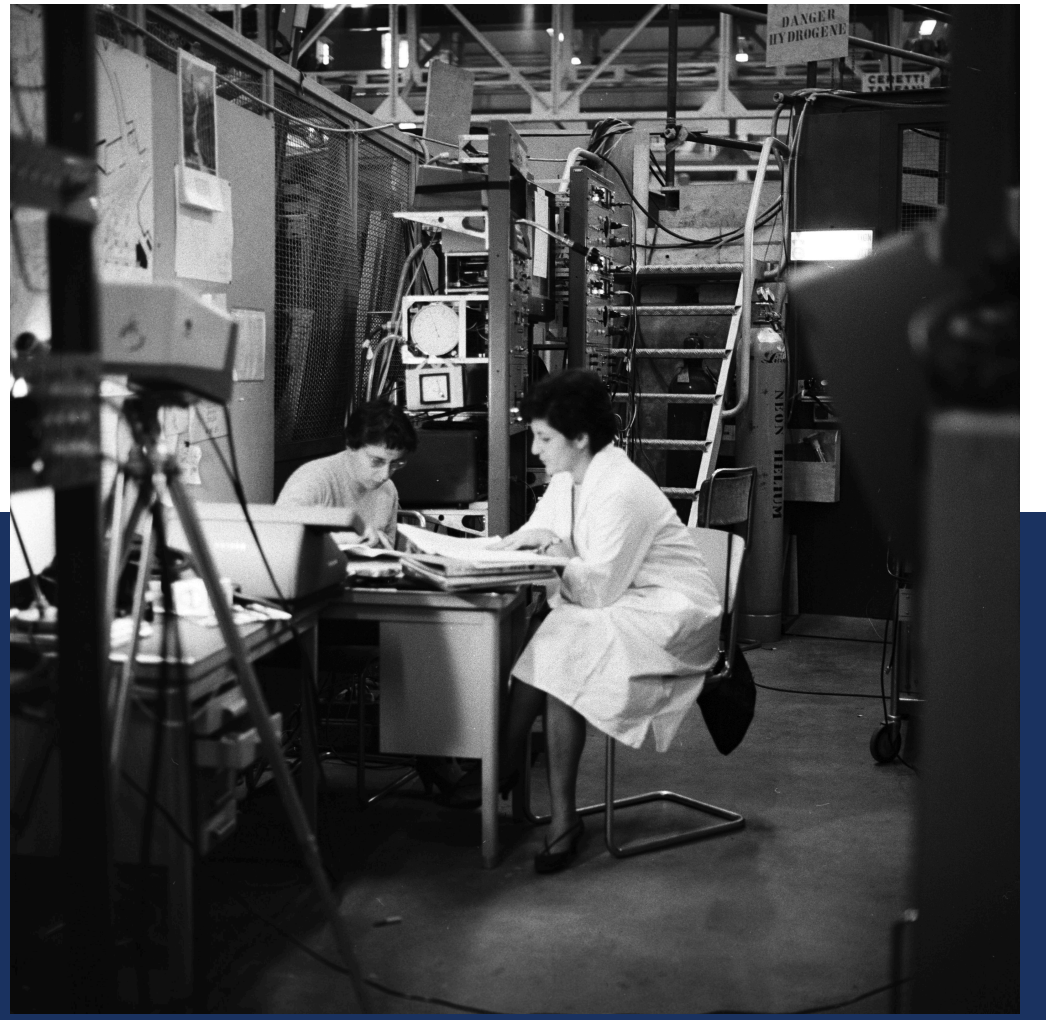
TOOLS & OBSERVABLES: EVENT ISOTROPY



CARI CESAROTTI

HARVARD UNIVERSITY

(2004.06125) W/ J. THALER, MIT

(2009.08981, 2011.06599) W/ M. REECE, M. STRASSLER, HARVARD

8TH WORKSHOP OF THE LHC LLP COMMUNITY

NOVEMBER 17, 2020

MOTIVATION

- Could be new physics at electroweak scale hiding with rare kinematic signatures
- Strategy for new physics searches: identify signatures *fundamentally* different from QCD backgrounds

MOTIVATION

When trying to quantify event shape

- Event shape observables designed to measure distance from *dijet*
  - *Thrust, C/D-parameter, sphericity, spherocity, supersphero…*

- Want distance from *isotropy*

Event Isotropy

(CC, J. Thaler, 2004.06125)

