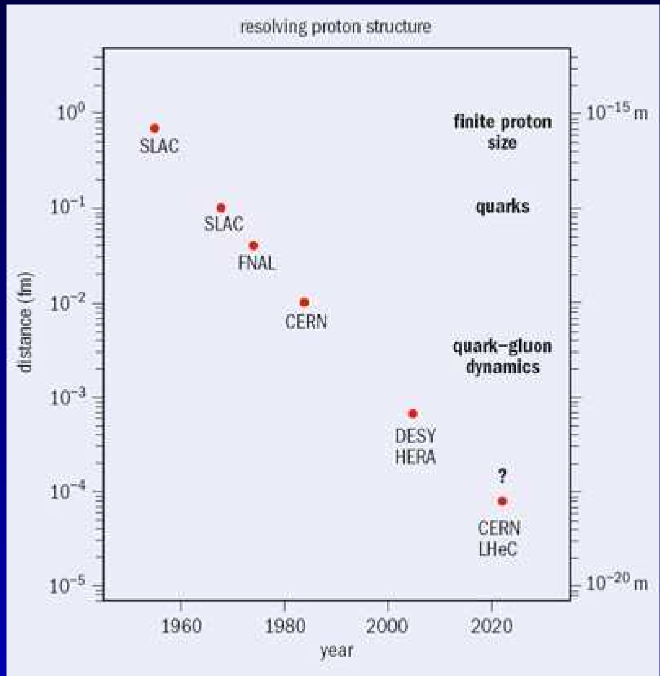
IR layout for the LHeC linac-ring option - Update from 2008



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Thanks to O. Brüning, H. Burkhardt, B. Holzer and P. Kostka.

Divonne 2009

Contents

2008:

- Wish list for an e^-p IP
- Conceptual layout at 20GeV e^-
- Conceptual layout at 50GeV e^-
- The proton triplet optics with L*=10m
- The e^- triplet optics with L*=20m (50GeV)

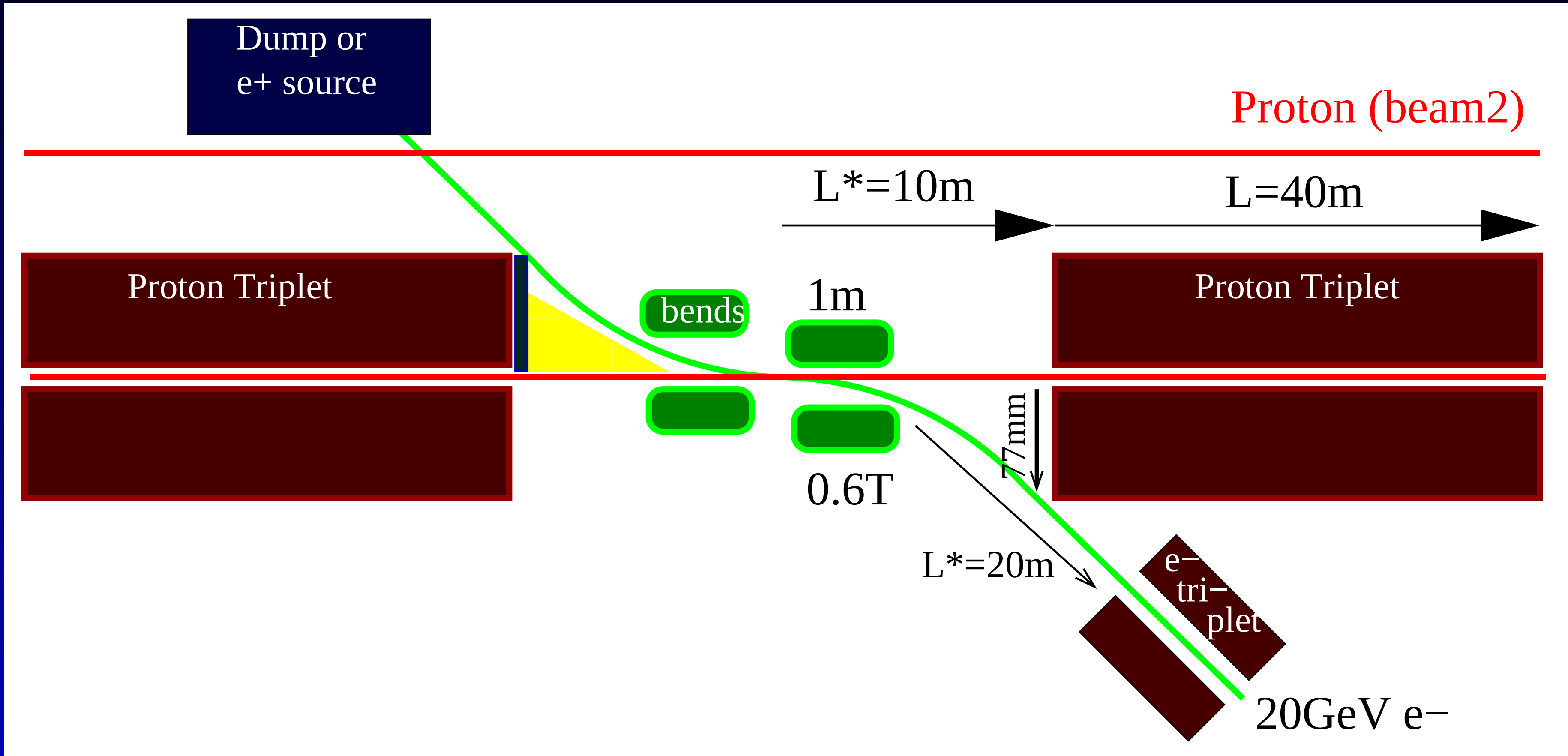
2009:

