

A young girl with pigtails, wearing a black soccer jersey with teal accents and black shorts with white stripes, is blowing bubbles on a green grassy field. The background shows trees and a bright sunset with lens flare. The scene is overlaid with a blue gradient on the left side where the text is located.

# Development of the Endosomal Escape Vehicle (EEV™) Platform for Enhanced Delivery of Oligonucleotides to Skeletal and Cardiac Muscle

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6<sup>th</sup> International Caparica Conference on Splicing





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## OUR MISSION:

# To Treat Devastating Diseases With Intracellular Therapeutics

*We're proud to share the stories of JJ,  
Andrew, Max and Franklin – all living with  
Duchenne muscular dystrophy*



# EEV™ PLATFORM





# ENDOSOMAL ESCAPE VEHICLE (EEV™)-BASED THERAPIES



## Unique chemistry

Improved uptake and endosomal escape

## Cyclic structure

Extended half-life and increased stability

## Phospholipid binding

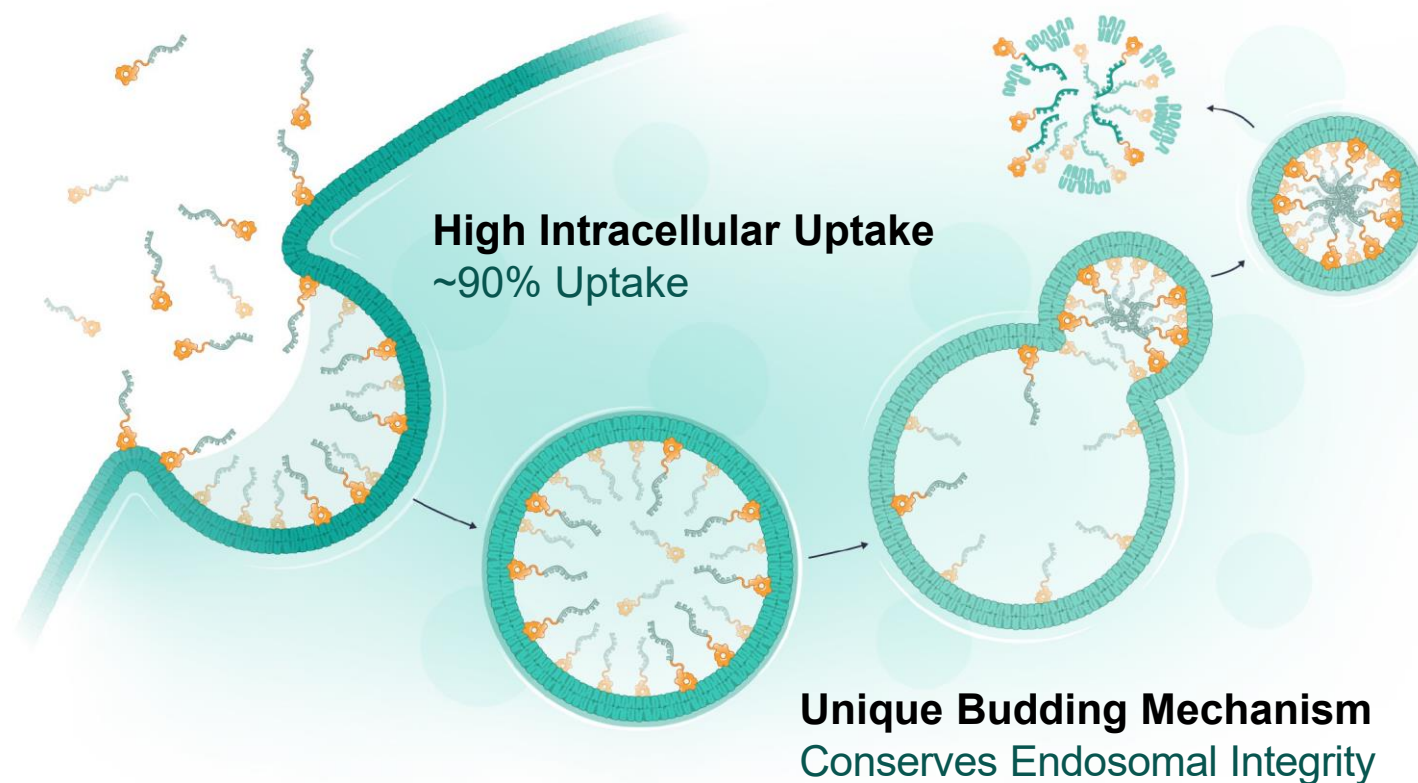
Broad biodistribution to all cells

## Consistent and predictable pharmacokinetics

Same EEV used across initial programs

## Efficient Endosomal Escape

~50% Escape vs. ~2% Standard



# PIPELINE EXPANSION OPPORTUNITIES

Entrada's flexible approach to intracellular therapeutics enables pipeline expansion by leveraging new moieties and by targeting additional therapeutic areas

## TARGET



**DNA**



**RNA**



**PROTEINS**

## APPROACH

**Gene  
Editing**

**RNA  
Editing**

**RNA  
Splicing**

**RNA  
Blocking**

**RNA  
Silencing**

**Protein  
Replacement**

**Protein  
Inhibition**

**Protein  
Degradation**

## GOAL

Deliver CRISPR enzyme and repair gene function with guide RNA

Deliver oligonucleotide therapeutics for RNA editing

Modify RNA via exon/intron splicing to activate protein expression

Block trinucleotide repeats in RNA to inhibit adverse binding

Silence or knockdown RNA to prevent protein expression

Replace proteins and enzymes

Inhibit protein signaling pathways

Degrade disease-causing proteins

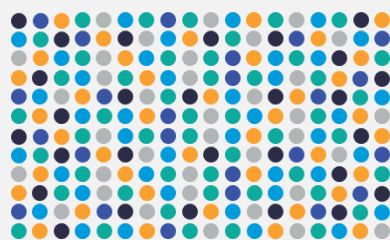
# DISCOVERY ENGINE FOR EEV THERAPEUTICS

## EEV-OLIGO EXAMPLE

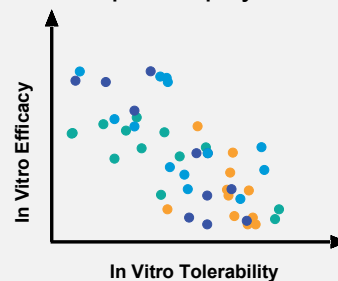
Fit-for-purpose EEVs can be designed for target indications and modalities via iterative optimizations of EEV peptides through medicinal chemistry, *in vitro* and *in vivo* screenings



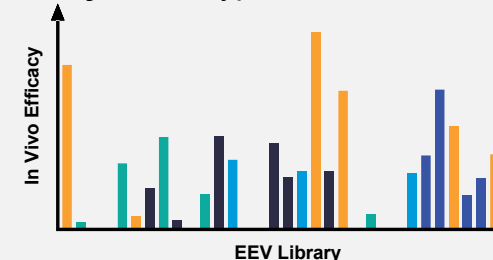
Chemically diverse macrocyclic **EEV library** generated through medicinal and combinatorial chemistry



***In vitro* delivery and counter-screening** in relevant cell types with therapeutic payload



***In vivo* screening to assess functional delivery and pharmacodynamic activity** in wild-type and disease models

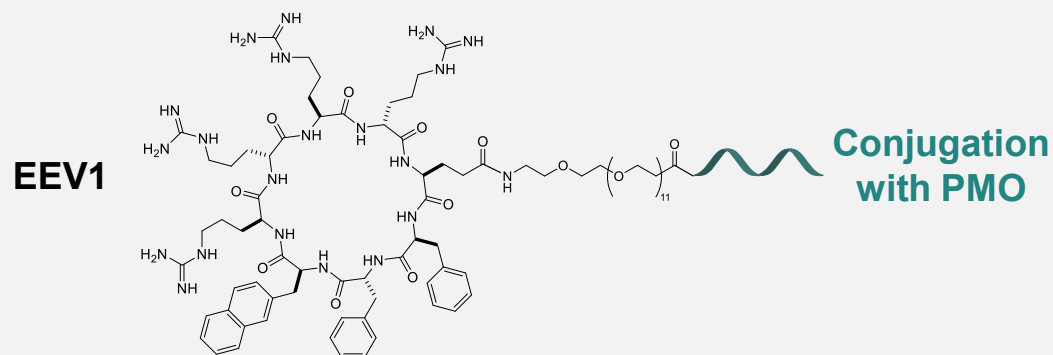


# OLIGO DELIVERY WITH FIRST GENERATION EEV

## EEV1 EXAMPLE

A first-generation EEV1 peptide-PMO construct enhanced splice correction *in vitro* and after local injection, demonstrated functional delivery of oligonucleotides

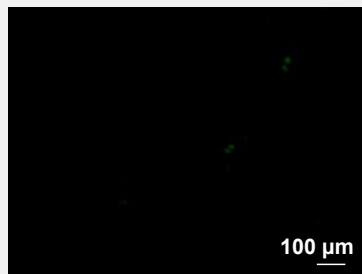
### Splicing Correction in HeLa EGFP-654 Cells



