

Large Piwinski Angle MD

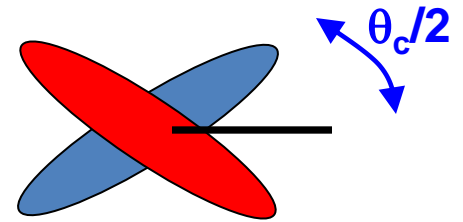
J. Abelleira, R. Assmann, P. Baudrenghien,
C. Bhat, T. Bohl, O. Brüning, R. Calaga,
R. De Maria, O. Dominguez, S. Fartoukh,
M. Giovannozzi, W. Herr, J.-P. Koutchouk,
M. Meddahi, E. Metral, K. Ohmi, G. Papotti,
T. Pieloni, S. Redaelli, L. Rossi,
E. Shaposhnikova, R. Tomas, F. Zimmermann, +...

LCU meeting, 24 January 2012

Piwinski angle

$$R_\phi = \frac{1}{\sqrt{1 + \phi^2}}; \quad \phi \equiv \frac{\theta_c \sigma_z}{2\sigma_x} \quad \text{“Piwinski angle”}$$

“luminosity reduction factor”
due to crossing angle

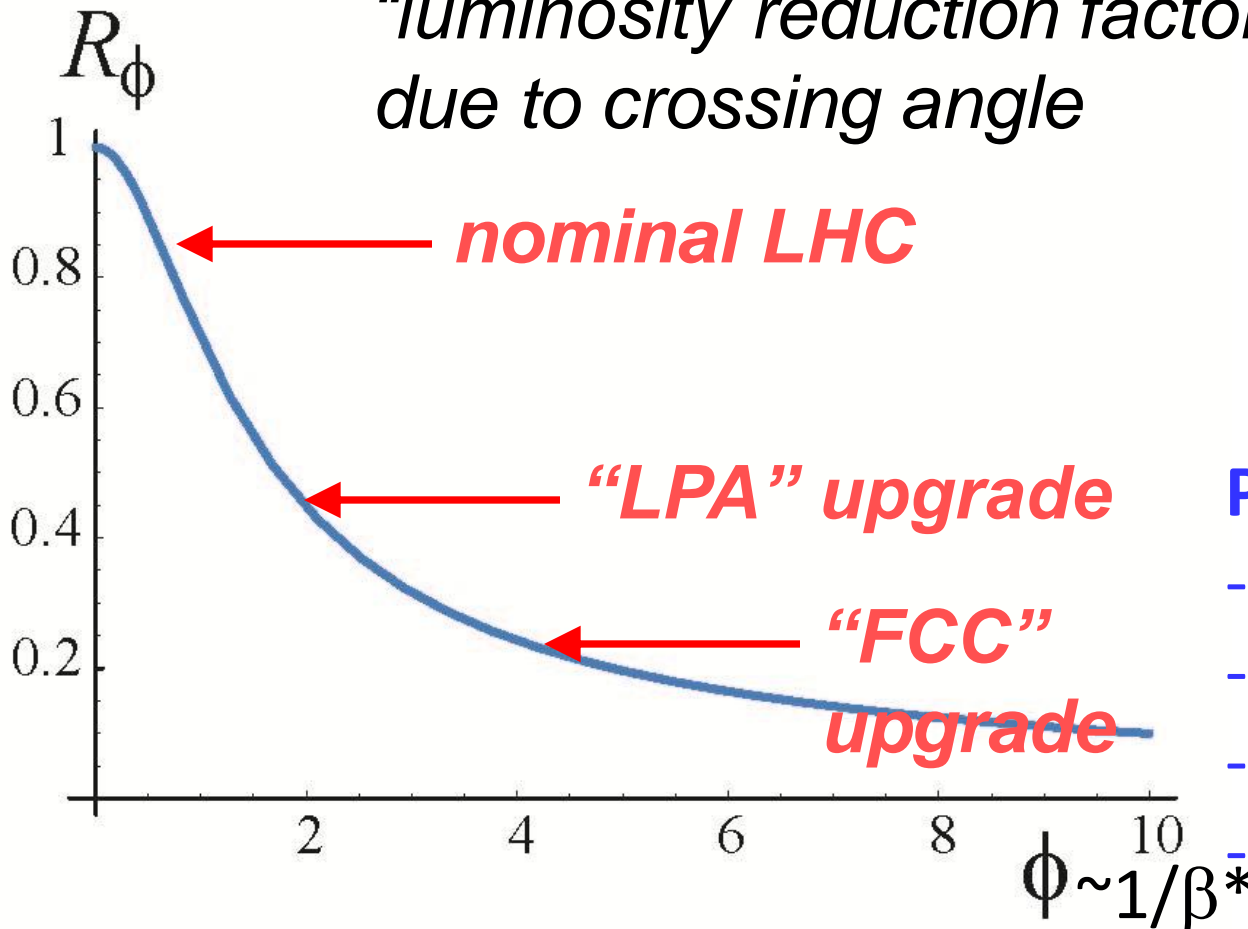


effective beam size:

$$\sigma_{x,\text{eff}}^* \approx \sigma_x^* / R_\phi$$