- Conceptual layout at 100GeV e^-:
  - SR & beam pipe
  - Detector acceptance

Wish list for an e$^-$p IP

- Head-on collisions (with dipoles)
- Low radiation power $\approx$ 10 kW
- Critical photon energy < 500 keV
- βs below 0.25m both for e$^-$ and p
- Same geometric e$^-$ and p emittances $(\epsilon_{e,n}, \epsilon_{p,n}) = (20, 3.75)$ μm

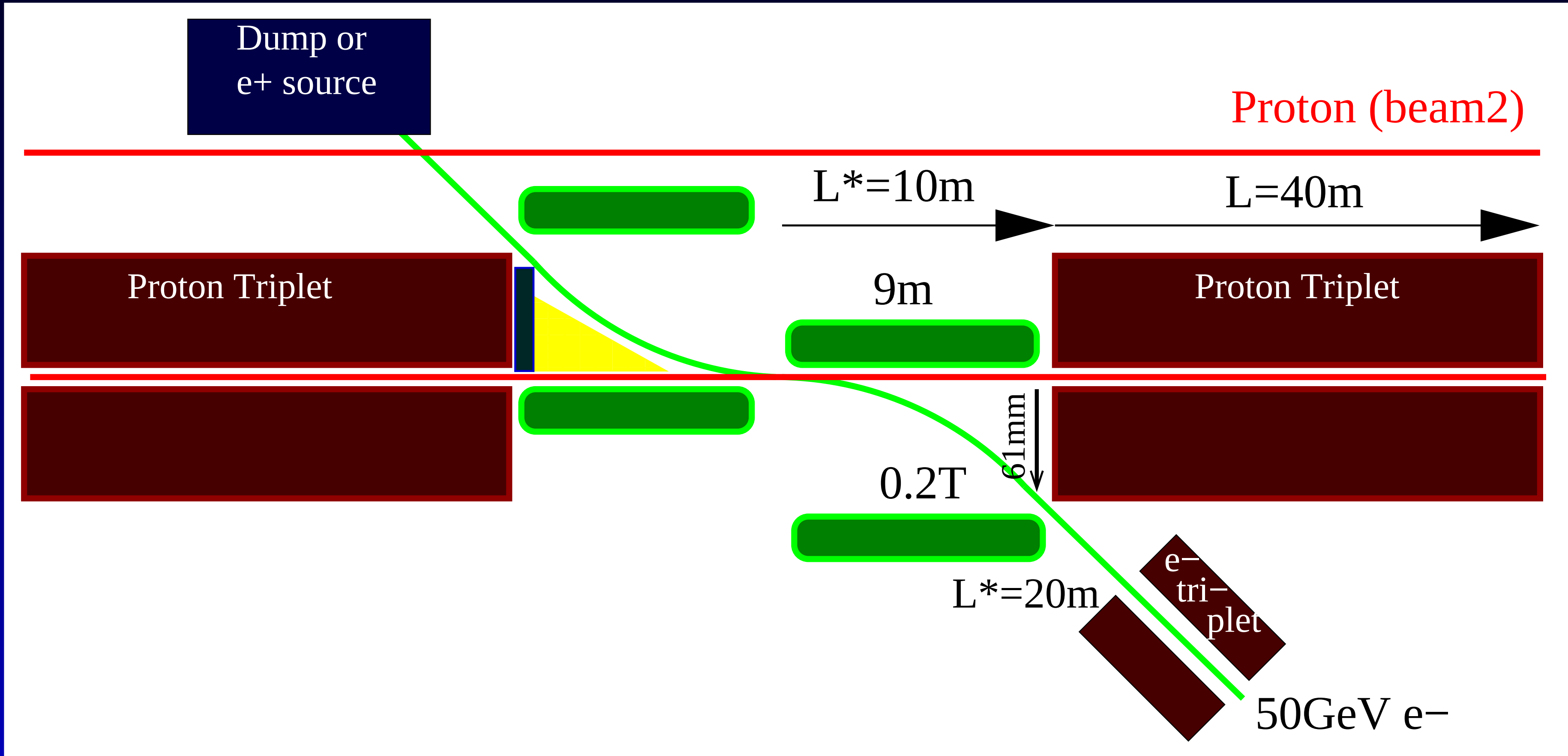
Conceptual layout for 20GeV e^-



Photon critical energy = 160 keV

Instantaneous power = 10.7 kW (@ $1.2 \times 10^9 ppb$)

