Summary of the Accelerator Working Group

- Thanks to all working group members for the enormous work and progress made over the last year!

- A lot of progress has been made since last year. The Ring-Ring and Linac-Ring proposals are much more developed and focused. Many questions have been addressed. Some issues have been clarified but also many new questions have been raised

  ➔ There is still a lot of work to be done for a CDR!

- Discussions with potential collaborators over the last year lead to first concrete contributions (see the large non-CERN participation in the Accelerator Group this year).

  ➔ This is a very good first step towards an international CDR!

Summary of the Accelerator Working Group

- The accelerator group had 15 scheduled presentations from 5 institutions. Main topics evolved around 2 main topics

➔ A Ring-Ring option ('known technology' ⇐⇒ integration):

-lattice optimization & magnet design for a Ring-Ring option

-RF issues for a Ring-Ring solution

-magnet designs for a Ring-Ring option

-B-B effects; unequal bunch lengths; mixed e-p and p-p collisions

-SPL based injector complex

➔ A Ring-Linac option (high energy reach ⇐⇒ new technology):

-beam dynamics (emittance) and optics in re-circulating linacs

-ERL options for a Ring-Linac solution

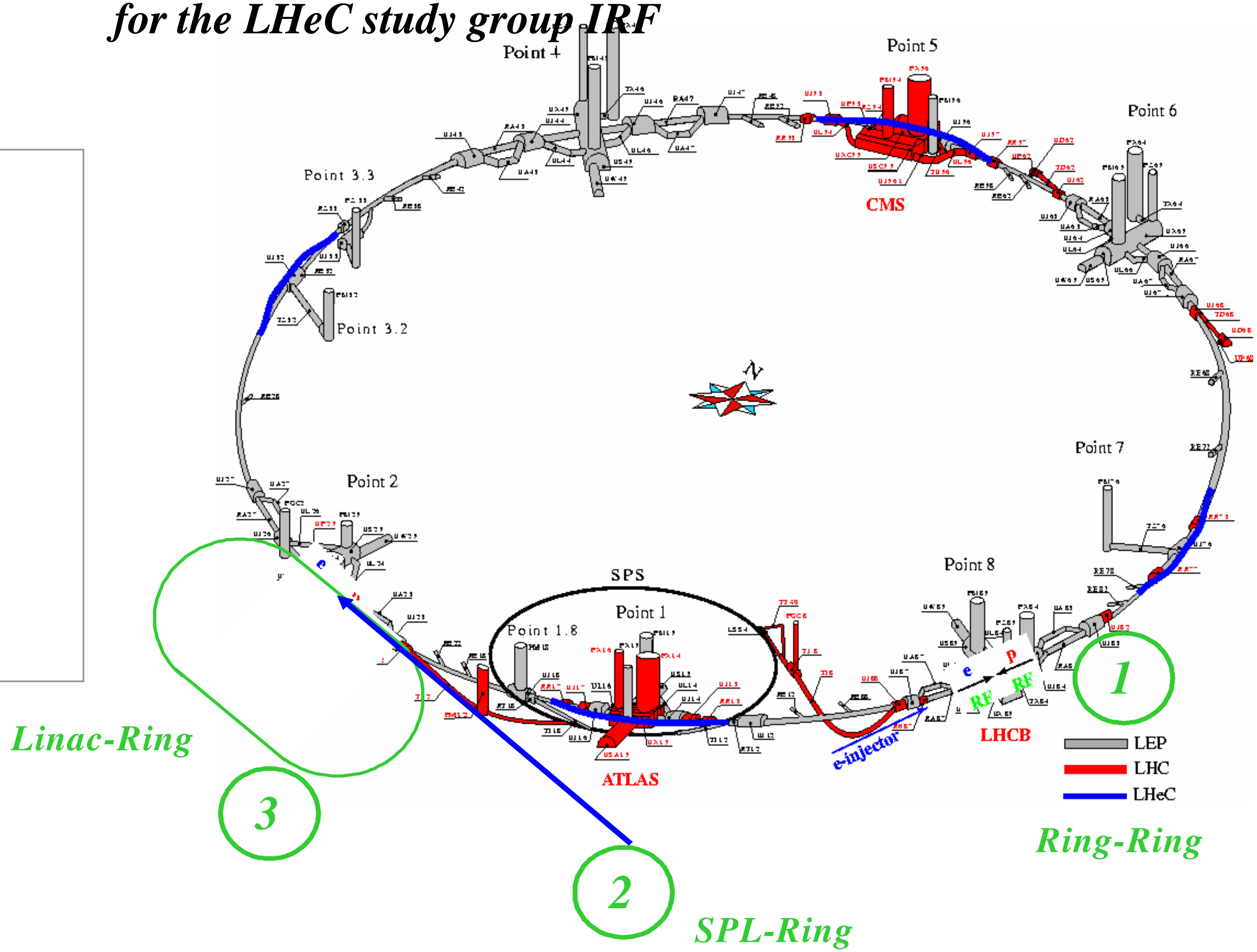
-e^+ / e^- source designs with and without polarization

Status of the LHeC Facility Plans

Bernhard Holzer, CERN
for the LHeC study group IRF

B. Holzer, CERN; Divonne 2009

Accelerator Design [RR and LR]
Oliver Bruening (CERN),
John Dainton (CI/Liverpool)
Interaction Region and Fwd/Bwd
Bernhard Holzer (CERN),
Uwe Schneeekloth (DESY),
Pierre van Mechelen (Antwerpen)
Detector Design
Peter Kostka (DESY),
Rainer Wallny (UCLA),
Alessandro Polini (Bologna)



Status Divonne 2008:

General Statement: Whatever we do ... the fundamental layout of the LHC delivers an enormous potential for e/p Luminosity

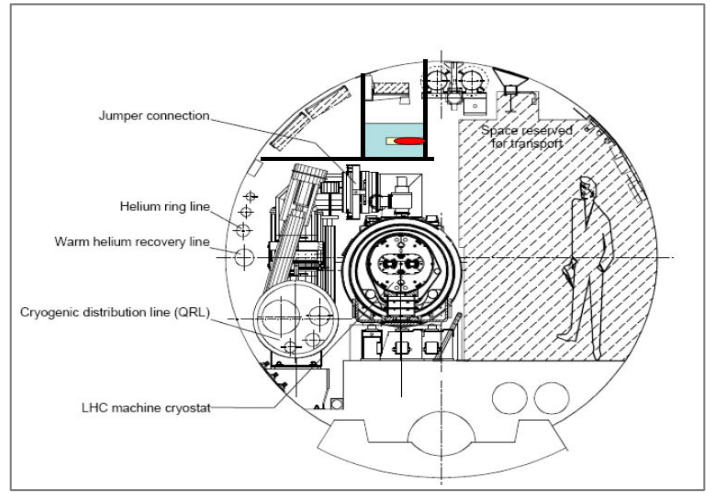
B. Holzer, CERN; Divonne 2009

2808 bunches
7 TeV
$\rightarrow \varepsilon_n = 3.75\ \mu m$

} *RR Option / RL Option*

LHeC Ring-Ring: basic parameters

	Protons	Electrons
Standard Parameters	$N_p = 1.15 \cdot 10^{11}$	$N_e = 1.4 \cdot 10^{10}$
	$E_p = 7$ TeV	$E_e = 70$ GeV
	$n_b = 2808$	$n_b = 2808$
	$I_p = 582$ mA	$I_e = 71$ mA
Optics	$\beta_{xp} = 180$ cm	$\beta_{xe} = 12.7$ cm
	$\beta_{yp} = 50$ cm	$\beta_{ye} = 7.1$ cm
	$\varepsilon_{xp} = 0.5$ nm rad	$\varepsilon_{xe} = 7.6$ nm rad
	$\varepsilon_{yp} = 0.5$ nm rad	$\varepsilon_{ye} = 3.8$ nm rad
Beam size	$\sigma_{xp} = 30\ \mu m$	$\sigma_{xe} = 30\ \mu m$
	$\sigma_{yp} = 15.8\ \mu m$	$\sigma_{ye} = 15.8\ \mu m$
Luminosity	$8.2 \cdot 10^{32}\ cm^{-2}\ s^{-1}$	



e storage ring on top of LHC

SUMMARY: To Do List (Status Divonne 2008)

