

New Targets and Targeted Therapy



UC DAVIS
**COMPREHENSIVE
CANCER CENTER**

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CCC**
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National Cancer Institute

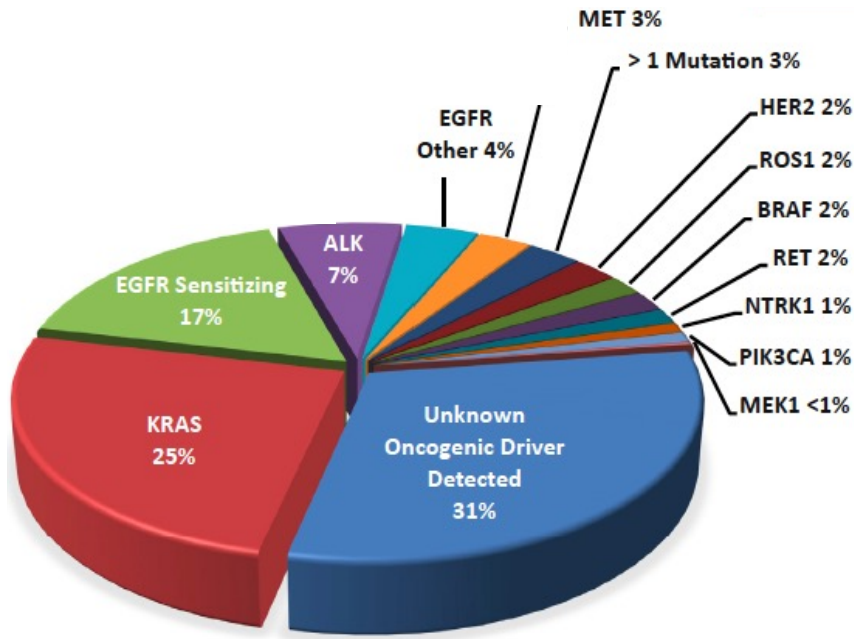
DISCLOSURES

Commercial Interest	Relationship(s)
Blueprint, Beigene, Daiichi Sankyo, EMD Serano, Janssen, Regeneron, Sanofi, Biodesix, Bayer, Turning Point, Bristol Myers Squibb, Jazz Pharmaceuticals, Novartis, Roche/Genentech, Boehringer Ingelheim, Merck, SeaGen	Consulting/Advisory Board
Merck, Novartis, AstraZeneca, Spectrum, Revolution Medicines, Arrivent, IO Biotech, Vitrac	Research Funding (To Institution)

New Targets and Targeted Therapies

- Overcoming EGFR-TKI Resistance
- Targeting Previously Undruggable Mutations (EGFR Exon 20 ins and KRAS)
- KRAS mutant NSCLC/Co-mutations that mediate resistance to systemic treatments (KEAP1/NFE2L2)

Progress in Targeted Therapy for NSCLC-Adenocarcinoma



KRAS G12C
adagrasib, sotorasib

EGFR exon 20 insertions
mobocertinib, poziotinib, amivantamab

EGFR:
gefitinib, afatinib, erlotinib, osimertinib, dacomitinib

ALK:
Crizotinib, ceritinib, alectinib, brigatinib, lorlatinib, ensartinib, entrectinib

ROS1:
Crizotinib, cabozatinib, ceritinib, brigatinib, lorlatinib, entrectinib, ropotrectinib

BRAF:
Dabrafenib/trametinib, vemurafenib, dabrafenib

MET:
Crizotinib, cabozatinib, capmatinib, tepotinib, savolitinib, merestinib, glesatinib

HER2:
Trastuzumab emtansine, afatinib, dacomitinib, poziotinib, neratinib-temsirolimus, XMT-1522, TAK-788, Trastuzumab deruxtecan

RET:
Cabozatinib, alectinib, vandetanib, sunitinib, ponatinib, lenvatinib, apatinib, selpercatinib, pralsetinib, RXDX-105

NTRK:
Larotrectinib, entrectinib, LOXO-195, DS-6051b, ropotrectinib

FDA

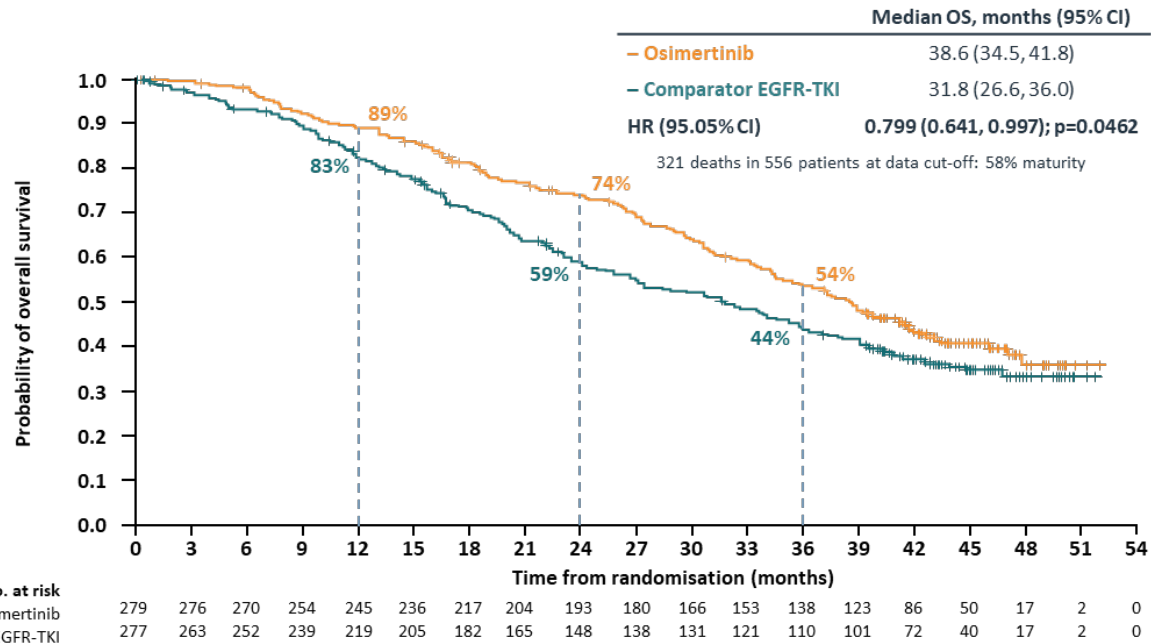
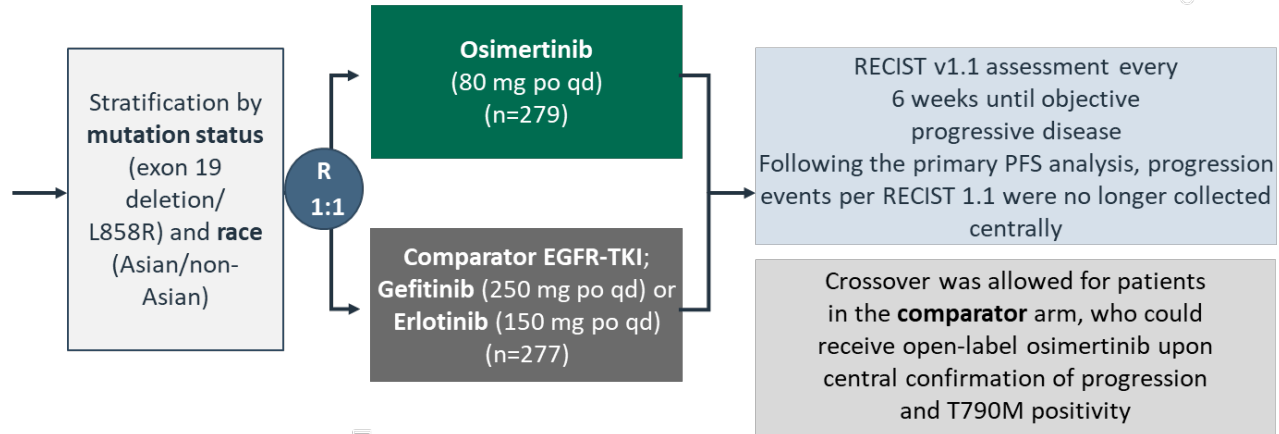
FLAURA: Osimertinib vs comparator EGFR-TKI as first-line treatment for EGFRm advanced NSCLC: Final overall survival data



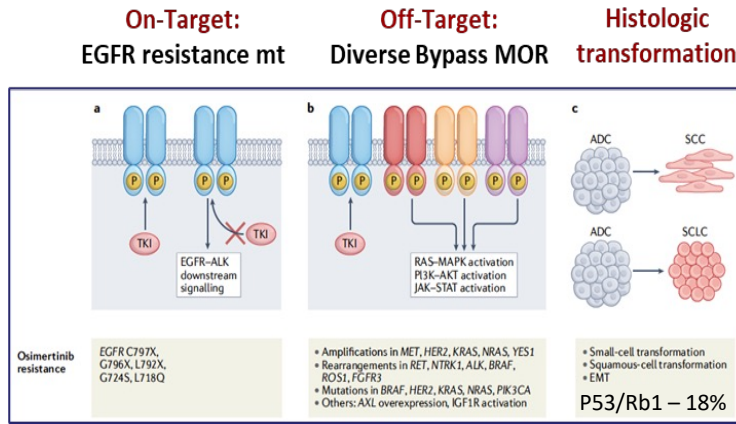
Patients with locally advanced or metastatic NSCLC

Key inclusion criteria

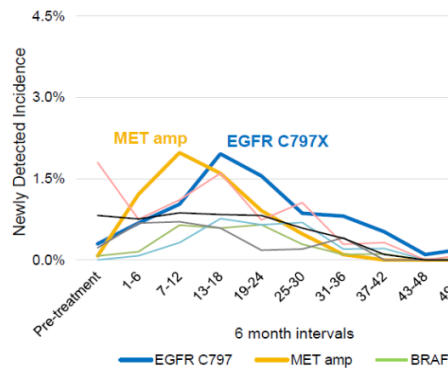
- ≥18 years old
- WHO performance status 0/1
- Exon 19 deletion/L858R (enrollment by local or central EGFR testing)
- No prior systemic anticancer/EGFR-TKI therapy
- Stable CNS metastases were allowed



Broad Mechanisms of Resistance to EGFR-TKI and Temporal Occurrence

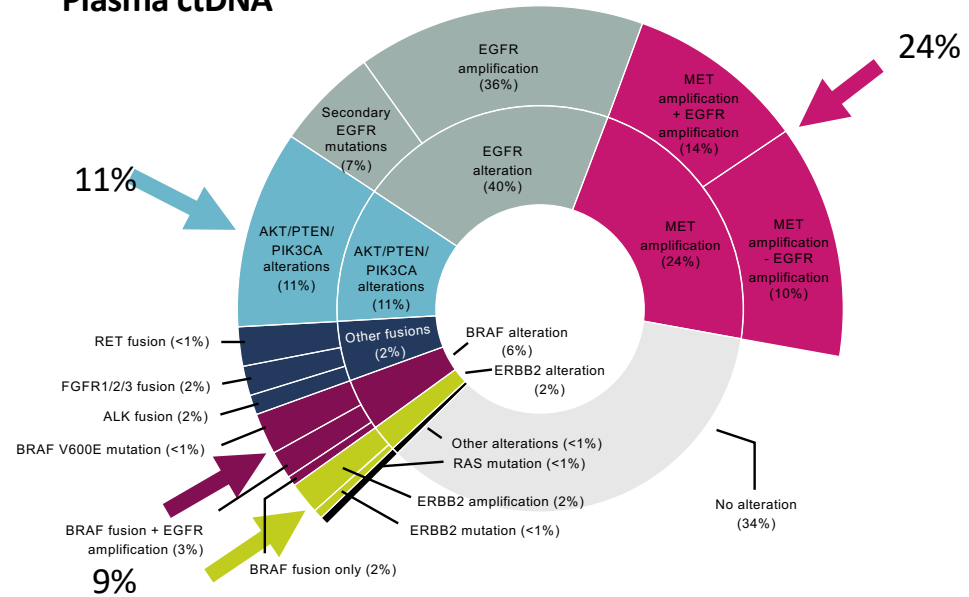


Cooper AS. et al. Nat Rev Clin Oncol 2022




Presented by S. Ramalingam WCLC 2022

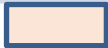
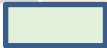

