New tools for precision collider physics

Aditya Pathak

FH Fellow Meeting

21/28 April 2023

HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

About Me

My journey across the globe …

Born: Ujjain, India

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My journey across the globe …

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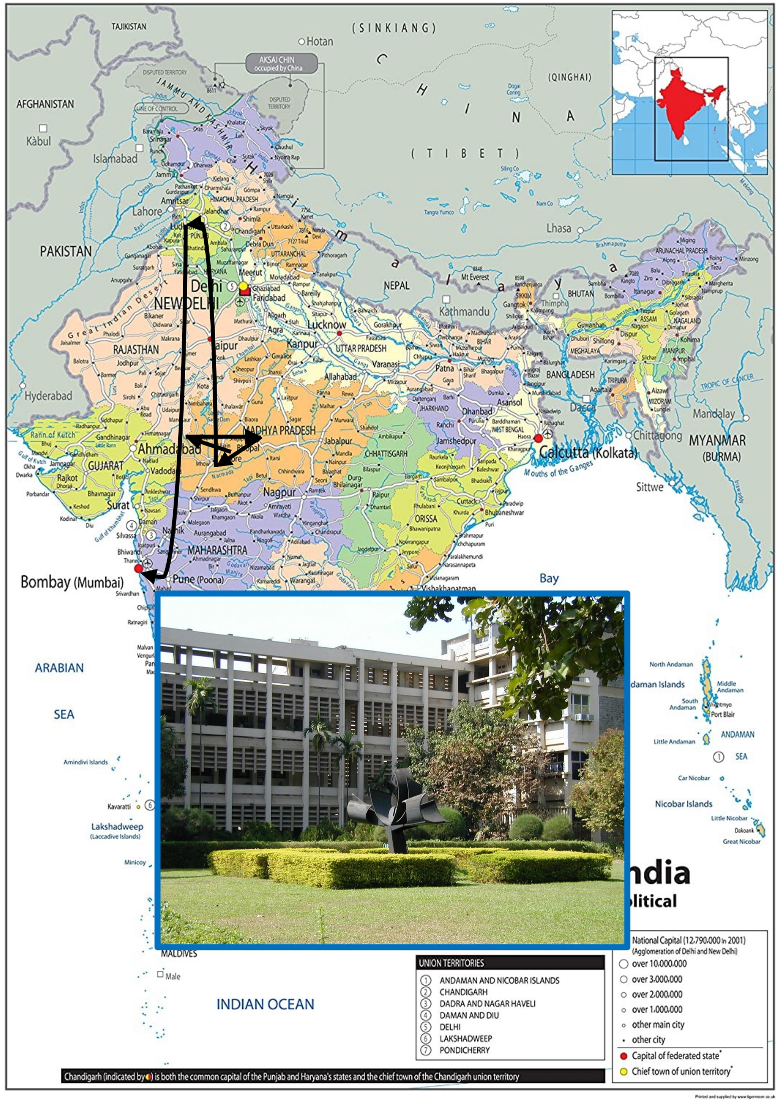

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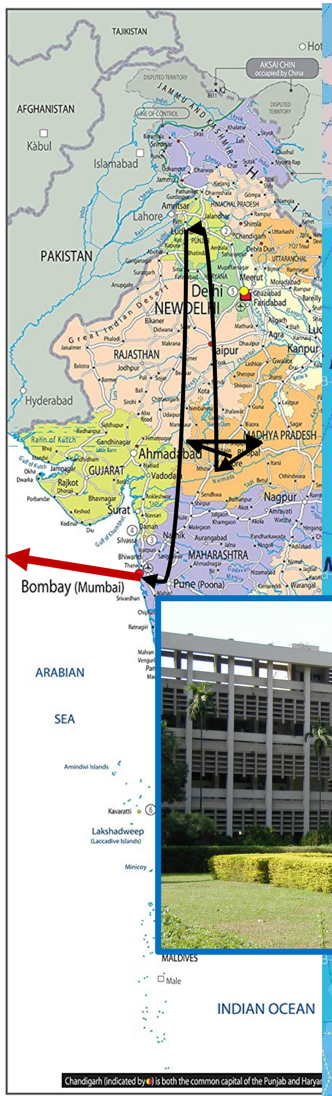

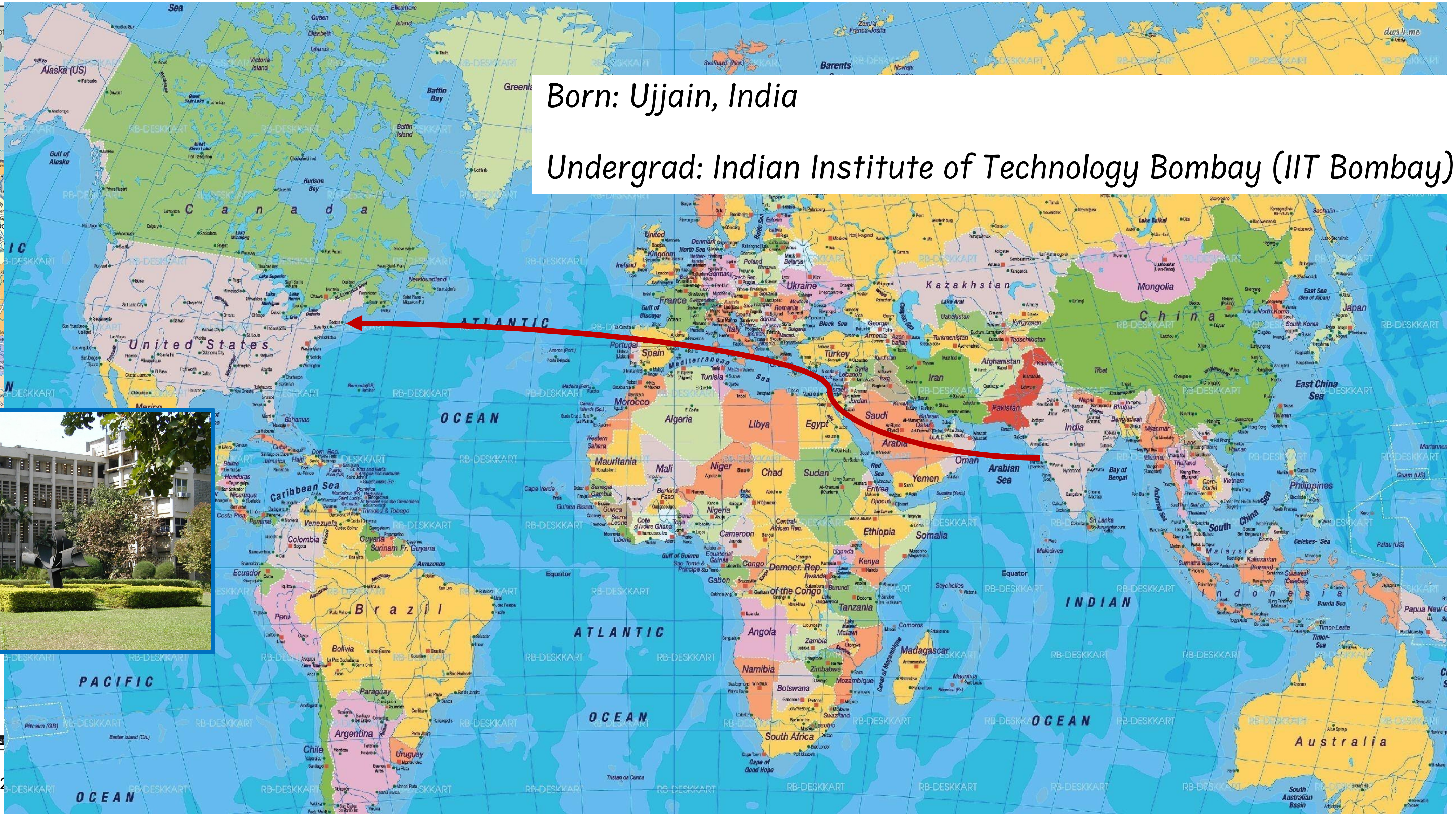

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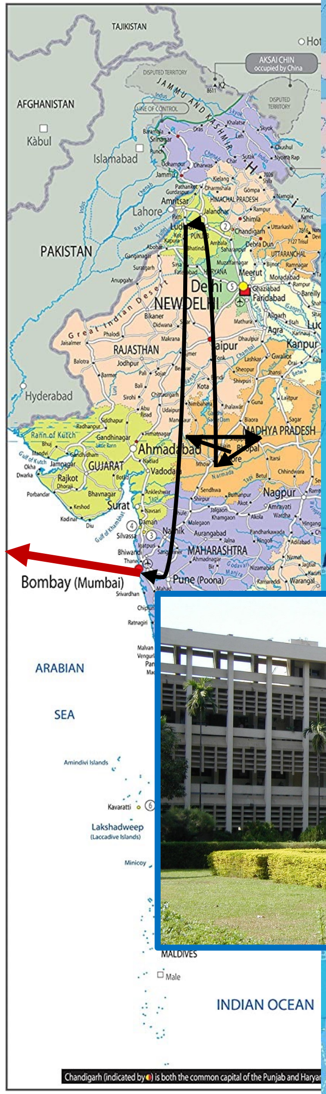

