Can PD/8 GeV Linac Help Tevatron ?

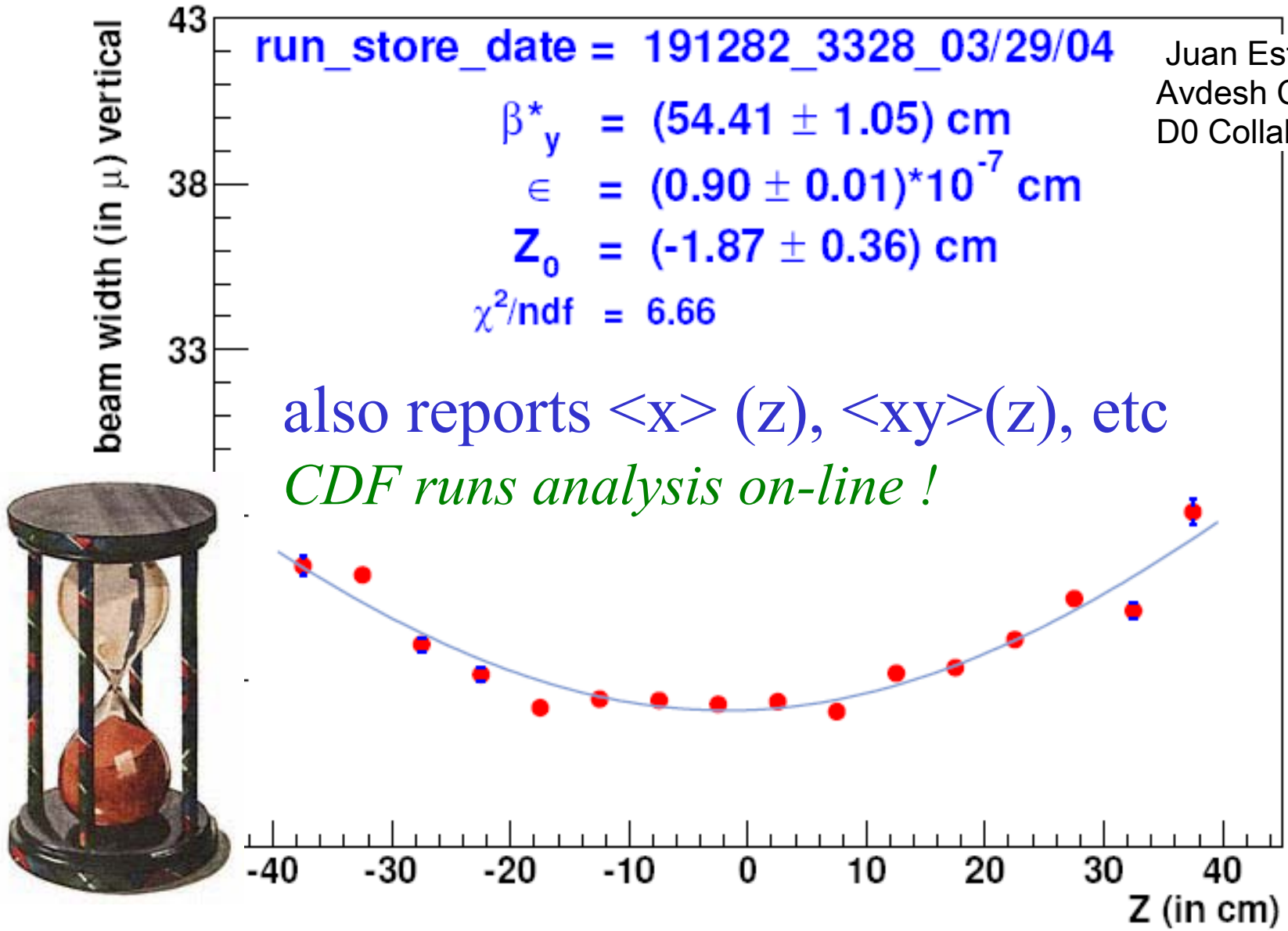
Vladimir Shiltsev
AD/Tevatron

Luminosity and Integral

$$L = \frac{3\gamma \ f_0 \ (B\, N_{\bar{p}}) N_p}{\pi\beta^* \left(\varepsilon_p + \varepsilon_{\bar{p}}\right)} H\left(\sigma_l / \beta^*\right)$$

- Peak Luminosity: primary factors
  - Beta* at IP - no relation to PD
  - Total Antiprotons: BN_a - may be x2, see P.Derwent
  - Bunchlength: H(s/beta)
  - Emittances
  - Number of protons per bunch N_p