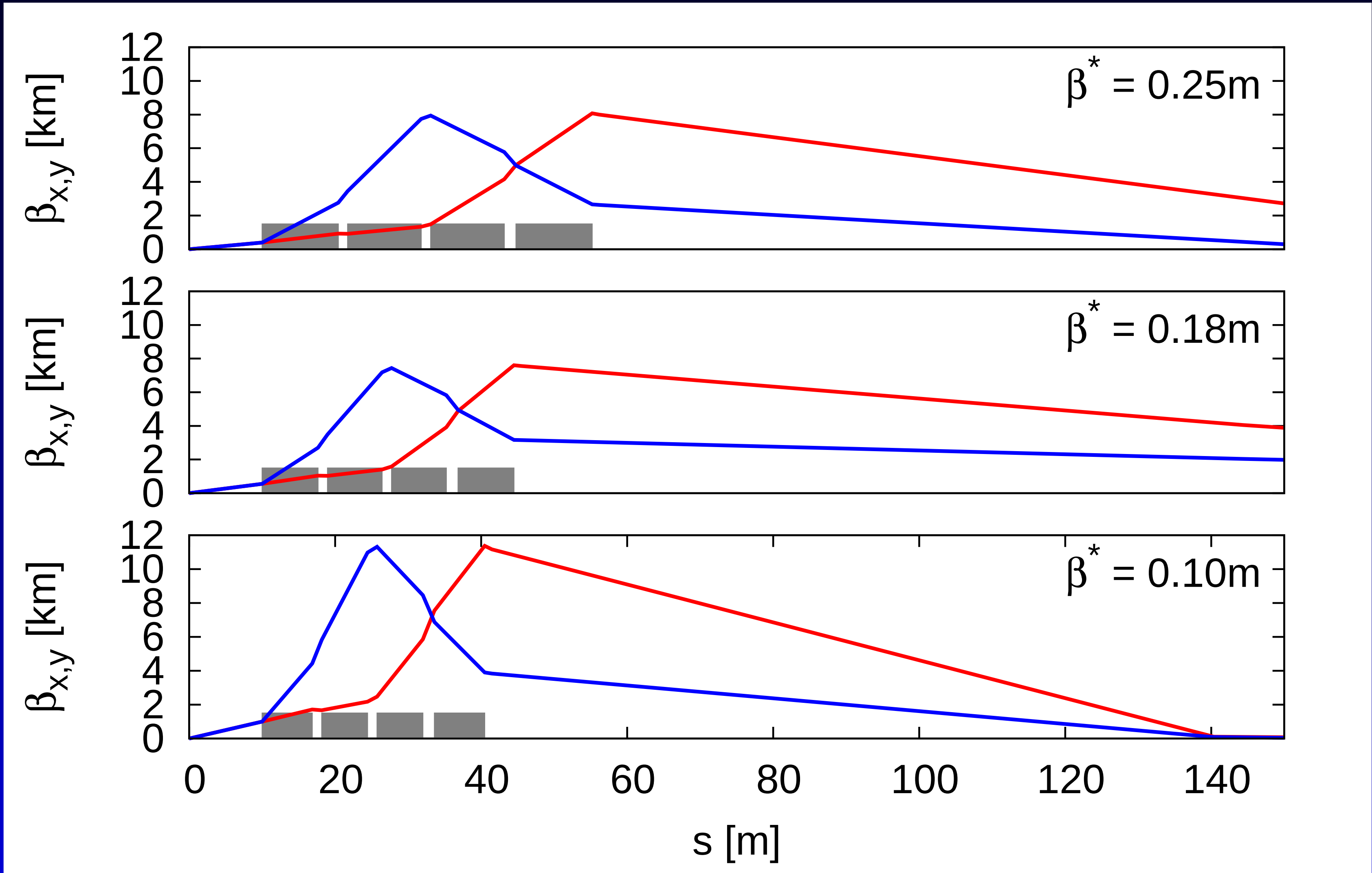
Conceptual layout for 50GeV e^-



Photon critical energy = 416 keV

Instantaneous power = 11.6 kW (@ $1.2 \times 10^9 ppb$)

Proton triplet options (L*=10m) I



Proton triplet options (L^*=10m) II

	Q_1			Q_2			
β^*	Aper	Grad	B_p	Aper	Grad	B_p	ξ
[m]	[mm]	[T/m]	[T]	[mm]	[T/m]	[T]	
0.25	23	176.7	4.0	32	115.0	3.7	635
0.18	23	264.5	6.0	32	180.0	5.7	660
0.10	26	318.6	8.4	36	250.0	9.1	1250

Aperture = 11σ + 10mm

$\beta^* = 0.18$m seems feasible today

$\beta^* = 0.1$m reachable with new technologies (Nb_3Sn, NbAl, ?) and some chromaticity correction scheme.