Genomics from Orchard: N-174 tissue samples/concurrent Plasma ctDNA



- **Pre-Existing Comutations Mediating Resistance (Impact for locally advanced/early stage treatment)**
- **Resistance to Immunotherapy**

C797S-Active Compounds in Development: Preclinical Data

Compound	Del19	L858R	Del19/ T790 M	L858R/ T790M	Del19/ C797S	L858R/ C797S	Triple Mutant	Other	CNS?	Status
 BLU-945	-	X	X	X	-	X	X		-	Phase 1/2 (NCT04862780)
BLU-701	X	X	-	-	X	X	X		X	Discontinued
BLU-525	X	X	-	-	X	X	X		X	Preclinical
BDTX-1535	X	X	-	-	X	X	X	Uncommon	X	Phase 1 (NCT05256290)
THE-349	X	X	X	X	X	X	X		X	Preclinical
H002	X	X	X	X	X	X	X		X	Phase 1/2 (NCT05552781)
BAY 2927088	X	X			X	X		Ex20ins		Phase 1 (NCT05099172)
JIN-A02	X	X	X	X	X		X		X	Phase 1/2 (NCT05394831)
BBT-176	X	X	X		X	X	X		X	Phase 1/2 (NCT04820023)

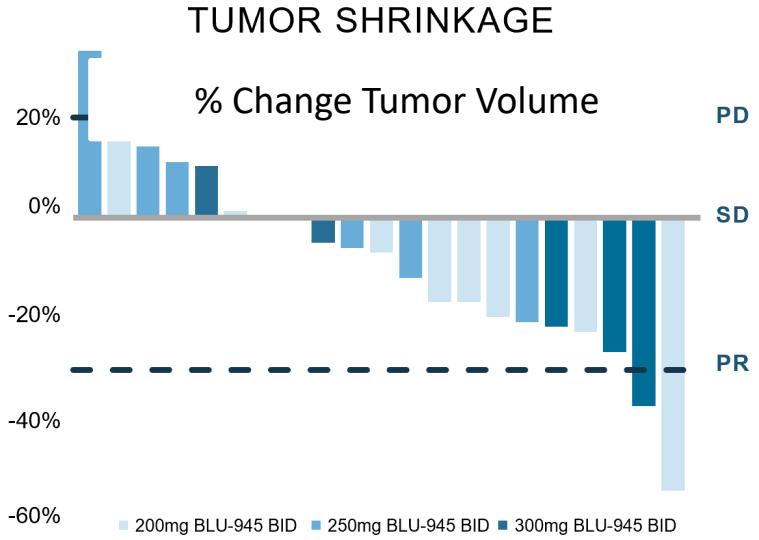
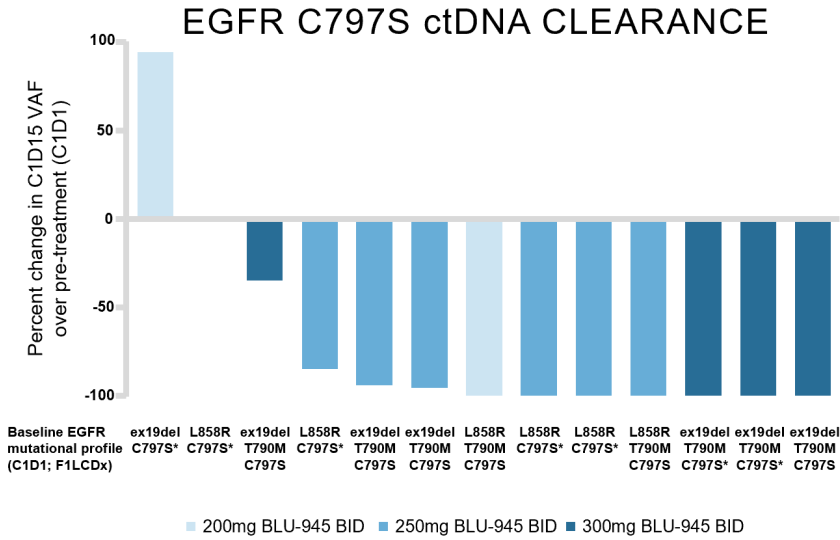
 Predicted Not Active
  Predicted Active
  No available data

Shum et al, AACR 2022; Tavera-Mendoza et al ENA 2022 #177; Lucas et al. ENA 2022. Abstract #64; Zhang et al. ENA 2022 #236; Siegel et al. ENA 2022 #17; Lim et al ESMO 2021; Yun et al ESMO 2022 #999P

Slide courtesy of Julia Rotow, MD

BLU-945: Preliminary Efficacy Data

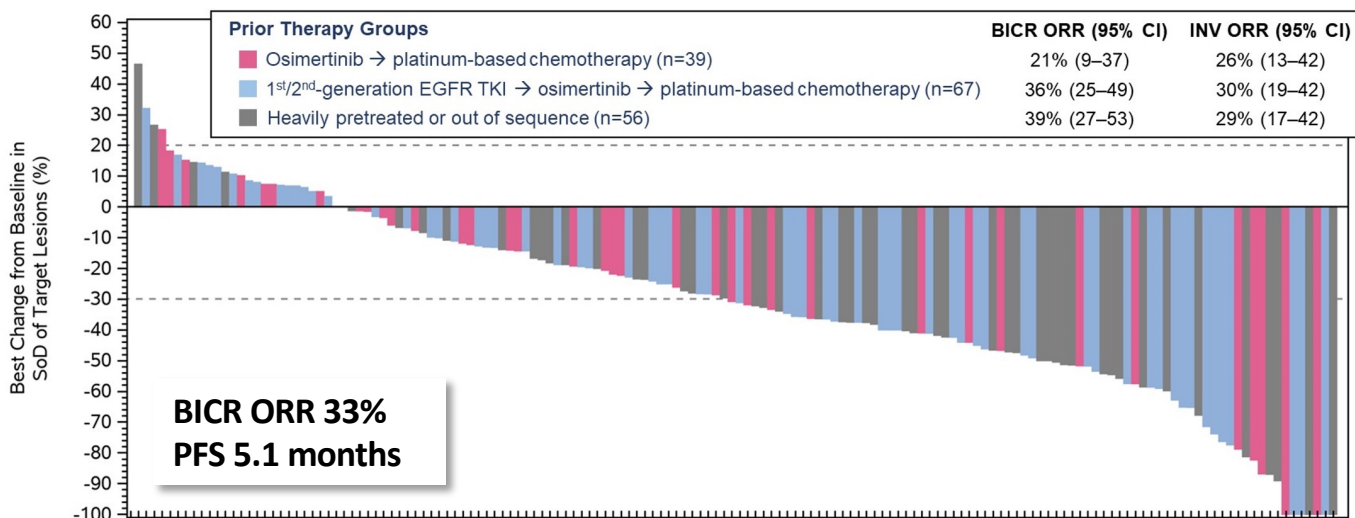
Monotherapy Cohorts, Top Dose Levels



Adapted from: Mar, B. Presented to EGFR Exon 20 Research Consortium

Amivantamab + Lazertinib

EGFR/MET Bispecific +3rd Gen EGFR TKI CHRYSALIS-2



**In CHRYSALIS-1, MET/EGFR
IHC score correlated with
response (n=20)**

ORR 90% if IHC+
ORR 10% if IHC-

Shu et al. ASCO 2022. #9006.; Bauml et al ASCO 2021 #9006

INSIGHT2: Tepotinib and Osimertinib

Key eligibility

- Locally advanced or metastatic NSCLC with activating *EGFR* mutation
- Acquired resistance to 1L osimertinib
- *METamp* detected by central/ local FISH testing (TBx) or central NGS testing (LBx)
- ECOG PS of 0 or 1
- Stable, treated brain metastases allowed

R
1:
1

Tepotinib 500 mg QD +
osimertinib 80 mg QD

Tepotinib monotherapy

Primary endpoint:

- ORR by IRC (patients with *METamp* centrally confirmed by TBx FISH treated with tepotinib + osimertinib)

Secondary endpoints:

- ORR by IRC in patients with:
 - *METamp* centrally confirmed by TBx FISH treated with tepotinib

Detection of *METamp*

METamp
definitions

TBx FISH:

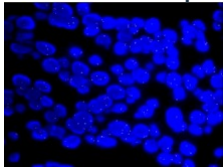
MET GCN ≥ 5
and/or
MET/CEP7 ≥ 2

and/or

LBx NGS:

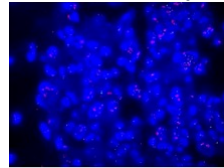
MET GCN ≥ 2.3 ;
Archer®

TBx FISH: *METamp* -ve



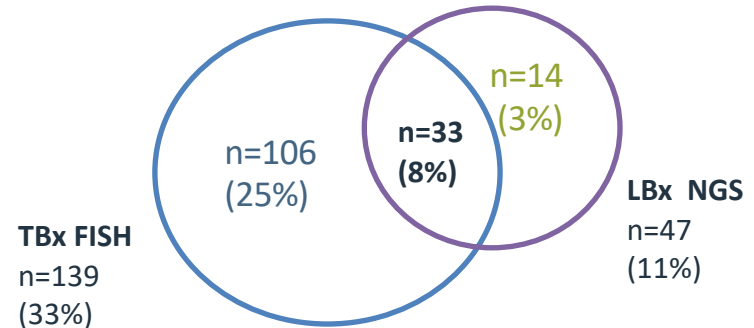
MET GCN, 2.33;
MET/CEP7, 0.96

TBx FISH: *METamp* +ve

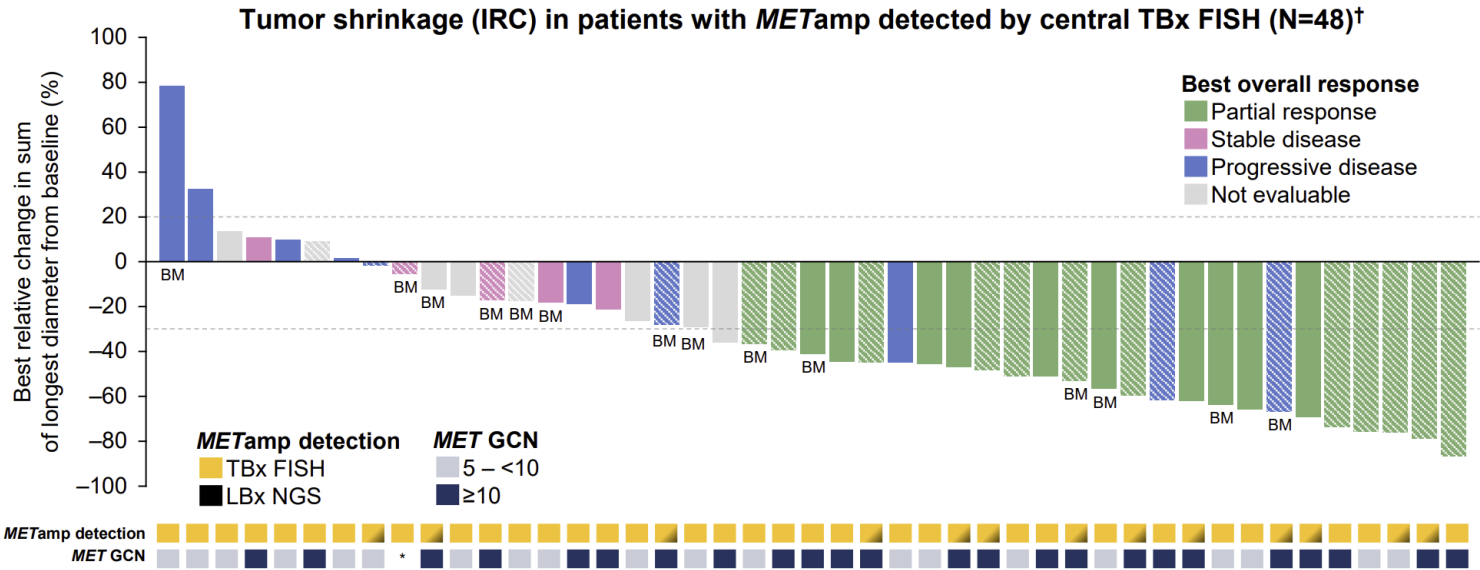


MET GCN, 17.4;
MET/CEP7, 7.35

METamp detected in 153/425 (36%) of pre-screened patients



INSIGHT 2: Osimertinib + Tepotinib for MET-amplified EGFRm NSCLC



ORR 45.8%-56.5% osimertinib + tepotinib

ORR 8.3% tepotinib monotherapy

EGFR + MET TKI Combinations

Osimertinib + Savolitinib for MET+ s/p Osimertinib

TATTON Phase Ib

FISH MET/CEP7 2+ or
MET 5x+; IHC 3+ in 50%+;
NGS 5X CNG)

