# Clinical Usage of Knowledge Based Treatment Planning

Xiaodong Zhang

Department of Radiation Physics, UT MDACC

# Disclosures

- Research funds from
  - Sister Institution Network Funds from MDACC
  - Varian Medical System
  - Philips Medial System
- License agreement between MDACC and GlobalOncologyOne

# Outline

- Significance of treatment planning automation
- How we can achieve treatment planning automation
  - Standardizing Naming Conventions
  - Automating contour generations
  - Automating Beam angle selections
  - Automating objective function parameter selections
- Some use cases of knowledge based treatment planning automation (MDACC experiences)

# Why automation: Quality of RO

- Expanding its definition of quality to include not only avoidance of gross errors but also consistent delivery of the full potential of the currently available technology and evidence

Santam et. al., “Standardizing Naming Conventions in Raidiation Oncology”, IJROBP, 2012, V83, p1344-1349

# Treatment plans were not designed the same in different institutions

The IMRT Gastric plan from National University of Singapore (NUS) was re-designed by the planners in UCSF

ELSEVIER

International Journal of Radiation Oncology*Biology*Physics

Volume 71, Issue 4, 15 July 2008, Pages 1167–1174

Clinical Investigation

Can All Centers Plan Intensity-Modulated Radiotherapy (IMRT) Effectively? An External Audit of Dosimetric Comparisons Between Three-Dimensional Conformal Radiotherapy and IMRT for Adjuvant Chemoradiation for Gastric Cancer

Hans T. Chung, M.D., F.R.C.P.C.*, Brian Lee, M.D., Ph.D.†, Eileen Park, B.Sc. (Hons)*, Jiade J. Lu, M.D., M.B.A.*, Ping Xia, Ph.D.†

* Department of Radiation Oncology, The Cancer Institute, National University Hospital, Singapore

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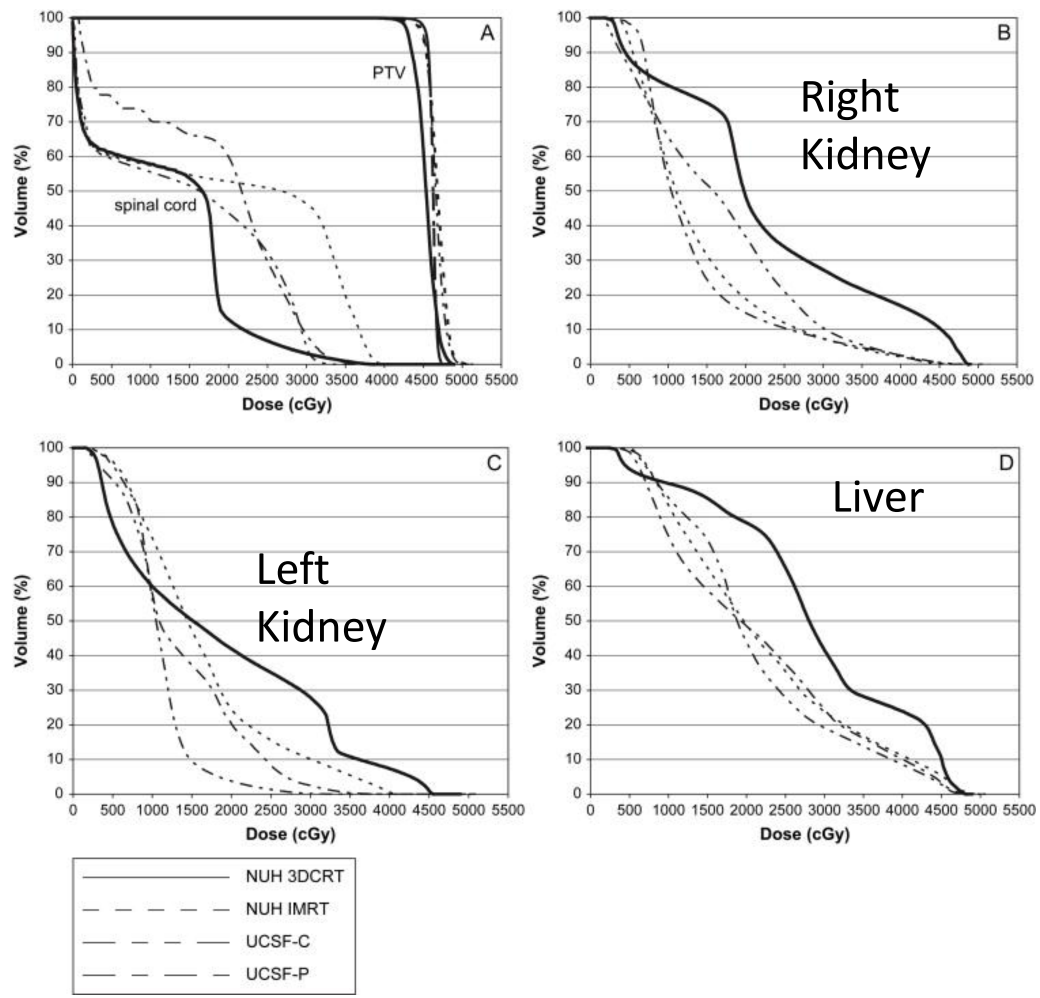
Received 5 July 2007, Revised 5 October 2007, Accepted 5 November 2007, Available online 30 January 2008

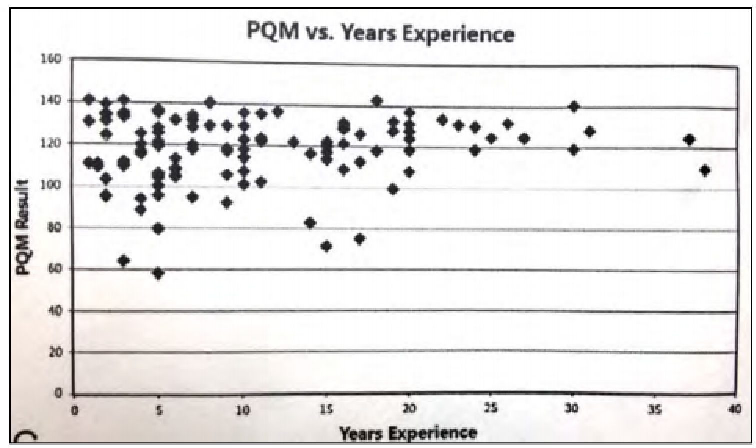
At our institution with early IMRT experience, IMRT improved PTV dose coverage and liver doses but not kidney doses. **An external audit of IMRT plans showed that an experienced center can yield superior IMRT plans.**



# What caused the variations of the plan quality among different planners?

**Quantifying Plan Variation:**

- CT images, contours, and scoring criteria sent out to AAMD members.
- 14 weighted plan metrics which would be used to assess plan quality.
- Analyzed 125 prostate plans created by different treatment planners.
- Found large variability in the plan quality scores (range 58-142, mean 116).
- **Quality not effected by**:
    - planners experience
    - certification or education
    - self rated confidence
    - computer system used
    - modality (fixed field vs rotational)
    - complexity (# fields or MU's.)




**Scores only significantly correlated with "Planner's skill" category**

Nelms BE, Robinson G, Markham J, et al. Variation in external beam treatment plan quality: An inter-institutional study of planners and planning systems. Pract Radiat Oncol. 2012;2(4):296–305. doi:10.1016/j.prro.2011.11.012 , slice from Sutherland AAMD presentation.

SAMS Question

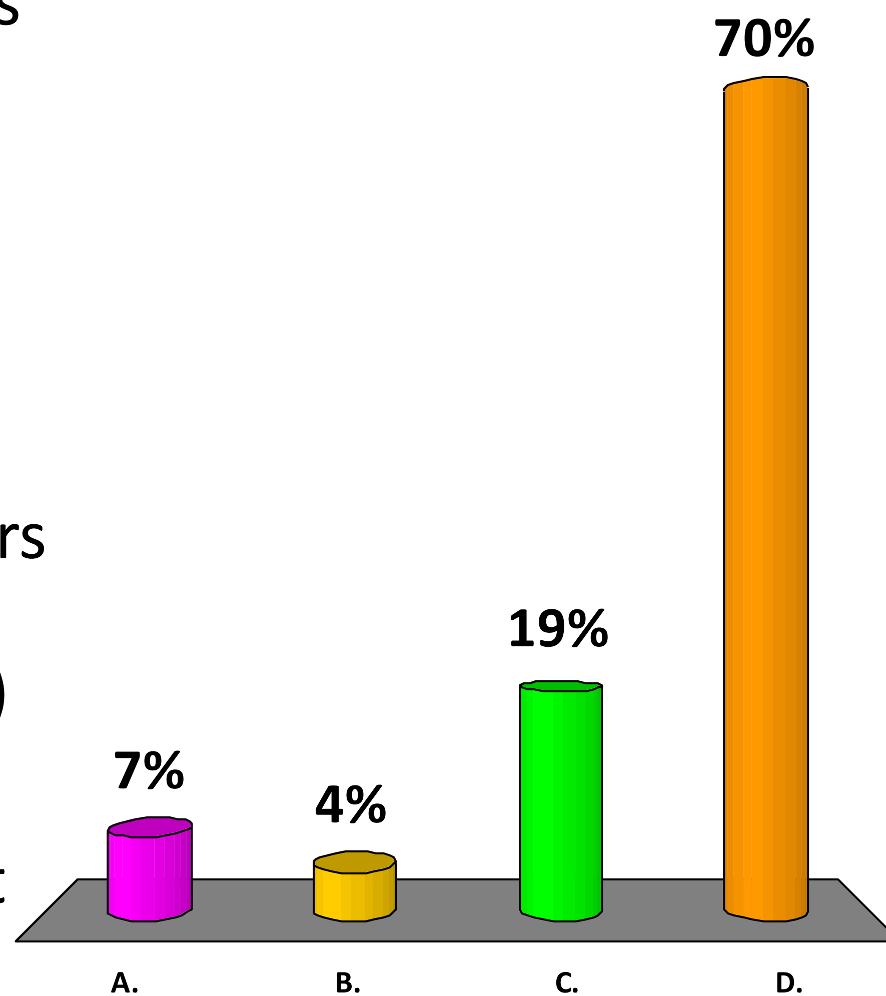
# What caused the variations of the plan quality among different planners?