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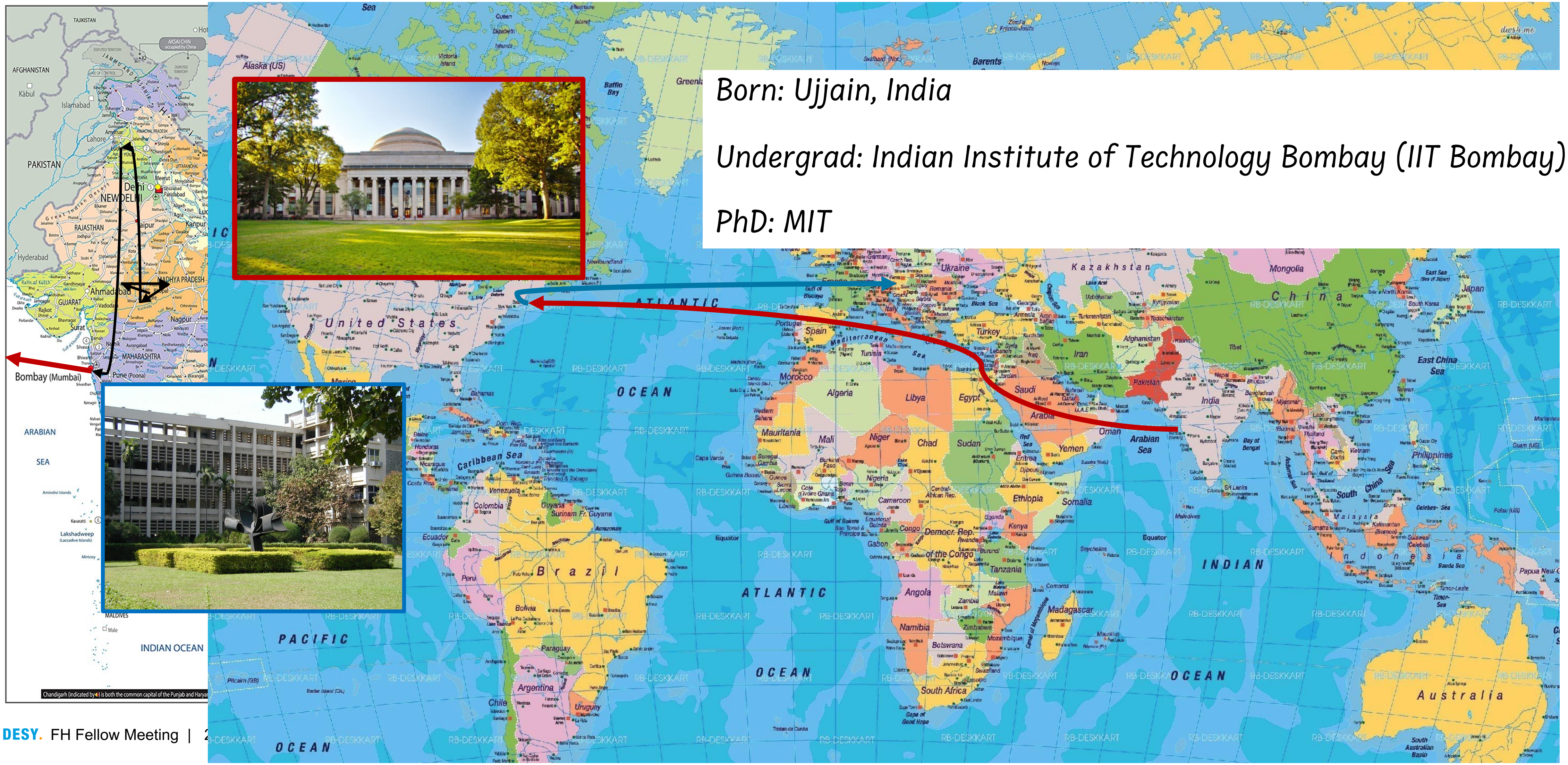

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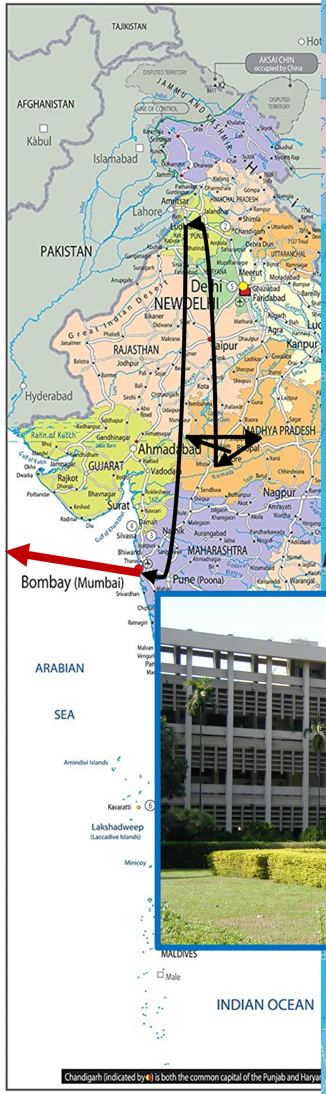

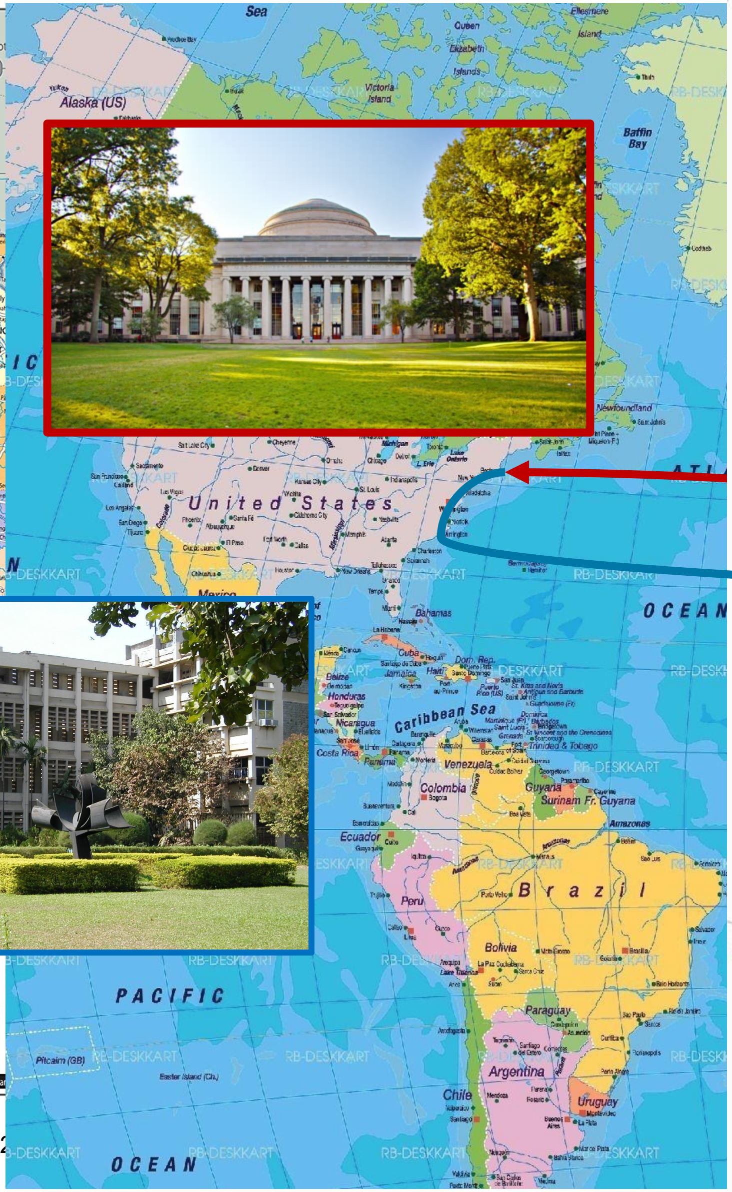

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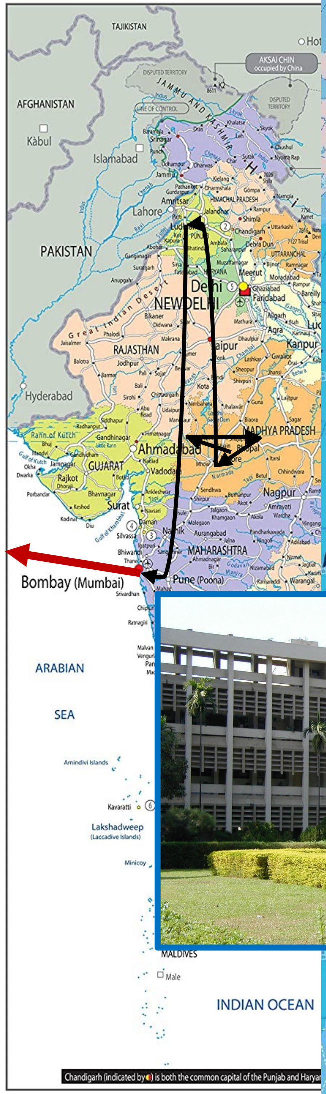

