

# The Hallucinogenic Belfry:

---

analyzing the first forty measures of  
Keith Hamel's Touch for piano and  
interactive electronics (2012)

Jeffrey E Boyd – Martin Ritter – Friedemann Sallis

# Broad goal

---

- establish a practice of computational musicology for contemporary live electronic music
  - where analysis of a piece is based in large part on recordings of performances

# Why?

---

- Scores do not provide a complete picture
  - not traditional
  - have electronic components that are difficult to penetrate
  - varies with performances
  - may not be possible to reproduce without composer and/or specific performers
    - raises archival issues
  - the scientific readings tell us something about the goals of the composer/performer

# Process

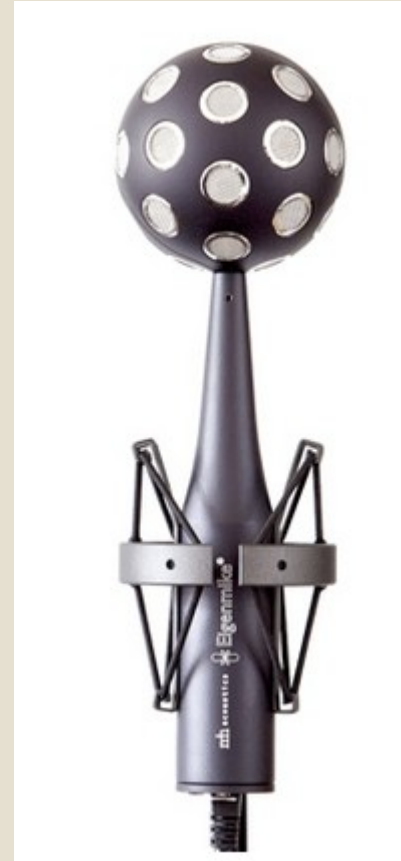
---

- Record instances of subject composition
- Through a variety of computational techniques
  - decompose the performance into musically relevant entities
  - interpret those entities

# Recording

---

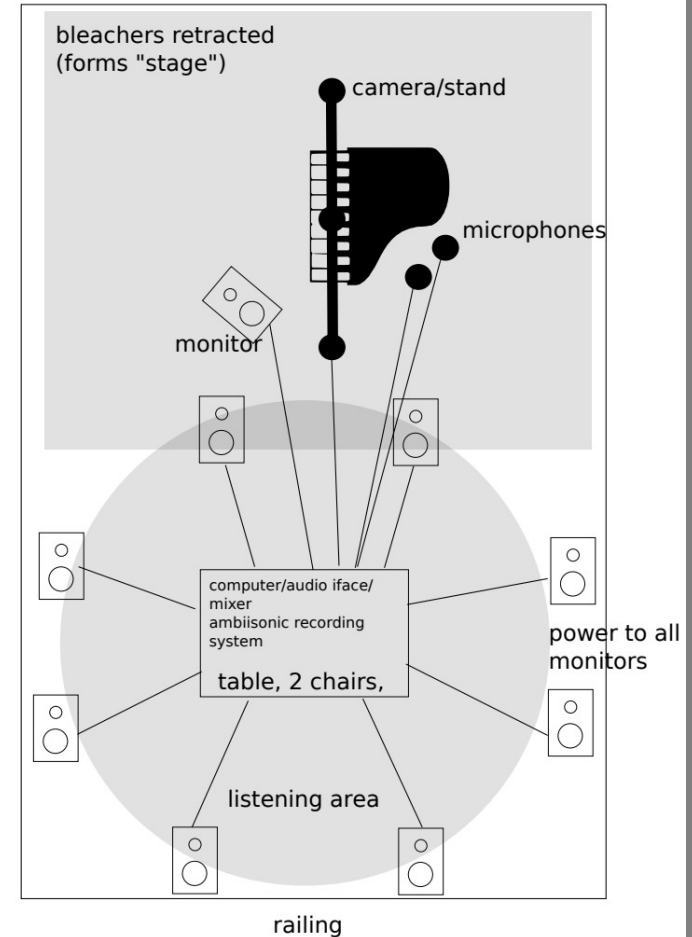
- Use mh Accoustics Eigenmike
- 32 microphone element
- 4<sup>th</sup> order ambisonics



