DANISH HEALTH AUTHORITY
Radiation Protection

GEISLAVARNIR RÍKISINS
ICELANDIC RADIATION SAFETY AUTHORITY

DSA Direktoratet for strålevern og atomsikkerhet

Nordic project: Establishing diagnostic reference levels for pediatric patients

Strål säkerhets myndigheten
Swedish Radiation Safety Authority

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Nordic Working Group on Medical Applications

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DRL: Diagnostic Reference Level

Setting DRLs for children

New trends

- BSS focus on DRL for special groups
- DRLs should be indication based

Special challenges – paediatric DRLs

- Large span in patient size
  - Weight: from less than 1 kg to more than 70 kg
  - Height/ Length: from around 50 cm to 180 cm
- Number of examinations
  - Children constitute only ≈20 % of the population
  - Lower number of examinations for children than for adults

- Even more pronounced for small countries

Project set -up

Data collection in
- Denmark
- Norway
- Iceland
- Sweden

Finnish data to be used for comparison
- Recent DRL values from 2015 (CT) and 2018

Time line
- Project plan approved December 2017
- Data collection started March 2018
  - Planned to end in September 2018 - extended
- Data analysis under way

Inspiration

PiDRL EUROPEAN DIAGNOSTIC REFERENCE LEVELS FOR PAEDIATRIC IMAGING

- Guidelines published 2018
- Recommendations
  - Body examinations: Weight groups or DRL curves
  - Head examinations: Age groups

ICRP INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION

- Publication 135
  - Diagnostic reference levels in medical imaging

Examinations per year

Conventional radiology (incl. fluoroscopy) 2016

Denmark, Finland, Iceland:
- Registry data

Sweden, Norway:
- Estimates

0-15 years
(Iceland 0-14 years)

	Denmark	Finland	Iceland	Norway	Sweden	Estimated Total
Chest	19.327	53.393	1.964		36.500	110.000
Pelvis, hip joints	5.574	3.943	438		6.000	16.000
Abdomen	3.512	1.492	388		7.800	13.000
Scoliosis	3.376	4.289	41	5.000	1.900	9.600
Lumbar spine	2.325	2.277	43		2.300	7.000
Small intestine passage	277	299	124		1.700	2.300
MCU	251	290	30		900	1.400

Examinations per year

CT
2016

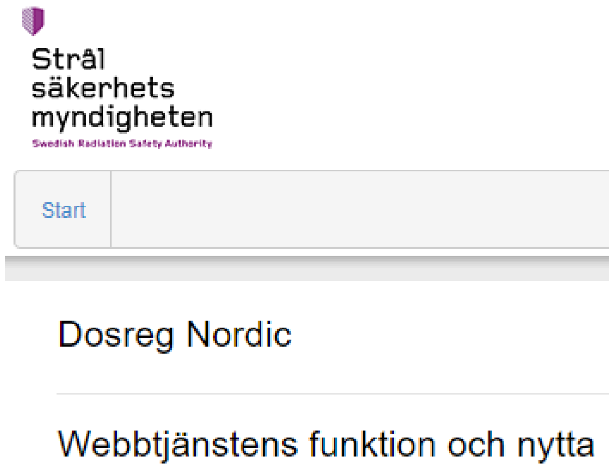
Denmark, Finland, Iceland:
- Registry data

Sweden:
- Estimates

0-15 years
(Iceland 0-14 years)

	Denmark	Finland	Iceland	Sweden	Estimated Total
Brain	1.542	1.415	220	10.200	13.400
Spine	1.460	847	32	1.300	3.600
Adomen , pelvis	413	184	83	1.500	2.200
Chest	546	509	84	1.040	2.200
Joints, soft tissue	0	100		1.275	1.400
Trauma	302	139		810	1.300
Hip joints	46	45	16	310	400
Urinary track	74	29		80	200

Data collection



Equipment – manufacture and type

Protocol – main parameters

- Conventional
  - Grid
  - FFA
  - Filtration
  - Focus size
- CT
  - kV
  - Axial/ spiral
  - Pitch
  - Number of phases
  - Dose modulation
  - Iterative reconstruction – description
  - Slice thickness – Scanned and reconstruction
  - Rotation time

Patient

- Common
  - Age
  - Height and Weight (except for head exams)
- Conventional
  - Number of images
  - DAP
  - kV
  - Automatic exposure control used
  - mAs
- CT
  - kV
  - $CTDI_{vol}$
  - DLP

How much data?

