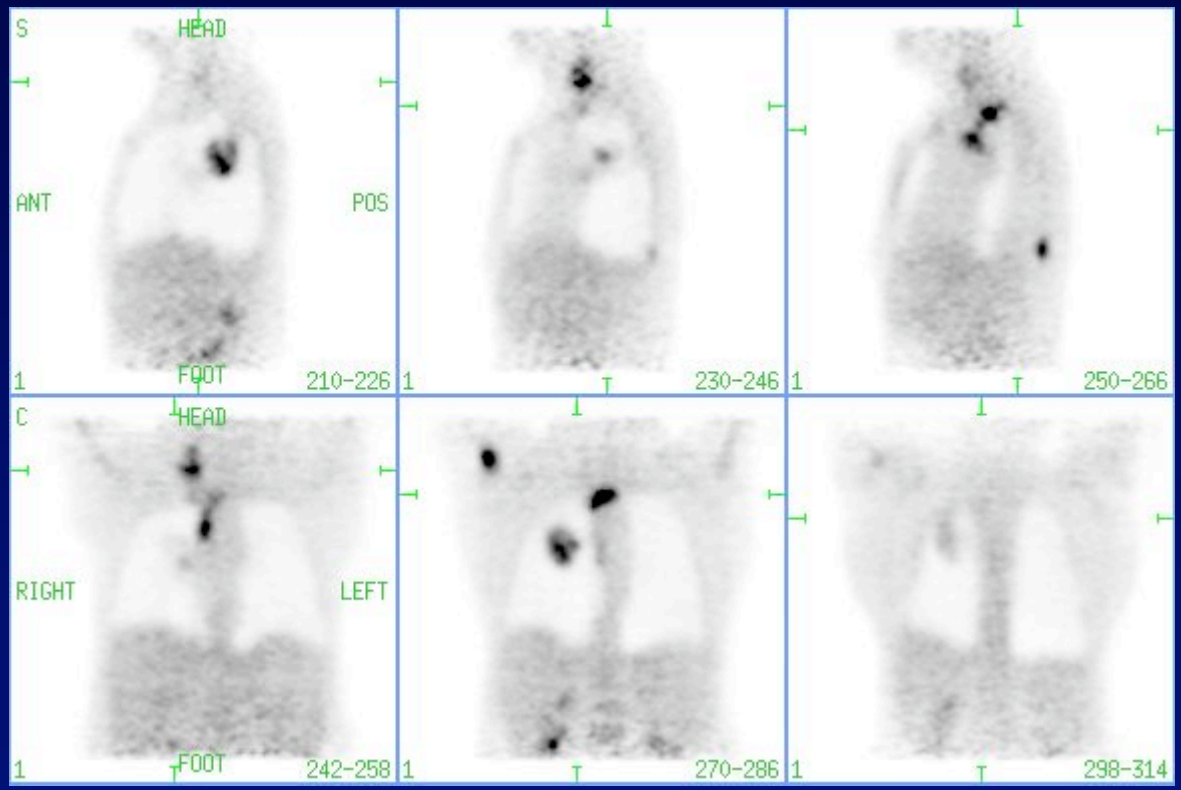
How PET is changing the management of lung cancer with radiotherapy

Michael Mac Manus
Department of Radiation Oncology
Peter MacCallum Cancer Institute
Melbourne, Australia

Patient Selection

FDG-PET in staging NSCLC
Pre-PET Stage IIIA Radical RT Candidate:



PET showed detected supraclavicular and bone metastases

Pre-operative mediastinal node assessment (Dwamena meta-analysis)

- English-language reports on performance of PET (14 studies, 514 patients) and/or CT (29 studies, 2,226 patients)
- PET more accurate than CT ($P < .001$)
- Mean sensitivity 0.79 PET vs 0.60 CT
- Mean specificity 0.91 PET vs 0.77 CT

Dwamena BA, Sonnad SS, Angobaldo JO, Wahl RL. Metastases from non-small cell lung cancer: mediastinal staging in the 1990s--meta-analytic comparison of PET and CT. Radiology. 1999 Nov;213(2):530-6.

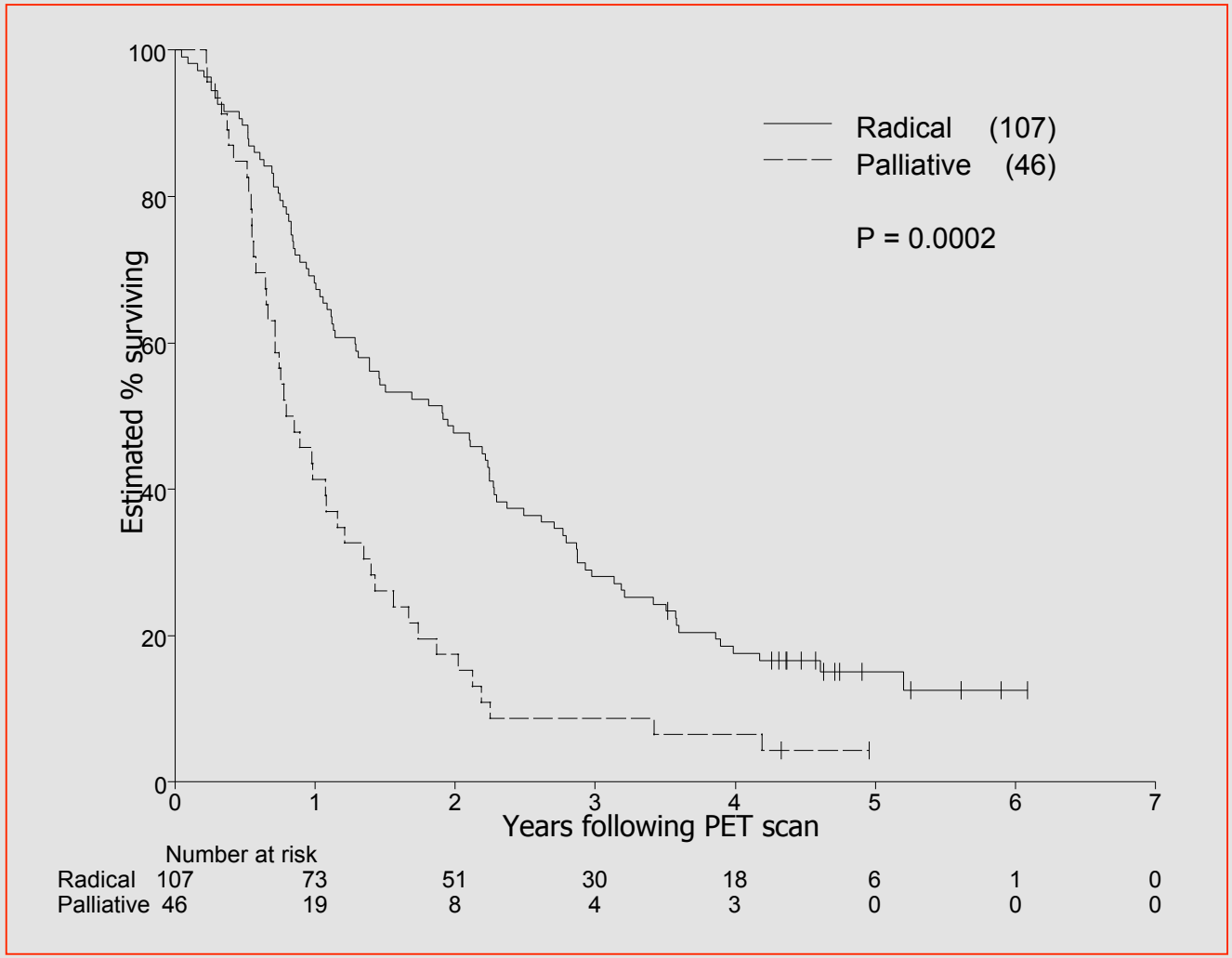
Treatment Given After PET

- Radical Therapies
  107 patients (70%)
- Palliation Only
  46 patients (30%)

