Part II of Summary for WG D/C

Conveners:

Ewan Paterson (*SLAC*), Nikolay Solyak (*FNAL*),
Andrei Seryi (*SLAC*), Masao Kuriki (*KEK*)

GDE meeting, Dubna, June 4-6, 2008

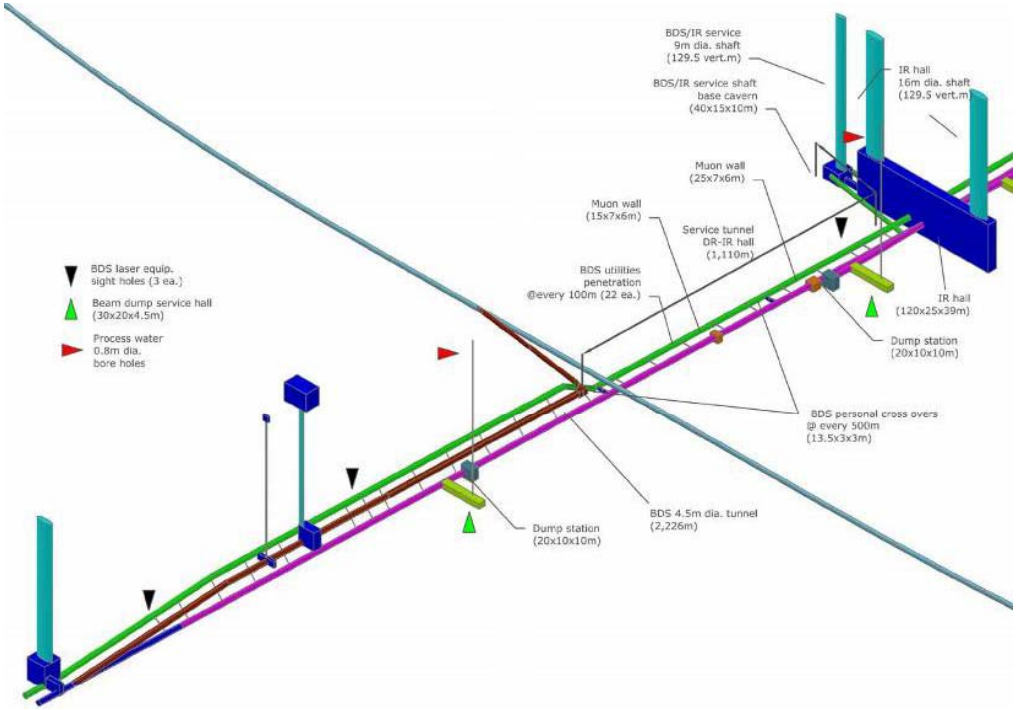
Contents

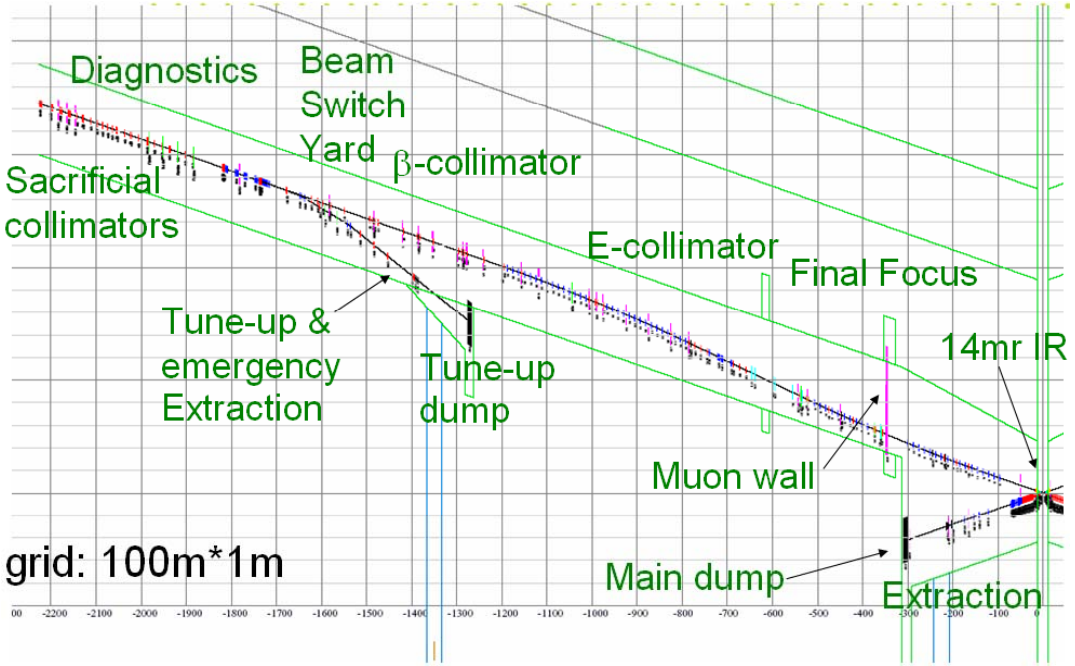
- Will cover contents of the following talks and discussions:

- Minimal Beam Delivery System, Andrei Seryi (SLAC)
- Advanced e+ source, Junji Urakawa (KEK)
- Central Region Integration, Ewan Paterson (SLAC)
- 1st stage , site filler and brainstorming session
- Next steps for study of Minimal machine

RDR BDS

- Single IR push-pull BDS, upgradeable to 1TeV CM in the same layout, with additional bends
- Length: 2.2km per side
- What would be the minimal 500GeV CM BDS?





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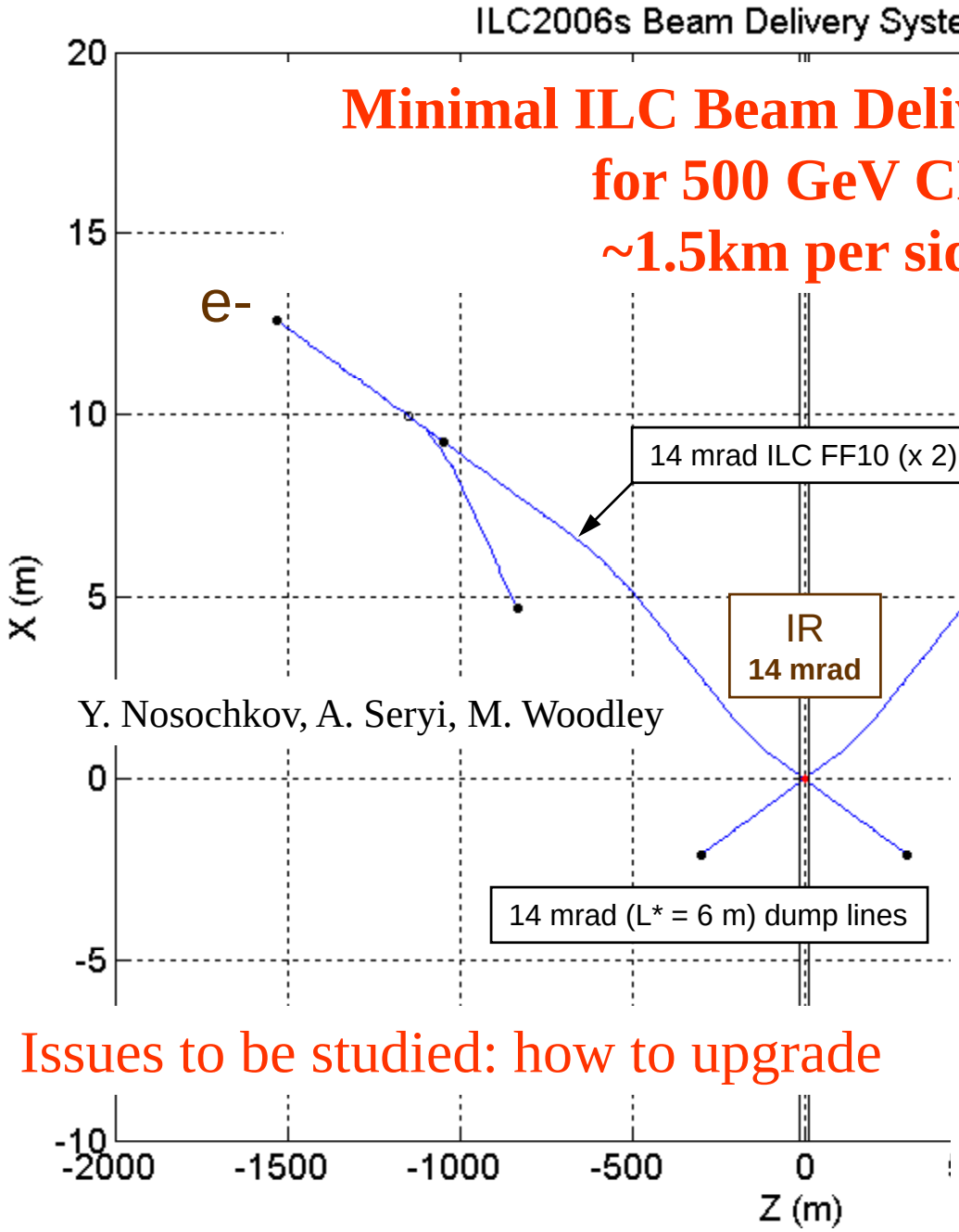
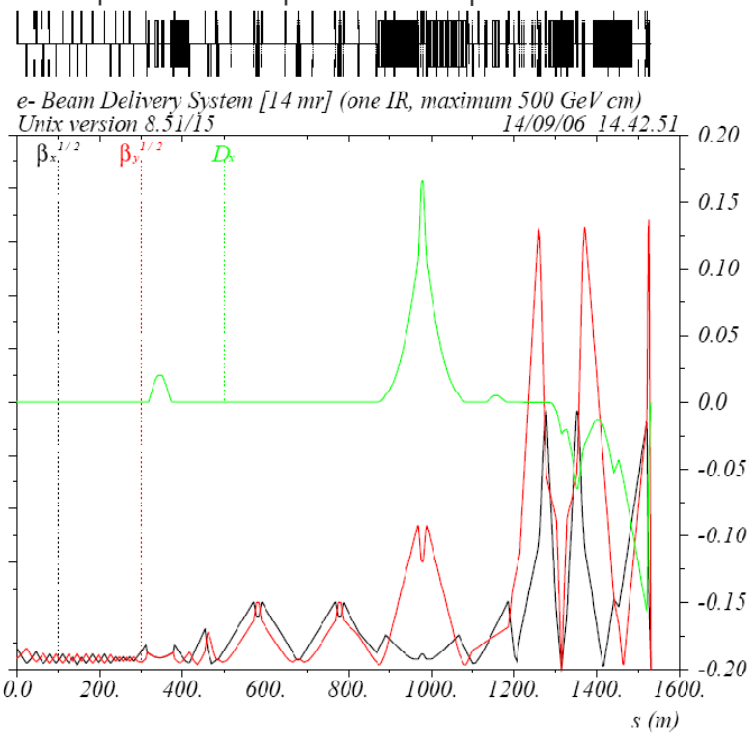
Minimal ILC Beam Delivery System for 500 GeV CM ~1.5km per side



