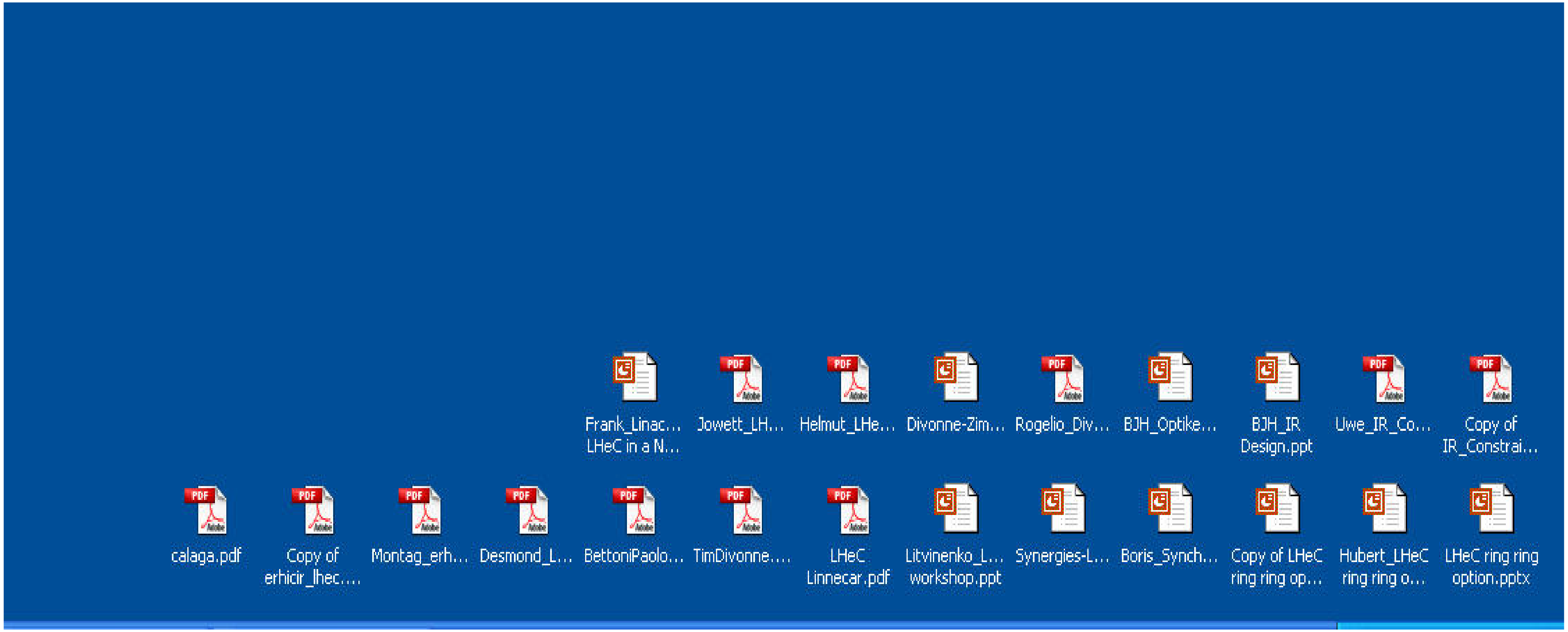
Interaction Region of the LHeC

Summary of the Working Group Presentations

Bernhard Holzer



**** a lot of contributions***

**** a lot of lively (!!!) discussions***

**** new ideas (!)***

"Herzlichen Dank " to all colleagues

Goal of the Working Group:

compare the two scenarios: ring-ring option / linac-ring option

with special emphasis on the layout of the interaction region
** beam optics,*
** beam separation,*
** crossing angle required*
** detector opening angle needed*

discuss present status of the required technical components

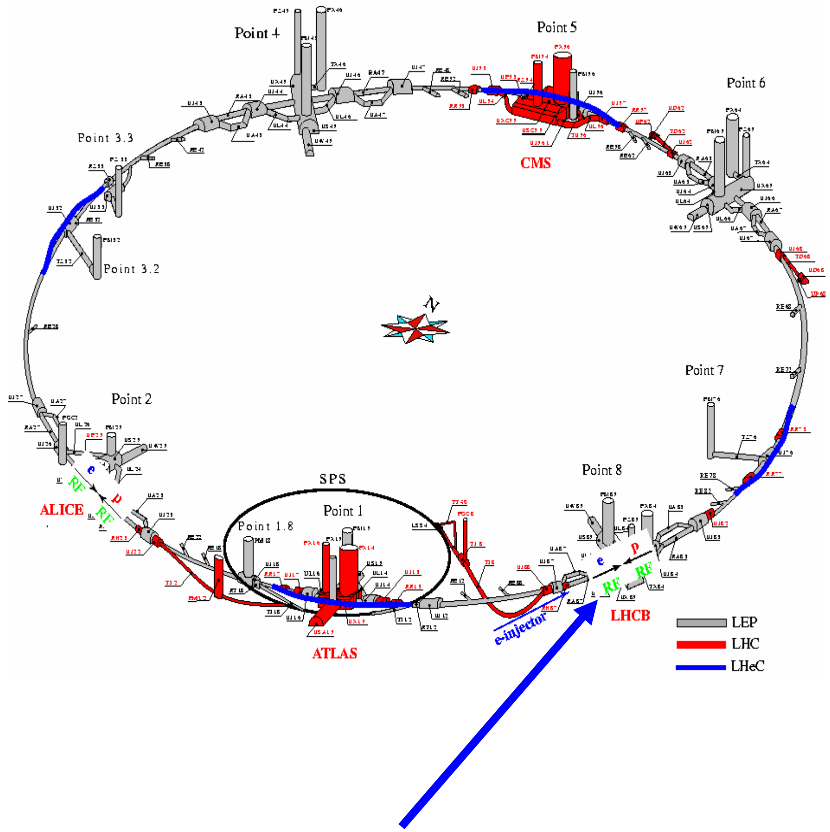
** crab cavities*
** exotic magnets*
** double magnets for fast beam separation*
** "active magnets"equiped for particle detection*

obtain input from other projects:
** eRHIC machine layout*
& IR design

Interaction Region Design of the LHeC Ring / Ring Version

Bernhard Holzer, DESY Hamburg

	Electrons	Protons *
Beam Energy	70 GeV	7 TeV
total current	74 mA	544 mA
part. / bunch	$1.4 \cdot 10^{10}$	$1.7 \cdot 10^{11}$
hor. emittance	7.6 nm	0.5 nm
vert. emittance	3.8 nm	0.5 nm
β^* hor	12.7 cm	180 cm
β^* vert	7.1 cm	50 cm
bunch spacing	25 ns	
Luminosity	$10^{33}\ cm^{-2}\ s^{-1}$	



