Highlights from the 13th Beam Instrumentation Workshop

Fernando Sannibale

Lawrence Berkeley National Laboratory

BIW08 13th Beam Instrumentation Workshop May 4-8, 2008

BERKELEY LAB

Contents

1- Preliminary considerations

2 – Old & New in BIW08

3 – Contribution highlights

- Tutorial and inviteds
- Contributed Orals
- Posters

Preliminary Considerations

Why a highlight talk?

- To inform people in the community that did not attend BIW08.
- To create a tighter link between DIPAC and BIW workshops.
- Egoistically, a great learning chance and an excuse for going through all the work presented at BIW08.

Drawback. One has to select among a large number of quality works and pick up only a few because of obvious time limitation.

No time for details!

Additionally, despite of any attempt **personal bias** cannot be completely avoided…

Disclaimer.
Although I tried to produce a balanced choice of highlights, the final list is surely incomplete due to time limitations of the talk, and also it unavoidably reflects my personal point of view and preferences

New in BIW08

• BIW08 offered partial financial support to graduate and undergraduate students attending the workshop.

• The proceedings of BIW08 will be now published also in the Joint Accelerator Conferences Website (JACoW) database in addition to the hardcover book version.

With these initiatives, the BIW Program Committee tried to:

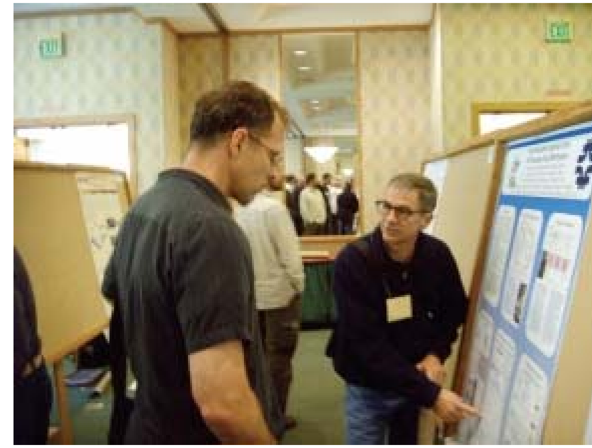
• boost the interest to beam diagnostics in new generations of engineers and physicists

• facilitate a free and wider diffusion of the workshop publications.

BIW08 Numbers & Facts

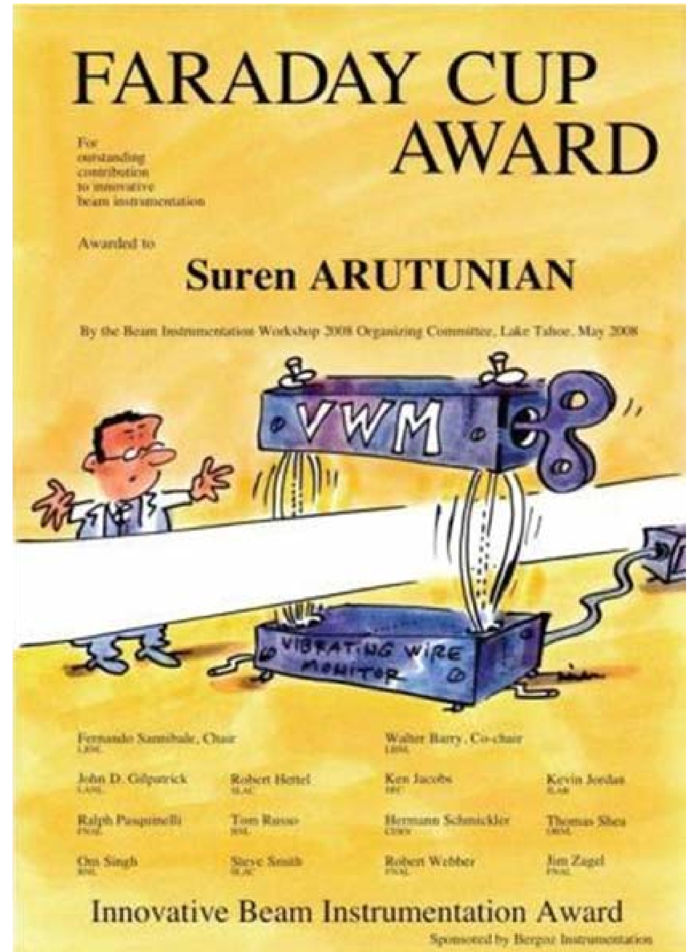
3.5 days workshop with

- 3 tutorials
- 8 invited talks
- 7 contributed talks
- 1 special talk
- 1 poster session with ~ 50 posters
- 1 discussion session
- ~ 130 attendees
- 9 exhibiting vendors



http://www.als.lbl.gov/biw08

10th Faraday Cup Award



The 10th Faraday Cup Award was assigned to Dr. Suren Arutunian (Yerevan Physics Institute of Armenia) for:

The invention, construction and successful test of the diagnostic system "A Vibrating Wire Scanner"

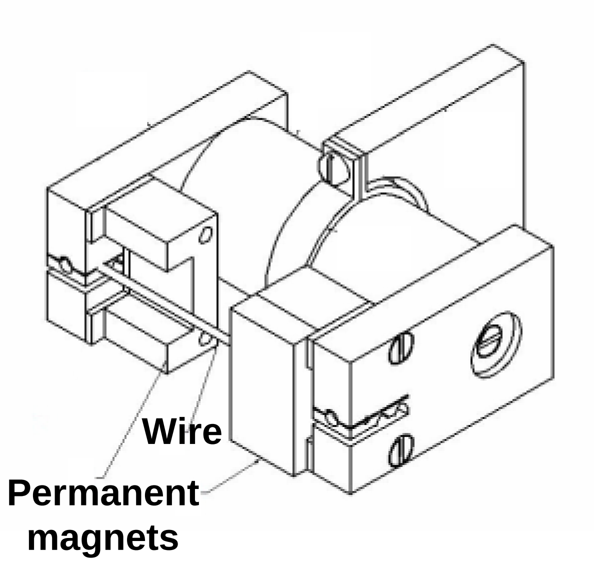
Vibrating Wire Scanner

• An oscillating current is applied to the wire that due the presence of the magnetic fields starts to oscillate (driven oscillator).

• The wire is part of active oscillator circuit that drives the oscillation on the natural mechanical resonance of the wire at few kHz (tuned oscillator)

• The interaction of the cable with the beam ultimately generates heating and the consequent temperature change and dilation in the wire causes a shift in the mechanical resonance.

• The frequency shift is proportional to the number of particles in the part of the beam interacting with the wire, so that by scanning the wire trough the beam it is possible to measure the beam profile.



