

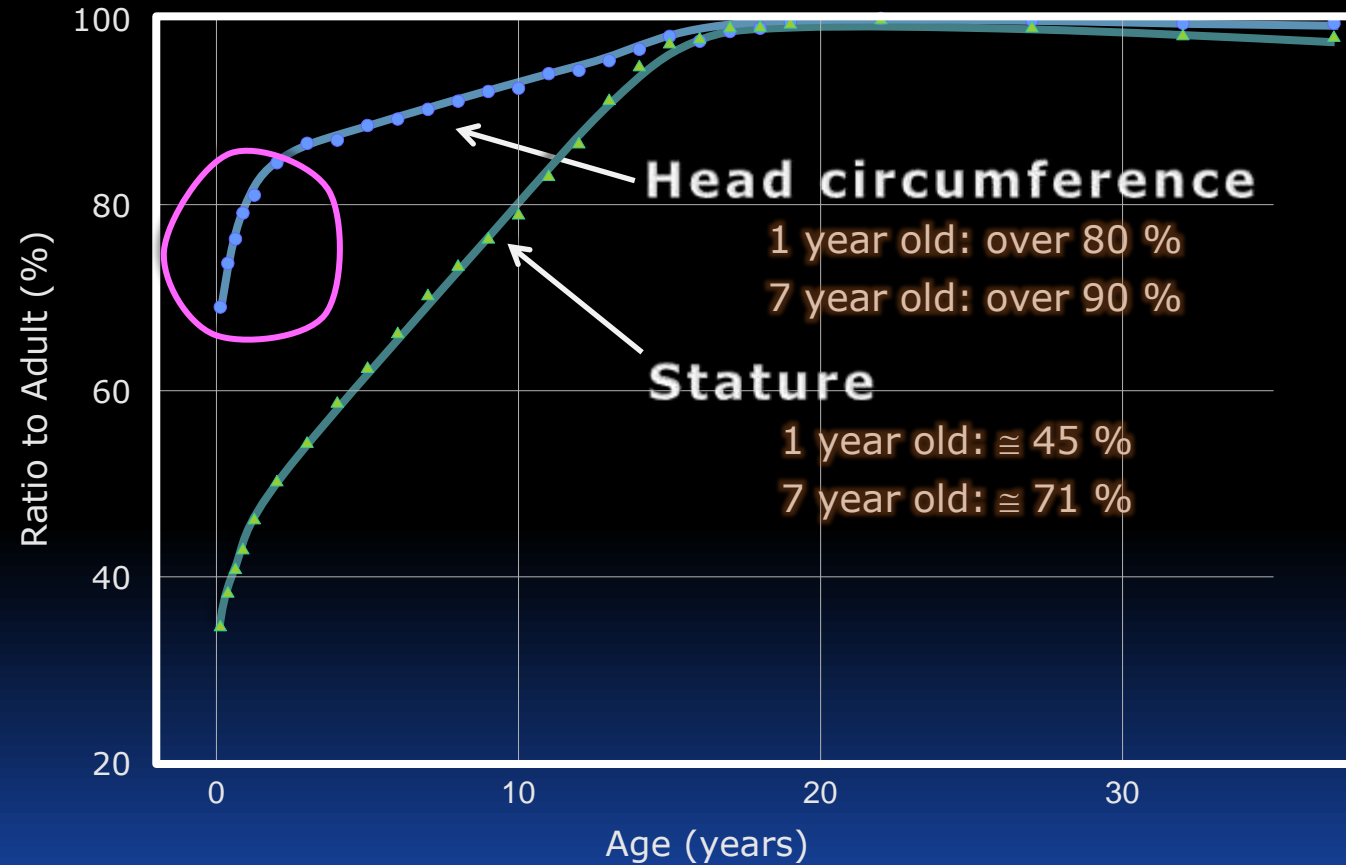
Development of a Child Voxel Model and Dosimetry

Ae-Kyoung Lee

- 1. Child Voxel Model Development**
- 2. Non-linearly Scaled Voxel Models at different ages**
- 3. Dosimetry for Whole Body Exposures**
- 4. Conclusion**

Statistics of Sizes by Age

Child head: Rapid growth at early stage





아주대학교



수신 한국전자통신연구원장
(경유) 전자파환경연구팀장

제목 의학연구윤리심의위원회(IRB) 연구과제 검토 확인서

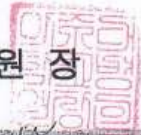
1. 관련근거:

- 연구과제명 : 어린이 Voxel 모델 제작
- <어린이 Voxel 모델 제작>관련 사실 확인 요청을 위한 경위서

2. 위 관련근거 의학연구윤리심의위원회(IRB)의 사실확인서 요청에 따라 본 연구과제에 검토한 바, 피험자와 부모가 연구에 대해 충분한 설명을 듣고 자발적으로 동의하여 연구에 참여한 것으로 보이고, MRI 와 같은 비침습적인 시술을 이용한 연구로서 피험자에게 큰 위험이 가해지는 부분은 없는 것으로 판단되었습니다.

3. 이에 아주대학교병원 의학연구윤리심의위원회(IRB)에서는 사전심의·승인을 통해 연구가 진행되지는 않았지만, 연구를 진행하고 연구결과를 활용함에 있어서 윤리적인 문제가 없었음을 확인하였습니다.