Conventional examinations

Examination type

	0-48 months	4-15 years	Total
Abdomen	66	150	216
Chest, bed	221	11	232
Chest, standing	310	453	763
Pelvis	99	144	243
Pelvis / hip joints	128		128
Lumbar spine	3	44	47
Scoliosis, primary	2	153	155
Scoliosis, follow -up	4	77	81

How much data?

CT

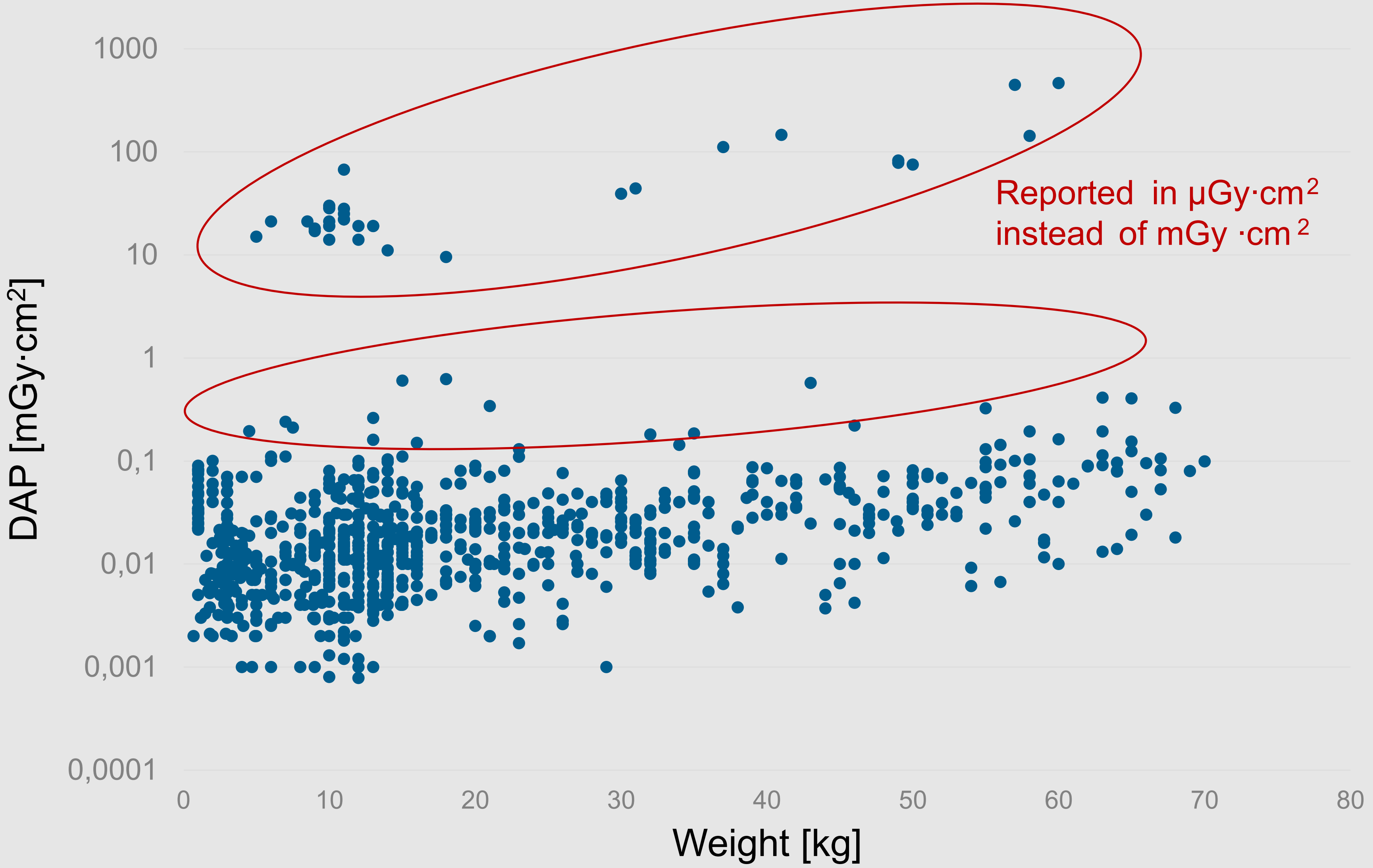
Examination type
Indication

	0-48 months	4-15 years	Total
Abdomen with contrast Tumor, infection, obstruction, birth defect	12	212	224
Brain Infarct/haemorrhage	391	876	1267
Brain Ventricular size/shunt	16	41	57
HRCT	19	67	86
Chest with contrast Tumor, birth defect, metastases	39	82	121
Head, chest, abdomen Trauma	1	26	27

Data check

Example:
Conventional chest

0,1 mGy·cm^2
=
1 Gy·cm^2
=
100 µGy·cm^2
=
1000 mGy·cm^2
=
1.000.000 µGy·cm^2



Data analysis – basics

Dependence of patient dose on patient size

- Attenuation increases exponentially with patient diameter
  - Patient diameter increases with body weight (and age)
- Field size increases slowly with increasing size of patient

➢ Assume overall exponential increase with body weight (or age)

Body examinations

➢ Dose values plotted vs. patient weight and fitted with exponential function

Head examinations

➢ Dose values plotted vs. patient age and fitted with exponential function

Data analysis – determining DRLs

Room	Sex	Length	Weight	DLP	DLP0_i
11, RTG-9612	Man	86	10,4	164,2	121,3
11, RTG-9612	Man	100	20	150,3	84,0
11, RTG-9612	Kvinna	115	20	82,2	45,9
11, RTG-9612	Kvinna	162	66	298,5	43,7
11, RTG-9612	Kvinna	164	52	307,4	67,6
11, RTG-9612	Kvinna	168	60	260,7	45,4
11, RTG-9612	Man	103	28	114,6	50,7

Data pooling

- Ideally: By hospital – requires very large numbers of data
- Other possibilities:
  - By healthcare region / country
  - By manufacturer, e.g. for CT