EVENT ISOTROPY

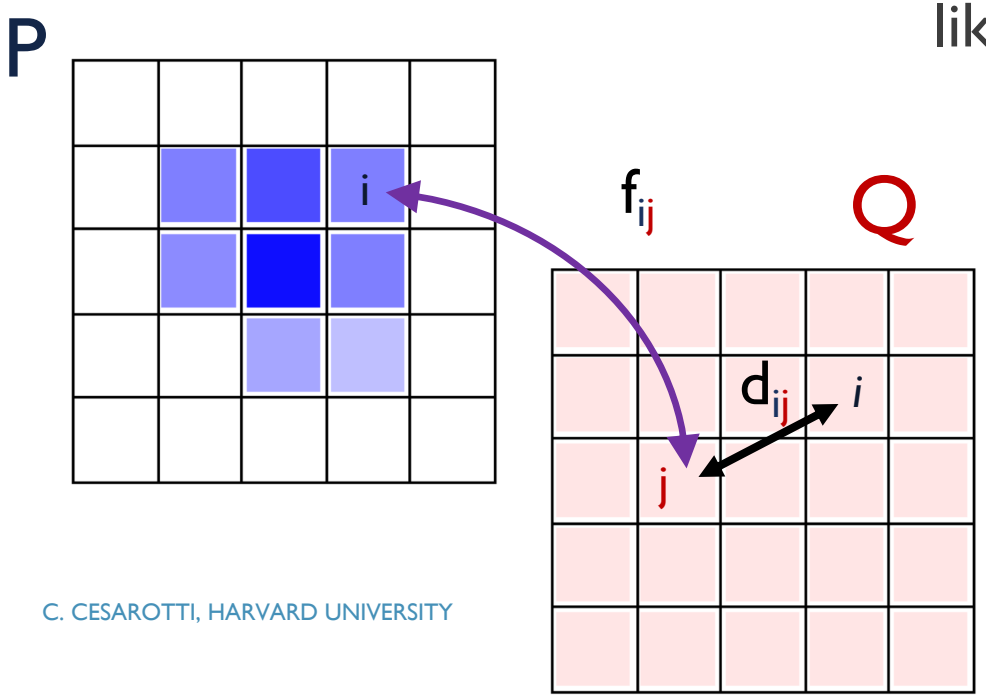
We propose a new event shape observable: event isotropy

CC, J.Thaler 2020

P. Komiske, E. Metodiev, J.Thaler 2019

Energy mover's distance (EMD):

What is the minimum work to rearrange the energy distribution in event *P* to look like event *Q*?



$$\mathrm{EMD}(P,Q) = \min_{\{f_{ij}\}} \sum_{ij} f_{ij} d_{ij}$$

f_{ij} : energy transported

d_{ij} : distance measure

$$f_{ij} \geq 0 \qquad \sum_{ij} f_{ij} = E_P^{\mathrm{tot}} = E_Q^{\mathrm{tot}} = 1$$

ENERGY MOVER'S DISTANCE

CC, J. Thaler 2020

We propose a new event shape observable: event isotropy

Energy mover's distance (EMD):
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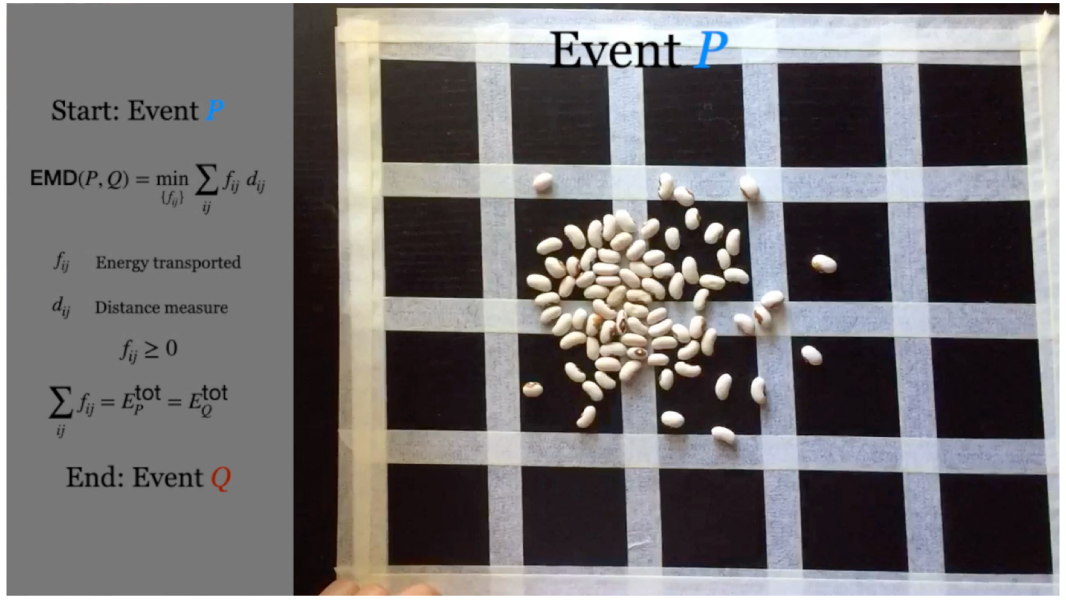