아주대학교병원장



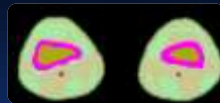
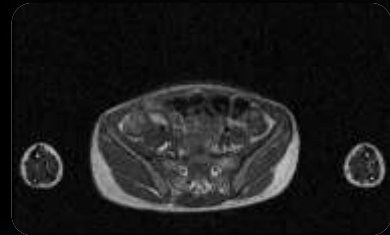
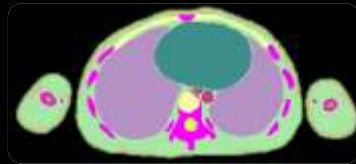
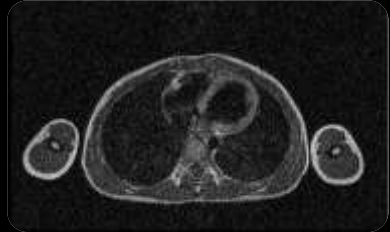
연구지원팀 [Signature] 간사 [Signature] 위원장 [Signature]

병원장 [Signature]
협조

시행 IRB - 3369호(2007. 1. 29) 접수
우 443-721 수원시 영통구 원천동 산 5번지 / http://www.ajoumc.or.kr
전화 031-219-5569 전승 031-219-4503/ oug196@ajou.ac.kr/

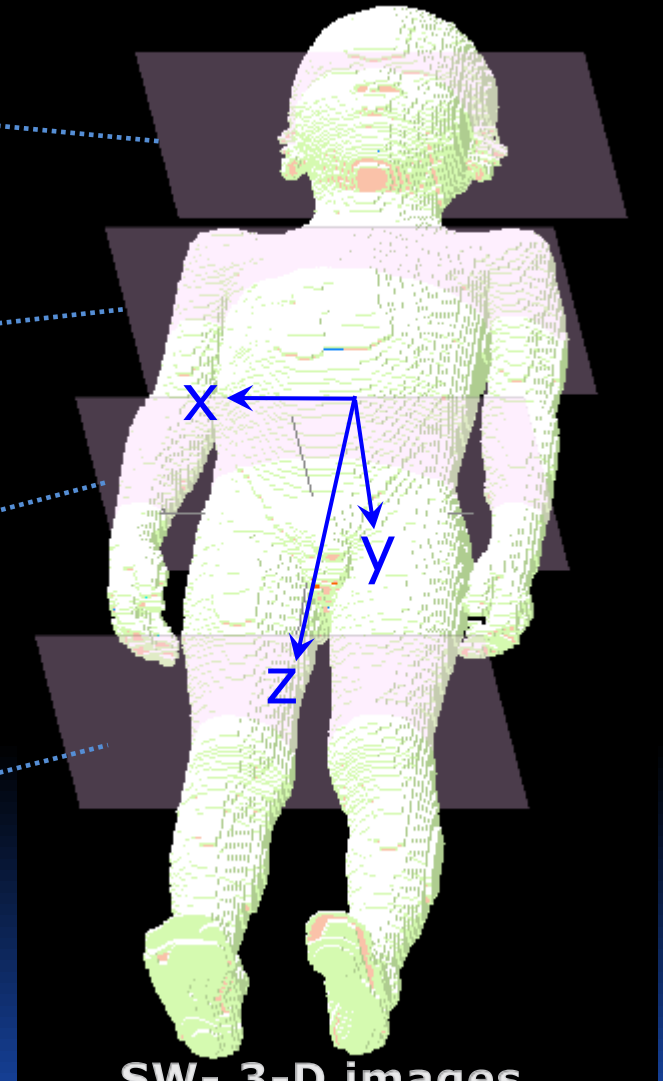
- ✓ Review and Approval of Research Project regarding Child Voxel Model Development (IRB in Aju University, Seoul)
- ✓ Volunteer: 7-year-old male
- ✓ MR image interval: 3 mm

Development of Voxel Model



MR images

SW- Cross-section



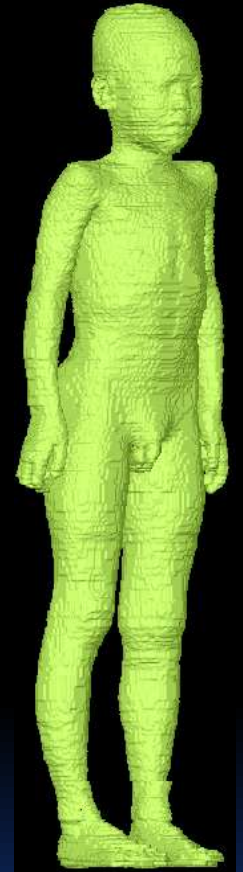
SW- 3-D images

Adjusted to 50th Percentile Dimensions

Table. Comparison of Physique (7-y) ('04 National Standard)¹

	Item (mm)	7-y
①	Head breadth	149
②	Head length	170
③	Face length	95
④	Head height	210
⑤	Neck circumference	270
⑥	Chest breadth	202
⑦	Chest depth	140
⑧	Waist breadth	194

	Item (mm)	7-y
⑨	Waist depth	143
⑩	Hip breadth	218
⑪	Buttock depth	154
⑫	Thigh Circumference	375
⑬	Calf Circumference	255
⑭	Foot length	190
⑮	Waist height	740
⑯	Stature	1224
⑰	Weight (kg)	24.1



Lee, A. K., Byun, J. K., Park, J. S., Choi, H. D. and Yun, J. H. Development of 7-year-old Korean child model for computational dosimetry . ETRI J. 31(2), 237-239 (2009).

¹ 50th percentile

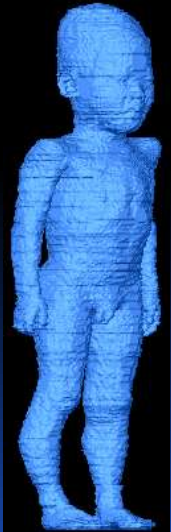
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Table. Comparison of Physique according to age ('04 National Standard) (50th Percentile)

Item (mm)	9-12 m	3-y	5-y	7-y	20-24y
① Head breadth	130	142	146	149	161
② Head length	150	164	168	170	186
③ Face length	-	85	89	95	121
④ Head height	-	194	204	210	236
⑤ Neck circumference	-	247	256	270	370
⑥ Chest breadth	158	171	182	202	310
⑦ Chest depth	-	-	-	140	205
⑧ Waist breadth	140	164	-	194	281
⑨ Waist depth	-	-	-	143	196
⑩ Hip breadth	162	180	198	218	330
⑪ Buttock depth	-	-	-	154	238
⑫ Thigh Circumference	250	306	332	375	564
⑬ Calf Circumference	194	211	230	255	376
⑭ Foot length	110	151	168	190	255
⑮ Waist height	-	-	-	740	1074
⑯ Stature	749	948	1088	1224	1740
⑰ Weight (kg)	10.0	14.7	18.4	24.1	68.5