TENTATIVE

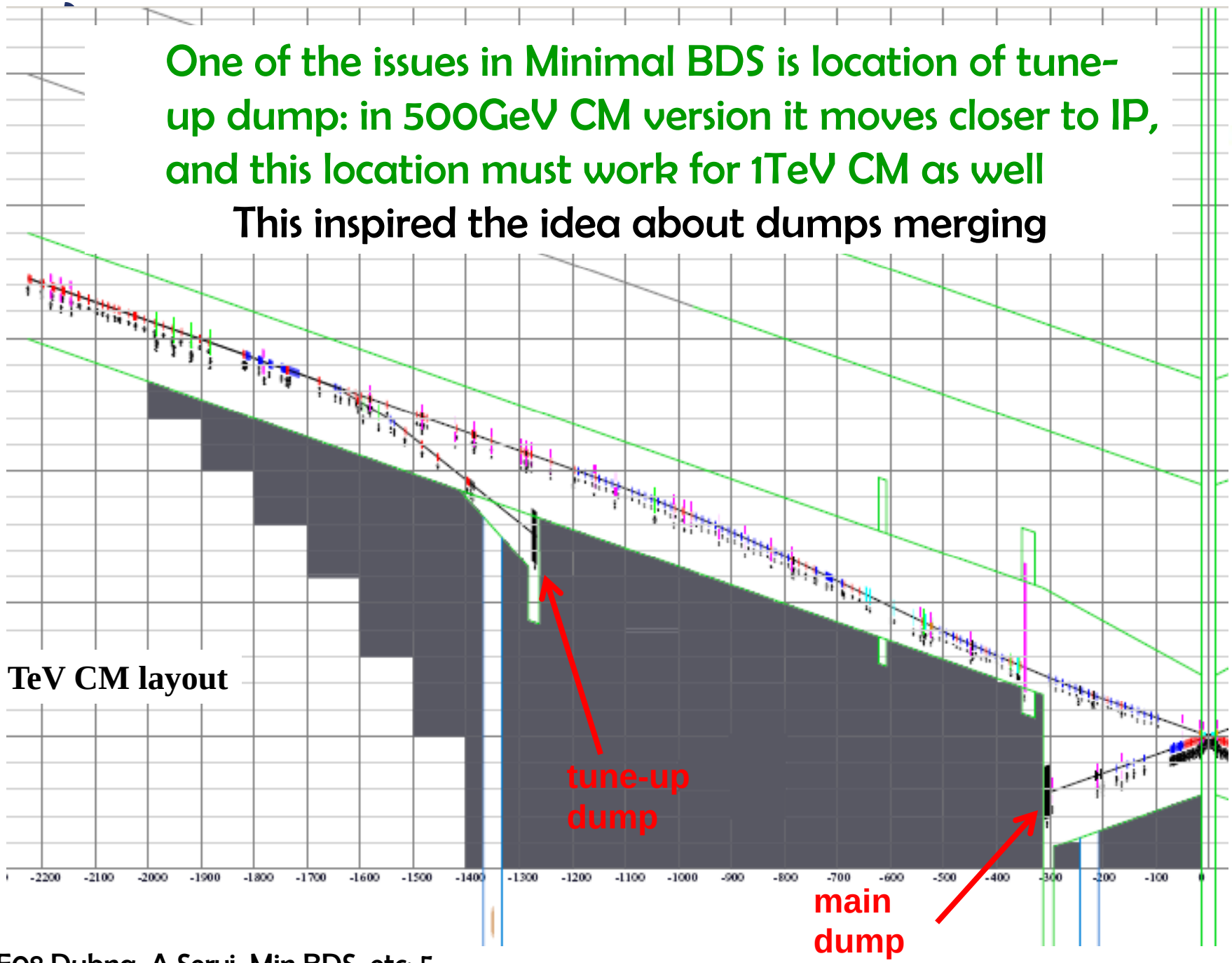
Y. Nosochkov, A. Seryi, M. Woodley



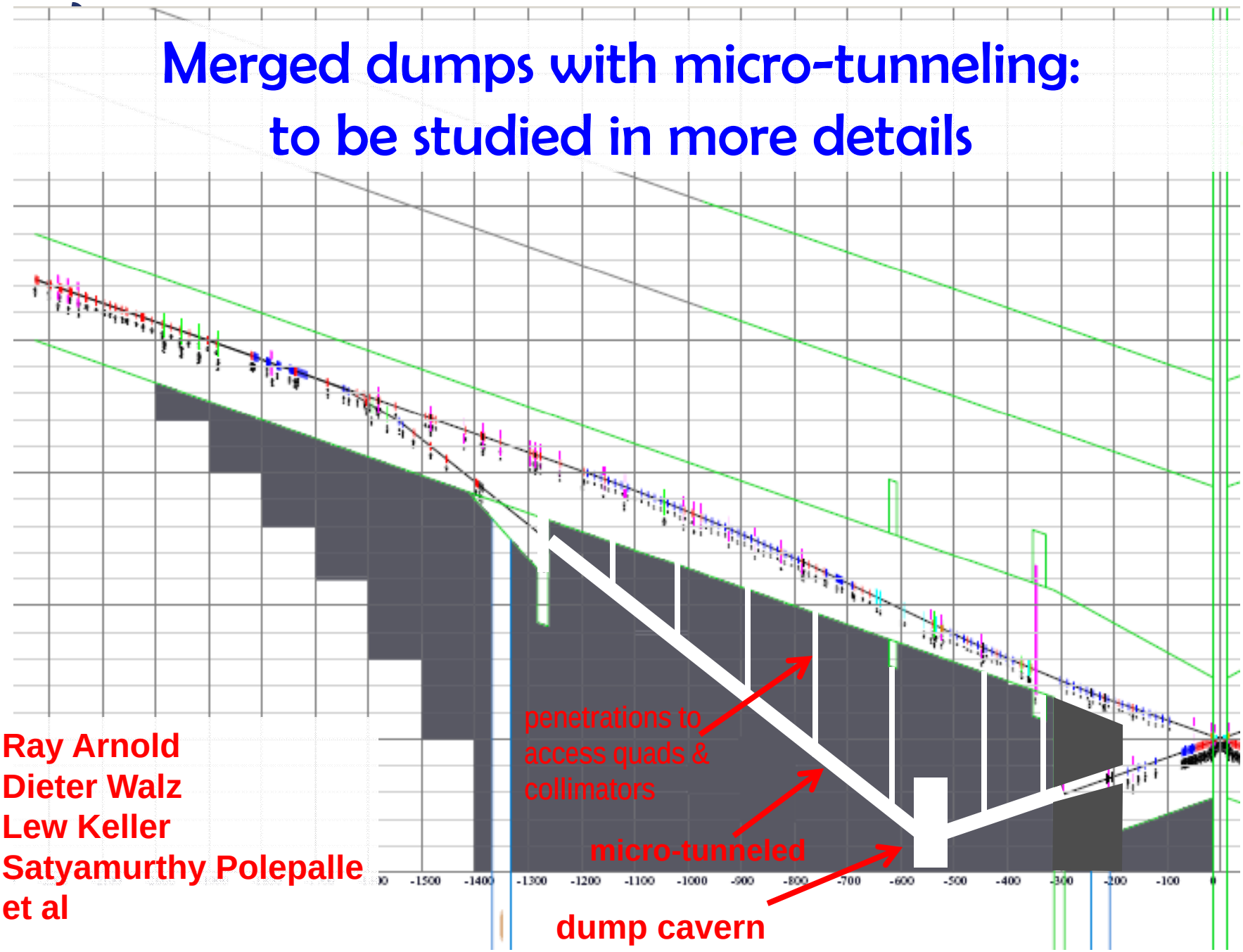
Issues to be studied: how to upgrade

One of the issues in Minimal BDS is location of tune-up dump: in 500GeV CM version it moves closer to IP, and this location must work for 1TeV CM as well

This inspired the idea about dumps merging



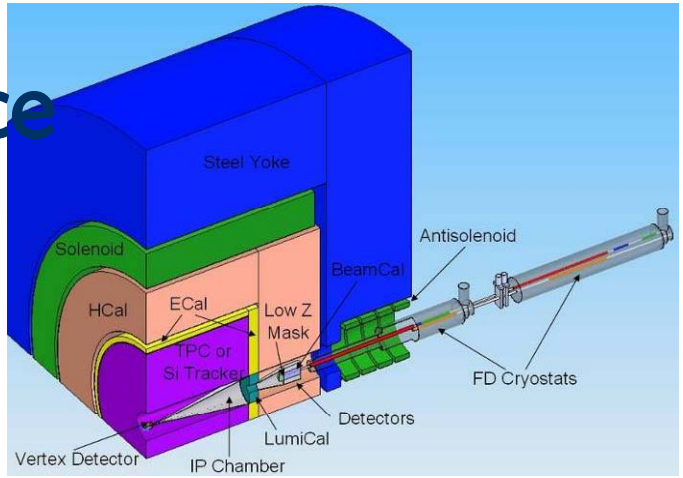
Merged dumps with micro-tunneling: to be studied in more details

