Next Generation Beacons

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2015-06-26 • Bo, OZ2M

Contents

- OZ7IGY in short
- Modern beacons and transmission sequence
- PI4 – A MGM for beacon purposes
- Hardware – Next Generation Beacons

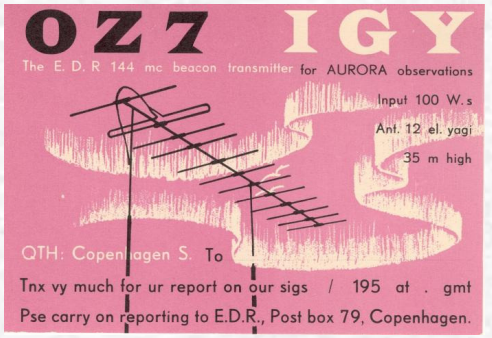
The world's oldest beacon

- OZ7IGY has expenses of ~2300 €/year, coming from using 800 W continuously
  - ~400 € from radio club memberships
  - ~1500 € form individual memberships
  - Member donations
  - The 70 MHz transverter project
  - The Next Generation Beacons project
- QRV
  - MHz: **28**, 40, **50**, **70**, **144** and **432**
  - GHz: **1**, **2**, **3**, **5**, 10 and **24**

Bold: PI4 + CW + carrier

What is a beacon?

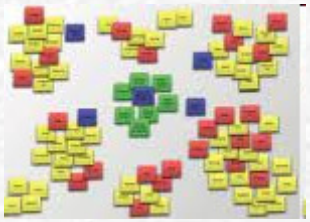
- A beacon is transmitting all the time
- It is reliable
- It is on frequency
- Status is publicly know and updated
- **It is not an ego booster!**



Collecting the requirements

- Should it be based on ideology or the users' needs?

- Digital for the sake of digital?



- What do the users say and want?

Who are the potential users?

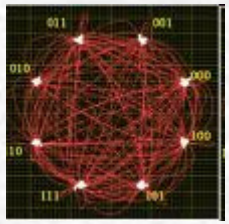
1	**FM user (VUHF)**	Never use beacons DX-ing has no appeal May become 3)
2a	**Analog DXer**	Understands propagations and beacons Not interested in digital communication
2b	**Mixed mode DXer**	Understands propagations and beacons Use whatever it takes to make a QSO and sees the benefits in both analog and digital
3	**Digital user**	Only preference is digital communication Does not really understand propagations May become 2b)

Empirically found

Don’t ask the users!

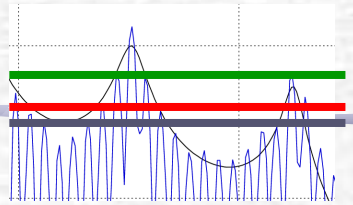
- They don’t know what they want
  - Henry Ford: “If I had asked people what they wanted, they would have said faster horses”

- The purpose of the Next Generation Beacons project was to start the discussion and identify the requirements (for OZ7IGY)



Digital modulation is the future - today

- Sensitivity >10 dB better than CW
  - G4JNT: For easy copy CW at 18 WPM in –9,2 dB S/N is needed (2,5 kHz)
  - AMSAT: Median –14,6 dB, top quartile –17,6 dB, top 1% -20,6 dB (2,5 kHz)
- Automated monitoring of conditions and comparison to average → alarm when x dB better than average
- Long term analysis – 24 h, (7 days), 28 days, one year and 11 years
- Modulation/sequence can be changed when improvements are available



Framework for future beacons

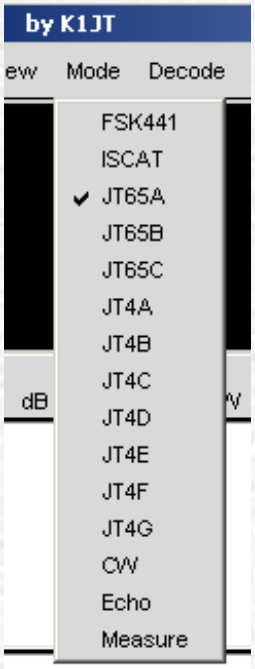
- Can be decoded both with and without a computer, like today
- Benefits from the digital capabilities
- Frequent ID to cope with QSB and "it is not a birdie"
- Possible to detect via unknown propagations
- Must be "zero beatable"
- Must fit into existing beacon spacing(s)
- Same modulation and sequence on "all" bands
- The combination may force a new sequence

Sensitivity is nonsense

- It is not all about the lowest S/N number
- Many people are lured by the S/N value(s)
- Sensitivity is one thing robustness is just as important – it is all about link probability

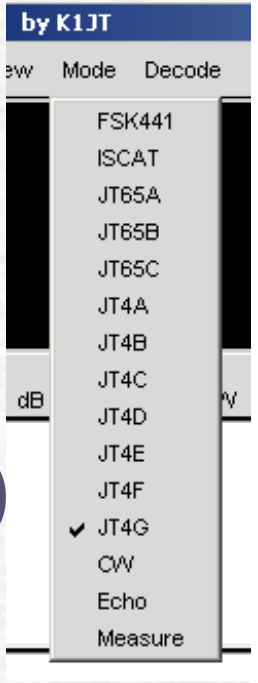
- There are no free lunches when it comes to sensitivity, flexibility, speed and robustness

Something exists, but ...