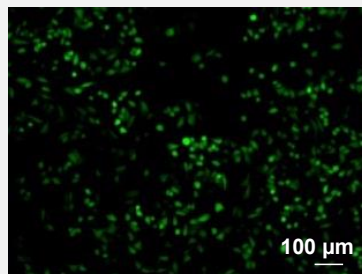
Control



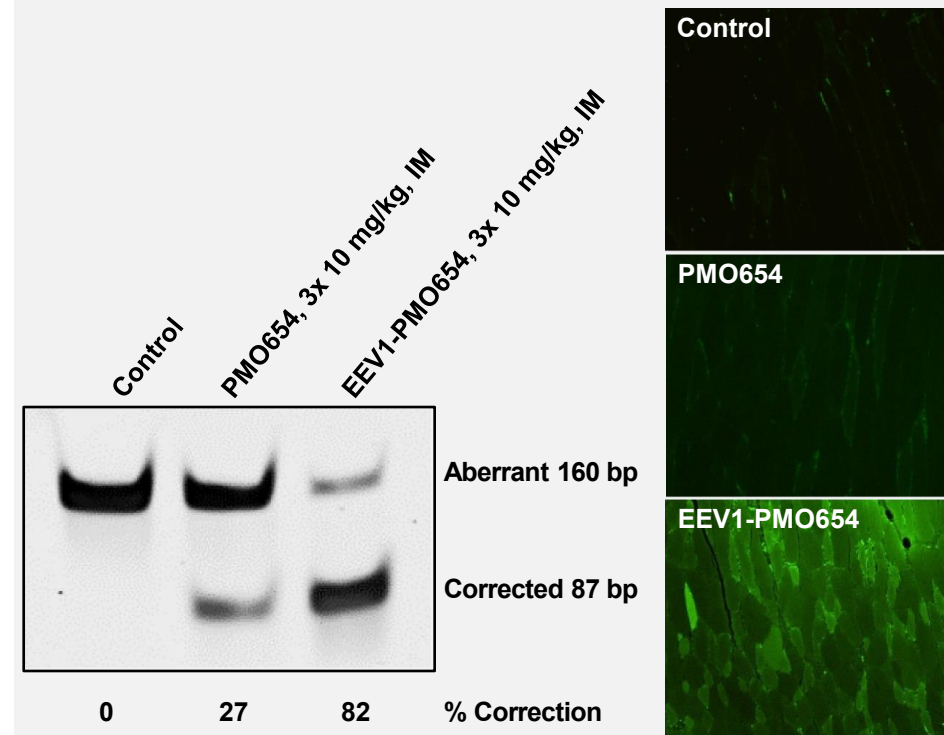
PMO654



EEV1-PMO654



### Three Daily IM Doses of EEV1-PMO654





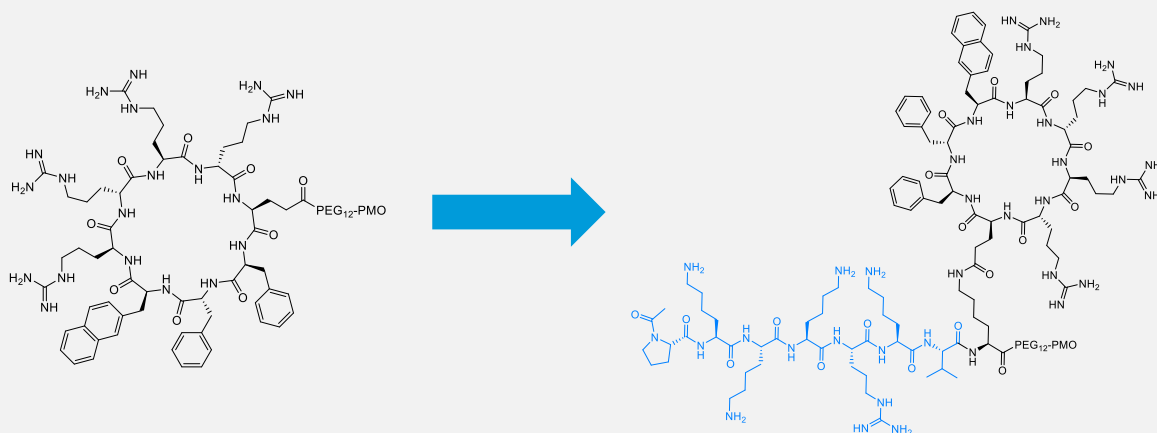
# ENHANCED OLIGONUCLEOTIDE DELIVERY

## EEV2 EXAMPLE

The addition of an exocyclic peptide sequence to a first-generation EEV1 peptide improved exon skipping in skeletal and cardiac muscle of *mdx* mice after intravenous injection

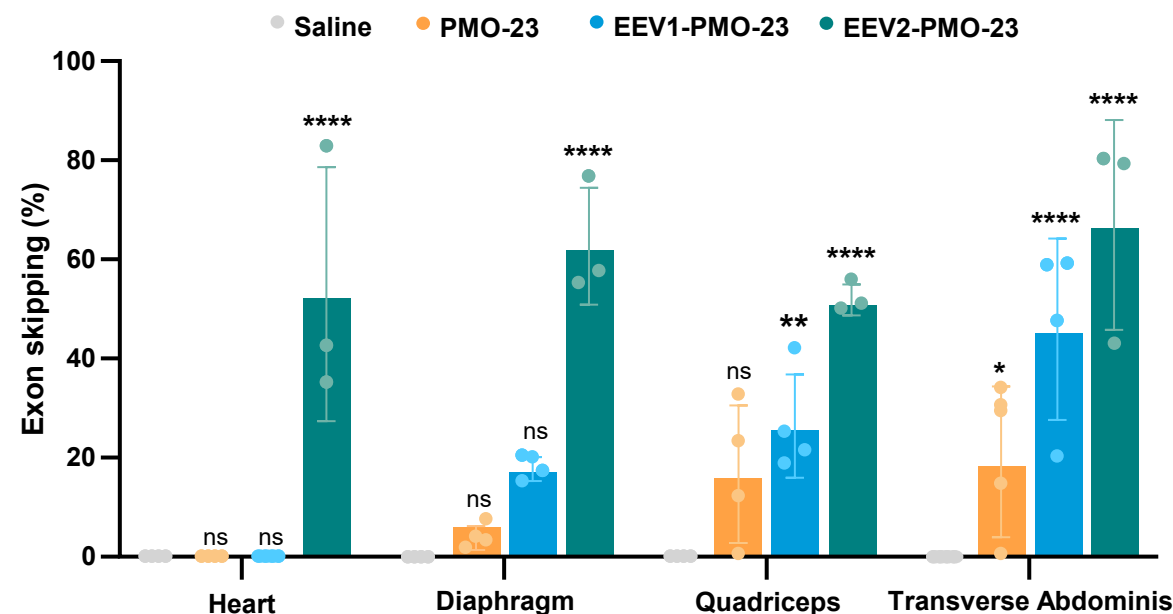
### Structure of EEV2 Construct

EEV1 + exocyclic peptide sequence = EEV2



- To create the EEV2 construct, EEV1 was modified to include an **exocyclic peptide sequence** to improve delivery to the nucleus

### Higher In Vivo Exon Skipping with EEV2 vs. EEV1



- mdx* mice were evaluated for exon skipping (via RT-PCR) 7 days following a single 20-mg/kg IV injection of saline, PMO-23, EEV1-PMO-23, or EEV2-PMO-23

# OPTIMIZATION OF EEV FOR MUSCLE DELIVERY

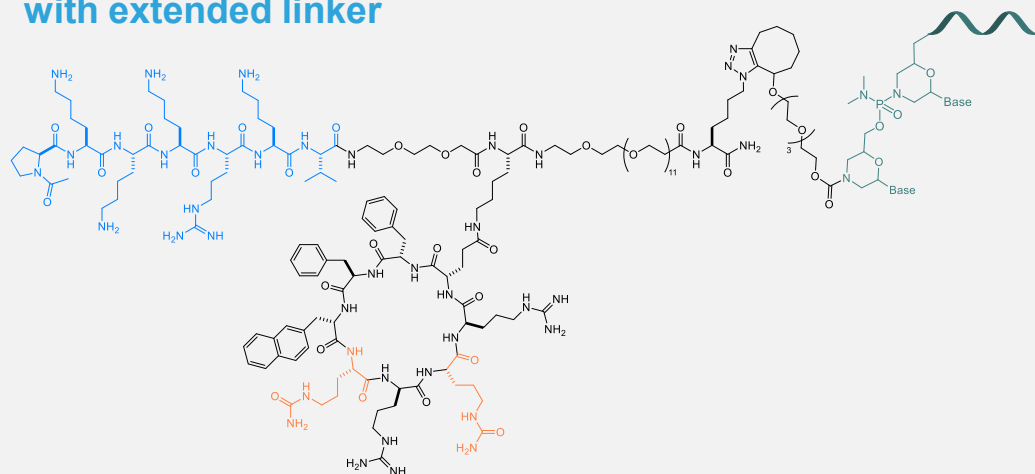
## EEV3 Example

Rational substitution of cationic residues with a surrogate results in robust functional delivery to skeletal and cardiac muscle

### EEV3-PMO654 Structure and Medicinal Chemistry

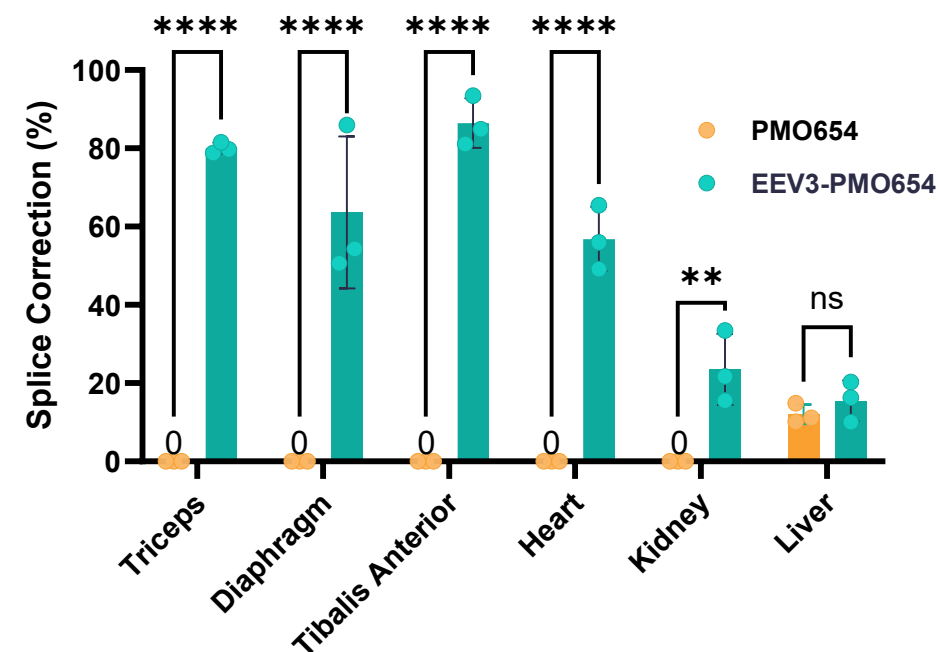
Exocyclic peptide sequence  
with extended linker

Conjugation with PMO



Substitution of positively charged arginine  
residues with neutral charged citrullines

### Enhanced Functional Delivery to Muscle



- EGFP654 mice were evaluated for splice correction 7 days following three weekly 10 mg/kg IV injections of PMO654 or EEV3-PMO654

\*\*p<0.01, \*\*\*\*p<0.0001; values are shown as mean  $\pm$  standard deviation. EEV, endosomal escape vehicle; IV, intravenous; ns, not significant; PMO, phosphorodiamidate morpholino oligomer.