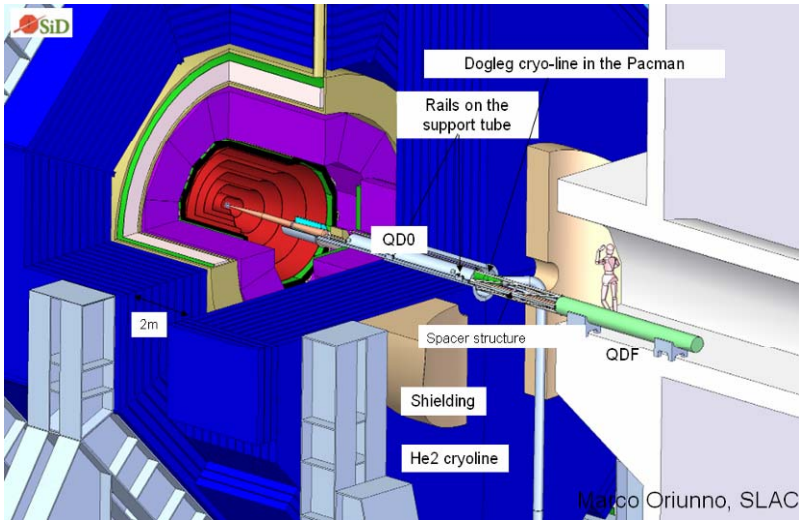


Ray Arnold
Dieter Walz
Lew Keller
Satyamurthy Polepalle
et al

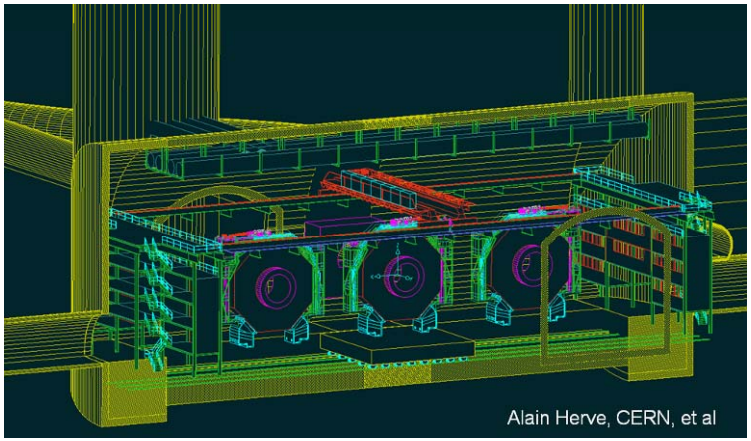
IR integration & Interface

- Push-pull sets requirements and challenges for many systems of detector and machine
- The Machine and Detector groups are now working on the optimized IR design, and on particular on so called IR Interface Document,
- The interface boundaries are complicated and inter-related





- A question can be asked if a simpler interface would be possible and what impact on performance it would make



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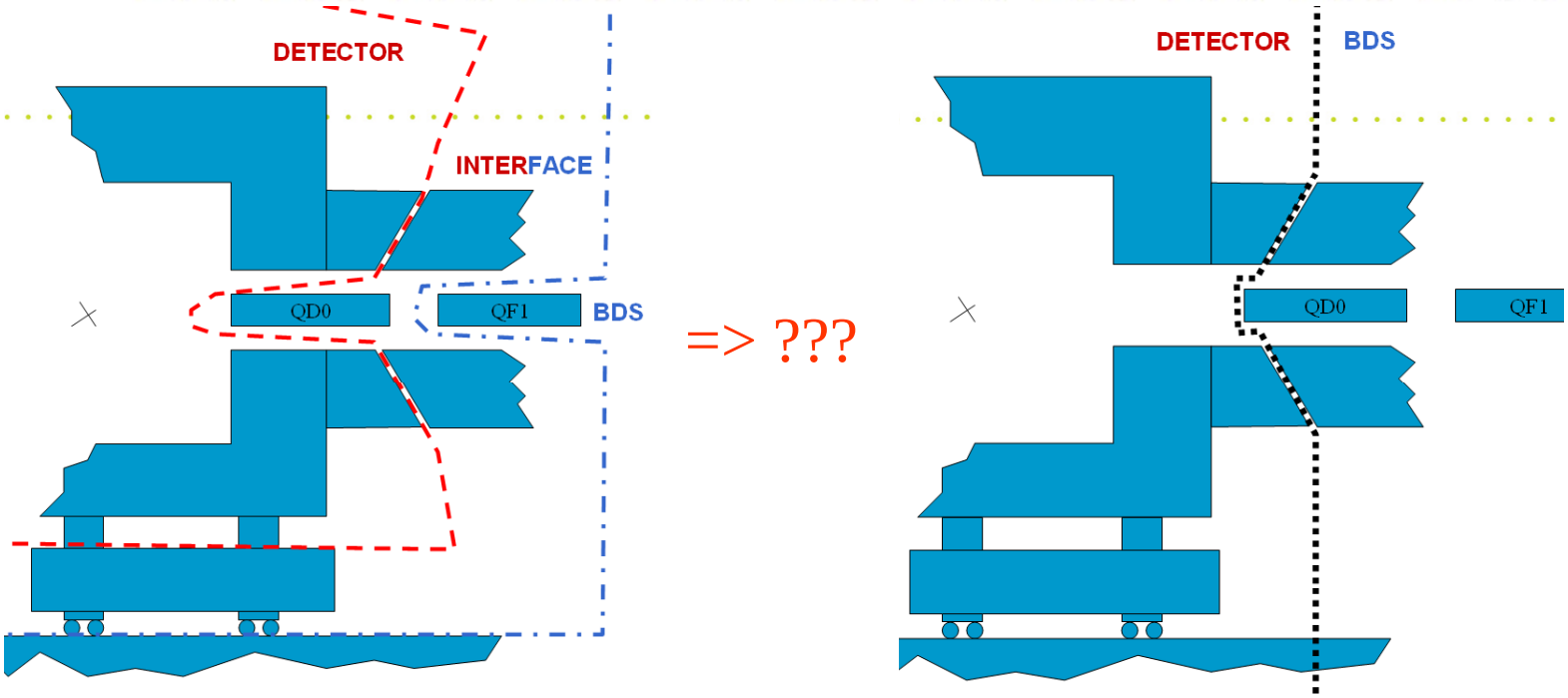
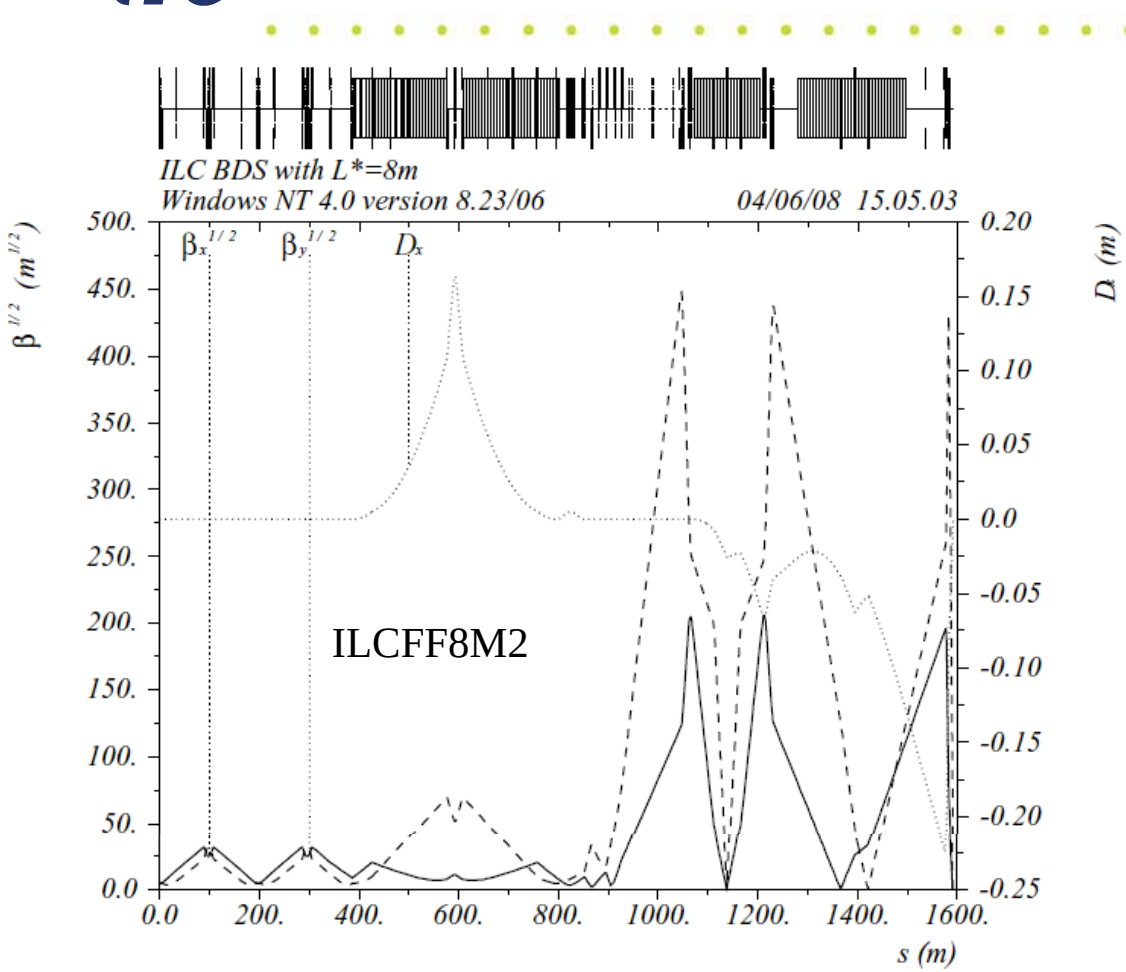
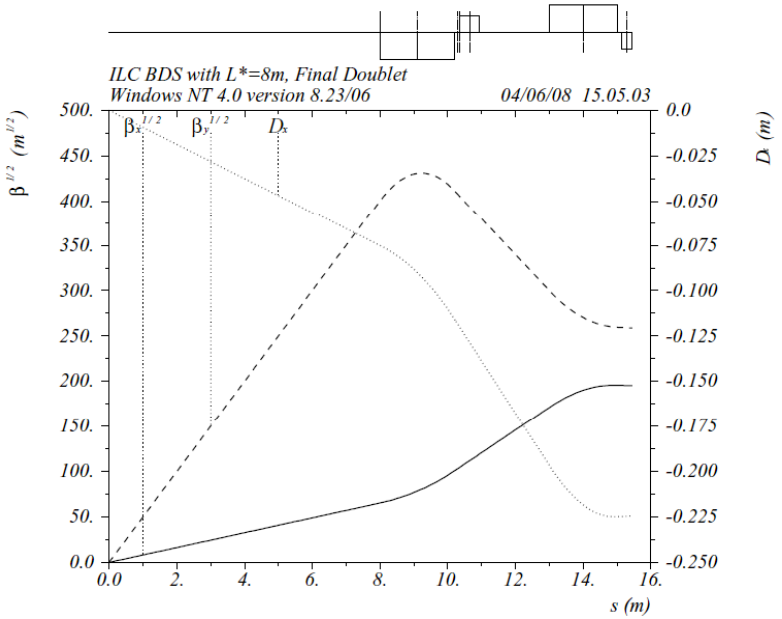
Simplified IR interface?

