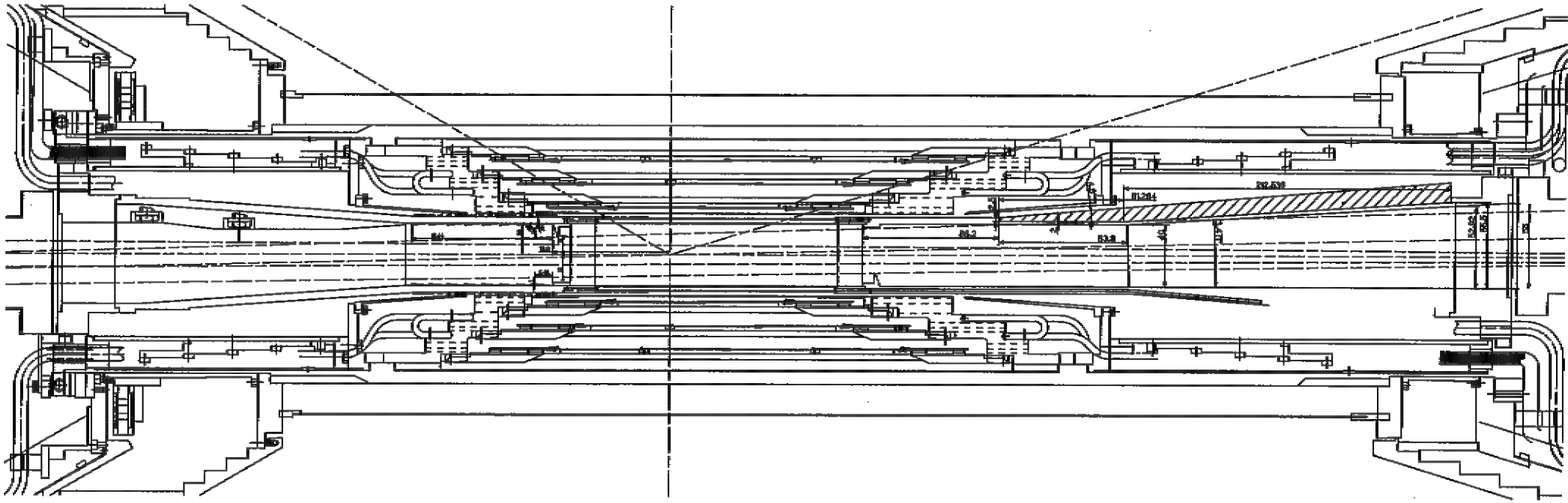
Beam pipe for SVD1.5

Y.Yamada at BELLE KEK meeting on Jan. 11th 2000
http://yamadapc1.kek.jp/~yamaday/BELLE/SVD1/doc/BELLE000111/



Design feature

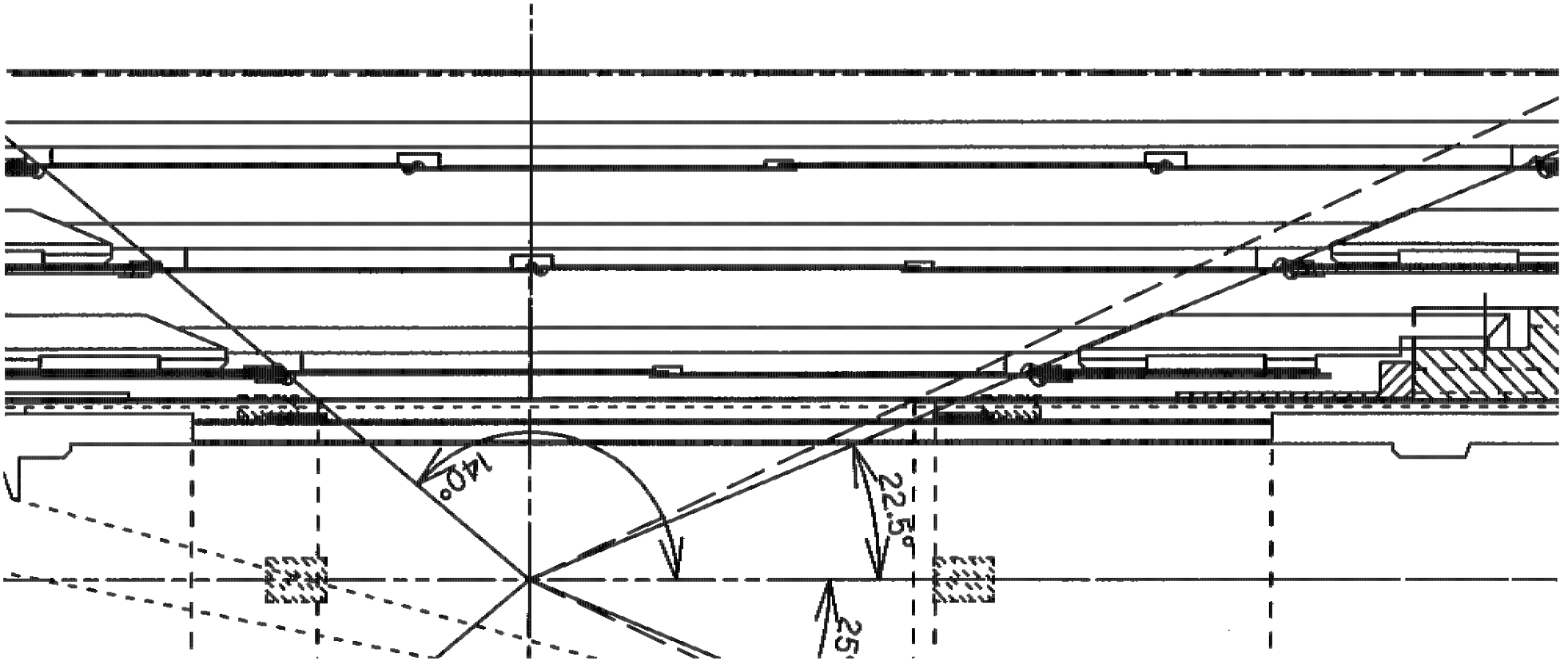
- Same concept with current beam pipe
  1. He cooling in Beryllium double walls
  2. Aluminum tapered section cooled by water

- Improvements from current beam pipe
  1. 10 μm thick Gold inside Beryllium pipe by vacuum sputtering
  2. Saw shape inner surface against low energy X ray
  3. Thicker Gold plating ? against high energy X ray on Aluminum section
  4. More Tungsten mask by reducing # of connection in cooling lines

Materials

- 1 mm Beryllium : 0.3 % Xo
- 0.3 mm Silicon first layer : 0.3 % Xo
- 20 μm Gold foil : 0.6 % Xo → 10 μm sputtered Gold : 0.3 % Xo