Department of  
Computer Science

# Subject matter

- Keith Hamel's Touch for piano and interactive electronics (2012)
  - spectralism
  - juxtaposes
    - piano
    - recordings of bells
    - electronically altered variations of both
  - 8-speaker planar surround



# Spectralism

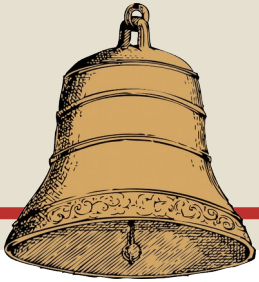
---

“Nous sommes des musiciens et notre modèle est le son et non la littérature, le son et non les mathématiques, le son et non le théâtre, les arts plastiques, la physique des quanta, la géologie, l’astrologie, ou l’acupuncture.”

- Gérard Grisey, (1979), full citation at end

“We are musicians, our model is sound and not literature, sound and not mathematics, sound and not theatre, the plastic arts, quantum physics, geology, astrology or acupuncture.”

- translation by Sallis (2018) full citation at end



# Touch scaffolding

1

C - chord 1 (T Bell-C60)



UNIVERSITY OF  
CALGARY

ent of  
r Science



# Touch scaffolding (cont'd)

---

- 8 bells total provide scaffolding
- 2 bells used in 1<sup>st</sup> 40 measures
  - T Bell-C60
  - tBellResAb
- 214 bell samples in electronic source
  - cBell
  - tBell
  - brassBellDry
  - glock
  - tBellRes
  - grain

# Start with the bells

---

- Want to find musical objects within the performance
- The bells are an obvious option
- Require access to source samples
- early
  - looked for specific bells in specific passages
- end point
  - built catalog of all occurrences
    - all bells
    - all times
    - all performances (2 + 2)

