Guided discussion, Provocative statements

BSM at the energy frontier

Roadmap

- Physics opportunities?
- Limitations?
- Experimental challenges?
- Long-term perspective on BSM

The CH perspective

- Opportunities for CH community for the coming years?
  - Consider expertise in CH (e.g. tracking)
- Goals:
  - Opportunities to make strong CH contributions?
  - How to facilitate collaboration
    - Common tools, e.g. simulation

What if?

Citation: Particle Data Group, 2016 update

F (750_{000})

$I(J^P) = ?(0^?)$
J needs confirmation

OMITTED FROM SUMMARY TABLE

Needs confirmation.

F MASS

VALUE (GeV)	EVTS	DOCUMENT ID	TECN	COMMENT
750 ± 30 OUR AVERAGE		ATLAS, CMS		$pp \to F$

• • • We do not use the following data for average, fits, limits, etc. • • •

F WIDTH

VALUE (GeV)	CL%	DOCUMENT ID	TECN	COMMENT
<100	95	ATLAS, CMS		$pp \to F$

• • • We do not use the following data for average, fits, limits, etc. • • •

F DECAY MODES

	Mode	Fraction (Γ_i/Γ)
Γ_1	$\gamma\gamma$	seen
Γ_2	$\gamma Z, ZZ, jj$	expected

What if?

- What else do we expect?

- Do we need a new machine/strategy?
  - HL-LHC → HE-LHC, lepton collider,…?

WHAT IF F(750) IS TRUE?

Consider two scenarios:

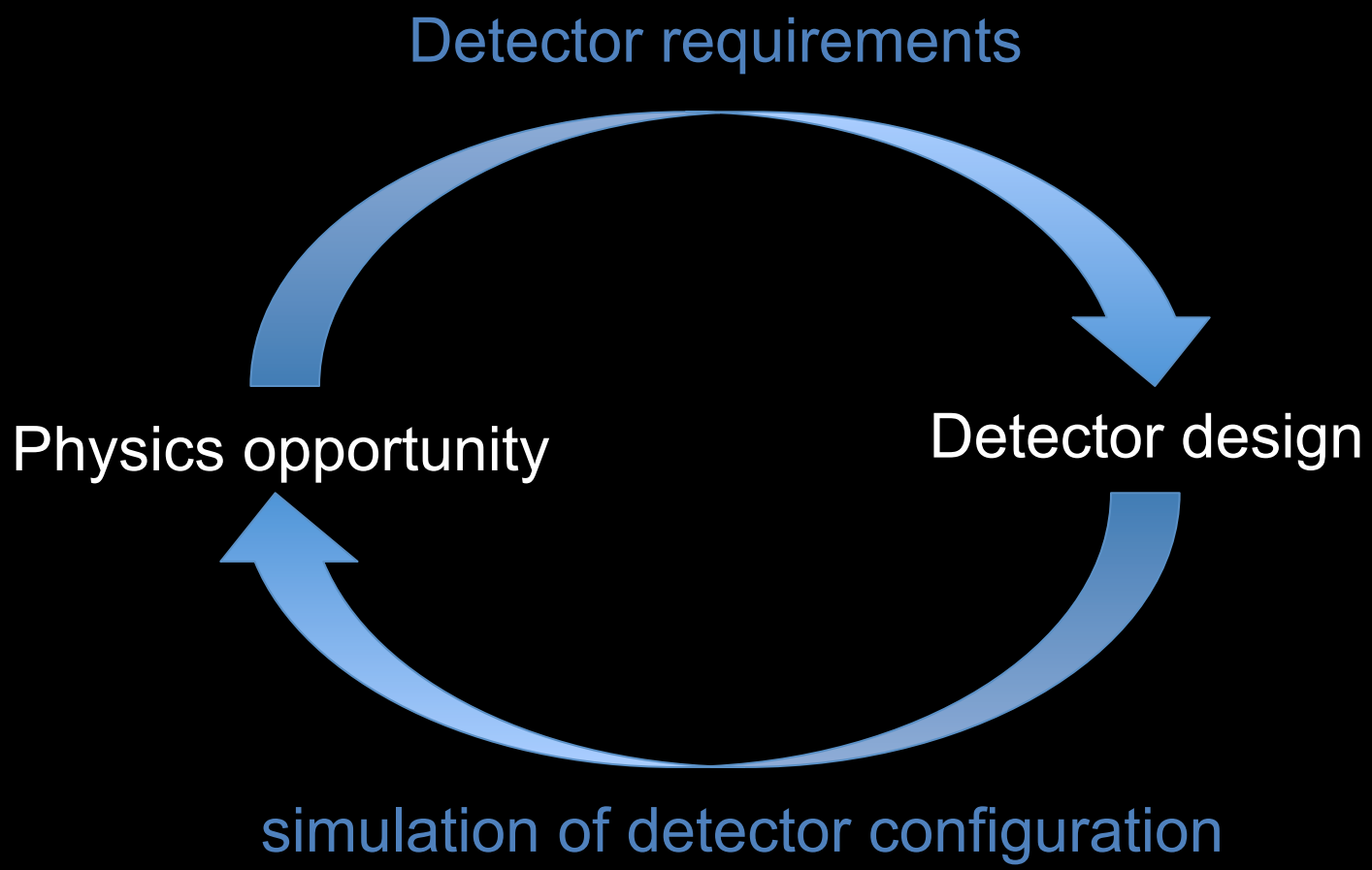
- **LHC Run 2 and HL-LHC do not find new physics**
  - The measurement of the Higgs boson couplings becomes the raison d'être for the HL-LHC
  - After ~1/ab (~2030) still have fairly good detectors, but are facing diminishing return
  - If the high-field magnet technology is ready, stop the HL-LHC and upgrade to run at 33 TeV in ~2035 (less than 20 years from now!)
  - Get ~3/ab @ 25ns with the HL-LHC pileup and ATLAS+CMS Phase II detectors, with the focus on the Higgs boson self-coupling measurement
- **Possibly the only machine we could afford in this scenario**
  - If HE-LHC finds new physics (or CEPC points to a concrete energy scale), go for ~100 TeV machine and reuse the HE-LHC magnets (1/3 of the full number needed for the FCC)
- **LHC Run 2 finds new physics (e.g., X(750))**
  - The scope of the program shifts toward study of its properties
  - Almost all the models predict other partners, which may very well be reachable at 33 TeV
  - Do not want to wait 35 years for the new machine - want to build it as soon as possible
- **Possibly revolutionize the field and break the spell of a flat funding**
  - Consider a 33 TeV machine to be a 30% demonstrator of the FCC at a ~10% cost
  - N.B. cost(33) ~ (cost(100) - CHF 10B)/3 ~ 5B [10B = tunnel + 2 detectors]

From discussion session 33 vs 100 TeV (Landsberg & Incandela), KITP Workshop on Future Colliders, UCSB, last week

