Other BEAMCAL Technologies and R&D Efforts

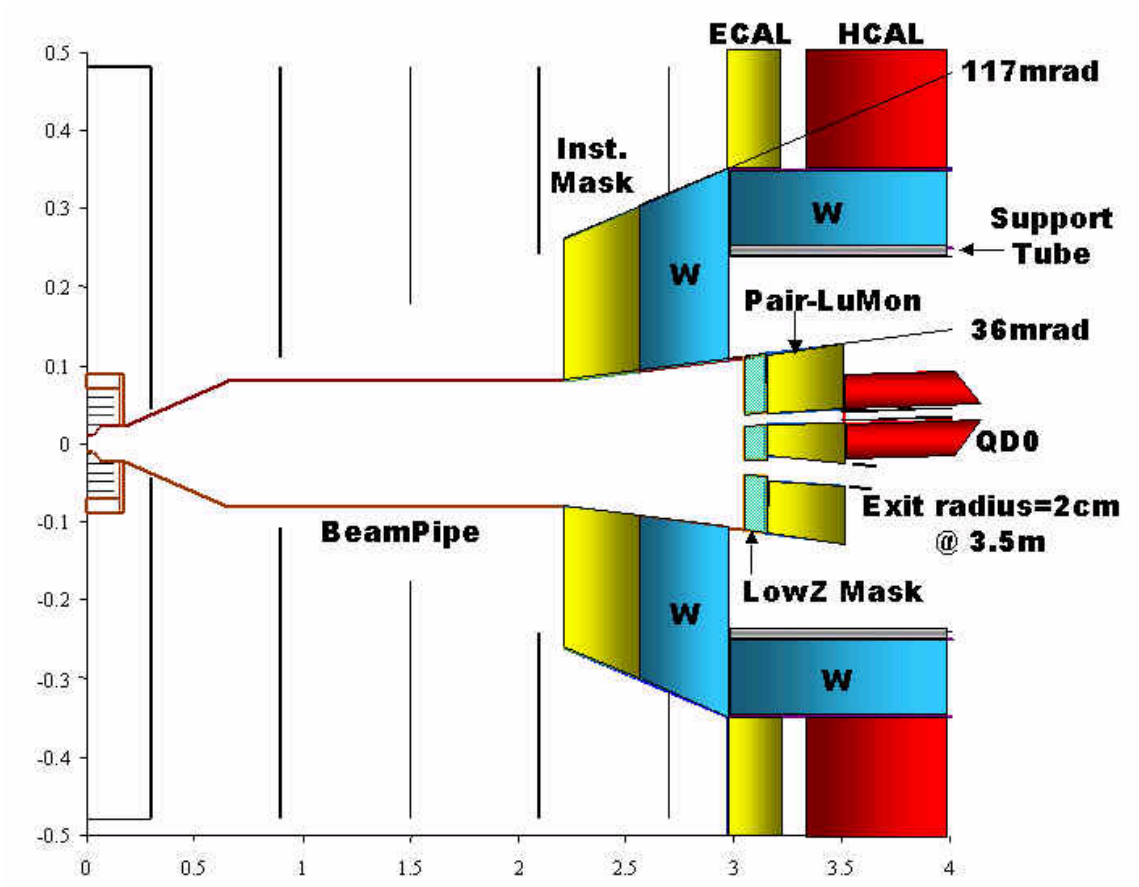
Mike Woods, SLAC LCD meeting June 17, 2004

Quartz Fiber (–W) Calorimeter

Gas (-W) Cherenkov Calorimeter

Parallel Plate Avalanche Chamber (PPAC) (–W) Calorimeter

Instrumentation in the "Forward Region"



Detector functionality:

1. (fast) luminosity diagnostics (5-40 mrad)
   i. #pairs or pair energy for total luminosity/bunch crossing
   ii. Angular distributions of pairs to infer beam aberrations
2. Electron id for 2-photon veto (today's discussion for BeamCal: 5-40 mrad)
3. Absolute luminosity measurement (40-120 mrad)
4. Bhabha acolinearity (EndCap Bhabhas >120 mrad)

