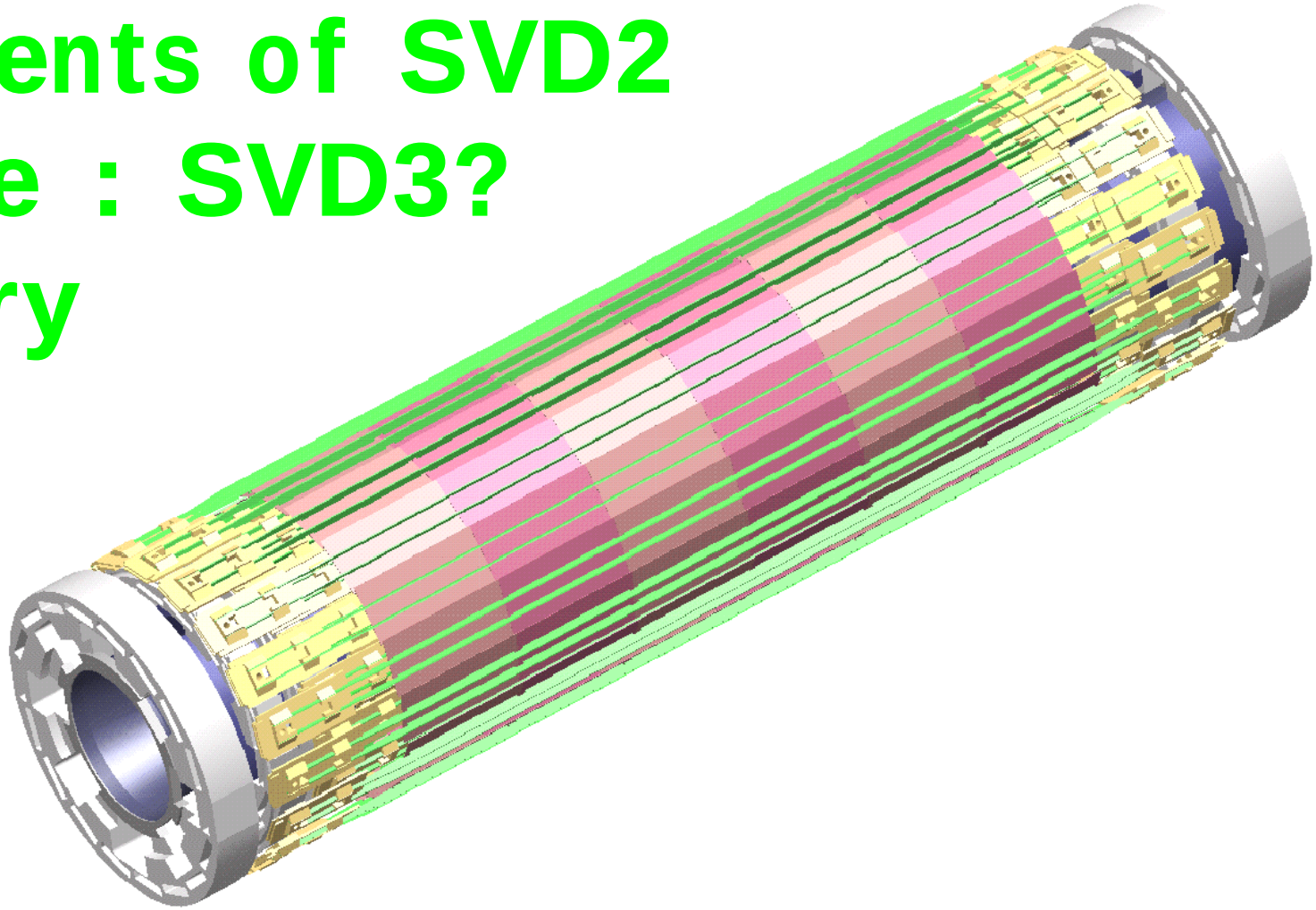
# Belle Silicon Vertex Detector (II)

Y.Yamada (KEK) on Feb.15,2002

1. Introduction to SVD2
2. Components of SVD2
3. Upgrade : SVD3?
4. Summary



# 1. Introduction to SVD2

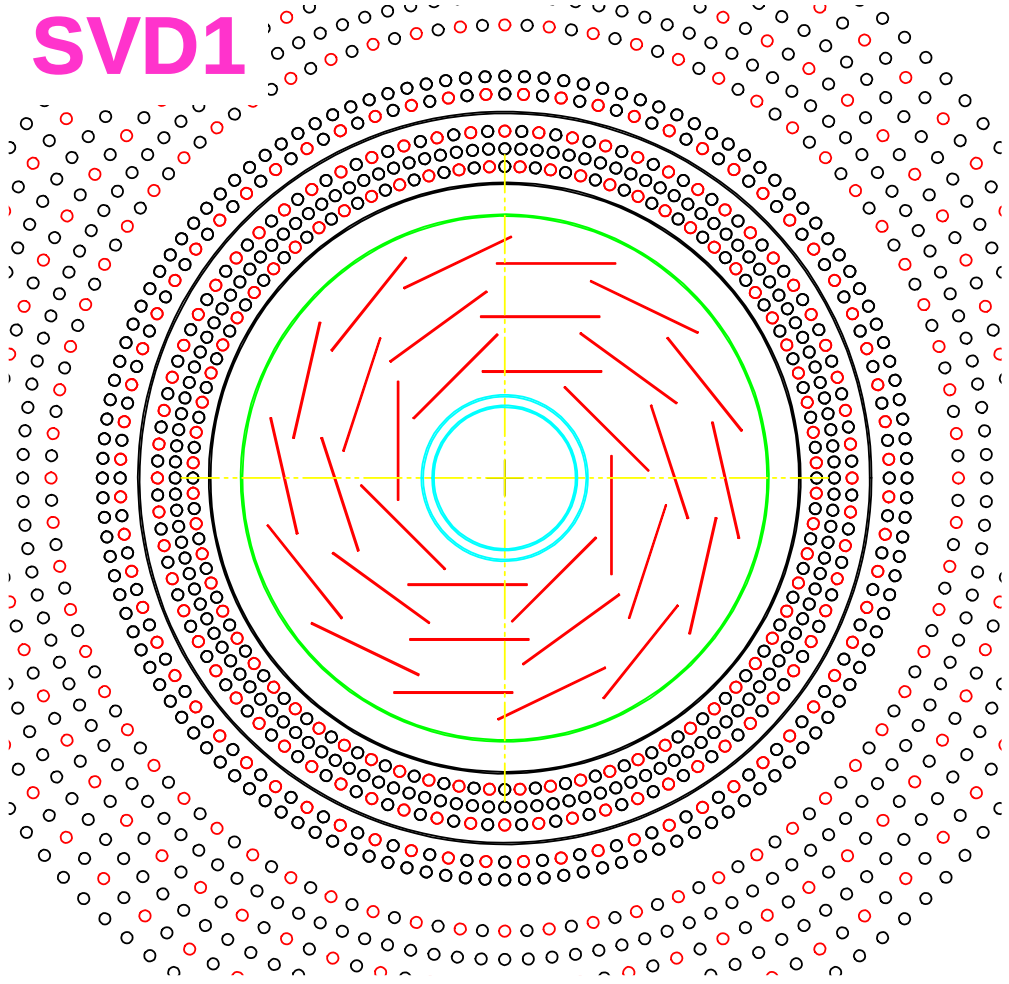
- **Better impact parameter resolution**
- **Better tracking efficiency for slow $\pi$**

