Luminosity Considerations for the LHC (II)

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Introduction

- **Average Luminosity and Luminous region**
- **Hourglass not needed**
- **Calculations for the LHC**
- **Some results**
- **Conclusions**

Average Luminosity and Luminous Region

- **Simplest case** $\rightarrow \mathcal{L} = \dfrac{N_1 N_2 f B}{4\pi\sigma_x\sigma_y}$

- **Luminous region** $(\pm s) \rightarrow \mathcal{L}(s) = \displaystyle\int_{-s}^{+s} \mathcal{L}(s')ds'$

- **Integrated luminous region** $(\pm s) \rightarrow$

$$\mathcal{L}_{\rm av}(s) = \frac{1}{T}\int_0^T \int_{-s}^{+s} \mathcal{L}(s',t)ds'dt$$

- **Crossing angle**

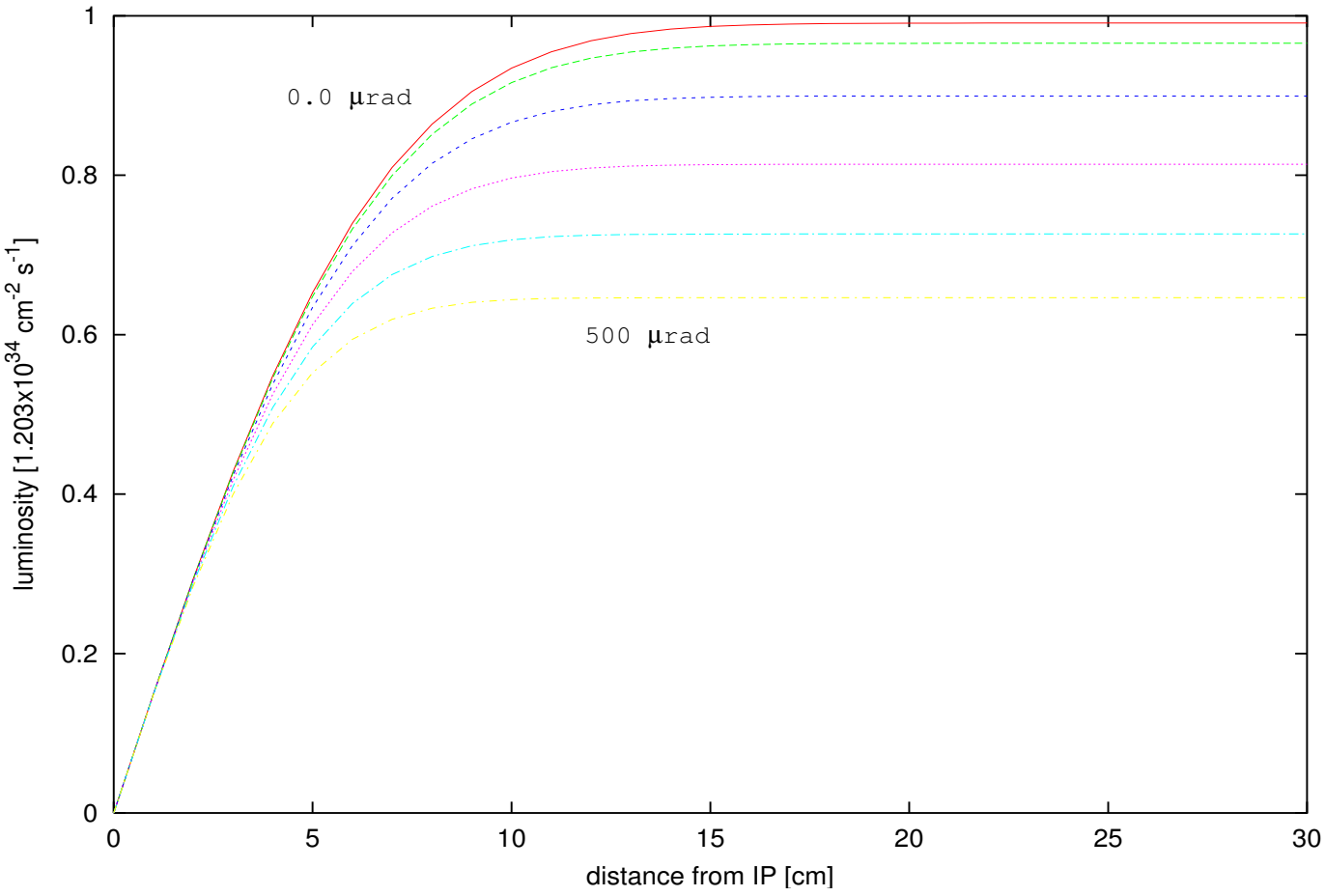

Figure 1: l. region for b.l. 7.5 cm, $\beta^* = 50$ cm and different $\times \angle$