References

1. LCWS 2004 Talks by
   i) John Hauptman reviewing 5 technology possibilities for BEAMCAL, Si/diamond–W, quartz fiber, gas cherenkov, PPAC, PbWO4
   ii) Wolfgang Lohman reviewing European R&D efforts
   See http://agenda.cern.ch/fullAgenda.php?ida=a04172#s17

2. Prague Workshop on Instrumentation of the Very Forward Region
   See http://www-zeuthen.desy.de/~astahl/Prague.html

3. IPBI talk by Ed Norbeck on PPAC
   See http://www.physics.uiowa.edu/~enorbeck/PPAC.ppt

Quartz Fiber Calorimetry

Spanier, Bugg & Onel, Winn
LCRD proposals for polarimetry detector

well understood (CMS-HF), fast and radiation-hard.

time spread of signal

$$\Delta t \approx \frac{5X_0}{c(n-1)} \approx 0.2\text{ns}$$

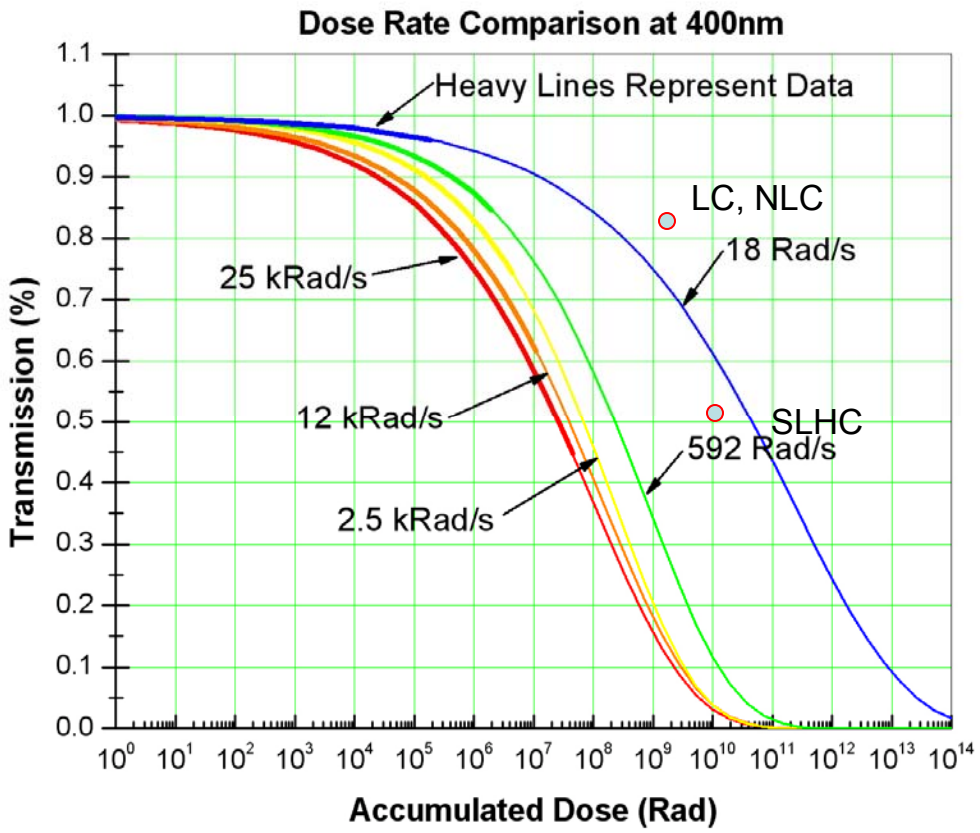
radiation hardness ~ 1 Grad

"Rapunzel"

J. Hauptman
LCWS 2004

Expected signal size ~10 photoelectrons/GeV?