**ORR 30% post 3rd gen
EGFR TKI**

SAVANNAH Phase II

Definition MET+: IHC 50+ or FISH 5+
(62% screened)
Definition MET-high: IHC 90+/FISH 10+
(34% screened)

ORR 49%, PFS 7.1 mo MET-high

Osimertinib + Capmatinib for MET+ s/p Osimertinib

GEOMETRY-E Phase III

Randomized osimertinib +
capmatinib vs platinum doublet
NCT 04816214 → study

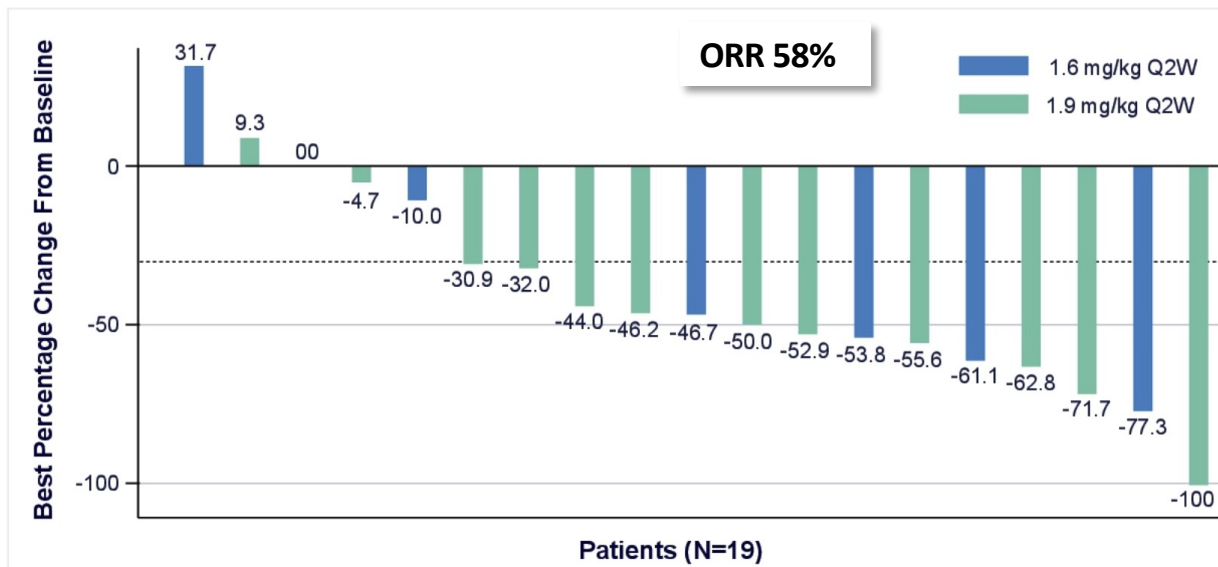
SAFFRON Phase III
NCT NCT05261399

Key Takeaways

- Biomarker
Definition of MET
high
- What does that
mean in the
patient?
- Tumor
Heterogeneity and
response
- Single agent MET
TKI likely unhelpful

Telisotuzumab vedotin + Osimertinib MET-ADC + EGFR TKI

MET-overexpression: IHC 3+ in at 25% of tumor cells



Goldman et al. ASCO 2022. #9013

Other Bypass Tracts That Are Potentially Actionable

ALK Fusions

Osimertinib + Alectinib

6 months DoR

Case

Reports

BRAF
Fusions

Osimertinib + Trametinib

Response, D/c at 5 mo (Tox) Case

Report

BRAF V600E

Dabrafenib/Trametinib

7-8 months DoR

Osimertinib+Vemurafenib

7+ months DoR

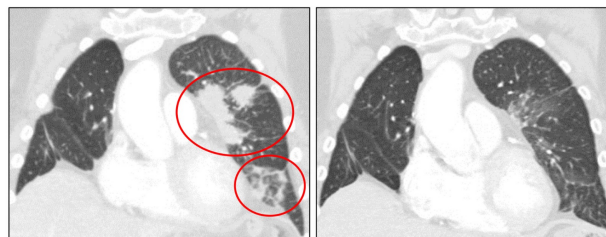
Case

Z. Piotrowska et al. Cancer Discovery 2022

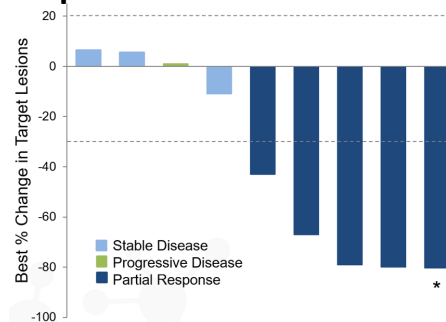
Osimertinib + RET TKI in Acquired Resistance Mediated by RET Fusion

Pralsetinib

B



Selpercatinib

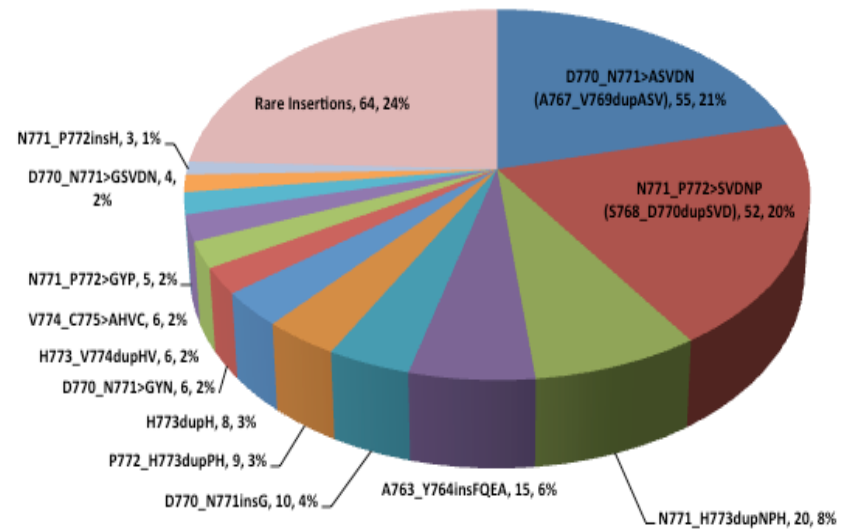
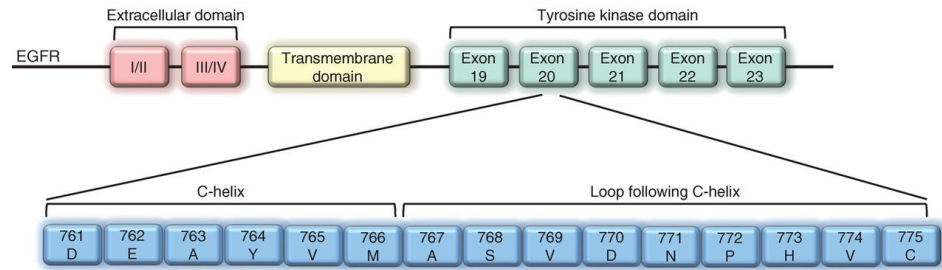
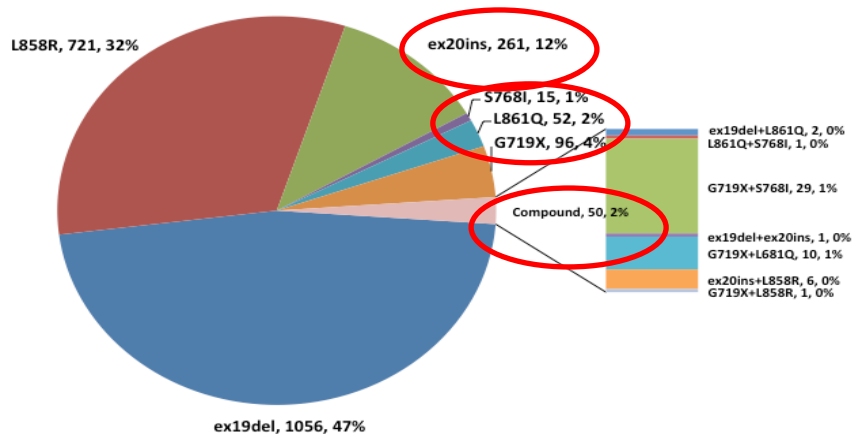


Best Response (n=10)	
Objective Response n (%)	5 (50%)
Partial Response*	5 (50%)
Stable Disease	3 (30%)
Progressive Disease	2 (20%)
Disease Control Rate n (%)	8 (80%)
Median Depth of Response (%)	-43%

*One partial response unconfirmed

One patient with clinical progression without radiographic evaluation not shown

EGFR mutations are heterogeneous



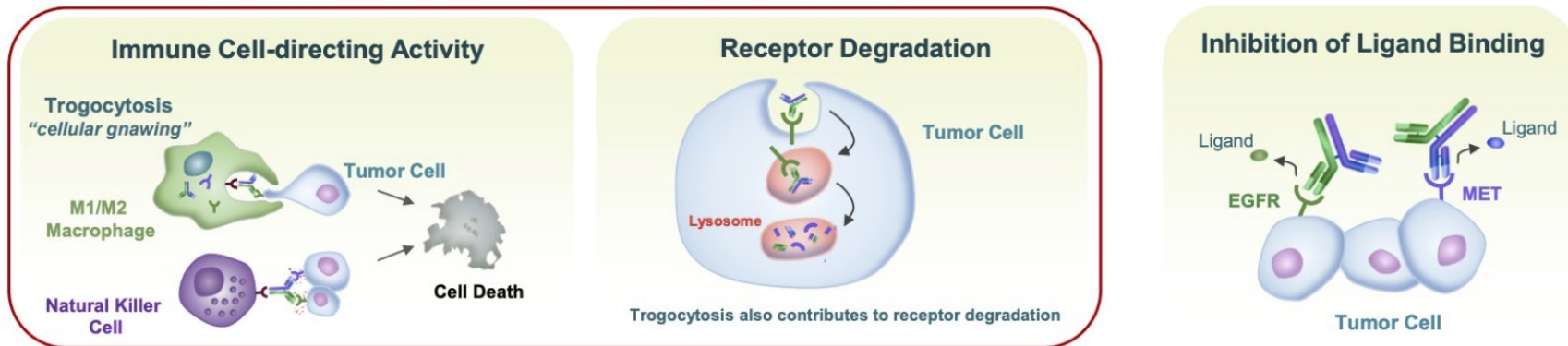
Meador, L. Sequist, Z. Piotrowska. *Cancer Discov.* 2021, 2021 Sep;11(9):2145-2157. Y. Elamin et al *Cancer Cell* 2022 40: 754-67. JW Riess et al *JTO* 2018. 13:10. P1560-1568,

Amivantamab: EGFR-MET Bispecific Antibody

- Fully human EGFR-MET bispecific antibody with immune cell-directing activity¹⁻²
- Targets activating and resistance EGFR mutations and MET mutations and amplifications³⁻⁴
- Demonstrated monotherapy activity in patients with diverse EGFRm disease including EGFR Exon19del, L858R, T790M, C797S, Exon20ins, and MET amplification³⁻⁴



