"Minimum Machine" is code for

Design and Integration Studies in 2009 toward a Re-Baseline in 2010 which will be the basis of TDP2 Engineering Design and Costing

Minimum Machine is shorter

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GDE

Today's Presentation

- **Quick look at topics?** (with personal opinions from JMP)
- **Review of status of some of the studies.**
- **First look at "impact" of some of the proposed topics**
- **Plans for continuing work through 2009 and into 2010.**

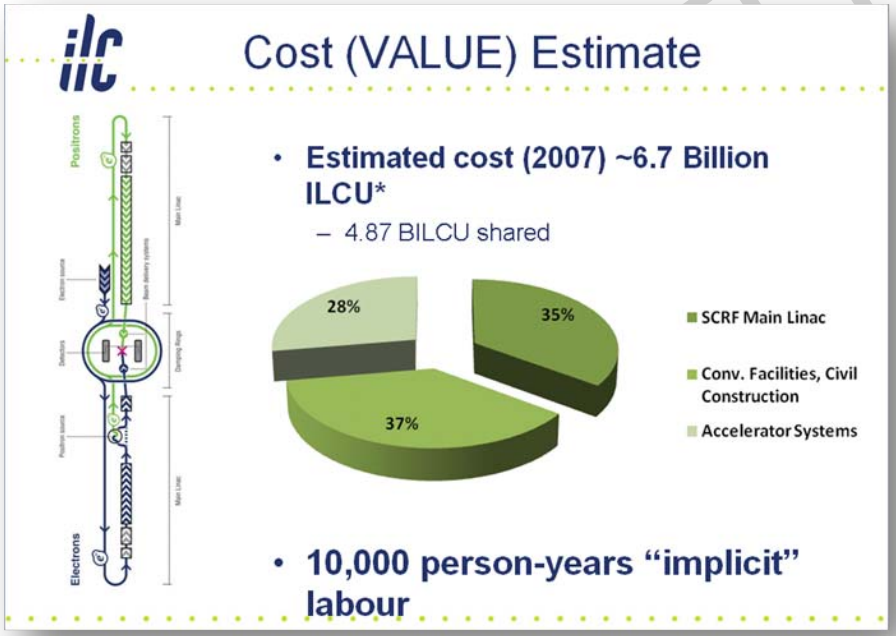
Minimum Machine Elements from PAC 08

1. Single-tunnel solution(s)
2. Klystron Cluster concept
3. Central region integration
4. Low beam power option
5. Single-stage compressor
6. Quantify cost of TeV upgrade support
7. "Value engineering" The whole exercise is global value engineering!

Cost Decrements (Rough Estimates) from PAC08

• Main Linac (total)	~ 300 MILCU	4.5%
• Low-Power option	~ 400 MILCU	6.0%
• Central injector Integration	~ 100 MILCU	1.5%
• Single-stage compressor	~ 100 MILCU	1.5%

VERY PRELIMINARY! Confirmed



– VERY preliminary: better estimates will be made (end 2009)
  - But still based/scaled from RDR value estimate

– Elements *not* independent! Careful of potential double counting!

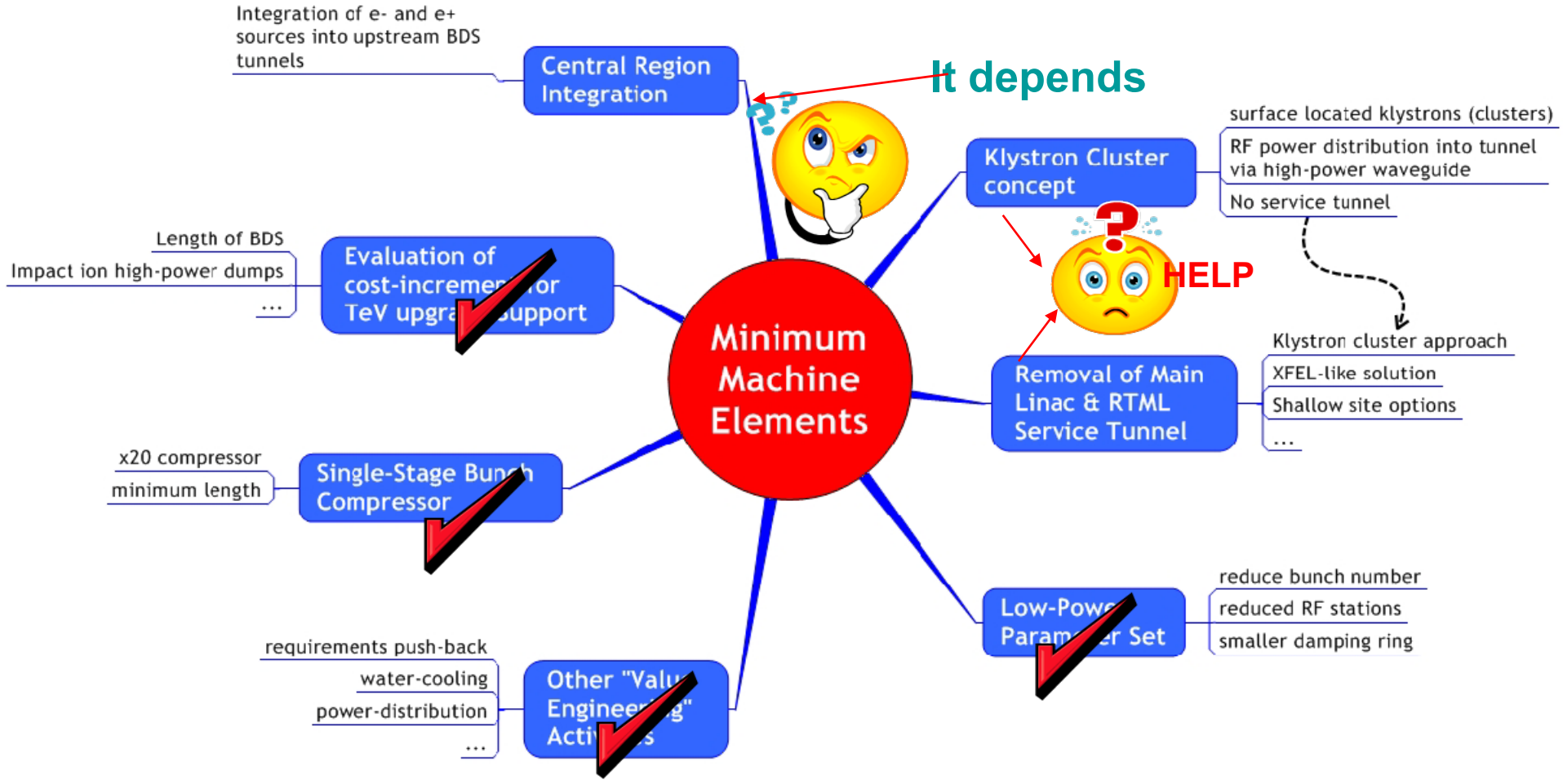
– **Cost vs Performance vs Risk**: important information for making informed decisions in 2010

COST IMPACTS

- The Cost Management Group will evaluate the cost delta's associated with all of these possible re-baseline topics using the RDR data for the basis of comparison.
- These delta's will be part of the cost/risk evaluation in the re-baseline discussions.