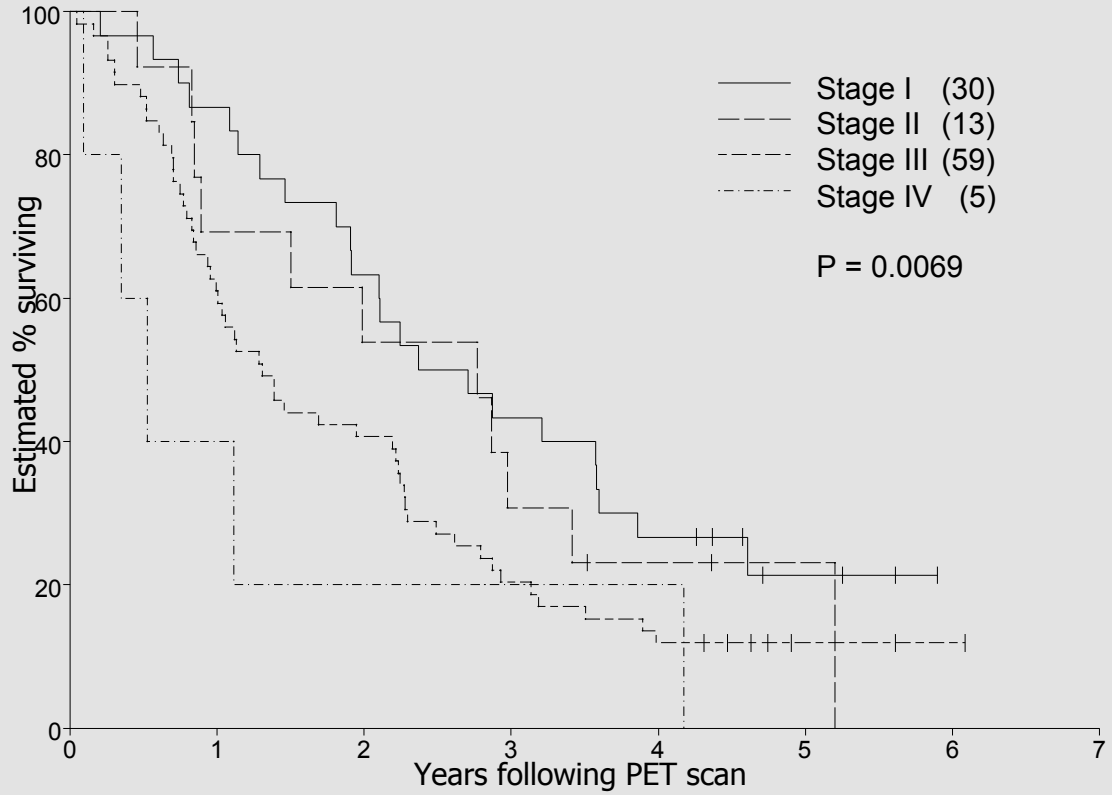
- Radical chemo RT
  68
- Radical RT alone
  34
- Radical Surgery 5

