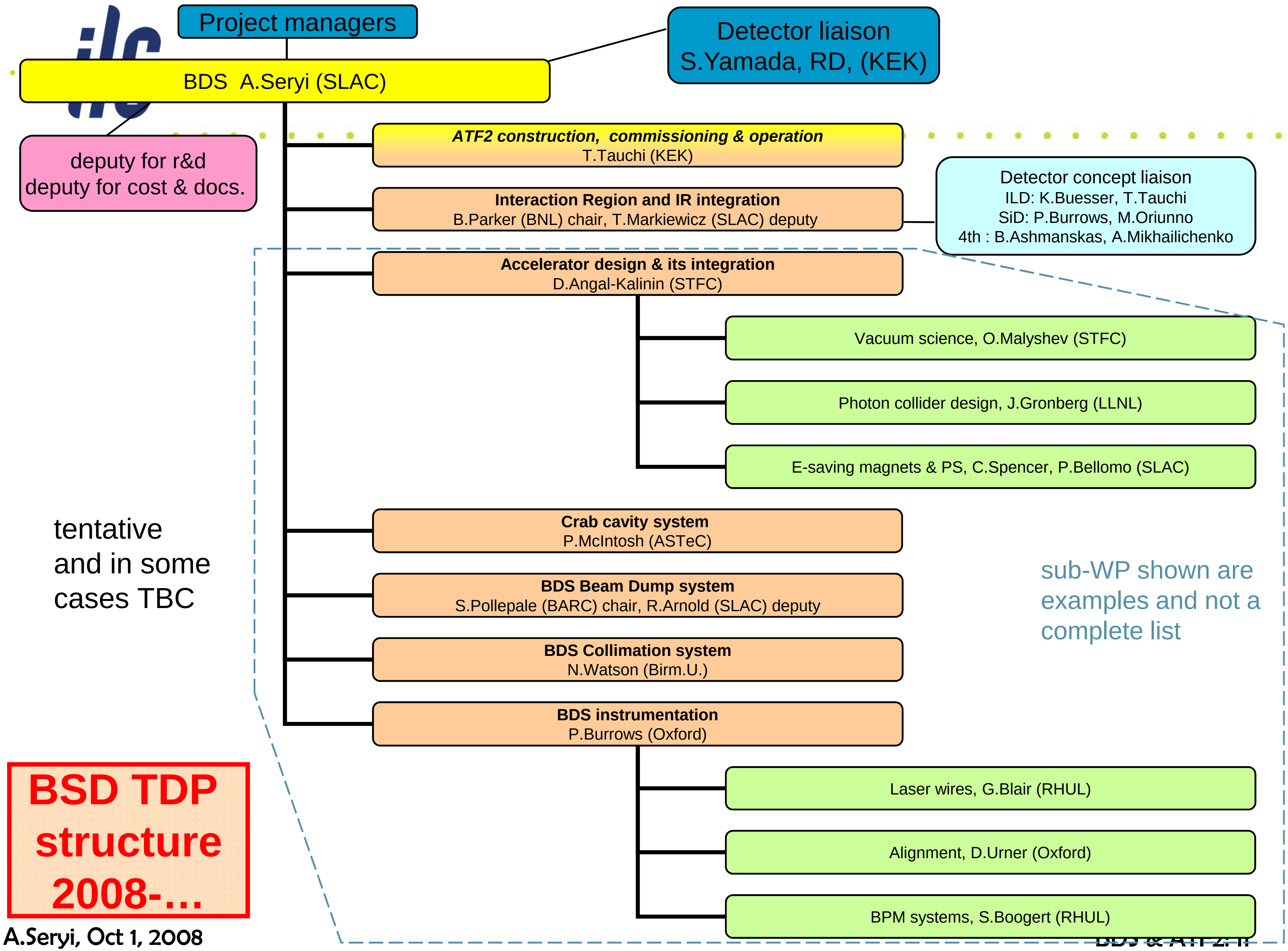


ILC-FF (660m)
electron beam
ATF2-FF (30m)
electron beam
$\sqrt{\beta_x}, \sqrt{\beta_y}\ (\sqrt{m})$
$\eta_x, \eta_y\ (m)$
SD0
SF1
B1
B2
SD4
SF5
B5
SF6
QM11
QM16
IP
F
D
m