Luminous Region Analysis

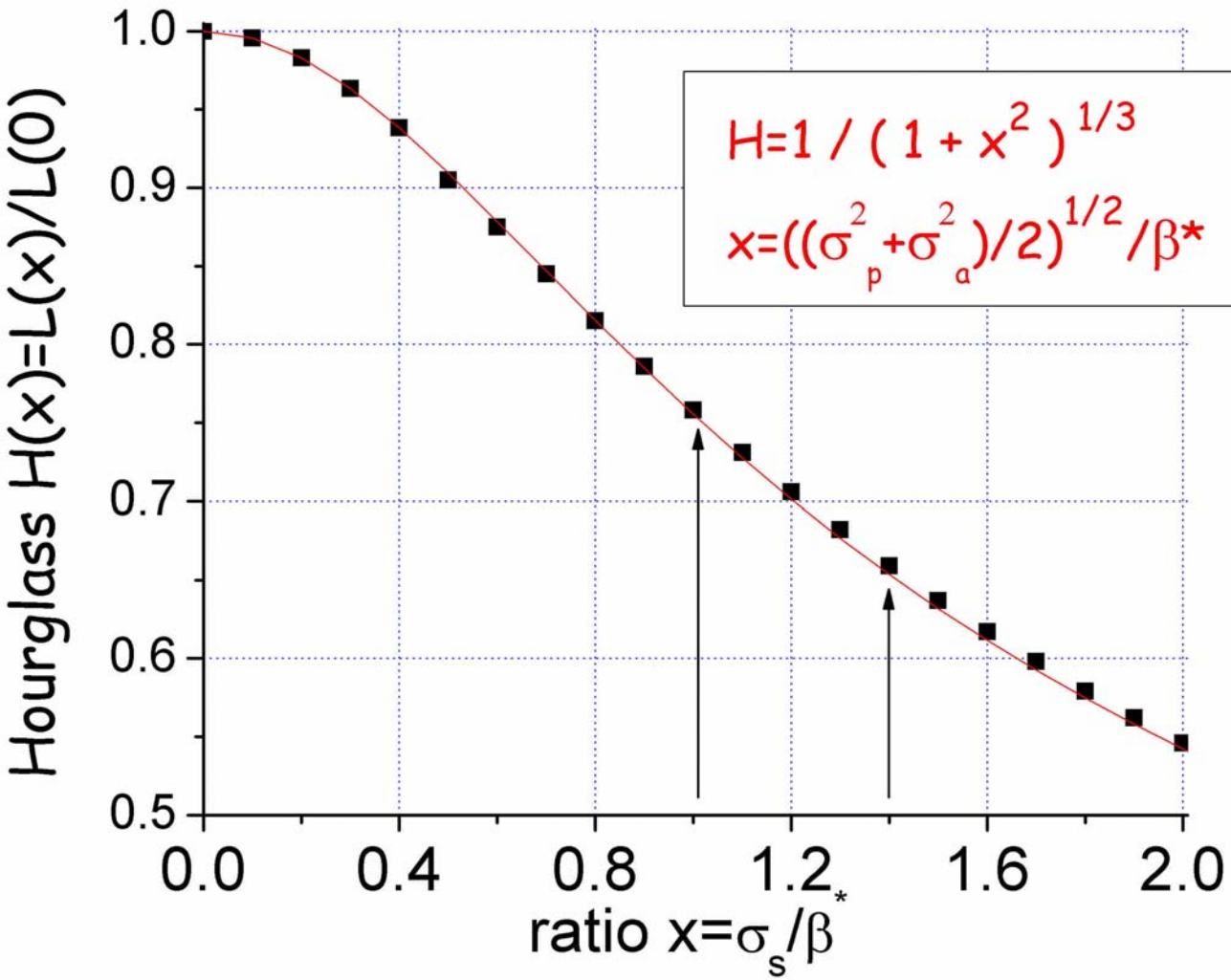


Juan Estrada,
Avdesh Chandra
D0 Collaboration

also reports <x> (z), <xy>(z), etc

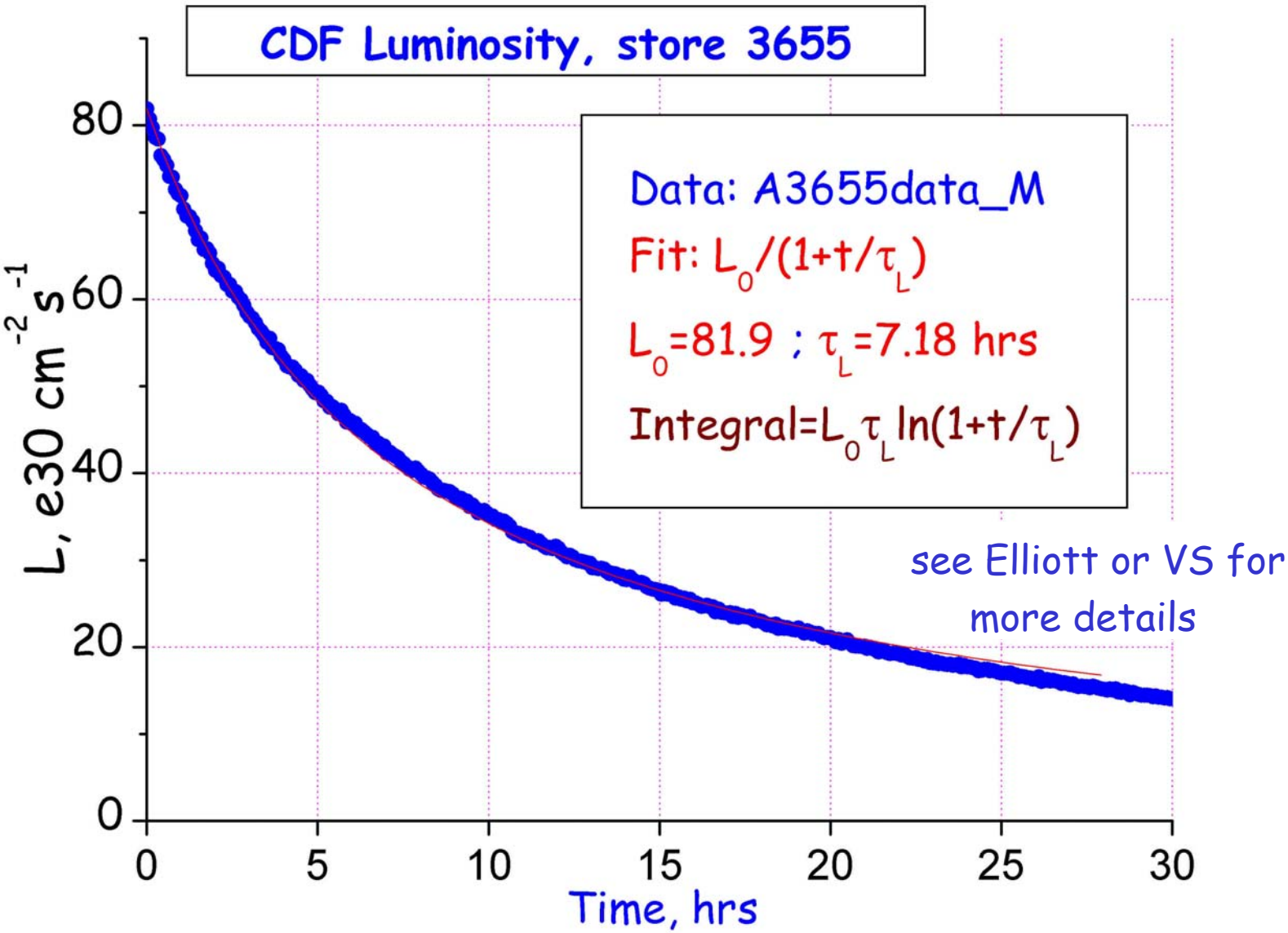
