

# Building a Stroke Portfolio

*June 28, 2018*



# Forward-Looking Statements

This presentation contains forward-looking statements, including statements relating to: the potential benefits, safety and efficacy of BIIB093 and TMS-007; results from certain studies of BIIB093 and TMS-007; the clinical development program for BIIB093 and TMS-007; the design and enrollment of the Phase 3 study of BIIB093; the design and enrollment of the Phase 2a study of TMS-007; the timing and status of current and future regulatory filings; risks and uncertainties associated with drug development and commercialization, including the potential commercialization, including timing considerations, of BIIB093; the potential benefits and results that may be achieved through Biogen's option agreement with TMS Co., Ltd.; Biogen's objectives and intentions regarding the option agreement, when, and whether, Biogen expects to exercise its option on TMS-007 and backup compounds; the anticipated completion and timing of the TMS-007 option transaction; the potential of Biogen's commercial business and pipeline programs, including BIIB093; capital allocation and investment strategy; and potential of investments, collaborations and business development activities. These forward-looking statements may be accompanied by such words as "aim," "anticipate," "believe," "could," "estimate," "expect," "forecast," "intend," "may," "plan," "potential," "possible," "will" and other words and terms of similar meaning. Drug development and commercialization involve a high degree of risk, and only a small number of research and development programs result in commercialization of a product. Results in early stage clinical trials may not be indicative of full results or results from later stage or larger scale clinical trials and do not ensure regulatory approval. You should not place undue reliance on these statements or the scientific data presented.

These statements involve risks and uncertainties that could cause actual results to differ materially from those reflected in such statements, including without limitation: Biogen may not fully enroll the clinical trials for BIIB093 or it will take longer than expected; TMS Co., Ltd. may not fully enroll the clinical trials for TMS-007 or it will take longer than expected; the risk that unexpected concerns may arise from additional data or analysis, or regulatory authorities may require additional data or information or further studies, or may fail to approve, or refuse to approve, or may delay approval of BIIB093 and/or TMS-007; uncertainty of success and timing in the development and potential commercialization of BIIB093 and/or TMS-007, which may be impacted by, among other things, unexpected concerns that may arise from additional data or analysis, the occurrence of adverse safety events, failure to obtain regulatory approvals in certain jurisdictions, failure to protect and enforce data, intellectual property and other proprietary rights and uncertainties relating to intellectual property claims and challenges; risks that the TMS-007 option transaction will be completed in a timely manner or at all; uncertainty as to whether the anticipated benefits of the TMS-007 option transaction can be achieved; the risks of other unexpected hurdles; product liability claims; and third party collaboration risks. The foregoing sets forth many, but not all, of the factors that could cause actual results to differ from Biogen's expectations in any forward-looking statement. Investors should consider this cautionary statement, as well as the risk factors identified in Biogen's most recent annual or quarterly report and in other reports Biogen has filed with the U.S. Securities and Exchange Commission.

These statements are based on Biogen's current beliefs and expectations and speak only as of the date of this presentation. Biogen does not undertake any obligation to publicly update any forward-looking statements, whether as a result of new information, future developments or otherwise.

# Agenda

**Introduction**

**Matt Calistri**  
VP, Investor Relations

**Stroke Overview  
& Review of Biogen Clinical  
Programs**

**Michael Ehlers, M.D., Ph.D.**  
EVP, Research & Development

**Biogen Approach to the  
Stroke Market**

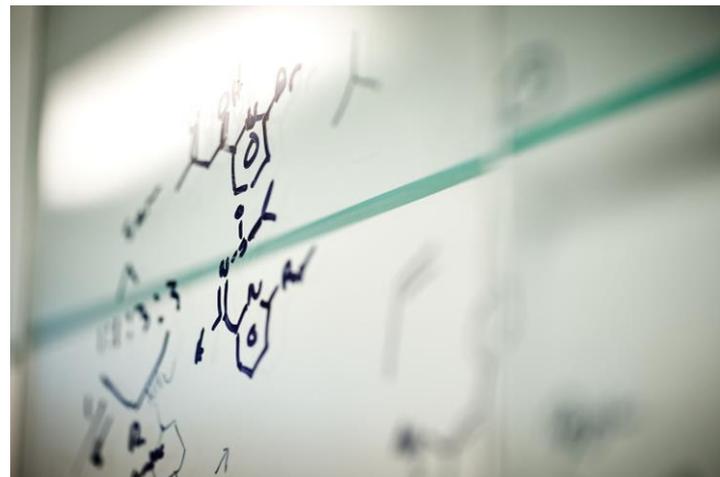
**Chirfi Guindo**  
EVP, and Head of Global Marketing,  
Market Access and Customer Innovation

**Available for Q&A**

**Jake Elkins, M.D.**  
VP, and Head of Acute Neurology Research Unit

# Stroke Overview & Review of Biogen Clinical Programs

Michael Ehlers, M.D., Ph.D.  
EVP, Research & Development



# Biogen R&D Strategy in Stroke

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1. The science and medicine of stroke leverages key capabilities of Biogen as we work to secure our definitive leadership in neuroscience
2. We believe stroke is an attractive area for innovative drug development to address significant unmet need
3. BIIB093 represents a novel approach to target edema in one of the most severe forms of ischemic stroke
4. TMS-007, which we have an option to acquire, is a potential best-in-class thrombolytic drug candidate
5. We believe there is a large market opportunity and attractive commercial model for bringing new potential stroke treatments to patients

# Stroke is a Devastating Condition in Great Need of Improved Therapeutic Approaches

## Acute Ischemic Stroke (AIS)

- ~85% of all stroke cases are AIS
- 5<sup>th</sup> leading cause of mortality in US
- Affects 1 in 6 people in their lifetime
- Avg. age: 65 yrs.; risk doubles each decade after 55