$R_{bp}^{in}$ = 2.0 cm
3 layers: R = 3.0,4.5,6.0 cm
8+10+14=32 ladders

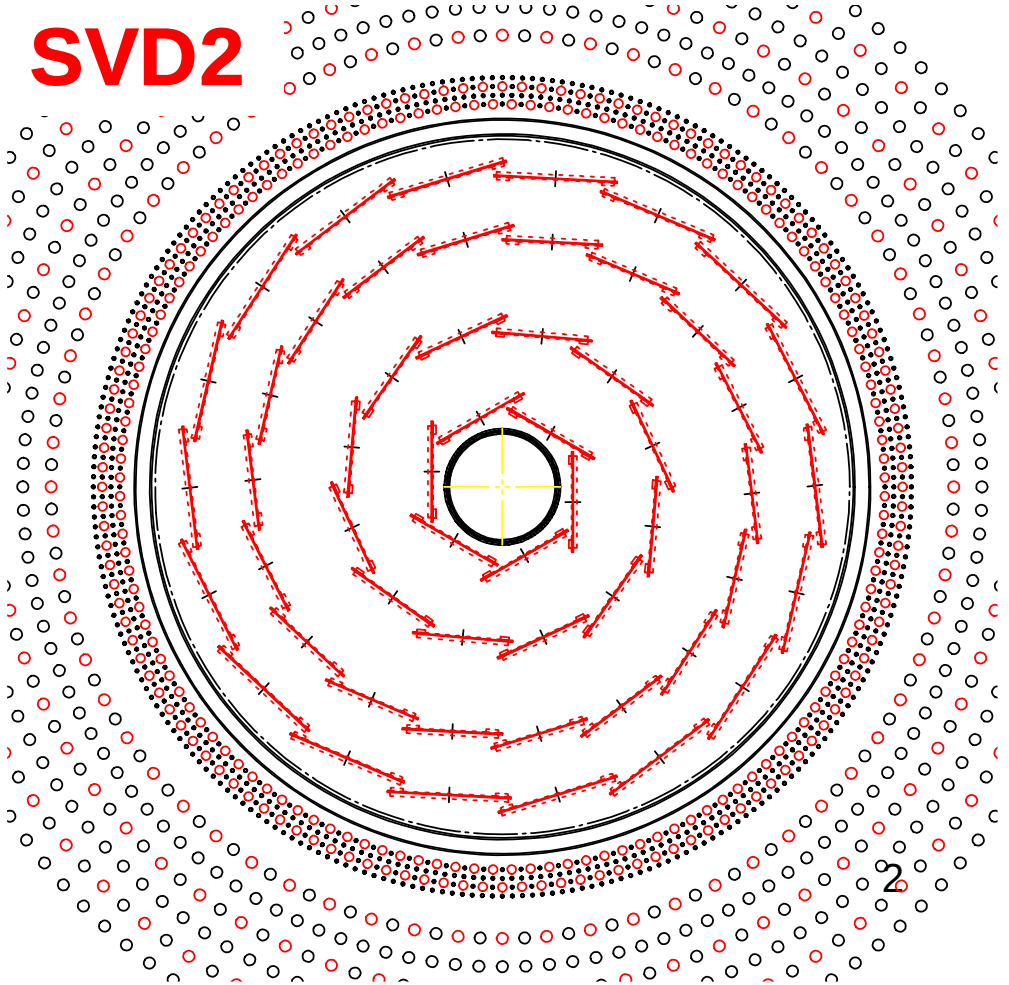
→

$R_{bp}^{in}$ = 1.5 cm
4 layers: R = 2.0,4.4,7.0,8.8 cm
6+12+18+18=54 ladders

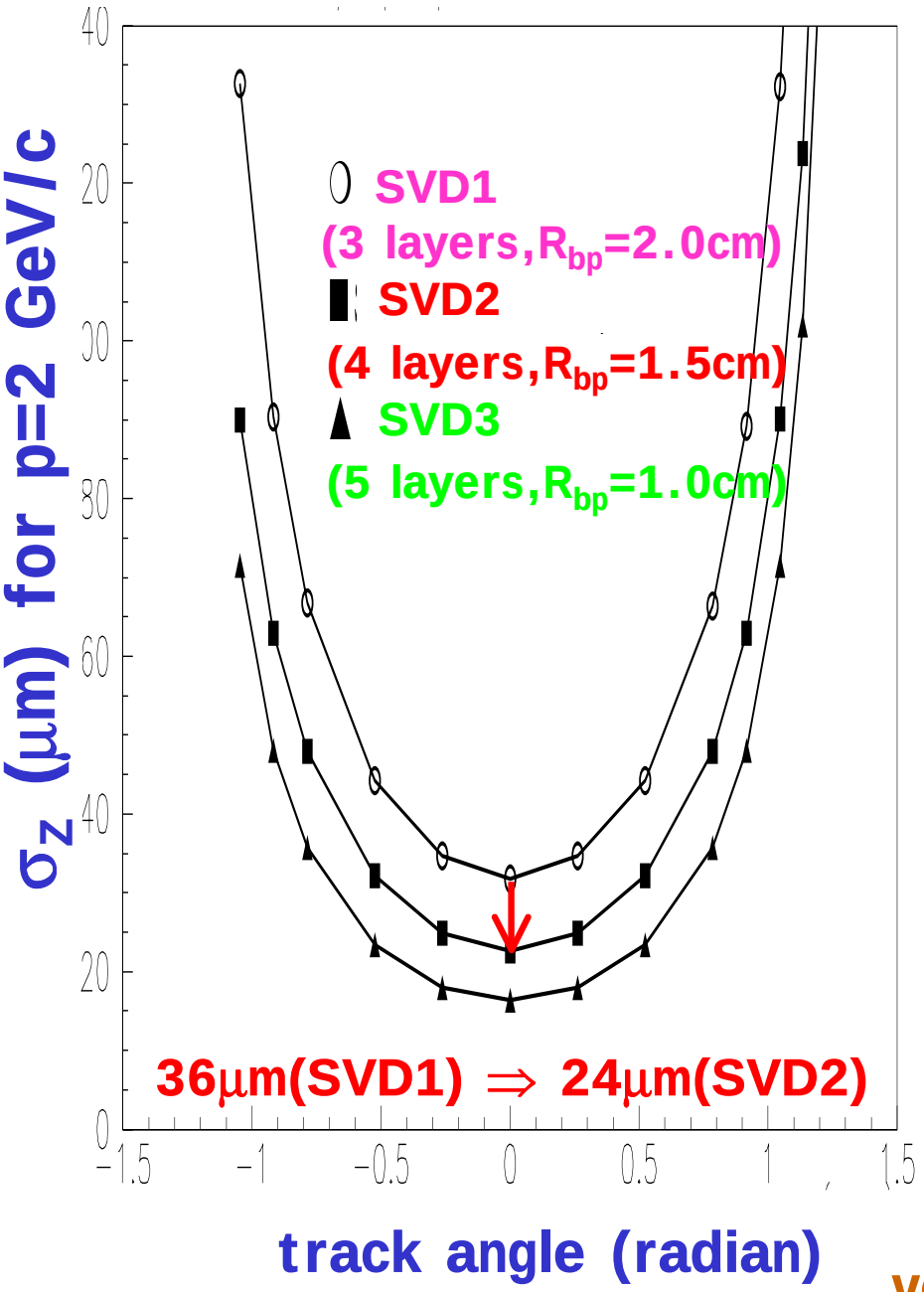
SVD1



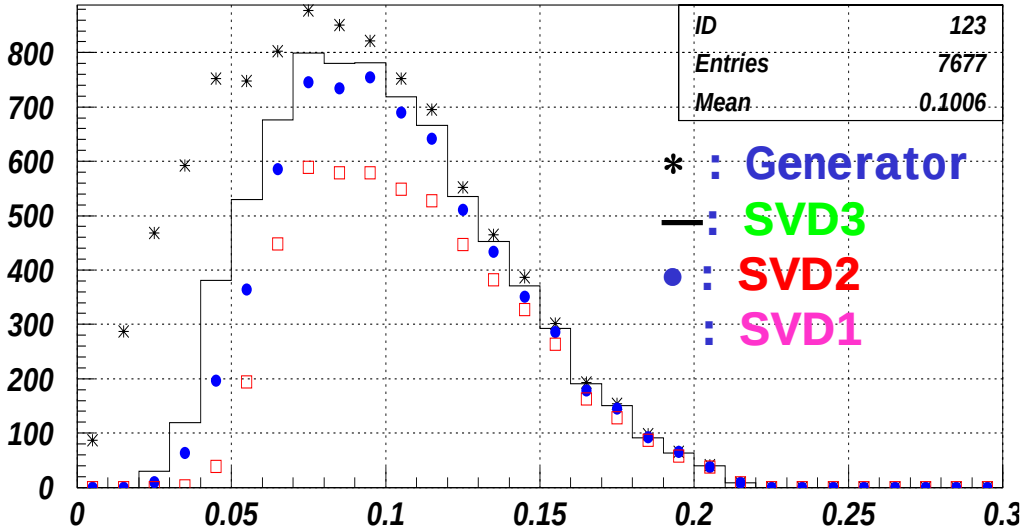
SVD2

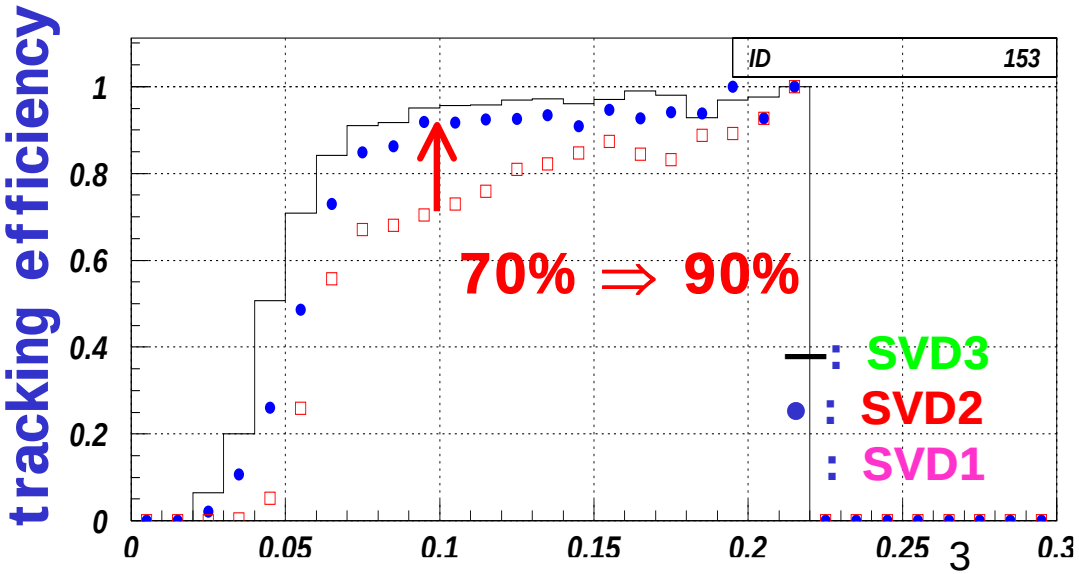


# Improvement on resolution/efficiency




## momentum reconstruction for slow π in B→D*lν



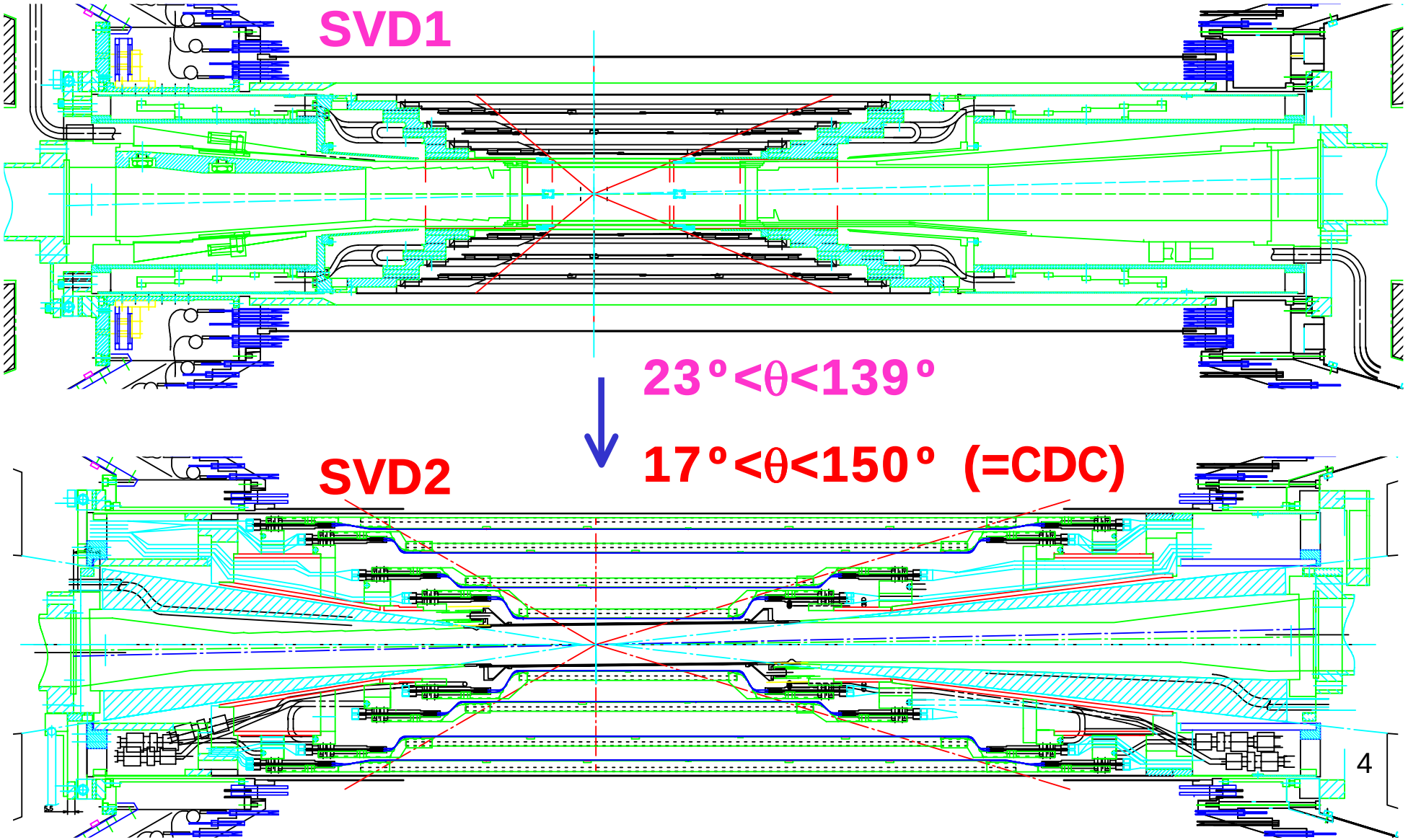




very preliminary

# Increase of acceptance

- **Larger acceptance**

  **Outermost ladder : L=22cm,R=6.0cm ⇒ L=46cm,R=8.8cm**

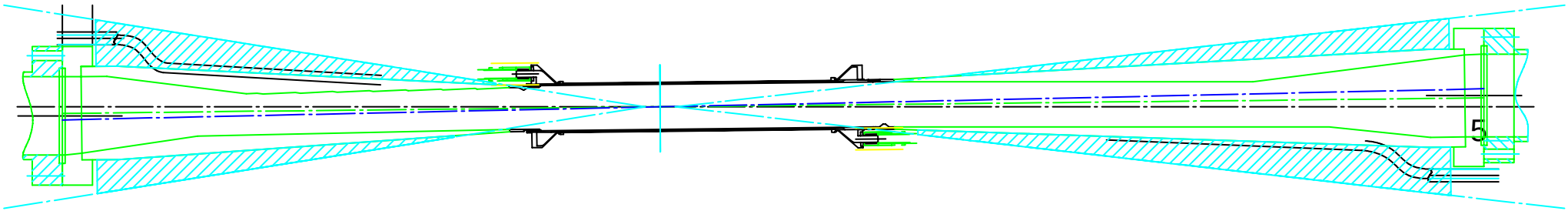


# New beam pipe for SVD2

- **Simulation study on beam background**

| | SVD1.4 $R_{bp}$=2.0cm @ 0.6/0.8A | SVD1.4 $R_{bp}$=2.0cm @ 1.1/2.6A | SVD2 $R_{bp}$=1.5cm @ 1.1/2.6A | SVD3 $R_{bp}$=1.0cm @ 1.1/2.6A |
|---|---|---|---|---|
| # of layers/$R_{1st}$ | 3/3.0cm | 3/3.0cm | 4/2.0cm | 5/1.5cm |
| SVD 1st layer dose(krad/yr=$10^7$s) | ~40 | ~130 | ~80 | ~660 |
| CDC 1st layer Occup. | ≡1 | ~3 | ~1.5 | ~3.6 |
| SVD 1st layer Occup. | ≡1 | ~3 | ~ 0.9 | ~ 8 |
| $\sigma_{\Delta Z}$ ($\mu$m) | ~100 | ~100×1.2? | ~75 | ~50×1.3? |

- $R_{inner}$: 2.0cm ⇒ 1.5 cm
- Better cooling (He⇒PF200) for higher beam current