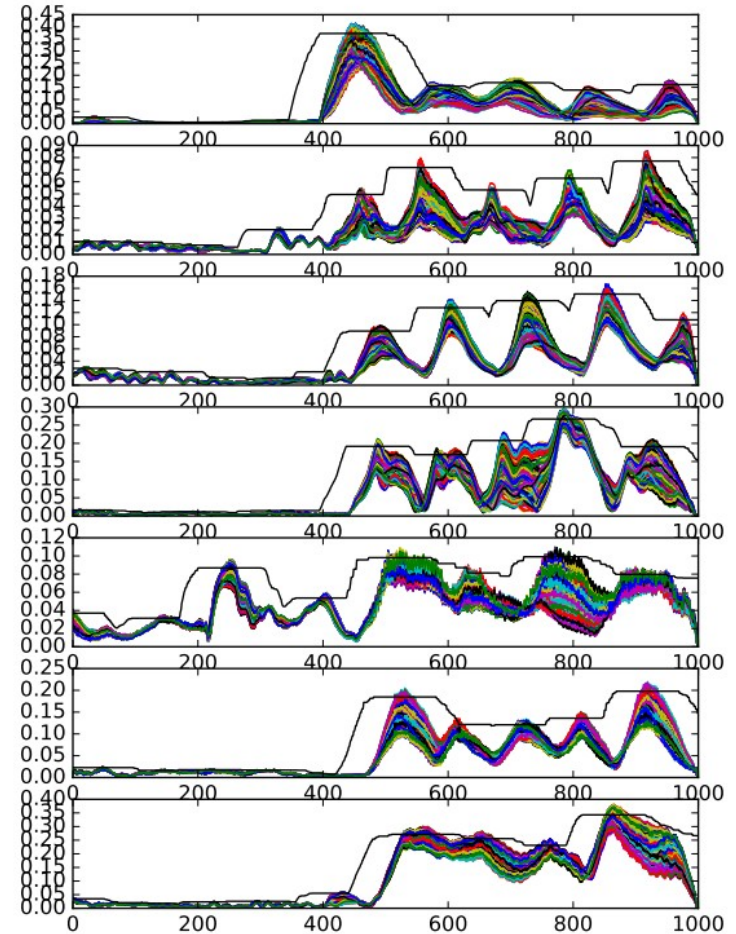
# Find bells

---

- From ambisonic recording
  - compute audio for 100 *virtual* microphones around sphere
- Compute quality of match between each bell and each virtual mic signal
  - use first 0.5s of bell
  - RMS strength of normalized correlation over 10ms
- Detect peaks in the match
  - local maxima that exceed minimum match threshold
- Save bell detections (peaks) in csv file
- for 4 recordings it took approximately 1 month of computation on a reasonably fast laptop

# Matching

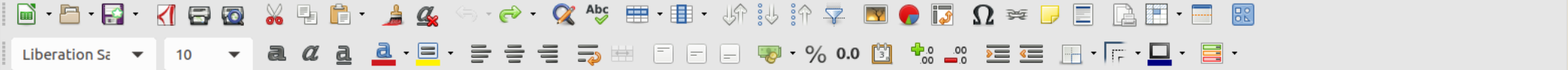
- Process in 5s chunks
  - keeps within limits of computer's main memory
  - proper attention to boundaries