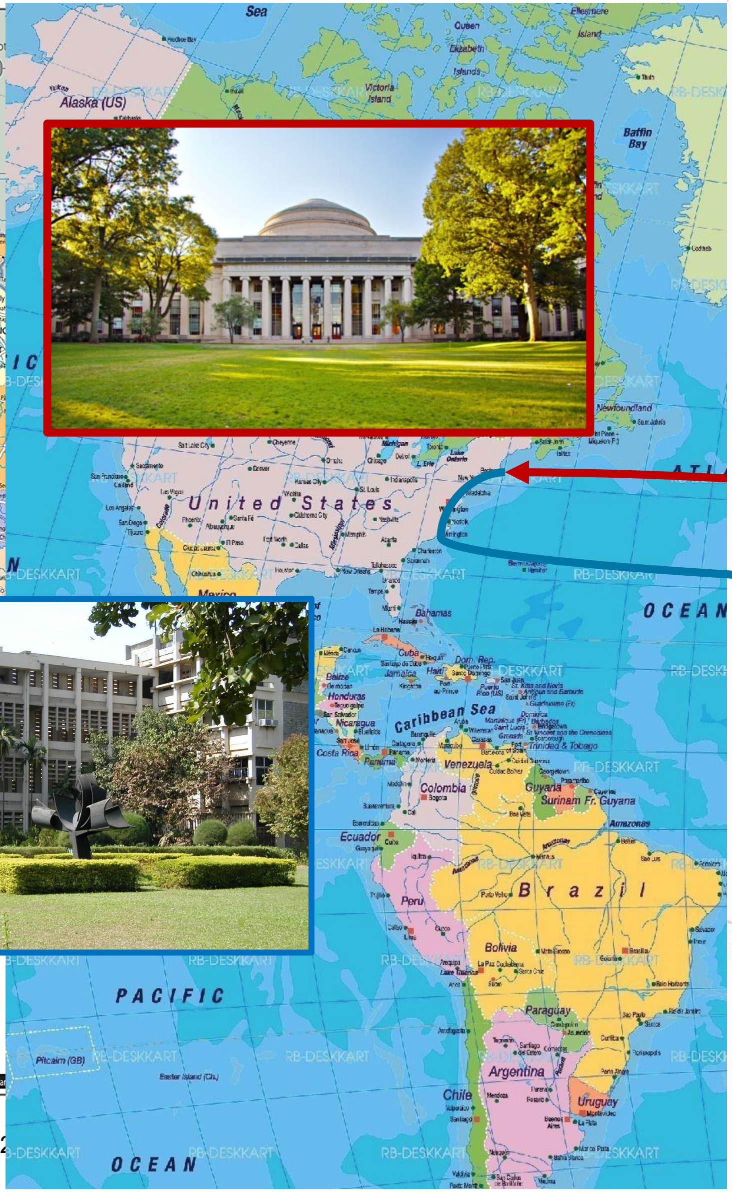

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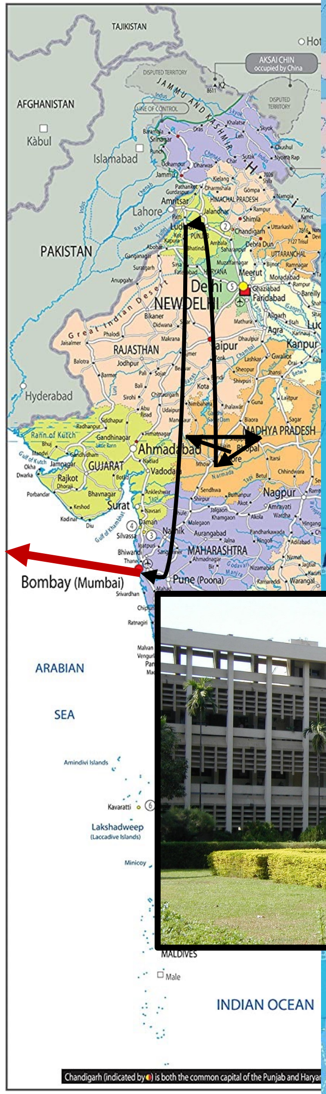

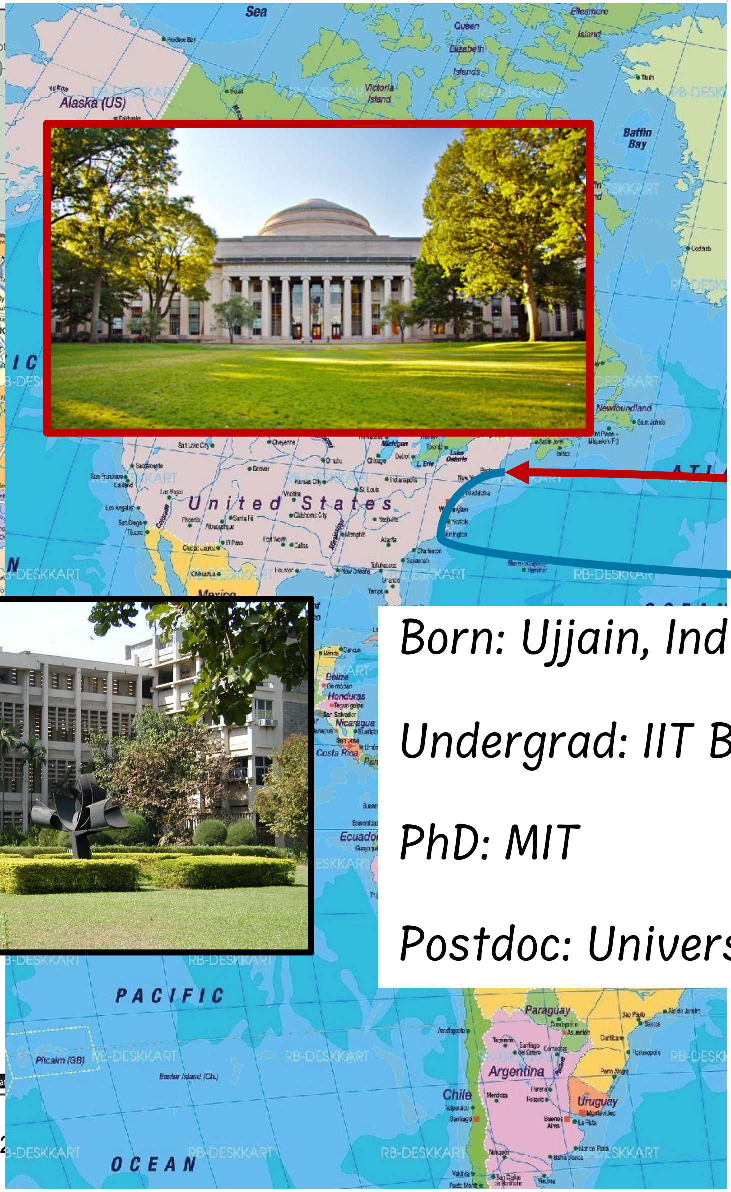

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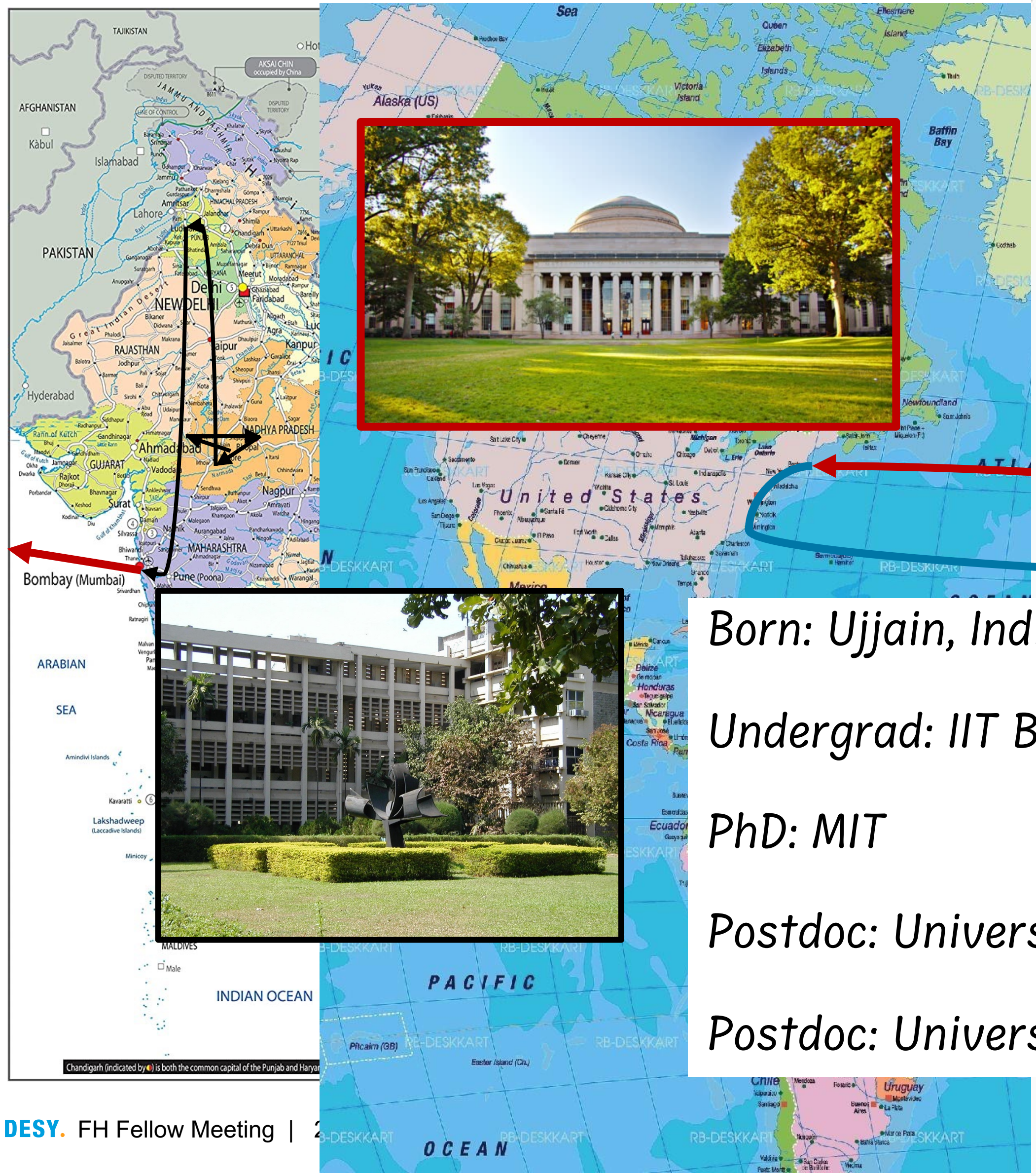