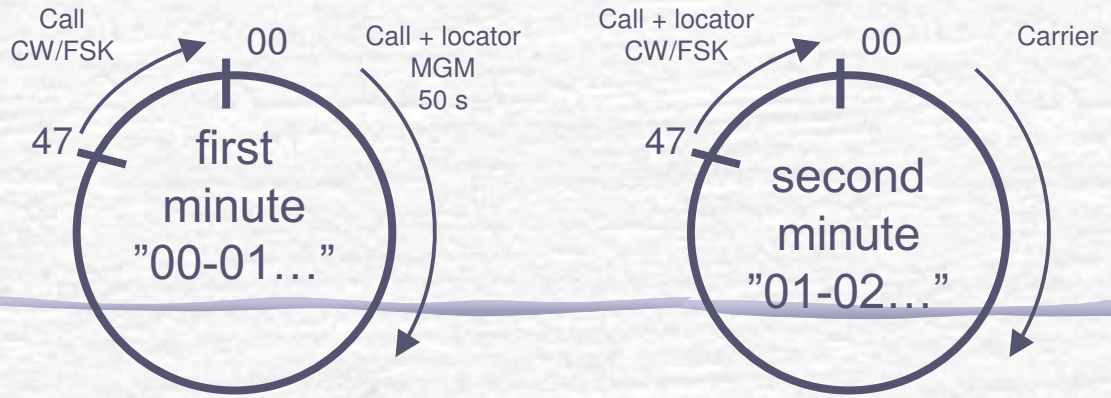


- JT9/WSPR
  - Designed for HF, OK for 6 m but not above
  - 2 min sequence and no CW ID
  - Not resistant to distortion or frequency jitter
  - "Birdie like" from an analog point of view
- JT65
  - Designed for EME, tropo and ionoscatter
  - 1 min sequence and no CW ID, or 2 min with CW ID
  - Only somewhat resistant to distortion

How about JT4x then?



- Designed for VUSHF communications
- Robust modulation and S/N –23,6 dB
- Can be used for 10 GHz EME (JT4F/G)
- Sequence
  - 1 min native (47 s)
  - 2 min with CW ID and carrier



Not for human beings

01)	0:00-0:30	**(MGM)**	OZ7IGY/B JO55WM ***Only if GPS fix is valid***
02)	0.30-1.00	**(CW)**	VVV OZ7IGY/B JO55WM **HHMMz** ***see C)***
03)	1:00-1:30	**(CW)**	VVV OZ7IGY/B JO55WM **HHMMz**
04)	1:30-2:00	**(BPSK)**	Carrier, ***see B)***
05)	2:00-2:30	**(MGM)**	OZ7IGY/B JO55WM ***Only if GPS fix is valid***
06)	2:30-3:00	**(CW)**	VVV OZ7IGY/B JO55WM **HHMMz** ***see C)***
07)	3:00-3:30	**(CW)**	VVV OZ7IGY/B 85 MASL **HHMMz**
08)	3:30-4:00	**(CW)**	VVV OZ7IGY/B JO55WM **HHMMz**
09)	4:00-4:30	**(MGM)**	OZ7IGY/B JO55WM **Only if GPS fix is valid**
10)	4:30-5:00	**(CW)**	VVV OZ7IGY/B JO55WM **HHMMz** ***see C)***
11)	5:00-5:30	**(CW)**	VVV OZ7IGY/B 10 W MLOOP **HHMMz**
12)	5:30-6:00	**(VAR)**	Carrier, ***see A)***

HHMMz is the GMT time from GPS
If non valid GPS data at the end of a CW message it append a **"NOGPS"**
If no supply from AC source at the end of a CW message it append a **"ACLOSS"**

A) Send a RF carrier > 5 s max power > 5 s -6 dB power > 5 s no power > 5 s -6 dB power > max power to the end of segment

B) Send a BPSK carrier for 30 s segment of alternate 1 s phase +-180° from 1 PPPs GPS timing

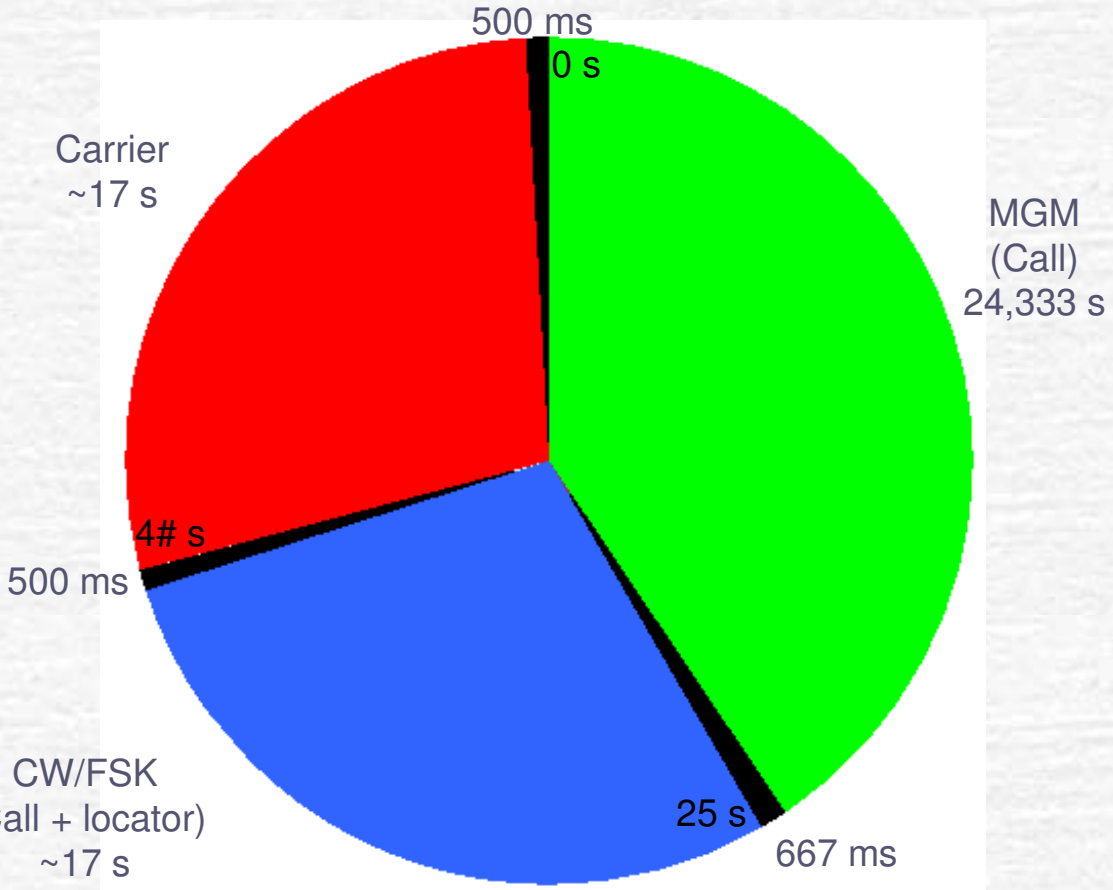
C) This line is ignored, except at boot-up and for loss of GPS signal. The first two sequence of group (1 min) are used for ***MGM*** if no GPS it send a "85 MASL 10 W MLOOP" CW message for two segment of 30 s.
The output carrier 50.471 MHz is locked to a GPS reference of +-0.1 Hz max var.

