Measuring Betatron Tunes with Synchrotron Light: A possibility for LHC?

LARP Collaboration Meeting

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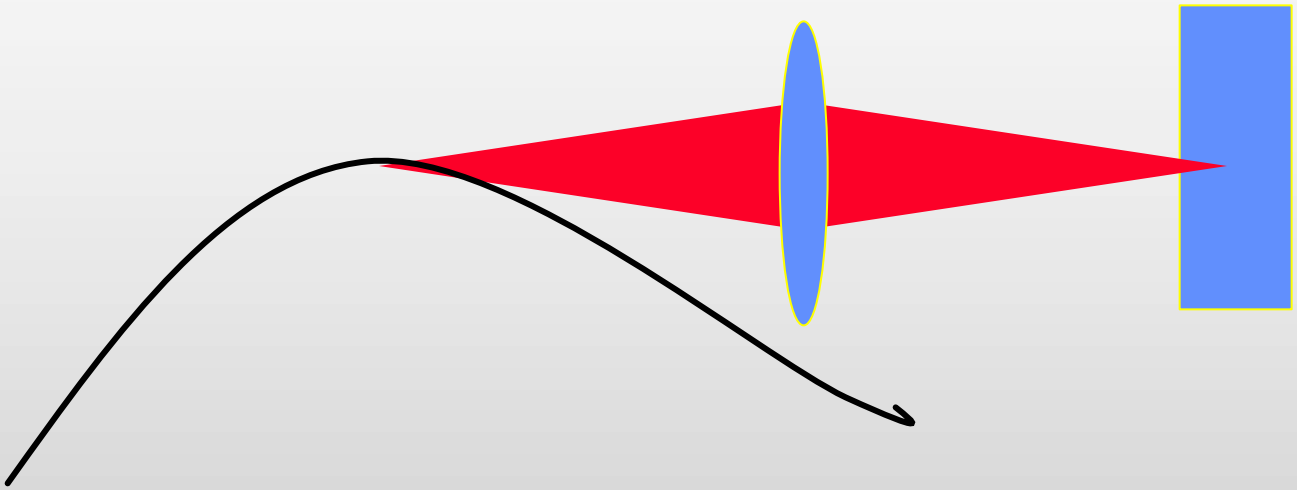
Basic Idea

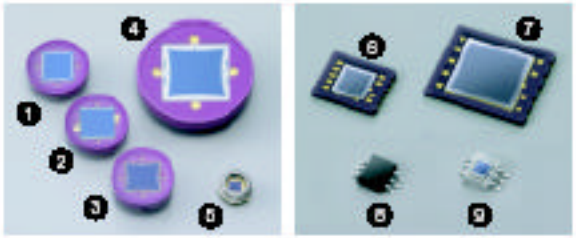


Use SR focused on a position sensitive detector to observe coherent betatron/synchrotron oscillations.Take advantage of detector developments in time response and resolution to measure betatron frequencies (at least for large rings.)

Hamamatsu Detector

Two-dimensional PSD

Two-dimensional PSDs are classified by structure into a tetra-lateral type and a duo-lateral type. The tetra-lateral type features high-speed response and low dark current. The duo-lateral type offers small position detection error and high position resolution. A pin-cushion type, which is a tetra-lateral type with improved active area and electrodes, has a position detection error as small as the duo-lateral type while still having the advantages of the tetra-lateral type.



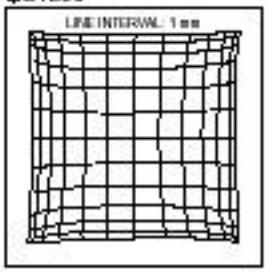
(Typ.)

