Hyperfast time of arrival measurement for pileup Mitigation in CMS Phase II Upgrade

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Clermont-Fd, March 14, 2014

More detailed presentations

over last 1-1/2 years in forward calorimeter task force

Paris calorimeter conference '13

Corfu summer school

Last week's picosecond timing meeting in Clermont-Fd.

Here: our paper at this week's ACES2014 mtg.

Development of Precision Timing Pileup Mitigation Tools within the Context of a Dual Readout Calorimeter for CMS: *Proposal Submitted to US-CMS*

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Electronics Challenges for HL-LHC pileup Mitigation with HyperFast Timing

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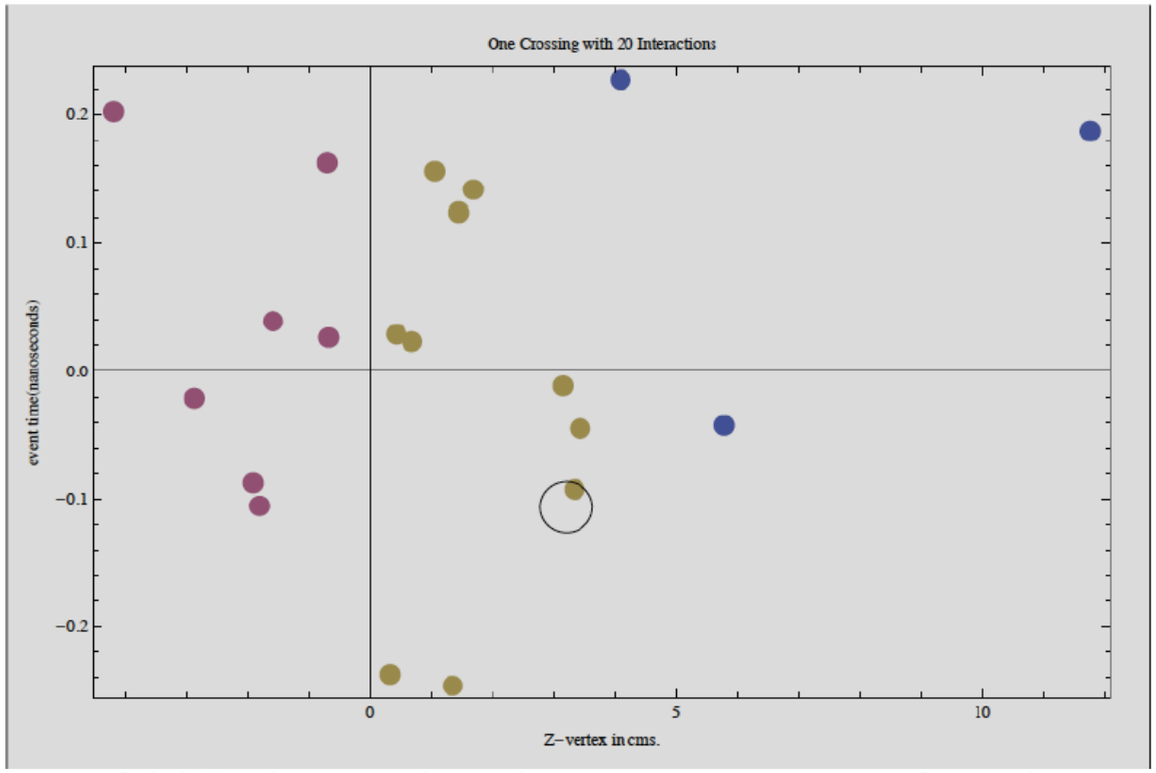
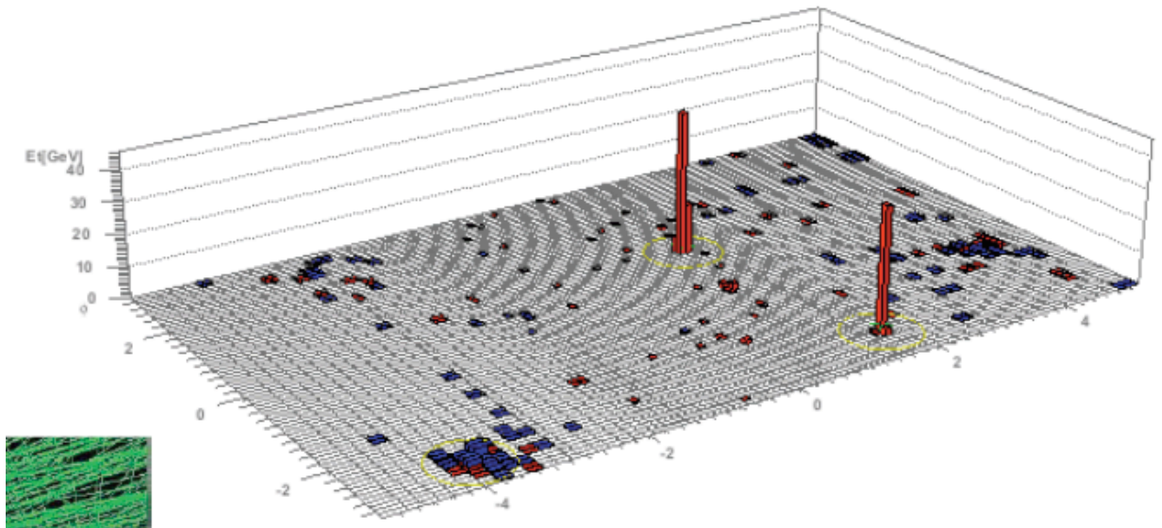
ACES2014@CERN Mar. 18-19,2014