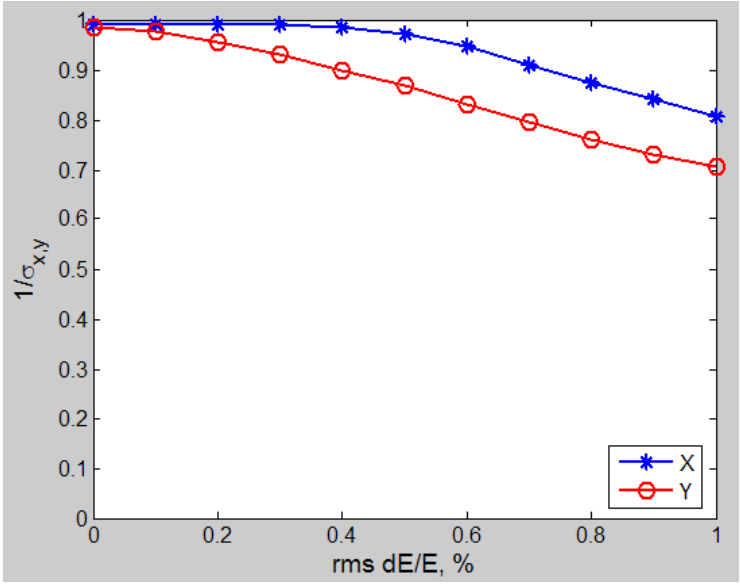


- Longer L*, long enough to have QD0 outside of detector, separating M/D more cleanly and simplifying push-pull
  - Some impact on luminosity is unavoidable; Rvx may need to be increased
- If a longer L* design will be found viable, a question will be
  - whether to consider it as a permanent solution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

Tentative BDS with L*=8m (1TeV CM)



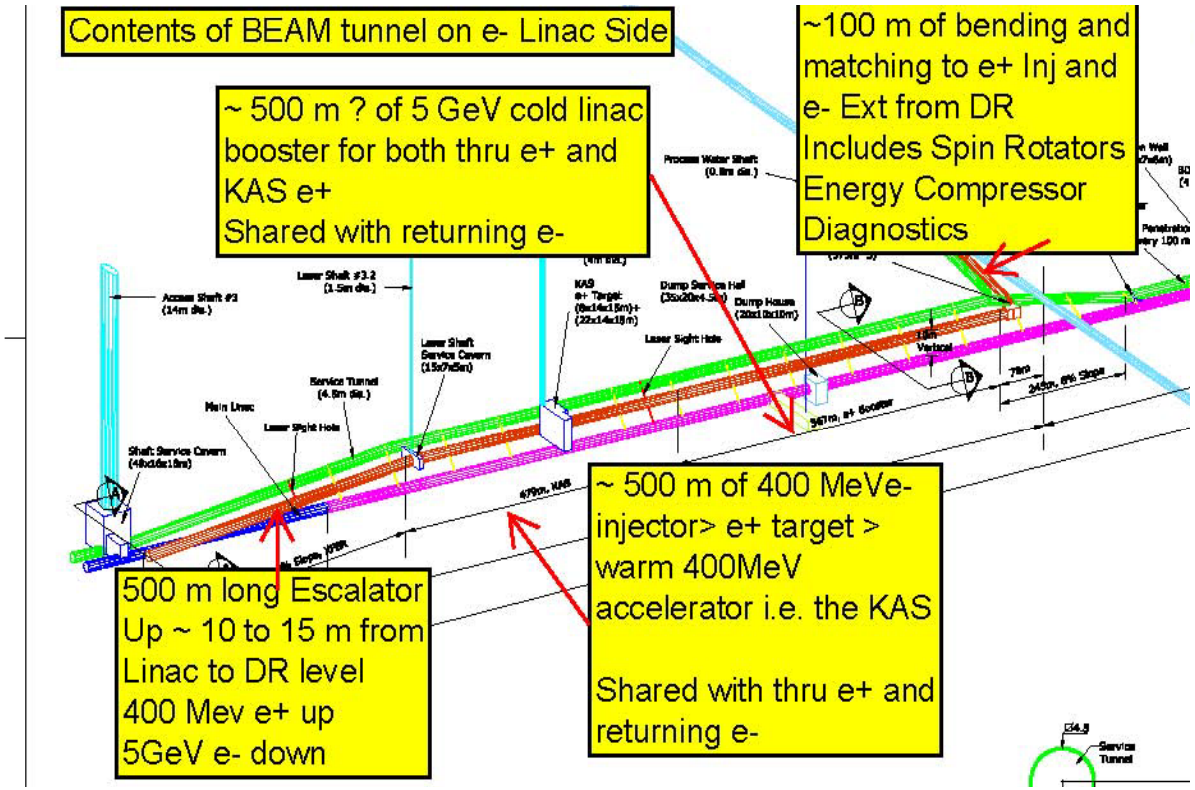




Detailed studies of long L* design and its implication on the performance are needed before a conclusion can be made

Integration Ideas for Central Region

Ewan Paterson



- assume that with additional shielding walls can enable independent operation of central region systems with open access to the BDS, the IR and linacs =>
- Put everything in the same plane and put the Injectors in the same shared tunnel with the BDS

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Summary (1)

three ideas:

a) Co-planar DR and BDS. i.e 3 to 2 tunnels

b) Remove KAS and move e+ source to end of the linac partially sharing source and BDS tunnel at end of the linac.

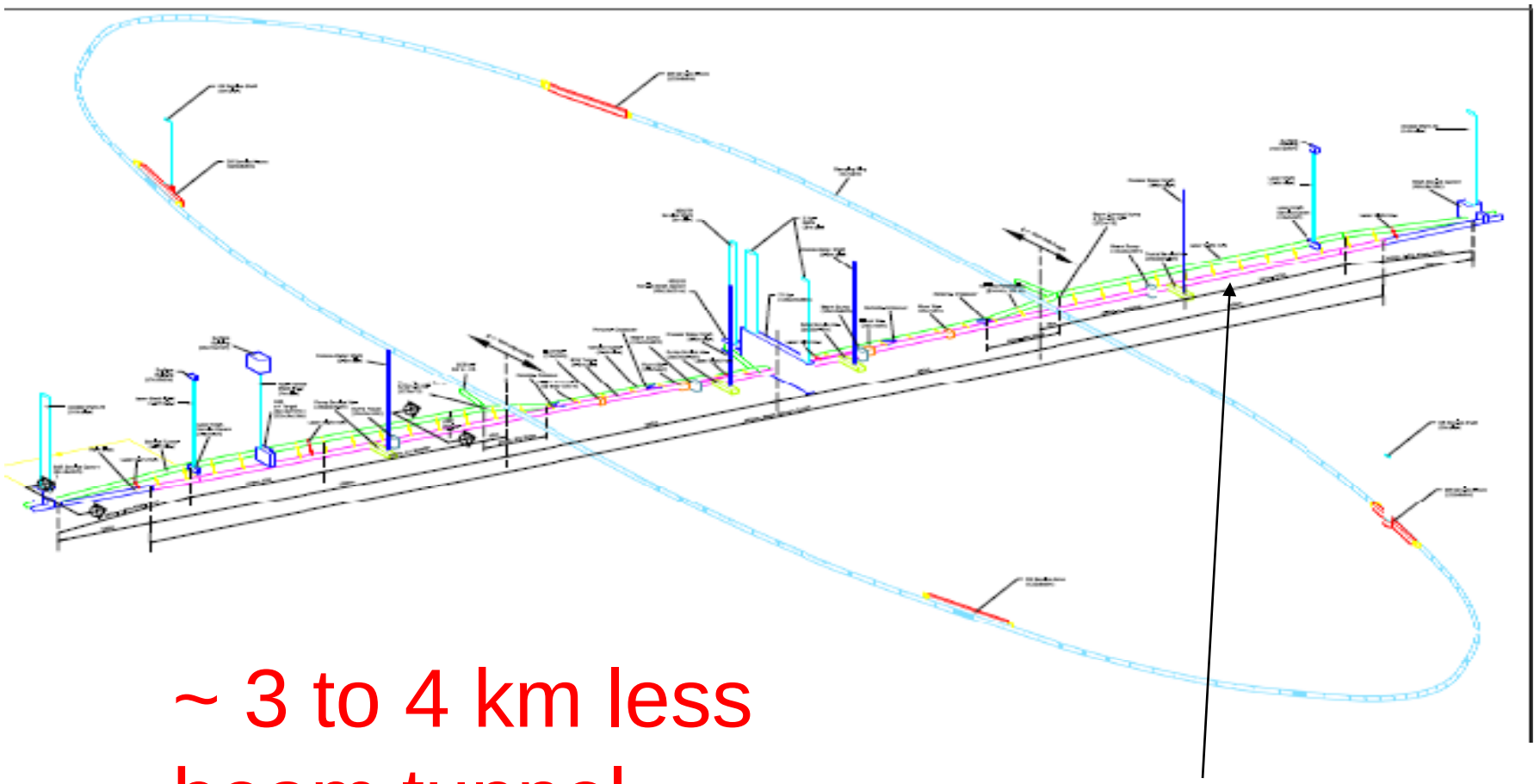
c) Add back a special compact ***KAS*** which shares many e+ source systems.

We need a representative group to evaluate these ideas and options before doing detail design work.

Sources, Damping Rings, BDS, RTML, CF&S, and why not Linac!

Later we will need some working decision to go ahead before investing effort in design changes to everything from optics to CF&S in almost all systems. This second stage will be major effort.

The result is Only One Beam Housing on each side



~ 3 to 4 km less beam tunnel

may need to use ~5.5 m tunnel

KAS or *KAS*

- The KAS is a candidate for deletion. Impact is on commissioning and availability and it includes a lot of expensive high power hardware.
- We need to review the design ***requirements*** for a KAS and its cost/benefits to overall ILC operation.
- RDR design has everything (except polarization) at 10% intensity…Injector, L-band linac, tgt/capture section and pre-accelerator. *Large and expensive!*
- An extreme alternate ***KAS*** could be a compact S-band single bunch linac whose e- beam uses the photon E+ tgt, capture and pre-accelerator, producing single bunches at a few % intensity.
- *Inexpensive, compact and could fit between the undulator and target alongside the photon and high energy e beam!*

Consider E+ Source Layout(1)

- Approx lengths in the RDR design in meters

Undulator	Drift&Dogleg	Target+ Capture	Pre-accelerator	TOTAL
100(200)	400	100	500	1200

Move the source system to the end of the E- linac.....>

The Target/Capture section would now be close to the MPS collimators at the beginning of the BDS.

