HD DVD promising design

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@ UNAXIS

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Agenda

- **Environment change**
  - **Market**
  - **Display**
  - **HDD//LSI**
- **Technical design**
  - **System design**
  - **Optical design**
  - **HD DVD family**
- **Summary**

Environmental change

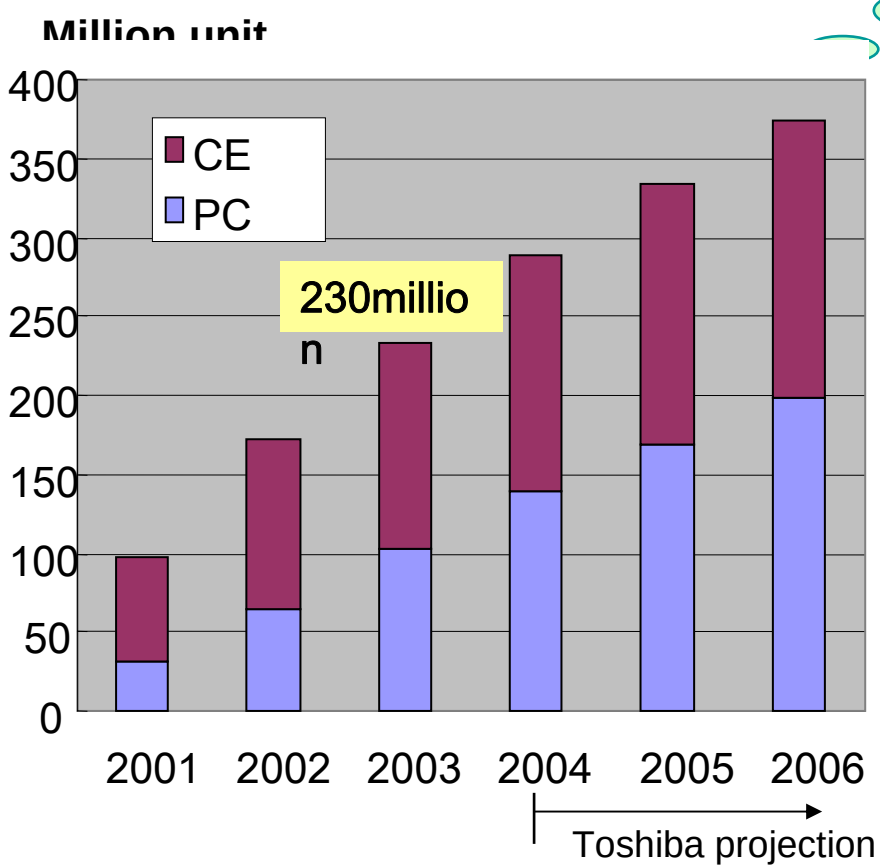
- **Market change**
- **Technology over shoot**
- **Internet threat**

Market projection Worldwide

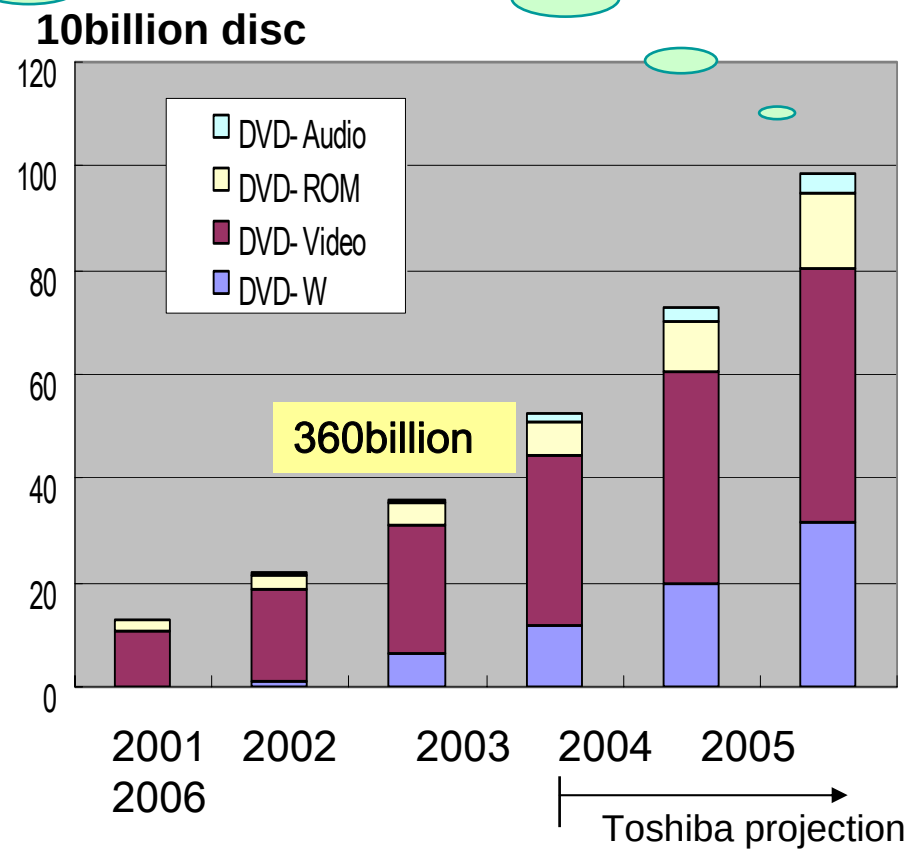
Source Techno-research (2004/2)

2006, market more than $100billion

Source：IRMA

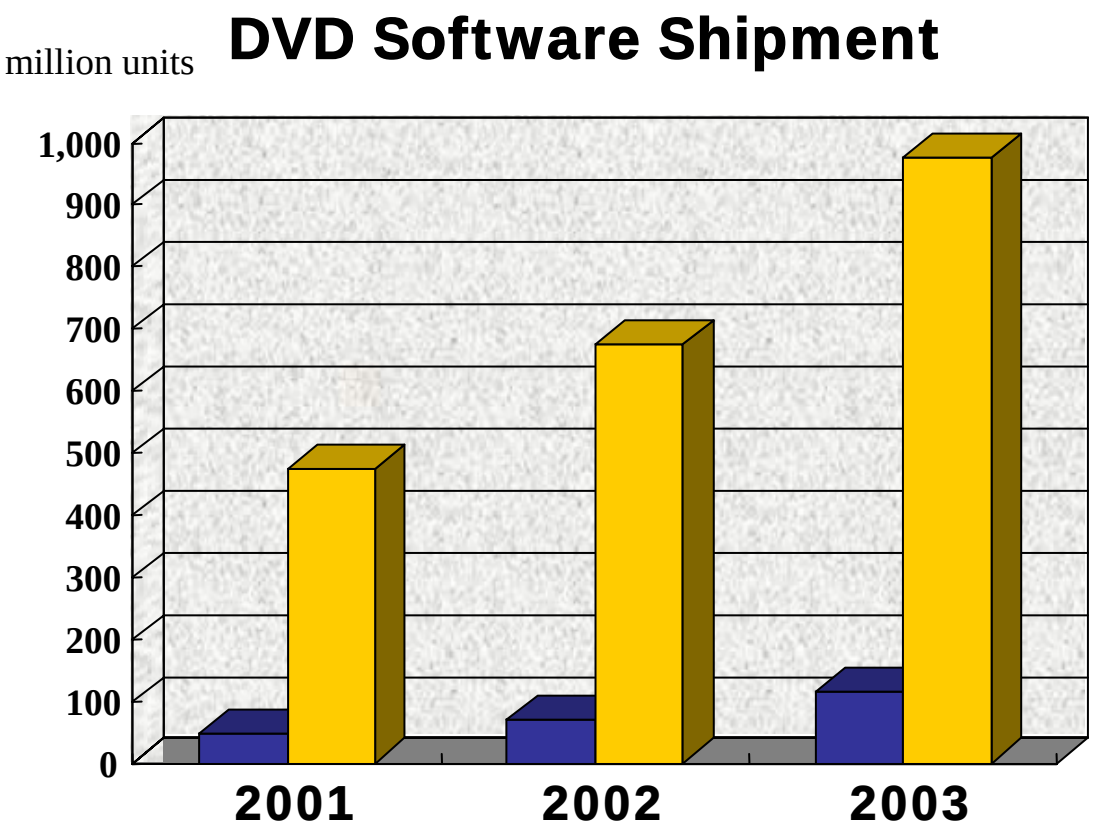


DVD Player/Drive market



DVD Disc Market

Shipment of DVD Video Software

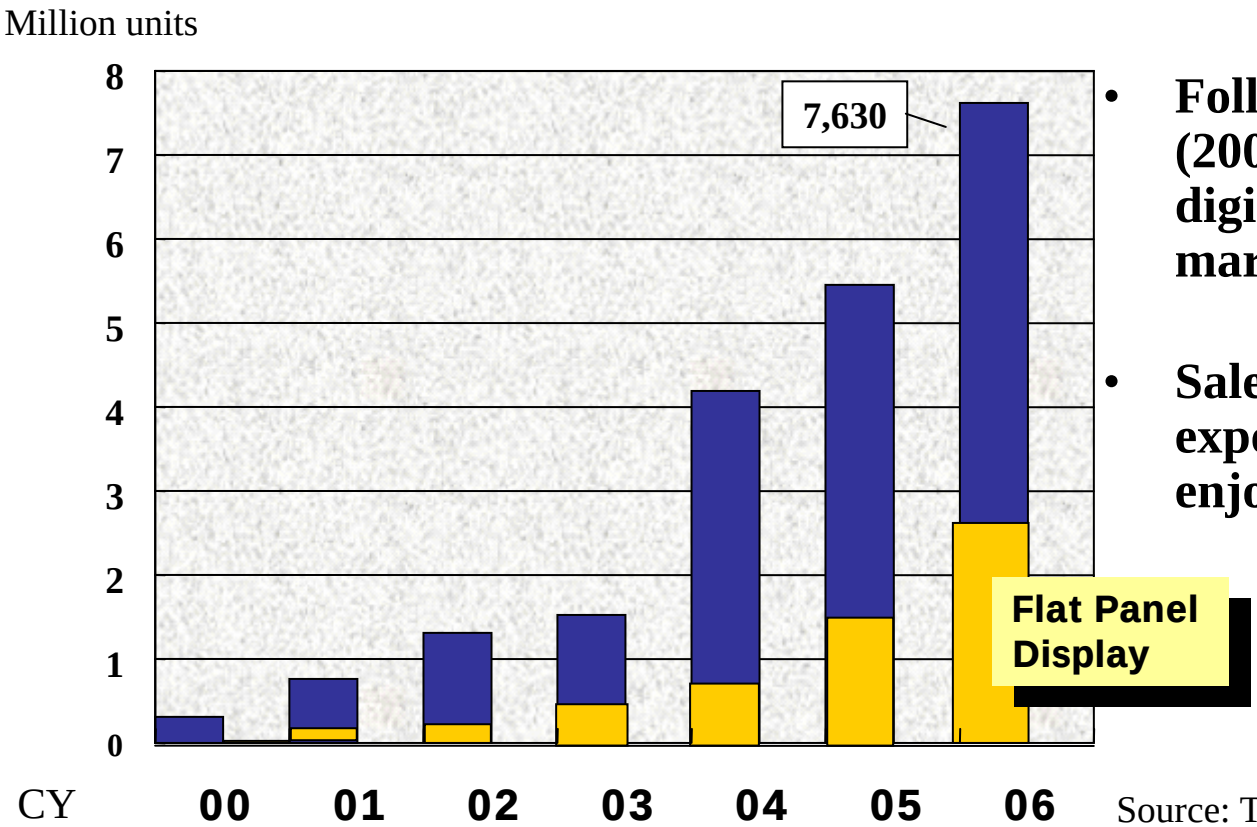


- **Shipments of DVD Video Software in the USA surpassed one billion units in 2003**
- **Continued growth is expected for another 5-6 years**

Source: Digital Entertainment Group (USA)
Japan Video Software Association (Japan)

Digital TV Market - Japan

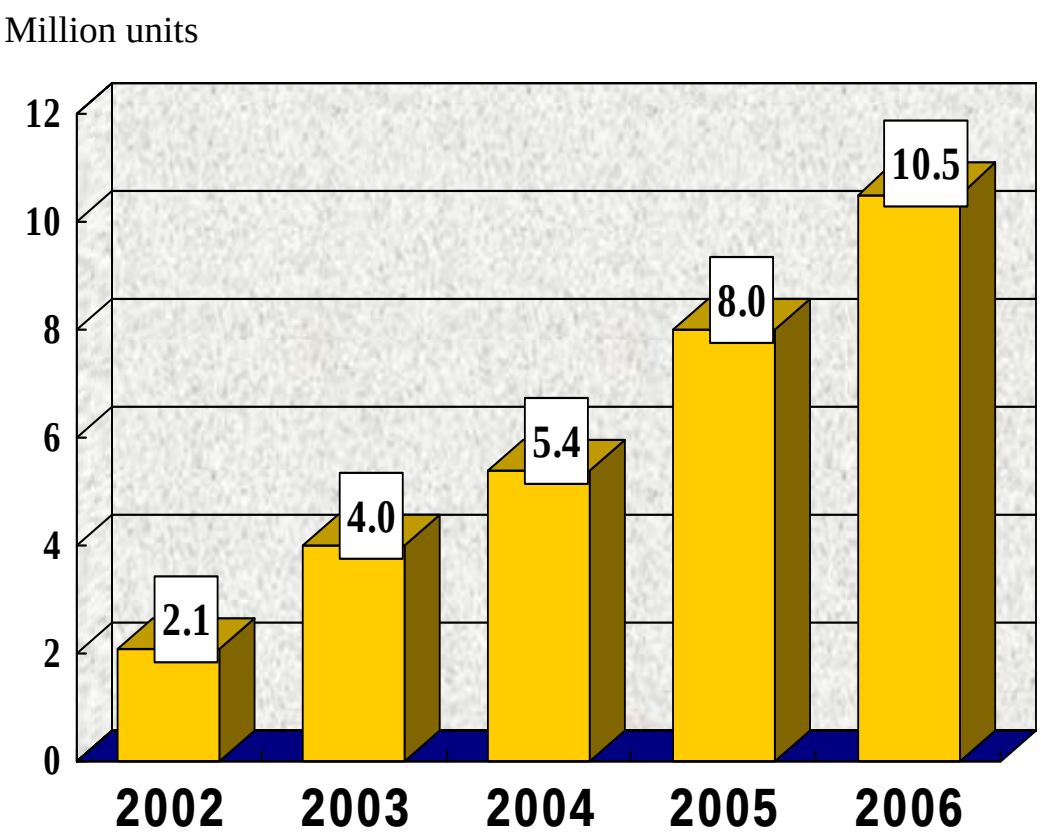
Digital TV (TV receiver + STB) Market in Japan



- **Following the start of BS (2000) and terrestrial (2003) digital broadcasts, rapid DTV market growth is forecasted**
- **Sales of 7,630,000 units are expected in 2006, in order to enjoy HD content at home**

Source: Toshiba Corp.

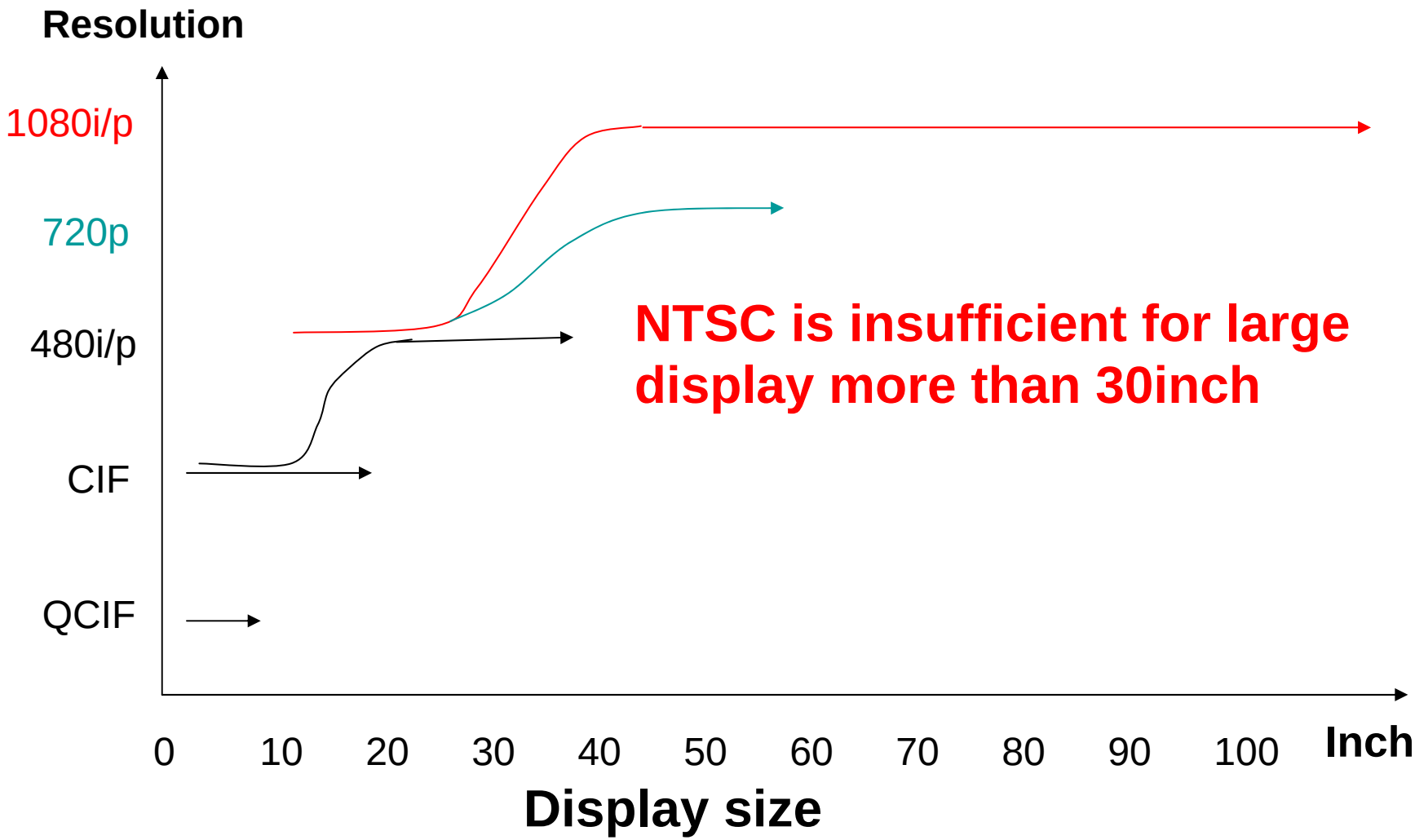
Digital TV Market – the USA



- **The U.S. DTV market is expected to grow at a faster pace**
- **The FCC mandate "Integration of DTV tuner in every DTV device of 36 inches and larger by July 2005" will accelerate DTV penetration**