- More masks for charged particle background
- will be delivered in June by IHI



# Improvement of electronics

- **New DSSD (CLEO3 type) : no pinhole problem**
  - **AC couple $\Rightarrow$ DC operation**
  - **Double metal layer $\Rightarrow$ FLEX readout**
- **More radiation hardness**

  **VA1-0.8$\mu$m : 1 MRad $\Rightarrow$ VA1-0.35$\mu$m : >20 MRad**
- **Better trigger capability**
  - **VA1 $\rightarrow$ VA1TA (VA1 with trigger)**
  - **Introduction of Level-1.5 trigger in SVD FADC system**
  - **Introduction of small cell chamber**
  - **Faster SVD / $CDC_{smallcell}$ electronics**

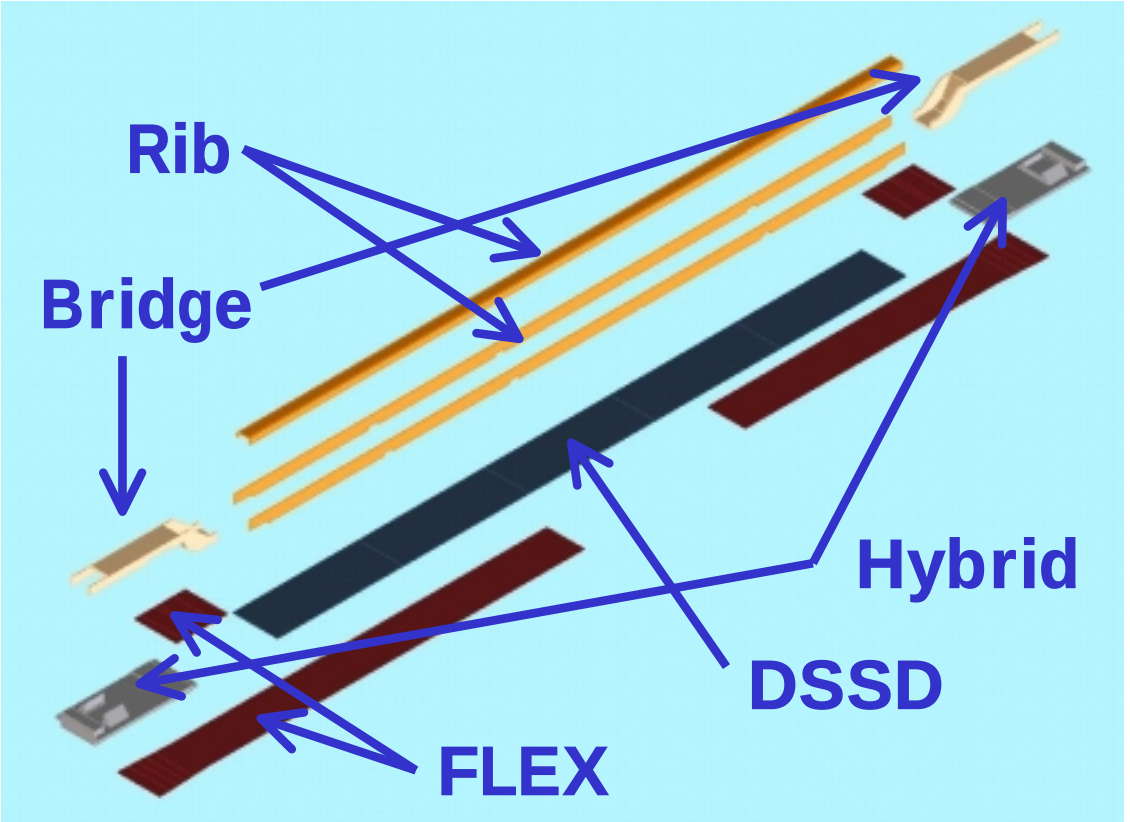
  **$\Rightarrow$ trigger rate @ design current : 1400 Hz $\rightarrow$ 500? Hz**

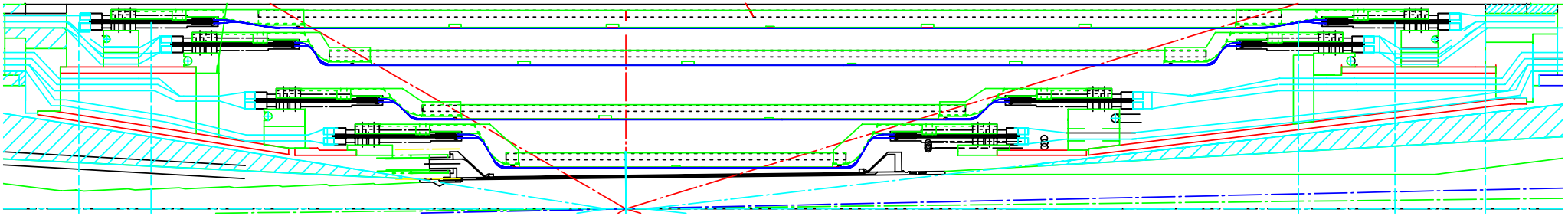
# 2. Components of SVD2

## DSSD ladder

4 kinds of half ladders

| L | Backward | forward |
|---|---|---|
| 1 | 1-DSSD | 1-DSSD |
| 2 | 2-DSSD | 1-DSSD |
| 3 | 3-DSSD | 2-DSSD |
| 4 | 3-DSSD(W) | 3-DSSD(W) |



- Prototyping and electrical test of the half ladder finished.
- Mass production will start soon in Melbourne and HPK.

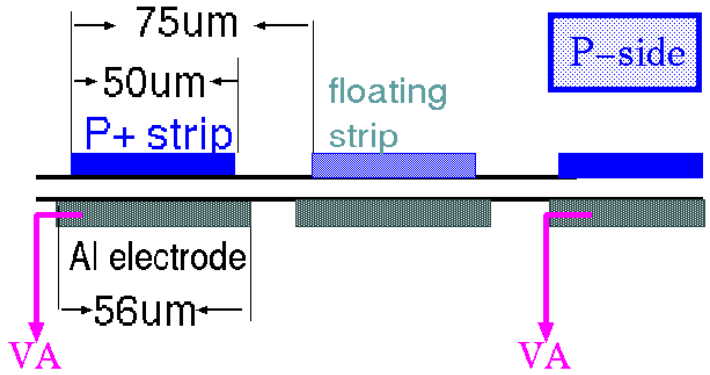
# DSSD for SVD2

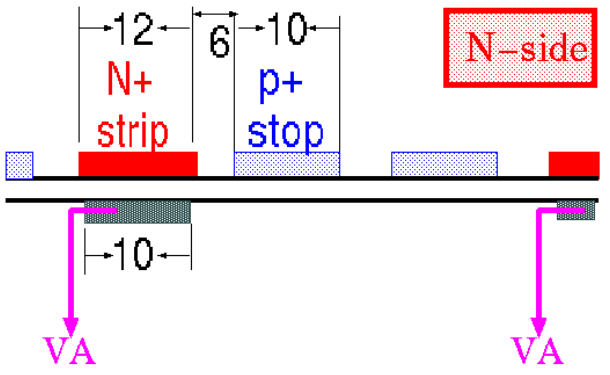
## DSSD (DSSD4387 manufactured by HPK for Belle)