Quartz Transmission vs. Dose & Dose Rate



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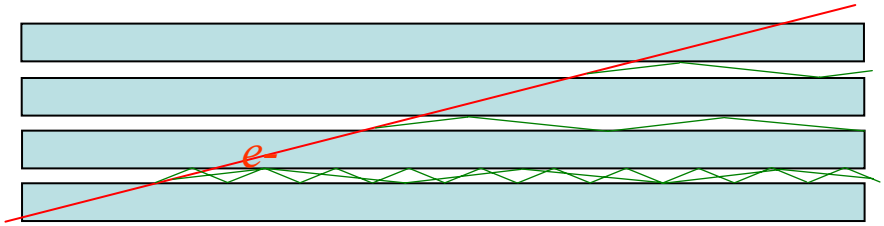
Ray Thomas, Texas Tech University – using an electron accelerator

ray.thomas@ttu.edu

$1/\lambda_{atten} = \alpha D^{\beta}$

D (MRad), α,β~ 0.3

Gas Cerenkov: Basic idea



- Shower particles generate Cerenkov light in gas between highly reflective metallic walls.
- Gas refractive index $n = 1+\delta$, where $\delta \sim 0.001$ for most gases at STP.
- Cerenkov angle is small: $\sin\ \theta_{\check{C}} \approx \sqrt{2\delta} \approx .05$
- Cerenkov threshold is high: $E_{th} \approx \frac{m_e}{\sqrt{2\delta}} \approx 11.2\ \text{MeV}$
- Cerenkov photons co-move with e+/- in a 15 ps pancake

Very radiation-hard: only gas and metal.

Does not "see" IP γ,e backgrounds nor radioactivation below10-20 MeV

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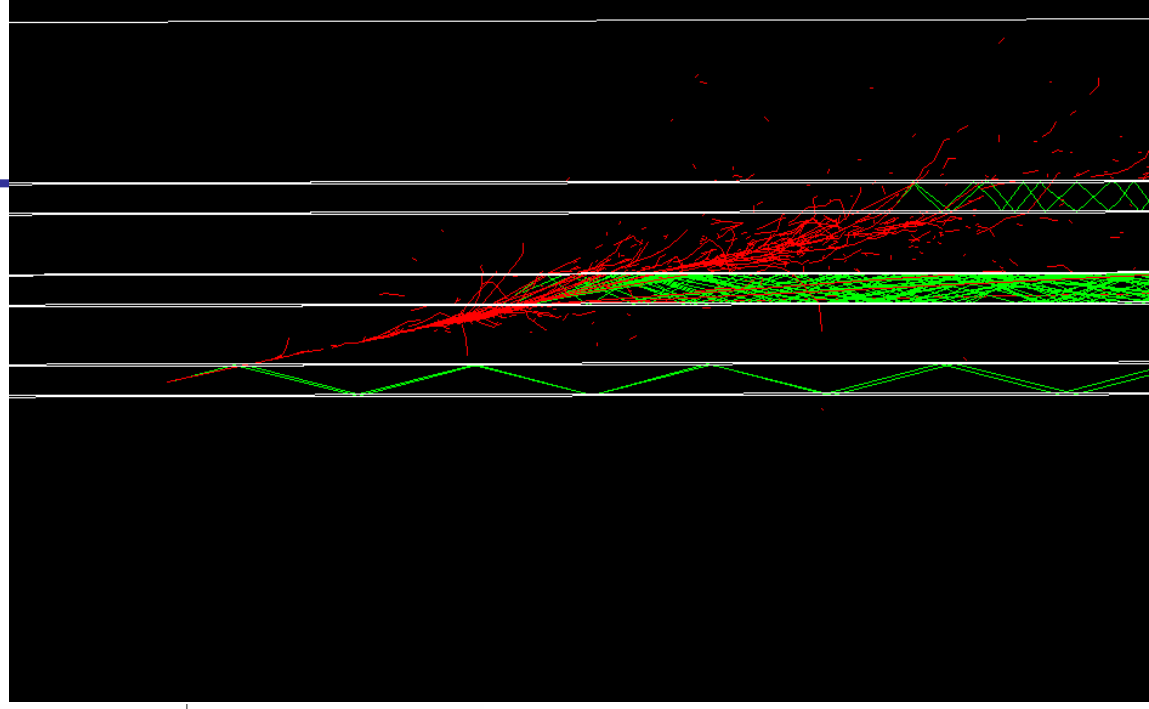
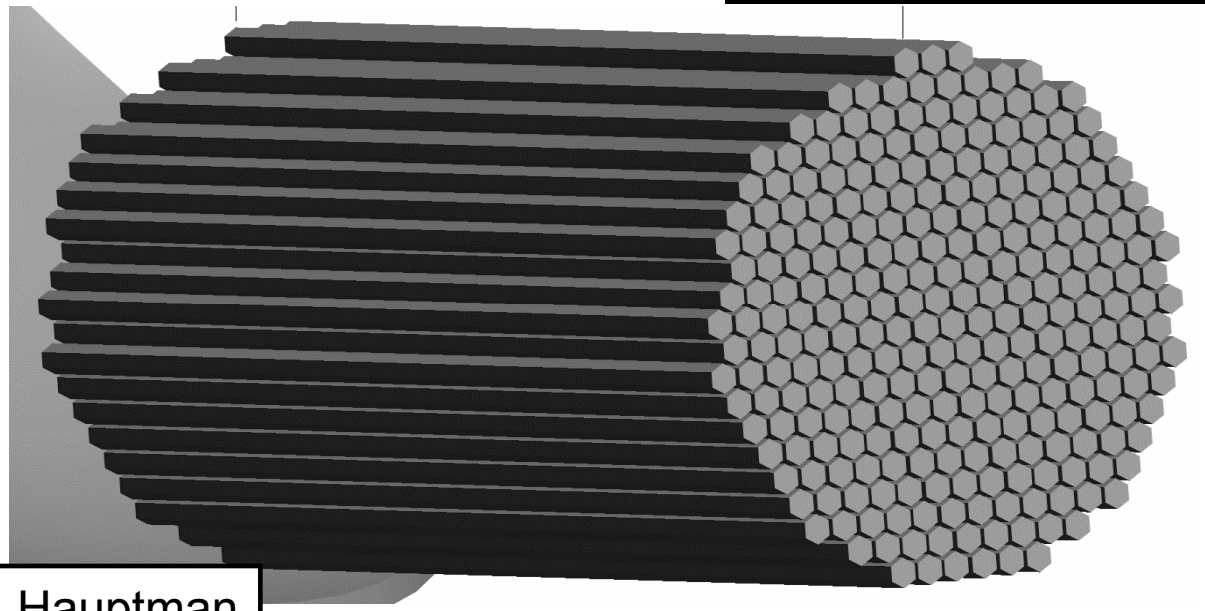
Gas Cerenkov



