Belle Silicon Vertex Detector

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

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3. Radiation dose on SVD1
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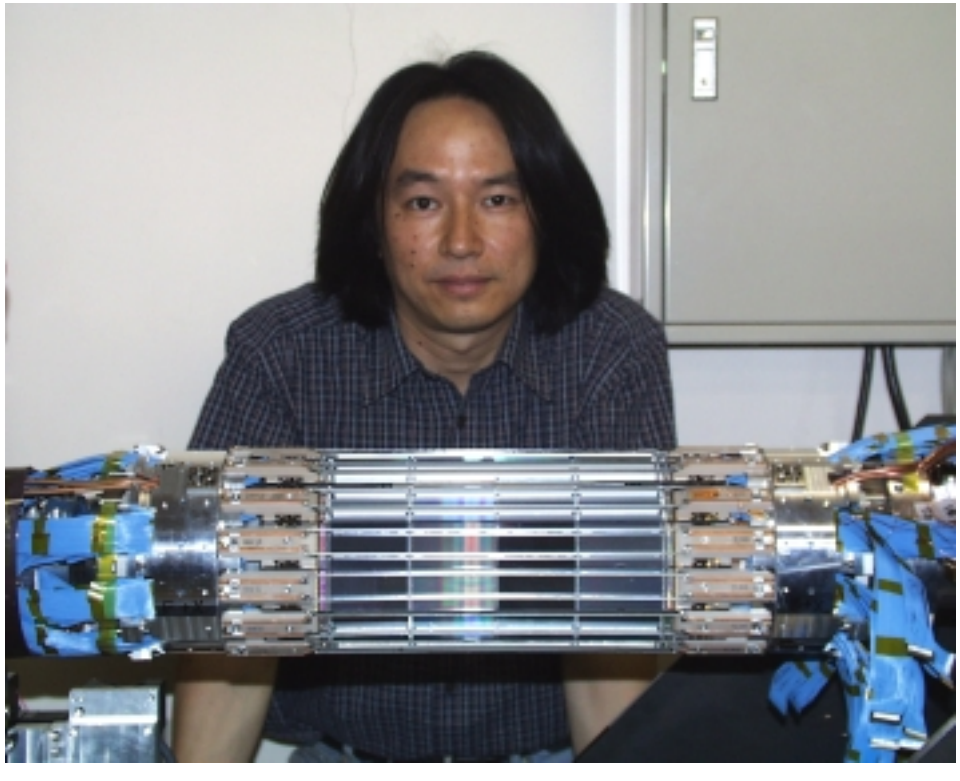
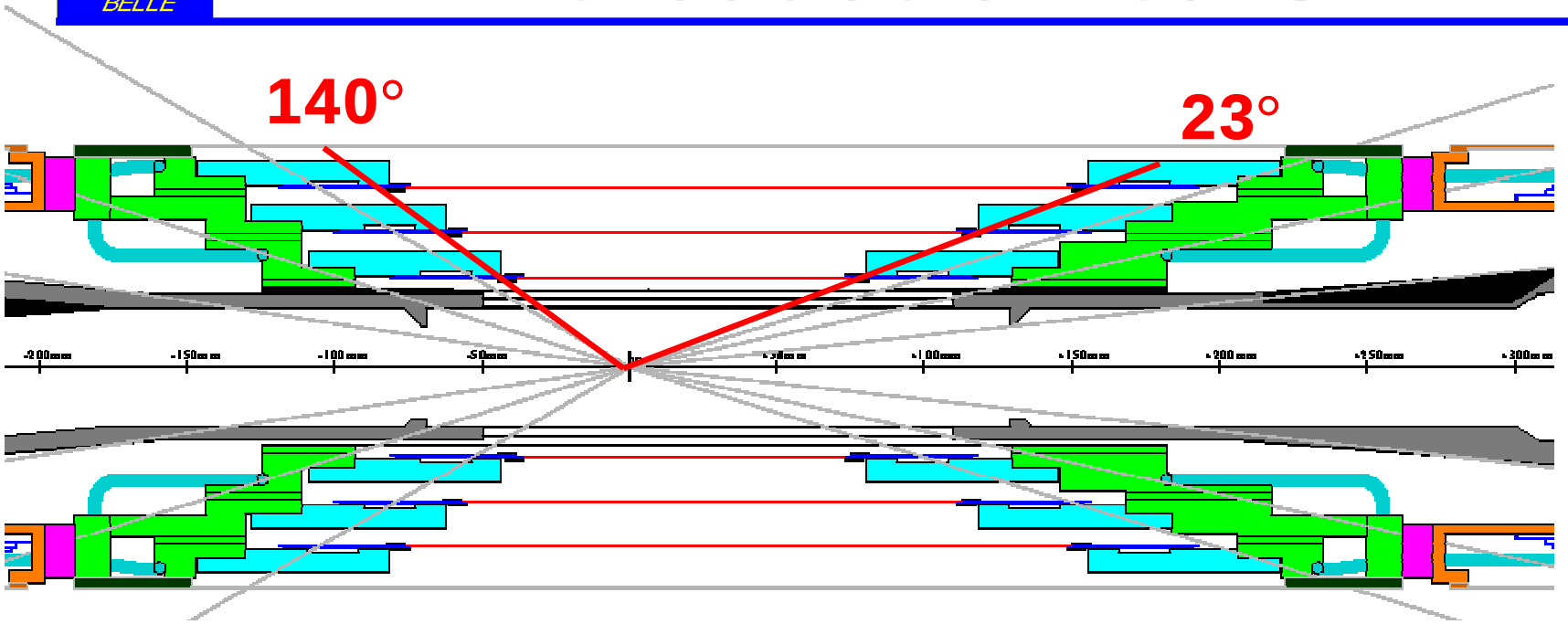
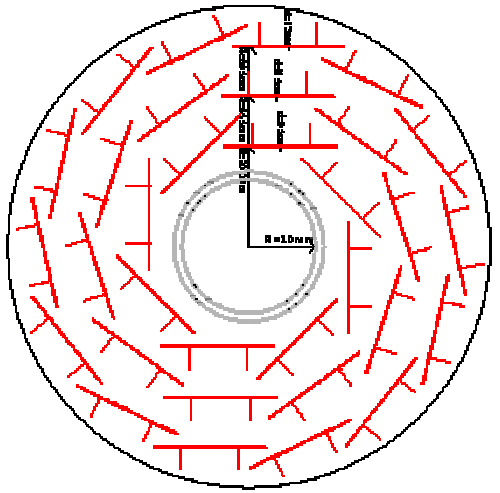


1. Introduction to SVD1





Three layers of DSSD(Double-sided Silicon Strip Detector) ladders

86% of angle coverage

	radius (mm)	# of ladders	# of DSSD in a ladder
1st layer	30.0	8	2
2nd layer	45.5	10	3
3rd layer	60.5	14	4

DSSD Ladders for SVD1

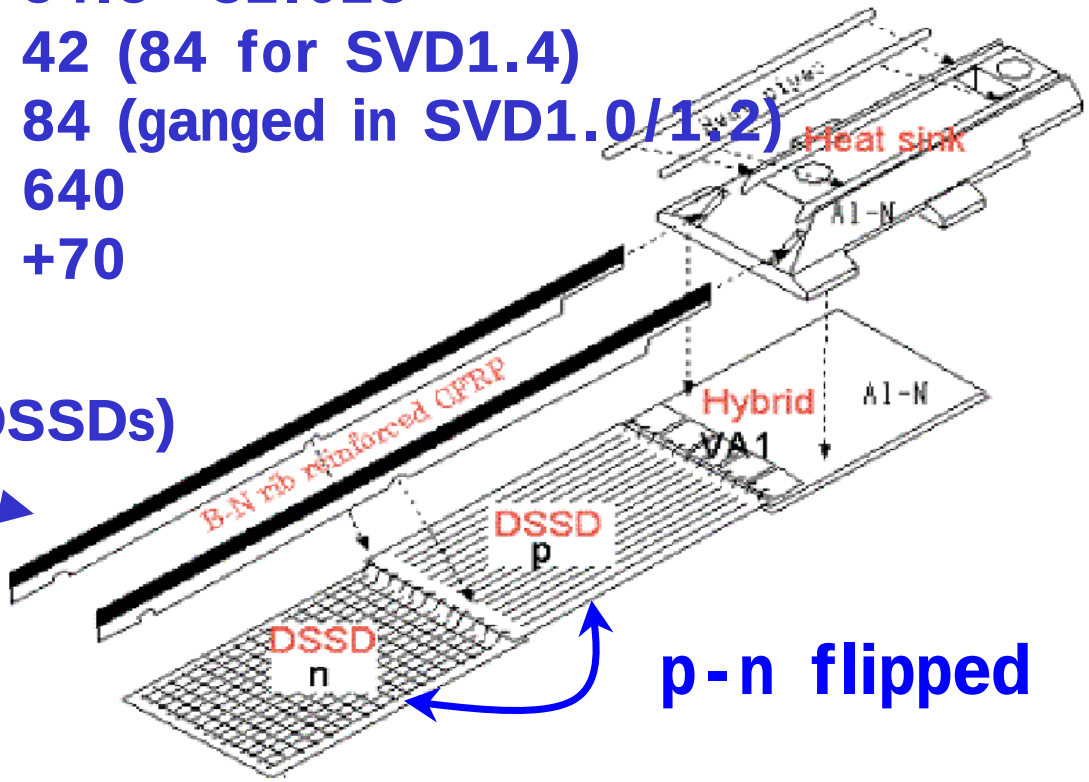
DSSD (S6936 manufactured by HPK)

AC couple, 25 MΩ polysilicon bias resister

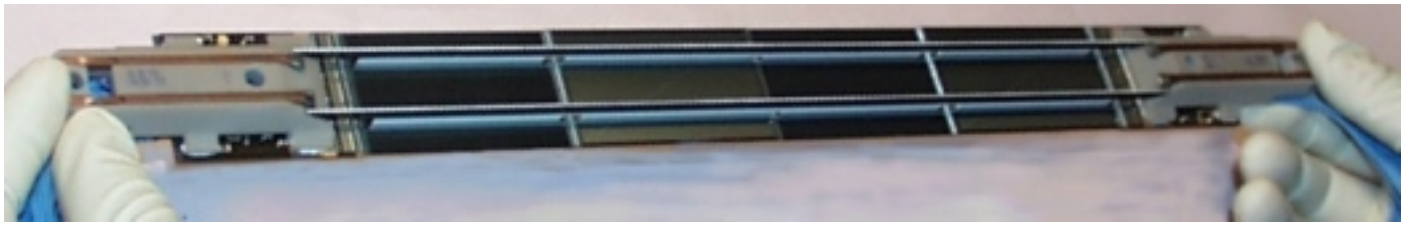
	p-side (rϕ)	n-side (Z)
Active area (mm^2)	53.5×32.04	54.5×32.025
Strip pitch (μm)	25	42 (84 for SVD1.4)
Readout pitch (μm)	50	84 (ganged in SVD1.0/1.2)
# of readout	640	640
Bias (volt)	-5	+70

Only 2 kinds of half-ladders
("short"=1-DSSD and "long"=2-DSSDs)

layer 1 : "short" + "short"
layer 2 : "short" + "long"
layer 3 : "long" + "long"

