Hopes for LHC jets from a theory perspective

Gavin Salam
LPTHE (Paris)

Physics at TeV Colliders workshop
Les Houches, 18 June 2007

Hopes

Minimal

Hope #1: Reproducibility

Hope #2: Infrared Collinear Safety

A great shame not to have

Hope #3: Flexibility

Reproducibility

Jet Algorithm
Parameters
Recomb. Scheme

http://www.lpthe.jussieu.fr/LesHouches07Wiki/index.php/Jets_nomenclature

If we agree on standard alg(s) or defn(s) then

- Naming of choices should be unambiguous (wasn't for Tevatron Run II).
- If one changes the definition, *say so clearly* (in talks) and *give all details* (in papers).

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Final−state truth−level spec.

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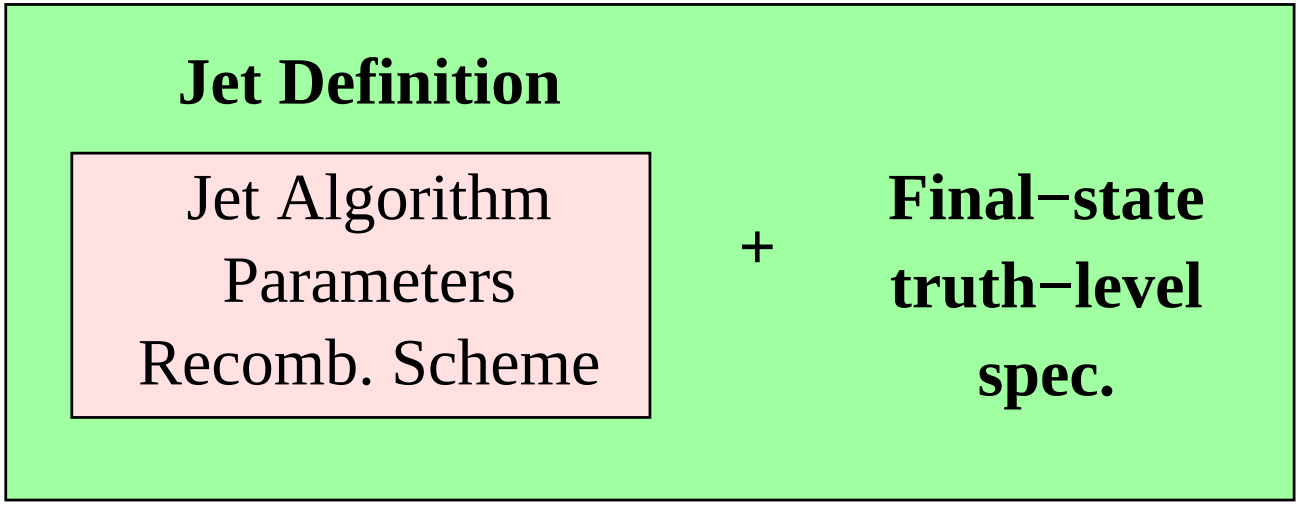
What's needed for communication of results



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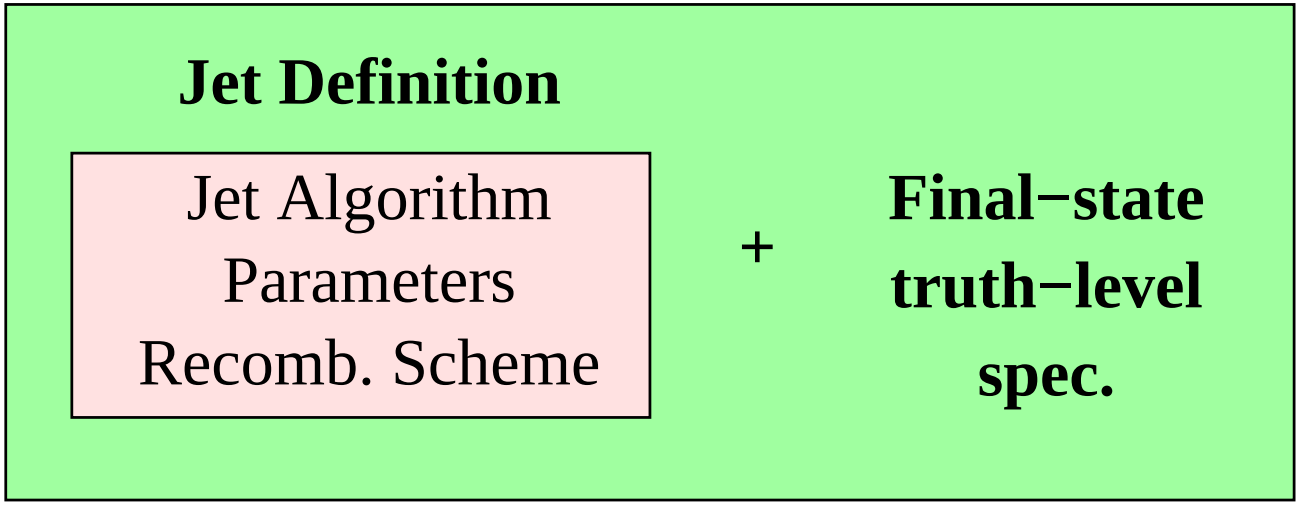