- **A 'Bottoms Up' ILC cost estimate will be part of the TDP2 process.**

Quick personal look at topics as of today!

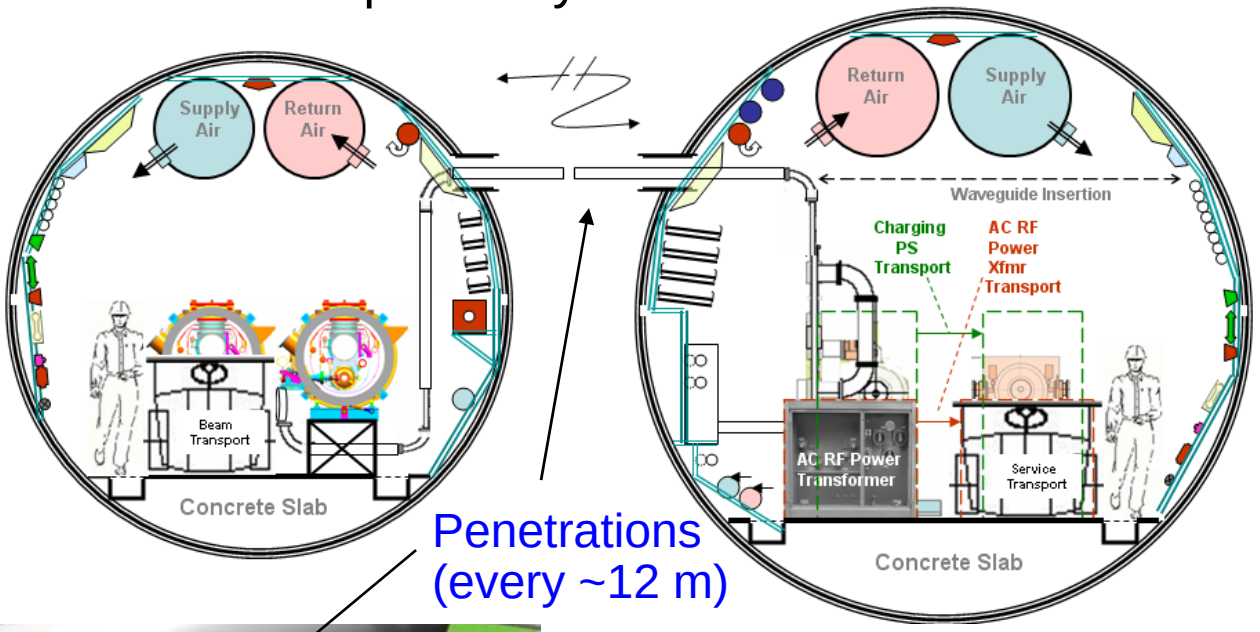


Klystron Clusters, DRFS and Single Tunnel Layouts

- High Level RF Systems have major impact on single tunnel studies.
- The impact depends on site assumptions
- Although R&D will continue on these different approaches, it is unlikely that full technical demonstrations will be possible on the re-baseline schedule.
- **We will need to make working decisions for the single tunnel studies and have some parallel efforts.** **Coming this month!**

RDR Baseline Tunnel Layout

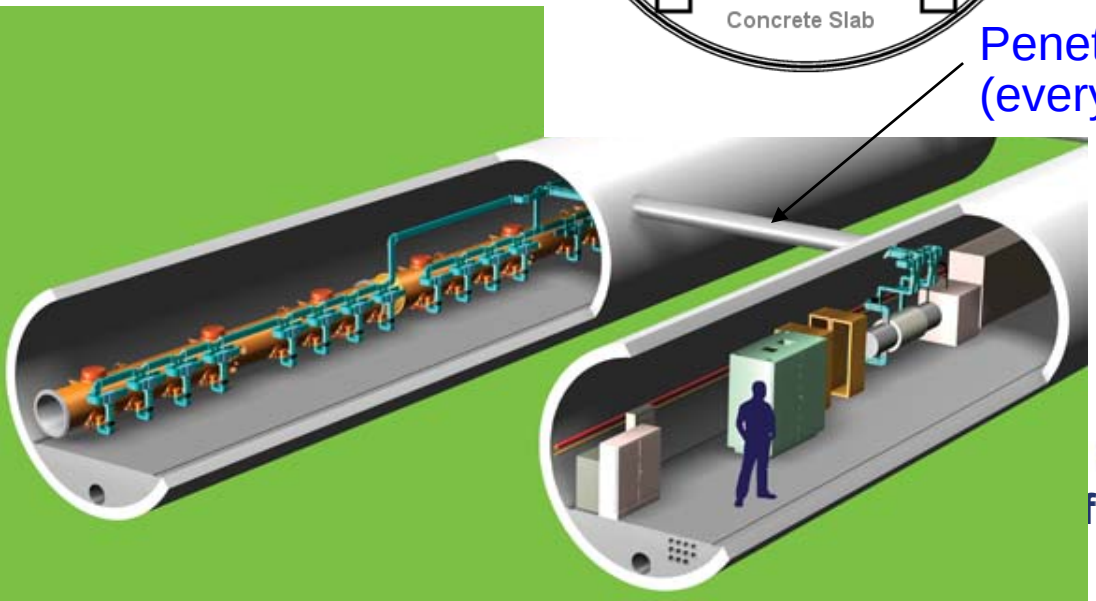
Two 4.5 to 5.5 m diameter tunnels spaced by ~7 m.



