A journey in (and out) of physics

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University of Michigan

Fermilab EDI Seminar
February 15, 2019

A few words on my science

- High-energy experimental QCD
  - Quark and gluon structure of the proton
  - Formation of QCD bound states from scattered quarks or gluons (hadronization)
  - Spin-momentum correlations, quark and gluon dynamics in QCD
  - Color flow in hadronic interactions
- PHENIX (since 2001) and future sPHENIX (since 2015) experiments at the Relativistic Heavy Ion Collider at BNL
- SeaQuest/E906 experiment (since 2010) at Fermilab
- LHCb experiment (since 2017) at CERN
- Leadership role in planning for a future Electron-Ion Collider

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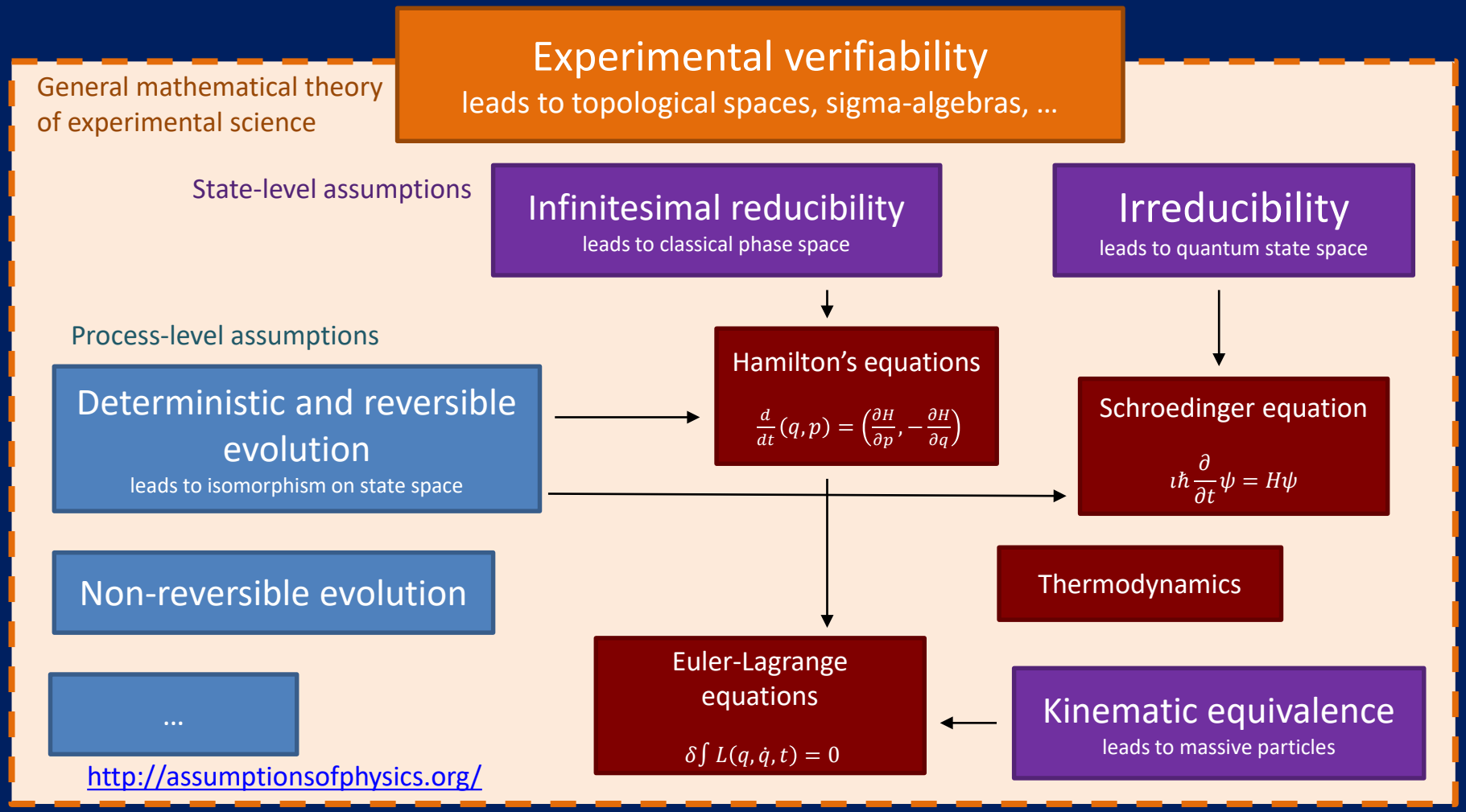
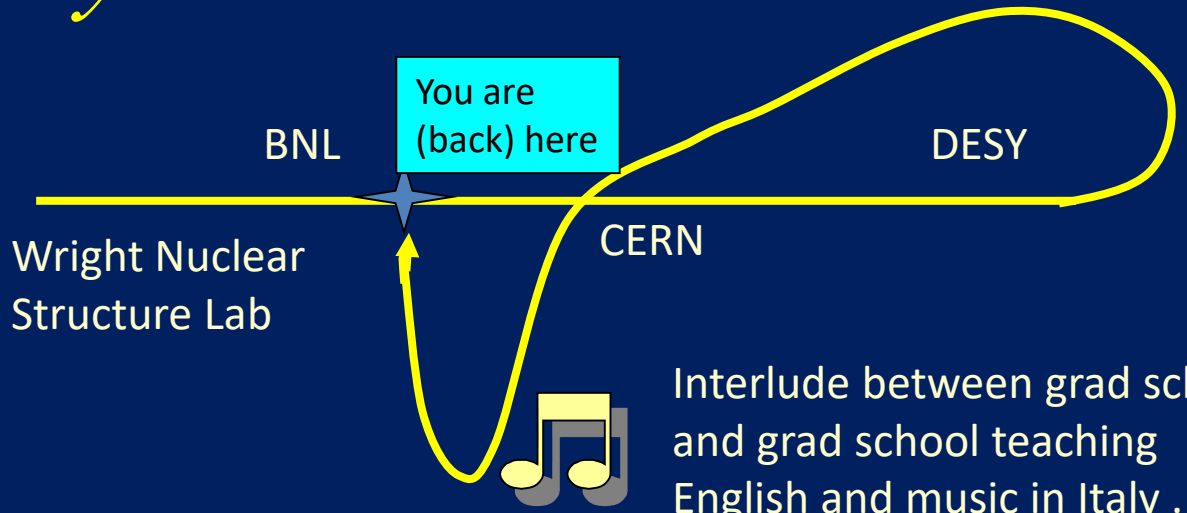
- Large international collaborations, ranging from dozens (SeaQuest) to >800 (LHCb) collaborators, doing experiments at user facilities

