Monitoring Protein Dynamics at Endogenous Levels with a Luminescent Peptide Tag

Christopher Eggers, Brock Binkowski, Kristin Riching, Sarah Mahan, Juliano Alves, Marie Schwinn, Braeden Butler, Danette Daniels, Hicham Zegzouti, Thomas Machleidt, Keith Wood, and Frank Fan



Promega Corporation, 2800 Woods Hollow Rd, Madison, WI 53711

1. Introduction

Intracellular signaling is largely mediated through protein dynamics, including changes in protein abundance, interactions, location, or post-translational modification. While the behavior protein abundance, interactions, location, or post-translational modification, while the behavior of proteins is commonly studied using overexpressed reporter genes, CRISPR/CasSo filters the possibility of tagging genes with reporters at the endogenous locus in order to maintain physiological expression levels, regulation, and stoichicmenty with briding partners. The 11-amino-acid peptide, HBiT, represents an ideal tag for studying the protein dynamics of endogenously expressed proteins. Its small size facilitates rapid knock-in of the tag using ribonucleoprotein complexes of Cas9 and gRNA along with synthesized single-stranded oligonucleotide donor DNA. High-affinity complementation of HiBiT with the 18 kDa LgBiT ounit generates the bright, luminescent NanoBiT™ enzyme, enabling sensitive quantification of HiBiT-tagged proteins over 7 orders of magnitude of linear dynamic range. Changes in protein abundance can be monitored in either a lytic endpoint assay using purified LgBiT protein or in a live-cell kinetic assay by expressing the LgBiT subunit in cells. Interactions of a HiBIT-tagged protein with protein fusions to HaloTag can be measured in live cells using bioluminescence resonance energy transfer (BRET). We apply these assays to the induced degradation by PROTAC compounds of the bromodomain-containing protein, BRD4, and show both a decrease of endogenously expressed HiBiT-BRD4 in cell lysates and live cells and increased protein interactions with the E3 ligase complex and ubiquitin. HiBiT can also be used to measure translocation of proteins to and from the cell surface in a live-cell assay that takes advantage of the membrane impermeability of LgBiT. We show that internalization of endogenously expressed HiBIT-EGFR and HiBIT-B2-AR can be measured in a matter of minutes as a loss in extracellular HiBiT signal. Furthermore, phosphorylation of HiBIT-EGFR upon activation can be monitored in a homogeneous assay by measuring BRET from the HiBiT/LgBiT complex to a fluorescently labeled secondary antibody to monitor binding of an anti-phospho antihody

2. Overview of HiBiT and Endogenous Tagging







High-affinity interaction between HiBiT and

LgBiT (K_D = 700 pM) drives spontaneous formation of a bright, luminescent enzyme with glow kinetics in the presence of furimazine substrate

· HiBiT can be fused to the N- or C-terminus of proteins or placed in accessible internal

- Rapid, Cloning-free CRISPR Knock-In Workflow Design and Order:
 Guide RNA (crRNA + tracrRNA)
- HiBiT Donor DNA (ssDNA oligo)
- Purified Cas9

2. Assemble Ribonucleoprotein

3. Deliver RNP Complex & Donor

Incubate 24-48hrs

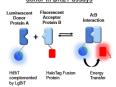
5. Detect Edit by Luminescence

3. Multiple Detection Formats to Measure Protein **Dynamics**

Directly measure HiBiT-tagged proteins

- · HiBiT Lytic Assay: sensitive detection of HiBiT-tagged proteins in cell lysates, IP complexes, or other samples
- HiBiT Extracellular Assay: Live-cell detection of secreted or cell-surface HiBiT-tagged
- HiBiT Blotting: simple and sensitive detection of HiBiTtagged proteins on blots.
- Intracellular HiBiT Assay: Live-cell, kinetic detection of intracellular HiBiT in LaBiTexpressing cells

Use complemented HiBiT as donor in BRET assays



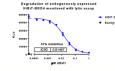
- BRET acceptor can be:
- HaloTag fusion for protein
- interaction assays Fluorescent tracer compound for
- small molecule engagement Labeled 2º antibody for posttranslational modifications

4. Quantify Protein Abundance Across Wide Dynamic Range with a Lytic Assay

- Monitor regulated degradation of endogenously expressed, HiBiTtagged proteins using a lytic assay.
- Lytic reagent: LgBiT protein, furimazine and detergent (homogeneous; <10 min; glow
- Sensitivity to 0.1 attomoles (3 fg of a 30kDa protein), ideal for monitoring expression at endogenous levels

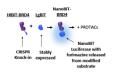
PROTACs Target Proteins for Degradation Degraded Target

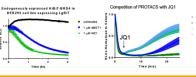
>7 logs linear dynamic range



5. Quantify Protein Abundance in Live Cells

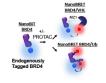
- · Live-cell, real-time monitoring of endogenously expressed, HiBiT-tagged proteins in cells expressing
- · Monitor reversible changes in protein degradation in real time

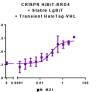


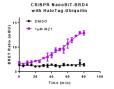


6. Measure Protein-Protein Interactions with **NanoBRET**

- Endogenously expressed, HiBiT-tagged proteins bind to stably expressed LgBiT (BRET donor).
- Exogenously expressed HaloTag fusions bind to a fluorescent dye (BRET acceptor).
- Treatment of endogenously expressed HiBiT-BRD4 with MZ1 leads to increased interactions with both VHL and ubiquitin.



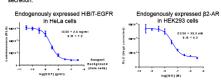




7. Measure Receptor Internalization

- Rapidly quantify the amount of endogenously expressed, HiBiTtagged protein exposed to the extracellular medium (<5 min)
- Extracellular reagent: LgBiT protein and furimazine in a nonlytic buffer.
- Monitor protein internalization, trafficking to surface, or

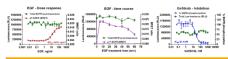




8. Measure Post-Translational Modifications



· Expected changes in BRET ratio were seen with agonist &



9. Conclusions

Monitor protein dynamics at endogenous levels of expression using HiBiT

- Tag genes at endogenous loci
 - 11 amino acid size greatly facilitates CRISPR/Cas9 workflow for genomic knock-ins
- Sub-attomole sensitivity enables measurement of proteins at endogenous levels

> Quantify protein abundance

- · Homogeneous, add-mix-read assay protocols
- >7-log linear dynamic range Monitor changes in regulated protein stability or degradation
- Lytic endpoint or live-cell kinetic assays
- > Measure protein-protein interactions in live cells Expression of LgBiT converts HiBiT into a BRET donor
 - · Fusions to HaloTag act as BRET acceptors
- Measure internalization or secretion of HiBiT-tagged proteins · Quantify surface-expressed or secreted HiBiT-tagged proteins in < 4 min
- > Measure post-translational modifications
 - · BRET in lysate from HiBiT/LgBiT complex to fluorescently labeled secondary antibody