If no GPS the carrier 50.471 MHz use internal reference at +-5 Hz max variation

The users wanted

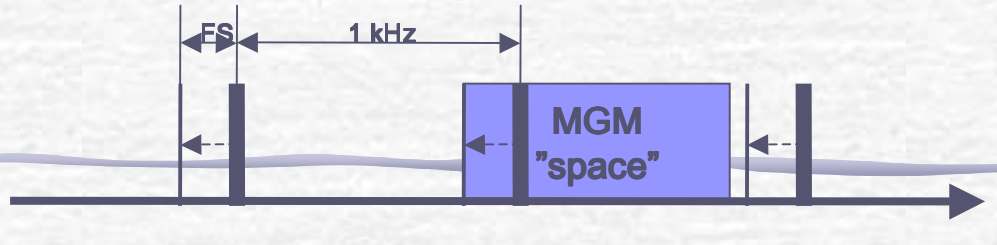
- Just the way it is, i.e. CW and carrier
- MGM only – CW only
- More carrier, less carrier, no carrier
- EME training beacon, i.e. JT65B
- Identical sequence all the time
- MGM decodable via aurora and rain scatter
- Fits into the existing beacon spacing(s)
- Identical tuning for all parts of the sequence

1 min MGM + CW ID + Carrier



PI4 - PharusIgnis4

- A digital modulation (MGM) for beacons
- Maximum reuse of K1JT's JT4 modulation
  - Class C transparent
  - Omit locator from message, i.e. faster message
  - 4 tone FSK designed for beacon spacing
    - Tones spaced ~234 Hz, or ~709 Hz wide
    - Leaves guard space for above beacon using CW FSK
    - Wider spacing possible if needed, e.g. SHF bands
  - 800 Hz offset



Comparing

JT4

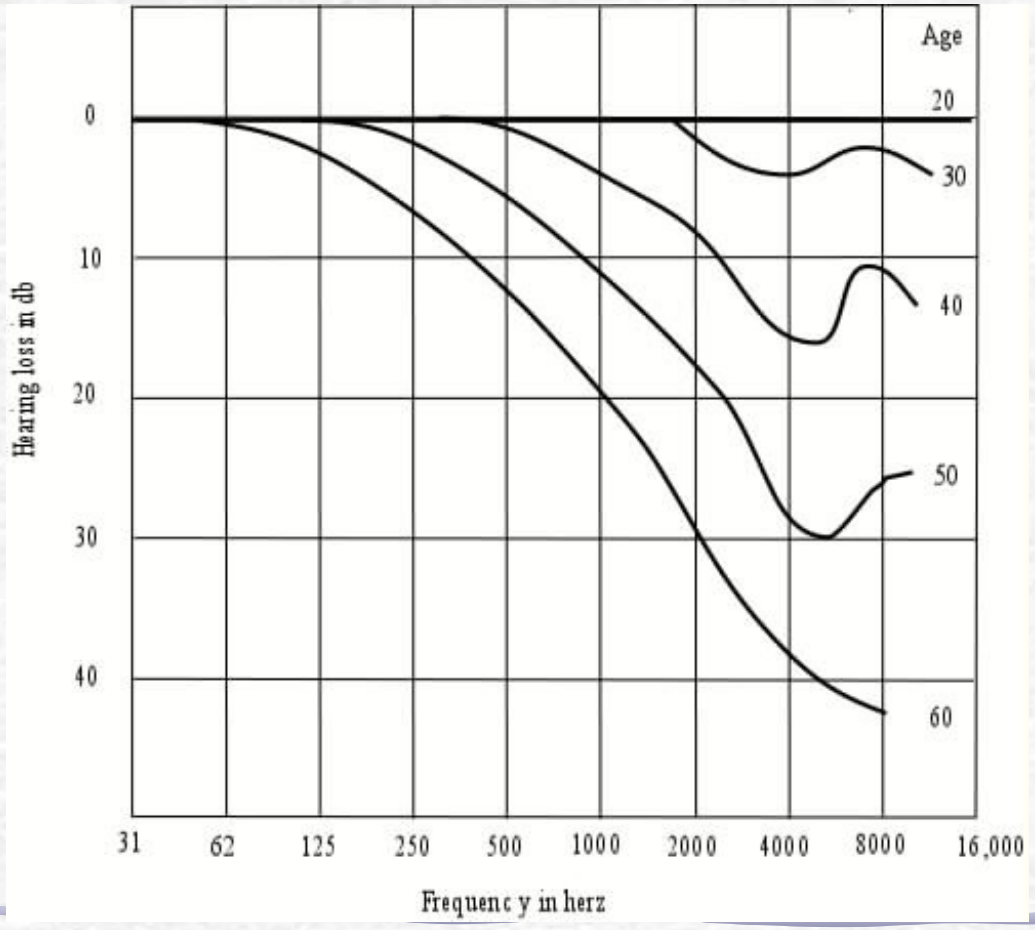
- Duration is 47,314 s
- 2 min sequence
- 13 char. message
- Call and locator
- “A”-“Z”, “0”-“9”, “/+-.?<space>” in total 42 chars
- ~F narrow, ~G wide
- S/N 23,6 dB
- Already in WSJT
- 262,5 time slots per min