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Infrared and Collinear Safety

Snowmass Accord (1990):

FERMILAB-Conf-90/249-E
[E-741/CDF]

Toward a Standardization of Jet Definitions *

Several important properties that should be met by a jet definition are [3]:

1. Simple to implement in an experimental analysis;
2. Simple to implement in the theoretical calculation;
3. Defined at any order of perturbation theory;
4. Yields finite cross section at any order of perturbation theory;
5. Yields a cross section that is relatively insensitive to hadronization.

Property 4 = Infrared and Collinear (IRC) Safety. It helps ensure:

- Non-perturbative effects are suppressed by powers of Λ_{QCD}/p_t
- Each order of perturbation theory is smaller than previous (at high p_t)

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Infrared and Collinear Safety

Giving up on IRC safety $\equiv$ renouncing optimal use of ~ 10 years' work on NLO from a community of $\sim 30 - 50$ theorists.

~ 20 million euros

See also FAQ at end

Process	*Last meaningful order*	
	Iterative cone	MidPoint
Inclusive jets	LO	NLO [NNLO being worked on]
W/Z + 1 jet	LO	NLO
3 jets	**none**	LO [NLO in `nlojet++`]
W/Z + 2 jets	**none**	LO [NLO in `MCFM`]
1-jet masses in $2j + X$	**none**	**none** [LO in `madgraph` etc.]

Problem:

- Long tradition of use of IRC unsafe jet algs in pp
- Previous recommendations to use IRC safe algs (Snowmass, Tevatron Run II, ...) not always followed

How can we change this?

Hadron-level effects not always obvious

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Flexibility

There is no single best jet definition.

Performance depends on

- number of hard partons in event (more jets $\longrightarrow$ smaller R)
- p_t scale (higher $p_t \longrightarrow$ larger R)
- amount of pileup (more pileup $\longrightarrow$ smaller R)

Different definitions have different systematics

- Large R: more underlying event
- Small R: more "hadronisation"

Neither predicted rigorously

New, better jet-algorithms may be invented in future

Qu: what is tradeoff between flexibility and accuracy of experimental calibration?

Can accuracte calibrations really hold over whole experimental range anyway?