Accelerator Tunnel

Waveguides
Cryomodules

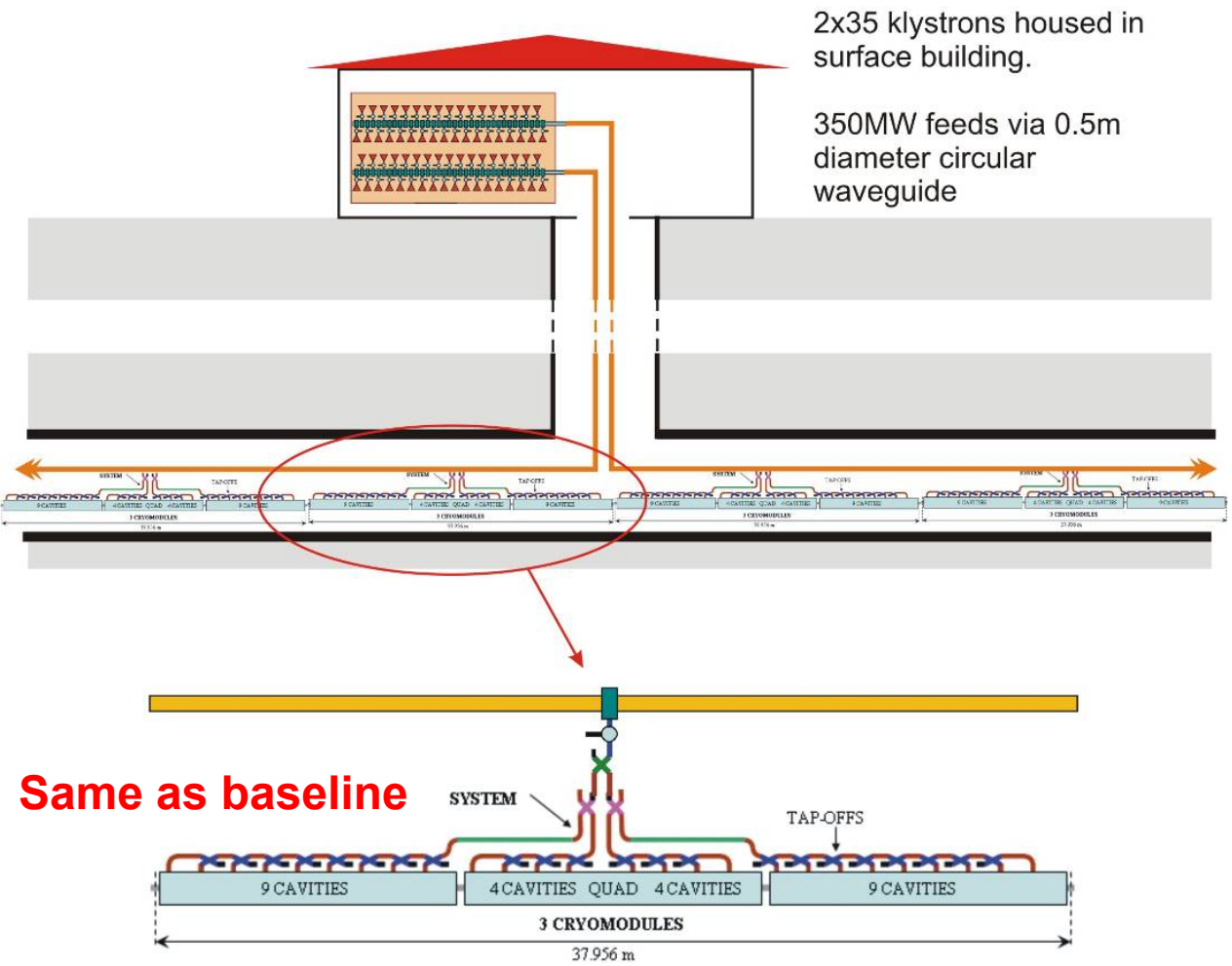
Penetrations (every ~12 m)



Service Tunnel

Modulators
Klystrons
Electrical Dist
Cooling System

KLYSTRON CLUSTER CONCEPT



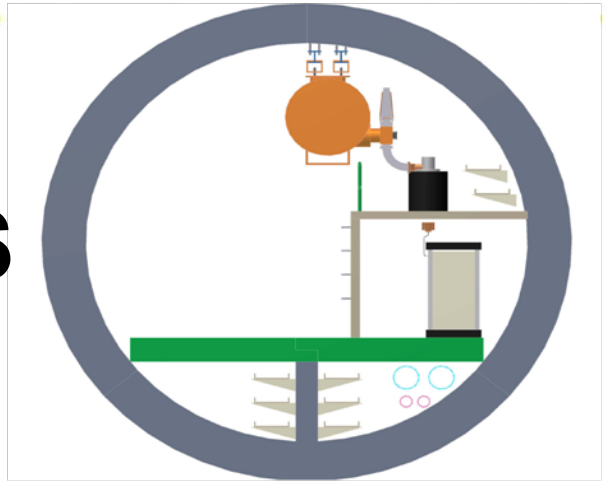
Same as baseline

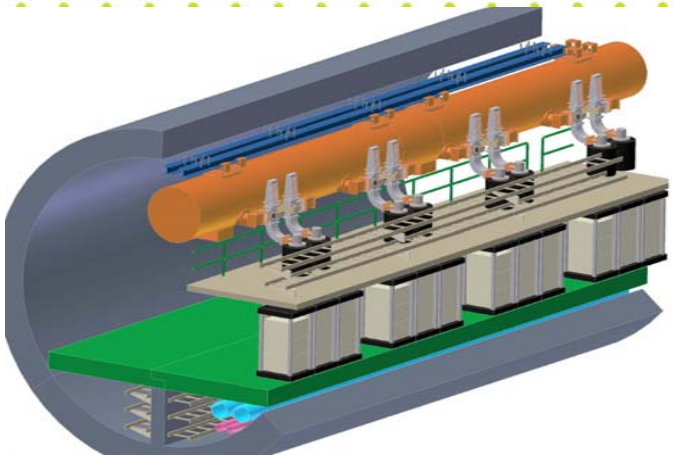
Each tap-off from the main waveguide feeds 10 MW through a high power window and probably a circulator or switch to a local PDS for a 3 cryomodule, 26 cavity RF unit (RDR baseline).

