# The SVT Upgrade

- Introduction
- Physics motivation
- Impact of the upgrade

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# What is being proposed

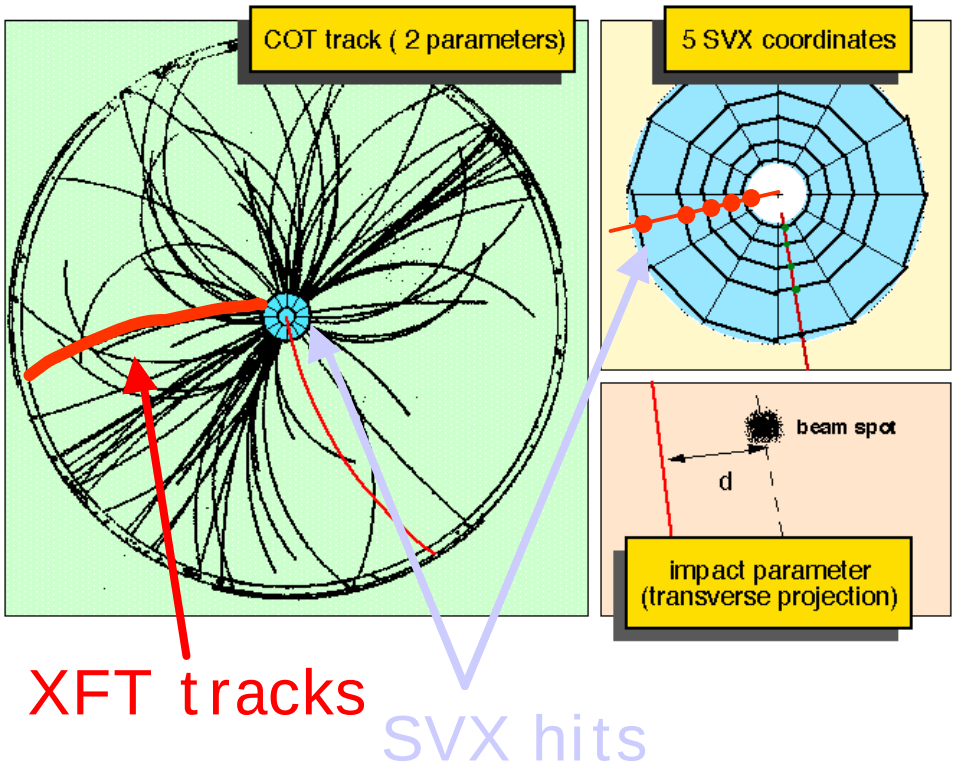
- Addition of a new SVT module: the Road Warrior (mostly timing improvements)
- Replacement of pattern recognition hardware, in particular

