
# Tracking R&D at SCIPP:

# Time-Over-Threshold Readout

# Long Ladder Readout Noise

# Non-Prompt Tracks with SiD

**Oregon ALCPG Linear Collider Workshop**
**March 19-23 2010**

# Time-Over-Threshold (TOT) Readout: the LSTFE

Pulse-development simulation ➔ no loss of accuracy for TOT readout (relative to direct ADC conversion)

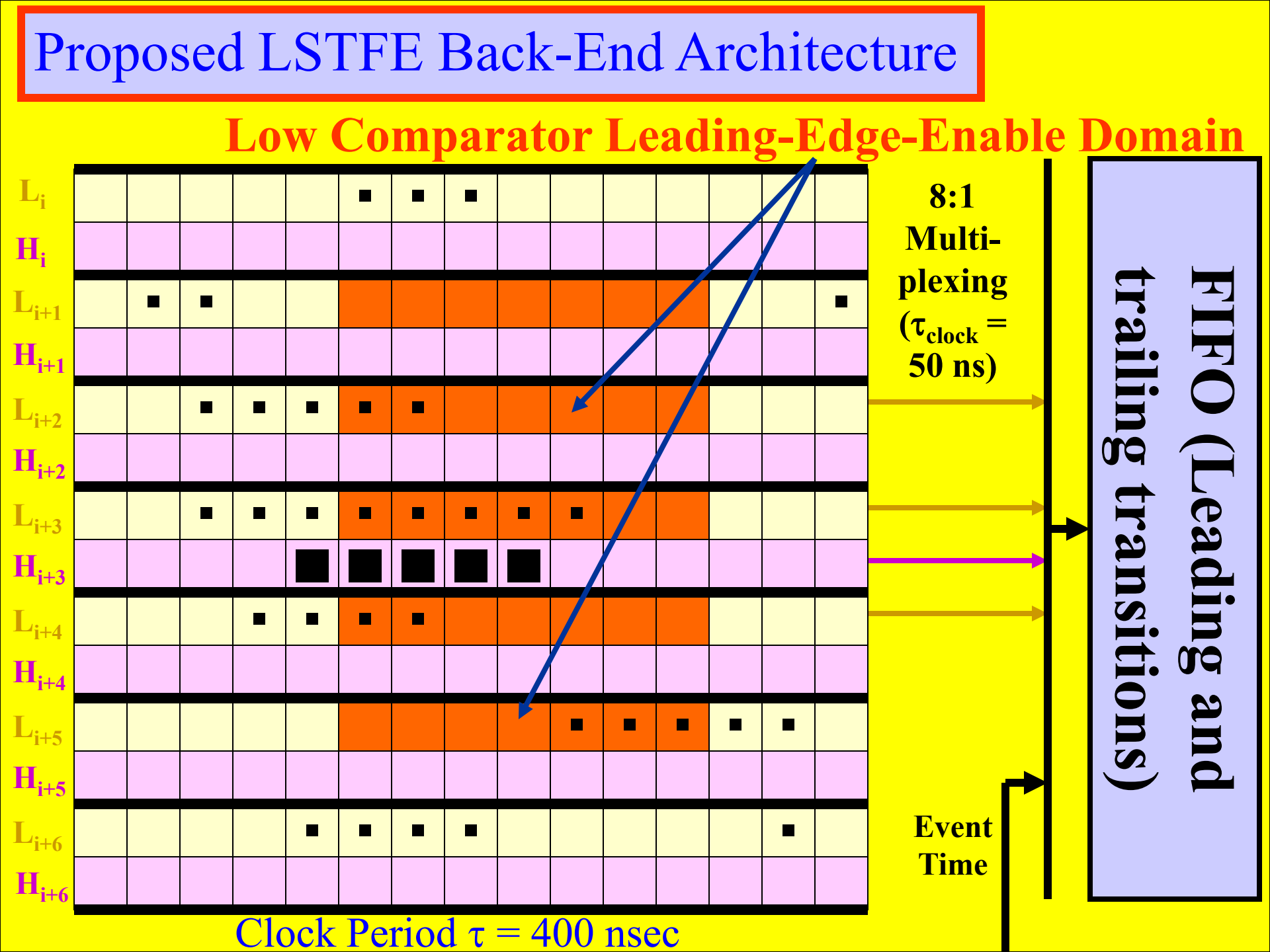
Targets low-complexity, long-ladder tracking solution

Real-time readout stream favorable for forward tracking also

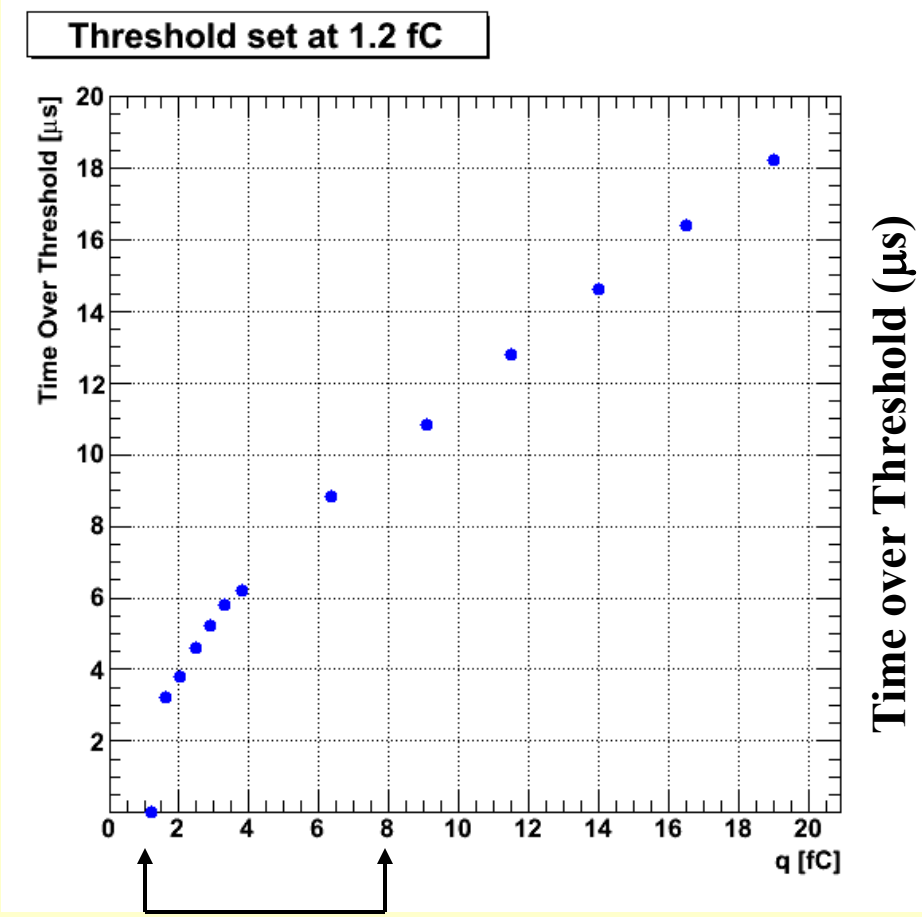
LSTFE-I prototype relatively successful; LSTFE II under testing. Upgrades relative to LSTFE-I include