ILC GDE Organization



BSD TDP structure 2008-…



New developments in ILC design

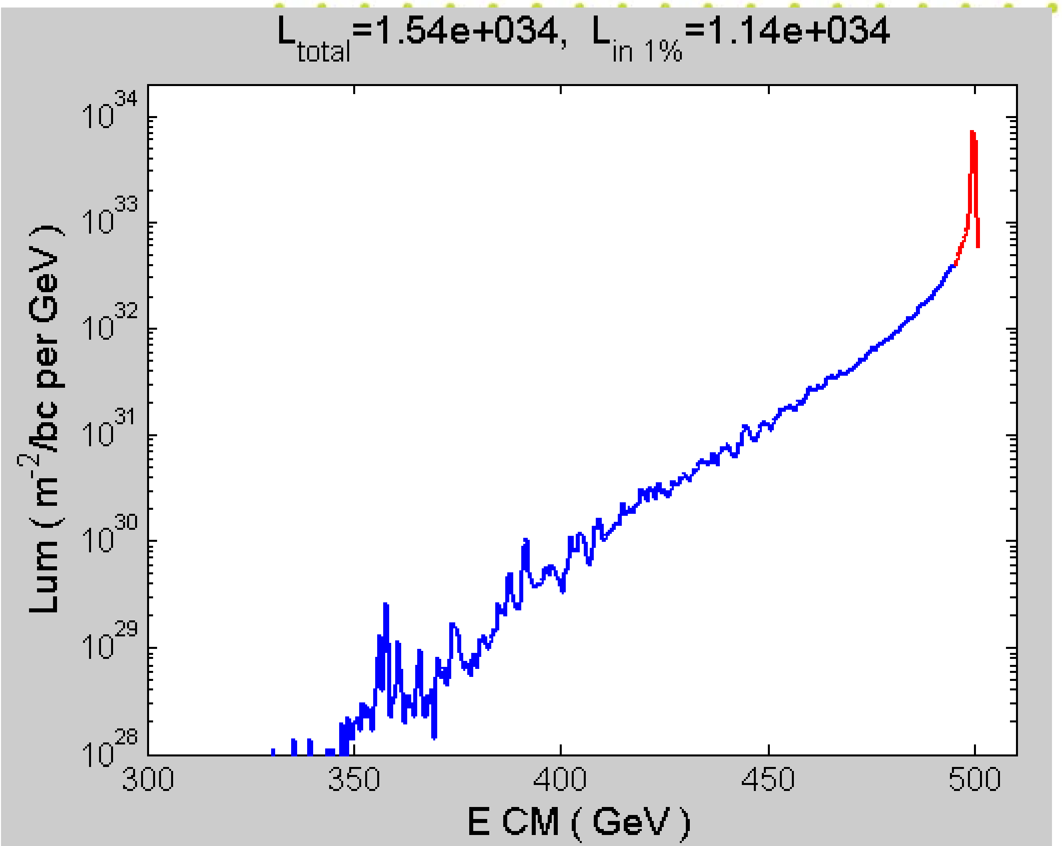
- A "minimal machine" is being investigated
  - It includes various cost saving ideas
    - e.g. rearrangements of beamlines in central region
  - AND a lower power option, but improved one, with better performance for physics
    - This new low P option may use tighter focusing at IP and travelling focus.
    - Are there ways to study these IP conditions at ATF2?
    - Could travelling focus be arranged? And if yes, could it be detected without second beam?

Comparison of parameter sets

	Nom. RDR	Low P RDR	new Low P	new Low P	new Low P	new Low P
Case ID	**1**	**2**	**3**	**30**	**4**	**5**
E CM (GeV)	500	500	500	500	500	500
N	2.0E+10	2.0E+10	2.0E+10	2.0E+10	2.0E+10	2.0E+10
n_b	2625	1320	1320	1320	**1105**	1320
F (Hz)	5	5	5	5	5	5
P_b (MW)	**10.5**	**5.3**	**5.3**	**5.3**	**4.4**	**5.3**
$\gamma\varepsilon_x$ (m)	1.0E-05	1.0E-05	1.0E-05	1.0E-05	1.0E-05	1.0E-05
$\gamma\varepsilon_y$ (m)	4.0E-08	3.6E-08	3.6E-08	3.6E-08	**3.0E-08**	**3.0E-08**
βx (m)	2.0E-02	1.1E-02	1.1E-02	1.1E-02	**7.0E-03**	**1.5E-02**
βy (m)	4.0E-04	2.0E-04	2.0E-04	**1.0E-04**	**1.0E-04**	**1.0E-04**
Travelling focus	No	No	**Yes**	**Yes**	**Yes**	**Yes**
Z-distribution *	Gauss	Gauss	Gauss	**Flat**	**Flat**	**Flat**
σ_x (m)	6.39E-07	4.74E-07	4.74E-07	4.74E-07	3.78E-07	5.54E-07
σ_y (m)	5.7E-09	3.8E-09	3.8E-09	2.7E-09	2.5E-09	2.5E-09
σ_z (m)	3.0E-04	2.0E-04	**3.0E-04**	3.0E-04	**5.0E-04**	**2.0E-04**
Guinea-Pig $\delta E/E$	0.023	0.045	0.036	0.036	0.039	0.038
Guinea-Pig L ($cm^{-2}s^{-1}$)	**2.02E+34**	**1.86E+34**	**1.92E+34**	**1.98E+34**	**2.00E+34**	**2.02E+34**
Guinea-Pig Lumi in 1%	1.50E+34	1.09E+34	1.18E+34	1.17E+34	1.06E+34	1.24E+34