MOA Relevant to EGFR Exon20ins-mutated NSCLC



¹Vijayaraghavan *Mol Cancer Ther* 19(10):2044. ²Yun *Cancer Discov* 10(8):1194. ³Haura *JCO* 37(15_suppl):9009. ⁴Park *JCO* 38(15_suppl):9512
EGFR, epidermal growth factor receptor; EGFRm, EGFR-mutant; MET, mesenchymal-epithelial transition; NSCLC, non-small cell lung cancer

Amivantamab Efficacy in EGFR Exon ins20

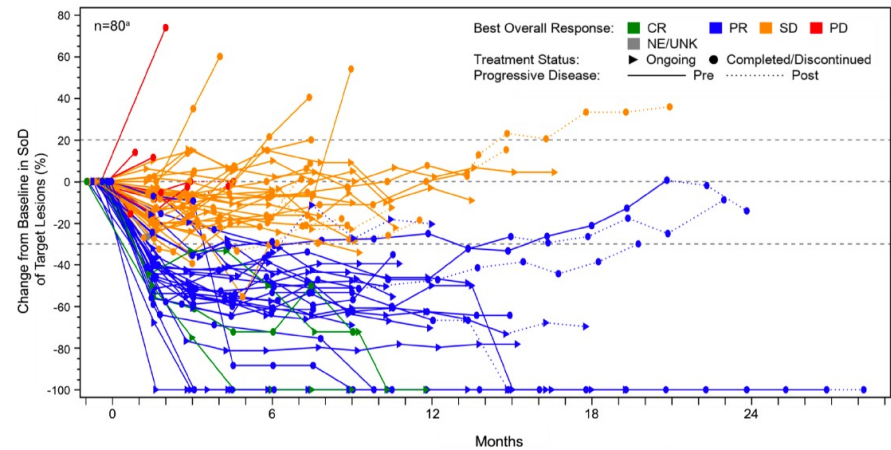
Amivantamab: Efficacy by BICR

BICR-assessed Response	Efficacy Population (n=81)
Overall response rate	40% (95% CI, 29–51)
Median duration of response	11.1 months (95% CI, 6.9–NR)
Best response, n (%)	
Complete response	3 (4)
Partial response	29 (36)
Stable disease	39 (48)
Progressive disease	8 (10)
Not evaluable	1 (1)
Clinical benefit rate ^a	74% (95% CI, 63–83)

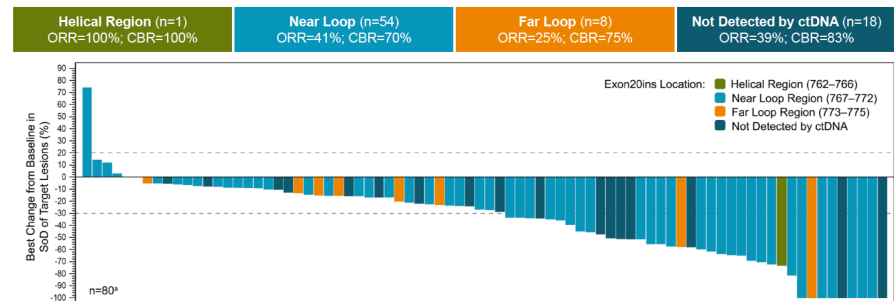
Median follow-up: 9.7 months (range, 1.1–29.3)

mPFS: 8.3 mo (95% CI, 6.5-10.9)
 mOS: 22.8 mo (95% CI, 14.6-NR)

Amivantamab: Responses Over Time

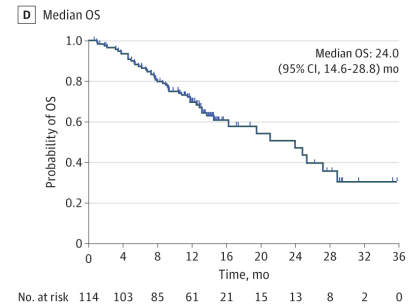
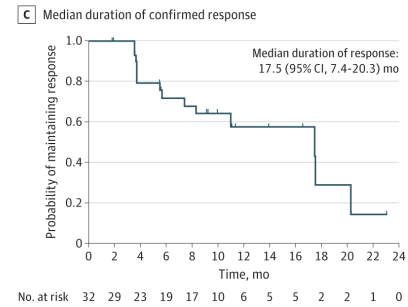
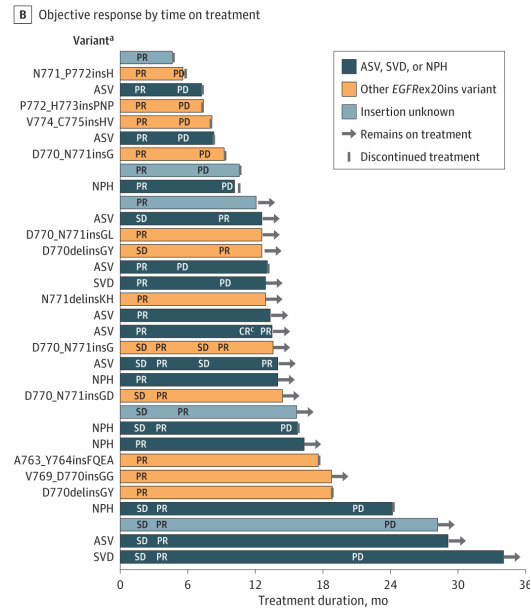
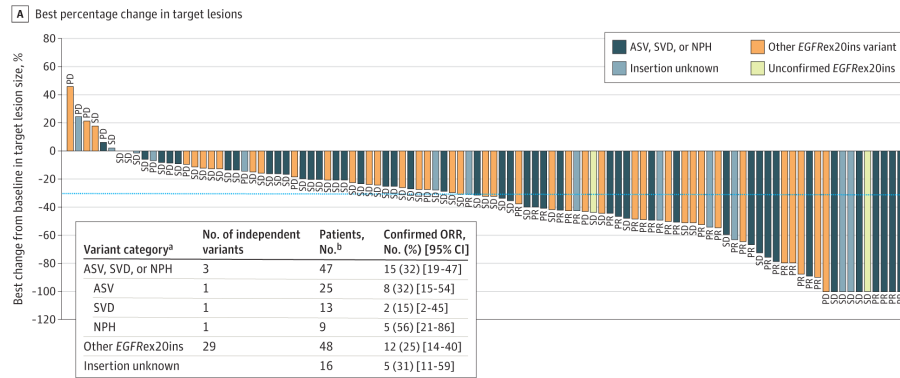


Best ORR by Insertion Region of Exon 20 (detected by ctDNA)



25 distinct Exon20ins variants identified by NGS of ctDNA (Guardant360®) from 63 evaluable patient samples

Mobocertinib in EGFR Exon20in NSCLC



ORR=28%

mPFS: 7.3 mo (95% CI, 5.5-9.2)

mDoR: 17.5 months (95% CI, 7.4-20.3)

mOS: 24.0 mo (95% CI, 14.6-28.8)

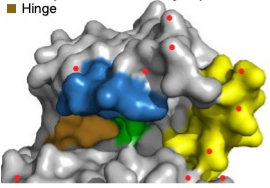
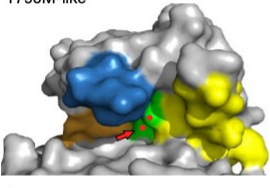
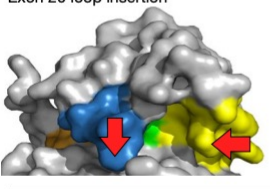
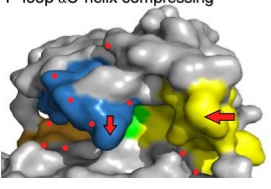
EGFR Exon 20 ins TKI with Putative CNS Penetration

Blu-451
Oric-114
Furmonertinib

	Mobocertinib ^{1,a} (N=114)	Amivantamab ² (N=81)	CLN-081 (TAS6417) ⁶ (N=42) ^c	Sunvozertinib (DZD9008) (N=97) WUKONG6
Investigator assessed				
ORR, %	35%	36%	38%	46.4%
Disease control rate, %	78%	73%	96%	
Duration of response, mos	11.2 mo	-	-	
IRC assessed (95% CI)				
ORR, %	28% (20-37%)	40% (29-51%)	-	60.8% (50.4-70.6%)
Disease control rate, %	78%	74%	-	87.6%
Duration of response, months	17.5 mo	11.1 mo	10 mo	64.4% responding at median fup of 5.6 mo.
PFS, months	7.3 mo	8.3 mo	10 mo	-
Brain Mets, ORR (N=)	-	-	33% (N=3)	44% (N=25) From pooled WUKONG studies

Zhou C. et al. *JAMA Oncol.* 2021 Oct 14;e214761. [Epub ahead of print]. Park K, et al. *J Clin Oncol.* 2021;39:3391-3404. 3. Nagasaka M, et al. Presented at: WCLC;2021. Abstract P50.04. 4. Piotrowska Z, et al. Presented at: ASCO;2020. Abstract 9513. 5. Zwierenga F, et al. Presented at: ESMO;2021. Abstract 1214P. 6. Piotrowska Z, et al. Presented at: ASCO; 2021. Abstract 9077. 7. Janne P, et al. Presented at: WCLC;2021. Abstract OA15.02.

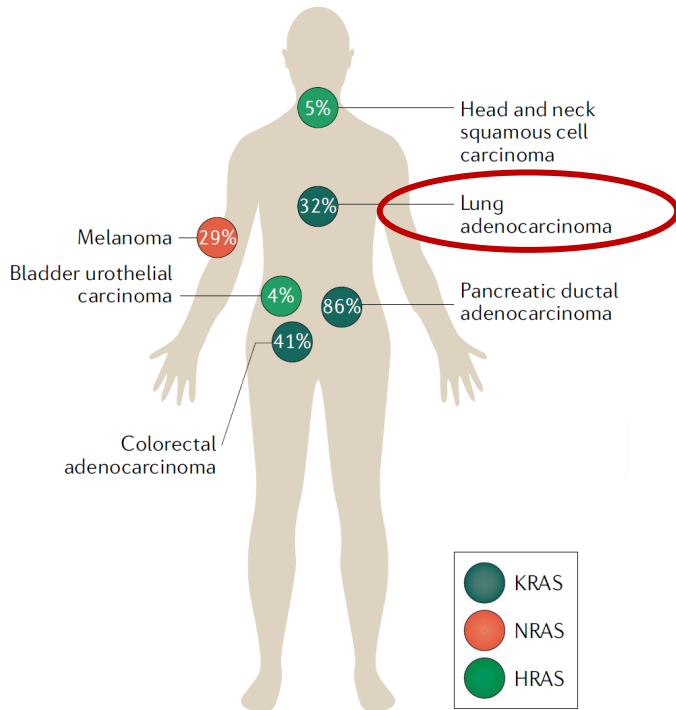
Osimertinib Efficacy in Atypical EGFR Mutations

Classical-like	Description	Representative mutations	Drug selectivity
 <p>■ P-loop ■ αC-helix ■ Hydrophobic core ■ Hinge</p>	<p>Distal to drug-binding pocket</p> <p>Modest to no impact on drug binding</p>	<p>L858R Ex19dels S720P L861Q/R S811F K754E T725M L833F/V A763insFOEA A763insLQEA</p>	<p>Selective</p> <p>Intermediate</p> <p>Resistant</p> <p>3rd gen 2nd gen 1st gen Ex20ins-active</p>
	<p>At least one mutation in hydrophobic core</p> <p>Increased affinity for ATP compared to classical-like mutations</p> <p>Two subgroups: T790M-like-3S T790M-like-3R</p>	<p>T790M-3S Classical/T790M G719X/T790M L747_K745del insATSP S768I/T790M</p> <p>T790M-3R Ex19del/T790M/L792H L858R/T790M/L718X Classical/T790M/ C797S</p>	<p>T790M-3S</p> <p>3rd gen PKCI ALKI</p> <p>2nd gen 1st gen</p> <p>T790M-3R</p> <p>PKCI ALKI</p> <p>3rd gen 2nd gen 1st gen</p>
	<p>C-terminal loop of αC-helix</p> <p>Indirect and substantial impact on drug binding (P-loop and αC-helix)</p> <p>Two subgroups: Ex20ins-near loop Ex20ins- far loop</p>	<p>Ex20ins-NL S768dupSVD A767dupASV D770insNPG D770del insGY</p> <p>Ex20ins-FL H773insNPH H773dupH V774insAV V774insPR</p>	<p>Ex20ins-NL</p> <p>Ex20ins-active 2nd gen 1st gen 3rd gen</p> <p>Ex20ins-FL</p> <p>Ex20ins-active 2nd gen 1st gen 3rd gen</p>
	<p>Proximal to drug-binding pocket</p> <p>Direct or indirect impact on drug binding via moderate displacement of P-loop and/or αC-helix</p>	<p>Primary G719X S768I L747P/S V769L E709_T710 delinsD</p> <p>Acquired C797S L792H G724S L718X T854I</p>	<p>2nd gen</p> <p>1st gen Ex20ins-active</p> <p>3rd gen</p>

