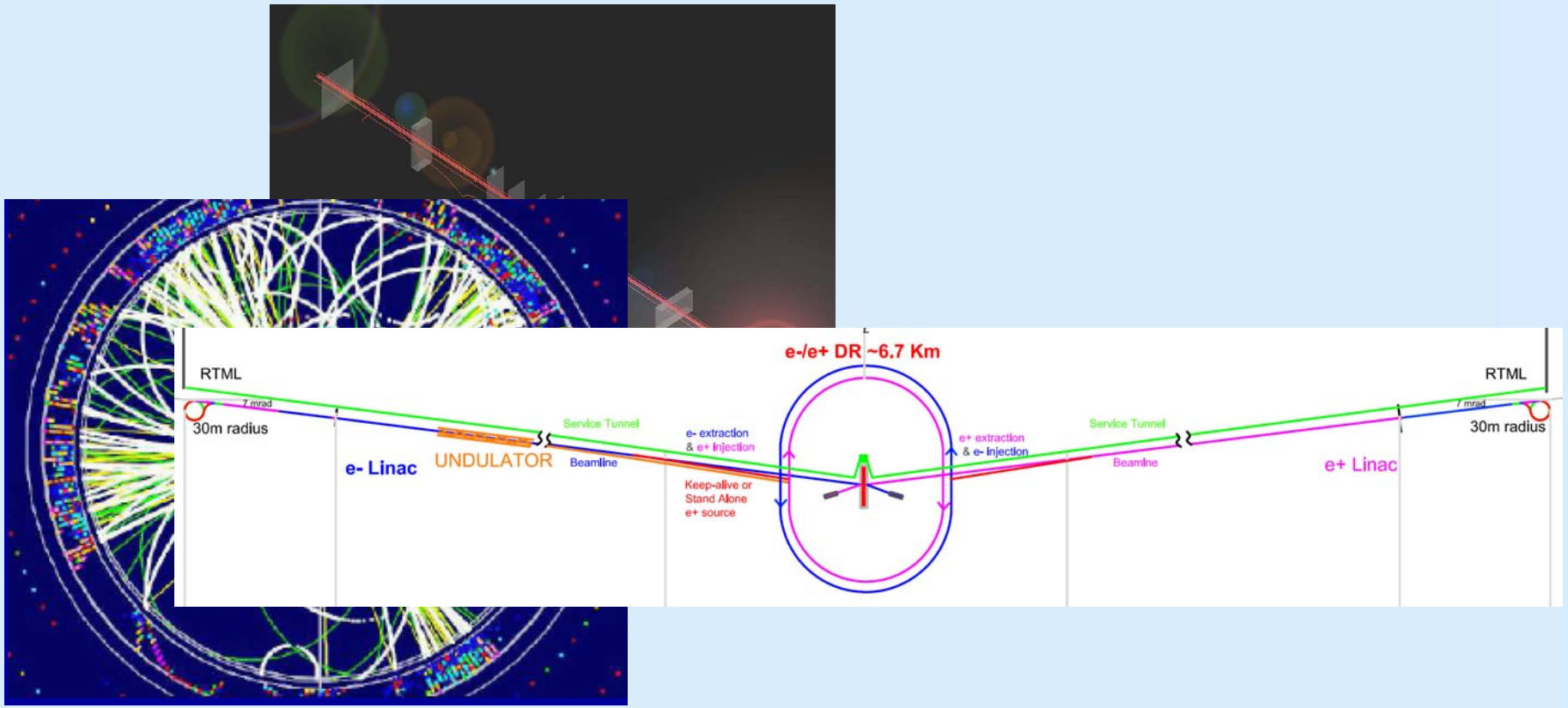
Vertex Detector – Test Beam
Future Requirements

Ingrid-Maria Gregor, DESY



ILC Detector Test Beam Workshop
January 17 - 19, 2007
Fermilab

Motivation

- Two out of ~10 pixel technologies need to be chosen some years before the ILC starts
- ILC vertex detector community informally agreed that any candidate ladder will need to be proven in one test beam (2010-2012)

- Many questions to answer:

  - What is needed for interim evaluation ?
  - What is needed for final sub-detector evaluation ?
  - What kind of test beam(s) are needed?