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

Case 1: Nominal ILC, RDR version



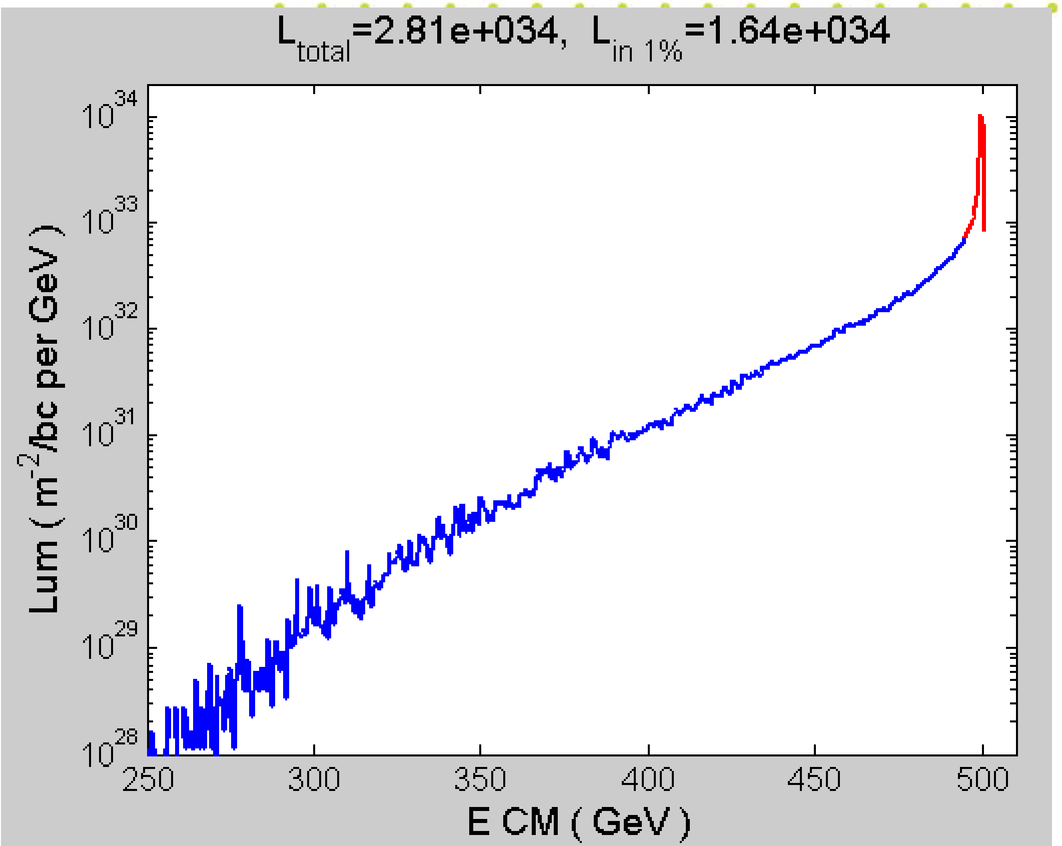
Red color indicate the part within 1%

Note:
Here L units are /m^2 /bunch crossing
Here /cm^2/s

par	E	N	B_X	B_Y	S_Z	E_X	E_Y	DISTZ	TRFOC	NB_FREP