	Type No.	Active area (mm)	Resistance length (mm)	Interelectrode resistance Vb=0.1 V (kΩ)	Spectral response range (nm)	Structure	Package	
★	S1200	13 × 13	13 × 13	10	320 to 1060	Tetra-lateral type	❶	Ceramic
★	S1300				320 to 1100	Duo-lateral type	❷	
★	S1880	12 × 12	14 × 14	10	320 to 1060	Pin-cushion type (improved tetra-lateral type)	❸	Ceramic
★	S1881	22 × 22	26 × 26	10			❹	
★	S2044	4.7 × 4.7	5.7 × 5.7	10	320 to 1060	Pin-cushion type (improved tetra-lateral type)	❺	Metal
	S5990-01	4 × 4	4.5 × 4.5	7	320 to 1100	Pin-cushion type (improved tetra-lateral type)	❻	Ceramic chip carrier
	S5991-01	9 × 9	10 × 10	7			❼	
	S7848	2 × 2	2 × 2	100	760 to 1100	Tetra-lateral type	❽	Plastic
	S7848-01				320 to 1100		❾	

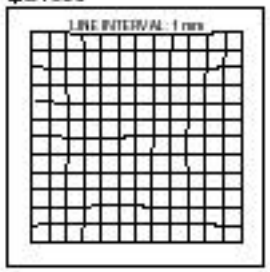
★ Works with microscopic spot light detection

Examples of position detectability (Ta=25 °C, λ=890 nm, spot light size: ϕ200 μm)

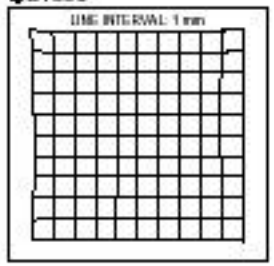
S1200



S1300



S1880

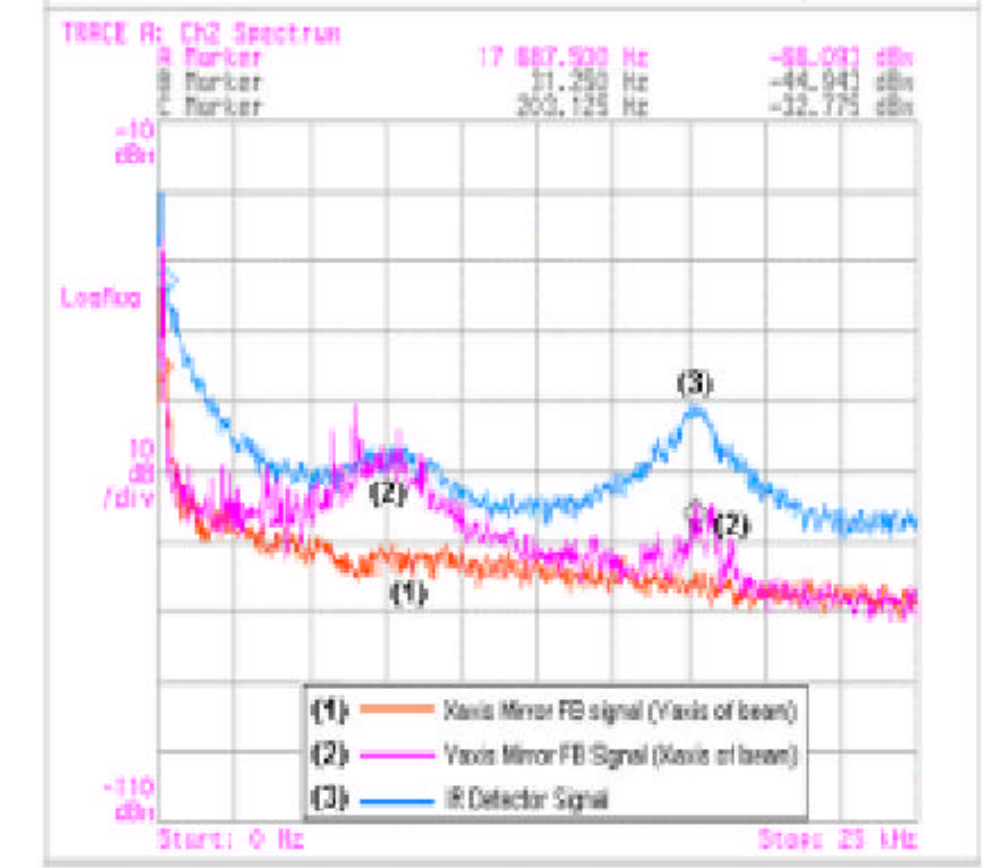


Detector Features

- Excellent position resolution (~1 micron)
- Wide spectral response range
- High-speed response (t_{rise}~15 microsec)
- Detects center-of-gravity position of spot light
- Simultaneously detects light intensity and center-of-gravity position of spot light
- High reliability

ALS Experience

- The detector is installed as part of an optical beam position feedback systemin ALS IR beamline 1.4.
- We found the detector to be more sensitive than a button BPM signal.
- Bandwidth only sufficient for observing zero-mode synchrotron oscillations in ALS.