A. Treatment planning systems are different

B. Rotational techniques such as VMAT or Tomotherapy are easy to generate better plan

C. Planner demographics (years of experience, confidence, certification and education) are different

D. Planners' skills are different



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C. Planner demographics (years of experience, confidence, certification and education) are different
D. Planners’ skills are different

**Answer: d) Planners’ skills are different**

Ref: Nelms BE, Robinson G, Markham J, et al. , “Variation in external beam treatment plan quality: An inter-institutional study of planners and planning systems” Pract Radiat Oncol. 2012;2(4):296–305

# The goal of knowledge based automatic planning

- Knowledge based planning attempts to minimize the variation of plan quality among different planners and different centers
  - Less inter-patient and inter-user variation
  - Sharing of KBP models is possible across the globe, allowing a treatment centers to use KBP models from other cancer centers
- Knowledge based automatic planning attempts to improve efficiencies:
  - Less trial and error required to achieve ideal plan

# Implementing autoplan technique in Clinic

- First step: Standardizing Naming Conventions in Radiation Oncology

# Standardizing Naming Conventions in Radiation Oncology: Why?

- Comparing dosimetry across patient datasets in inter-institutional data sharing
- Clinical trial repositories
- Integrated multi-institutional collaborative datasets and quality control centers
- Facility plan benchmarking and automated plan quality control

# Good Naming Convention

**Table 1** Examples of target volume (TV) names

| TV ICRU name | Primary/ node | Single/ multiple | Number | Prescription dose (cGy) | Proposed name |
|---|---|---|---|---|---|
| PTV | Primary | Single | N/A | 5000 | PTV_5000 |
| PTV | Node | Multiple | 1 | 5000 | PTVn1_5000 |
| CTV | Node | Multiple | 2 | 4000 | CTVn2_4000 |
| PTV | Node | Multiple | 2 | 4000 | PTVn2_4000 |
| PTV | Primary | Multiple | 1 | 5000 | PTVp1_5000 |

*Abbreviation:* ICRU = International Commission on Radiation Units and Measurements.

**Table 2** Planning organs at risk volumes

| Organ at risk name | Left/right | Margin (mm) | Proposed name |
|---|---|---|---|
| SpinalCord | N/A | Nonuniform | SpinalCord_PRV |
| SpinalCord PRV | N/A | 5 | SpinalCord _05 |
| Parotid | Left | 0 | Parotid_L |
| Parotid | Right | 0 | Parotid_R |
| Total parotid | Left+Right | 0 | Parotids |
| Kidney | Left | 10 | Kidney_L_10 |



**Table 3a** Standardized organ at risk names

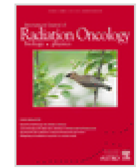
| Standard names | Description | Standard names | Description |
|---|---|---|---|
| AnalCanal | Anal Canal | **Esophagus_Middle** | **Middle Esophagus** |
| **A_Pulmonary** | **Pulmonary Artery** | External | Skin |
| **A_Carotid** | **Carotid Artery** | **Eye** | **Eye** |
| **A_Brachiocephali** | **Brachiocephalic Artery** | Femur | Femur |
| **A_Coronary** | **Coronary Artery** | **FemoralJoint** | **Femoral Joint** |
| **A_Subclavicular** | **Subclavicular Artery** | **FrontalLobe** | **Frontal Lobe** |
| **A_Hypophyseal** | **Hypophyseal Artery** | **GHJoint** | **Glenohumeral Joint** |

# Two good references to implement the standardizing naming convention

ELSEVIER

International Journal of Radiation Oncology*Biology*Physics

Volume 83, Issue 4, 15 July 2012, Pages 1344–1349



Physics Contribution

## Standardizing Naming Conventions in Radiation Oncology

Lakshmi Santanam, Ph.D.[*], Coen Hurkmans, Ph.D.[†], Sasa Mutic, Ph.D.[*], Corine van Vliet-Vroegindeweij, Ph.D.[‡], Scott Brame, Ph.D.[*], William Straube, M.S.[*], James Galvin, D.Sc.[‡], Prabhakar Tripuraneni, M.D.[§], Jeff Michalski, M.D.[*], Walter Bosch, D.Sc.[*, ¶]

Journal of Radiation Oncology Informatics

## A Rational Informatics-enabled approach to the Standardised Naming of Contours and Volumes in Radiation Oncology Planning

Research Article

Alexis A. Miller [1,2*]

1 Centre for Oncology Informatics, Faculty of Engineering & Information Science, University of Wollongong, Wollongong NSW, Australia

2 Department of Radiation Oncology, Illawarra Cancer Care Centre, Wollongong NSW, Australia

# Automatic Contour Generation/Auto Segmentation

- Auto-Segmentation algorithms are being extensively developed. It will be covered in other sessions
- The development also reached to the point that majority contours can be generated automatically with minimal human intervention

# Implementing autoplan technique in Clinic

- First step: Standardizing Naming Conventions in Radiation Oncology
- Second step: Automatic Beam Angle Placement

# Automatic Beam Angle Placement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**Fast VMAT Planning with Interactive Real-Time Dose Manipulation**

**K Otto*,University of British Columbia, BC, Canada**

TH-A-137-1 Thursday 8:00AM - 9:55AM Room: 137

Purpose: Develop a planning platform for real-time interactive manipulation of dose distributions including DVHs and other dose metrics.

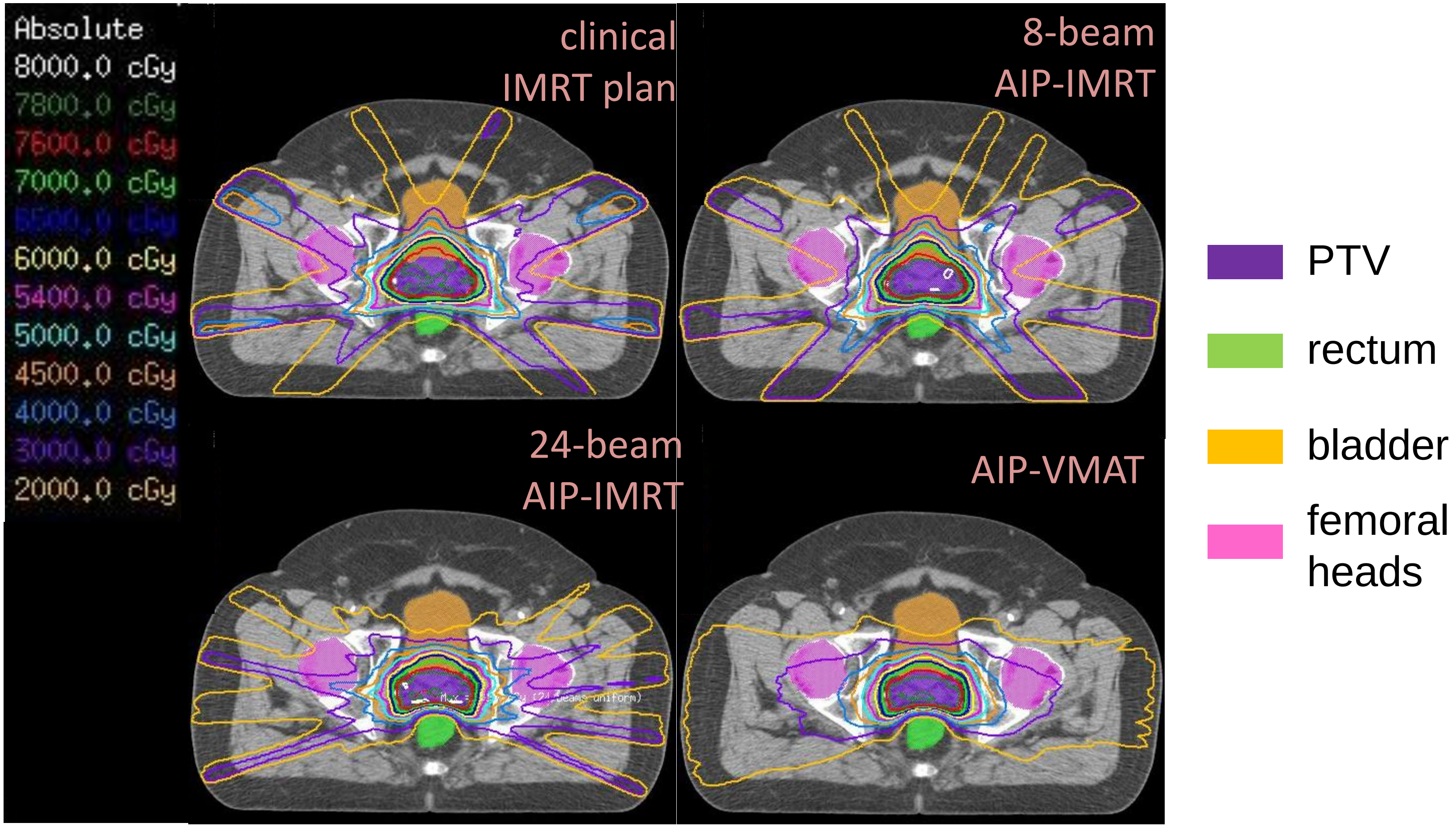
Methods: Intercomparisons of fixed beam IMRT, VMAT and Tomotherapy have been performed by several investigators. Other studies have compared number of beams, number of arcs and type of MLC. Generally these studies have shown only small differences in dose distribution quality. The hypothesis presented here is that delivery systems for photon external beam radiation therapy have reached a fundamental limit in their ability to create arbitrary dose distributions and that achievable dose distributions may be modeled more efficiently without requiring an exact representation of delivery parameters and beam characteristics. An interactive dose manipulation system was developed that incorporates a novel method for modeling achievable dose distributions. Computationally efficient methods for 3D fluence projection, photon scatter and electron transport were developed. Graphical navigation of dose distributions is achieved by a sophisticated method of identifying contributing fluence elements, modifying those elements and re-computing the entire dose distribution.

K Otto

Intercomparisons of fixed beam IMRT, VMAT and Tomotherapy have been performed by several investigators. Other studies have compared number of beams, number of arcs and type of MLC. Generally these studies have shown only small differences in dose distribution quality. The hypothesis presented here is that delivery systems for photon external beam radiation therapy have reached a fundamental limit in their ability to create arbitrary dose distributions