IR Design in Point 8

IR Design: Ingredients for a ring ring option

IR layout is dominated by the separation scheme

well known ... HERA- I & II, KEK & SLAC B-factories

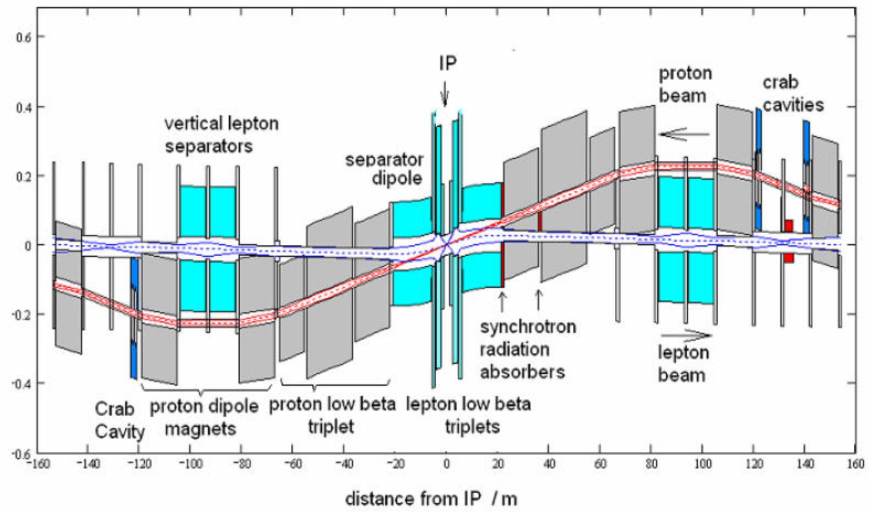
spectrometer effect: use dipole fields to separate the beams according to their momentum.
... don't loose too much space: → shift the quadrupole triplett in horizontal plane

LHC bunch distance: 25 ns = 7.5 m
1st parasitic crossing: 3.75m

first e-quad: positioned at s = 1.2m
... too late for sufficient beam separation

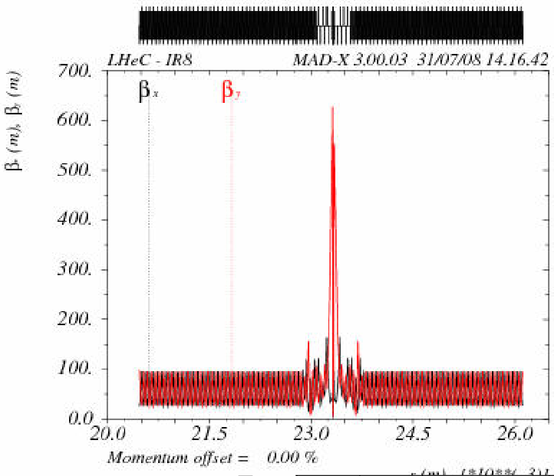
separation has "to start at the IP"

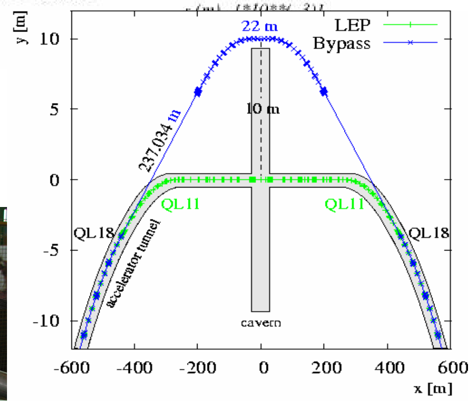
--> support the off-centre-quadrupole separation scheme by crossing angle at the IP.



Interaction Region Design: ring ring option

detailed presentations about ...

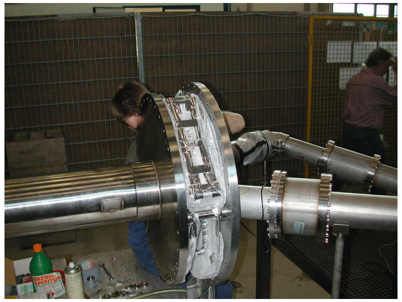




* *e-optics:* ***design of a low beta ínsertion,***
embedded into a LEP-2 like arc structure
(Alexander Kling, B.H.)

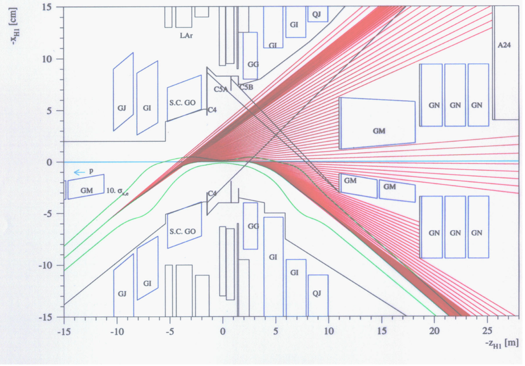
* *e-geometry:* ***bypass regions,*** *(Helmut Burkhardt)*

* *p-optics:* ***low beta insertion combined with***
the LHC luminosity lattice *(B.H.)*



* *sc. IR magnets*: ***first*** *exotic (?)* ***ideas about***
(Stephan Russenschuck)

* *sc. double magnet design, active magnets*
(Eugenio Paolomi, Simona Bettoni,Tim Greenshaw,)