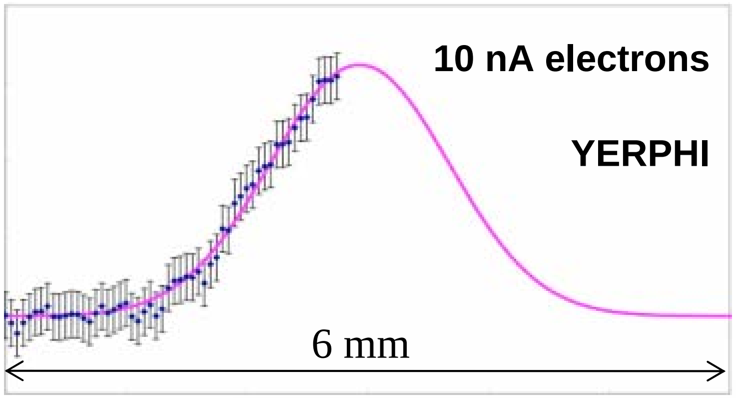
$$\frac{\Delta f}{f} = K \ \Delta T \propto N_{particles}$$

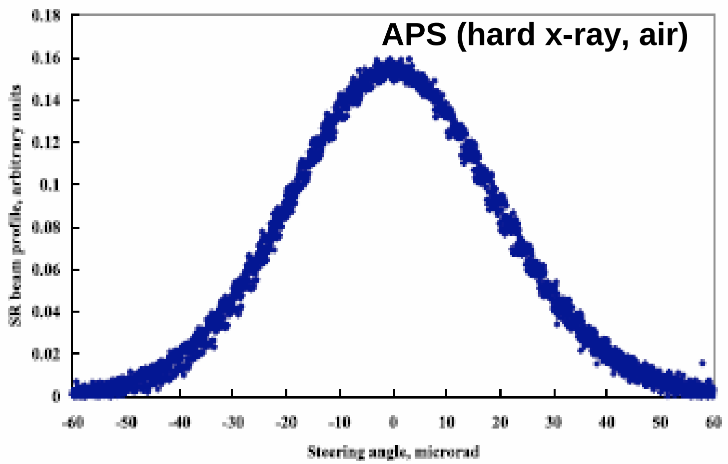
Mechanical property constant

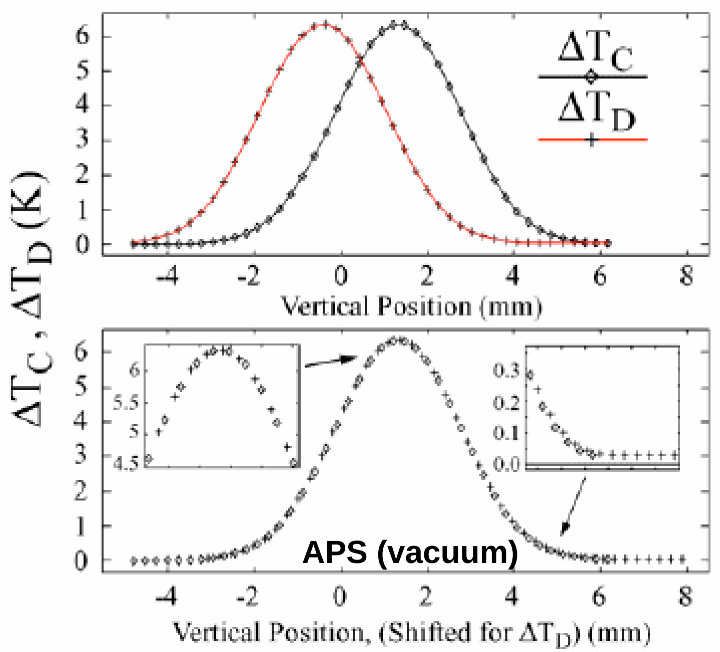
MOSTFA01 — Vibrating Wire Sensors for Beam Instrumentation, *S.G. Arutunian*

Vibrating Wire Scanner

- **Relatively slow response time (tenths of seconds in air, seconds in vacuum)**
- **Very sensitive, best for measuring low intensity beams and halos**
- **Already tested with ions, protons, electrons and photons.**







MOVTC02 — Hard X-Ray Synchrotron Radiation Measurements at the APS with Vibrating Wire Monitors, *G. Decker*

Tutorials

Laser in Beam Diagnostics – G. A. Blair

Accelerator Vacuum 101, Made Easy ??? – T. G. Anderson

Digital Signal Processing Using Field Programmable Gate Arrays – J. Serrano

- **TUPTPF001, Performance of FPGA-Based Data Acquisition for the APS Broadband Beam Position Monitor System, *G. Decker***
- **TUPTPF017 — ALS FPGA-Based Transverse Feedback Electronics, *J. Weber, M. Chin***
- **TUPTPF074 — Advanced Light Source FPGA-Based Bunch Cleaning, *M. J. Chin, J. M.Weber, F. Sannibale, W. M. Barry***
- **TUPTPF078 — An FPGA-Based Tune Measurement System for the APS Booster, *C.-Y. Yao, W. E. Norum, Ju Wang.***

Very "hot" topic! Everybody uses and does everything with FPGA!

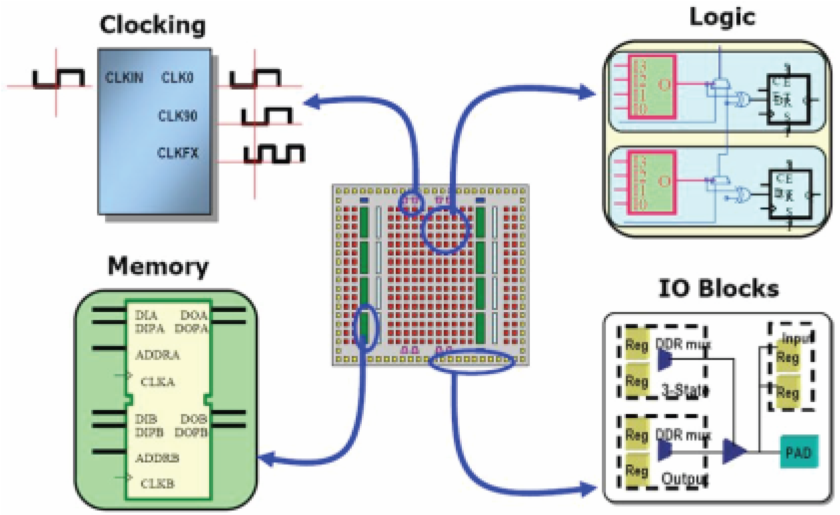
Digital Signal Processing Using FPGA

THTT01 — Digital signal processing using Field Programmable Gate Arrays, *Javier Serrano*

An authentic tutorial, that historically introduces the argument, explains the main components of a FPGA and their functionality, and then dives deeply into the different design phases that allow to transform abstract ideas into a real digital circuit.