Also have a project on the foundations of physics



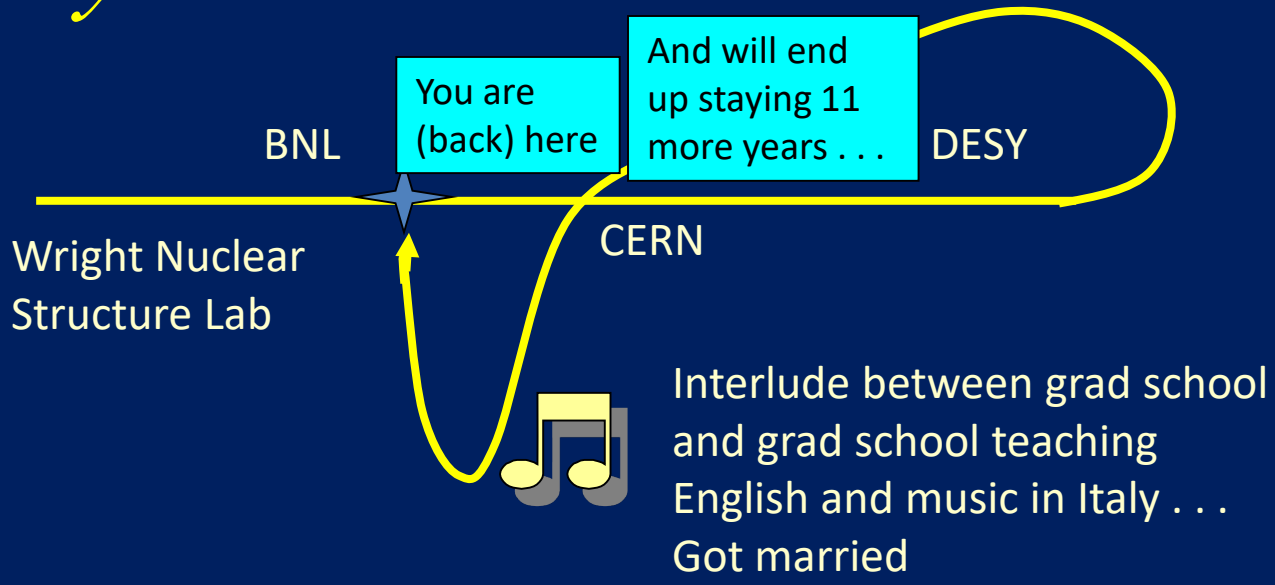
In collaboration with Gabriele Carcassi (my husband!)