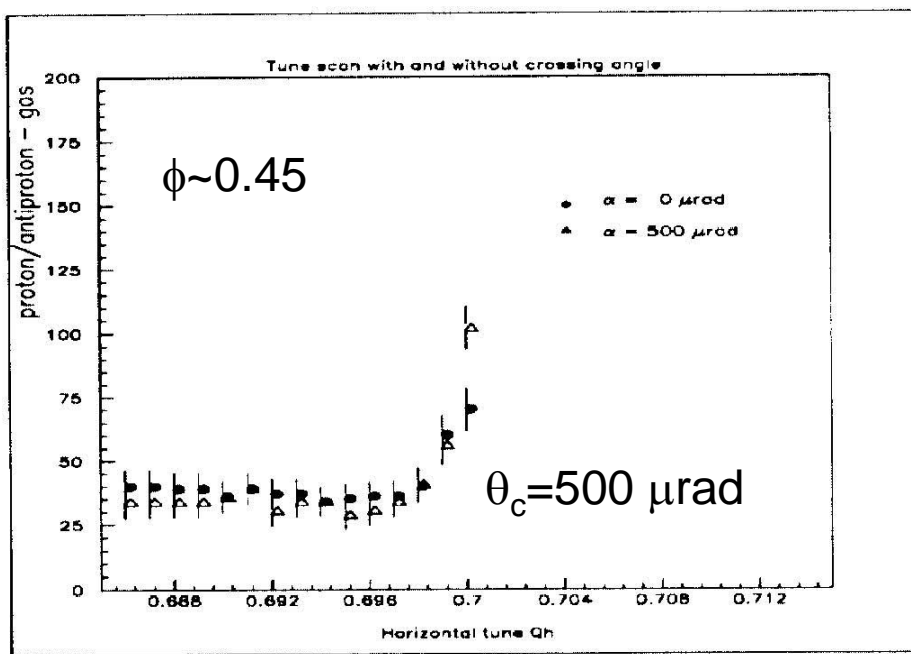
Piwinski angle:

- geometric overlap
- tune shift
- syn.beta resonances
- symmetry breaking



motivation

- for e+e- colliders crossing angle could lead to large reduction in beam-beam limit & luminosity
(DORIS-I → *“Piwinski angle”* ϕ , KEKB → crab cavities)
- little is known about hadron collider beam-beam limit with crossing angle; RHIC & Tevatron: head-on collisions
- the only controlled experiment was done at SppbarS
- nominal LHC was pushed to $\phi \sim 0.64$
- ϕ will further increase for smaller-than-design emittance
- HL-LHC scenarios consider ϕ up to 2.5
- beam-beam limits experiments so far were done for head-on collisions or very small Piwinski angle