The core of the tutorial is dedicated to digital signal processing using FPGAs. Central in beam diagnostics and instrumentations for applications

Special emphasis is given on the design techniques used for a "safe design" that avoids undetermined states.



Courtesy of Xilinx, Inc.

A comprehensive and clear presentation of the subject, useful to beginners, curious ones but also to the more experts…

Invited Talks

The invited talk program, partially reflected the exciting moment in accelerator physics were a major project (LCLS) was starting the commissioning phase and were another one (LHC) was performing a final cross check before the initial commissioning phase.

MOIOTIO01 — Future Accelerator Challenges in Support of High-Energy Physics, *M. Zisman*
MOVTIO01 — Beam Measurements at LCLS, *J. Frisch*
MOVTIO02 — LHC Machine Protection, *B. Dehning*
TUIOTIO01 — Electro-Optic Techniques in Electron Beam Diagnostics, *J. van Tilborg*
TUIOTIO02 — Radiation Damage in Detectors and Electronics, *R. Lipton*
WEIOTIO01 — Transition, Diffraction and Smith-Purcell Radiation Diagnostics for Charged Particle Beams, *R. Fiorito*
WEIOTIO02 — The CLIC Test Facility 3 Instrumentation, *T. Lefevre*
THVTIO01 — Recent Beam Measurements and New Instrumentation at the Advanced Light Source, *F. Sannibale*

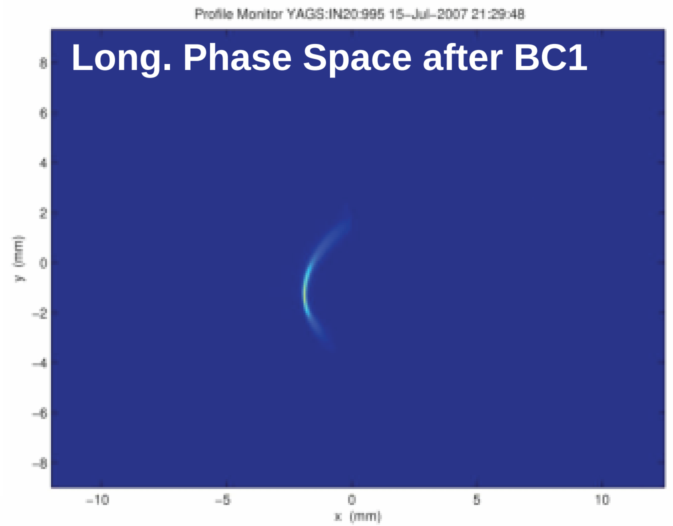
In addition, a number of presentations were dedicated to state of the art and developing techniques to measure beam quantities.

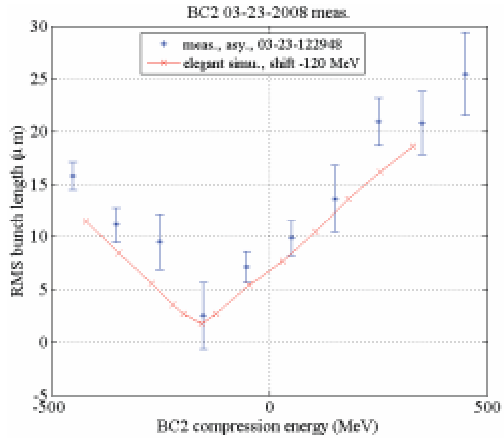
Last but not least, some of the talks addressed the future of accelerator based HEP, by investigating challenges or by describing present R&D ideas

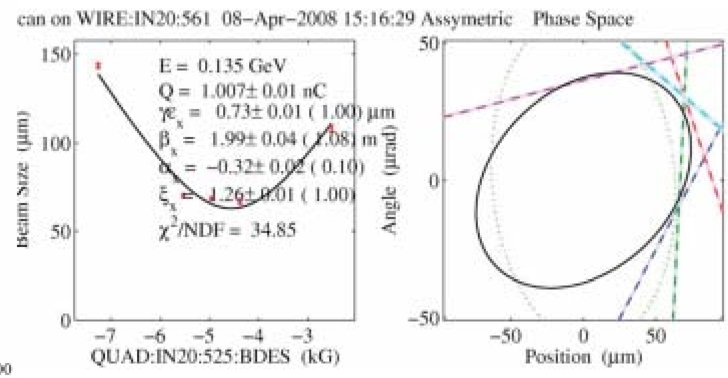
Beam Measurements at LCLS

A large number of impressive measurements:

MOVTIO01 — Beam Measurements at LCLS, *J. Frisch*





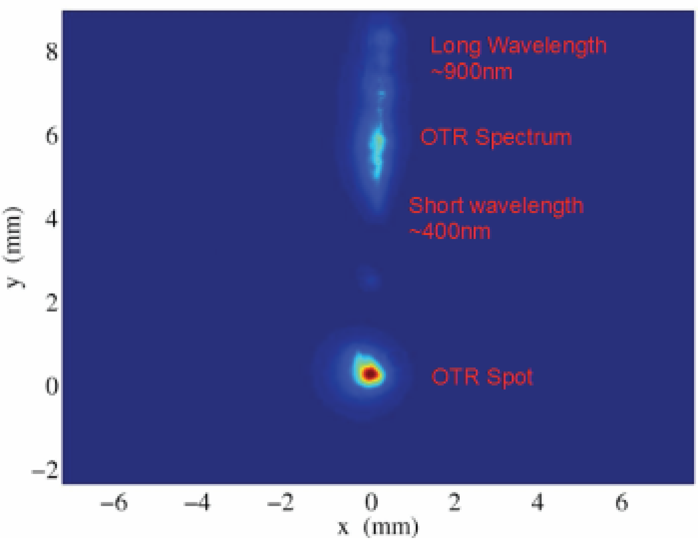


An unexpected presence of **coherent radiation at the OTR screens** along the linac made the diagnostics unusable.

Indication of longitudinal structures in the bunch with characteristic length comparable (and probably shorter) than visible wavelengths.

After the introduction of the "laser heater" the coherent intensity was reduced but not completely eliminated.