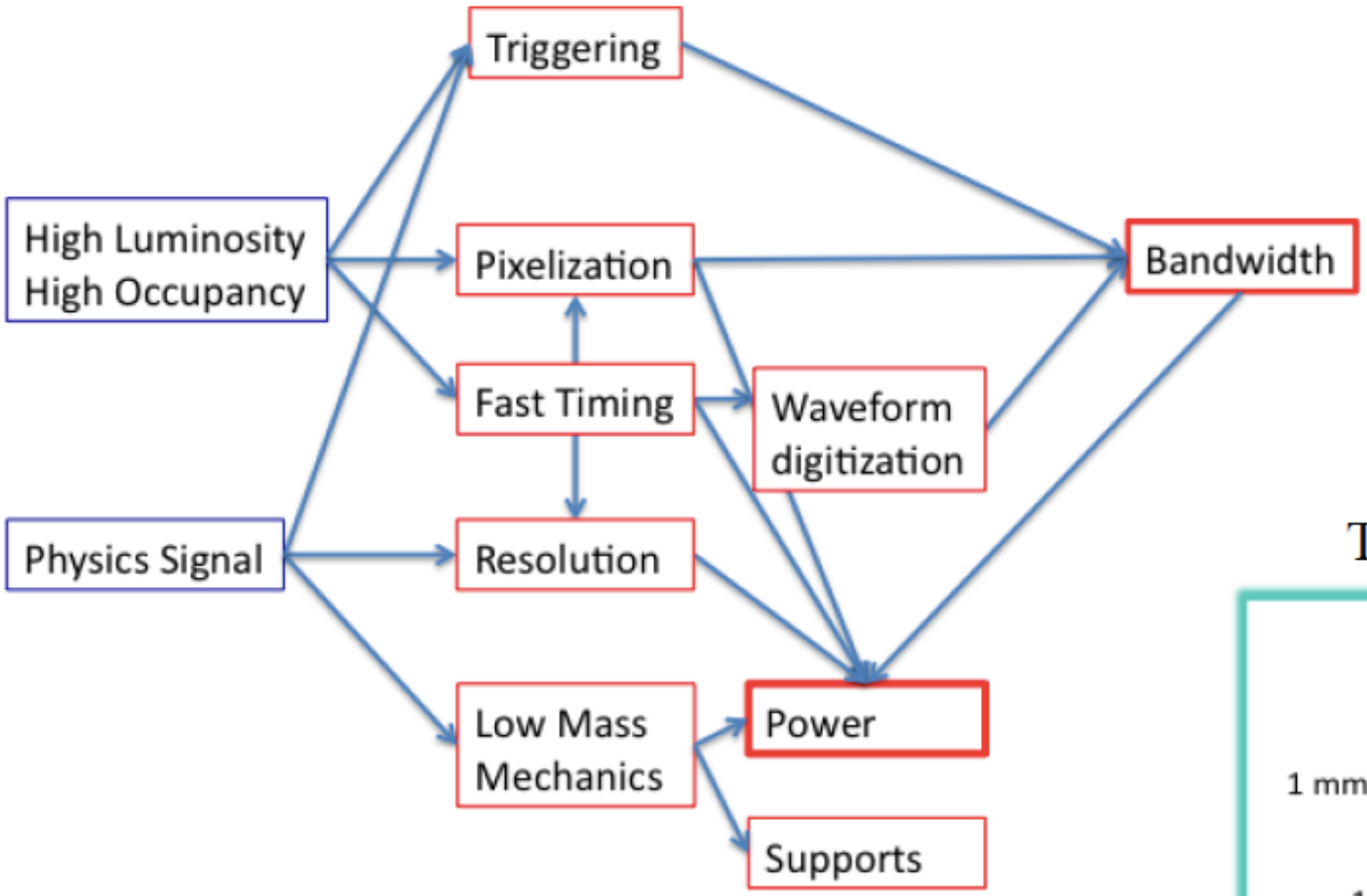
2 energy staging scenario

- Tunnel, then magnets
  - 14 TeV → 50 TeV → 100 TeV
- Magnets, then tunnel
  - 14 TeV → 30 TeV (HE-LHC) → 100 TeV

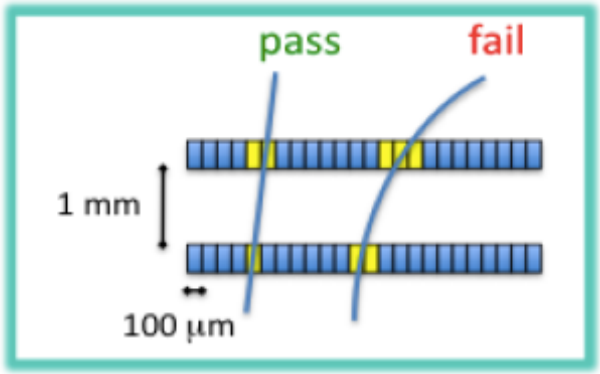
Benchmarking future machines



Whole Picture – The Drivers



Track triggering



R. Lipton

Radiation damage:

$0.01\ ab^{-1}$ (Tevatron) → $0.3\ ab^{-1}$ (LHC) → $3\ ab^{-1}$ (HL-LHC) → $15\ ab^{-1}$

Calorimeter vs. tracker

Space and cost constraints

$\Rightarrow$

Highly specialized calorimeter experiment (at the expense of the tracker) or vice versa?