- e-Ring: Design straight sections 1-7 : replace dummy straight sections by bypass regions (H. Burkhardt / M. Fitterer)
- Include Rf sections ... can be done in the by pass regions
- Include sextupoles for correction of chromatic lattice functions.
- Optimise damping partition numbers ... not needed anymore (?)
- Optimise Phase Advance in the FoDo to reduce beam emittance . (goal = 7.6 nm !) (J. Jowett)
- compare the two schemes: linac-ring / ring-ring ... for a given overall wall plug power: 100MW (M. Klein)
- calculate the linear beam beam tune shift for both beams (B. Holzer)
- calculate the (long range) beam beam effect (W. Herr, T. Pieloni -EPFL-)
- design for a 1 °/ 179 ° option --> Cockcroft (R. Appleby)
- synchrotron radiation & Luminosity Counter
  → close collaboration with detector people

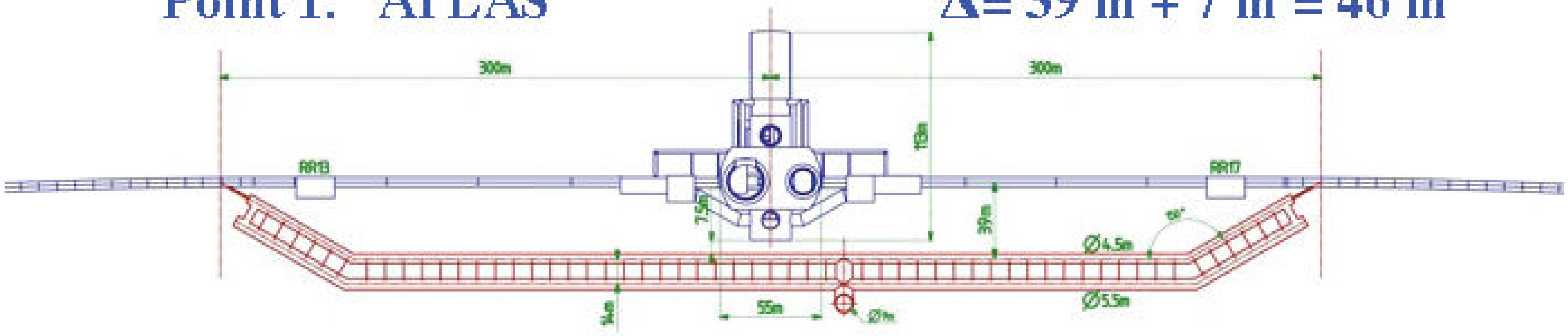
- R & D on technical components ... exotic quads, crab cavities

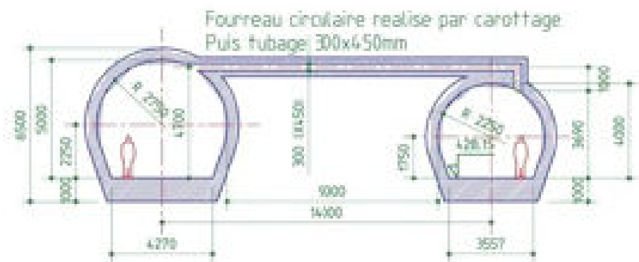
Ongoing Studies for Ring-Ring

- Beam-Beam:
  - ➔ large crossing angle might be acceptable without Crab Cavities
- Bypass design:
  - ➔ RF integration into the bypass tunnels
- Lattice design:
  - ➔ lattice optimization for compact magnet design
  - ➔ e-Ring magnet design
- Injector complex:
  - ➔ design based on multi-pass SPL