Profile measurements rely on wire scanners



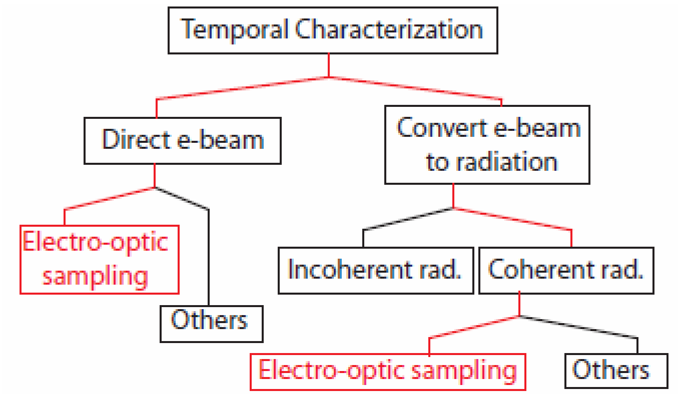
BIW08 Highlights

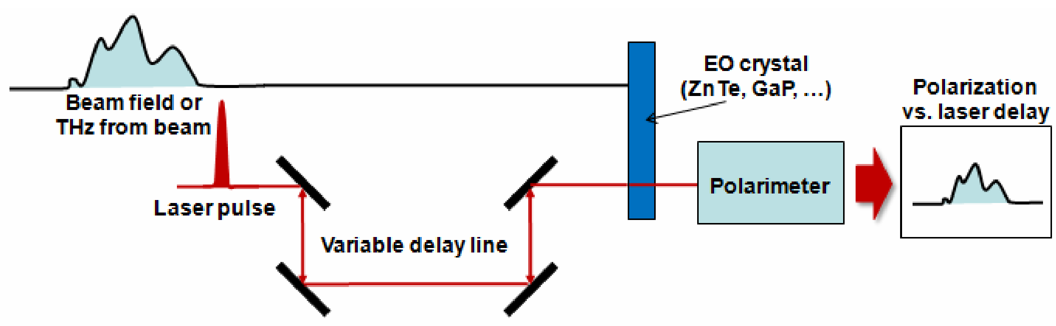
F.Sannibale

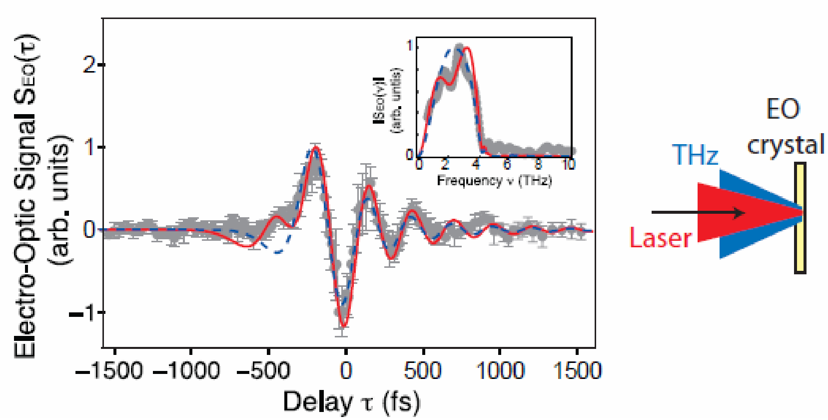
Electro-Optic Techniques in Electron Beam Diagnostics

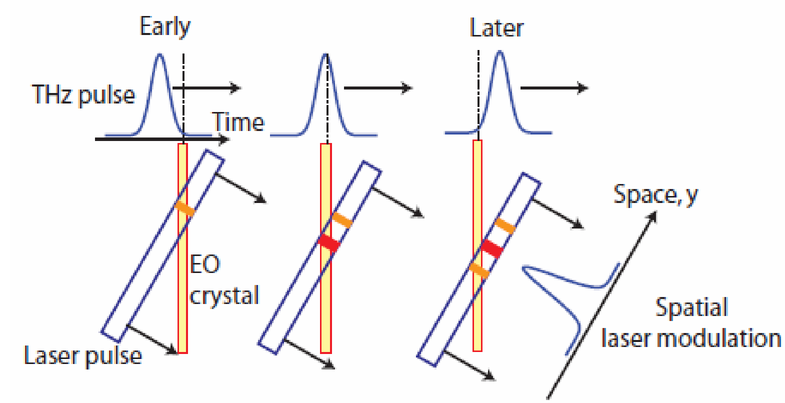
BERKELEY LAB

TUIOTIO01 — Electro-Optic Techniques in Electron Beam Diagnostics, *J. van Tilborg*









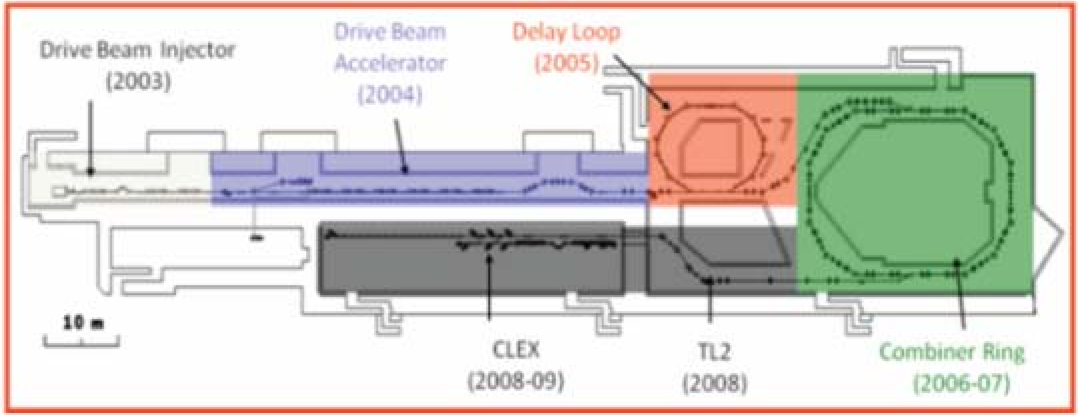
Theoretical introduction of the technique followed by an extensive description of different schemes, including time and frequency domain, scanning and single shot applications.

Numerous experimental data per each of the schemes are also presented.

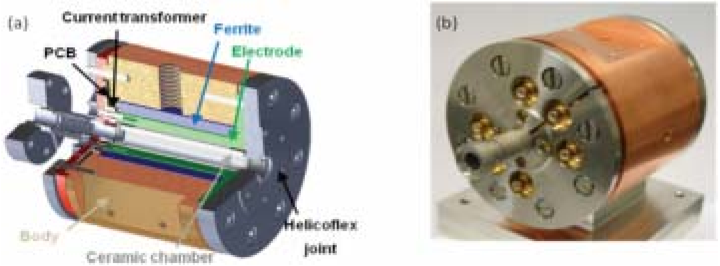
CTF3 Instrumentation

WEIOTIO02 — The CLIC Test Facility 3 Instrumentation, *T. Lefevre*

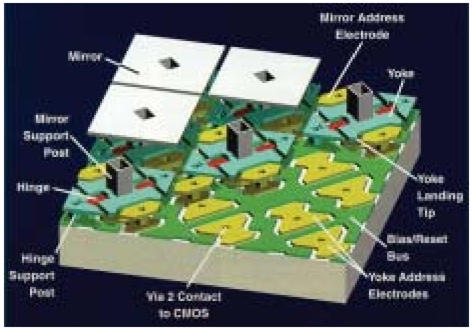
CTF3 at CERN shall demonstrate by 2010 the key technological challenges for the construction of a high luminosity 3TeV e+-e- collider



CTF3 beam diagnostic R&D put special emphasis on short bunch length measurements, nanometer beam position monitors, femtosecond synchronization technique and high dynamic range beam imaging system.