# csv file

touch-all-bells-single.csv - LibreOffice Calc

File Edit View Insert Format Styles Sheet Data Tools Window Help



A1 recording

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	
1	recording	venue	time	ntime	bell_id	bell_no	peak_value	x0	y0	z0	mean_resultant_length	spherical_variation	sample_variation	az0	e0	start_time	end_time	
2	mic_121617_103906_egh	1148	0.030803696	363	363	0.18322262720823	-0.68453112969649	-0.572606621480026	-0.451152734130784	0.923484044533217	0.147177219492571	-140.087698824699	-26.8176662575786	1146	1150			
3	mic_121617_103906_egh	1150	0.0308248	356	356	0.17010491018559	-0.63223826164467	-0.592402394369829	-0.499333739754709	0.87953963789504	0.204092072420992	0.193678678914718	-136.86309555152	-29.9559303577541	1148	1152		
4	mic_121617_103906_egh	1270	0.03209104	12	12	0.188157828091101	-0.46483167125783	0.833407466042458	-0.298937306036471	0.982034827776154	0.035930344447692	0.035607597034659	119.150522702814	-17.3937864469744	1267	1273		
5	mic_121617_103906_egh	1331	0.032734712	12	12	0.15615967120985	-0.15545005372932	0.942898782246028	-0.294579644976548	0.068468956674807	-0.861673572194063	0.976263433567035	0.04747313286593	0.046909708279904	172.245772022319	-59.5050139953987	1364	1369
6	mic_121617_103906_egh	1337	0.032798024	367	367	0.17819400142497	-0.56577651078019	-0.077651626782287	-0.820894125151022	0.941437925805811	0.117124148388379	0.113694631854453	-172.1851013307722	-55.1743995227427	1334	1340		
7	mic_121617_103906_egh	1364	0.033082928	55	55	0.15068869581443	-0.50282268937886	0.068468956674807	-0.843304884478786	0.902205118217869	0.195589763564263	0.186025924661482	174.788055160393	-57.4907705641914	1701	1729		
8	mic_121617_103906_egh	1708	0.036712816	367	367	0.20579619987834	-0.74635738856872	0.070566561442646	-0.661797841259159	0.919401856836098	0.161196286327805	0.154700225646336	174.598831560138	-41.4371309392573	1705	1711		
9	mic_121617_103906_egh	1723	0.036871096	355	355	0.15715389413693	-0.53520727864855	0.048088042478426	-0.001149943356994	0.945097077139115	0.109805845721777	0.106791514783101	-40.1370664178174	-0.065886915555598	1758	1761		
10	mic_121617_103906_egh	1737	0.037018824	55	55	0.17558524304244	0.004070034207164	0.058930580455996	-0.998253786122884	0.885304456668893	0.229391086662213	0.216236019002195	86.0491469766349	-86.613511807728	1735	1740		
11	mic_121617_103906_egh	1759	0.037250968	177	177	0.15302061431737	0.764504031836075	-0.644617920117539	-0.001149943356994	0.945097077139115	0.109805845721777	0.106791514783101	-40.1370664178174	-0.065886915555598	1758	1761		
12	mic_121617_103906_egh	1882	0.034886864	12	12	0.16449406948956	0.867603586238432	-0.24219276519586	0.434288707696845	0.880292081462433	0.239415837075134	0.225085851314537	-15.5971506864313	25.7400418794827	1871	1888		
13	mic_121617_103906_egh	2282	0.027476964	356	356	0.15052457374781	-0.65688517952781	-0.648232848492429	-0.38509224226426	0.804476153460832	0.391047693078336	0.352818118512863	-130.58226609798	12.2601156338647	2486	2496		
14	mic_121617_103906_egh	2491	0.044975032	12	12	0.27841999804142	-0.63570274367868	-0.742151880817052	-0.21235020009201	0.804476153460832	0.391047693078336	0.352818118512863	-130.58226609798	12.2601156338647	2486	2496		
15	mic_121617_103906_egh	2620	0.04633624	370	370	0.15615707950175	-0.81684731785025	0.295088384934223	0.495664507906077	0.852602526597637	0.294794946804727	0.273068931639326	160.13760401997	29.7135782897256	2617	2624		
16	mic_121617_103906_egh	2676	0.04927152	177	177	0.16039932409668	0.92295264916467	-0.330532520600474	-0.197216838421281	0.930557969485643	0.138884061029073	0.134061865427091	19.7035911496414	-11.3742543071447	2667	2685		
17	mic_121617_103906_egh	3079	0.051179608	12	12	0.15664032845931	-0.71784840641468	-0.653365196766092	-0.24032079936749	0.921445676267701	0.157108647464598	0.150937865687559	-137.692429420622	-13.912043464608	3073	3084		