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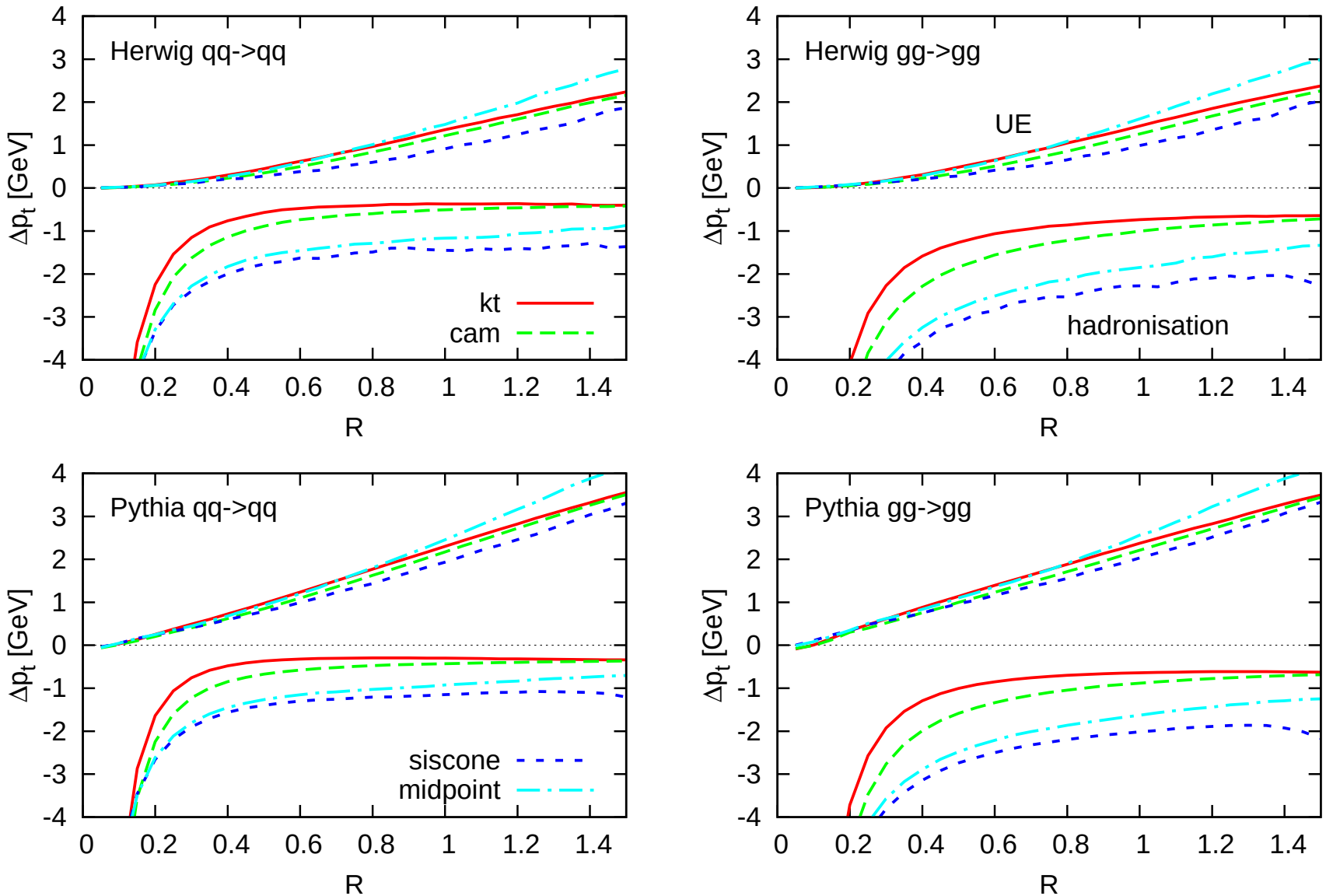