Inductive pick-up BPM (100 nm resolution)



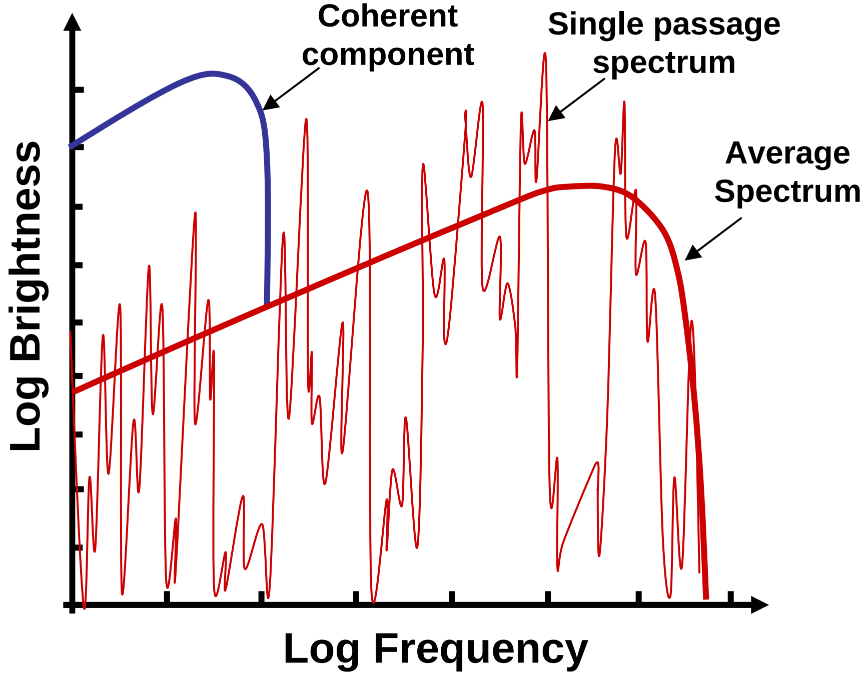
Halo Monitor with > 10^5 dynamic range. By using charging injection devices (CIDs) and adaptive optics (micro-mirrors) for masking out the core of the beam

Beam Absolute Bunch Length by Radiation Fluctuation Analysis

THVTIO01 — Recent Beam Measurements and New Instrumentation at the ALS, *F. Sannibale*

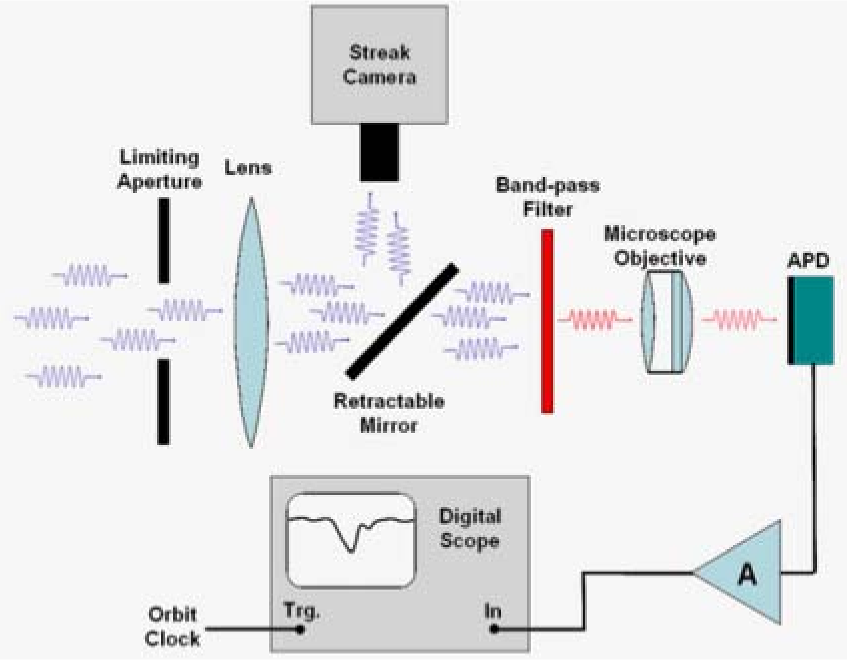
In real beams, due to presence of random modulation in the particle distribution, and to the variation of this modulation passage to passage, incoherent radiation is emitted with intensity fluctuating passage to passage.

It has been shown (Stupakov, Zolotorev SLAC-PUB 7132, 1996) that by measuring the passage-to-passage variance of the radiation intensity in a part of the spectrum where the emission is incoherent, the bunch length can be measured.



A non-destructive, remarkably simple bunch length measurement scheme has been developed that can be used in both circular and linear accelerators, with any kind of radiating process, including those cases where the very short length of the bunches makes difficult the use of other techniques.

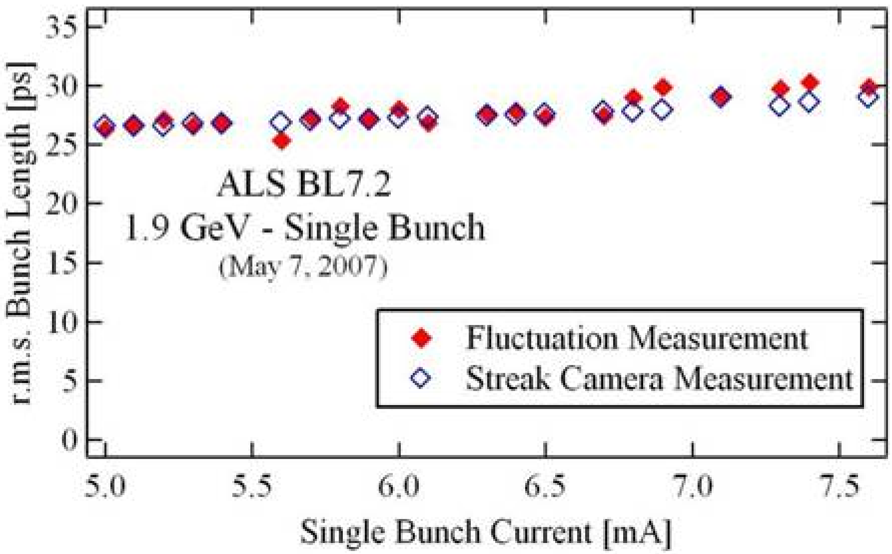
Beam Absolute Bunch Length by Radiation Fluctuation Analysis



By using a bandpass filter with bandwidth σ_ω and measuring the passage to passage relative variance δ^2 of the radiation intensity, the bunch length σ_τ can be measured from:

$$\delta^2 = 1\Big/\sqrt{1+4\sigma_\tau^2\sigma_\omega^2}$$

The method has been successfully demonstrated at the Advanced Light Source using synchrotron radiation from a dipole.