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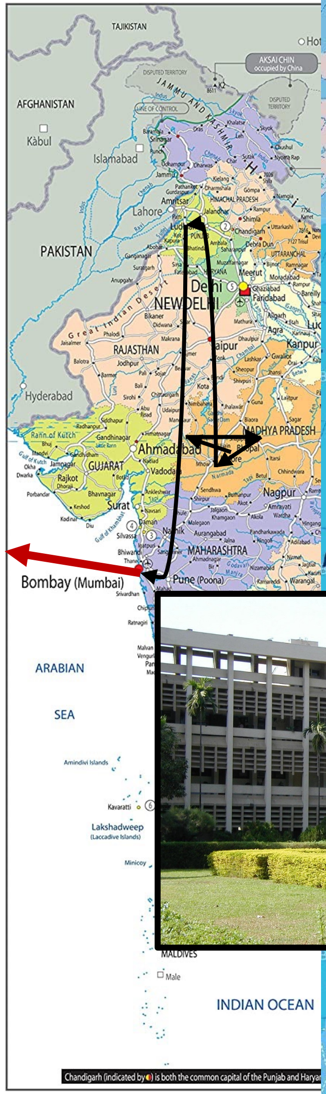

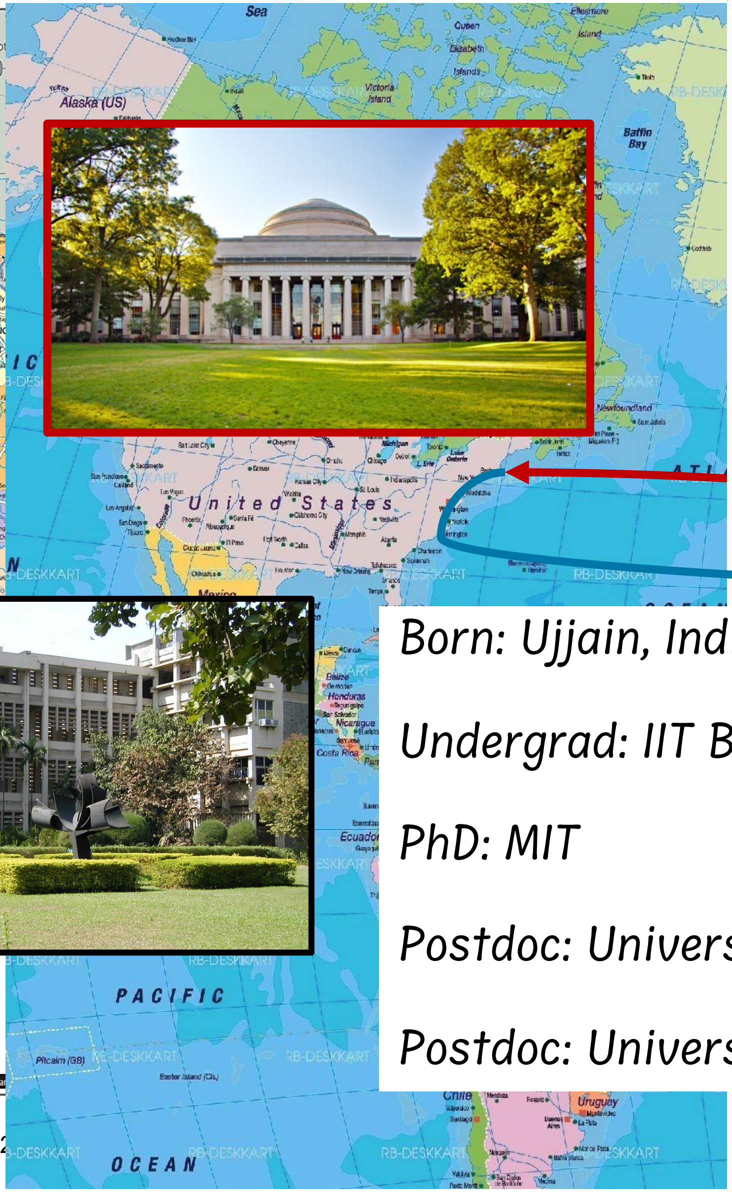

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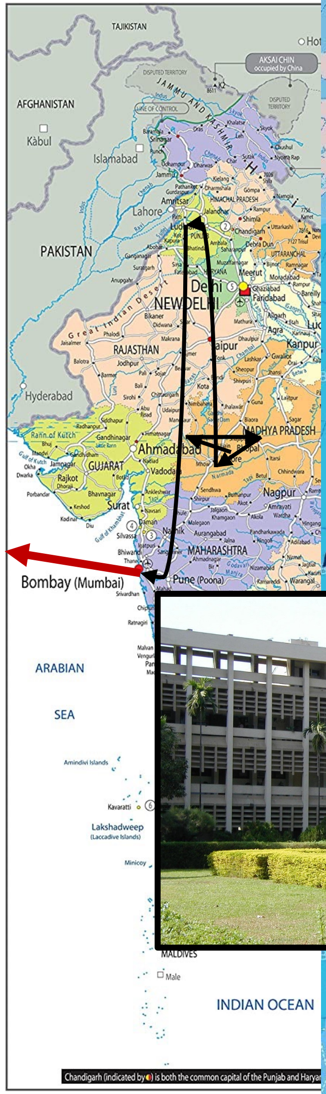