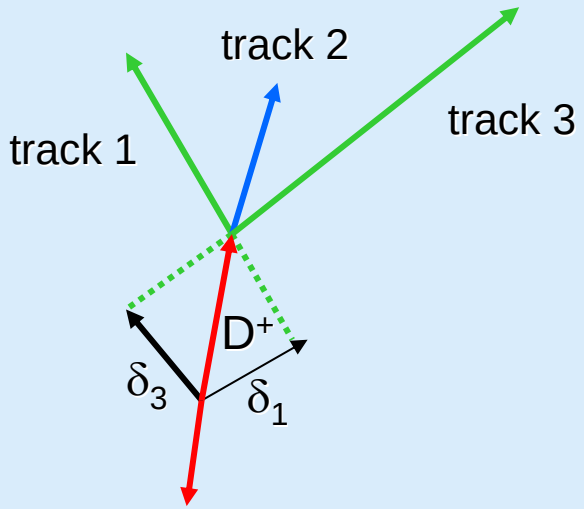
- This talk: some ideas to start discussion and detailed planning

Outline

- Vertex Detector for ILC
- Possible tests for different stages
- Bunch Structure

The Vertex Detector at the ILC

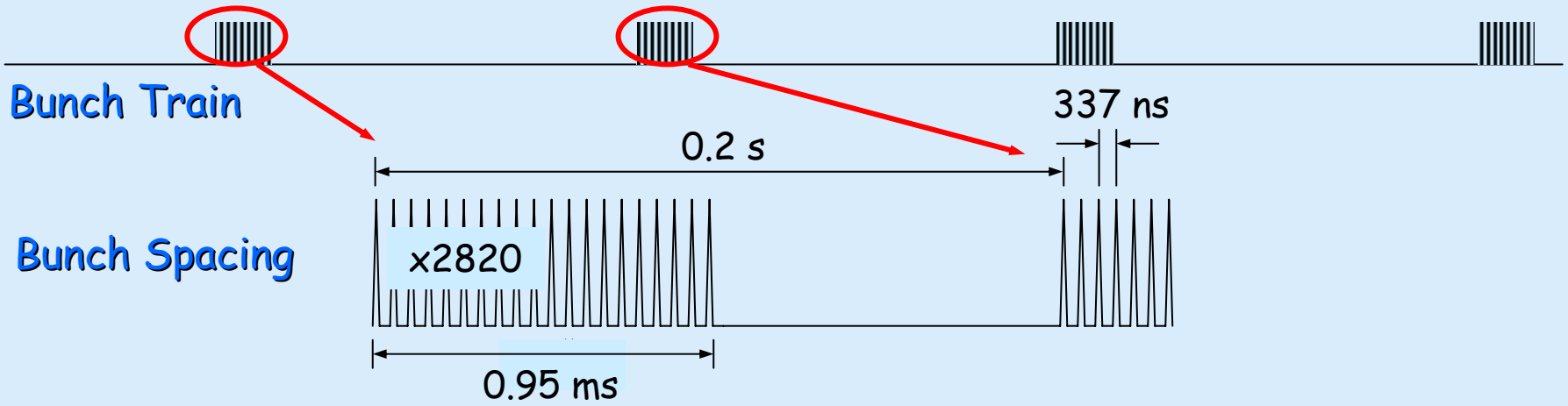
Measure impact parameter, charge for every charged tracks in jets, and vertex mass.



Need:

- Good angular coverage with many layers close to vertex:
  - $|\cos\theta| < 0.96$.
  - First measurement at r ~ 15 mm.
  - Five layers out to r ~ 60 mm.
- Efficient detector for very good impact parameter resolution
- Material ~ 0.1% X_0 per layer.
- Capable to cope with the ILC beamstrahlungs background
- Modest average power consumption < 100W
- Hit resolution better than 5 μm.

The Vertex Detector at the ILC



- Approximately 10 different technologies under study for ILC vertex detector
  - All use silicon pixels
  - Sensitive window varies from single bunch (ie. <300ns), through 50us (20 time slices per train) to integration over the entire bunch train (1ms)

Individual Chip Performance Assessment

- Performed with small prototypes or reticle size sensors
- For evaluation of
  - S/N ratio
  - detection efficiency (before/after ionising and non-ionising irradiation)
  - single point resolution, double hit separation (?), etc.
- May be of interest to run within "sizeable" magnetic field in order to assess effects on cluster characteristics (e.g. single point resolution)

"any" beam may be fine, except for spatial resolution, which requires particles with energy of the order of ~100 GeV

Ladder Performance Assessment

- Performed with ladders
- Same tests as for the small prototype

Plus:

- Homogeneity of the performances over the ladder surface
- Test multi-channel + multi-chip operation
- Test chip electrical servicing
- Test cooling system operation : mechanical properties and influence on performances,
  - e.g. sagitta & vibrations vs. single point resolution
  - heating versus S/N ratio or fake hits (noisy pixel rate)
- Data flow management

"any" beam may be fine, except for spatial resolution, which requires particles with energy of the order of 5-100 GeV

Multi-layer Performance Assessment

- Performed with 4 to 5 (6?) ladders composing a slice of a full detector
- Same tests as before

Plus:

- Homogeneity over the whole device
- Test internal tracking abilities vs beam intensity:
  - internal alignment
  - effect of high occupancy (may be obtained with shrunk/concentrated beam spot)
- Also in magnetic field

several beams may be of interest: high energy for alignment, low energy for low momentum tracking performance assessment, etc.