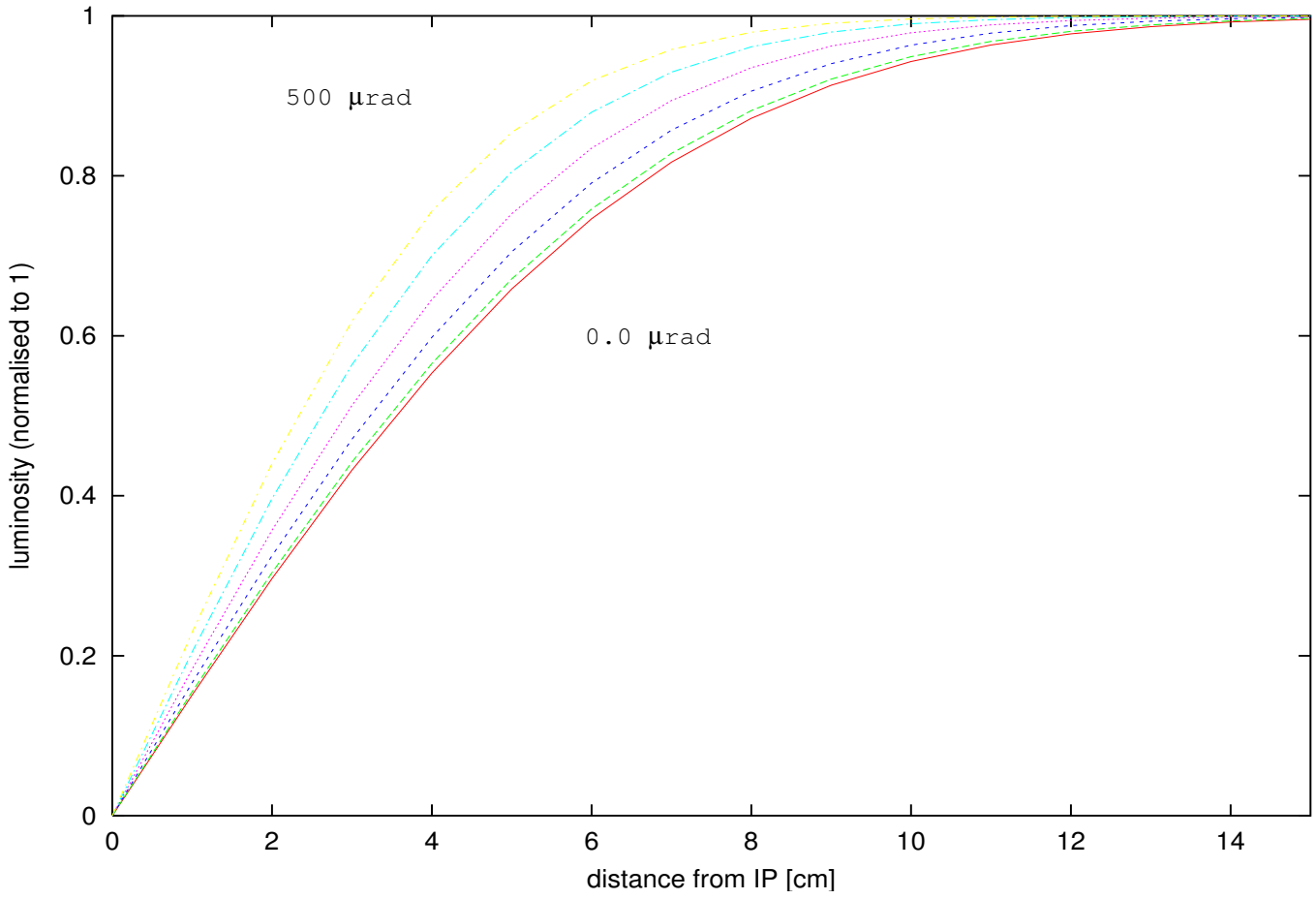

Figure 2: l. region for b.l. 7.5 cm, $\beta^* = 50$ cm and different $\times \angle$

Hourglass not needed

- $\sigma_z = \sigma_z^* \sqrt{1 + \left(\frac{s}{\beta^*}\right)^2}$
- $\rightarrow$ **Numerical integration required**
- **Not needed for LHC parameters**
- $N_1 = N_2 = 1.1 \times 10^{11}$ **particles/bunch**
- 2808 **bunches/beam**
- $f = 11.2455$ kHz, $\phi = 300$ μrad **(total** $\times$ $\angle$**)**
- $\beta_x^* = \beta_y^* = 0.5$ m
- $\sigma_x^* = \sigma_y^* = 15.9$ μm, $\sigma_s = 7.7$ cm