## Large Hemispheric Infarction (LHI)

- ~15% of AIS cases are LHI
- Associated with occlusion of the middle cerebral artery
- Risk of severe edema, herniation
- Avg. age: ~10 yrs. younger (~55 yrs)
- 40-80% mortality with high risk of severe disability

# Current Treatment Landscape for AIS

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## IV Alteplase (tPA)

- Alteplase (recombinant tissue plasminogen activator) is the only FDA-approved medical therapy indicated for AIS
- Utilization limited to patients presenting within 3-4.5 hours of last known normal with neurological deficit (utilized in < 5% of all AIS patients)
- Untargeted mechanism of action acts throughout circulatory system
- Carries risk of bleeding including intracranial hemorrhage

## Endovascular Thrombectomy

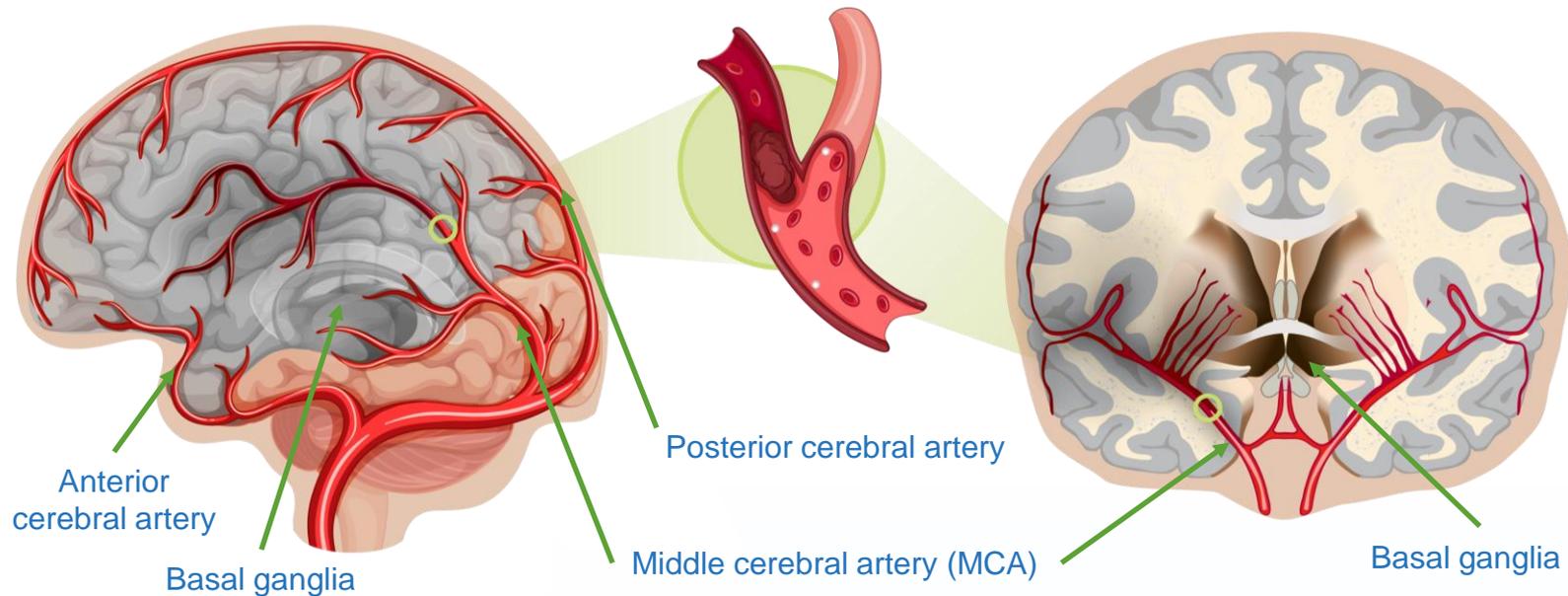
- Endovascular surgical procedure to physically remove a clot
- Guidelines recommend treatment window up to 16-24 hours of last known normal in selected patients
- Limited to specialists in certain hospitals

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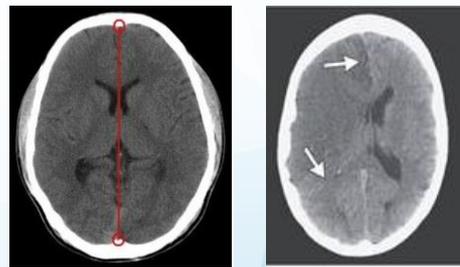
## Decompressive Craniectomy for LHI

- Invasive surgical procedure in which a section of the skull is removed
- Performed within ~48 hours of stroke onset in patients with malignant edema following stroke
- Nearly all survivors suffer permanent residual disabilities