LHC bunch crossing in space and time



- w. LHC design book parameters z-distribution invariant wrt time and vice versa
- time and z measurement are both potentially tools for pileup mitigation



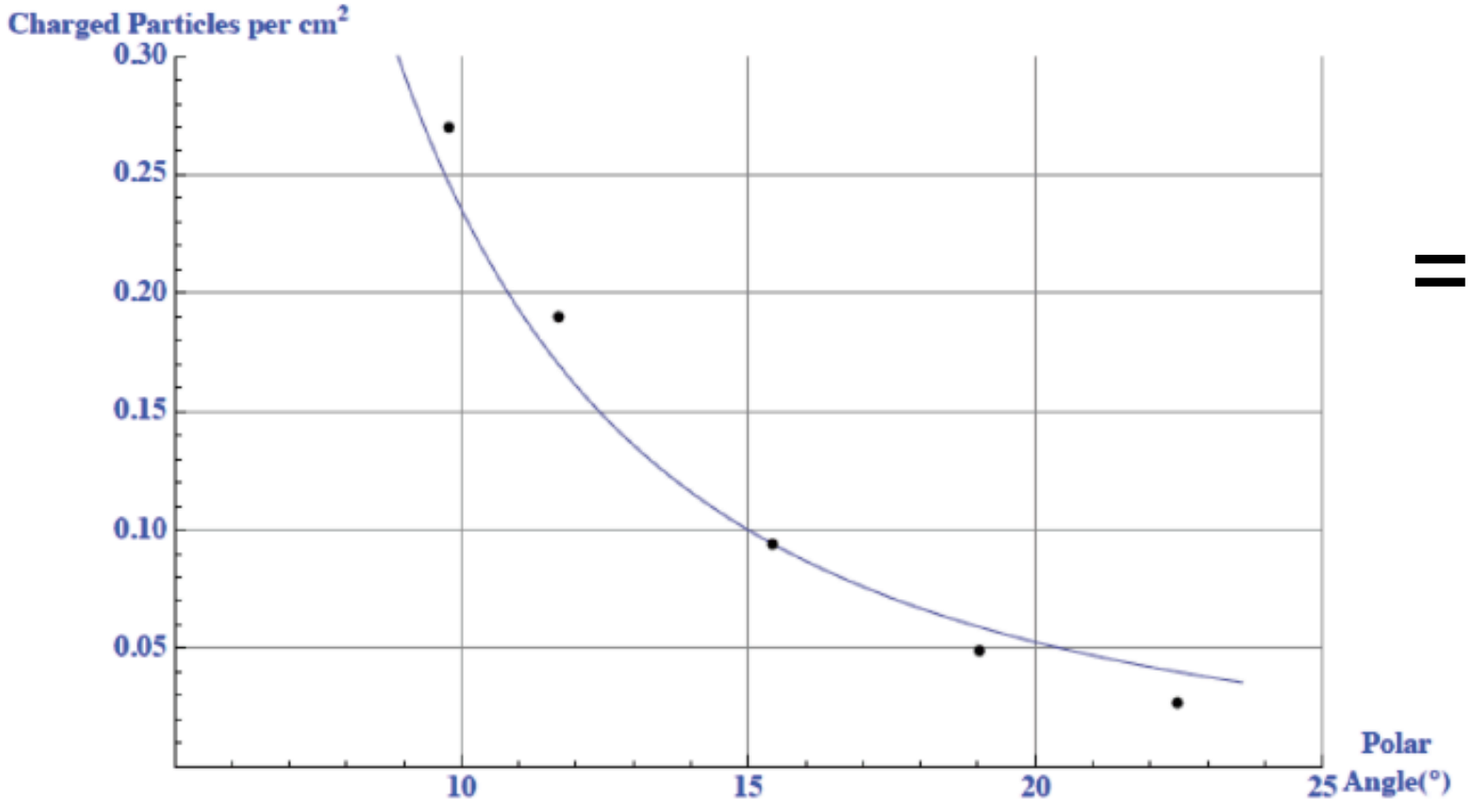
in above Higgs->2 gamma and proton jet fragments observed very forward region