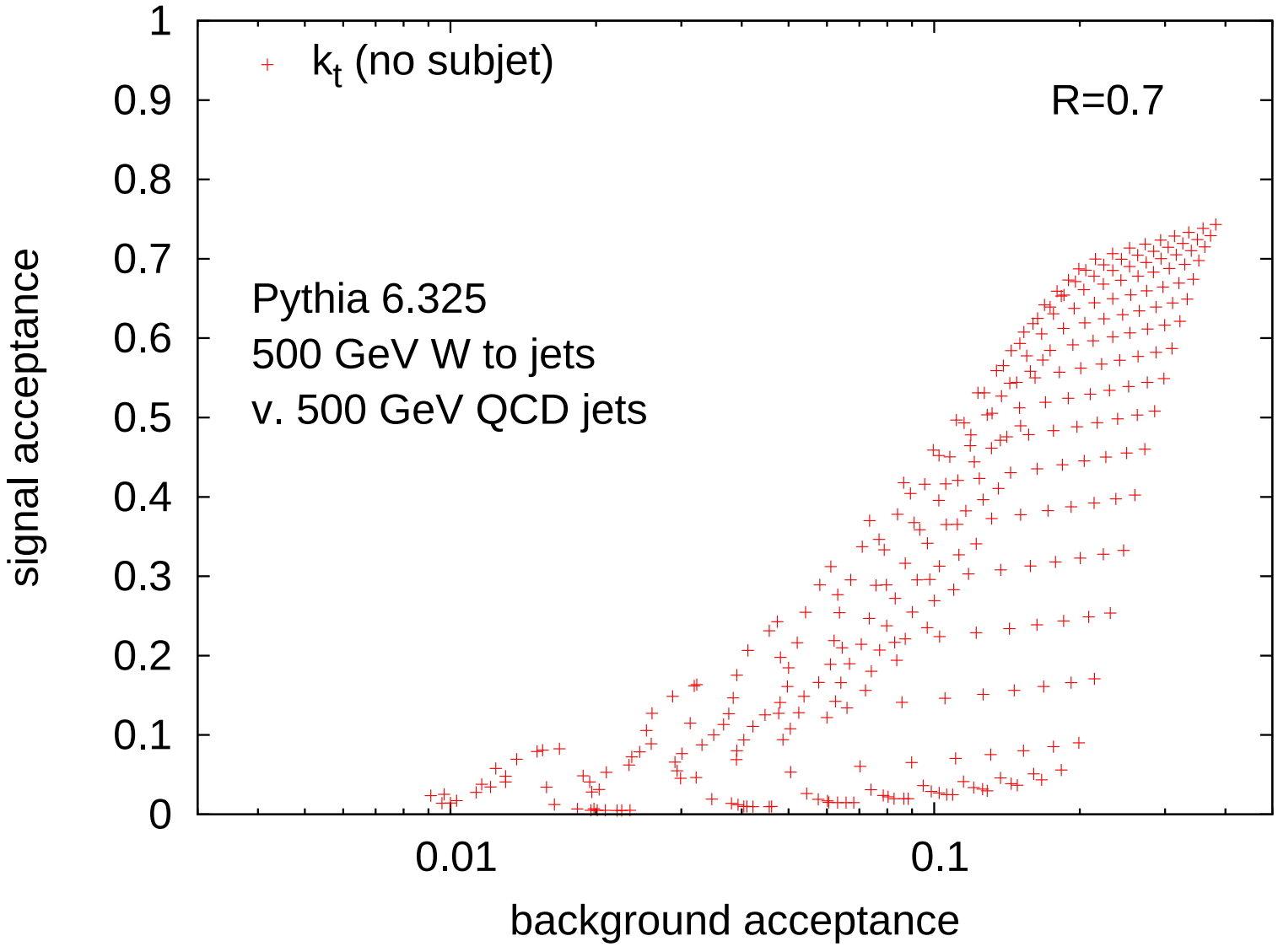
NP effects v. R