Implementation of Voxel Models at Different Ages

9-12m



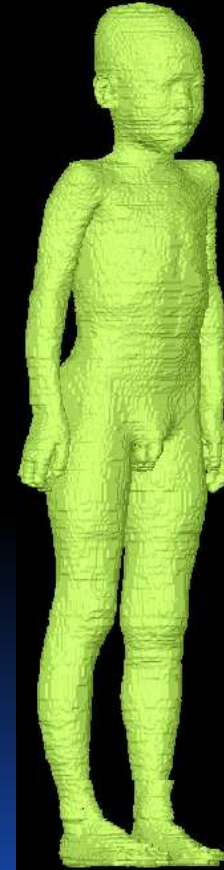
3y



5y



7y



20y

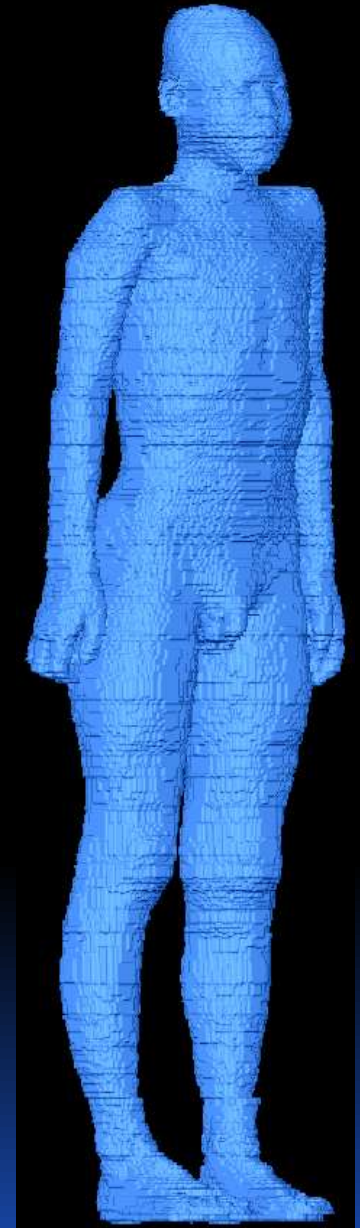


Table. Difference between National Standard and Implemented Voxel models (%)

Item (mm)	9-12 m	3-y	5-y	7-y	20-24y
① Head breadth	0	0	0	0.7	0.6
② Head length	0	0	0	0	0
③ Face length	-	1.2	1.1	1.1	0.8
④ Head height	-	0	0	0	0
⑤ Neck circumference	-	0.4	0.8	1.1	0.3
⑥ Chest breadth	0	0.6	0	0	0
⑦ Chest depth	-	-	-	0	0.5
⑧ Waist breadth	0	0	-	1.0	0.4
⑨ Waist depth	-	-	-	0.7	2.0
⑩ Hip breadth	0	0	0	-0.9	1.8
⑪ Buttock depth	-	-	-	-1.3	0.8
⑫ Thigh Circumference	0.4	-0.3	0.3	-1.1	0.9
⑬ Calf Circumference	-1.0	-1.9	-1.7	-1.6	1.1
⑭ Foot length	1.8	0.6	0	0	1.6
⑮ Waist height	-	-	-	0.5	-0.2
⑯ Stature	0.1	-0.3	-0.2	0.3	0
⑰ Weight (kg)	3.0	2.0	1.6	1.2	4.4

Implementation of Voxel Models at Different Ages (**Arms-up posture**)