goal of pileup mitigation in endcap region
is to reduce background to eg. VBF jets and MET

Dedicated timing detector layer in current CMS pre-shower volume for TP simulations

Charged Particle Density, μ=140
Points= 'total charged'– Fluka Output

$$\text{line= } 5*\text{primary}\frac{dn^{ch}}{d\eta}$$

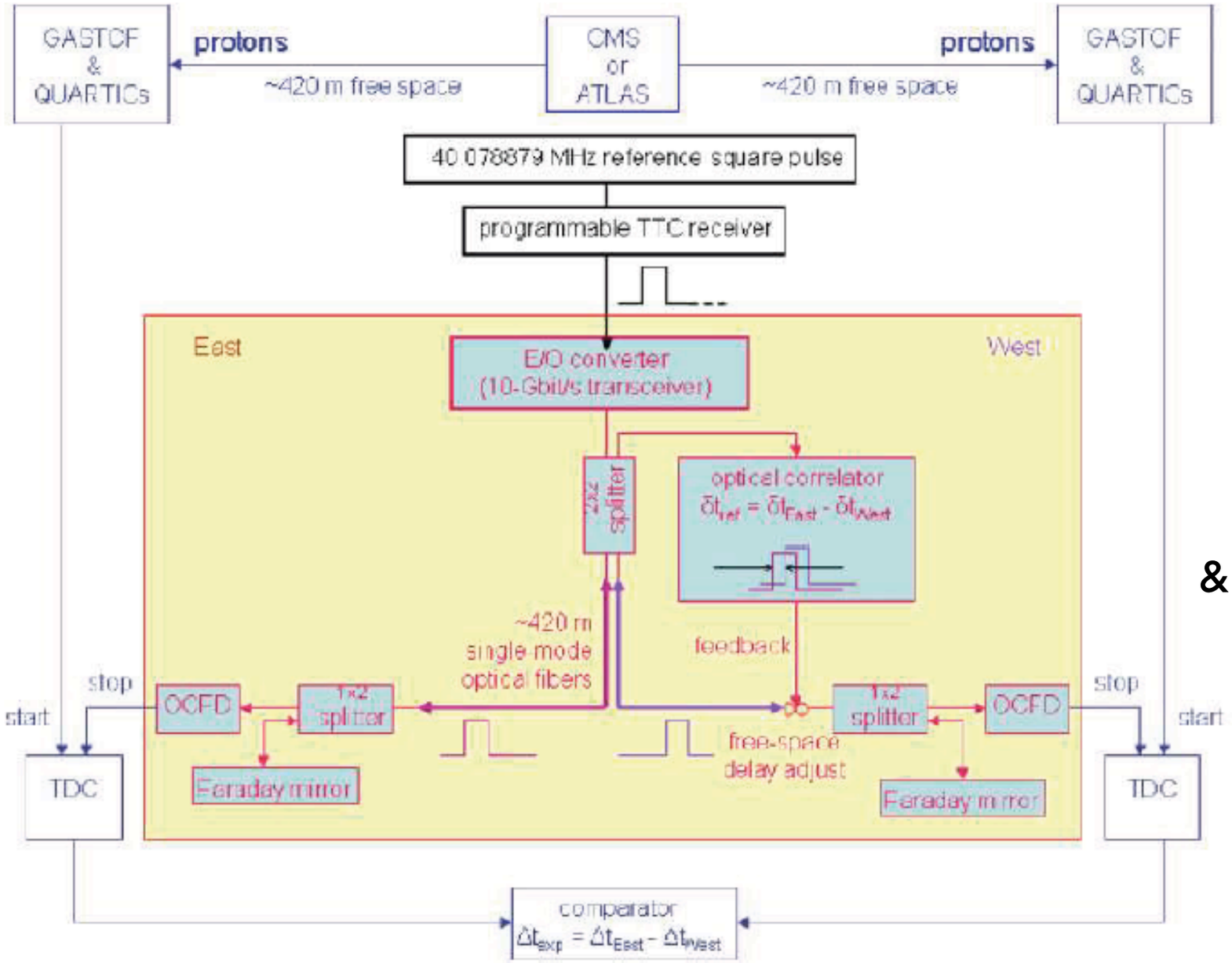


Fluka HL-LHC calculation shows 1 cm**2 is about right pixel size

=> large pixel size Si detector convenient but hard to maintain good signal risetime and response with larger C_{Det}(50-60 pF).

In this presentation discuss fe electronics solution.

Ancilliary systems (ie clock distribution)-
we' ve found cost effective solutions