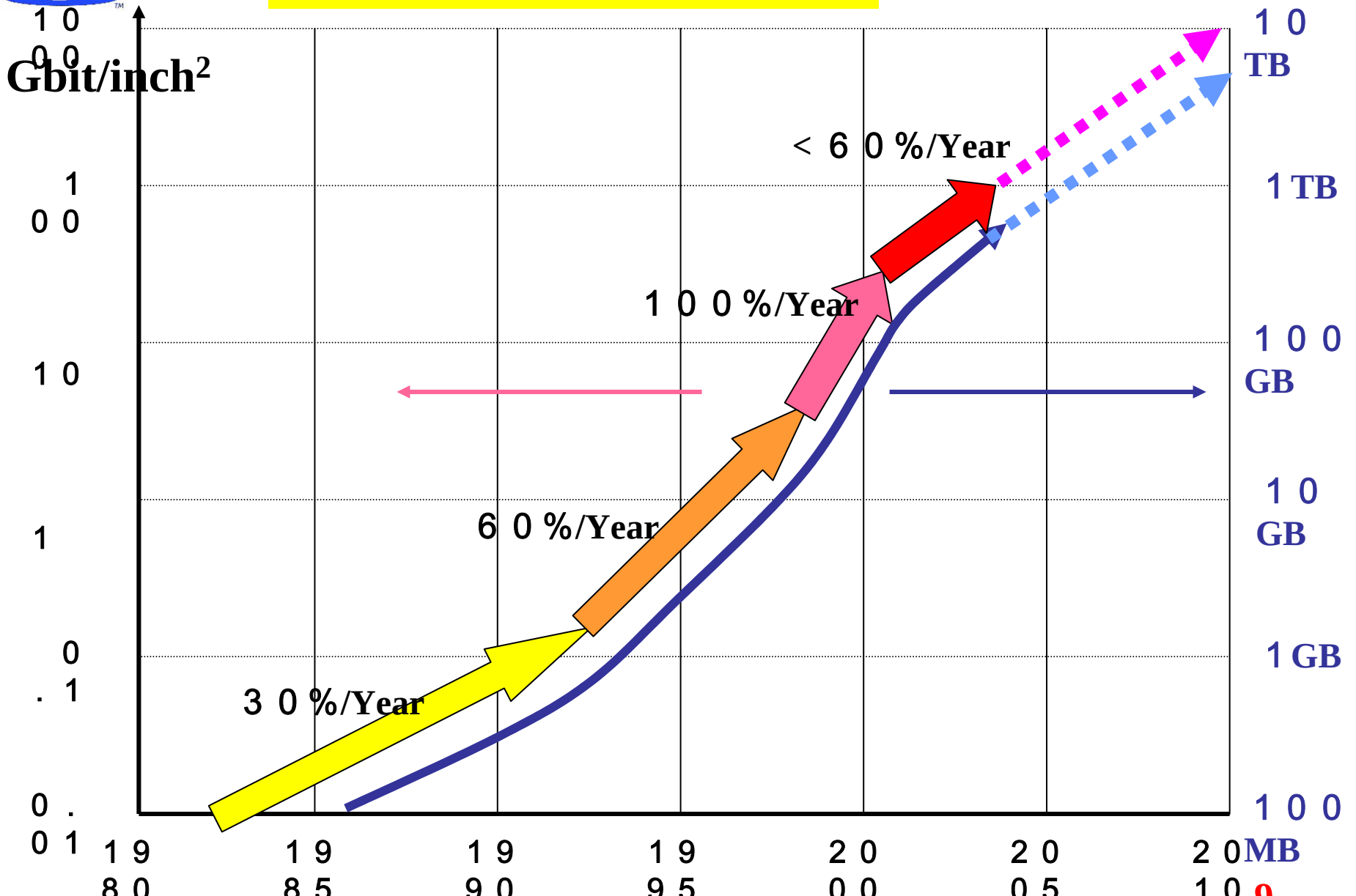
Source: CEA

Technology overshoot

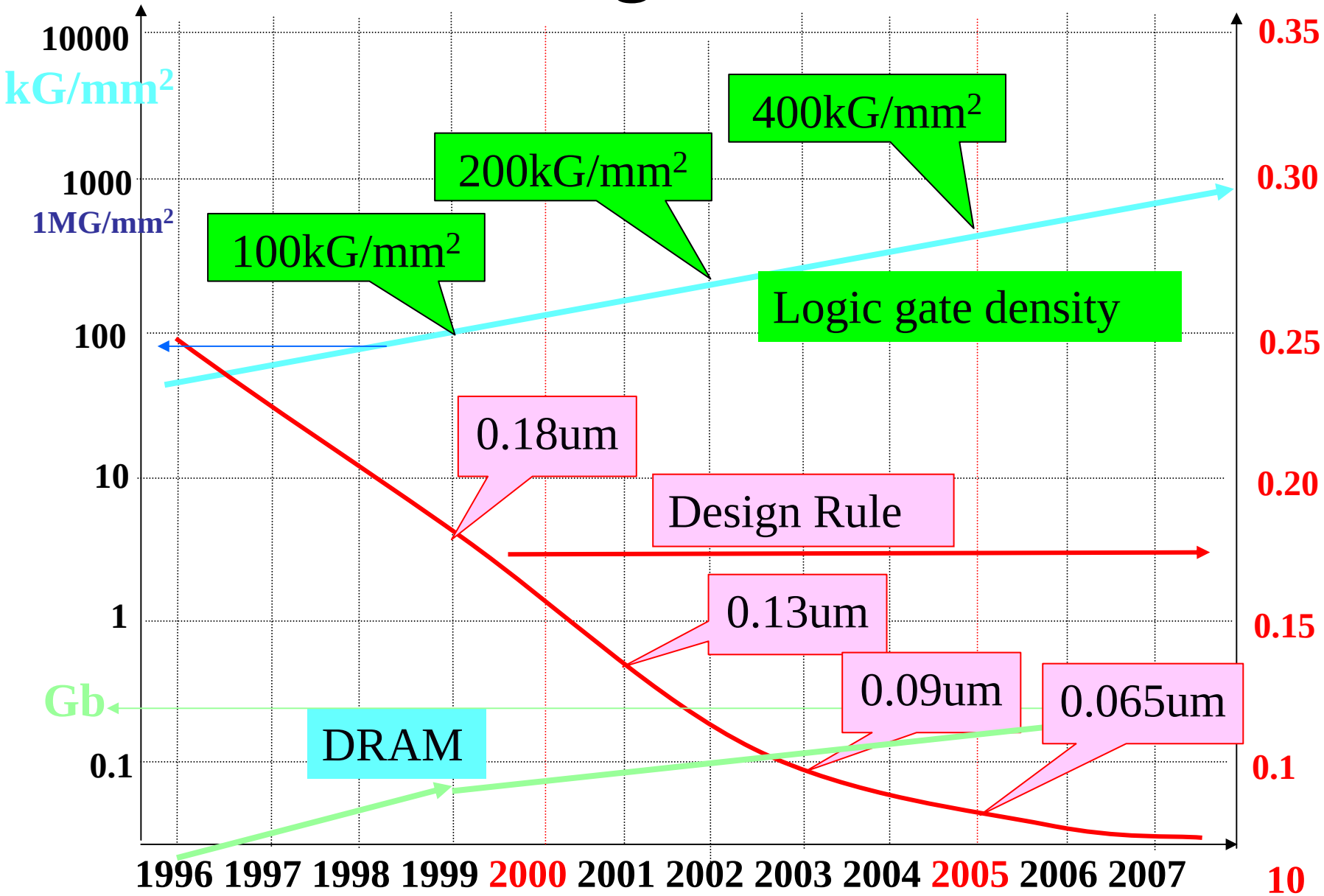


HDD recording density

3．5“1 disk、2．5”2 disk



Trend of Logic Gate Count/ mm²



LSI design

- **Design rule is still emerging**
- **Integration density will be increased**
- **Complexity of system can be solved by LSI**
- **Use advanced signal processing technology**
  - **PRML**
  - **Advanced CODEC**
  - **Improved Modulation ECC**

Role of Optical disc

- **ROM Video for content distribution will be principal usage**
- **Recordable media will be used together with HDD**
- **HDD became primary storage for time shift recording in the home.**
- **Recordable/ReWritable Optical disc will be used as archival storage for broadcasted content and download content through the Internet**
- **HD DVD is suitable for either purpose**

Internet piracy

- **Down load Activity experience**
  - **Total: 24%**
  - **France: 27%, Germany:19%, Italy: 20% ,Japan 10%, Korea: 58%, UK :20% , US:24%**
- **Peer to peer file copy**
  - **2.6 billion copy per month**
  - **Already , loss to the entertainment industry reached to billions of dollars**

Source: MPAA

Environment change

- **Display Technology over shoot**
  - **Too good big display will show current DVD picture quality is poor**
- **Broadband network threat**
  - **28% of general American experienced pirated disc downloaded through Internet**
  - **Actual damage on business might begin in 2006?**
- **Need promotion of secure environment in advance. HD DVD can realize quick introduction and long format life for the future**

Comprehensive System Design Target

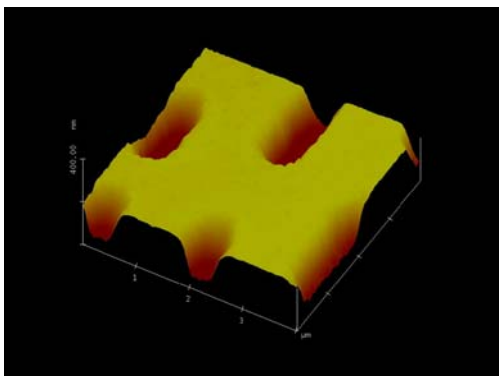
- **Provide sufficient quality necessary for HD movie content**
- **Provide sufficient capacity for 132min movie**
- **Add new features on current DVD and Internet connectivity**
- **Provide secure content protection**
- **Use current DVD production facility and know how already accumulated**
- **Make low cost production of disc possible**
- **Assume HDD with ODD in usual home environment**
- **Optimum design using most advanced CODEC and LSI technology**

Technical design

- **Reasonable design considering the essential condition for the next generation DVD**
- **Consistency with DVD**
- **Optimum from user's point of view**

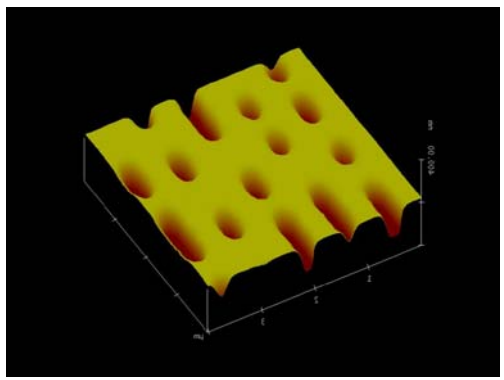
Pit Comparison of Read-only Disc

viewed through atomic force microscope
4um x 4um



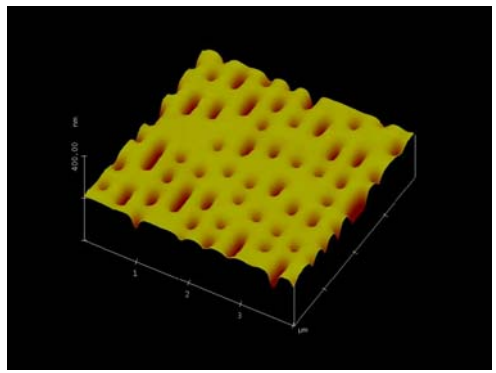
CD

track pitch	1.60 um
min. pit length	0.83 um
pit width	0.50 um
capacity	650 MB



DVD

track pitch	0.74 um
min. pit length	0.40 um
pit width	0.35 um
capacity	4.7 GB



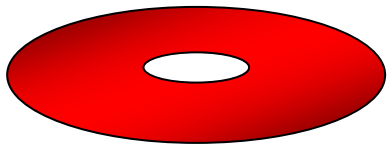
HD DVD

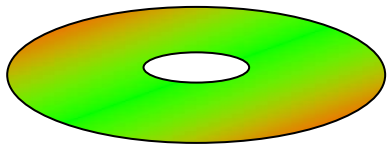
Track pitch	0.40 um
min. pit length	0.204 um
pit width	0.25 um
capacity	15 GB/30GB

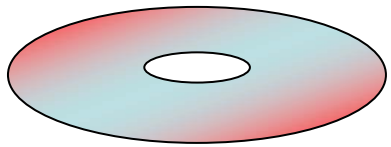
CD>>DVD>>HD DVD

- **CD: 1.2mm substrate open a way to use precision injection technology and digital signal processing for bit data (modulation and ECC)**
- **DVD: 0.6mm bonding structure open a way to use bonding technology of two discs and more sophisticated digital signal processing and compression technology and digital copy protection**
- **HD DVD: To develop ?**

Technology selection

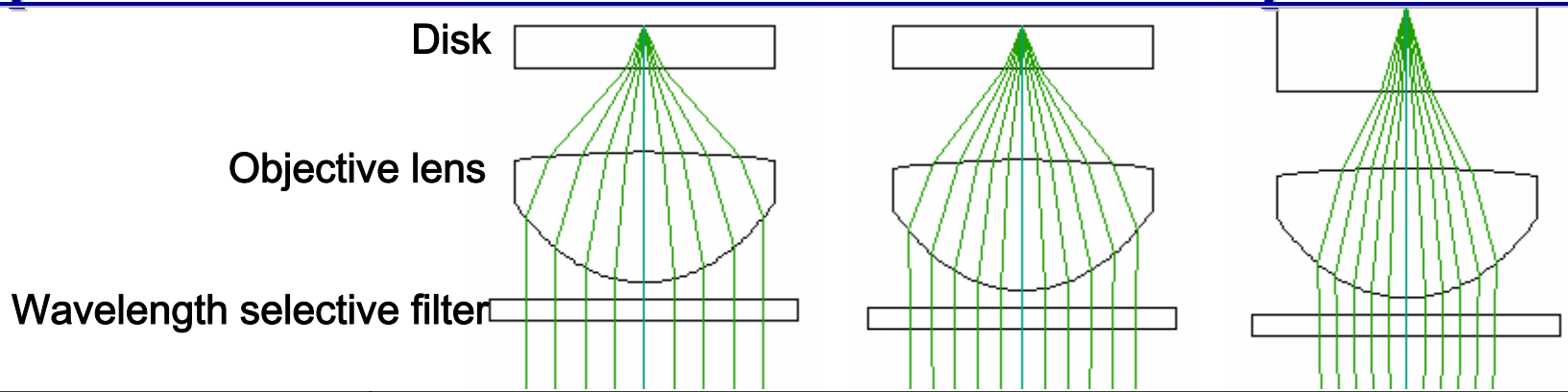






	CD	DVD	HD DVD (BrD)
Substrate Thickness	1.2mm	0.6mm x 2	0.6 x 2 (0.1)
NA	0.45	0.6	0.65 (0.85)
Capacity (GB)	0.78	4.7/8.5	15/30 20/32 (25/50)
CODEC	none	MPEG2	MPEG4 AVC VC1/MPEG2 (MPEG2>>Same)

Optical characteristics of HD-DVD/DVD/CD compatible head



	H D - D V D	D V D	C D
Wavelength	405 nm	660 nm	790 nm
N A	0.65	0.60	0.45
Focal length	2.60 mm	2.68 mm	2.70 mm
Disk thickness	0.6 mm	0.6 mm	1.2 mm
Working Distance	1.2 mm	1.304 mm	1.099 mm
Magnification	0	-0.0164	-0.0766
Object distance	INF.	165.24 mm	37.27 mm
Wavefront aberration	0.0001 λrms	0.0063 λrms	0.0017 λrms
Chromatic aberration	0.63 μm/nm	0.16 μm/nm	0.11 μm/nm
Wavefront aberration (±0.2mm objective lens shift)	0.0001 λrms	0.0071 λrms	0.0258 λrms
Field angle / Image height (35mλrms tolerance)	±0.74 deg. / ±34.2 μm	±0.57 deg. / ±25.6 μm	±0.42 deg. / ±19.2 μm
Disk tilt (35mλrms tolerance)	±0.15 deg.	±0.34 deg.	±0.56 deg.

Technical design parameters

Substrate

CD	DVD	HD DVD
1.2mm	0.6mm →	0.6mm
	No!	**0.1mm**

Systems to be compared

- (A) Current DVD
- (B) 0.1mm cover layer & 0.85 NA system
- (C) 0.6mm cover layer & 0.65 NA system

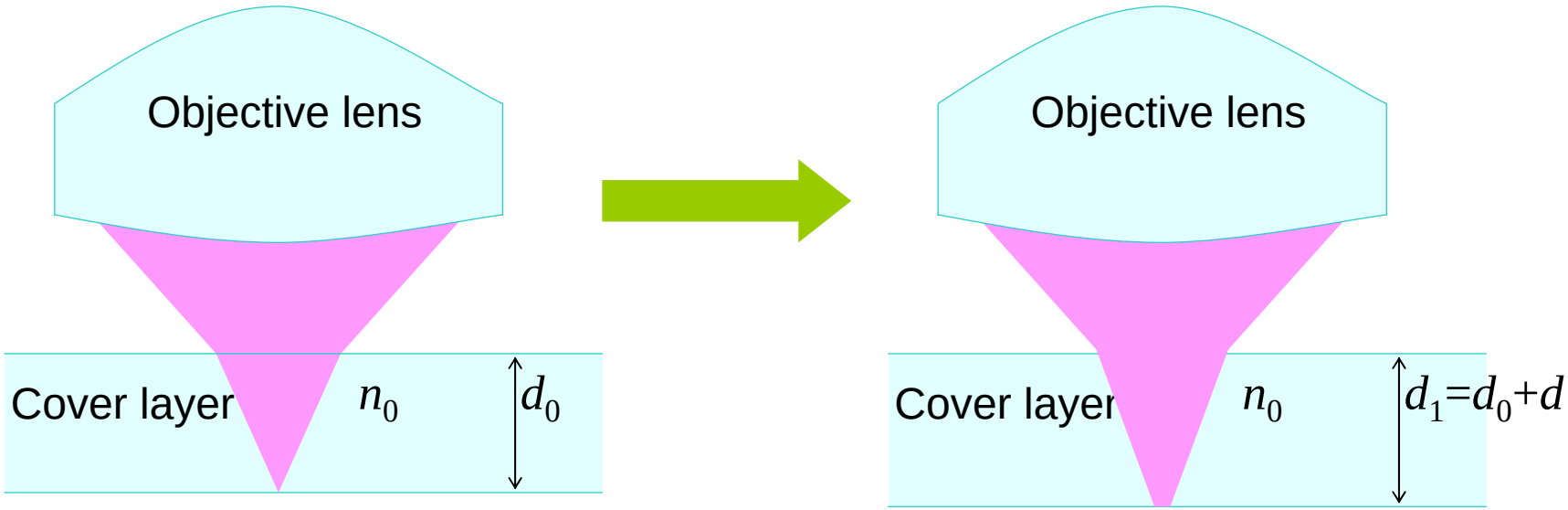
			(A)	(B)	(C)
Wavelength	λ	(μm)	**0.65**	**0.405**	**0.405**
Refractive index	n_0		**1.58**	**1.62**	**1.62**
Numerical aperture	*NA*		**0.6**	**0.85**	**0.65**
Cover thickness	d_0	(μm)	**600**	**100**	**600**

Issues to be discussed

- **Cover-layer thickness error**
- **Disk-tilt**
- **Depth of focus**
- **Dust on cover**
- **Tracking error signal (L/G and G-only)**