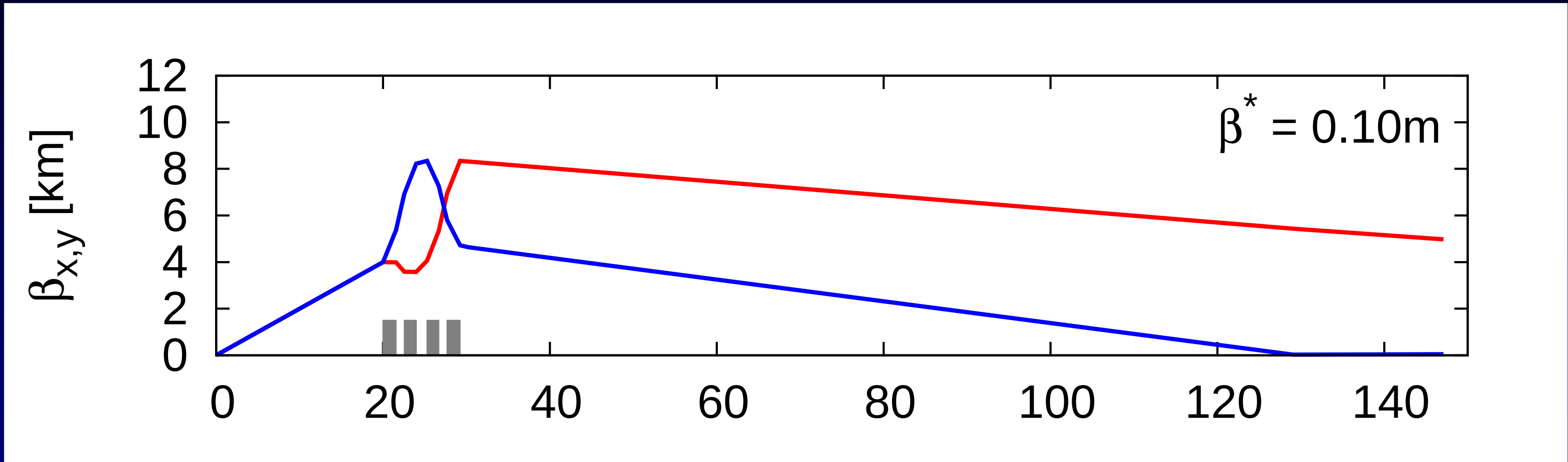
Proton triplet remarks

- For $\beta^* = 0.25$m the L* could also be 20m
- Increasing energy?
  lower B field to keep critical energy constant $(BE^2 = const)$ and increase L* (and β^* for ξ) to keep beams separation constant:

  $$\frac{E^3}{(L^* - 1)^2} = const\ ,\quad \frac{E^3}{\beta^{*2}} \approx const$$

  20% energy increase needs 31% β^* increase.
  Power scaling: $P_\gamma E^2 = const$.
- How critical is critical energy?