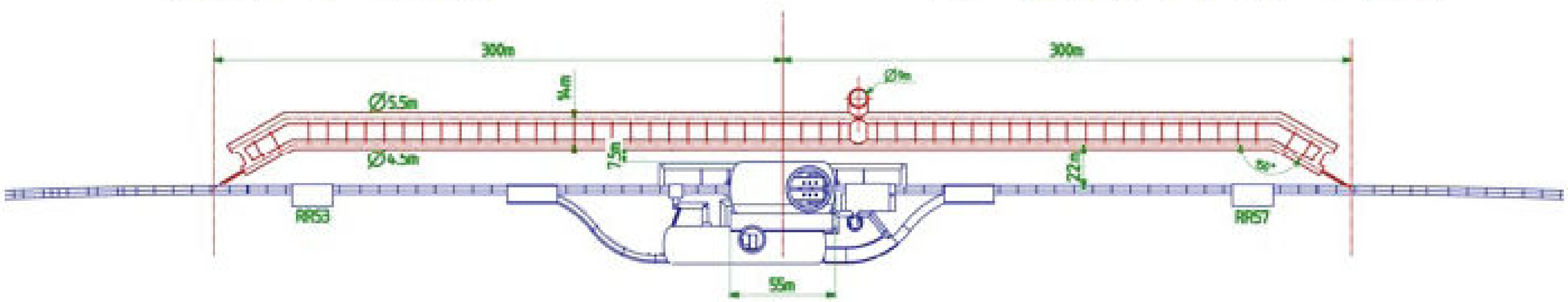
Larger “de-coupled” by-passes

Point 1. ATLAS Δ= 39 m + 7 m = 46 m





Point 5. CMS Δ= 22 m + 7 m = 29 m



from J.A. Osborne

Study Topics - 2

E. Chiapala, CERN; Divonne 2009

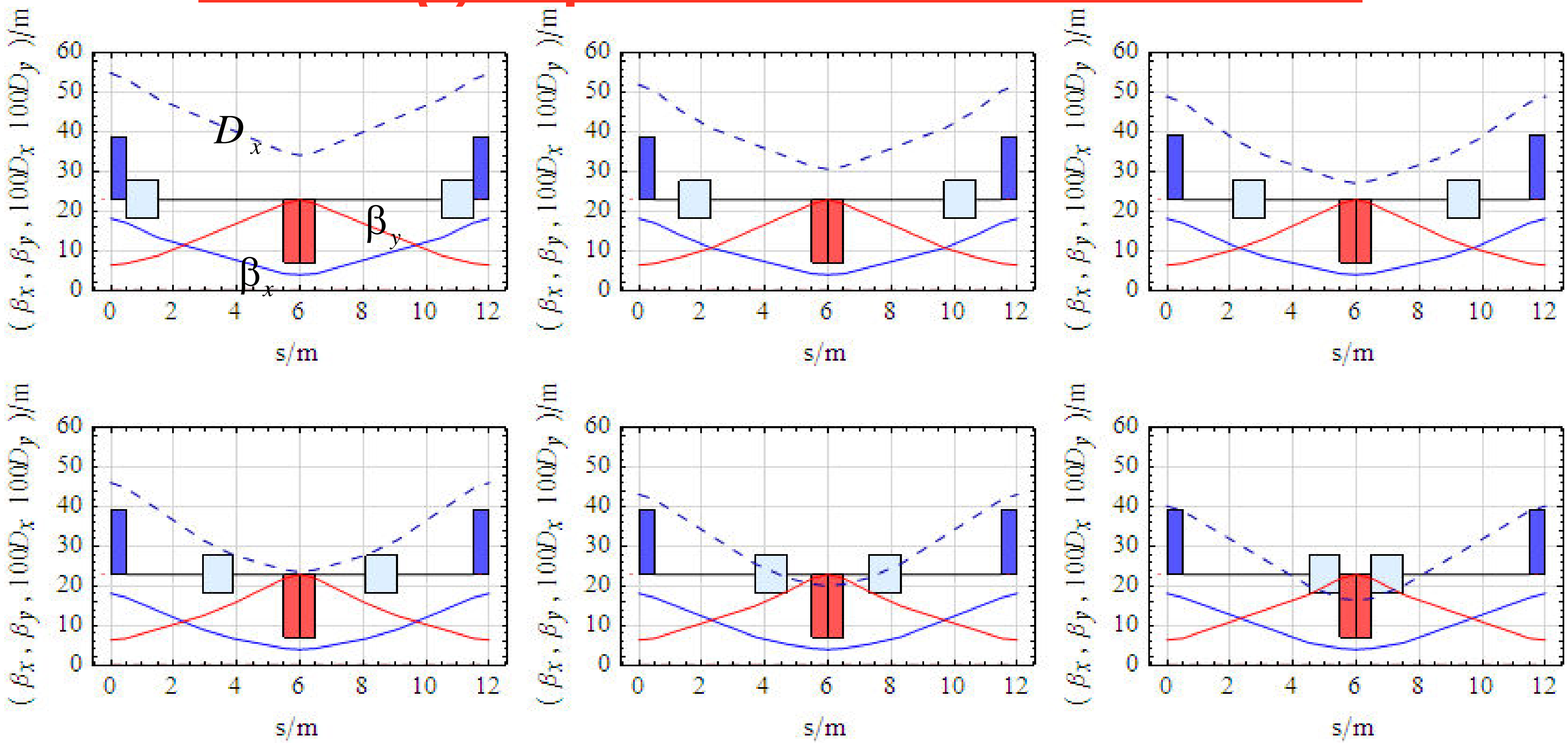
Cavity and Cryomodule

- Define a cavity geometry, number of cells
- Helium: Is 2K needed, 4.5 K may be adequate at this gradient.
  - LHC cw 400MHz sputtered cavities can easily run at 8 MV/m (Pushed to 11MV/m)
  - Needs Study & Cost Estimation
- Cryomodule – Need schematic design, with dimensions, decide number of cavities per cryomodule.
- Overall heat load estimations, static & dynamic.

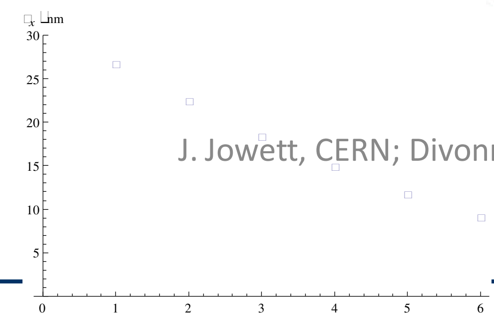
Cryo System

- Total cooling power needed - from above
- He supply system - Connection to existing system – new separate system?
- Location & footprints of additional cryo plant elements on surface and underground

Sliding dipoles around the cell



Modification of dispersion by putting dipoles near QDs gives > factor 2 in emittance