Muon stand-alone tracking needed?

Precision tracking: hit resolution

$$\frac{\sigma(p_T)}{p_T} = \frac{\sigma(\kappa)}{\kappa} = \frac{\sigma_x \cdot p_T}{0.3BL^2}\sqrt{\frac{720}{(N+4)}}$$

- Boosted
- Pile-up
- B-tagging, long-lived particles
- dE/dx – data rate?
- Forward
- Power?
- All-pixel, 3D,…resolution (central) vs. timing (forward)

Calorimeters

- Larger dynamic range needed
  - ~20 GeV → ~40 TeV ⇒ Deep (12λ)
  - Larger rapidity range ⇒ Forward
  - Resolution
    - Constant term
  - Granularity → Tracking / particle flow?

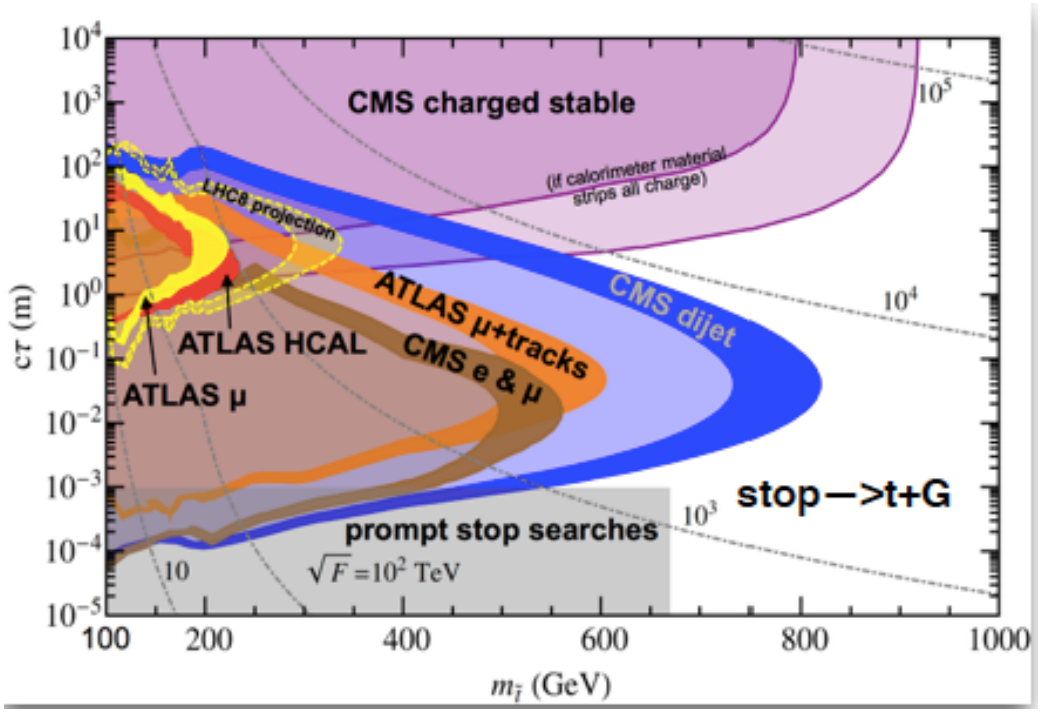
5 ns

$$L = f \frac{n_1 n_2}{4\pi s_x s_y}$$

- Pileup↘: n↘ f↗
  - Faster detectors: 5 ns
  - 30 ps calorimeters
  - Beam power?

Unconventional signatures

- What are we missing?
- Learn from ATLAS/CMS
  - Displaced dijets possible in ATLAS?
  - CMS: better offline track reconstruction than ATLAS
- Figures of merit
  - Maximize cτ coverage
  - Minimize #analyses
  - Common vertex
  - Low p_T (Higgs portal)
  - Trigger on LLP (FTK)
  - Generic vs, specific
  - Jets, leptons,…



Data scouting & parking

- Scouting
  - (event size) x (rate)
  - Large flexibility ⇒ benchmarking
  - Tracking limitations?

- Parking – no brainer (?)