T958: Fast Timing Detectors

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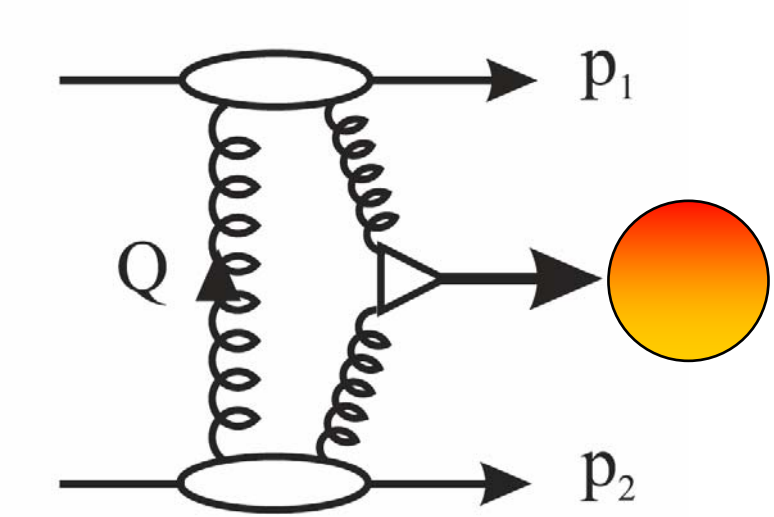
Physics Motivation: FP420 an R&D program to investigate feasibility of double proton tagging at 420m as a means to discover new physics/measure properties of new physics at LHC



Used to be called Double Pomeron Exchange

now Central Exclusive Diffraction

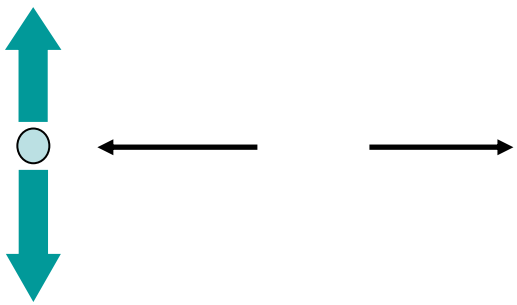
- Tagging the protons means excellent mass resolution (~ 2 GeV) independent of decay channel
- Selection rules mean that central system is dominantly 0^{++} (CP even)
- If you see a new particle in any decay channel with proton tags, you know its quantum numbers
- Proton tagging may be ***THE*** Higgs discovery channel in certain regions of the MSSM

Fast Timing Detectors for FP420

WHY? Pileup Background Rejection at LHC

Ex: 3 interactions, one with hard scatter, and two with diffractive protons increases with $\mathcal{L}^2$ (1% of diffractive protons within acceptance of FP420 proton detectors) . Kinematic cuts give large rejection, but more needed.

How?



Compare z-vertex of central system from SVX (50 μm) with that from TOF of protons

$z=c(TR-TL)/2$

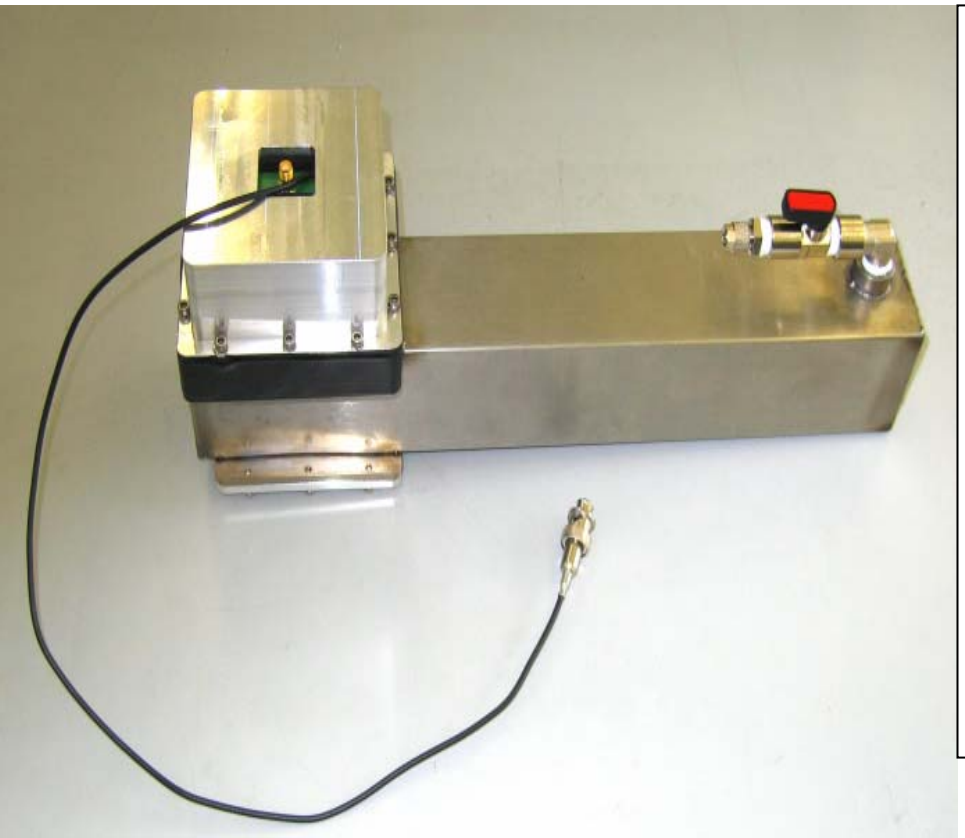
How Fast?