# TRANSLATION FROM UPTAKE TO OUTCOMES

## Murine Example

EEV-therapeutic candidates have demonstrated favorable pharmacological properties: efficient intracellular delivery, significant uptake in target tissues and potent pharmacodynamic outcomes

### Tissue Uptake in Muscle



- ✓ Skeletal muscle
- ✓ Cardiac muscle

+

### Intracellular Delivery



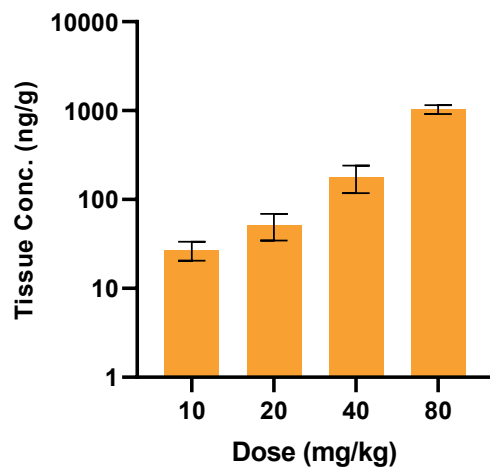
- ✓ Endosomal escape
- ✓ Nuclear localization

=

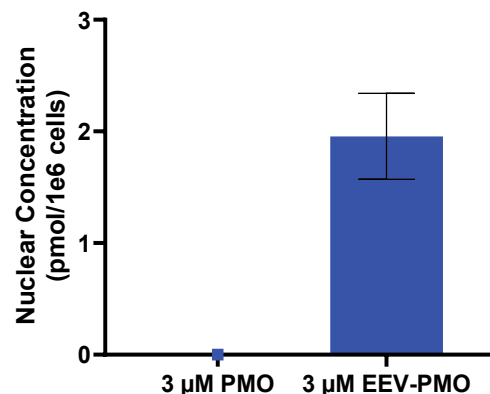
### Pharmacodynamic Outcome



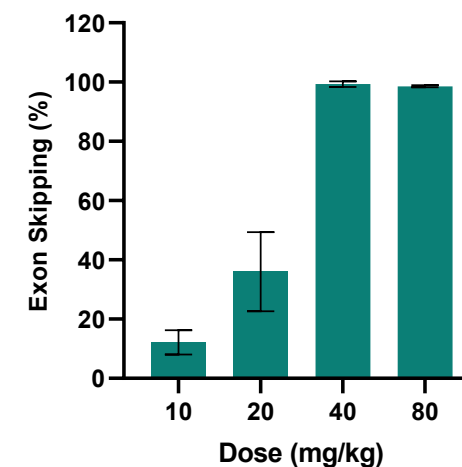
- ✓ Rapid, dose-dependent response
- ✓ Duration of at least 12 weeks



IV, hDMD mice, 5-day post injection



24-hour incubation



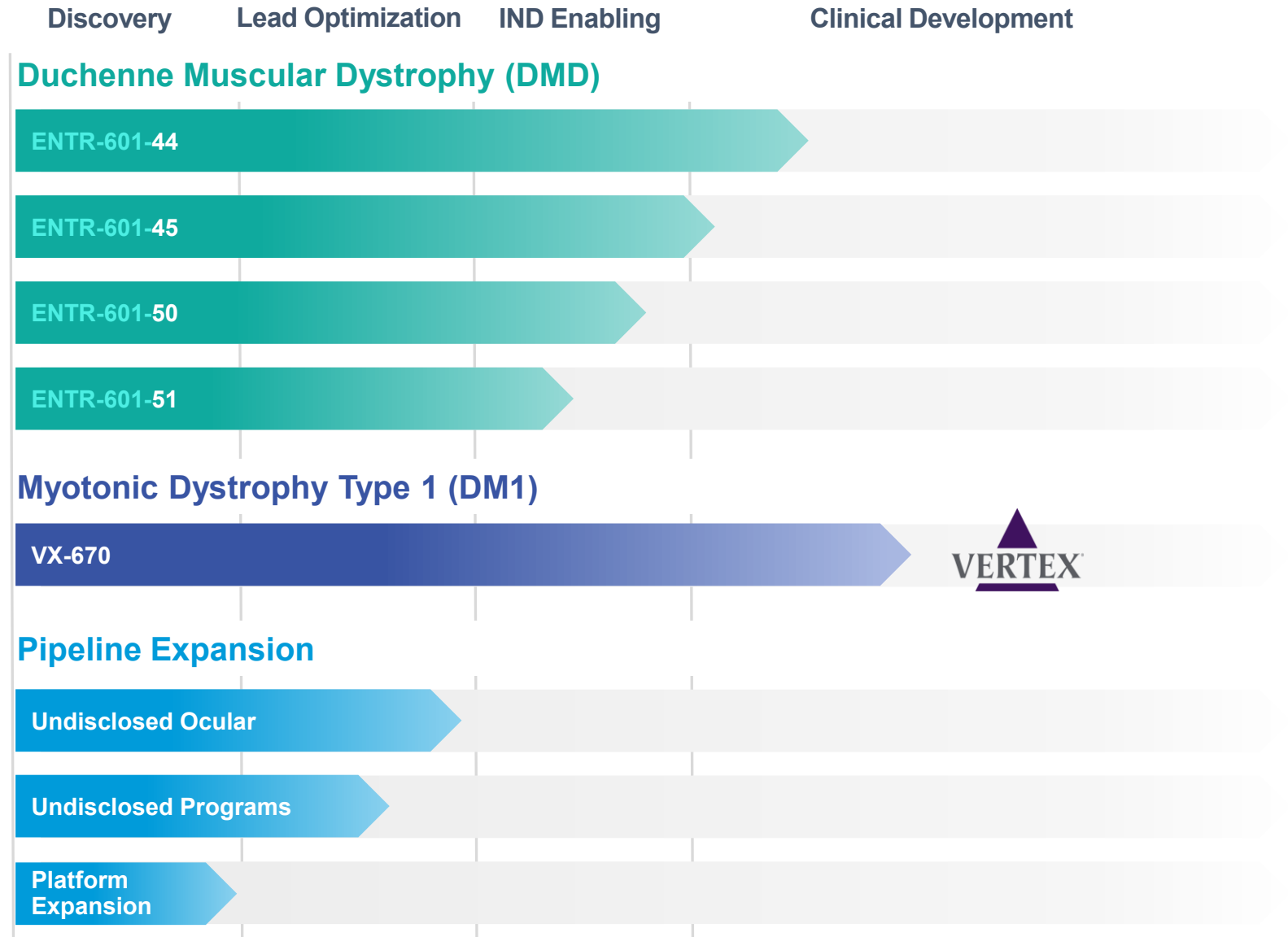
IV, hDMD mice, 5-day post injection



# An Expanding Pipeline of Intracellular Therapeutics

Entrada's pipeline includes a diverse array of high potential and high value assets

Each target disease has a substantial patient population with a significant unmet medical need



# DUCHENNE MUSCULAR DYSTROPHY

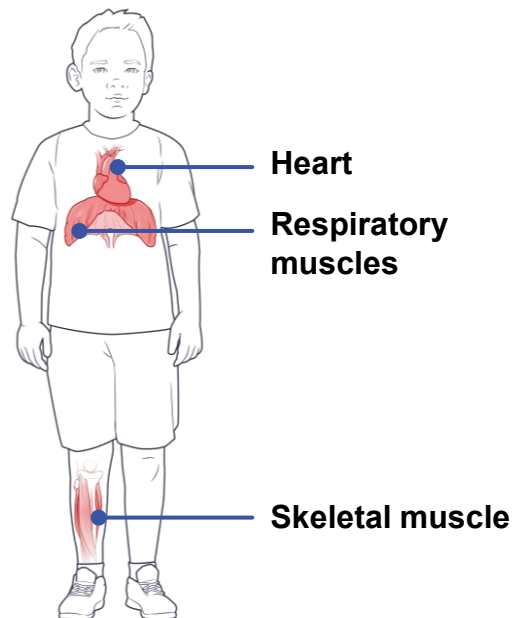
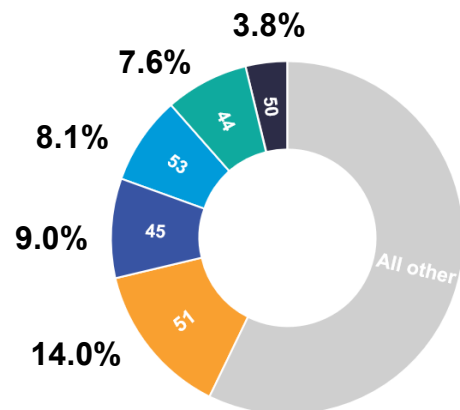


# SIGNIFICANT THERAPEUTIC NEED EXISTS WITHIN A VALIDATED DUCHENNE MARKET

Duchenne is caused by **mutations in the DMD gene, which lead to a lack of functional dystrophin**, causing progressive loss of muscle function throughout the body

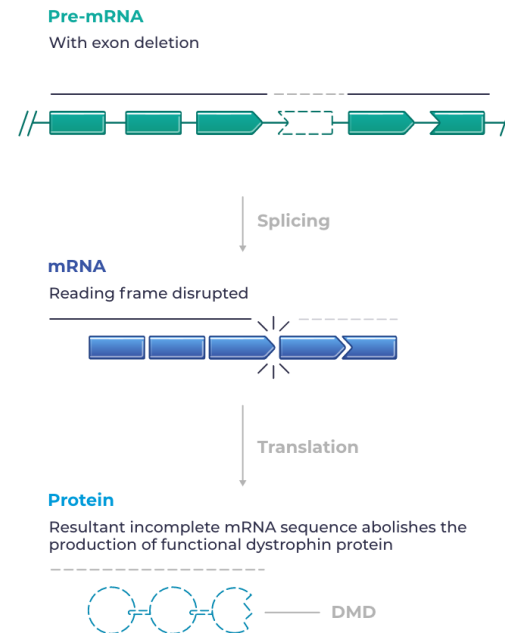
Approximately **41,000** people in the **U.S.<sup>1</sup> and Europe<sup>2</sup>** have Duchenne