Cover-layer thickness error

Optical scheme



No aberration when| cover thickness is d_0

,

and refractive index is n_0

Cover-layer thickness error

Models

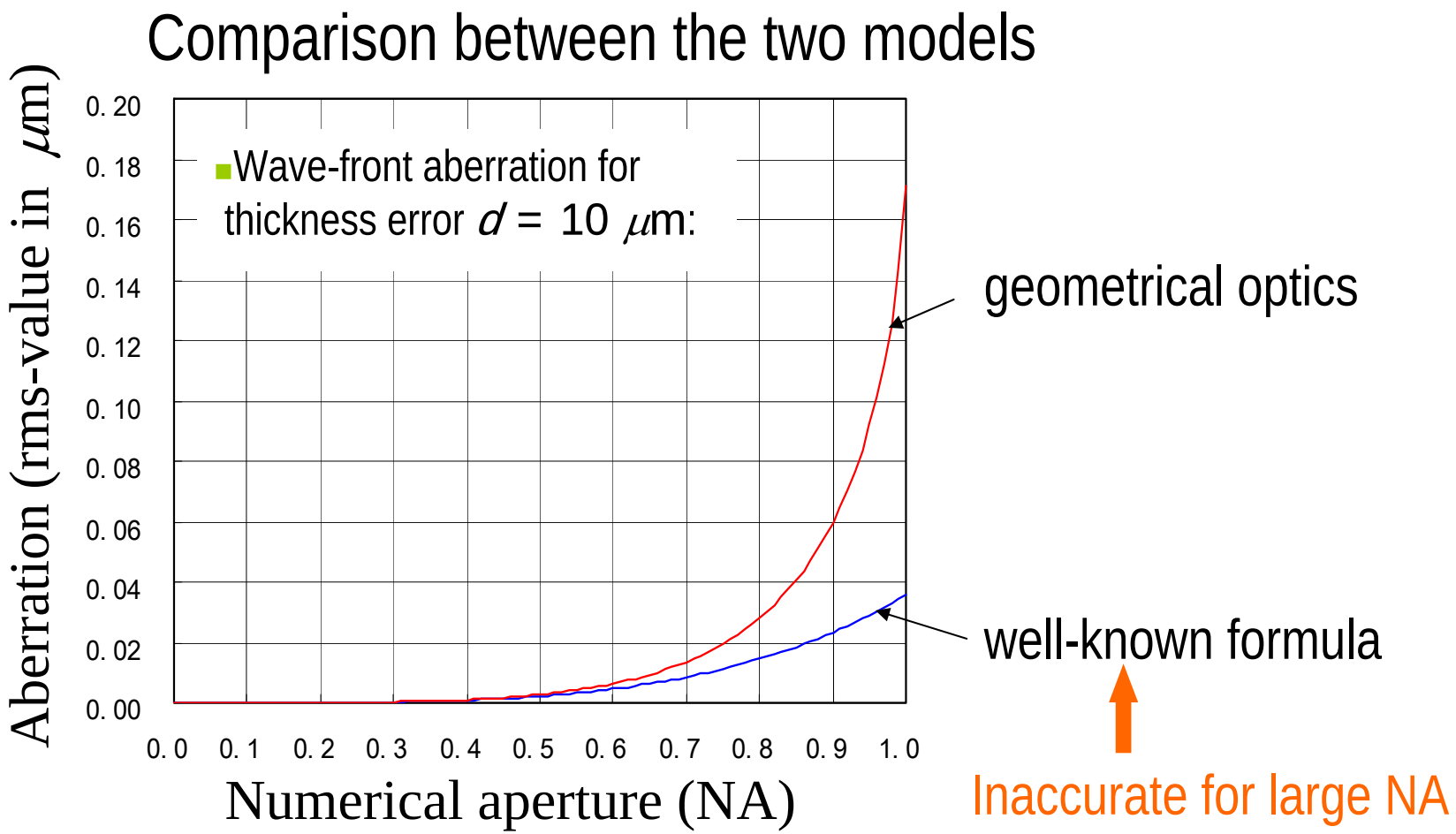
(1) Well known formula：

$$W(r) = W_{40} r^4 = \frac{\left(n_0{}^2 - 1\right)}{8 n_0{}^3} d (NA)^4 r^4$$

(2) By geometrical optics： ← This calculation

$$W(r) = \left\{ \sqrt{n_0{}^2 - (NA)^2 r^2} - n_0 + (1/n_0) - \left(\sqrt{1 - (NA)^2 r^2} \,/ n_0 \right) \right\} d$$

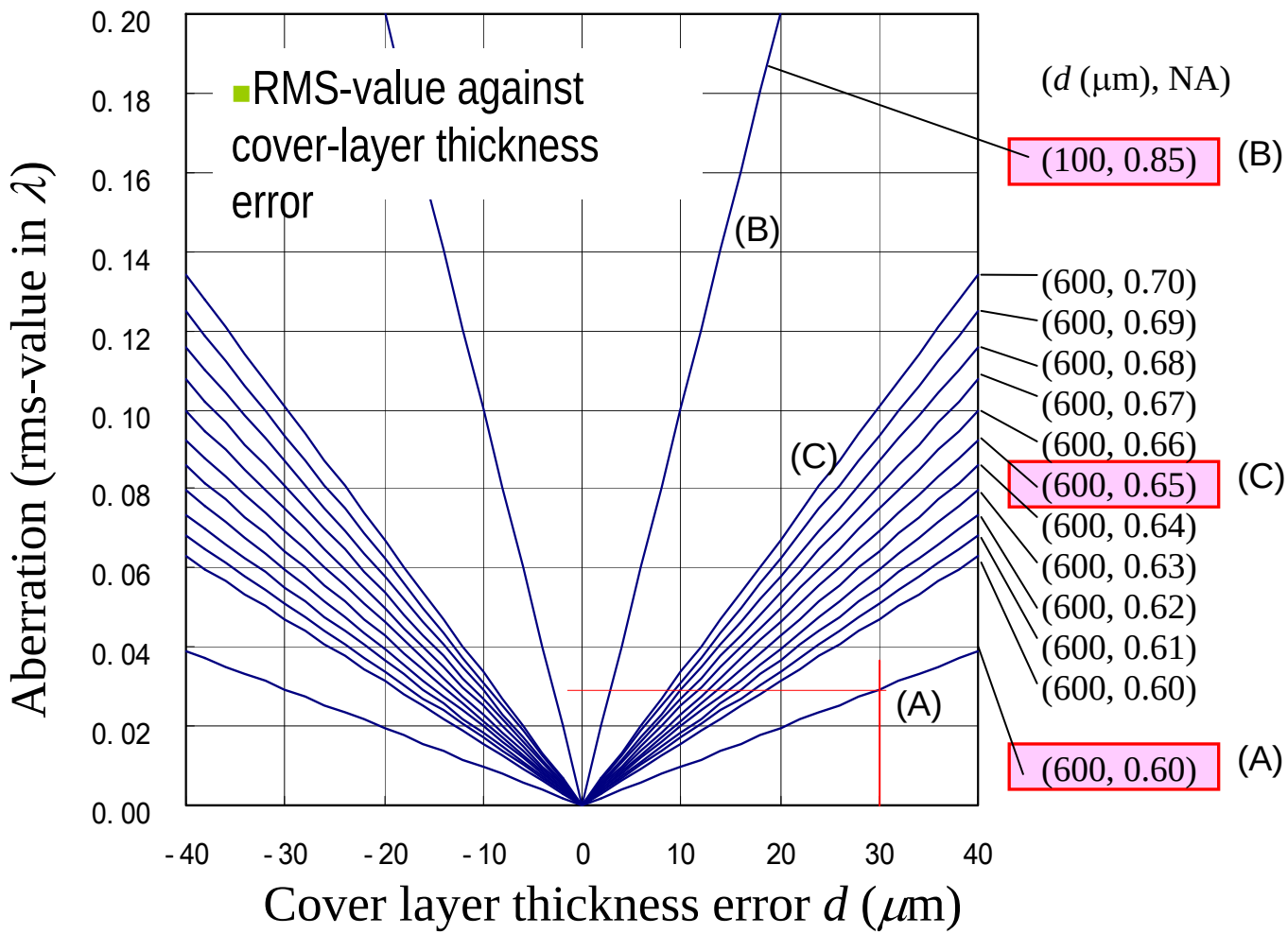
Cover-layer thickness error



Thin substrate will not give any advantage over thick substrate

Cover-layer thickness error

Result



Cover-layer thickness error

Conclusion for cover-layer thickness error

Margin d_m is defined so that the following expression holds:

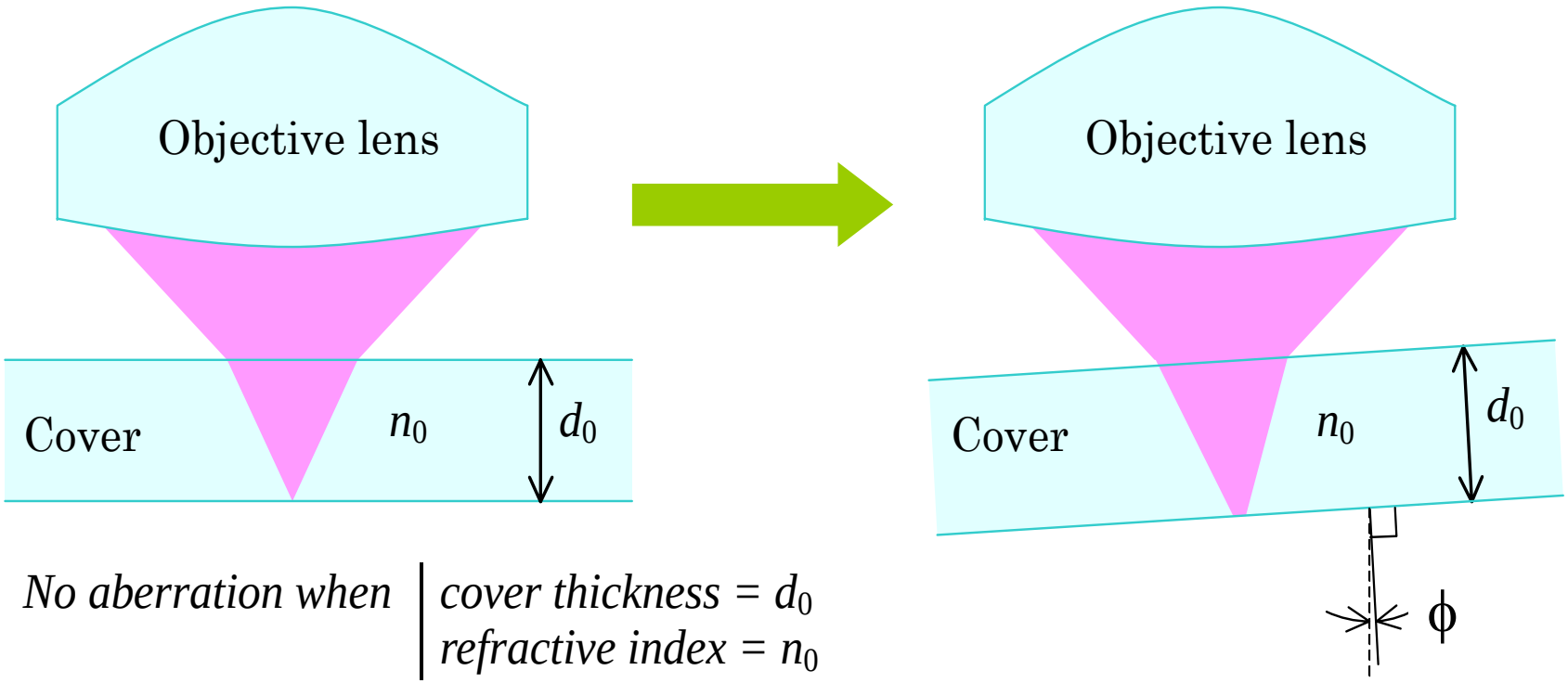
" if $|d| < d_m$ ==> $w_{RMS} < 0.0293(\lambda)$ "

			(A)	(B)	(C)
Wavelength	λ	(μm)	**0.65**	**0.405**	**0.405**
Refractive index	n_0		**1.58**	**1.62**	**1.62**
Numerical aperture	NA		**0.6**	**0.85**	**0.65**
Cover thickness	d_0	(μm)	**600**	**100**	**600**
thickness margin	d_m	(μm)	**30**	**2.9**	**12.7**

DVD specification

Disk-tilt

Optical scheme



No aberration when | *cover thickness* = d_0
refractive index = n_0

Disk-tilt

RMS value of phase error

(1) Well known formula：

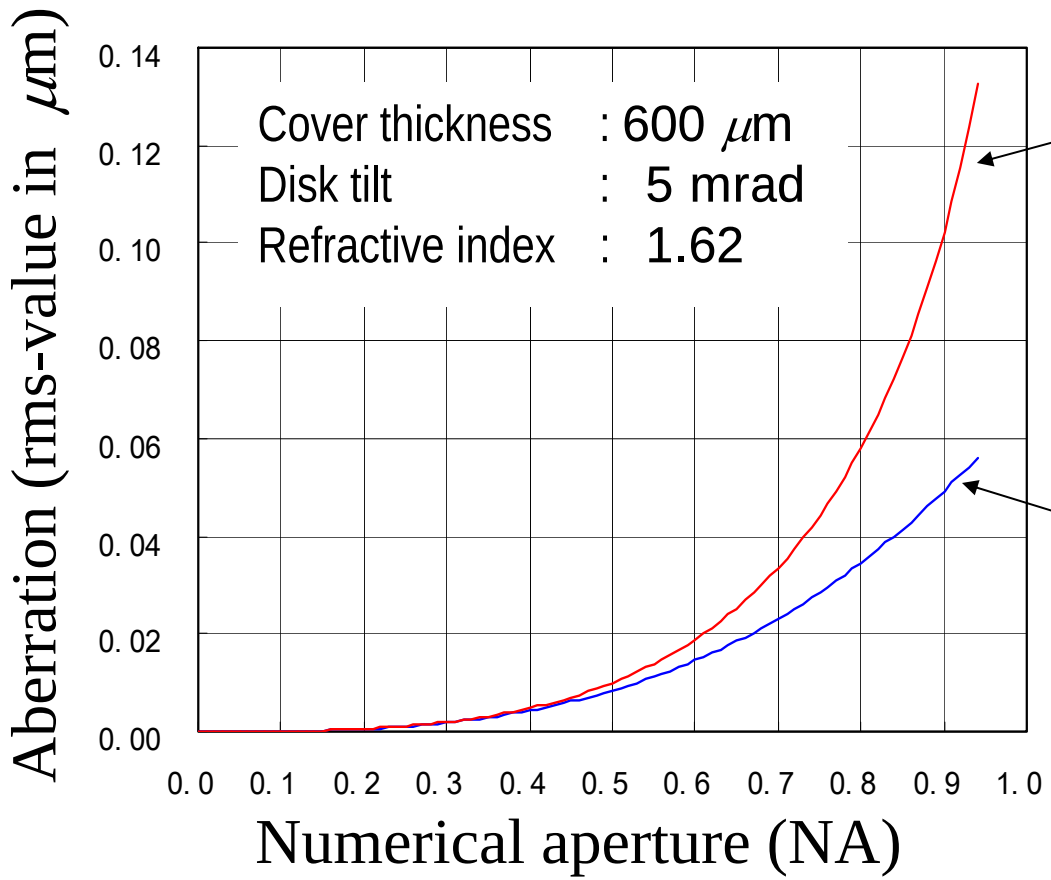
$$W(r,\phi) = W_{31} r^3 \cos\phi = \frac{\left(n_0{}^2 - 1\right)}{2n_0{}^3} d\left(NA\right)^3 r^3 \cos\phi$$

(2) By geometrical optics：← This calculation

$$W(r,\phi) = Optical\ \ Path\ Difference$$
$$\left(geometrica\ lly\ calculated\ \right)$$

Disk-tilt

Comparison between the two models



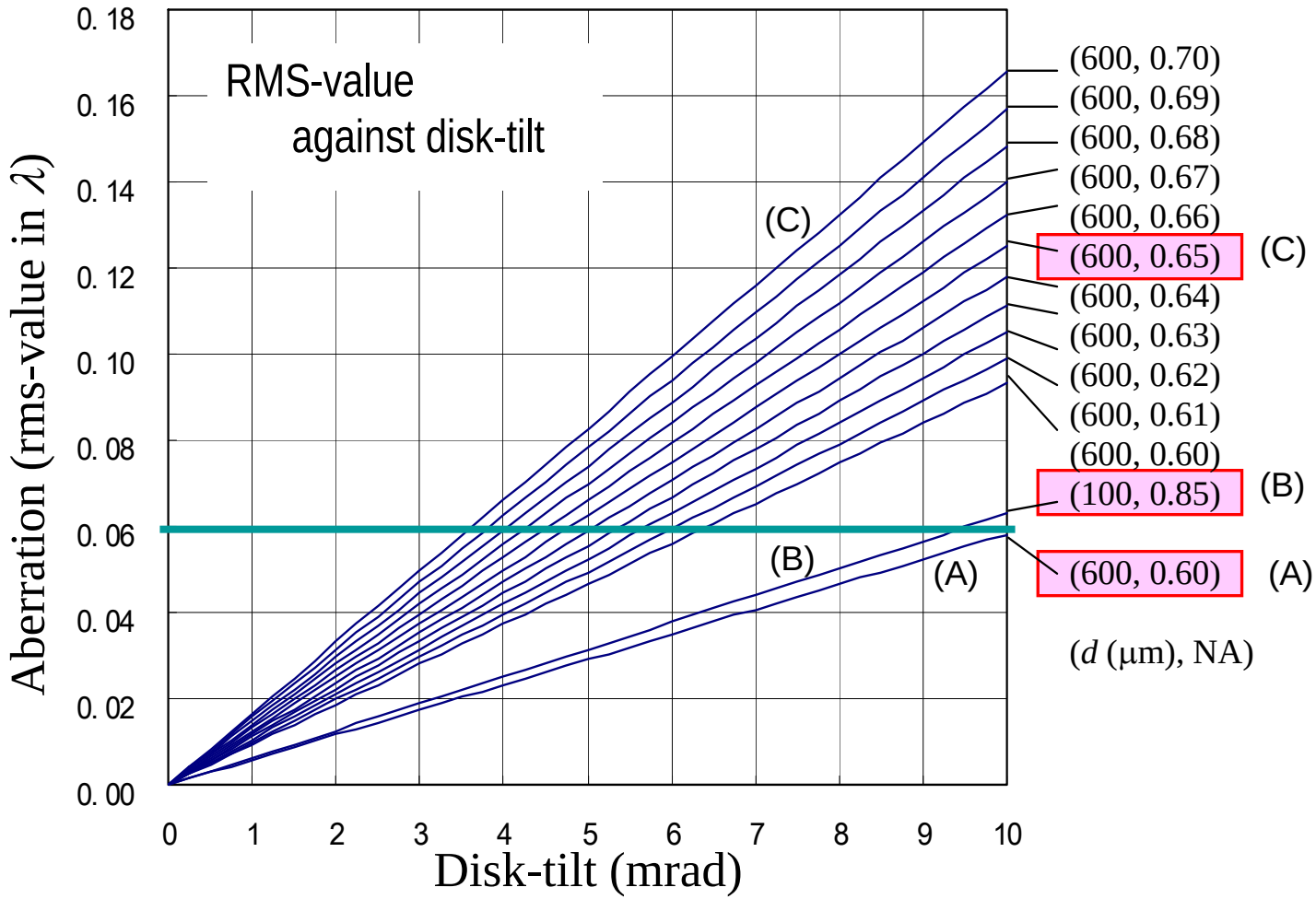
geometrical optics

well-known formula

Inaccurate for large NA

Disk-tilt

Result



HD DVD system need a measure to improve tilt margin
>> Tilt servo

Disk-tilt

Conclusion for disk-tilt

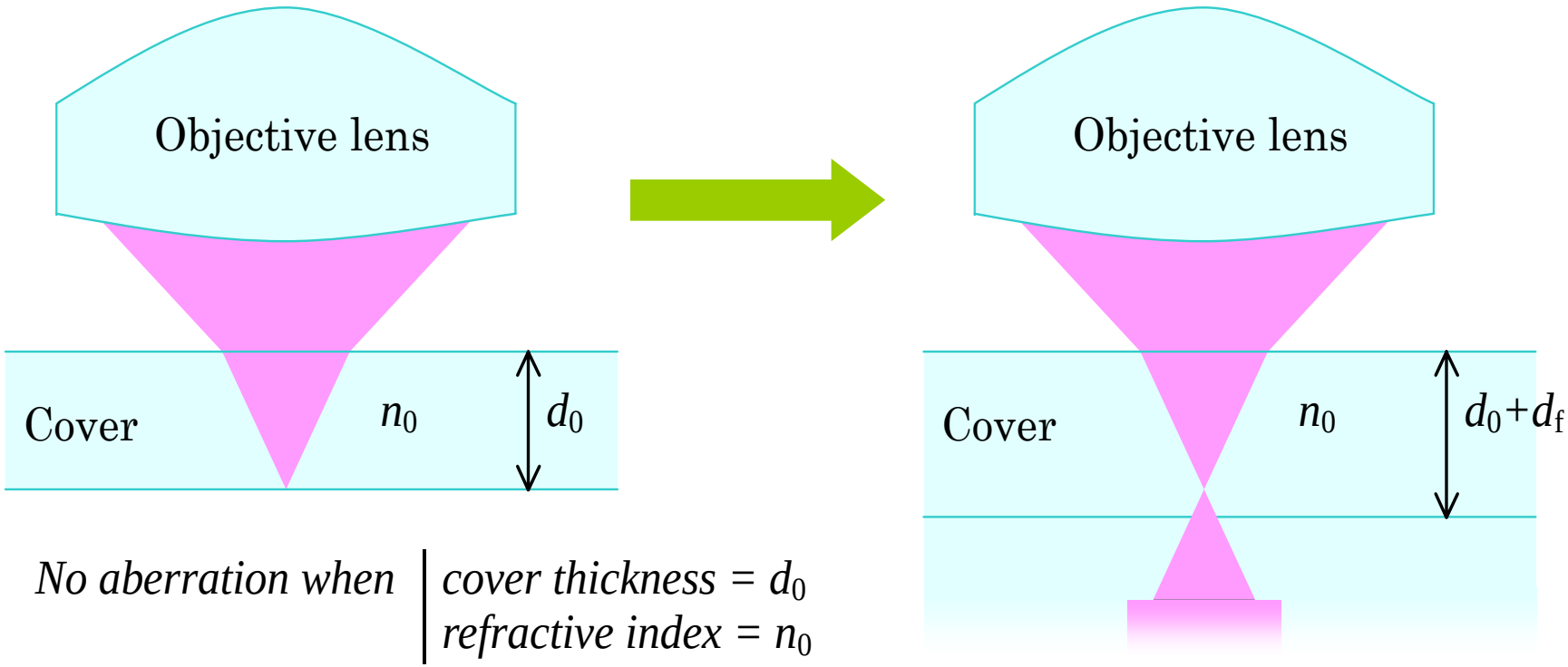
Tilt margin θ_m is defined so that the following expression holds:

" if $|\theta| < \theta_m$ ==> $w_{RMS} < 0.04(\lambda)$ "

			(A)	(B)	(C)
Wavelength	λ	(μm)	**0.65**	**0.405**	**0.405**
Refractive index	n_0		**1.58**	**1.62**	**1.62**
Numerical aperture	NA		**0.6**	**0.85**	**0.65**
Cover thickness	d_0	(μm)	**600**	**100**	**600**
Tilt margin	θ_m	(mrad)	**6.9**	**6.4**	**3.2**

Depth of focus

Optical scheme



No aberration when | *cover thickness* = d_0
refractive index = n_0

Depth of focus

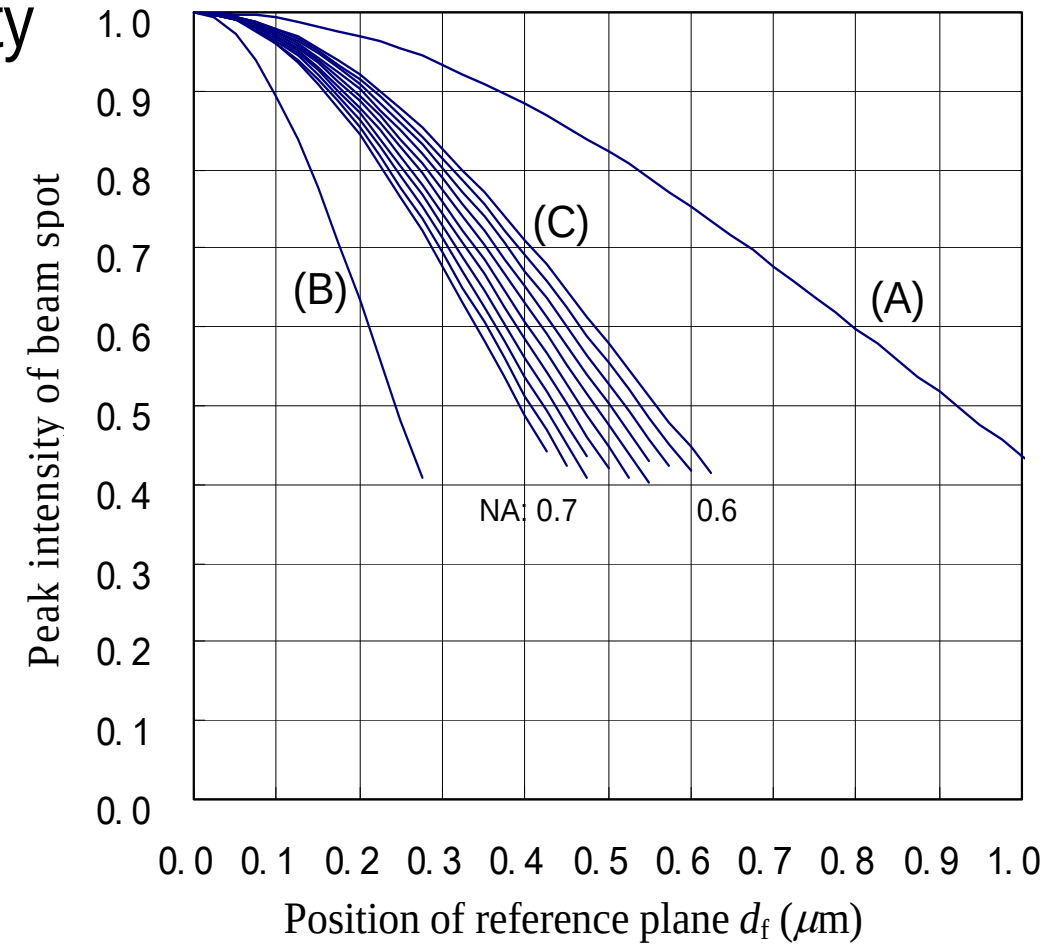
Diffraction model

$$W(r) = n_0 \, d_f \left(1 - \sqrt{1 - (NA)^2 r^2}\right)$$

- (a) Scalar model
- (b) Vector model
  - Linear polarization
  - Circular polarization ← This calculation

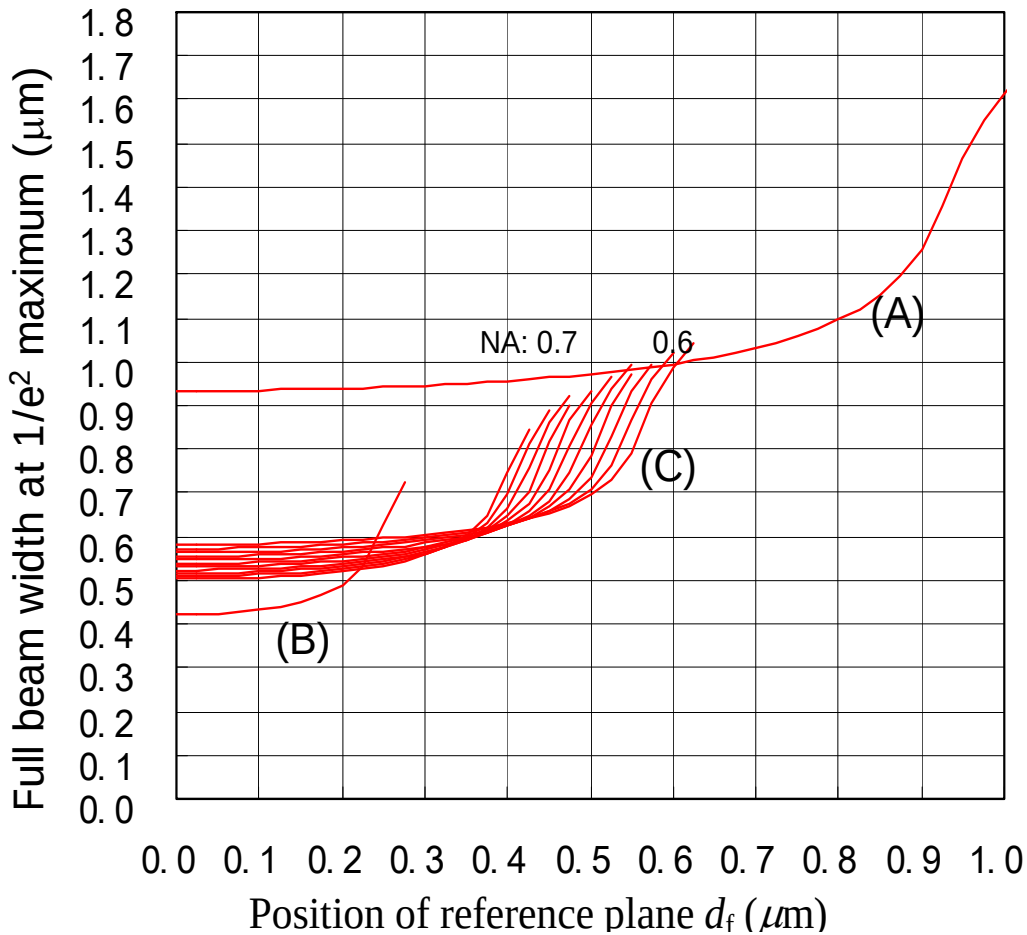
Depth of focus

Peak intensity



Depth of focus

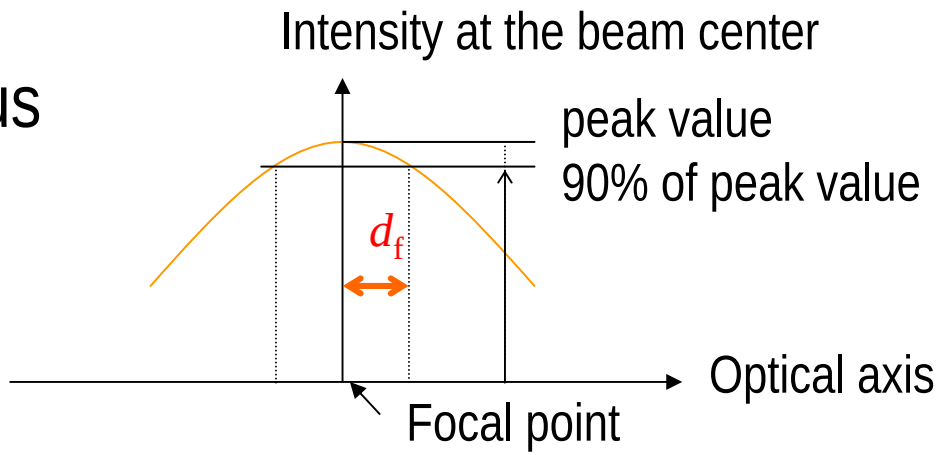
Beam width



Depth of focus

Conclusion for depth of focus

Depth of focus d_f is defined as show in the figure



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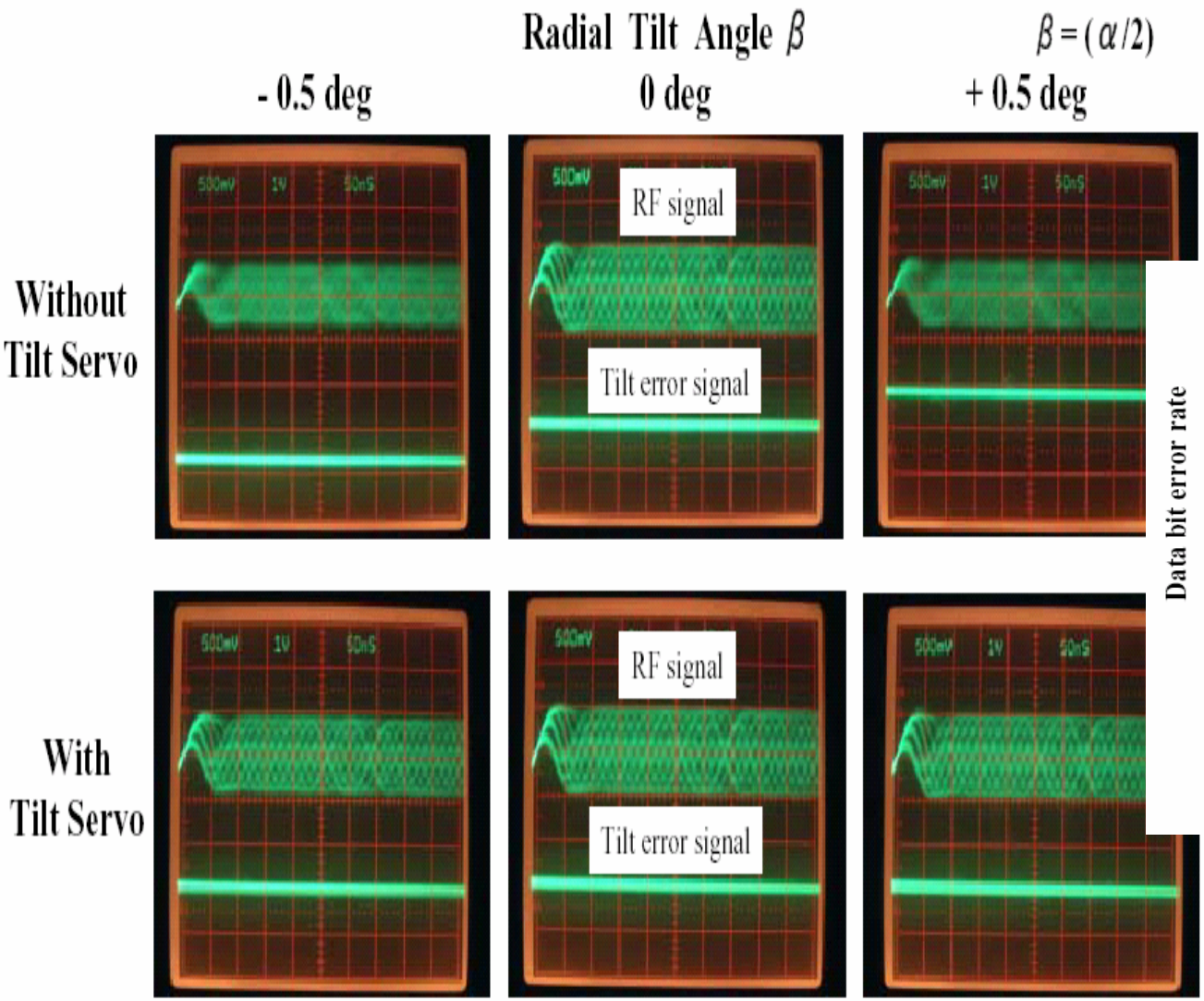
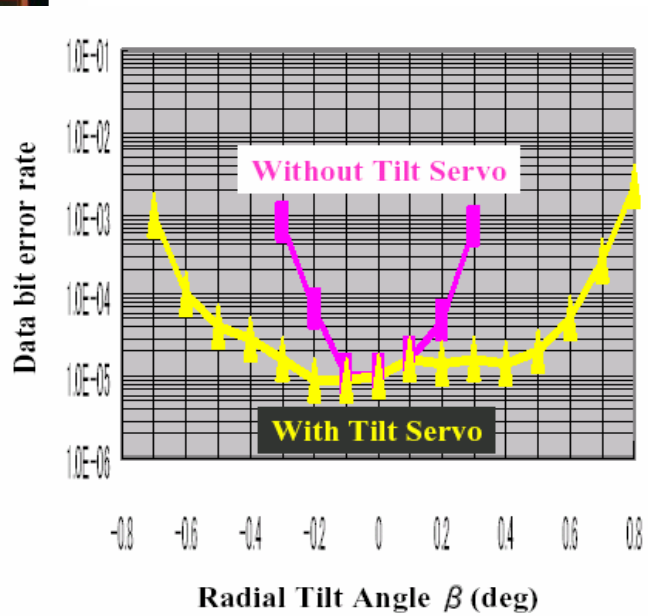
Refractive index	n_0		**1.58**	**1.62**	**1.62**
Numerical aperture	NA		**0.6**	**0.85**	**0.65**
Cover thickness	d_0	(μm)	**600**	**100**	**600**
Depth of focus	d_f	(μm)	**0.370**	**0.097**	**0.187**

Radial tilt margin improvement

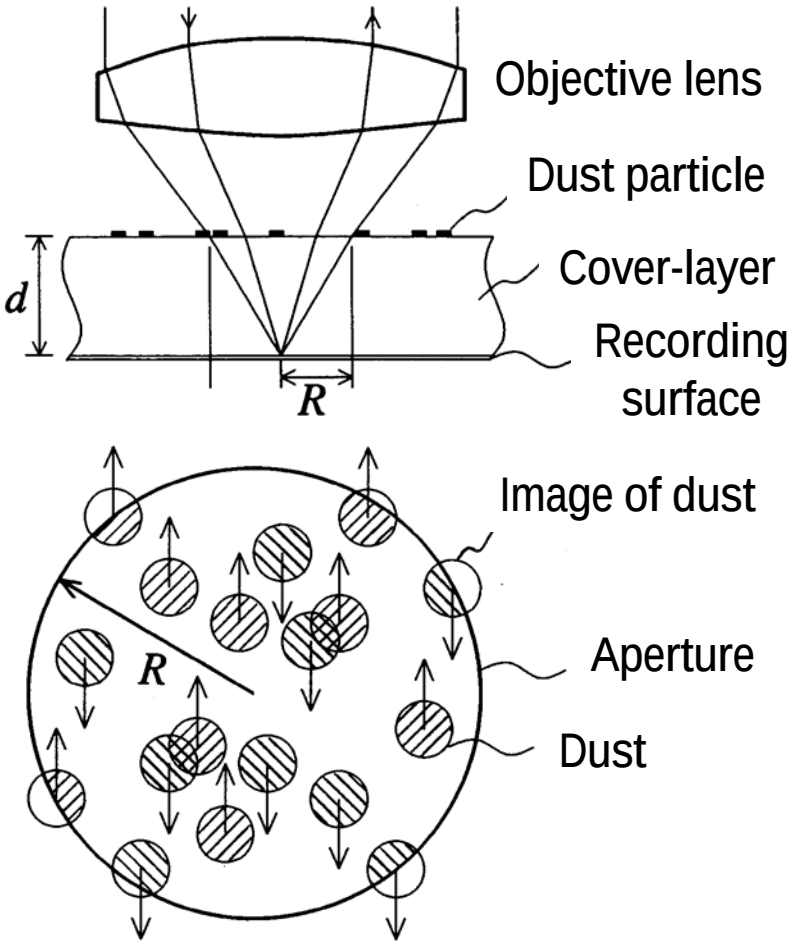




Experimental results of radial tilt servo for ROM disc

Dust noise

Model

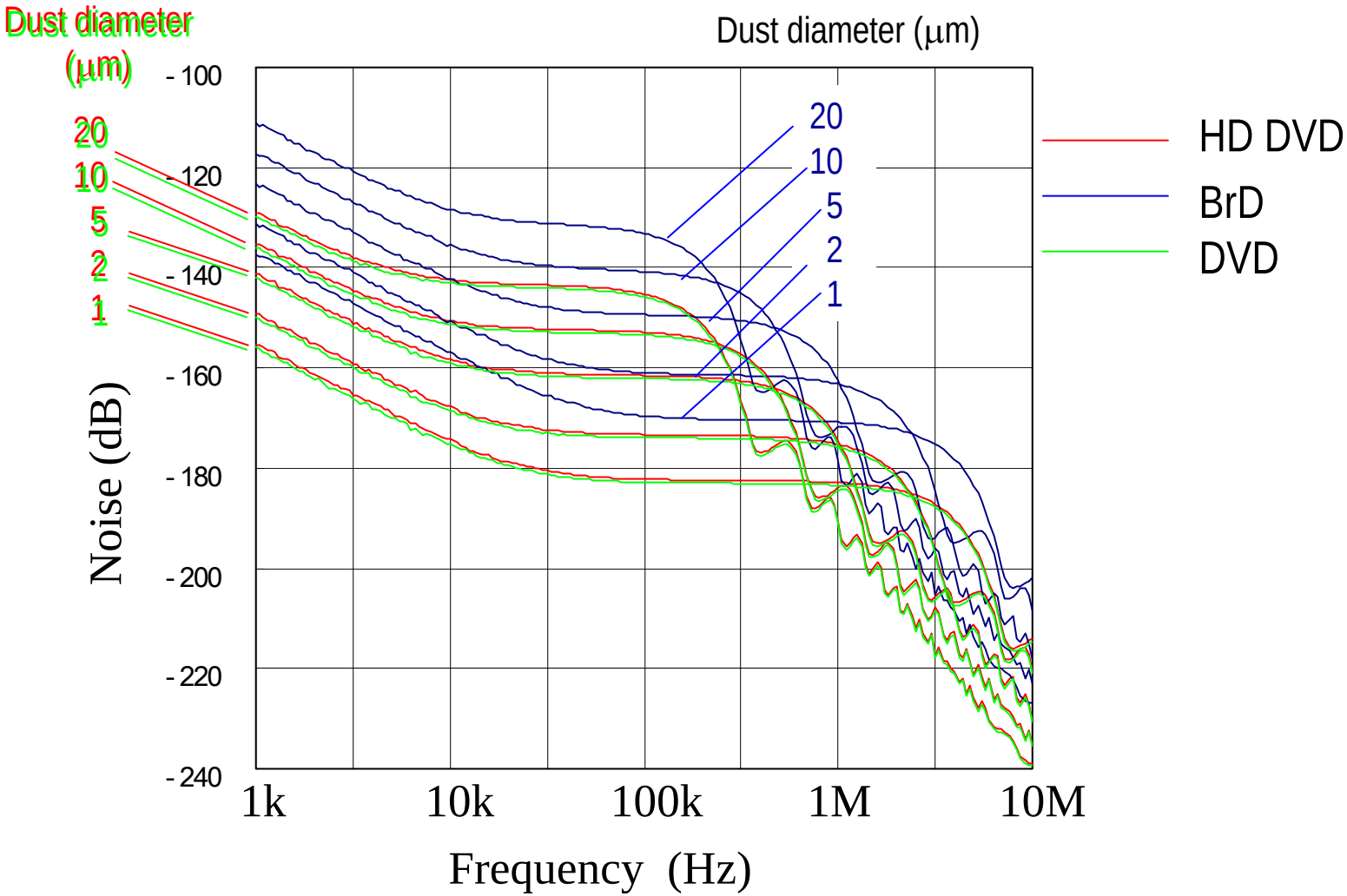


Conditions of dust-noise simulation

Scanning velocity	v	**(m/s)**	**3.49**
Areal density of dust	D_a		**0.02**
Res. Band Width	RBW	**(kHz)**	**1.0**
Dust diameter	d_0	**(μm)**	**1 ~ 20**