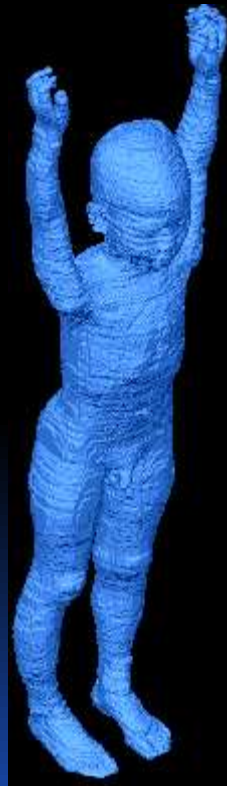
9-12m



3y



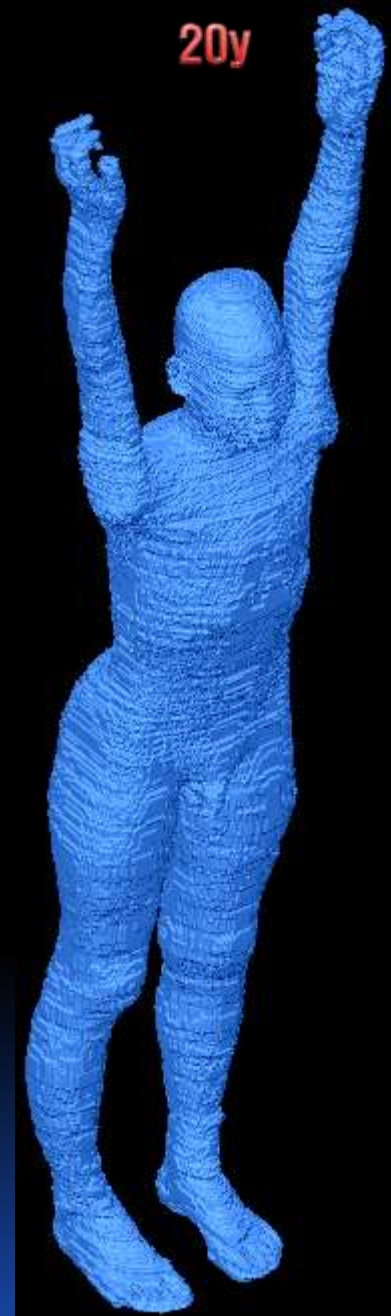
5y



7y



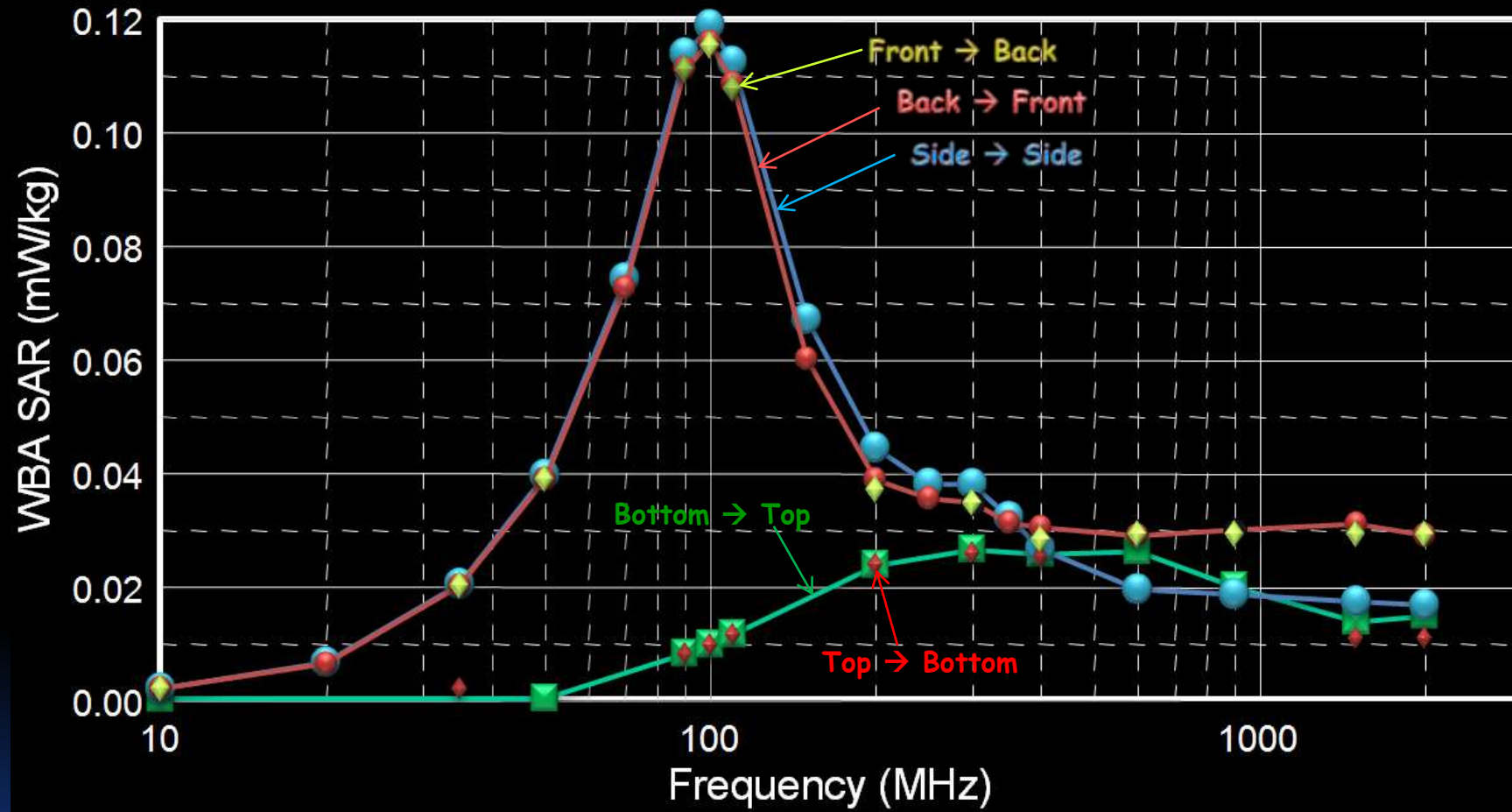
20y



R.P. Findlay, A-K. Lee, and P.J. Dimbylow, FDTD calculations of SAR for child voxel models in different postures between 10 MHz to 3 GHz. Radi. Prot. Dosim. pp . 1-6 (2009).

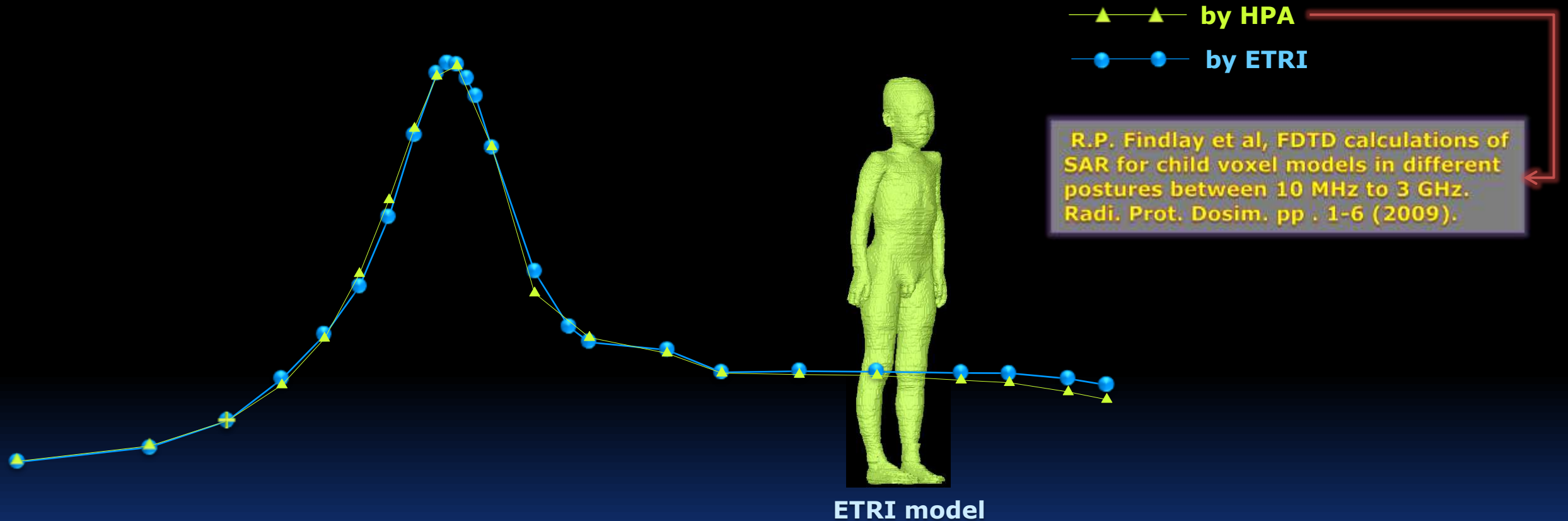
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Angle of Incidence & WB-SAR