  32K $\rightarrow$ O(128K) patterns/wedge

In progress

Italian funds

# SVT: Silicon Vertex Trigger




**XFT + SVX 4/4 (until 6/2003)**

**XFT + SVX 4/5**, more efficient

**Instead of XFT:**

m **1<h<1.5**

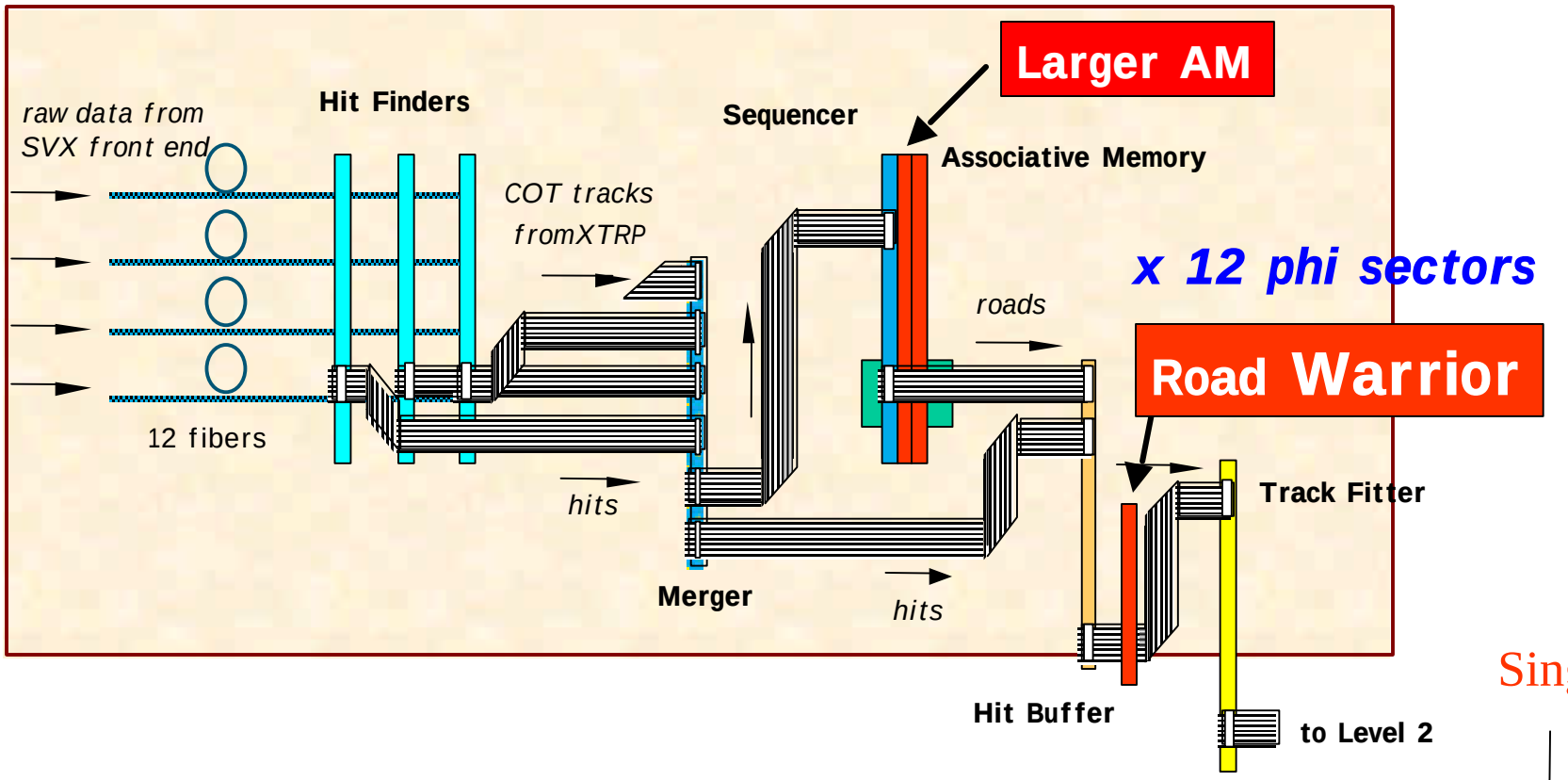
**e 1<h<2.5**

**New Functionalities:**

m **+ SVX 4/5,** 1< h< 1.5

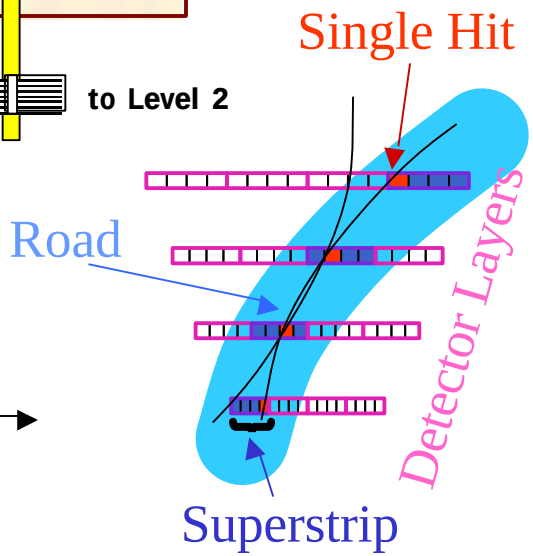
**e + SVX 4/5,** 1< h< 2.5

# What does the new Hardware do?




How to speed up SVT:

1. Thinner roads (larger AM) → less fits.
2. Road Warrior → ghosts removal



# Physics motivations

- We have one fundamental resource:

  $\rightarrow$ bandwidth $\leftarrow$

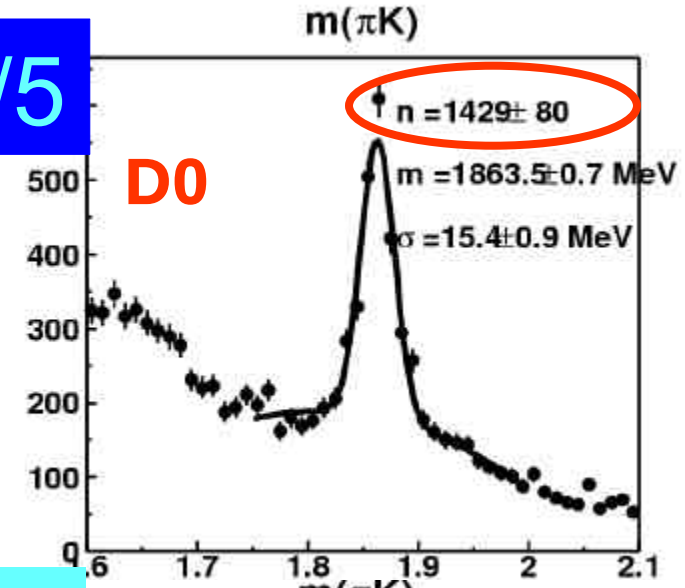
- SVT is in the critical path for L2 timing/L1 accept rate
- Additional hardware provides better flexibility for trigger design.
  Example: forward muons