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



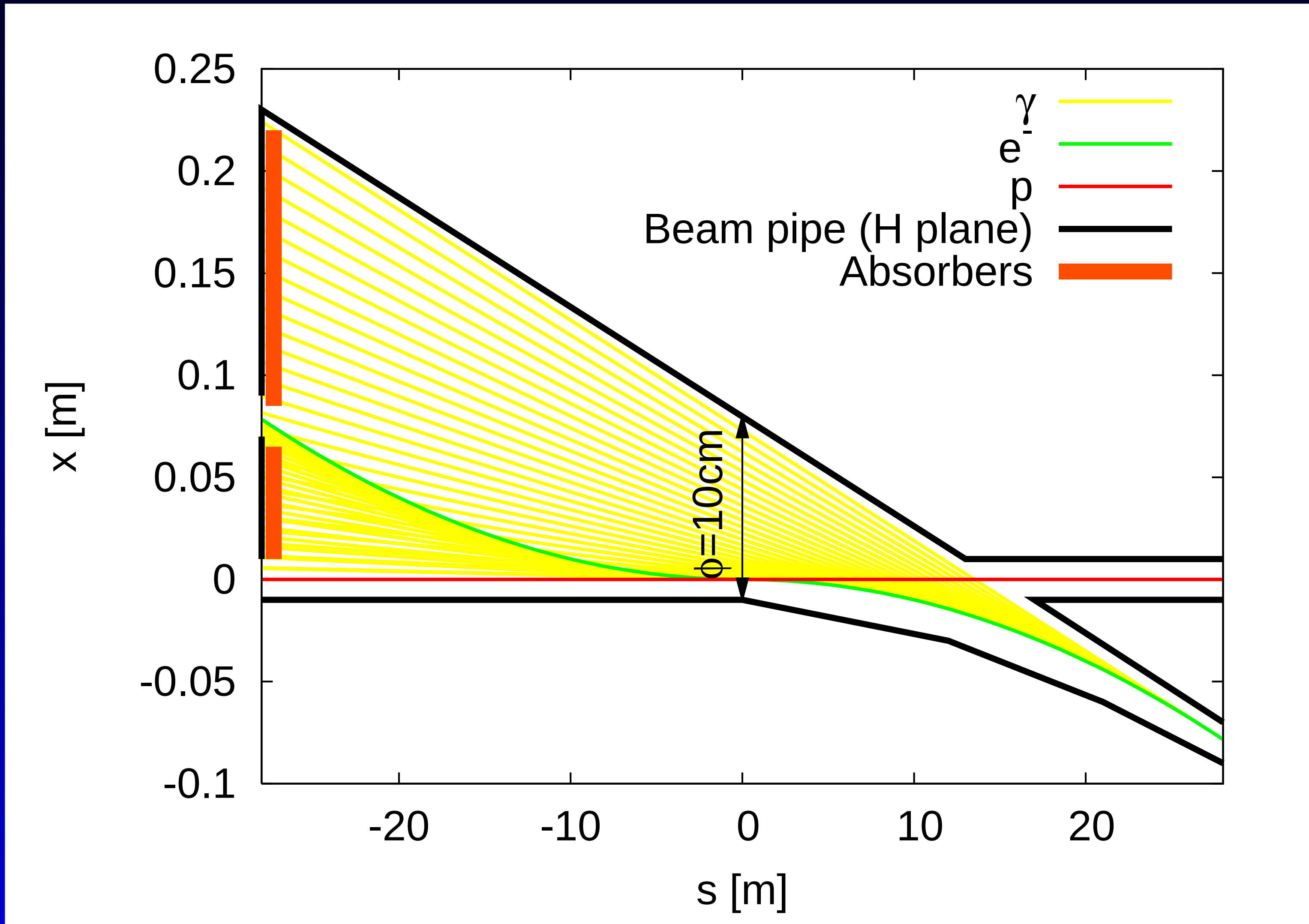
	Q_1			Q_2			
β^*	Aper	Grad	B_p	Aper	Grad	B_p	ξ
[m]	[mm]	[T/m]	[T]	[mm]	[T/m]	[T]	
0.10	21	13	0.26	23	15	0.3	1100

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

100 GeV e^-

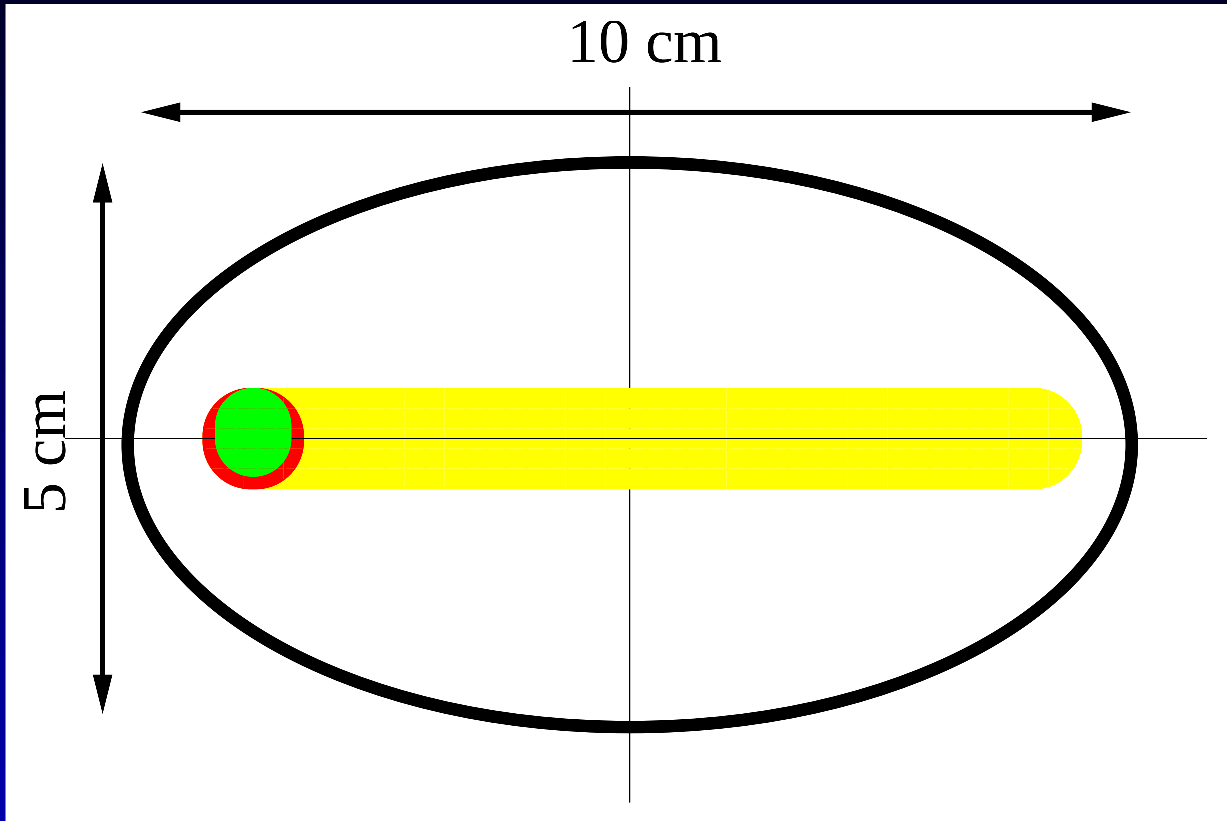
- Need lower B field to keep low critical photon energy
- Need longer dipole and therefore longer L*
- L*=28 m, B=0.075 T
- Minimum β^* with present magnet technology $\approx$ 0.2m
- Critical photon energy = 0.5 MeV
- Instantaneous Power= 4.2 kW