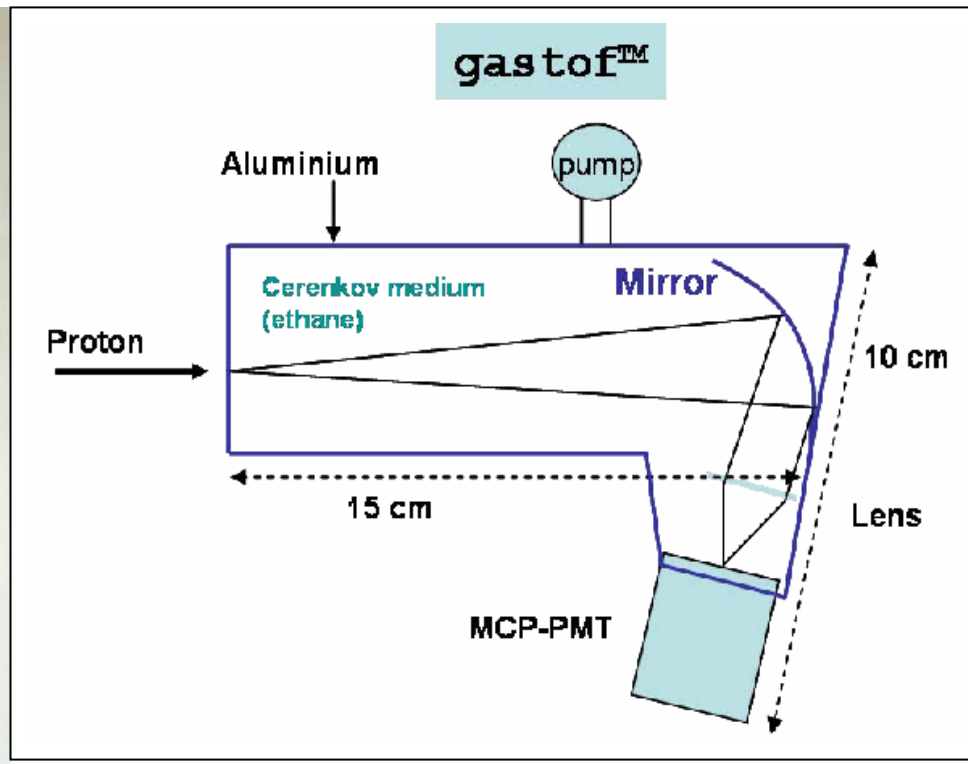
δz (mm) $=0.21\ \delta t$ (psec)
(2.1 mm for $\delta t=10$ psec)
(width of luminous region =7 cm)