**>40% of patients with Duchenne<sup>3</sup>** have mutations amenable to exon skipping of exons 44, 45, 50, 51 and 53

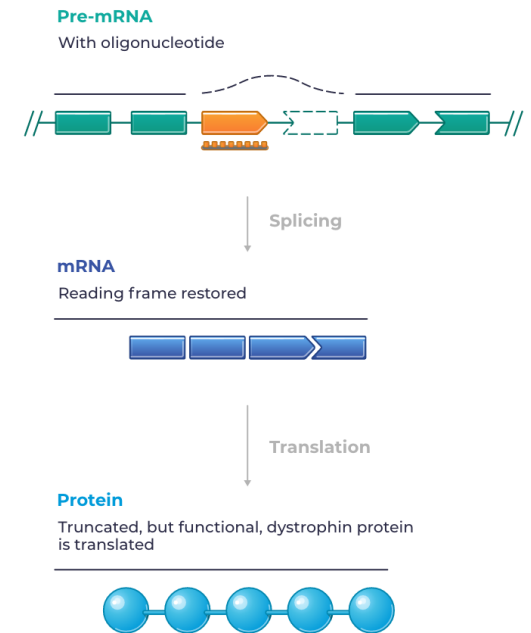


Exon skipping therapeutics have been approved based on **modest improvement in dystrophin levels ranging from ~1% to 6%<sup>4-7</sup>**

## Patients with Duchenne



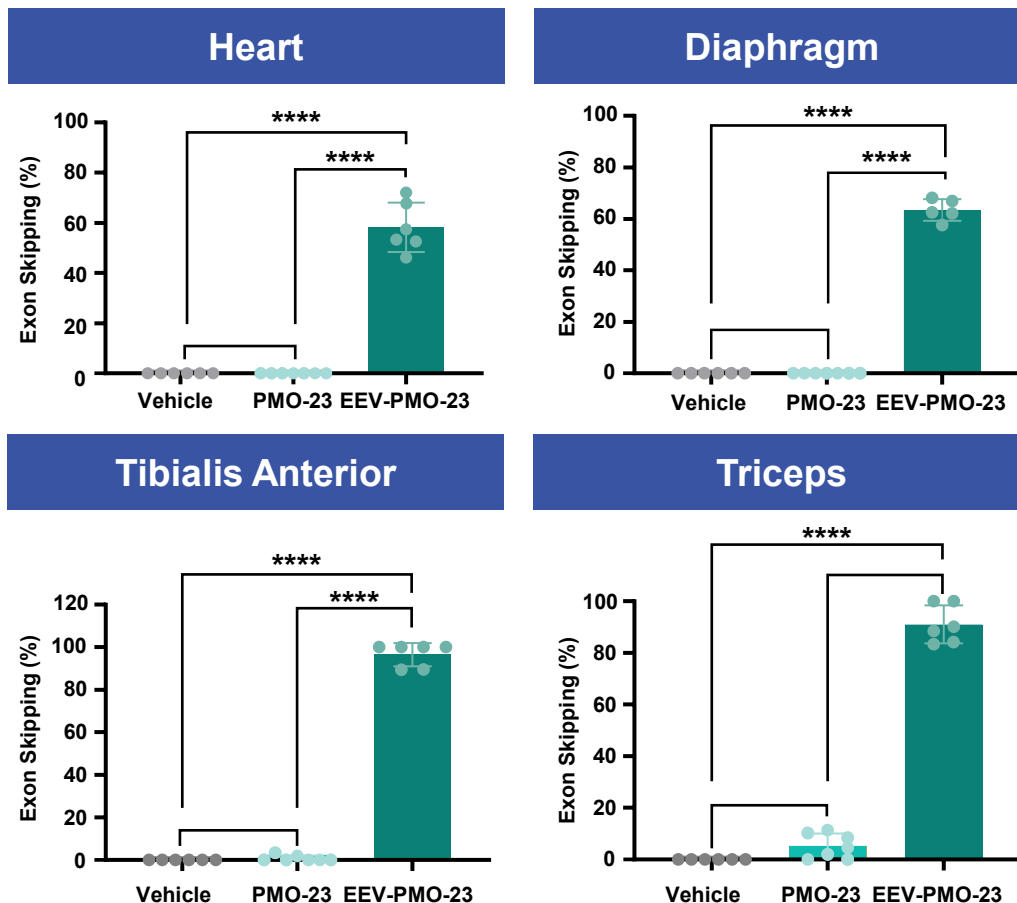
## EEV-Oligonucleotide Approach



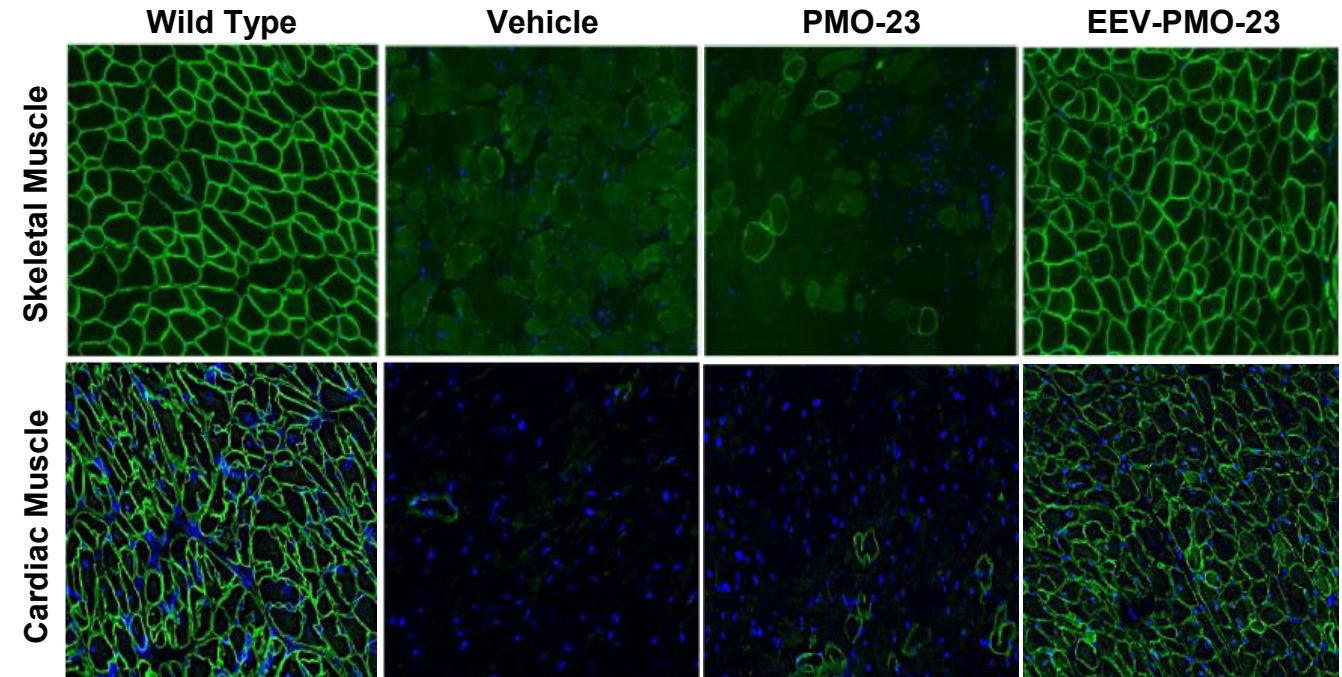


# REPEAT EEV-PMO-23 TREATMENT IN D2-*mdx* MICE

Robust exon 23 skipping after 4 monthly IV doses of EEV-PMO-23 in D2-*mdx* mice



Broad dystrophin expression and restoration of muscle integrity after four monthly IV doses of EEV-PMO-23 in D2-*mdx* mice



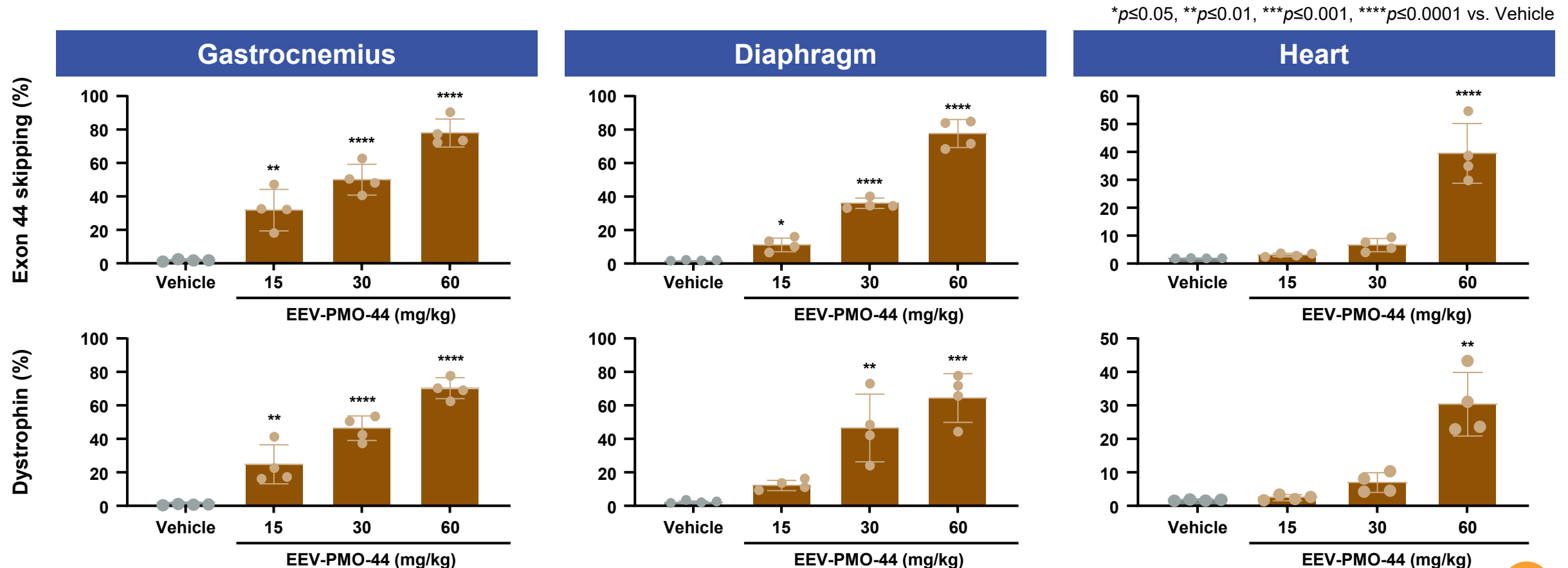
- D2-*mdx* mice (male, n=6-7) were treated with 4 monthly doses of either vehicle, 20 mg/kg unconjugated PMO-23 or 20 mg/kg PMO-23 equivalent of EEV-PMO-23, and the data were collected ~4 weeks after the last dose.