- RF power “piped” into accelerator tunnel every 2.5 km
- Service tunnel eliminated
- Electrical and cooling systems simplified
- Concerns: power handling, LLRF control coarseness

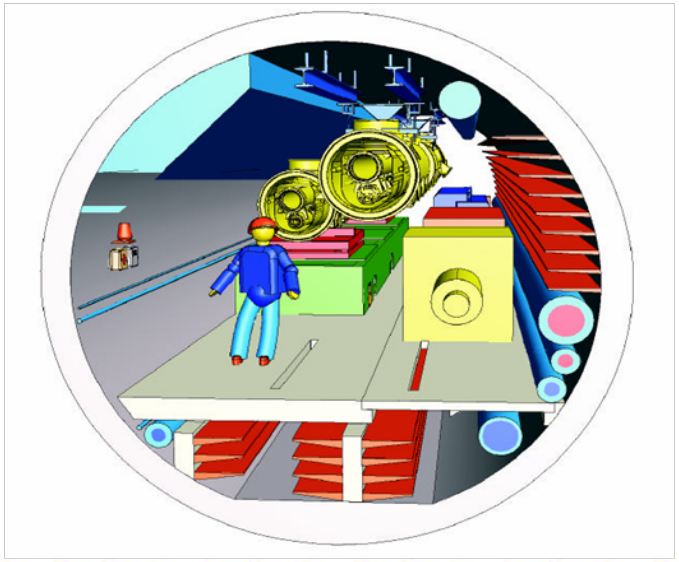
Other RF Distribution Examples

DRFS





One 800 Kw source
Per 2x9 cell cavity



XFEL

Similar to RDR with 10 Mw Klystrons in beam tunnel
And modulator elsewhere

Low Power Parameter Set

- The Low Power Parameter Set (½ power using ½ length bunch train length) is part of the RDR Parameter Plane and has impact on many systems. They are in brief :-
- e- Injector--- Easier on laser/photocathode
- e+ Source----Easier target,/ capture systems
- Damping Rings----Makes ½ circumference DR possible without other negative affects.
- RTML/Bunch Compressor-----Increases importance of achieving short (200-300 micron) bunch length over a variety of conditions

Low Power Parameters (2)

- **Main Linac---Reduces by factor of two the required number of RF sources**

- **BDS--- Requires 200 micron bunch length, or use of Travelling Focus, to maintain design luminosity. First studies are encouraging showing Travelling Focus alleviates these problems.**

- **Ability to upgrade to higher power via longer bunch train, *if required*, would be dominated by the cost and interference of adding damping rings.**

- **How much head room or safety factor do we have in other systems to, for example increase the single bunch current, giving flexibility in the parameter plane around the low power set?**

  This is part of the study.

Some results from early studies look encouraging. The next three slides show the following:-

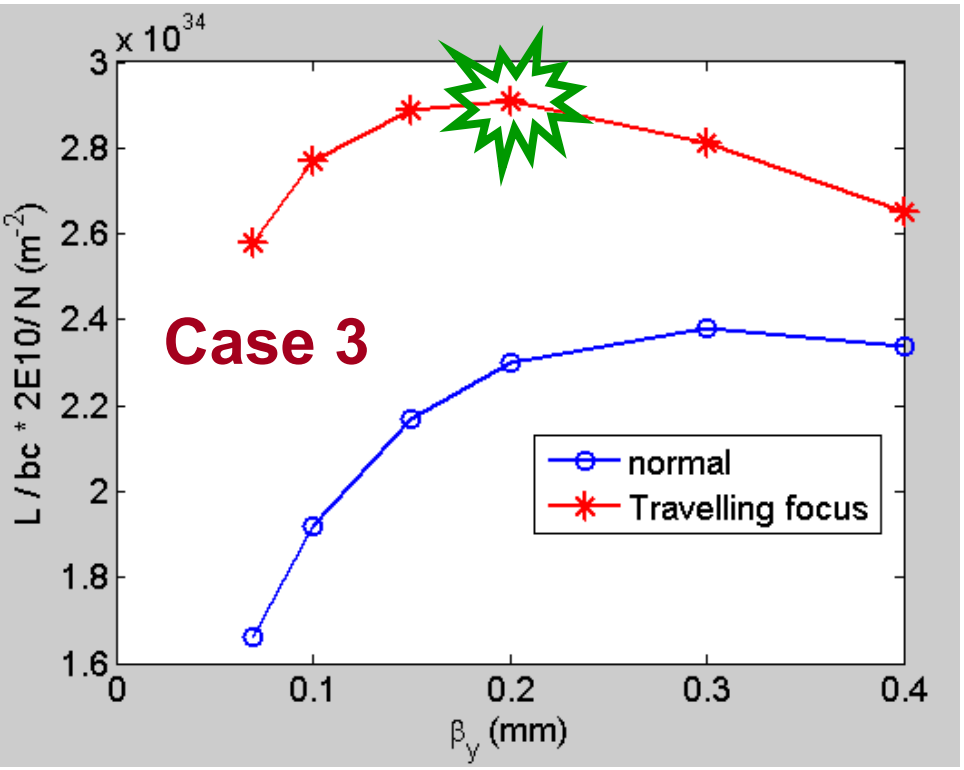
- The application of “travelling focus” in the BDS maintains performance of nominal RDR central parameters
- There is an increased sensitivity to beam- beam alignment but not extreme
- The proposed Low Power parameters with “travelling focus, control the backgrounds in detectors.

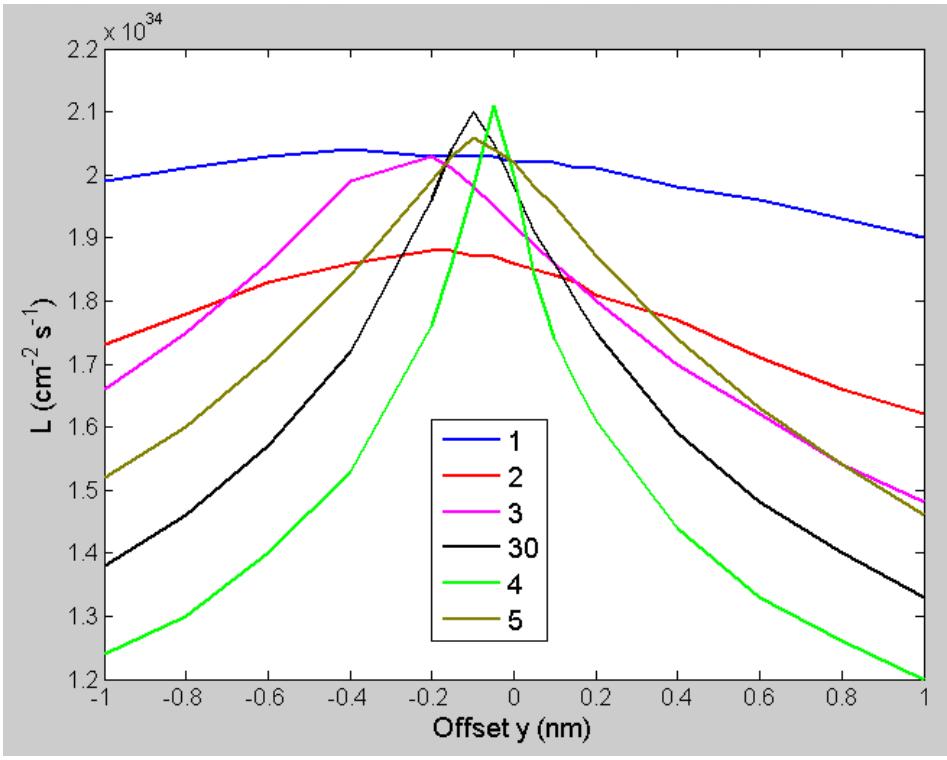
Candidates for new Low P parameter sets

	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 δE/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 $\sigma_z \cdot 2\sqrt{3}$