Dust noise

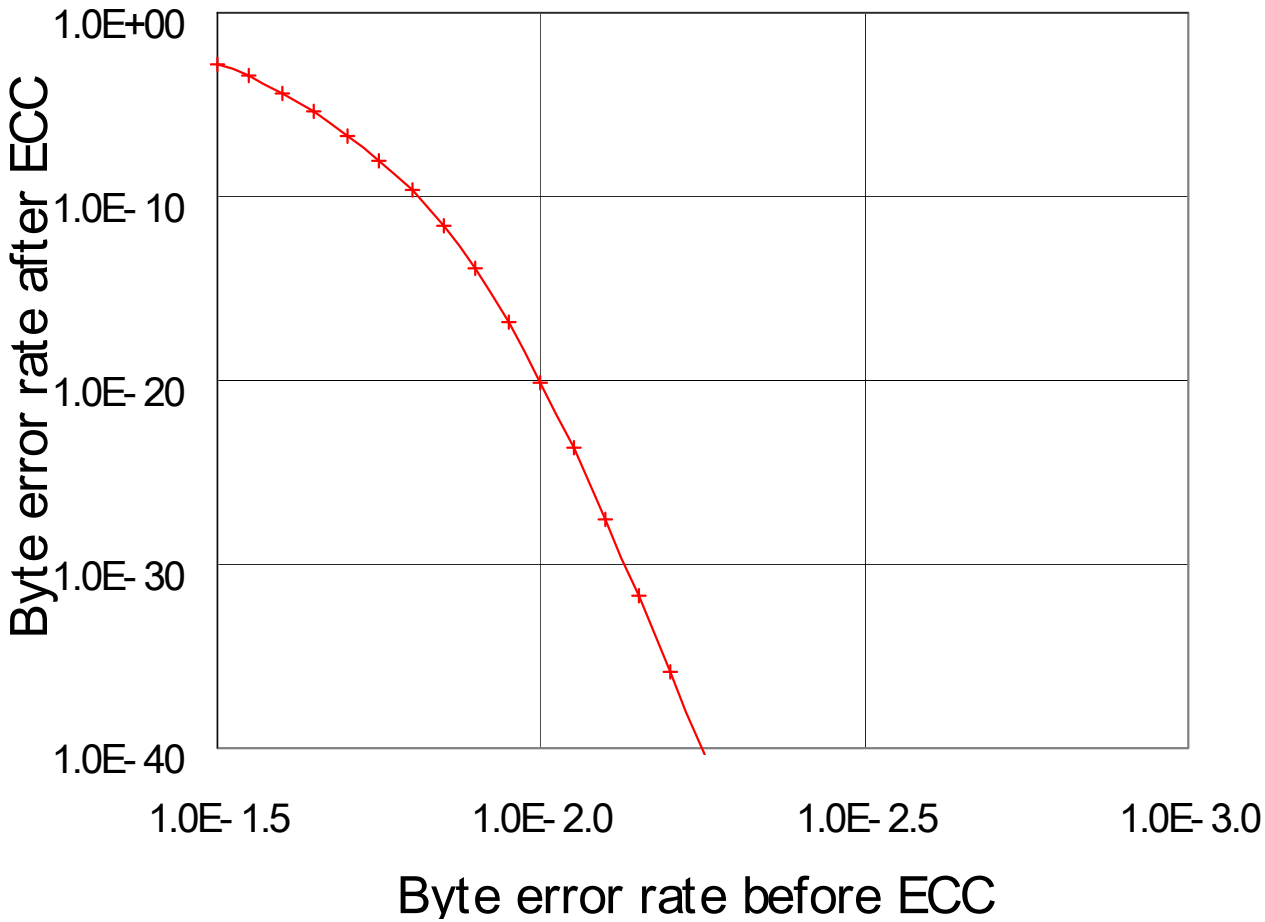
Result



Error Correction Code

- **Data Sector : 2064 bytes**
  = 4 ID + 2 IED + 6 RSV
  + 2048 Data + 4 EDC
- **ECC Block : 32 Data sector**
  = 2 RS Product Code
- **Inner code : RS(182, 172, 11)**
- **Outer code : RS(208, 192, 17)**
- **Row Interleave : Every 12 rows**
- **Correctable : 4.6mm for 30Gbytes disk**
  burst error length 7.0mm for 15Gbytes disk
- **Buffer memory : 160KB**

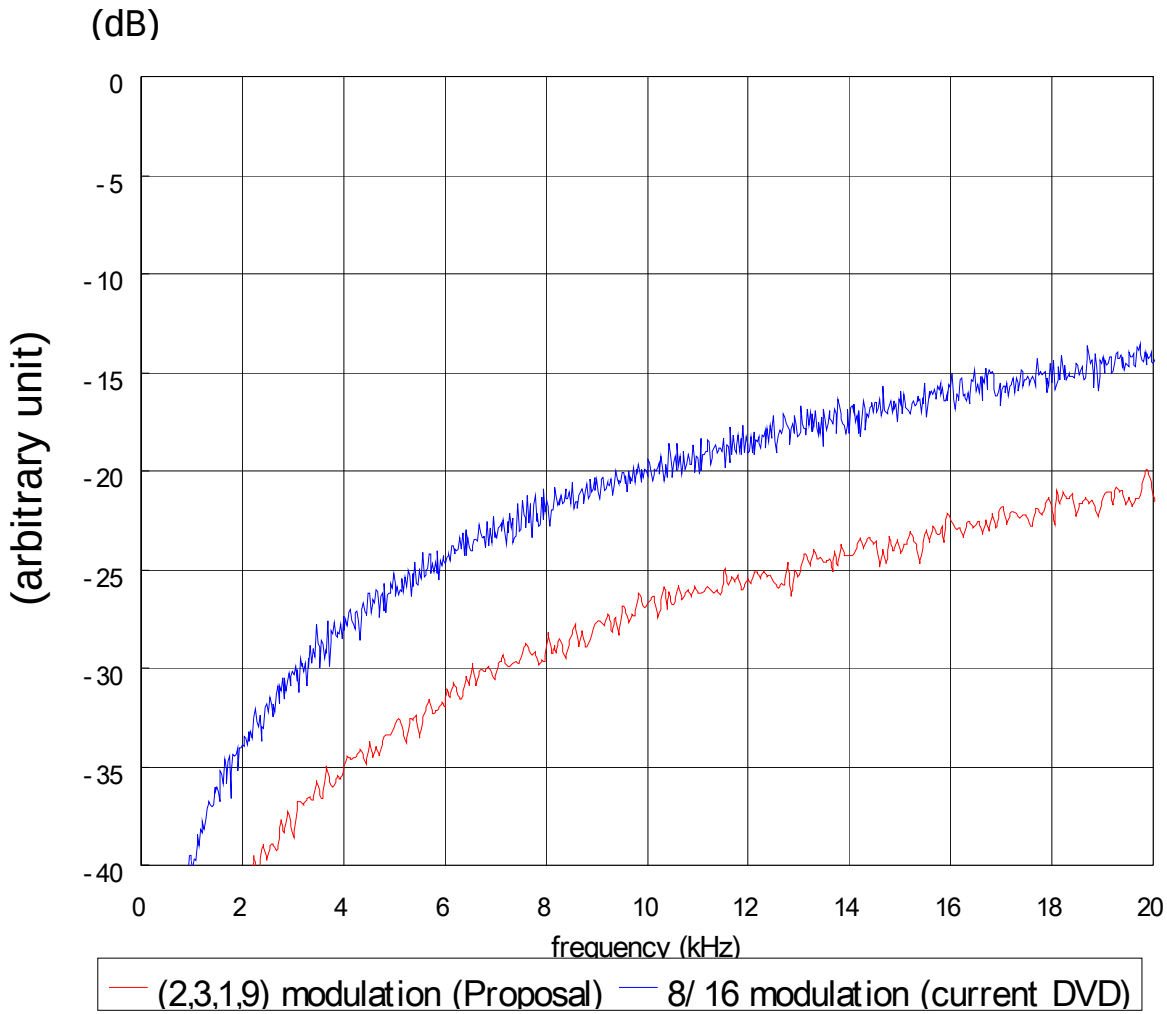
Random error correction capability



Modulation method

	(2,3,1,9) modulation
Conversion rate	2 : 3
Minimum runlength	2T
Maximum runlength	10T
DC component suppression control	possible
Additional DC control bit	0%
PRML signal processing	suitable

Comparison of spectrum

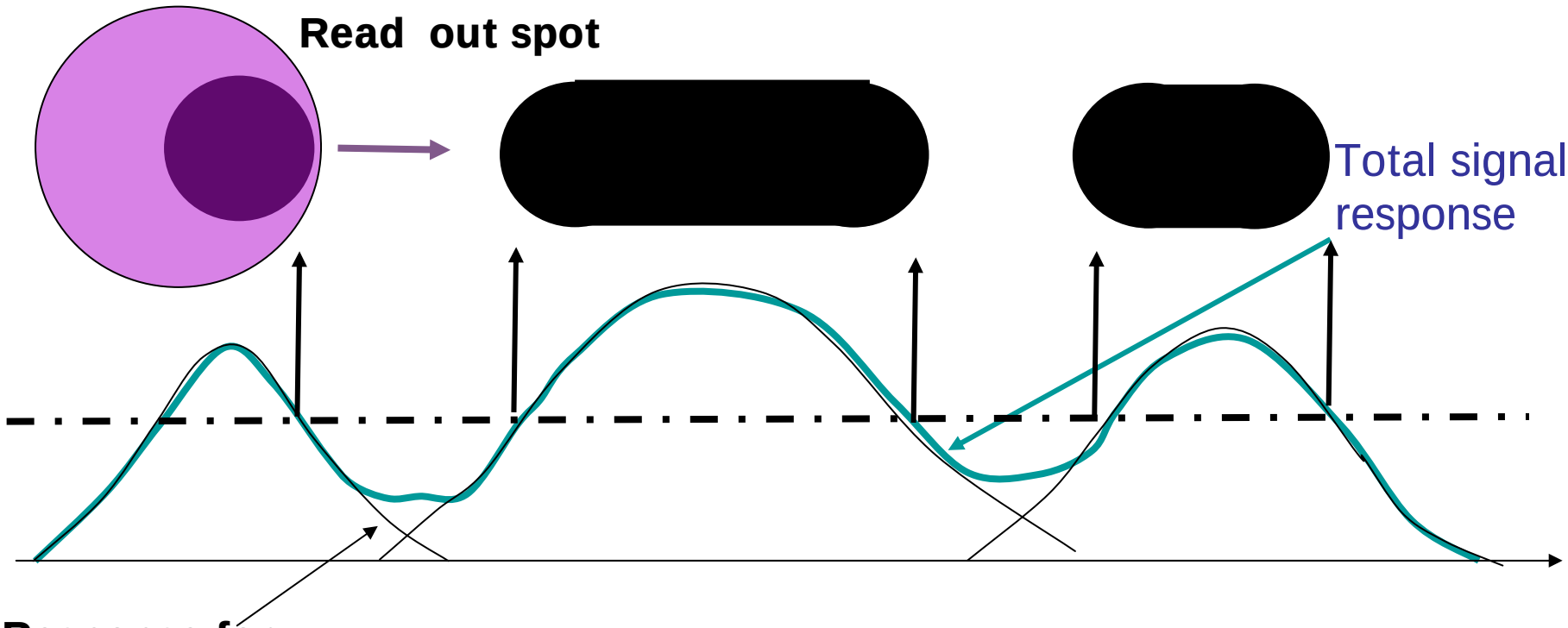


Channel clock
Proposal : 64.8MHz
Current DVD : 22.16MHz

PRML

- **Can provide about 20% more capacity than slice method**
- **SbER, PRSNR were introduced to measure disc characteristics without measuring actual bit error for volume production line**
- **SbER, PRSNR is rather analog parameter to estimate actual error rate**

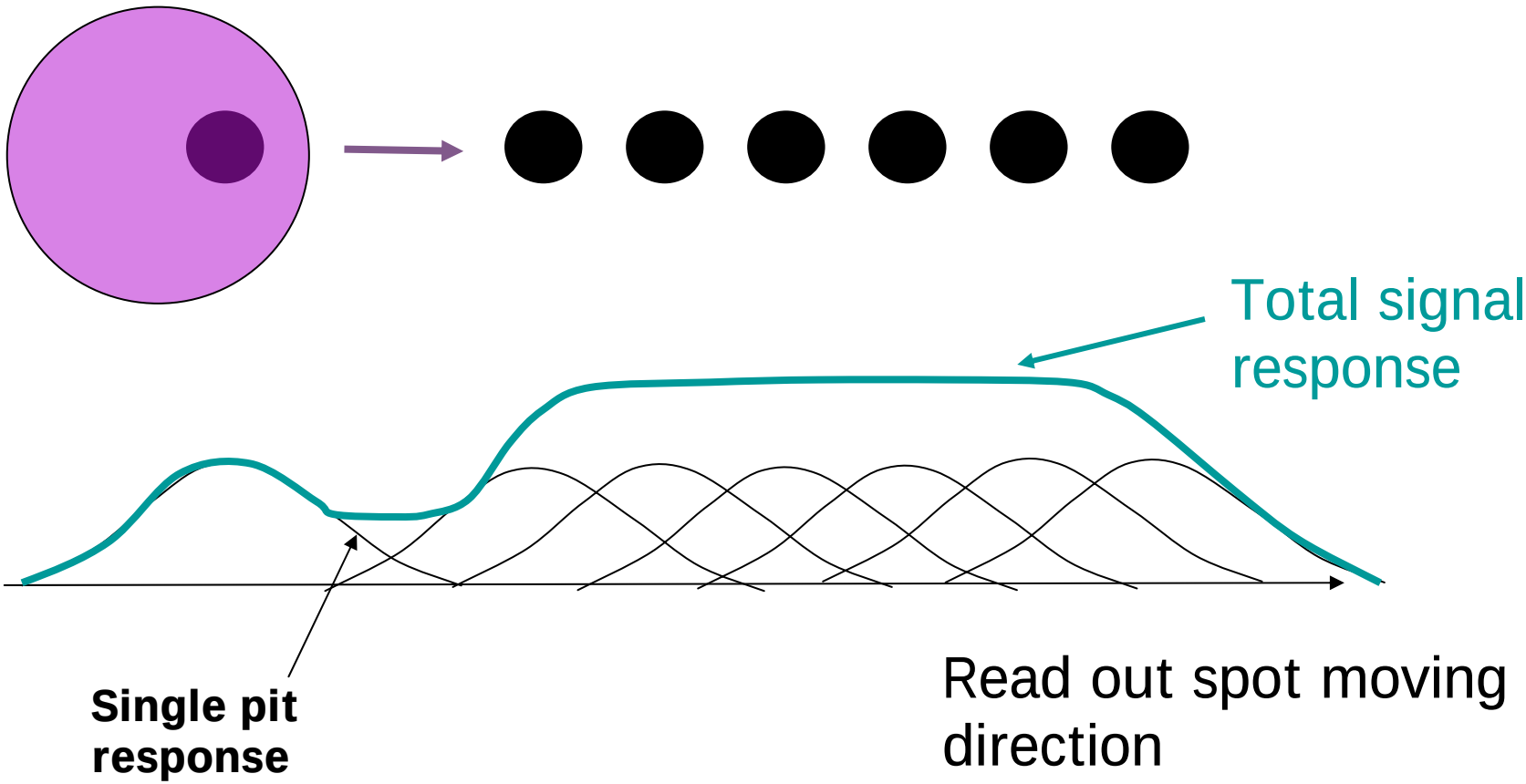
Binary data recording with Slice method



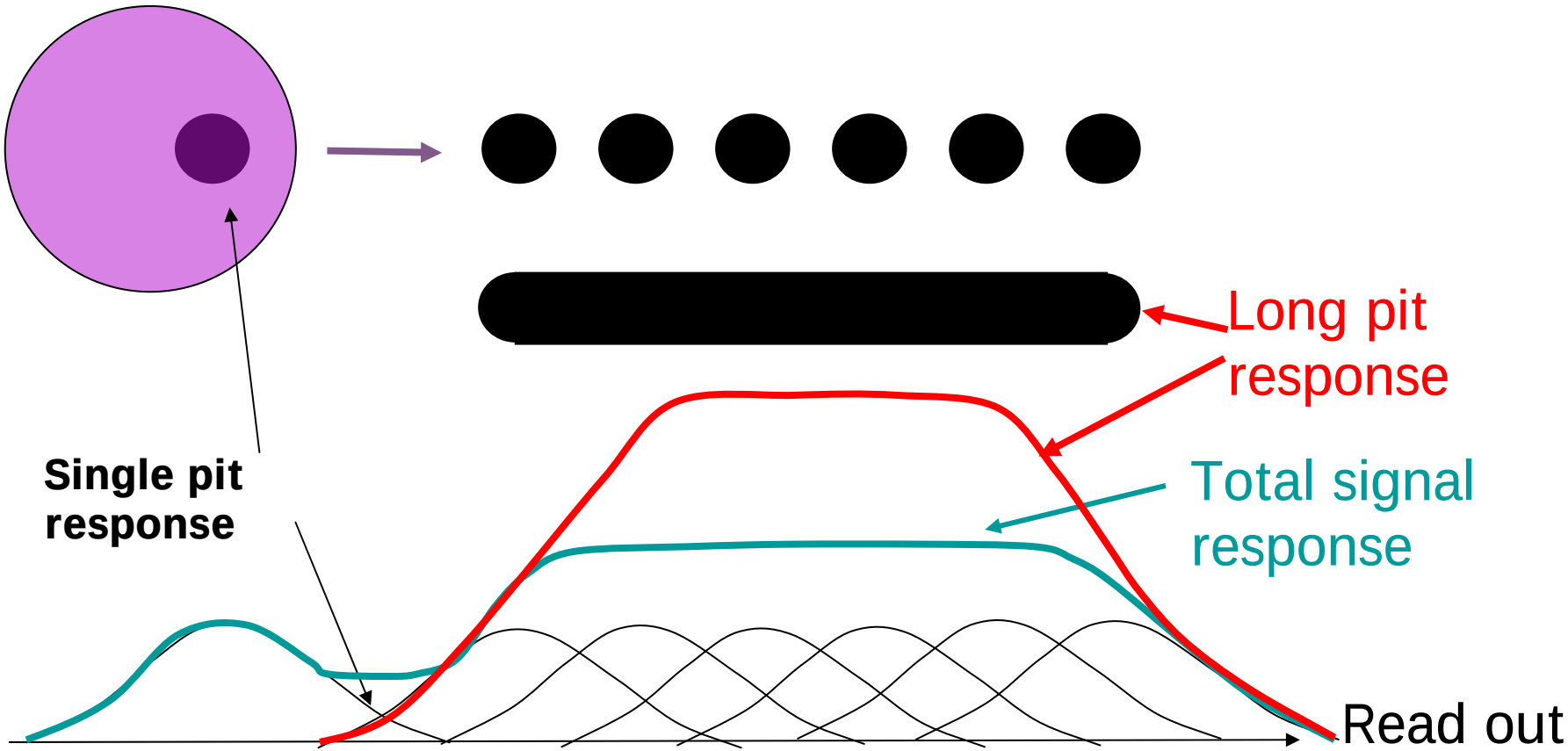
合成信号がスライスレベルを横切るときに、前の信号の影響は無くなっており、ピットのエッジが正確に検出可能