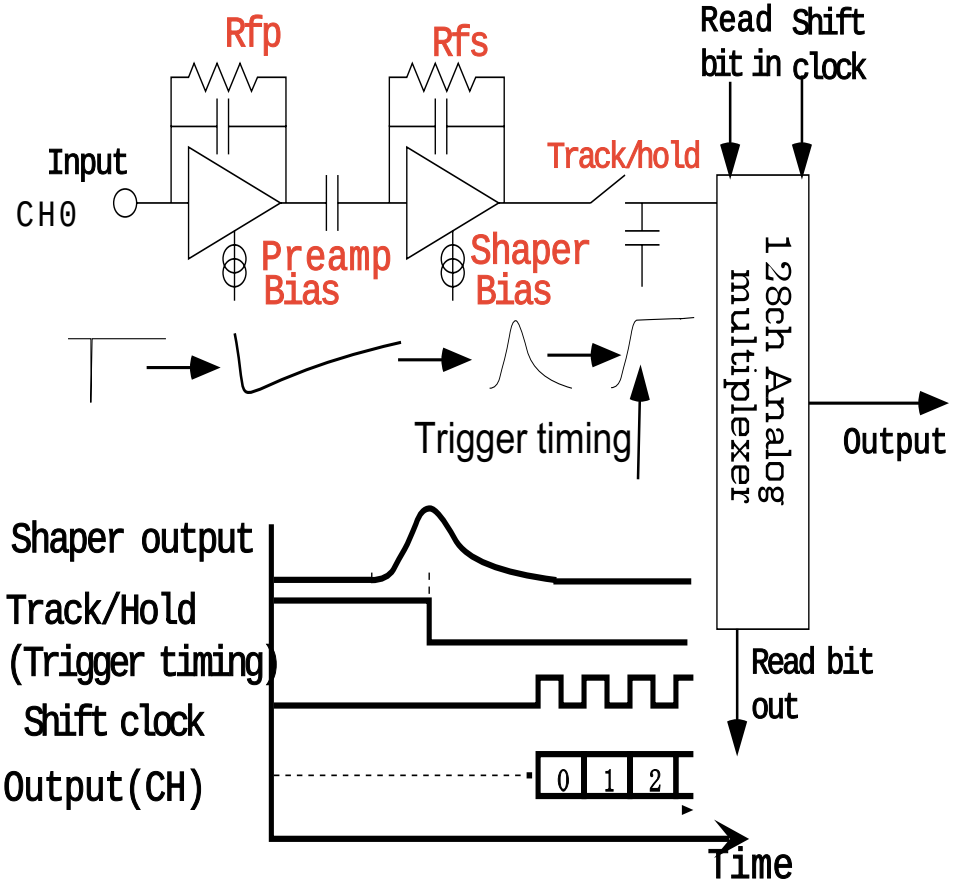


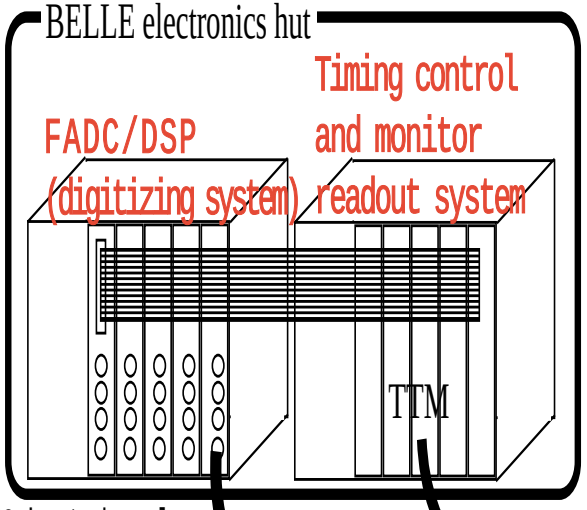
•640×2(p/n)×2(F/B)
×32(ladders)
=81,920 channels

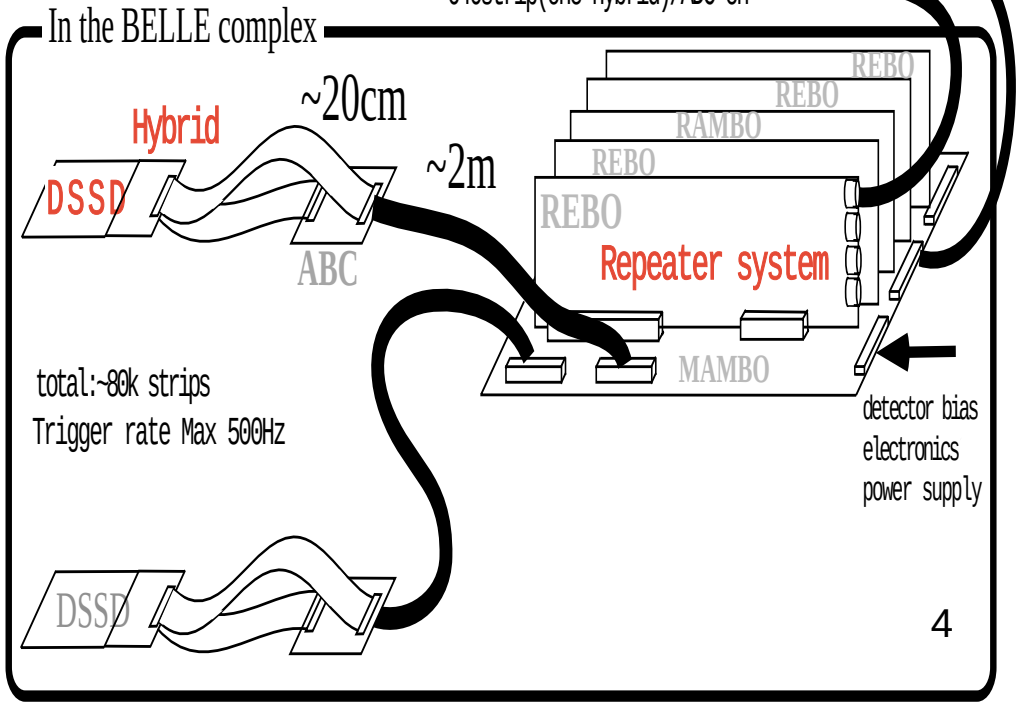


Front-end electronics for SVD1

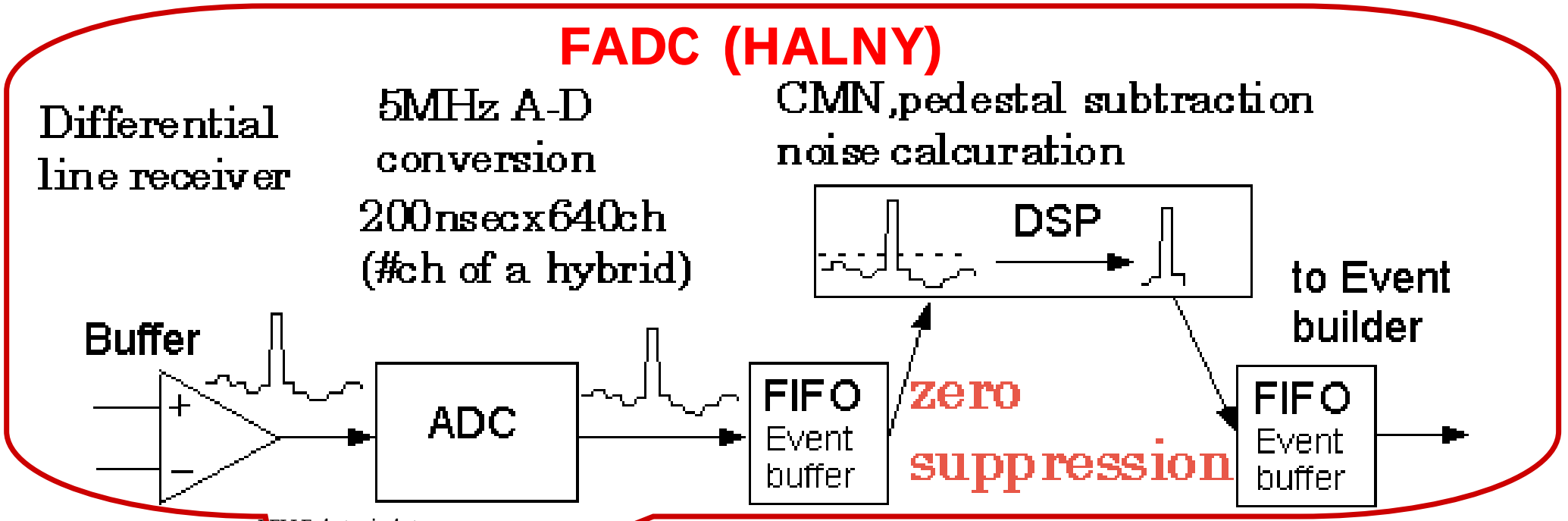
- VA1: Pre.amp.+Shaper+Hold+Multiplex
- IDEAS with AMS 1.2/0.8μm CMOS proc.
- Rad-tolerant up to 200krad/1Mrad
- ENC: 200+8×C_d(pF) (e^-) at τ_p~1μs
- 128 channels/chip, 1.2 mW/channel

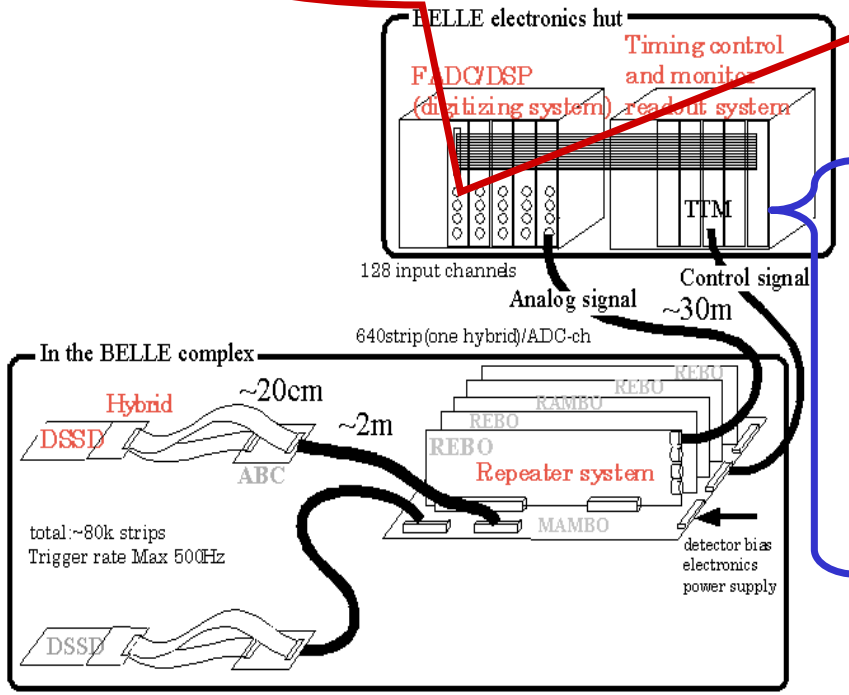






Backend Electronics for SVD1





Typical data size: ~16KB

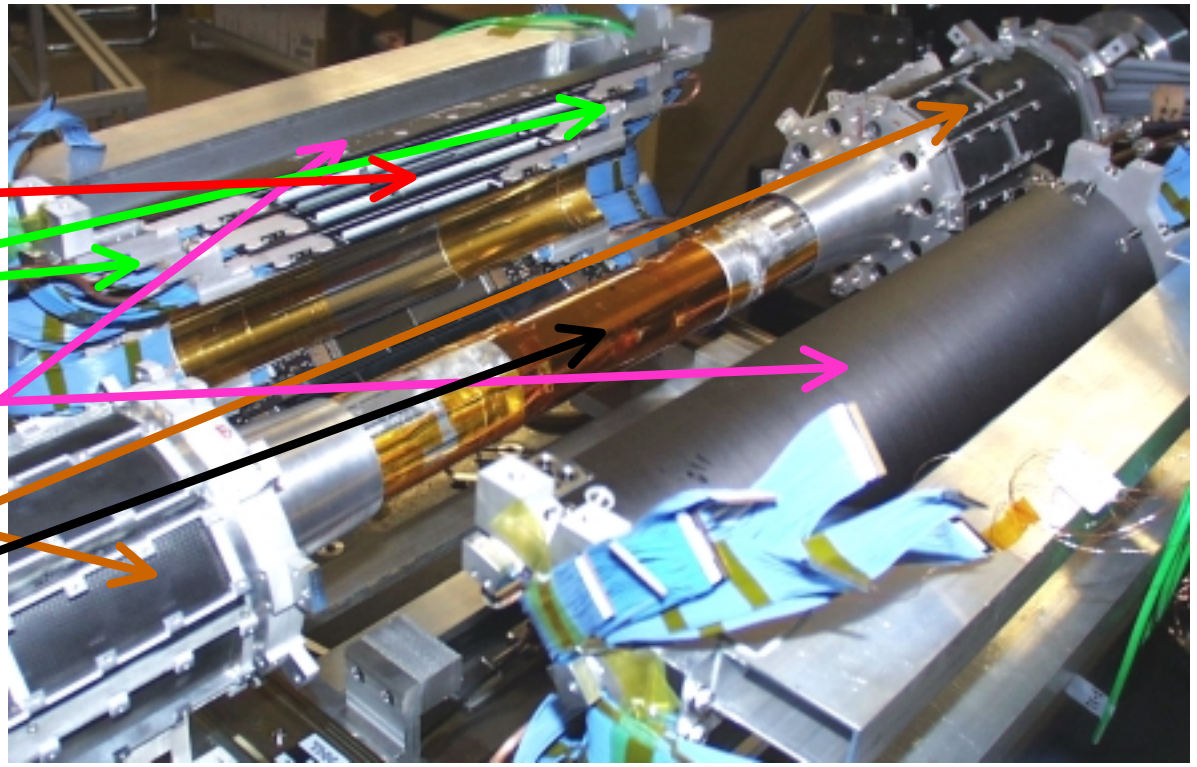
TTMs (Trigger Timing Modules)

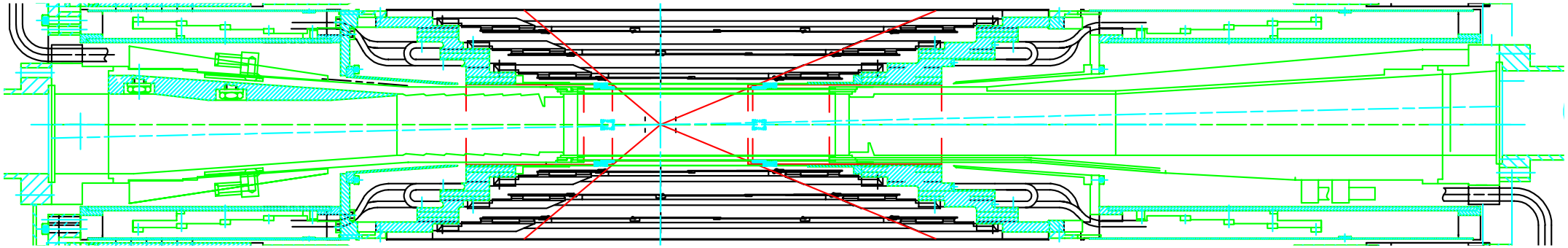
- Firmware-based flexible logic modules
- Provide timing signals to FADCs and Repeaters
- Control VA bias parameters
- Issue (CAMAC-like) commands to repeaters
  - Monitoring, Gain measurement etc.