* *synchrotron radiation:* ***and beam separation*** *(Boris Nagorny)*

* *rf cavities* **&** ***power consumption*** *(John Jowett, Trevor Linnecar)*

Boundary Conditions for the Interaction Region Design

Uwe Schneekloth, DESY Hamburg

Luminosity vs. Acceptance

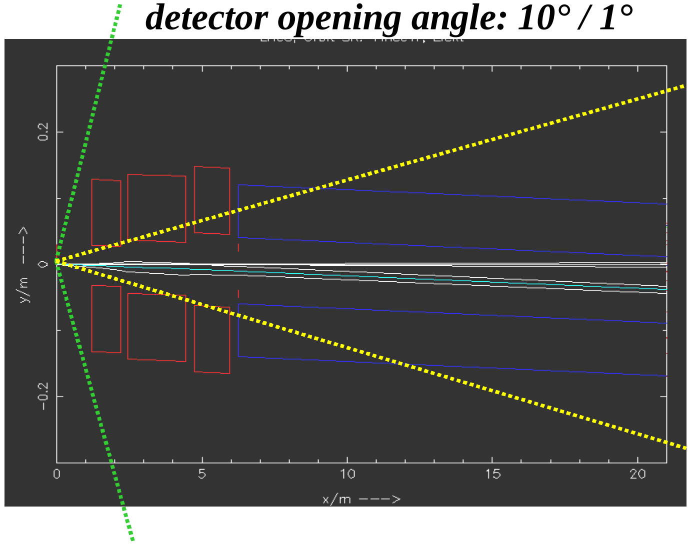
Luminosity and acceptance very much depend on physics program
(to be defined during this workshop)

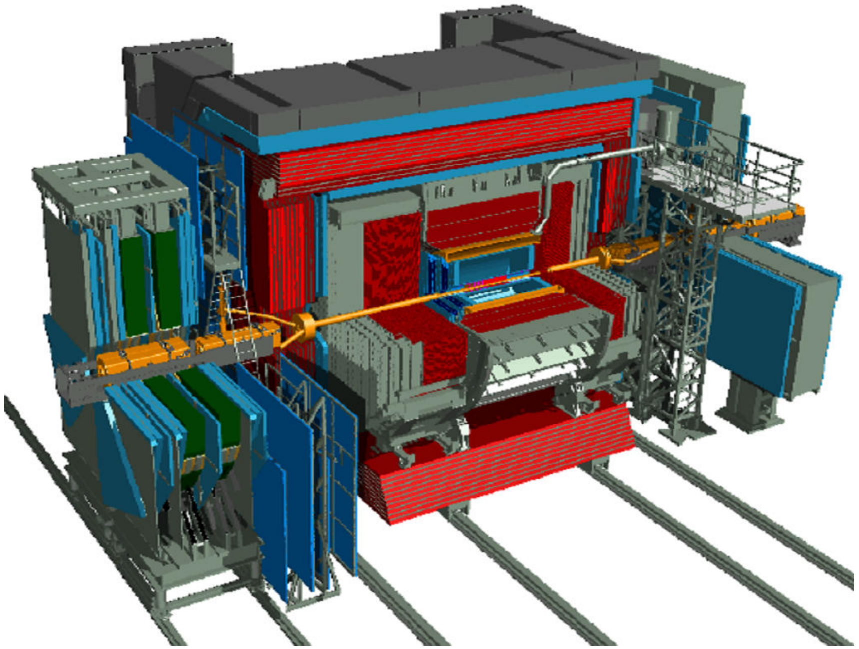
=> Possible scenario two different interaction region setups

$L = 10^{33}\ cm^{-2}\ s^{-1}$, $10° < \theta < 170°$ (prefer magnets not in front of calorimeter)

$L = 10^{31}\ cm^{-2}\ s^{-1}$, $1° < \theta < 179°$

detector opening angle: 10° / 1°





Example: ZEUS detector in HERA II with integrated mini beta quads

Comment from the WG discussion:
needs new calculation, requires machine design, will not be a "modular" change for the accelerator