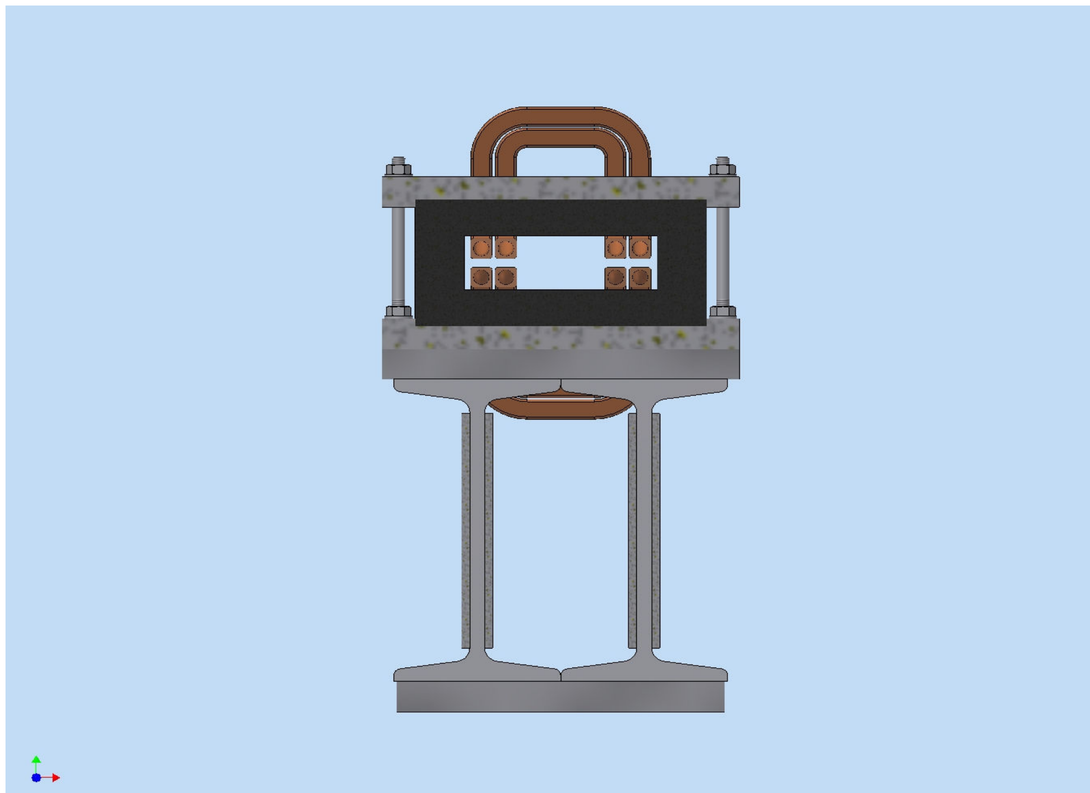


J. Jowett, CERN; Divonne 2009

LHeC main dipoles,
Pavel Vobly suggestions

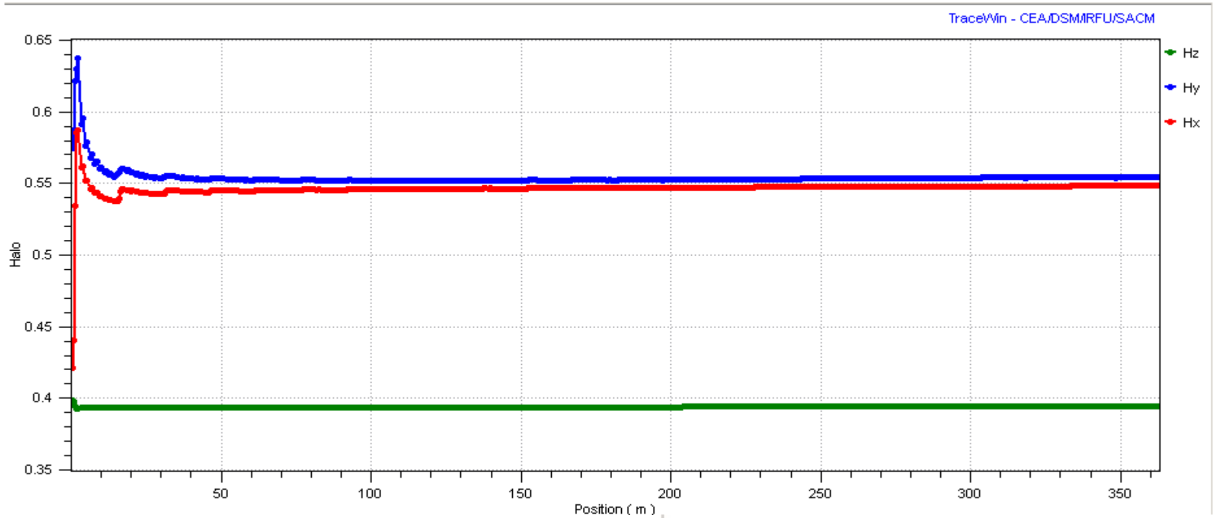
I. Morozov, Budker Institut Novosibirsk;
Divonne 2009

O-shaped magnet with the Ferrites core



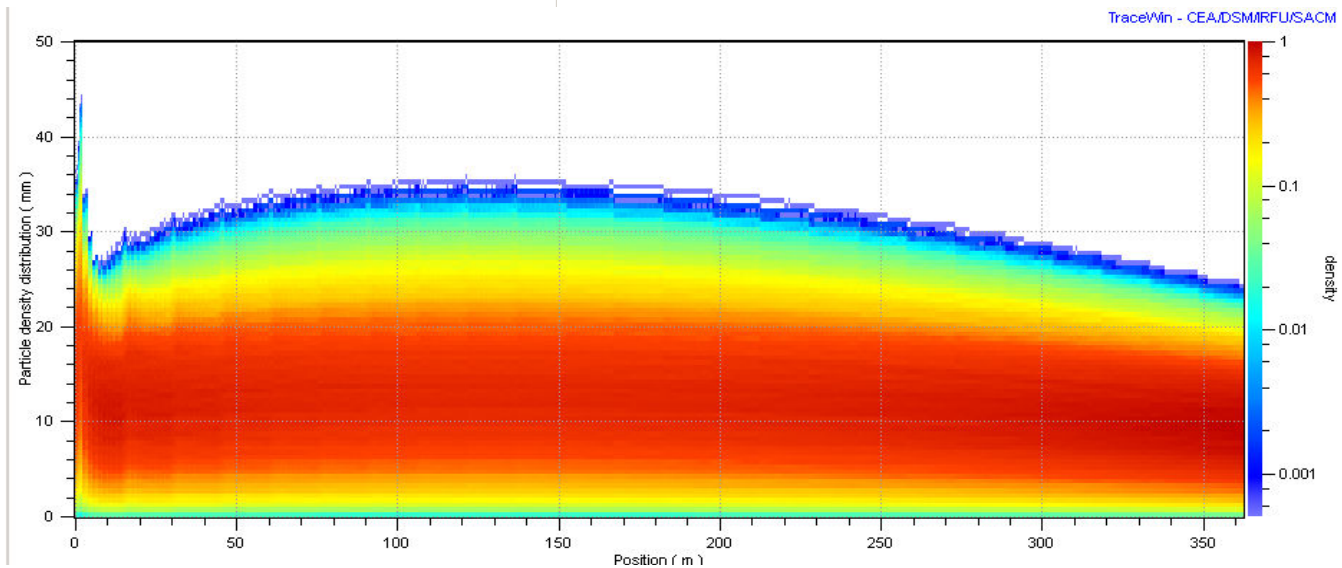
Halo and Density

M. Eshraqi, CERN; Divonne 2009



Halo evolution along the line, after the first turn, it stays constant

Radial density of particles along SPL, beam aperture is 50 mm



3-km long greenfield SC linac

F. Zimmermann, CERN; Divonne 2009

"ILC-like" SC linac parameters

Anders Eide

LHeC-RL scenario	lumi	baseline	energy
final energy [GeV]	60	100	140
cell length [m]	24	24	24
cavity fill factor	0.7	0.7	0.7
tot. linac length [m]	3000	2712	3024
cav. gradient [MV/m]	13	25	32
operation mode	CW (ERL)	pulsed	pulsed

RF frequency: ~700 MHz

4 passes

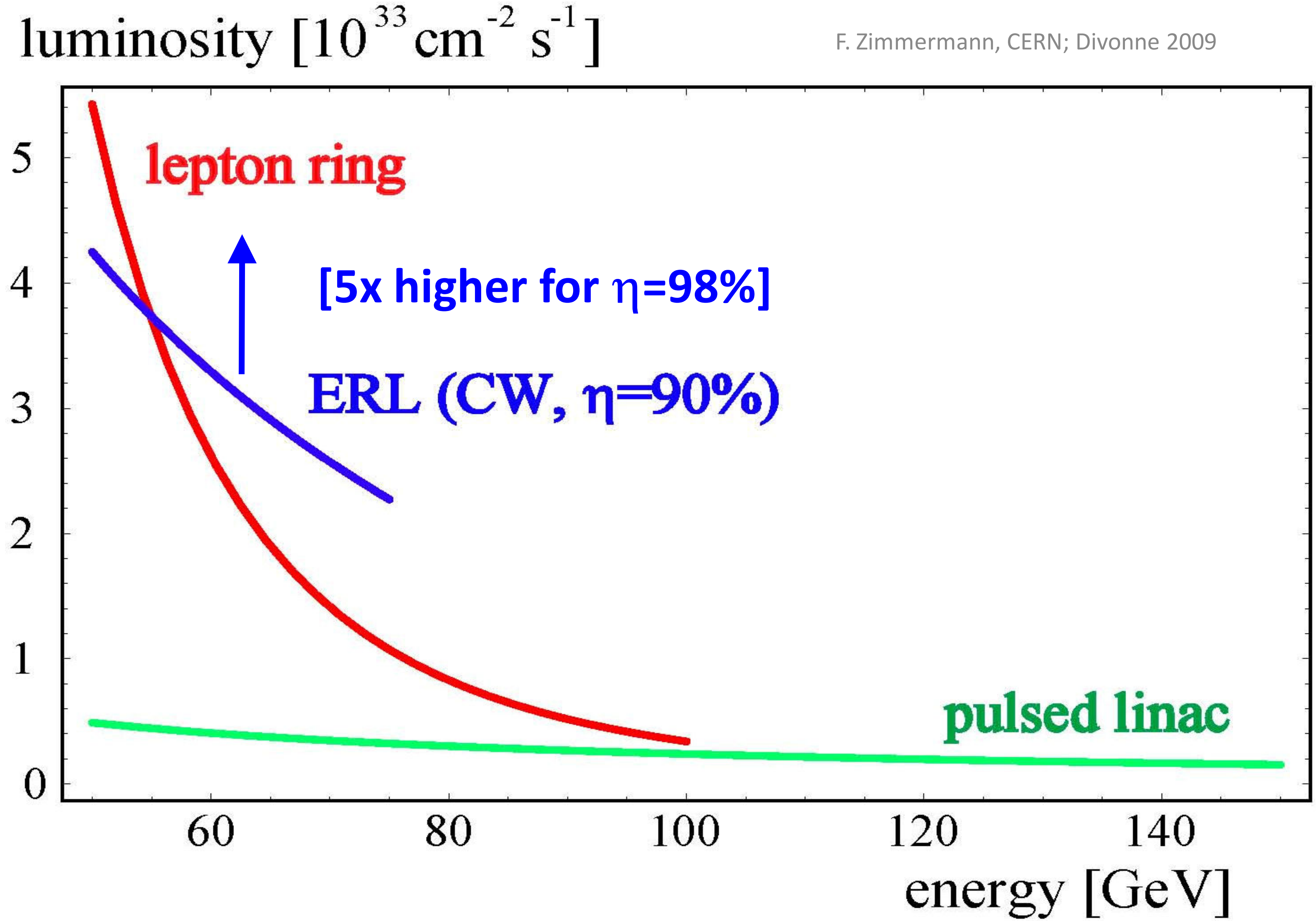
2 passes

we can use the same linac for all energies!