PRML（Partial Response Maximally Likelihood)

- Multi-level recording : Assuming interaction between symbols, and estimates the most likelihood signal trajectory . Pit more than limit of OTF can be read



PRML（Partial Response Maximally Likelihood)



From the difference of trajectory the actual series of pits can be estimated

Concepts of ROM/Rewritable/R

- Compatibility between ROM and rewritable disc
- Random writing
- Easy reading of physical address
- Defect management
- -R is same as ROM

Merit of Land & Groove format

Wide groove pitch

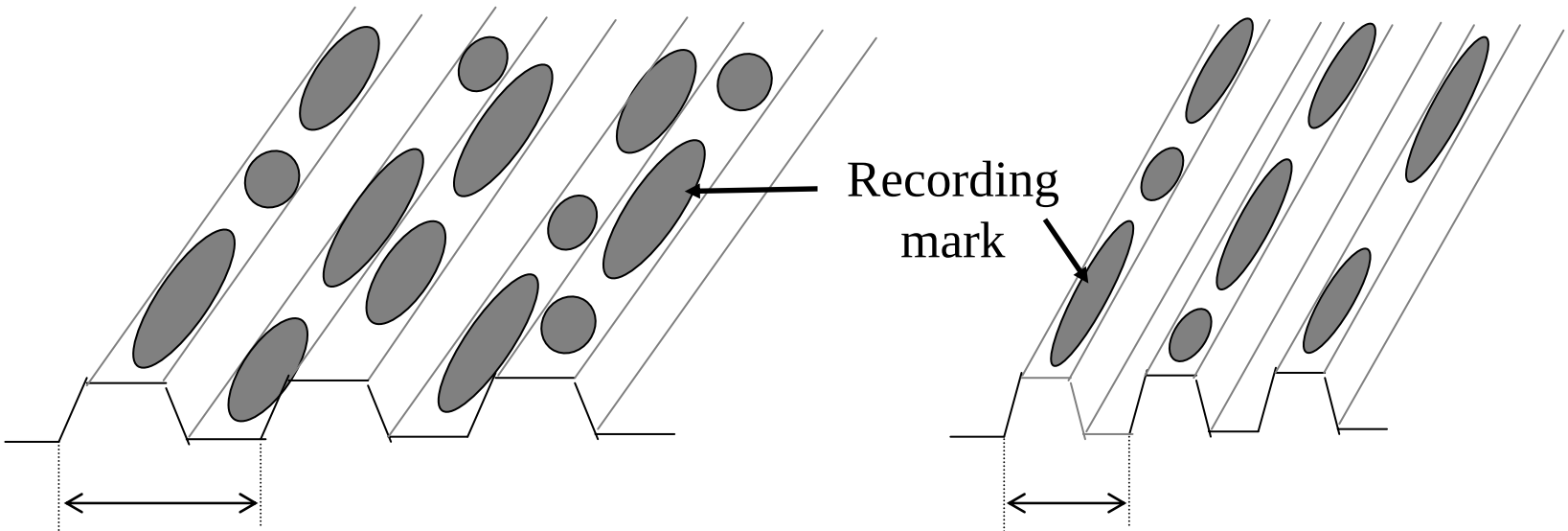
Narrow groove pitch

Easy to make a disc

Large tracking signal

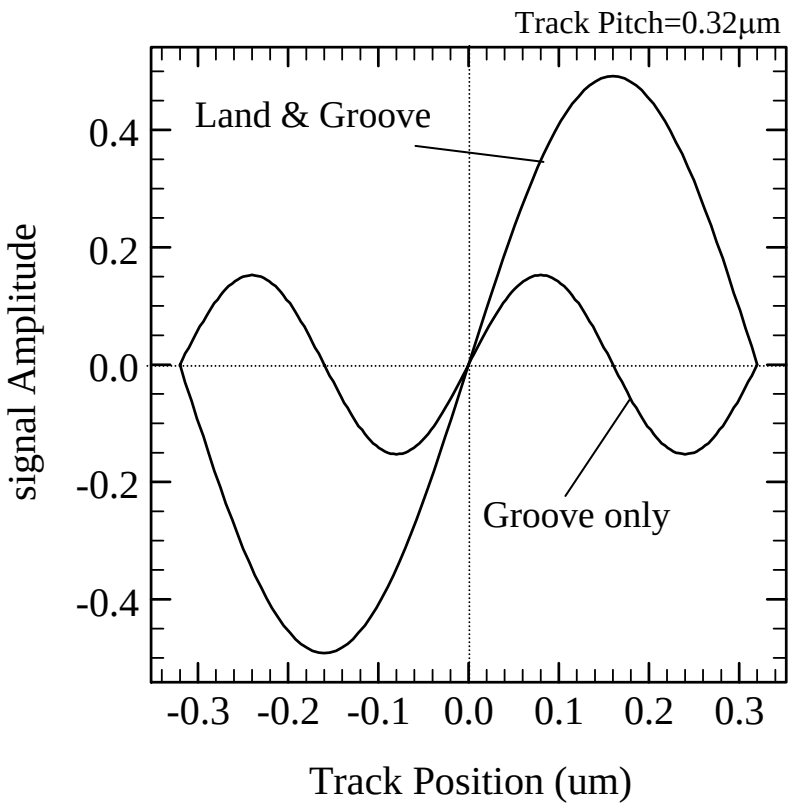
Land & Groove recording

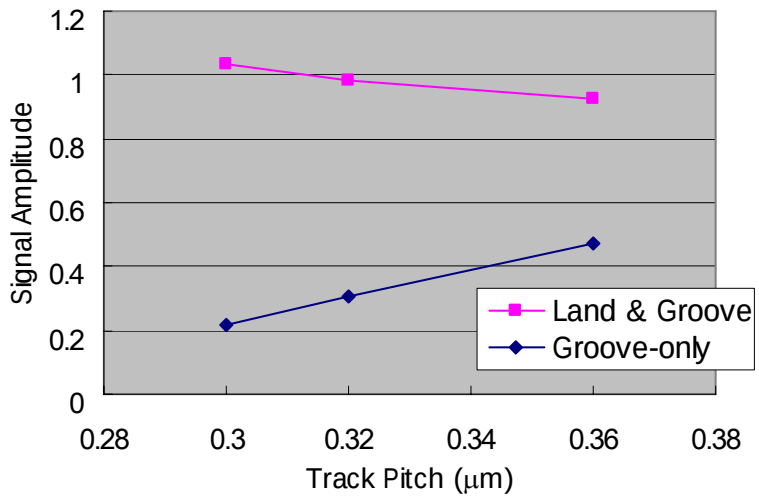
Groove recording



Tracking error signal amplitude

Land & Groove Format Brings Large Tracking Error Signal





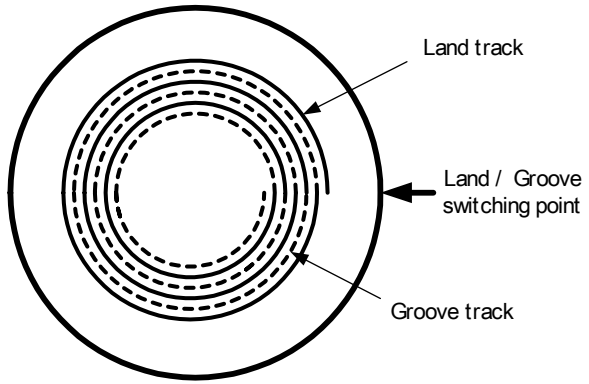
Signal Amplitude: Normalized by total reflectivity at mirror surface

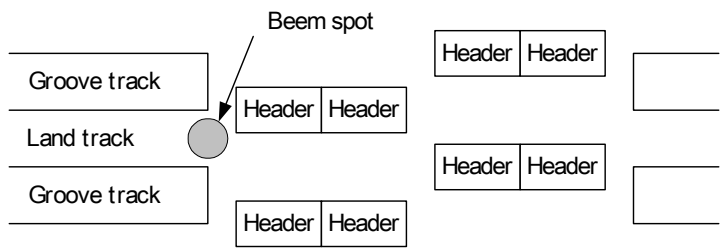
Advantages of current DVD

- **DVD-RAM**
  - **Random access by block writing**
  - **High track density by land and groove format**
  - **Defect management on physical layer**
- **DVD-RW**
  - **Almost same readout data signal as DVD-ROM by wobble and Land Pre-Pit(LPP)**
  - **Continuous groove**

Current DVD-RAM

- **Single spiral track**
  - **Tracking polarity should be switching every one revolution. Makes drive design difficult**
- **CAPA**
  - **Header is not set at the center of beam spot-difficult to make Pick up**

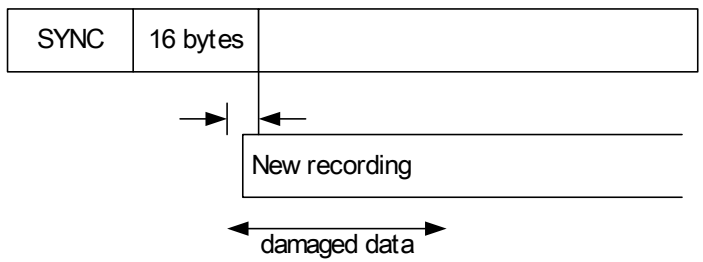




Current DVD-RW

- **Loss less linking makes error bits.**

  Because some connection data are damaged by loss less linking, because there is not buffer area.

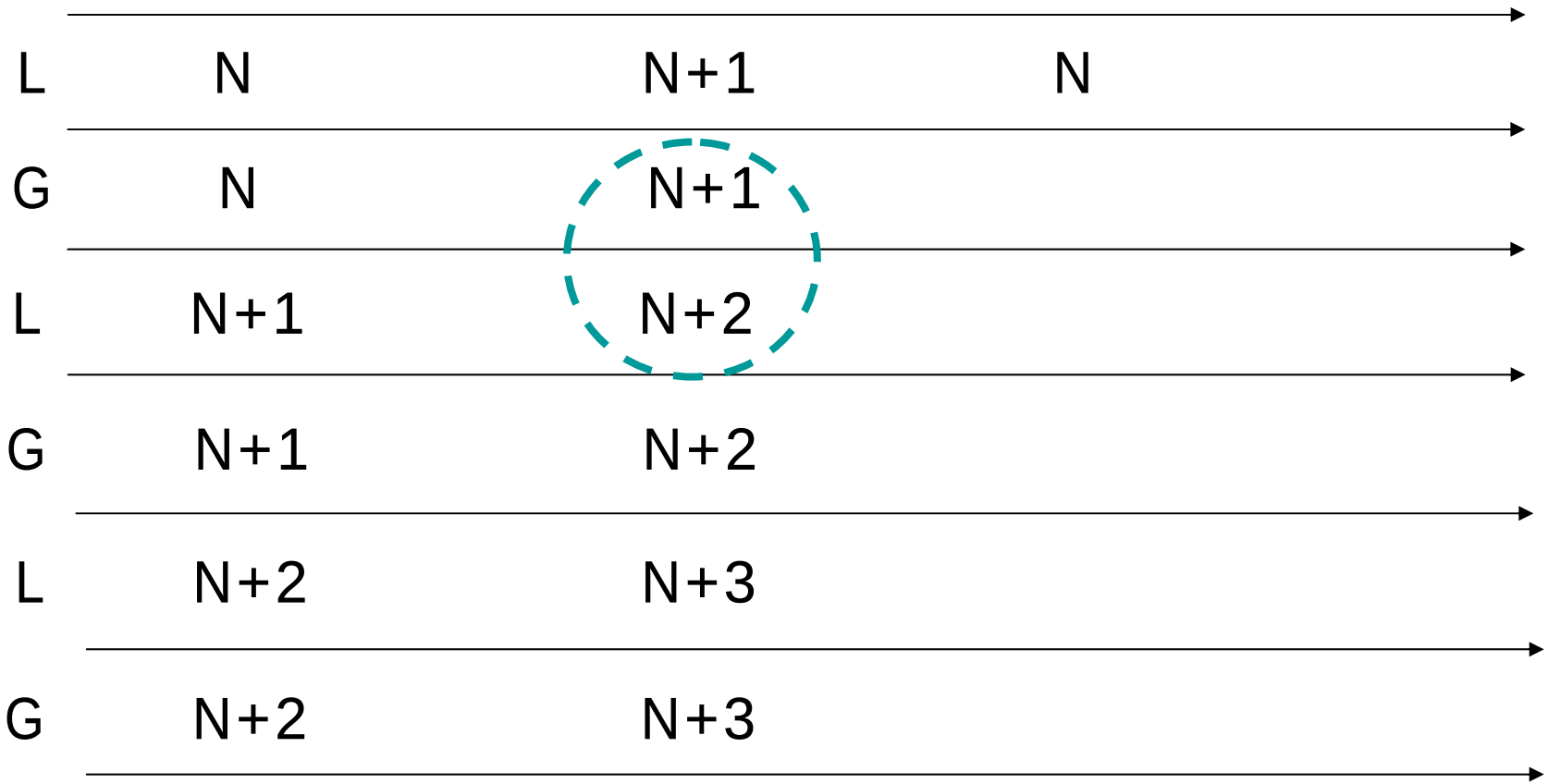


- **Land Pre-Pit (LPP)**
  - **LPP reading is difficult because it is not set at the center of beam spot.**

Compatibility between ROM and ReWritable disc

- **Wobble address scheme realizes same ROM data format as ReWritable.**
- **New wobble address allows to read both land track and groove track address even Land & Groove format is used.**
- **Simple mastering by 1beam mastering machine is achieved**

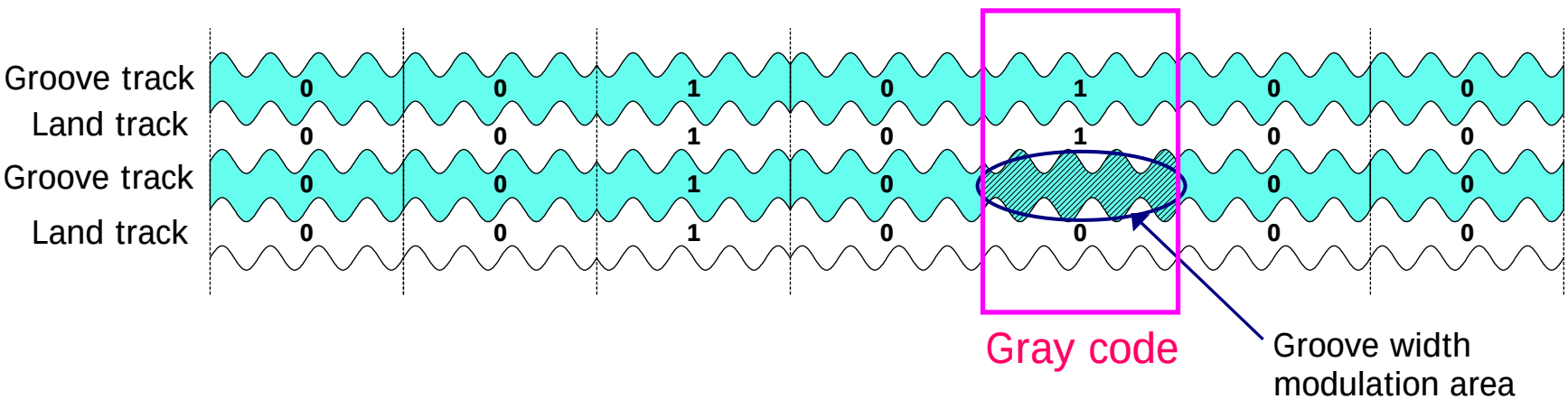
Gray code and L & G format



Wobble address

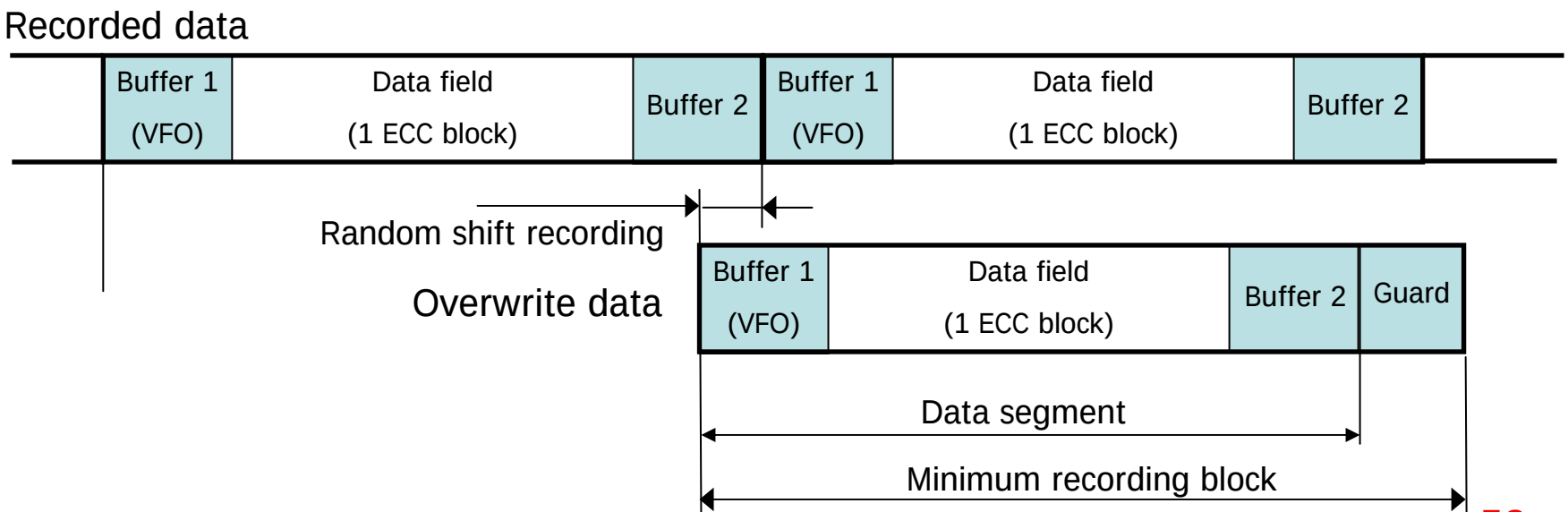
- **Groove width modulation gives address signals for land track.**
- **Gray codes are adopted for address data.**

Only 1 bit of track address data is different from adjacent track address data.



Random writing

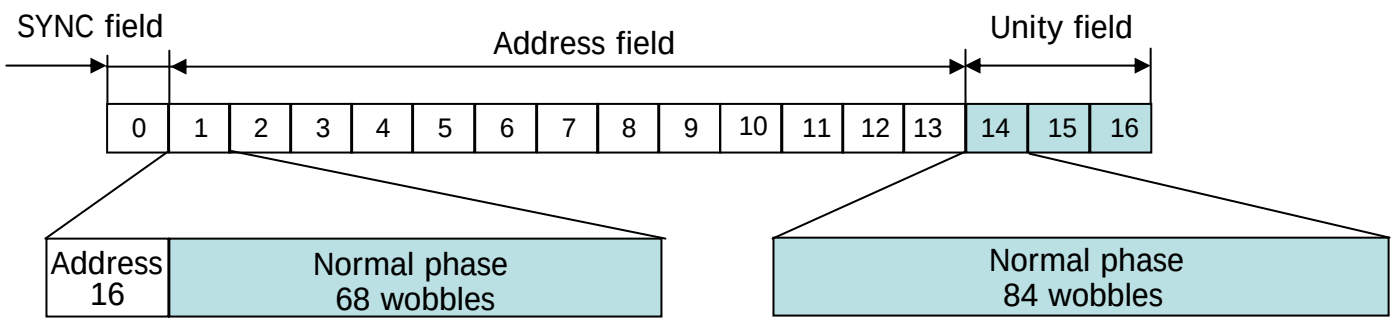
- **Recording block consists of one ECC block, and the recording block has buffer area for linking. Therefore, loss less linking is available without error.**
- **Start point of the recording data is shifted randomly within 168 channel bits for increasing over write cycle.**



Easy physical address reading

- **Wobble address signal uses phase modulation.**

  And 84 % of wobbles is fixed phase.
  Therefore, wobble PLL ca be locked easily.