Synchrotron radiation distribution in the interaction region of LHeC

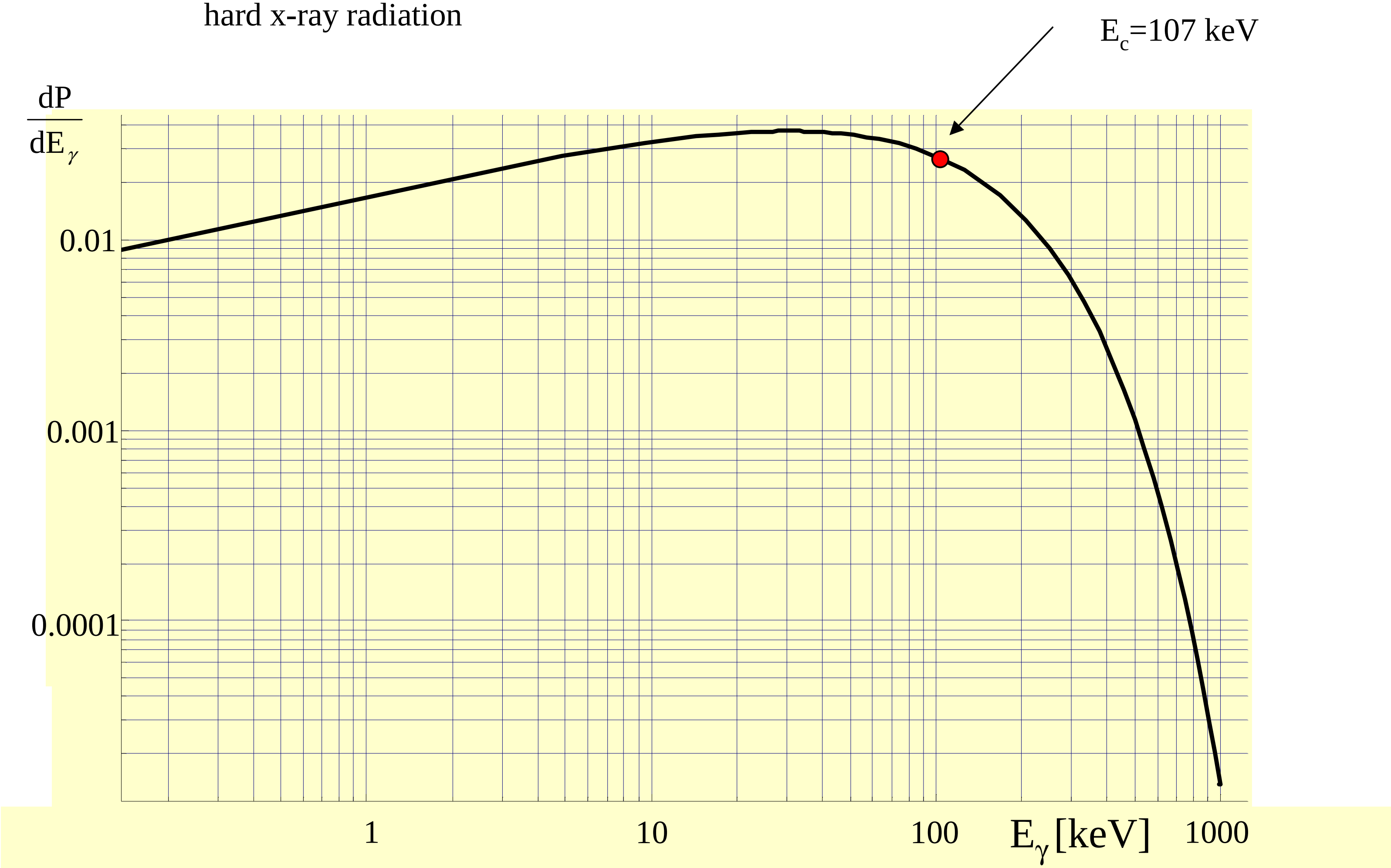
Boris Nagorny , DESY Hamburg

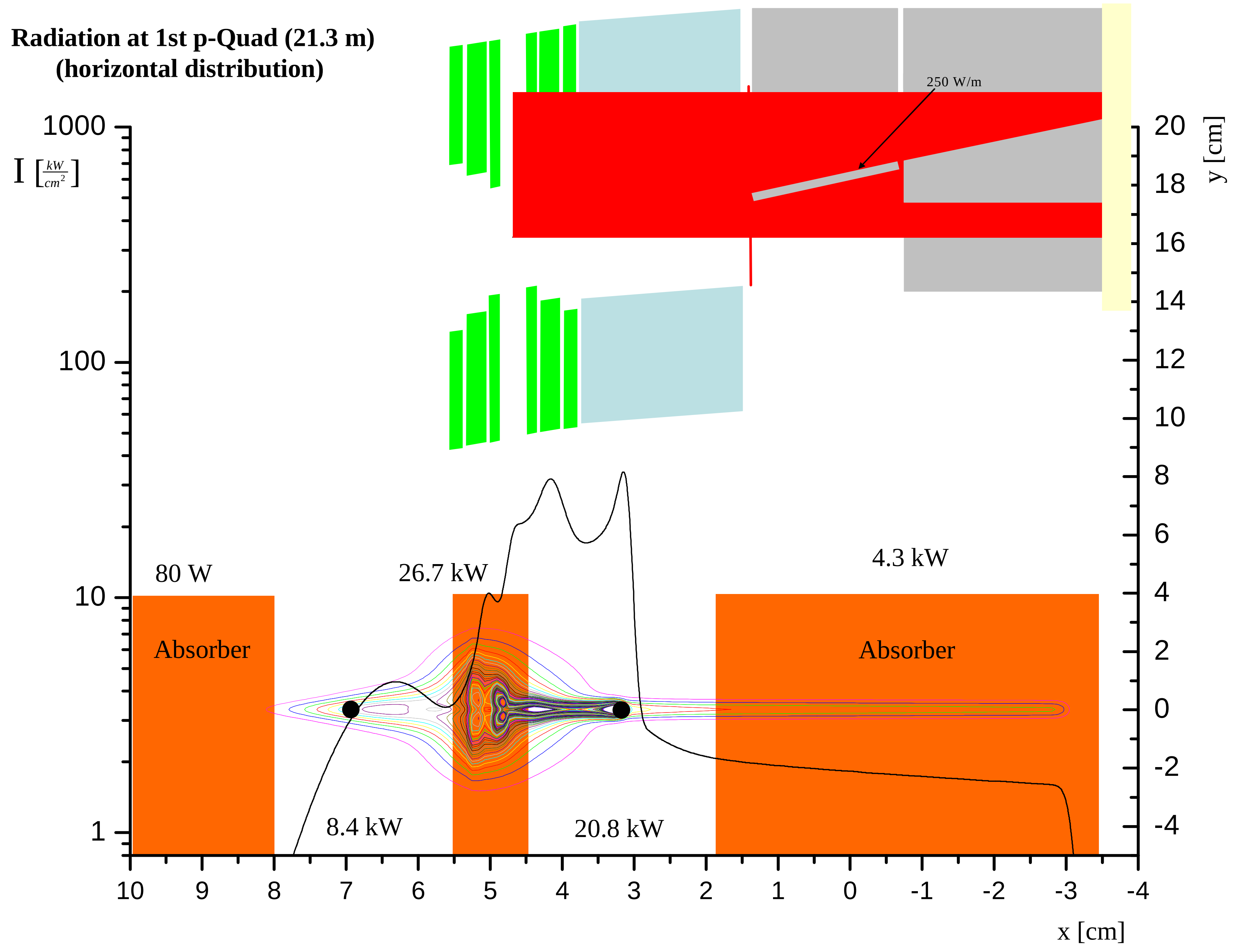
Radiation properties

Total power : 60.2 kW

Total number of photons : ≈ 10^{19} s^{-1}

hard x-ray radiation





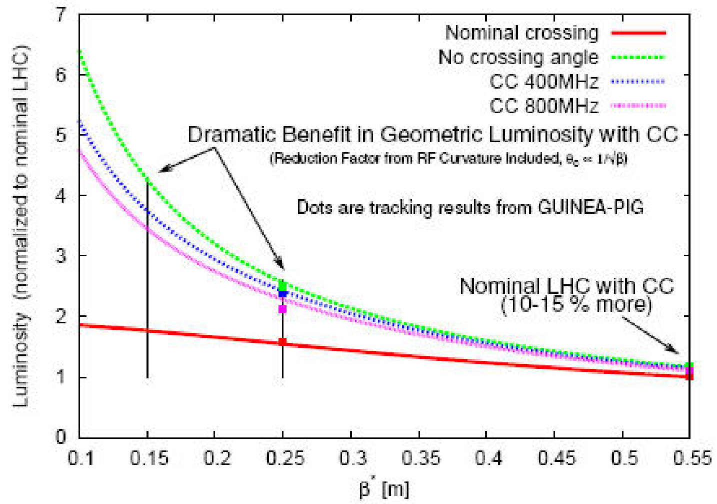
Radiation at 1st p-Quad (21.3 m)
(horizontal distribution)
I [kW/cm²]
1000
100
10
1
250 W/m
80 W
26.7 kW
4.3 kW
Absorber
Absorber
8.4 kW
20.8 kW
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
-4
x [cm]
y [cm]
20
18
16
14
12
10
8
6
4
2
0
-2
-4