# ENTR-601-44 PRECLINICAL STUDIES



# EEV-PMO-44 EFFICACY IN *del45hDMD.mdx* MICE

A single dose of EEV-PMO-44 produced robust human *DMD* exon 44 skipping and dystrophin production 2 weeks post-dose in mice amenable to exon 44 skipping

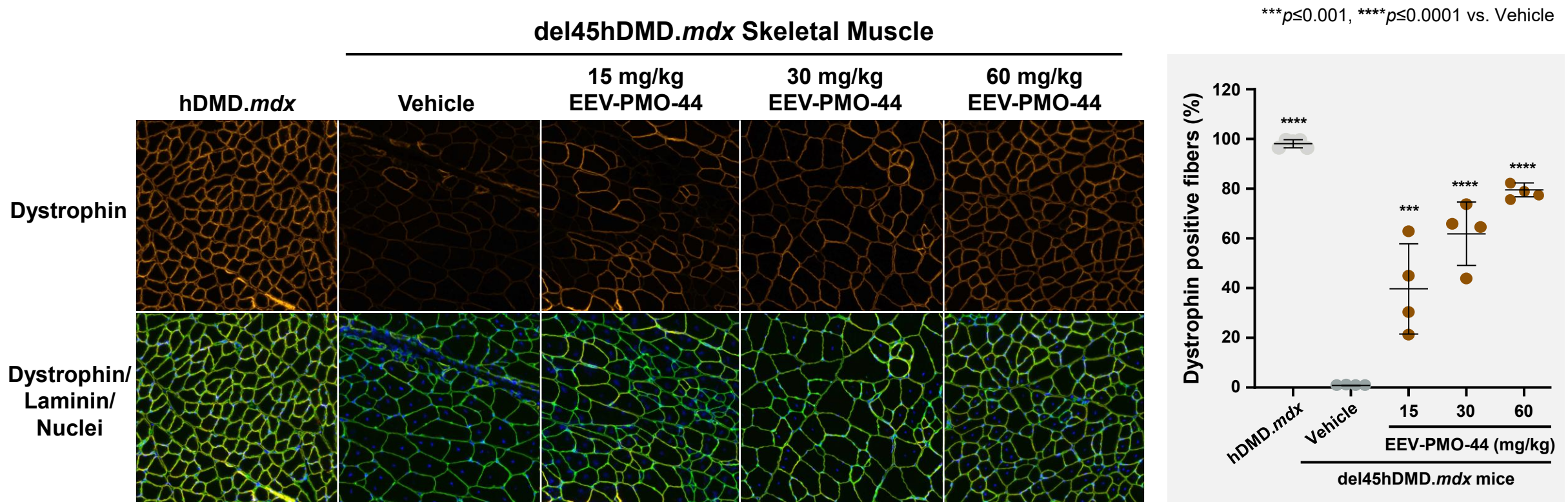


*del45hDMD.mdx* mice were treated with a single IV injection of EEV-PMO-44 (*DMD* exon 44 skipping EEV-oligonucleotide construct) or vehicle. Human *DMD* exon 44 skipping (top) and dystrophin protein expression (bottom) were analyzed in the gastrocnemius, diaphragm, and heart 2 weeks after the final dose. Percent dystrophin protein restoration is normalized to total protein and normalized to *hDMD.mdx* controls. Data shown as mean  $\pm$  standard deviation. One-way ANOVA was used for statistical comparison; **ANOVA**, analysis of variance; **hDMD**, human dystrophin transgene; **IV**, intravenous.



# DYSTROPHIN LOCALIZATION WITH EEV-PMO-44 IN *del45hDMD.mdx* Mice

EEV-PMO-44 produced dose-dependent increases in dystrophin-positive muscle fibers localized to the sarcolemma of *del45hDMD.mdx* mice 2 weeks post-dose



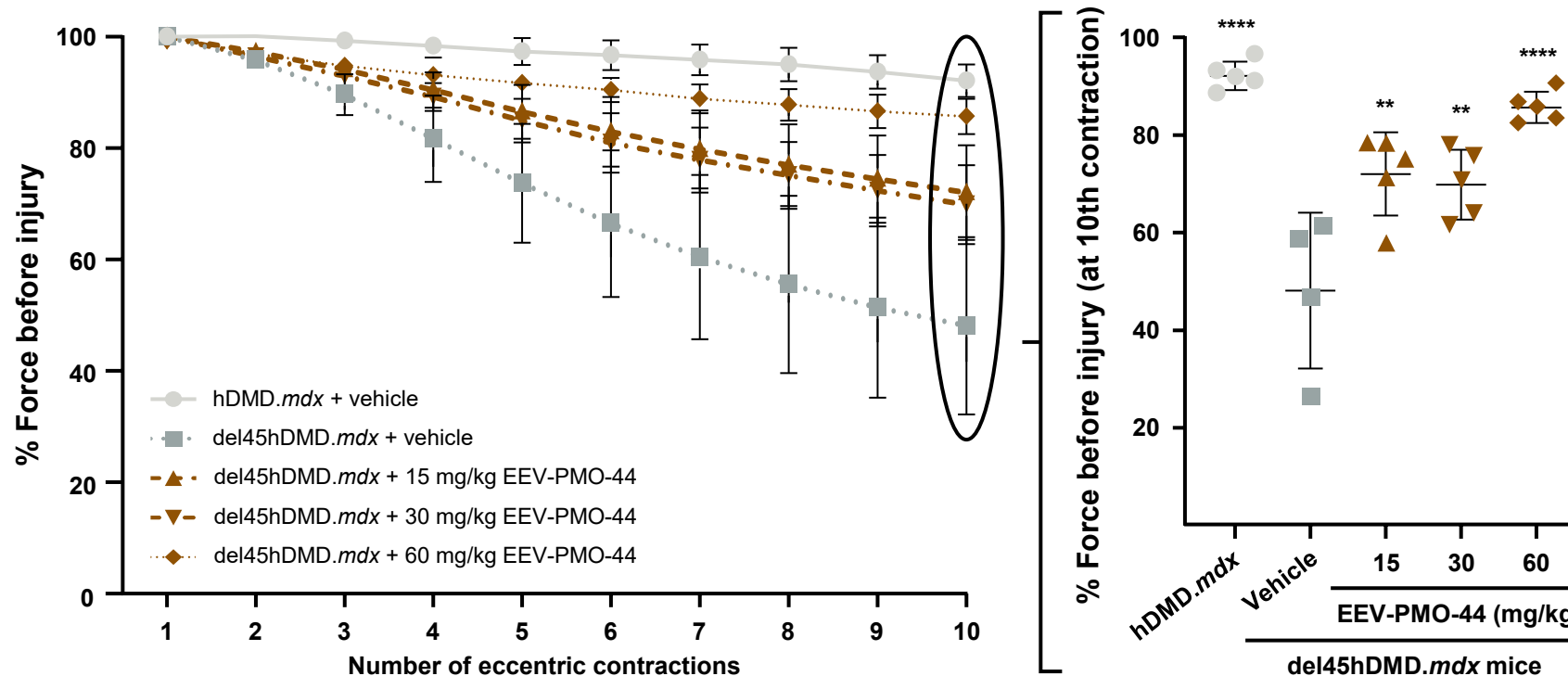
- del45hDMD.mdx* mice were treated with a single IV dose of EEV-PMO-44 or vehicle. Dystrophin protein distribution and cellular localization were analyzed by immunofluorescence in the gastrocnemius 2 weeks post-dose.

# EEV-PMO-44 IMPROVES MUSCLE FUNCTION IN *del45hDMD.mdx* Mice

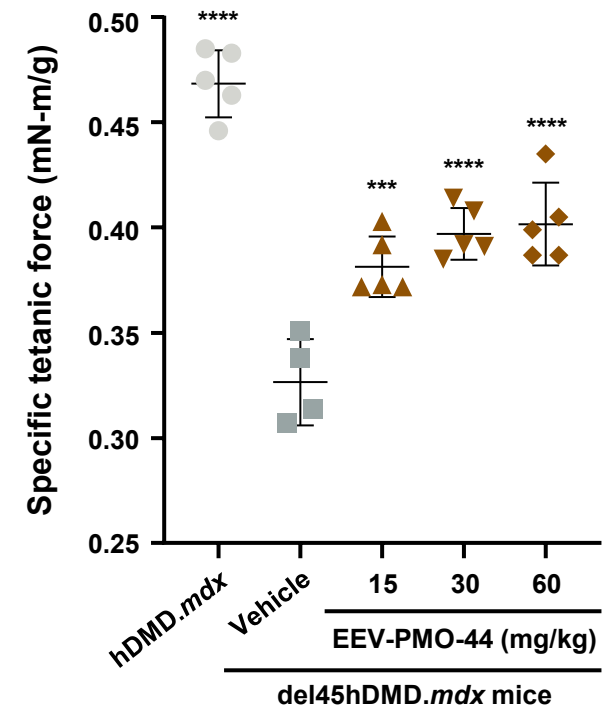
A dose-dependent increase in resistance to membrane damage was observed following the tenth contraction, as well as an increase in tetanic force 2 weeks post-dose of EEV-PMO-44