Total : 1.2 % Xo → 0.9 % Xo

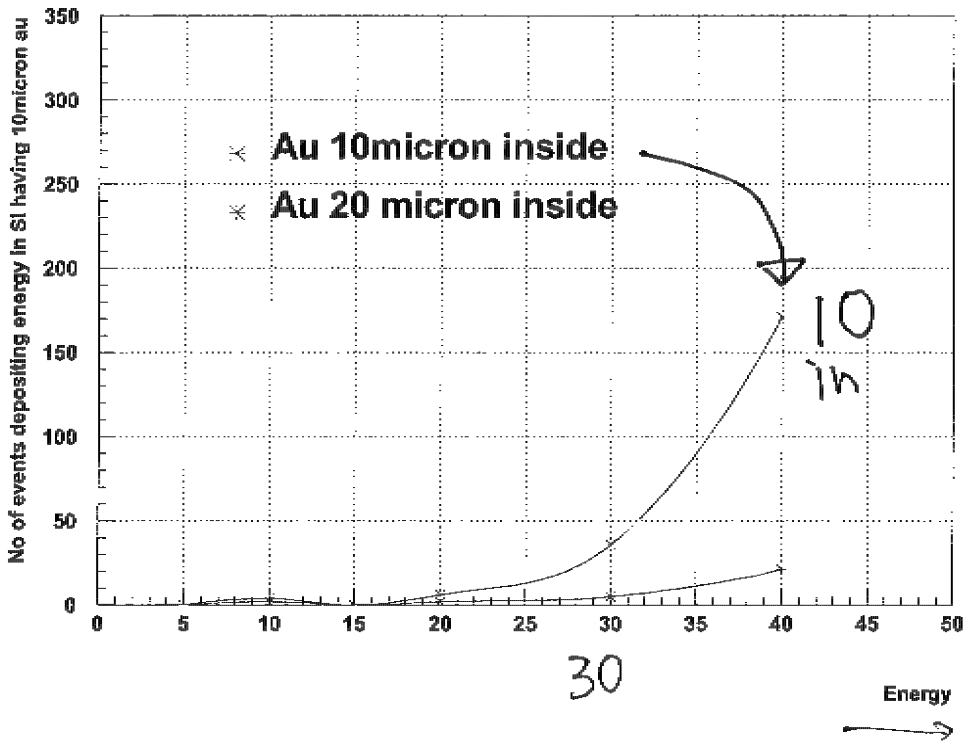


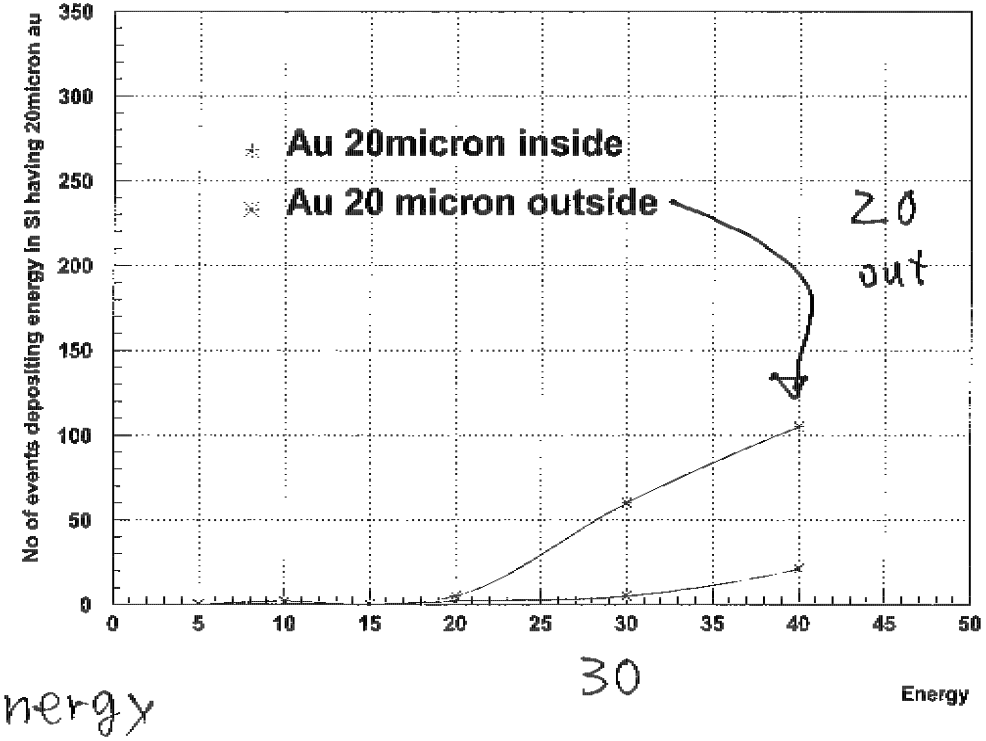
Rejection power of 10 μm Gold inside Be

Rejection power for <35keV photon
is equivalent to 20 μm Gold outside.

EGS4 simulation for 10,000 photons with incident angle of 5 degree

# of photons which hits SVD





Effect of Gold on resolution

dz resolution : $\sigma_{dz} = \mathrm{sqrt}(\sigma_{res}^2 + \sigma_{MCS}^2)$

where

$\sigma_{res} \sim 40\ \mu m$

and

$\sigma_{MCS} \sim 30000\ \mu m \times 13.6(MeV) / \beta p(MeV) \times \mathrm{sqrt}(X)$

at $\theta = 90^o$.

e.g. for 250 MeV/c pion : σ_{dz} =

~122 μm : 0 μm Gold (0.6%Xo)