SR and beam-pipe for 100GeV e^-



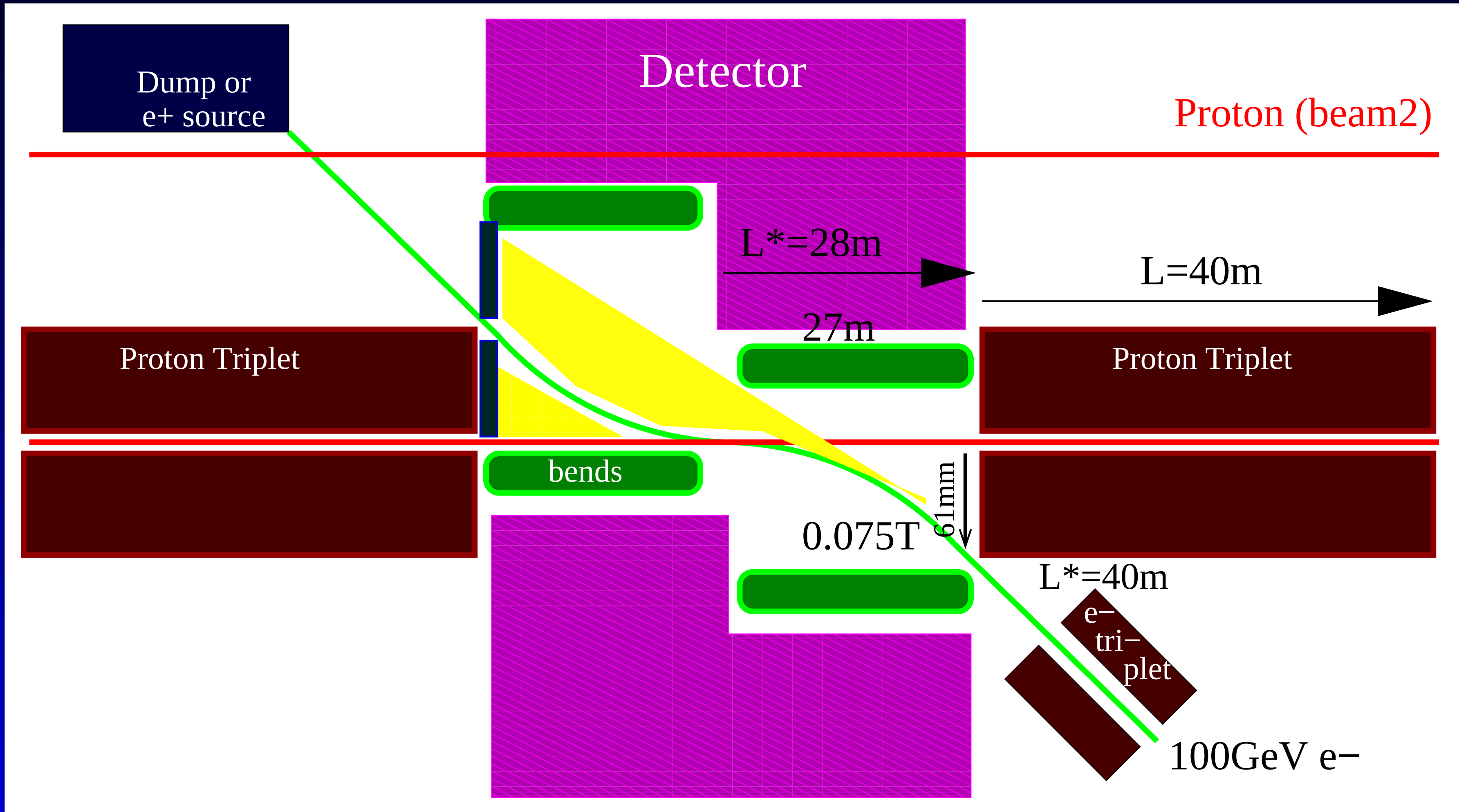
Solenoid field not considered. Acceptance $\approx 1^\circ$.