# 4/4 vs 4/5

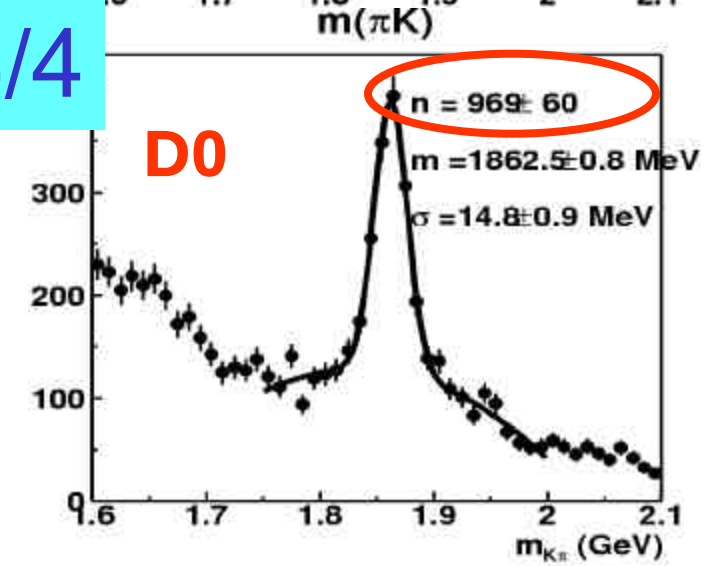
Improving the SVT timing

# Why do we want 4/5?

4/5

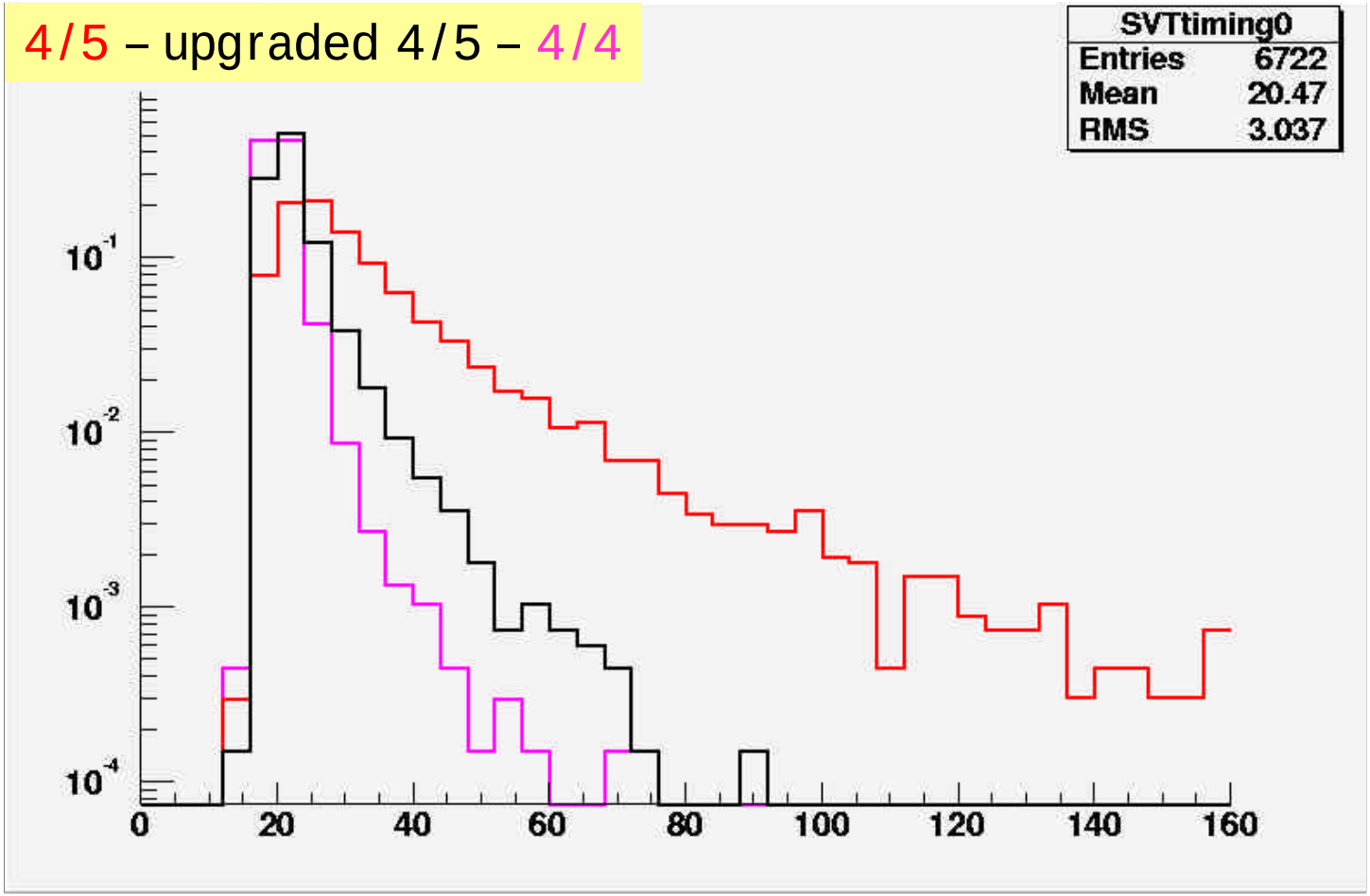



4/4




| source | 4/4 | 4/5 | R |
|---|---|---|---|
| D0 yield | 11.2 (nb) | 17.5 (nb) | 1.55 ⊅0.06 |
| J/psi yield | 663 | 974 | 1.5 |
| Bs MC (Pt_b>5.5; \|η_b\|<1.3) | | | 1.59 ⊅0.05 |
| Bs MC after offline reconstruction (Ivan F.) | | | 1.58 |

