Considerations for ATF2 FFS Results Publication

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ATF2 Topical Meeting, KEK

Publication Proposal

- “Novel Final Focus Design for Future Colliders”
  - *Raimondi/Seryi, Phys.Rev.Lett. 86, 3779 (2001)*
- Write short summary of ATF2 results so far, making case that we have in principal demonstrated operability and suitability of compact, local chromaticity-correction FFS optics for future lepton colliders.
  - “Experimental Verification at ATF2 of Novel Compact Final Focus System for Future High Energy Lepton Colliders”
  - Aim for publication in PRL
  - 3,500 word (3-4 pages) limit
    - Will be essentially a summary of longer ICFA BD write-up currently in preparation

Layout

- Introduction (0.5 page)
  - Purpose and relevance to LC's
- Overview of ATF2 (1 page)
  - Design, instrumentation, tuning and operations
- Presentation of beam tuning results (1 page)
  - Explain operational conditions: large IP beta_x & low Q etc…
- List and discussion of remaining systematics 65 -> 35nm (0.5 page)
- Lessons learned for ILC (0.5 page)
- Future ATF2 plans (0.5 page)
  - Reducing beam size close to beta limit
  - Understanding tuning performance vs. IP beta
  - nm-level IP beam position stability

Tuning Results to Present

- March 14 2013 (10 consecutive meas.)?
  - 0.306 +/- 0.043 M
  - 65 +/- 5 nm
  - Also referring to subsequent and frequent <70nm measurements
- How to make the case that the optics work:
  - Design optics with no chromaticity correction (sextupoles off) σ_y=450nm
    - Demonstrated local-chromaticity correction scheme works (>90% fully corrected)
    - Demonstrates sextupoles correct the chromaticity and balancing of high-order terms by sextupole strengths and placement is working as expected
  - Compares favourably with FFTB results with "traditional" FFS scheme (77nm)
- **State that remaining beam size sources understood and mainly due to systematic effects peculiar to ATF2.**
  - **List expected sources**
  - **Critical to demonstrate a solid understanding of this**

LC FFS Design Parameters

	ILC (TDR 500 GeV)	ATF2	FFTB	ATF2 (pushed)	CLIC (CDR 3 TeV)
L^* (m)	3.5 / 4.5 ^	1	0.4	1	3.5
ε_y (pm.rad)	0.07	12	34	12	0.003
$\xi_y \sim (L^*/\beta^*_y)$	7,300/9,400 ^	10,000	4,000	33,000	50,000
σ_E	0.07/0.12 % +	0.1 %	0.3 %	0.1 %	0.3 %
$\Delta\sigma_y/\sigma_y \sim (\sigma_E.L^*/\beta^*_y)$	5/9 . 7/11 +,^	10	12	33	150
σ_y (nm)	5.9	35	60	20	1
σ_y (nm) *Achieved*	---	**65 +/- 5** *	**77 +/- 7**	---	---
β^*_x (mm)	11	4 (40*)	10	4 - 40	4
β^*_y (mm)	0.48	0.1	0.1	0.03	0.07

~ Tuning difficulty

*March 2012
+ [e+ / e-]
^ SiD / LCD

Explaining Beam Size Results by Considering Remaining Systematics

- 65nm @ 1E9 bunch charge
  - For 3/14, measured 25pm using OTRs (12pm in May)
  - Beta size limit 35nm
  - Explain remaining 30nm
- Expectations from tuning simulations with all expected static and dynamic error sources **(<7nm)**
  - 90% seeds tune <42nm after ~30 scans
  - Includes IPBSM statistical errors as per design
    - e.g. 5% error @60nm, same as consistency scans indicate
- Wakefield effects **(10-20nm @ 1E9)**
  - Includes effects due to orbit drifts?
- IPBSM systematics **(5-10nm)**
  - Single out fringe pattern rotation (5nm for 1mrad) and phase drift (5nm from J.Y. presentation) as main concerns
- Beta mismatch at IP **(0-13nm)**
  - 0.19mm beta_y measured 3/15. Usually closer to or below design 0.1mm (as measured e.g. in December and May)
  - If take measurements in March for emittance and beta get expected sqrt(25e-12*0.19e-3)=69nm!

Total 22 – 50 nm

Smaller and Unknown Effects

- Correlated beam jitter
  - IP beam jitter causes over-estimate of beam size due to IPBSM. OK if beam jitter reduces with beam size.
  - What if e.g. x-y at IP phase correlated jitter (e.g. through rotated extraction bend magnet)?
    - Beam jitter would not be minimum at minimum beam size
    - Probably small effect but should check with simulations
- Effect of square-shaped pulse due to wake effects
  - O(120nm) beam size mis-measured in 174-mode as O(70)
  - Would make sense of 174 -> 30 degree mode measurement discrepancy
  - How to rule this out?
- Multipole fields
  - Assume negligible as little effect of skew-sextpoles in May and no degradation in tuned beam size when going from 10X to 5X beta_x

Potential Reviewer Questions

- How do you know the beam size estimate is correct without any cross-calibrations?
  - Have to rely on theoretical estimate based on list of considered IPBSM systematics. Stress systematics mainly lead to over-estimation of beam size.
- How do you account for larger than expected wakefield effect at IP?

Checklist (To Do Before Paper Submission)

- Long write-up for references
  - ICFA BD newsletter
- Concise and complete write-up of full list of IPBSM systematics
- Final data quality checks on IPBSM results used in published result?
- Derive a plausible explanation for 10-20nm wake effect @ IP
- What number to assign to max IPBSM fringe rotation systematic?
  - 1mrad seems reasonable from rotation scans in the past?