Fitting process

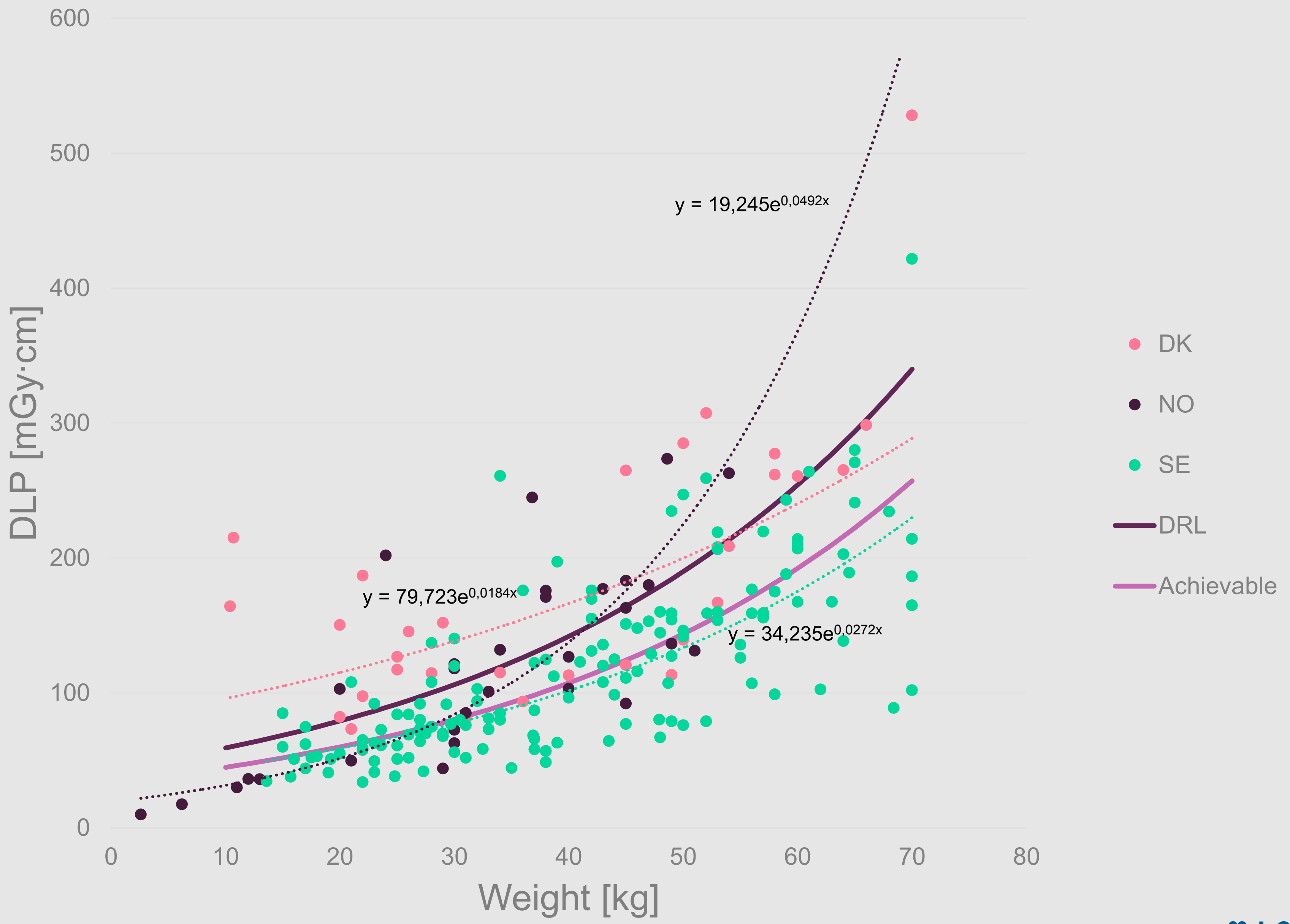
- Exponential fit for each pool of data: $DLP_i = DLP_{0,i} \cdot \exp(a_i \cdot Weight)$
- Common exponential factor determined: ***a***
  - Weighted average of a_i
  - Weighted by the number of data points in each pool
- Calculate $DLP_{0,dp}$ from each individual data point based on ***a***
- Calculate values from all of $DLP_{0,dp}$ values
  - 50% quartile – achievable level
  - 75% quartile – reference level (DRL)