10 psec -> ~x40 rejection

The Detectors : 1) GASTOF

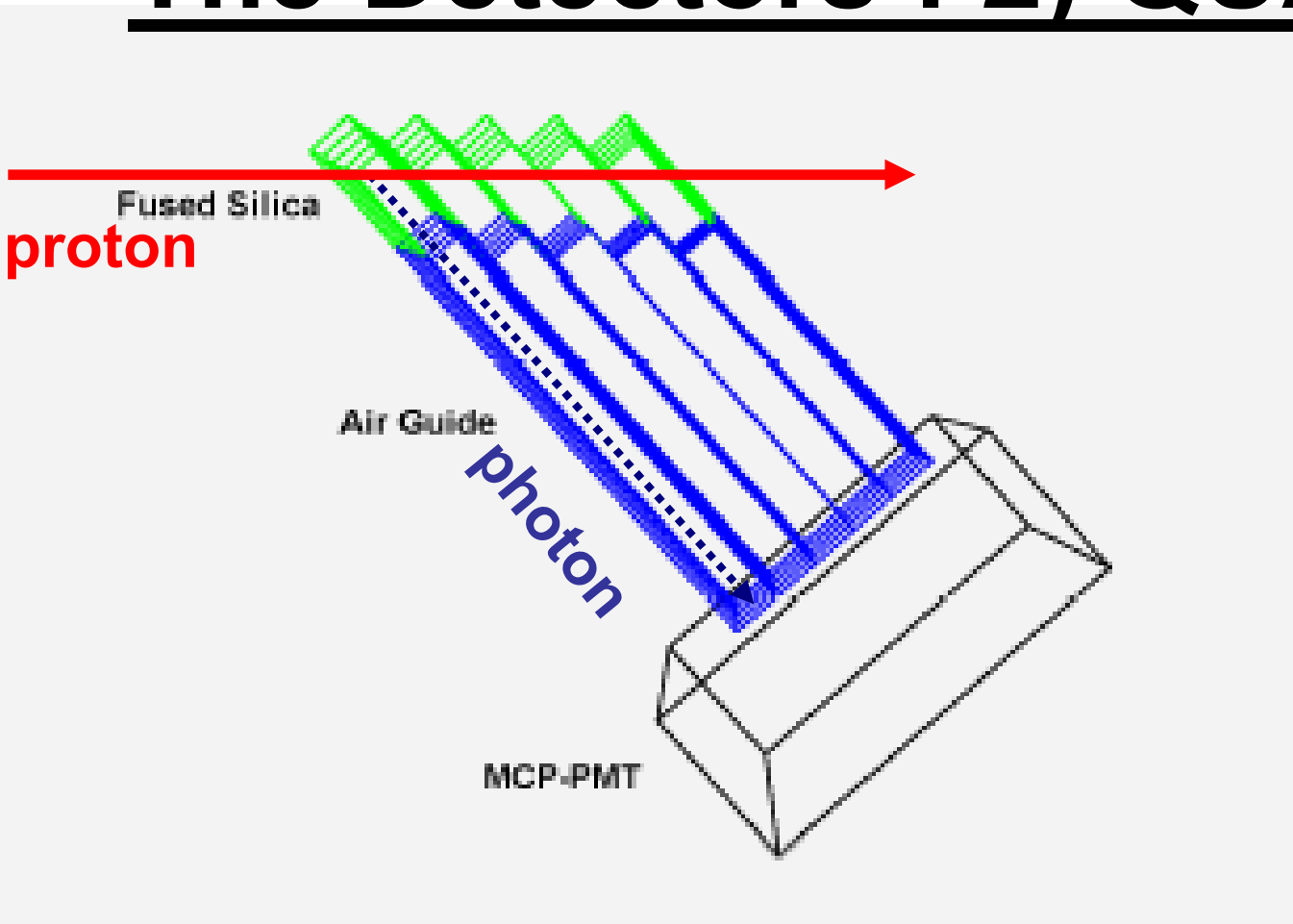
(Louvain)