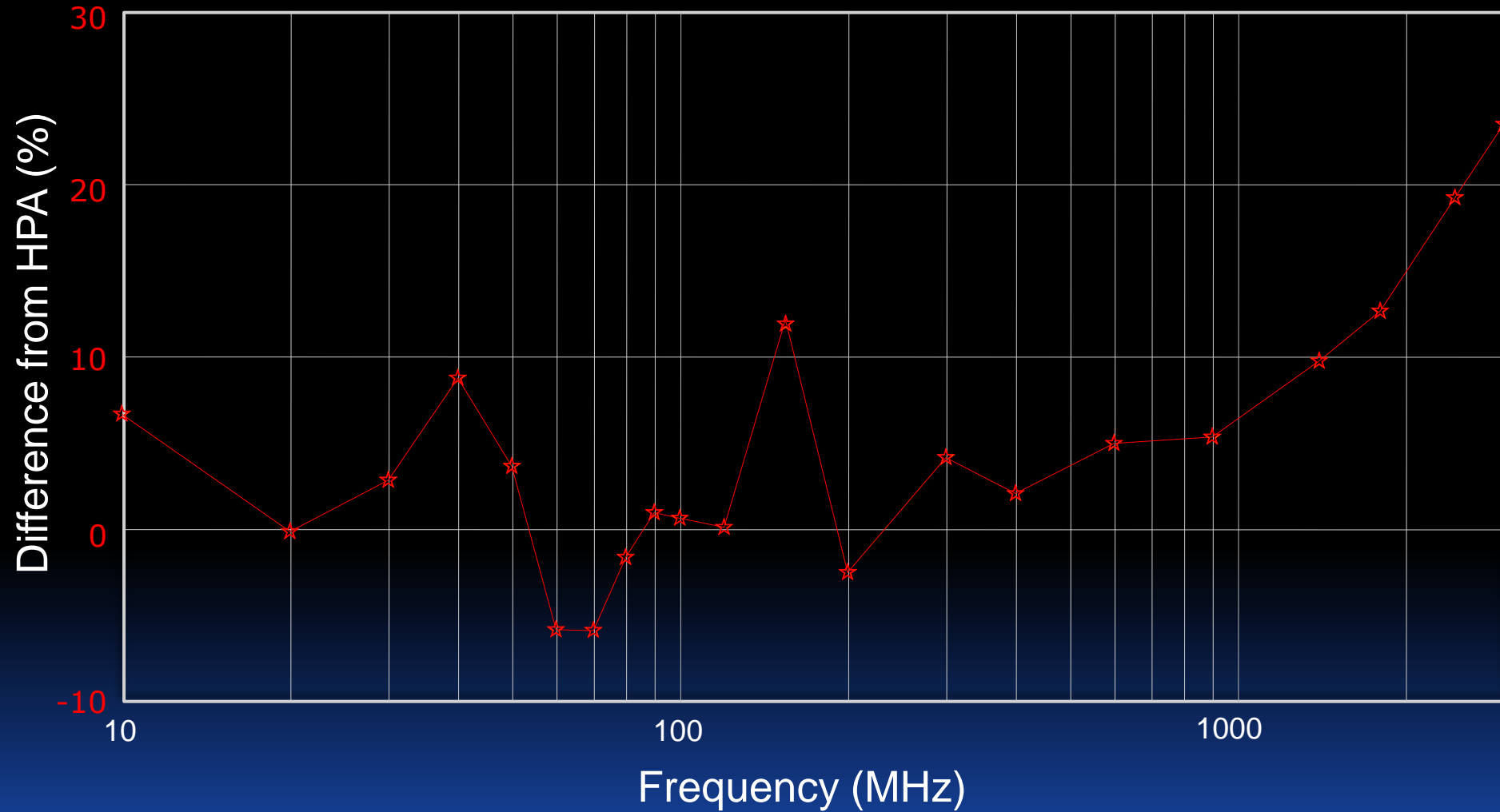


Incident field = 1 V/m

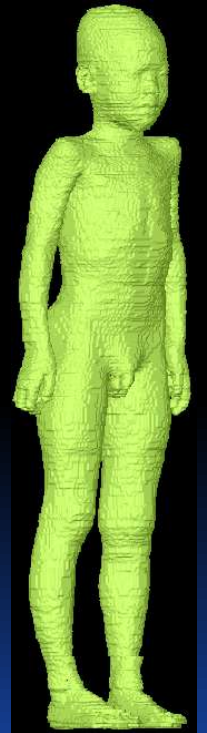
WB-SAR_7-y-o (Arms-down posture)



WB-SAR_7-y-o (Arms-down posture)