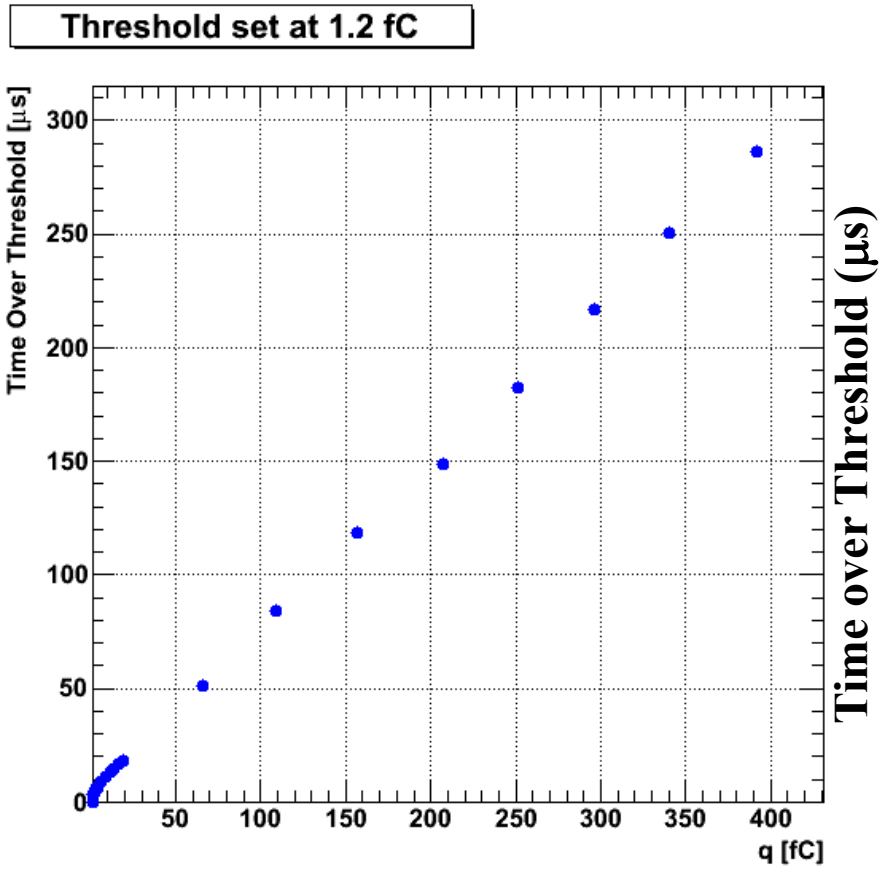
- Improved environmental isolation
- Additional amplification stage to improve S/N, control of shaping time, and channel-to-channel matching
- Improved control of return-to-baseline for < 4 mip signals (time-over-threshold resolution)
- 128 Channels (256 comparators) read out at 3 MHz, multiplexed onto 8 LVDS outputs

# Proposed LSTFE Back-End Architecture



# Some early results: TOT respone

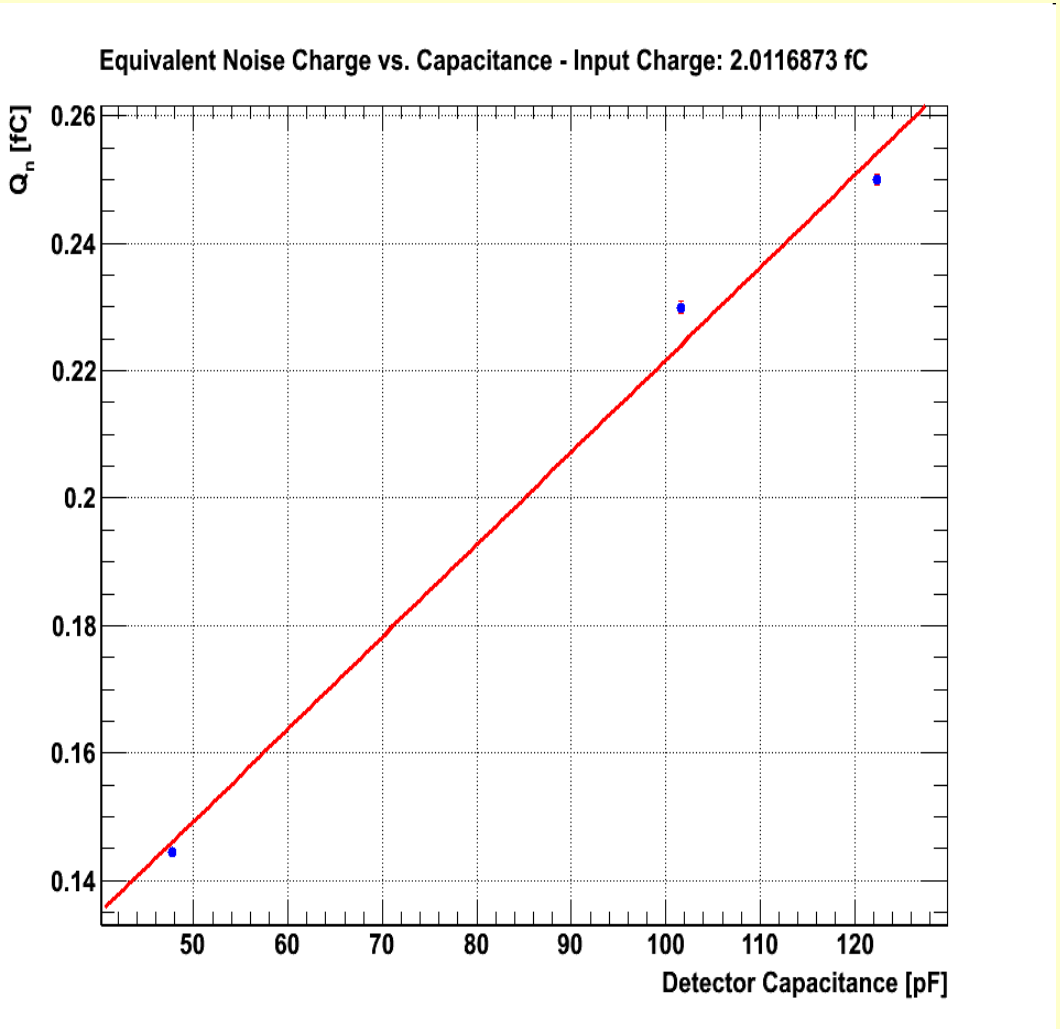



Minimum ionizing region

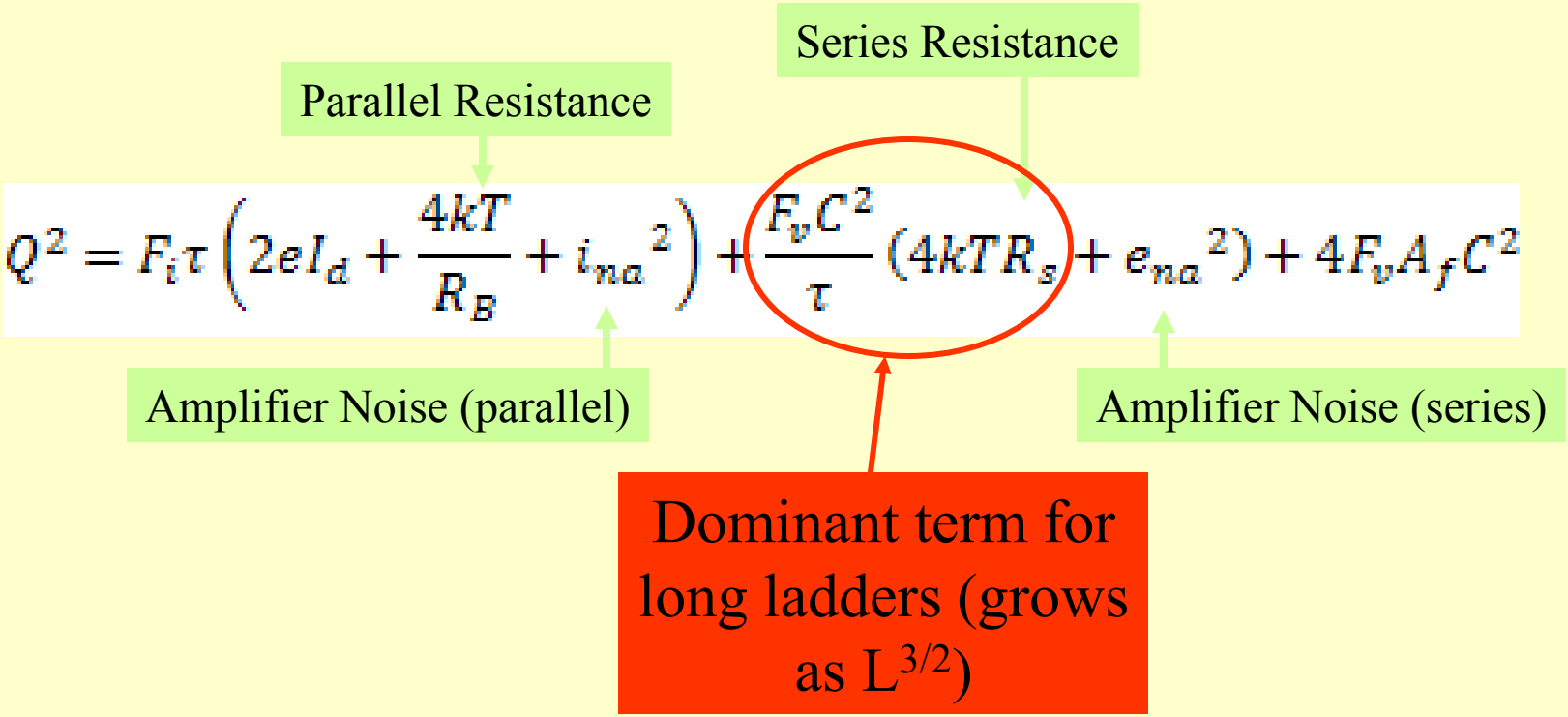
Very uniform response for large pulses; increased sensitivity in min-i region