# Upgrades:
# T(4/5) → T(4/4) !



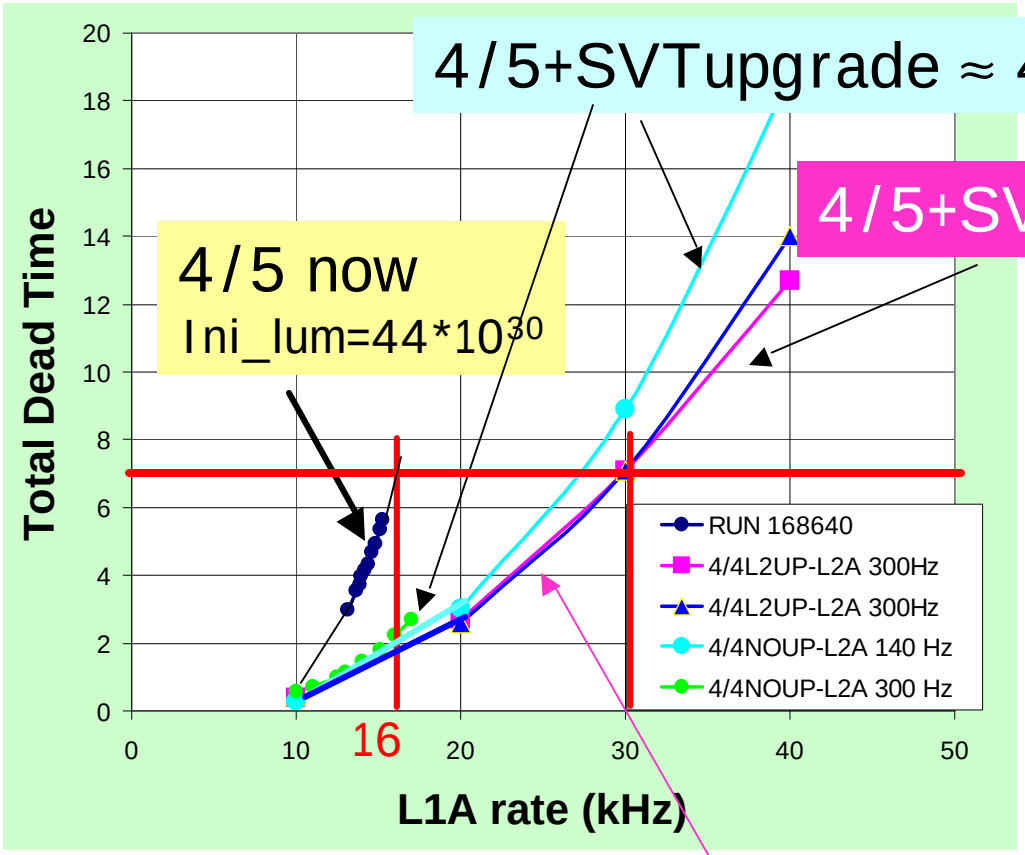
SVT is running right now @4/5

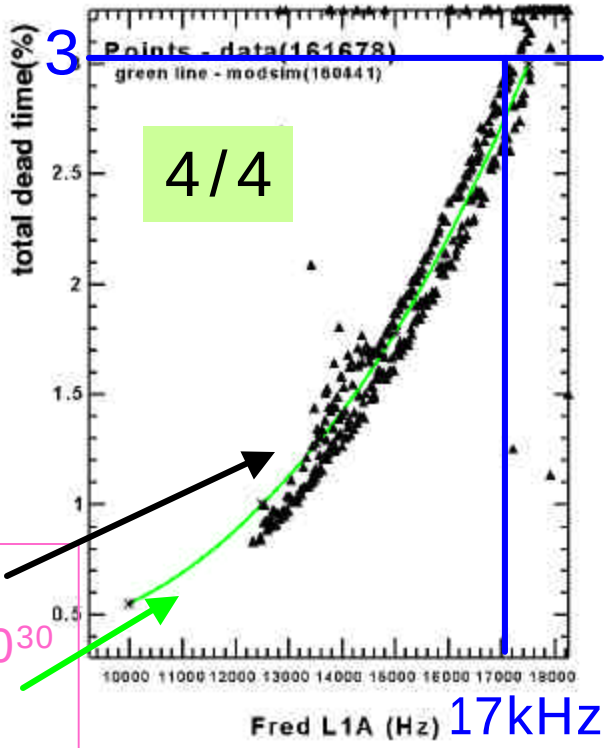
| | L1_TWO_TRK_PT2 B physics | L1_TWO_TRK2_&_TWO _CJET5 Z→bb |
|---|---|---|
| SVTconfiguration | # of fits | # of fits |
| 32 kpatt 4/4 | 3.9 | 9.4 |
| 32 kpat 4/5 (now) | 39.1 | 94 |
| 32 kpat 4/5 + **RW** | 17.6 | 42 |
| 128 kpat 4/5 + **RW** | 9.3 | 23 |
| Ghost removal | 4.3 | 14.5 |

4/5

ROAD WARRIOR + AM ++ bring us back to the old 4/4 timing, with better efficiency!

# What if…




Ini_lum=32*10^30
Ini_lum= 17.5 *10^30
Ini_lum=22*10^30

# Forward Muons

An example of the added flexibility

# Flexibility

- The larger AM bank allows new strategies:
  1. Narrower patterns to improve timing
  2. Trigger bit dependent patterns
  3. (L1) Lepton seeded pattern recognition
  4. Standalone Si tracking
  5. …?
- As an example we tried to merge 3. And 4. To build a forward $z \rightarrow \mu\mu$ trigger!