PI4

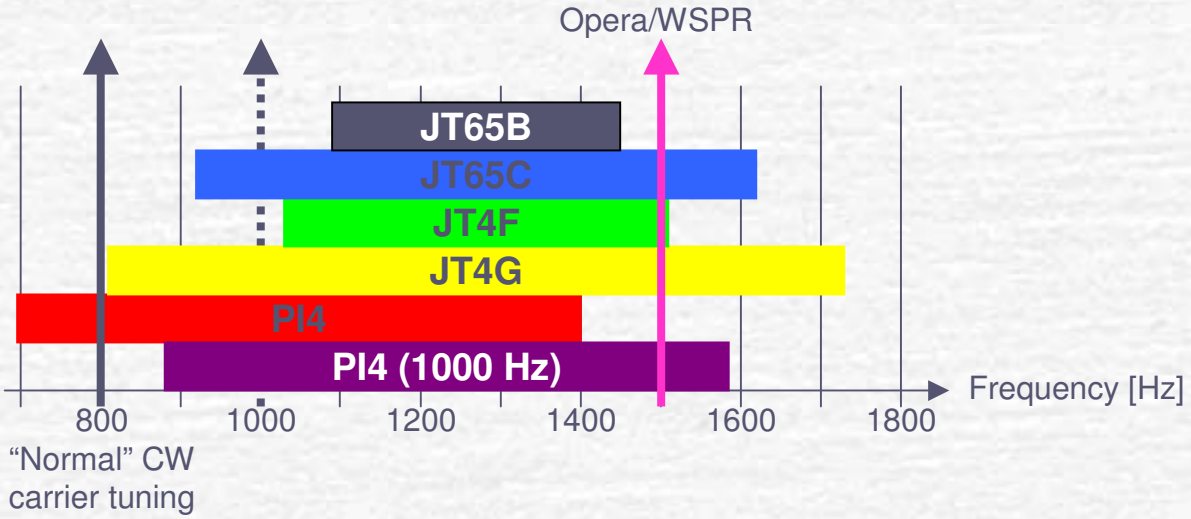
- Duration is 24,333 s
- 1 min sequence
- 8 char. message
- Call, or other msg.
- “A”-“Z”, “0”-“9”, “/<space>” in total 38 chars
- BW 709 Hz, just right
- S/N 22,2 dB
- PI-RX decoder
- 360 time slots per min