$60k clock distribution developed for FP420 (Tsang and SNW-2008)

similarly recent developments in waveform digitizers at Orsay/Saclay, PSI, Chicago, Hawaii &HPTDC ASIC development @CERN -see Clermont Fd. picosecond meeting last week

Sensor technology

- previous picosecond timing developments not optimized for $10^{6\text{-}7}$Hz/cm^2 (eg ALICE TOF, MCP-PMTs, etc)
- solid state sensor SNR an issue (ie CVD diamond)
- conventional Si sensors limited by
  - weighting field uniformity
  - Landau/Vavilov fluctuations
  - SNR

hyperfast Si sensor development

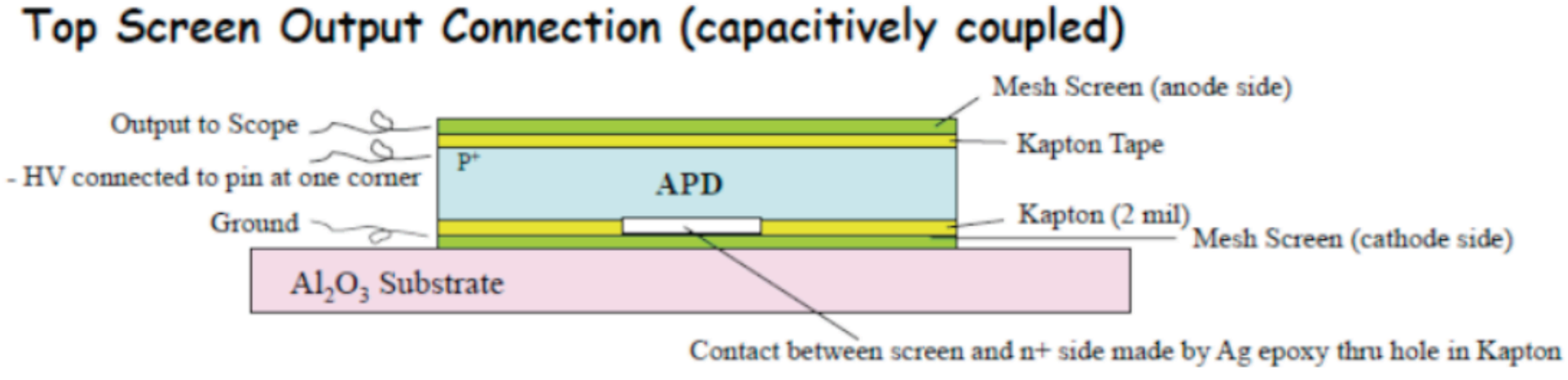
over past several years our collaboration has worked w. RMD/ Dynasil on developing a solution to these limitations

