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LC TPC R&D

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LC TPC Group

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A Proposal to the DESY PRC for LC TPC R&D

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- Objective → develop a high-performance TPC for the LC detector
- Motivation → reasons for a TPC as central tracking detector
- R&D issues → towards achieving the ultimate performance
- Plans → overview of the groups' efforts, priorities, timescale

- higher backgrounds than Lep \Rightarrow goals:
 - achieve finest possible granularity, as near as possible to the diffusion limit of drifting electrons
 - very large-scale integration of readout electronics
 - micropattern gas detectors?
- high momenta, complex topologies: $\sqrt{s} \approx 100 - 1000$ GeV
- high measuring performance needed: $e^+ e^- \rightarrow HZ \rightarrow H\bar{H}$

TPC central tracker

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- large volume $\sim 40 \text{ m}^3$ → cost-effective way to instrument large volume
- continuous tracking ~ 200 space pts./track → 95% tracking efficiency in high backgrounds
- minimize material for $\sim 10^3 \gamma/\text{BX}$ $\sim 3\%$ (30%) X_0 barrel (endcaps)
- timing precision $\sim 2 \text{ ns}$ for BX i.d.
- happy with large B field ($\text{drift} \parallel B$)
- good V_0 detection for energy flow
- gate to eliminate ion feedback from gas-amplification region
- caveat: drift time integrates over 150 BX
- easy to maintain
- therefore maximize granularity: $1.5 \cdot 10^6$ readout pads
- diffusion limit of single electron e.g. $\phi \sim 2 \text{ mm}$ for P10 gas in 4T field $\Rightarrow 8.5 \cdot 10^6$

Motivation

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- backgrounds
 - simulations imply $< 1\%$ occupancy,
 - but be ready for $20 \times$ more
- gas amplification
 - MPGD (micropattern gas detectors) GEM or Micromegas promise better granularity than wires
 - * detect drifting electrons directly
 - * no prf (pad response function) of wire-to-pad induced signal
 - * no $E \propto B$ wire effect
 - are they robust? \Leftarrow our R&D programme
- gases, fieldcage
 - wire chamber backup
 - Ar + which quencher?
 - * CH_4 sensitive to neutron background
 - * CO_2 slow
 - * CF_4 fast but aggressive
 - influences operation and field-cage design

TPC R&D issues (I)

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- electronics
 - r_ϕ :
 - ~ $1.5 \cdot 10^6$ pads $\approx 10 \times$ Star
 - * massive integration wanted with less material
 - Z: faster sampling
 - * > 20 MHz (Star type)
 - * > 100 MHz (ATWD) if use induction signal for GEM
- pad structure
 - "pads partout"
 - if arriving e- cloud hits only one pad (short drift dist. for MPGD), resolution degraded:
 - how to "spread the charge"? Ideas...
 - chevron pads?
 - * conductive glass?
 - * resistive coating?
 - * capacitive coupling?
 - * pad-induction signals (ATWD)?
 - * ...?

TPC R&D issues (2)

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- **gating, distortions**
 - devise techniques to keep systematics $< 10\mu\text{m}$ ($3 \times$ smaller than lep)
 - gating plane to eliminate \oplus ion feedback from amplification region
- **mechanics**
 - goal:
 - * $3\%X_0$ in r , $30\%X_0$ in z
 - * non-trivial (start now)
 - roll back TPC to work on inner detectors
- **cooling**
 - for large number of channels non-trivial
 - TESLA operation allows to ramp off between trains
 - $\Leftarrow \sim kV$ per side

TPC R&D issues (3)

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Topic	MPGD development	MPGD signal pickup	Si readout	MPGD ageing	MPGD ion feedback	MPGD 2-track resolution	Gas studies	Mechanics	Field cage Design	Pad simulation	Alignment	Laser	Software
Institution	Aachen	Berkeley	Karlsruhe	Krakow	MIT	DESY/Hamburg	Orsay / Saclay	Novosibirsk	Carleton/Montreal	Rostock	Montreal Settles/MPI-Munich	Toronto	UCLA
Topic	G	B	G	B	B	D	M	M	D	B	M	G	G
Institution	C	B	C	B	B	D	M	M	D	B	M	B	B
Topic	G	G	G	G	G	G	G	G	G	G	G	G	G

- **Plans(2)**
 - design/build this prototype following year, then start serious testing years
 - make decisions based on R&D toward realistic MPGD or wire prototype within 2
- **Timescale**
 - begin electronics/fieldcage studies
 - compile information/knowhow on MPGDs
- **Priorities**