While on access into the IR all systems operate and the main e- drive beam would go to the tune up dump, a shared dump.

We save ½ , 600m, of the positron insert! But we also shorten the low energy e+ transport by several kilometers and open up several possible scenarios for starting the machine at lower energies and simple upgrades to "full" energy.

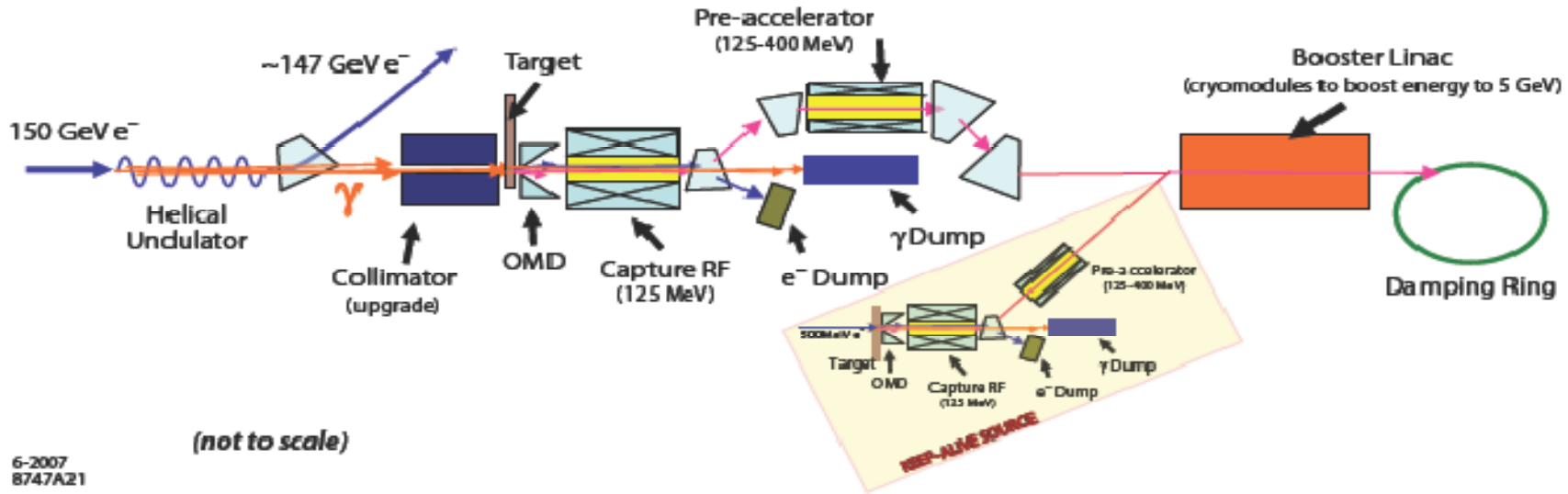
All systems except the linac are now within +/- 2.5 km of the IR.

A Central Campus

Consider E+ Source Layout (2)

- Lengths of the RDR e+ systems in meters

Undulator	**Drift&Dogleg**	Target+ Capture	Pre-accelerator	TOTAL
100(200)	**400**	100	500	1200



Q? Can we insert a warm 400 MeV E-accelerator in the drift/dogleg section and use the same target/capture, preaccelerator as a new type of "*KAS*" YES, WHY NOT?

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SUMMARY (2)

These changes could deliver considerable cost savings in both CF&S and Technical Systems

They can apply for deep or shallow sites and one or two tunnel approaches. However, in addition there

are many potential benefits in having all the area systems except the repetitive linac systems within a 5 X 3 km central campus.

For example, this could also work in a mountainous region where this central campus is shallow beneath the floor of a valley while the linacs are deep under the mountains!

Advanced e+ source

High possibility to make reliable target system using liquid lead target and S-band linac as one of advanced e+ source for ILC.

Junji Urakawa (KEK)

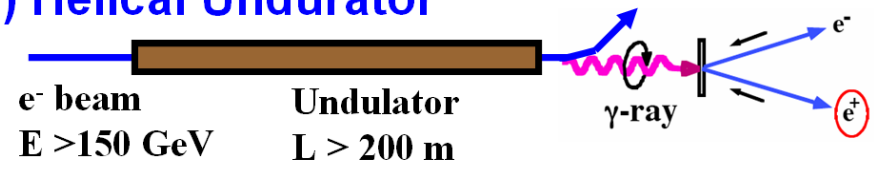
Present members : T. Omori (KEK), J. Urakawa (KEK), M. Kuriki (Hiroshima Univ.),T. Takahashi (Hiroshima Univ.), Pavel Logachev (BINP, Novosibirsk)

ILC positron sources

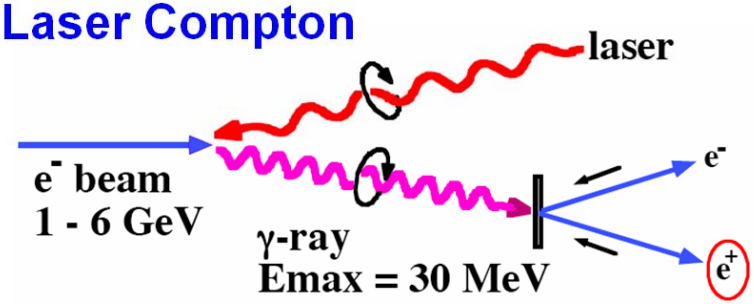
1) undulator-based e^+ source
   - base line choice
   - 1st stage: non-polarized source
   - later: upgrade to polarized source
2) Compton-based e^+ source
   - advanced alternative
   - polarized source
3) Conventional e^+ source
   - back up
   - non-polarized source

Two ways to get pol. e^+

(1) Helical Undurator

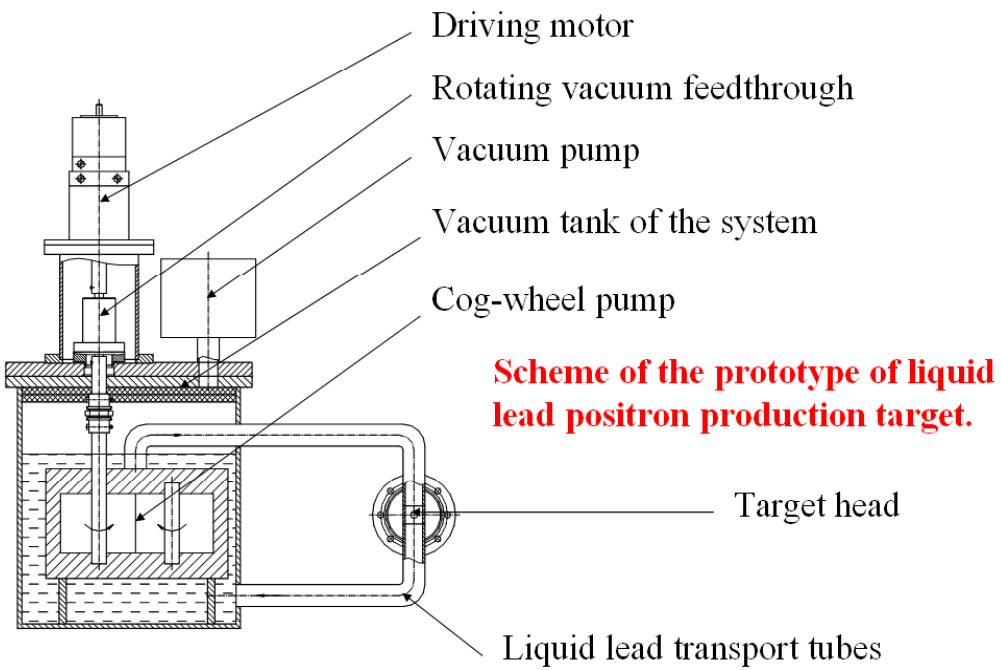


(2) Laser Compton

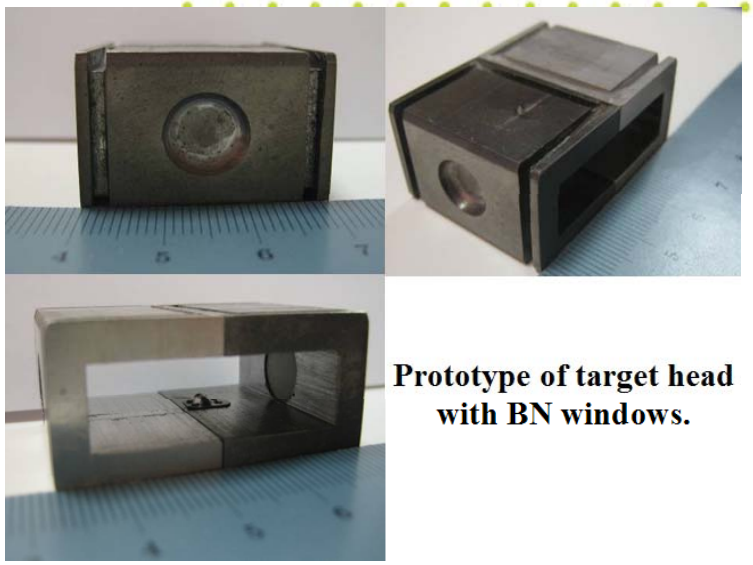


The present stage of BINP activity in liquid lead target development.