- AC couple, but DC readout by floating ground
- already delivered

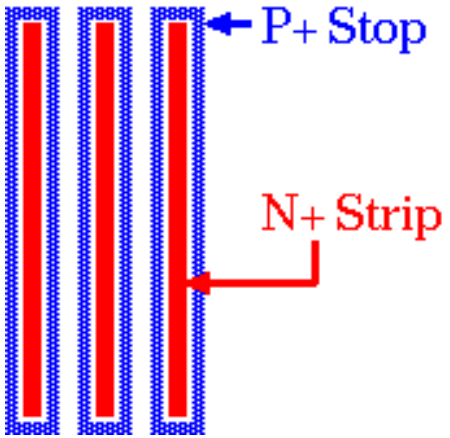
| | p-side (Z) | n-side (rϕ) |
|---|---|---|
| Active area ($mm^2$) | 76.8×25.6 | 76.8×25.6 |
| ($4^{th}$ layer) | (73.8×33.3) | (73.8×33.3) |
| Strip pitch (μm) | 75 (73) | 50 (65) |
| Readout pitch (μm) | 150(Cap. charge div.) | 50 |
| # of readout | 512 | 512 |
| Bias (volt) | -5 | +70 |

- 512x2(p/n)X2(F/B)X54(ladders)=110,592 channels



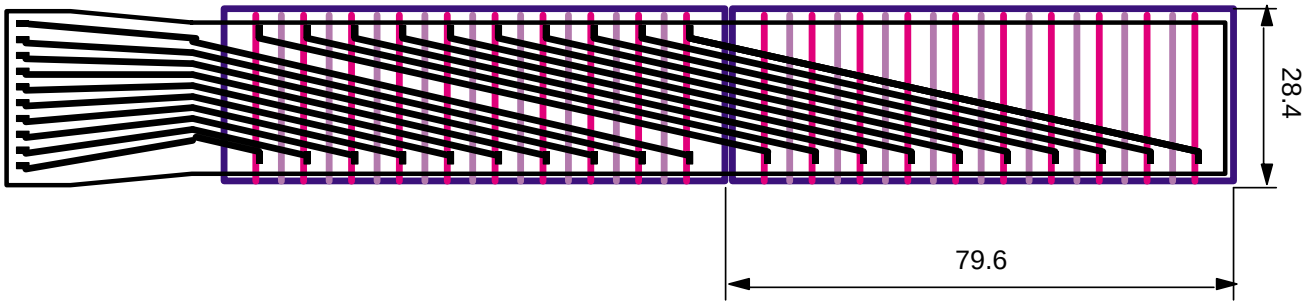

"atoll"
p stop

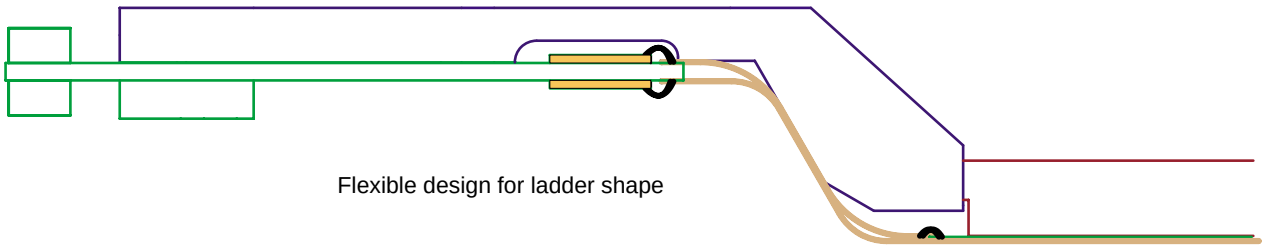


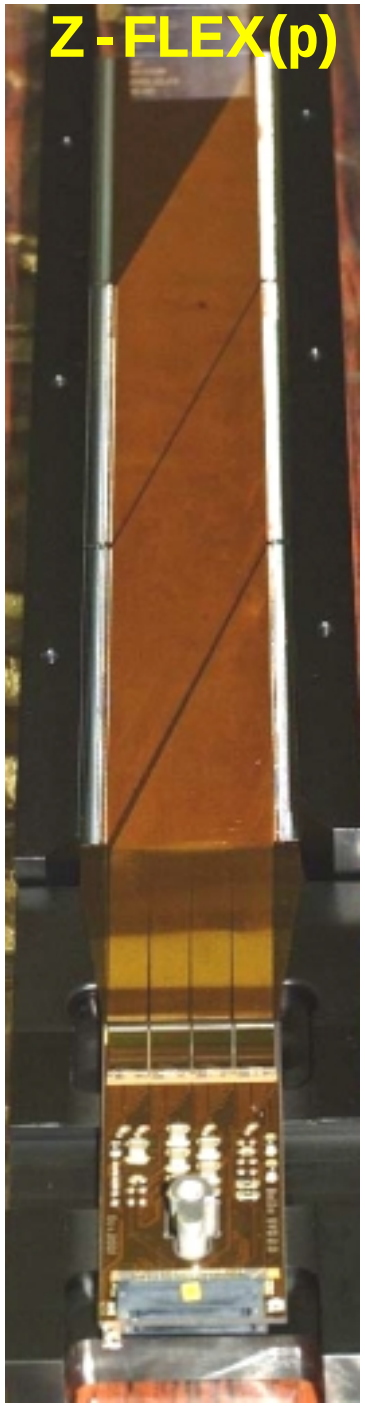
# Flex Circuit for SVD2

## FLEX circuit

- Flexible layout of Si detector
- Lower capacitance than double metal
- Fine pitch (~50μm)
- Wide area (~30x3.3cm²)
- Under mass production
- Yield is issue for 3-DSSD



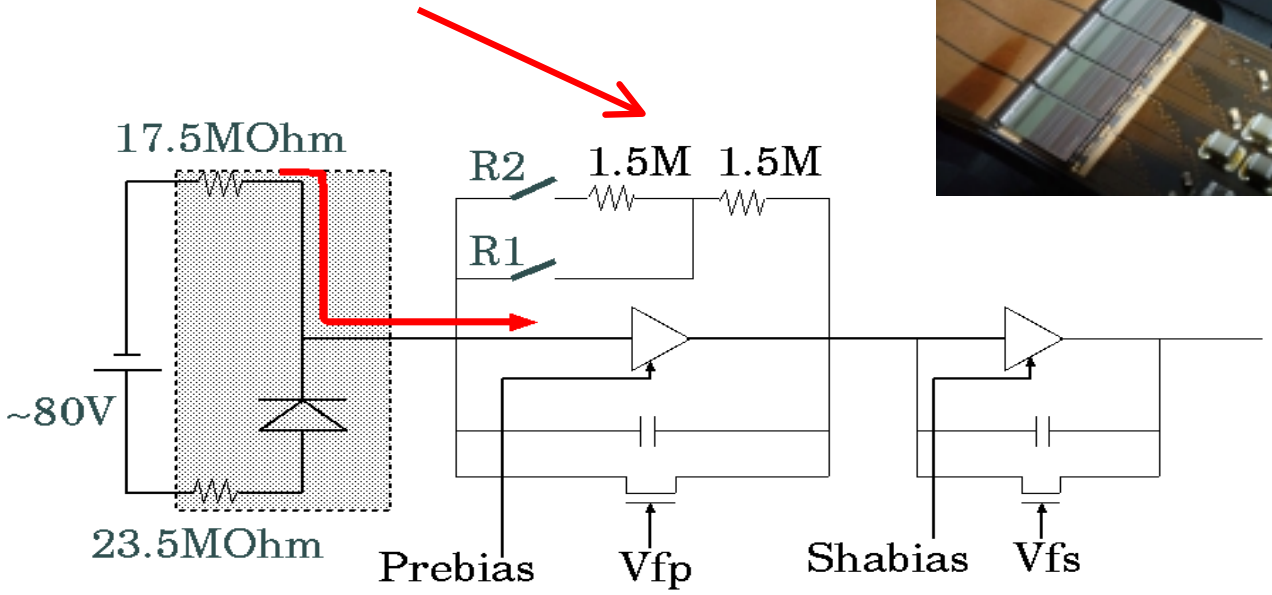



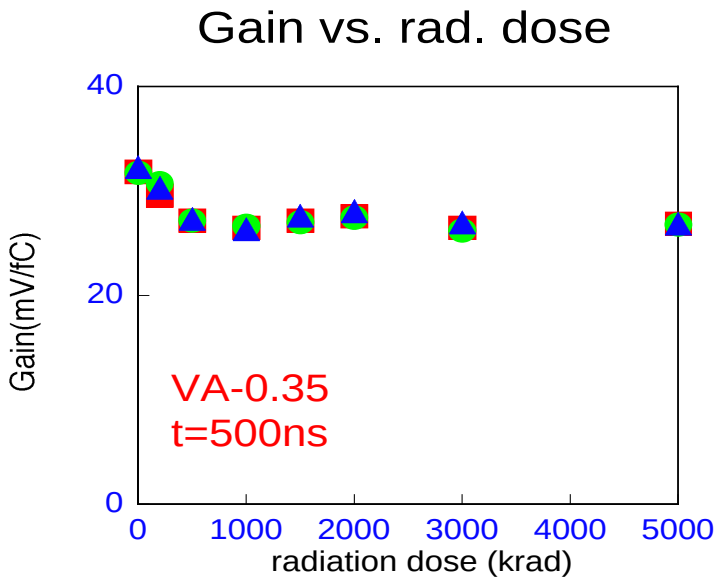

# VA1TA for SVD2 (1)

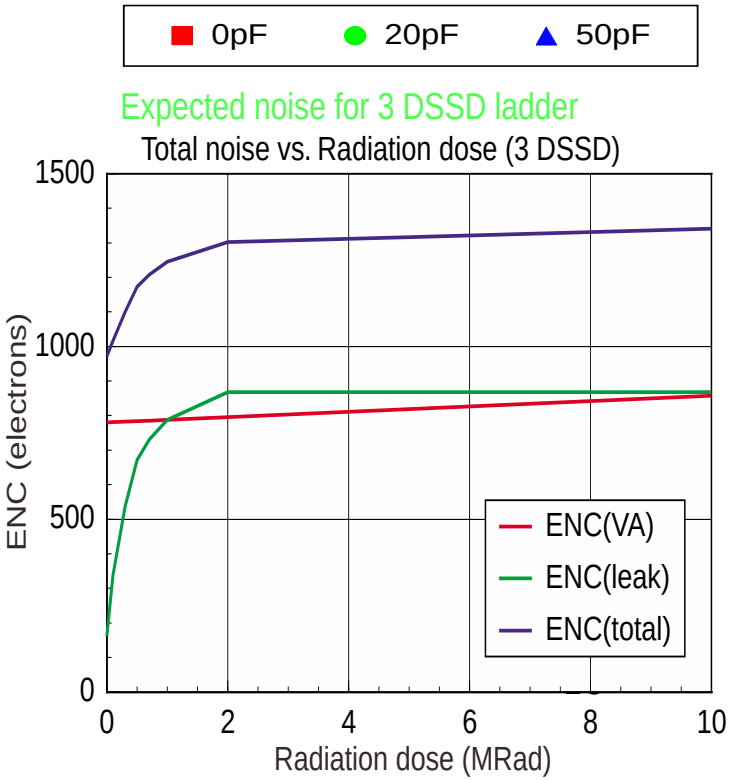
## VA1TA

- VA1(AMS-0.35μm, $\tau_p$=0.3~1.0μs) +TA(fast shaper and discriminator)
- Radiation hardness up to >20 MRad
- ENC~800(e), S/N~25
- four VA1TAs on a hybrid
- four analog signals read out in parallel
- Bias current compensator