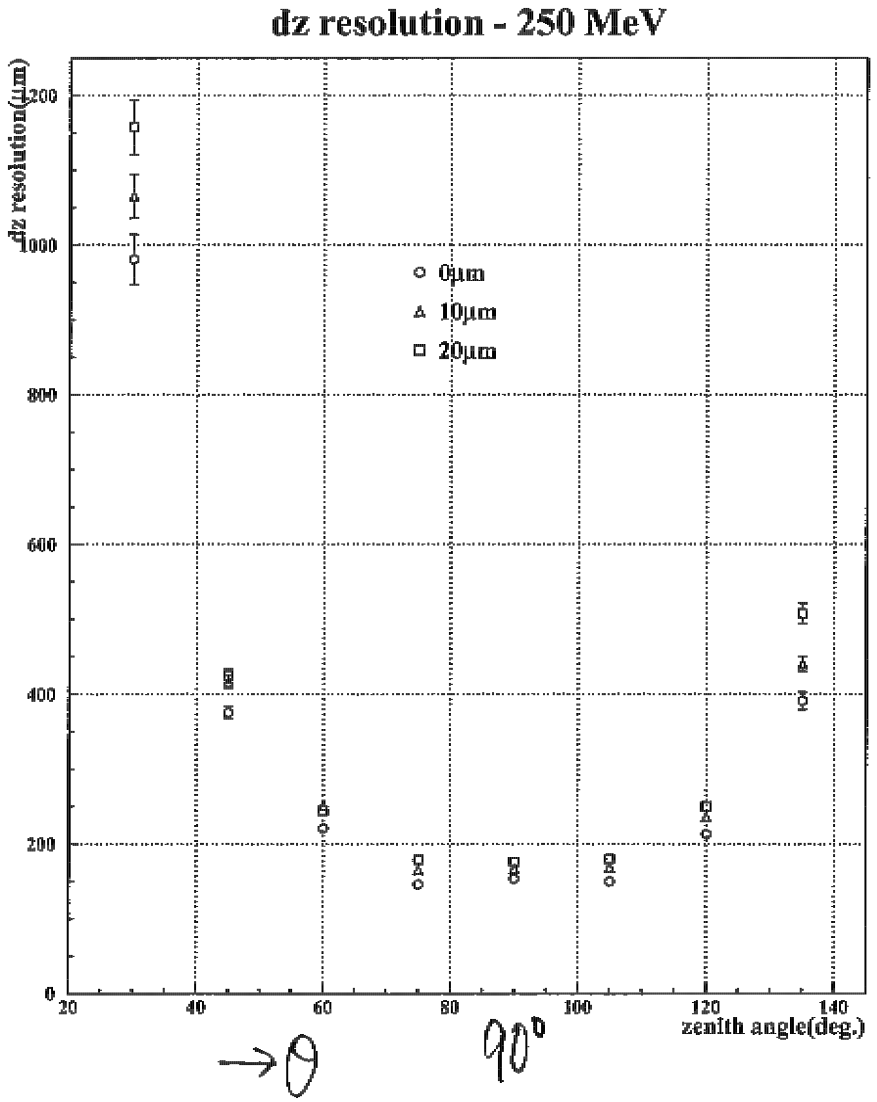
~150 μm : 10 μm Gold (0.9%Xo)

~176 μm : 20 μm Gold (1.2%Xo)

20 μm to 10 μm →

15% improvement in σ_{dz} for p < 250 MeV/c

94 μm to 91 μm in $\sigma_{CP\text{-}tag}$



Saw shape inner surface

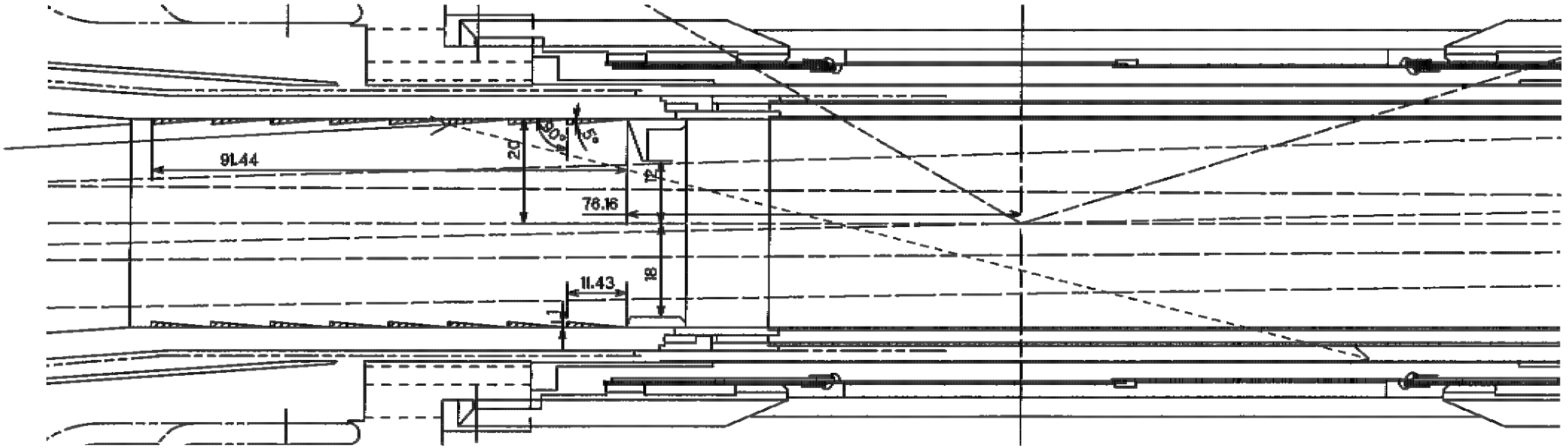
~5 keV X ray

- from HER upstream due to bad optics(?) (suppressed in current optics)
- which killed SVD1.0

→ Saw shape inner surface for backward straight section

made by Aluminum coated by 30μm thick Gold plating

Materials and scattering probability for 5keV X ray
Cu : 0.09, Al : 0.03, Au : 0.05



HOM heating on beam pipe

HOM loss = $k \times I_{beam}^2 / f$

where

k : loss factor of the beam pipe

I_{beam} : LER beam current (2.6A)

f : crossing per sec (~5×10^8 /sec)

= 1100 W if k~8×10^{10} V/C

Some fraction (under estimation)

⟶ HOM heating

one estimation : 100 W @ 2.6A

FEM simulation for current beam pipe

dT ~ 5 °C (outer Be) / 25 °C(inner Be)