Mechanical structure of SVD1

SVD1 consists of

- 32 DSSD ladders
- Al end-rings
- CFRP outer covers
- Support cylinders
- IP beam pipe

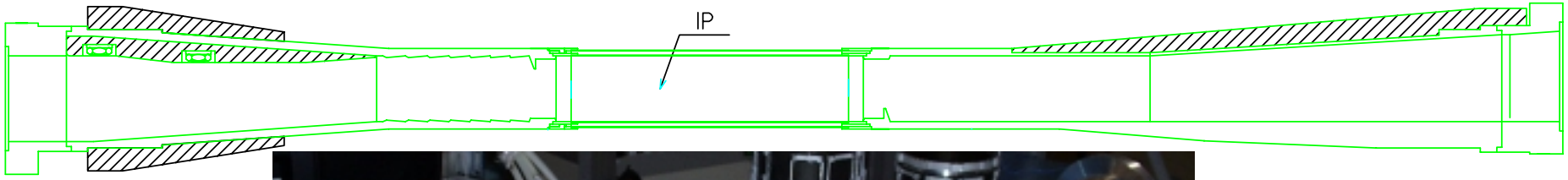


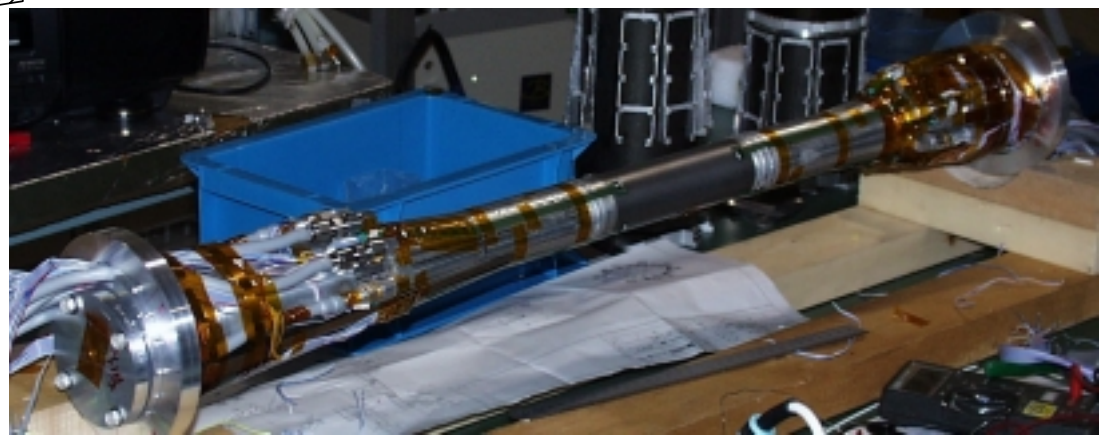


- Machining precision: ~20 μm
- Clam shell structure for ladders, end-rings and outer covers
- SVD and the beam pipe are independently supported by CDC.

IP Beam pipe for SVD1

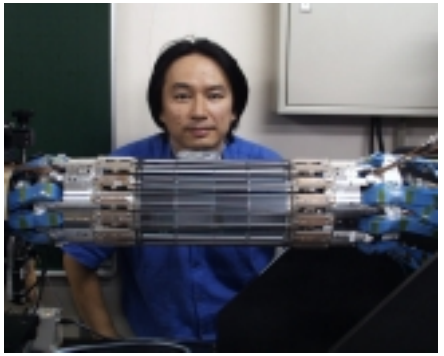
- Central part:
  - Double wall of beryllium cylinders (2×0.5mm-t)
  - Cooled by He gas (12°C, 1g/s)
- Forward/Backward part
  - Aluminum cylinders with inner gold plating
  - Cooled by water (12°C, 4l/s)
  - Mask structure for synchrotron light
  - Tungsten masks for charged particle background





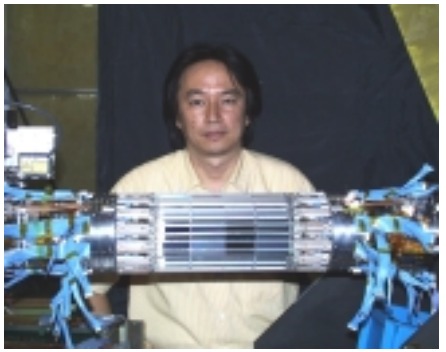
History of SVD1

- **SVD1.0 (Dec.1998 ~ July 1999)**
  - VA1-1.2 μm
  - First layer ladders were damaged due to low energy Synchrotron X ray



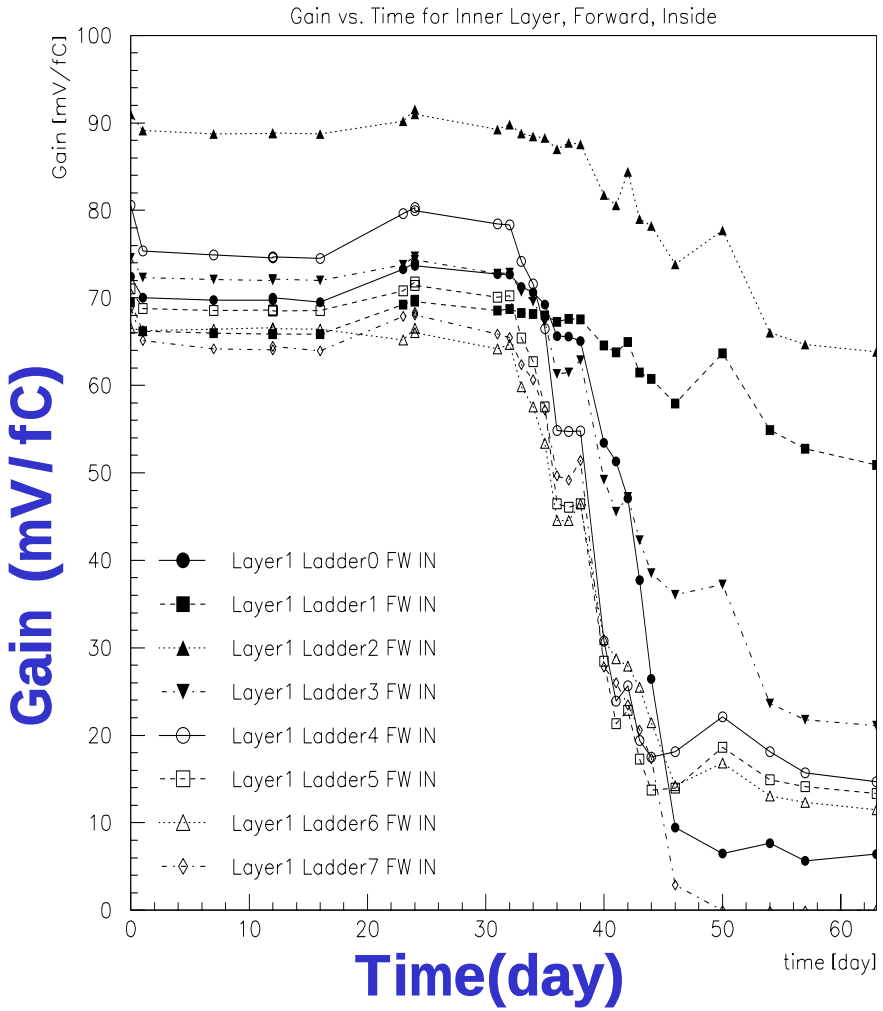
- **SVD1.2 (Aug.1999 ~ July 2000)**
  - VA1-1.2 μm
  - 20 μm thick gold foil outside the beampipe
  - Dismounted when SVD1.4 was ready because of some dead VA1s and gain decrease

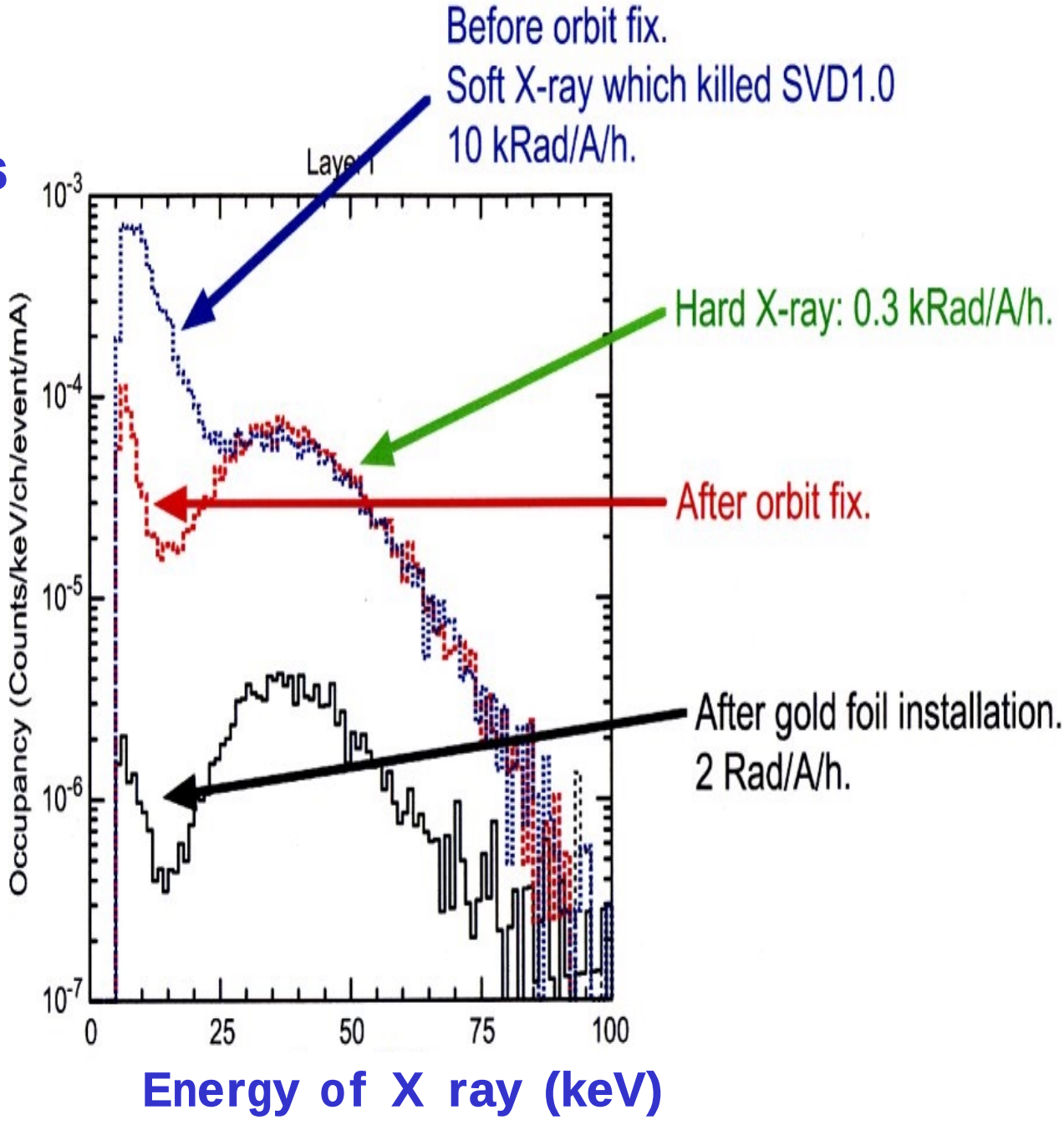
- **SVD1.4 (Aug.2000 ~)**
  - VA1-0.8 μm : 28 ladders
    VA1-1.2 μm : 4 ladders in second layer
  - 10 μm thick gold sputter inside the beampipe



Gain decrease of SVD1.0

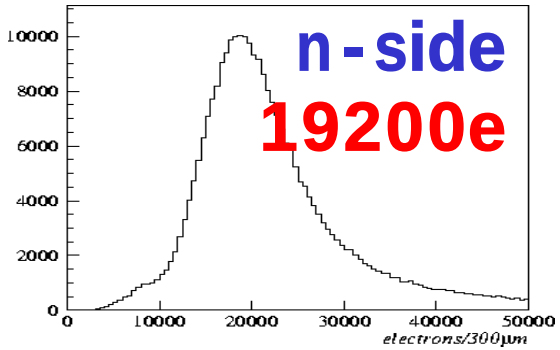
Gain of VA for inner and forward DSSD of 1st layer ladders started to decreas on July 4, 1999.