1	250	2	20	0.4	300	10	0.04	0	0	13125

L=2.02e+034, L in 1%=1.5e+034 dE/E =0.0231 Ymax =0.127

Case 2: Low Power ILC, RDR version

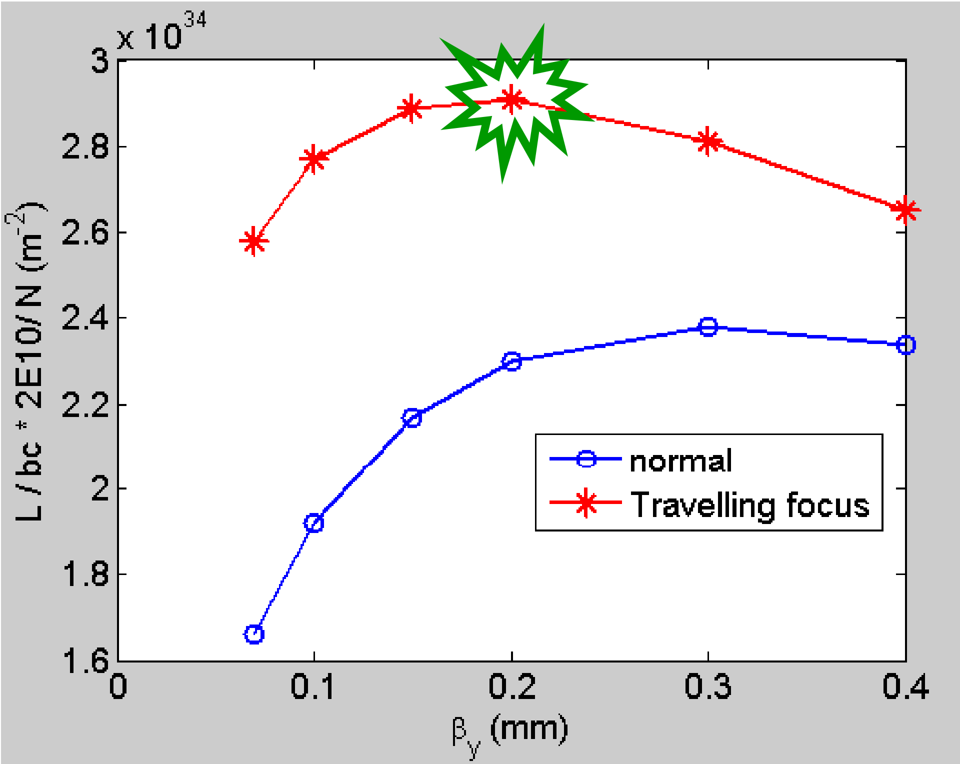


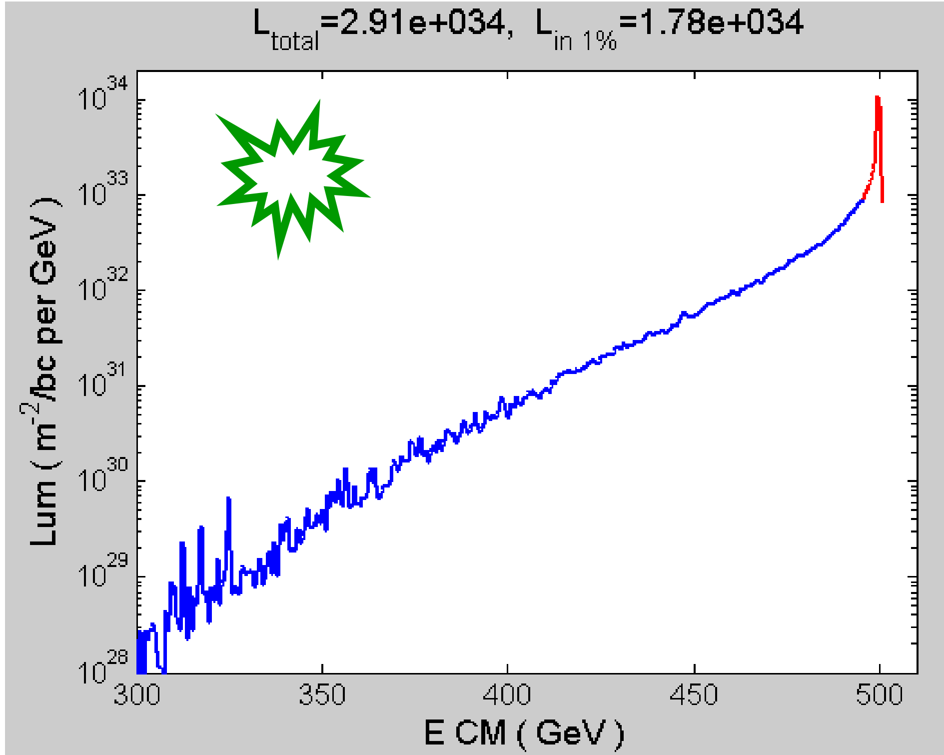
- The RDR Low P set has large beamstrahlung energy spread (in comparison with other RDR sets)