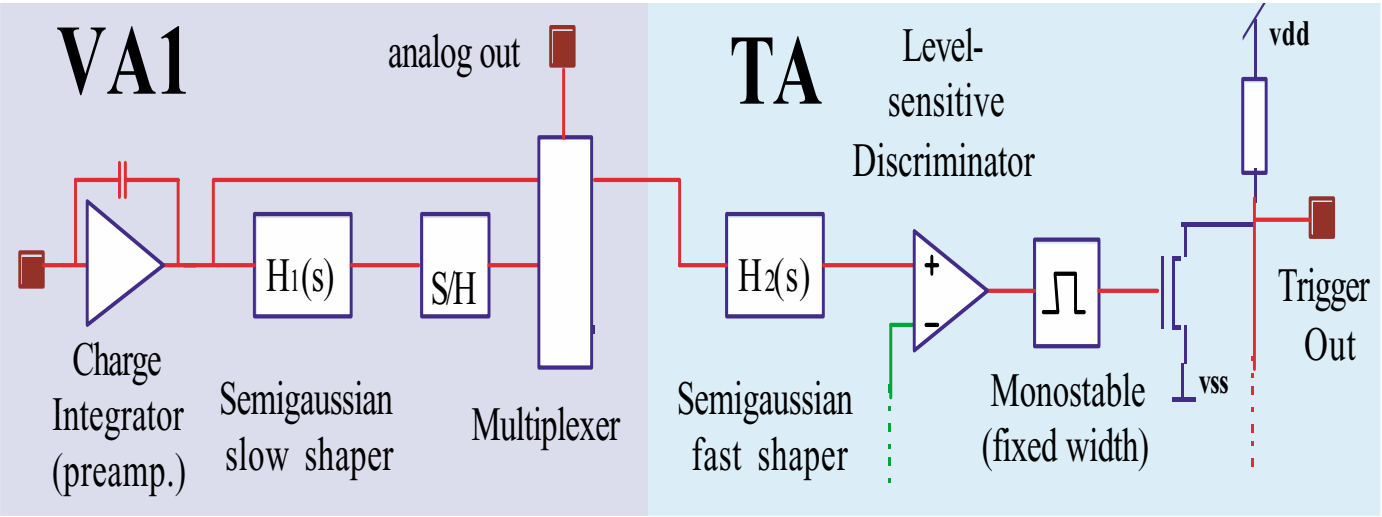



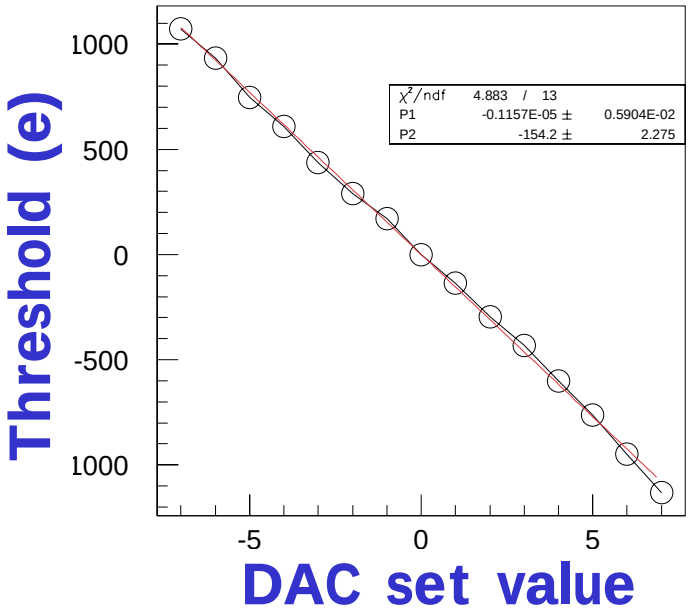



# VA1TA for SVD2 (2)

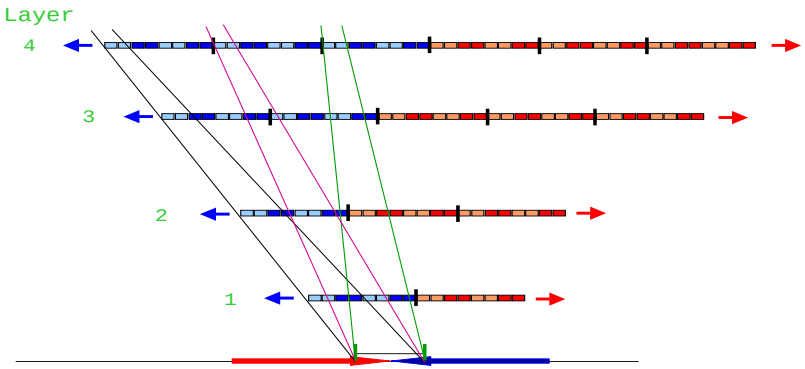
## VA1TA (cont.)

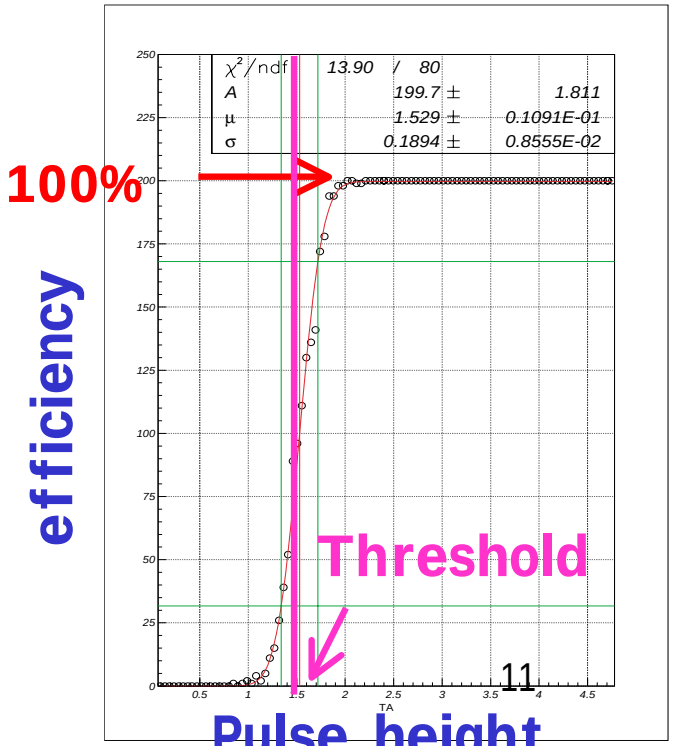
- Trigger function was confirmed
- 128 channels/chip, 4 mW/channel
- Hybrid board under mass production