- Palliative RT 33
- Palliative chemo 12
- Supportive care 1

Overall survival by radical or palliative therapy post-PET for all 153 patients



Overall survival by post-PET stage for 107 radically treated patients

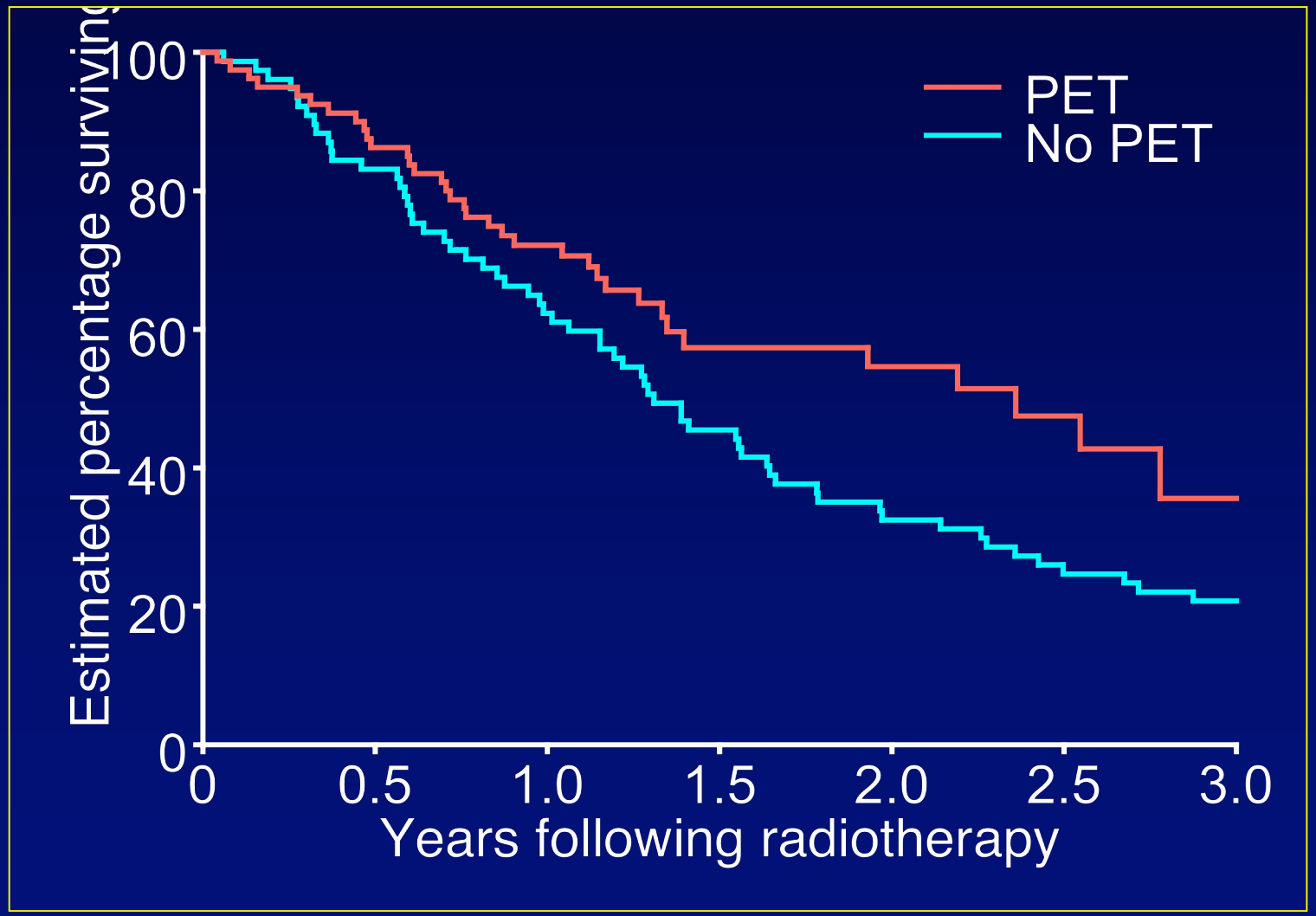


Number at risk

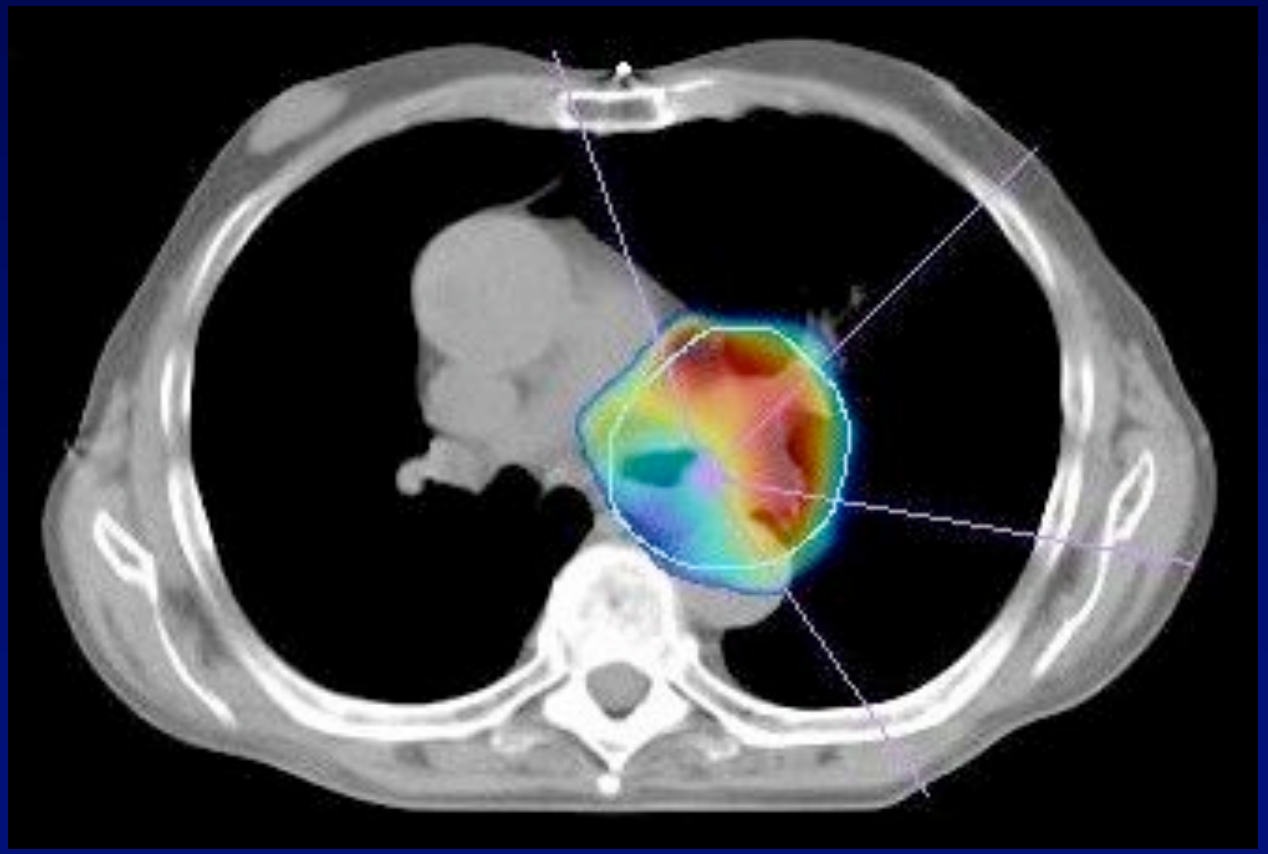
Stage I	30	26	19	13	8	3	0	0
Stage II	13	9	7	4	2	1	0	0
Stage III	59	36	24	12	7	2	1	0
Stage IV	5	2	1	1	1	0	0	0

Influence of PET staging on survival

Mac Manus et al IJROBP 2002; 52:351



PET in Radiotherapy Planning



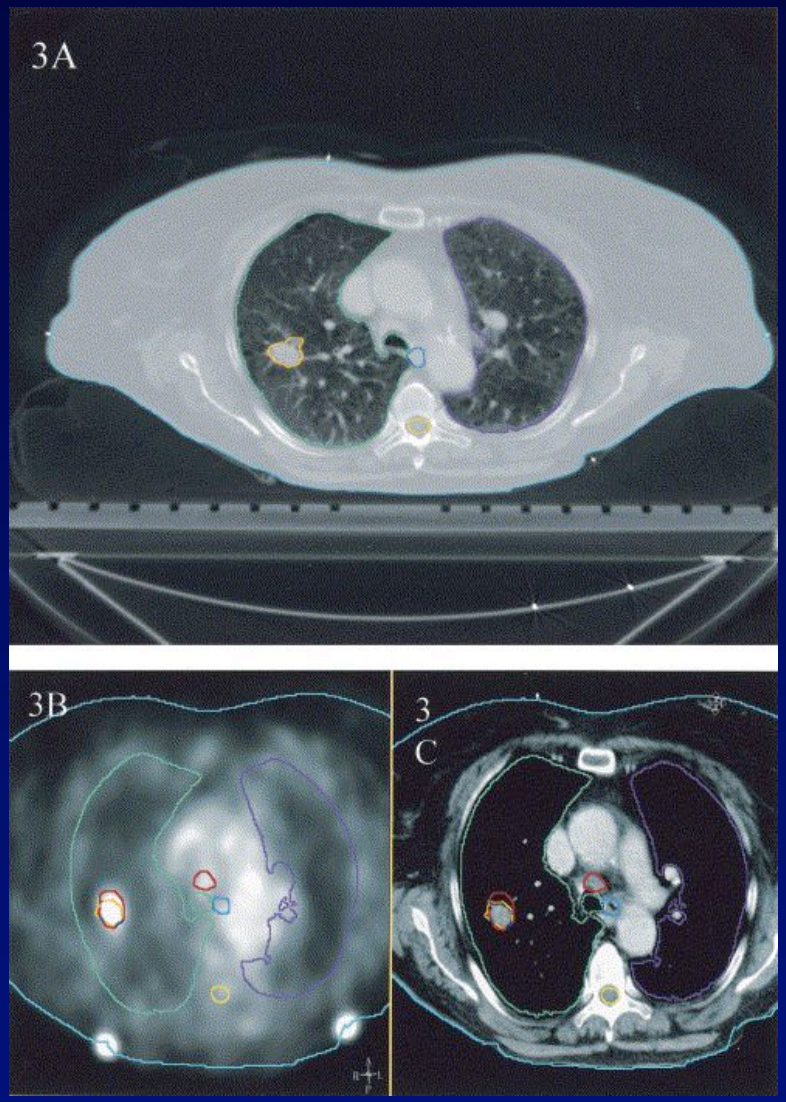
Peter Mac Pet Radiotherapy Planning Procedures 1

- Position patient on hard couch top, using tattoos, lasers (ideally done by or with help of RT)
- Use immobilisation device / procedure ensure constant arm position above head
- (Position and immobilisation must be identical for PET, CT scan if no PET/CT, simulator, linac)
- (Routine diagnostic PET scans are unsuitable for RT planning)
- Acquire images during quiet respiration, screen for movement

Peter Mac PET Radiotherapy Planning Procedures 2

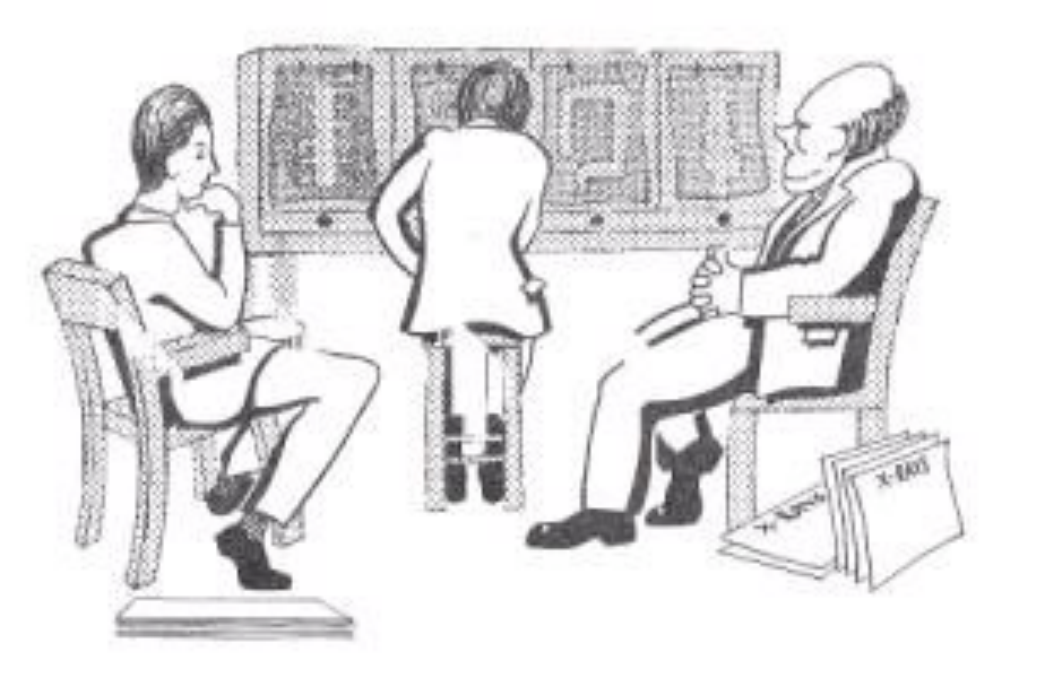
- Import PET and CT or PET/CT images to RT planning computer
- Define gross tumour volume (GTV) for nodes and primary
- Define planning target volume (PTV)
- Create treatment plan utilising wedges, MLC, IMRT as appropriate
- Deliver treatment and check accuracy with port films or online portal imaging