Full Tracking Performance Assessment:

To be done after decision

- Performed with surrounding detectors in magnetic field (e.g. SIT, TPC, etc. in final solenoid)
- Test track linking and momentum reconstruction

several beams may be of interest: high energy for alignment, low energy for low momentum tracking performance assessment, etc.

Robustness against Dominant Beam Background

- Performed with individual sensors and with ladders installed on a 10 MeV electron beam, like in the TH Darmstadt
- Study influence of beamstrahlung electrons on tracking performances (study response to representative electron energies)
- Test the pattern of the low energy electrons in a 4 T magnetic field, i.e. with the multiladder device

several beams may be of interest: high energy for alignment, low energy for low momentum tracking performance assessment, etc.

ILC Pixel Technologies

ILC long bunch trains
~10^9 pixels
relatively low occupancy

Read out during the bunch train:

- DEPFET
- MAPS
- CPCCD
- CAPS/FAPS
- SOI/3-D
- SCCD

All assume 20 frames/train

Read out in the *gaps*:

- FPCCD
- Chronopixel*
- ISIS

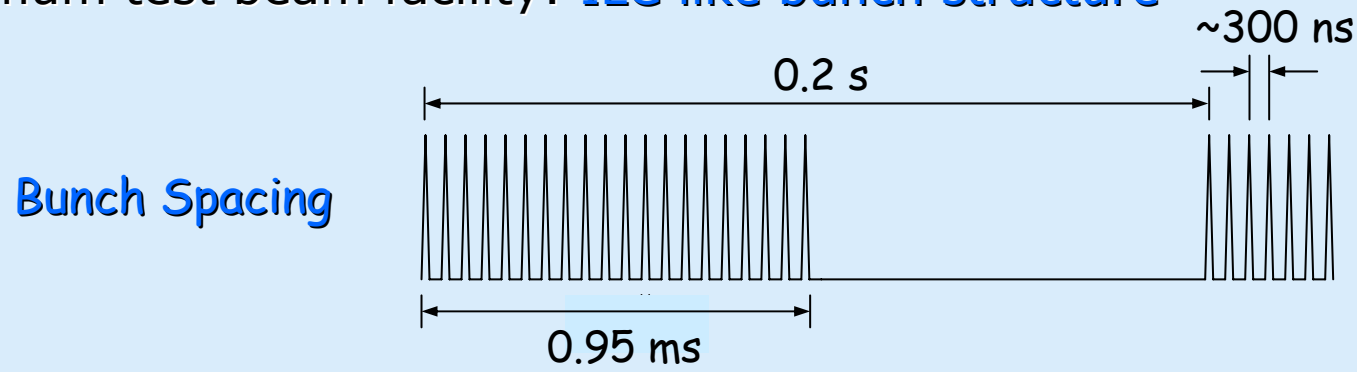
*During bunch train to the level of digitised data

Read out during the Bunch Train

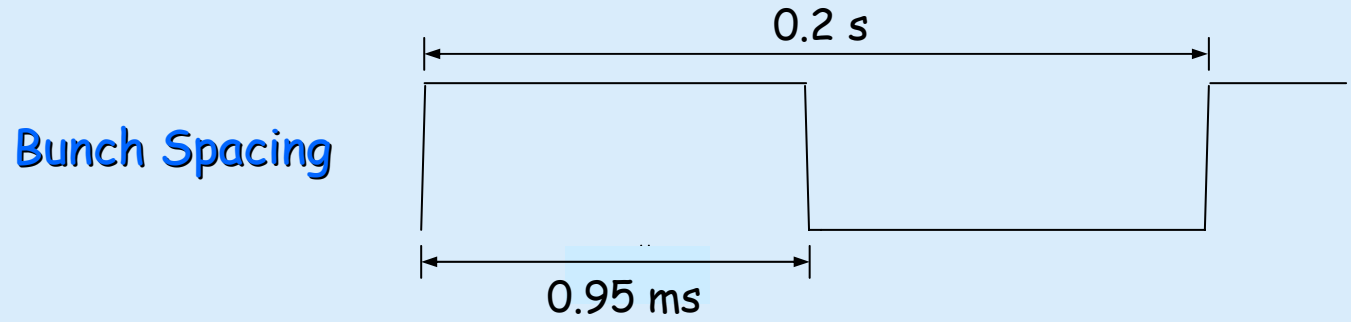
- Very similar ideas about test beam requirement;
  - High energy beam for resolution studies (~100GeV/c)
  - Medium energy beam for ladder yield studies
  - No specific bunch structure needed
- High precision telescope useful for further studies and comparison
  - Strasbourg and Bonn already use their own telescopes
- DEPFET: use SPS at CERN for many studies
  - Access to SPS is difficult as CERN activities have priority and therefore application for test beam time not always successful
  - **Proposal: ILC should get higher priority**