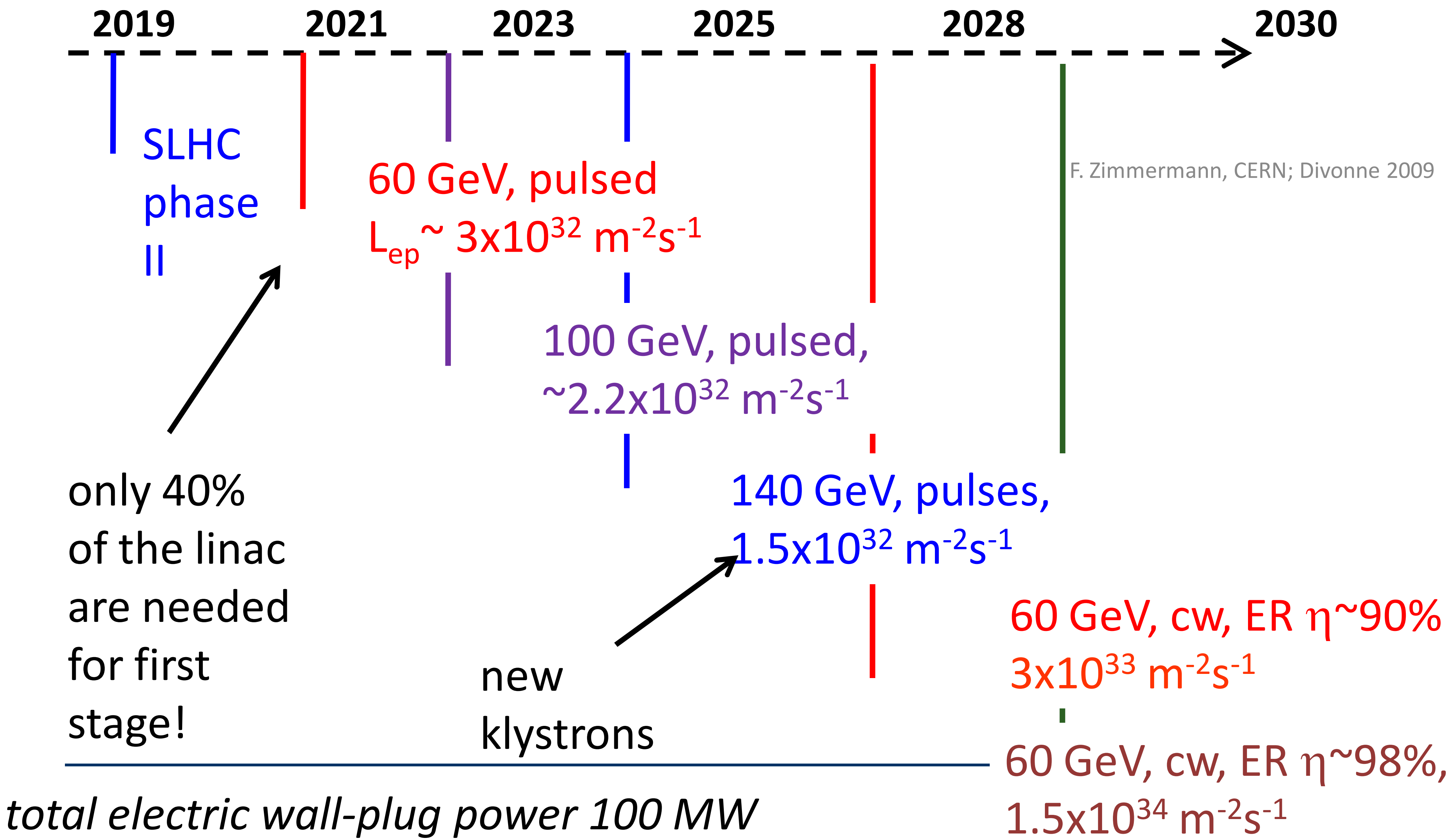
(different klystrons and modulators for cw and pulsed mode)