Crab Cavities for LHeC

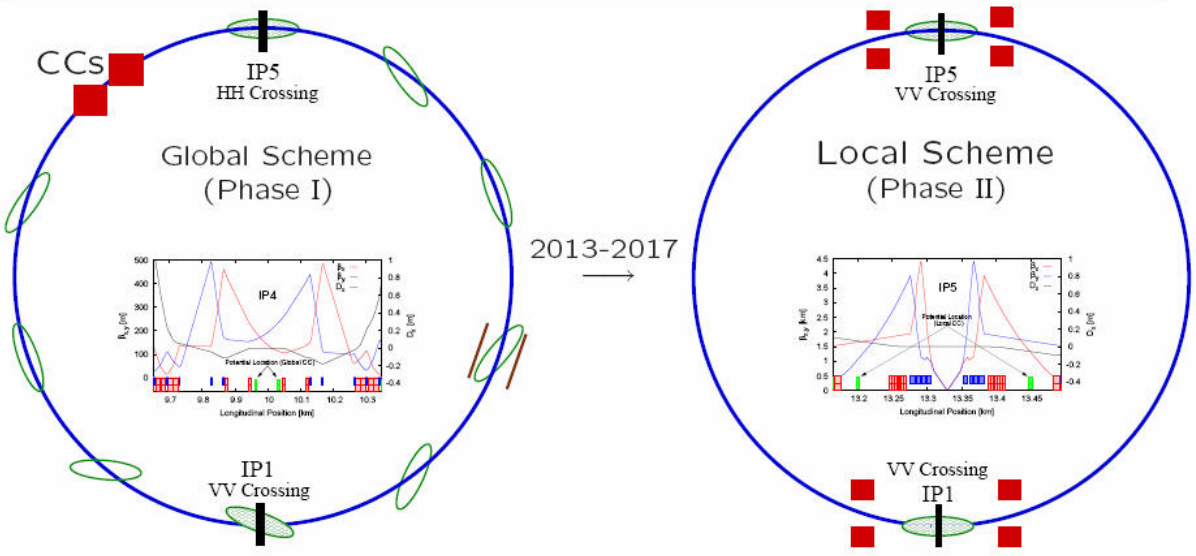
R. Calaga, Y. Sun, R. Tomás
BNL/LARP, CERN