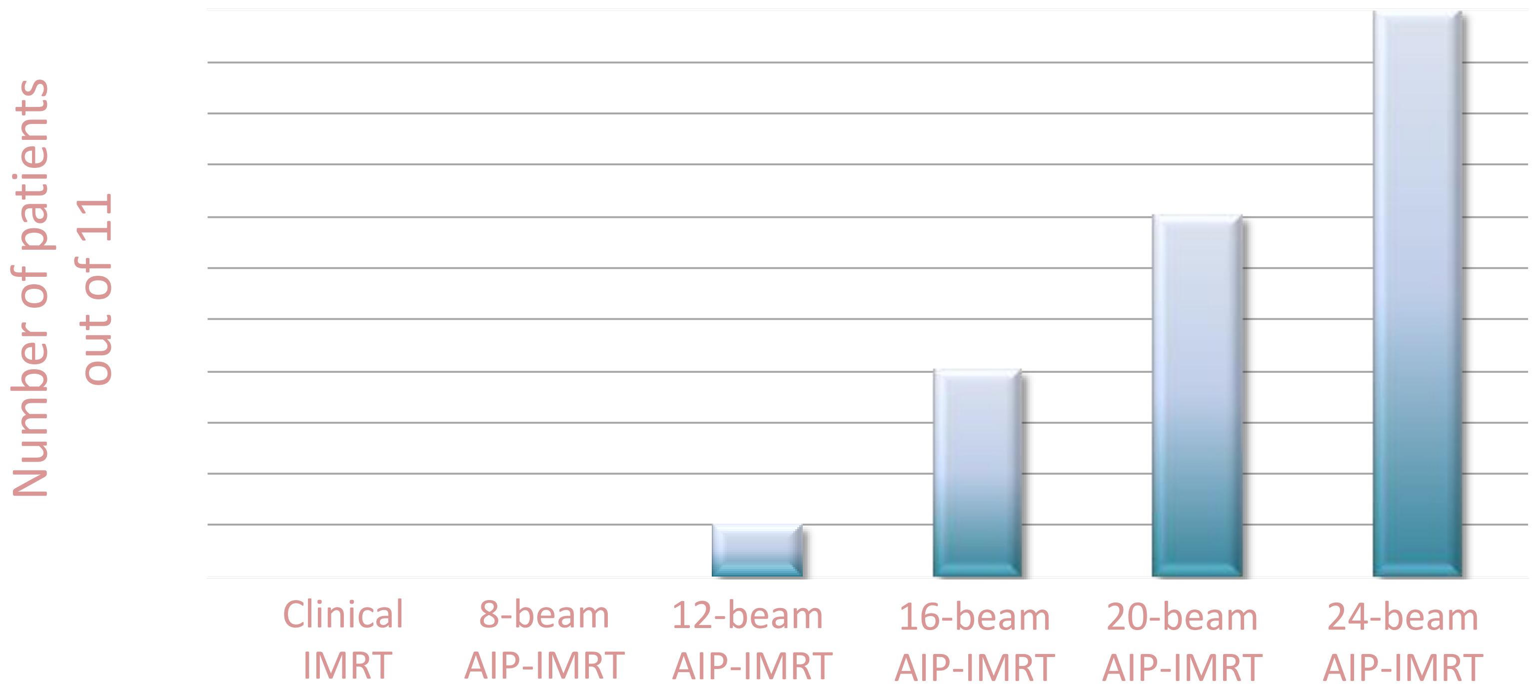
Karl Otto, “Real-time interactive treatment planning”, Phys. Med. Biol. (2014) 4845-4859

# 24-beam IMRT ~ VMAT




- AIP-based plans, especially the VMAT plan, show
  - Improved the dose sparing in the rectum and the bladder
  - Greatly reduced the amount of hot spots near the body surface
  - Reduced dose spreading out to normal tissue

# Number of Patients with Superior or Equal Rectum Sparing in IMRT to VMAT

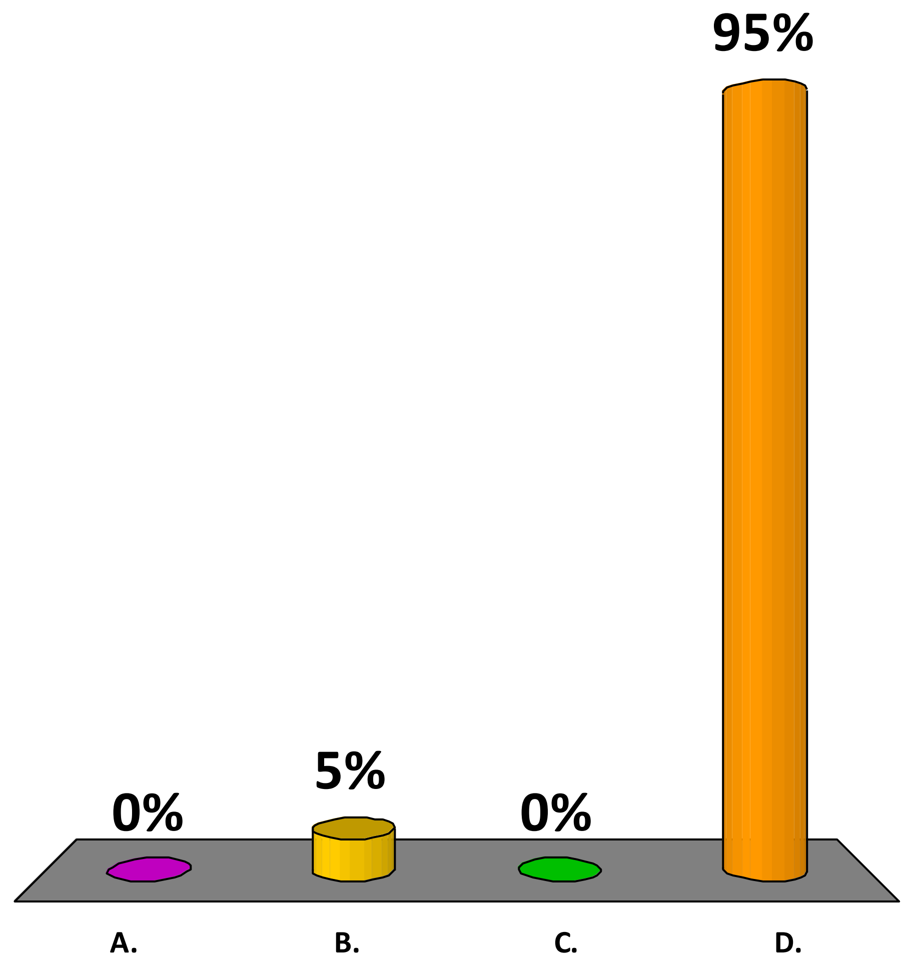



- AIP-based VMAT plans are consistently better than 8-beam clinical plans and 8-beam AIP-based IMRT plans
- IMRT plan quality improves as more beams are used
- Different patients show variations in IMRT plan quality in comparison to VMAT plan

SAMS Question

# Intercomparisons of fixed beam IMRT, VMAT and Tomotherapy indicated that:

A. Fixed beam IMRT plans are better
B. VMAT/RapidArc plans are better
C. Tomotherapy plans are better
D. Only small differences in dose distribution quality if each type of plans are designed optimally



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**Answer: d) Only small differences in dose distribution quality if each type of plans are designed optimally**

Ref: Karl Otto, “Real-time interactive treatment planning”, Phys. Med. Biol. (2014) 4845-4859

# Beam Angle Selection Automation for mdaccAutoPlan System: VMAT/RapidArc

- It is relatively easy to have a class solution for VMAT/RapidArc plans
  - Two-arcs (Partial or full arc)  class solution is automatically provided without planner’s input
- How about fixed beam IMRT plan?

# It is much harder to design a 5-beam plan than a 7-beam plan

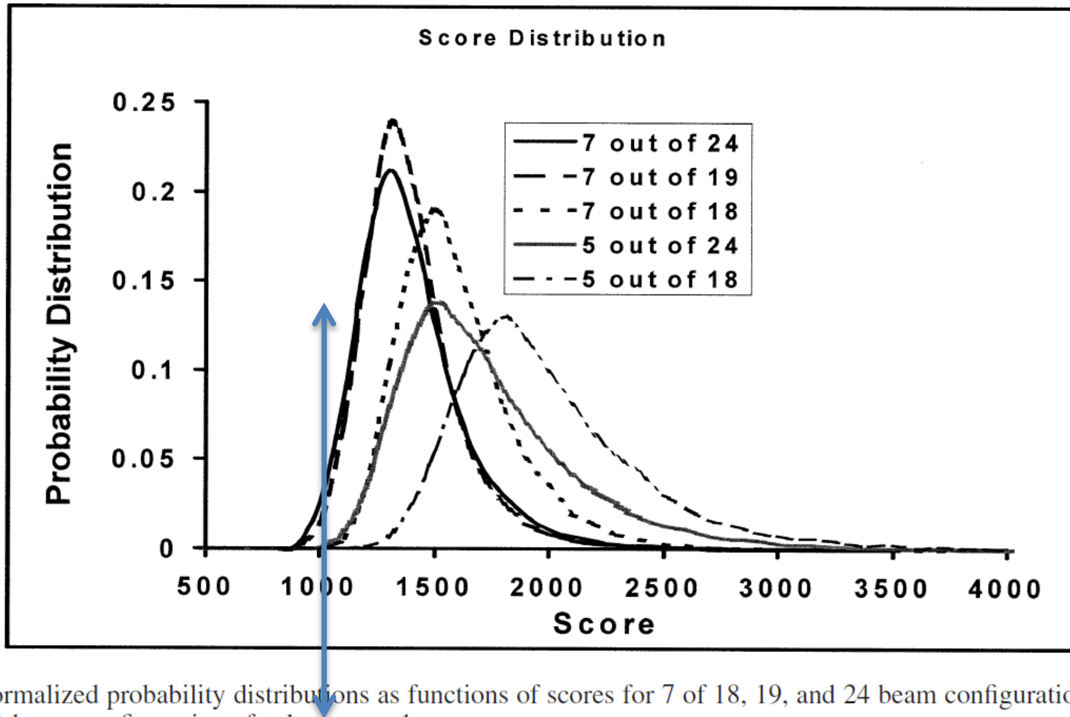



Fig. 4. Normalized probability distributions as functions of scores for 7 of 18, 19, and 24 beam configurations and 5 of 18 and 24 beam configurations for lung case 1.