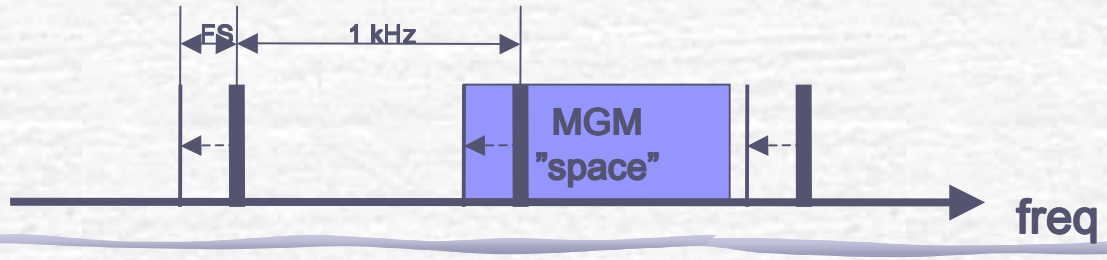
Human tuning offset – 800 Hz

- SM6ESG says that he hears PI4 tone0 better than the carrier/CW from OZ7IGY



Frequency comparisons



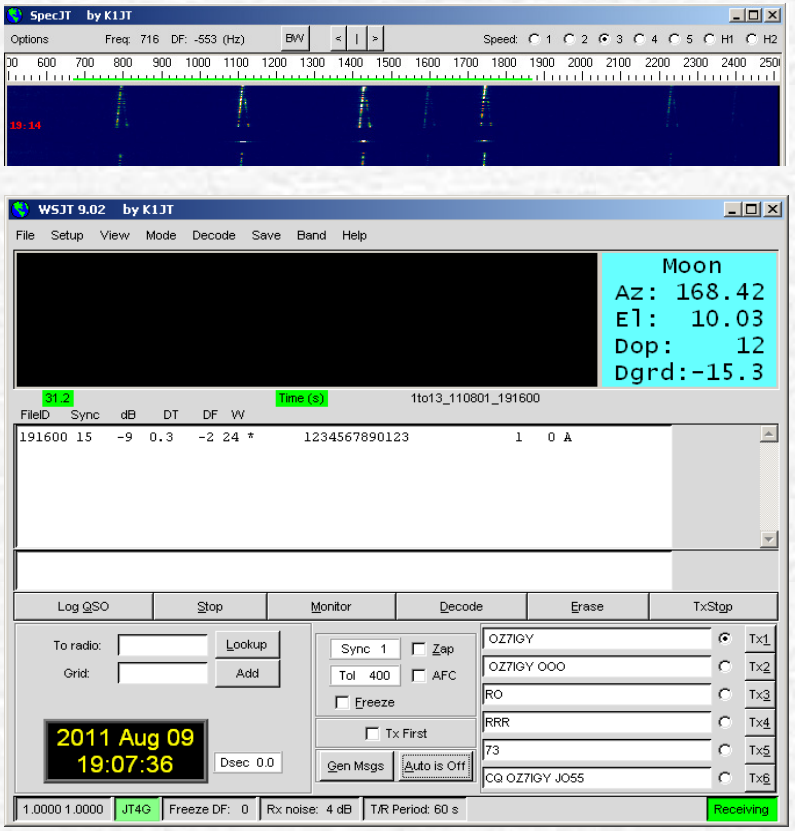


Improving PI4

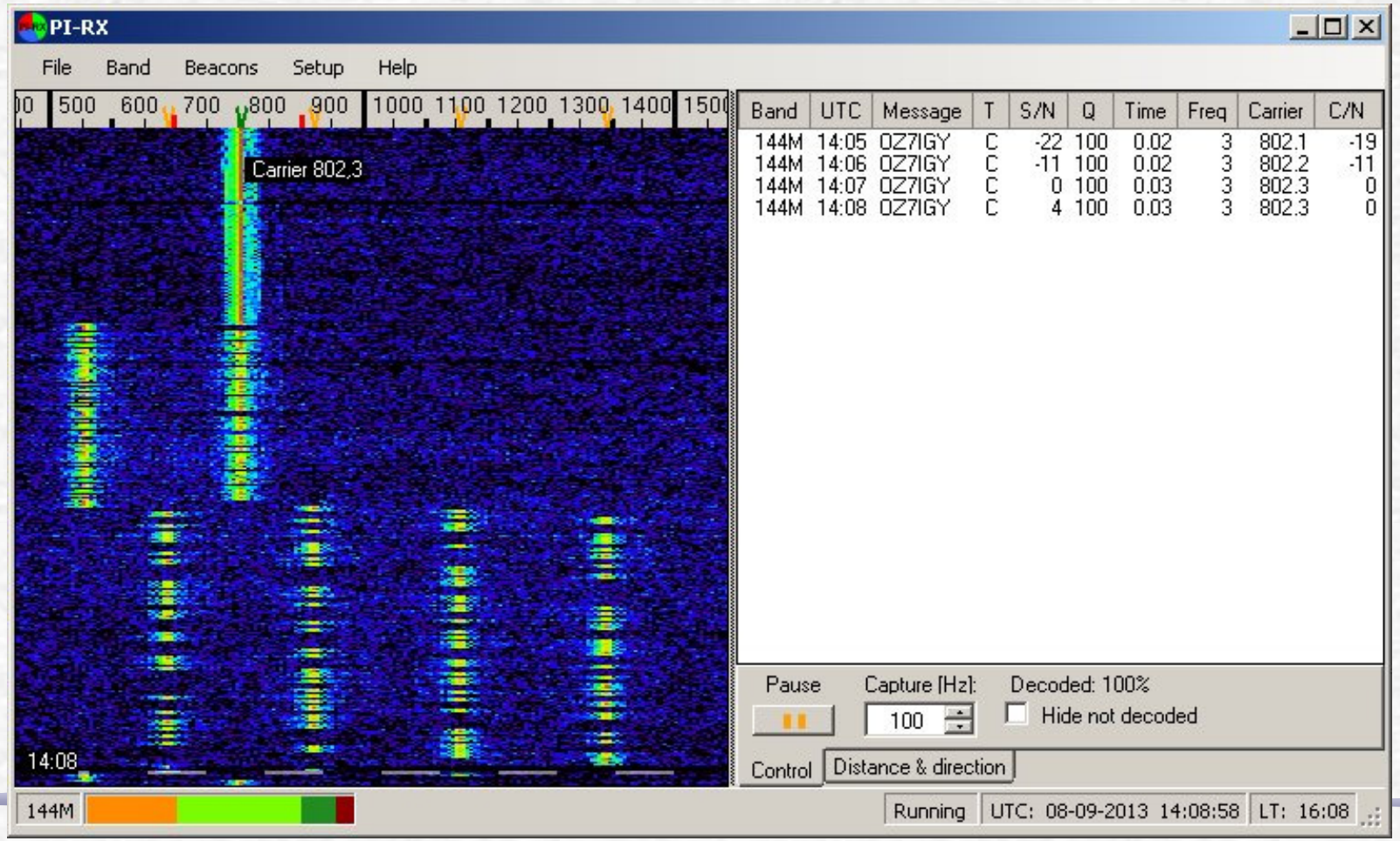
- Even before using PI4 we knew we could have improved the sensitivity by 0,8 dB by not being close to JT4
- In hindsight we should not have pursued the WSJT path
- Improved sensitivity by some 2 dB but more complex encoding yet same way of sync
- (Four times as fast PI4 repeated four times, 6 dB worse S/N, avg. improvement up to 3 dB)
- (A PI8 with eight tones and sync across all)