Sannibale et al. PRST-AB 12, 032801 (2009).

Contributed Talks

MOVTC02 — Hard X-Ray Synch. Rad. Measurements at the APS with Vibrating Wire Monitors, *G. Decker*
MOVTC03 — The Progress of BEPCII Storage Ring Diagnostics System, *J. Cao*
MOVTC05 — Measurements of the Electron Cloud Density in the PEP-II Low Energy Ring, *S. De Santis*
MOVTC06 — The Beam Diagnostic Instrumentation of PETRA III, *K. Wittenburg*
WECOTC01 — Near-field Optical Diffraction Radiation Measurements at CEBAF, *P. Evtushenko*
WECOTC02 — Commissioning of Soleil Fast Orbit Feedback System, *N. Hubert*
WECOTC03 — Beam Diagnostics at DAFNE with Fast Uncooled IR Detectors, *A. Bocci*

WECOTC01 — Near-field Optical Diffraction Radiation Measurements at CEBAF
P. Evtushenko

WEIOTIO01 — Transition, Diffraction and Smith-Purcell Radiation Diagnostics for Charged Particle Beams, *R. Fiorito*

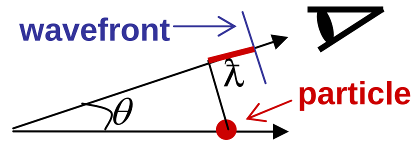
TUPTPF061 — Conditions on ODR Beam-Size Monitoring for γ = 1000 Beams
A.H. Lumpkin, C.-Y. Yao, E.Chiadroni, M. Castellano, A. Cianchi

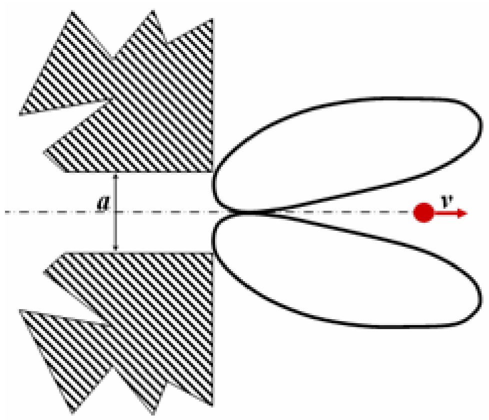
Significant interest in ODR for the development of non-destructive beam diagnostics.

ODR Basics Recap

ODR formation length:

$$L_F = \frac{\lambda\!\!\!^{-}}{1/\beta - \cos(\theta)} \sim \frac{2\lambda\!\!\!^{-}}{1/\gamma^2 + \theta^2} \sim \lambda\!\!\!^{-}\gamma^2 \text{ when } \theta \sim \frac{1}{\gamma}$$





ODR critical frequency:

$$\Rightarrow \quad f_C \sim \gamma\, c/2\pi\, a$$

So for a = 1 mm and a 1 GeV electron, the diffraction radiation spectrum extends to up $\sim f_C \sim 100$ THz ($\lambda_C \sim 3$ μm).

The intensity peaks at $\theta \sim 1/\gamma$ where $L_F \sim \lambda\gamma^2/2\pi$ and the power spectrum per single electron is:

$$\frac{dP}{d\omega} = \hbar\omega \frac{c}{L_F} n(\omega) \sim \frac{e^2}{c}\frac{1}{\gamma^2}\omega$$

Low frequency power spectrum @ $\theta \sim 1/\gamma$

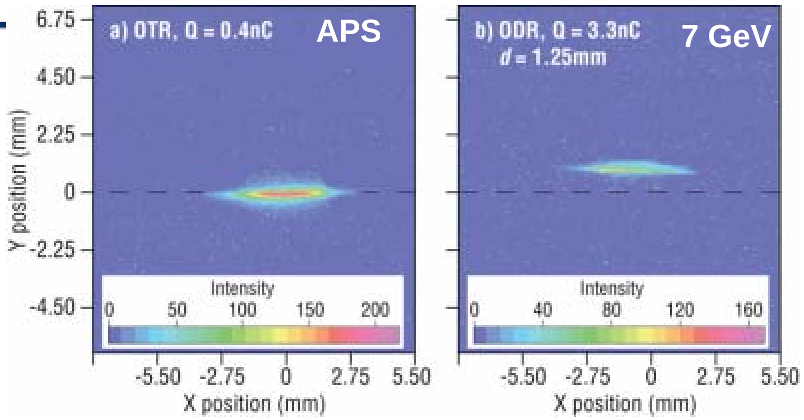
$$\frac{dP}{d\omega} \sim \frac{e^2}{c}\frac{1}{\gamma^2}\omega \exp\left(-2\frac{\omega}{\omega_C}\right)$$

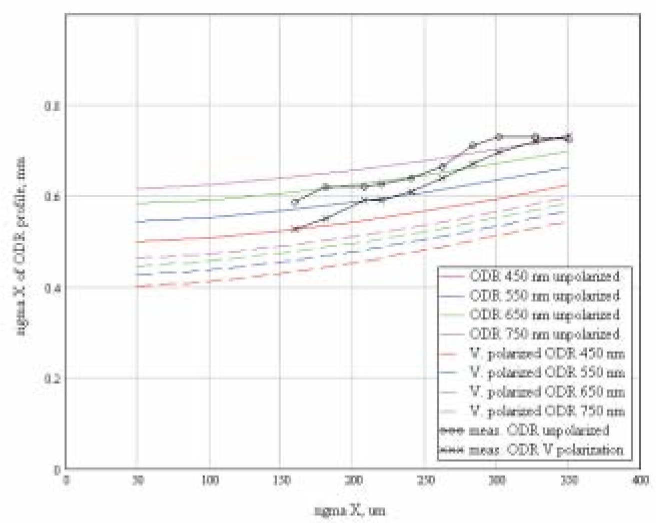
High frequency power spectrum @ $\theta \sim 1/\gamma$

ODR-Based Beam Diagnostics

WEIOTIO01 — *Transition, Diffraction and Smith-Purcell Radiation Diagnostics for Charged Particle Beams*, by R. Fiorito, offers a complete review of OTR, ODR and Smith-Purcell based diagnostics systems, from both the theoretical and experimental point of view.