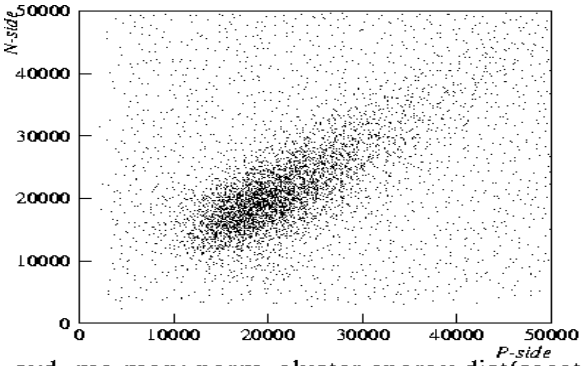




2. Performance of SVD1

- **Noise**
  - p: 550e (S/N~35)
  - n: 1000e (S/N~19)
  - p+n: 1100e (S/N~17)

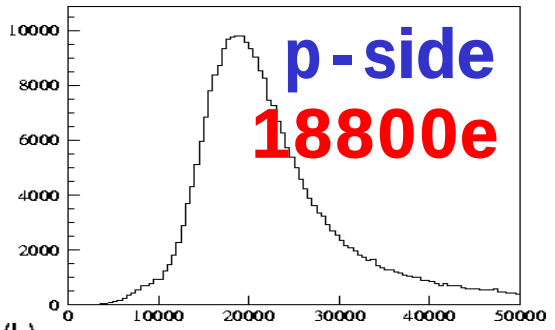




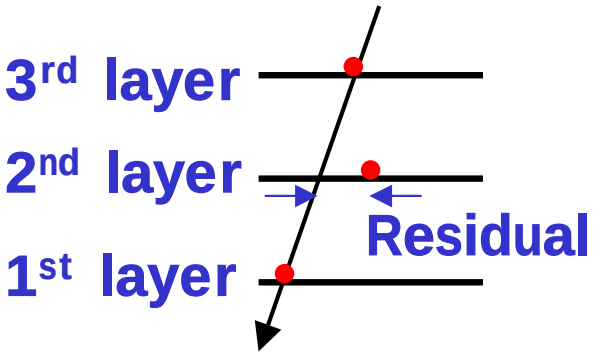
svd_me-mon: norm. cluster energy dist(sccater)

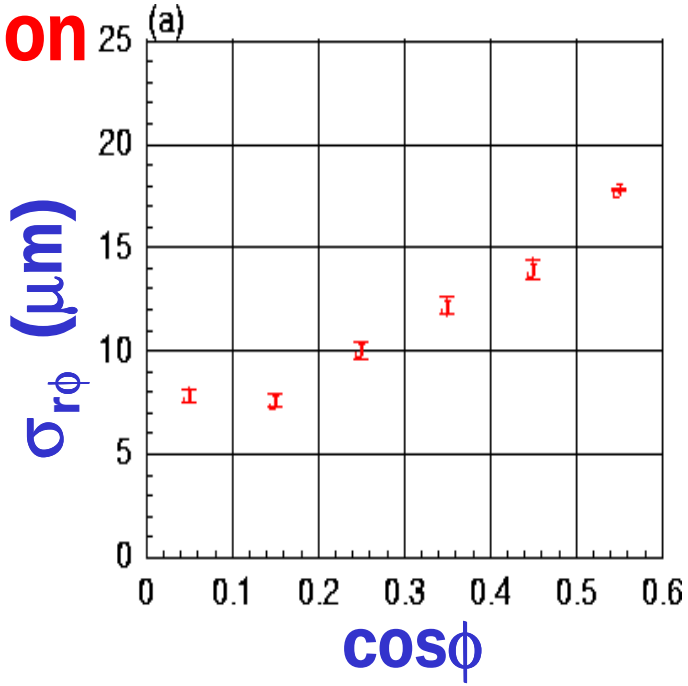
- **Yield (SVD1.2)**
  - 1st layer: 98.8%
  - 2nd layer: 96.3%
  - 3rd layer: 93.5%