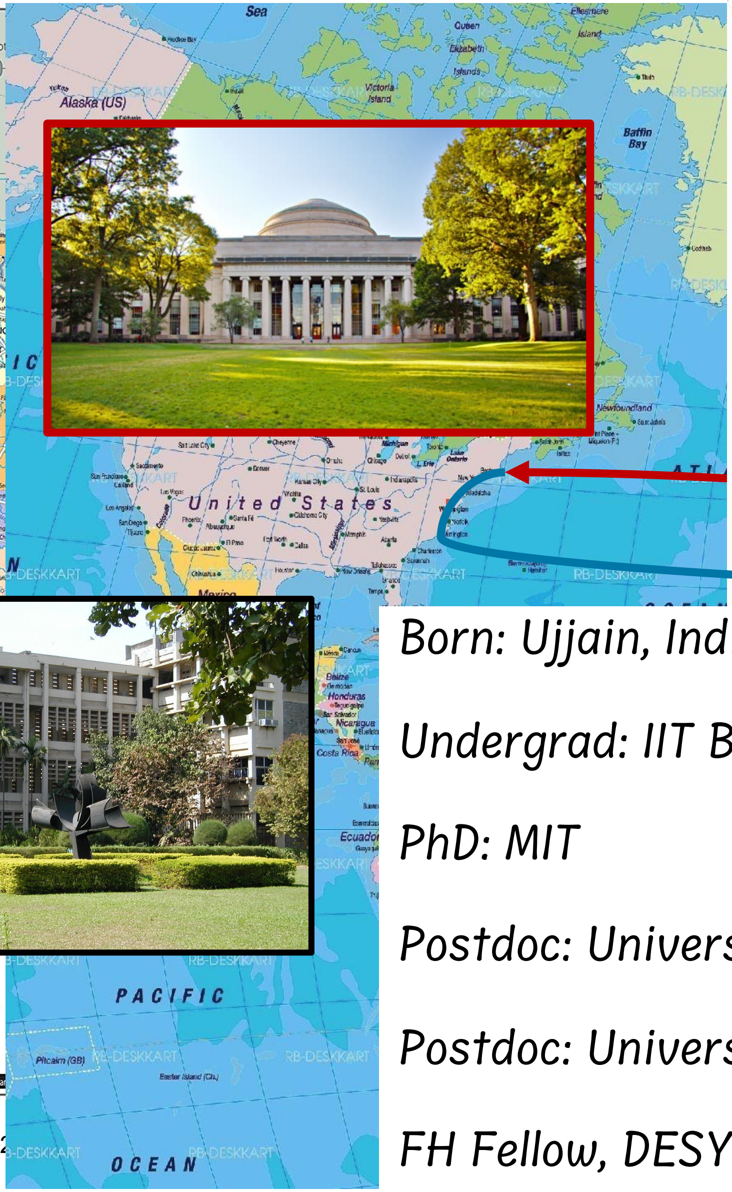

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FH Fellow, DESY

My Research

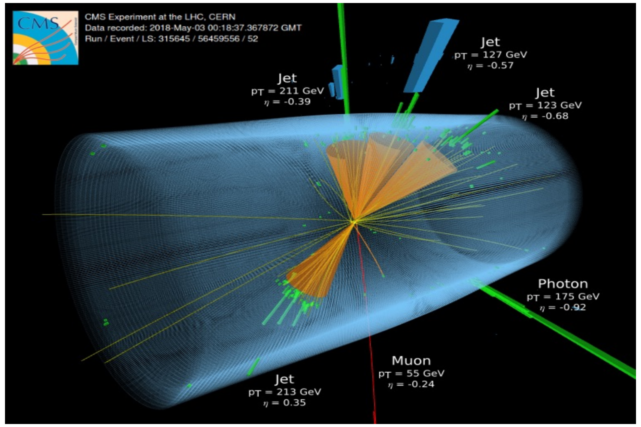
Research interests

I am broadly interested in analytical QCD calculations for collider physics and how they can be used to achieve precision mesurements and improving Monte Carlo simulations.

- *Effective field theory methods (SCET, HQET, …) in QCD*
- *Precision top quark mass and strong coupling constant*
- *Hadronization corrections in jet observables*
- *Forward scattering and BFKL dynamics*
- *Subleading power corrections in TMD cross sections*

My Research

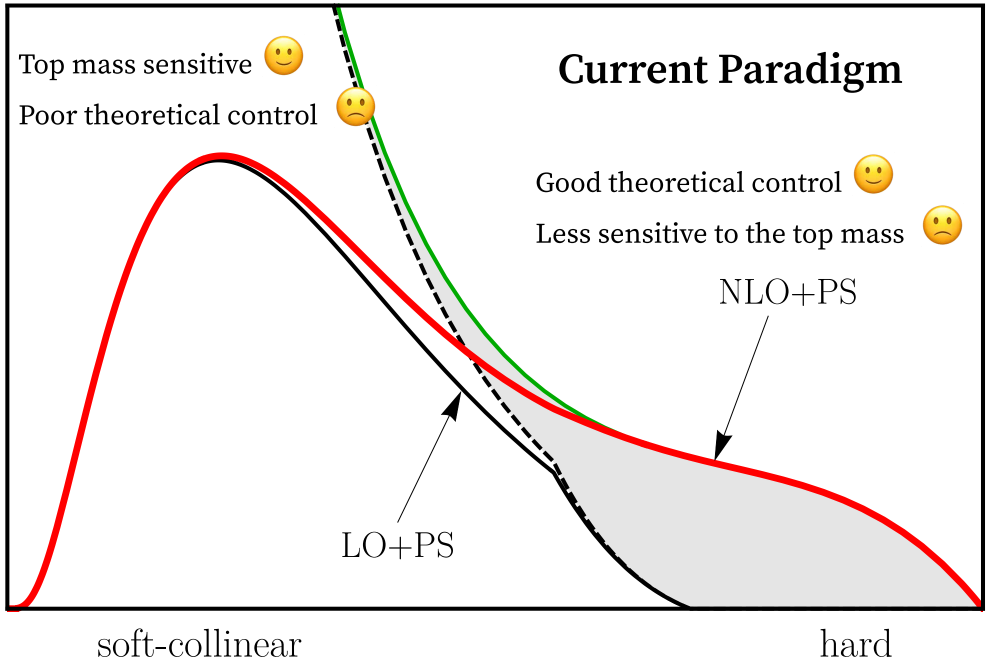
Top quark mass measurement

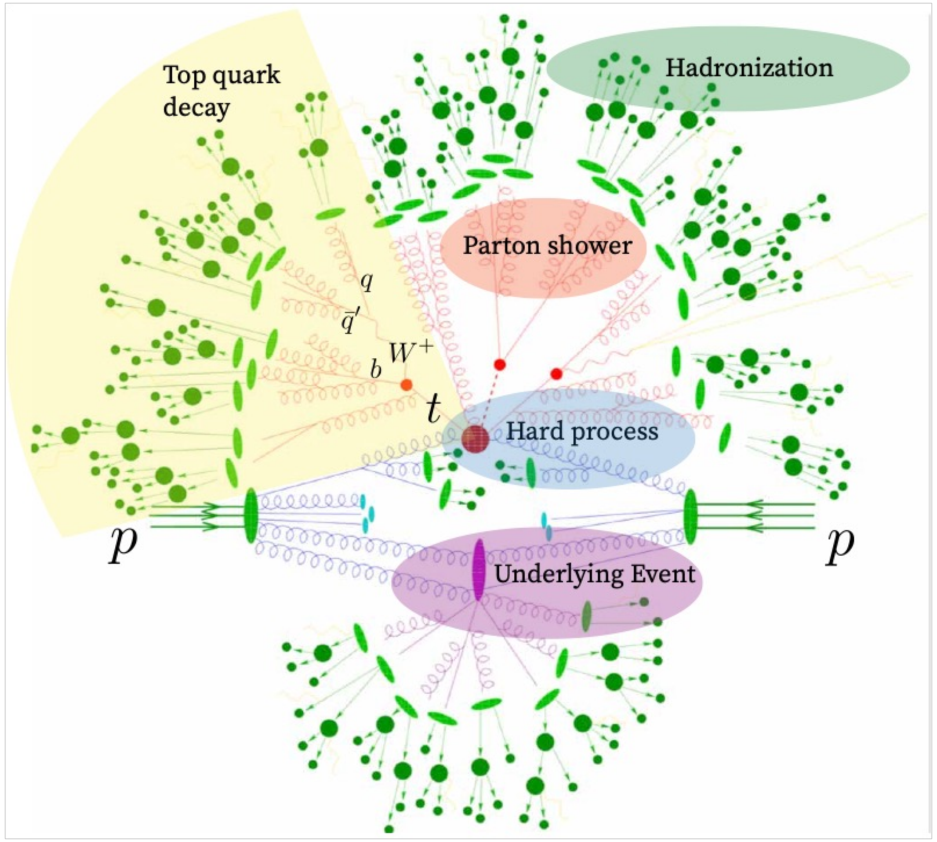


$$m_t^{\mathrm{MC}} = 172.76 \pm 0.3\,\mathrm{GeV}$$ PDG

$\mathcal{O}$(1 GeV) theory uncertainty from *the top mass interpretation problem*

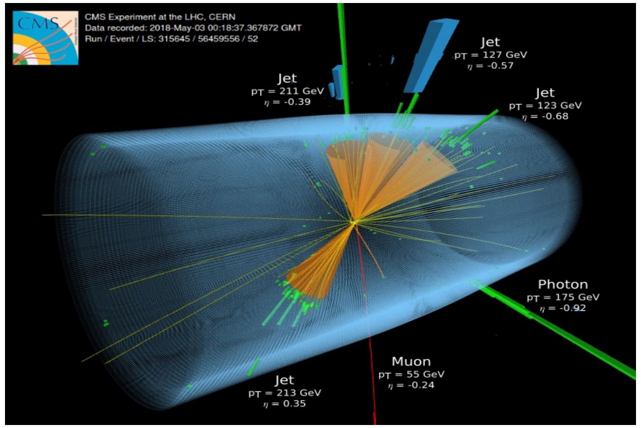
To resolve the theory ambiguity in the Monte Carlo top mass we need a direct comparison of (unfolded) data with accurate theory prediction.