A. Lumpkin, et. al., PRST-AB 10, 022802 (2007).





WECOTC01 — *Near-field Optical Diffraction Radiation Measurements at CEBAF* by P. Evtushenko, presents a number of ODR measurements with a 4.5 GeV and several tens of μA beam at CEBAF.
The results show a potential use of ODR as relative beam size monitor.

TUPTPF061 — Conditions on ODR Beam-Size Monitoring for $\gamma = 1000$ Beams
A.H. Lumpkin, C.-Y. Yao, E.Chiadroni, M. Castellano, A. Cianchi

Posters' Highlights

TUPTPF005 — Injection of Direct-Sequence Spread Spectrum Pilot Tones into Beamline Components as a Means of Downconverter Stabilization and Real-Time Receiver Calibration ***J. Musson, T. Allison, C. Hewitt*****TUPTPF010,**

TUPTPF010 - Commissioning of Electron Beam Diagnostics for a SRF Photoelectron Injector, ***T. Kamps, D. Boehlick, M. Dirsat, D. Lipka, T. Quast, J. Rudolph, M. Schenk, A. Arnold, F. Staufenbiel, J. Teichert, G. Klemz, I. Will***

TUPTPF020, Transition Effects in Coherent Transition Radiation Diagnostics for Submm Bunch Length Measurement, ***T. J. Maxwell, D. Mihalcea, P. Piot.***

TUPTPF021, Prototype Laser Emittance Scanner for Spallation Neutron Source (SNS) Accelerator, ***J. Pogge, Igor Nesterenko, Alexander Menshov, Dong-O Jeon***

TUPTPF029 — Crab Waist Scheme Luminosity and Background Diagnostic at DAFNE, ***M. Boscolo, F. Bossi, B. Buonomo, G. Mazzitelli, F. Murtas, P. Raimondi, G. Sensolini, M. Schioppa, F. Iacoangeli, P. Valente, N. Arnaud, D. Breton, A. Stocchi, A. Variola, B. Viaud, Paolo Branchini.***

TUPTPF032 — A Gated Beam-Position Monitor and its Application to Beam Dynamics Measurements at KEKB, ***T. Ieiri, H. Fukuma, Y. Funakoshi, K. Ohmi and M. Tobiyama***

TUPTPF044 — Beam Quality Measurements of the Synchrotron and HEBT of the Heidelberg Ion Therapy Center, ***T. Hoffmann, D. Ondreka, A. Peters, A. Reiter, M. Schwickert.***

TUPTPF047 — Creating a Pseudo Single Bunch at the ALS — First Results, ***G. Portmann, S. Kwiatkowski, J. Julian, M. Hertlein, D. Plate, R. Low, K. Baptiste, W. Barry, D. Robin.***

TUPTPF050, Low Energy Beam Diagnostics at the VENUS ECR Ion Source, ***D.S. Todd, D. Leitner, and M. Strohmeier.***

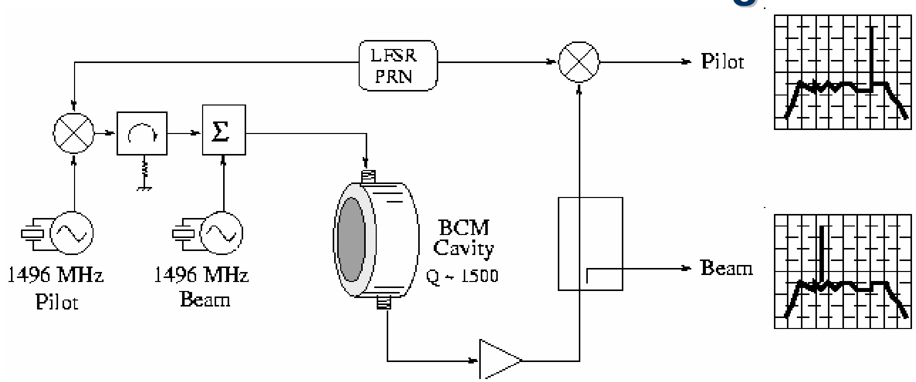
TUPTPF054 — Beam Induced Fluorescence (BIF) Monitor for Intense Heavy Ion Beams, ***F. Becker, C. Andre, F. M. Bieniosek, P. Forck, P. A. Ni, D.H.H. Hoffmann.***

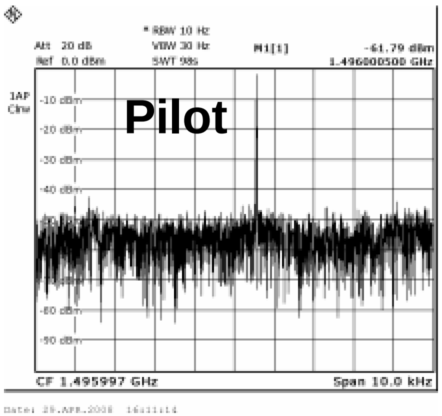
Orthogonal Pilot Tone Calibration

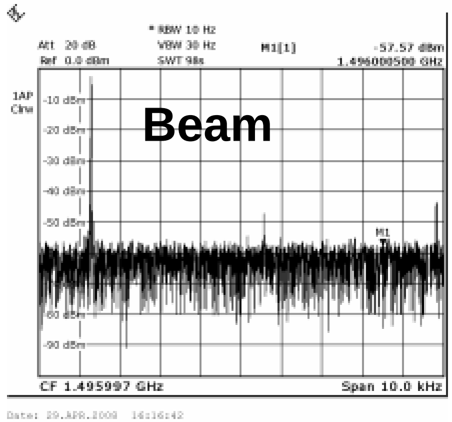
TUPTPF005 — Injection of Direct-Sequence Spread Spectrum Pilot Tones into Beamline Components as a Means of Downconverter Stabilization and Real-Time Receiver Calibration

J. Musson, T. Allison, C. Hewitt

The paper describes a successful bench test at TJNAF of a technique that allows to combine a reference/calibration tone to a beam signal without deteriorating the beam signal.