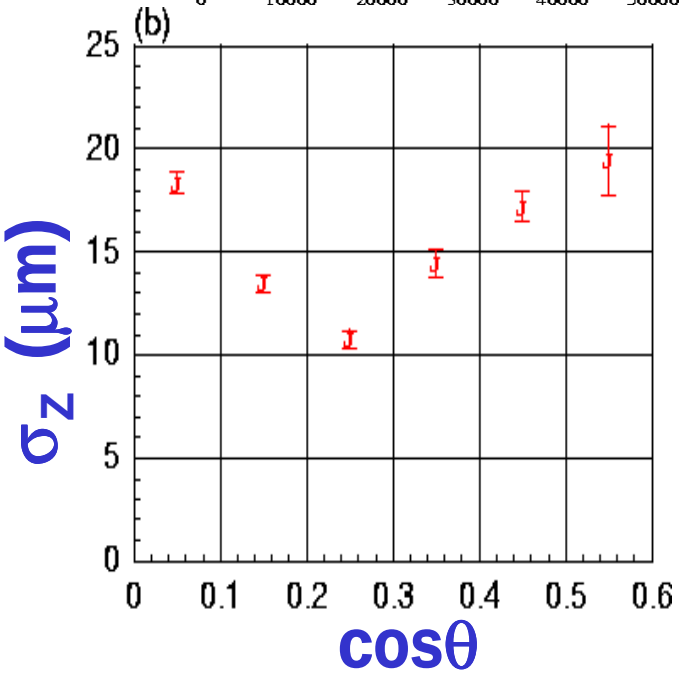
- **Signal**



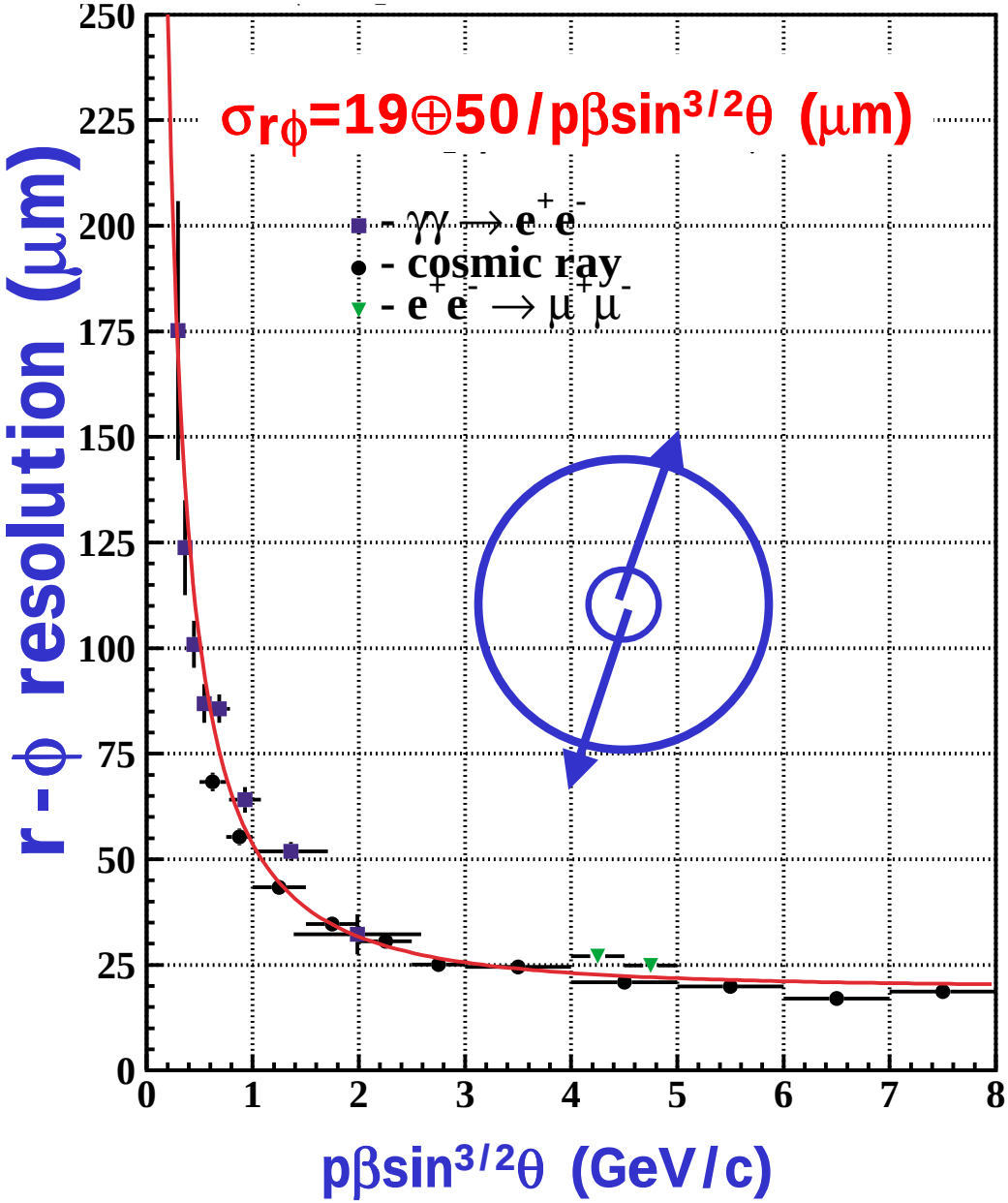
- **Intrinsic resolution**

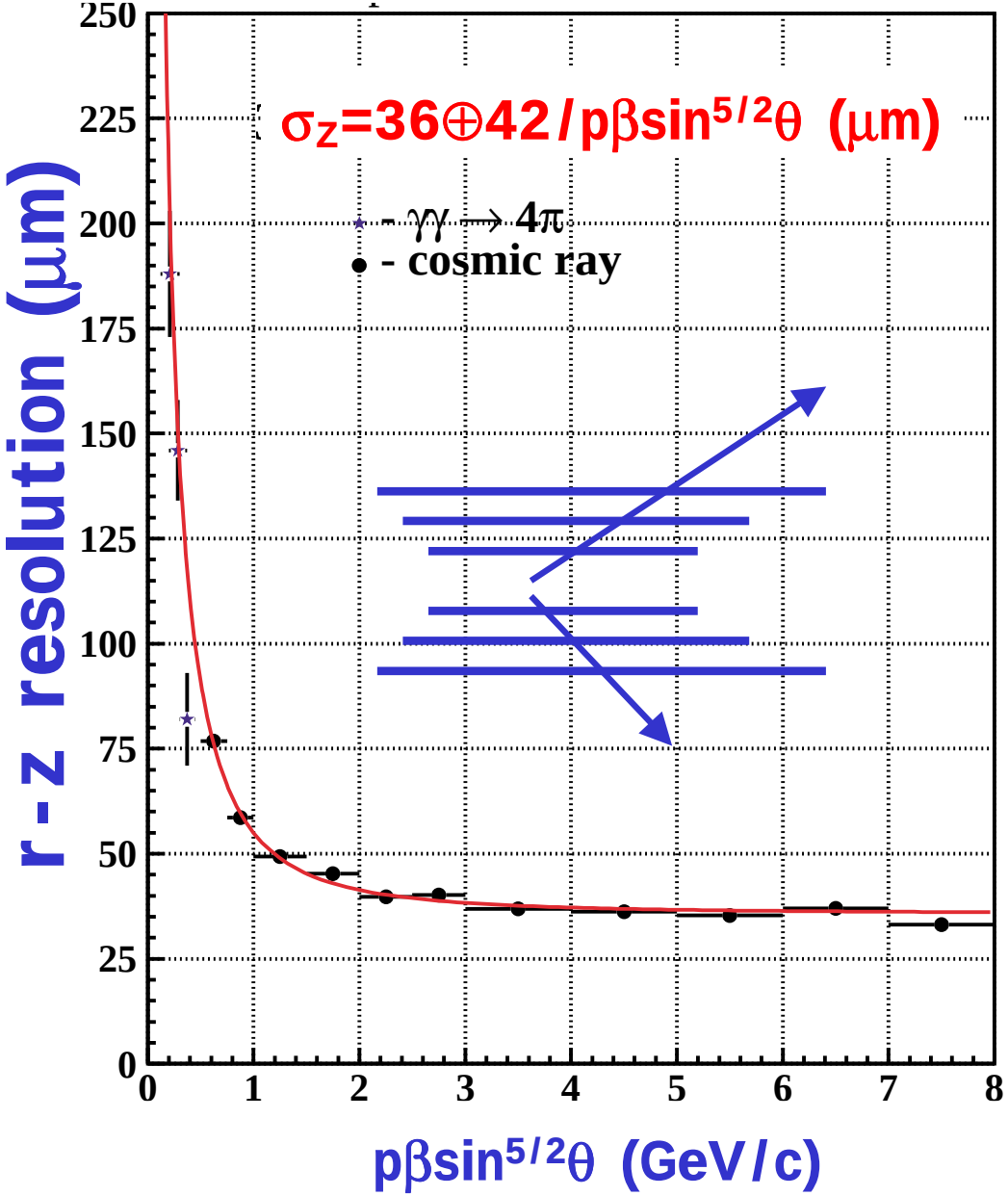






Impact parameter resolution

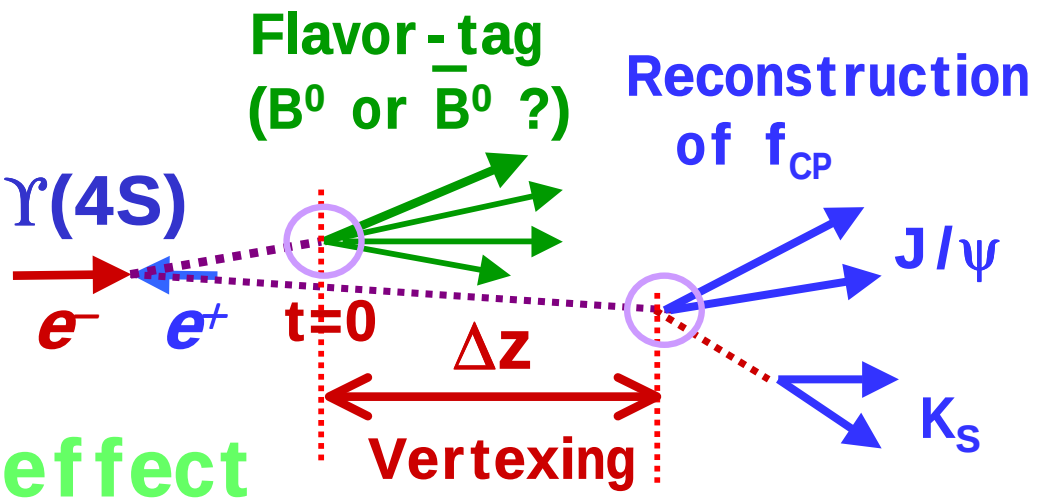




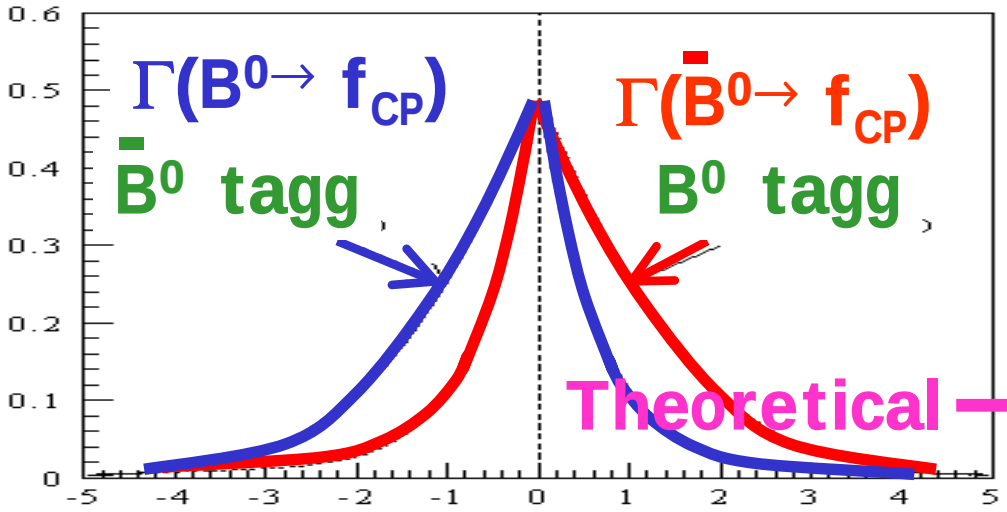
$\sigma_{r\phi}=15\oplus49/p\beta\sin^{3/2}\theta$ (μm) ⇐ **Ideal MC** ⇒ $\sigma_z=28\oplus41/p\beta\sin^{5/2}\theta$ (μm)

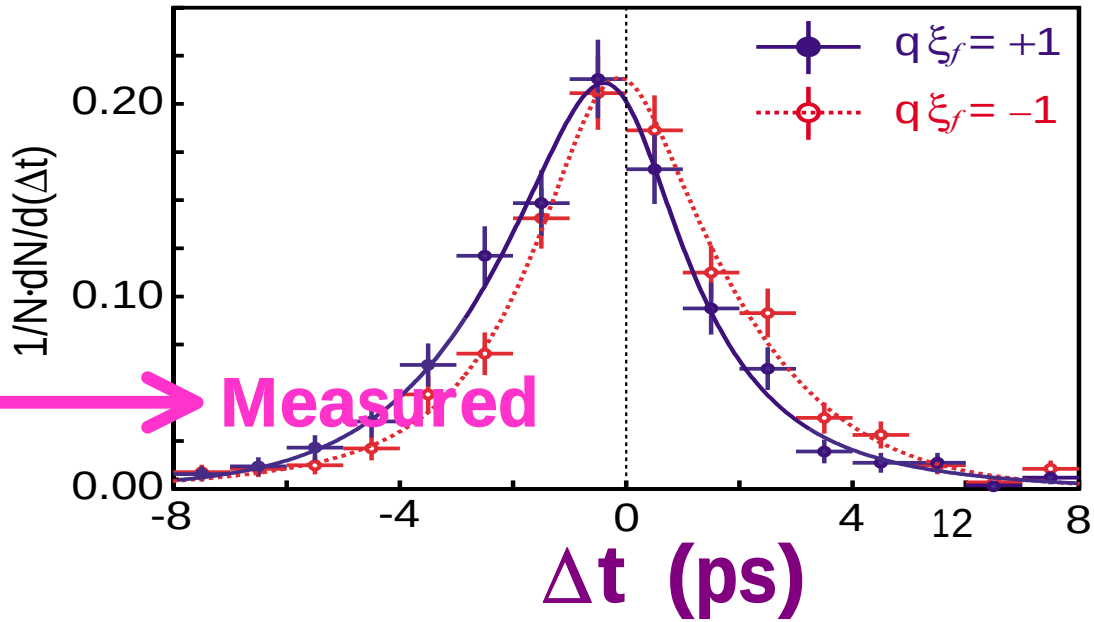
Vertex Resolution in CP analysis

- For CP-side, use $J/\psi \to l^+l^-$
  - $\sigma z_{CP} \approx 75\ \mu m$
  - eff. $\approx 92\%$
- For Tag-side,
  - $\sigma z_{tag} \approx 140\ \mu m \Leftarrow$ Charm effect
  - eff. $\approx 91\%$



$\sin 2\phi_1 = 0.99 \pm 0.14 \pm 0.06$





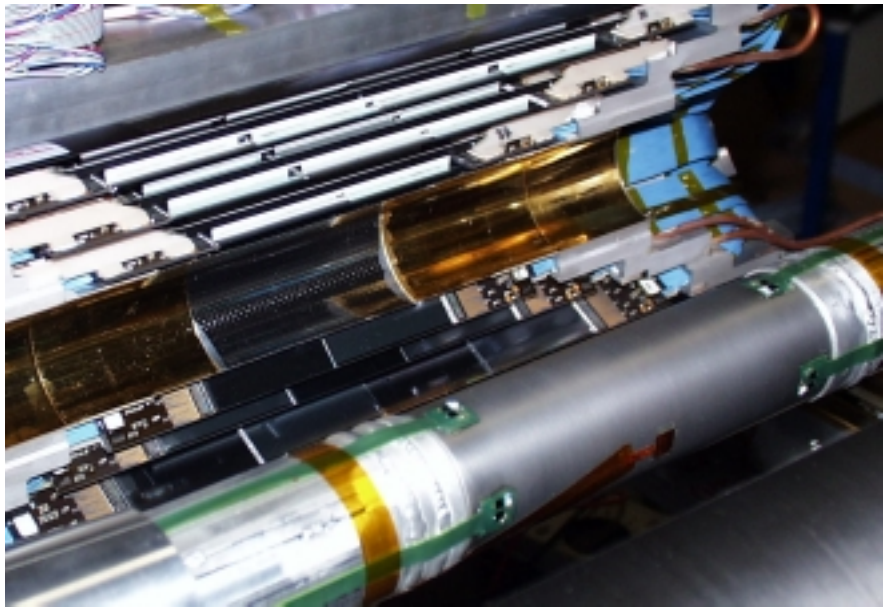
3. Radiation dose on SVD1

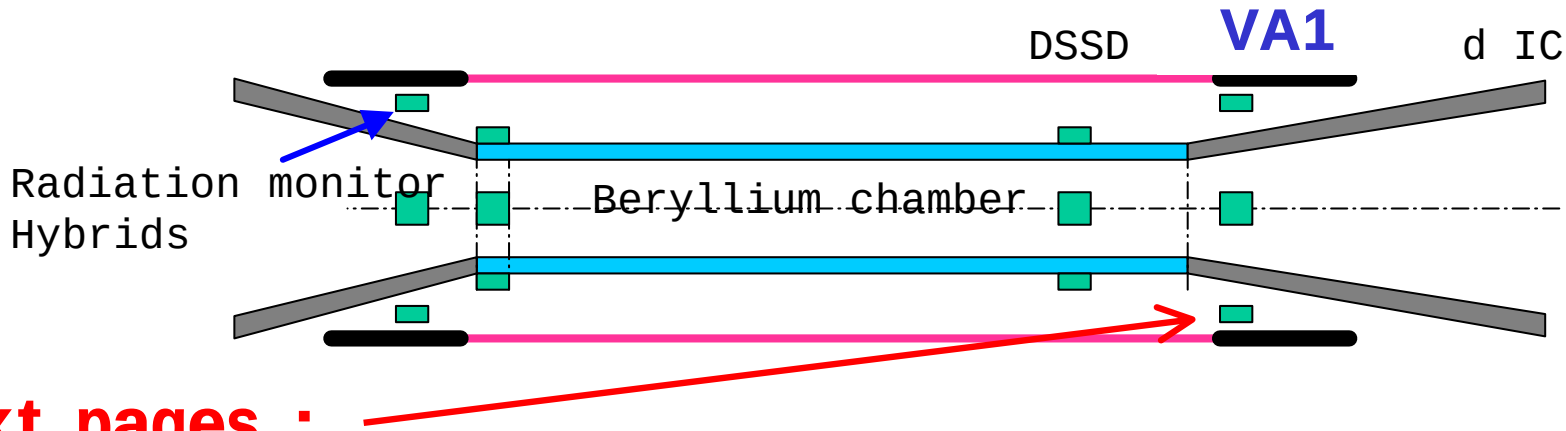
16 radiation monitor hybrids are installed

- 4(Fwd)/4(Bwd) on the beam pipe
- 4(Fwd)/4(Bwd) close to the VA1

3 kinds of sensors integrated

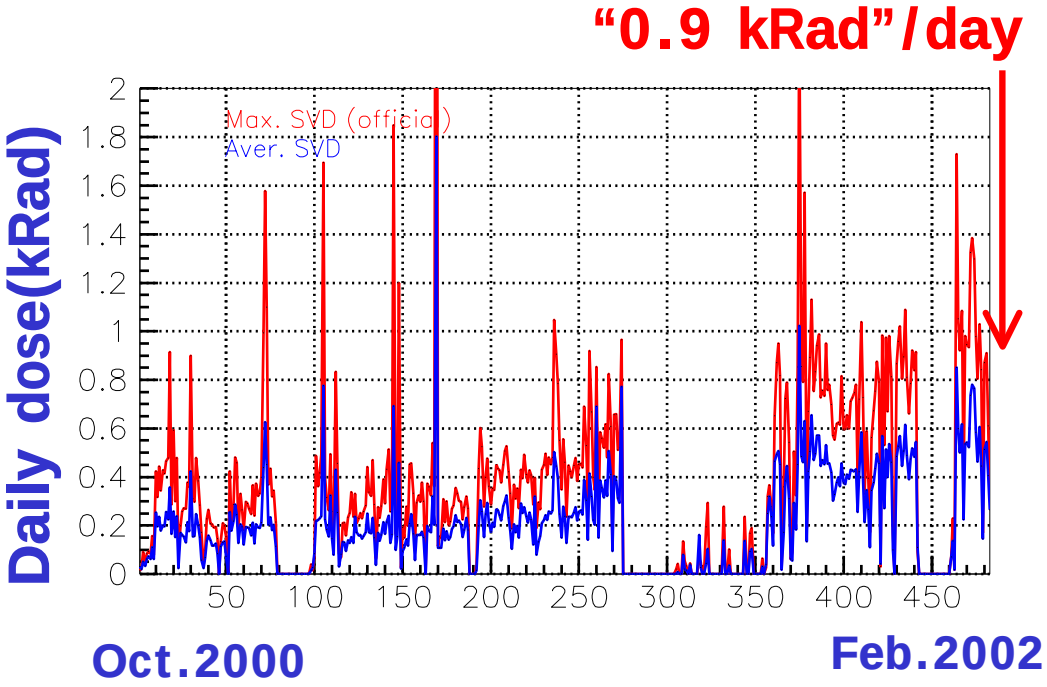
- RADFETs (high and low gain)
- PIN diodes (high and low gain)
- RTD (temperature compensation)