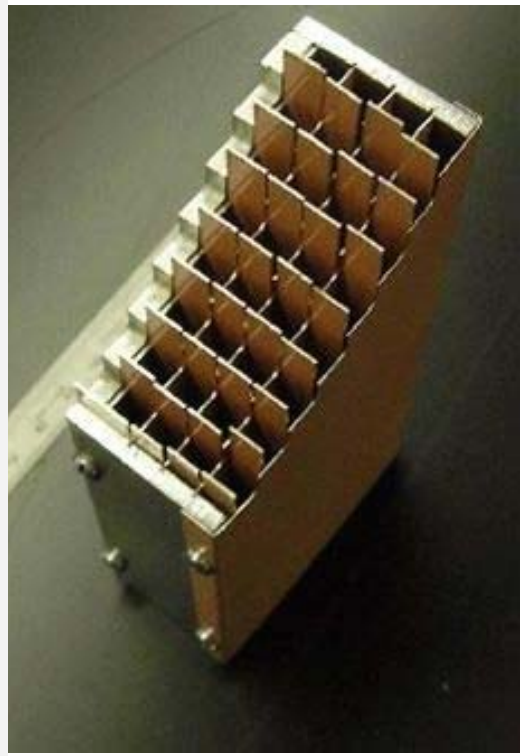




Presents little material to beam, extremely fast

The Detectors : 2) QUARTIC





Segmented, provides multiple measurements

T958

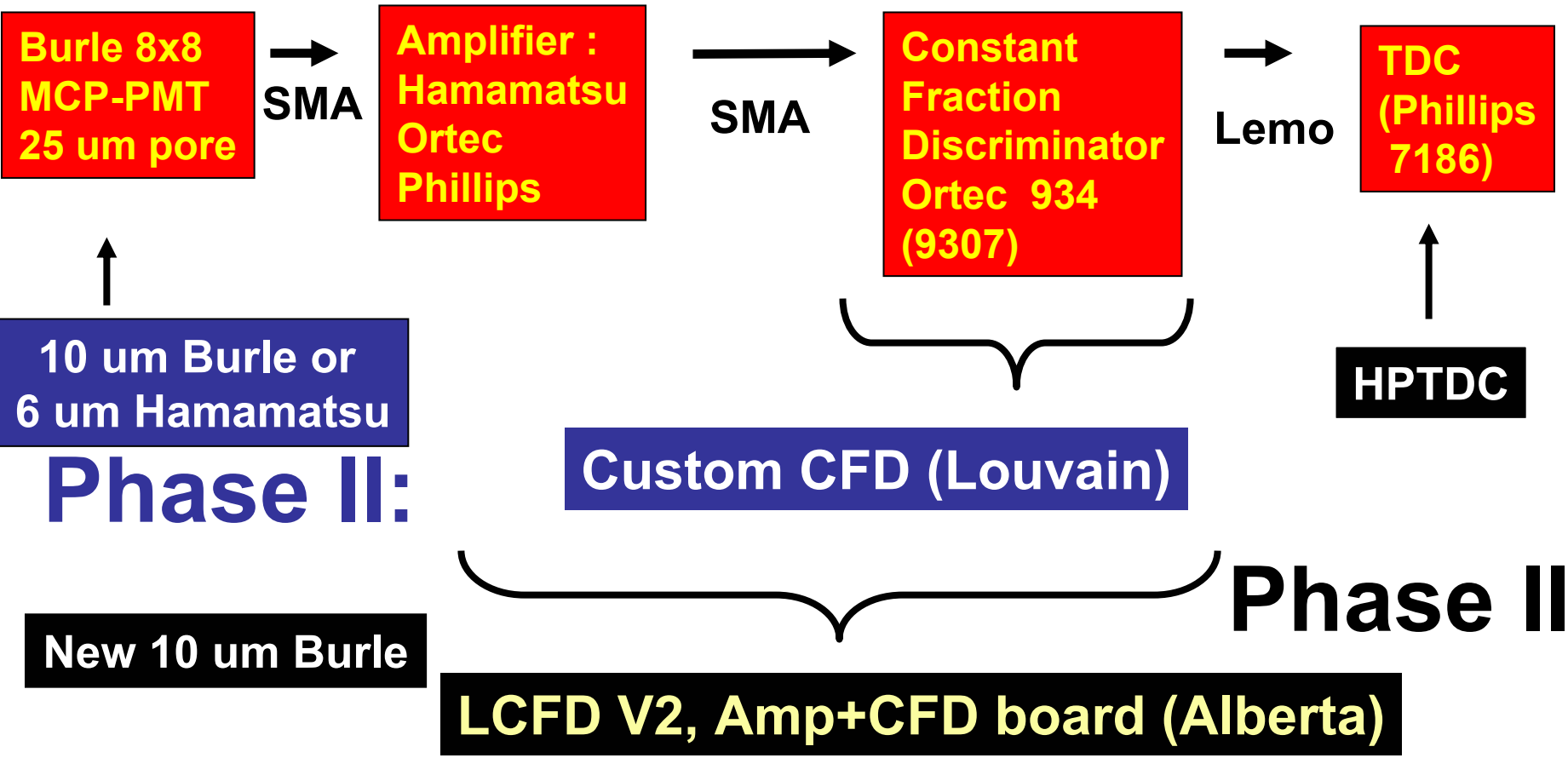
- Fermilab (MTBF) Test beam experiment to study fast timing counters for FP420 (Brandt spokesman)
- Used prototype/preprototype detector with NIM/CAMAC to test concept in Fall 2006, Mar 2007
- Next run planned July 11-18 2007