IP beam-pipe for 100GeV e^-



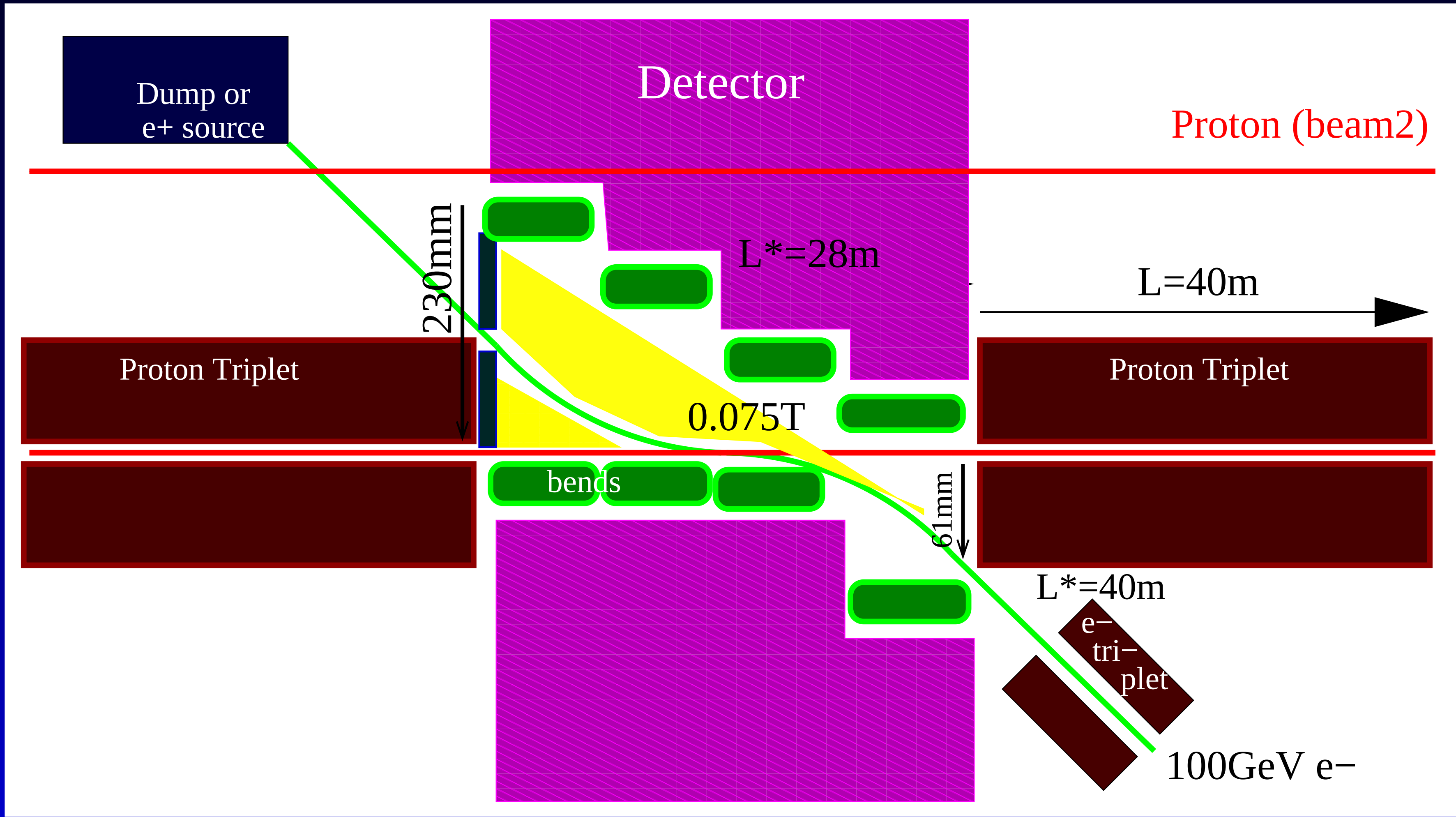
Horizontal dimension is defined by SR. Vertical dimension is a guess by P. Kostka. Precise calculation needs to include solenoid, radiation from e- triplet, etc.