Decoding digital modulation

- The leading VUSHF digital modulation program is WSJT
- We had hoped to persuade Joe, K1JT, to implement a PI4 decoder but no response



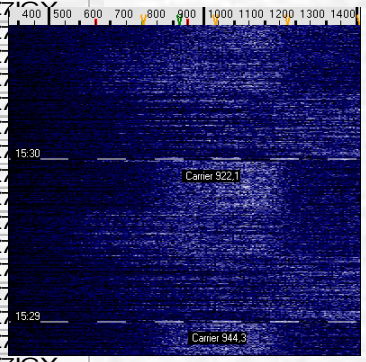
PI-RX by OZ1CKG



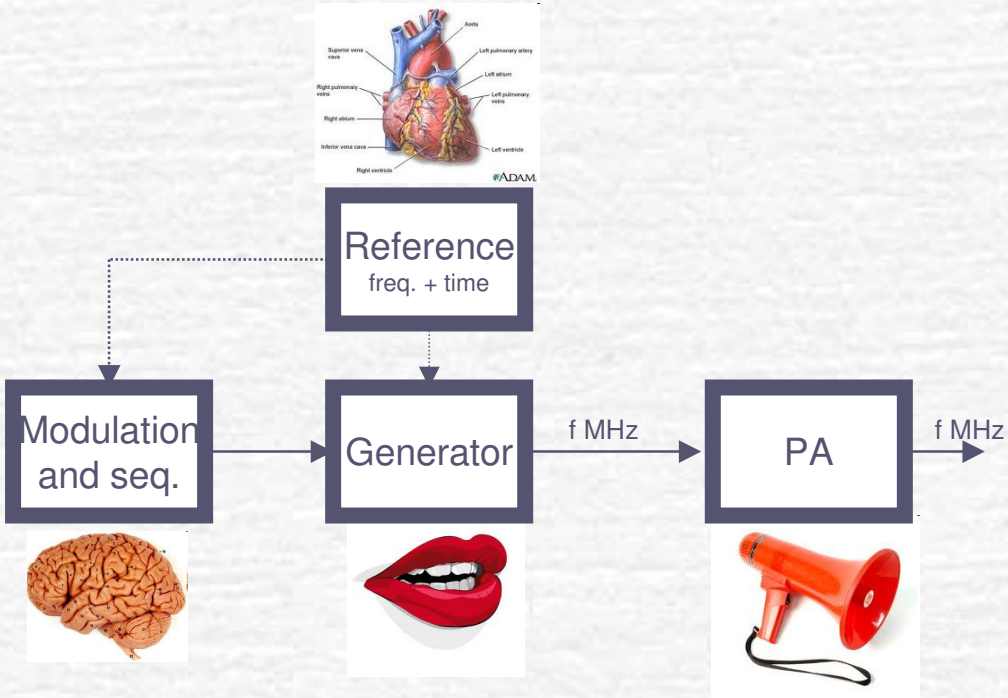
PI-RX decoder development

- 0.9.0.4, ~5, ~9, 0.9.0.10
- Aurora recordings by Jan, LA3EQ on 7 June 2013
- From 33% to 100% aurora decodes by optimizing the decoder performance
- Added wide scatter mode
- Handles multipath and MS