LHeC luminosity

F. Zimmermann, CERN; Divonne 2009



one staged schedule – *E* first

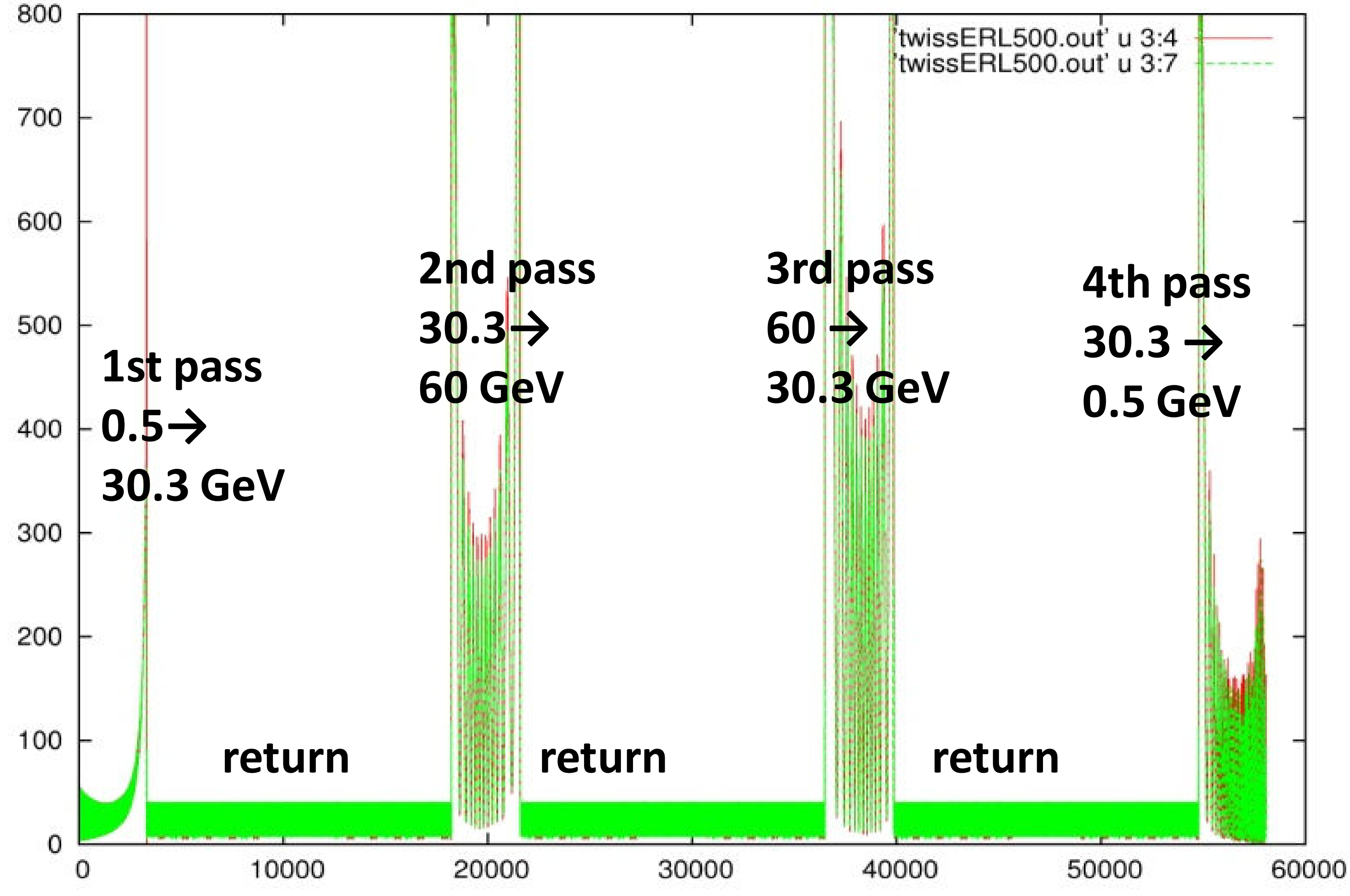


Ongoing Studies for Linac-Ring

- Re-circulating linac:
  - ➔ optics studies for multi pass in linac and return arcs
  - ➔ study of β-beat and emittance blow-up for multi-pass operation
- Energy recovery:
  - ➔ cost & infrastructure estimates based on planned projects
  - ➔ novel ERL options for high energy reach
- Source design:
  - ➔ options for polarized and non-polarized sources

complete optics – 60 GeV ERL

Anders Eide



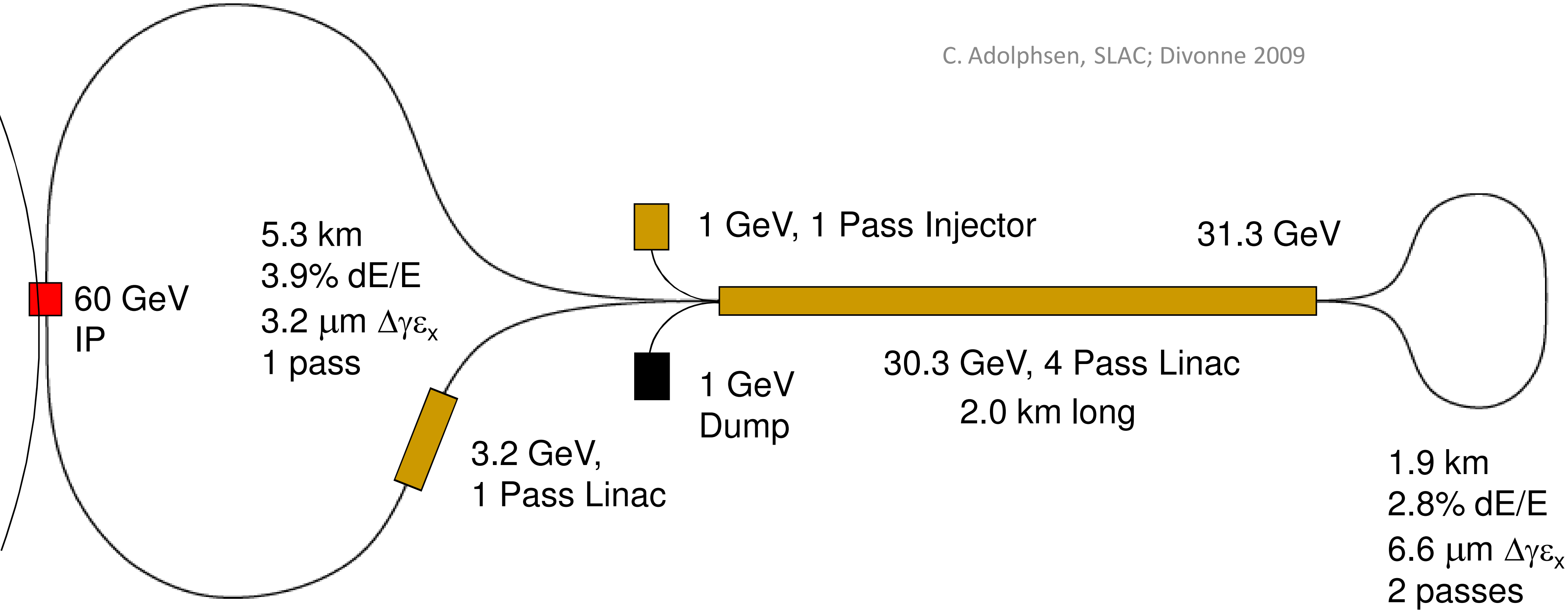
Conclusion

- Energy spread + chromaticity, small effect (10% growth for 140 GeV)
- +Radiation fluctuations at 140 GeV, $\Delta\gamma\epsilon = 50$ μm emittance growth;
- Up to E = 100 GeV, $\gamma\epsilon = 50$ μm is preserved in the RLA
- For E = 140 GeV, $\gamma\epsilon > 100$ - 200 μm at IP

What To do next

- Improvement of lattice (transition)
- Beam break up due to wake field (Placet & formulae)
- Higher Order Mode heat loss

60 GeV,1.3 GHz ERL

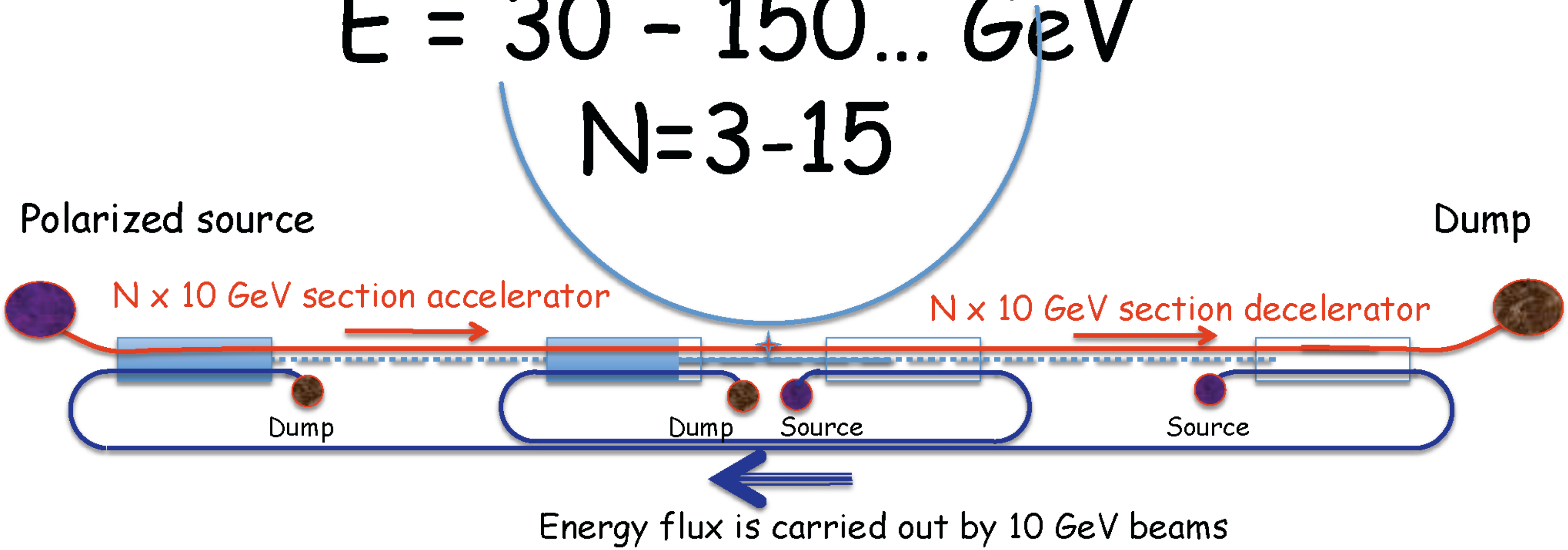


Assume SLC like arcs with F = H*(R^2/Lq^3) = 1.6, more conservative than F=0.1 assumed in CERN studies – makes arcs F^(1/4) = 2 times longer although stronger focusing at low F probably reduces this ratio – tried to keep big arc length < 6 km.