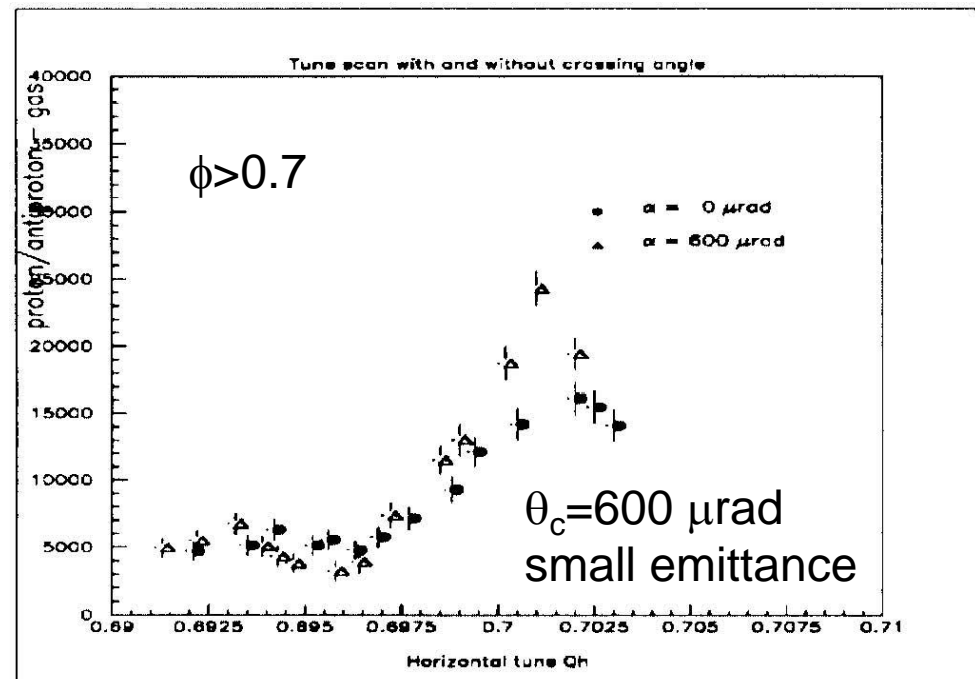


historical experiments at SPS collider

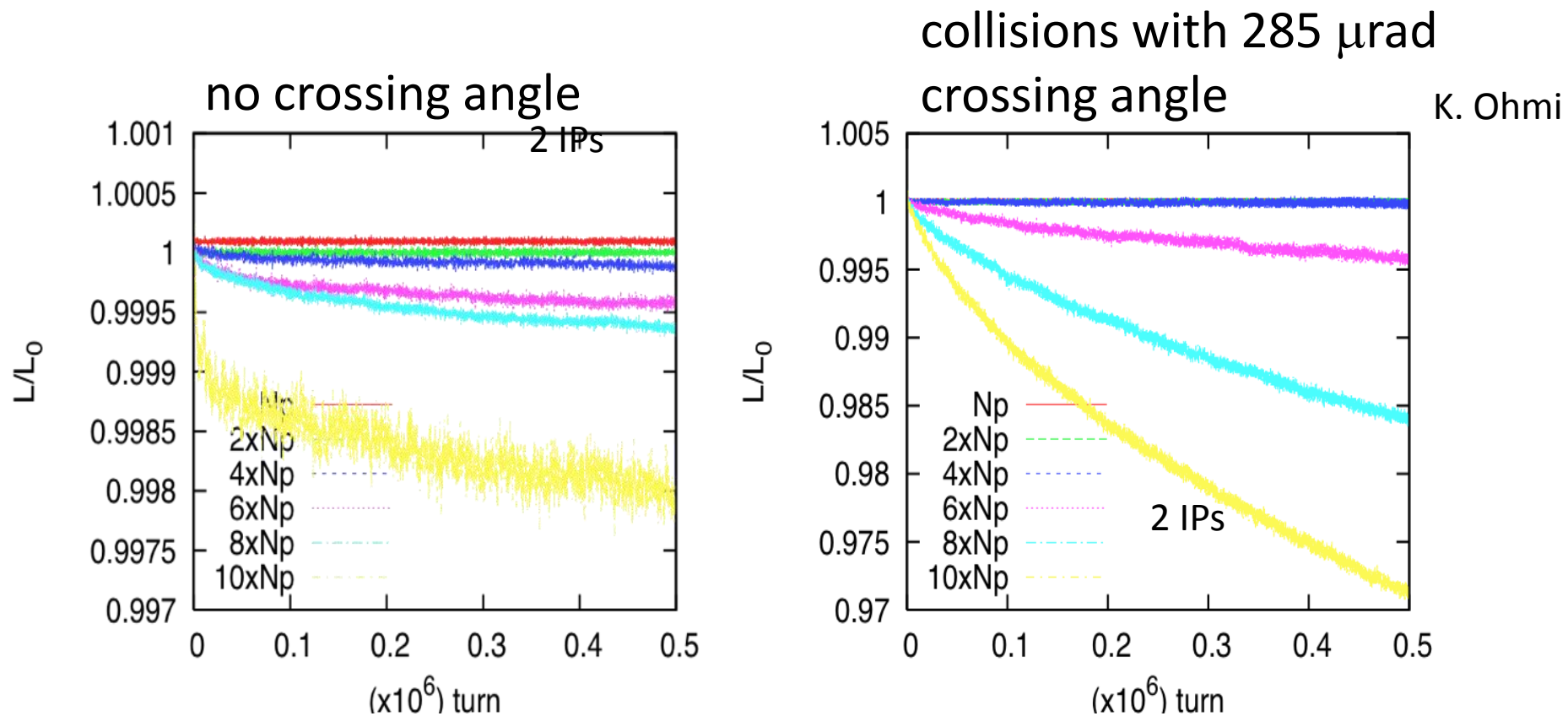
K. Cornelis, W. Herr, M. Meddahi,
“Proton Antiproton Collisions at a
Finite Crossing Angle in the SPS”,
PAC91 San Francisco