Tevatron: $55 < p_t < 70$ GeV (bin 04)



Cacciari, Dasgupta, Magnea & GPS prelim.

Boosted W


k_t (no subjet)
R=0.7
Pythia 6.325
500 GeV W to jets
v. 500 GeV QCD jets
signal acceptance
background acceptance
1
0.9
0.8
0.7
0.6
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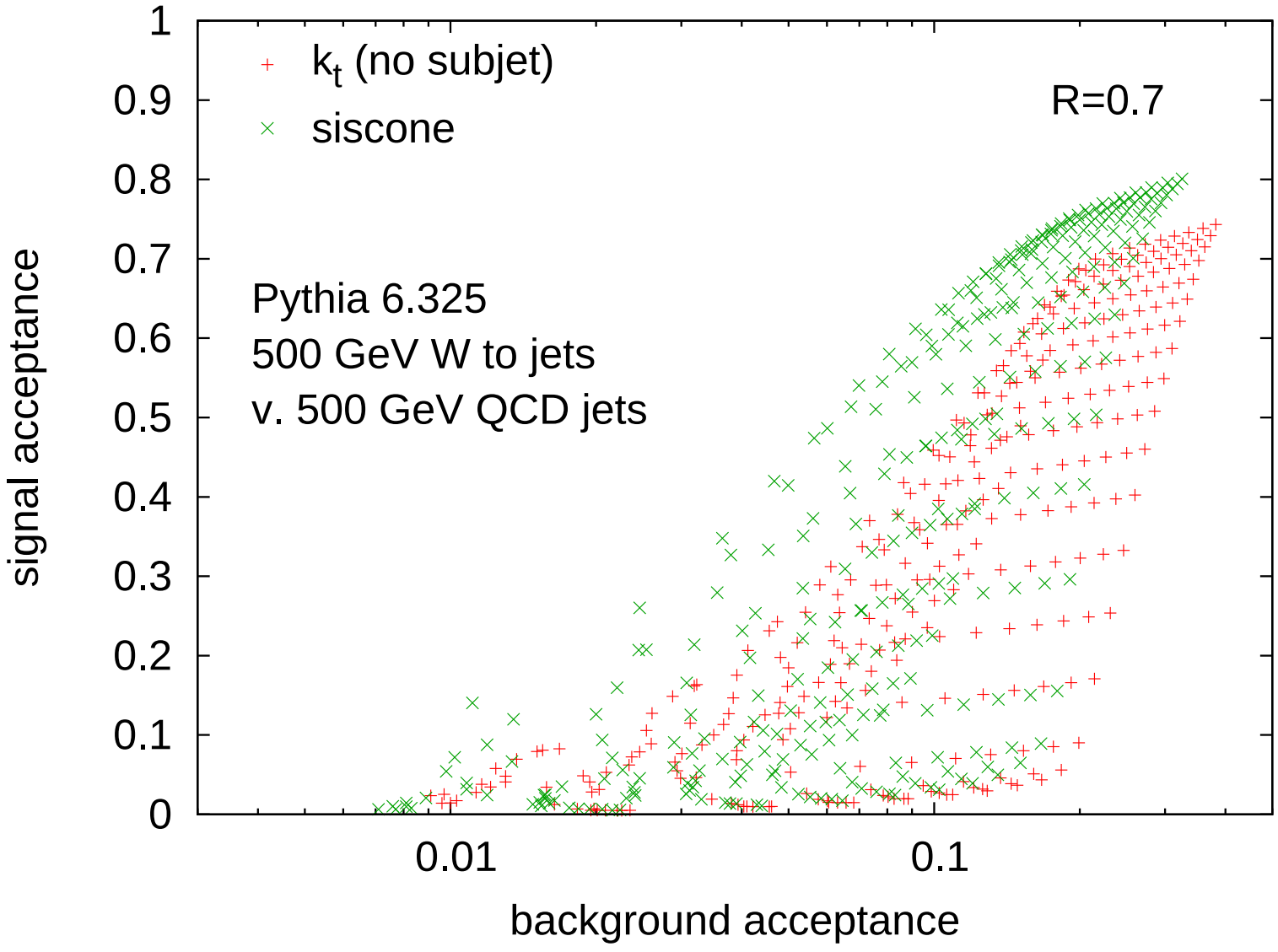
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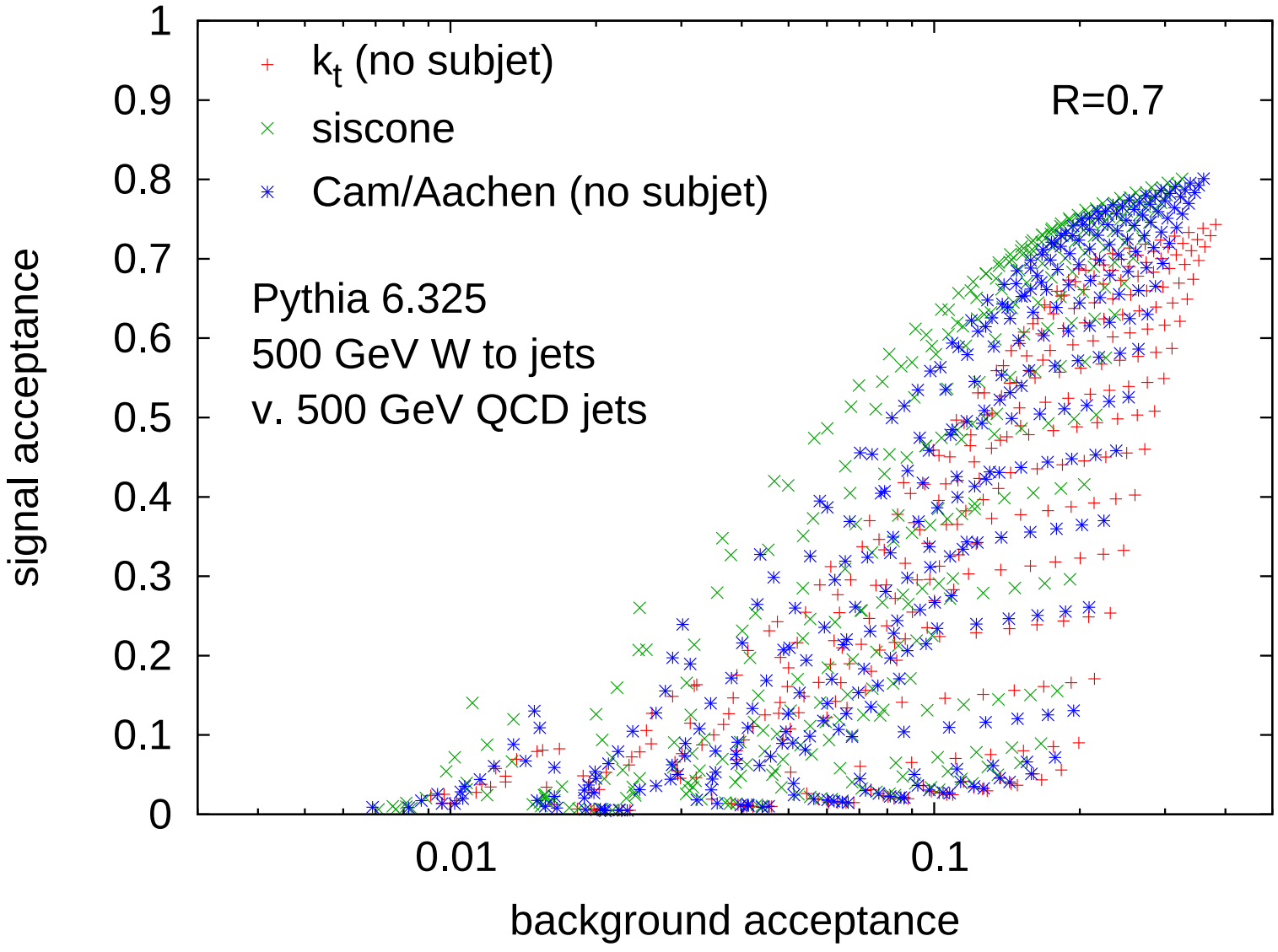