From Bradley et al



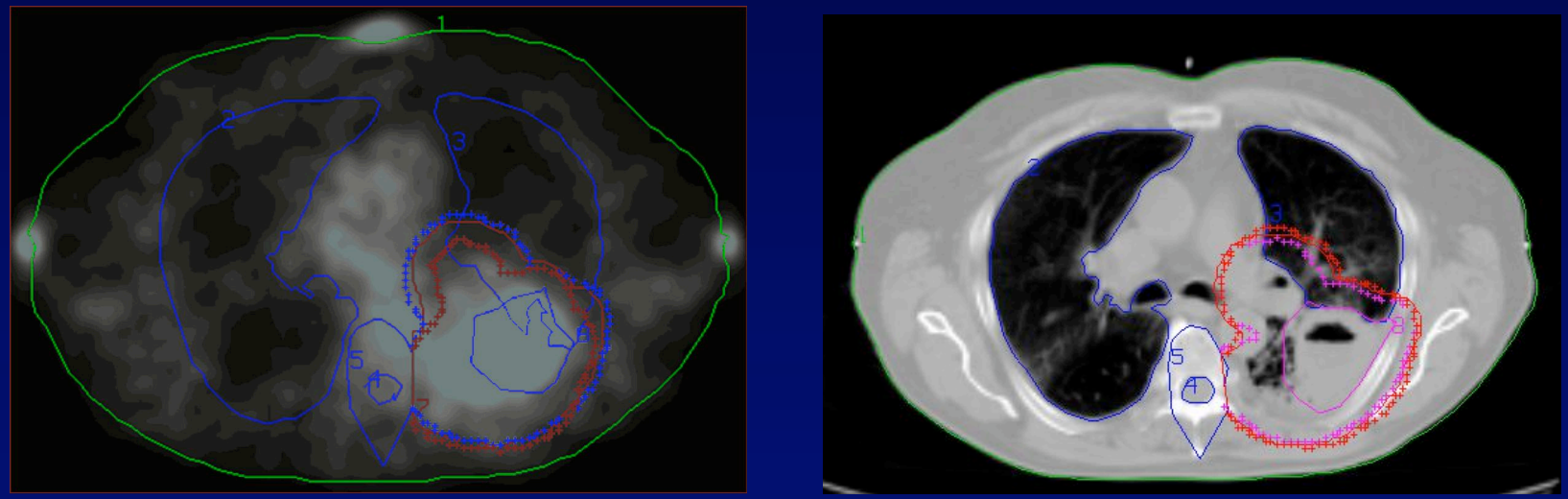
T1N0M0, Stage I adenocarcinoma of the lung. The positron emission tomography (PET) scan demonstrated an FDG-avid pretracheal lymph node, changing the clinical stage to T1N2M0, IIIA disease.

How should we incorporate PET into the Radiotherapy planning Process?



Poor:
Viewing images side by side

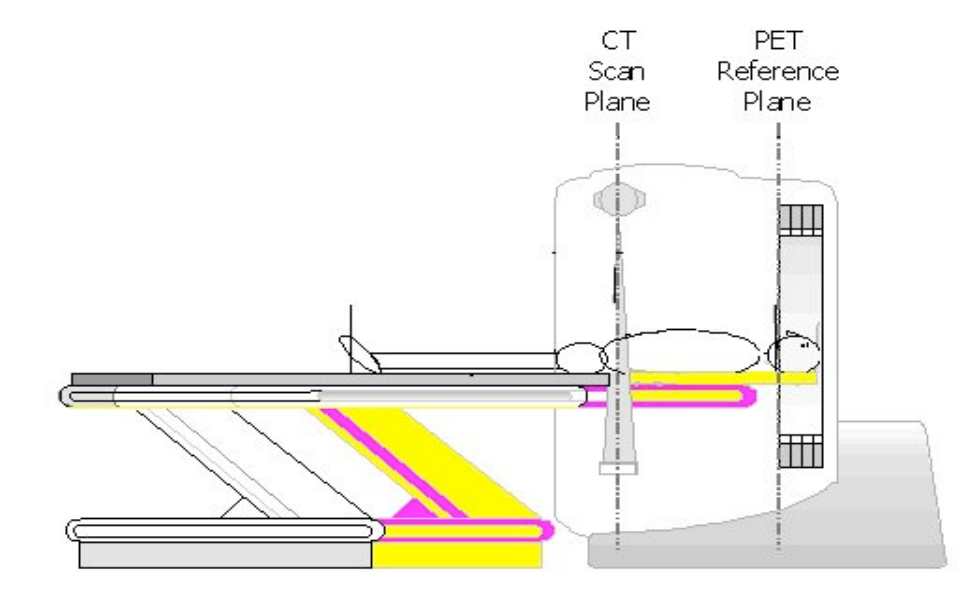
Better: Combining PET and CT information:
Co-registration of separately-acquired images