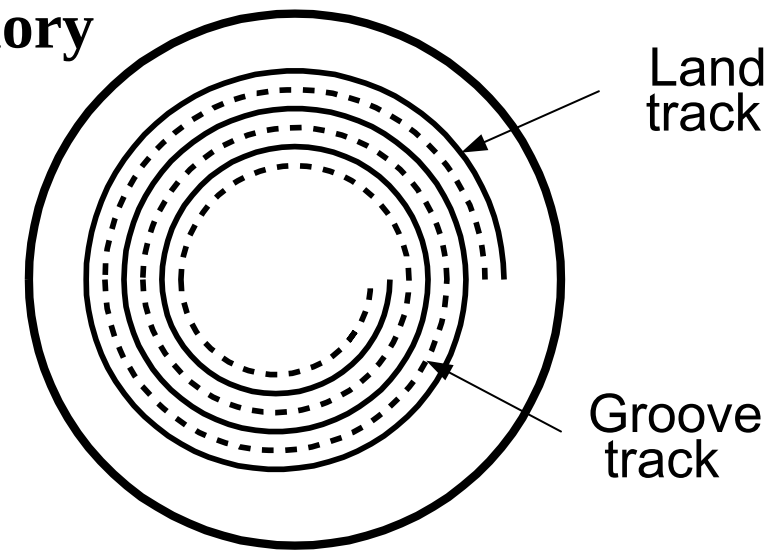


Defect Management

- **Defect management tables are located at Lead-in area and Lead-out area.**
- **Defect management will be made by drive**

Land and Groove format

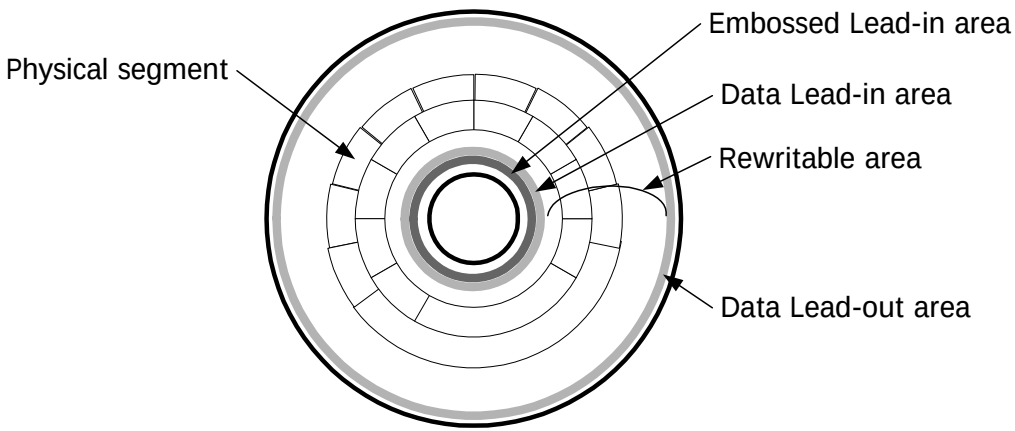
- **Land and Groove track structure**
- **Double spiral track**
  - **Continuous groove track**
  - **Continuous land track**
  - **Transition from Land to Groove will not require additional memory**
  - **No track switching during a recording**



Zoned CLV format

- **Zoned CLV in rewritable data area**
  - **The number of zone in the Data area is 19.**
- **CLV in embossed data area**
- **Low density embossed pits in Lead-in area**
  - **Common for ROM and rewritable disc**

Zone number	Number of segment per track
0	13
1	14
. . .	. . .
18	31



Conclusion

System allowances are theoretically studied and are summarized bellow

			(DVD)	(BrD)	(HD DVD)
Wavelength	λ	(μm)	**0.65**	**0.405**	**0.405**
Refractive index	n_0		**1.58**	**1.62**	**1.62**
Numerical aperture	*NA*		**0.6**	**0.85**	**0.65**
Cover thickness	d_0	(μm)	**600**	**100**	**600**
Thickness margin	d_m	(μm)	**30**	**2.9**	**12.7**
Tilt margin	θ_m	(mrad)	**6.9**	**6.4**	**3.2**
Depth of focus	d_f	(μm)	**0.370**	**0.097**	**0.187**
Dust noise	*N*	(dB)	N_0	N_0+10 ~ 20	$\fallingdotseq N_0$

DVD Forum

- **Steering Committee on June 9-10**
  - **MPEG2, MPEG4 AVC(H.264) and VC-9 were approved as mandatory CODEC for Video**
  - **HD DVD-ROM Ver. 1.0 was approved**
- **WG-11/TG11-1**
  - **HD DVD-R round robin test has been made and will be finished in August , 7companies submitted good sample discs**
  - **Draft specification for Ver.0.9 was distributed**
  - **HD DVD-R specification Ver. 0.9 ,**
    - **RRT(16companies participated) is finished**
    - **To be approved at Sept. Steering Committee**

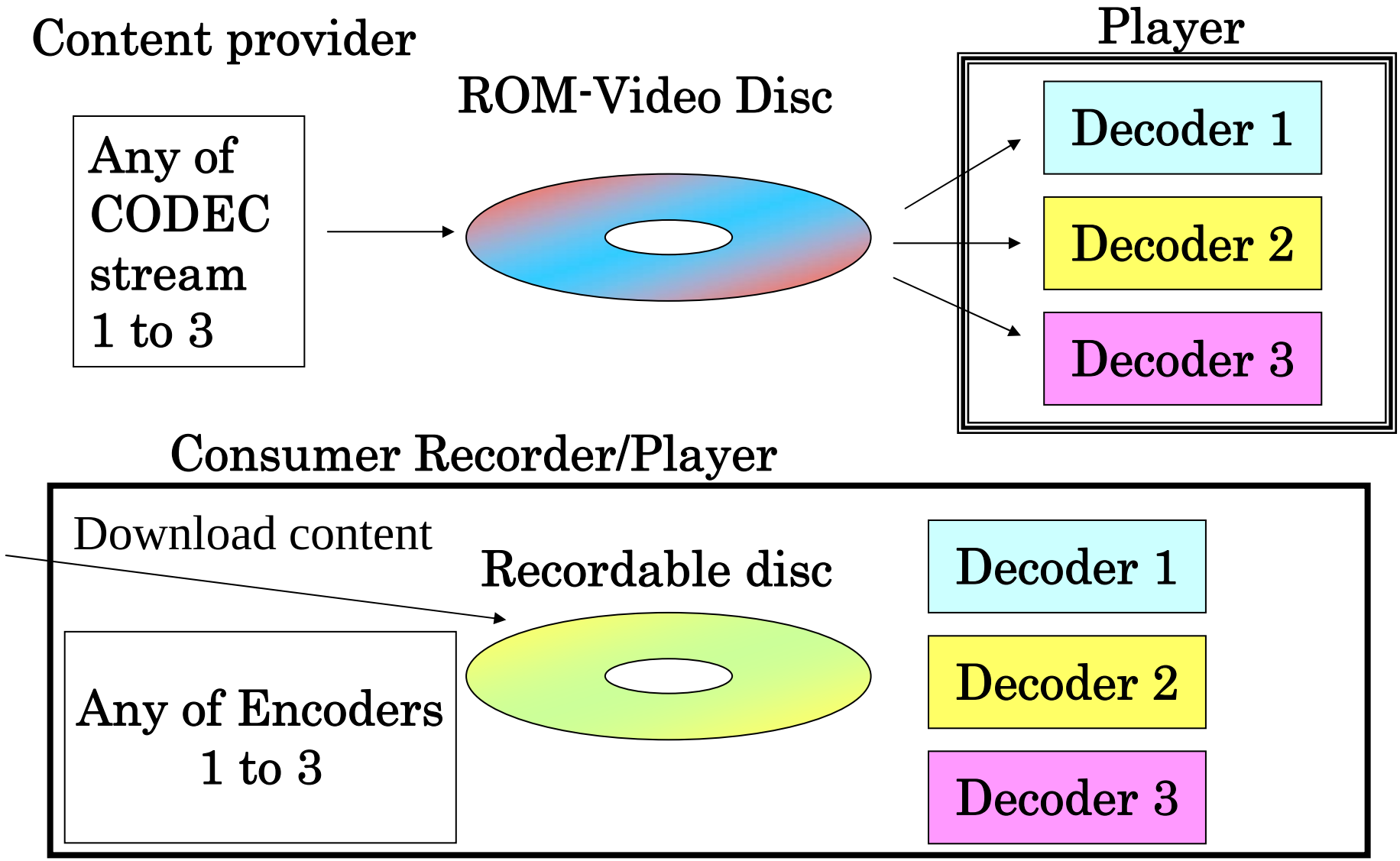
WG-11 members (79 companies as of March 24, 2004)

Almedio Inc.
ALPINE Corporation
AMC CO., LTD
ASAHI KASEI MICROSYSTEMS CO., LTD.
AudioDev AB
Cheertek Inc.
Ciba Specialty Chemicals Holding Inc.
Cinram Manufacturing Inc.
CMC Magnetics Corporation
Columbia Music Entertainment, Inc.
CREST NATIONAL
DCA Inc.
Deluxe Media Services, Inc.
DiskWare CO.,LTD.
Digital Theater Systems, Inc.
Dolby Laboratories Inc.
Eclipse Data Technologies
FUJI PHOTOFILM CO., LTD.
Funai Electric Co., Ltd.
Hitachi, Ltd.
IBM Corporation
Industrial Technology Research Institute (ITRI) (V-chair)
INFODISC TECHNOLOGY CO., LTD.
Interaxia AG
KENWOOD CORPORATION
Leader Electronics Corp.
LG Electronics Inc.
LITEON IT Corp.
LSI Logic Corporation
MediaTek Inc.
MEMORY-TECH CORPORATION
Meridian Audio Limited
Microsoft Corporation
MIPS Technologies
Mitsubishi Chemical Corporation
Mitsubishi Electric Corporation
MITSUI CHEMICALS, INC.
Moser Baer India Limited
NEC Corporation (Chair company)
Optodisc Technology Corporation
PIONEER CORPORATION
Pixonics, Inc.
Prodisc Technology Inc.
PULSTEC INDUSTRIAL CO., LTD.
RICOH COMPANY, LTD.
RITEK CORPORATION
ROXIO, Inc.
SAMSUNG ELECTRONICS CO., LTD.
SANYO Electric Co., Ltd (V-chair)
Scientific Atlanta Inc.
Seiko Epson Corporation
SHARP CORPORATION
Shibasoku Co., Ltd.
Shinano Kenshi Co., Ltd.
Sigma Designs, Inc.
SINGULUS TECHNOLOGIES AG
SKC Limited.
Sonic Solutions
STMicroelectronics K.K.
Sunext Technology Co., Ltd.
TAIYO YUDEN CO., LTD
TDK Corporation
TEAC CORPORATION
Texas Instruments Japan Limited
Thomson
Time Warner (V-chair, Ex-chair)
TOPTICA Photonics AG
Toshiba Corporation (V-chair, Ex-chair)
Twentieth Century Fox Film Corporation
Unaxis Balzers Ltd.
Victor Company of Japan, Limited
Walt Disney Pictures & Television
YAMAHA CORPORATION
Yokogawa Electric Corporation
Zoran Corporation

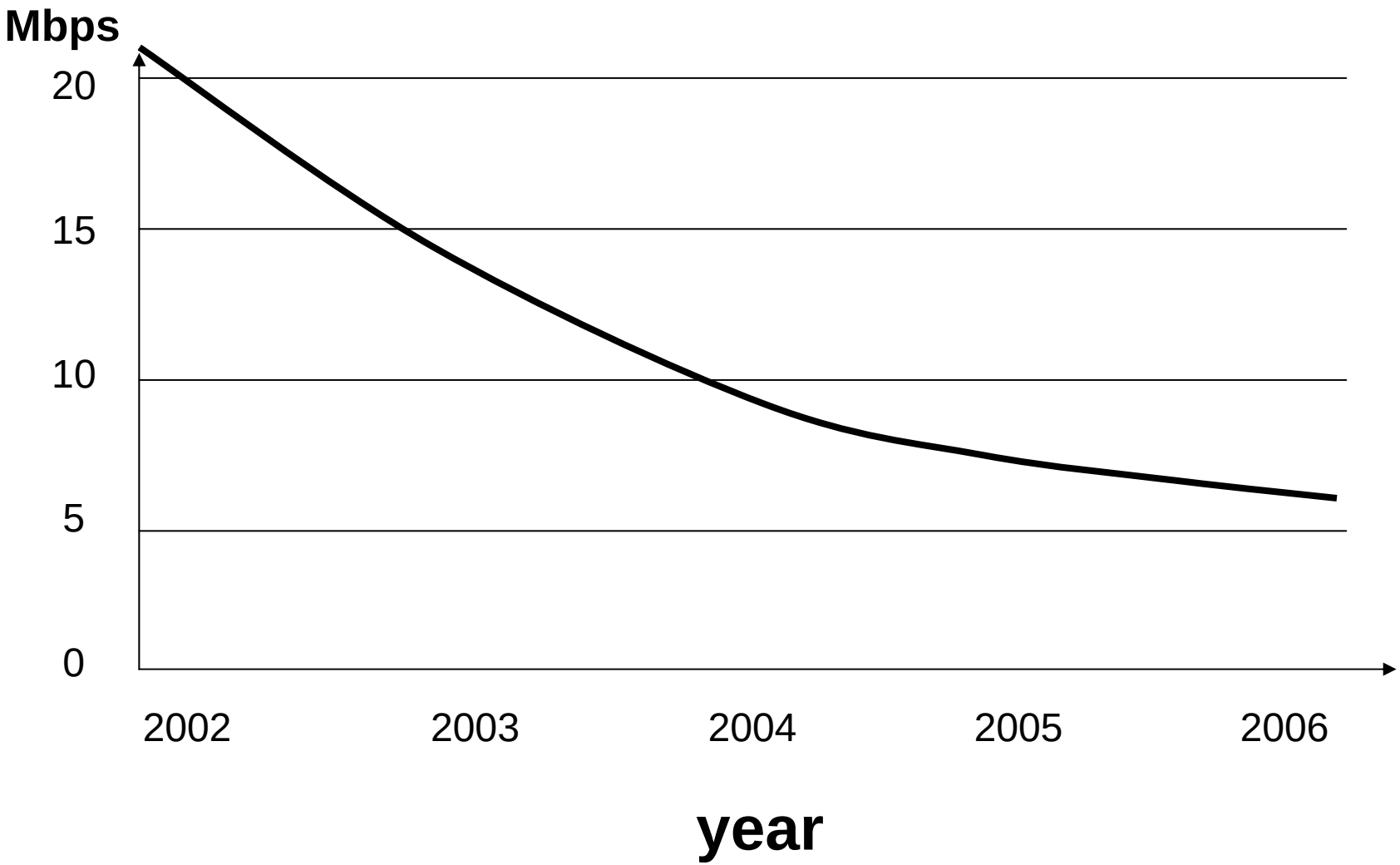
Video application

- New advanced and efficient CODECs
  - MPEG4 AVC/ VC-1/ MPEG2
- New interactive features
  - Combination with web content
  - Improved graphic
- Internet capability
  - Access content provider web site
  - New application

Multi-CODEC

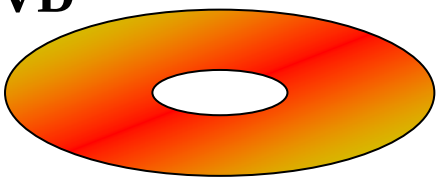

Content provider
Any of CODEC stream 1 to 3
ROM-Video Disc
Player
Decoder 1
Decoder 2
Decoder 3
Consumer Recorder/Player
Download content
Recordable disc
Any of Encoders 1 to 3
Decoder 1
Decoder 2
Decoder 3

Bit rate reduction for High Definition content



Example

8.5GB red laser DVD



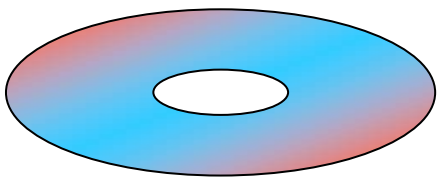
90min HD content @ 8Mbps = 5.45GB

90min SD content @1Mbps =0.7GB

90min 3language × 2sets =1.4GB

} 7.55GB

15GB blue laser DVD



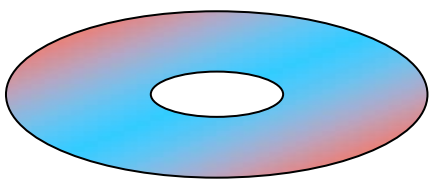
132min HD content @12Mbps = 12GB

132min SD content @1Mbps =1GB

132min 3 language tracks × 2sets =2GB

} 15GB

30GB blue laser DVD



132min HD content @ 12Mbps = 12GB

132min SD content @1Mbps =1GB

132min LPCM 48ksample 20bit 5.1ch = 4.56GB ➡ 3GB*

×3language=9GB * If lossless coding is applied

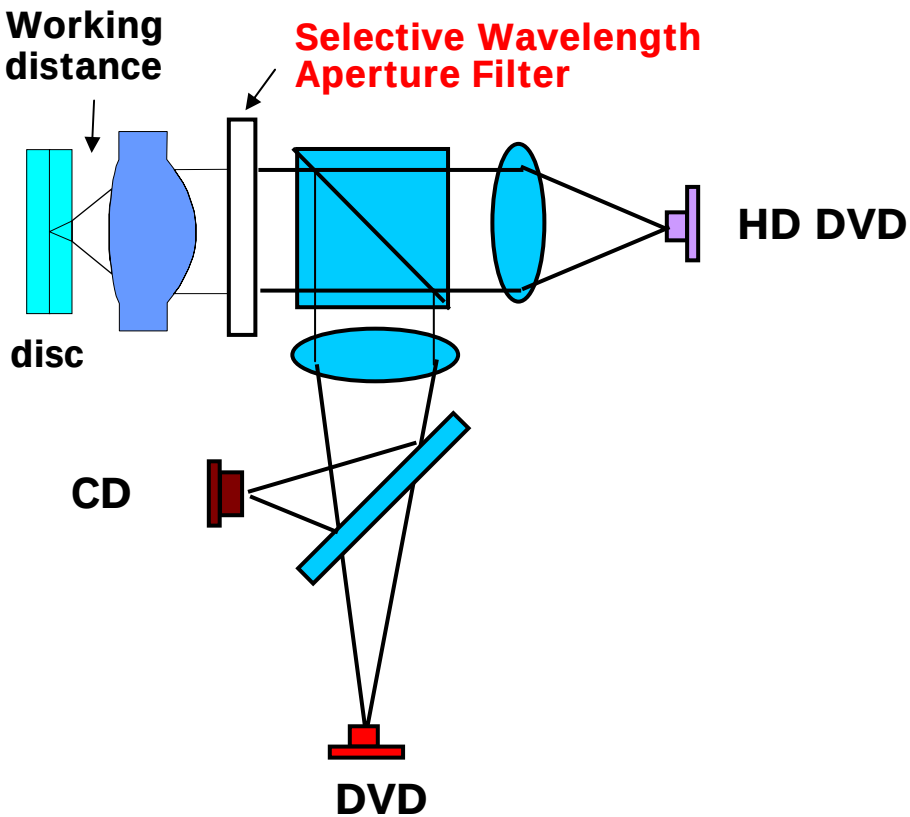
} 22GB*

Copy protection

- **AACS (Advanced Access Content System) was announced to the public at CPTWG on July 14th.**
  - **Founders(8company) : Disney, IBM, Intel, Matsushita, Microsoft, Time Warner, Toshiba, Sony**
    - **AES 128 bit encryption**
    - **Tree based Media Key Block to make precise key revocation**
    - **Enhanced Drive Authentication –Device key for drive**
    - **Network connectivity**
    - **Disc manufacturer ID bound to key**
    - **Unlock content by internet**
- **New business opportunity for Content holders**
- **HD DVD will adopt this technology**
- **BD might adopt this technology**