# Large Hemispheric Infarction (LHI): Severe Ischemic Stroke Affecting the Territory of the Middle Cerebral Artery



## Cerebral Edema Following LHI

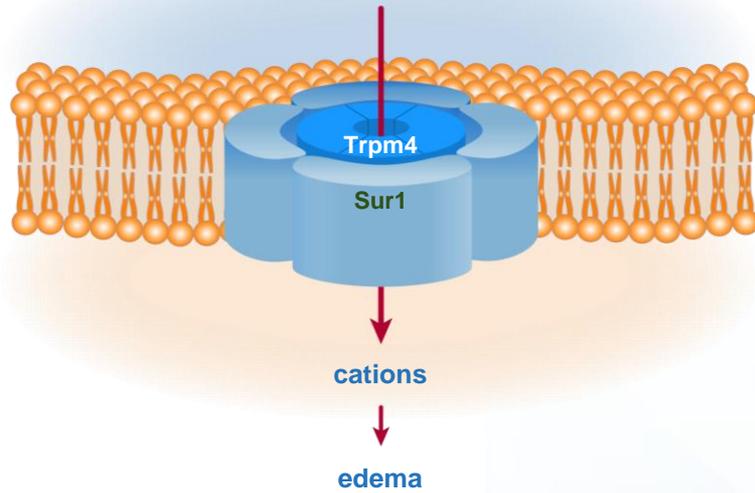


Normal

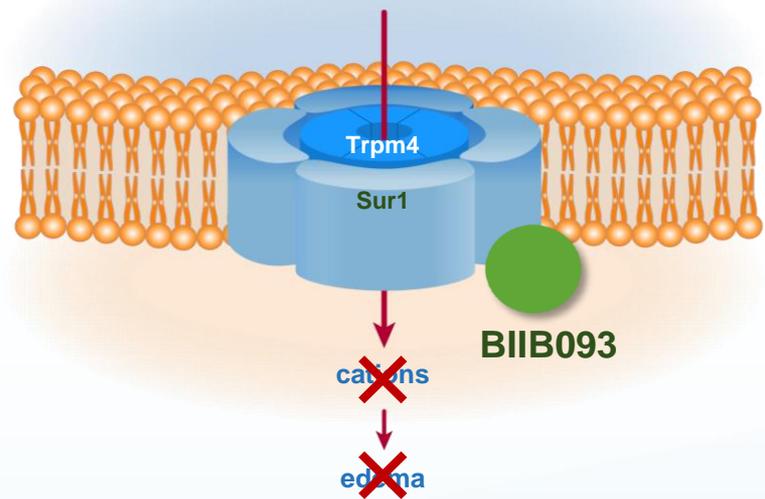
LHI

# BIIB093 Inhibits the SUR1-TRPM4 Ion Channel, a Key Regulator of Cerebral Edema

Low ATP



Low ATP



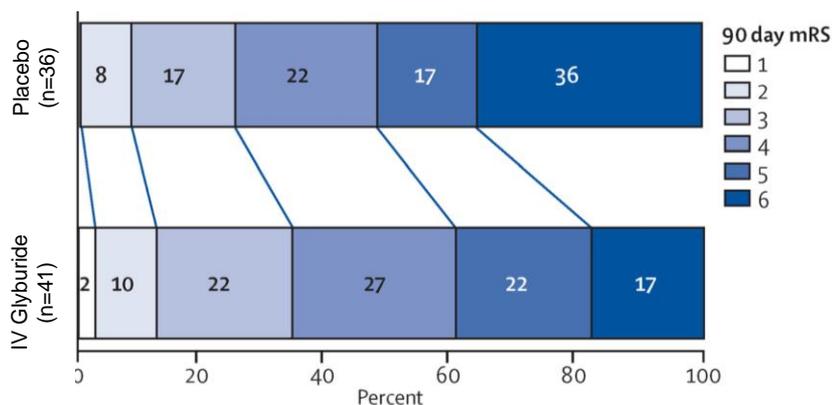
SUR1-TRPM4 = sulfonylurea receptor 1-transient receptor potential melastatin 4

# BIIB093 Administration was Associated with Significantly Reduced Disability and Mortality

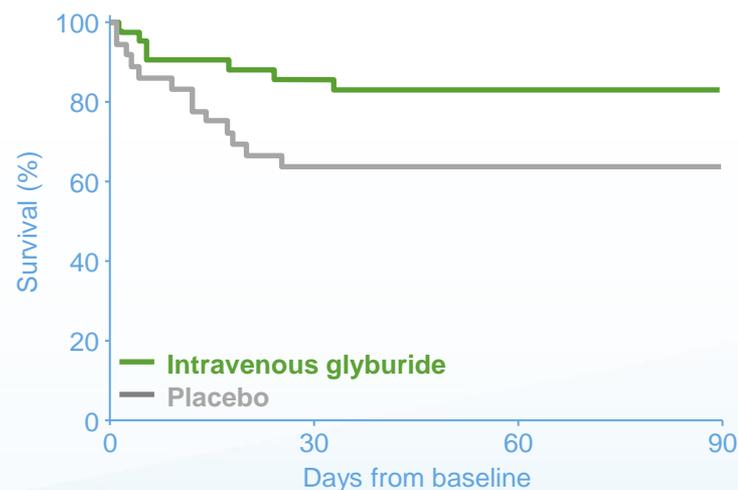
Consistent signals for clinical benefit observed in a small Phase 2 study

Primary endpoint\* missed, but results likely confounded by patients receiving decompressive craniectomy

### Reduced Disability at Day 30 in Patients Administered BIIB093



### Reduced Mortality in Patients Administered BIIB093



\* Primary endpoint: proportion of patients with a modified Rankin Scale (mRS) score of 0-4 at 90 days without undergoing decompressive craniectomy.

Data from BIIB093 Phase 2 GAMES-RP study: Sheth KN, Lancet Neurology, 2016.