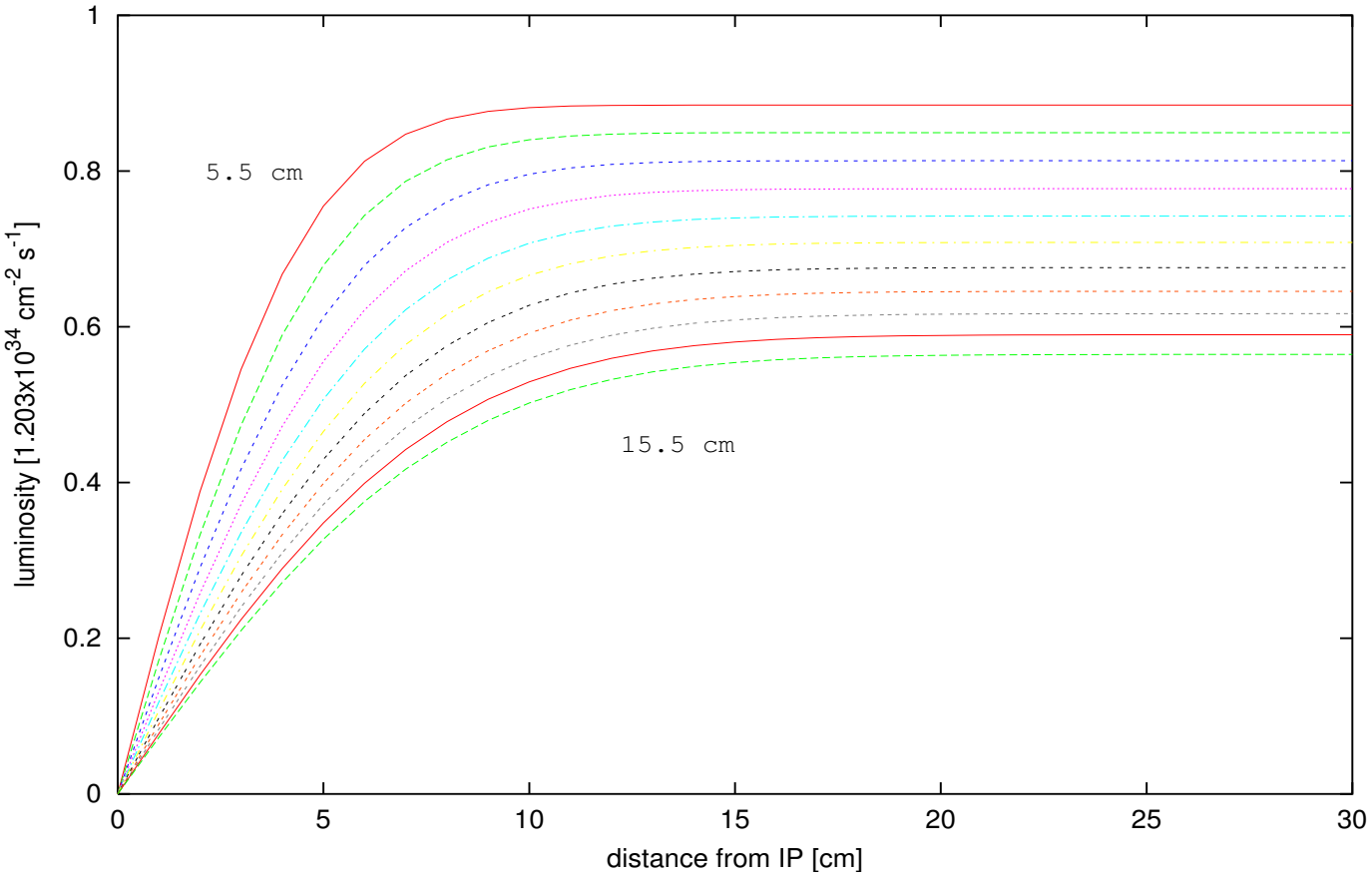

Figure 3: Luminous region for $\phi = 300$ μrad, $\beta^* = 50$ cm

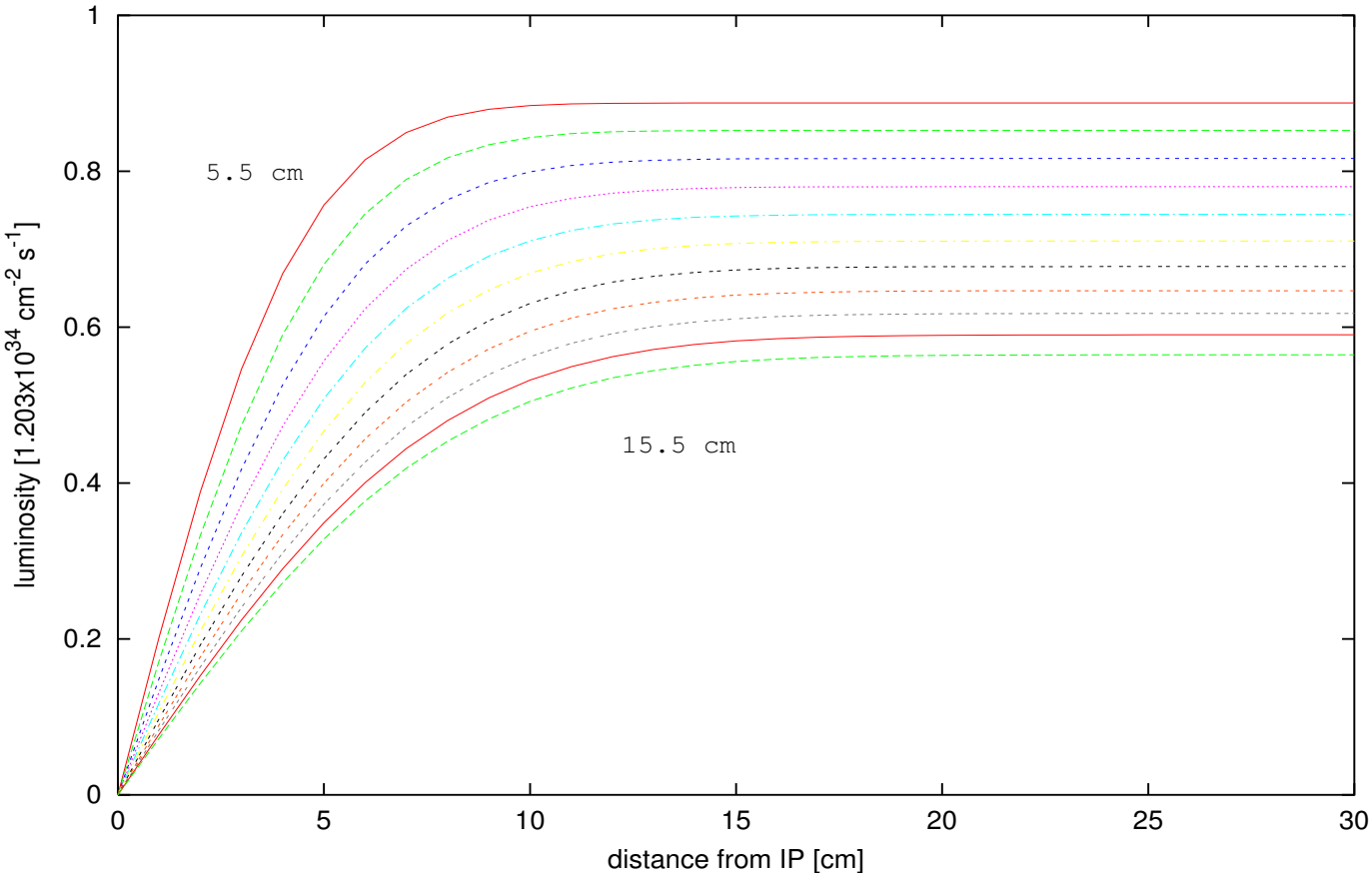

Figure 4: Luminous region for $\phi = 300$ μrad, $\beta^* = 50$ cm no h.g.

Calculations for the LHC

- **Bunch length increases by** 30 **%** **in** 10 **hours** **(P. Baudrenghien)**
- **Assume this is linear**
- **Intensity falls off as** $N = N_0 \exp\left(-\frac{t}{10}\right)$ **(O. Brüning)**
- $\rightarrow N \propto \frac{1}{e}$ **after** 10 **hours**