CDF runs analysis on-line !

"Hour Glass " Reduction



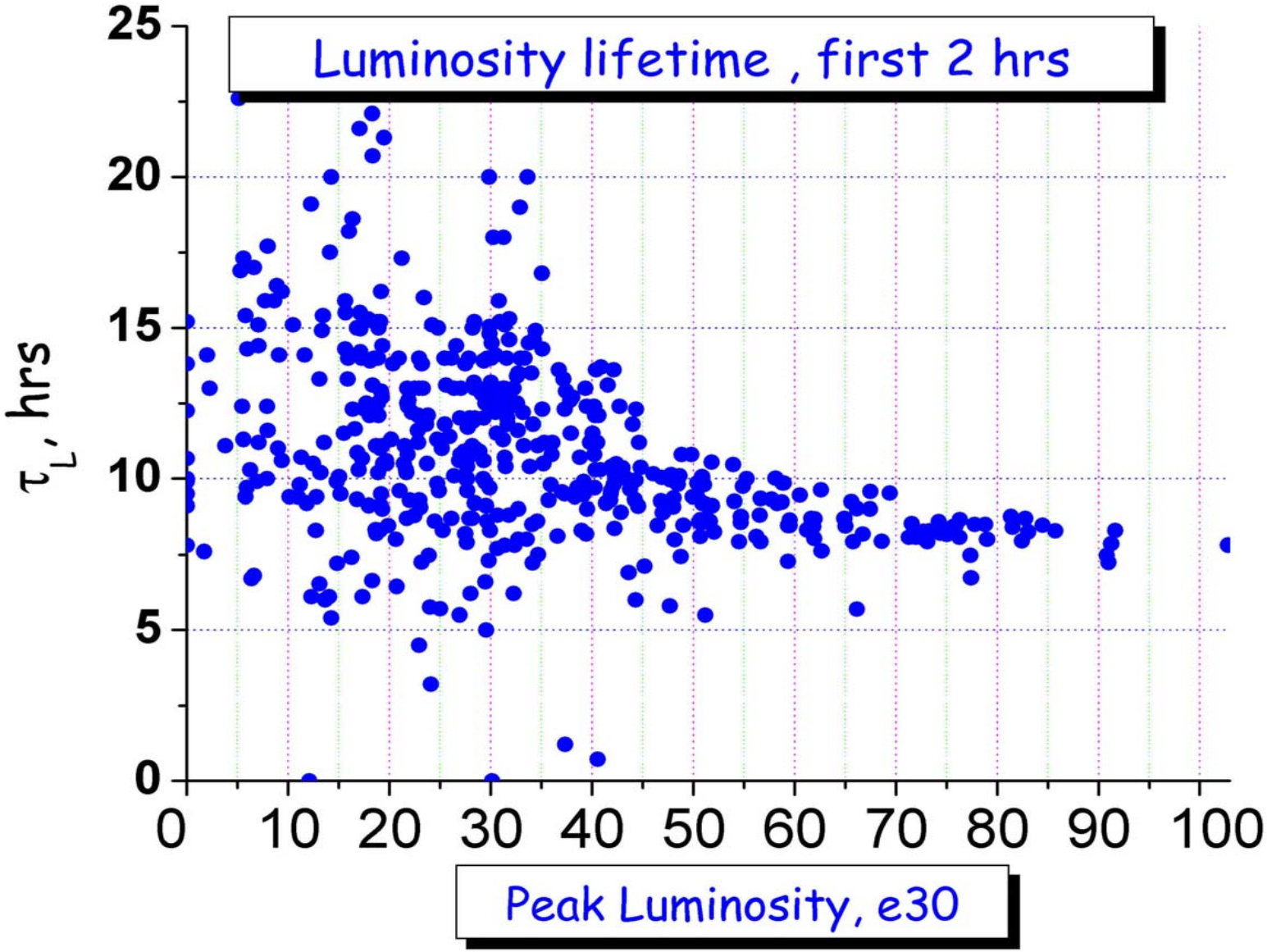
Even many-fold reduction of proton long emittance say 2eVs→0.2eVs will result +13% at most