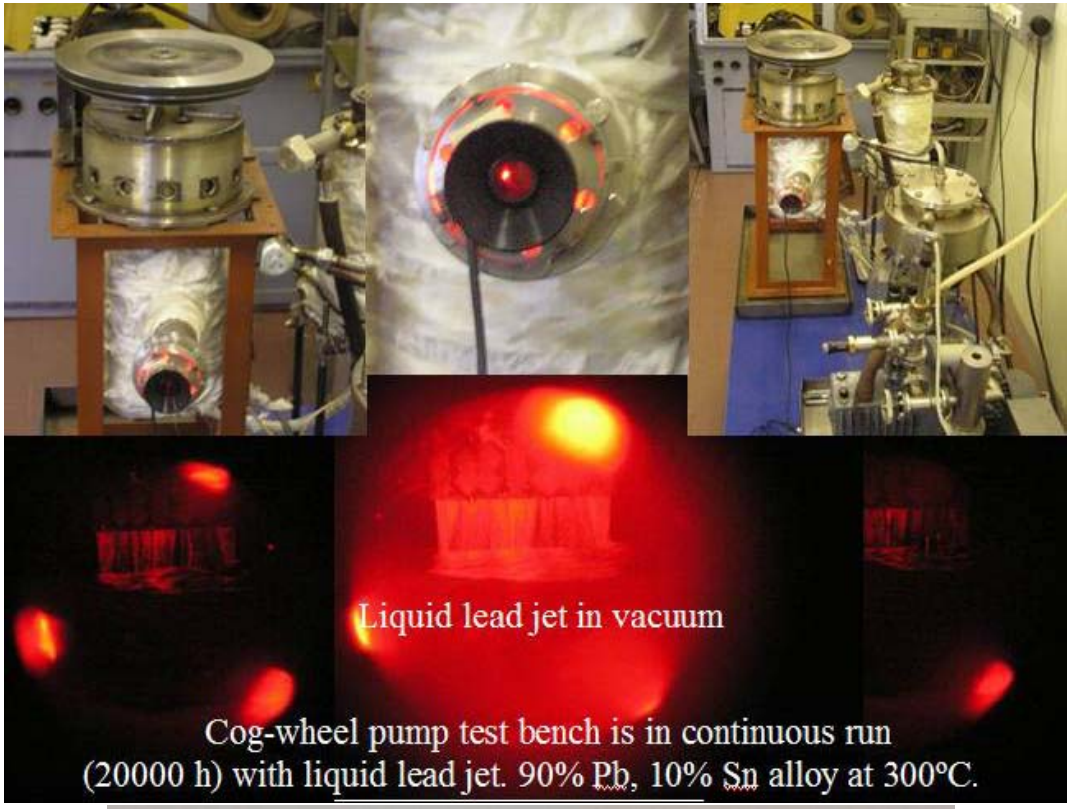
- 20000 h of liquid lead contour successful run with cog-wheel pump has been reached (90% Pb, 10% (mass)Sn alloy, 300ºC).
- The test of window braising technology successfully finished.
- The prototype of liquid lead positron production target is under commissioning now. This prototype is specially designed for output window destruction test on KEKB.

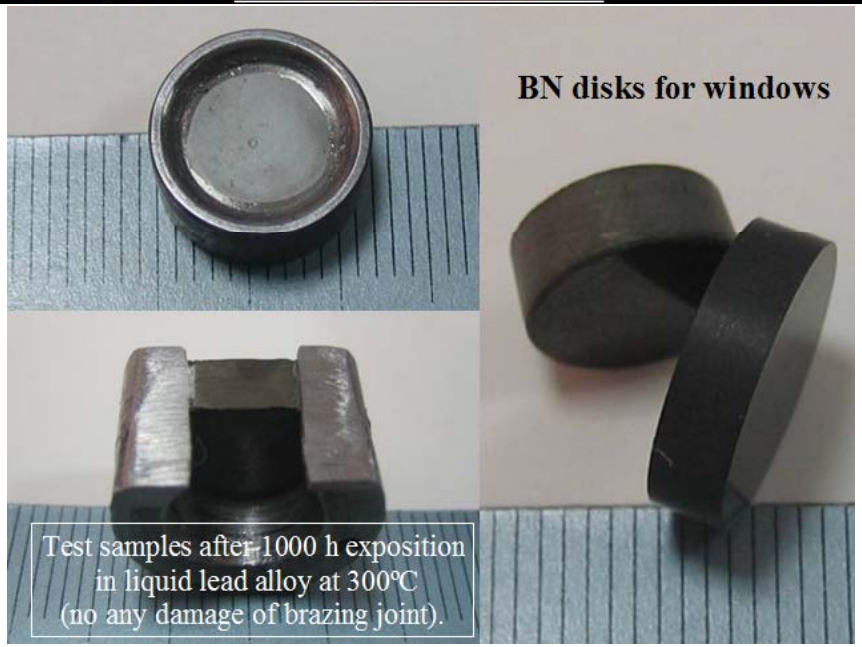


Scheme of the prototype of liquid lead positron production target.



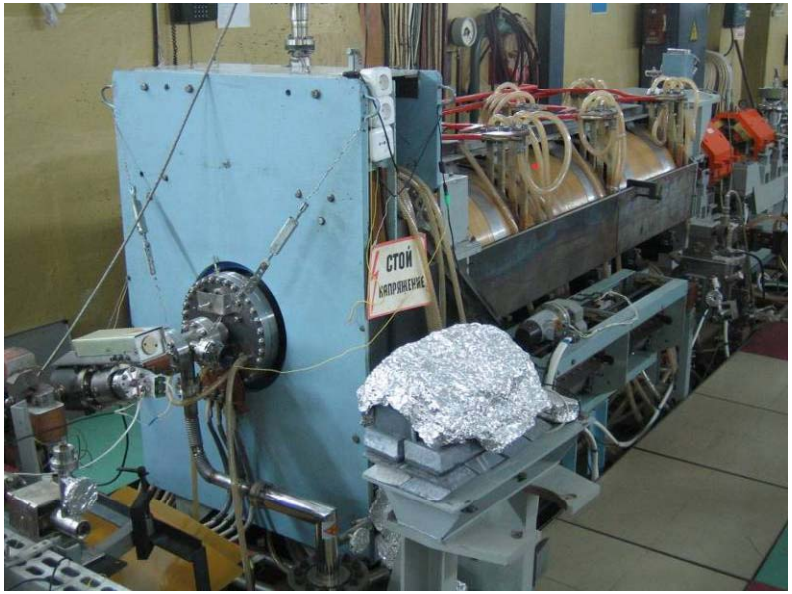
Prototype of target head with BN windows.

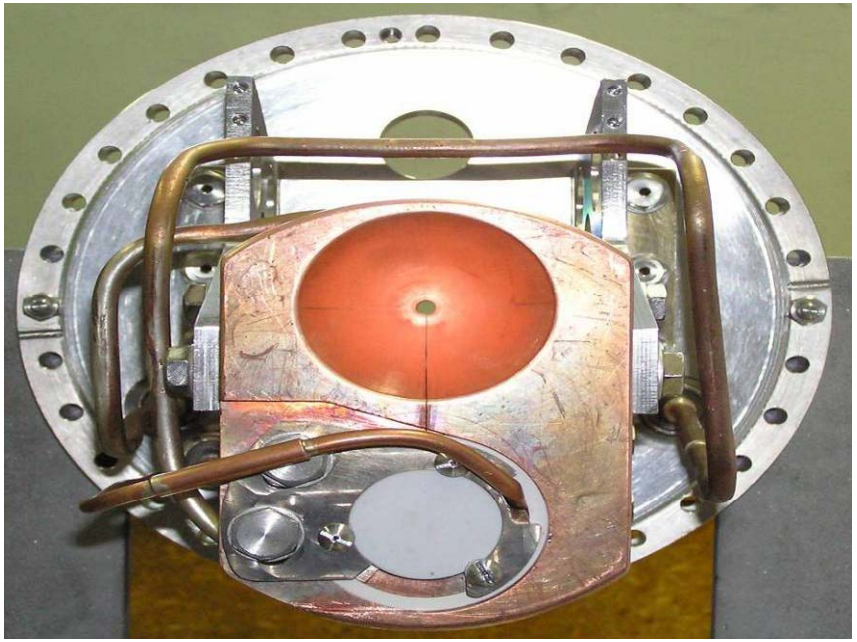


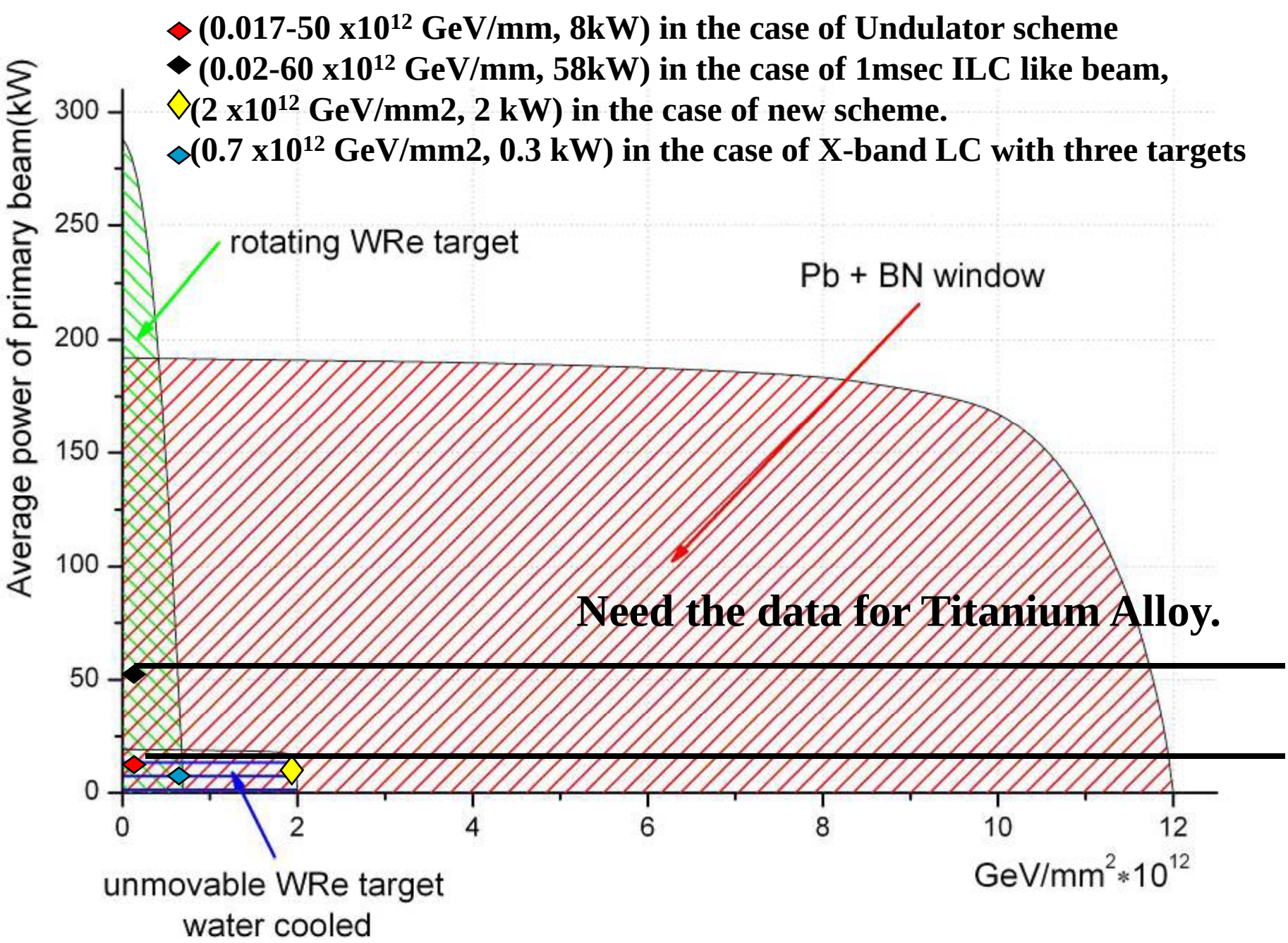


The present stage of BINP activity in Matching Device development.