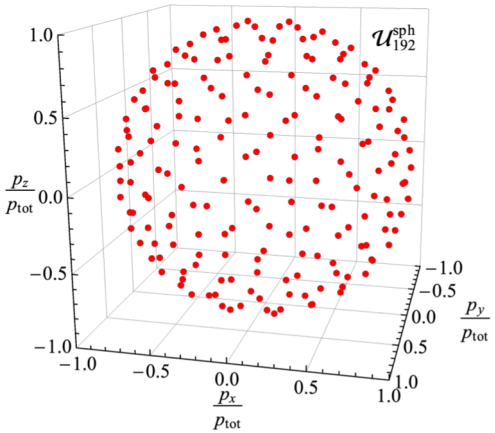
EVENT ISOTROPY:

EMD OF AN EVENT TO UNIFORM RADIATION PATTERN

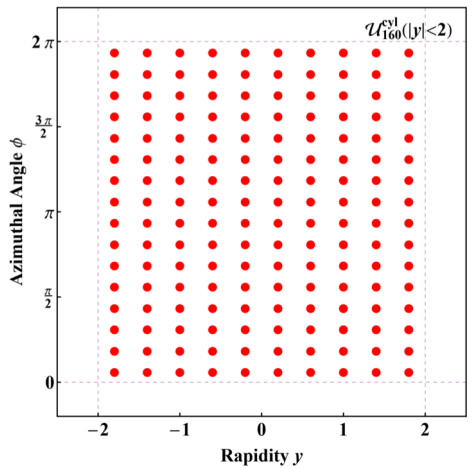
$$\mathcal{I}_n^{\text{geo}}(\mathcal{E}) = \text{EMD}_{\text{geo}}(\mathcal{U}_n^{\text{geo}}, \mathcal{E})$$

- *Geo*: Geometry of isotropic radiation pattern (sphere, cylinder, ring)
- *n*: Number of particles in quasi-uniform "reference" sample

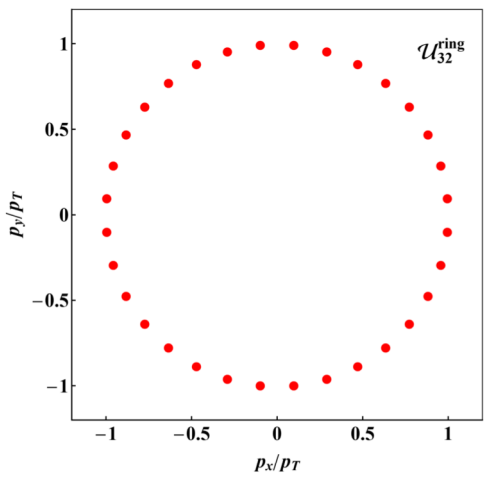
n = 192



n = 160



n = 32



EVENT ISOTROPY:

EMD OF AN EVENT TO UNIFORM RADIATION PATTERN

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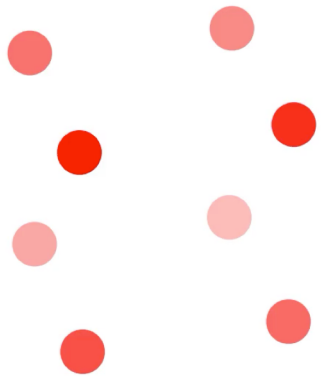
EXAMPLE of OPTIMAL TRANSPORT:
8 particles spread into a sphere



EVENT ISOTROPY

- IRC safe
- Dimensionless
- Defined on sets of massless particles with zero net momentum
- $\mathcal{I} \in [0,1]$, where 0 is isotropic and 1 is dijet

$$\mathcal{I}_n^{\text{geo}}(\mathcal{E}) = \text{EMD}_{\text{geo}}(\mathcal{U}_n^{\text{geo}}, \mathcal{E})$$