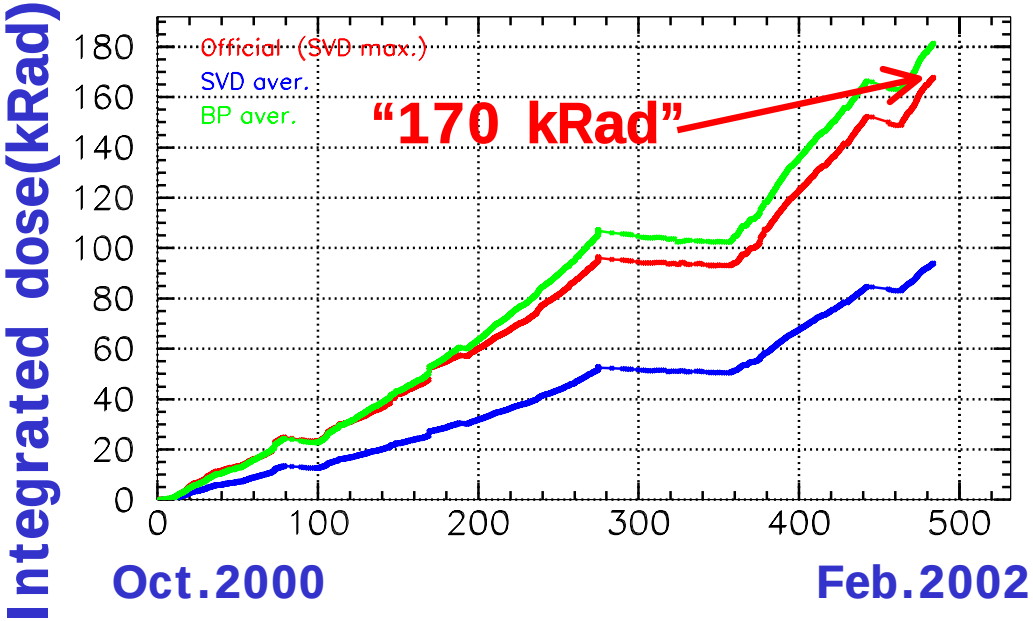


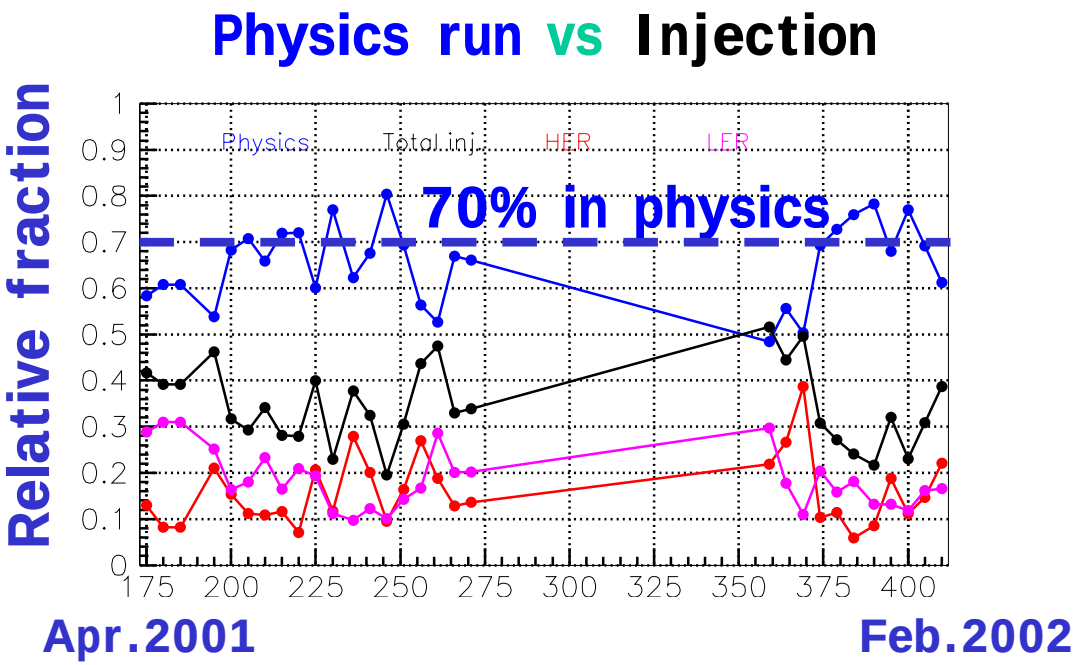


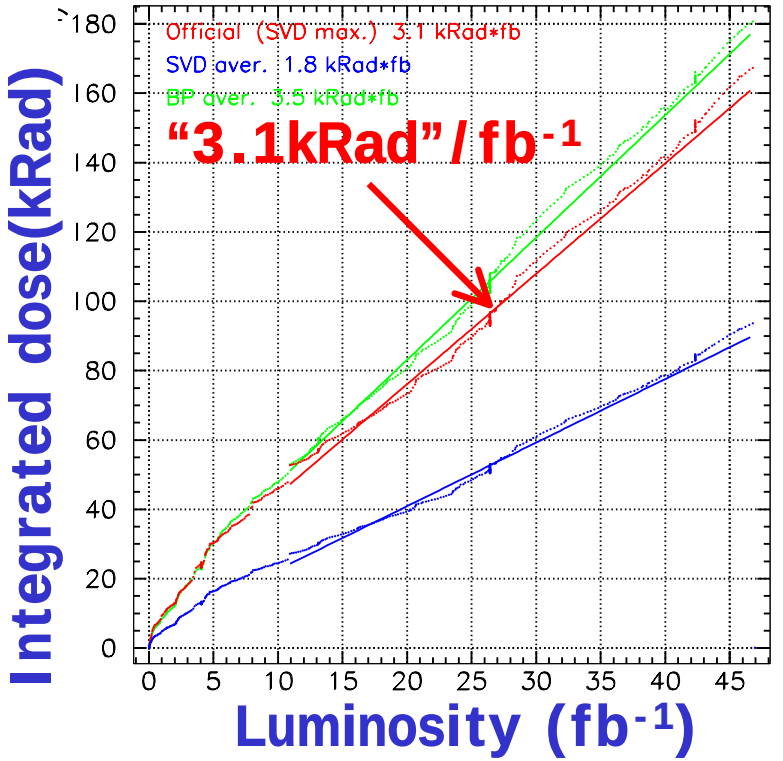
"dose" in next pages :
maximum(fwd,ϕ=270°) RADFET value close to VA1

Radiation dose on SVD1.4





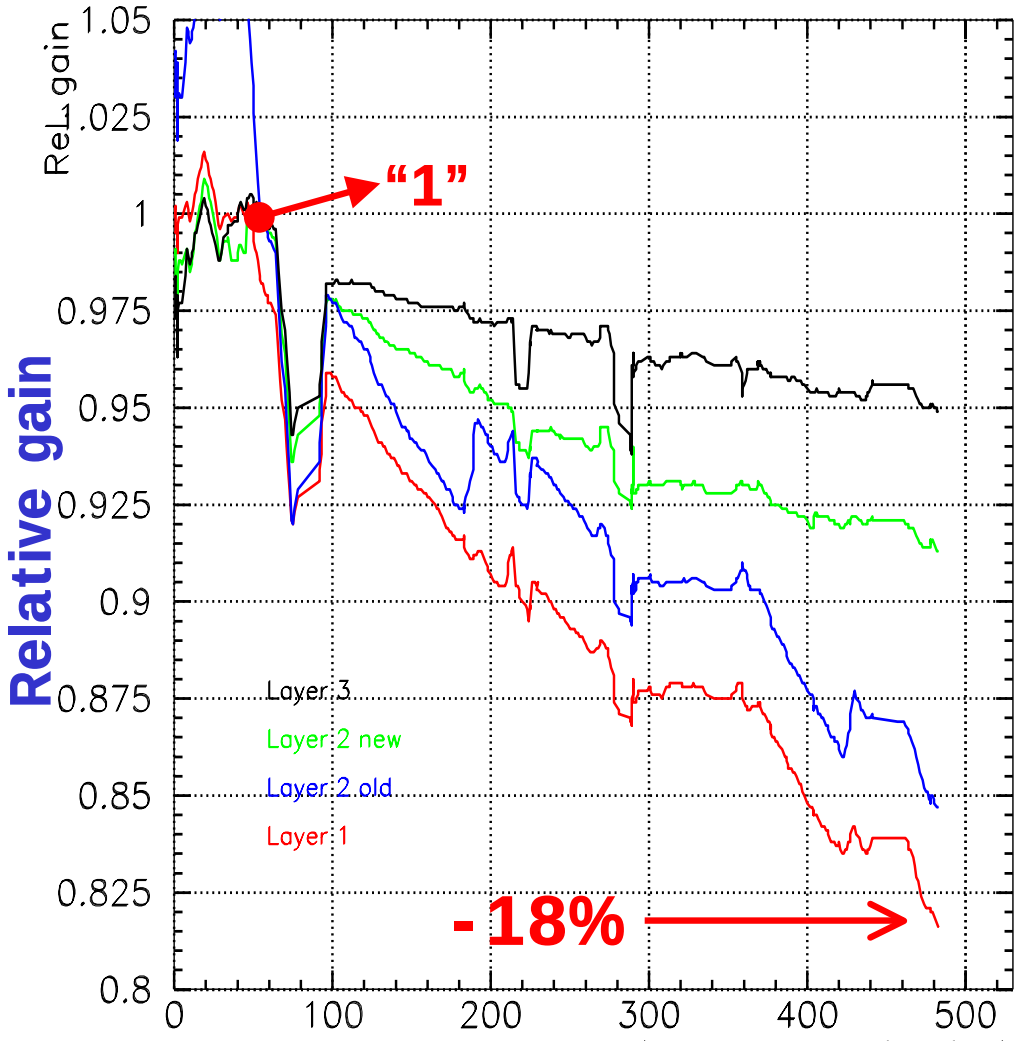




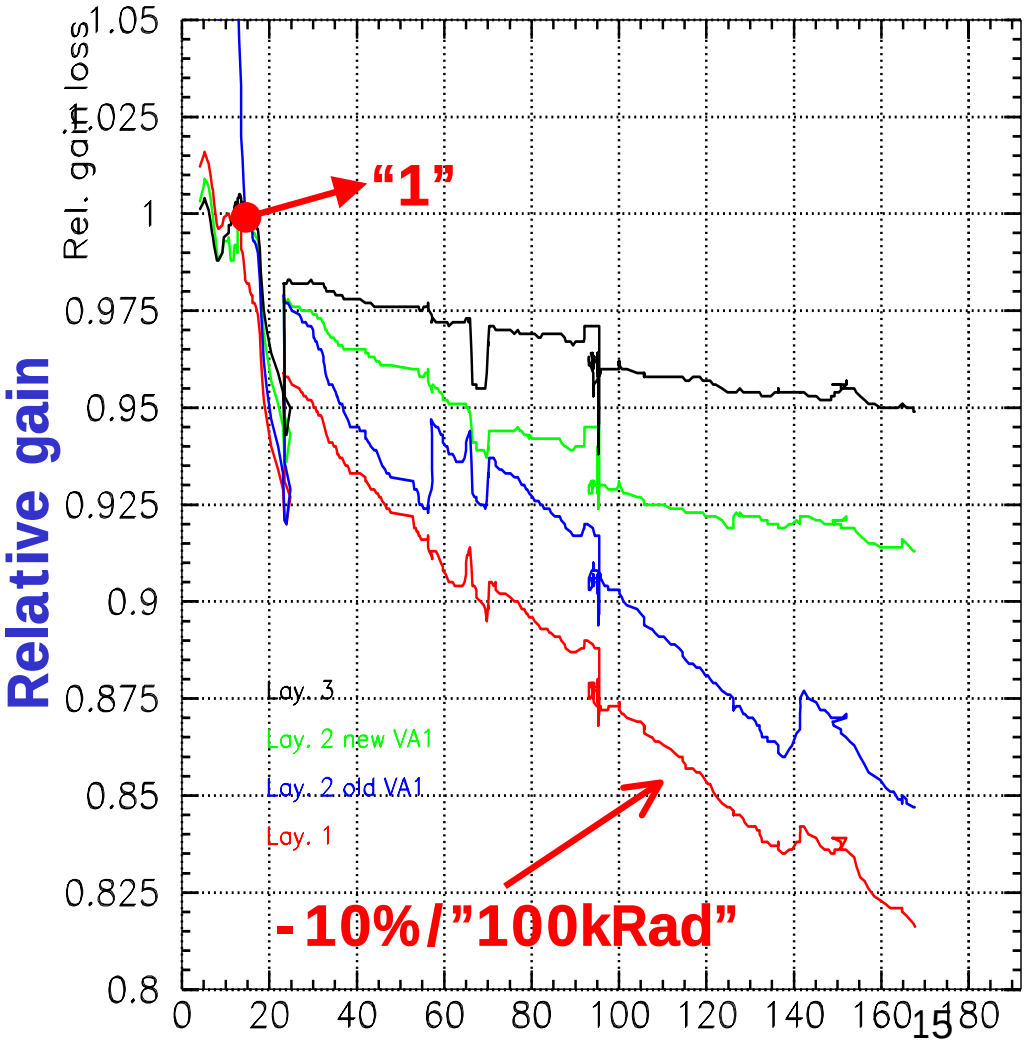
Gain drop of VA1 in SVD1.4

- **Gain drop of VA1: -10%/"100kRad"**

  for 1st layer VA1-0.8 (& 2nd layer VA1-1.2)