- The successful test of VEPP-5 positron production system was performed. Flux Concentrator magnet (FC) was tested up to 70 kG (30 μs pulse duration) without saturation in positron yield.
- The investigation of the technical limit for maximum FC pulse duration is in progress.
- Flat face FC for 30 μs pulse duration, 10 T maximum field and good field quality for KEKB is under the tests now at BINP.



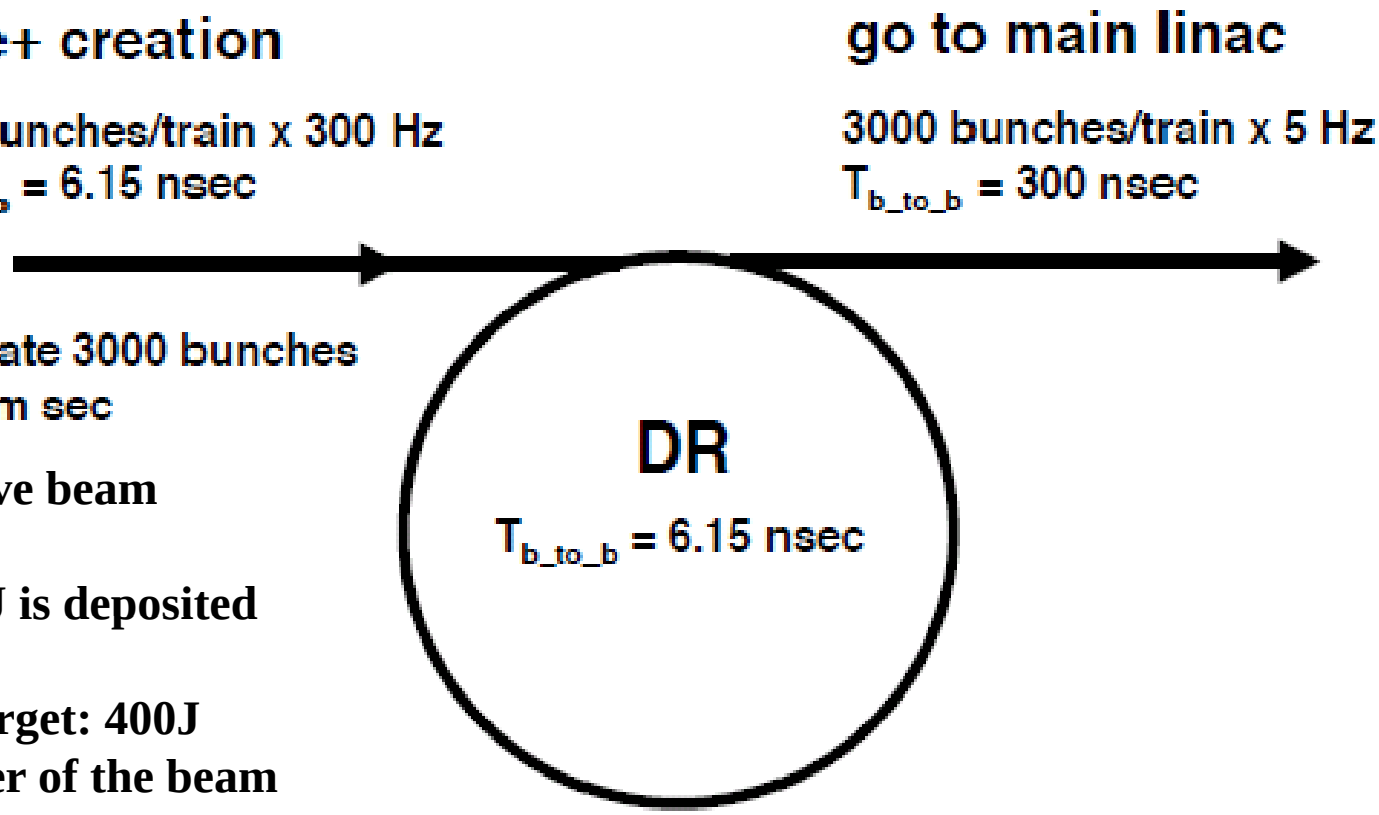



◆ (0.017-50 x10^12 GeV/mm, 8kW) in the case of Undulator scheme
◆ (0.02-60 x10^12 GeV/mm, 58kW) in the case of 1msec ILC like beam,
◆ (2 x10^12 GeV/mm2, 2 kW) in the case of new scheme.
◆ (0.7 x10^12 GeV/mm2, 0.3 kW) in the case of X-band LC with three targets
Average power of primary beam(kW)
300
250
200
150
100
50
0
rotating WRe target
Pb + BN window
Need the data for Titanium Alloy.
0
2
4
6
8
10
12
GeV/mm^2*10^12
unmovable WRe target
water cooled

Advanced e+ source
New Target : Liquid Lead

Liquid Lead Target
Question: Can Liquid Lead Target (& BN window) survive the 3000-bunch-creation in 1 m sec?
Answer: No
BN window is OK against shock wave. BN window is broken by heat. Lead evaporates.

Solution: e+ Creation in 100 m sec --> 100 bunches/train x 300 Hz S-band Linac operation
BN window is OK for 100 bunches.
Lead dose not evaporate with 100 bunches.
Lead move 32 mm in 3.3 msec, then heat is removed. (speed of lead = 10 m/sec)



total energy of the drive beam bunch: 2000J
Assume 20 % of 2000J is deposited in the target.
every deposit in the target: 400J
Assume 5 mm diameter of the beam on the target. Weight of the target :
5.6 g =0.0056 kg for 4.5 r.l.
(2.5x2.5x3.14x28x11gx10x{-3} = 5.6g)
28mm correspond to 4.5 r.l.
ΔT = 400J / (140J/K*Kg) / 0.0056Kg= 510K

Time for damping = 100 m sec which requests about 14msec damping time.

14msec damping time is requested to DR Area Group.

Table : The 300 Hz Conventional e+ Source Option with Liquid Lead Target
bunches/train : 100, repetition rate: 300 Hz (We can create 3000 bunches in 100 m sec.)
drive beam energy: 6 GeV, bunch-to-bunch separation: 6.15 n sec
pulse length 615 n sec (6.15x100)

Rough Estimation of beam power and density on target

1. Undulator Scheme, γ-beam requirement for ILC positron source :
5 x 10^{15} at 10 MeV γ is enough to generate necessary positron beam.
5 x 10^{15} x 10 MeV=8 kJ / 1msec, 8 kJ/1.6x10^{-19} =50 GeV/mm^2 x10^{12}
(0.017-50 x10^{12} GeV/mm^2, 8 kW)

2. Conventinal Scheme, 1m electron beam generates positron :
6 GeV, 2x10^{10}, 1msec electron beam can generate necessary positron beam.
6 x 10^9 x2x10^{10} x 3000 =58 kJ , (0.02-60 x10^{12} GeV/mm^2, 58 kW)

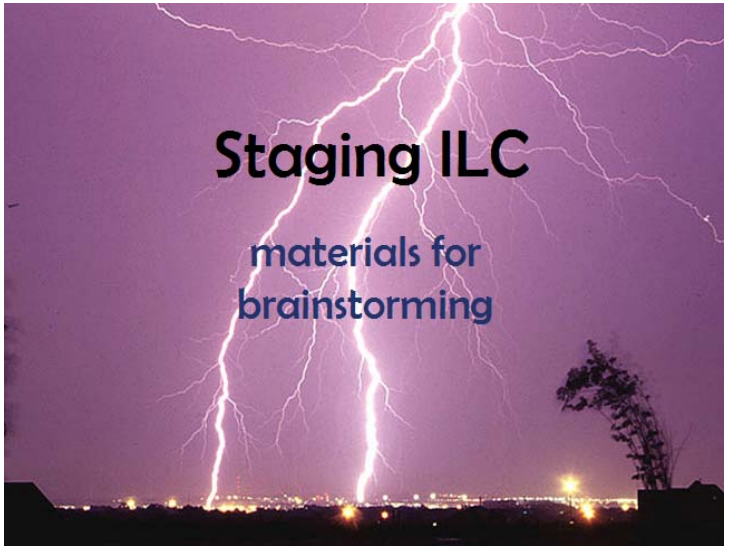
3. New scheme using liquid lead target and S-band linac
100 bunches/train x 2 x 10^{10} x 6GeV =2000J, (2 GeV/mm^2 x 10^{12},2kW)
300Hz Operation

4. X-band Linear Collider positron source target
Assuming 150Hz operation, 192 bunches/train, 1.4nsec, 0.79 x 10^{10}
We need three targets for keeping target safe.
6GeV, 0.79x10^{10}, 300nsec pulse width, 6 x 10^9 x0.79x10^{10} x 192 = 0.91kJ
Need three rotating target (4.5 r.l. WRe), 0.91kJ/3 = 0.3kJ
1.92x10^{12} GeV/mm^2 , 1.92/3=0.7 x 10^{12} GeV/mm^2
This is reason for three targets. (0.7 x10^{12} GeV/mm^2, 0.3 kW)

Summaries

- Pavel's summary:
  - Existing positron sources, which are in operation, haven't reached yet the limits of their application areas.
  - Significant improvements in some directions may lead to about one order of magnitude increase in positron production rate for best existing installations.
  - Conventional positron production technology still has some reserves for such up-to-date projects as International Linear Collider (ILC) or Super B-factory.
- Junji's summary on new target:
  - Enough margin as reliable positron source system.
  - Use usual injection kicker system.
  - Use mature technology on AMD---
  - Mini-bunch train : 50 to 200 bunches/pulse.
  - Require about 14msec damping time, we consider 3km double ring or increase damping wigglers.
  - Need the test of BN window and liquid lead target with KEKB Ampere beam. Small hall is necessary.