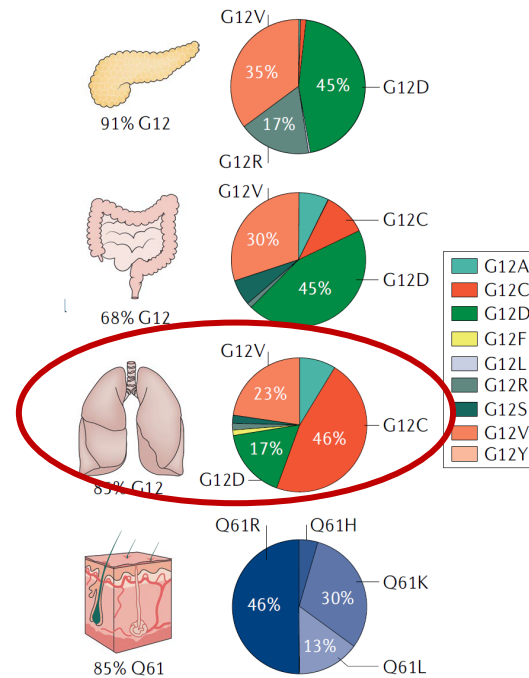
- Structure-Function relationship and classification predicts TKI activity in EGFR mutant NSCLC.
- Role of EGFR moAb and bispecifics by mutation needs to be more fully explored.

KRAS mutations in cancer – Focus on NSCLC

Frequency of KRAS Mutations by Tumor Type

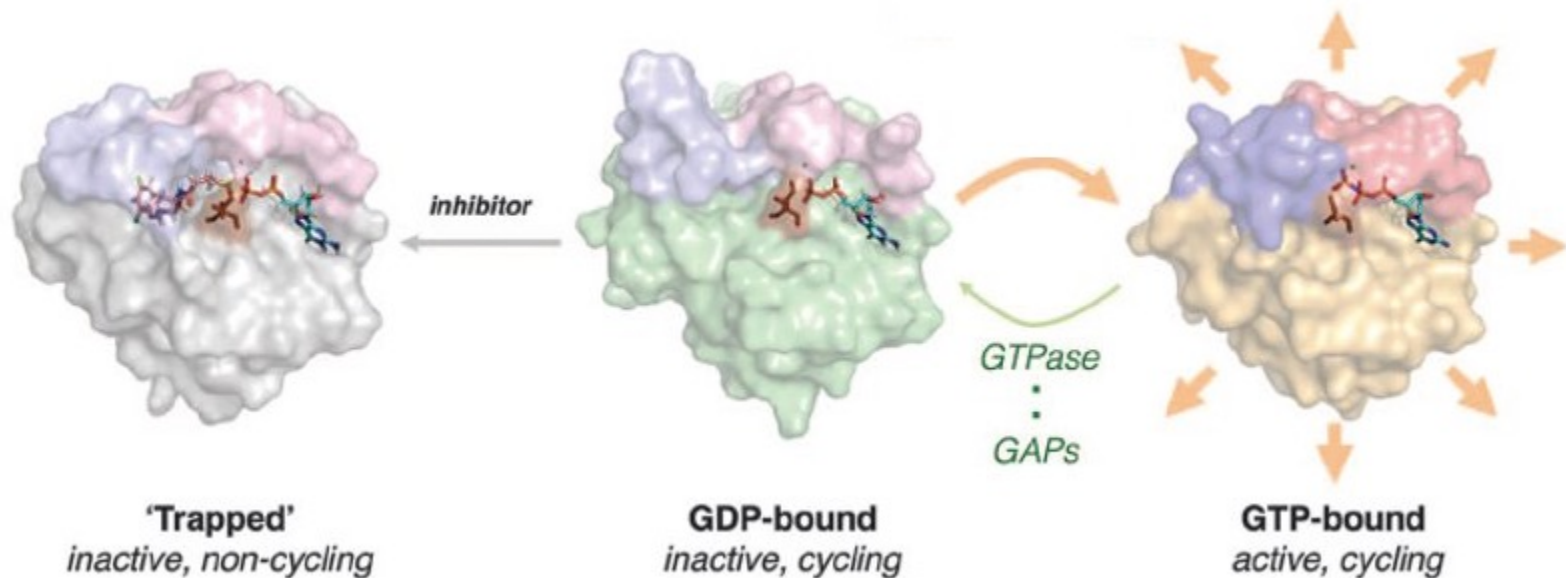


KRAS Mutation Subtypes By Tumor Type



Figures from Moore AR et al. Nat Rev Drug Discov 19, 533–552 (2020).

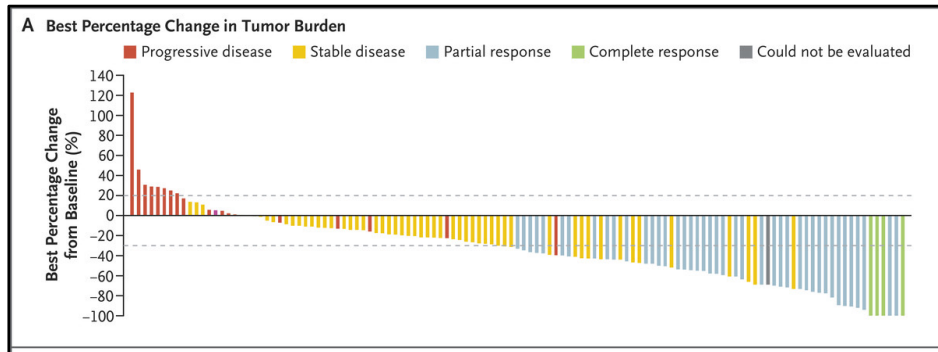
KRAS G12C Inhibitors Bind, Inactive GDP bound RAS and Trap It In Inactive State



From P. Lito et al. Science 2016

KRAS G12C inhibitors have activity in *KRAS* G12C NSCLC

Sotorasib CodeBreakK100 (Ph 2)



N=124 pts at 960 mg po qd

Median 2 prior lines of therapy

81% received both platinum and anti-PD-(L)1

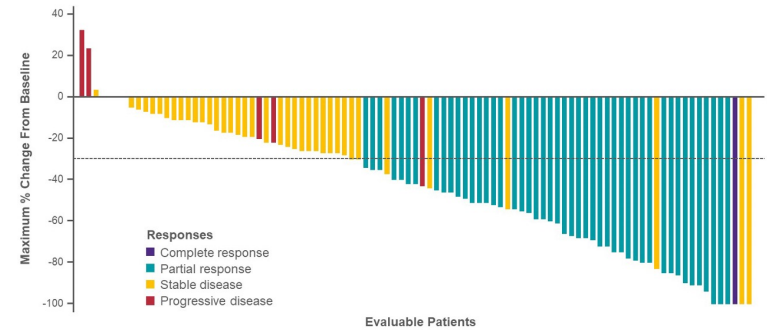
ORR 37.1% (95% CI 28.6-46.2) // **DCR 80.6%** (95% CI 72.6-87.2)

mDOR 11.1 mo (95% CI 6.9-NE); **mPFS 6.8 mo** (95% CI 5.1-8.2)

mOS 12.5 mo (95% CI 10.0-NE)*

*median f/u 15.3 months F Skoulidis et al. N Engl J Med 2021;384:2371-2381.

Adagrasib KRYSTAL-1 study (Ph 1/1b & 2)



N=112 pts at 600 mg po bid

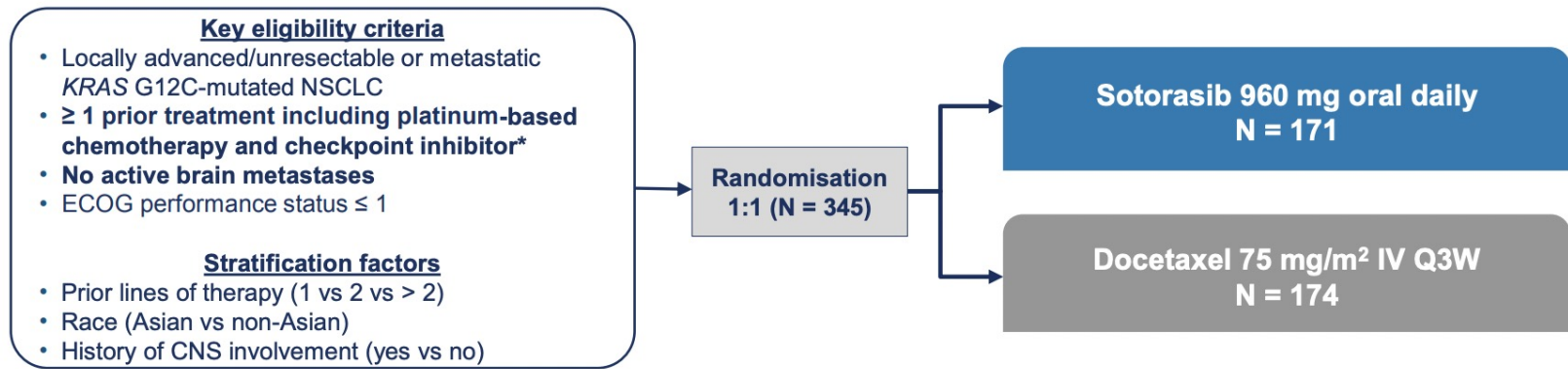
98% received both chemo and anti-PD-(L)1

ORR 43% // **DCR 80%** // **mPFS 6.5 months** (95% CI 4.7-8.4)

mOS 12.6 months (95% CI 9.2-19.2)

Spira A. ASCO 2022

CodeBreakK 200 Phase 3 Study Design

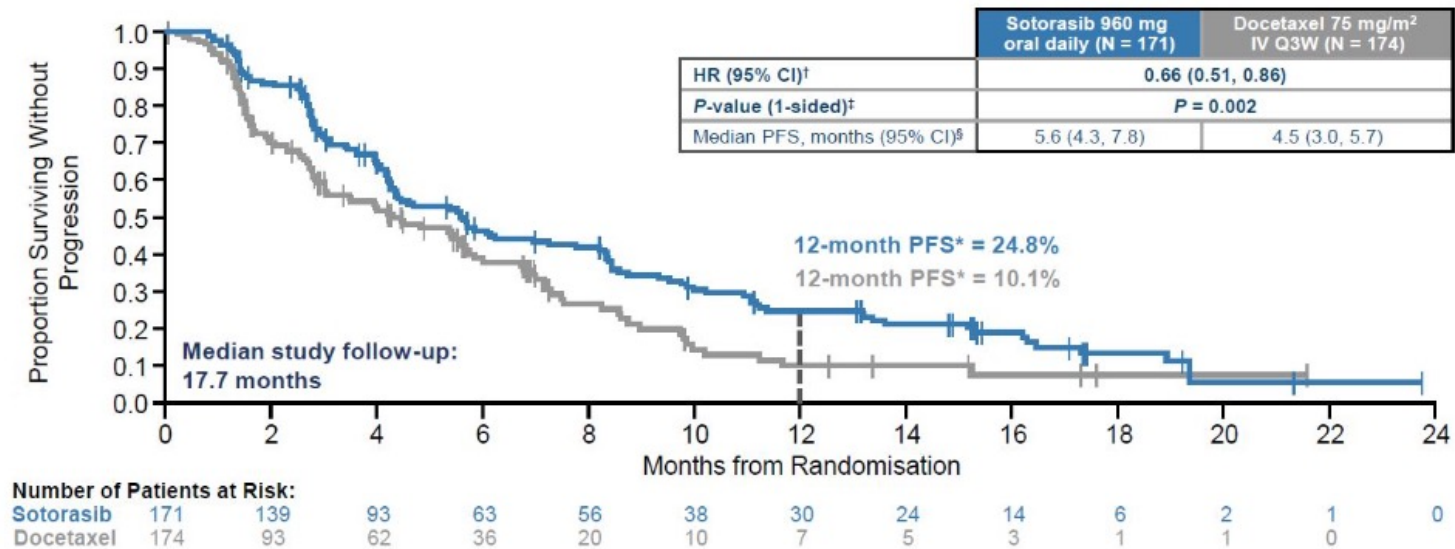


Primary Endpoint: PFS by BICR
Secondary Endpoints: Efficacy (OS[†], ORR, DOR, TTR, DCR), safety/tolerability, PRO
ITT population analysis included all randomised patients

Per regulatory guidance, protocol was amended to reduce planned enrolment from 650 to ~330 patients, and crossover from docetaxel to sotorasib was permitted.