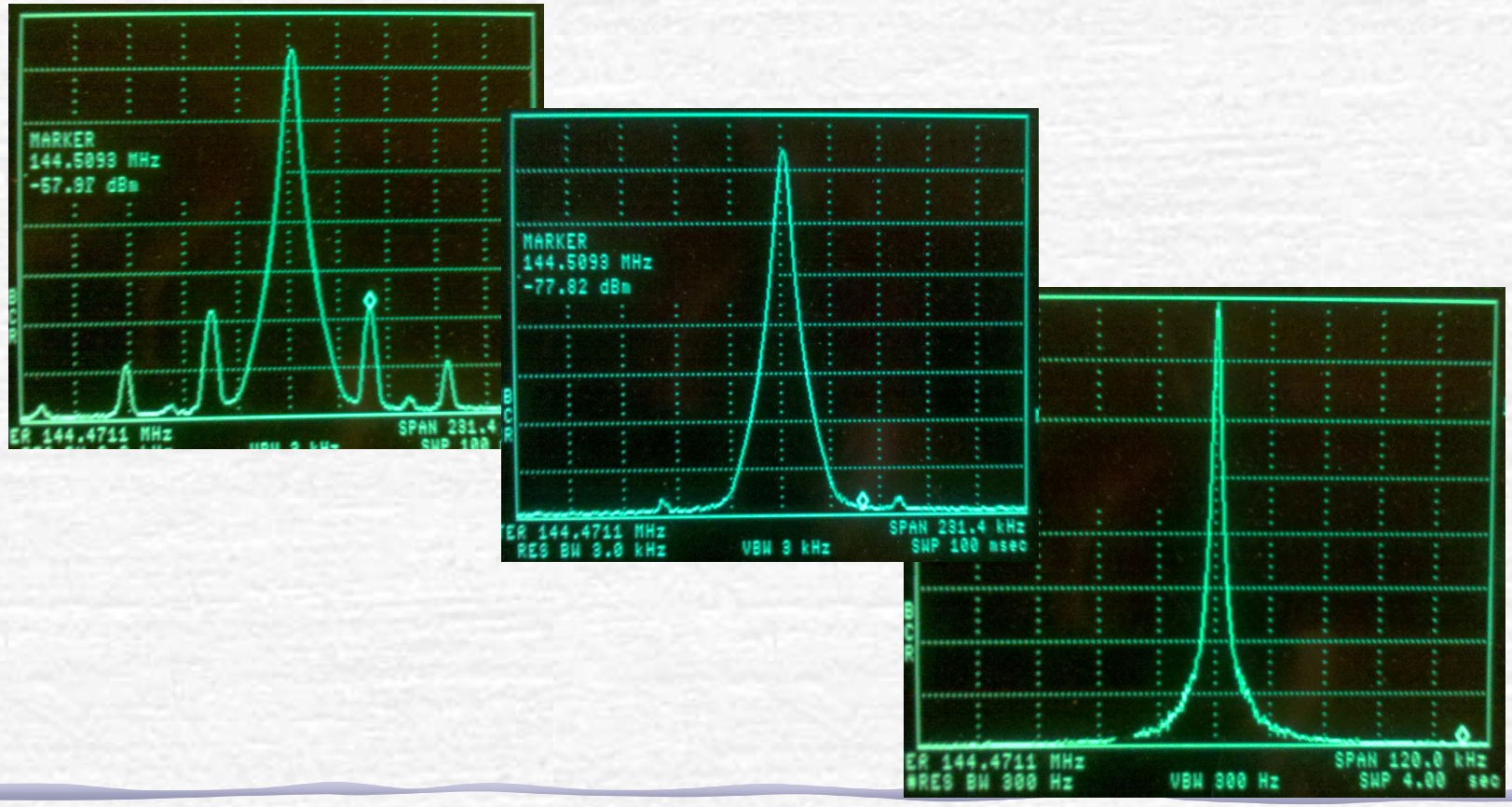
Decoder:	0.9.1.0	0.9.1.9	0.9.2.0
04:31	-----	OZ7IGY	OZ7IGY
04:32	-----	-----	OZ7IGY
04:33	-----	OZ7IGY	OZ7IGY
04:34	-----	-----	OZ7IGY
04:35	-----	-----	OZ7IGY
04:36	-----	-----	OZ7IGY
04:37	-----	-----	OZ7IGY
04:38	-----	OZ7IGY	OZ7IGY
04:39	-----	OZ7IGY	OZ7IGY
04:40	-----	OZ7IGY	OZ7
04:41	OZ7IGY	OZ7IGY	OZ7
04:42	-----	-----	OZ7
04:43	-----	-----	OZ7
04:44	-----	OZ7IGY	OZ7
04:45	-----	OZ7IGY	OZ7
04:46	OZ7IGY	OZ7IGY	OZ7
04:47	OZ7IGY	OZ7IGY	OZ7
04:48	-----	OZ7IGY	OZ7
04:49	-----	OZ7IGY	OZ7
04:50	-----	OZ7IGY	OZ7
04:51	OZ7IGY	OZ7IGY	OZ7
04:52	OZ7IGY	OZ7IGY	OZ7
04:53	OZ7IGY	OZ7IGY	OZ7
04:54	-----	OZ7IGY	OZ7IGY
04:55	OZ7IGY	OZ7IGY	OZ7IGY
04:56	-----	OZ7IGY	OZ7IGY
04:57	-----	OZ7IGY	OZ7IGY
04:58	OZ7IGY	OZ7IGY	OZ7IGY
04:59	OZ7IGY	OZ7IGY	OZ7IGY
05:00	OZ7IGY	OZ7IGY	OZ7IGY
05:01	OZ7IGY	OZ7IGY	OZ7IGY
05:02	OZ7IGY	OZ7IGY	OZ7IGY
05:03	-----	OZ7IGY	OZ7IGY
05:04	-----	OZ7IGY	OZ7IGY
05:05	-----	-----	OZ7IGY
05:06	-----	OZ7IGY	OZ7IGY