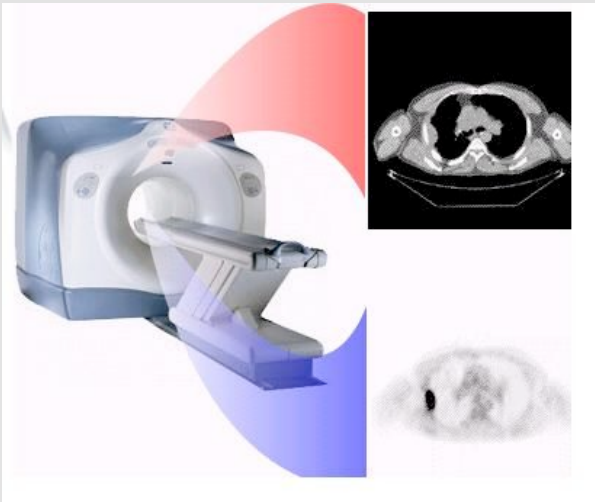


Coregistered PET and CT Scans with
Fiducial markers and PTV marked

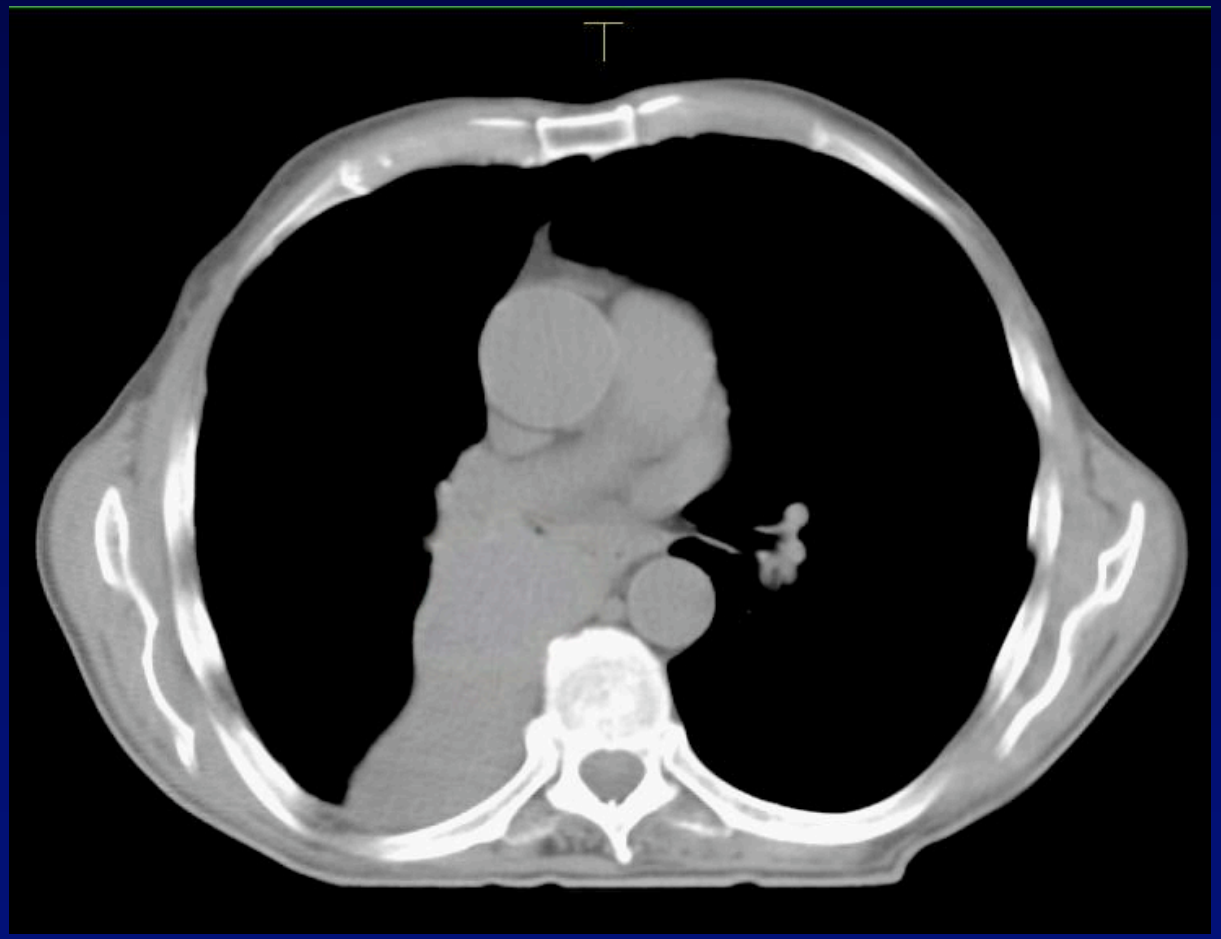
Best: Using a Combined PET/CT Scanner to create fused images