18	mic_121617_103906_egh	3108	0.051485616	8	8	0.16374299912341	-0.65580912804674	0.502500083520442	-0.563389788363726	0.8161220609500663	0.367755878099874	0.333944781630622	142.539611085473	-34.2905498937467	3105	3113		
19	mic_121617_103906_egh	3159	0.052023768	360	360	0.15718006765675	-0.85043534085967	0.396769430527416	-0.345447173987349	0.586499579649324	0.827000840701352	0.666018243077166	154.988661033961	20.2090953126074	3157	3161		
20	mic_121617_103906_egh	3173	0.052171496	367	367	0.18376437968973	-0.69840965134293	-0.103334427879553	-0.708199092717474	0.966348615285947	0.0673022769428106	0.066170353734963	-171.583761606801	-45.0885768337003	3169	3177		
21	mic_121617_103906_egh	3187	0.052319224	355	355	0.15069812820856	-0.52927131453349	-0.144287292278047	-0.83609392588337	1	0	0	-164.750869593535	-56.7299176389449	3186	3190		
22	mic_121617_103906_egh	3200	0.0524564	55	55	0.17193220020239	-0.42264006083247	-0.212728947618064	-0.87992830098976	0.907043296489602	0.185913407020796	0.177272458293276	-152.819150132707	-61.6337156258449	3196	3204		
23	mic_121617_103906_egh	3319	0.053712088	12	12	0.20564106505133	-0.00794348841043	-0.910713728433045	0.412961748634732	0.895347828902474	0.209304342195052	0.198352265279626	-90.49973642112	24.3910235135484	3315	3323		
24	mic_121617_103906_egh	3378	0.054334656	12	12	0.198565596211765	0.335594639330804	-0.790827569272209	0.511828090017964	0.849250852533002	0.30148294933997	0.27877298947197	-67.0056325716791	30.7856747959925	3374	3386		
25	mic_121617_103906_egh	4092	0.061868784	12	12	0.23565646093565	-0.54554150226844	-0.837557266852074	-0.029703434918817	0.892195001069158	0.215609997861684	0.203988080067206	-123.078141253694	-1.70213181728278	4086	4099		
26	mic_121617_103906_egh	4184	0.062839568	8	8	0.1792099535605	0.18268117129015	0.981666155015329	0.054398067552797	0.835707017479649	0.328585965040703	0.30159378093527	79.4582432439866	3.11831890461652	4179	4196		
27	mic_121617_103906_egh	4261	0.063652072	12	12	0.18998428499452	-0.859992425353	0.460196168499166	0.220527809661624	0.738705755689916	0.452611537146814	0.151848027816596	12.7400356768686	4254	4269			
28	mic_121617_103906_egh	4394	0.065055488	12	12	0.168593131431211	-0.01373419744221	-0.996602768013995	-0.081205262190706	0.889017171859961	0.221965656280078	0.209648468138117	-90.7895440024592	-4.65784759818177	4367	4399		
29	mic_121617_103906_egh	4604	0.067271408	12	12	0.281137298535707	-0.31403827869642	-0.928333525663658	-0.198939248621974	0.92737280576185	0.1452543884763	0.139979679133394	-108.689739341983	-11.4749360389461	4599	4611		
30	mic_121617_103906_egh	4673	0.067999496	12	12	0.23837911191311	0.301690329543005	0.939031963996512	0.16493003259729	0.586624766874799	0.862750646250240	0.676665874496581	72.1889296720979	9.49316994530683	4668	4678		
31	mic_121617_103906_egh	4743	0.068738136	370	370	0.18371922166181	-0.89103262389875	-0.1378069898124802	0.432744790539067	0.920212422242445	0.153975155531509	0.148608068401271	-171.283520140741	25.6318953762102	4740	4746		
32	mic_121617_103906_egh	4765	0.06897028	367	367	0.22407721433455	-0.43020672290595	0.000276946173479	-0.902730357785393	0.96521948992203	0.069576102015594	0.06836589352673	179.963115767709	-64.5193143314697	4759	4771		
33	mic_121617_103906_egh	4770	0.06903204	1	1	0.158822020436	0.511109164135122	-0.85691811648623	0.066854838225603	0.945153017290806	0.116973965149828	0.113552328273318	-59.1858336679198	3.83335927247584	4768	4773		
34	mic_121617_103906_egh	4779	0.069118008	67	67	0.17449942764556	-0.39047589180198	-0.530948584665189	-0.752078571934794	0.926601640578193	0.146796718843613	0.141409399677801	-126.331905182407	-48.7707524203516	4771	4788		
35	mic_121617_103906_egh	4779	0.069118008	355	355	0.17141209915567	-0.43389830624951	-0.105115875994509	-0.894808869272731	0.950471994940419	0.099056010119162	0.09660298683398	-166.381934396323	-63.483890201871	4774	4784		
36	mic_121617_103906_egh	4790	0.06923408	55	55	0.200661570224119	-0.37117306199672	-0.177992040837504	-0.911344825763818	0.960860119662909	0.067279760674182	0.07647483044138	154.380455052945	-65.691863074527	4777	4794		