**SPS tests up to $\phi > 0.7$
showed some
additional
beam-beam effect**

**present nominal LHC:
 $\phi \sim 0.64$,
ATS upgrade:
 $\phi \sim 2.5!$**



simulations for nominal LHC with higher bunch charge

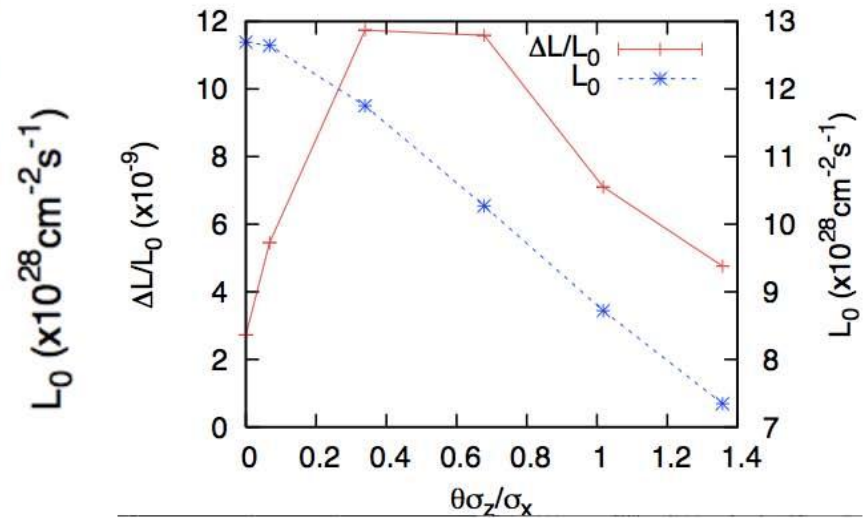
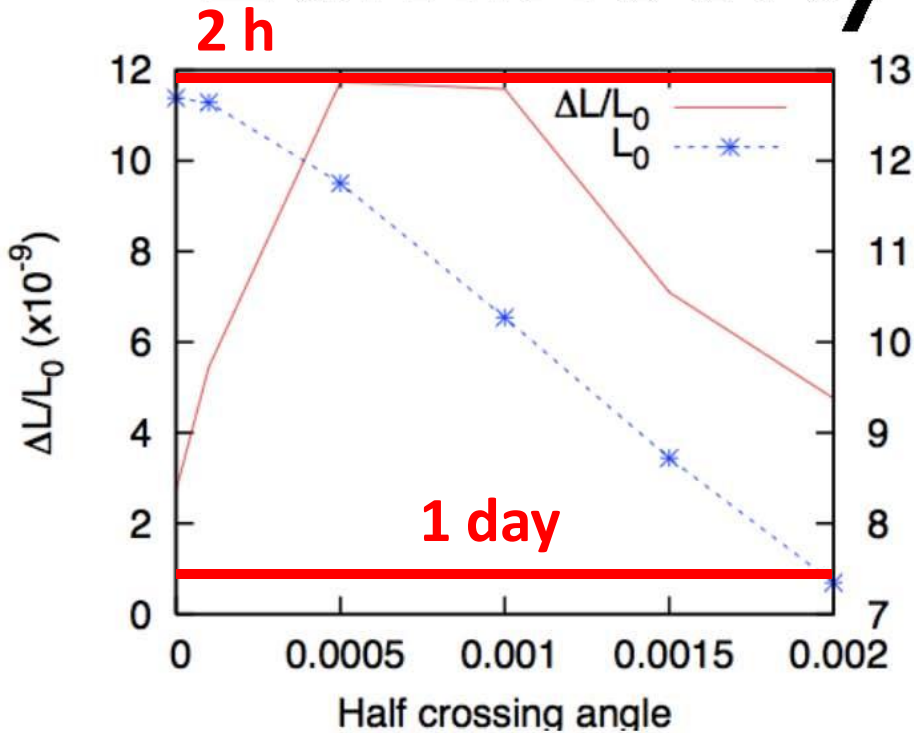