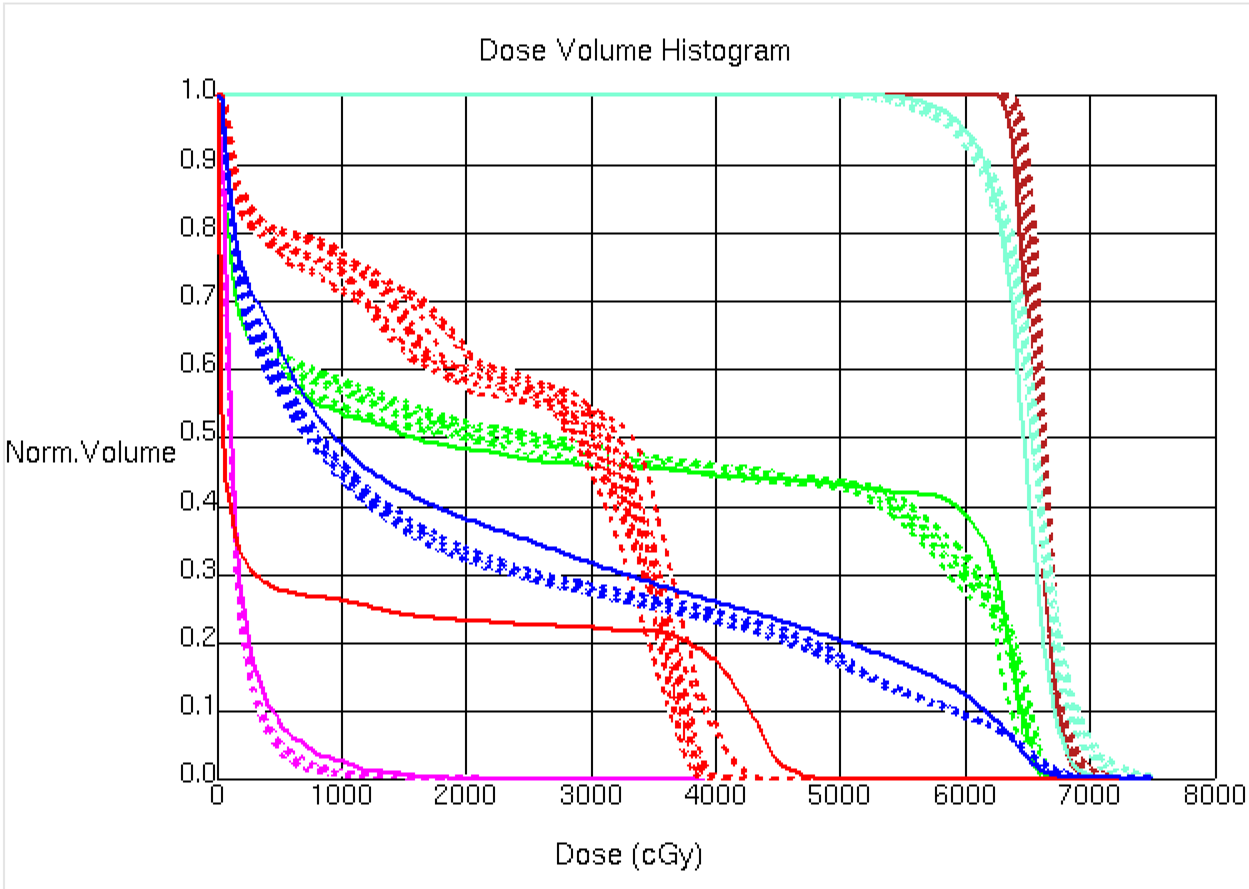
The lower score, the better the plan. The chance of achieving a lower score plan (better plan) using 7 beams is much higher than that using 5 beams


Wang X, Zhang X, Dong L, Liu H, Wu Q, Mohan R. Development of beam angle optimization for IMRT using accelerated exhaustive search strategy. Int J Radiat Oncol Biol Phys 60:1325-1137, 11/2004. PMID: 15519806.

# Beam Angle Selection Automation for mdaccAutoPlan System: fixed beam IMRT

- Provide a plan with 7 beams  using a fast BAO algorithm: very good chance that the beam angle is optimized.
- Meanwhile, also provide a 5 beam plan using a fast BAO algorithm: for majority cases, plan also has a high quality. But for some case, you might need to use 7 beam angle plan

# DVHs of the plans with different number of beam angles




Dashed lines: autoplans with 5,6,7,…,19 beams. Solid line: clinical plan

IOP Publishing | Institute of Physics and Engineering in Medicine Physics in Medicine & Biology
Phys. Med. Biol. 60 (2015) 1831–1843 doi:10.1088/0031-9155/60/5/1831

## Standardized beam bouquets for lung IMRT planning

Lulin Yuan[1], Q Jackie Wu[1], Fangfang Yin[1], Ying Li[2], Yang Sheng[3], Christopher R Kelsey[1] and Yaorong Ge[4]

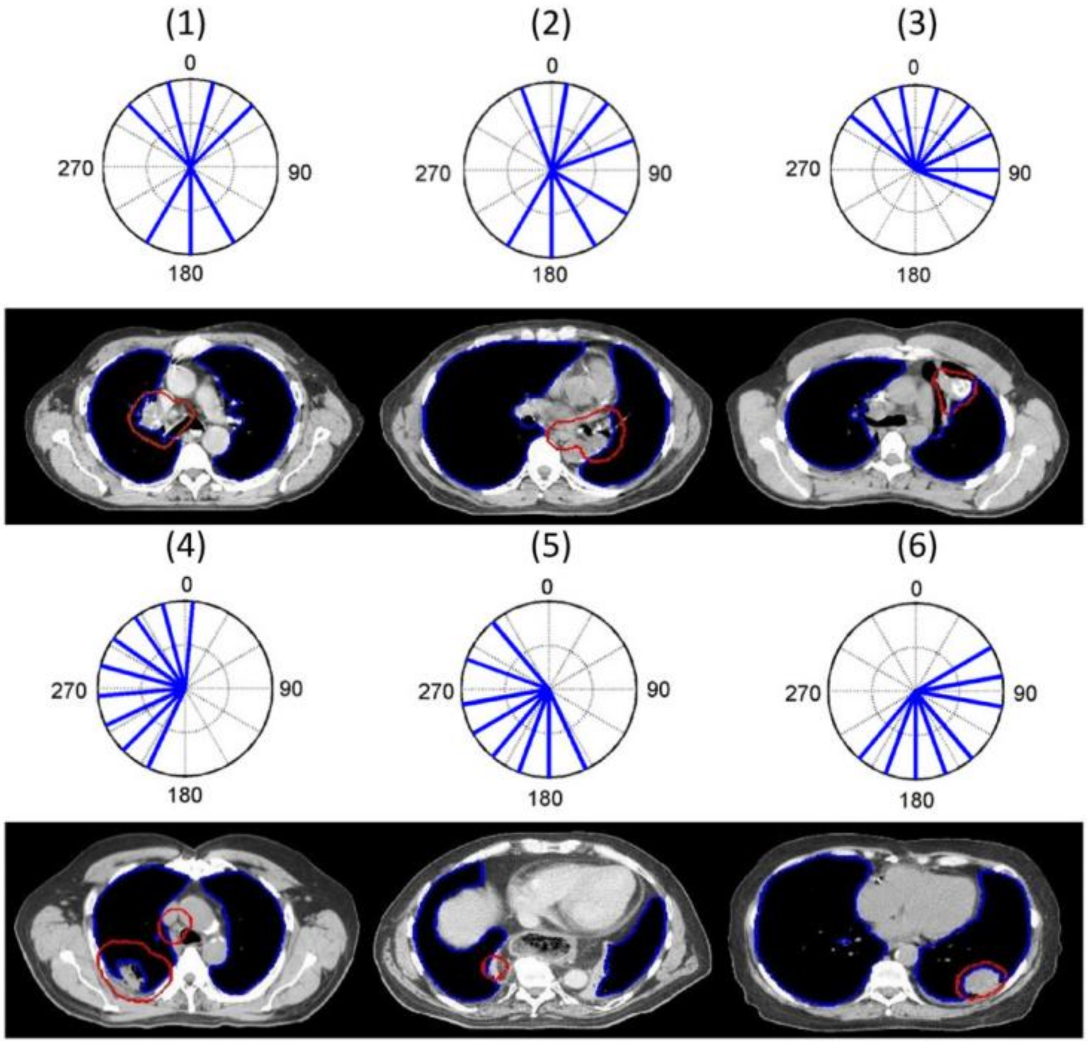



**Figure 2.** The six beam bouquets are shown in polar coordinates using International Electrotechnical Commission beam angle convention at the first and third rows. The solid radial lines indicate the beam directions. The number inside the parenthesis on top of each bouquet labels the ID of the bouquet. The representative axial CT image slices of the reference cases corresponding to the medoids of the six clusters are shown under each medoid at the second and fourth rows. The PTV is denoted by the red contours and the lung by the blue contours.

6 beam bouquets are good enough for all lung cases. Each beam bouquet has 7-9 beams

# Implementing autoplan technique in Clinic

- First step: Standardizing Naming Conventions in Radiation Oncology
- Second step: Automatic Beam Angle Placement
- Third step: Objective function parameter automation/optimization

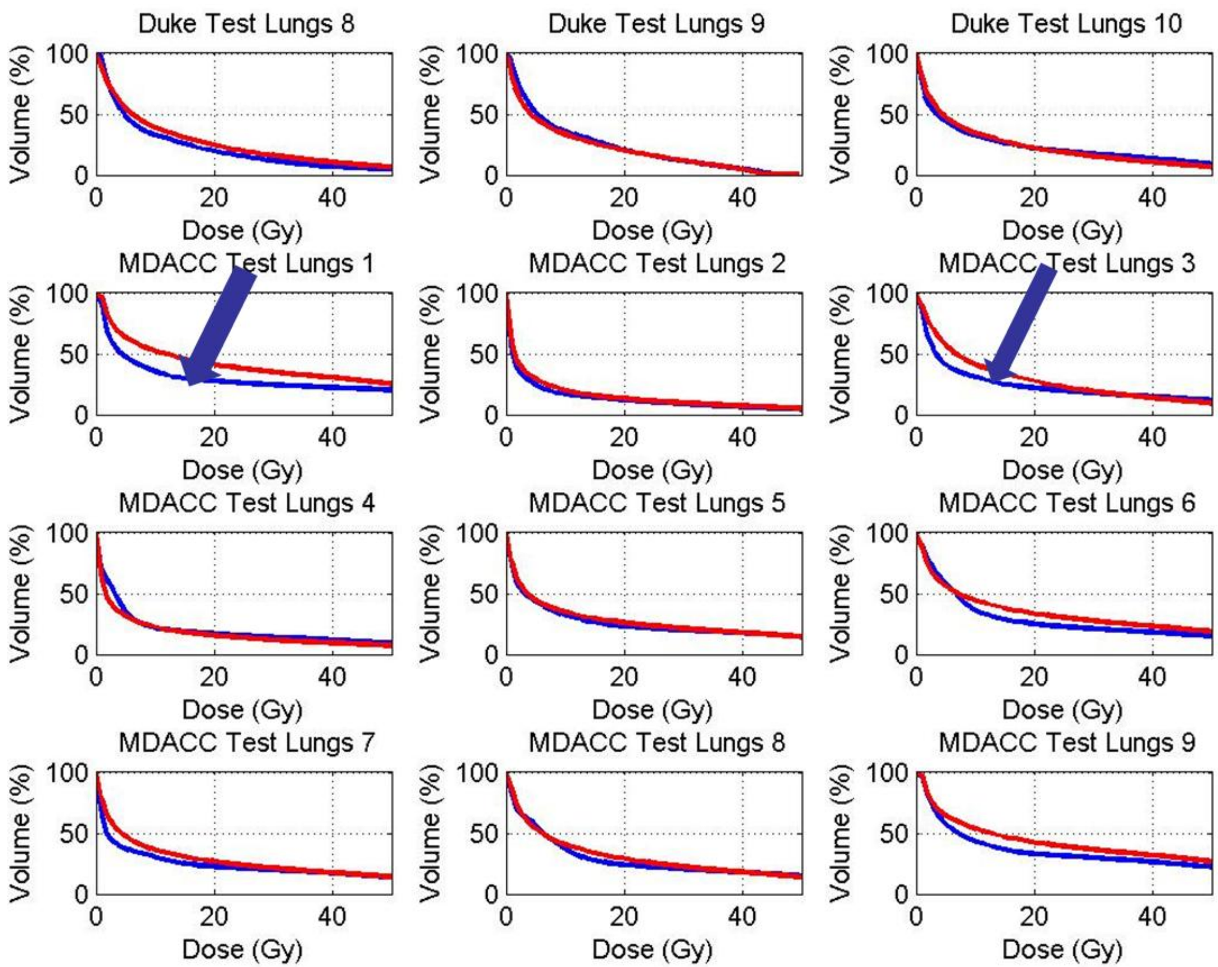
# Objective function parameter automation/optimizaiton

- Varian approach: Rapidplan
- Philips approach: automatic planning
- mdaccAutoPlan system: Very experienced planners + computational scientists (treatment planning language) provided a solution which can generate high quality plan for majority cases with one button click.