	# points	Fitted a
DK	30	0,0184
NO	30	0,0492
SE	147	0,0272
Weighted average		0,0291
DLP0		
Median	33,5	
3 quartile	44,3	

CT Abdomen

Pooled by country

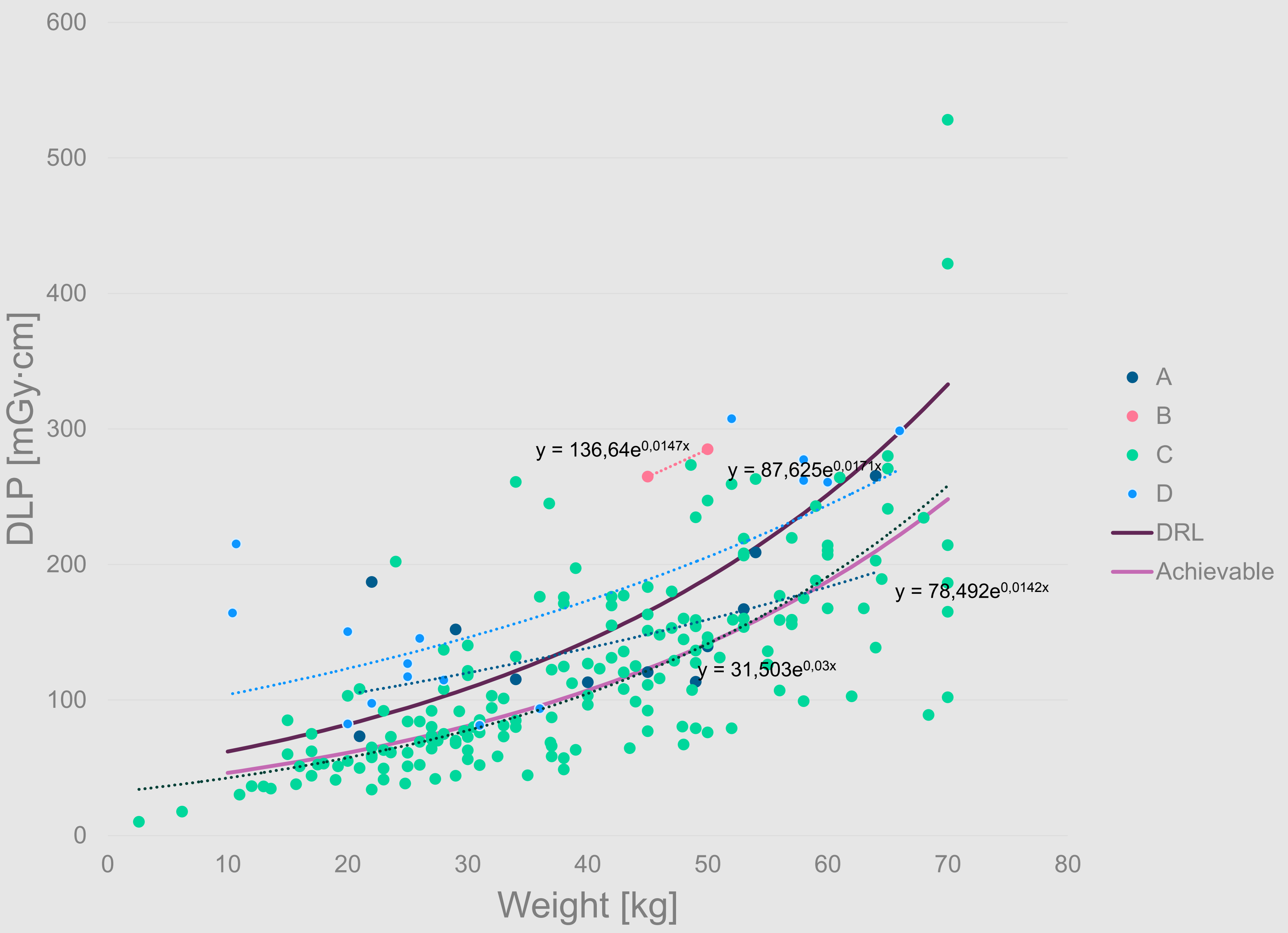
	DRL	Ach.
10 kg	59	45
70 kg	340	257



CT Abdomen

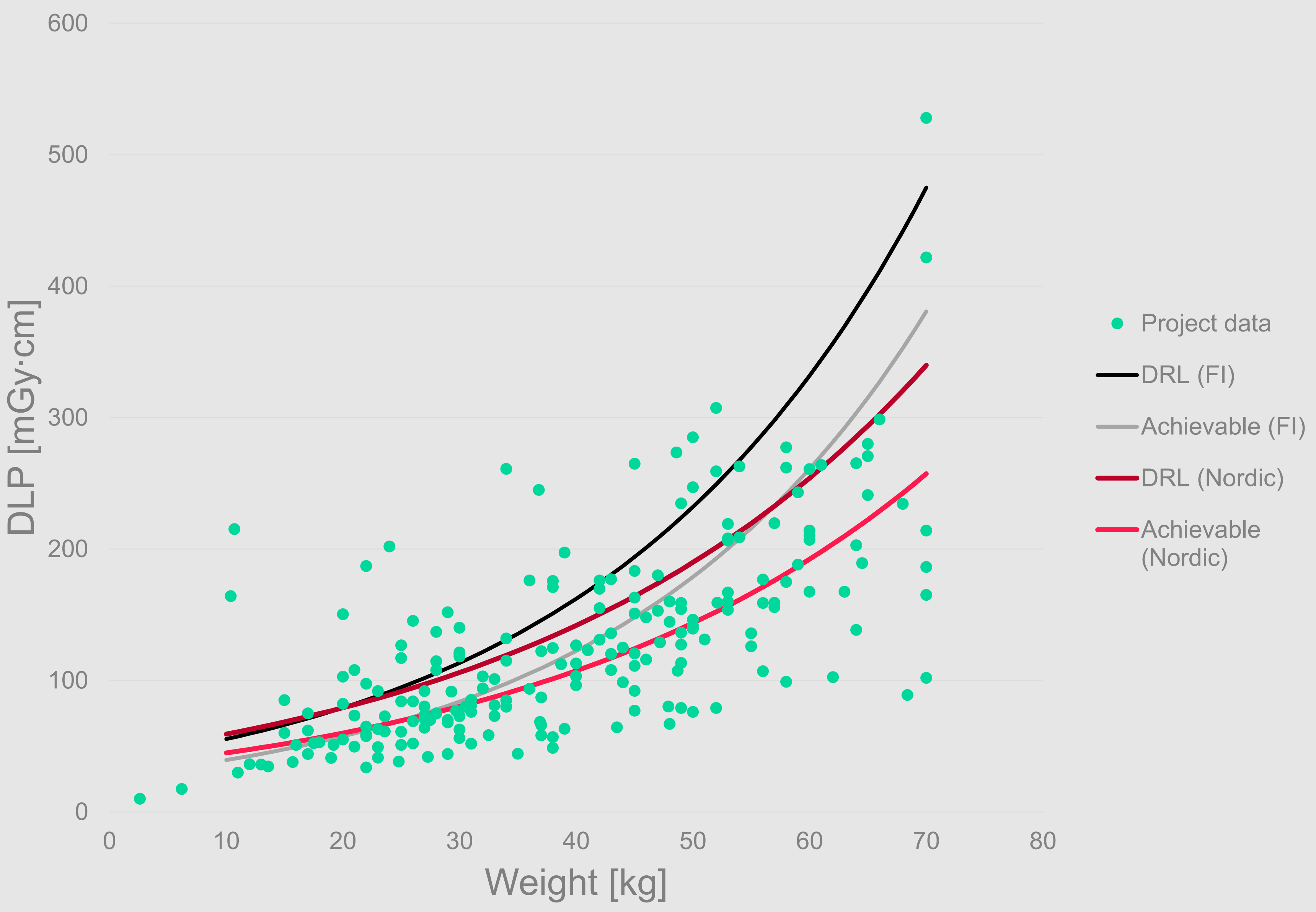
Pooled by manufacturer

	DRL	Ach.
10 kg	62	46
70 kg	333	248



CT Abdomen

Comparison
- Finnish DRLs 2015