- Simultaneous acquisition
- Reduces spatial inaccuracies

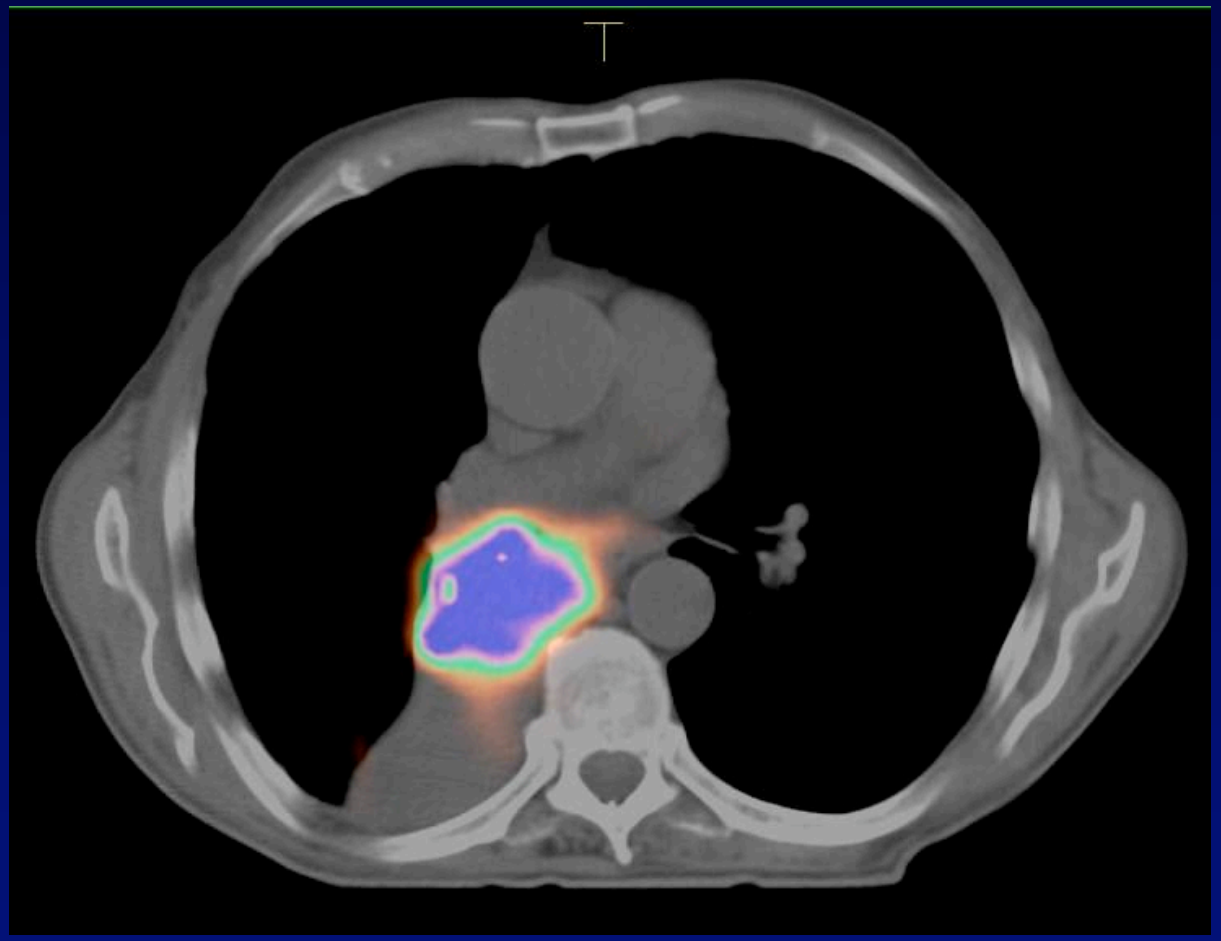




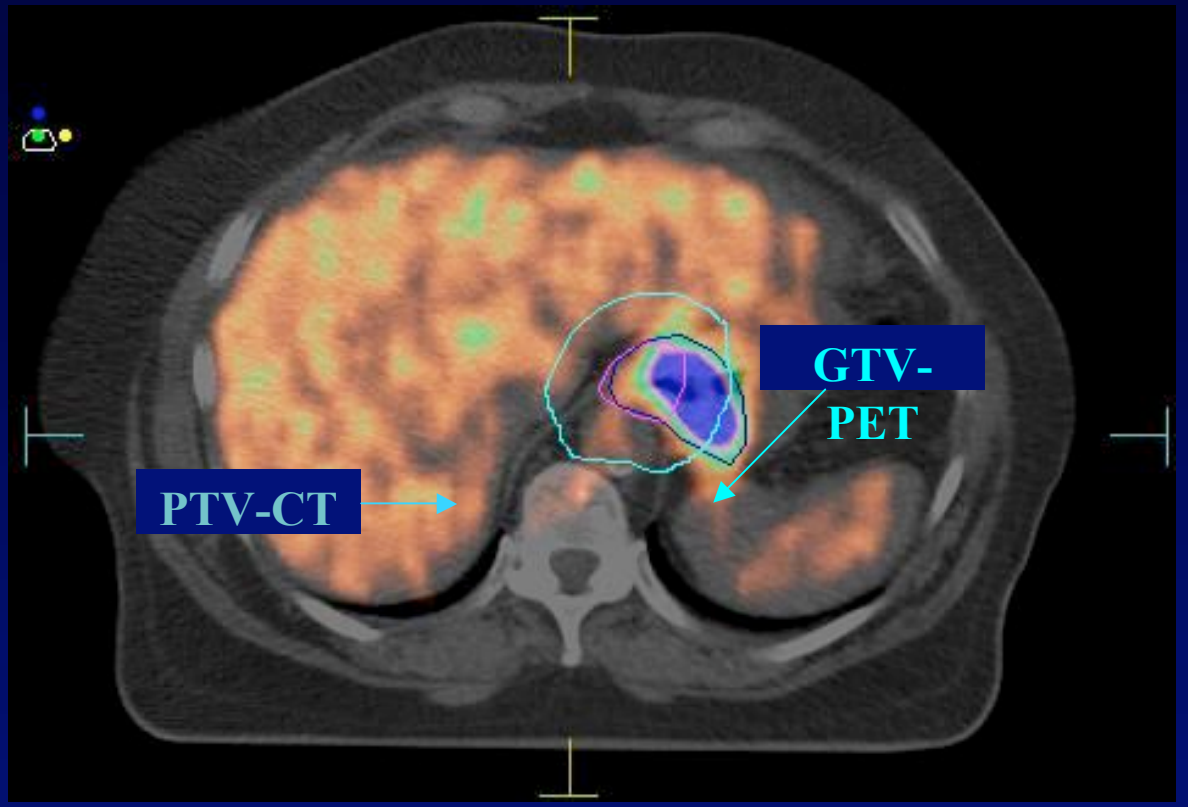
CT scan in NSCLC with bland atelectasis:
Where is the edge of the tumour?



Fused CT PET Scan:
Tumour seen much more clearly



CT and PET/CT Planning Target Volumes



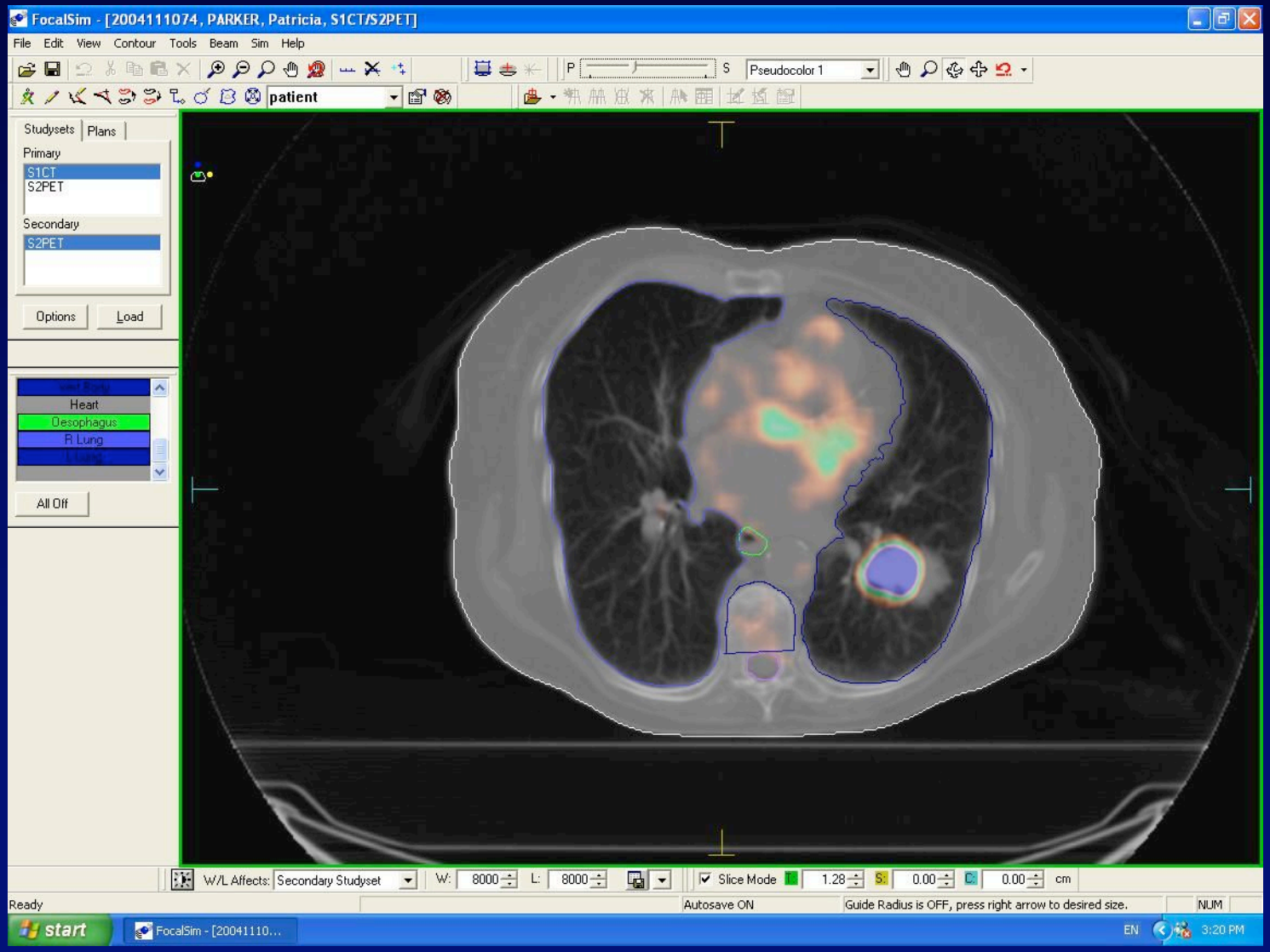
- GTV based on CT alone excluded PET-avid disease in 90%
- In 30% of patients this would have resulted in a geographic miss