# More early results: Noise v. Capacitive Load




Result at 100 pF (optimization point): 1375 electrons noise, but without detector resistance (distributed RC network)

# Standard Form for Readout Noise (Spieler)

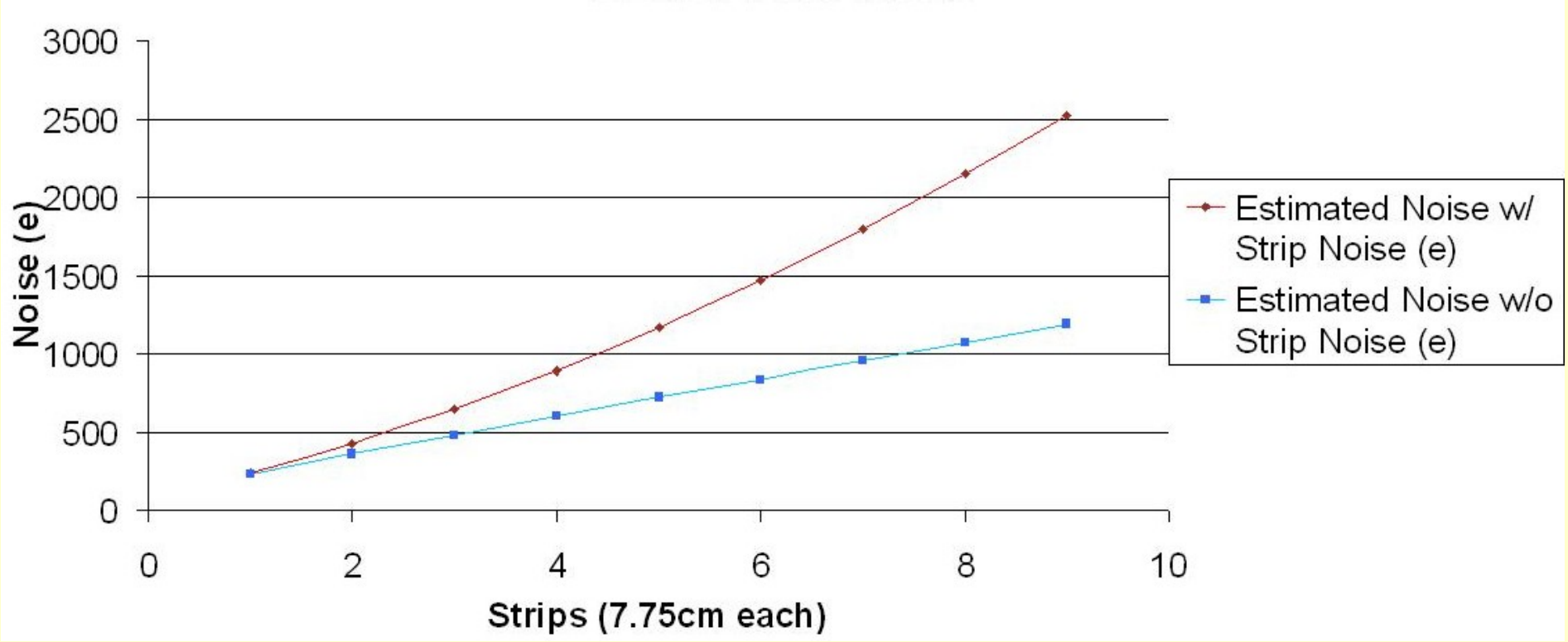



$F_i$, $F_v$ are signal shape parameters that can be determined from average scope traces.

# Long-Ladder Readout Noise

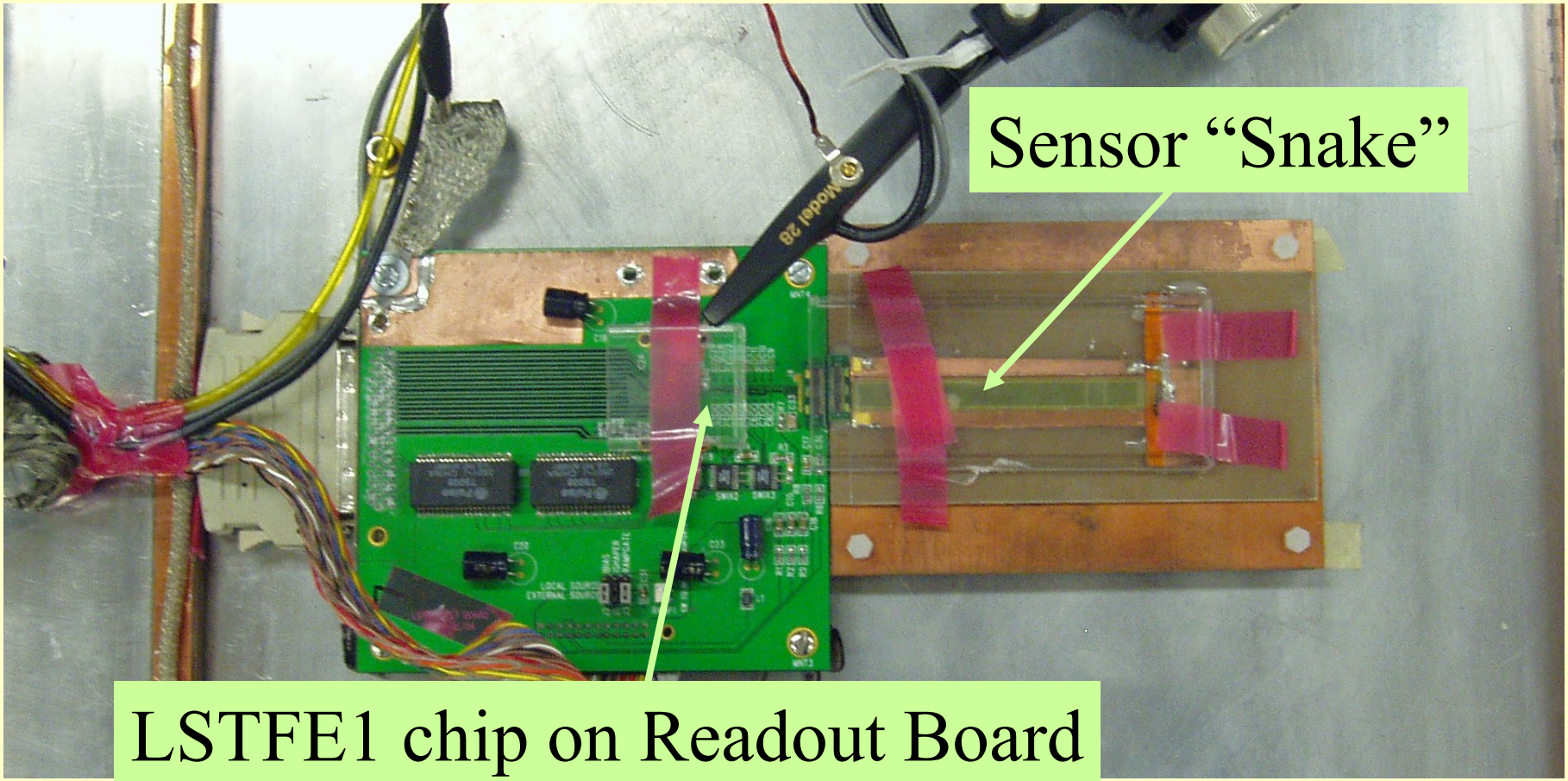
Probe conventional notions about dependence of readout noise on distributed capacitance and series resistance