# BIIB093 Administration Reduced Edema and Improved Biomarker Levels Associated with Blood Brain Barrier Integrity

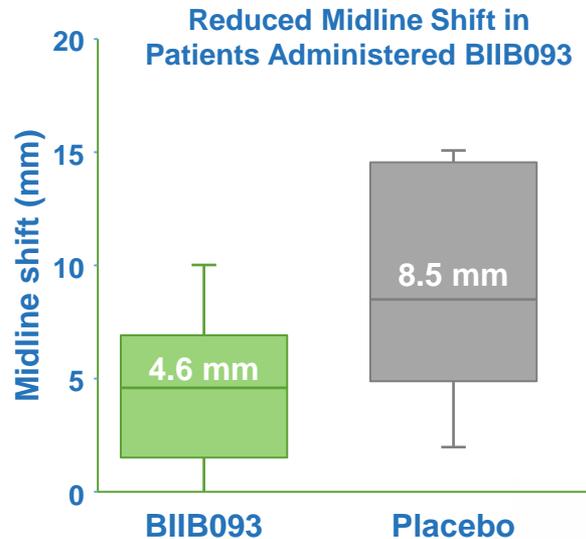
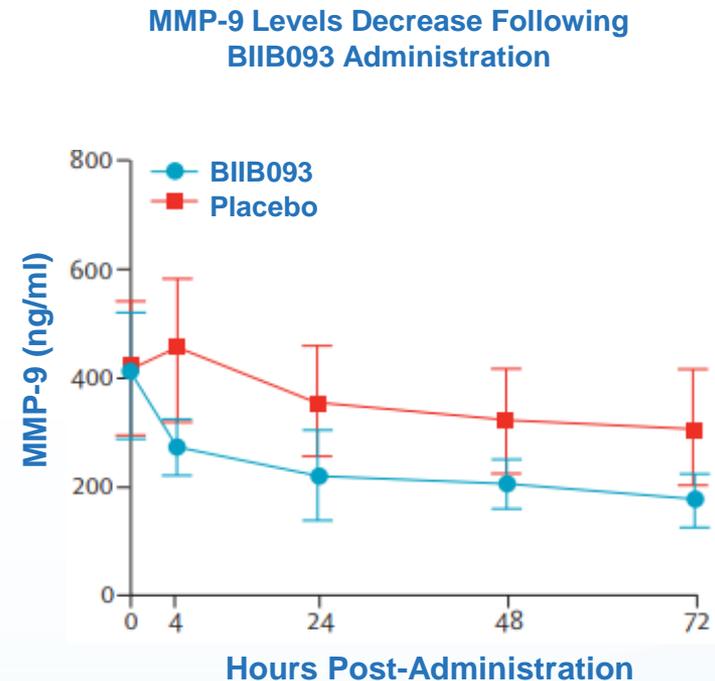
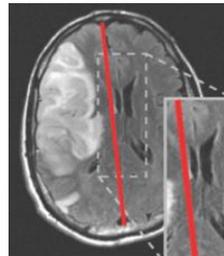
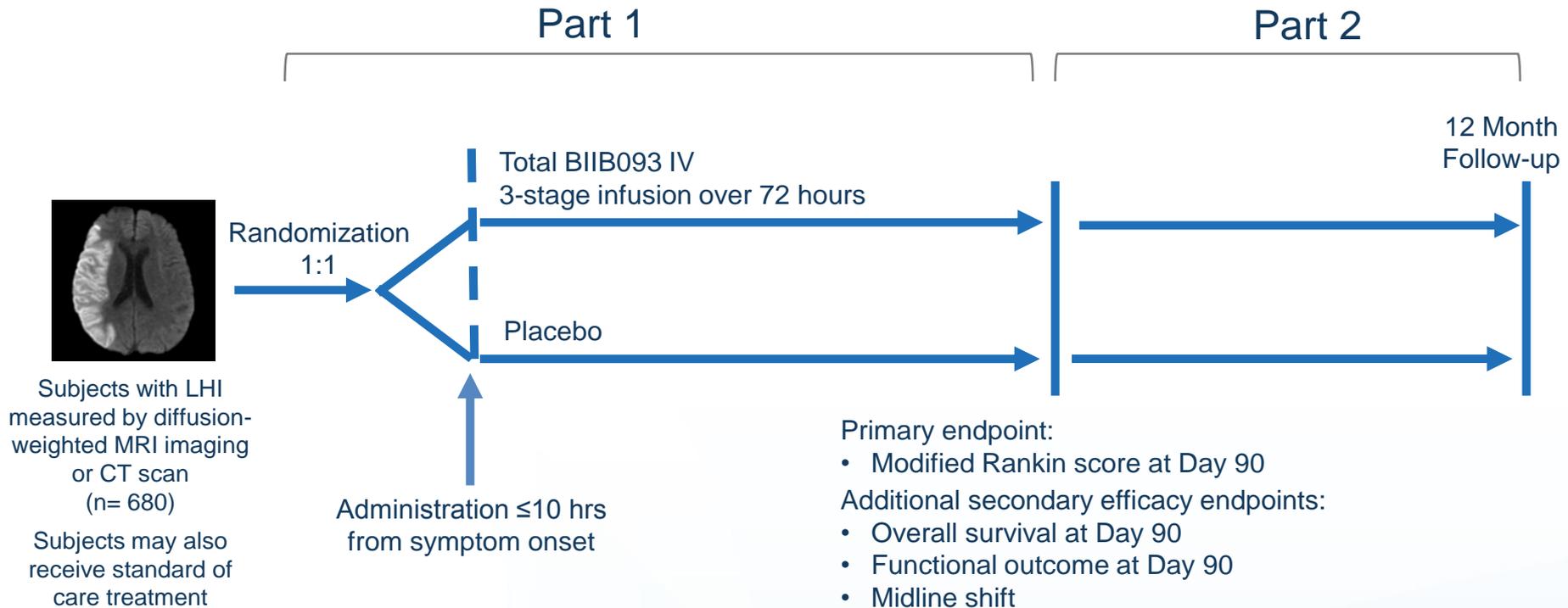


Image: patient administered placebo with severe edema (9 mm midline shift)