# Rapidplan in Eclipse

- **Build Model:** RapidPlan uses model libraries that contain dose distributions and OAR and PTV geometries of previously treated patients to generate a **prediction range of achievable DVHs** for individual OARs of new patients
- **Optimization:** Optimization is automated by placing numerous dose-volume objectives along the **lower range** of the predicted DVHs.
- **Priorities:** Although RapidPlan can calculate optimal priorities for optimization objectives, this feature is still being refined and needs to be input manually now. (under development)

# DUKE IMRT Model, MDACC IMRT Test Case




Model can be shared in different institutions: DVH predicted based on Duke's IMRT experience for MDACC 10 P01 lung cases (Thanks Jackie Wu to share this result with me)

# Publication validating Rapidplan



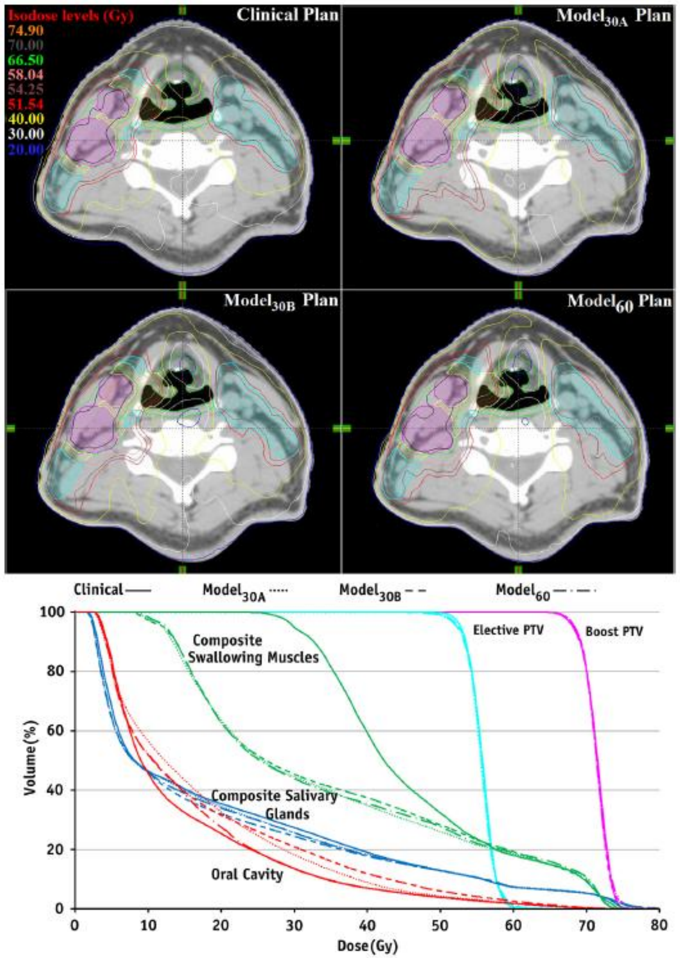



Fig. 2. Dose distributions and dose-volume histograms are shown for the clinical plan and 3 knowledge-based plans for a patient from EG1 in whom improved sparing of the composite swallowing muscles (green DVH line) was obtained at the cost of lower dose conformity outside the boost and elective planning target volumes (PTVs, magenta and cyan, respectively).

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Physics Contribution

## Evaluation of a Knowledge-Based Planning Solution for Head and Neck Cancer

Jim P. Tol, MSc, Alexander R. Delaney, BSc,
Max Dahele, MBChB, MSc, PhD, FRCP, FRCR, Ben J. Slotman, MD, PhD,
and Wilko F.A.R. Verbakel, PhD

*Department of Radiotherapy, VU University Medical Center, Amsterdam, The Netherlands*

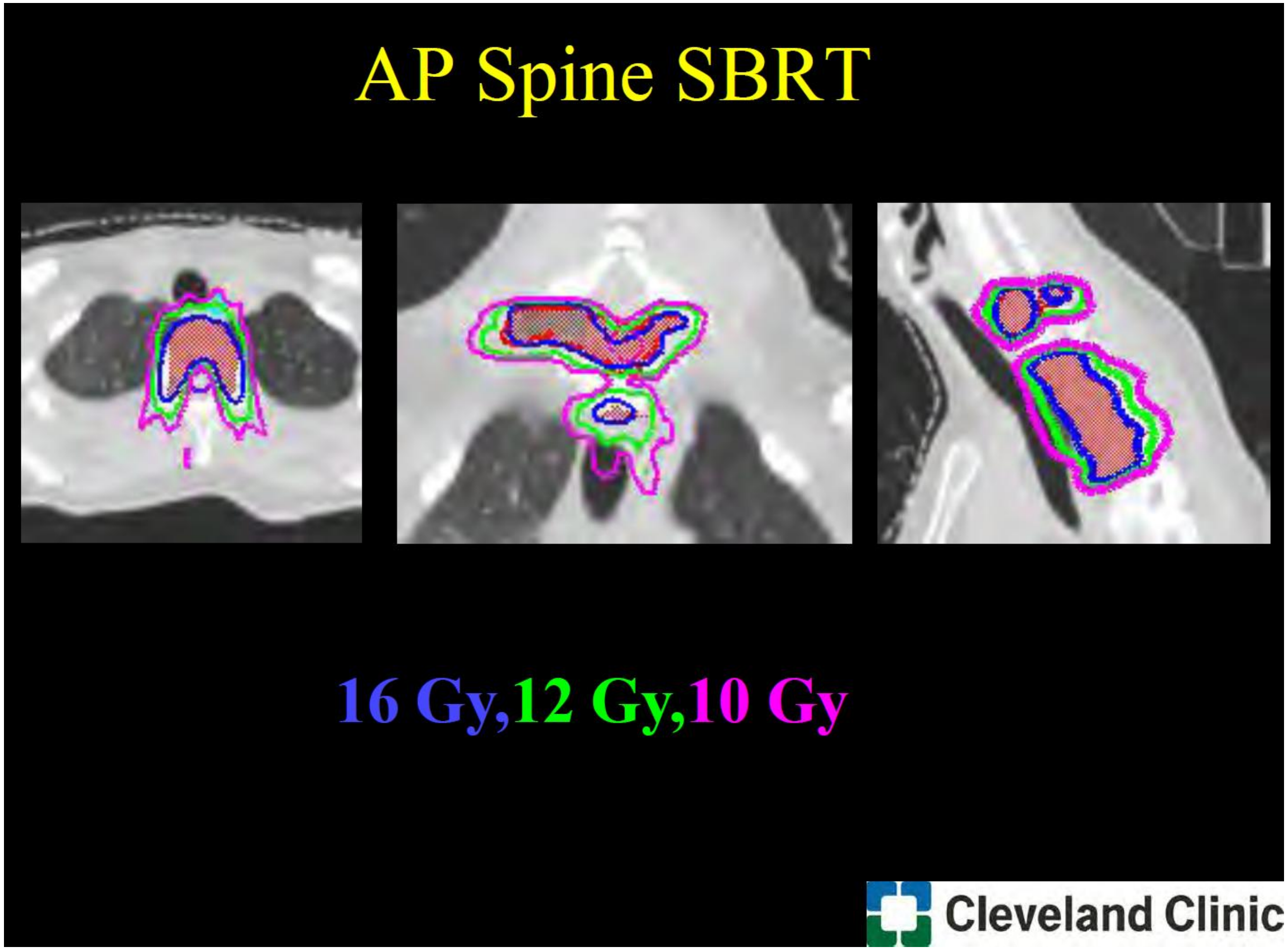
Received Jun 20, 2014, and in revised form Oct 16, 2014. Accepted for publication Nov 11, 2014.

# Auto-Planning in Pinnacle

- Mimics the planners’ thought process
- Utilizes the planners’ tricks, such as creation of surrounding structures, tuning contours automatically
- Automatically runs multiple loops while adjusting planning objectives-similar to what planners manually do

From Dr. Ping Xiao’s (Cleveland Clinic) presentation

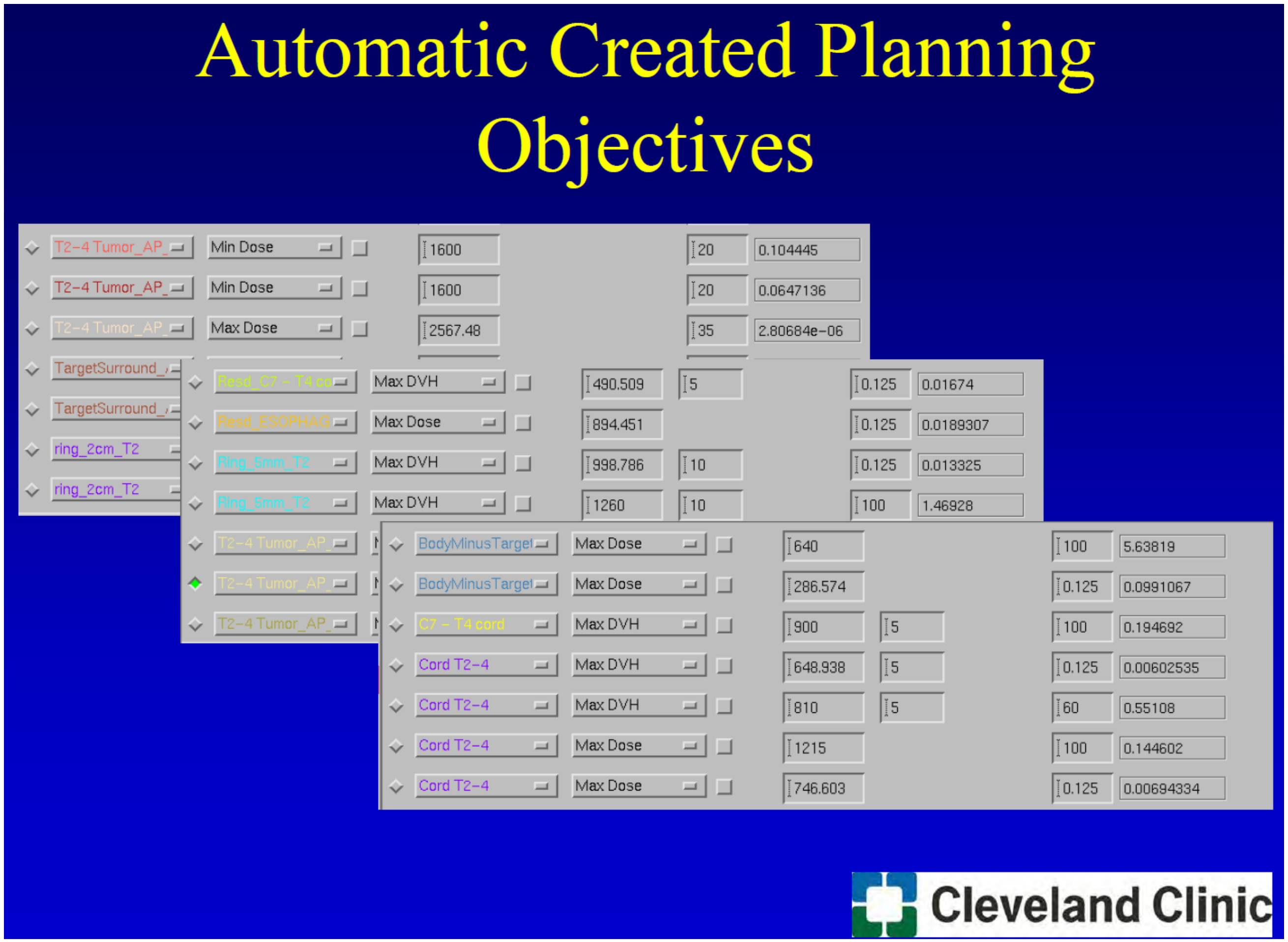
# A spine SBRT plan generated by Auto-Planning tool in Pinnacle