# Expected Noise vs. Ladder Length



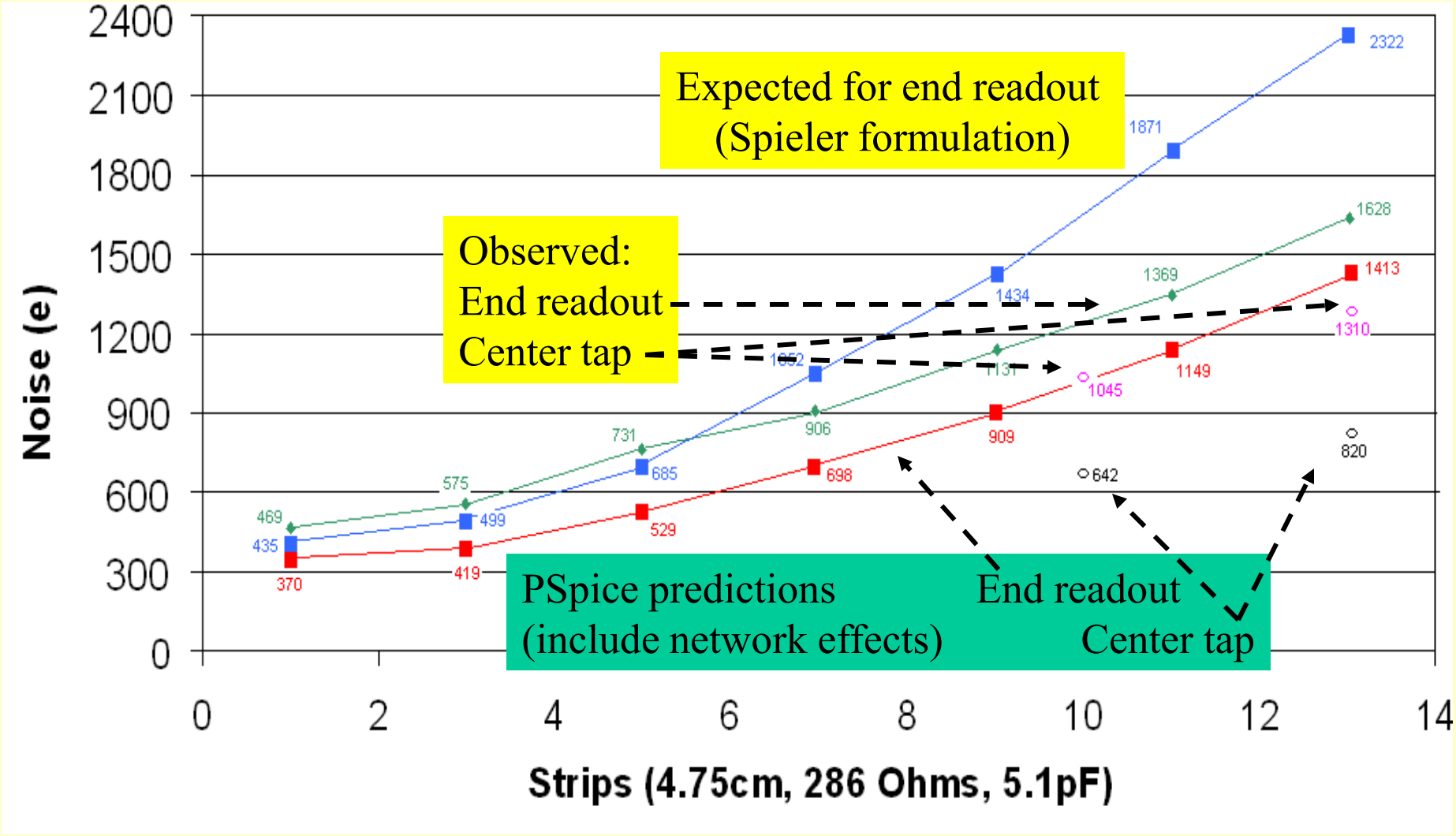

Series noise expected to dominate for narrow (50 μm) pitch sensors above ~25 cm long

# Sensor “Snake”: Read out up to 13 daisy-chained 5cm sensors (with LSTFE-1 ASIC)



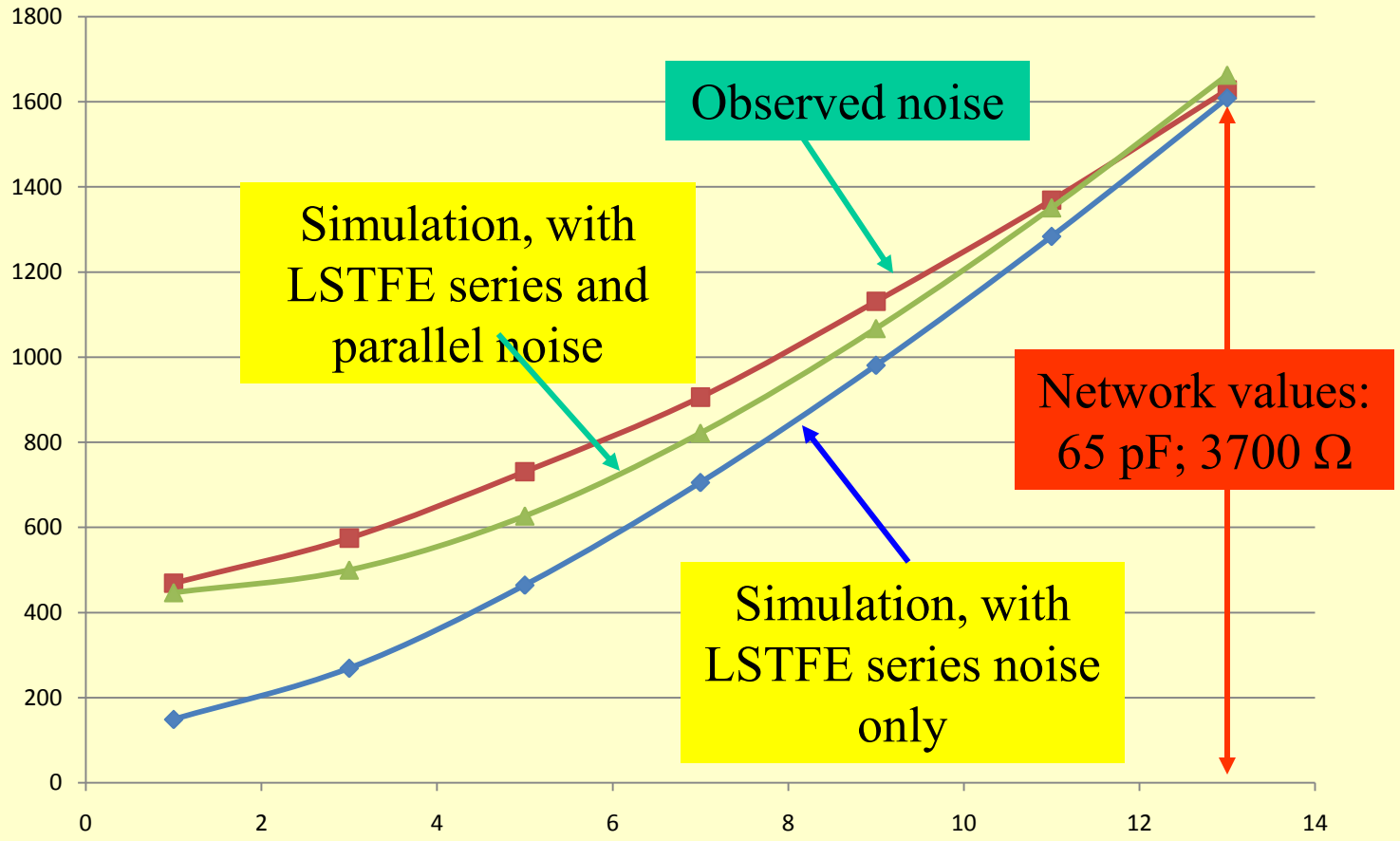

**Can read out from end, or from middle of chain (“center-tap”)**

# First-Pass Results vs. Expectations (old…)




**But: need to add in amplifier noise…**

# Include realistic feedback network; measured LSTFE-I noise (LSTFE-II now known to be similar)




Good agreement; significantly less than naïve expectation
Need to look at "center-tap" readout next.