# BIIB093 Phase 3 Study is Designed to Evaluate Short- and Long-Term Functional Outcomes in LHI Patients



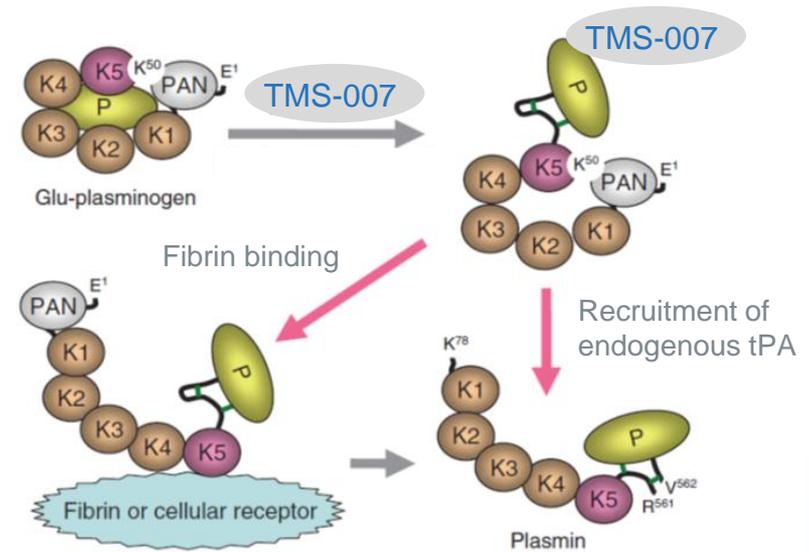
## FDA

- Special Protocol Assessment agreement obtained
- US Orphan Drug designation and Fast Track status granted

# TMS-007: Option to Acquire a Potential Best-In-Class Therapeutic for Acute Ischemic Stroke

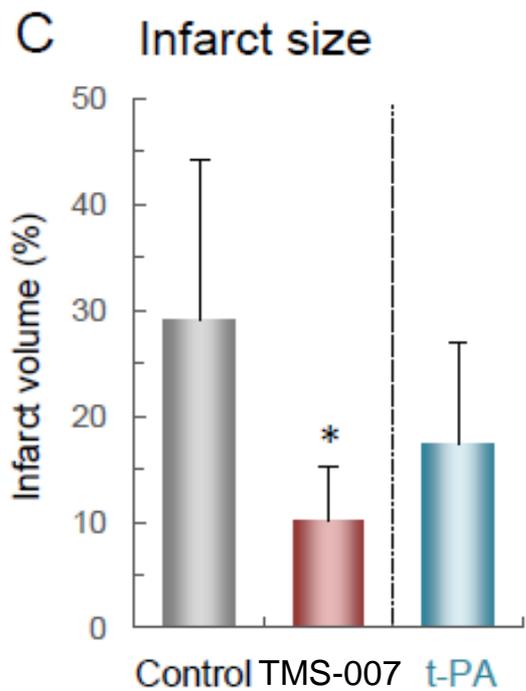
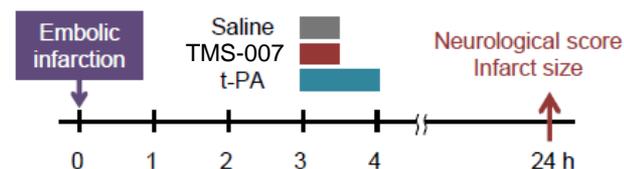
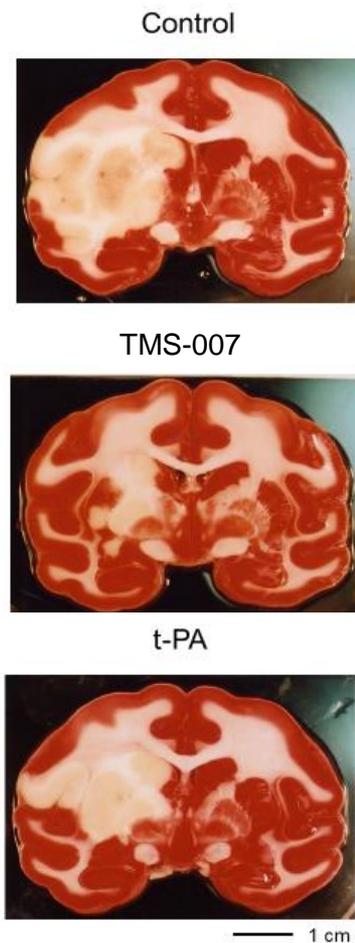
## Hypothesized Mechanism of Action

- TMS-007 changes conformation of plasminogen to increase fibrin binding and facilitate activation from endogenous tPA
- Does not directly convert plasminogen to plasmin, thereby limiting systemic effects
- Inhibits soluble epoxide hydrolase, reducing production of pro-inflammatory mediators of vasoconstriction and breakdown of the blood brain barrier
- **Potential best-in-class thrombolytic agent with an extended therapeutic window and a favorable safety profile**