My Research

Strong coupling constant measurement



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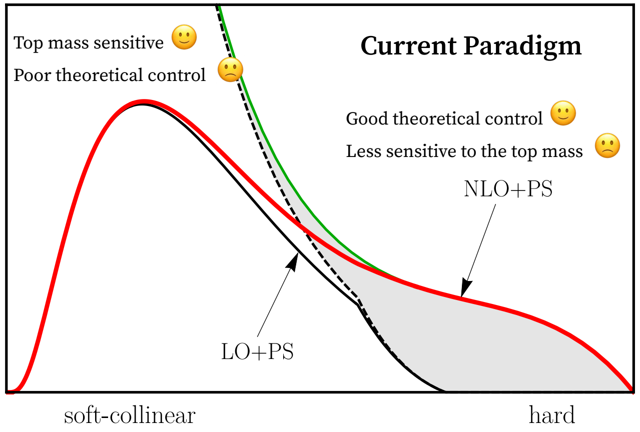
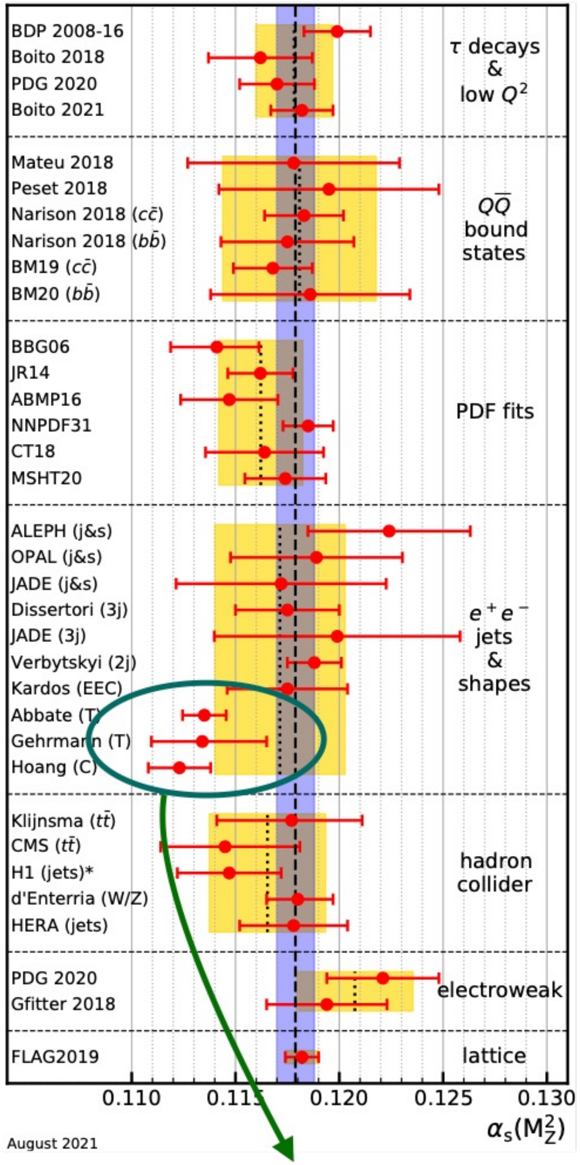
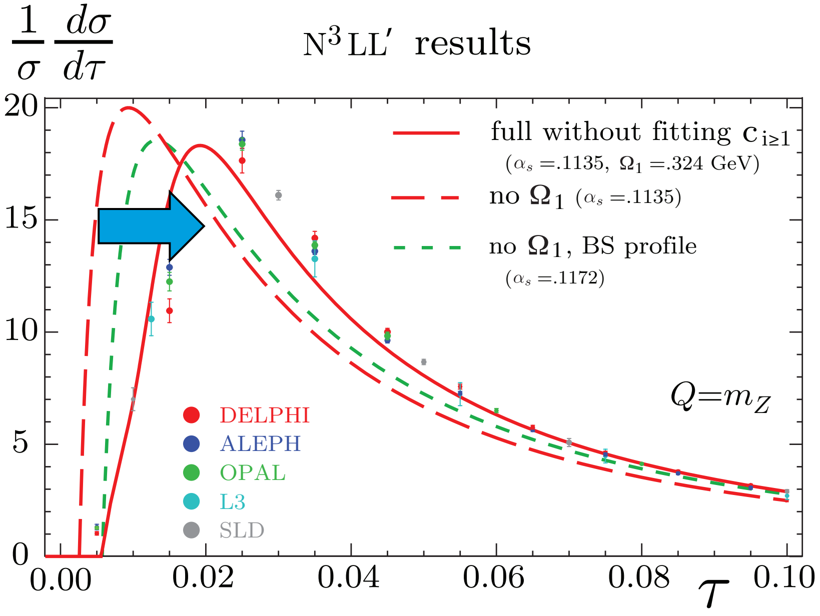




LEP measurements in tension with world average

What is causing this deviation in α_s from the lattice extractions?

Hadroniztion corrections?



Soft QCD effects make these measurements challenging

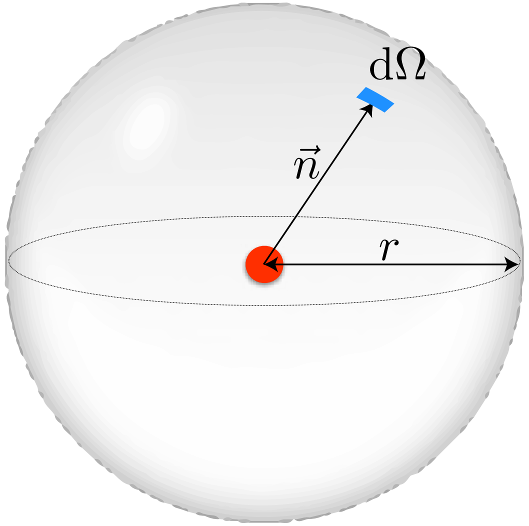
My Research

Energy correlators for precision physics

Correlation functions of energy flow operators are powerful tools for precision physics

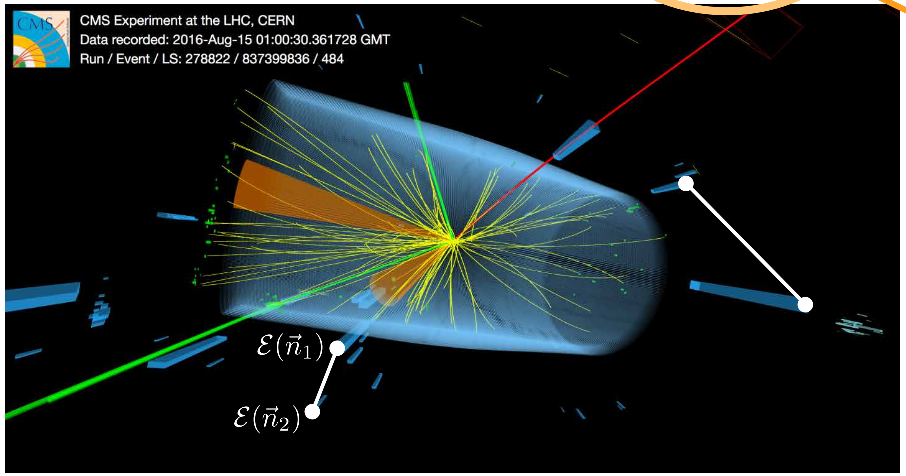
QFT definition of a calorimeter:

$$\mathcal{E}(\vec{n}) = \int_0^\infty dt \lim_{r\to\infty} r^2 n^i T_{0i}(t, r\vec{n})$$



Hoffman, Maldacena 2008

$$\langle \mathcal{E}(\vec{n}_1)\mathcal{E}(\vec{n}_2)\rangle = \sum_{ij}\int \frac{\mathrm{d}\sigma_{ij}}{\mathrm{d}^2\vec{n}_i \mathrm{d}^2\vec{n}_j} E_i E_j \delta^2(\vec{n}_1 - \vec{n}_i)\delta^2(\vec{n}_2 - \vec{n}_j)$$



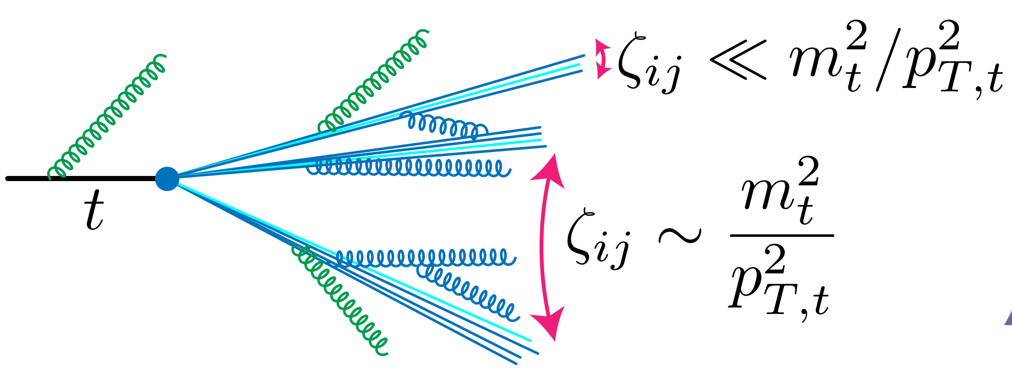
Energy weighting suppress soft contributions

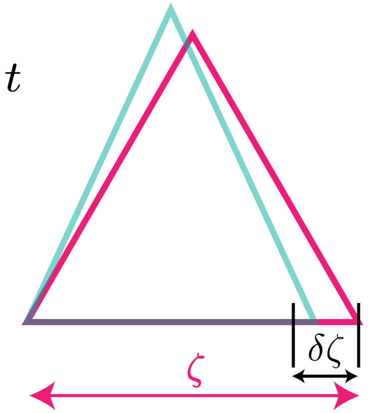
Inclusive cross sections simpler to calculate