# Input to Pinnacle Auto-Planning tool


Optimization goals are different from objectives. Need to validate that same optimization goals can be used for different patients

# Planning Objectives are automatically generated



# mdaccAutoPlan System

- One-button click to generate the treatment plan without human interactions
- Most recent development: Treatment planning language to allow the advanced user to extend the system.
- First version has been used in the clinical trial at 2009. Currently, several sister institutions in china are implementing mdaccAutoPlan  system supported by a sister institution network grant by MDACC.

# Validation of mdaccAutoPlan

- Autoplan algorithm: **Zhang X**, Li X, Quan EM, Pan X, Li Y. A methodology for automatic intensity-modulated radiation treatment planning for lung cancer**. Physics in Medicine and Biology 56:3873-3893, 6/2011**.
- Validation of IMRT and VMAT autoplan for prostate cancer: Quan EM, Li X, Wang X, Kudchadker,R, Johnson J, Lee A, Kuban D**, Zhang X**. A comprehensive comparison of IMRT and VMAT plan quality for prostate cancer treatment. **Int. J. Radiat. Oncol., Biol., Phys 83(4):1169-1178, 7/2012**.
- Validation of IMRT and VMAT autoplan for lung cancer: Quan EM, Chang JY, Liao Z, Xia T, Yuan Z, Liu H, Li X, Wages C, Mohan R**, Zhang X**. **Automated** VMAT treatment planning for stage III **lung cancer**: how does it compare with IMRT? **Int. J. Radiat. Oncol., Biol., Phys 84(1):e69-e76, 9/2012**.
- Validation of automated adaptive planning for prostate cancer based on autoplan: Li X, Quan EM, Li Y, Pan X, Zhou Y, Wang X, Du W, Kudchadker RJ, Johnson JL, Kuban DA, Lee AK, Zhang X. A fully automated method for CT-on-rails-guided online adaptive planning for prostate cancer intensity modulated radiation therapy. Int J Radiat Oncol Biol Phys 86(5):835-41, 8/2013. e-Pub 5/2013. PMID: 23726001.

# Validation of autoplan

- Automated IMRT planning for stage III lung cancer: how does it compare with clinical IMRT plan?

ARTICLE IN PRESS

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Clinical Investigation

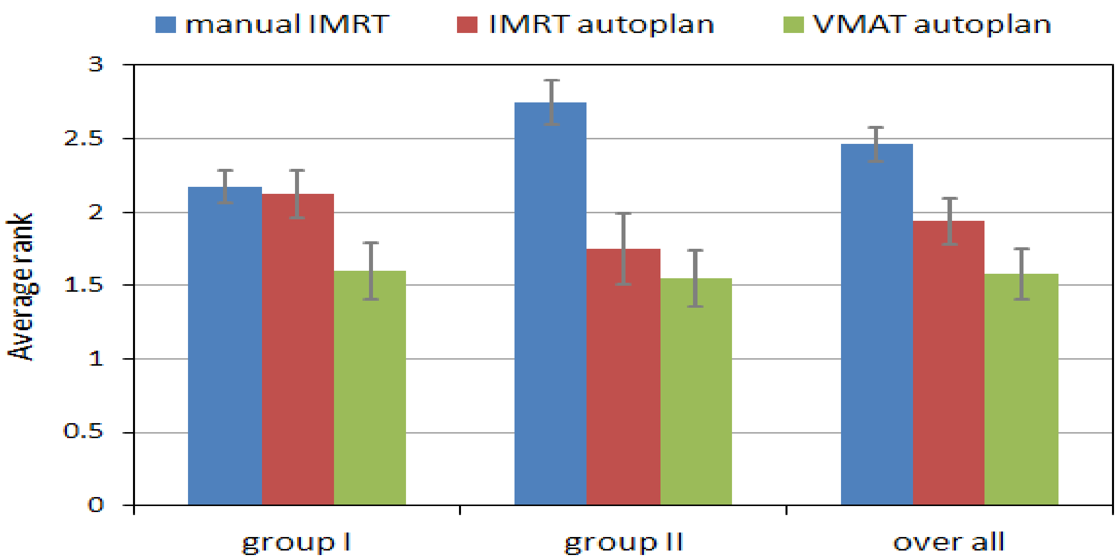
**Automated Volumetric Modulated Arc Therapy Treatment Planning for Stage III Lung Cancer: How Does It Compare With Intensity-modulated Radiotherapy?**

Enzhuo M. Quan, PhD,[*] Joe Y. Chang, PhD,[†] Zhongxing Liao, PhD,[†] Tingyi Xia, PhD,[‡] Zhiyong Yuan, PhD,[§] Hui Liu, PhD,[†,‖] Xiaoqiang Li, MS,[*] Cody A. Wages,[*] Radhe Mohan, PhD,[*] and Xiaodong Zhang, PhD[*]

# Plan quality comparison between manually designed best effort plan with autoplan

- **Group I patients/best effort manual plan**: dosimetrists and mdaccAutoPlan system designed IMRT plan simultaneously. The better plan was used for patient treatment. (in a trial comparing proton and photon, PI Z Liao)
- **Group II patients/conventional plan**, mdaccAutoPlan system retrospectively re-designed clinical plans.
- mdaccAutoPlan system designed auto-VMAT plans for both group patients
- “unbiased” plan evaluation
  - Five radiation oncologists blind-reviewed and ranked the three plans of each patient independently.
  - Drs. Chang, Liao (MDACC), Dr. T Xia (301 Hospital, China),Dr. Z. Yuan, (Tianjin Cancer Institute, China), Dr. H. Liu (Zhong Shang Hospital, China) reviewed and ranked plan

# Blind review results




- A lower rank value indicates a better plan quality and vice versa.
- Group I, dosimetrist and mdaccAutoPlan system designed the plan for the same patient simultaneously
- Group II, mdaccAutoplan system replan the previous approved clinical plan

SAMS Question

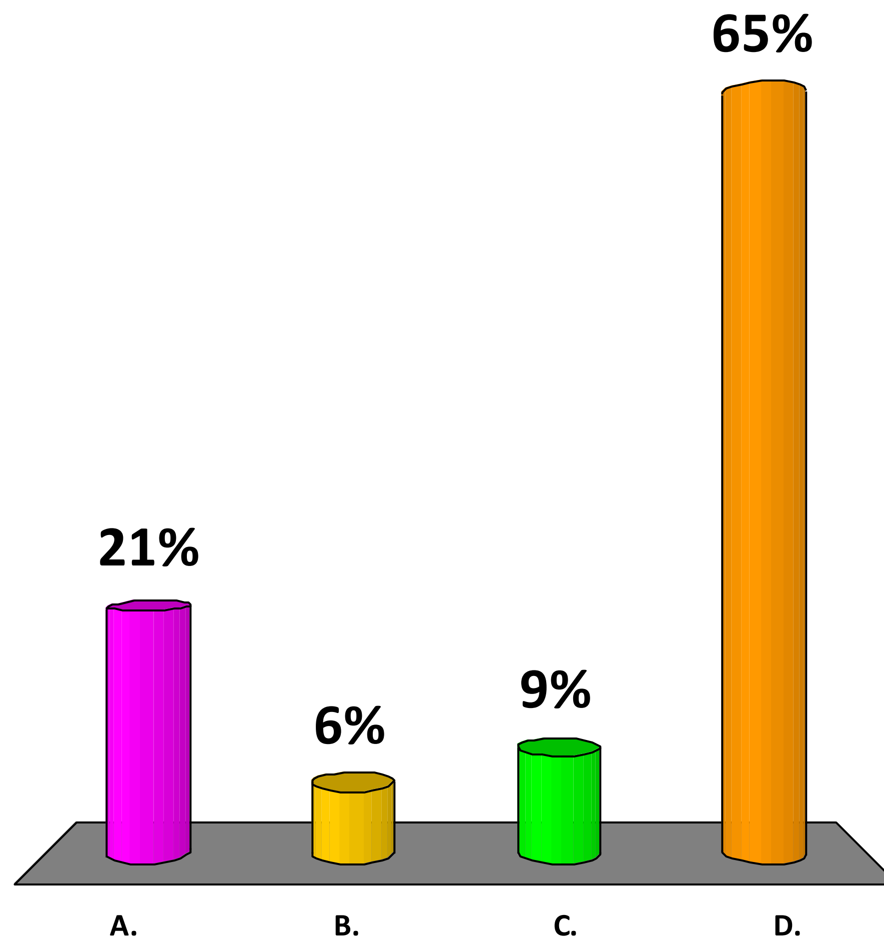
# Comparison of the plan quality of autoplan with the plan designed manually indicated:

A. Knowledge based autoplans are always better

B. Manually generated plans are always better

C. There is no difference in plan quality

D. If planners spent enough effort, the quality of manually generated plan can reach that of autoplans



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**Answer: d) If planners spent enough effort, the quality of manually generated plan can reach that of autoplan**

Ref: Quan EM, Chang JY, Liao Z, Xia T, Yuan Z, Liu H, Li X, Wages C, Mohan R, Zhang X. Automated VMAT treatment planning for stage III lung cancer: how does it compare with IMRT? Int. J. Radiat. Oncol., Biol., Phys 84(1):e69-e76, 9/2012.