Integral: Log in time, $\propto L_0$ and Lifetime



see Elliott or VS for more details

Luminosity Lifetime is a Big Issue



Luminosity Integral

$$I = \int L dt = N_{stores} \tau_L L_0 \ln(1 + T/\tau_L)$$

- Luminosity lifetime

$$\tau_L^{-1} = \tau_\varepsilon^{-1} + \tau_a^{-1} + \tau_p^{-1} + \tau_H^{-1}$$

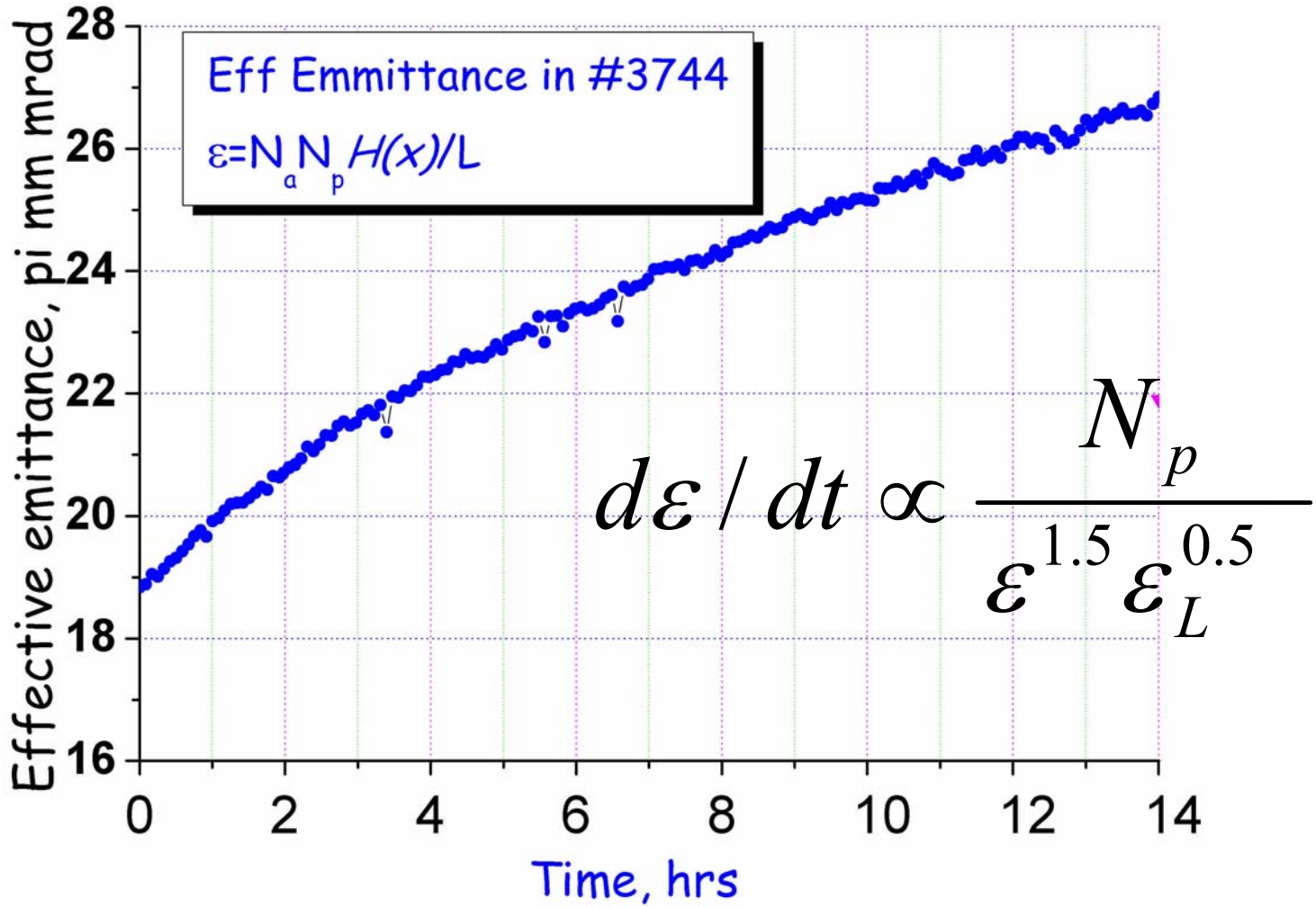
(15-20) + (20-25) +(35-210)+(70-80) =(7.5-9.0)hrs