# Forward Muons Trigger

1<η<1.25 (FRONT) L1:

BMU*BSU(F)*XFT11

rate 8-16Hz @ 4E31

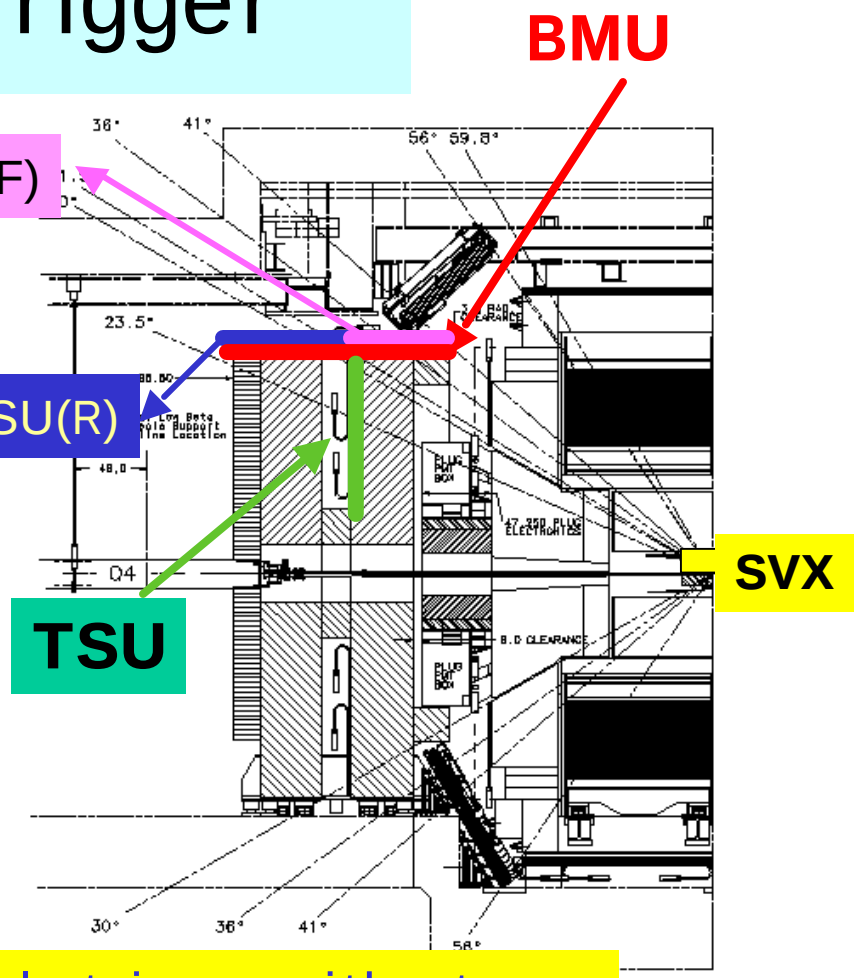
L2: RateLimited @ 0.7 Hz

1.25<η<1.5 (REAR) L1:

BMU*BSU(R)*TSU

Rate 200-400Hz @ 4E31

L2: RateLimited @ 1.3 Hz




We can use **SVT***BMU*BSU for a single trigger, without η bias! Goal rejection ~ 20-50.

•high Pt prompt leptons → "only" 30kpatterns @ 95% eff.
(Pt>8 GeV [excellent down to 4 GeV] & d0<500μm)

# In a glimpse..

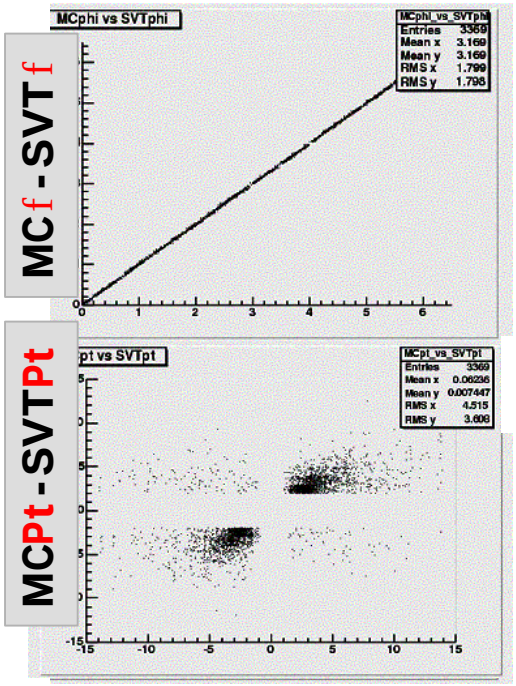
- Efficiency @ L2: study $Z0 \rightarrow \mu\mu$ from data
- Back. Rejection: L1 backup from data

| Selection | # Z0 | # L1_BMU_REAR |
|---|---|---|
| L1_MU | 250 | 4678 |
| match $\Delta\phi<2.5^o$ Pt>4 & $\chi^2<10$ | 132 | 362 |
| + $\eta$ match | 126 | 213 |
| L2 Eff. | **0.50** | |
| L2 Rej. | | **22** |

# Tracking Performance

This is SVT doing standalone SVX tracking ON THE FLY!!!