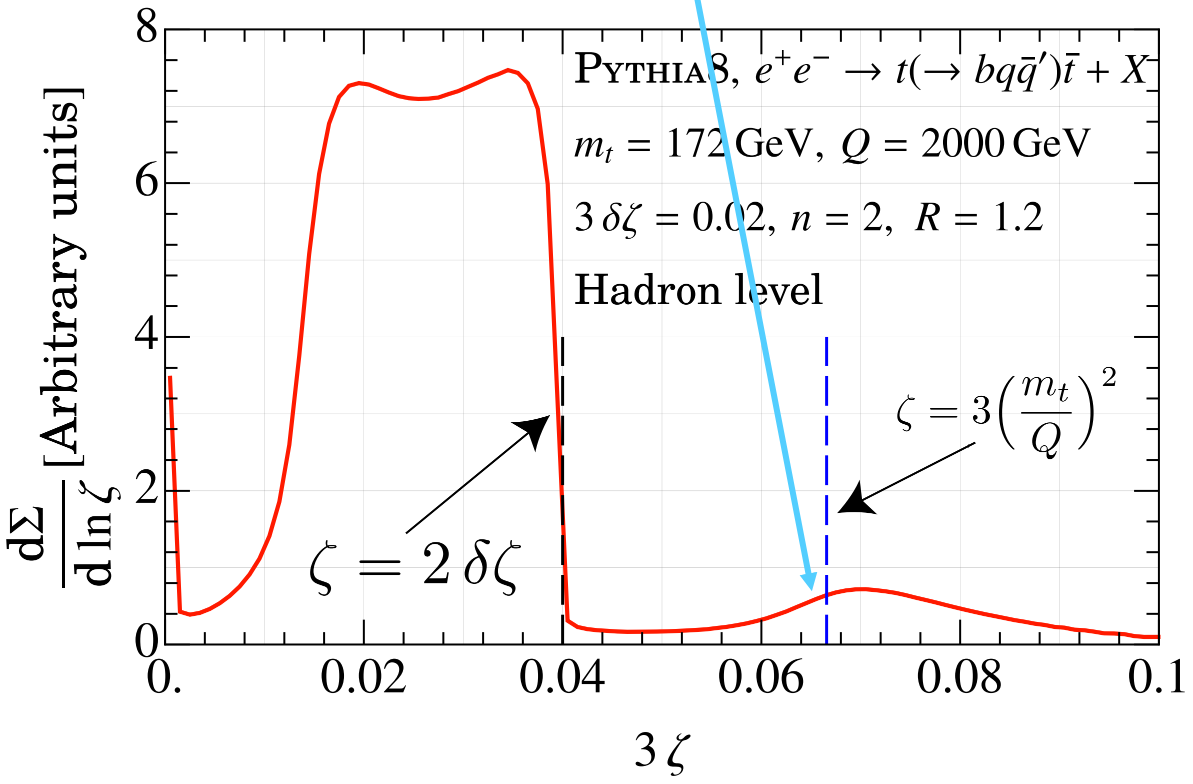
My Research

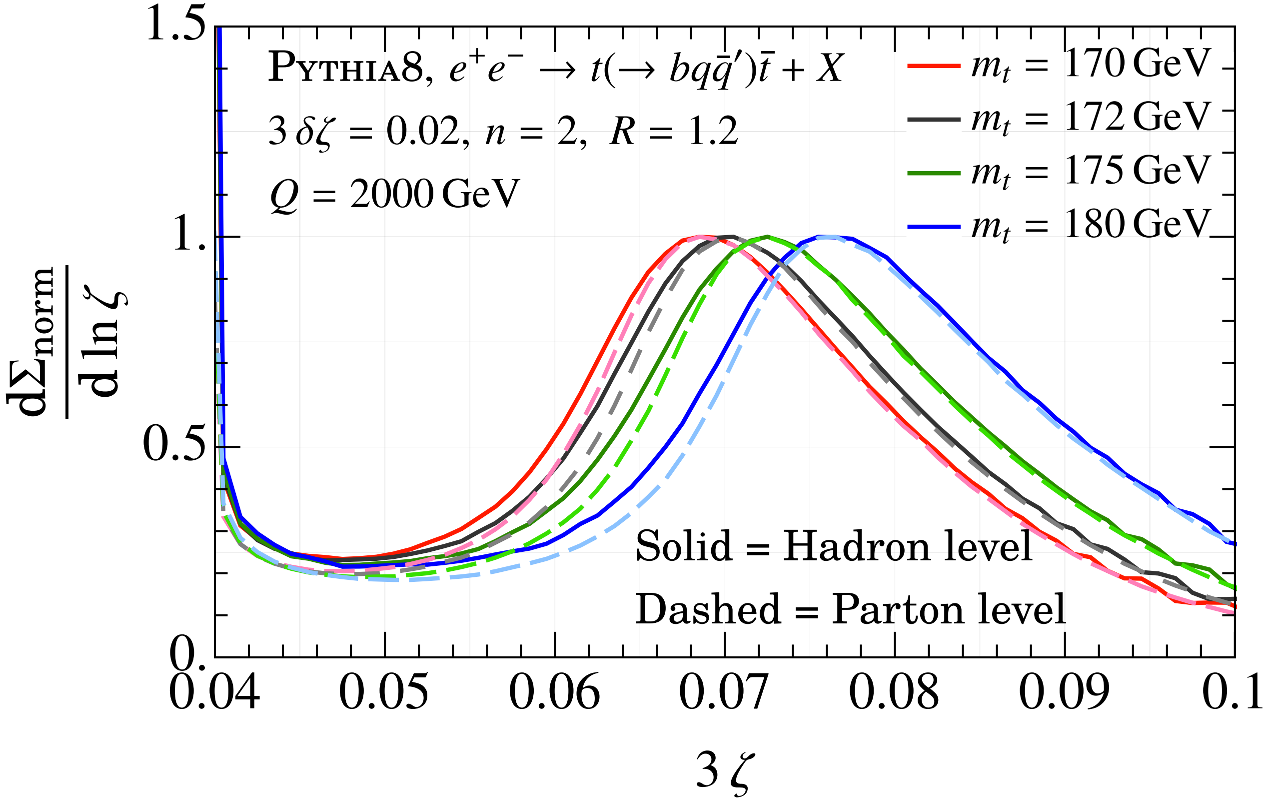
Energy correlators for top quark mass

Peak dominated by hard decay of the top









Holguin, Moult, AP, Procura 2022

Many more such exciting applications of EECs!