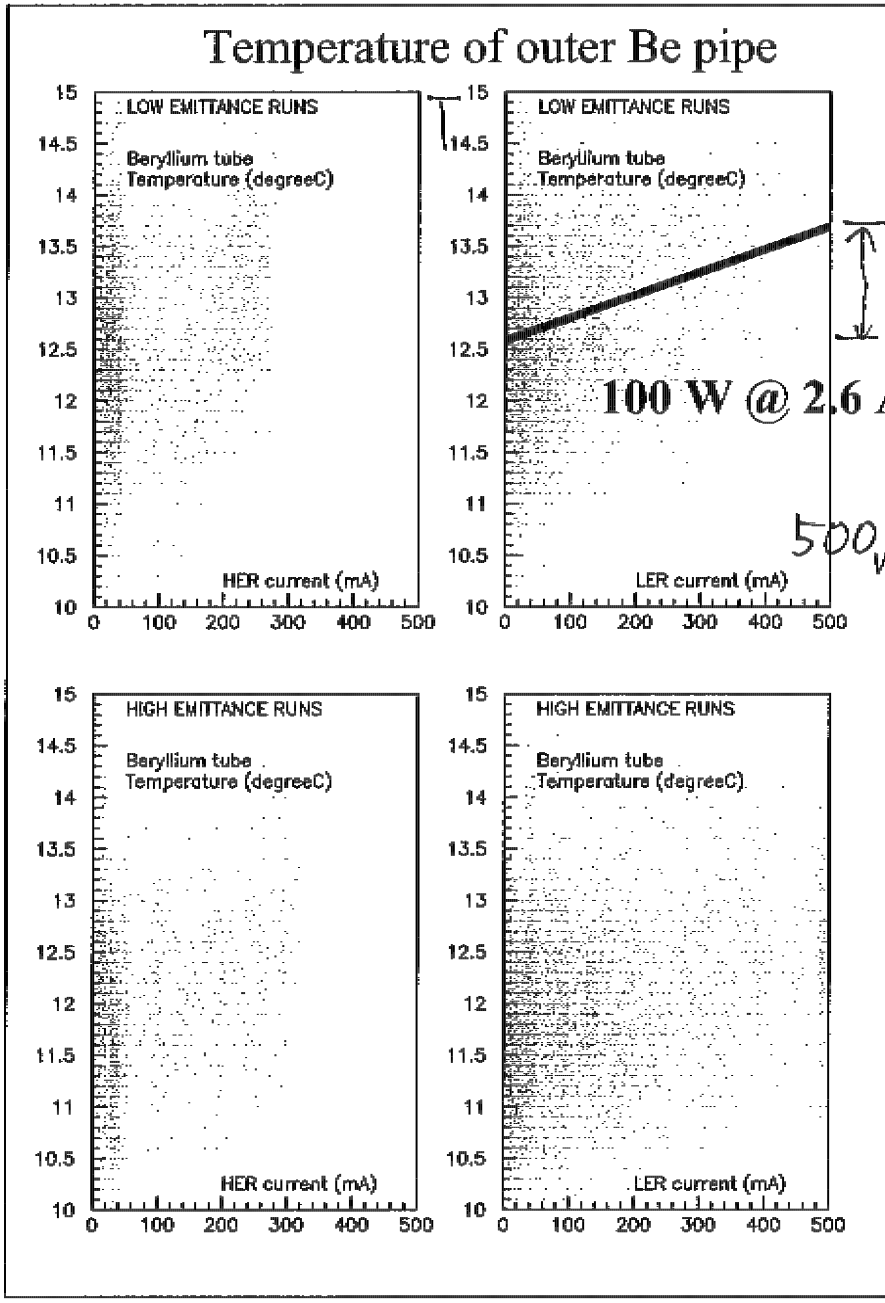
if He flow rate is 700 l/min (2 g/s).

not inconsistent with

- measurement at BEAST pipe
- measurement of outer Be pipe

Saw shape inner surface

k : 8×10^{10} V/C ⟶ 10 $\times10^{10}$ V/C



Thicker Gold plating ?

~30 keV X ray

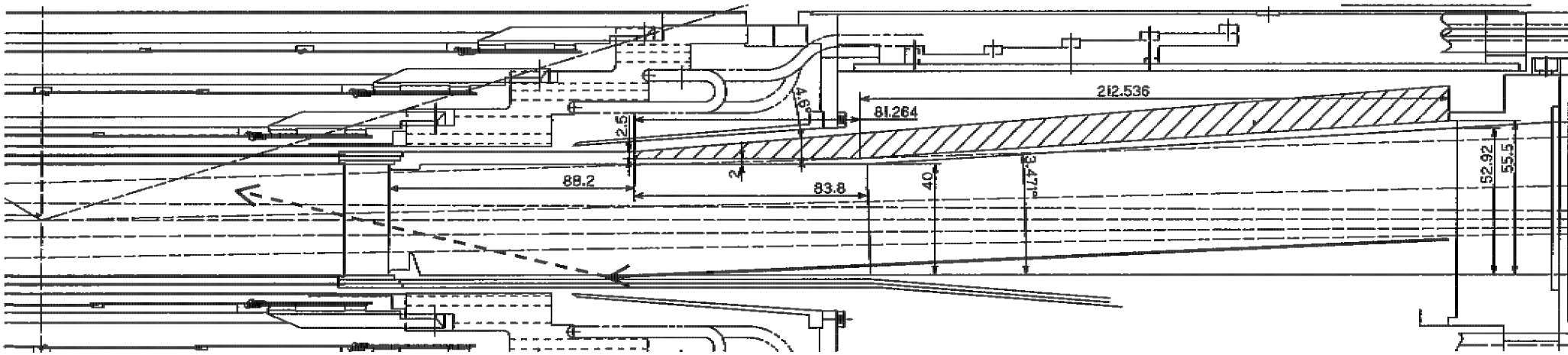
- backscattered from HER downstream
- causes SVD/CDC background (: not major part at current vacuum level)

→ Thicker gold plating on forward Aluminum cylinder

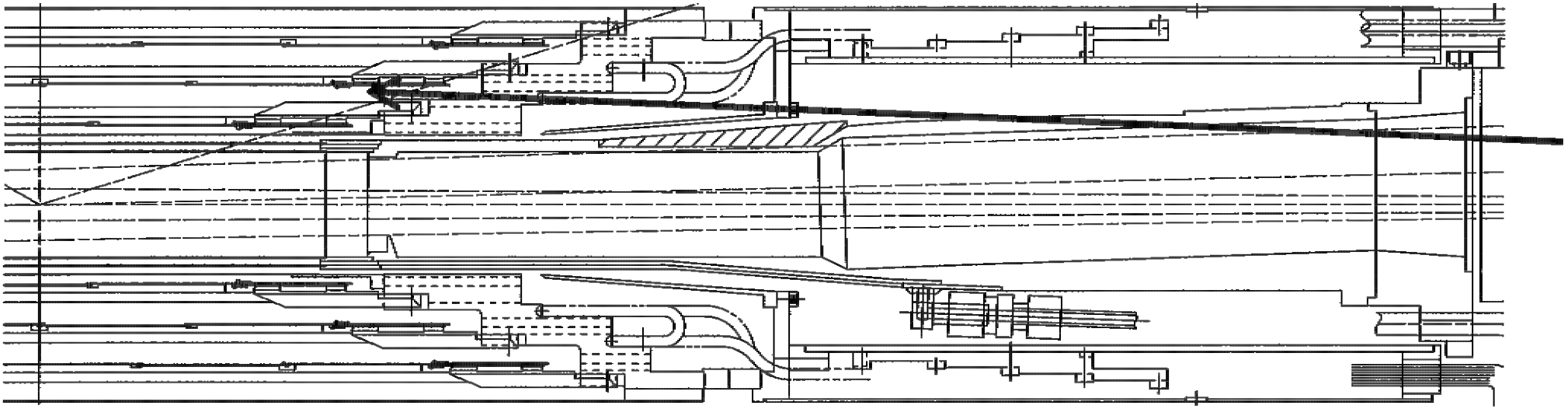
EGS4 simulation on scattering probability