par	E	N	B_X	B_Y	S_Z	E_X	E_Y	DISTZ	TRFOC	NB_FREP
2	250	2	11	0.2	200	10	0.036	0	0	6600

L=1.86e+034, L in 1%=1.09e+034 dE/E =0.045 Ymax =0.283

Case 3: better Low P, with TRAV_FOCUS

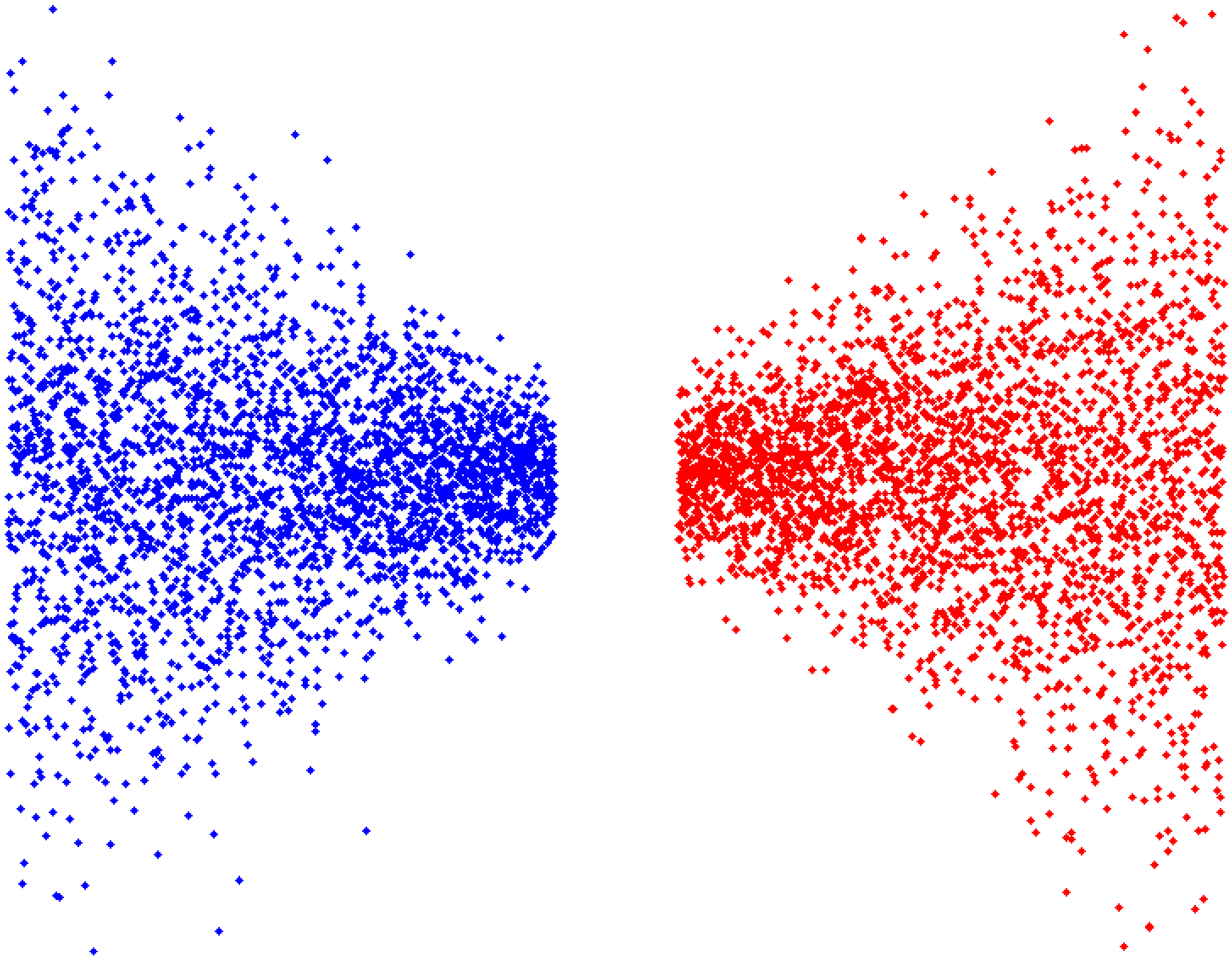




par	E	N	B_X	B_Y	S_Z	E_X	E_Y	DISTZ	TRFOC	NB_FREP
3	250	2	11	0.2	300	10	0.036	0	1	6600

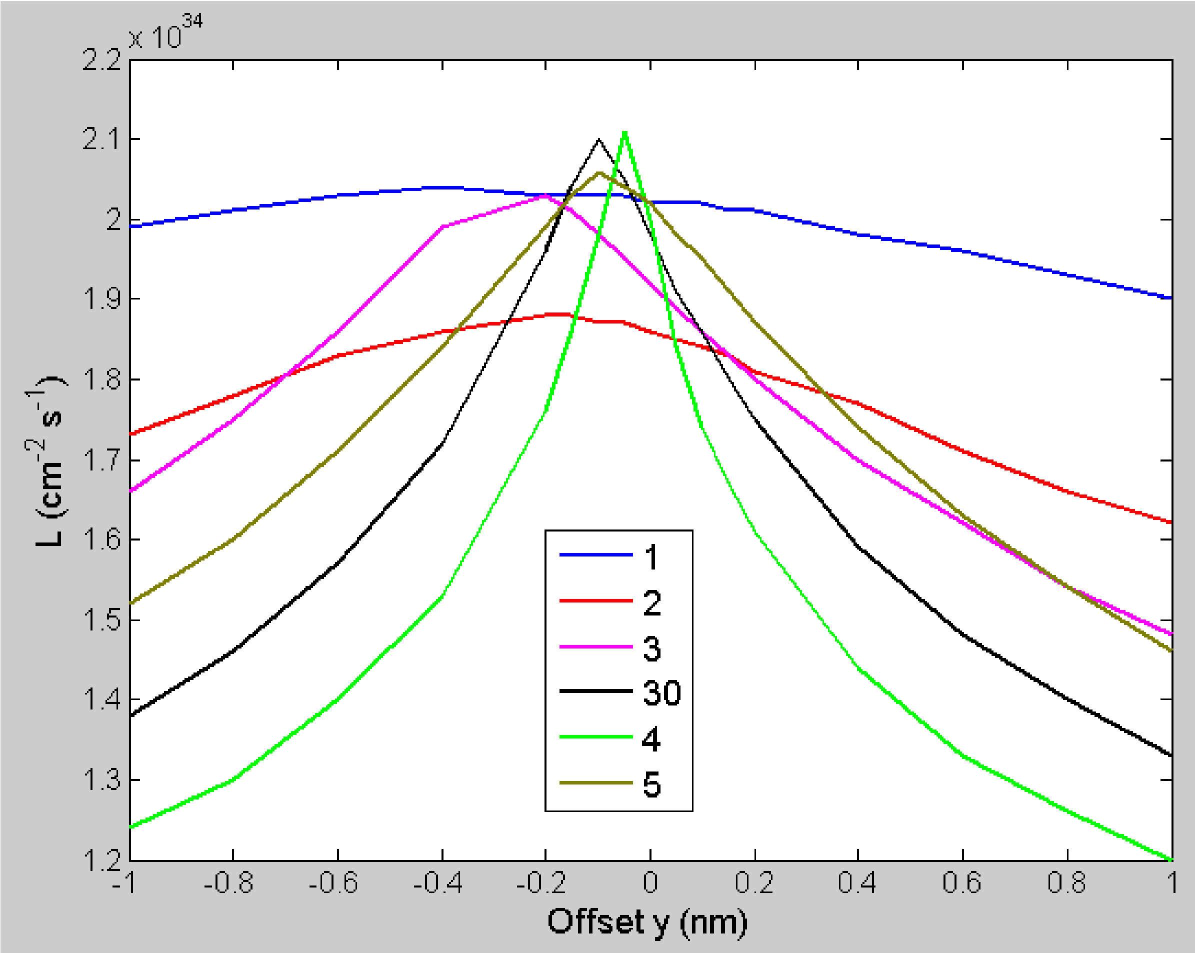
L (tot,	in 1%)	dE/E	Ymax
1.92e+034	1.18e+034	0.0356	0.243