- Emittance growth = 90% IBS + 10% Beam-Beam Effects
- Pbar lifetime = (70-80)% burnup + (20-30)% Beam-Beam
- Proton lifetime = 80% Beam-Beam + 20 % burnup
- Hourglass lifetime = 90% IBS + 10 % Beam-Beam

IBS constitutes 50% of luminosity lifetime

Beam-Beam Interaction reduces luminosity lifetime by 15-20%

Intrabeam Scattering (Internal Heating)



Beam-Beam Tune Shifts

$$\xi = \frac{N_p r_p}{4\pi\varepsilon_p}$$

head-on tune shift per IP, now with N_p=250e9 and 95% emittance 18p

total max head-on tuneshift is 0.021 for pbars, 0.004 for protons

tune shift for separated beams is smaller:

$$\Delta\nu = \sum_i \frac{\beta_i N_p r_p}{2\gamma\pi d_i^2} = \sum_i \frac{2\xi}{(d_i/\sigma_i)^2}$$

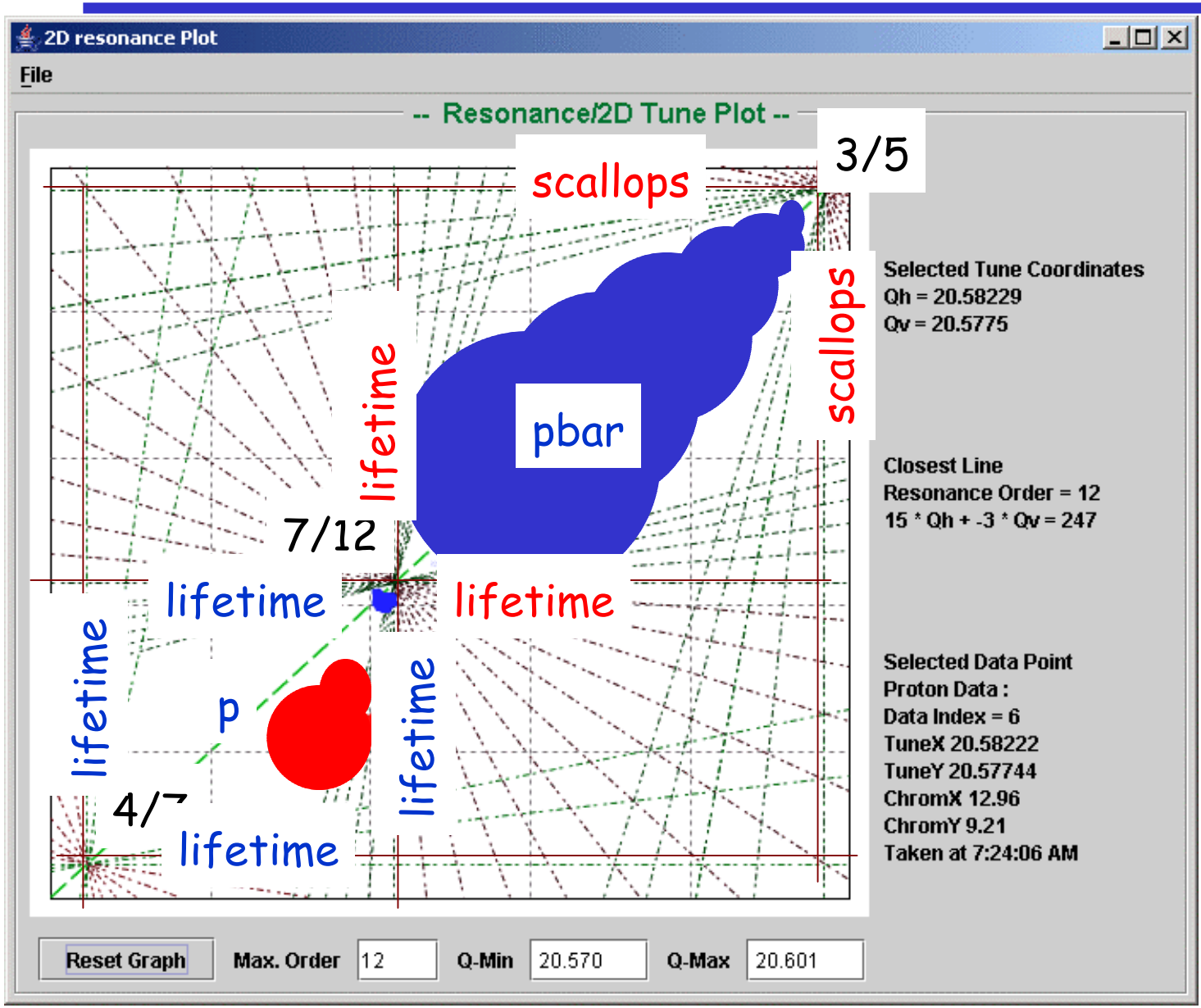
but: a) always present

b) MANY near-misses i = 70

c) different bunch-by-bunch

d) HV separator limited: gd^2 scales as V^2 / g

Betatron Tunes (Working Points)



- Balancing btw major resonances

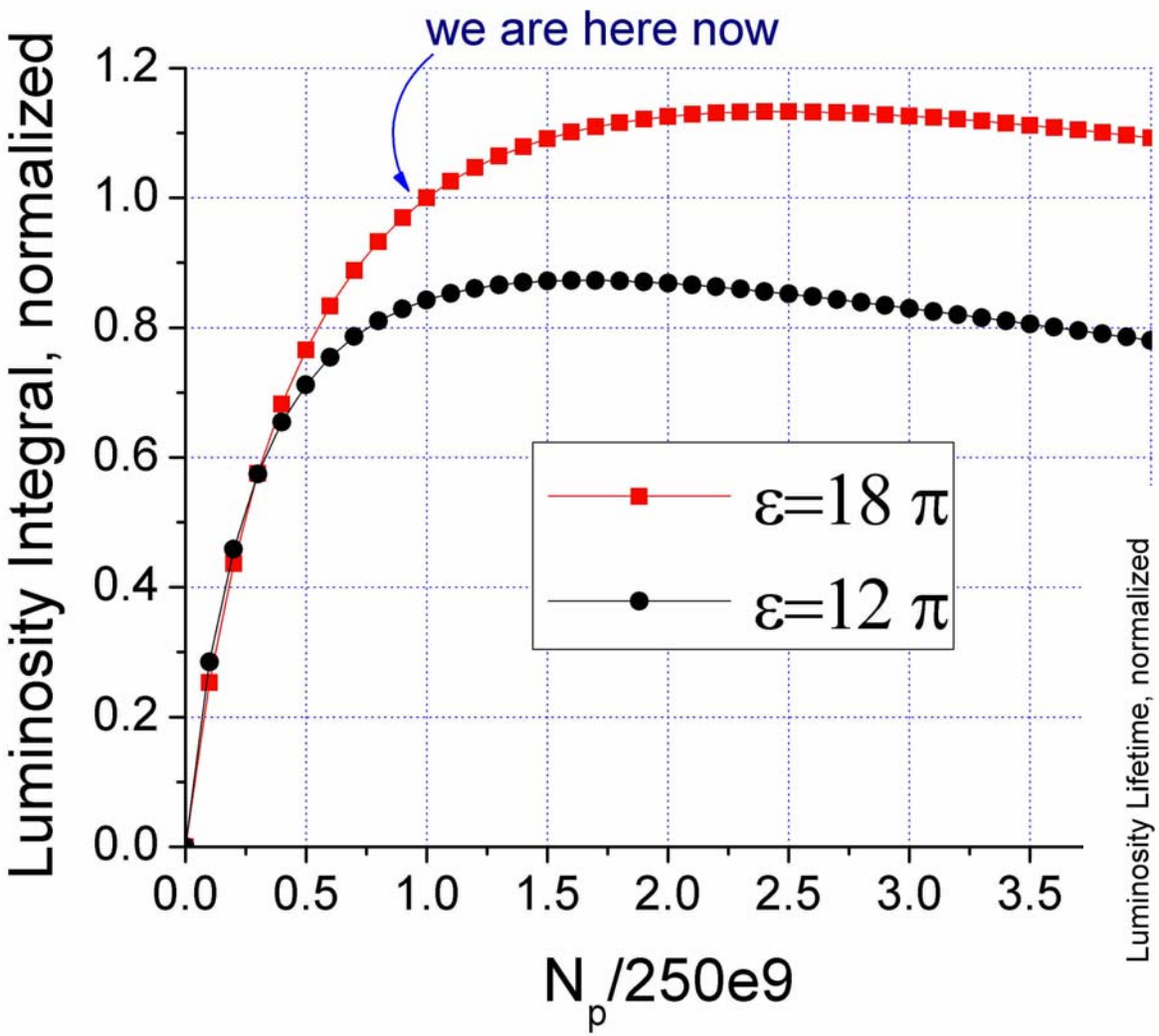
Total Beam-Beam Tune Shifts

Tevatron	980 GeV	0.025
RHIC	106 GeV	0.015
LHC	7000 GeV	0.010
HERA-p	920 GeV	0.0014
ISR	31 GeV	0.008
SppS	315 GeV	0.028