▲ by HPA
● by ETRI



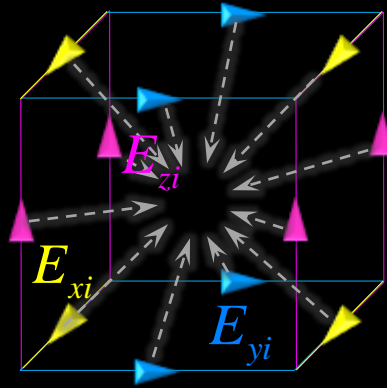
Concerning calculation

- **FDTD conditions: 8 cell-thick PML, 10 cells between a human body and the PML**
- **SAR averaging time: 1 period during steady state**
- **Voxel SAR: 12-SAR components approach**

SAR in a voxel

HPA

12-E-field components approach



ETRI

12-SAR components approach

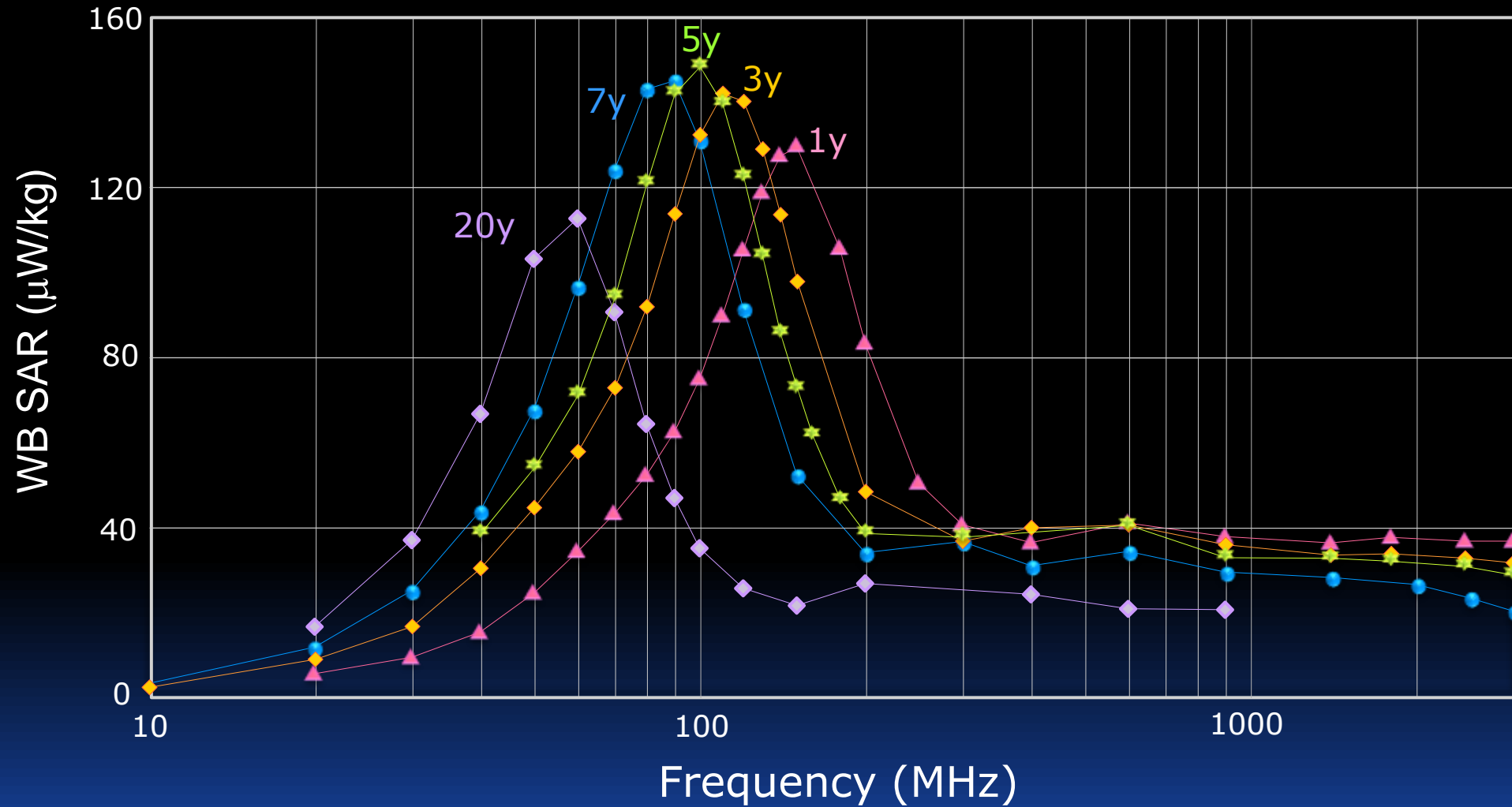
$$SAR_{voxel} = \frac{\sigma}{\rho} (E_x^2 + E_y^2 + E_z^2)$$