- Current results

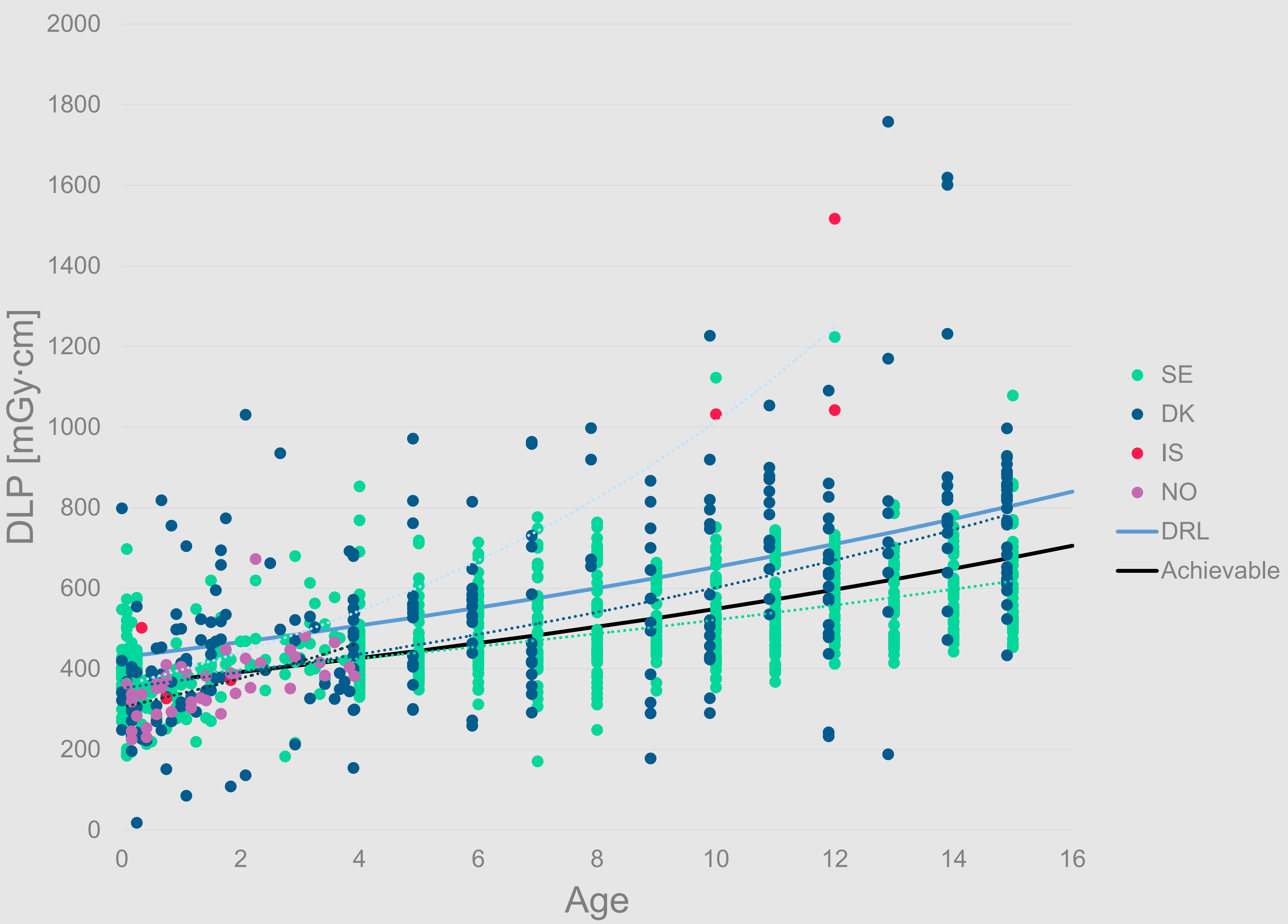


CT Brain

0-4 years
- Age in months

4-15 years
- Age in years

Common analysis ?
- Seems feasible
- Curve is a possibility



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Next steps

Nordic Working Group on Medical Applications (NGMA)

Further data analysis

Consultation with paediatric radiologists

- Presentation of results
- Comparison of protocols

Publication

- Collected data
- Guidance DRLs

- In website of Nordic Working Group of Medical Applications
- In national websites

Encourage further work with optimisation of paediatric x-ray examinations

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Thank you for your attention

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