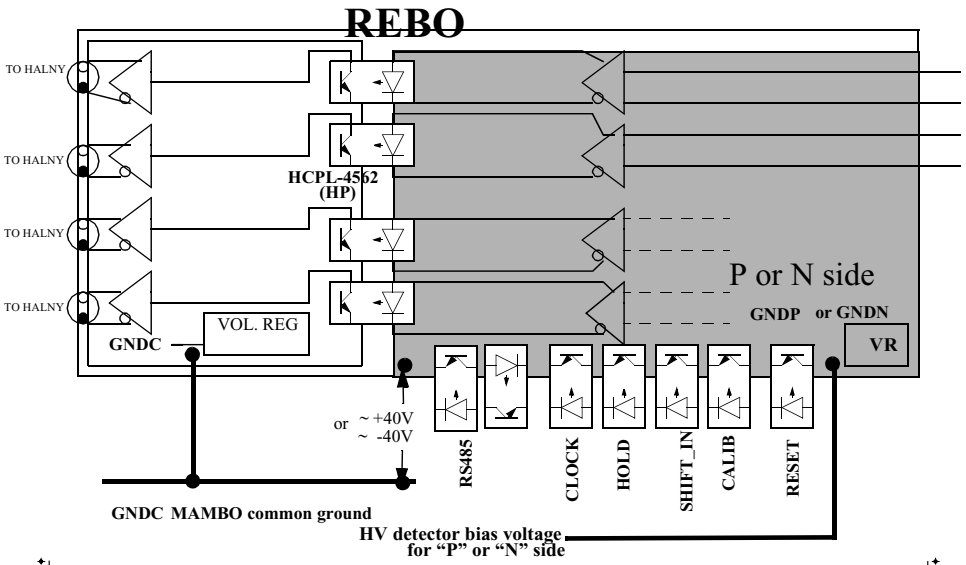

- Level-0 trigger logic in FADC are under study

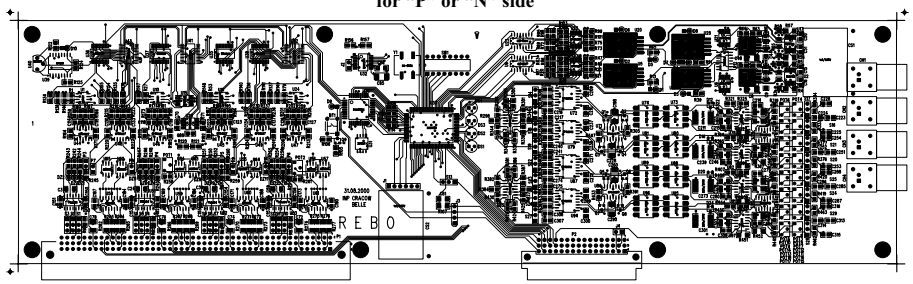


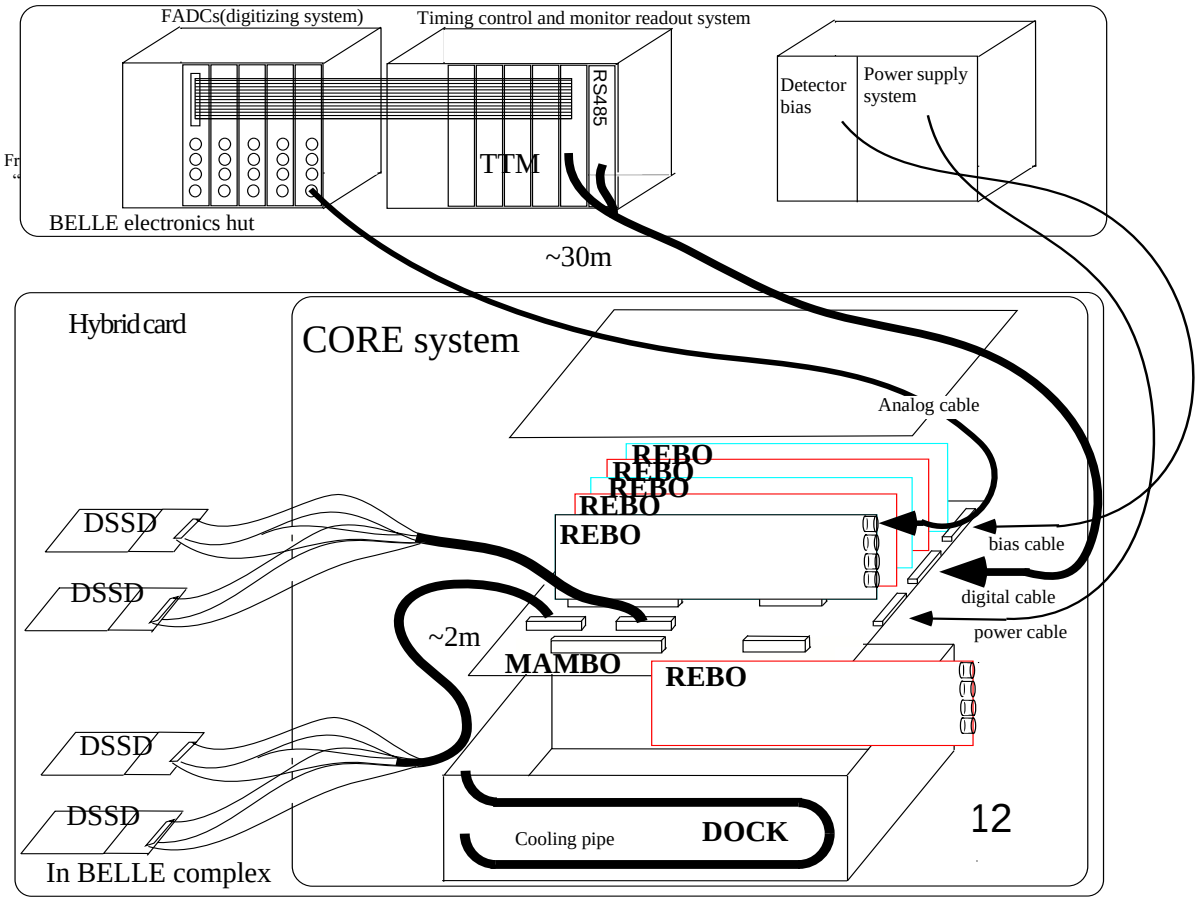



# Repeater system for SVD2 (3)

- Two floating grounds for p/n side
- one ground in one repeater board (REBO)
- 3-REBO(p-side)+3-REBO(n-side) on a board (MAMBO)
- 16 signals (from 4 hybrids) read by one REBO
- Optical couplers for analog/digital signals
- Prototype is under test



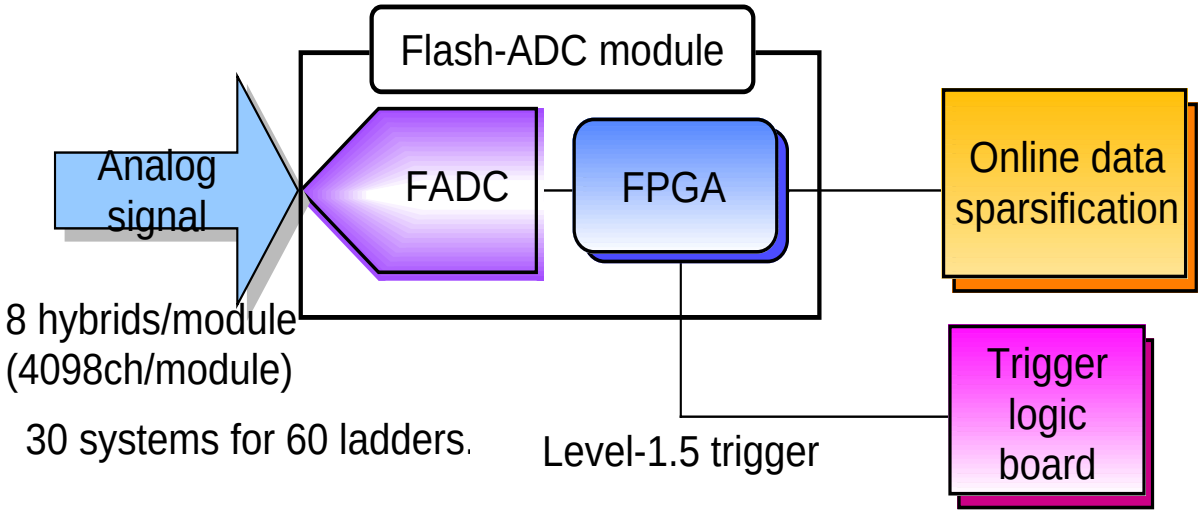


# FADC system for SVD2

## New FADC system

- 24 FADC(40MHz,10 bit) on a board
- search L-0 triggers (VA1TA,TOF)
- generate L-1.5 trigger signal
- two events data can be stored
- prototype finished

Backend electronics schematic diagram



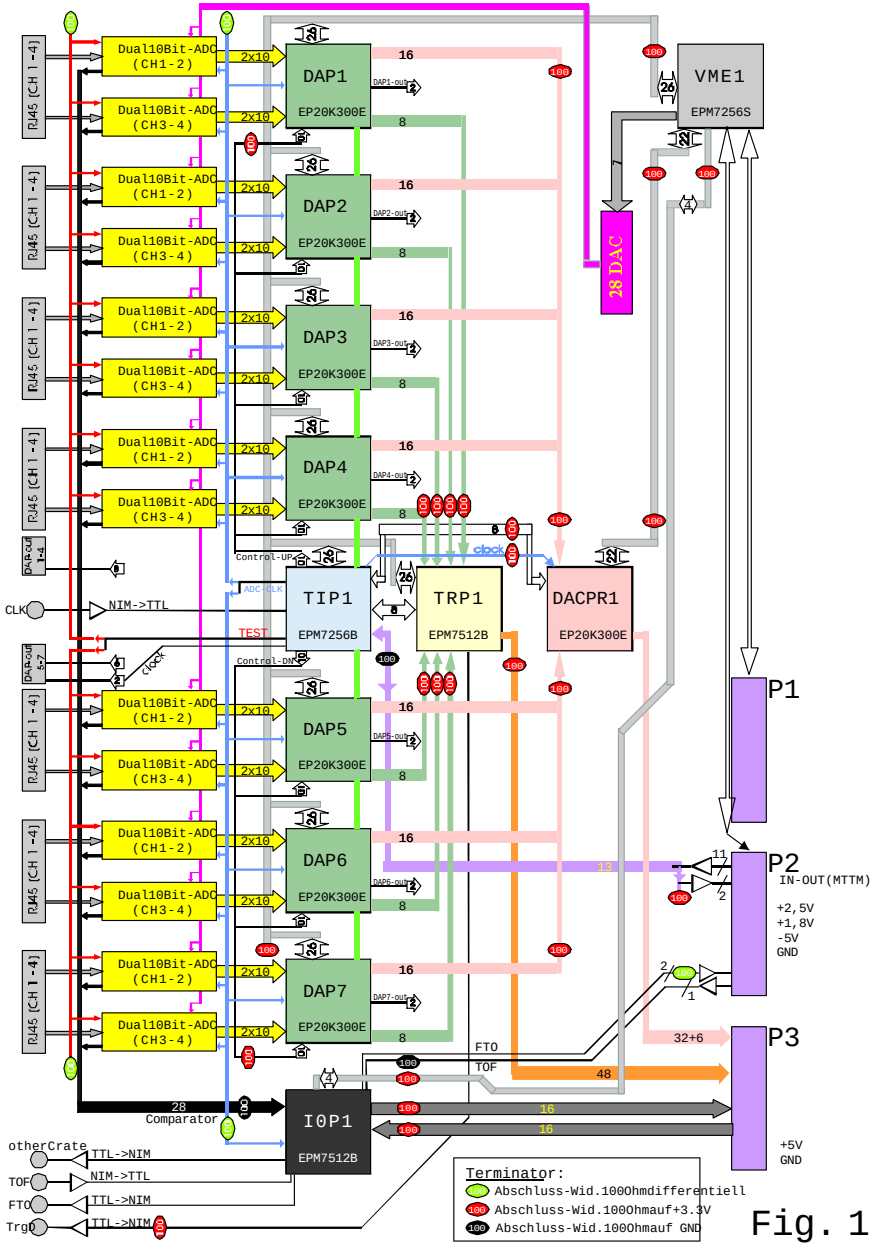
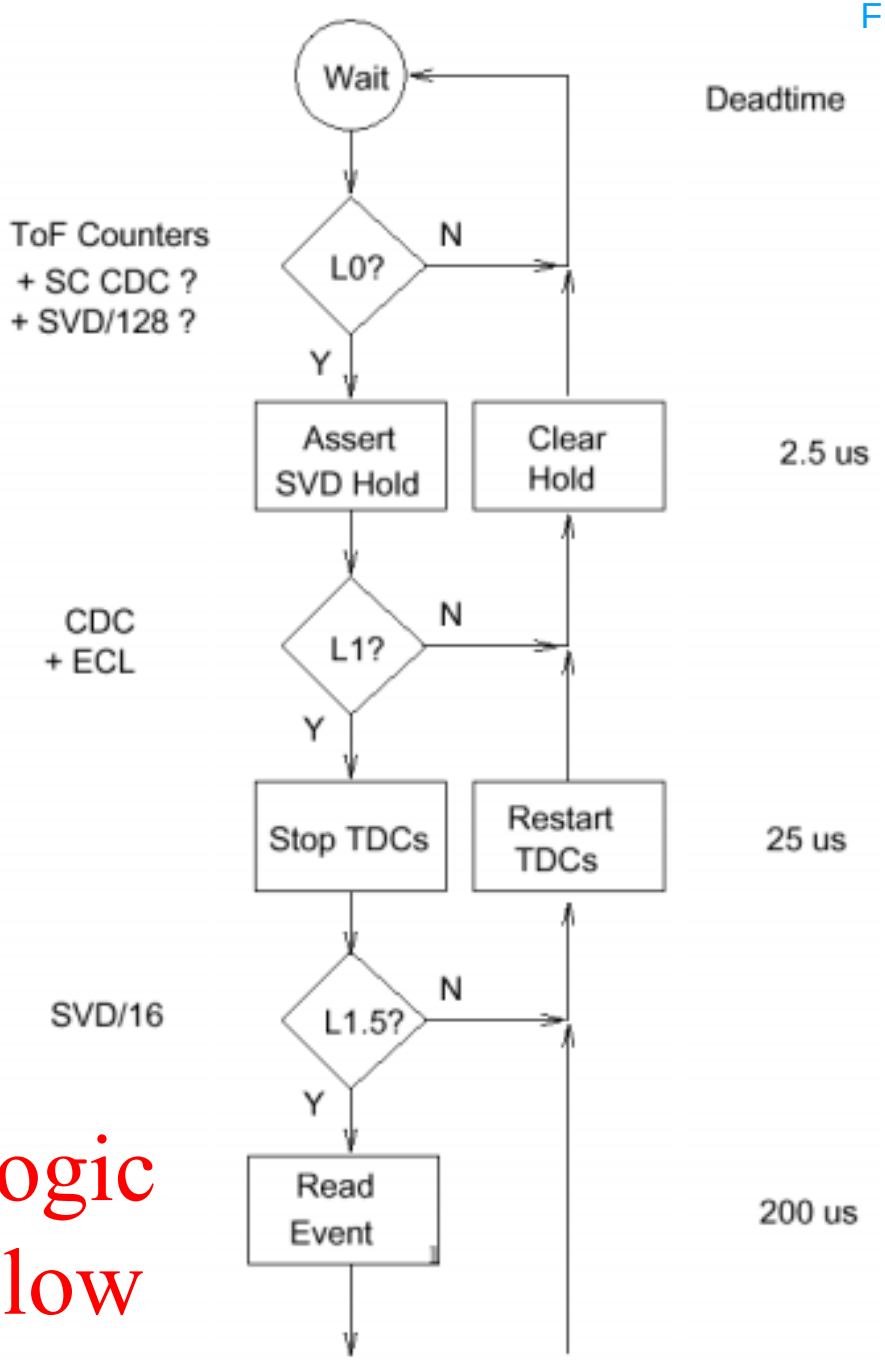