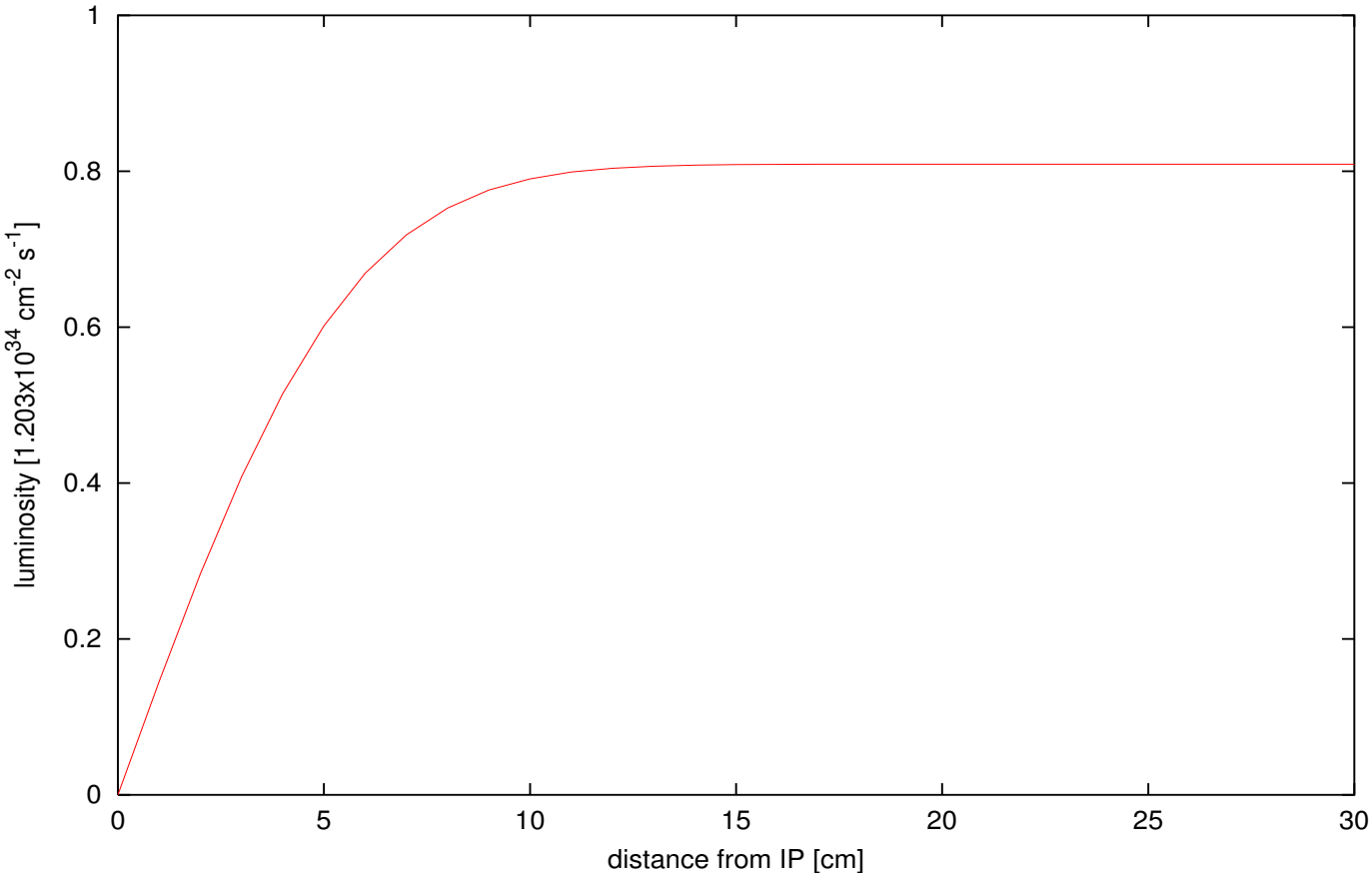

Figure 5: L. region for $\phi = 300$ μrad, $\beta^* = 50$ cm, bunch l. 7.7 cm

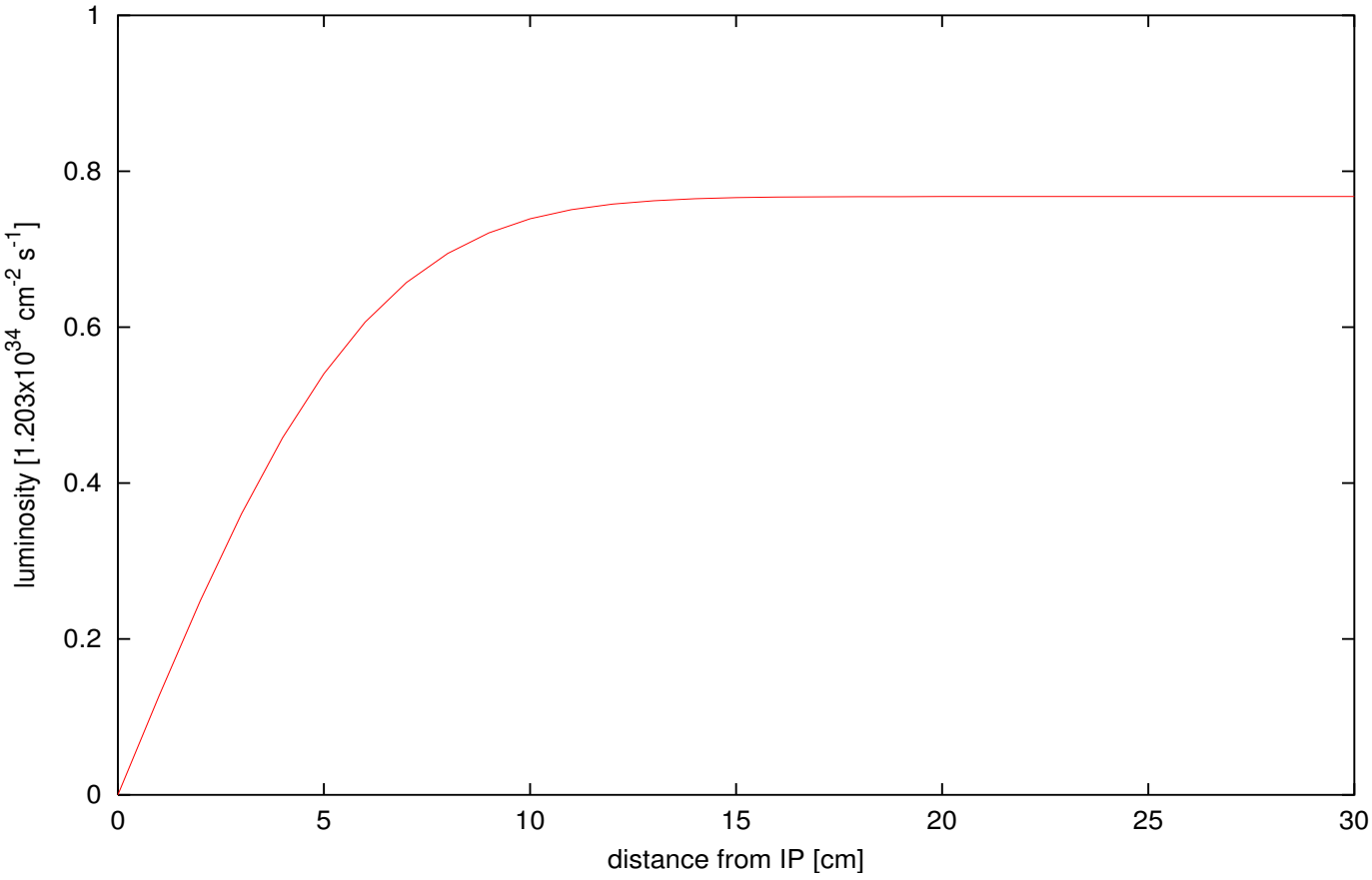

Figure 6: Same after 10 hour coast with bunch length increase only

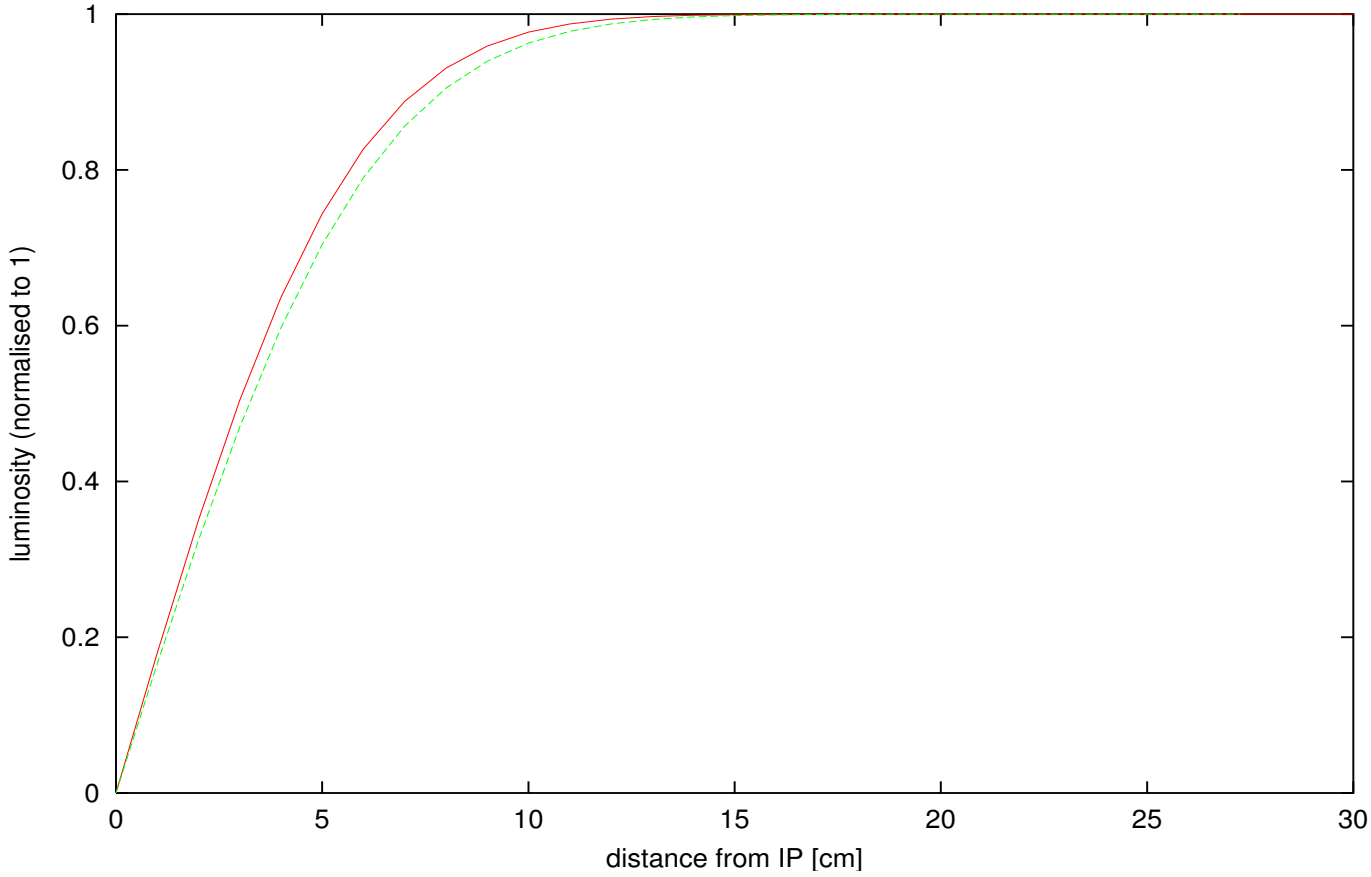

Figure 7: Same normalised w.r.t. nominal case