# Clinical Use Cases for Automatic Planning: Sharing MDACC experiences

- Knowledge based planning attempts to minimize the variation of plan quality among different planners and different centers
  - To validate the quality of the radiotherapy could be improved through automation in a hospital system (MDACC's sister institutions in china) which is very different from MDACC

# Status report of application and development of mdaccAutoPlan system in Tianjin Medical University Cancer Institute and Hospital

Shengpeng Jiang (TJMUCIH, CHINA), Chengwen Yang (TJMUCIH, CHINA), Wei Wang (TJMUCIH, CHINA), Jian Sun (TJMUCIH, CHINA), Qi Wang (TJMUCIH, CHINA), Jie Chen (TJMUCIH, CHINA), Yao Sun(TJMUCIH, CHINA), Jinqiang You (TJMUCIH, CHINA), Peiguo Wang (TJMUCIH, CHINA), Lujun Zhao (TJMUCIH, CHINA), Li Zhu (TJMUCIH, CHINA) , Zhiyong Yuan (TJMUCIH, CHINA) , Ping Wang (TJMUCIH, CHINA) , Joe Chang (MD Anderson, USA) , Xiaodong Zhang (MD Anderson, USA)

Jiang et. al., Oral Presentation of 2015 MDACC Global Academic Program Meeting

# Background

- Basically, the mdaccAutoPlan system is a kind of human intelligence.
- The advantages of mdaccAutoPlan system:

1. convenient (one button click)
2. time efficient (~1h)
3. good plan quality (pretty much can achieve the best balance between best OAR and normal tissue protection and  target coverage compromise)

Jiang et. al., Oral Presentation of 2015 MDACC Global Academic Program Meeting

# Methods

- MdaccAutoPlan system developed in MD Anderson Cancer Center can be used directly for lung cancer, esophagus cancer, lymphoma and mesothelioma in Tianjin Medical University Cancer Institute and Hospital because the requirements of physicians are similar.

Jiang et. al., Oral Presentation of 2015 MDACC Global Academic Program Meeting

# Methods

- In the same way, we summarized general optimization methods for nasopharynx cancer, head and neck NK/T cell lymphoma, cervical cancer, endometrial cancer, prostate cancer, sarcoma and different kinds of cancer with bone metastasis and embedded them in mdaccAutoPlan system to satisfy Tianjin Medical University Cancer Institute and Hospital physicians.

Jiang et. al., Oral Presentation of 2015 MDACC Global Academic Program Meeting

# Results

- More than 200 autoplans has been generated by mdaccAutoPlan system and delivered including lung cancer, esophagus cancer, lymphoma, nasopharynx cancer, head and neck NK/T cell lymphoma, cervical cancer, endometrial cancer, prostate cancer, sarcoma and different kinds of cancer with bone metastasis in Tianjin Medical University Cancer Institute and Hospital from December 2014 to March 2015

Jiang et. al., Oral Presentation of 2015 MDACC Global Academic Program Meeting

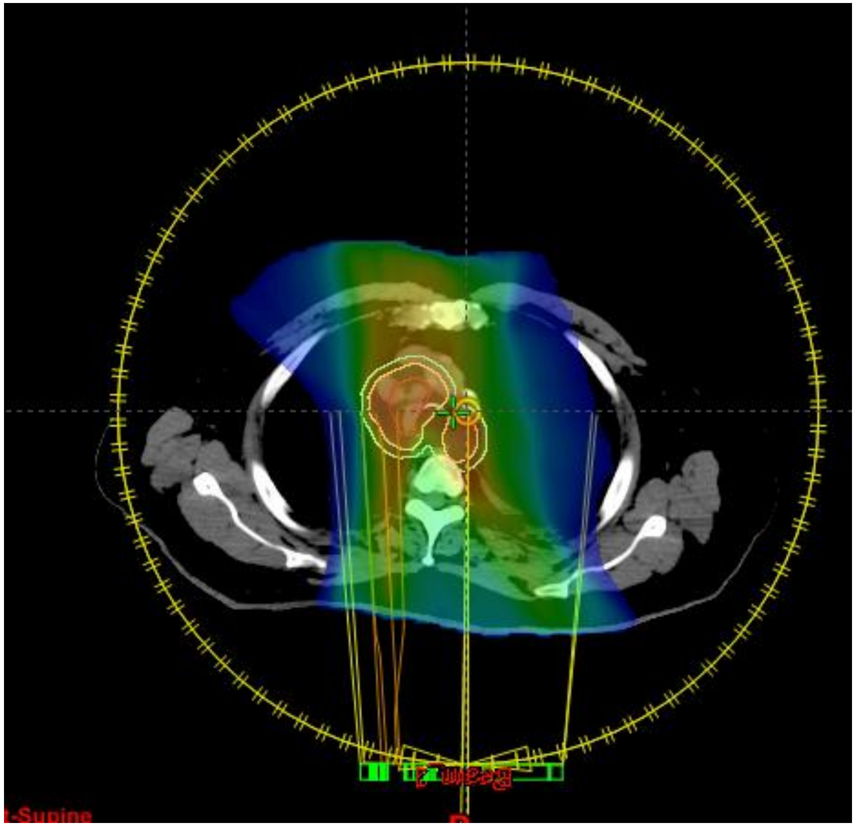
# Clinical Use Cases for Automatic Planning: achieving full potential of new technology

- The quality of IMPT plan designed by in-experienced planner could be inferior to that of VMAT plan designed by experienced planner: Photon Challenge
- Using the knowledge gained in VMAT plan design can help efficiently and effectively design high quality IMPT plan. The quality of IMPT plan can be controlled to ensure the superiority of IMPT plan compared to VMAT/IMRT plan.

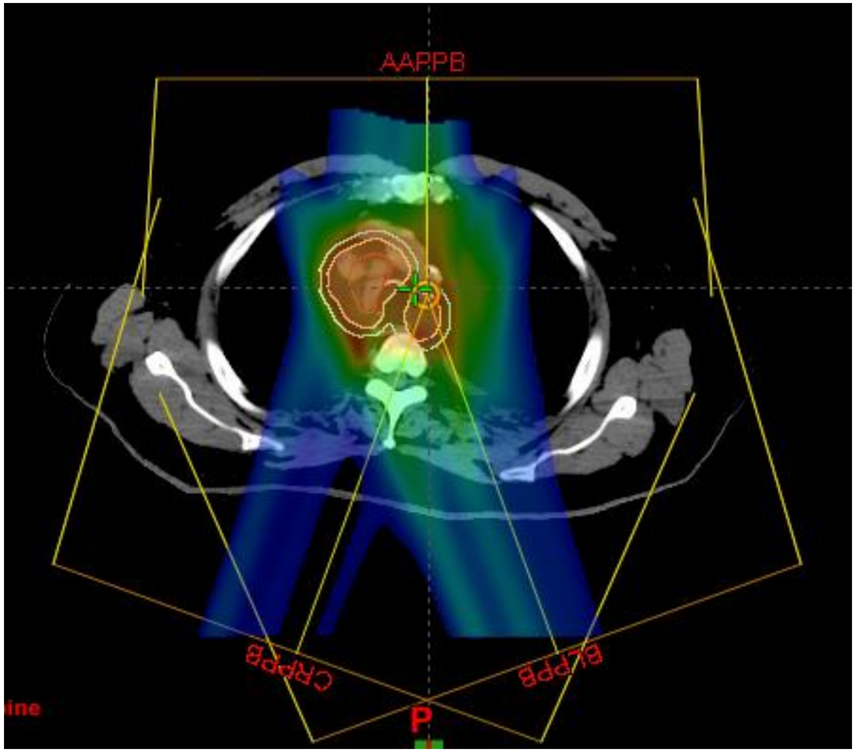
# A Methodology for Quality Control of IMPT Treatment Plan based on VMAT Plan

- A VMAT plan is first generated by in-house developed automatic planning system.
- An in-house developed tool is used to generate the dose volume constrains from automatically generated VMAT plan for the IMPT plan as a plan template to Eclipse TPS.
- The beam angles for IMPT plan are selected based on the preferred angles in the VMAT plan.
- The dose volume constrains of IMPT plan are determined by importing the plan objectives generated from VMAT plan.