$$E_x = \frac{1}{4} \sum_{i=1}^4 E_{ix}$$

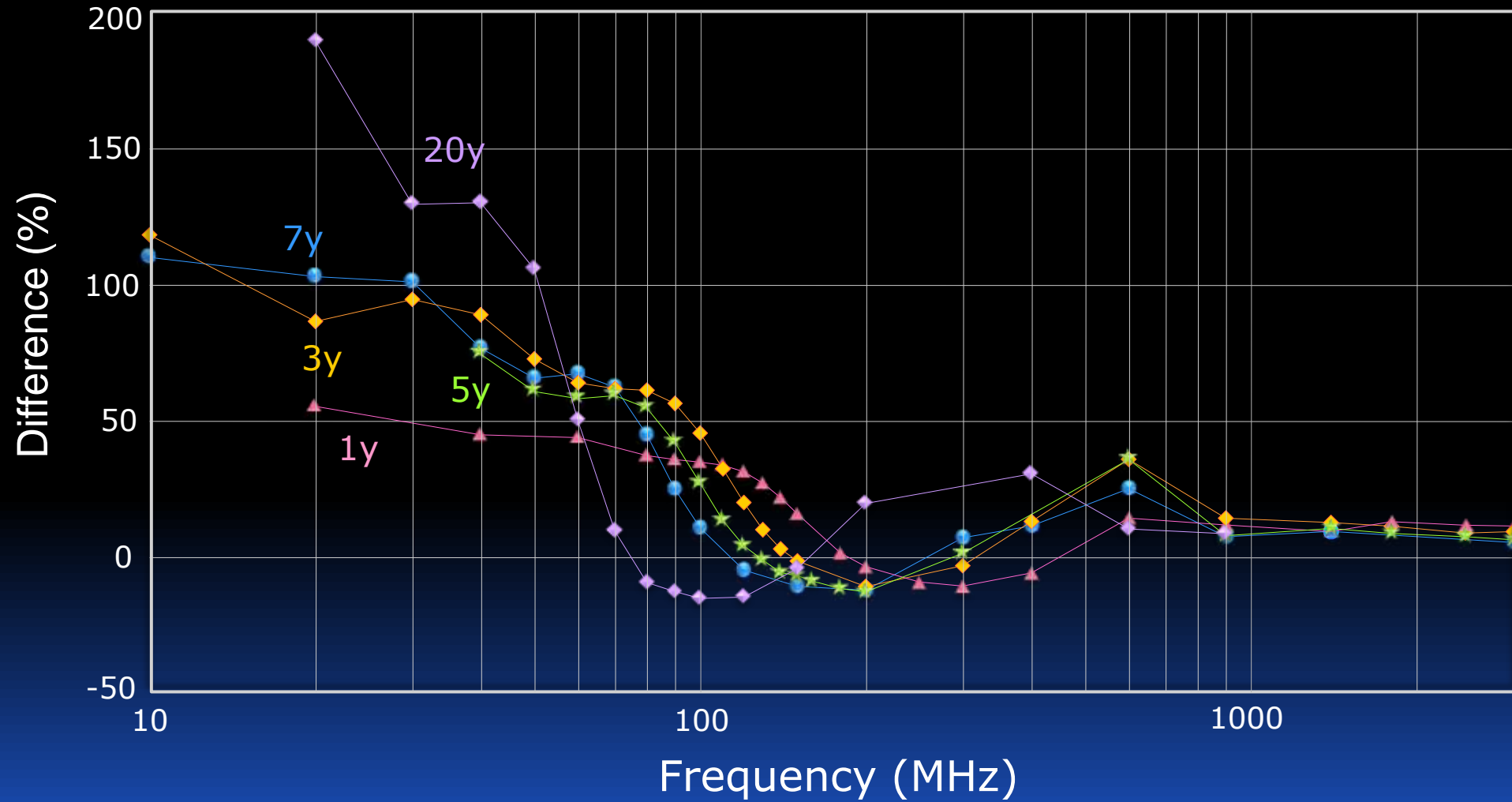
$$SAR_{voxel} = \sum_{i=1}^{12} SAR_i$$

$$SAR_i = \frac{|E_i|^2 \sigma_i}{\rho_i}$$

20-, 7-, 5-, 3-, 1 y-o (Arms-up posture)