\*\* $p < 0.01$ , \*\*\* $p < 0.001$ , \*\*\*\* $p < 0.0001$  vs. Vehicle

## Skeletal Muscle Membrane Stability



## Specific Tetanic Force

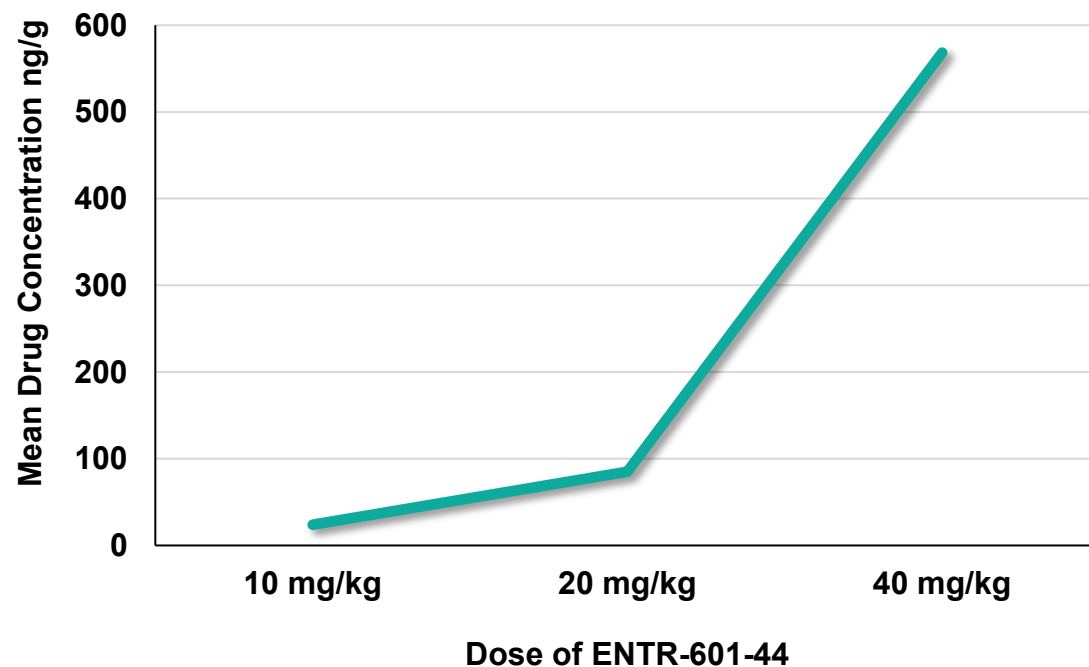


*del45hDMD.mdx* mice were treated with a single IV injection of EEV-PMO-44 or vehicle. ECC-induced muscle force loss generated by repeated ECC contraction and tetanic force of the gastrocnemius muscle was assessed 2 weeks post-dose. Data (mean  $\pm$  standard deviation) shown across 10 ECC contractions normalized into a percentage of the initial force before any ECC contractions and as the percentage of force retained after the 10th contraction. Vehicle-treated hDMD.mdx mice were used as a control group for normal muscle function. One-way ANOVA was used for statistical comparison to vehicle-treated *del45hDMD.mdx* mice. **ECC**, eccentric force; **hDMD**, human dystrophin transgene; **IV**, intravenous.

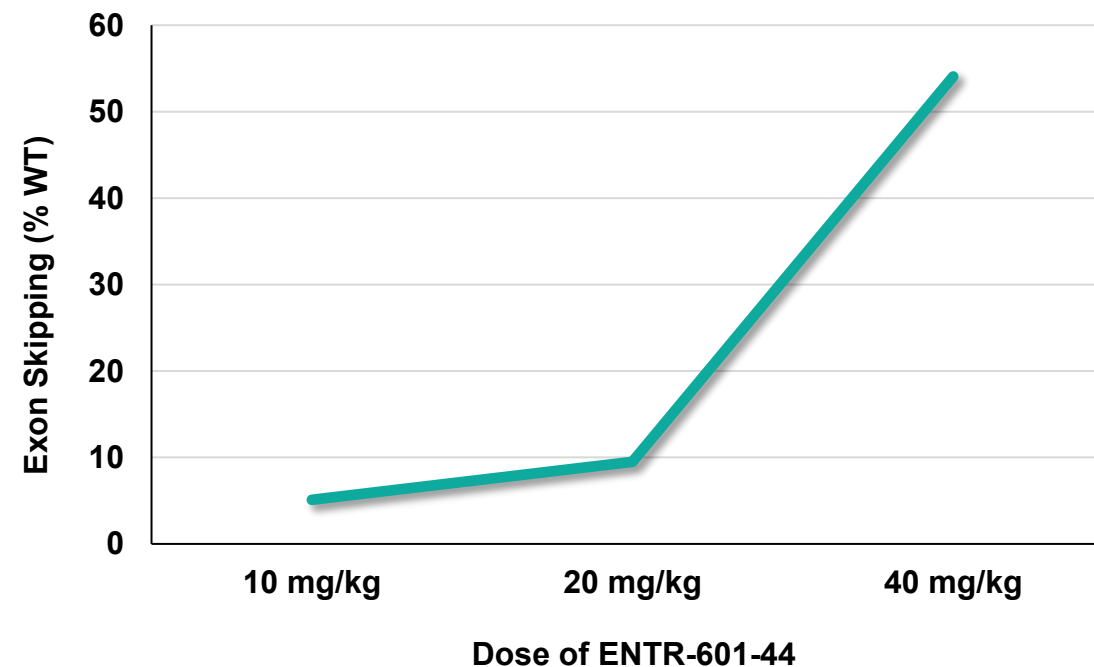
# DOSE-DEPENDENT PK/PD WITH ENTR-601-44 IN NHP

NHP data demonstrated exponential increases in exon skipping at higher doses;  
A close correlation between drug concentration and exon skipping was observed

**NHP Mean Drug Concentration**



**NHP Exon Skipping**

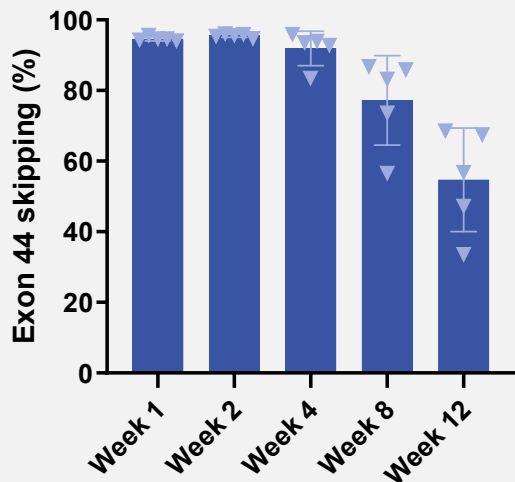




# CONSISTENT AND DURABLE EFFICACY OF EEV-PMO WAS DEMONSTRATED ACROSS SPECIES

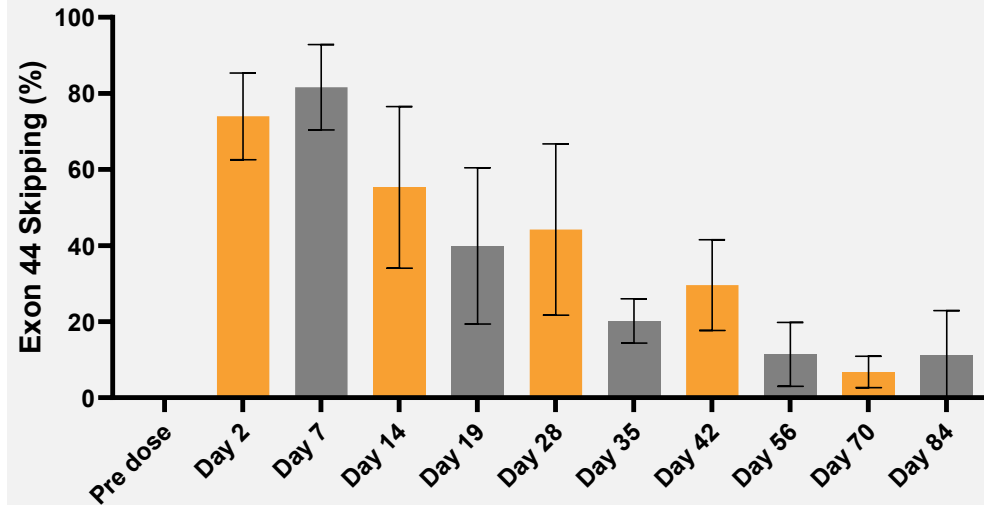
Significant patient benefit is implied by data in the mouse and the monkey at clinically relevant levels; *in vitro* data suggests much higher target engagement in patient cells

## Exon 44 Skipping in hDMD Mouse



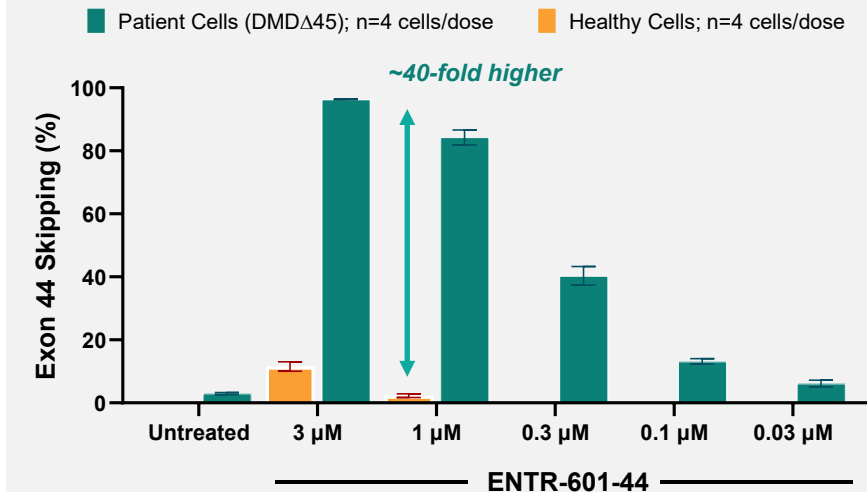
- Single IV 80 mg/kg dose of ENTR-601-44
- Tibialis Anterior

## Exon 44 Skipping in Monkey



- Post IV infusion of single 45 mg/kg dose of ENTR-601-44, robust exon 44 skipping observed in biceps of treated monkeys (n=3 per cohort) for at least 12 weeks

## Exon 44 Skipping in Healthy and Patient-Derived Muscle Cells



- Robust dose-dependent exon 44 skipping was observed in DMD patient-derived muscle cells harboring an exon 44 skip-amenable mutation