**MC(J/Psi): generator vs SVT** **L1_MU data: offline vs SVT**



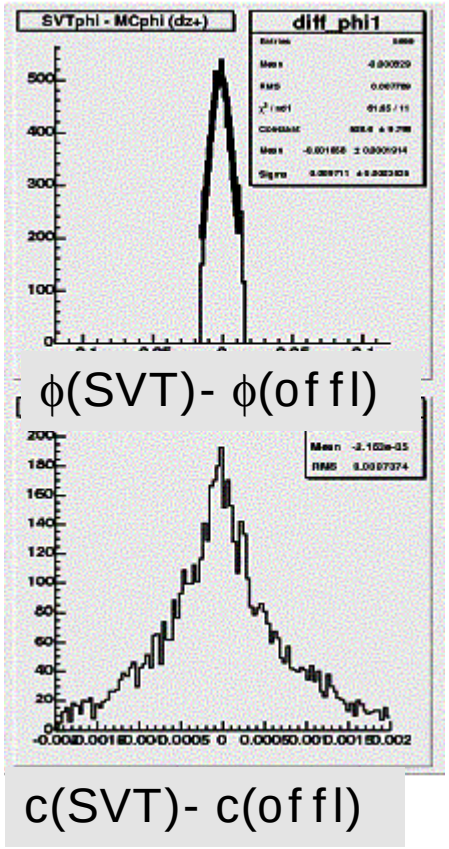

$\sigma(\phi)=0.007$ $\sigma(\phi)=0.008$

$\sigma Pt/Pt^2=0.08$ $\sigma Pt/Pt^2=0.095$

Offline standalone Si (from TDR):

$\sigma(\phi)=0.002$

$\sigma Pt/Pt^2=0.07$

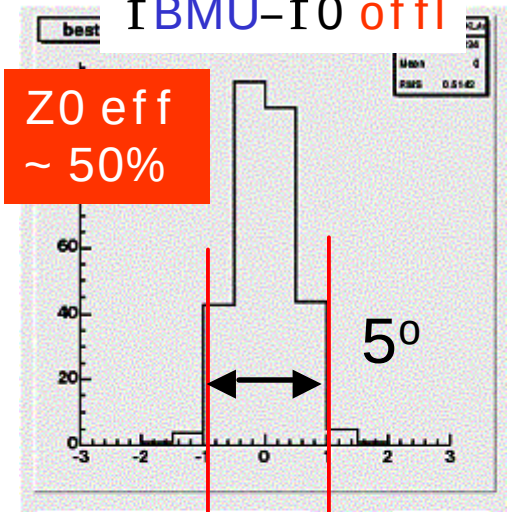



Occupancy is huge!→seed SVT with muons!

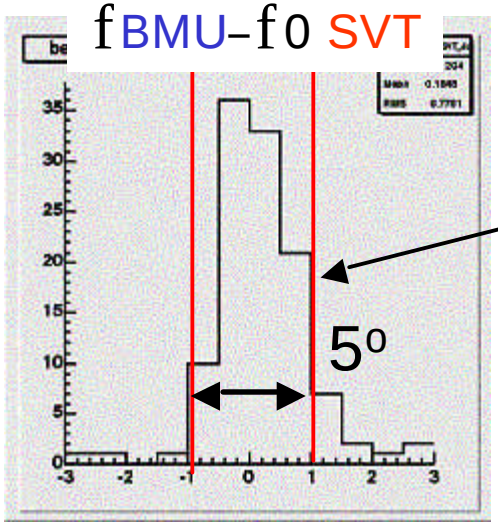
# Forward muons as SVT seeds!

**Z0->mm data: Pt>4 & $c^2$<10**

fBMU–f0 offl

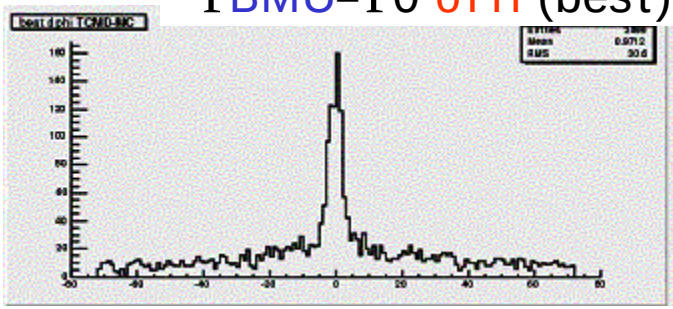



fBMU–f0 SVT

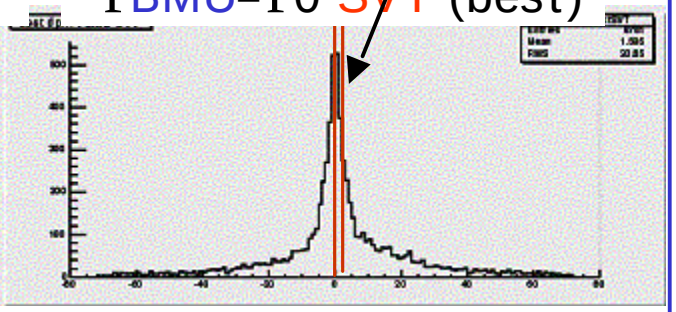



|fBMU–f0 SVT| < 5°

fBMU–f0 offl (best)



fBMU–f0 SVT (best)



**Rejection from L1 MU data: ~22**

# New Hardware Summary

# Road Warrior

- Implemented on PULSAR HW, with no changes
- Further reprogramming could help SVT:
  - Cope with ageing hardware (AMS & HB)
  - Provide new functionalities*:

(See next slide for examples!)