IR sketch for 100GeV e^-

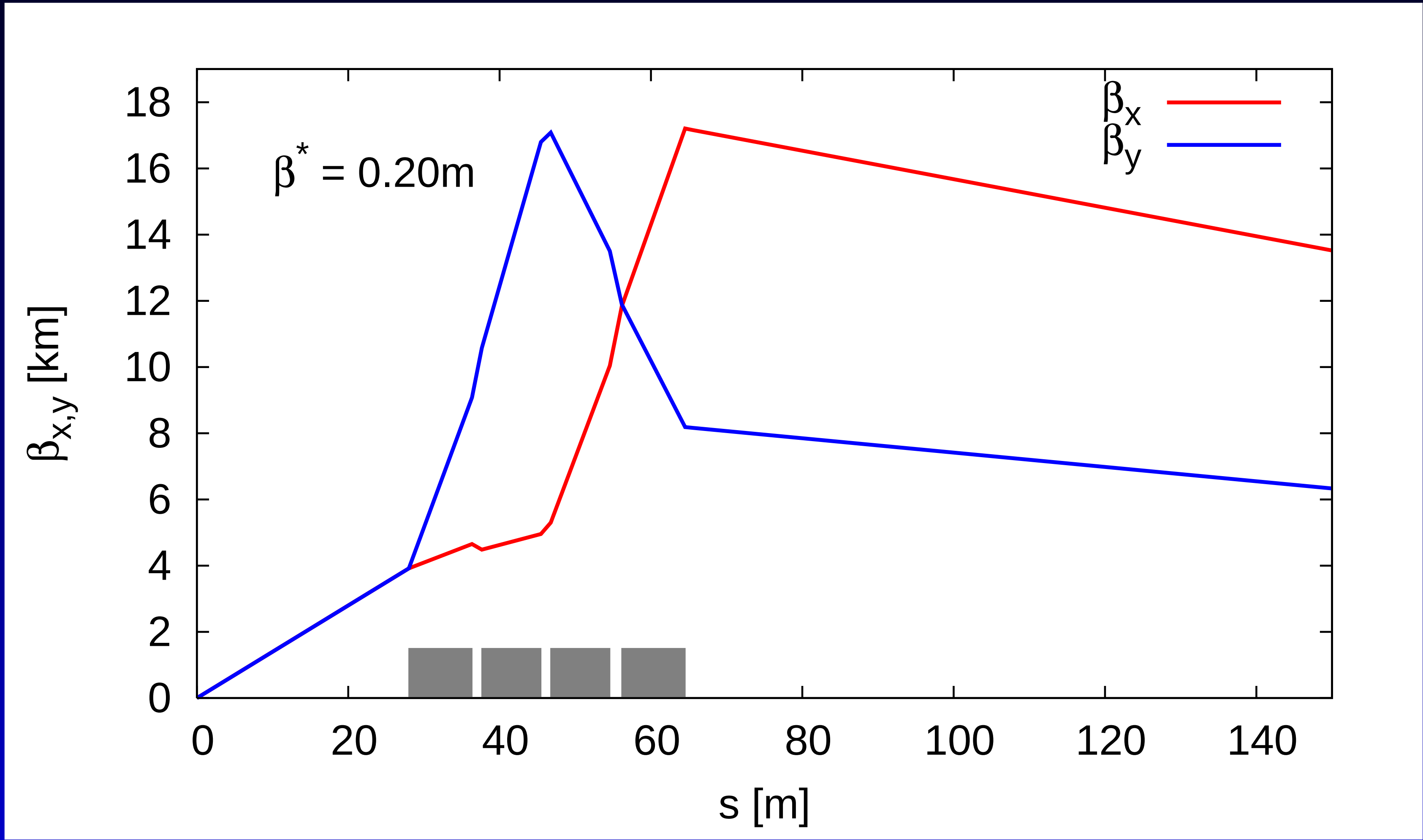


Bends are very weak! They are small, further splitting is possible...

IR sketch for 100GeV e^-



Proton optics L*=28m, 100GeV e⁻



Proton triplet for 100GeV e^-

	Q_1			Q_2			
β^*	Aper	Grad	B_p	Aper	Grad	B_p	ξ
[m]	[mm]	[T/m]	[T]	[mm]	[T/m]	[T]	
0.20	33	131.4	4.4	42	125.0	5.3	990

Aperture = 11σ + 10mm

OK for normal SC technology.

Summary & Outlook

- Head-on collisions seem possible for 20-100GeV e^- and β^* within 0.10-0.20m with current SC magnet technology.
- Higher e^- energies could be aided by proton crab cavities. (how critical is critical energy?)
- Proton triplet quadrupoles need design with beams separation 60-70mm.
- Electron triplet should not be an obstacle.
- Precise radiation calculations need to be done including solenoid field too.
- Chromaticity correction (maybe “a la Fartoukh”) needs to be studied.