Acceleration and de-acceleration between 1 and 30 GeV through ~ 30 m FODO optics. Use waist optics (beta min ~ 500 m) for 30-60 GeV ?

Non ERL energy fraction = 7% (no IP losses), 1 GeV injector only guess for stability

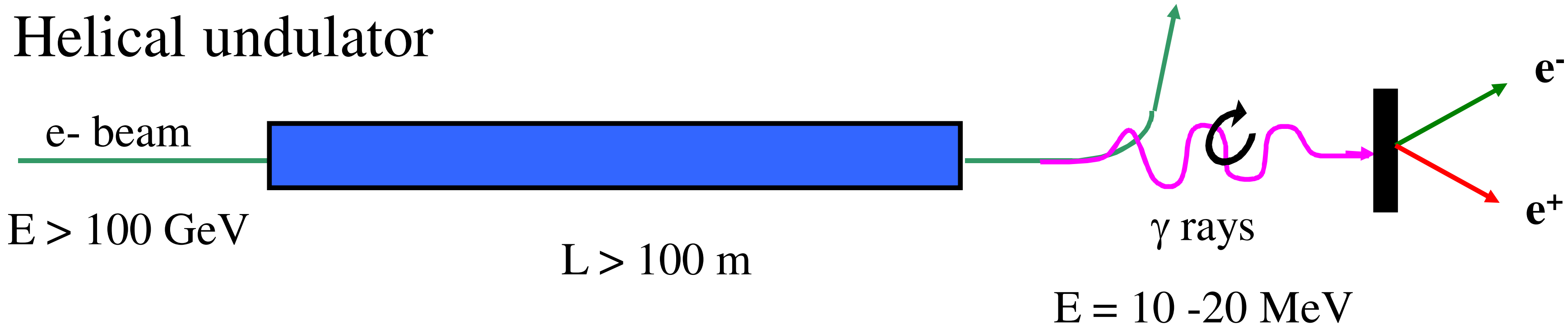
100% energy recovery
E = 30 - 150... GeV
N=3-15