Oct.2000 Feb.2002

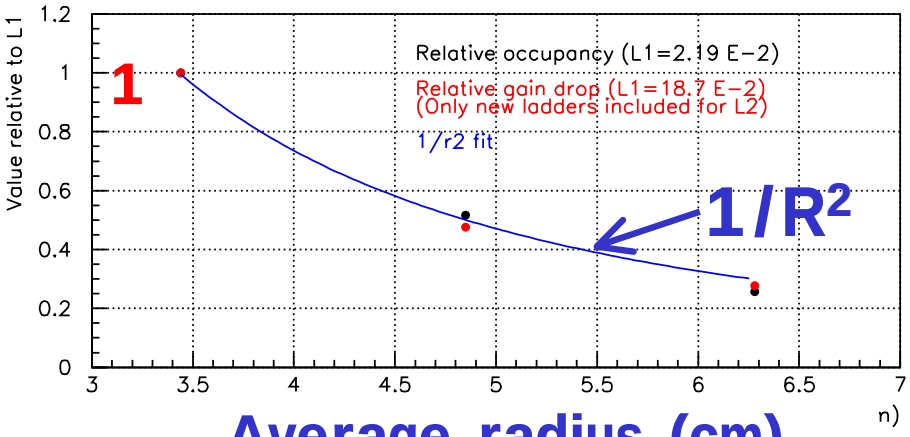


0 "dose" (kRad) 180

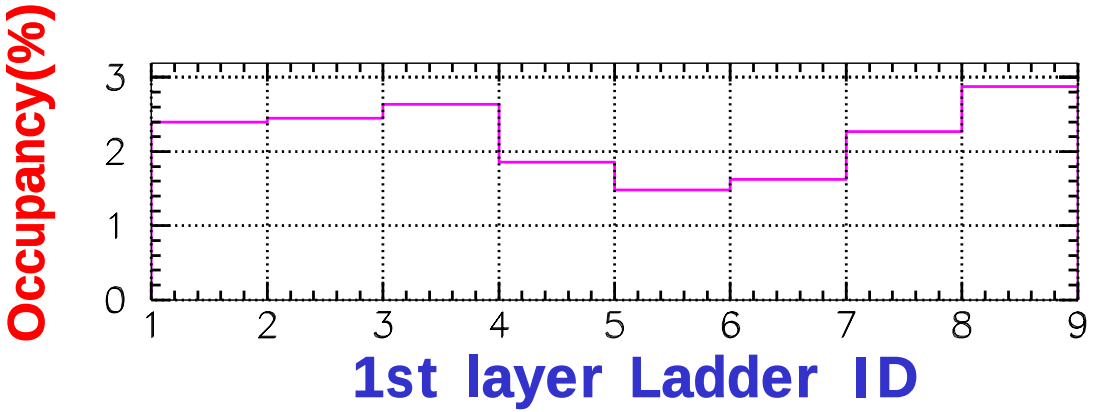
Gain drop of VA1 in SVD1.4 (2)

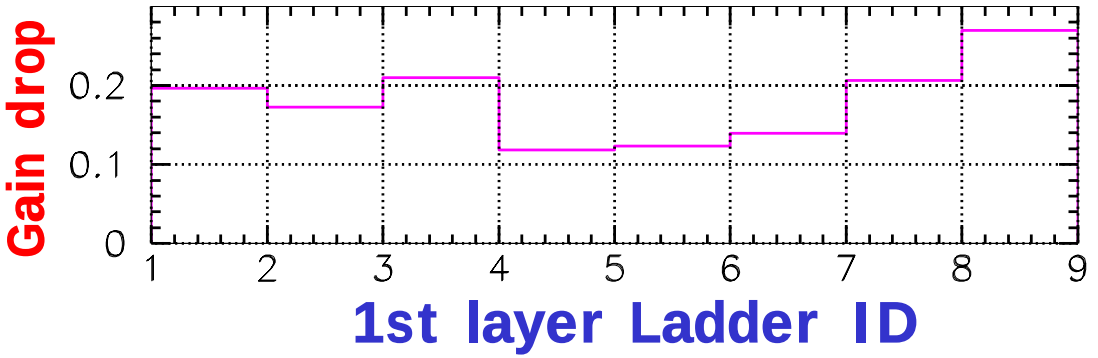
Gain drop of VA1
∝ occupancy ∝ 1/R²

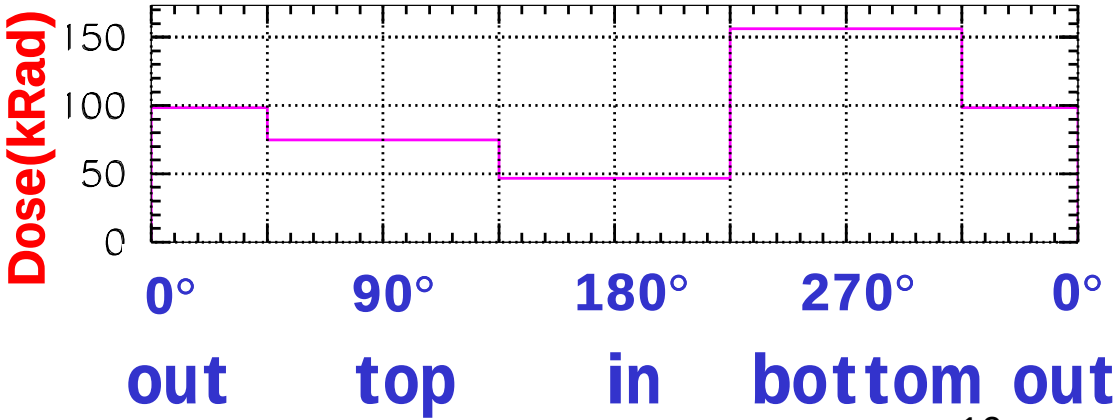
- Relative occupancy to L1(2.2%)
- Relative gain drop to L1(18%)



1st layer 2nd layer 3rd layer



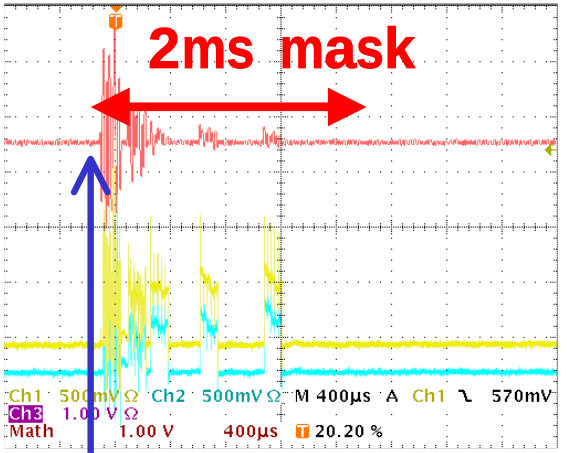




Effect of continuous injection

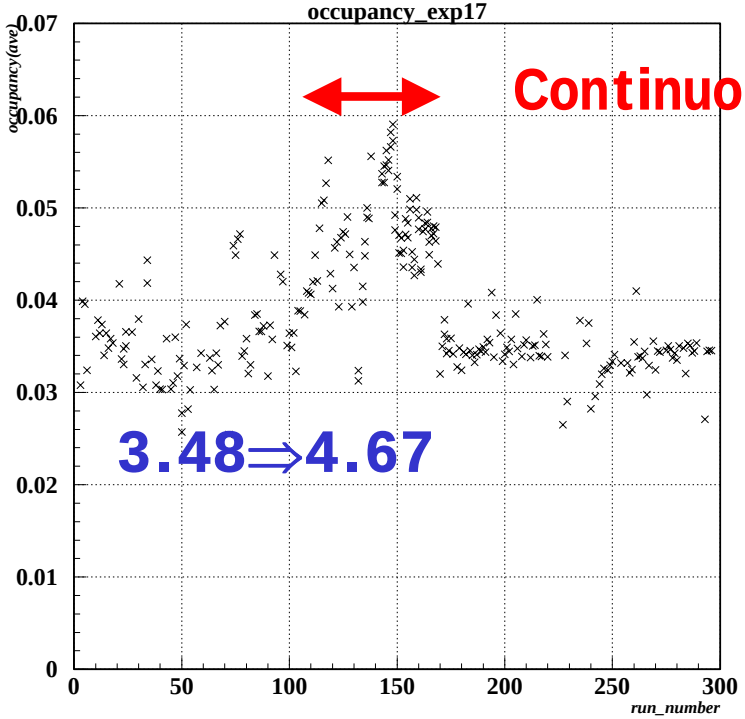
- SVD can be operated with
  2 ms mask on L-0 trigger signal
  ,which starts SVD readout system
- Higher radiation dose (due to worse vac.?)
  (0.7kRad/day ⇒ 1.3kRad/day)

Input of FADC →



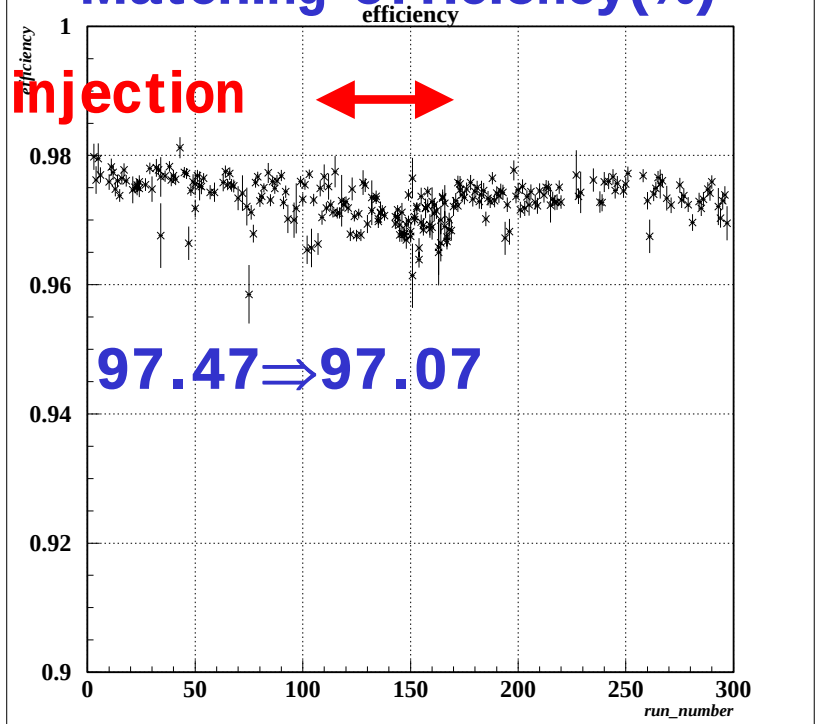
Injection
(5 or 10 Hz)

Occupancy (%):



Run number

Matching efficiency(%)