Sept 2, 2008

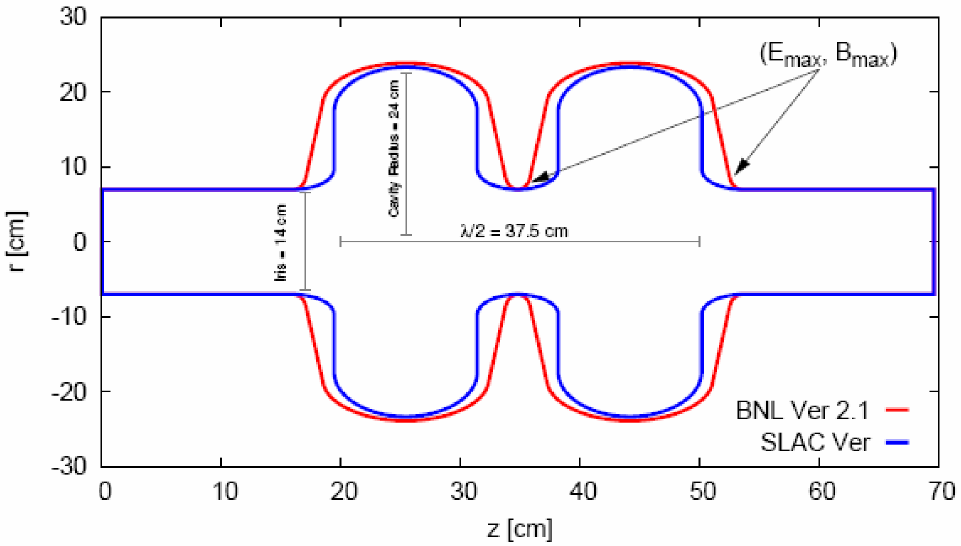
Luminosity Gain



Two Schemes for LHC



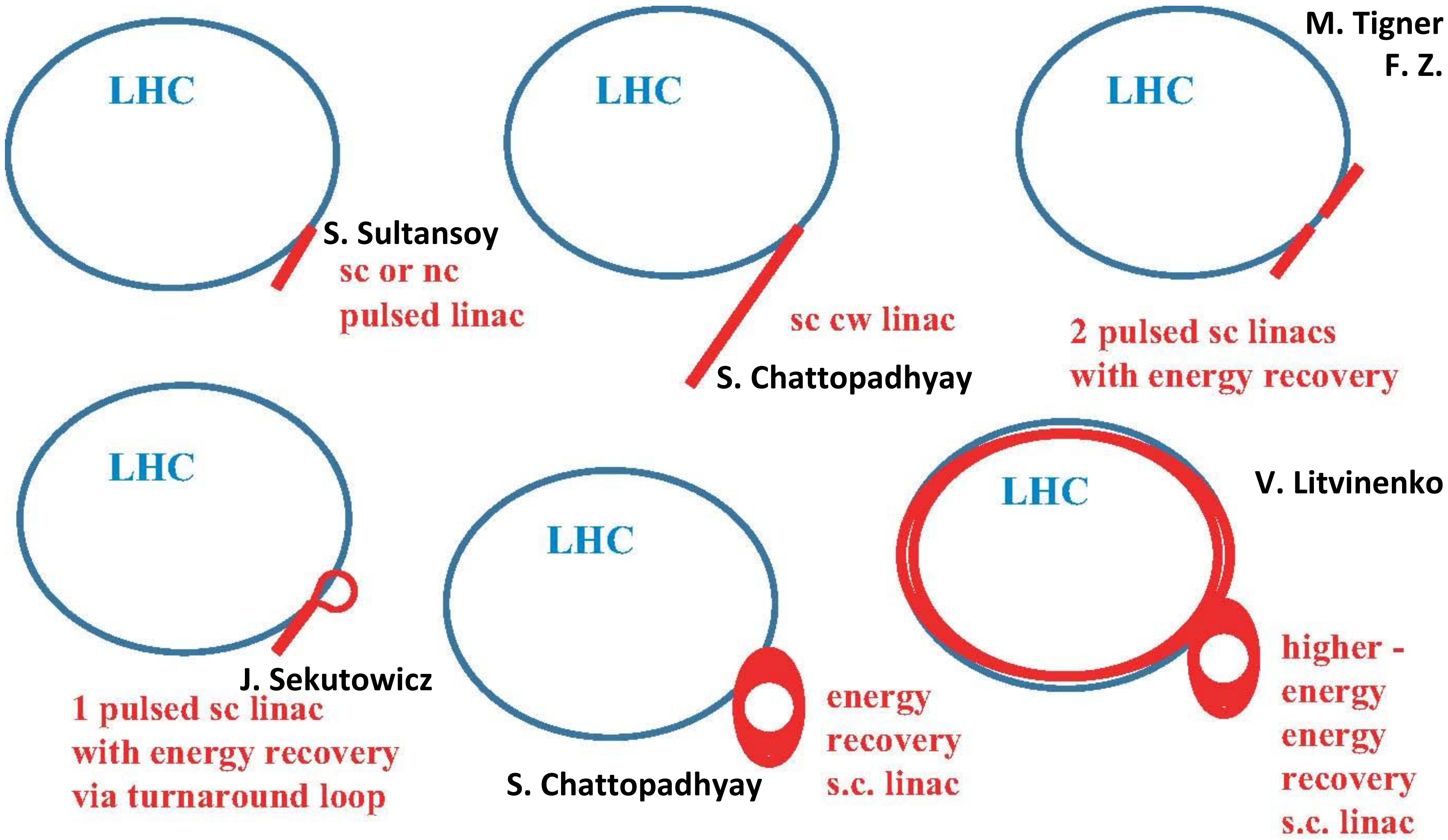
Baseline LHC Cavity, 800 MHz



- Crab cavities have very high potential for LHC upgrade. R&D is being pursued aggresively, expected to be ready by 2013
- LHeC has similar constraints as the LHC and technologically similar challenges
- For $\theta c > 0.5$ mrad, luminosity gain is considerable with crabbed protons
- RR (1 mrad): Assuming $\beta cc = 420$ m & $\beta * = 180$ cm, Vcc ≈ 7.6 MV (LR option is similar)

IR layout for the LHeC linac-ring option

F. Zimmermann et al., CERN



Linac-Ring Potential

100 MW wall plug power

20 GeV 98% energy recovery	**60 GeV w/o energy recovery**	**60 GeV 98% energy recovery**	140 GeV 98% energy recovery
5×10^{34} $cm^{-2}s^{-1}$	**5×10^{32} $cm^{-2}s^{-1}$**	**1×10^{34} $cm^{-2}s^{-1}$**	4×10^{33} $cm^{-2}s^{-1}$

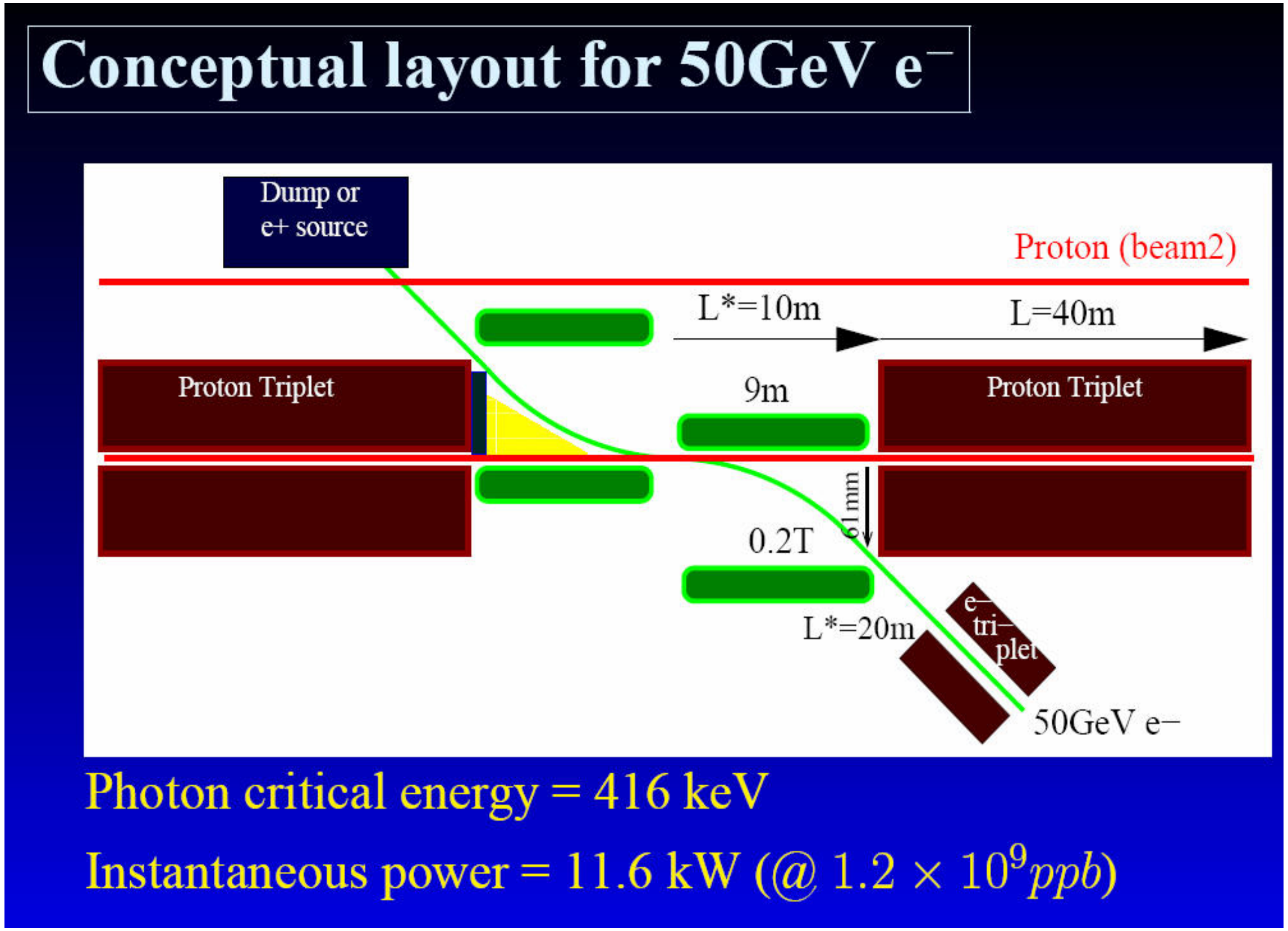
proton parameters from LHC "phase-2" upgrade
N_b=5x10^{11}, 50 ns spacing, $\gamma\varepsilon$=3.75 μm, β^*=0.1 m