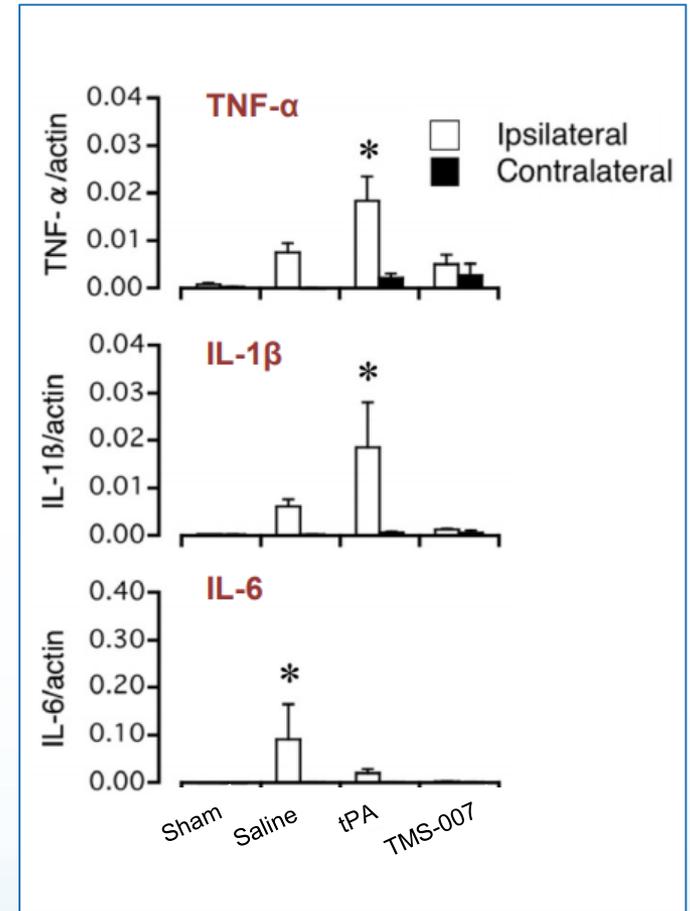
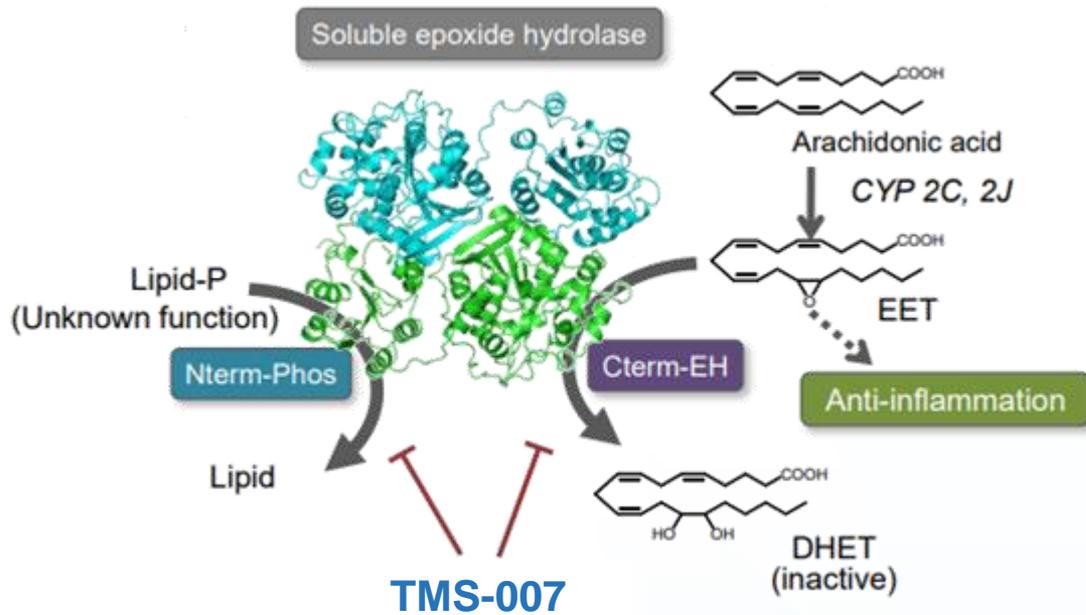


- **Clot-dissolving effect**
- **Anti-inflammatory properties at infarct site**

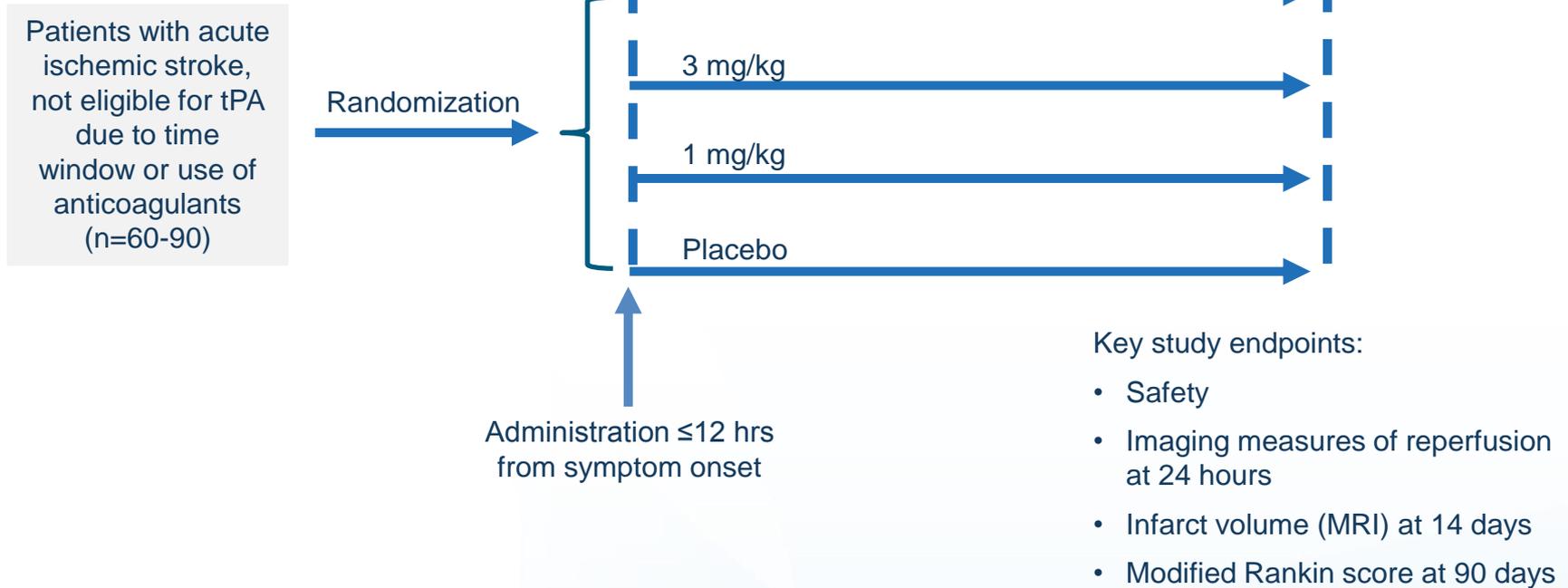
# TMS-007 Reduced Infarct Size in Preclinical Stroke Models