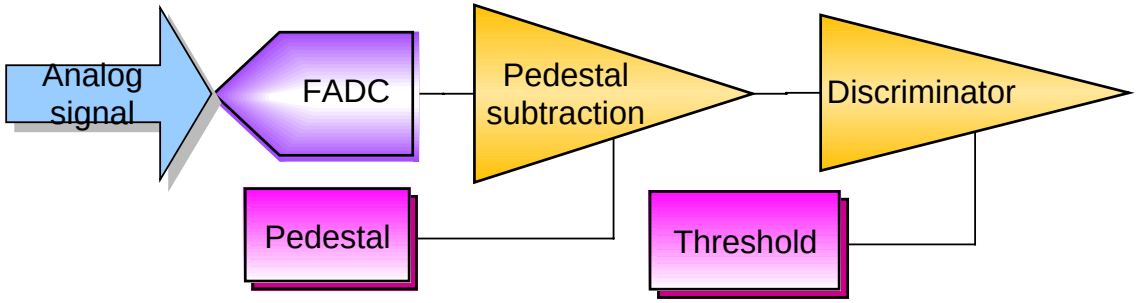

Fig. 1

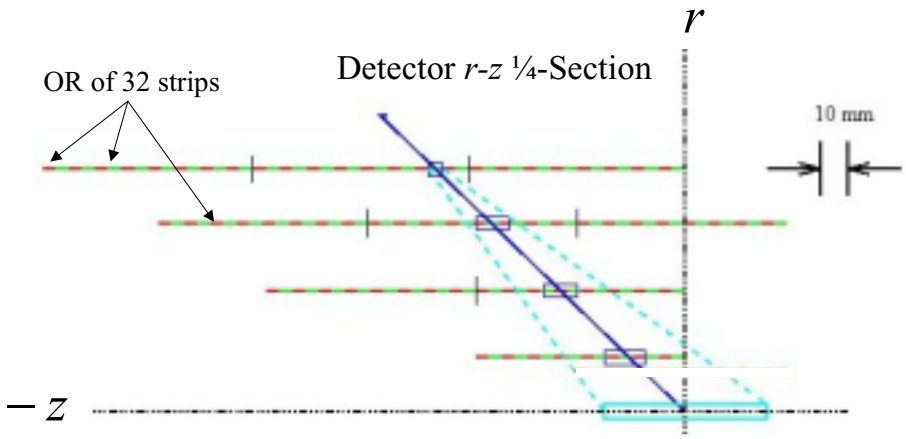
# Level 1.5 trigger for SVD2



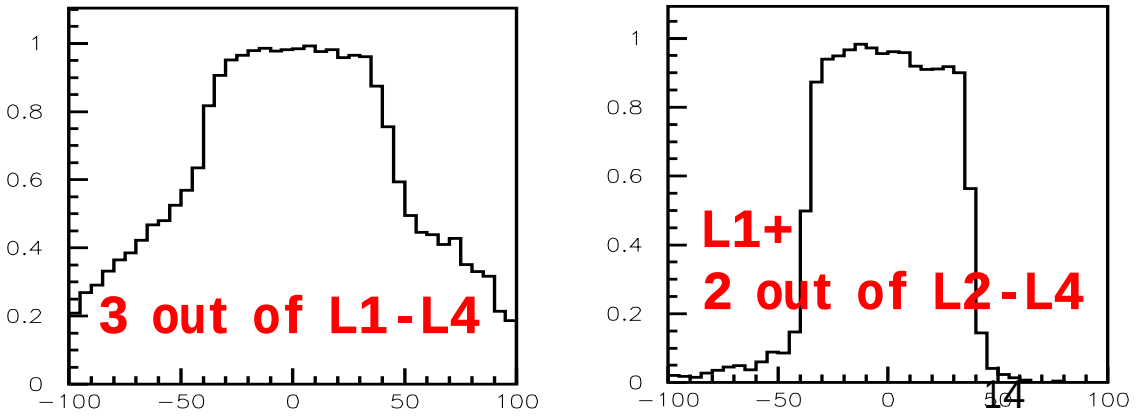

Logic Flow

FPGA algorithm for L1.5 trigger



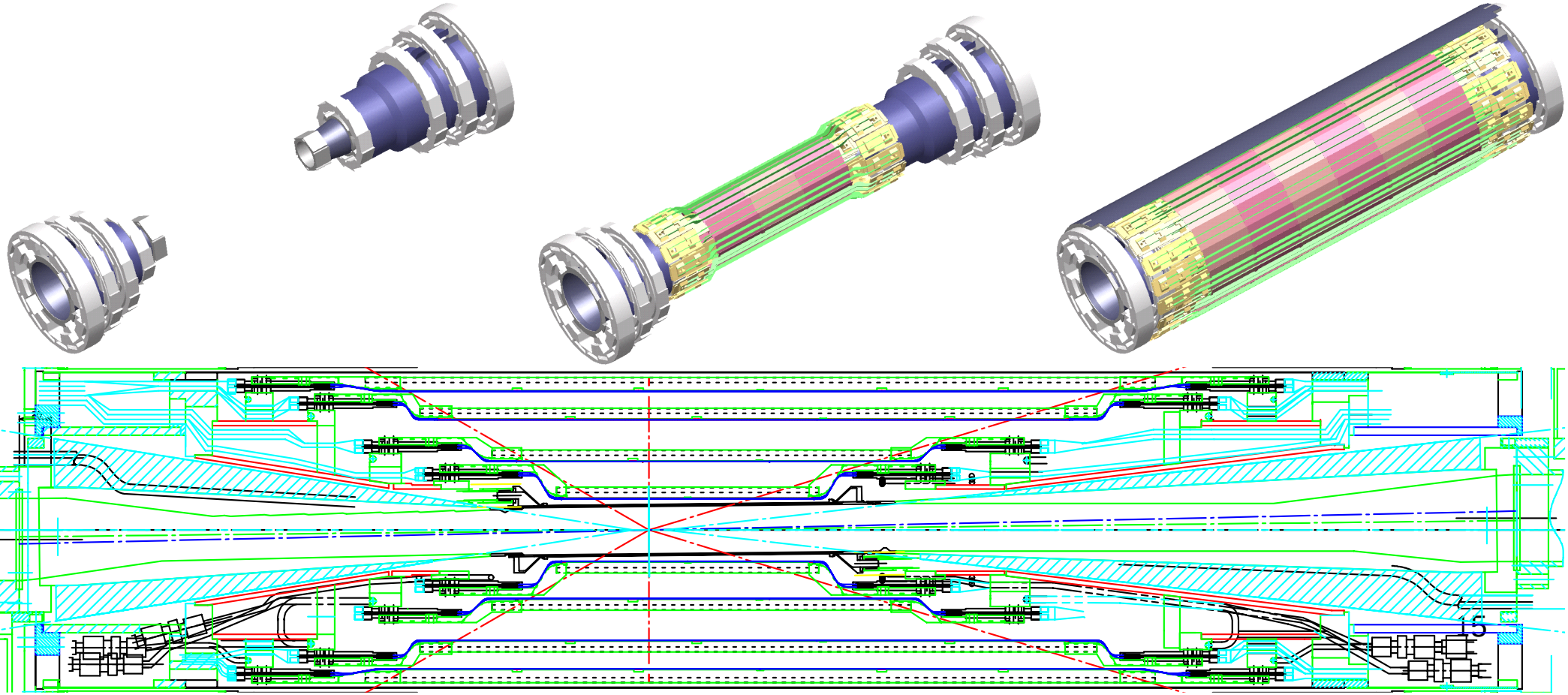

## L-1.5 trigger efficiency (MC)



# Mechanical structure of SVD2

Same concept with SVD1 (clam shell design)

- more ladders (32⇒54)
- Endrings : aluminum rings + CFRP cones (CTE ~ a few ppm)
- Longer/larger CFRP outer cover
- Heavier beam pipe (but independently supported by CDC)



# 3.Upgrade: SVD3?

KEKB($L\sim10^{34}$) $\Rightarrow$ Super-KEKB($L\sim10^{35}$)

- **New phase of physics:**
  - more full-reconstruction efficiency
  - more background-rejection for rare decay

  $\rightarrow$ Better vertex resolution $\rightarrow$ smaller($R_{bp}\sim1$cm?) beam pipe
- **Higher beam current:**