- 2 mm Al : 0(10keV), 2×10^{-3}(20keV), 3×10^{-2}(30keV)
- 2 mm Al+100μm Au : 0(10keV), 0 (20keV), 1×10^{-4}(30keV)

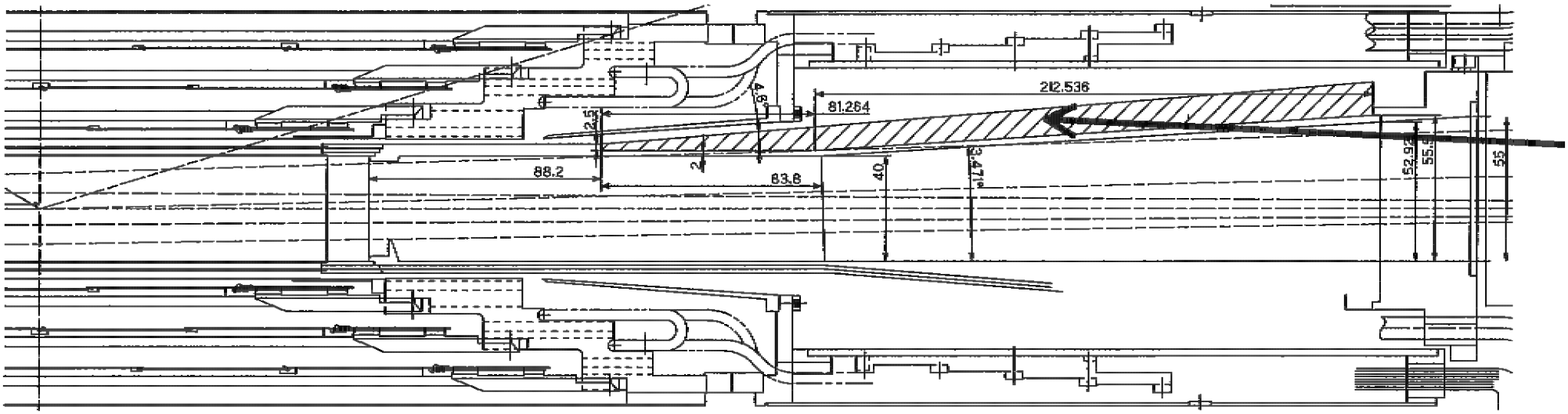
30 keV : 30 μm → 100 μm (1/100) or 200 μm (1/30000)



More Tungsten mask



More space by changing inner shape and reducing connectors



Simulation on particle background

TURTLE + GSIM

Beam current : HER / LER = 1.1 A / 2.6 A

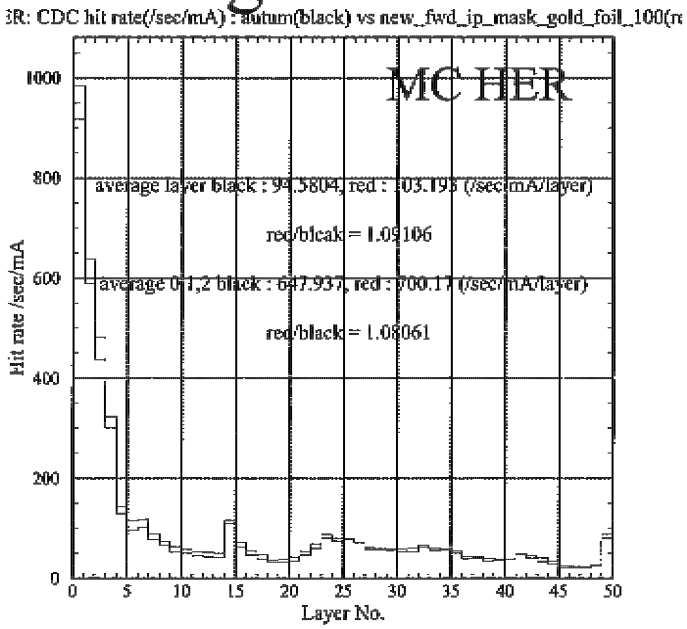
Vacuum : 1×10^{-7} Pa

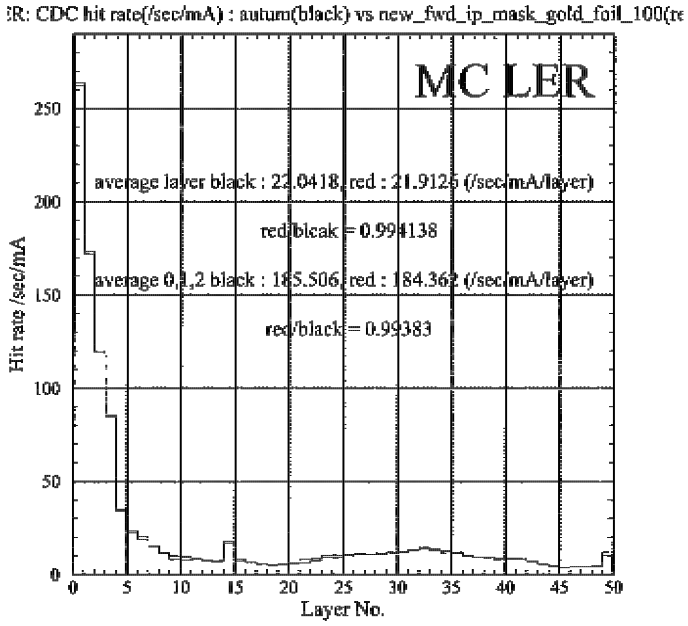
Unit : krad/year for SVD and hit/sec/mA for CDC

Mask	SVD 1st layer	SVD 2nd layer	SVD 3rd layer	CDC inner 3	CDC All layer
Present + 30 μm Gold	1.8/2.2	0. 8/1.2	0.6/0.4	648/186	95/22
New + 30 μm Gold	1.7/1.5	0.8/0.7	0.5/0.4	648/160?	95/20?
New + 100 μm Gold	1.7/1.6	0.8/0.8	0.5/0.4	700/184	103/22
New + 200 μm Gold	1.7/1.9	0.8/0.9	0.5/0.5	688/187	101/22