# TMS-007 Decreased Inflammatory Cytokine Levels via Inhibition of Epoxide Hydrolase



# Ongoing TMS-007 Phase 2a Study Conducted by TMS Co., Ltd. in Japan to Provide Safety and Efficacy Data

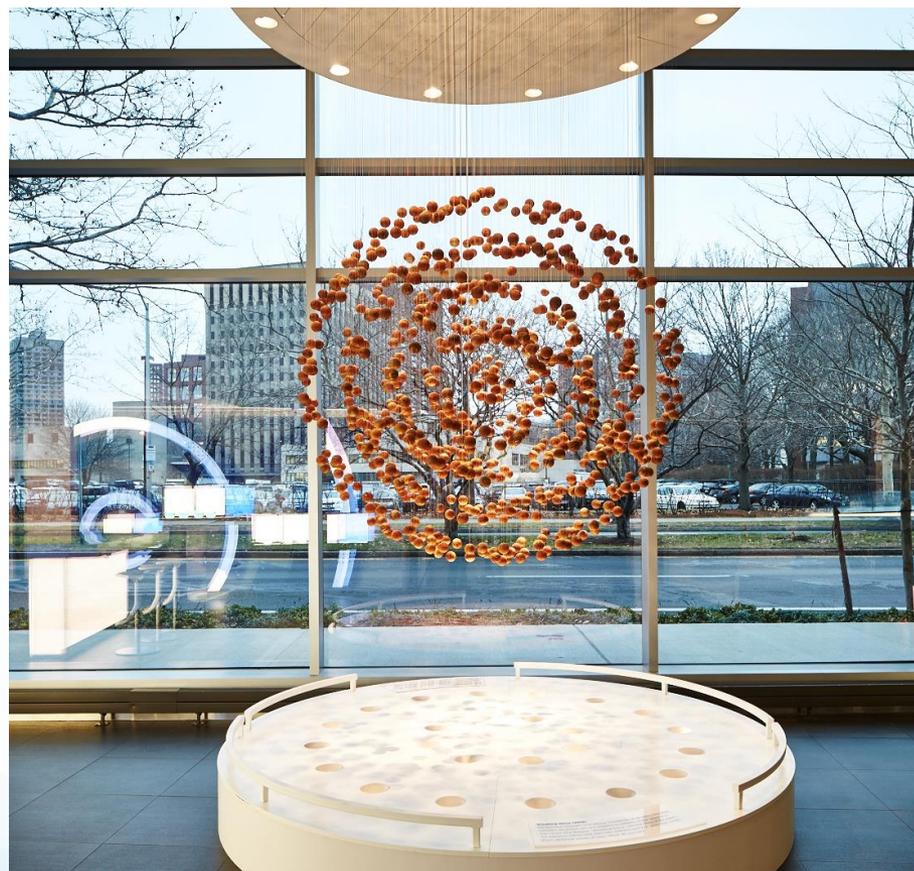


TMS-007 Phase 2a data expected in 2019

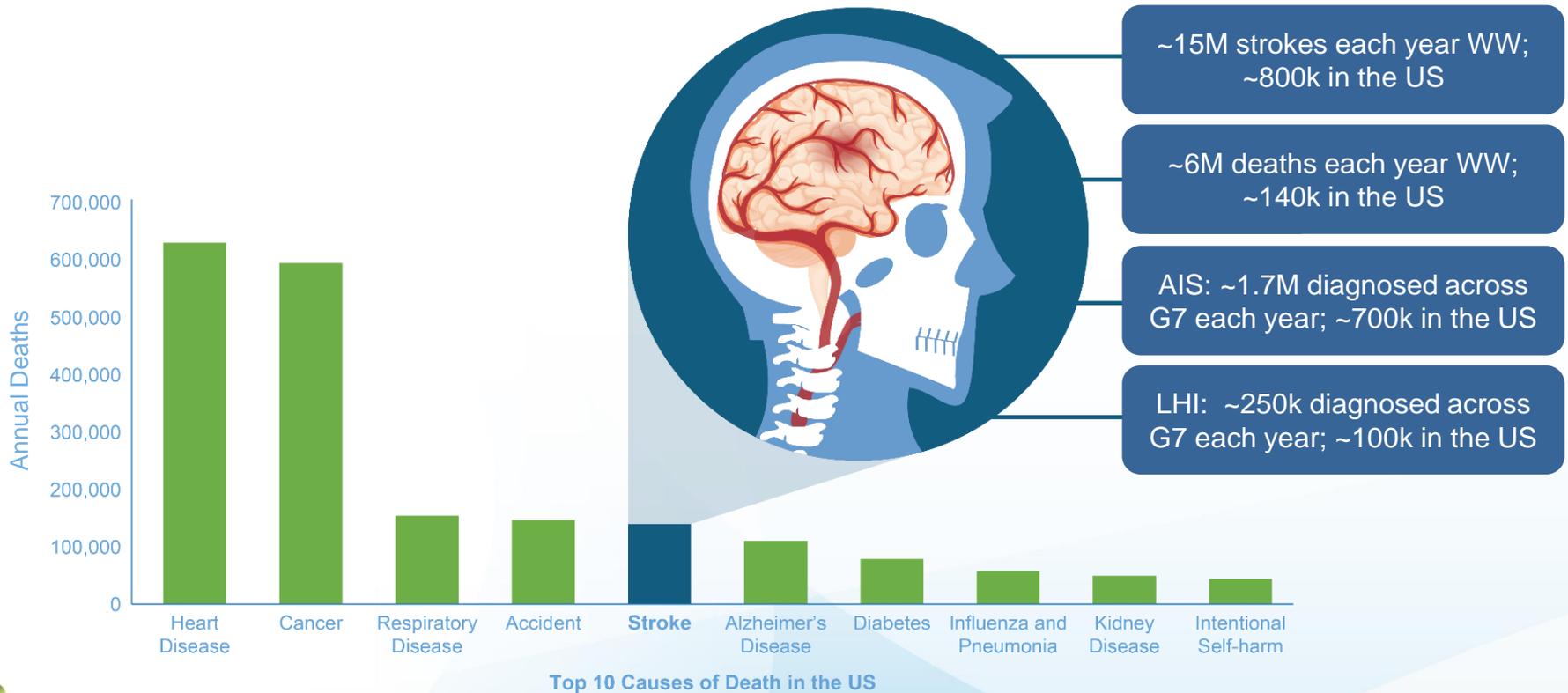
# Biogen Approach to the Stroke Market

## Chirfi Guindo

EVP, and Head of Global Marketing,  
Market Access and Customer  
Innovation

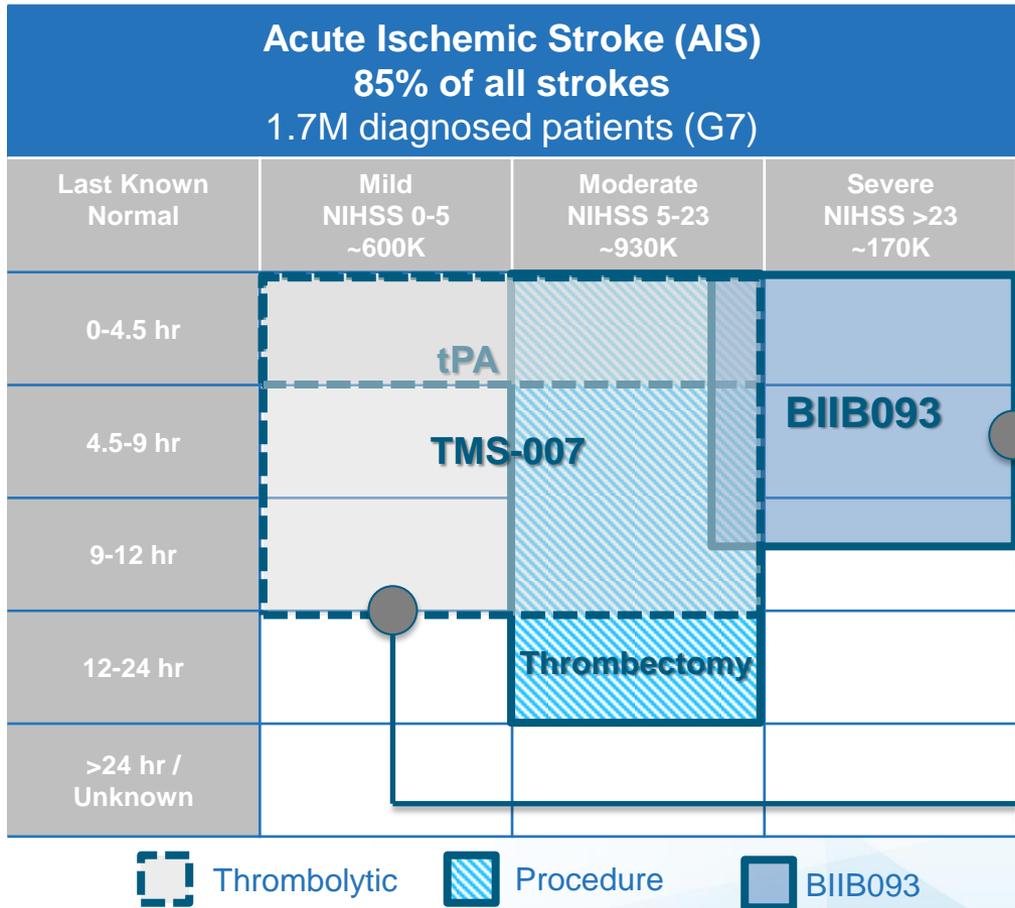


# Stroke is the Second-Leading Cause of Death Worldwide and the Fifth-Leading Cause of Death in the US



World Heart Federation, 2014. Centers for Disease Control and Prevention, 2017. Biogen analysis.

# Targeting Distinct Patient Segments



## BIIB093 in Large Hemispheric Infarction

- Within 10 hours of last known normal
- Addressable patient population:
  - ~160K in the G7
  - ~70K in the US
- Potential launch as early as 2022
- Potential peak revenues > \$1B if Phase 3 study is successful

## TMS-007 in Acute Ischemic Stroke (Thrombolysis)

- Within 12 hours of last known normal
- Mild to moderate (NIHSS 0-23)
- Addressable patient population:
  - ~700K in the G7
  - ~285K in the US

# Questions & Answers