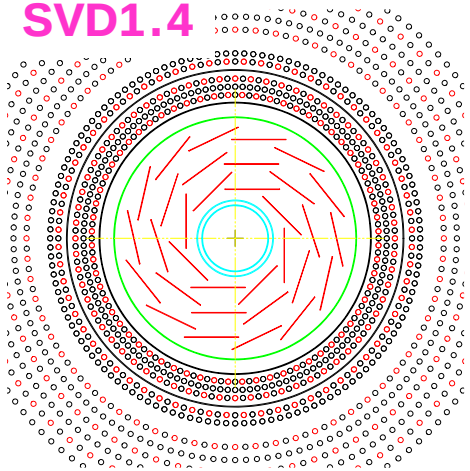


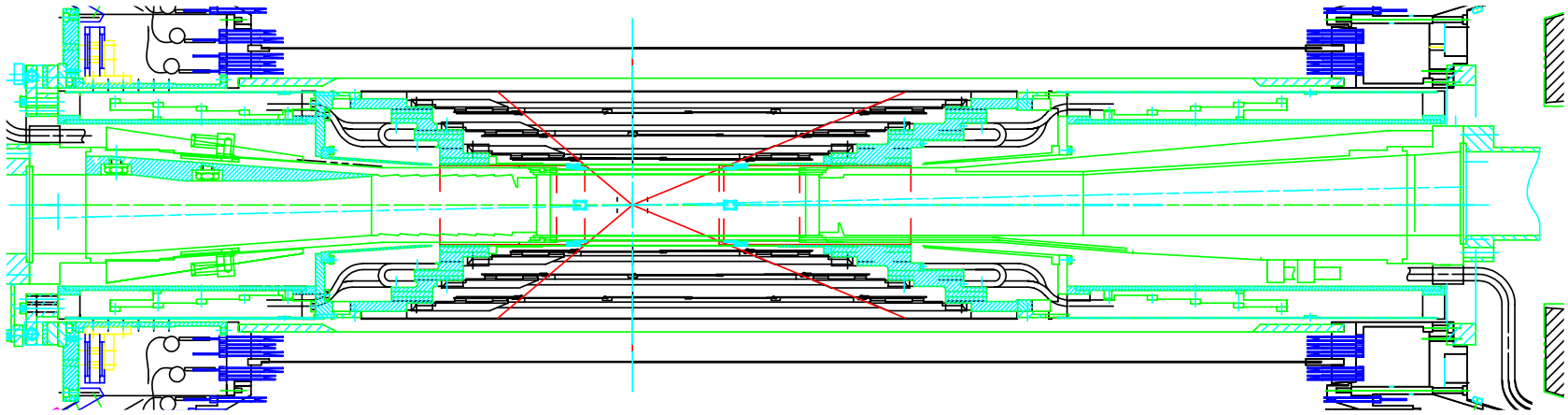
Run number

4. Upgrade :SVD2

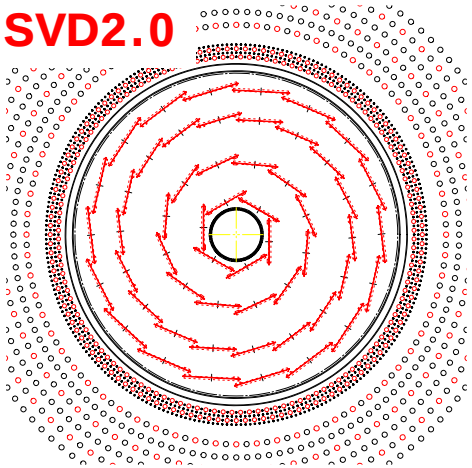
- Better impact parameter resolution: R_{bp} = 2.0 cm → 1.5 cm
- Larger acceptance: 23°<θ<139° → 17°<θ<150°
- More radiation hardness : 1 MRad → >20 MRad
- **Installation in Summer 2002**

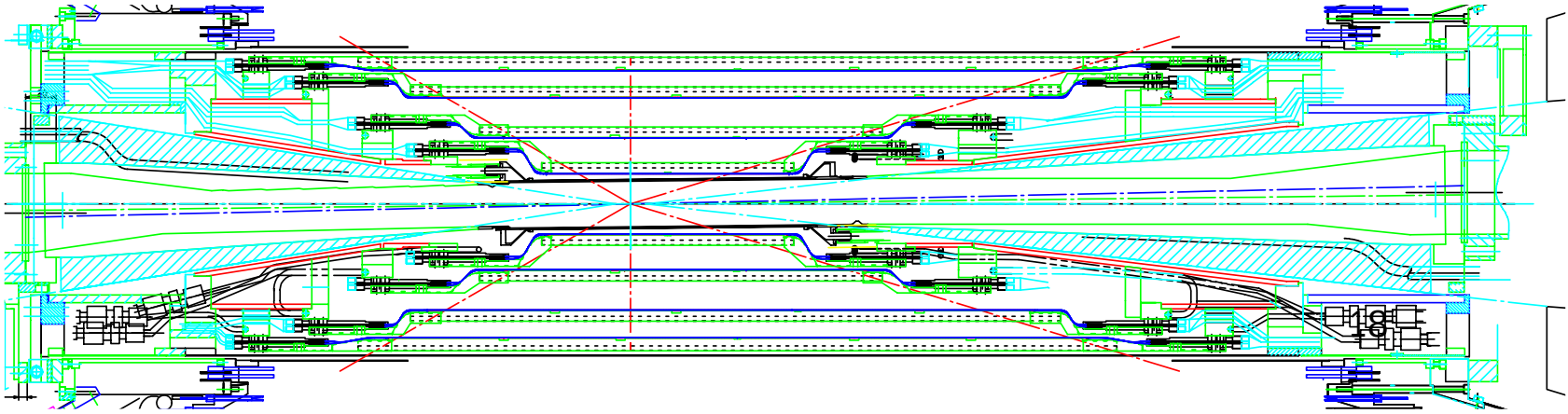
SVD1.4



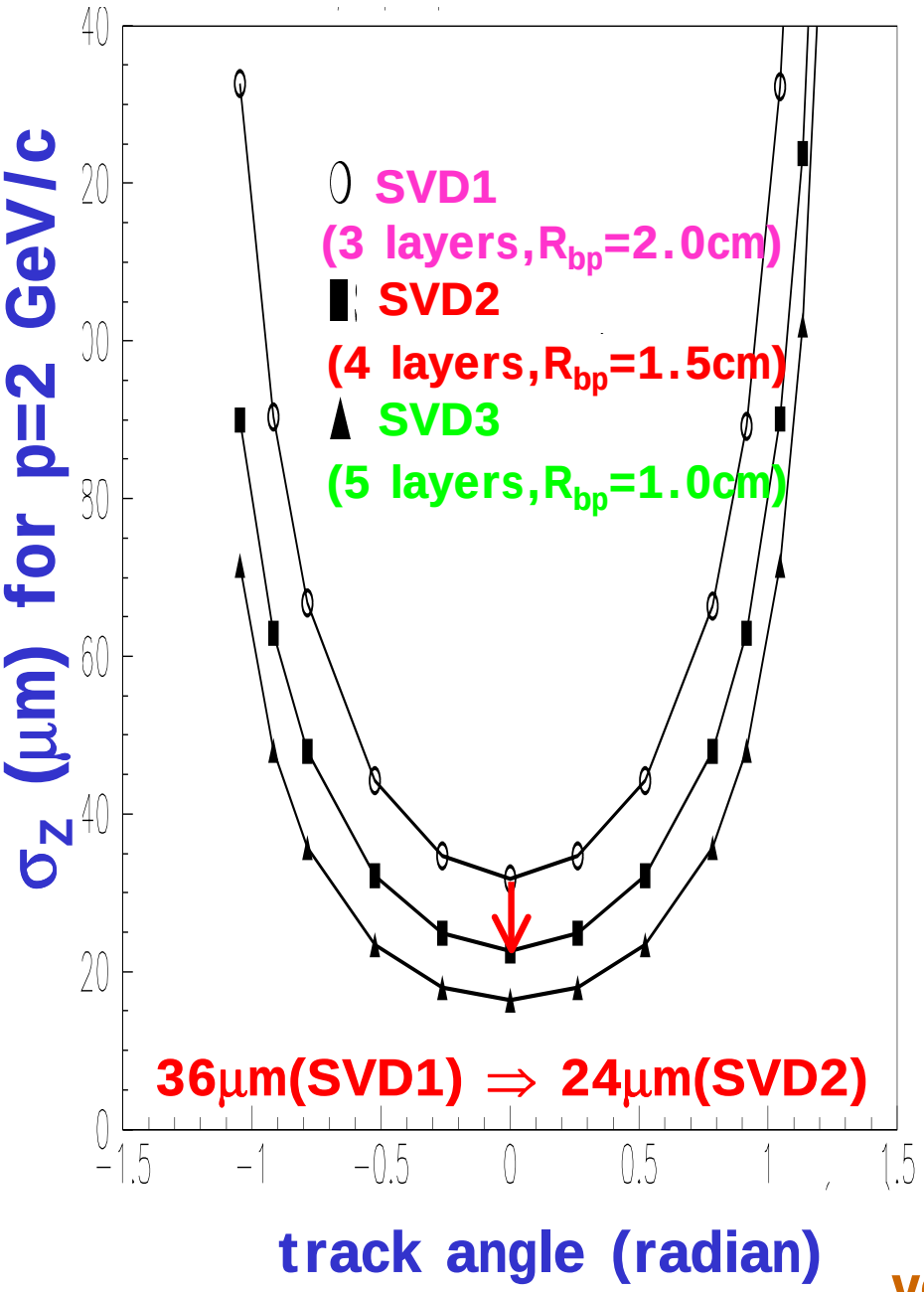


SVD2.0

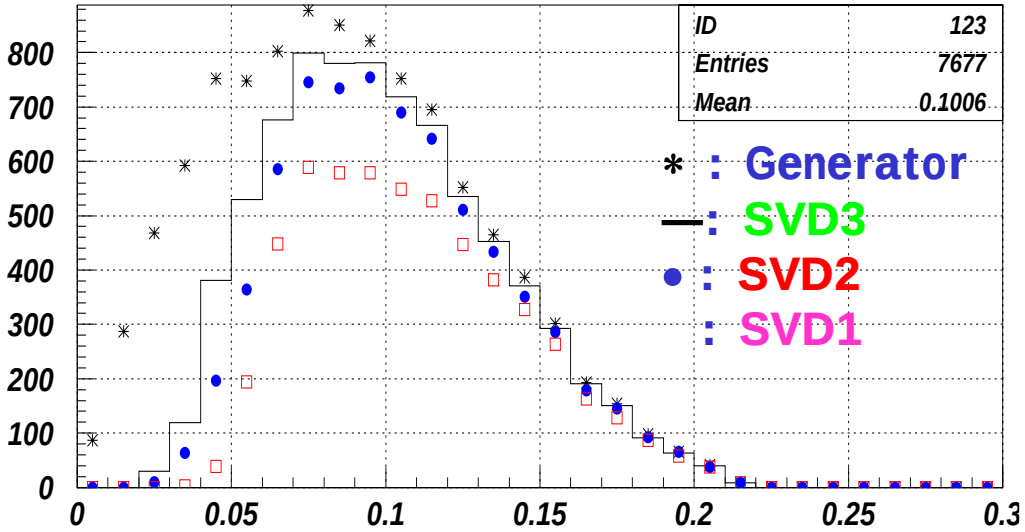


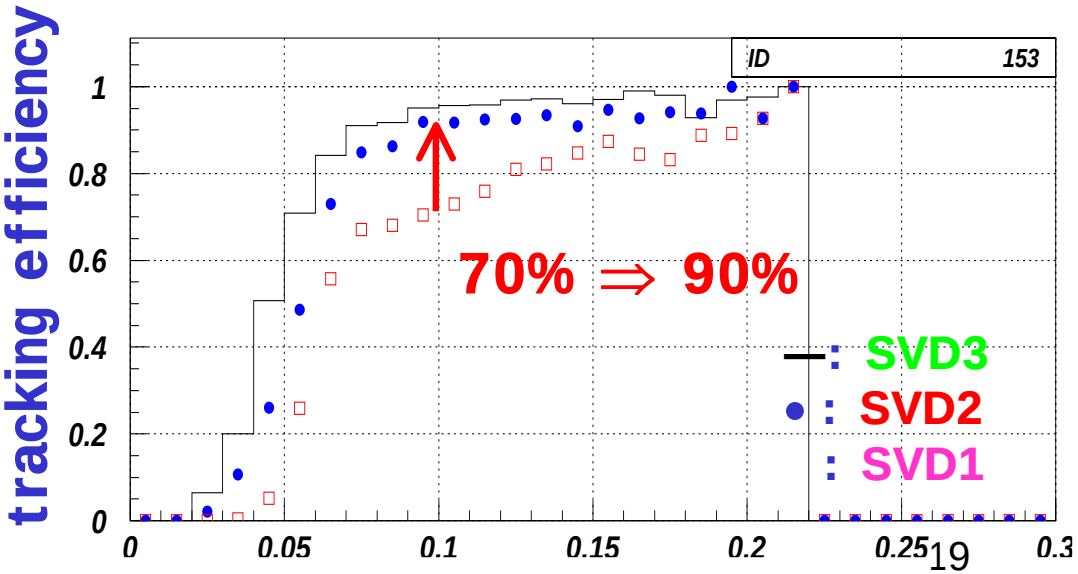


Improvement on resolution/efficiency



momentum reconstruction
for slow π in B→D*lν





very preliminary

5. Summary

- We have constructed and operated SVD1
  - DSSD(S6936)+VA1: 97% eff. S/N>17, σ_z<20μm
  - Impact parameter Resolution:
    - $\sigma_{r\phi}=19\oplus 50/p\beta\sin^{3/2}\theta$ (μm)
    - $\sigma_z=36\oplus 42/p\beta\sin^{5/2}\theta$ (μm)
  - Vertex resolution: $\sigma z_{CP} \approx 75$ μm with 92% eff.
  - Gain drop: -10%/"100kRad"
  - We will install new SVD2 in summer 2002.

    (detail $\Rightarrow$ Parallel session 3b)