Time resolution for the full detector system:
1. Intrinsec detector time resolution
2. Jitter in PMT's
3. Electronics (AMP/CFD/TDC)

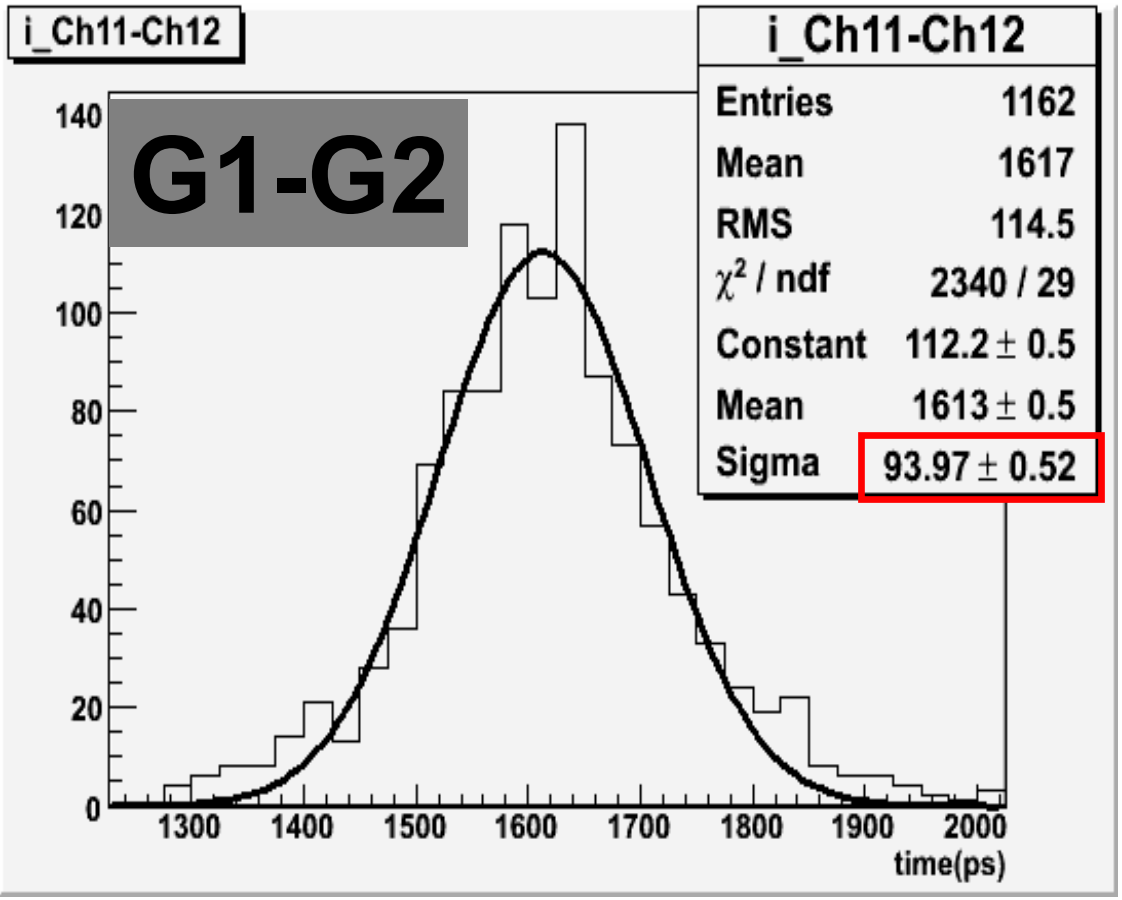
UTA support from Texas ARP program/ DOE ADR

T958 Electronics

Phase I:



First TB Results



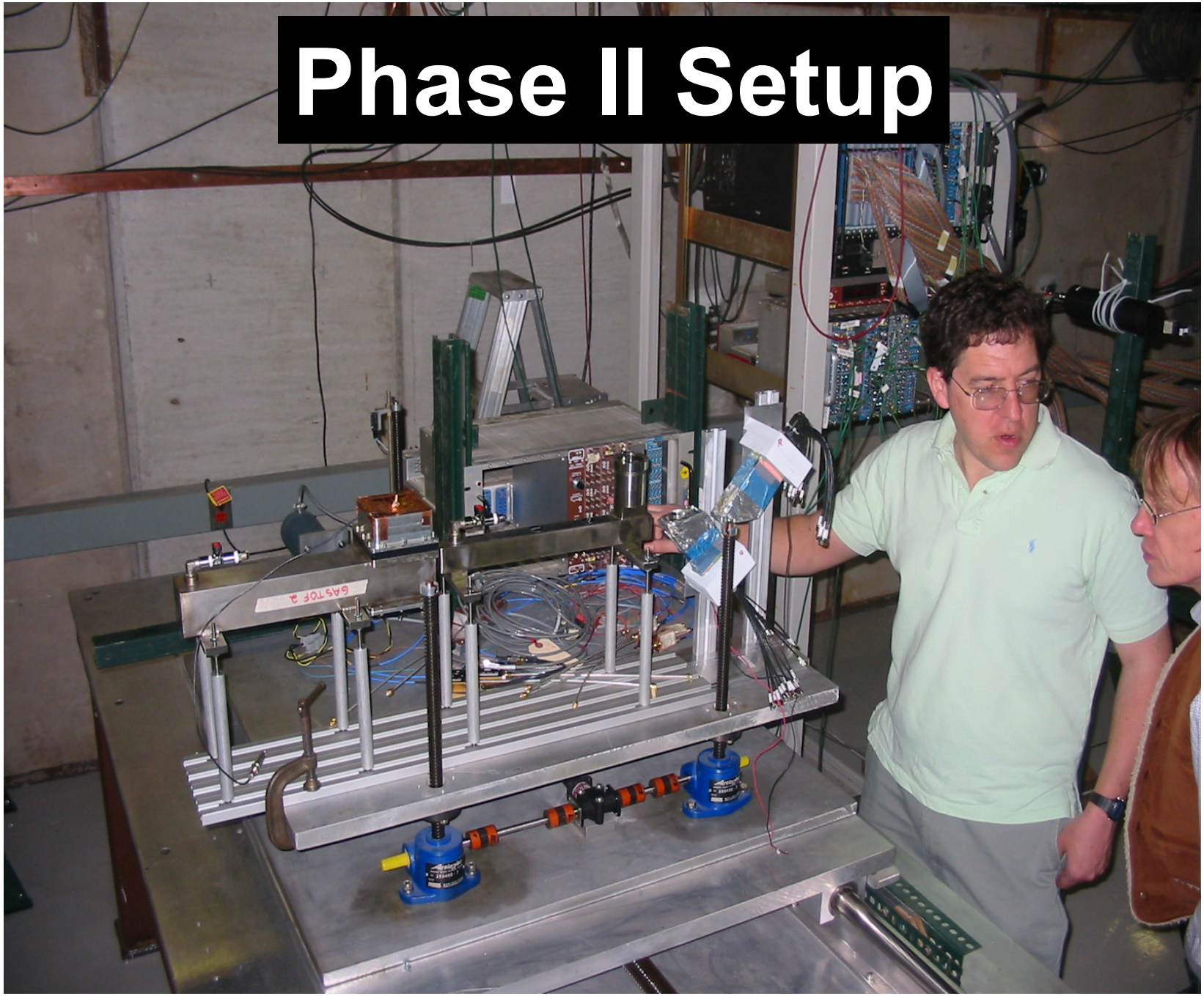
- For QUARTIC used a 4-bar, one row prototype
- Average QUARTIC bar resolution: 110 psec
- Efficiency 50-60%
- Resolution dominated by electronics