IR layout for the LHeC linac-ring option

R. Tomás et al. CERN

Wish list for an e−p IP

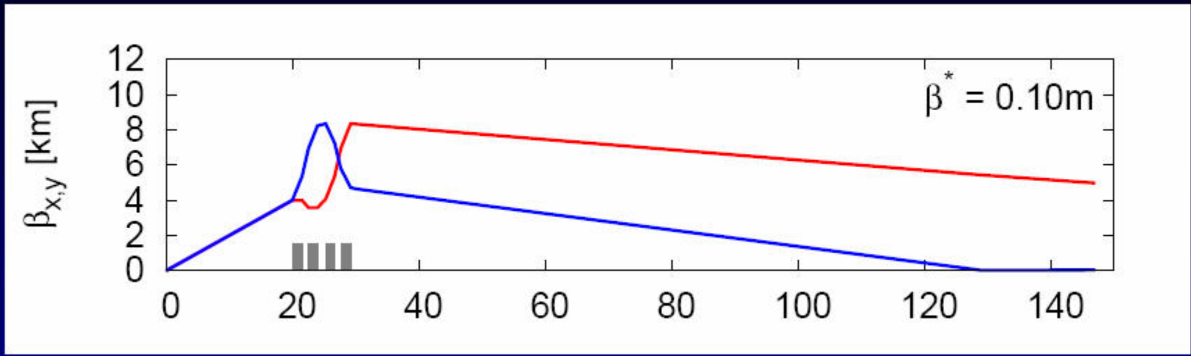
- Head-on collisions (with dipoles)
- Low radiation power 10 kW
- Critical photon energy < 500 keV
- βs below 0.25m both for e− and p



Nota bene:
1.) second proton beam

2.) remind option of integrated dipoles in the solenoid !

Electron triplet (L^{*}=20m, E=50GeV)



	Q1			Q2			
β^*	Aper	Grad	B_p	Aper	Grad	B_p	ξ
[m]	[mm]	[T/m]	[T]	[mm]	[T/m]	[T]	
0.10	21	13	0.26	23	15	0.3	1100

e^{-} triplet is easy, it could even be moved to 40m (after the p-triplet!).

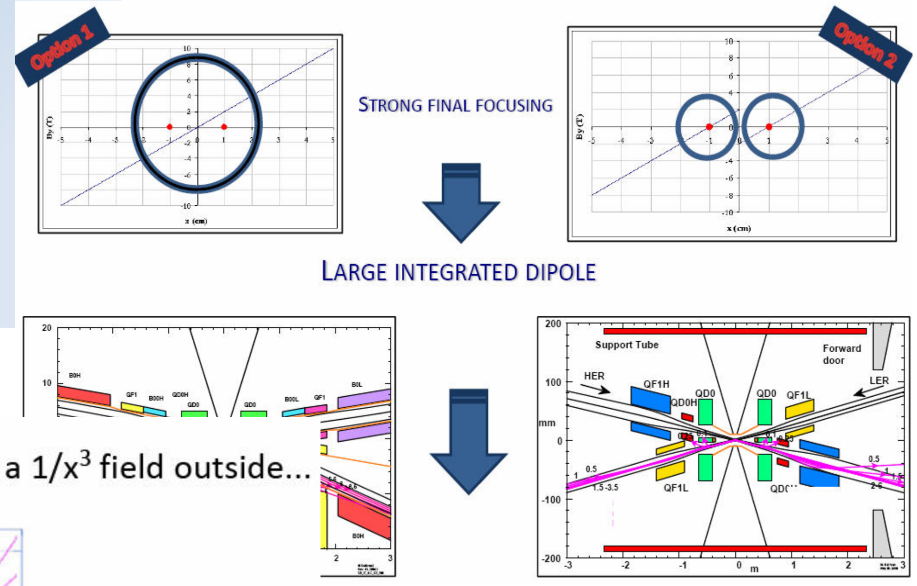
***Nota bene:* electron emittance in linac small, β* rel. large,**
--> relaxed requirements for l* of the electron triplett !!

Magnetic design studies for the final doublet of the Super*B*

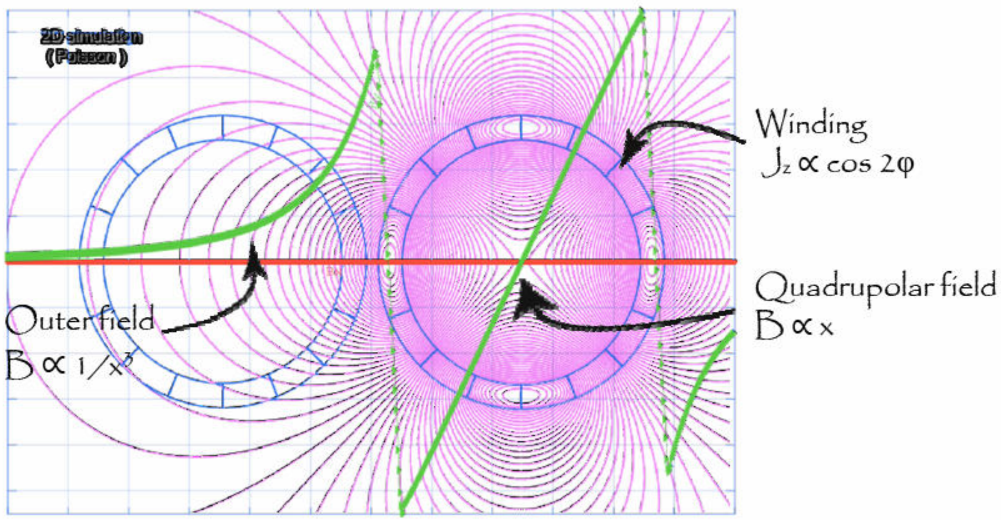
(large crossing angle scheme)