# Non-Prompt Tracking with the SiD

Explore performance via explicit signature: Metastable stau NLSP (Gauge-Mediated SUSY)

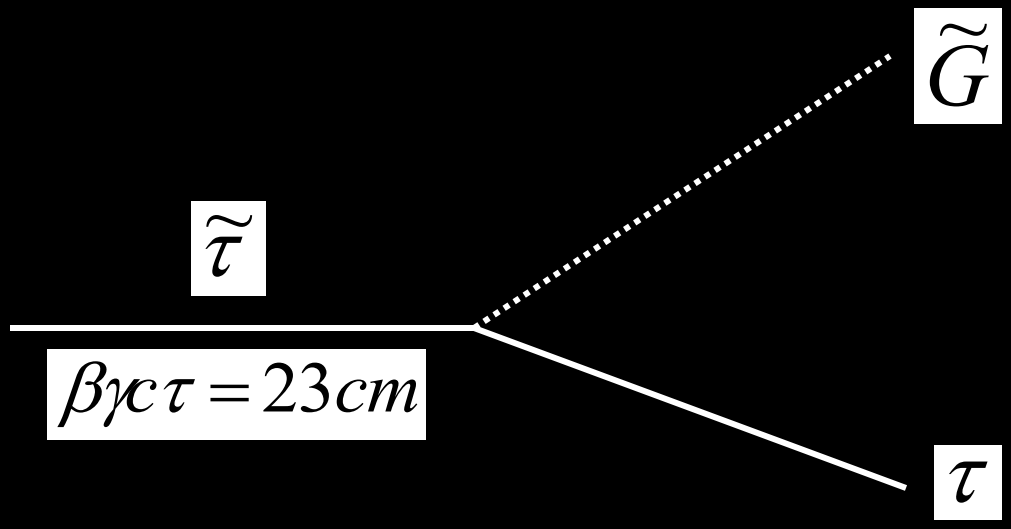
# Reconstructing Metastable Staus w/ SiD

## Gauge-Mediated SUSY

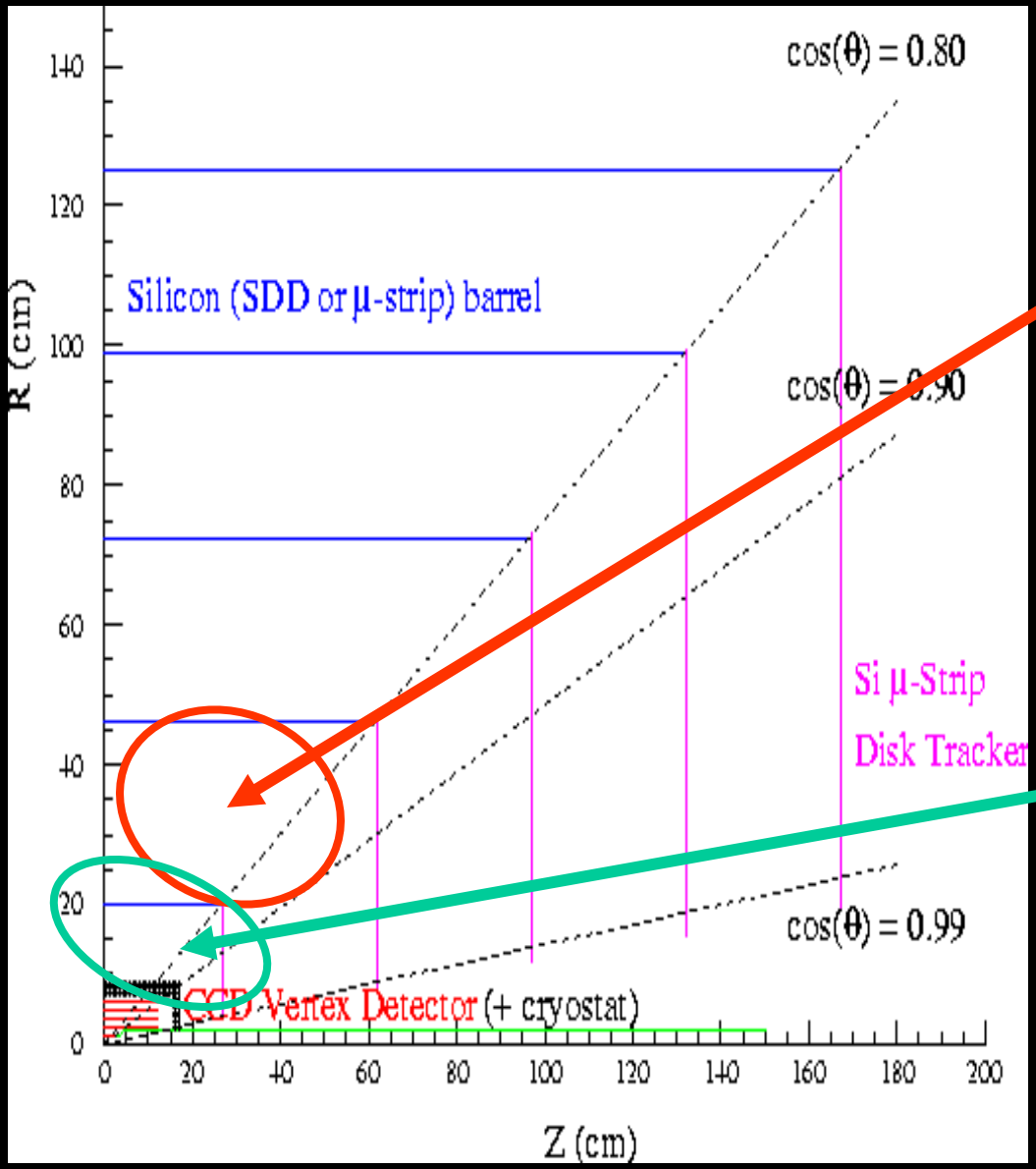
- Large tract of parameters space as stau NLSP
- Metastable ($\gamma\beta c\tau_{stau}$ ~ centimeters) is in cosmologically preferred region

Process is $e^+e^- \rightarrow \tilde{\tau}^+\tilde{\tau}^-$

with



# Reconstructing Metastable Staus w/ SiD




**Started with:**

**5+1 layers for inside track**

**4 layers for outside track**

**New result: Include VTX-only inside track**

# Measuring Staus with the SID

**Stau sample:**

**11.1 $fb^{-1}$ of $e^+e^- \rightarrow$ stau pairs with**

- **$m_{stau}$ = 75 GeV**
- **$E_{cm}$ = 500; $\sigma_{\tau\tau}$ = 90 fb**
- **$\beta\gamma c\tau$ = 23 cm**