Case 3 Low P & offset sensitivity

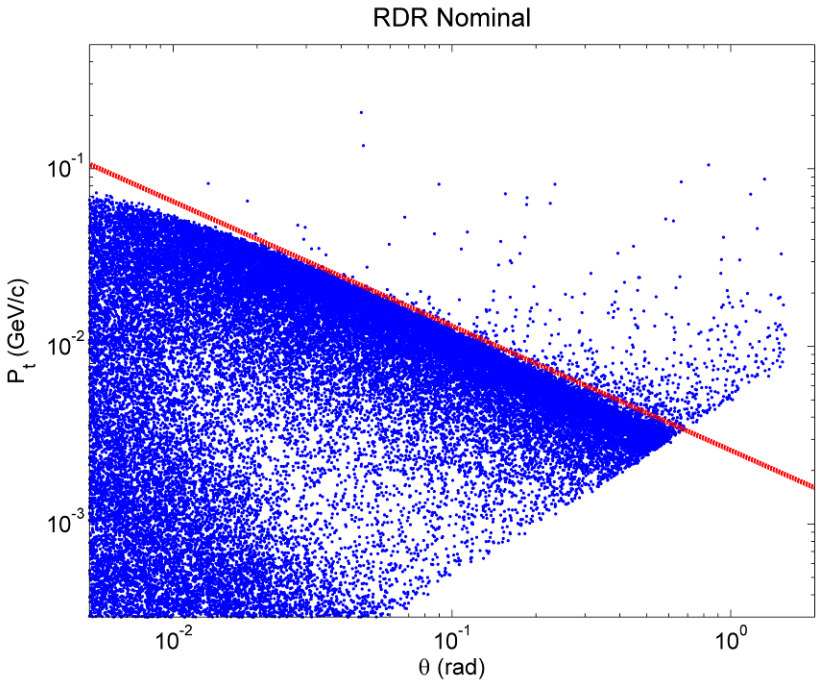


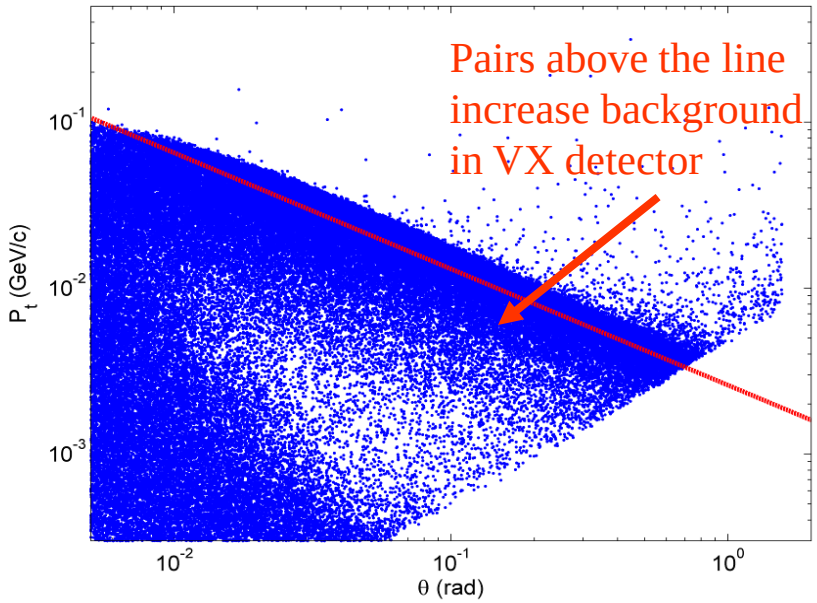


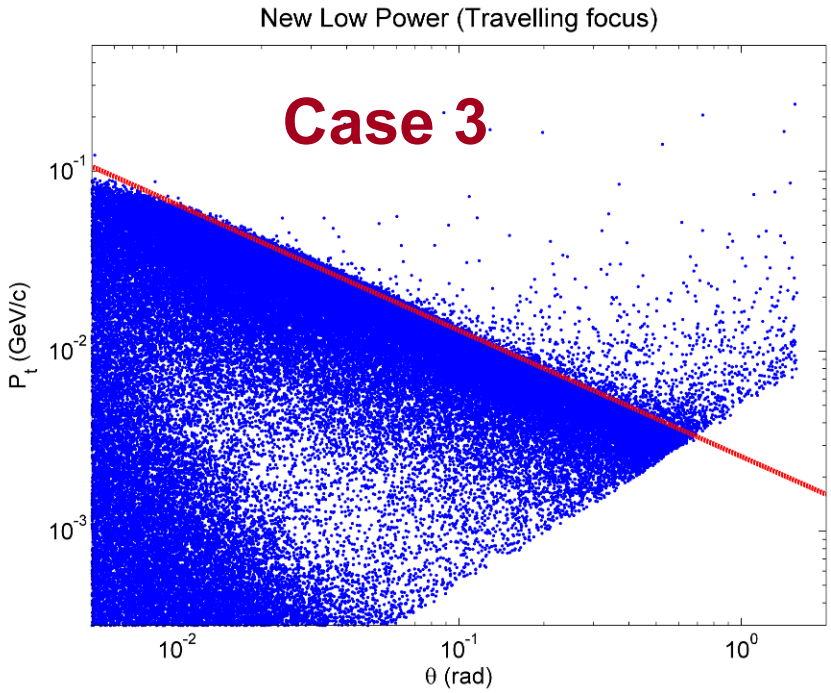
- Luminosity kept by tighter focusing ($\beta^*_y < \sigma_z$) while the moving focus and beam-beam force keep beam focusing each other
- Higher disruption needed, which produces higher sensitivity to offset of the beams
- Operation of intratrain luminosity optimization is more challenging

e+e- pairs

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



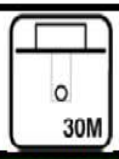
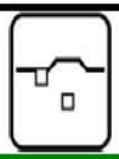




Value Engineering

- Work continues in studying water, power, cryogenic, surface buildings, and systems costs and their dependence on other system assumptions.
- Evaluation of different tunnel geometries for different potential sites.
- See examples in next slide