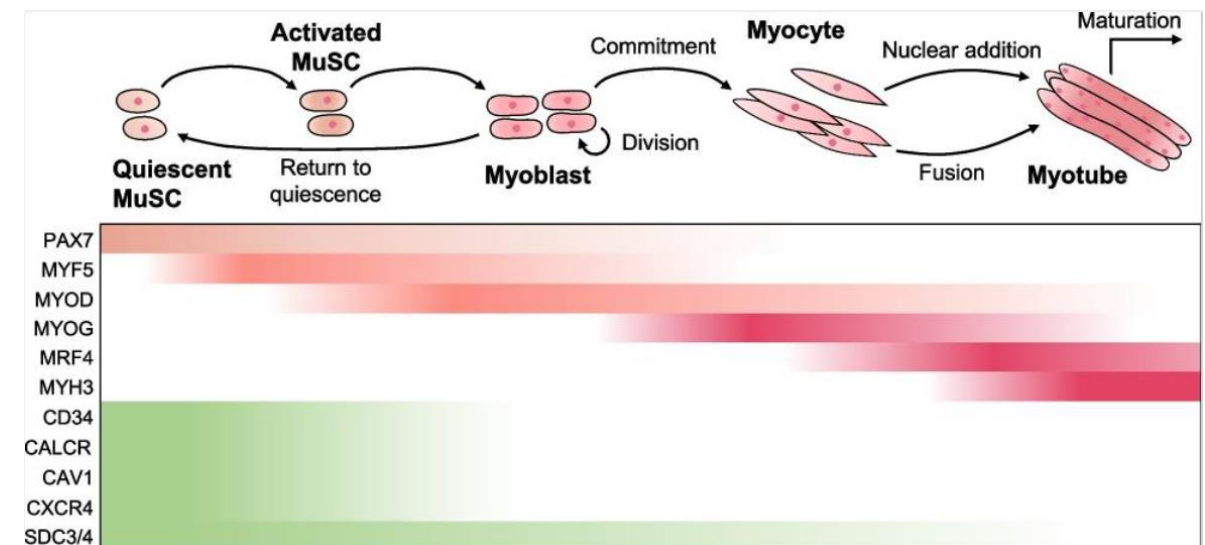
# DELIVERY OF PMO TO SATELLITE CELLS



## Muscle satellite cells as a new therapeutic target with potential in several neuromuscular disorders

- **Satellite cells are muscle stem cells responsible for generating myoblasts for early muscle growth**
  - Mitotically quiescent in mature muscle, satellite cells maintain their own population by self renewal
  - In post-mitotic muscles, they can be activated to generate myoblast for homeostasis, repair, and hypertrophy
- **Quiescent satellite cells are historically challenging to access by therapeutic modalities**
- **EEV-mediated delivery to access quiescent satellite cells could enable early disease intervention**
  - Ability to deliver to myonuclei of muscle fibers and to quiescent satellite cells holds potential in several neuromuscular disorders
- **The ability to access satellite cells provides an opportunity to treat several satellite cell-opathies, including DMD**

### Developmental Stages of Muscle Satellite Cells



- **The developmental stages of muscle satellite cells can be delineated by various myogenic factors**
  - Pax7, a canonical myogenic marker essential for orchestrating proper muscle regeneration, is mainly expressed in **quiescent** state, and at a lower level in activated state
  - Stage-specific expression of myogenic factors provides tools for studying EEV-PMO uptake at different developmental stages of satellite cells

# DELIVERY OF PMO TO SATELLITE CELLS PROVIDES A BASIS FOR THE RAPID AND DURABLE EFFICACY IN DMD

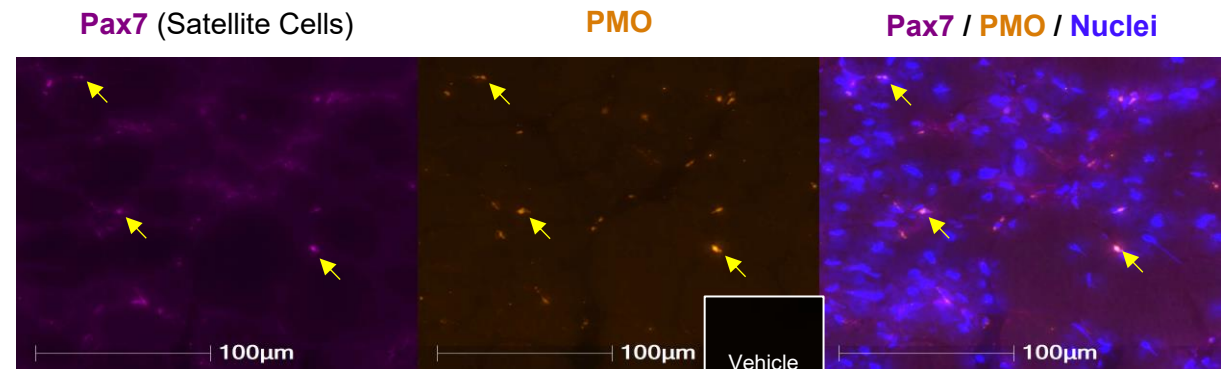
EEV-PMO shows co-localization with quiescent satellite cells (Pax7 positive) at 48 hours and 1-week post-dose by both RNA-ISH and IHC

- Two independent molecular techniques were utilized to determine EEV-PMO distribution within specific cell lineages across muscle tissue
  - RNA-ISH: Highly selective and sensitive technique to assess specific cell lineages across muscle tissue
  - Immunohistochemistry Assessment
- Quantification analysis of RNA-ISH data confirms that EEV-PMO is co-localized in 100% of satellite cells at 48 hours
  - Quantitative assessment confirms qualitative data (data not shown)
- Qualitative assessment of IHC data demonstrates co-localization of satellite cells in hDMD mice with EEV-PMO at 7 days

## PMO Distribution (48 hours, RNA-ISH Quantitation)

Treatment Group (D2- <i>mdx</i> mice)	% Pax7 Positive Cells	% Pax7 + PMO Positive Cells
Saline	1-10%	0%
EEV-PMO Treated	1-10%	1-10%

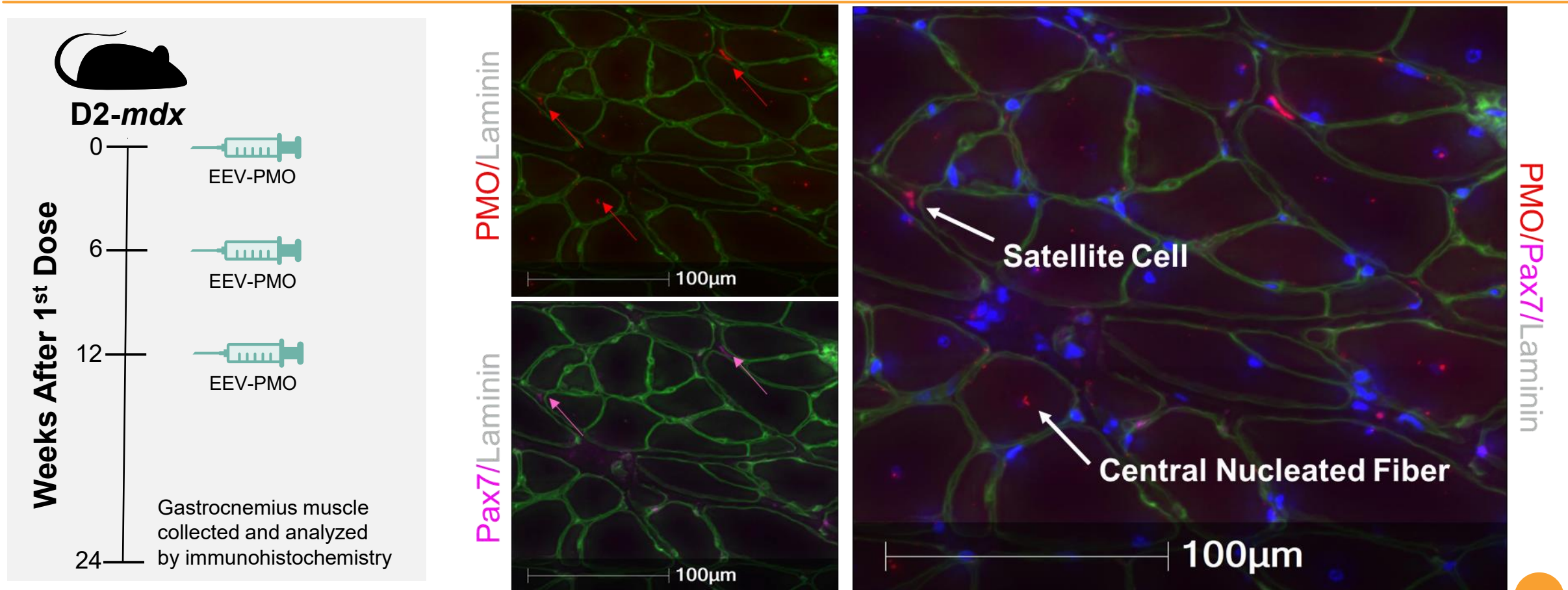
## PMO Distribution in hDMD Mice (Day 7, IHC)





# EEV-PMO PERSISTS IN SATELLITE CELLS 12 WEEKS AFTER FINAL DOSE

PMO co-localizes with satellite cells and newly regenerated centrally nucleated fibers 12 weeks post washout after 3 Q6W doses

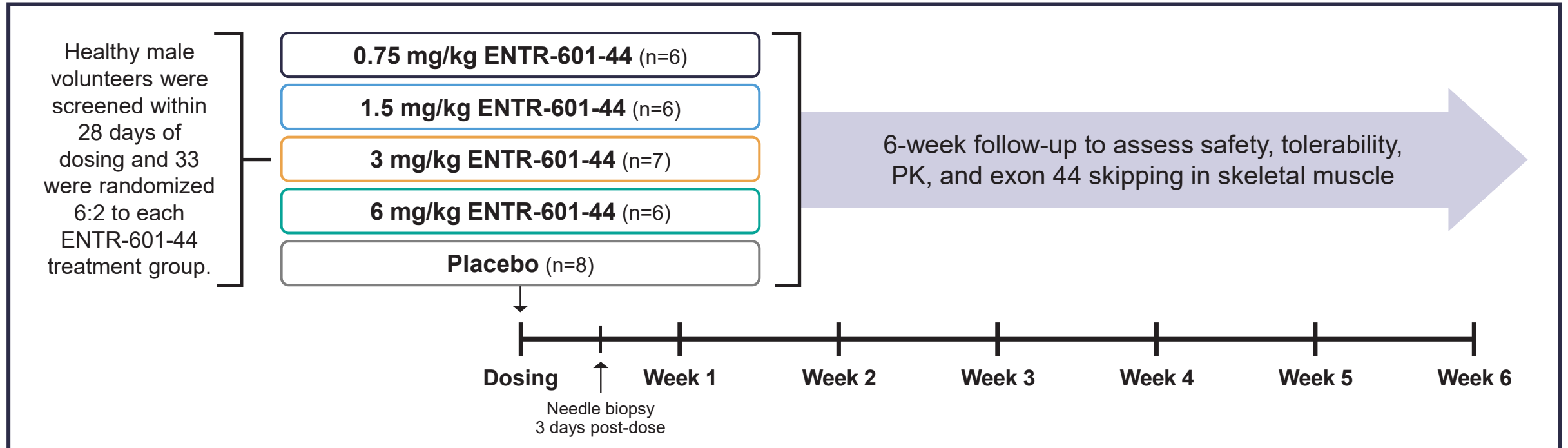


D2-mdx mice were treated with 3 IV doses of EEV-PMO administered every six weeks; Gastrocnemius was collected 12 weeks after the 3<sup>rd</sup> dose and analyzed by immunohistochemistry. **Q6W**: every six weeks.