V. Litvinenko, BNL; Divonne 2009

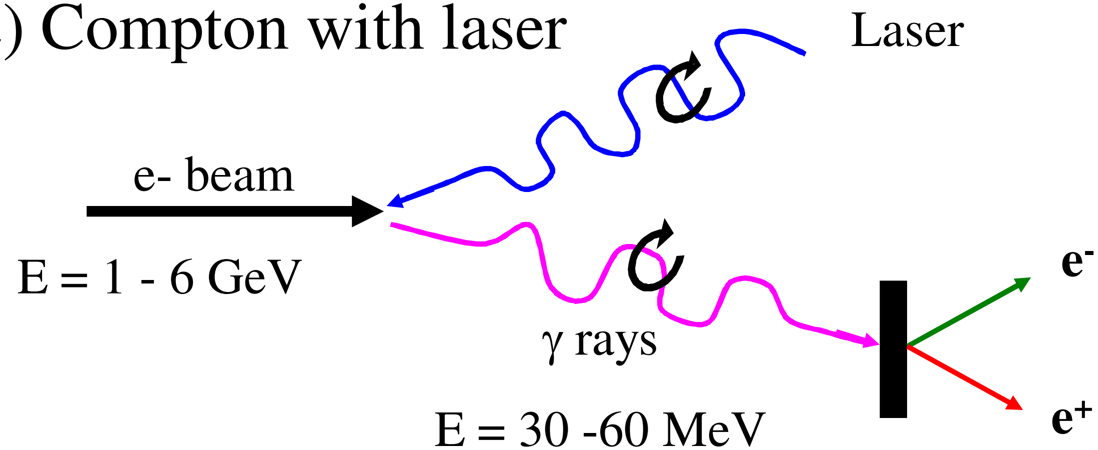
Two methods to produce polarized e^+

1) Helical undulator



L. Rinolfi, CERN; Divonne 2009

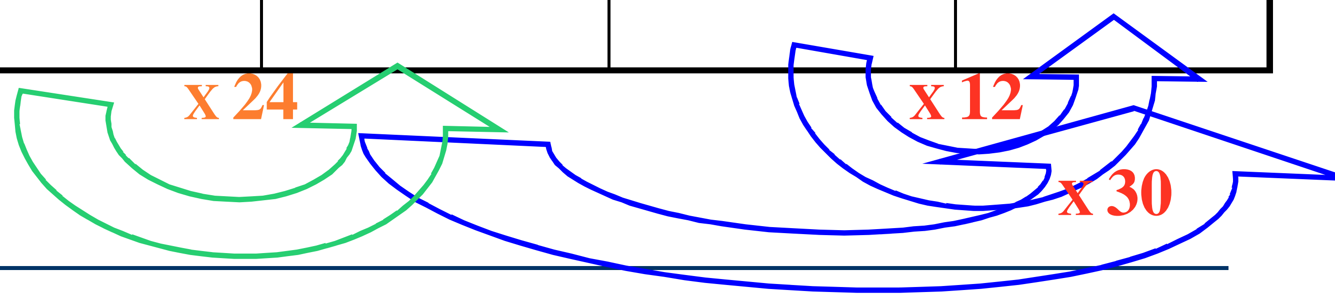
2) Compton with laser



Flux of e^+

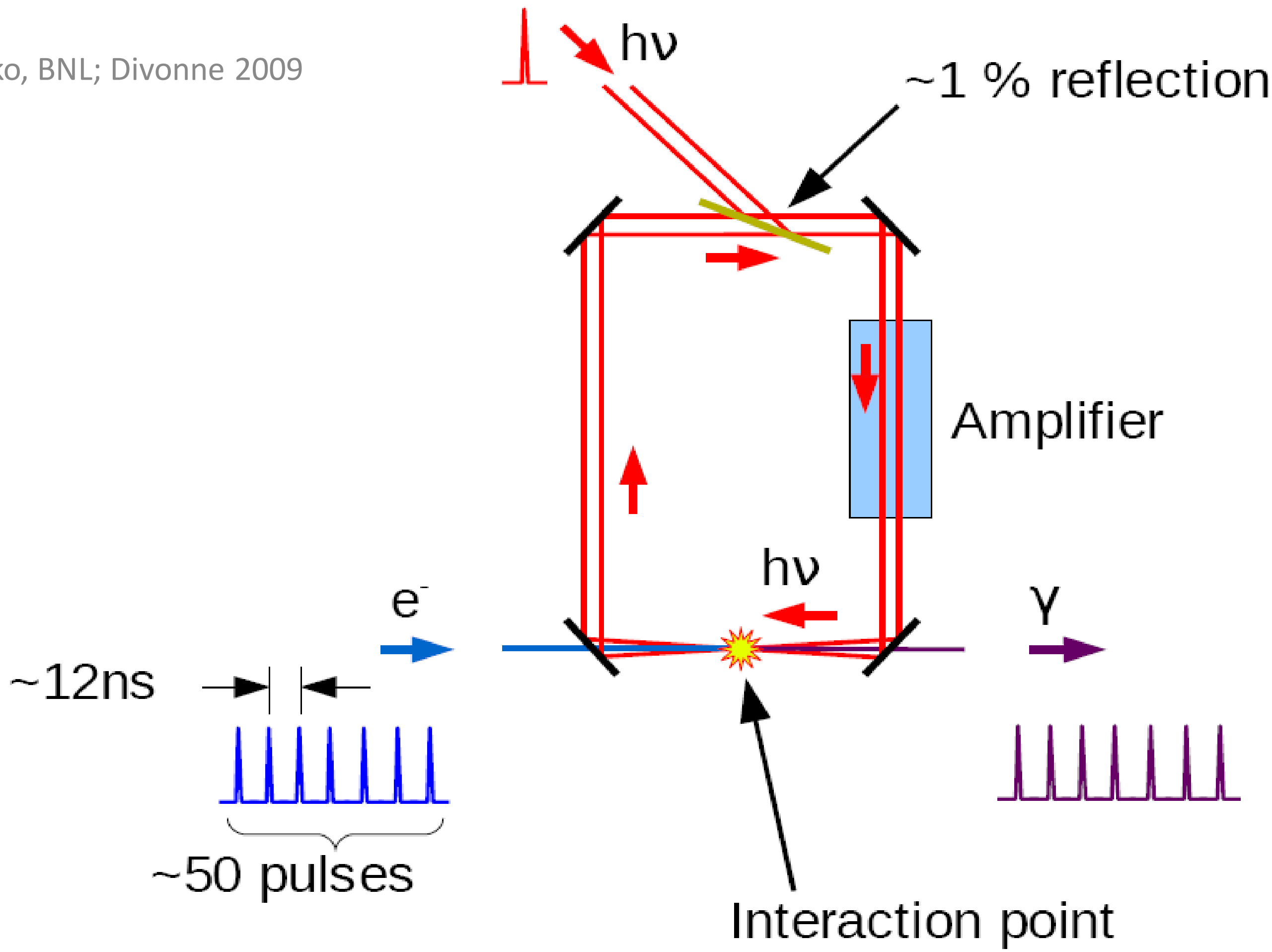
L. Rinolfi, CERN; Divonne 2009

	SLC	CLIC	ILC	LHeC
Positrons / bunch	3.5 x 10^{10}	0.64x10^{10}	2 x 10^{10}	1.5x10^{10}
Bunches / macropulse	1	312	2625	20833
Macropulse Rep Rate	120	50	5	10
Positrons / second	**0.042 x 10^{14}**	**1 x 10^{14}**	**2.6 x 10^{14}**	**31 x 10^{14}**



Concept of the Multi-kHz gamma source

V. Yakimenko, BNL; Divonne 2009



Summary

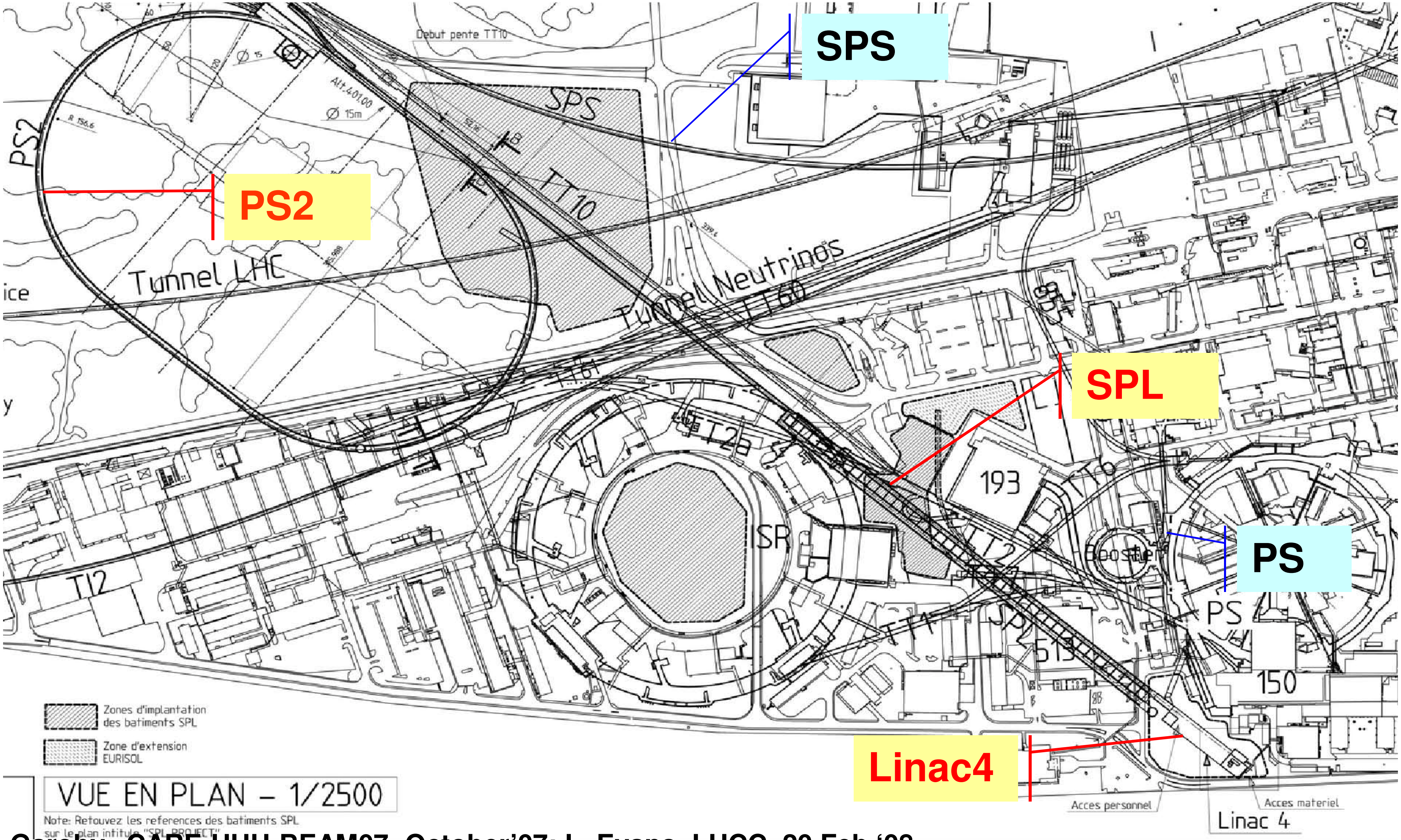
- Impressive progress since Divonne 2008. Big step towards CDR. Thanks to enthusiasm and dedication of CERN staff and collaborators!

- Both options show technical feasibility within reach.

- A CDR still implies a large ‘to do’ list. We have to be well organized in order to meet the CDR deadline!
  An LHeC office at CERN is an important step in the right direction.

- Contributions from external contributors and firm commitment from CERN colleagues are vital for meeting the CDR deadline (e.g. infrastructure; injection and dump; RF; vacuum etc)

layout of the new injectors



R. Garoby, CARE-HHH BEAM07, October'07; L. Evans, LHCC, 20 Feb '08