# Basic statistics

---

- 11,973 bell events over 4 recordings
- approximately 3000 bell events per recording
- 187 bells
  - 214 bell samples less 27 duplicates

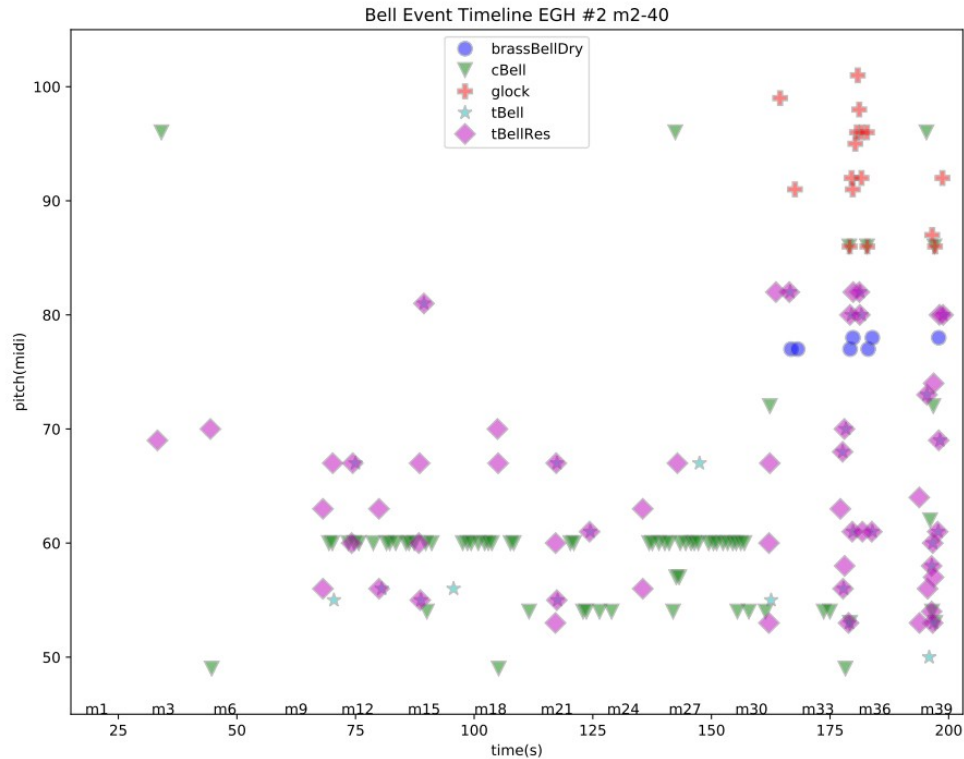
# The surprise

---

- many more bell events detected than we know are produced by the electronics
  - by a factor of 10 or more