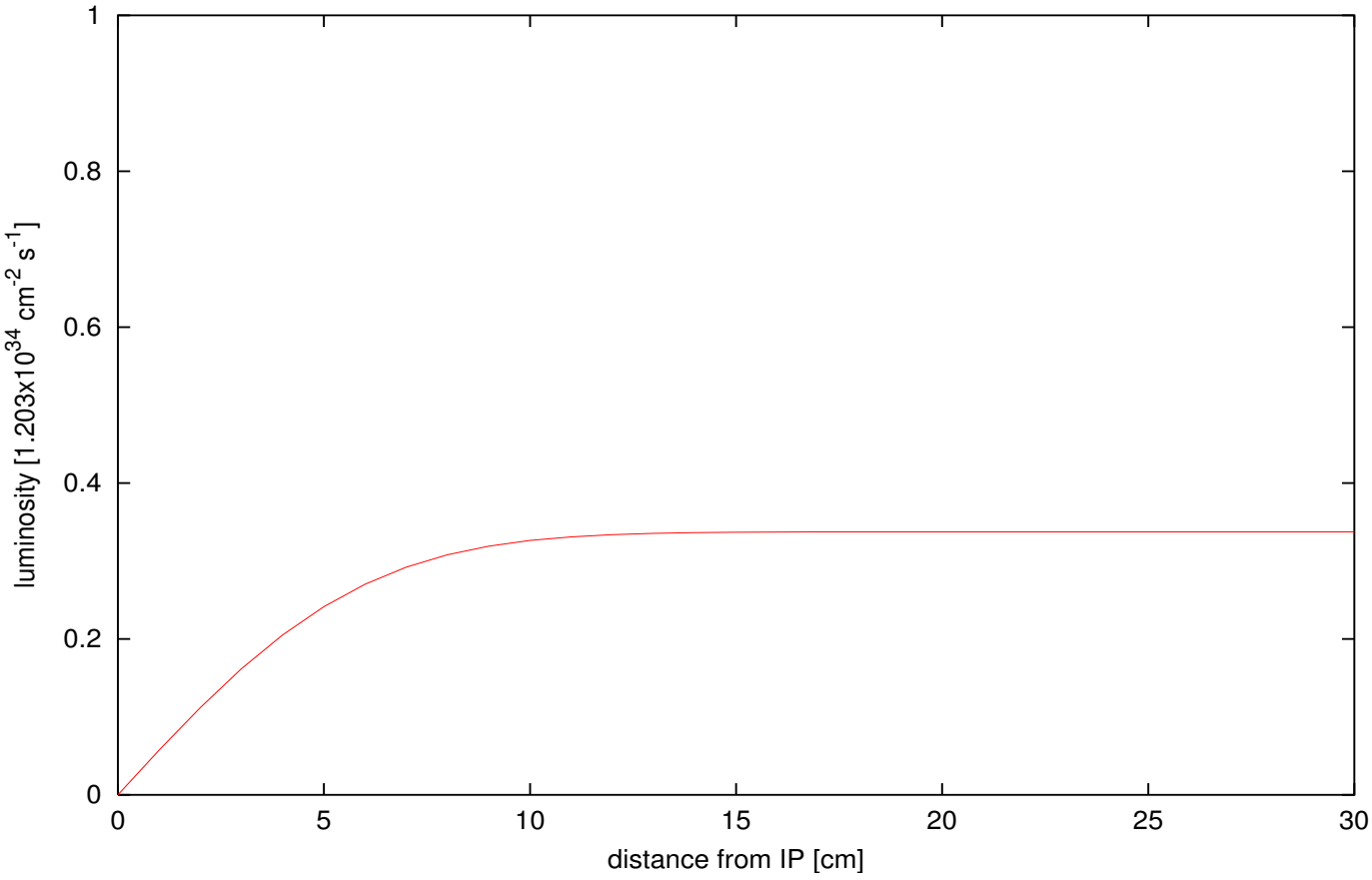

Figure 8: Same after 10 hour coast with both changes

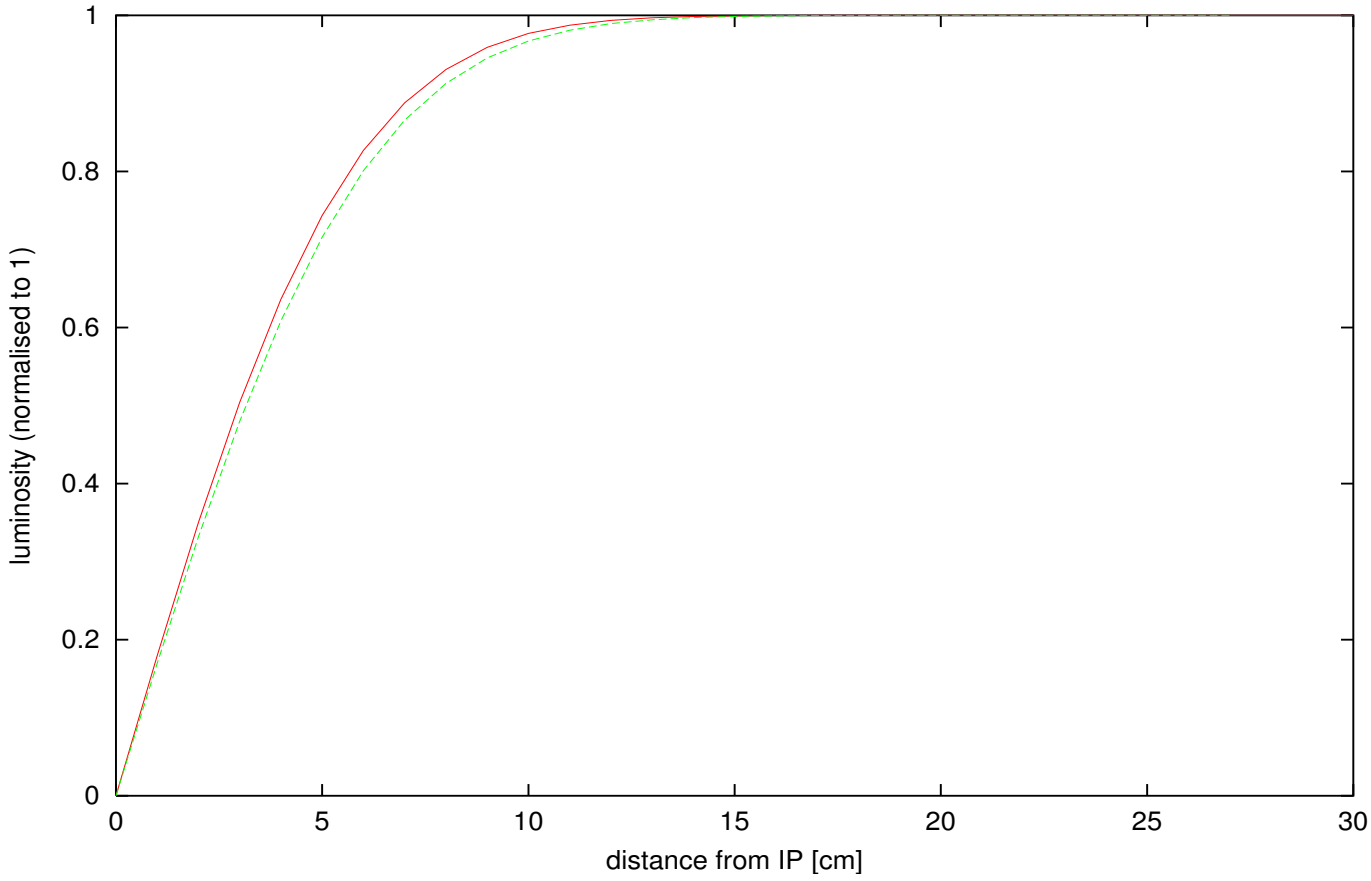

Figure 9: Same normalised w.r.t. nominal case

Some results

- $\sigma_s = 7.5$ cm, $\beta^* = 50$ cm, $\phi = 300$ μrad**:**
- 100% **lumi** $\rightarrow$ $s = \pm$ 12 cm $\longrightarrow$ $s = \pm$ 12 cm
- 95% **lumi** $\rightarrow$ $s = \pm$ 8 cm $\longrightarrow$ $s = \pm$ 9 cm
- 90% **lumi** $\rightarrow$ $s = \pm$ 7 cm $\longrightarrow$ $s = \pm$ 8 cm
- 85% **lumi** $\rightarrow$ $s = \pm$ 6 cm $\longrightarrow$ $s = \pm$ 6.5 cm
- 80% **lumi** $\rightarrow$ $s = \pm$ 5.5 cm $\longrightarrow$ $s = \pm$ 6 cm

Conclusions

- **Detailed results will be available**

  /afs/cern.ch/user/b/bmurator/public/lumi/

- **Hourglass not important for $\mathcal{L}$ with current settings $\rightarrow$ ignored**

- **May become important for longer bunch length and/or lower β^***

- **Luminosity changes dramatically**

- **Luminous region largely unchanged**