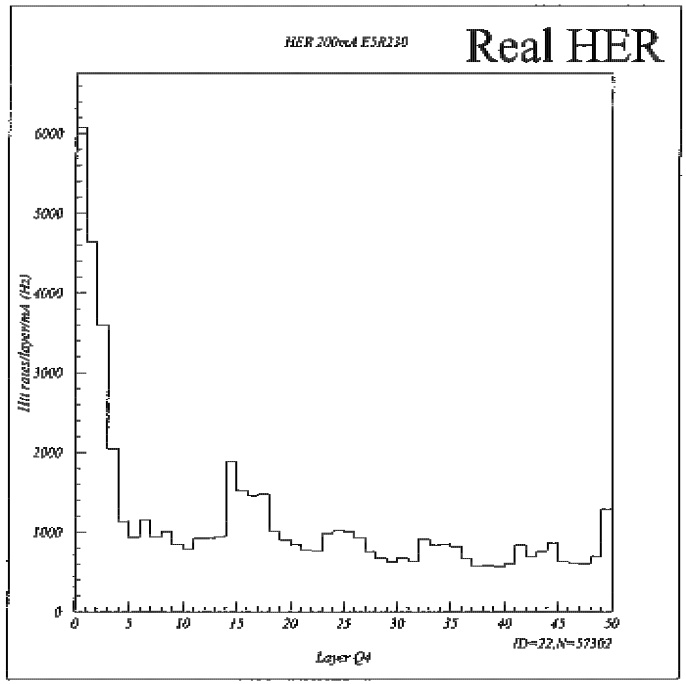
- New forward (LER) mask reduces
  30 % of SVD and 15% of CDC LER background
- Backward (HER) mask is under study

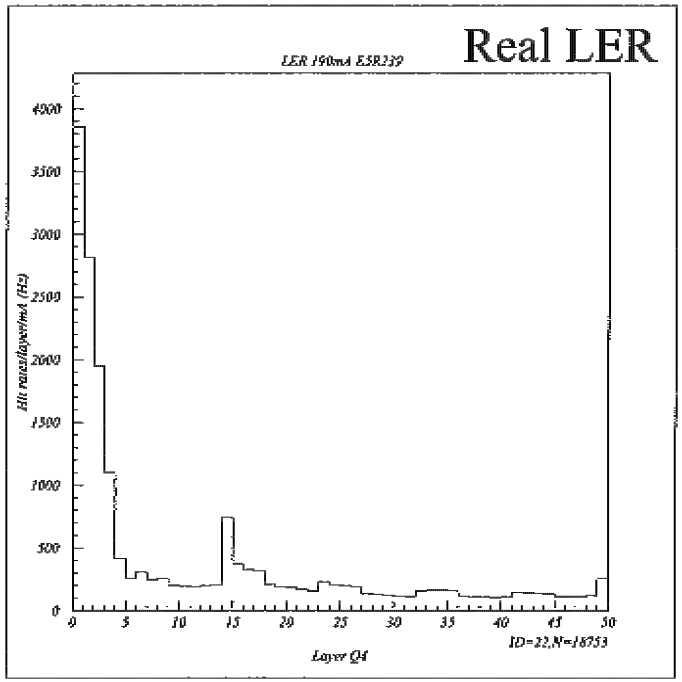
R dependence of CDC background





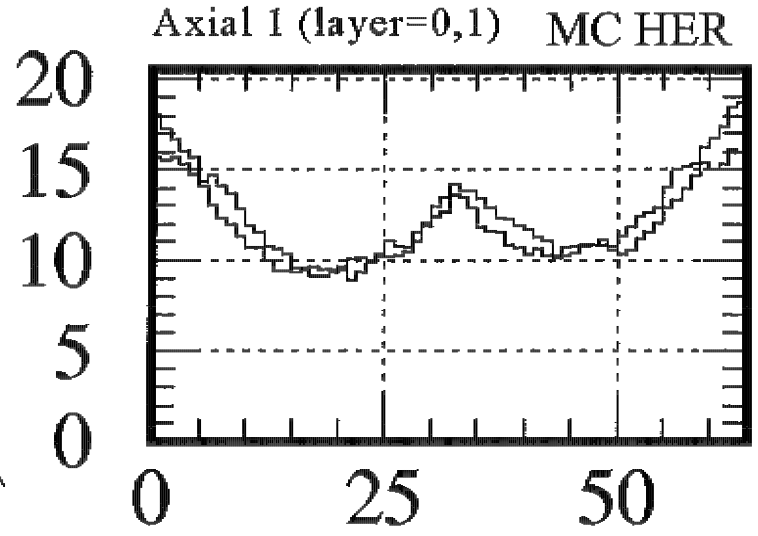
CDC hit rate (hit/sec/mA)