=>Deep Depleted APD/w. Micromegas mesh readout

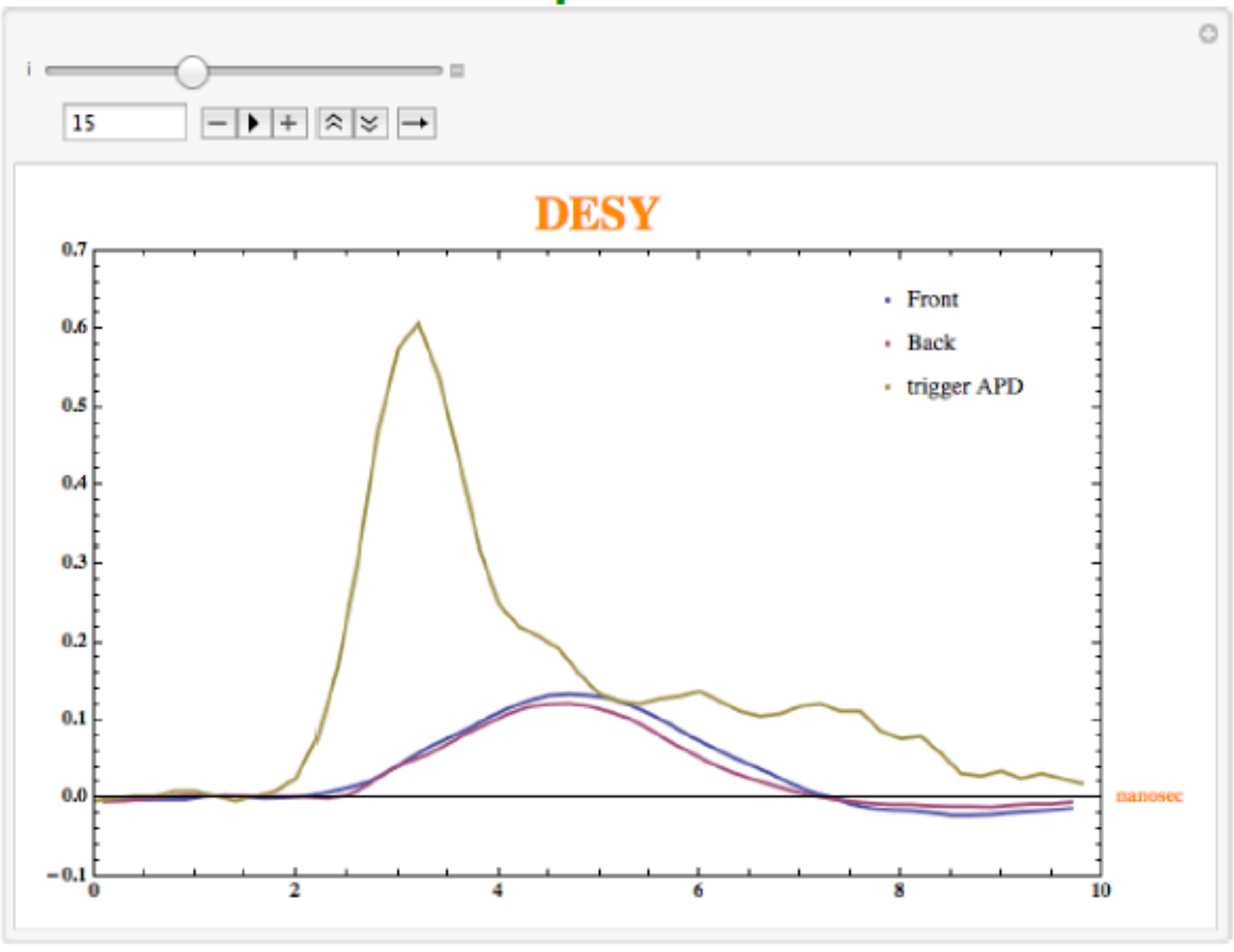
- Large MiP signal (3600 eh pairs*520 internal APD gain)
- weighting field controlled w. scinterred Au(bottom) and MicroMegas(top) layer
- Landau contribution limited to <9 picosec w. 80% eff' n

This technology has several other benefits:

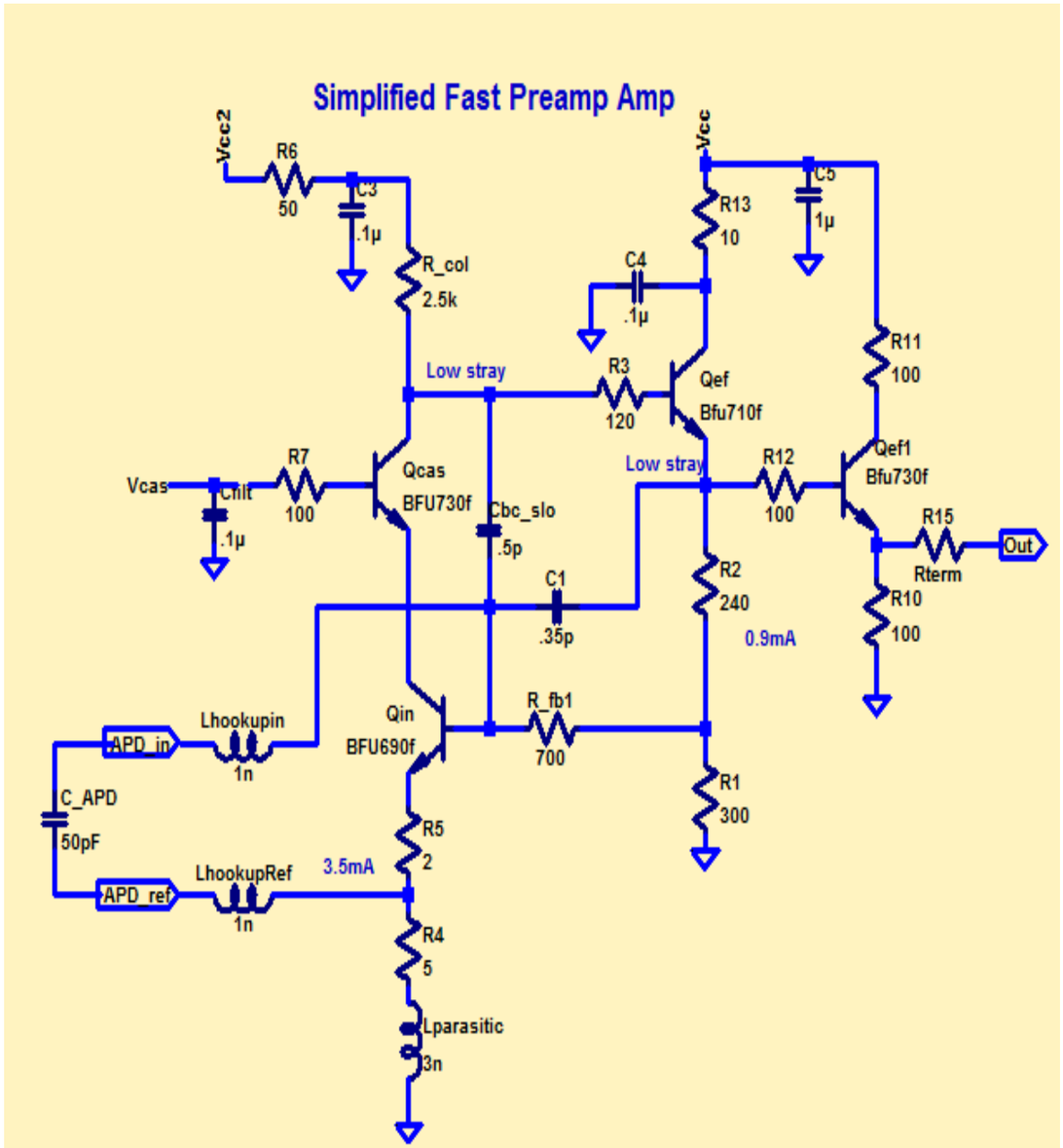
- eliminates need for blocking Cap.
- reduces(eliminates?) effect of R_S
- big reduction in time walk and jitter