Enrollment period: June 4, 2020 to April 26, 2021; protocol amendment: February 15, 2021; data cutoff: August 2, 2022.

Primary Endpoint: PFS by BICR



CodeBreak 200 met its primary endpoint with sotorasib demonstrating superior PFS over docetaxel (HR 0.66, P = 0.002); 12-month PFS rate was 24.8% for sotorasib and 10.1% for docetaxel

ORR 28.1% vs. 13.2%

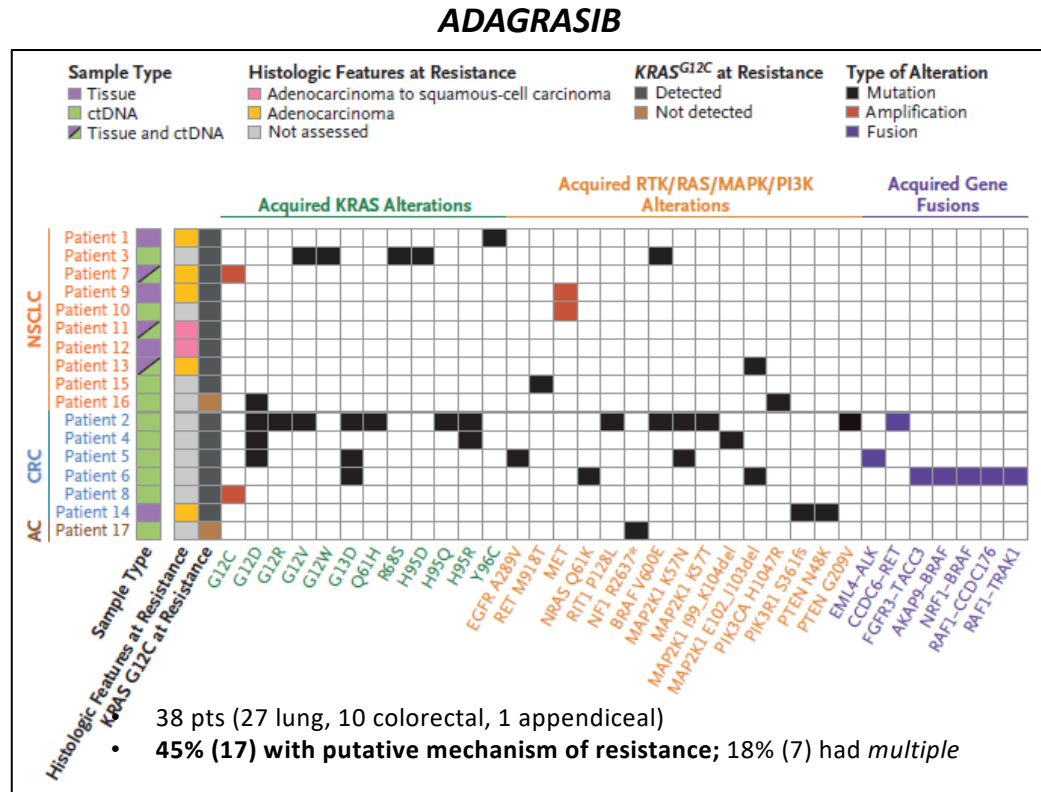
mOS 10.6 (soto) vs. 11.3 months (doce). No difference in OS.

34% crossover in docetaxel arm

M. Johnson et al ESMO 2022

Acquired resistance to KRAS G12C inhibitors

- **On-target resistance (in green)**
 - *KRAS* G12D/R/V/W, G13D, Q61H, **R68S, H95D/Q/R, Y96C***
 - High level *KRAS* G12C amplification
- **Bypass resistance (in orange)**
 - *MET* amplification
 - Activating mutations in *NRAS*, *BRAF*, *MAP2K1*, *RET*
 - Oncogenic fusions *ALK*, *RET*, *BRAF*, *RAF1*, *FGFR3*
 - LOF *NF1*, *PTEN*
- **Histologic transformation**
 - 2/9 NSCLC adenoca → squamous

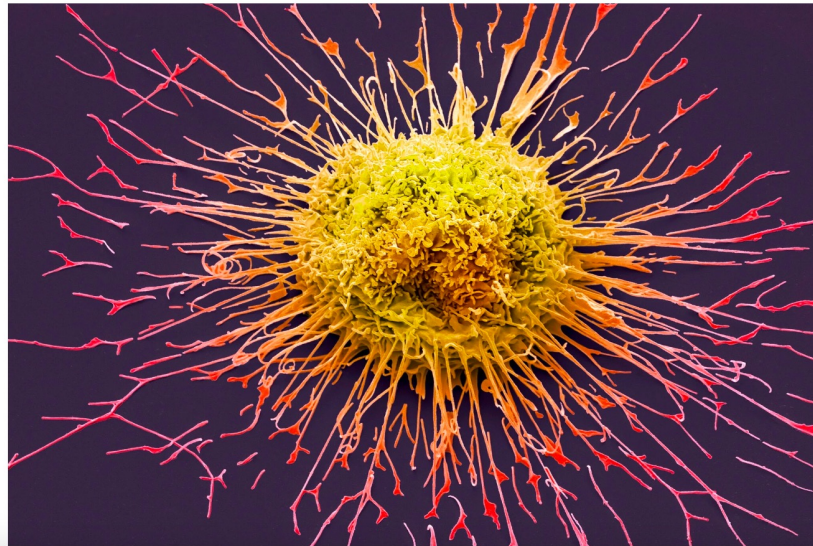


*in switch II pocket

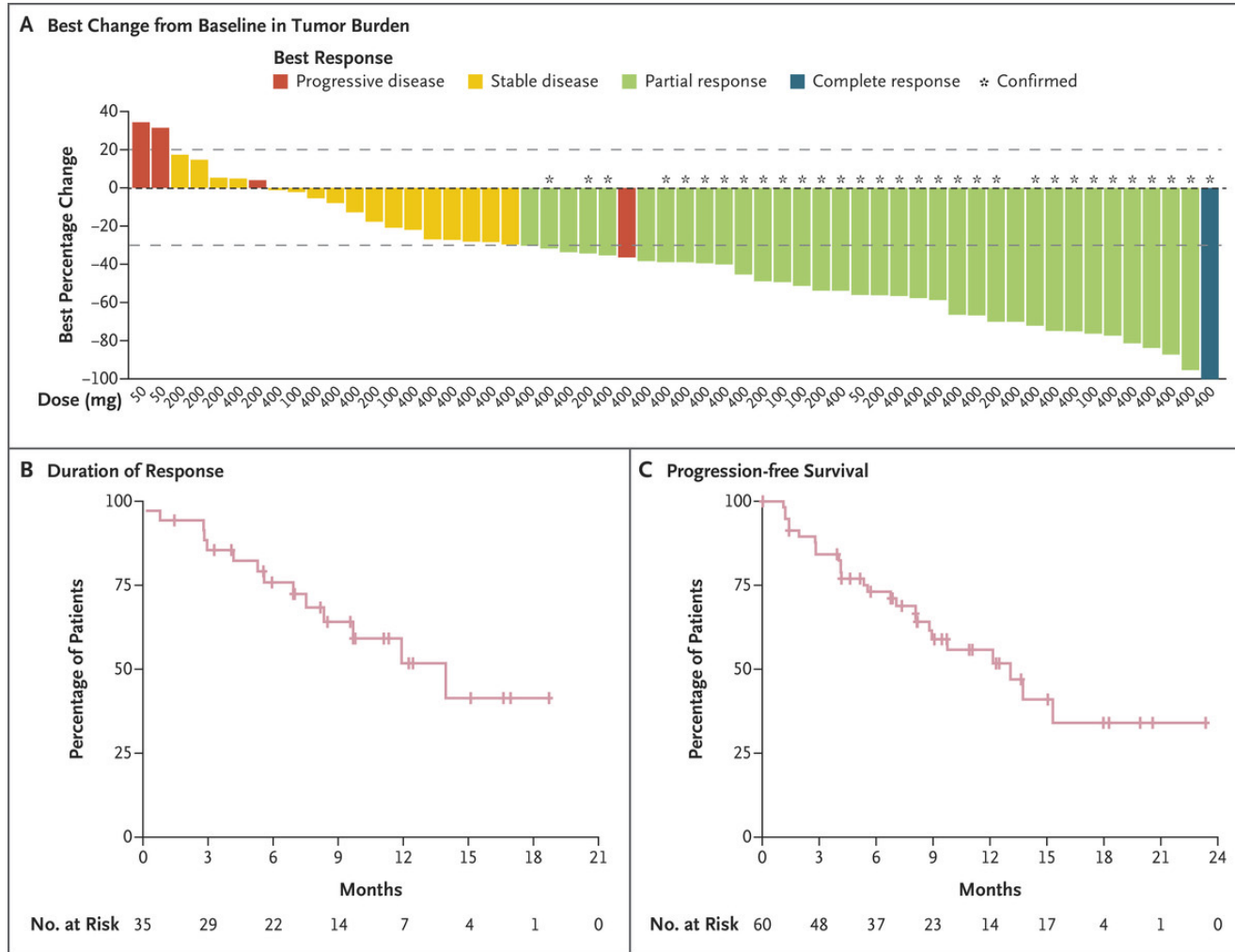
The New York Times

How Scientists Shot Down Cancer's 'Death Star'