Hex simulation



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LCWS 2004

Expected signal size ~few photoelectrons/GeV?

Fast Photodetectors needed for both Quartz Fiber and Gas Cherenkov Calorimeters

Fastest PMTs: ~0.6ns risetime, 1.5ns FWHM

Micro-channel plate PMTs: 0.3ns FWHM possible with 2 x 10^5 gain
radiation damage issues

Other fast photodetectors?

Need R&D and design study to achieve a workable system, including:

- sub-1.5ns FWHM
- radiation hard or shielded location
- how much gain needed?
- geometry
- local GHz sampling or switching to capacitor array, which is robust against beam-induced EMI (similar issue for other technologies, including Si-W or diamond-W)

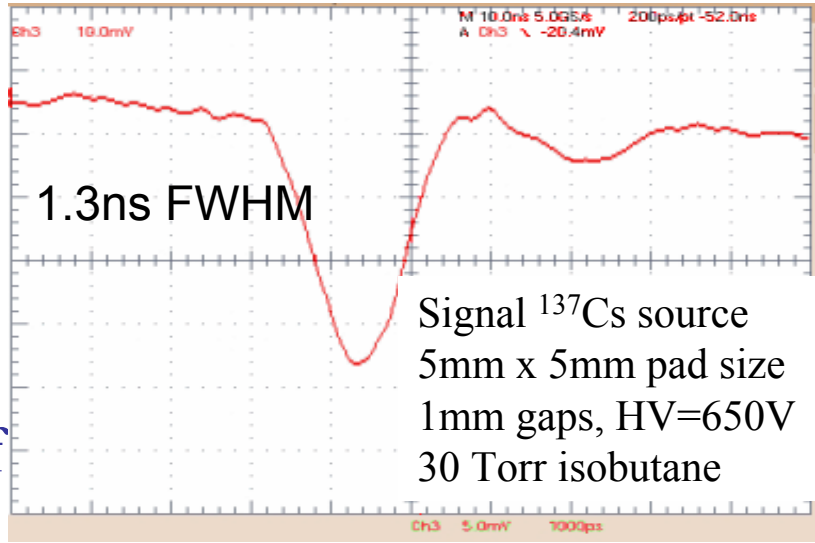
Typical low-pressure PPAC

Ed Norbeck
IPBI Meeting June 2, 2004

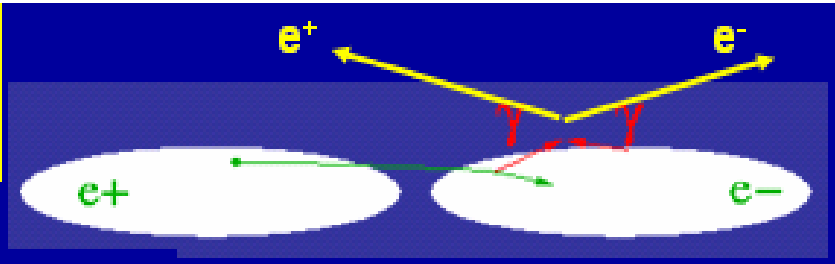
- Two flat plates
- Separated by 2 mm
- Filled with 10 torr isobutane
- MIPs often leave no signal
- 700 V between plates
- Used with 50 MeV/nucleon heavy ions

PPAC in Calorimeter

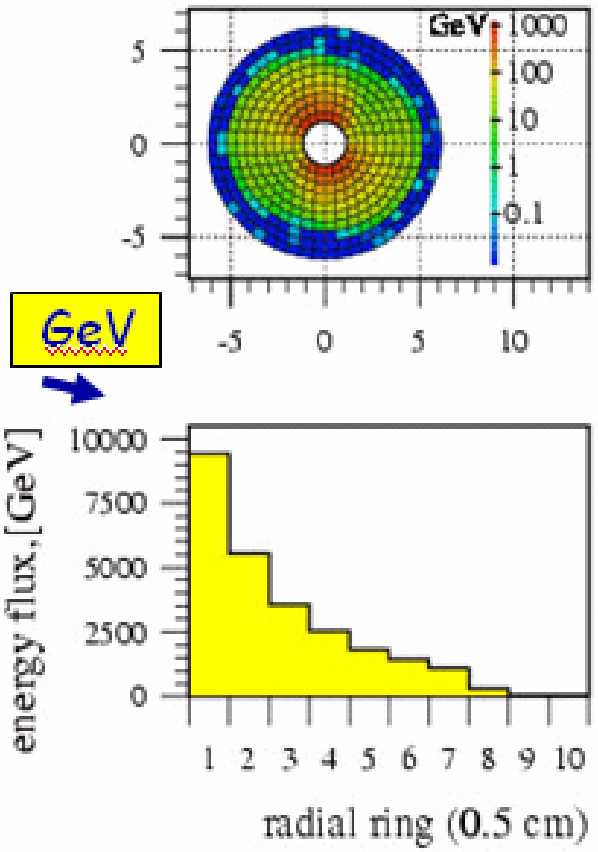
- Three flat plates, separated by 2 mm
- Middle plate at high voltage
- Outer plates hold atmospheric pressure
- Filled with 10-40 torr of a suitable gas
- Gas flows in one side and out the other
- Plate composition chosen to maximize signal, i.e. maximize conversion of photons to electrons



•Fast Beam Diagnostics (BeamCal)



- e^+e^- pairs from beamstrahlung are deflected into the LCAL
- 15000 e^+e^- per BX ⟶ 10 – 20 TeV
- 10 MGy per year ⟶ Rad. hard sensors



Technologies: Diamond-W Sandwich

Scintillator crystals

Gas ionisation chamber

W. Lohmann
LCWS 2004

• Fast Beam Diagnostics (BeamCal)