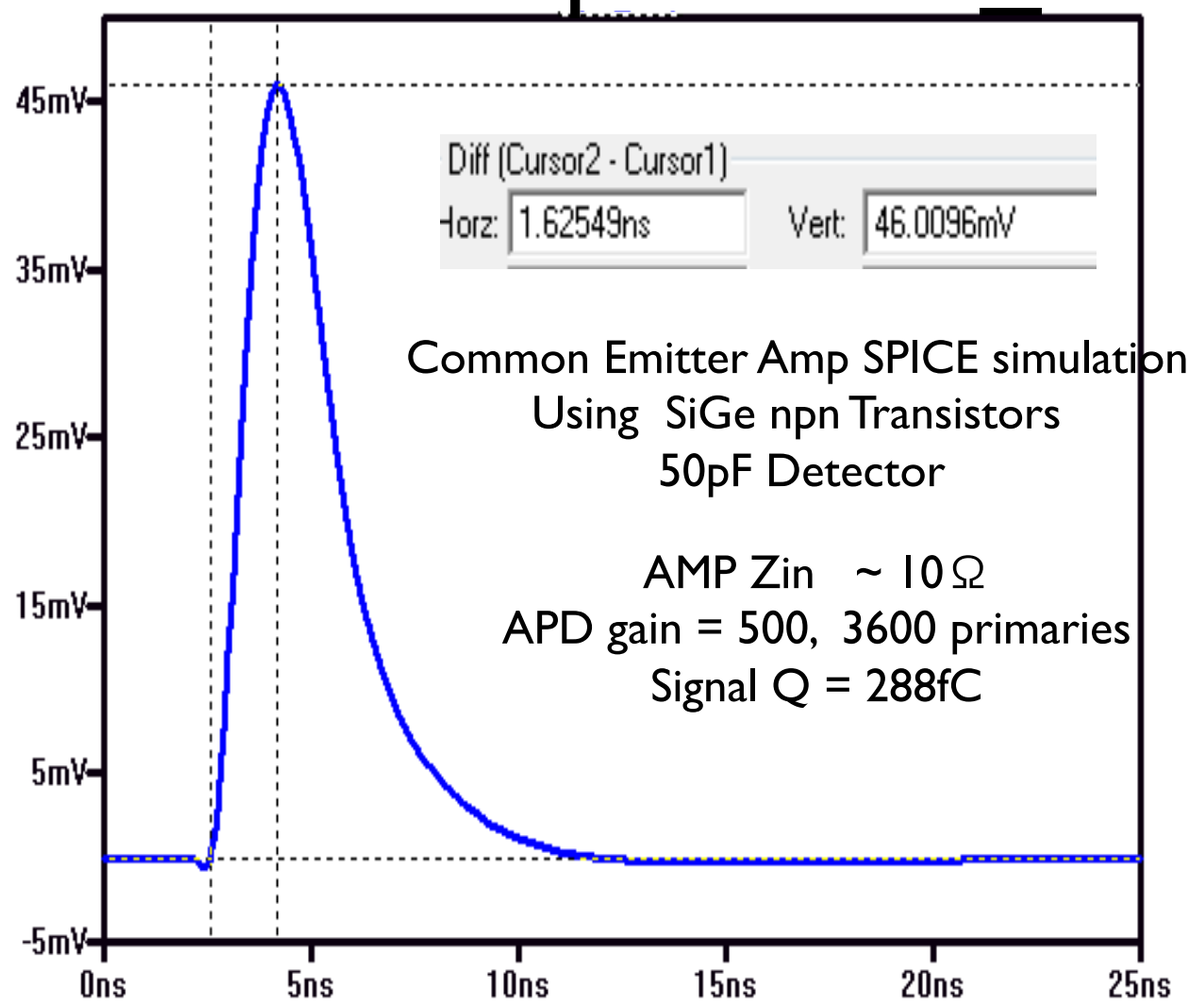
Expected features reproduced in DESY data



Peak amplitude 1/5 that of 4 pF detector
in large area 60 pF detector
and
Risetime degraded from 0.7 to 2 nsec when using 50 ohm voltage amp
We expect significant improvement in Spring PSI run w. new amp.



Preamp Out AC_Vout



Common Emitter Amp SPICE simulation
Using SiGe npn Transistors
50pF Detector

AMP Zin ~ 10 Ω
APD gain = 500, 3600 primaries
Signal Q = 288fC

APD Preamp Objectives ~1ns Risetime, Low (series) noise,

- **Low RinCTotal Time Const. → Remove as much charge as possible APD Fast APD signal RinCTotal ≈ 1ns → Rin ~ < 20 Ω**
- **Limit Amplifier Series Noise Use Low rbb' bipolar Input transistor.**
- **Gain BW ~ >1GHz → Choose Fast Bipolar Transistors**
- **Connections Short, Low inductance → Amplifier within CM of detector**

Backup slides