Case 4: even Low P, TRAV_FOCUS, FLAT_Z

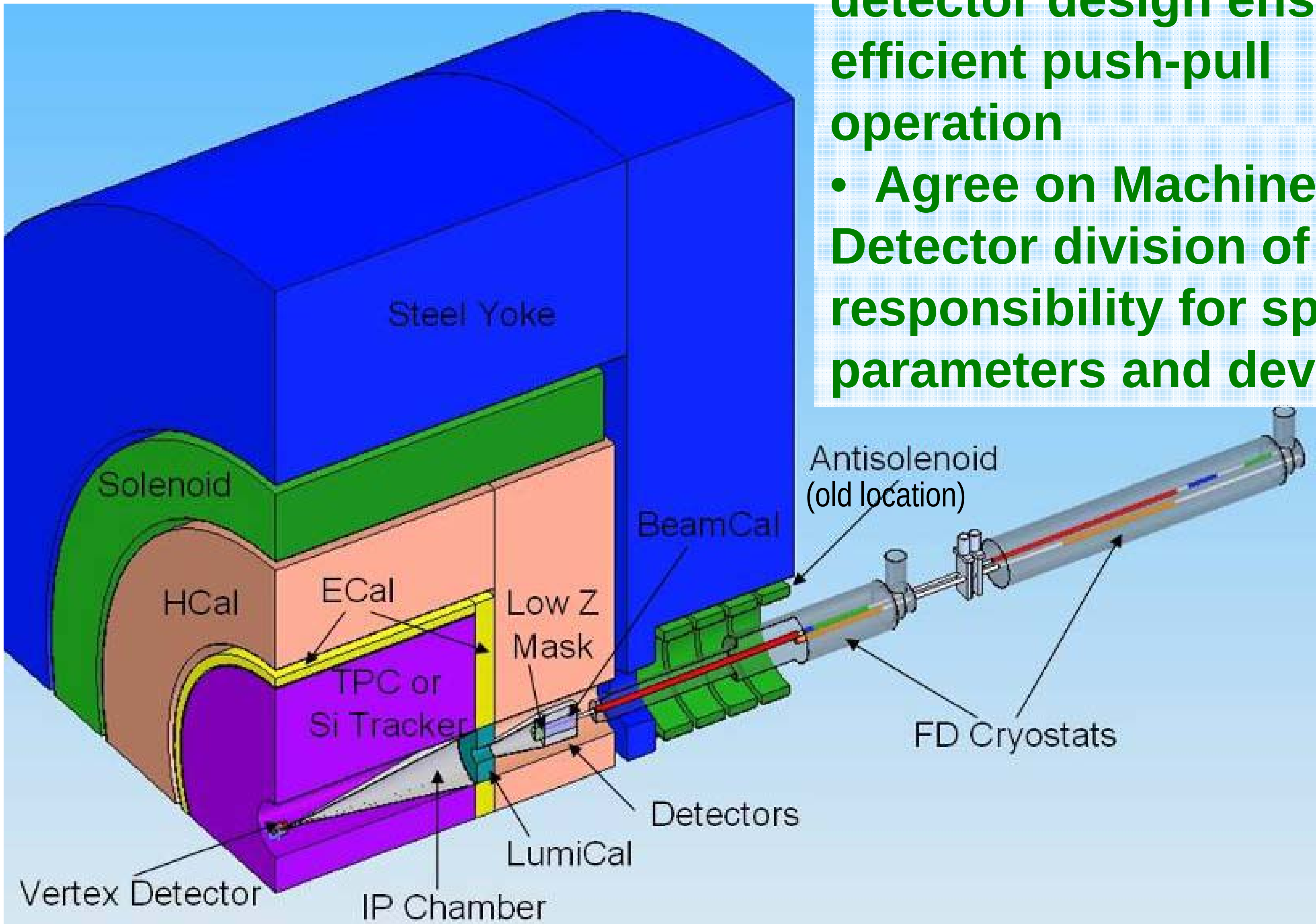


Higher sensitivity to offset

- In travelling focus case, higher disruption is needed for the bunches to keep focusing each other
- It then produces higher sensitivity to offset of the beams
- Operation of intratrain luminosity optimization is more challenging



IR integration



Challenges:

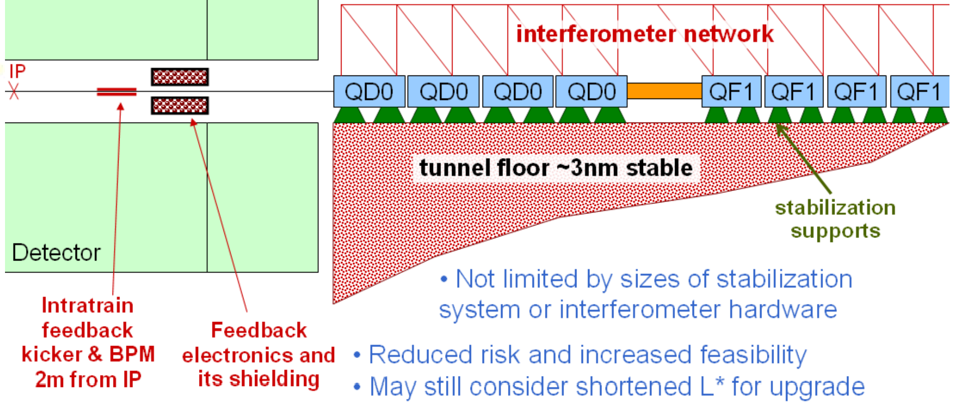
- **Optimize IR and detector design ensuring efficient push-pull operation**
- **Agree on Machine-Detector division of responsibility for space, parameters and devices**

Longer L* study

- Study of higher chromaticity optics at ATF2
  - smaller beta* or
  - longer L*
- may be interesting for studies of simplified IR interface
- and for possible studies of CLIC BDS

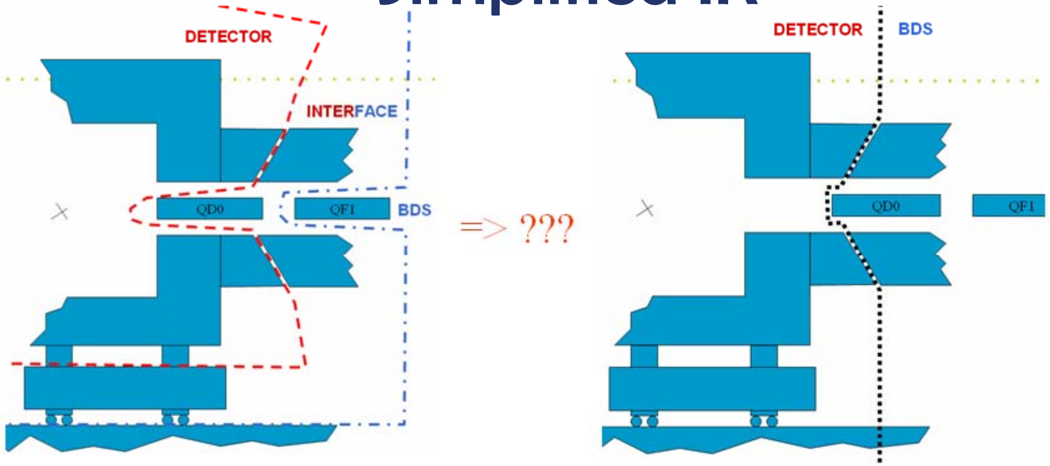
Discussed approach to CLIC stability

- Slower than 1/L* dependence of Lum => ↑L*
- Reduced feedback latency – several iteration of intratrain feedback over 150ns train
- FD placed on tunnel floor, which is ~ten times more stable than detector – easier for stabilization



- Not limited by sizes of stabilization system or interferometer hardware
- Reduced risk and increased feasibility
- May still consider shortened L* for upgrade