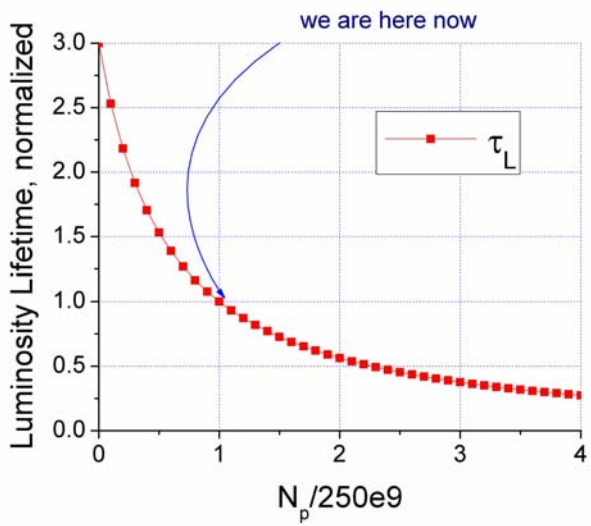
Can We Gain From Np and Emittance?

- IBS "likes" larger emittance lower intensity
- Head-On Beam-beam likes larger emittance and smaller intensity, also prefers same emittance of p and pbar bunches (pbar = 12 pi)
- Parasitic Beam-beam likes lower intensity
- Peak Luminosity likes higher intensity and lower emmittance
  - ➢ Where is the optimum?