Beacon hardware for dummies

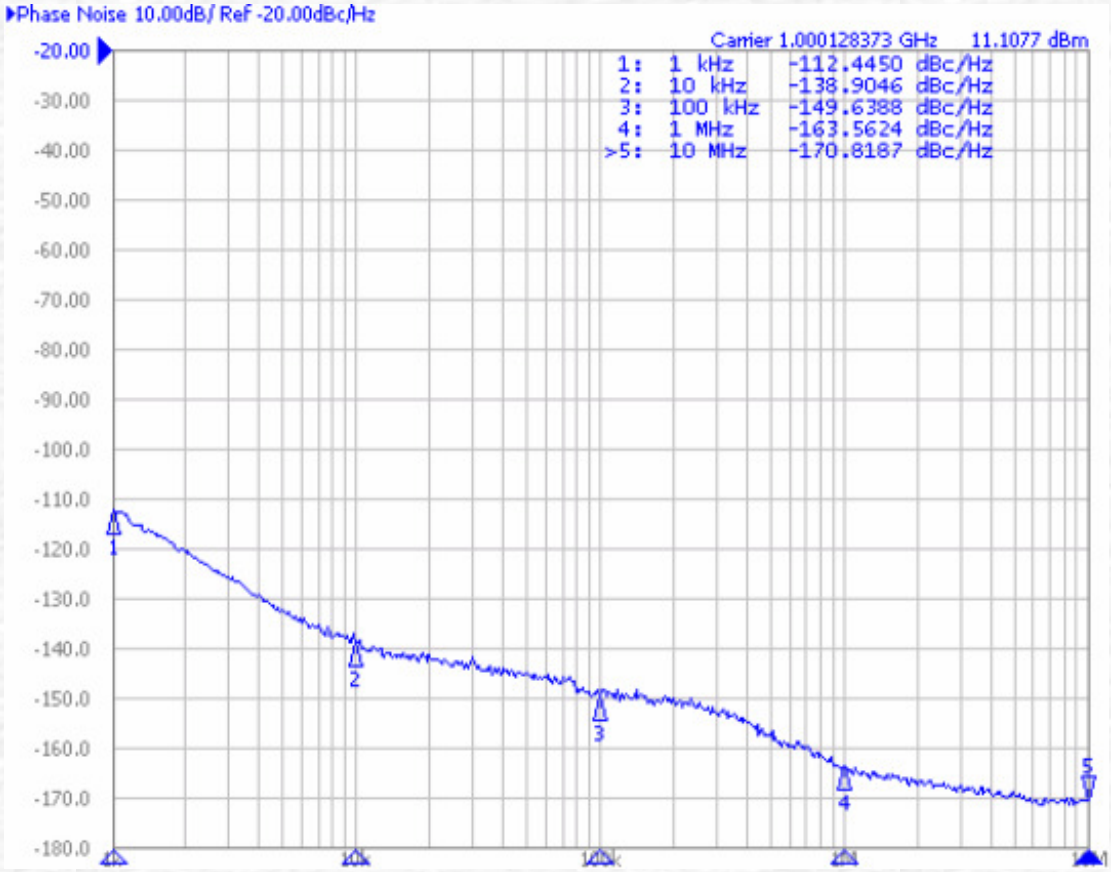


Close in spectrum matters!

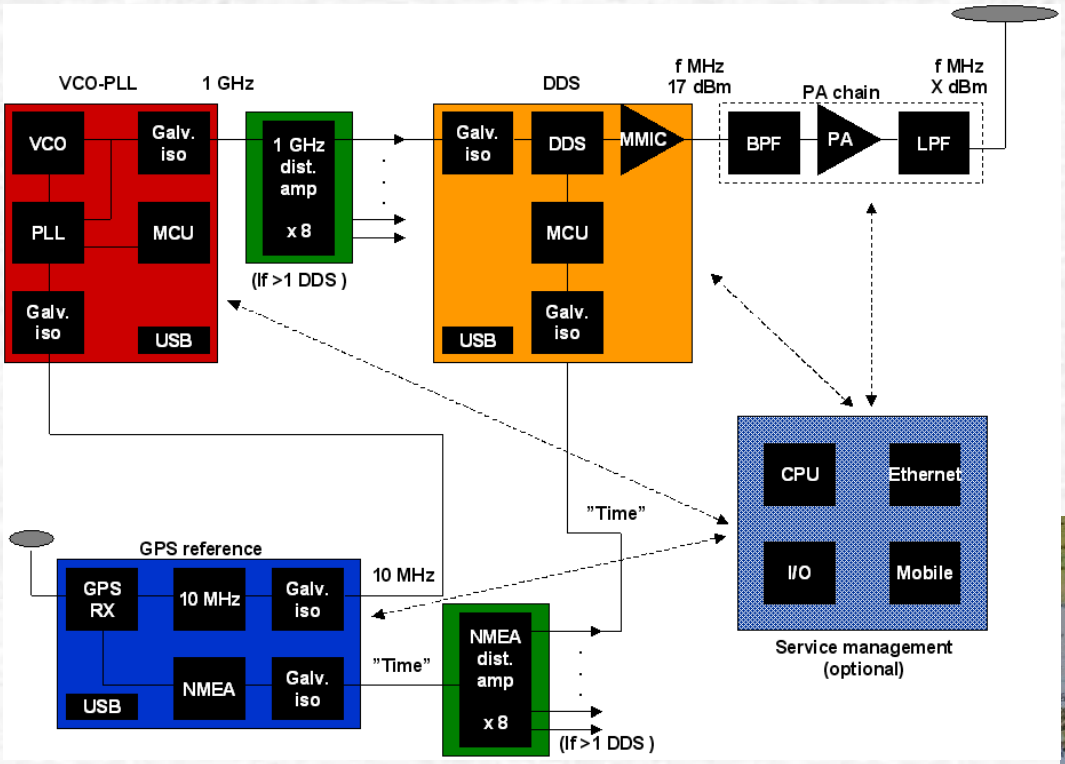


Please take care!

- It is not just about harmonics
- Phase noise
- Inband spurii



Next Generation Beacons



PI4 beacons on the air

- OZ7IGY – March 2013, 2 m and 6 m (all)
- IW9GDC/B – August 2013, 4 m
- DB0JG – February 2014, 70 cm
- DB0IH – July 2014, 70 cm
- ED5YAE – August 2014, 3 cm
- PE1MXP/B – September 2014, 4 m
- DB0LTG – January 2015, 23 cm
- GB3MHZ – April 2015, 3 cm
- SK4MPI – Summer 2015, 2 m (/6 in June)
- GB3CFG – Summer 2015, 4 m
- Next Generation Beacons hardware also in ON, OH, K and VK
- Another handful is in the pipeline for 2015

Conclusion

- Find out what the users want and what is needed – don't just use what is available
- PI4 has been decoded using PI-RX via aurora, rain scatter and EME → PI4 is a general purpose MGM for beacon purposes
- Users really like the PI4 + CW + carrier sequence
- Available hardware solutions from state of the art to eBay-level and roll-your own

More information

- PI4 specification
  - www.rudius.net/oz2m/ngnb/pi4.htm
- PI-RX, PI4 decoder program
  - www.rudius.net/oz2m/software/pi-rx
- OZ7IGY home page
  - www.oz7igy.dk