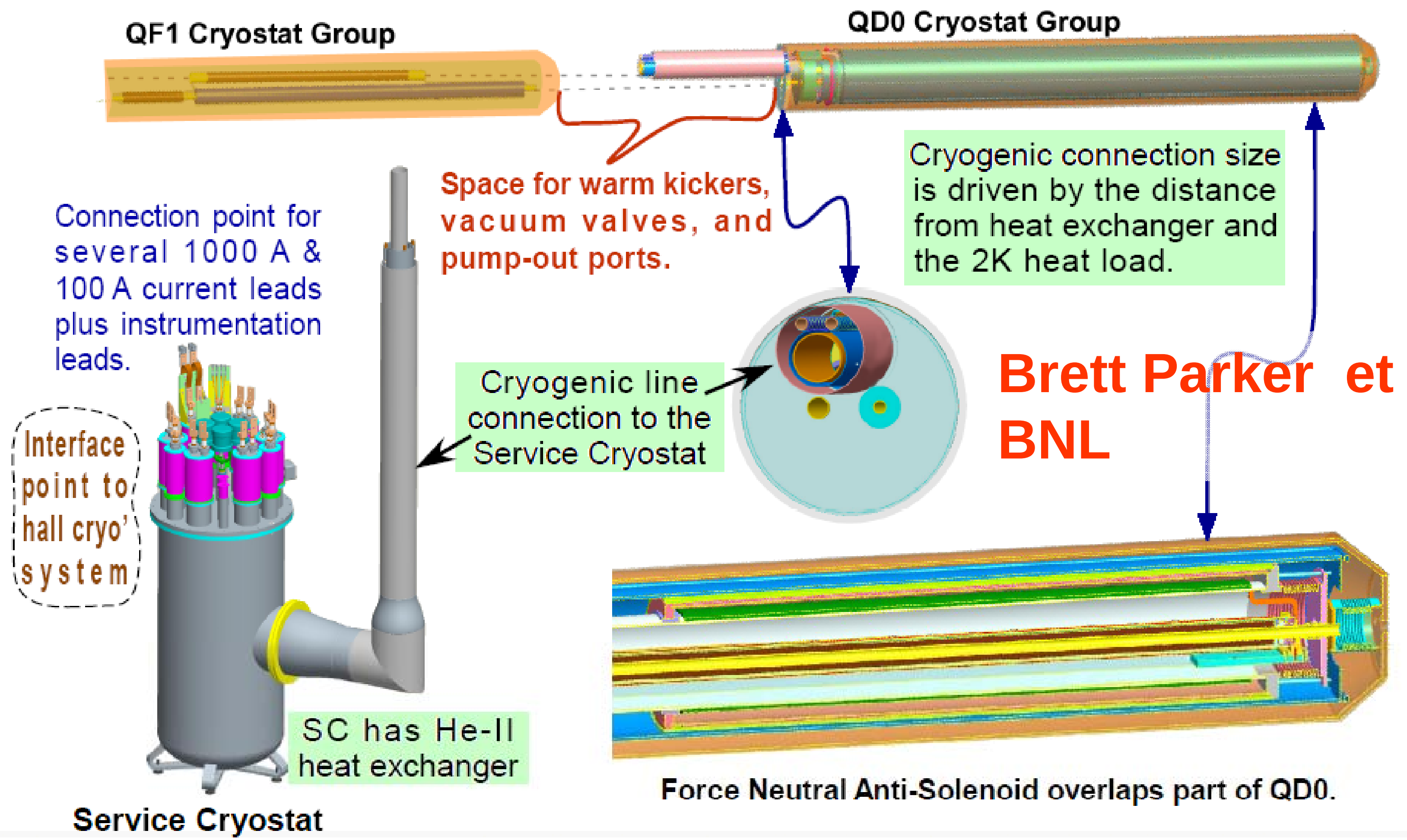
Simplified IR



- Longer L*, long enough to have QD0 outside of detector, separating M/D more cleanly and simplifying push-pull
  - Some impact on luminosity is unavoidable; Rvx may need to be increased
- If a longer L* design will be found viable, a question will be
  - whether to consider it as a permanent solution
  - if a Luminosity upgrade, by shortening the L*, would be considered later, after operational experience will be gained with a simpler system

SC final doublet plans at BNL

Consistent design of SC FD, suitable for push-pull operation

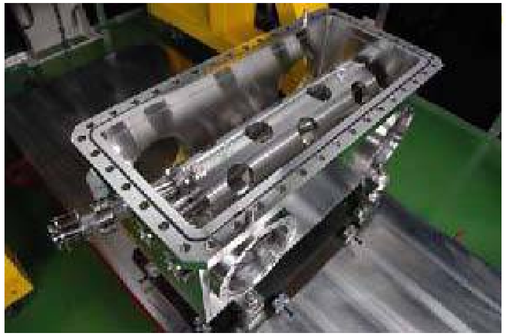


Brett Parker et al BNL

SC FD modified plans

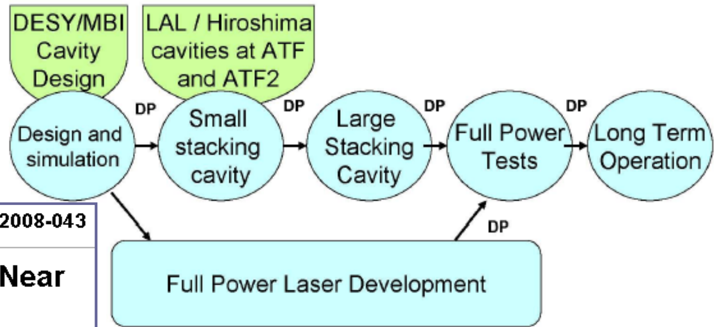
- Adjust the plans for SC FD prototype
  - reduce efforts on ILC-like FD prototype to cold mass tests
  - enhance efforts on ILC-technology-like SC Final Doublet for ATF2 upgrade
- Questions that required more studies:
- by ATF2 design team:
  - Would it be suitable to build only QD0-SD0 cryostat for ATF2? (the QF1 will remain a warm quad);
  - What ranges of beta*, L*, collimation depth one need to look for?
- by BNL colleagues:
  - What are the exact benefits of 2K vs 4K for ILC?
  - If 2K is essential, could we use 2K in BNL tests and 4K at ATF2?
- by KEK and BNL colleagues:
  - What are cryo-system requirements and possible design?