Configuration Matrix of Tunnel Options

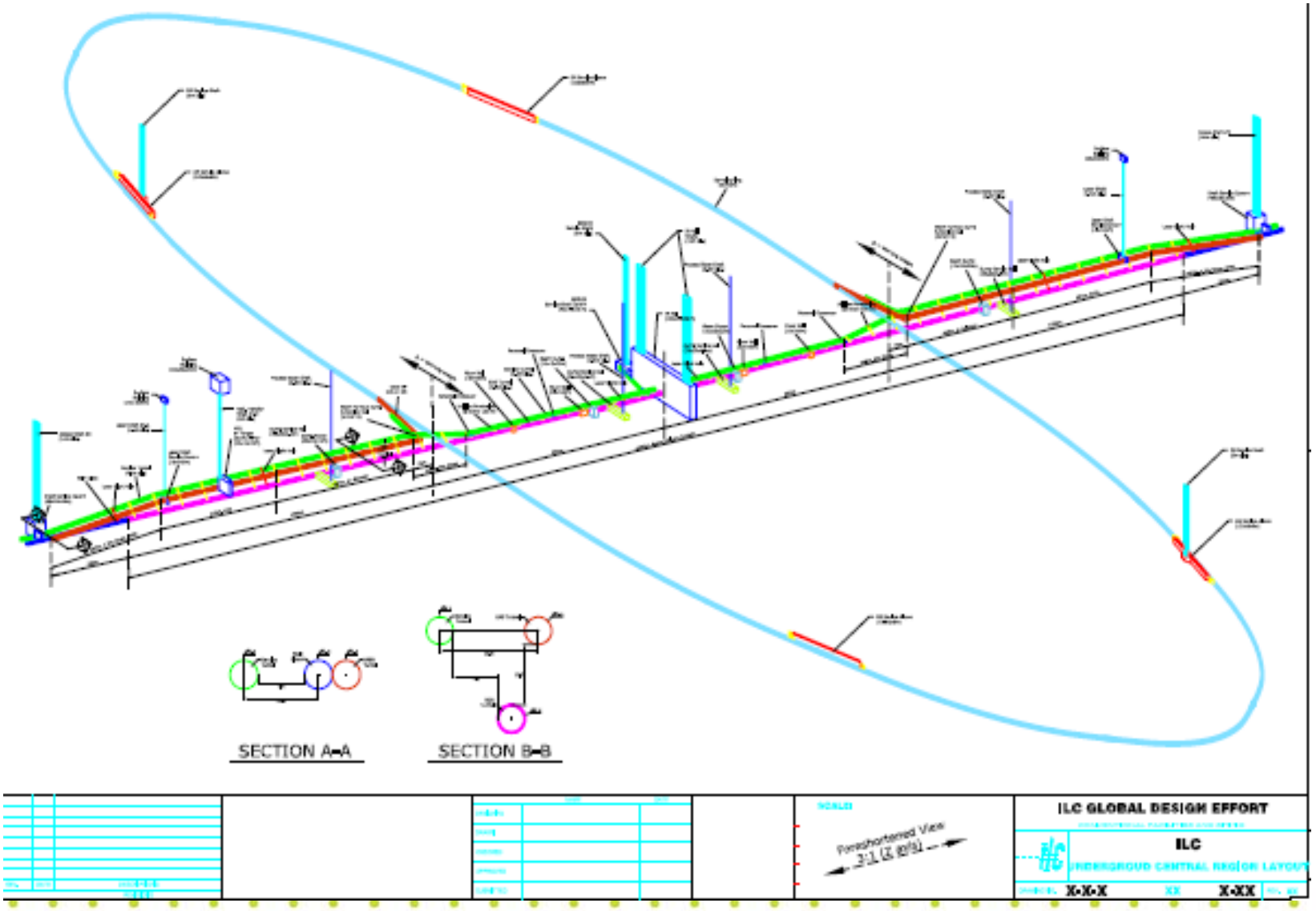
							
	DEEP		NEAR SURFACE				
	Twin Deep Tunnels	Single Deep Tunnel	Twin Near Surface Tunnels	Near Surface Tunnel, at Surface Gallery	Single near Surface Tunnel	Enclosure in Open Cut, Cont. Gallery	Enclosure & Cont. Gallery in Open Cut
EXCAVATION	TBM	TBM	TBM	TBM & OPEN CUT	TBM	OPEN CUT	OPEN CUT
No of TUNNELS	TWO-TUNNEL	ONE-TUNNEL	TWO-TUNNEL	TWO-TUNNELS	ONE-TUNNEL	ONE-TUNNEL	TWO-TUNNELS
SHAFT SOIL	VARIES	VARIES	VARIES	VARIES	SOFT / SLURRY	NA	NA
TUNNEL SOIL	ROCK	ROCK	COHESIVE SOIL or ROCK	COHESIVE SOIL -Low permeability	Saturated Sand & Gravel	SOILS VARIES	SOILS VARIES
SERVICE SPACE	SECOND TUNNEL	SURFACE BUILDINGS	SECOND TUNNEL	CONTINOUS SERVICE GALLERY	AT CAMPUSES	CONTINOUS SERVICE GALLERY	CONTINOUS SERVICE GALLERY
ILC Technology	DISTRIBUED RF	CLUSTERED RF	DISTRIBUED RF	DISTRIBUED RF	CLUSTERED RF	DISTRIBUED RF	DISTRIBUED RF
SIMILAR TO	RDR Sample Sites	RDR & CLIC	RDR	Dubna ILC	XFEL	Project X	Project X
ACCESS	Vertical Shaft	Vertical Shaft	Vertical Shaft	Vertical Shaft	Vertical Shaft	Hatch	Hatch

- Electrical power levels remains constant. Clustered RF reduces electrical distribution.