* Might need hardware add-ons

# SVT II?

- Pulsar reprogramming leaves open the option of increasing the SVT performance "ad libitum":
  - More flexibility in pattern handling
    - 1M pattern?
    - More than 5 layers?
      - Multiple PID sources (TOF, muons, electrons)
      - 3D tracking?
    - Pattern "segmentation":
      - "Trigger bit awareness": can decide how to seed pattern recognition/track fitting depending on L1 bits!
      - Potentially could even activate/deactivate some of these features based on a partial outcome of the pattern recognition stage!

# AM++

- Replace old AM boards with 1 AM++/wedge
  - Increased pattern density: standard cell chips (2K [↔128] pattern/5x5 mm)
  - Potentially larger I/O bandwidth
  - Provide backward compatibility with older hardware?
  - Can house potentially up to 1Mpattern!

# AM++ schedule

- New AM-board: summer 2004 (Pisa)
  during summer 2004: test with FPGA chips (Pisa)
- AM-chip design: july 2004 (Ferrara-Pisa)
  first chip ~2 months $\rightarrow$ october
- New LAMB: assemble AM-chip in october 2004 (Pisa)
- test chip + board: october – december 2004 (Pisa-Ferrara)
- Mass production: beginning 2005 (Pisa-Ferrara)
- install: summer 2005 (Pisa-Ferrara)

# Impact on data taking

- Boards can be completely developed and tested in test-stands
- Algorithm development & tuning may require some test runs
- Overall the experiment dead time will come from:
  - Boards swapping
  - Development/modification of online code
- Everything will be back-compatible: virtually no point of no-return!

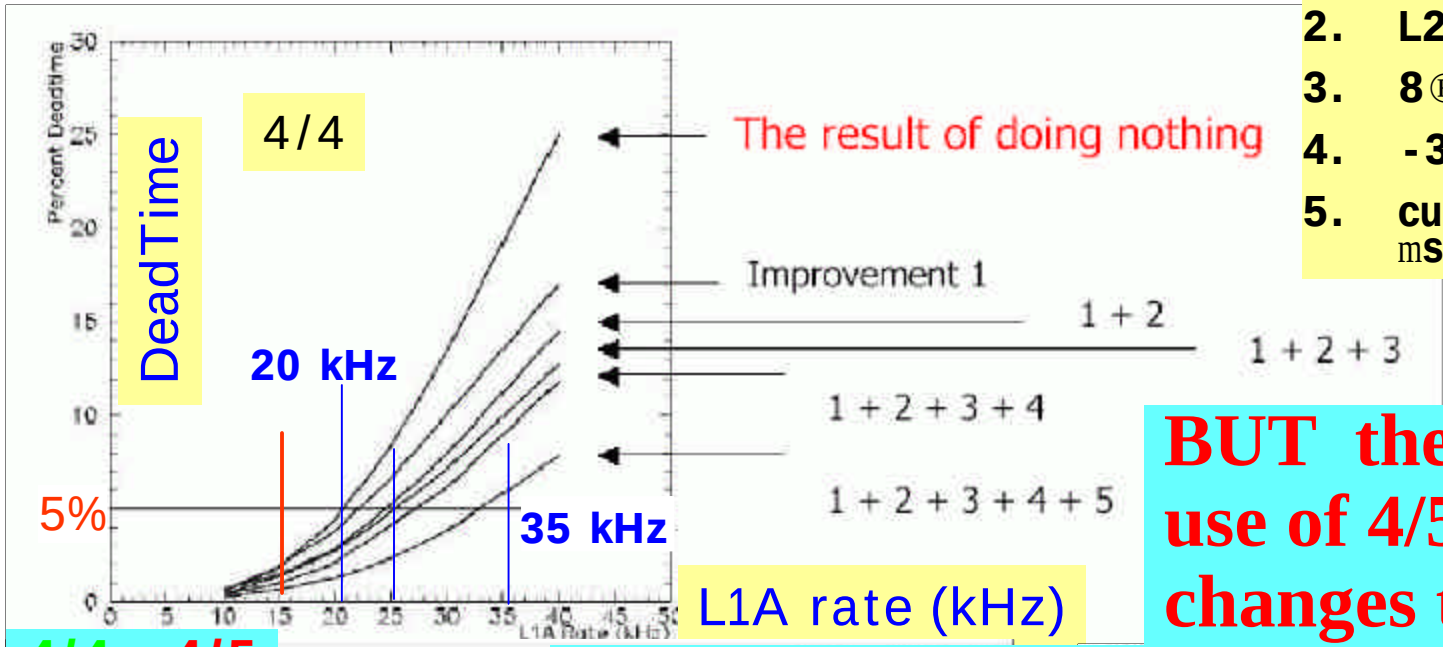
# Conclusions:

- L2 Timing is critical in the CDF DAQ
- SVT is critical to the L2 Timing
- RW & AM++ helps improving SVT efficiency with reasonable timing
- Both address also the issue of ageing of critical components:
  - AMS & HB
  - AM Chips/boards
- RW is a PULSAR $\rightarrow$ Provides additional flexibility:
  - Change RW algorithms
  - Open to new SVT options

# Backup

# ModSim (What If…)

1. Two SRCs in parallel
2. L2 processor upgrade
3. 8®7 bit SVX digit.
4. -3 ms in SVT proc.time
5. cut SVT tails above 27 msec

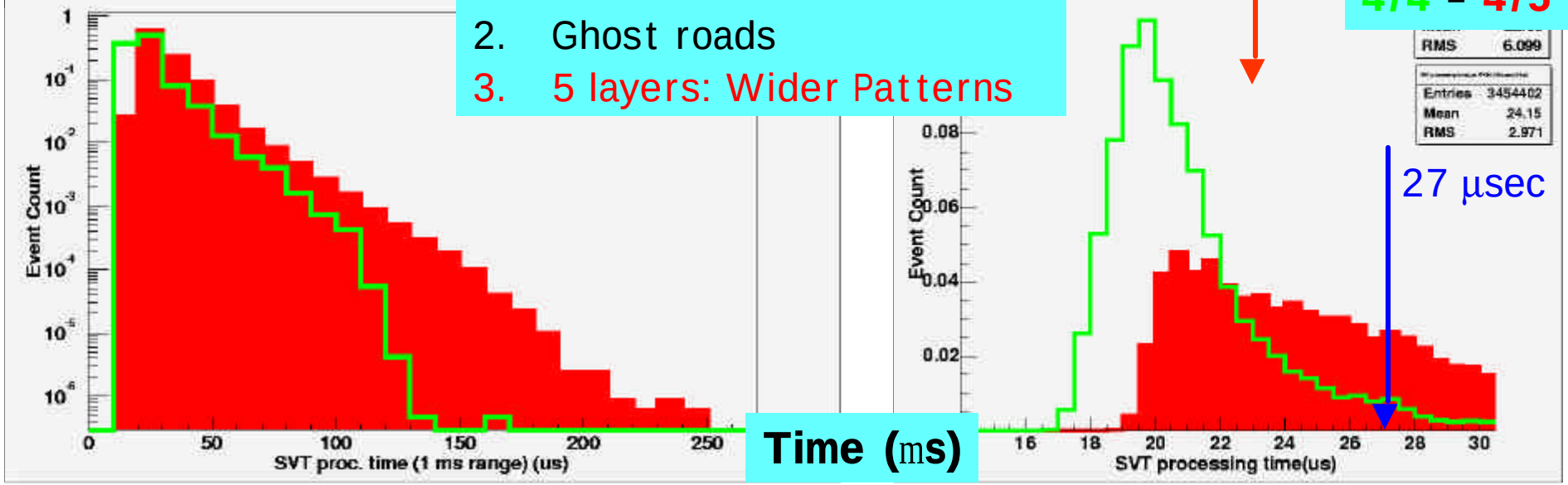



**BUT the recent use of 4/5 in SVT changes the conditions!**

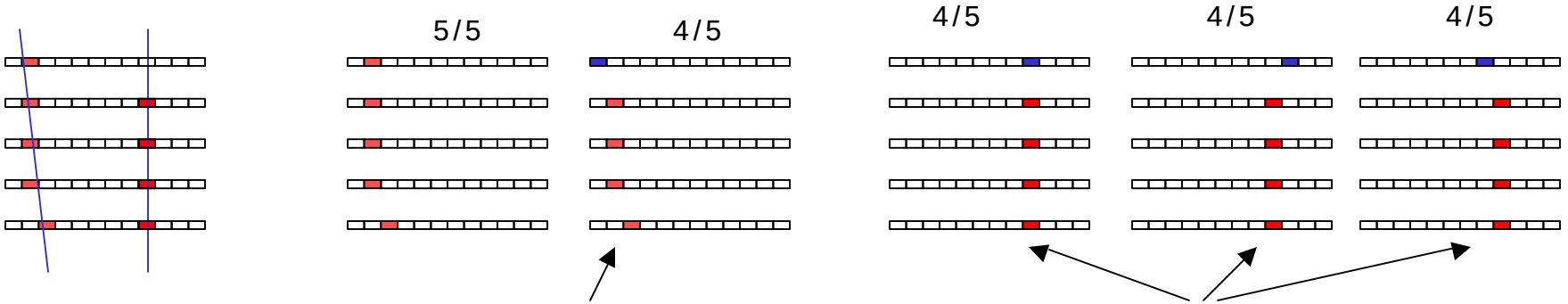
4/4 – 4/5

25 kHz

1. Looser match
2. Ghost roads
3. 5 layers: Wider Patterns



# Why 4/5 is more complex?




This road share all hits with the 5/5. It's a ghost.

These 3 roads share all hits. Two are ghosts.

Ghosts are 60-70% of 4/5 roads.
Removing them speeds up 4/5 processing time.

NOW pattern recognition with 5 SVX layers uses larger patterns w.r.t. 4 SVX layers

More fake roads and more hits inside roads

Solution: More AM → thinner patterns → reduce fakes