**Background sample:**

**5.3 $fb^{-1}$ combined SM background**

# Reconstructing Metastable Staus w/ SiD

**Focus initially on $r_{decay}$ = 22-47 cm…**

**Reconstruct decays by requiring:**

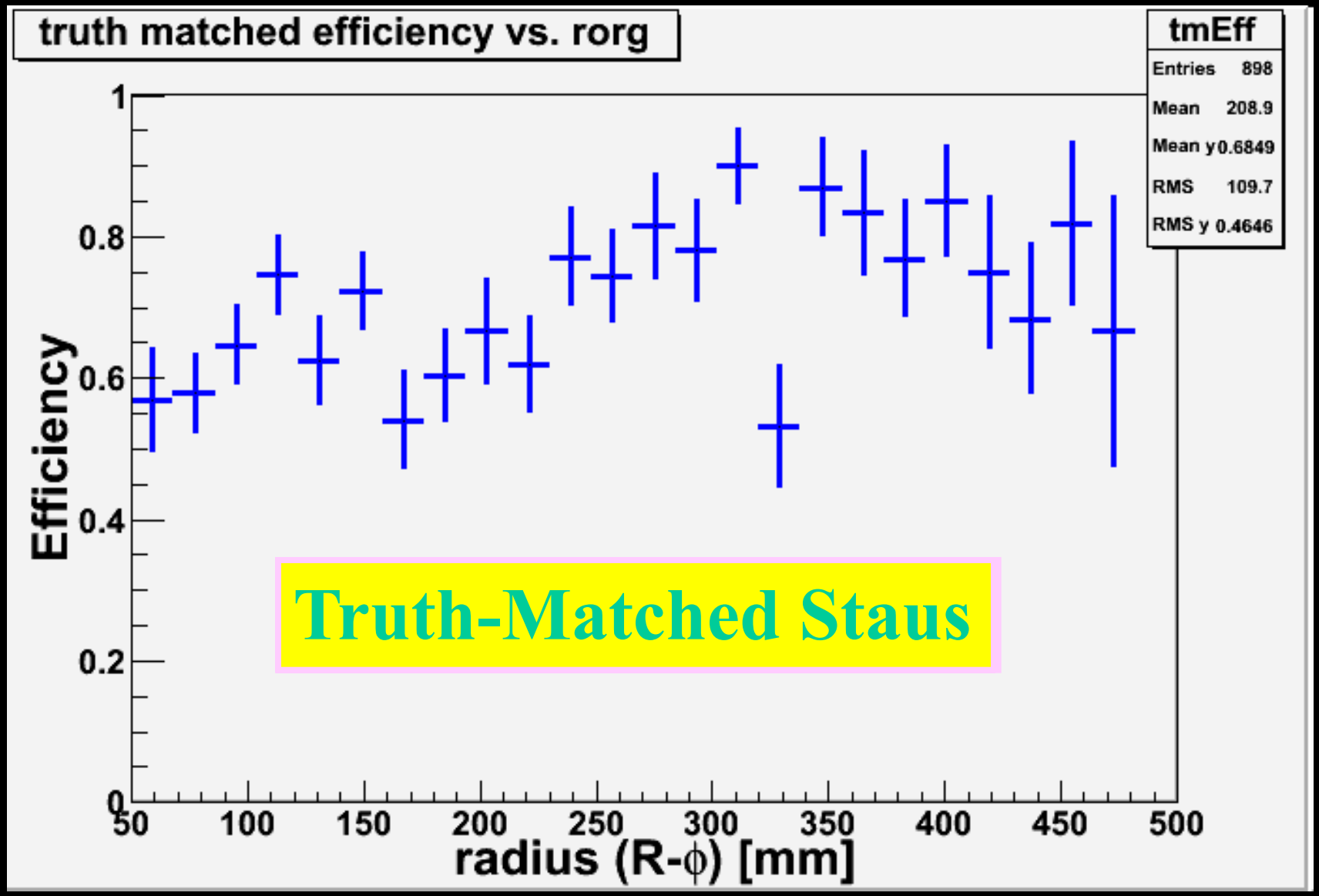
- **Outer hit of inner trk on last VXD or 1st tracker layer**
- **≤ 1 missing layer between inner & non-prompt trks**
- **Both tracks on the same side of the Barrel (in z)**
- **Tracks have a geometric intersection in the x-y plane**

**And: When inside track has ≥ 1 Central Tracker Hit**

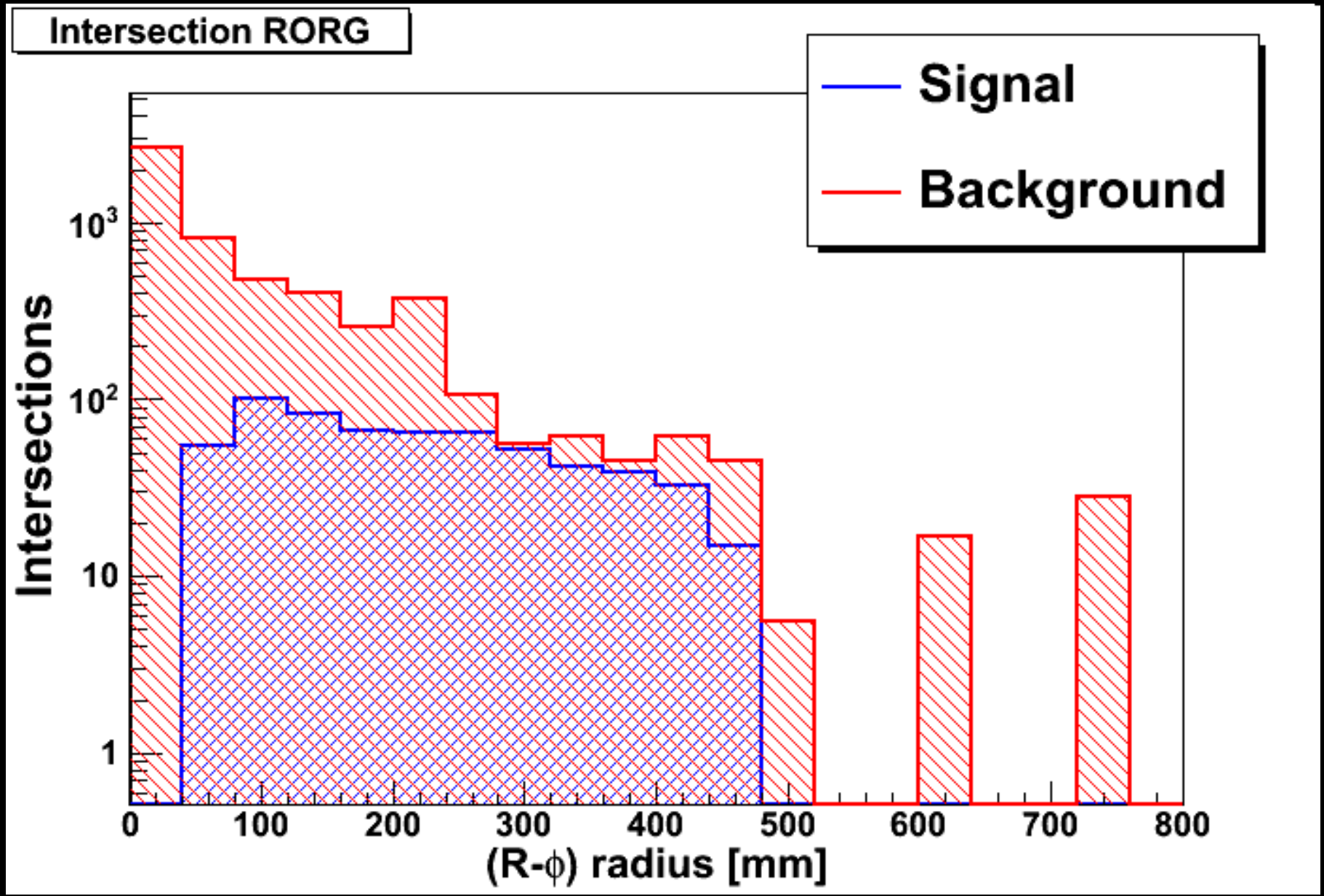
- **The sign of the track curvatures match**
- **Non-prompt track curvature larger than the primary**