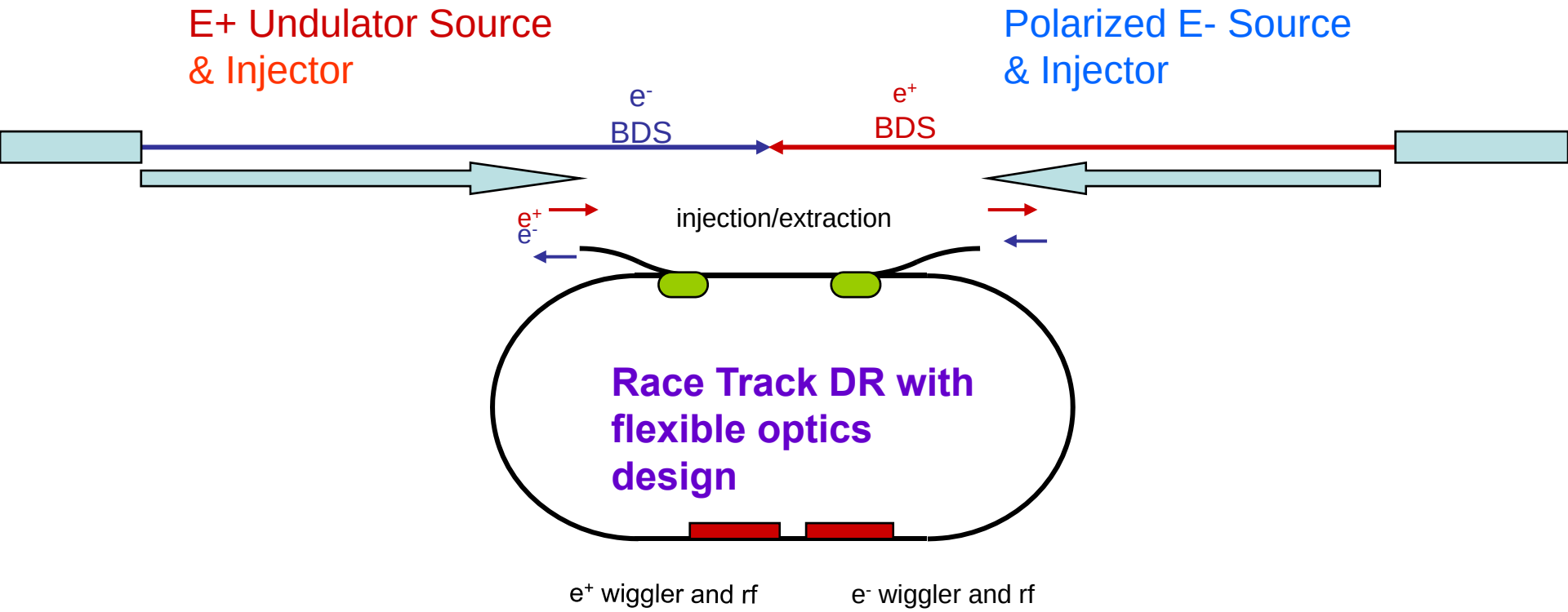
Single Stage Bunch Compressors

- The RDR design two stage compressor system was designed to accept very long bunches from the damping rings (≥ 9mm) and compress, with good emittance control, to very short bunches (≤ 200μ) for operation with some parts of the parameter plane including the RDR Low Power.
- The present DR designs have shorter bunches (~ 6mm) and it appears possible to achieve adequate compression with a simpler single stage of compression which would be shorter in length and would have fewer active components. A design is under study from the point of view of performance beam dynamics and emittance control.
- This study looks towards a positive outcome and does not interact with other system parameters

RDR Central Region



A Compact Central Region



All systems in same plane sharing tunnels where possible.

A Compact Central Region (1)

- Central Region Integration
- This is a simple concept but requires a complex design effort and impact analysis. The general idea is to group all systems except the actual linacs in the central region and minimize the underground housings required to house them. Basic assumptions for the study are that :-

- a) Everything will be in one plane, Inj's, DR, RTML, BDS

- b) The distance from the IP to the linac exit does not have to the same on either side

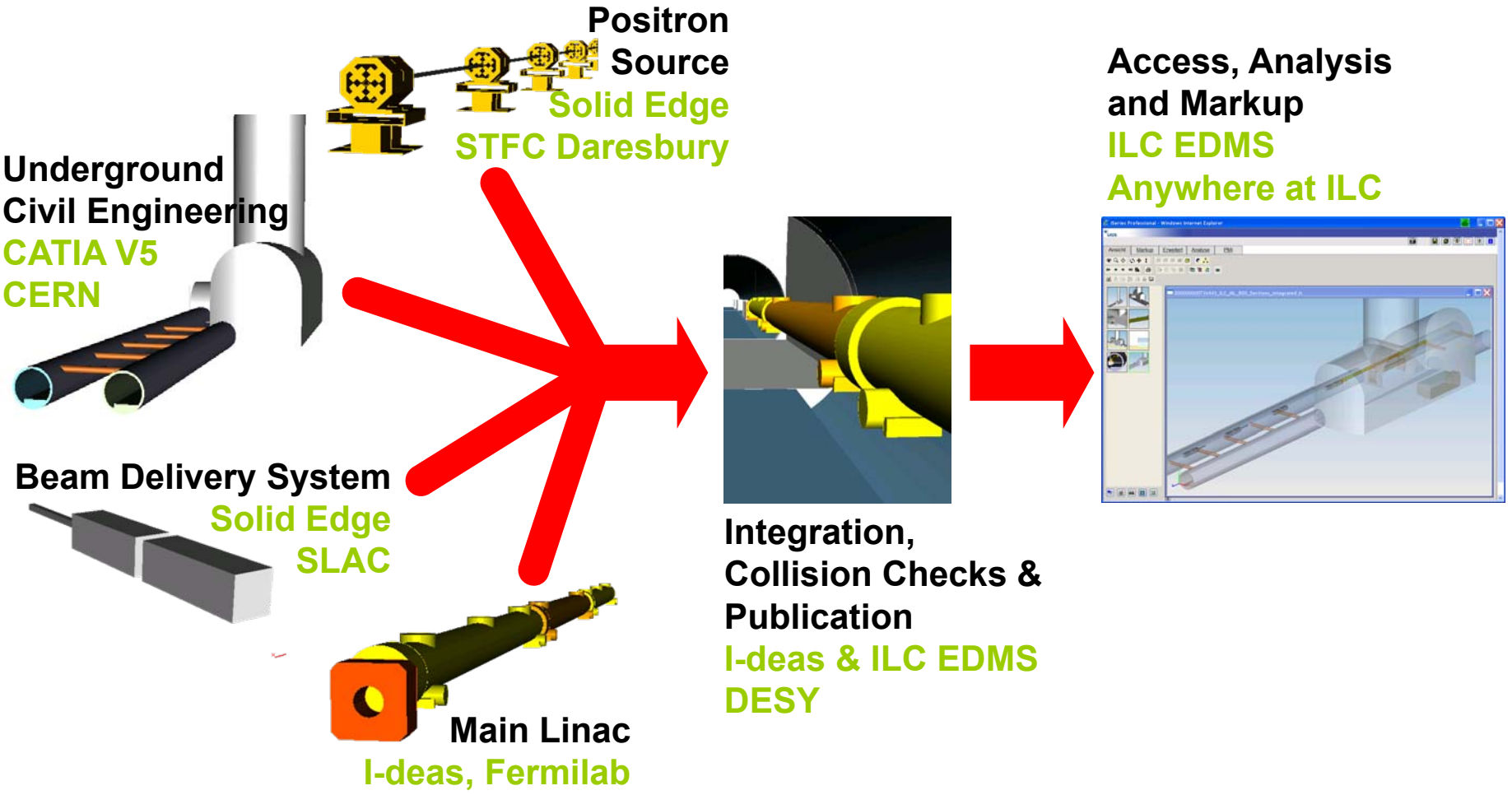
- c) The 'Keep Alive Source' will be functionally replaced with an 'Auxiliary Source' which is integrated into the E+ Source.