Tevatron Test

- We are proposing a test of this detector in the Tevatron using the existing SR light diagnostic area.

QuickTime™ and a TIFF (Uncompressed) decompressor are needed to see this picture.

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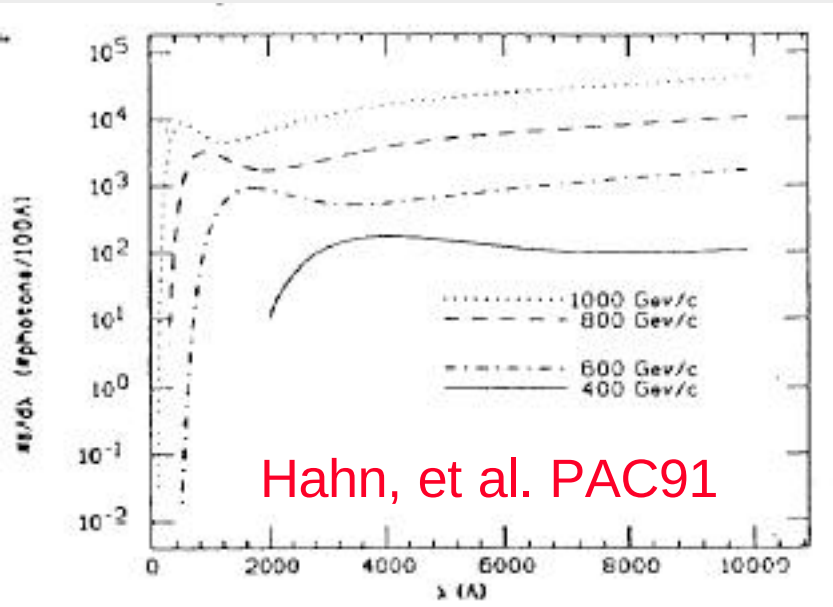
Tevatron Test (cont.)

- SR light in the visible is generated at the edges of an upstream dipole



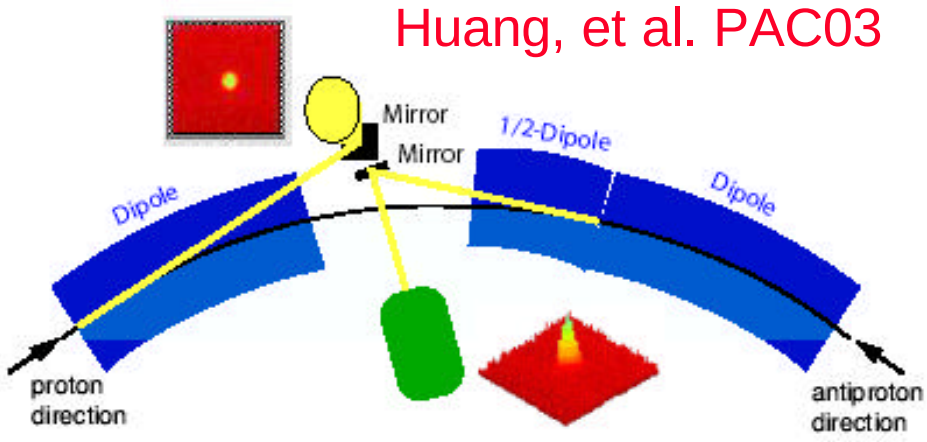


Figure 1: Synclite schematic showing radiation point locations for protons and antiprotons.

Summary and Status

- Using SR for tune measurement has a number of features:
  - Sufficient BW for large rings using sensitive detectors. Provides baseband signal.
  - No vacuum hardware needed if SR port exists.
  - Possibly useful as part of optical feedback system.
  - Components cost is minimal. Setup is simple.
  - Highly directional signal useful for counterrotating beams.
  - Sensitive to optical beam vibration (i.e. mirrors, etc.)
  - SR signal strength beam energy dependent
- Tevatron Test
  - Parts ordered for Tevatron test
  - Position for LBNL postdoc for Tevatron work posted
  - We will update the LARP Instrumentation group on the results.