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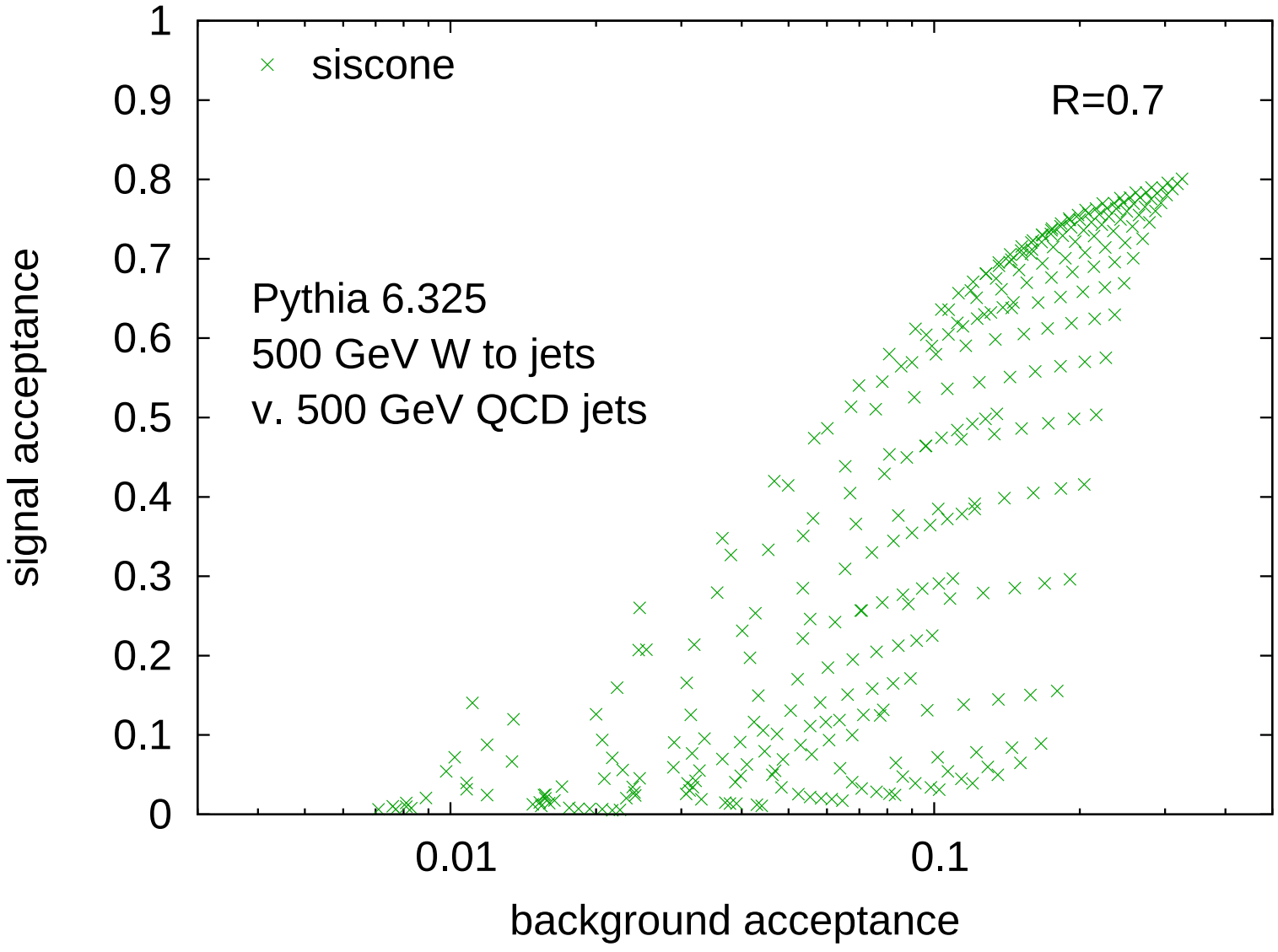
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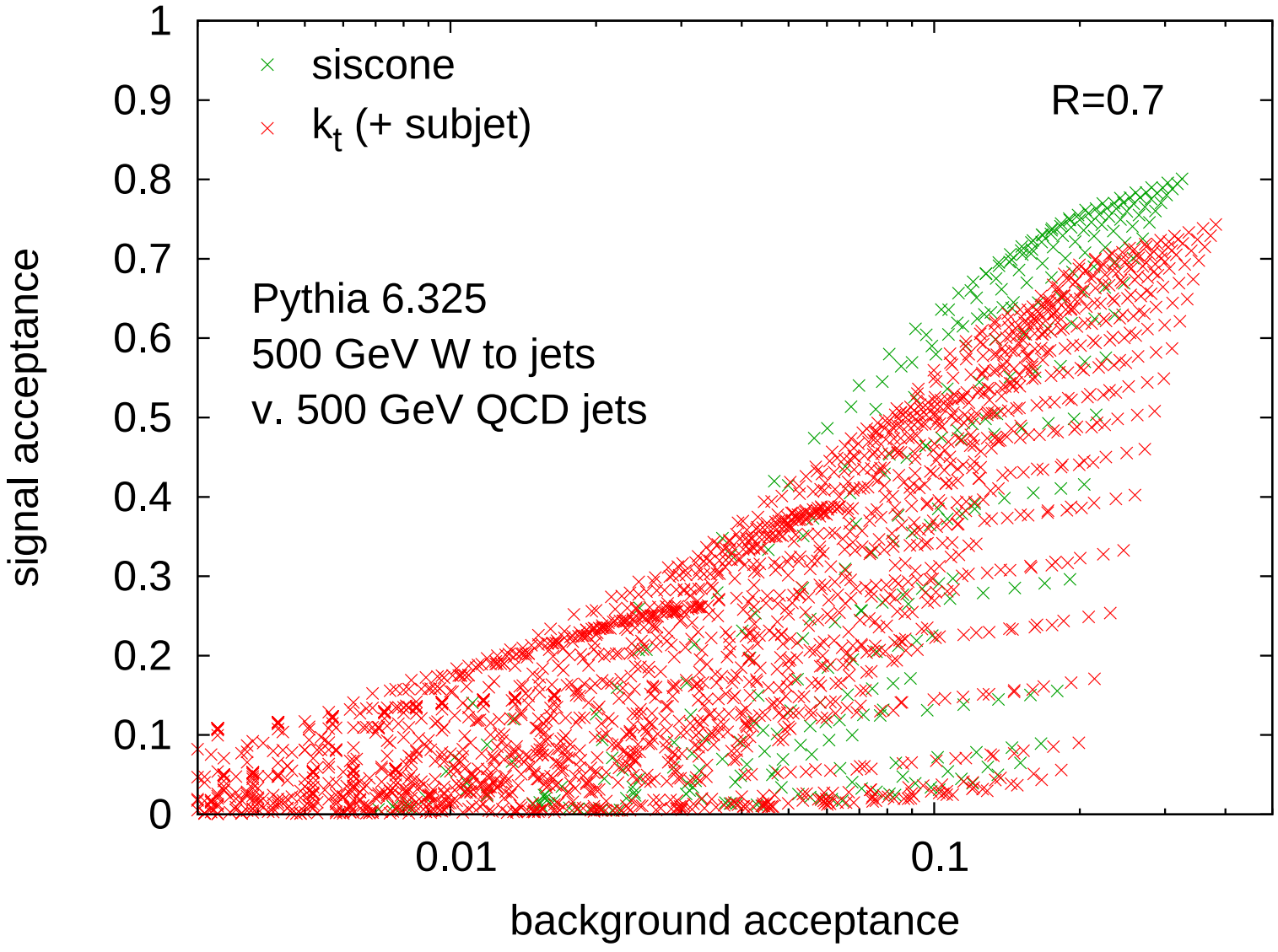
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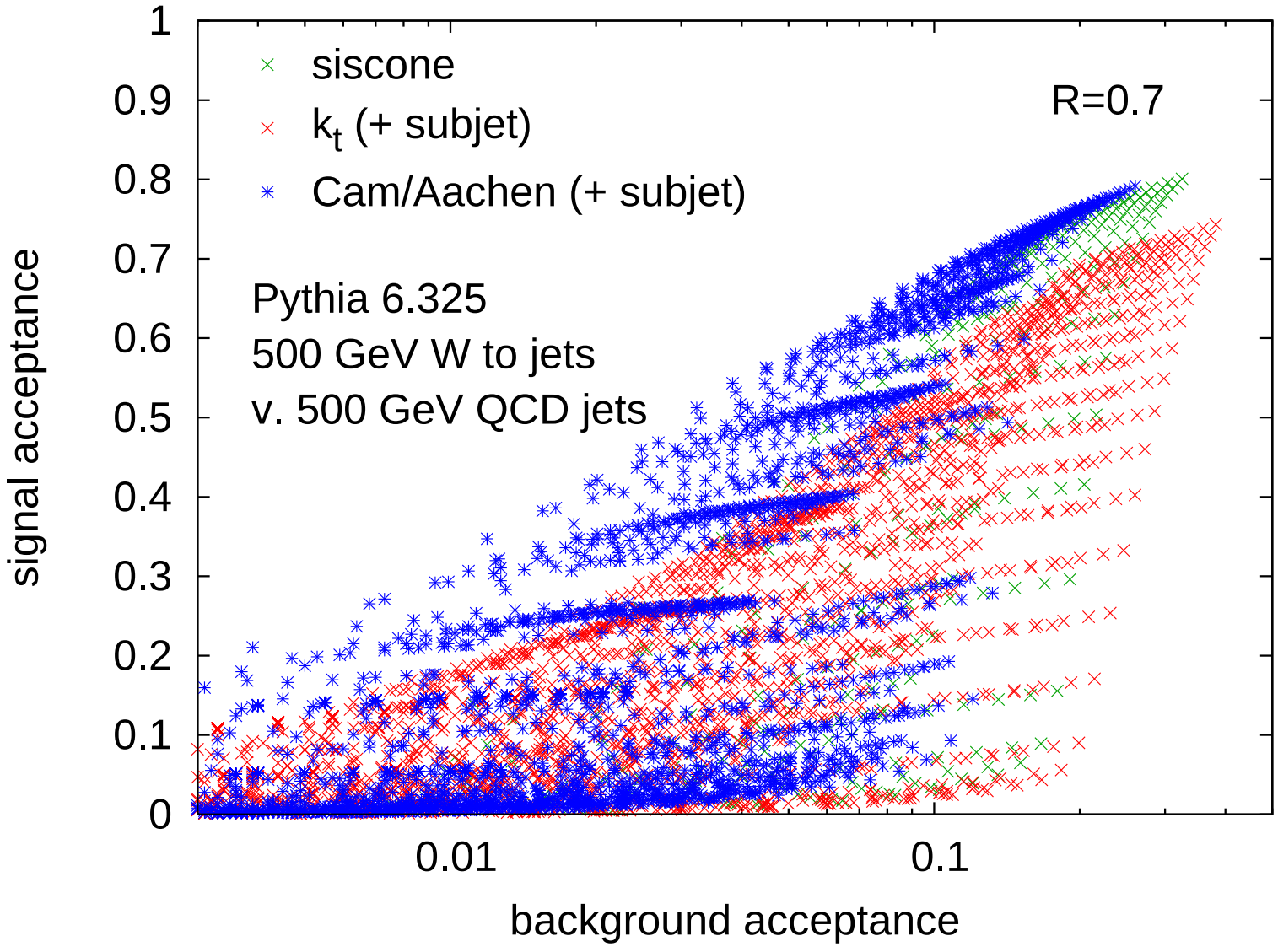
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EXTRA SLIDES

IRC safety FAQ

1. *I tried replacing [JetClu → Midpoint], effect was small, so maybe IR safety doesn't matter?*

   a) Effect can be small in one place (e.g. inclusive jet spectra), but big elsewhere; b) It still breaks partonic calculations (so theorists will use your competitors' results instead of yours)

2. *Now that we have MC@NLO we don't need parton-level theory and all its infinities*

   MC@NLO is a powerful tool, but still misses many processes (and will do for a while): $2j$, $3j$, $V+j$, $H+j$, $V+2j$, $H+2j$, $Q\bar{Q}+j$, NLO t-decay in single top, NLO t-decay in $t\bar{t}$, many SUSY ones...

3. *I'm searching for XYZ & only ever use data and Pythia — there, at hadron level, [JetClu]'s answer is well defined*

   It's well defined but not robust: a 1 GeV particle can change your 200 GeV jets. a) Do you really want your analysis to be that random and b) do you really trust Pythia's modeling of 1 GeV particles?

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