# IMPT beam angle assisted by VMAT dose distribution



VMAT plan generated by autoplan system



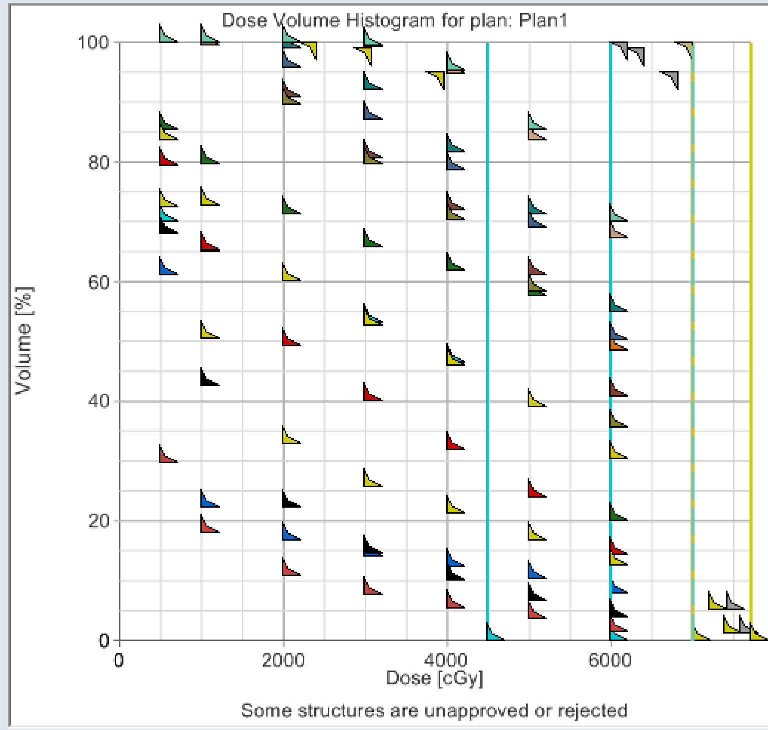

Beam angles and dose distributions in IMPT plan

# Dose volume objectives for IMPT plan directly obtained from VMAT plan designed by autoplan

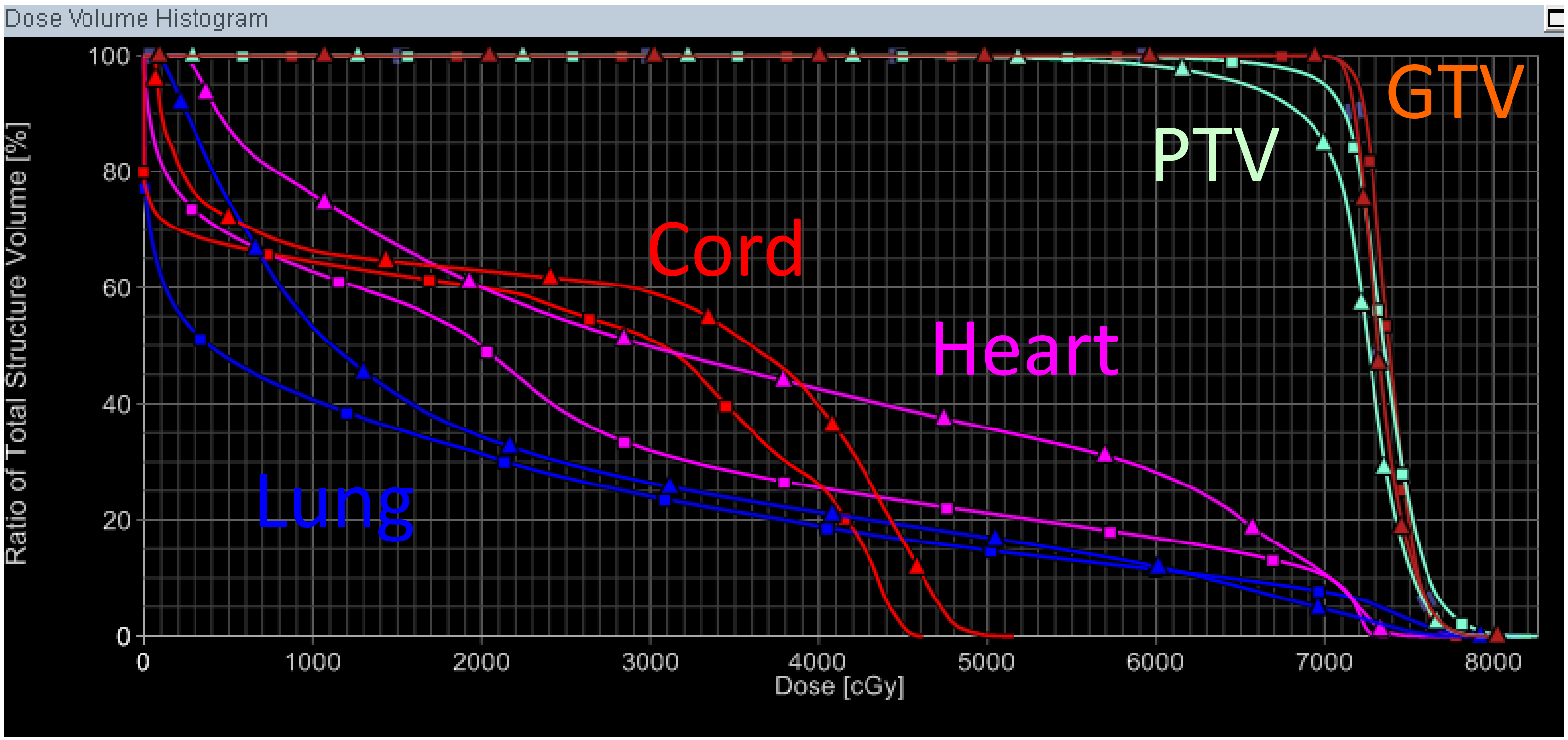
**Structures and Objectives** | Exclude Structures...

| | | | | | | |
|---|---|---|---|---|---|---|
| Upper | Volume [%]: | 10.0 | Dose [cGy]: | 4000.0 | Priority: | 150 |
| Upper | | 6.6 | | 5000.0 | | 150 |
| Upper | | 3.9 | | 6000.0 | | 150 |
| 1FSLungL | Volume [cc]: | 1421 | Points: | 47349 | Resolution [mm]: | 3.00 |
| 1FSLungR | Volume [cc]: | 1723 | Points: | 57447 | Resolution [mm]: | 3.00 |
| 1NT | Volume [cc]: | 27637 | Points: | 24872 | Resolution [mm]: | 10.00 |
| Upper | Volume [%]: | 29.7 | Dose [cGy]: | 500.0 | Priority: | 150 |
| Upper | | 18.0 | | 1000.0 | | 150 |
| Upper | | 10.7 | | 2000.0 | | 150 |
| Upper | | 7.5 | | 3000.0 | | 150 |
| Upper | | 5.4 | | 4000.0 | | 150 |
| Upper | | 3.5 | | 5000.0 | | 150 |
| Upper | | 1.4 | | 6000.0 | | 150 |
| 1PTV1 | Volume [cc]: | 901 | Points: | 30033 | Resolution [mm]: | 3.00 |
| Upper | Volume [%]: | 5.0 | Dose [cGy]: | 7420.0 | Priority: | 300 |
| Upper | | 1.0 | | 7580.0 | | 300 |
| Upper | | 0.0 | | 7960.0 | | 800 |
| Lower | Volume [%]: | 95.0 | Dose [cGy]: | 6820.0 | Priority: | 400 |
| Lower | | 99.0 | | 6400.0 | | 400 |
| Lower | | 99.9 | | 6200.0 | | 400 |
| 1PTV1-3mm | Volume [cc]: | 702 | Points: | 23395 | Resolution [mm]: | 3.00 |
| Lower | Volume [%]: | 99.9 | Dose [cGy]: | 7000.0 | Priority: | 300 |
| 1PTV12ring | Volume [cc]: | 213 | Points: | 7116 | Resolution [mm]: | 3.00 |
| Upper | Volume [%]: | 5.0 | Dose [cGy]: | 7210.0 | Priority: | 150 |

Add Upper Objective | Add Lower Objective | Delete Objective



# The quality of IMPT plan is ensured to be better than that of VMAT plan




Square: IMPT plan; Triangle: VMAT plan

# Summary

- Automatic planning will become one of the major planning method of choice for the future design of treatment plan
- Automatic planning plays essential role from expanding its definition of quality in radiation oncology to include not only avoidance of gross errors but also consistent delivery of the full potential of the currently available technology and evidence

# What autoplan means?

## Cutting dosimetrist jobs? No!

### New challenges:

1. Oversee entire process
2. More complex deliveries
3. Oversee dose accumulation processes
4. ADAPTIVE RT

From Dr. Patrick Kupelian's 2012 AAPM talk on the therapy symposium "Automatic Treatment Planning"

# Full potential of new technology might not been fully utilized

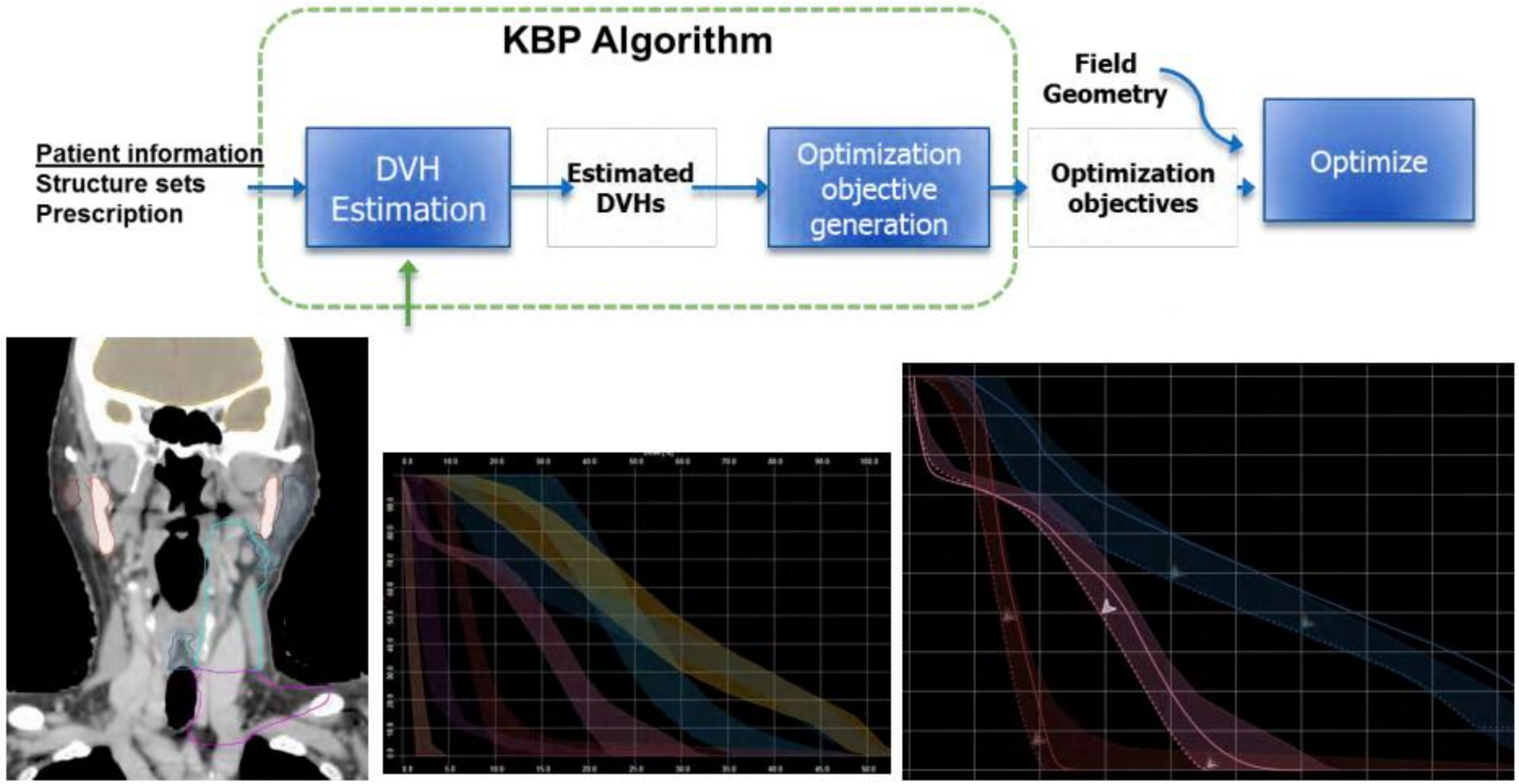
- Proton

| Total Lung | V5 | V10 | V20 | V30 | Mean (Gy) |
|---|---|---|---|---|---|
| Photon | 58.5 | 45.3 | 34.5 | 29.1 | 20.1 |
| Proton | 43.1 | 37.0 | 30.8 | 25.6 | 17.5 |
| autoplan | 51.9 | 38.3 | 28.8 | 24.6 | 17.4 |

| ROI | PTV (Vprescription) | Cord (Dmax) | Esophagus (V55) | Heart (V40) | CI | HI |
|---|---|---|---|---|---|---|
| Photon | 95.4 | 43.0 | 30.4 | 9.7 | 0.7 | 1.1 |
| Proton | 95.8 | 37.1 | 30.7 | 6.4 | | |
| autoplan | 95.0 | 37.9 | 26.7 | 8.5 | 0.8 | 1.2 |

Work published in 2006, Chang and Zhang et. al. , IJROBP, 65(4) 1087-1096

Zhang X, Li X, Quan EM, Pan X, Li Y. A methodology for automatic intensity-modulated radiation treatment planning for lung cancer. Phys Med Biol 56(13):3873-3893, 7/7/2011. e-Pub 6/8/2011. PMID: 21654043.




slice from Sutherland AAMD presentation