simulated luminosity lifetime with no crossing angle is
10 times better than with 285 μrad angle
($\phi \approx 0.65$, $\beta^* = 0.55\text{m}$, $\gamma\varepsilon = 3.75 \mu\text{m}$, $E = 7 \text{ TeV}$)

MD plan

- **injection energy, collision tunes**
- **two high-brightness bunches per beam**, $2.5e11$, $\epsilon \sim 2 \mu\text{m}$
- “long” bunches (1.6 ns): blow up in SPS & low voltage in LHC (3.5 MV) [Philippe Baudrenghien]
- **collisions in 3 IPs**
- fill pattern: **one bunch / beam colliding in IPs 1,5 and 8; the other in IP8 only ; tune shift ~ 0.01 / IP**
- **change IP8 spectrometer in 3 steps from nominal to zero**
 $\theta_c = 4 \rightarrow 0$ mrad (**TCT adjustment**, & orbit correction at each step?) [nominal, $\frac{1}{2}$, $\frac{1}{4}$, 0 strength]
- **monitor transient losses going into collision, beam lifetime and luminosity lifetime for large, intermediate, and zero Piwinski angle**

Luminosity degradation



$\Delta L/L_0 = 10^{-9}$: 1 day

- $L = L_0 - \Delta L$ t/T_0 (L_0 is different from previous page)
- Fit $3 \times 10^5 - 10^6$ turns
- We can see the difference for crossing angle.

MD plan – cont'd

- in order to save time the **TCTs might not be readjusted, in which case they should be at intermediate settings** and the pertinent **BIS interlock** be masked; **masking is only possible when the total intensity is below $5e11$ at 450 GeV**
- new **IR reference for orbit feedback** needed after spectrometer change if the feedback is active and/or **orbit correction if the internal crossing bump is insufficiently closed** when moving the spectrometer and the compensator in IR8; **transverse damper** probably not needed
- collision tune, e.g. **new ref. values sent to QFB**
- **diagnostics needed:** orbit, bunch intensity, bunch lifetime, bunch length, emittance, tune signal, Schottky spectra

further pushing the Piwinski angle

a squeeze of IR8 down to $\beta^*=5$ m at zero external crossing angle could eventually be done in an eventual second LPA MD in order to further boost the Piwinski angle to the highest values considered for the HL-LHC

with $\beta^*=10$ m and 2 mrad half crossing angle in IP8 the Piwinski angle reaches 1.5 (twice as high as previous studies), with 5 m β^* the Piwinski angle will exceed 2

your comments and suggestions
are welcome!

thank you for your attention