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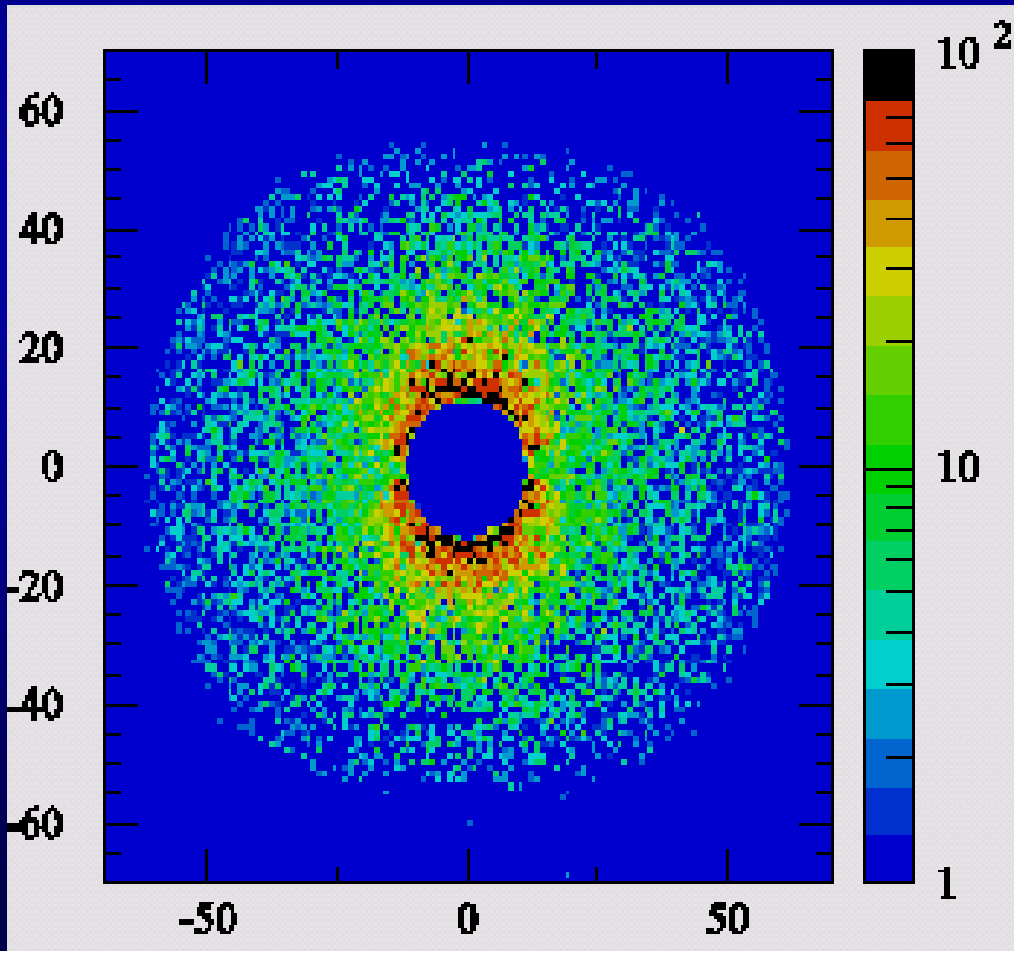
LCWS 2004

Observables

detector: realistic segmentation, ideal resolution
single parameter analysis, bunch by bunch resolution

- first radial moment
- first moment in 1/r
- thrust value
- total energy
- angular spread
- $E(\text{ring} \geq 4) / E_{tot}$
- (A + D) – (B + C)
- (A + B) – (C + D)
- E / N

forward / backward calorimeter



The very Forward Calorimeter Collaboration

Recent meeting in Prague, April 16.

see: PRC R&D 01/02

W. Lohmann
LCWS 2004

R&D for the TESLA Detector: Instrumentation of the Very Forward Region

Collaboration Meeting
Prague, 16. April 2004

- Vaclav Vrba: Silicon Sensor Status
- Wojciech Wierba: Silicon Sensor Development for the LAT Detector
- Katerina Kouznetsova: CVD Diamond Sensors for the Very Forward Calorimeter
- Irakli Minashvili: Dubna Activities
- Igor Emelianchik: Electronics for first Beam Test of Diamond Sensors
- Yuri Arestov: GaAs:Cr for HEP Radiation Tests
- Aston Komar: GaAs
- Wojciech Wierba: Laser Measurment of the LAT Detector Displacement
- Achim Stahl: Beam Monitoring from Beam Strahlung
- Leszek Suszycki: LAT Performance Studies
- ???: Fake showers at the border to ECal
- Ronan Ingbir: A Luminsoity Detector for the Future Linear Collider
- Karsten Büsser: Beam Induced Backgrounds
- Vladimir Drugakov: Impact of Bhabha Scattering on the BeamCal Performances