**Of 897 staus with 6cm < $r_{dec}$ < 47cm, 642 staus are reconstructed, of which 592 truth-match**

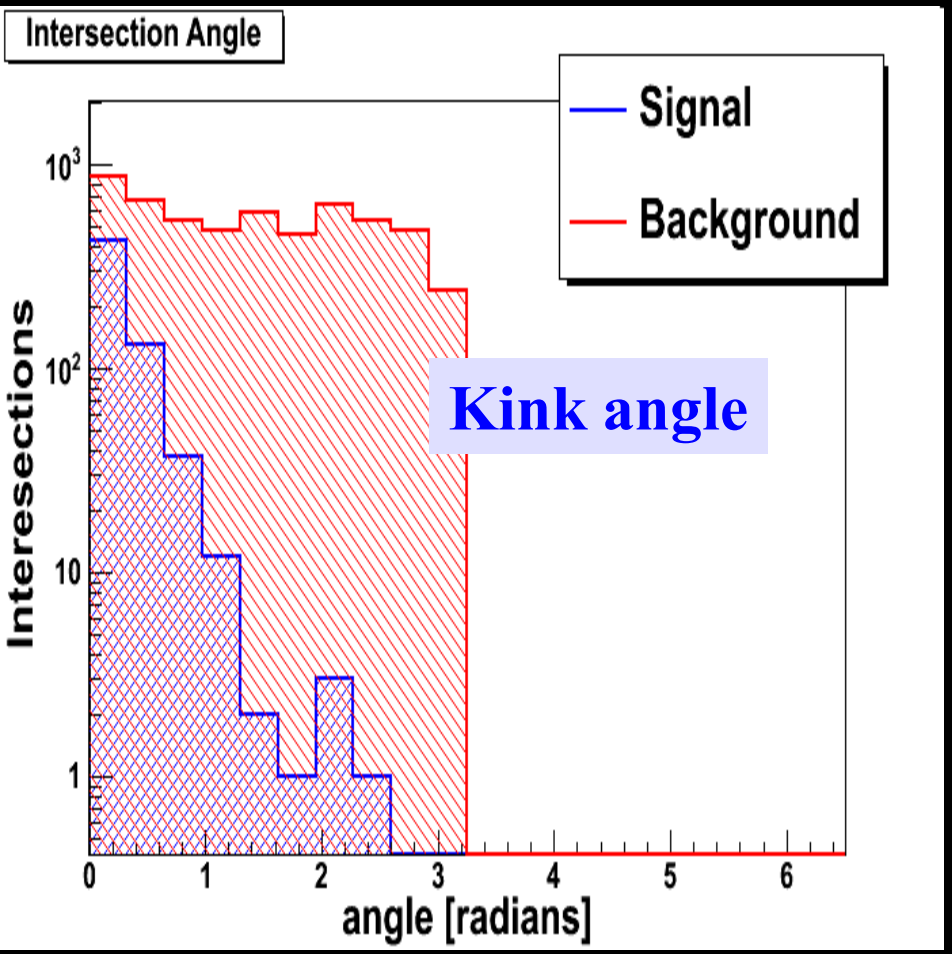
# Stau Reconstruction Efficiency

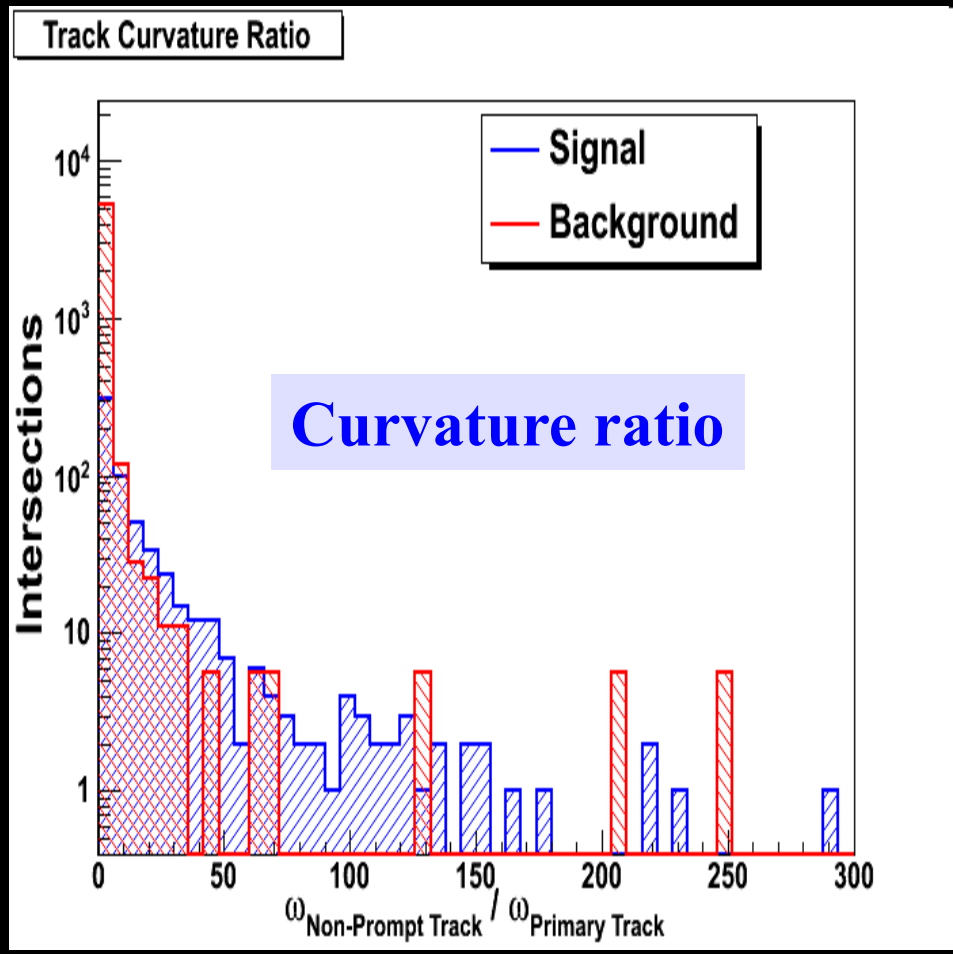


# Signal to Background for 10 $fb^{-1}$

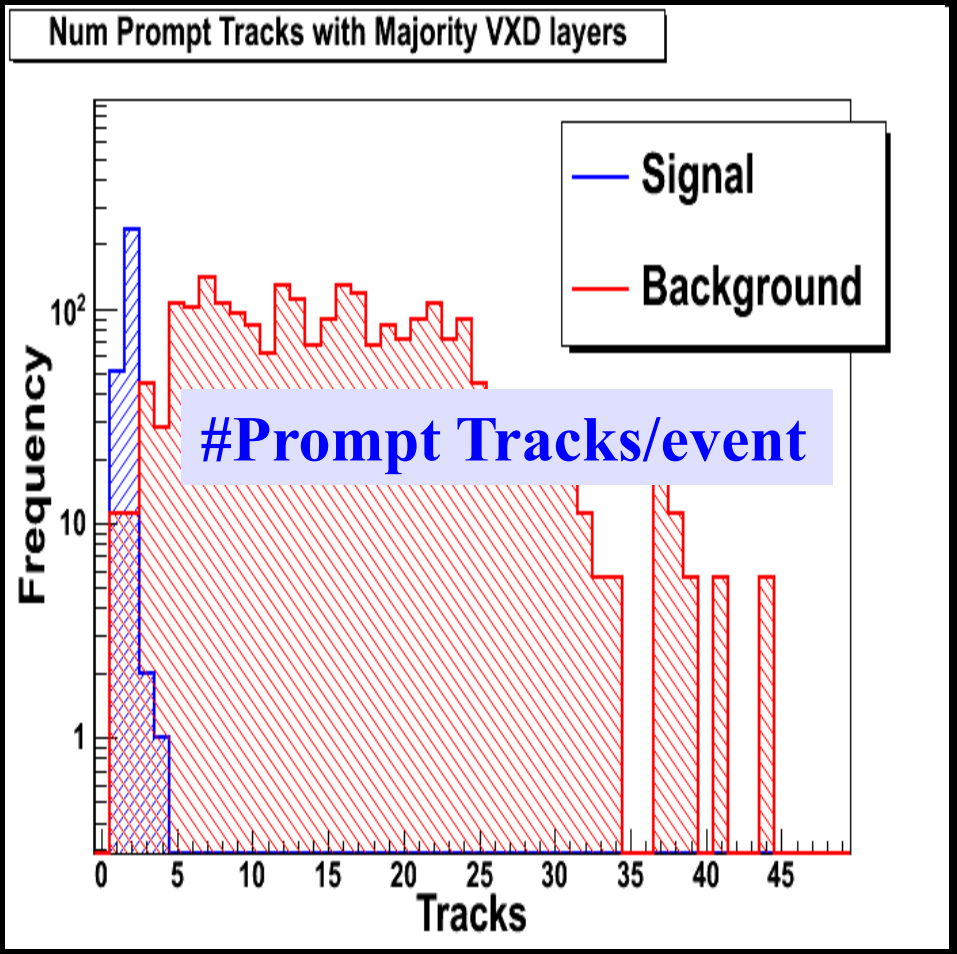


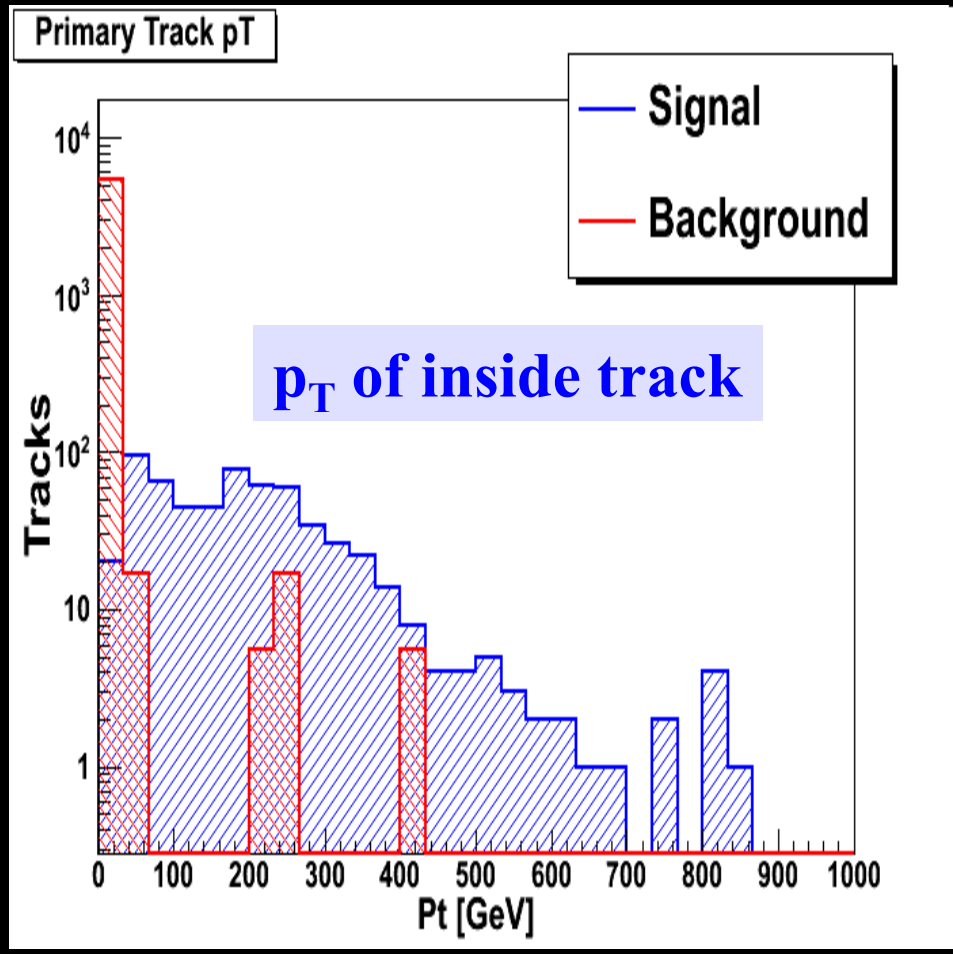
# Signal to Background (10 $fb^{-1}$)



# Signal to Background (10 $fb^{-1}$)

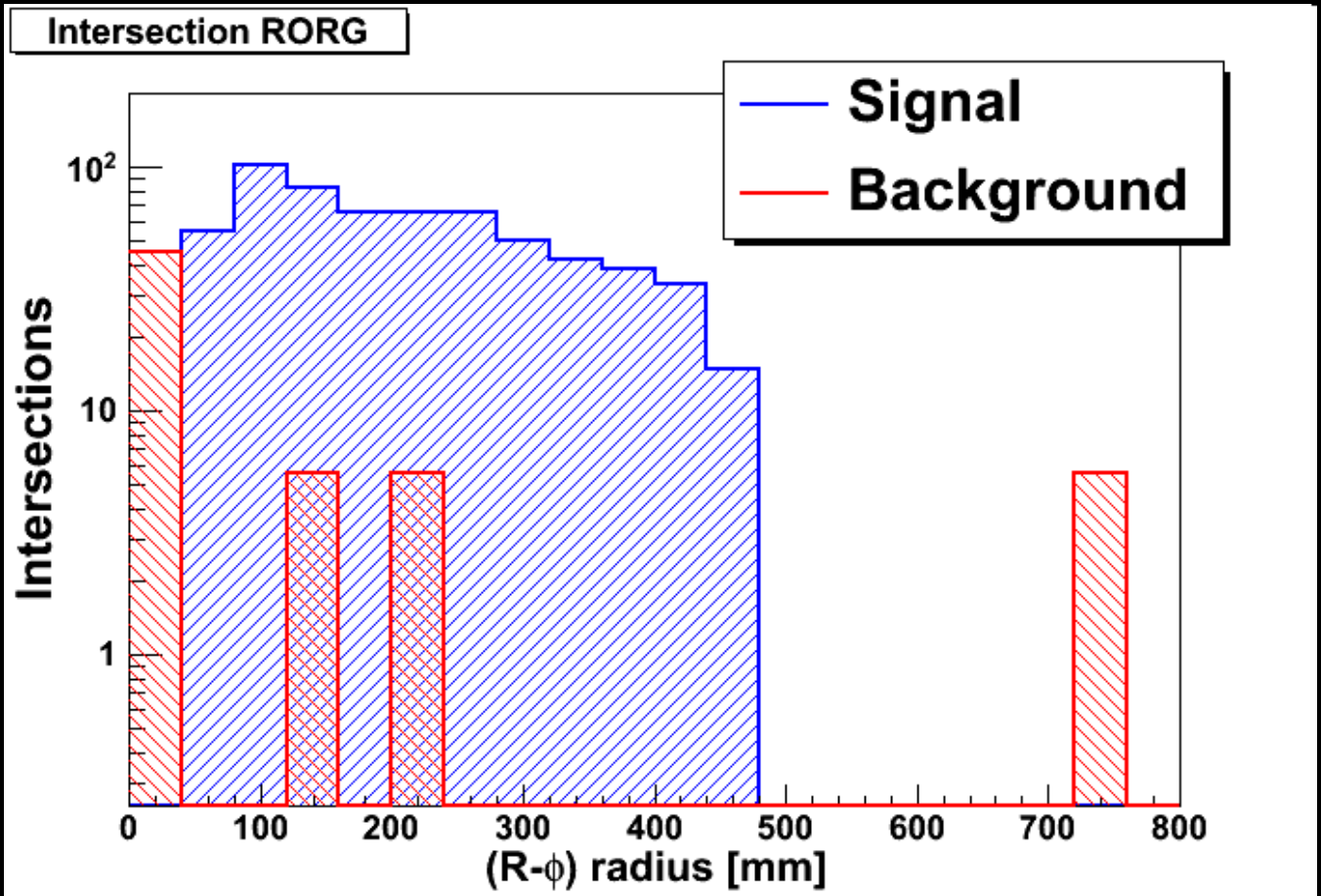



**Good separation between signal and background for #prompt tracks/event and inside track $p_t$**

**➔ Require, e.g., fewer than three prompt tracks**

# Signal to Background (After <3 Track Requirement)




**Essentially no background after three-track cut**

➔ **Next challenge: $46 < r_{org} < 71$ cm (3 tracker hits)**

# Wrap-Up

Time-Over-Threshold Readout (LSTFE)

Second prototype under study in lab; functionality looks good (except for power cycling)

Long Ladder Readout Noise:

Measurements show much lower noise than naïve (lumped-element) analysis. Now confirmed with simulation ➔ promising for long-ladder solutions.

Non-Prompt Tracks with SiD:

Extended radial range of stau decay kinks from 21-46 cm to 6-46 cm, maintaining good efficiency and purity. Exploring 46-71 cm range.

# (No) Backup Slides