# ENTR-601-44-101 PHASE 1 STUDY



# ENTR-601-44-101: STUDY DESIGN



## Key Inclusion Criteria

- Healthy males aged 18–55 years, inclusive.
- Body mass index (BMI) of 18.0 to 32.0 kg/m<sup>2</sup>, inclusive, and a minimum weight of 50 kg at screening.

## Key Exclusion Criteria

- No current or prior history of clinically significant illness, organ transplant, cardiac disease, hypertension, long QT syndrome, hepatitis B, or diabetes.

A single IV dose of ENTR-601-44 was well-tolerated in healthy human volunteers up to a dose of 6 mg/kg. No treatment-related adverse events were reported in the study.

- No AEs related to study drug
- Most common AE was headache (n=7; 5 mild and 2 moderate)
- No clinically significant findings with lab values, ECG or vital signs
- No adverse findings or clinically relevant changes to biomarkers of renal toxicity at highest dose of 6 mg/kg

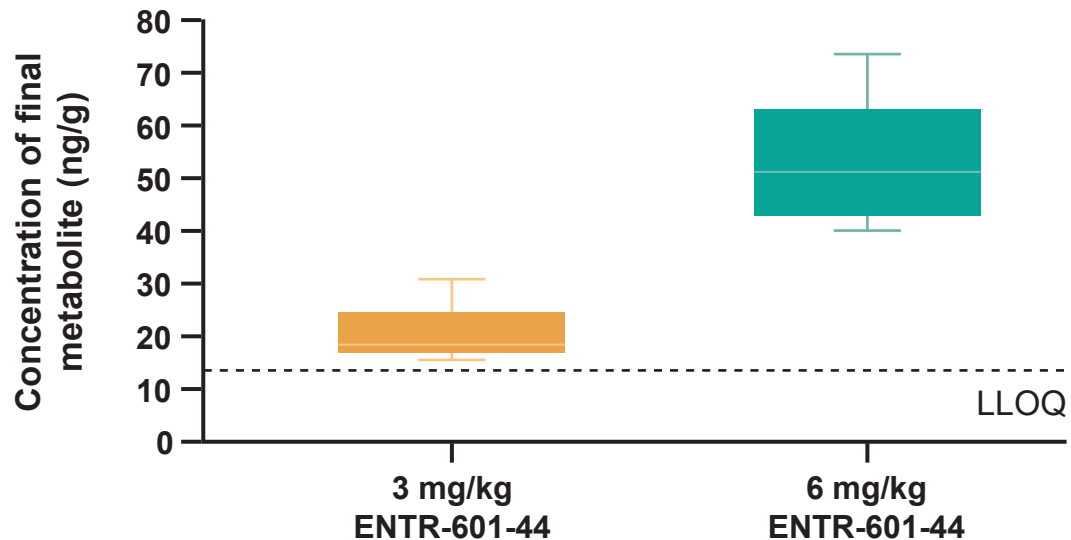
n (%)	Pooled placebo (N=8)	ENTR-601-44				
		0.75 mg/kg (n=6)	1.5 mg/kg (n=6)	3.0 mg/kg (n=7)	6.0 mg/kg (n=6)	Total (N=25)
Randomized	8 (100)	6 (100)	6 (100)	7 (100)	6 (100)	25 (100)
Dosed	8 (100)	6 (100)	6 (100)	6 (85.7)	6 (100)	24 (96)
Completed study	8 (100)	6 (100)	6 (100)	6 (85.7)	6 (100)	24 (96)
Any TEAE	1 (12.5)	5 (83.3)	2 (33.3)	3 (50)	3 (50)	13 (54)
Treatment-related TEAE	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Severe AEs	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
SAEs	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)



# ENTR-601-44-101: MUSCLE CONCENTRATION AND EXON SKIPPING

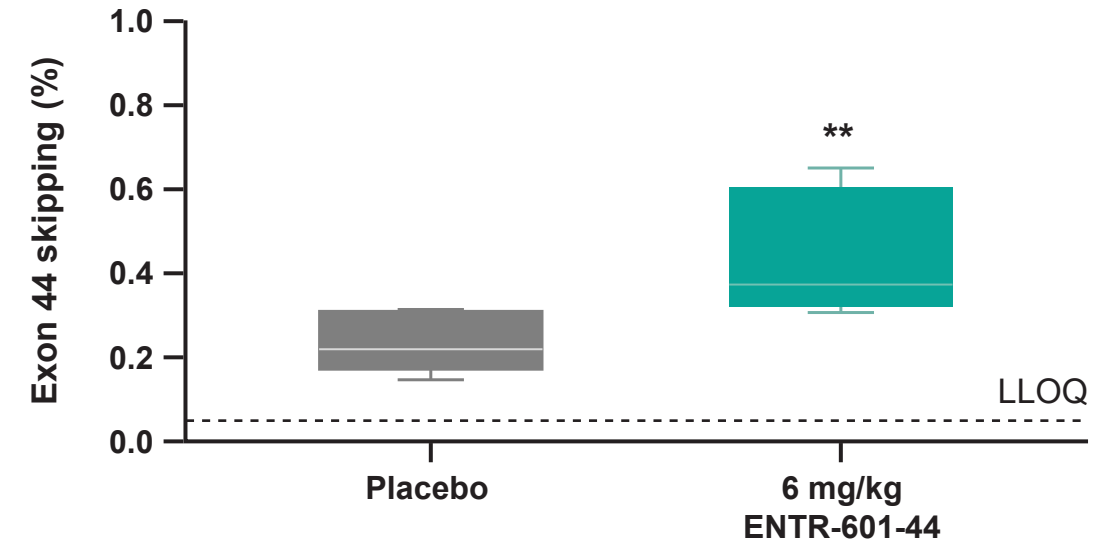
Dose-dependent increases in muscle concentration and *DMD* exon 44 skipping were observed 72 hours following a single IV dose of ENTR-601-44

## Skeletal Muscle Concentration



- All six volunteers in the 6 mg/kg dose group had detectable levels of PMO-44 metabolite in skeletal muscle (mean 52.4 ng/g, range 40.0–73.5 ng/g)
- Concentrations of PMO-44 metabolite were below LLOQ in 3 of 6 volunteers in the 3 mg/kg dose group and all volunteers in the 0.75 and 1.5 mg/kg dose groups

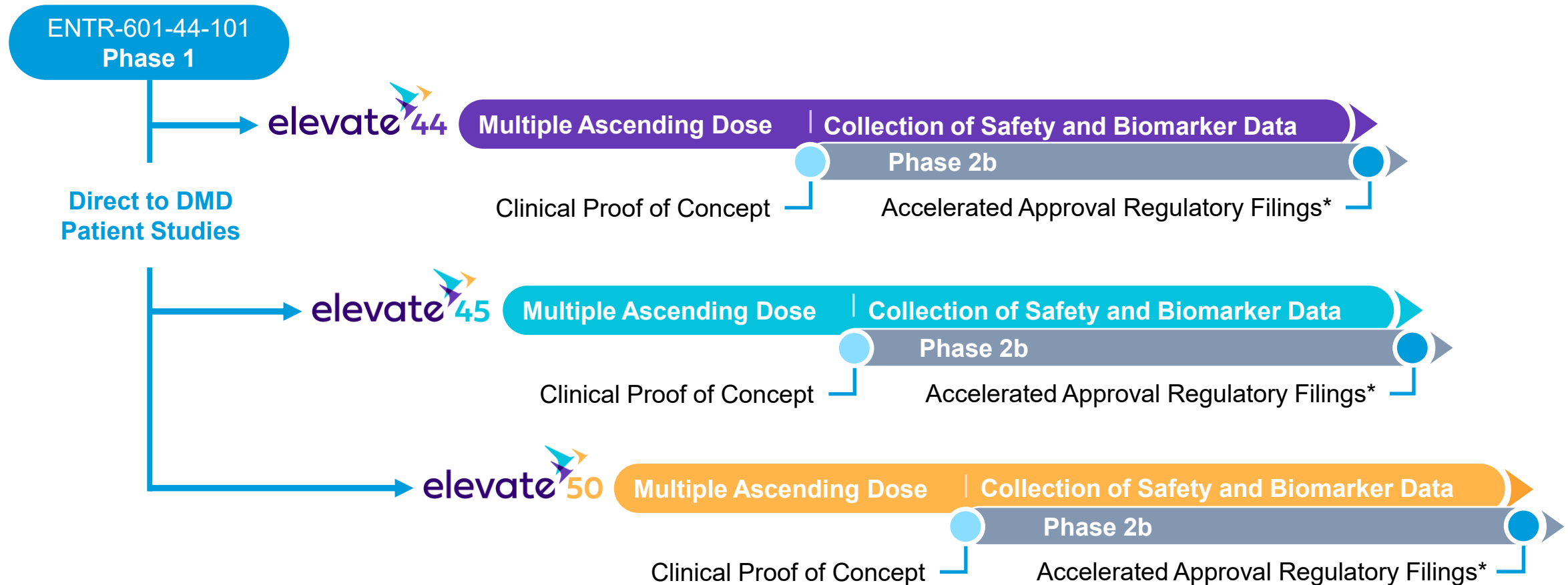
## *DMD* Exon 44 Skipping



- Statistically significant *DMD* exon 44 skipping was observed with 6 mg/kg ENTR-601-44 (mean 0.44%, range 0.30%–0.65%) in comparison with placebo (mean 0.22%, range 0.14%–0.31%)
- No other ENTR-601-44 dose group was statistically significant in comparison with placebo.

# CLINICAL STRATEGY IS DESIGNED FOR EFFICIENT REGULATORY PATH

All ENTR-601-series programs will follow a similar clinical and regulatory approach



Protocols pending regulatory feedback; \*Potential for Accelerated Approval in the US, followed by confirmatory Phase 3 studies to obtain Full Approval in the US and ex-US countries.



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