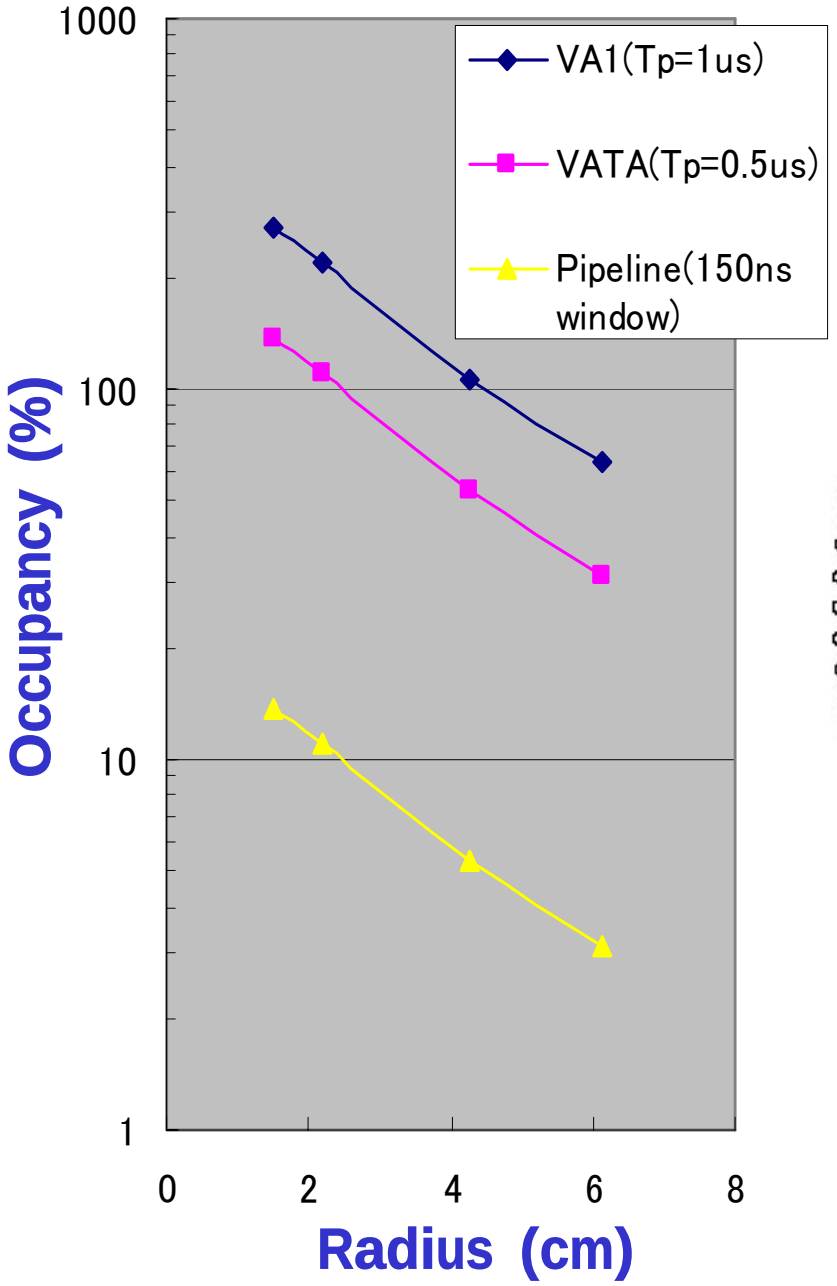
  2.6A(LER)+1.1A(HER) $\Rightarrow$ 10A(LER)+4A(HER)

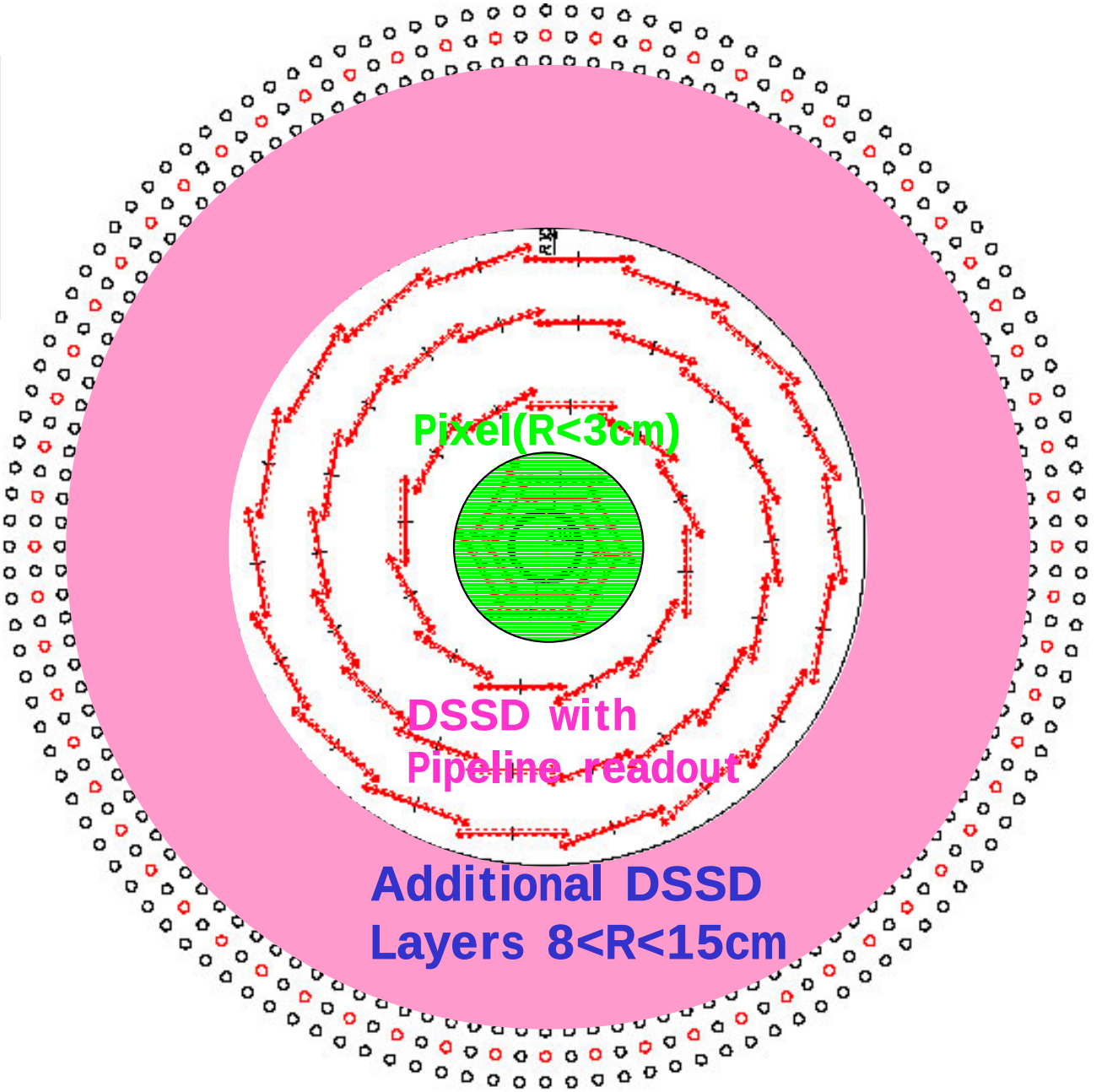
  $\rightarrow$ 0.2MRad/year@$R_{bp}\sim1.5$cm $\Rightarrow$ 7MRad/year@$R_{bp}\sim1.0$cm

  $\rightarrow$ 1st layer occupancy : 3% $\Rightarrow$ >100% for DSSD

**Pixel detector for inner layer of new vertex detector (SVD3?)**

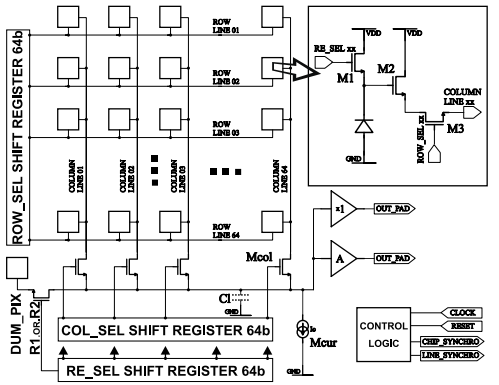
# Configuration of SVD3?

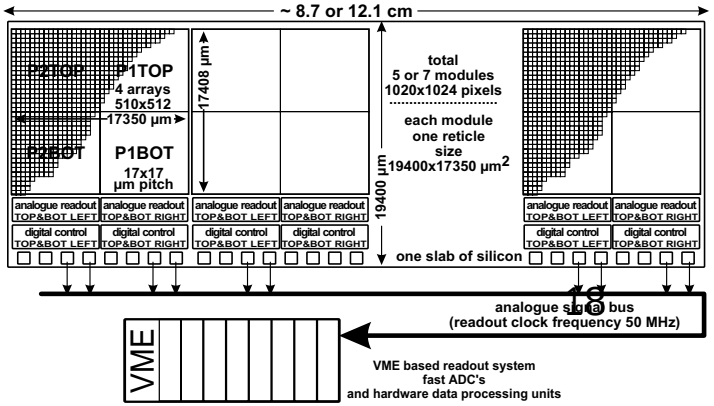


# Pixel detector for SVD3?

- **Requirements on pixel detector**
  - Pixel pitch: <100 μm
  - Low material: <300 μm
  - Radiation hardness: >30MRad
  - Fast readout: <10 μs
- **Possibilities:**
  - Hybrid pixel (CMS type) : Material?
  - CCD : Speed?, Radiation?, Cryogenics?
  - MAPS (Monolithic Active Pixel Sensor)
    - similar to CMOS sensor for digital camera
    - Developed by Strasbourg with Como, Karlsruhe and Krakow
    - S/N~20,eff.~99%,σ~3μm achieved
    - Realistic sample in Mar.2002 →
    - Issues:
      - Readout time (serial in 50MHz)
      - Radiation hardness (~0.6MRad)



# 4.Summary

- We are constructing the new detector **SVD2**:
  - 3 layers: R=3.0,4.5,6.0 cm
    - $\Rightarrow$ 4 layers: R=2.0,4.4,7.0,8.8 cm
  - New DSSD ladder and repeater system
    - Floating DC operation and FLEX readout
  - More radiation hardness
    - VA1-0.8$\mu$m : 1 MRad $\Rightarrow$ VA1-0.35$\mu$m : >20 MRad
  - Better trigger capability
    - VA1 $\rightarrow$ VA1TA (VA1 with trigger)
    - L-1.5 trigger in FADC system
  - Will be installed summer 2002?
- We have started to design the Vertex Detector for Super-KEKB