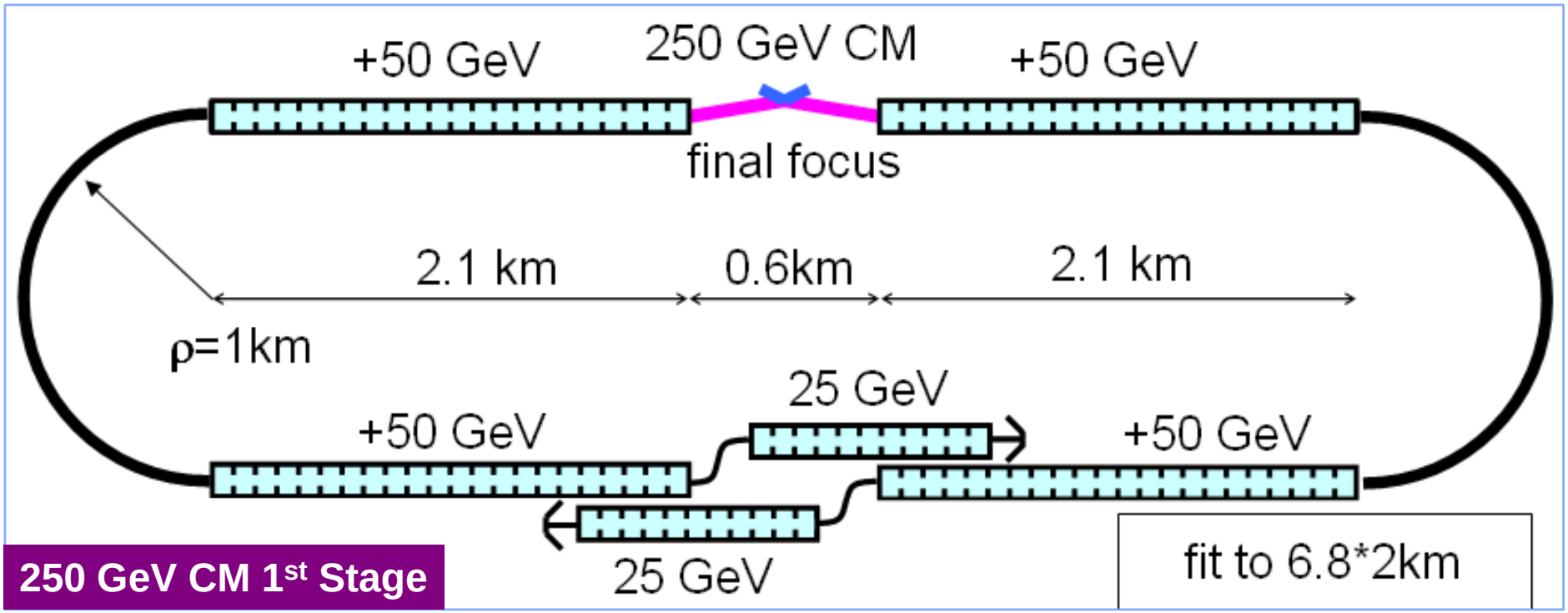
Motivation and strategy



- Strong physics motivation for ILC
  - Difficulty to sell the full scale ILC
  - Energy upgrade is brute force lengthening, thus expensive
- → **staged ILC ?**

- Requirement to the first stage:
  - more **affordable**
  - can be potentially upgraded to **full RDR performance**
  - allow upgrades, especially for >1TeV, based on **advanced ideas**

- Focus on Fermilab site as an example
  - prefer not to expand beyond the site boundaries
  - explore synergies with Fermilab projects (neutrino source, project-X, muon collider)
- Assume that LHC physics will motivate a lower E 1st stage



250 GeV CM 1st Stage

The radius of turn is scaled from SLC arc, assuming $\delta\gamma\varepsilon$<0.5e-6m
Assumed geographic gradient 23.1MeV/m (31.5MeV/m * 75%)

- DR may be in the racetrack tunnel or in the Tevatron tunnel
- Positron source may be conventional-advanced or Compton
- Arcs scaled from SLAC arcs to limit emittance growth to $\delta\gamma\varepsilon$<5E-7m
- Mostly fits to FNAL site
- Upgrades: expansive (beyond site boundary) or by advanced ideas like plasma acceleration on the same site
- Linacs & tunnels -- potential synergy with other FNAL projects

All statements tentative & require detailed studies

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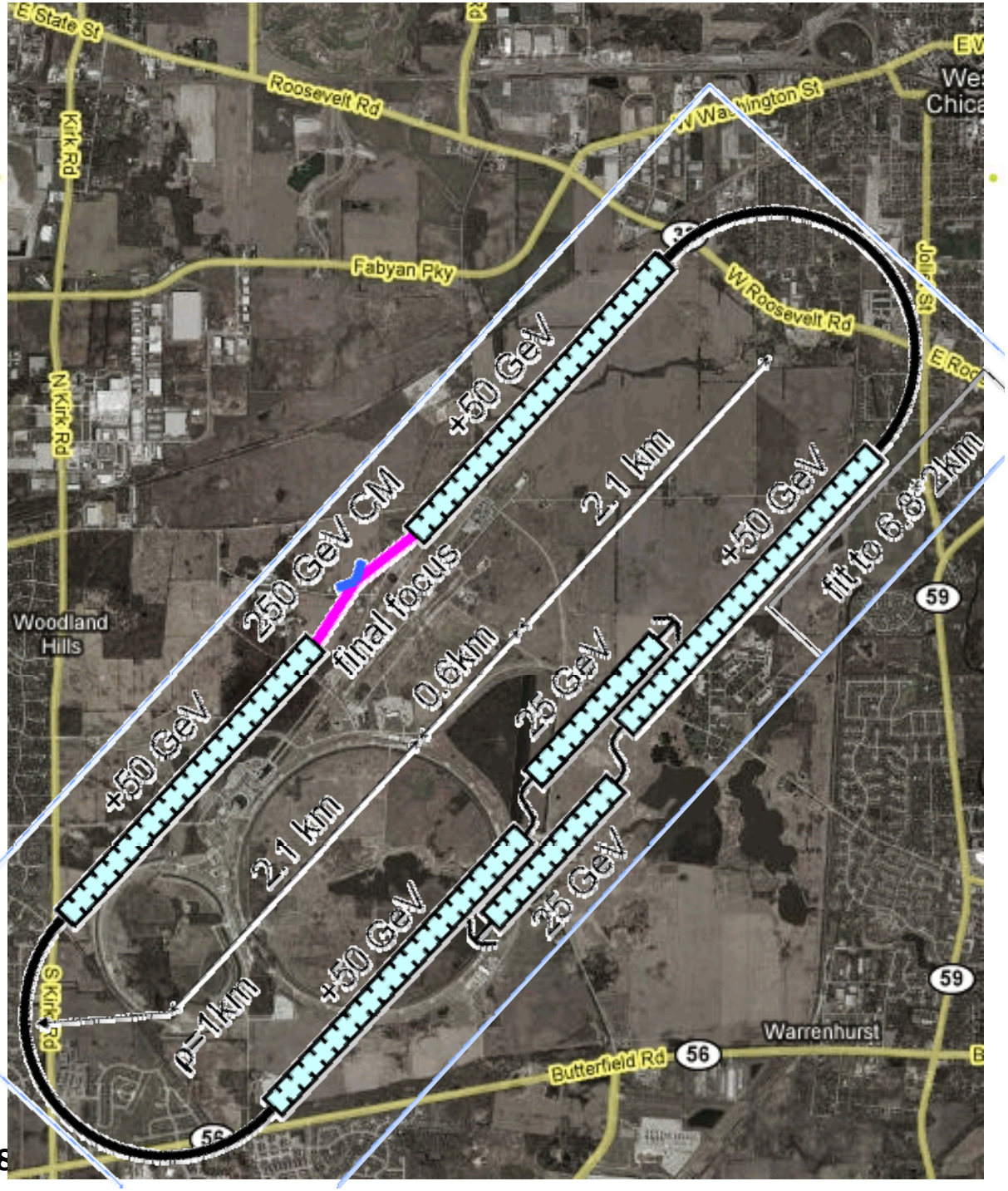
ilc 1st stage

250 GeV CM e+e- at FNAL

Potentially upgradeable to ~0.5TeV CM and higher E by expansion beyond site boundary or by advanced techniques on the same footprint

Options like e-e- or **gg** may also be considered if motivated by LHC results

Potentially synergic with project-X & other FNAL project



All statements tentative & **require detailed studies**

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Comments on Staging

Ewan Paterson

- What is staging?
- There is a very large range of opinions. Here are two extremes
  - e.g. All spares or backup equipment moves to operations
  - or Start with 2 low emittance, polarized guns (not yet developed), no DR's, 2 linacs of 150GeV in different layout.

Ewan's definition:

- Staged energy, luminosity or related parameters on an e+/e- machine which is a subset of the base design
- AND
- The upgrade path to the base machine or beyond must be realistic in terms of time down for physics??
- Still rather vague!

Staging Energy Issues

- The most "attractive" approach to energy staging is to do everything in the center and expand outwards.
- BUT there are issues
- The turnaround, ...what does it cost to duplicate?
- Compressor(s).....Could we compress before transport and turn?
- Where is the E+ source?
- Can we standardize linac quads (presently there are 3 strengths in every third cryostat) to operate over a larger range?
- Construction during operation?

Staging the present CDR design

- Build the CDR CF&S
- Install only first ½ linacs after the compressors with E+ source at midpoint
- Install second half of linacs during downtimes of first 2 to 3 years of operation.
- Continue civil construction outwards??
- If questions on previous slide get positive answers then one would re-optimize this scenario.
- There are many other options with only ½ the power sources and cryostats that have to be looked at but my opinion is they cost more!

Overall summary on staging discussion: inconclusive

Summary: steps to study minimal machine

Ewan's table:

STUDY TOPIC		ORDER for FOLLOW-UP
New few % diagnostic e+ source (kas)		one
3km or dog bone Damping Rings		two
RTML layout in central region		three
Single stage bunch compressor		one
500 GeV BDS		two
Co-planar DR,BDS, and e+/- Sources		one
Shared tune-up and main dumps		one
Potential cost reductions		
	5km of tunnel	~ 100 M ILCU
	Technical systems	~100 M ILCU