My career 1996-2001 . . .



Interlude between grad school and grad school teaching
English and music in Italy . . .
Got married

My career 1996-2012 . . .



- A 12-month temporary contract at BNL generated the initial conditions that set much of my course for the next 11 years
- Sat in same hallway in BNL Physics Dept. for that time, supported in turn by 4 different institutions!
  - Turned down multiple career opportunities to maintain geographical stability

Back to grad school—with a lot of uncertainties but a strong sense that I needed to advocate for myself

- From my 12-month position at Brookhaven National Lab, reapplied to Physics Ph.D. programs to which I could commute from Long Island, and which would allow me to continue research at the Relativistic Heavy Ion Collider
- Landed at Columbia

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- Decided to start a family as a grad student

Defended November 2005, the day before my son turned 1!
Commencement May 2006.

Challenges as a postdoc (2006-08)


2007 APS
Division of
Nuclear Physics
Meeting, JLab
APS
physics

Assistants at the PHENIX experiment at the Relativistic Heavy Ion Collider

Now ages 14 and 11, 9th and 6th grade

December 2018

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But then landed a Frederick Reines Distinguished Postdoctoral Fellowship at Los Alamos National Lab (Jan 2009 – Dec 2011)—negotiated to remain stationed at BNL

Time to find a long-term solution one way or another

- In 2011, declined yet another opportunity for personal reasons, but accepted promotion to a "Scientist 2" staff position with LANL starting in Jan 2012, with the understanding that by the end of the fiscal year I had to find another position or relocate long-term to New Mexico.

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- Everywhere I applied was advertised as either "experimental nuclear" or "experimental particle or nuclear," except the University of Michigan
  - "all fields of physics, experimental and theoretical"
- Michigan was the only place that even interviewed me!

A place at the table

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… Even now, I still find the tables turning on me sometimes!

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- Some of the skills that make individuals strong very early in their careers don't necessarily translate to strength in different roles typical of more advanced career stages

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- There are often a lot more win-win solutions than immediately obvious
  - Take time to understand others' goals
- There's tremendous value in building environments and relationships of respect and trust
- The success of people working under your authority reflects well on you—put them in a position to succeed!

May 2013

August 2017

May 2018

My group February 2018:
Joe Osborn, Catherine Ayuso, Nicole Lewis, Jordan Roth,
Kara Mattioli, Dillon Fitzgerald, Desmond Shangase, Cynthia Nuñez,
Anna Cooleybeck, Yuxi Xie
Not pictured: William Dean, Enrique Gamez, Dylan Manna

Thank you to all of my former and current group members for the meaning they give to me in my job, and for letting their successes reflect back onto me and our whole group …