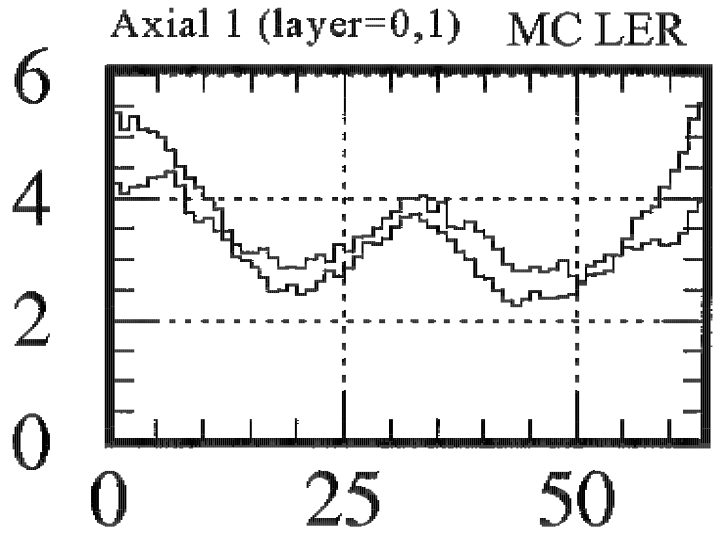




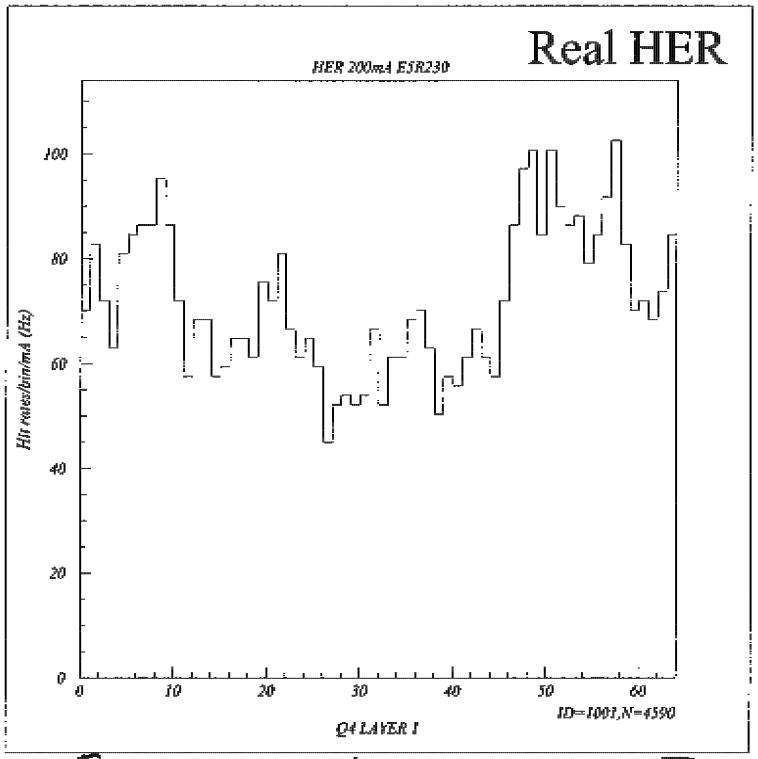
→ Layer

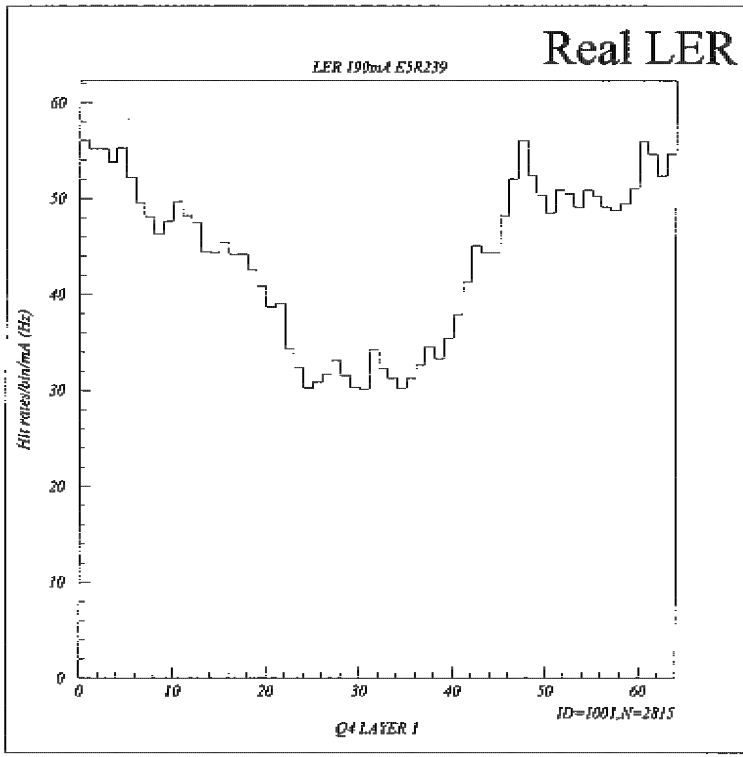
ϕ dependence of CDC 1st layer background





CDC hit rate (hit/sec/mA) →

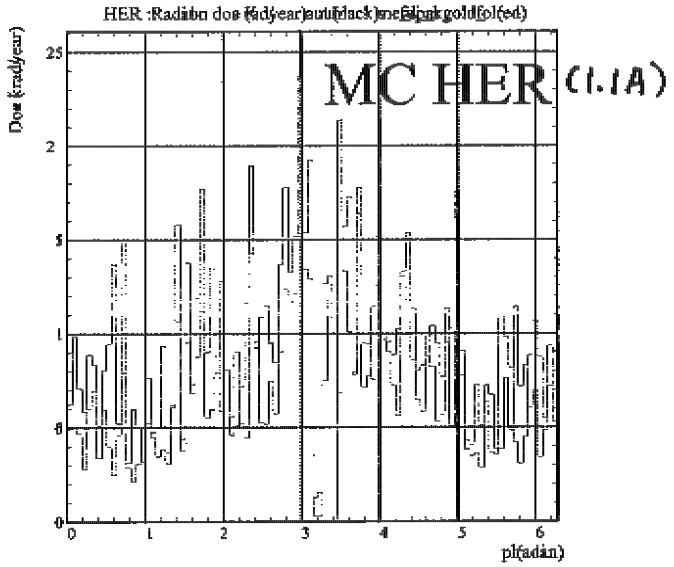


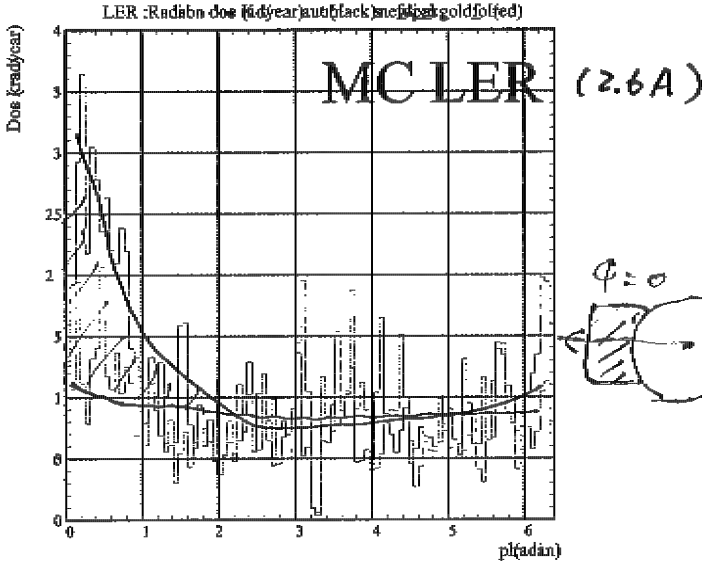


0 → ϕ 2π

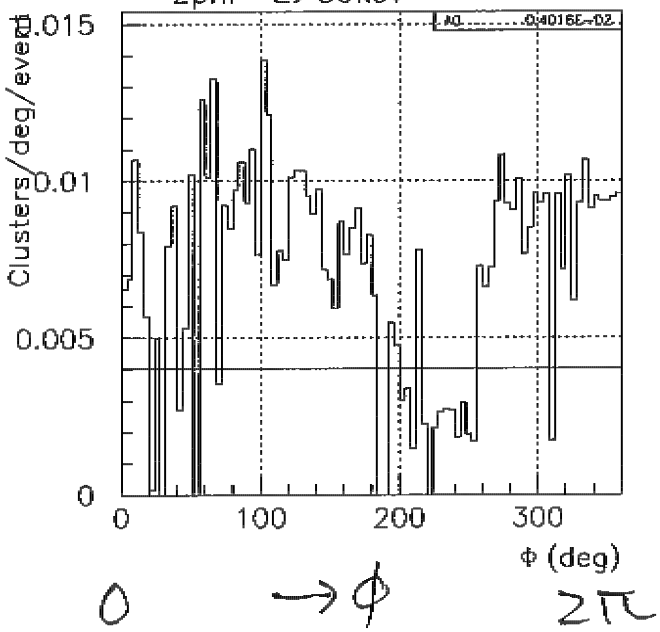
ϕ dependence of SVD 2nd layer background