Store Length Optimization Factor *F*

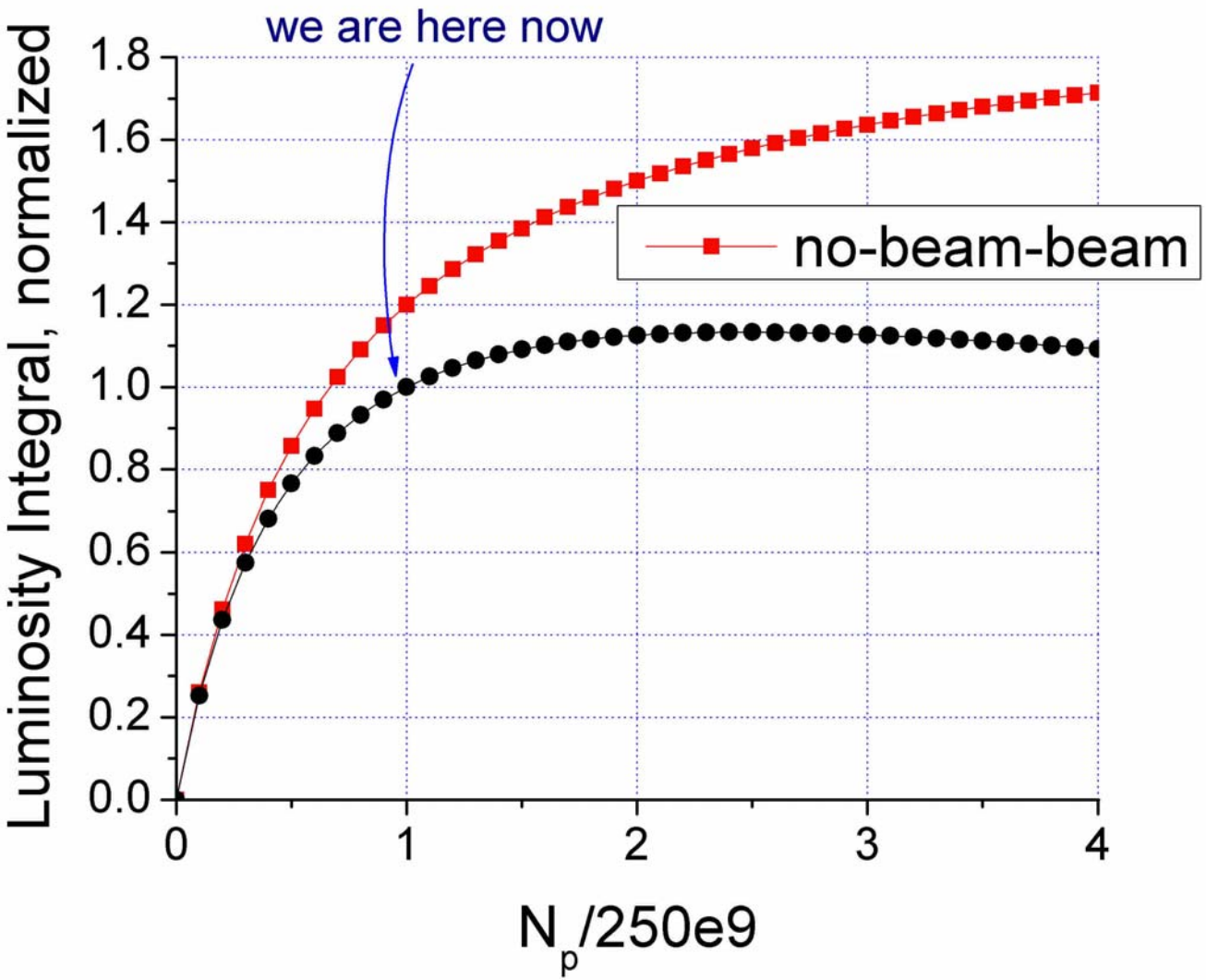


- One can gain 17% at the expense of terrible lifetime (halo rates)



…final gain doubtful

Beam-Beam Compensation



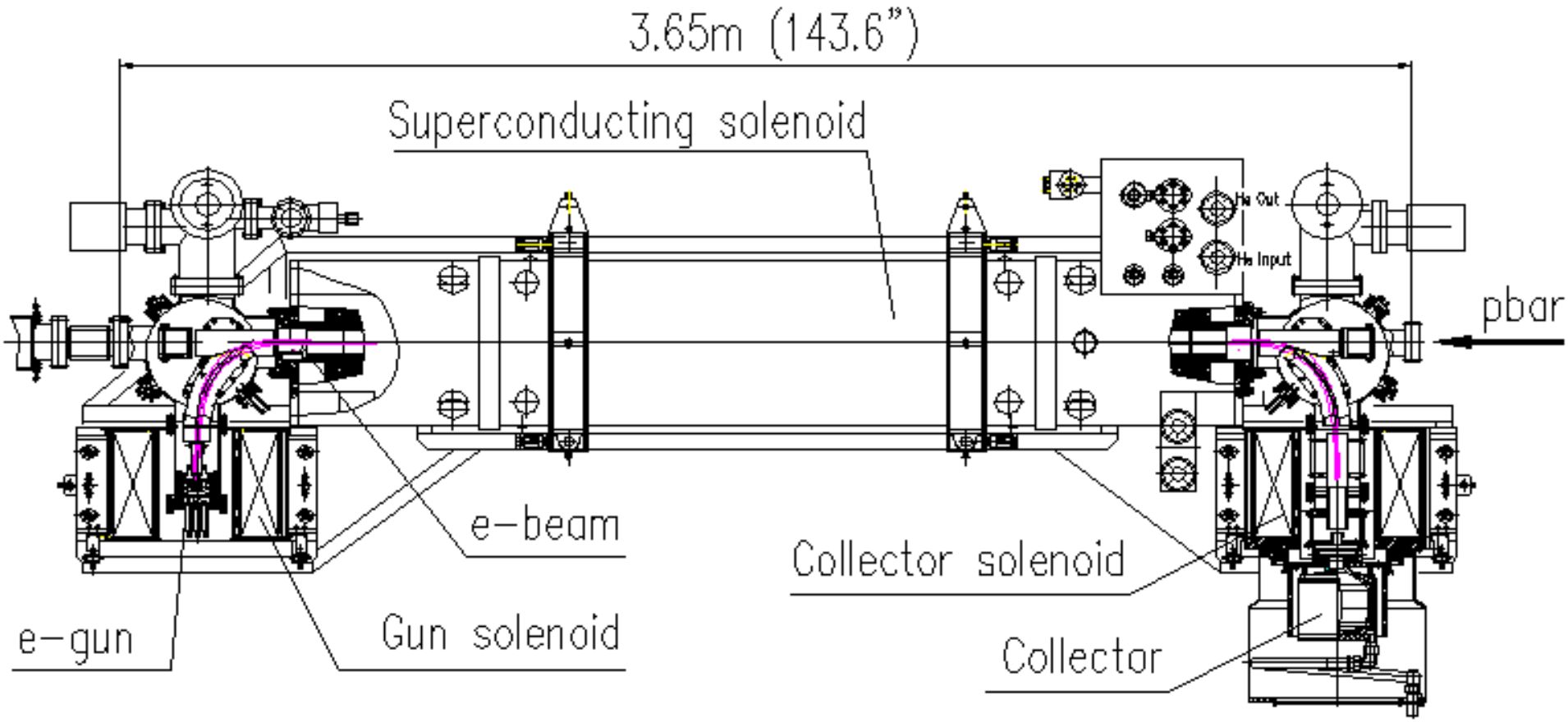
- 20-50% gain possible
- BBC is still in an R&D phase

Now , Let's Count Everything:

- More pbars — x2 (if)
- More p's w/o BBC — 17% - ?
- More P's with BBCompensation — 20-50%

Total — x3 – "if" [2]

BBC with Tev Electron Lens



+ HV Modulator, HV+HC PSs, Cryo, QPs, Vacuum, Controls, Diagnostics, Cables

Total $N_a N_p$ Inefficiency in Tevatron