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Extra

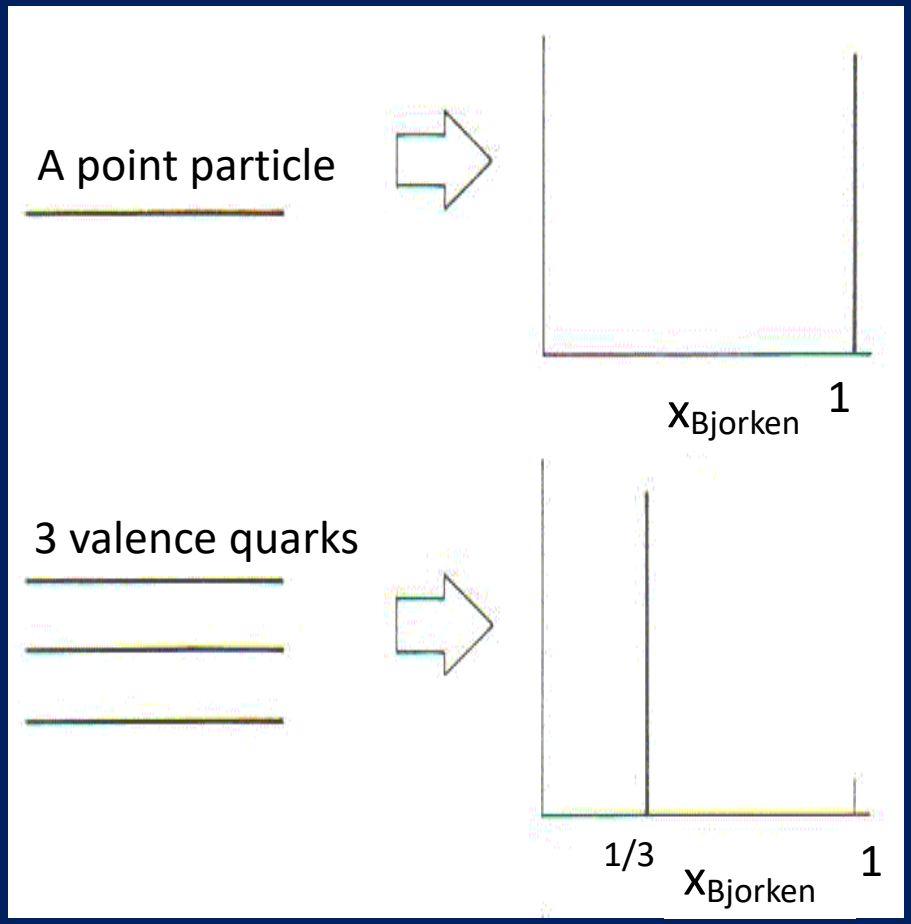
Concluding remarks

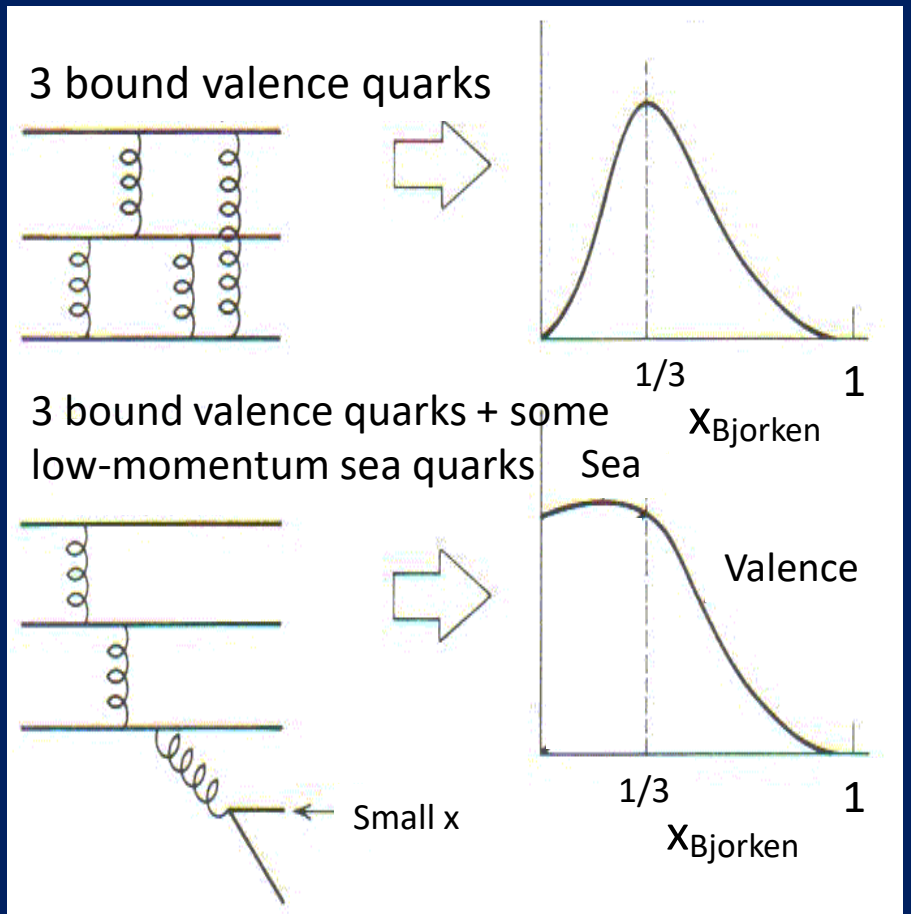
- Actively think about where you'd like your path to take you, but don't be afraid to change directions (or have them changed by external forces) en route
  - You usually have more options than are immediately obvious!

- There are many paths—some more linear than others—to success (= happiness)!