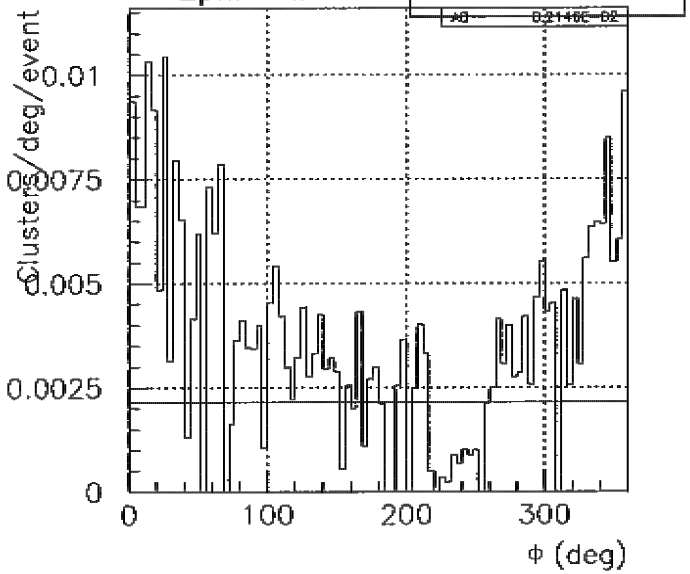
SVD Dose





SVD Cluster/deg





Cost

- Design and drawing : 11.9 Myen (Myen = 1,000,000 yen = 10,000 $)
- Materials : 4.0 Myen
- Machining : 4.9 Myen
- Gold sputtering : 0.6 Myen
- Gold plating : 3.5 Myen
- Assembly : 4.3 Myen
- Others : 4.3 Myen

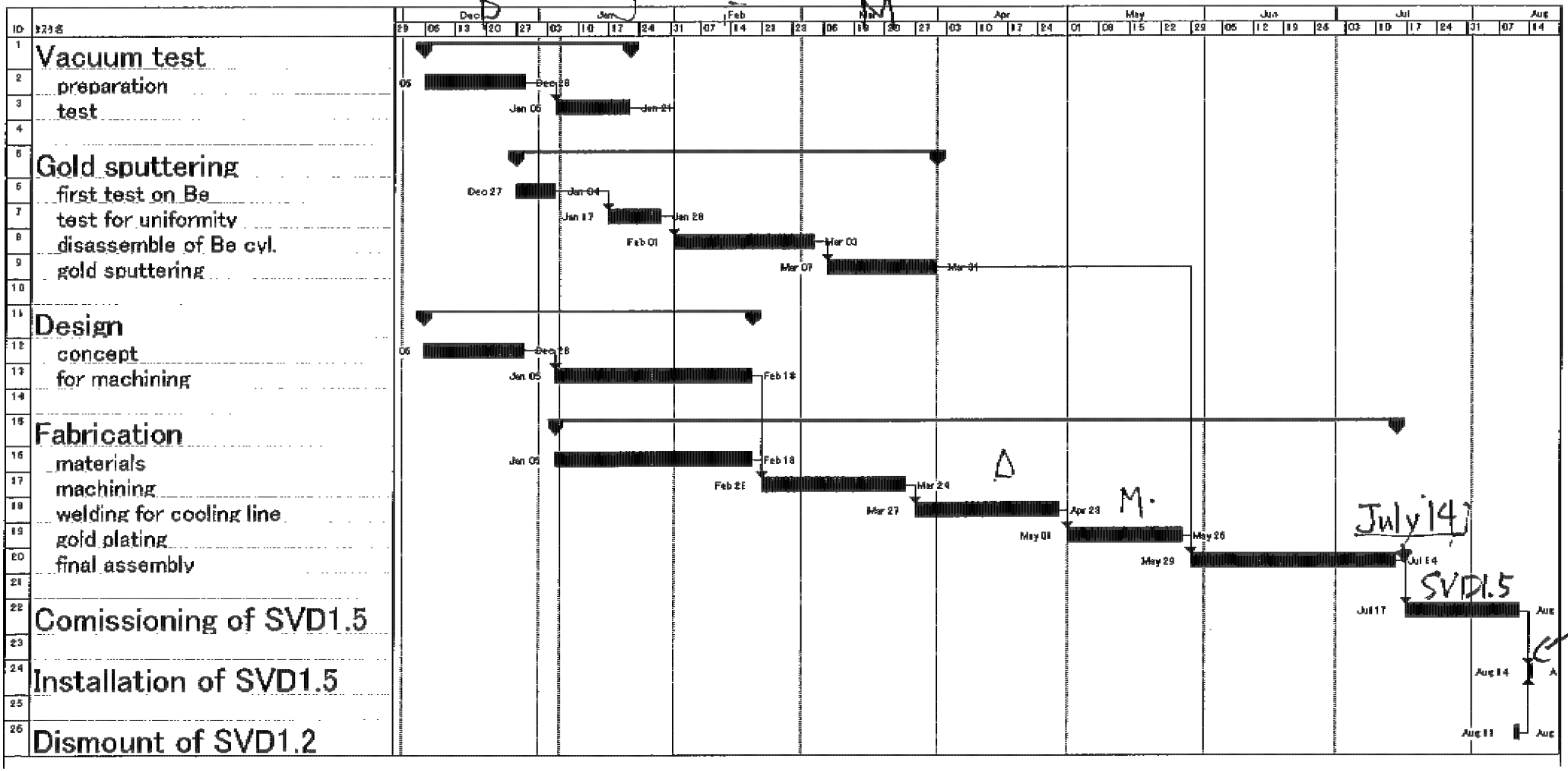
Total : 33 Myen (First one : 49 Myen, Second one : 32 Myen)
(Under negotiation, 10% work is already done.)

Other costs

- Vacuum test : 5.8 Myen (done)
- Test for Gold sputtering : 1.6 Myen (done)
- New Beryllium pipes if present one is broken : 13.8 Myen

Status and schedule

- Vacuum test for old beam pipe will finish soon
  to check chemical plating is OK or not. (preliminary result : acceptable)
- First trial for Gold sputtering by vacuum succeeded.
- Placing order to company should be ASAP for the delivery in July 2000.



Summary

- Improvements from current beam pipe
  1. 10 μm thick Gold inside Beryllium pipe by vacuum sputtering

     ⟶ **15% improvement in σ_{dz}** for $p < 250$ MeV/c
  2. Saw shape inner surface

     ⟶ Safe from low energy X ray due to bad optics
  3. Thicker Gold plating ?

     ⟶ reduces ~30 keV X ray into 1/100 (100 μm) or 1/30000 (200 μm)
  4. More Tungsten mask

     ⟶ reduces 30 % of SVD and 15% of CDC LER background
- Spare for present beam pipe
  1. Safe from vacuum accident
  2. Shorten summer shut down by 2 weeks (reassemble of SVD1.5)