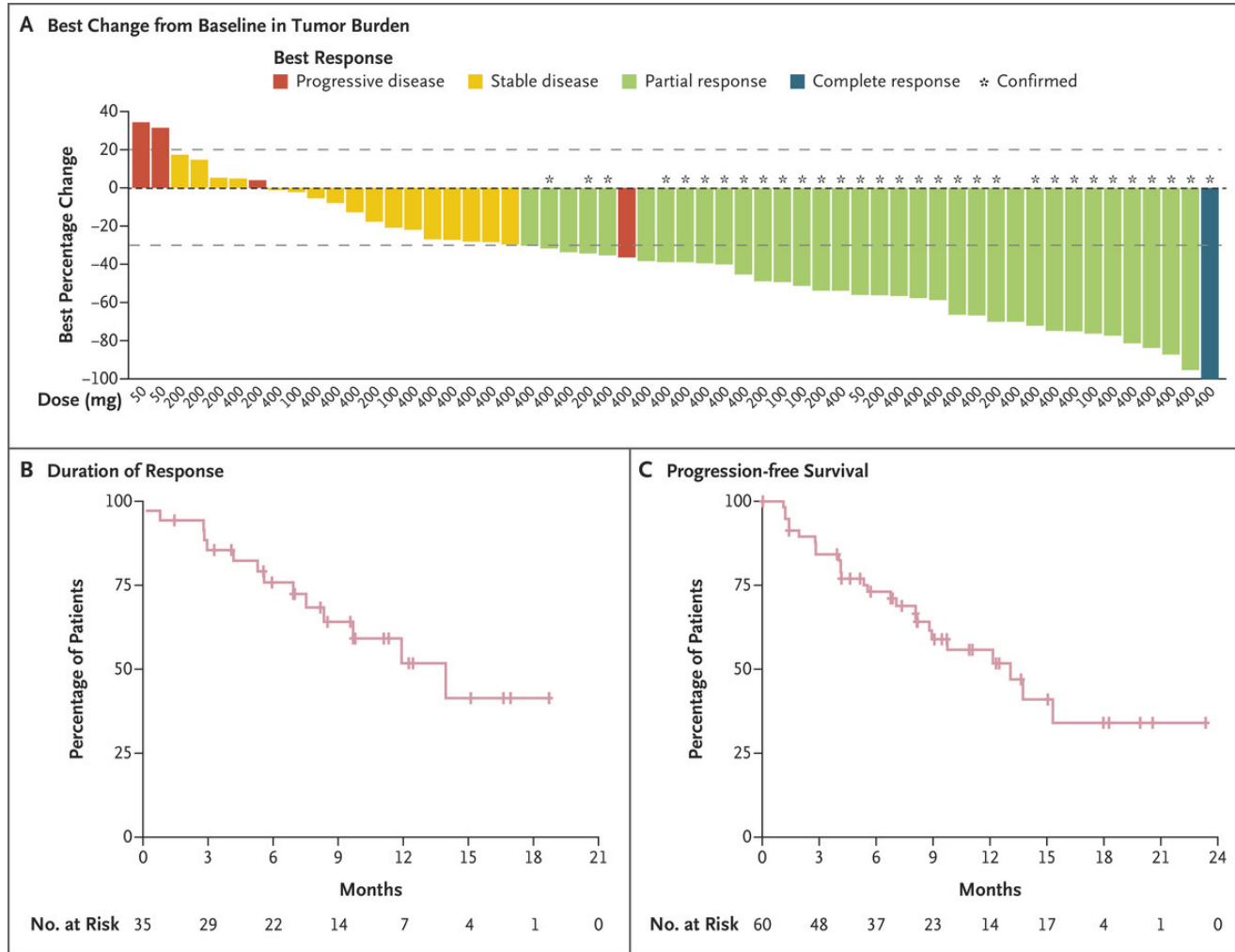
No drug could touch a quivering protein implicated in a variety of tumors. Then one chemist saw an opening.



Antitumor Activity of Divarasilb in Patients with KRAS G12C Non-Small-Cell Lung Cancer (NSCLC).

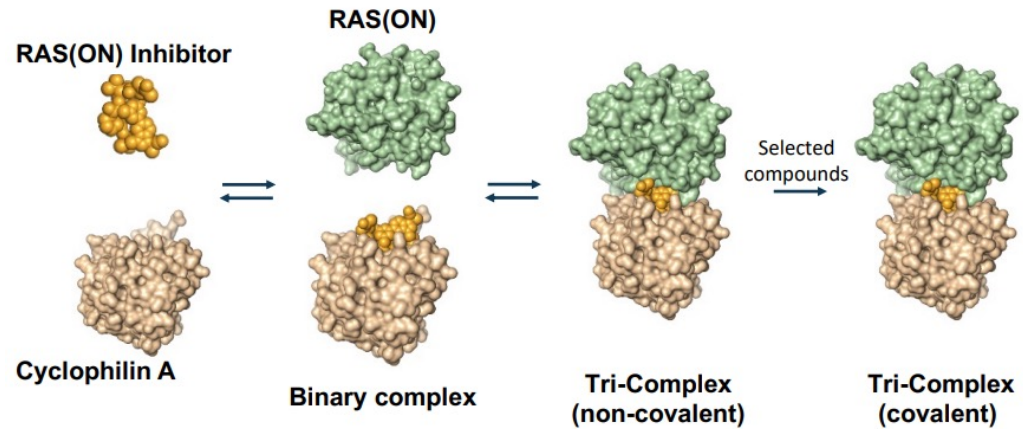


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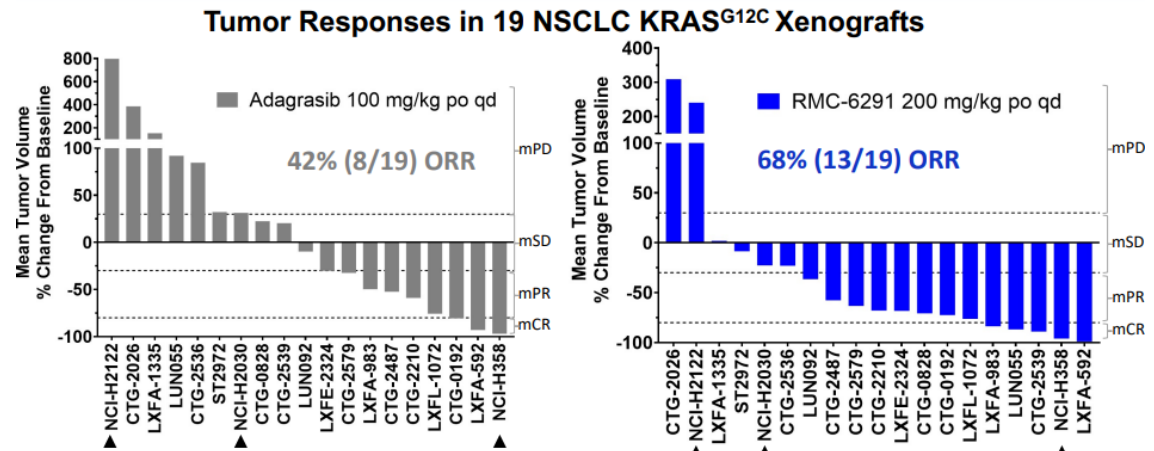


RAS(ON) Inhibitors

- Less susceptible to adaptive resistance compared to GDP bound RAS

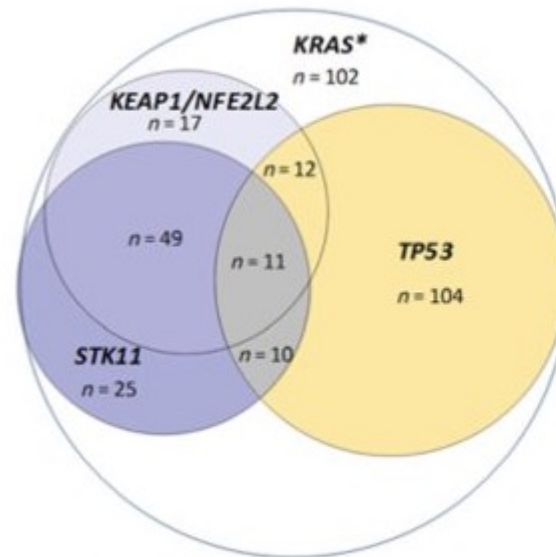
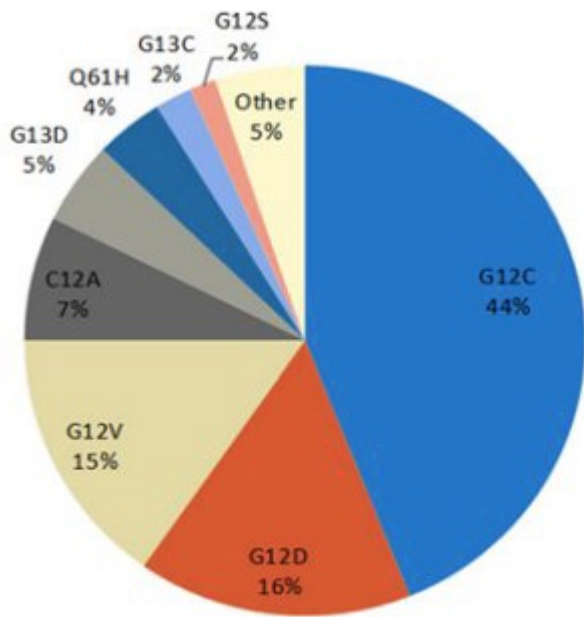


- RMC-6291 KRAS G12C (ON) inhibitor
- RMC-9805 KRAS G12D (ON) inhibitor
- RMC-6236-Pan RAS(ON)



▲ Denotes CDX model; all others are PDX. Responses assigned according to mRECIST (modified from Gao et al Nat Med. 2015).

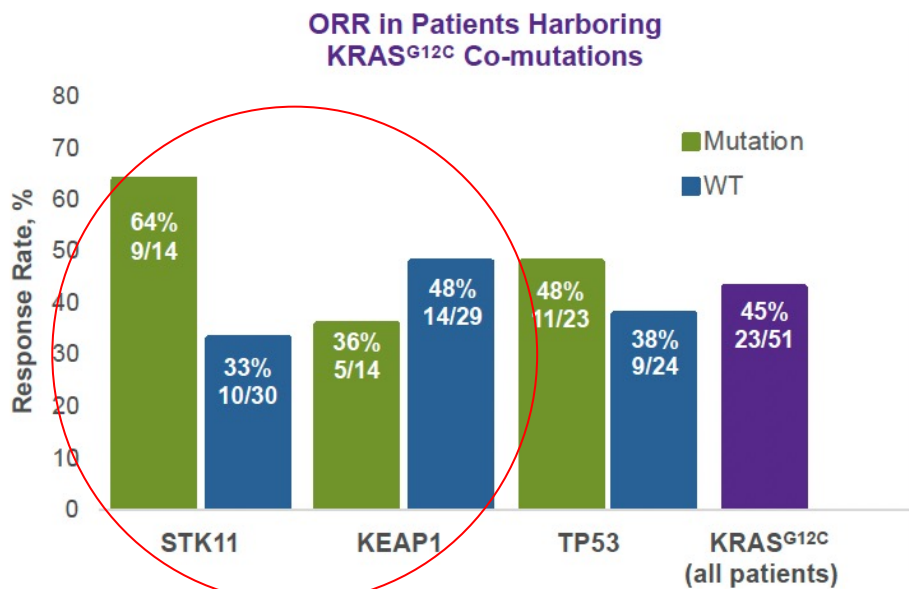
Spectrum of KRAS mutations and Co-Mutations in NSCLC



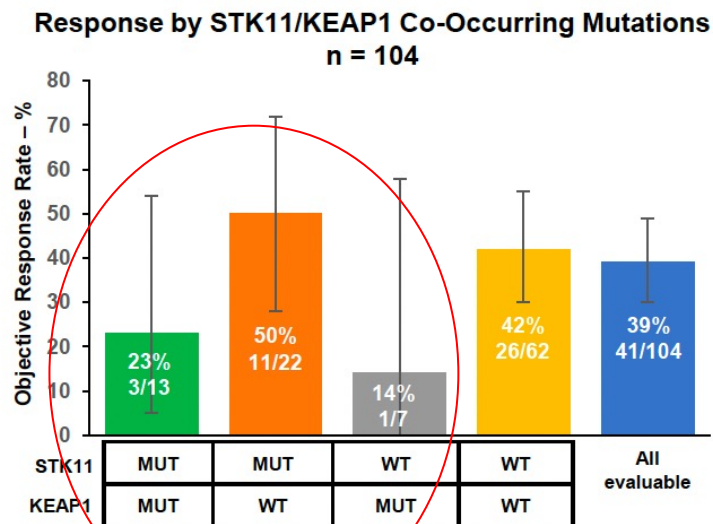
*KRAS (n = 102) listed above represents number of patients with KRAS mutations but without cooccurring mutations in TP53, STK11, KEAP1 or NFE2L2

Differential Efficacy in Co-Occurring Mutations in KRAS G12C NSCLC

Adagrasib (MRTX849)