Full Compatible Optical head

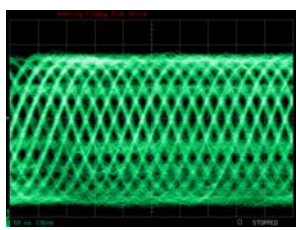
- The newly developed optical head can drive CD, DVD and HD DVD discs with single objective lens.
- More economical than dual-lens head or dual optical heads



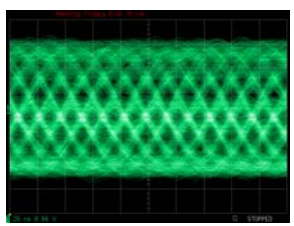
3 Laser diodes System

	CD	DVD	HD DVD
Wave length	780nm	650nm	405nm
Lens NA	0.45	0.6	0.65
Substrate thickness	1.2mm	0.6mm	0.6mm
Working distance	1.5mm	1.7mm	1.7mm

Read out signal eye-pattern



DVD



HD DVD

Second generation DVD specification

		HD DVD	Blu-ray	DVD
Capacity (Single/Double)	ROM	15/30 GB	25/50?GB	4.7/8.5GB
	-R	15GB	? GB	4.7GB
	RAM/RW	20/32~ GB	25/50 GB	4.7GB
Laser wave length		405nm	405nm	650nm
Disc structure		0.6mm ×2	0.1mm cover +1.1mm sub.	0.6mm ×2
NA	Pick Up lens numerical aperture	0.65	0.85	0.6
Disc thickness error	Single layer Dual layer	55+-15μm 20+-5μm	100 ± 3μm	

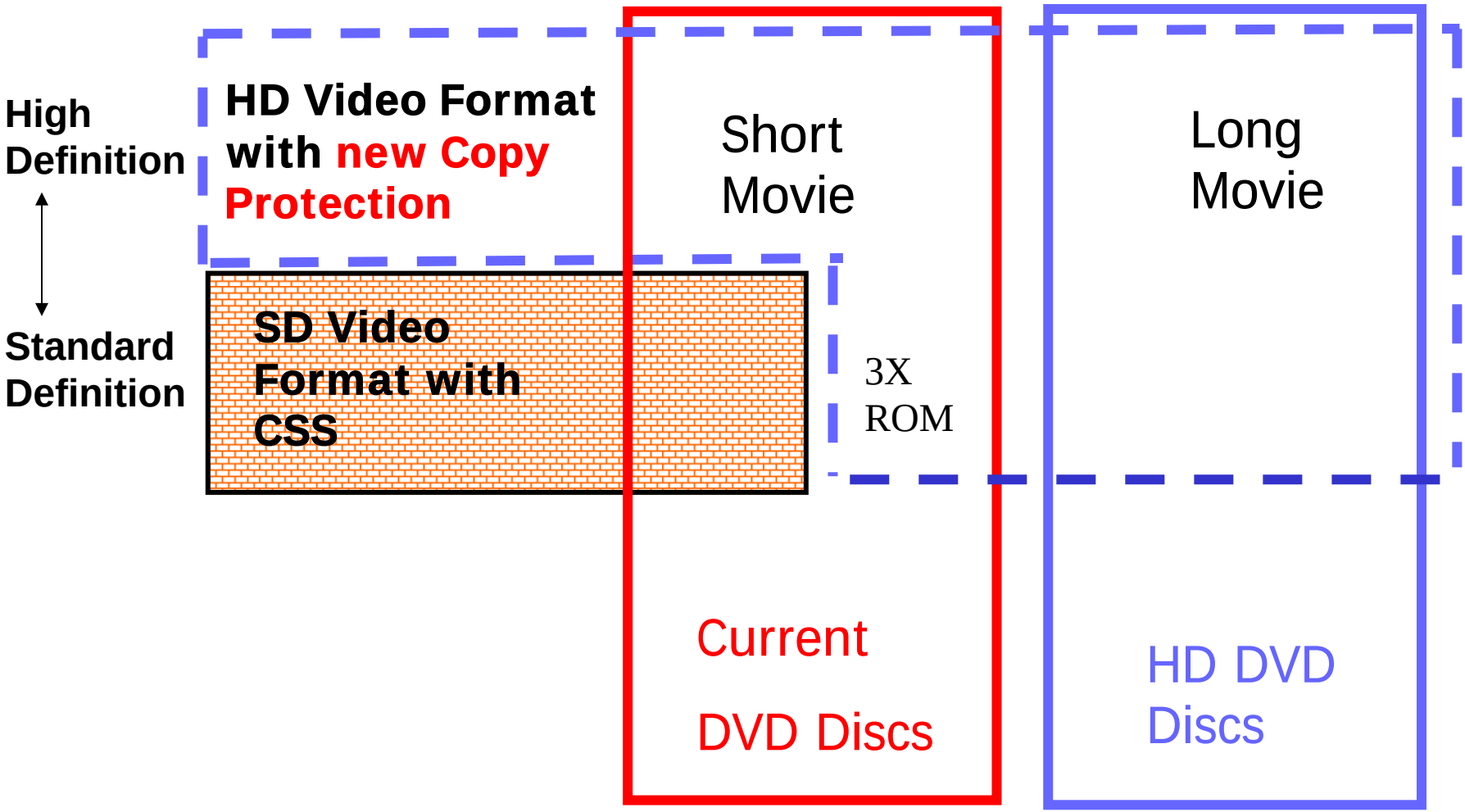
Disc spec summary

- **BrD has slightly more capacity than HD DVD**
- **Capacity difference is disappearing because of efficient CODEC**
- **Manufacturing cost is the key issue for ROM**
- **HD DVD-ROM manufacturing is already completed**
- **Refer the examples**

Second generation DVD specification Summary

- New copy protection will be applied
- The advanced efficient CODECs will be applied to Standard Definition content and High Definition content
- New CODECs will extend recording time 2-3times
- The new Video specification will be applied to both red laser DVD and Blue laser DVD
- Some advanced features like web connectivity will be introduced

Basic Concept of HD DVD Video



Bit rate calculation

Y2002: MPEG2 22M bps was adopted for DVHS and Japanese broadcasting by Constant bit rate

⇒6-12Mbps is enough to provide equivalent picture quality after 2years

⇒More bit rate reduction (30-50%) can be expected by Variable Bit Rate

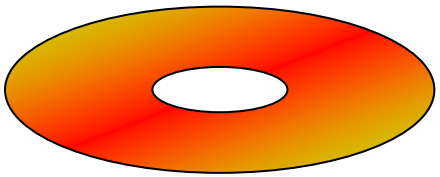
⇒15GB(HD DVD single layer) can provide enough playing time

8Mbps 132min movie: 8GB

LPCM 5.1ch, 48k s/s , 16bit : 4.6Mbps => 3Mbps (with lossless)

Example

8.5GB red laser DVD—SD long time 12hr

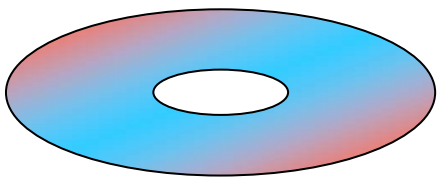


660min(10Hr) SD content @1Mbps =5.45GB

660min Audio: AC-3 @384kbps =2.09GB

} 7.54 GB

15GB blue laser DVD— SD long time 24hr

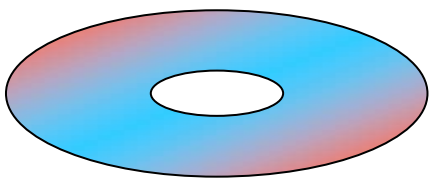


24hr SD content @ 1Mbps = 10.9GB

24hr Audio: 384kbps(AC-3) = 4.18GB

} 15.08GB

30GB blue laser DVD—SD long time 47hr

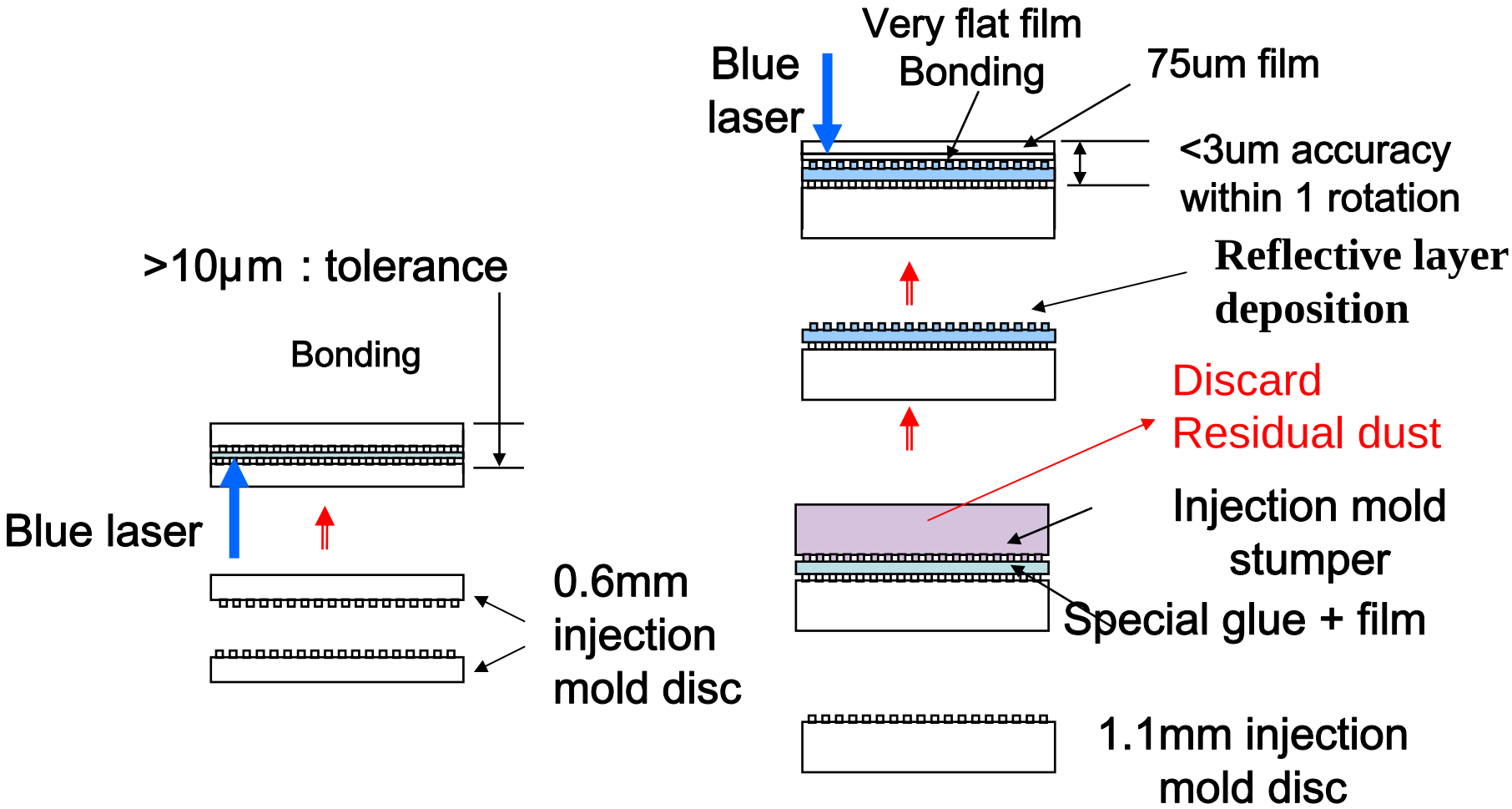


47hr SD content @1Mbps = 21.36GB

47hr Audio @384kbps=8.2GB

} 29.56GB`

Disc manufacturing



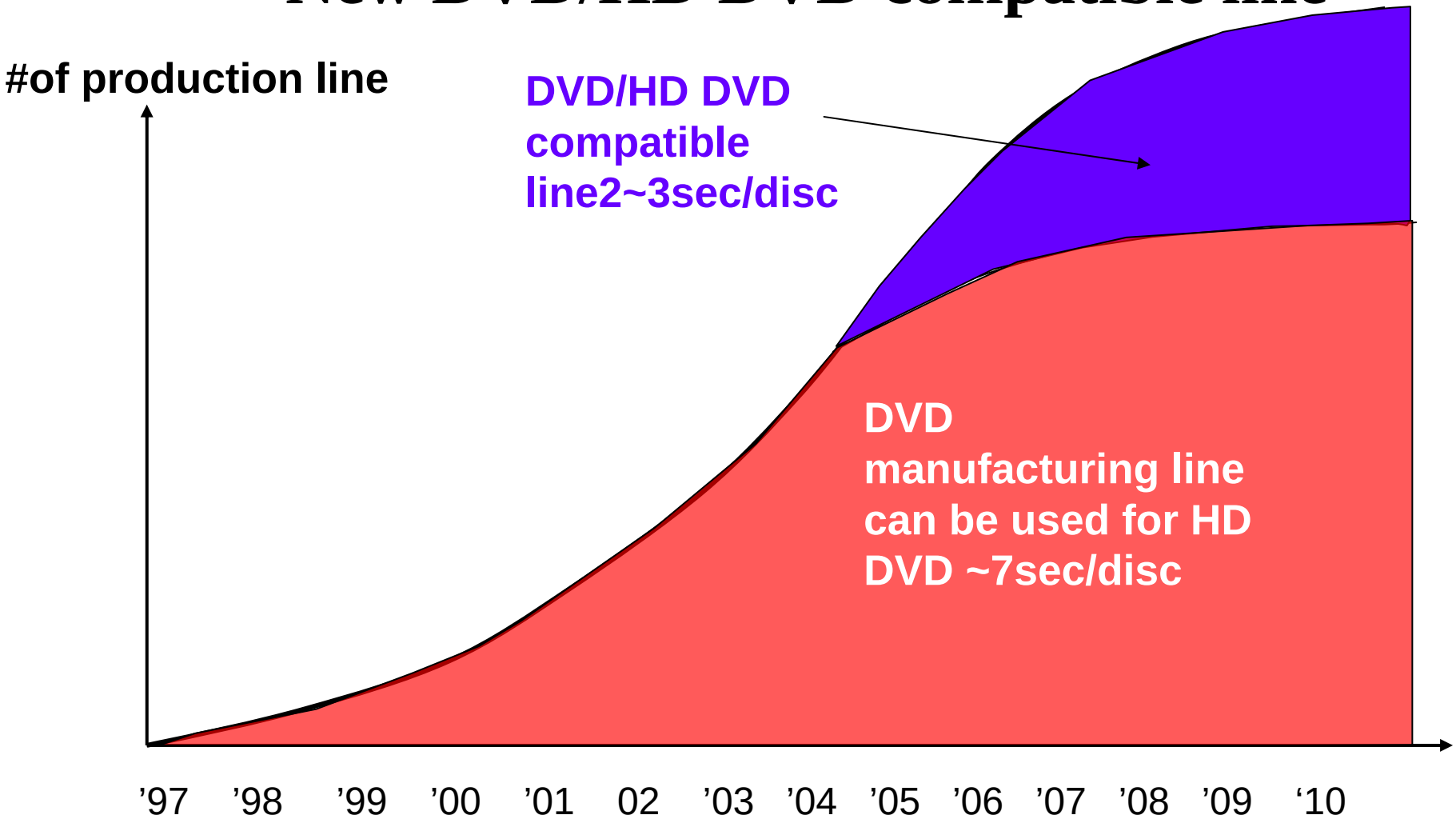
(A)2layer Disc manufacturing same as current DVD

(B) 2 layer disc manufacturing of 0.1mm substrate disc

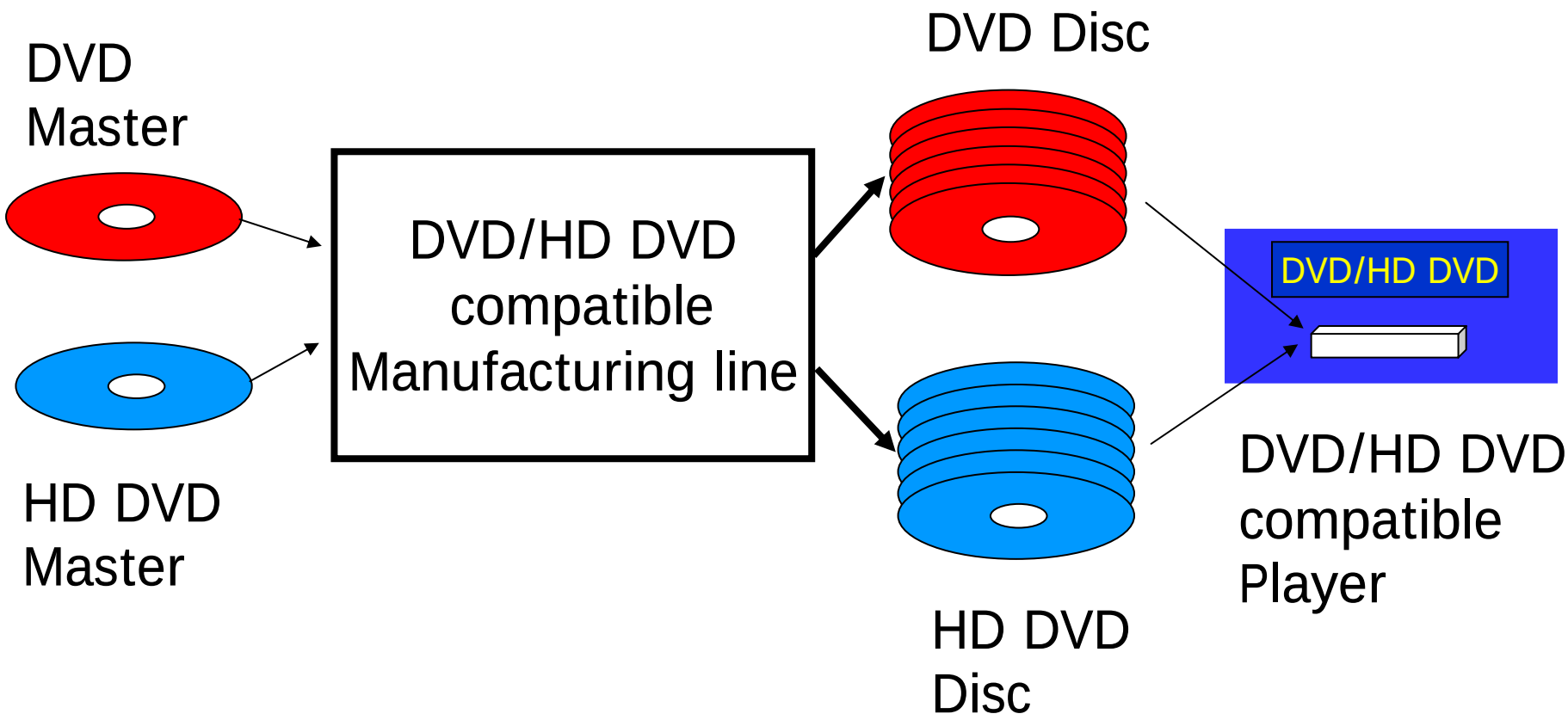
HD DVD disc manufacturing

- **Memory Tech new manufacturing line can make 1disc/3.5sec.**
- **It can change production line from DVD to HD DVD or vice versa in 5 minutes**
- **90-95% yield is already achieved**
- **Cost for the new manufacturing line is almost same as existing line**
- **Naturally, HD DVD manufacturing line will be increased to 20-50% of total DVD manufacturing line within 3 years**
- **The existing manufacturing line can be used at a little longer cycle time**

New DVD/HD DVD compatible line



Basic concept of HD DVD



HD DVD yield merits

- **DVD/HD DVD compatible player can be realized at reasonable cost – steady and smooth introduction of player can be expected**
- **DVD/HD DVD compatible disc manufacturing line will be introduced without costly new investment**
- **Compatible player deployment can rely on current DVD titles at the introduction**

- **Source tape in the studio is already HD quality by HD telecine.**

Summary

- **Comprehensive design to establish :**
  - **Low cost disc manufacturing**
  - **Compatible disc manufacturing with DVD/HD DVD**
  - **Sufficient recording time for content providers**
  - **Superior picture quality for general consumers**
  - **Reasonable optical system for compatible player**
  - **Security by AACS**
  - **Smooth transition from DVD to HD DVD**
- **Enjoy HD Video quality pictures!**