Read out in the Gaps:

- Optimum test beam facility: ILC like bunch structure



- Long spill secondary beam which is chopped by a kicker into trains of 3k bunches at ~300ns interval
  - If machine spill is ~1sec one might get several trains at 200ms intervals



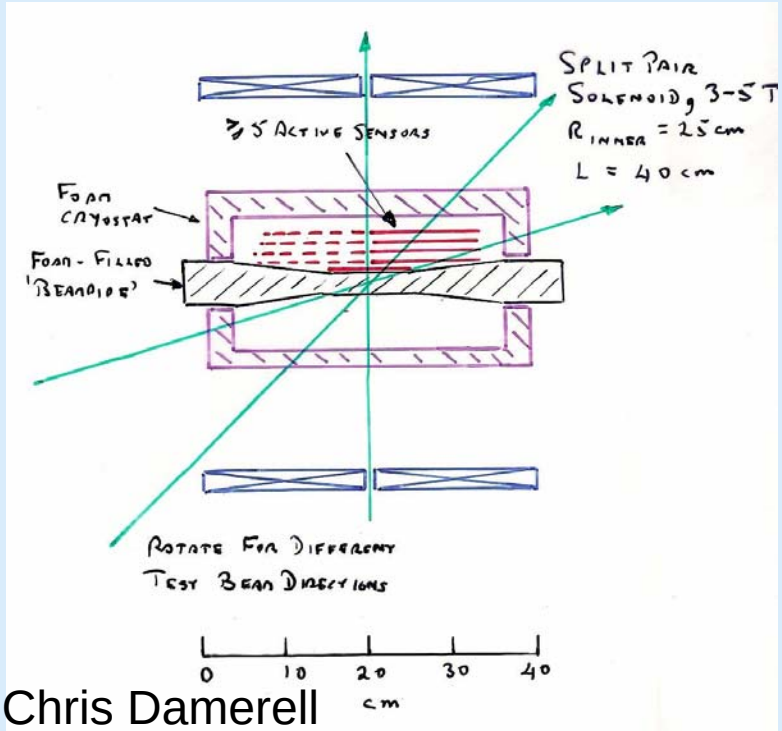
- Subdivide slow spill into 1ms 'trains' at 200ms interval
  - Subdivide this trains furthermore
  - Suitable kicker/collimator system needed

Beam with ILC like Bunch Structure

- Such a beam would give the opportunity to test all technologies under ILC like conditions
  - Might be necessary close the technology decision
  - Interesting for all technology options

- Such test beam not available right now and investment would be needed
- Technically feasible
  - Loose two orders of magnitude of intensity

Infrastructure



Chris Damerell

Magnet

- Power pulsing, wirebonds etc. should be tested in magnetic field

- Split pair super-conduction solenoid
- 3-5T, R_{inner}=25cm, L=40cm
  - Test ladders in a very realistic environment
  - assess effects on cluster characteristics
  - Costs?

Telescope

- High precision telescope with adequate readout speed
- Certain technologies may want a telescope which resolve the individual bunches
  - built with a fast-timing technology that isn't candidate for the ILC
- Most technologies might build their own telescope

Summary

- Preparation for this talk showed that the different technologies also have different requirements at the test beam facilities
- Define a single test beam facility that can be used for all technologies
- This talk -> starting point for discussions to get an idea what is needed

- What is for sure needed:
  - **High energy beam for resolution studies (~100 GeV)**
  - **Low energy for ladder performance (~5 GeV)**

- For final decision tests: test beam with ILC bunch structure might be useful ->significant investment necessary
- High precision telescope with adequate readout speed
- Magnetic field: 4-5T split pair solenoid would an essential tool

  - ILC Detector R&D panel was asked by WWS-OC (World-Wide Study Organisation Committee) to form a task force for ILC vertexing
  - Task force will be charged to study the requirements in detail, also all infrastructure