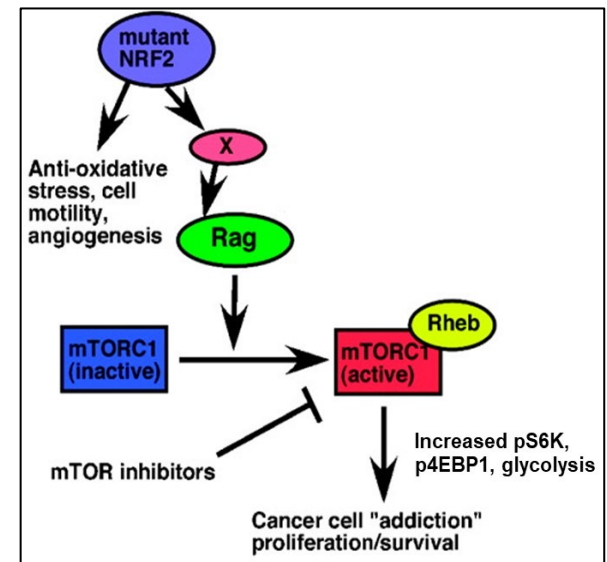


Sotorasib (AMG510)



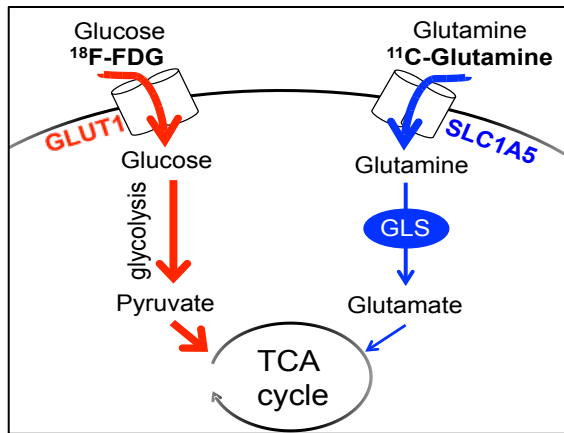
Upregulated Nrf2 is a Druggable Target in Squamous NSCLC and KRAS mutant NSCLC

- Nrf2 (encoded by NFE2L2) is a transcription factor that binds to antioxidant response elements (AREs)
- Keap1, the product of *KEAP1*, sequesters Nrf2 to the cytoplasm (negative regulator)
- Worse outcomes to systemic treatments in retrospective studies (Frank et al CCR 2018).
- *NFE2L2* and *KEAP1* are mutated in 30% of SQCLCs (*NFE2L2*>*KEAP1*). ~20-25% of KRAS mutant NSCLC (*KEAP1*>*NFE2L2*)
 - Transforming, oncogenic
 - *NFE2L2* mutations disrupt *KEAP1* binding and upregulate mTOR through RagD



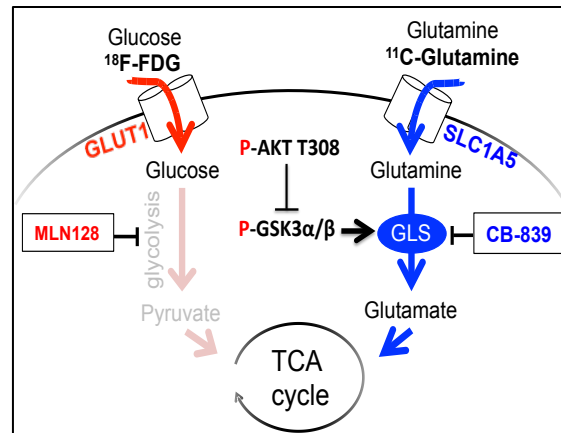
Adaptive Glutamine Metabolism by GSK3 Signaling Axis Circumvents MLN0128 Inhibition of Glycolysis in Squamous NSCLC

Glucose and Glutamine Dependent Metabolism

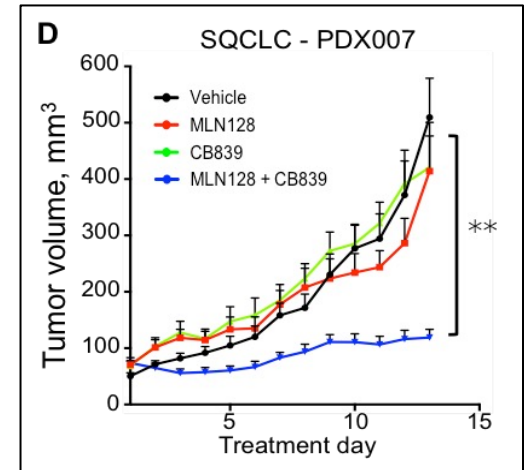


Basal metabolism – high uptake of glucose and glutamine to sustain SCC growth

Adaptive Glutamine Metabolism



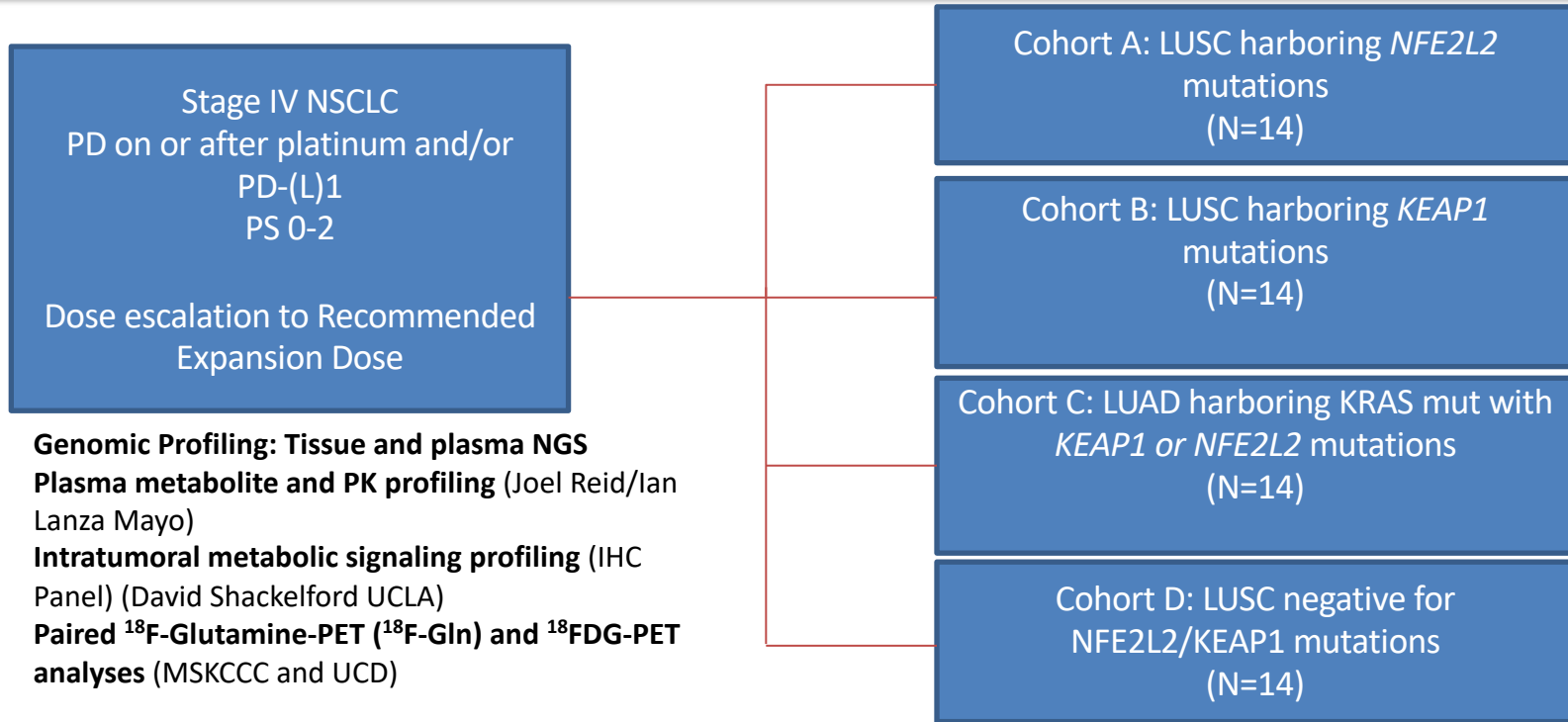
Overcoming resistance – GSK signaling axis with adaptive GLN metabolism



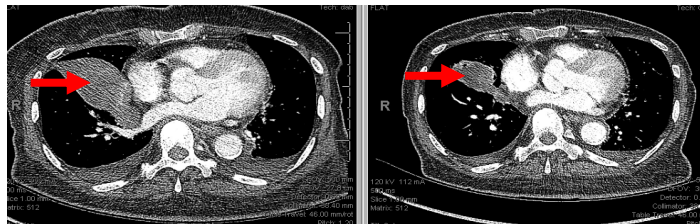
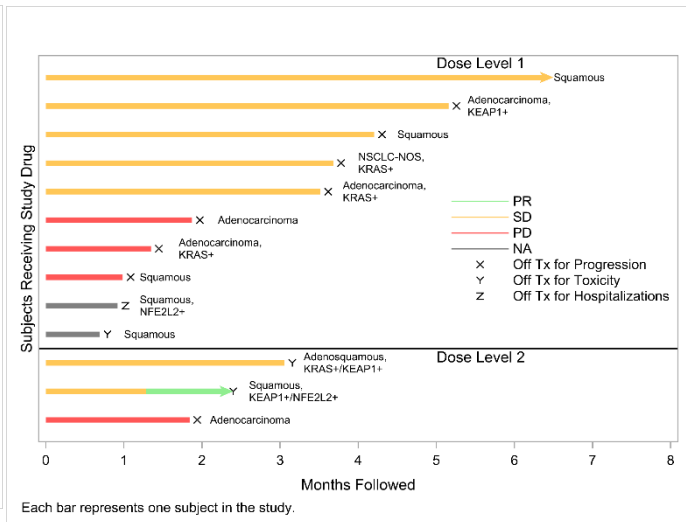
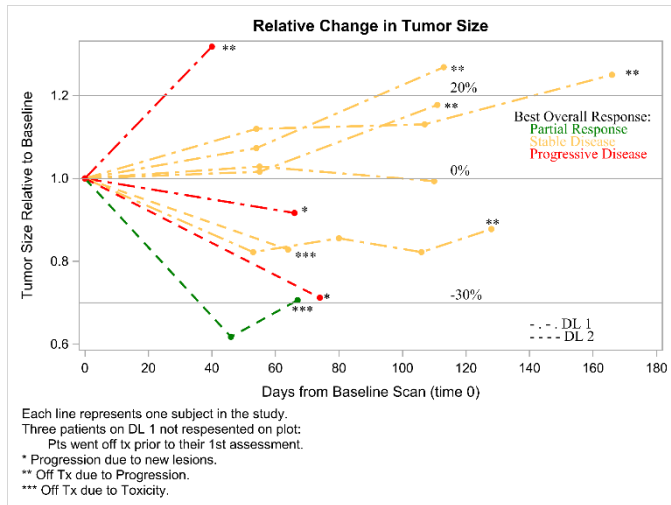
Actionable in vivo with dual mTOR and GLS inhibition

From the Shackelford lab. Momcilovic et al. Cancer Cell 2018.

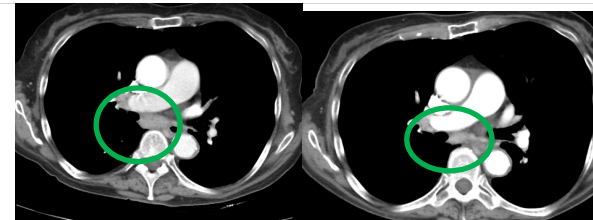
A Phase 1 Trial of MLN0128 (Sapanisertib) and CB-839 in Advanced NSCLC (NCI 10327)



co-PIs: JW Riess, Paul Paik



Pre-treatment On Treatment
KRAS G13C/KEAP1 Adenosquamous NSCLC



Pre-treatment On Treatment
NFE2L2 mutant Squamous NSCLC

Conclusions

- Effective targeted therapeutics against 8+ mutations comprising over a third of lung adenocarcinoma.
- Next generation agents in development as well as targeted therapy of bypass tracts and ADCs
- Still targets with unmet need – KRAS G12D, PIK3CA and others.