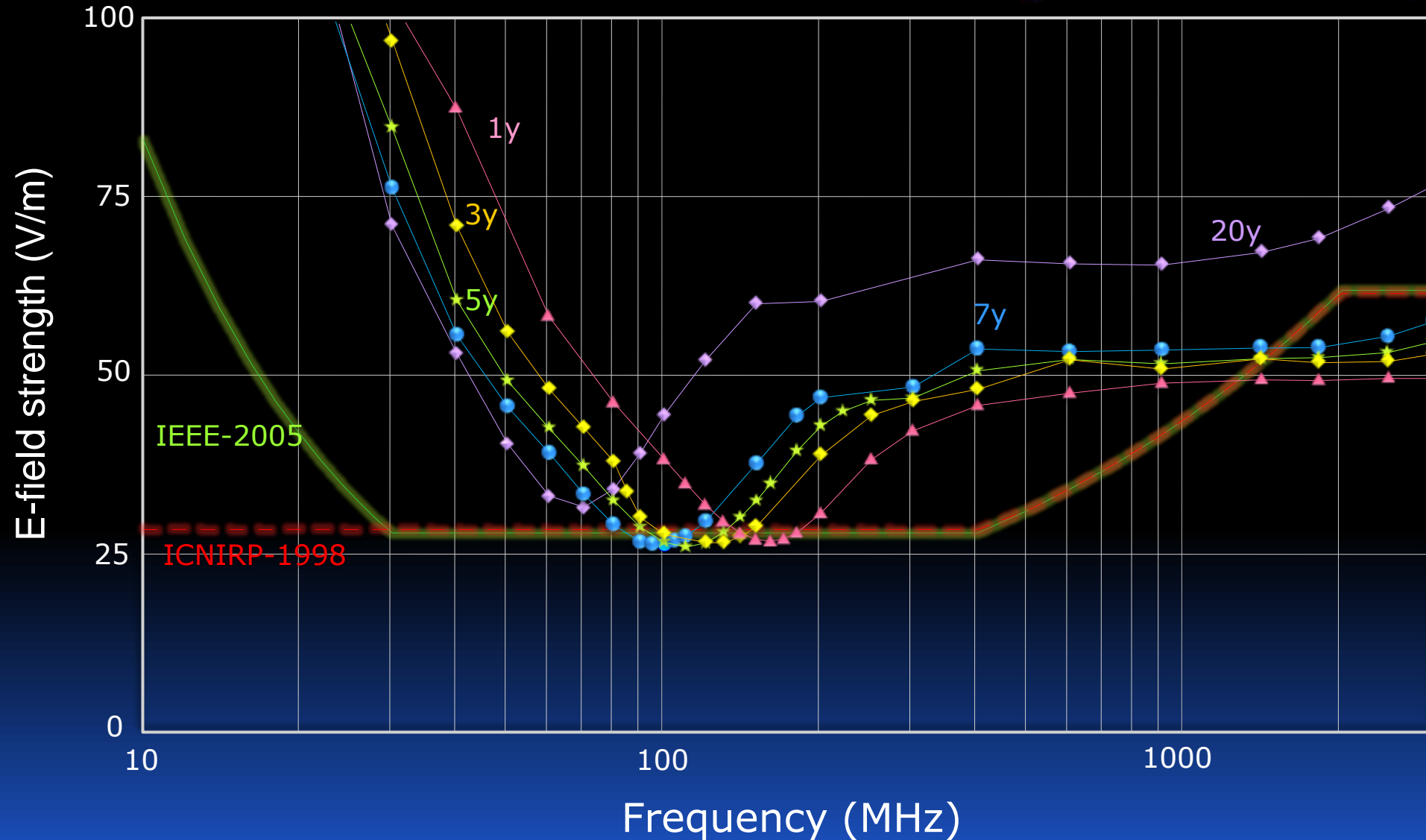


$$\text{SAR difference} = \frac{\text{SAR}_{\text{arms up}} - \text{SAR}_{\text{arms down}}}{\text{SAR}_{\text{arms down}}} \cdot 100 (\%)$$



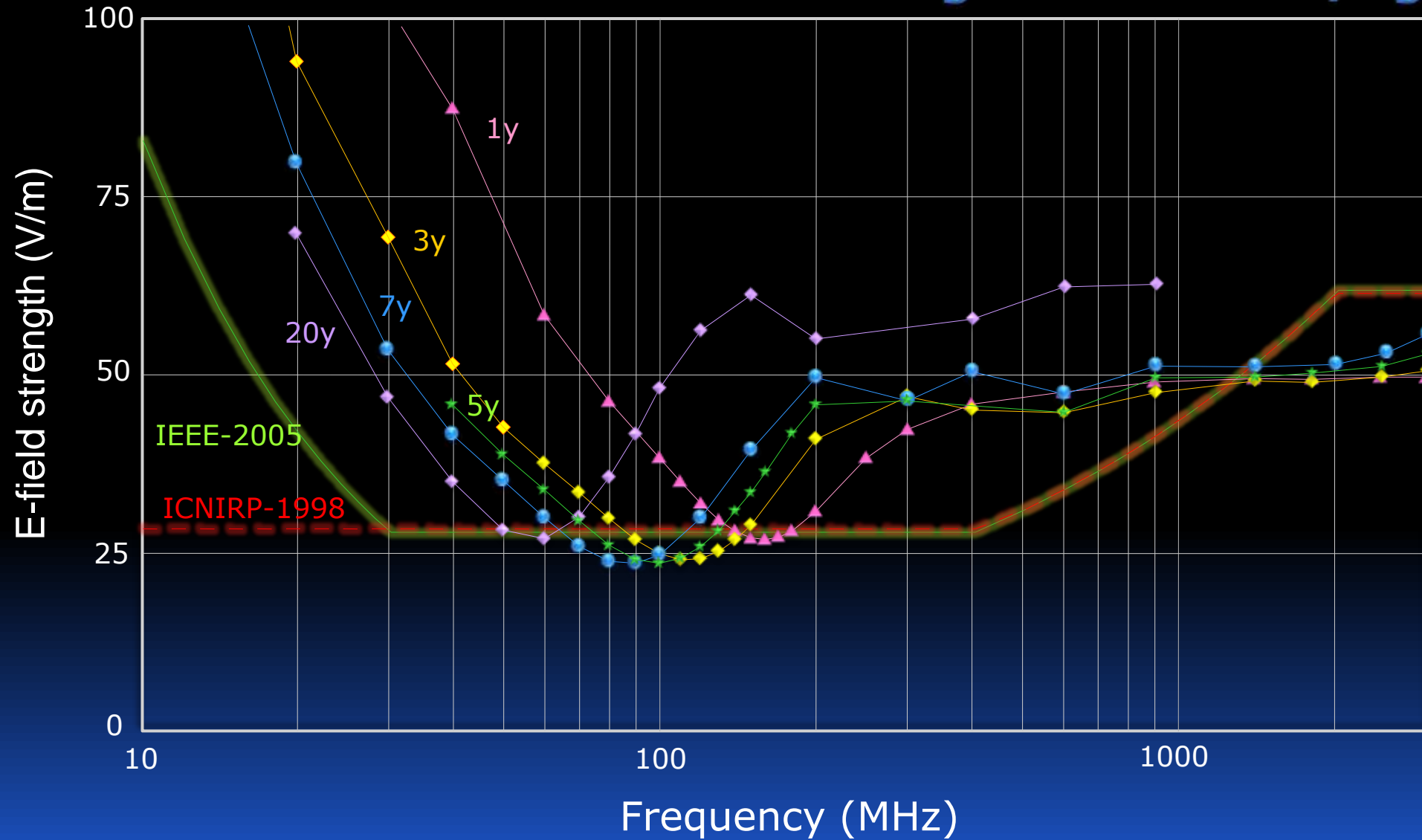
20-, 7-, 5-, 3-, 1 y-o (Arms-down posture)

E-field strength for 0.08 W/kg



20-, 7-, 5-, 3-, 1 y-o (Arms-up posture)

E-field strength for 0.08 W/kg



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- **Voxel SAR algorithm seems to highly affect WB-SAR at frequencies over 1 GHz**
- **WBA - Resonance**

Item	1-y		3-y		5-y		7-y		20-24y	
	Arms down	Arms up	Arms down	Arms up	Arms down	Arms up	Arms down	Arms up	Arms down	Arms up
Resonance frequency	0.40λ	0.40λ	0.41λ	0.40λ	0.40λ	0.41λ	0.41λ	0.42λ	0.41λ	0.42λ
Resonance peak	113	129	117	142	123	148	119	145	83	113

- **ICNIRP & IEEE E-field limits: not conservative** } **over 1.5 GHz resonance region**

Thank you.