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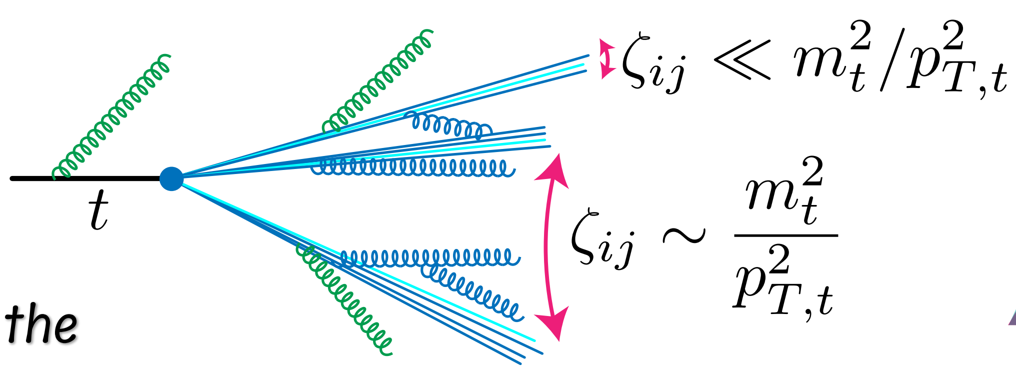
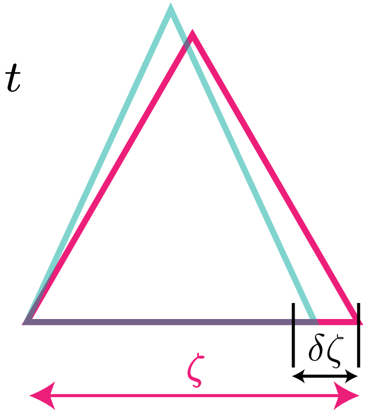
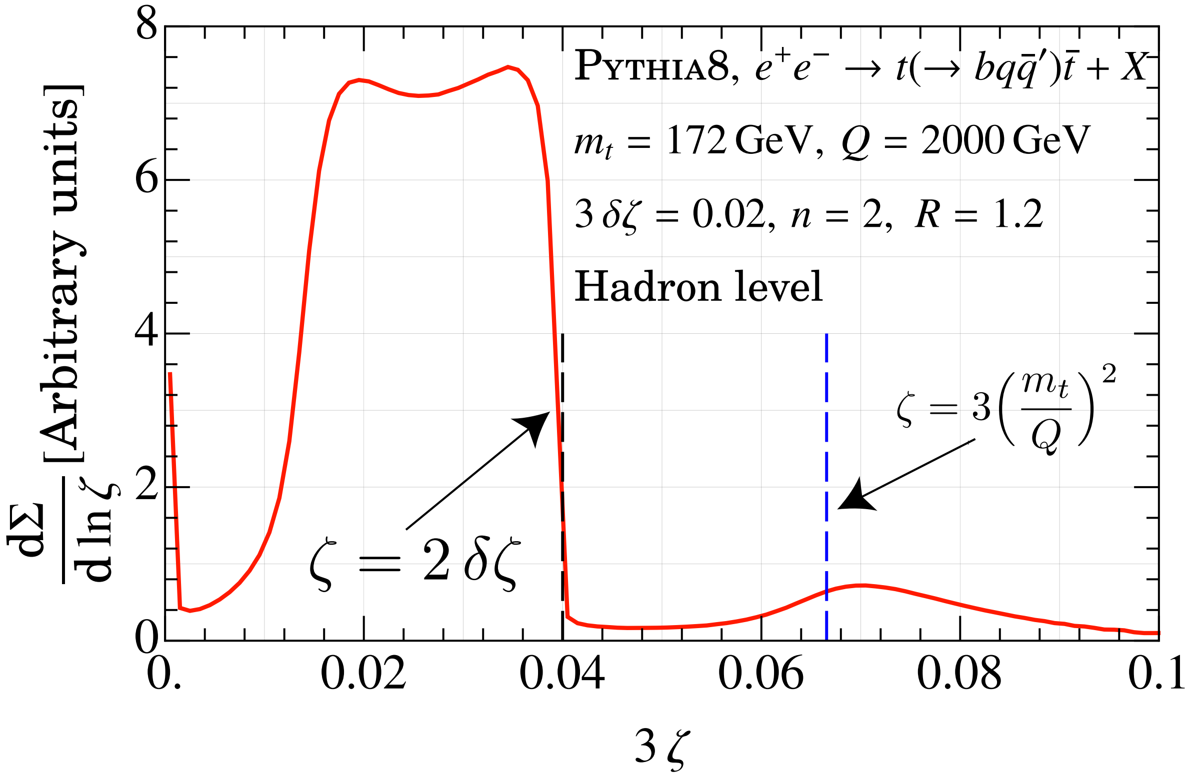
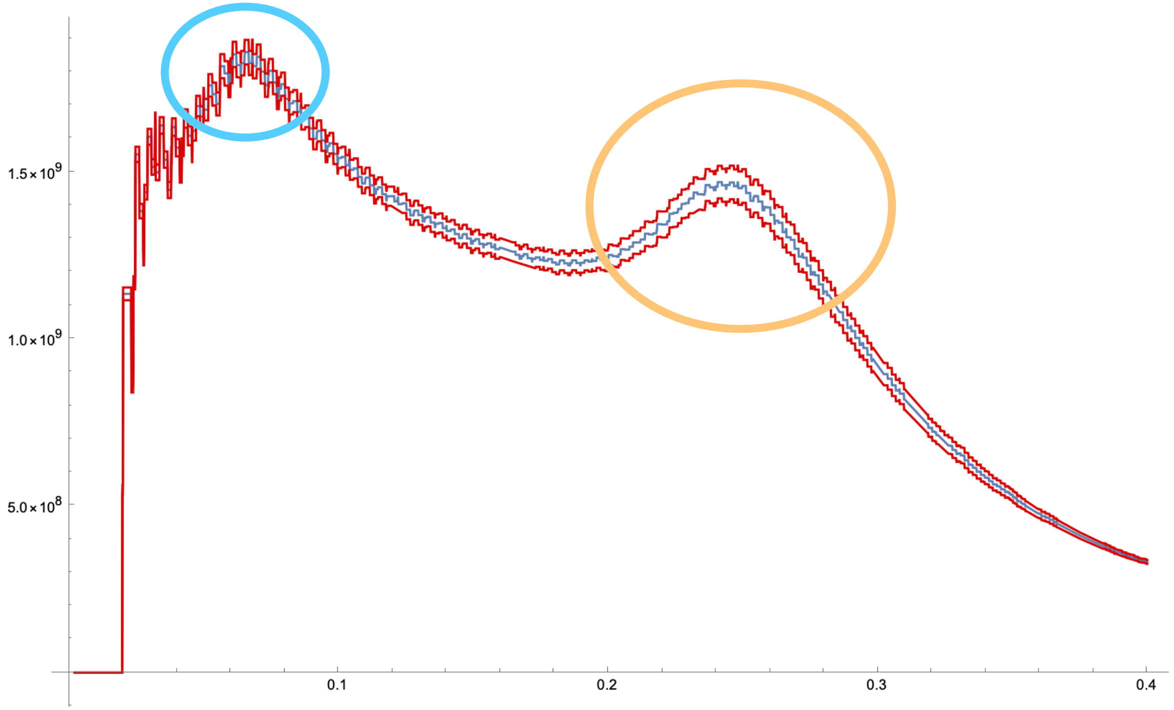




*New: Can exploit the two body **W** decay in the **top** jet to eliminate top velocity dependence*

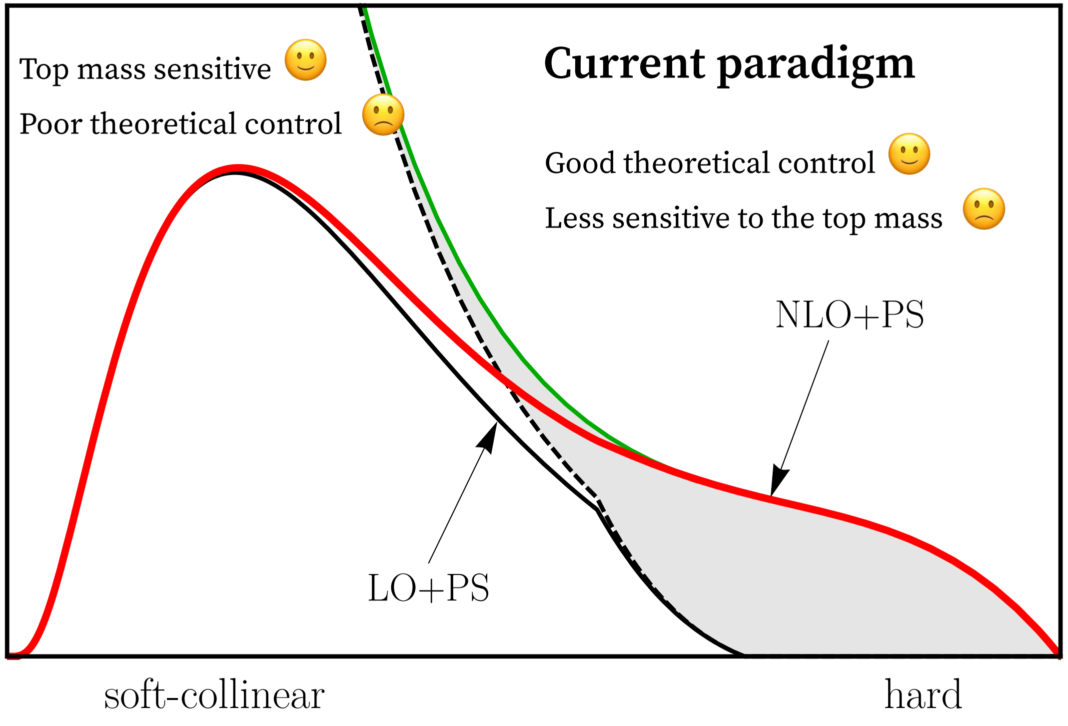


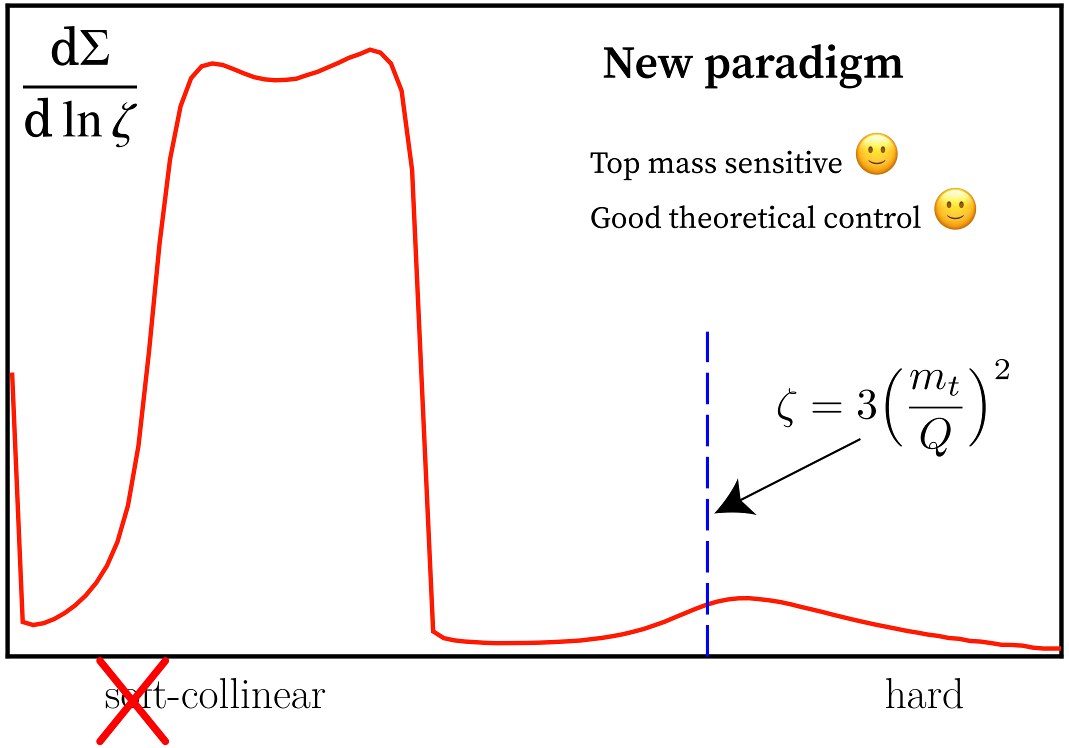


Another projection

Many more such exciting applications of EECs!

My Favourite Plot





Thank you!