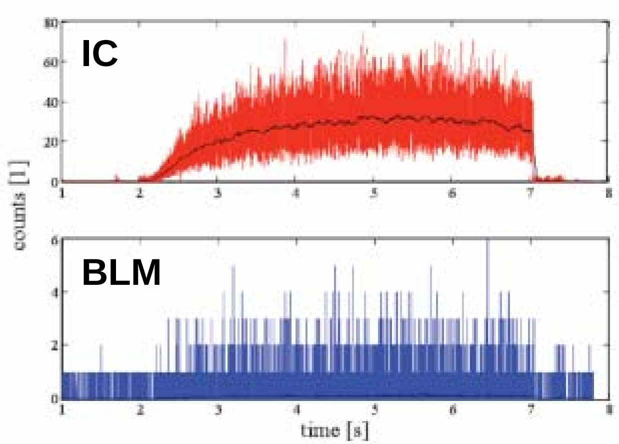


The orthogonality between the tone and the beam signal is obtained by expanding at the “trasmitter” the tone signal in many components using an orthonormal base with pseudo-random coefficients. In this way the energy of the tone signal is spread over a large number of randomly distributed components at the noise level.
The receiver by knowing the pseudo-random sequence can reconstruct the tone signal for calibration purposes.

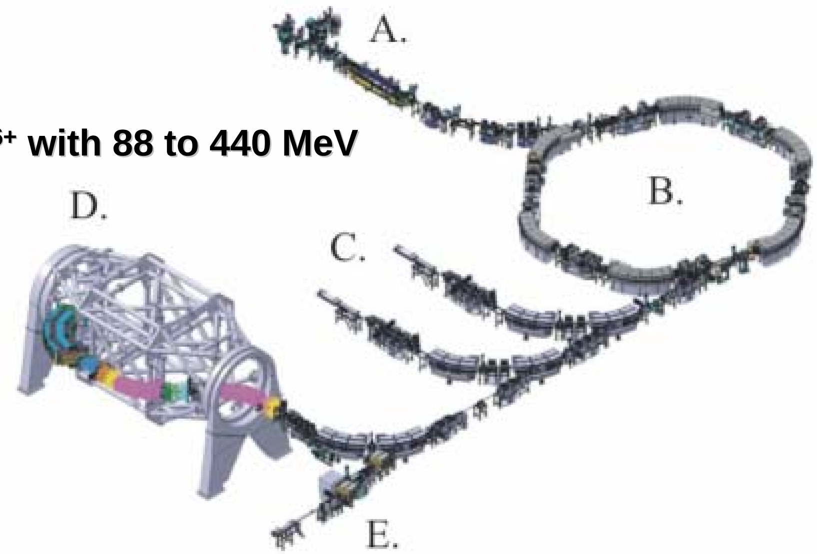
Hadron Therapy Diagnostics

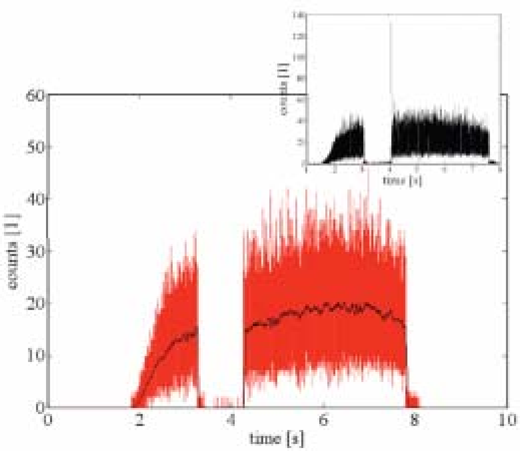
TUPTPF044 — Beam Quality Measurements of the Synchrotron and HEBT of the Heidelberg Ion Therapy Center, *T. Hoffmann, D. Ondreka, A. Peters, A. Reiter, M. Schwickert.*

Beam diagnostics in hadron therapy facilities plays a very peculiar role. Reliability, calibration and precision are a "must"!



$^{12}C^{6+}$ with 88 to 440 MeV





The "spill structure" is redundantly measured by using ionization chambers, scintillators and beam loss monitors.

The "spill pause" is important to minimize undesired healthy tissue exposure to the beam. If the spill pause does not work properly a fast "RF knock-out" kills the beam within a spill.

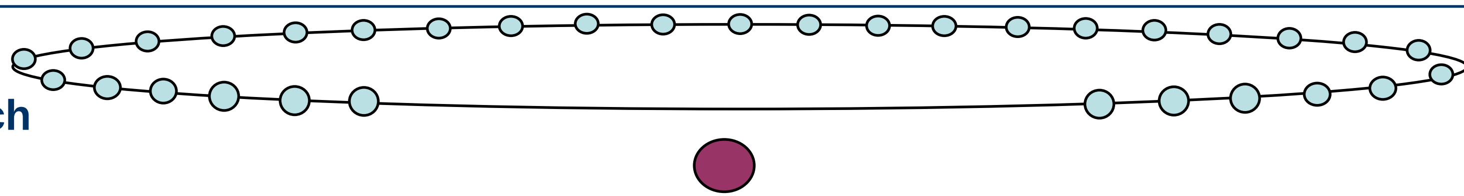
Pseudo-Single Bunch

TUPTPF047 — Creating a Pseudo Single Bunch at the ALS — First Results, ***G. Portmann, S. Kwiatkowski, J. Julian, M. Hertlein, D. Plate, R. Low, K. Baptiste, W. Barry, D. Robin***

In 3rd generation light sources, users performing experiments requiring a long relaxation time are usually satisfied by dedicated special runs where few buckets are filled and several hundreds of ns gaps are present.

In standard multibunch user operation, by kicking every turn by a faster kickers only one bunch, it is possible to place that bunch on a stable different orbit.
By collimating out the light from the other bunches, a pseudo single bunch operation could be obtained.

Pseudo single bunch



The paper describes the successful test of the scheme performed at the Advanced Light Source in Berkeley.

Acknowledgements

BIW08 Program Committee.
Walter Barry, Co-chair (LBNL)
John D. Gilpatrick (LANL)
Robert Hettel (SLAC)
Ken Jacobs (SRC)
Kevin Jordan (JLAB)
Ralph Pasquinelli (FNAL)
Thomas Russo (BNL)
Fernando Sannibale, Chair (LBNL)
Hermann Schmickler (CERN)
Thomas Shea (ORNL)
Om Singh (BNL)
Steve Smith (SLAC)
Robert Webber (FNAL)
Jim Zagel (FNAL)

Local Organizing Committee
Joe Chew, Proceedings Editor
Martha Condon, Conference Administrator
Grace Covarrubias, Conference Secretariat
Joy Kono, Administrative Coordinator
Elizabeth Moxon, Web/Communications
Fernando Sannibale, Chair
Tom Scarvie, Discussion Sessions and Banquet
Greg Vierra, Designer
Jonah Weber, Vendor Contact and Poster Section

AFRD Accelerator & Fusion Research Division
ALS Advanced Light Source
Engineering Division
DOE - OFFICE OF HIGH ENERGY PHYSICS
U.S. DEPARTMENT OF ENERGY
HEP office of high energy physics
GMW Associates

Acknowledgements

THANKS!!