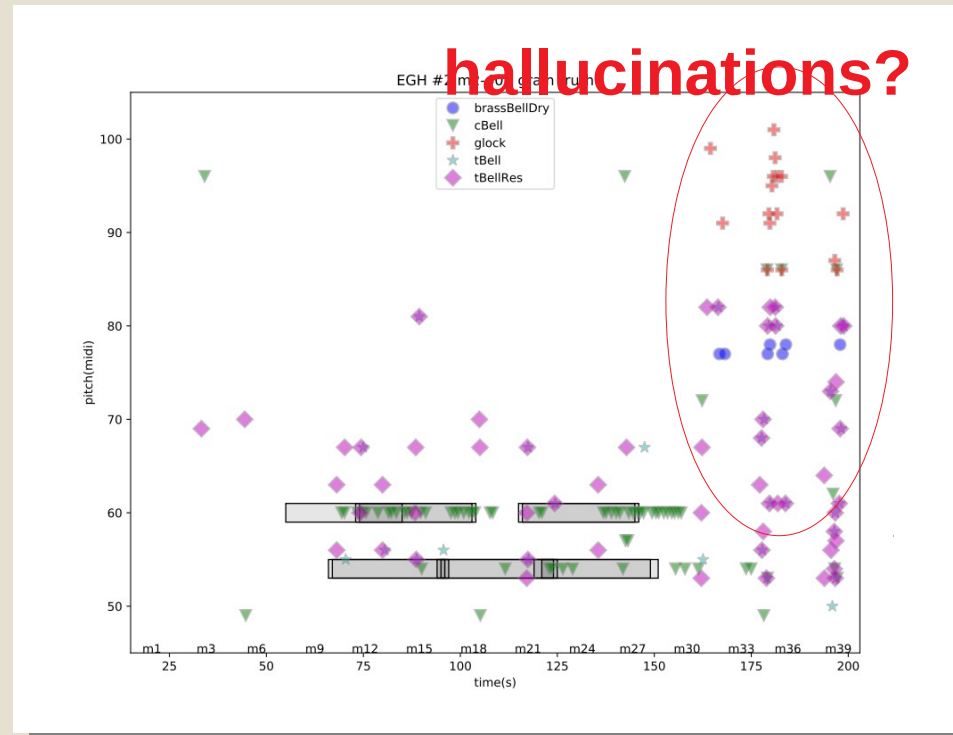
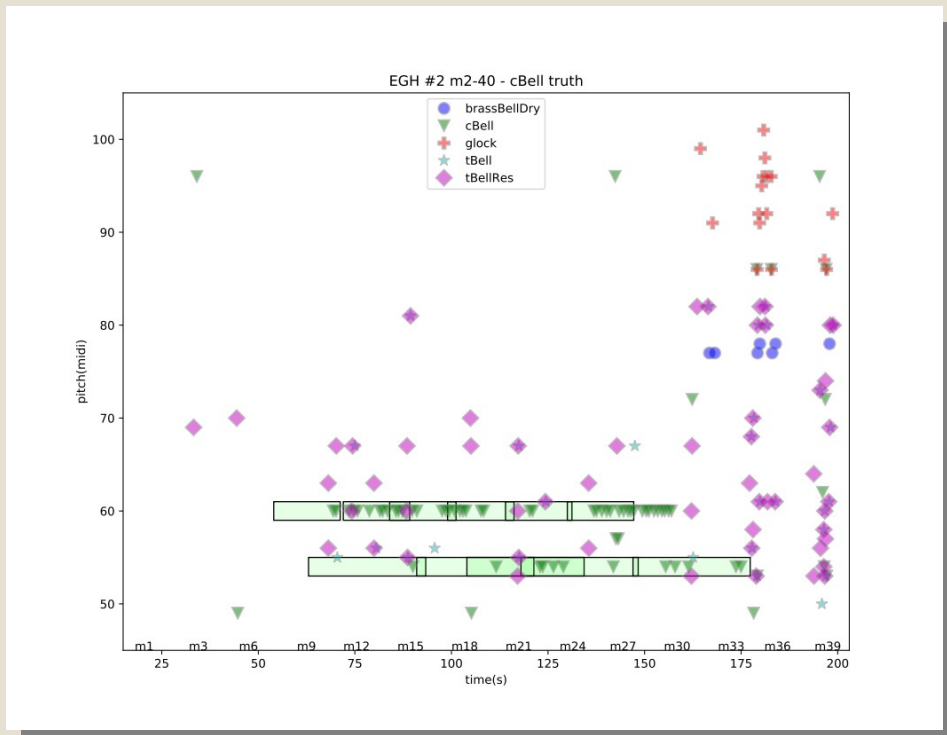


# The first 40





# Ground truth



# Play audio

---

# The harmonizers

---

- Hamel uses digital harmonizers
  - piano/mic notes modified
  - triggered by electronics
    - presets in the electronic staves
  - modified piano heard in surround

- From Hamel
  - schedule for adjusting harmonizers

step	shift(cents)	shift(cents)
1	0	0
2	-9	11
3	-39	34
4	-53	76
5	-150	118

not like  
a bell

like a  
bell



# Hallucinated bells

---

- piano pitches
  - carefully harmonized in real time
  - bring them closer to the bell samples
  - *a harmonizer crescendo* over 40 measures
  - spatial moved from the stage to the surround

# Final words

---

*By disseminating these sounds in the concert space, the composer invites the audience to gradually enter his hallucinogenic belfry, where the musical work takes place.*

# Citations

---

Gérard Grisey, “La musique : le devenir des sons” [written 1979], in Gérard Grisey, *Écrits*, 2<sup>e</sup> édition, Guy Lelong éd. avec la collaboration d’Anne-Marie Réby (Paris: Éditions MF, 2018), 57 [page range 49-60]; originally published in French in the *Darmstädter Beiträge zur Neuen Musik* 19 (1982): 16–23.

Gérard Grisey, cited in Friedemann Sallis, “A spectral examination of Luigi Nono’s *A Pierre. Dell’azzurro silenzio, inquietum* (1985),” in *Live Electronic Music: Composition, Performance, Study*, Friedemann Sallis, Valentina Bertolani, Jan Burle, Laura Zattra eds. (London and New York: Routledge, 2018), 277 [page range 275-289].