- d) Both E- and E+ sources, including the 5 GeV booster linacs and housings, will be in-line with the Linac and BDS

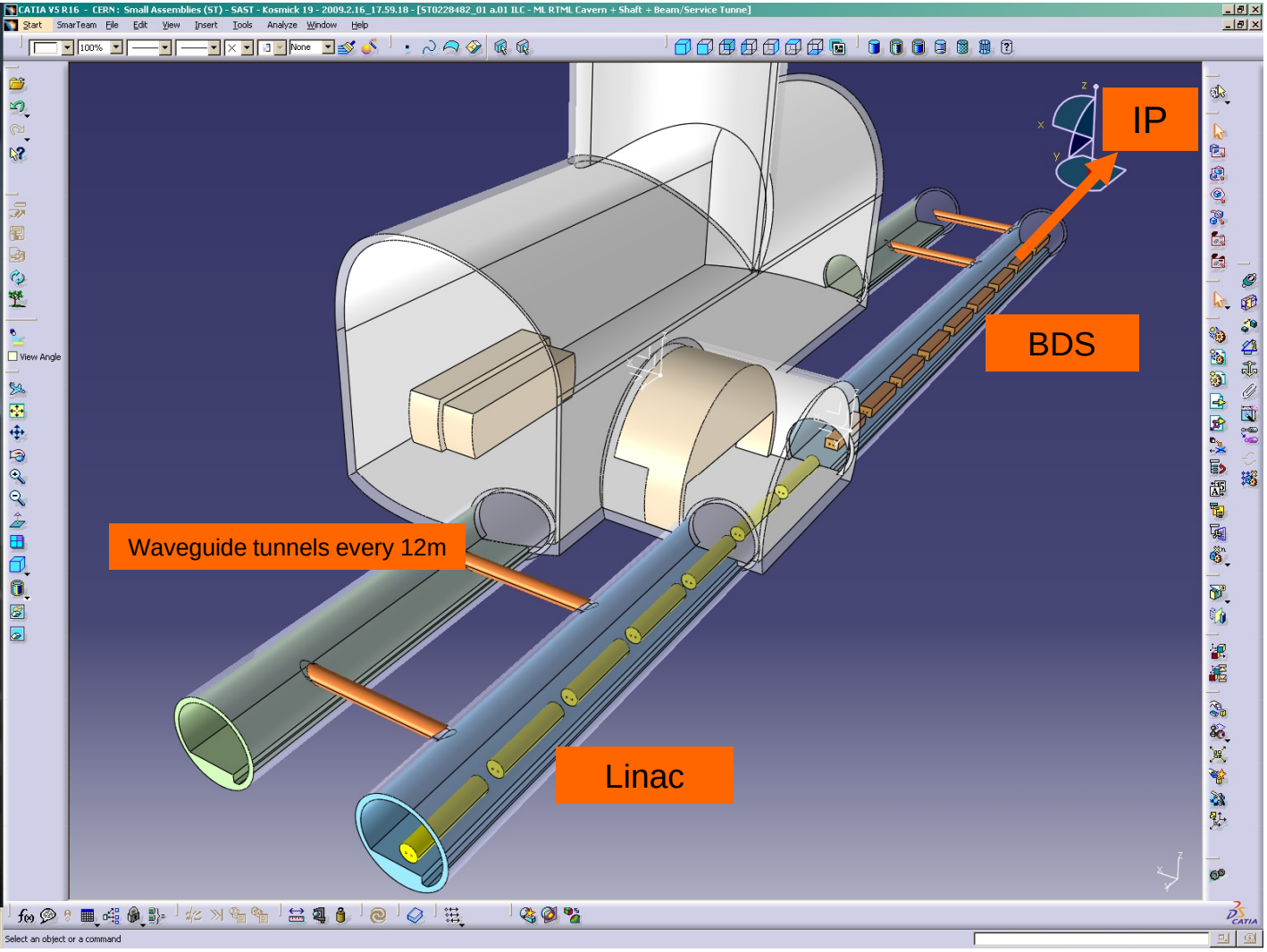
A Compact Central Region (2)

- e) The degree of overlap, and therefore savings in tunnel length between the Sources and the BDS has to be studied and considered as a variable.
- f) 3D CAD capability will be available in studying this tunnel sharing from the points of view of feasibility, cost, operability, installation planning and personnel safety.
- g) The final layout should support either 3.2 or 6.4 km circumference damping rings.
- The end result should be a Central Region Layout which does not necessarily have the minimum of underground civil construction or cost but has a more optimized lower cost design than the RDR.

3D CAD Collaboration Team Test Scenario as of TILC09



First step before adding sources etc.



Study area, 50m either side of Shaft No. 3 That is the end of the linac and the start of the BDS

Potential Impact on Design

After answering the questions of **technical feasibility** of tightly coupling everything in the central region. (The Compact Central Region)

One must look at

Availability Looks not unreasonable.

Impact on installation and repair Part of the 3D CAD study. Will be a complex issue!

Commissioning Still maintains the desirable features that injectors and DR's can be early but with some interference with BDS installation.

Updated AD&I Schedule

- **Project Management will drive re-baseline design**
- **Core "design & integration" team**
  - **TAG leaders**
  - **Cost Management Group**
  - **Few key (specialist) additions**

  ~30 people
- **Series of face-to-face meetings foreseen**
  - **DESY 28-29.05**
  - **ALCPG GDE meeting (Albuquerque) 29.09-03.10**
  - **(Possible meeting in early December – tbd)**
- **Produce proposed re-baseline changes early 2010**
  - Review process → consensus → sign-off

Processes that still require more definition

- How do we evaluate impacts on construction, installation and commissioning schedules (and associated cost impact)
- Technical risk tables (from Dec 2007) can be updated and can provide qualitative basis for some comparisons!
- Computer modeling of “Availability” for different assumed baselines can again give only qualitative comparisons.
- As usual nothing will be BLACK or WHITE

Conclusions

- Obviously this is work in progress but with good progress. The potential cost reductions are significant but not huge.
- To maintain the desired schedule, design choices will have to be made to limit the number of variations on any given theme.
- However we will be ready in 2010 with some recommendations to management and the community for some worthwhile design changes.