Movement: With long acquisition time, moving structures have indistinct edges

PET CT for RT planning: Technical Problems

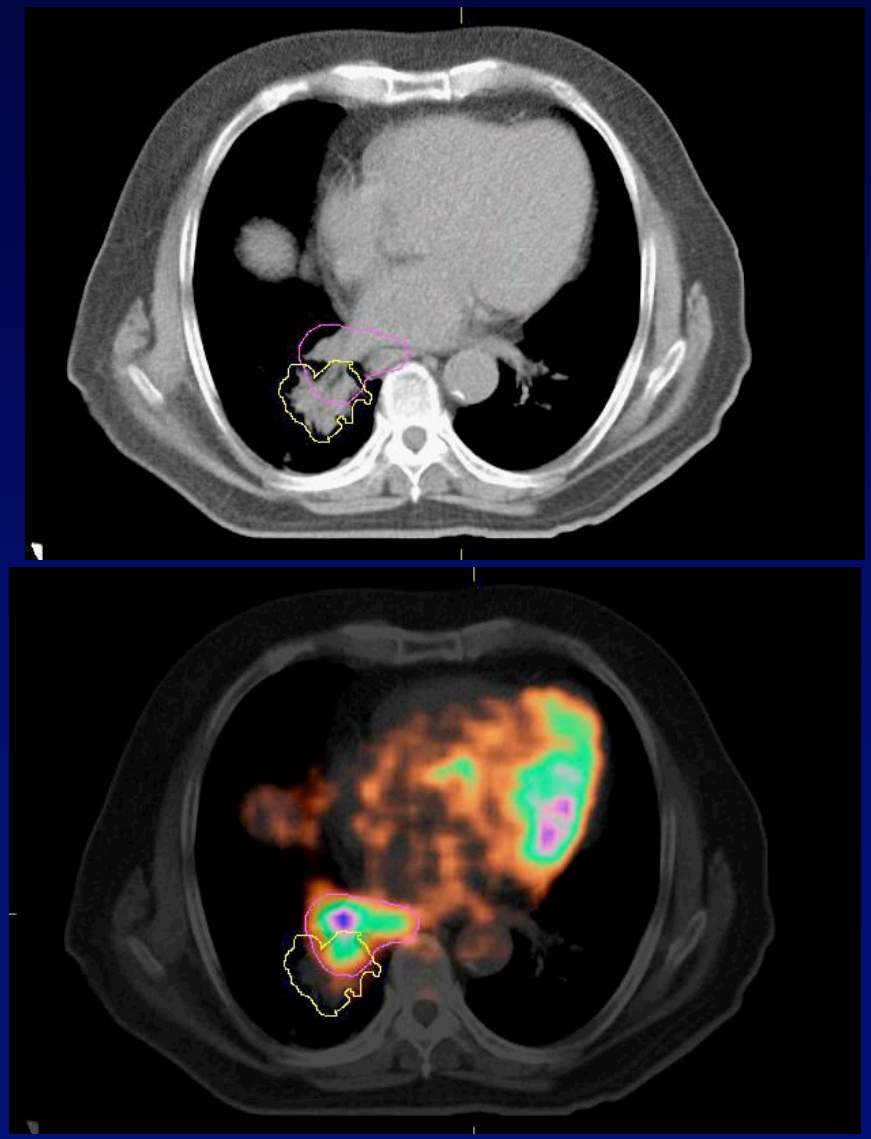
- Misregistration: tumour movement, instantaneous (CT) vs prolonged (PET) image acquisition
- Where is the edge of the tumour on PET?
- What to do with small positive nodes with low measured SUV and large PET negative nodes?
- Varied SUV between and within tumours
- Standardisation across platforms: SUV measurement is not absolute
- Inter and intra observer variability
- Most Rad Oncs are not (yet) trained in PET

Treatment planning on CT-PET
Consolidation adjacent to tumour



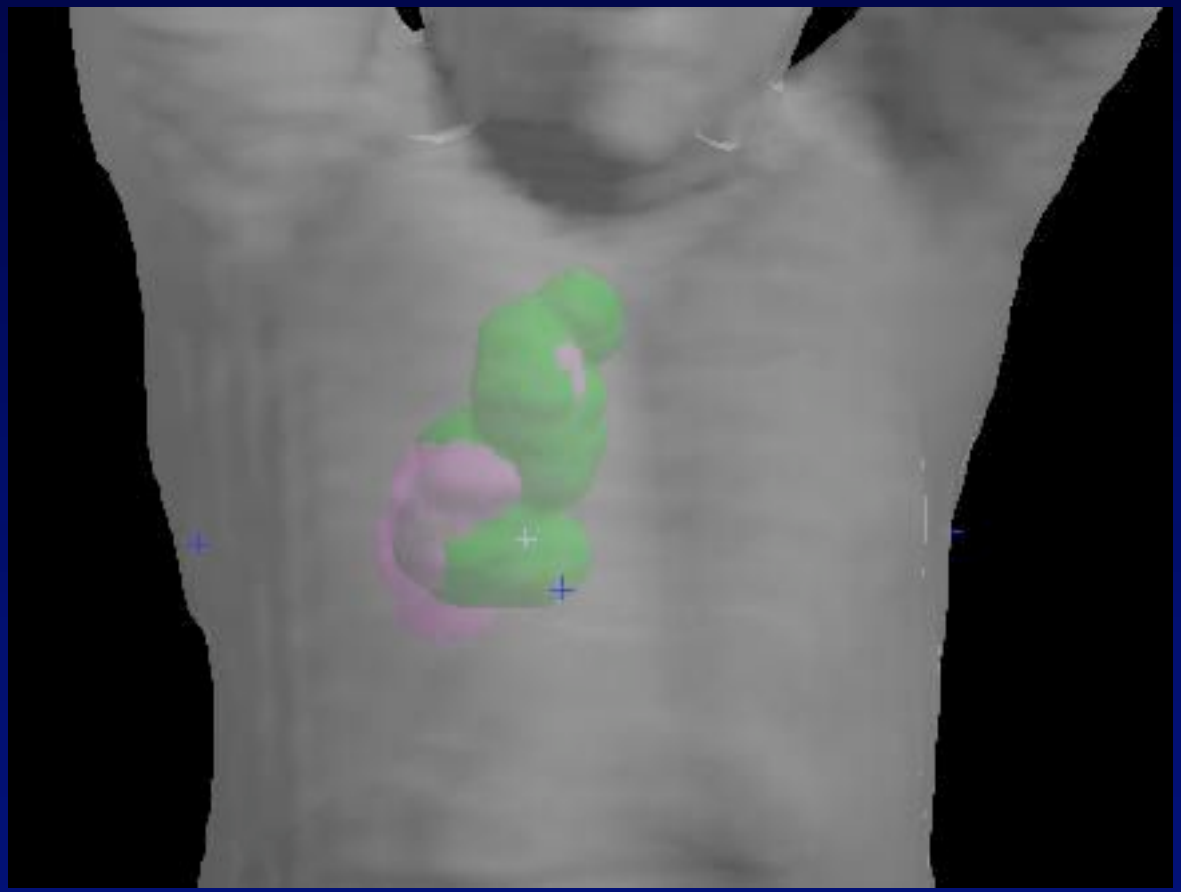
Effects of Movement

- Discrepancy between PET and CT volumes related to respiratory excursion
- PET also showed paratracheal nodes



Effects of Movement and upstaging

Effects of movement and upstaging nodes; CT and PET CT PTV are very different!