Proton structure and momentum fraction

What momentum fraction would the scattering particle carry if the proton were made of …

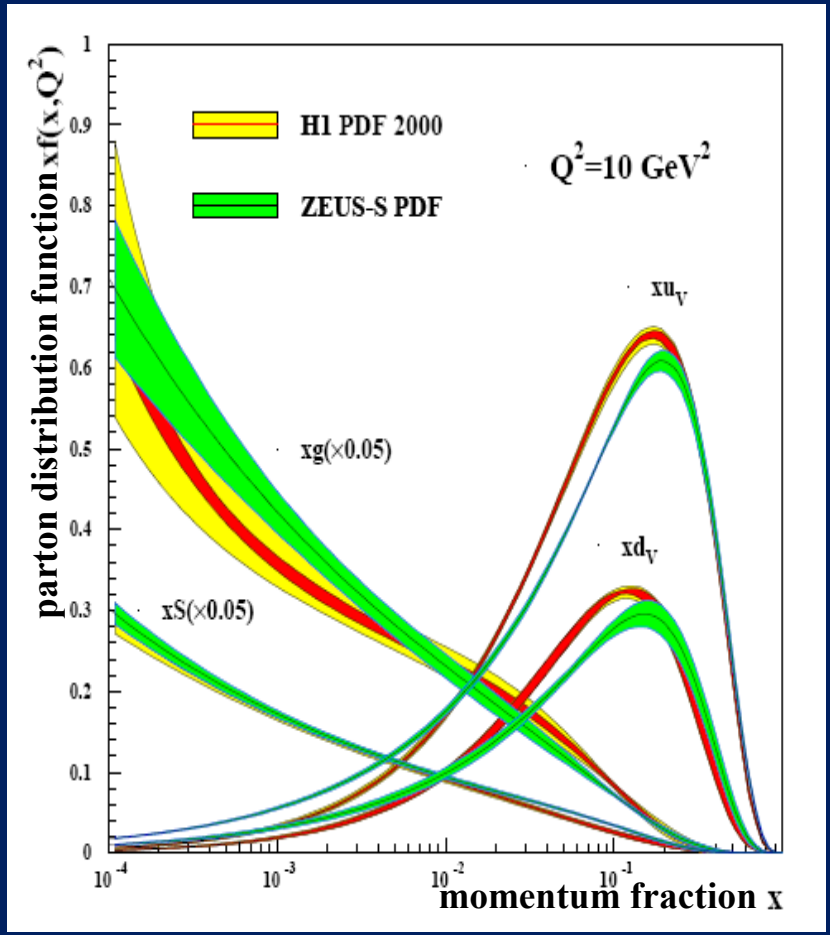




Halzen and Martin, "Quarks and Leptons", p. 201

So what do the parton distribution functions look like?

- Wealth of data largely thanks to proton-electron collider, HERA, in Hamburg, Germany (1992-2007)
- Up and down valence quark distributions peaked at a little less than 1/3
- Lots of sea quark-antiquark pairs and even more gluons (scaled down by 20x in figure!)



PRD67, 012007 (2003)

Mapping out the proton: Other questions to ask!

What does the proton look like in terms of the quarks and gluons inside it?

- *Position*
- *Momentum*
- *Spin*
- *Flavor*
- *Color*

Theoretical and experimental concepts to describe and access position only born in mid-1990s. Pioneering measurements over past decade.

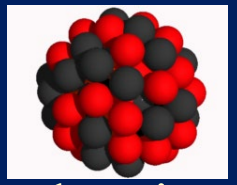
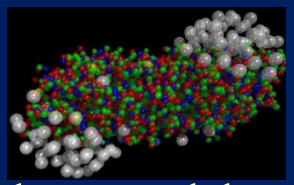
Polarized protons first studied in 1980s. How angular momentum of quarks and gluons add up still not well

Good measurements of flavor distributions in valence region. Flavor structure at lower momentum fractions

Accounted for by theorists from beginning of QCD, but more detailed, potentially observable effects of color have come to forefront since 2010.

The Relativistic Heavy Ion Collider at Brookhaven National Laboratory

- A great place to be to study QCD!
- An accelerator-based program, but not designed to be at the energy (or intensity) frontier. More closely analogous to many areas of condensed matter research—create a system and study its properties!

- What systems are we studying?
  - "Simple" QCD bound states—the proton is the simplest stable bound state in QCD (and conveniently, nature has already created it for us!)
  - Collections of QCD bound states (nuclei, also available out of the box!)
  - QCD deconfined! ("quark-gluon plasma", some assembly required!)

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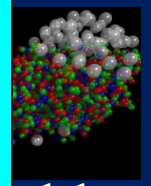

Understand more complex QCD systems within the context of simpler ones

→RHIC was designed from the start as a *single* facility capable of nucleus-nucleus, proton-nucleus, and proton-proton collisions

  - able
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SeaQuest model: Reuse, recycle!

Station 4 tracking plane assembled from old proportional tubes scavenged from Los Alamos National Lab "threat reduction" experiments!