Development of a transition radiation profile monitor - OTR

- some controversy over minimum resolvable beam image
  - achieved 7μm (12/00) well beyond purported limit – *OTR provides light at very large angles → high resolution*
  - *not like synchrotron light*
  - smallest OTR spot imaged to date
- theoretical limit: ~ λ

- Parameters for ATF OTR (built at SLAC)
  - resolution – 2μm
  - field of view – 300 x 200 μm (or ~2x)
  - depth of field – 8 μm vertical displacement
  - OK light for normal camera – 5e9 ppb
  - Industrial microscope objective
  - 35 mm working distance
  - various target materials

Also – ‘Diffraction Radiation’ from an aperture/edge
successive images illustrating damage:

Cu
7e9
20x12μm

Be 5e10
10x13μm
Bunch length

• Streak cameras
  – resolution limited to \( \sim 1 \text{mm} \)
  – space charge, calibration
• Coherent radiation
  – stronger signal with shorter beams
  – asymmetry difficult (use power spectrum – phase info lost)
• Deflecting RF structures
  – promising \( \rightarrow \)
• Broadband microwave emission
  – cheap, relative – a given

• accurate monitor critical for short wave FEL

**Multi-stage compression**
S-band deflecting TM11 structure

LCLS Bunch length monitor

Schematic:

\[ \sigma_z = \frac{\lambda_{rf}}{2\pi} \frac{\sqrt{E_d E_s}}{|eV_0 \sin \Delta\psi \cos \phi|} \sqrt{\frac{\sigma_y^2 - \sigma_{y0}^2}{\beta_d \beta_s}} \]
Bunch length monitor -

Transverse RF Cavity for Bunch Length and Slice-Emittance Measurements
(J. Frisch, X.-J. Wang, old SLAC ’60s)

\[ V(t) \]

\[ e^- \]

\[ \phi \approx 20^\circ \]

\[ V \approx 20 \text{ MV at } \phi \approx 20^\circ \]

\[ \sigma_z \approx \frac{\lambda E}{2\pi eV_0 \cos\phi \sqrt{\beta_0 \beta_1 \sin\Delta \psi}} \sqrt{\sigma_{x}^2 - \sigma_{x0}^2} \]
Storage ring instabilities – electron cloud

A diffuse cloud of electrons gathers quickly and surrounds the positron (proton) beam.
Electrons generated by photoelectric/secondary emission

Very serious impact on b-factory / damping ring design and operation

Schematic of electron-cloud build up in the LHC beam pipe.
Electron cloud effect in KEK-B LER

Showing the rise time of cloud density

Bunch spacing ~ 5 ns
Buildup of electron cloud as a function of time

- during bunch train passage
- for 3 nominal bunch intensities
- (simulation)
- very little done for ‘direct’ measurements of cloud

Buildup of electron cloud (Simulation by F. Zimmermann)

Accelerator Instrumentation, Controls & Diagnostics

Marc Ross – SLAC

May 31, 2002
Radiation modeling

- Collider single beam power $\sim 14$ MW
  - (1 Rad/hr $\sim 0.3$ mW into 1 kg of material)

- Need to model:
  - locally installed electronics/plastics radiation dose
    - how much local shielding is needed?
    - Optics/Lasers/Electronics/HV power supplies/μwave components/?
  - material damage from extreme radiation
  - background processes for a variety of detectors
    - (not limited to IR)
  - machine component ‘damage’ processes
  - environmental – (NUMI)
Tunnel electronics enclosures in main linac tunnel wall

estimate of neutron fluence for 1.4W steady loss for 3000 days of operation
RF Breakdown Diagnostics

- Goals:
  - Location within mm
  - Quantify energy deposition
    - Comprehensive recording
  - Observe emitted light
- Provide feedback to manufacturing & fabrication process
- Optimize conditioning protocol
- Observations:
  - Multi-breakdown events caused by reflection
  - Breakdown grouping in time
  - Structure damage is not explained by material removed by arc pits themselves
  - Many (most) structures show enhanced concentration of breakdown in WG coupler