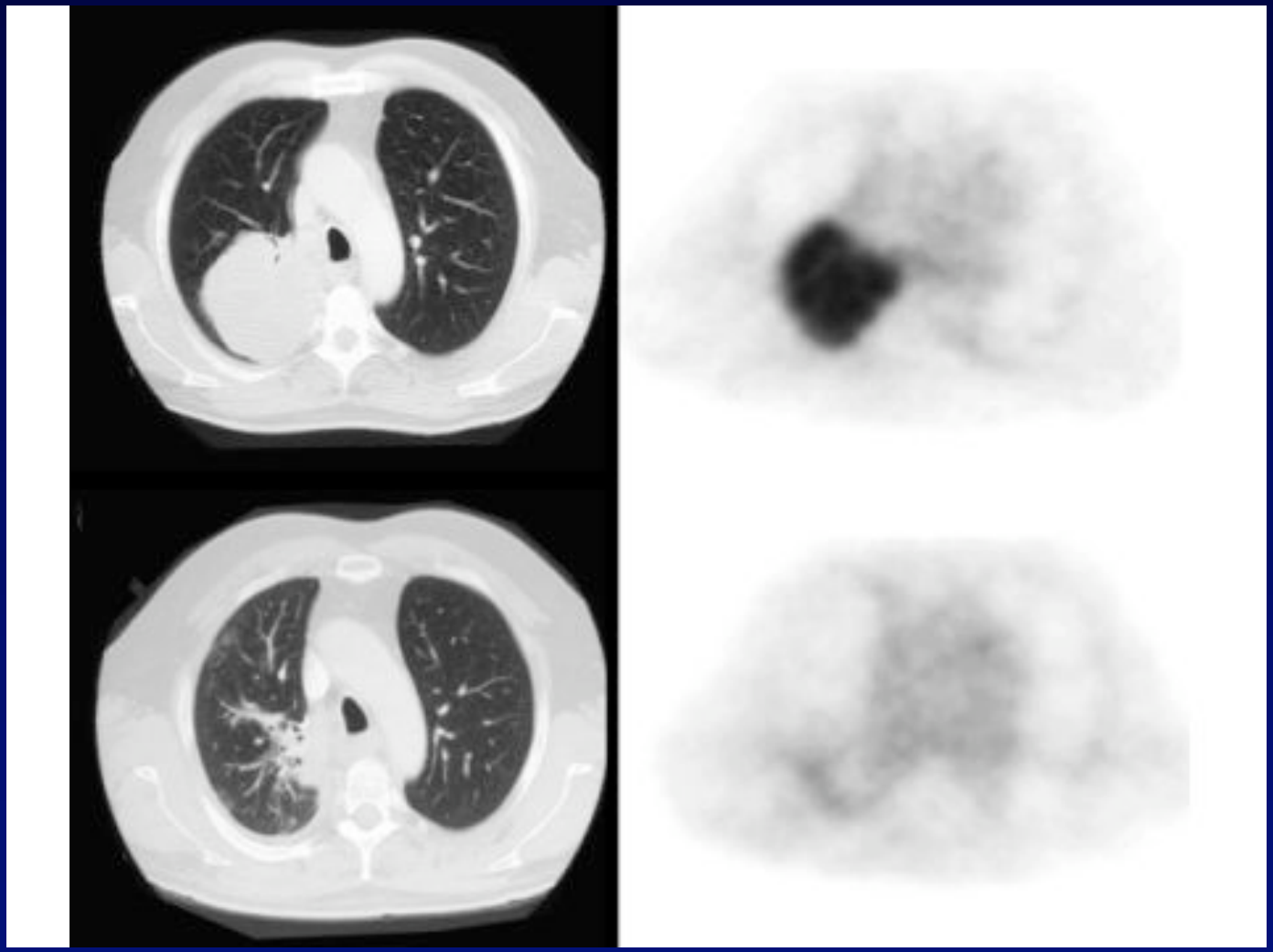


CT PTV PET PTV

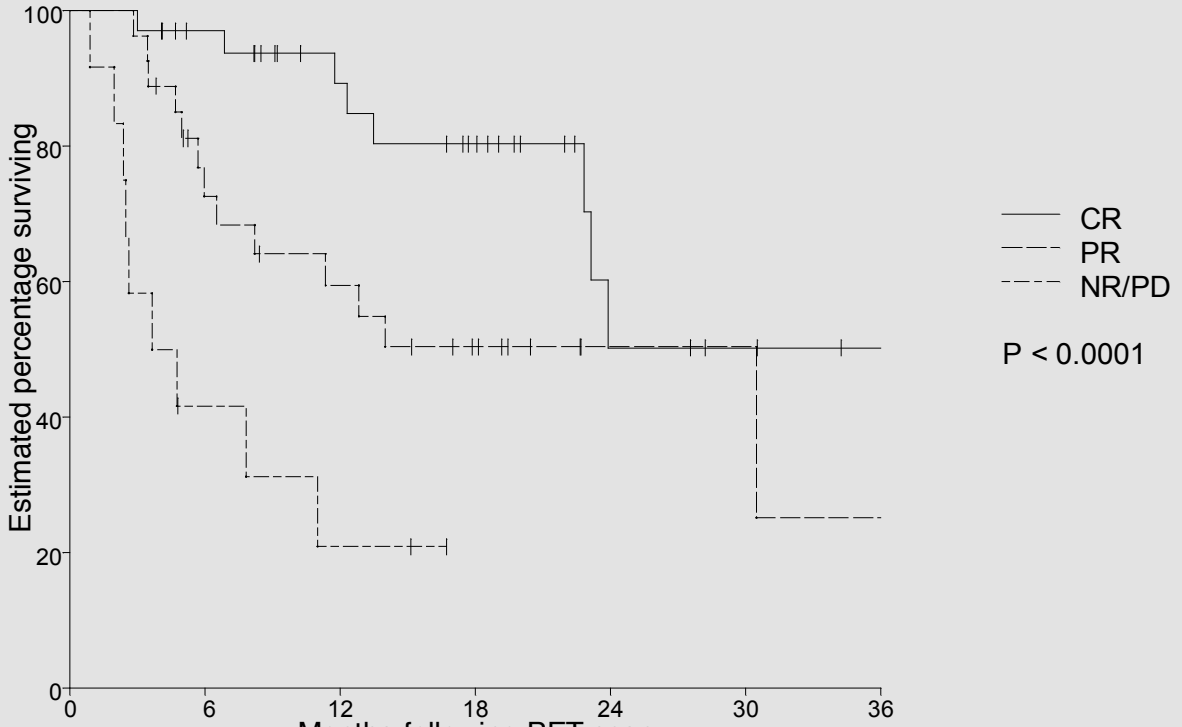
Suggestions to assist with contouring GTV on PET CT

- Involve your highly trained and experienced nuclear medicine physician
- Use fused / co-registered images (not hard copies)
- Optimise window settings in RT planning system
- Use your brain and all of the clinical and imaging information available
- Do not become fixated on SUV
- Consider pattern as well as intensity
- Consider effects of movement (eg fluoroscopy)
- Remember effects of co-morbidities

NSCLC: CT PR, PET CR
FFP 4 years later



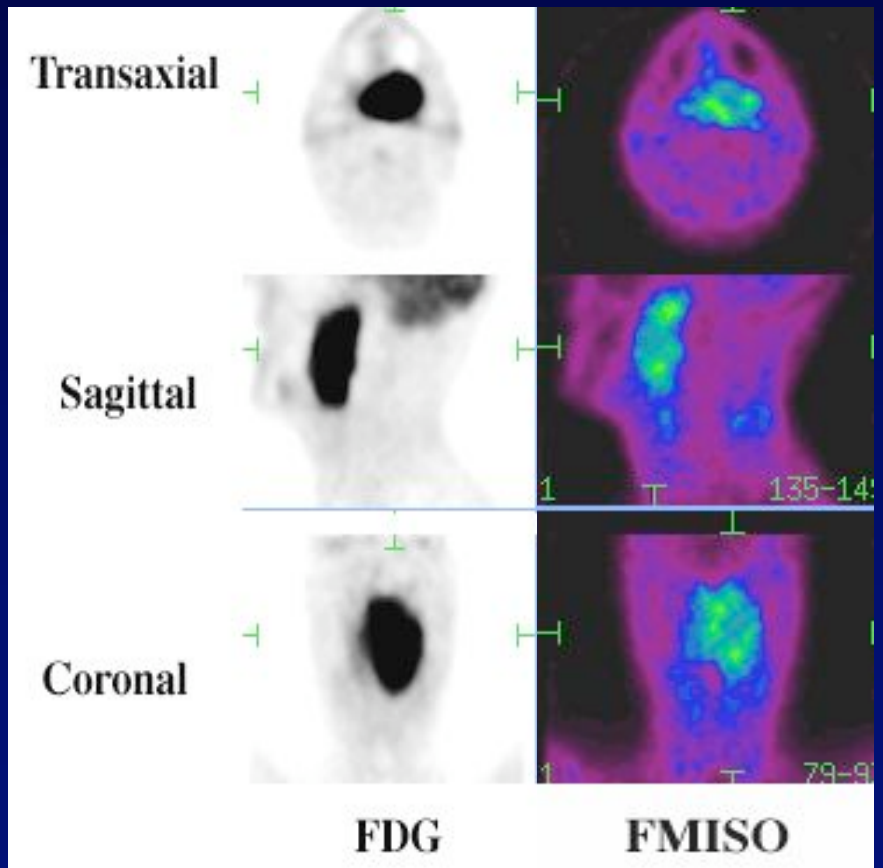
Survival by PET Response (n=73)



Number at risk							
CR	34	29	20	15	5	3	1
PR	27	17	13	8	2	2	1
NR/PD	12	4	2	0	0	0	0

Hypoxia Imaging with ^{18}F-Misonidazole TROG Tirapazemine study

98.02



patients had baseline imaging of tumo

Conclusions

- Survival is already better in some PET-staged cohorts due to better patient selection
- Incorporation of PET into RT planning leads to significant changes in treatment and will reduce risk of geographic miss
- Without PET, full potential of RT dose escalation cannot be achieved
- Much non-PET RT literature is obsolete
- Work need on target definition, movement, gating