For events with a few bars on see anticipated √N dependence

<70 psec/GASTOF

>90% efficiency

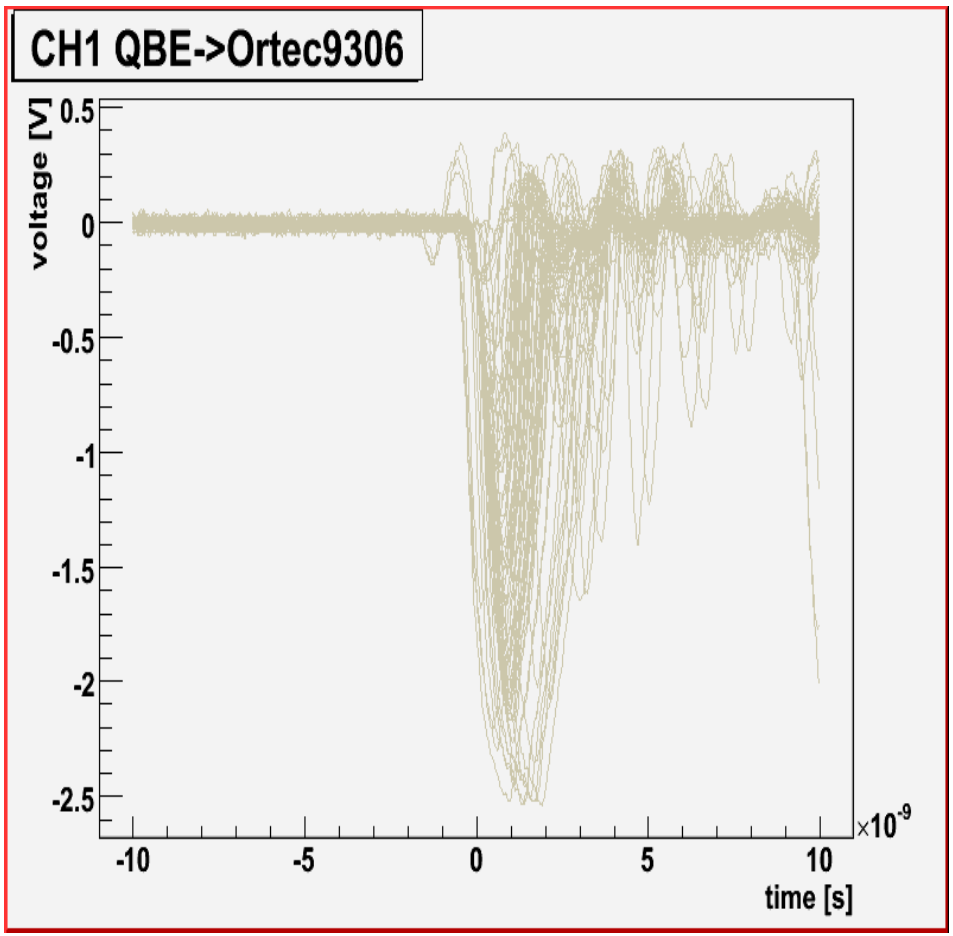
Phase II Setup

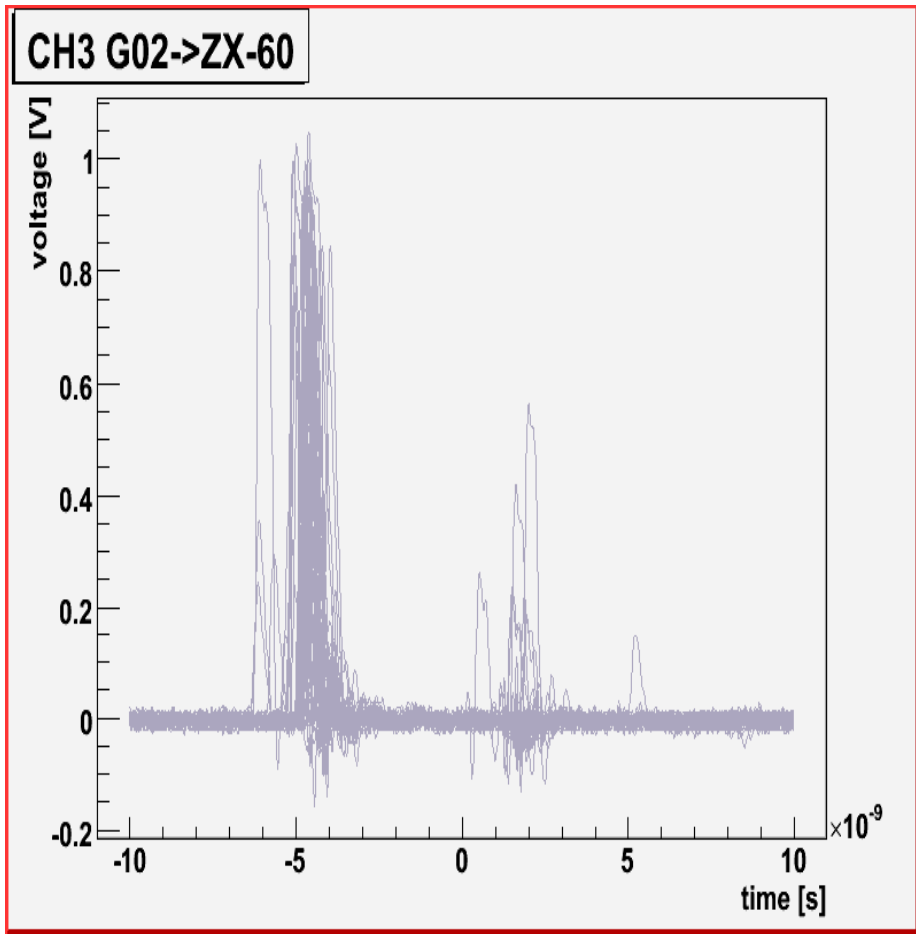


Scope (Tektronix DPO70404) Analysis

Waveform2 sample 755 events: Trigger Ch3xCh1

CH1:QBE CH2:G01 CH3:G02 CH4:QBD





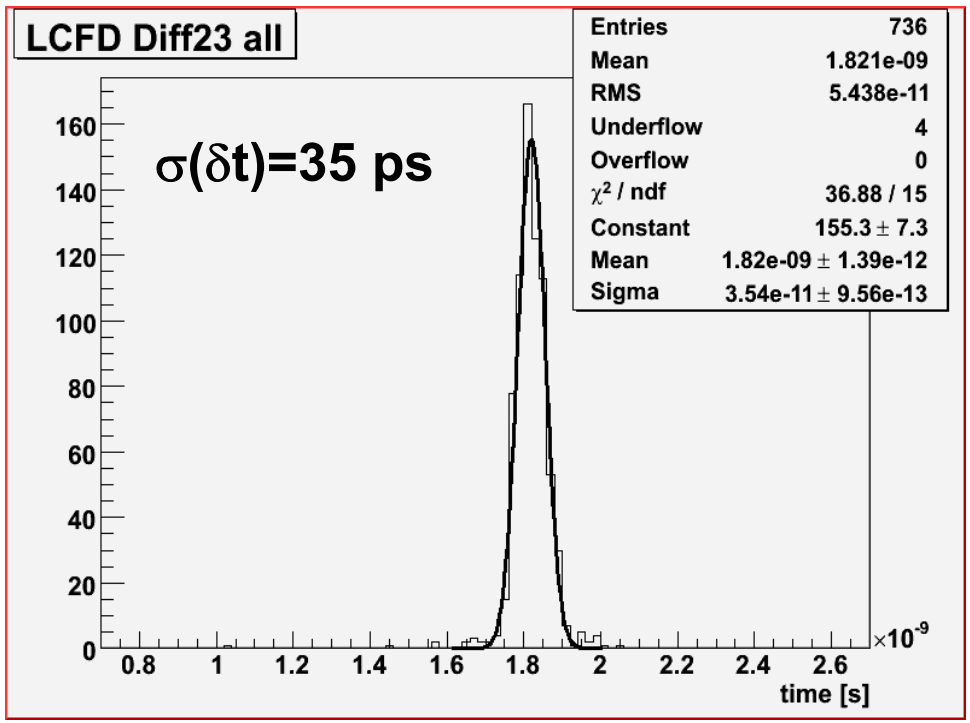
TB Phase II Analysis

I) Pedro Duarte (UTA) data analysis of CAMAC data (TDC, tracking) leads to understanding of coherent noise, tracking, efficiency (~80% for Q-Bar), cross talk.

II) Tomek Pierzchala (Louvain) scope data analysis gives data base of pulses, allows separation of detector/tube response from electronics.

Scope Analysis

Time difference of (old G01 and new G02) GASTOF counters



CFD algorithm simulated

From fitting all pairs of differences:

individual counters	
σ(G01)	32 ps
σ(G02)	13 ps
σ(QBE)	68 ps
σ(QBD)	52 ps

Conclusions

GASTOF works well, some concerns about new G2 efficiency, will study in next run

QUARTIC:

Run I: Average QUARTIC bar resolution 110 ps dominated by electronics
Showed improvement of resolution using several bars; efficiency 50-60%

Run II: Average QUARTIC bar resolution 82 ps ~equal contribution from detector/PMT and electronics; efficiency 80%

With no further improvements already have an integrated detector with about 20 psec resolution (For two QUARTICS with 8 bars each 82/√13=23)

Next steps:

Need to study correlations/cross talk further (new Burle tube)
Test next generation of electronics
Q3 design (try to get more light with modified geometry/optimized bar length)