S. Bettoni (CERN-AB/ABP) on behalf of the whole team

(S. Bettoni, M. E. Biagini, E. Paoloni, P. Raimondi, M. Sullivan)

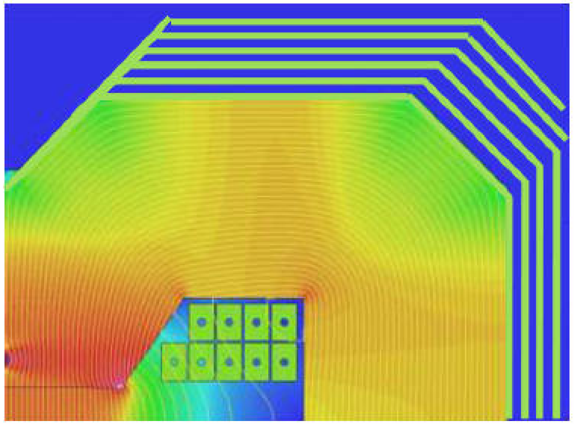


A cos (2 φ) magnet producing a quadrupolar field produces also a $1/x^3$ field outside...



Active Magnets:

Tim Greenshaw

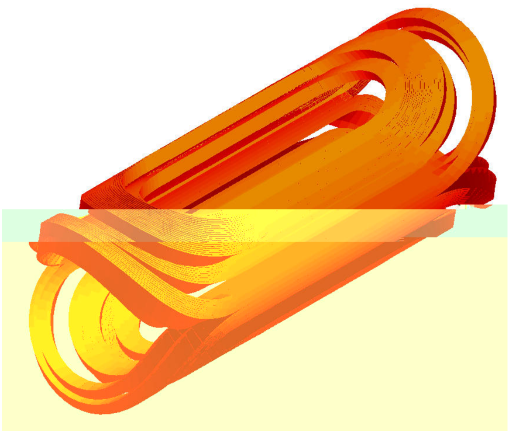


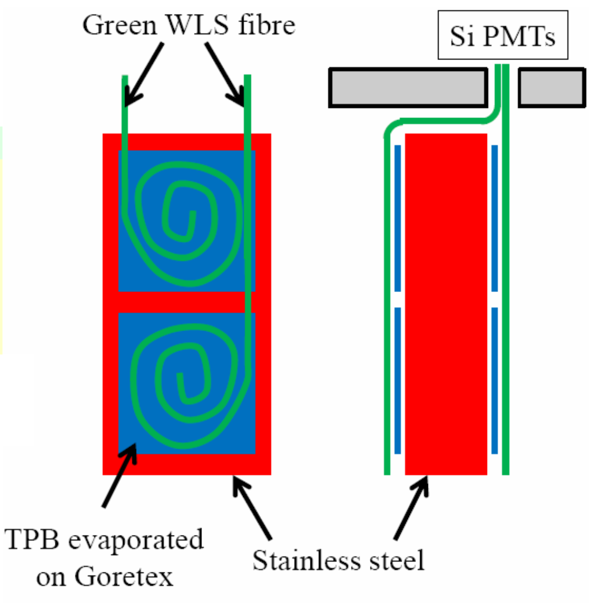
nc. magnets:

■Highest luminosities will always need magnets close to IP, so attempt to reduce their effects on acceptance.

■Normal conducting magnet, coils surround iron core.

■Segment core and insert scintillator between layers so magnet also becomes calorimeter





sc. magnets:

■Alternative: LHe is efficient scintillator, emitting light in the extreme ultra-violet (l~ 80 nm).

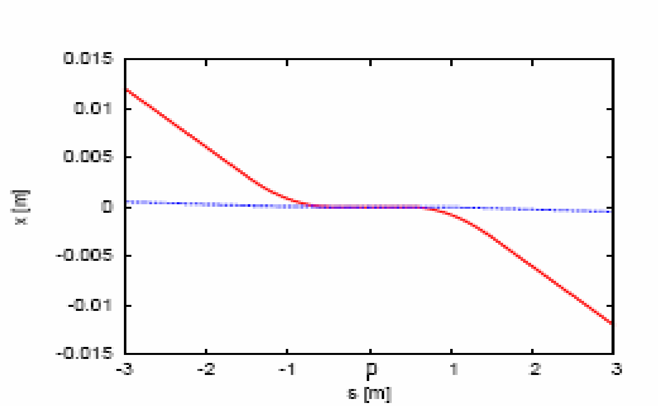
■Consider steel/LHesandwich design.

eRHIC Interaction Region Design Status

Christoph Montag, BNL

Parameters

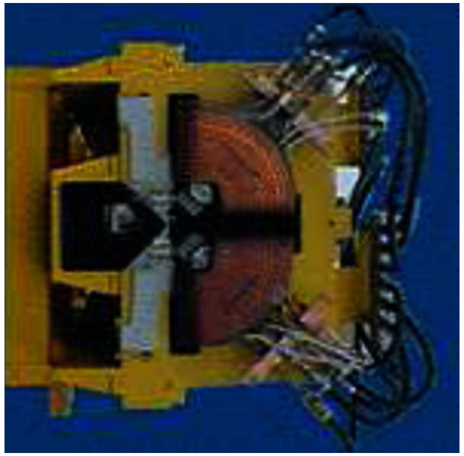
	p	e
energy [GeV]	250	10
rms emittance [nm]	3.8	4.0
β^* [cm]	26	25
rms bunch length [cm]	20	1
peak luminosity [$10^{33}\,cm^{-2}sec^{-1}$]	2.6	



Head-on collision scheme, "S"-shape

Beam separation: dipoles integrated in Solenoid
3m element-free space
12σ minimum aperture for ions
10σ minimum aperture for electrons

HERA-type septum quadrupole magnet



to do list ...

a lot of work ...

1° / 179° option --> new design
baseline for cdr: 10° / 170°

synchrotron radiation needs careful design of geometry & absorbers → close collaboration with detector people

profit from new ideas (active magnets, double quad design, solenoid & dipole field ...)

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

compare the two schemes: linac-ring / ring-ring
... for a given overall wall plug power: 100MW