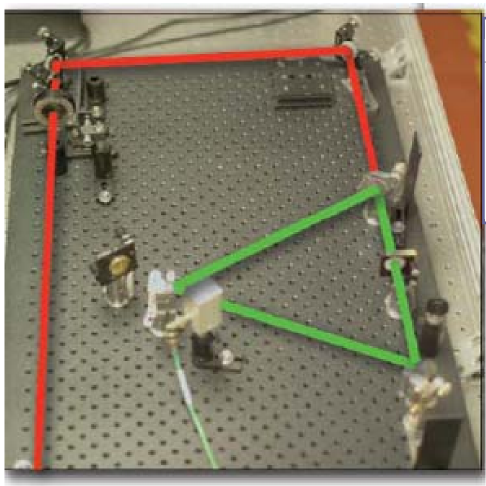
R&D plan for e→γ and ATF2



Pulse Stacking Cavity
(R&D for Positron source KEK-LAL-Hiroshima-Waseda-Kyoto-IHEP)
enhancement: 300-1000,
tight motion tolerances

- Photon collider option
- Physics reach and cost
- Technically feasibility to be developed
- ATF2 gg work need to be planned



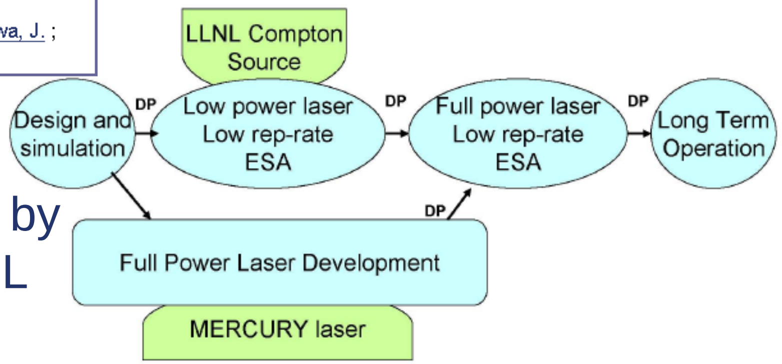


I. Jovanovic, LLNL

Public Note / ACCDT / BDS   LLNL-TR-403955   ILC-NOTE-2008-043

Photon Collider Technology Readiness and Near Term Plans

Gronberg, J. ; Omori, T. ; Seryi, A. ; Takahashi, T. ; Telnov, V. ; Urakawa, J. ; Variola, A. ; Woods, M. ; Zomer, F.

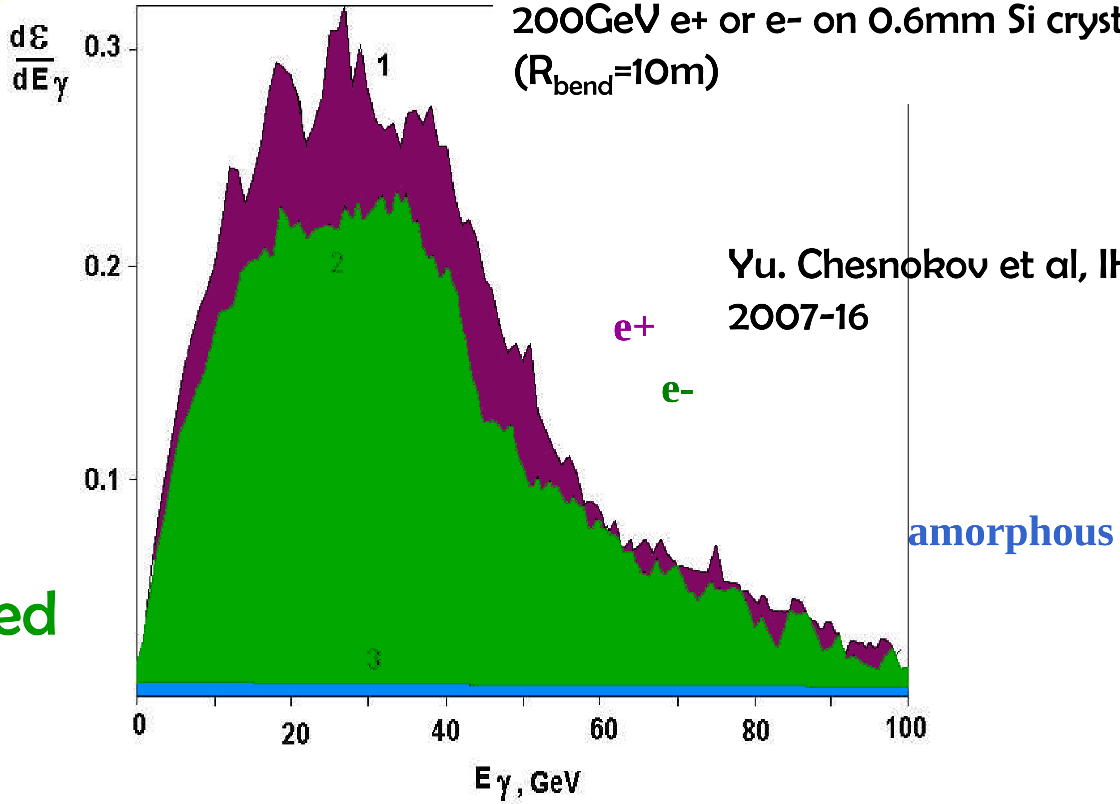


RING (Recirculation Injection by Nonlinear Gating) Cavity LLNL
recirculation of a pulse ~50 times
compensation of circulated pulse decay

Collimation system studies

- Crystal collimation
  - Potential for more robust & shorter collimation system
  - Application as photon source
  - What can be studied at ATF2?

Volume reflection radiation of 200GeV e+ or e- on 0.6mm Si crystal (R_{bend}=10m)



Yu. Chesnokov et al, IHEP 2007-16

- Above: volume reflection radiation spectra
  - This phenomena may be suitable as a base for the collimation system

Your comments & suggestions :

- hope that colleagues, especially the BDS work-package leaders, could tell about their thoughts how the planned ATF2 studies could affect their WP, and vice versa,
- and what ATF2 studies could be proposed, that would allow to make BDS design better, more reliable, more versatile, etc.

- also welcome suggestions on the agenda of BDS 1/2-1 day session at December ATF2 project meeting